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Radiation test results and analysis for optocoupler devices in space applications

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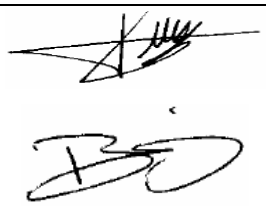
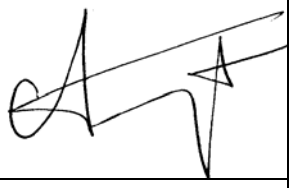
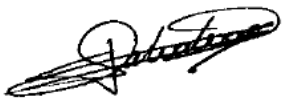
Prepared by	**D. Peyre** Radiation expert **C. Binois** Radiation test lab manager		
Verified by	**R. Mangeret** Radiation expert		
Approved by	**G. Salvaterra** Application part engineer		
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1. INTRODUCTION

This document contains preliminary analysis on protons test results performed on optocouplers, in the frame of ESA contract n°19623/05/NL/PA, and constitutes the work-package WP2 furniture.
Proton tests were performed at PSI facility, on September 29th to October 1st 2007, and from November 24th to November 25th 2007. Used energies and fluences are described in [1].

2. REFERENCE DOCUMENTS

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3. PROTON IRRADIATION AND VARIATION OF CTR (CURRENT TRANSFER RATIO)

As described in [1], studied optocouplers are constituted with separated diodes (AsGa material) and transistors (Si material). Hence, during these irradiations, it has been possible to irradiate both diode and transistor at the same irradiation steps and to perform their CTR measurement with their respective degradation level thanks to their coupling with their reference counterpart (not irradiated). Each irradiation step was performed on optocoupler group gathering 3 optocoupler samples.

In complement of the informations provided in [1], the following table gives the technological characteristics of the studied parts including datecodes and emitter and receiver lot numbers (when available).

Part type	**Emitter**	**Receiver**			**Package**
	LED	**Photodiode**	**Phototransistor**	**Output transistor**	
4N49 / ISOLINK **(DC0626)**	880 nm Amphoteric Si doped Single heterojunction AlGaAs **(Ref : OLQ244E)**	N/A	**0.025 inch sq** **(Ref : OLQ244D)**	N/A	Window can

Part type	Emitter	Receiver			Package
	LED	Photodiode	Phototransistor	Output transistor	
OLH249 / ISOLINK **(DC0626)**	830 nm Double heterojunction AlGaAs **(Ref : OLQ243E)**	N/A	**0.045 inch sq (Ref : OLQ243D)**	N/A	Window can
66099 / MICROPAC **(DC0636)**	660 nm Double heterojunction AlGaAs	**0.04 inch sq**	N/A	**2N2222**	Window can

3.1 DEFINITIONS

Given the following definitions:

CTR optocoupler: CTR of irradiated optocoupler (diode and transistor)

CTR diode: CTR of irradiated diode with reference transistor.

CTR transistor: CTR of irradiated transistor with reference diode.

CTR reference: CTR of reference diode with reference transistor.

I_F : applied forward current through the diode.

I_C: measured collector current of the transistor.

If Φp_1, Φp_2 and Φp_3 are the final fluences and *i* is the sample index (i=1,2,3):

$$\text{CTR optocoupler}\left[\Phi p_{1,2,3}, \#i\right] = \frac{I_C \text{ irradiated transistor}\left[\Phi p_{1,2,3}, \#i\right]}{I_F \text{ irradiated diode}\left[\Phi p_{1,2,3}, \#i\right]} \quad \text{Eq. 1}$$

$$\text{CTR diode}\left[\Phi p_{1,2,3}, \#i\right] = \frac{I_C \text{ reference transistor}\left[\#i\right]}{I_F \text{ irradiated diode}\left[\Phi p_{1,2,3}, \#i\right]} \quad \text{Eq. 2}$$

$$\text{CTR transistor}\left[\Phi p_{1,2,3}, \#i\right] = \frac{I_C \text{ irradiated transistor}\left[\Phi p_{1,2,3}, \#i\right]}{I_F \text{ reference diode}\left[\#i\right]} \quad \text{Eq. 3}$$

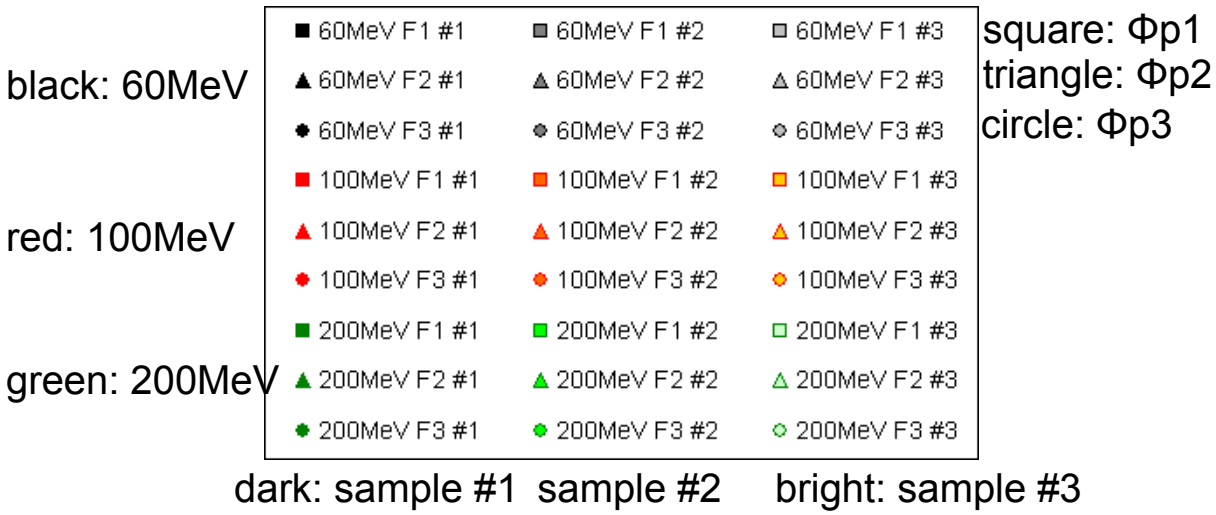
$$\text{CTR reference}\left[\#i\right] = \frac{I_C \text{ reference transistor}\left[\#i\right]}{I_F \text{ reference diode}\left[\#i\right]} \quad \text{Eq. 4}$$

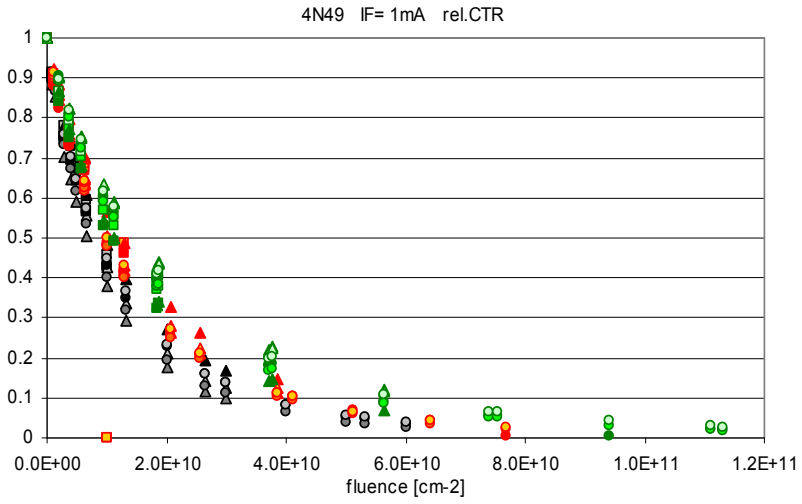
3.2 IRRADIATION RESULTS

3.2.1 Evolution with fluence

For all irradiated optocouplers, irradiated diodes and irradiated transistors, of all components (4N49, OLH249 and 66099), the CTR degradation decreases as energy increases from 60MeV to 200 MeV. This can be easily seen on the relative CTR curves, Fig. 3-1 to Fig. 3-9. All the CTR measurements (relative and absolute) are reported in appendixes. Since the NIEDR (Non-Ionizing Energy Deposition Rate) decreases with energy it could be interesting to study how the degradation depends on the NIEL of the particle (Non-Ionizing Energy Loss, integrated NIEDR, next section 3.2.2).

The figures below depict the CTR optocoupler, CTR diode, and CTR transistor, in this order, with the following color and shape codes:





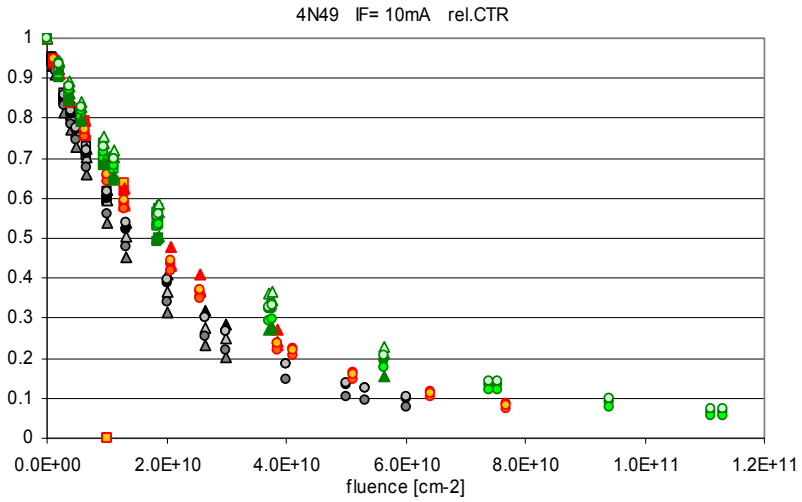
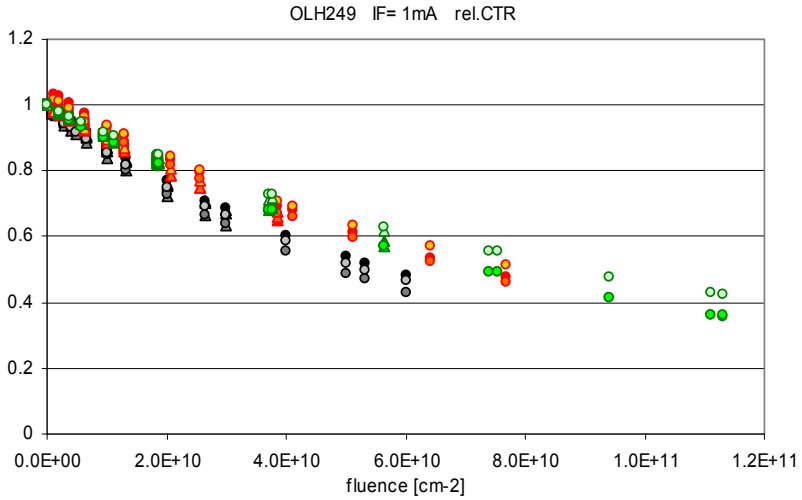


Fig. 3-1: 4N49 optocoupler: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA



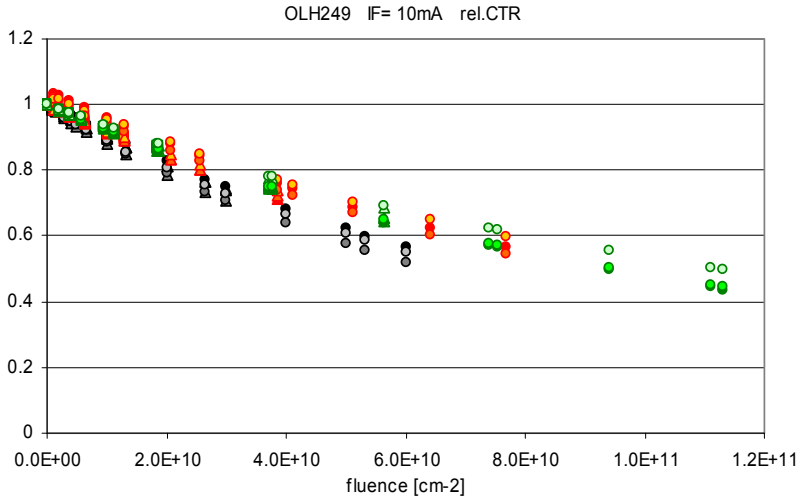


Fig. 3-2: OLH249 optocoupler: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA

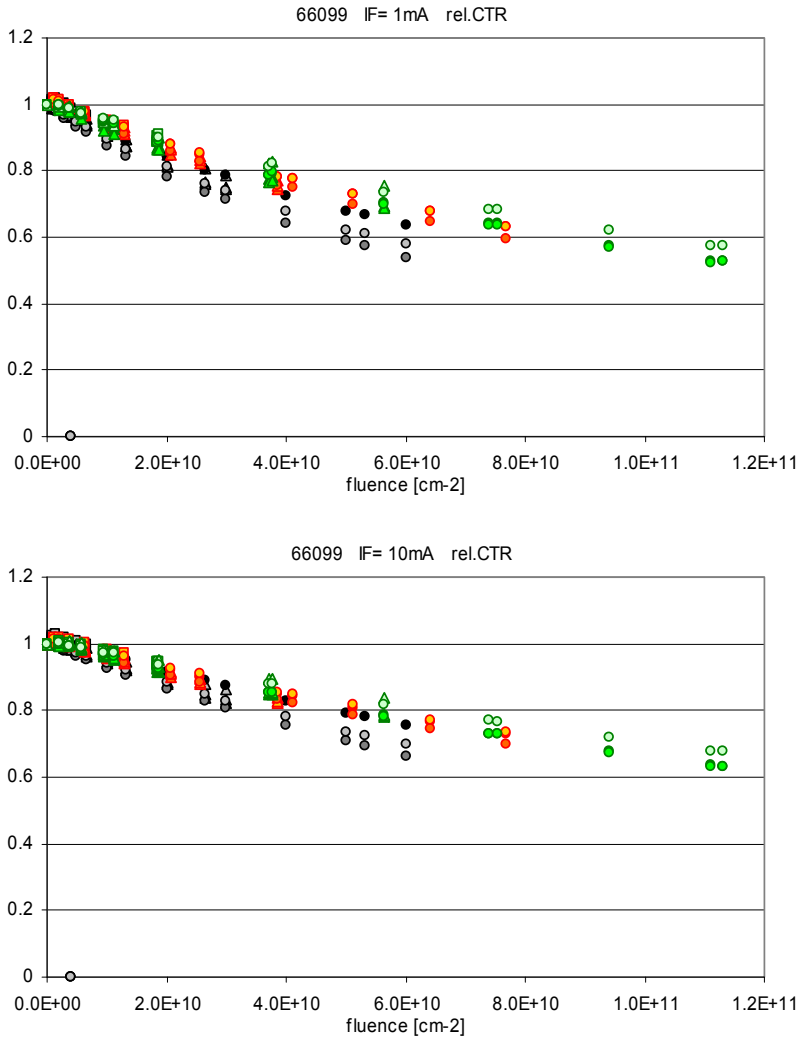
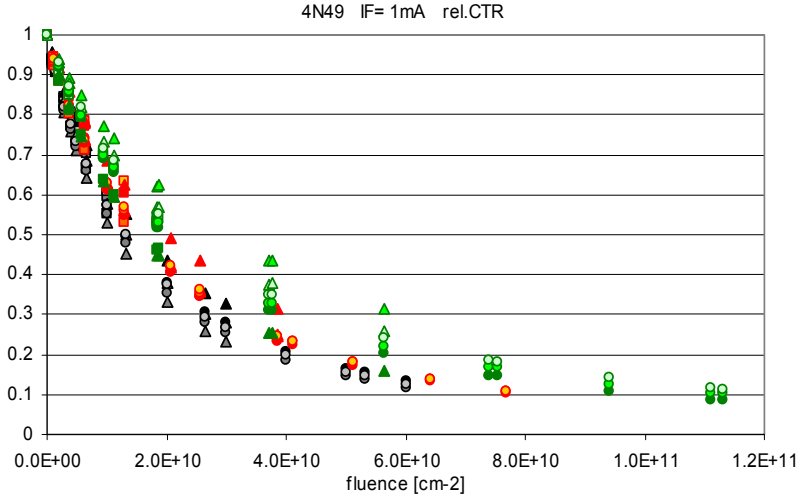


Fig. 3-3: 66099 optocoupler: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA



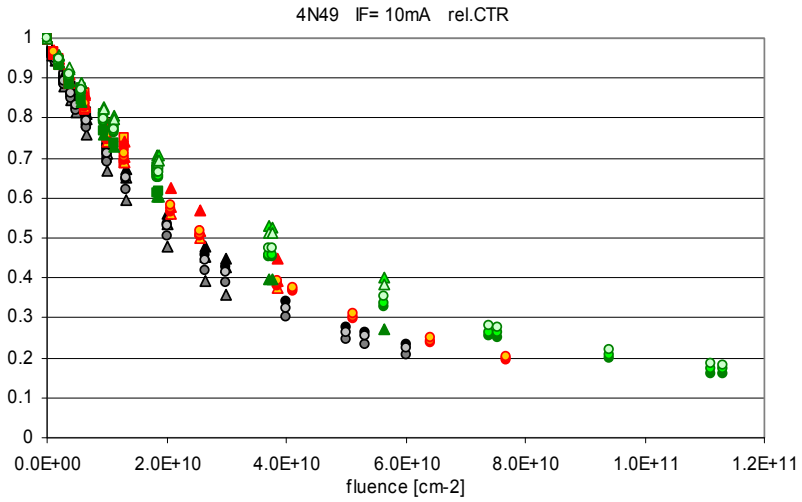


Fig. 3-4: 4N49 diode: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA

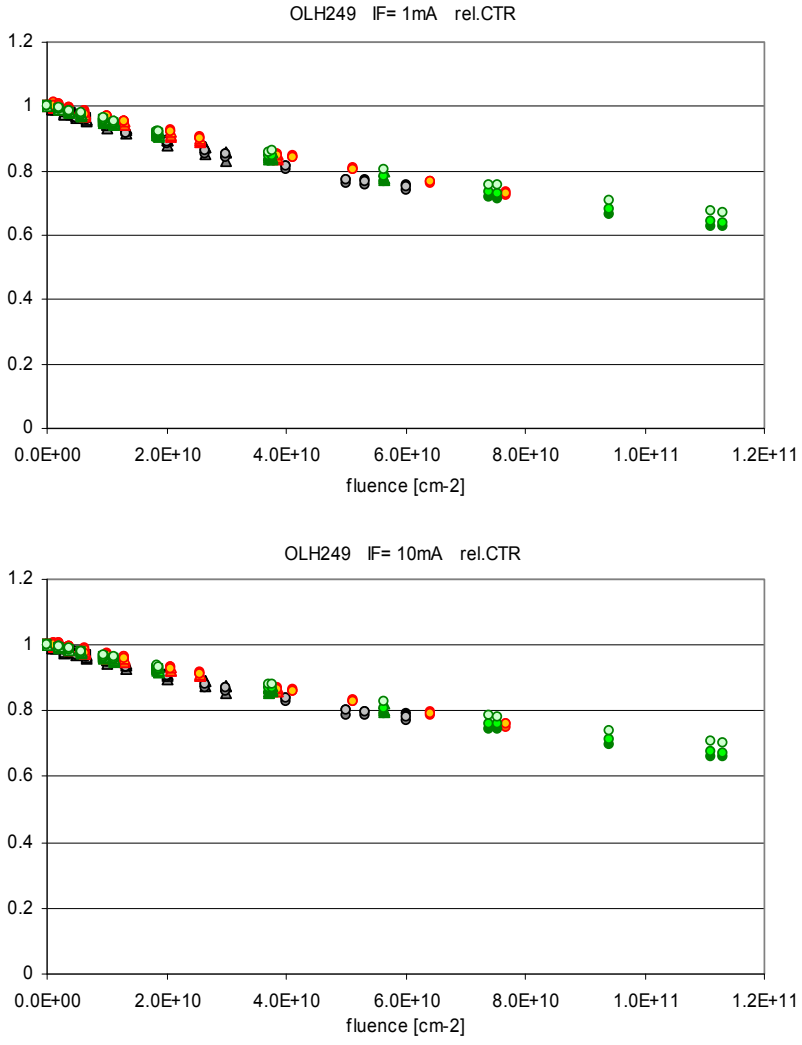


Fig. 3-5: OLH249 diode: relative CTR with respect to fluence at I_F=1mA and I_F=10mA

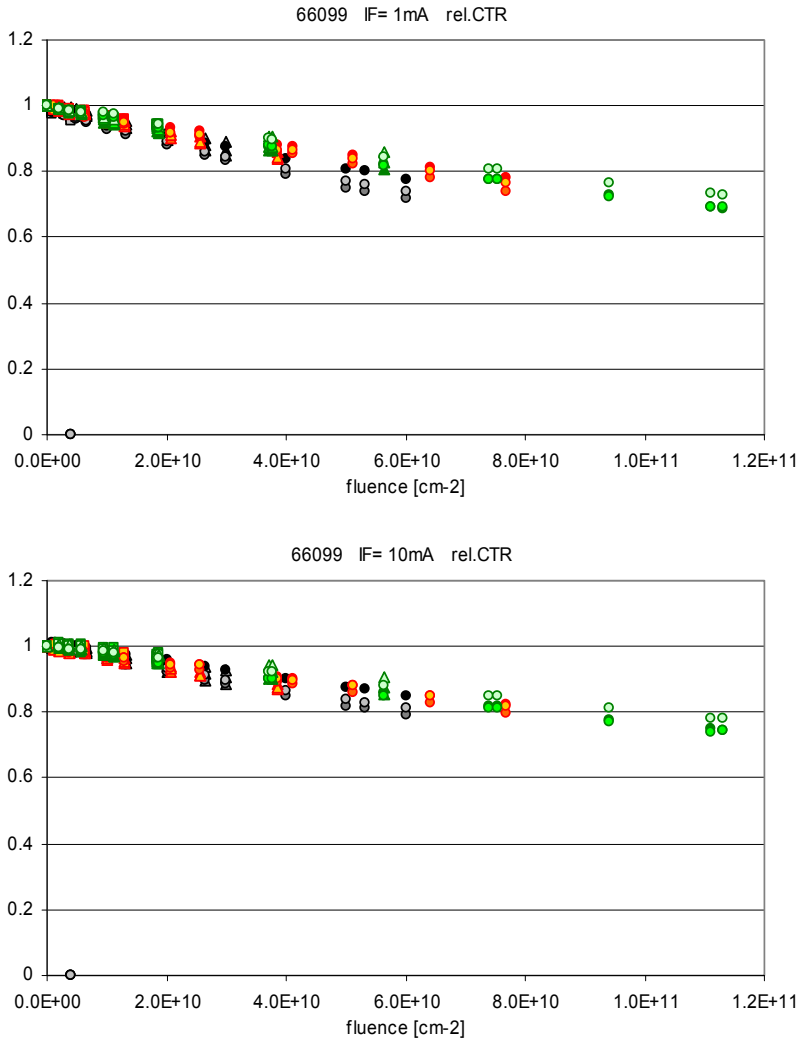
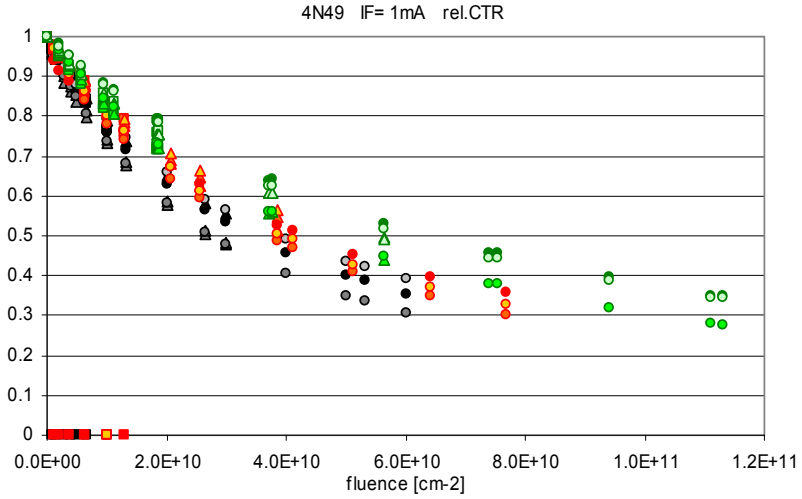


Fig. 3-6: 66099 diode: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA



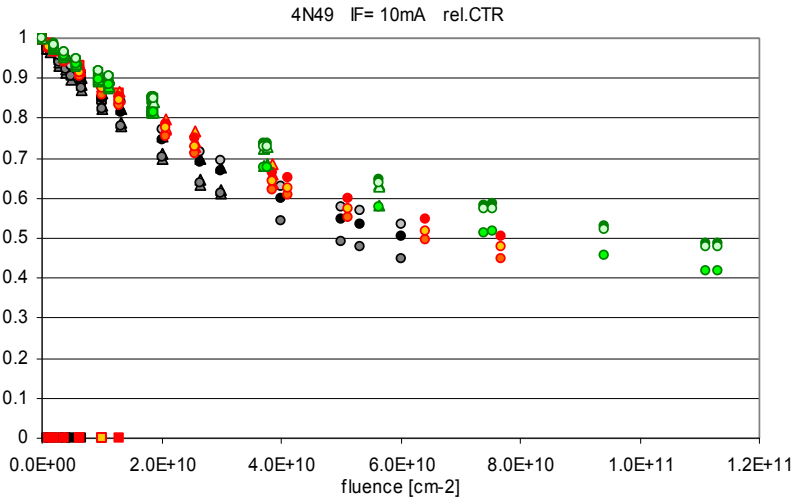


Fig. 3-7: 4N49 transistor: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA

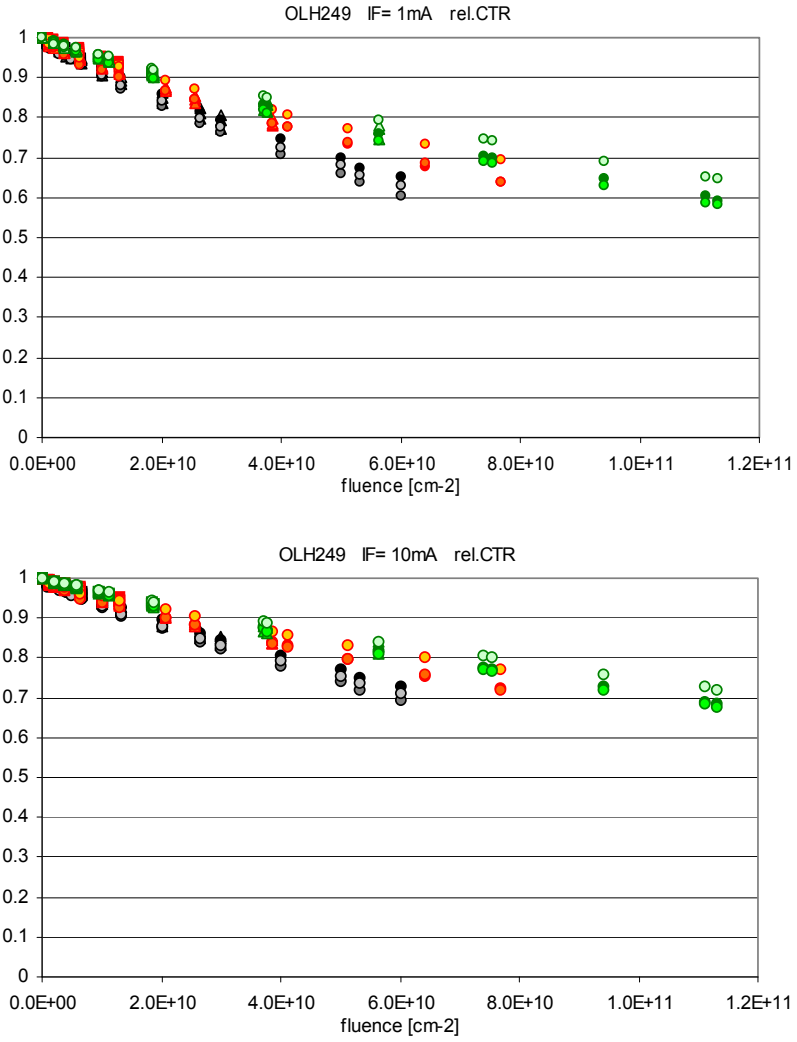


Fig. 3-8: OLH249 transistor: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA

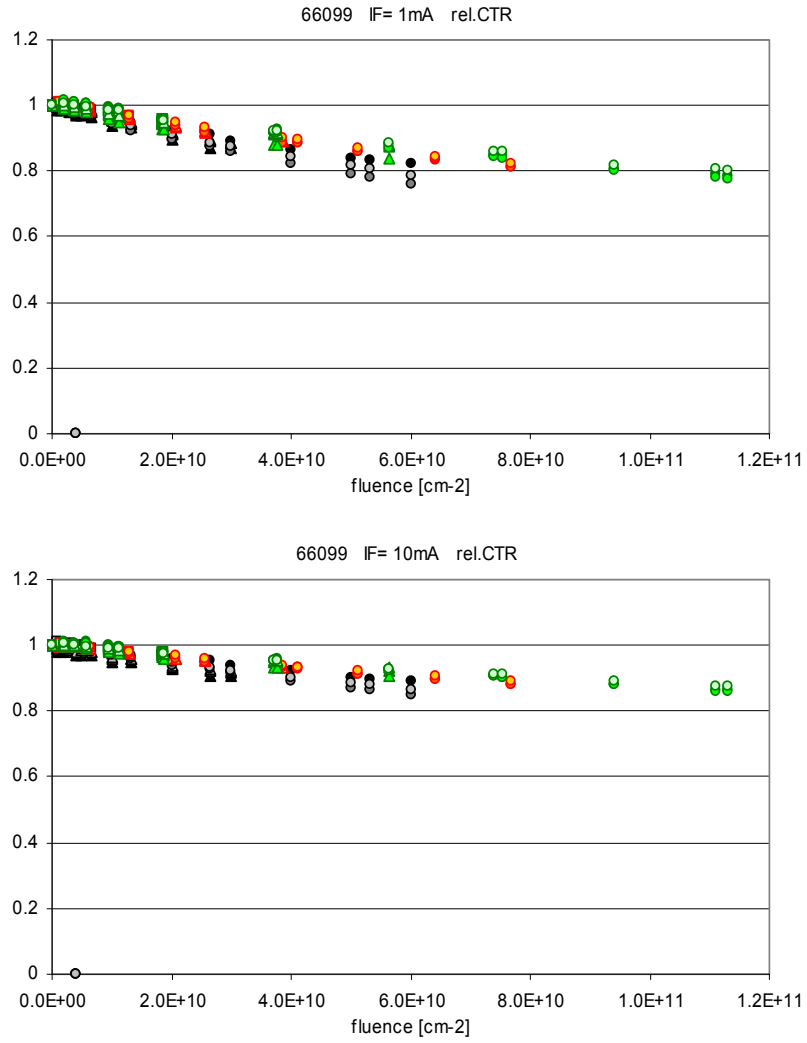


Fig. 3-9: 66099 transistor: relative CTR with respect to fluence at I_F= 1mA and I_F= 10mA

It has to be noticed that for each irradiated part (whole optocoupler, diode or transistor), 4N49 experiences by far the strongest degradation, then OLH249 is much less degraded, and 66099 even less (slightly). As a general result, degradation observed at 200 MeV exhibits lower level than with the other energies. At first glance, this is in line with the respective NIEDR expected on AsGa and/or Si (see Table 1 and Table 2 below). However, each “curve-end” (grey, orange or green family) is aimed to represent an identical level of degradation. This is roughly verified for Si based transistor while this is far from being verified for 4N49 and OLH249 diodes, especially between 200 MeV and other energies curves. Further investigation is necessary to identify a potential effect from material thickness surrounding the diode’s active regions.

CTRtransistor of 66099 and OLH249 present the least discrepancy between each other, but 66099 transistors still withstand more proton irradiation. As already reported in [1], the wavelengths λ are 880nm for 4N49, 830nm for OLH249 and 660nm for 66099. At first glance the transistor CTR degradation can be related to the absorption coefficient which increases while λ decreases, thus decreasing the transistor sensitivity to displacement effect. This relation to wavelength can be studied

thanks to cross-measurement between each diode type coupled with all the other transistor types. This will be presented in the section related to neutron results (future edition).
From the comparison of the variation versus the fluence of CTRdiode and of CTRtransistor, it is found that the main contribution in the decrease of 4N49 optocoupler CTR is due to the decrease of the light emission from the diode. At about $4.10^{10}cm^{-2}$ CTRtransistor can reach twice the value of CTRdiode, and up to thrice the value at $1.13.10^{11}cm^{-2}$, at 200MeV. It is also the case for 66099, but much less pronounced as CTRtransistor does not exceed around 13% of CTRdiode.

On the opposite for OLH249, CTRtransistor is more degraded than CTRdiode, remaining in a 10% range. However for the highest fluences (> $7.10^{10}cm^{-2}$) at 100MeV and 200MeV, and only for important forward currents (8mA and 10mA, Fig. 13-21 and Fig. 13-21), CTRtransistor becomes higher than CTRdiode.

3.2.2 Evolution with NIEL

Table 1 and Table 2 here below recall the NIEDR values presented in [1].

	AsGa NIEDR (MeV.cm²/g)		
	Ep = 60 MeV	Ep = 100 MeV	Ep = 200 MeV
Barry [1], [2]	$1.60.10^{-3}$	$1.25.10^{-3}$	$8.50.10^{-4}$
Barry new hypothesis [4]	$1.19.10^{-3}$	$8.4.10^{-4}$	$5.30.10^{-4}$
GEANT4 elastic	$1.204.10^{-3}$	$7.76.10^{-4}$	$4.32.10^{-4}$
GEANT4 inelastic	$7.39.10^{-4}$	$8.48.10^{-4}$	$7.76.10^{-4}$
GEANT4 total	$1.943.10^{-3}$	$1.624.10^{-3}$	$1.208.10^{-3}$
Burke 1987 [4]	$1.90.10^{-3}$	$1.52.10^{-3}$	$1.50.10^{-3}$

Table 1. Proton NIEDR values in AsGa according to Barry and GEANT4 [MeV.cm²/g] with respect to energy.

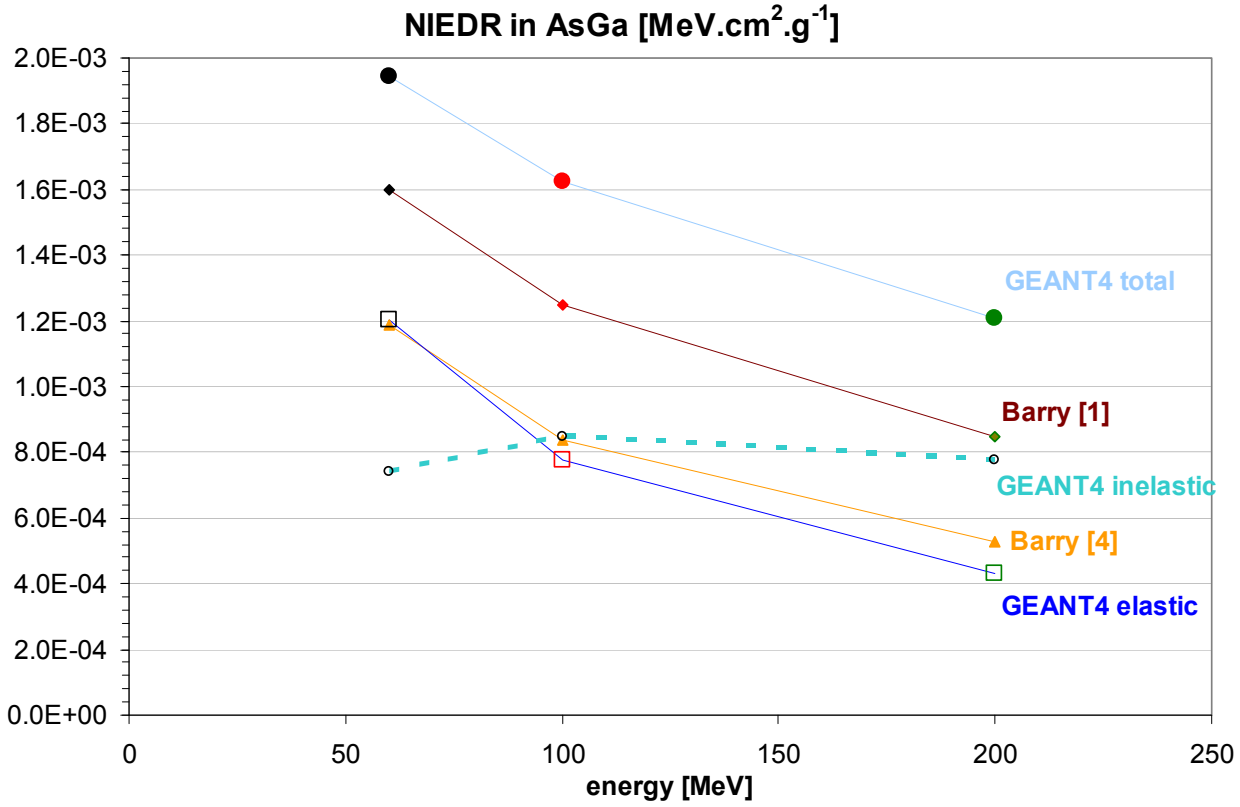


Fig. 3-10. Proton NIEDR values in AsGa according to Barry and GEANT4 with respect to energy

Barry [4] NIEL comes from new hypothesis extracted from [4] after GEANT4 calculations. In [4], Barry's hypothesis corresponds to corrected values that takes into account the layer thickness limited to 10 µm, calculated with GEANT4. One can notice the close values obtained between Barry's corrected values [4] and GEANT4 calculations limited to elastic interactions. This approach supports the idea that the damage coefficient to consider must be related to elastic interactions. Hence, Coulombic elastic interactions of the beam generate electrically active defects more efficiently on a per-unit-energy basis than do the residual nuclei [6].

	Si NIEDR (MeV.cm²/g)		
	Ep = 60 MeV	Ep = 100 MeV	Ep = 200 MeV
Barry [1]	$3.36.10^{-3}$	$2.60.10^{-3}$	$2.02.10^{-3}$
GEANT4 elastic	$1.744.10^{-3}$	$1.104.10^{-3}$	$5.70.10^{-4}$
GEANT4 inelastic	$5.88.10^{-4}$	$5.83.10^{-4}$	$4.99.10^{-4}$
GEANT4 total	$2.332.10^{-3}$	$1.687.10^{-3}$	$1.069.10^{-3}$

Table 2. Proton NIEDR values in Si according to Barry and GEANT4 [MeV.cm²/g] with respect to energy

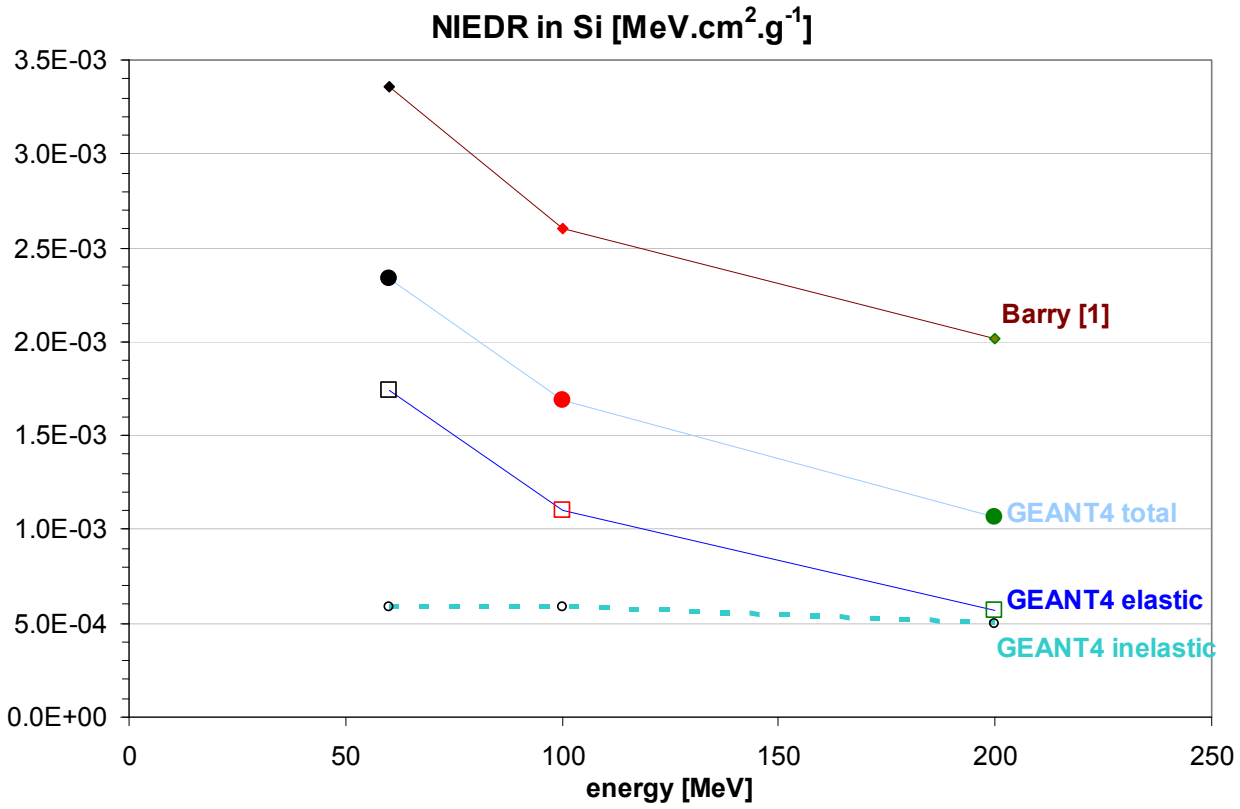


Fig. 3-11. Proton NIEDR values in Si according to Barry and GEANT4 with respect to energy

Even though damage ratio is not reported in [4] for Si, one can reasonably assume that elastic interaction must be considered as the most effective to induce active defects. The calculation presented here above on Si was performed with a hypothesis of 10 µm Si thickness.

3.2.2.1 Based on Barry's hypothesis

When the NIEL according to Barry is considered, the degradations at 60MeV and 100MeV are close with each other. The degradation at 200MeV is stronger for optocouplers and diodes (built in AsGa). There is no or very little effect of energy on the transistors (built in Si material) degradation. Hence, the NIEL equivalence concept seems to be applicable on transistor, and does not stand any more on diode built in AsGa: at 200 MeV the degradation level is higher than with the other energies (60 and 100 MeV).

This has implication for orbits whose proton energy spectrum would contain non negligible high energy contribution: in that case, part assessment regarding NIEL would underestimate the degradation level if tested with 60 MeV.

The figures below depict the CTR optocoupler, CTR diode, and CTR transistor, in this order. They are plotted versus the NIEL according to Barry [1] or [2], from **Fig. 3-12** to **Fig. 3-20.**

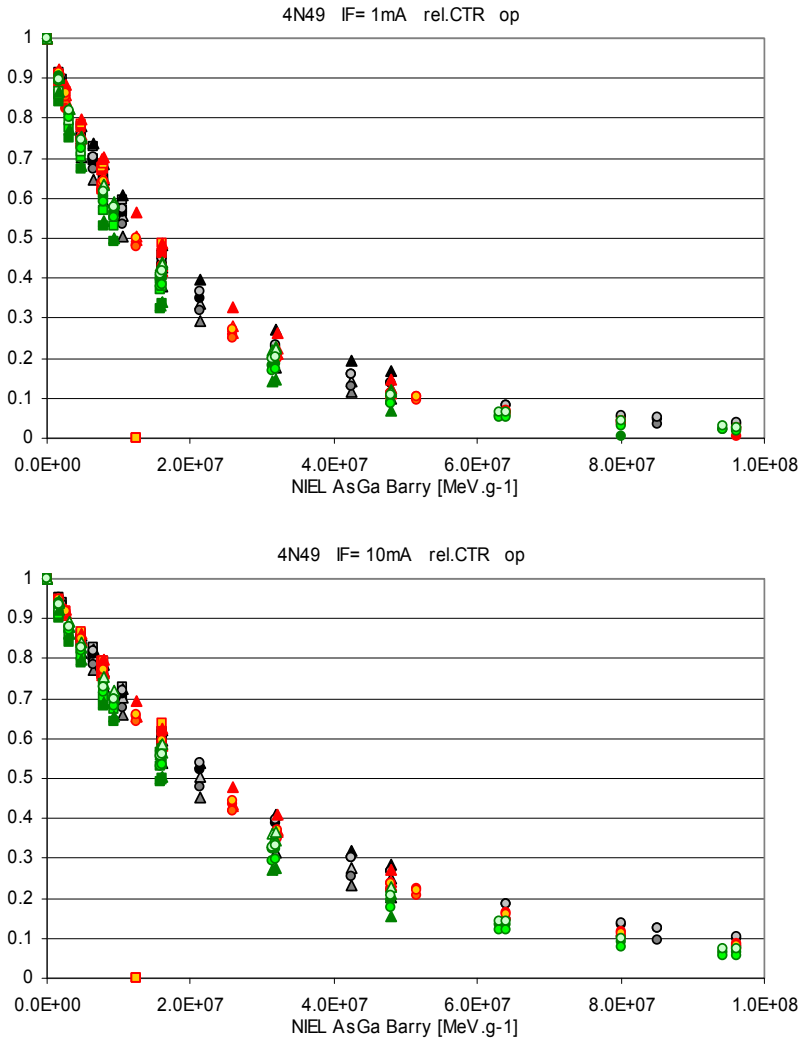
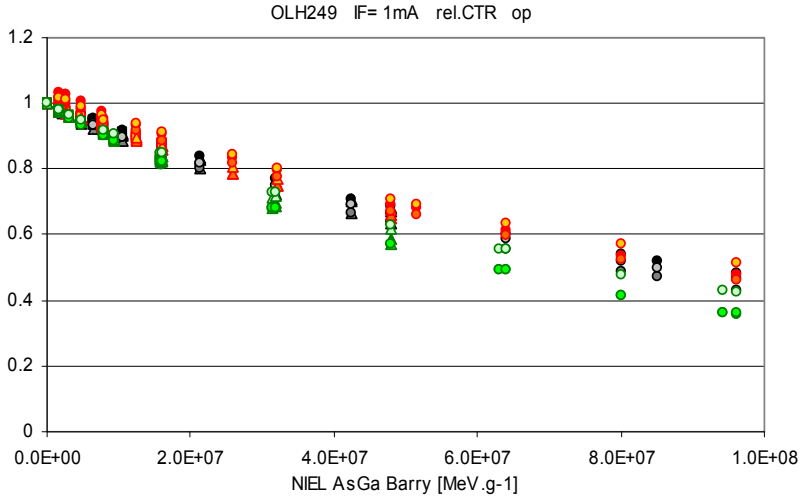


Fig. 3-12: 4N49 optocoupler: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA



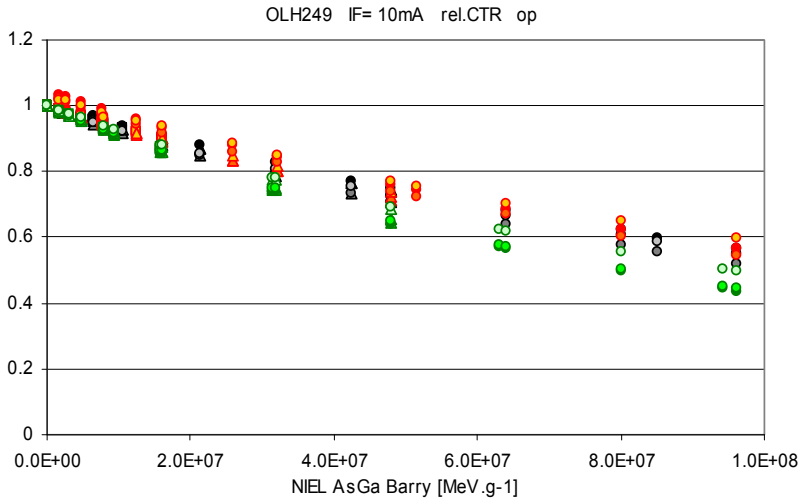


Fig. 3-13: OLH249 optocoupler: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

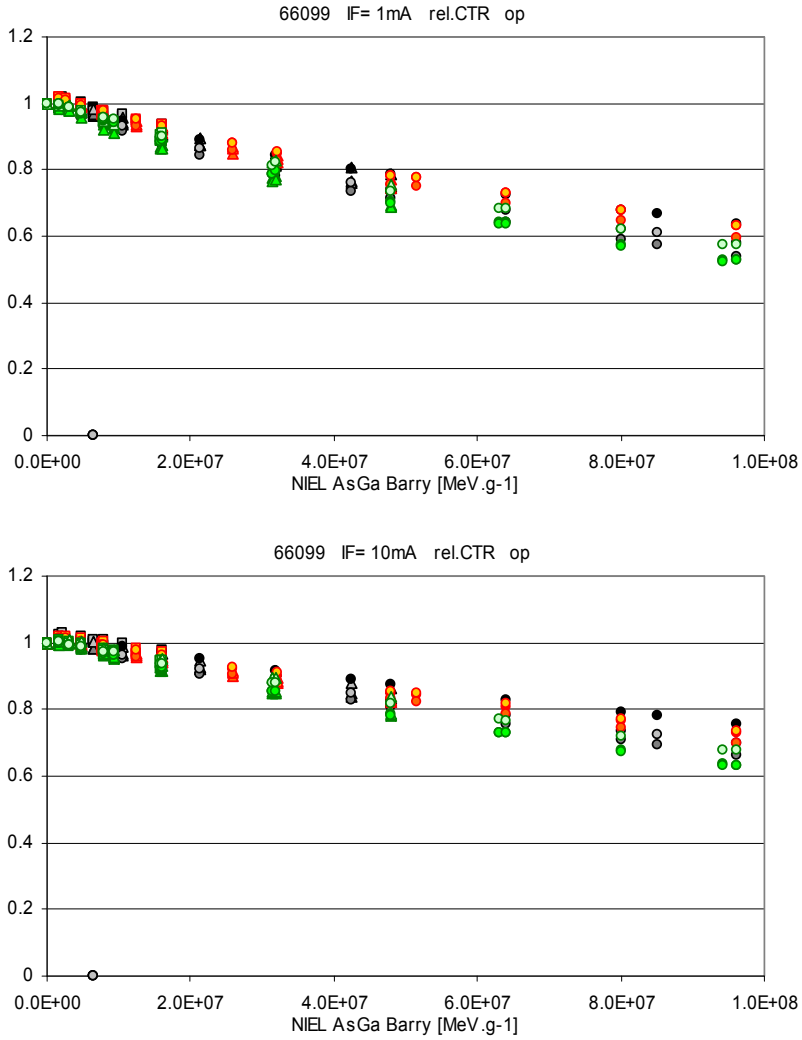


Fig. 3-14: 66099 optocoupler: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

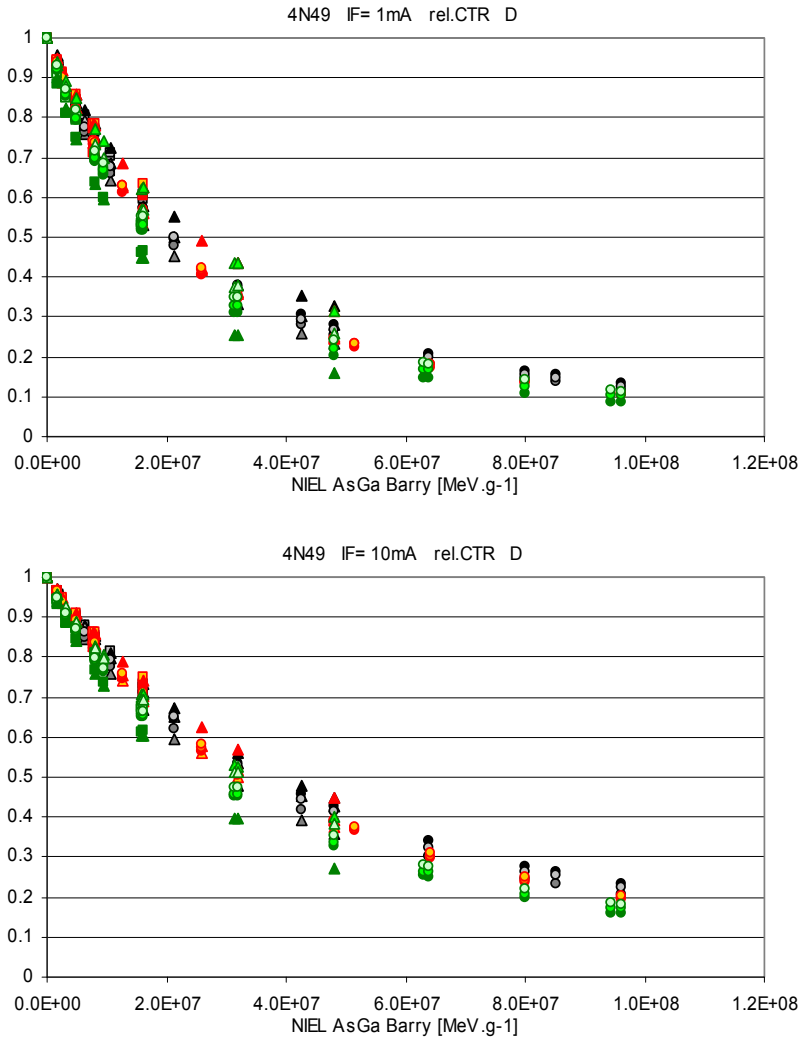
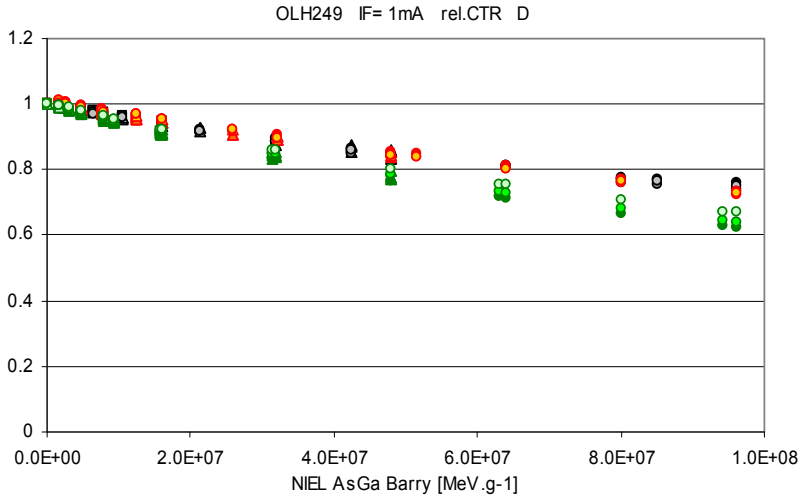


Fig. 3-15: 4N49 diode: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA



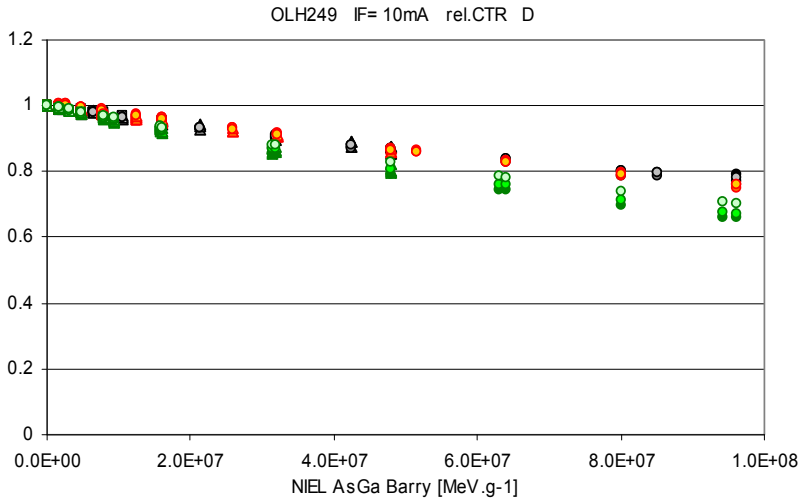


Fig. 3-16: OLH249 diode: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

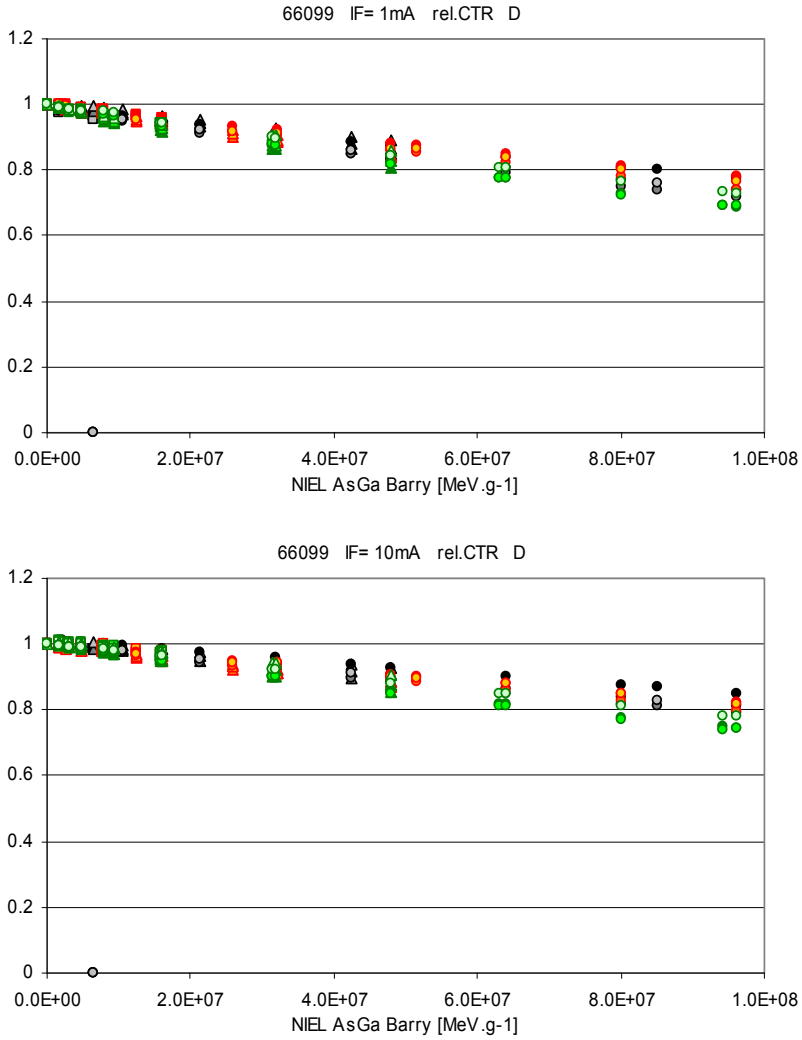


Fig. 3-17: 66099 diode: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

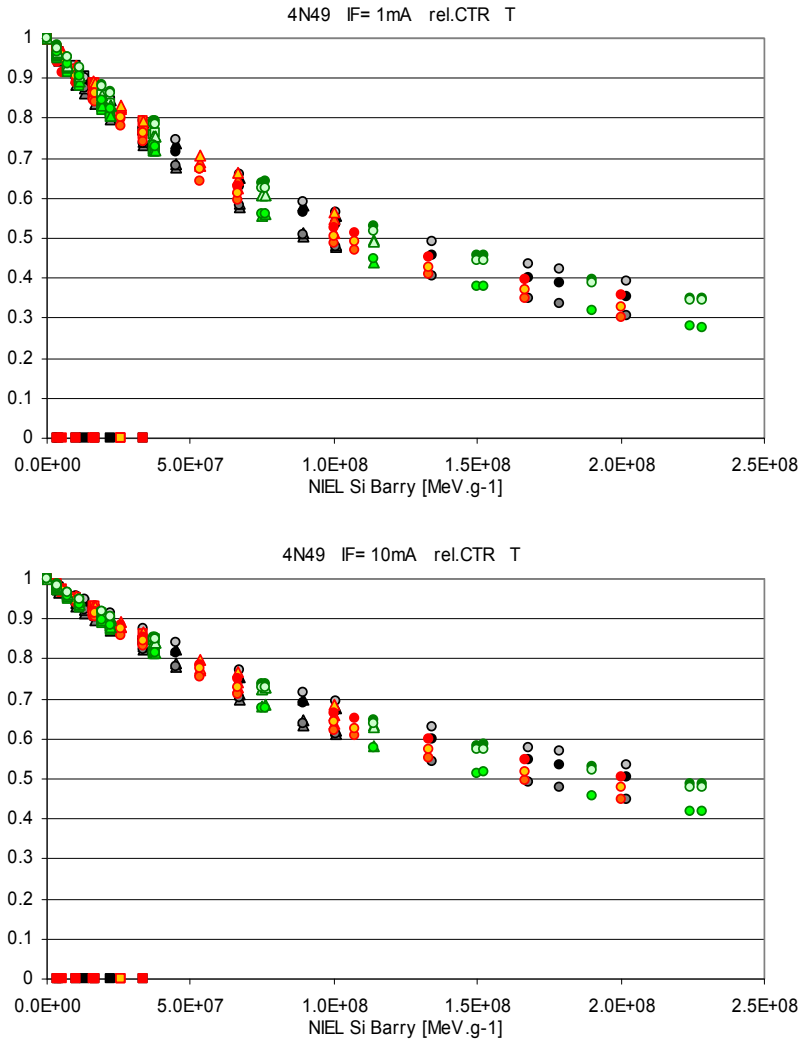
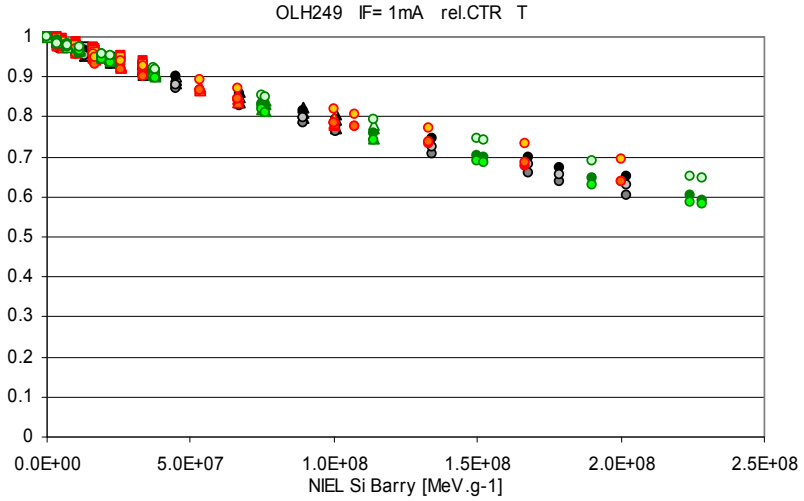


Fig. 3-18: 4N49 transistor: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA



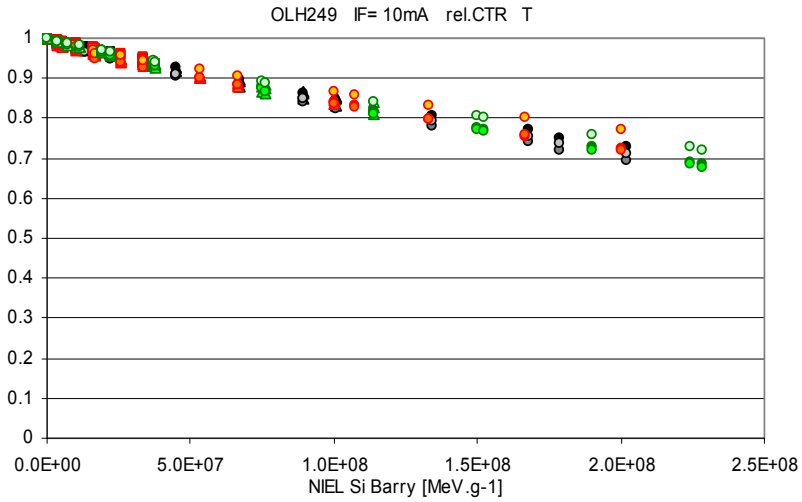


Fig. 3-19: OLH249 transistor: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

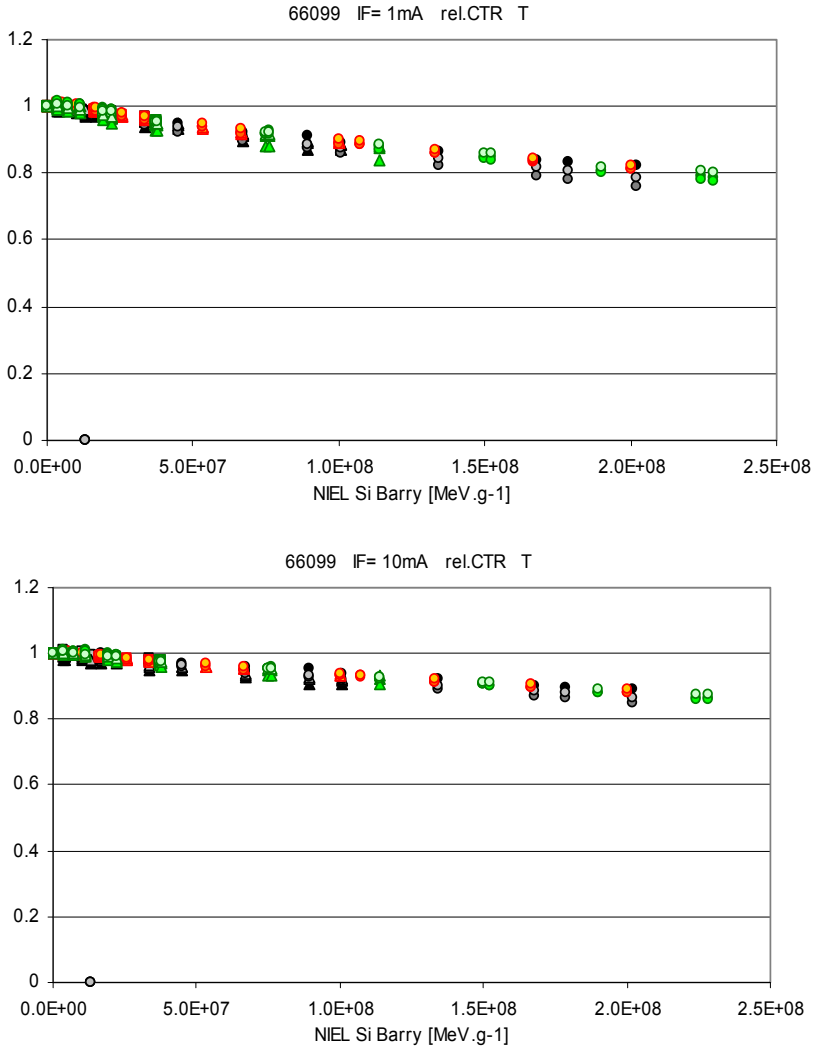


Fig. 3-20: 66099 transistor: relative CTR with respect to NIEL_Barry at I_F= 1mA and I_F= 10mA

Again, 200 MeV protons induce higher degradations on AsGa diode than with other energies, while they are inducing comparable degradation level on transistors (Si). Excepted for OLH249, optocoupler degradation is mainly induced by diodes.

4N49 (880 nm diode) transistors exhibit higher degradation than the OLH249's (830 nm diode), and the 66099's one (660nm diode). The absorption coefficient is decreasing while the wavelength increases. The transistor degradation level being increasing while the wavelength increases, this may indicate that transistor's base thicknesses are different, and clearly support the idea of a correlation between a transistor degradation increase and transistor's base thickness increase.

3.2.2.2 Based on Elastic NIEL computed with GEANT4

Considering the elastic NIEL by GEANT4 makes the degradation increase as energy increases. 200MeV curves are apart from 60 and 100MeV curves. The figures Fig. 3-21 to Fig. 3-29 below depict the CTR optocoupler, CTR diode, and CTR transistor, in this order. They are plotted versus the elastic NIEL according to GEANT4 calculations performed on 10µm thick material.

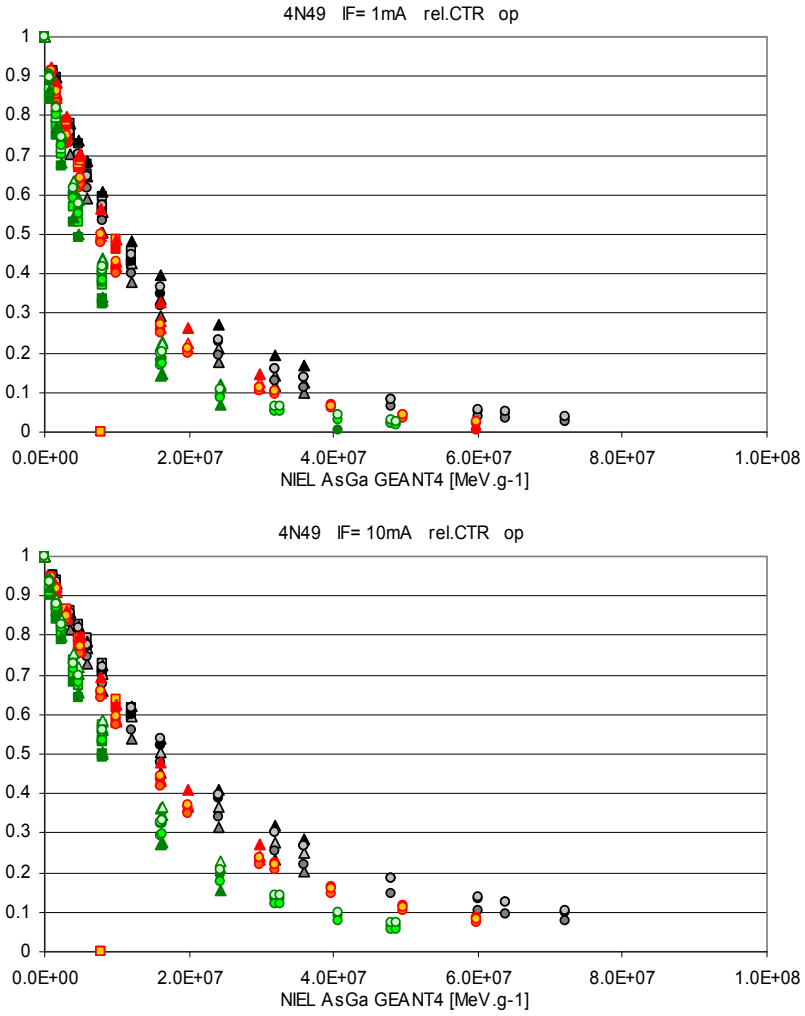


Fig. 3-21: 4N49 optocoupler: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

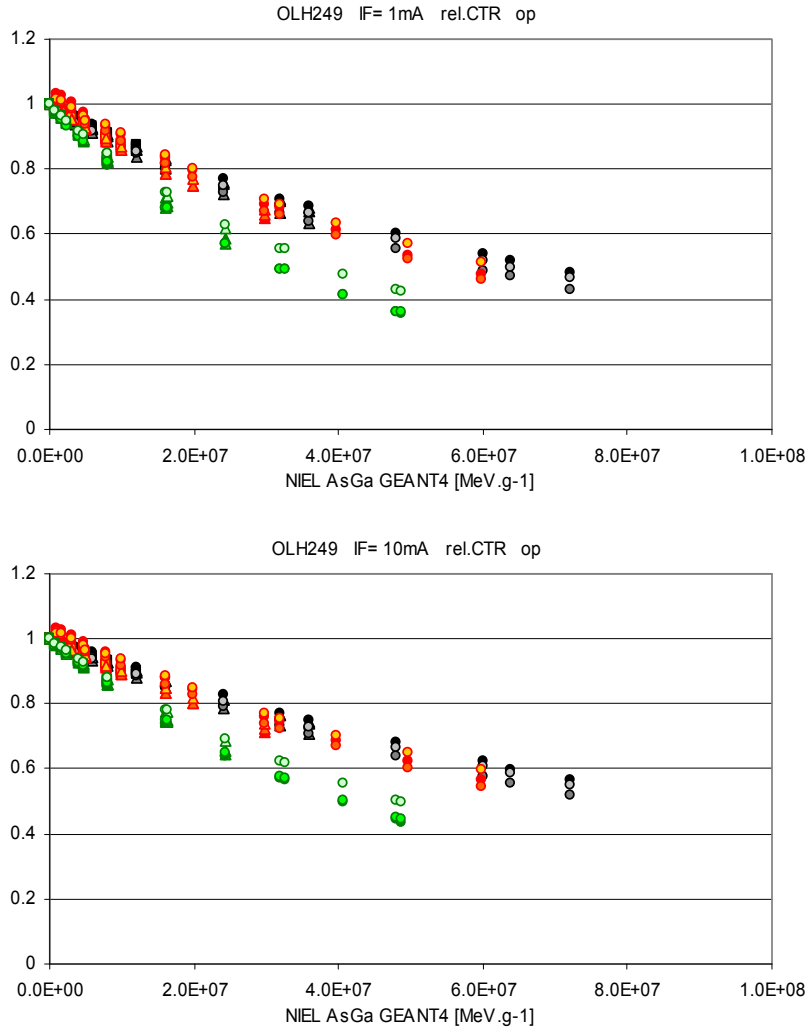
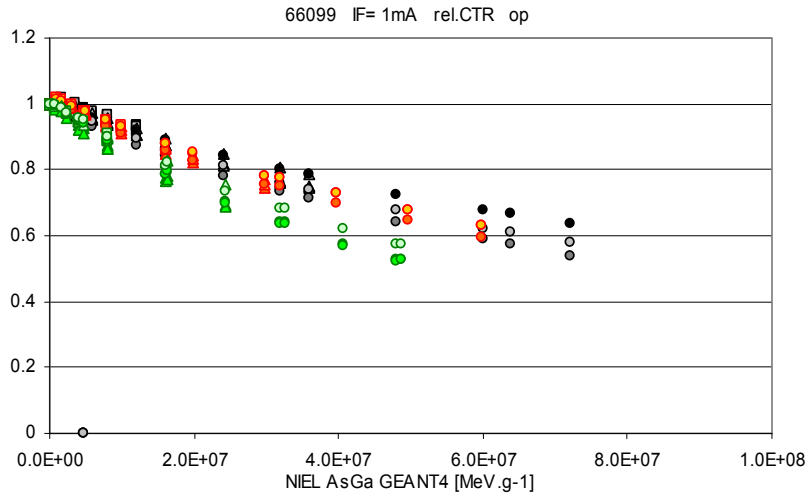


Fig. 3-22: OLH249 optocoupler: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA



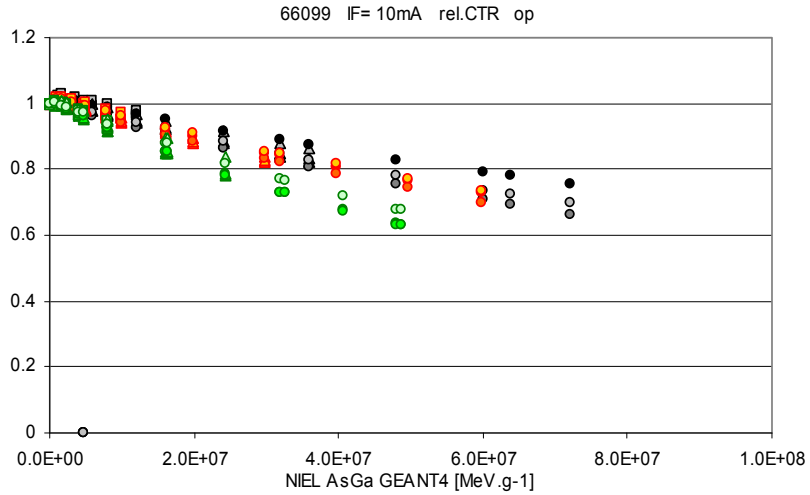


Fig. 3-23: 66099 optocoupler: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

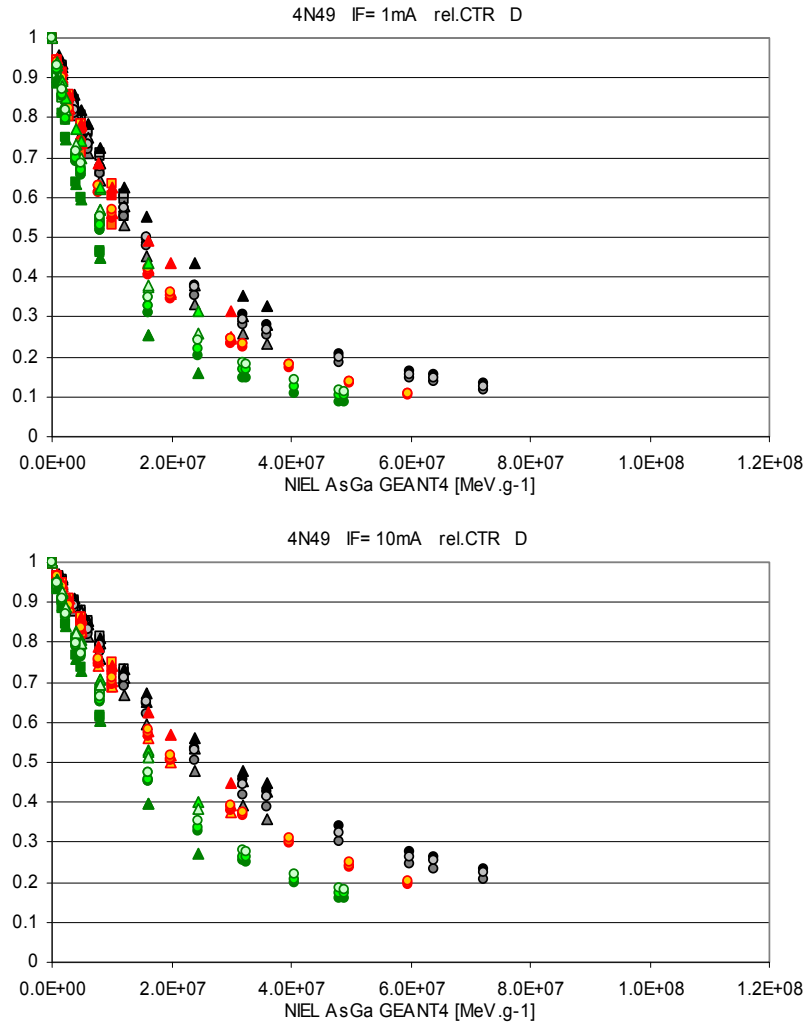


Fig. 3-24: 4N49 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

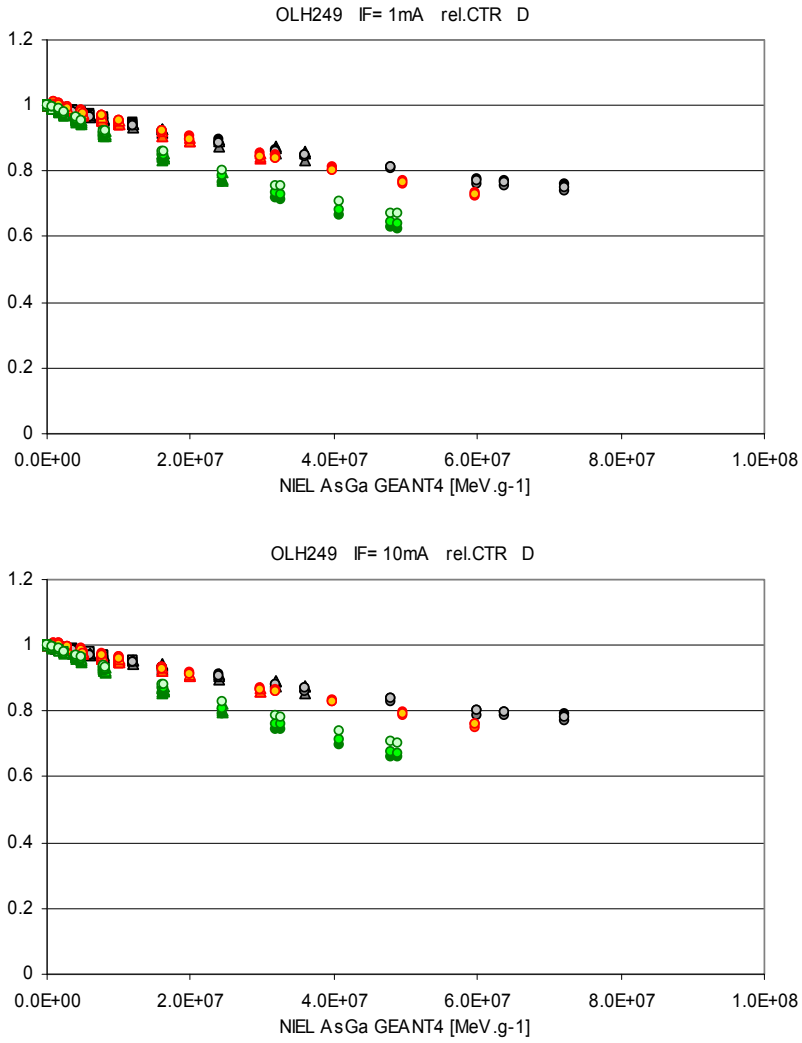
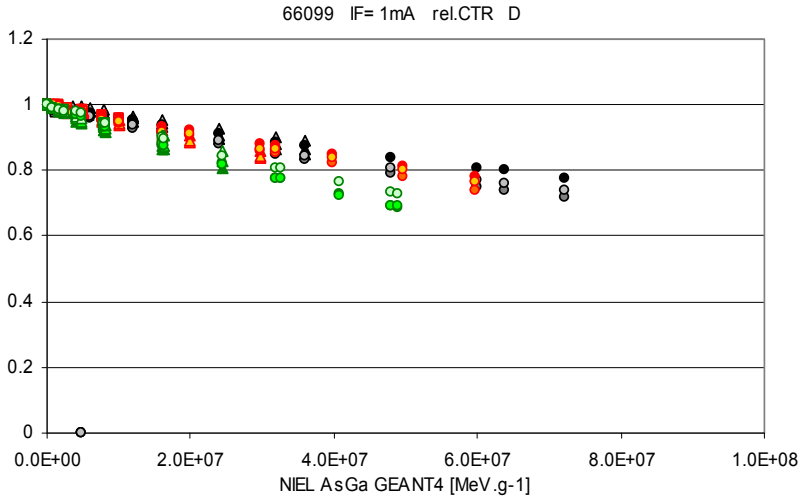


Fig. 3-25: OLH249 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA



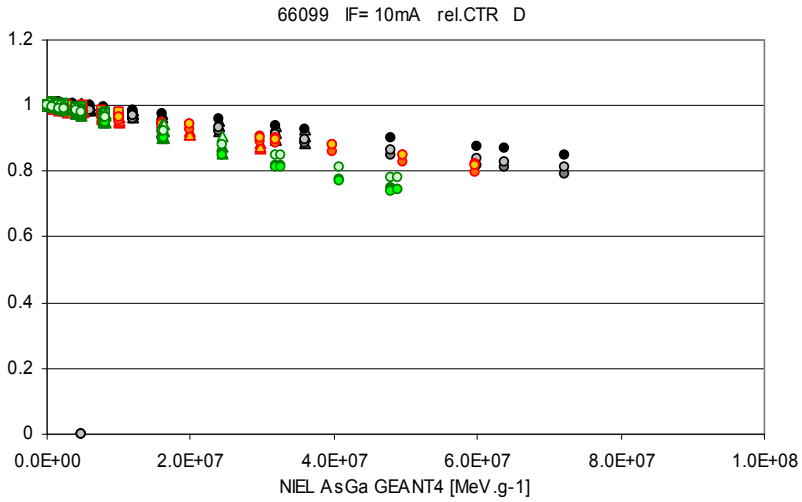


Fig. 3-26: 66099 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

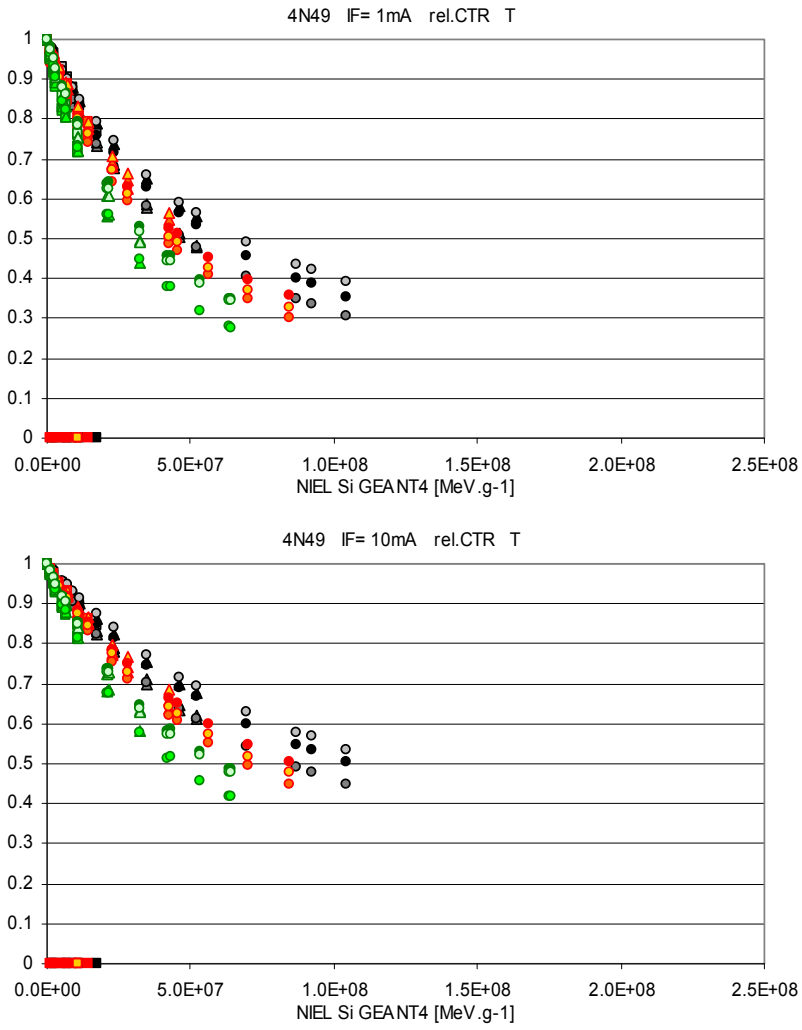


Fig. 3-27: 4N49 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

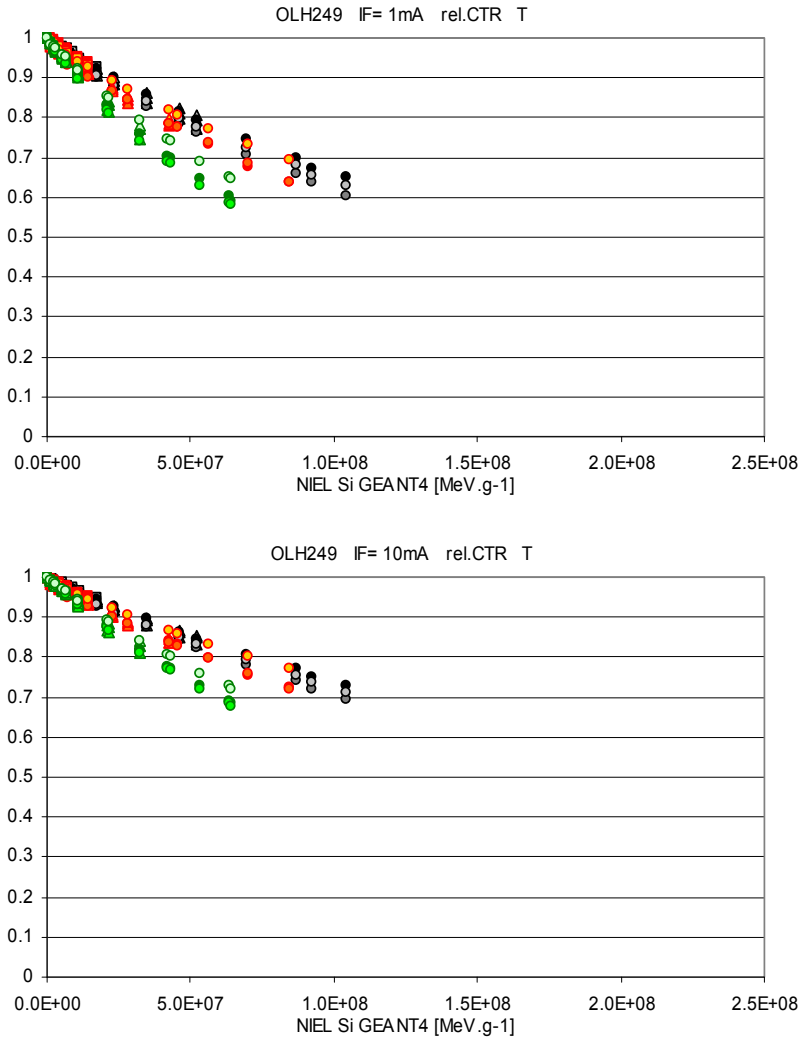
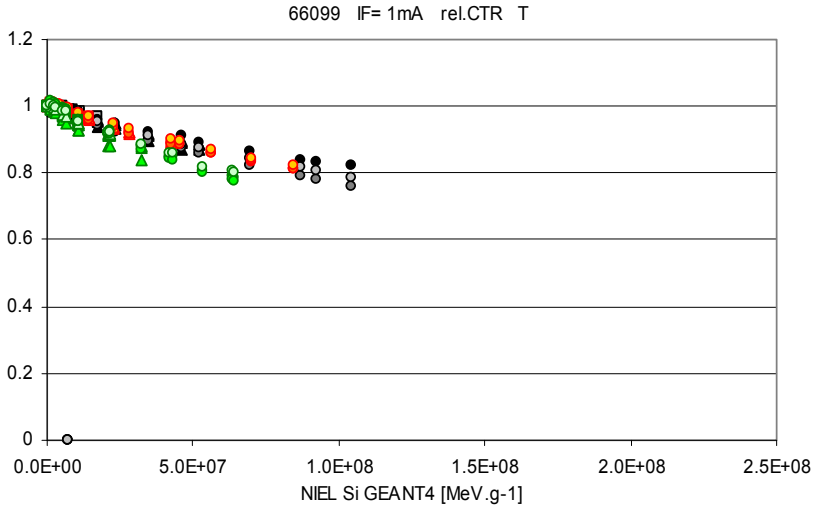


Fig. 3-28: OLH249 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA



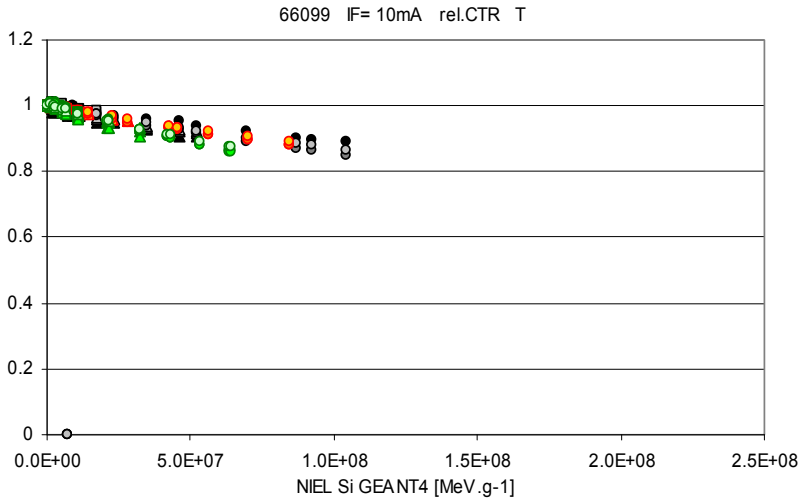


Fig. 3-29: 66099 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic at I_F= 1mA and I_F= 10mA

3.2.2.3 Based on total NIEL computed with GEANT4

The total NIEL is the sum of the elastic and inelastic contributions computed with GEANT4.

When the total NIEL is considered, CTR degradation at 200MeV is stronger for optocouplers, diodes, and transistors. However it is closer to the degradations at other energies than when NIEL_Barry or NIEL_GEANT4_elastic are considered. For instance 200MeV degradation of 66099 optocoupler is quite the same as 60MeV degradation. For 66099 diode, energy influence is visible only at strong NIEL values: 200MeV degradation seems stronger than at 60 and 100 MeV. Inversely, the energy influence on 4N49's optocoupler and diode seems to have no effect.

The CTR degradation at 60MeV is more important than at 100MeV for OLH249 optocoupler and transistor, and 66099 optocoupler, diode and transistor. The differences for 66099 transistors are small. The CTR degradations of OLH249 diode at 60 and 100MeV are the same.

The figures below depict the CTR optocoupler, CTR diode, and CTR transistor, in this order. They are plotted versus the total NIEL from Fig. 3-30 to Fig. 3-38.

The relative CTR transistor can be compared between transistors types from Fig. 3-36 to Fig. 3-38, at same diode current. One can notice 4N49 transistor is more sensitive than the other ones. However this comparison would be relevant if the optical powers received by transistors were known as identical. Up to now, this information is missing since no optical measurement was foreseen during this study.

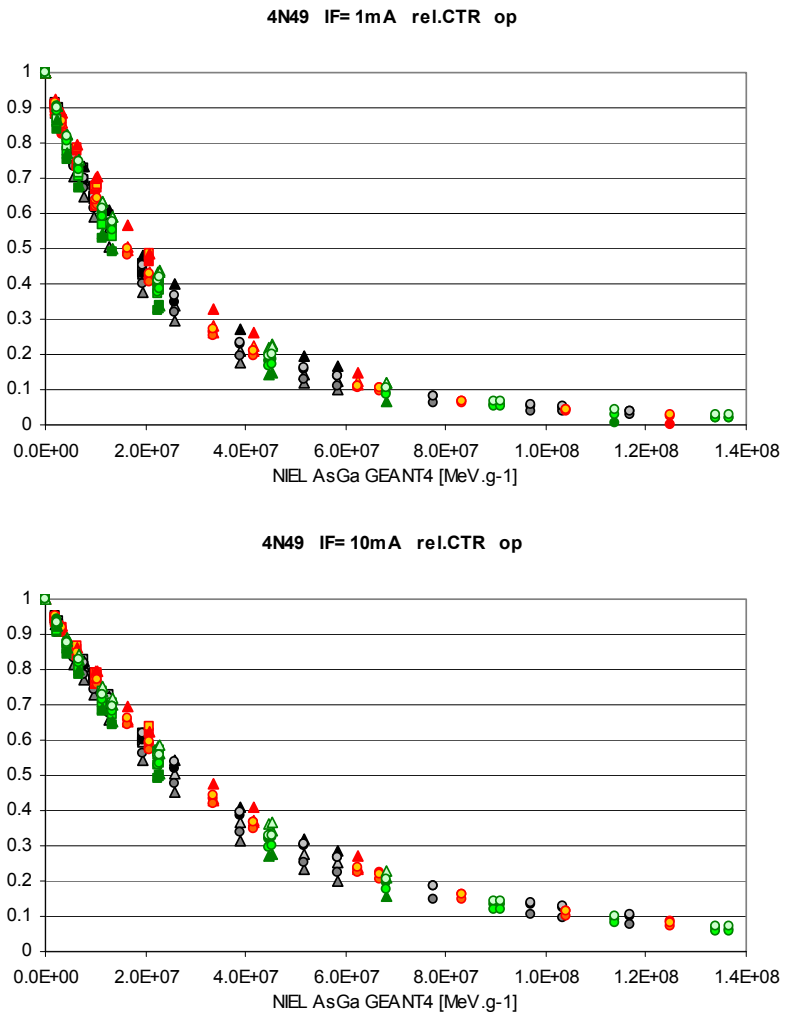
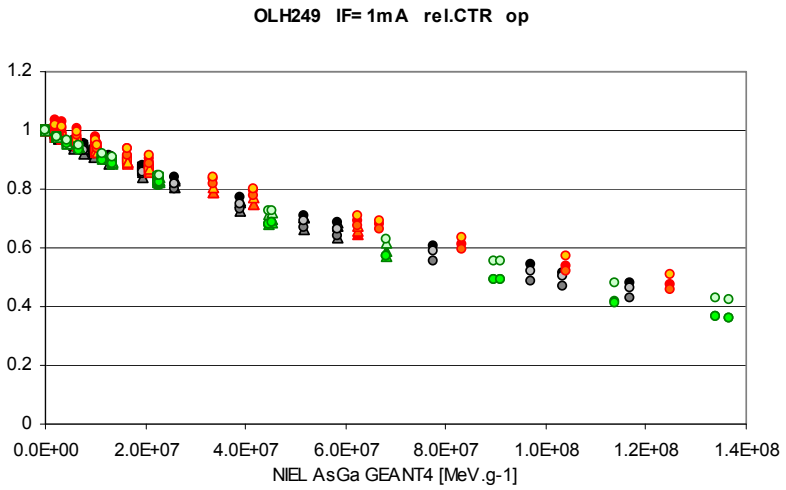


Fig. 3-30: 4N49 optocoupler: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



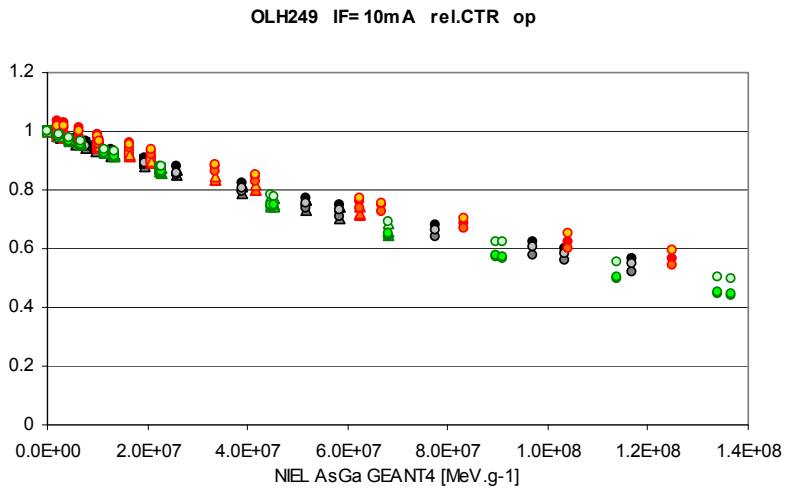
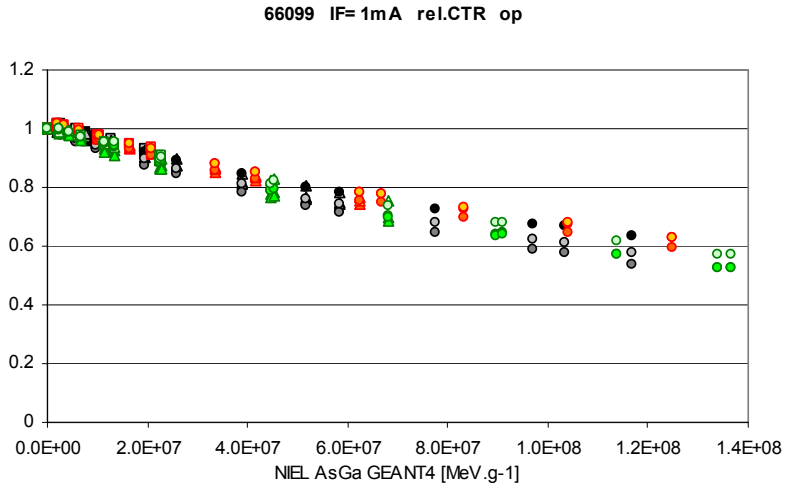


Fig. 3-31: OLH249 optocoupler: CTR/CTR_0 with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



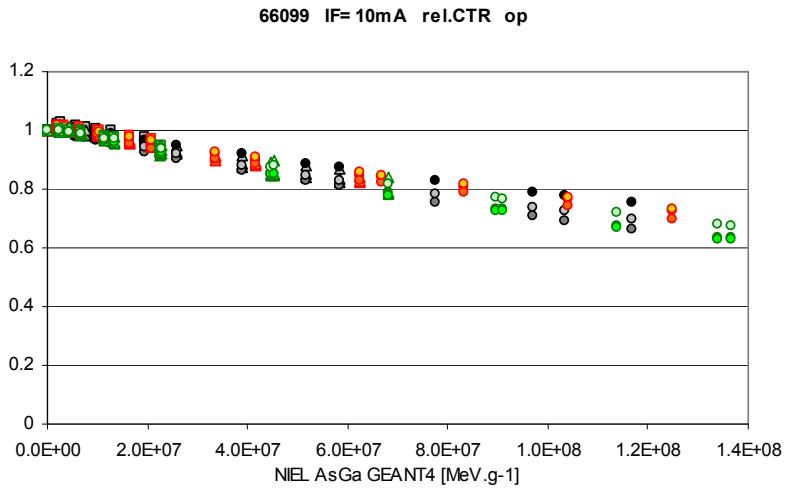
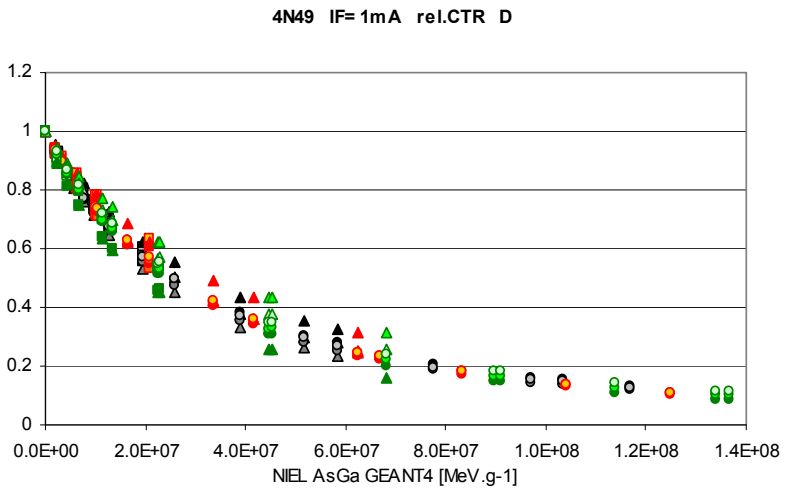


Fig. 3-32: 66099 optocoupler: CTR/CTR_0 with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



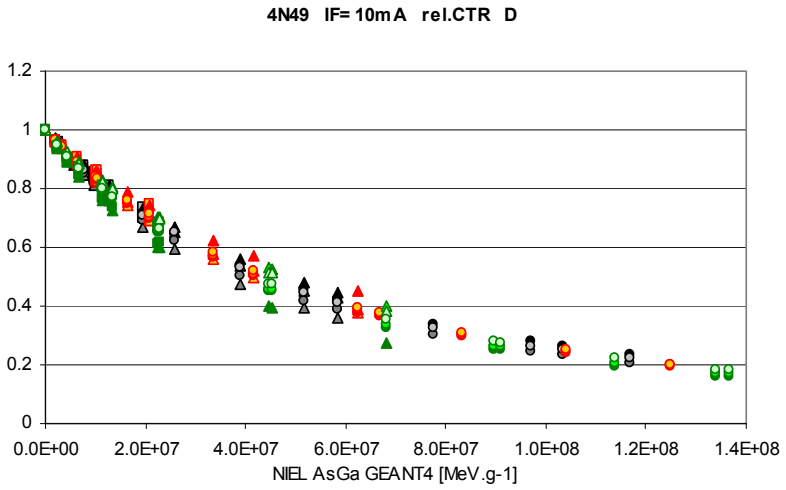
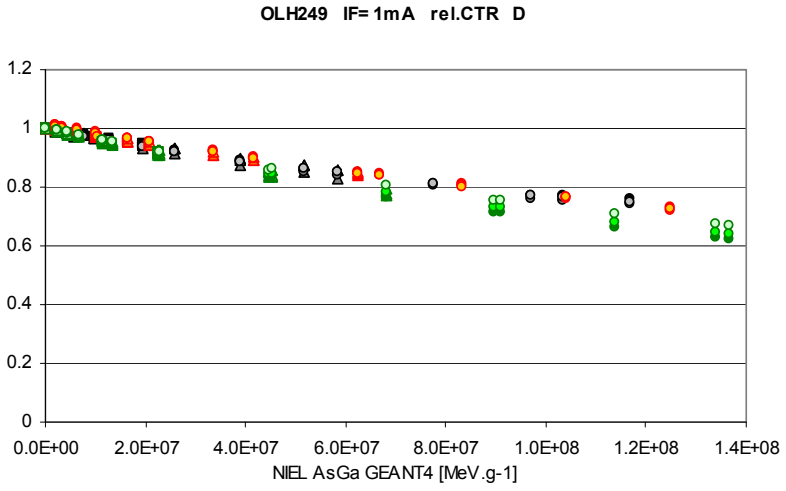


Fig. 3-33: 4N49 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



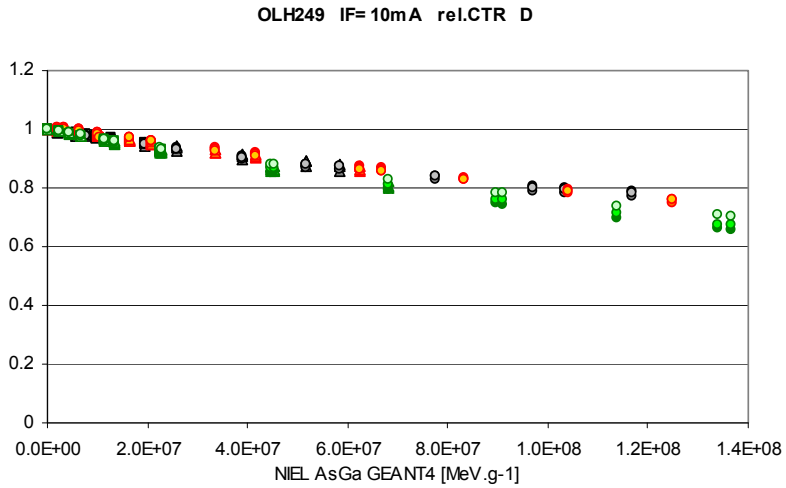
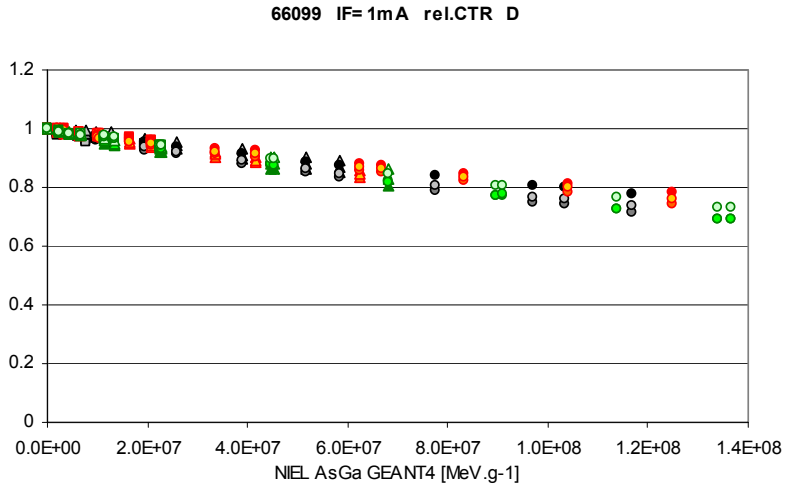


Fig. 3-34: OLH249 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



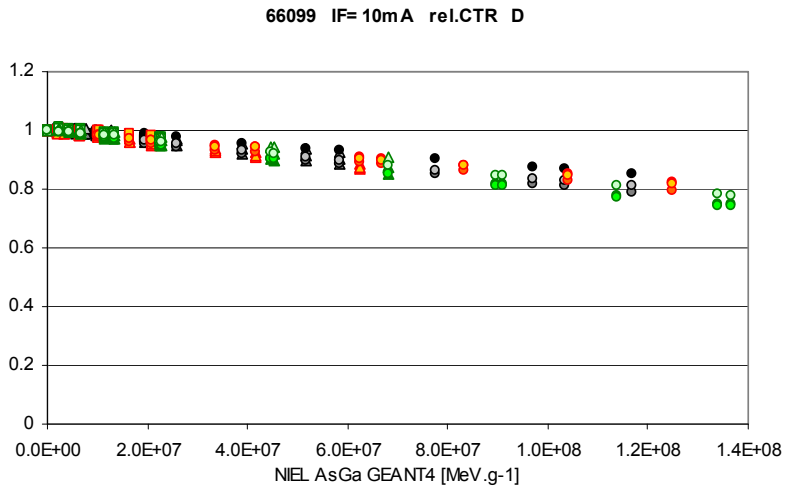


Fig. 3-35: 66099 diode: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA

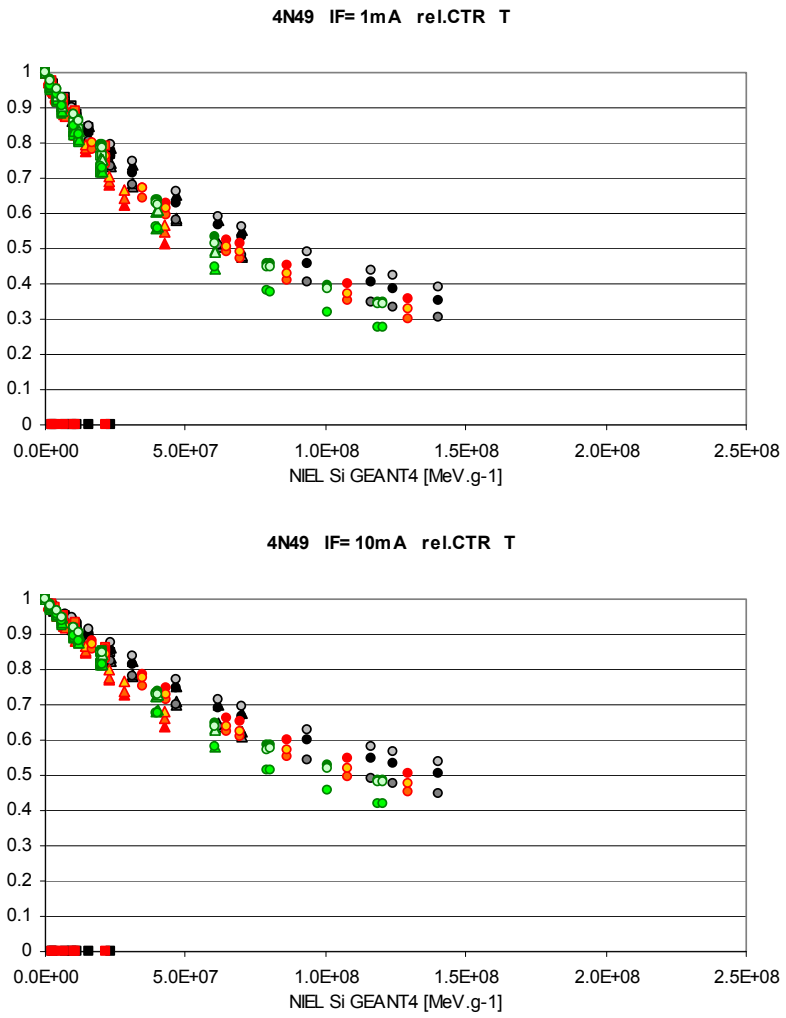
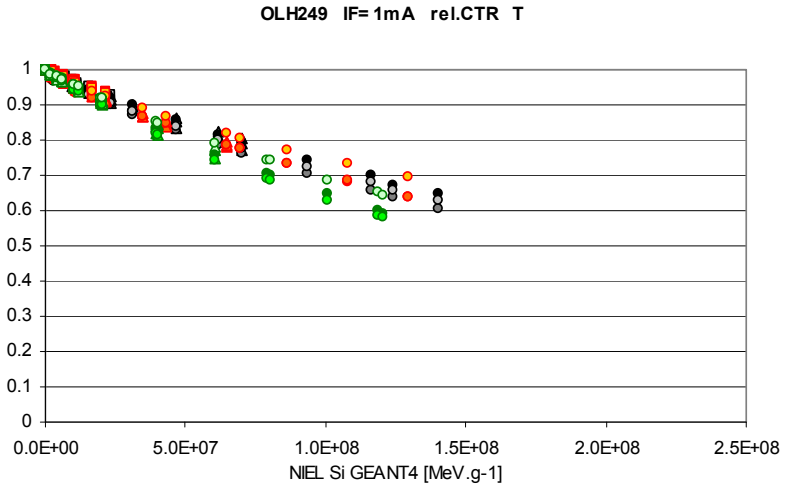


Fig. 3-36: 4N49 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



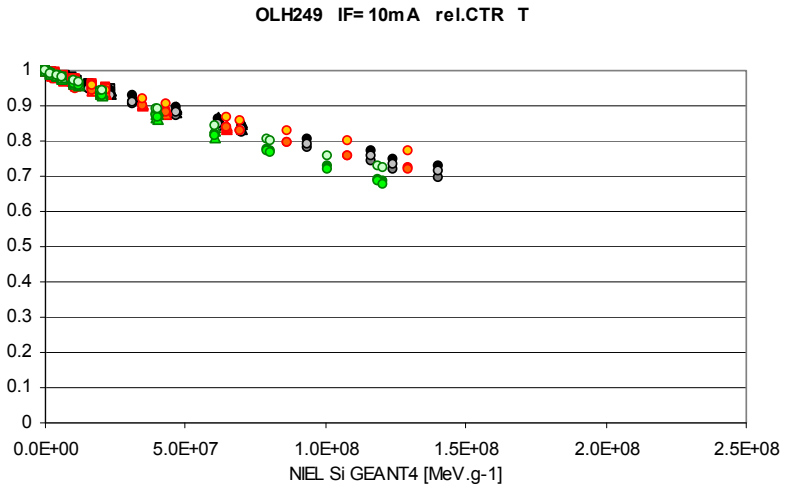
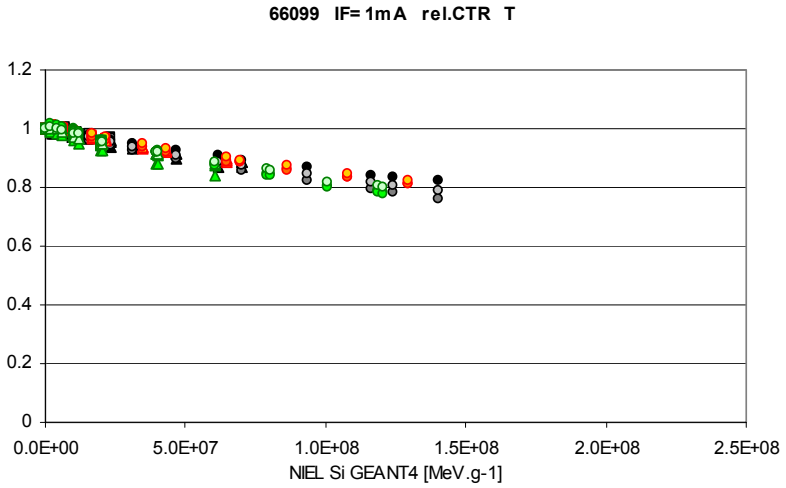


Fig. 3-37: OLH249 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA



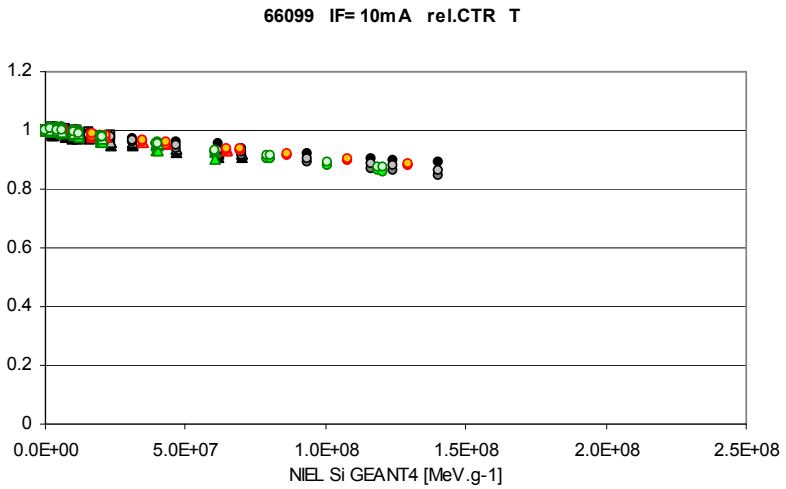


Fig. 3-38: 66099 transistor: CTR/CTR$_0$ with respect to NIEL_GEANT4_elastic + inelastic at I_F= 1mA and I_F= 10mA

In less extend than previously, 200 MeV protons induce higher degradations than at lower energies. As already presented this is highly noticeable on transistors and 4N49/66099 diodes.

3.2.3 Effect of diode current

The relative CTR degradation decreases as the injected current in the diode I_F is increased (1 to 10 mA). This effect is observed whatever the irradiated part: whole optocoupler (Fig. 3-39 to Fig. 3-41), diode, and even only the transistor. The curves are given for each energy, at different fluences $\Phi p_{i\ (i=1,3)}$ corresponding respectively at same NIEL. These curves highlight in a more clear way the energy effect on the degradation level: the highest the energy the highest the degradation.

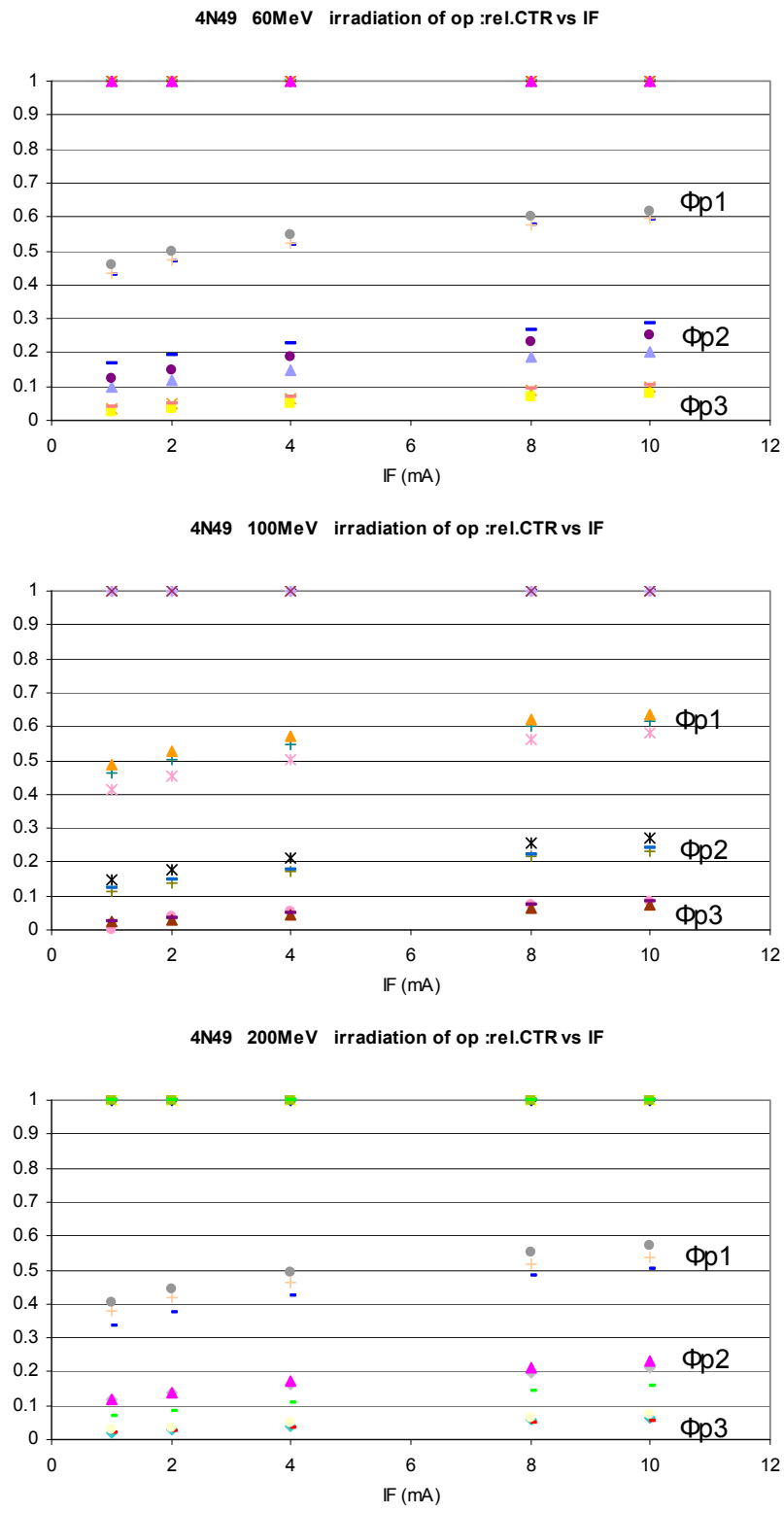


Fig. 3-39: 4N49 optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for step0 prior irradiation, step Φp$_1$, step Φp$_2$ and step Φp$_3$ with respect to diode current I$_F$.

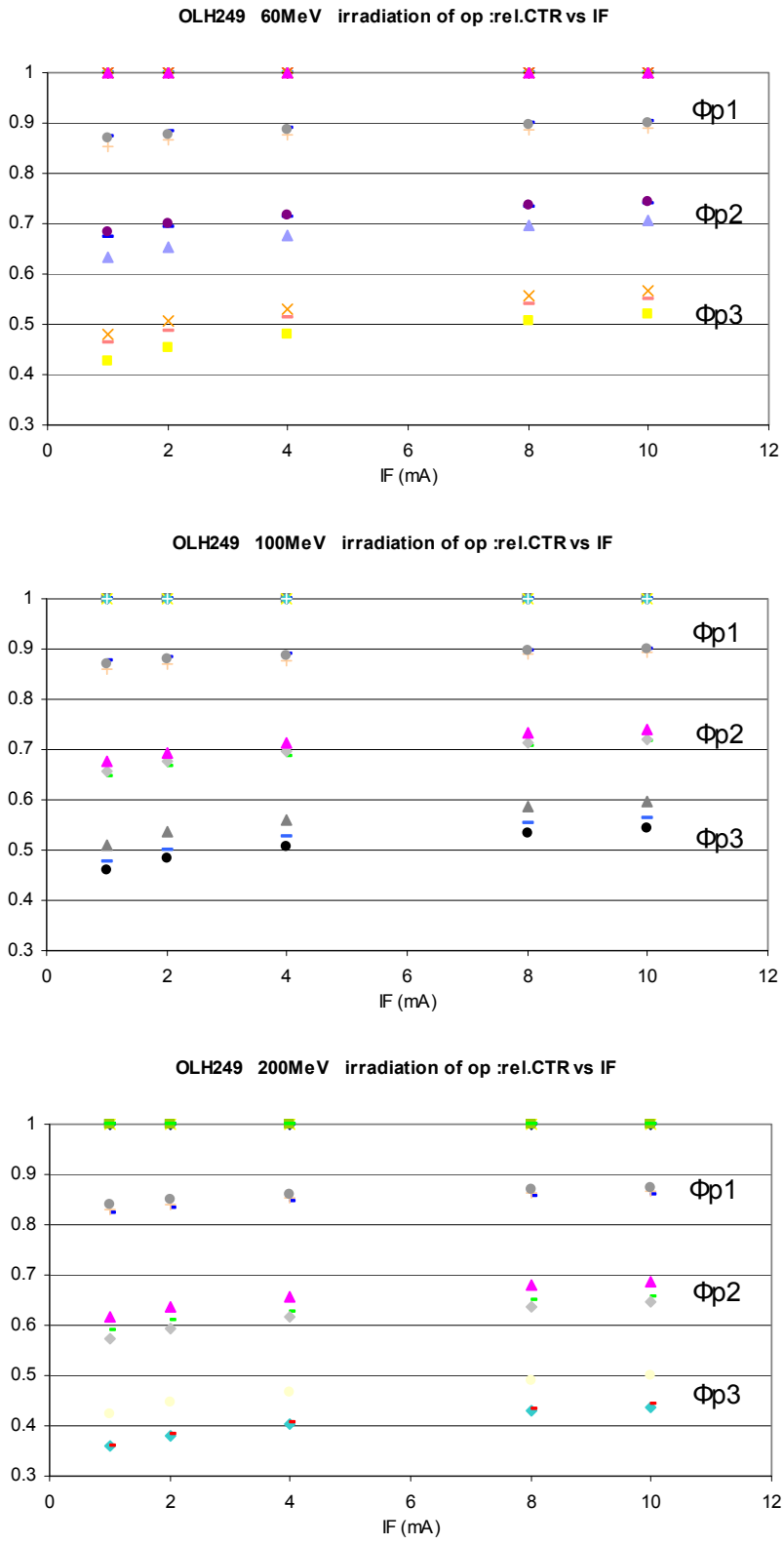


Fig. 3-40: OLH249 optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for step0 prior irradiation, step Φp_1, step Φp_2 and step Φp_3 with respect to diode current I_F

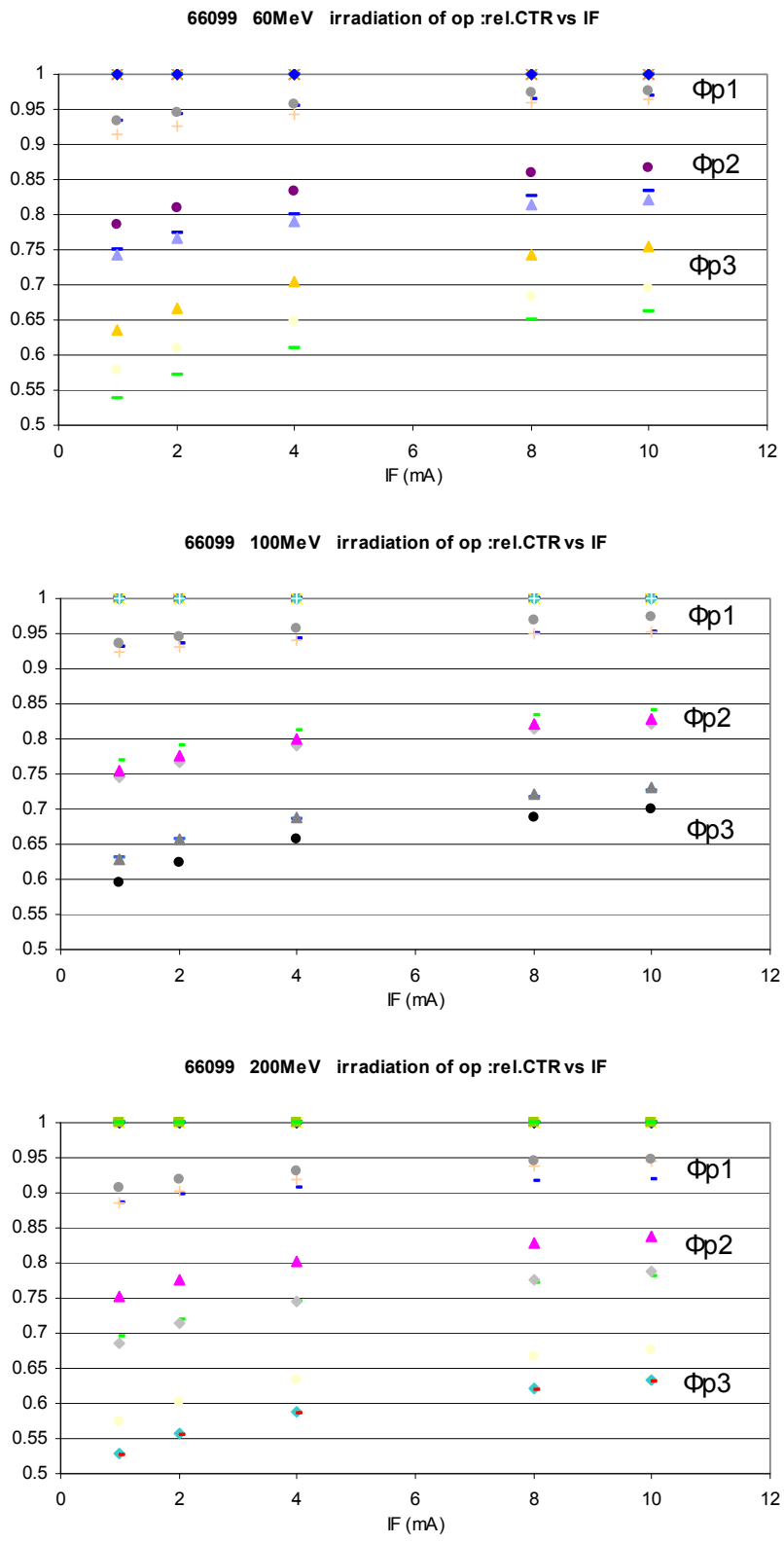


Fig. 3-41: 66099 optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for step0 prior irradiation, step Φp_1, step Φp_2 and step Φp_3 with respect to diode current I_F

3.3 COMPARISON BETWEEN WHOLE OPTOCOUPLER CTR-DEGRADATION MEASUREMENTS AND ITS CALCULATION OBTAINED FROM SEPARATED MEASUREMENTS ON IRRADIATED DIODE AND IRRADIATED TRANSISTOR

3.3.1 1st method: Product of Current Transfer Ratios

Given the products:

$$\text{CTR transistor}_i \times \text{CTR diode}_i = \frac{I_C \text{ irradiated transistor}_i}{I_F \text{ reference diode}_i} \times \frac{I_C \text{ reference transistor}_i}{I_F \text{ irradiated diode}_i} \quad \text{Eq. 5}$$

$$\text{CTR optocoupler}_i \times \text{CTR reference}_i = \frac{I_C \text{ irradiated transistor}_i}{I_F \text{ irradiated diode}_i} \times \frac{I_C \text{ reference transistor}_i}{I_F \text{ reference diode}_i}$$

Eq. 6

If we do not pay much attention, it seems they are equal.

Let define:

$$\text{absolute CTR ratio}_i = \frac{\text{CTR transistor}_i \times \text{CTR diode}_i}{\text{CTR optocoupler}_i \times \text{CTR reference}_i} \quad \text{Eq. 7}$$

$$\boxed{\text{relative CTR ratio}_i = \frac{\text{relative CTR transistor}_i \times \text{relative CTR diode}_i}{\text{relative CTR optocoupler}_i \times \text{relative CTR reference}_i}} \quad \text{Eq. 8}$$

The following figures -Fig. 3-42 to Fig. 3-50- present those absolute and relative CTR ratios for samples irradiated at Φp3. If the products of Eq. 5 and Eq. 6 were equal, absolute and relative CTR ratio would be equal to 1. Clearly with 4N49, but with the other optocouplers too, these ratios drift upper and upper as the materials are more and more damaged by the proton irradiation. This strongly supports that absolute or relative CTR cannot be extrapolated by the product of relative CTR obtained separately on diode and transistor. This proves the degradation's superposition non-linearity. Clearly, doing such would lead to underestimate the final degradation, whatever the optocoupler.

Legend for Fig. 3-42 to Fig. 3-50:

IF= 1mA F3#1	IF= 2mA F3#1	IF= 4mA F3#1	IF= 8mA F3#1	IF= 10mA F3#1
IF= 1mA F3#2	IF= 2mA F3#2	IF= 4mA F3#2	IF= 8mA F3#2	IF= 10mA F3#2
IF= 1mA F3#3	IF= 2mA F3#3	IF= 4mA F3#3	IF= 8mA F3#3	IF= 10mA F3#3

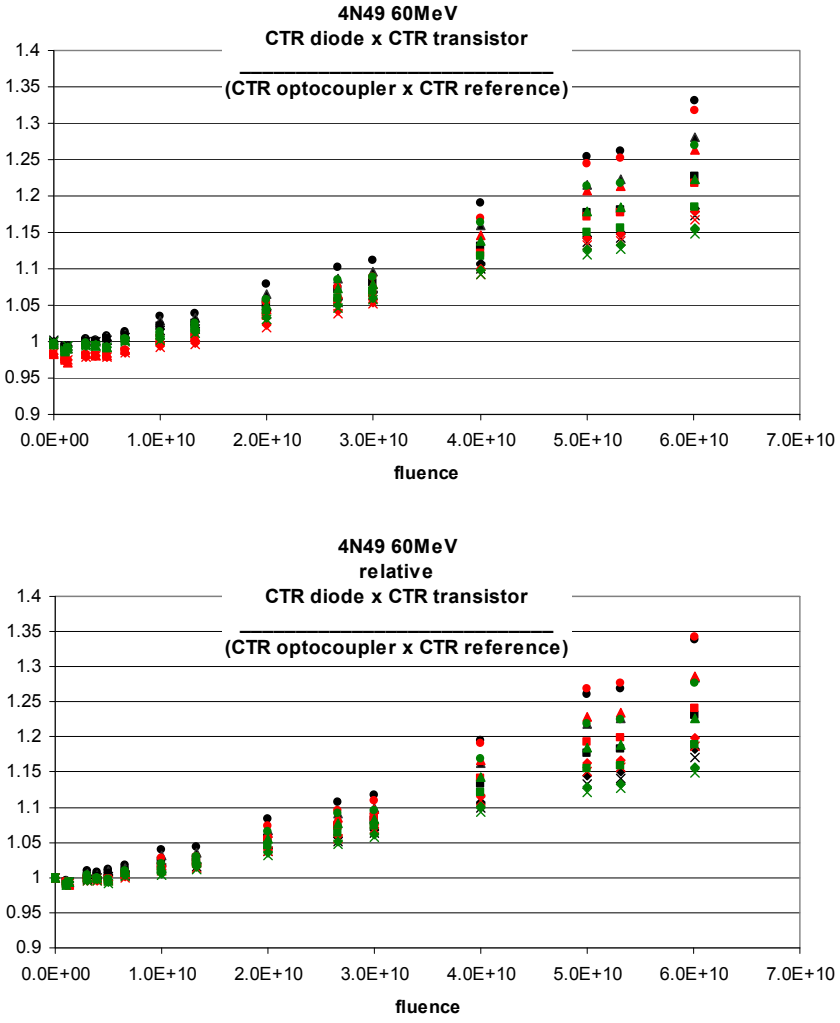
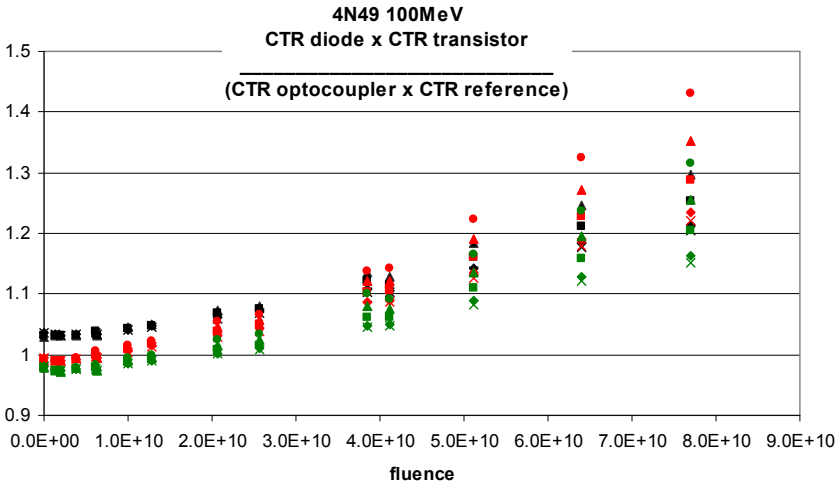


Fig. 3-42: 4N49 : CTR ratio and relative CTR ratio versus fluence at 60MeV



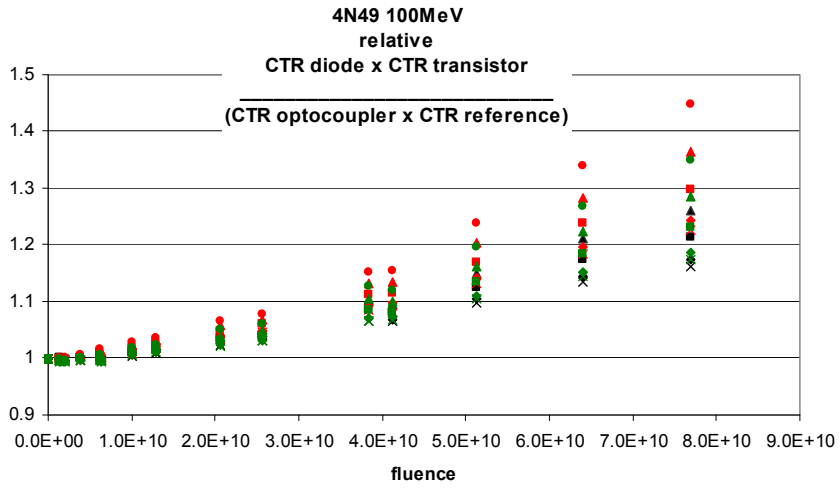
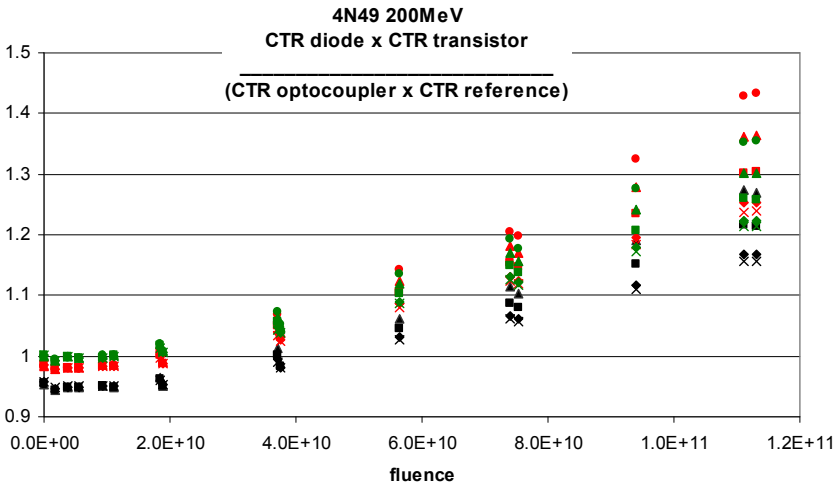


Fig. 3-43: 4N49 : CTR ratio and relative CTR ratio versus fluence at 100MeV



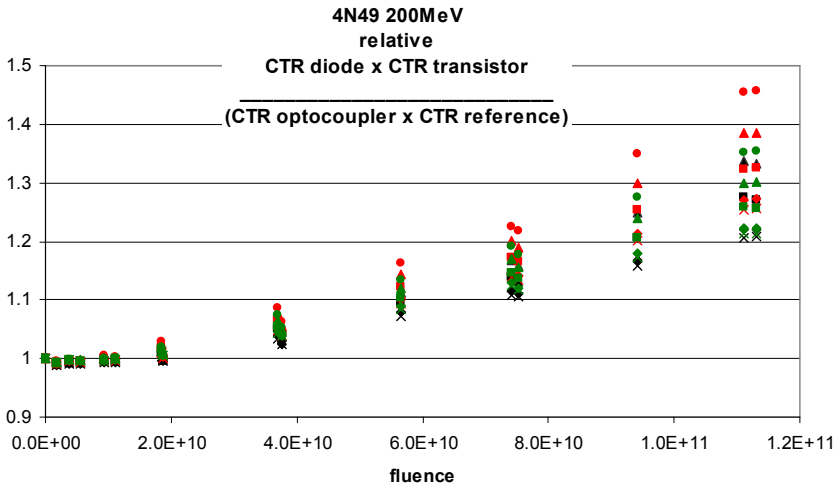


Fig. 3-44: 4N49 : CTR ratio and relative CTR ratio versus fluence at 200MeV

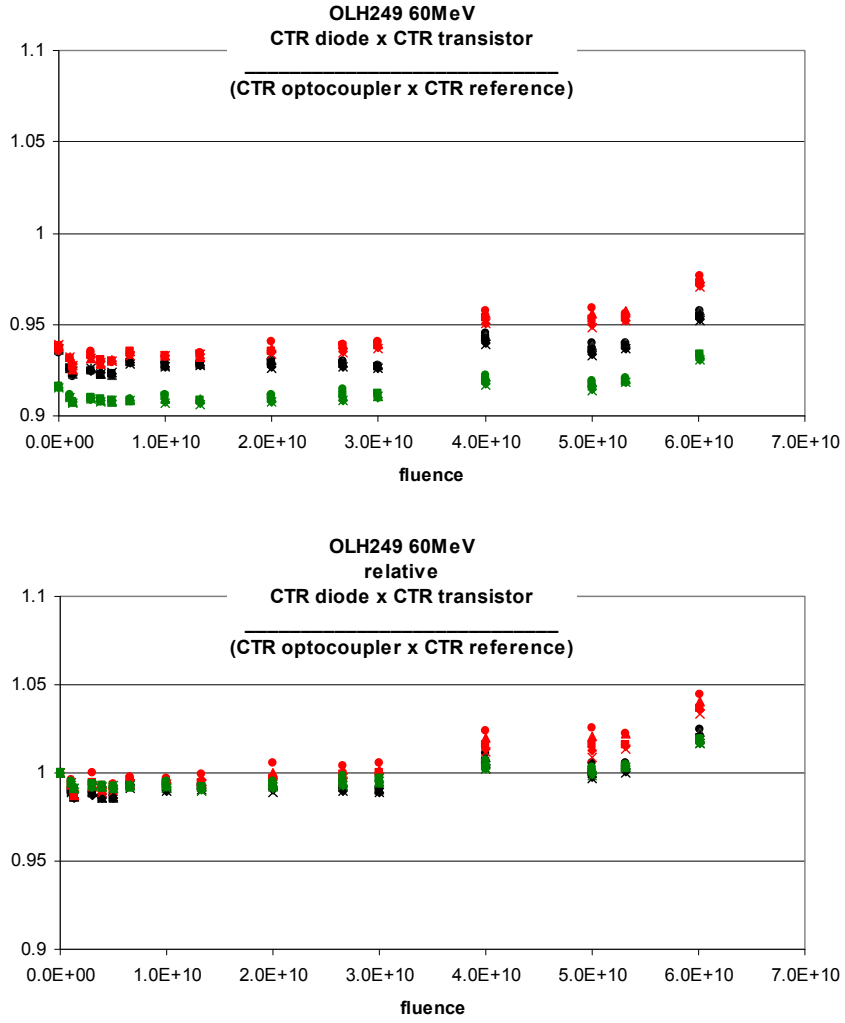
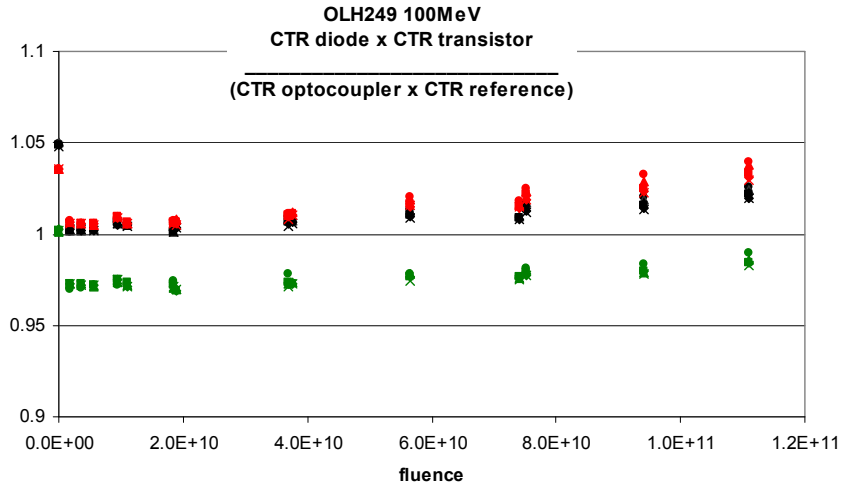


Fig. 3-45: OLH249: CTR ratio and relative CTR ratio versus fluence at 60MeV



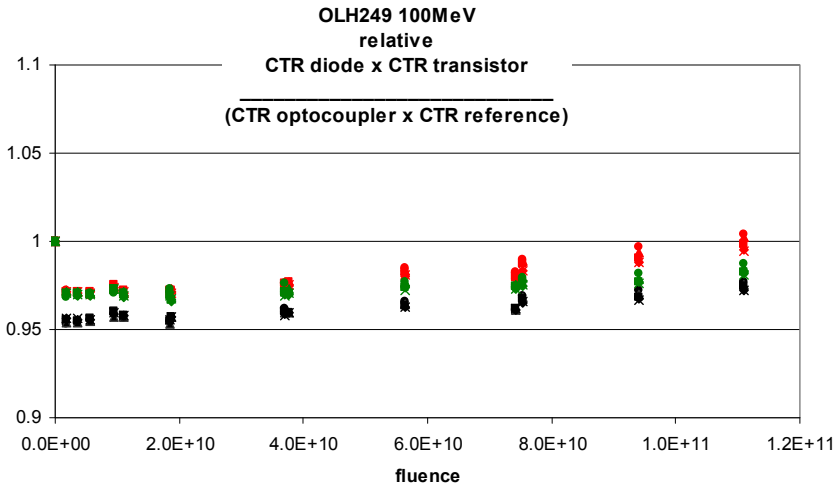
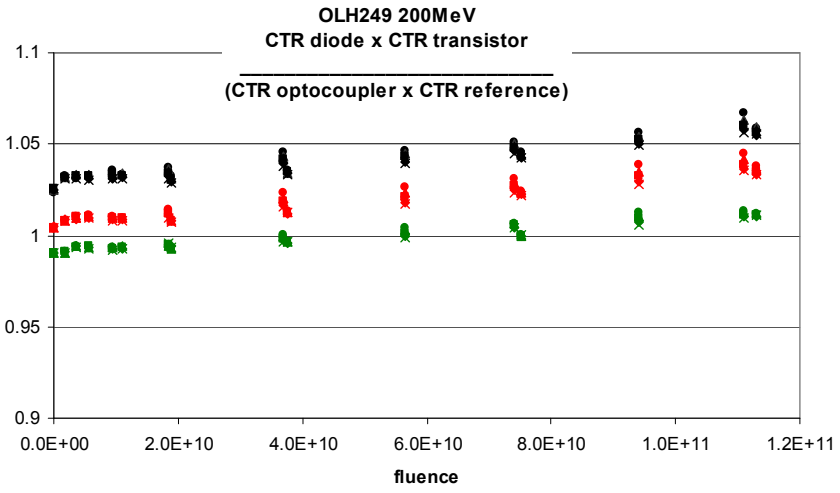


Fig. 3-46: OLH249: CTR ratio and relative CTR ratio versus fluence at 100MeV



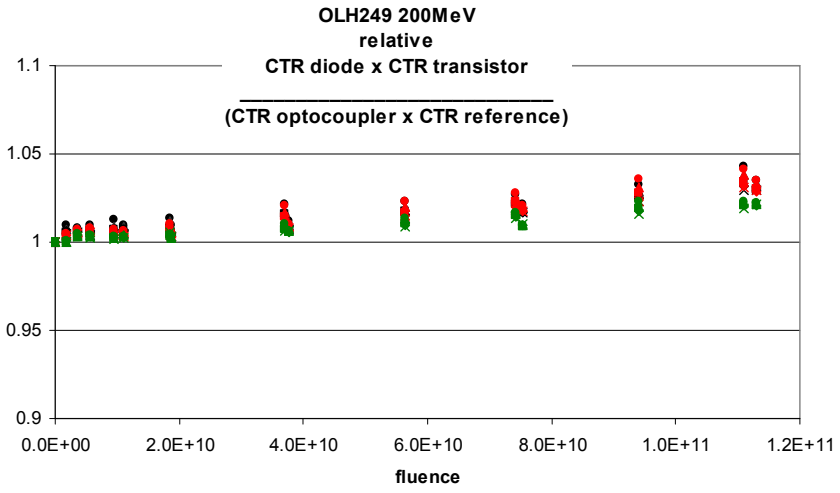
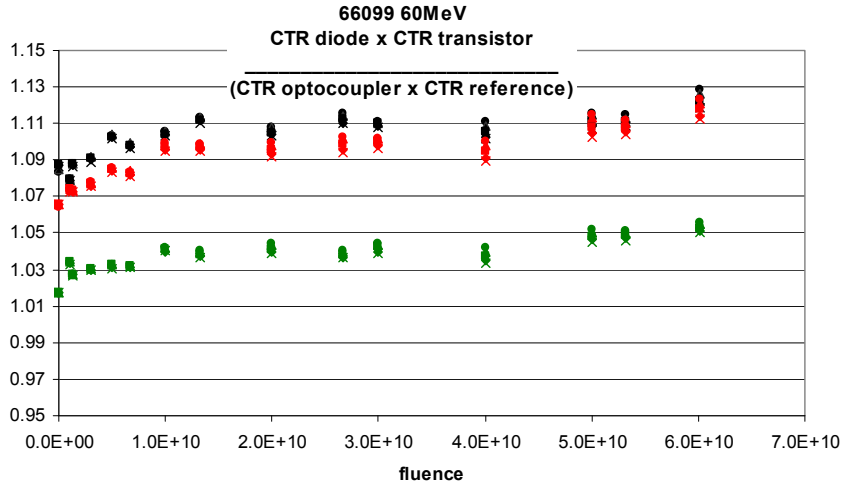


Fig. 3-47: OLH249: CTR ratio and relative CTR ratio versus fluence at 200MeV



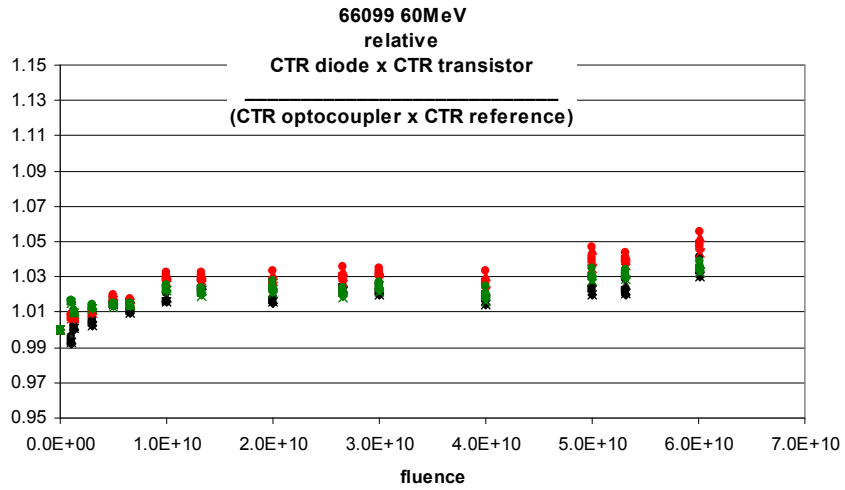
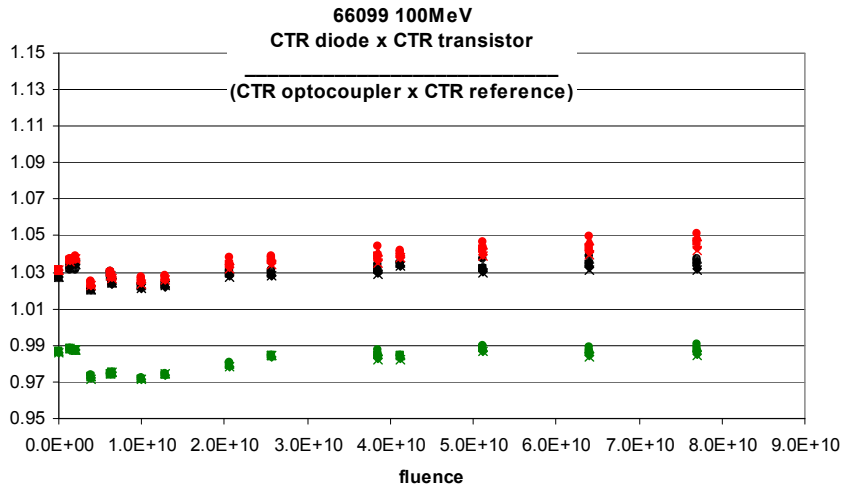


Fig. 3-48: 66099: CTR ratio and relative CTR ratio versus fluence at 60MeV



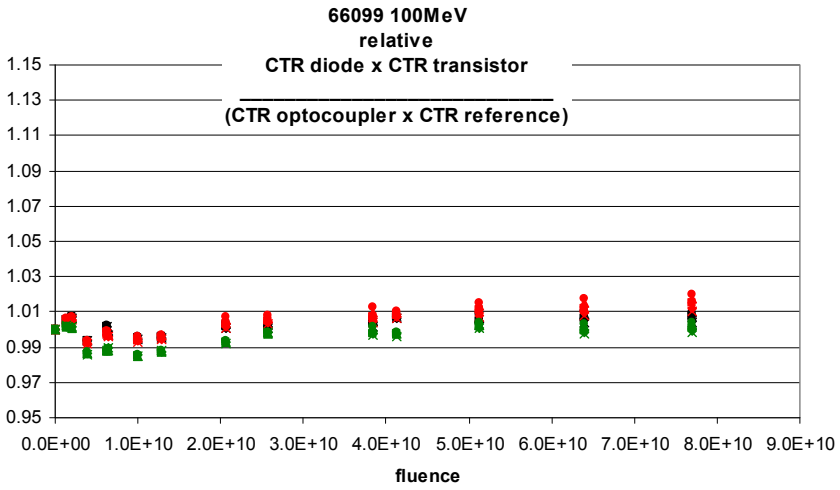
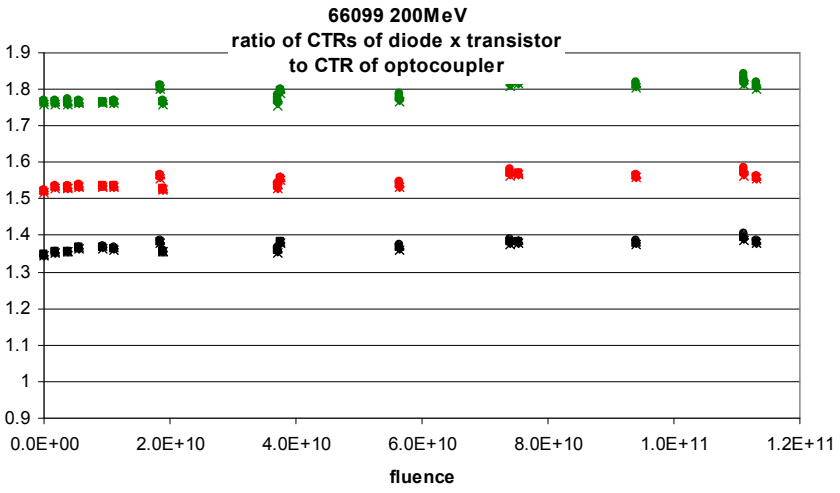


Fig. 3-49: 66099: CTR ratio and relative CTR ratio versus fluence at 100MeV



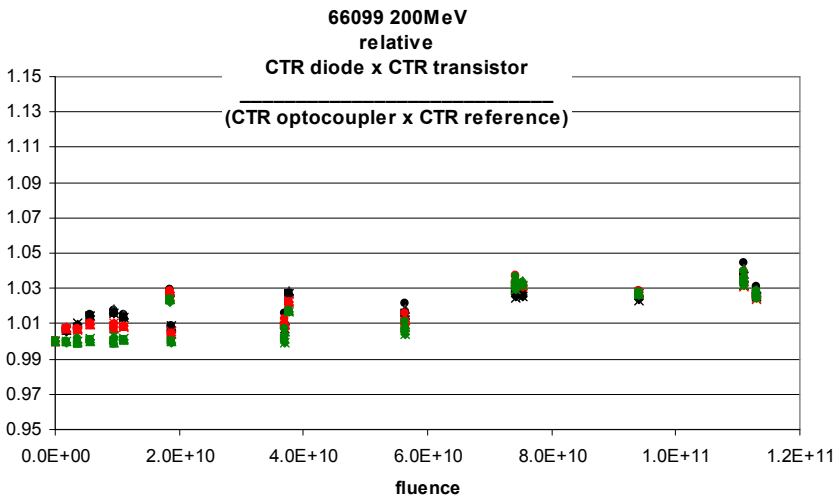


Fig. 3-50: 66099: CTR ratio and relative CTR ratio versus fluence at 200MeV

3.3.2 2nd method: "transfer function"

This section describes the "graphical method" that allows to estimate the expected global degradation of the diode coupled to the transistor. We will get an approximation of irradiated optocoupler CTR by assuming that the transistor collector current is the same as it would be with the non-irradiated diode operated at a lower current I_F.

The irradiation diminishes the photon flux from the diode; the hypothesis is that the same photon flux is obtained with a lower I_F through a pristine diode: if we assume a perfectly identical diode-transistor alignment, a given transistor response is obtained thanks to identical photon flux.

First, an optocoupler is chosen such that its CTR prior irradiation is similar to the diode's one measured with a reference transistor. By doing such, one approaches the situation where the irradiated optocoupler would have its CTR comparable to the other one built with its diode and the corresponding reference transistor.

In the ideal case, the comparison should be perfect if the irradiated transistor coupled with the reference diode could exhibit the same pre-irradiation CTR as the irradiated couple. However since the main contribution in CTR degradation comes from the diode (4N49, 66099), such approach still remains valid from comparison with the couple irradiated diode-reference transistor and irradiated optocoupler.

For instance, the 4N49's irradiation at Φp_3 #3 and 60MeV depicted in Fig. 3-51. At 8mA, the I_C in the reference transistor after the irradiation of the diode at $6.10^{10}cm^{-2}$ fluence is $1.2.10^{-4}$mA (step 1 in Fig. 3-51). The irradiated diode photon flux at I_F= 8mA is equal to its photon flux at I_F= 2.2mA prior irradiation (step 2 in Fig. 3-51). The irradiated collector current for this photon flux is $5.1.10^{-5}$A (step 3 in Fig. 3-51). This value is quite close to the collector current measured at 8mA for the whole irradiated optocoupler which is $5.32.10^{-5}$A (top graph in Fig. 3-51).

Other examples are presented in Fig. 3-52 and Fig. 3-53, at 100 and 200MeV respectively.

Such approach presented at 100 and 200MeV shows good estimation of overall 4N49 degradation.

It is not described with OLH249 and 66099 because of the too small CTR degradations.

It is advisable to proceed according to this way rather than by the first method described in 3.3.1. Since the degradation does not exhibit a linear shape with I_F, Eq. 5 being not equal to Eq. 6.

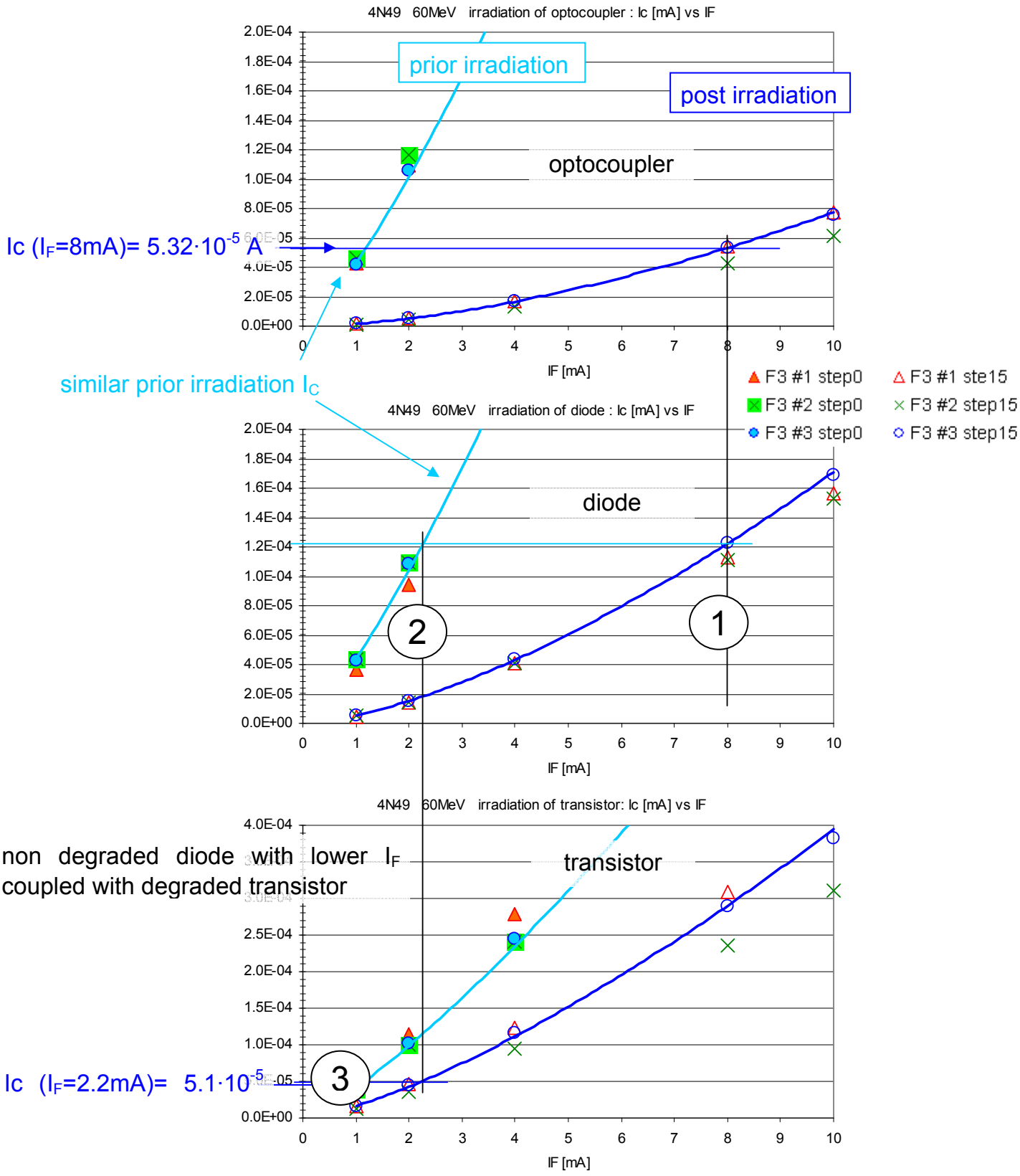


Fig. 3-51: estimation of 4N49 optocoupler CTR degradation at 60MeV from separated measurements on diode and transistor (collector currents plots, sample Φp$_3$#3)

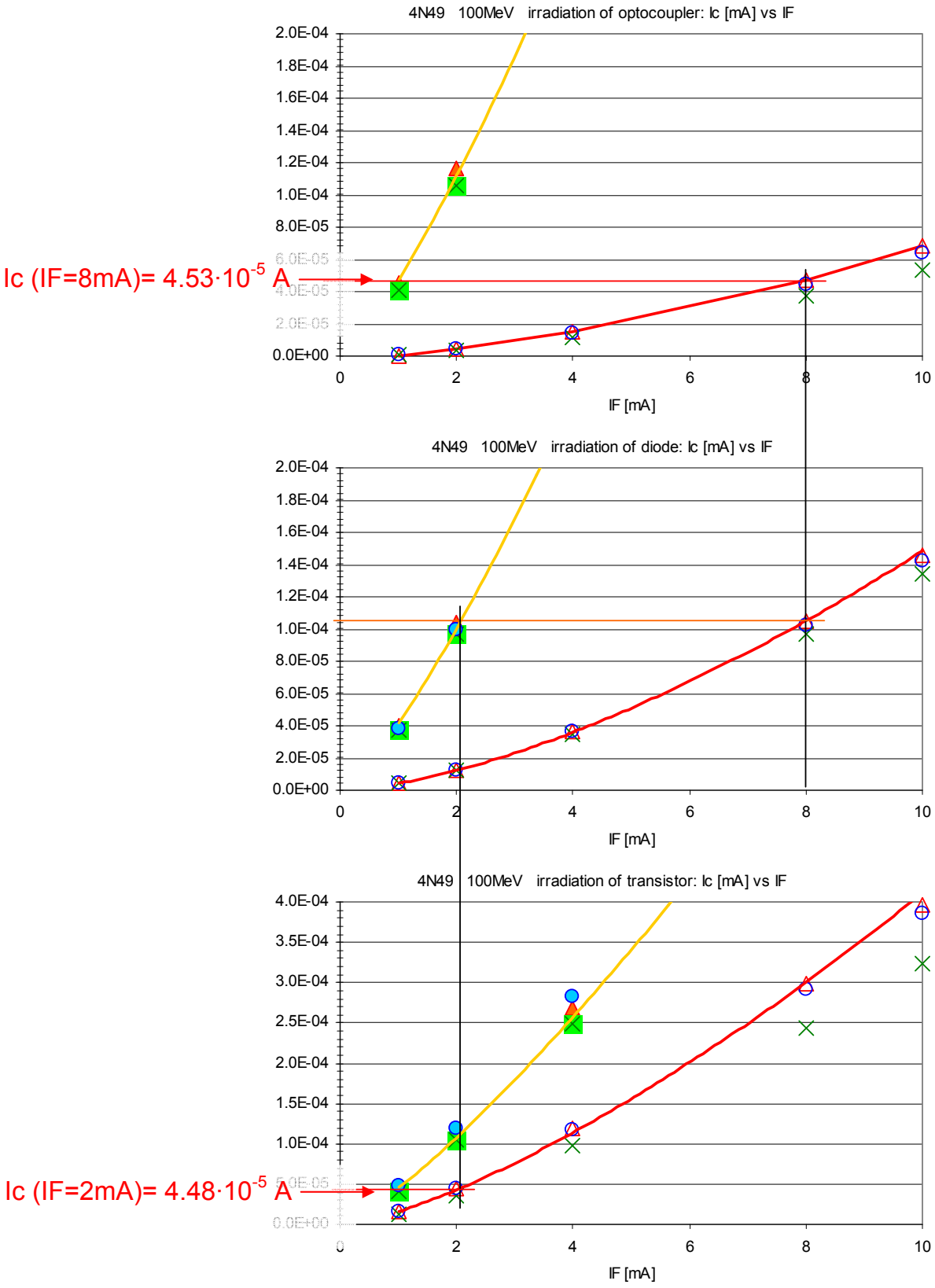
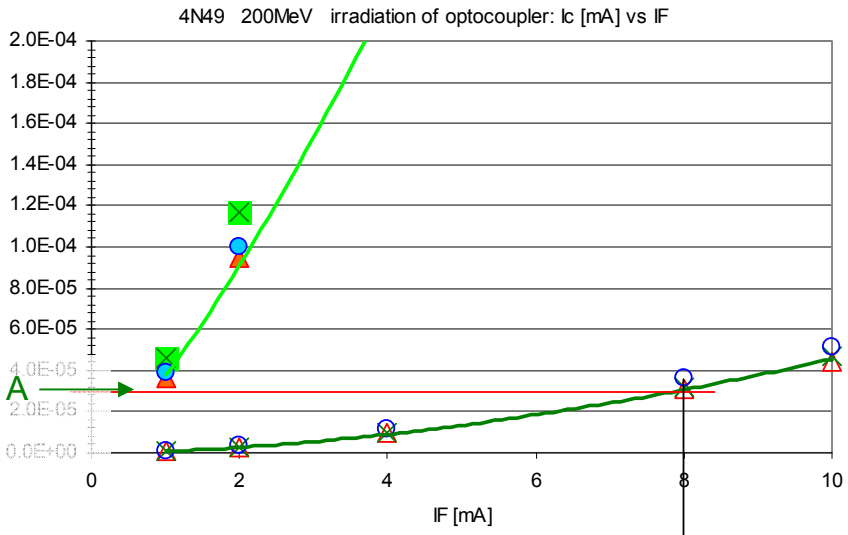
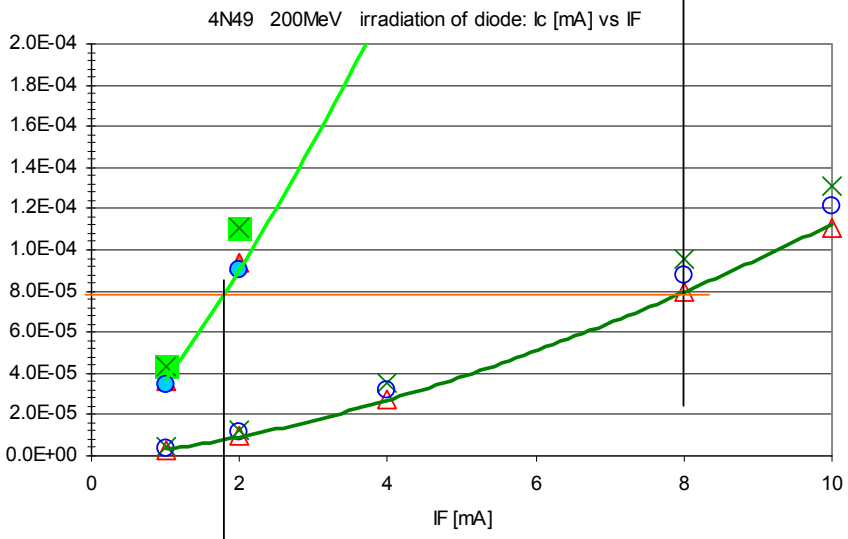


Fig. 3-52: estimation of 4N49 optocoupler CTR degradation at 100MeV from separated measurements on diode and transistor (collector currents plots, sample Φp_3#1)

Ic (IF=8mA)= $3.06 \cdot 10^{-5}$ A





Ic (IF=1.8mA)= $3 \cdot 10^{-5}$ A

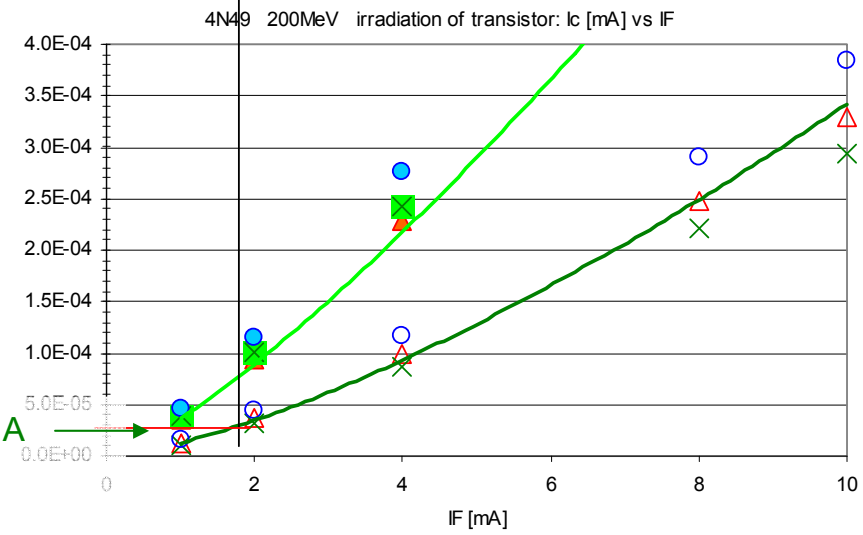


Fig. 3-53: estimation of 4N49 optocoupler CTR degradation at 200MeV from separated measurements on diode and transistor (collector currents plots, sample Φp_3#1)

4. VARIATION OF REVERSE RECOVERY TIME

4.1 DEFINITION OF τ_{RR}

When a PN-junction diode is forward biased by a voltage, a current I_F flows through it. When applying a transient reverse voltage, a reverse current I_R is injected, and is maintained during a certain time τ_{RR}, then it decays to zero. The reverse current lasts until the excess of minority free carriers injected in their respective zone are recombined. This phenomenon is depicted on the Fig. 4-1 below. This figure describes the τ_{RR} parameter evolution versus protons fluence. This evolution can be measured at a given fixed I_R value, for instance at -4mA (mid-height), -2mA or -1mA. For the remaining document this criteria is fixed to I_R = -4 mA.

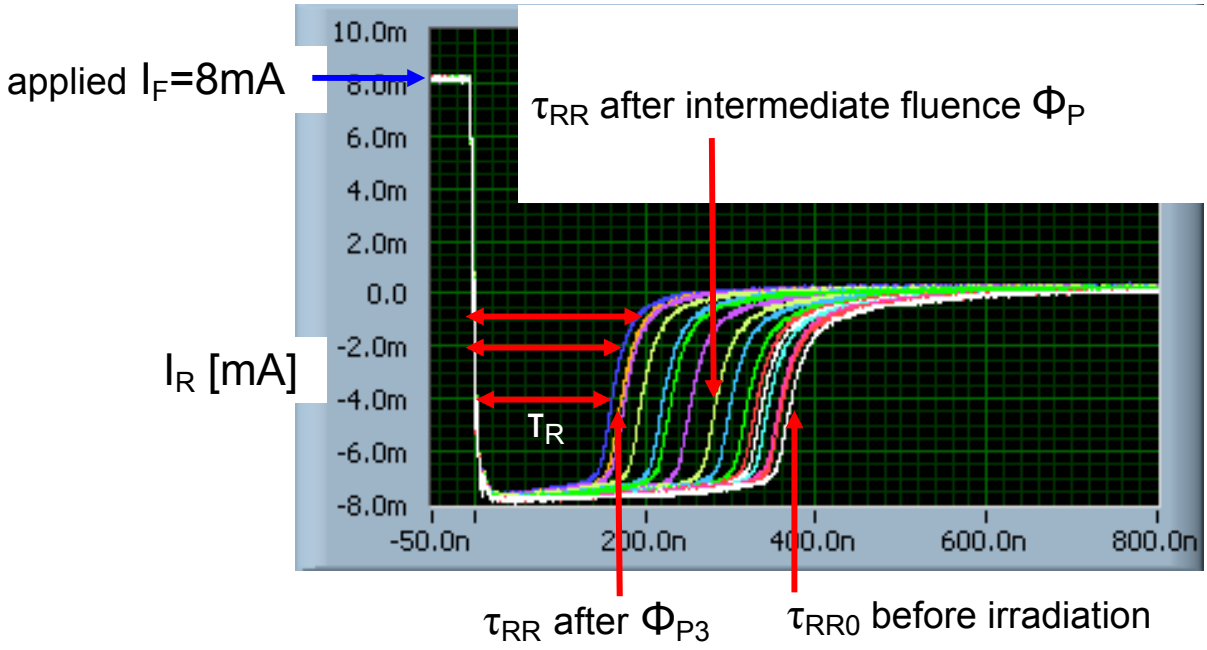


Fig. 4-1 : definition of τ_{RR}

τ_{RR} is proportional to minority carriers life-times τ_e for electrons in P-doped region and τ_p for protons in N-doped region. Empirically:

$$\frac{1}{\tau_{RR}} = \frac{A}{\tau_e} + \frac{B}{\tau_p} \qquad \text{Eq. 9}$$

with A and B depending on the geometry and doping profiles.

The τ_{RR0} parameter shape shows that the minority carrier lifetime is distributed.

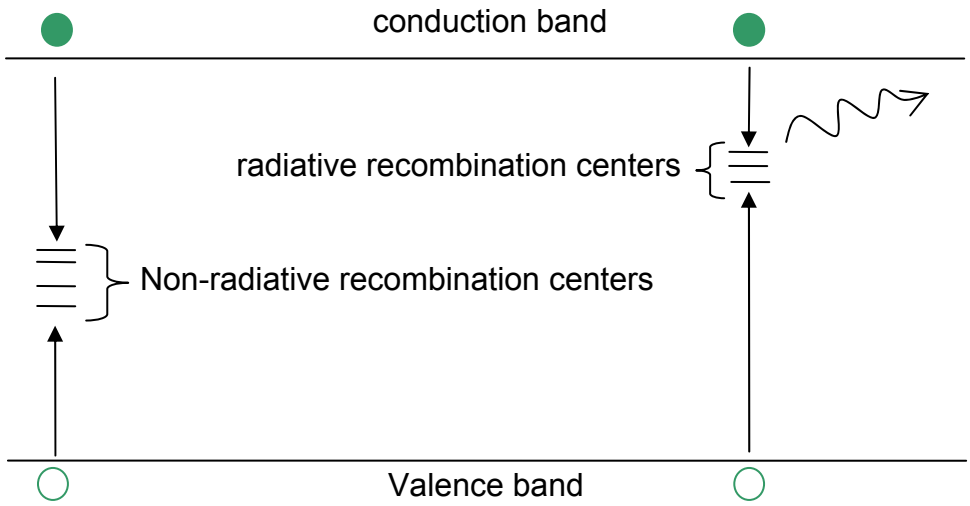


Fig. 4-2 : radiative and non-radiative recombination processes

The recombination process occurs mainly in the neutral zone. A recombination between an electron and a hole can be radiative when the carriers are trapped by certain recombination centers and non-radiative by other recombination centers (Fig. 4-2). The radiative or non-radiative nature of the recombination depends mainly on the centers nature.

The recombination rate R, the number of recombination's per second and per cm^3, is split into two parts, R_r (radiative) and R_{nr} (non-radiative) accordingly:

$$R_0 = R_{r0} + R_{nr0} \qquad \text{Eq. 10}$$

where index 0 is for initial values prior irradiation.

Recombination rates are in a first approximation proportional to the concentrations of recombination centers. Concentrations of recombination centers are inversely proportional to life-times. Eq. 10 translates into terms of life-times associated to recombination processes as is:

$$\frac{1}{\tau_0} = \frac{1}{\tau_{r0}} + \frac{1}{\tau_{nr0}} \qquad \text{Eq. 11}$$

LED's photon emission is the phenomenon induced by radiative recombination. To maximize the efficiency of the LED the radiative recombination rate R_r has to be the highest possible in comparison with the non-radiative R_{nr} recombination rate. The optocoupler CTR increases as diode's minority carriers' radiative life-time τ_r decreases.

4.2 IRRADIATION EFFECT

The proton irradiation creates displacement damage in the material. The concentration of non-radiative recombination centers rises consequently of a quantity ΔN_{nr}, increasing as a consequence the non-radiative recombination rate R_{nr}. The global effect is a τ_{RR} decrease, and the LED's emitted photon flux decrease, induced by the non-radiative recombination rate R_{nr} increase.

In a reasonable assumption, ΔN_{nr} can be expected as being proportional to the proton fluence Φ.

Hence, after irradiation: $R = R_r + R_{nr}$ Eq. 12

$$\frac{1}{\tau} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}}$$ Eq. 13

Which is equivalent to the following : $$\frac{1}{\tau} = \frac{1}{\tau_{r0}} + \frac{1}{\tau_{nr0}}(1 + \Delta N_{nr})$$ Eq. 14

The induced variation of $1/\tau$ is: $$\Delta\frac{1}{\tau} = \frac{1}{\tau} - \frac{1}{\tau_0} = \left(K_\Phi\right)\cdot\Phi$$ Eq. 15

whereby K_Φ the fluence proportionality coefficient.

This means that the variation of the reverse recovery time $\Delta 1/\tau_{RR} = 1/\tau_{RR} - 1/\tau_{RR0}$ can be written as:

$$\Delta\frac{1}{\tau_{RR}} = K_\Phi \cdot \Phi$$ Eq. 16

Which is equivalent to : $$\frac{\tau_{RR0}}{\tau_{RR}} = 1 + K_\Phi \cdot \Phi \cdot \tau_{RR0}$$ Eq. 17

According to Eq. 16, the highest the τ_{RR0}, the highest the expected degradation. The following paragraph depicts the experimental result's plot of Eq. 16 here above.

4.3 K: DEGRADATION COEFFICIENT

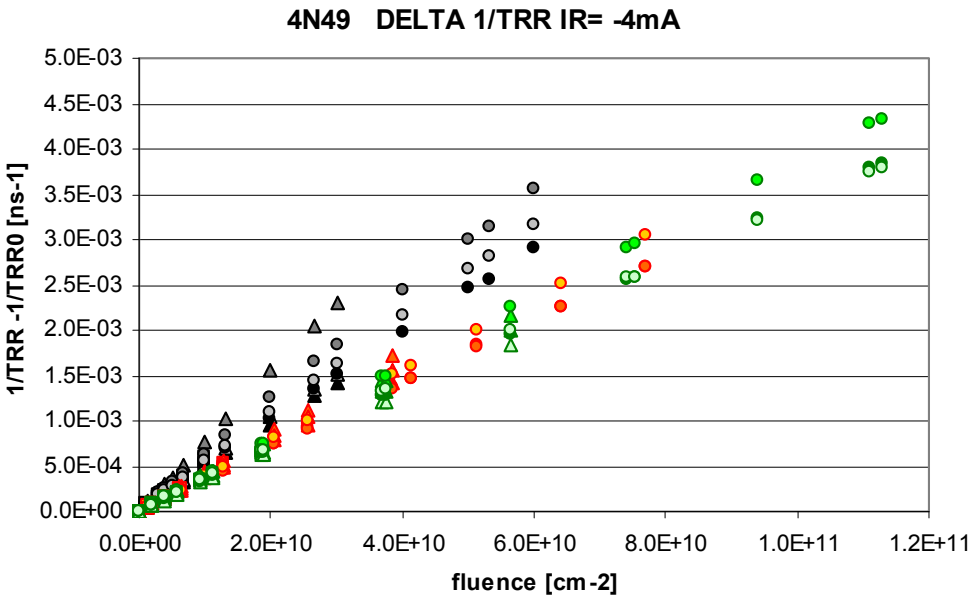


Fig. 4-3: 4N49 Δ $1/\tau_{RR}$ with respect to the proton fluence

Fig. 4-3 to Fig. 4-8 verify the hypothesis of $1/\tau_{RR}$ linear variation versus Φ [2] and NIEL. Since NIEL is assumed to be proportional to fluence. Eq. 16 is verified by those experiments, therefore also:

$$\Delta\ 1/\tau_{RR} = K_{NIEL_Barry}.NIEL_Barry \qquad \text{Eq. 18}$$

$$\Delta\ 1/\tau_{RR} = K_{NIEL_GEANT4}.NIEL_GEANT4 \qquad \text{Eq. 19}$$

The different K coefficients represent the degradation rate versus constraint (Φ, NIEL).

For each irradiated diode and three reverse currents (-1, -2 and -4 mA), a linear regression is performed with a non-zero y-intercept, i.e.:

$$\Delta\ 1/\tau_{RR} = a.x + b \qquad \text{Eq. 20}$$

For optocoupler 4N49, the regressed values for b parameter are close to zero. Several are negative. The highest absolute value of b is 5.31E-05, which is to compare with the scale on Fig. 4-3 above.

For optocouplers OLH249 and 66099 the regression does not fit as well because of the measurement uncertainty in this range of time (30ns-110ns while for 4N49 it is 144ns-630ns). OLH249 Φp_1 points (squares) are believed to be very affected by noise uncertainty, and are pointed out as “bad points” in Fig. 4-6 to Fig. 4-12.

Values arrange in the following order: KΦ(OLH249) < KΦ(4N49) < KΦ(66099), whatever the energy.

K_Φ coefficients for all optocouplers range within $[10^{-14}, 10^{-13}]$ $cm^{-2}.ns^{-1}$.

Besides it appears there is no K dependence on initial recovery time τ_{RR0} (see Fig. 12-86 to Fig. 12-88, Fig. 13-86 to Fig. 13-88, Fig. 14-86 to Fig. 14-88 in appendixes). The coefficients seem to be distributed. Hence, by virtue of the equation Eq. 17, one can guess that the less affected diode will be with the lowest τ_{RR0}.

4.4 EVOLUTION WITH FLUENCE

For all diode types -4N49, OLH249, 66099-, K_Φ decreases as the energy increases, even if the difference between 60 and 100 MeV is not very obvious for OLH249 diode. Like the CTR degradation, this is consistent again with the NIEL values: NIEL decreases with the energy increasing. Regarding 4N49, K_Φ[60MeV] is very distinct from K_Φ[100MeV] and K_Φ[200MeV]. While regarding 66099, K_Φ[200MeV] is very distinct from K_Φ[60MeV] and K_Φ[100MeV].

4.5 EVOLUTION WITH NIEL ACCORDING TO BARRY’S HYPOTHESIS

K_{NIEL_Barry} is the same at 100MeV as at 60MeV, but the coefficient grows at protons energy Ep=200MeV. 4N49’s K_{NIEL_Barry} increase is the most noticeable. This directly comes from an a better measurement accuracy with this diode.

4.6 EVOLUTION WITH ELASTIC NIEL

$K_{NIEL_GEANT4_ELASTIC}$ gets higher as the energy increases. Similar observations to 4.5 and 4.6 were done regarding the CTR in 3.2.2.

4.7 EVOLUTION WITH TOTAL NIEL

$K_{NIEL_GEANT4_elastic+inelastic}$ is depicted in Fig. 4-11, Fig. 4-13 and Fig. 4-15. It seems to not depend on the energy. However for the 4N49 diode, the coefficient at 100MeV is slightly lower than at 60MeV, and at 200MeV higher than at 60MeV. The evolution of $K_{NIEL_GEANT4_elastic+inelastic}$ is very similar to the evolution of K_{NIEL_Barry}, as compels the closeness of NIEDR values depicted in Fig. 3-10.

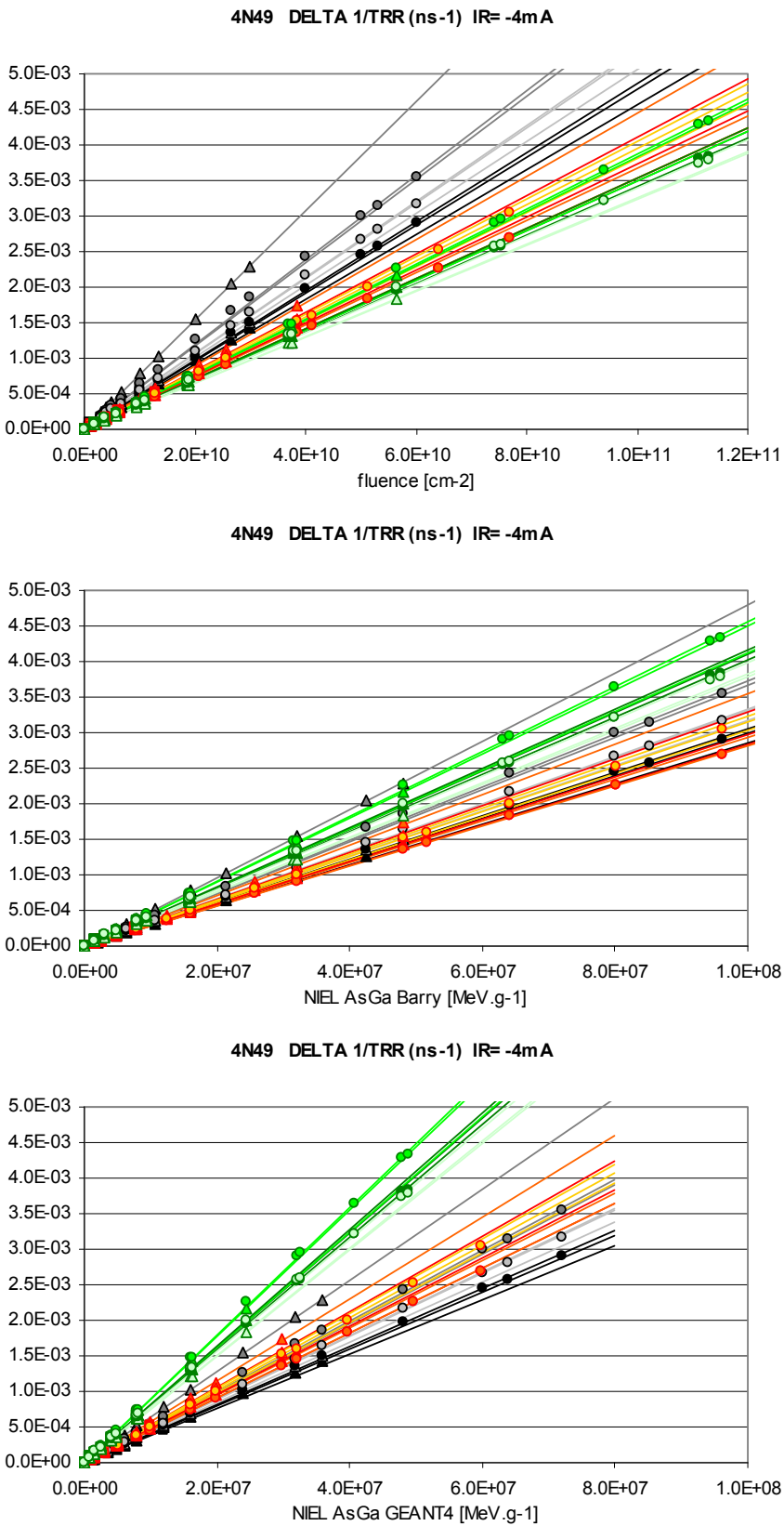


Fig. 4-4: 4N49 Δ $1/\tau_{RR}$ with respect to fluence (top), NIEL_Barry (middle), NIEL_GEANT4_elastic (bottom), and corresponding linear fits

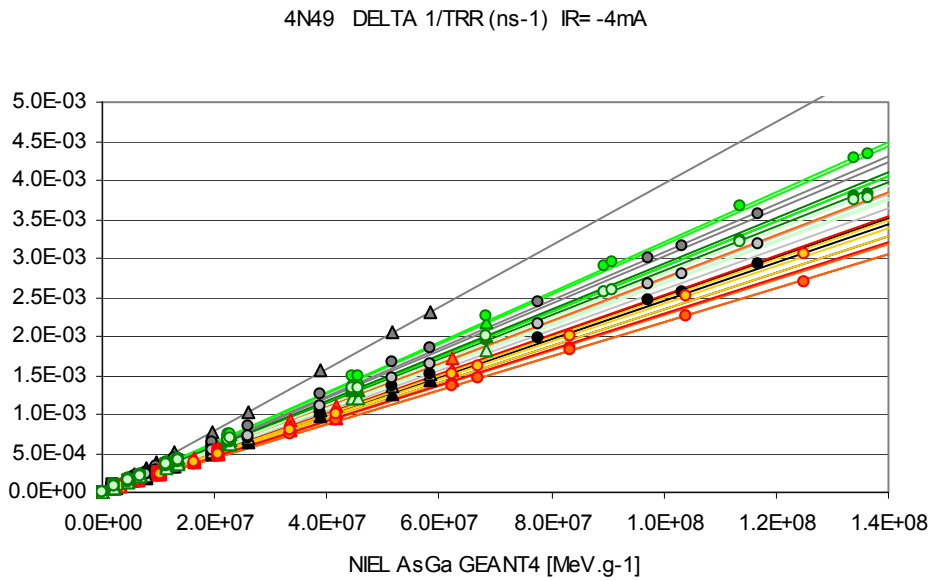


Fig. 4-5: 4N49 Δ $1/\tau_{RR}$ with respect to NIEL_GEANT4_elastic + inelastic

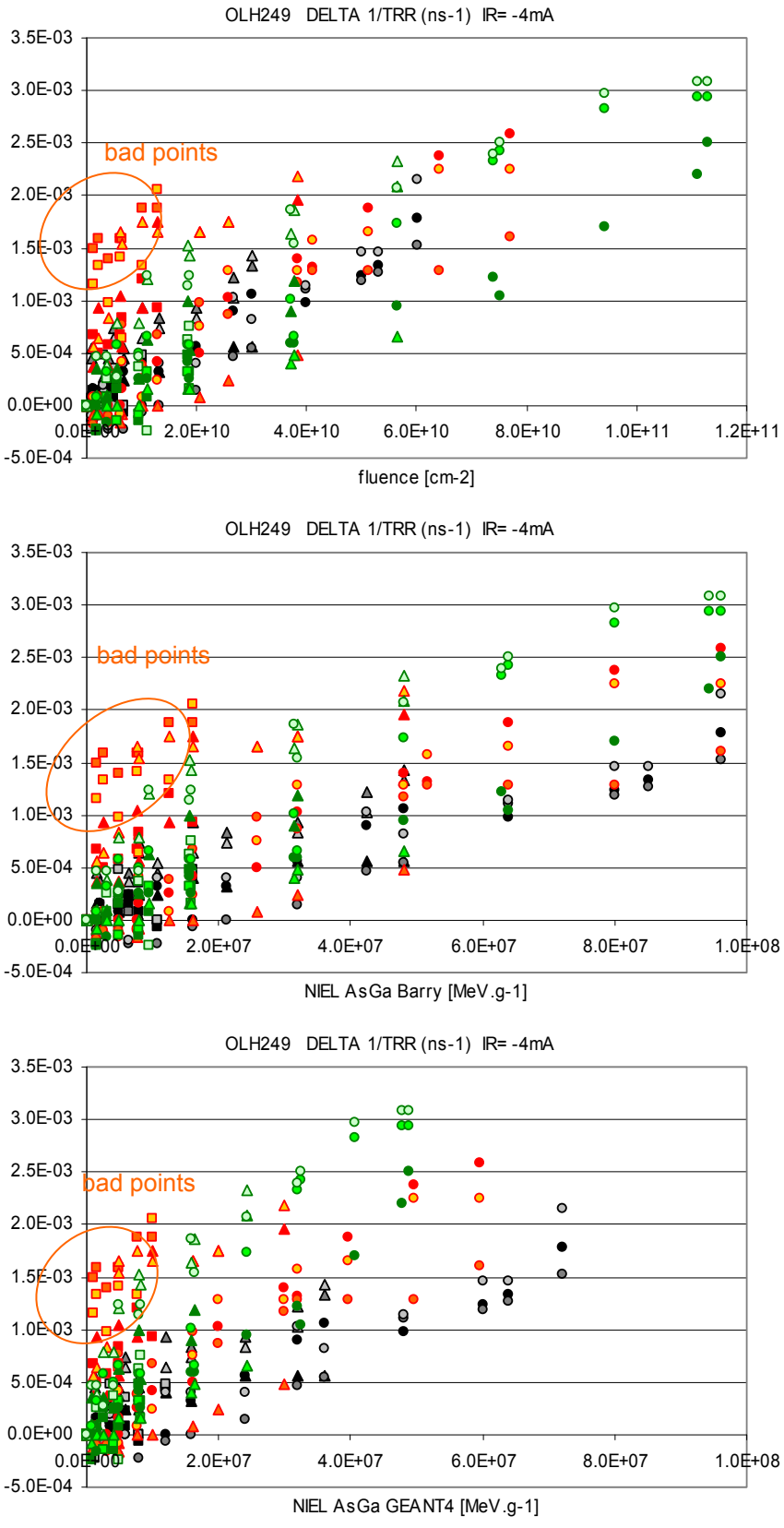


Fig. 4-6: OLH249 Δ $1/\tau_{RR}$ with respect to fluence (top), NIEL_Barry (middle), NIEL_GEANT4_elastic (bottom)

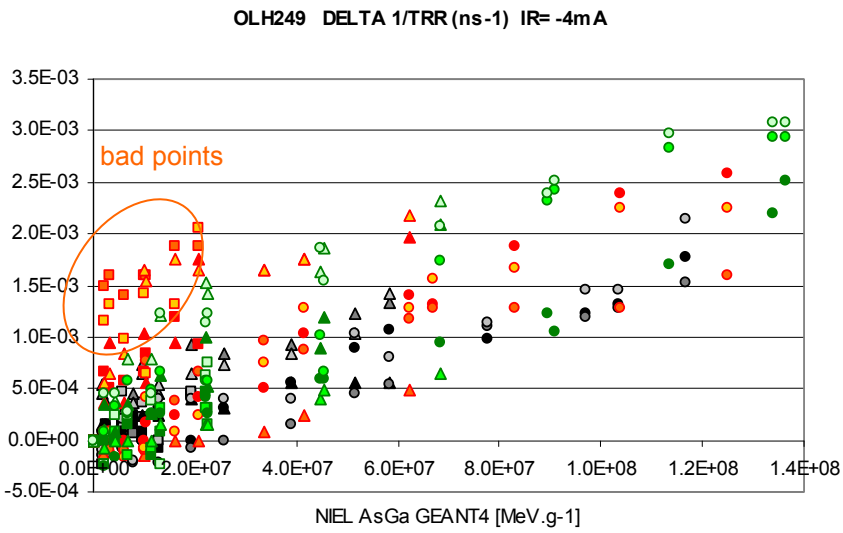


Fig. 4-7: OLH249 Δ $1/\tau_{RR}$ with respect to NIEL_GEANT4_elastic + inelastic

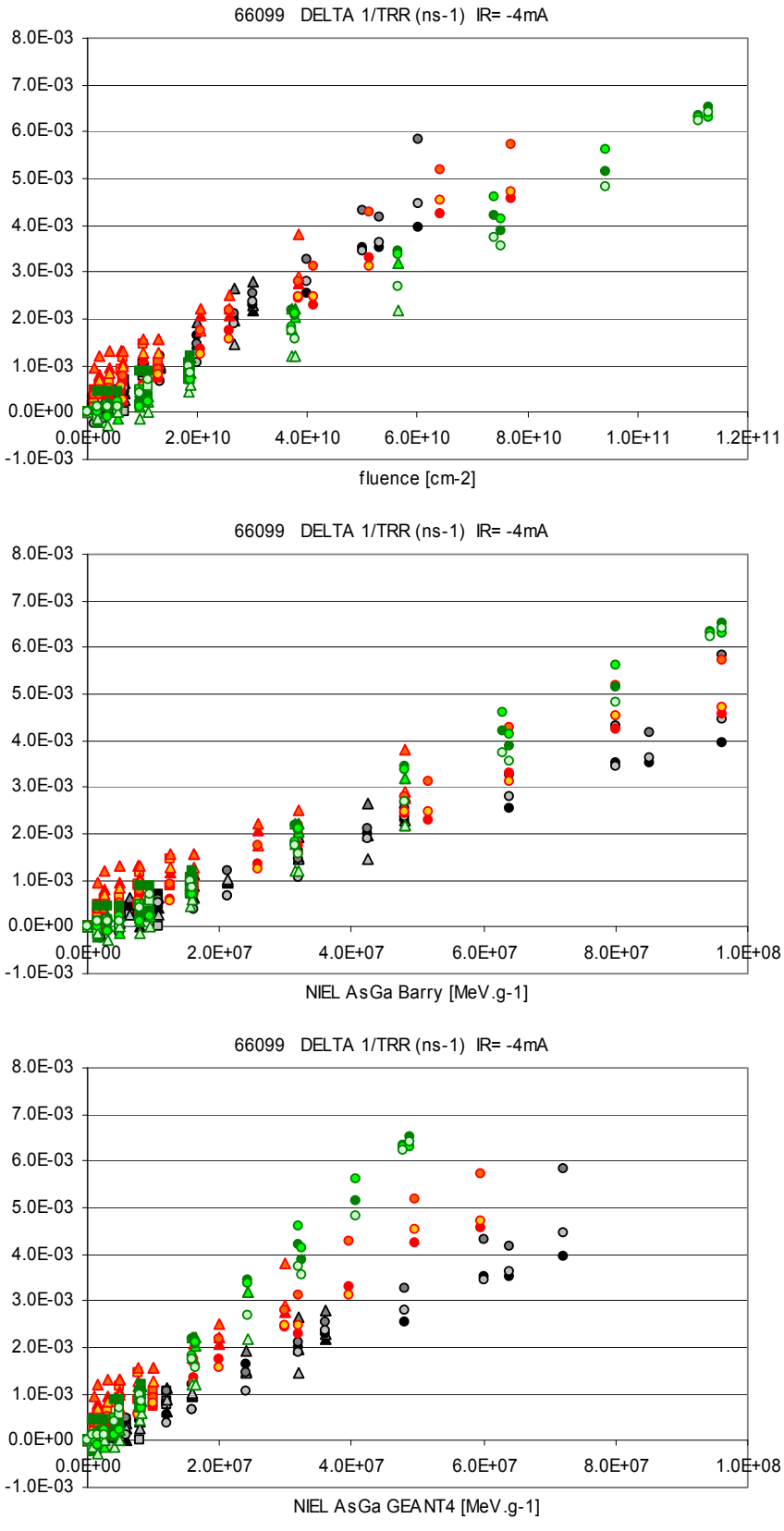


Fig. 4-8: 66099 Δ $1/\tau_{RR}$ with respect to fluence (top), NIEL_Barry (middle), NIEL_GEANT4_elastic (bottom)

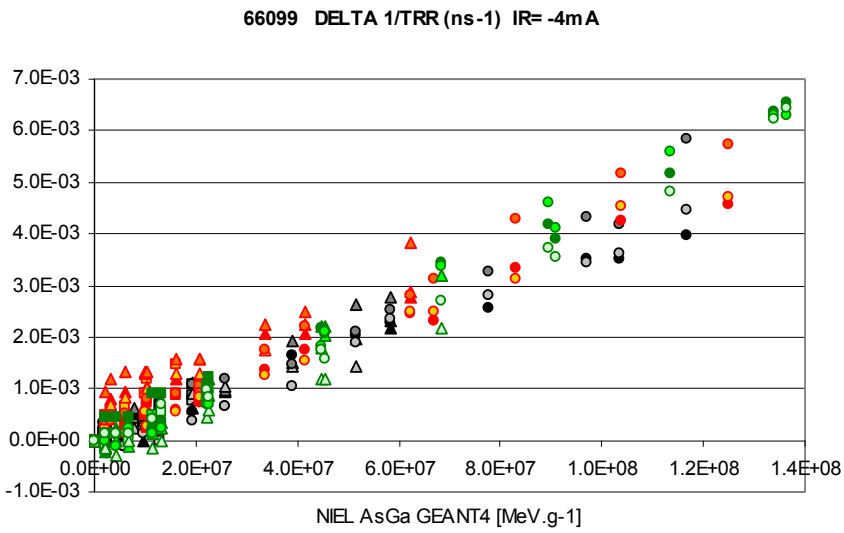


Fig. 4-9: 66099 Δ $1/\tau_{RR}$ with respect to NIEL_GEANT4_elastic + inelastic

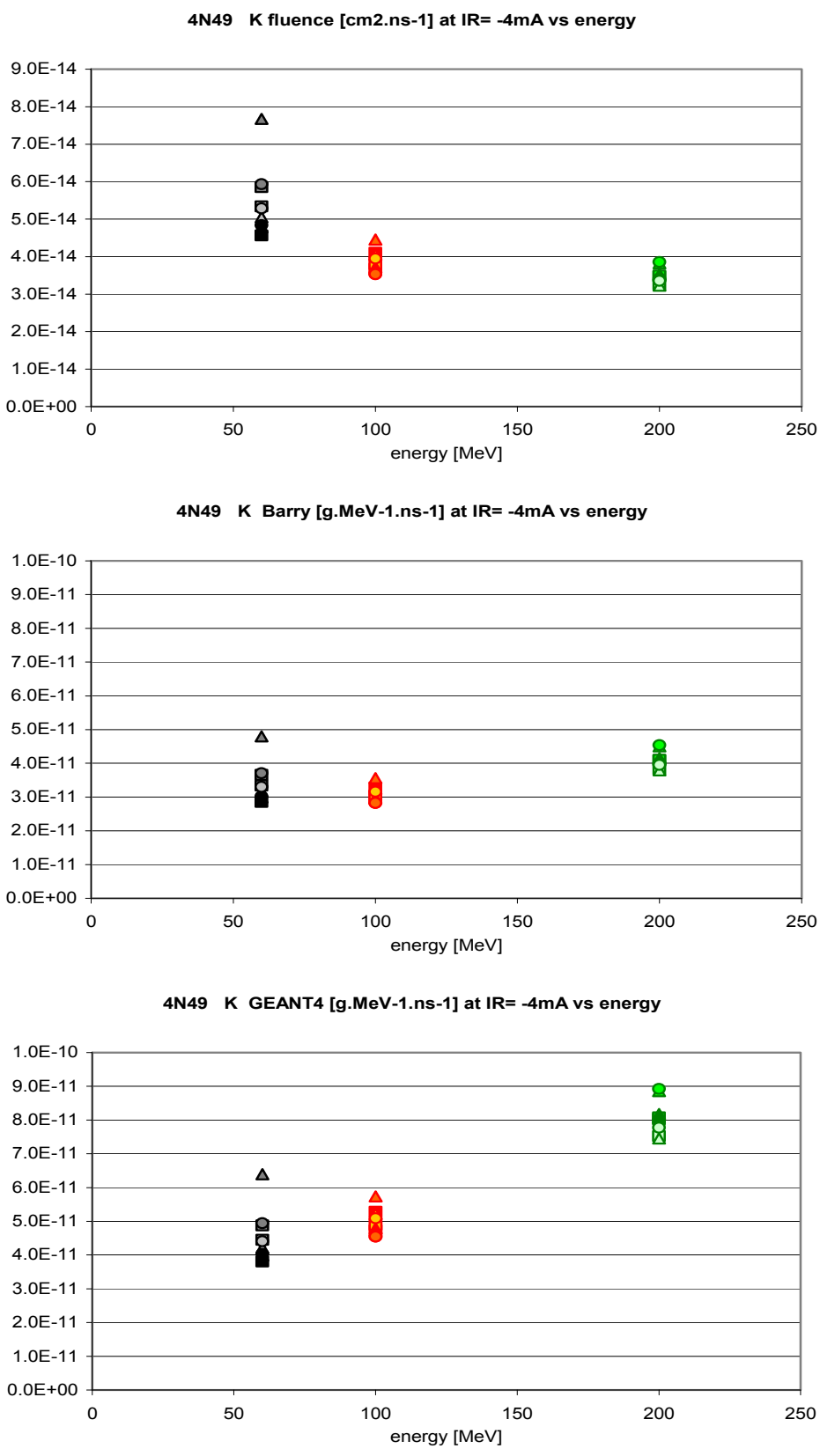


Fig. 4-10: 4N49: K_{Φ}, K_{NIEL_Barry}, $K_{NIEL_GEANT4_ELASTIC}$ at I_R=-4mA, with respect to energy

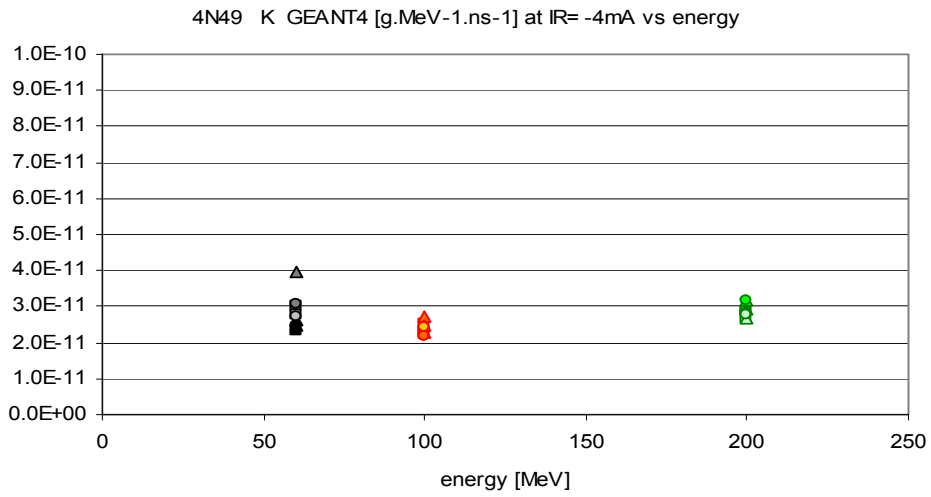
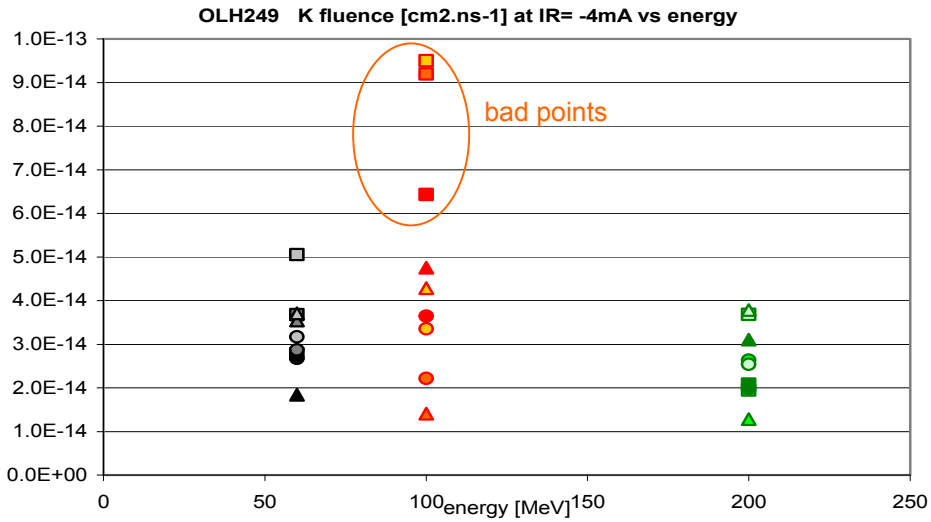
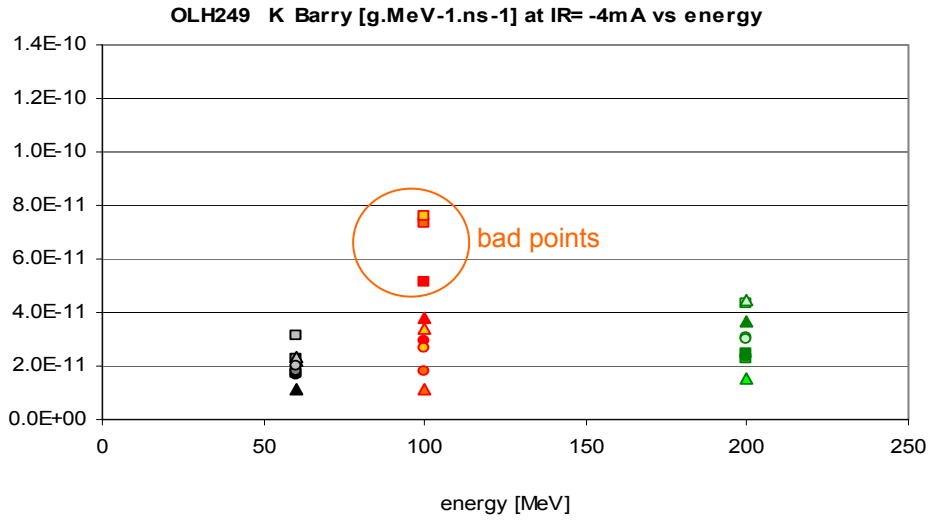


Fig. 4-11: 4N49: $K_{NIEL_GEANT4_elastic+inelastic}$ at I_R=-4mA, with respect to energy





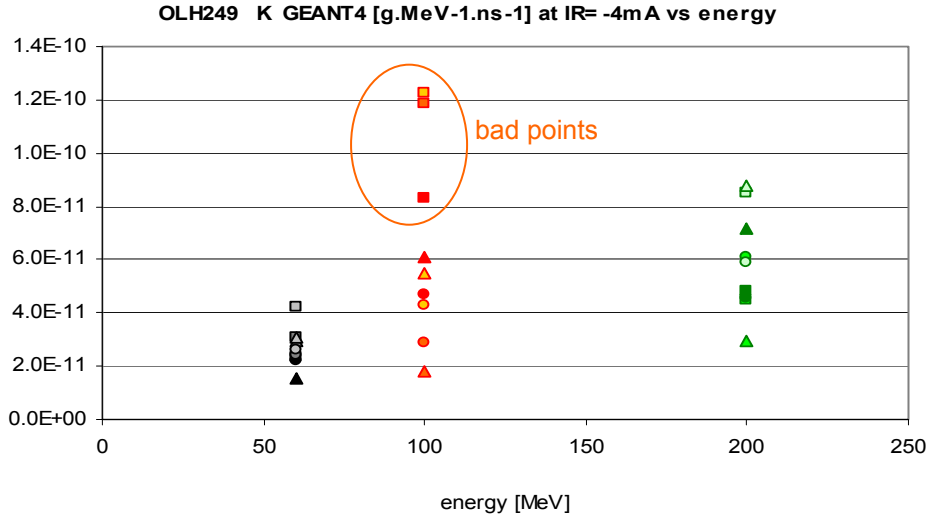


Fig. 4-12: OLH249: K_{Φ}, K_{NIEL_Barry}, $K_{NIEL_GEANT4_ELASTIC}$ at I_R=-4mA, with respect to energy

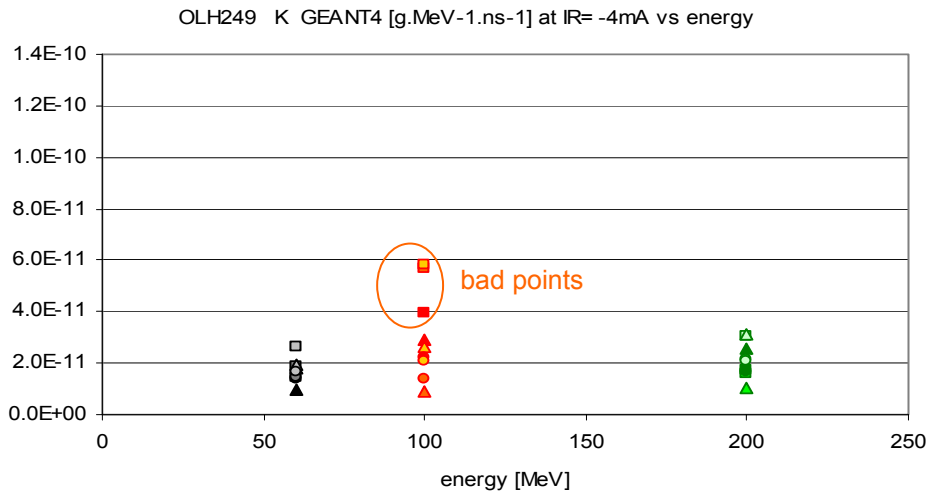
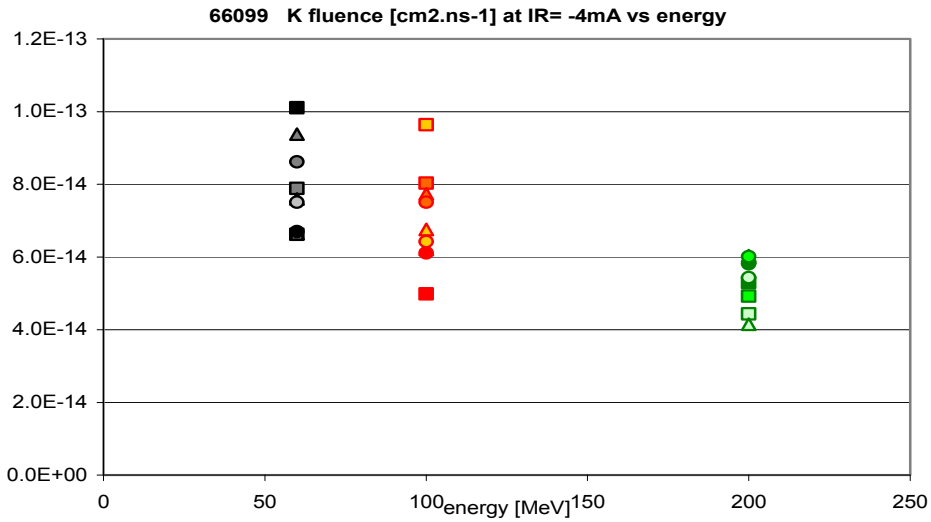
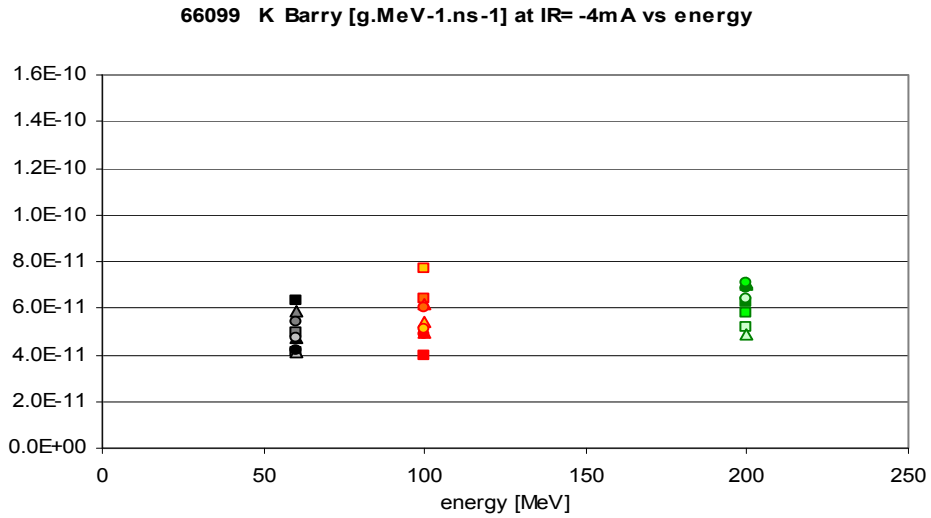


Fig. 4-13: OLH249: $K_{NIEL_GEANT4_elastic+inelastic}$ at I_R=-4mA, with respect to energy





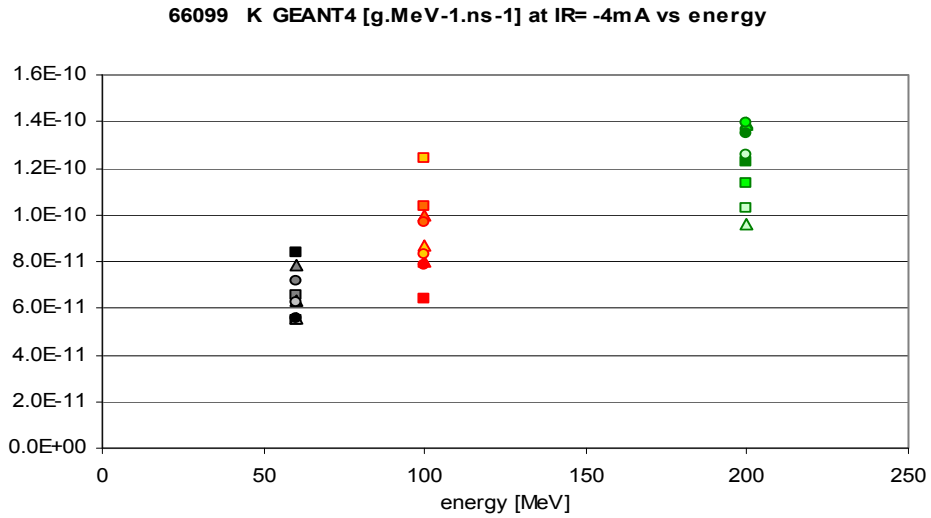


Fig. 4-14: 66099: K_{Φ}, K_{NIEL_Barry}, $K_{NIEL_GEANT4_ELASTIC}$ at I_R=-4mA, with respect to energy

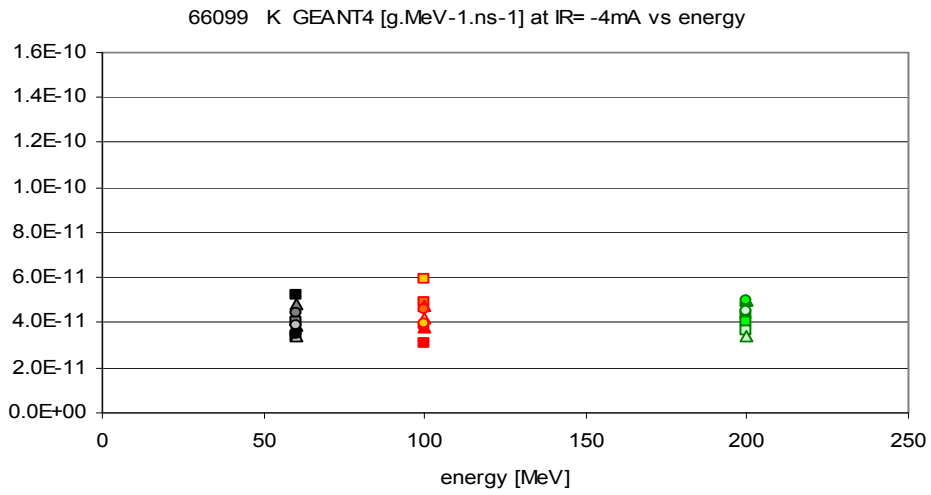


Fig. 4-15: 66099: $K_{NIEL_GEANT4_elastic+inelastic}$ at I_R=-4mA, with respect to energy

5. CORRELATION BETWEEN CTR DEGRADATION AND τ_{RR} DEGRADATION

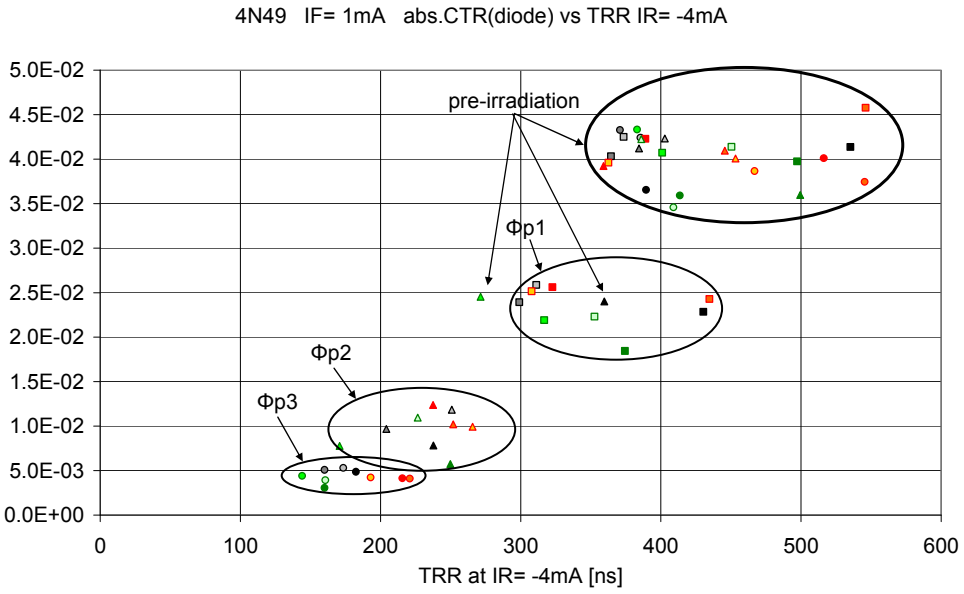


Fig. 5-1: 4N49 diode CTR at I_F= 1mA with respect to τ_{RR}

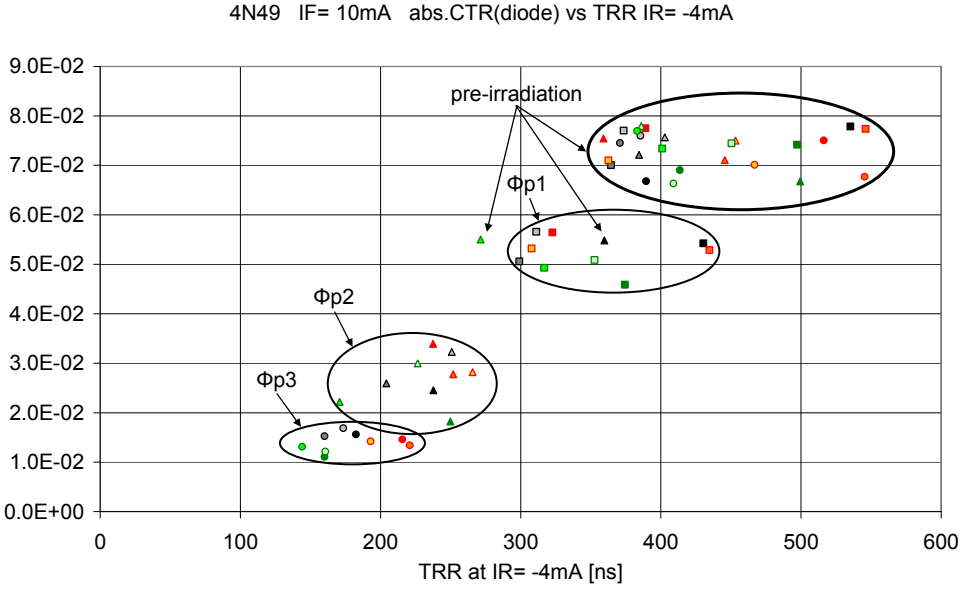


Fig. 5-2: 4N49 diode CTR at I_F= 10mA with respect to τ_{RR}

As it can be seen with the pre- and post- irradiation points on Fig. 5-1 and Fig. 5-2, the absolute diode CTR is independent from τ_{RR}. There is however obviously a correlation between CTR degradation and that of the τ_{RR}.

The variation of the relative CTRdiode (Δrel.CTR = 1 - CTR/CTR_0) is linearly interpolated between two irradiation steps and plotted in Fig. 5-3 to Fig. 5-11 with respect to the initial recovery time τ_{RR0} measured at I_R = -4mA for three NIEL values: 8.10^6, 2.10^7 and $4.88.10^7$ MeV.g^{-1}.

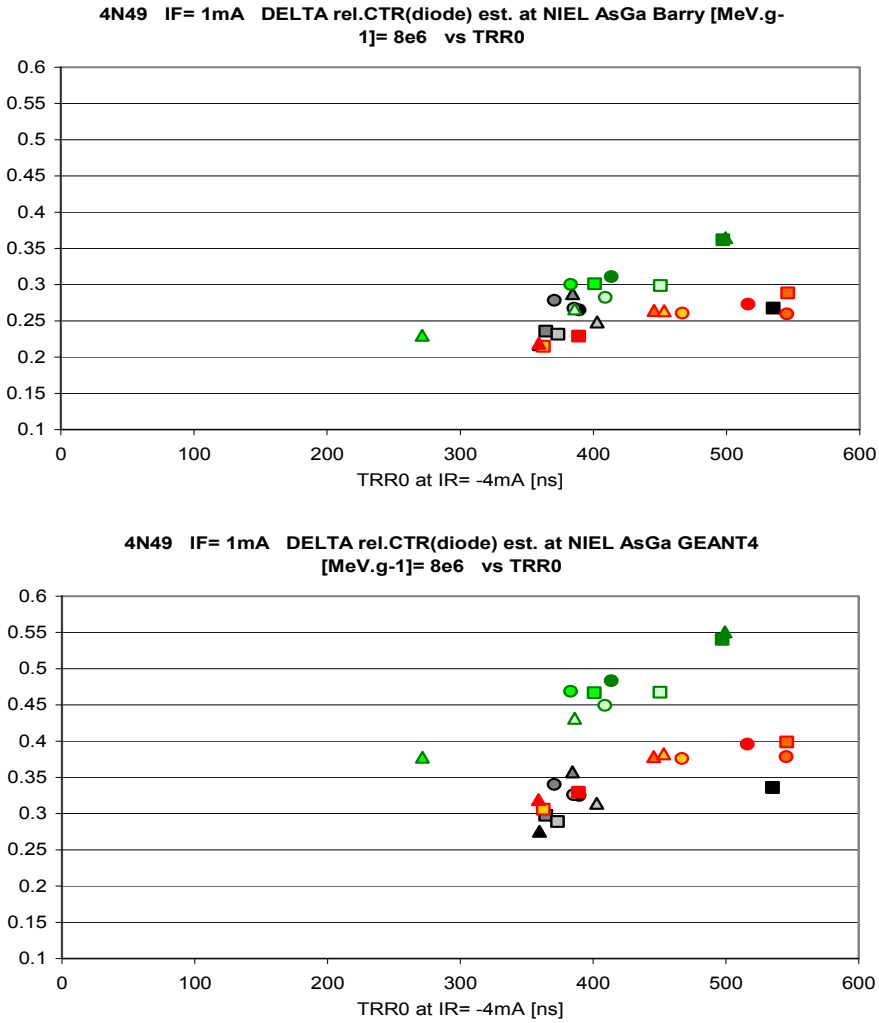
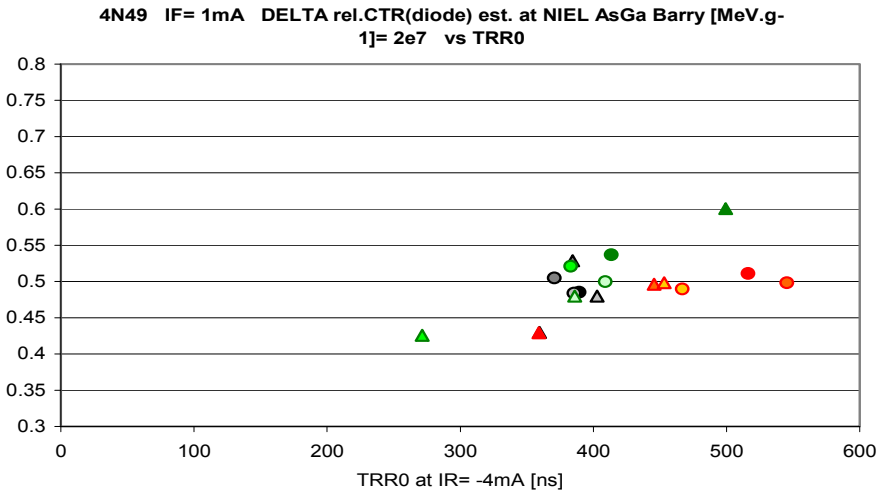


Fig. 5-3: 4N49 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 8.10^{6}MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)



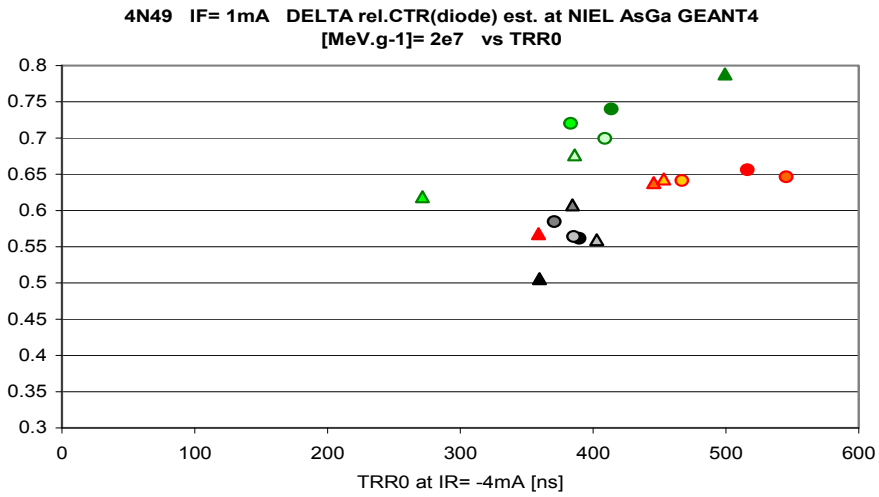


Fig. 5-4: 4N49 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 2.10^7MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

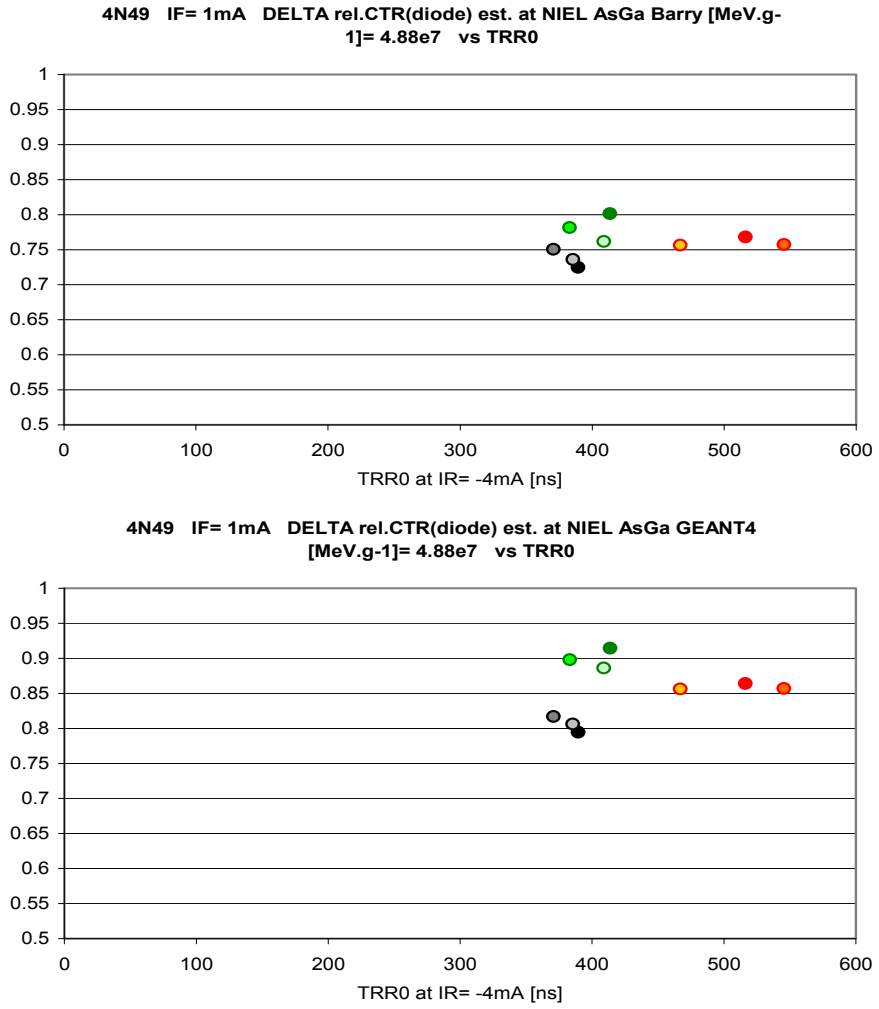


Fig. 5-5: 4N49 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of $4.88.10^7$MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

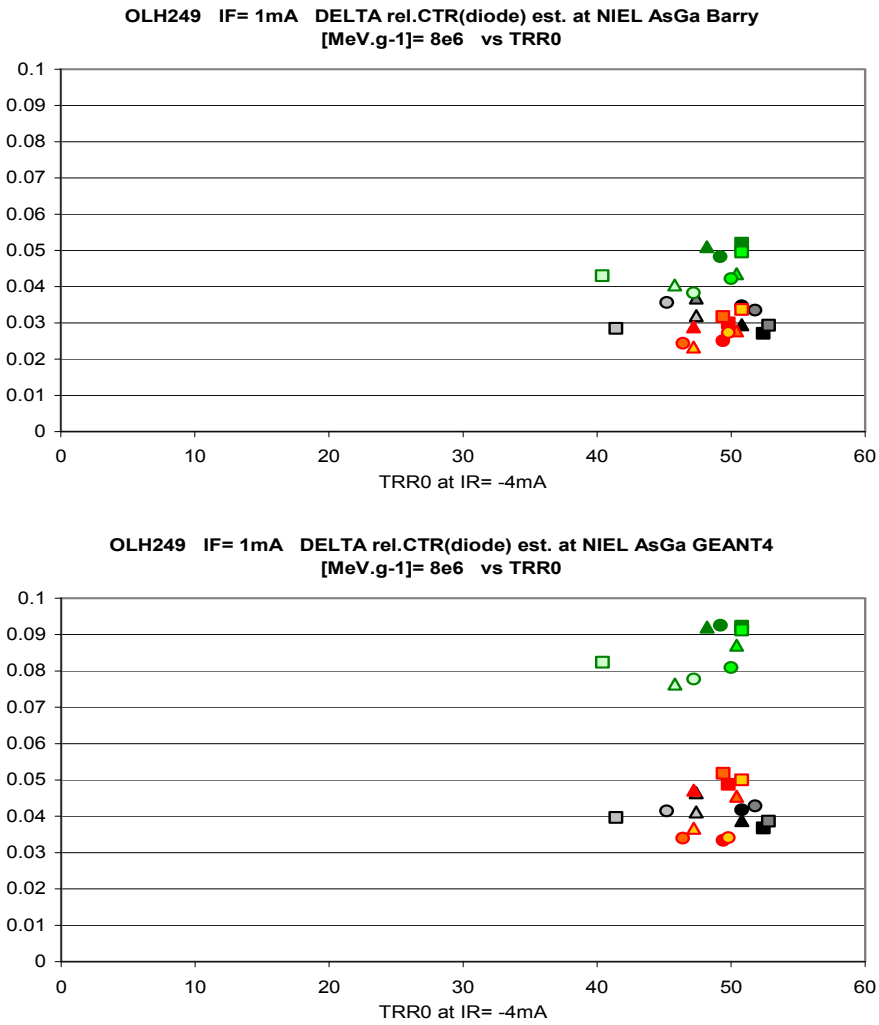
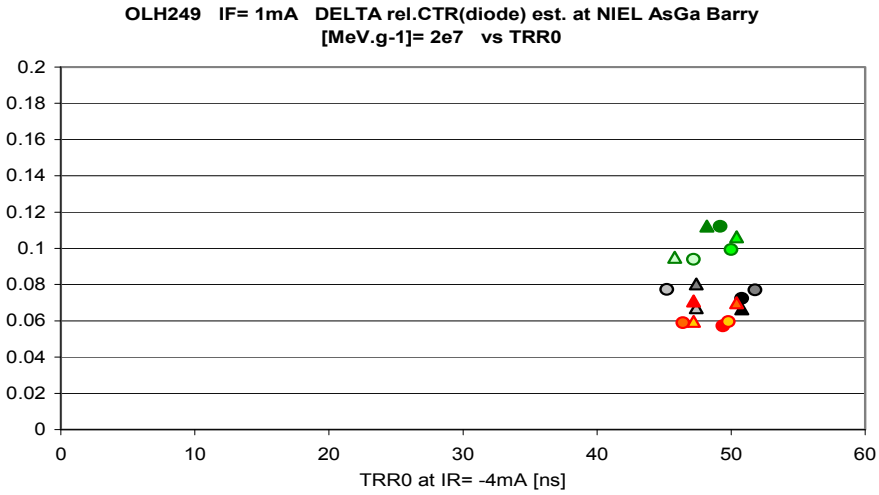


Fig. 5-6: OLH249 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 8.10^6MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)



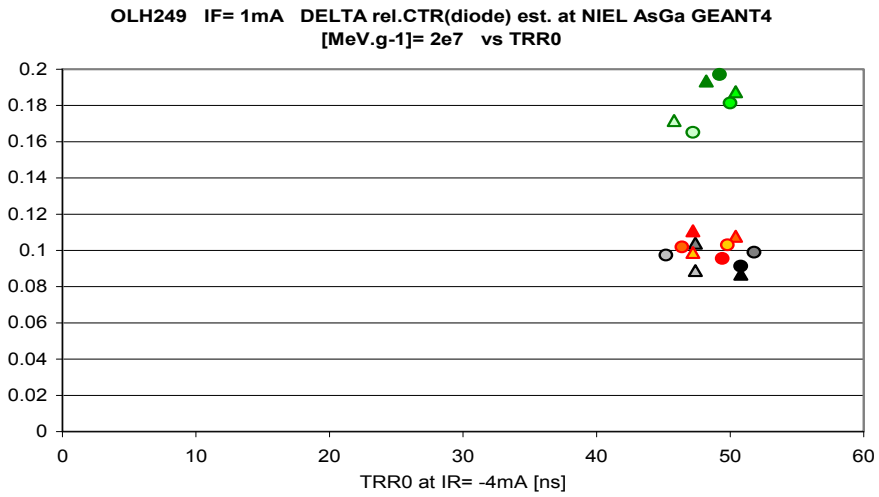


Fig. 5-7: OLH249 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 2.10^{7}MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

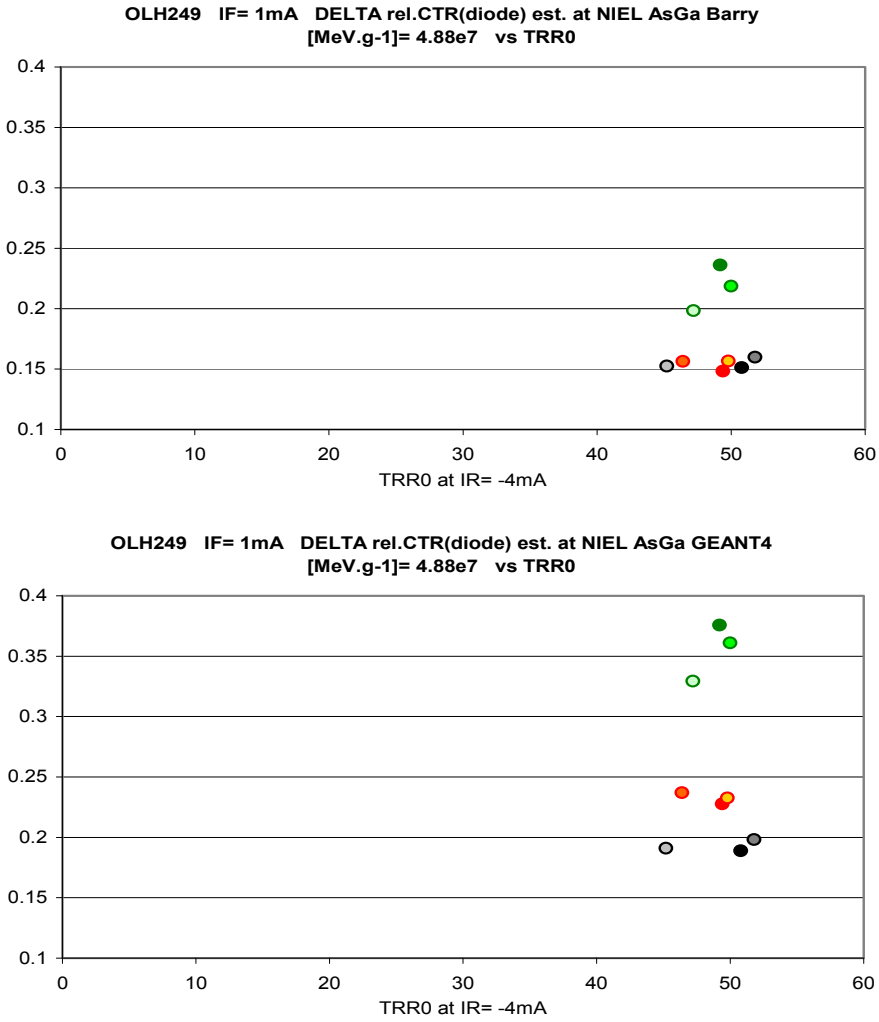


Fig. 5-8: OLH249 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 4.88.10^{7}MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

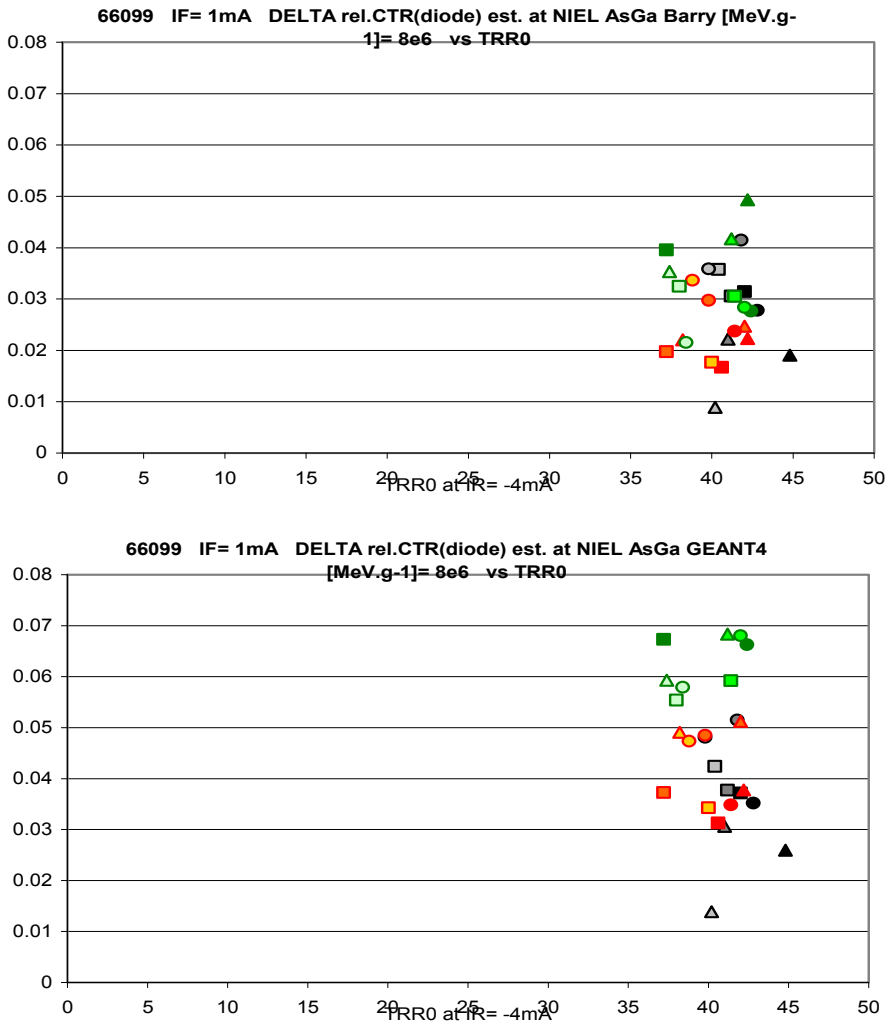
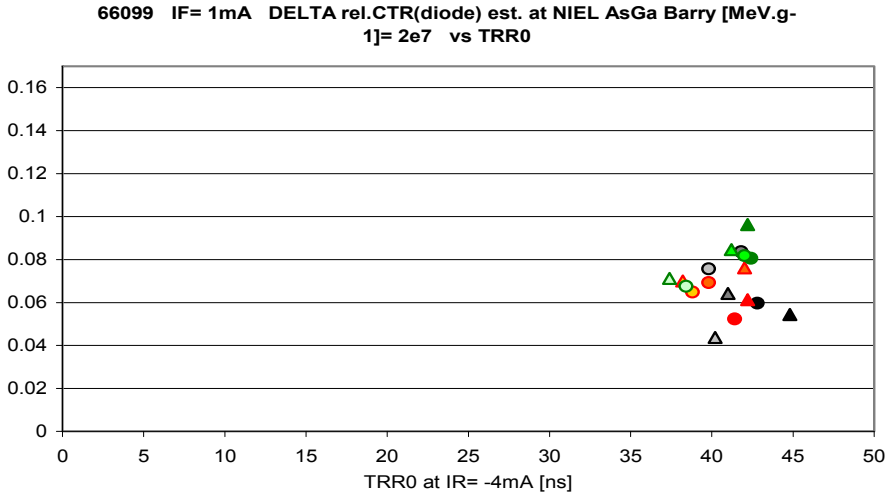


Fig. 5-9: 66099 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 8.10^6MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)



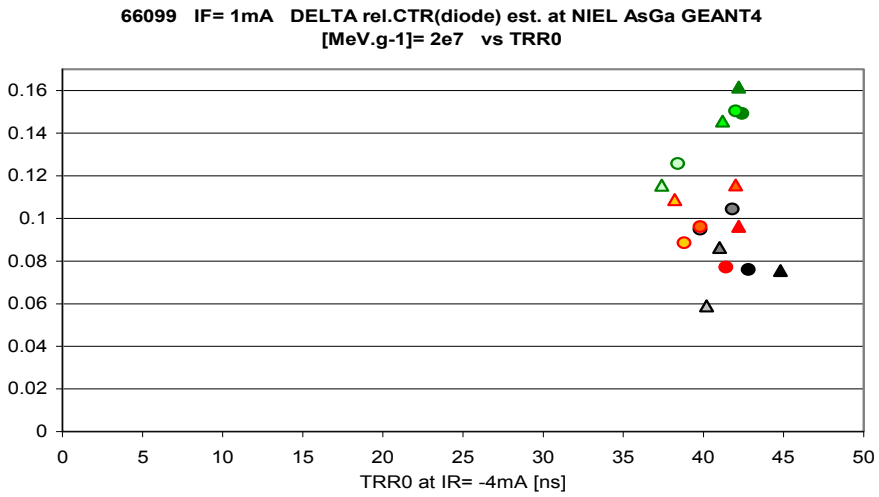


Fig. 5-10: 66099 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of 2.10^7MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

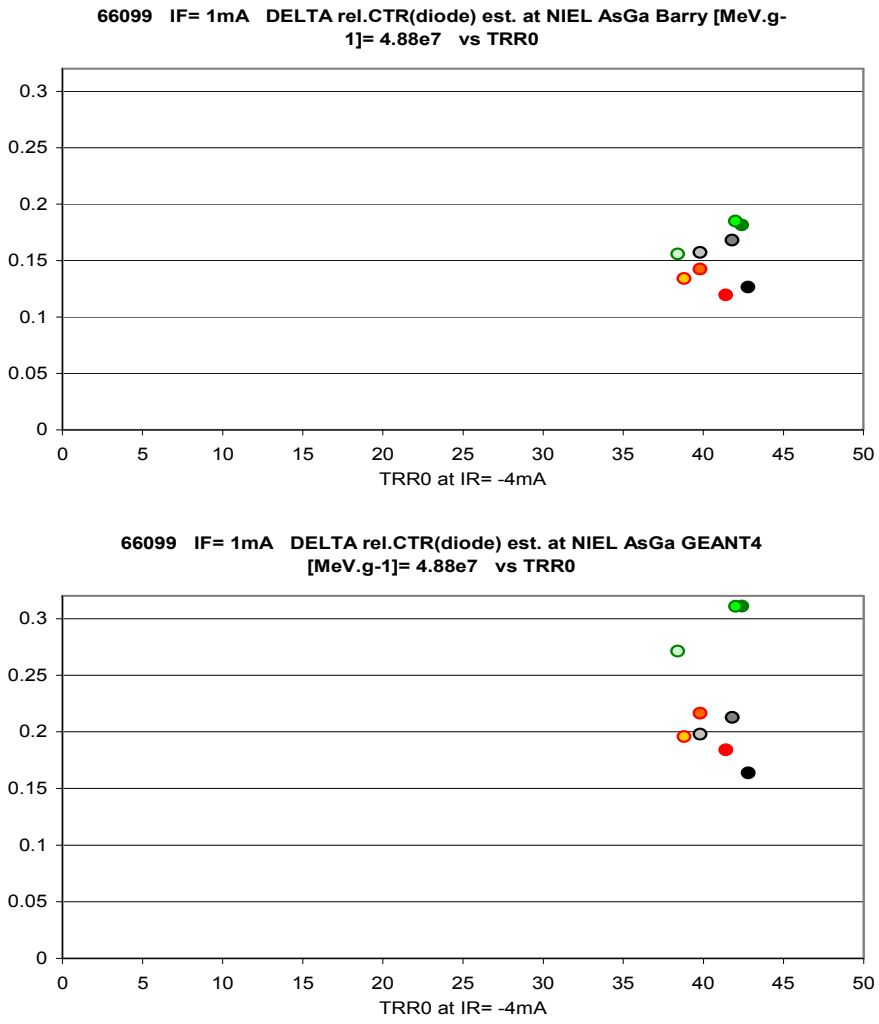


Fig. 5-11: 66099 diode: Δrel.CTR at I_F= 1mA estimated at a NIEL of $4.88.10^7$MeV.g^{-1} with respect to τ_{RR0} (Barry: top, GEANT4 ELASTIC: bottom)

A trend emerges in 4N49 plots, Fig. 5-3 to Fig. 5-5: the higher τ_{RR0}, the higher the relative CTR degradation. It is not visible at $4.88.10^{7}$MeV.g^{-1} because of there is not enough points. It is not patent either on OLH249 and 66099 because the time difference is too narrow (<10ns) and the dispersion masks the trend. It is worth to note that when 4N49, OLH249 and 66099 points are plotted on the same graph, the lower the diode τ_{RR0}, the more resistant the diode. Moreover, for a whole of associated points within a given range, an energy effect is evidenced.

Fig. 5-12 to Fig. 5-19 show the continuous degradation by proton irradiation of the relative diode's CTR and relative τ_{RR}. The point with coordinates (1,1) is the relative one prior to irradiation.

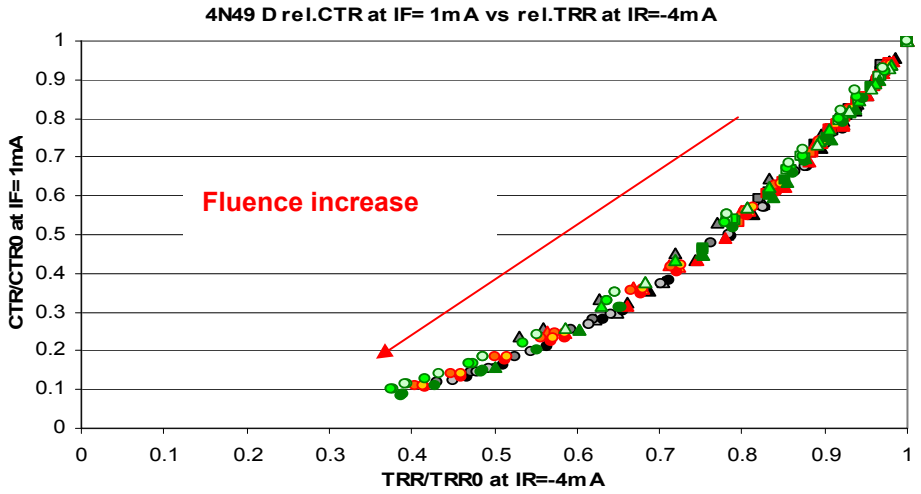


Fig. 5-12: 4N49 diode CTR/CTR$_0$ at I$_F$= 1mA with respect to τ_{RR}/τ_{RR0}

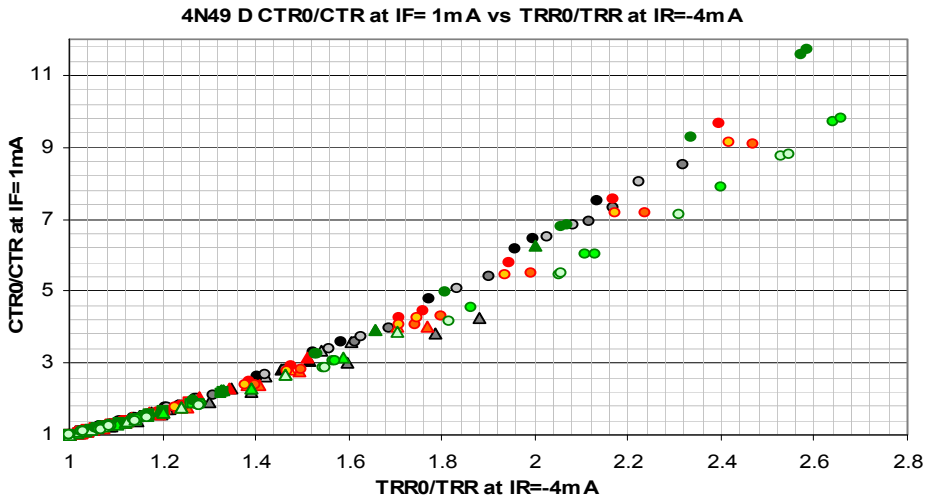


Fig. 5-13: 4N49 diode CTR$_0$/CTR at I$_F$=1mA with respect to τ_{RR0}/τ_{RR}

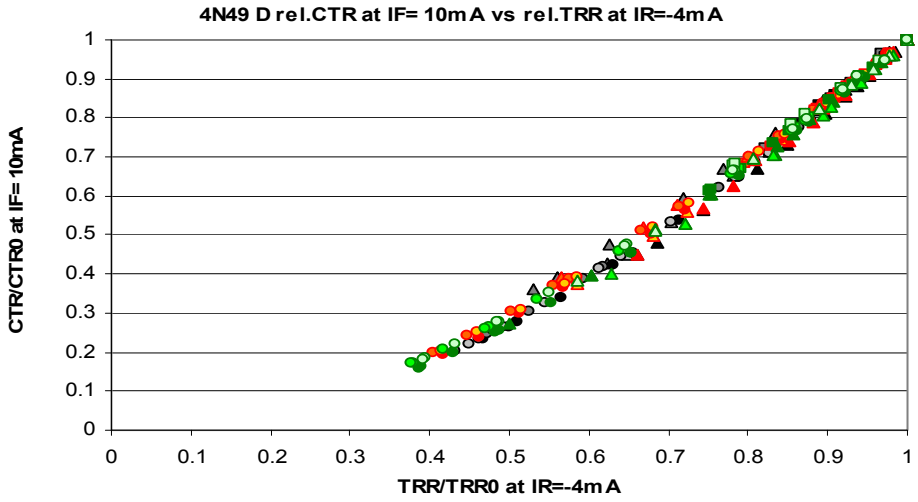


Fig. 5-14: 4N49 diode CTR/CTR$_0$ at I_F= 10mA with respect to τ_{RR}/τ_{RR0}

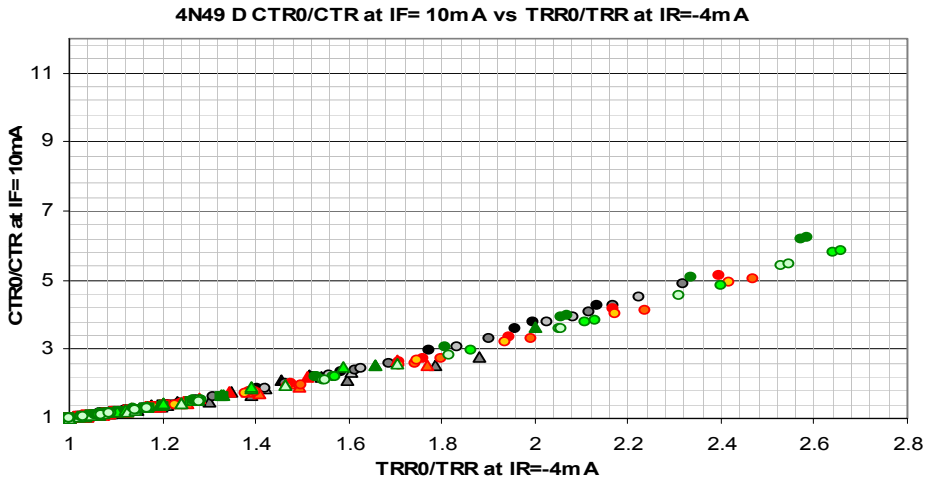


Fig. 5-15: 4N49 diode CTR$_0$/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

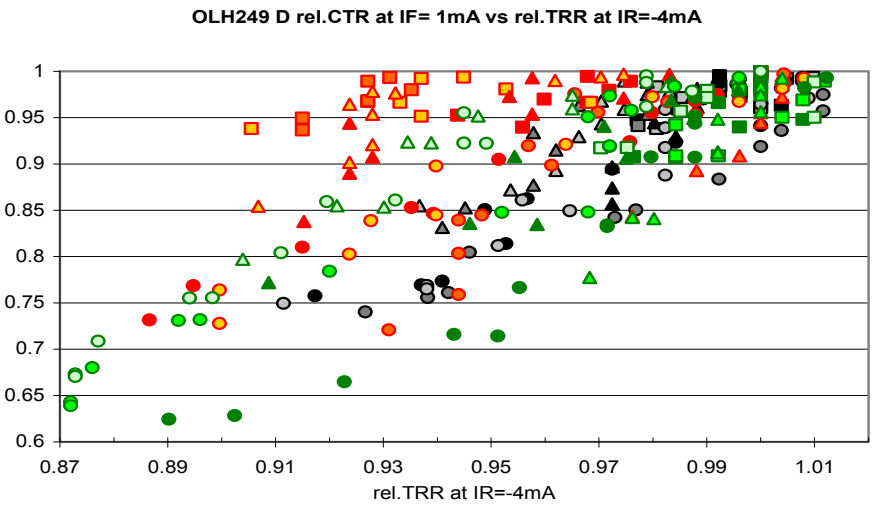


Fig. 5-16: OLH249 diode CTR/CTR$_0$ at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

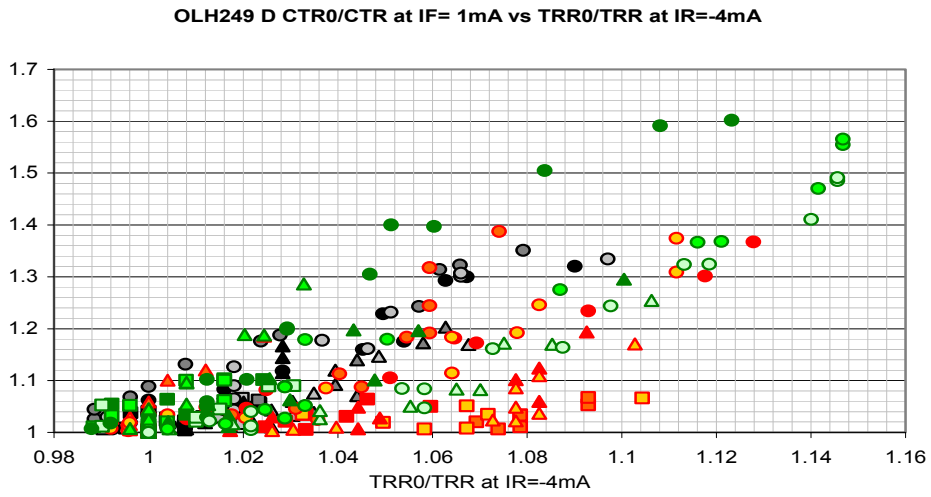


Fig. 5-17: OLH249 diode CTR_0/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

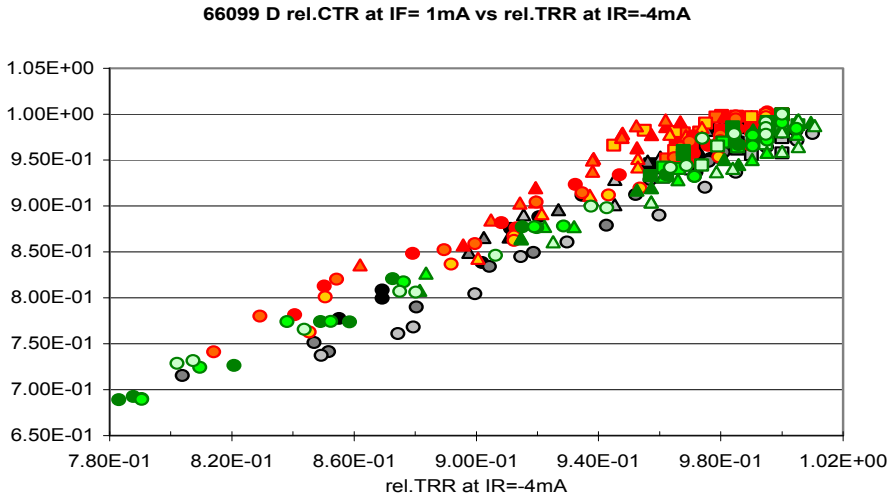


Fig. 5-18: 66099 diode CTR/CTR_0 at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

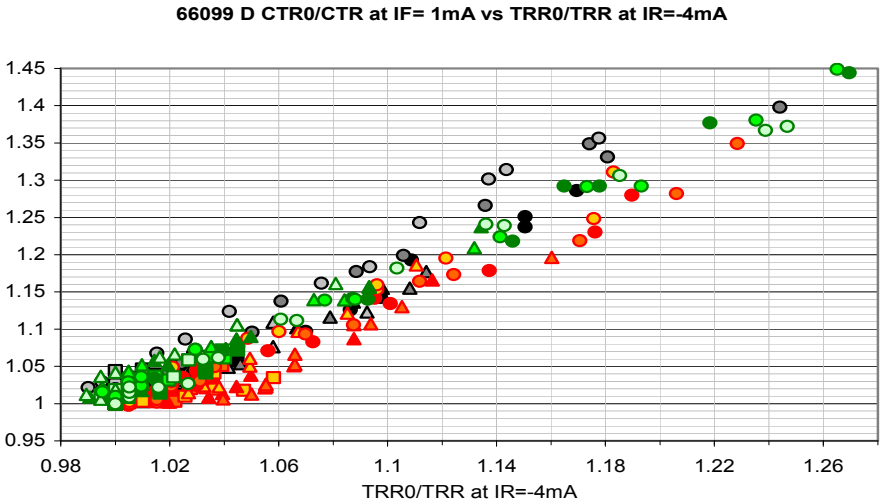


Fig. 5-19: 66099 diode CTR_0/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

The τ_{RR0} measurements are affected of all the more important inaccuracy as their values are small. It is particularly the case for the OLH249 and the 66099 for which the τ_{RR0} values are in the [40-80] ns range. A fit is performed according to the hypothesis: relative CTR is a power of relative τ_{RR}

$$CTR/CTR_0 = (\tau_{RR}/\tau_{RR0})^N \quad \text{Eq. 21}$$

$$(CTR/CTR_0)^\alpha = \tau_{RR}/\tau_{RR0} \quad \text{Eq. 22}$$

Power N formula is used in [3] while power α one is used in [2].

For each irradiated diode, five forward currents I_F (CTR measurement), three reverse currents I_R (τ_{RR} measurement), the linear regression is performed with a non-zero y-intercept, i.e.:

$$ln\ (CTR/CTR_0) = N.\ ln\ (\tau_{RR}/\tau_{RR0}) + d \quad \text{Eq. 23}$$

$$CTR/CTR_0 = exp(d).(\tau_{RR}/\tau_{RR0})^N \quad \text{Eq. 24}$$

Regressed values of d are close to zero, they are positive and negative. The highest value of d is 3.38E-02 and the minimal value is -2.86E-02, which means e^d is between 0.971 and 1.035.

There is no apparent dependence of N to energy and to τ_{RR0} (Fig. 5-20 to Fig. 5-22, and in appendixes Fig. 12-103 to Fig. 12-108, Fig. 13-103 to Fig. 13-108, Fig. 14-103 to Fig. 14-108).

The dispersion of N values in Fig. 5-21 and Fig. 5-22 translates the τ_{RR0} and CTR measurement difficulties that occurred during the test. Regression on Φp1 data with few fluence points only is not fully satisfactory.

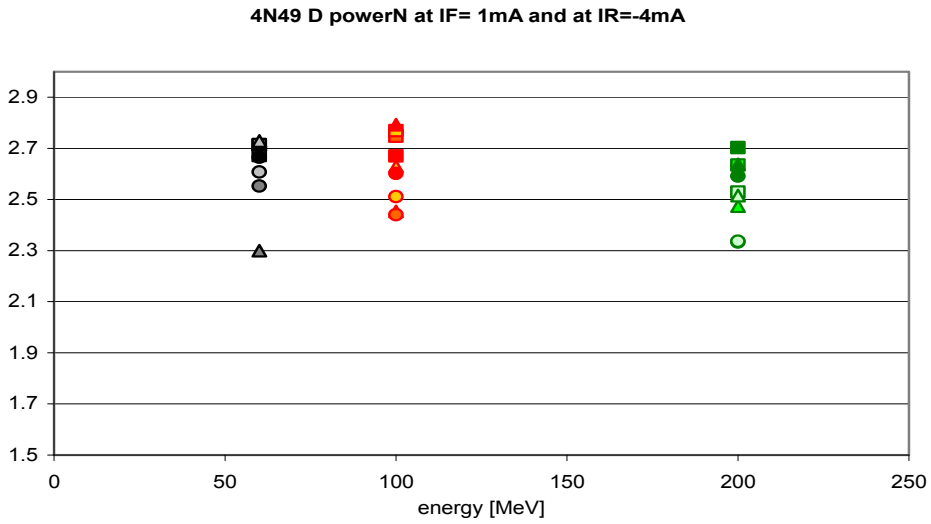


Fig. 5-20: 4N49 diode: N with respect to energy at (I_F, I_R) = (1, -4)mA

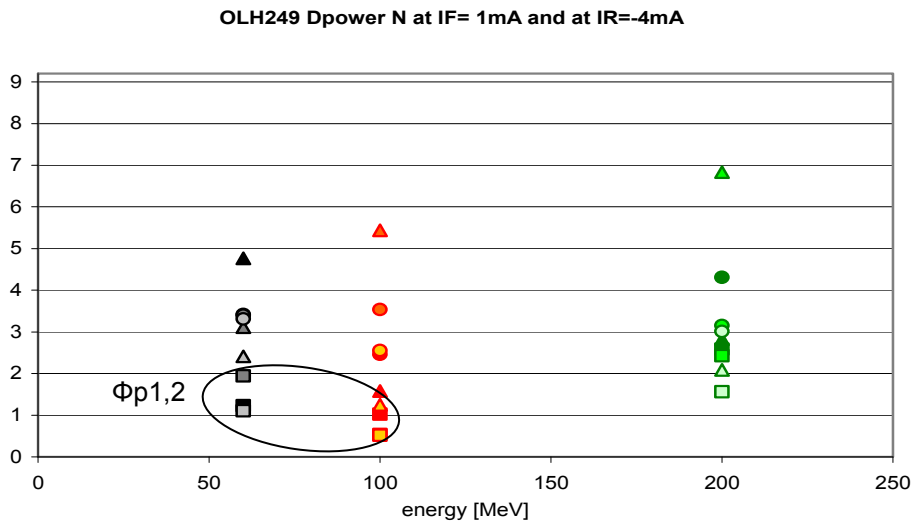


Fig. 5-21: OLH249 diode: N with respect to energy at (I_F, I_R) = (1, -4)mA

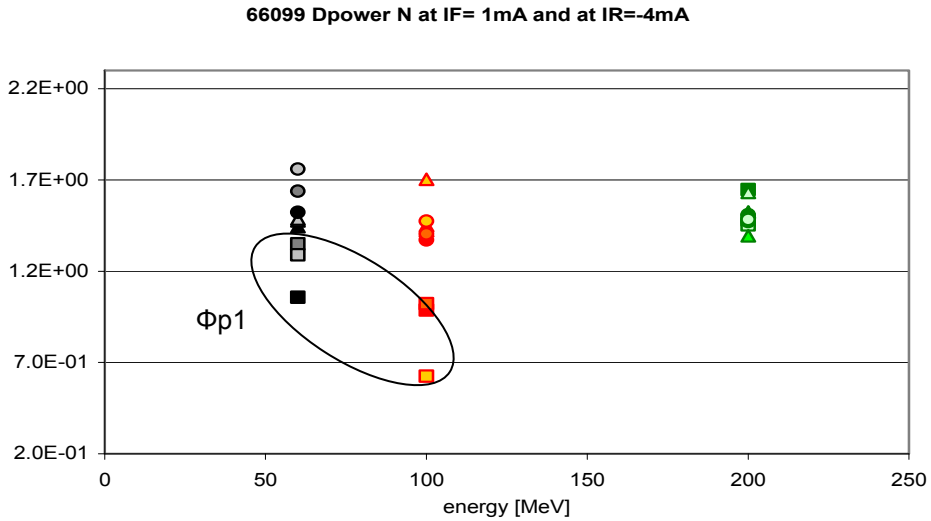


Fig. 5-22: 66099 diode: N with respect to energy at (I_F, I_R) = (1, -4)mA

6. DIODE DEGRADATION ESTIMATION

From the previous equations and according to [2] and [3], the variation of the relative CTR can be expressed as a function of τ_{RR0}:

$$\Delta rel.CTR = 1 - (\tau_{RR0}/\tau_{RR})^{-N} \quad \text{Eq. 25}$$

Which becomes versus fluence:

$$\Delta rel.CTR = 1 - (1 + \tau_{RR0}.K_{\Phi}.\Phi)^{-N} \quad \text{Eq. 26}$$

or, versus the NIEL :

$$\Delta rel.CTR = 1 - (1 + \tau_{RR0}.K_{NIEL}.NIEL)^{-N} \quad \text{Eq. 27}$$

Δrel.CTR of all samples are plotted versus their respective pre-irradiation recovery time τ_{RR0} measured at I_R = -4mA. The corresponding plots are depicted from Fig. 6-5 to Fig. 6-10, and Fig. 6-19 to Fig. 6-20, with I_F =1mA and I_F =10mA. For each energy, three Δrel.CTR curves are also plotted according to the above equation, corresponding to three 4N49's (N, K) couples: "medium", "lowest point" and "highest

point". 4N49 points are chosen because they correspond to less noised measurements than OLH249 and 66099, especially regarding τ_{RR}.

6.1 NIEL COMPUTED BY GEANT 4 (ELASTIC)

- "**medium**" : the value of N and K are chosen within the range of the regressed values.

As assumed in [2][3], the value of N is independent of energy. This property is also depicted in Fig. 6-1 and Fig. 6-2 here below. The three "medium" curves at 60, 100 and 200 MeV share this value. Let one choose the following values for N (see Fig. 6-1 and Fig. 6-2):

I_F	1mA	10mA
N	2.6	1.81

Table 3. Chosen values of N for « medium » curves at I_R= -4mA. N is common to all energies.

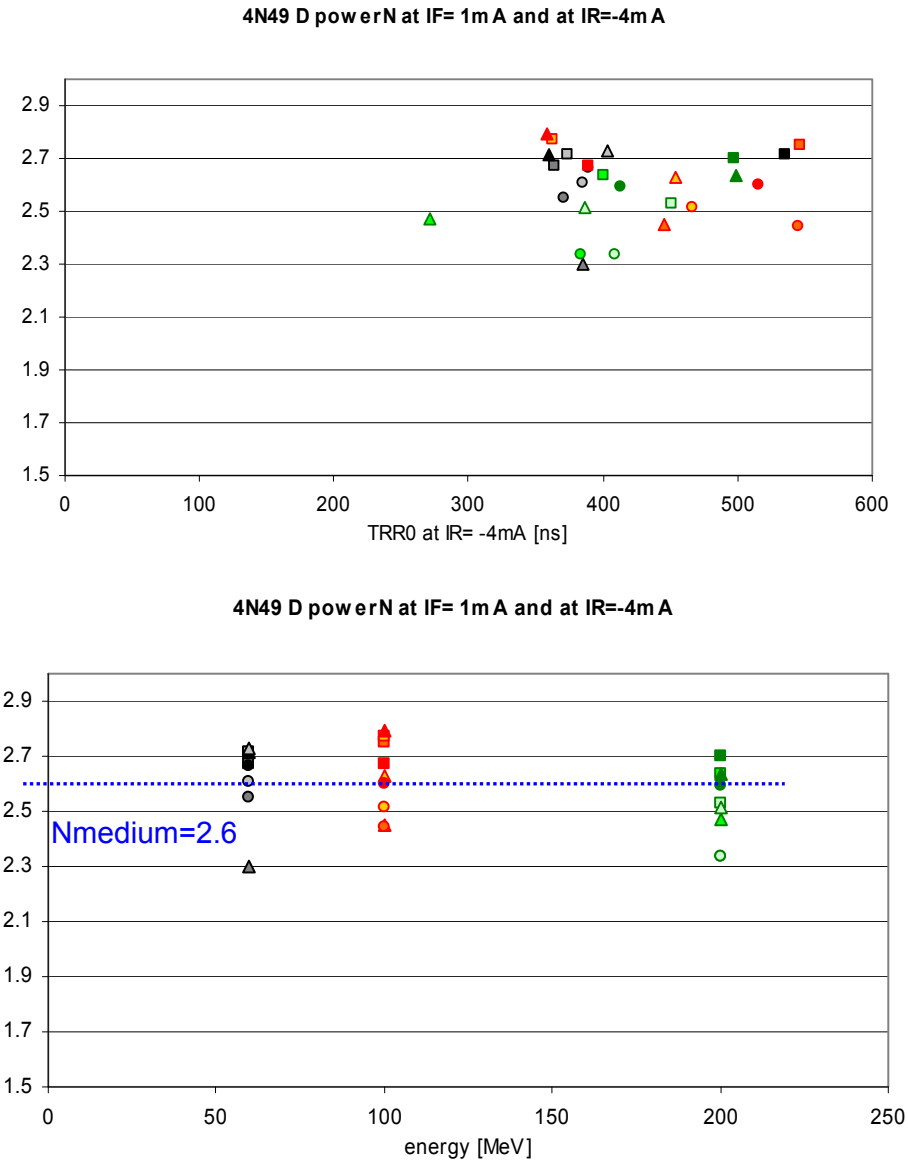
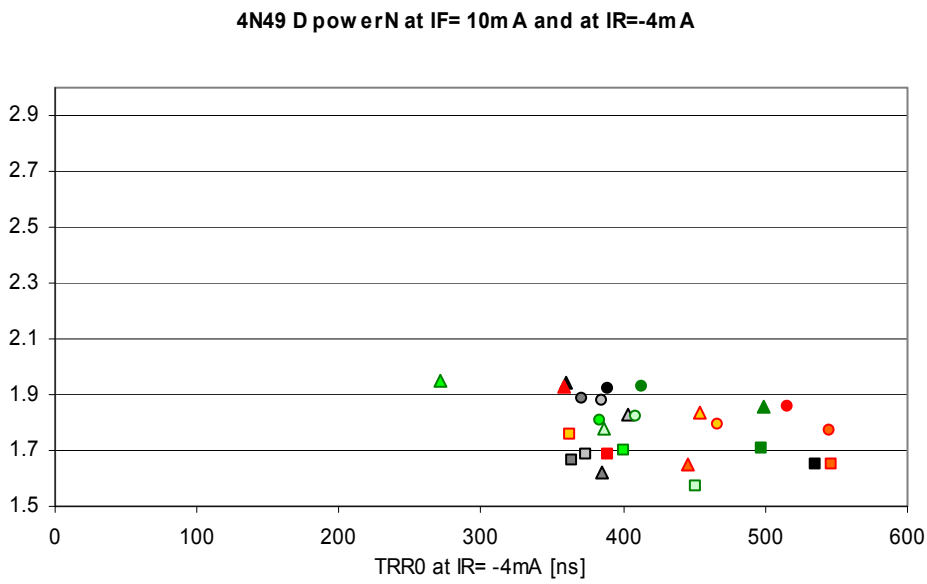


Fig. 6-1 : N at (I_F, I_R) = (1, -4)mA with respect to τ_{RR0} (top) and to energy (bottom)



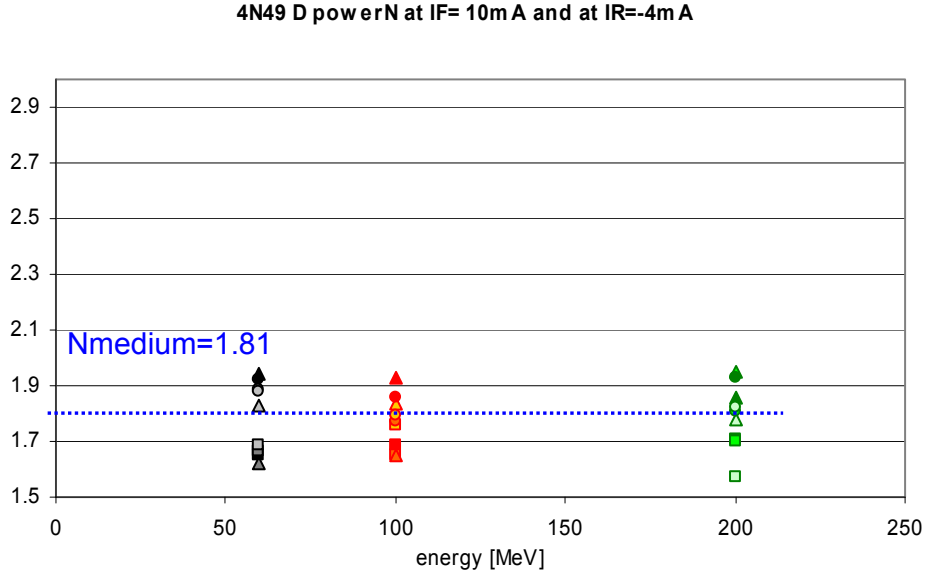


Fig. 6-2 : N at (I_F, I_R) = (10, -4)mA with respect to τ_{RR0} (top) and to energy (bottom)

The value of K depends on energy and reverse current. Let one choose at I_R = -4mA :

E [MeV]	60	100	200
$K_{GEANT4_ELASTIC}$ [g.MeV^{-1}.ns^{-1}]	4.5E-11	5E-11	8E-11

Table 4. Chosen values of K for "medium" curves at I_R= -4mA

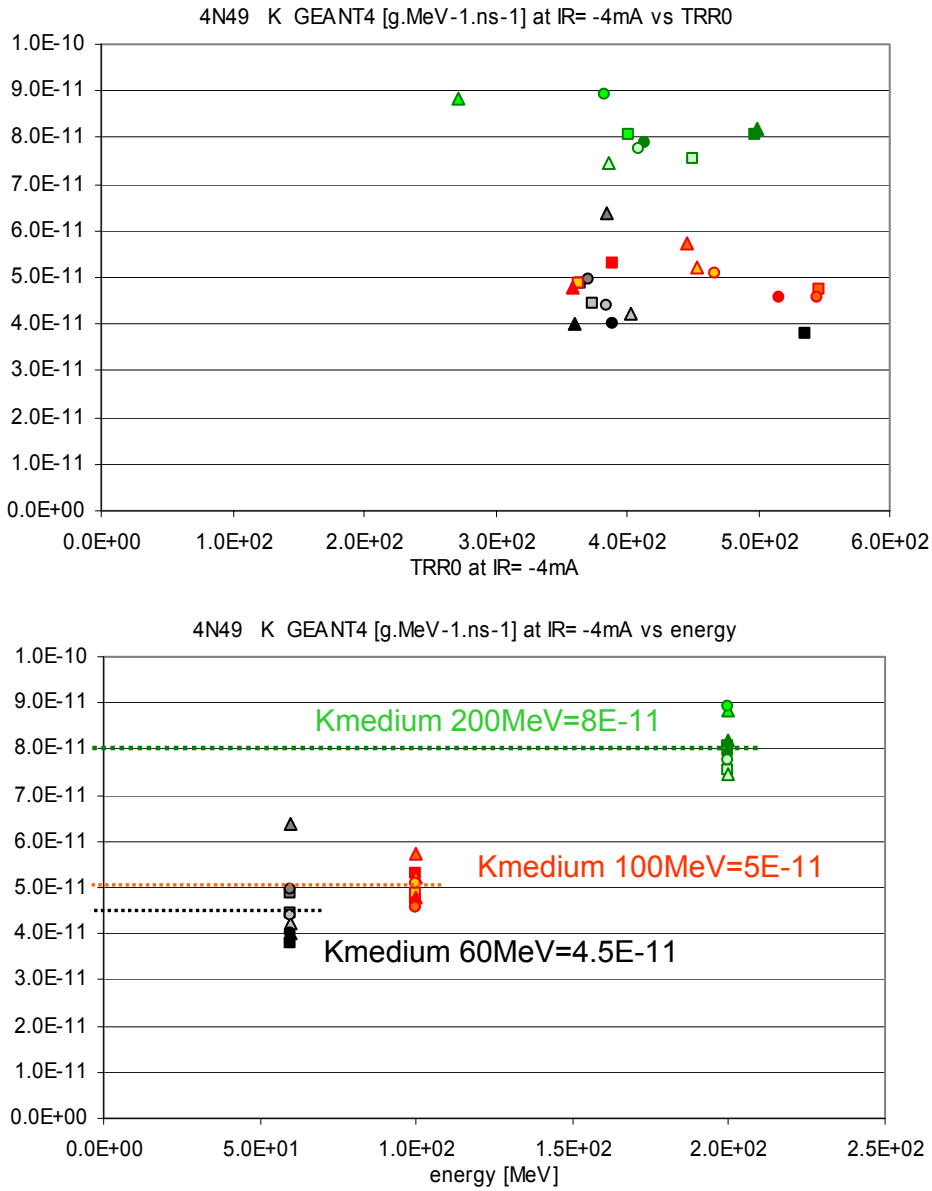


Fig. 6-3 : K_GEANT4_ELASTIC at I_R = -4mA with respect to τ_{RR0} (top) and to energy (bottom)

The explicit curve equations are therefore:

		E [MeV]		
I_R	I_F	60	100	200
-4mA	1mA	$1-(1+\tau_{RR0}.4.5E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.5.0E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.8.00E\text{-}11.NIEL)^{-2.6}$
	10mA	$1-(1+\tau_{RR0}.4.5E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.5.0E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.8.00E\text{-}11.NIEL)^{-1.81}$

Table 5. "medium" expressions of 1 - CTR/CTR$_0$ as a function of τ_{RR0} and NIEL$_{GEANT4_ELASTIC}$

- "**lowest point**" : the values of N and K are the values corresponding to the diode which apparently on the graph will give the lowest curve.

  For example at 60MeV in Fig. 6-4, the diode F1 #1 (black square at τ_{RR0}= 535ns) is chosen as the "lowest point".

E [MeV]		60			100	200		
chosen sample		F1 #1	F2 #1	F3 #1	F3 #2	F1 #3	F2 #3	F3 #3
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	all	8.10^6	$2.7.10^7$	$4.88.10^7$
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		3.80E-11	3.99E-11	4.03E-11	4.55E-11	7.52E-11	7.46E-11	7.77E-11
N	I_F= 1mA	2.71E+00	2.71E+00	2.66E+00	2.44E+00	2.53E+00	2.52E+00	2.34E+00
	I_F= 10mA	1.65E+00	1.94E+00	1.92E+00	1.77E+00	1.57E+00	1.78E+00	1.82E+00

Table 6. Values of (N, K) of chosen 4N49 samples for "lowest point" curves

- "**highest point**" : the values of N and K are the values corresponding to the diode which apparently on the graph will give the highest curve.

  For example at 60MeV in Fig. 6-4, the diode F2 #2 (dark grey triangle at τ_{RR0}= 384ns) is chosen as the "highest point".

E [MeV]		60		100			200	
chosen sample		F2 #2	F3 #2	F2 #1	F2 #2	F3 #3	F2 #2	F3 #1
interpolation NIEL [MeV.g^{-1}]		8.10^6 $2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6 $2.7.10^7$	$4.88.10^7$
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		6.39E-11	4.94E-11	4.79E-11	5.74E-11	5.09E-11	8.86E-11	7.90E-11
N	I_F= 1mA	2.30E+00	2.55E+00	2.79E+00	2.45E+00	2.51E+00	2.47E+00	2.59E+00
	I_F= 10mA	1.62E+00	1.88E+00	1.93E+00	1.65E+00	1.79E+00	1.95E+00	1.93E+00

Table 7. Values of (N,K) of chosen 4N49 samples for "highest point" curves

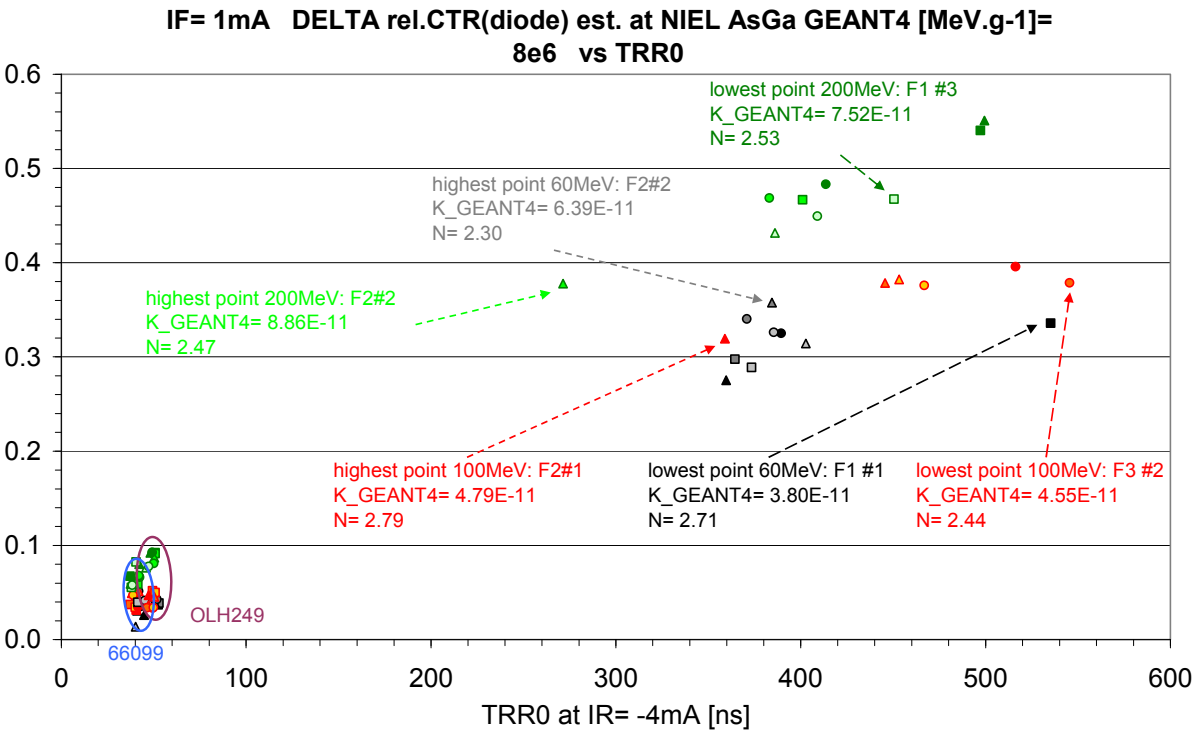
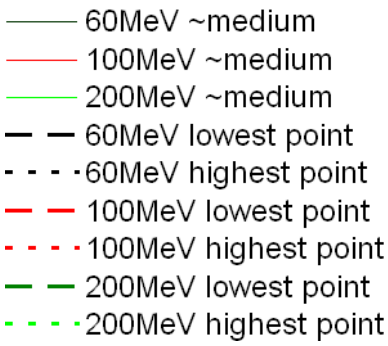
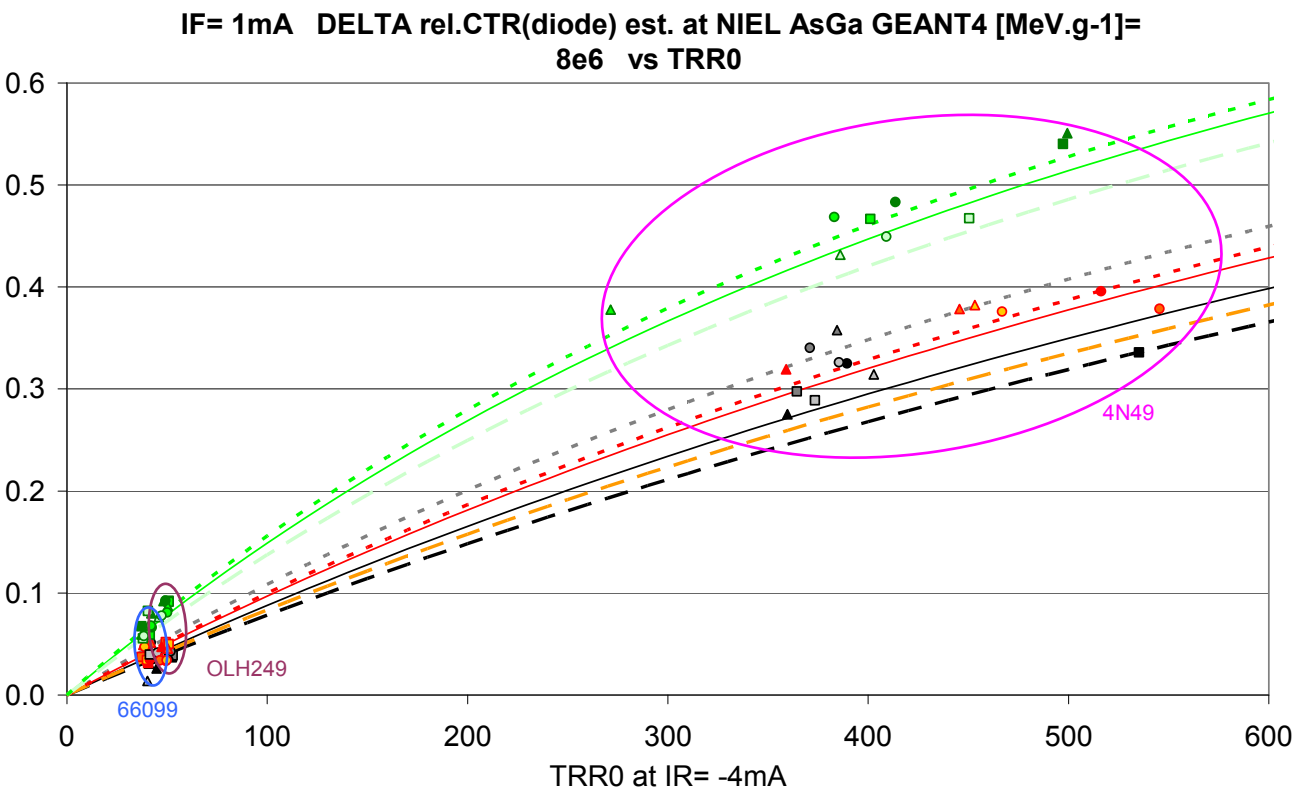


Fig. 6-4: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and 4N49 points chosen for Δrel.CTR curves

Let's glance at shorter times on bottom graphs of Fig. 6-5 to Fig. 6-10, which are zooms of top graphs. The 66099 and OLH249's relative diode CTR degradation (1 - CTR/CTR$_0$) estimations deduced from the curves can be compared with their respective measurement points. Their whole points are not so far from the curves, despite the (N, K) parameters are obtained by regression from 4N49 data. This result seems to demonstrate that the expected diode degradation would not depend on the technology but on the initial recovery time τ_{RR0}. Moreover, this supports that predicting diode degradation is possible (within 10-20% precision) provided that its τ_{RR0} is lower than the 4N49's diode one.



Legend for Fig. 6-5 to Fig. 6-10, and Fig. 6-19 to Fig. 6-20



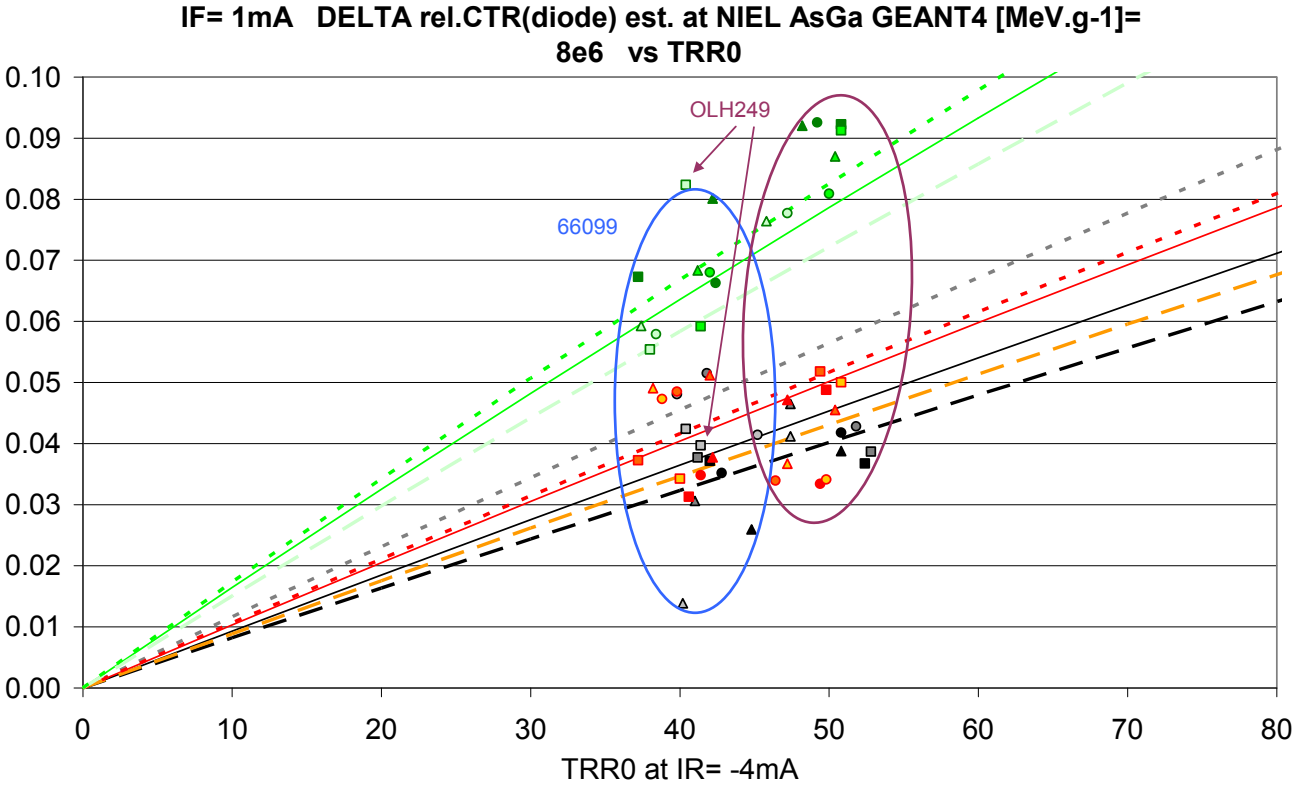
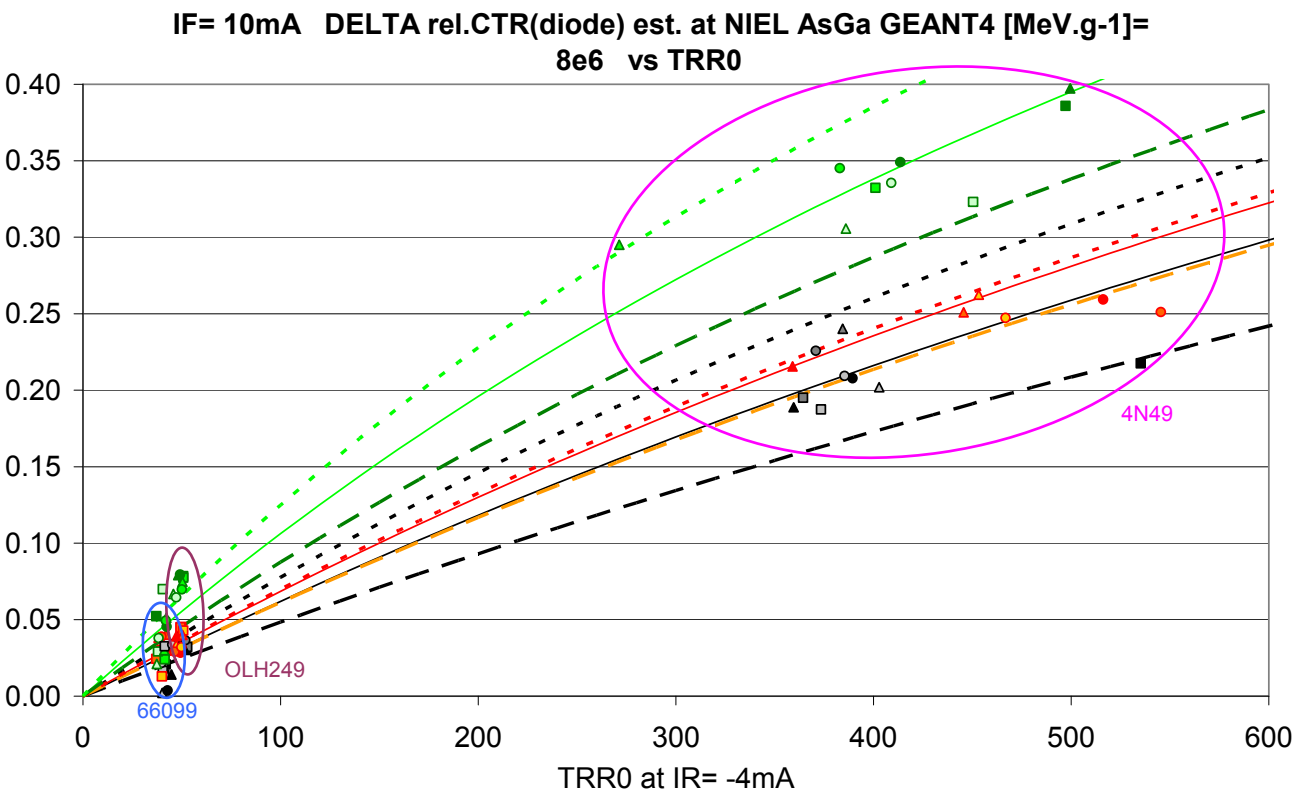


Fig. 6-5: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



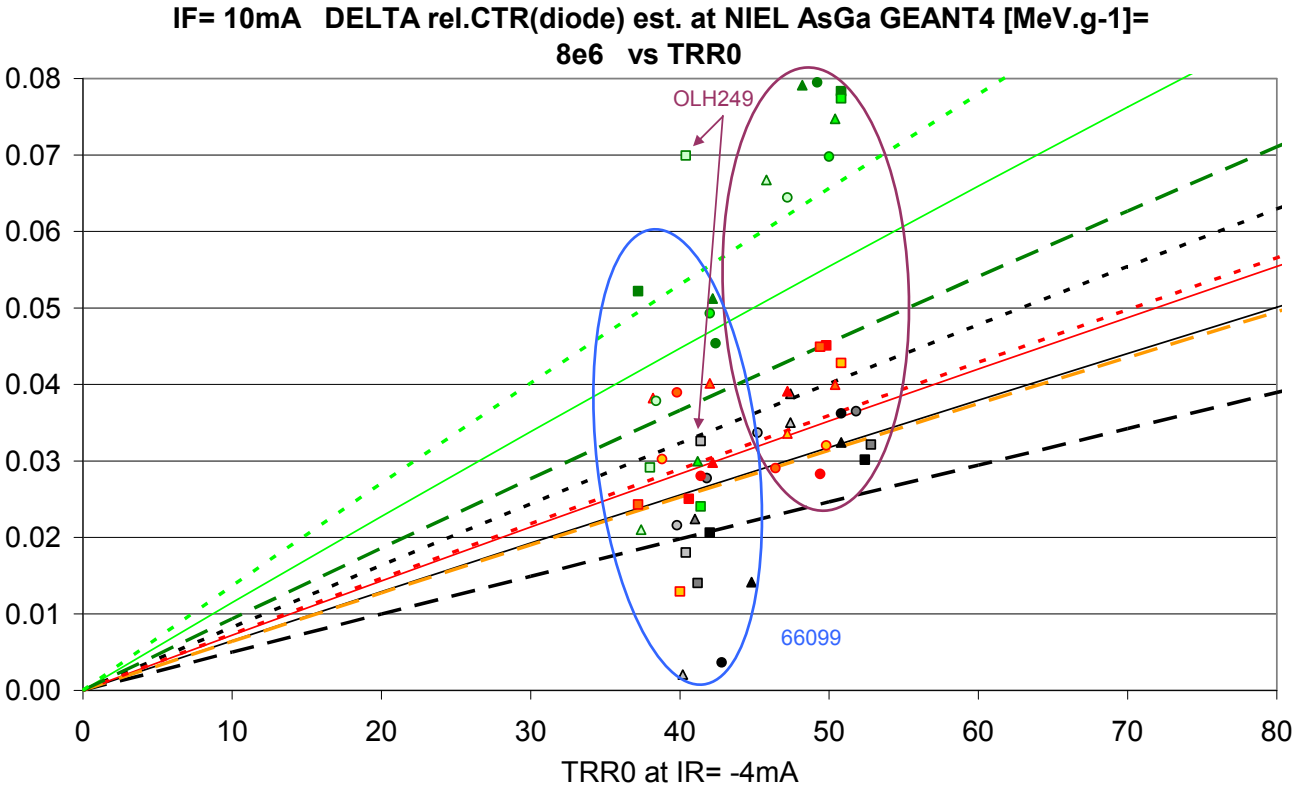
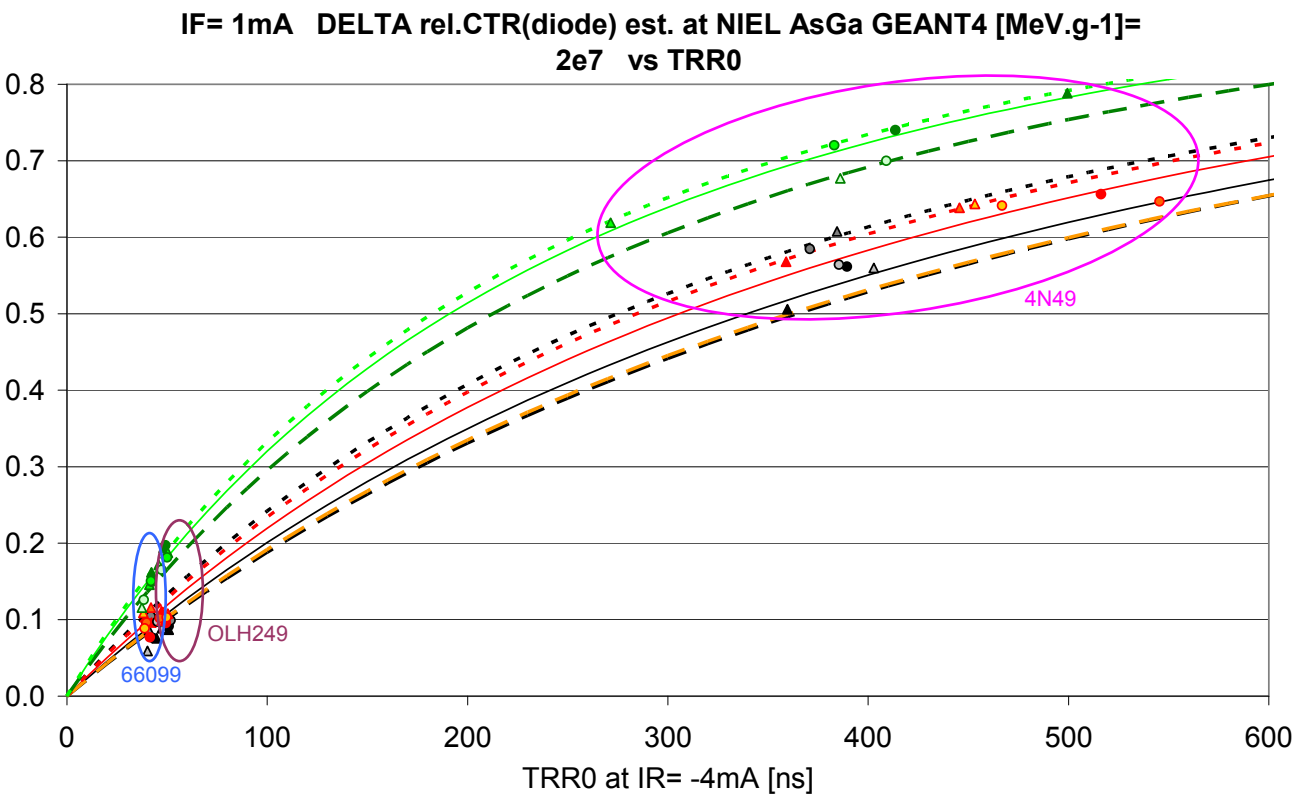


Fig. 6-6: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



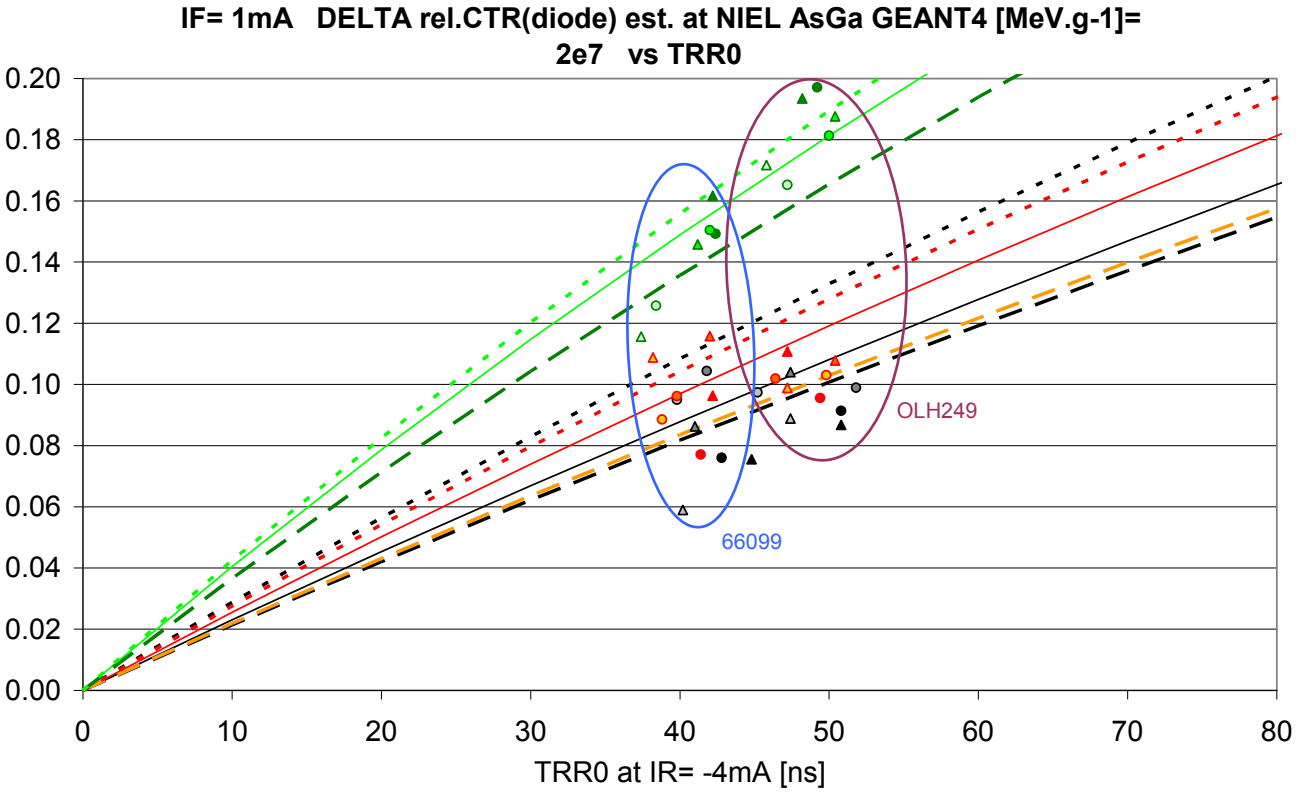
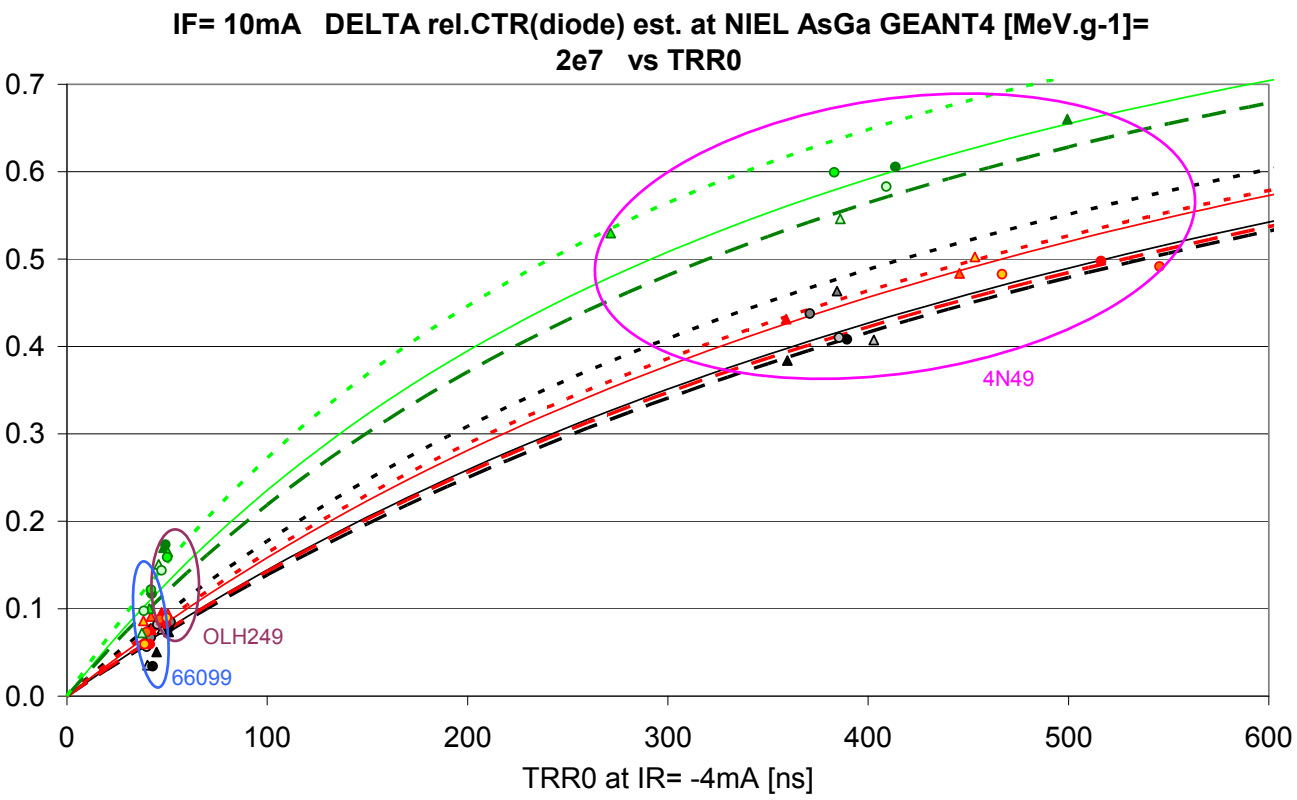


Fig. 6-7: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



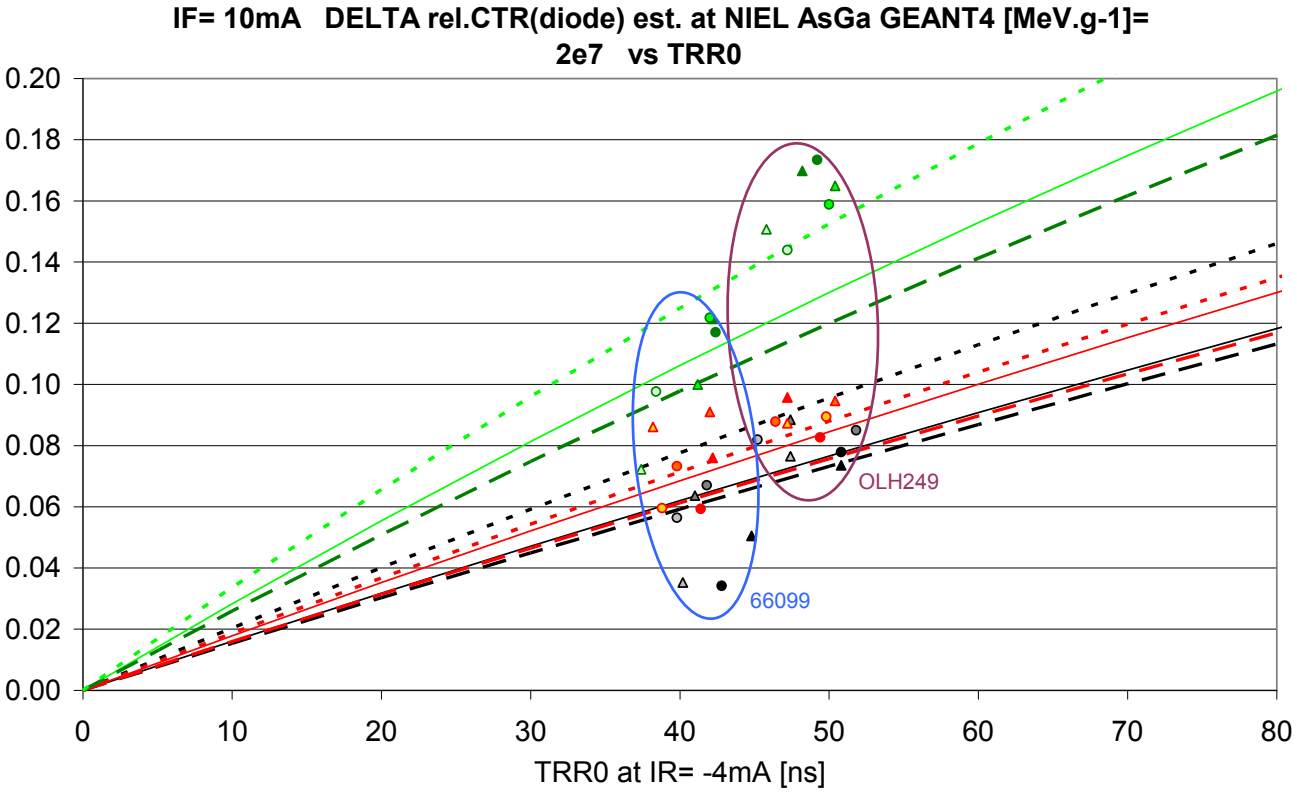
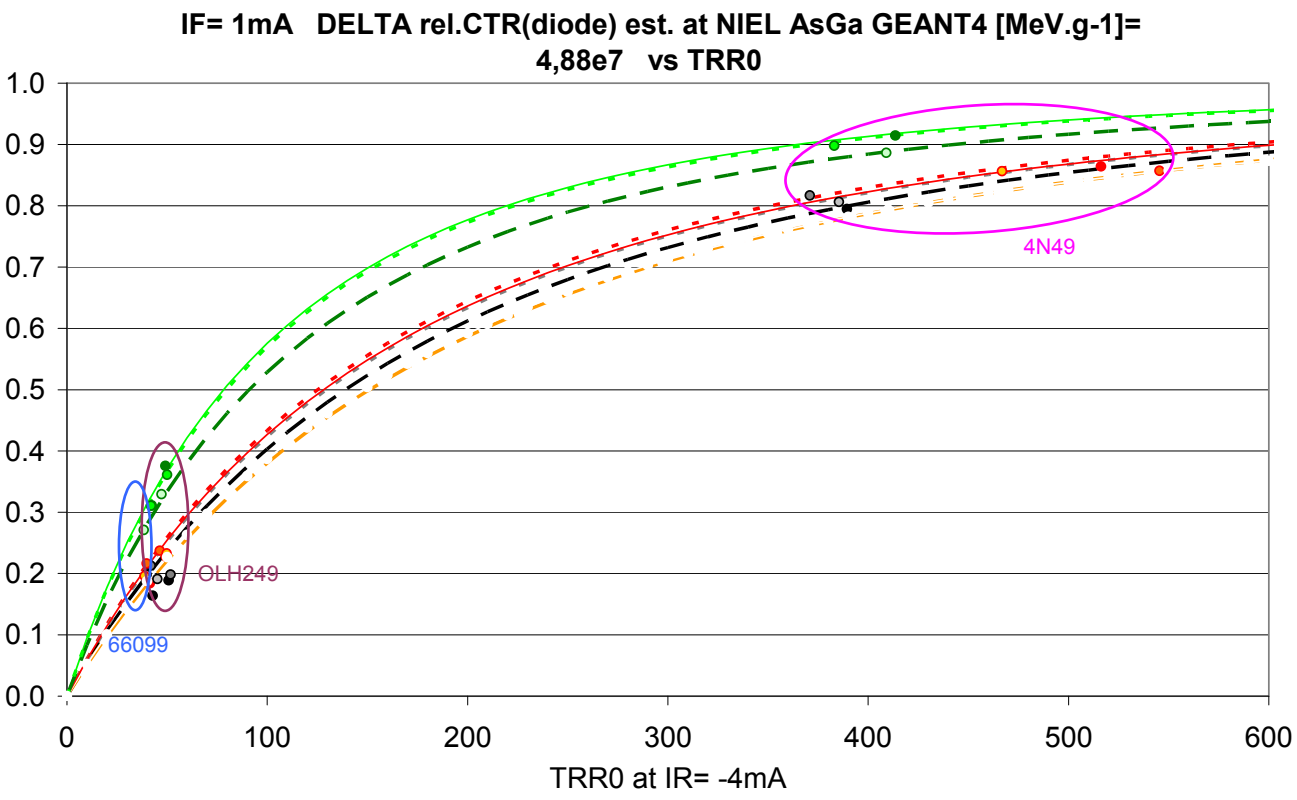


Fig. 6-8: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



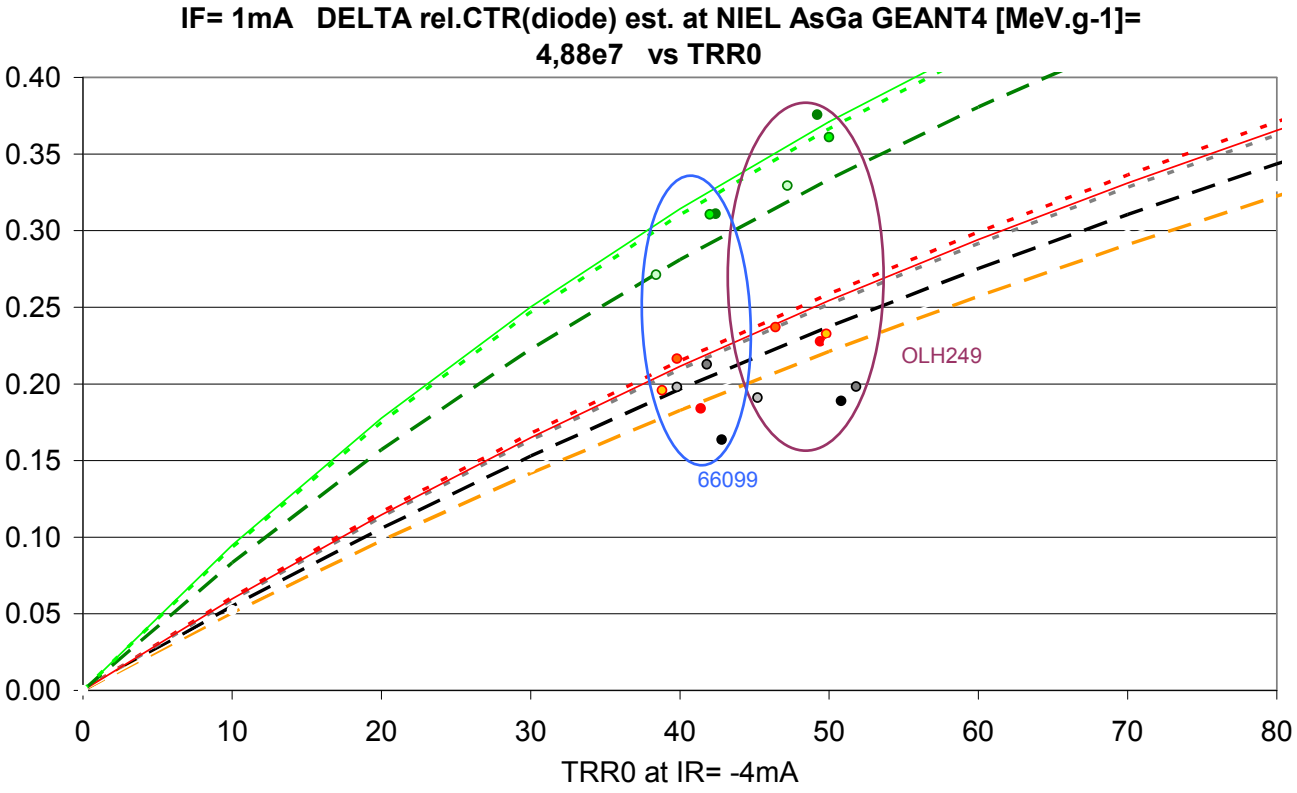
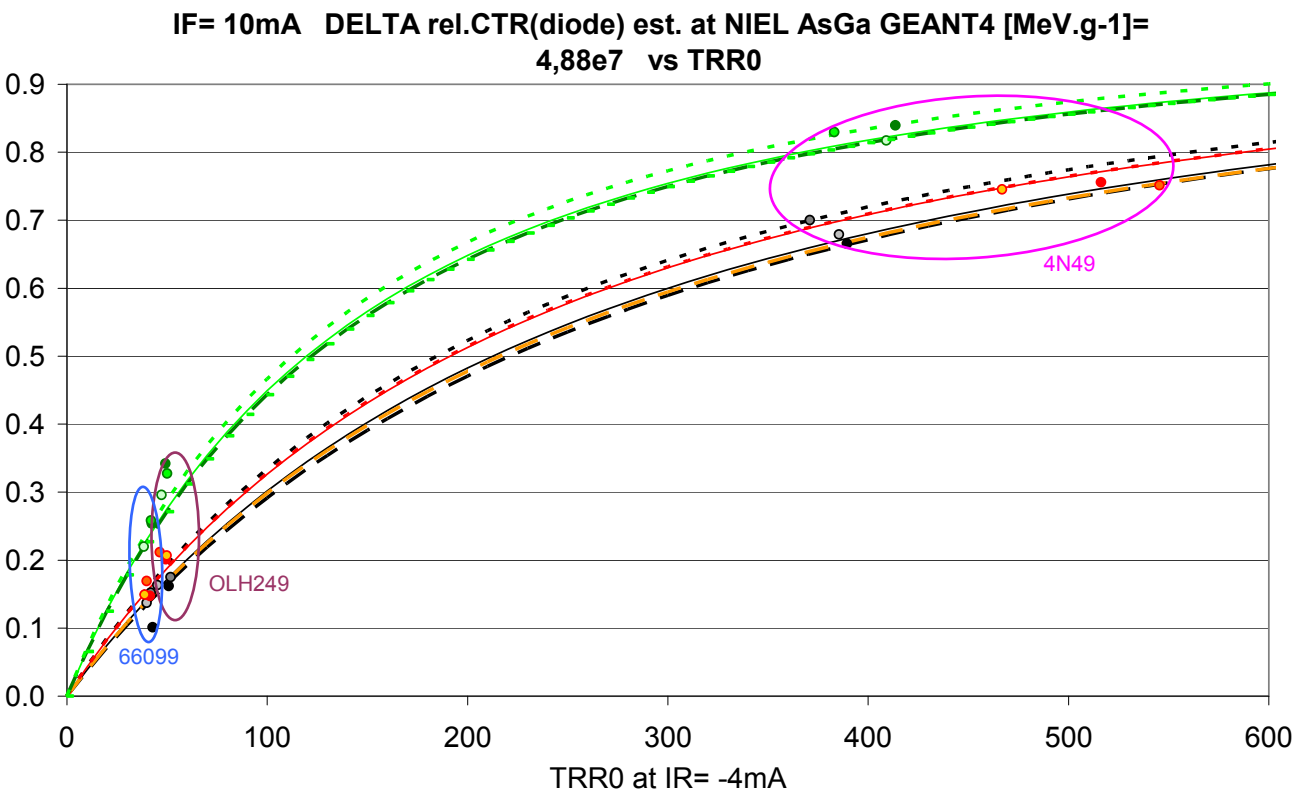


Fig. 6-9: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



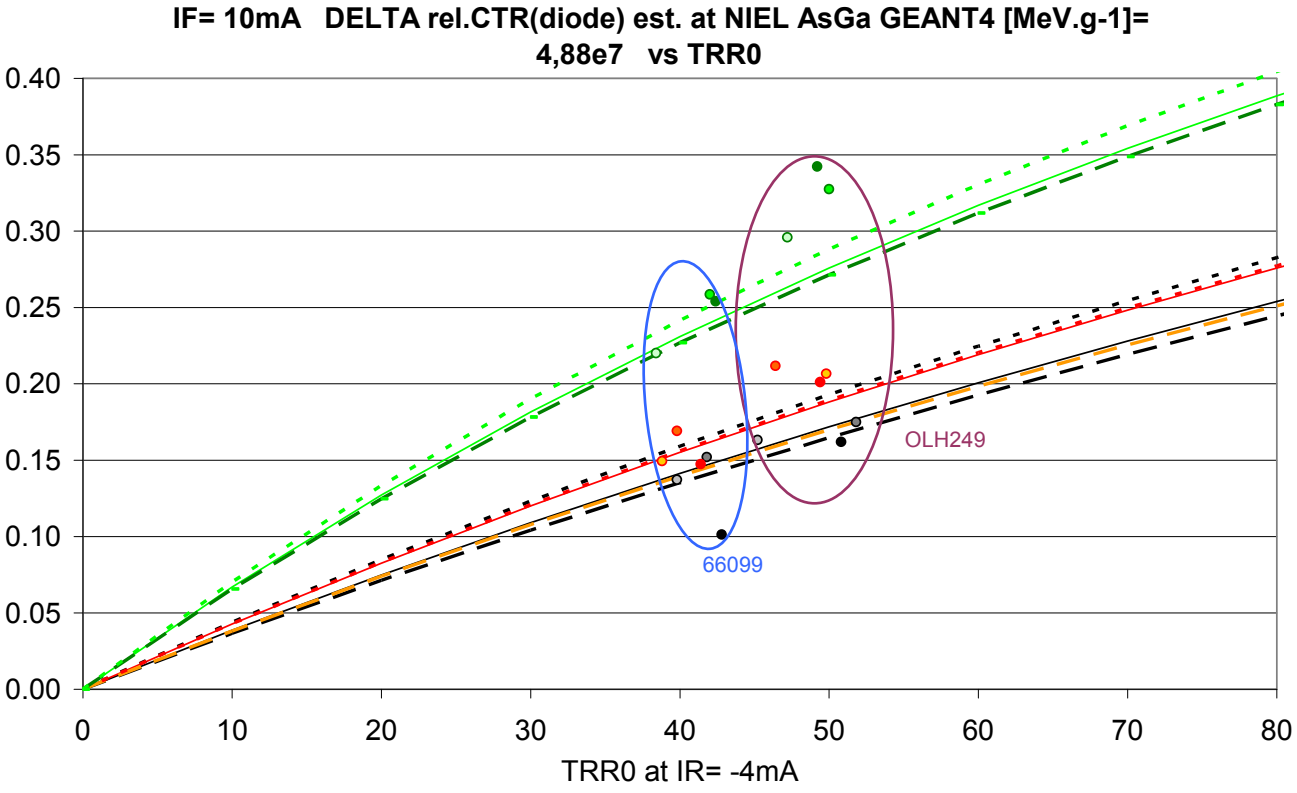


Fig. 6-10: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

6.2 NIEL COMPUTED BY GEANT 4 (ELASTIC + INELASTIC)

- "**medium**" : the value of N and K are chosen within the range of the regressed values.

N does not depend on the NIEL calculation, hence the values of Table 3 still apply.

The value of K depends on energy and reverse current. Let one choose at I_R = -4mA :

E [MeV]	60	100	200
$K_{GEANT4_EL+INEL}$ [g.MeV^{-1}.ns^{-1}]	2.7E-11	2.4E-11	2.9E-11

Table 8. Chosen values of K for "medium" curves at I_R= -4mA

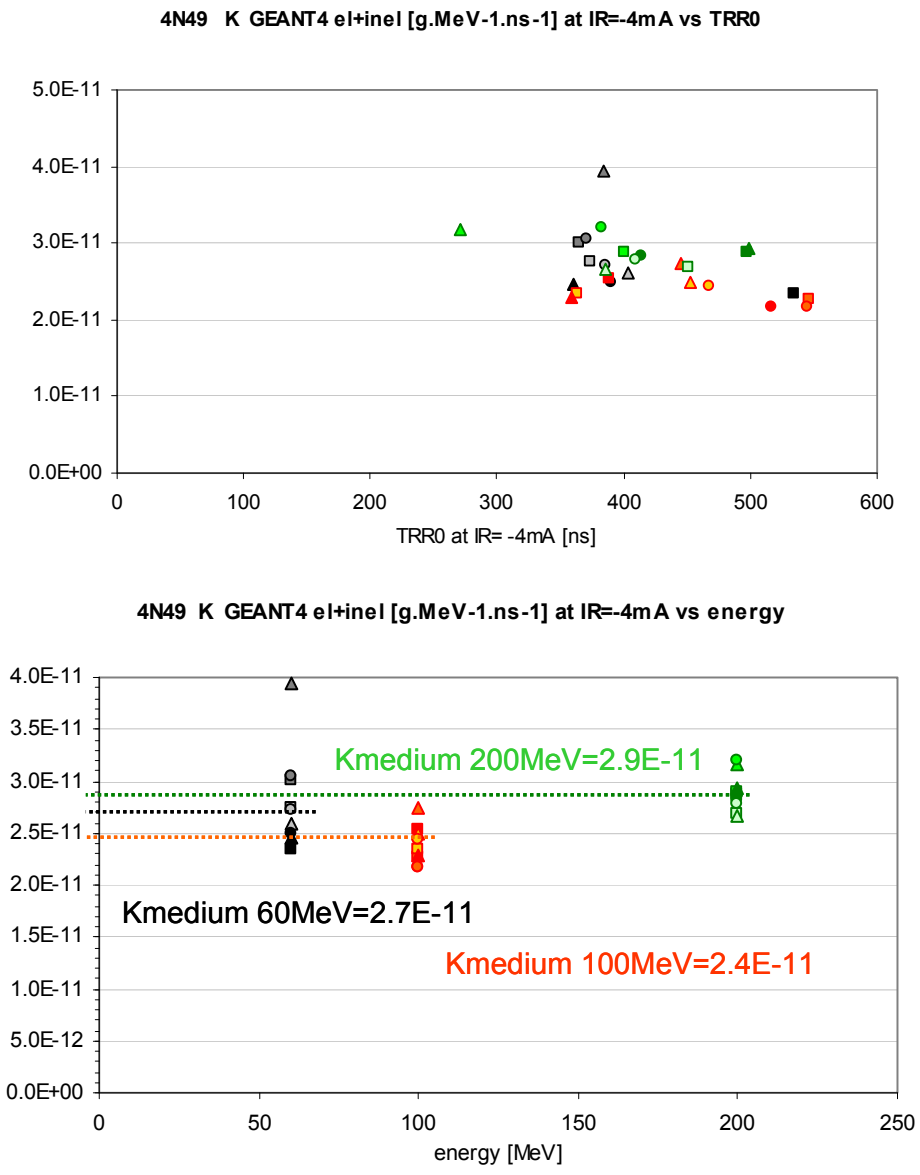


Fig. 6-11. K_GEANT4_elastic+inelastic at I_R = -4mA with respect to τ_{RR0} (top) and to energy (bottom)

The explicit curve equations are therefore:

		E [MeV]		
I_R	I_F	60	100	200
-4mA	1mA	$1-(1+\tau_{RR0}.2.7E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.2.4E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.2.9E\text{-}11.NIEL)^{-2.6}$
	10mA	$1-(1+\tau_{RR0}.2.7E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.2.4E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.2.9E\text{-}11.NIEL)^{-1.81}$

Table 9. "medium" expressions of $1 - CTR/CTR_0$ as a function of τ_{RR0} and $NIEL_{GEANT4_EL+INEL}$

The same samples as with the elastic NIEL by GEANT4 give the "lowest point" and "highest point" curves (Table 10 and Table 11). F3#2 and F3#1 provide very close curves.

E [MeV]		60			100			200		
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$
chosen sample		F1 #1	F2 #1	F3 #1	F3 #2	F3 #2	F3 #2	F2#3	F2#3	F3 #3
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		2.35E-11	2.46E-11	2.49E-11	2.17E-11	2.17E-11	2.17E-11	2.67E-11	2.67E-11	2.78E-11
N	I_F= 1mA	2.71E+00	2.71E+00	2.66E+00	2.44E+00	2.44E+00	2.44E+00	2.52E+00	2.52E+00	2.34E+00
	I_F= 10mA	1.65E+00	1.94E+00	1.92E+00	1.77E+00	1.77E+00	1.77E+00	1.78E+00	1.78E+00	1.82E+00

Table 10. Values of (N, K) of chosen 4N49 samples for “lowest point” curves

E [MeV]		60			100			200		
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$
chosen sample		F2#2	F2#2	F3 #2	F2 #2	F2 #2	F3 #3	F3 #2	F3 #2	F3 #2
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		3.95E-11	3.95E-11	3.05E-11	2.74E-11	2.74E-11	2.43E-11	3.19E-11	3.19E-11	3.19E-11
N	I_F= 1mA	2.30E+00	2.30E+00	2.55E+00	2.45E+00	2.45E+00	2.51E+00	2.33E+00	2.33E+00	2.33E+00
	I_F= 10mA	1.62E+00	1.62E+00	1.88E+00	1.65E+00	1.65E+00	1.79E+00	1.81E+00	1.81E+00	1.81E+00

Table 11. Values of (N,K) of chosen 4N49 samples for “highest point” curves

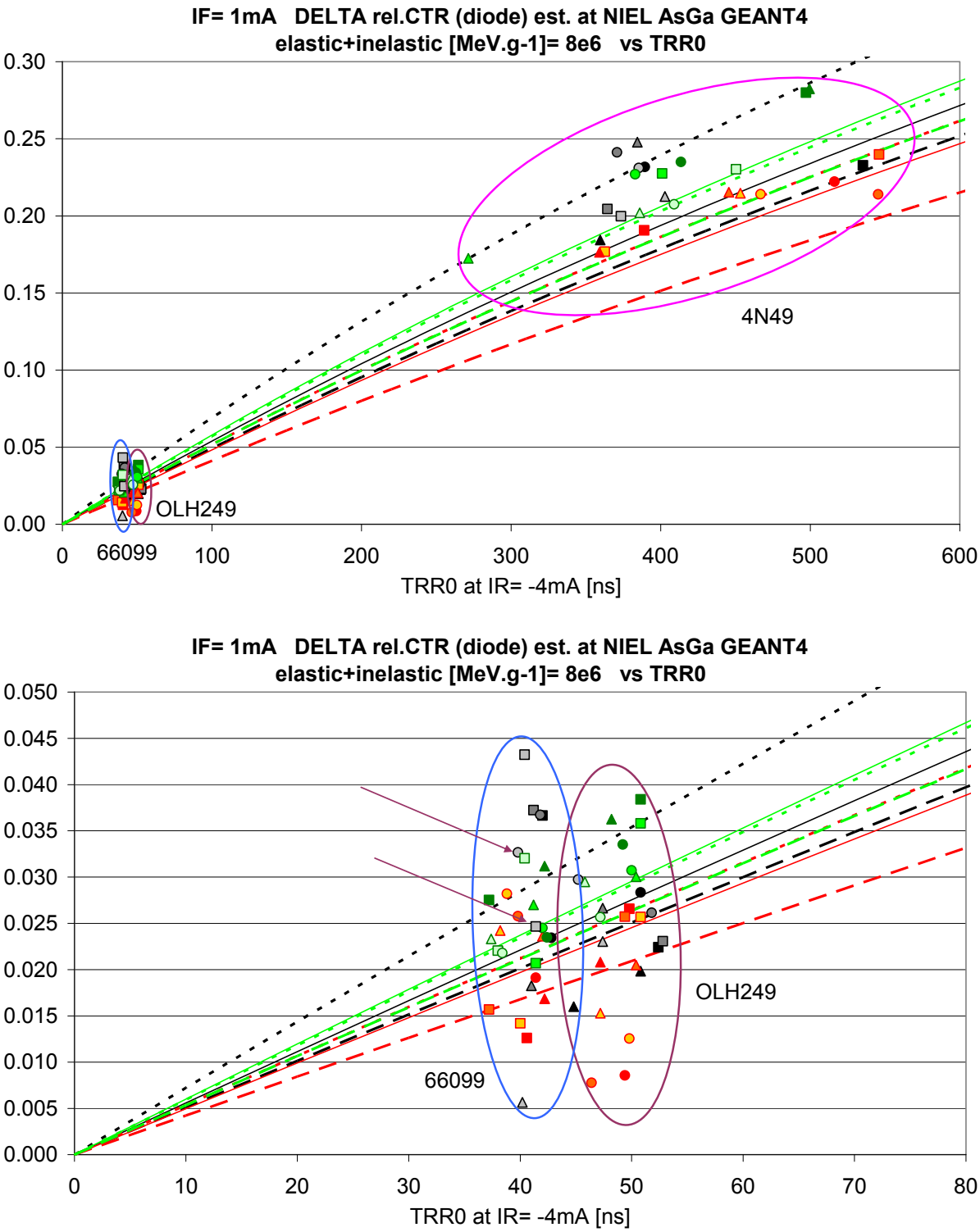


Fig. 6-12. 1 – CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

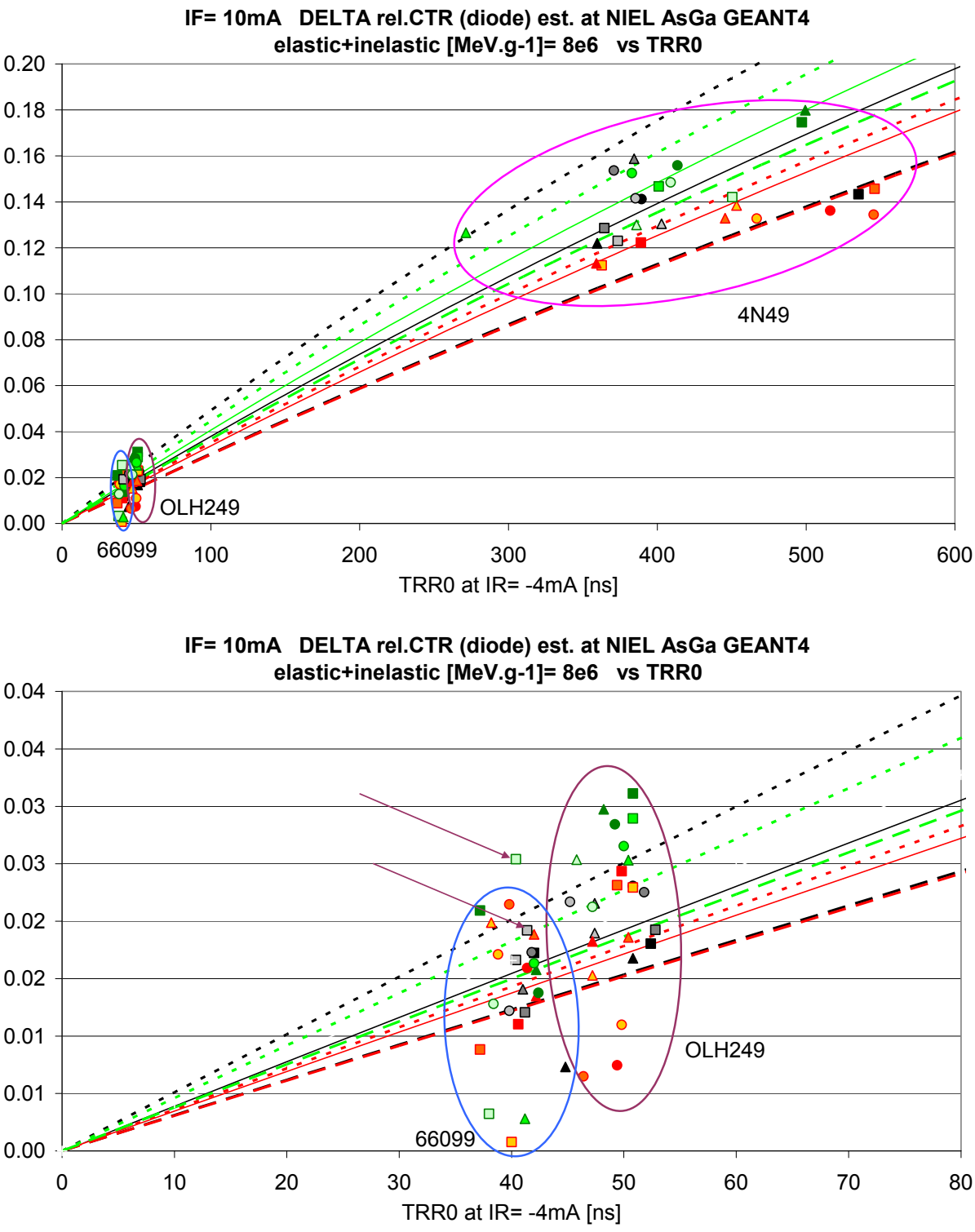


Fig. 6-13. 1 – CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

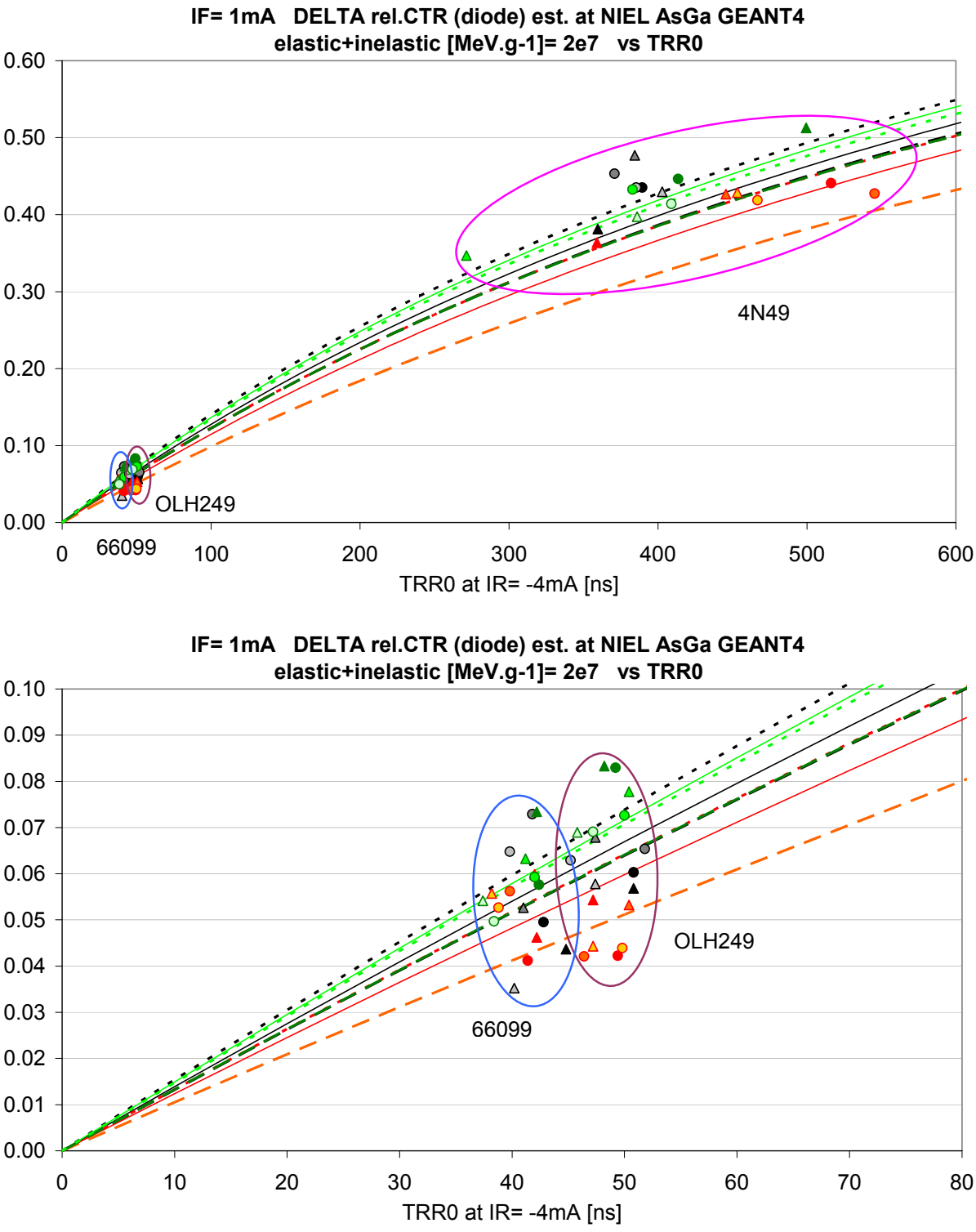


Fig. 6-14. 1 – CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

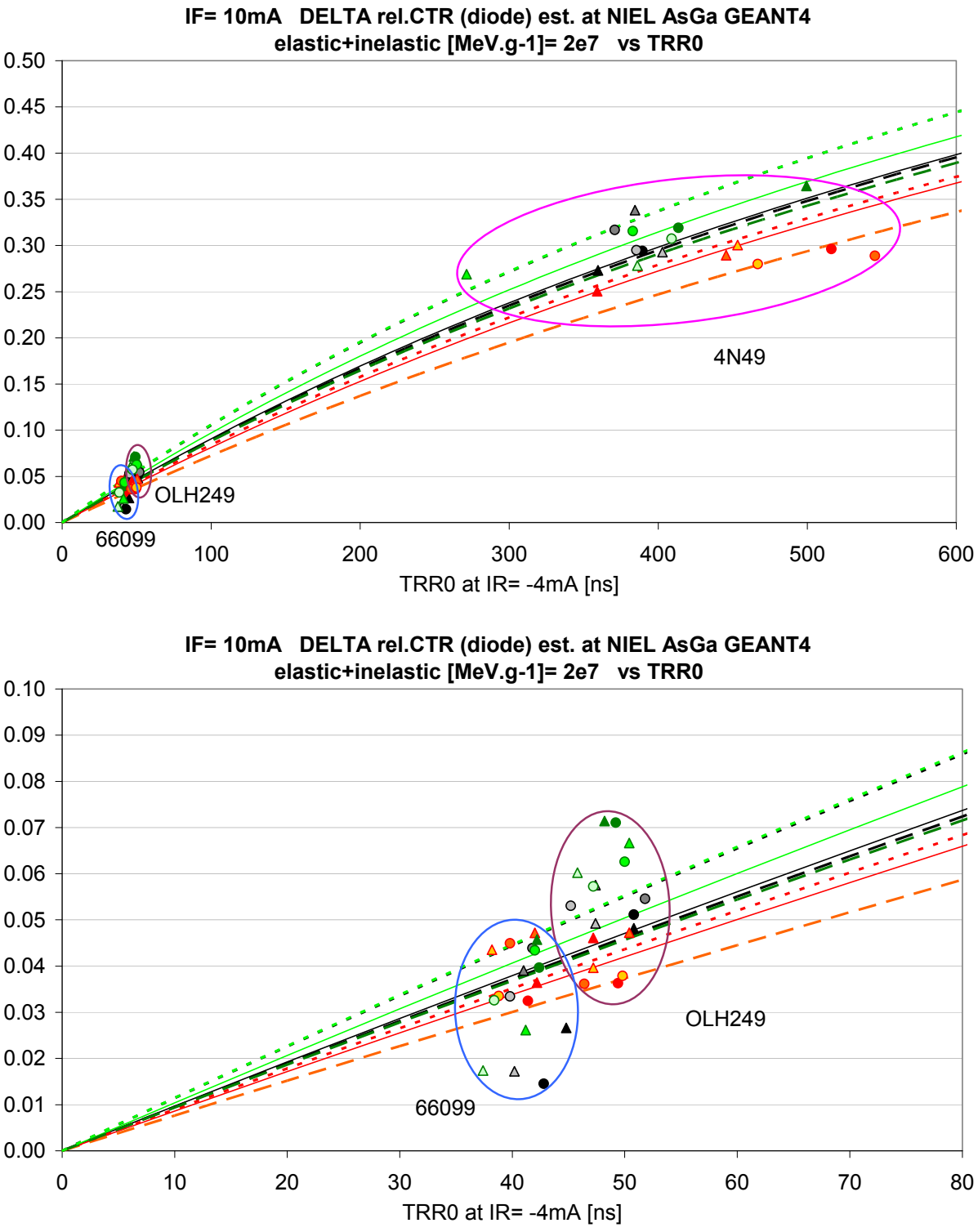
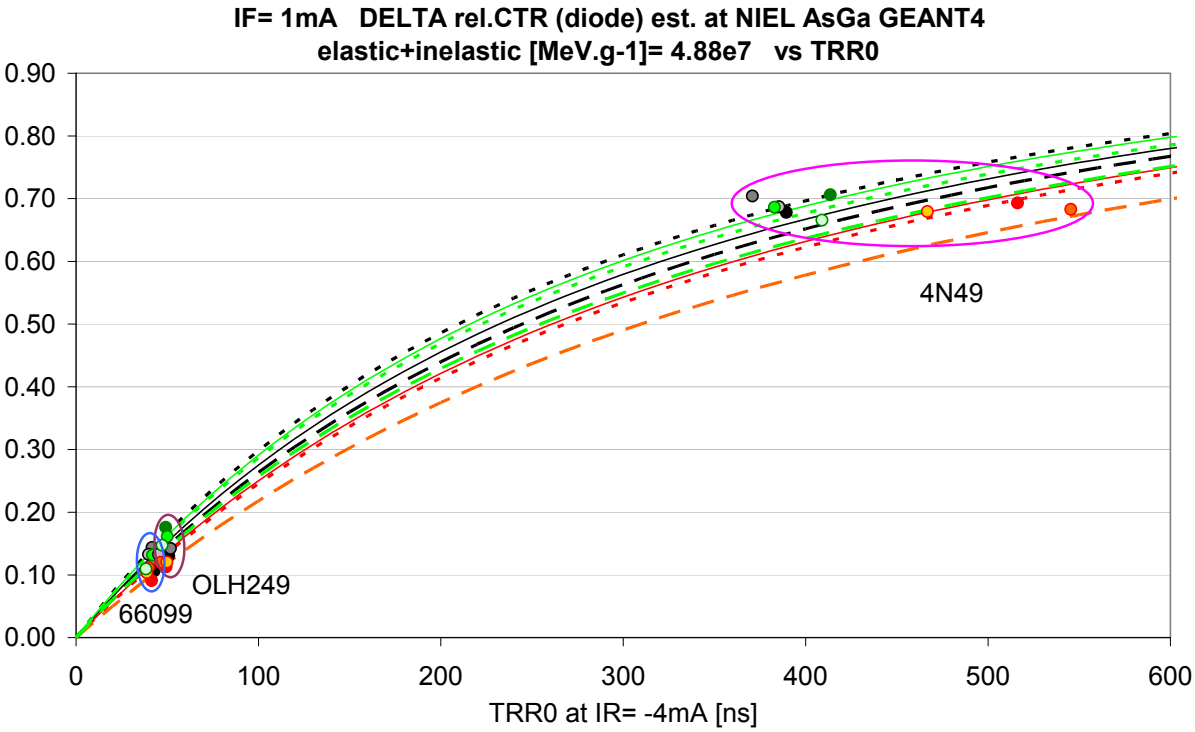


Fig. 6-15. 1 – CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



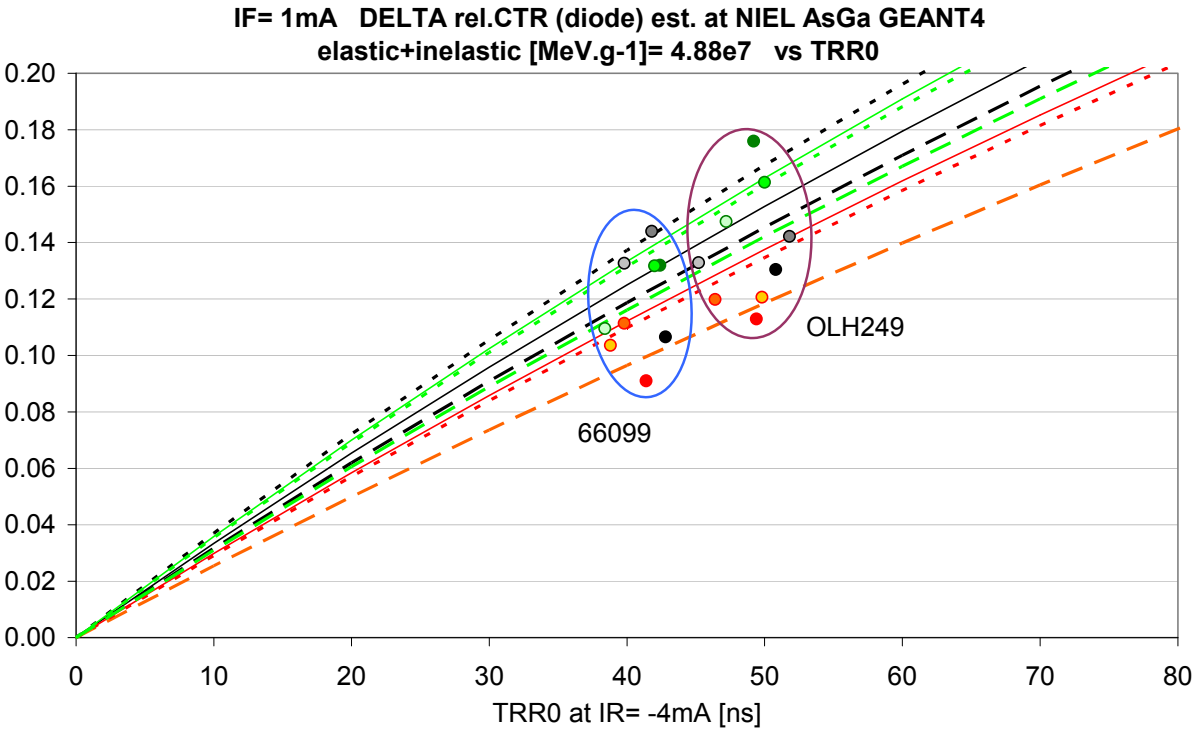
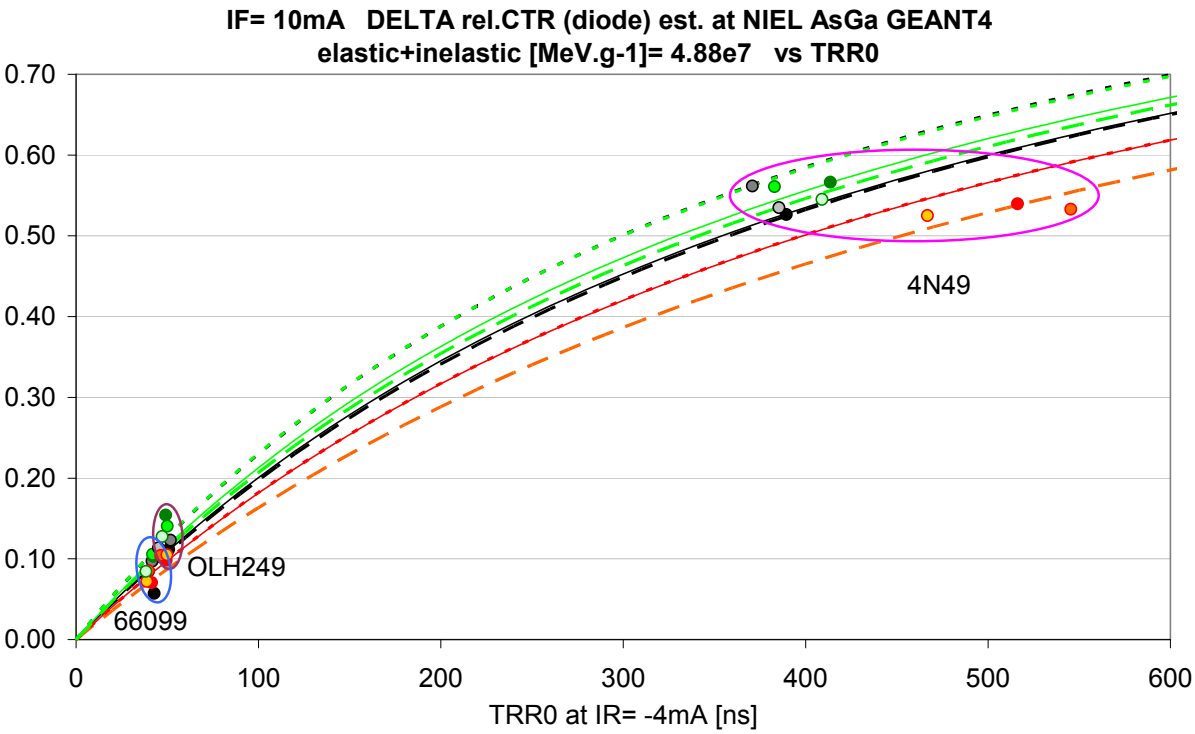


Fig. 6-16. 1 – CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



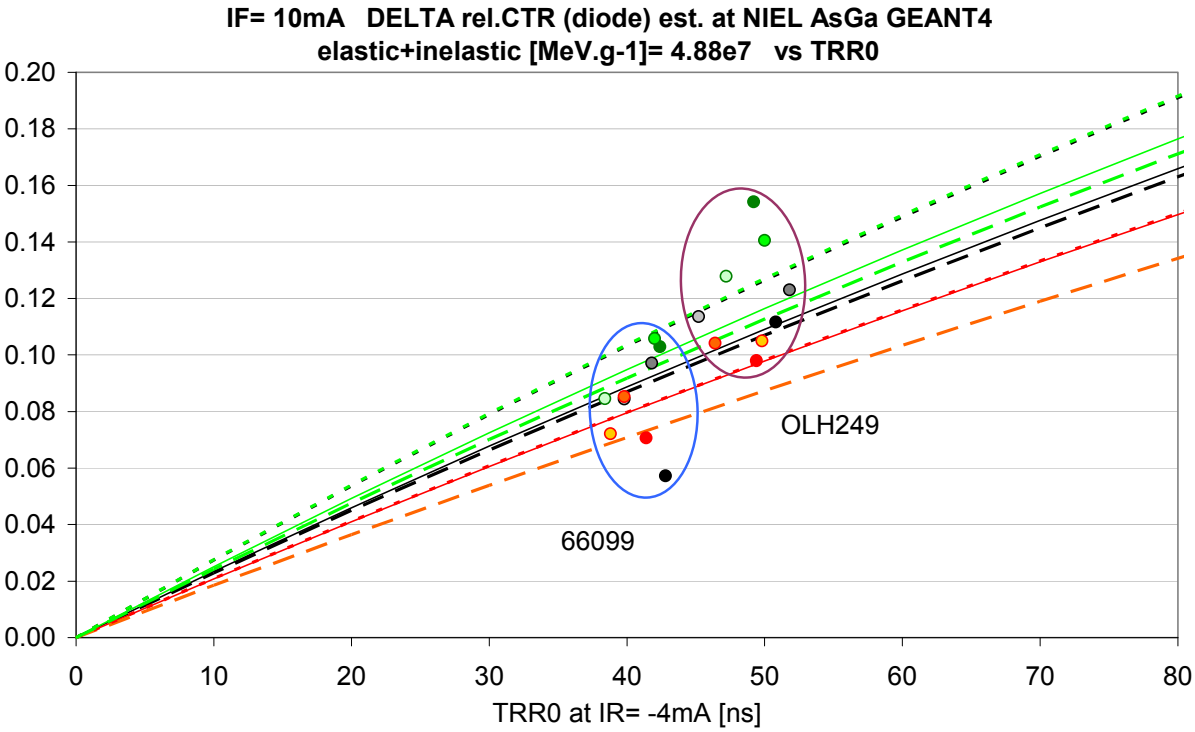


Fig. 6-17. 1 – CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

6.3 NIEL FROM BARRY'S TABLES

At the NIEL value of 8.10^6 MeV.g^{-1}, the previous curves are also plotted for the NIEL according to the Barry's tables.

- "**medium**" : the value of N and K are chosen within the range of the regressed values

N does not depend on the NIEL calculation, hence the values of Table 3 still apply.

The values of K are chosen at I_R = -4mA :

I_R	E [MeV]	60	100	200
-4mA	K_{Barry} [g.MeV^{-1}.ns^{-1}]	3.60E-11	3.20E-11	4.20E-11

Table 12. Chosen values of K for "medium" curves

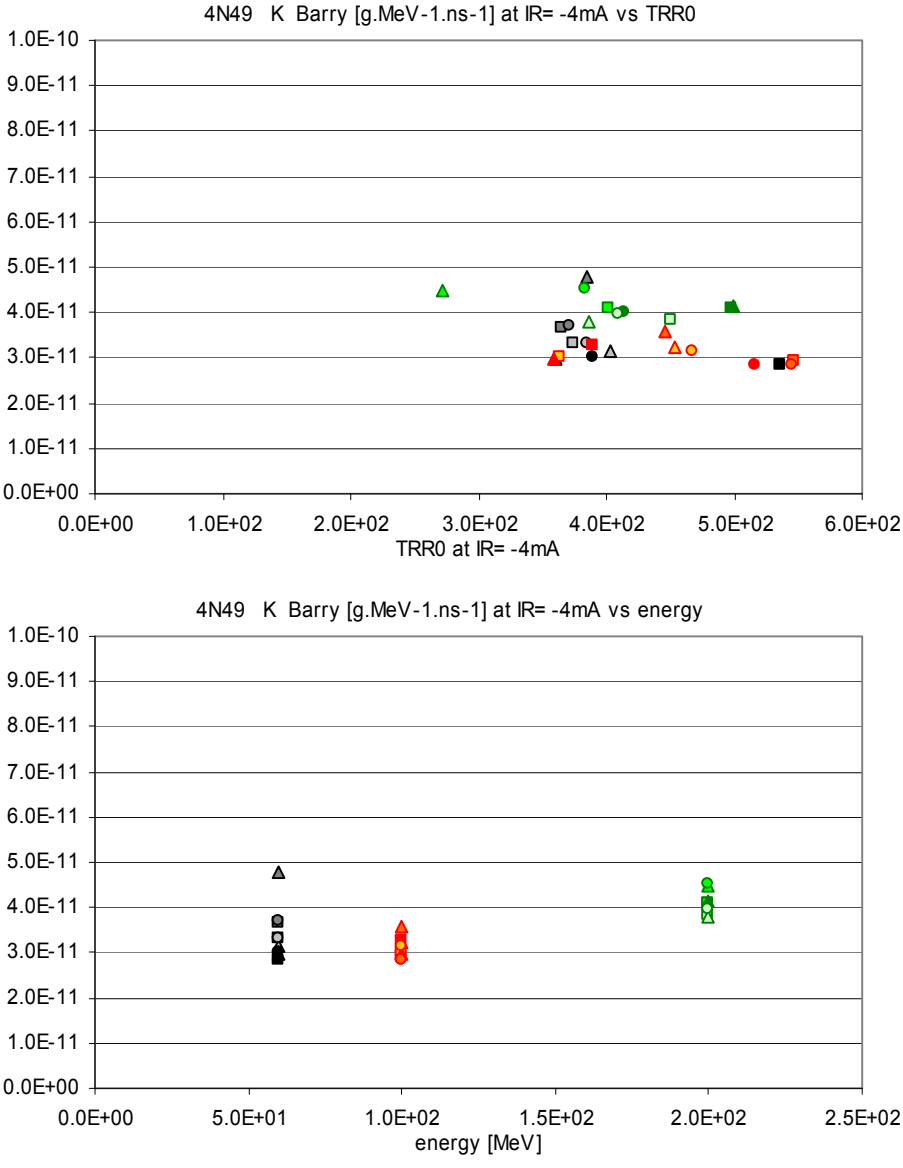


Fig. 6-18: K_Barry at I_R = -4mA with respect to τ_{RR0} (top) and to energy (bottom)

The explicit curve equations are therefore:

		E [MeV]		
I_R	I_F	60	100	200
-4mA	1mA	$1-(1+\tau_{RR0}.3.6E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.3.2E\text{-}11.NIEL)^{-2.6}$	$1-(1+\tau_{RR0}.4.2E\text{-}11.NIEL)^{-2.6}$
	10mA	$1-(1+\tau_{RR0}.3.6E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.3.2E\text{-}11.NIEL)^{-1.81}$	$1-(1+\tau_{RR0}.4.2E\text{-}11.NIEL)^{-1.81}$

Table 13. "medium" expressions of 1 - CTR/CTR$_0$ as a function of τ_{RR0} and NIEL

The same samples as with the NIEL by GEANT4 give the "lowest point" and "highest point" curves.

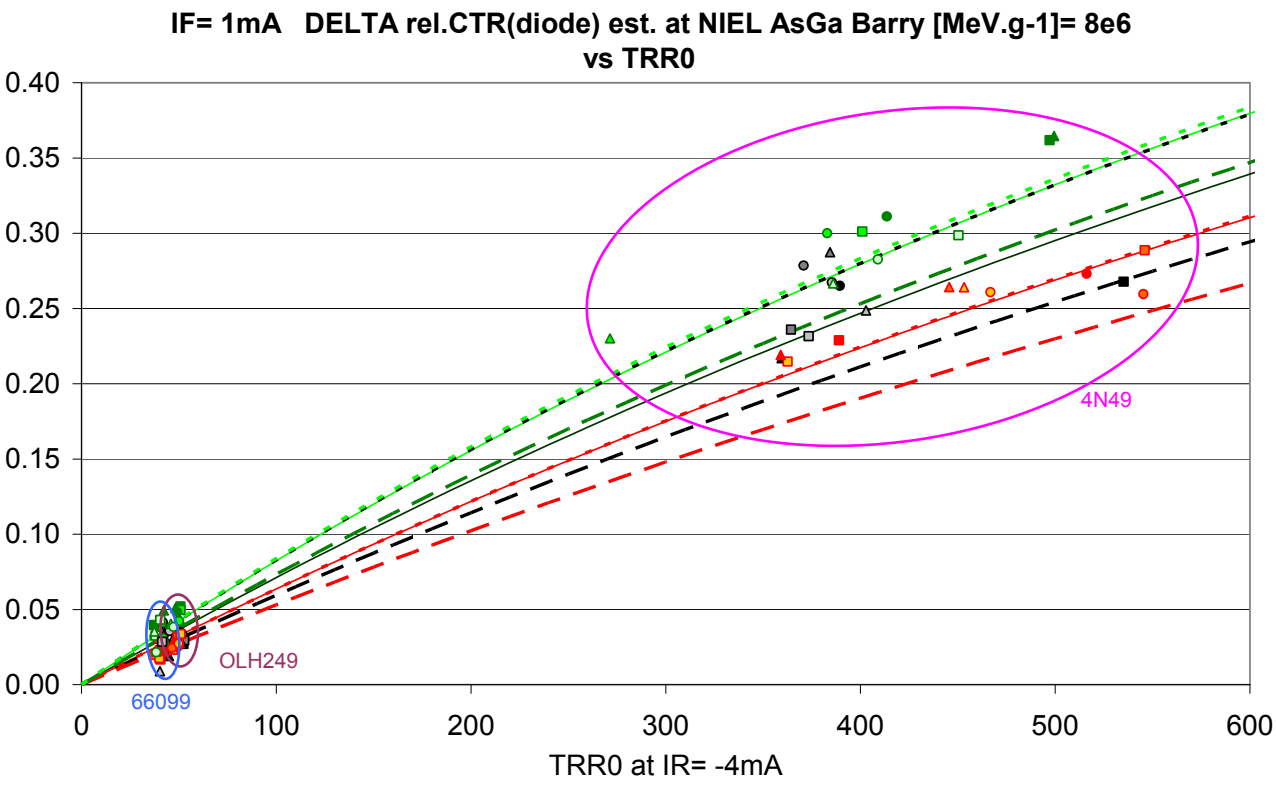
E [MeV]		60			100	200		
chosen sample		F1 #1	F2 #1	F3 #1	F3 #2	F1 #3	F2 #3	F3 #3
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	all	8.10^6	$2.7.10^7$	$4.88.10^7$
K_{Barry} [g.MeV^{-1}.ns^{-1}]		2.85E-11	2.99E-11	3.02E-11	2.82E-11	3.82E-11	3.79E-11	3.95E-11
N	I_F= 1mA	2.71E+00	2.71E+00	2.66E+00	2.44E+00	2.53E+00	2.52E+00	2.34E+00
	I_F= 10mA	1.65E+00	1.94E+00	1.92E+00	1.77E+00	1.57E+00	1.78E+00	1.82E+00

Table 14. Values of (N, K) of chosen 4N49 samples for "lowest point" curves

E [MeV]		60		100			200	
chosen sample		F2 #2	F3 #2	F2 #1	F2 #2	F3 #3	F2 #2	F3 #1
interpolation NIEL [MeV.g^{-1}]		8.10^6 $2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6 $2.7.10^7$	$4.88.10^7$
K_{Barry} [g.MeV^{-1}.ns^{-1}]		4.80E-11	3.71E-11	2.98E-11	3.56E-11	3.16E-11	4.50E-11	4.01E-11
N	I_F= 1mA	2.30E+00	2.55E+00	2.79E+00	2.45E+00	2.51E+00	2.47E+00	2.59E+00
	I_F= 10mA	1.62E+00	1.88E+00	1.93E+00	1.65E+00	1.79E+00	1.95E+00	1.93E+00

Table 15. Values of (N,K) of chosen 4N49 samples for "highest point" curves

The agreement with the estimation points of Δrel.CTR = 1 - CTR/CTR$_0$ is less good than when the NIEL is computed by GEANT4, for all optocouplers even 4N49.



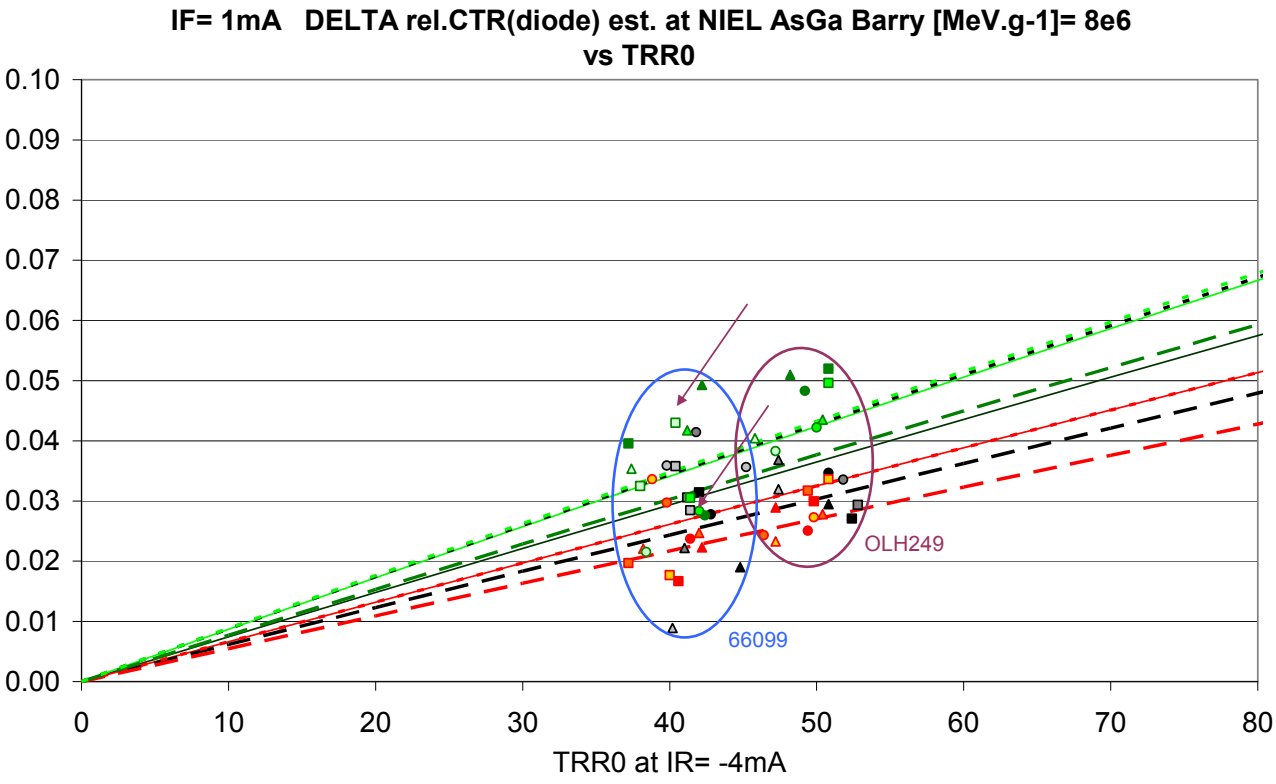
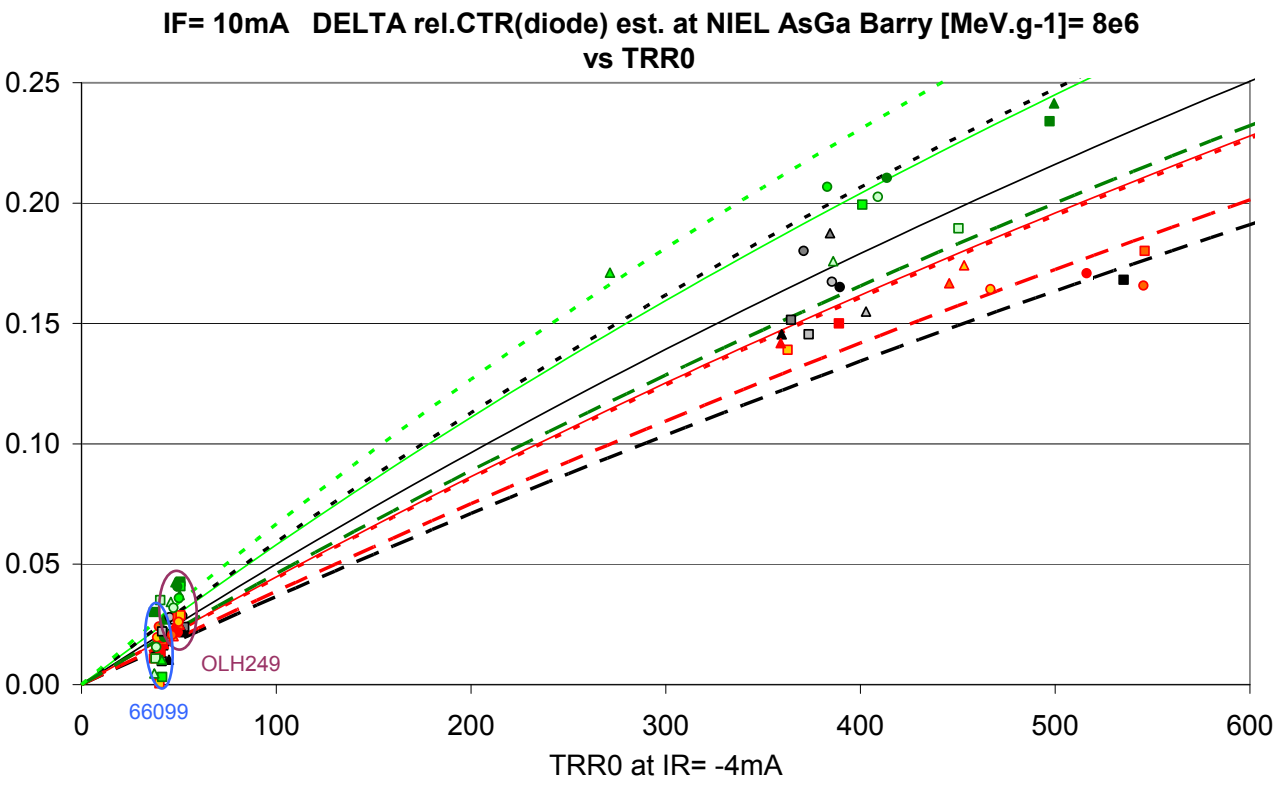


Fig. 6-19: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



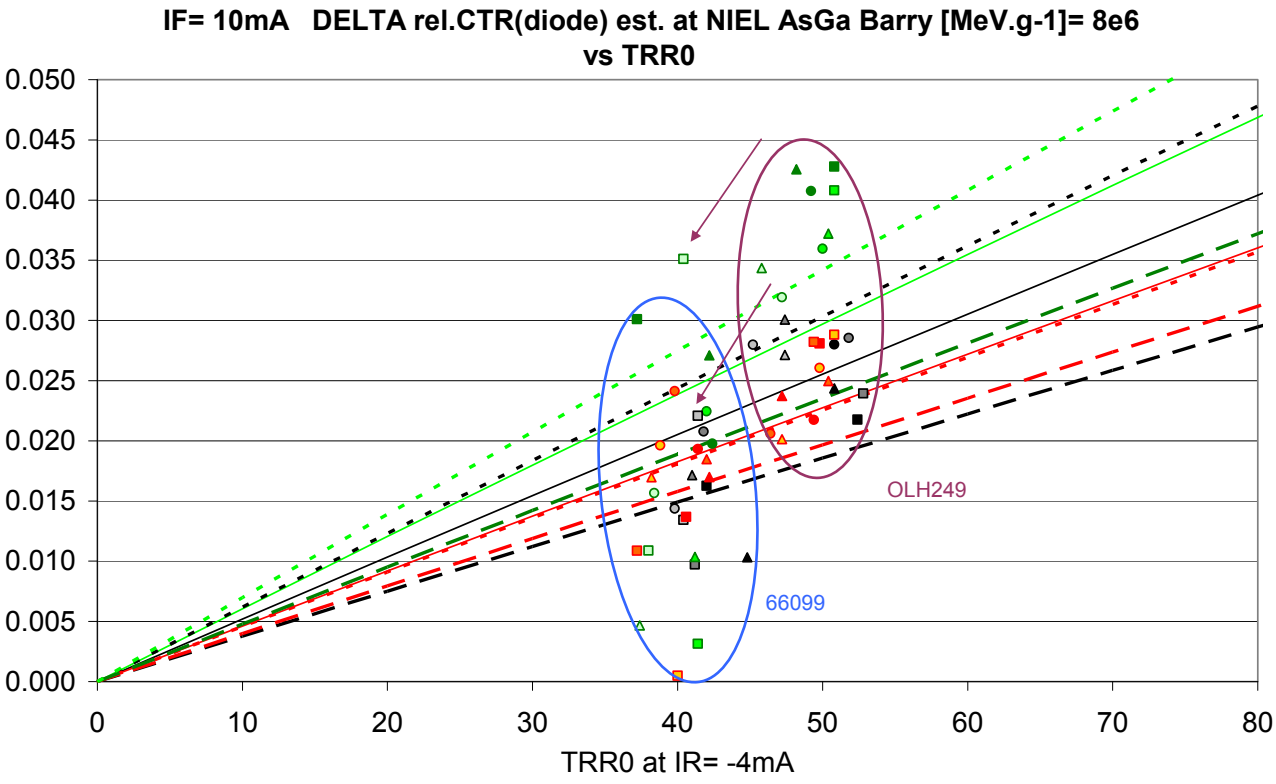
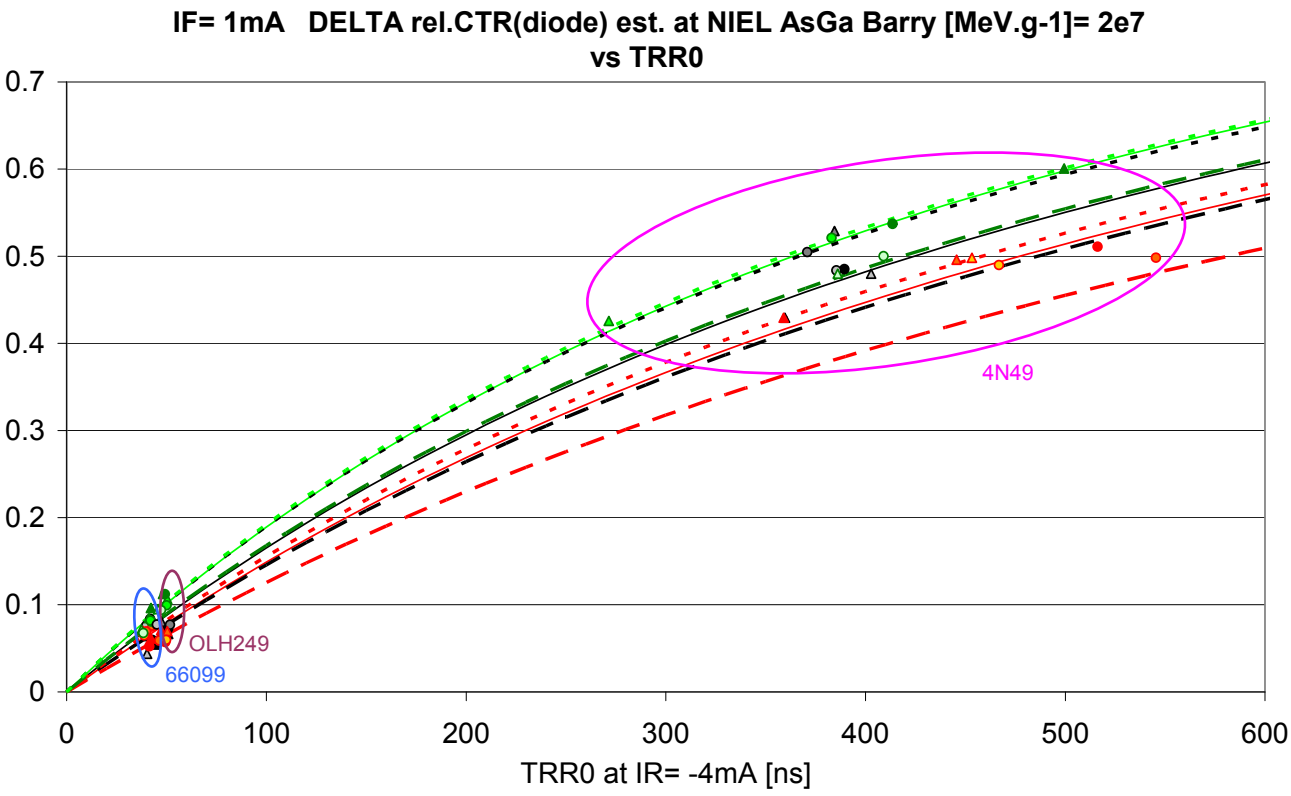


Fig. 6-20: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



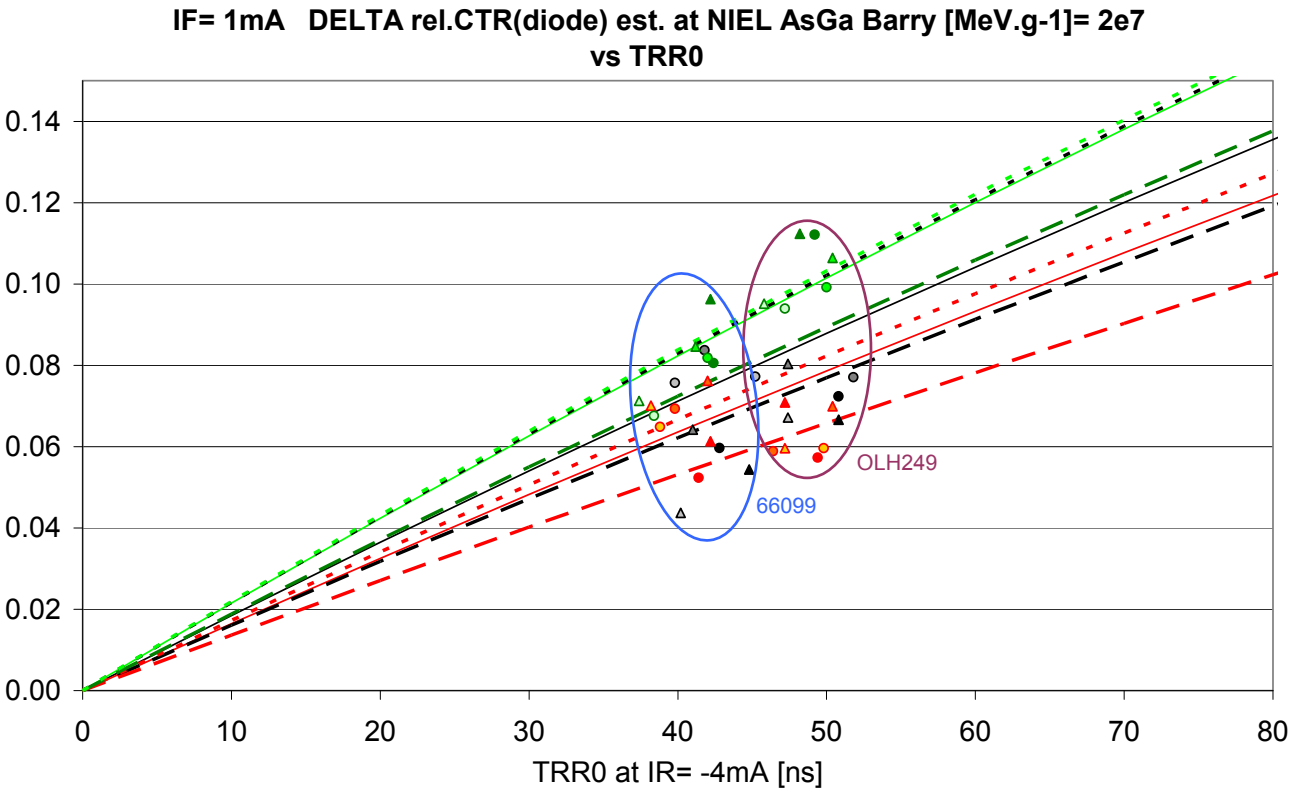
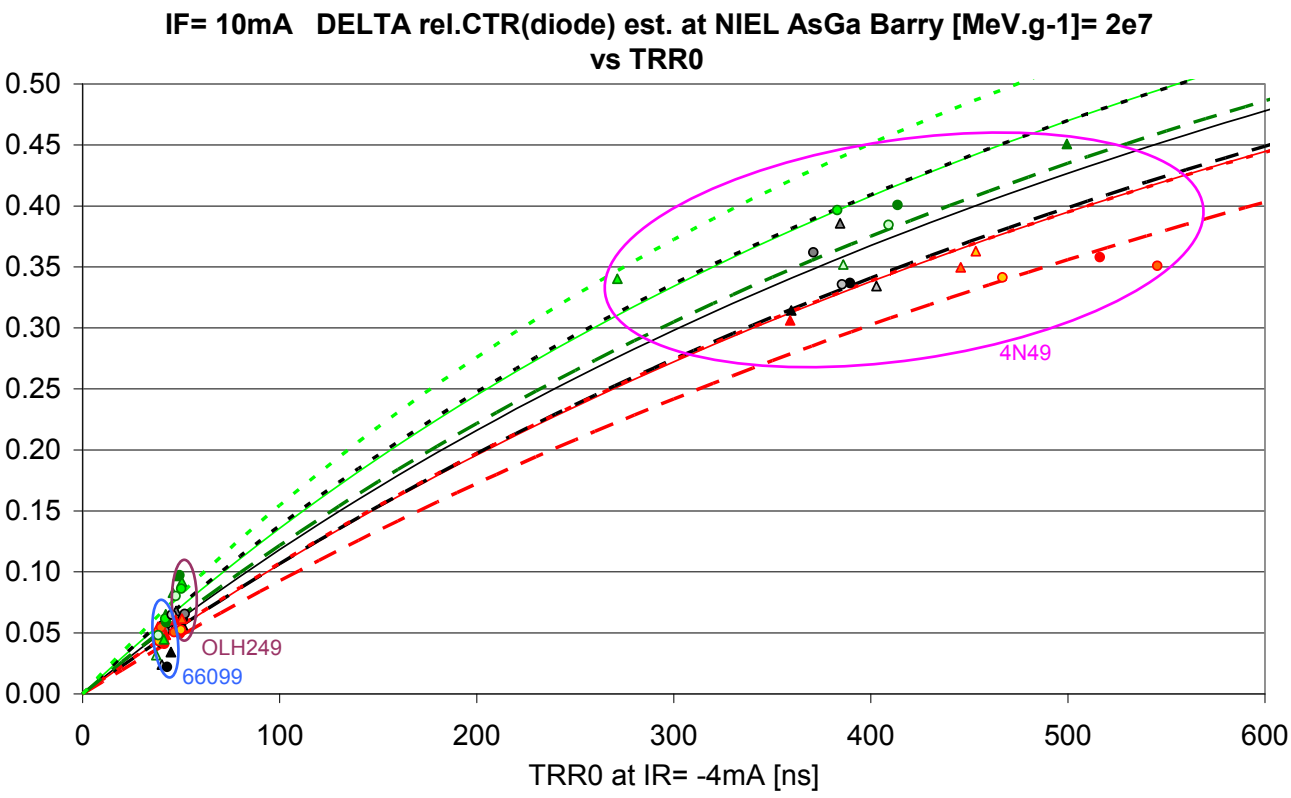


Fig. 6-21: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



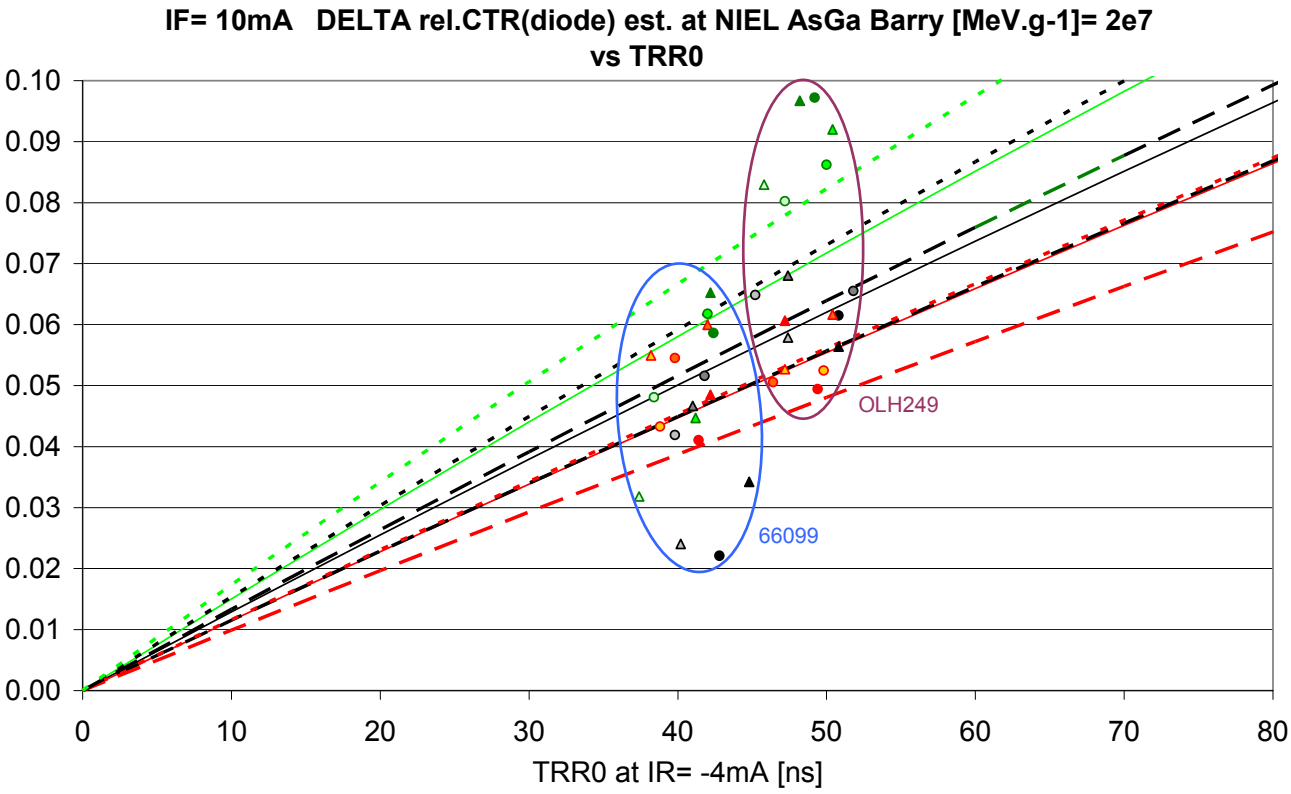
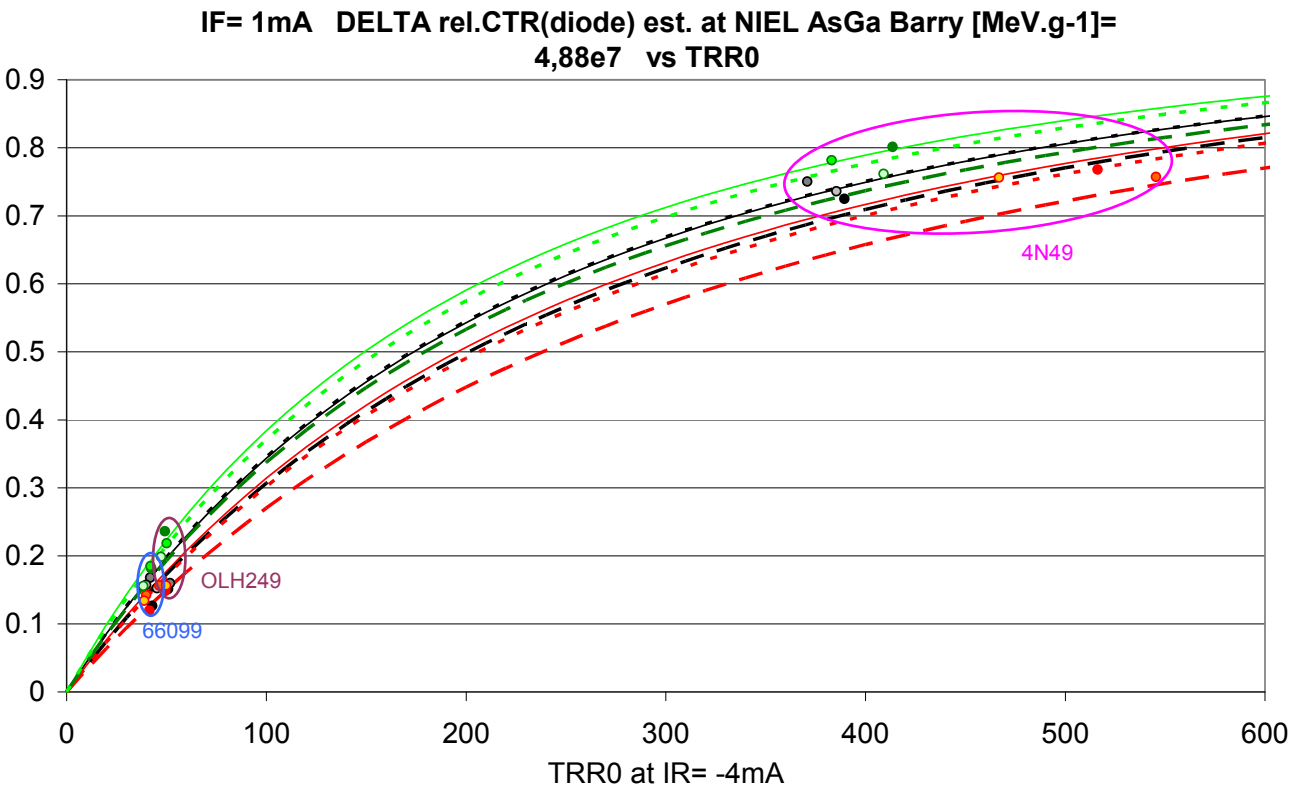


Fig. 6-22: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



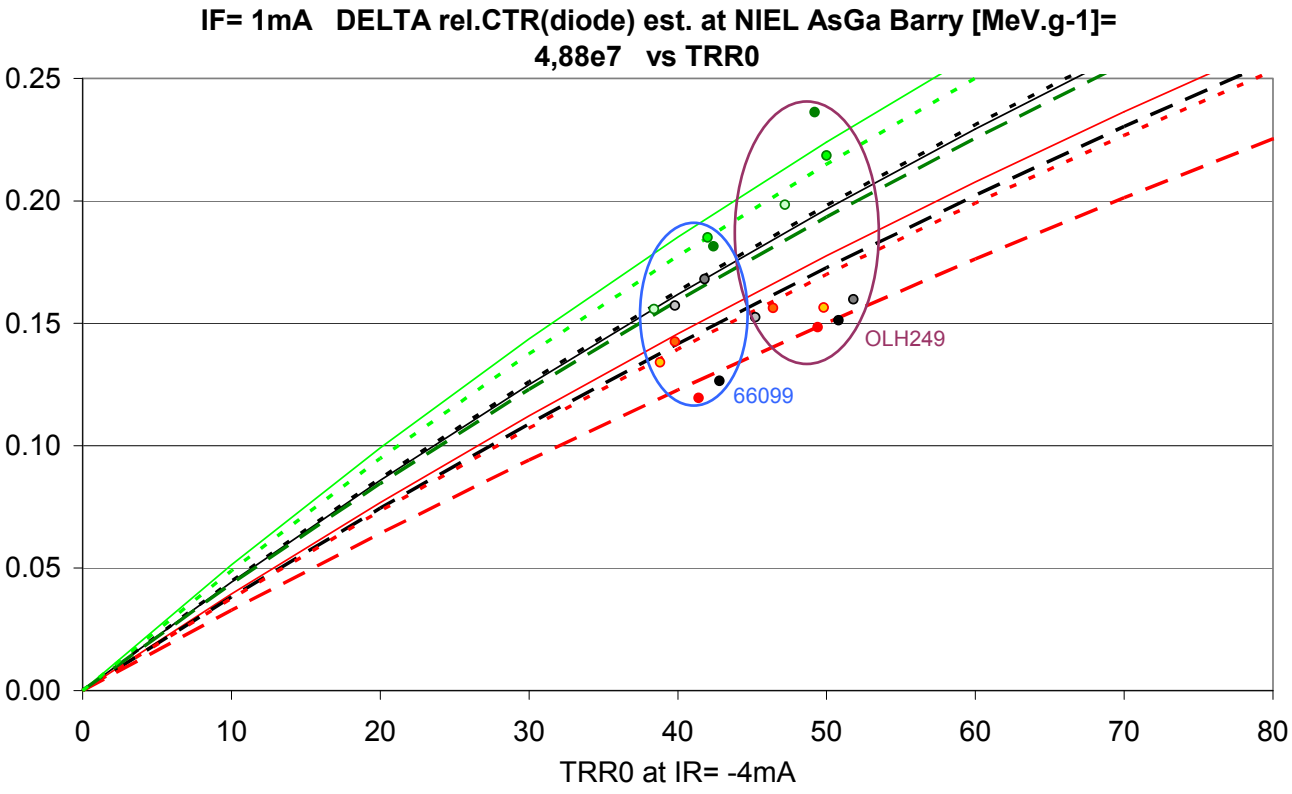
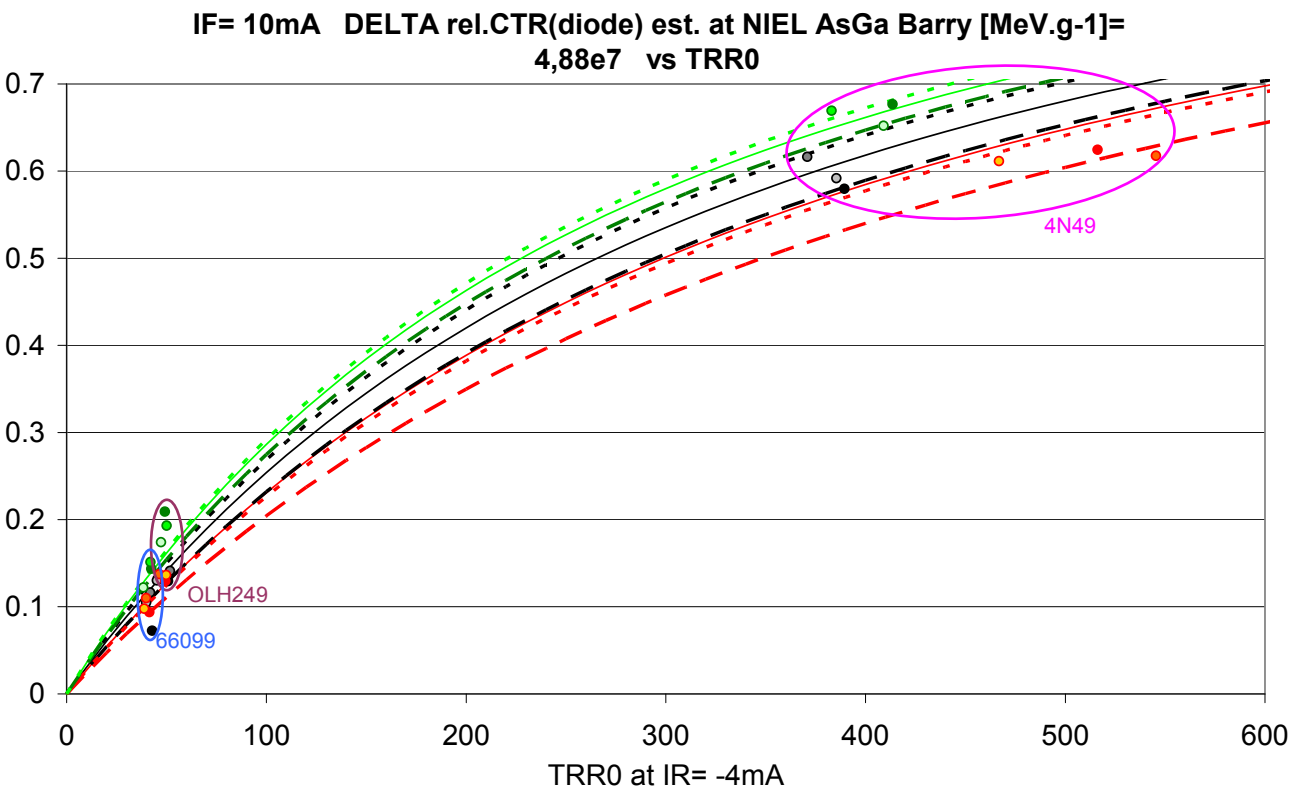


Fig. 6-23: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



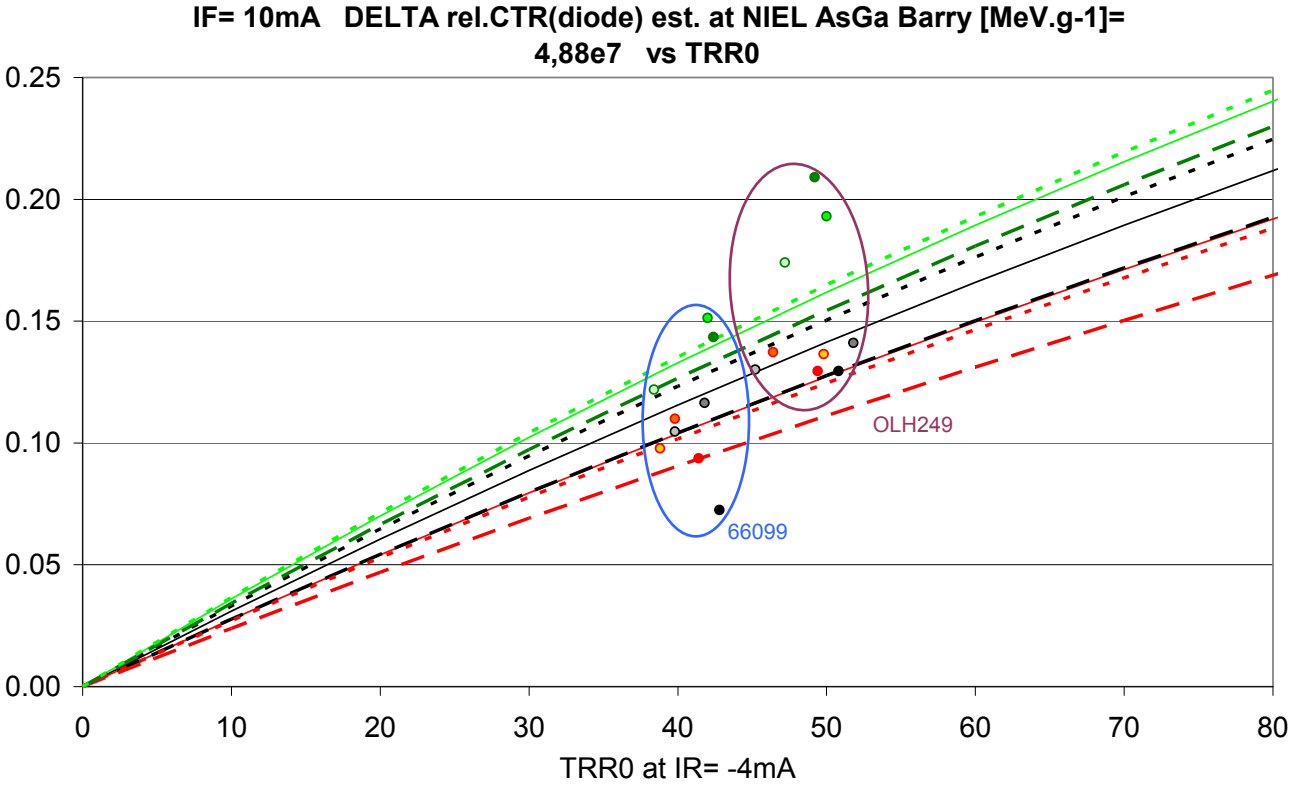


Fig. 6-24: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

7. ESTIMATION OF AN OPTOCOUPLER DEGRADATION

Here is assumed that Eq.25 to Eq.27 apply not only for the diode but also for the optocoupler, i.e. the optocoupler CTR variation at a given fluence or NIEL can be derived as a function of initial diode's recovery time τ_{RR0} from the results on the diode irradiated separately. Of course the (N, K) couples defining Δrel.CTR curves ("medium", "lowest point" and "highest point"), are modified. K is a diode's feature whereas N is obtained by the optocoupler CTR/CTR$_0$ regression versus $(\tau_{RR}/\tau_{RR0})^N$. It has not a direct physical sense, in this section N is renamed N_{op}.

It would have been better to estimate the optocoupler degradation from initial diode and transistor (τ_{RR0}) respective characteristics, but no (τ_{RR0}) measurement has been done on transistor.

7.1 NIEL COMPUTED BY GEANT 4 (ELASTIC)

- "**medium**" :

Let one choose the following values for N_{op}:

I_F	1mA	10mA
N_{op}	4.16E+00	2.76E+00

Table 16. Chosen values of optocoupler N_{op} for « medium » curves at I_R= -4mA.

These values are the averages of all regressed values (nine values).

K values are recalled below:

E [MeV]	60	100	200
$K_{GEANT4_ELASTIC}$ [g.MeV^{-1}.ns^{-1}]	4.5E-11	5E-11	8E-11

Table 17. Chosen values of K for "medium" curves at I_R= -4mA

The explicit curve equations are therefore:

		E [MeV]		
I_R	I_F	60	100	200
-4mA	1mA	$1-(1+\tau_{RR0}.4.5E\text{-}11.NIEL)^{-4.16}$	$1-(1+\tau_{RR0}.5.0E\text{-}11.NIEL)^{-4.16}$	$1-(1+\tau_{RR0}.8.00E\text{-}11.NIEL)^{-4.16}$
	10mA	$1-(1+\tau_{RR0}.4.5E\text{-}11.NIEL)^{-2.76}$	$1-(1+\tau_{RR0}.5.0E\text{-}11.NIEL)^{-2.76}$	$1-(1+\tau_{RR0}.8.00E\text{-}11.NIEL)^{-2.76}$

Table 18. "medium" expressions of $(1 - CTR/CTR_0)_{opto}$ as a function of τ_{RR0} and $NIEL_{GEANT4_ELASTIC}$

- "**lowest point**" : the values of N_{op} and K are the values corresponding to the same samples chosen for diodes' "lowest point" Δrel.CTR curves.

E [MeV]		60			100	200		
chosen sample		F1 #1	F2 #1	F3 #1	F3 #2	F1 #3	F2 #3	F3 #3
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	all	8.10^6	$2.7.10^7$	$4.88.10^7$
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		3.80E-11	3.99E-11	4.03E-11	4.55E-11	7.52E-11	7.46E-11	7.77E-11
N_{op}	I_F= 1mA	3.85E+00	4.30E+00	4.37E+00	4.11E+00	3.70E+00	3.98E+00	3.85E+00
	I_F= 10mA	2.36E+00	3.02E+00	3.03E+00	2.85E+00	2.30E+00	2.73E+00	2.84E+00

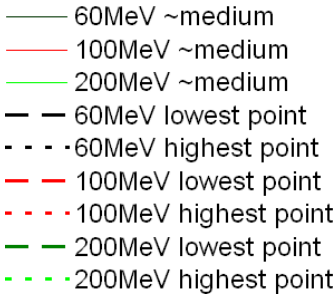
Table 19. Values of (N_{op}, K) of chosen 4N49 samples for "lowest point" curves

- "**highest point**" : the values of N_{op} and K are the values corresponding to the same samples chosen for diodes' "highest point" Δrel.CTR curves.

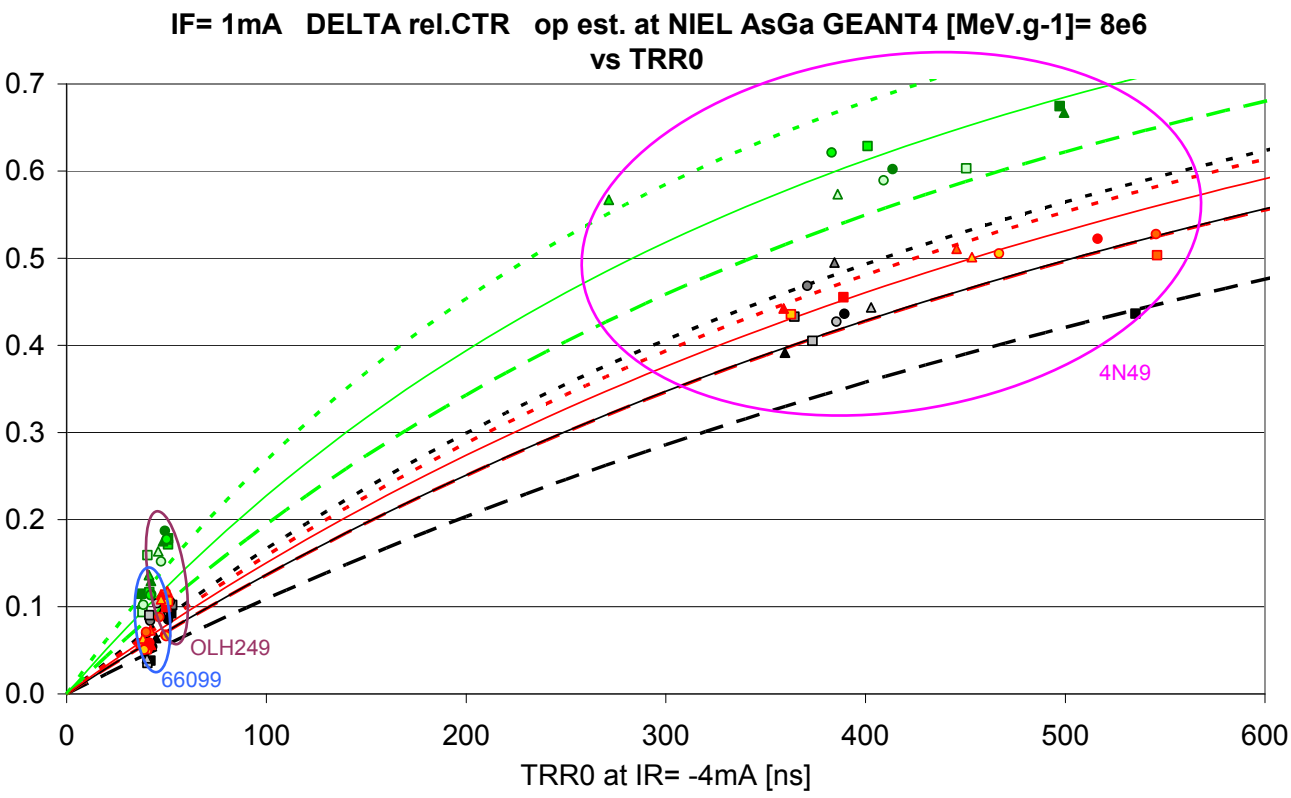
E [MeV]		60		100			200	
chosen sample		F2 #2	F3 #2	F2 #1	F2 #2	F3 #3	F2 #2	F3 #1
interpolation NIEL [MeV.g^{-1}]		8.10^6 $2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6 $2.7.10^7$	$4.88.10^7$
K_{GEANT4} [g.MeV^{-1}.ns^{-1}]		6.39E-11	4.94E-11	4.79E-11	5.74E-11	5.09E-11	8.86E-11	7.90E-11
N_{op}	I_F= 1mA	3.65E+00	4.29E+00	4.59E+00	3.83E+00	4.09E+00	4.56E+00	4.69E+00
	I_F= 10mA	2.53E+00	3.05E+00	3.11E+00	2.55E+00	2.81E+00	3.33E+00	2.90E+00

Table 20. Values of (N_{op},K) of chosen 4N49 samples for "highest point" curves

The 66099 and OLH249's relative optocoupler CTR degradation $(1 - CTR/CTR_0)_{optocoupler}$ estimations deduced from the curves can be compared with their respective measurement points. Their whole points are not so far from the curves, despite the (N, K) parameters are obtained by regression from 4N49 optocoupler's data. While the agreement on 66099 is quite acceptable, the degradation of OLH249 optocoupler is underestimated. It has to be underlined that the main contribution to its degradation is due to the transistor and not the diode, on the contrary to 66099 and 4N49. Moreover, this supports that predicting optocoupler degradation is possible (within 10-20% precision) provided that its degradation mainly comes from its diode whose τ_{RR0} is lower than the 4N49's diode one.



Legend for Fig. 6-5 to Fig. 6-10, and Fig. 6-19 to Fig. 6-20



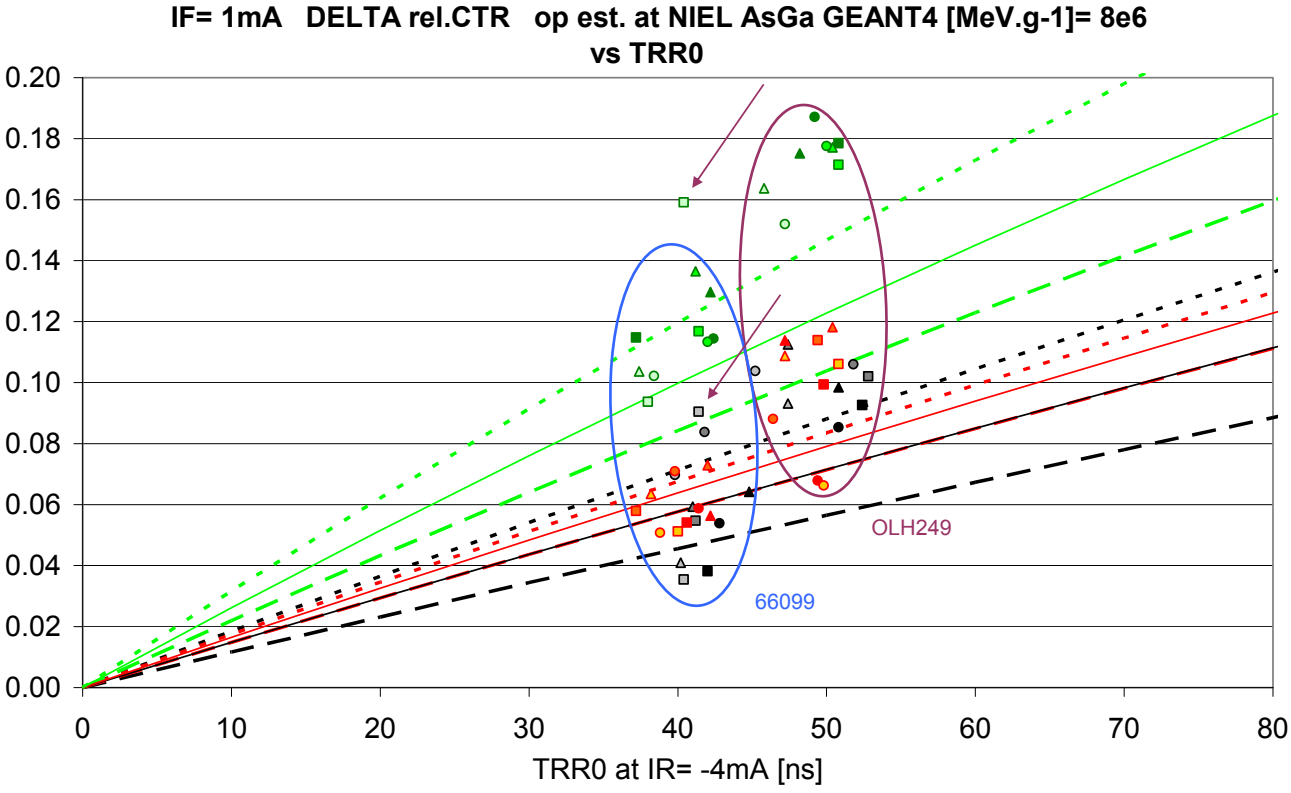
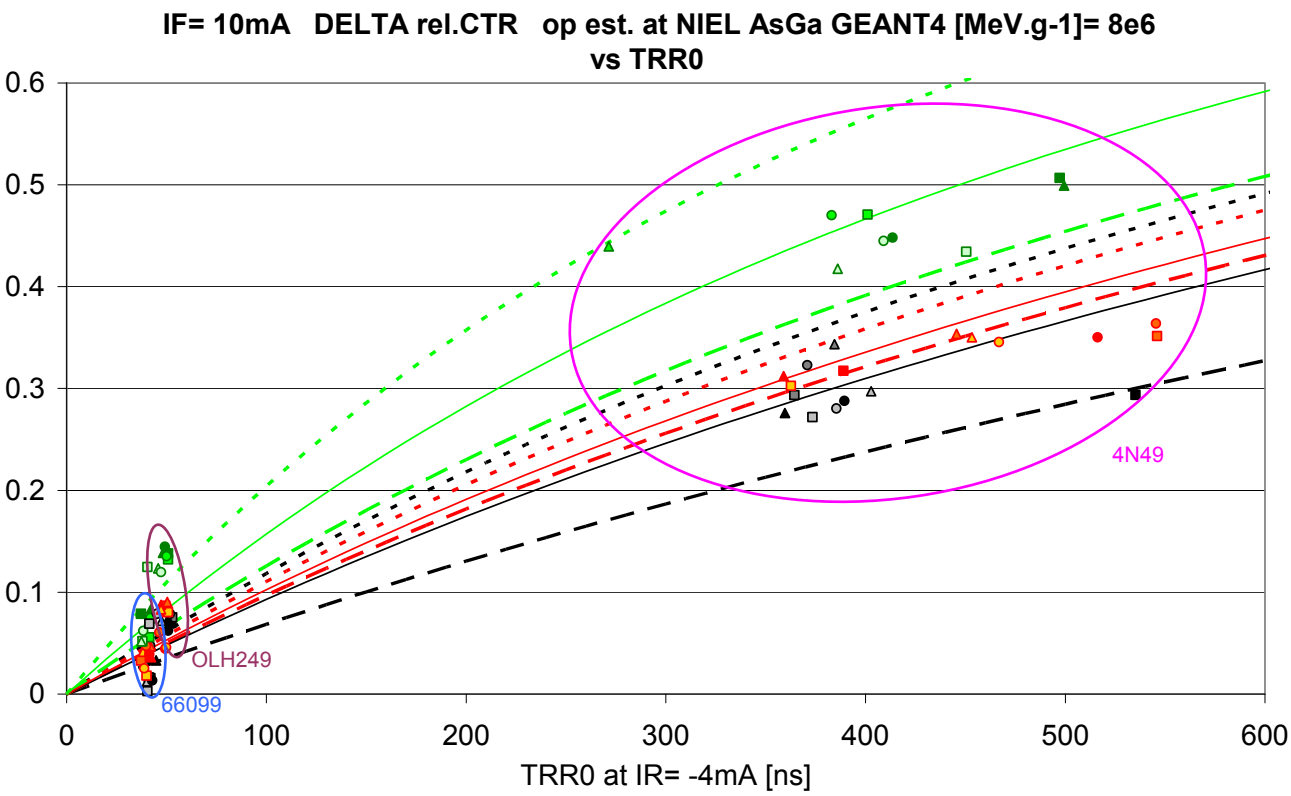


Fig. 7-1: (1 - CTR/CTR$_0$)$_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



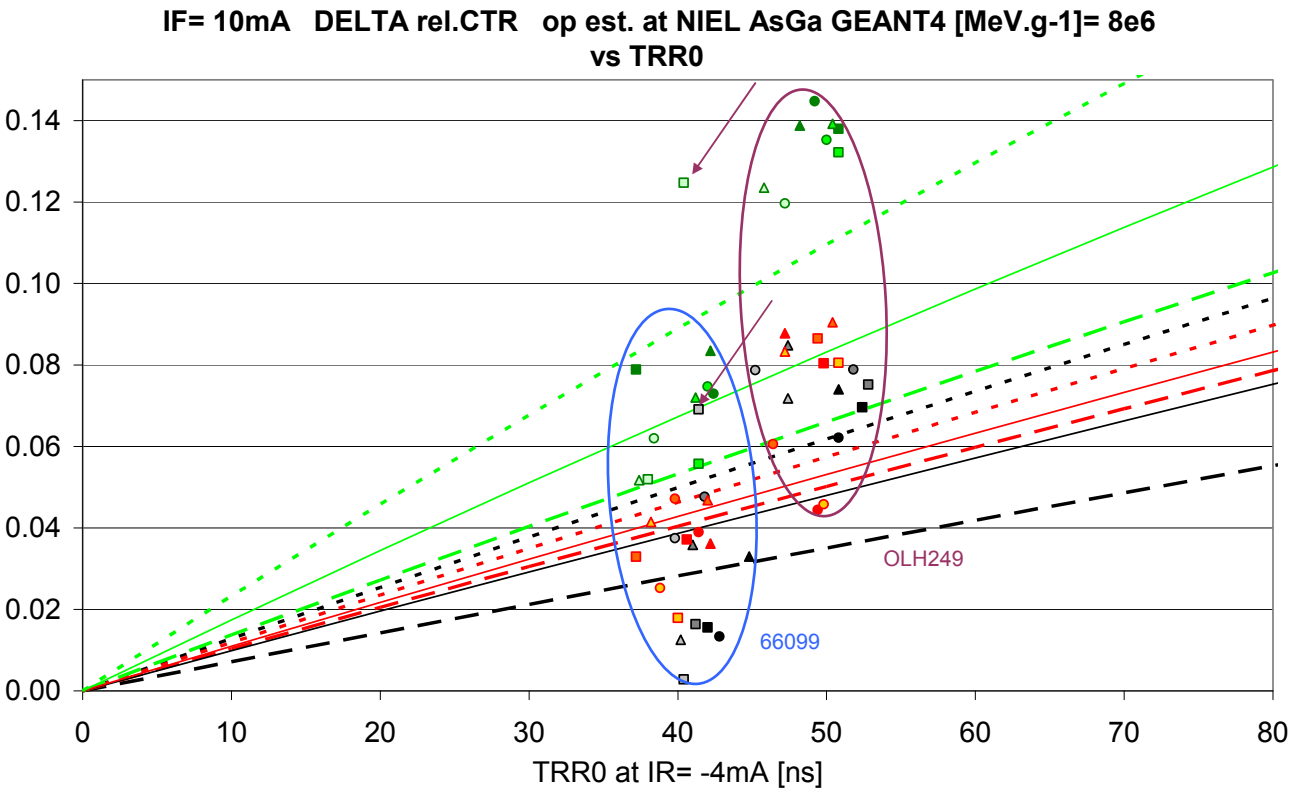
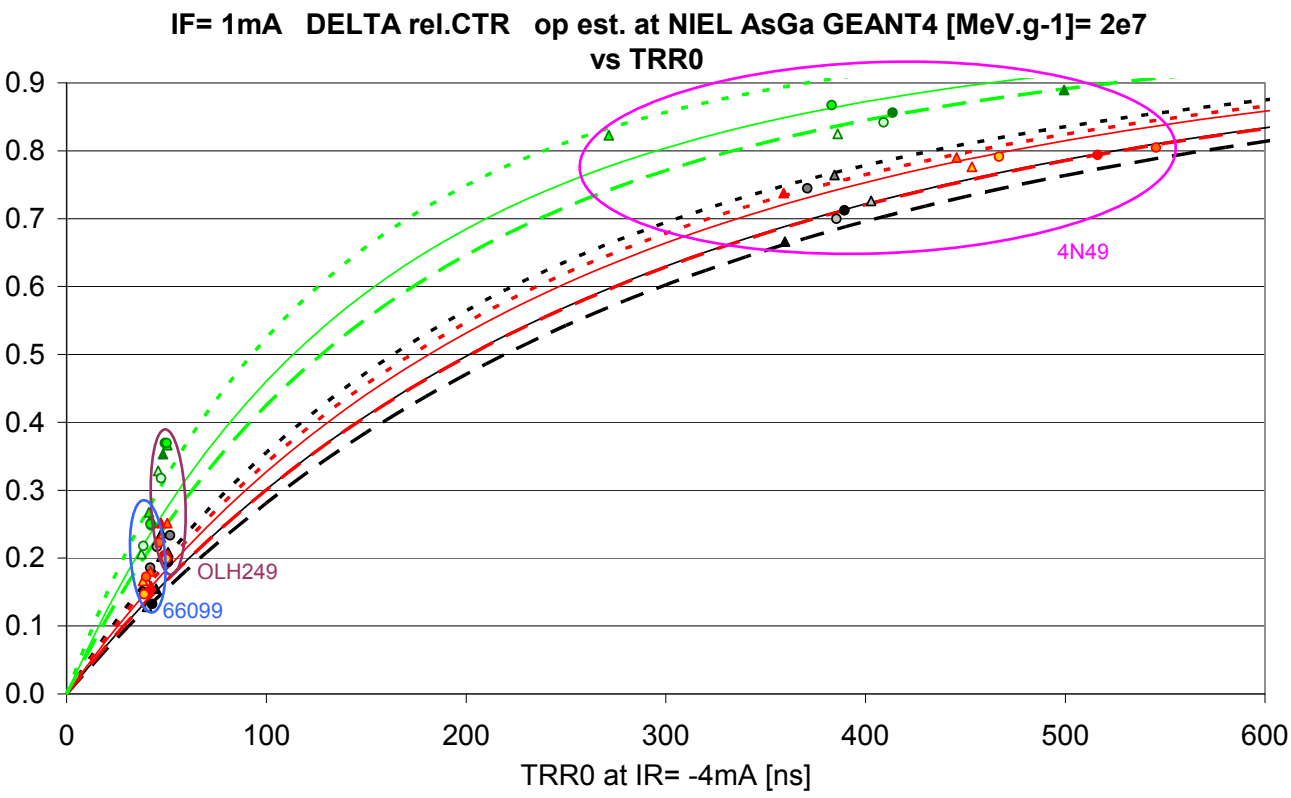


Fig. 7-2: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



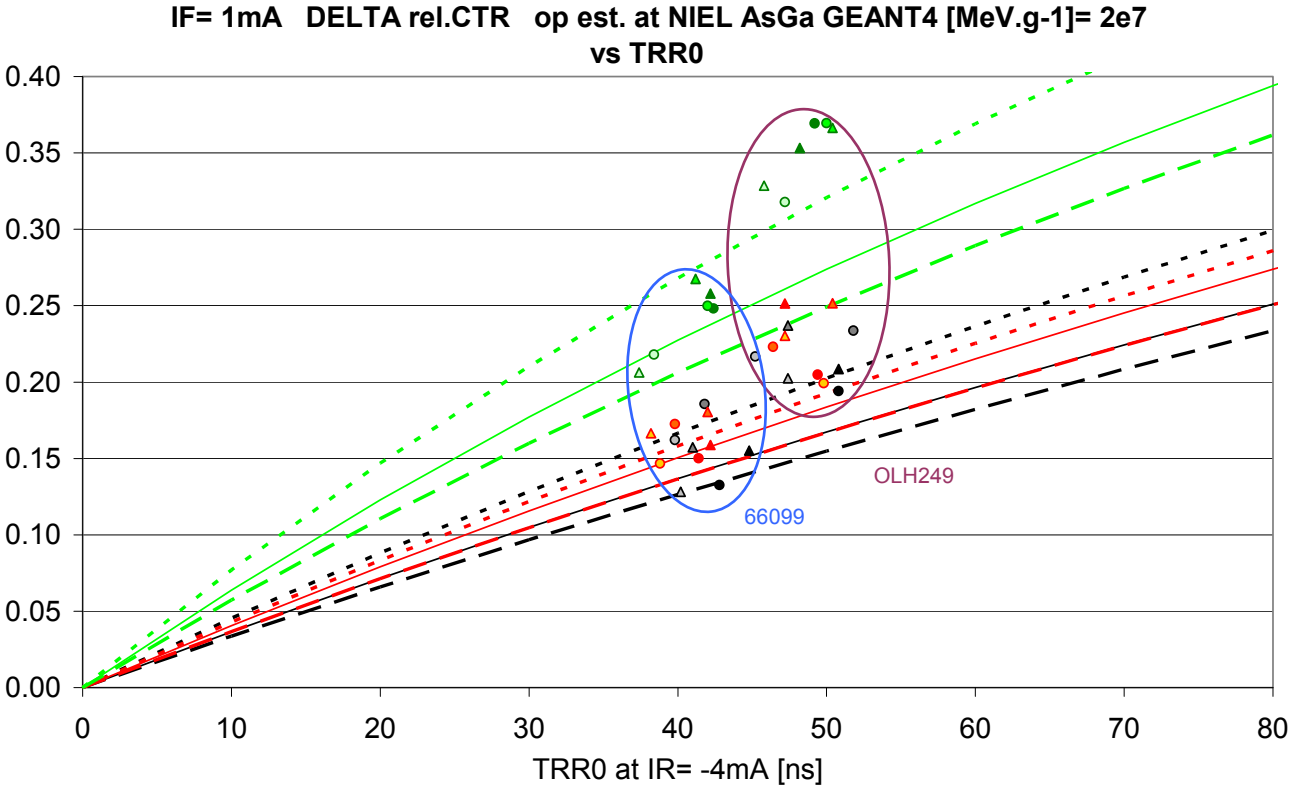
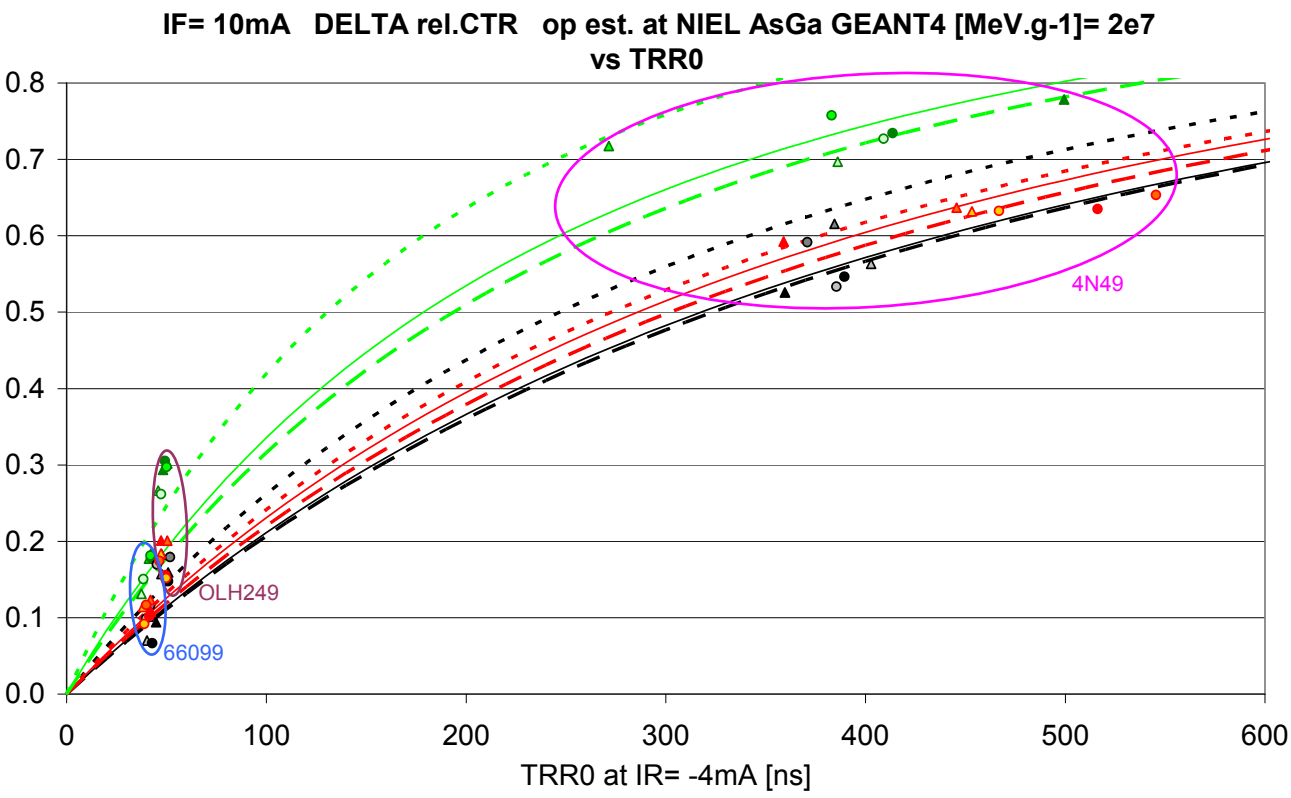


Fig. 7-3: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 $MeV.g^{-1}$ (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



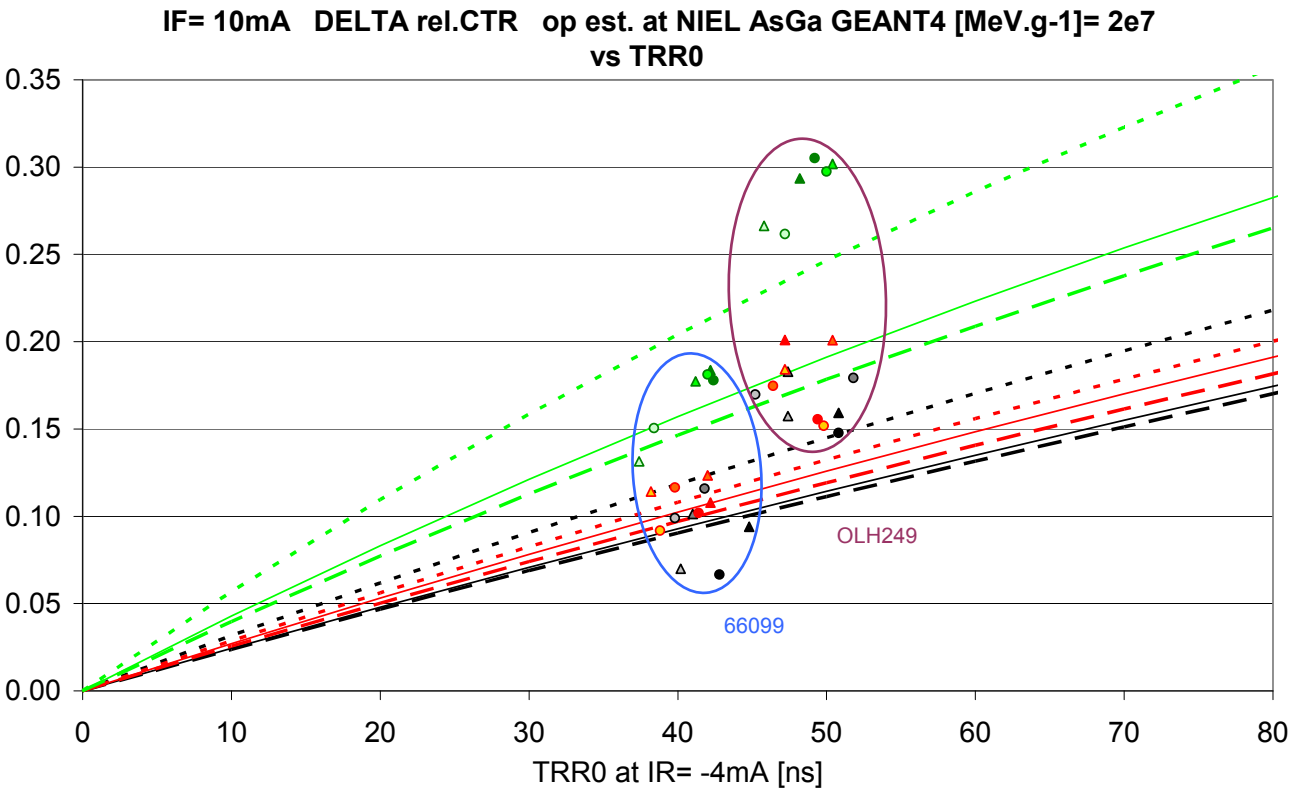
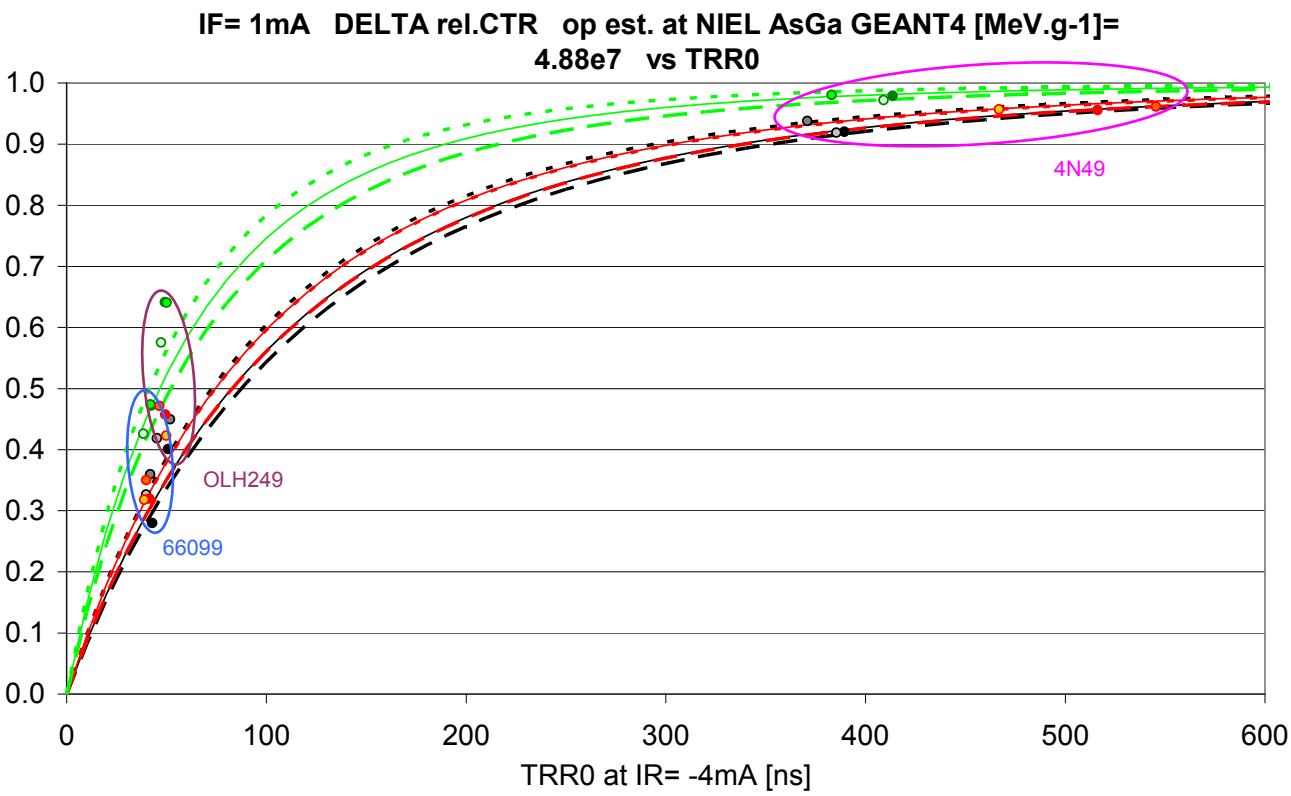


Fig. 7-4: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



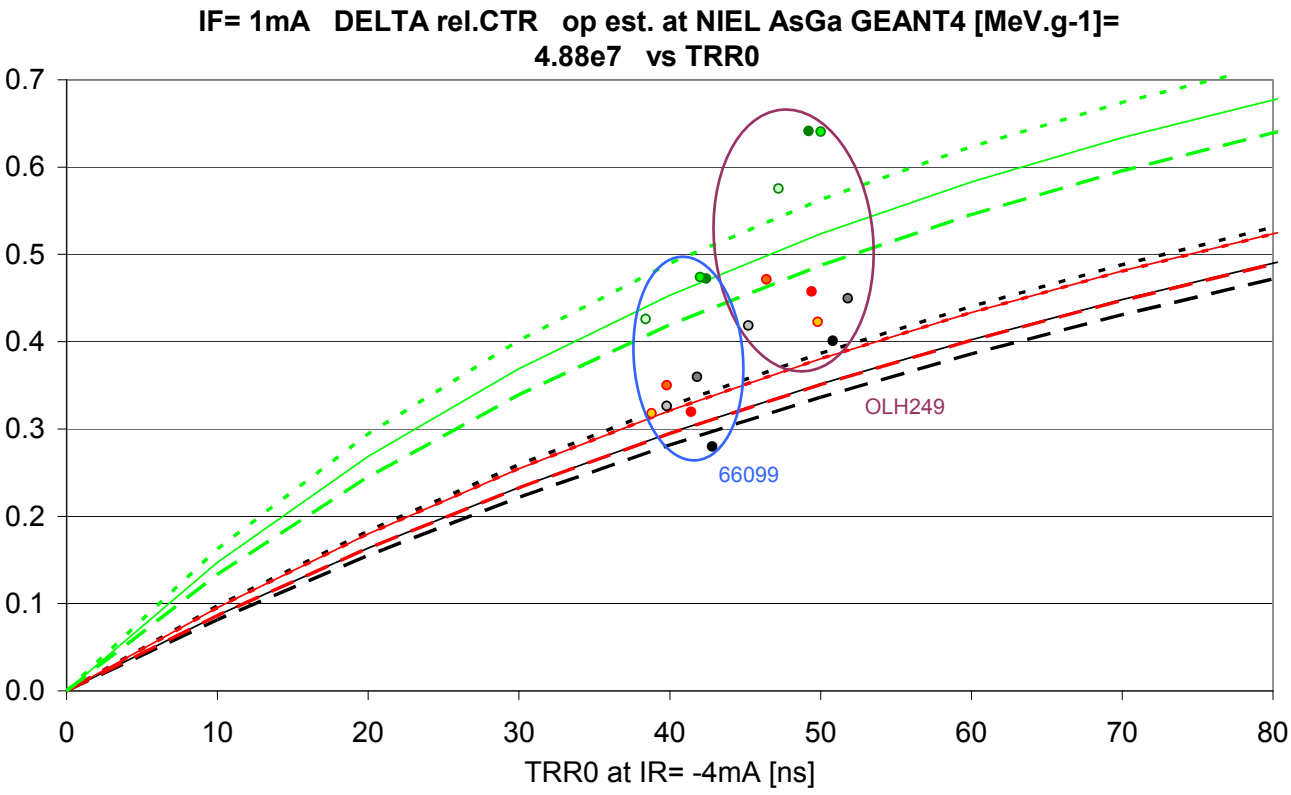
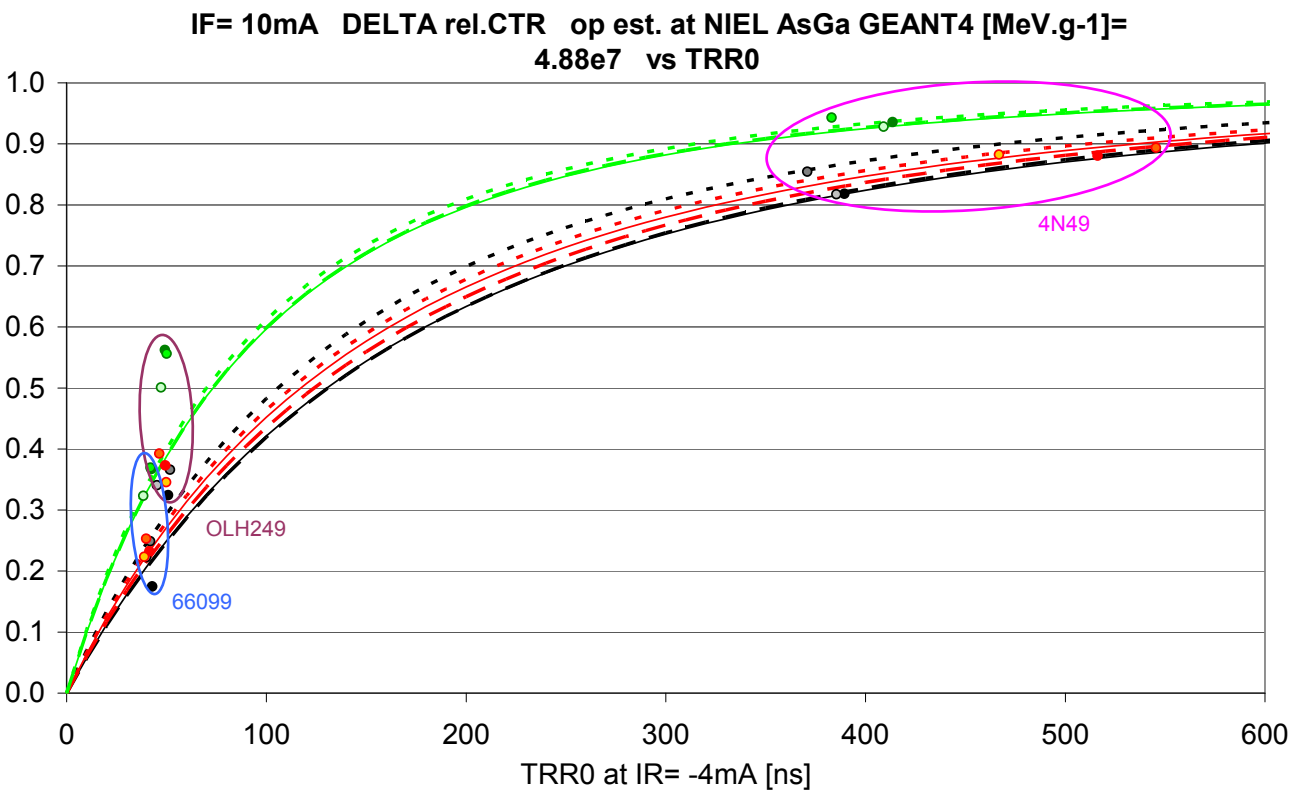


Fig. 7-5: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ $MeV.g^{-1}$ (GEANT4 ELASTIC) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



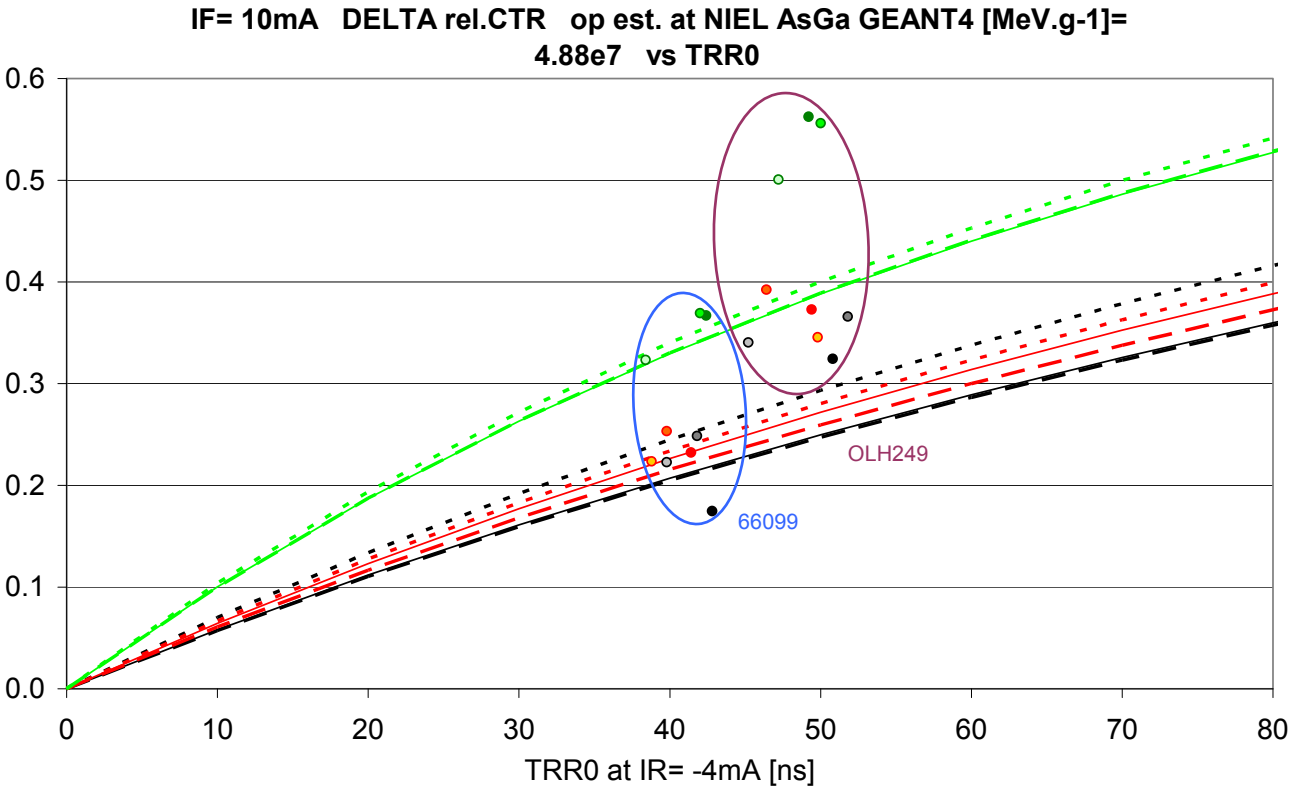


Fig. 7-6: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ $MeV.g^{-1}$ (GEANT4 ELASTIC) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

7.2 NIEL COMPUTED BY GEANT 4 (ELASTIC + INELASTIC)

Same N values as in 7.1 and same K values as in 6.2 are used.

K values are recalled below:

E [MeV]	60	100	200
$K_{GEANT4_EL+INEL}$ [$g.MeV^{-1}.ns^{-1}$]	2.7E-11	2.4E-11	2.9E-11

Table 21. Chosen values of K for "medium" curves at I_R= -4mA

The explicit curve equations are therefore:

		E [MeV]		
I_R	I_F	60	100	200
-4mA	1mA	$1-(1+\tau_{RR0}.2.7E\text{-}11.NIEL)^{-4.16}$	$1-(1+\tau_{RR0}.2.4E\text{-}11.NIEL)^{-4.16}$	$1-(1+\tau_{RR0}.2.9E\text{-}11.NIEL)^{-4.16}$
	10mA	$1-(1+\tau_{RR0}.2.7E\text{-}11.NIEL)^{-2.76}$	$1-(1+\tau_{RR0}.2.4E\text{-}11.NIEL)^{-2.76}$	$1-(1+\tau_{RR0}.2.9E\text{-}11.NIEL)^{-2.76}$

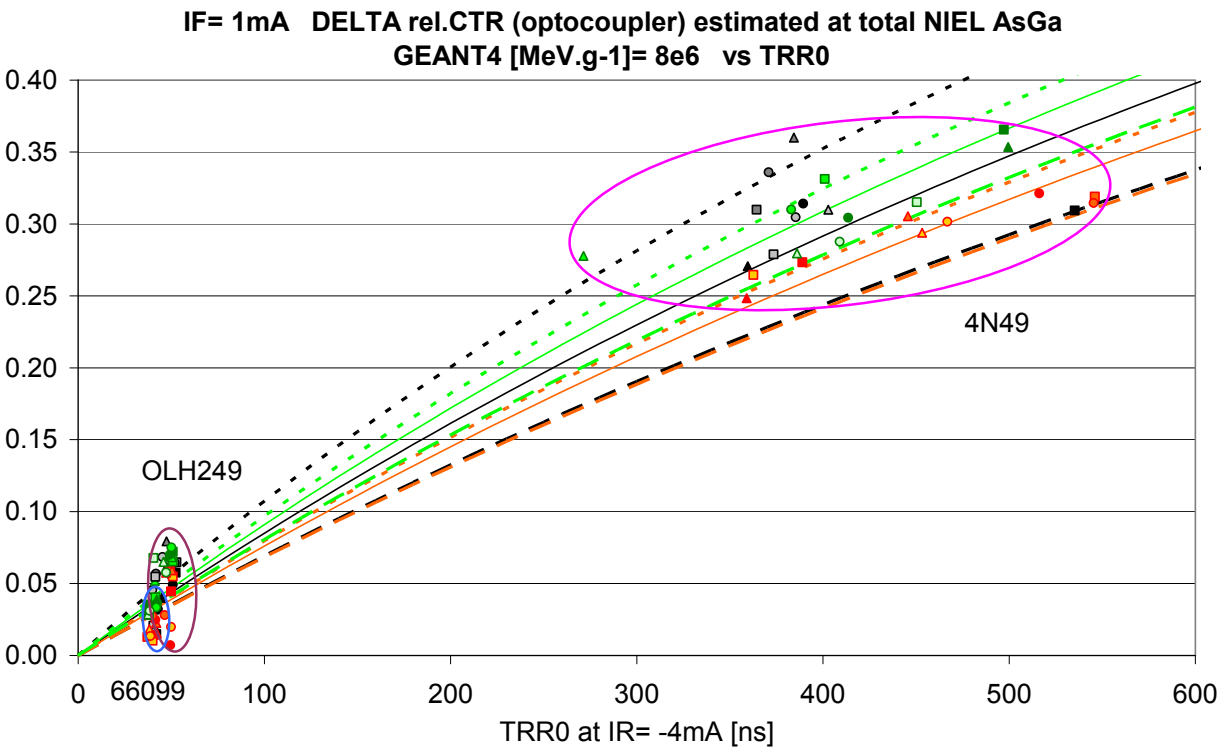
Table 22. "medium" expressions of $(1 - CTR/CTR_0)_{opto}$ as a function of τ_{RR0} and $NIEL_{GEANT4_EL+INEL}$

E [MeV]		60			100			200		
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$
chosen sample		F1 #1	F2 #1	F3 #1	F3 #2	F3 #2	F3 #2	F2#3	F2#3	F3 #3
K_{GEANT4} [g.MeV^{-1}.ns^{-1}		2.35E-11	2.46E-11	2.49E-11	2.17E-11	2.17E-11	2.17E-11	2.67E-11	2.67E-11	2.78E-11
N_{op}	I_F= 1mA	3.85E+00	4.30E+00	4.37E+00	4.11E+00	4.11E+00	4.11E+00	3.98E+00	3.98E+00	3.85E+00
	I_F= 10mA	2.36E+00	3.02E+00	3.03E+00	2.85E+00	2.85E+00	2.85E+00	2.73E+00	2.73E+00	2.84E+00

Table 23. Values of (N_{op}, K) of chosen 4N49 samples for "lowest point" curves

"E [MeV]		60			100			200		
interpolation NIEL [MeV.g^{-1}]		8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$	8.10^6	$2.7.10^7$	$4.88.10^7$
chosen sample		F2#2	F2#2	F3 #2	F2 #2	F2 #2	F3 #3	F3 #2	F3 #2	F3 #2
K_{GEANT4} [g.MeV^{-1}.ns^{-1}		3.95E-11	3.95E-11	3.05E-11	2.74E-11	2.74E-11	2.43E-11	3.19E-11	3.19E-11	3.19E-11
N_{op}	I_F= 1mA	3.65E+00	3.65E+00	4.29E+00	3.83E+00	3.83E+00	4.09E+00	4.03E+00	4.03E+00	4.03E+00
	I_F= 10mA	2.53E+00	2.53E+00	3.05E+00	2.55E+00	2.55E+00	2.81E+00	2.95E+00	2.95E+00	2.95E+00

Table 24. Values of (N_{op},K) of chosen 4N49 samples for "highest point" curves



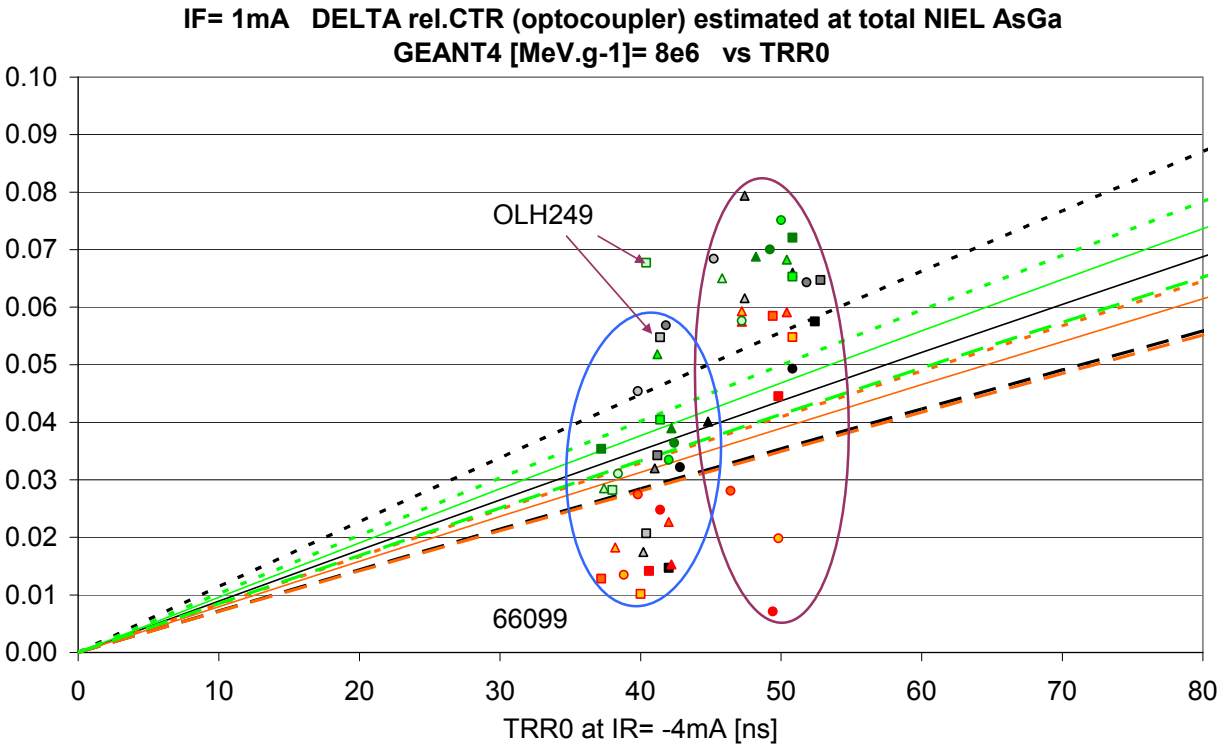


Fig. 7-7. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

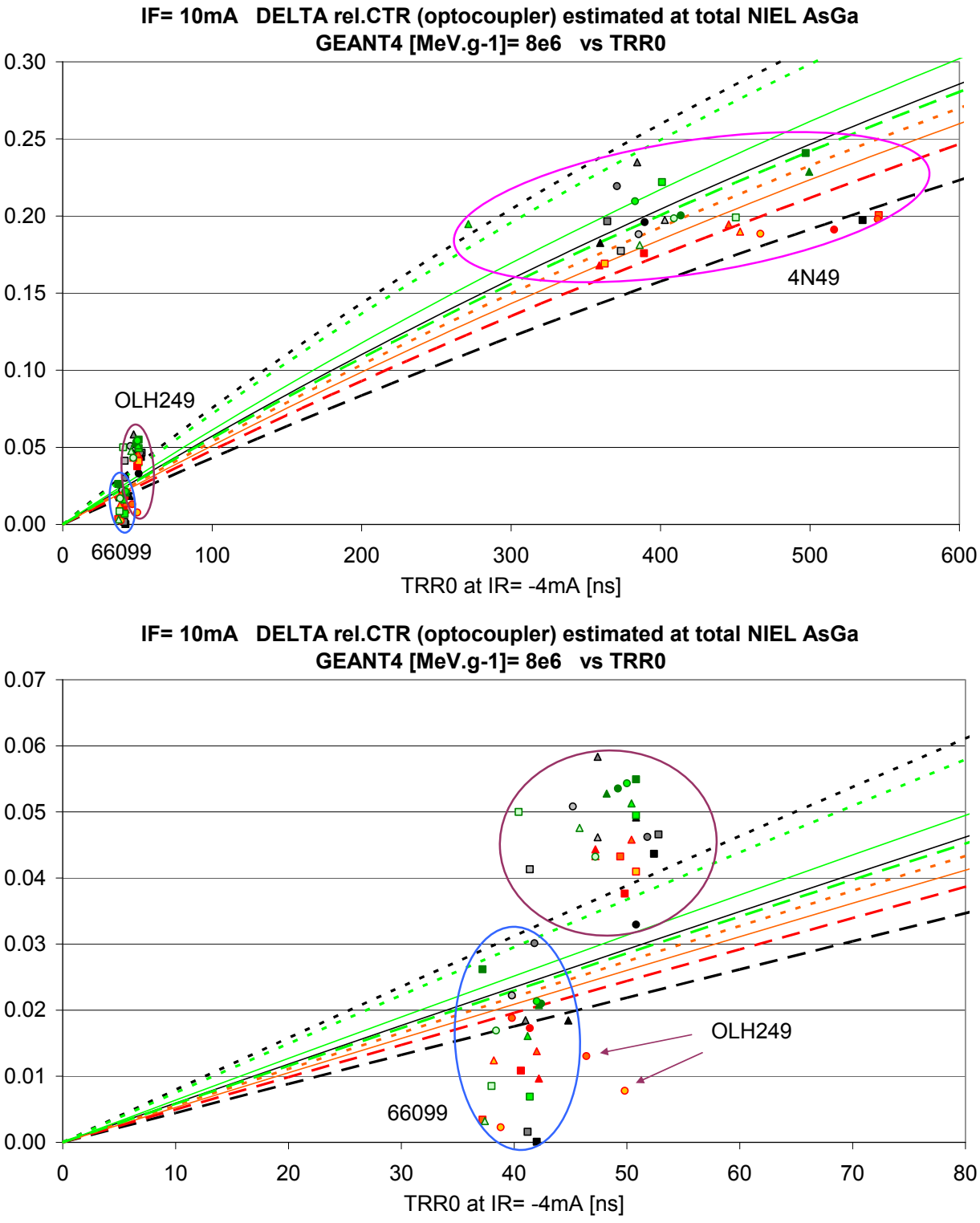
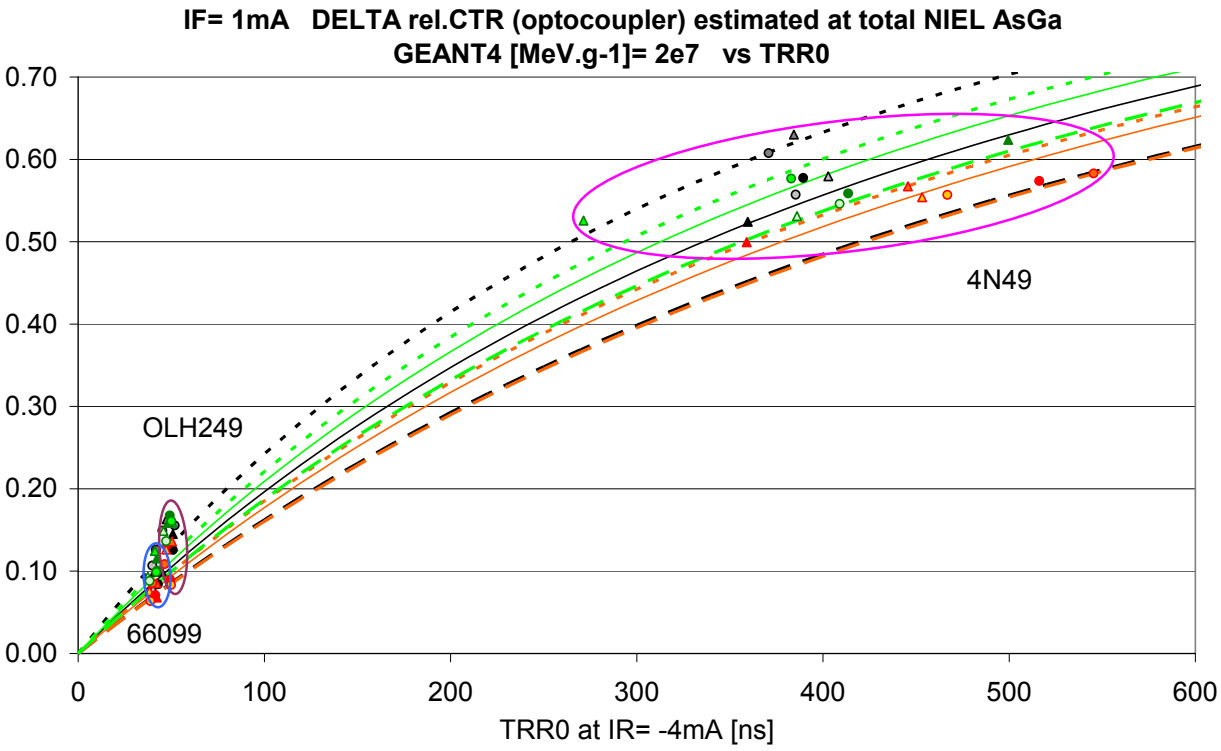


Fig. 7-8. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



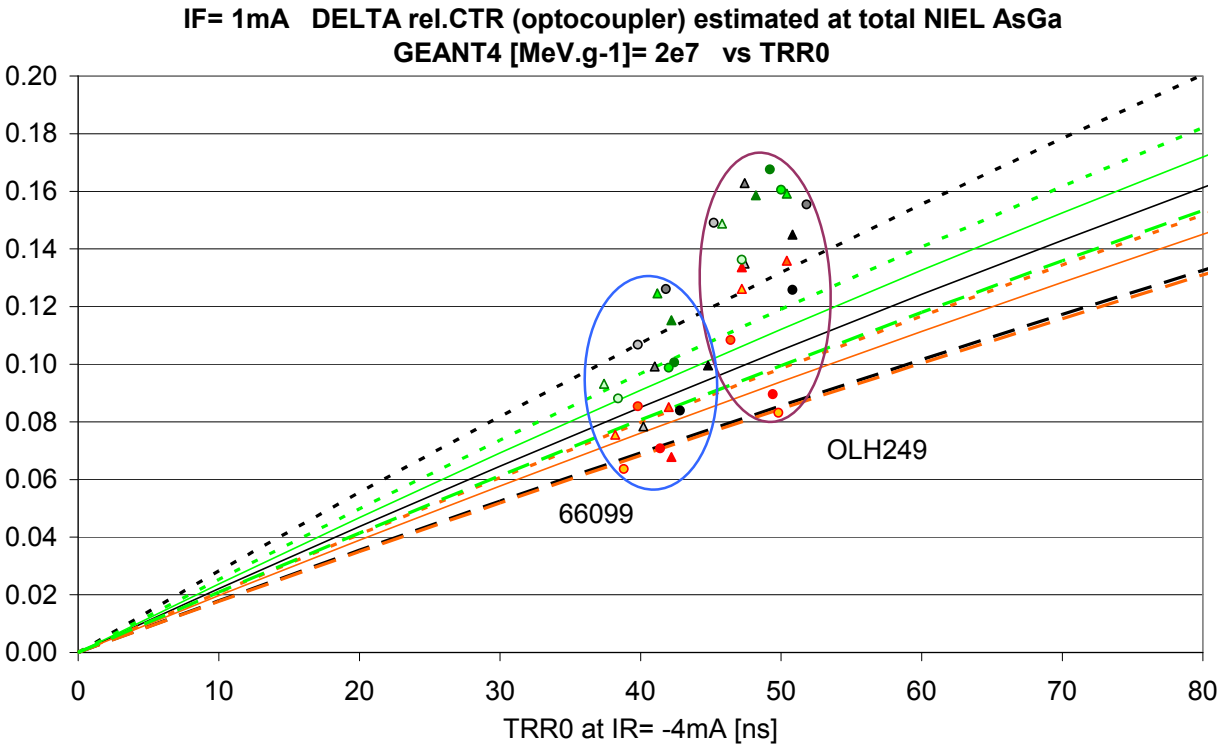
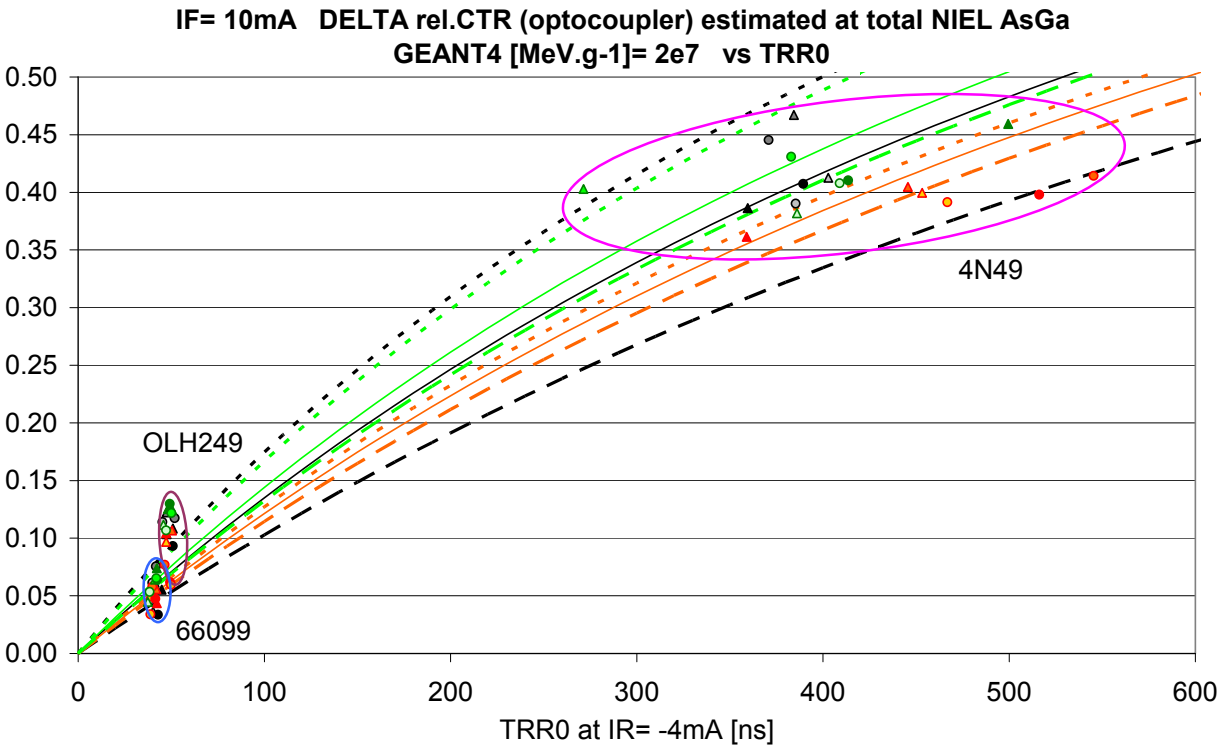


Fig. 7-9. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



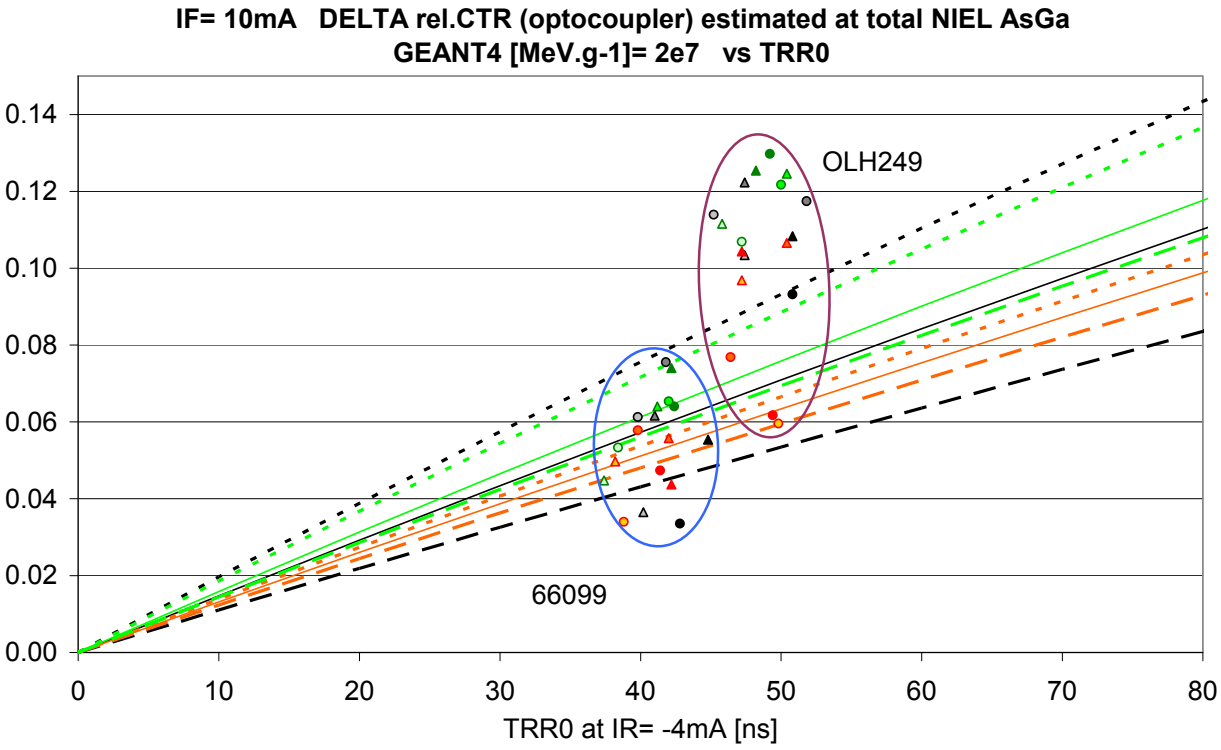
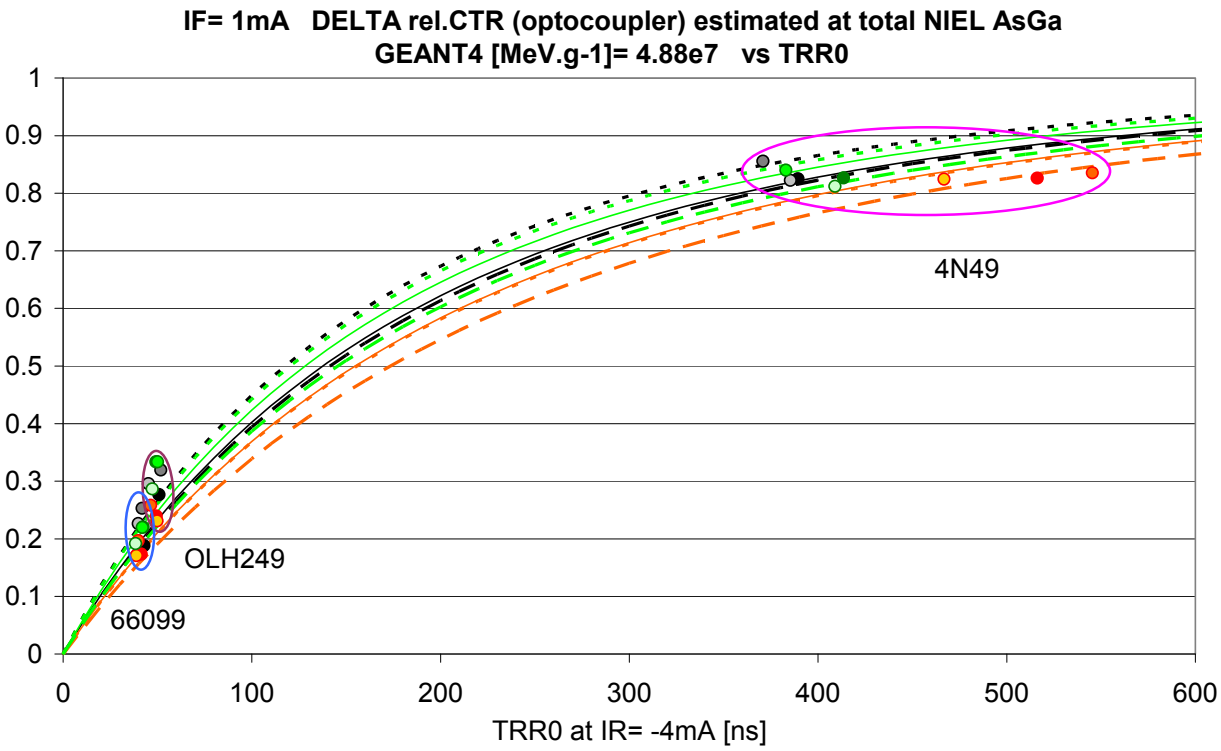


Fig. 7-10. 1 – CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



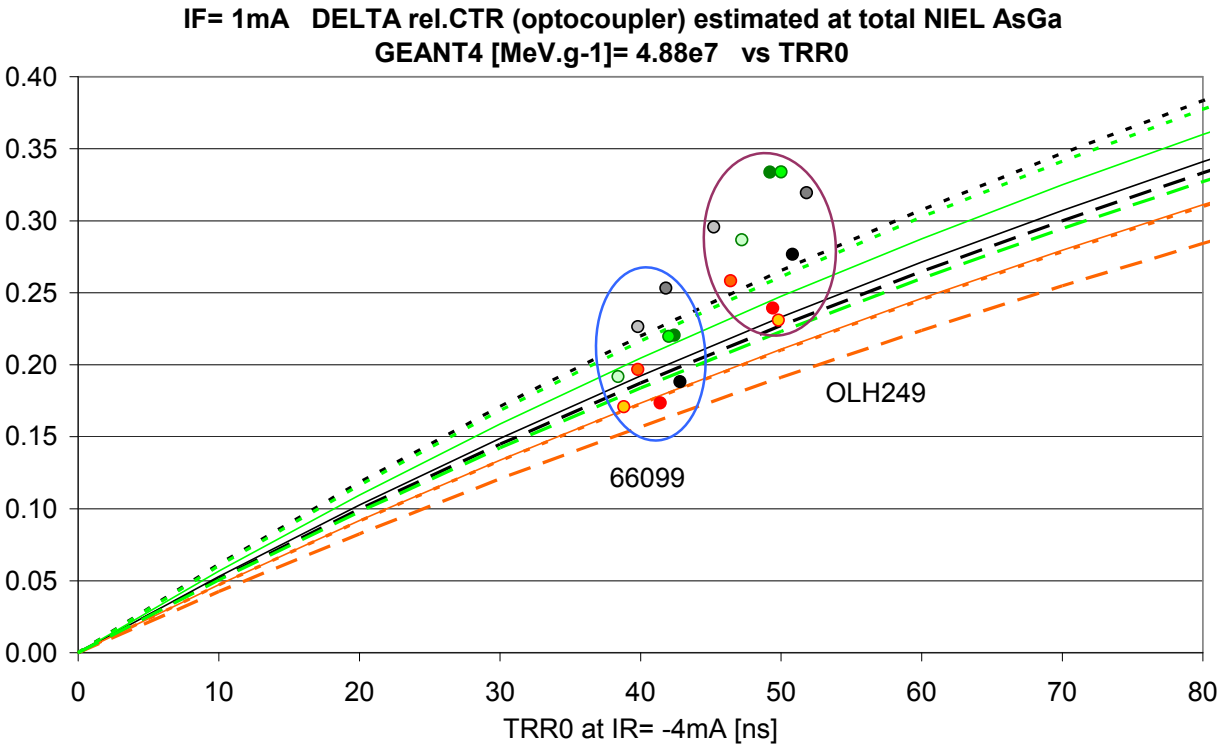
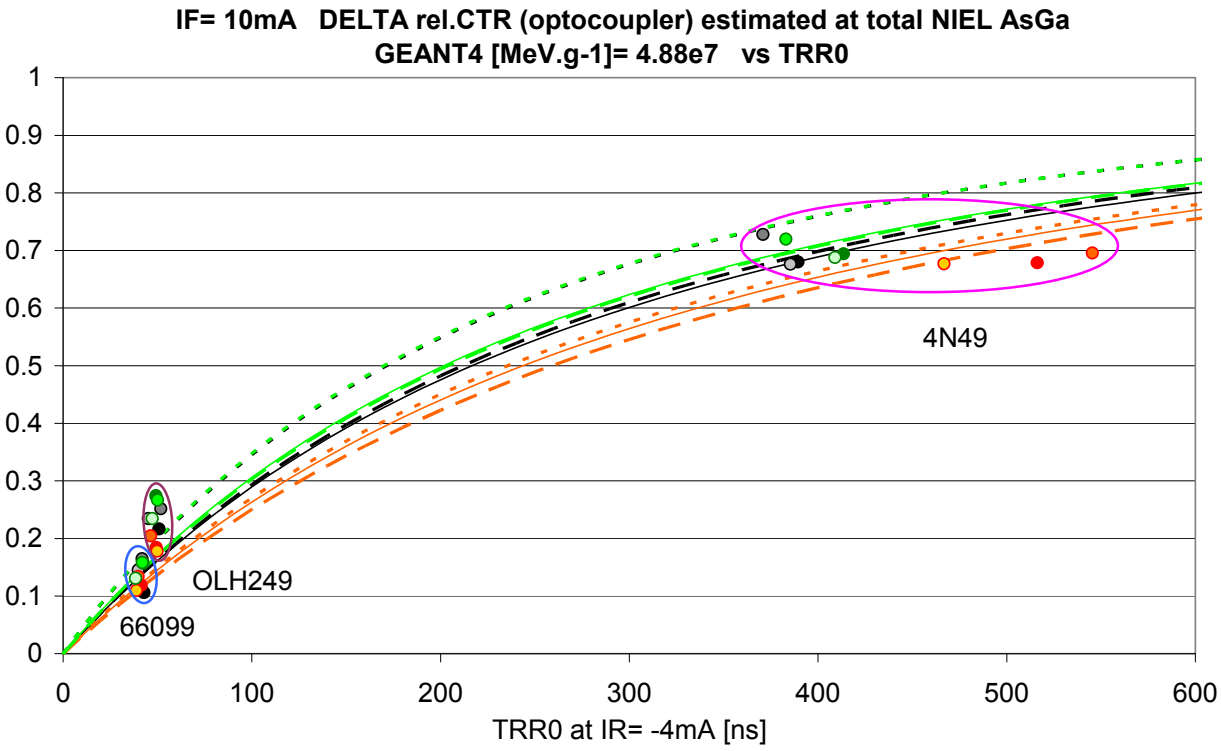


Fig. 7-11. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



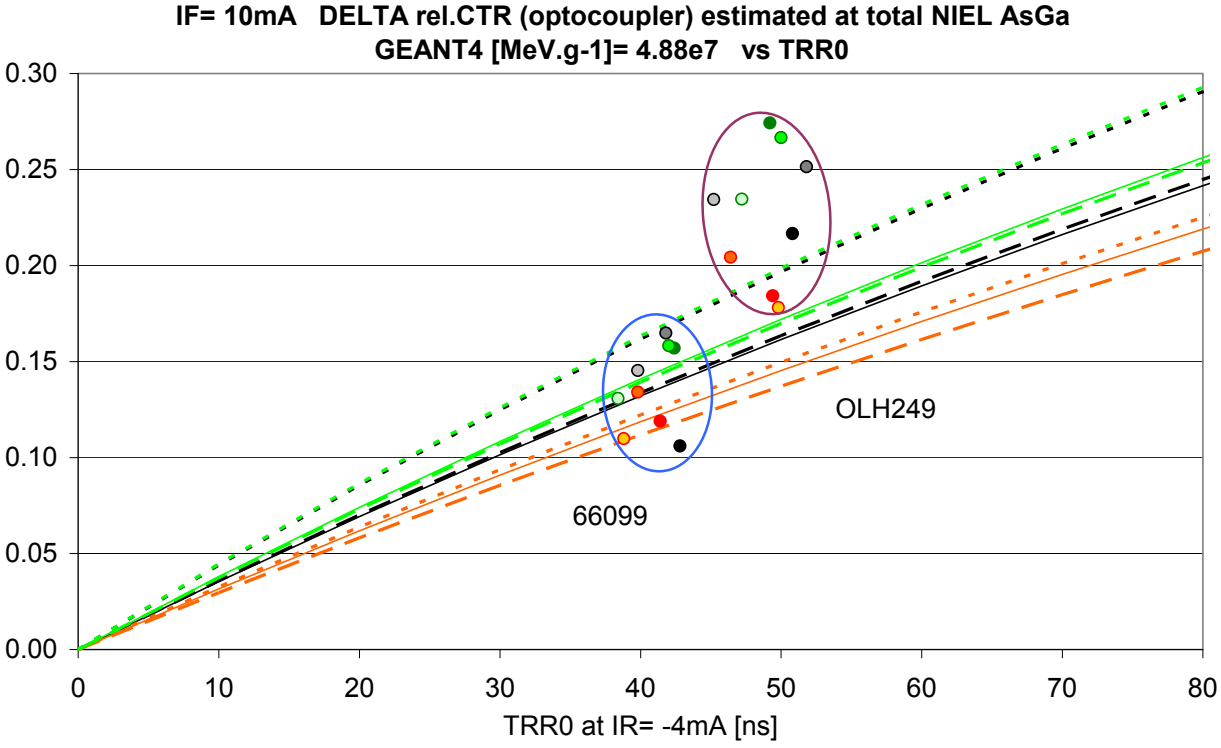
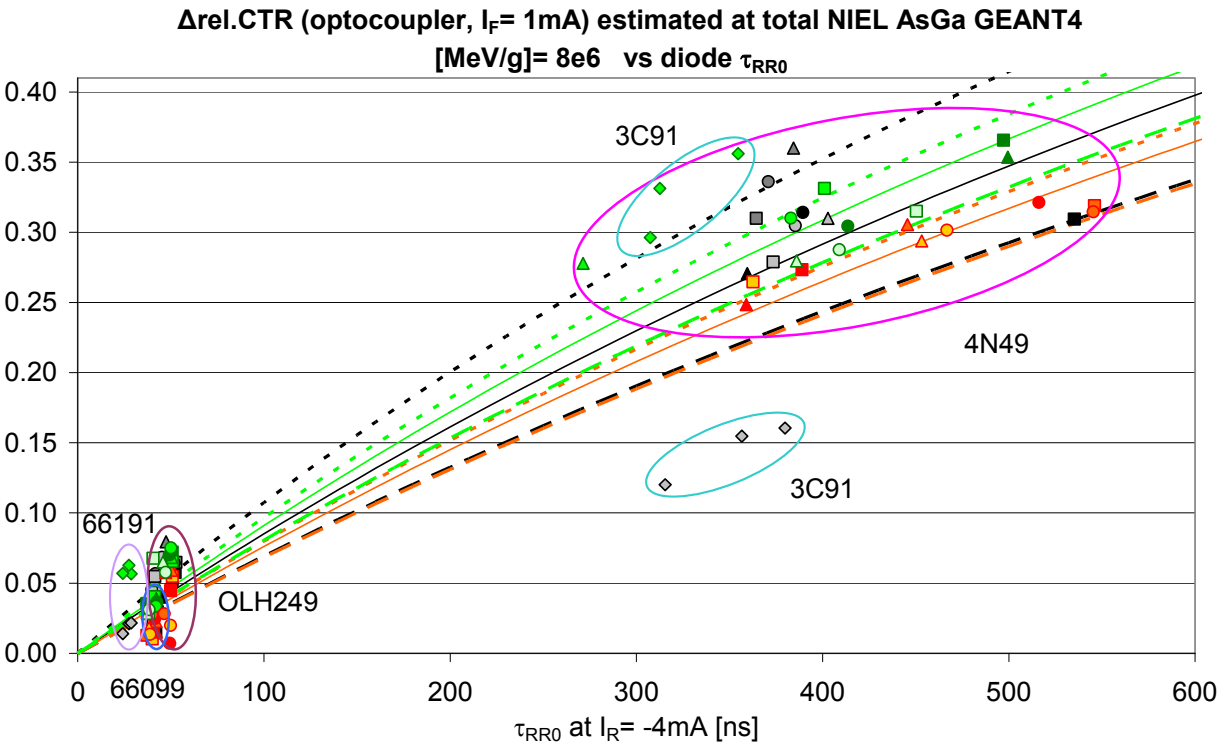


Fig. 7-12. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ MeV.g^{-}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

3C91 and 66191 optocouplers (that are not part of this study) degradations are plotted on same graphs (Fig. 7-13 to Fig. 7-18) as per 4N49 plots. It is noticeable that 3C91 and 66191 optocoupler's degradation can be estimated from 4N49 diode equations, excepted at 200 MeV, for reasons still unclear.



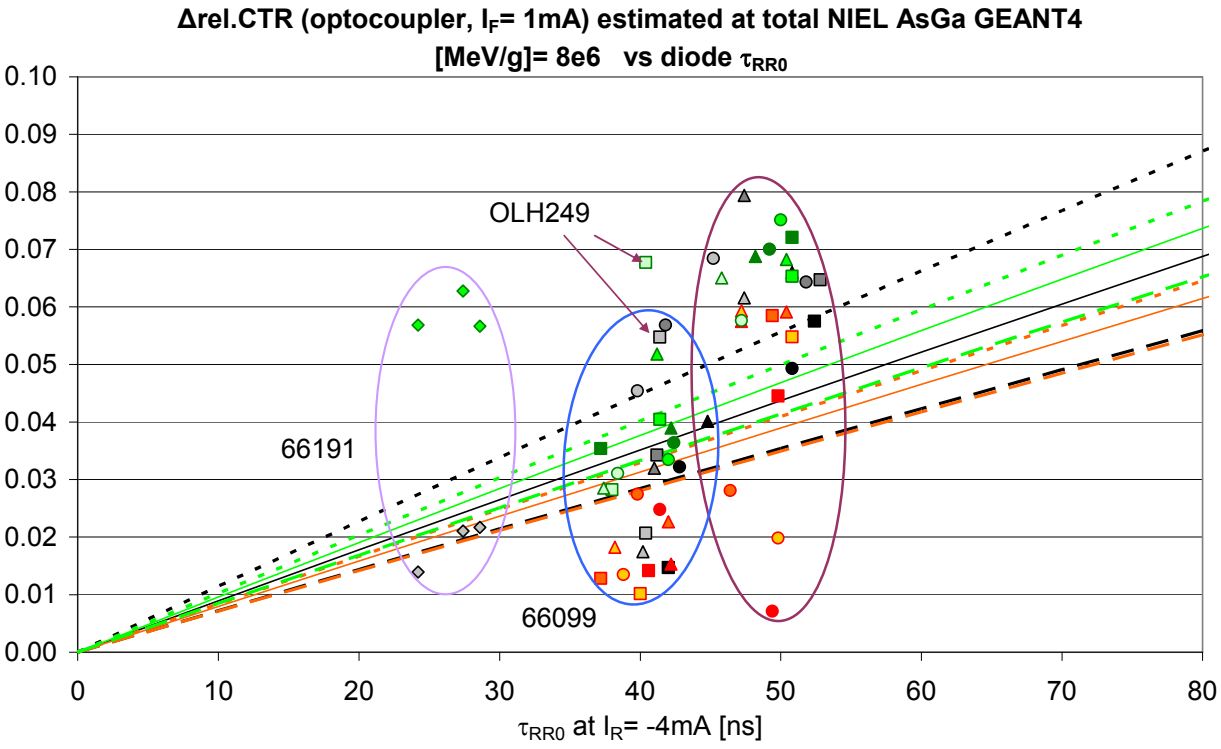
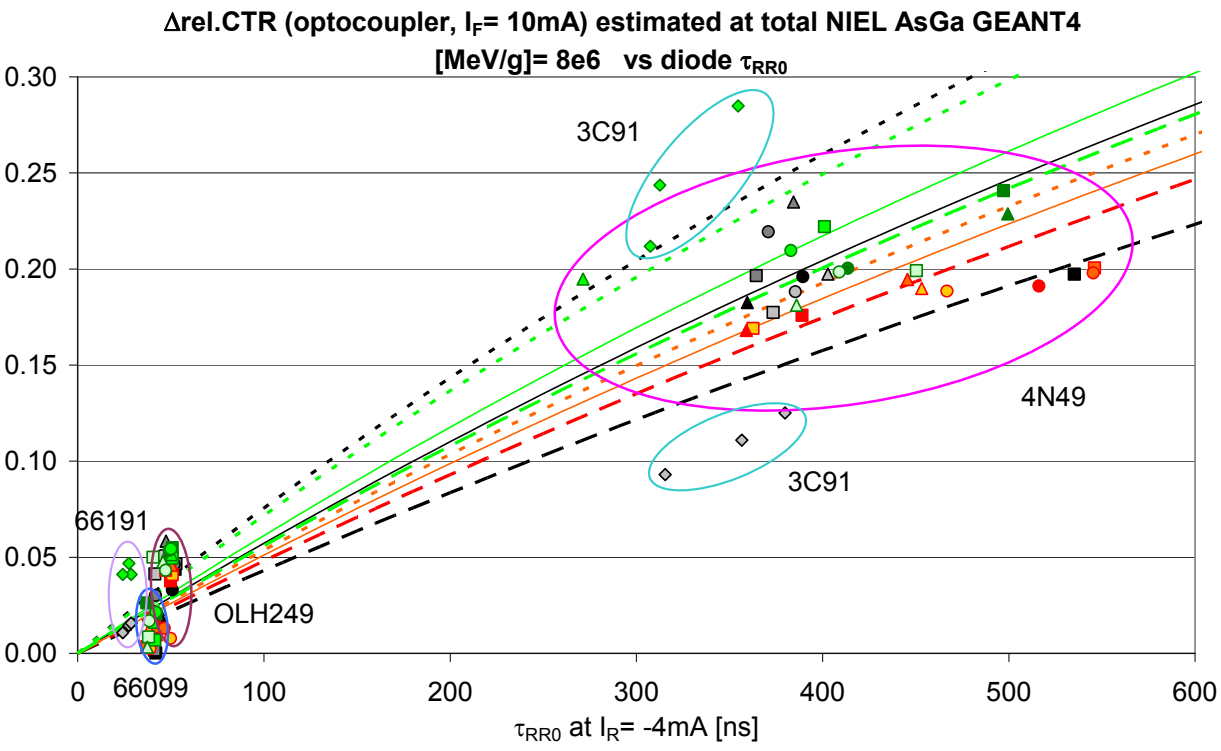


Fig. 7-13. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations



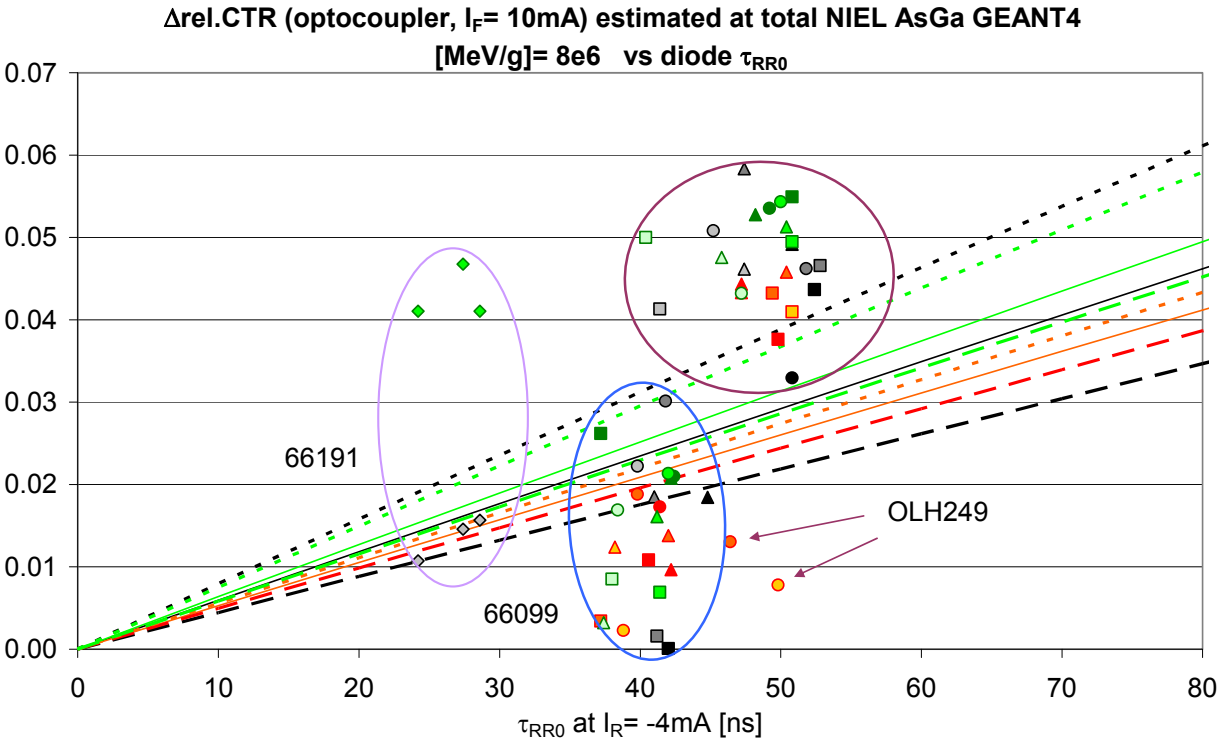
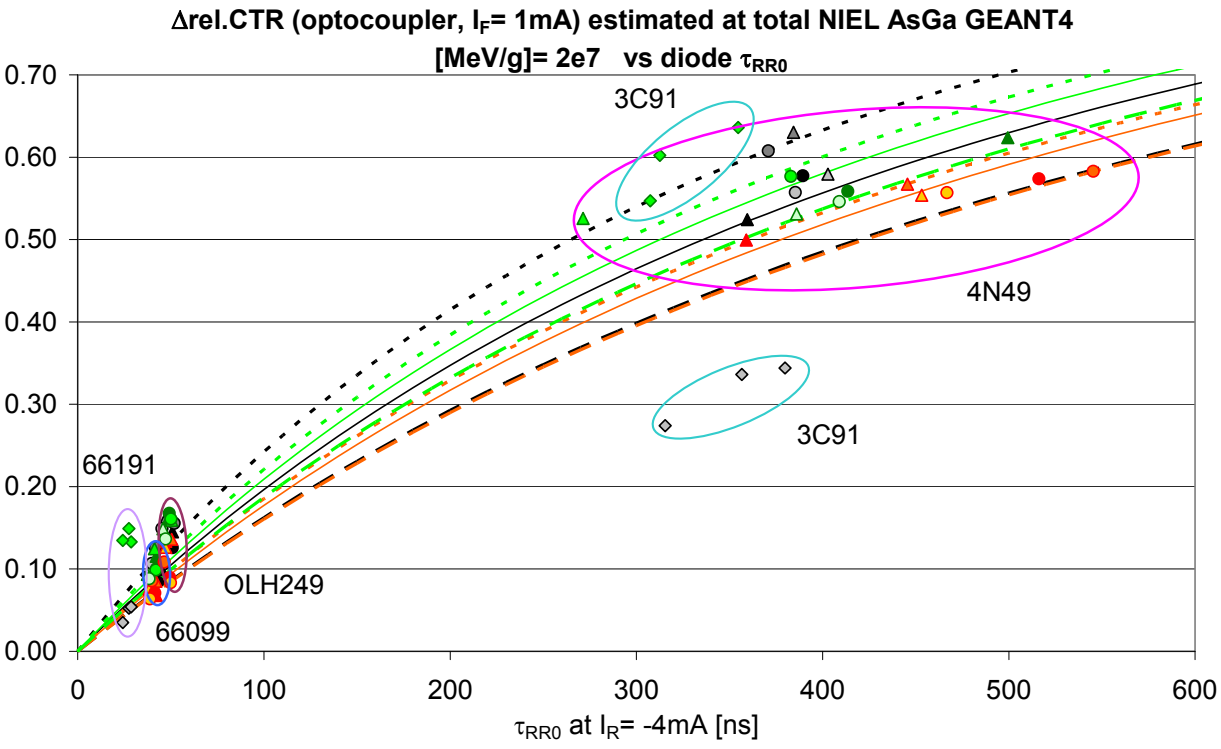


Fig. 7-14. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations



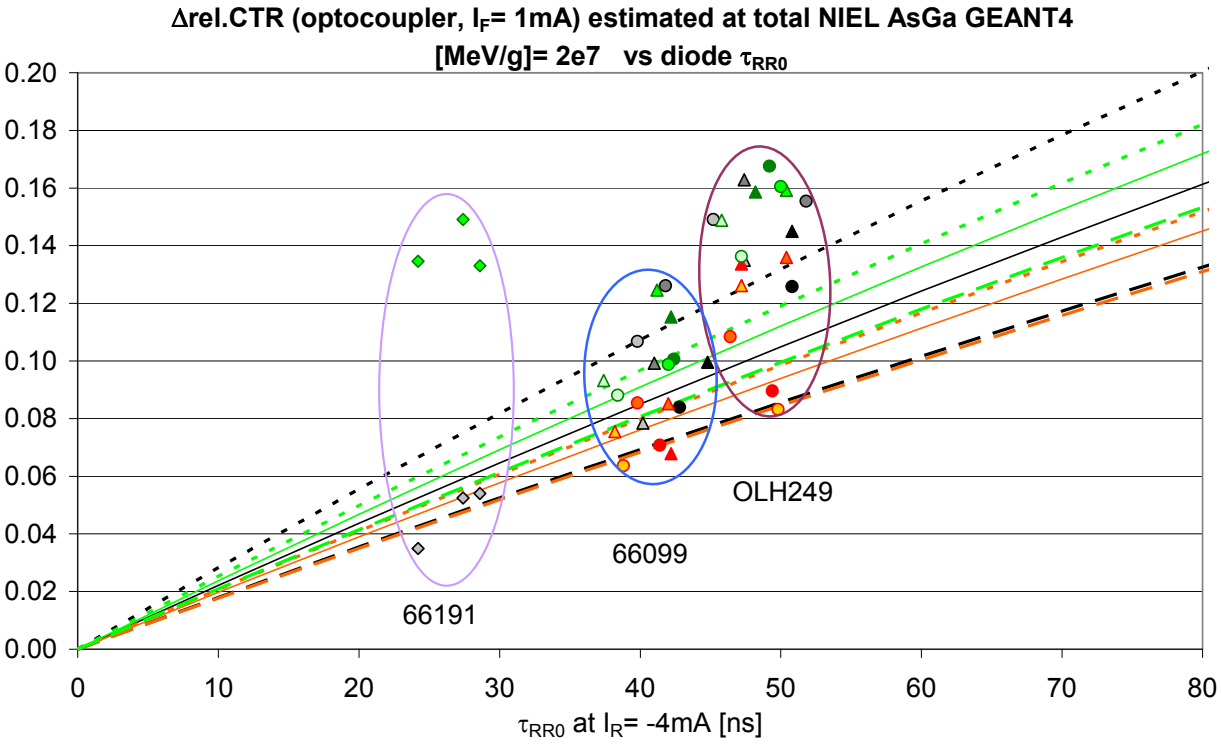
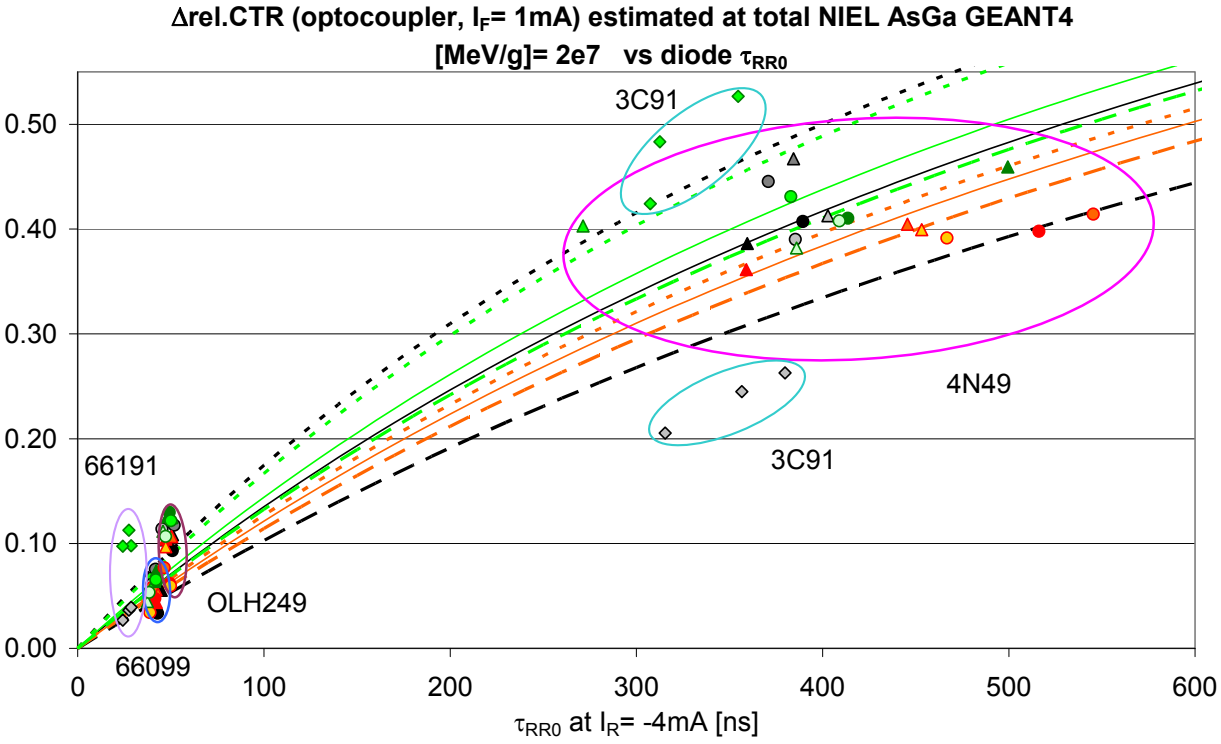


Fig. 7-15. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations



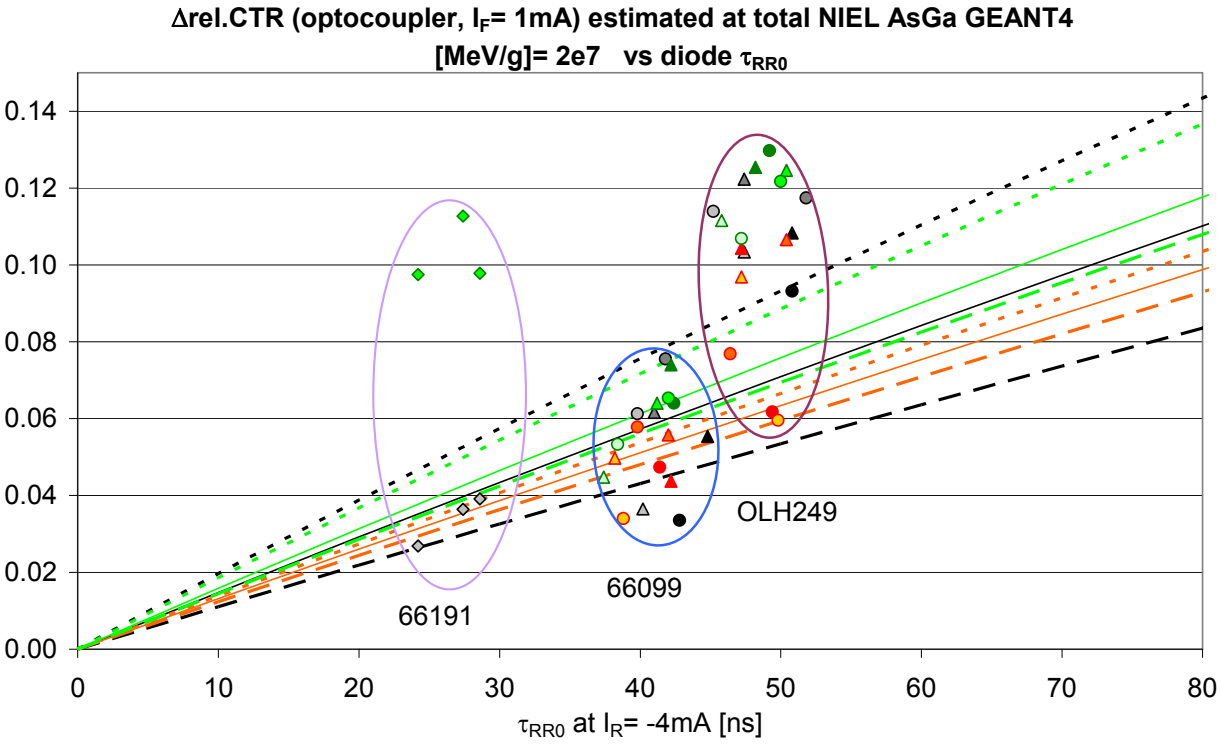
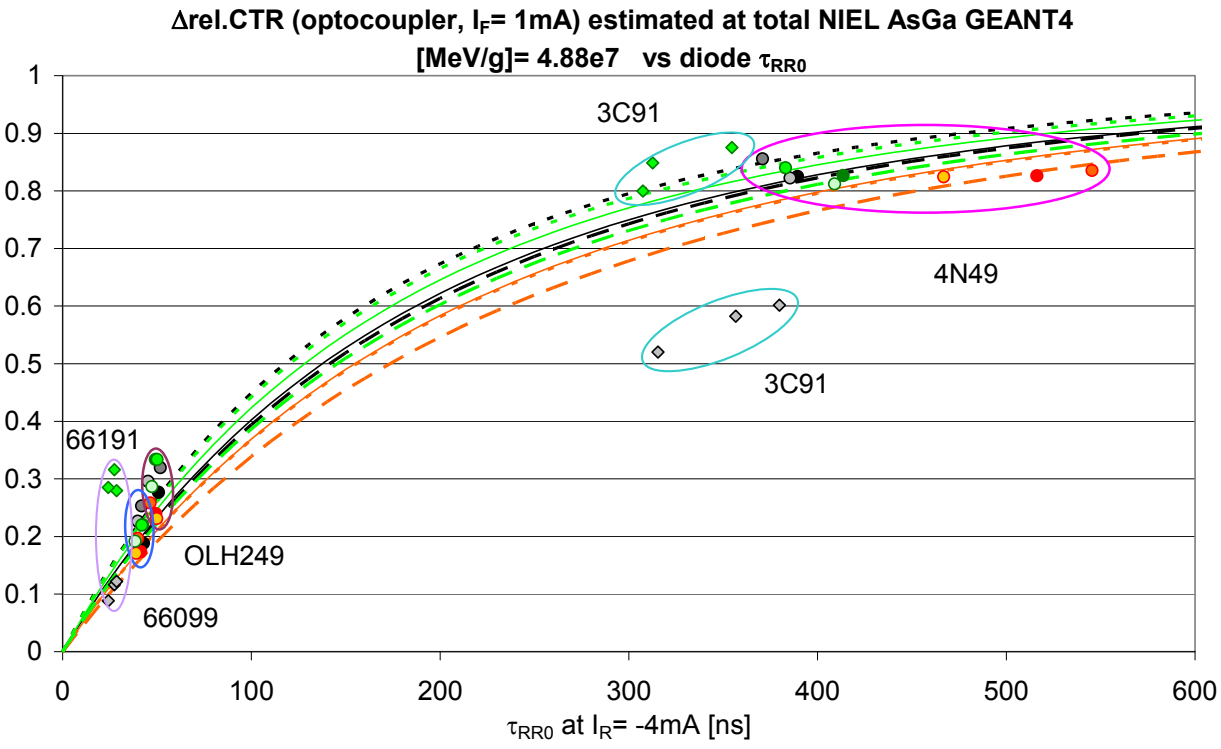


Fig. 7-16. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 MeV.g^{-1}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations



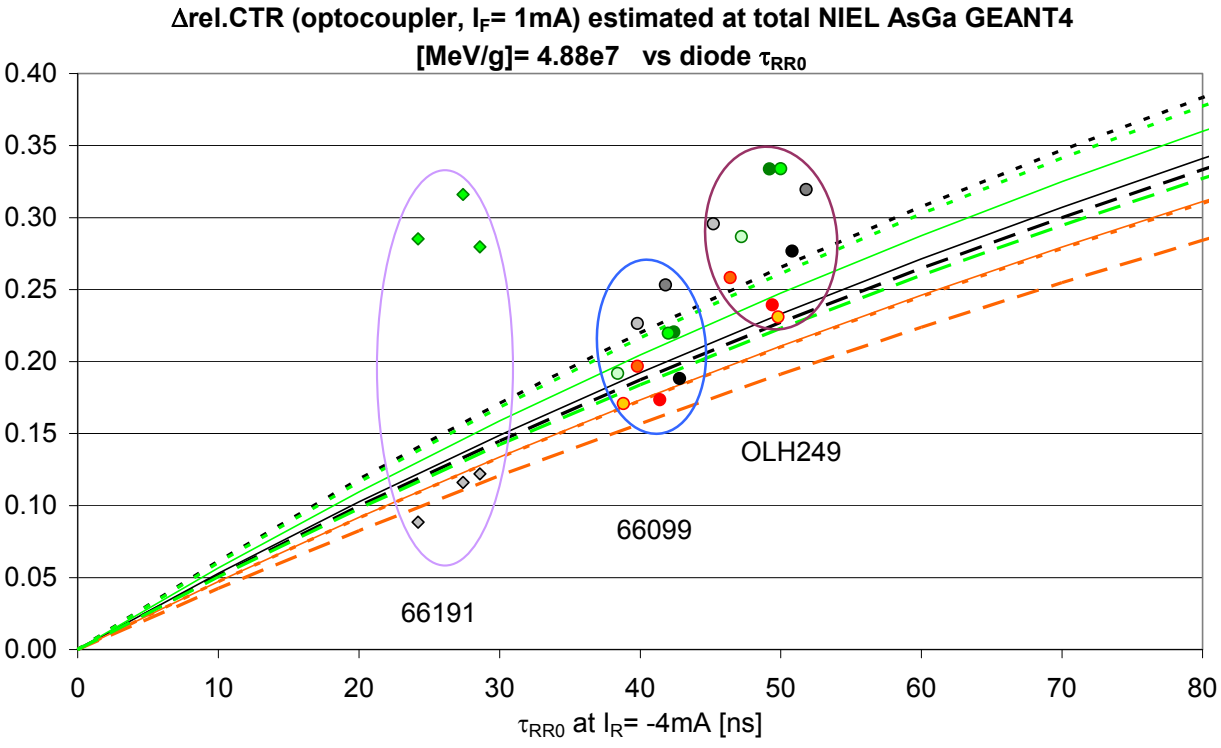
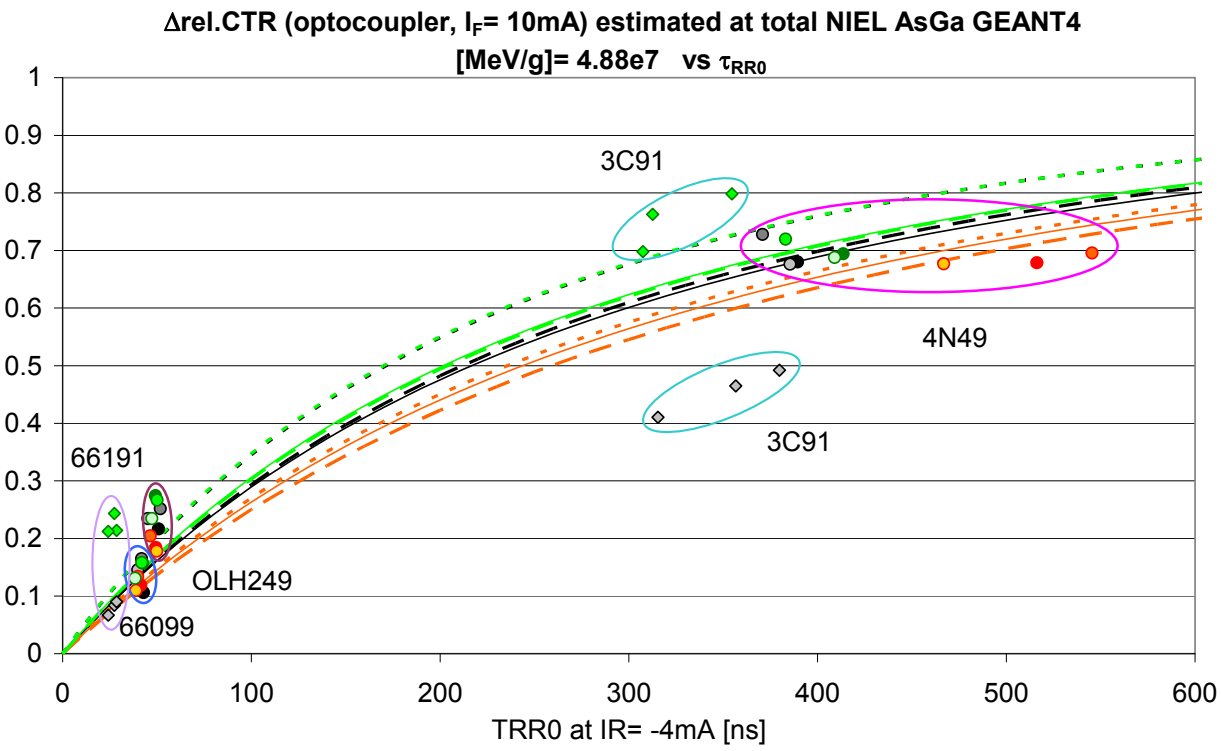


Fig. 7-17. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ MeV.g^{-1}1 (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations



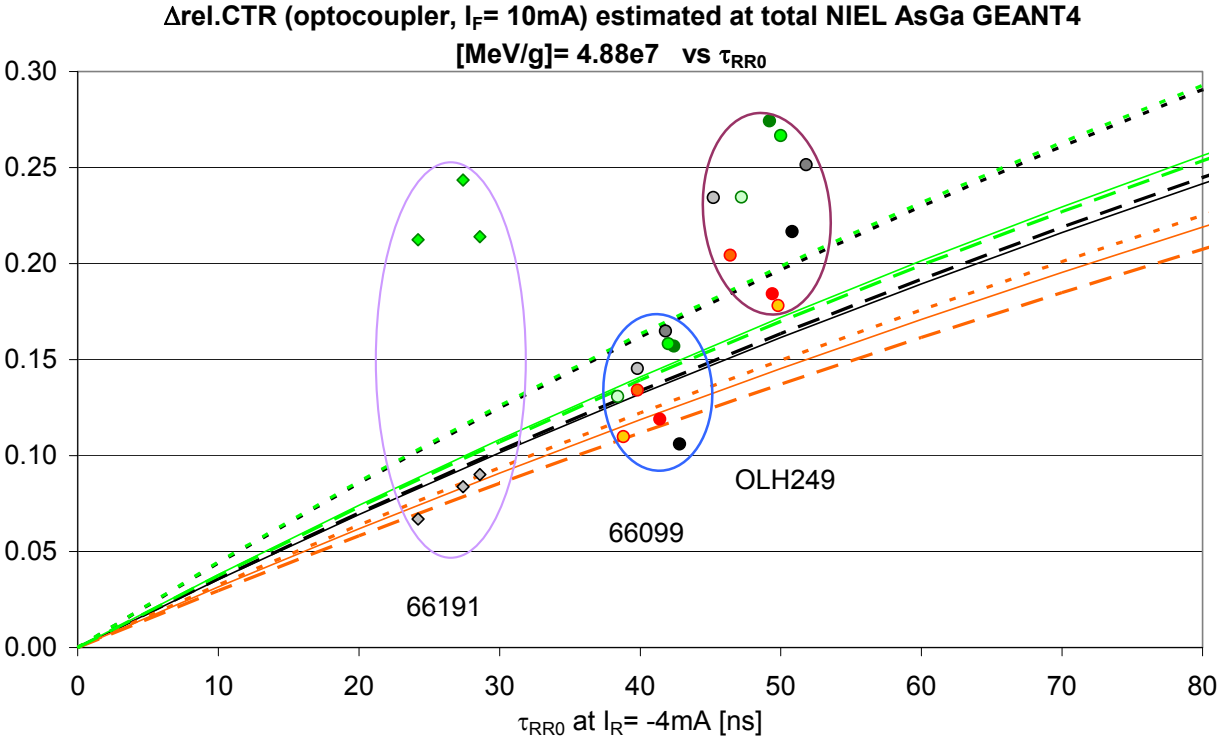


Fig. 7-18. $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ MeV.g^{-1}1 (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves, and 66191 and 3C91 degradations

7.3 NIEL FROM BARRY'S TABLES

Same N values as in 7.1 and same K values as in 6.3.

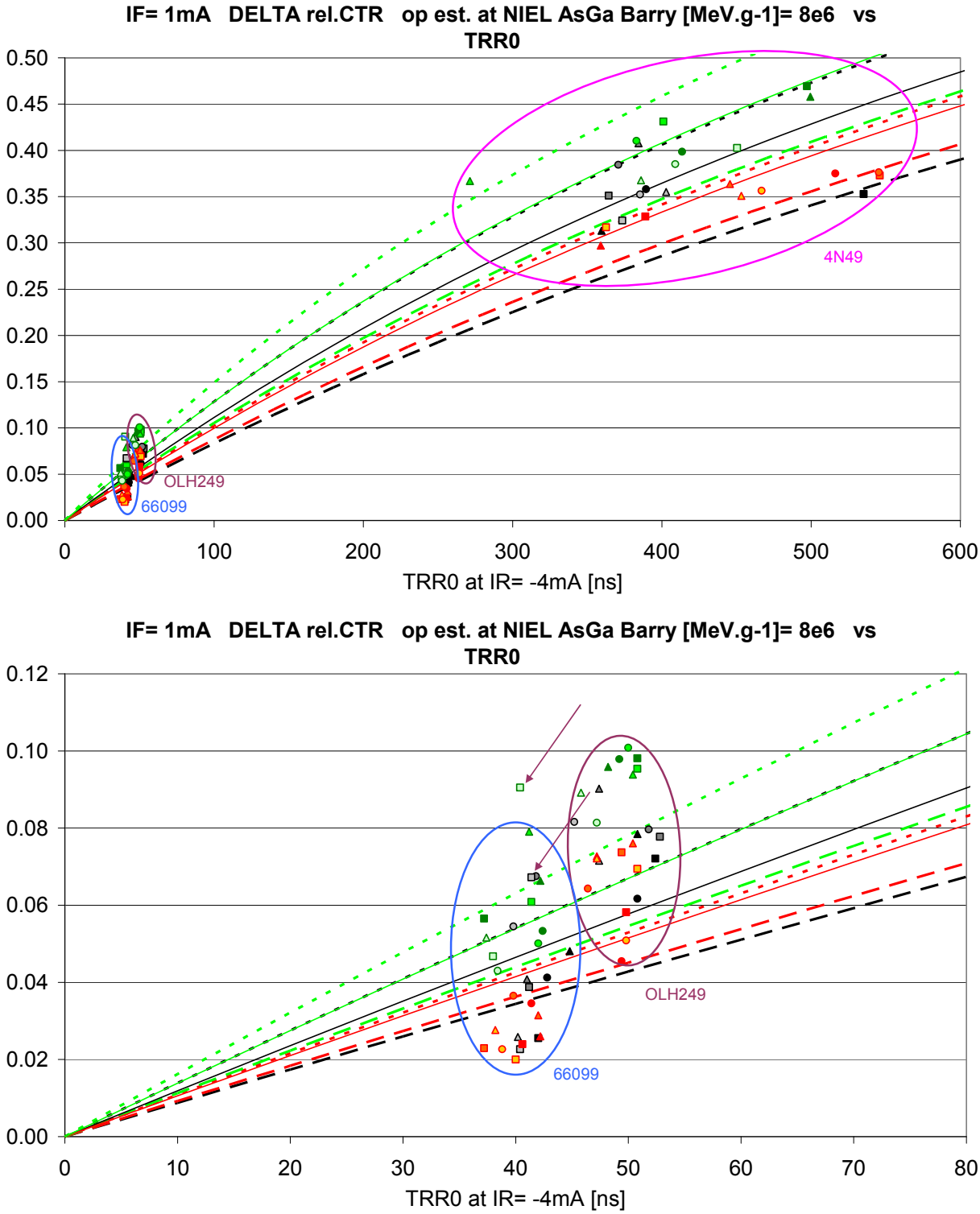
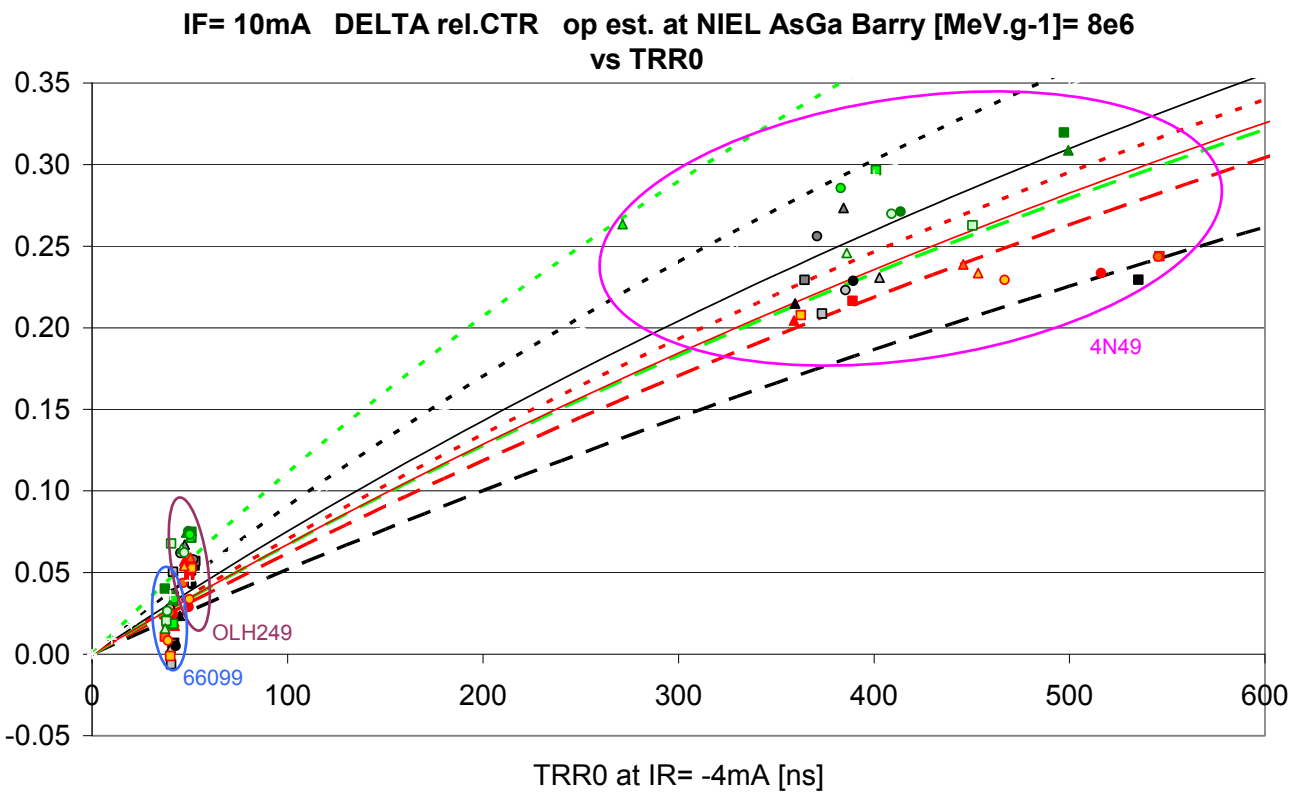


Fig. 7-19: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



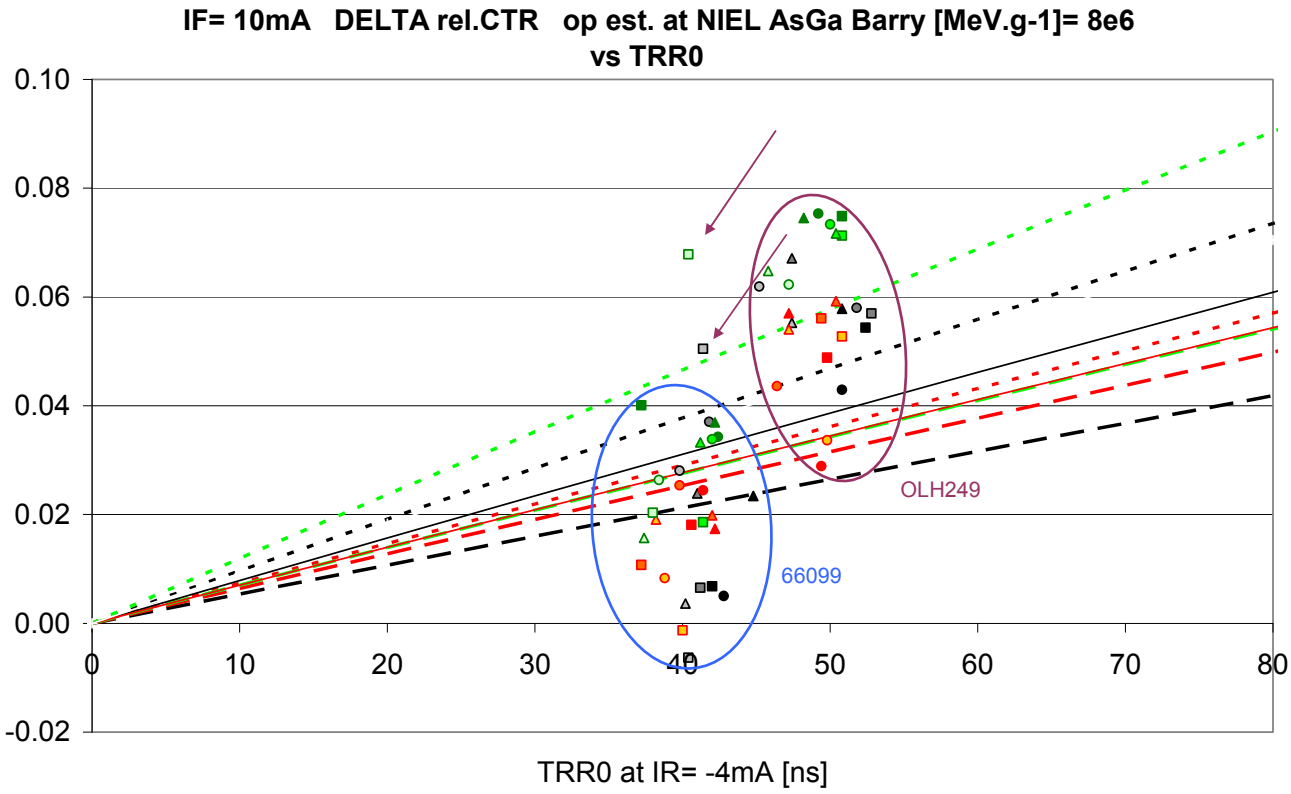
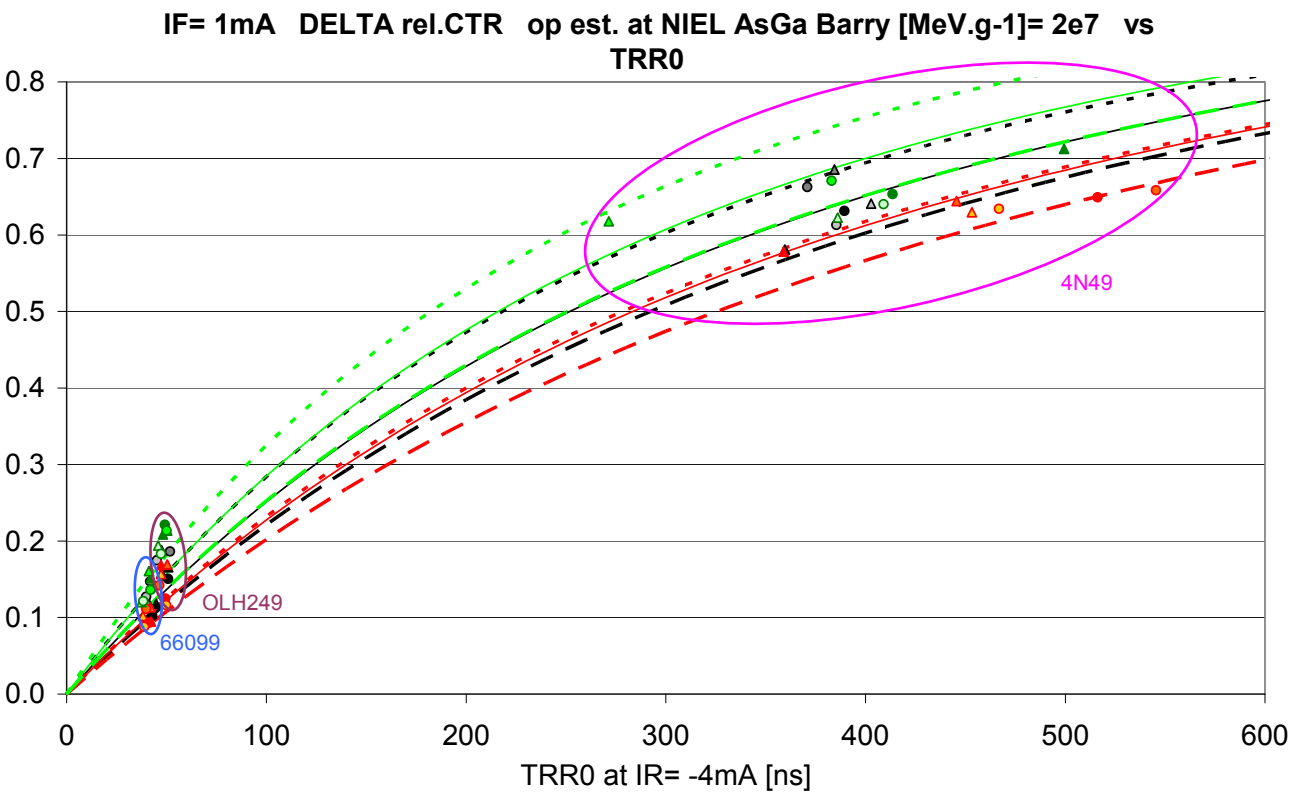


Fig. 7-20: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



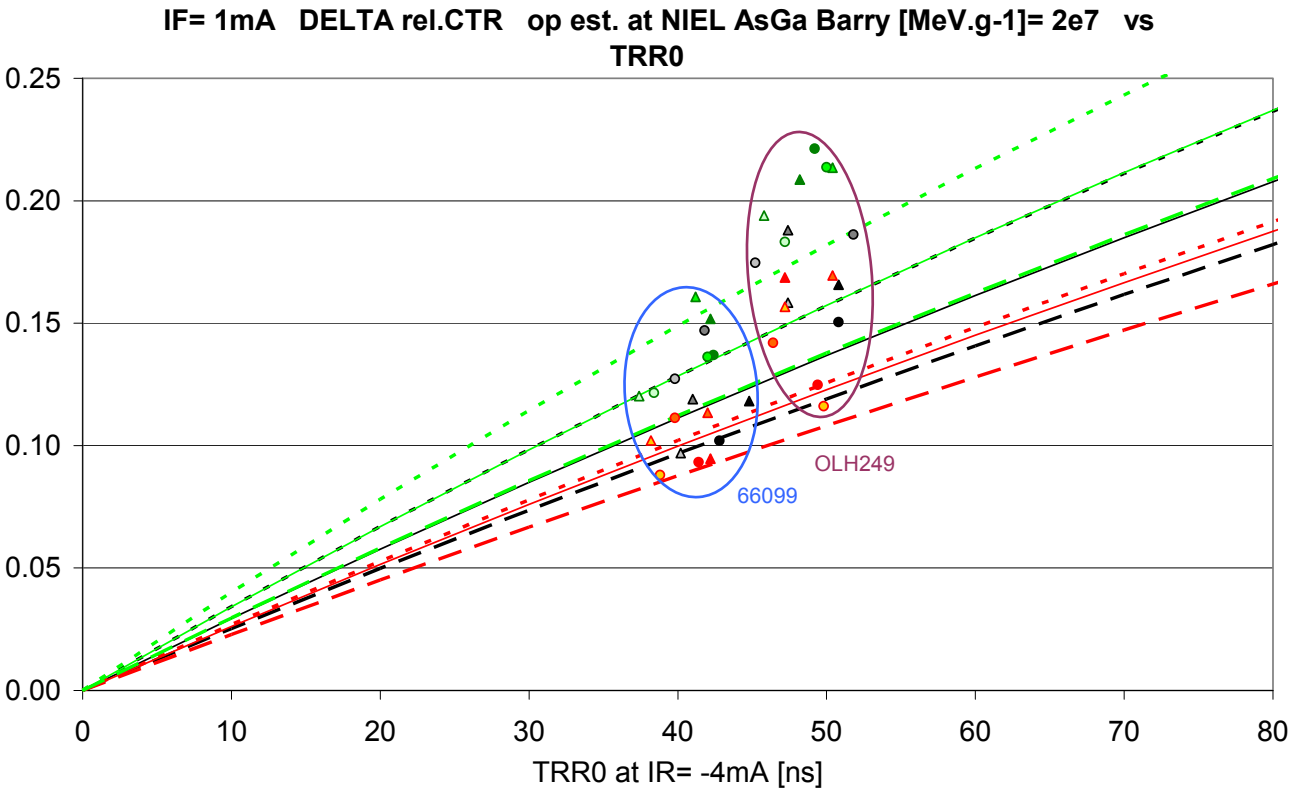
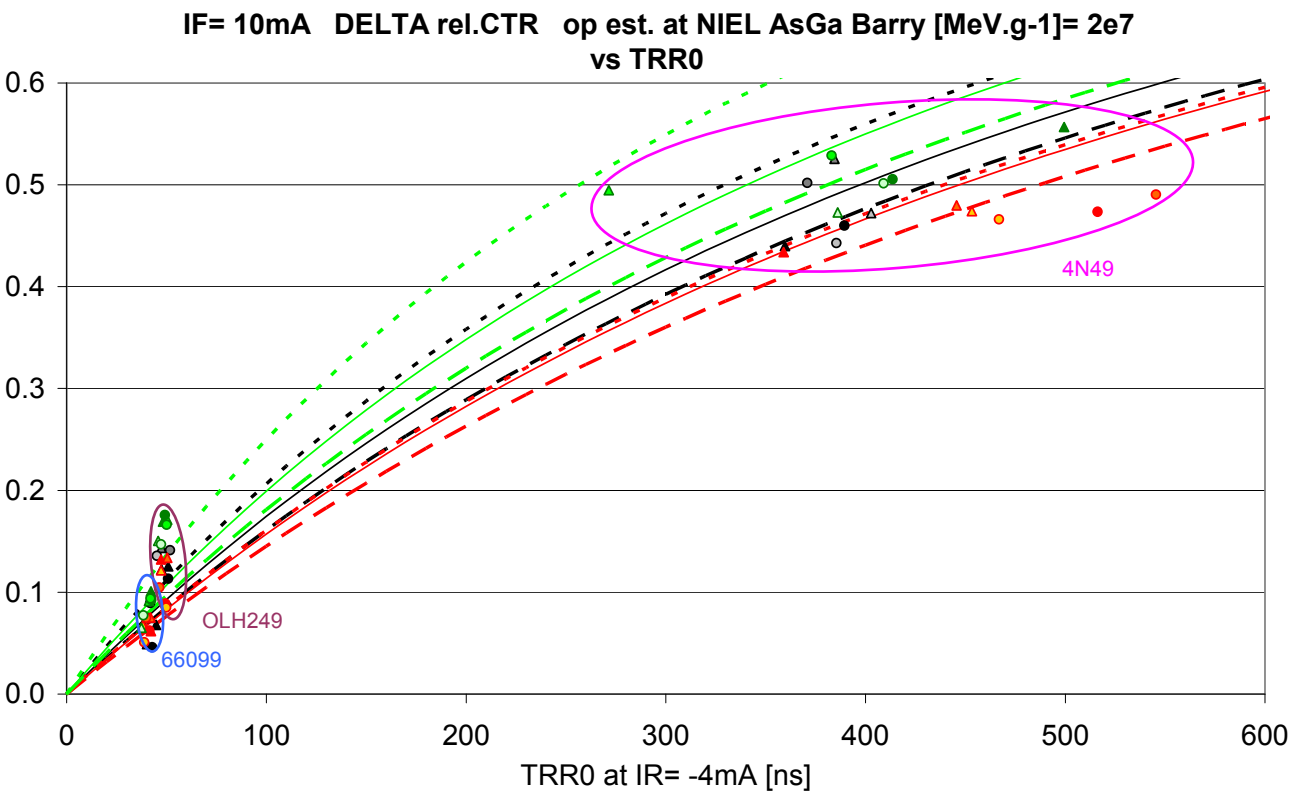


Fig. 7-21: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 $MeV.g^{-1}$ (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



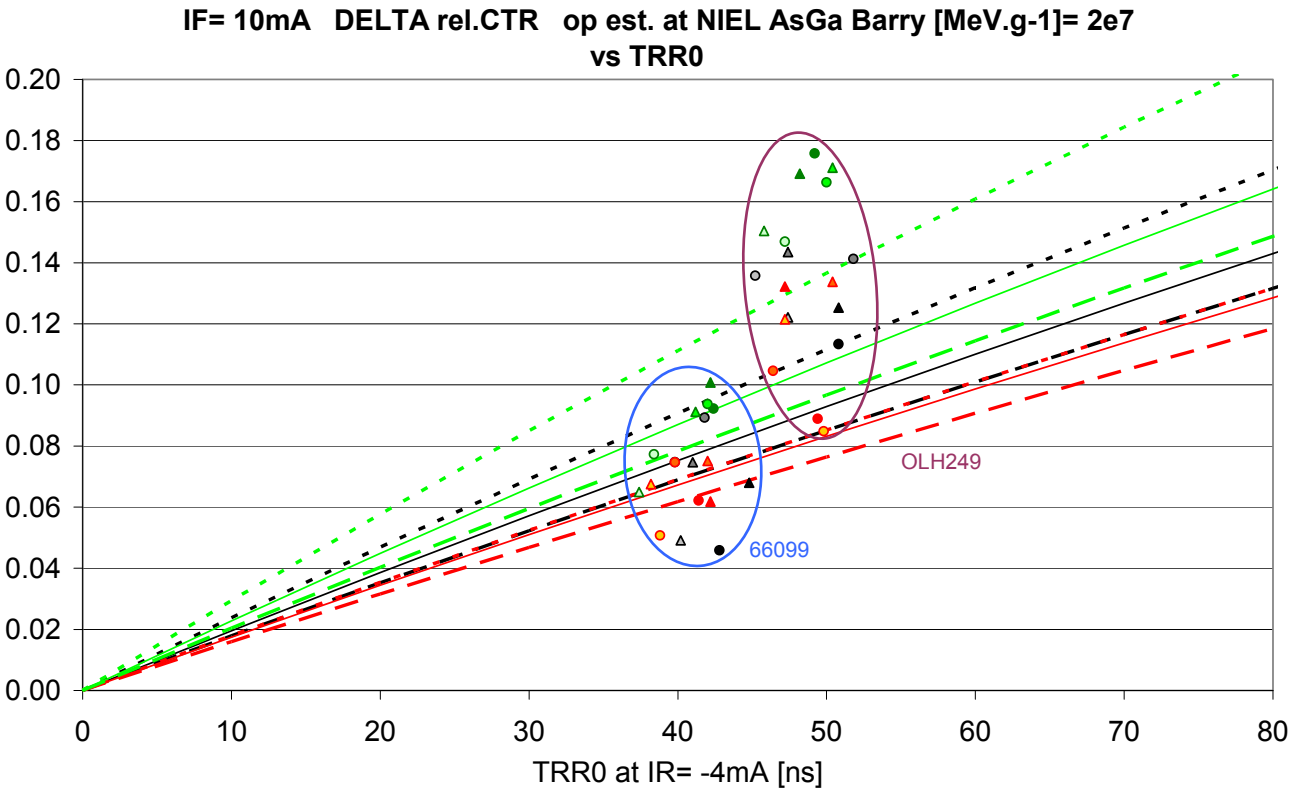
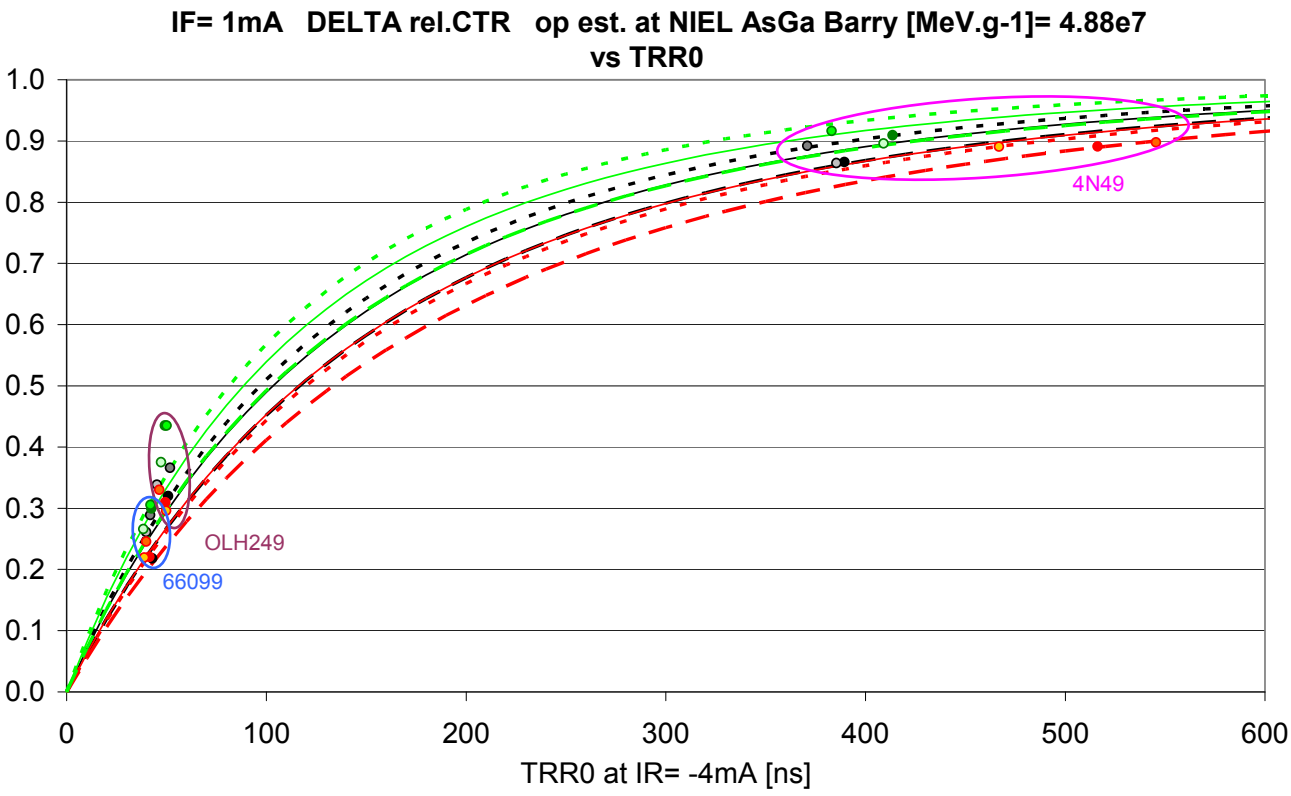


Fig. 7-22: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of 2.10^7 $MeV.g^{-1}$ (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



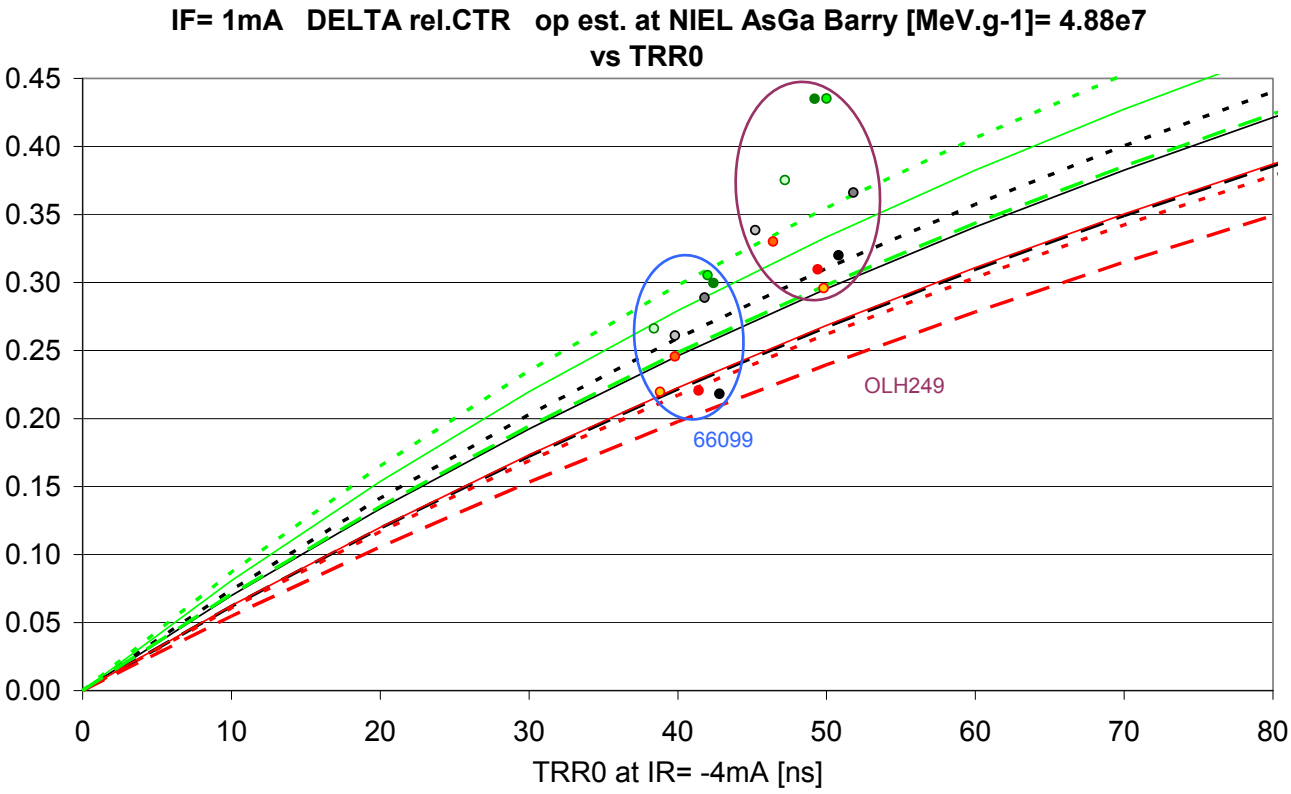
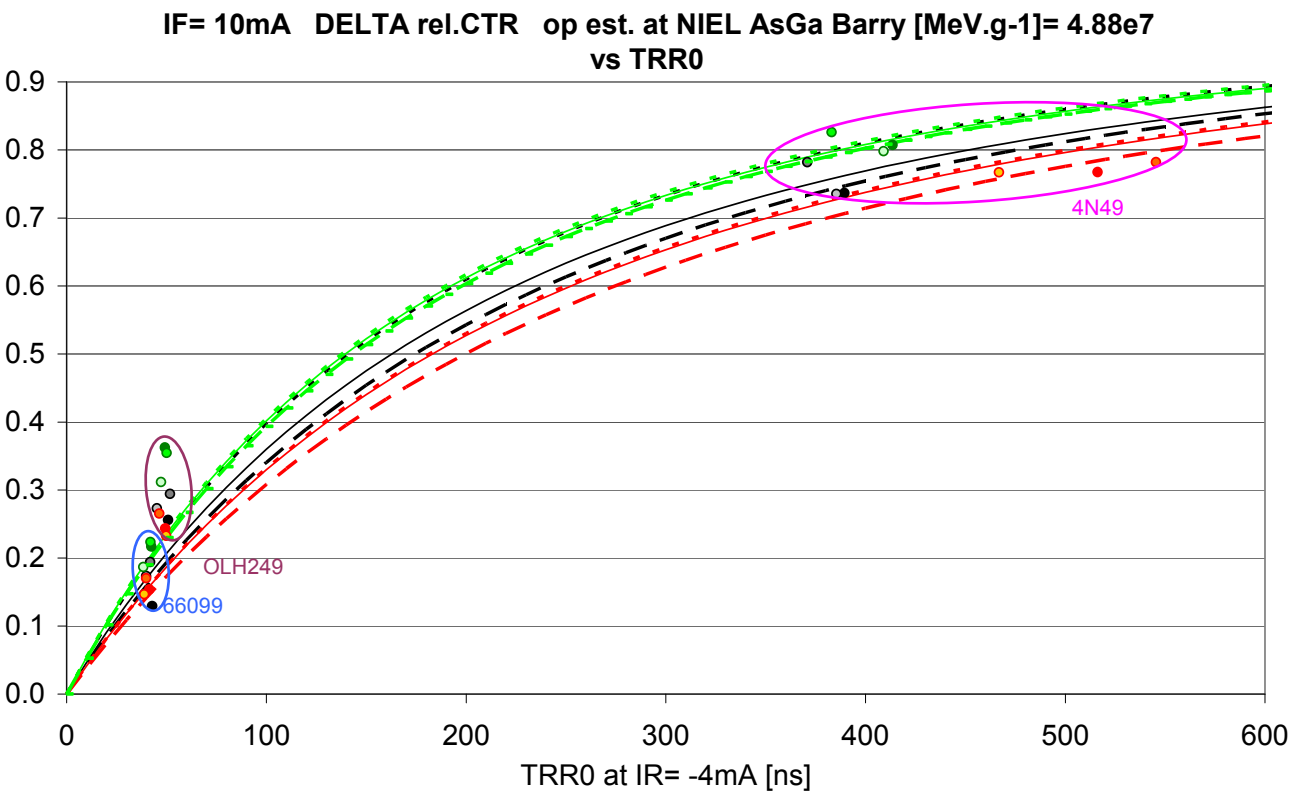


Fig. 7-23: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ $MeV.g^{-1}$ (Barry) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



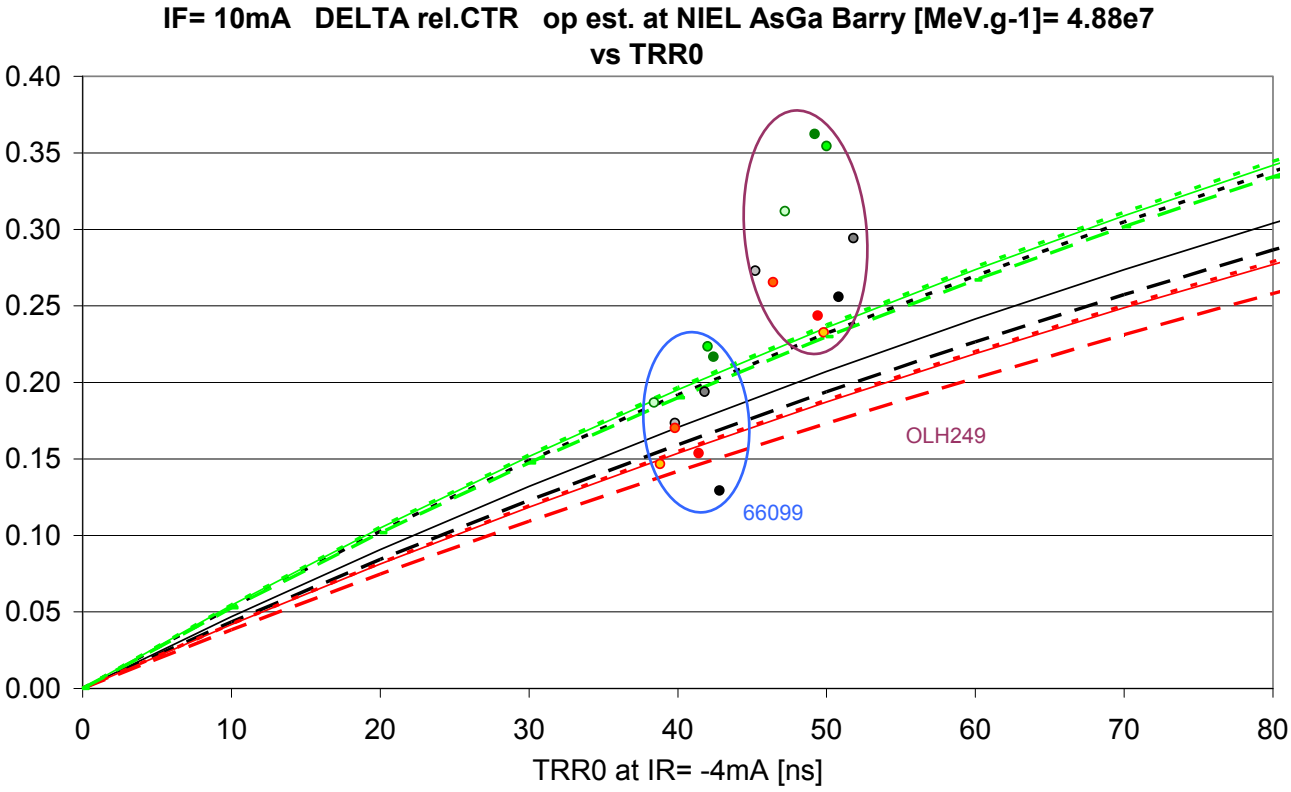


Fig. 7-24: $(1 - CTR/CTR_0)_{optocoupler}$ estimated at a NIEL of $4.88.10^7$ $MeV.g^{-1}$ (Barry) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

Provided that transistor degradation is dominated by diode's one (66099), 4N49 optocouplers curves allow to estimate other optocoupler degradation, with lower diode τ_{RR0}.

8. NEUTRON WIDE SPECTRUM IRRADIATION

8.1 CTR DEGRADATION

8.1.1 CTR correction

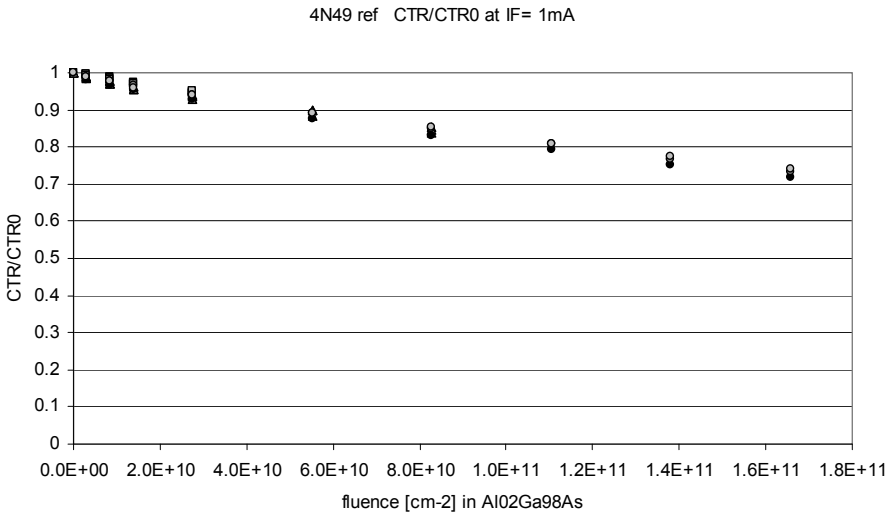


Fig. 8-1: example of reference optocoupler degradation: 4N49 $(CTR/CTR_0)_{reference}$ at I_F= 1mA with respect to fluence

Because of the non directionality of the "beam", references are hit by neutrons and encounter significant damage which affects "CTR diode" and "CTR transistor" measurements. A correction is brought as follows.

Let one correct CTR diode, measured on an optocoupler constituted by so called irradiated diode and reference transistor. The fraction $f_{transistor}$ to optocoupler degradation from the reference transistor has to be known to get "CTR diode corrected":

$$\Delta CTRdiode(i) = \Delta CTRdiode(i)_{corrected} + \Delta CTRref.transistor(i)$$

(i is the sample number)

This fraction is assumed to be independent from the fluence/degradation/NIEL.

It is estimated at a low NIEL where the degradation of the reference devices is neglected, i.e. for the measurement of ΔCTRtransistor(i) at low NIEL the degradation of the reference diode is neglected:

$$f_{transistor(i)} \approx \left[\frac{\Delta CTRtransistor(i)}{\Delta CTRoptocoupler(i)} \right]_{NIEL=lowvalue}$$

The considered low NIEL value is the NIEL at irradiation step number 2. So this value vary according the optocoupler type and to the fluence group Φn.

Hence:

$$\Delta CTRdiode(i)_{corrected} = \Delta CTRdiode(i) - \Delta CTRref.transistor(i)$$
$$\Delta CTRdiode(i)_{corrected} = \Delta CTRdiode(i) - f_{transistor(i)} x \Delta CTRref(i)$$

$CTRdiode(i)_0$ is the measured CTRdiode(i) at step0, prior irradiation.

$$\Delta CTRdiode(i)_{corrected} = \Delta CTRdiode - \left[\frac{\Delta CTRtransistor(i)}{\Delta CTRoptocoupler(i)}\right]_{NIEL=lowvalue} x \Delta CTRref(i)$$

$$CTRdiode(i)_{corrected} = CTRdiode(i)_0 + \Delta CTRdiode(i)_{corrected}$$

$$relativeCTRdiode(i)_{corrected} = 1 + \frac{\Delta CTRdiode(i)_{corrected}}{CTRdiode(i)_0}$$

CTR transistor is corrected in a similar way.

From here “CTR” will always refer to the “corrected CTR”.

8.1.2 Evolution with NIEL

	$Al_xGa_{1-x}As$ NIEDR (MeV.cm²/g)			
	x = 0	x = 0.02	x = 0.11	x = 0.35
optocoupler type		4N49	OLH249	66099
GEANT4 elastic	$2.1.10^{-4}$	$1.7.10^{-4}$	$1.8.10^{-4}$	$2.0.10^{-4}$
GEANT4 inelastic	$3.5.10^{-4}$	$4.1.10^{-4}$	$4.3.10^{-4}$	$4.6.10^{-4}$
GEANT4 total	$5.6.10^{-4}$	$5.8.10^{-4}$	$6.1.10^{-4}$	$6.6.10^{-4}$

Table 25. UCL neutron spectrum NIEDR values in AlGaAs [MeV.cm²/g] with respect to Al stoechiometry within AlGa

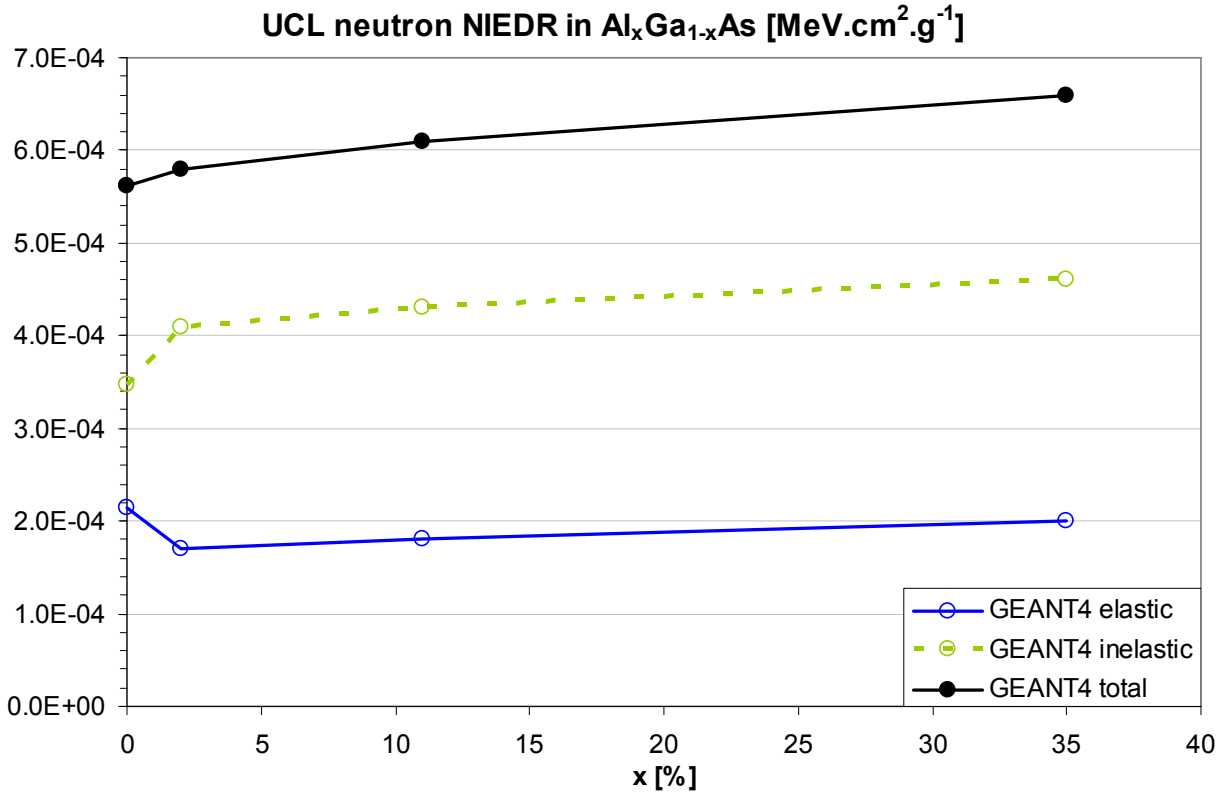


Fig. 8-2. UCL neutron spectrum NIEDR values in $Al_xGa_{1-x}As$ [MeV.cm²/g] with respect to Al stoechiometry within AlGa

	Si NIEDR (MeV.cm²/g)
GEANT4 elastic	$3.45.10^{-4}$
GEANT4 inelastic	$7.33.10^{-4}$
GEANT4 total	$1.08.10^{-3}$

Table 26. UCL neutron spectrum NIEDR values in Si [MeV.cm²/g]

The relative CTR transistor can be compared between transistors types from Fig. 8-9 to Fig. 8-11, at same diode current. One can notice 66099 transistor is less sensitive than the other ones. However this comparison would be relevant if the optical powers received by transistors were known as identical. Up to now, this information is missing since no optical measurement was foreseen during this study.

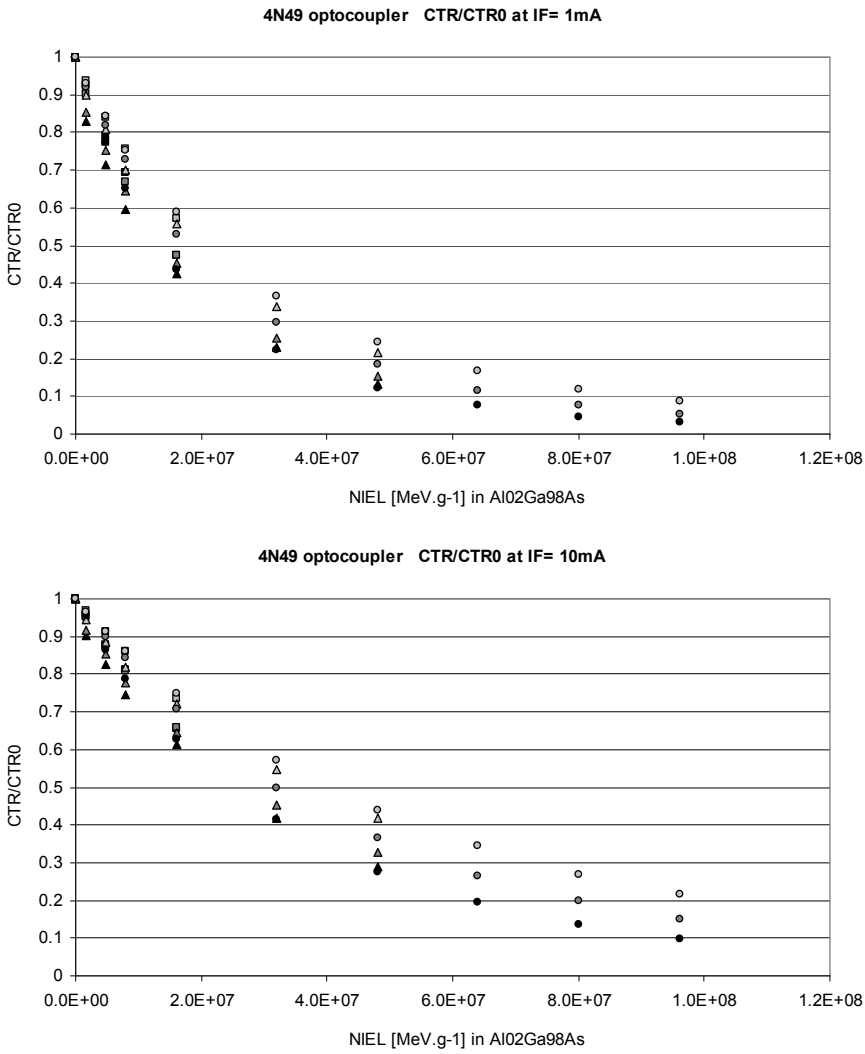
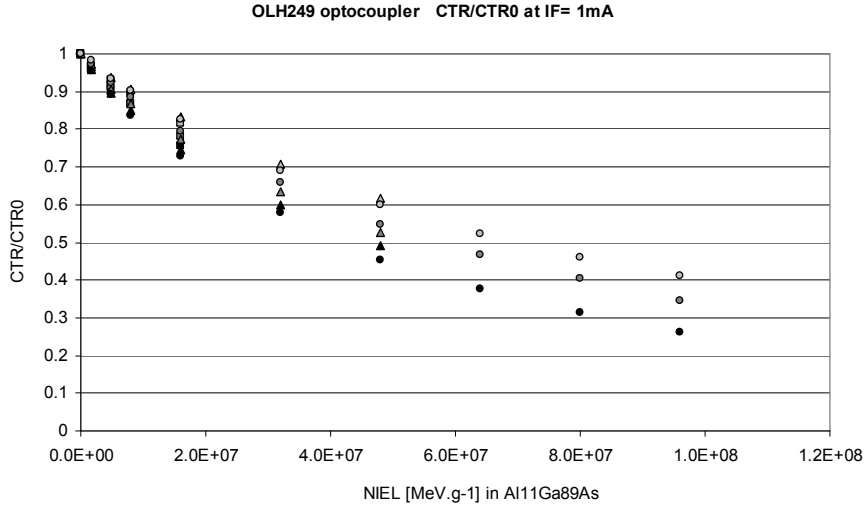


Fig. 8-3: 4N49 optocoupler: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA



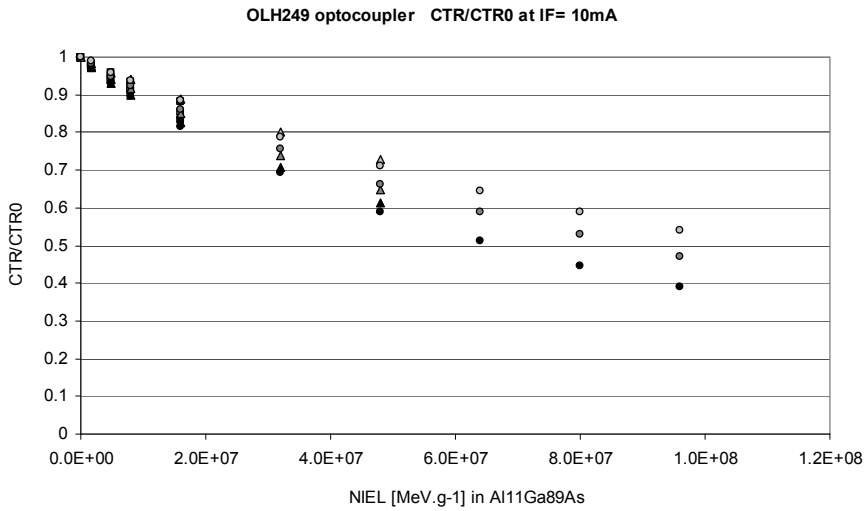


Fig. 8-4: OLH249 optocoupler: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA

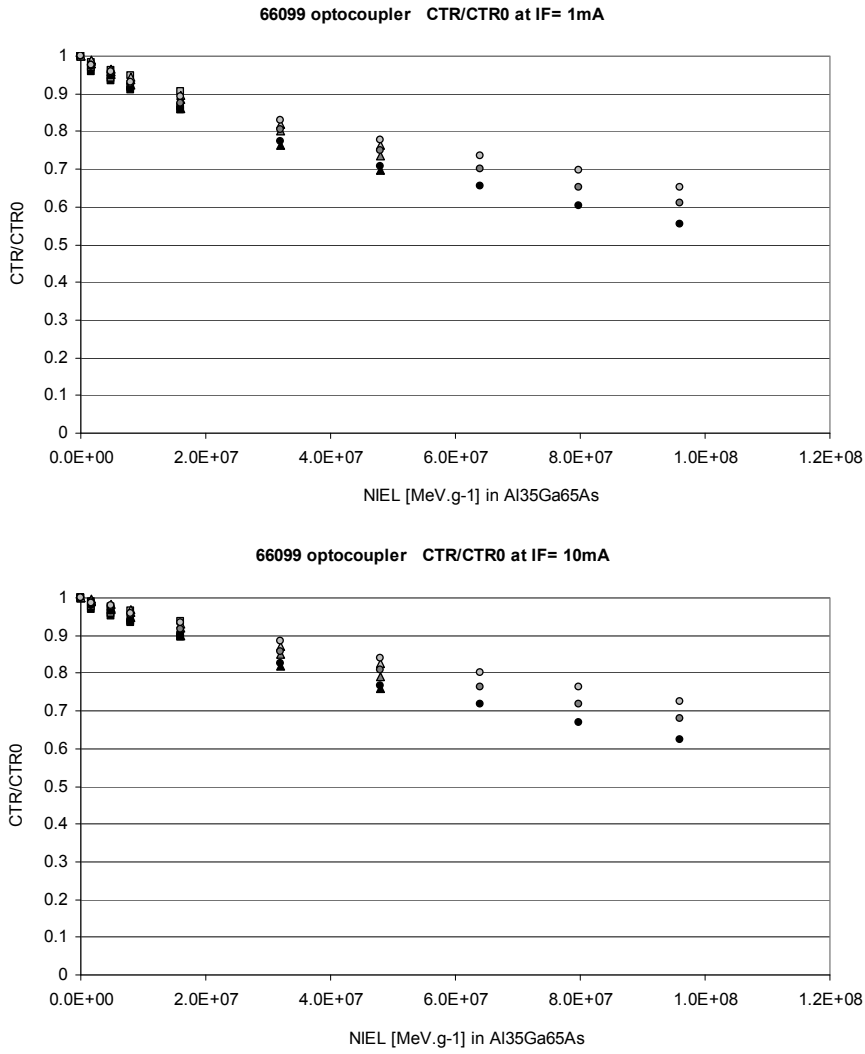


Fig. 8-5: 66099 optocoupler: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA

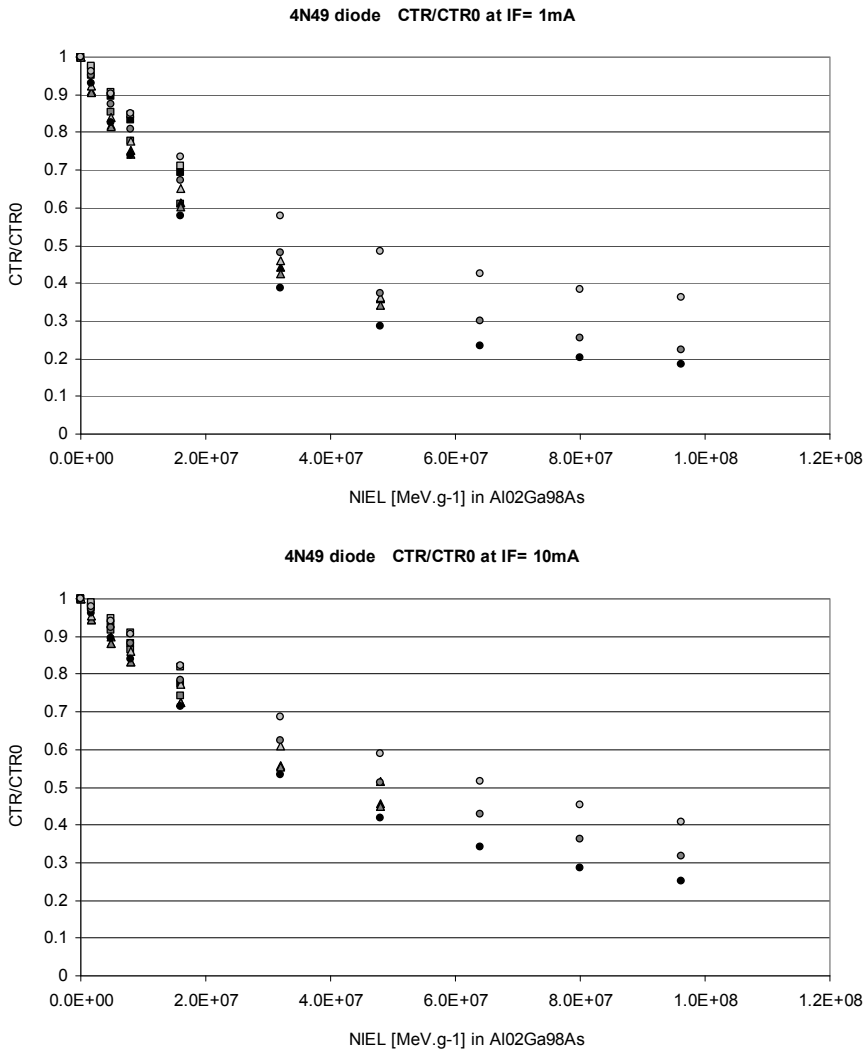
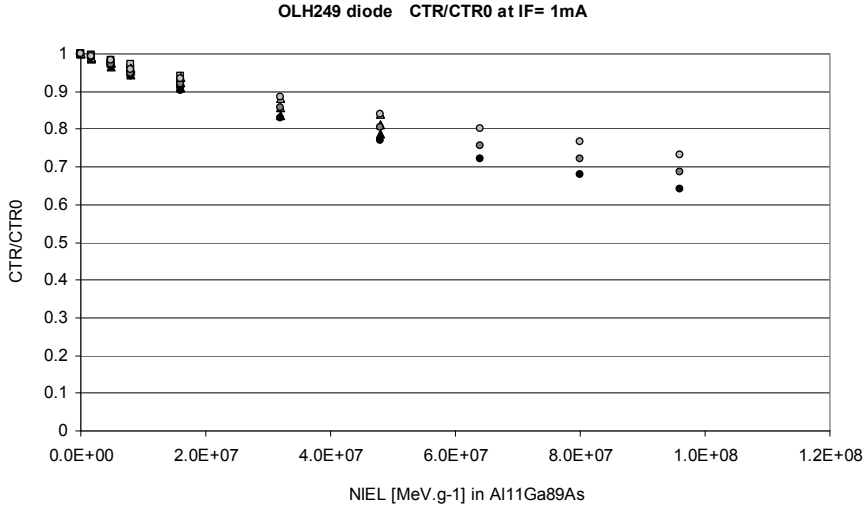


Fig. 8-6: 4N49 diode: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA



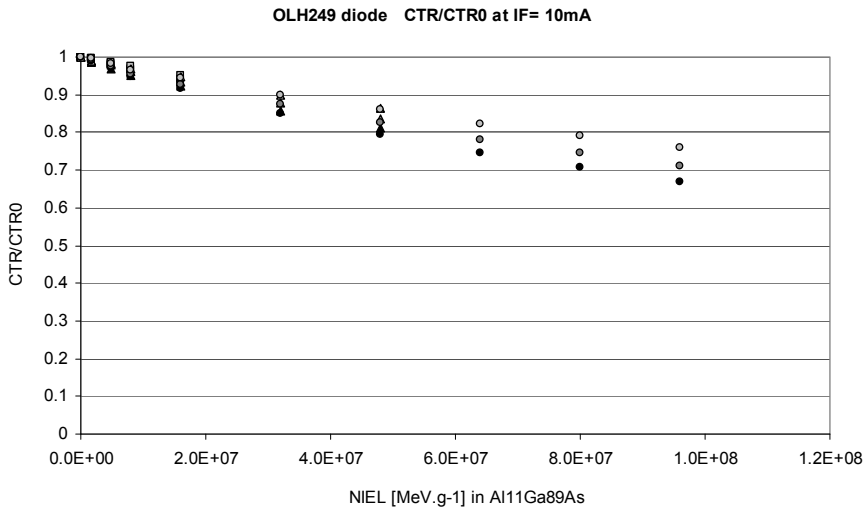


Fig. 8-7: OLH249 diode: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA

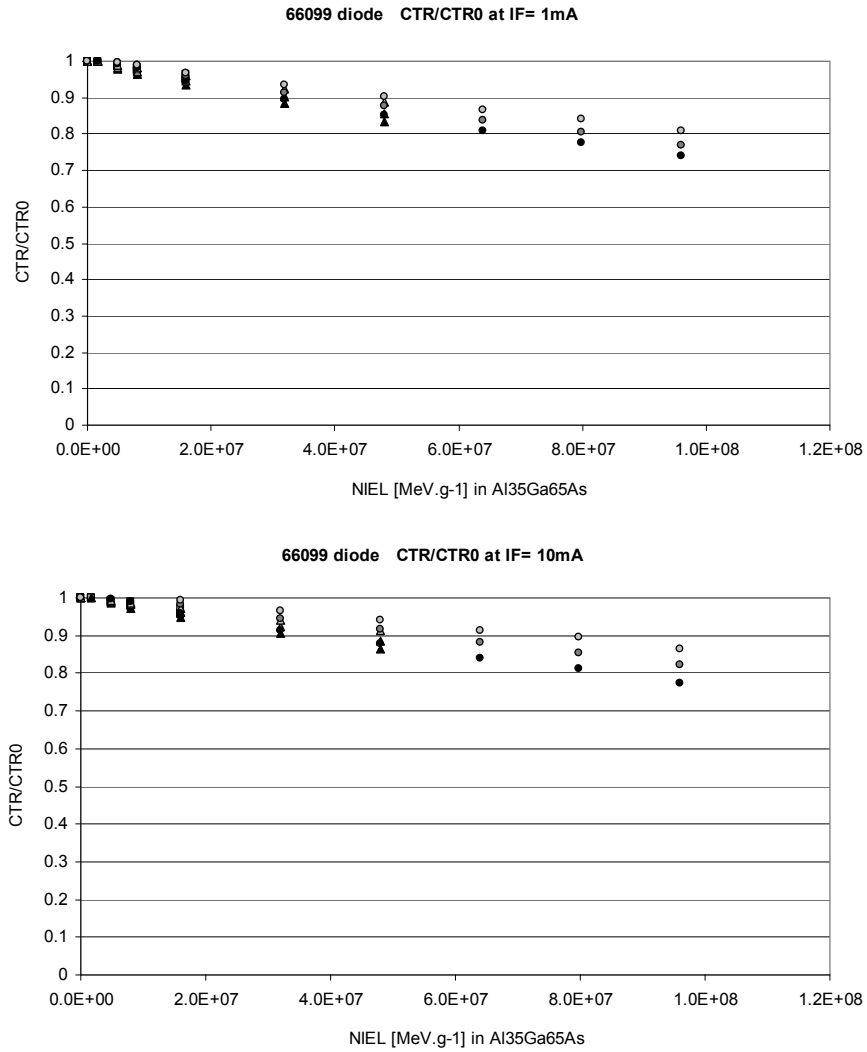


Fig. 8-8: 66099 diode: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA

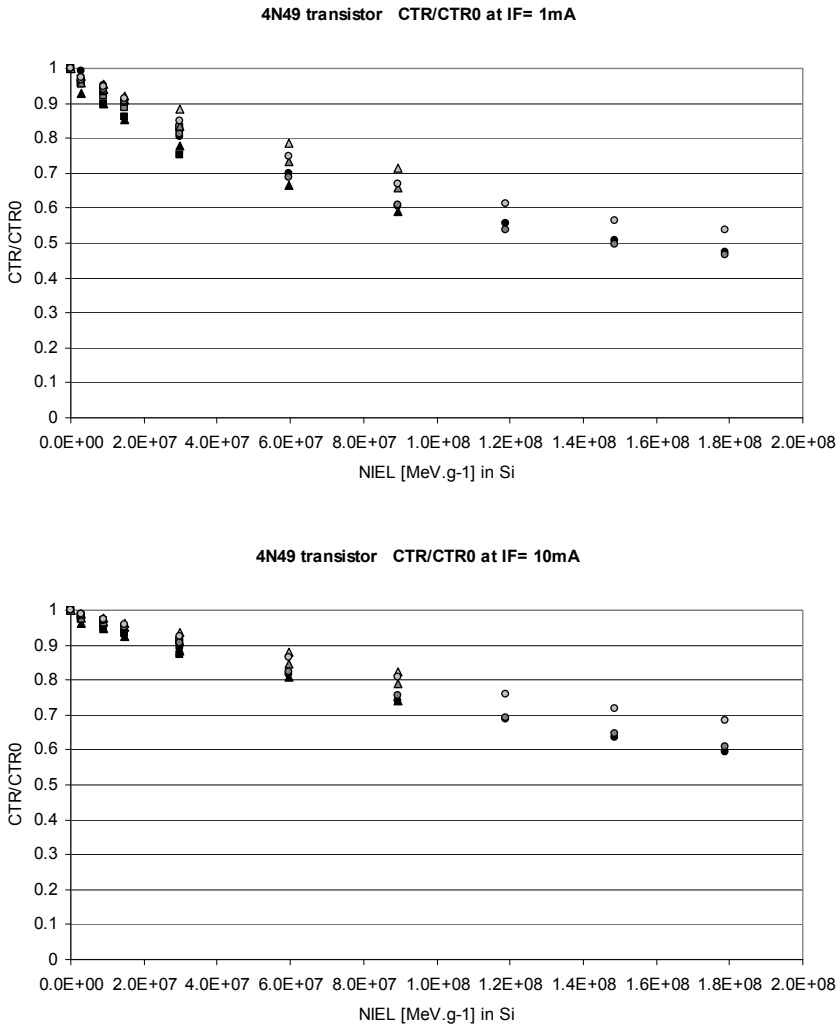
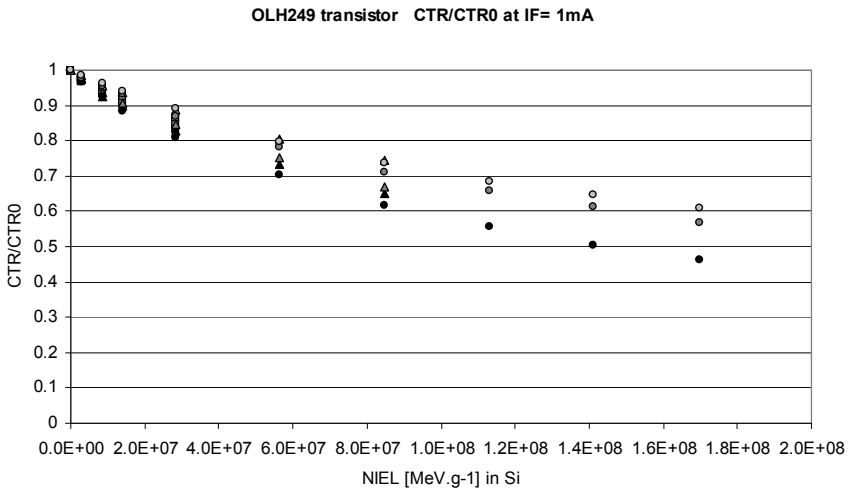


Fig. 8-9: 4N49 transistor: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA



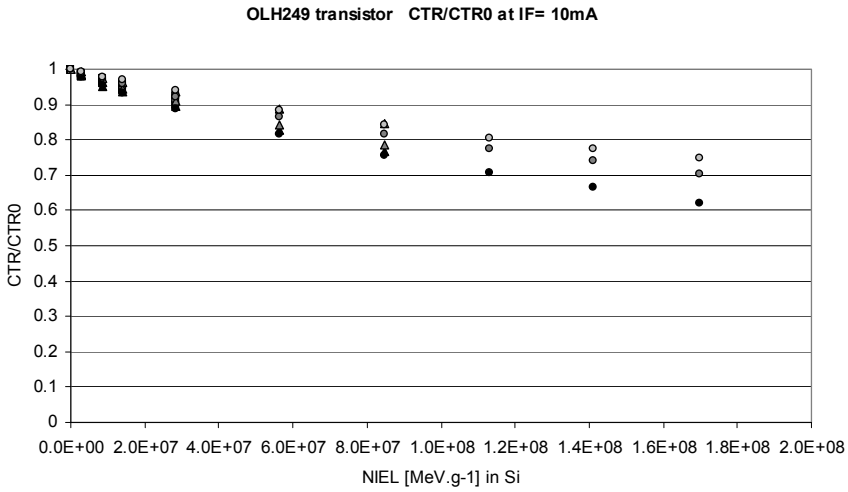
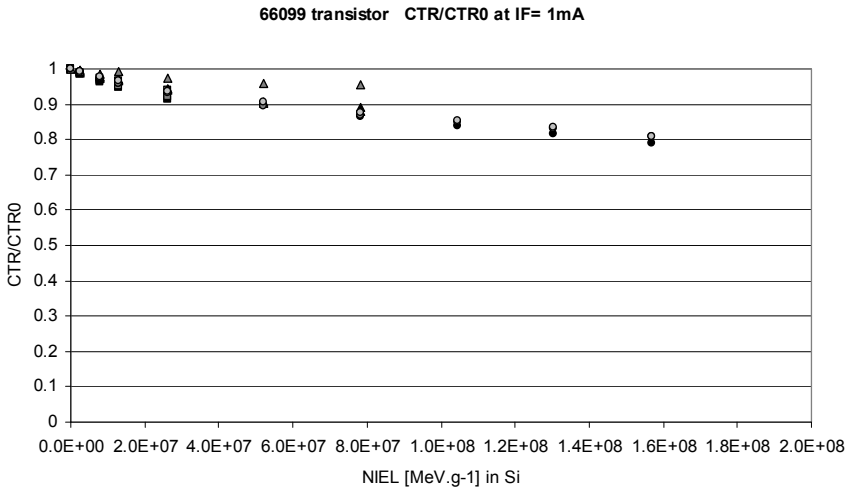


Fig. 8-10: OLH249 transistor: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA



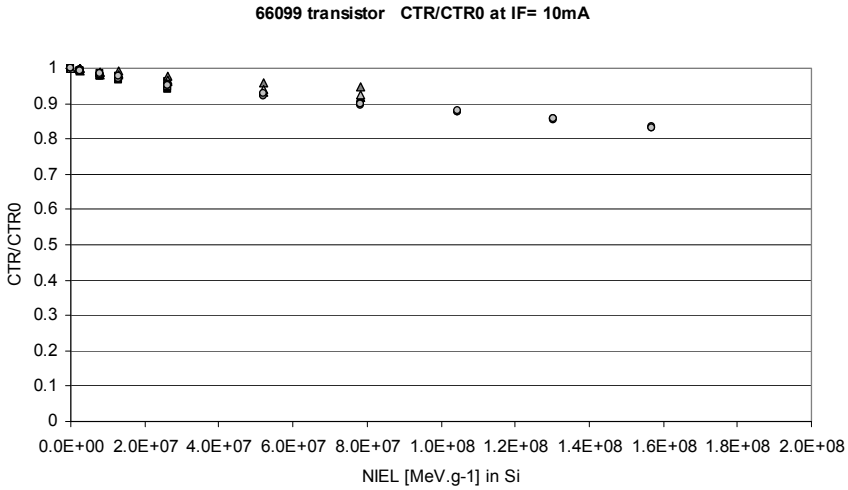


Fig. 8-11: 66099 transistor: relative CTR with respect to neutron NIEL at I_F= 1mA and I_F= 10mA

8.1.3 Effect of diode current

The relative CTR degradation decreases as the injected current in the diode I_F is increased (1 to 10 mA). This effect is observed whatever the irradiated part: whole optocoupler, diode, and transistor. The curves are given at different fluences $\Phi p_{i\ (i=1,3)}$.

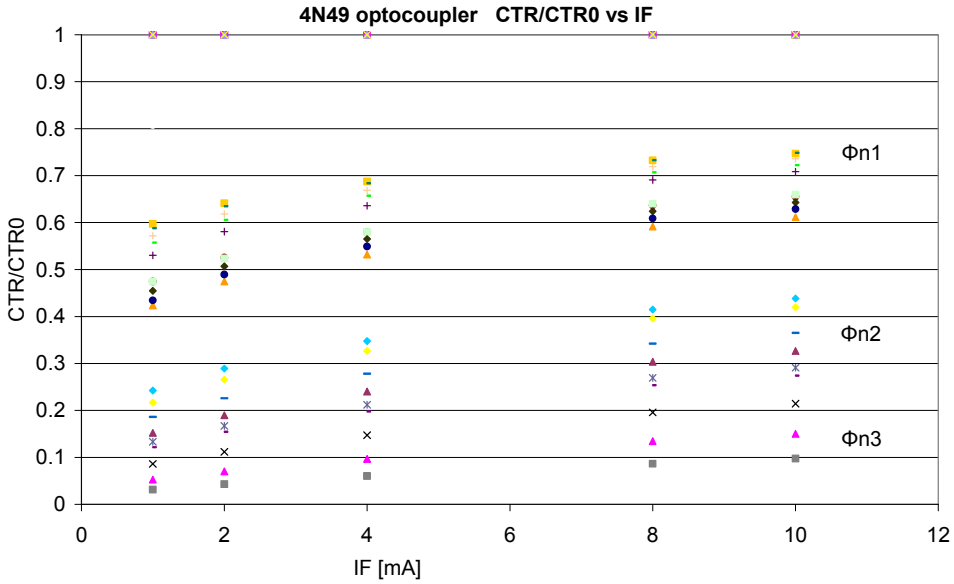


Fig. 8-12: 4N49 optocoupler irradiated by neutrons: CTR/CTR$_0$ for step0 prior irradiation, step Φn_1, step Φn_2 and step Φn_3 with respect to diode current I_F.

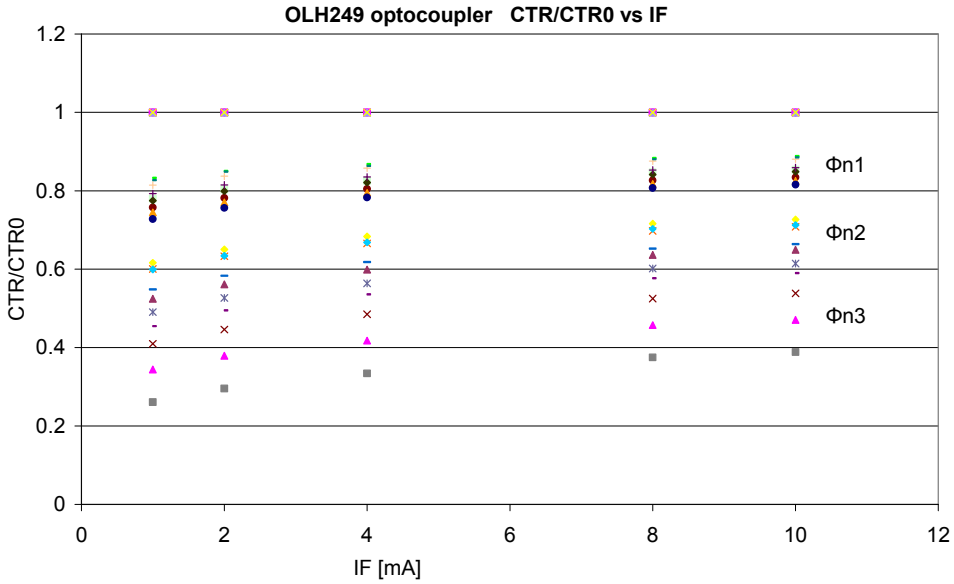


Fig. 8-13: OLH249 optocoupler irradiated by neutrons: CTR/CTR$_0$ for step0 prior irradiation, step Φn_1, step Φn_2 and step Φn_3 with respect to diode current I_F.

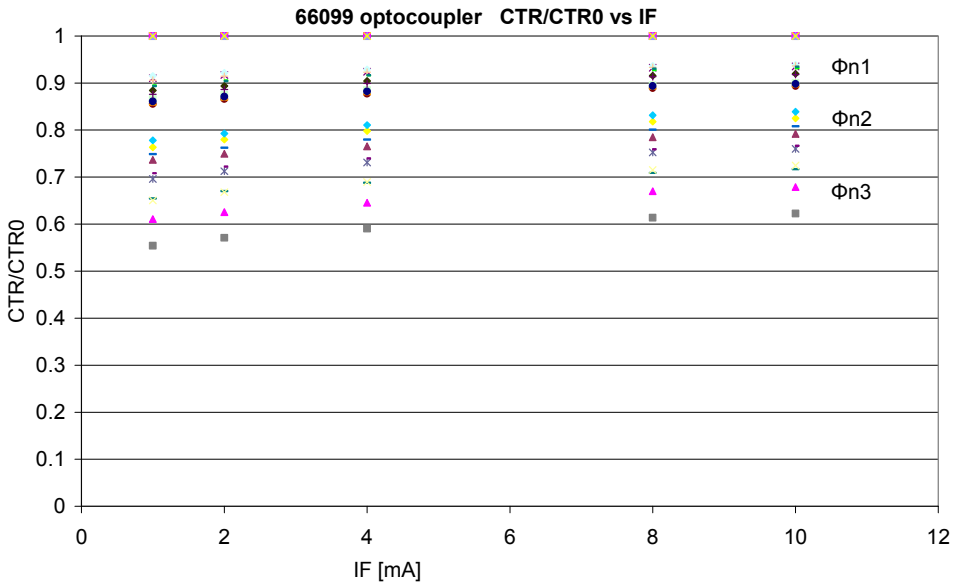


Fig. 8-14: 66099 optocoupler irradiated by neutrons: CTR/CTR$_0$ for step0 prior irradiation, step Φn_1, step Φn_2 and step Φn_3 with respect to diode current I_F.

8.2 VARIATION OF REVERSE RECOVERY TIME

Fig. 8-15 for 4N49 verifies the hypothesis of $1/\tau_{RR}$ linear variation versus Φ and NIEL in $Al_{02}Ga_{98}As$ like previously with proton irradiation (§4.4). K_{NIEL} ranges from 1.6 10^{-11} to 2.9 10^{-11} g.MeV^{-1}.ns^{-1} (Fig. 8-16). $K_{NIEL_GEANT4_total}$ in GaAs varied from 2.2 10^{-11} to 3.9 10^{-11} g.MeV^{-1}.ns^{-1} for 60, 100 and 200 MeV proton irradiation. The similar values of K_{NIEL} for neutrons and protons confirms the validity of the model presented in sections 4.1 and 4.2. The arithmetic mean value of K_{NIEL} values obtained from all those irradiations is 2.6 10^{-11} g.MeV^{-1}.ns^{-1}. Fig. 8-17 depicts K_{NIEL} for 4N49 diode irradiated by neutrons and 60, 100 and 200 MeV protons. Neutrons points are placed at 25MeV, the energy mean of the neutrons.

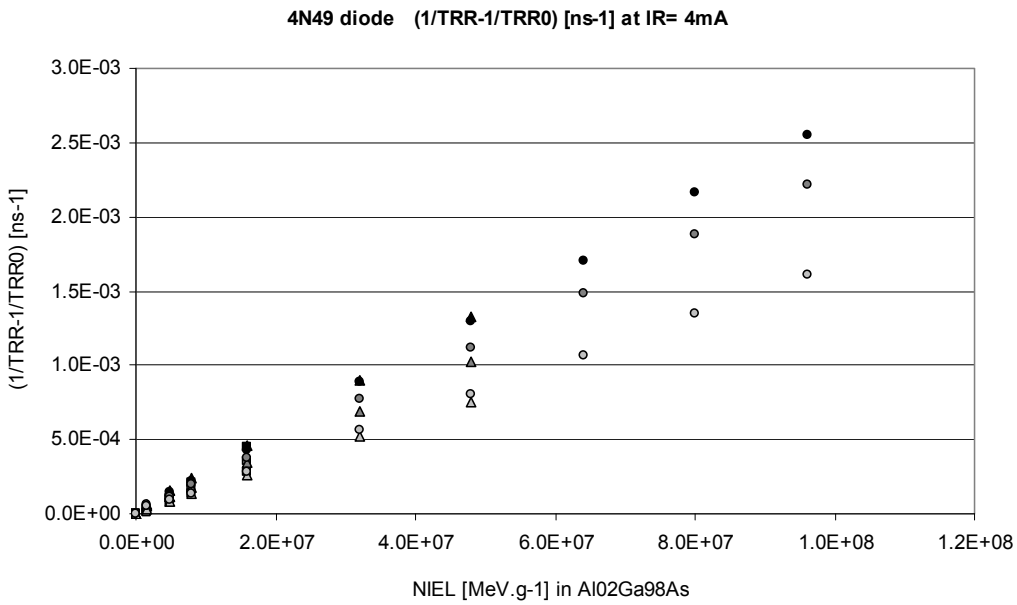


Fig. 8-15: 4N49 Δ $1/\tau_{RR}$ with respect to NIEL

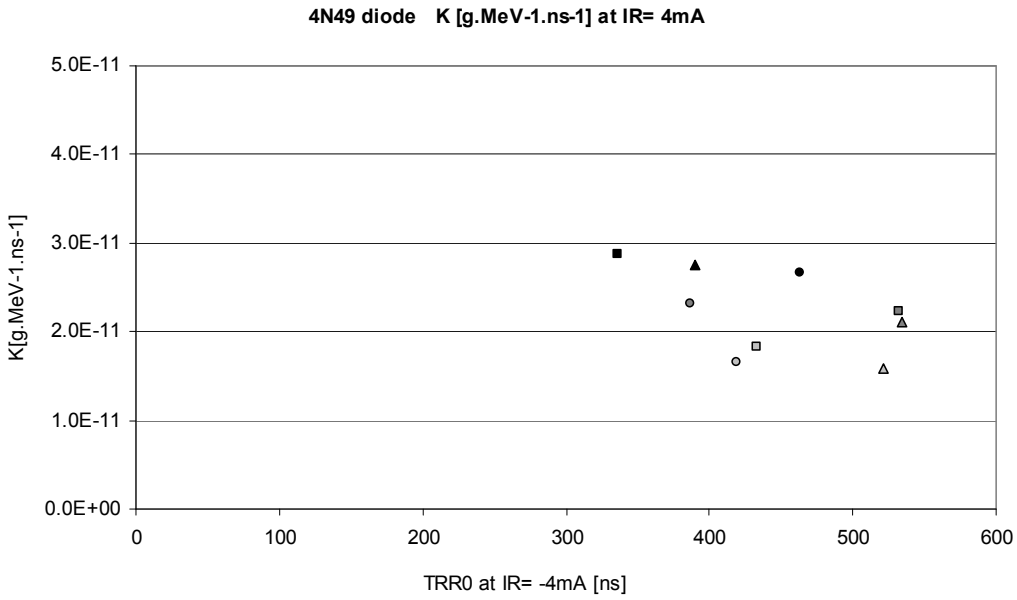


Fig. 8-16: 4N49 K_{NIEL} with respect to τ_{RR0}

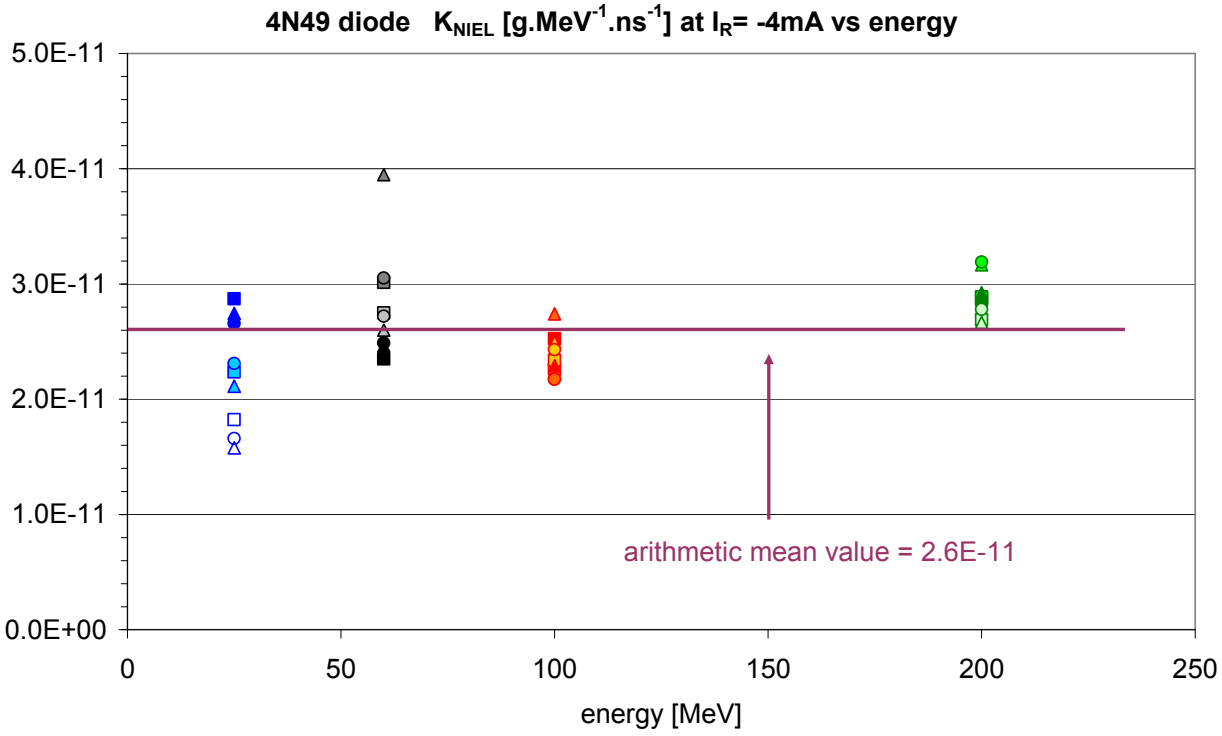


Fig. 8-17: 4N49: K_{NIEL} at I_R=-4mA, with respect to energy

Fig. 8-17 shows a strong spatial inhomogeneity of the neutrons compared to protons beams, since $K_{NIEL_neutron}$ depends on the sample number: $K_{samples\#1} > K_{samples\#2} > K_{samples\#3}$, which expresses that the actual fluence is higher for samples #1 than for samples #2, and than for samples #3.

As depicted in Fig. 8-19 and Fig. 8-20, measurement of OLH249 and 66099 reverse recovery times encountered noise that make the linear variation unobvious. Measurement of τ_{RR} during neutron irradiation campaign was performed with longer wires than during proton campaign due to constraints at Louvain facility. The already noisy values because of short τ_{RR} have thus become difficult to exploit for K_{NIEL} calculation. The curve shape of reverse current versus time (Fig. 8-18) leads to a bigger error for OLH249 than for 66099.

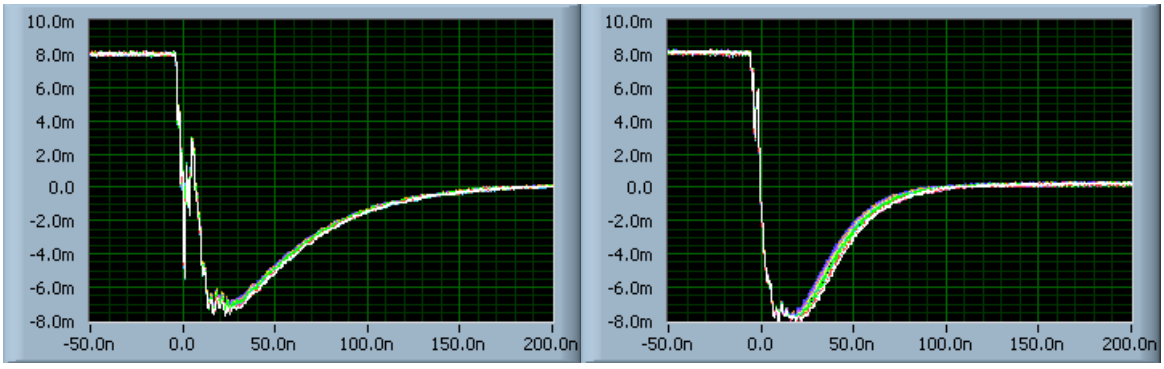


Fig. 8-18: typical shapes of $I_R(t)$ during τ_{RR} measurements for OLH249 (left) and 66099 (right)

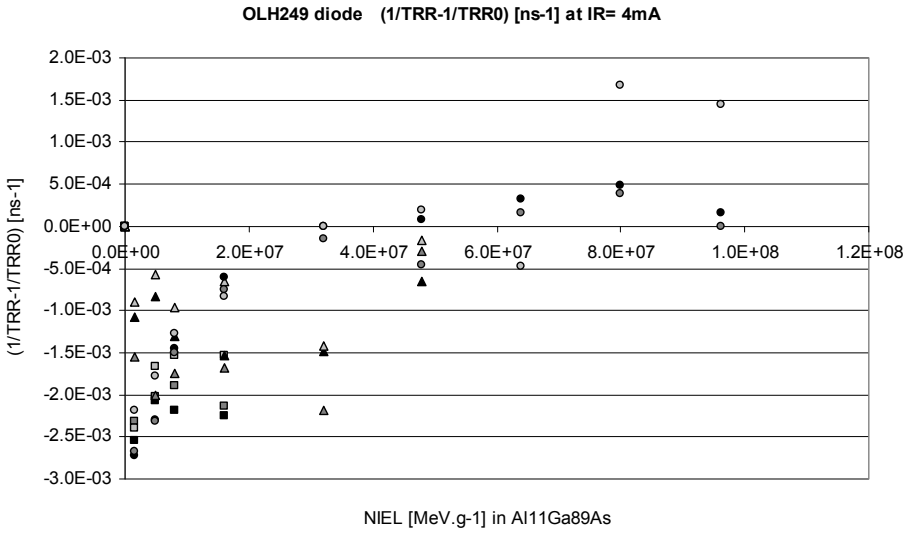


Fig. 8-19: OLH249 Δ $1/\tau_{RR}$ with respect to NIEL: bad measurement

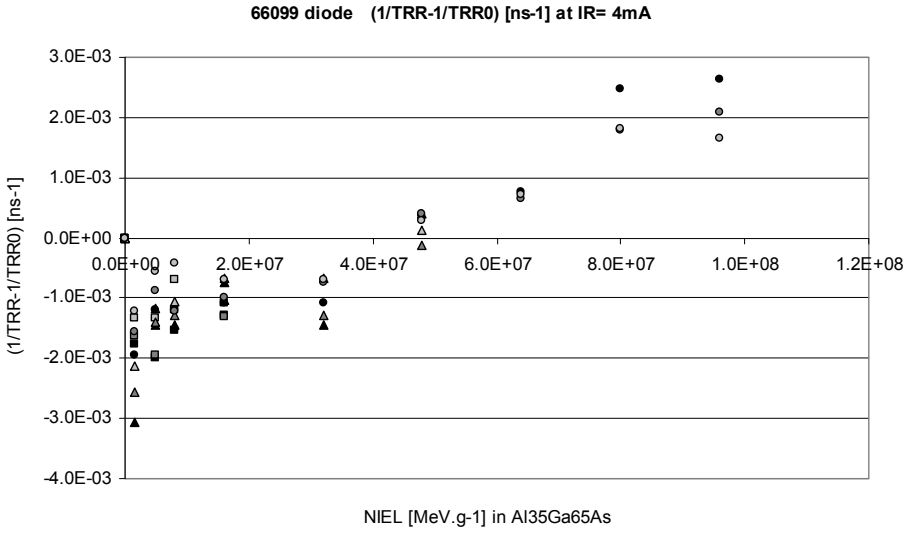


Fig. 8-20: 66099 Δ $1/\tau_{RR}$ with respect to NIEL: bad measurement

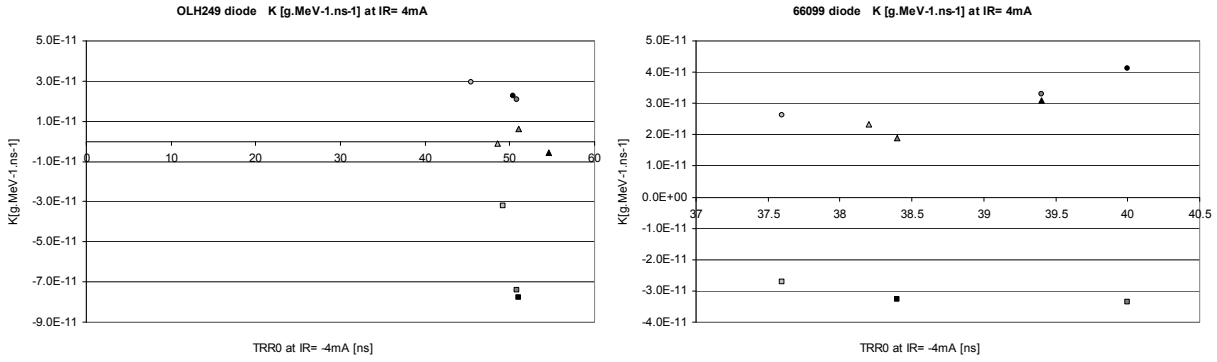


Fig. 8-21: unsuccessful regression for degradation coefficient K_{NIEL} (OLH249: left, 66099: right)

8.3 CORRELATION BETWEEN CTR DEGRADATION AND τ_{RR} DEGRADATION

8.3.1 Neutron irradiation

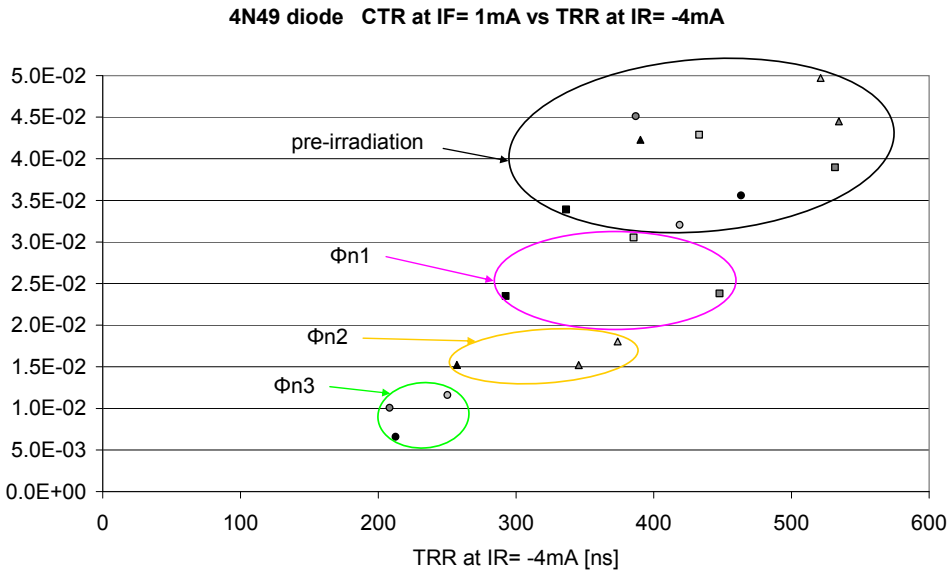


Fig. 8-22: 4N49 diode CTR at I_F= 1mA with respect to τ_{RR}

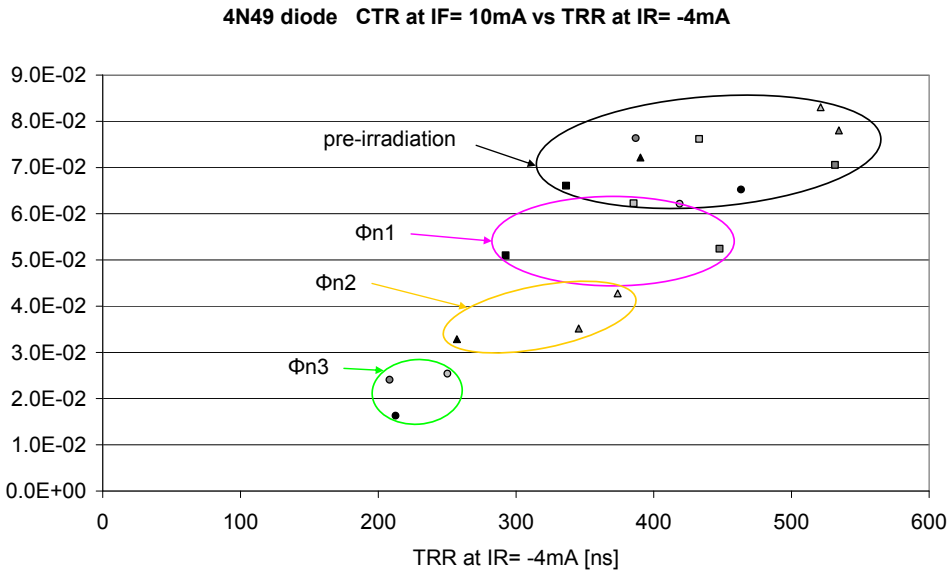


Fig. 8-23: 4N49 diode CTR at I_F= 10mA with respect to τ_{RR}

Fig. 8-22 and Fig. 8-23 demonstrate the same type of correlation between CTR degradation and reverse recovery time as for proton irradiation. Fig. 8-24 to Fig. 8-35 show the continuous degradation by proton irradiation of the relative diode's CTR and relative τ_{RR}. Again, the noise in measurement for OLH249 and 66099 make the N power calculation difficult.

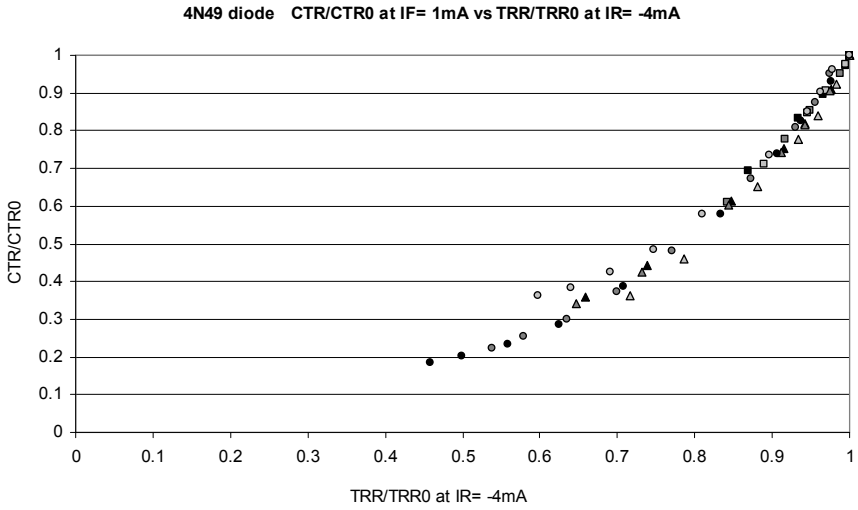


Fig. 8-24: 4N49 diode CTR/CTR$_0$ at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

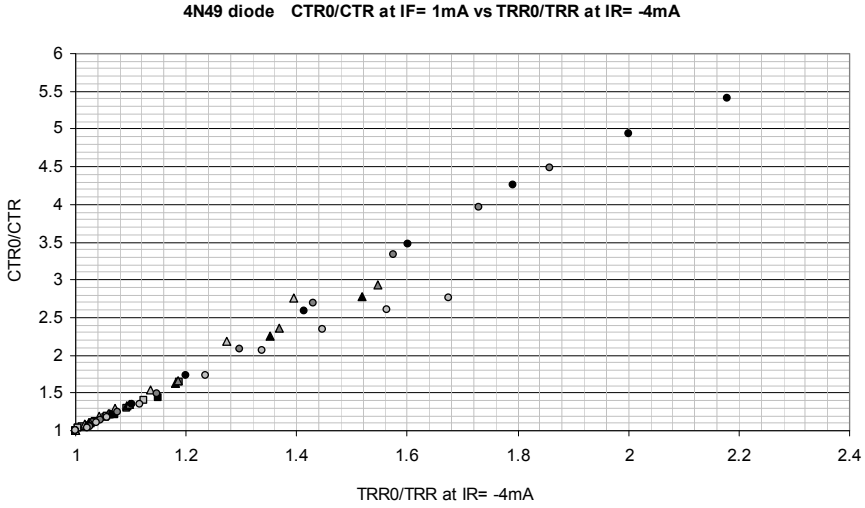


Fig. 8-25: 4N49 diode CTR$_0$/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

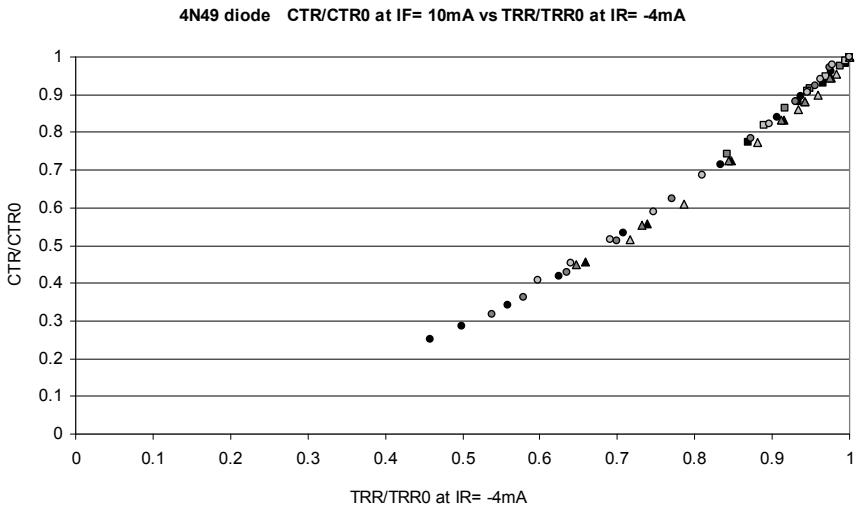


Fig. 8-26: 4N49 diode CTR_0/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

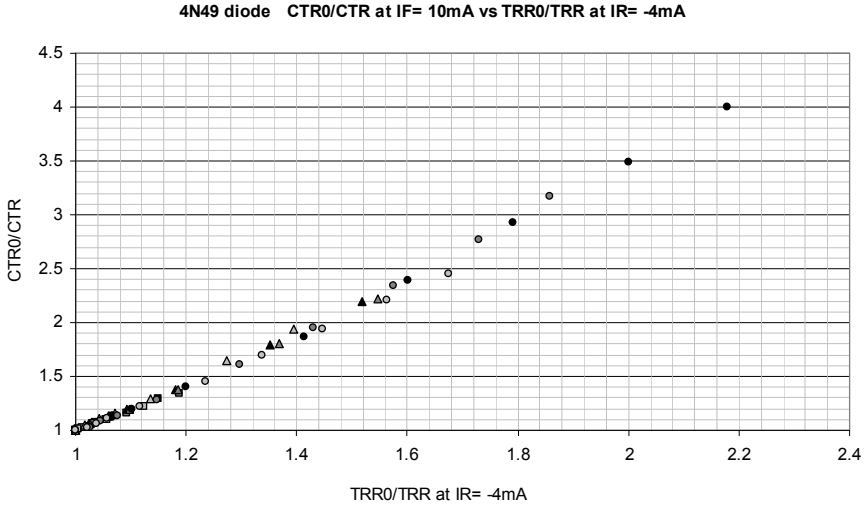


Fig. 8-27: 4N49 diode CTR_0/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

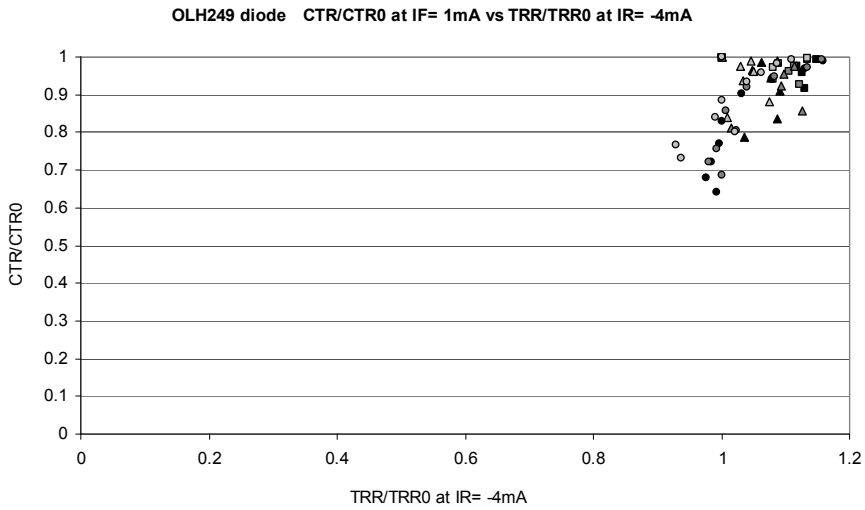


Fig. 8-28: OLH249 diode CTR/CTR_0 at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

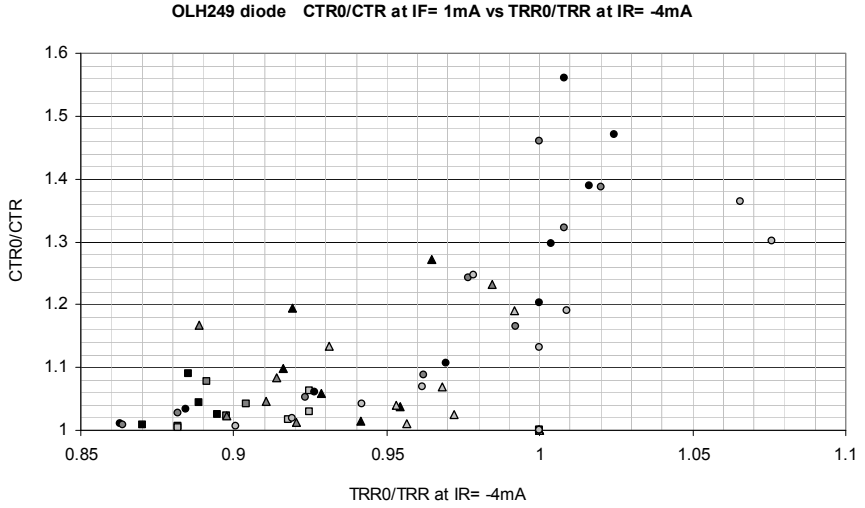


Fig. 8-29: OLH249 diode CTR_0/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

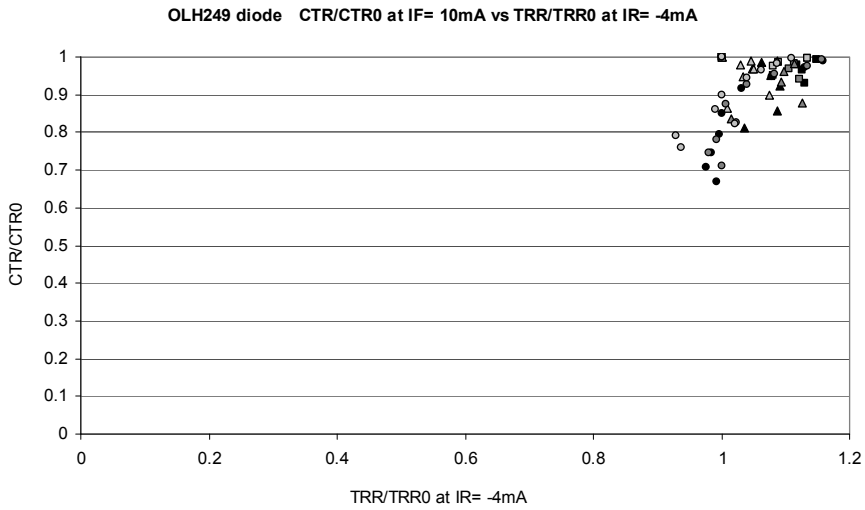


Fig. 8-30: OLH249 diode CTR/CTR$_0$ at I_F= 10mA with respect to τ_{RR}/τ_{RR0}

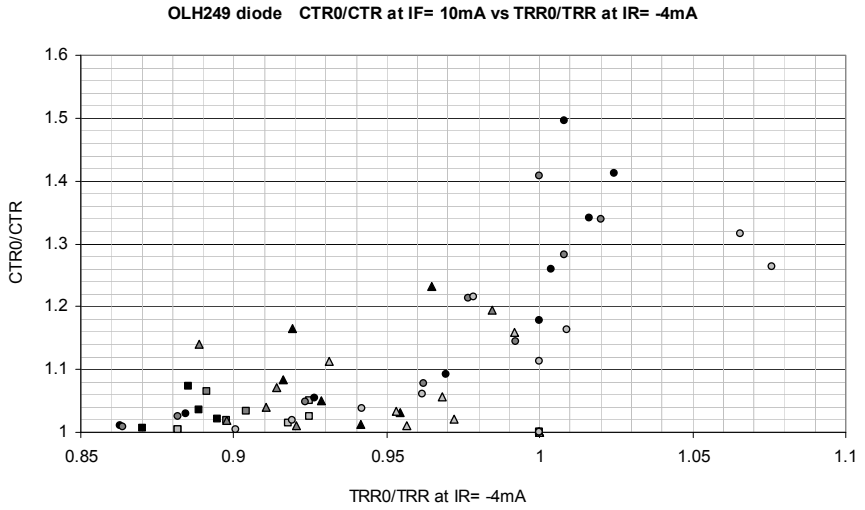


Fig. 8-31: OLH249 diode CTR$_0$/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

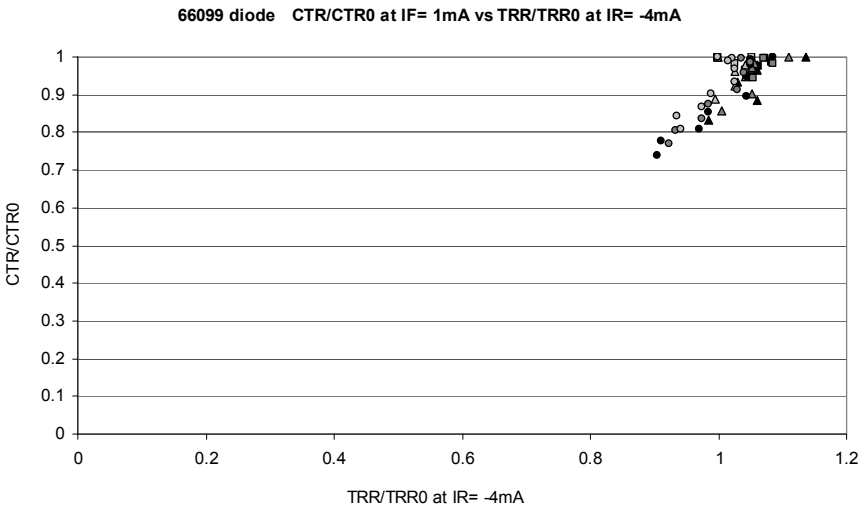


Fig. 8-32: 66099 diode CTR/CTR_0 at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

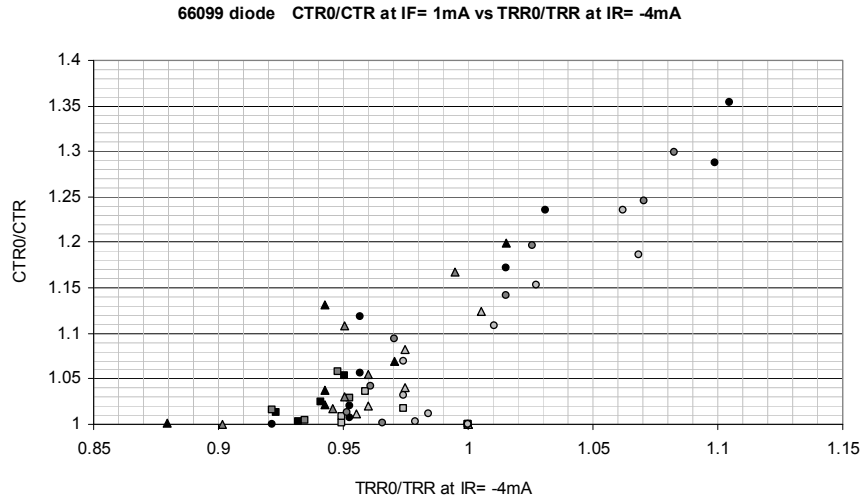


Fig. 8-33: 66099 diode CTR_0/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

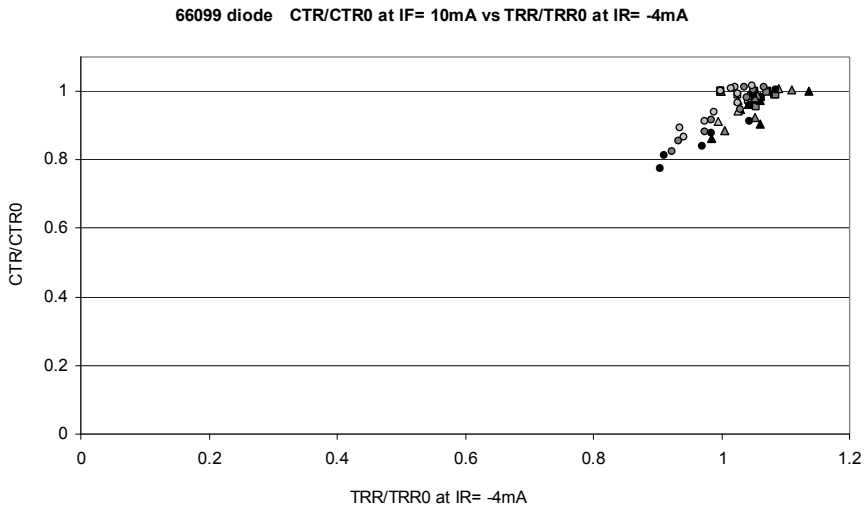


Fig. 8-34: 66099 diode CTR/CTR$_0$ at I_F= 10mA with respect to τ_{RR}/τ_{RR0}

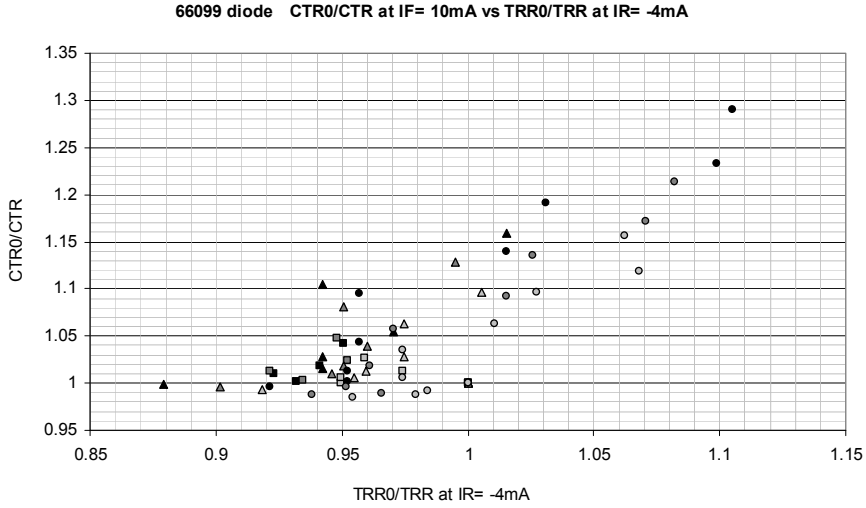
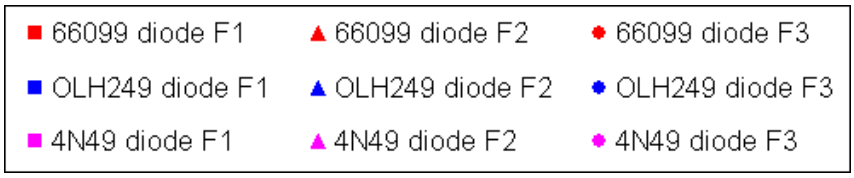


Fig. 8-35: 66099 diode CTR$_0$/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

The figures above are merged for all diode types in Fig. 8-36 to Fig. 8-39.



Legend for Fig. 8-36 to Fig. 8-39

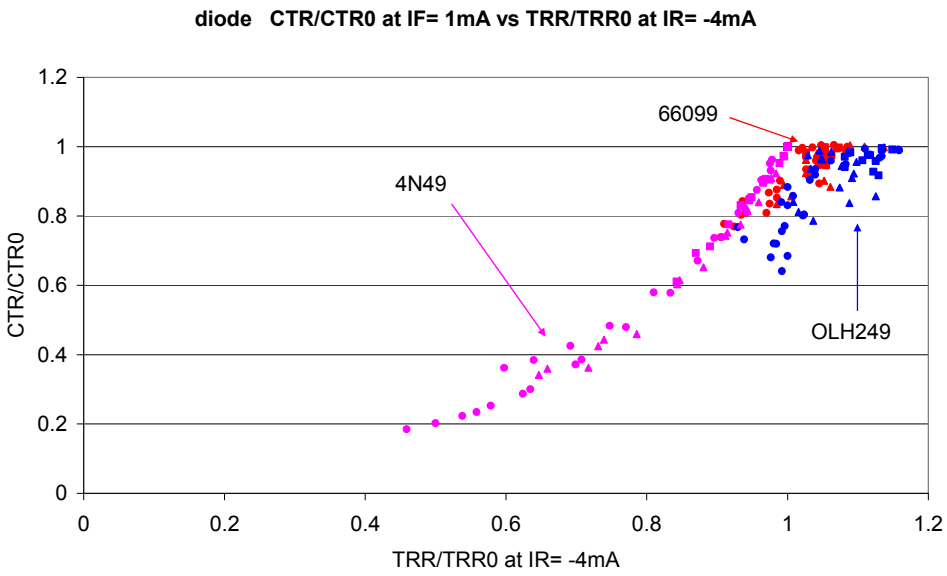


Fig. 8-36: 4N49, OLH249, 66099 diodes: CTR/CTR_0 at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

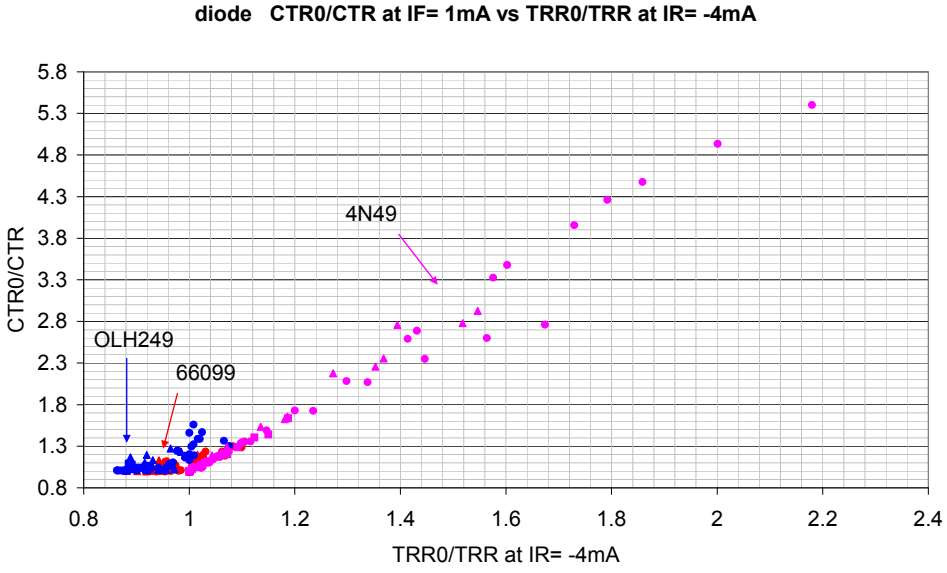


Fig. 8-37: 4N49, OLH249, 66099 diodes: CTR_0/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

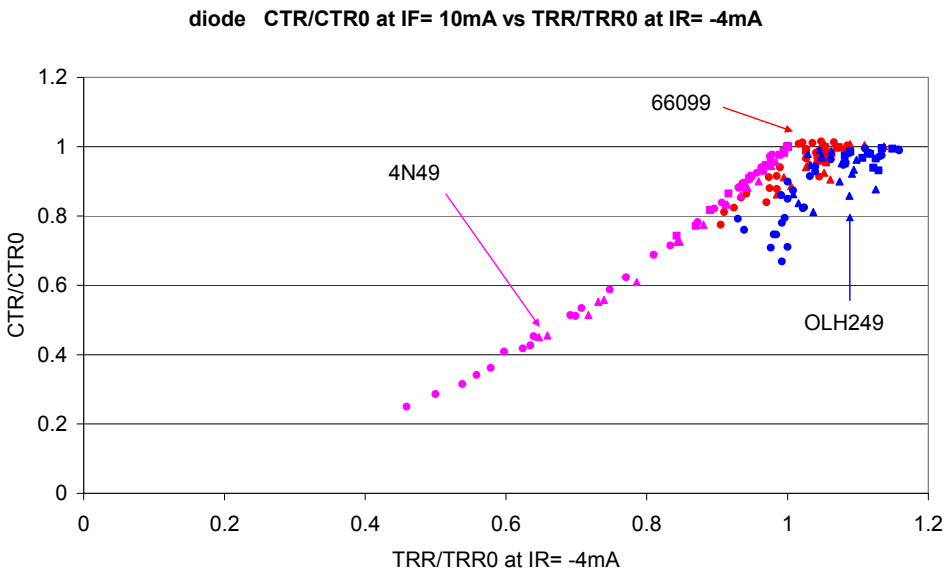


Fig. 8-38: 4N49, OLH249, 66099 diodes: CTR/CTR$_0$ at I$_F$= 10mA with respect to τ_{RR}/τ_{RR0}

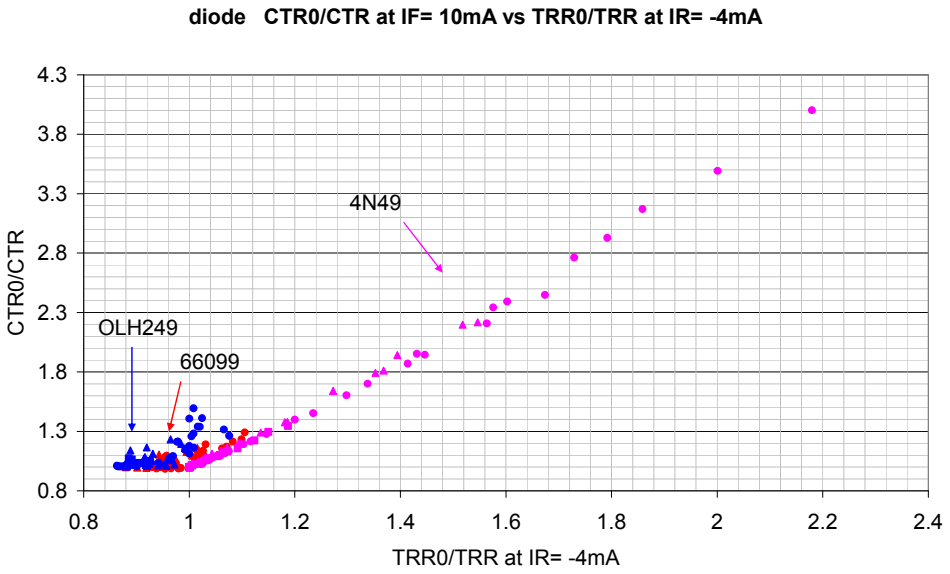


Fig. 8-39: 4N49, OLH249, 66099 diodes: CTR$_0$/CTR at I$_F$=1mA with respect to τ_{RR0}/τ_{RR}

8.3.2 Agreement with proton results

Neutron and proton results are superimposed for 4N49 diode in Fig. 8-40 to Fig. 8-43. There is no difference in the correlation between CTR degradation and τ_{RR} degradation. The following colour and shape code is used when neutron and proton results are superimposed.

proton irradiation data points

black: 60MeV	60MeV F1 #1	60MeV F1 #2	60MeV F1 #3	square: Φp1
	60MeV F2 #1	60MeV F2 #2	60MeV F2 #3	triangle: Φp2
	60MeV F3 #1	60MeV F3 #2	60MeV F3 #3	circle: Φp3
red: 100MeV	100MeV F1 #1	100MeV F1 #2	100MeV F1 #3	
	100MeV F2 #1	100MeV F2 #2	100MeV F2 #3	
	100MeV F3 #1	100MeV F3 #2	100MeV F3 #3	
green: 200MeV	200MeV F1 #1	200MeV F1 #2	200MeV F1 #3	
	200MeV F2 #1	200MeV F2 #2	200MeV F2 #3	
	200MeV F3 #1	200MeV F3 #2	200MeV F3 #3	

neutron irradiation data points

blue	neutron F1#1	neutron F1#2	neutron F1#3	square: Φn1
	neutron F2#1	neutron F2#2	neutron F2#3	triangle: Φn2
	neutron F3#1	neutron F3#2	neutron F3#3	circle: Φn3

dark: sample #1 sample #2 bright: sample #3

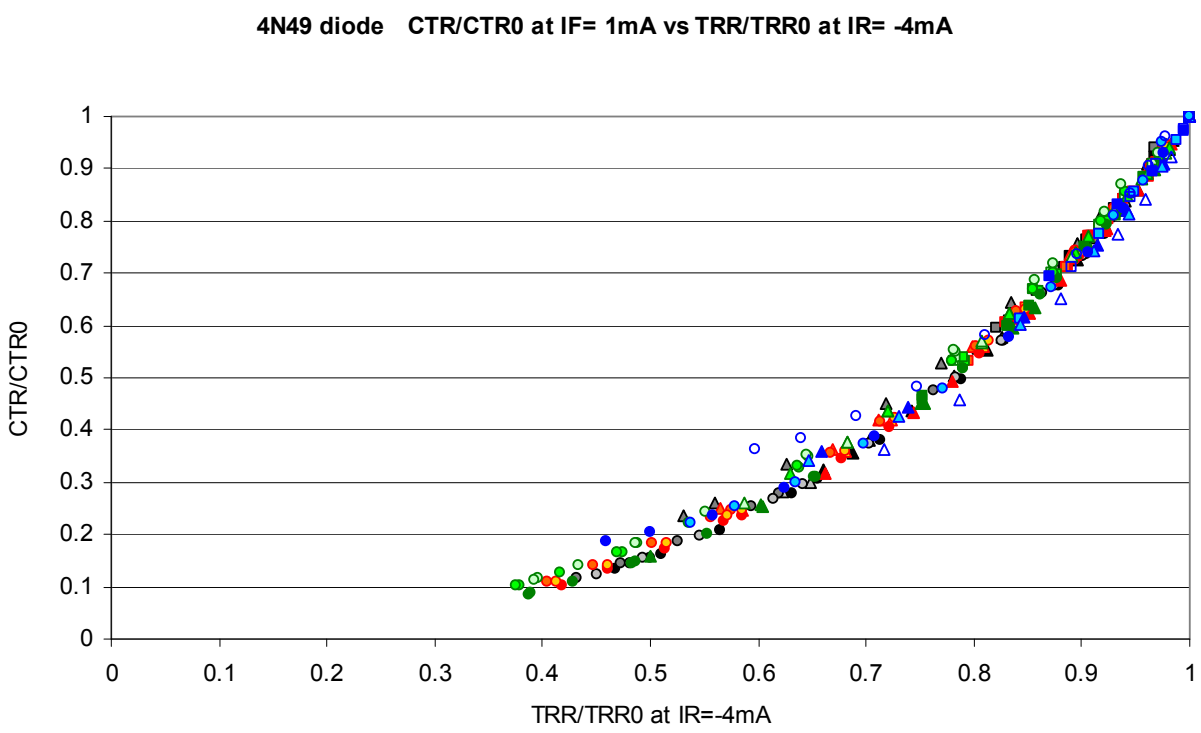


Fig. 8-40: 4N49 diode CTR/CTR$_0$ at I_F=1mA with respect to τ_{RR}/τ_{RR0}

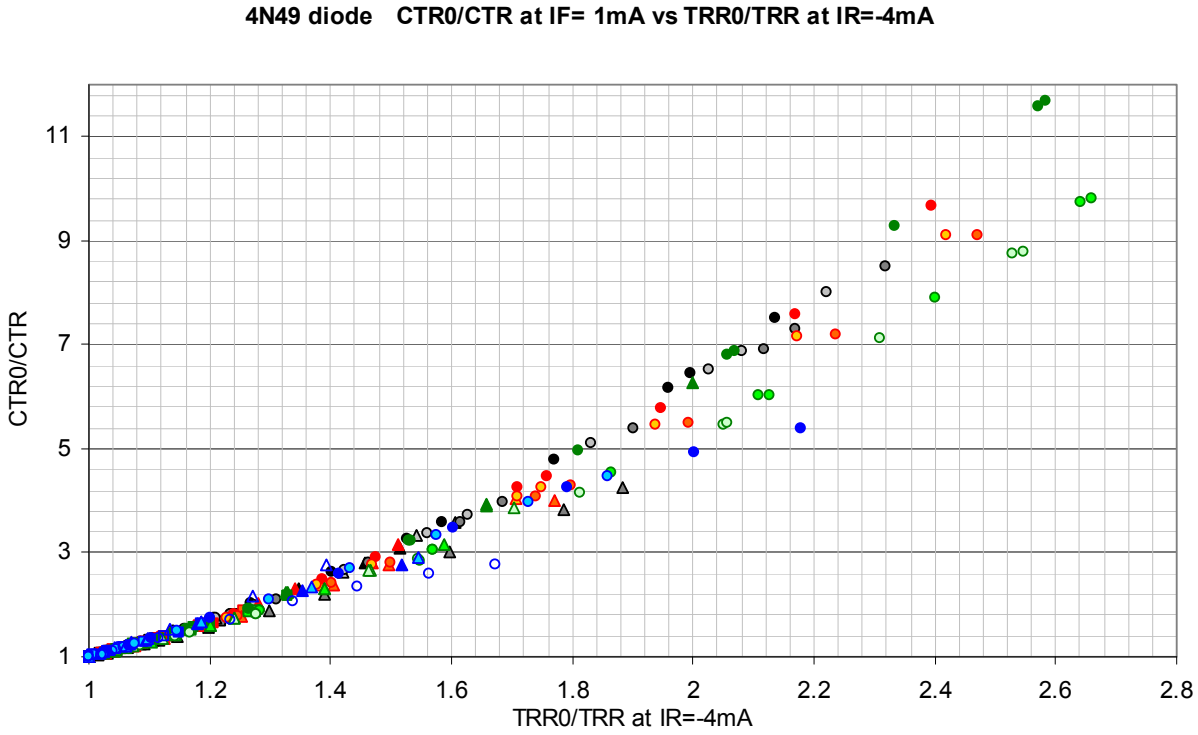


Fig. 8-41: 4N49 diode CTR$_0$/CTR at I_F=1mA with respect to τ_{RR0}/τ_{RR}

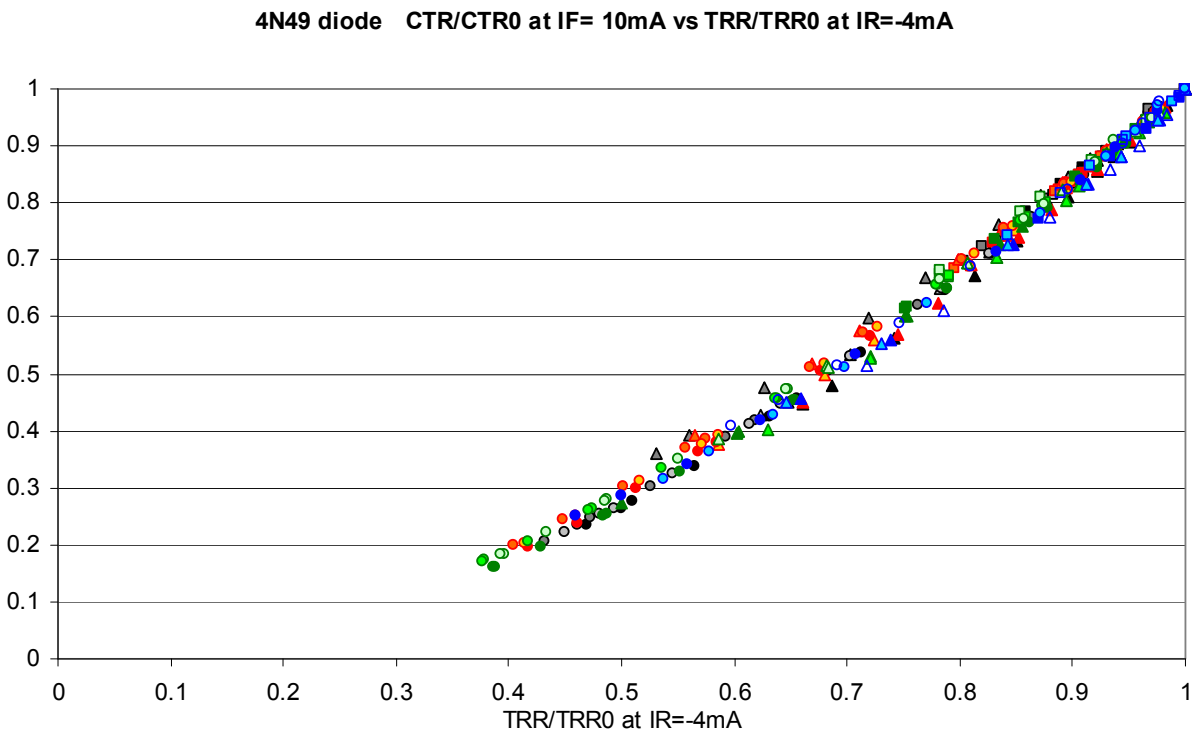


Fig. 8-42: 4N49 diode CTR/CTR_0 at I_F=10mA with respect to τ_{RR}/τ_{RR0}

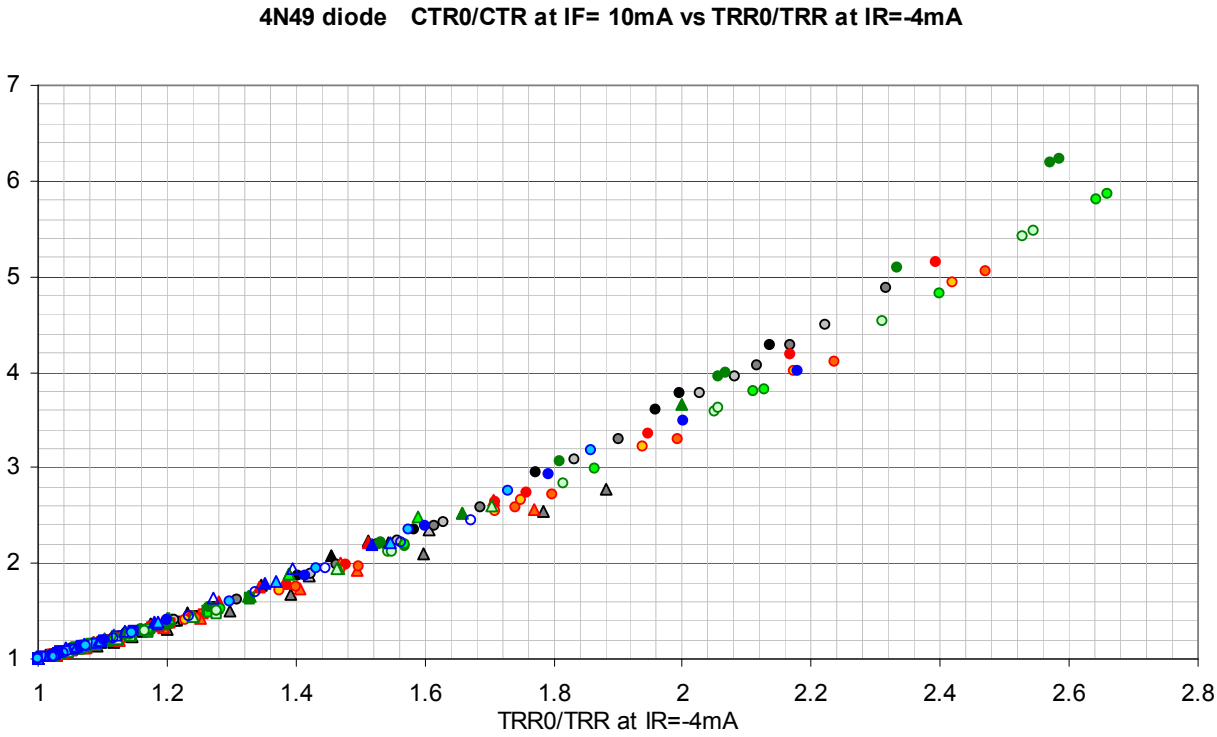


Fig. 8-43: 4N49 diode CTR_0/CTR at I_F=10mA with respect to τ_{RR0}/τ_{RR}

The regressed N values are in the range of the values obtained from the proton irradiations. As previously τ_{RR0} has no influence on N (Fig. 8-44 and Fig. 8-45).

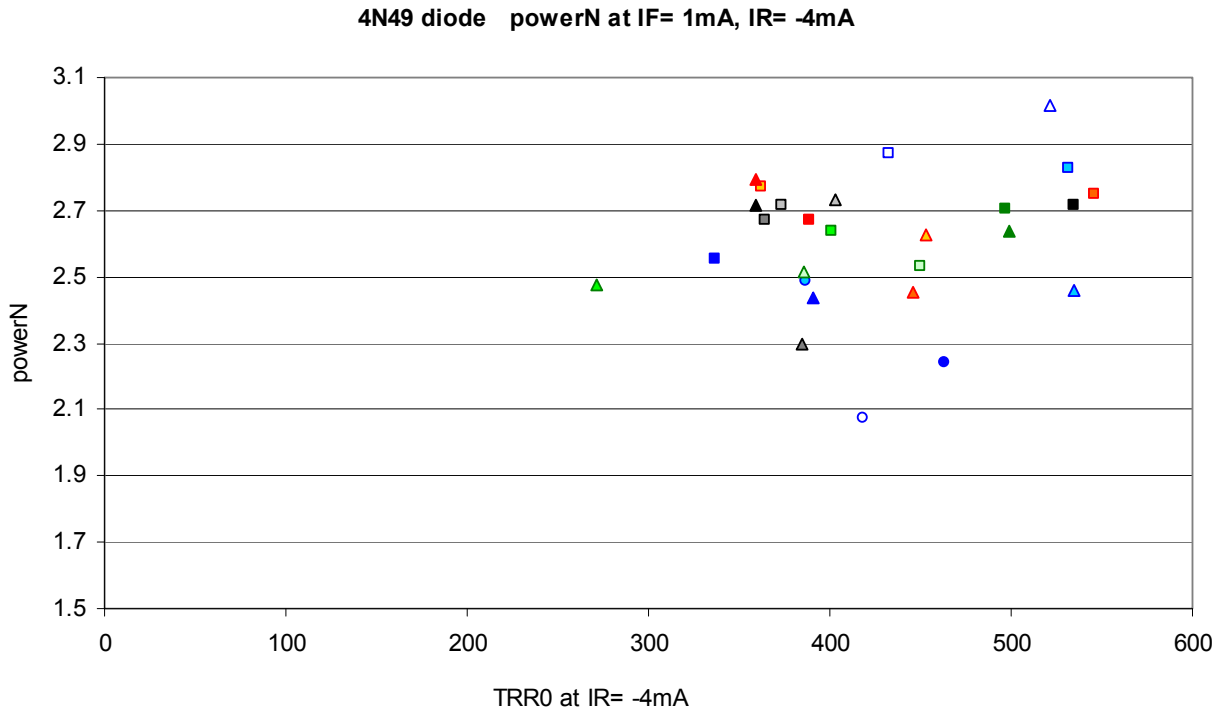


Fig. 8-44 : N at (I_F, I_R) = (1, -4)mA with respect to τ_{RR0}

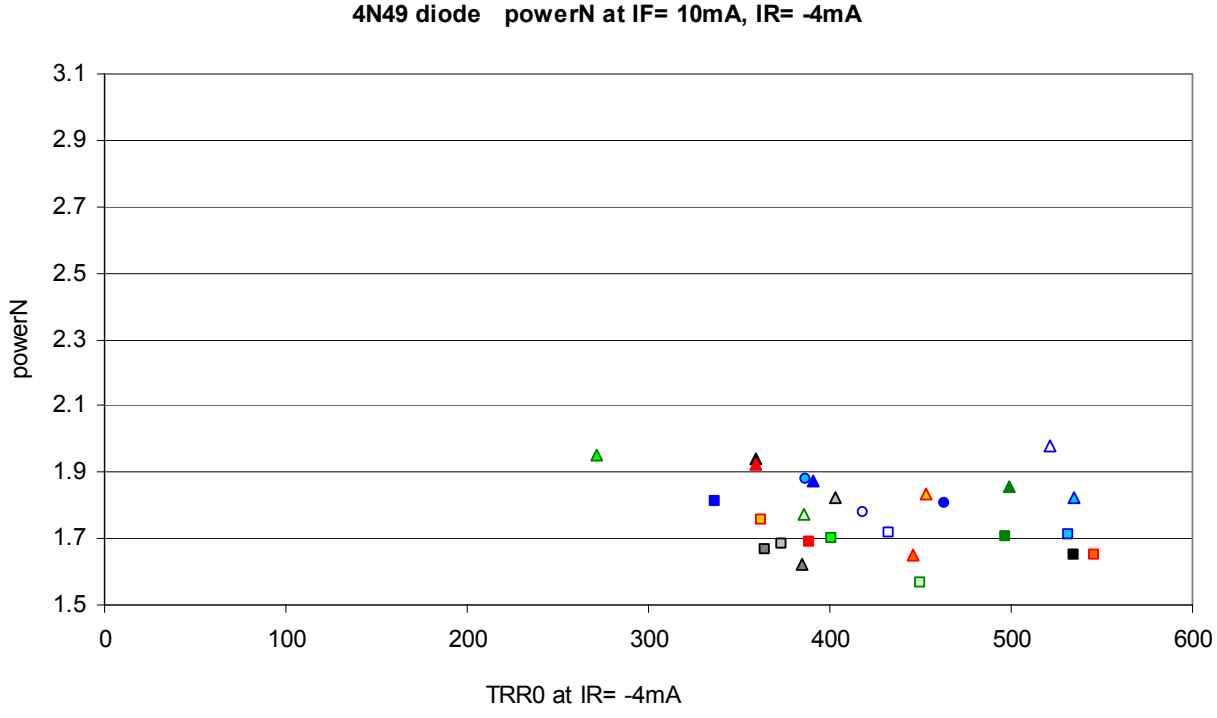
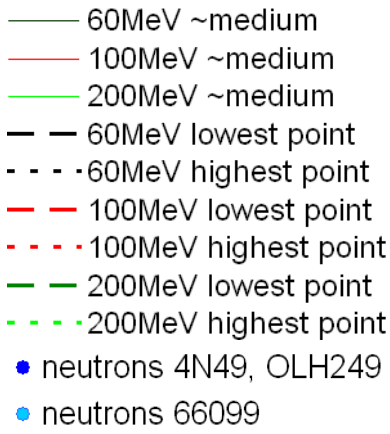


Fig. 8-45 : N at (I_F, I_R) = (1, -4)mA with respect to τ_{RR0}

8.4 ESTIMATION OF A DIODE DEGRADATION

Here are picked up the figures presented in §6.2 at 8 10^6, 2 10^7 and 4.88 10^7 MeV.g^{-1}, with the same regressed curves from 4N49 proton irradiation and with neutron points superimposed.



Legend for Fig. 8-46 to Fig. 8-57

Neutron points agree very well with the previous proton points, except for OLH249 diode. For OLH249, CTRdiode neutron degradation at a given NIEL is higher than proton CTRdiode degradation.

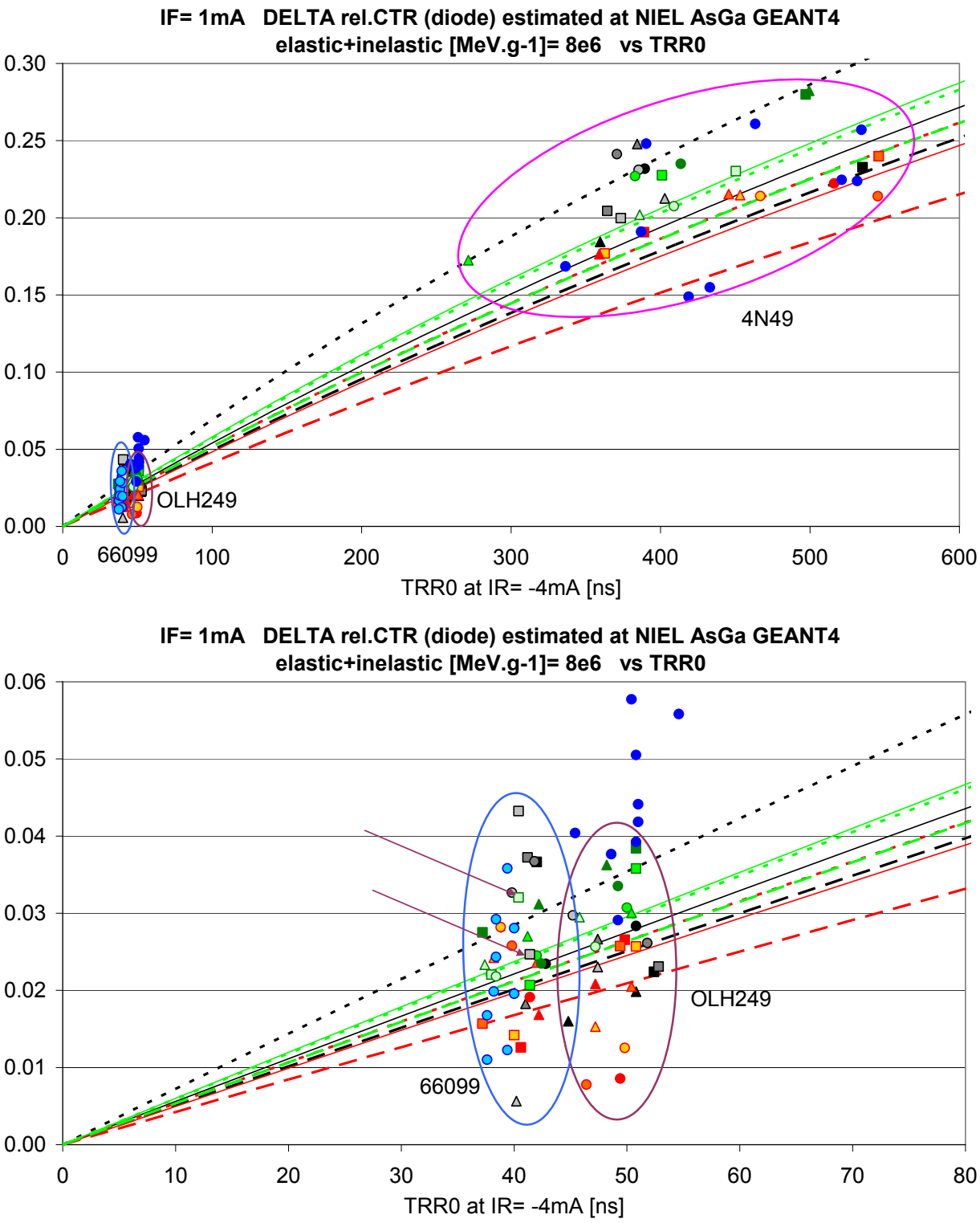
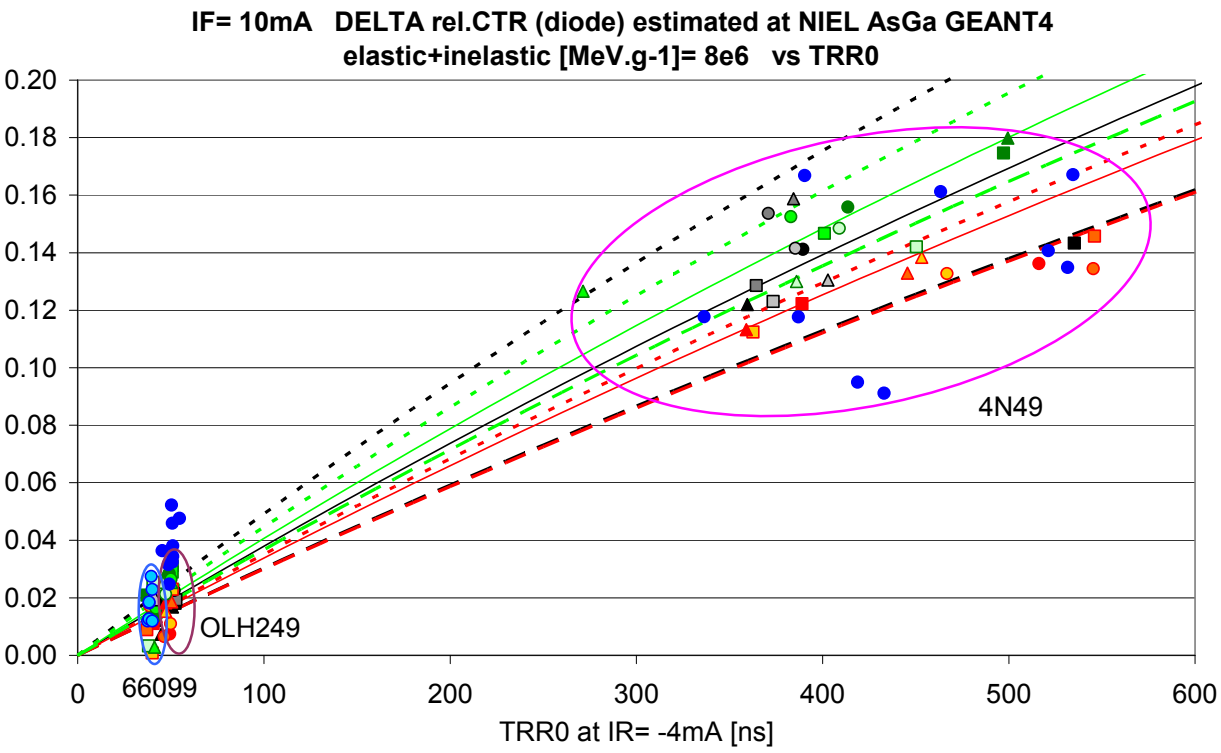


Fig. 8-46: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



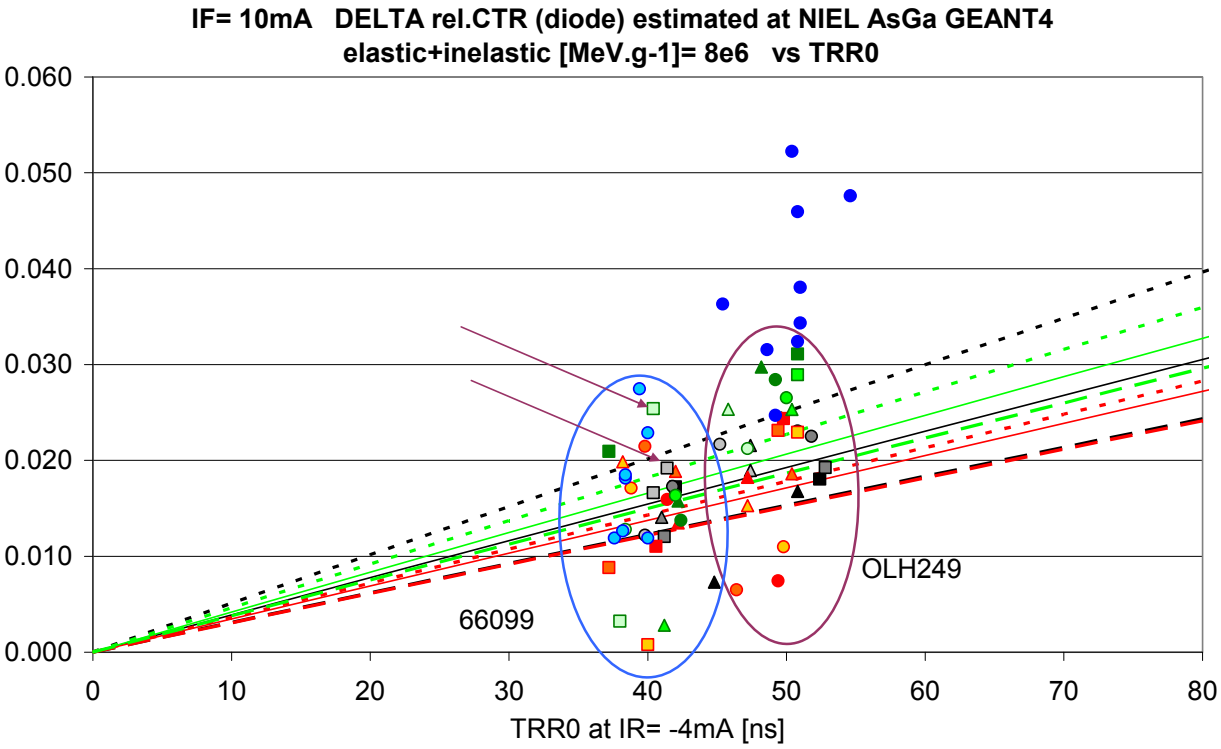


Fig. 8-47: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

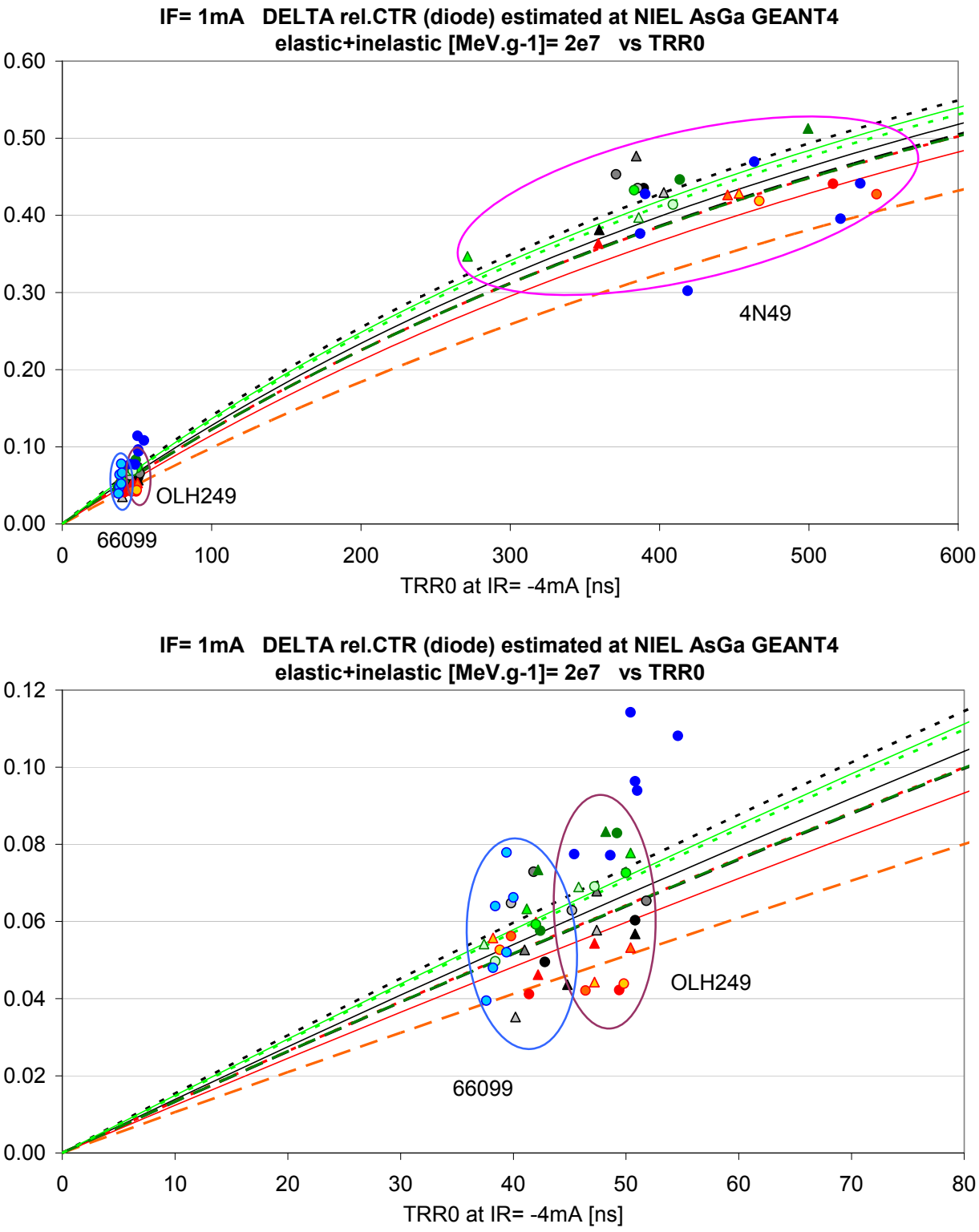


Fig. 8-48: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

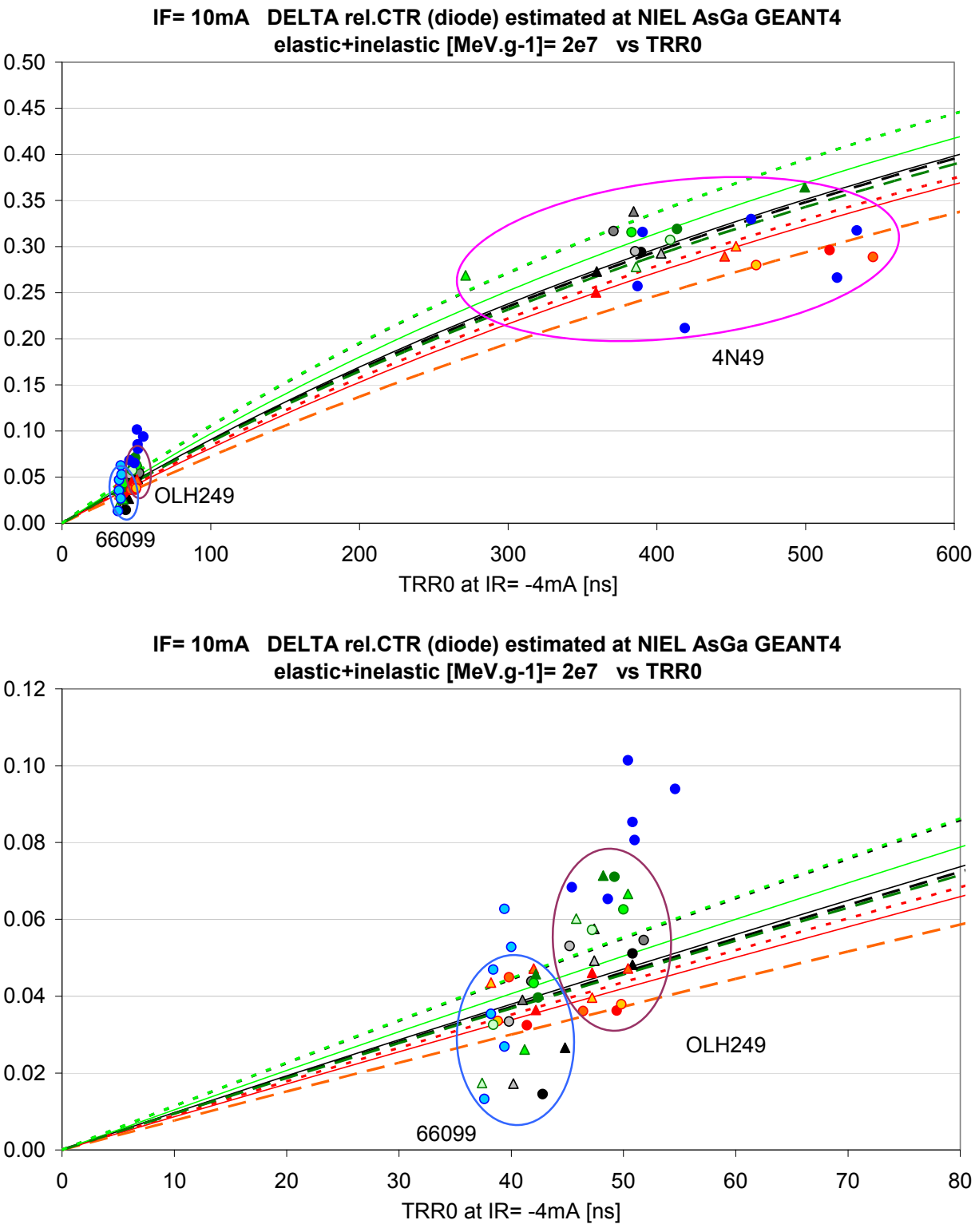
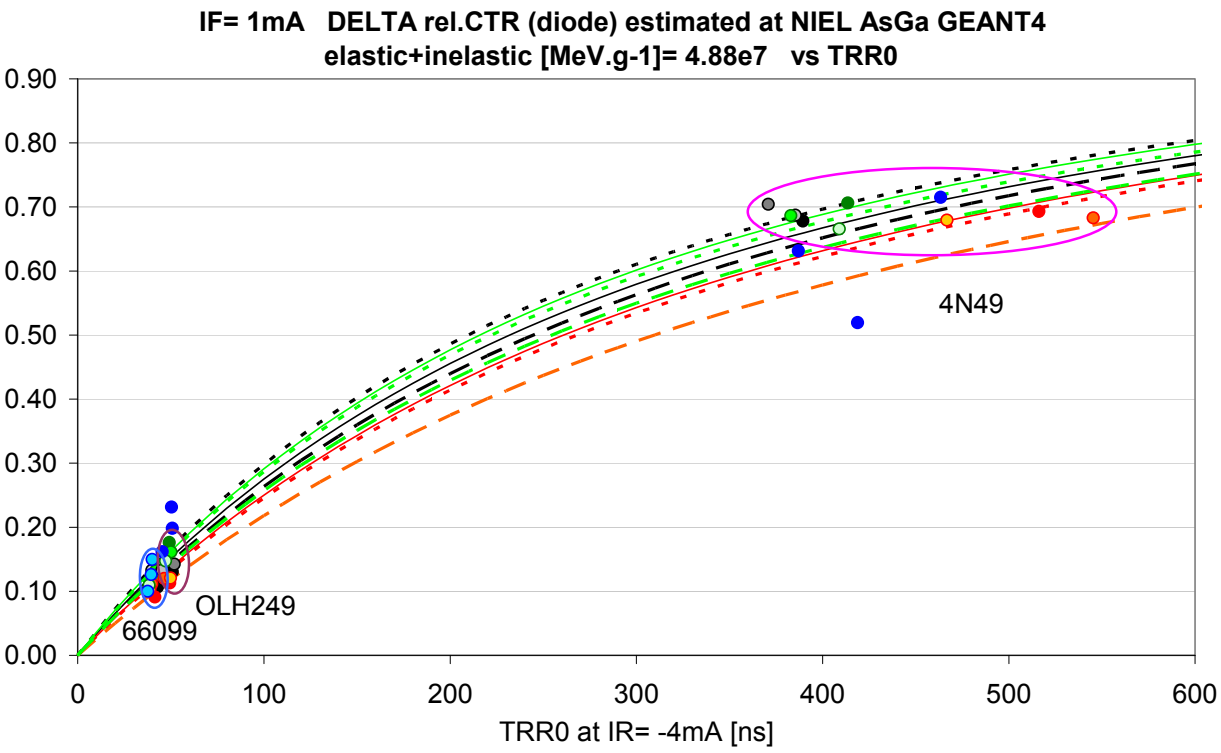


Fig. 8-49: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



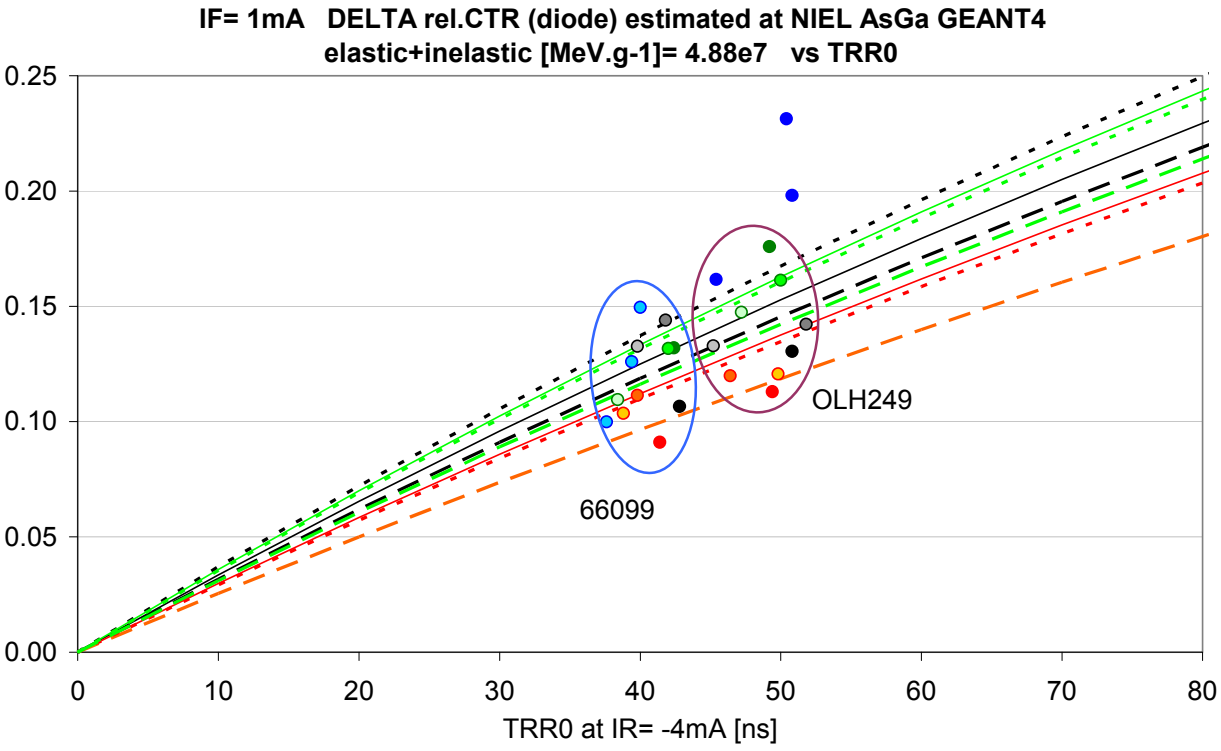
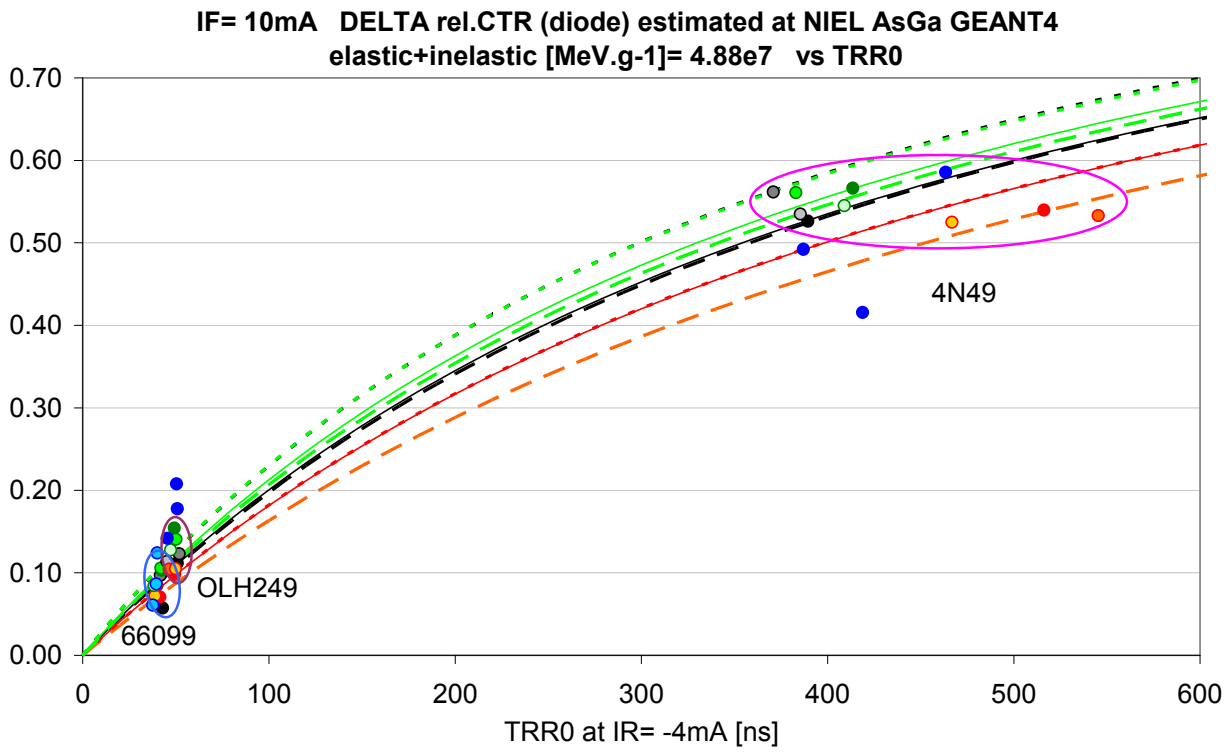


Fig. 8-50: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



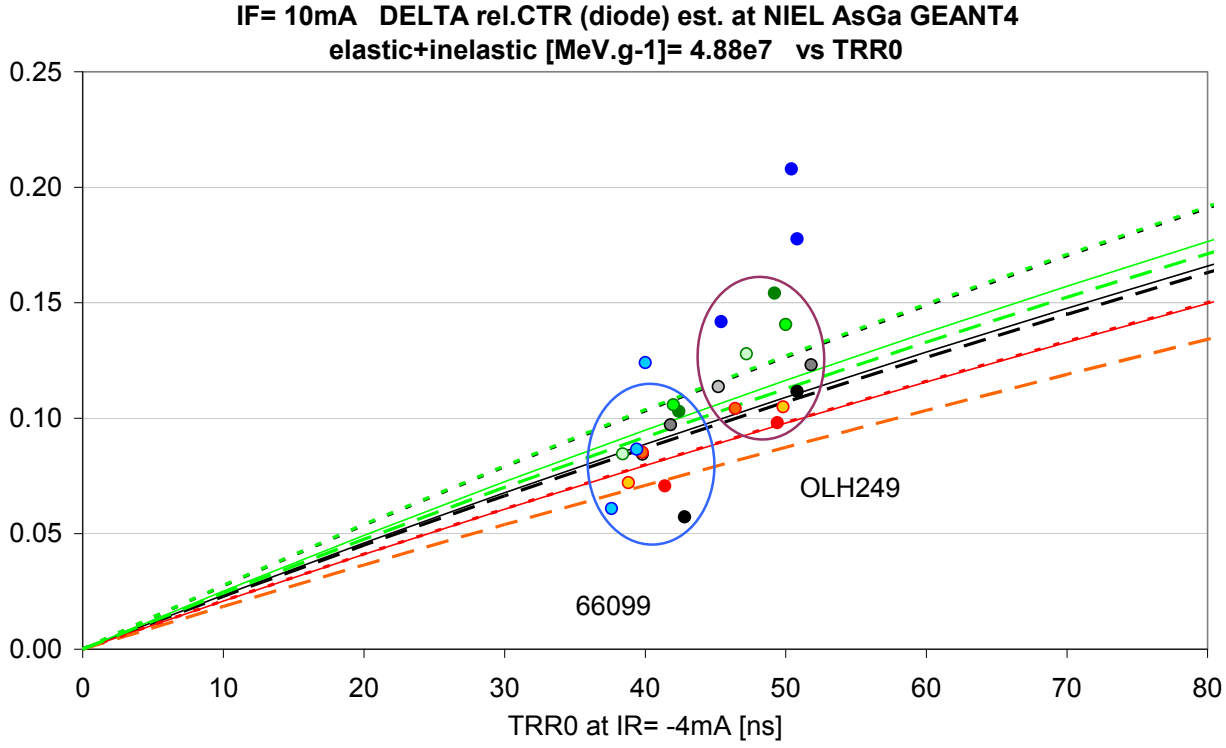
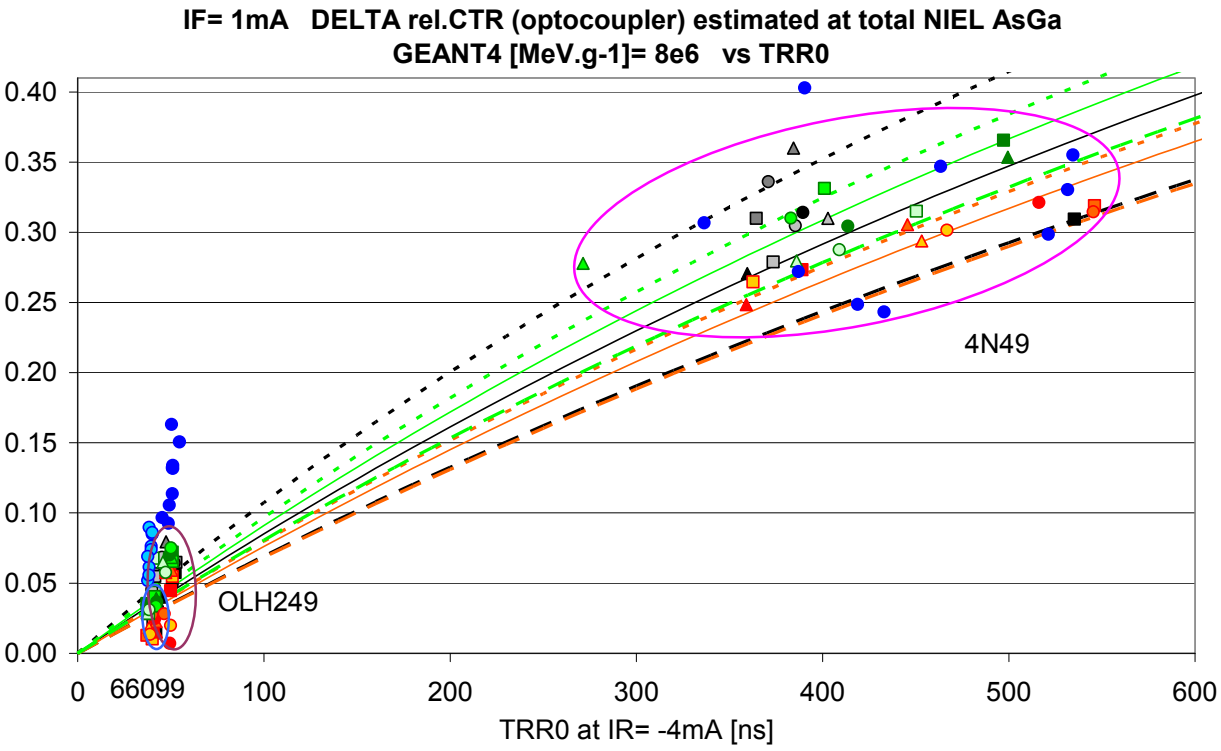


Fig. 8-51: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

8.5 ESTIMATION OF AN OPTOCOUPLER DEGRADATION

Here are picked up the figures presented in §7.2 at 8 10^6, 2 10^7 and 4.88 10^7 MeV.g^{-1}, with the same regressed curves from 4N49 proton irradiation and with neutron points superimposed.

4N49 neutron points agree very well with the previous proton points. As expected from CTRdiode degradation, CTRoptocoupler neutron degradation at a given NIEL is higher than proton CTRoptocoupler degradation for OLH249. However it is also the case for 66099.



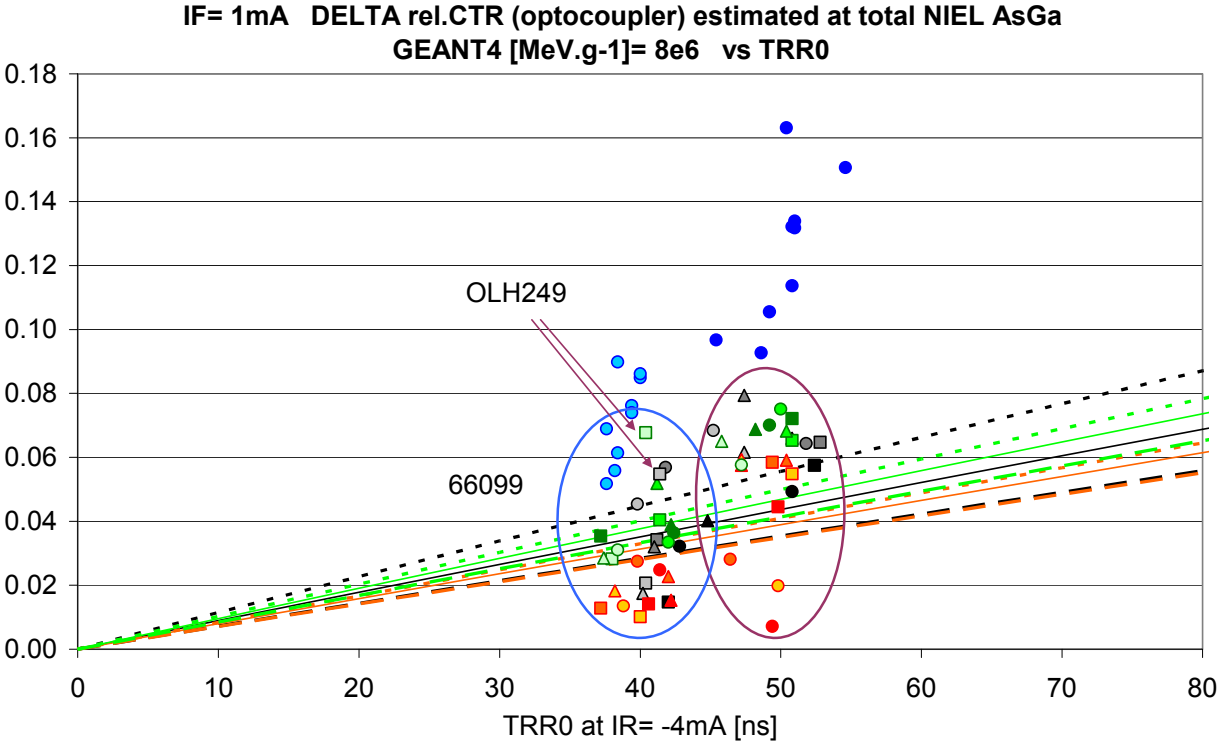


Fig. 8-52: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

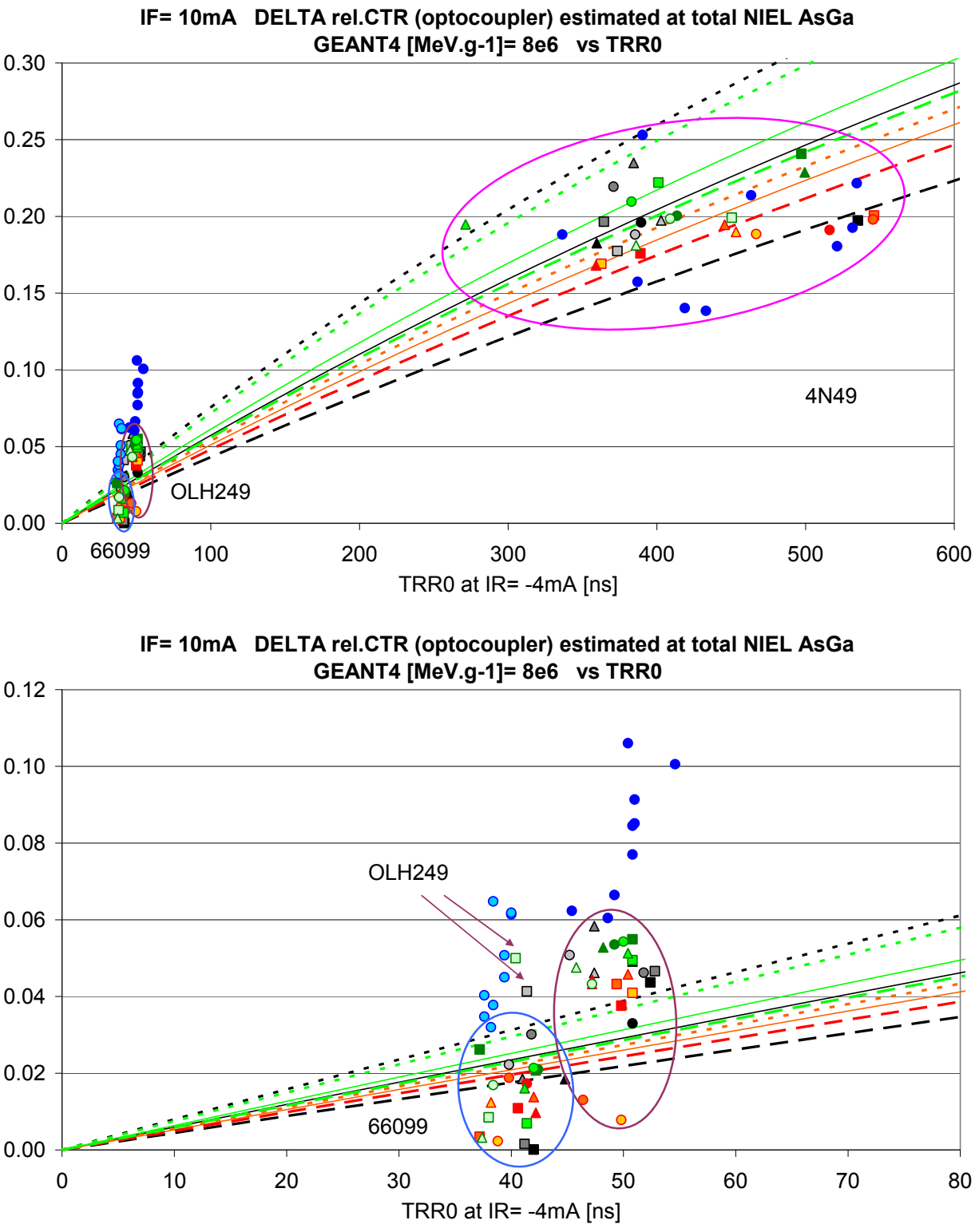
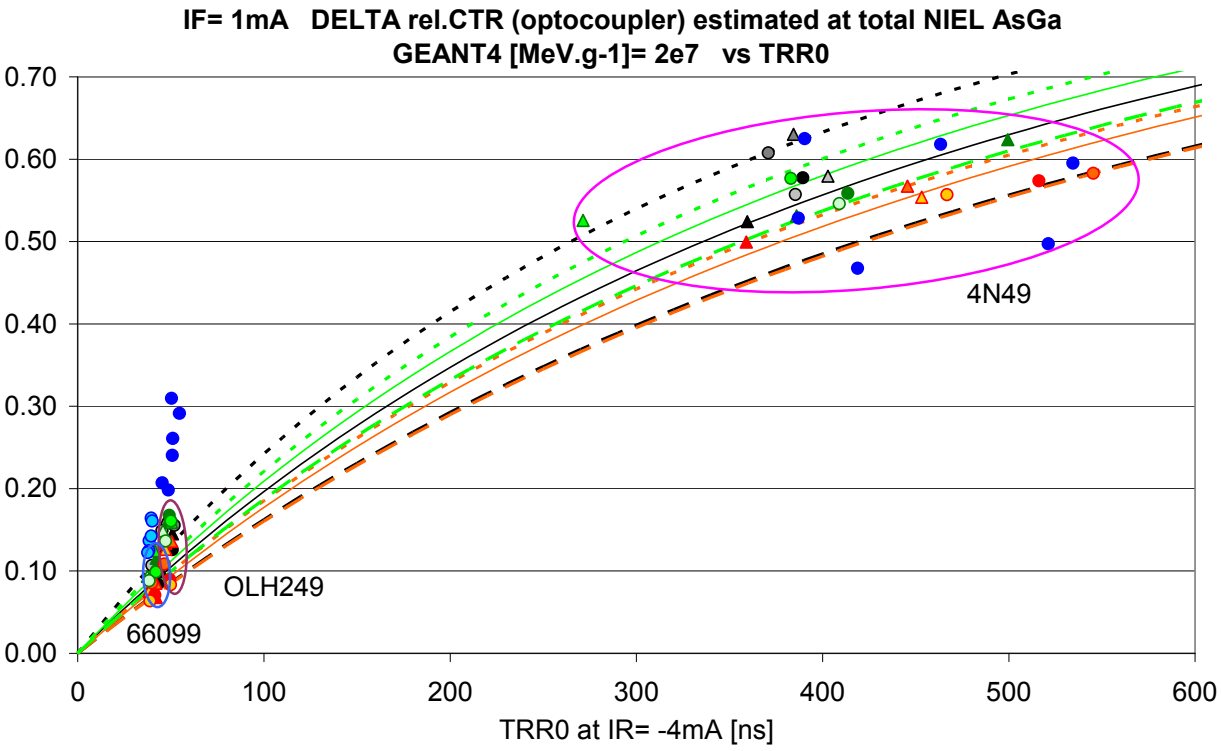


Fig. 8-53: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



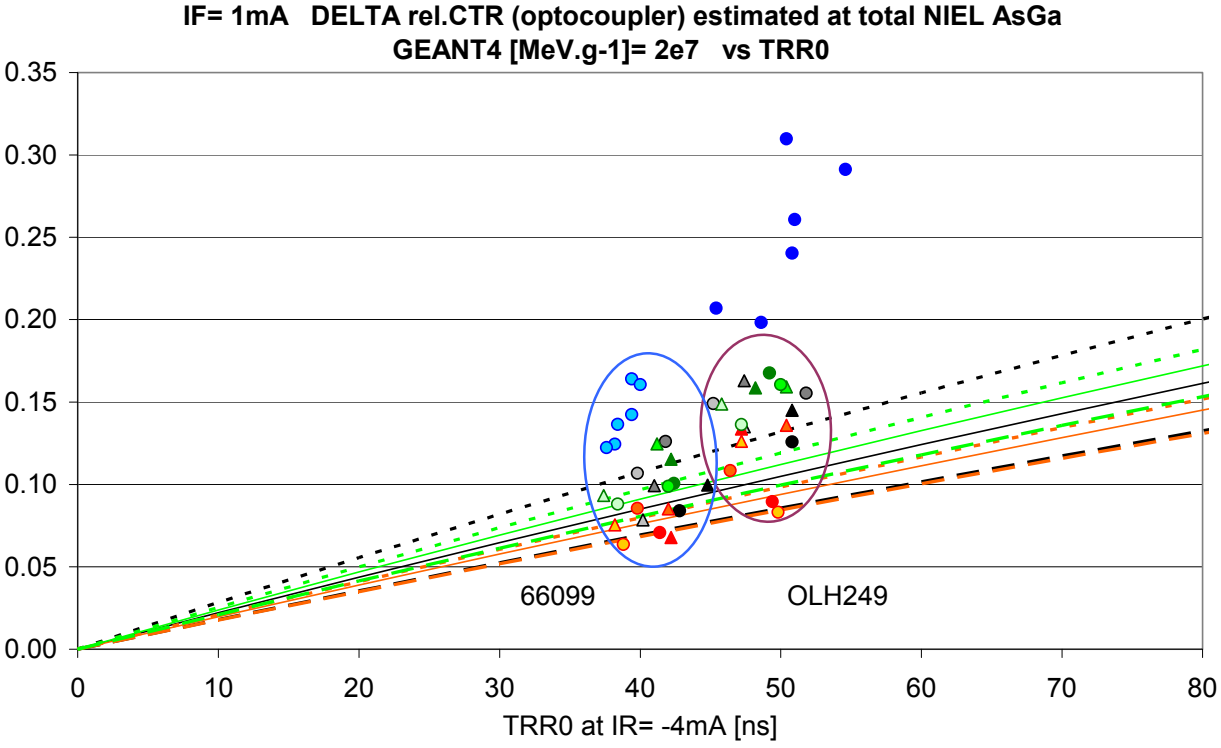
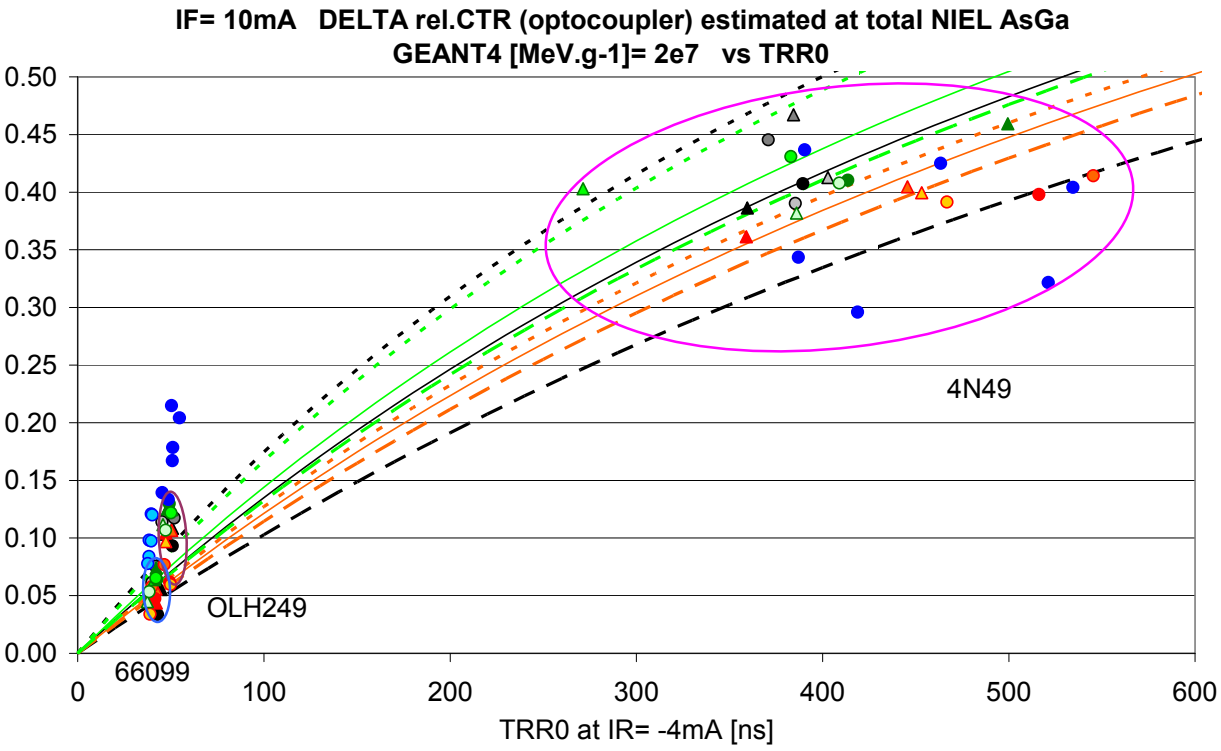


Fig. 8-54: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



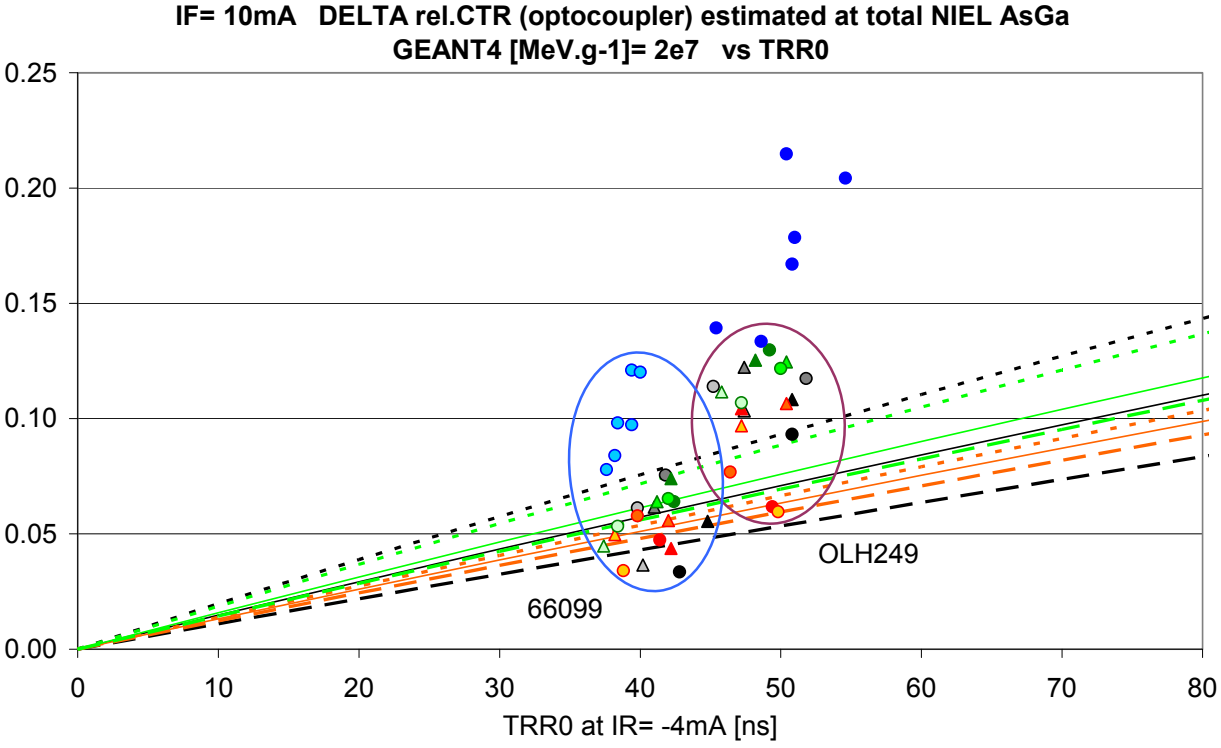
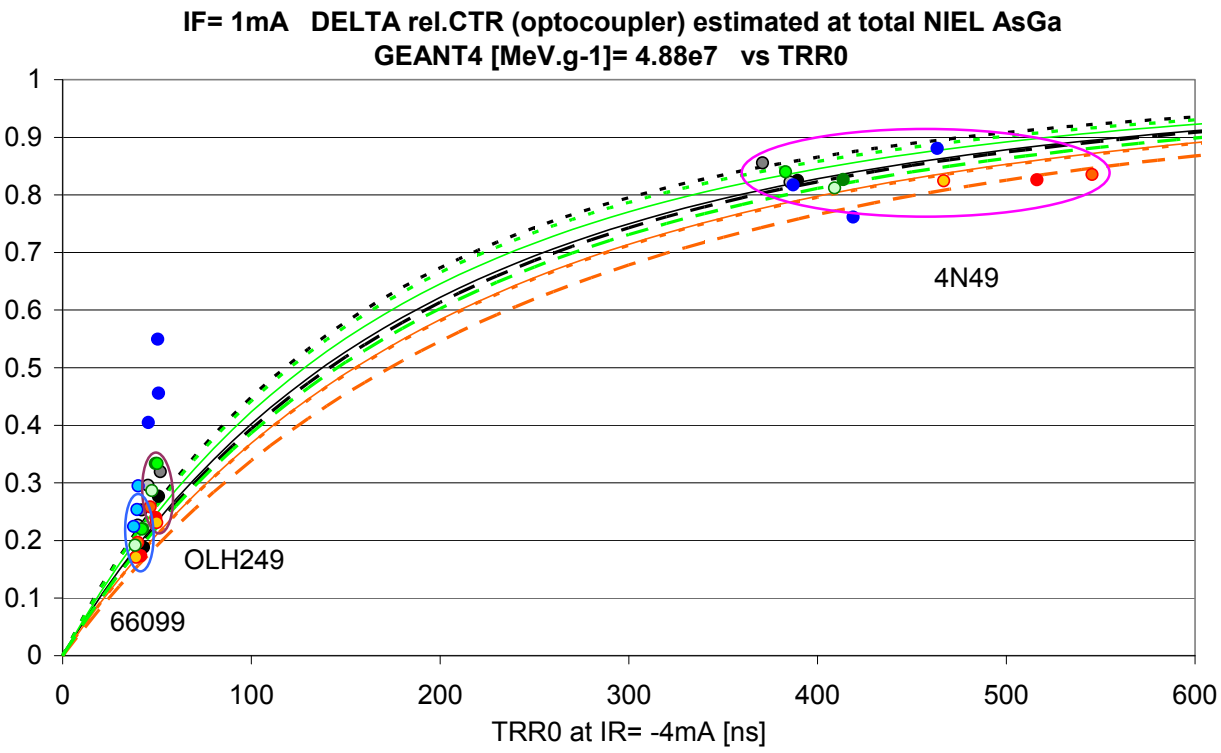


Fig. 8-55: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



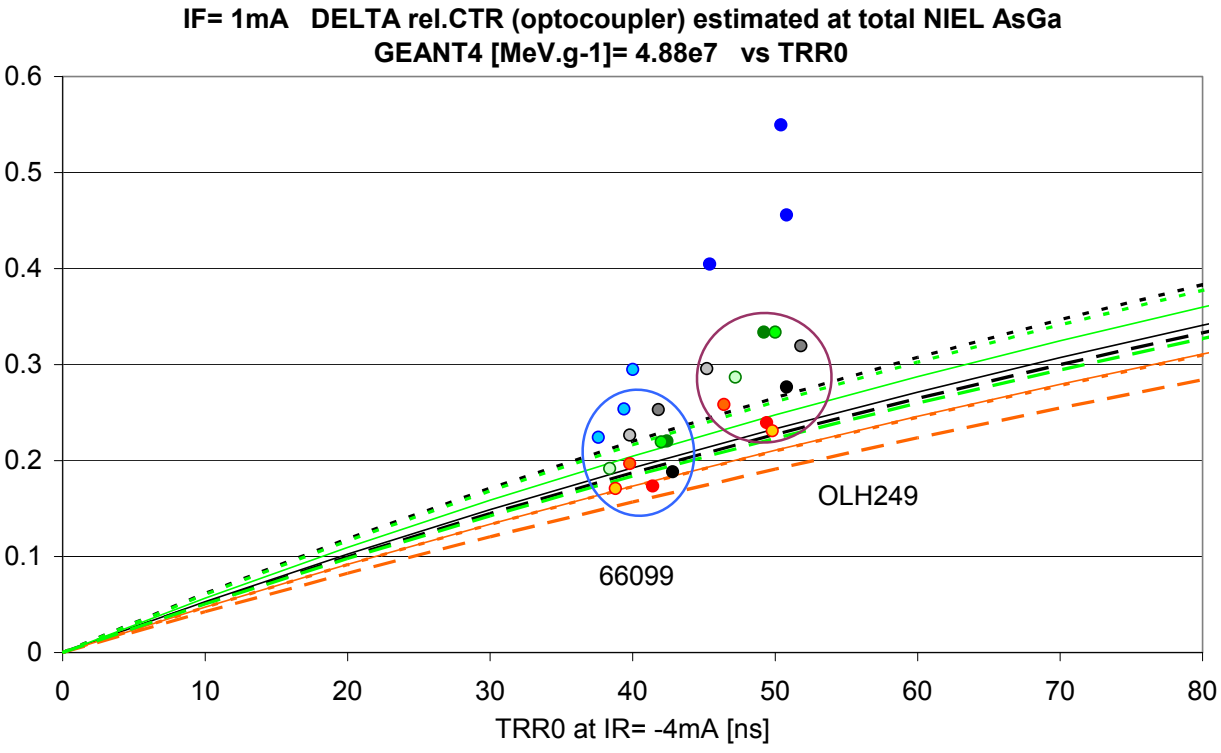
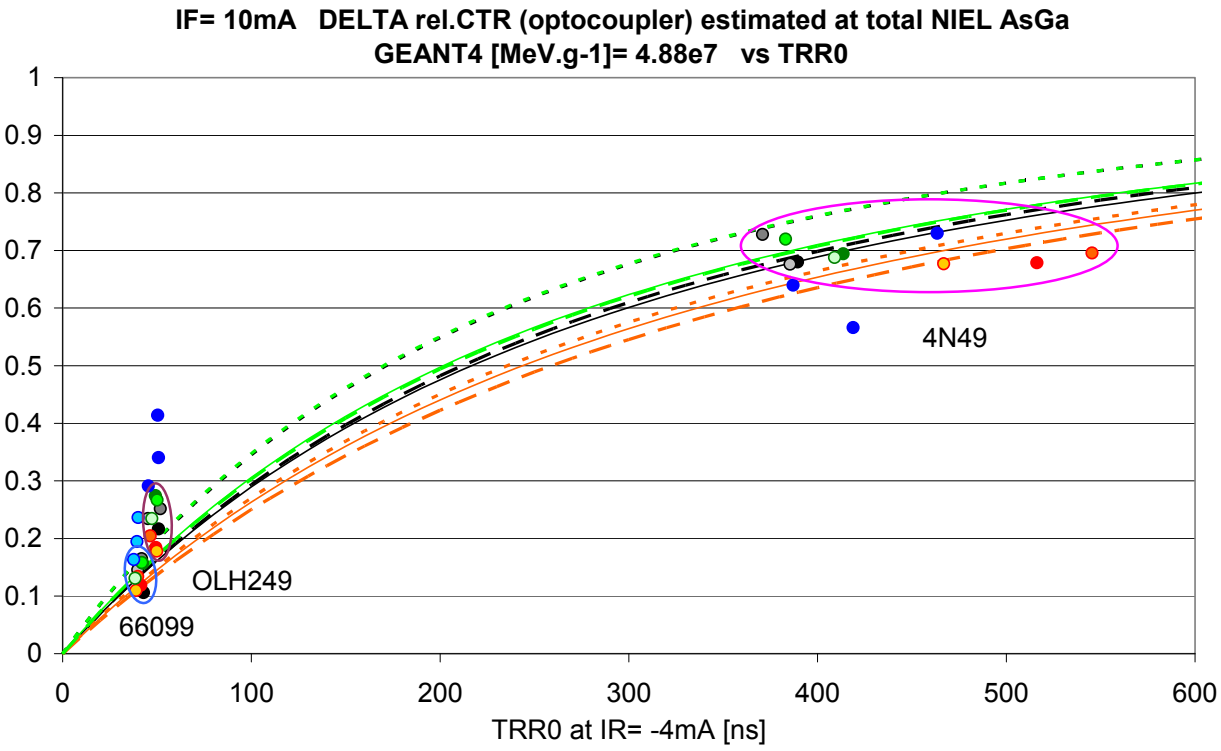


Fig. 8-56: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves



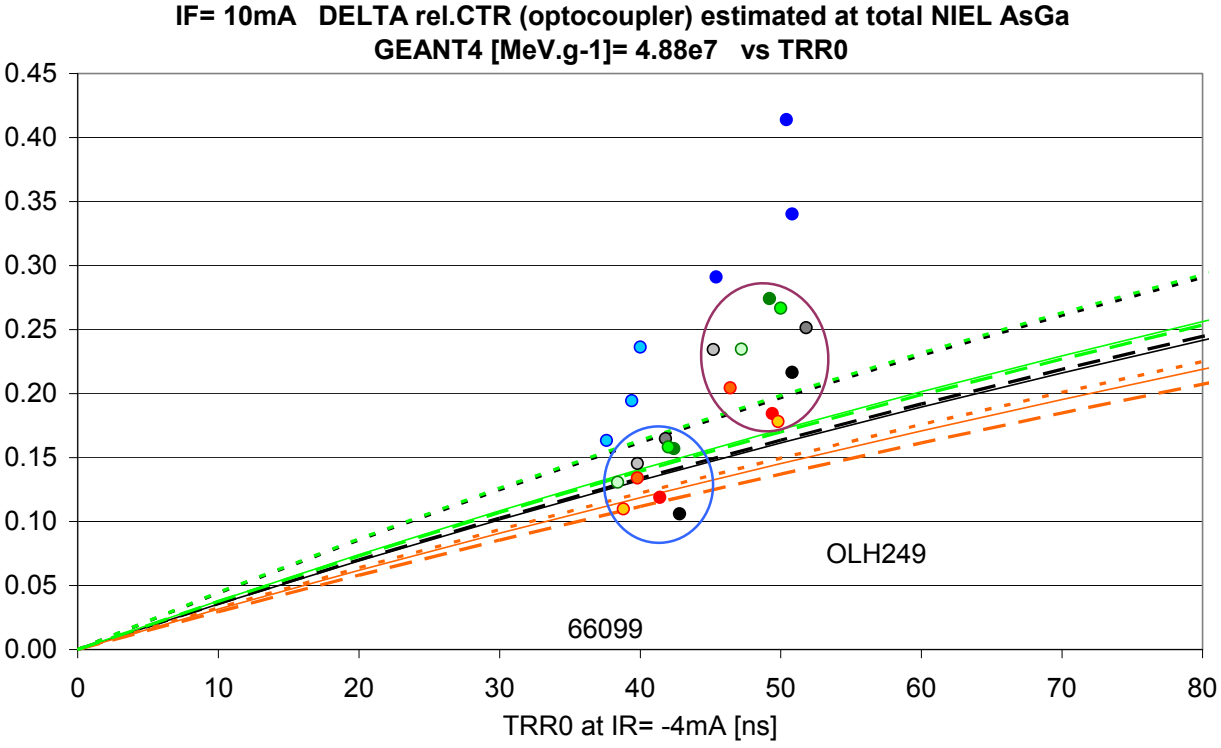
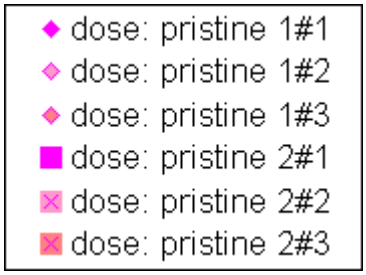


Fig. 8-57: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 10mA with respect to τ_{RR0} at I_R = -4mA and "medium", "lowest point" and "highest point" curves

9. GAMMA IRRADIATION

9.1 CTR DEGRADATION



Legend for Fig. 9-1 to Fig. 9-32

Like for proton and neutron irradiation 4N49 optocoupler experiences by far the strongest degradation, then OLH249 is much less degraded, and 66099 even less.
But unlike displacement damage the main contribution in the dose induced CTR degradation is the decrease of phototransistor gain for all part types. While 4N49 CTRdiode decreases still significantly (however 4N49 relative CTRdiode is > 21 x CTRtransistor at 40krad(Si) and > 85 x CTRtransistor at 75krad(Si)), OLH249 and 66099 relative CTRdiode attenuations are similar and totally negligible compared to the diminution of CTRtransistor.

4N49 transistors exhibit higher degradation than the OLH249's, and the 66099's one (Fig. 9-7 to Fig. 9-9), at same diode current. However this comparison would be relevant if the optical powers received by transistors were known as identical. Up to now, this information is missing since no optical measurement was foreseen during this study.

Again, the relative CTR degradation decreases as the injected current in the diode I_F is increased (1 to 10 mA). This effect is observed whatever the irradiated part: whole optocoupler, diode, and transistor.

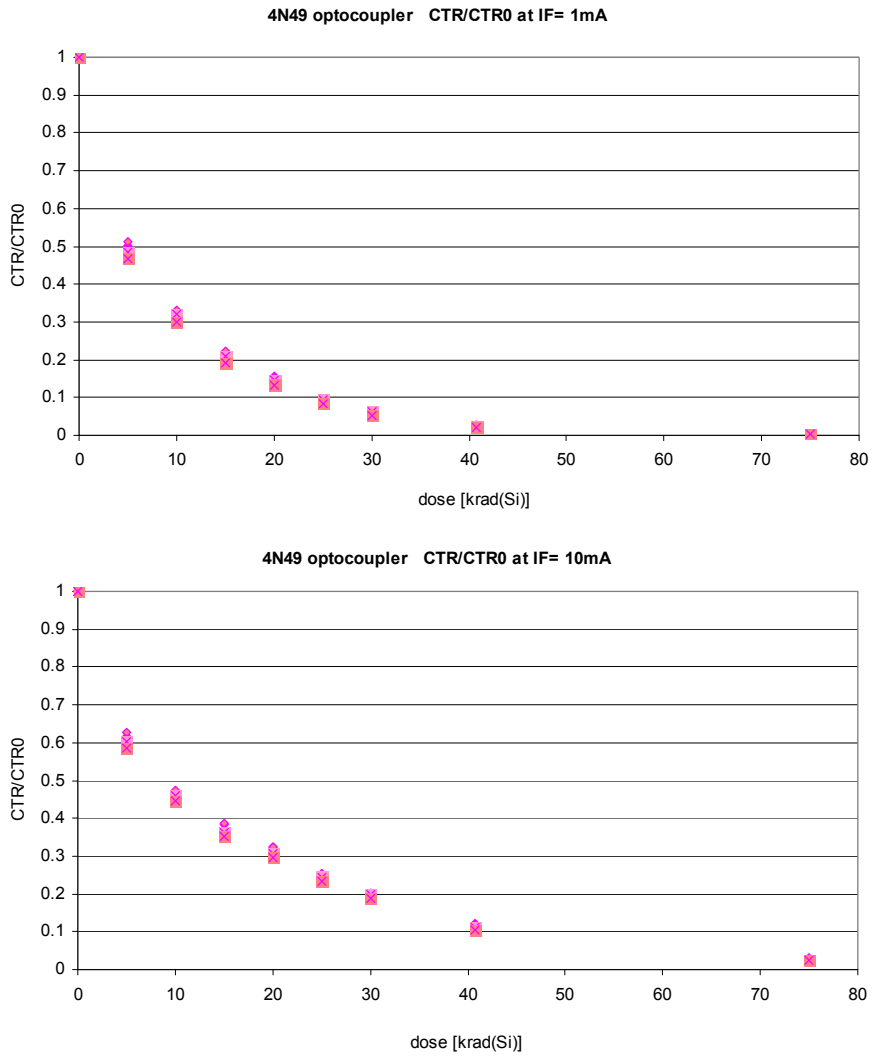
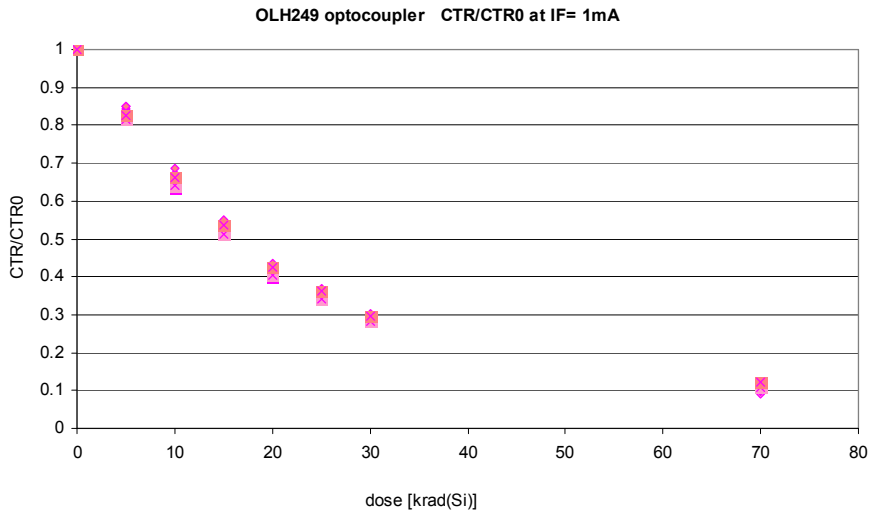


Fig. 9-1: 4N49 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA



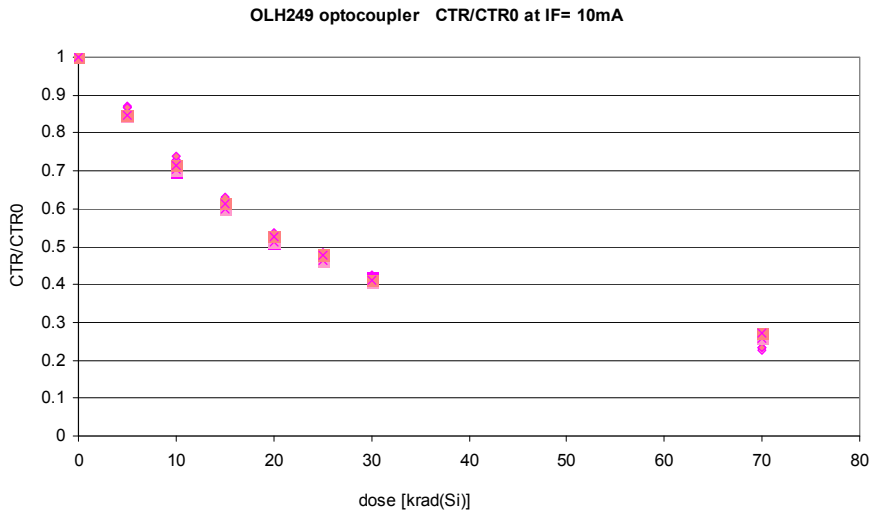


Fig. 9-2: OLH249 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA

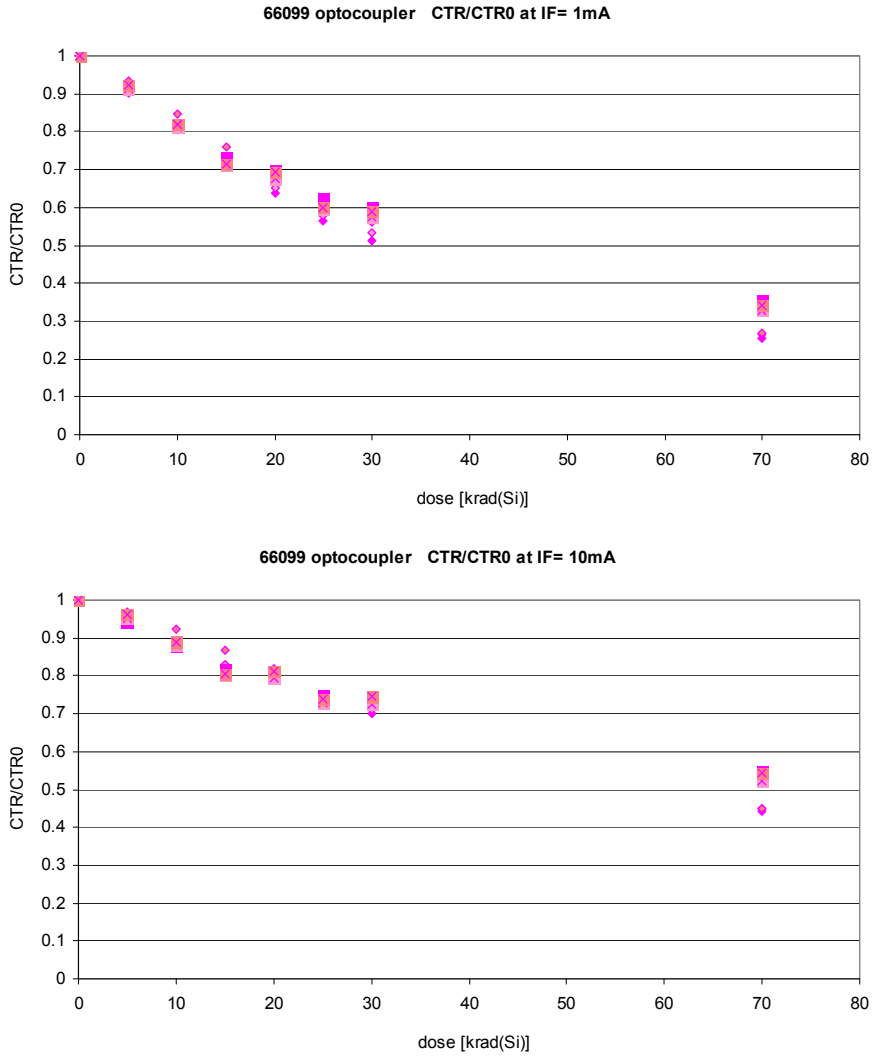


Fig. 9-3: 66099 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA

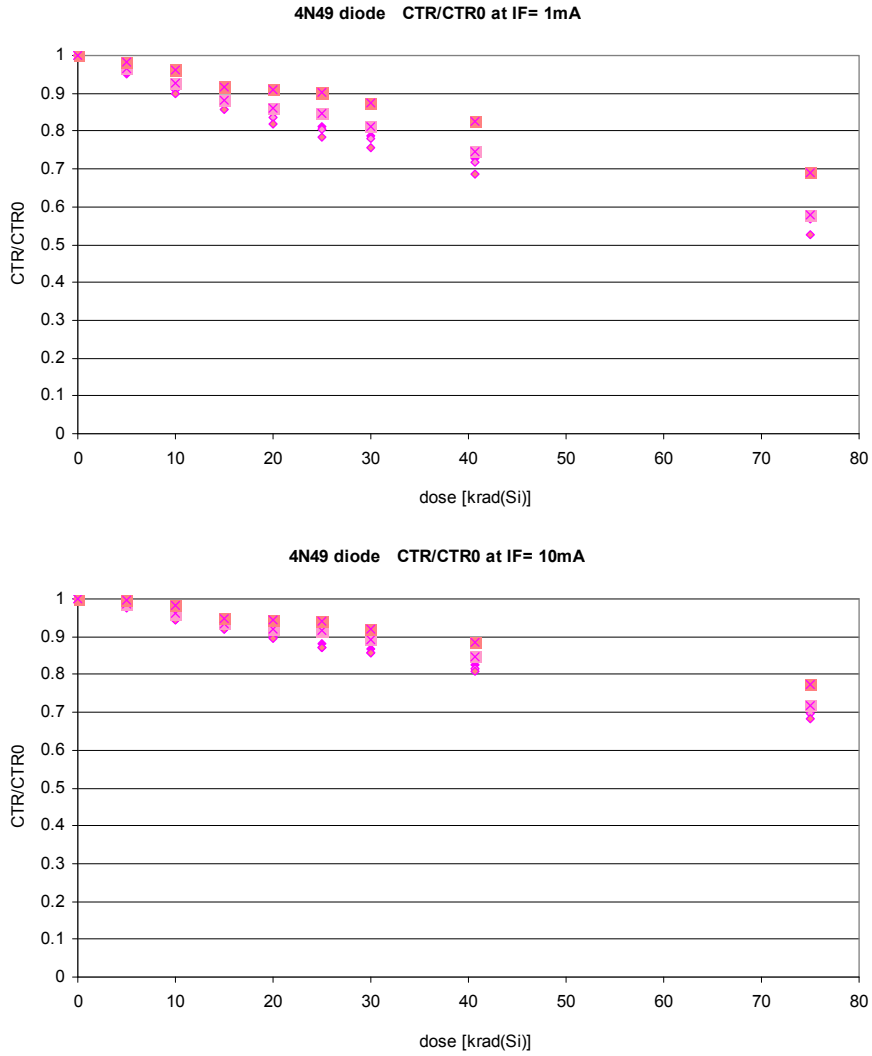
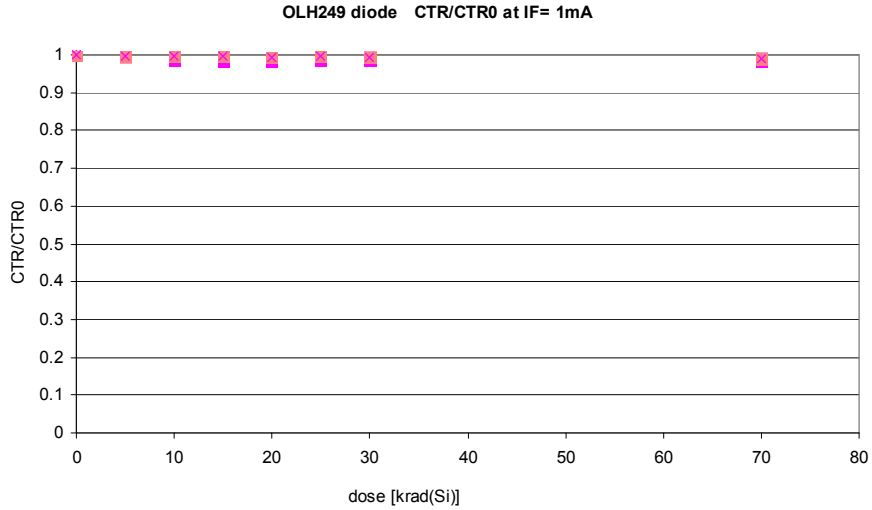


Fig. 9-4: 4N49 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA



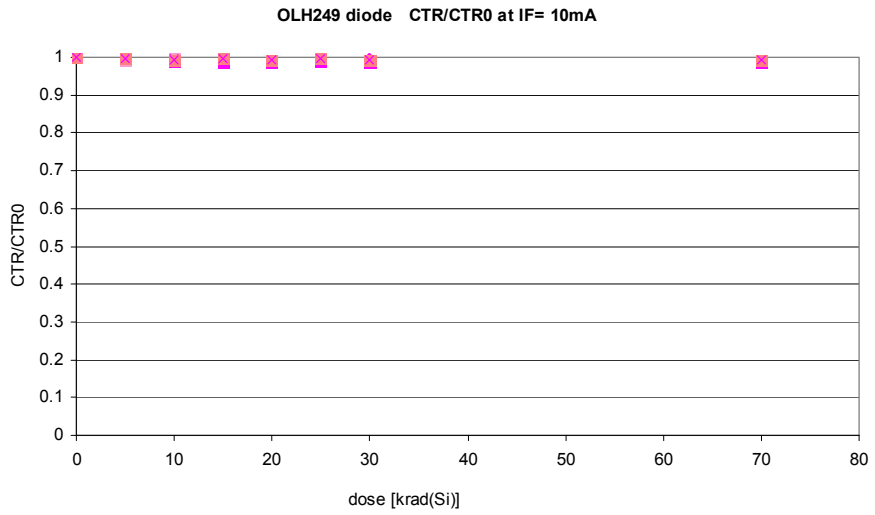


Fig. 9-5: OLH249 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA

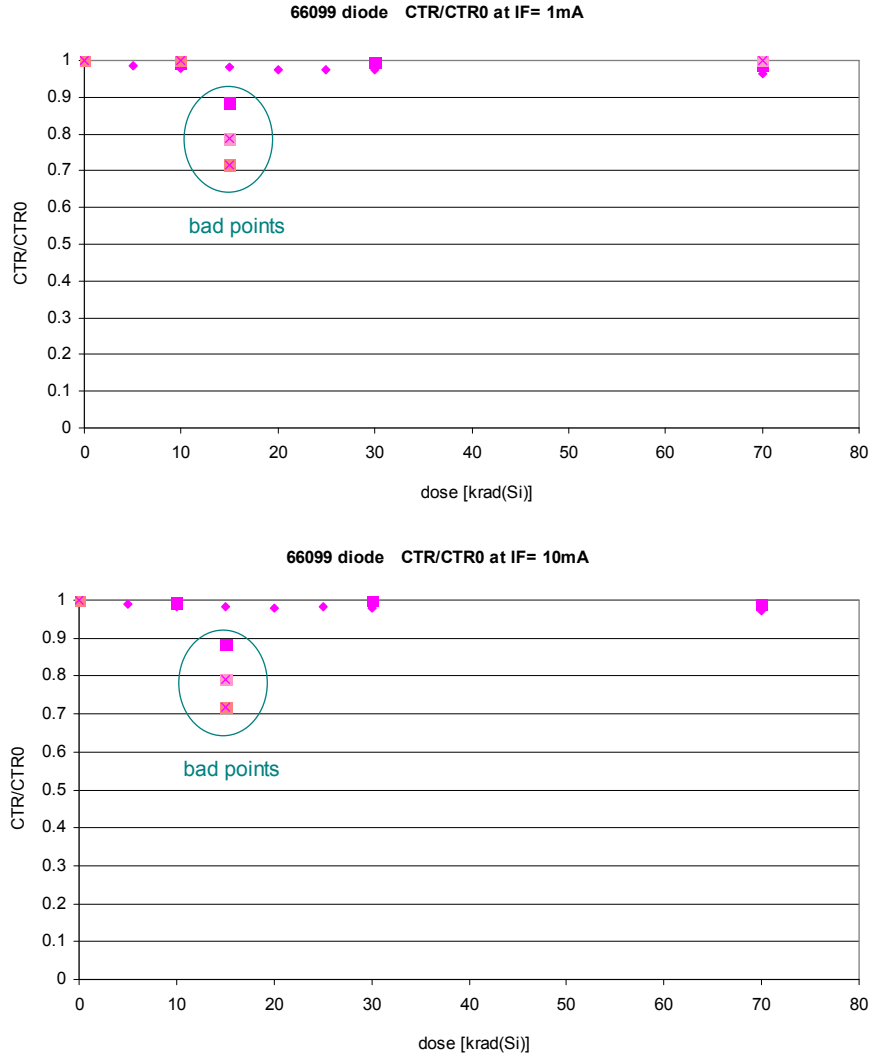


Fig. 9-6: 66099 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA

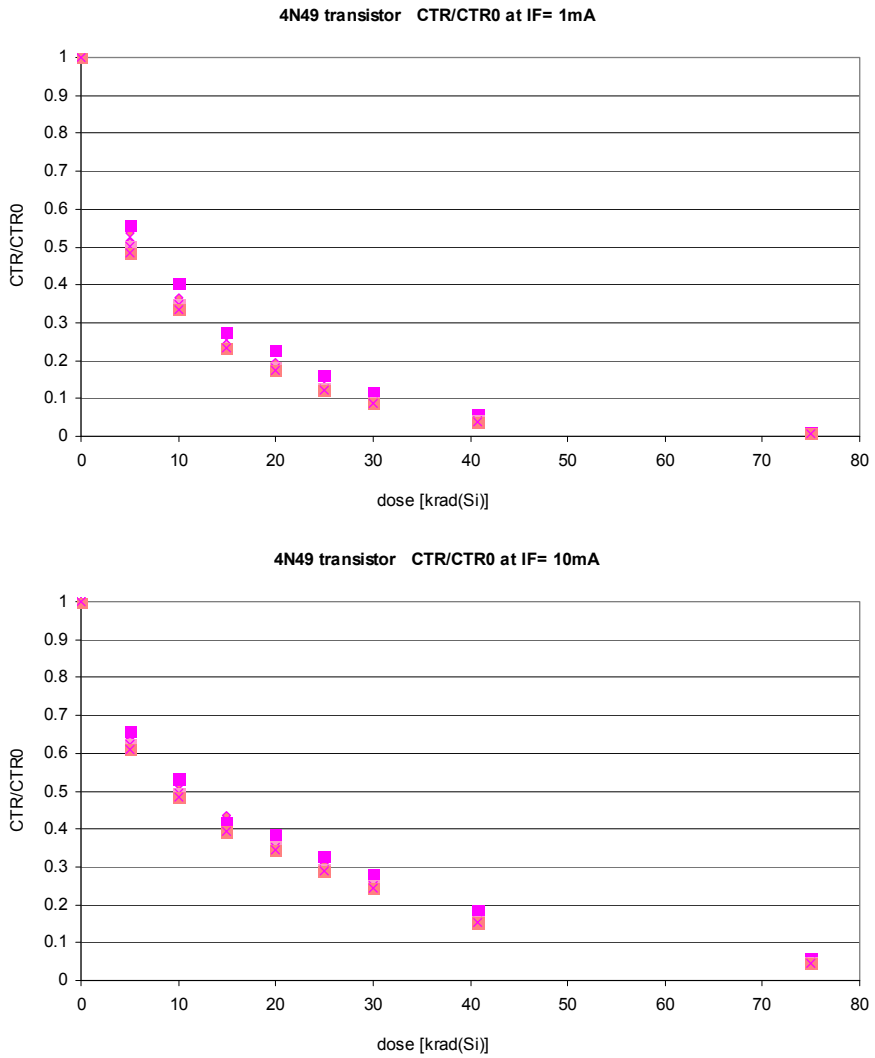
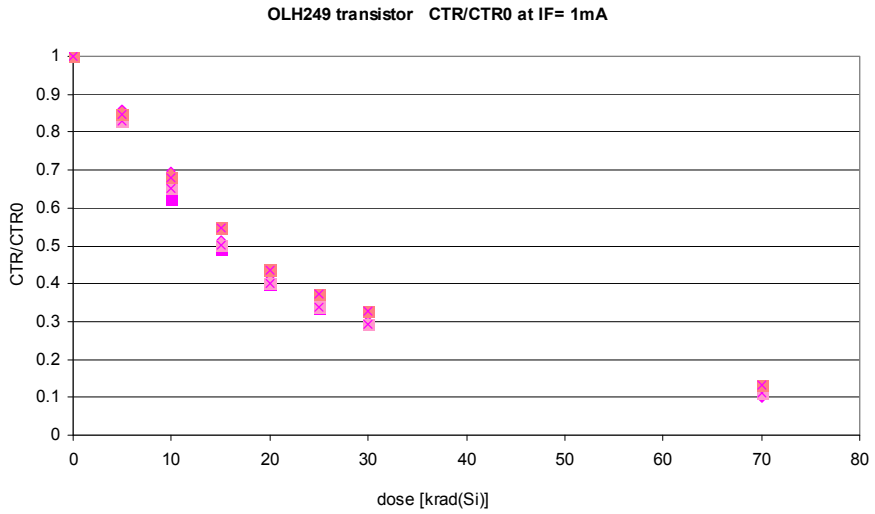


Fig. 9-7: 4N49 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA



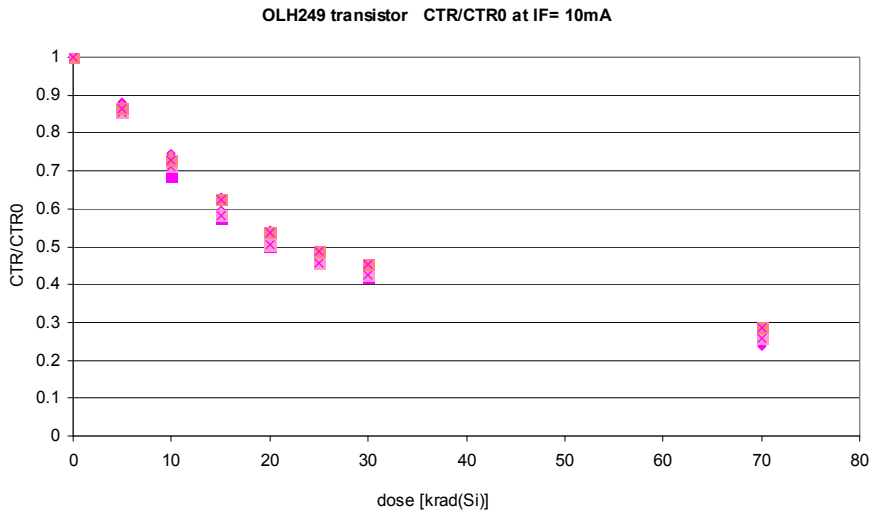


Fig. 9-8: OLH249 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA

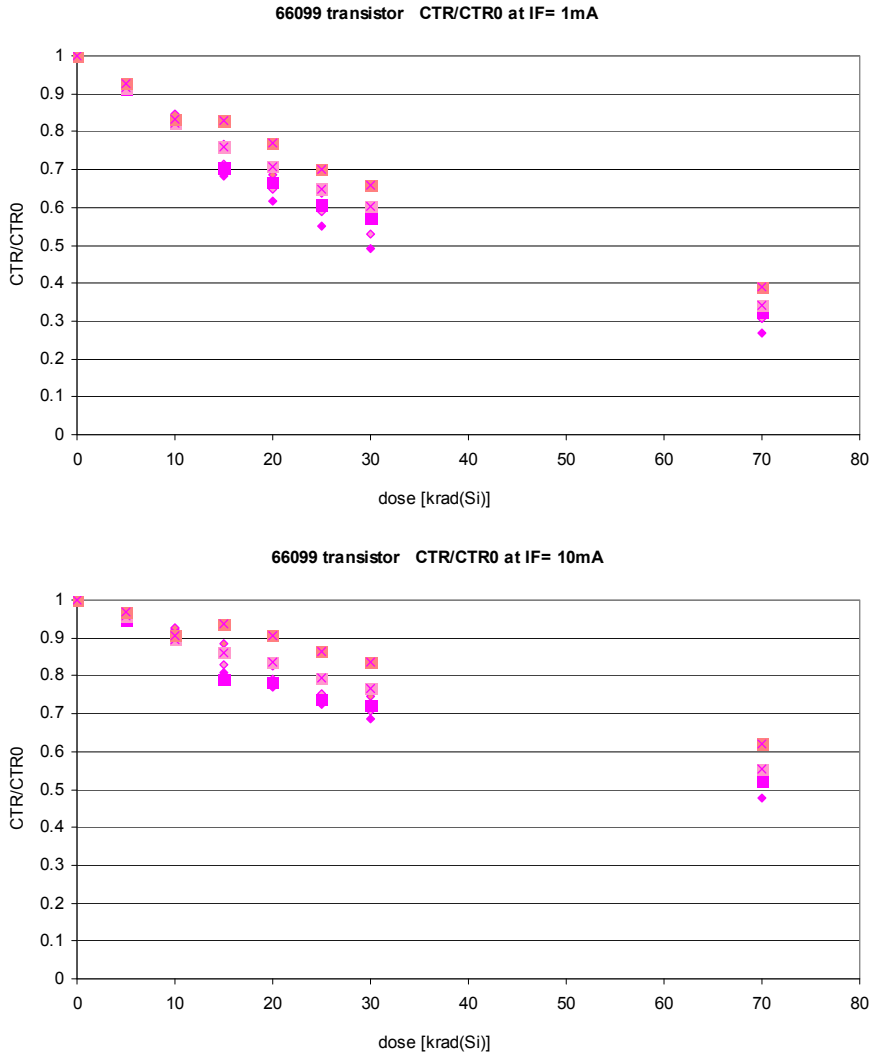


Fig. 9-9: 66099 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10m

9.2 VARIATION OF REVERSE RECOVERY TIME

In this section the reverse recovery time of the diode is considered at I_R = -4mA.

Diode CTR degradation is again related to the reverse recovery time decrease. Like for displacement damage, the faster the diode, the lower the degradation.
4N49 diode $\Delta\ 1/\tau_{RR}$ plotted in Fig. 9-10 exhibits a linear variation with respect to the dose, in the same manner as during proton and neutron irradiation with respect to the NIEL, though the processes are different. The proportionality coefficient K_{dose} or K_{TID} is determined in Fig. 9-13. The proportionality coefficient seems to be again independent from initial recovery time.

As depicted in Fig. 9-11 and Fig. 9-12, measurement of OLH249 and 66099 reverse recovery times encountered noise again, even worse than during neutron campaign (Fig. 8-19 and Fig. 8-20). K_{TID} calculation is difficult for OLH249 and 66099.

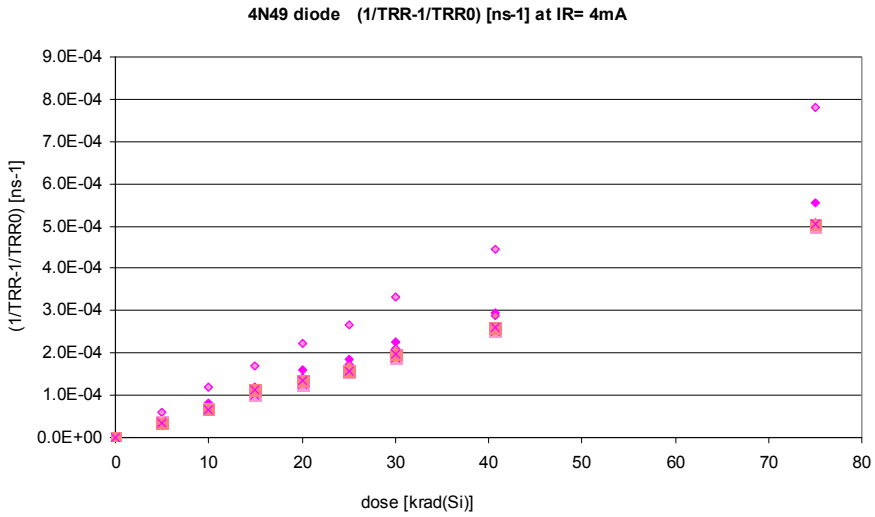


Fig. 9-10: 4N49 $\Delta\ 1/\tau_{RR}$ with respect to TID

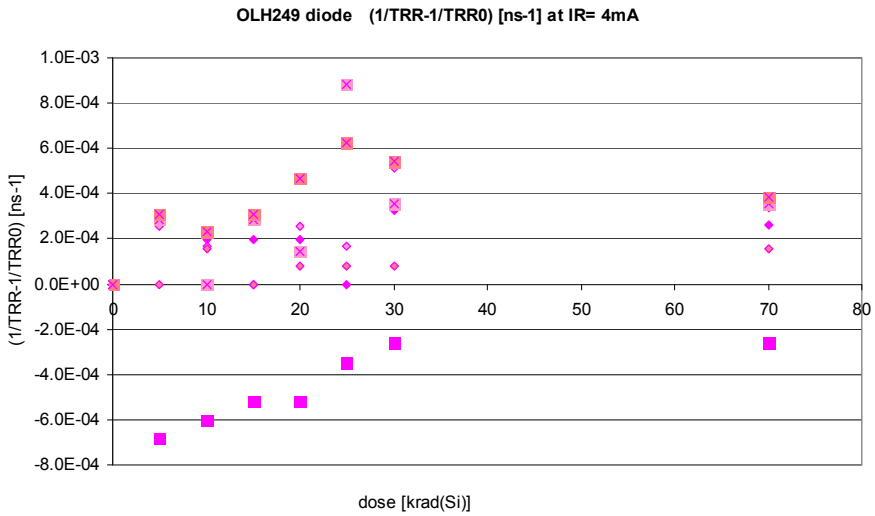


Fig. 9-11: OLH249 $\Delta\ 1/\tau_{RR}$ with respect to TID: bad measurement

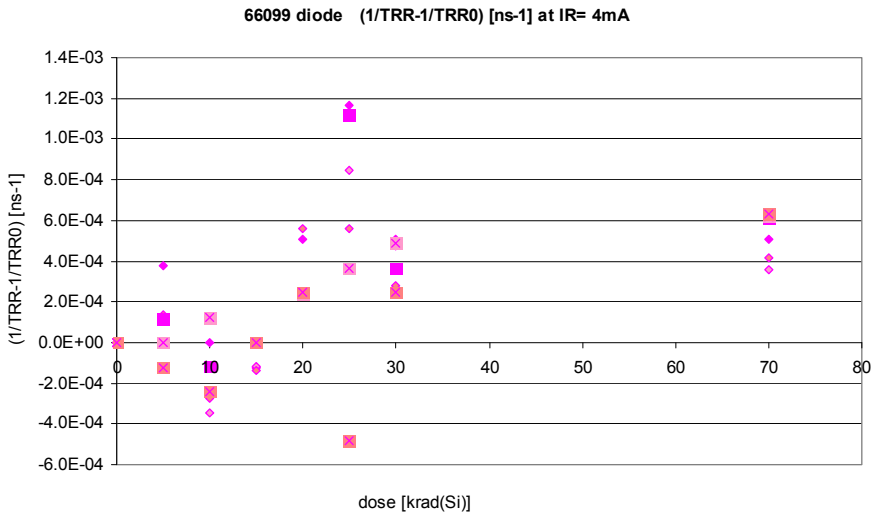


Fig. 9-12: 66099 Δ $1/\tau_{RR}$ with respect to TID: bad measurement

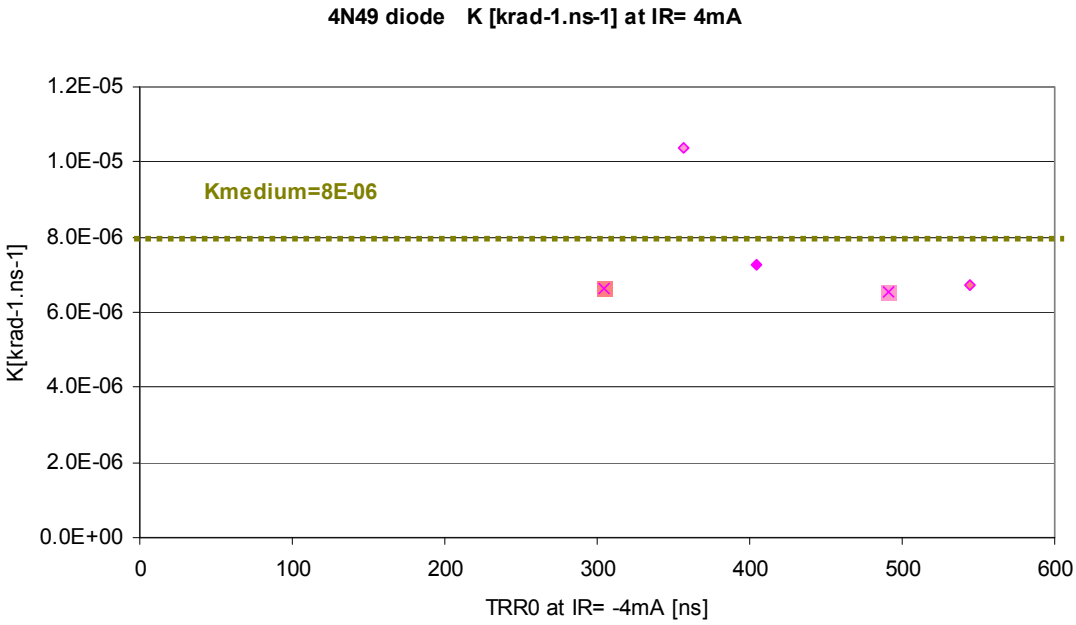


Fig. 9-13: 4N49 K_{dose} with respect to τ_{RR0}

4N49 is between 6.54E-06 and 1.04E-05 krad.ns^{-1}. Kmedium is arbitrarly defined at 8E-06 krad.ns^{-1}.

9.3 CORRELATION BETWEEN CTR AND τ_{RR} DEGRADATIONS

9.3.1 Gamma irradiation

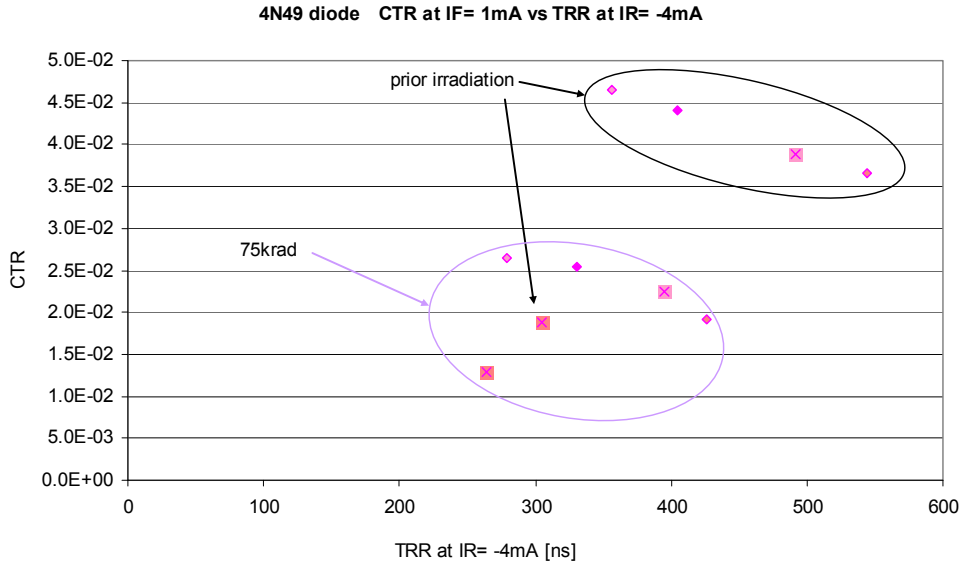


Fig. 9-14: 4N49 diode CTR at I_F= 1mA with respect to τ_{RR} (gamma irradiation)

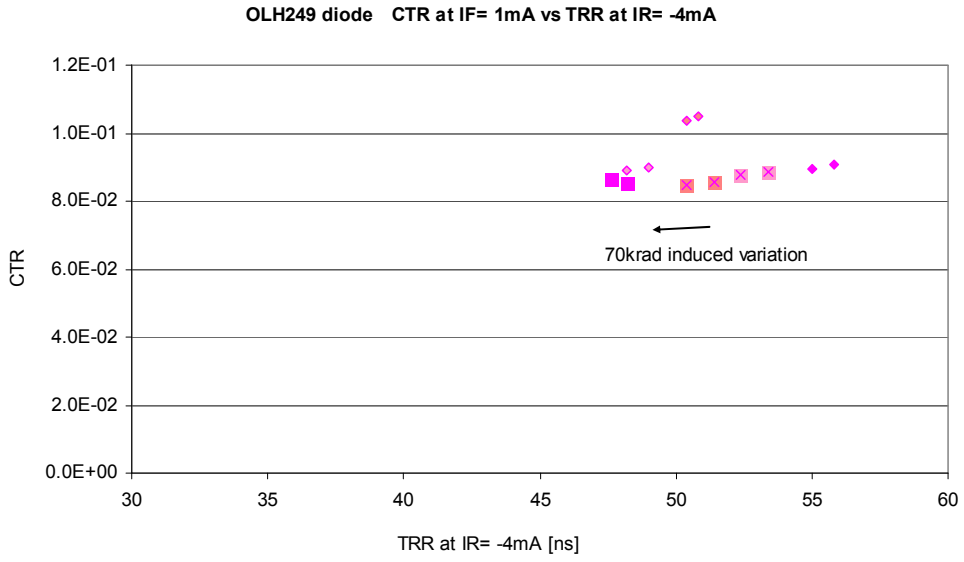


Fig. 9-15: OLH249 diode CTR at I_F= 1mA with respect to τ_{RR} (gamma irradiation)

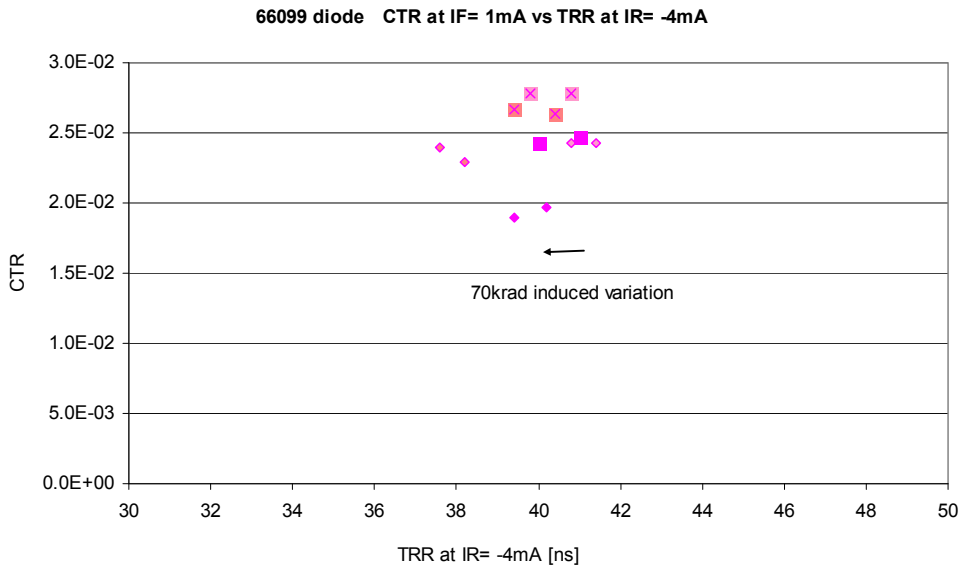


Fig. 9-16: 66099 diode CTR at I_F= 1mA with respect to τ_{RR} (gamma irradiation)

The correlation between CTR/CTR_0 and τ_{RR}/τ_{RR0} is evaluated like in the previous sections regarding proton and neutron irradiations thanks to a power law. The regressed power value is still called N or N_{dose}. The noise in measurement for OLH249 and 66099 make the N power calculation impossible. The dose induced variation in OLH249 and 66099 diodes is inferior to initial sample dispersion (Fig. 9-15 and Fig. 9-16).

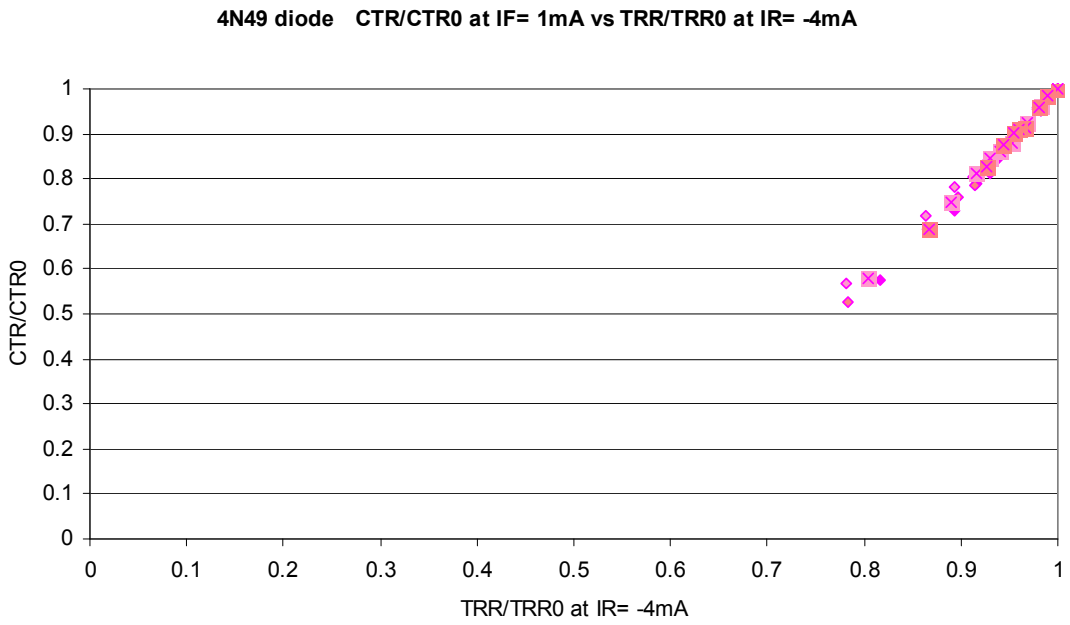


Fig. 9-17: 4N49 diode CTR/CTR$_0$ at I_F= 1mA with respect to τ_{RR}/τ_{RR0} (gamma irradiation)

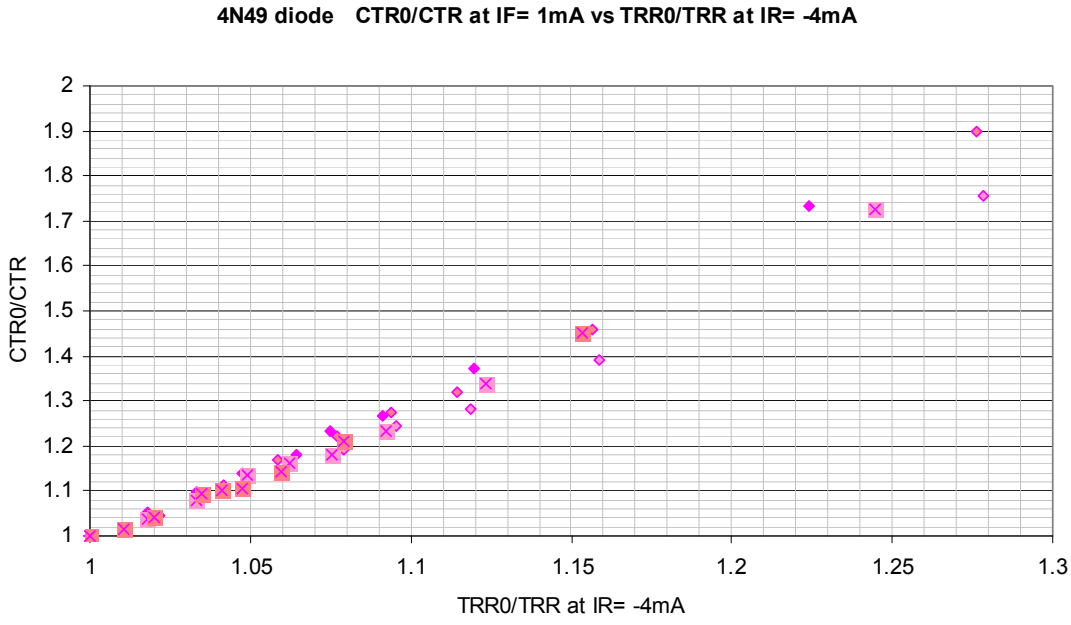


Fig. 9-18: 4N49 diode CTR$_0$/CTR at I_F= 1mA with respect to τ_{RR0}/τ_{RR} (gamma irradiation)

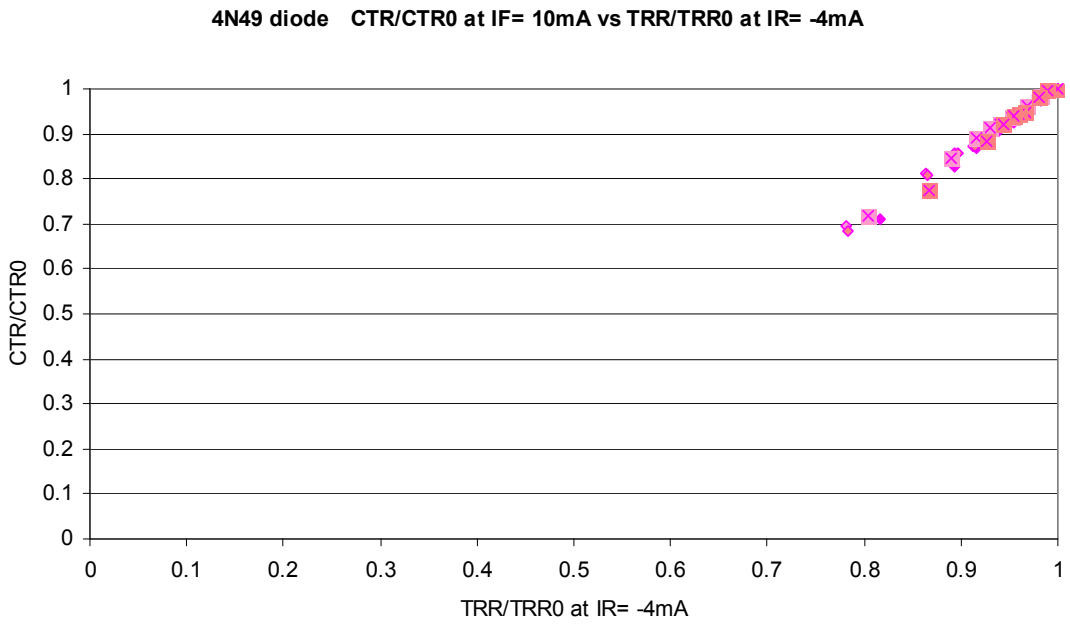


Fig. 9-19: 4N49 diode CTR/CTR_0 at I_F= 10mA with respect to τ_{RR}/τ_{RR0} (gamma irradiation)

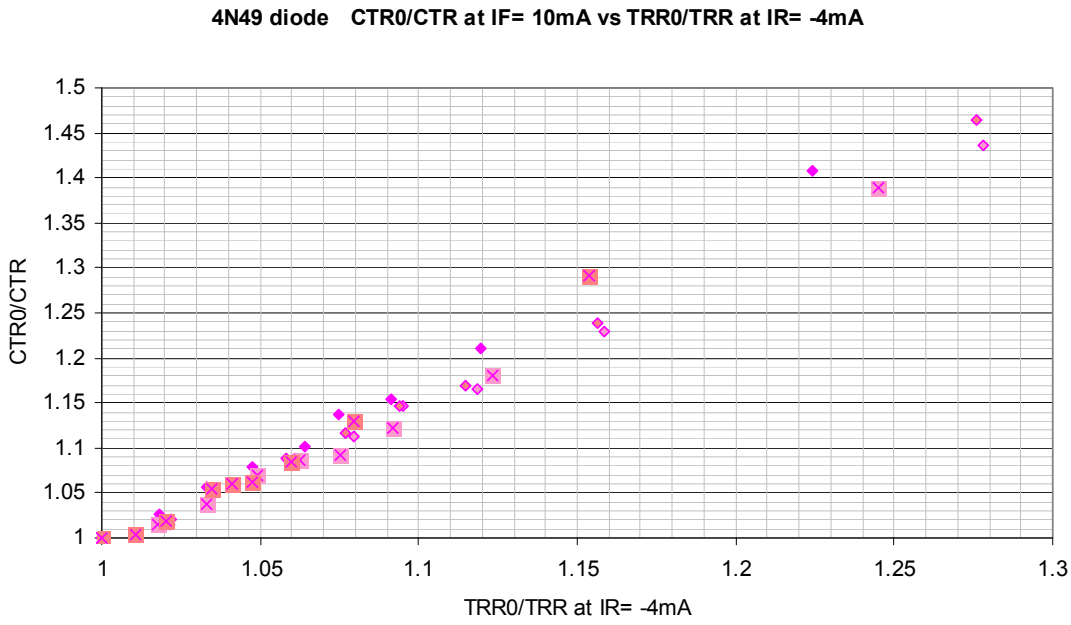


Fig. 9-20: 4N49 diode CTR_0/CTR at I_F= 10mA with respect to τ_{RR0}/τ_{RR} (gamma irradiation)

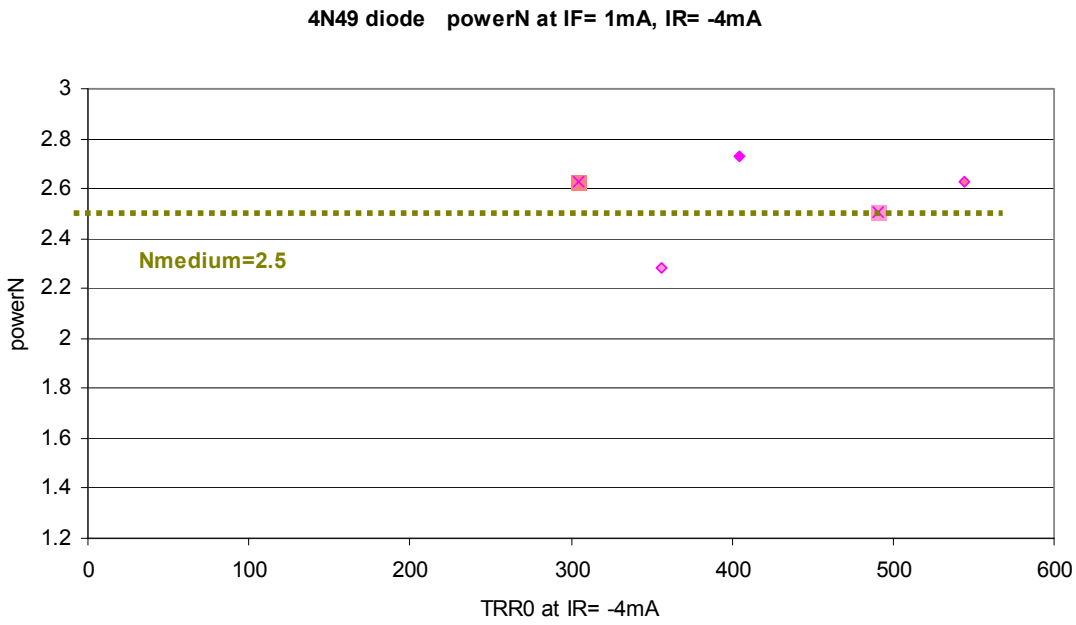


Fig. 9-21 : 4N49 diode : N_{dose} at I_F =1 mA with respect to τ_{RR0}

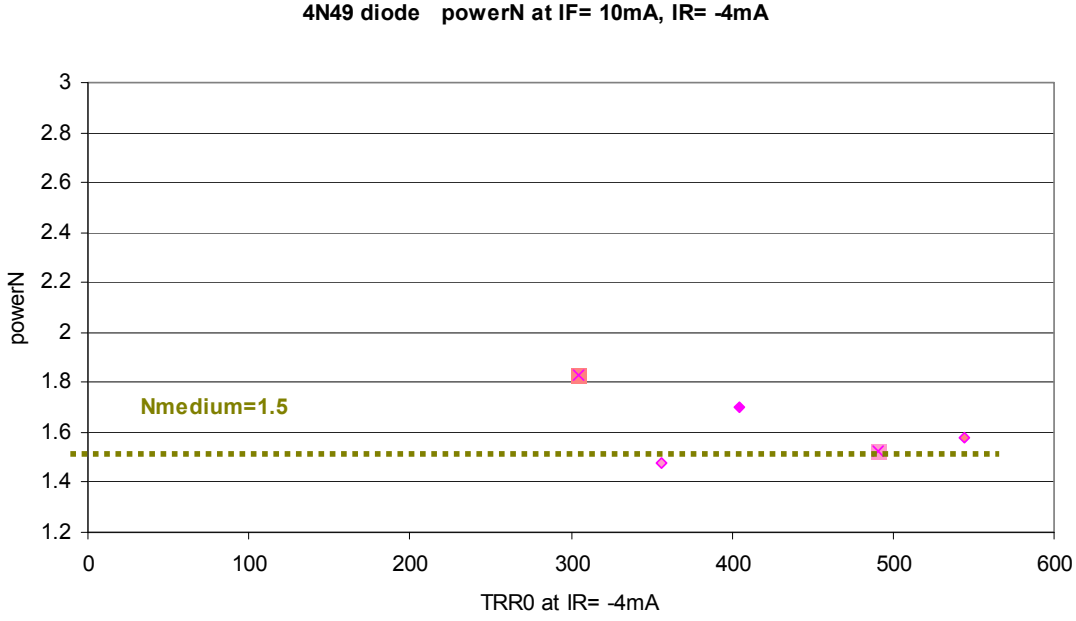


Fig. 9-22 : 4N49 diode : N_{dose} at I_F =10 mA with respect to τ_{RR0}

This choice of values for N_{dose} will be modified in 10.5, where N will be equal to the previous values obtained from proton irradiation.

9.3.2 Similarity with displacement damage

The correlation between CTR/CTR_0 and τ_{RR}/τ_{RR0} is quite the same whatever the irradiation source indeed, as depicted in the following Fig. 9-23 to Fig. 9-26. Gamma irradiation points have been enlarged while proton and neutron points have been shrinked for clarity.

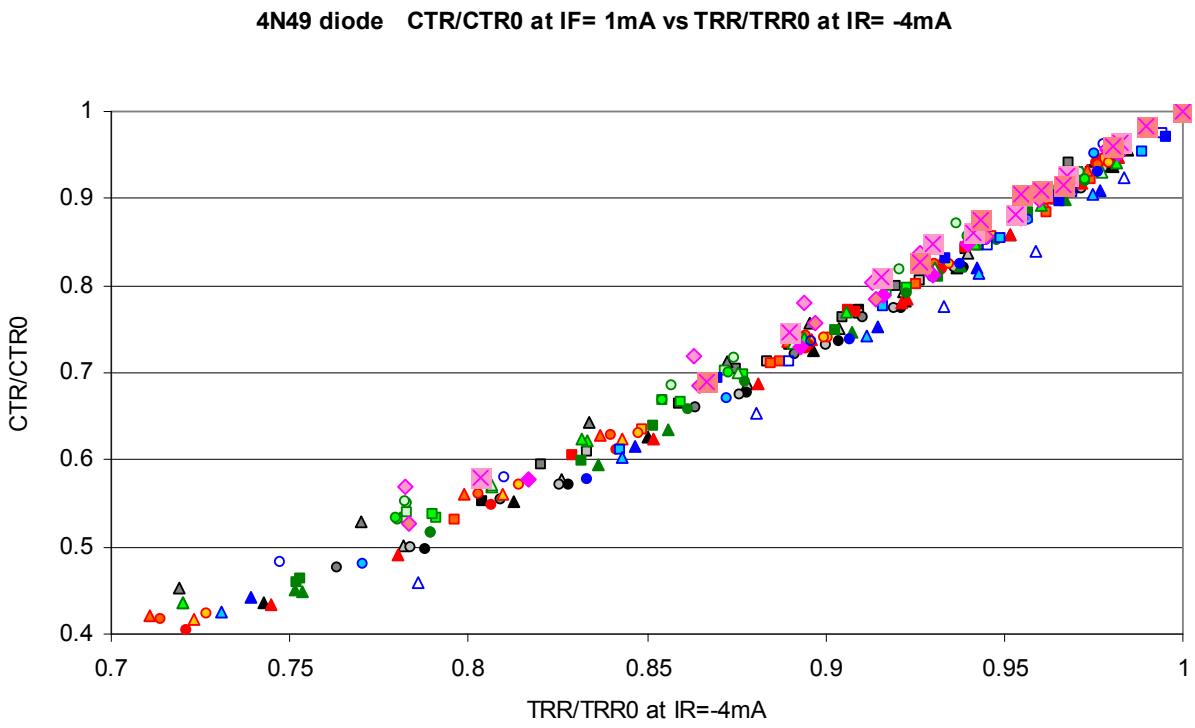


Fig. 9-23: 4N49 diode CTR/CTR$_0$ at I_F= 1mA with respect to τ_{RR}/τ_{RR0}

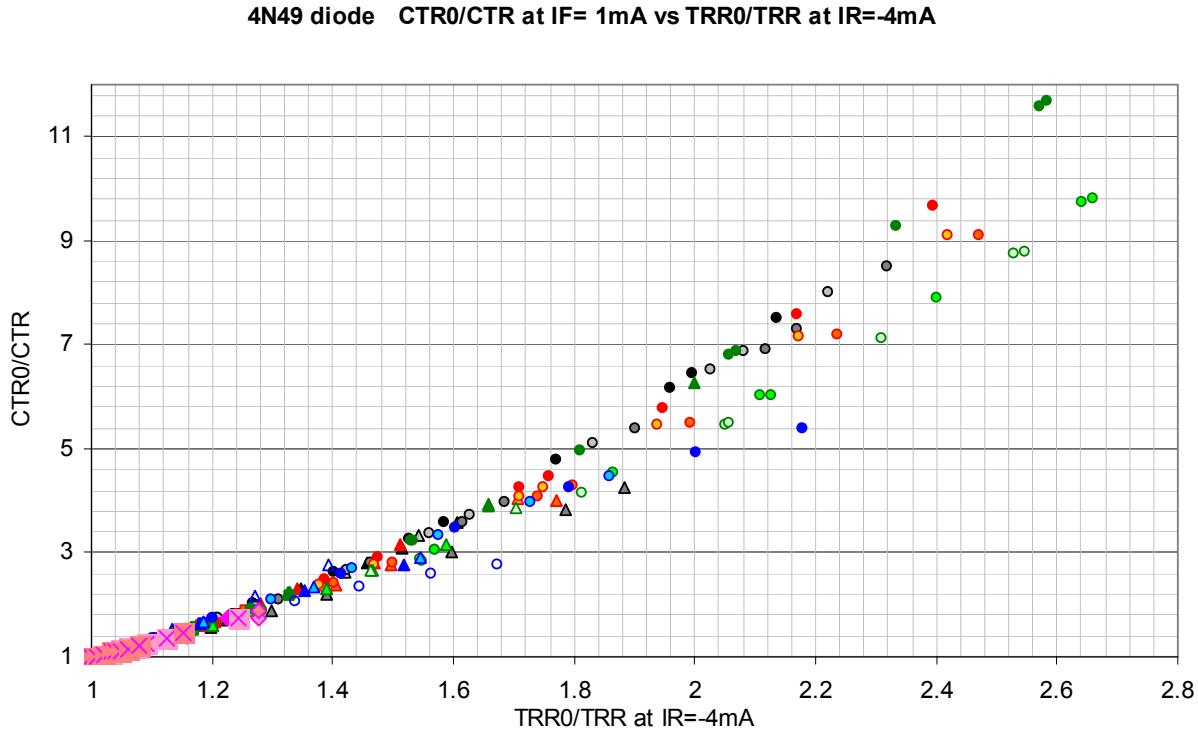


Fig. 9-24: 4N49 diode CTR$_0$/CTR at I_F= 1mA with respect to τ_{RR0}/τ_{RR}

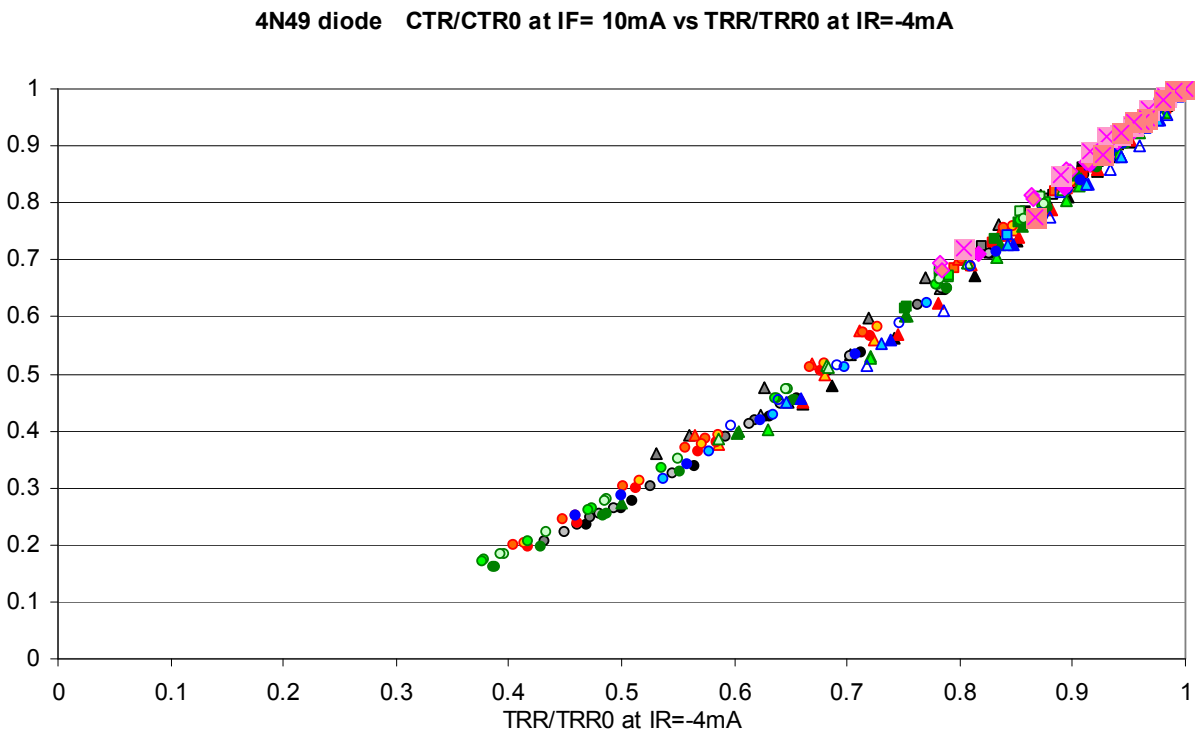


Fig. 9-25: 4N49 diode CTR/CTR_0 at I_F= 10mA with respect to τ_{RR}/τ_{RR0}

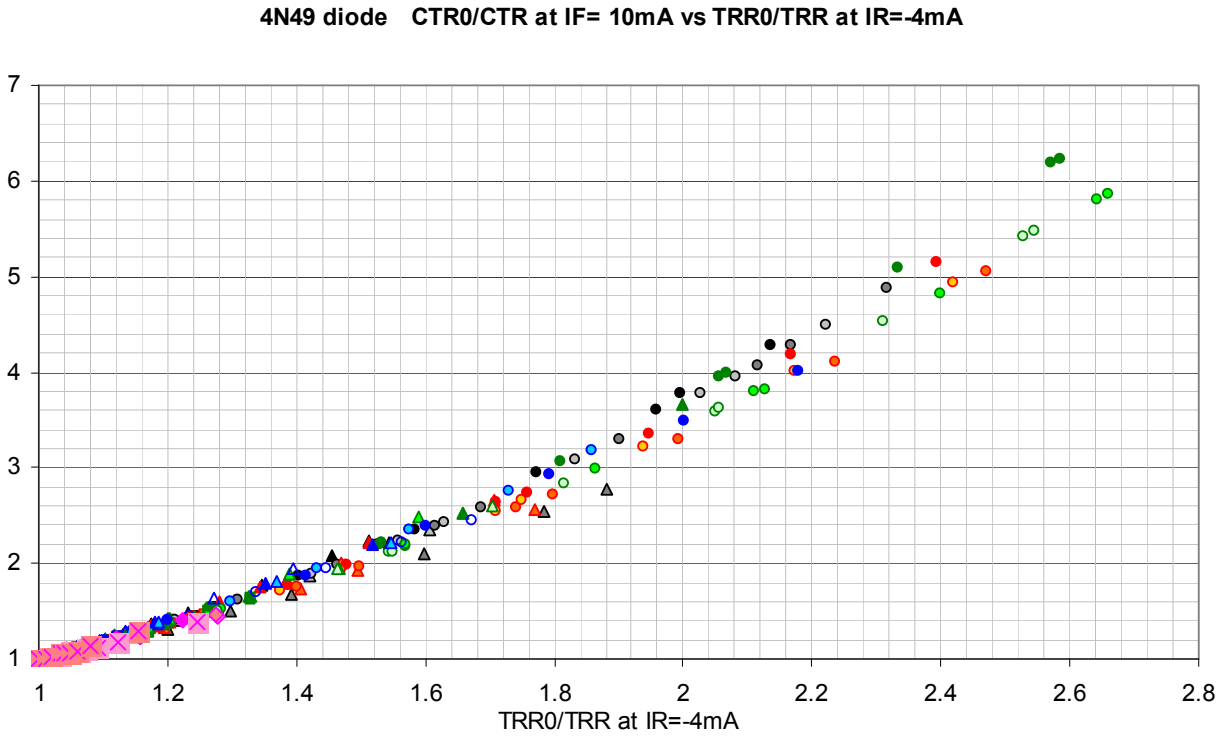


Fig. 9-26: 4N49 diode CTR_0/CTR at I_F= 10mA with respect to τ_{RR0}/τ_{RR}

9.4 ESTIMATION OF A DIODE DEGRADATION

- "**medium**" : the value of N and K are chosen within the range of the regressed values.

The chosen value of K at I_R = -4mA is 8 10^{-6} $krad^{-1}.ns^{-1}$ (see Fig. 9-13). The chosen values of N at (I_R, I_F)= (-4, 1)mA and (-4, 10) mA are 2.5 and 1.5 respectively. Explicit curve equations are therefore:

I_R	I_F	Dose
-4mA	1mA	$1-(1+\tau_{RR0}.8E\text{-}06.TID)^{-2.5}$
	10mA	$1-(1+\tau_{RR0}.8E\text{-}06.TID)^{-1.5}$

Table 27. "medium" expressions of 1 - CTR/CTR$_0$ as a function of τ_{RR0} and TID

- "**lowest point**" :

interpolation dose [krad]		20	40	70
chosen sample		2 #2	2 #2	2 #2
K_{GEANT4} [$krad^{-1}.ns^{-1}$]		6.54E-06	6.54E-06	6.54E-06
N	I_F= 1mA	2.50E+00	2.50E+00	2.50E+00
	I_F= 10mA	1.52E+00	1.52E+00	1.52E+00

Table 28. Values of (N, K) of chosen 4N49 sample for "lowest point" curves

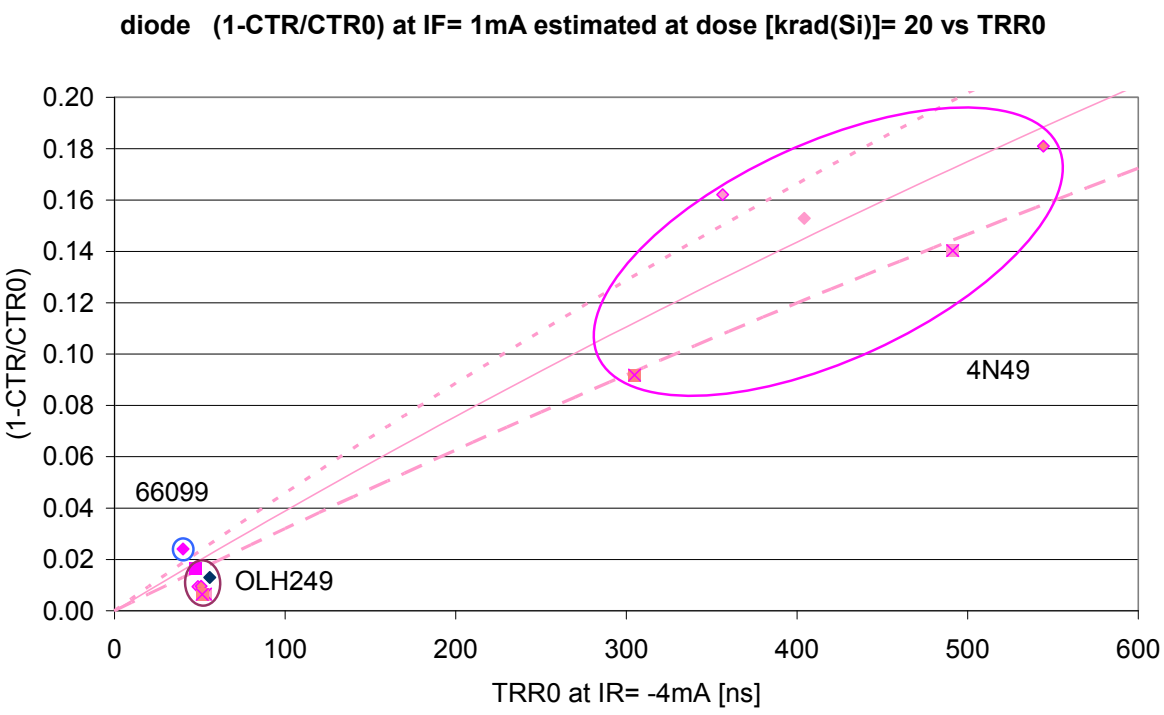
- "**highest point**" :

interpolation dose [krad]		20	40	70
chosen sample		1 #2	1 #2	1 #2
K_{GEANT4} [$krad^{-1}.ns^{-1}$]		1.04E-05	1.04E-05	1.04E-05
N	I_F= 1mA	2.28E+00	2.28E+00	2.28E+00
	I_F= 10mA	1.48E+00	1.48E+00	1.48E+00

Table 29. Values of (N,K) of chosen 4N49 sample for "highest point" curves

On Fig. 9-27 and Fig. 9-28 appears only one 66099 point because all the values of 1 – CTR/CTR$_0$ of other samples are negative at 20krad. The degradation is so small that the measurement precision is insufficient.

Except for this sample at 20krad, Fig. 9-27 to Fig. 9-32 show 66099 and OLH249 diodes CTR degradations induced by gamma irradiation between 20 and 70krad are under the estimation made from 4N49 diode CTR measurements.



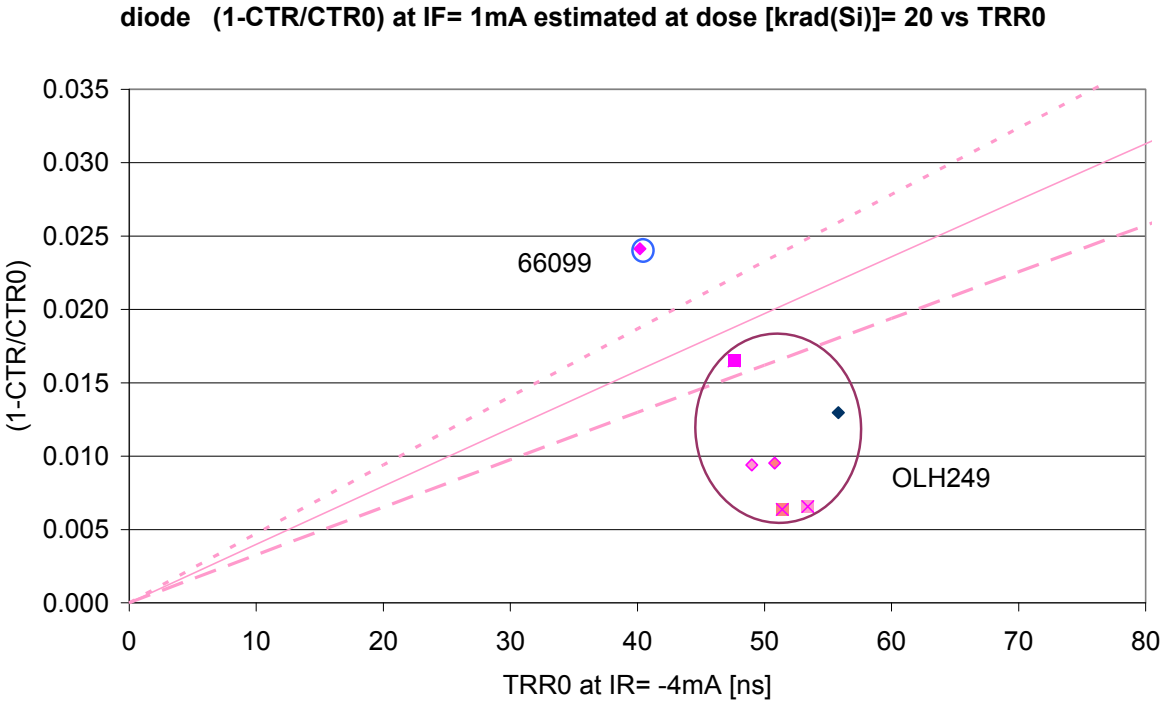
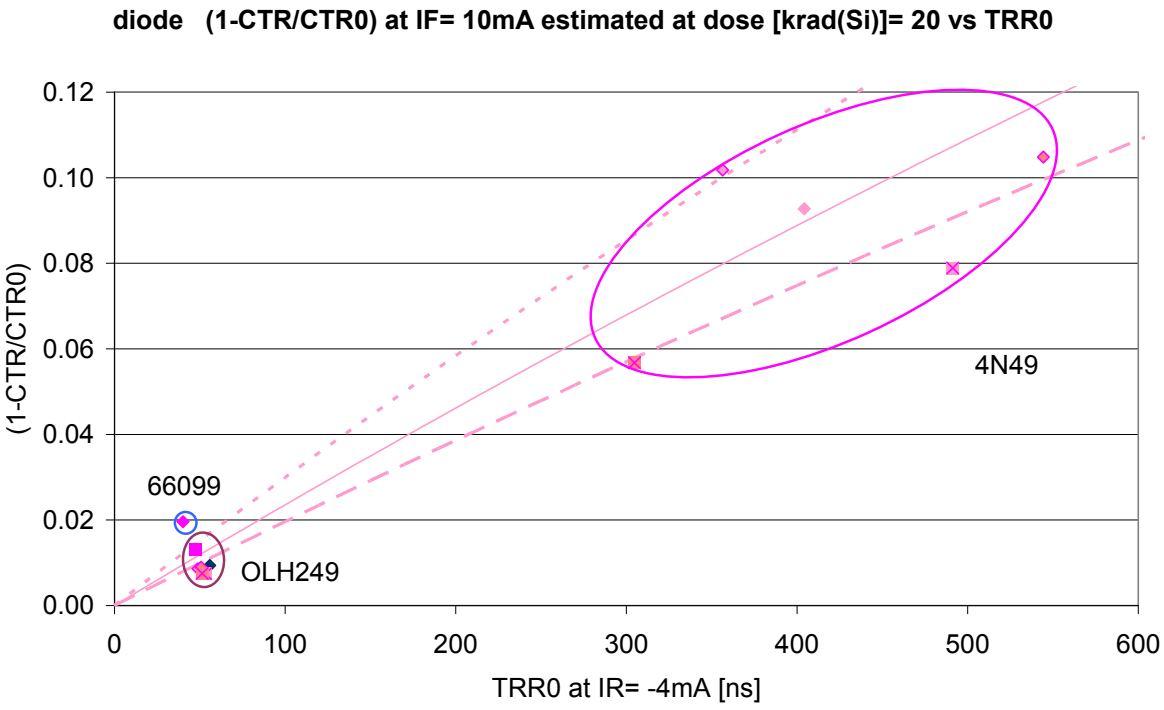


Fig. 9-27. 1 – CTR/CTR$_0$ estimated at a TID of 20 krad at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



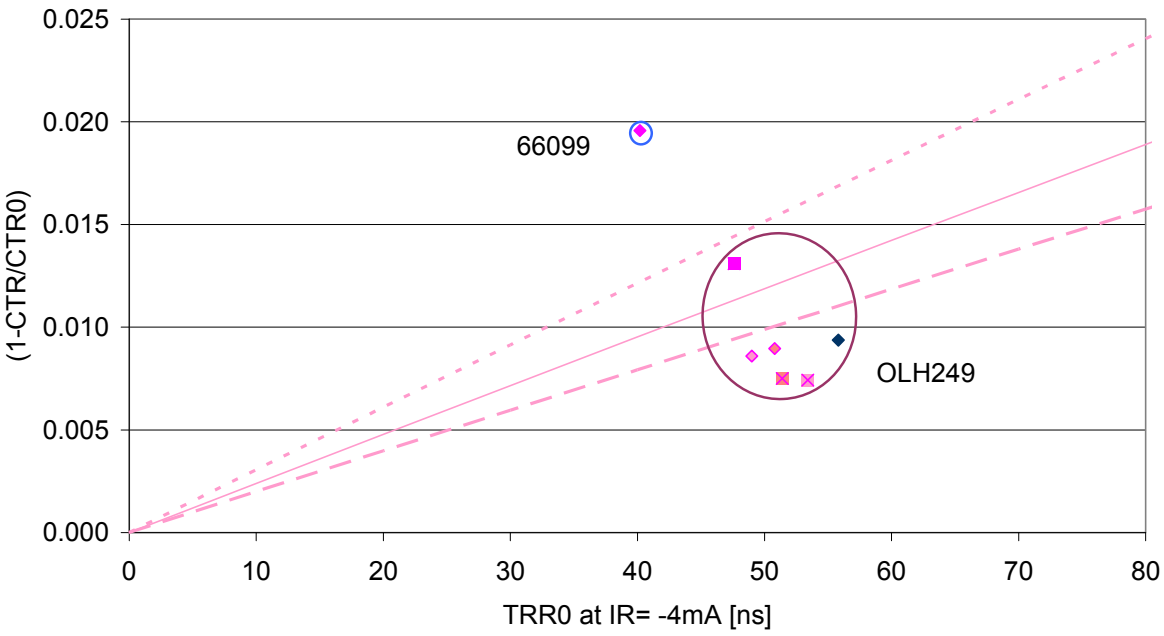
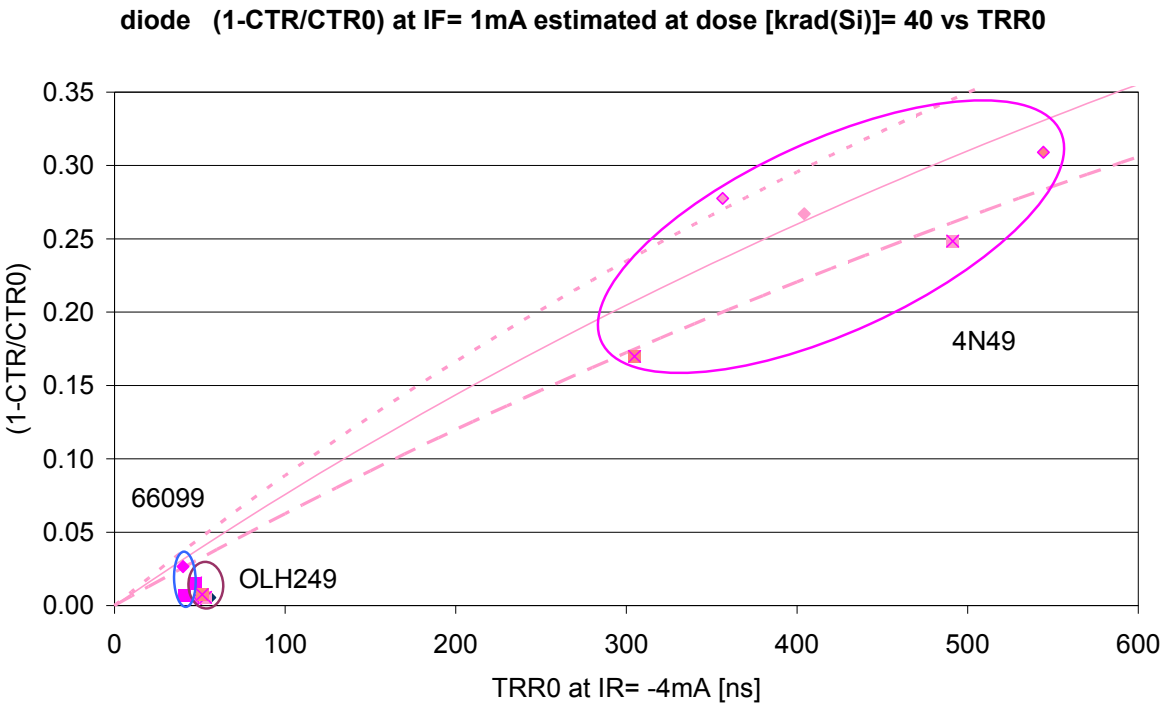


Fig. 9-28. 1 – CTR/CTR$_0$ estimated at a TID of 20 krad at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



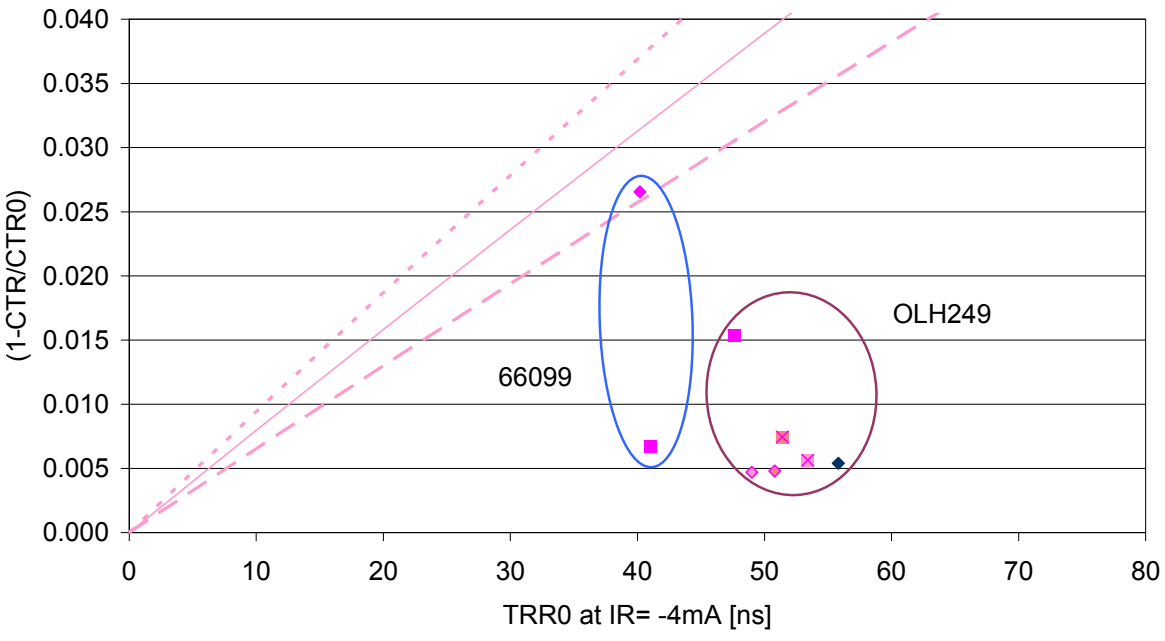
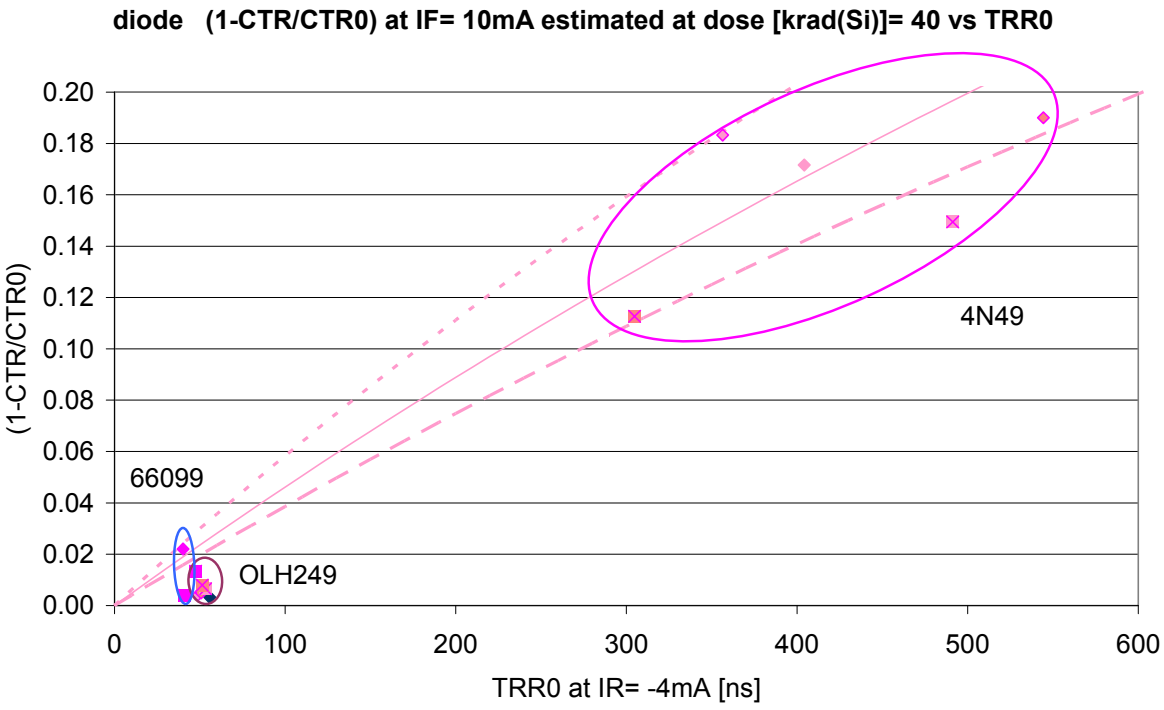


Fig. 9-29. 1 – CTR/CTR$_0$ estimated at a TID of 40 krad at I_F= 1mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



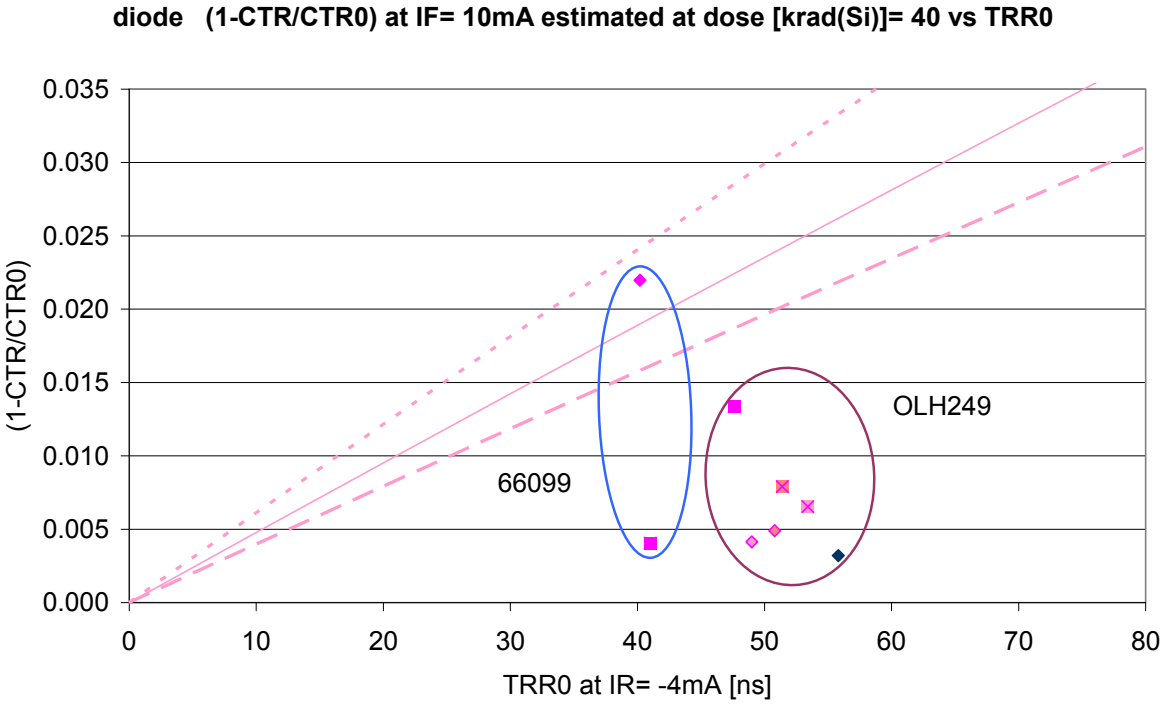
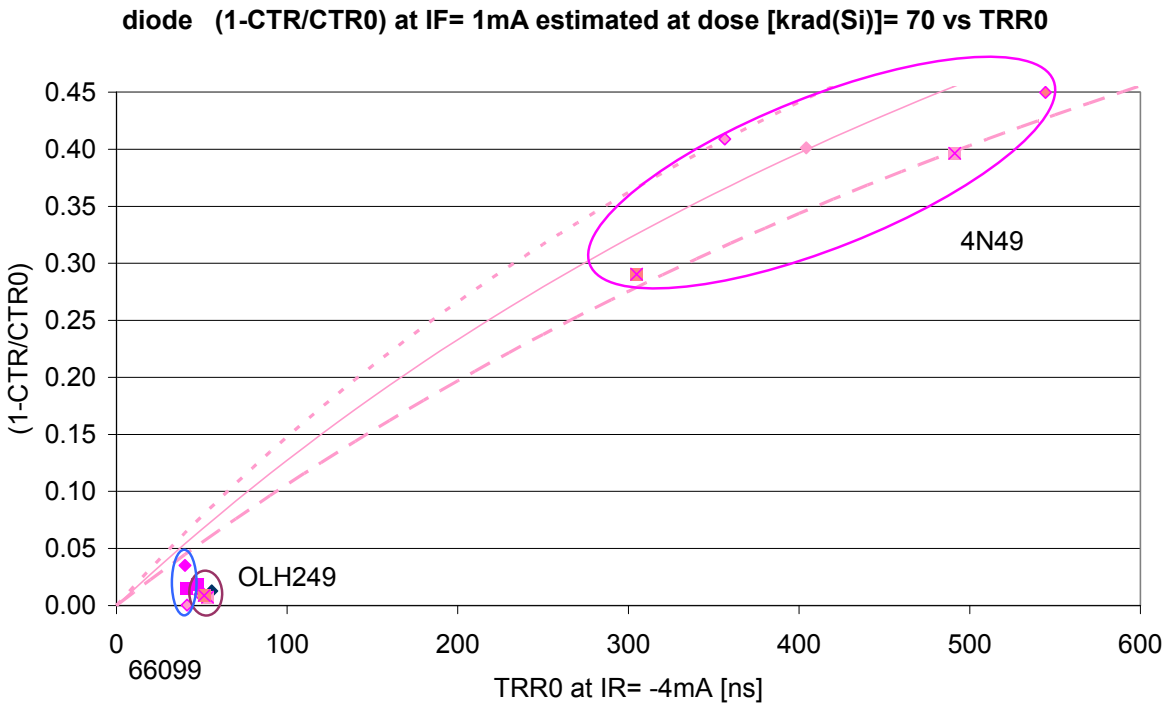


Fig. 9-30. 1 – CTR/CTR$_0$ estimated at a TID of 40 krad at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



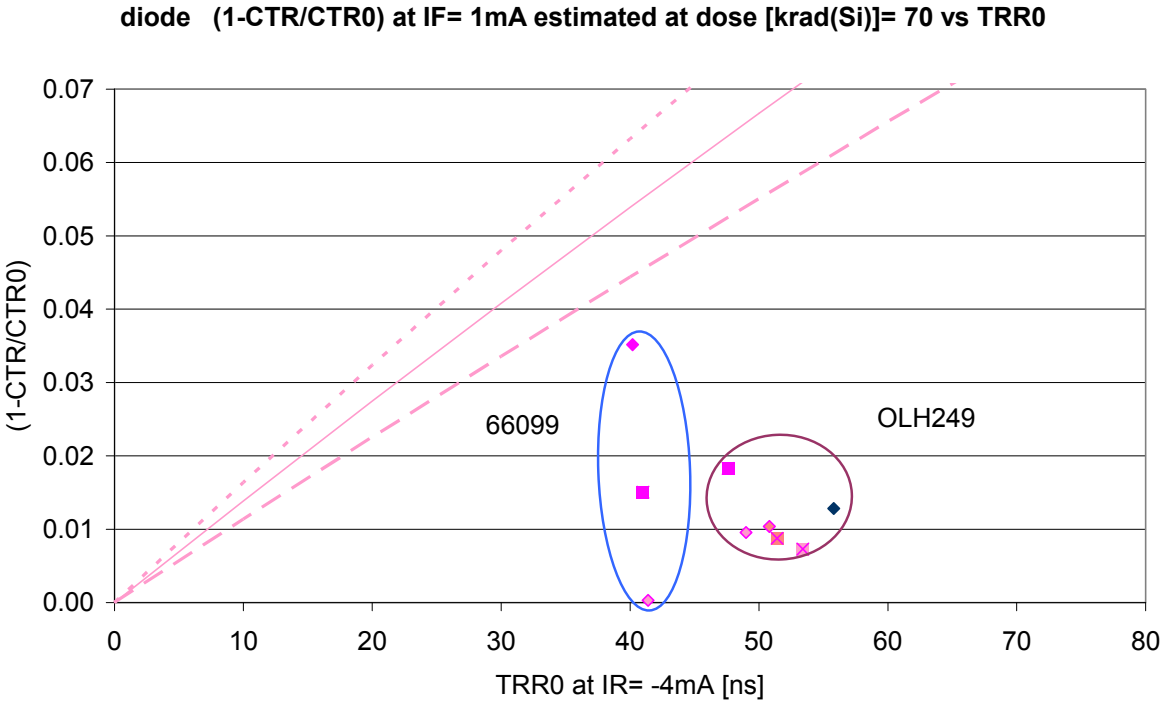
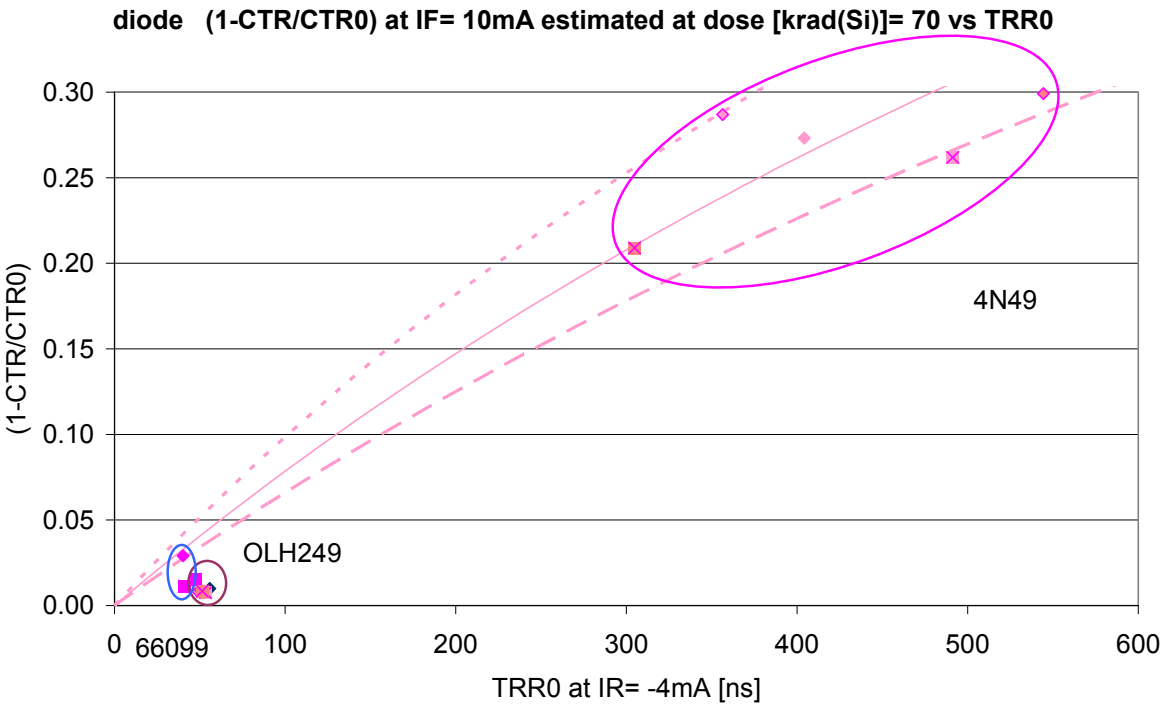


Fig. 9-31. 1 – CTR/CTR$_0$ estimated at a TID of 70 krad at I_F= 1mA with respect to τ_{TRR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves



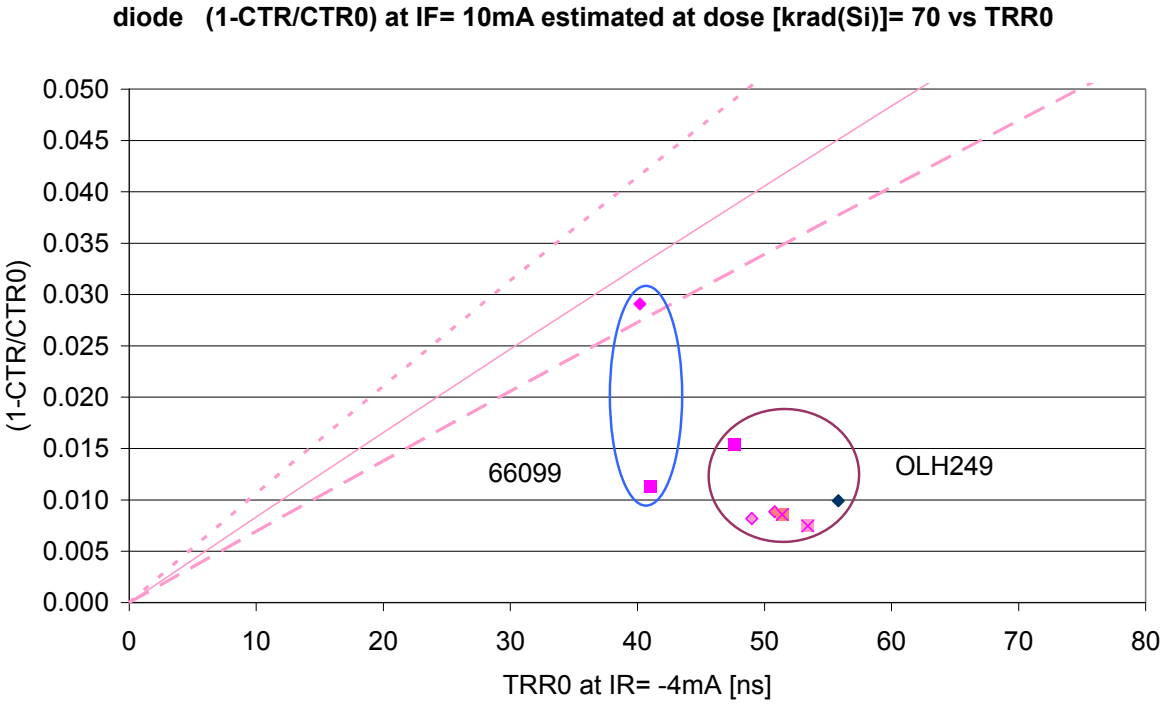
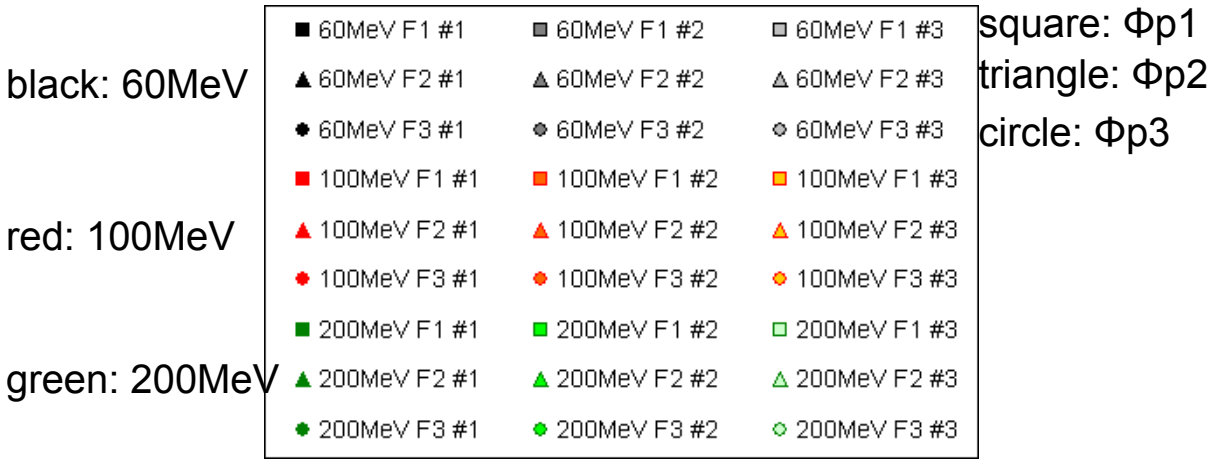


Fig. 9-32. 1 – CTR/CTR$_0$ estimated at a TID of 70 krad at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves

10. GAMMA IRRADIATION AFTER NEUTRON AND PROTON IRRADIATION

The samples which had been irradiated by protons (§3-§7) and neutrons (§8) were exposed to the Cobalt source.

proton pre-irradiated data points



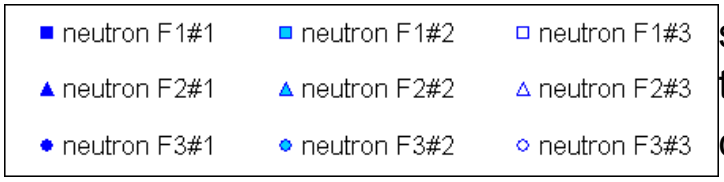
black: 60MeV

red: 100MeV

green: 200MeV

square: Φp1
triangle: Φp2
circle: Φp3

neutron pre-irradiated data points

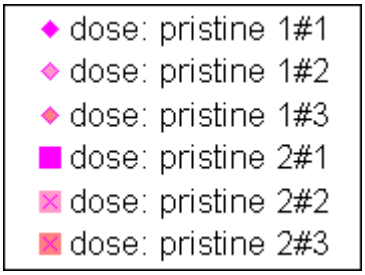


blue

square: Φn1
triangle: Φn2
circle: Φn3

dark: sample #1 sample #2 bright: sample #3

pristine data points



Legend for gamma irradiation figures

10.1 CTR DEGRADATION

CTR is plotted from Fig. 10-1 to Fig. 10-9 for all devices types at I_F = 1mA and 10mA. The observed dose-induced degradation of pre-irradiated devices is similar to the degradation of pristine parts. This is consistent with similar initial recovery times of pristine diodes τ_{RR0} and of pre-irradiated diodes τ_{RR0^*}. However pristine 4N49 diodes degrade a bit quicker than pre-irradiated diodes (Fig. 10-4), in accordance with τ_{RR0} a bit longer than τ_{RR0^*} (Fig. 10-18).

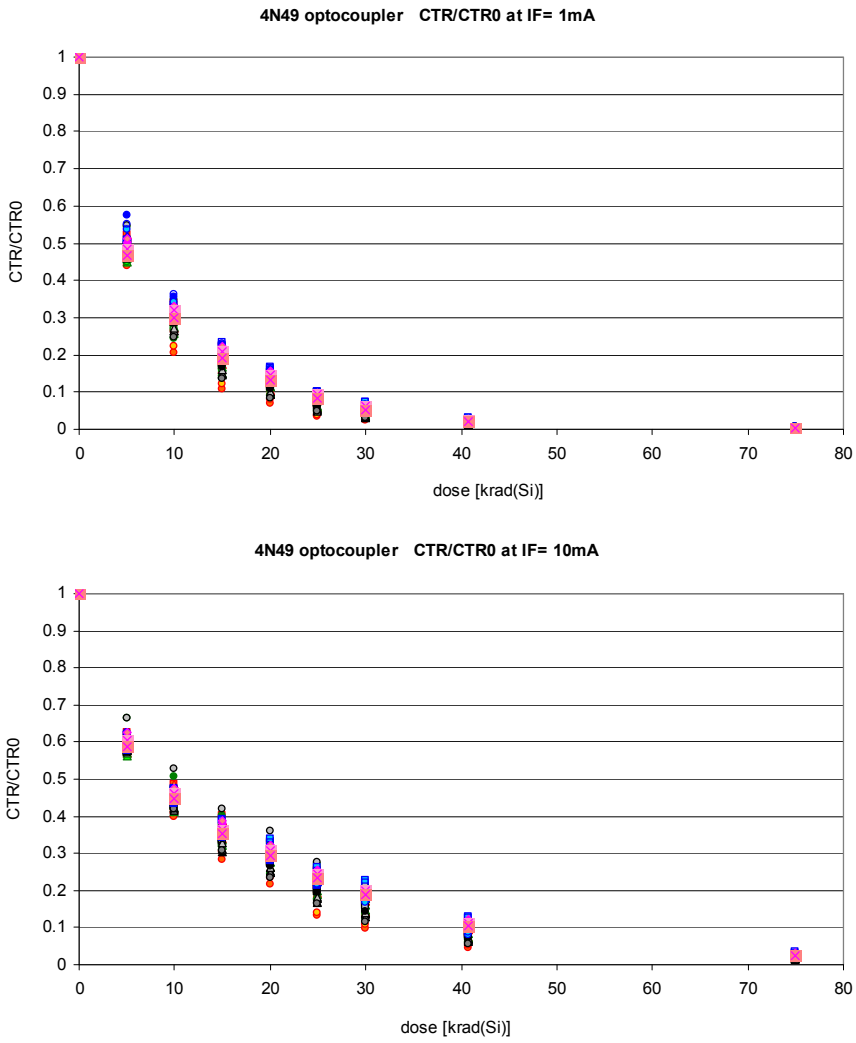


Fig. 10-1: 4N49 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

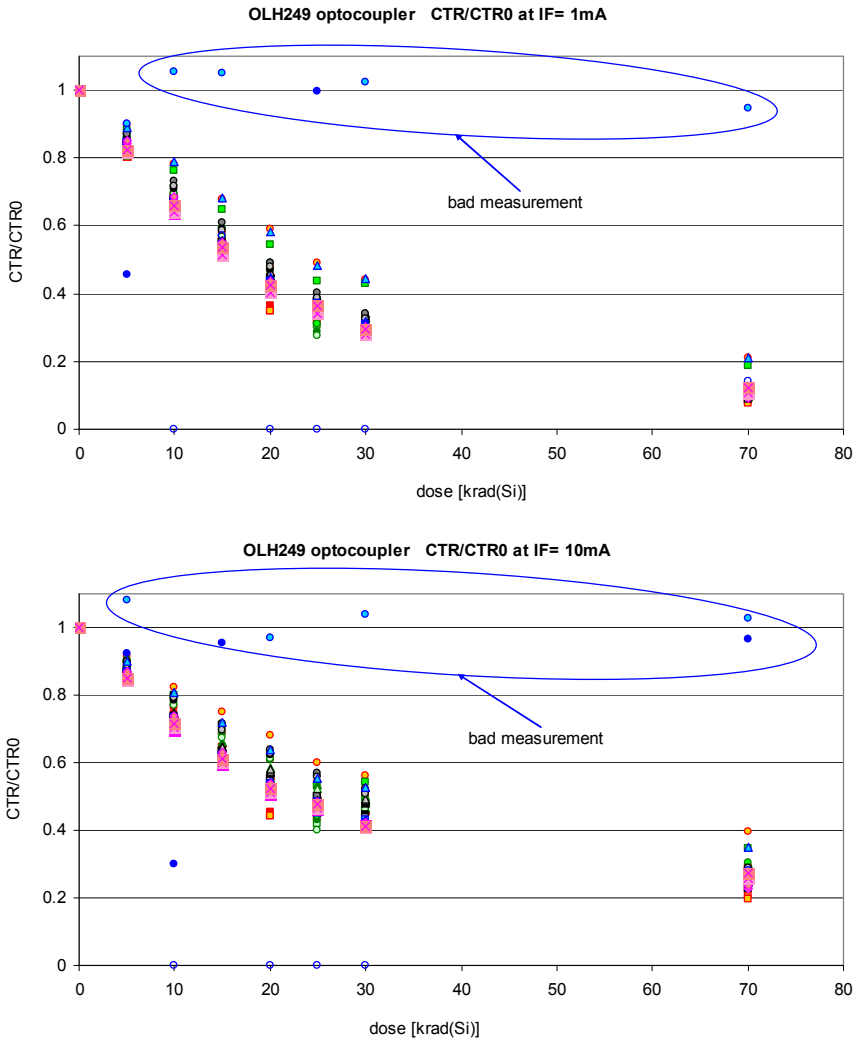
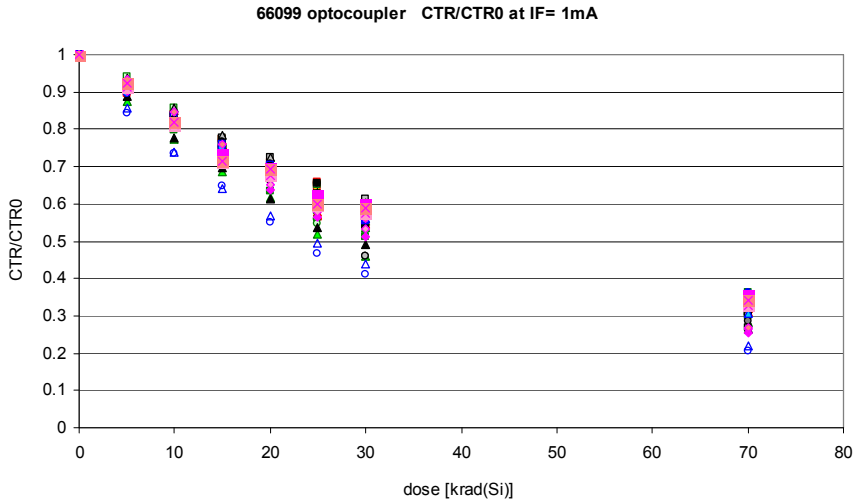


Fig. 10-2: OLH249 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)



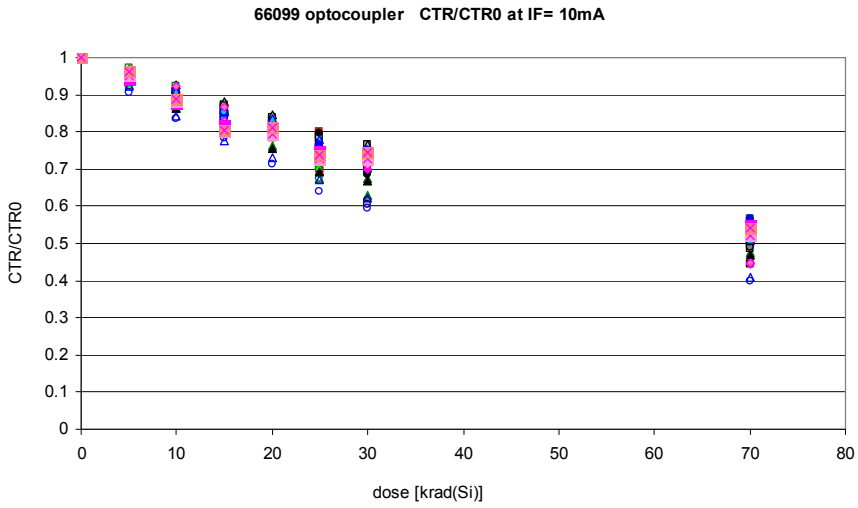


Fig. 10-3: 66099 optocoupler: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

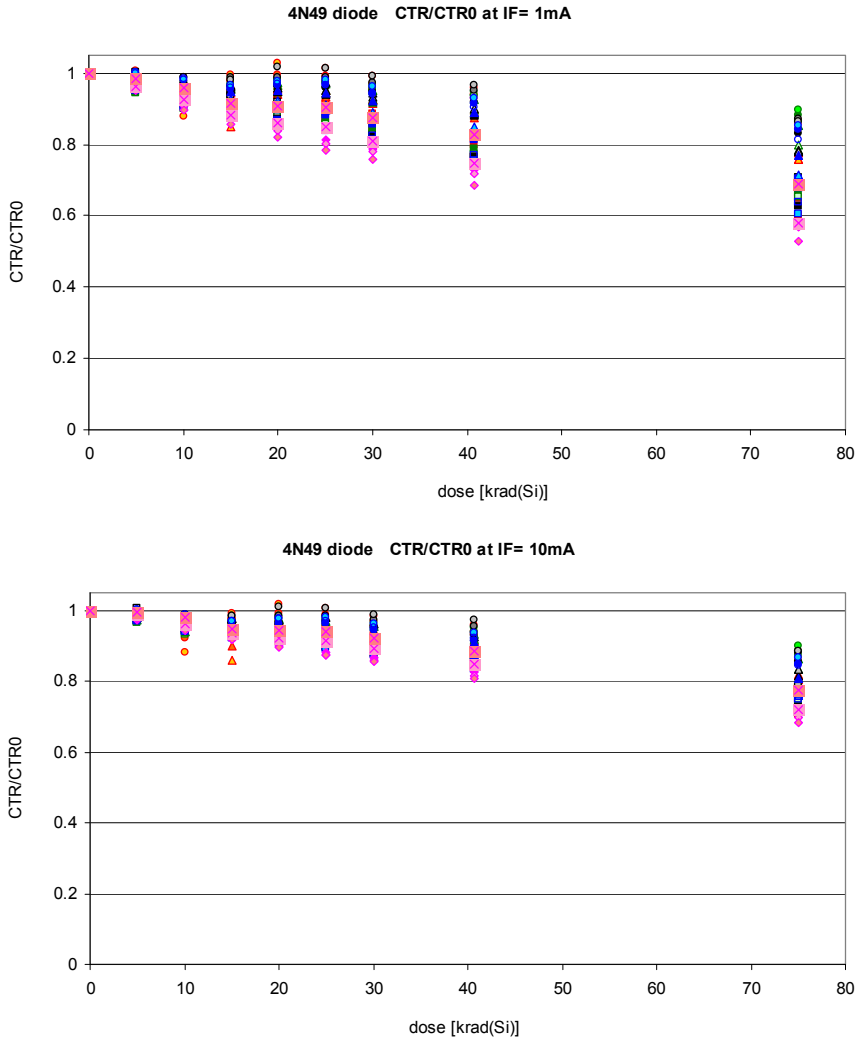


Fig. 10-4: 4N49 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

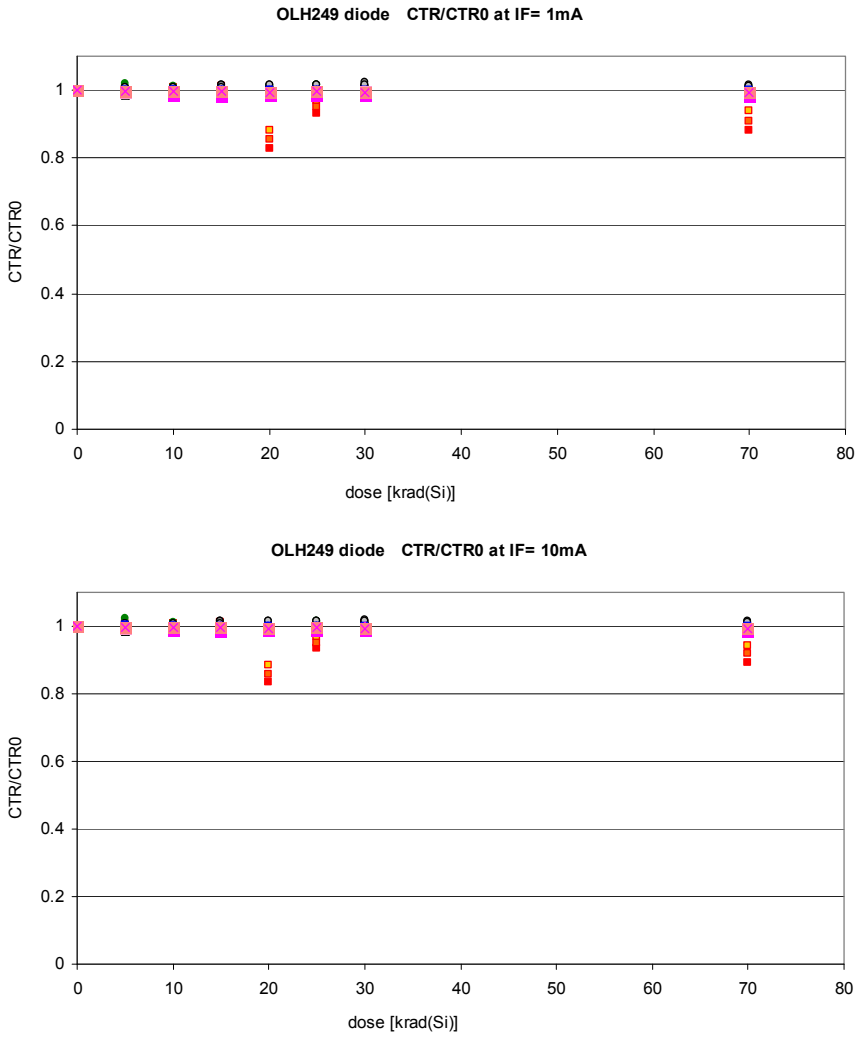
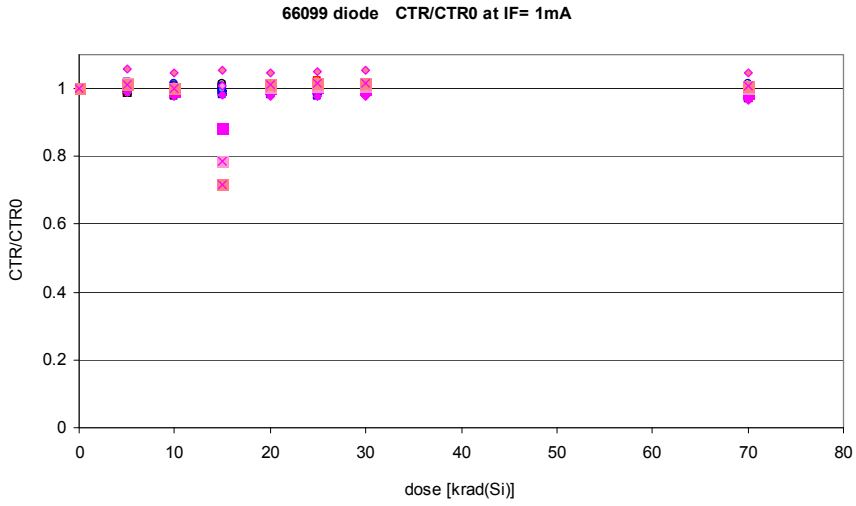


Fig. 10-5: OLH249 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)



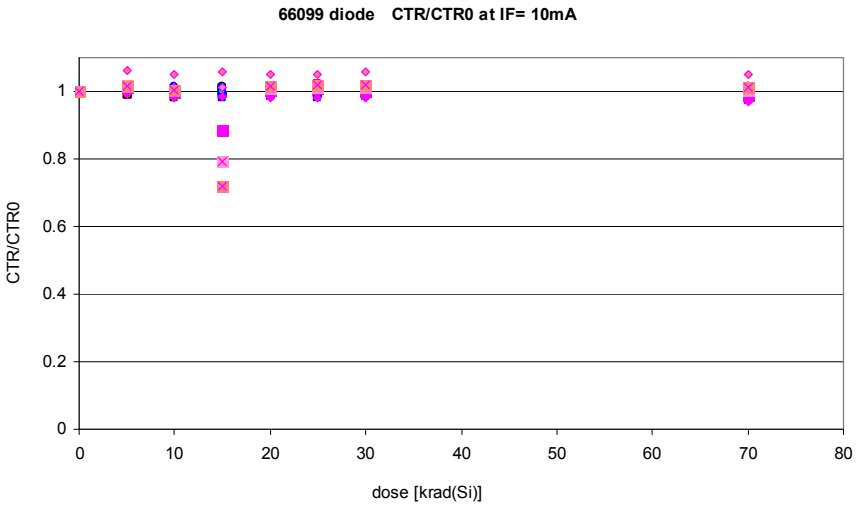


Fig. 10-6: 66099 diode: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

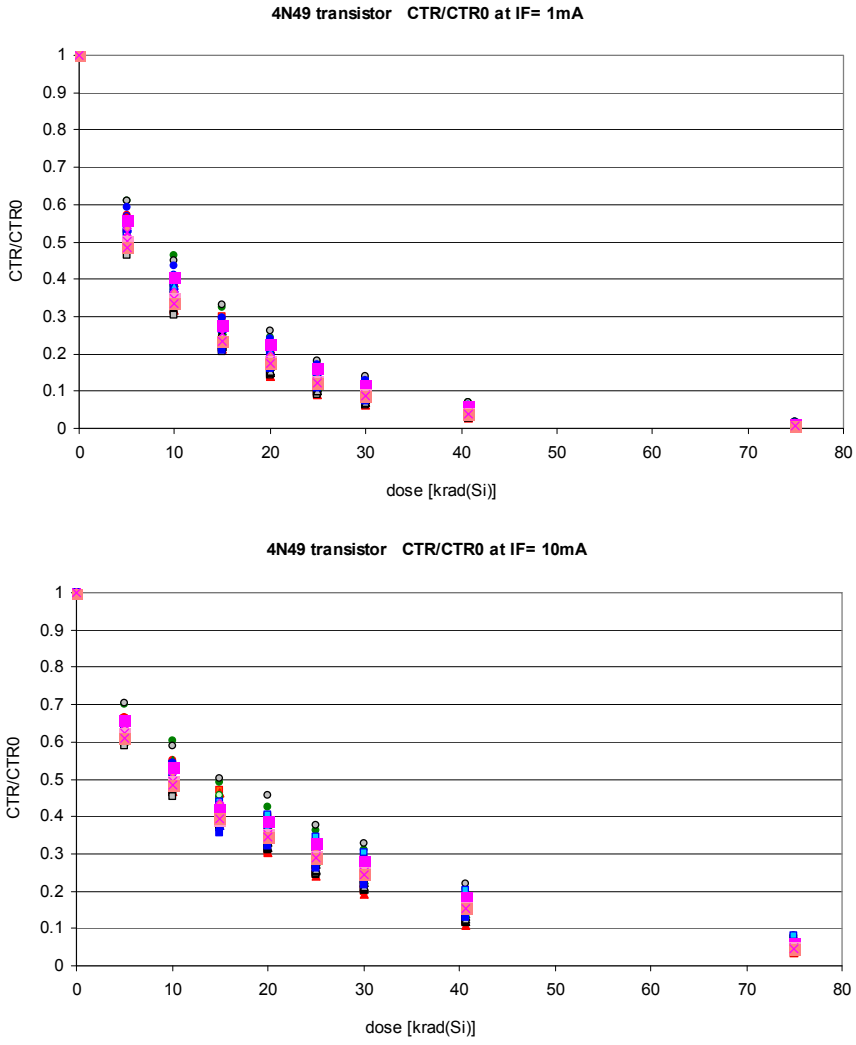


Fig. 10-7: 4N49 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

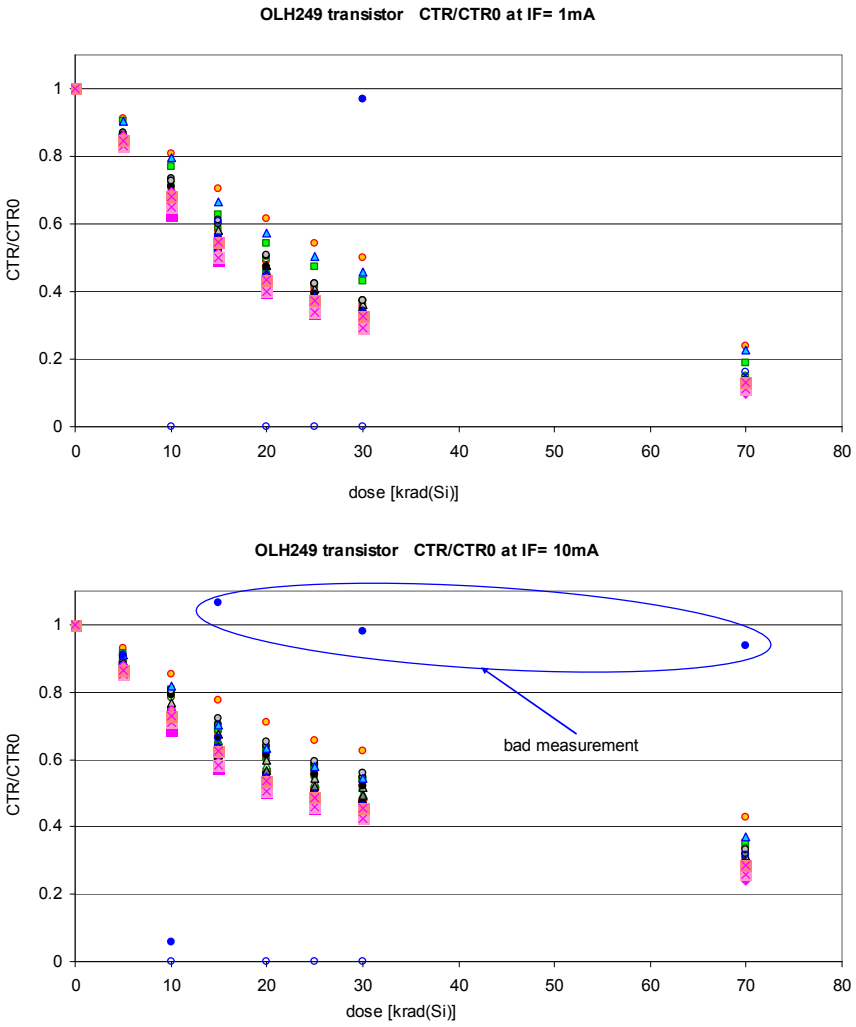
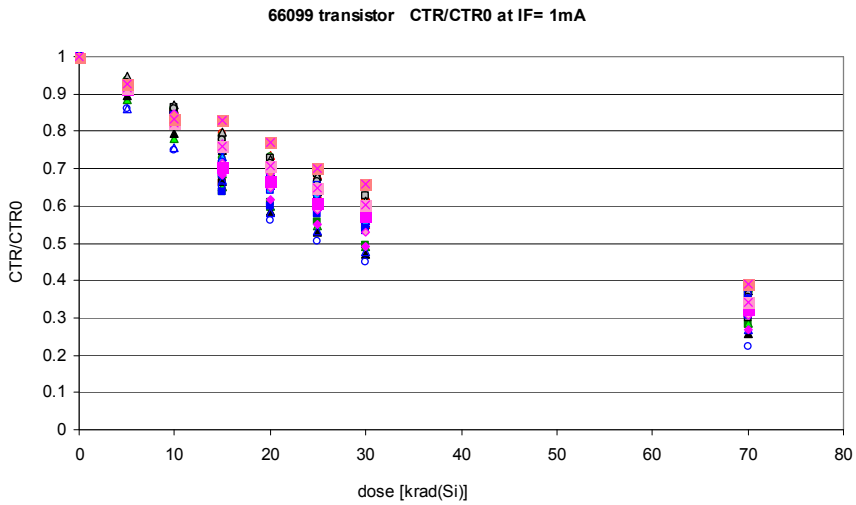


Fig. 10-8: OLH249 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)



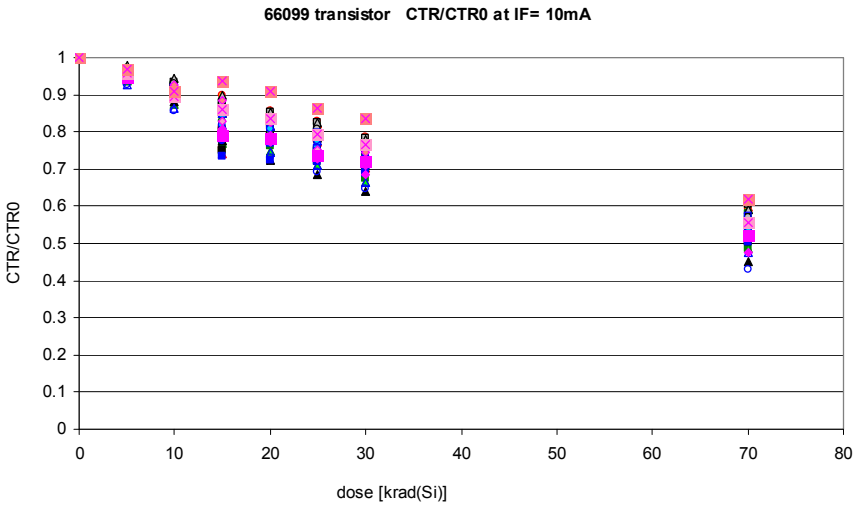


Fig. 10-9: 66099 transistor: relative CTR with respect to TID at I_F= 1mA and I_F= 10mA (pre-irradiated and pristine samples)

10.2 VARIATION OF REVERSE RECOVERY TIME

Fig. 10-10 depicts the variation of 4N49 diode $1/\tau_{RR}$ with respect to the dose. The pre-irradiated samples and pristine samples curves are alike. Because of the noise in OLH249 and 66099 reverse recovery times measurements $\Delta\ 1/\tau_{RR}$ is not plotted for those diodes. Proportionality coefficient K_{dose} is depicted by Fig. 10-11 with respect to "initial" reverse recovery time τ_{RR0^*} which is τ_{RR} measured prior gamma irradiation and after the degradation due to displacement damage. K_{dose} increases very slightly with τ_{RR0^*}.

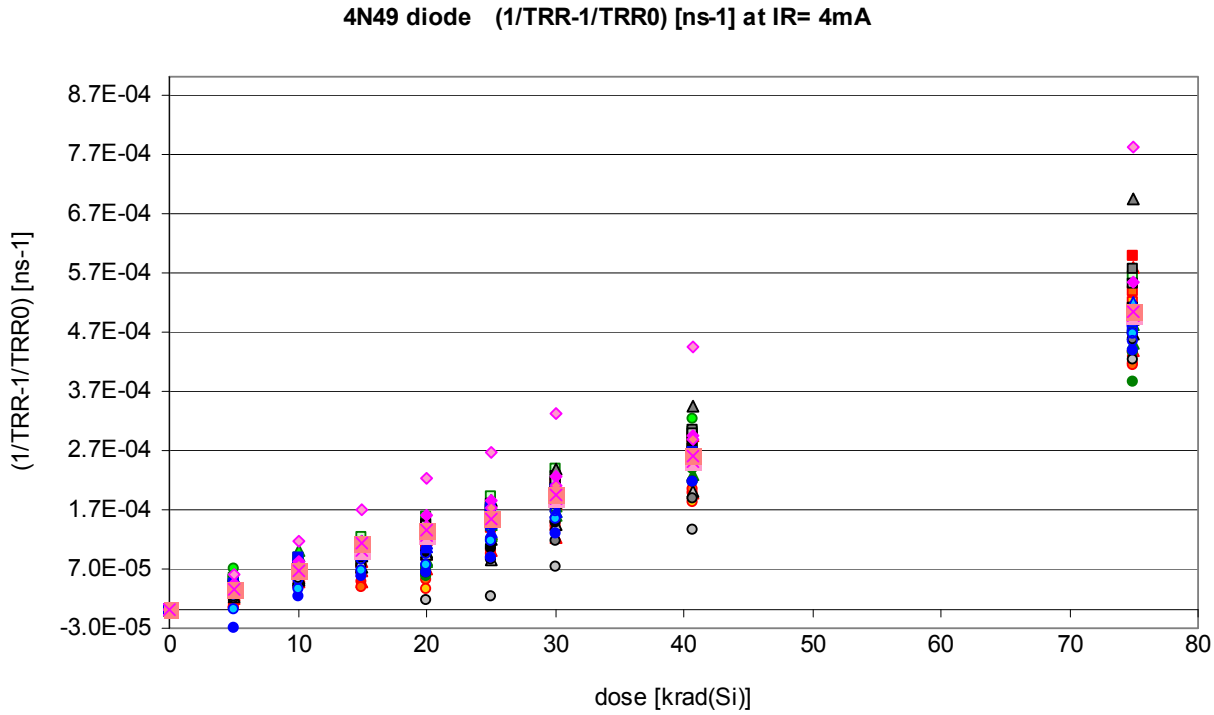


Fig. 10-10: 4N49 $\Delta\ 1/\tau_{RR}$ with respect to TID (pre-irradiated and pristine samples)

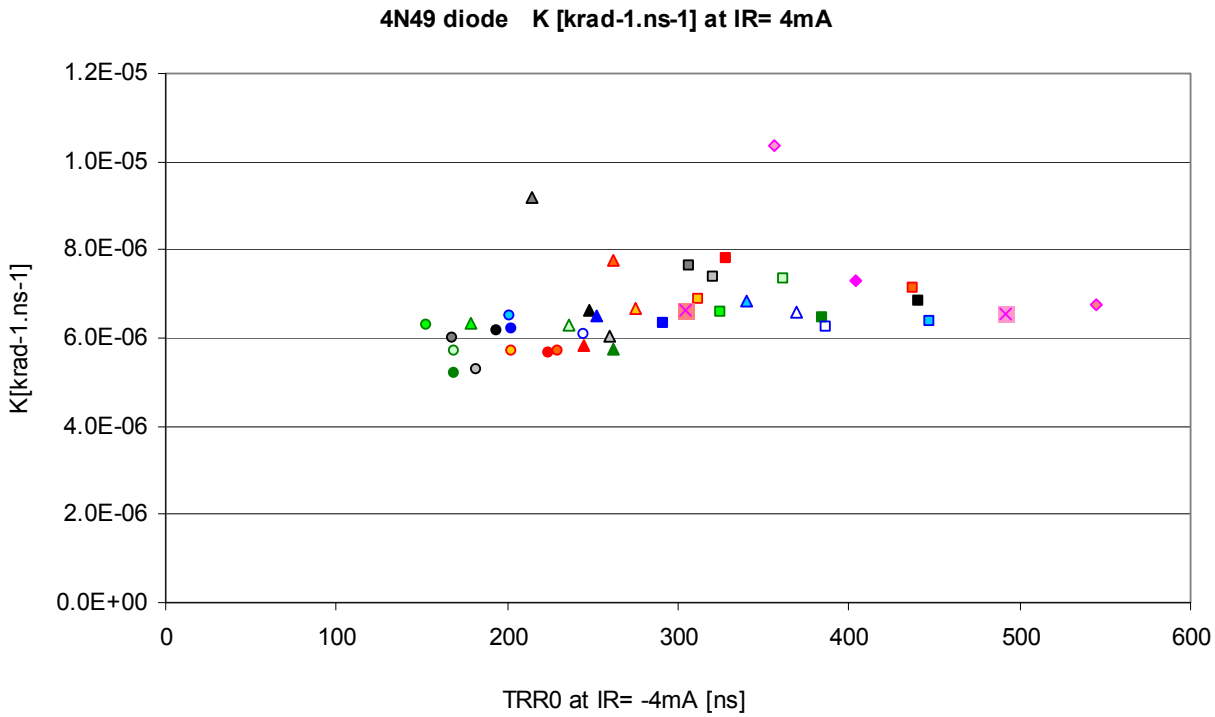


Fig. 10-11: 4N49 K_{dose} with respect to τ_{RR0*} (pre-irradiated and pristine samples)

10.3 CORRELATION BETWEEN CTR AND τ_{RR} DEGRADATIONS

The initial reverse recovery time considered τ_{RR0*} for these samples is τ_{RR} measured prior gamma irradiation and after the degradation due to displacement damage.

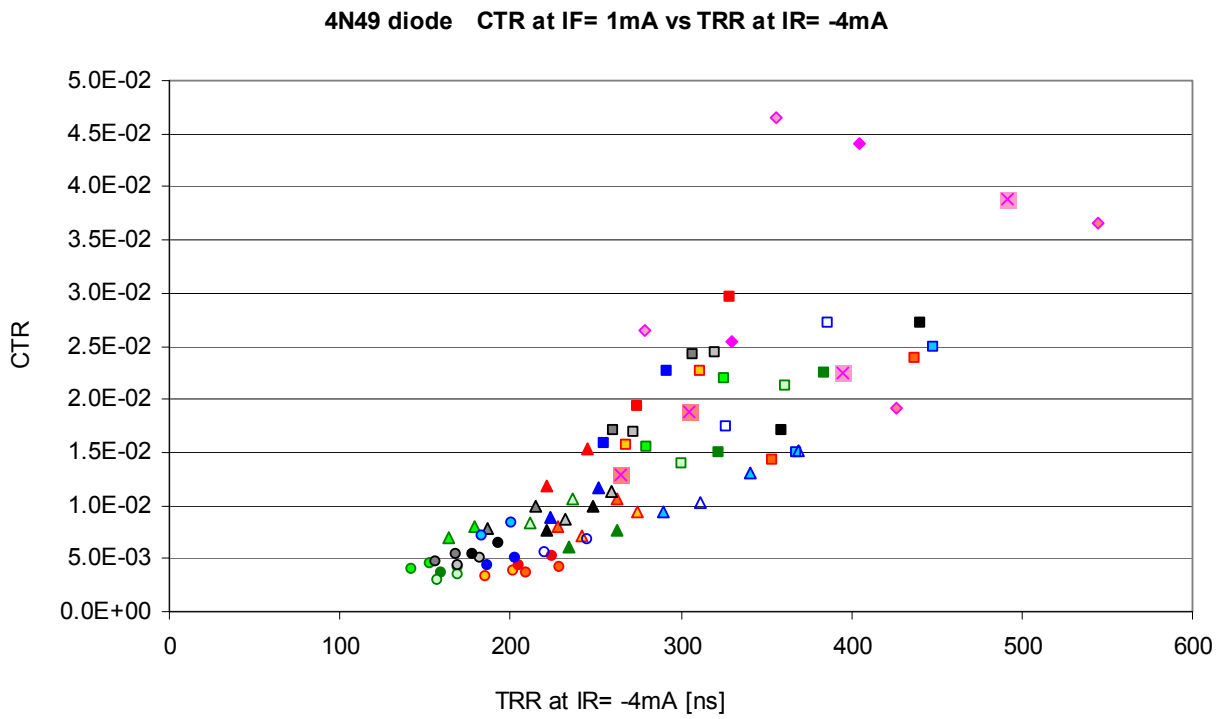


Fig. 10-12: 4N49 diode CTR at I_F= 1mA with respect to τ_{RR} (gamma irradiation, pre-irradiated and pristine samples)

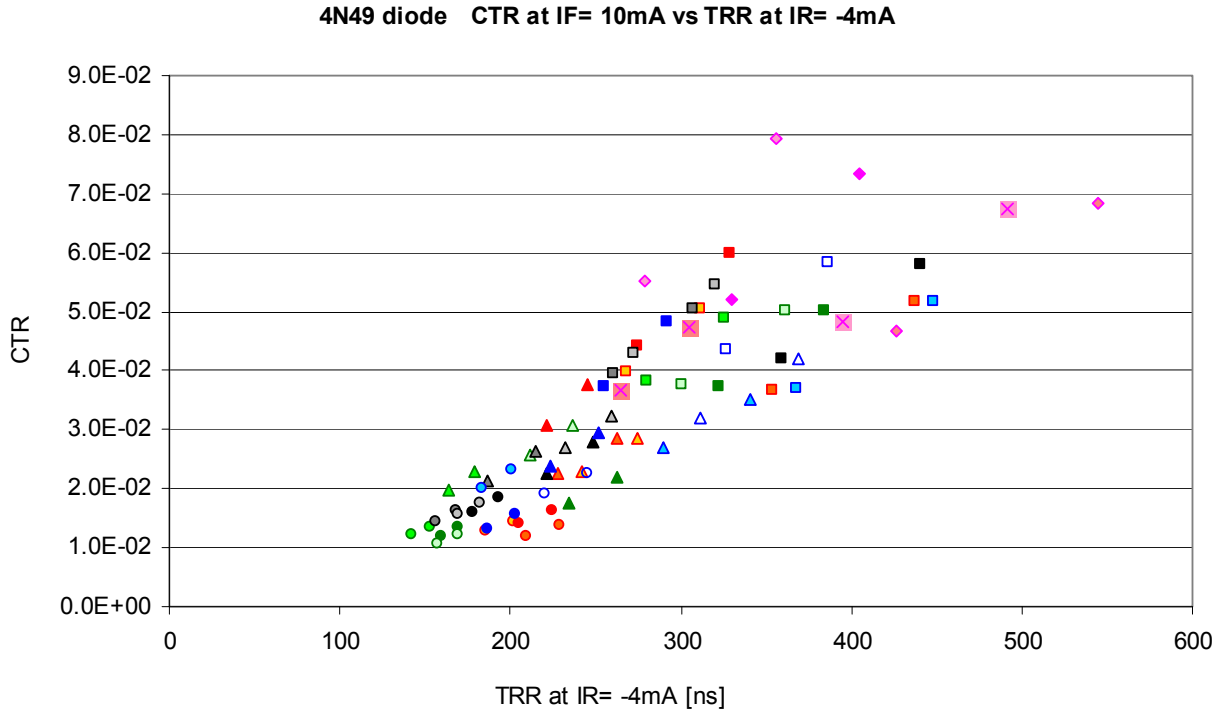


Fig. 10-13: 4N49 diode CTR at I_F= 10mA with respect to τ_{RR} (gamma irradiation, pre-irradiated and pristine samples)

As expected from the results plotted in Fig. 10-1 to Fig. 10-11, the correlation between relative CTR and relative reverse recovery time in gamma irradiation is not modified by the pre-irradiation (Fig. 10-14 to Fig. 10-17).

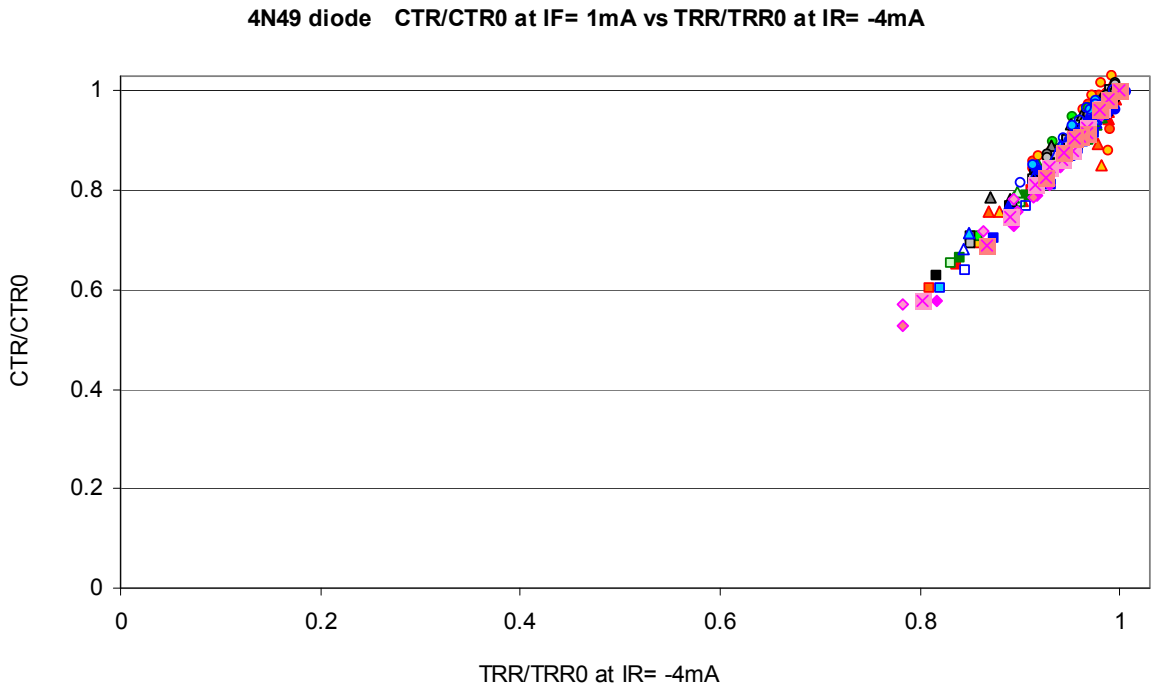


Fig. 10-14: 4N49 diode CTR/CTR$_0$ at I_F= 1mA with respect to τ_{RR}/τ_{RR0^*} (gamma irradiation, pre-irradiated and pristine samples)

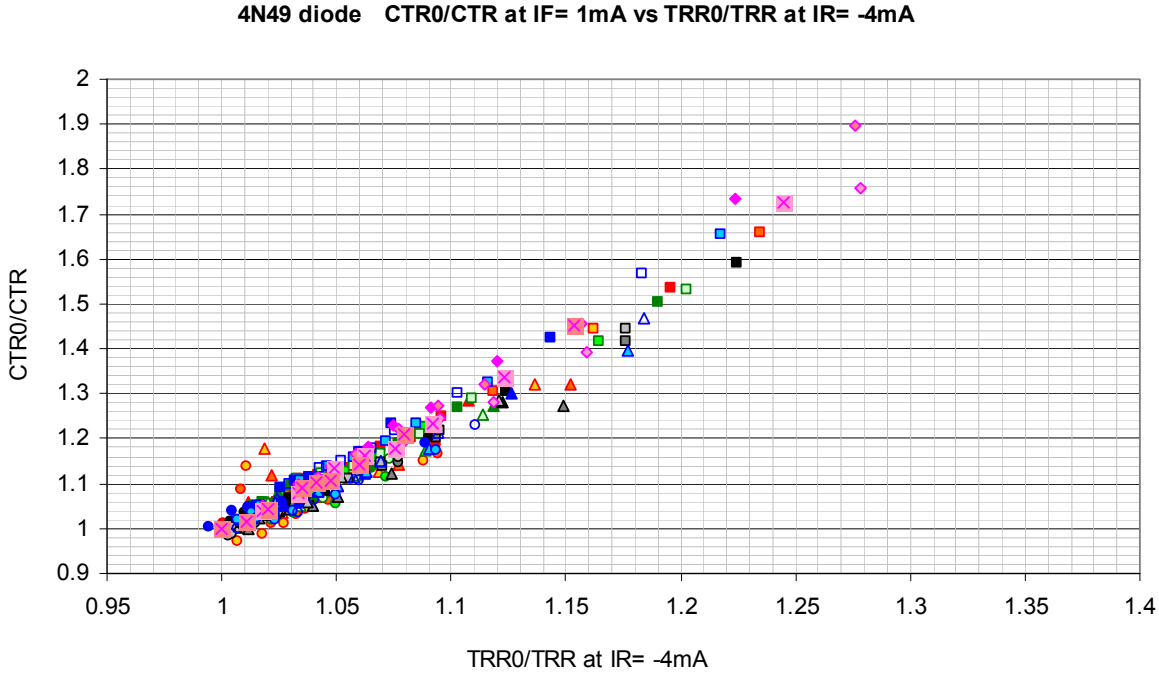


Fig. 10-15: 4N49 diode CTR$_0$/CTR at I_F= 1mA with respect to τ_{RR0^*}/τ_{RR} (gamma irradiation, pre-irradiated and pristine samples)

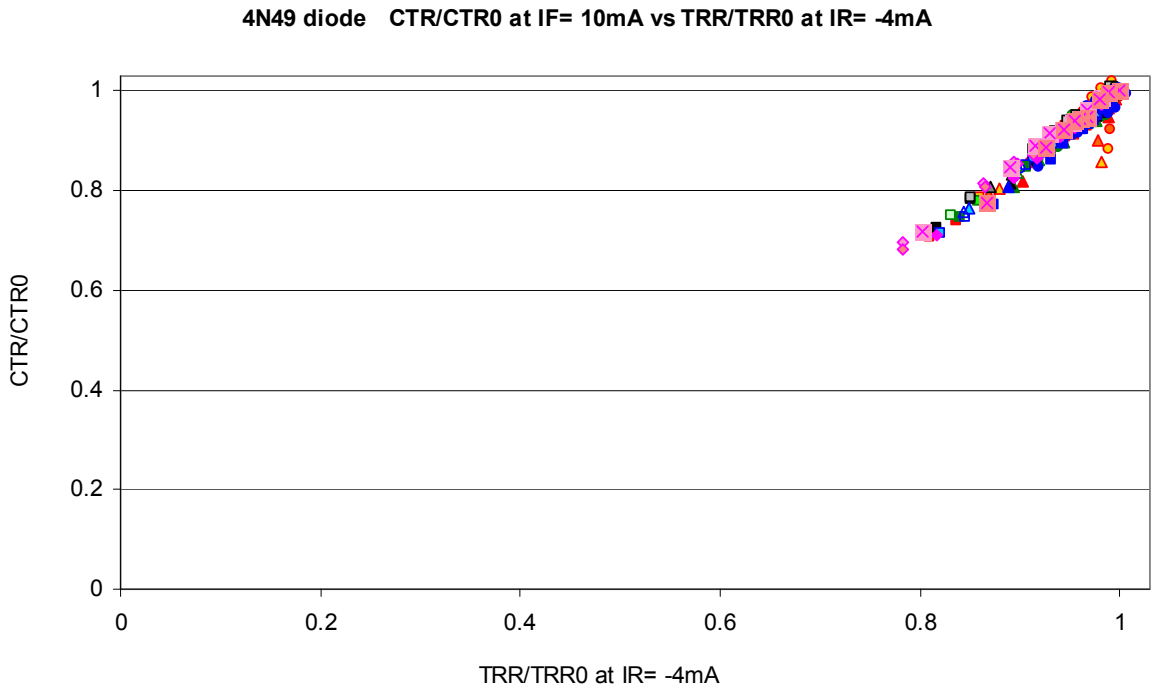


Fig. 10-16: 4N49 diode CTR/CTR$_0$ at I_F= 10mA with respect to τ_{RR}/τ_{RR0*} (gamma irradiation, pre-irradiated and pristine samples)

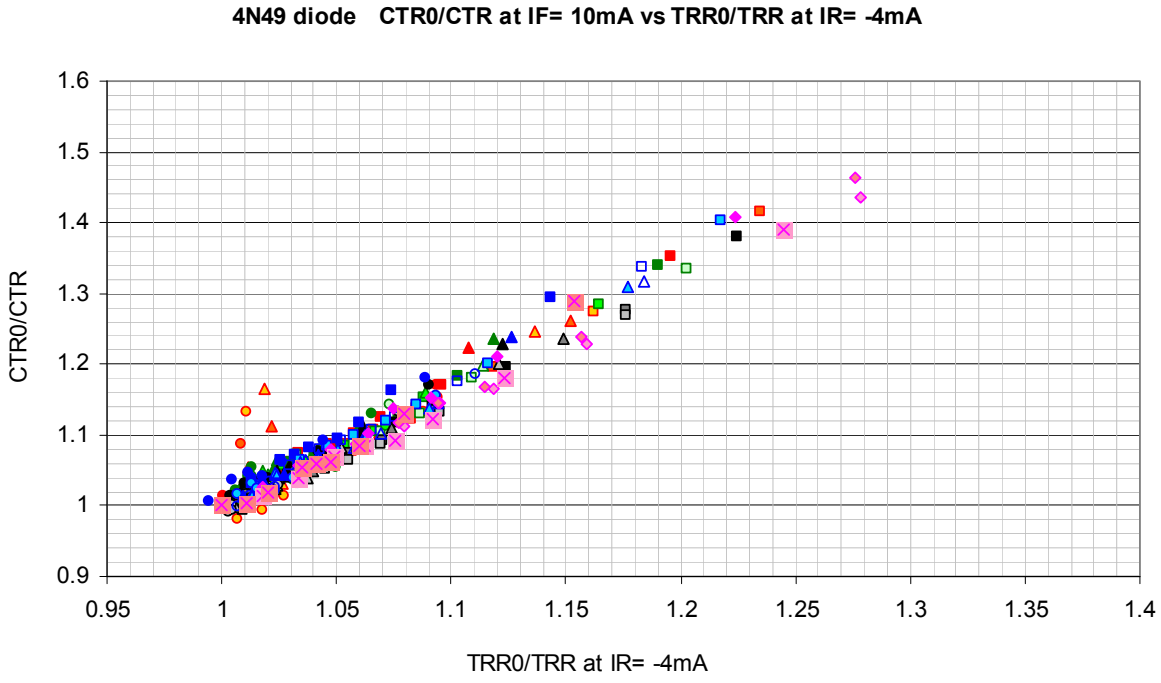
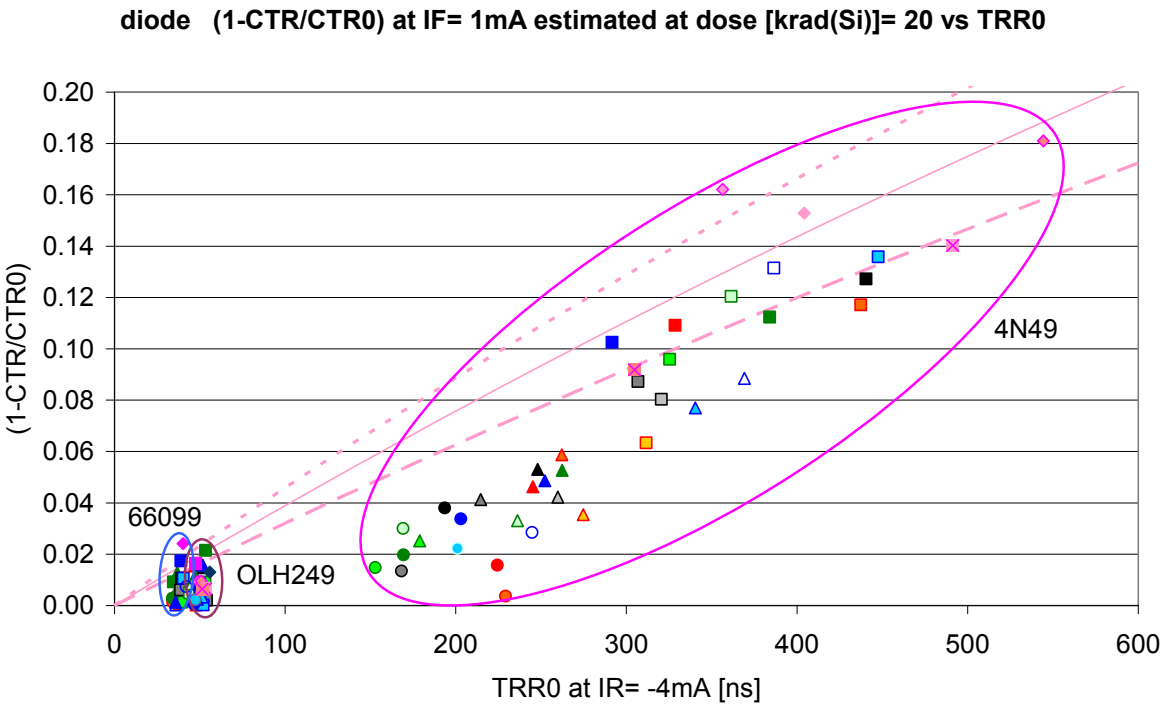


Fig. 10-17: 4N49 diode CTR$_0$/CTR at I_F= 10mA with respect to τ_{RR0*}/τ_{RR} (gamma irradiation, pre-irradiated and pristine samples)

10.4 ESTIMATION OF A DIODE DEGRADATION: COMPARISON WITH SOLE GAMMA IRRADIATION

The measurements of these pre-irradiated samples are added to the previous figures of pristine samples (Fig. 9-27 to Fig. 9-32) in Fig. 10-18 to Fig. 10-23. The initial reverse recovery time considered τ_{RR0^*} for these samples is τ_{RR} measured prior gamma irradiation and after the degradation due to displacement damage. These points are of course under the previous curves obtained from the pristine diodes.

However the degradation is quite much overestimated for 4N49. This is a saturation effect, since already degraded diodes degrade less easily.



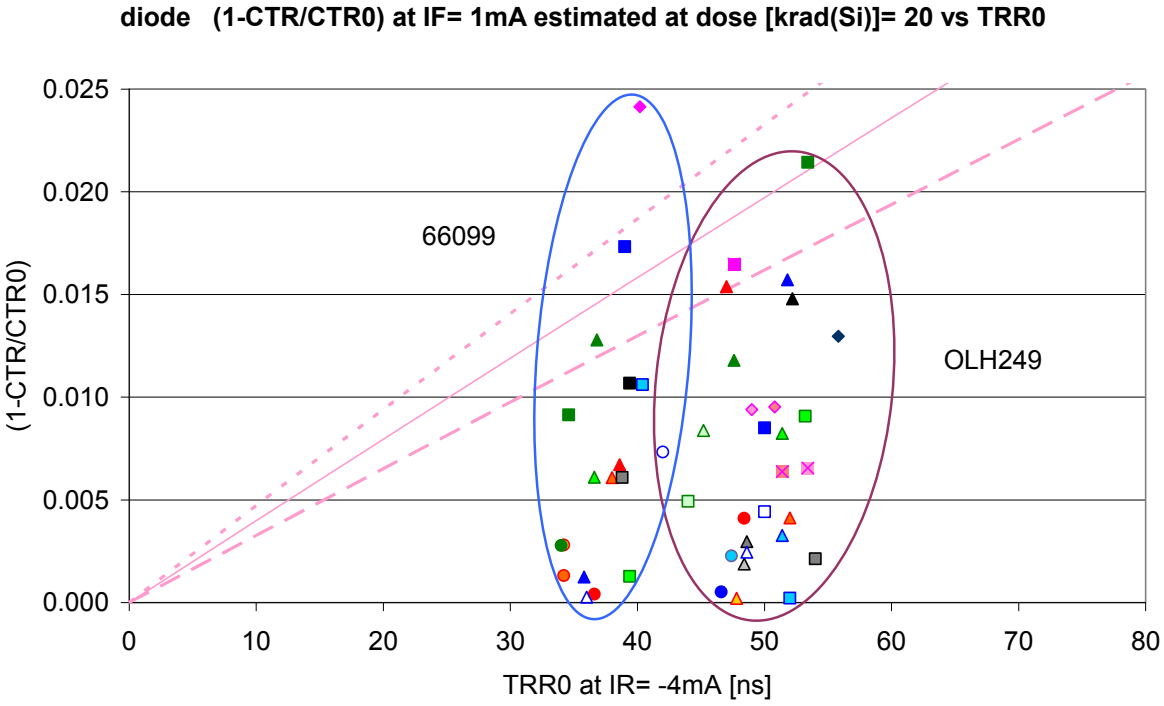
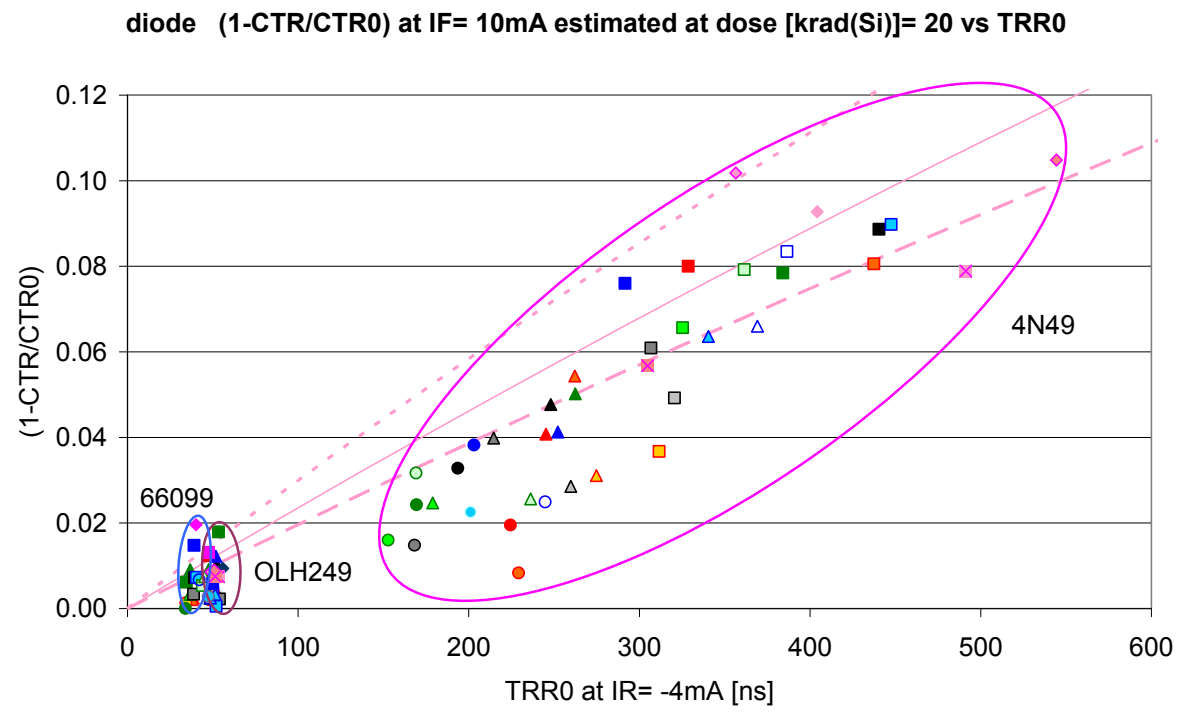


Fig. 10-18. 1 – CTR/CTR$_0$ estimated at a TID of 20 krad at I_F= 1mA with respect to τ_{TRR0^*} at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)



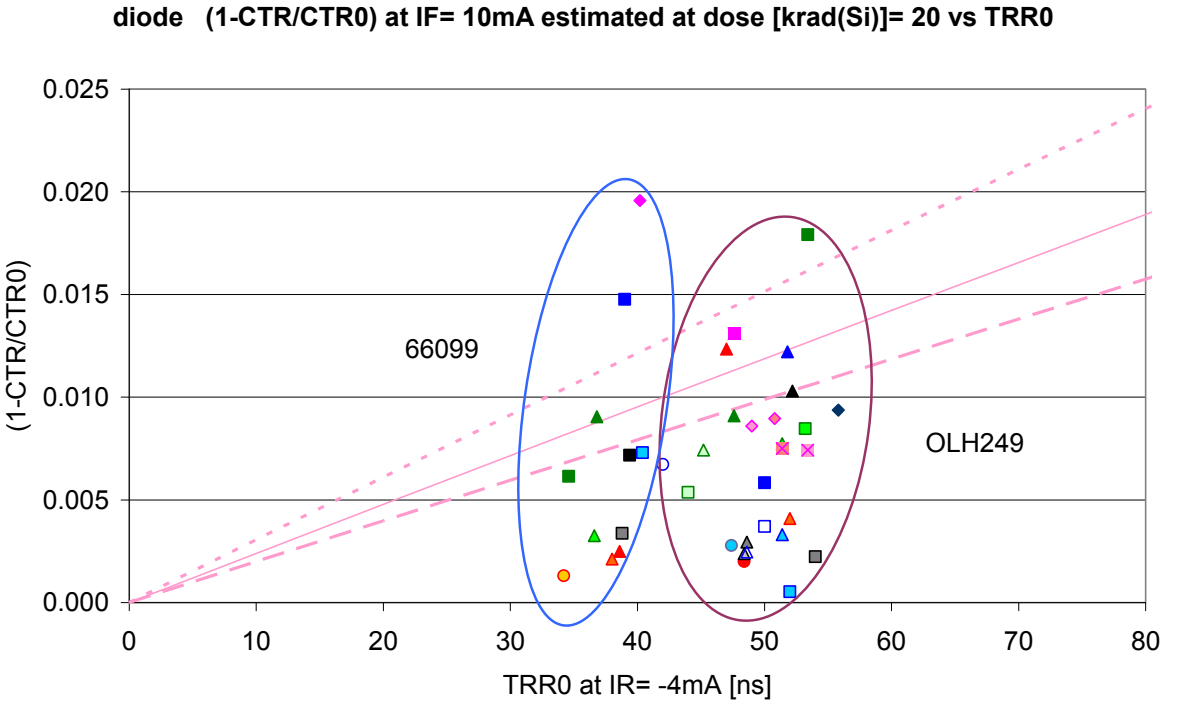
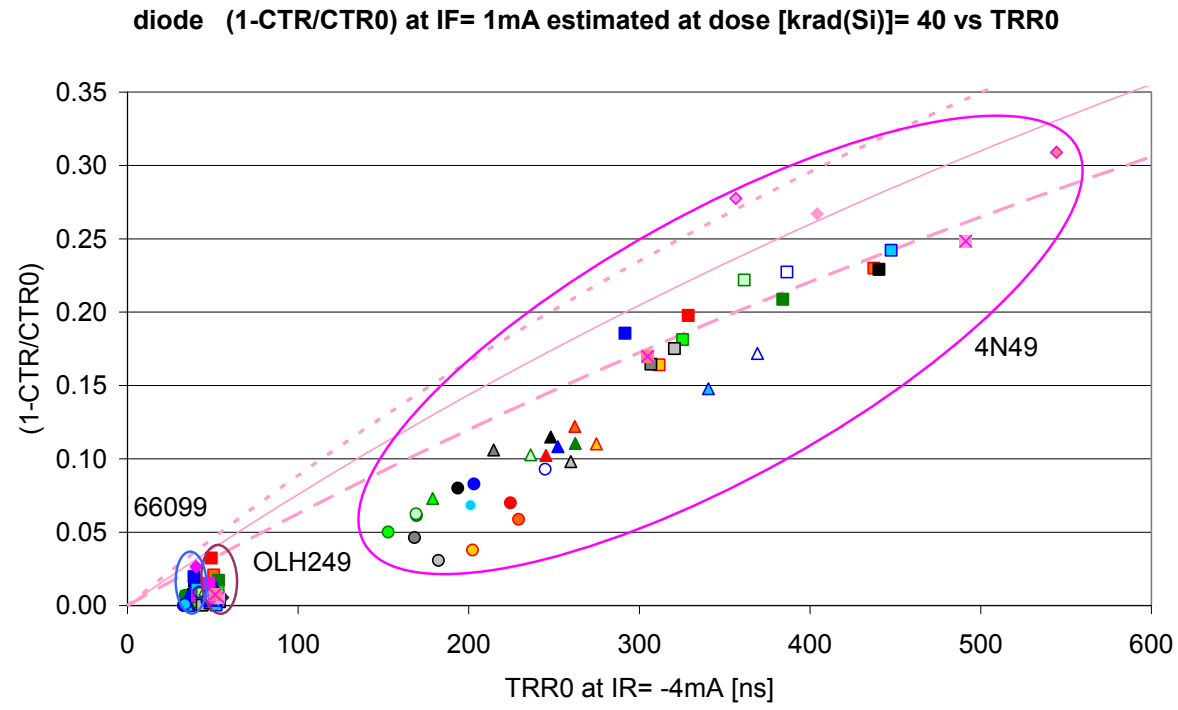


Fig. 10-19. 1 – CTR/CTR$_0$ estimated at a TID of 20 krad at I_F= 10mA with respect to τ_{RR0}, at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)



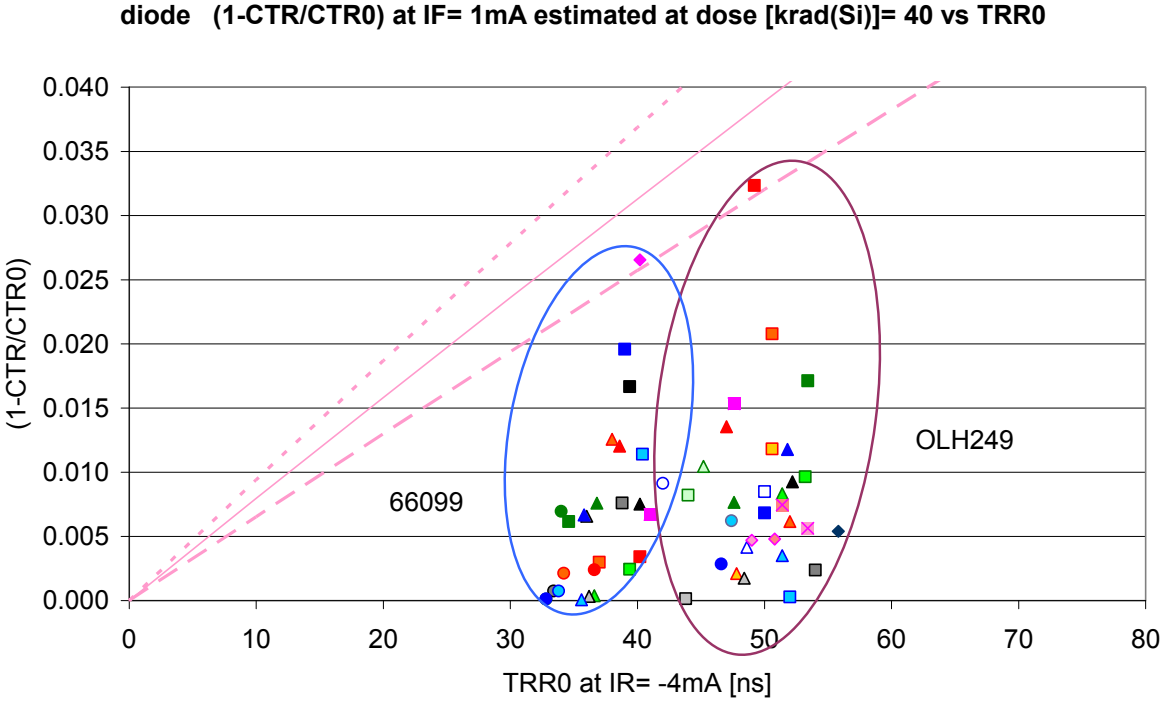
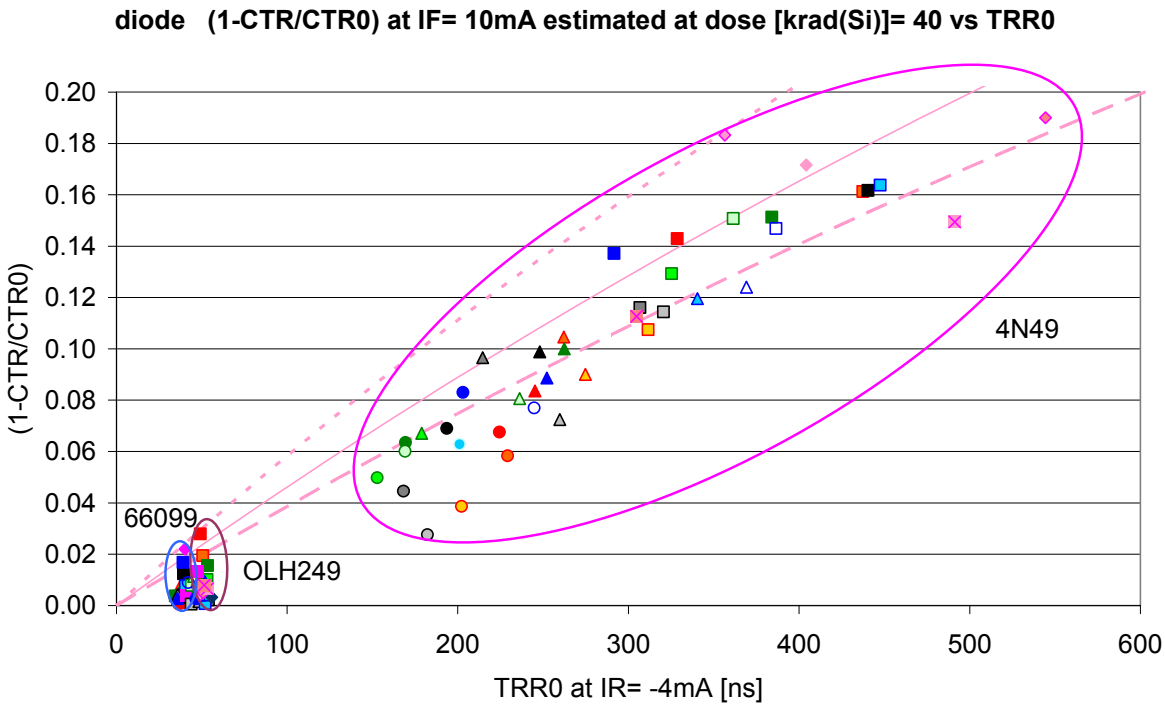


Fig. 10-20. 1 – CTR/CTR$_0$ estimated at a TID of 40 krad at I_F= 1mA with respect to τ_{RR0*} at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)



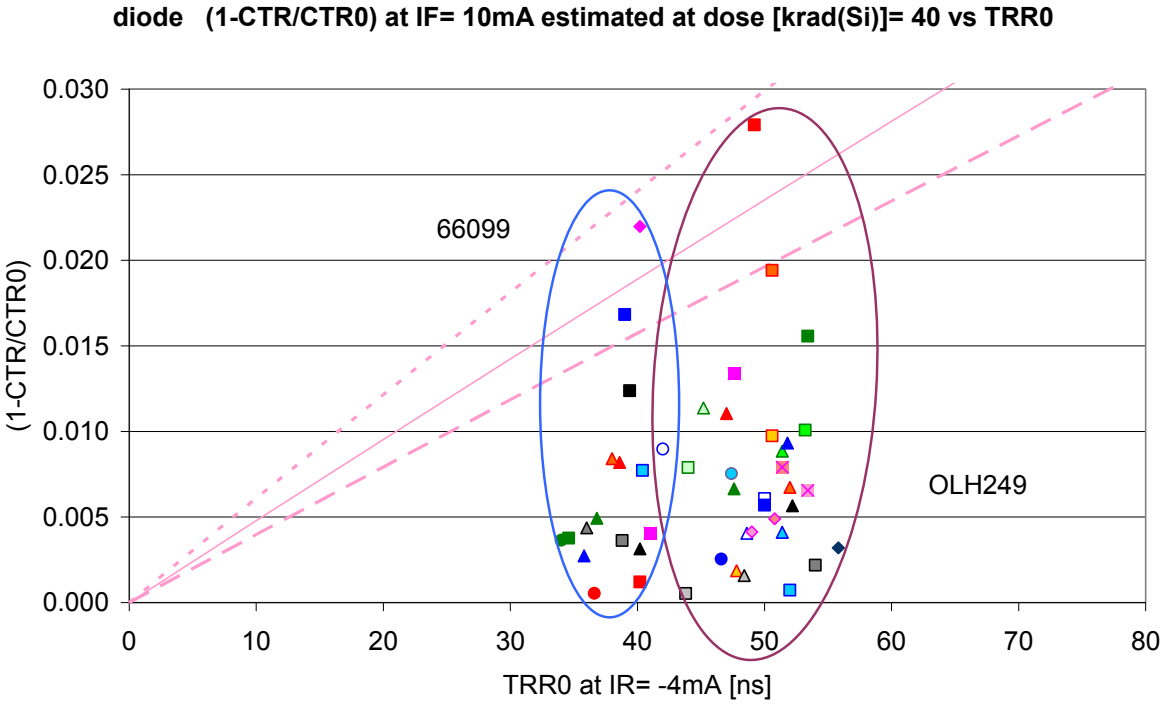
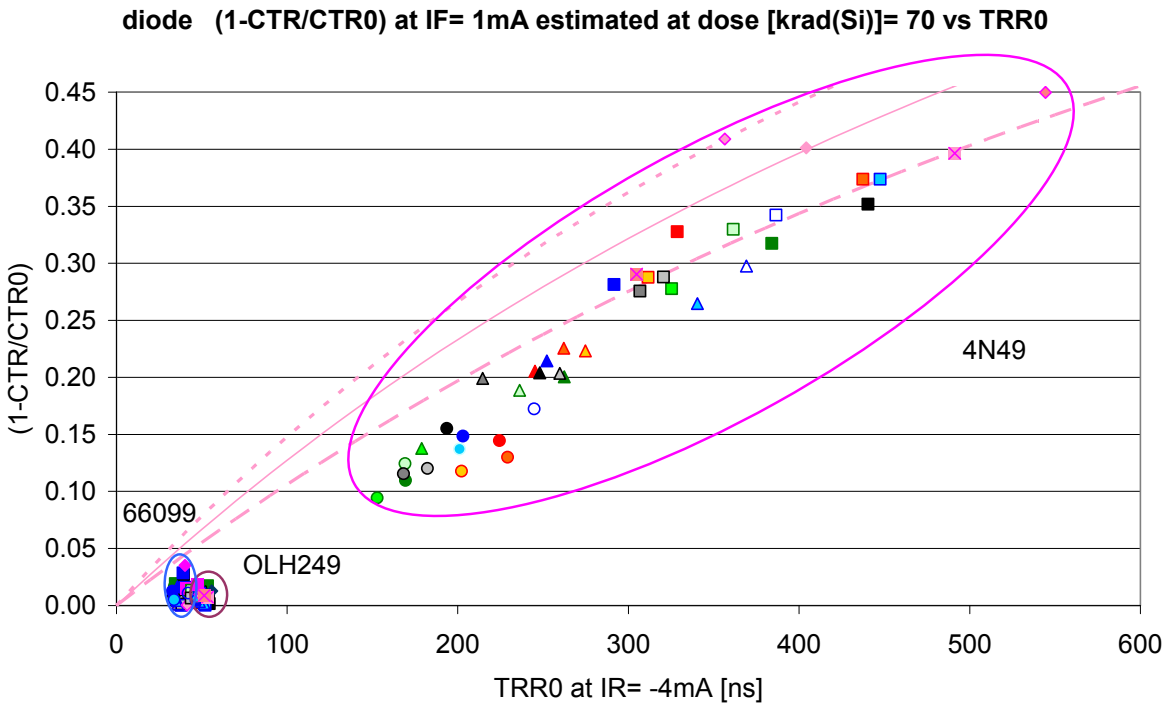


Fig. 10-21. 1 – CTR/CTR$_0$ estimated at a TID of 40 krad at I_F= 10mA with respect to τ_{RR0}, at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)



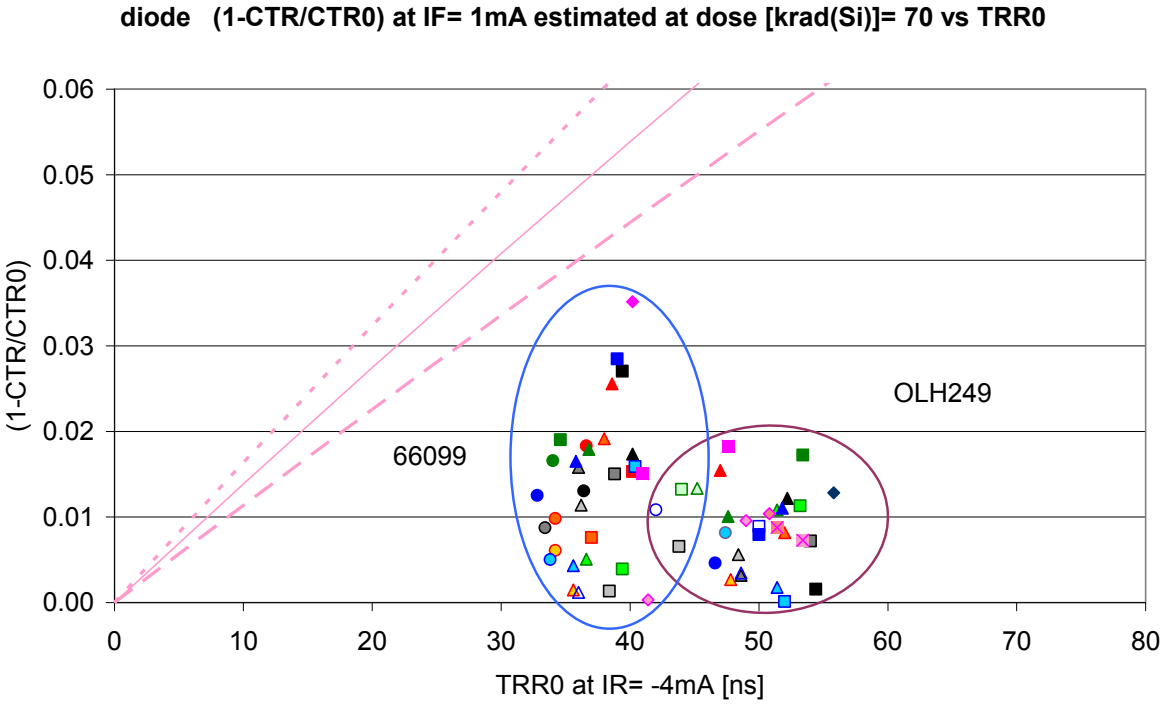
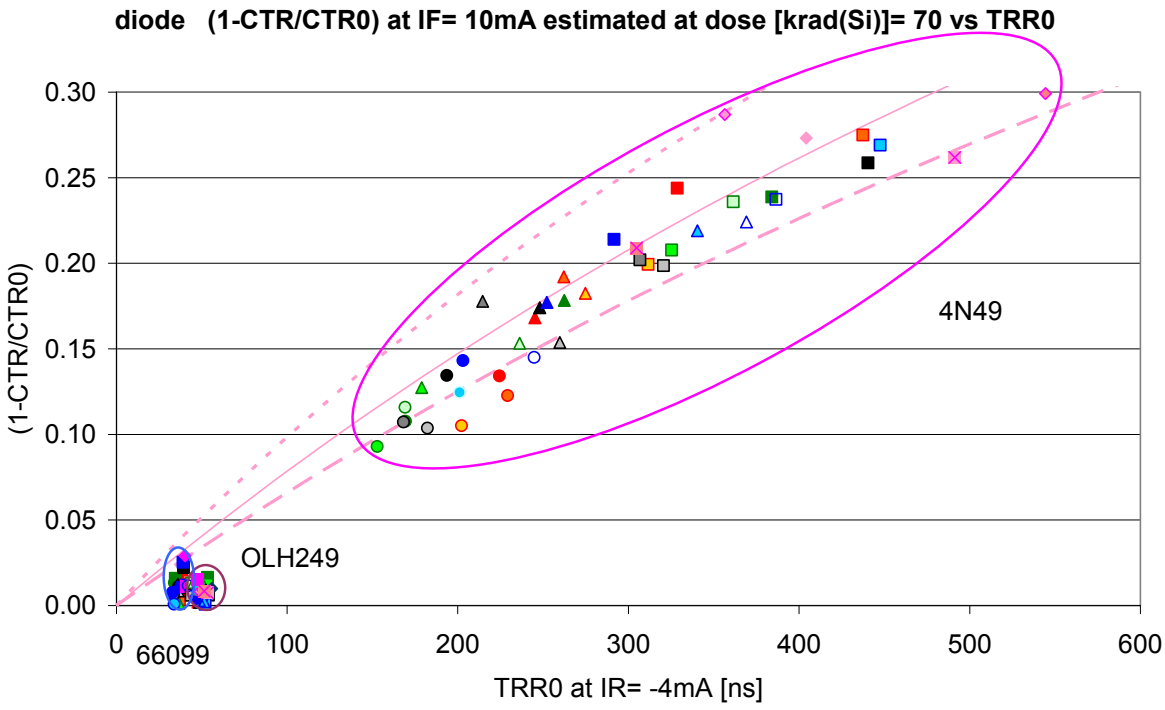


Fig. 10-22. 1 – CTR/CTR$_0$ estimated at a TID of 70 krad at I_F= 1mA with respect to τ_{RR0*} at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)



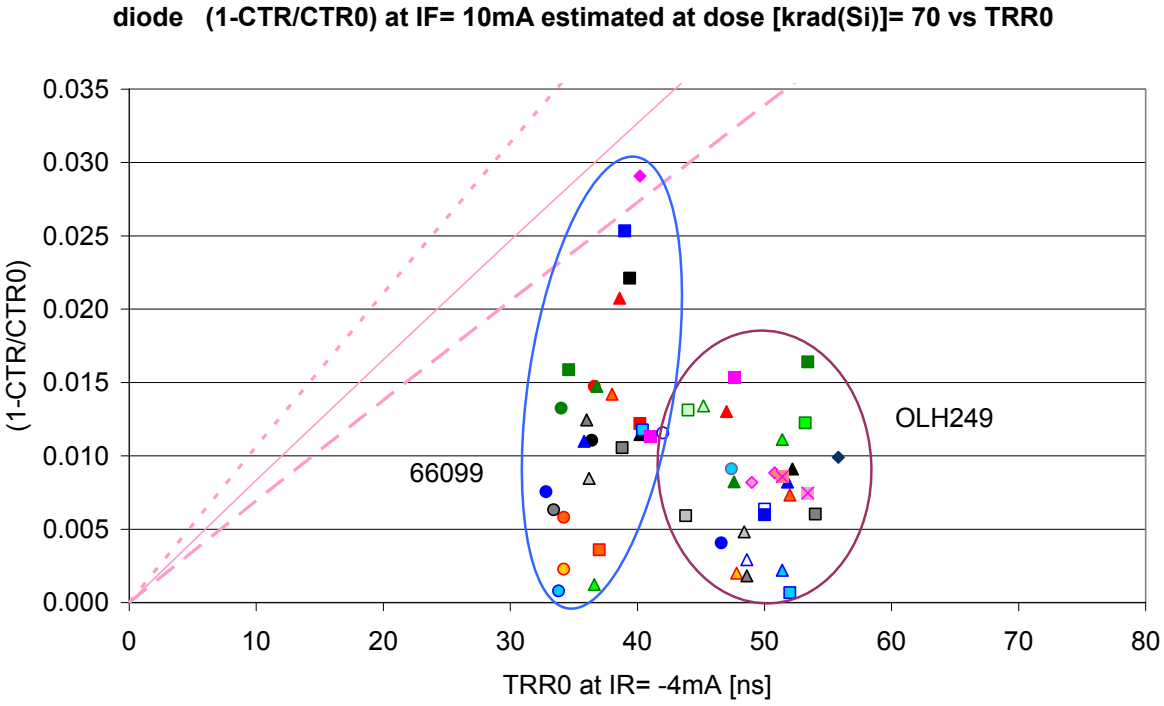


Fig. 10-23. 1 – CTR/CTR$_0$ estimated at a TID of 70 krad at I_F= 10mA with respect to τ_{RR0} at I_R= -4mA and "medium", "lowest point" and "highest point" curves (pre-irradiated and pristine samples)

10.5 ESTIMATION OF A DIODE DEGRADATION BY DISPLACEMENT AND IONIZING DOSE

In this section τ_{RR0} refers to the reverse recovery time measured prior any irradiation. The law of the correlation between CTR/CTR_0 and τ_{RR}/τ_{RR0} takes into account both displacement damage degradation and ionizing dose degradation.

Assuming there is no effect of the displacement damage degradation on the ionizing dose degradation, Eq.27 derived for proton/neutron irradiation can be easily injected in the equation at Table 27 derived for gamma irradiation on pristine diodes to get the CTR degradation of non-pristine diodes as a function of τ_{RR0}, which gives:

$$1-\frac{CTR}{CTR_0}=1-\left(1+\frac{\tau_{RR0}\cdot K_{TID}\cdot TID}{1+\tau_{RR0}\cdot K_{NIEL}\cdot NIEL}\right)^{-N_{TID}}\left(1+\tau_{RR0}\cdot K_{NIEL}\cdot NIEL\right)^{-N_{NIEL}} \qquad \text{Eq. 28}$$

Fig. 9-23 to Fig. 9-26 show the correlation between CTR degradation and τ_{RR} degradation is the same whatever the irradiation type. As a consequence N_{TID} is chosen equal to N_{NIEL}, and the equation becomes :

$$1-\frac{CTR}{CTR_0}=1-\left(1+\tau_{RR0}\cdot\left(K_{NIEL}\cdot NIEL+K_{TID}\cdot TID\right)\right)^{-N} \qquad \text{Eq. 29}$$

The following N values are considered to derive the curves of Fig. 10-25 to Fig. 10-42:

I_F	1mA	10mA
N	2.6	1.8

Table 30. N at I_R= -4mA as a function of I_F

The following K values have been considered in the previous sections:

energy E [MeV]	60	100	200	neutron spectrum UCL	gamma source	Co60
K_{NIEL} [g.MeV^{-1}.ns^{-1}]	2.7E-11	2.4E-11	2.9E-11	-	K_{TID} [krad^{-1}.ns^{-1}]	8.0E-06

Table 31. K values at I_R= -4mA considered in the previous sections

For comparison Table 32 gives the mean values:

energy E [MeV]	60	100	200	neutron spectrum UCL	gamma source	Co60
K_{NIEL} [g.MeV^{-1}.ns^{-1}]	2.82E-11	2.38E-11	2.89E-11	2.22E-11	K_{TID} [krad^{-1}.ns^{-1}]	7.52E-06

Table 32. K mean values at I_R= -4mA

For protons and neutrons, one single value of K_{NIEL} is considered. It is the arithmetic mean value of all samples, 2.6E-11 g.MeV^{-1}.ns^{-1} (see Fig. 8-17). The K values taken into account are summarized in Table 33:

K_{NIEL} [g.MeV^{-1}.ns^{-1}]	2.6E-11
K_{TID} [krad^{-1}.ns^{-1}]	8E-06

Table 33. K at I_R= -4mA

Fig. 10-24 depicts how the experimental points spread around the two lines defined by their slopes in Table 33.

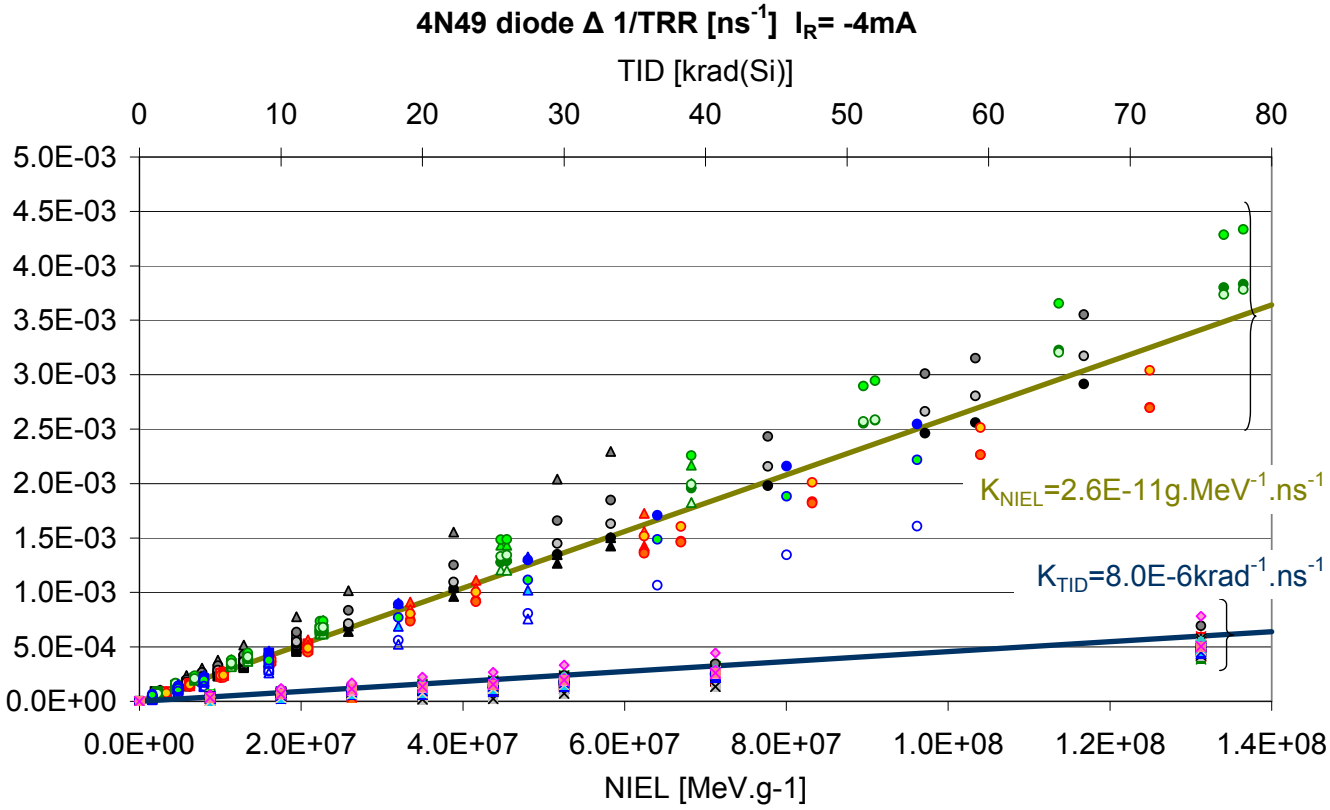
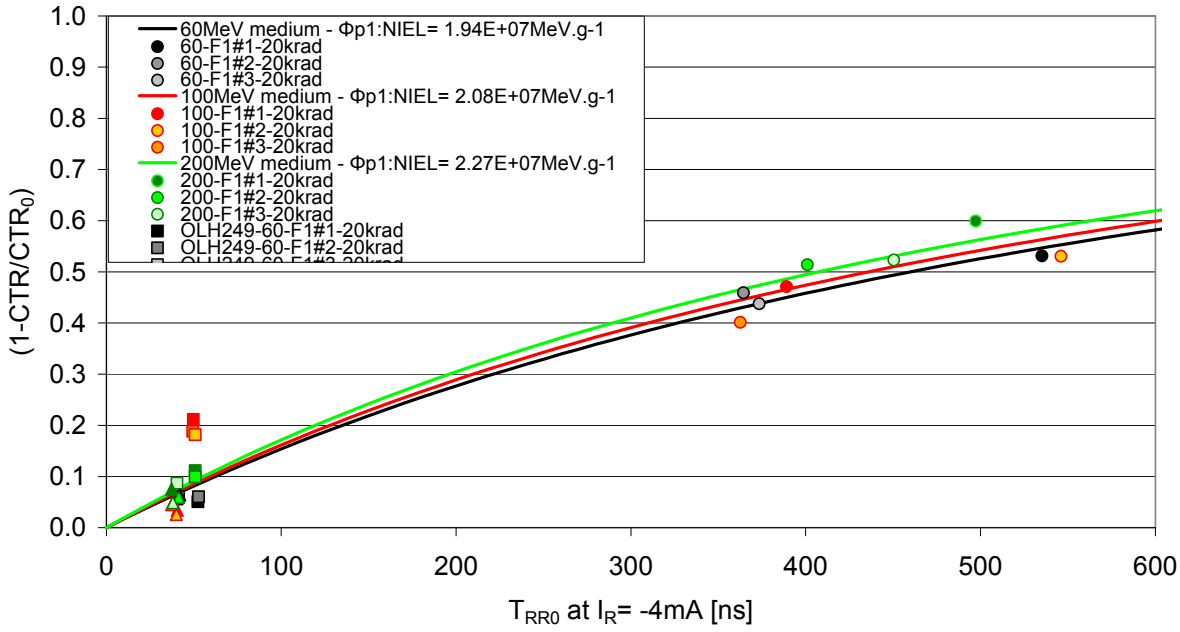


Fig. 10-24: 4N49 Δ 1/τ_{RR} for all all samples with respect to TID (top axis) and NIEL (bottom axis). The lines show the evolution considering K_{TID} and K_{NIEL} from Table 33

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 20krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 20krad(Si) vs T_{RR0}

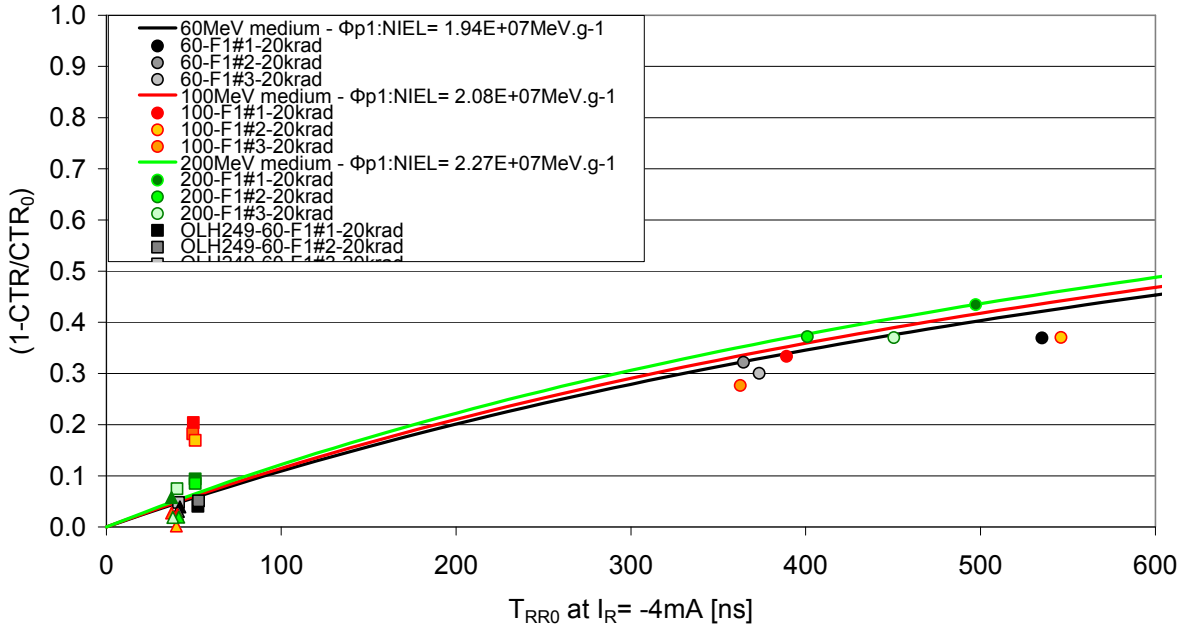
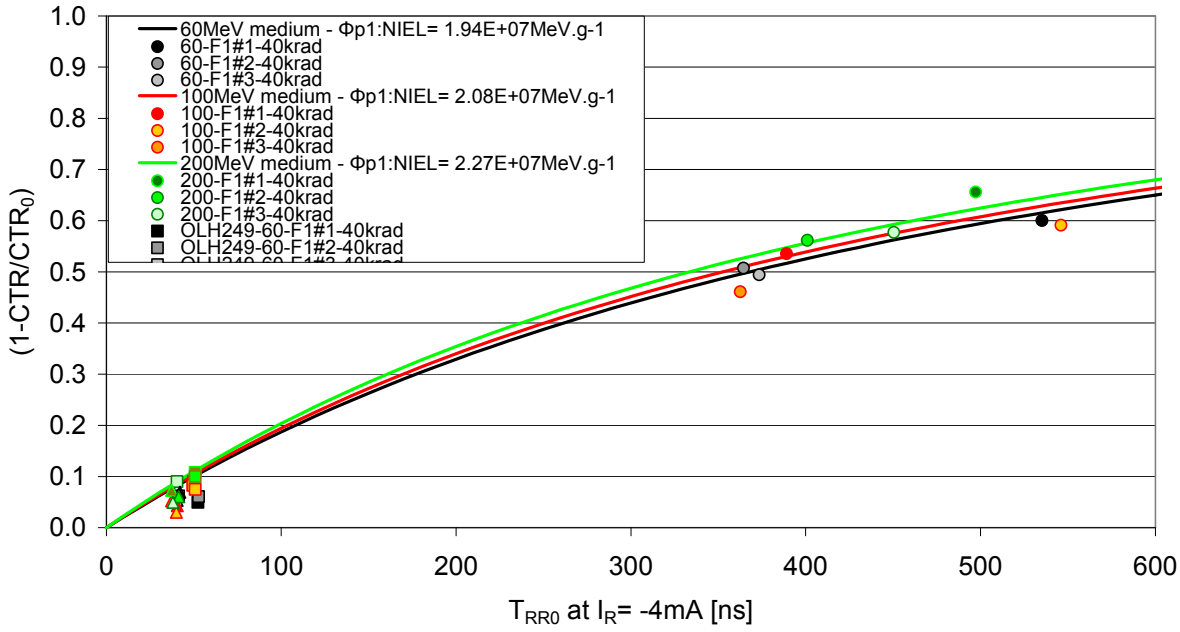


Fig. 10-25. (1 – CTR/CTR$_0$) at 20krad after Φp1 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 40.7krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 40.7krad(Si) vs T_{RR0}

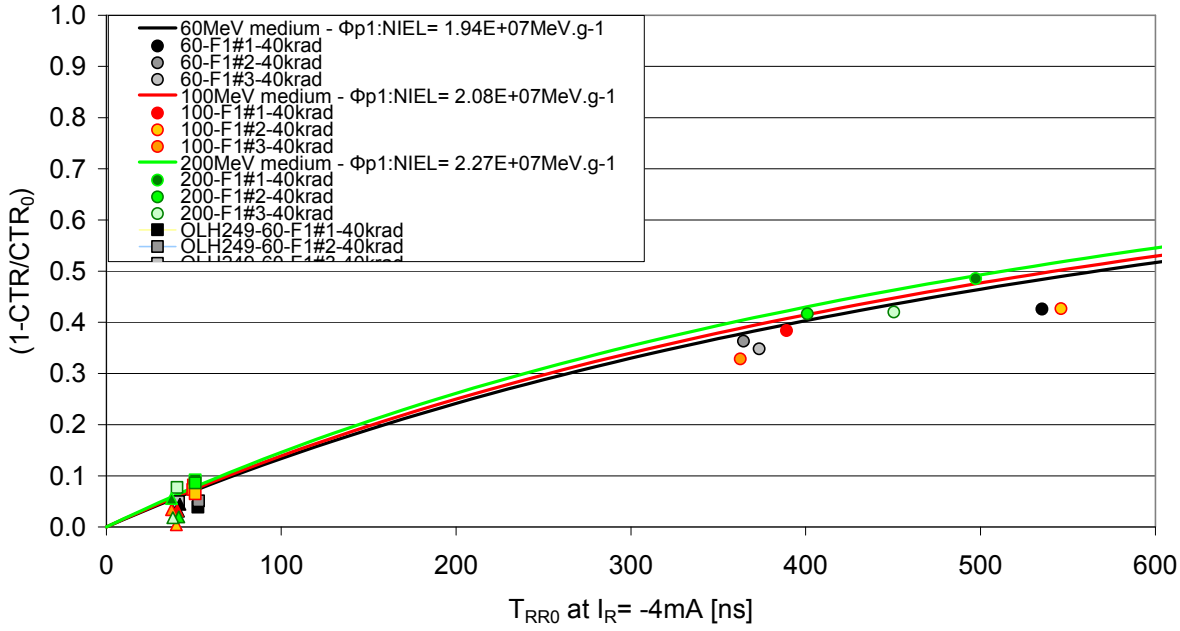
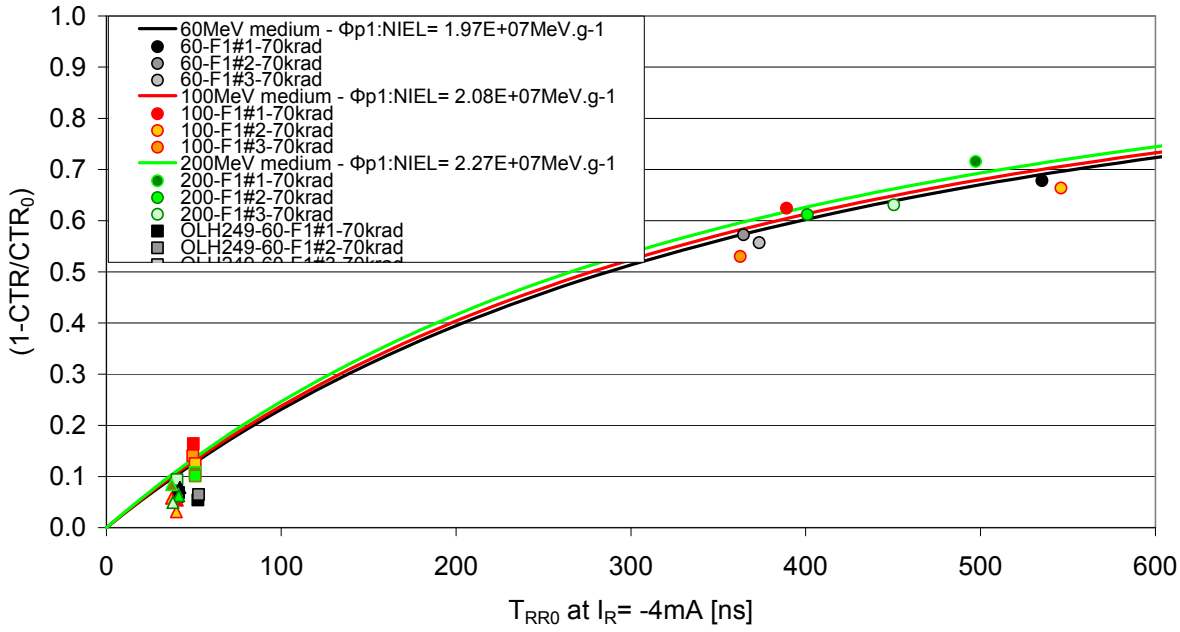


Fig. 10-26. (1 – CTR/CTR$_0$) at 40.7krad after Φp1 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 70krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 70krad(Si) vs T_{RR0}

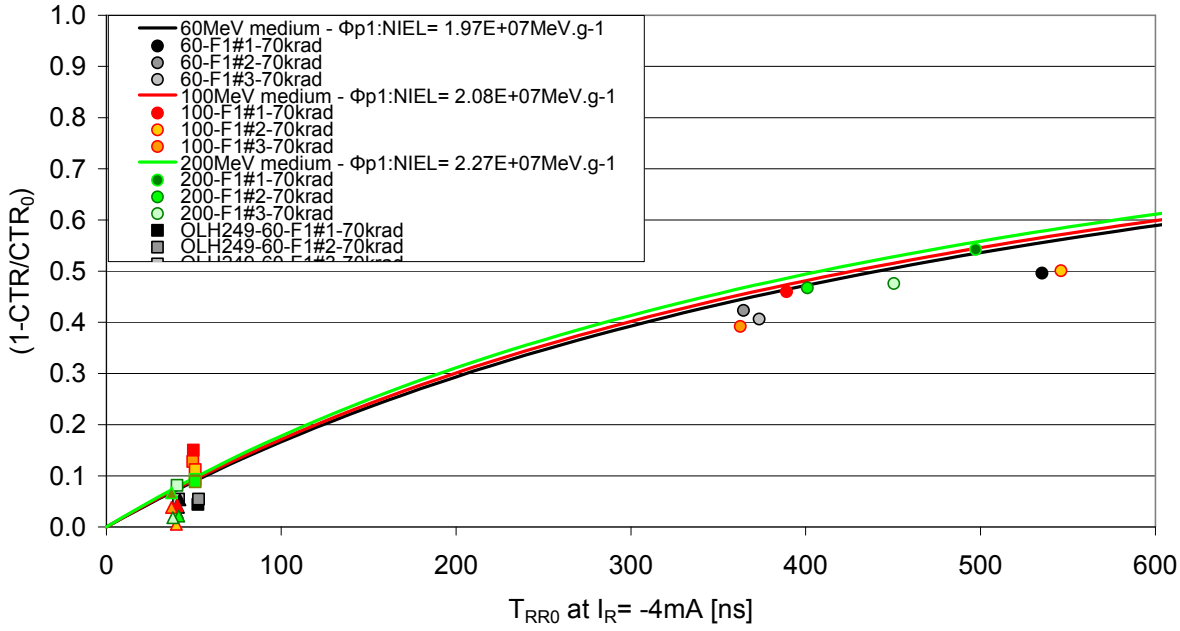
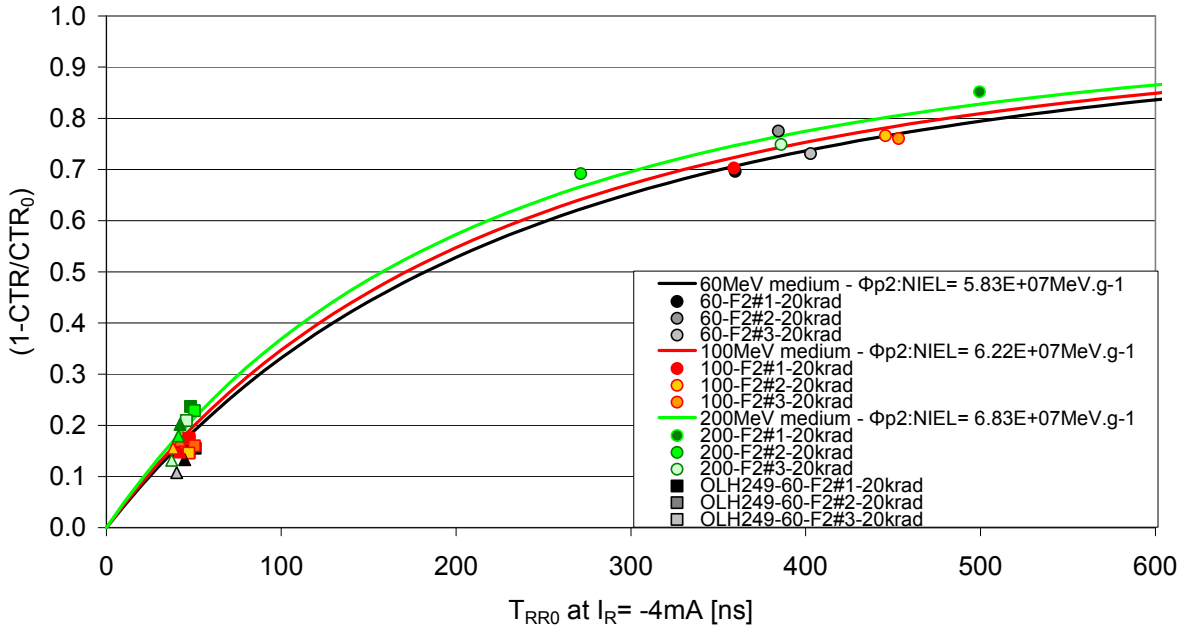


Fig. 10-27. (1 – CTR/CTR$_0$) at 70krad after Φp1 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 20krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 20krad(Si) vs T_{RR0}

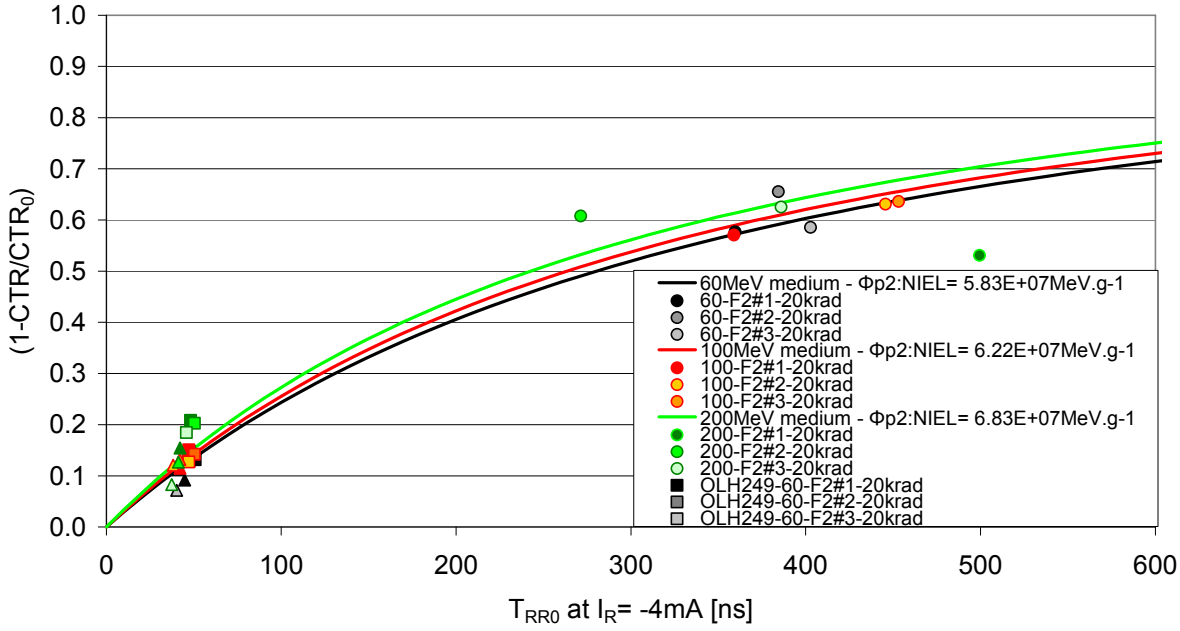
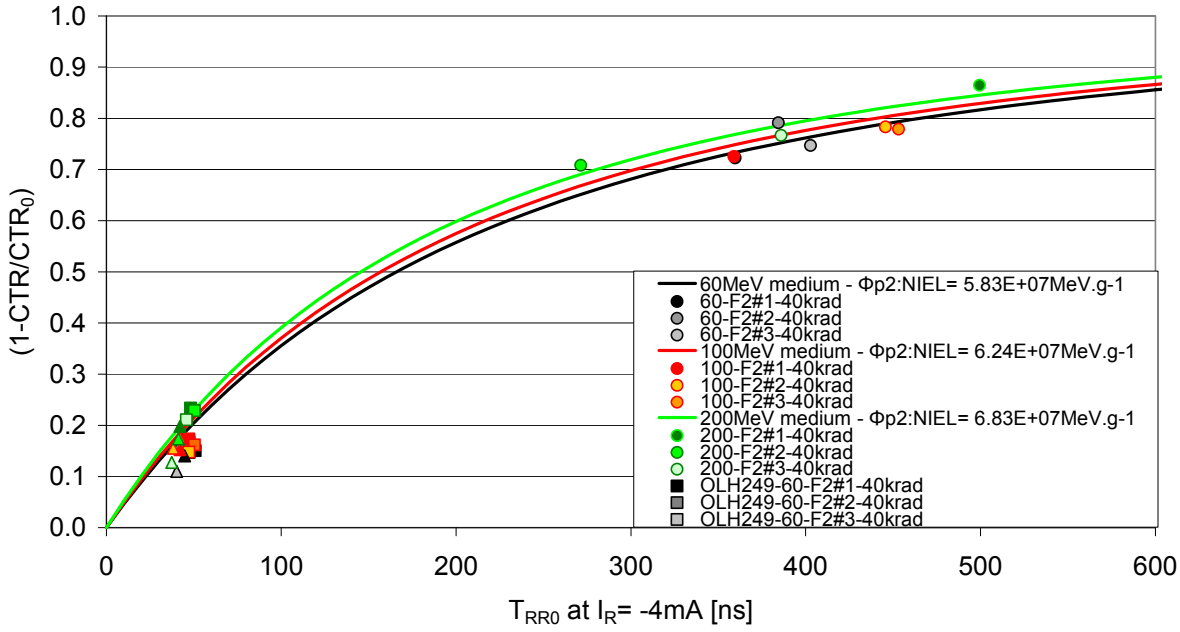


Fig. 10-28. (1 – CTR/CTR$_0$) at 20krad after Φp2 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 40.7krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 40.7krad(Si) vs T_{RR0}

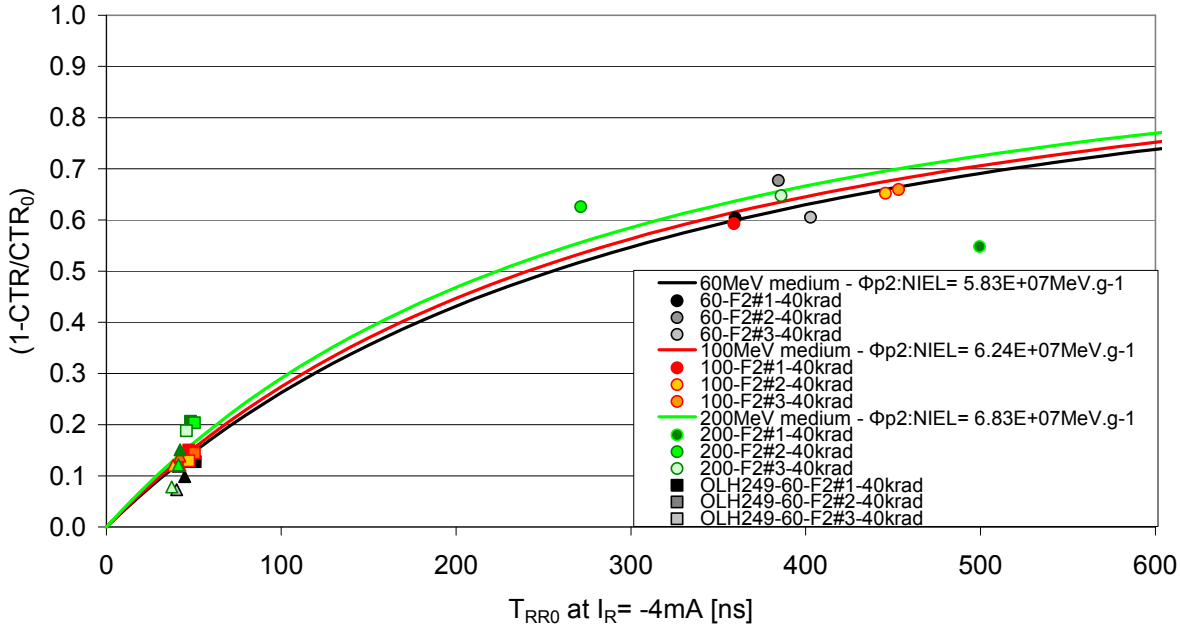
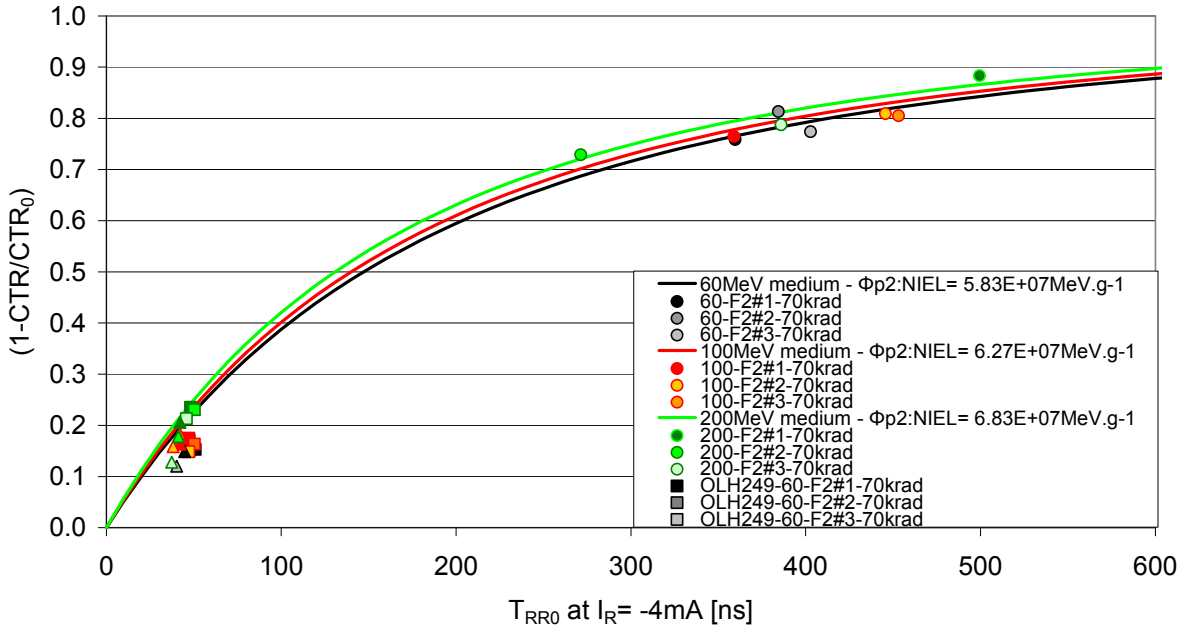


Fig. 10-29. (1 – CTR/CTR$_0$) at 40.7krad after Φp2 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 70krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 70krad(Si) vs T_{RR0}

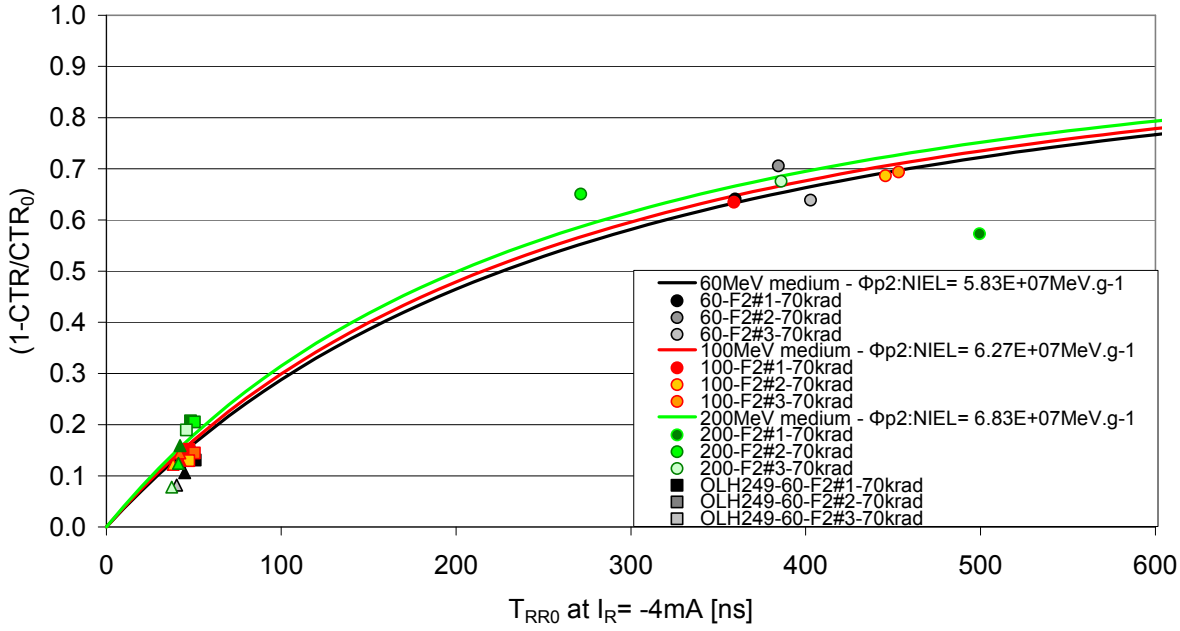
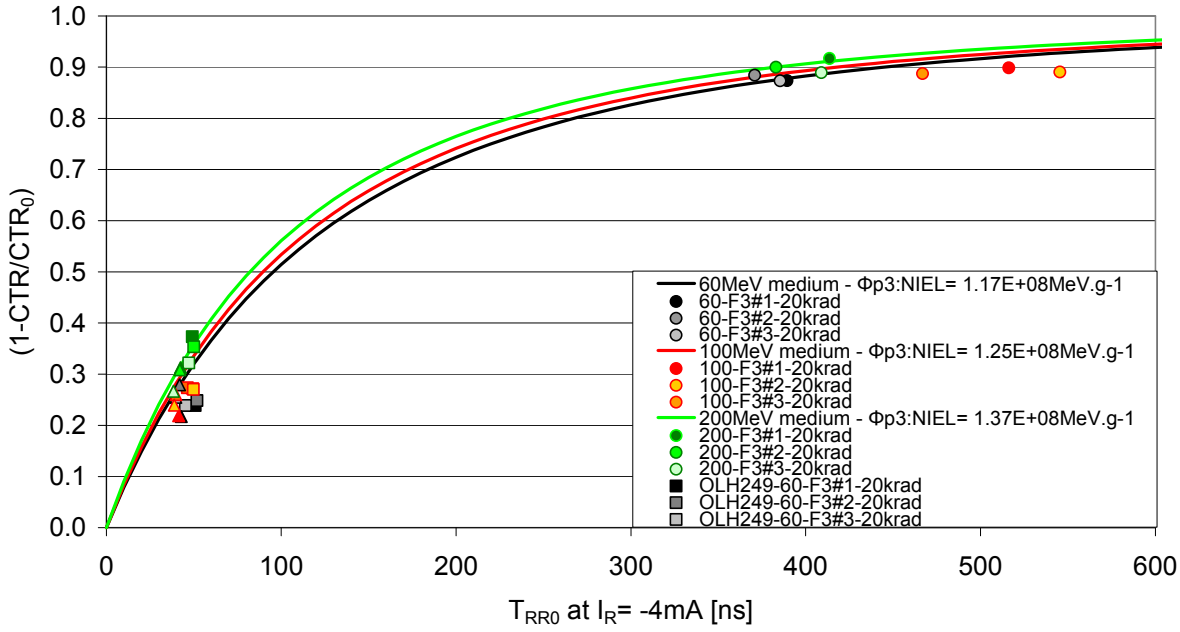


Fig. 10-30. (1 – CTR/CTR$_0$) at 70krad after Φp2 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 20krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 20krad(Si) vs T_{RR0}

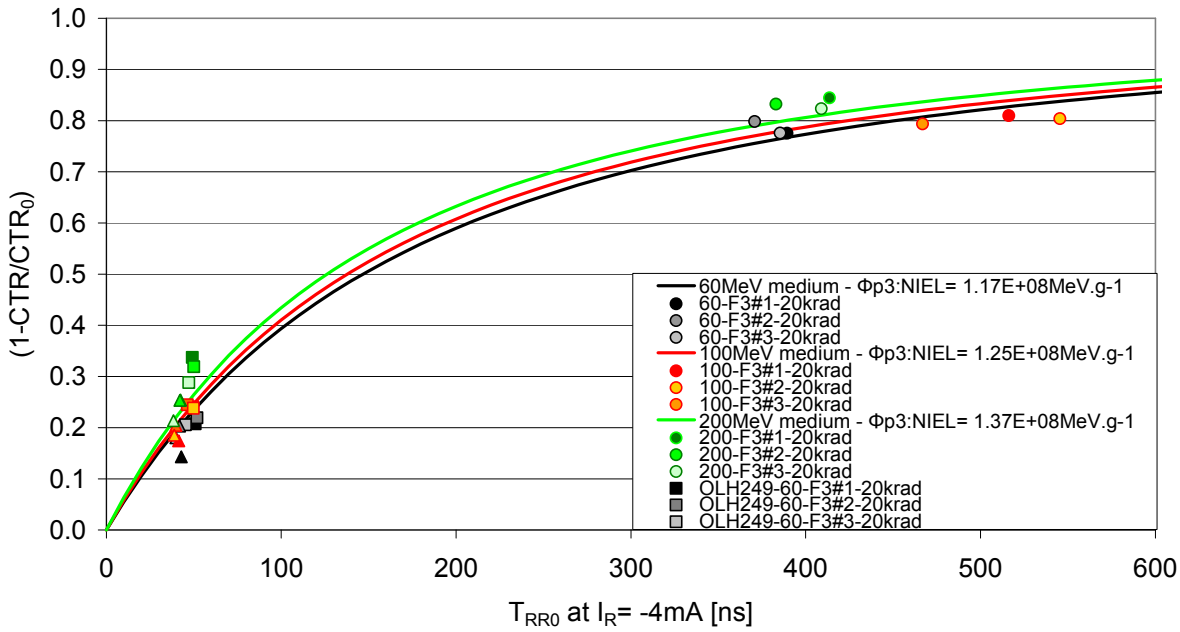
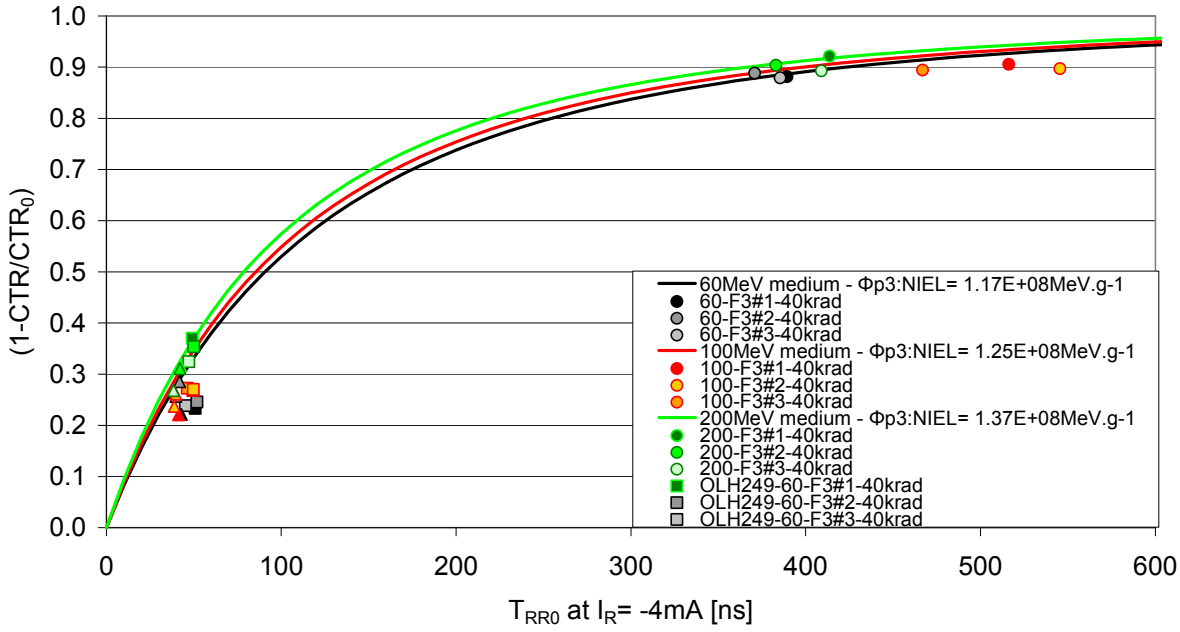


Fig. 10-31. (1 – CTR/CTR$_0$) at 20krad after Φp3 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 40.7krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 40.7krad(Si) vs T_{RR0}

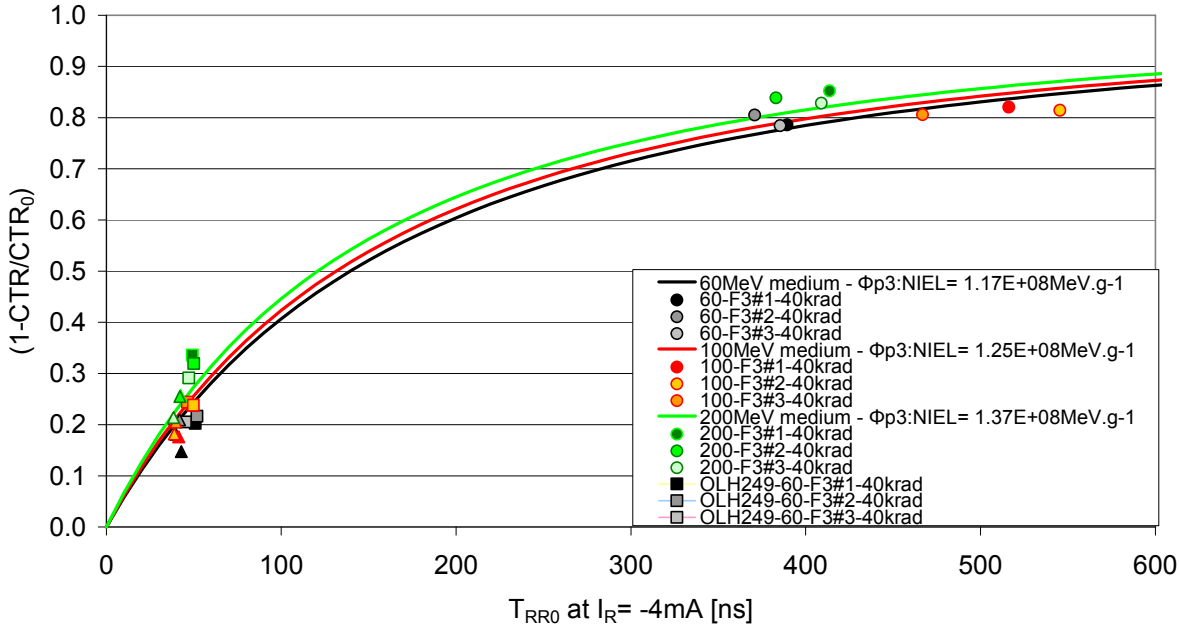
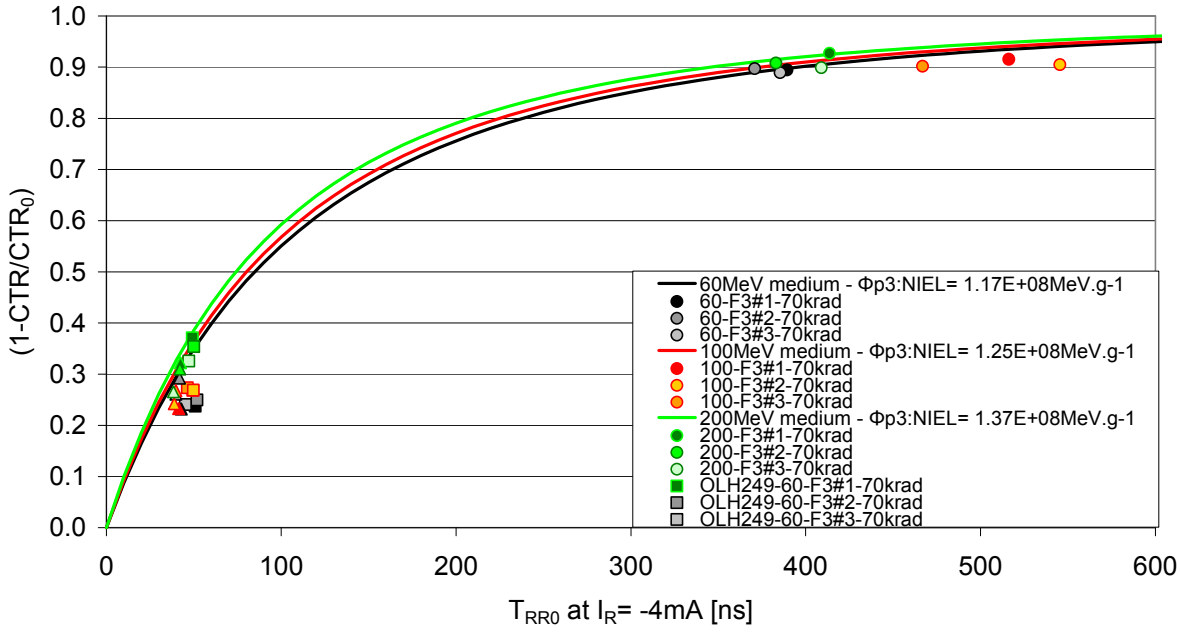


Fig. 10-32. (1 – CTR/CTR$_0$) at 40.7krad after Φp3 proton irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 70krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 70krad(Si) vs T_{RR0}

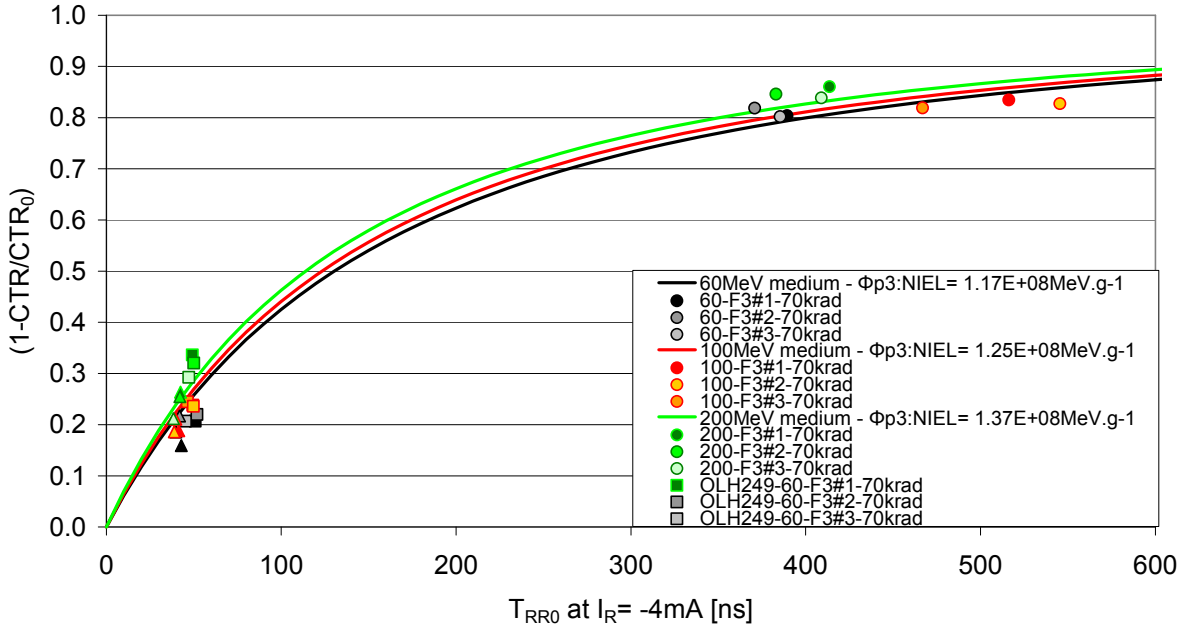
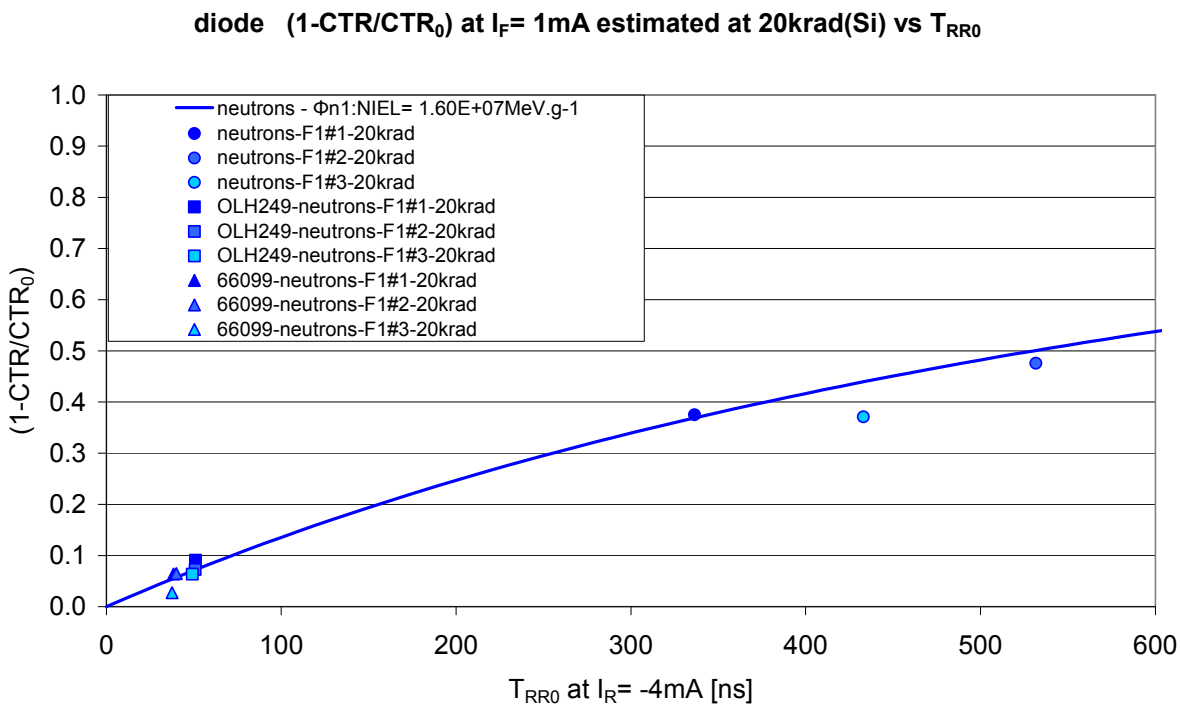


Fig. 10-33. (1 – CTR/CTR$_0$) at 70krad after Φp3 proton irradiation with respect to τ_{RR0}



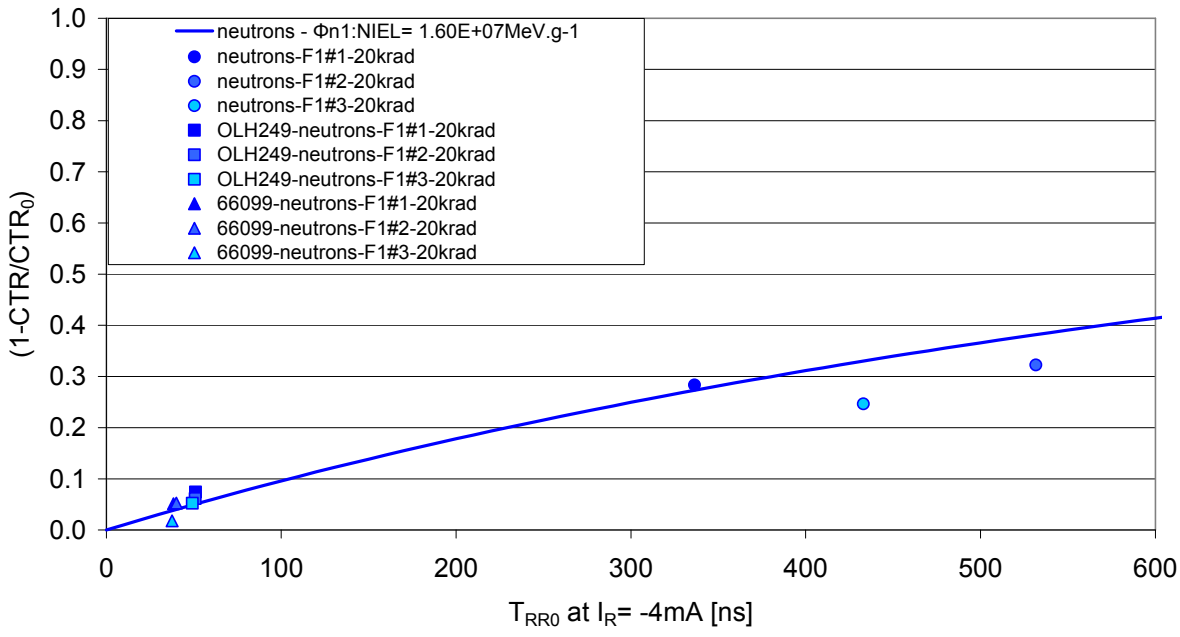
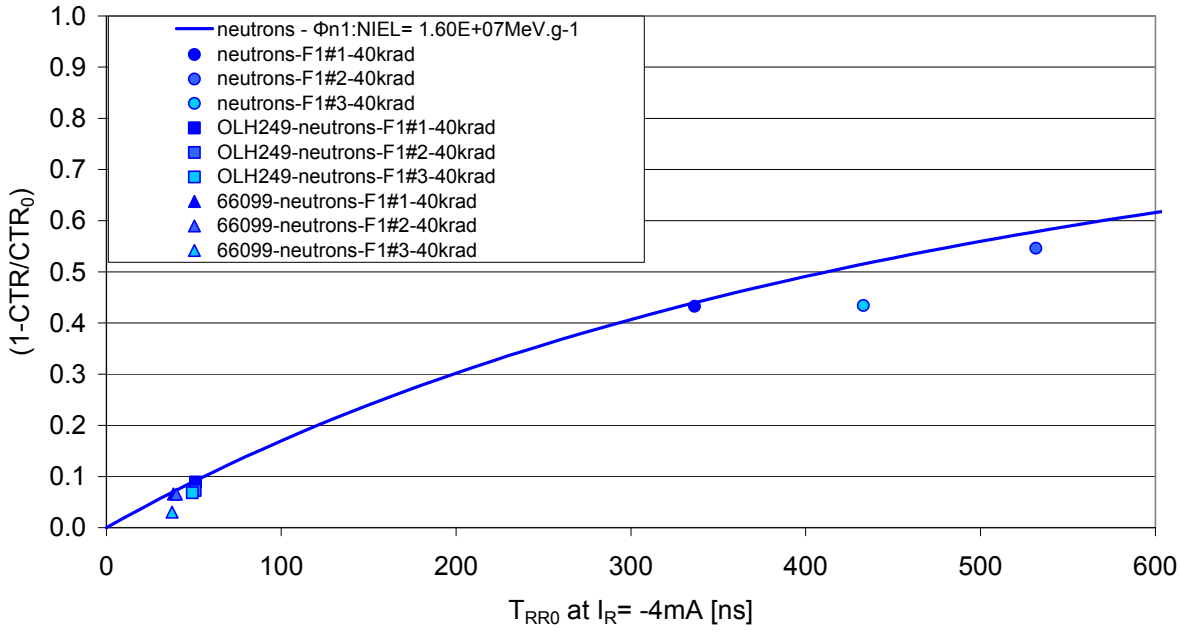


Fig. 10-34. (1 – CTR/CTR$_0$) at 20krad after Φn1 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 40.7krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 40.7krad(Si) vs T_{RR0}

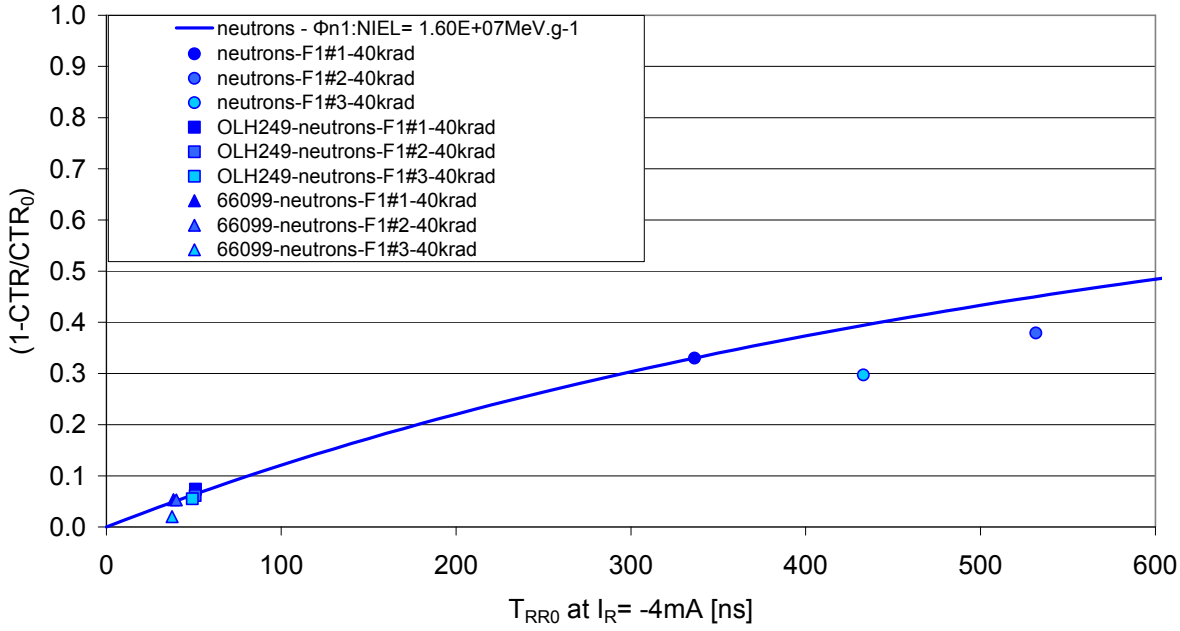
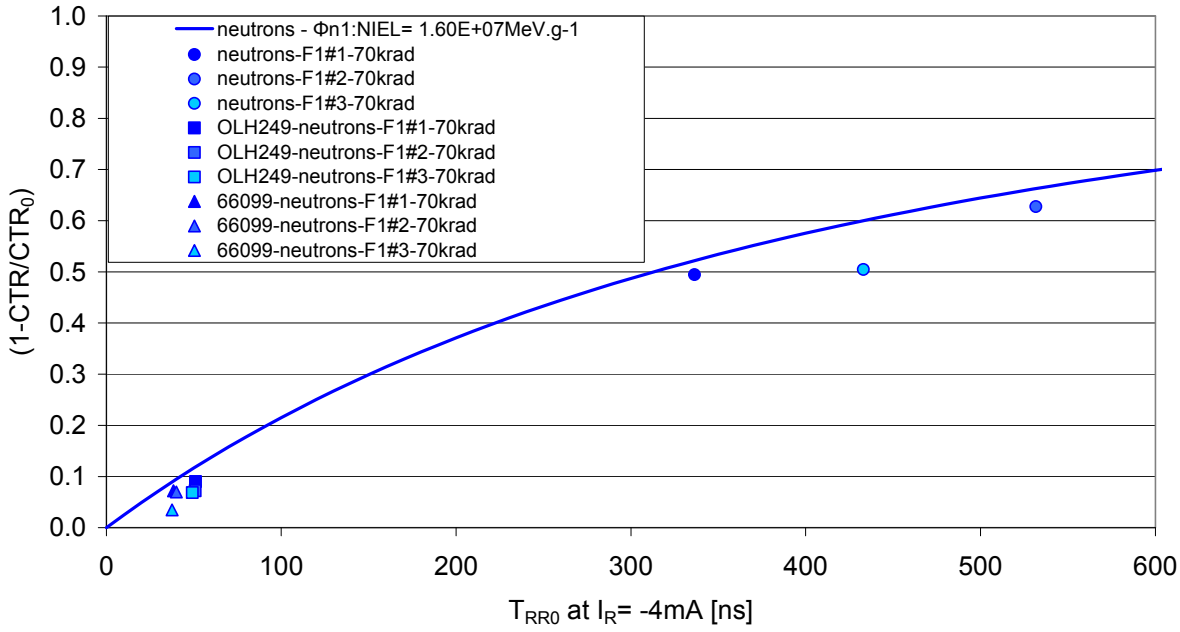


Fig. 10-35. (1 – CTR/CTR$_0$) at 40.7krad after Φn1 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 70krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 70krad(Si) vs T_{RR0}

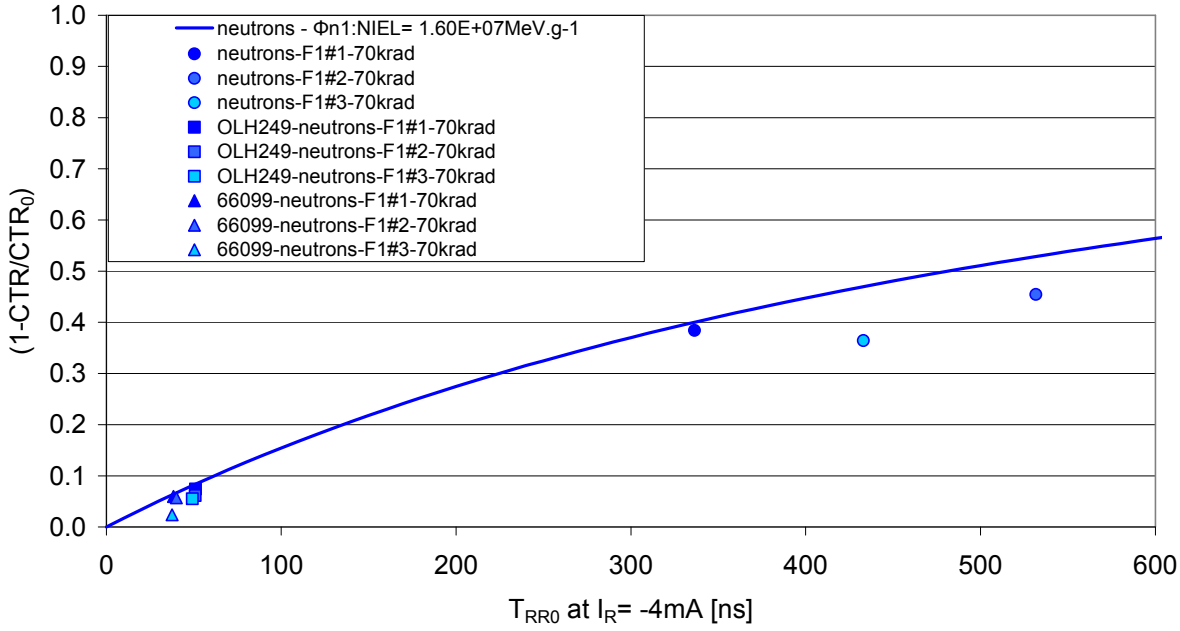
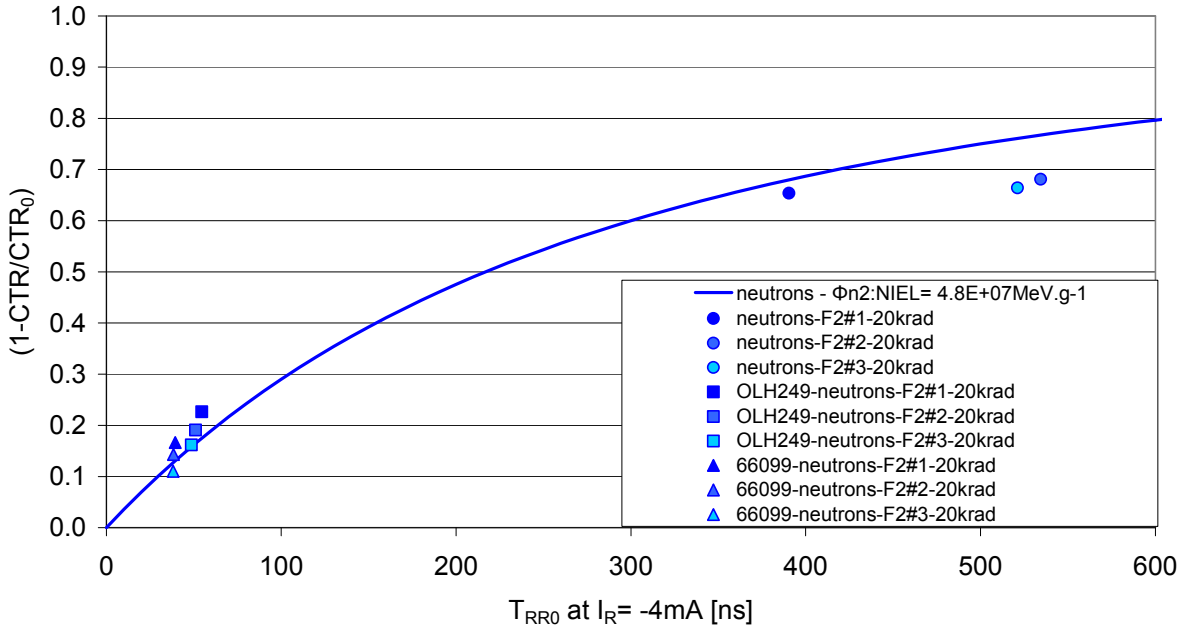


Fig. 10-36. (1 – CTR/CTR$_0$) at 70krad after Φn1 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 20krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 20krad(Si) vs T_{RR0}

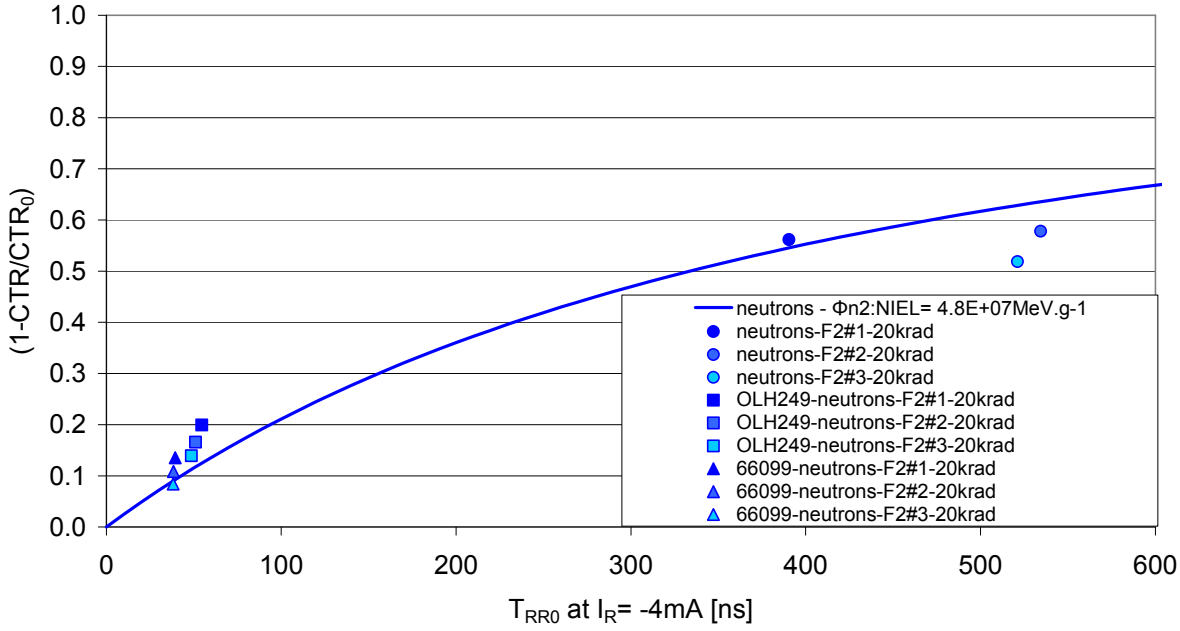
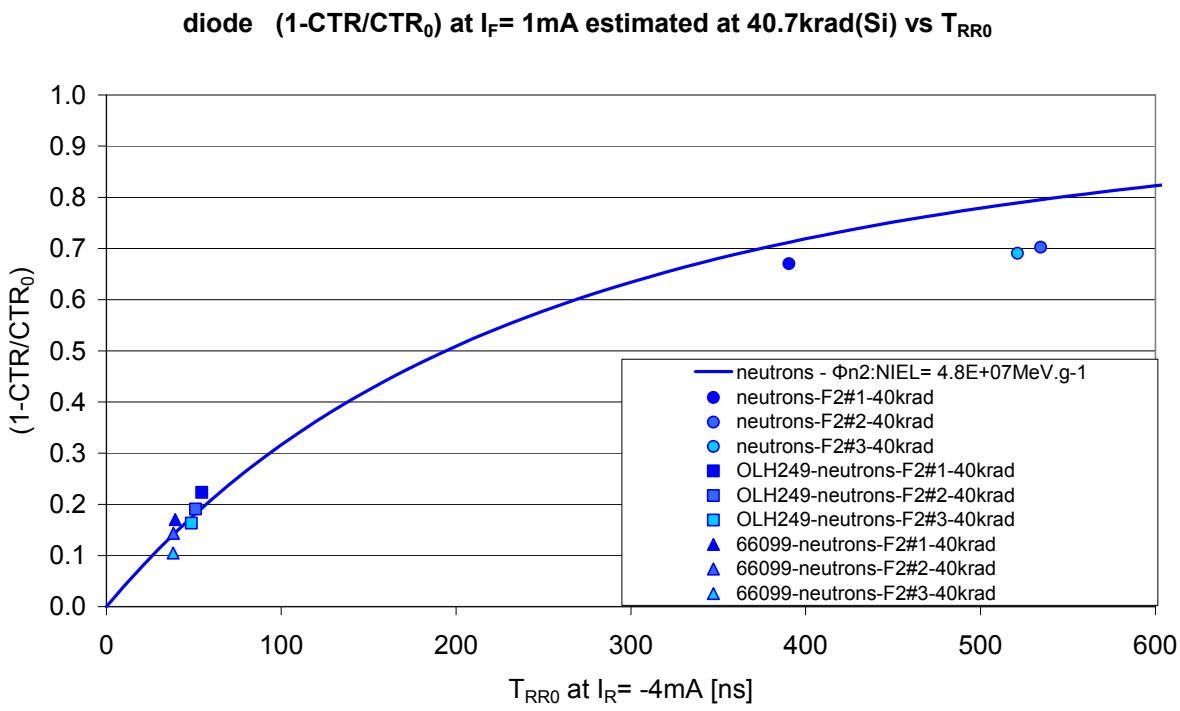


Fig. 10-37. (1 – CTR/CTR$_0$) at 20krad after Φn2 neutron irradiation with respect to τ_{RR0}



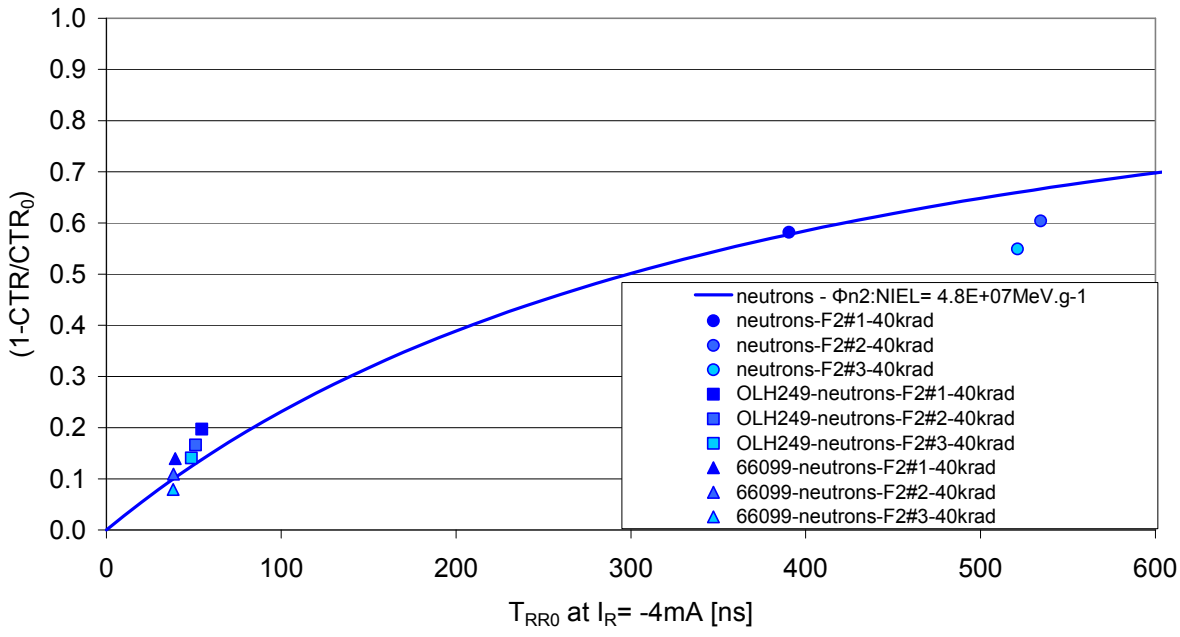
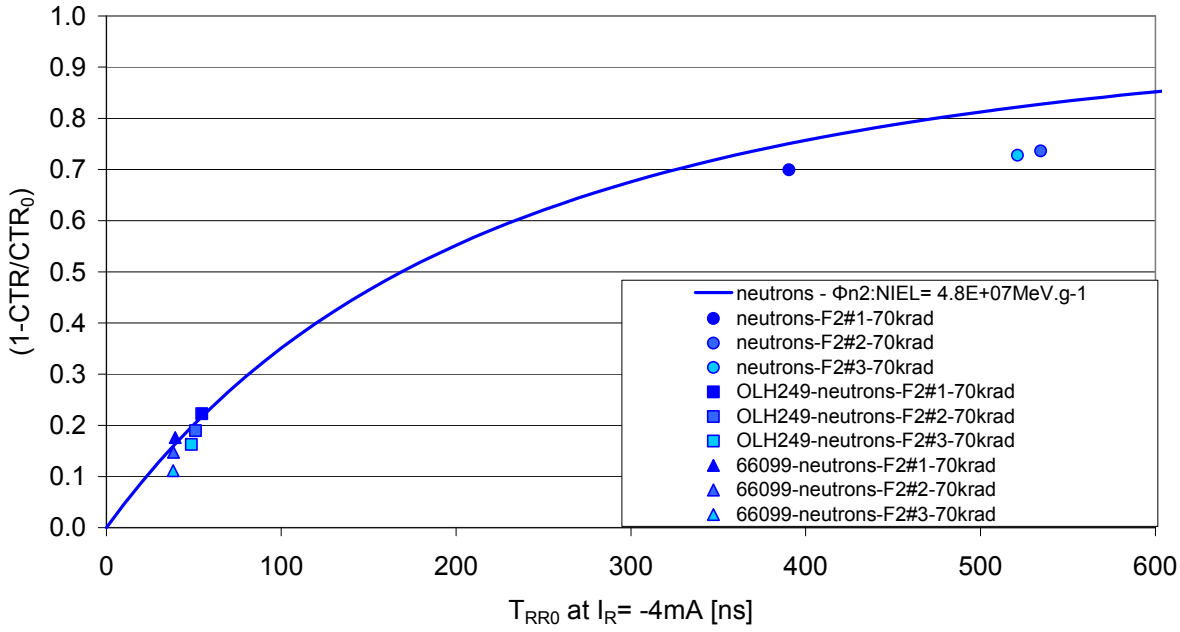


Fig. 10-38. (1 – CTR/CTR$_0$) at 40.7krad after Φn2 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 70krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 70krad(Si) vs T_{RR0}

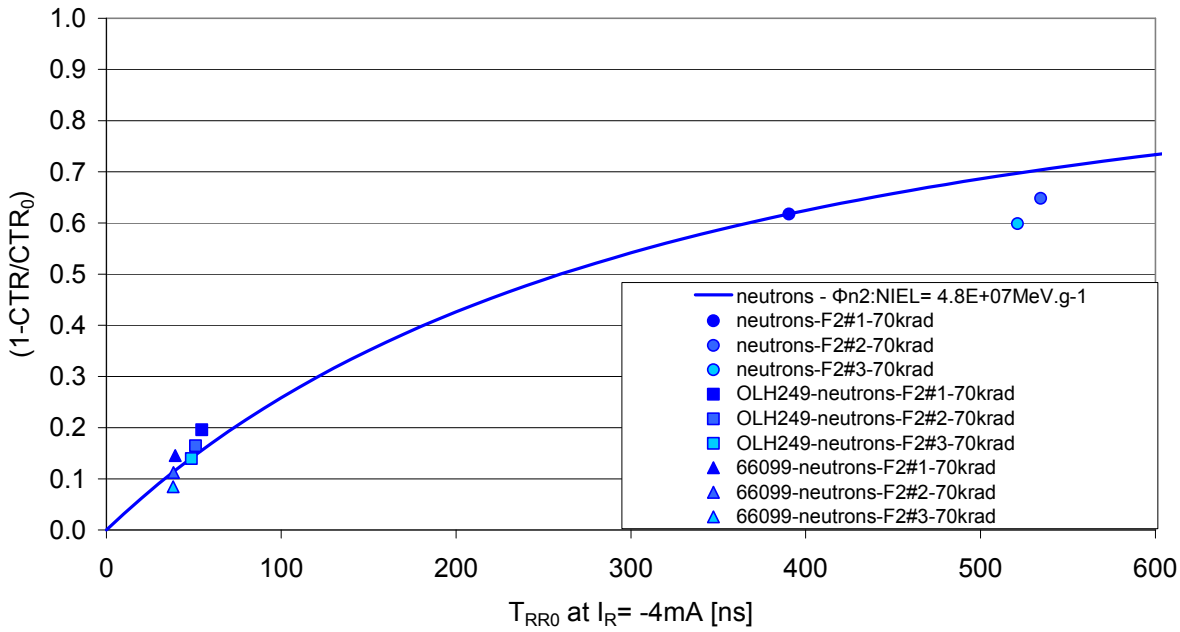
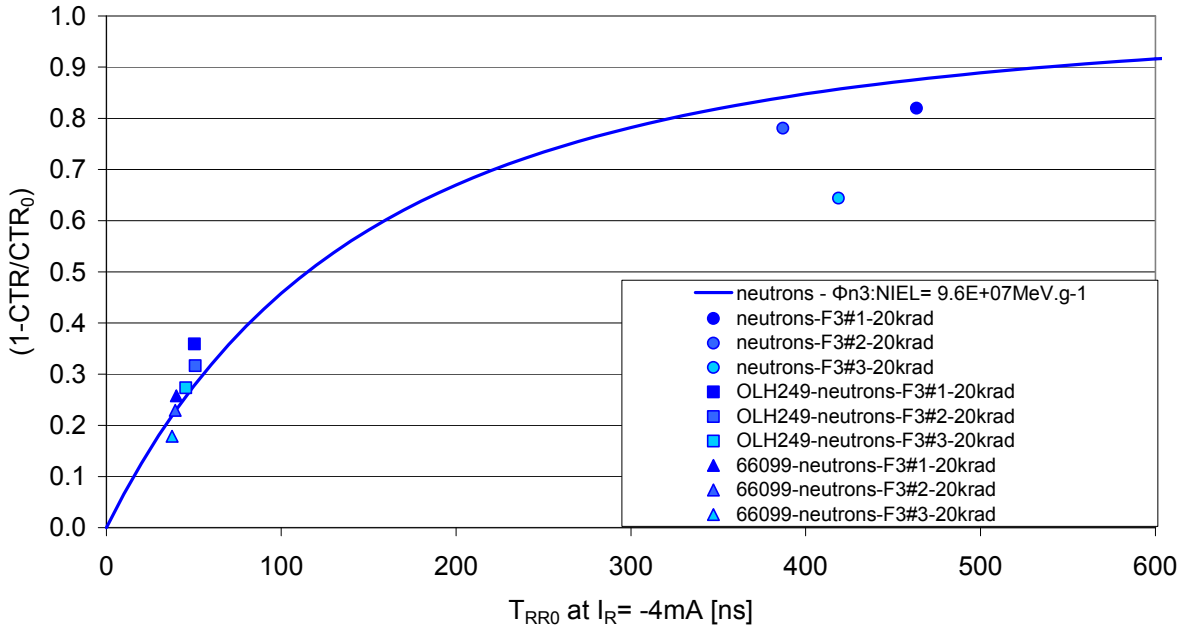


Fig. 10-39. (1 – CTR/CTR$_0$) at 70krad after Φn2 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 20krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 20krad(Si) vs T_{RR0}

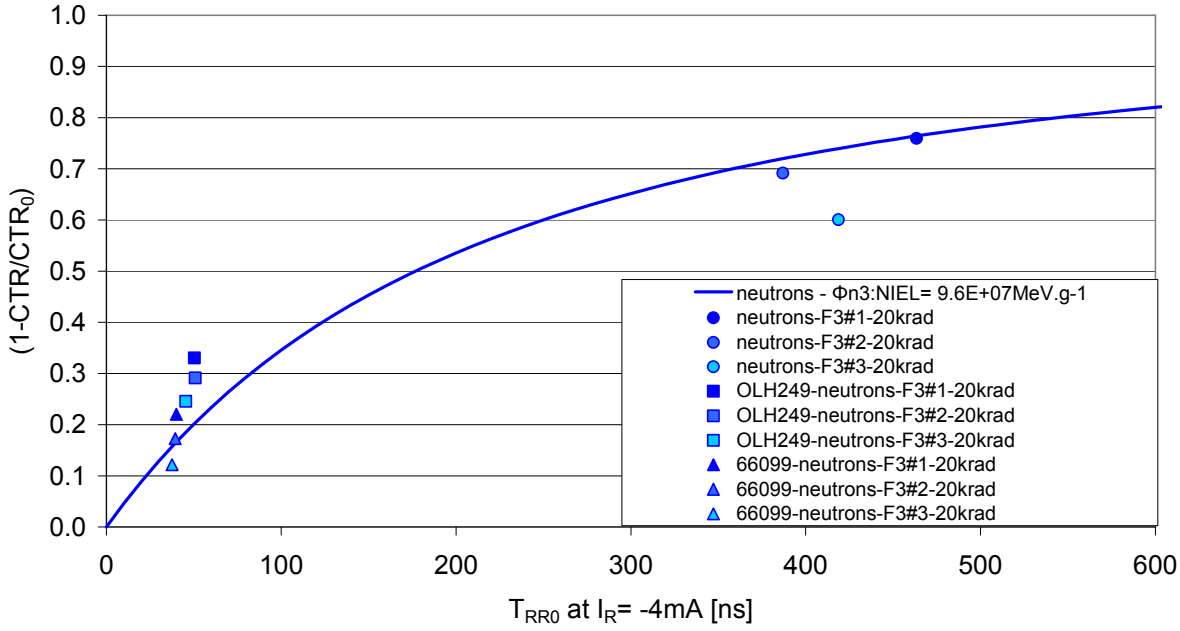
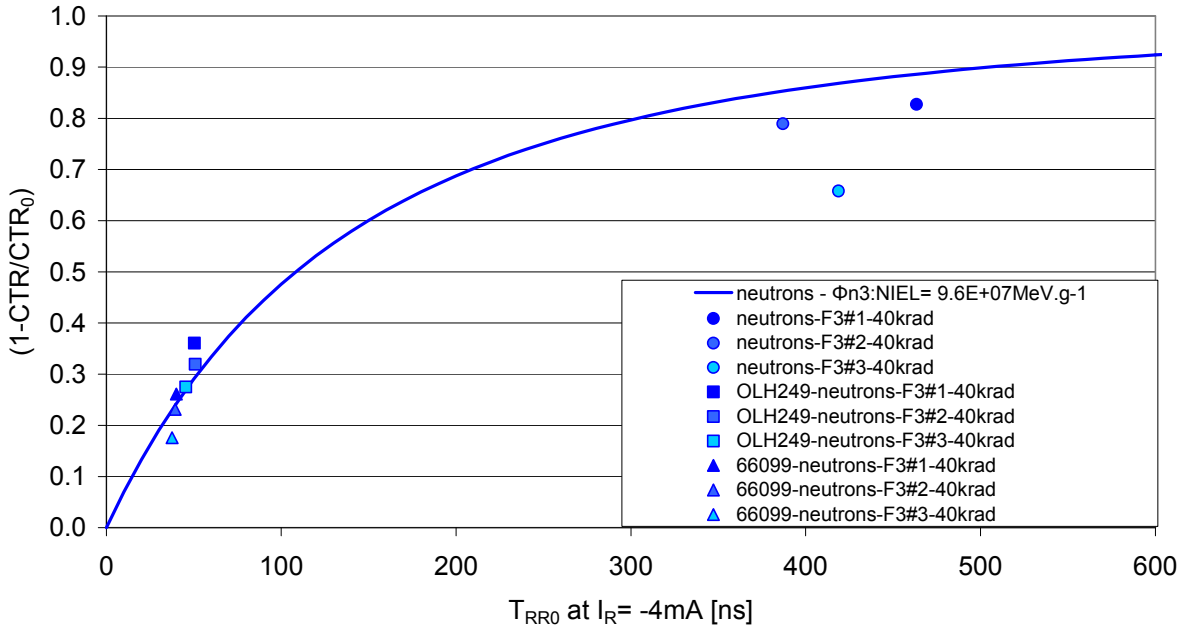


Fig. 10-40. (1 – CTR/CTR$_0$) at 20krad after Φn3 neutron irradiation with respect to τ_{RR0}

diode (1-CTR/CTR$_0$) at I_F= 1mA estimated at 40.7krad(Si) vs T_{RR0}



diode (1-CTR/CTR$_0$) at I_F= 10mA estimated at 40.7krad(Si) vs T_{RR0}

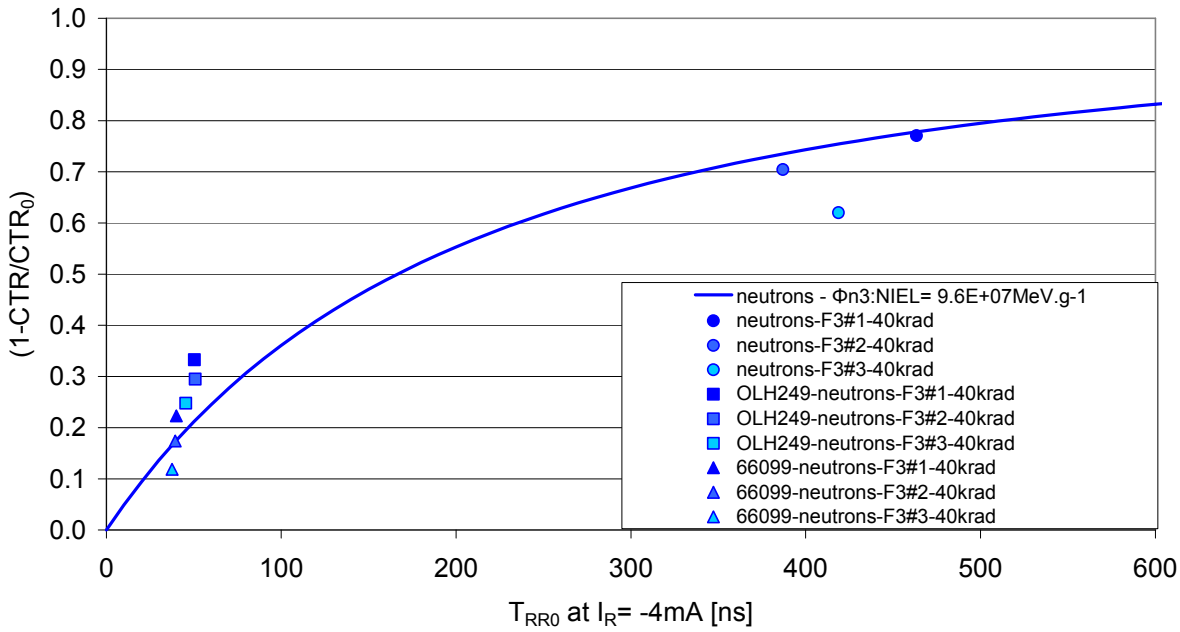
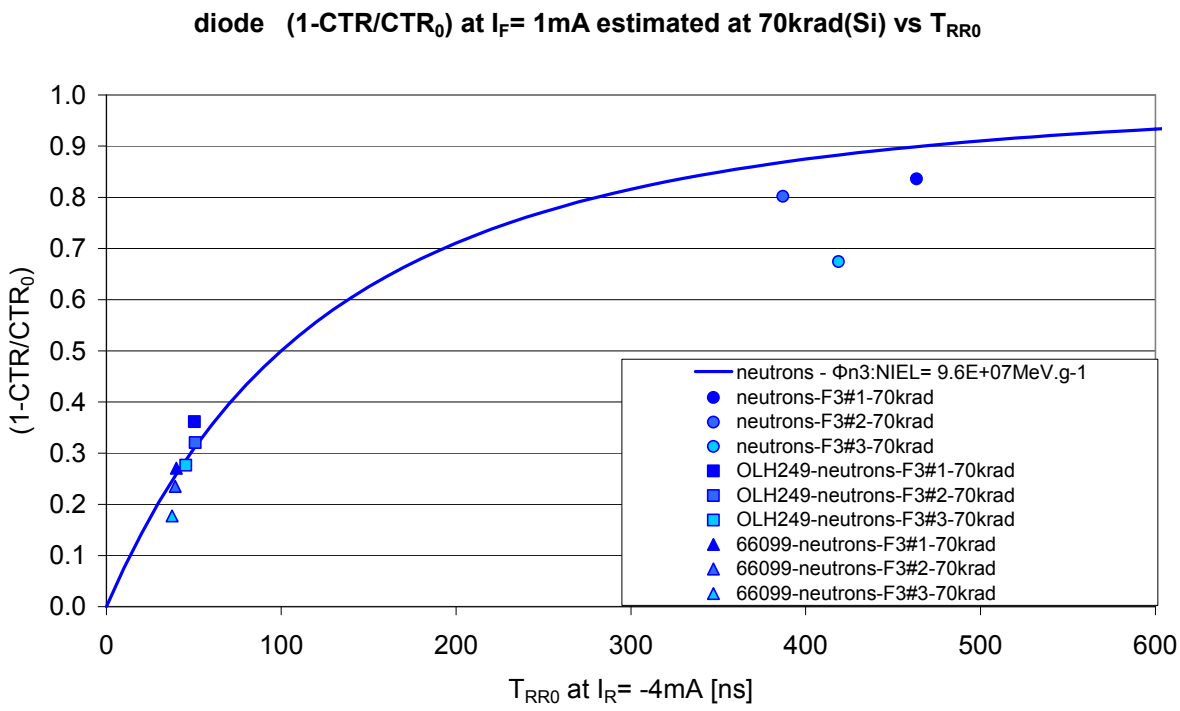


Fig. 10-41. (1 – CTR/CTR$_0$) at 40.7krad after Φn3 neutron irradiation with respect to τ_{RR0}



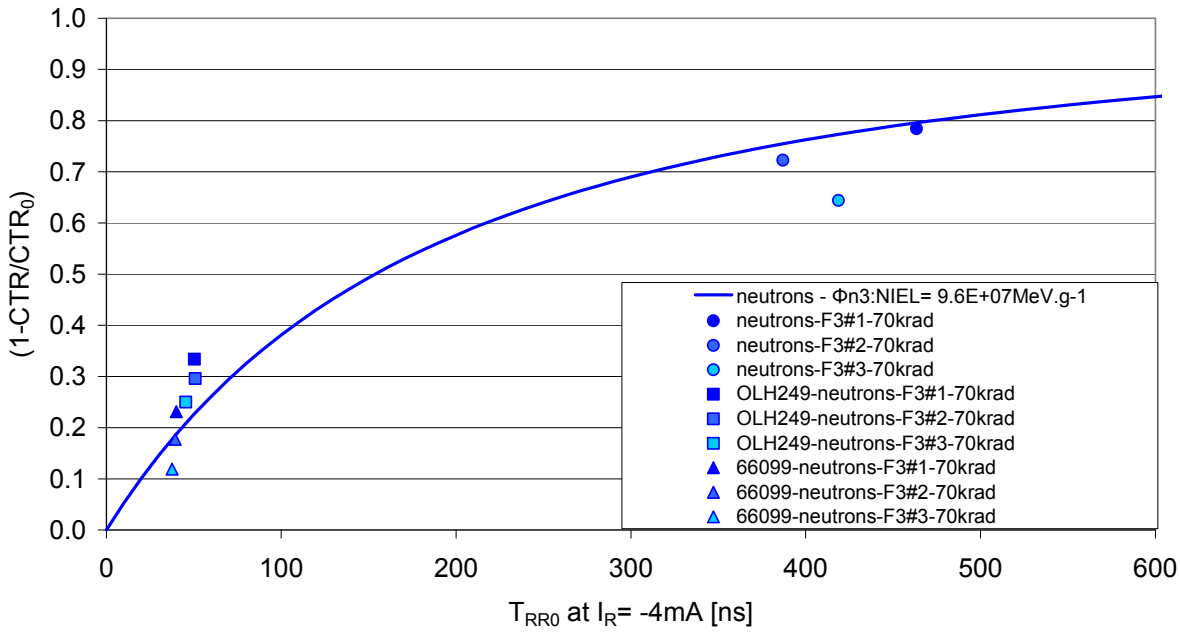


Fig. 10-42. (1 – CTR/CTR$_0$) at 70krad after Φn3 neutron irradiation with respect to τ_{RR0}

11. CONCLUSION

11.1 SUMMARY

Non-Ionizing Energy Displacement Rate (NIEDR) has been computed in [1] with GEANT4, by considering an active layer thickness of 10µm, which represents a reasonable assumption. These calculations were performed for proton energies of 60, 100 and 200 MeV. The equivalent fluences Φp_i aimed to give same degradation levels both at diode and transistor levels fit very well at 60 and 100 MeV for all optocoupler types, and exhibit some discrepancy at 200 MeV. The NIEL parameter gathering the elastic and inelastic contributions leads to better agreement for all energies as compared with elastic contribution alone.

At 200 MeV, even though the corresponding Φp_i is aimed to give the same degradation level as with other energies, the optocouplers exhibit higher degradations than expected.
The reason of such discrepancy may come from the theoretical approach that consisted NIEDR calculation based on 10 µm thick material. Some contribution coming from materials surrounding the active layer (inducing an indirect-like NIEL) is suspected for energy ≥ 200 MeV. Further calculations performed with GEANT 4 may still have to be performed to verify this assumption. The consequence of such results is that performing part assessment regarding TNID may underestimate the degradation especially if the proton test is performed in the [60-100 MeV] energy range, for missions in which the high energy protons contribution (>200MeV) is not negligible.

Another salient result is the degradation prediction deduced from 4N49's results at two levels.

- The first level is at diode one. Provided that the diode's minority carrier lifetime τ_{RR0} is lower than the 4N49's one, the empirical equations (Eq. 25 to 27 p.119) allow to estimate the diode's degradation level given by $\Delta RelativeCTR = CTR(Fluence,Niel)/CTR_0 = (CTR_0 - CTR(Fluence,Niel))/CTR_0$. This comparison has been performed for all energies and the measured degradations for other diodes corresponding to other technologies (OLH249, 66099) fit very well with the empirical curves deduced from 4N49's measurements at 60 and 100 MeV energies after K_{NIEL}(4N49) and N(4N49) parameters regression. As we expect some surrounding material effect at 200 MeV (see above) this comparison shows that the extrapolated results may underestimate the degradation.

  As the same correlation between CTR degradation and τ_{RR} degradation is observed under gamma irradiation, the measured diode degradation induced by ionizing dose was well estimated after K_{TID}(4N49) regression. The simple equation Eq.29 p.262 even allows to predict the degradation brought by TID and a proton/neutron irradiation from τ_{RR0} measurement. Hence, starting from K_{TID}, K_{TNID} and N parameters extracted from measurements performed on 4N49 diodes, the degradation measured on OLH249 and 66099 diodes could be estimated thanks to these equations and their respective τ_{RR0} measurements.

  As a consequence the diode degradation seems to depend only on the τ_{RR0} parameter and not on its technology.

- The second level is for the whole optocoupler. Even though there was no physical meaning between the whole optocoupler degradation and its diode τ_{RR0}, same type of approach as

above was attempted for proton only, just to see. The optocoupler proton degradation fit very well for 66099 whose τ_{RR0} is lower than τ_{RR0}(4N49), and for which the degradation is mainly coming from the diode. This approach does not fit for OLH249 whatever the energies at first glance surprisingly. However, despite the relation τ_{RR0}(OLH249)<< τ_{RR0}(4N49) is verified, the main degradation is coming from the transistor, not taken into account in the Eq. 25 to 27.

At 60 MeV, the 66191 and 3C91 optocoupler degradations (Fig. 7-13 to Fig. 7-18) are well estimated from 4N49's curves. At 200 MeV, even though the corresponding NIEL is aimed to give the same degradation level as with 60 MeV, the optocouplers exhibit higher degradations than expected. The reason of such discrepancy may come in some minor extend from the transistor (whose degradation behavior is unknown here). We think it mainly comes from the NIEDR calculation performed on 10 µm thick material.

For neutrons, this approach failed in predicting the global degradation.

As a preliminary conclusion, a simple method to select optocoupler regarding both TNID and TID would be based on diode τ_{RR0} and transistor τ_{RR0} measurements: the lower initial recovery time would lead to the lower degradation for both transistor and diode.

11.2 WORK ON-GOING

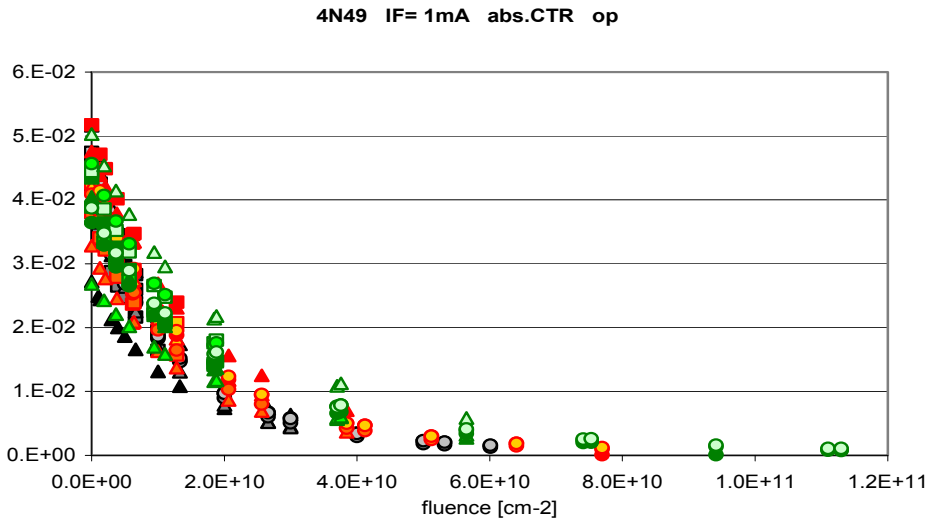
Verify that the lower transistor τ_{RR0} would lead to the lower transistor degradation, whatever its technology. Verify whether the transistor degradation follows the same rule as per Eq.29 p.262.

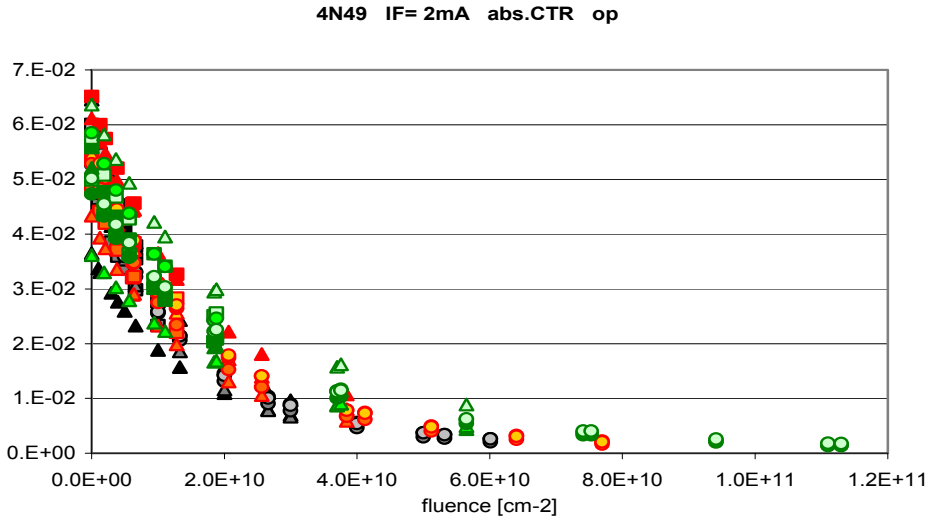
12. APPENDIX 4N49

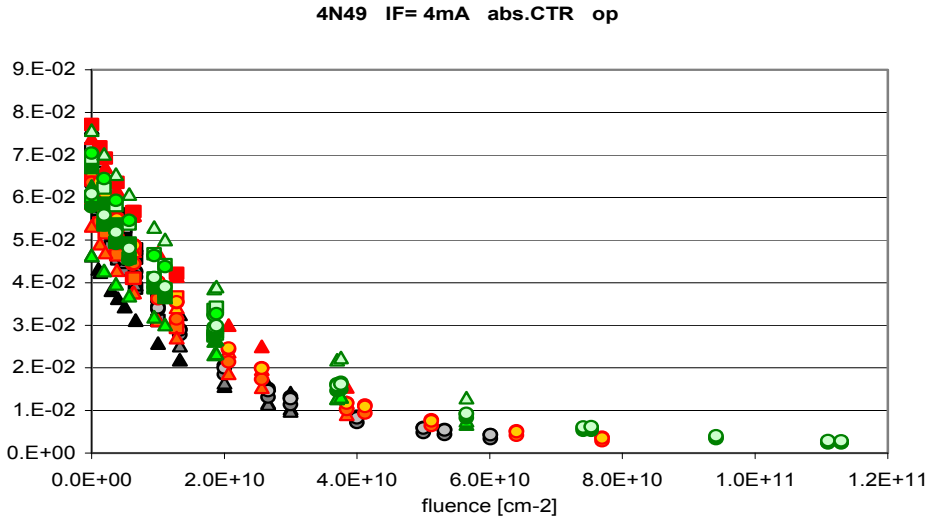
Part type	Emitter	Receiver			Package
	LED	Photodiode	Phototransistor	Output transistor	
4N49 / ISOLINK **(DC0626)**	880 nm Amphoteric Si doped Single heterojunction AlGaAs **(Ref : OLQ244E)**	N/A	**0.025 inch sq (Ref : OLQ244D)**	N/A	Window can

12.1 PROTON IRRADIATION

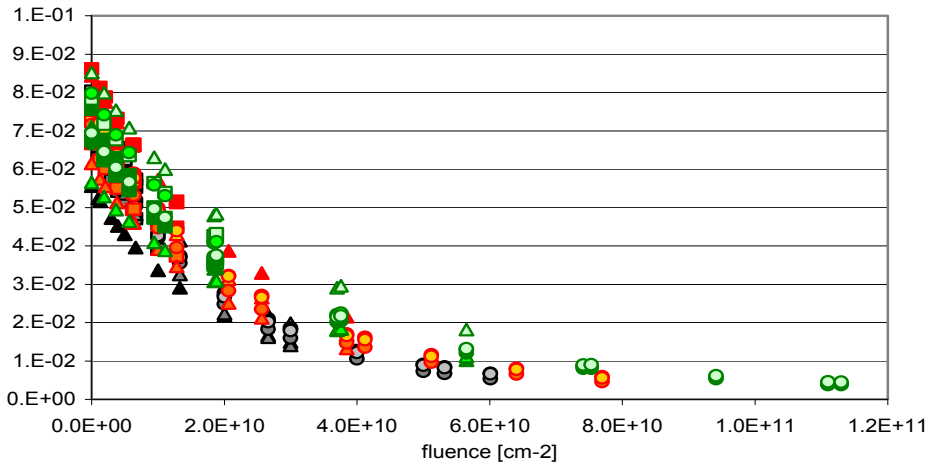
Fig. 12-1: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







4N49 IF= 8mA abs.CTR op



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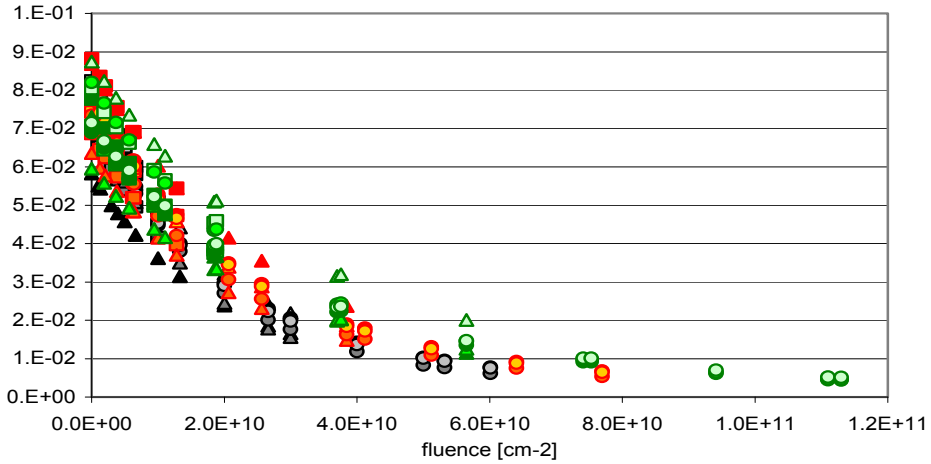
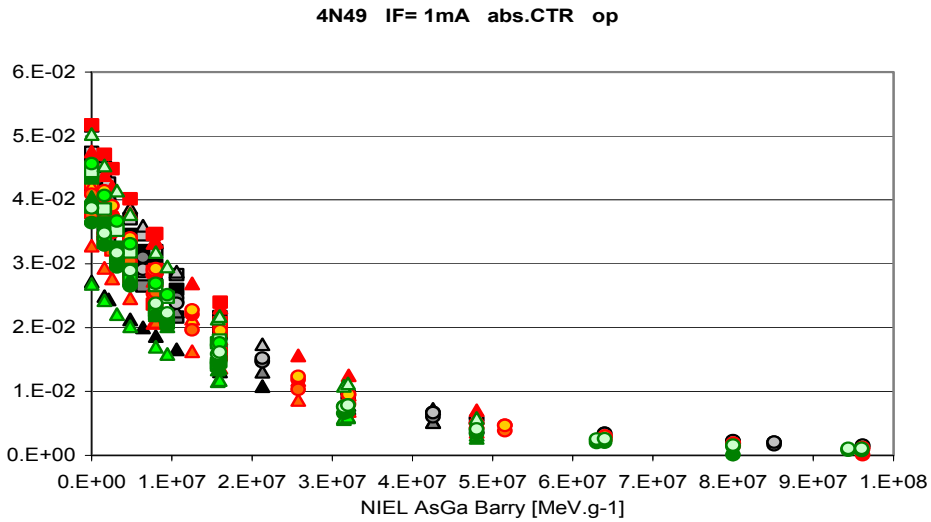
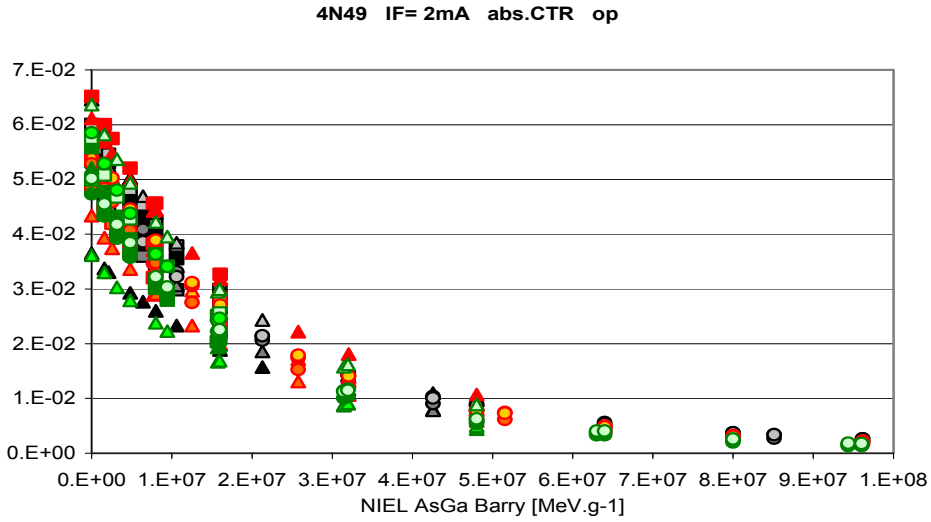
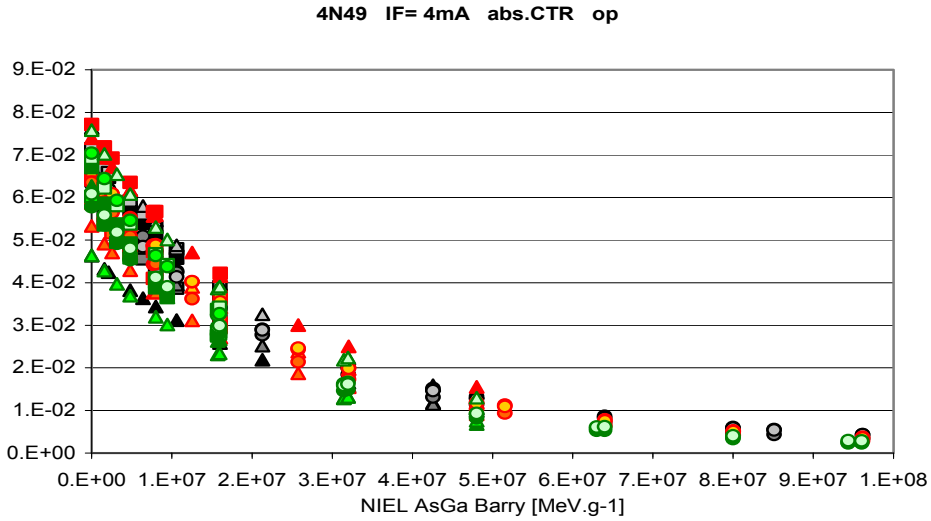


Fig. 12-2: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







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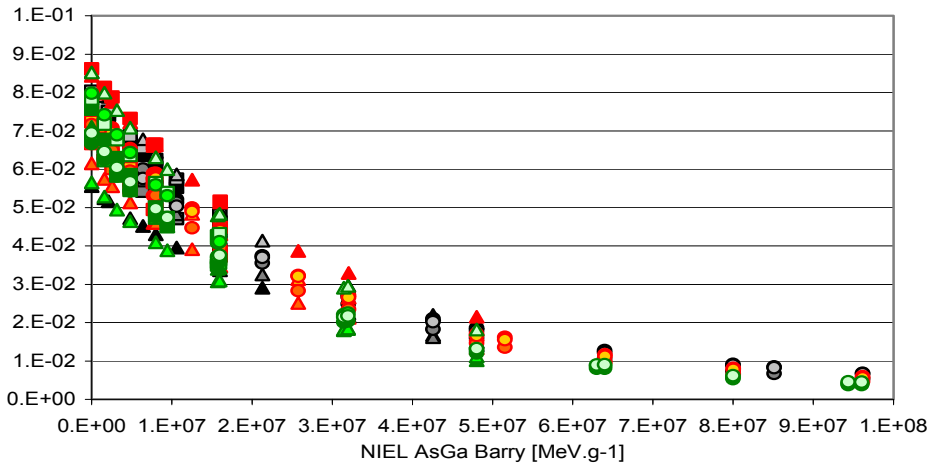


4N49 IF= 10mA abs.CTR op

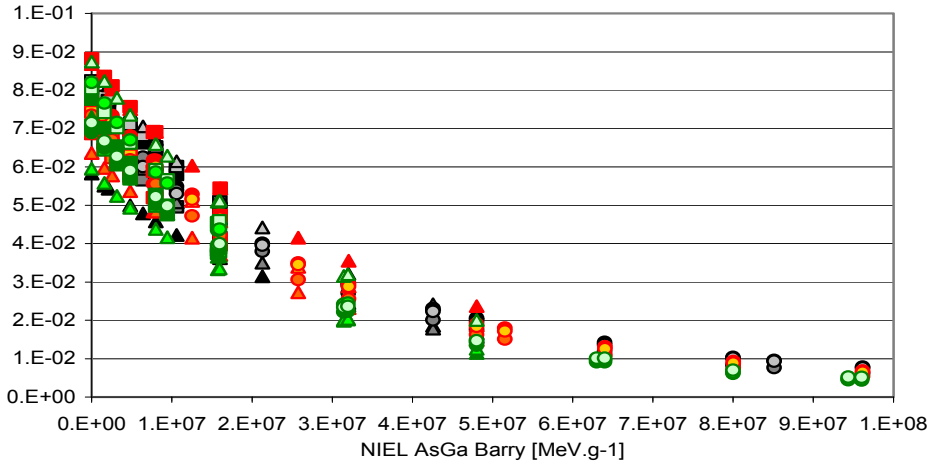
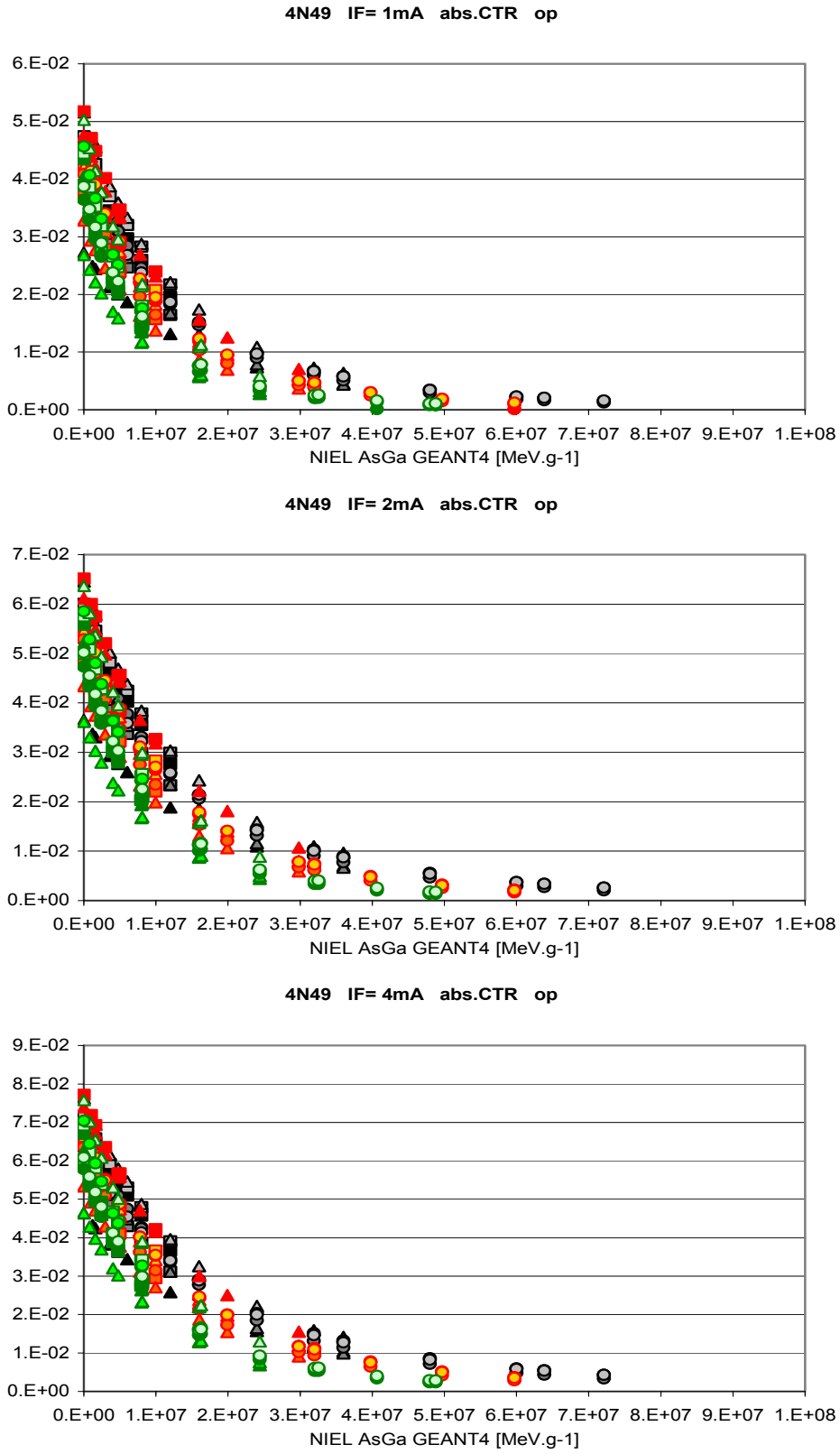
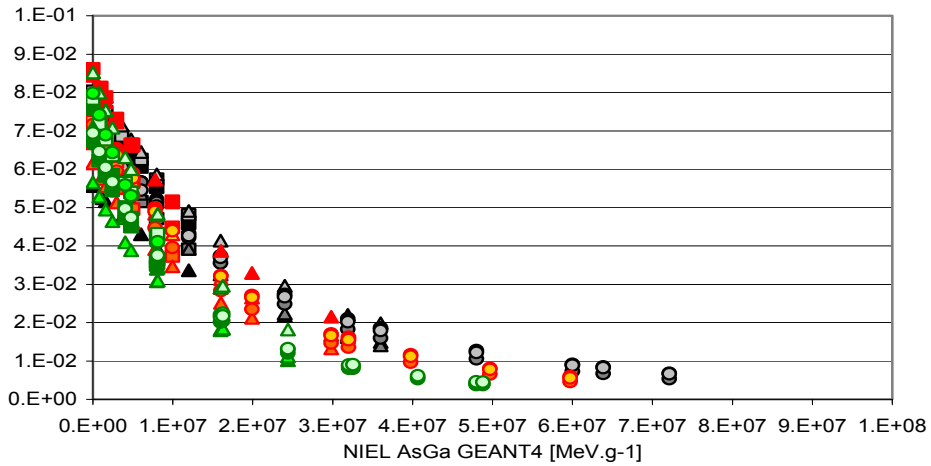


Fig. 12-3: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



4N49 IF= 8mA abs.CTR op



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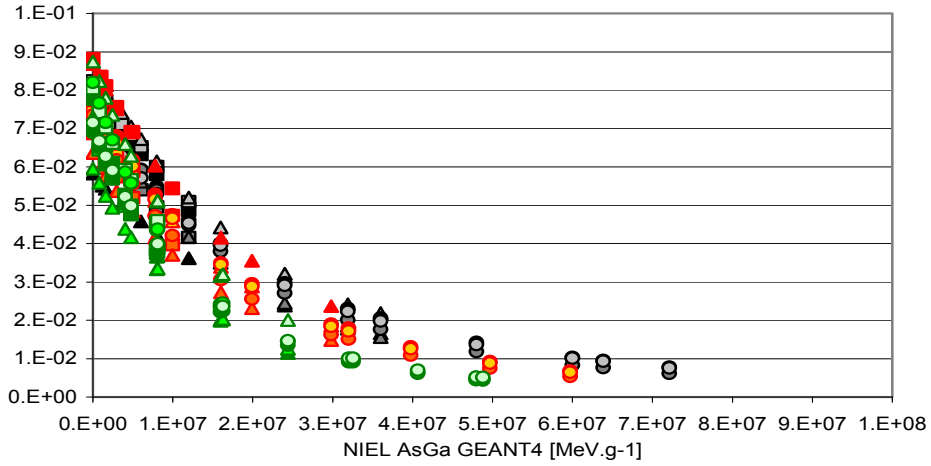
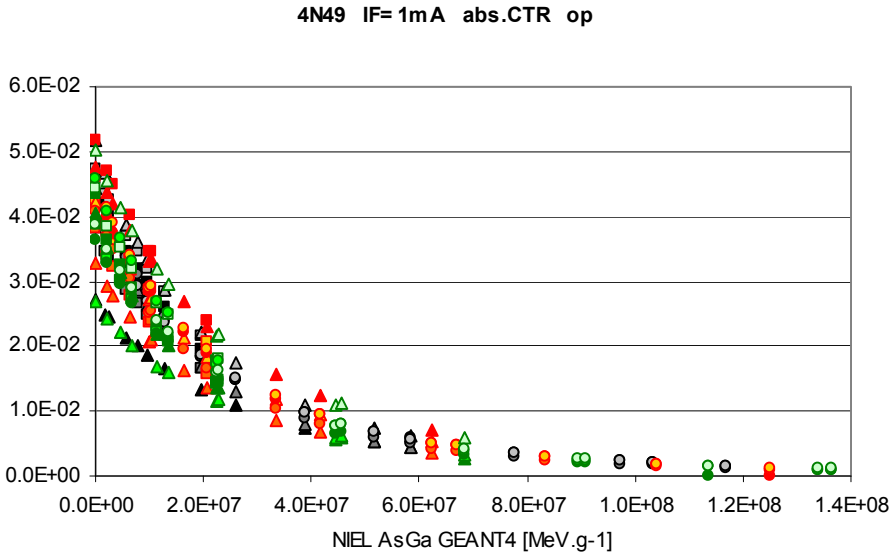
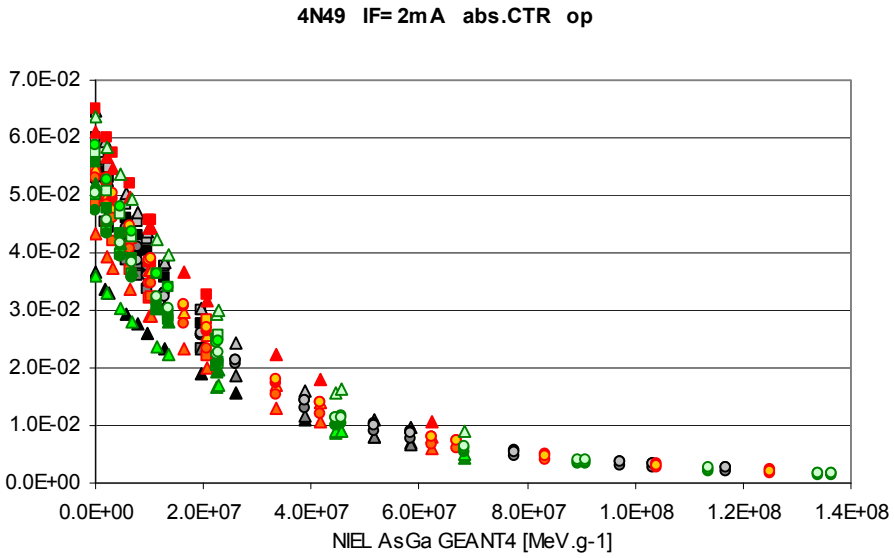
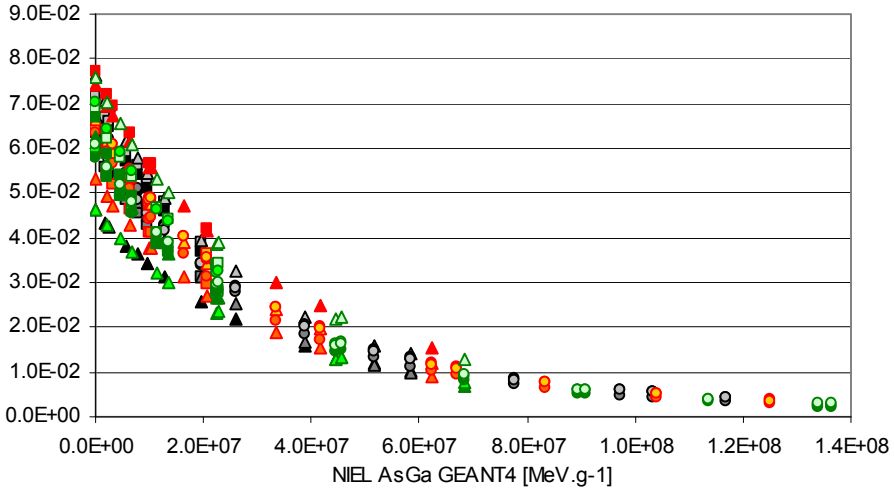


Fig. 12-4: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)





4N49 IF= 4mA abs.CTR op



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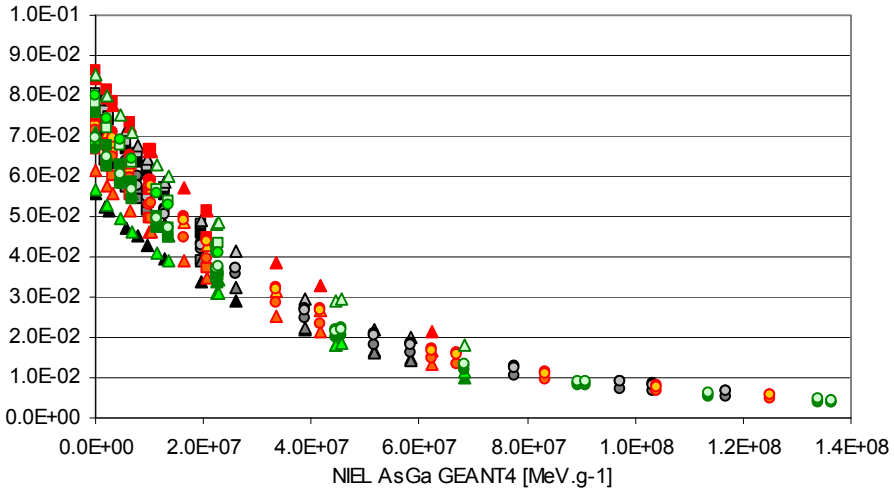


4N49 IF= 10mA abs.CTR op

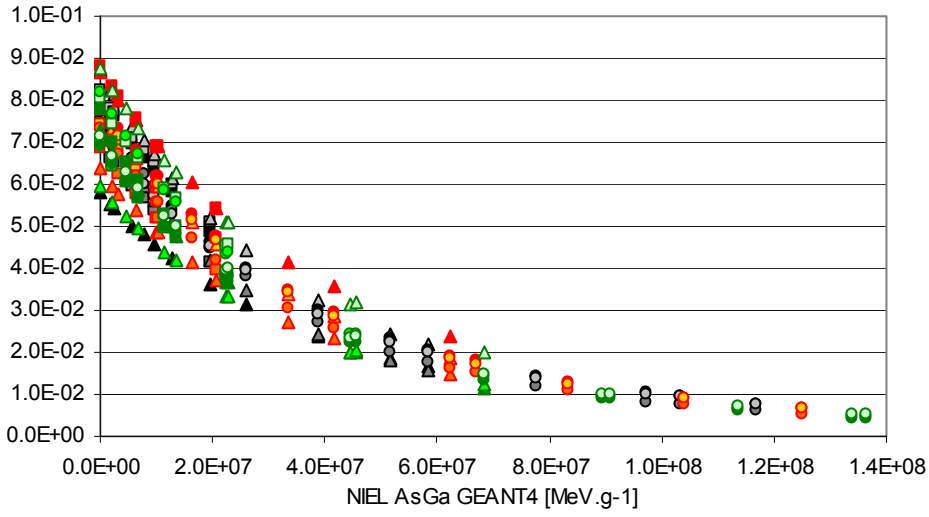
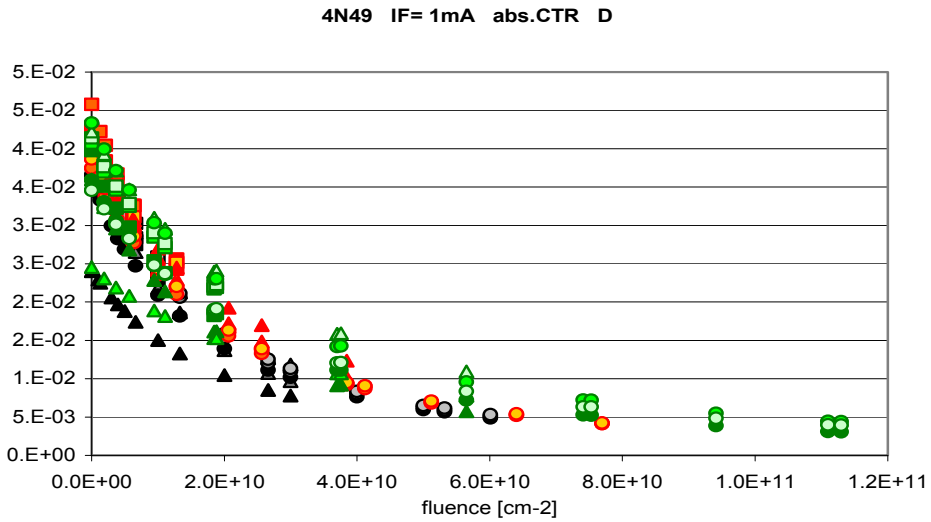
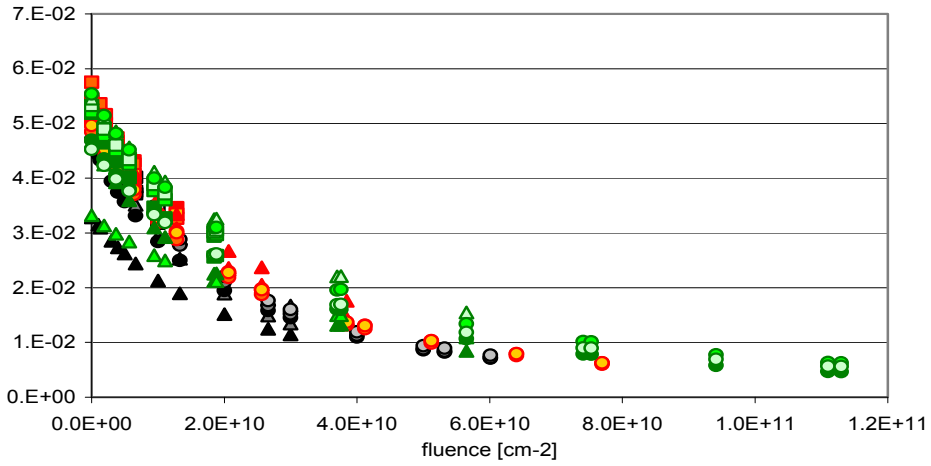
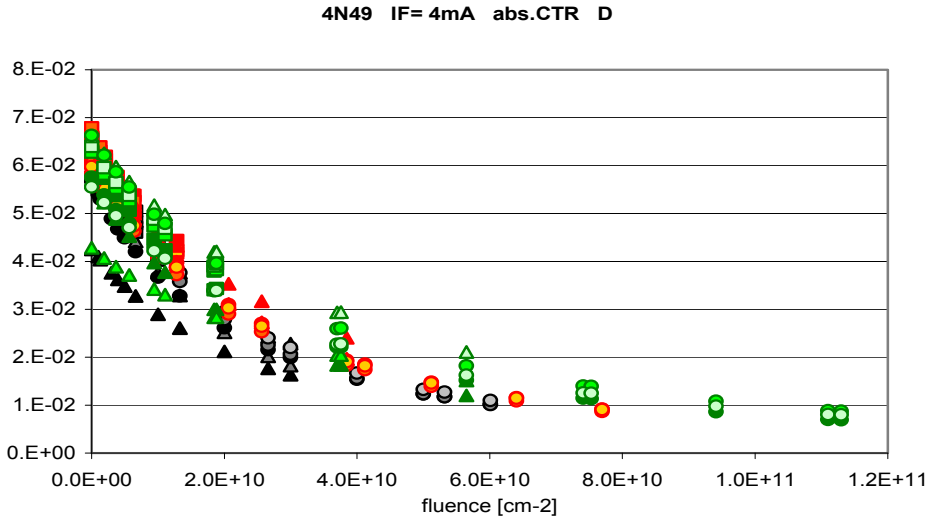
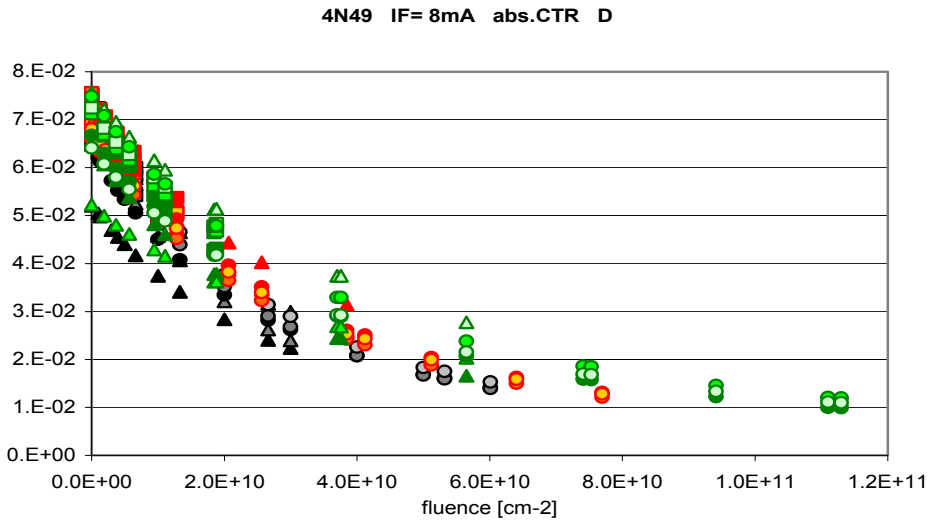


Fig. 12-5: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








4N49 IF= 8mA abs.CTR D
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7.E-02
6.E-02
5.E-02
4.E-02
3.E-02
2.E-02
1.E-02
0.E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

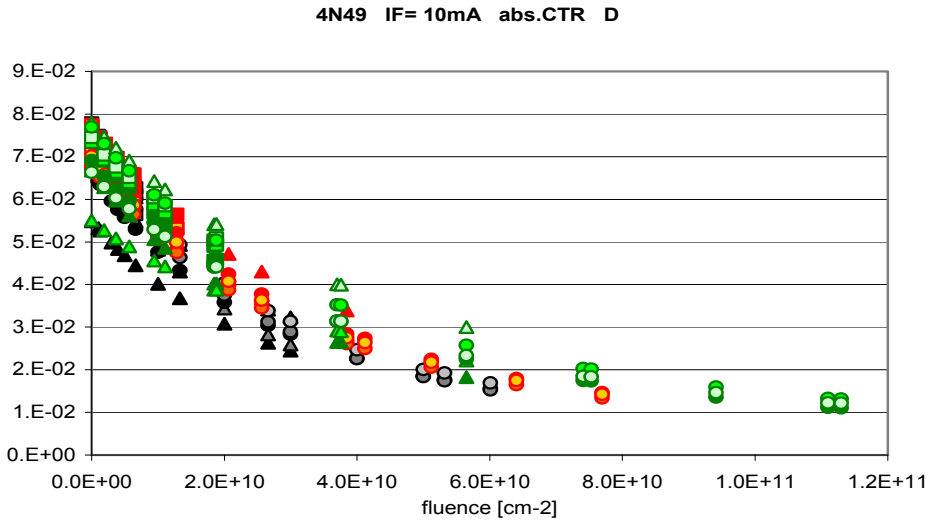
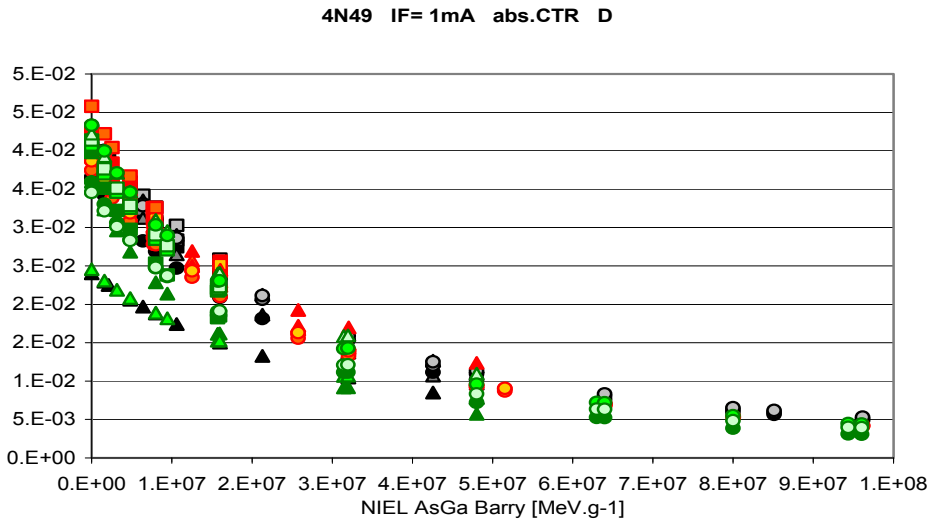
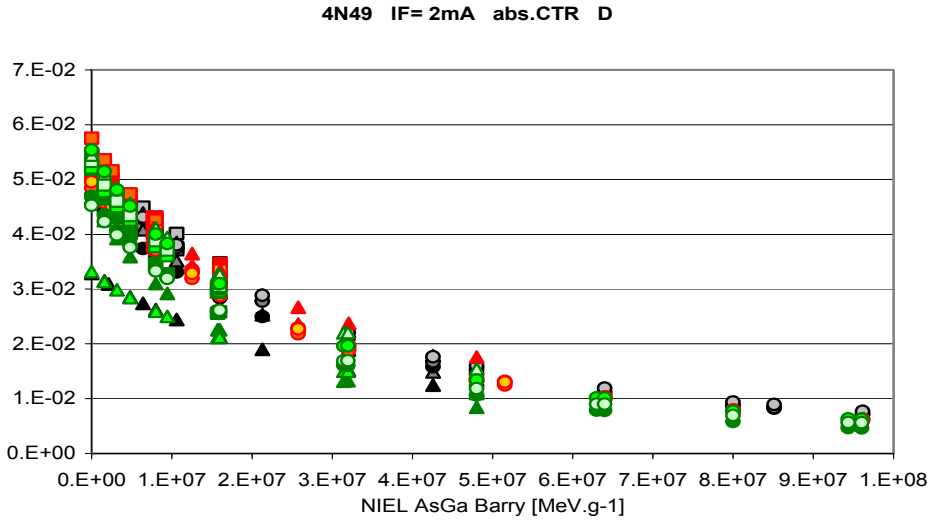
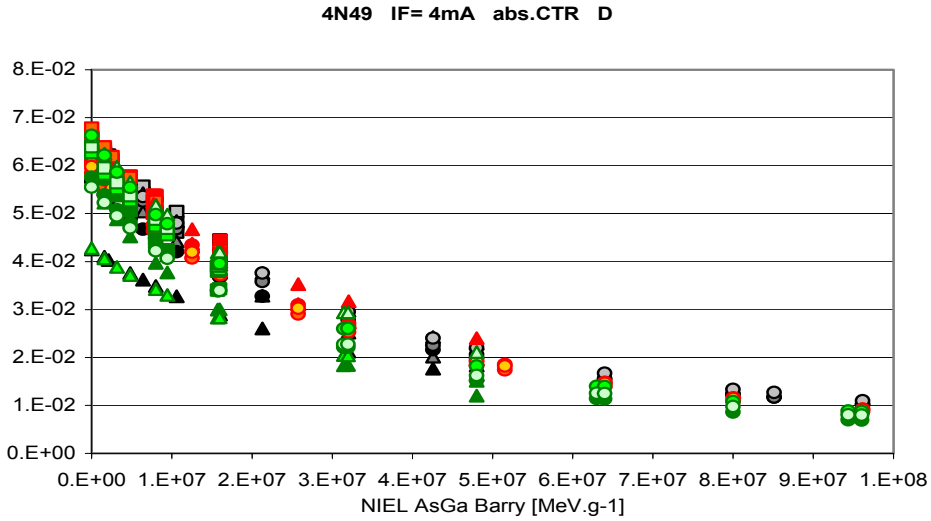

4N49 IF= 10mA abs.CTR D
9.E-02
8.E-02
7.E-02
6.E-02
5.E-02
4.E-02
3.E-02
2.E-02
1.E-02
0.E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

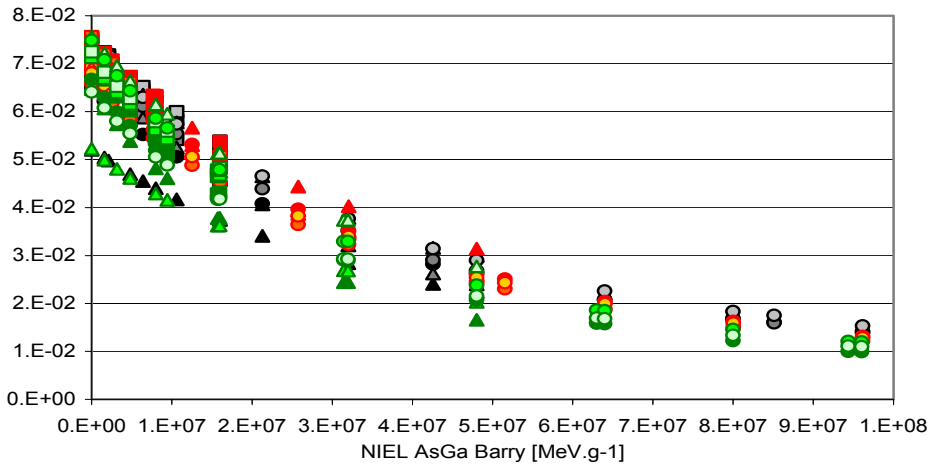
Fig. 12-6: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







4N49 IF= 8mA abs.CTR D



4N49 IF= 10mA abs.CTR D

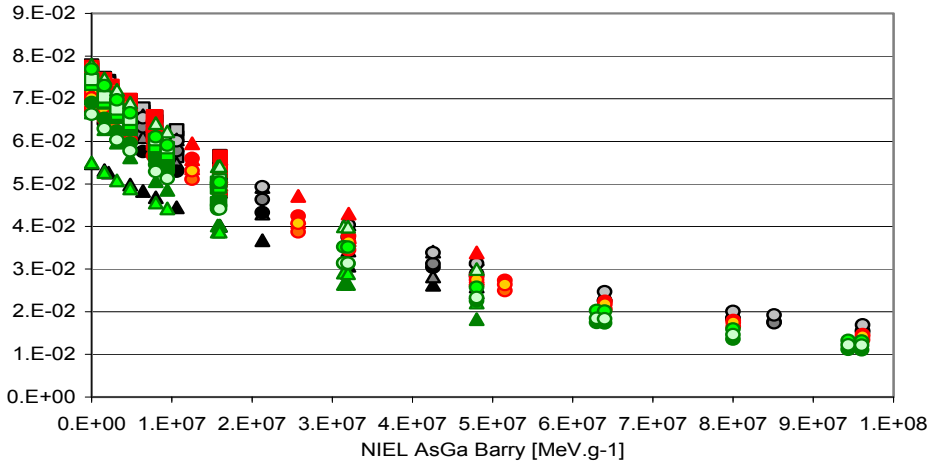
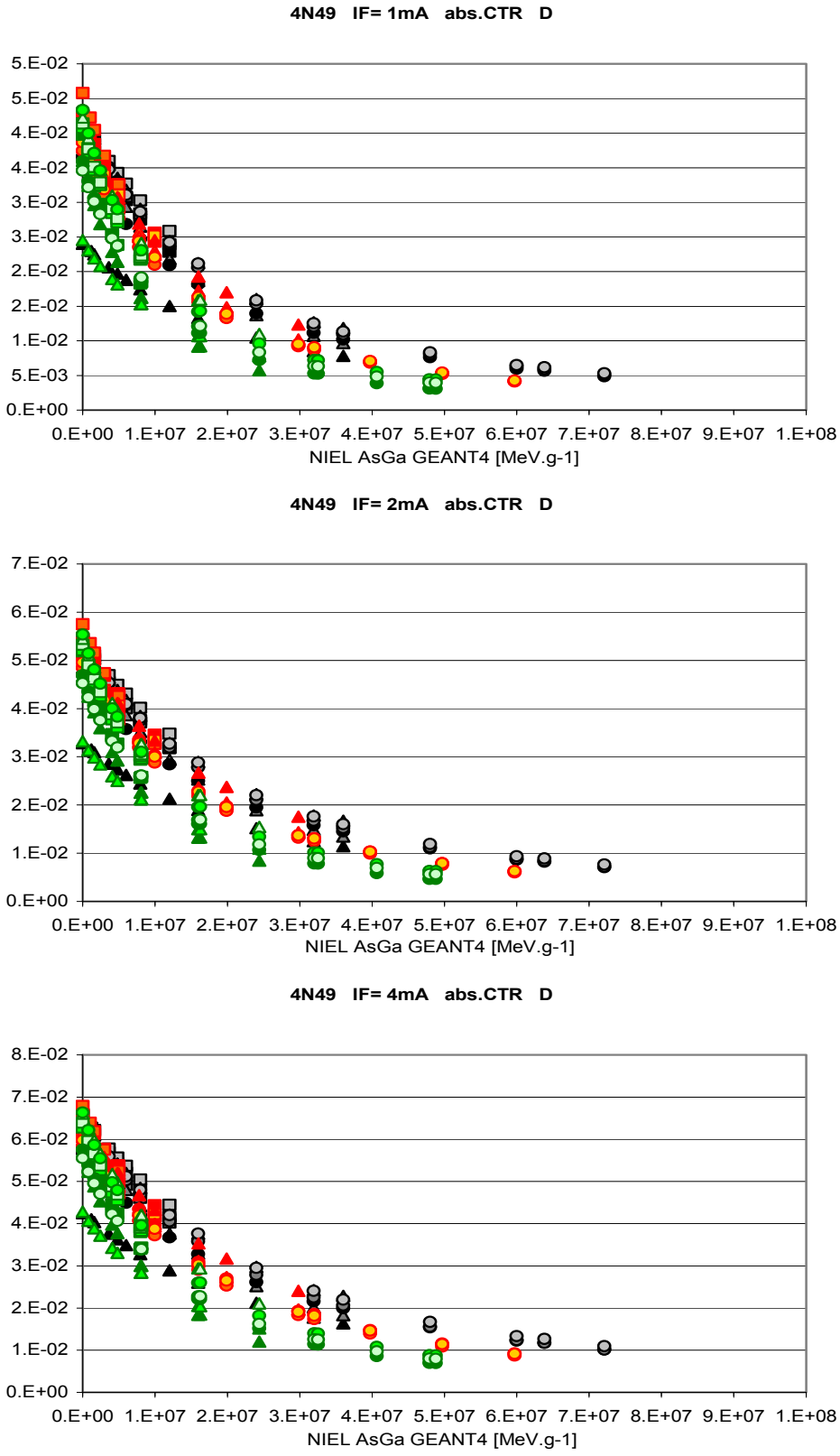
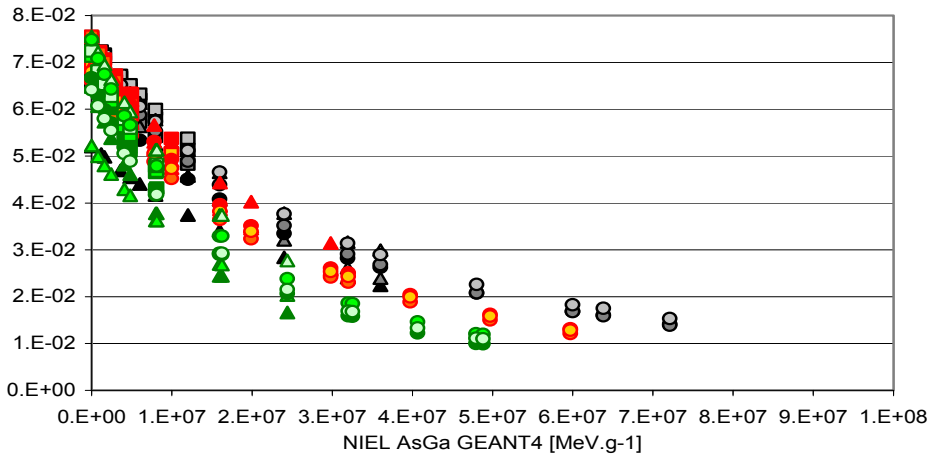


Fig. 12-7: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



4N49 IF= 8mA abs.CTR D



4N49 IF= 10mA abs.CTR D

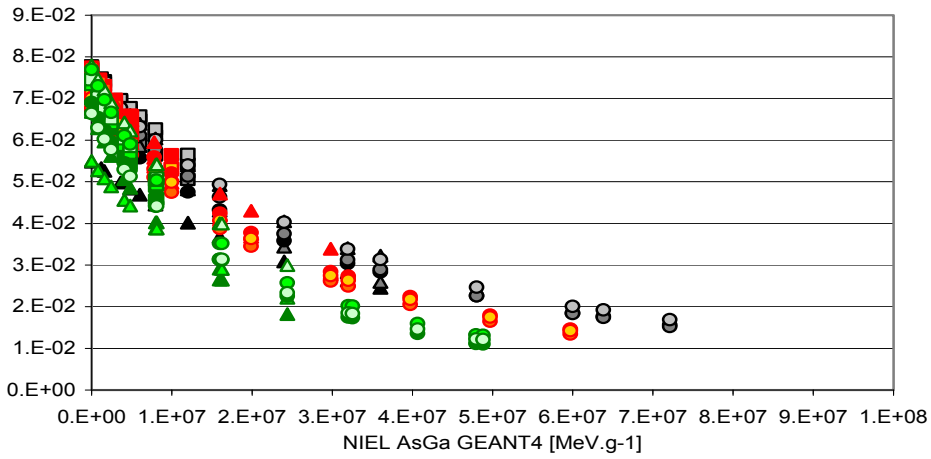
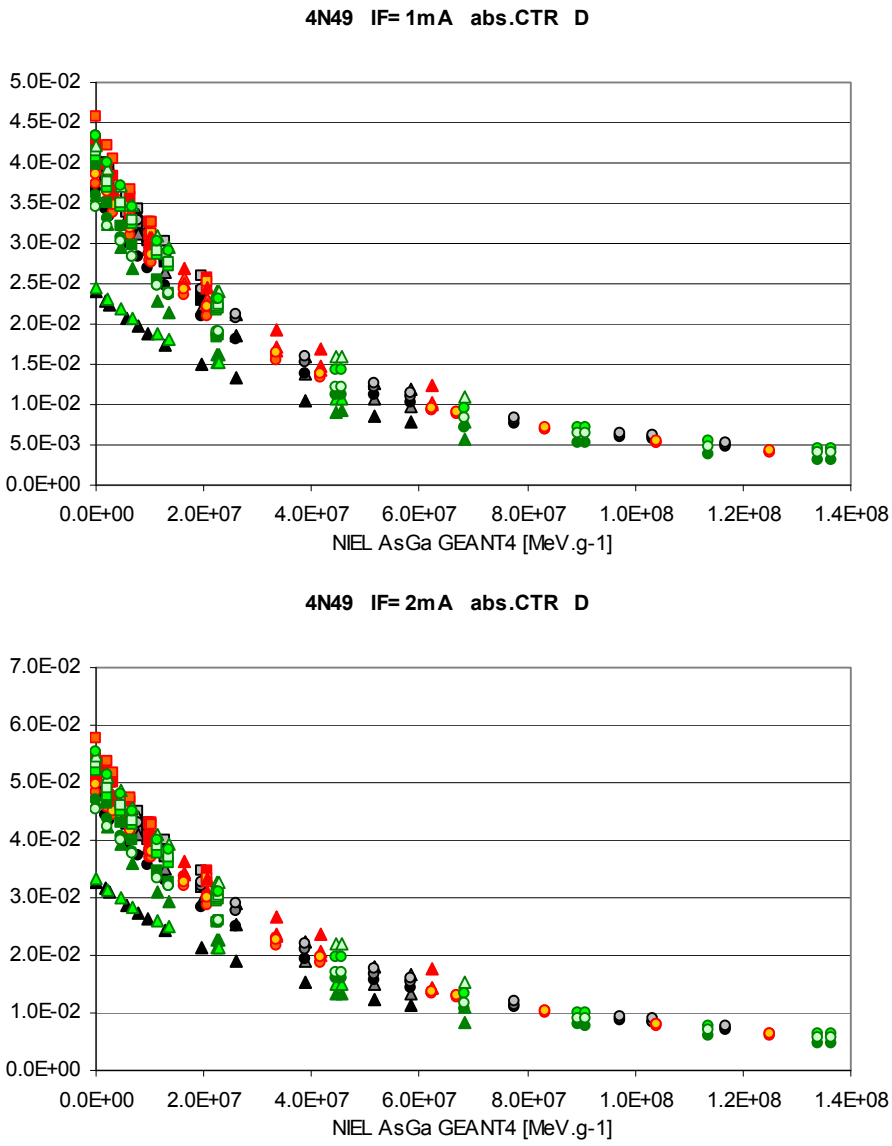
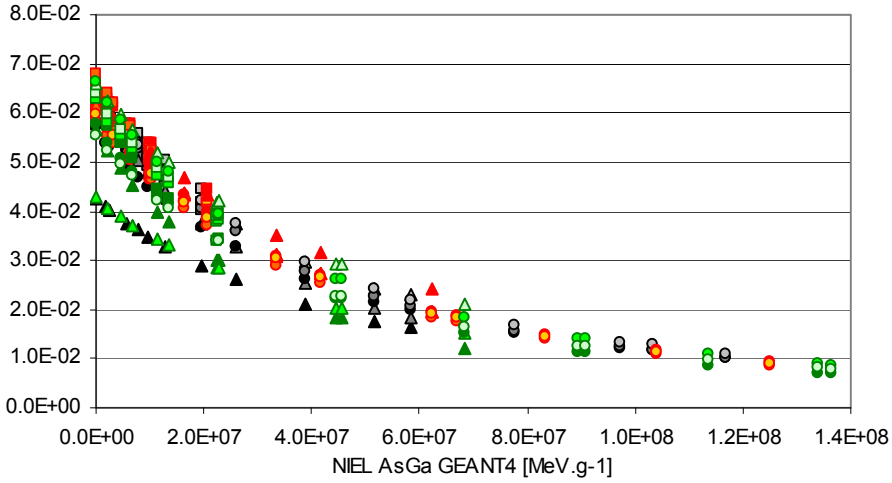


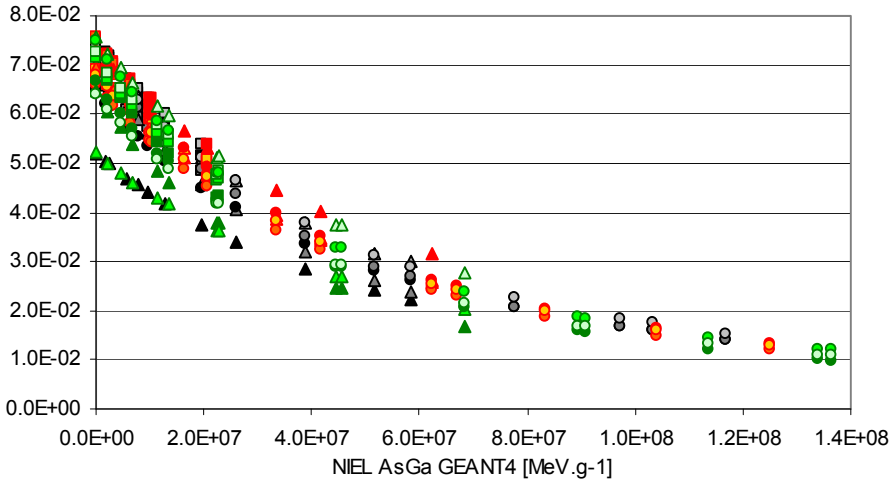
Fig. 12-8: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)



4N49 IF= 4mA abs.CTR D



4N49 IF= 8mA abs.CTR D



4N49 IF= 10mA abs.CTR D

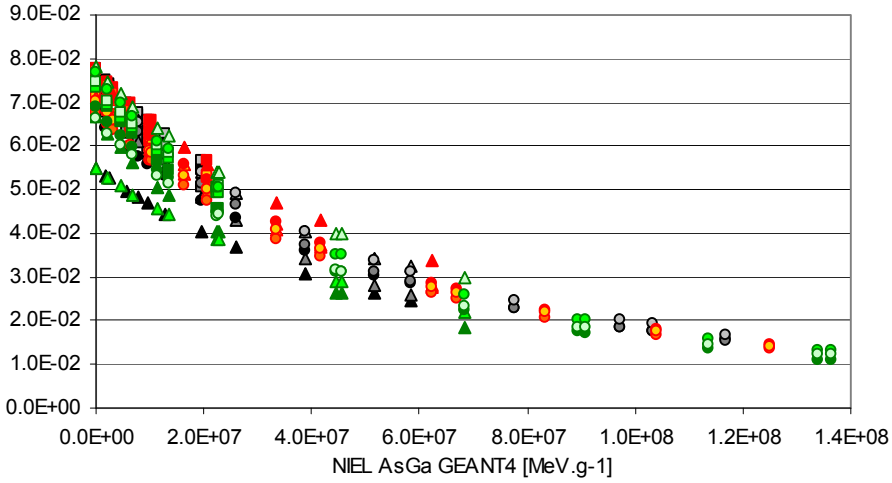
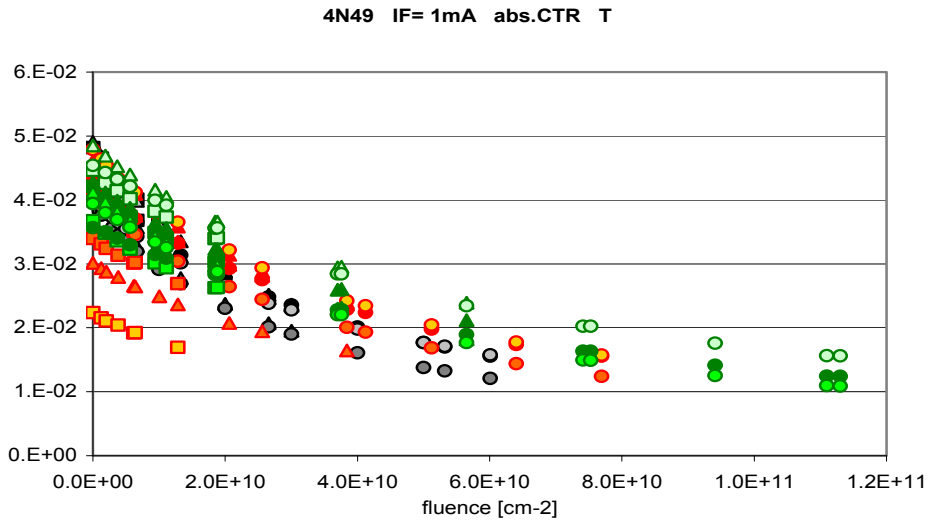
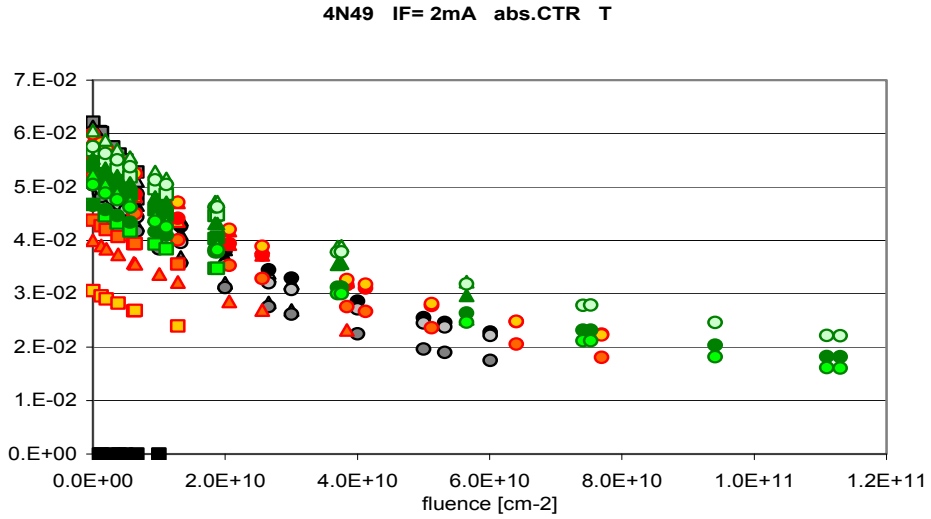
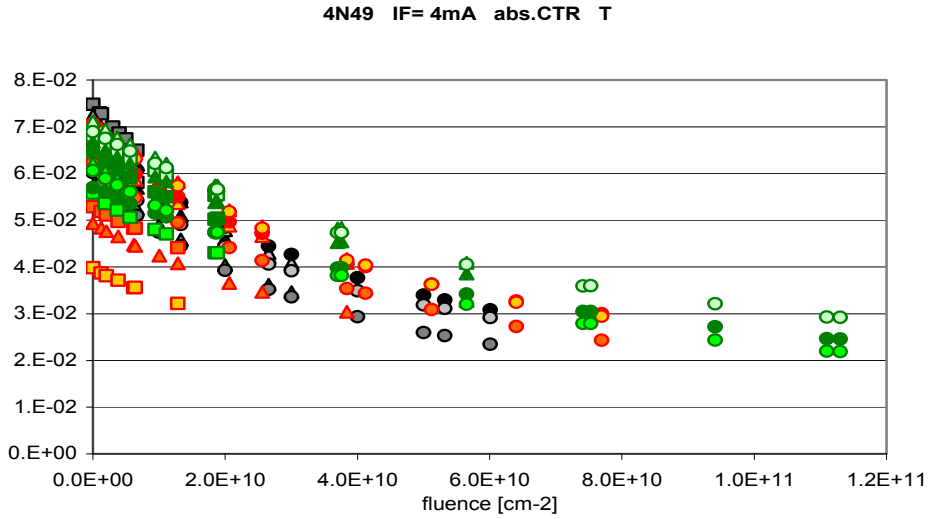


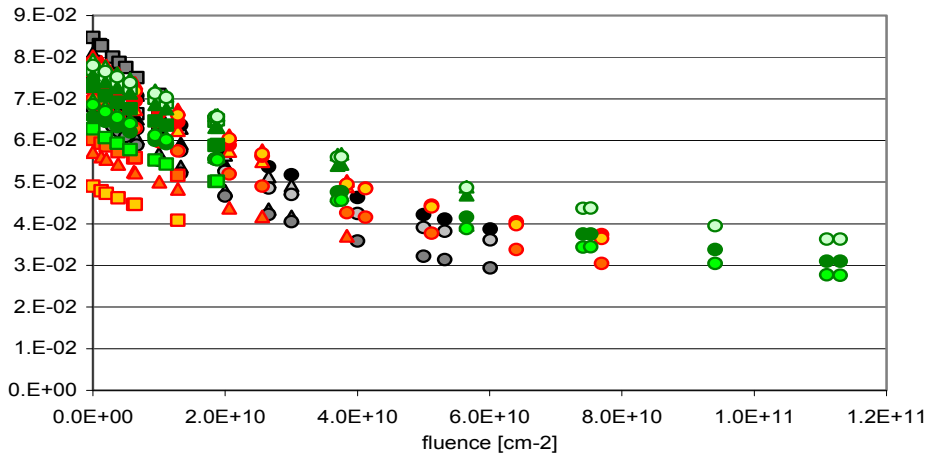
Fig. 12-9: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







4N49 IF= 8mA abs.CTR T



4N49 IF= 10mA abs.CTR T

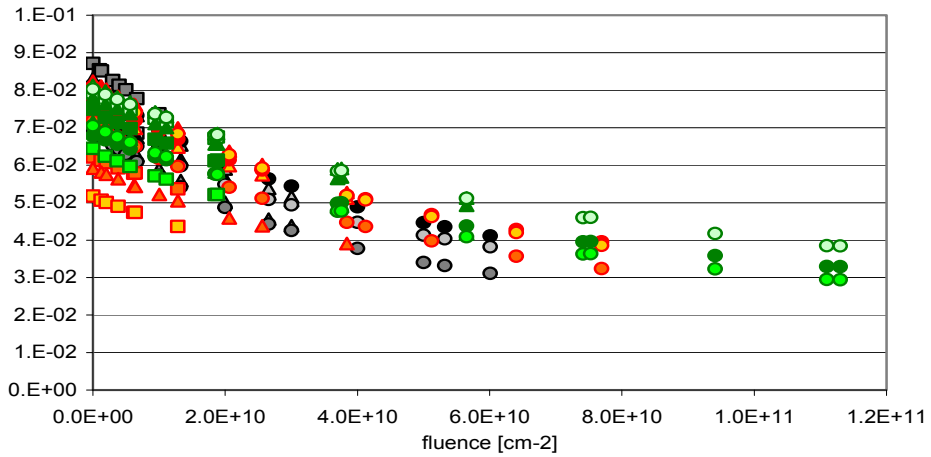
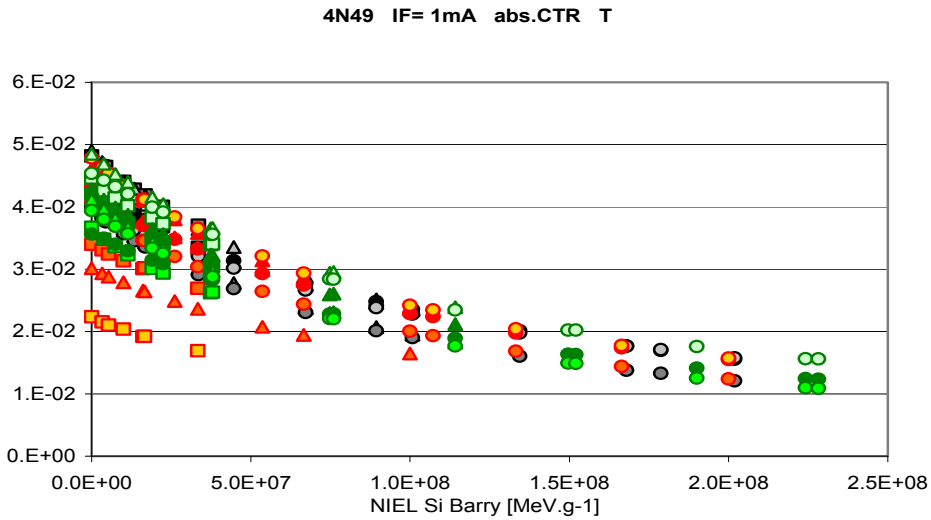
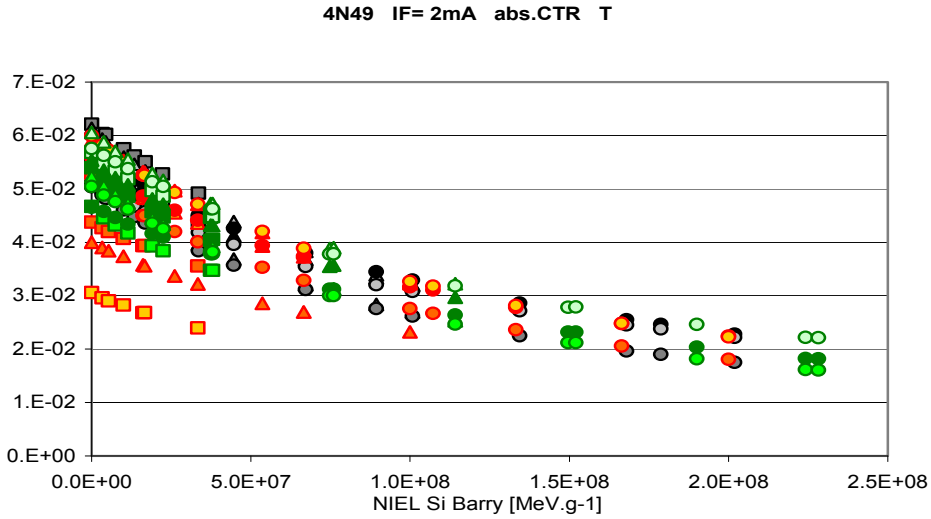
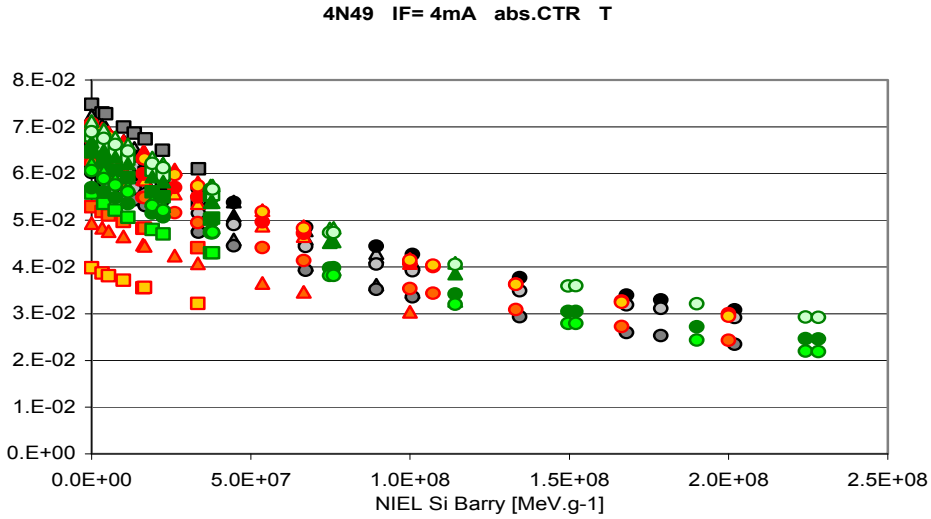


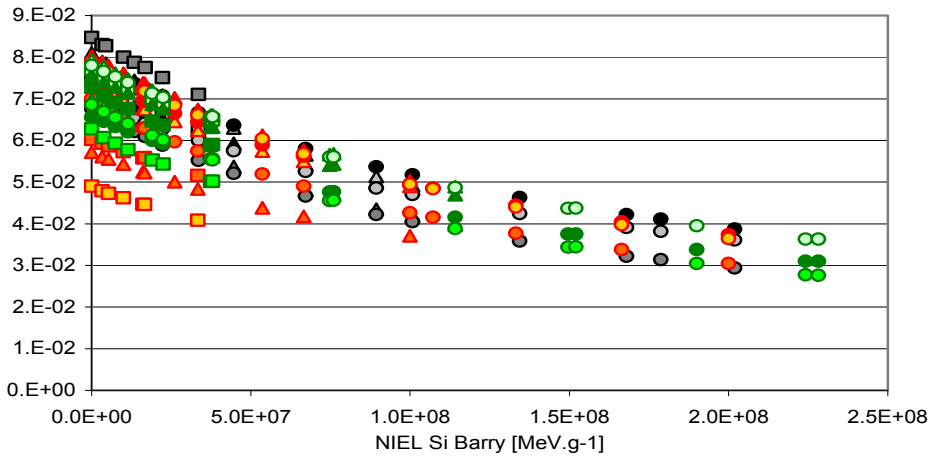
Fig. 12-10: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)







4N49 IF= 8mA abs.CTR T



4N49 IF= 10mA abs.CTR T

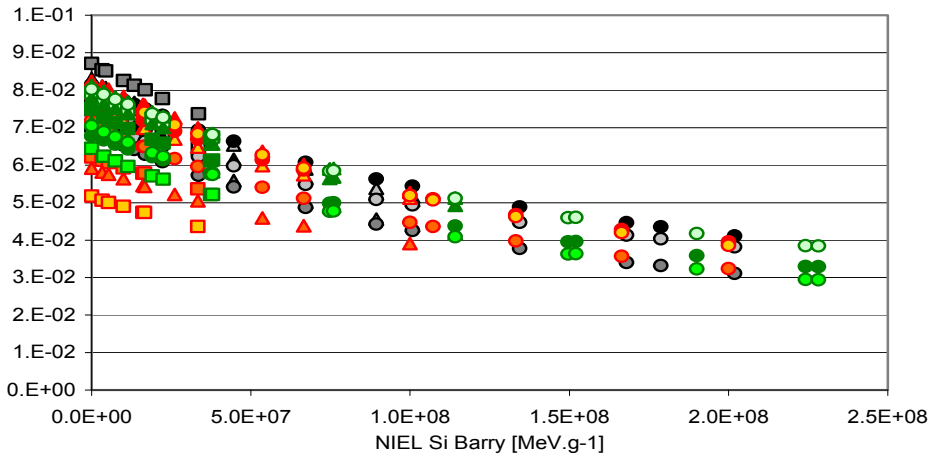
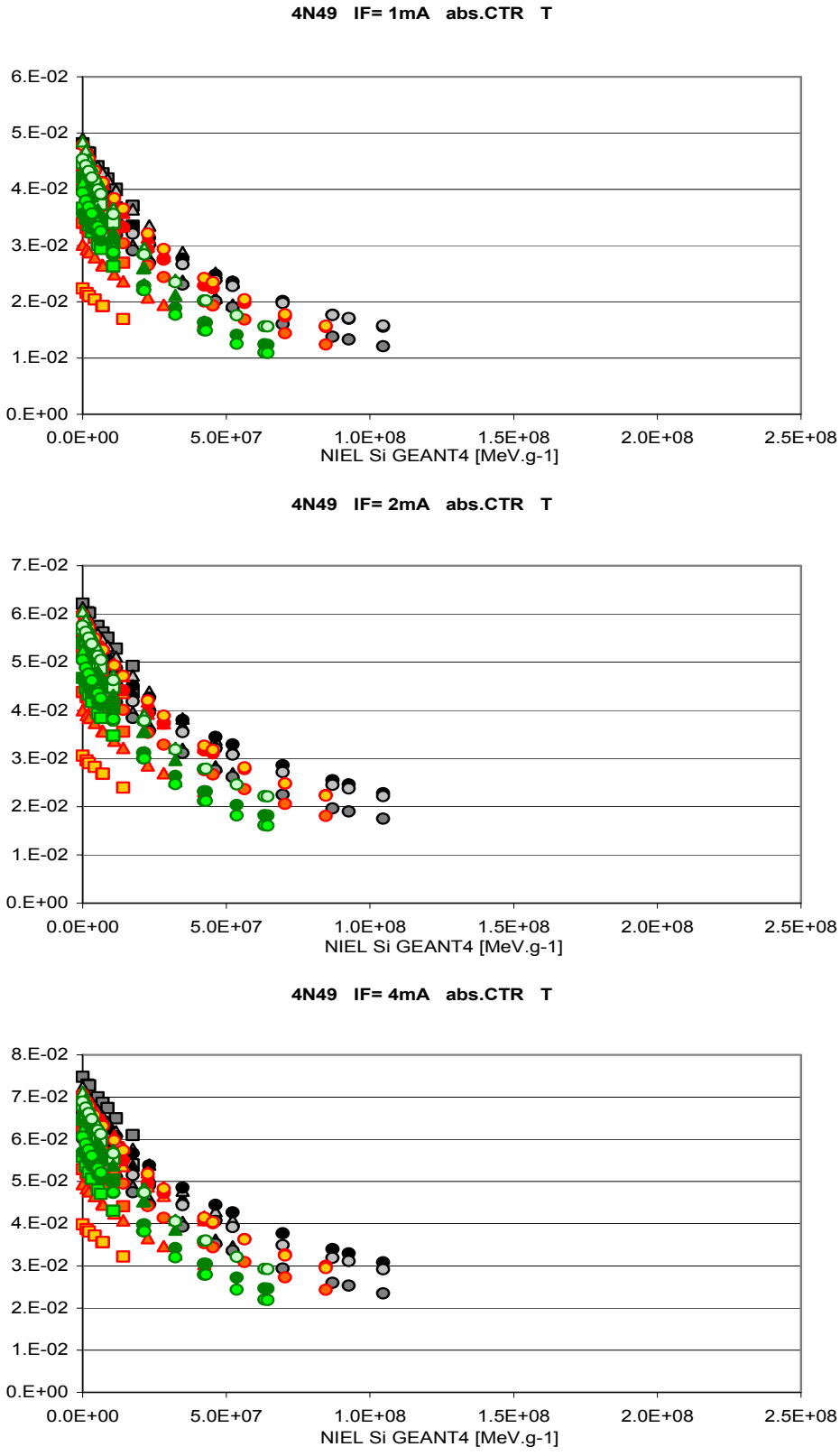
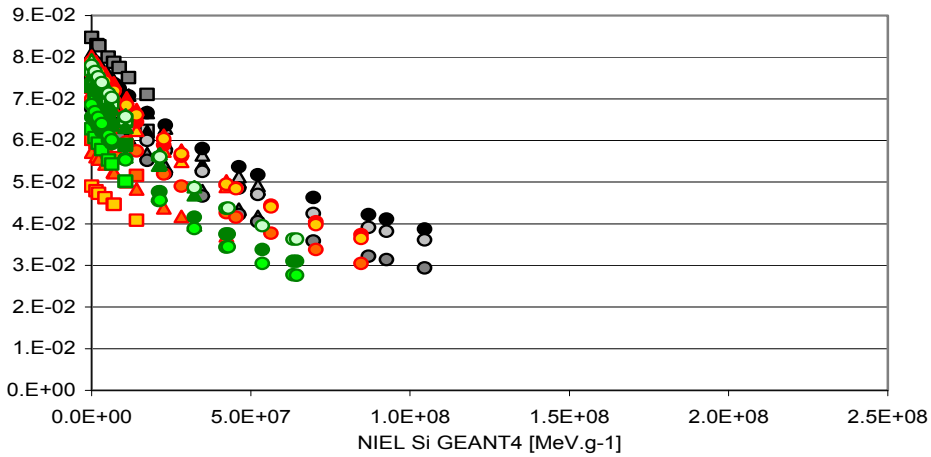


Fig. 12-11: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)



4N49 IF= 8mA abs.CTR T



4N49 IF= 10mA abs.CTR T

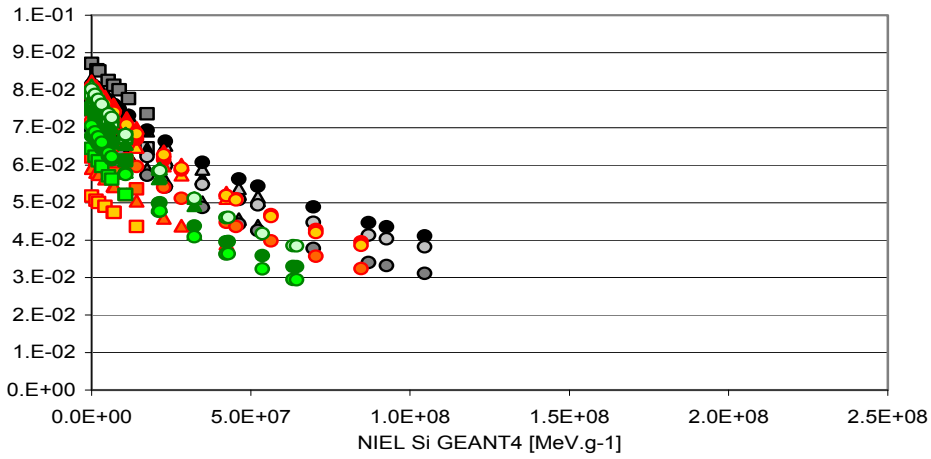
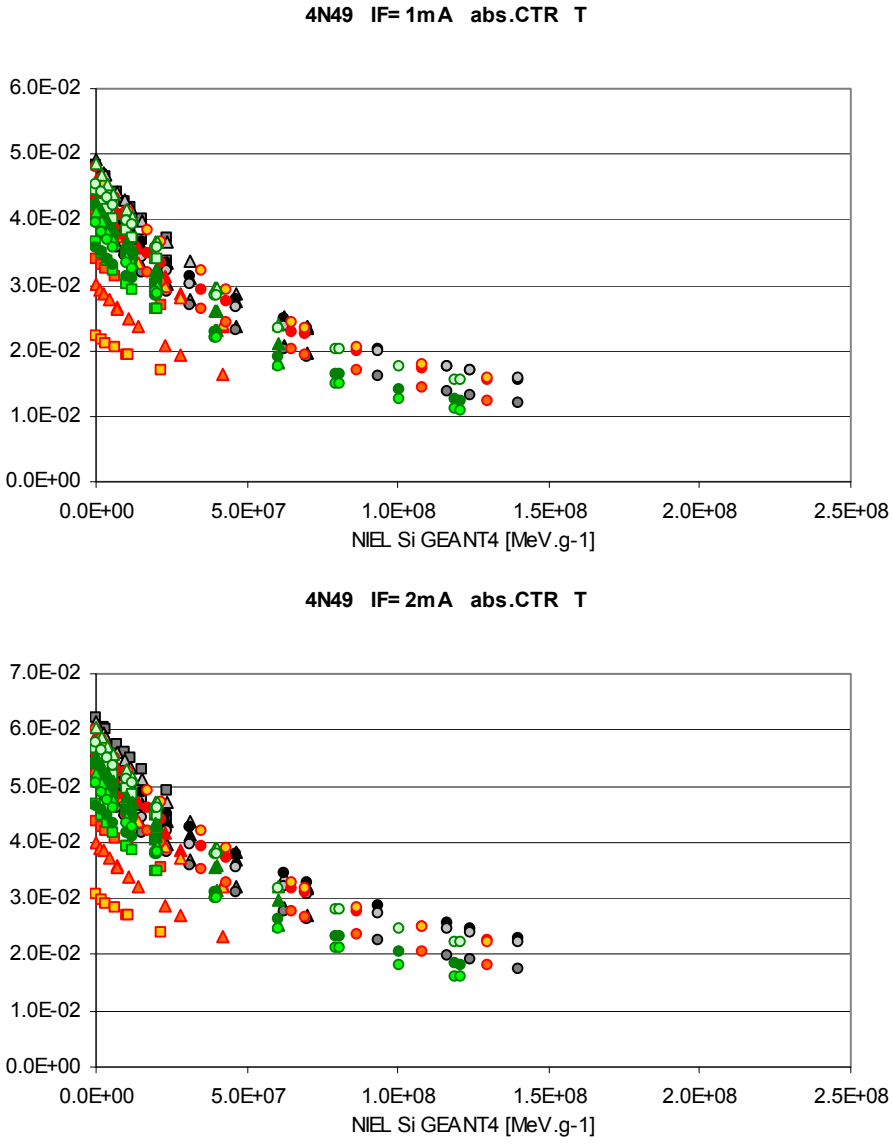
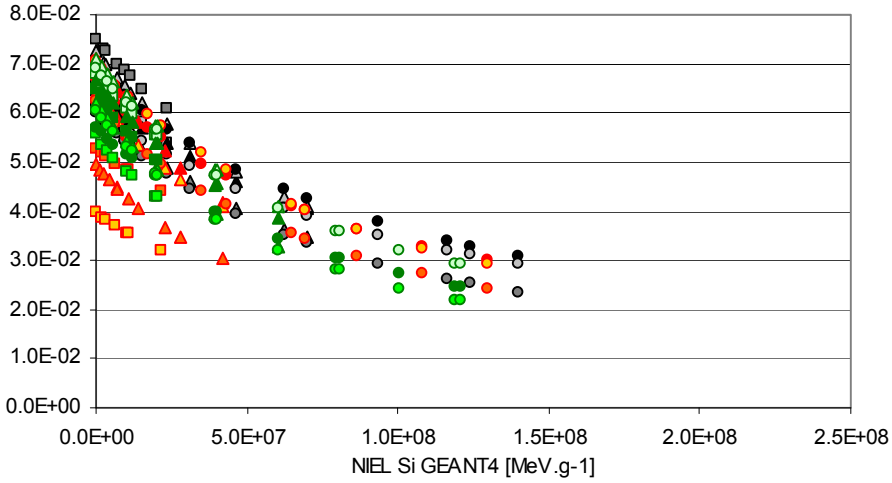


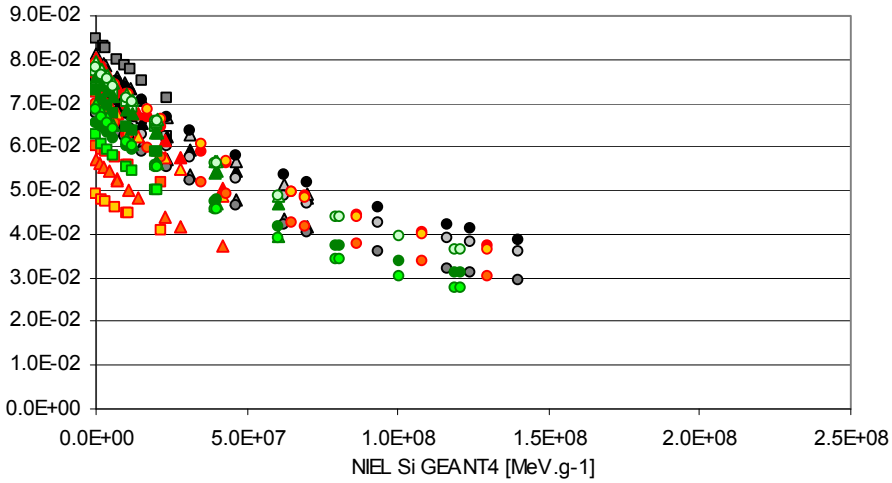
Fig. 12-12: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)



4N49 IF= 4mA abs.CTR T



4N49 IF= 8mA abs.CTR T



4N49 IF= 10mA abs.CTR T

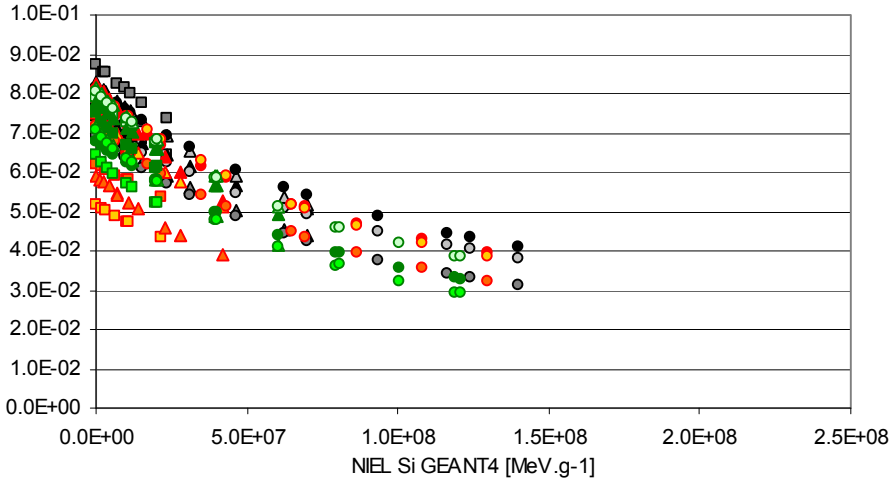
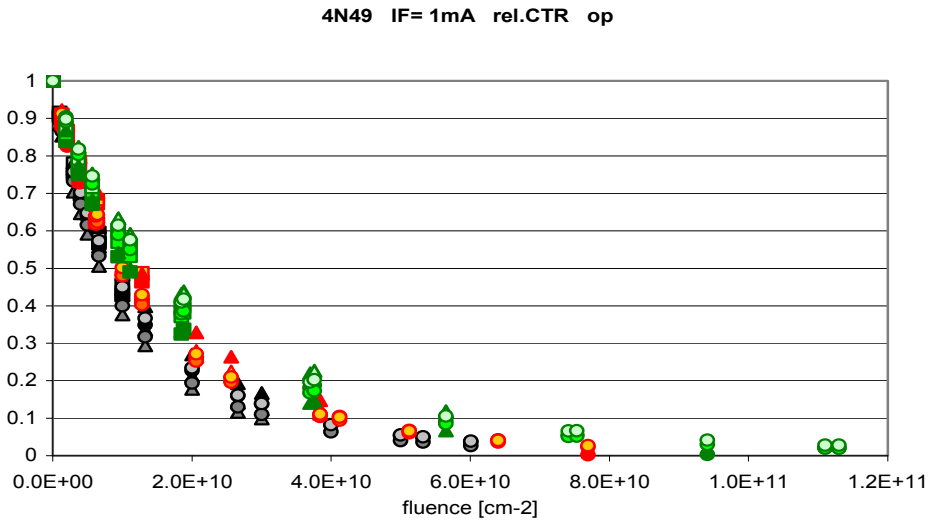
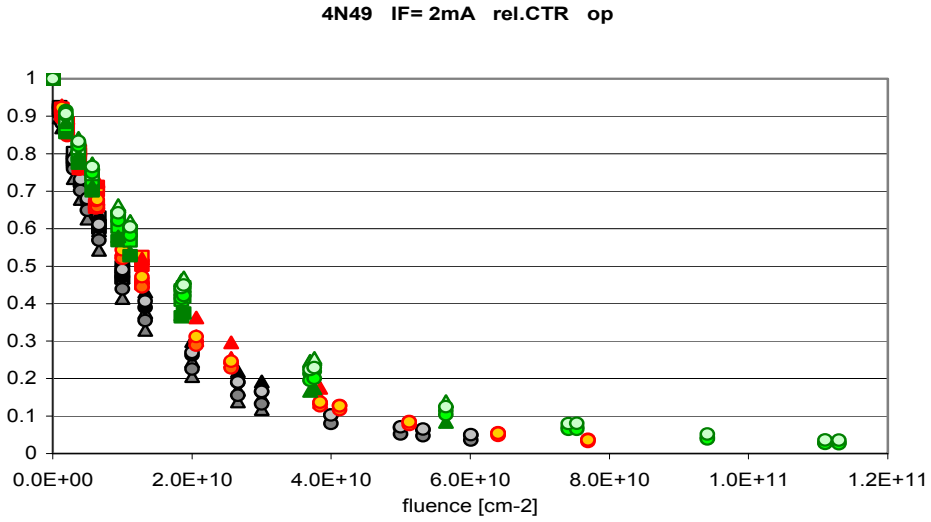
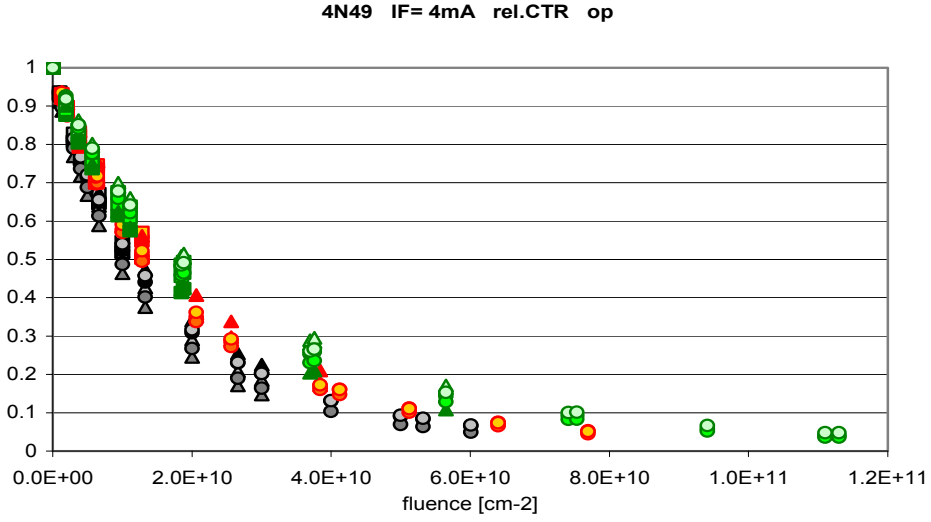


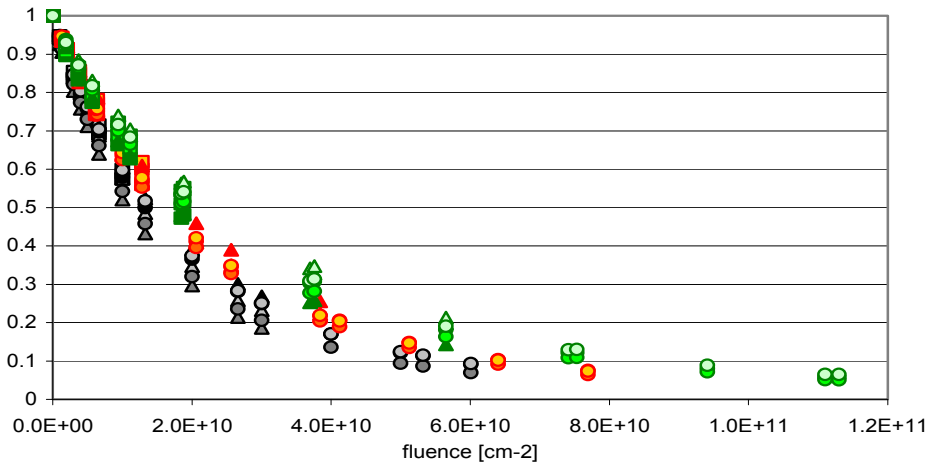
Fig. 12-13: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







4N49 IF= 8mA rel.CTR op



4N49 IF= 10mA rel.CTR op

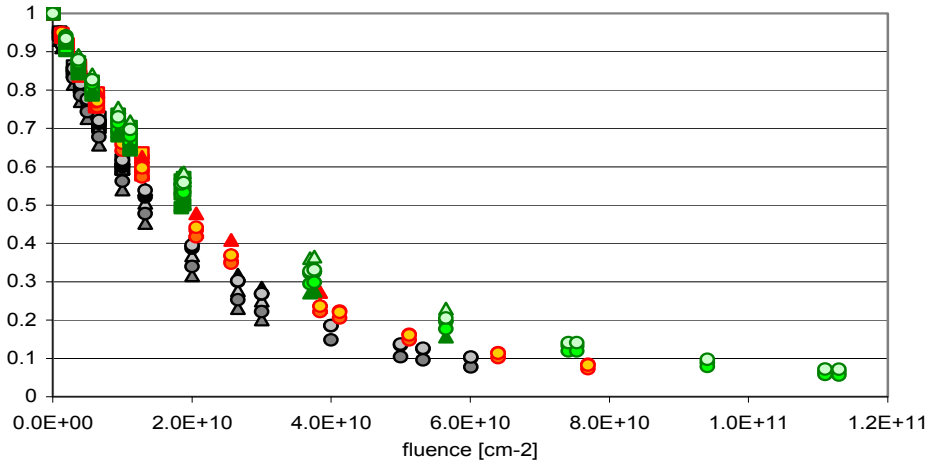
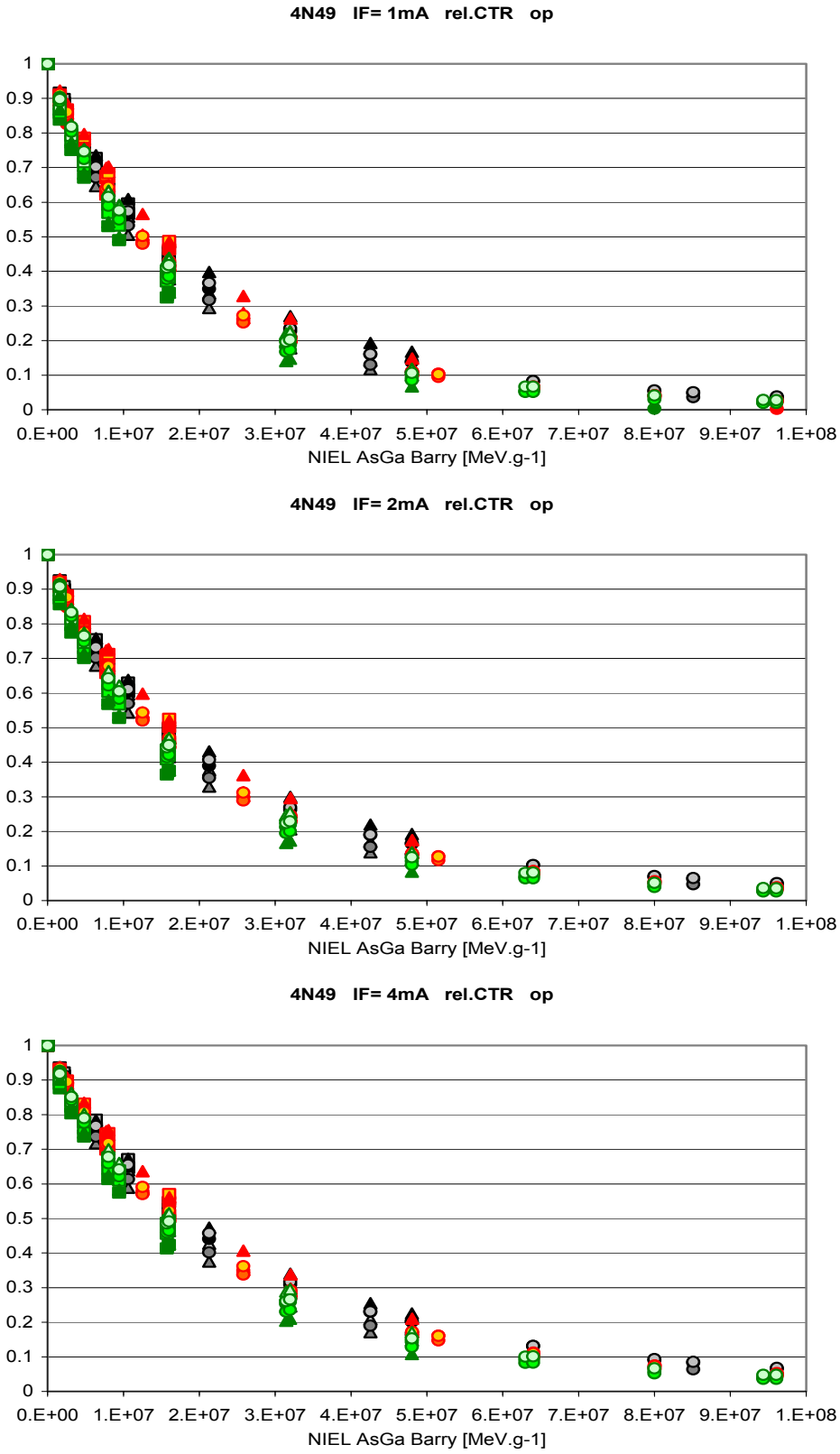
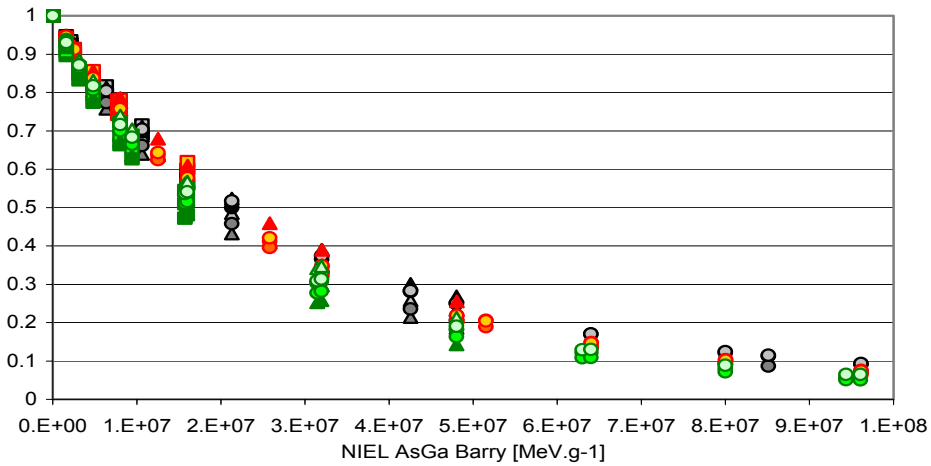


Fig. 12-14: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



4N49 IF= 8mA rel.CTR op



4N49 IF= 10mA rel.CTR op

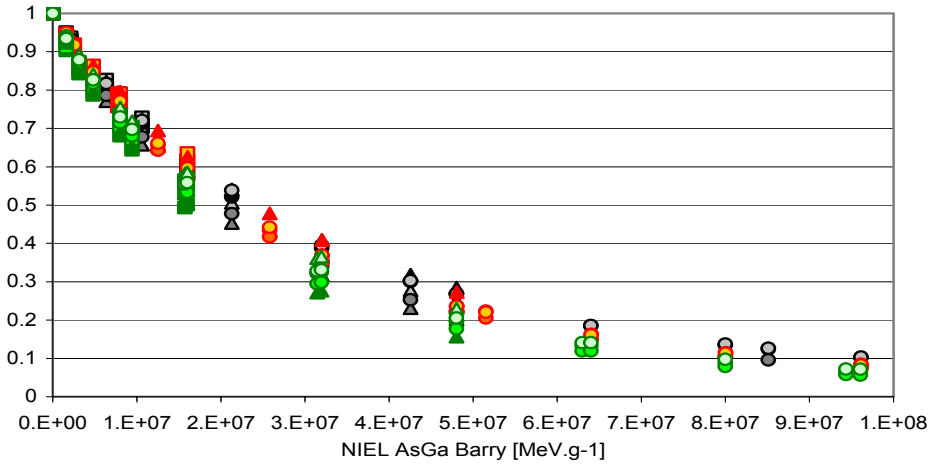
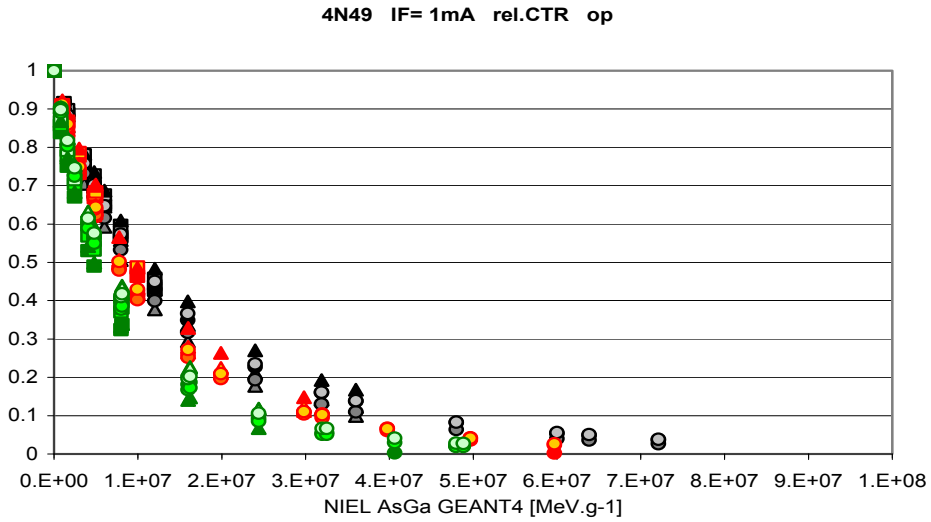
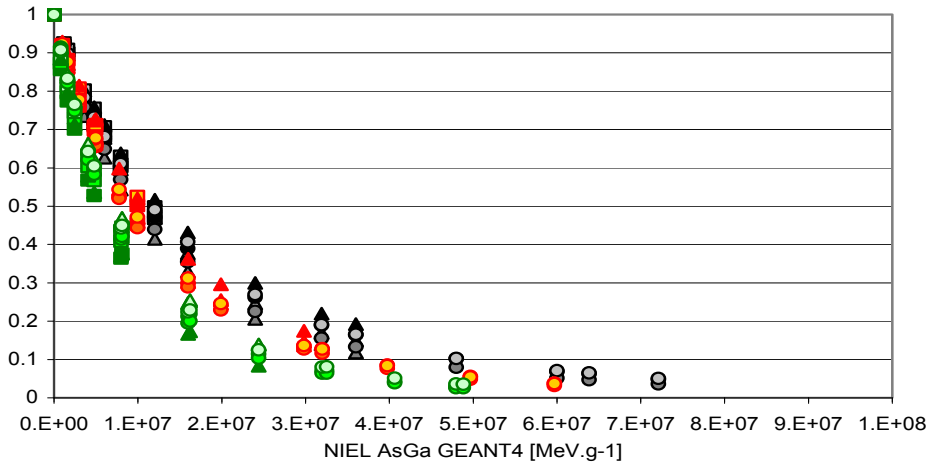
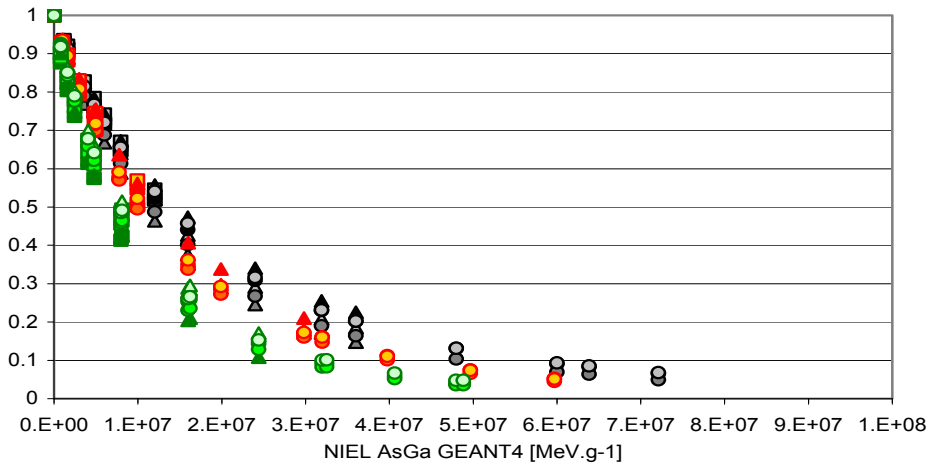


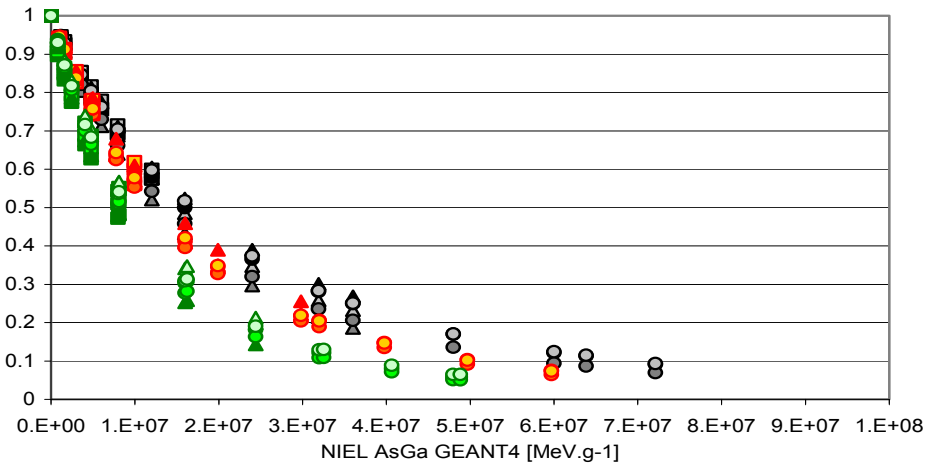
Fig. 12-15: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







4N49 IF= 8mA rel.CTR op



4N49 IF= 10mA rel.CTR op

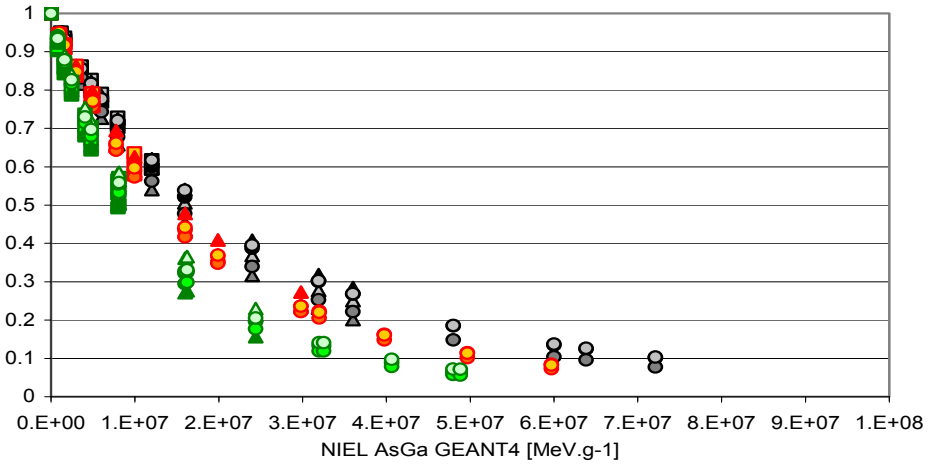
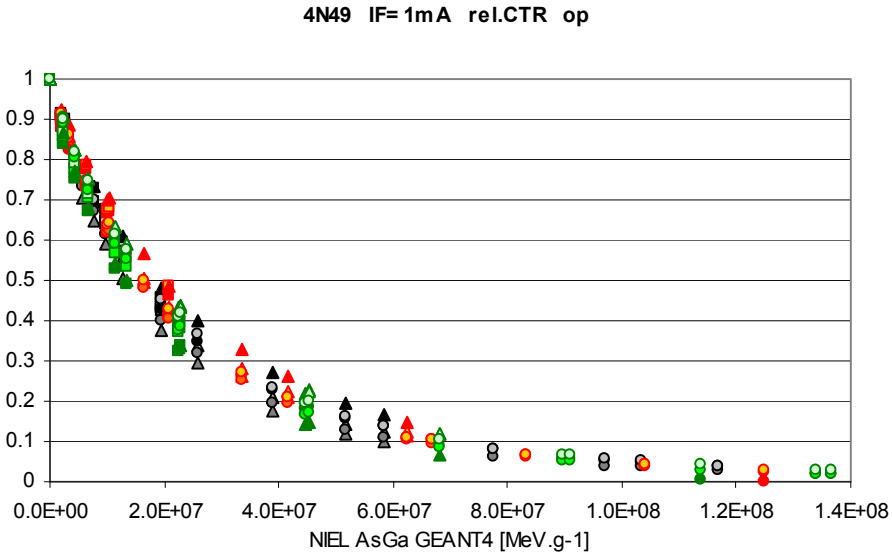
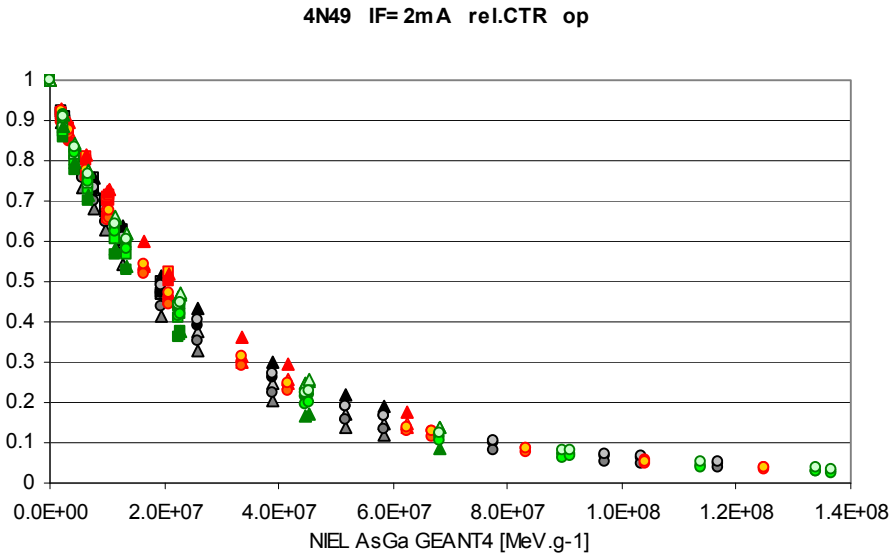
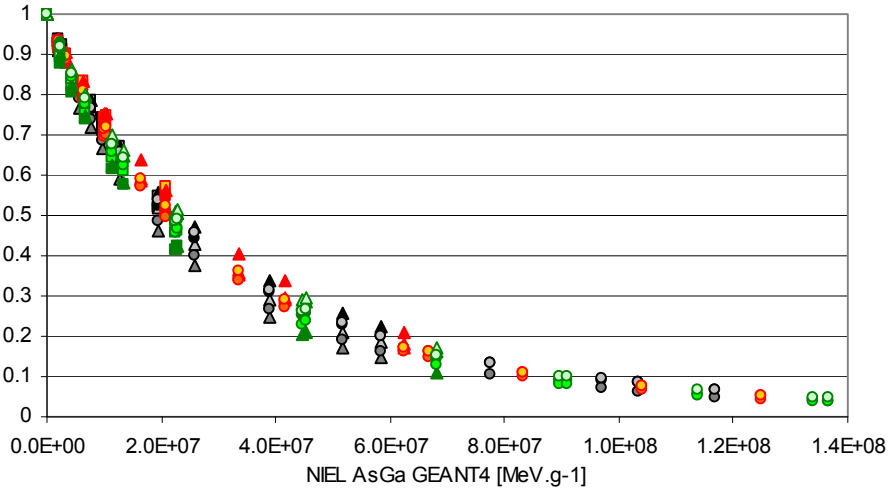


Fig. 12-16: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)

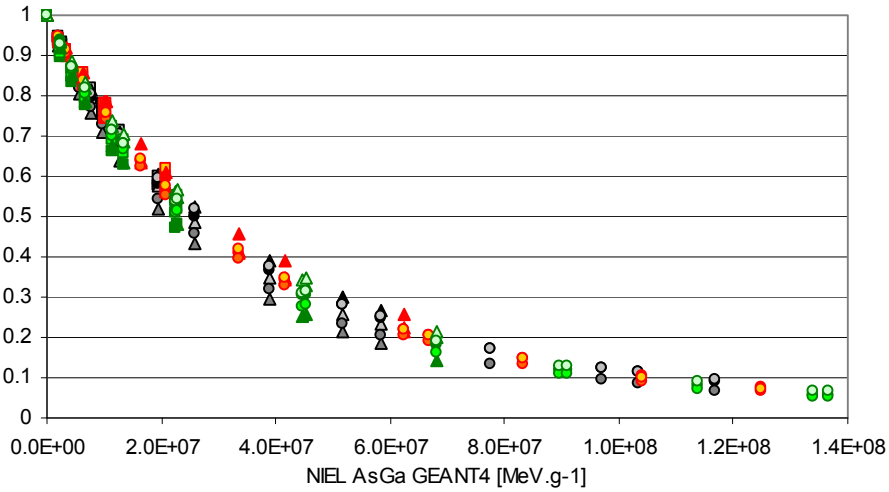




4N49 IF= 4mA rel.CTR op



4N49 IF= 8mA rel.CTR op



4N49 IF= 10mA rel.CTR op

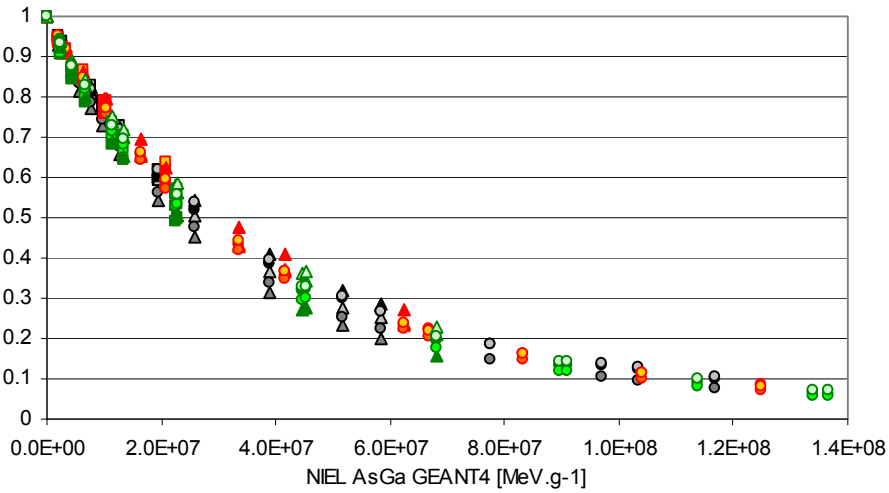
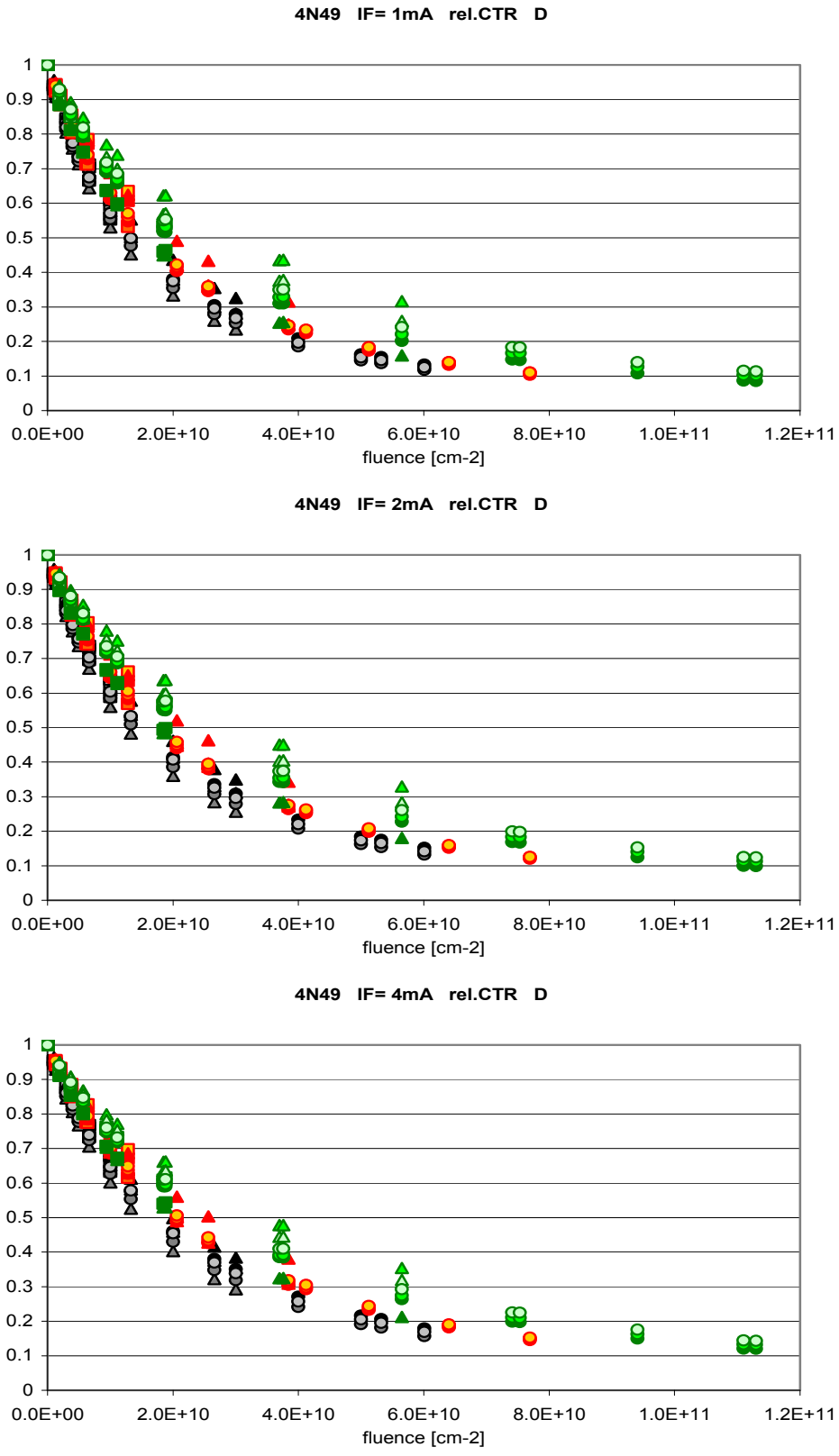
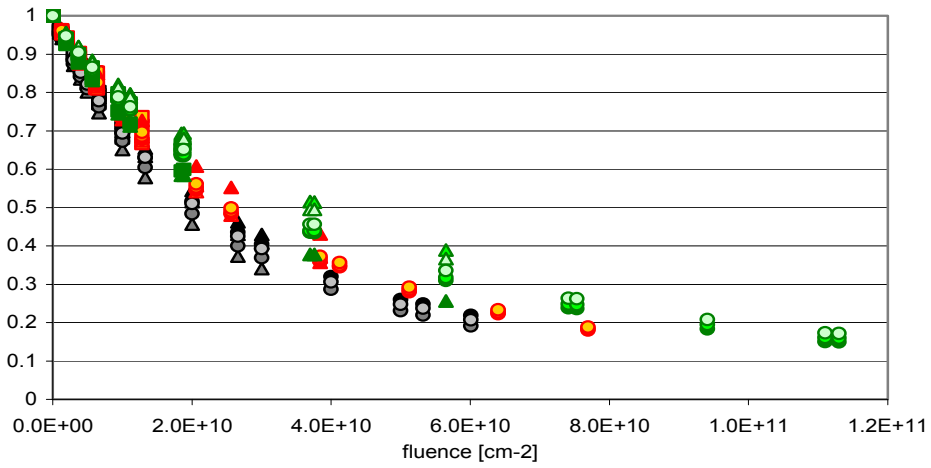


Fig. 12-17: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



4N49 IF= 8mA rel.CTR D



4N49 IF= 10mA rel.CTR D

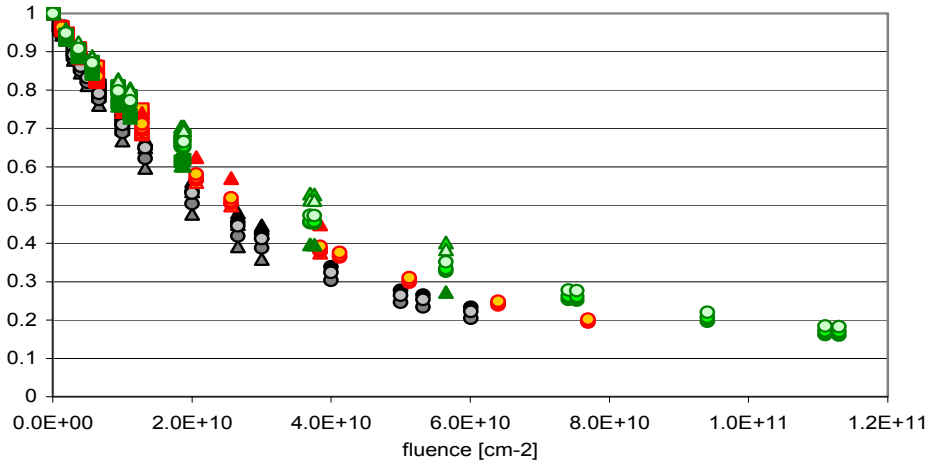
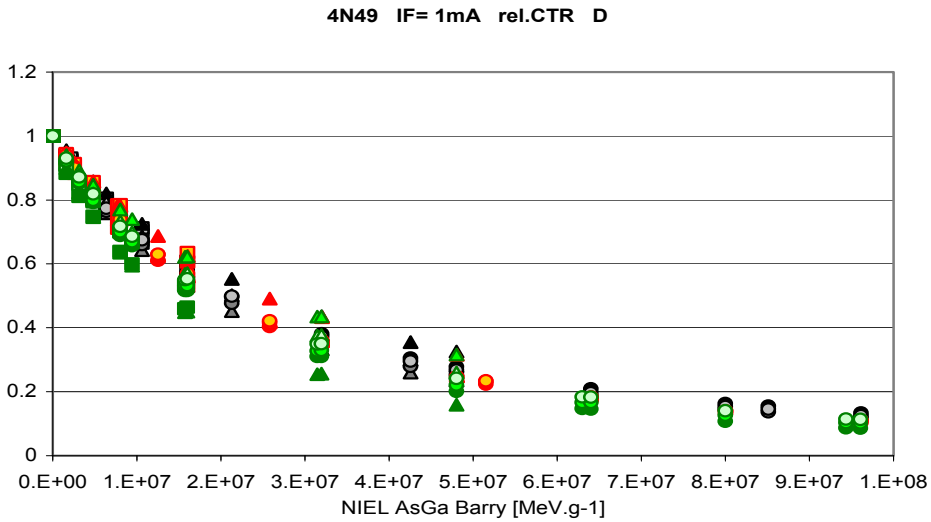
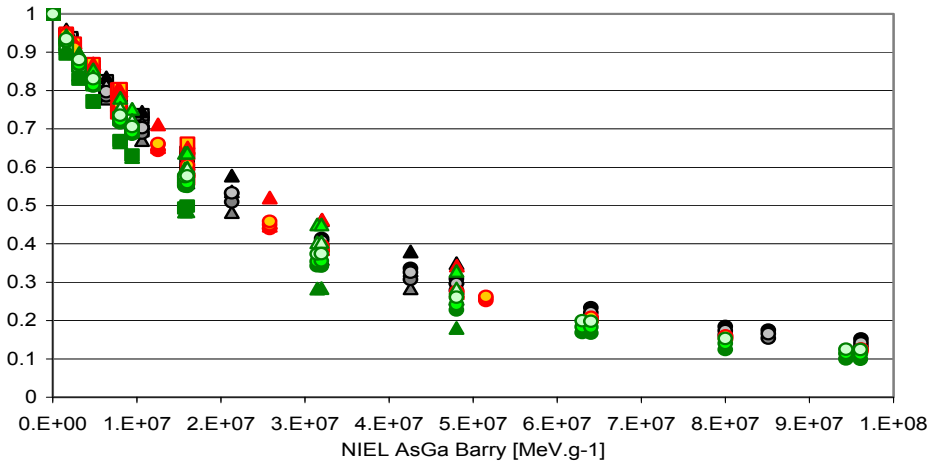
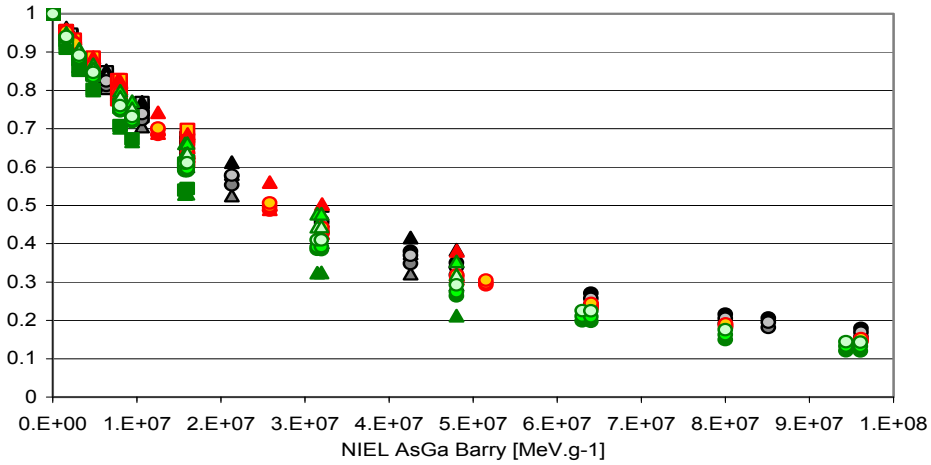


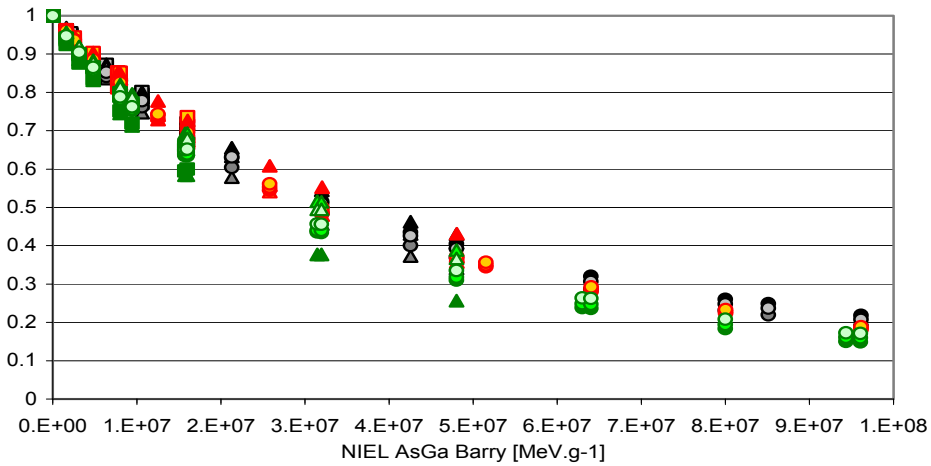
Fig. 12-18: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







4N49 IF= 8mA rel.CTR D



4N49 IF= 10mA rel.CTR D

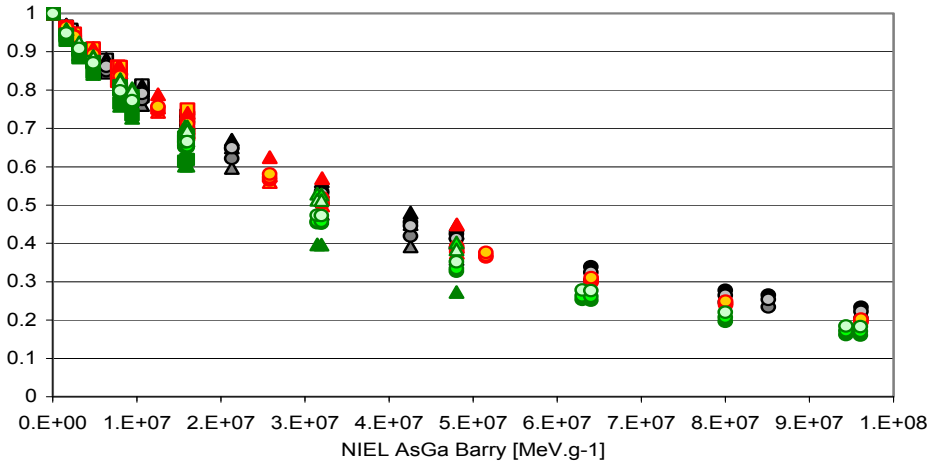
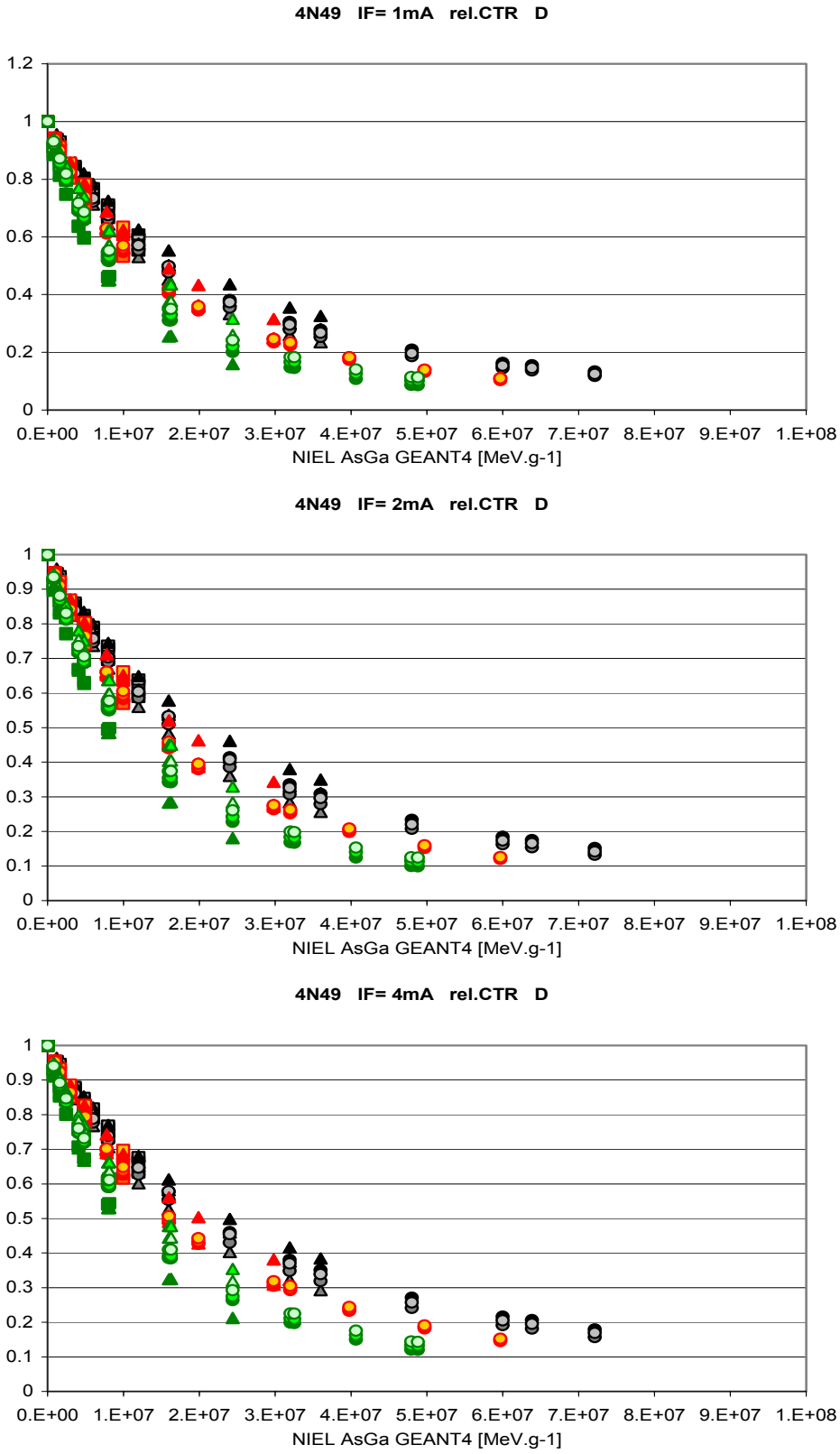
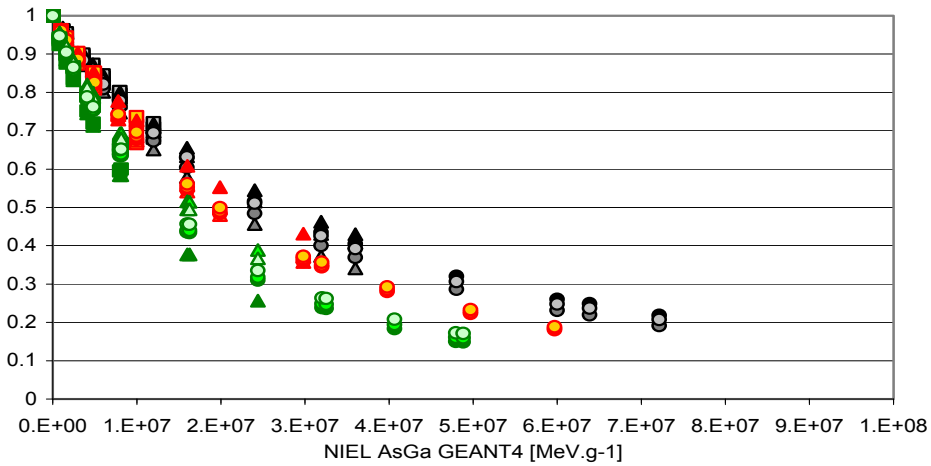


Fig. 12-19: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



4N49 IF= 8mA rel.CTR D



4N49 IF= 10mA rel.CTR D

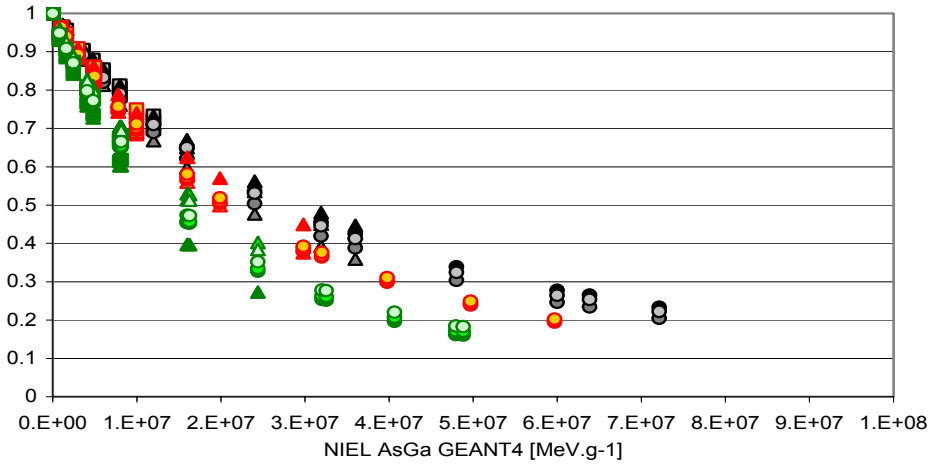
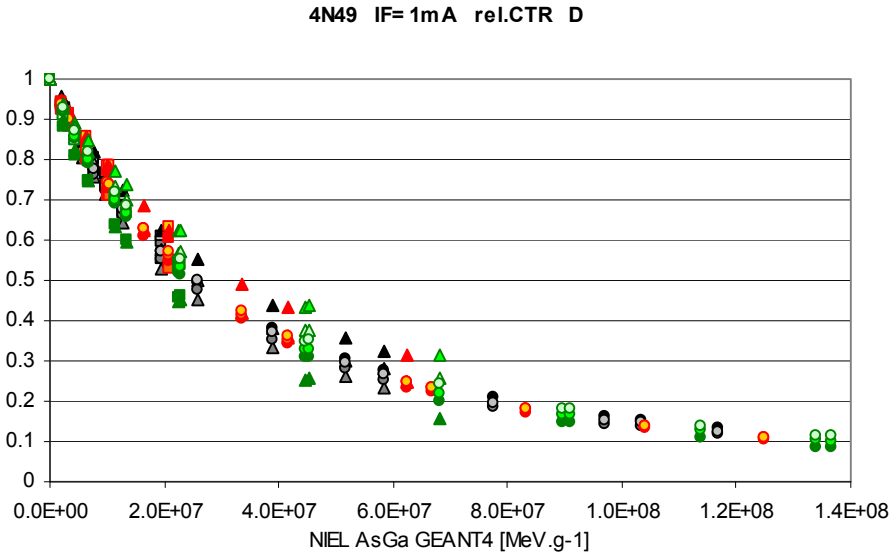
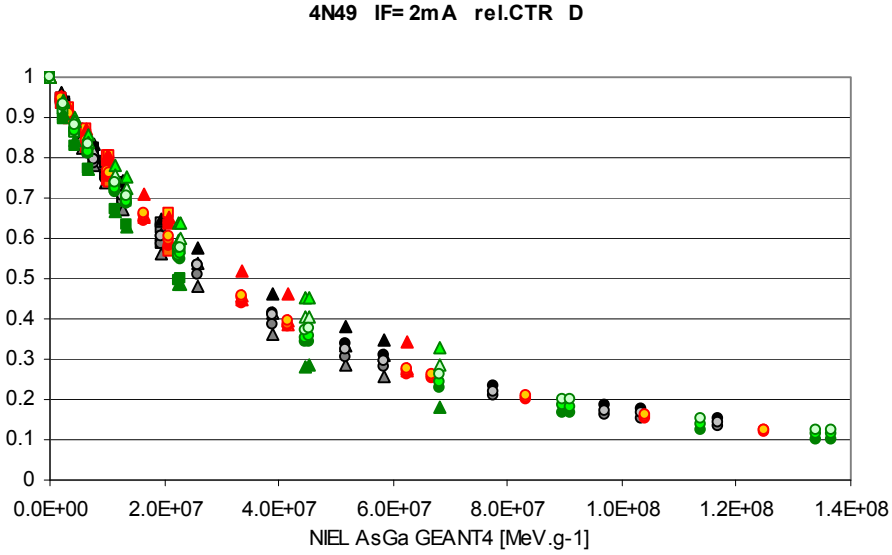
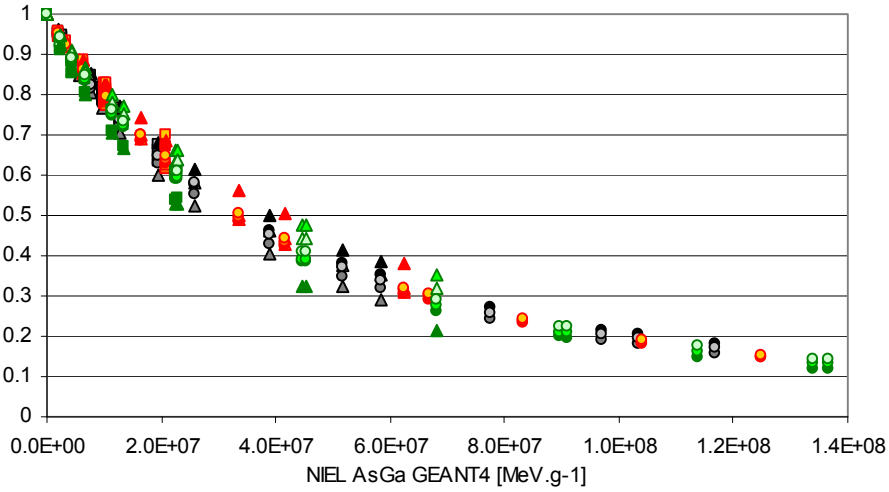


Fig. 12-20: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)

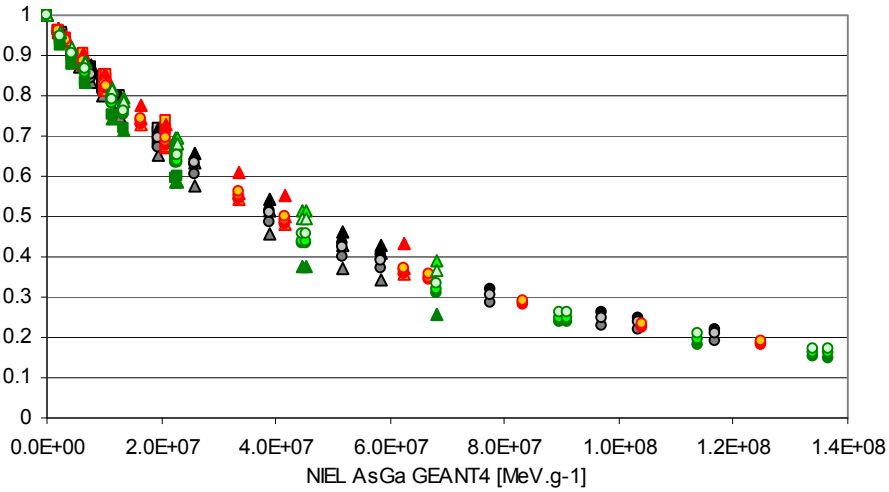




4N49 IF= 4mA rel.CTR D



4N49 IF= 8mA rel.CTR D



4N49 IF= 10mA rel.CTR D

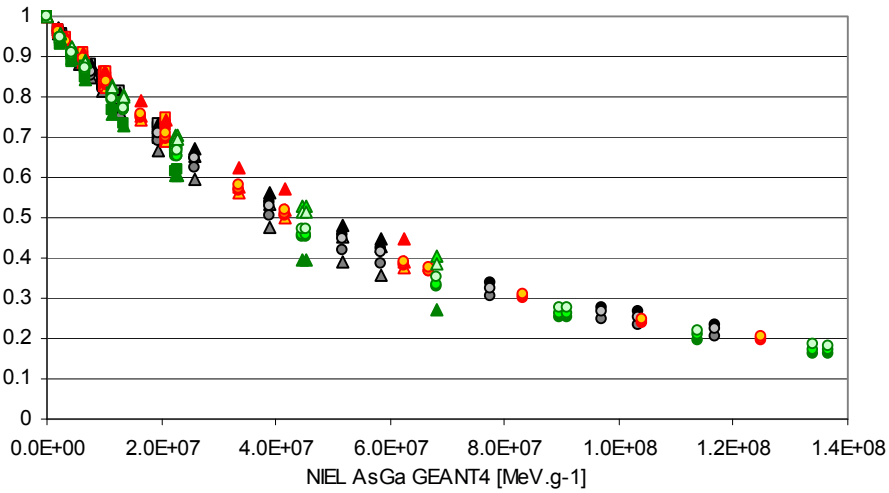
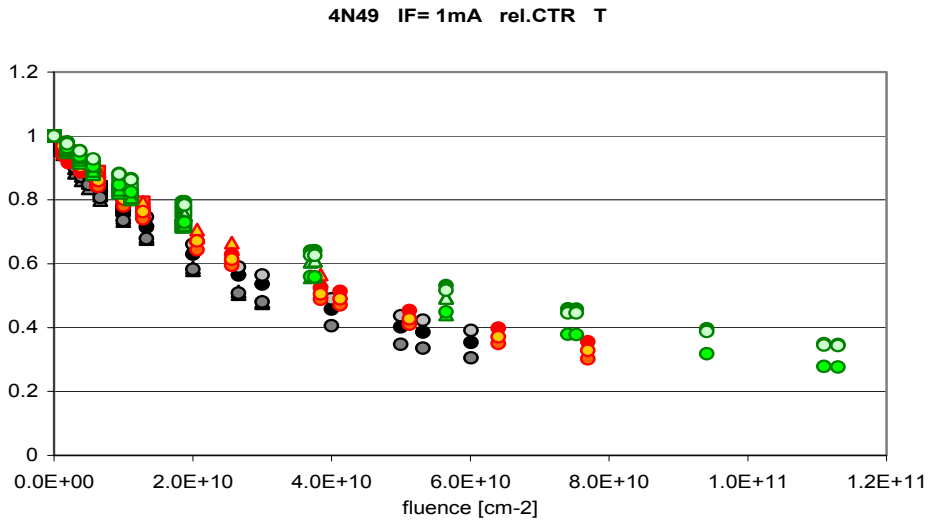
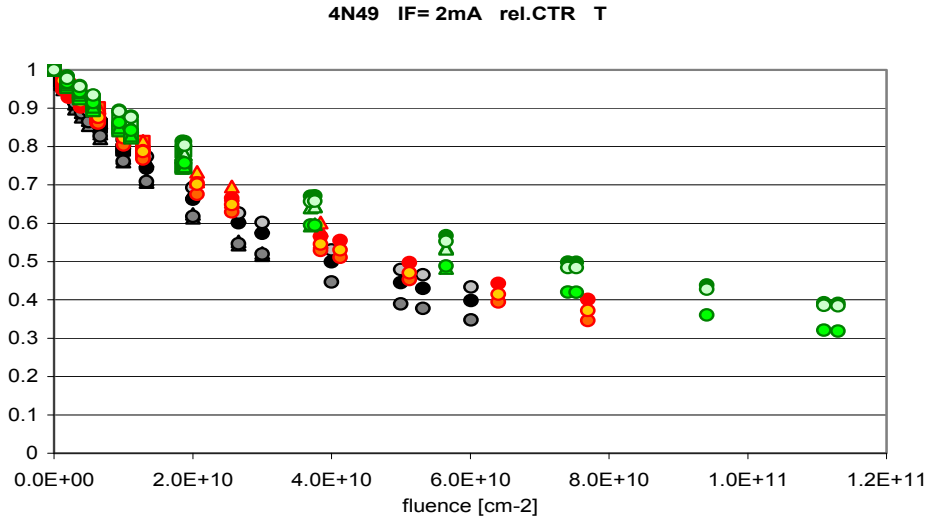
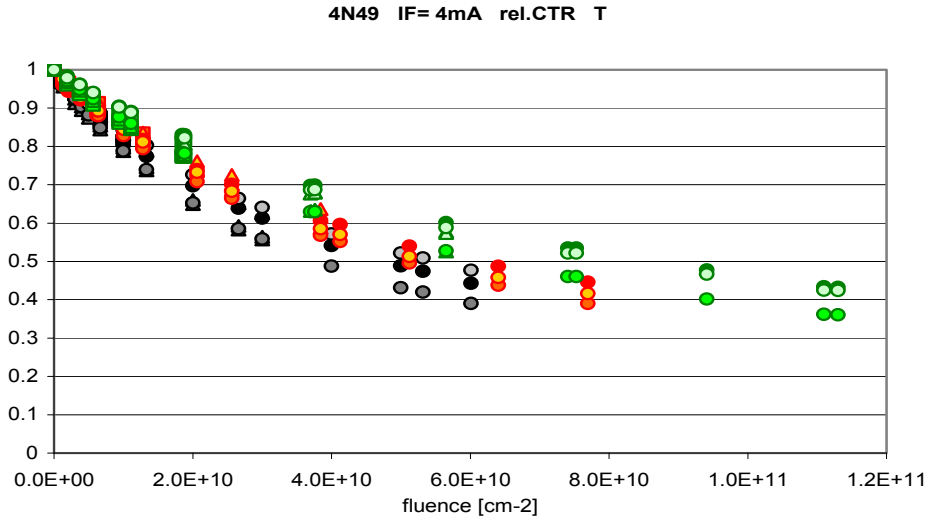


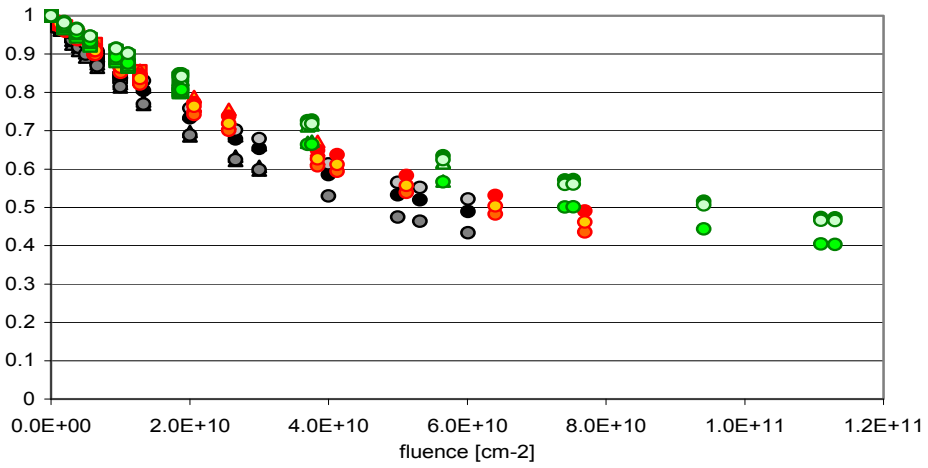
Fig. 12-21: 4N49 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







4N49 IF= 8mA rel.CTR T



4N49 IF= 10mA rel.CTR T

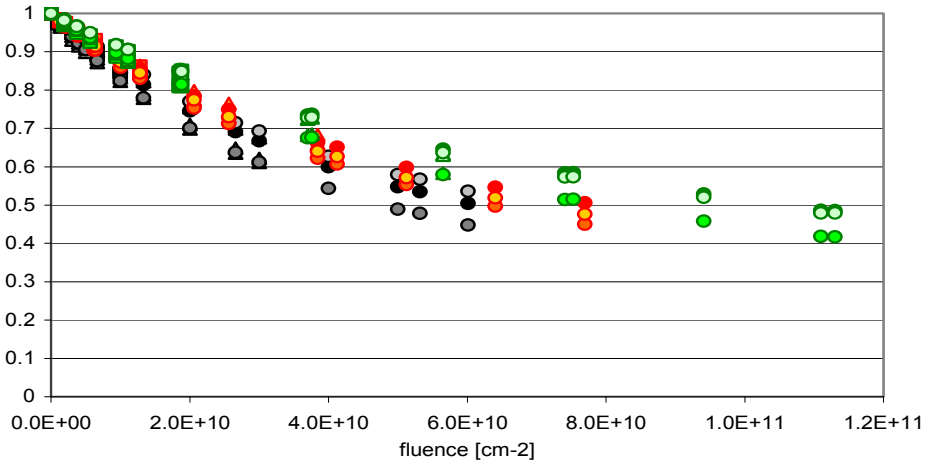
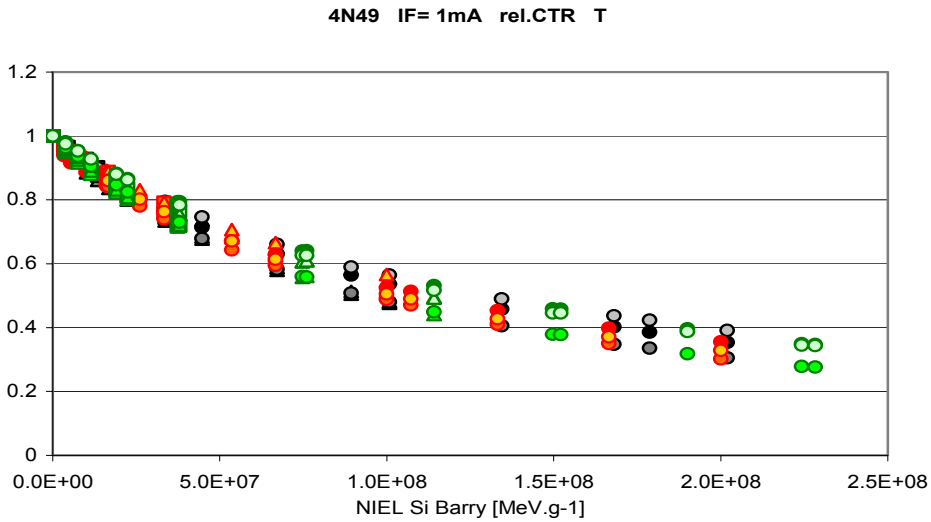
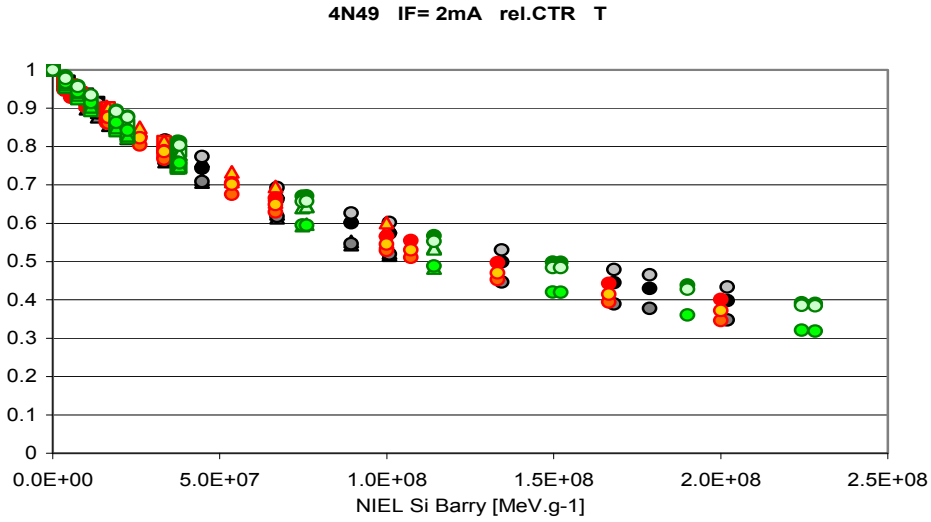
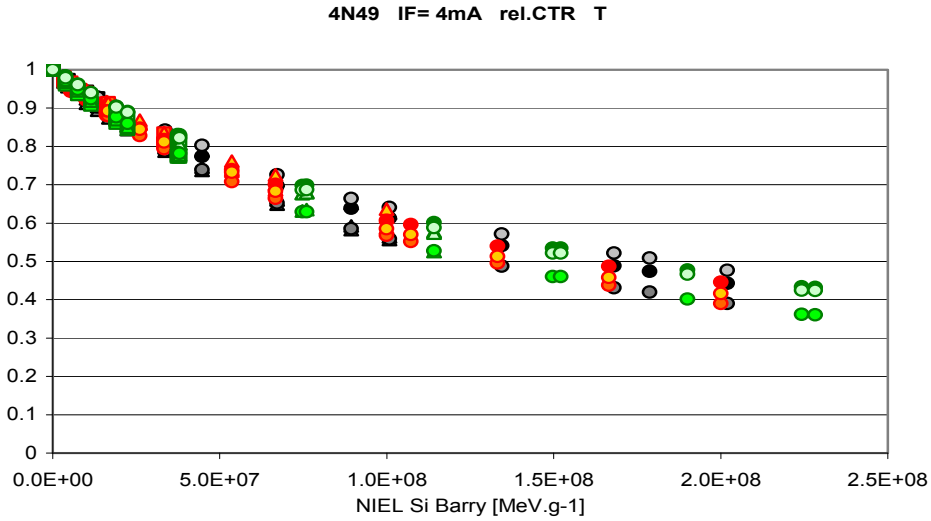
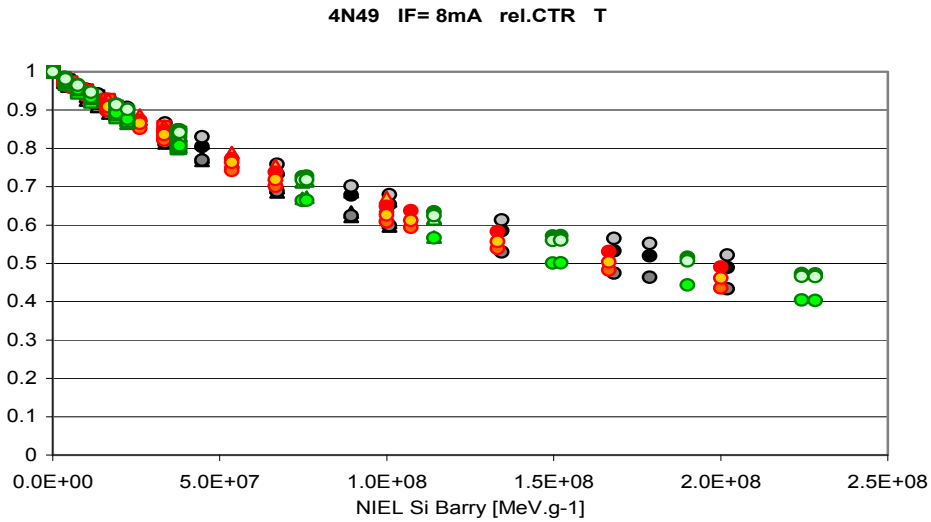


Fig. 12-22: 4N49 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)








4N49 IF= 8mA rel.CTR T
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

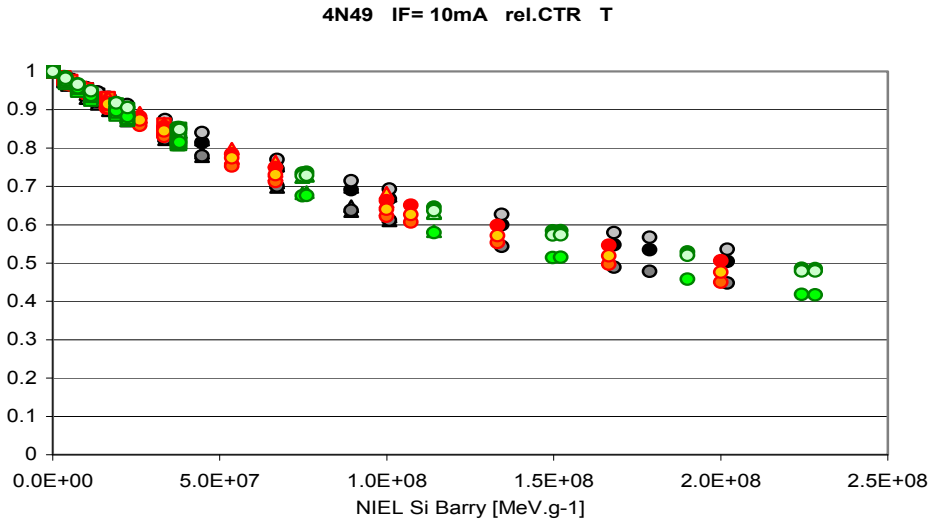
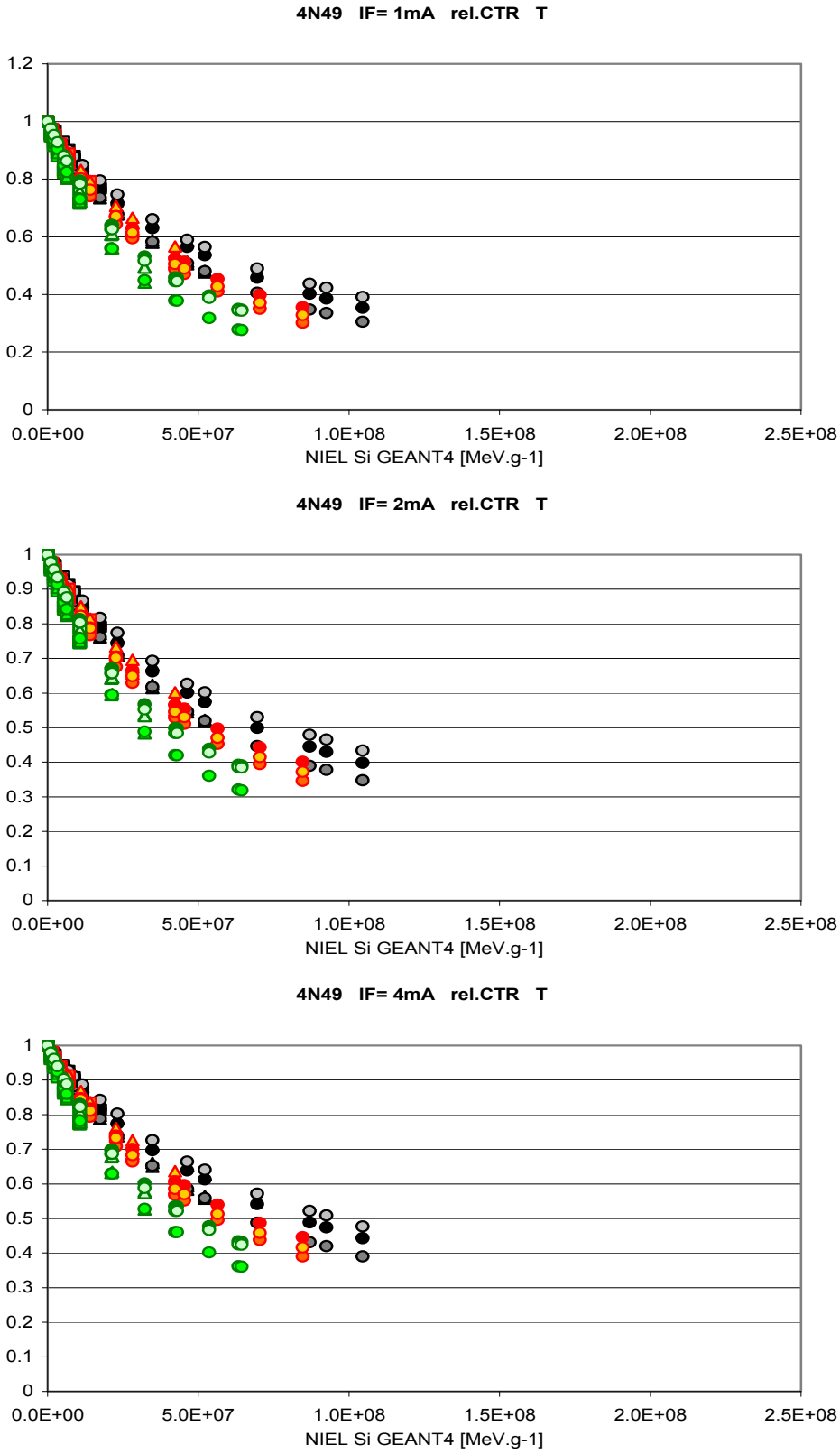
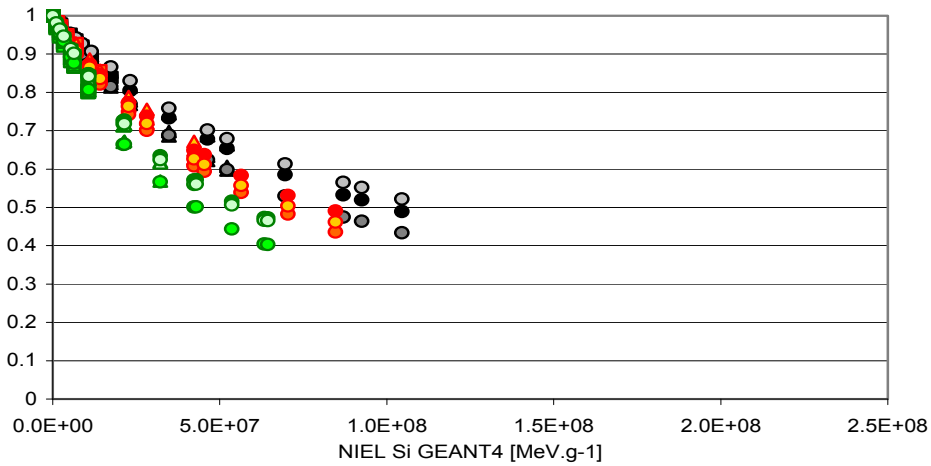

4N49 IF= 10mA rel.CTR T
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 12-23: 4N49 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)



4N49 IF= 8mA rel.CTR T



4N49 IF= 10mA rel.CTR T

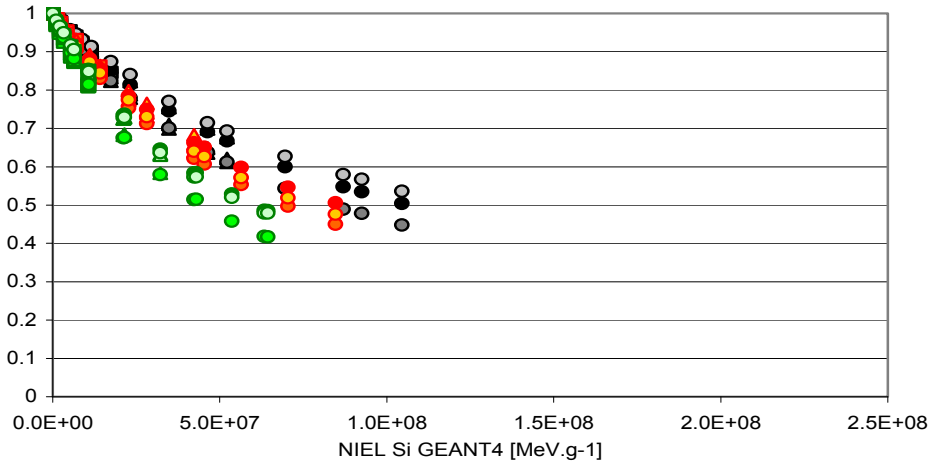
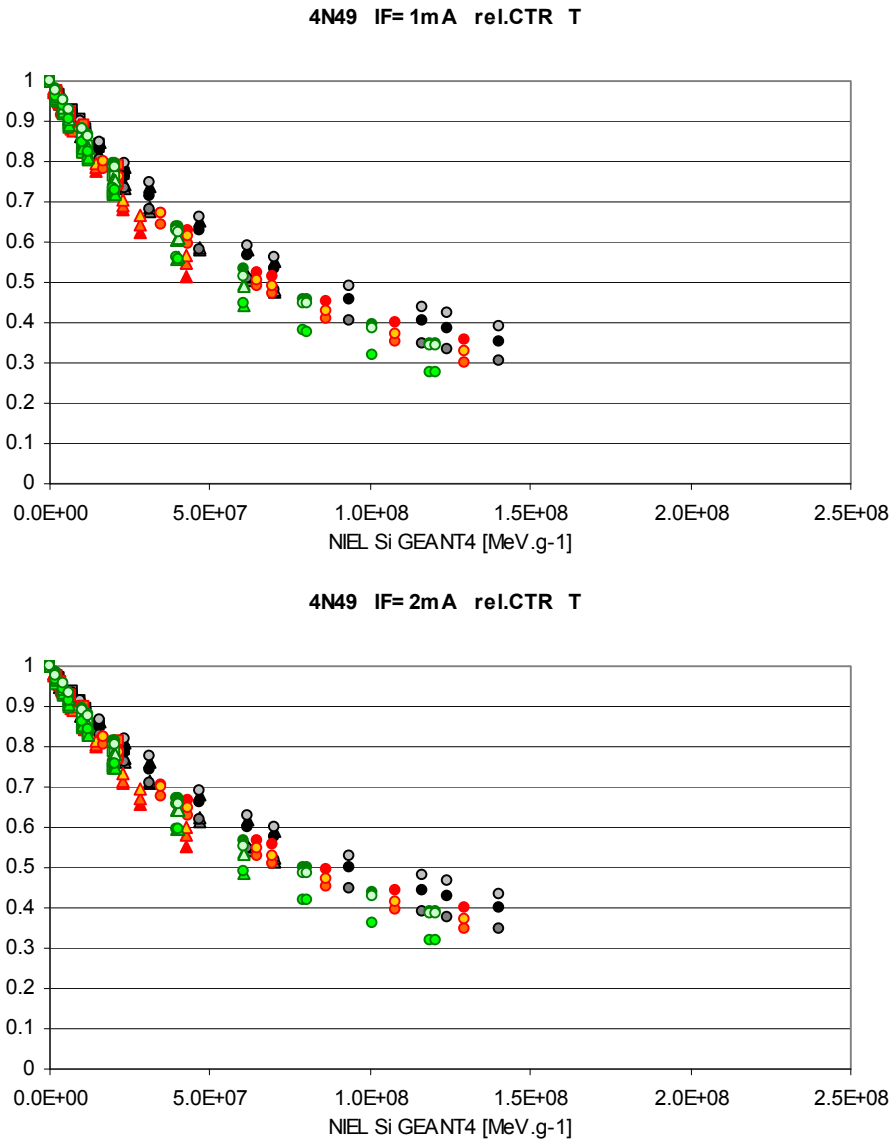
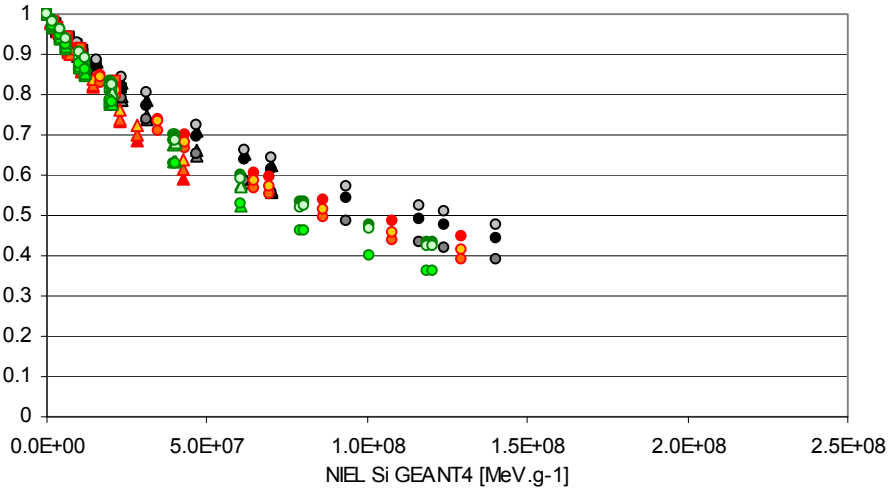


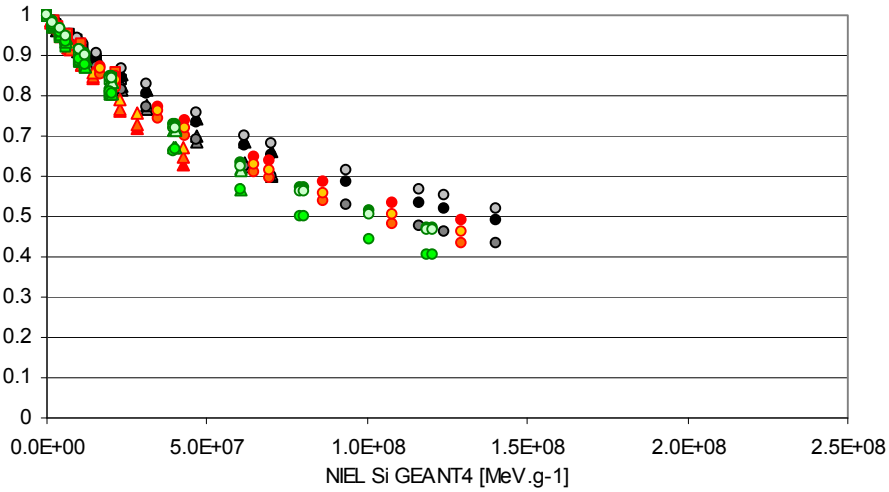
Fig. 12-24: 4N49 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)



4N49 IF= 4mA rel.CTR T



4N49 IF= 8mA rel.CTR T



4N49 IF= 10mA rel.CTR T

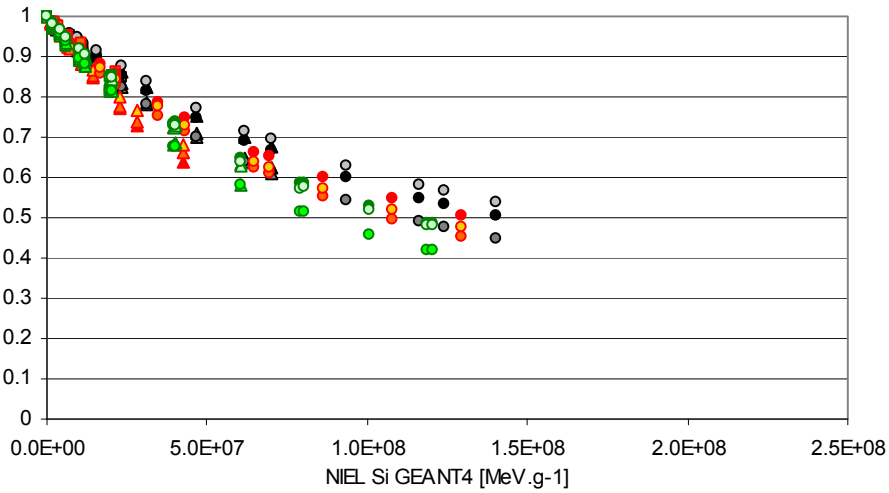
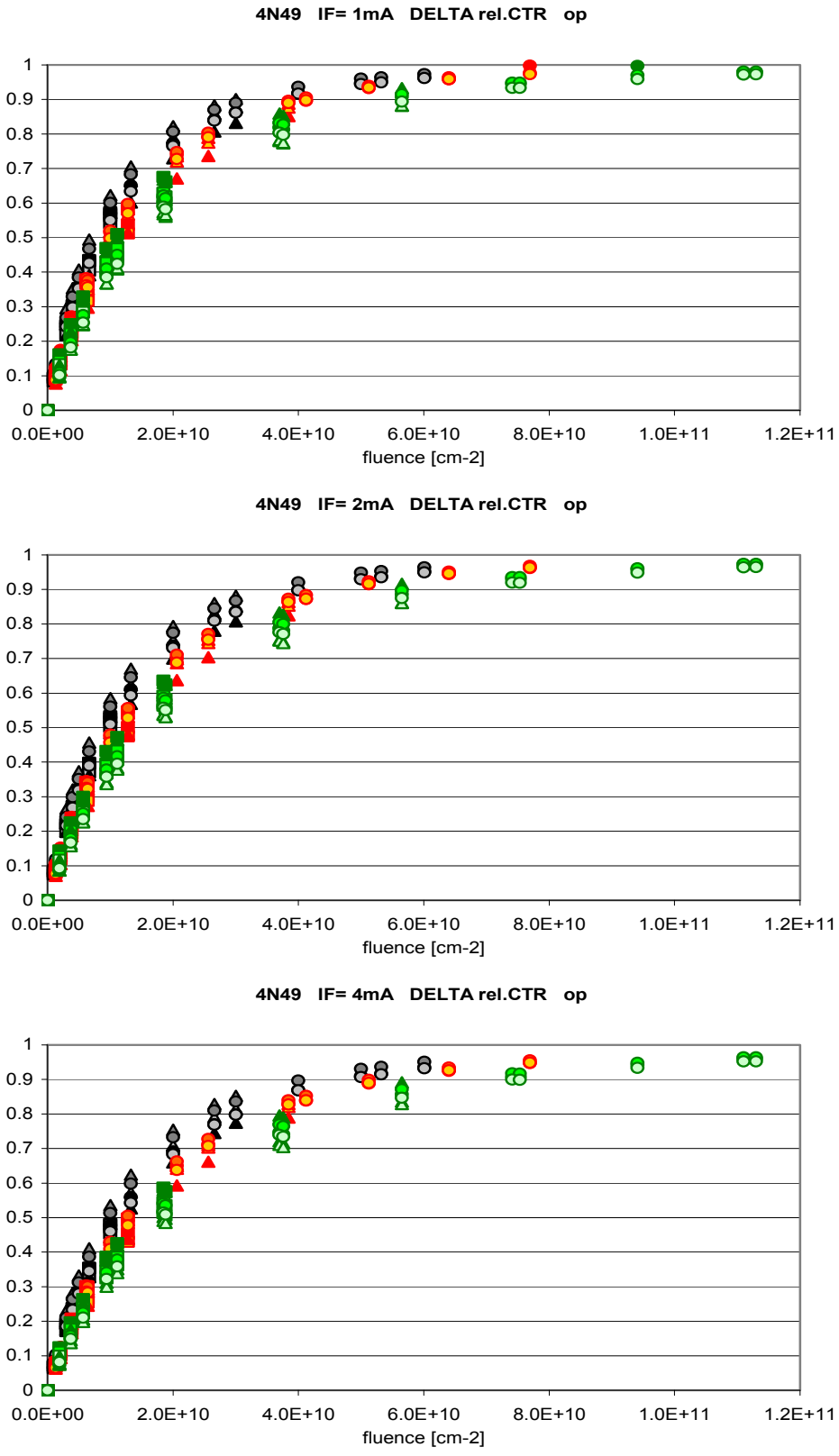
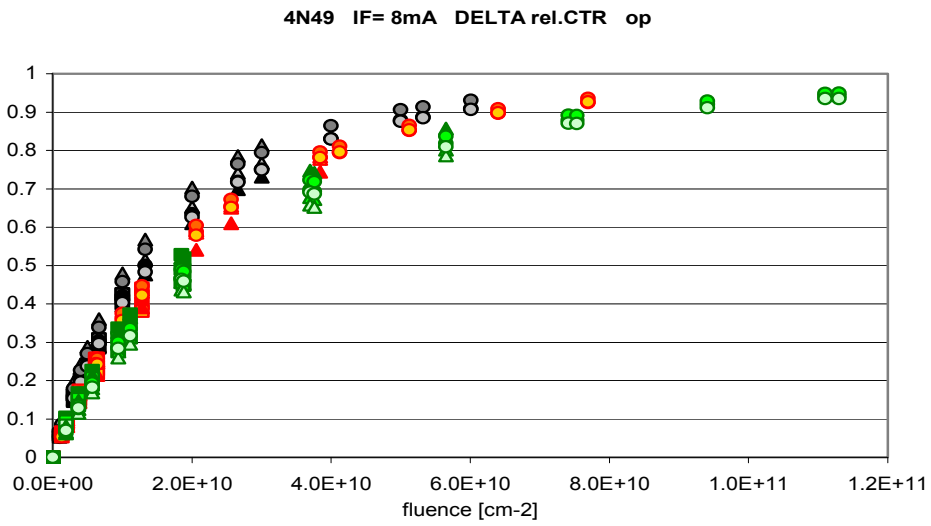


Fig. 12-25: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 IF= 8mA DELTA rel.CTR op
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

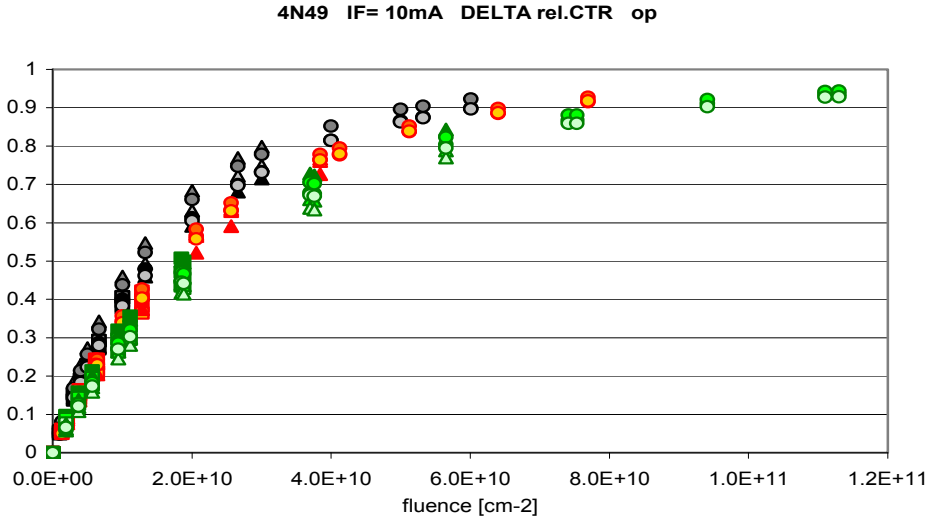
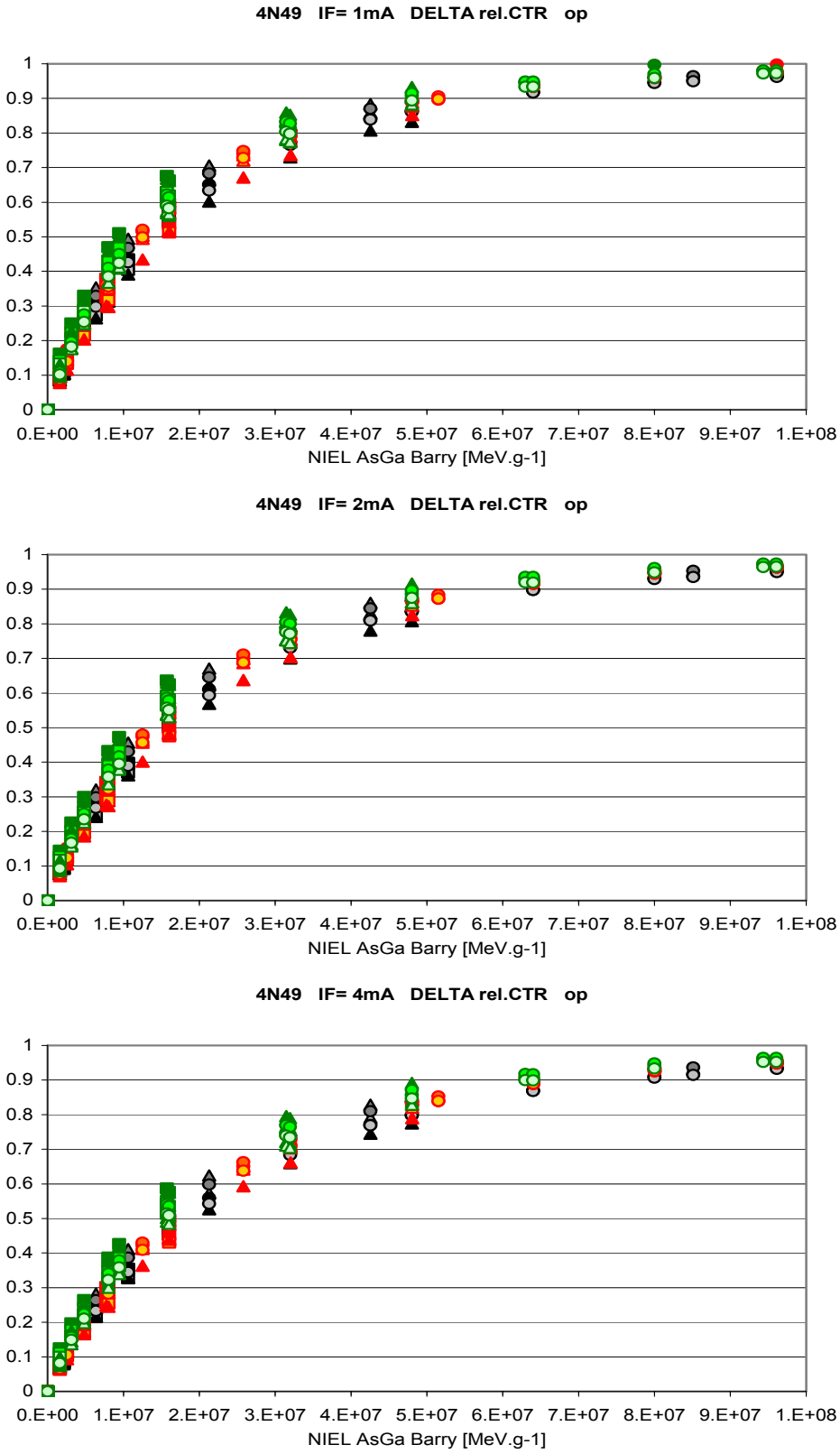
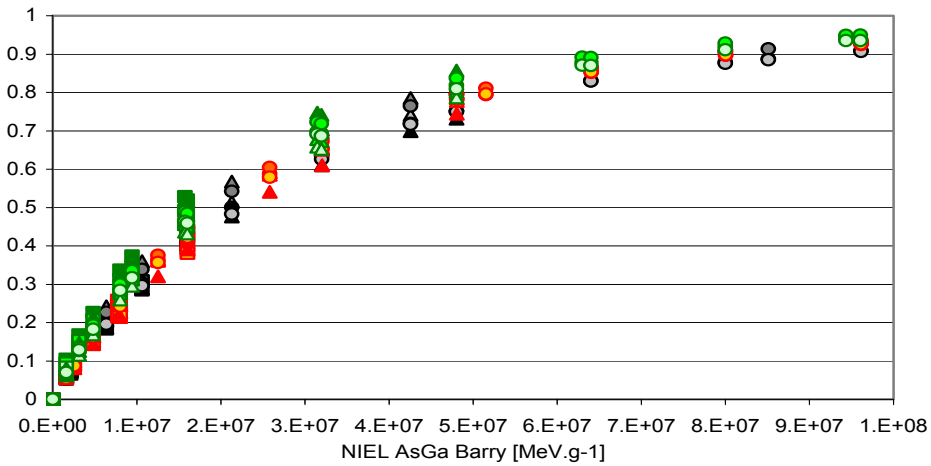

4N49 IF= 10mA DELTA rel.CTR op
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 12-26: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



4N49 IF= 8mA DELTA rel.CTR op



4N49 IF= 10mA DELTA rel.CTR op

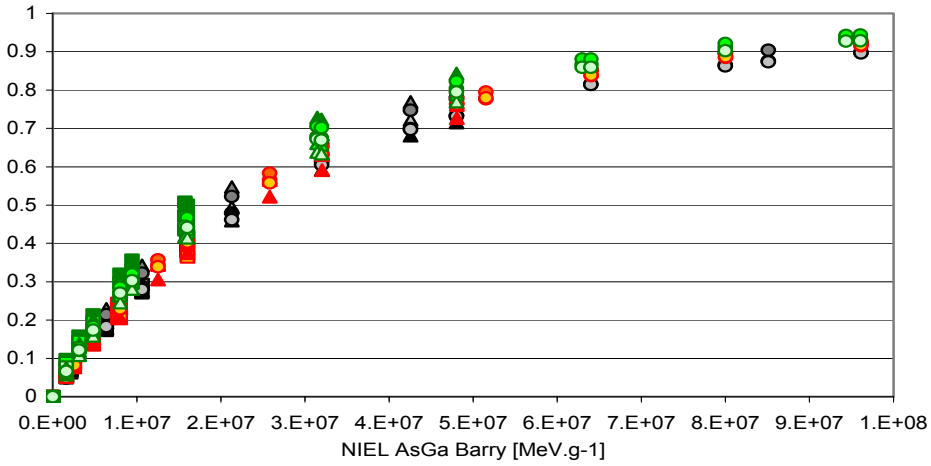
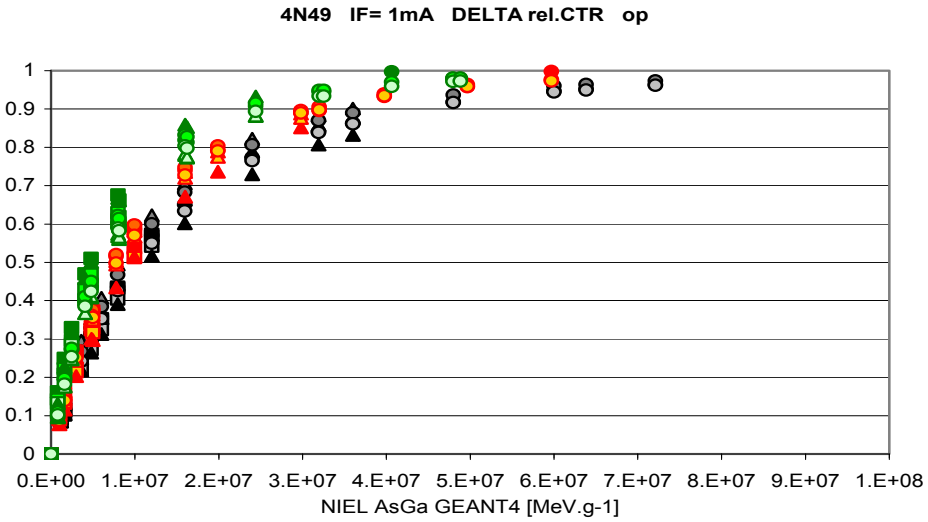
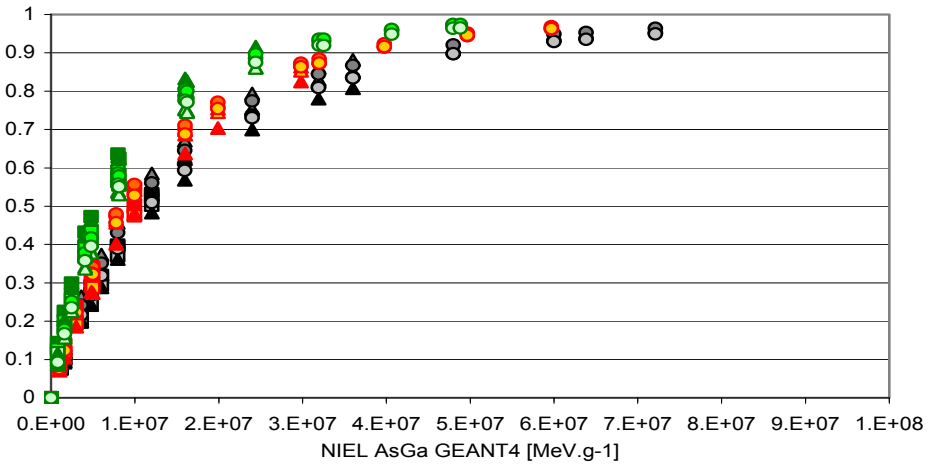
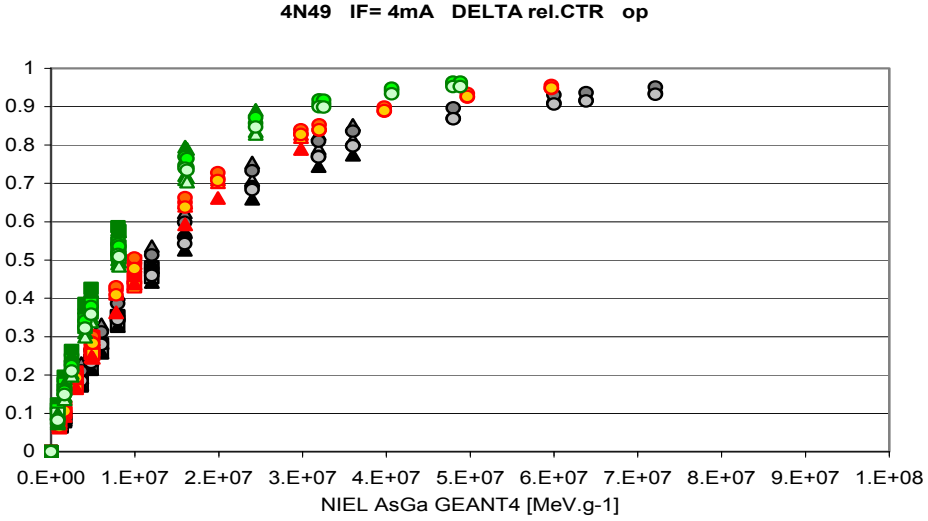


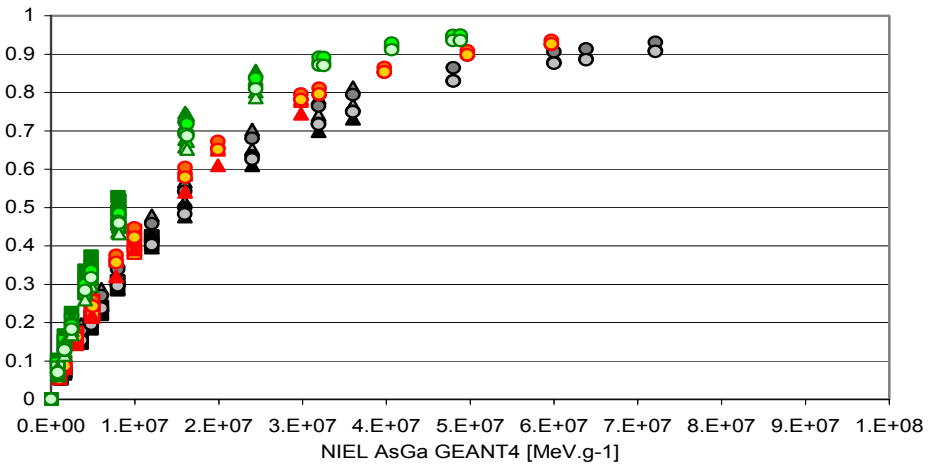
Fig. 12-27: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







4N49 IF= 8mA DELTA rel.CTR op



4N49 IF= 10mA DELTA rel.CTR op

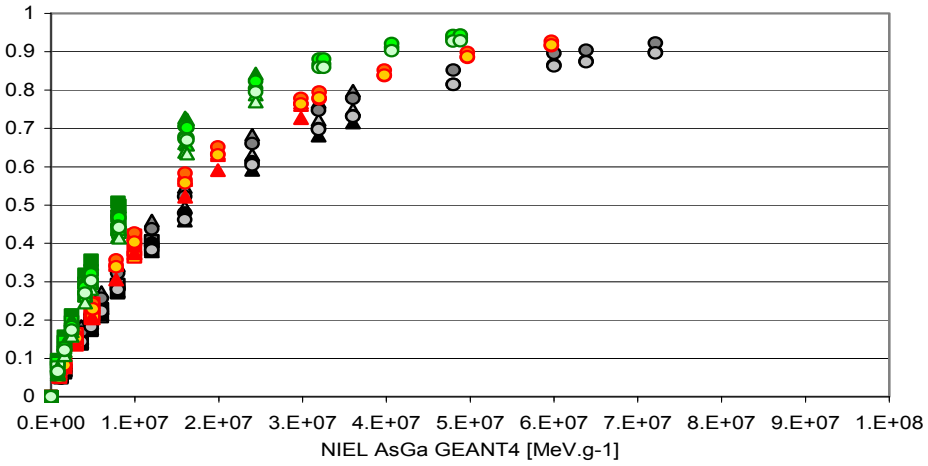
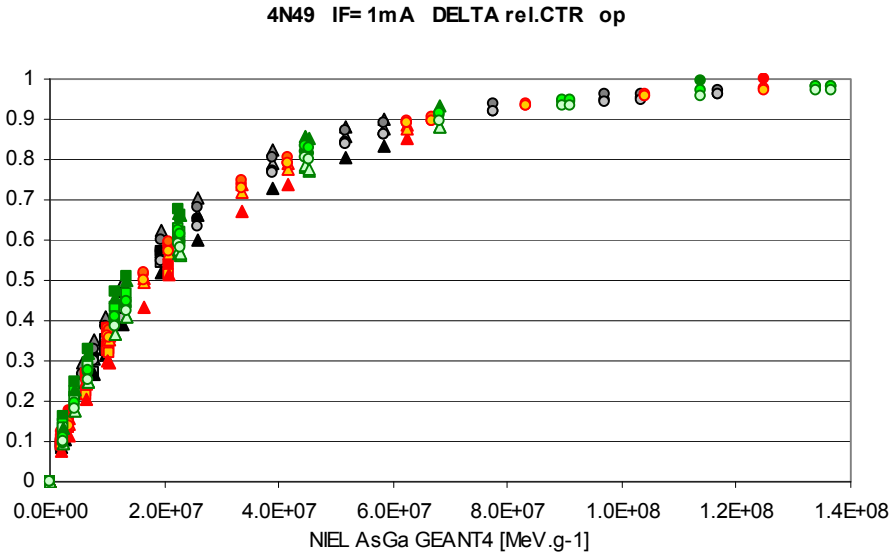
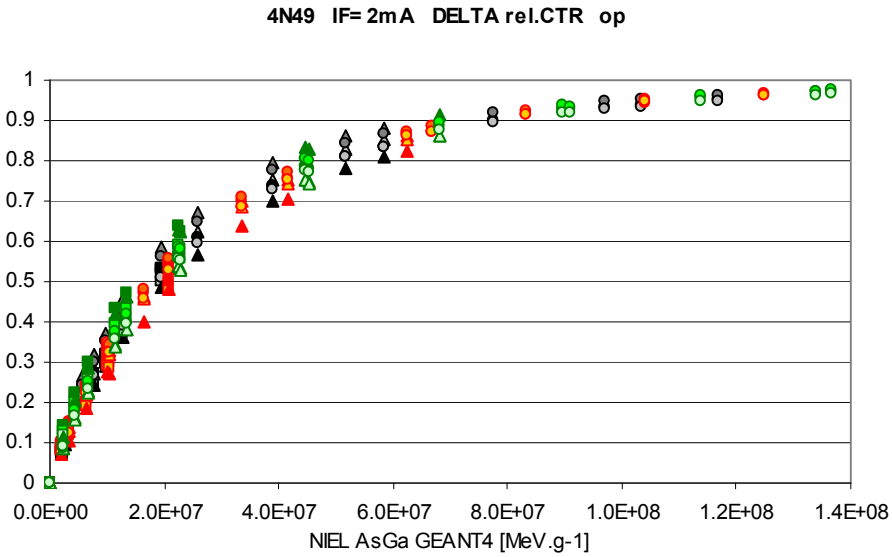
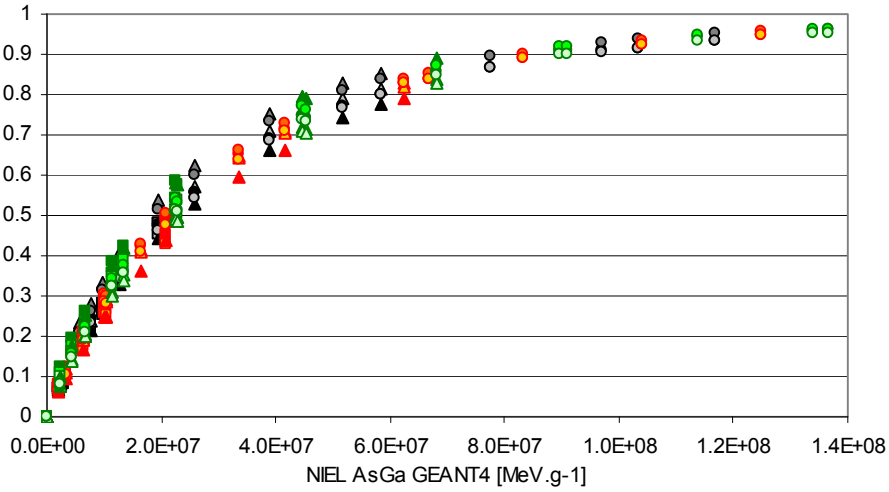


Fig. 12-28: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)

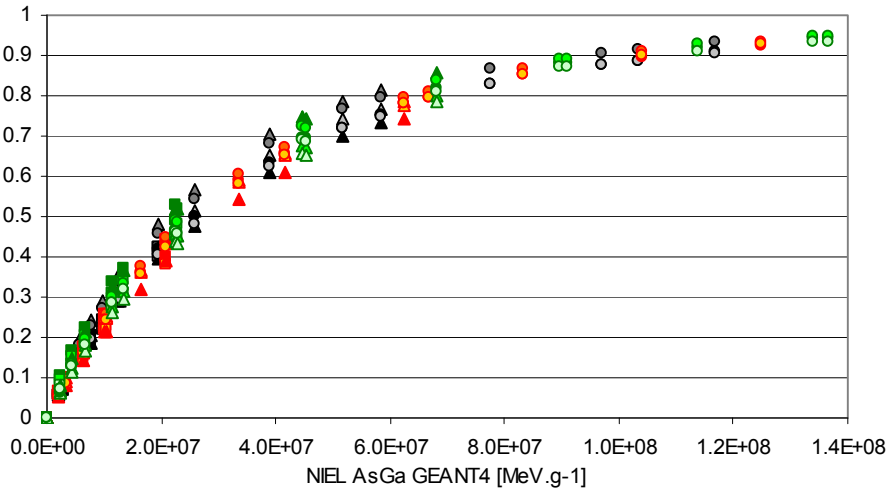




4N49 IF= 4mA DELTA rel.CTR op



4N49 IF= 8mA DELTA rel.CTR op



4N49 IF= 10mA DELTA rel.CTR op

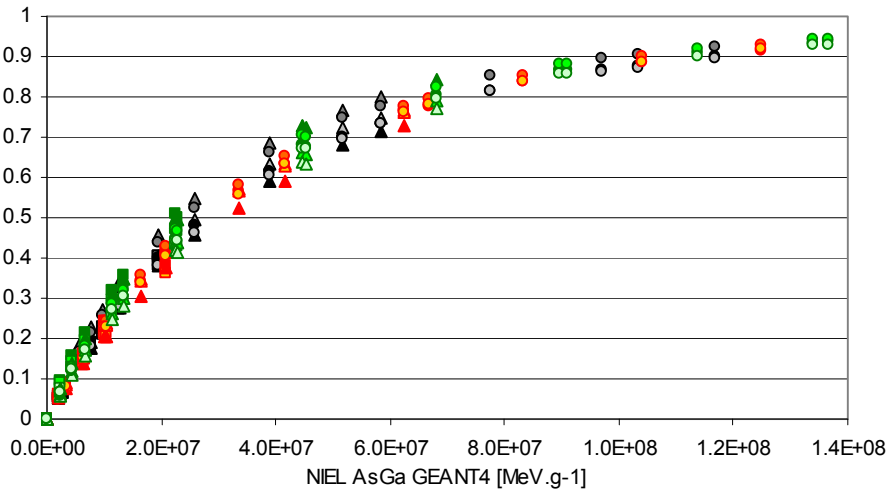
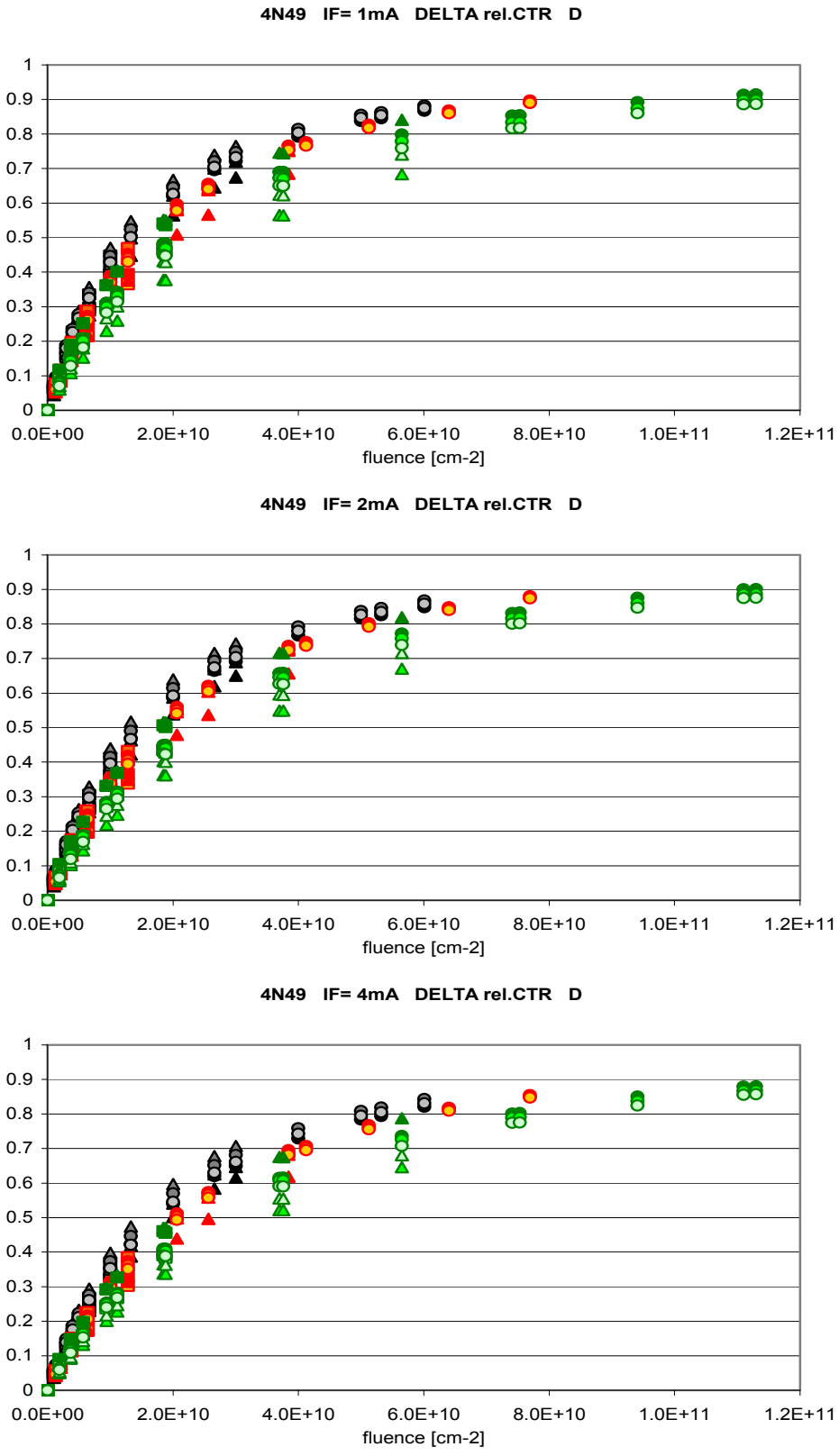
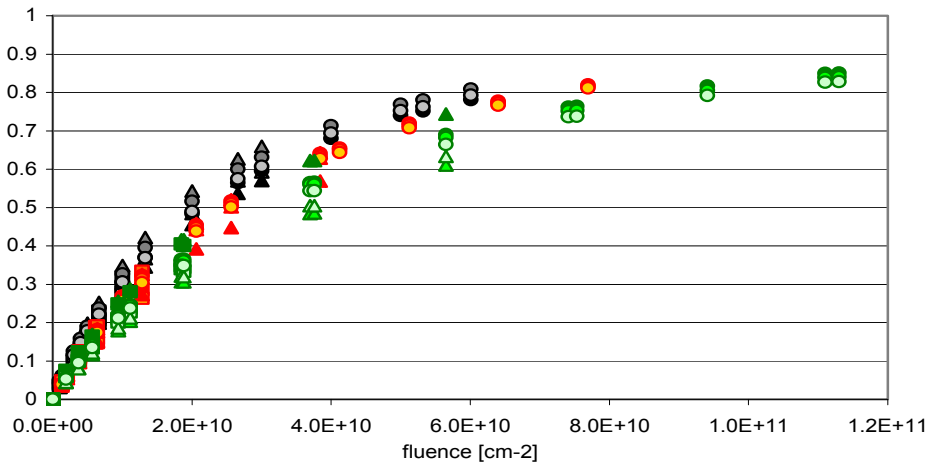


Fig. 12-29: 4N49 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



4N49 IF= 8mA DELTA rel.CTR D



4N49 IF= 10mA DELTA rel.CTR D

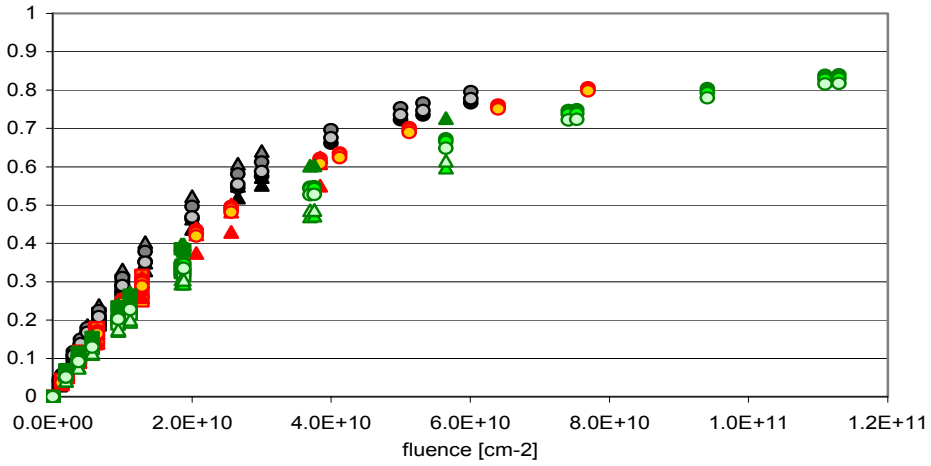
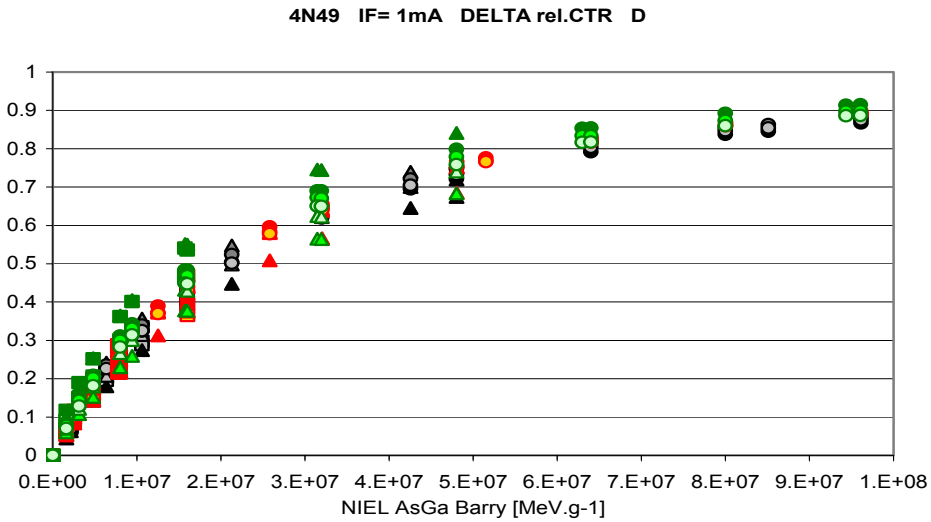
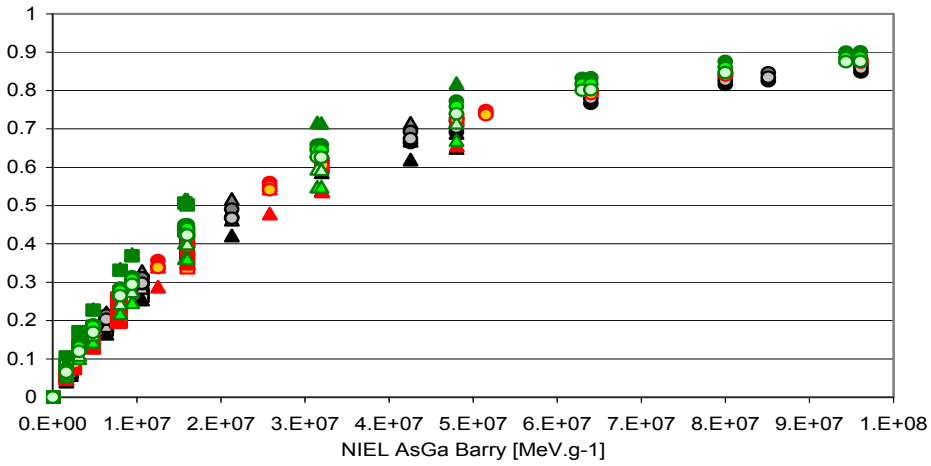
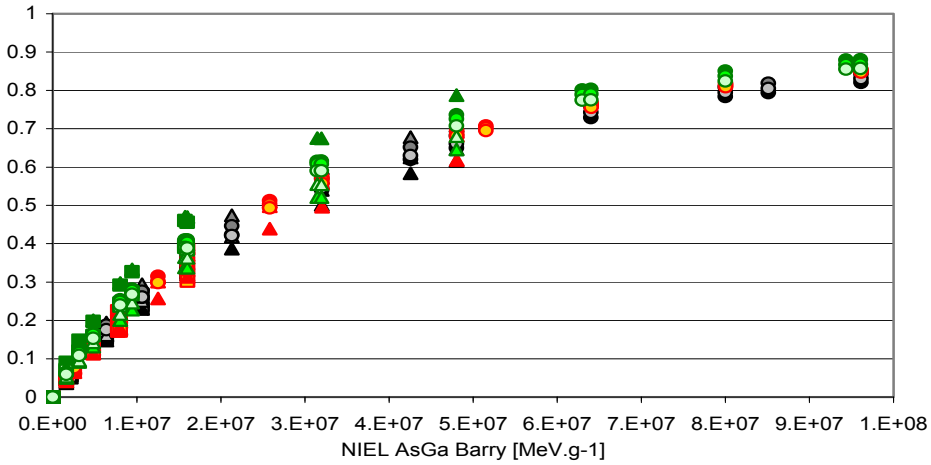


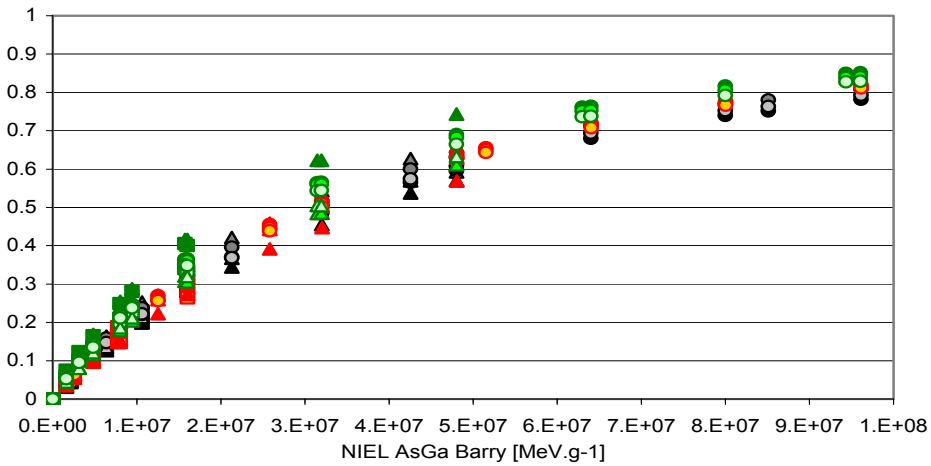
Fig. 12-30: 4N49 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







4N49 IF= 8mA DELTA rel.CTR D



4N49 IF= 10mA DELTA rel.CTR D

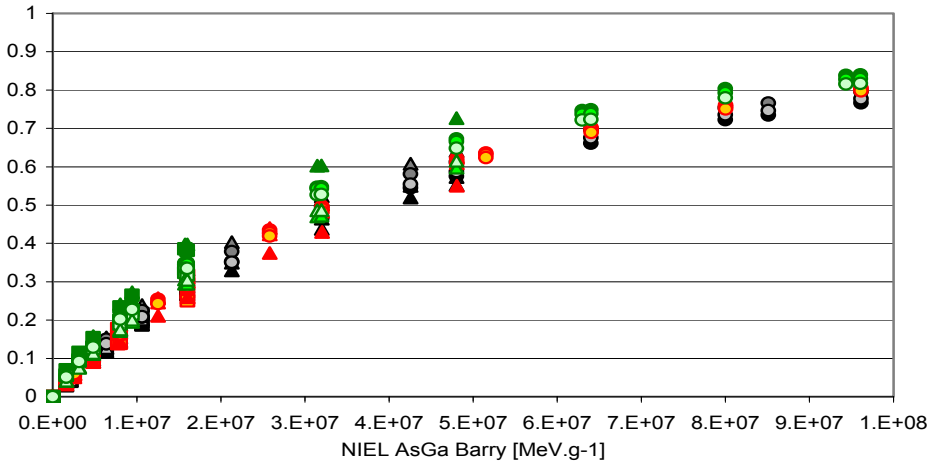
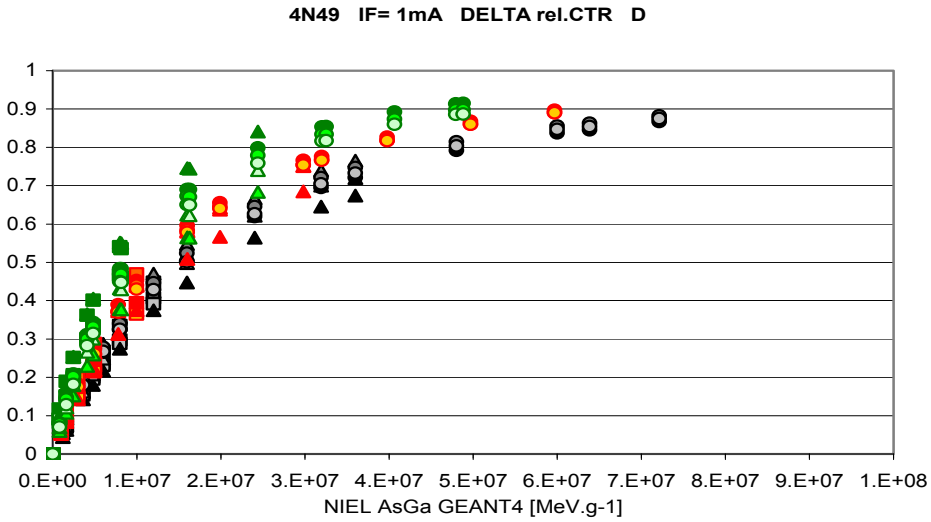
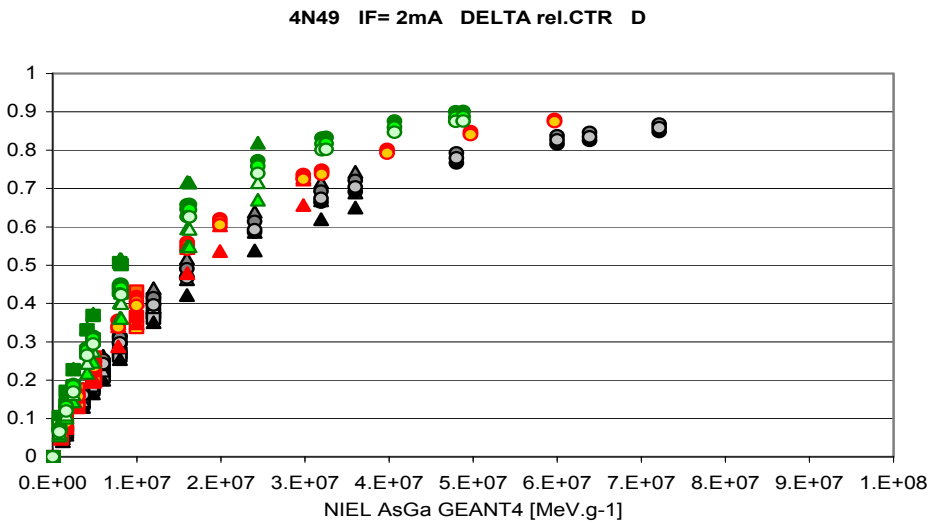
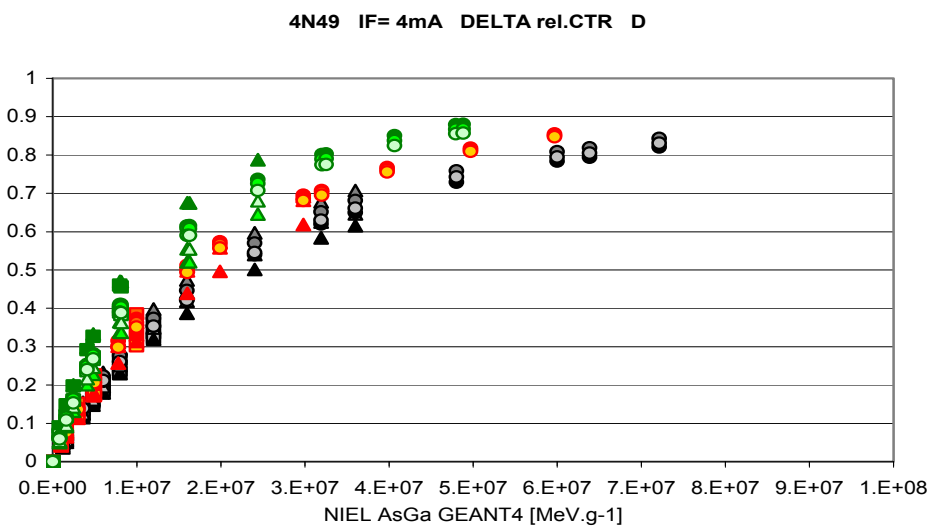


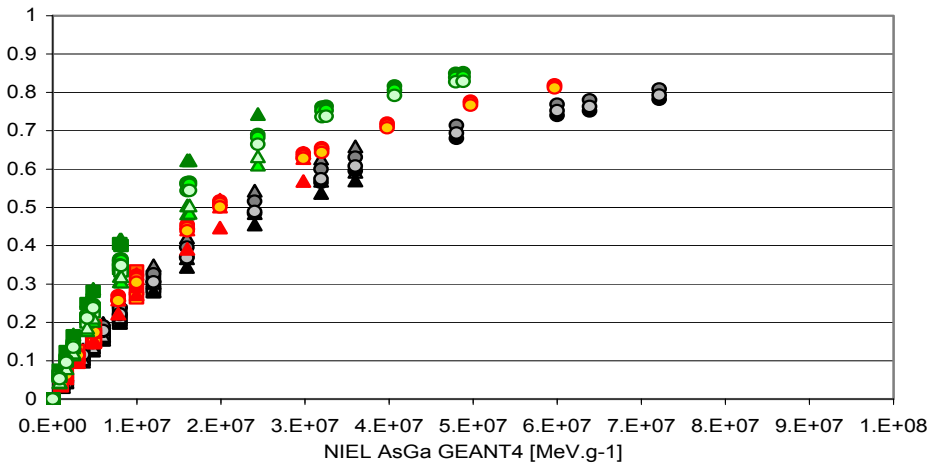
Fig. 12-31: 4N49 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







4N49 IF= 8mA DELTA rel.CTR D



4N49 IF= 10mA DELTA rel.CTR D

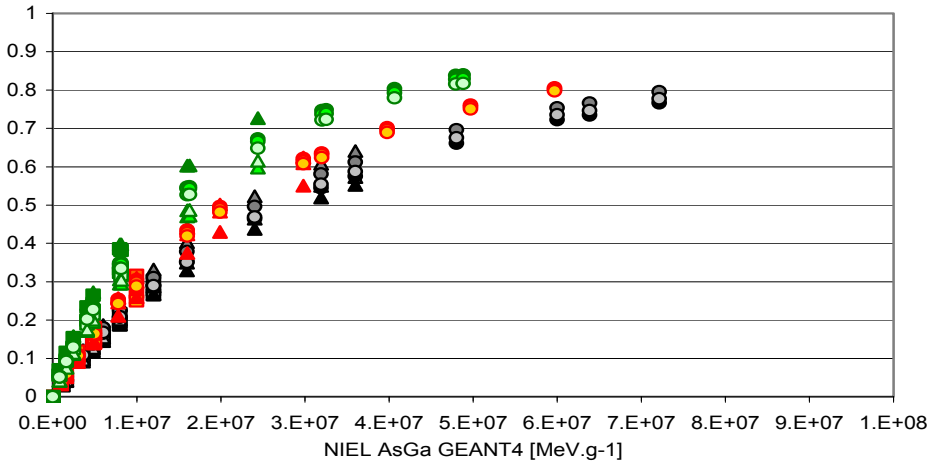
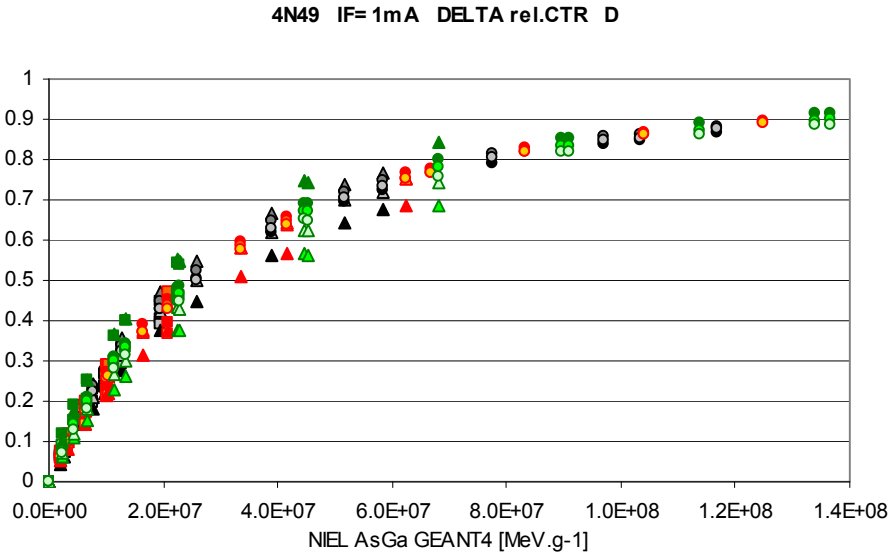
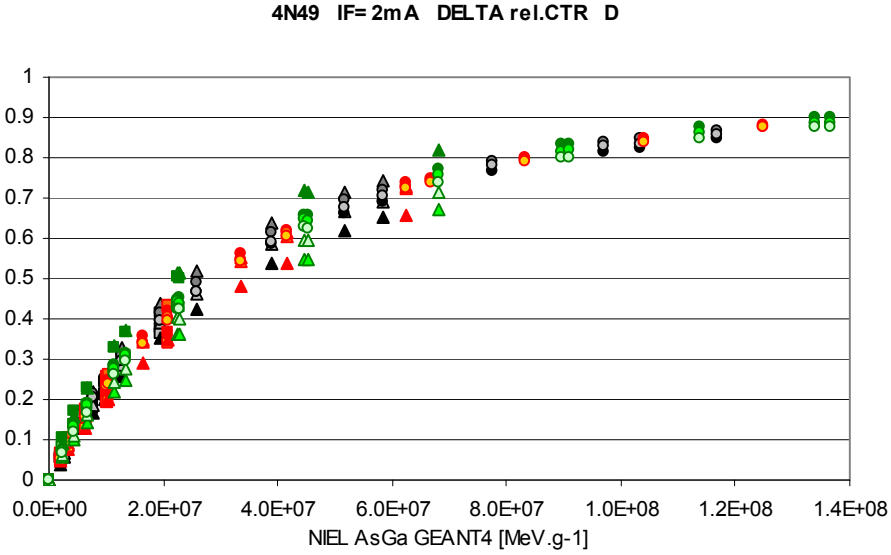
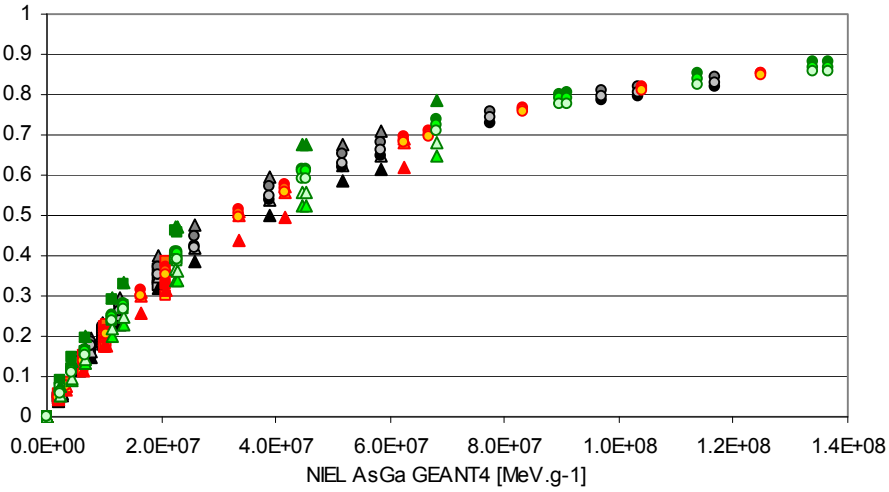


Fig. 12-32: 4N49 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)

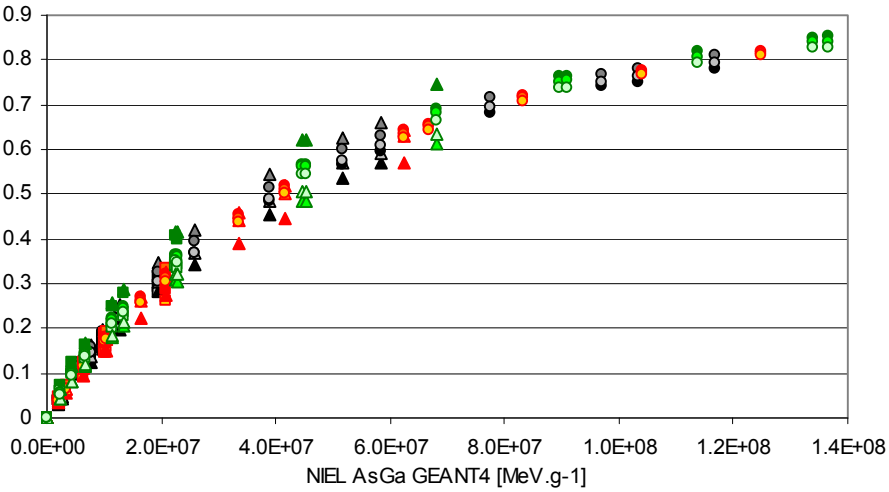




4N49 IF= 4mA DELTA rel.CTR D



4N49 IF= 8mA DELTA rel.CTR D



4N49 IF= 10mA DELTA rel.CTR D

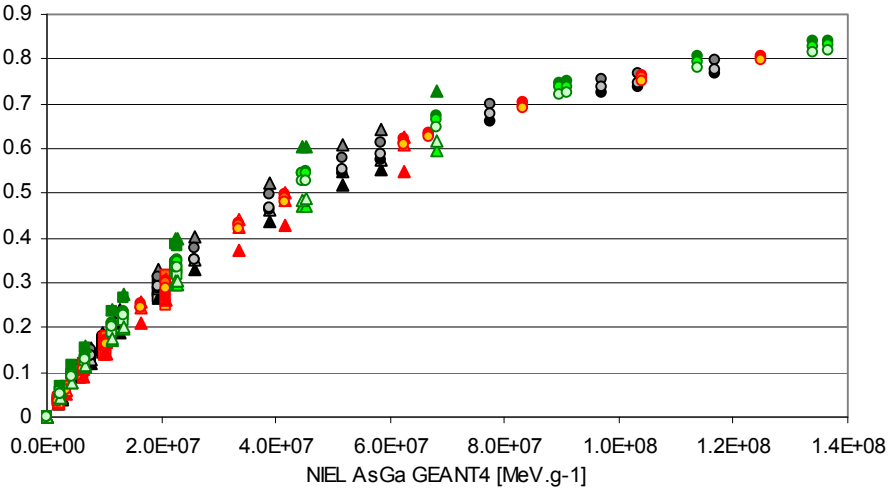
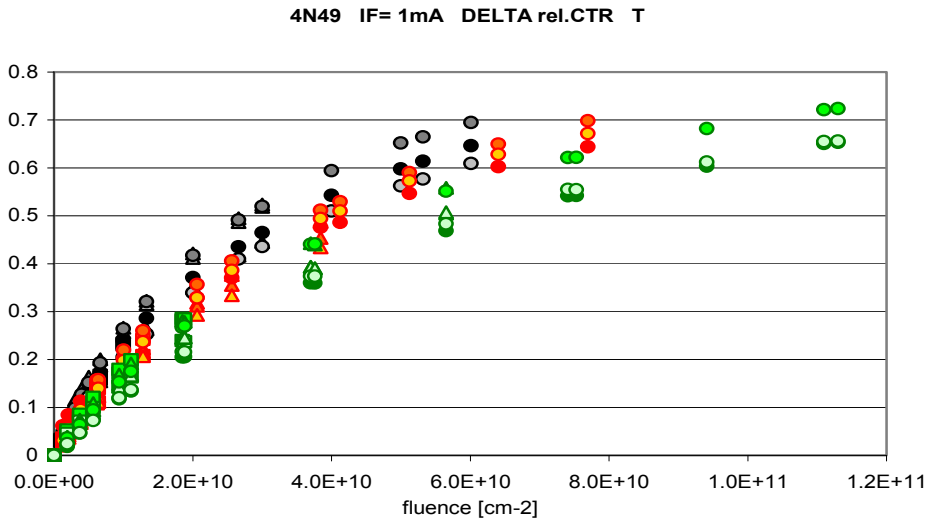
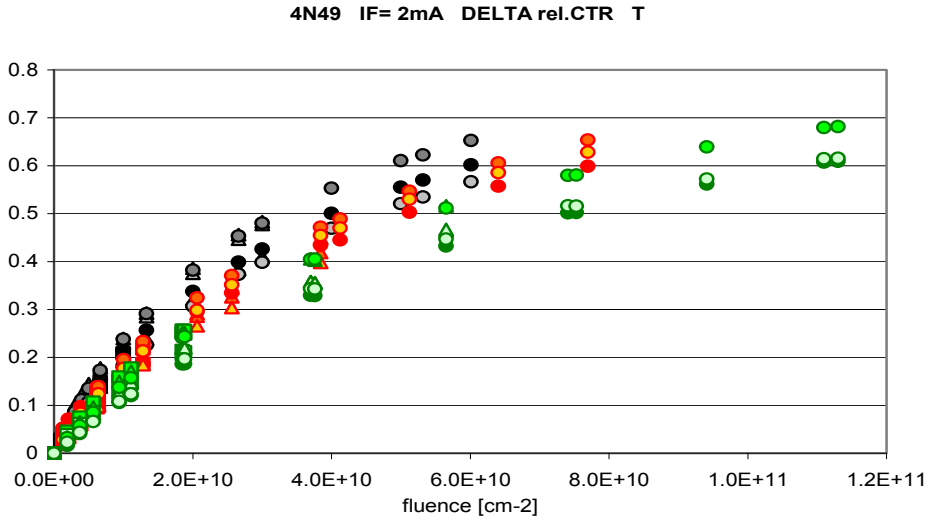
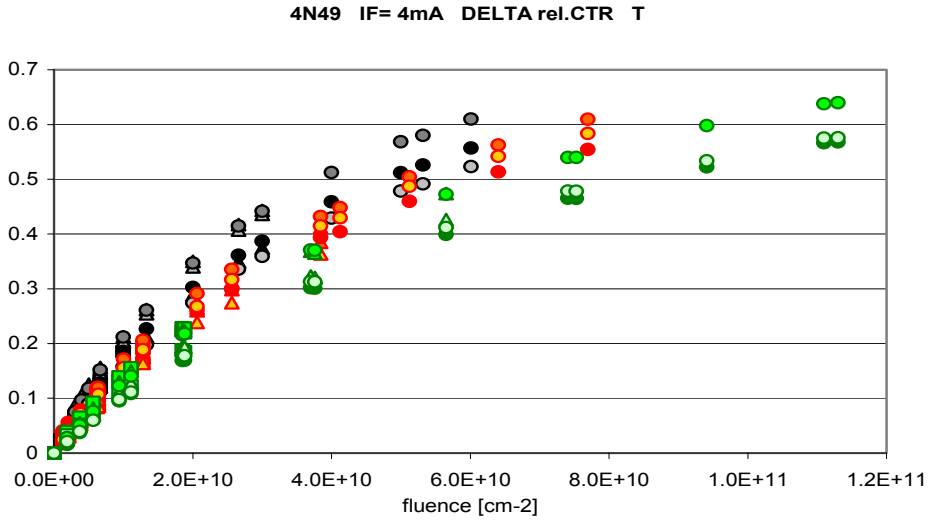


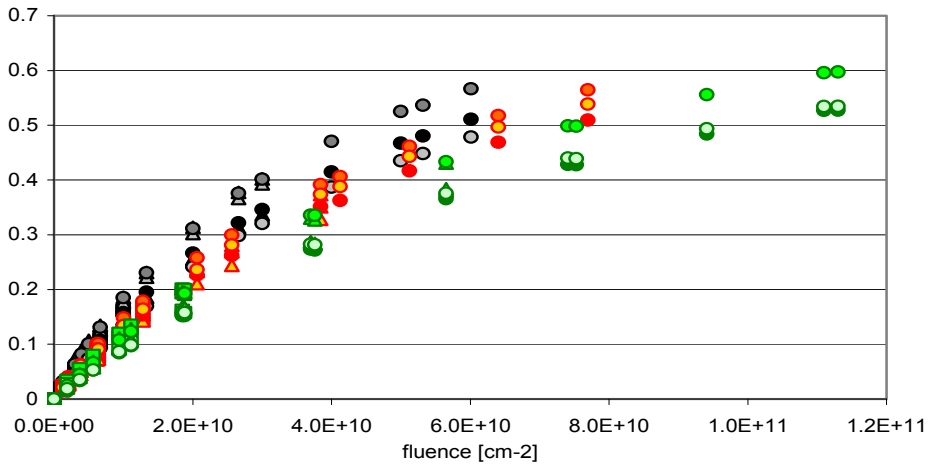
Fig. 12-33: 4N49 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







4N49 IF= 8mA DELTA rel.CTR T



4N49 IF= 10mA DELTA rel.CTR T

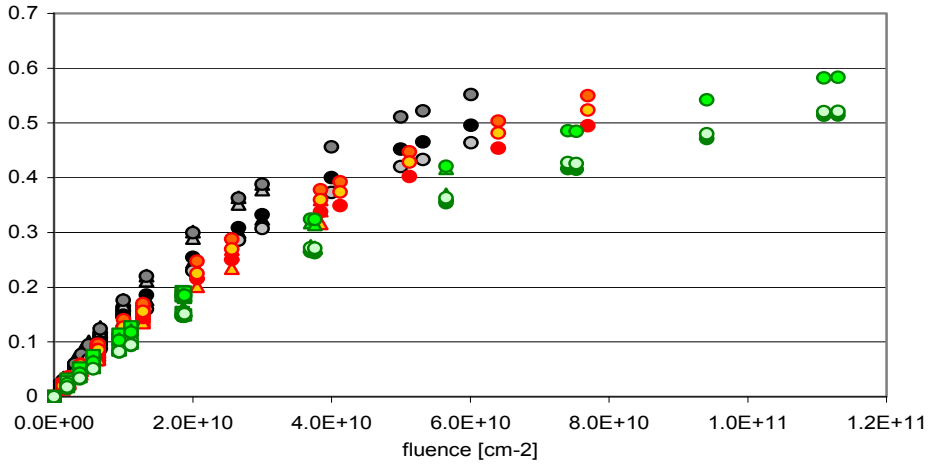
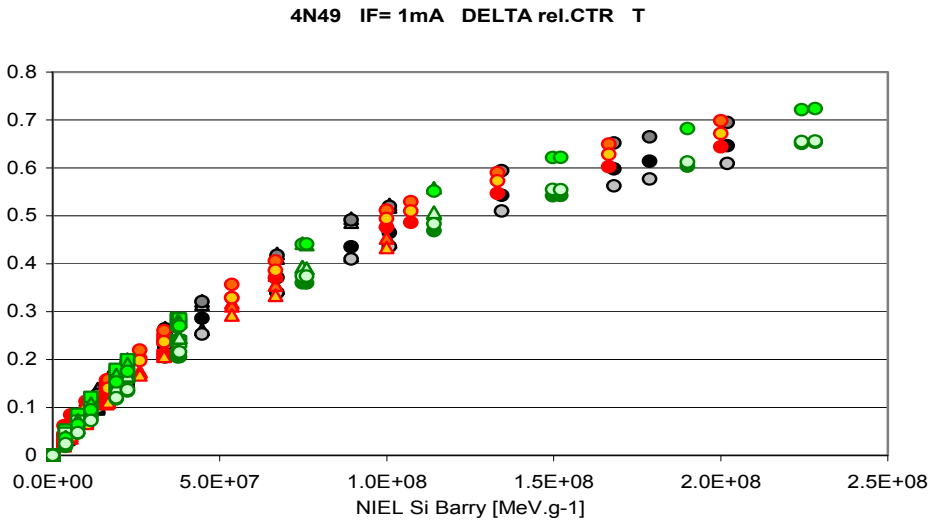
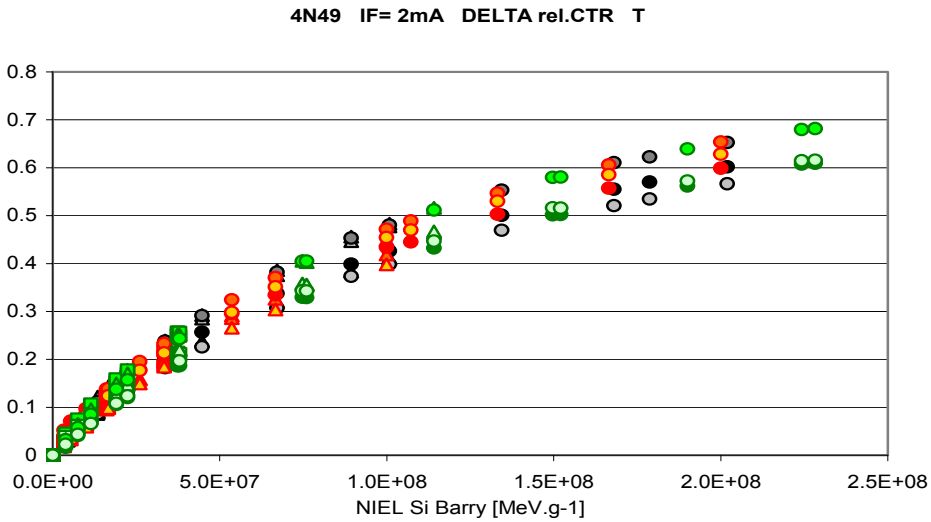
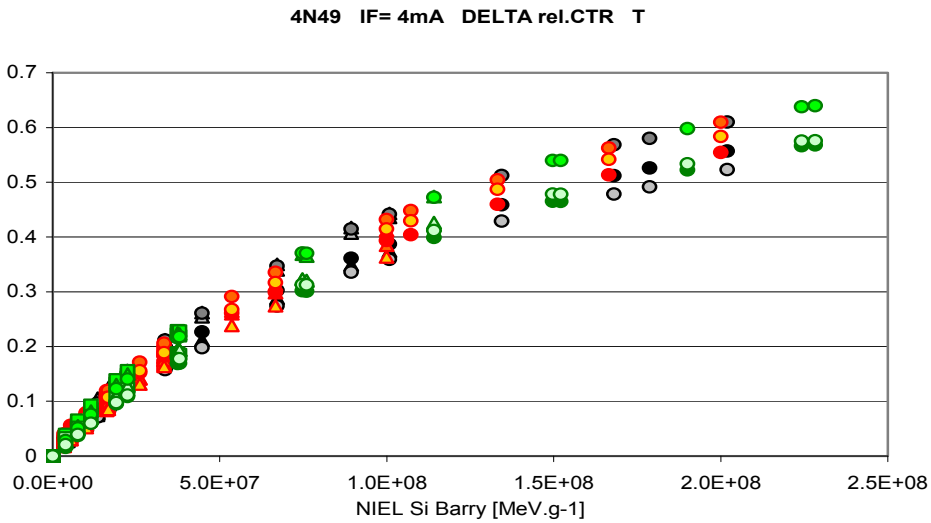


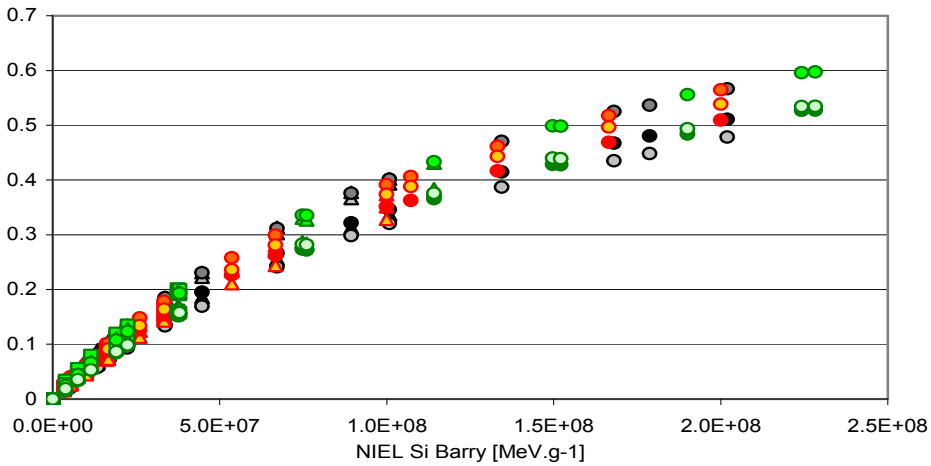
Fig. 12-34: 4N49 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)







4N49 IF= 8mA DELTA rel.CTR T



4N49 IF= 10mA DELTA rel.CTR T

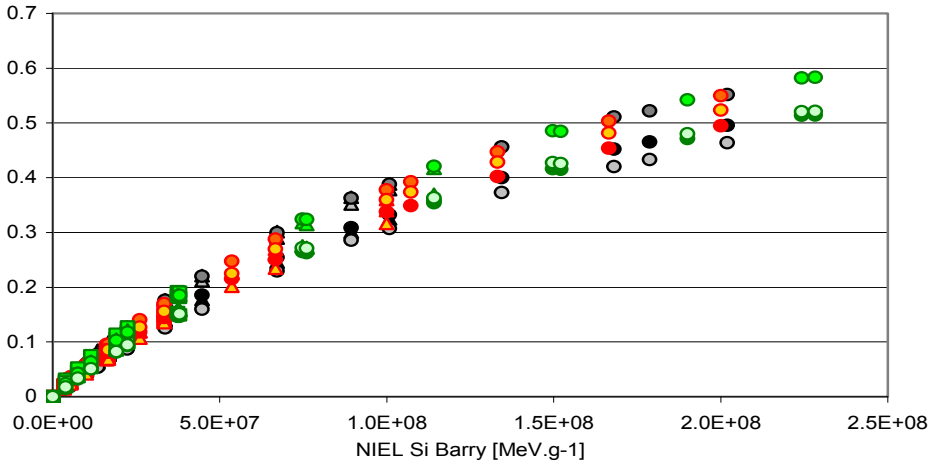
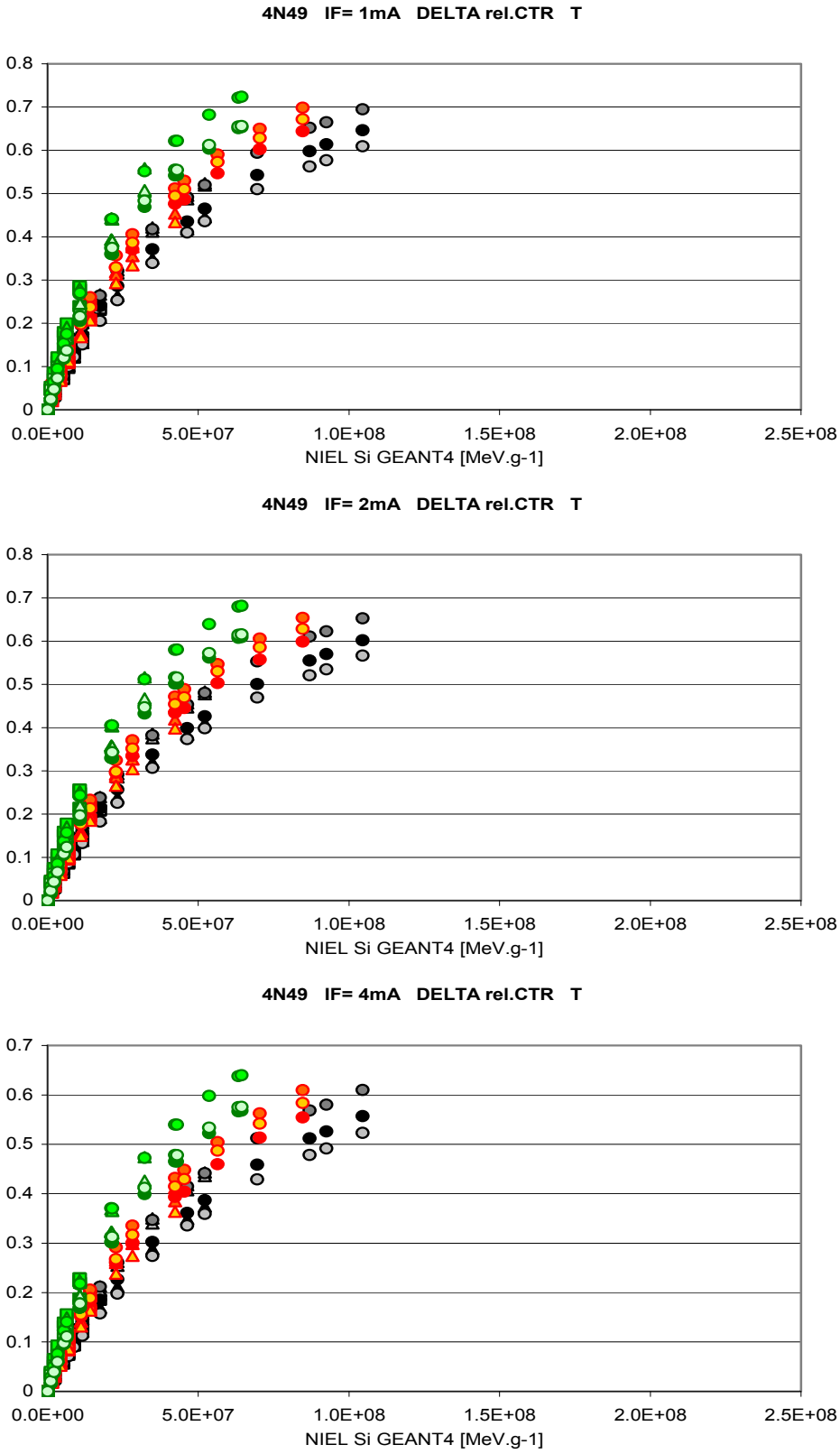
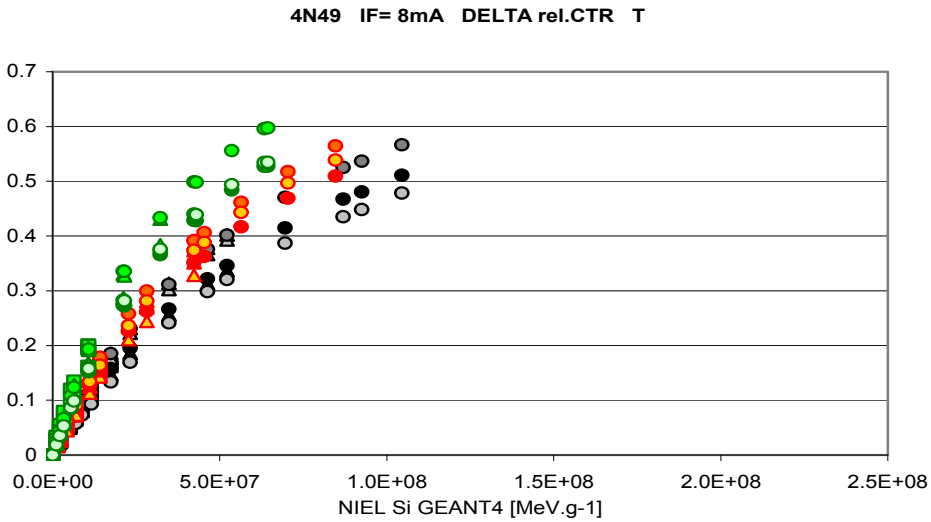


Fig. 12-35: 4N49 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




4N49 IF= 8mA DELTA rel.CTR T
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

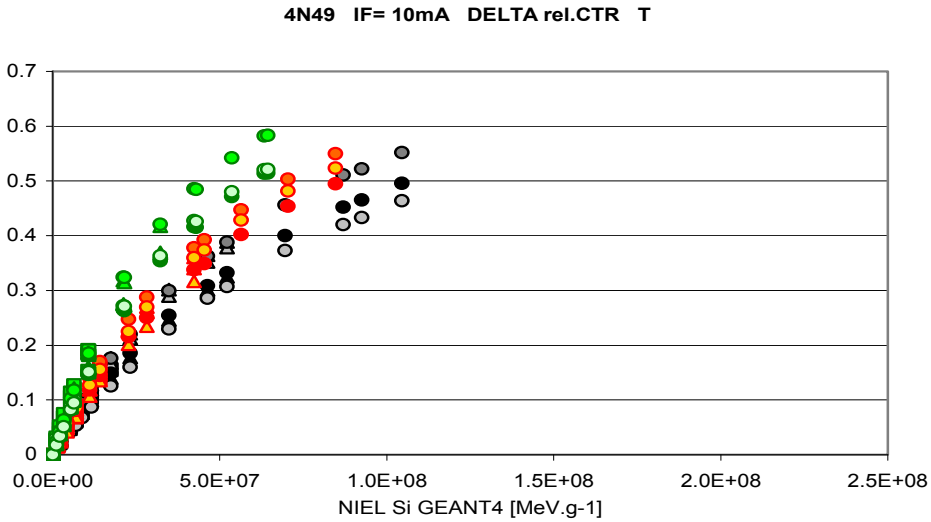
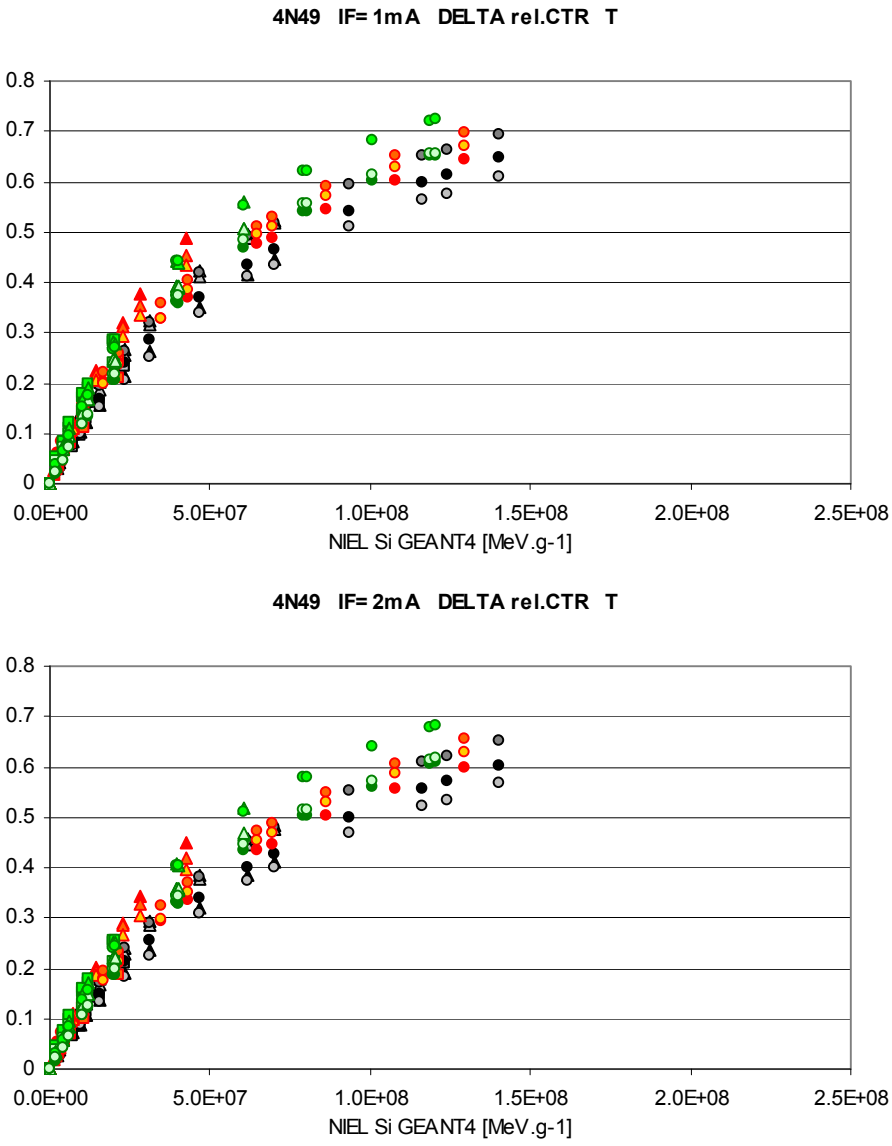
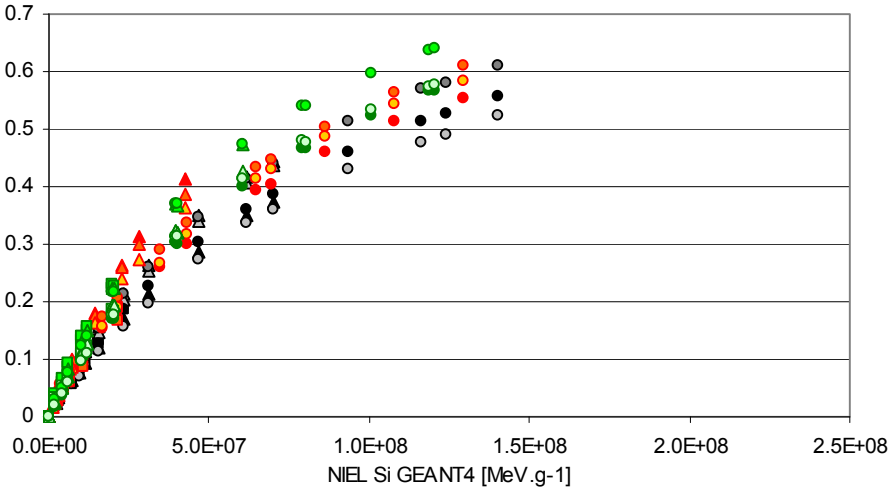

4N49 IF= 10mA DELTA rel.CTR T
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

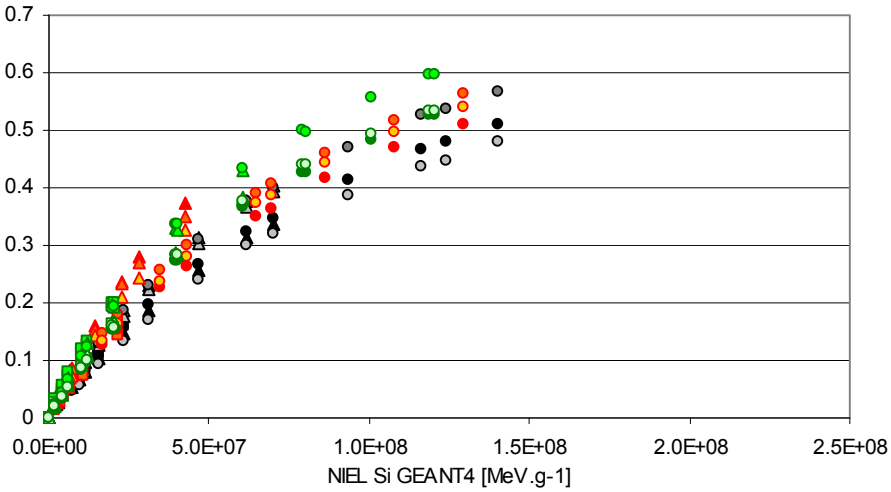
Fig. 12-36: 4N49 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)



4N49 IF= 4mA DELTA rel.CTR T



4N49 IF= 8mA DELTA rel.CTR T



4N49 IF= 10mA DELTA rel.CTR T

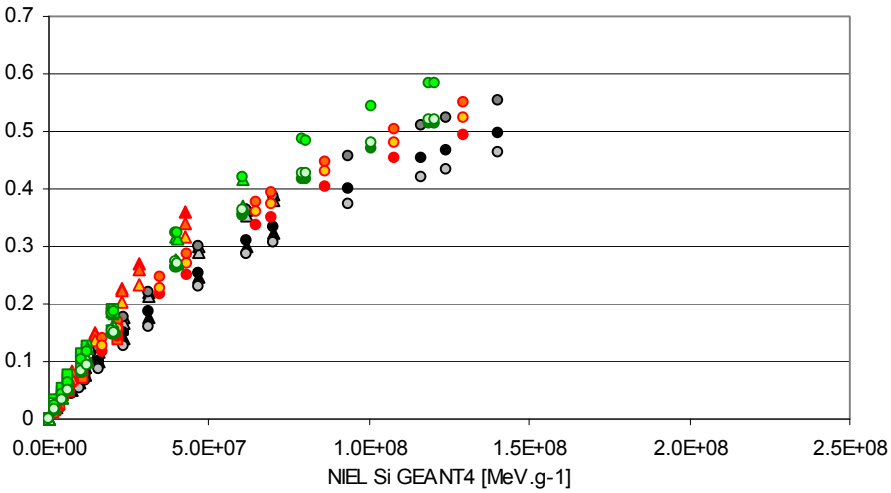
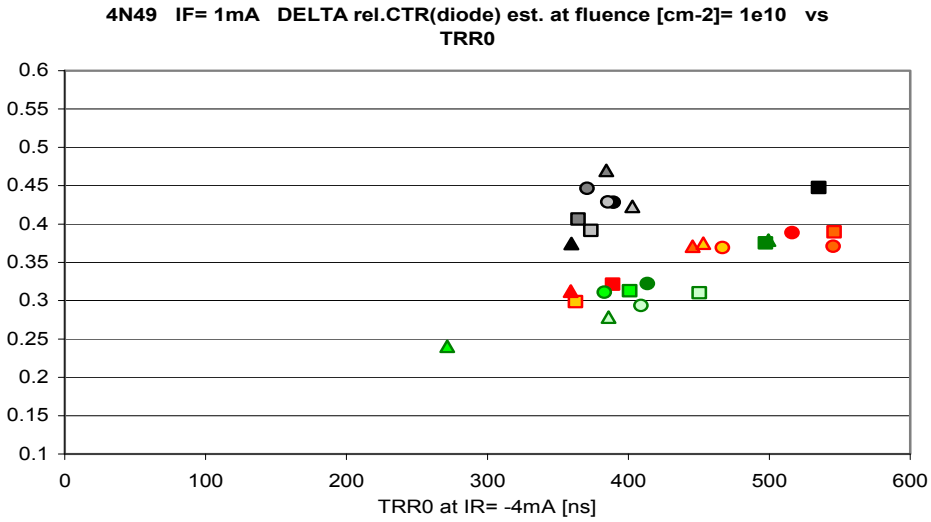
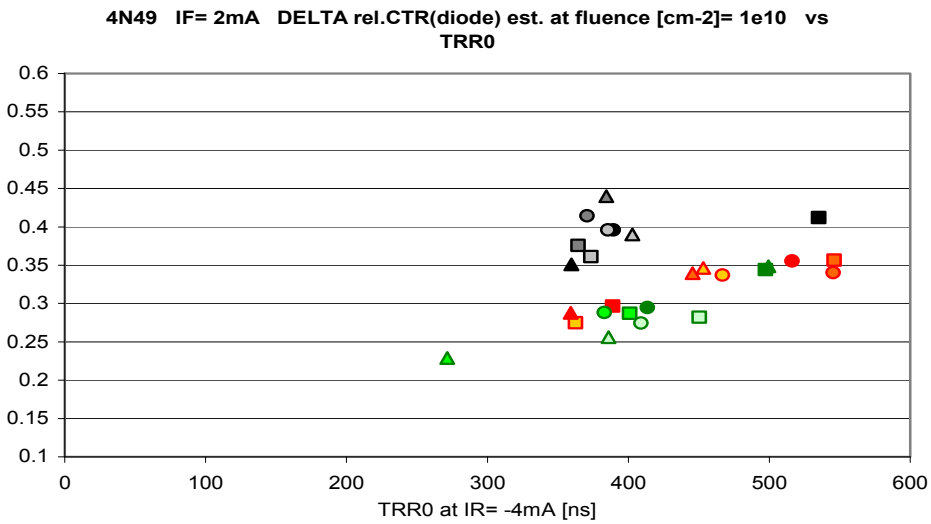
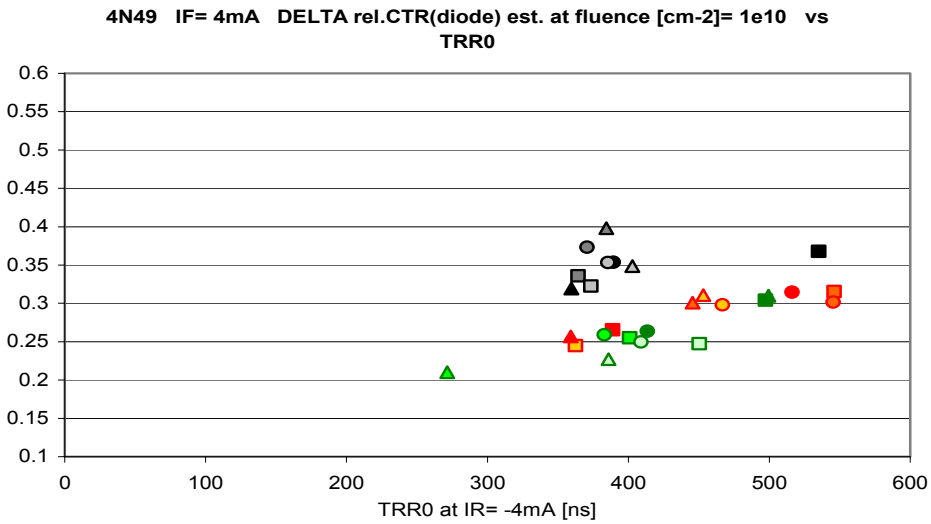
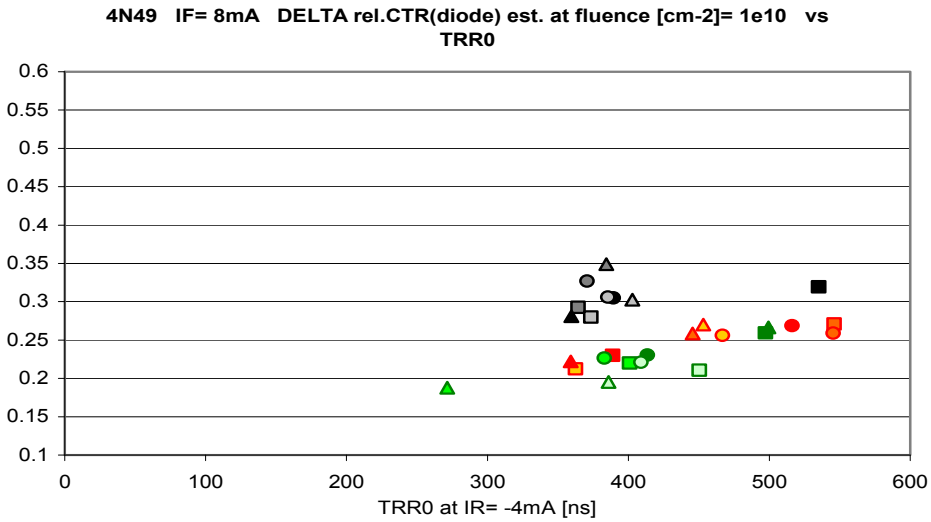


Fig. 12-37: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 1.10^{10} cm^2 at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

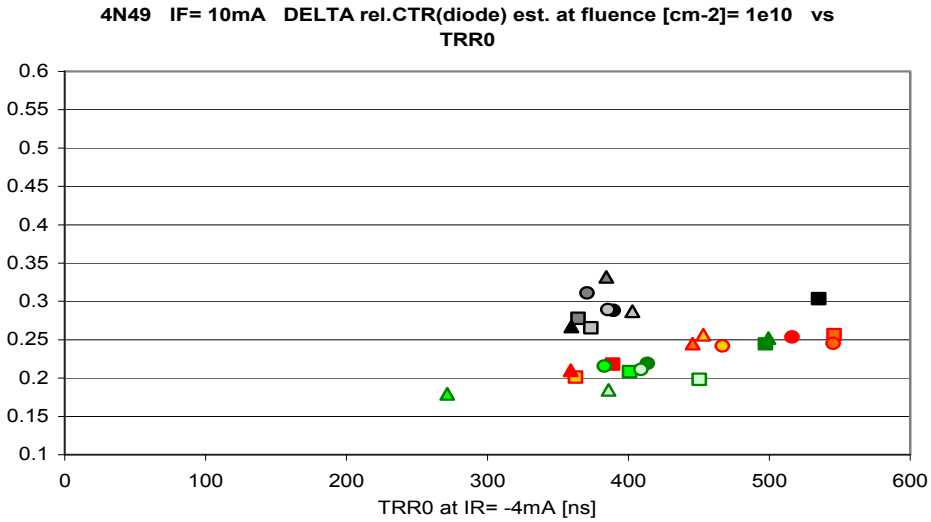
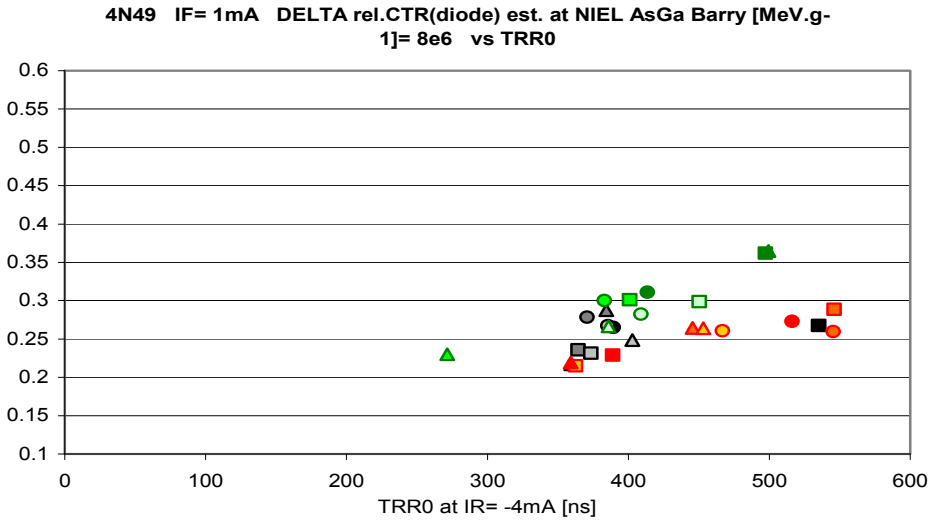
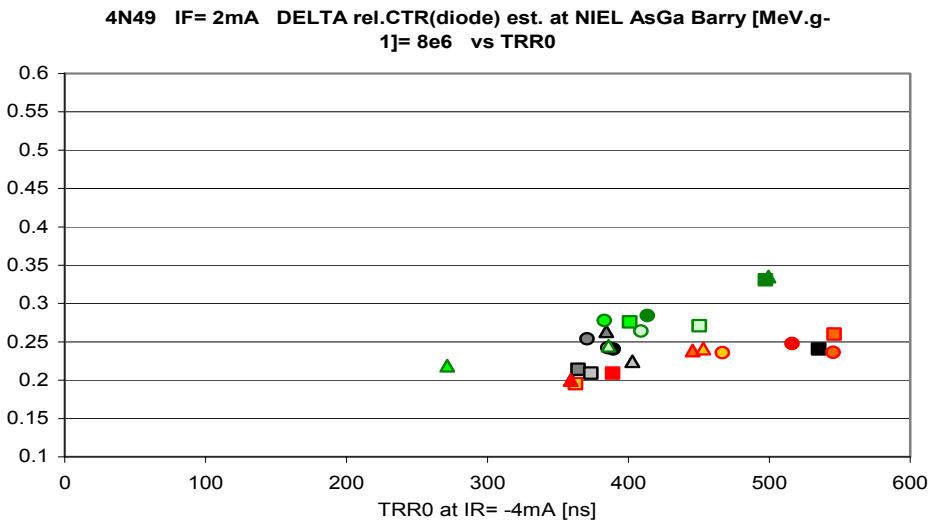
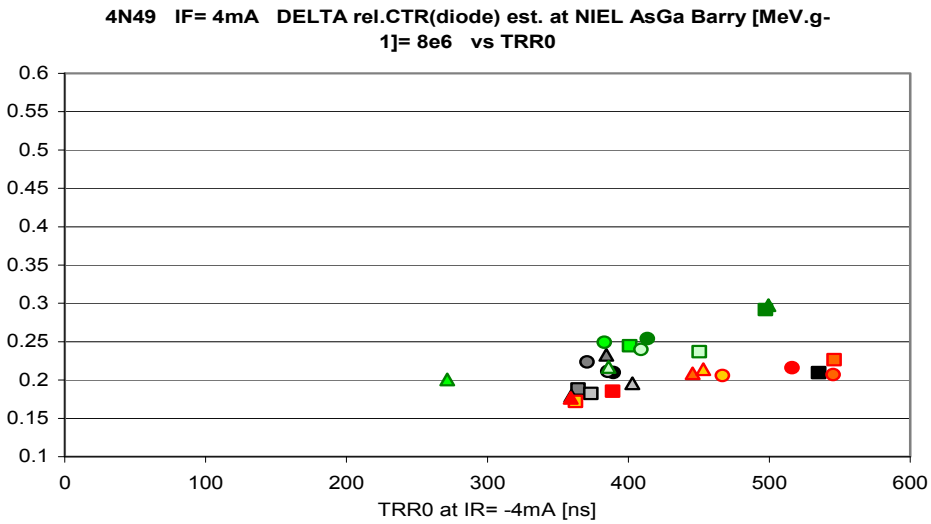
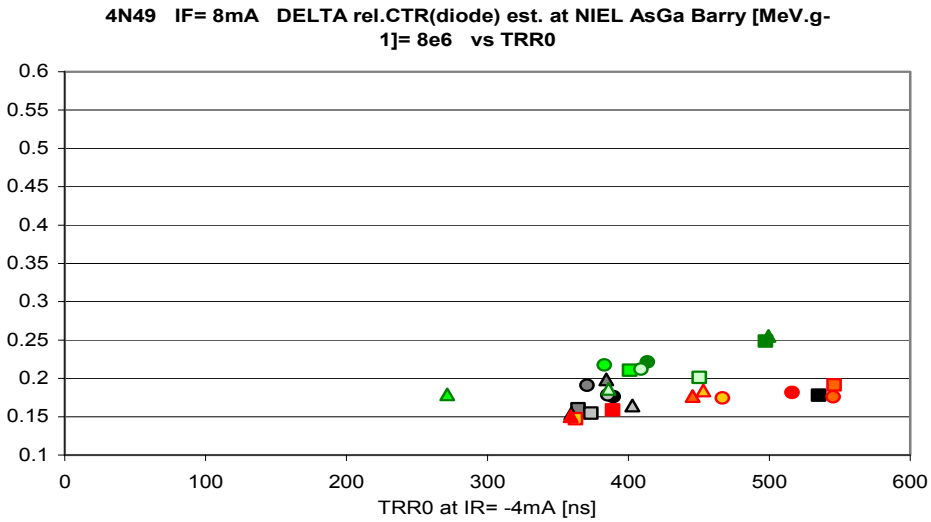

4N49 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-38: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 8e6 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

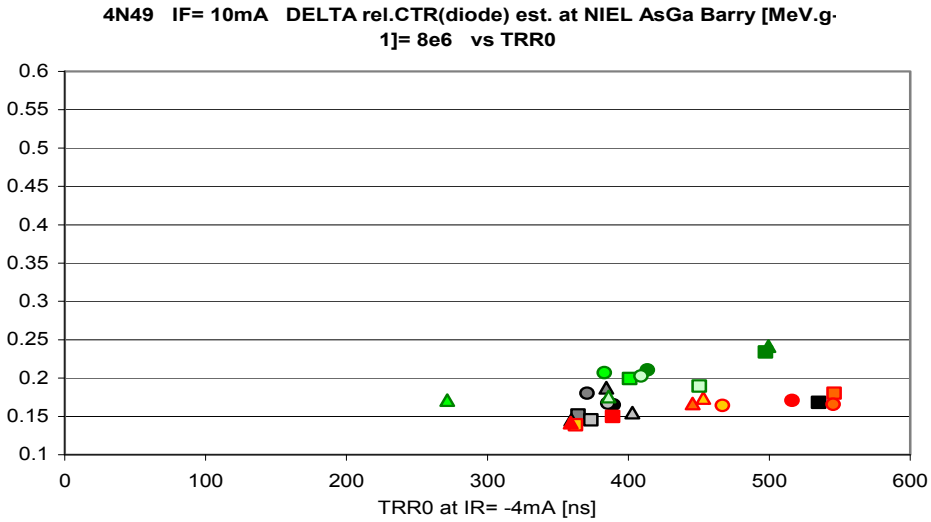
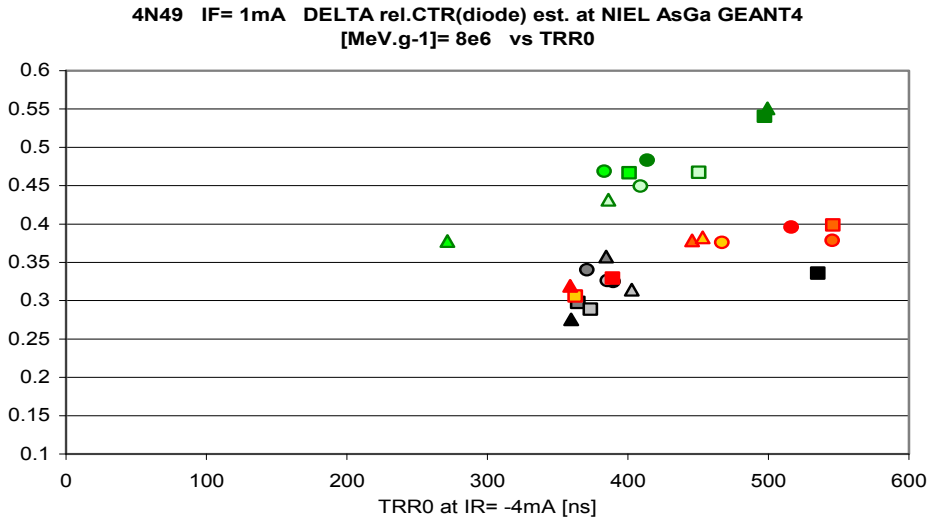
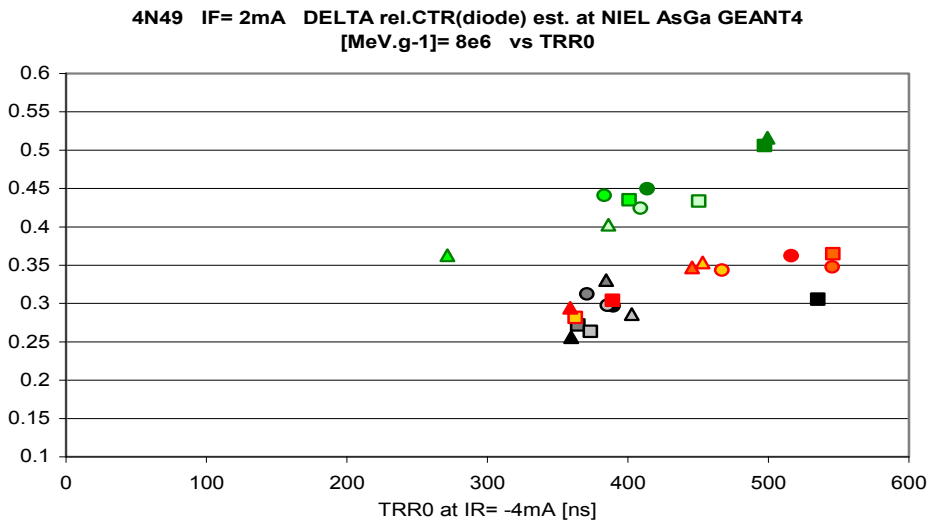
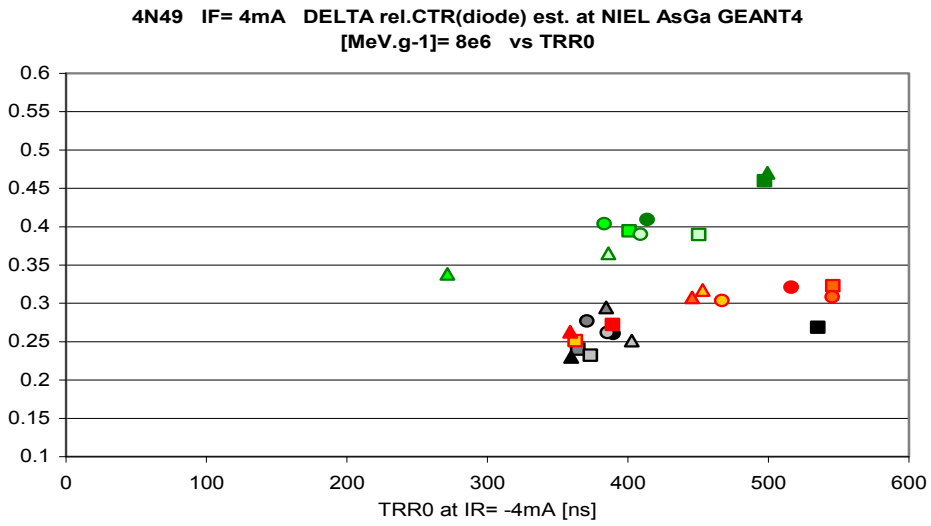
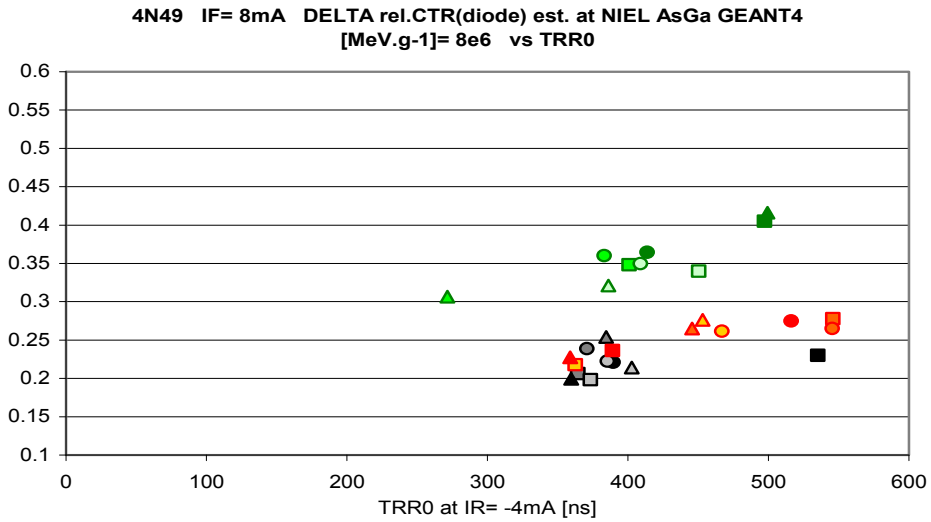

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 8e6 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-39: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

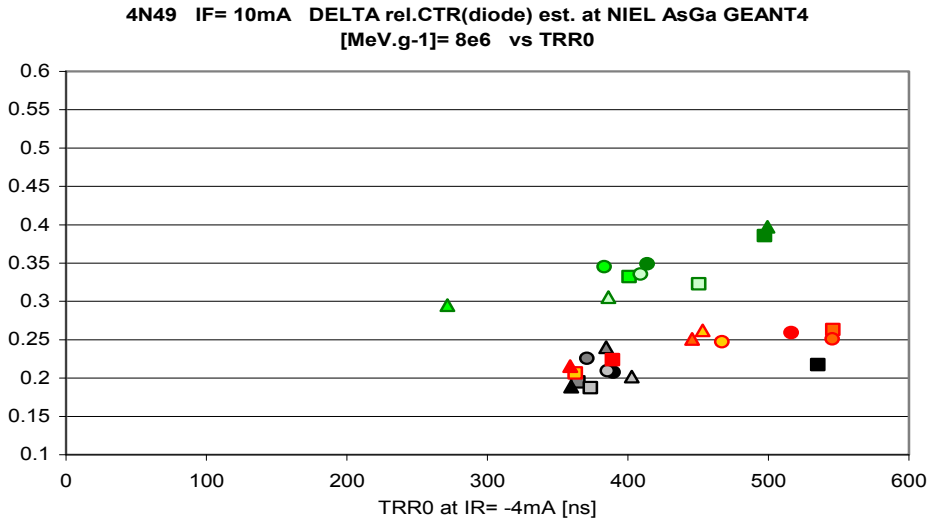
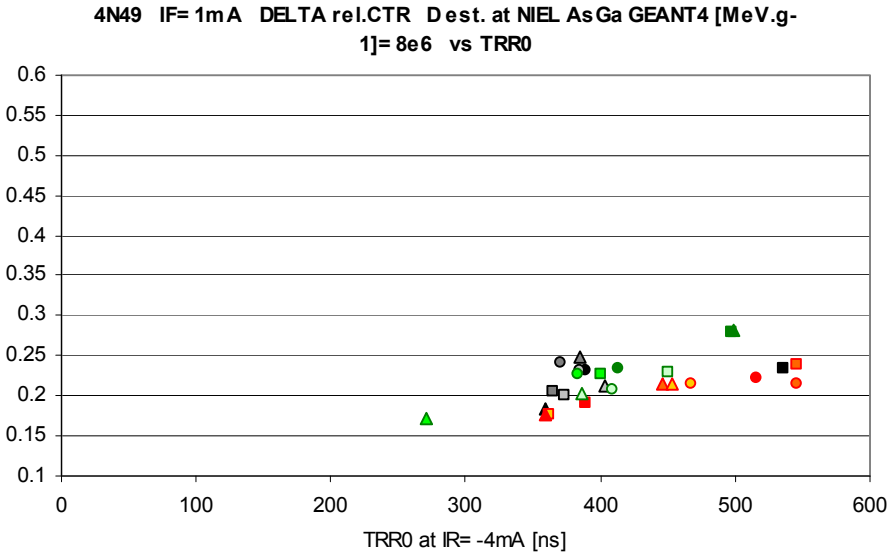
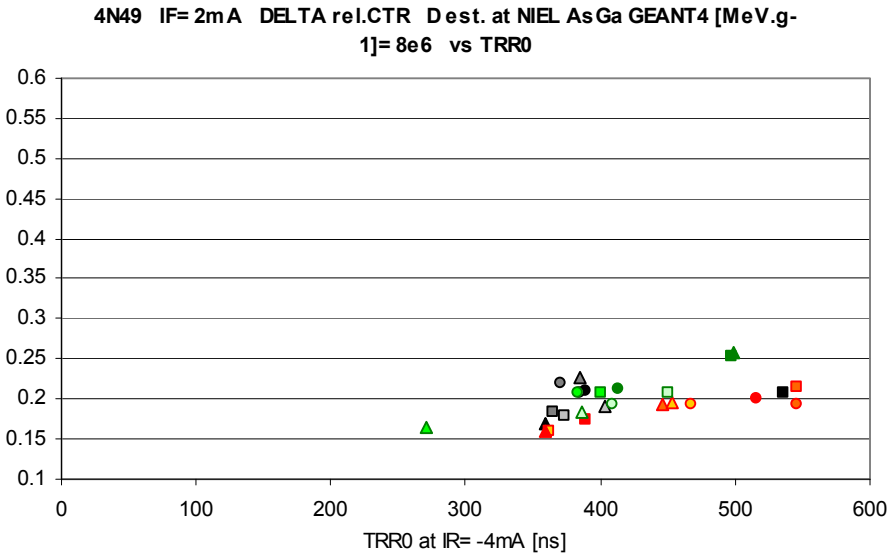
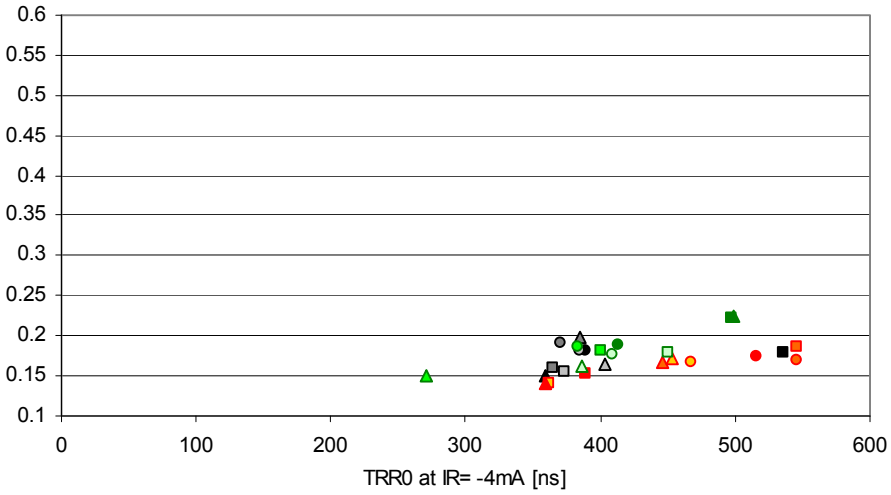

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-40: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

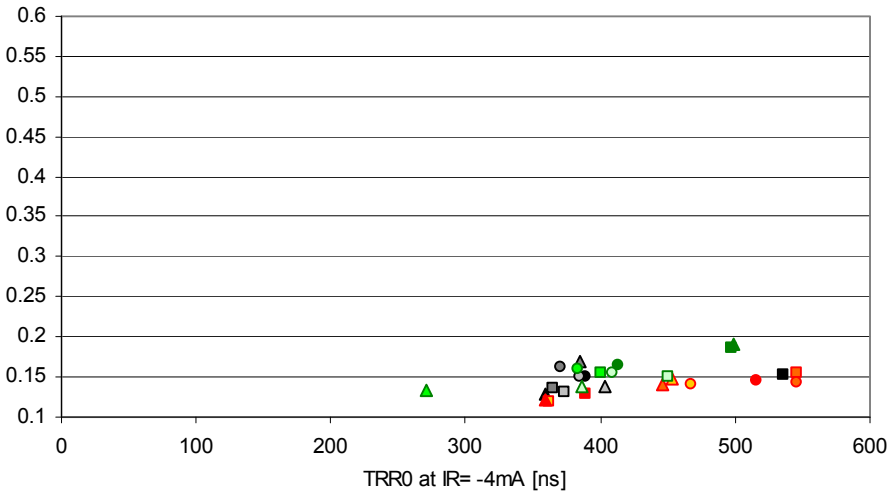




4N49 IF= 4mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 8e6 vs TRR0



4N49 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 8e6 vs TRR0



4N49 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 8e6 vs TRR0

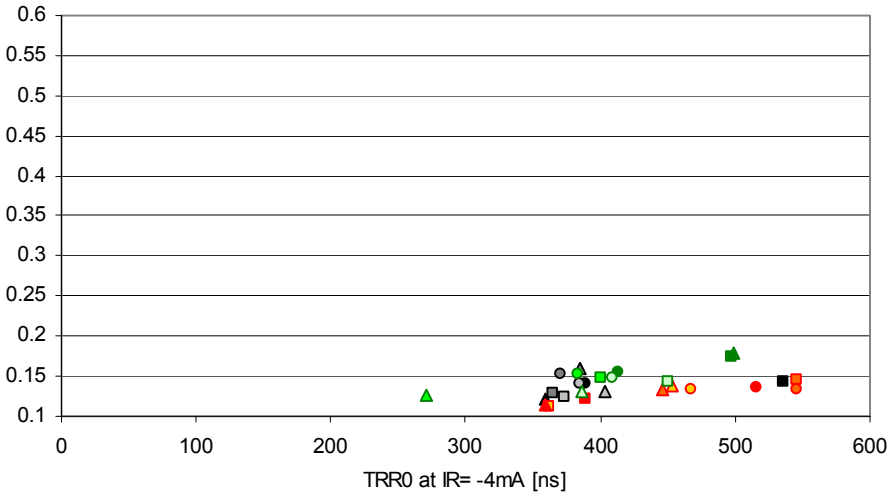
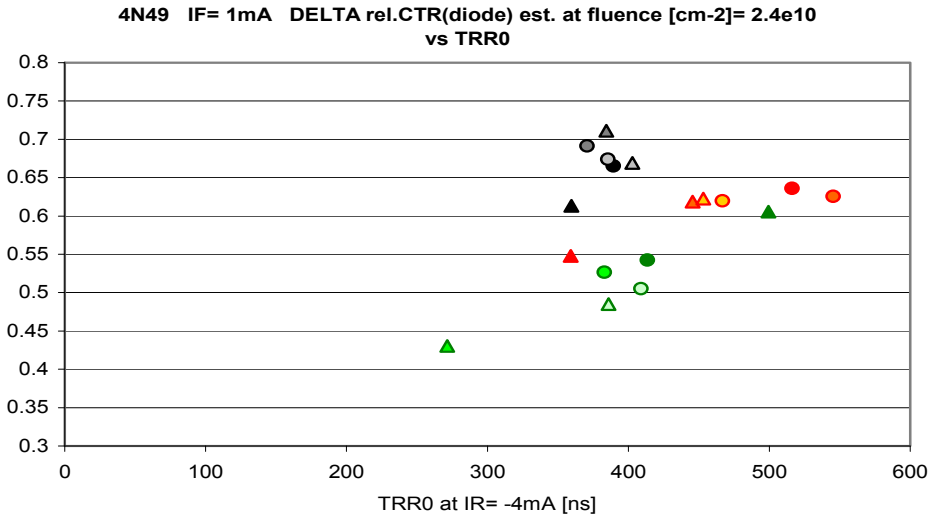
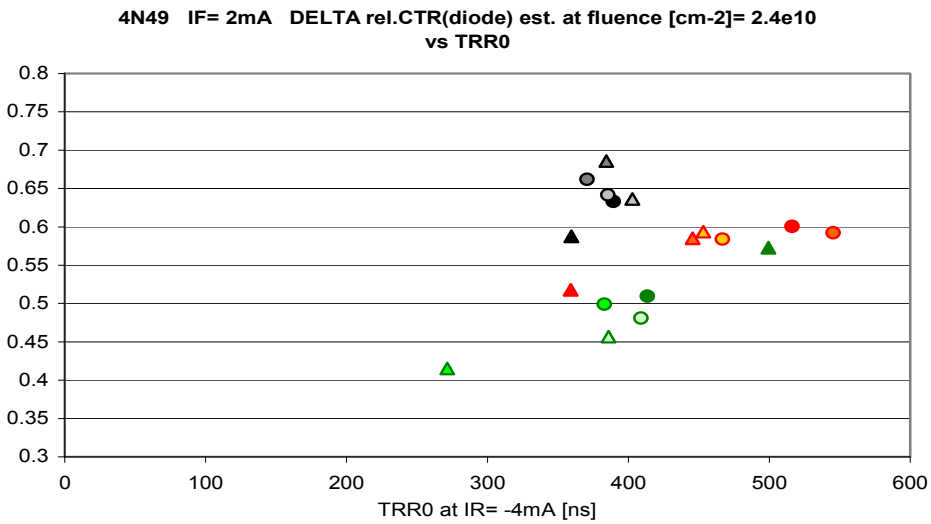
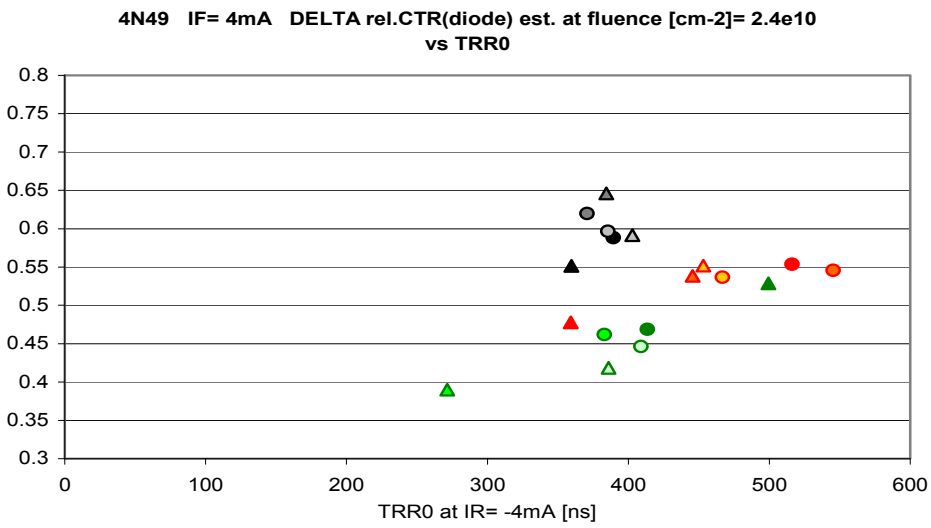
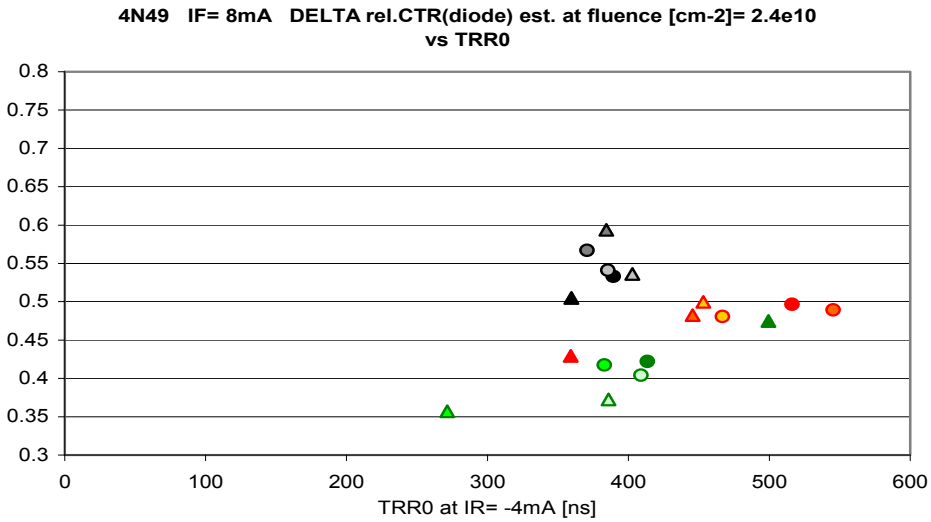


Fig. 12-41: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 2.4.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10
vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

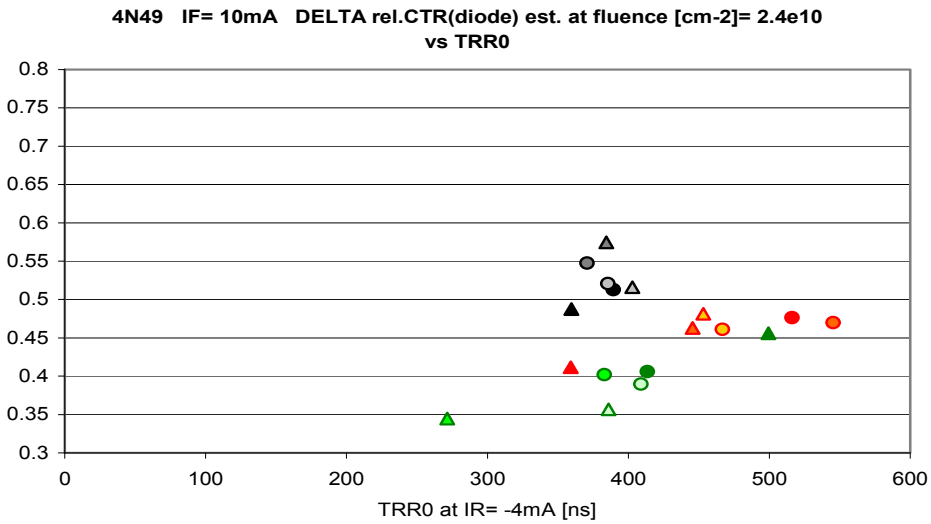
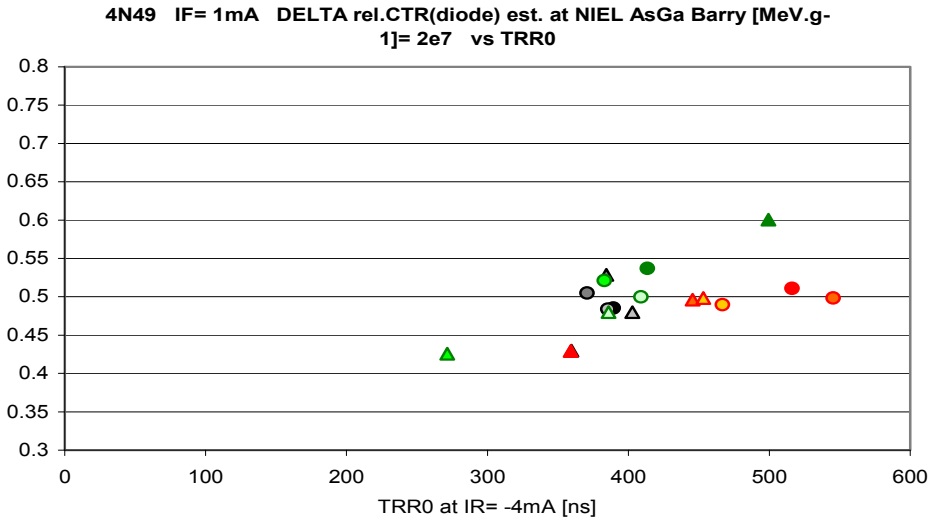
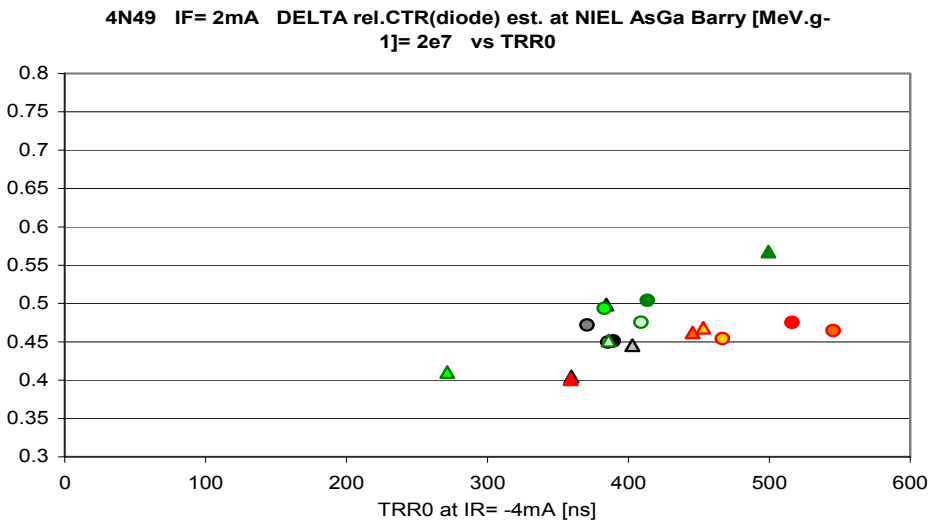
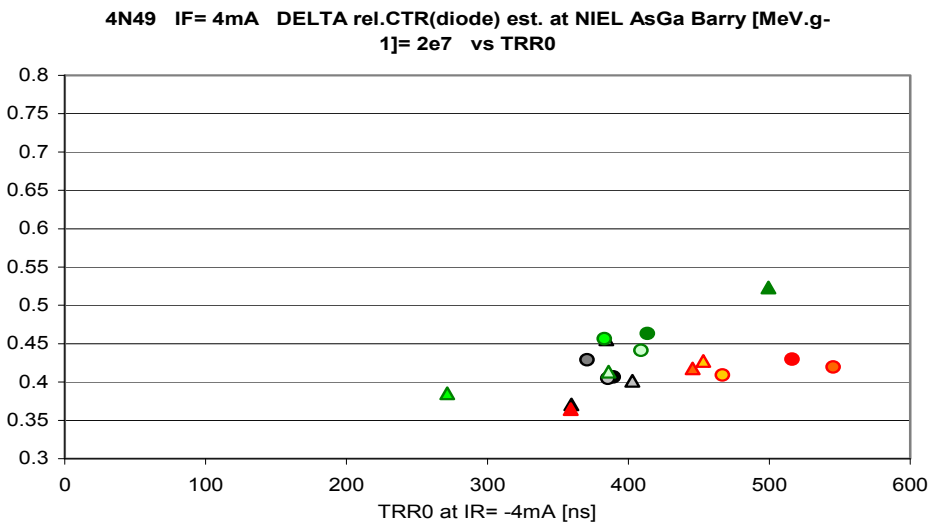
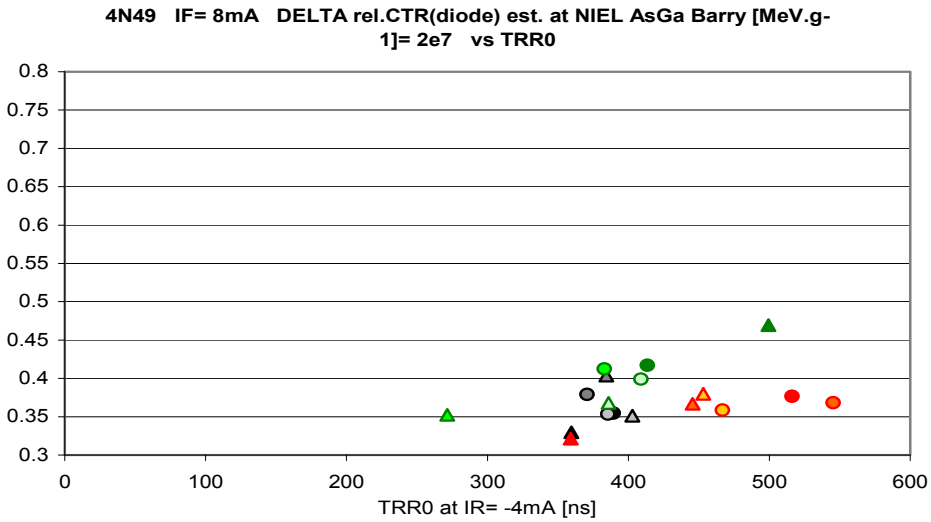

4N49 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10
vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-42: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 2e7 vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

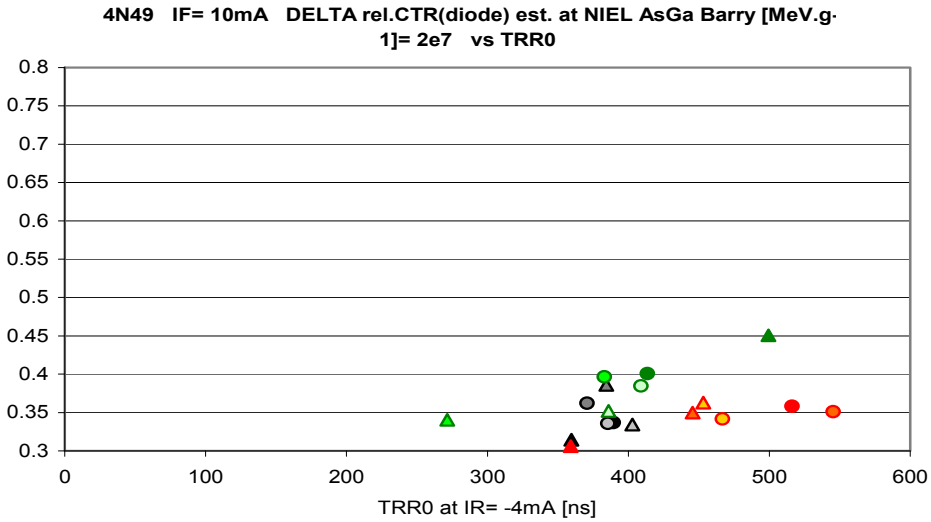
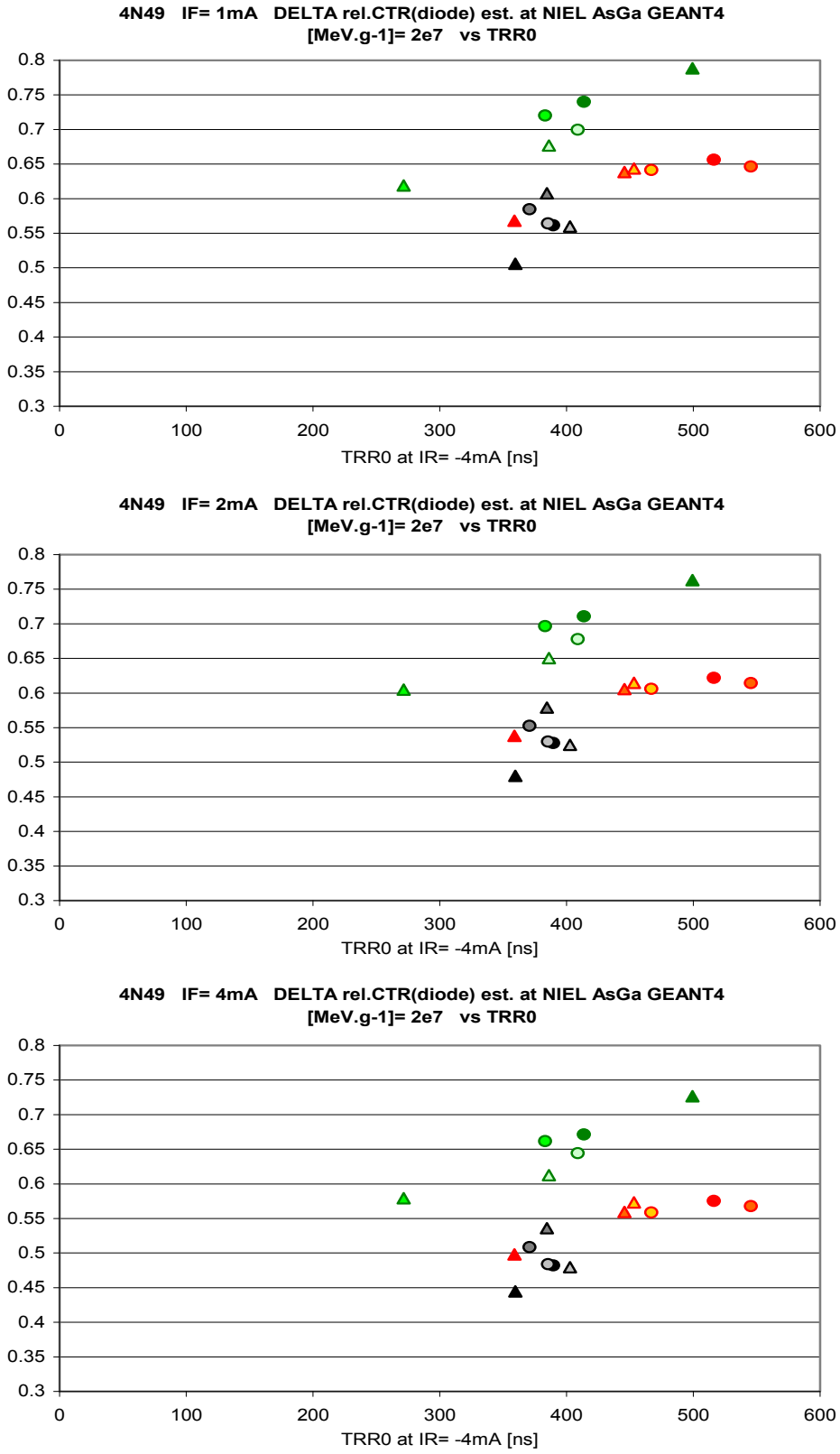
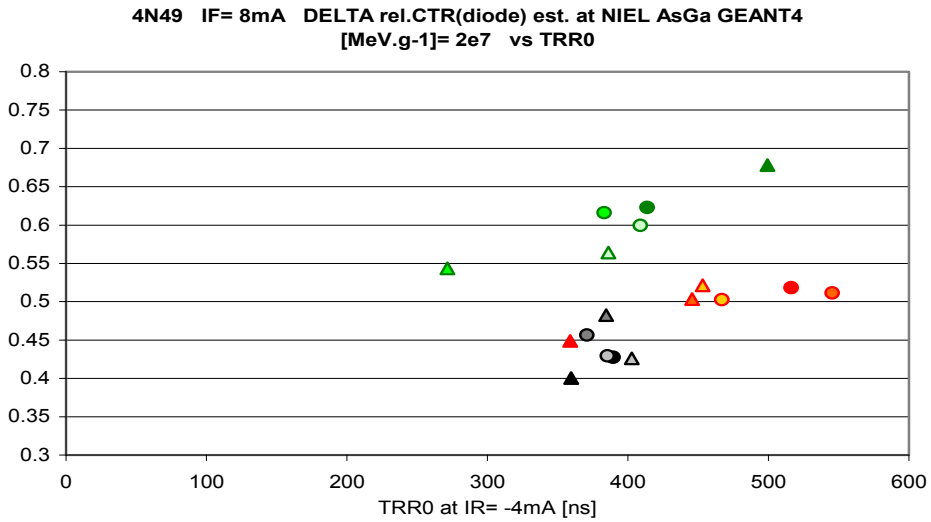

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 2e7 vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-43: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

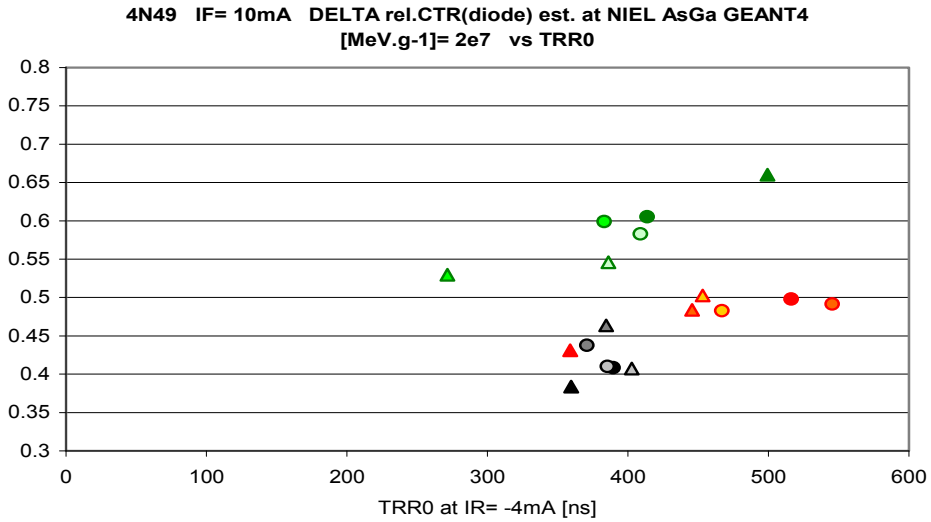
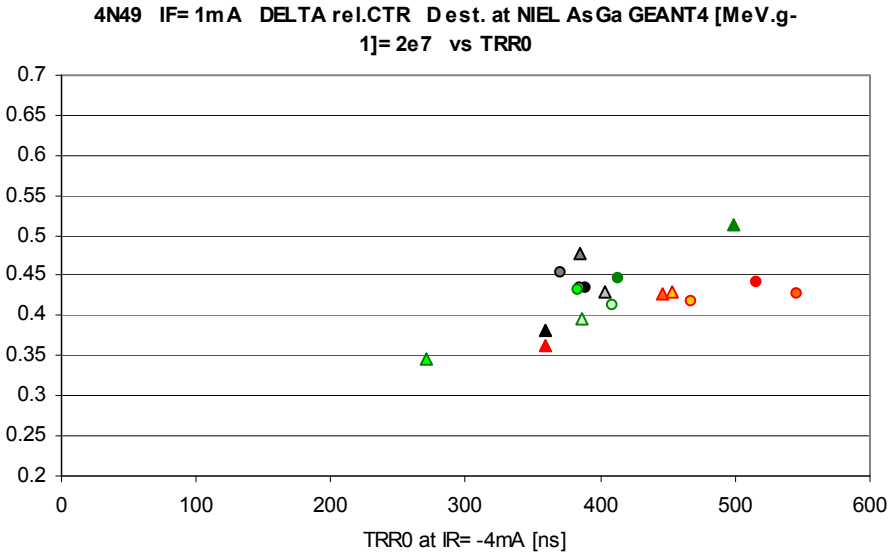
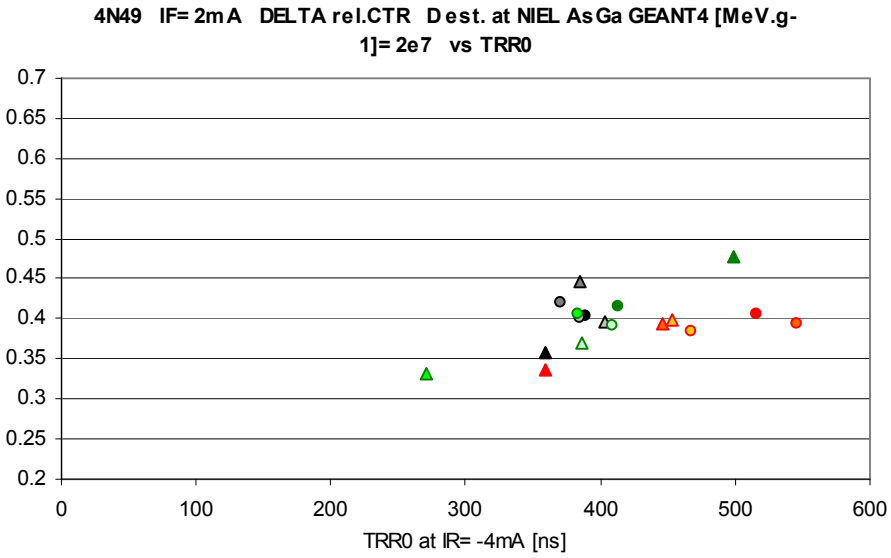
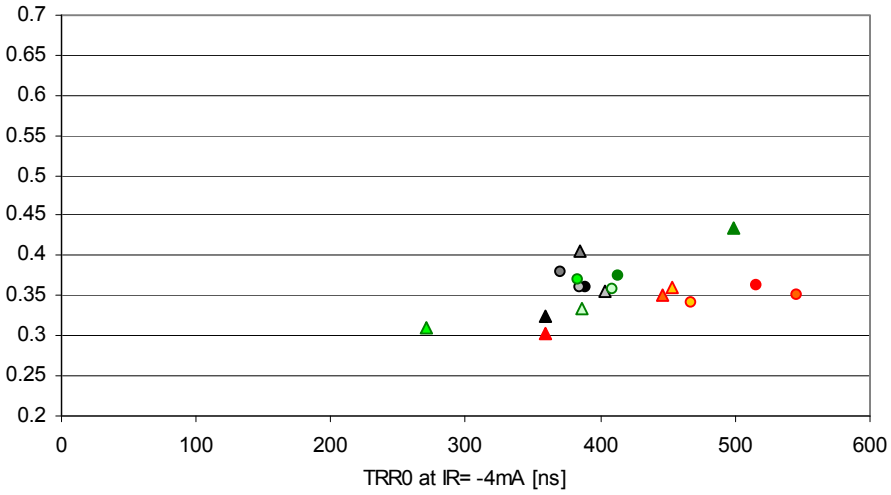

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-44: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

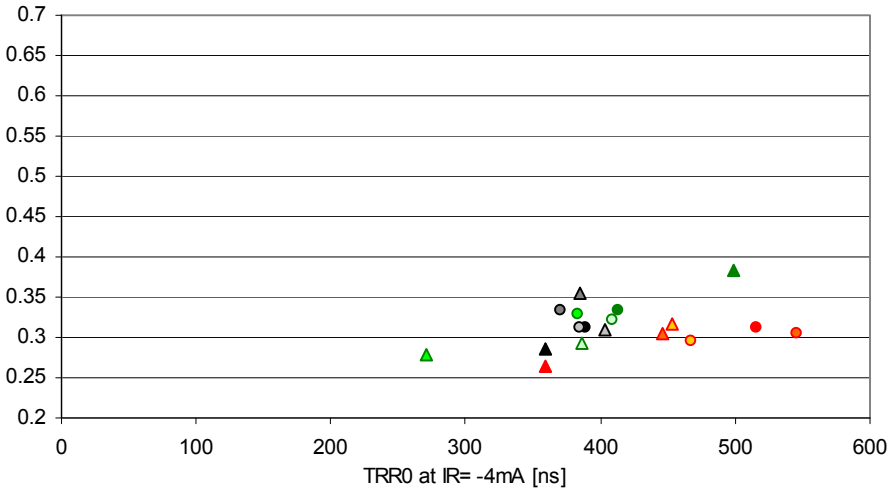




4N49 IF= 4mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 2e7 vs TRR0



4N49 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 2e7 vs TRR0



4N49 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 2e7 vs TRR0

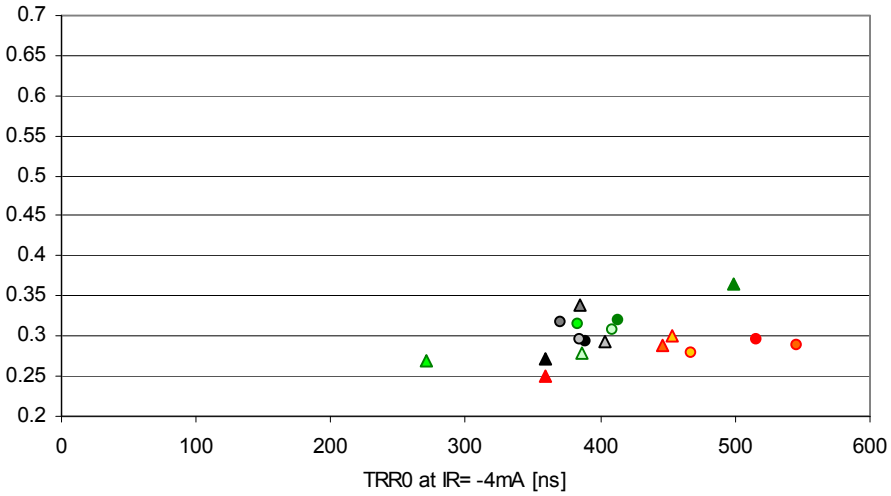
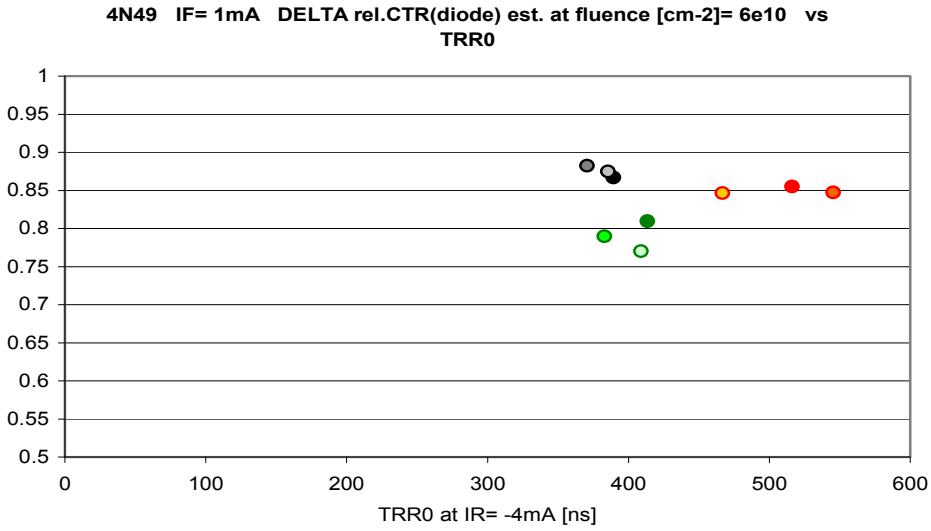
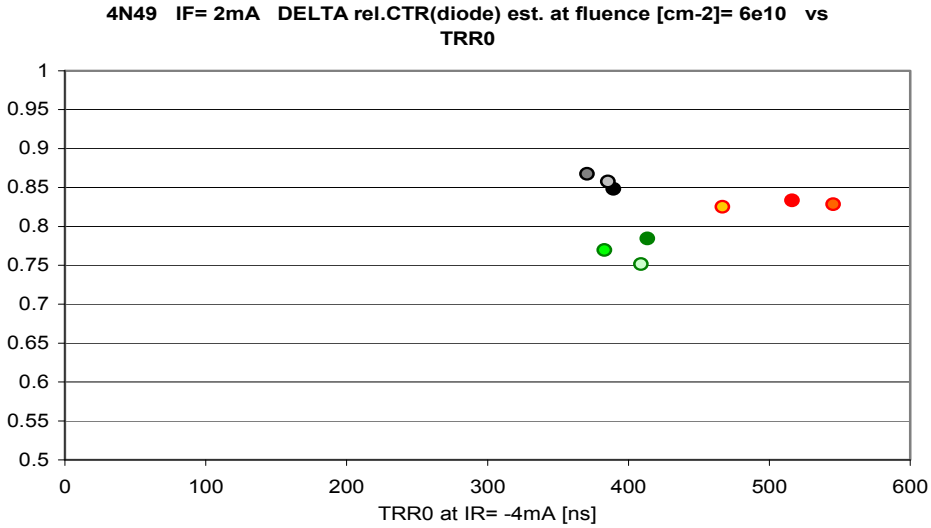
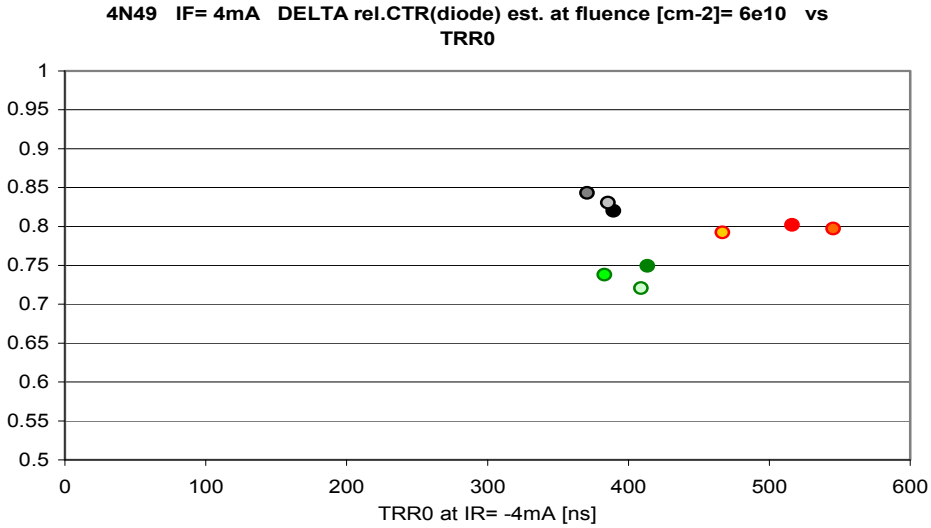


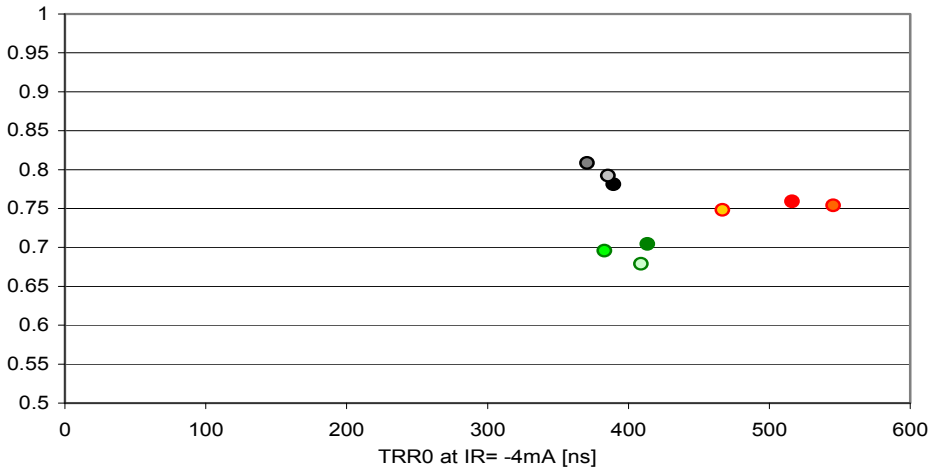
Fig. 12-45: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 6.10^{10} cm^{-2} at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA







4N49 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10 vs TRR0



4N49 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10 vs TRR0

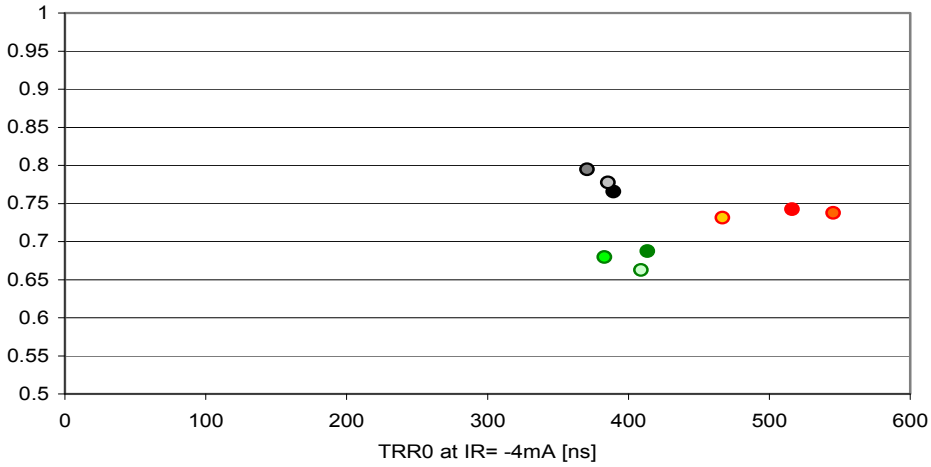
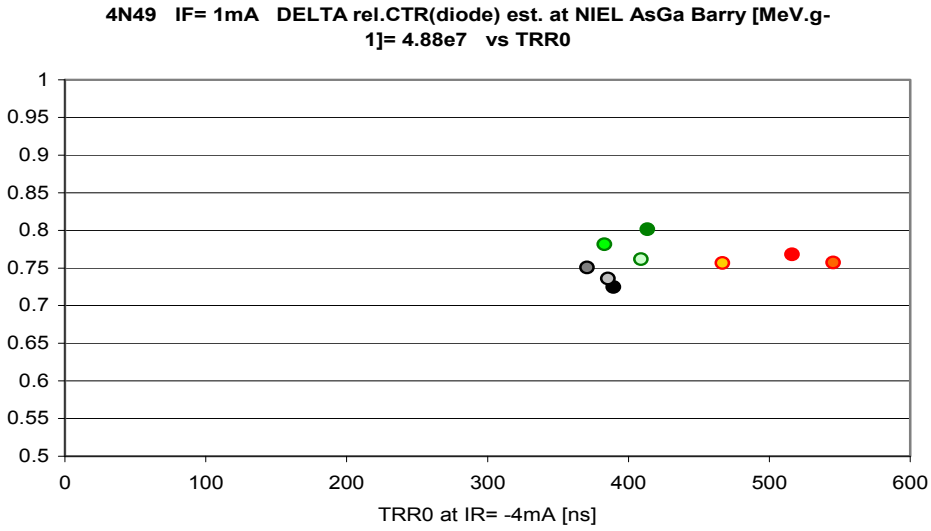
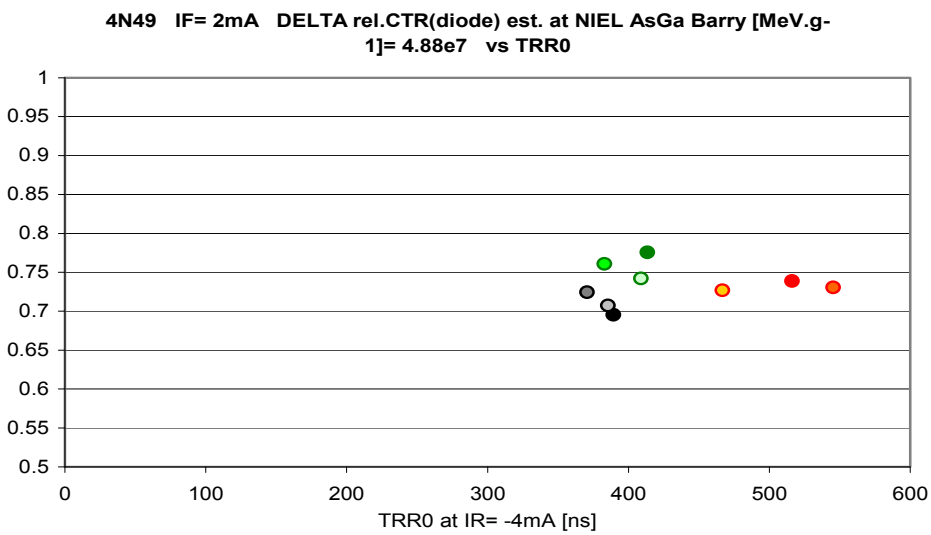
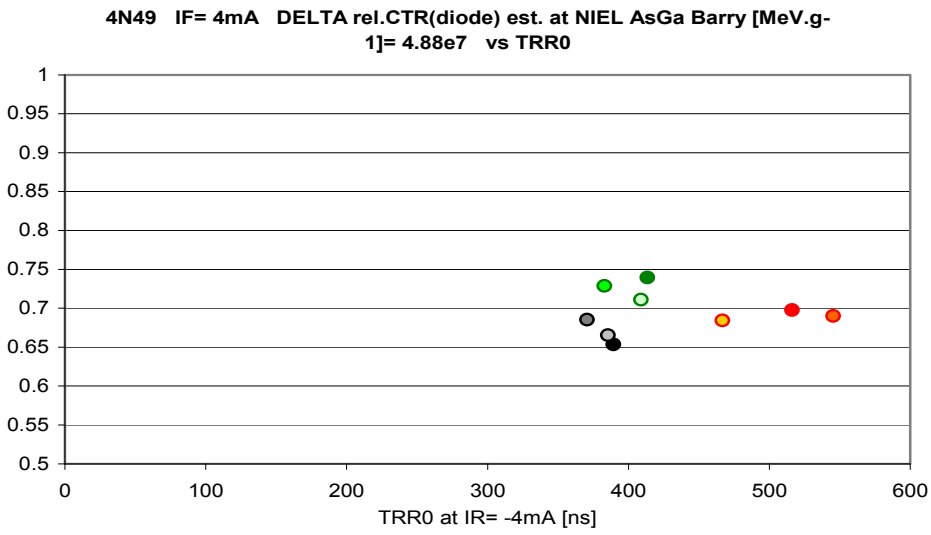
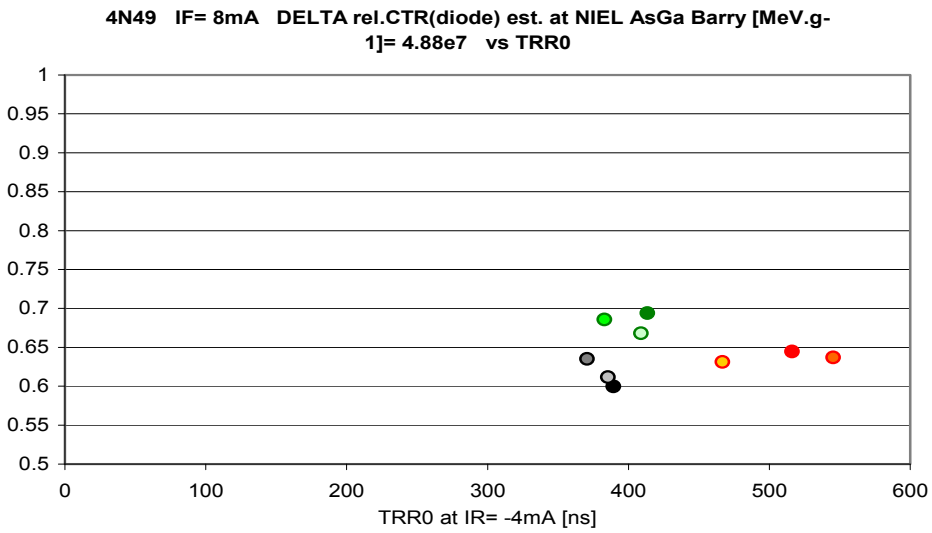


Fig. 12-46: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 4.88e7 vs TRR0
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

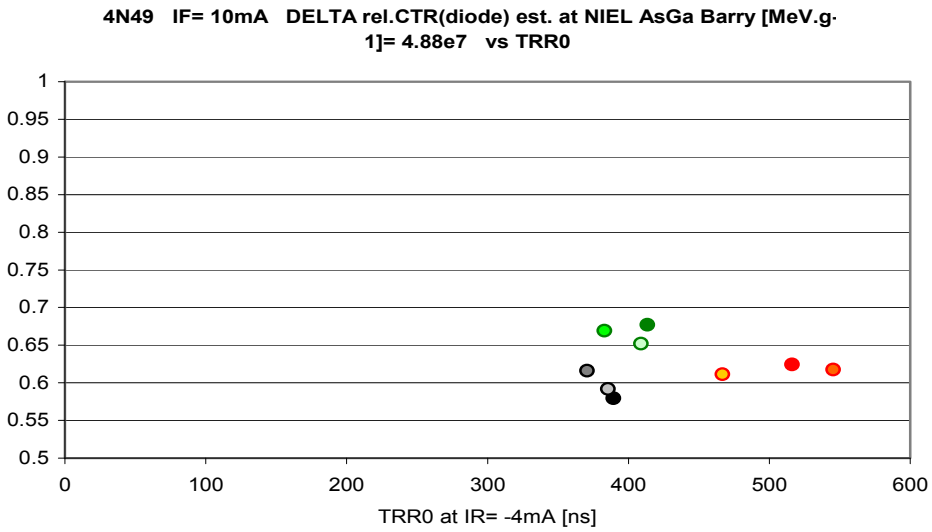
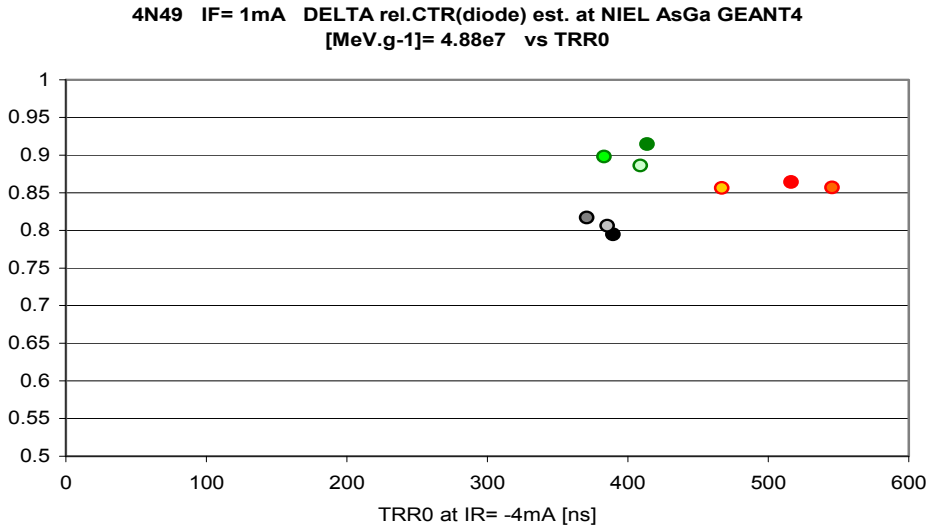
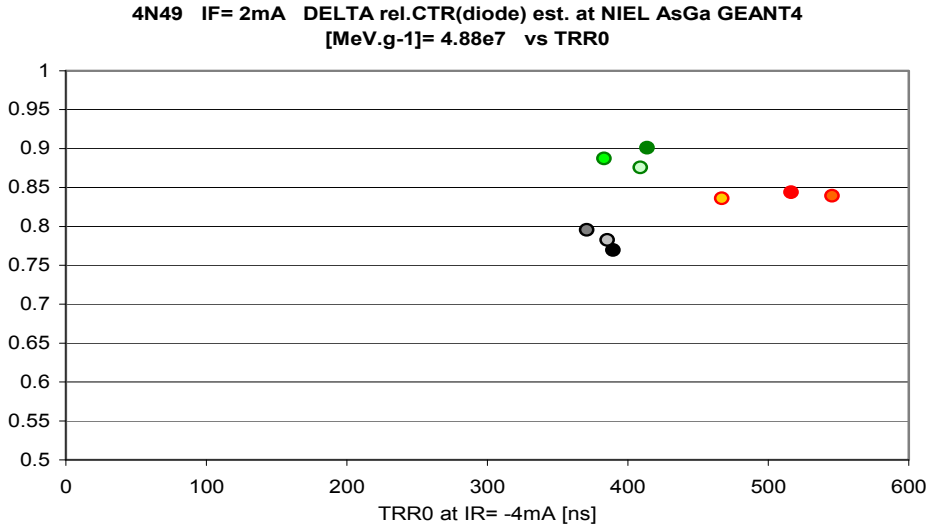
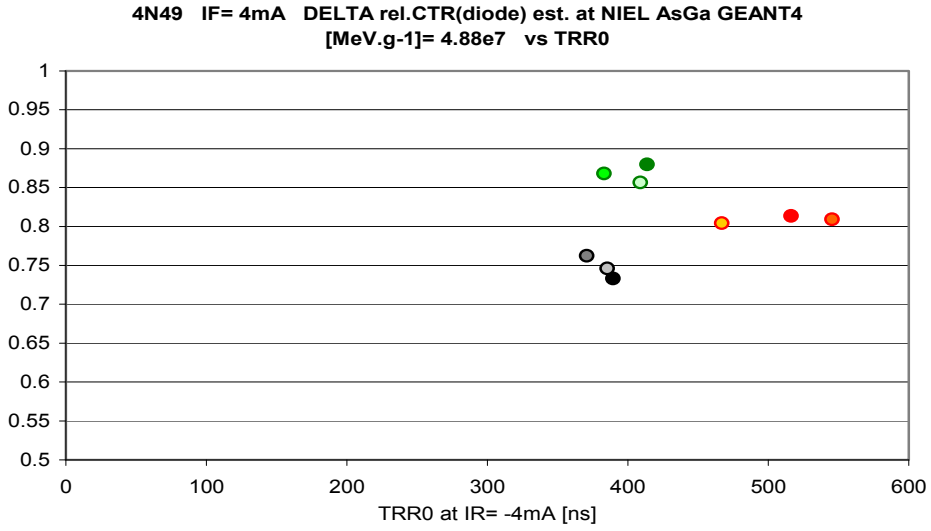
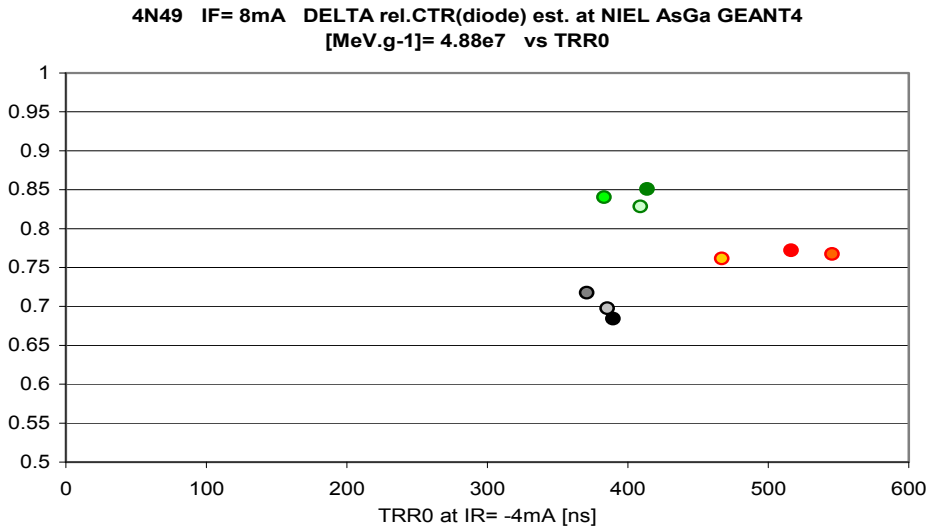

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 4.88e7 vs TRR0
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-47: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








4N49 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

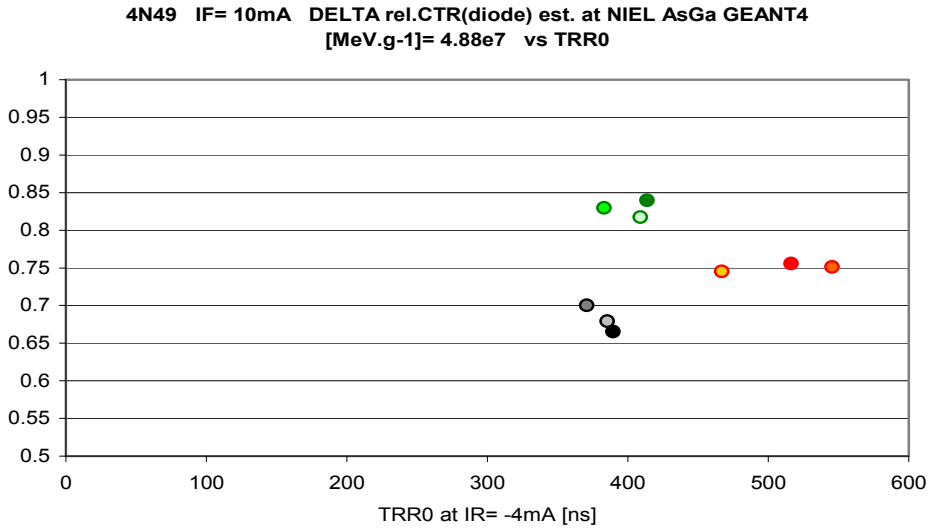
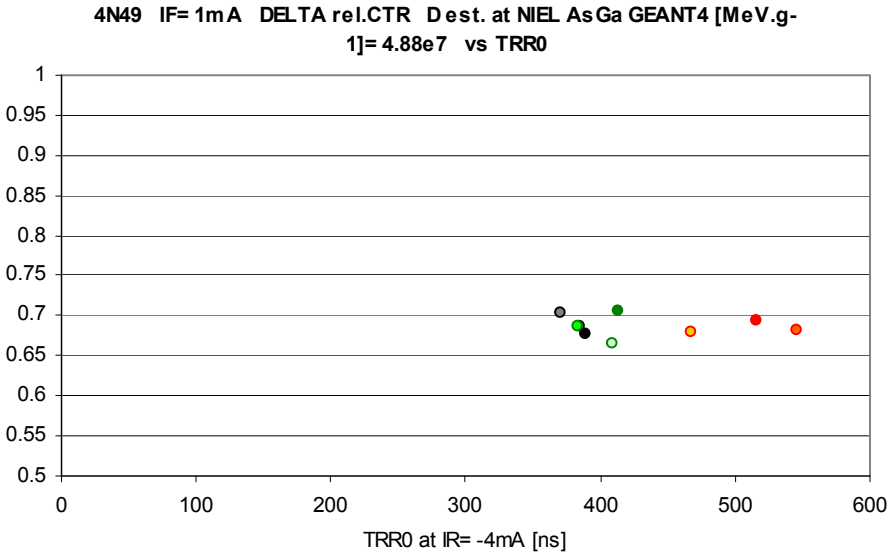
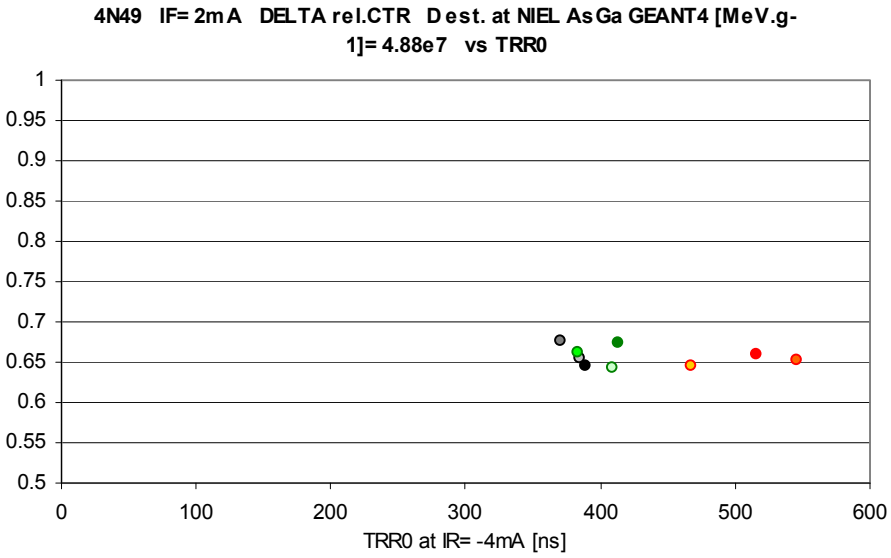
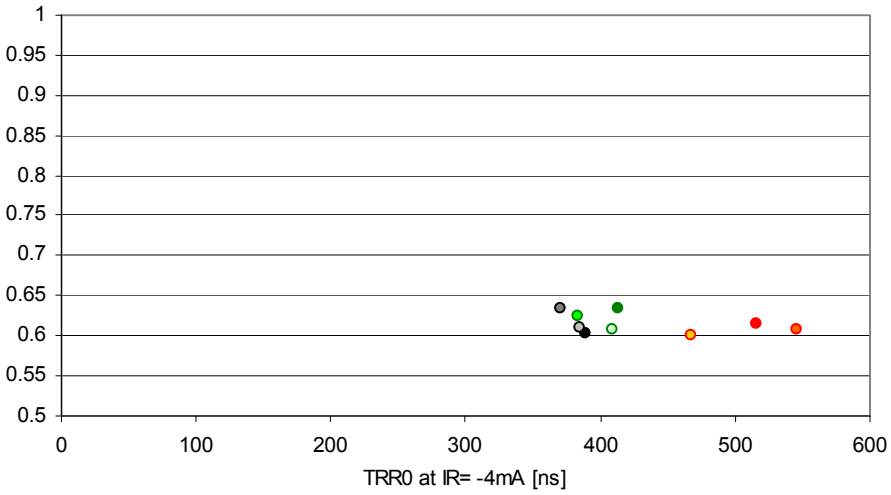

4N49 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-48: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

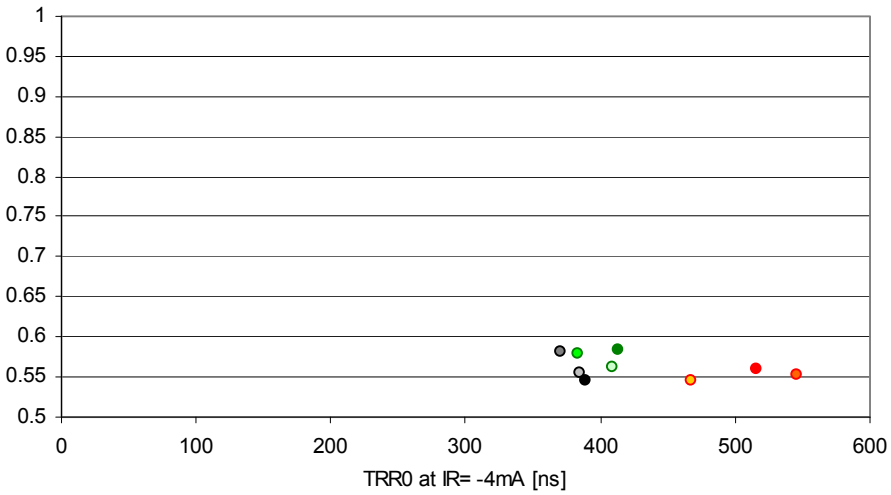




4N49 IF= 4mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0



4N49 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0



4N49 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0

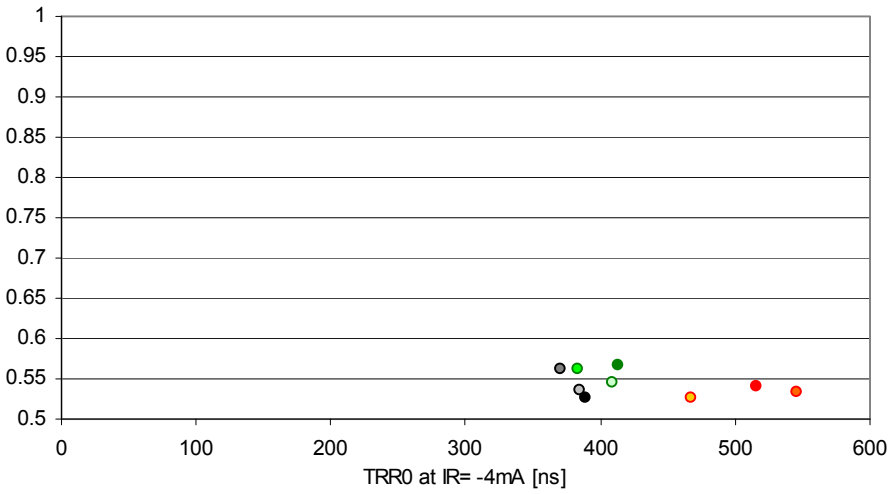


Fig. 12-49: optocoupler irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to diode current I_F

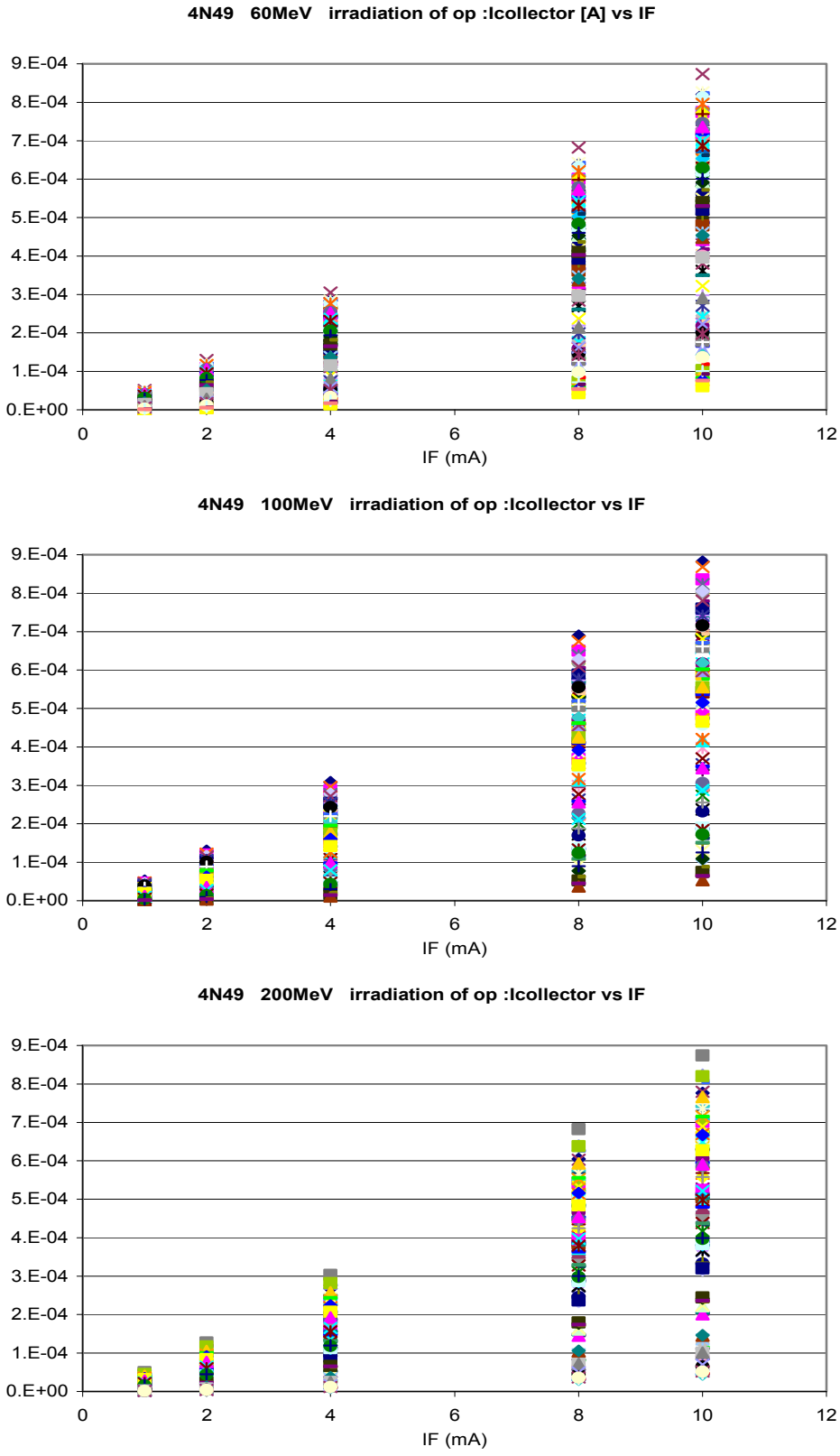


Fig. 12-50: diode irradiated at E=60, 100, 200 MeV: reference transistor collector current I_C for each step with respect to diode current I_F

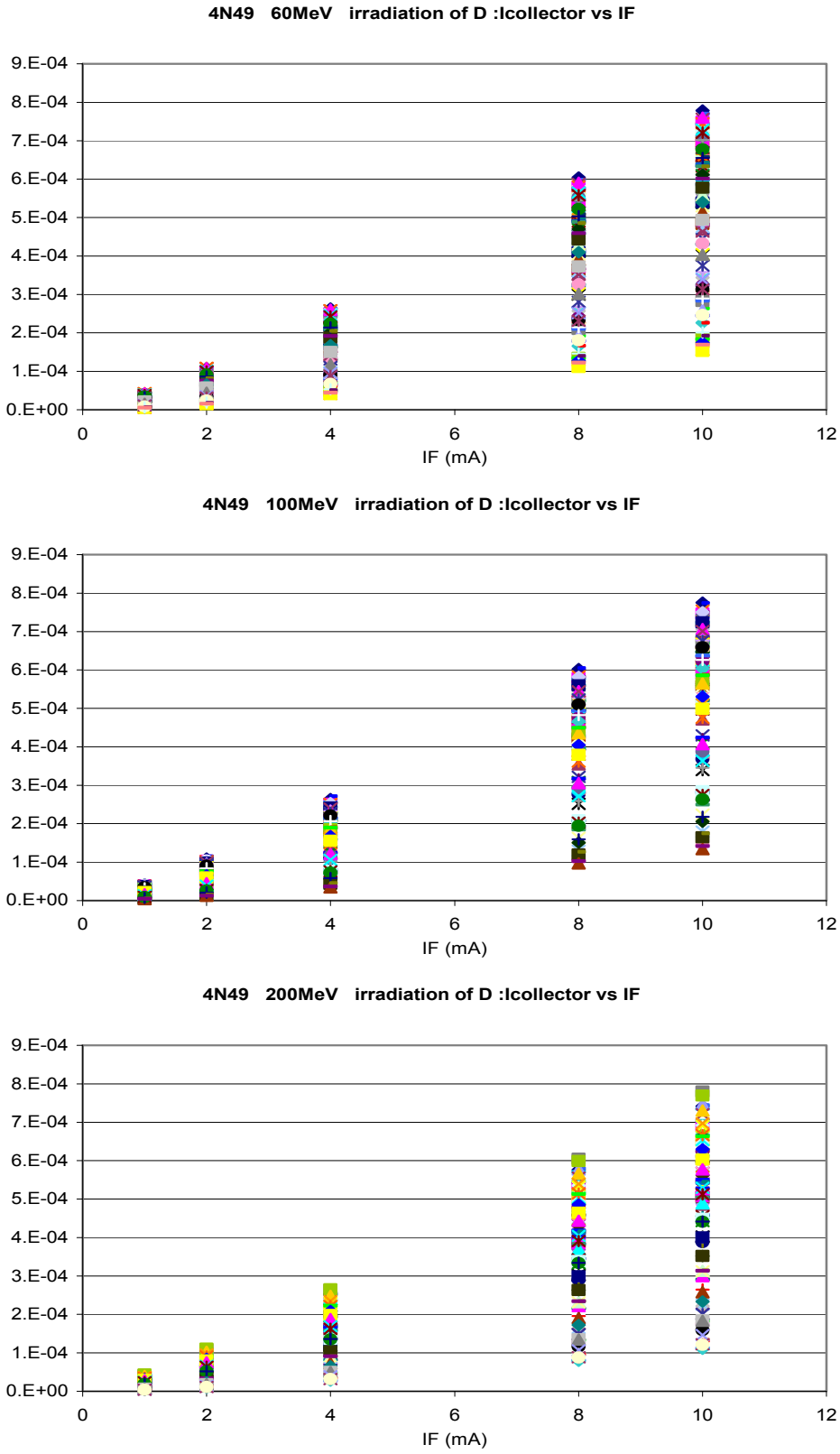


Fig. 12-51: transistor irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to reference diode current I_F

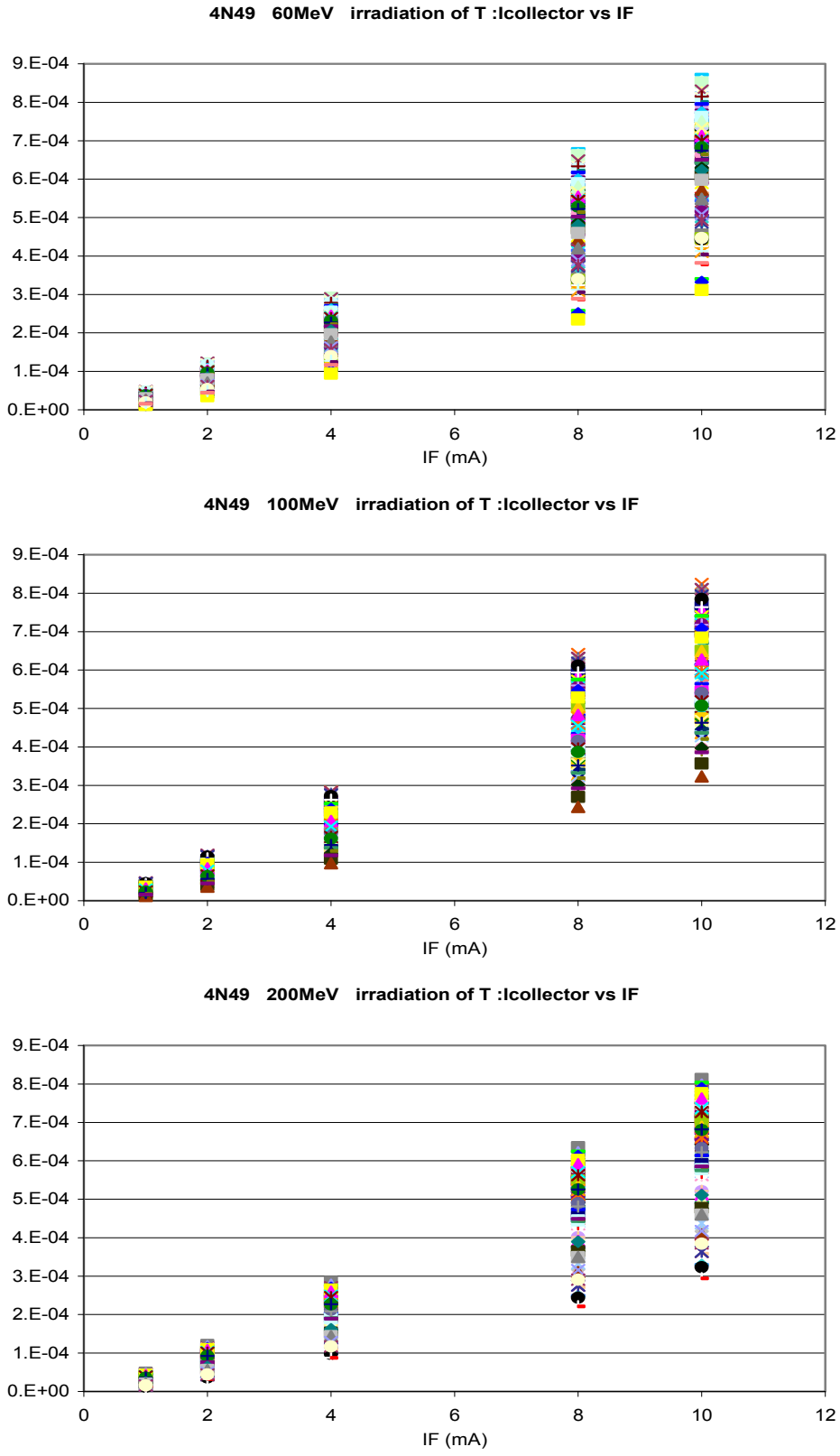
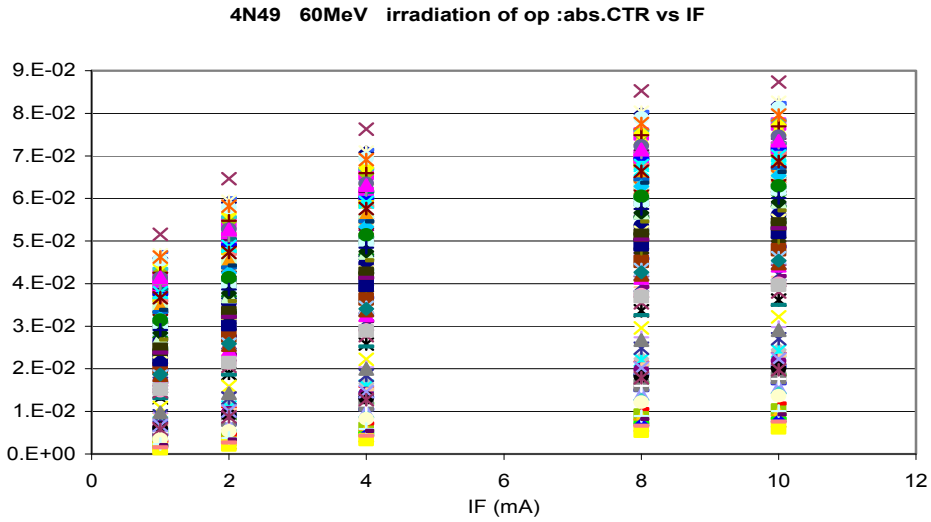
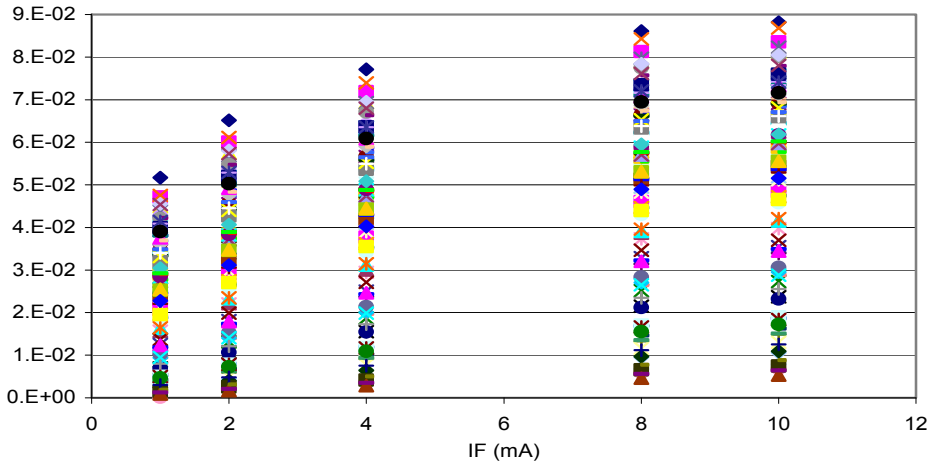


Fig. 12-52: optocoupler irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F





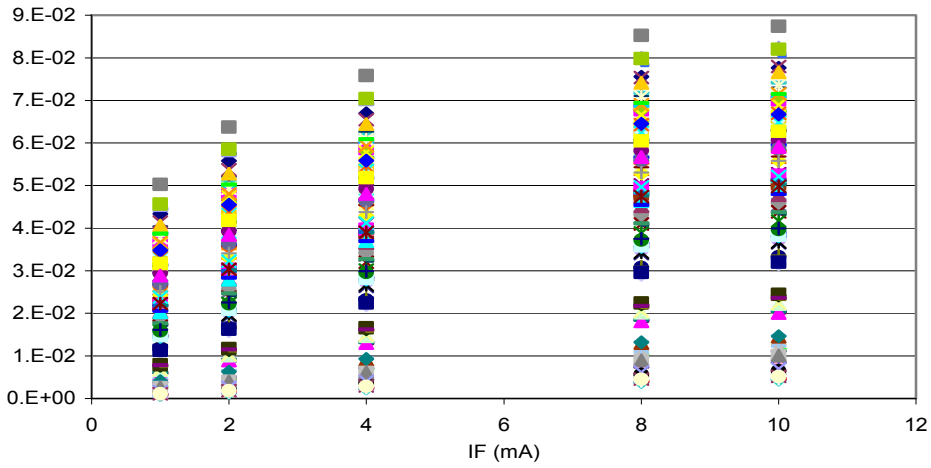
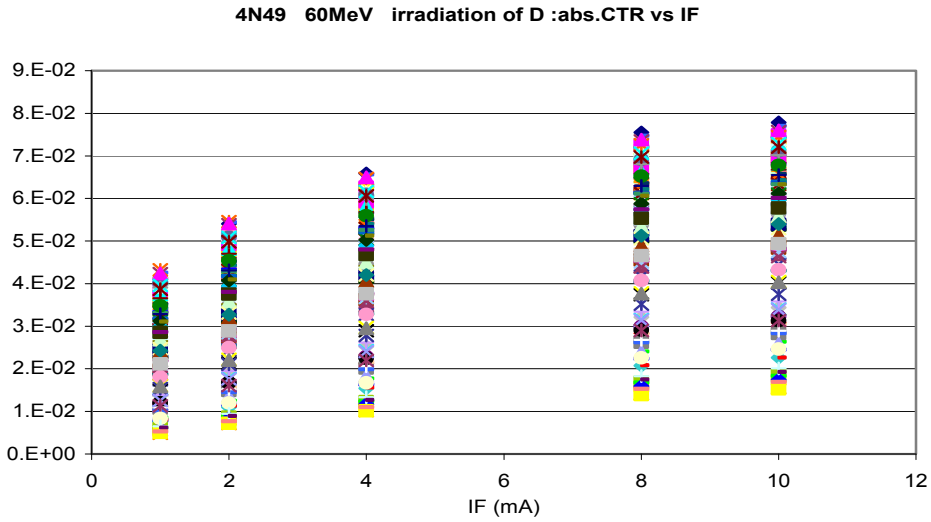
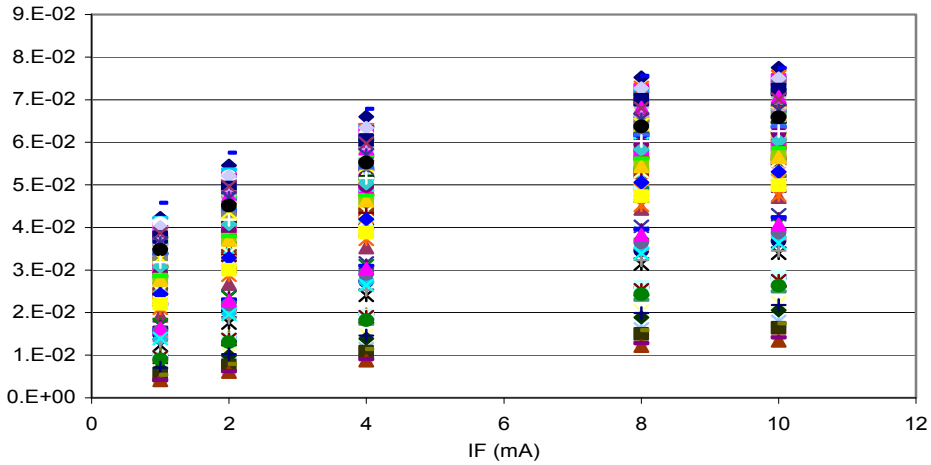


Fig. 12-53: diode irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F





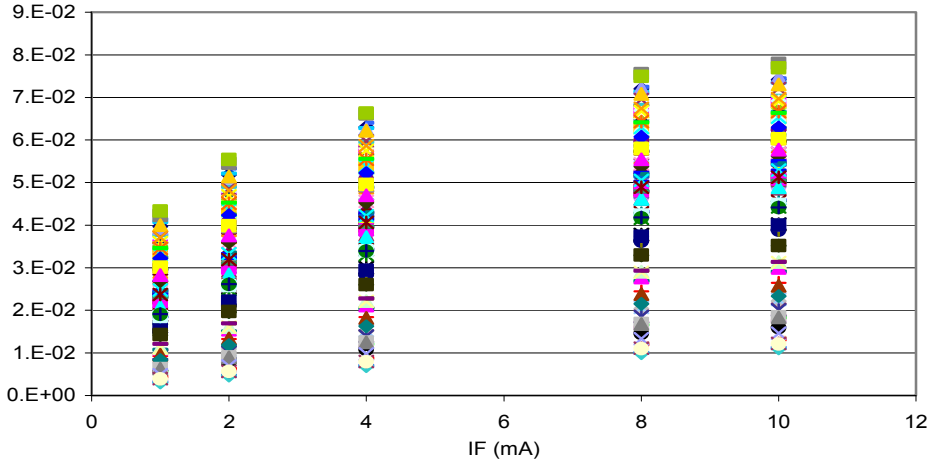


Fig. 12-54: transistor irradiated at E=60, 100, 200 MeV: CTR for each step with respect to reference diode current I_F

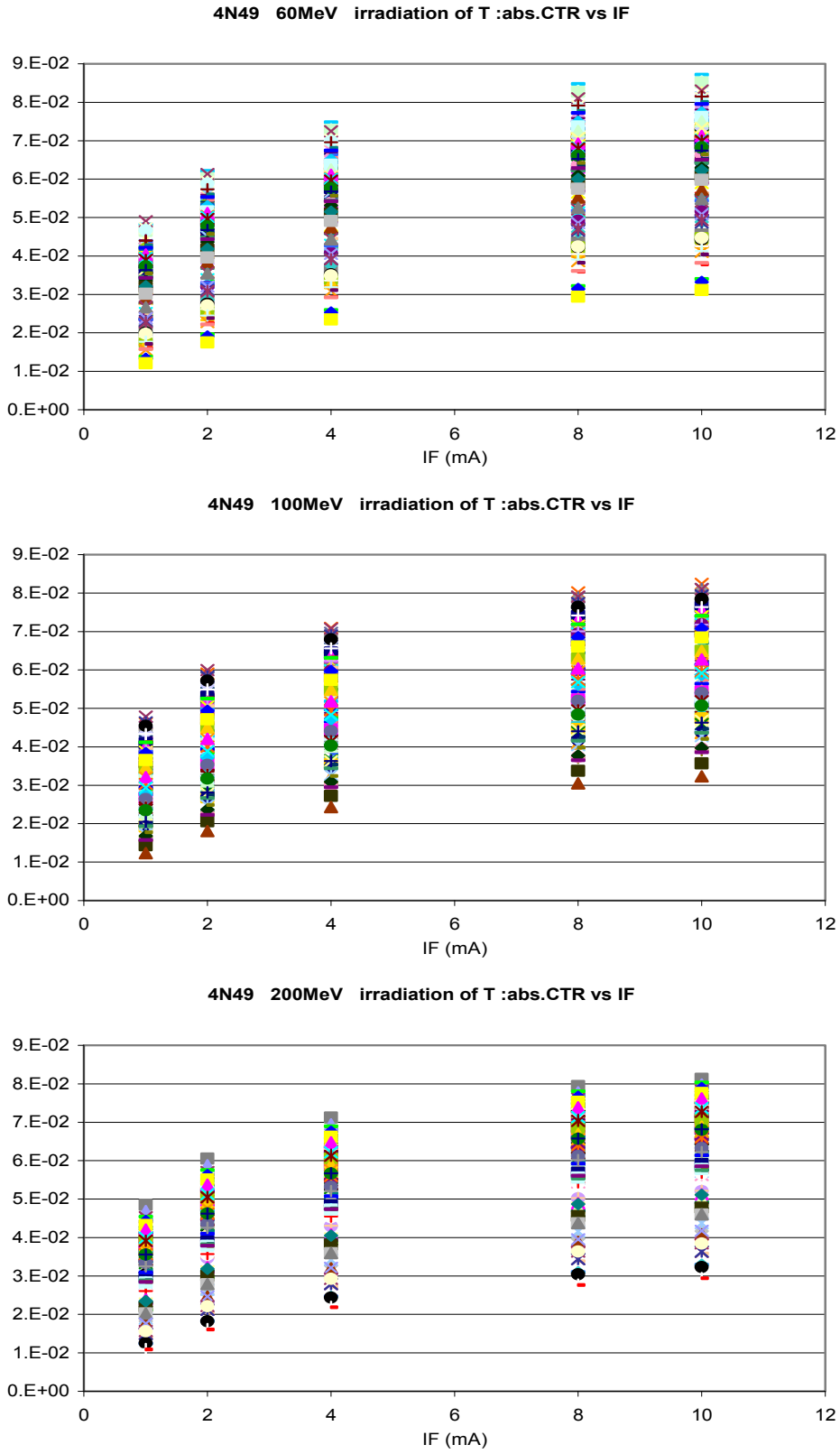
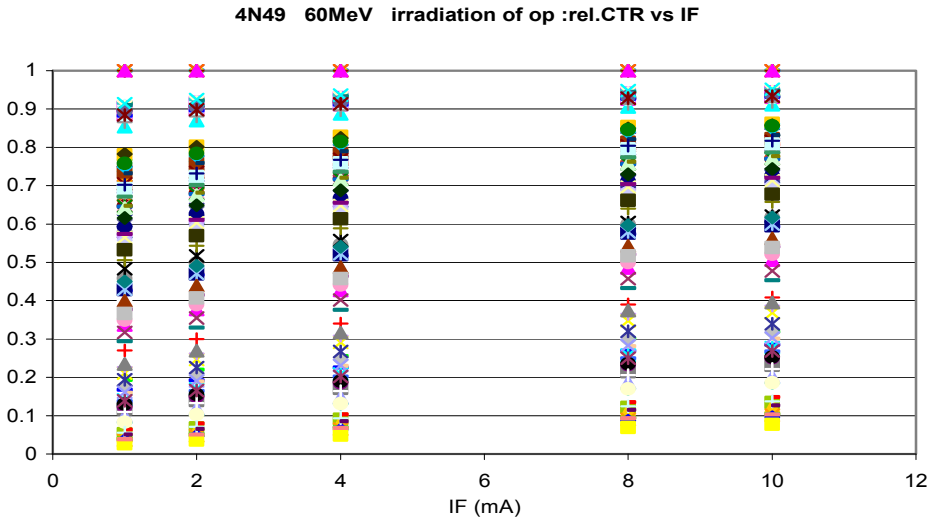
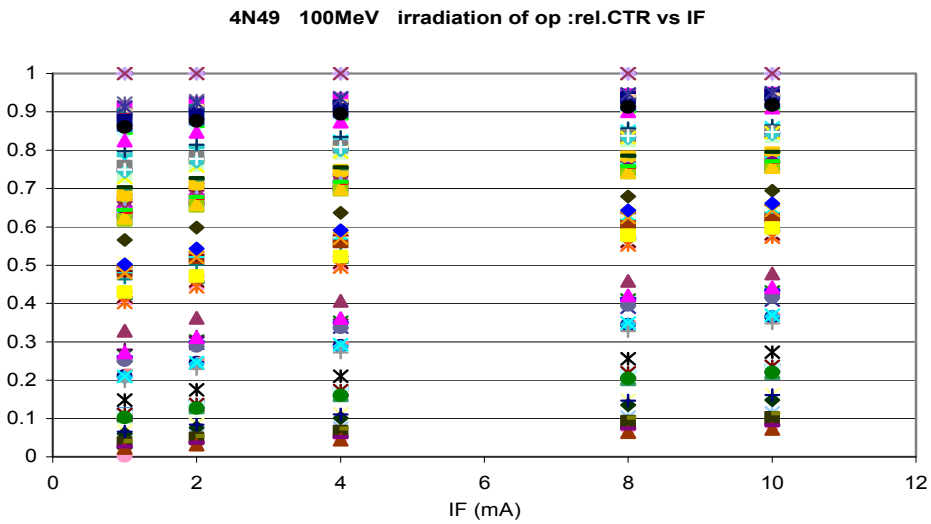


Fig. 12-55: optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F





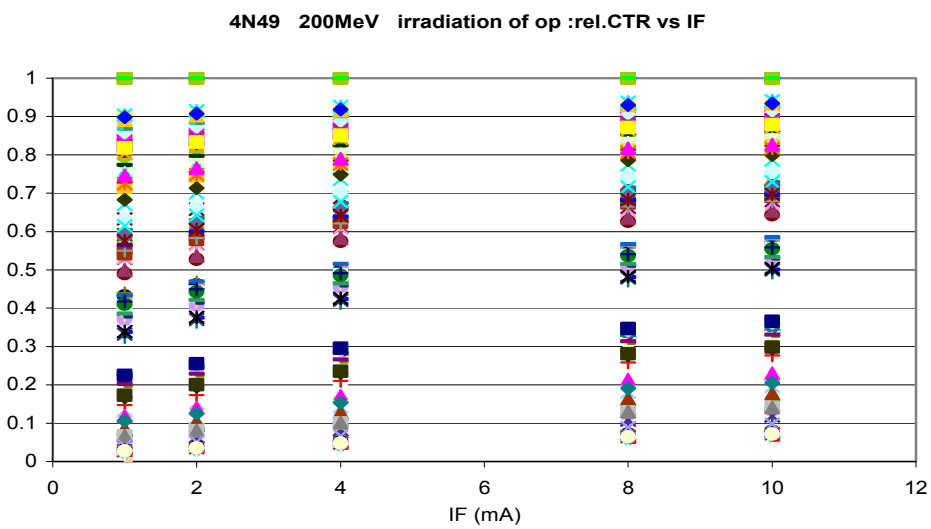
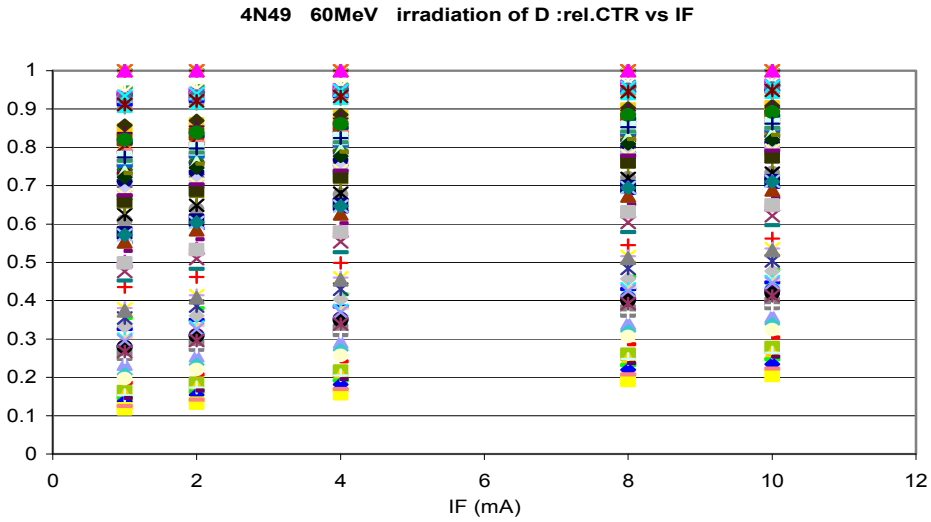
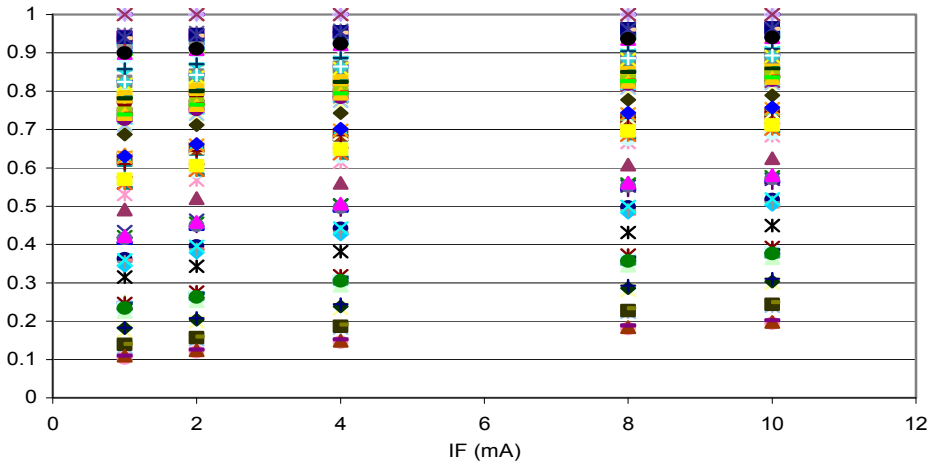


Fig. 12-56: diode irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F





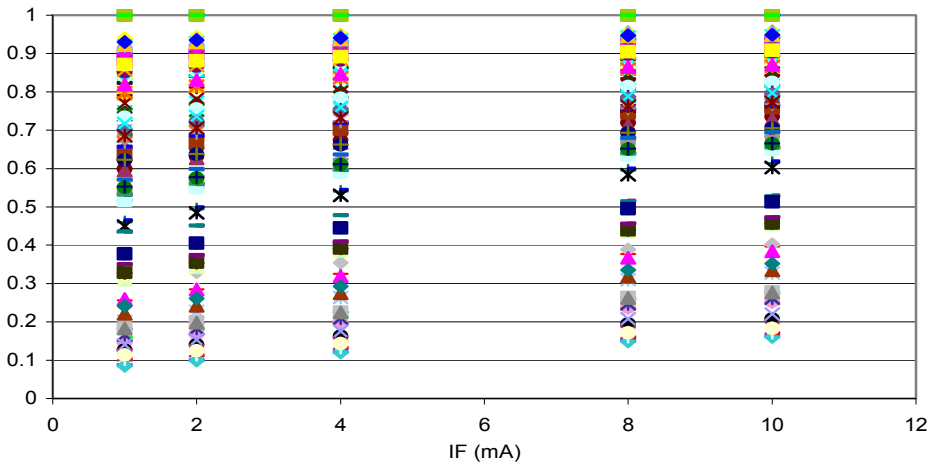
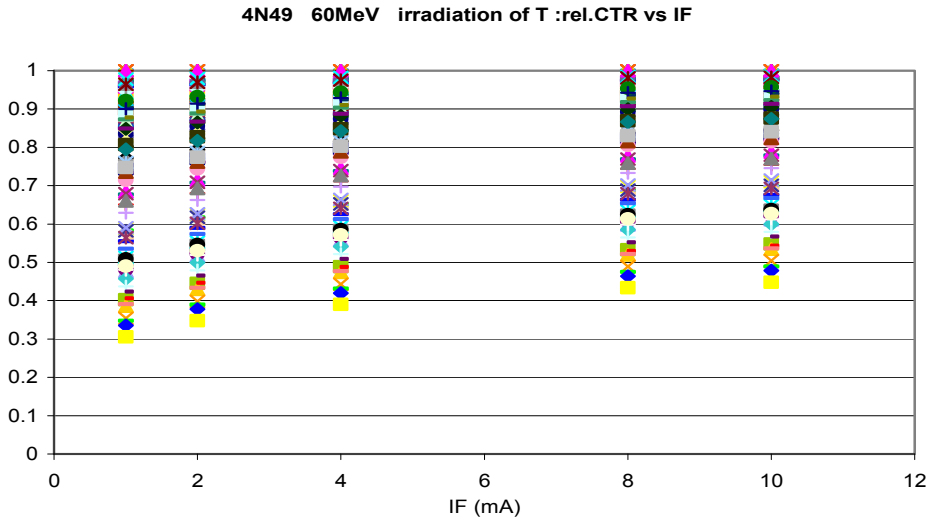
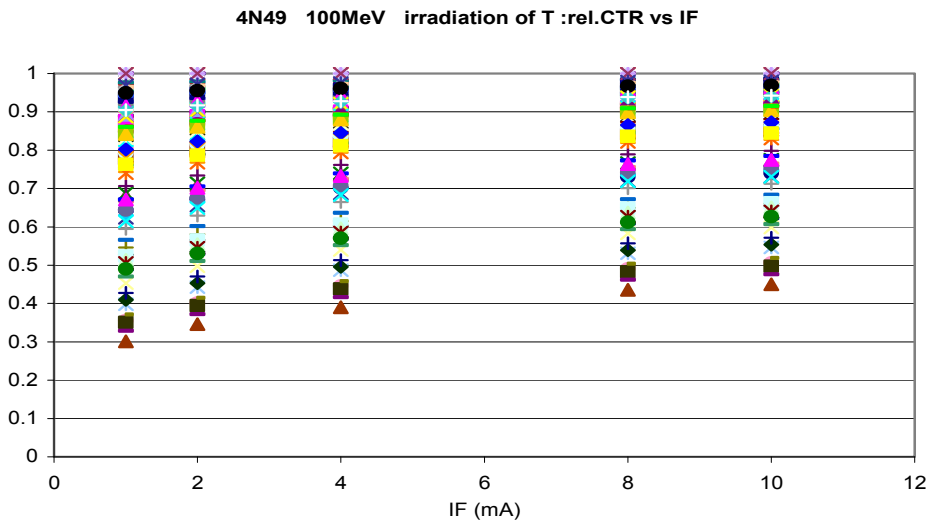


Fig. 12-57: transistor irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to reference diode current I_F





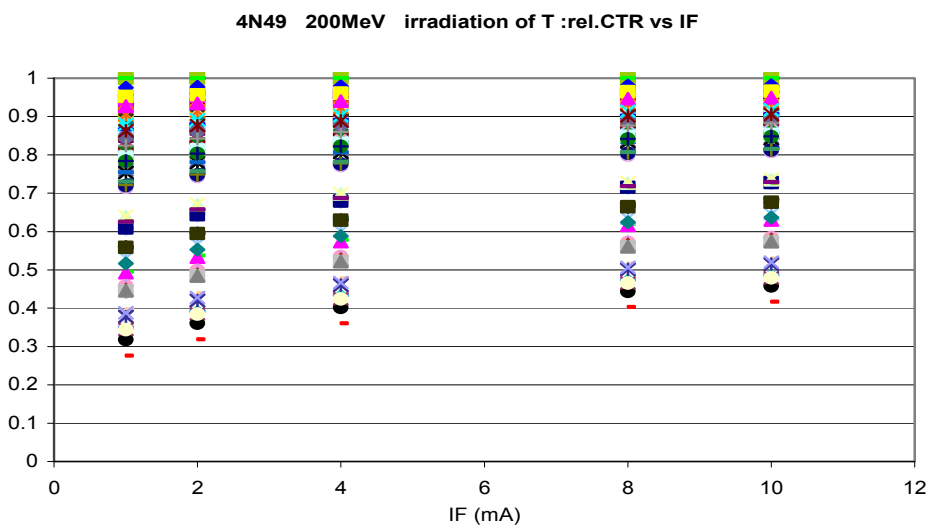


Fig. 12-58: 4N49 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA

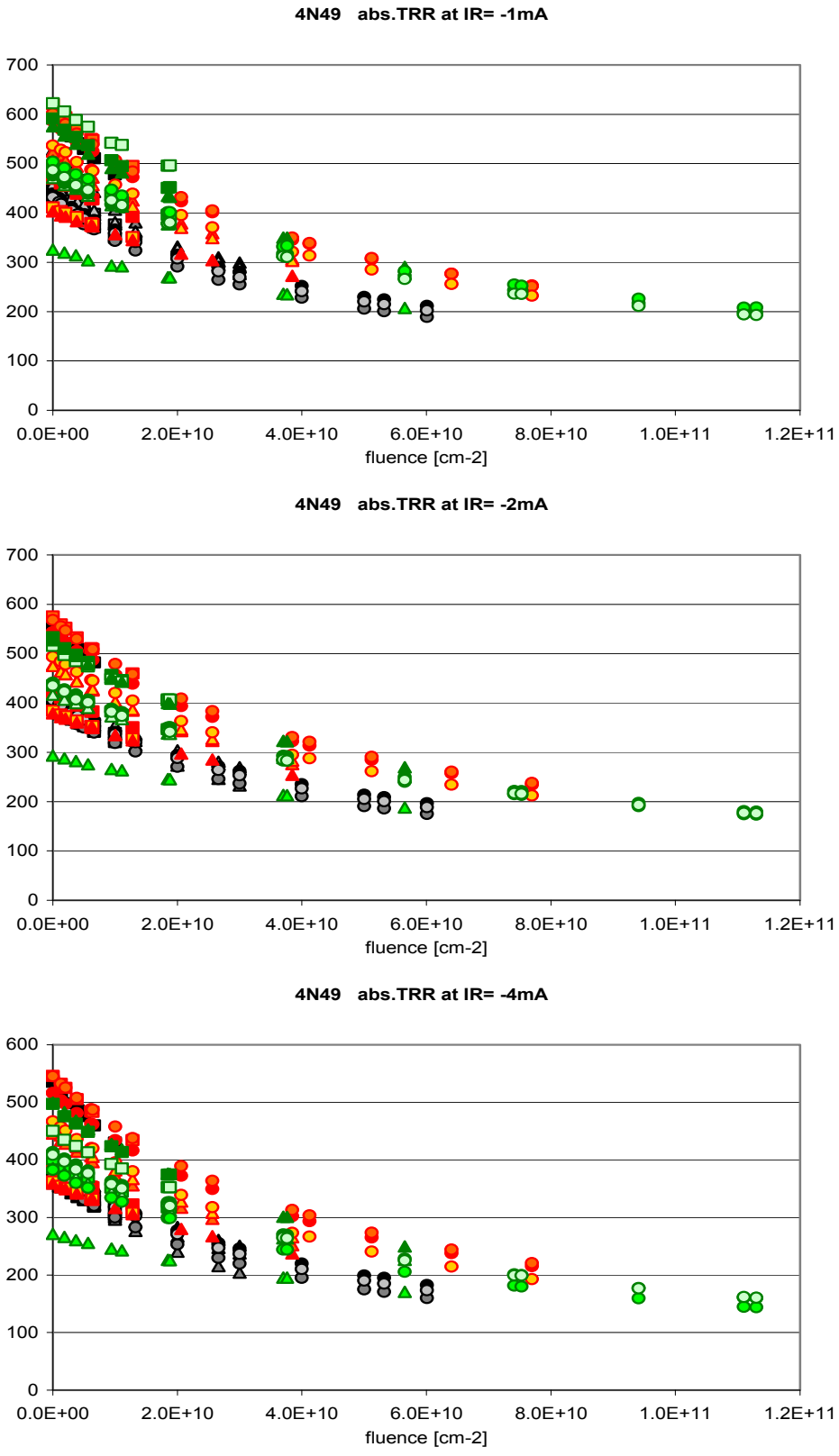
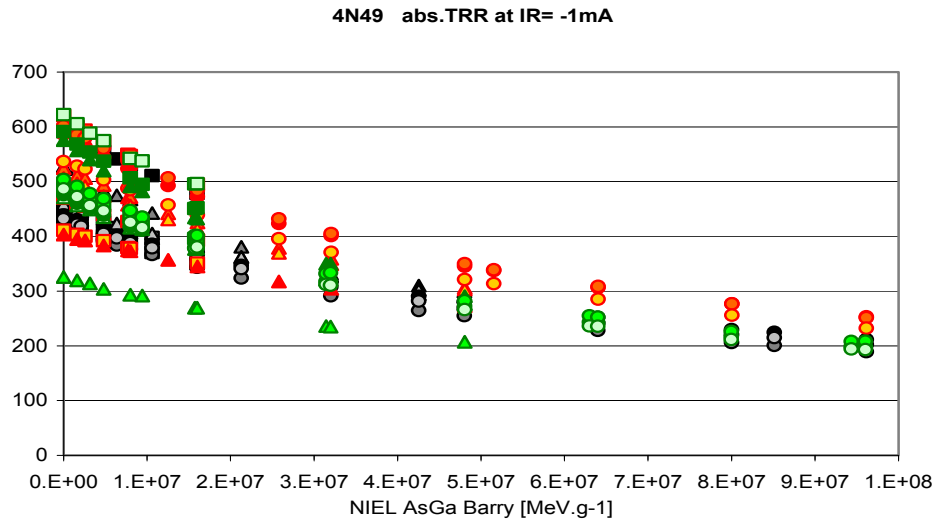
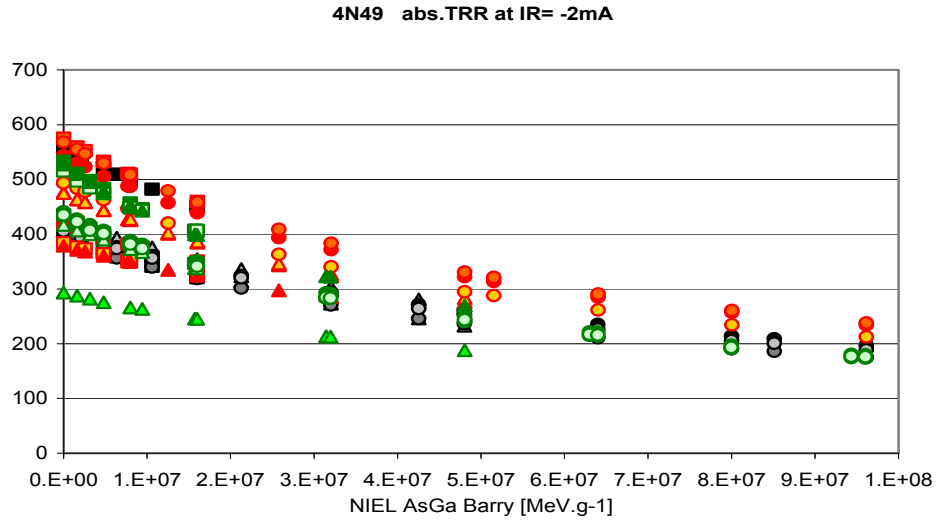


Fig. 12-59: 4N49 diode: τ_{RR} [ns] with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





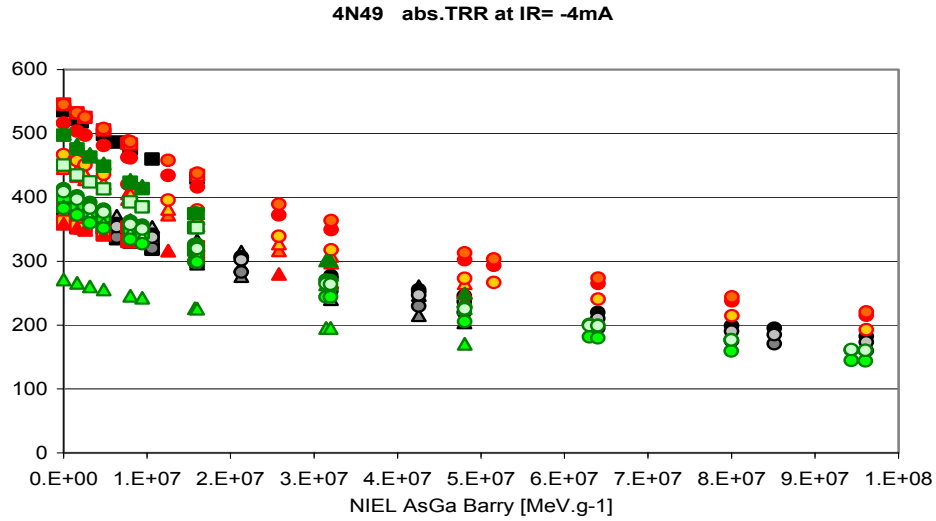
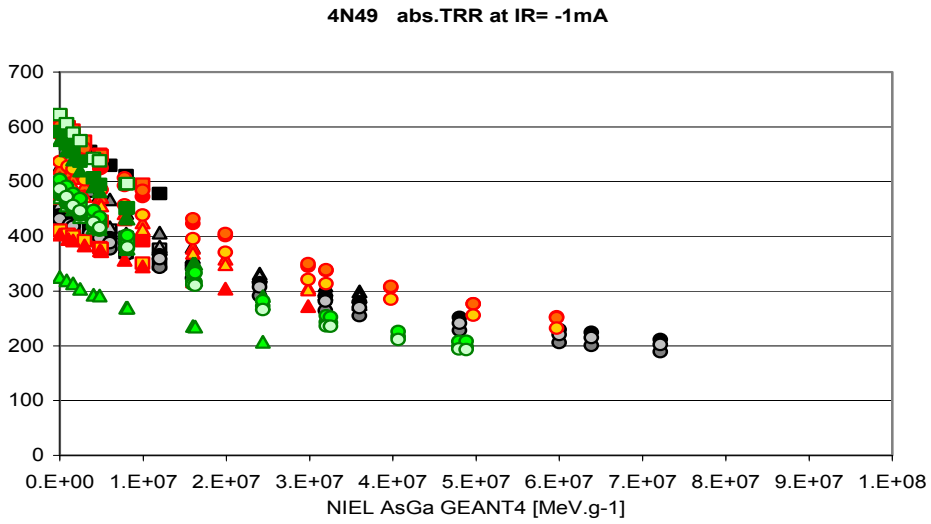
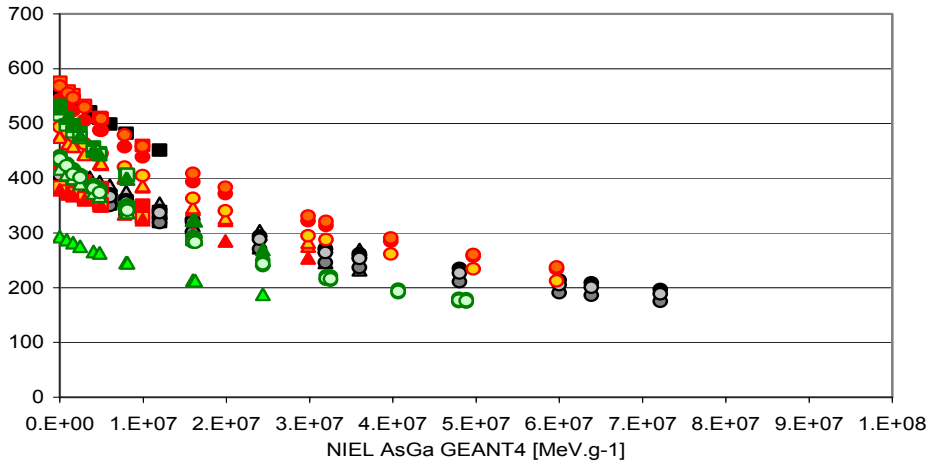


Fig. 12-60: 4N49 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





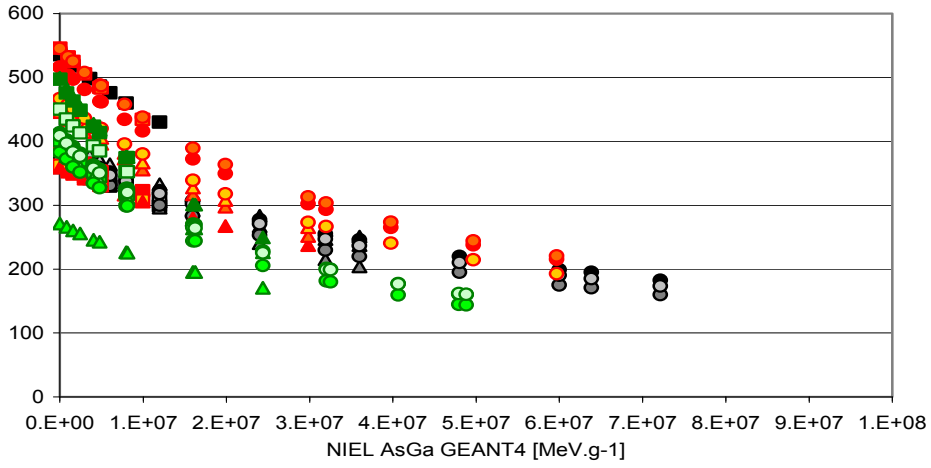
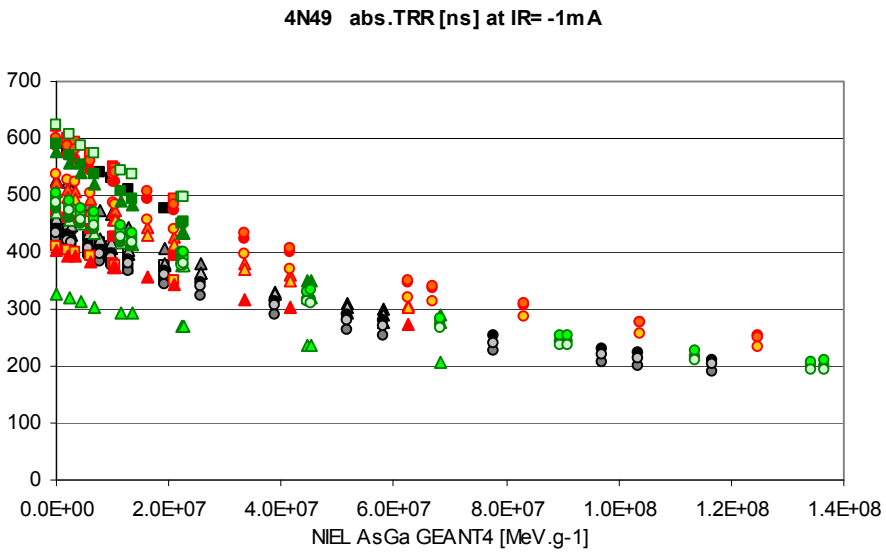
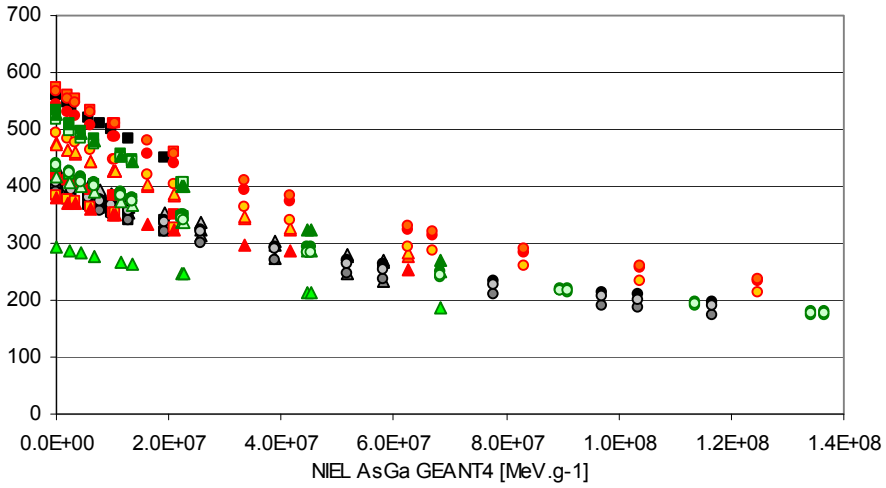


Fig. 12-61: 4N49 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





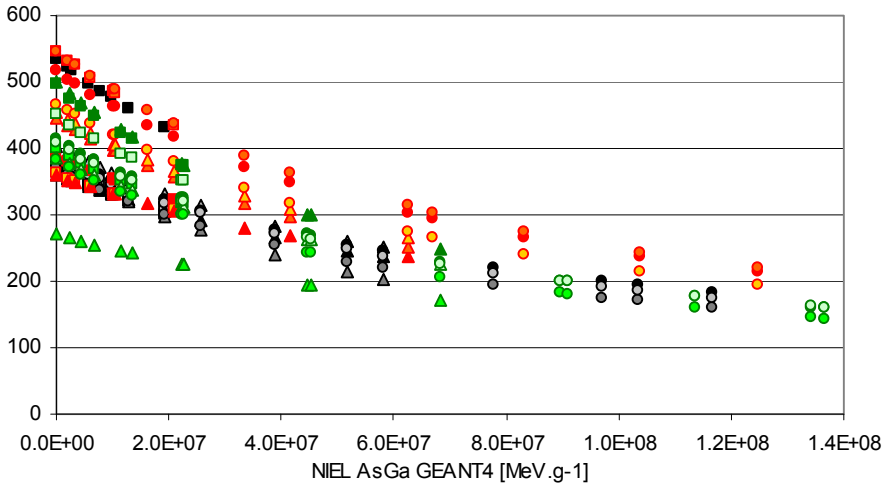
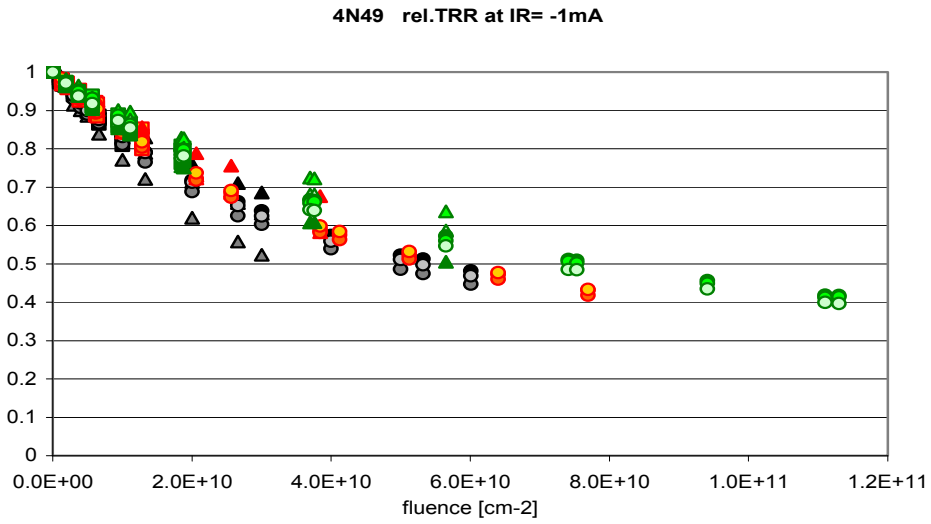
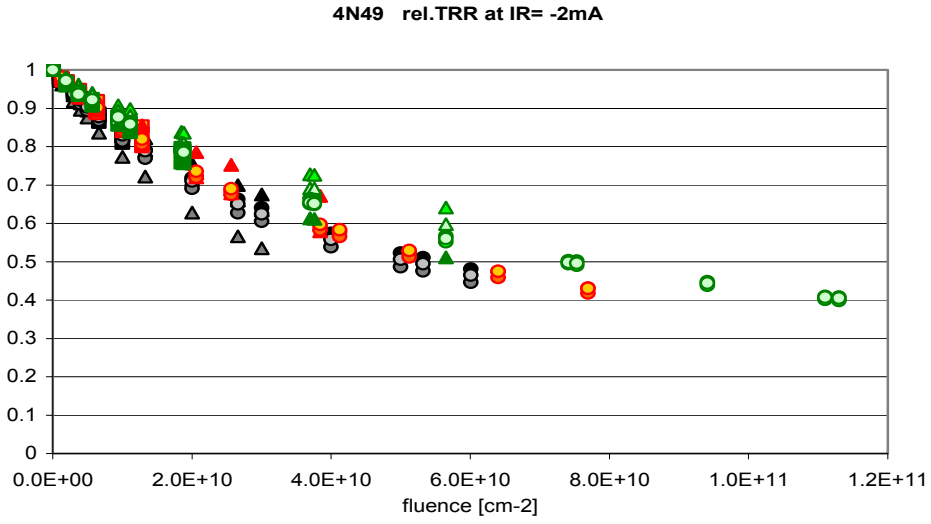


Fig. 12-62: 4N49 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA





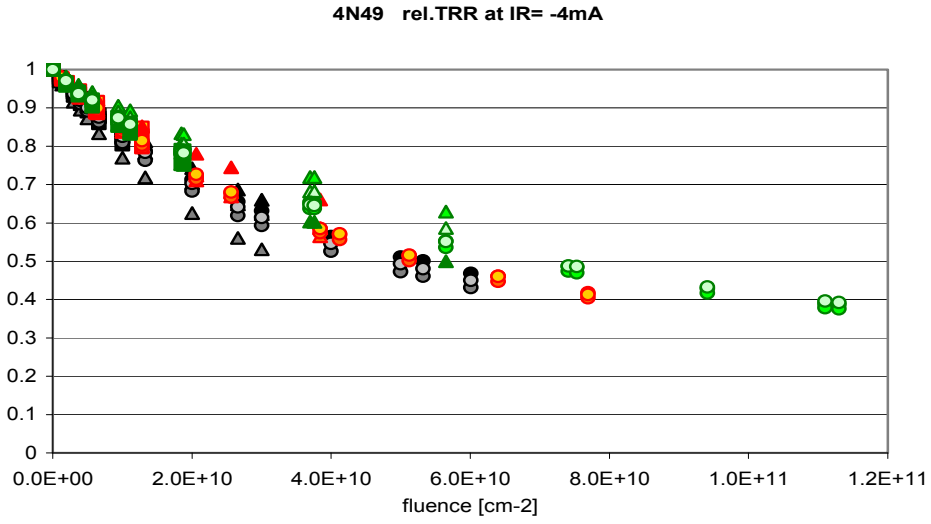
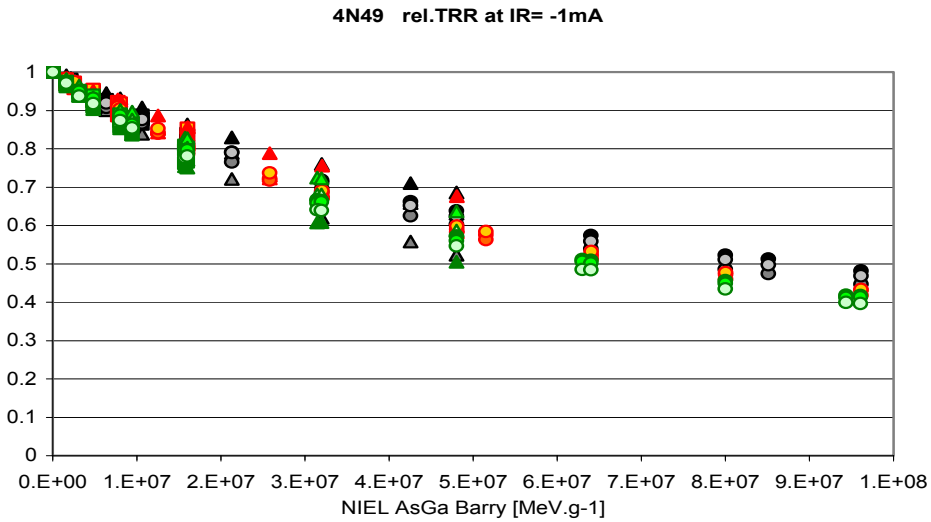
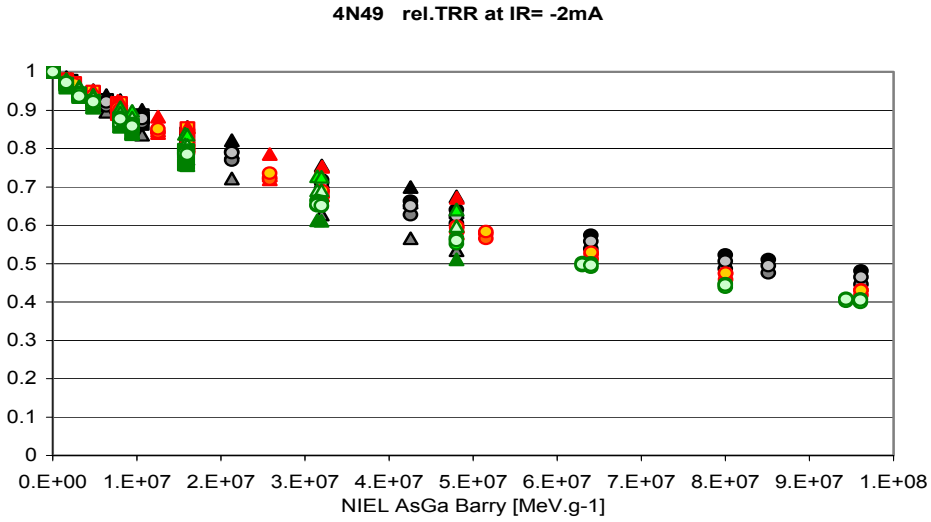


Fig. 12-63: 4N49 diode: τ_{RR}/τ_{RR0} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





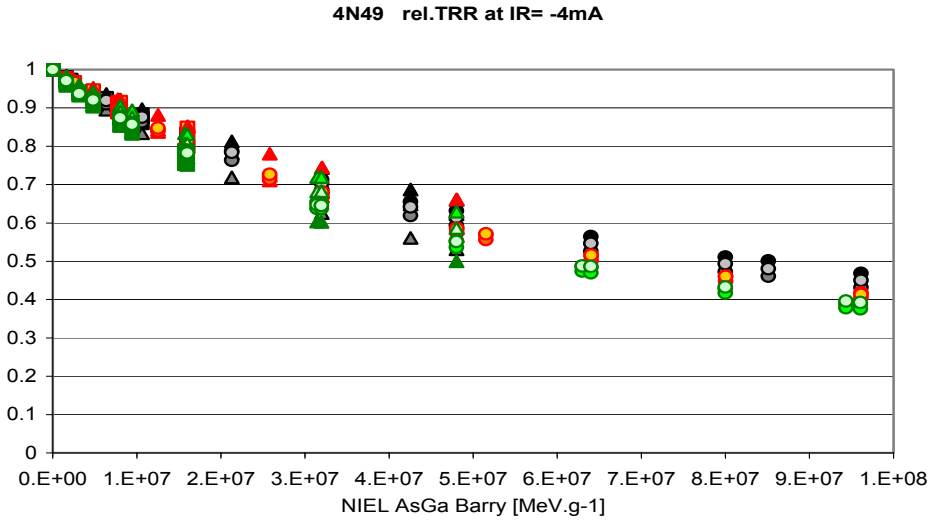


Fig. 12-64: 4N49 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA

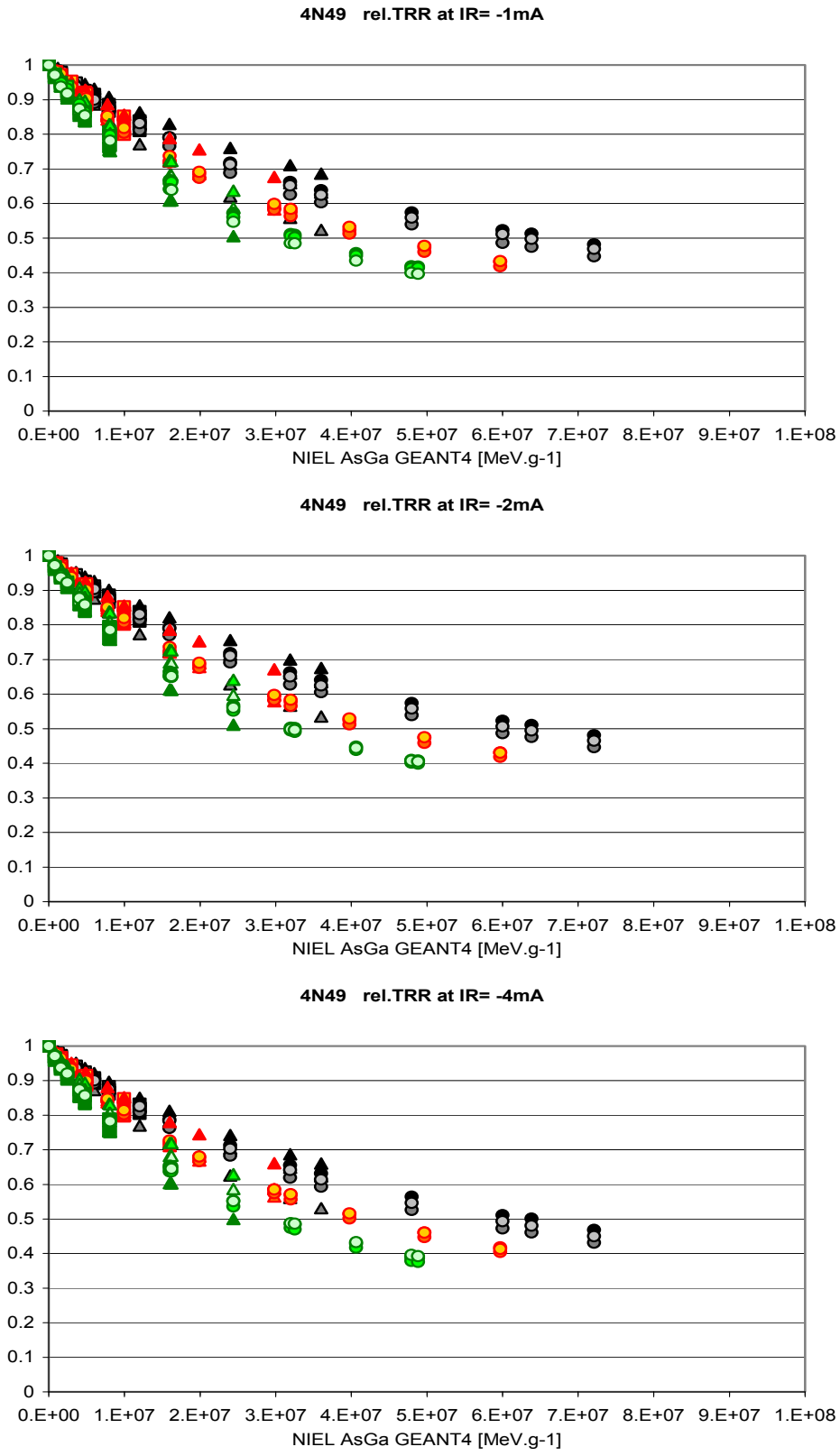
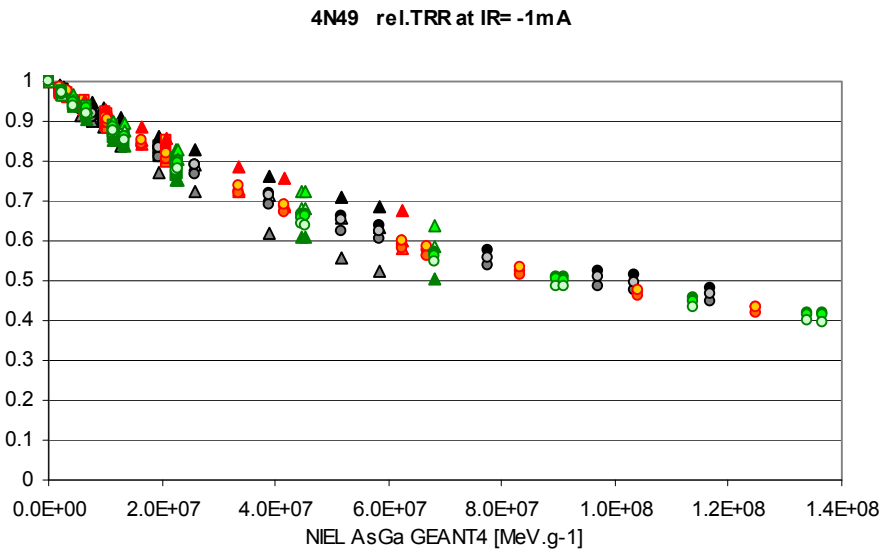
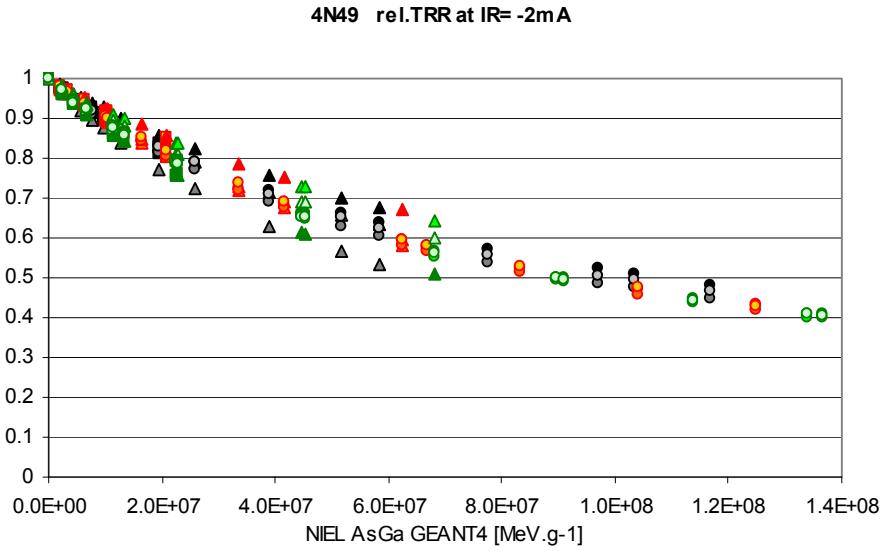


Fig. 12-65: 4N49 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





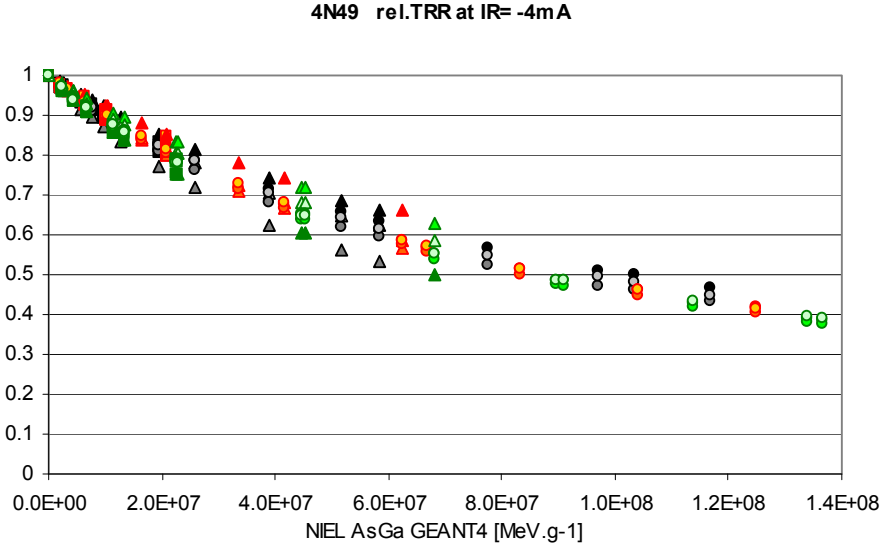
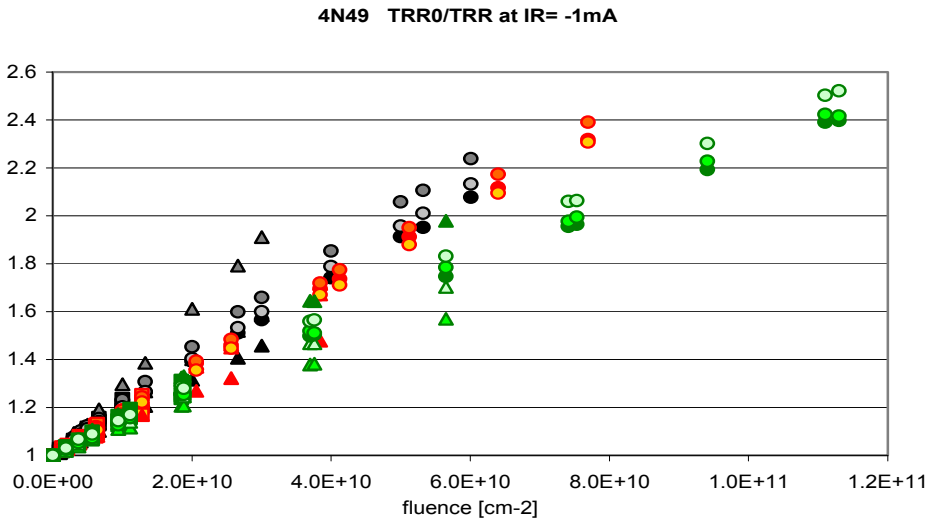
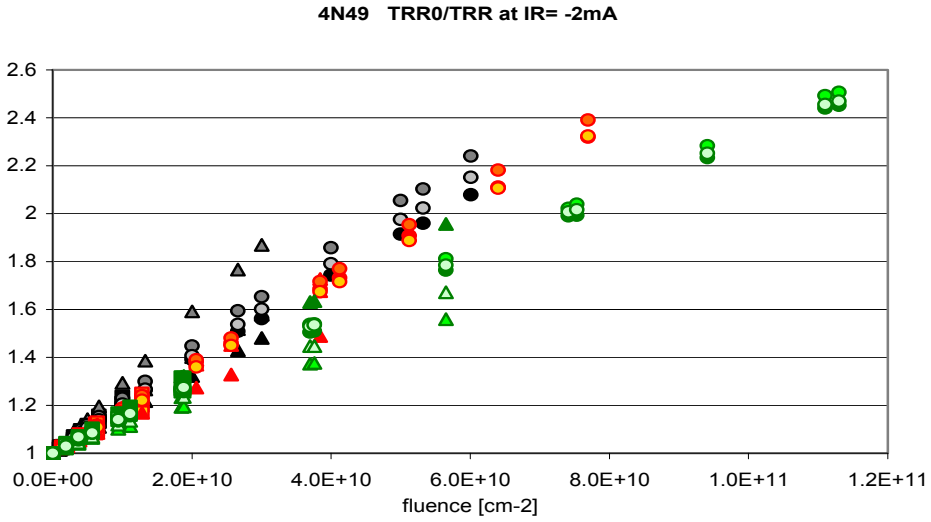


Fig. 12-66: 4N49 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





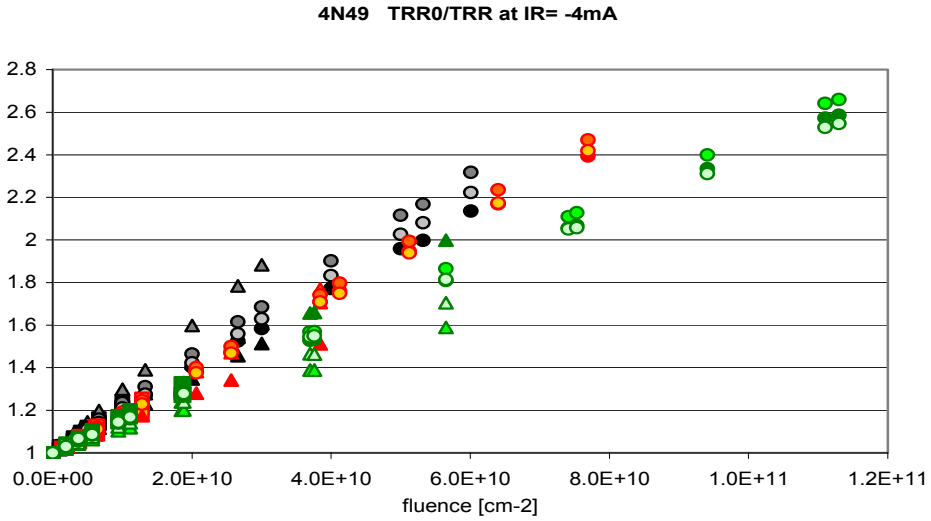
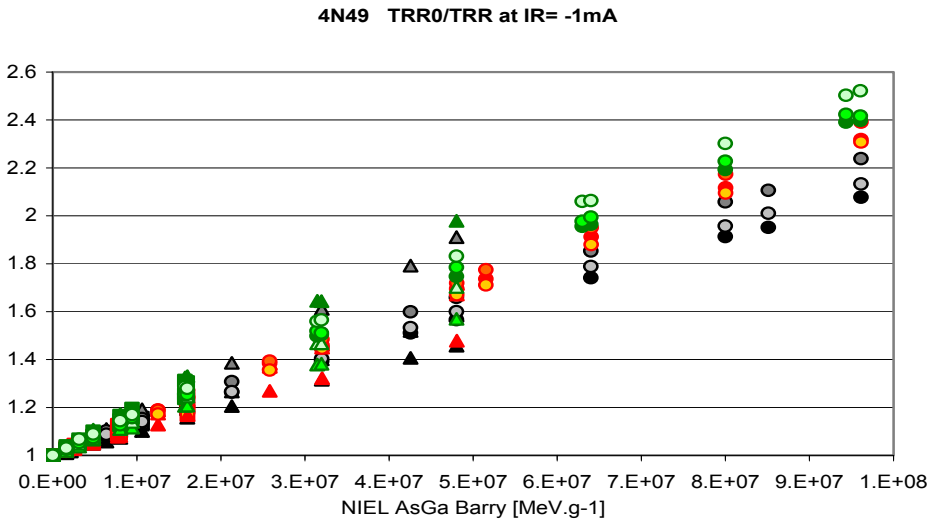
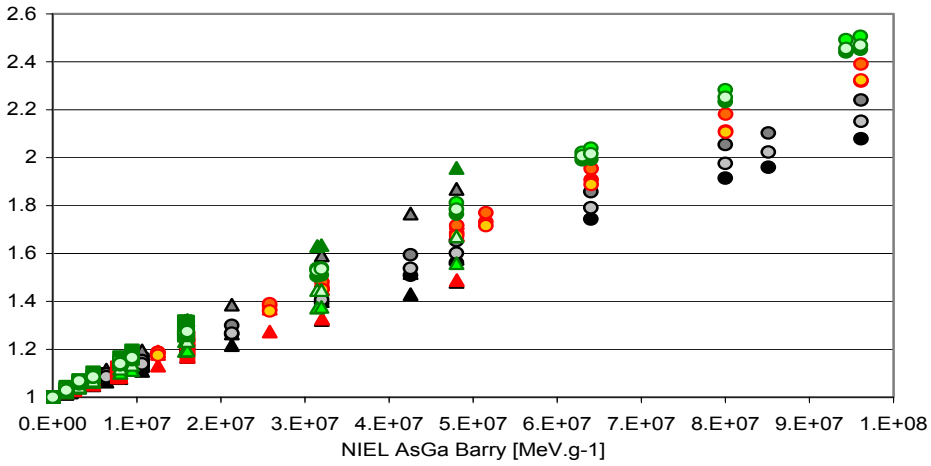


Fig. 12-67: 4N49 diode: τ_{RR0}/τ_{RR} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





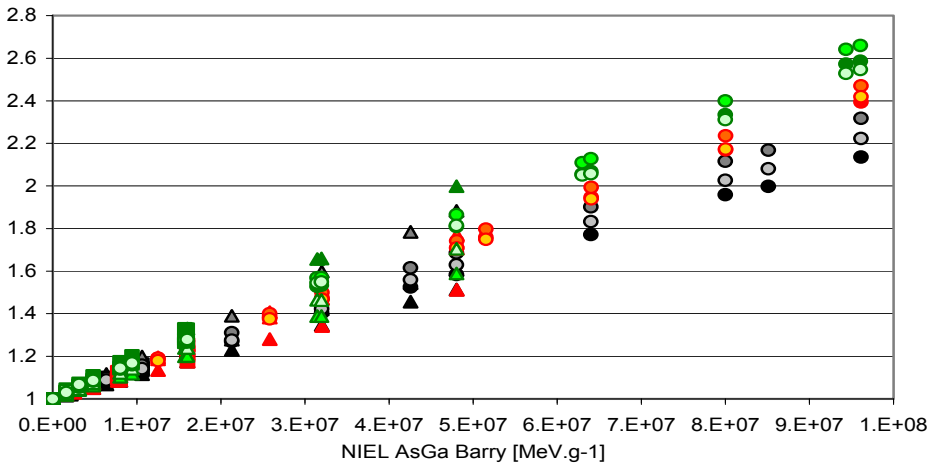
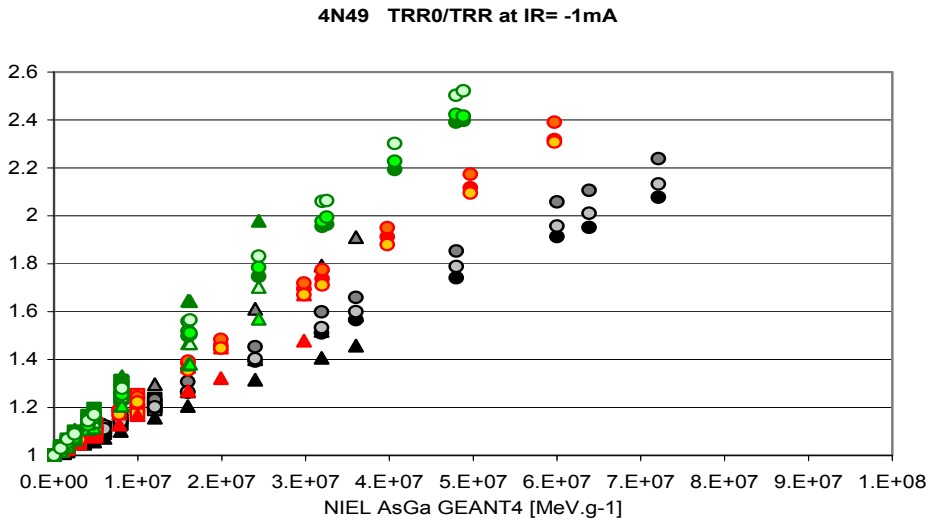
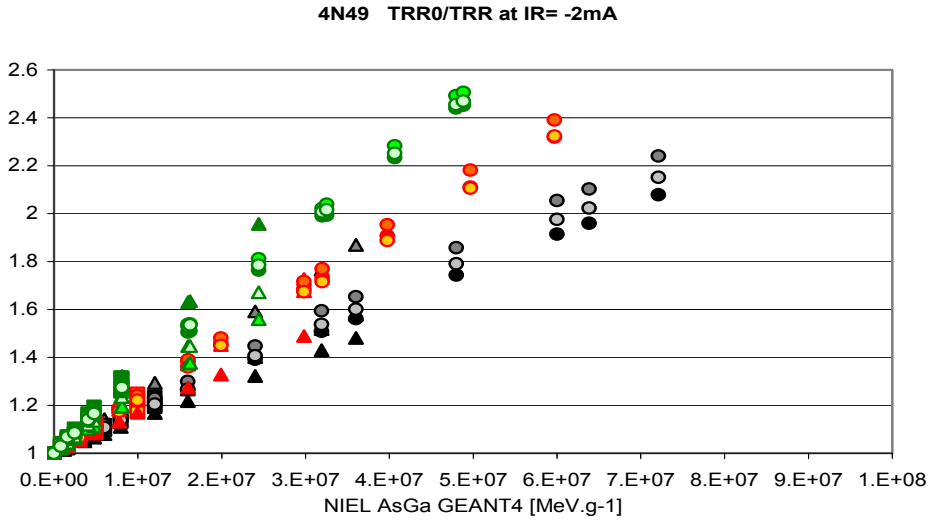


Fig. 12-68: 4N49 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





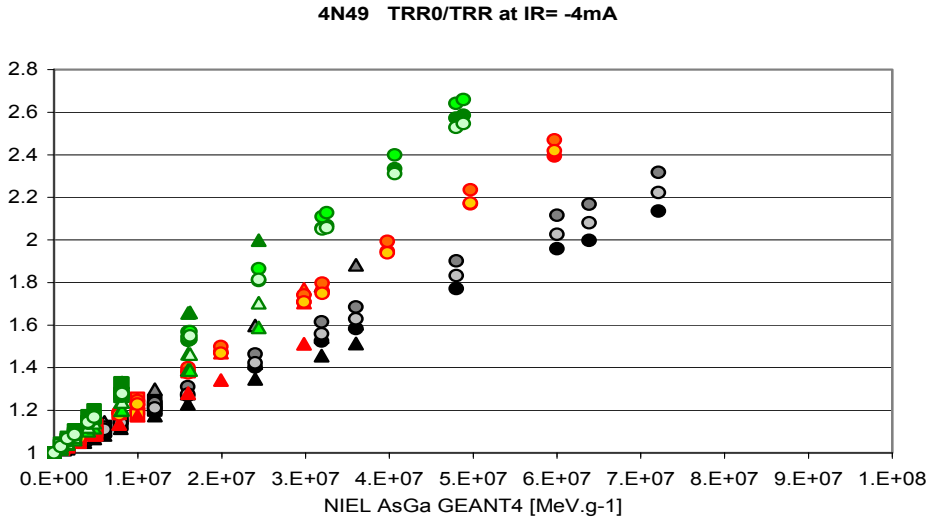
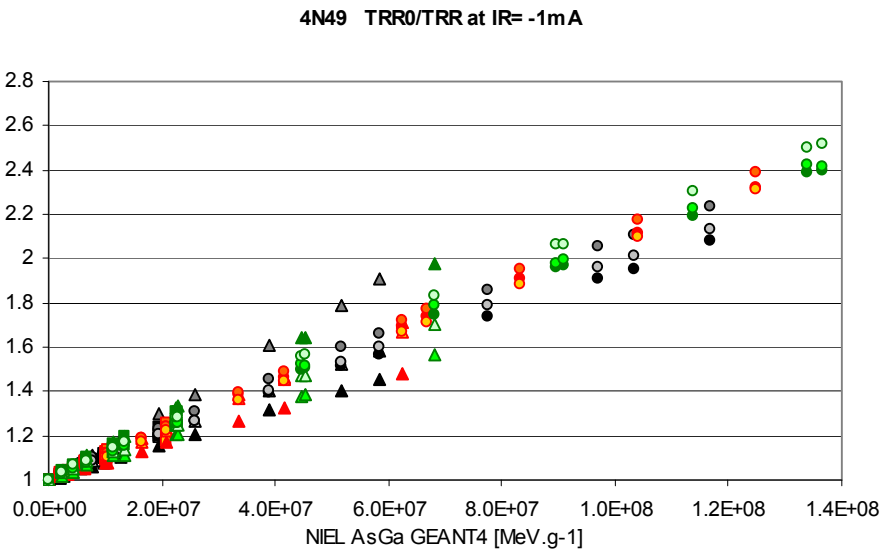
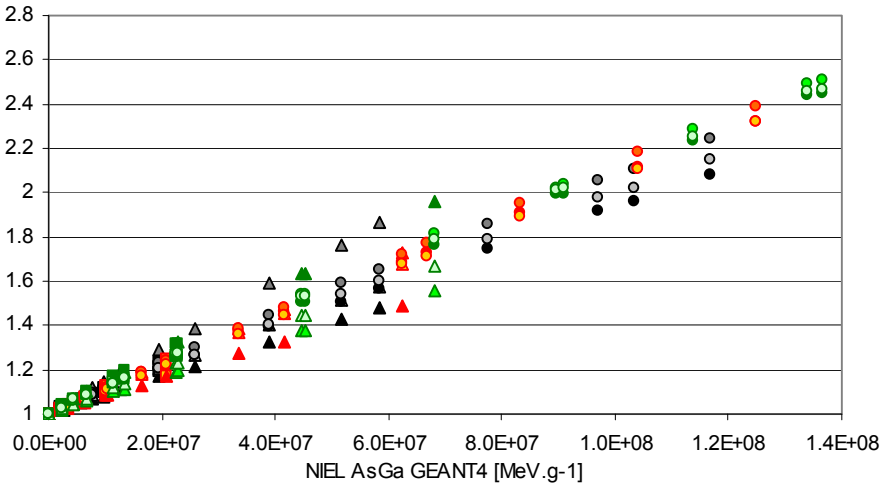


Fig. 12-69: 4N49 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





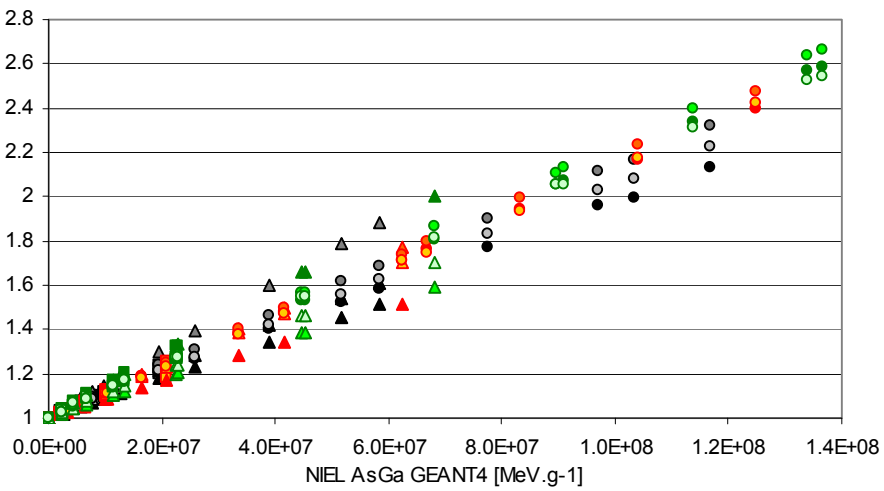


Fig. 12-70: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 1.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4 mA

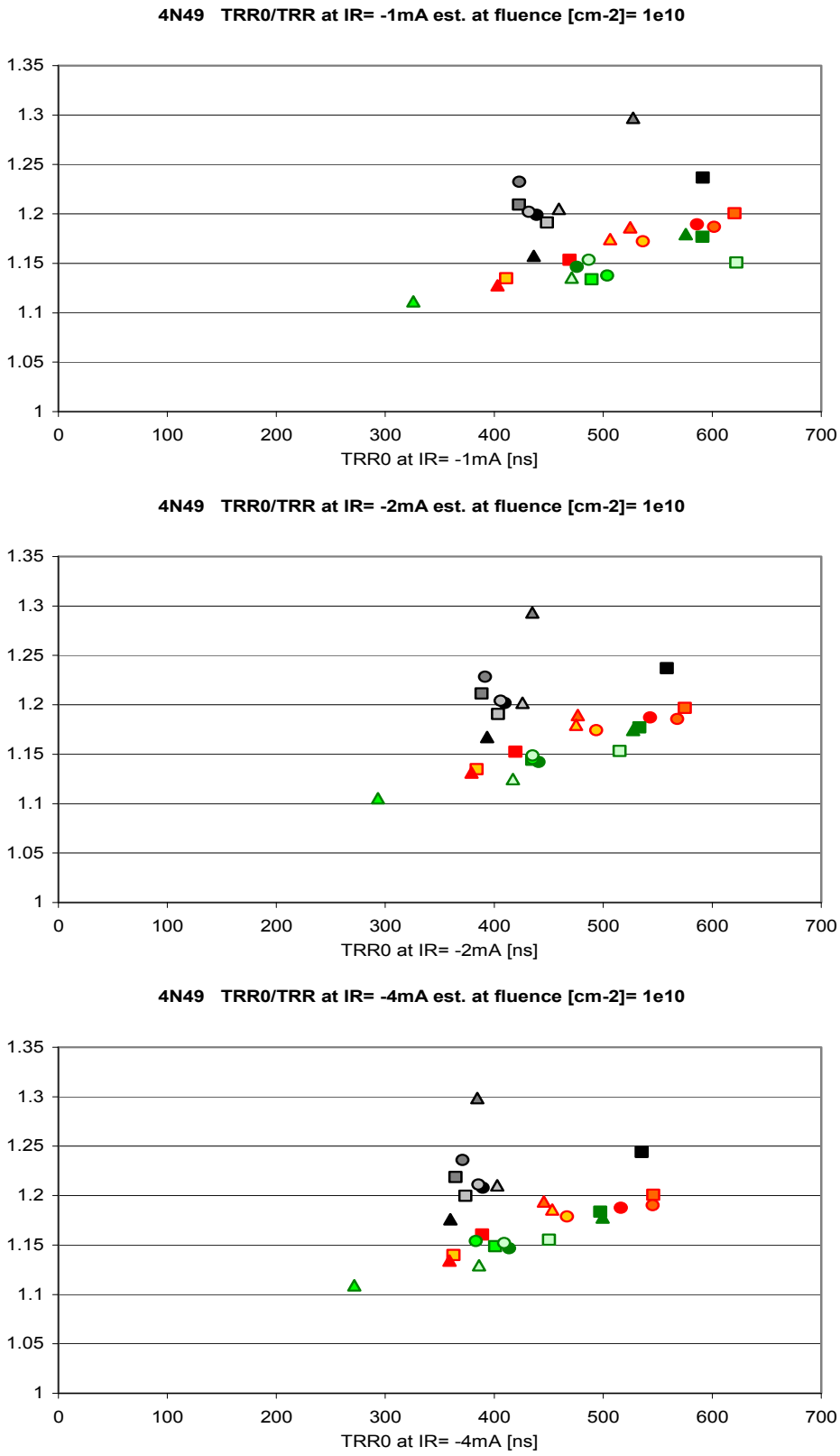


Fig. 12-71: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

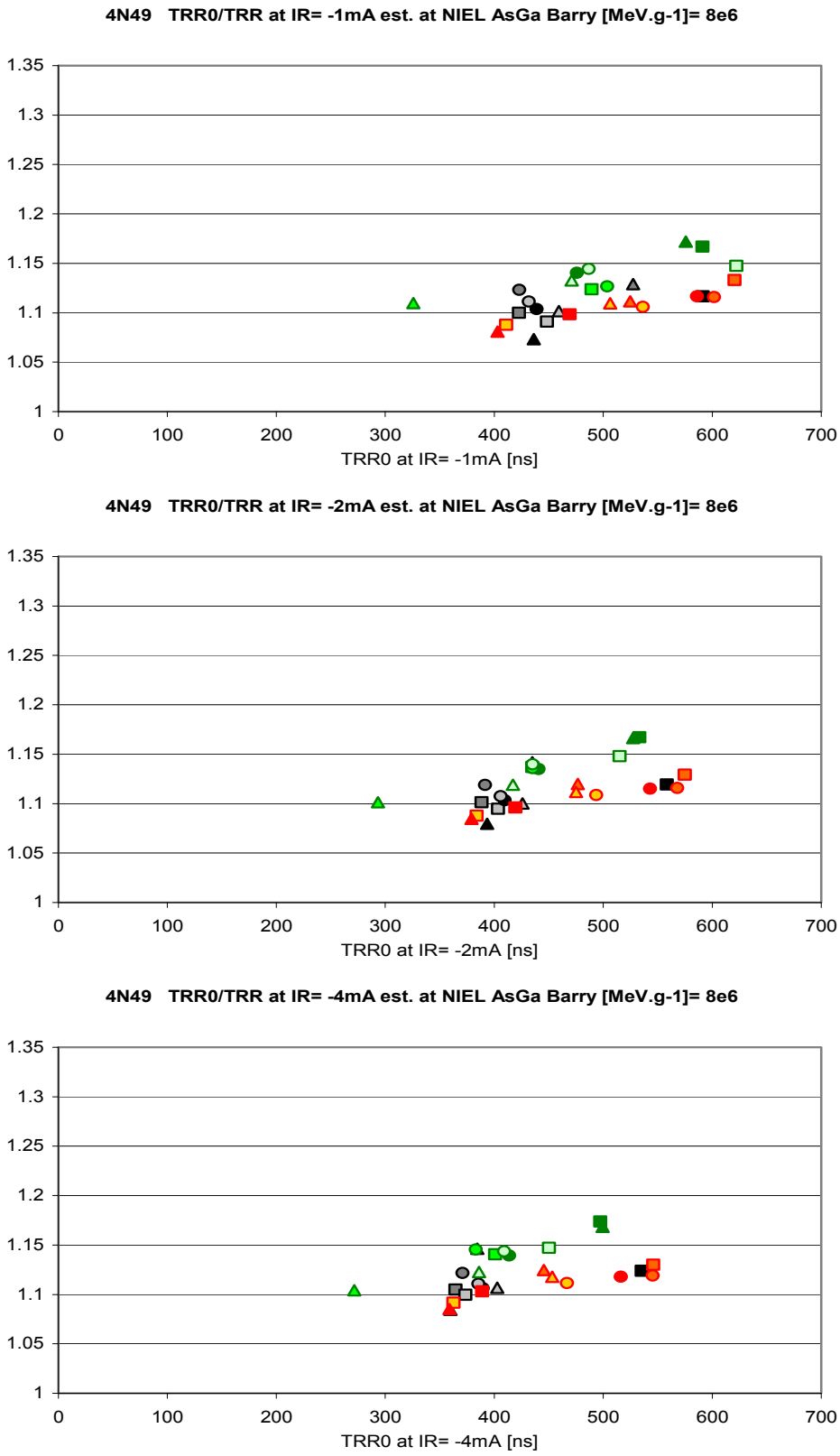


Fig. 12-72: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

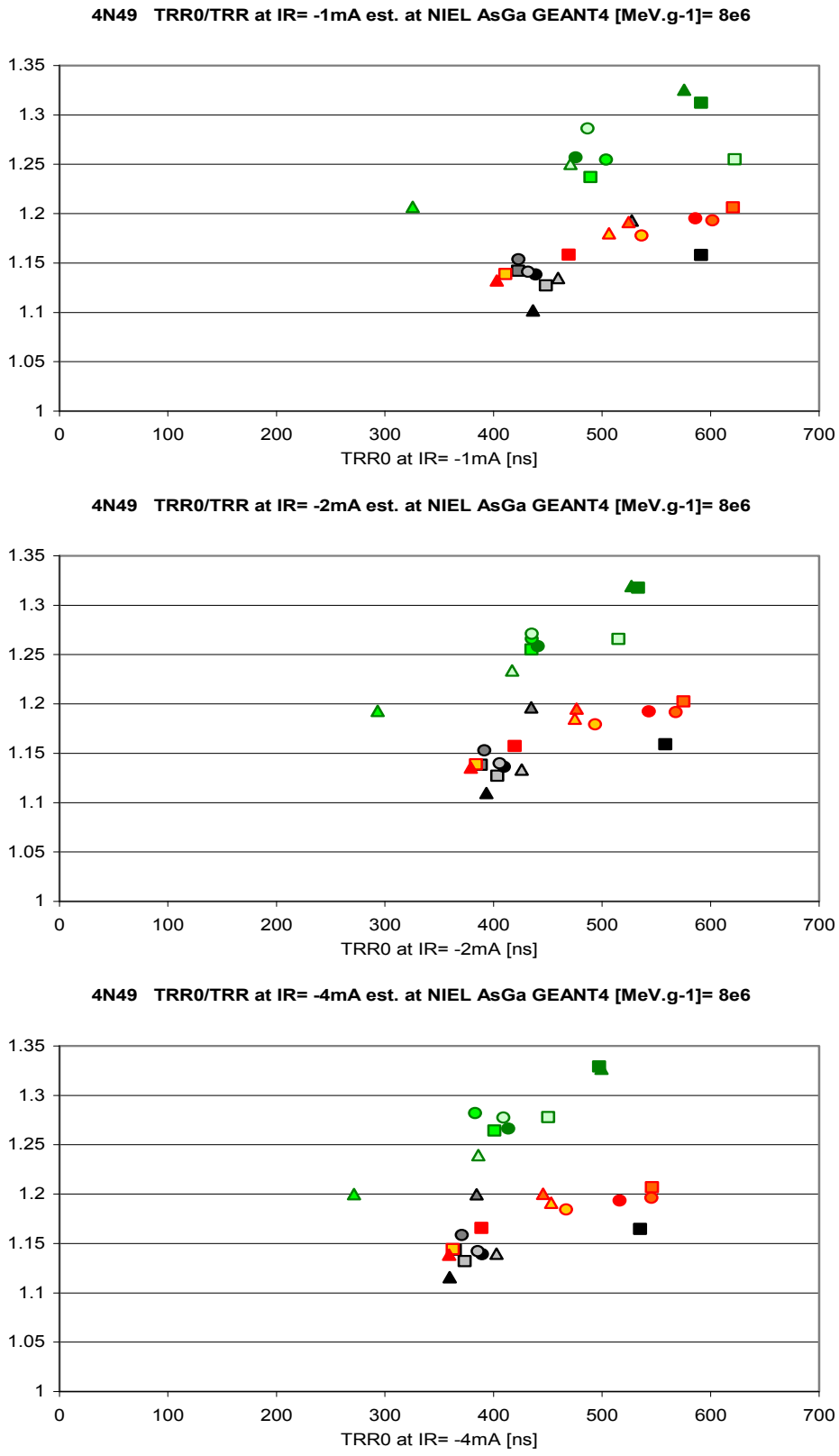


Fig. 12-73: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

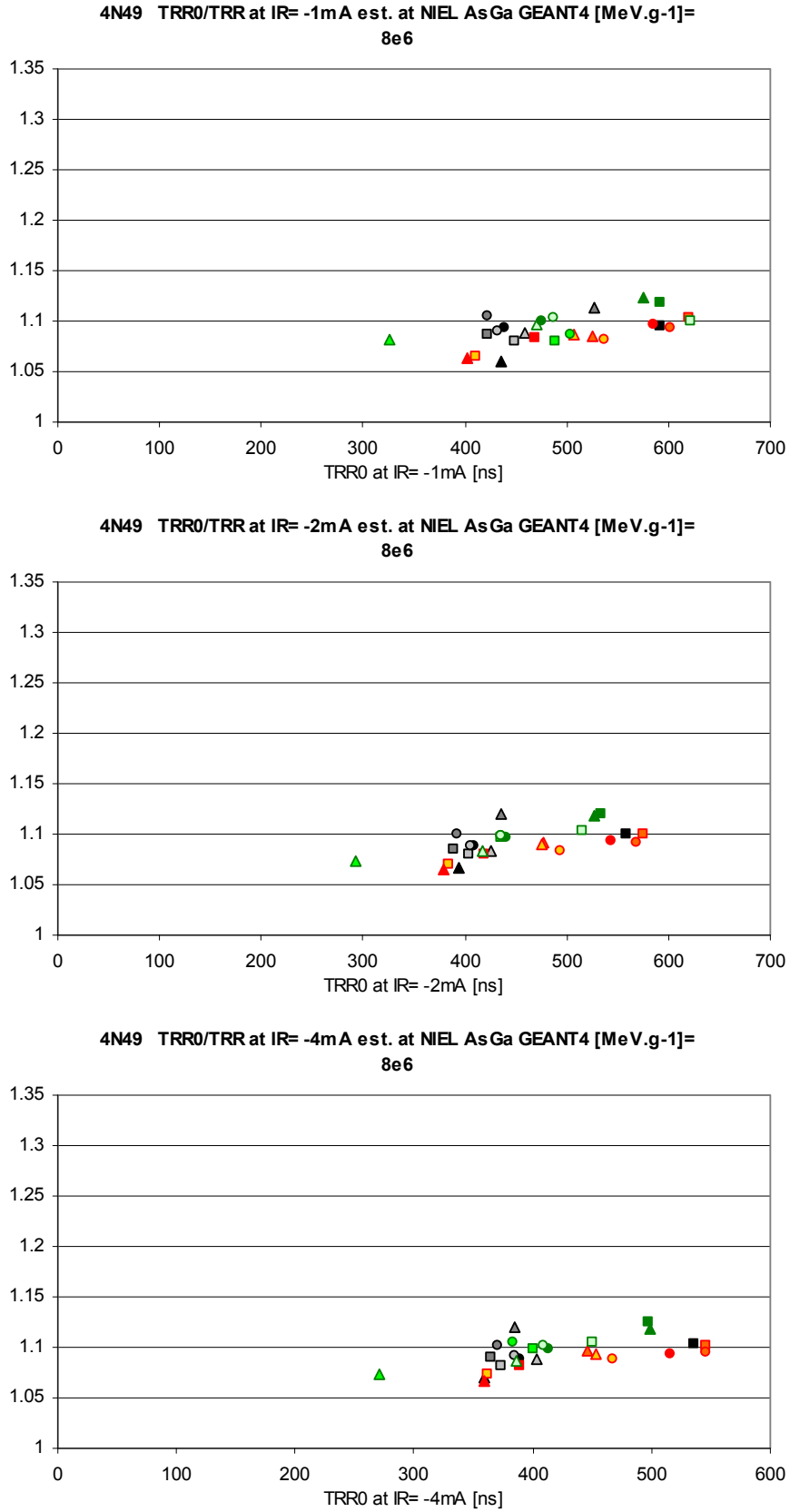


Fig. 12-74: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a fluence of $2.4.10^{10}$ cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

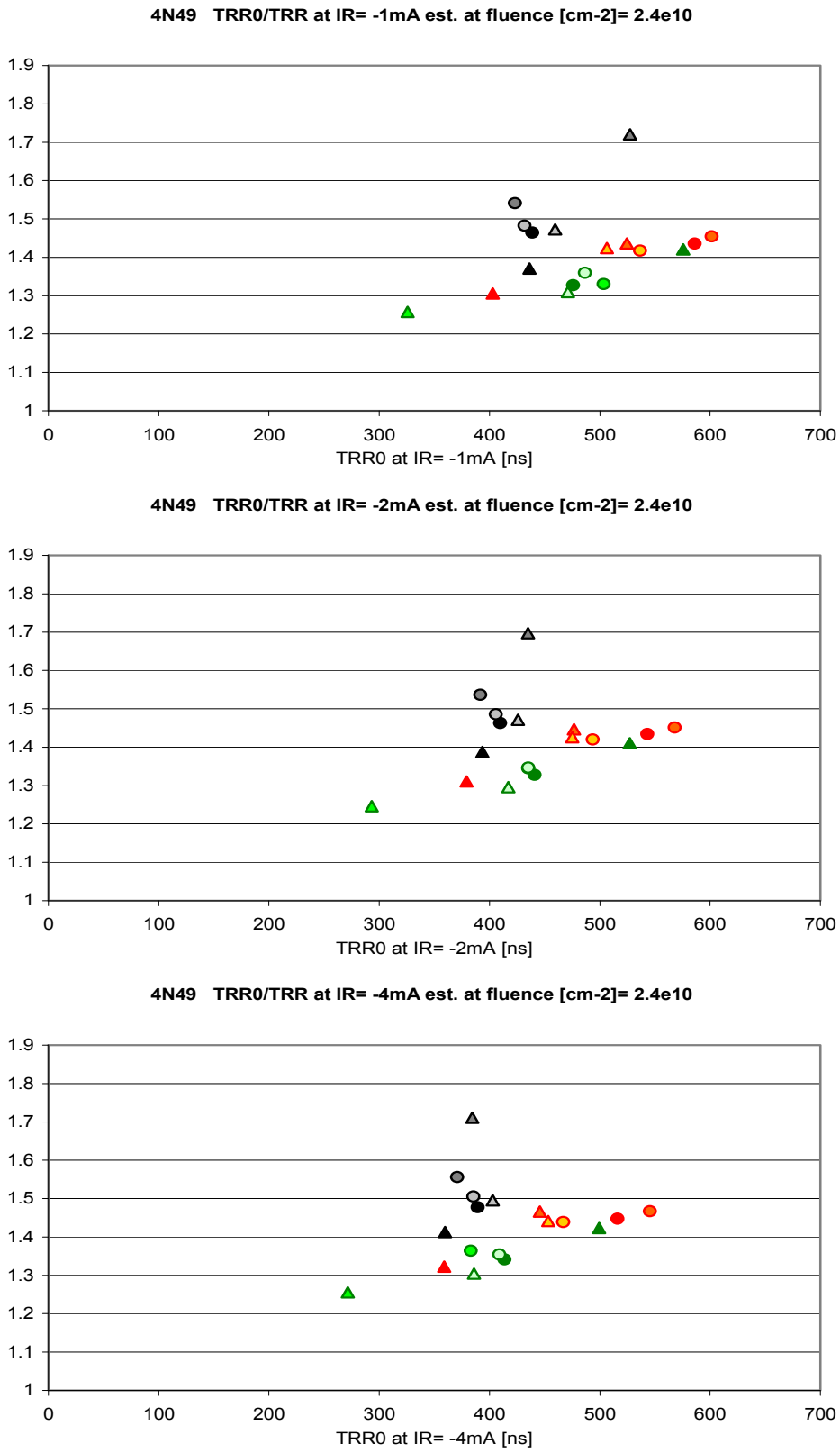


Fig. 12-75: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA

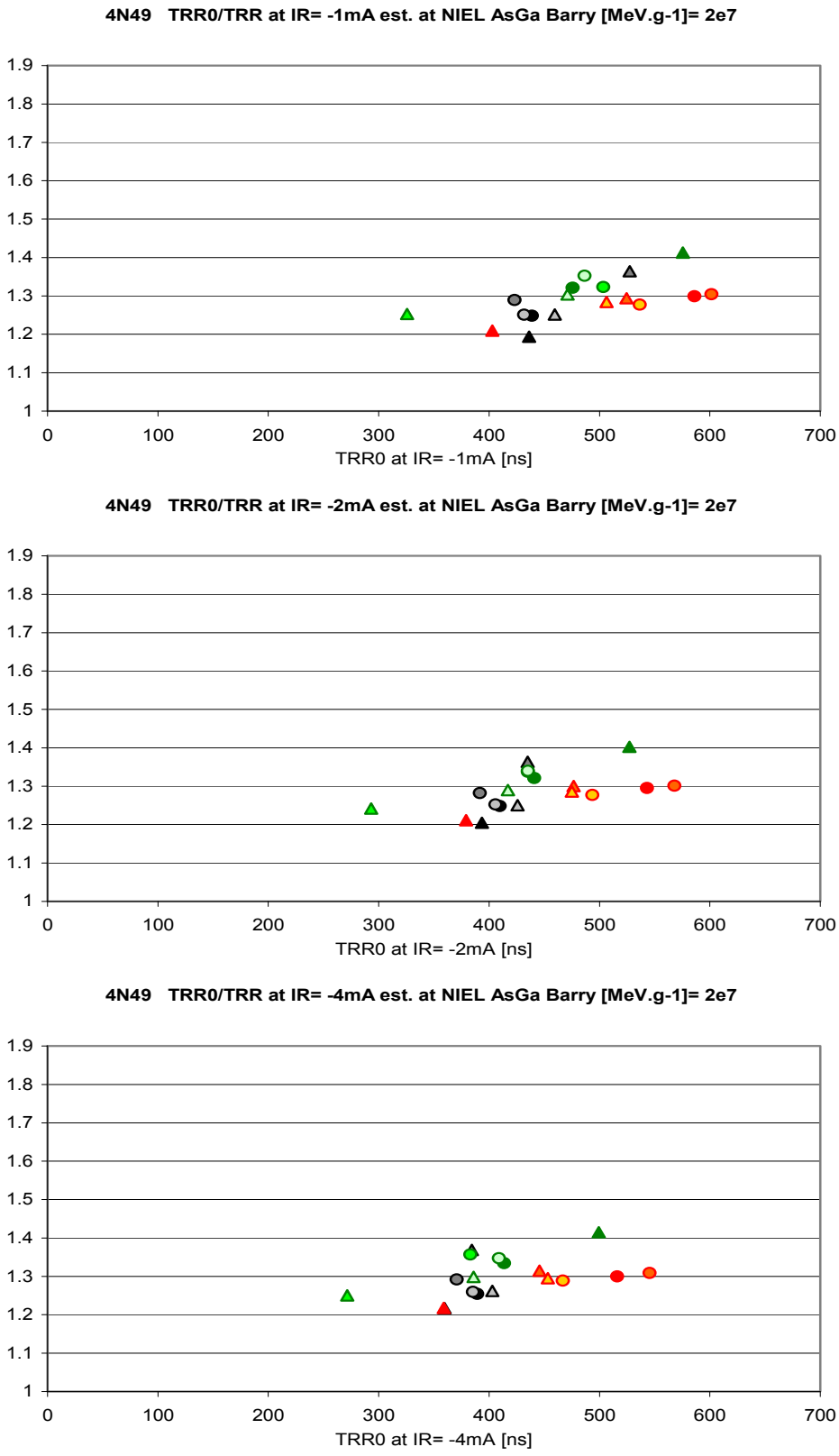
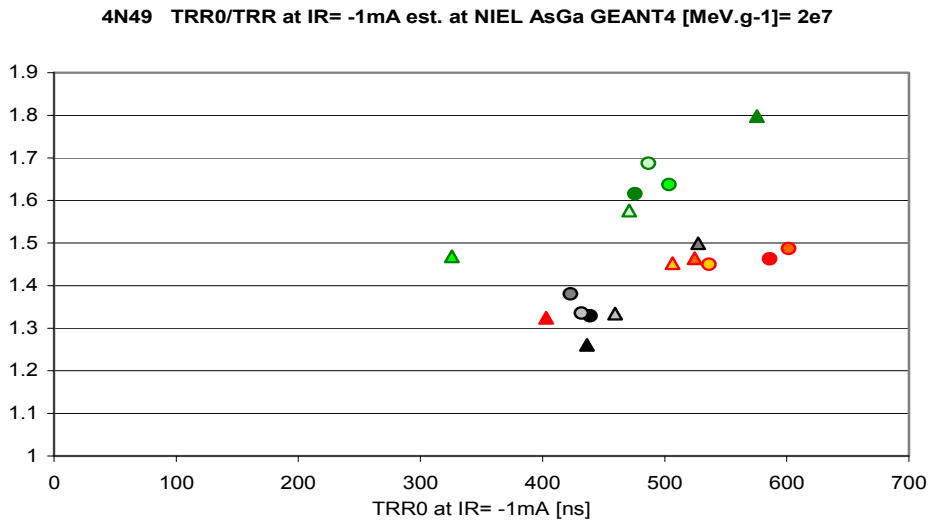
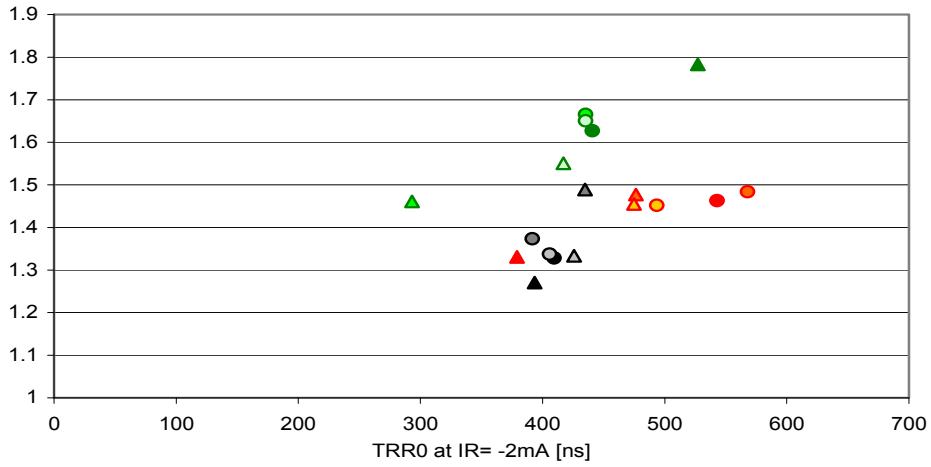


Fig. 12-76: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA





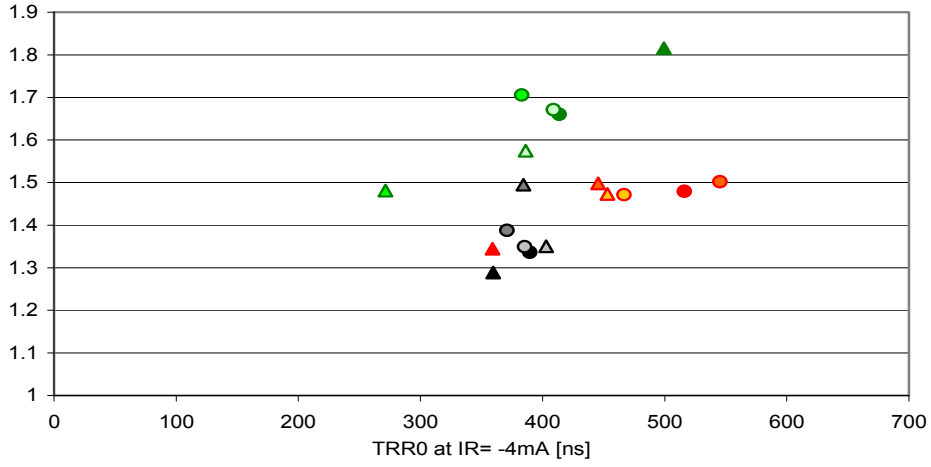


Fig. 12-77: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA

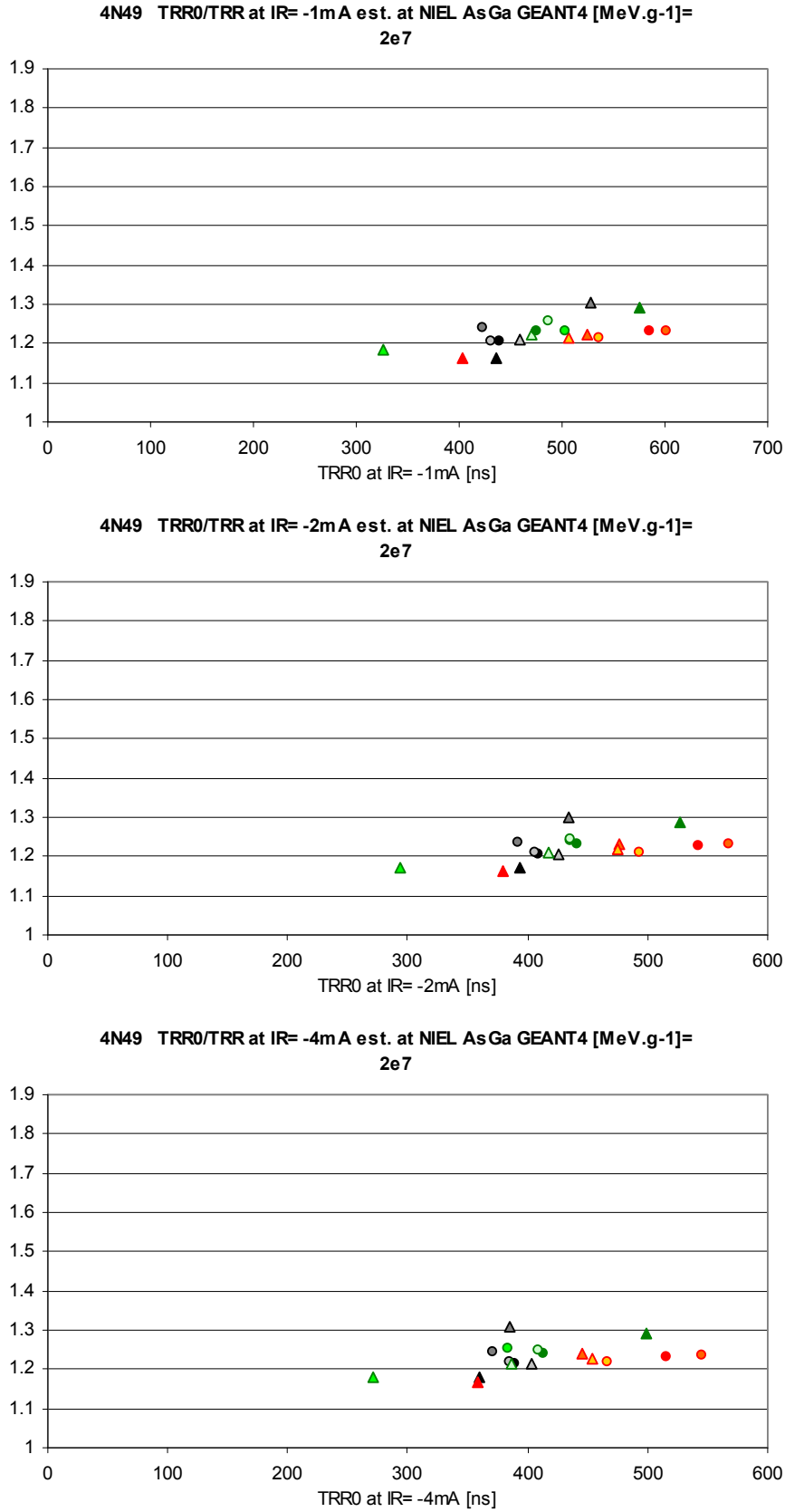


Fig. 12-78: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 6.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

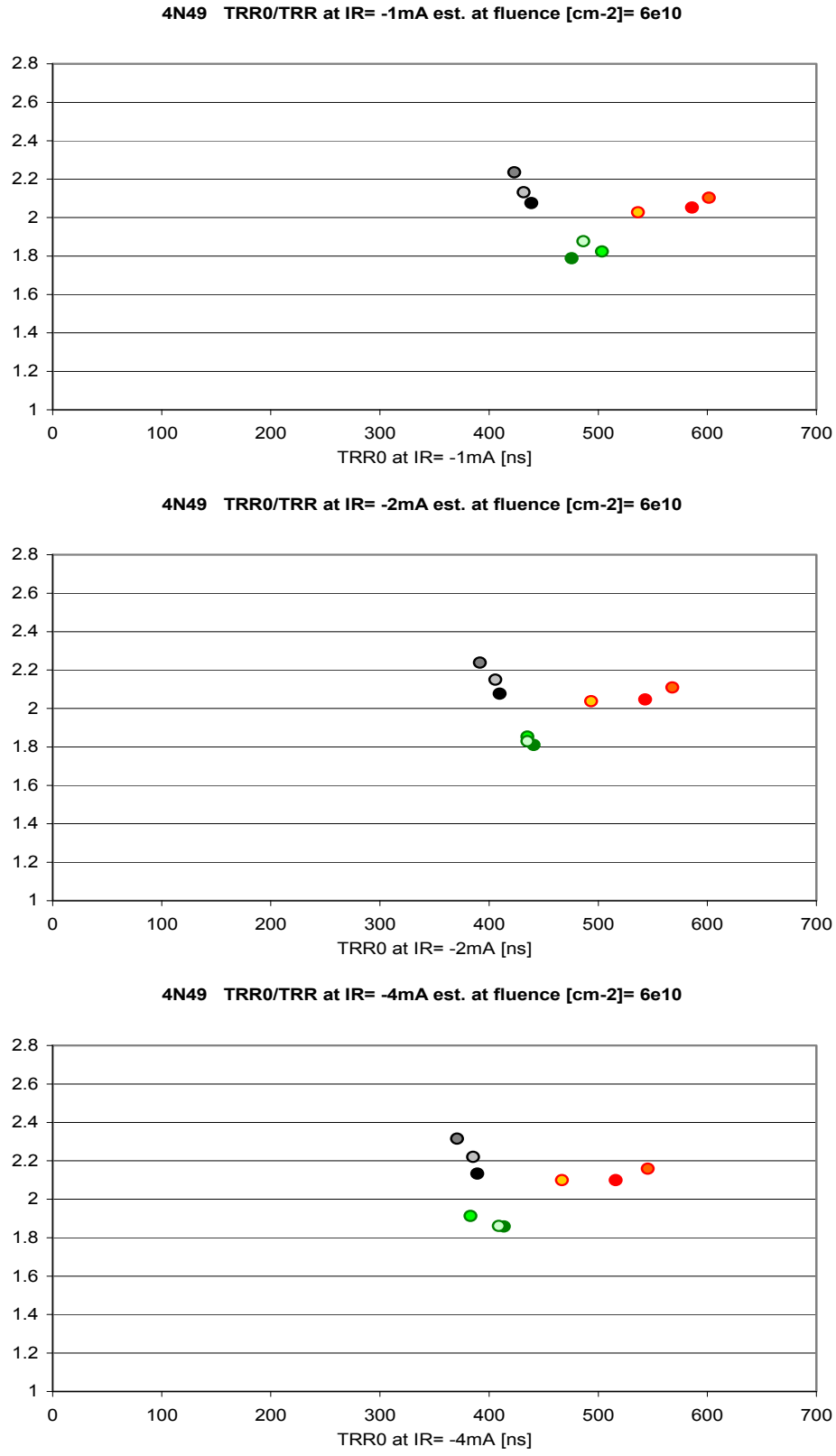


Fig. 12-79: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^7$ MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA

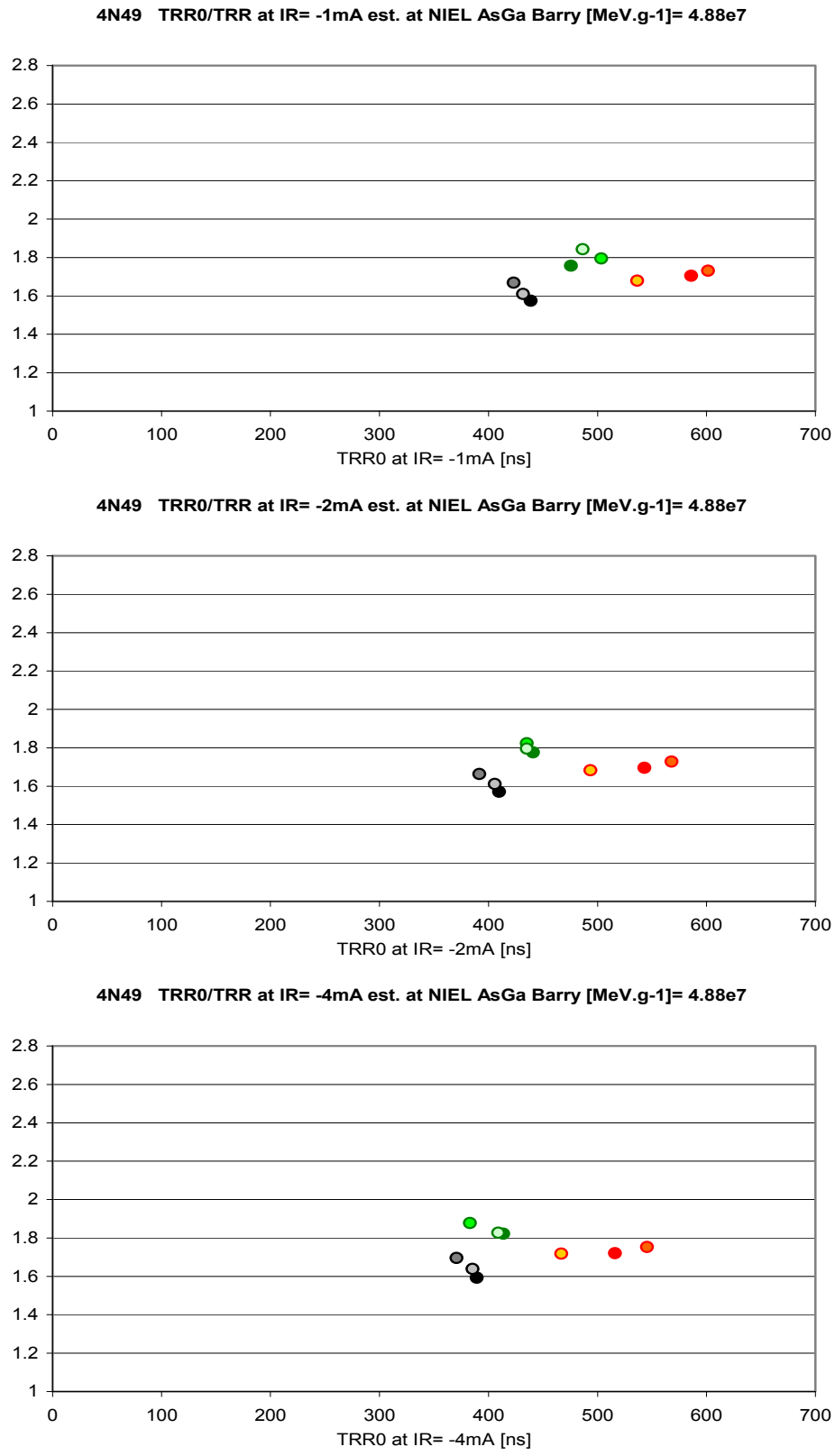
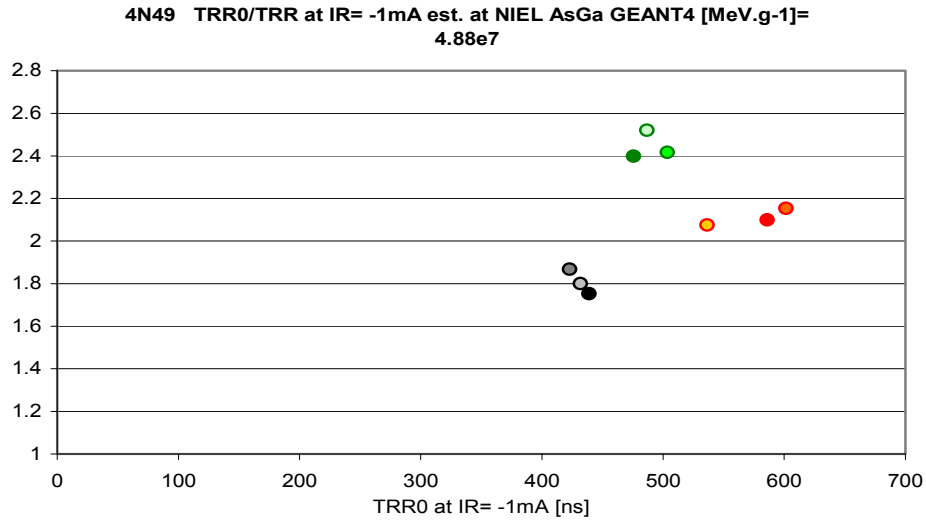
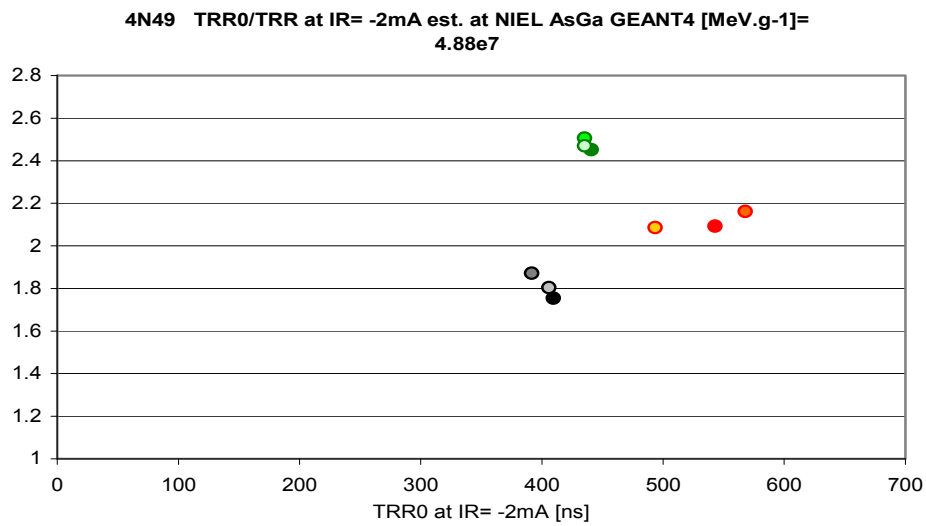


Fig. 12-80: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA





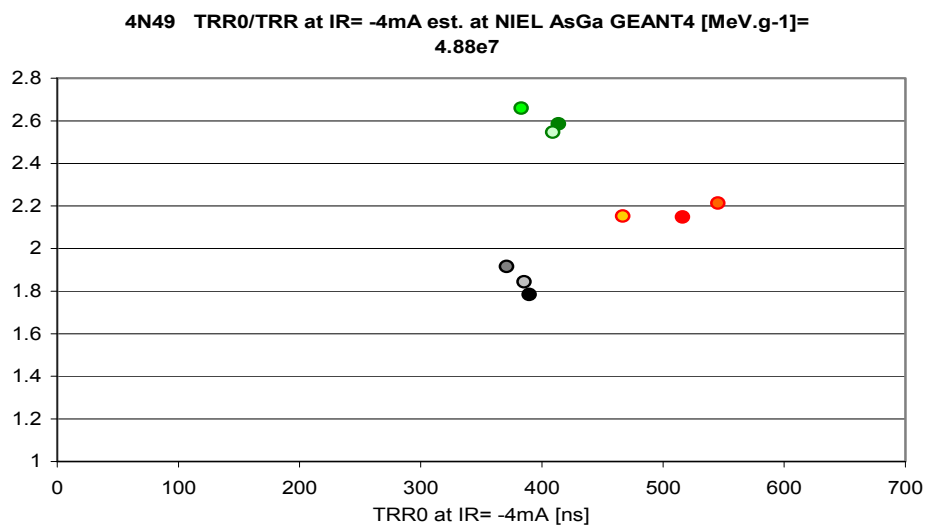
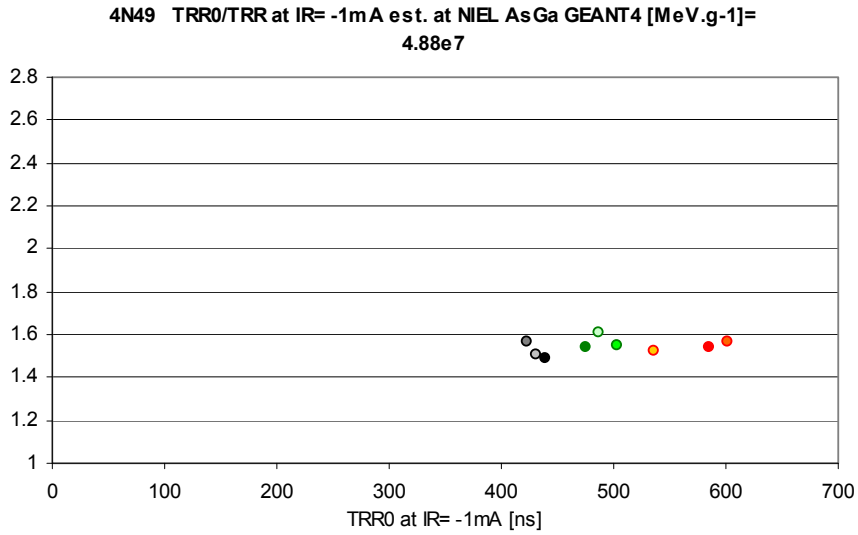
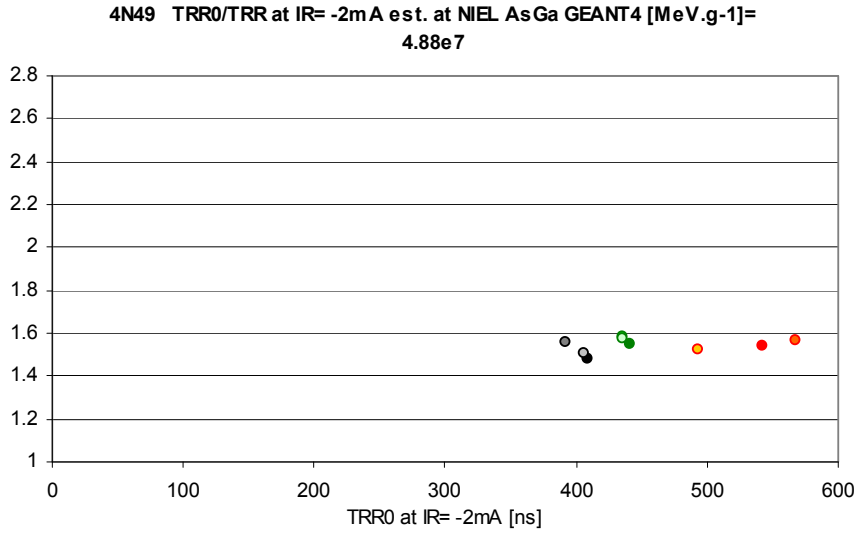


Fig. 12-81: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^7$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





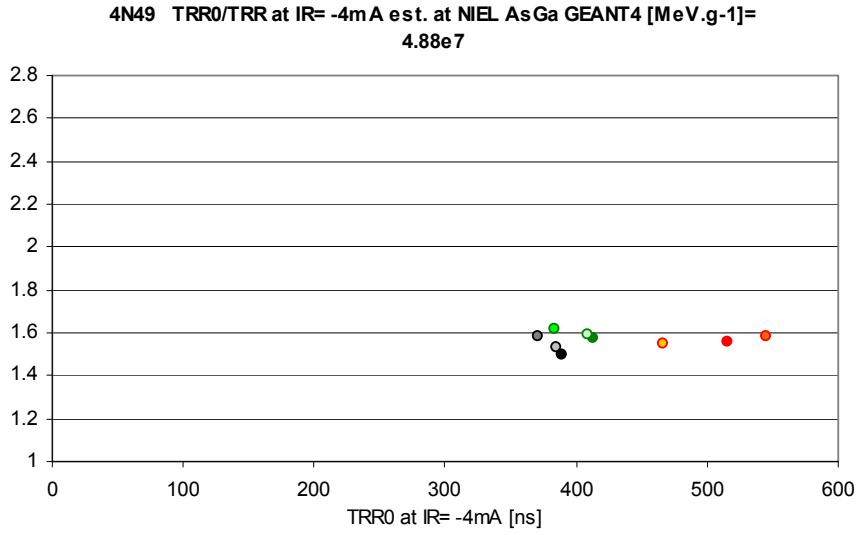
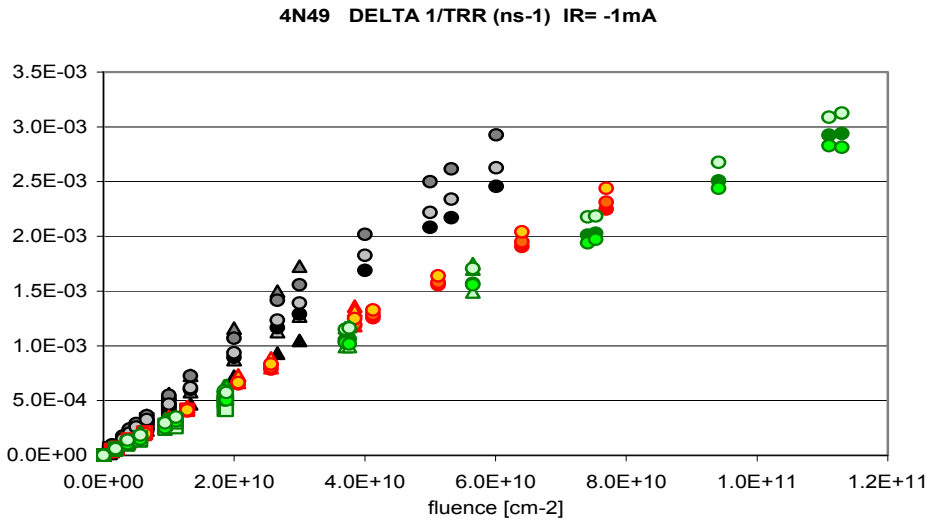
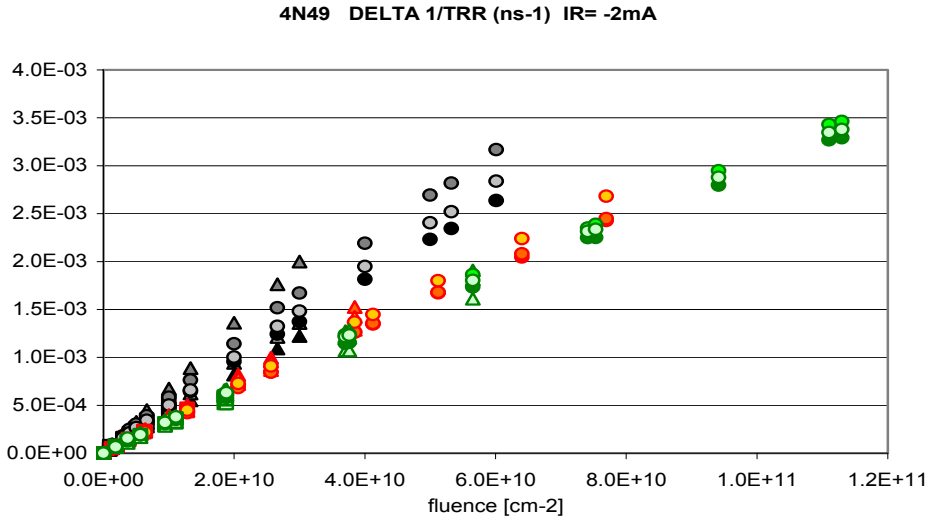


Fig. 12-82: 4N49 diode: Δ 1/τRR at IR = -1, -2, -4 mA with respect to fluence





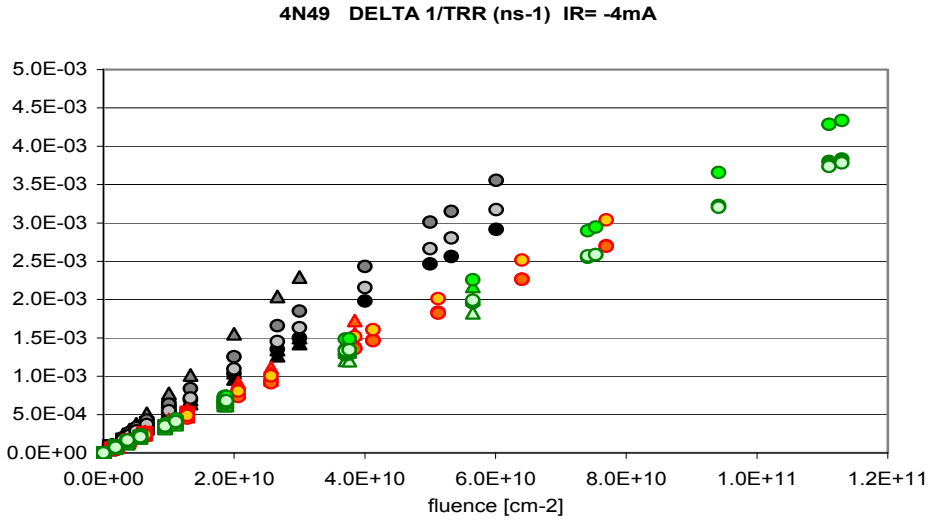
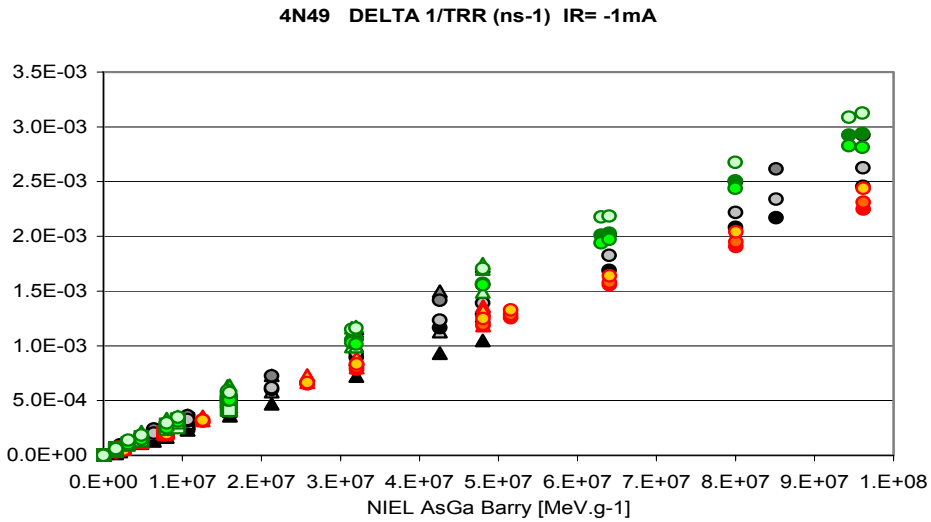
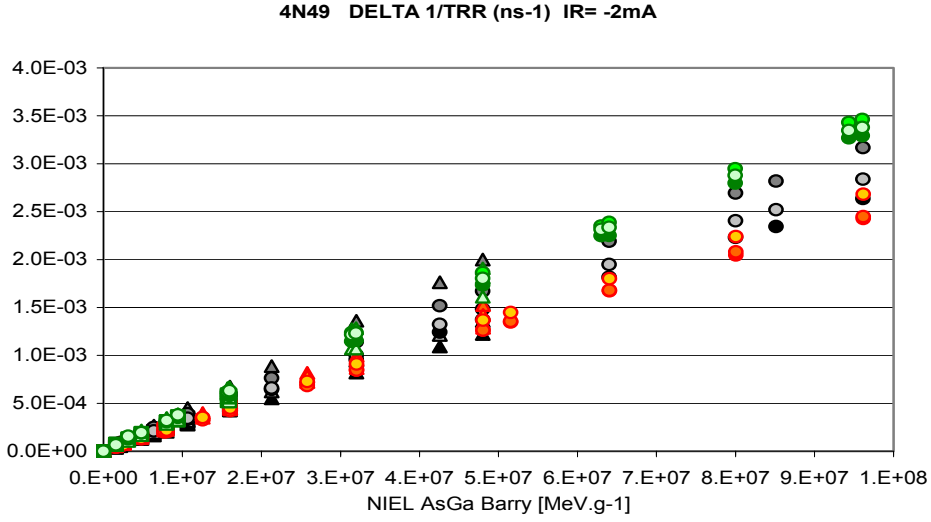


Fig. 12-83: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (Barry)





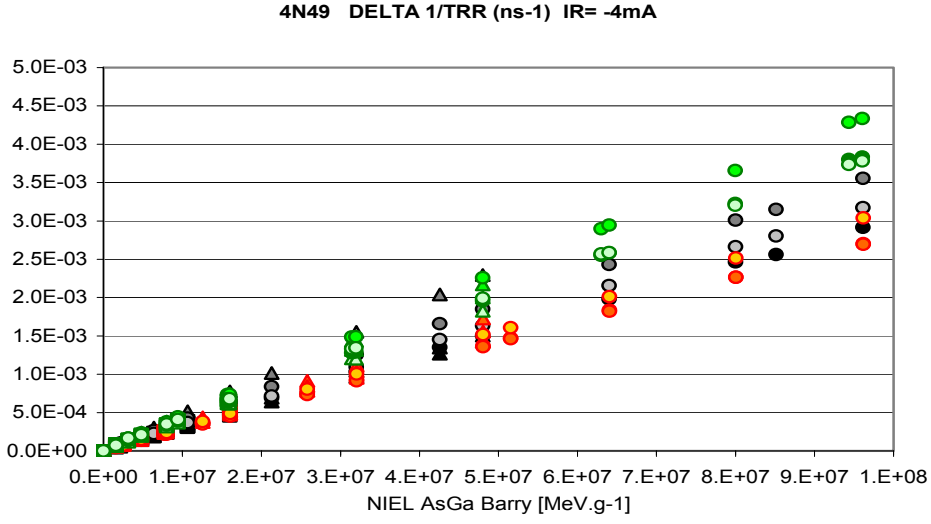
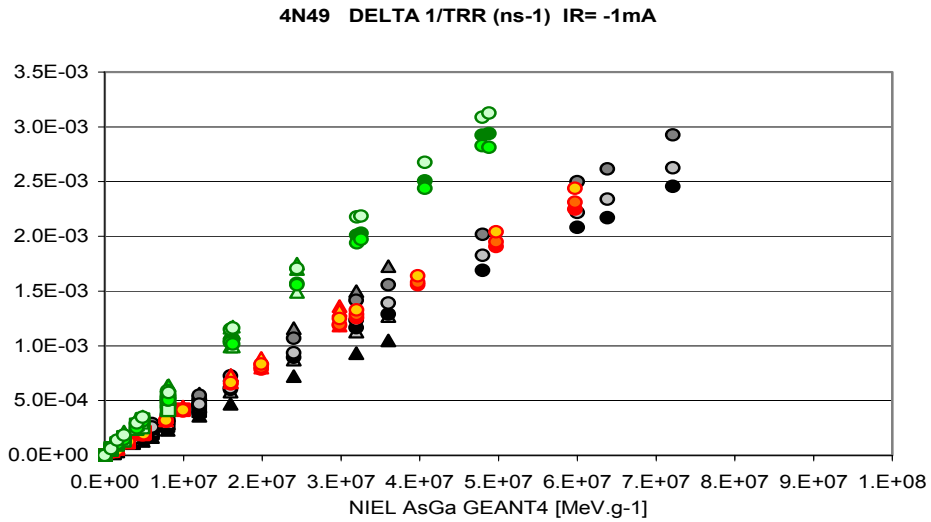
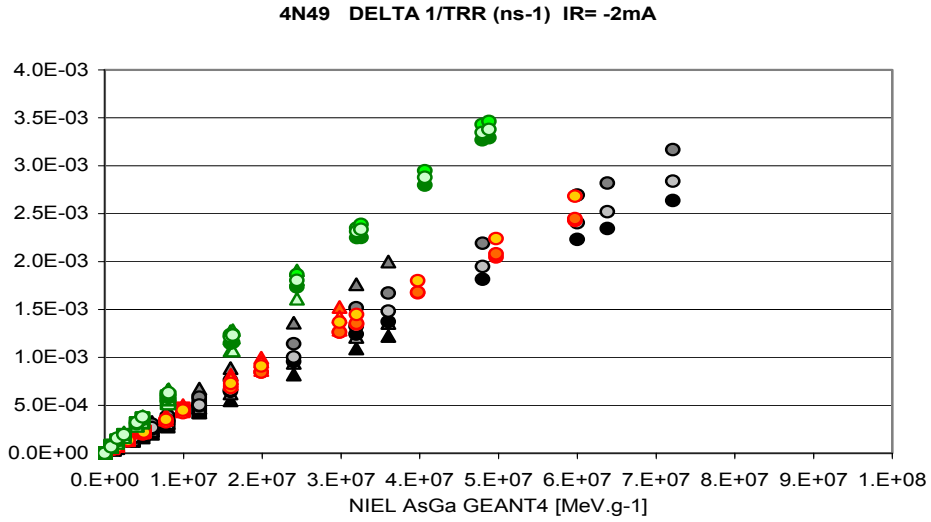


Fig. 12-84: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 ELASTIC)





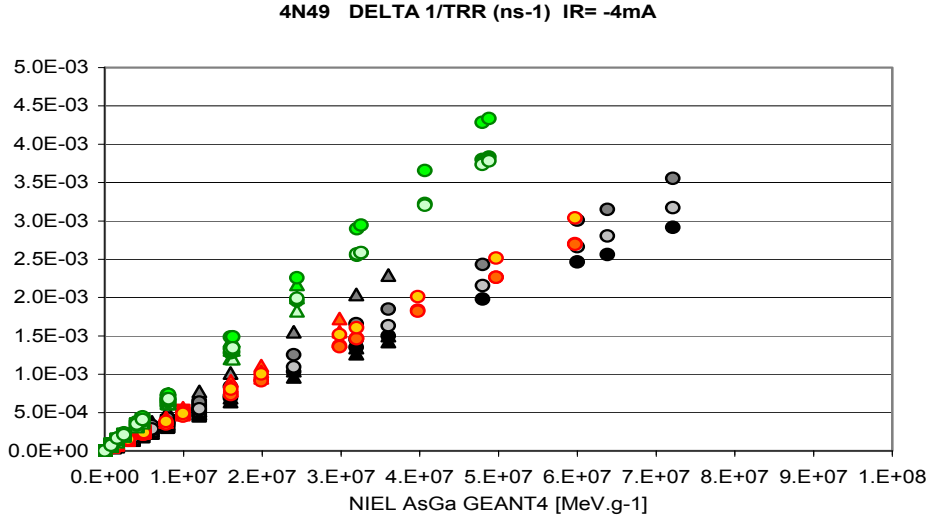
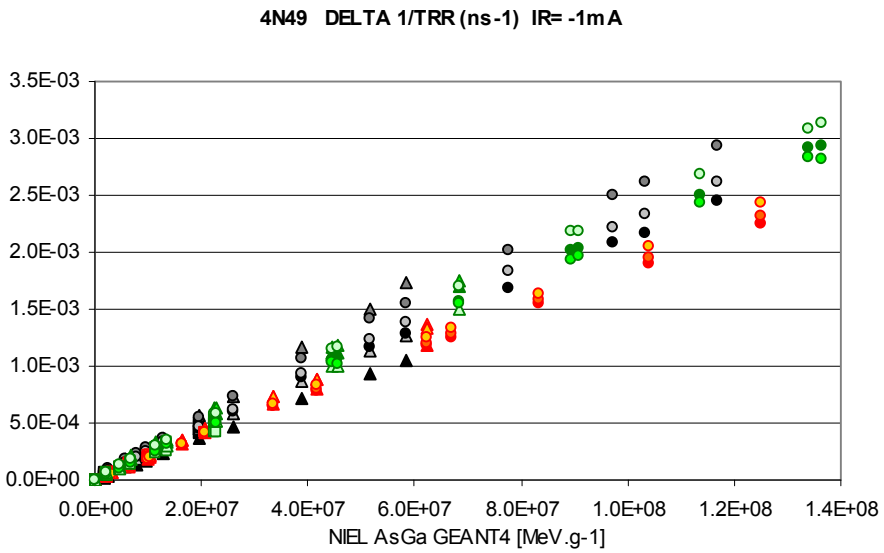
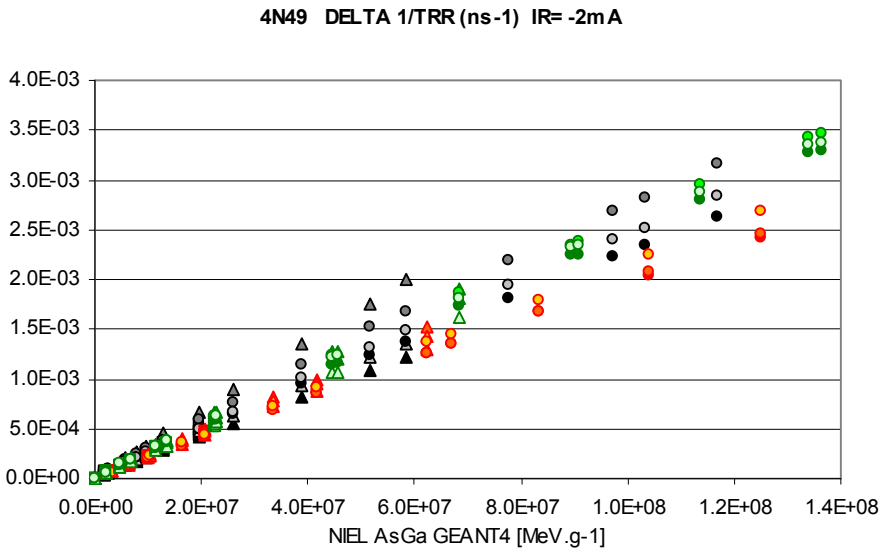


Fig. 12-85: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 TOTAL)





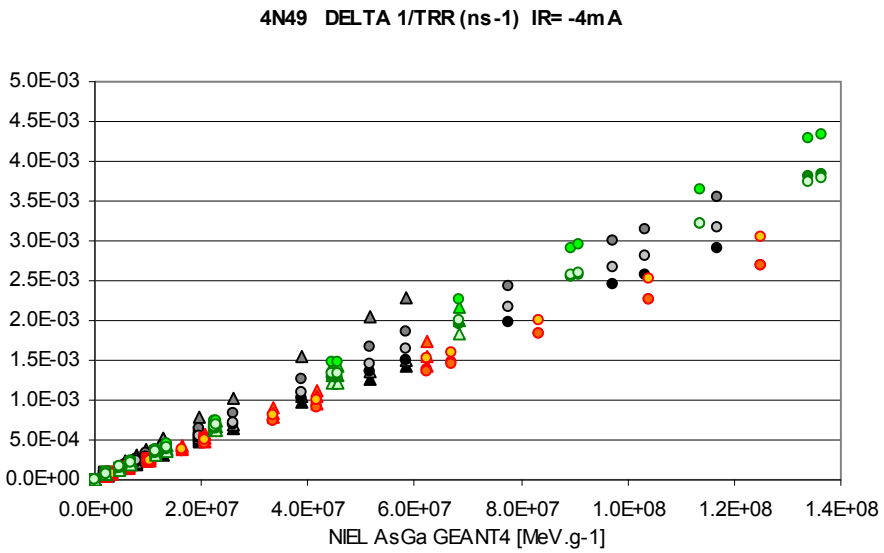


Fig. 12-86: 4N49 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{TRR0}

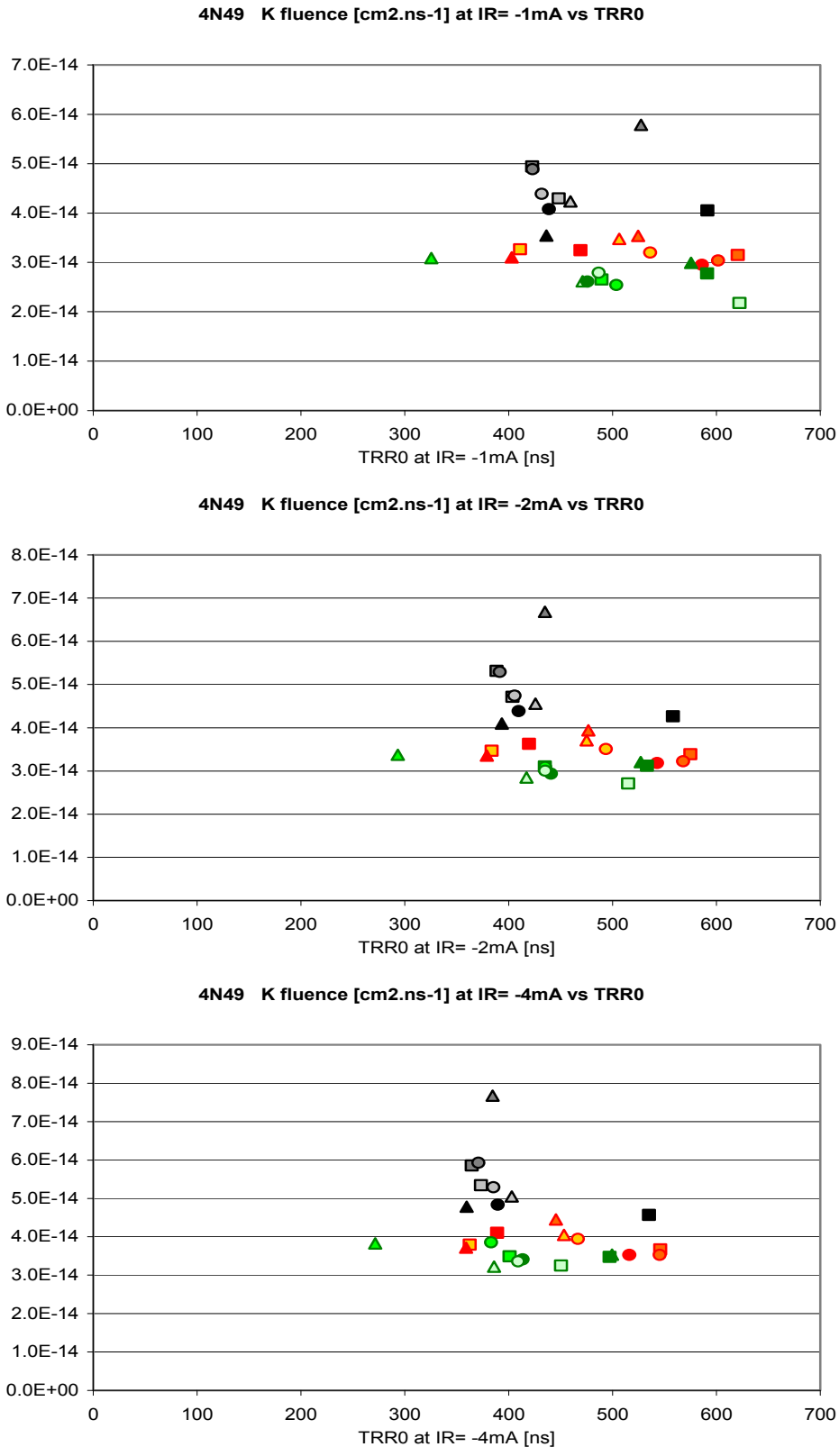
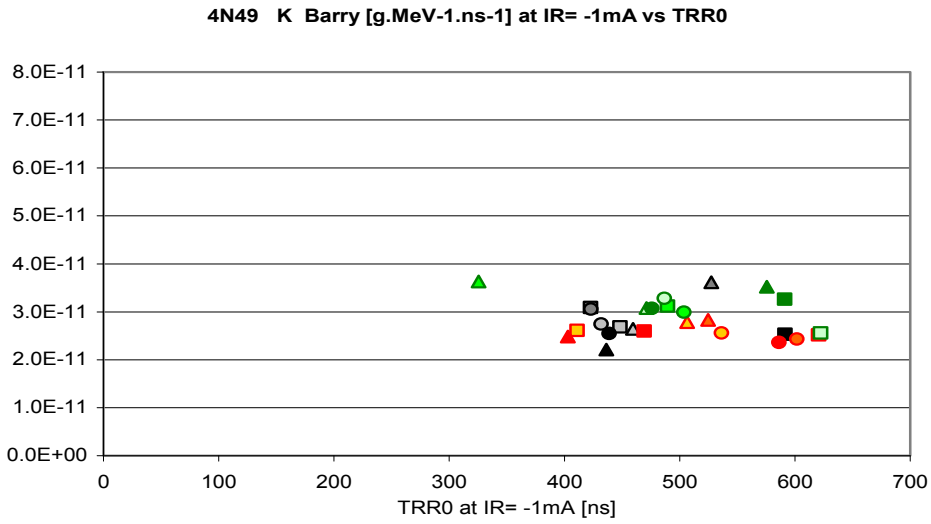
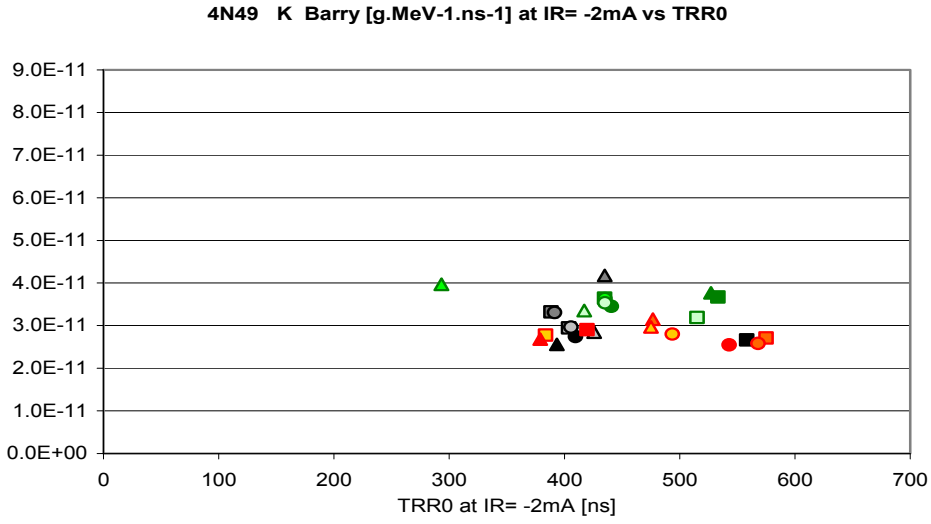


Fig. 12-87: 4N49 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to τ_{RR0}





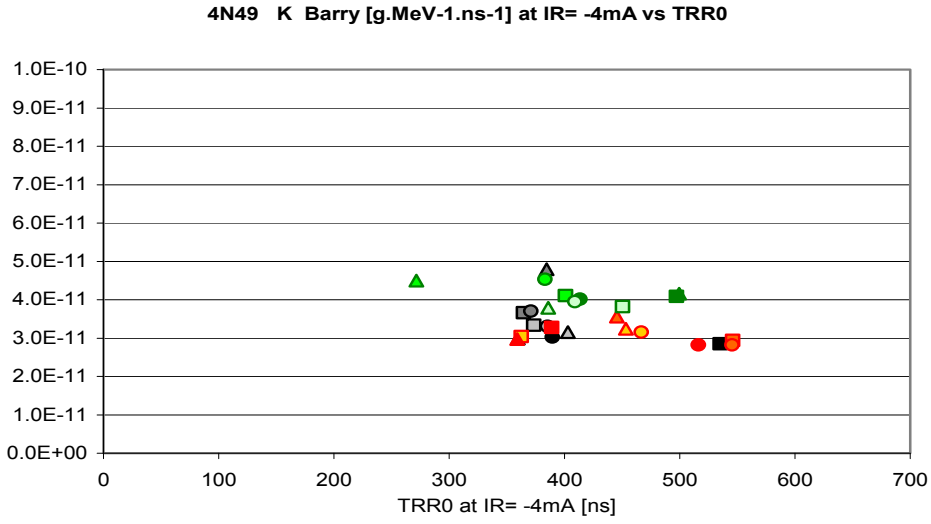
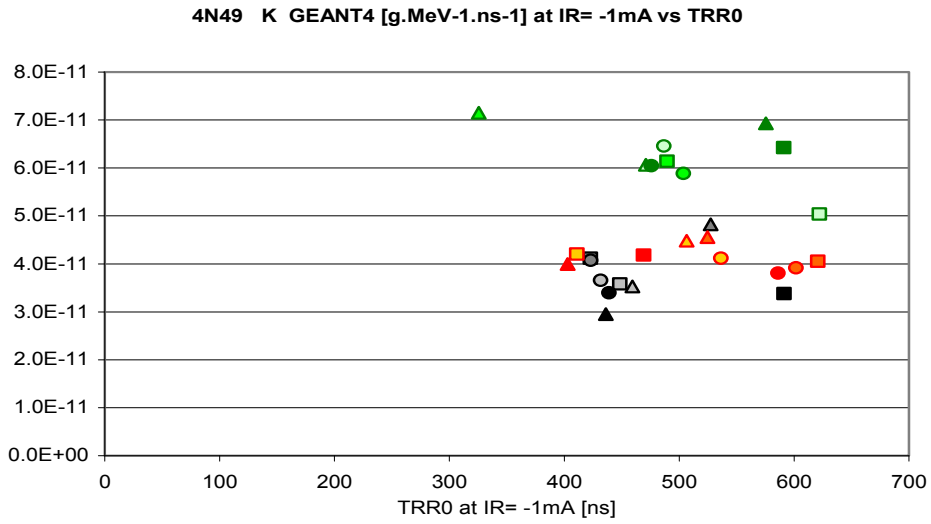
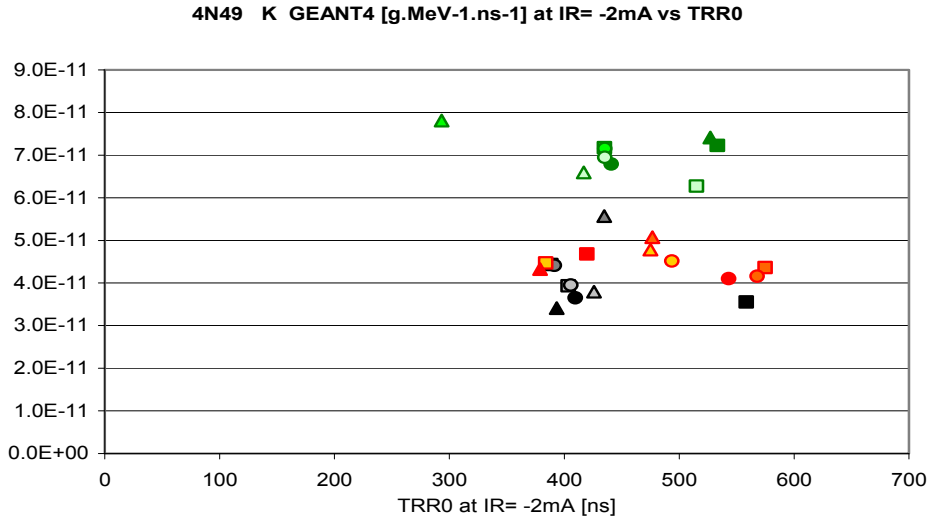


Fig. 12-88: 4N49 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to τ_{TRR0}





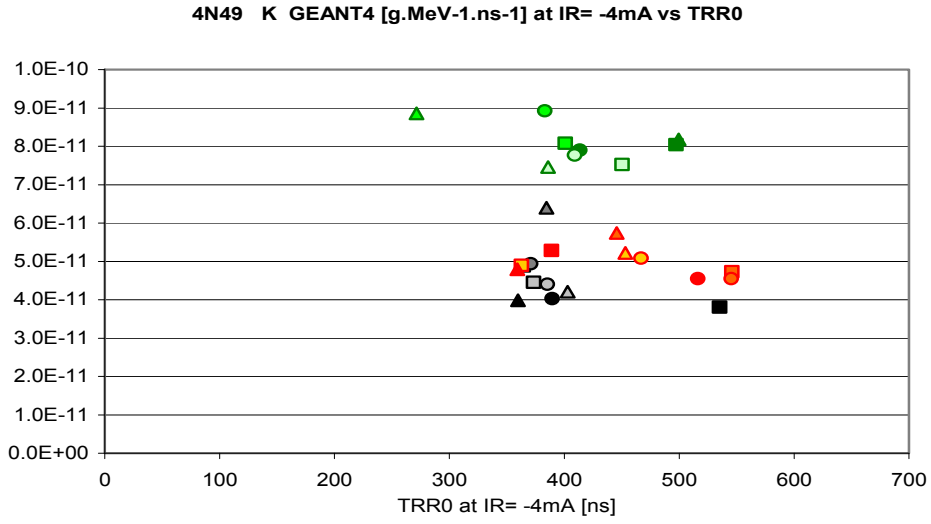
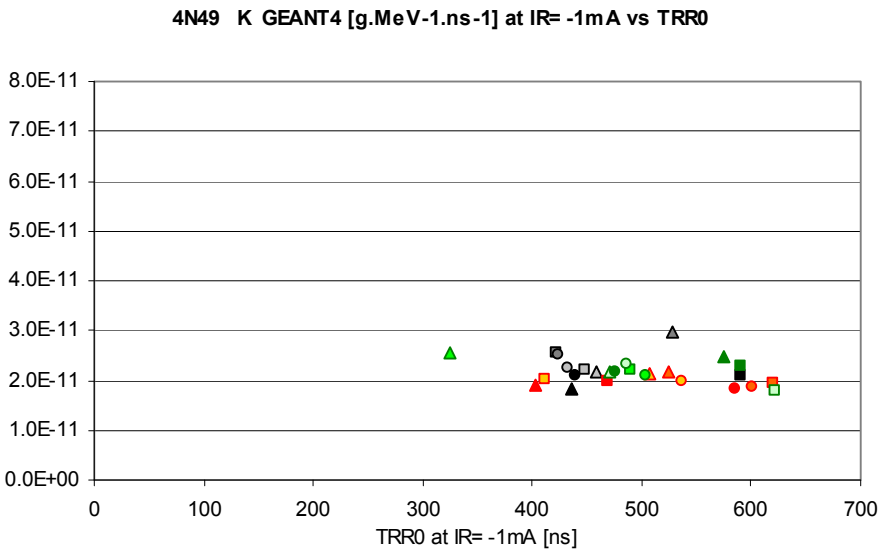
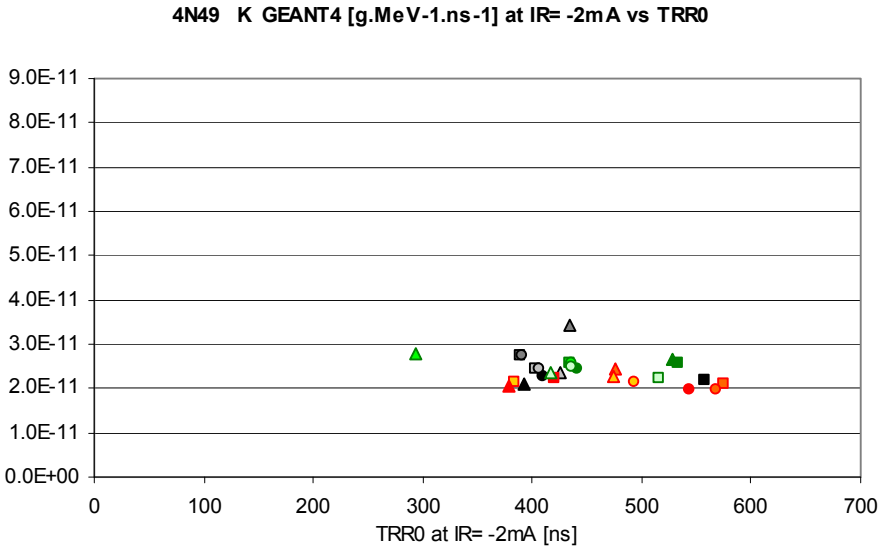


Fig. 12-89: 4N49 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}





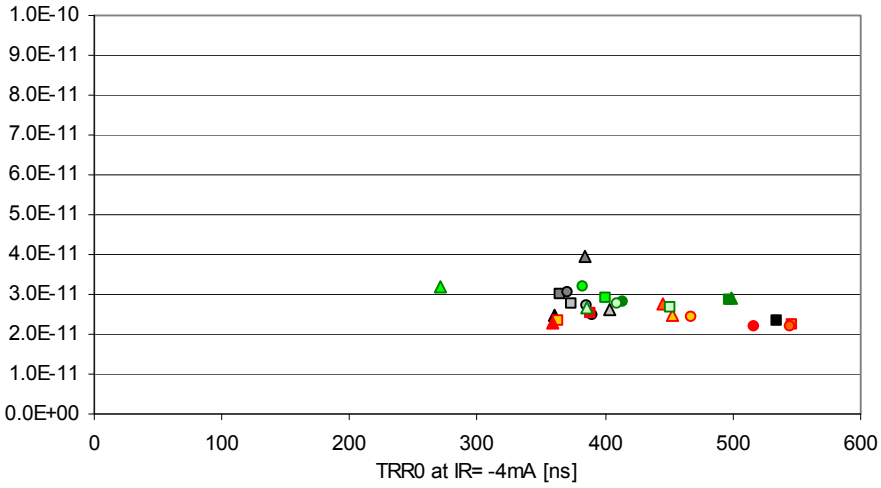
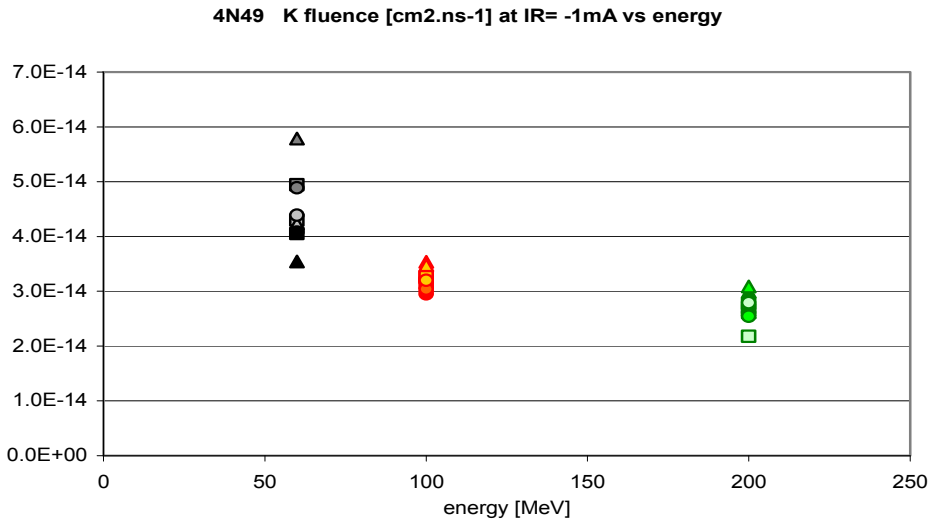
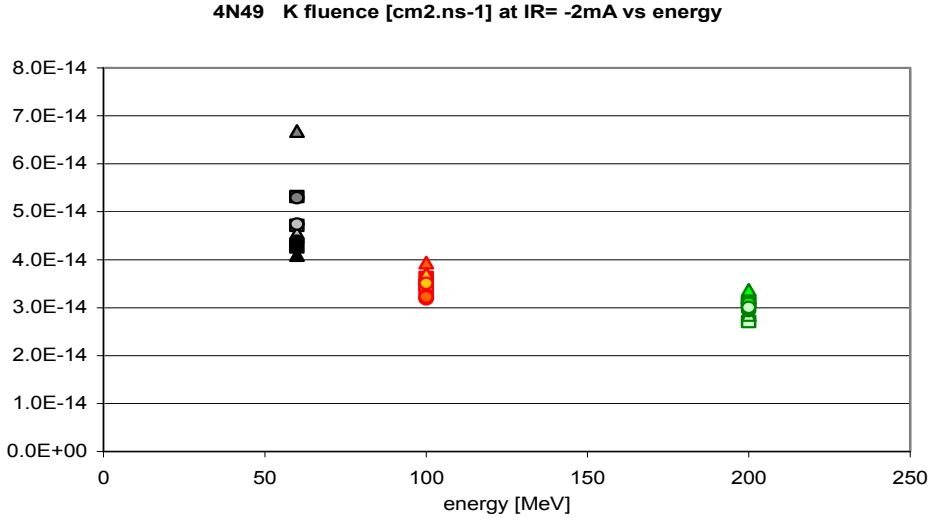


Fig. 12-90: 4N49 diode: K_Φ at I_R = -1, -2, -4mA with respect to energy





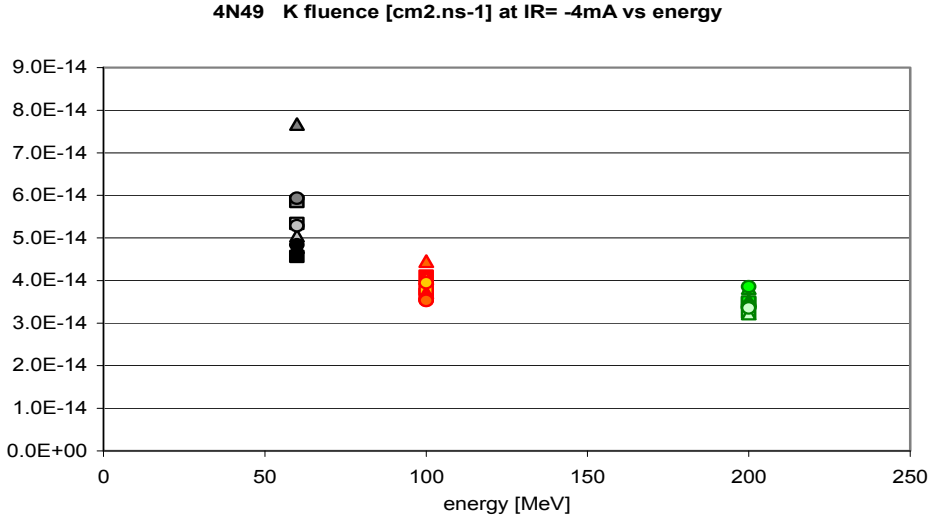
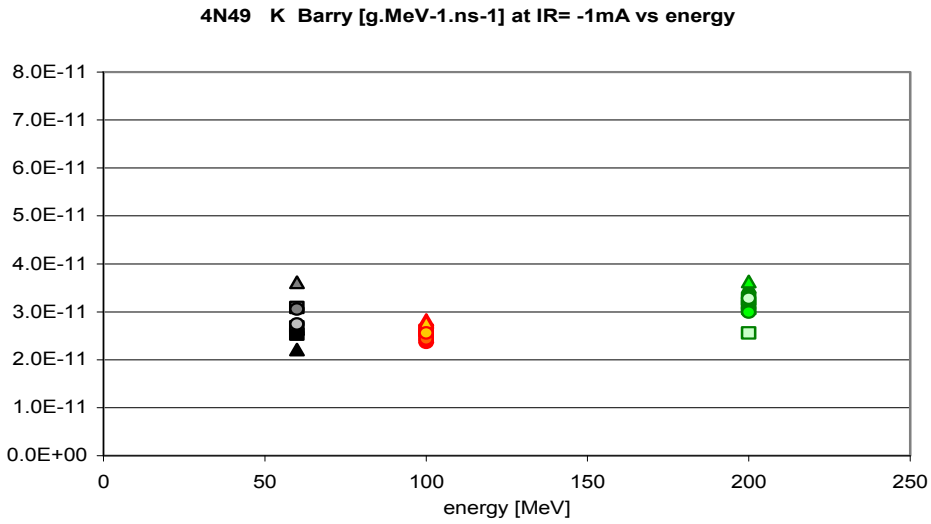
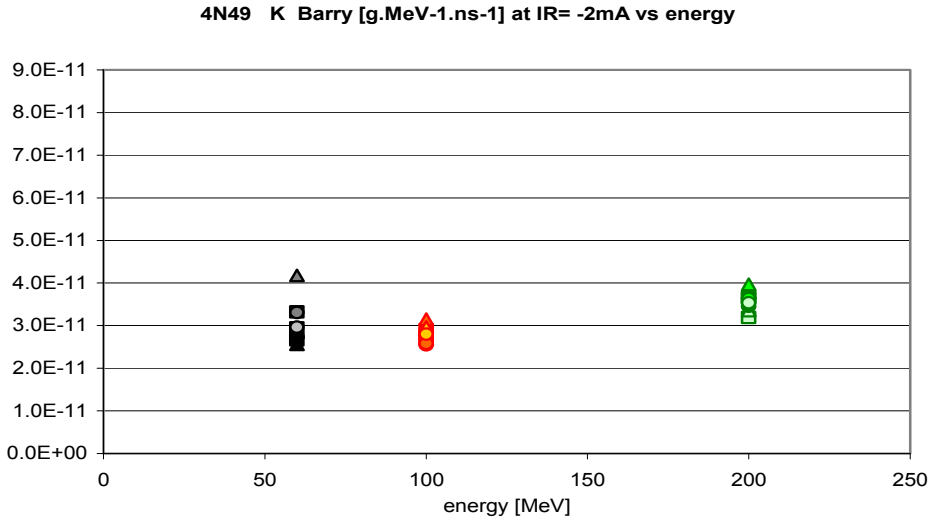


Fig. 12-91: 4N49 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to energy





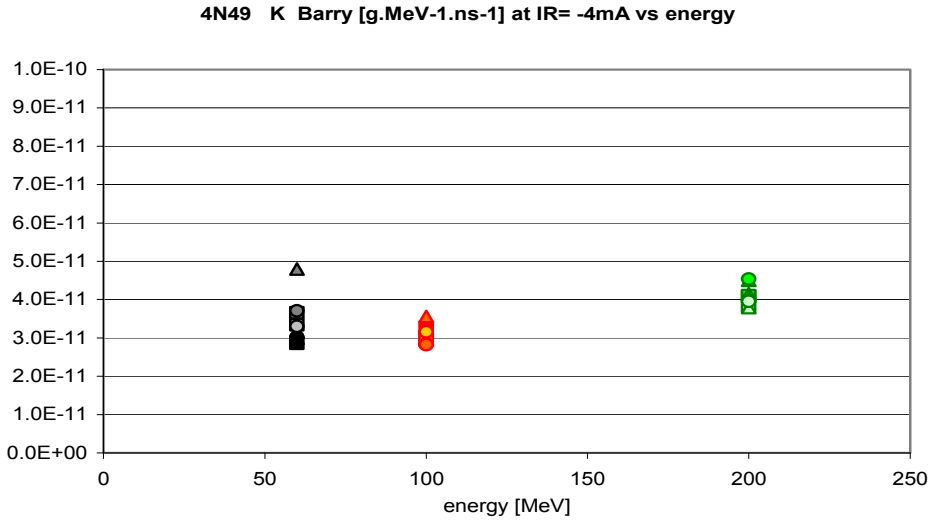
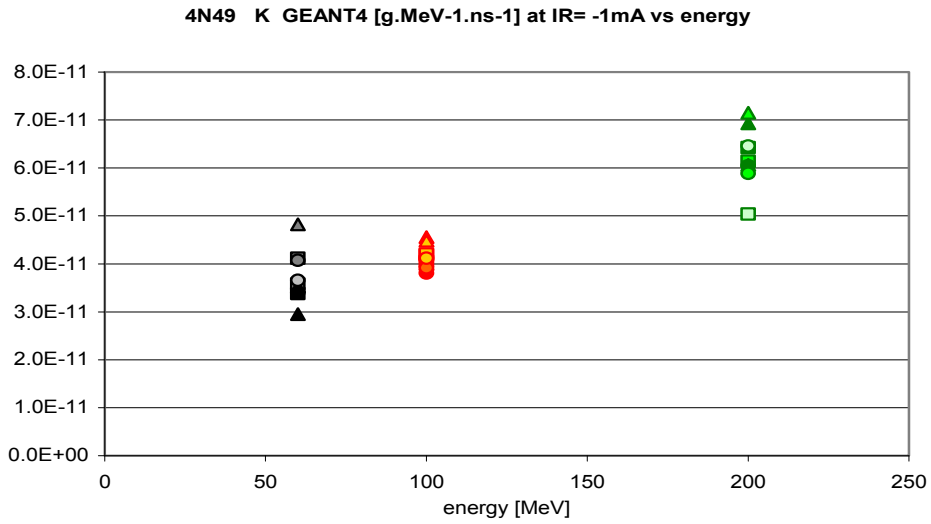
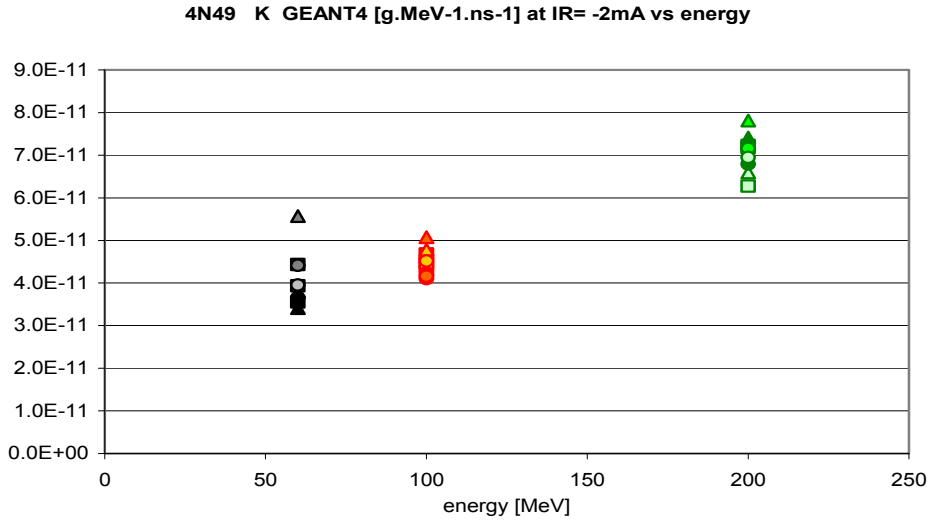


Fig. 12-92: 4N49 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to energy





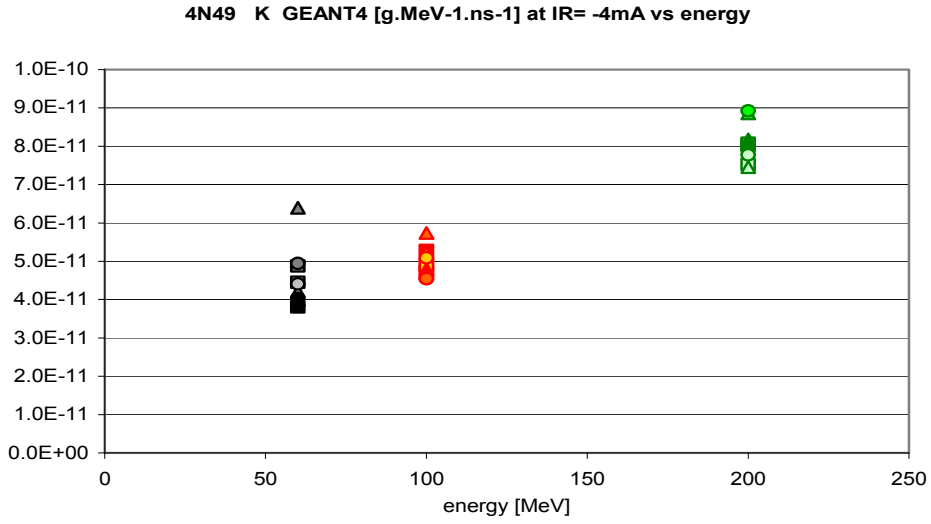
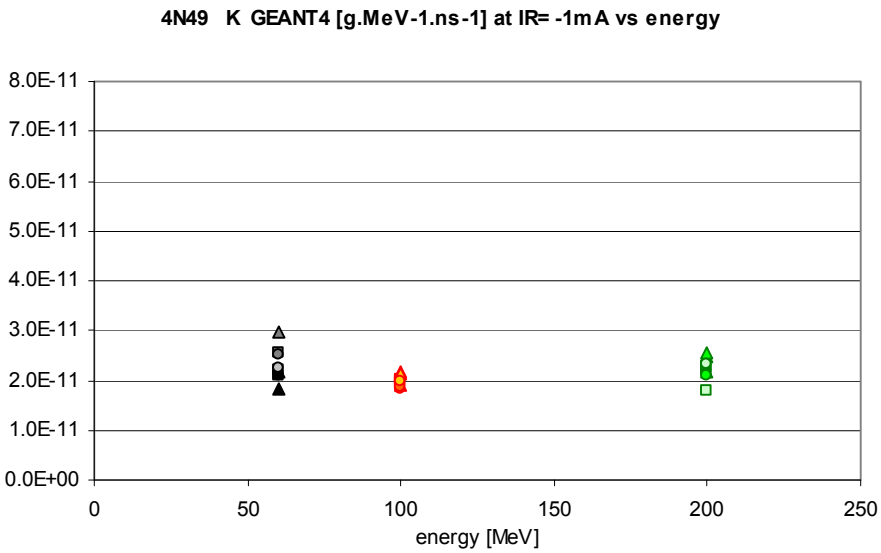
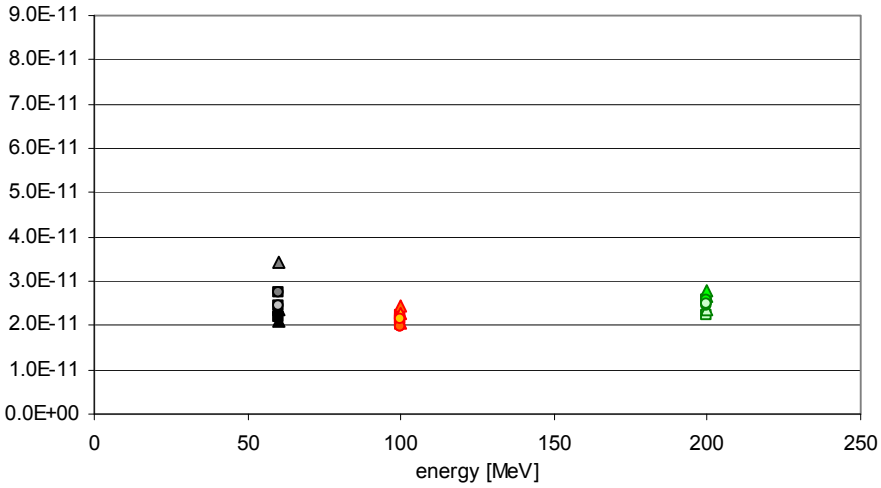


Fig. 12-93: 4N49 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to energy





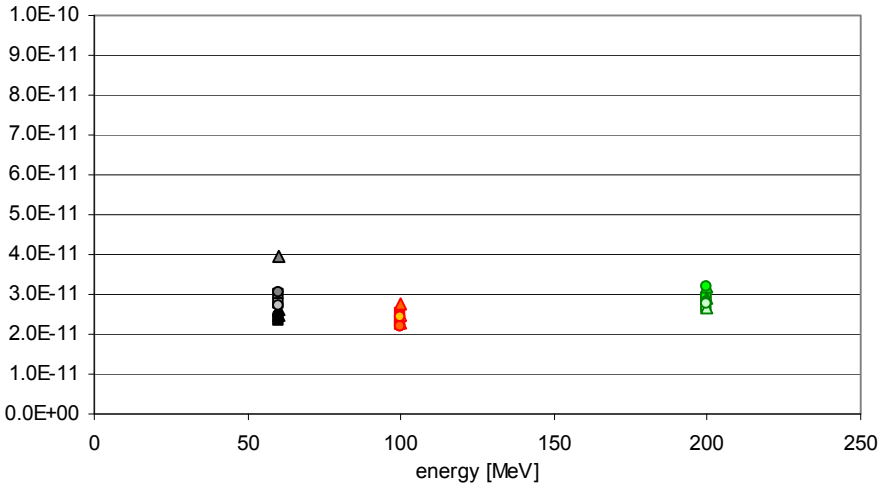
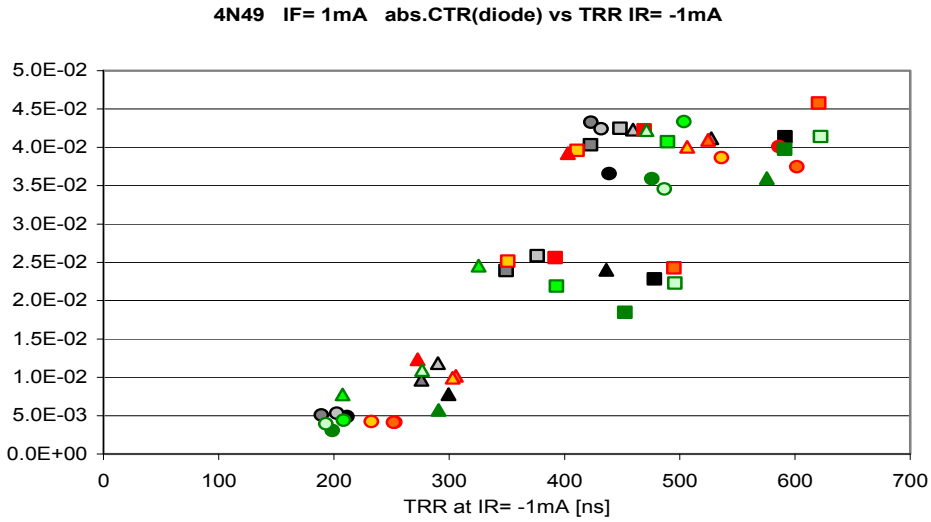
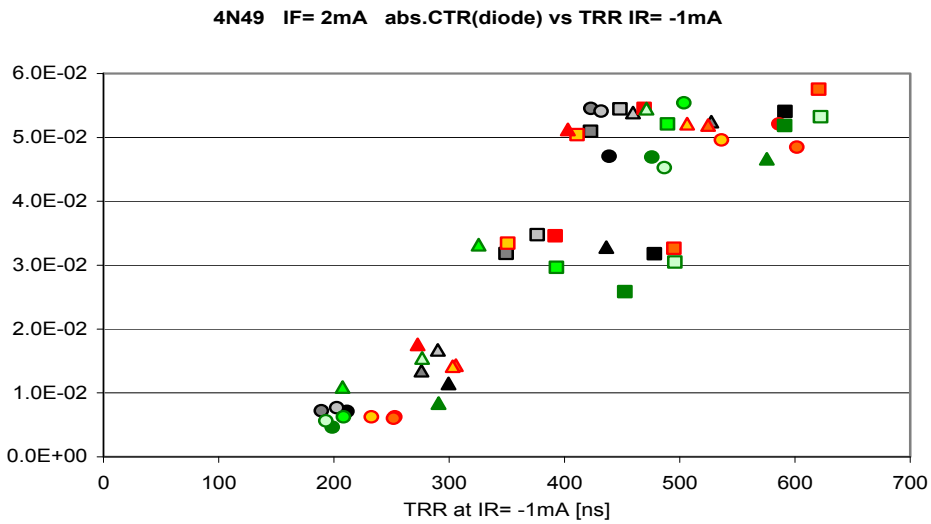
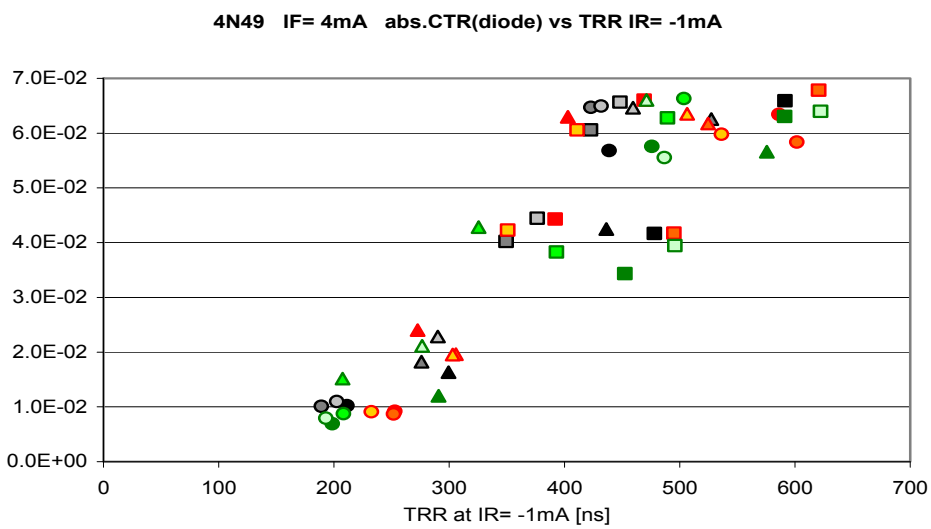


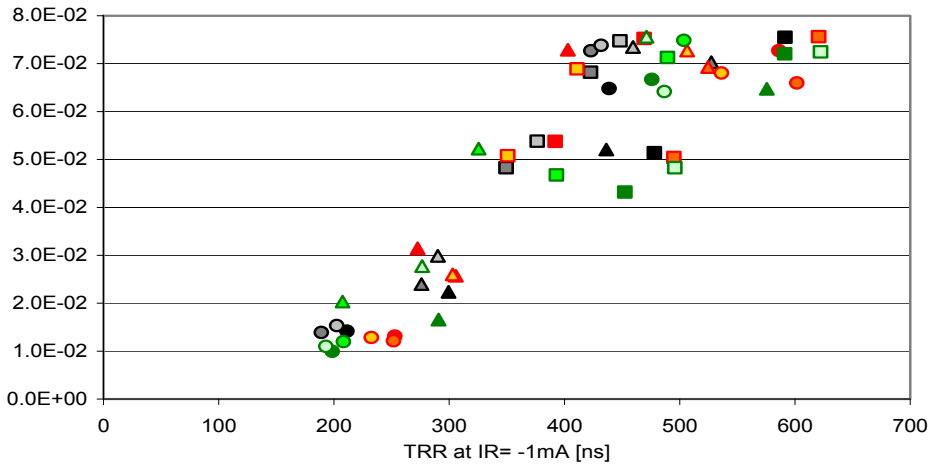
Fig. 12-94: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA







4N49 IF= 8mA abs.CTR(diode) vs TRR IR= -1mA



4N49 IF= 10mA abs.CTR(diode) vs TRR IR= -1mA

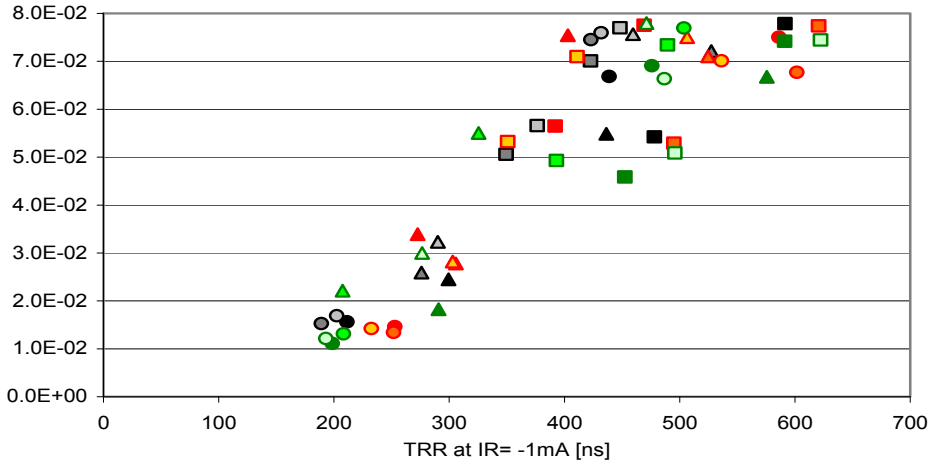
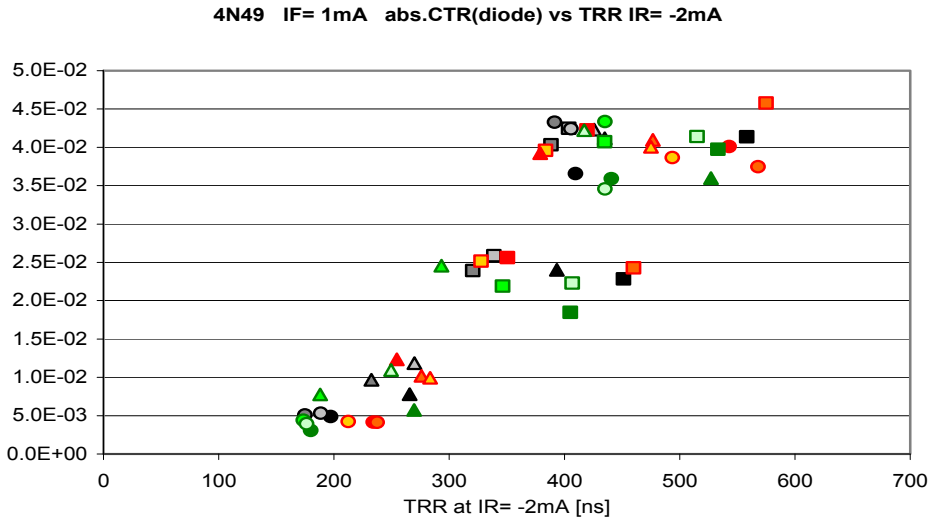
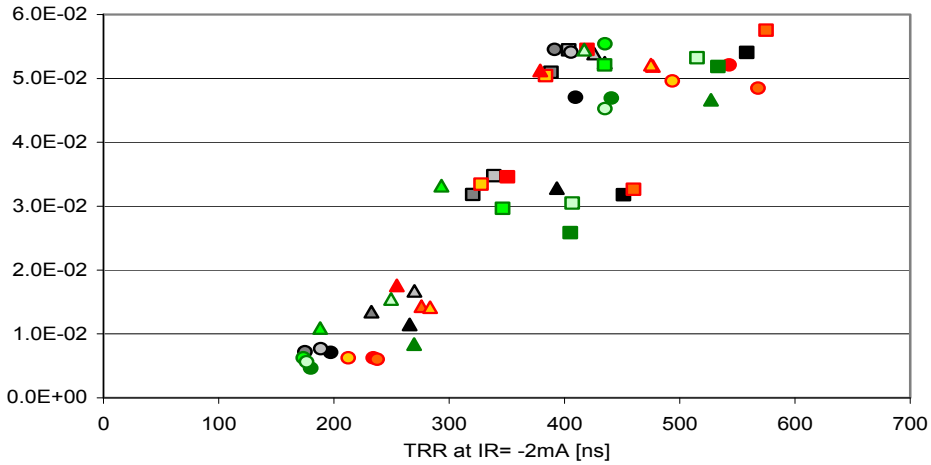
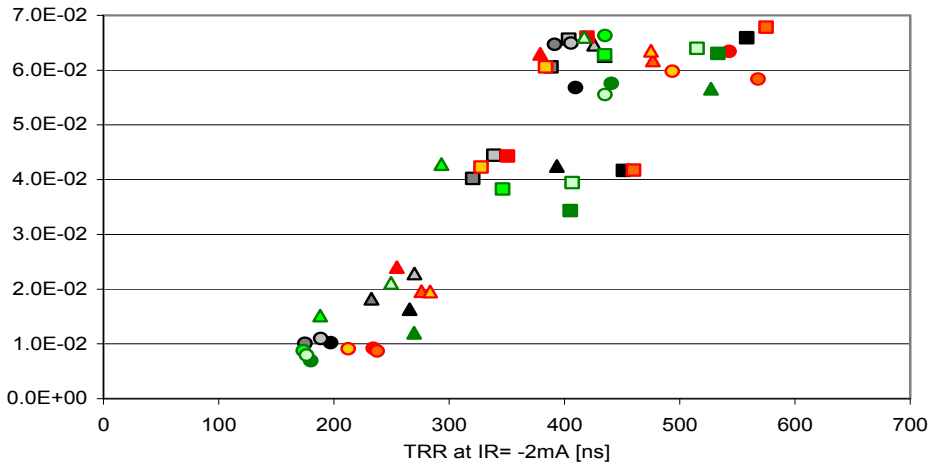


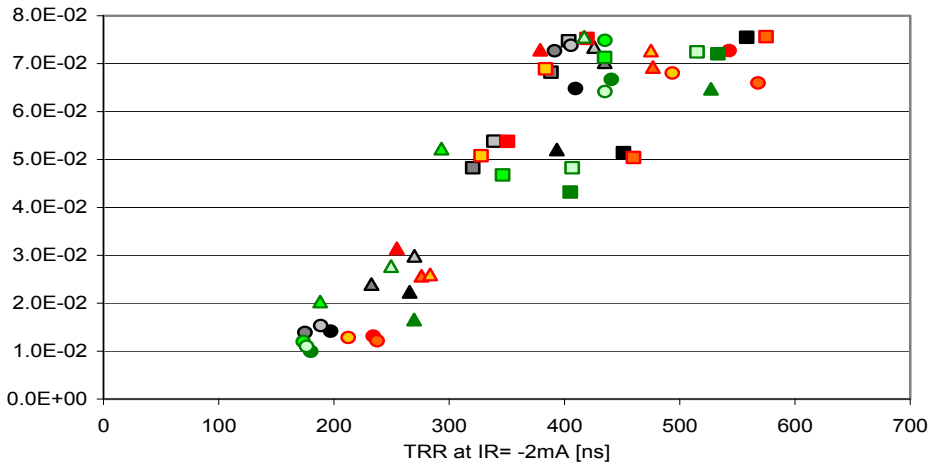
Fig. 12-95: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA







4N49 IF= 8mA abs.CTR(diode) vs TRR IR= -2mA



4N49 IF= 10mA abs.CTR(diode) vs TRR IR= -2mA

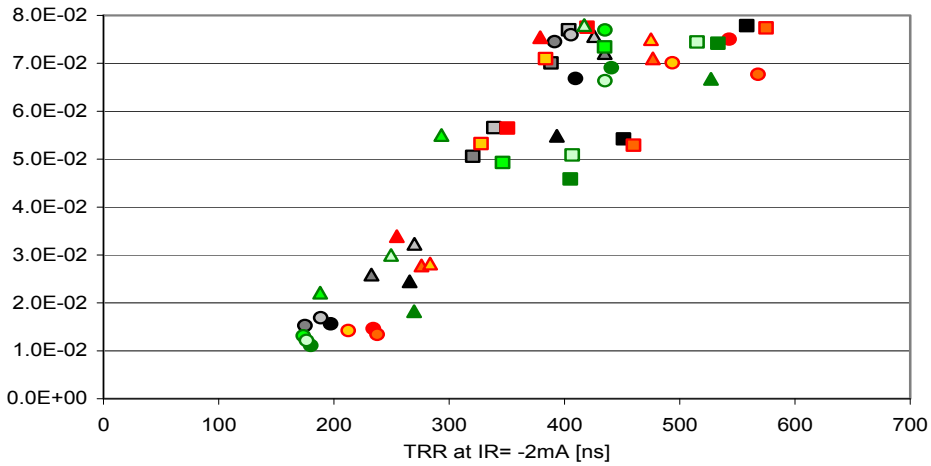
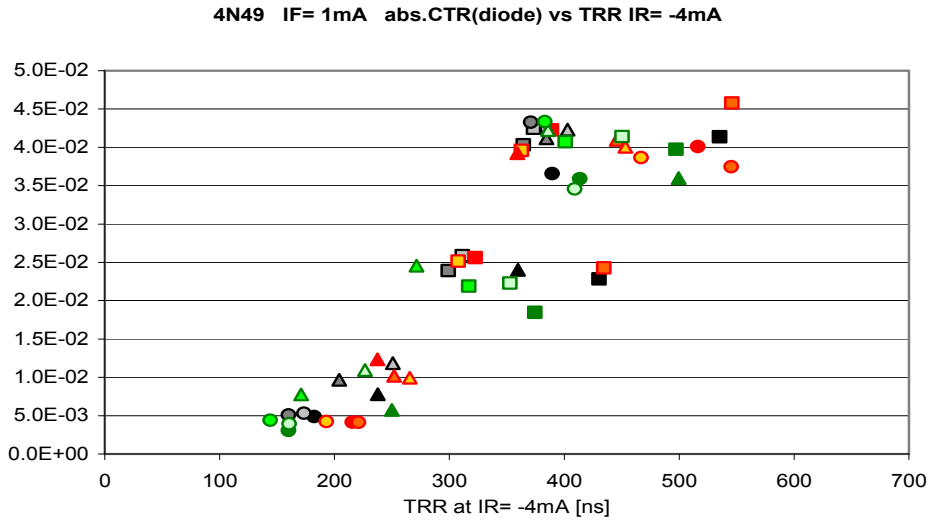
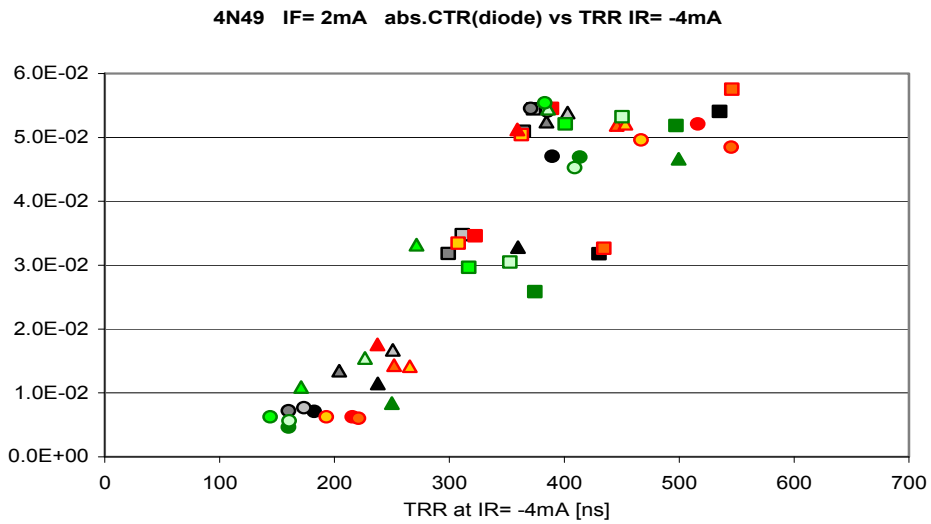
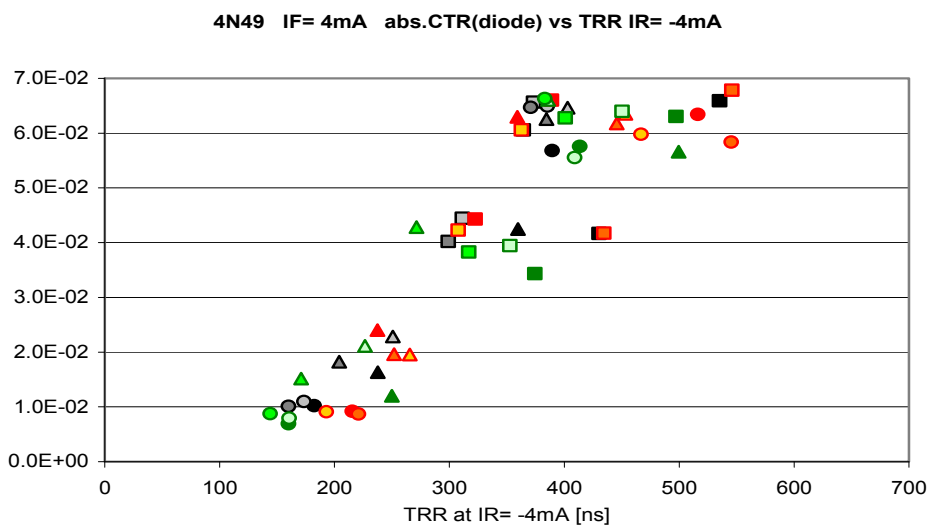


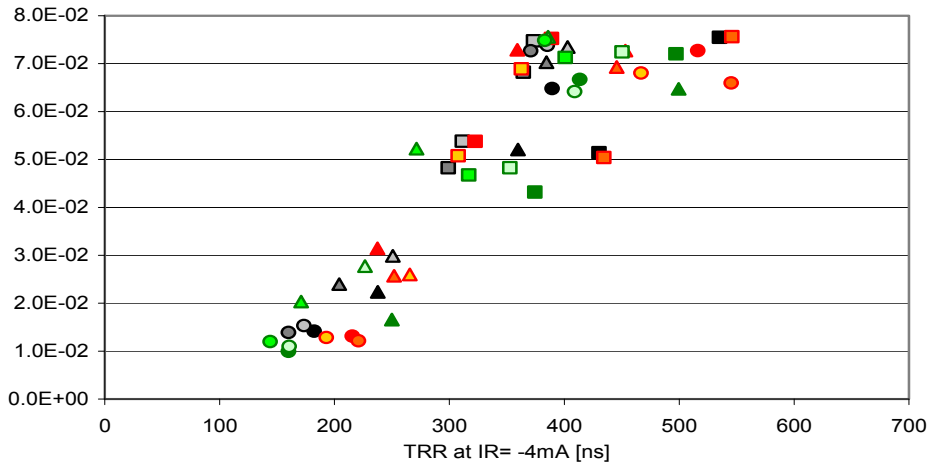
Fig. 12-96: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA







4N49 IF= 8mA abs.CTR(diode) vs TRR IR= -4mA



4N49 IF= 10mA abs.CTR(diode) vs TRR IR= -4mA

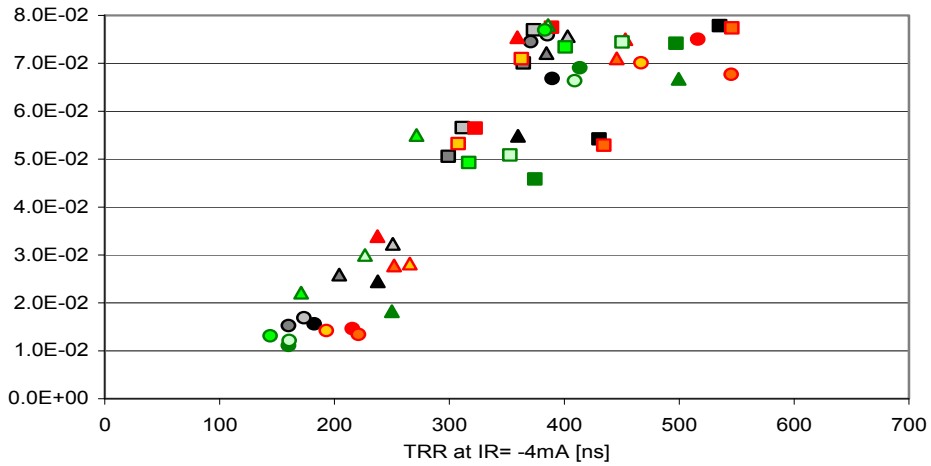
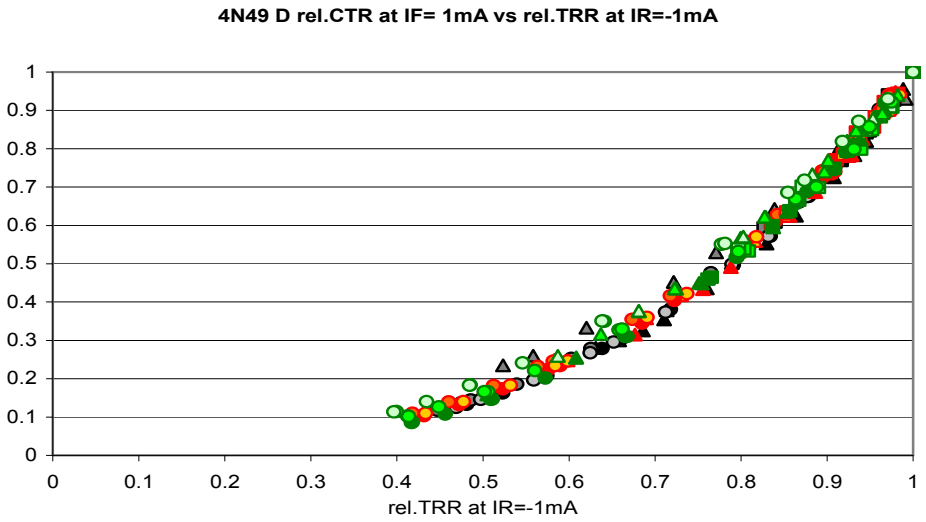
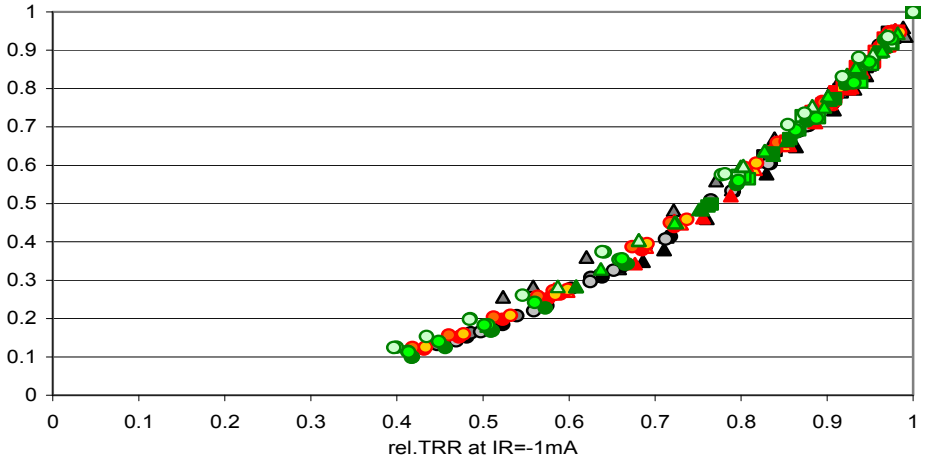
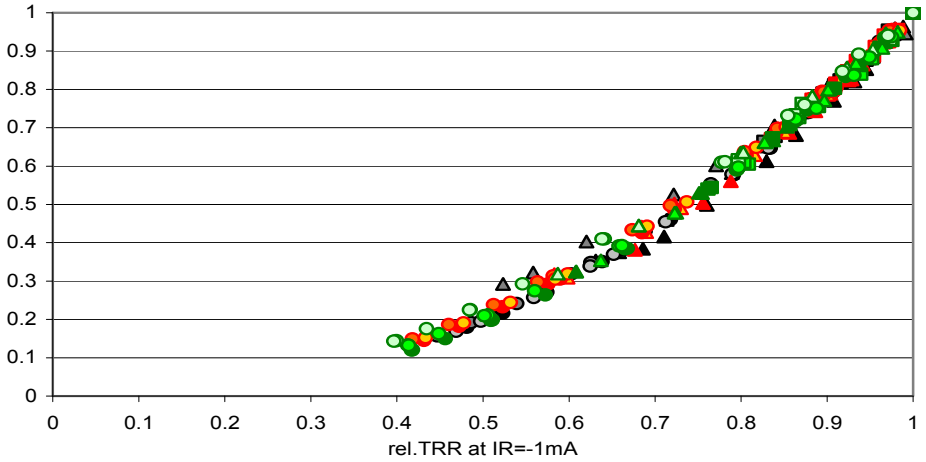


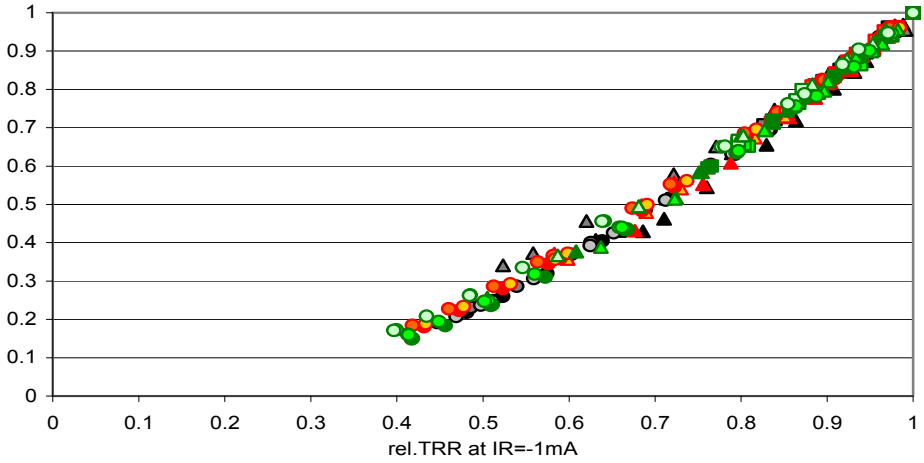
Fig. 12-97: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







4N49 D rel.CTR at IF= 8mA vs rel.TRR at IR=-1mA



4N49 D rel.CTR at IF= 10mA vs rel.TRR at IR=-1mA

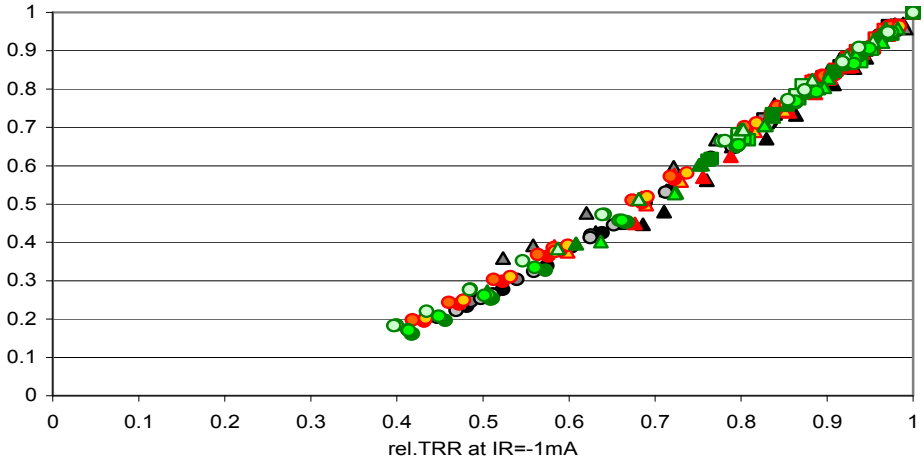
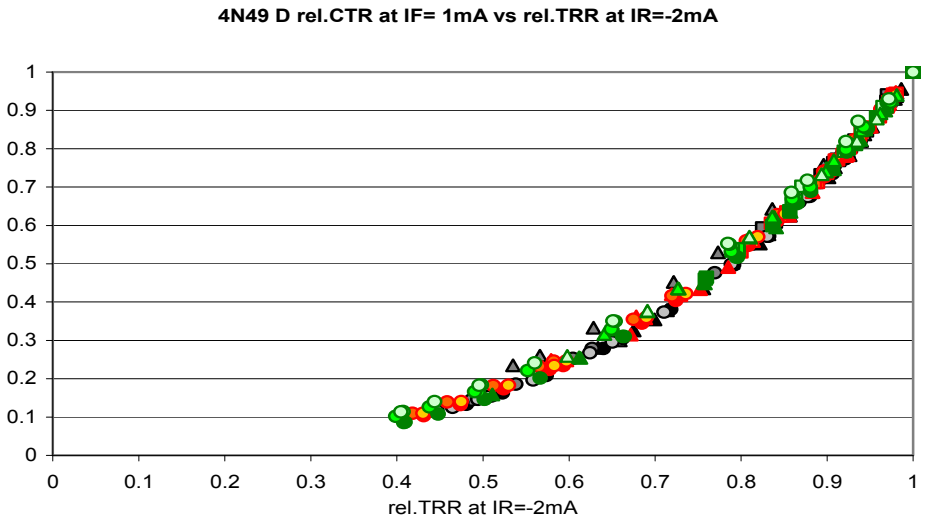
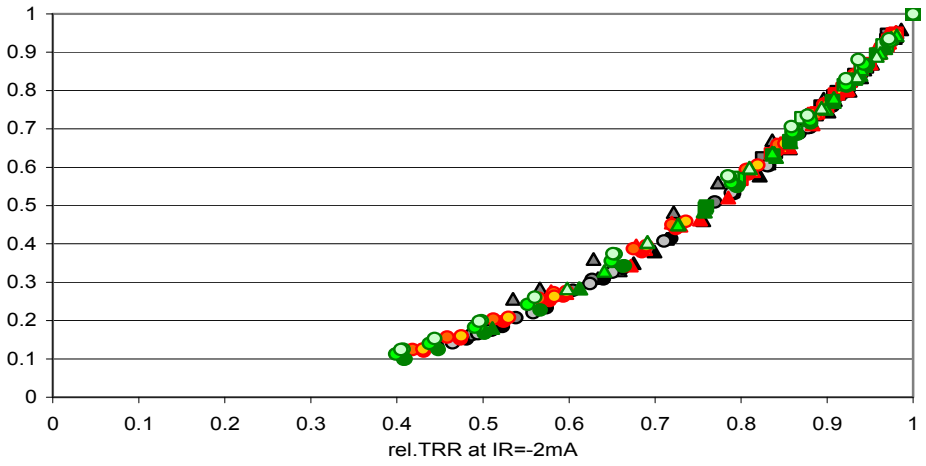
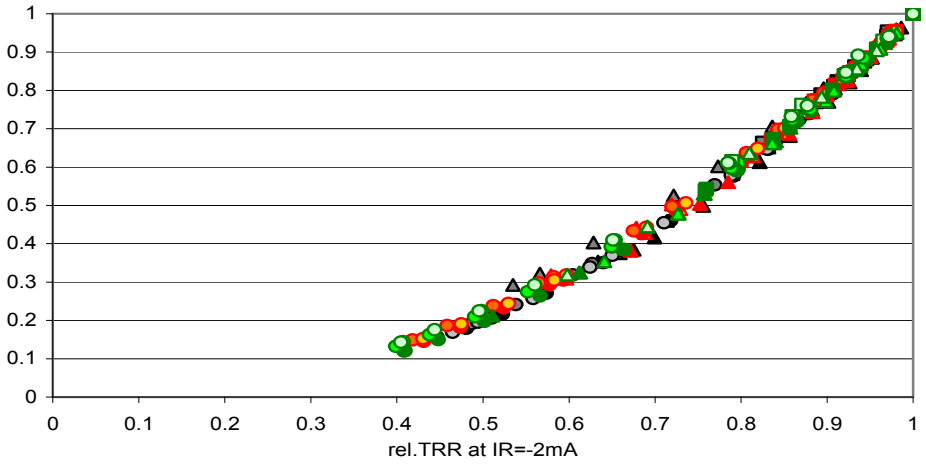


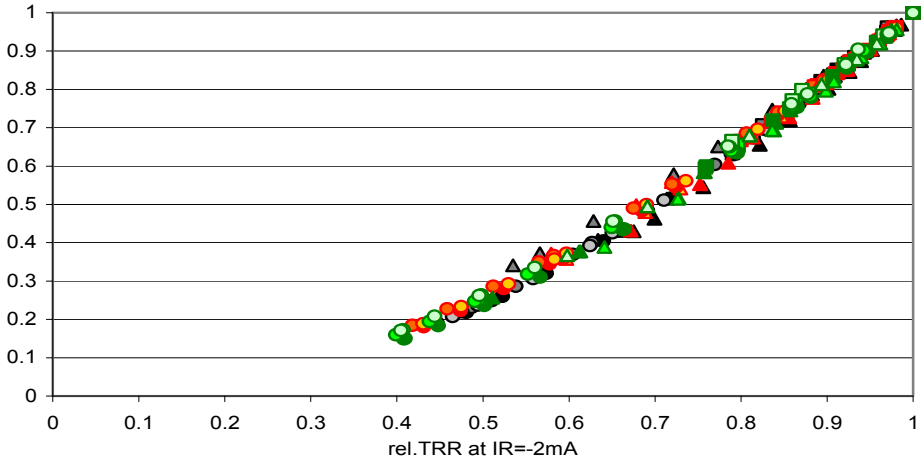
Fig. 12-98: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA







4N49 D rel.CTR at IF= 8mA vs rel.TRR at IR=-2mA



4N49 D rel.CTR at IF= 10mA vs rel.TRR at IR=-2mA

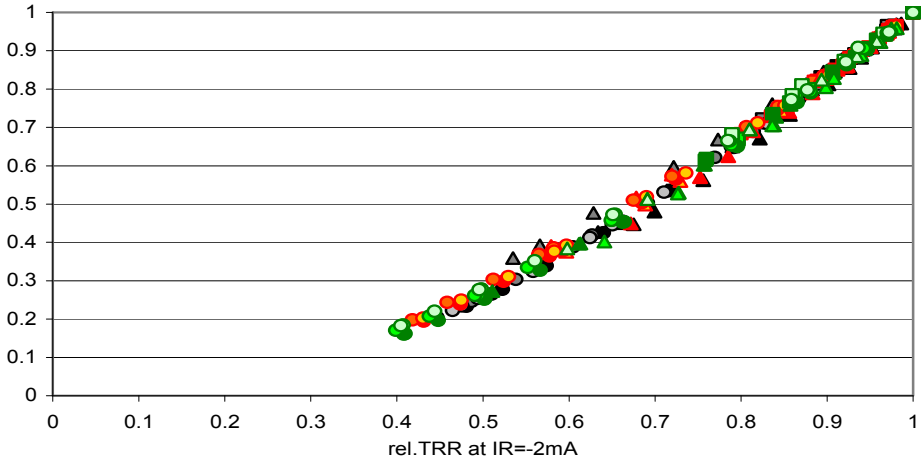
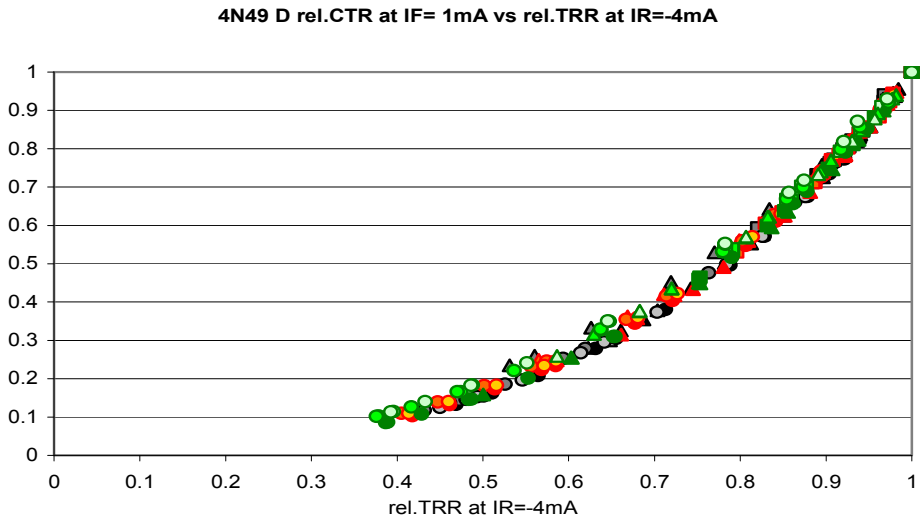
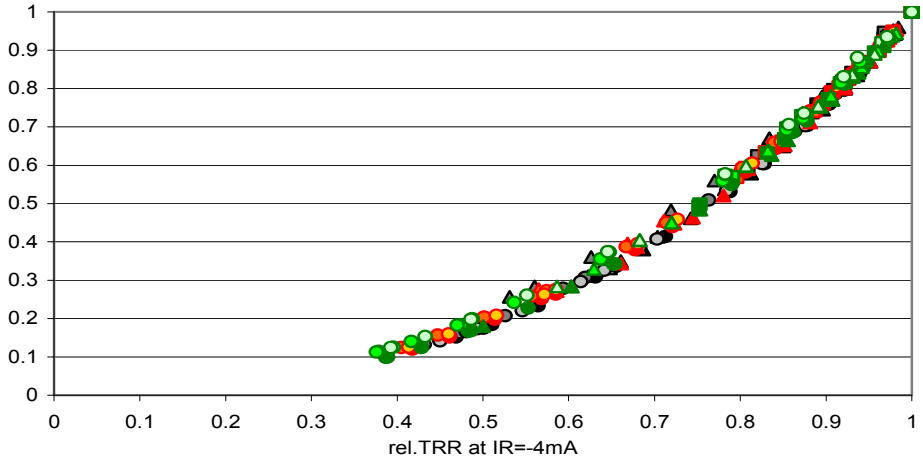
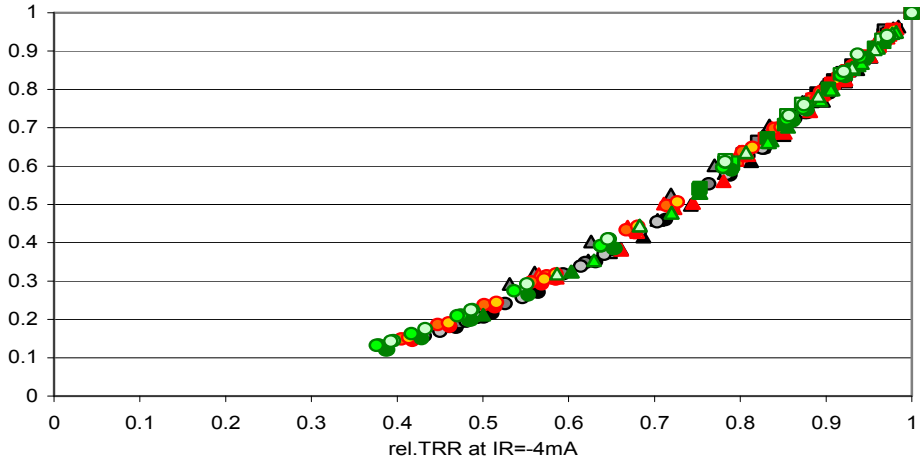


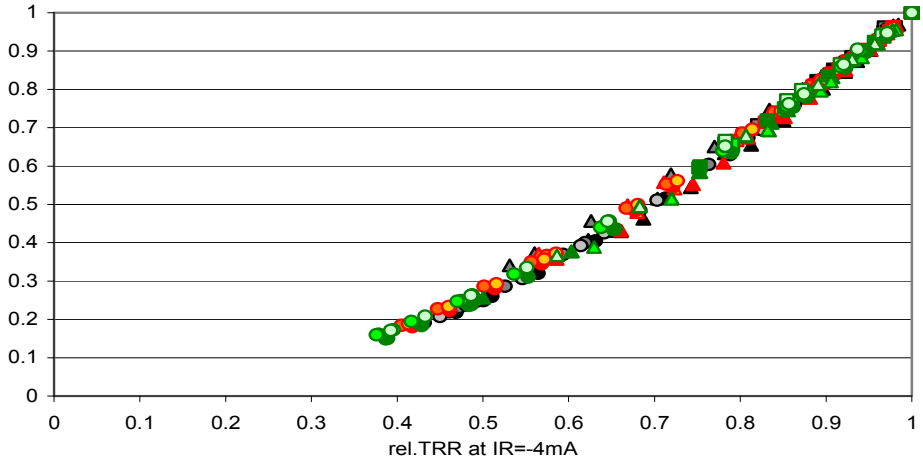
Fig. 12-99: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA







4N49 D rel.CTR at IF= 8mA vs rel.TRR at IR=-4mA



4N49 D rel.CTR at IF= 10mA vs rel.TRR at IR=-4mA

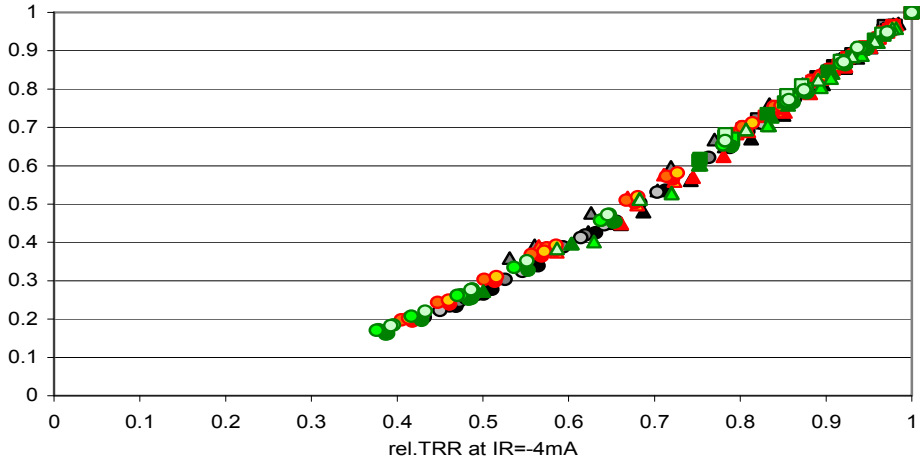
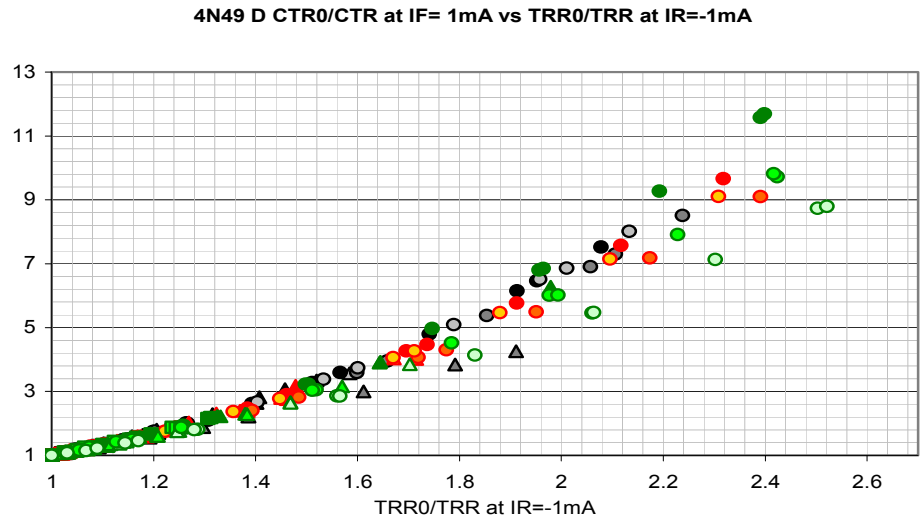
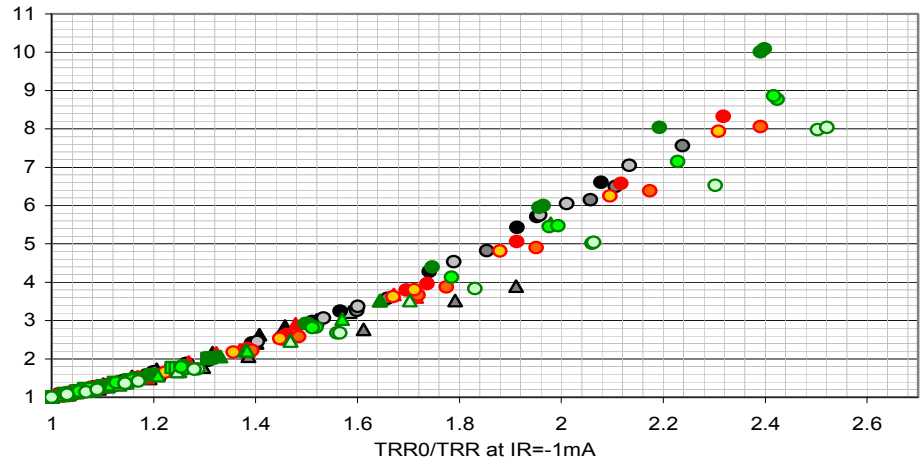
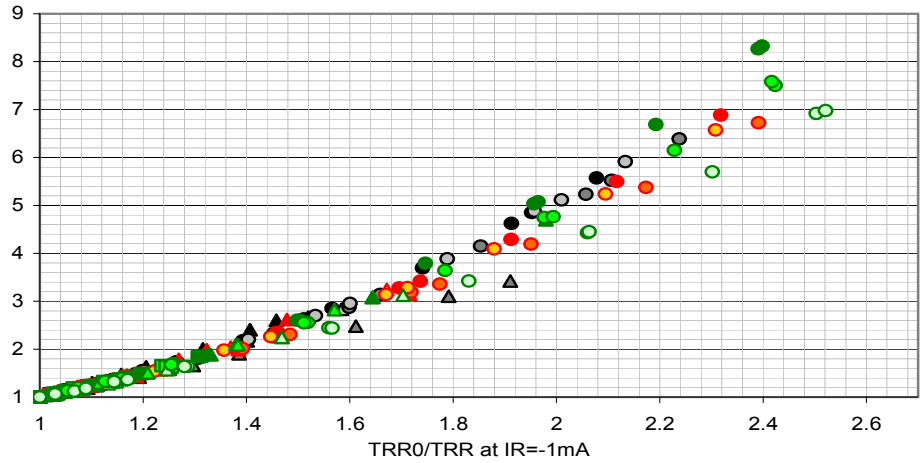


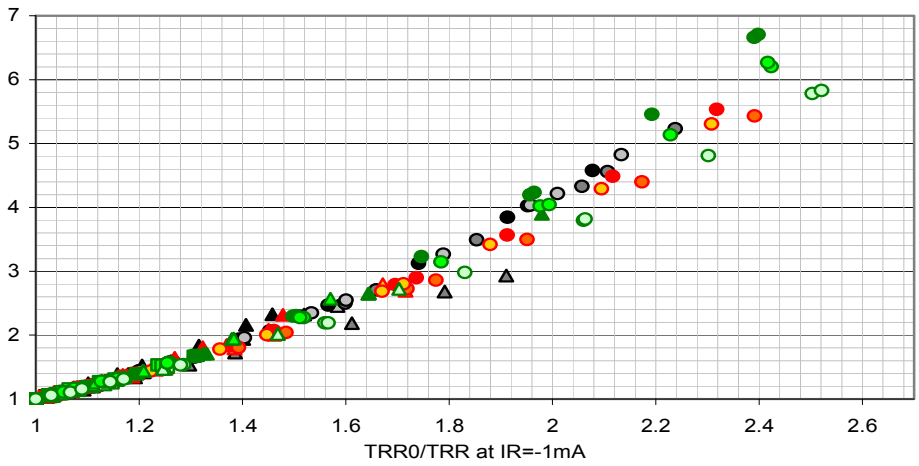
Fig. 12-100: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA







4N49 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-1mA



4N49 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-1mA

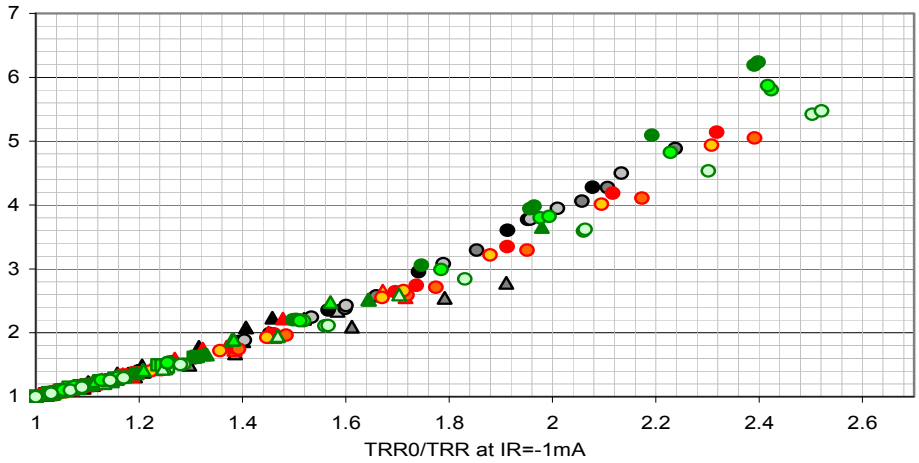
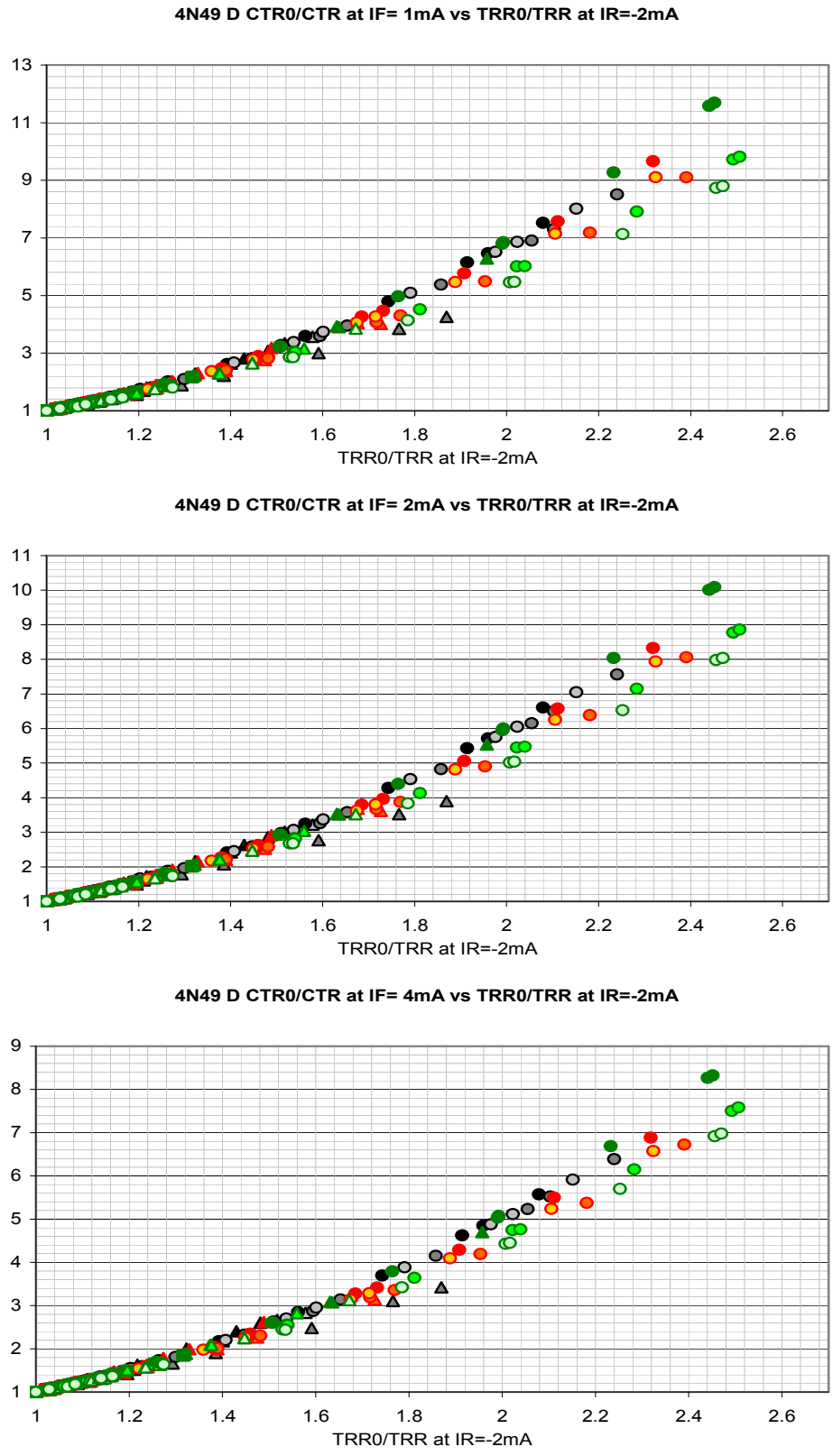
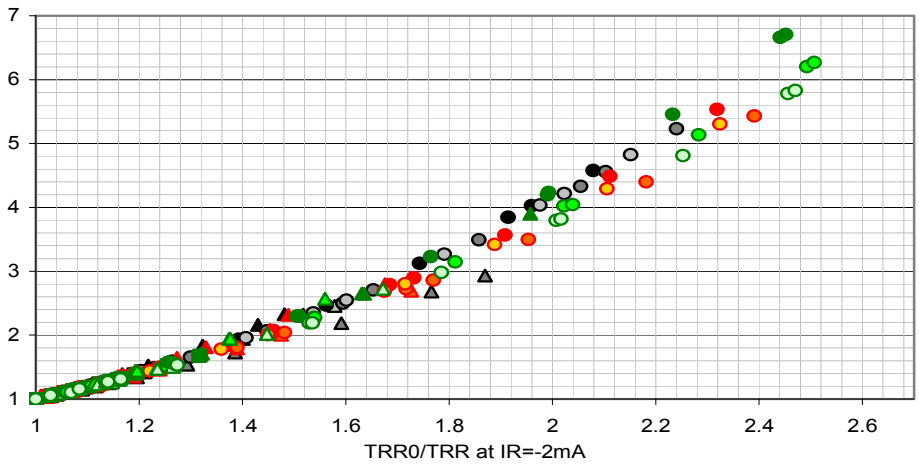


Fig. 12-101: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



4N49 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-2mA



4N49 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-2mA

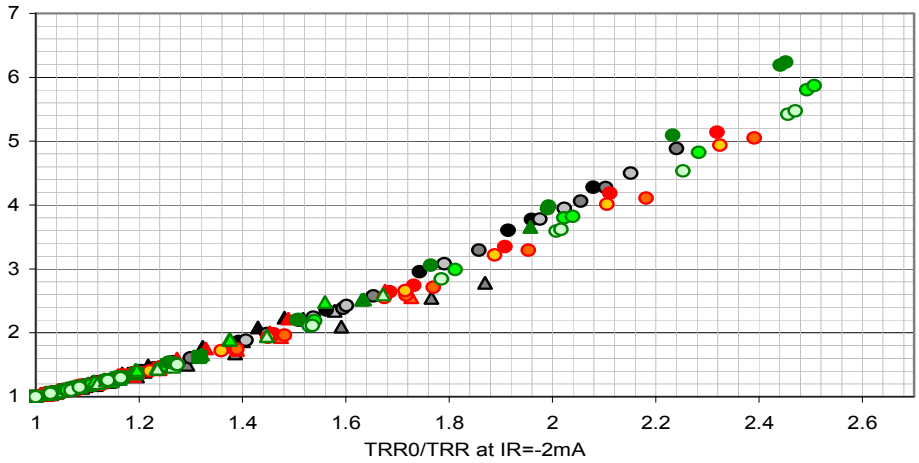
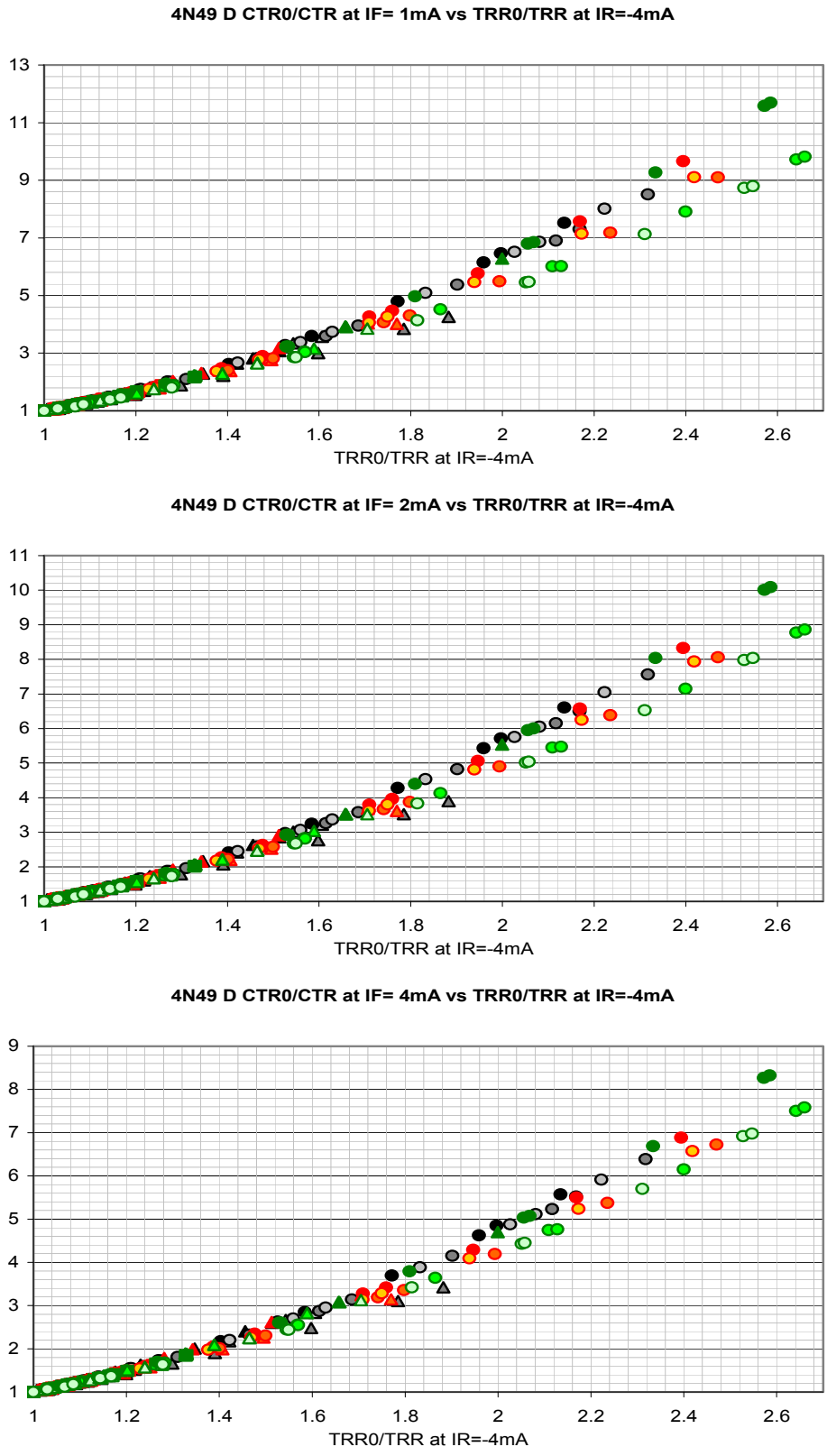
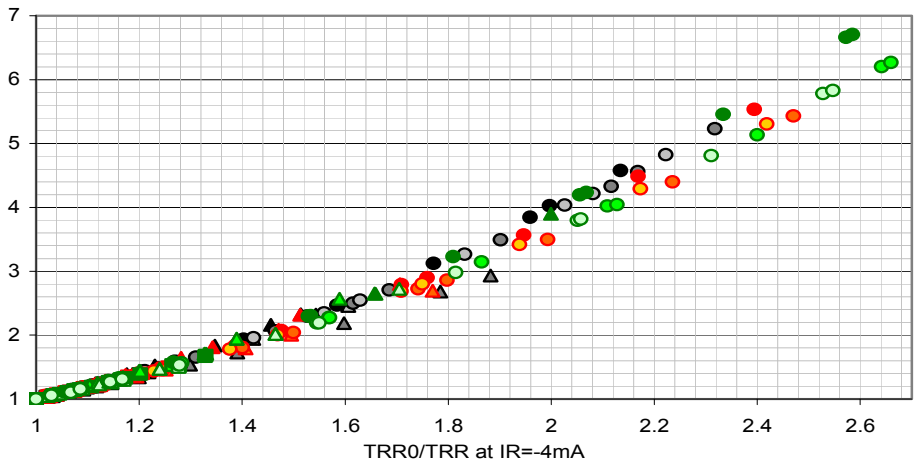


Fig. 12-102: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA



4N49 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-4mA



4N49 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-4mA

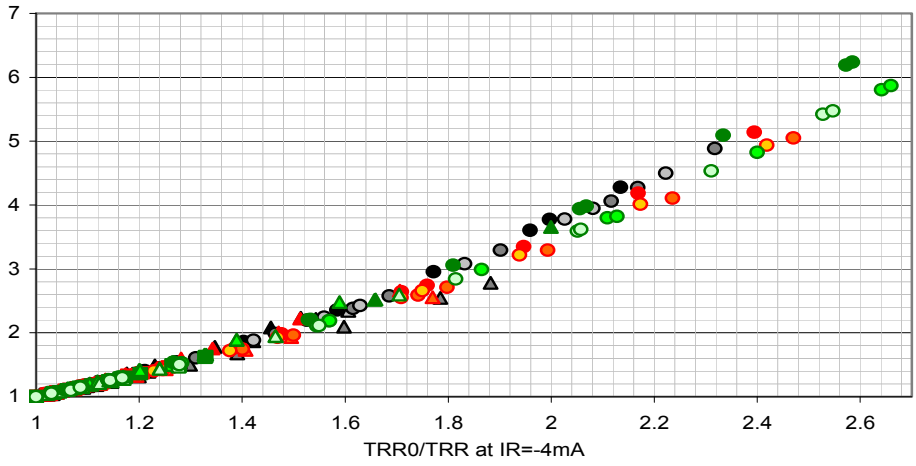
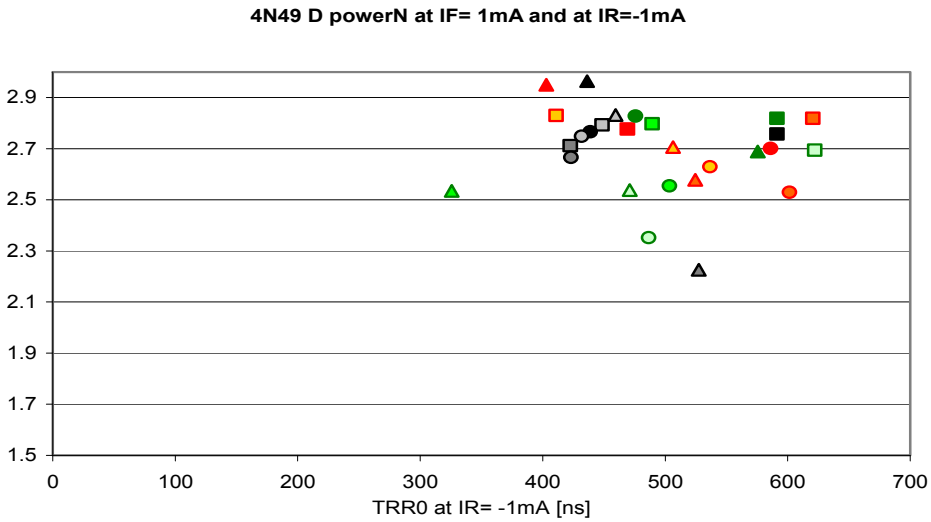
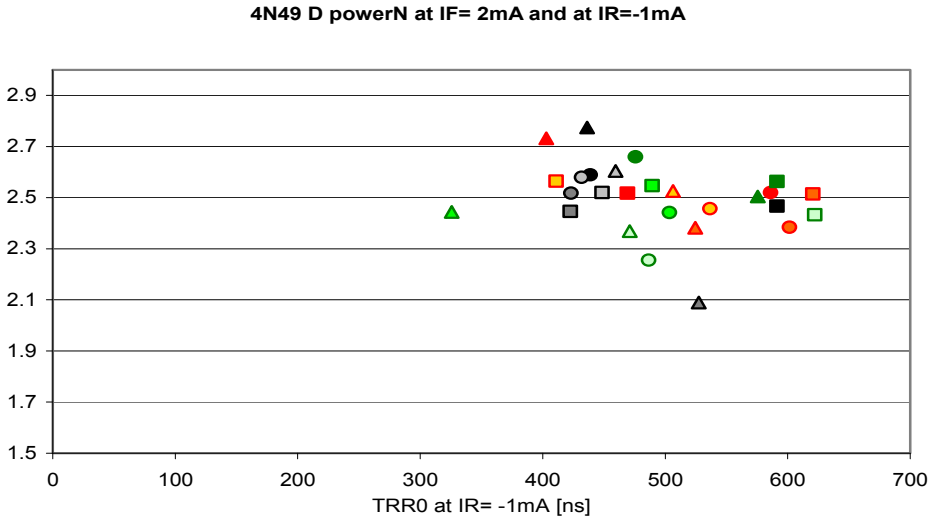
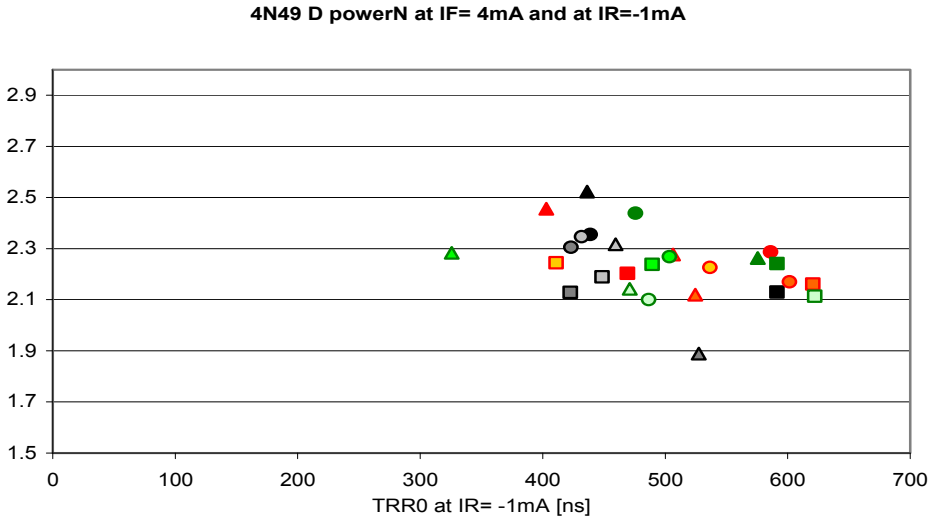


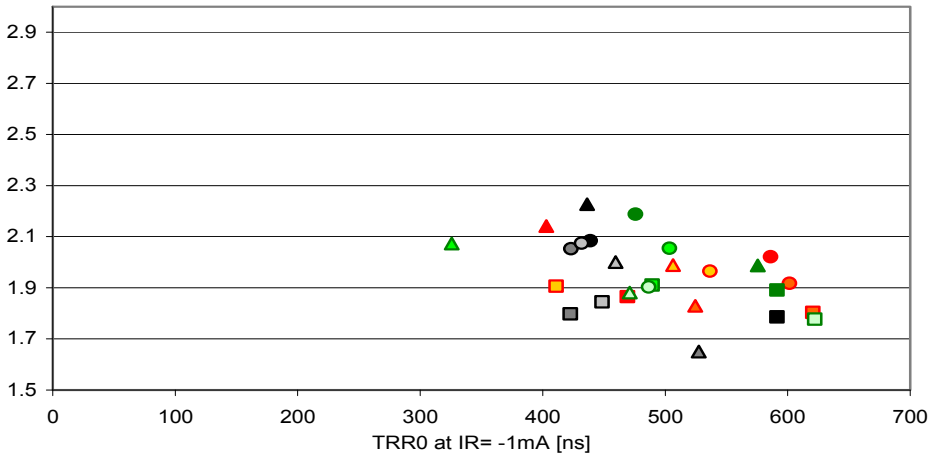
Fig. 12-103: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA







4N49 D powerN at IF= 8mA and at IR=-1mA



4N49 D powerN at IF= 10mA and at IR=-1mA

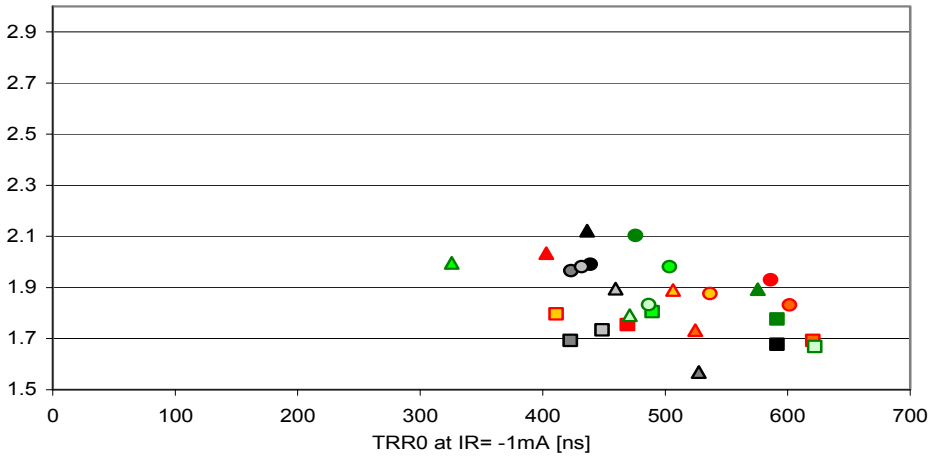
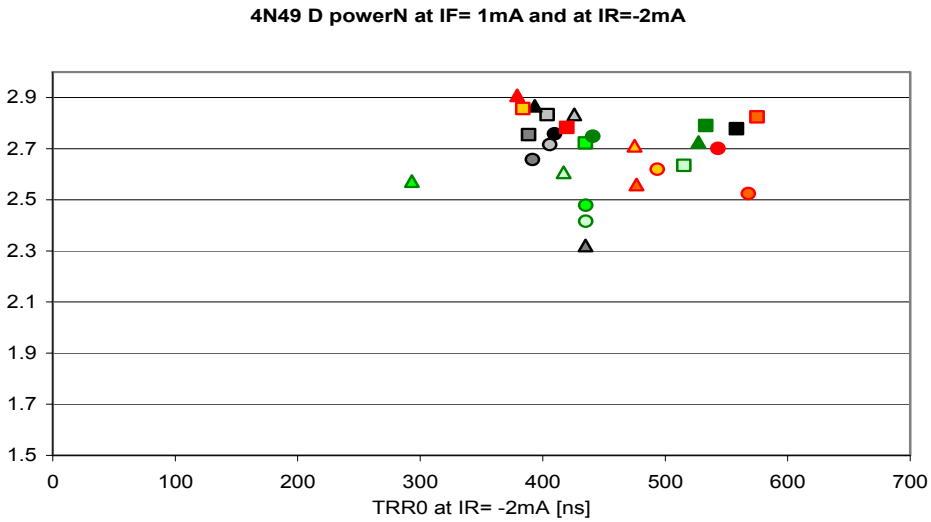
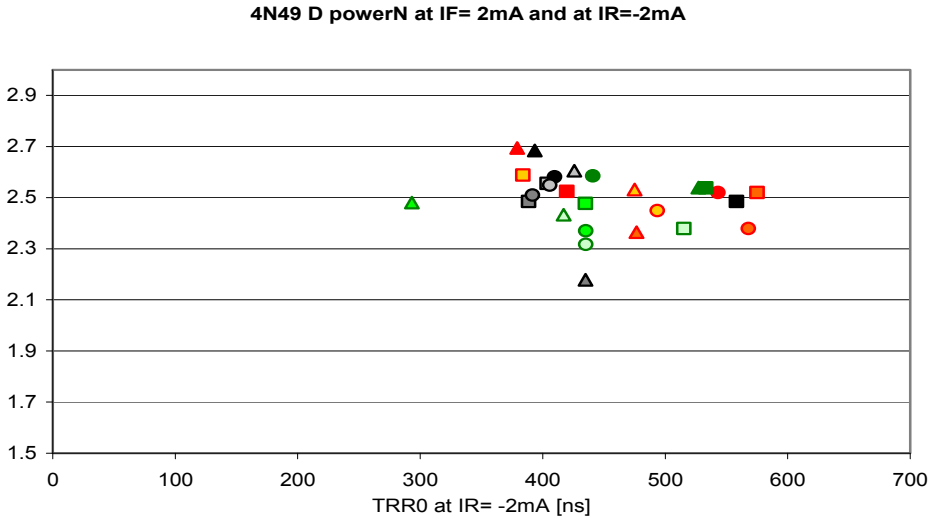
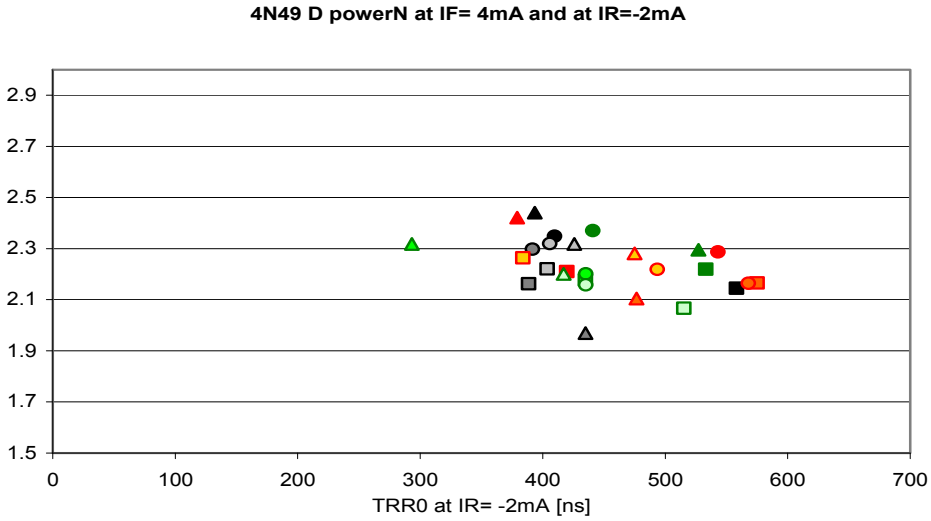


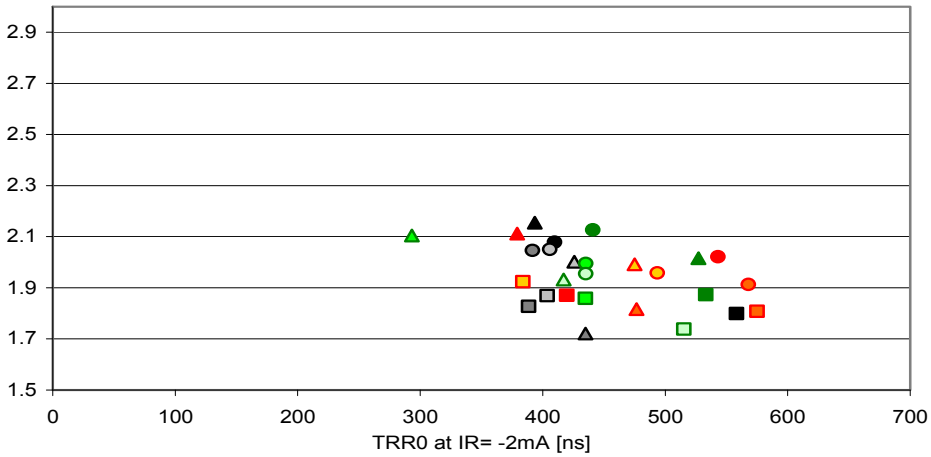
Fig. 12-104: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA







4N49 D powerN at IF= 8mA and at IR=-2mA



4N49 D powerN at IF= 10mA and at IR=-2mA

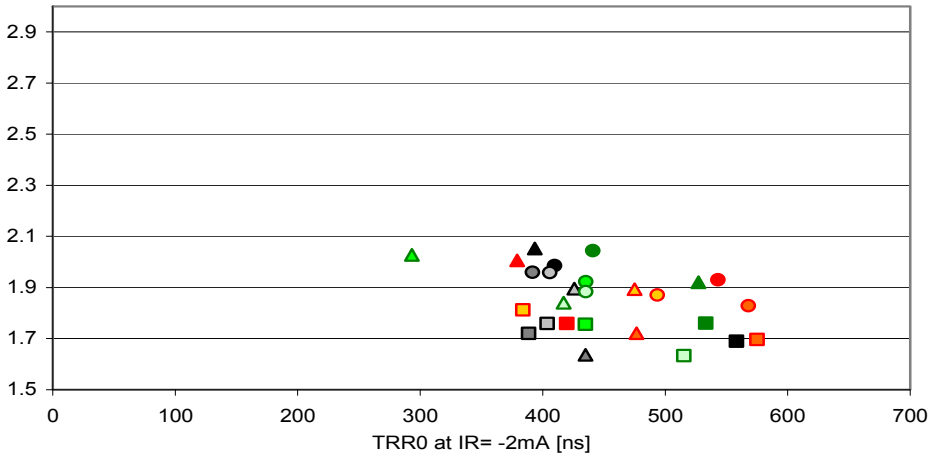
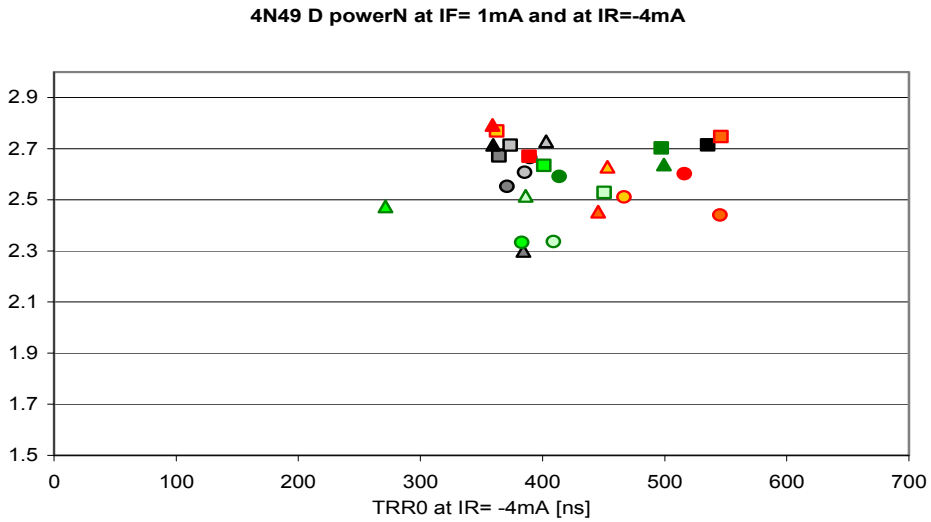
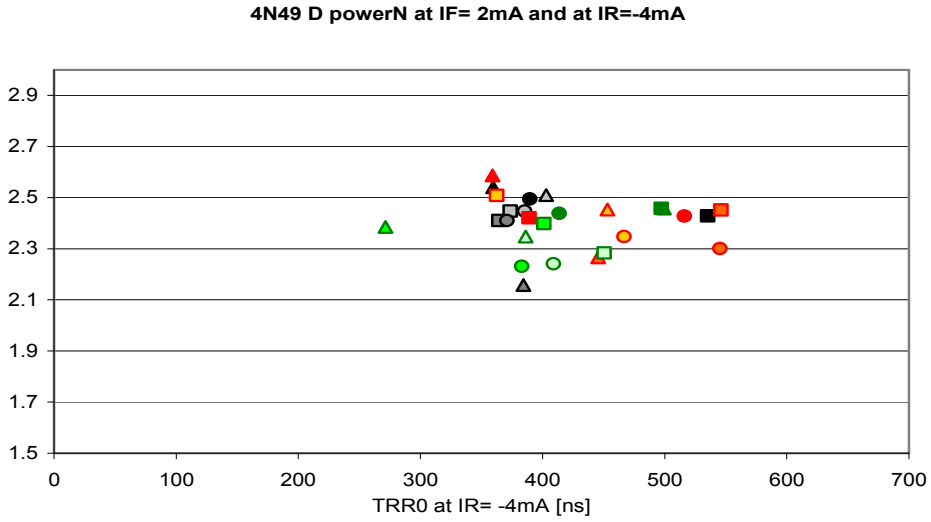
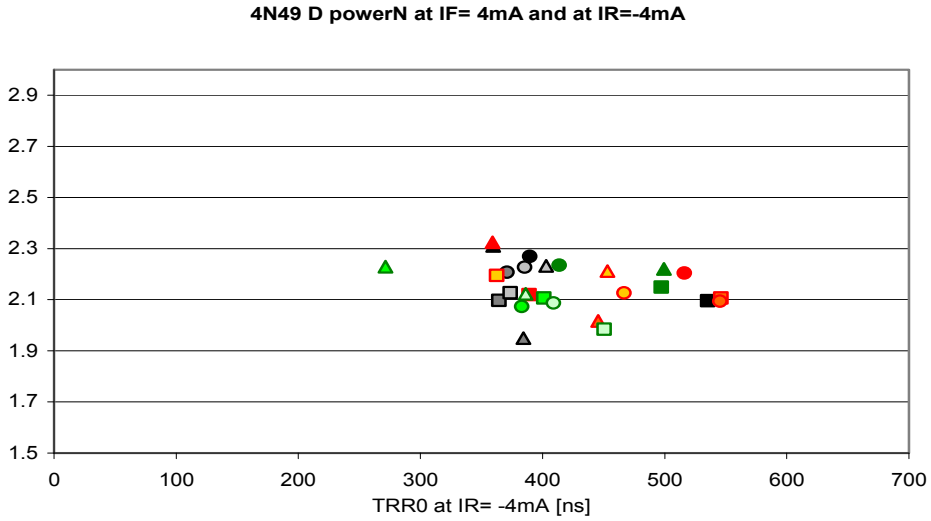


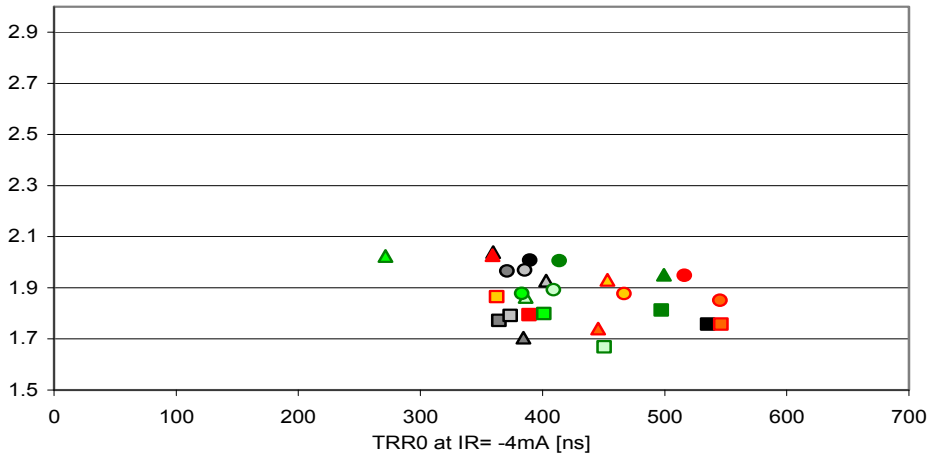
Fig. 12-105: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA







4N49 D powerN at IF= 8mA and at IR=-4mA



4N49 D powerN at IF= 10mA and at IR=-4mA

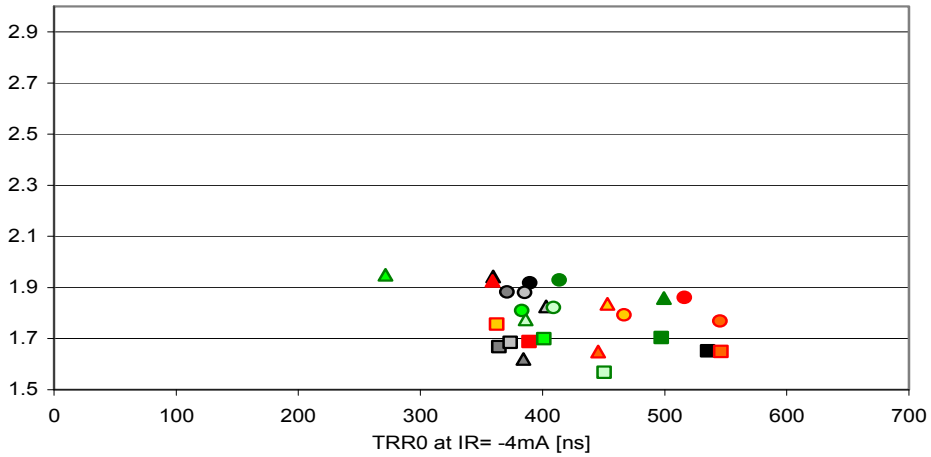
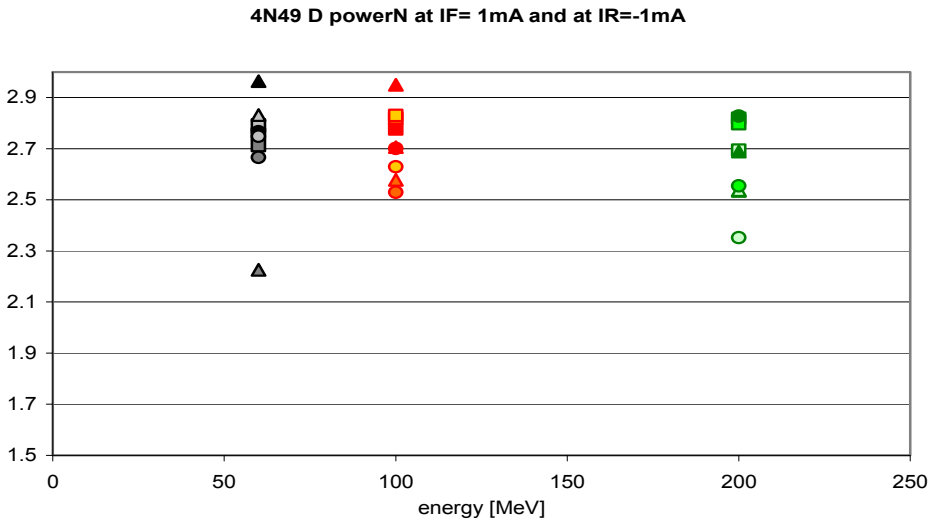
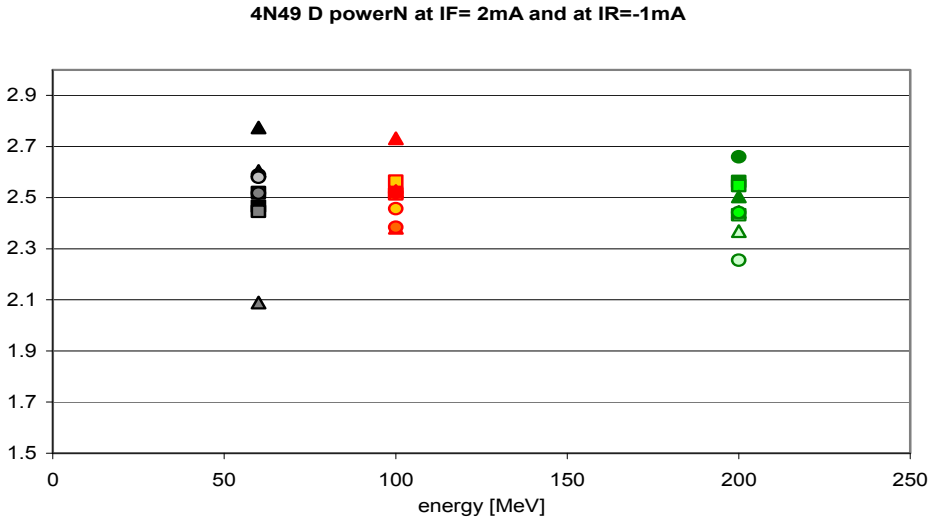
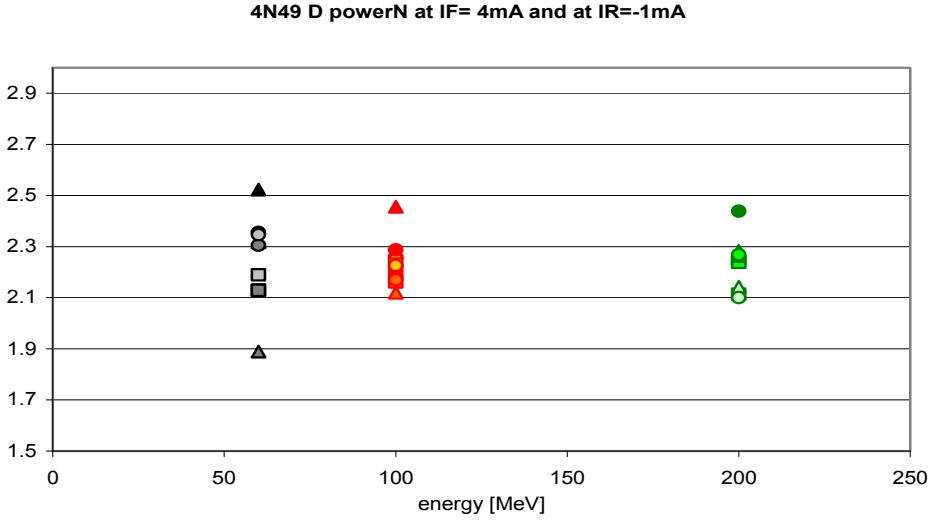


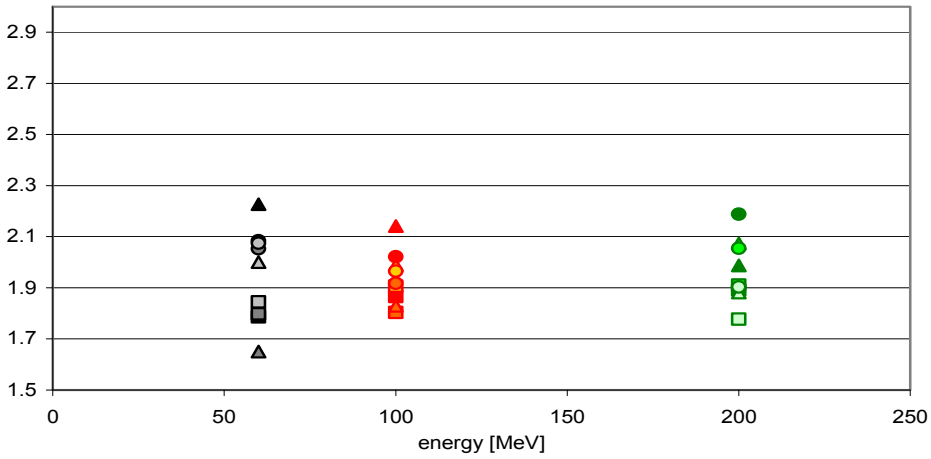
Fig. 12-106: 4N49 diode: N at I_R = -1 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy







4N49 D powerN at IF= 8mA and at IR=-1mA



4N49 D powerN at IF= 10mA and at IR=-1mA

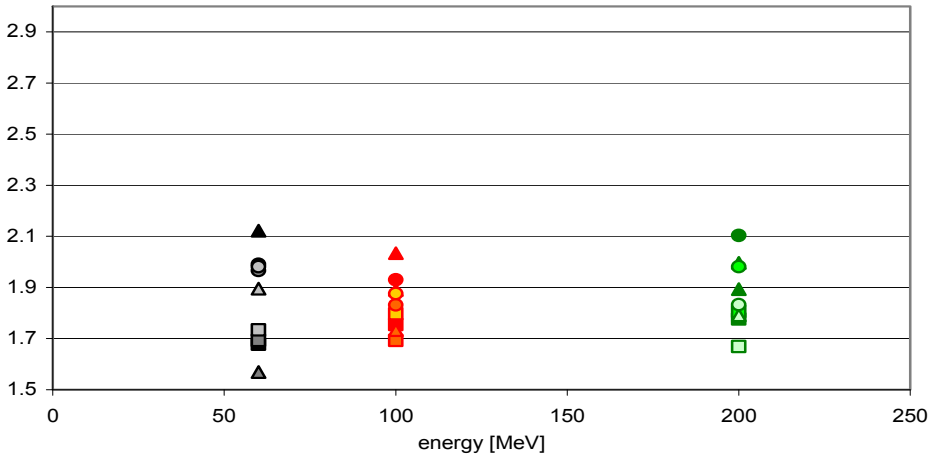
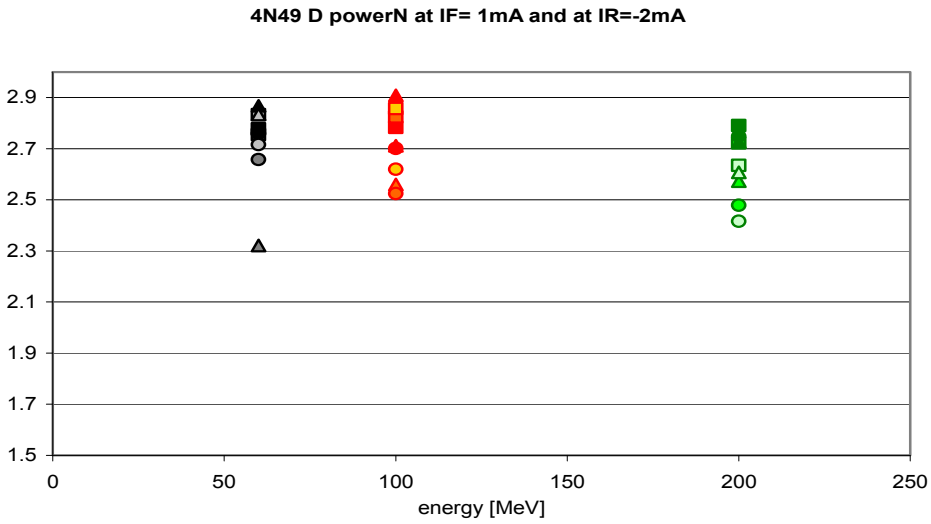
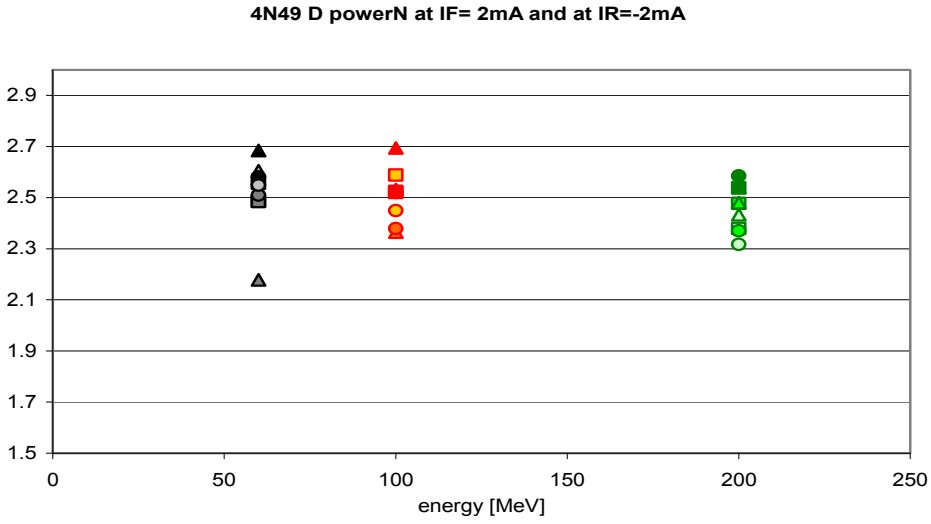
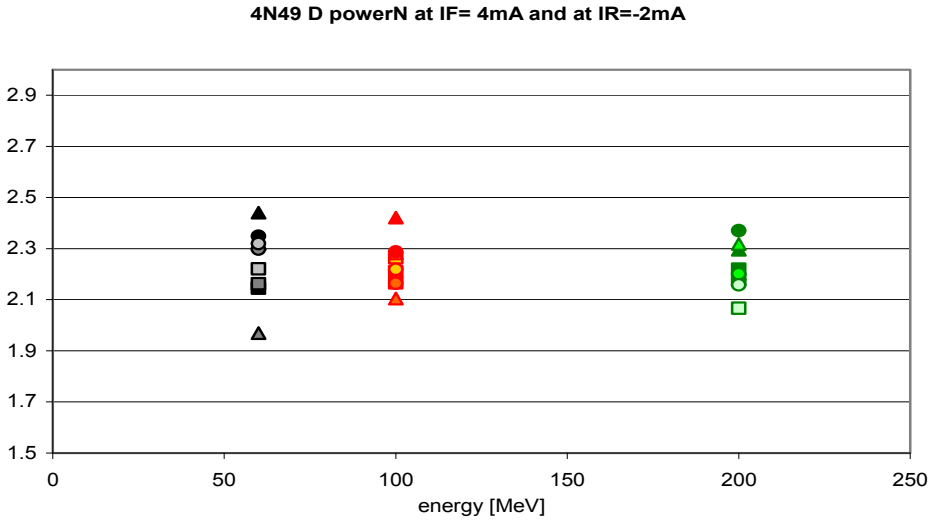


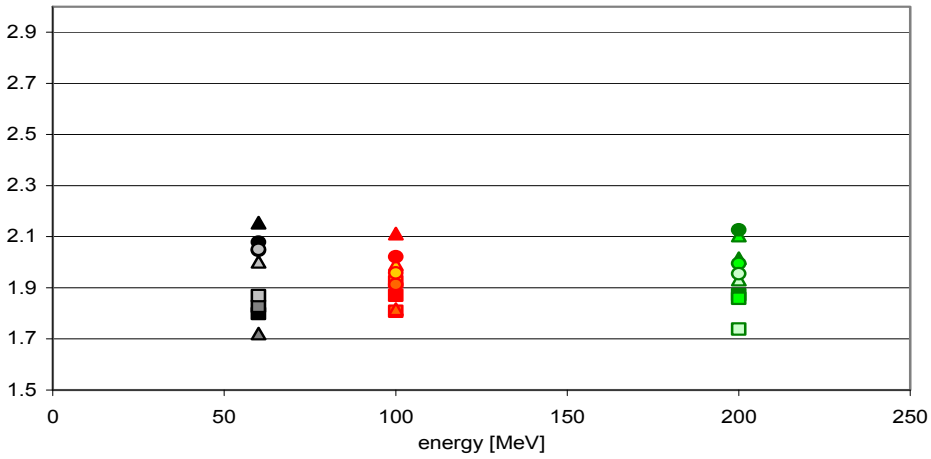
Fig. 12-107: 4N49 diode: N at I_R = -2 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy







4N49 D powerN at IF= 8mA and at IR=-2mA



4N49 D powerN at IF= 10mA and at IR=-2mA

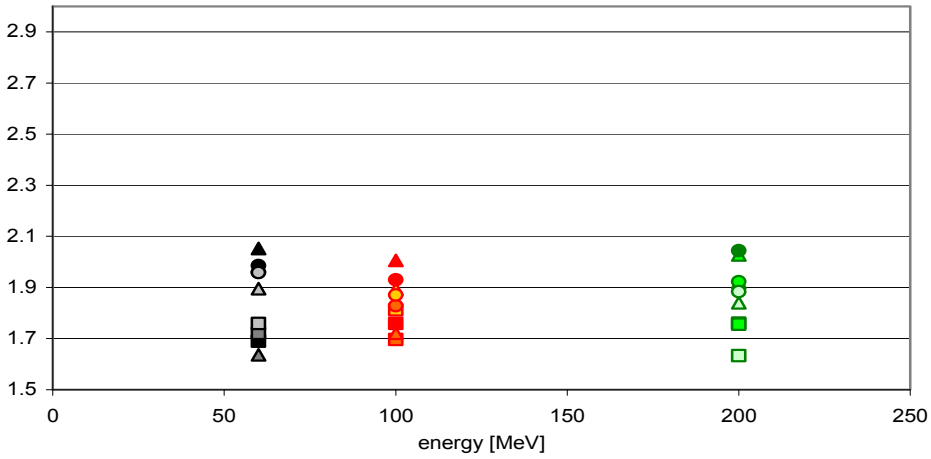
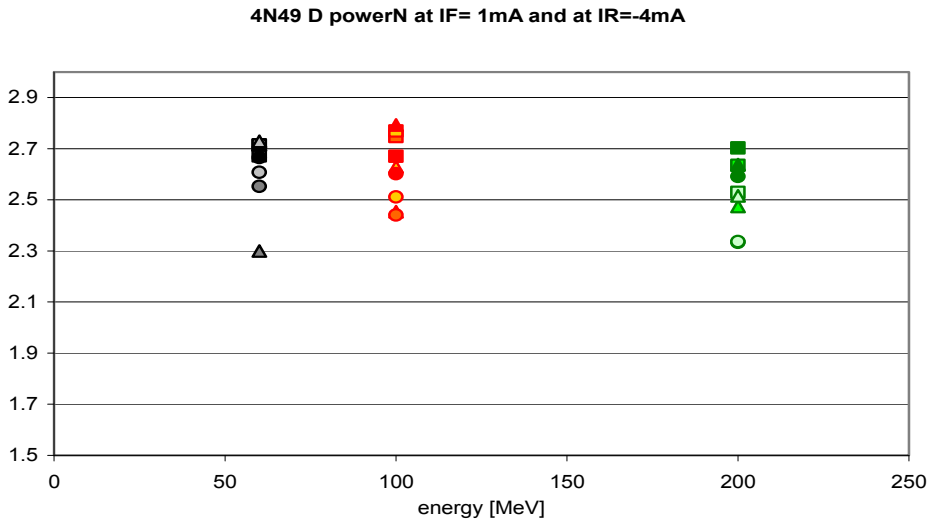
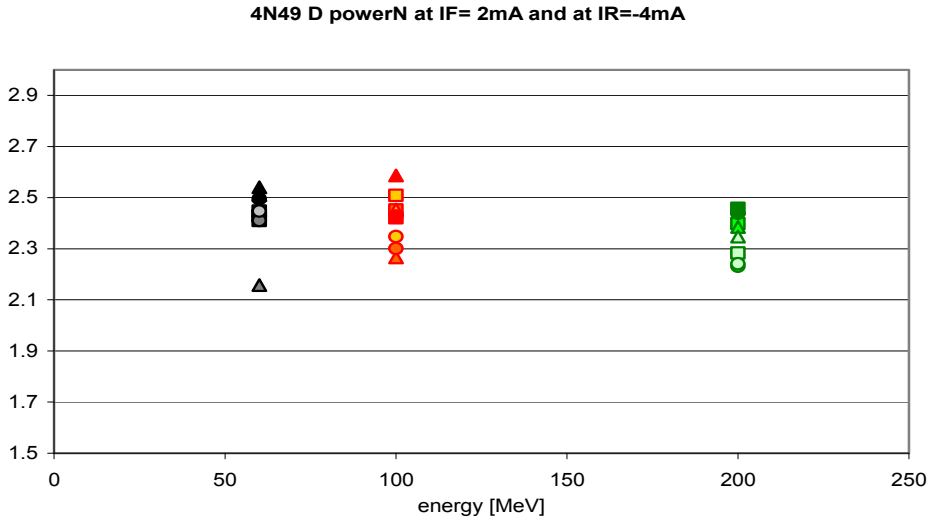
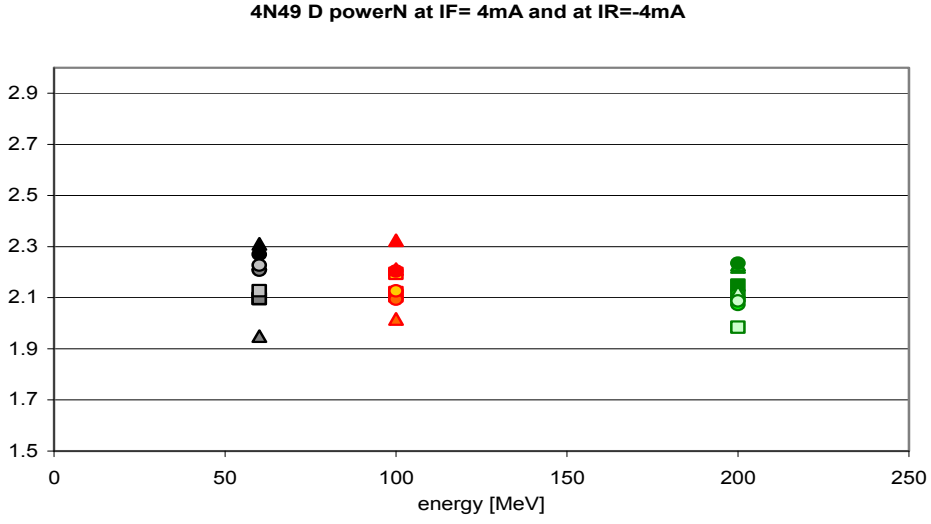


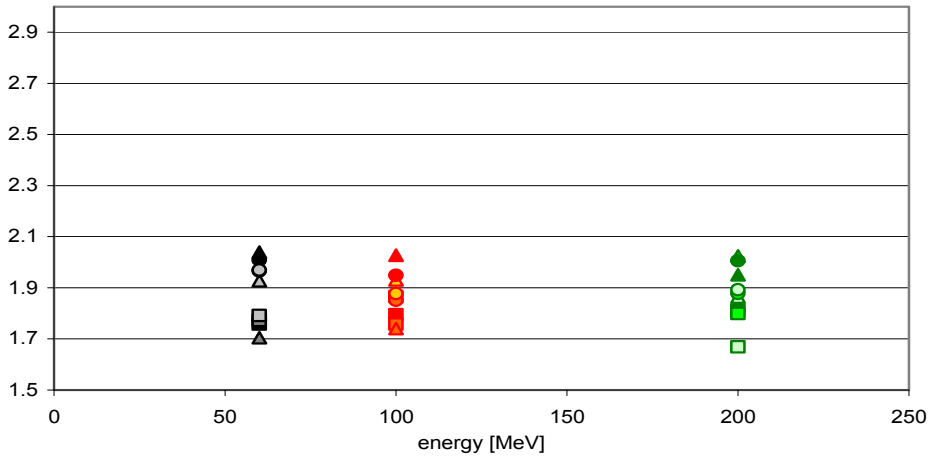
Fig. 12-108: 4N49 diode: N at I_R = -4 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy



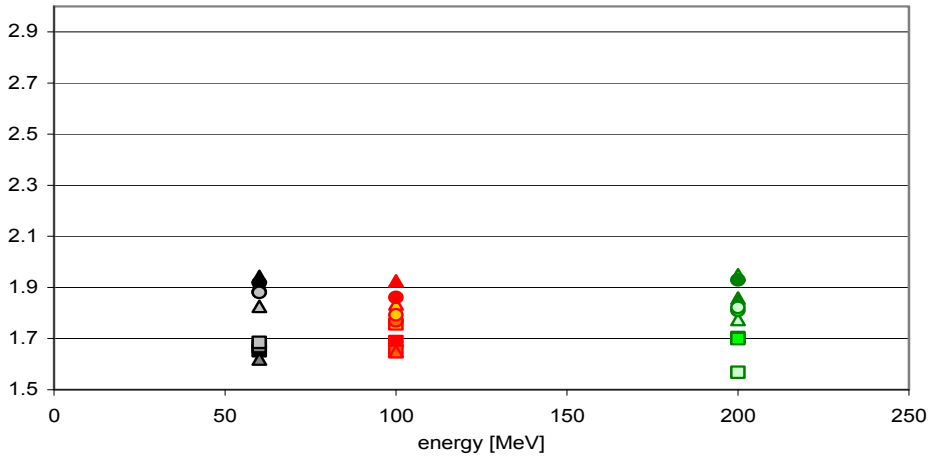




4N49 D powerN at IF= 8mA and at IR=-4mA

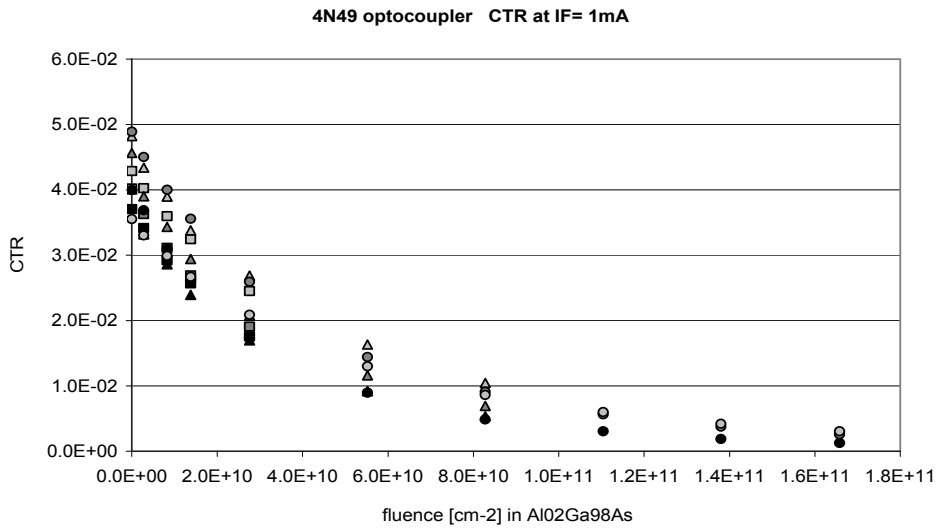


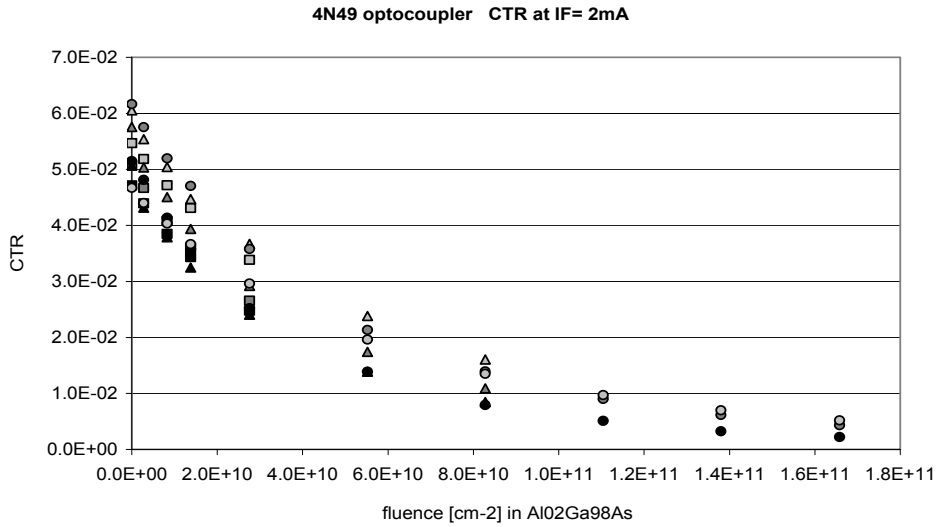
4N49 D powerN at IF= 10mA and at IR=-4mA

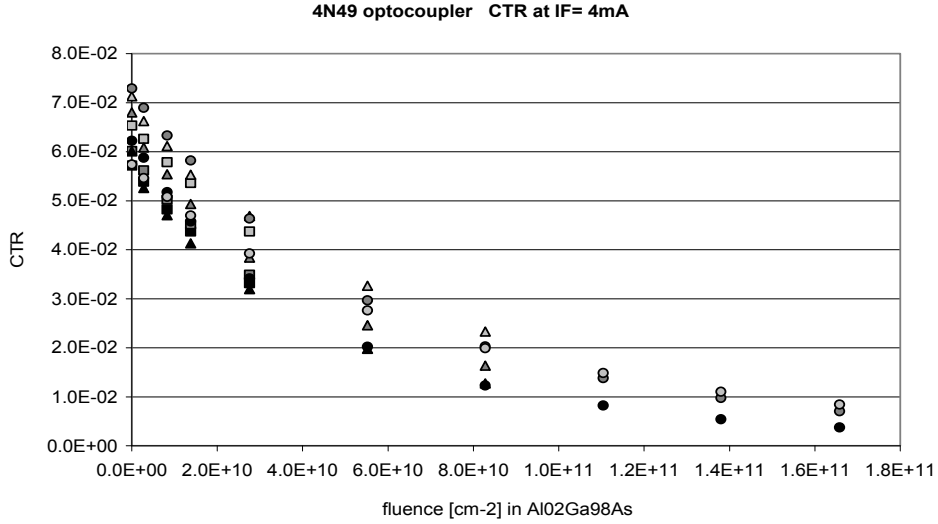


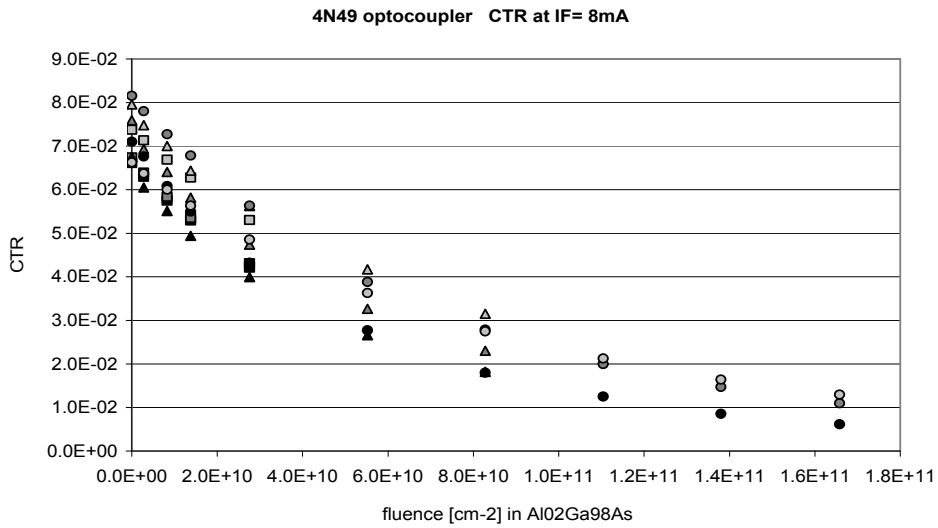
12.2 NEUTRON IRRADIATION

Fig. 12-109: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








4N49 optocoupler CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

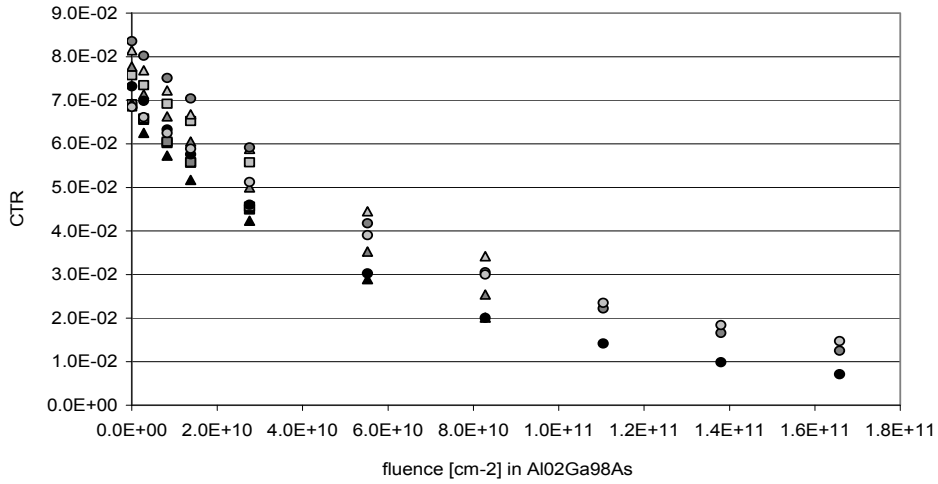
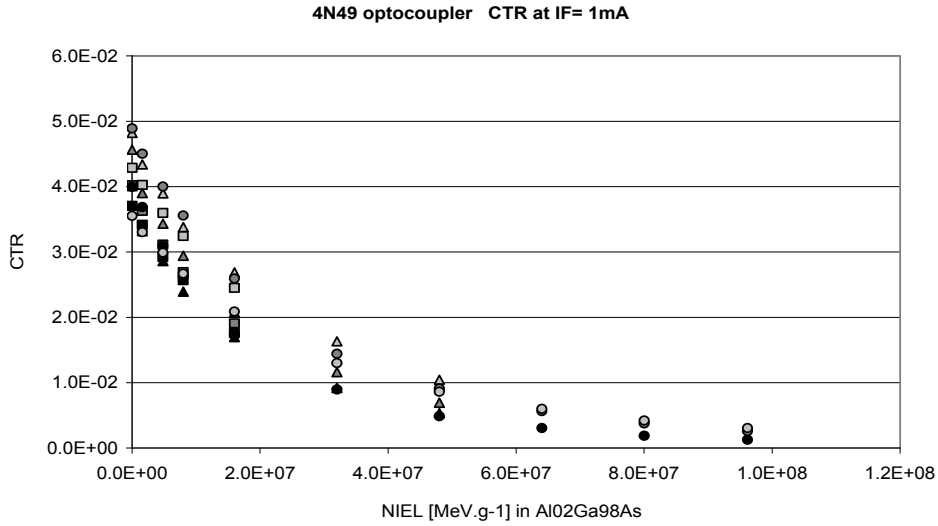
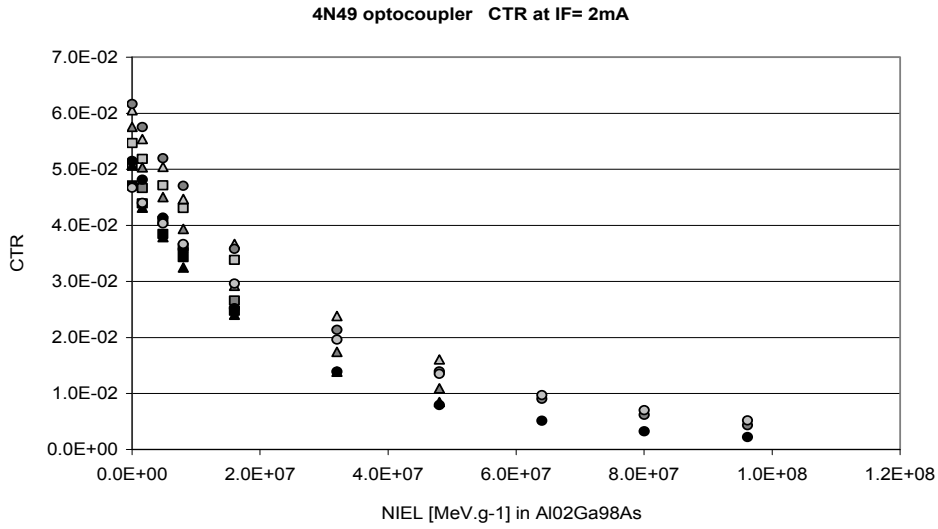
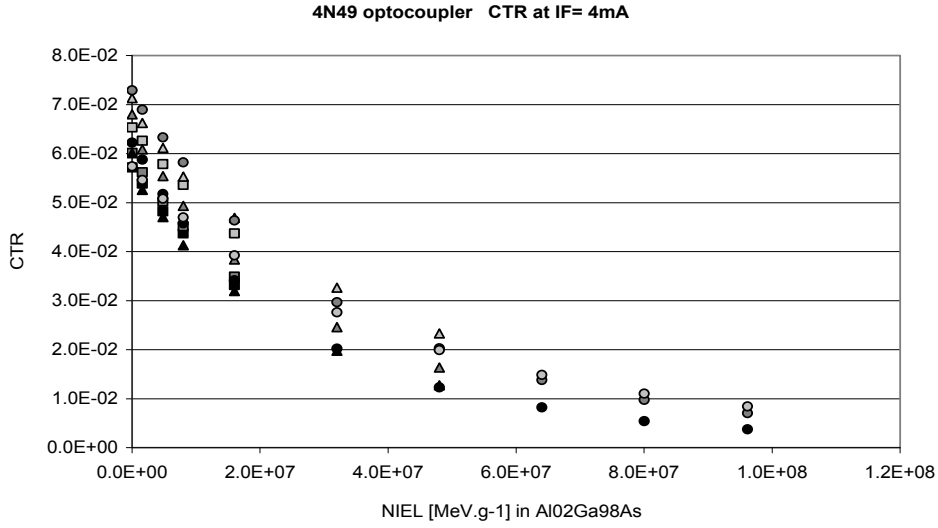
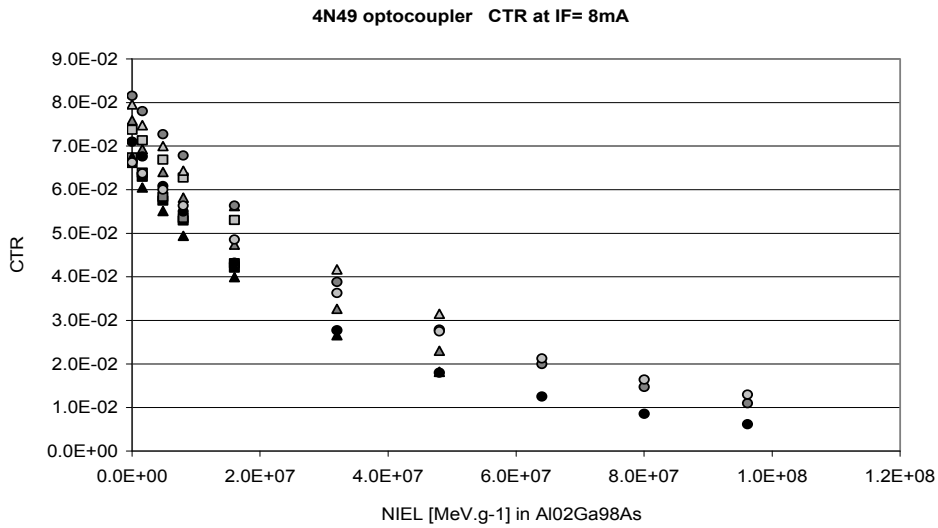

4N49 optocoupler CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-110: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)








4N49 optocoupler CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

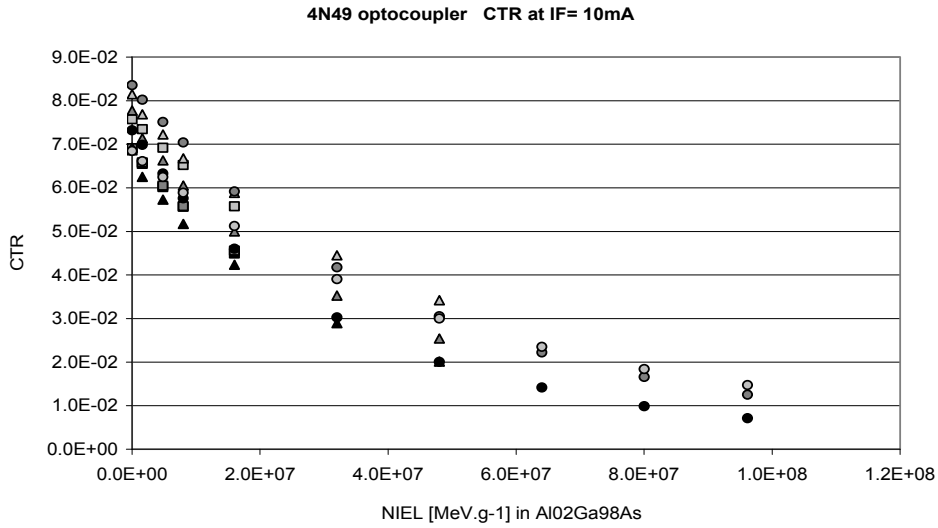
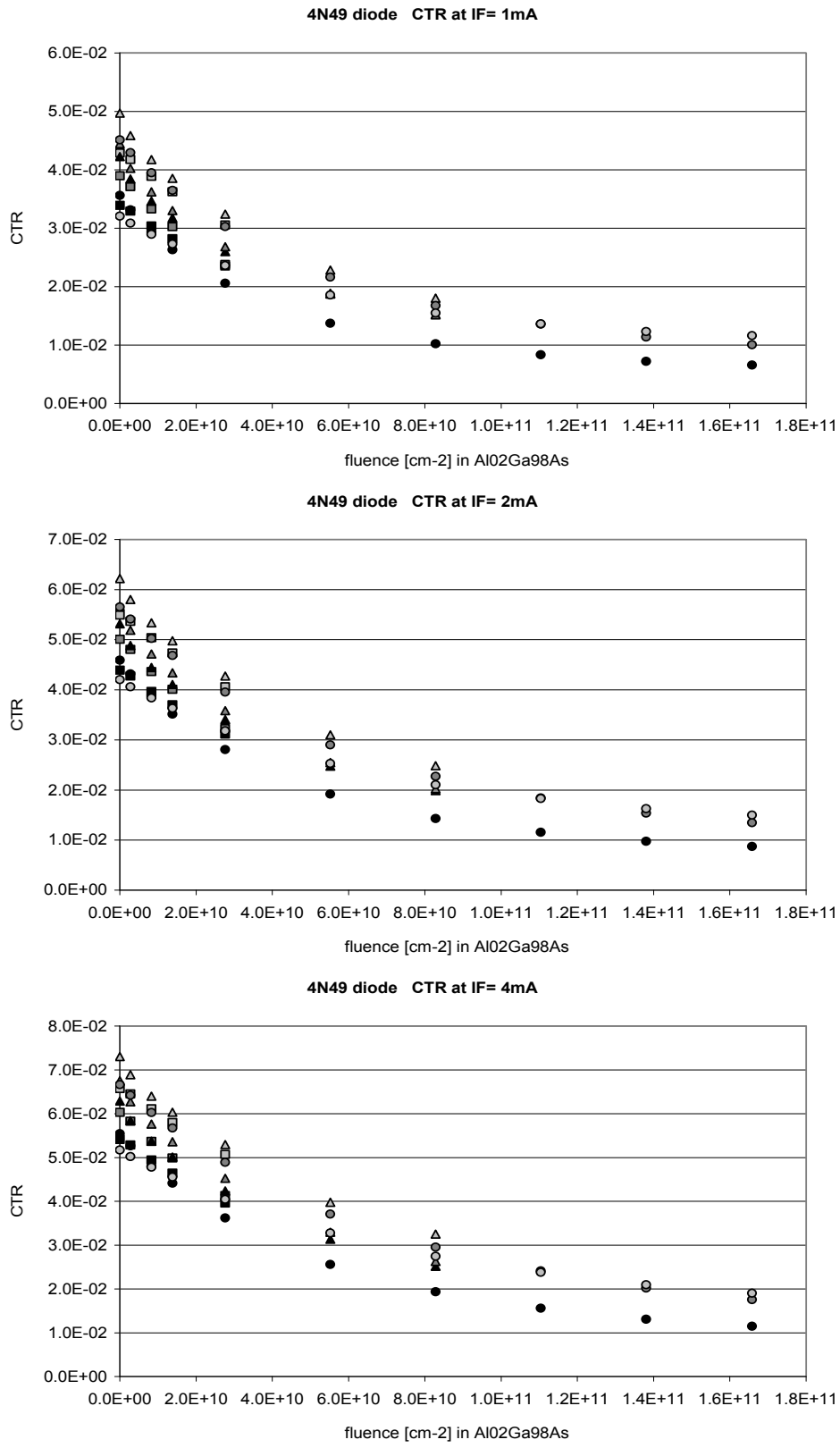
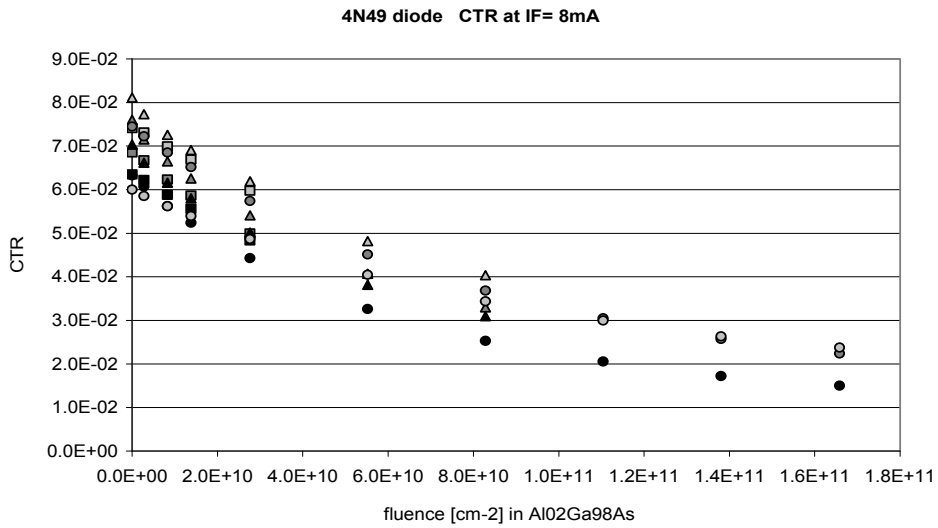

4N49 optocoupler CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-111: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 diode CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

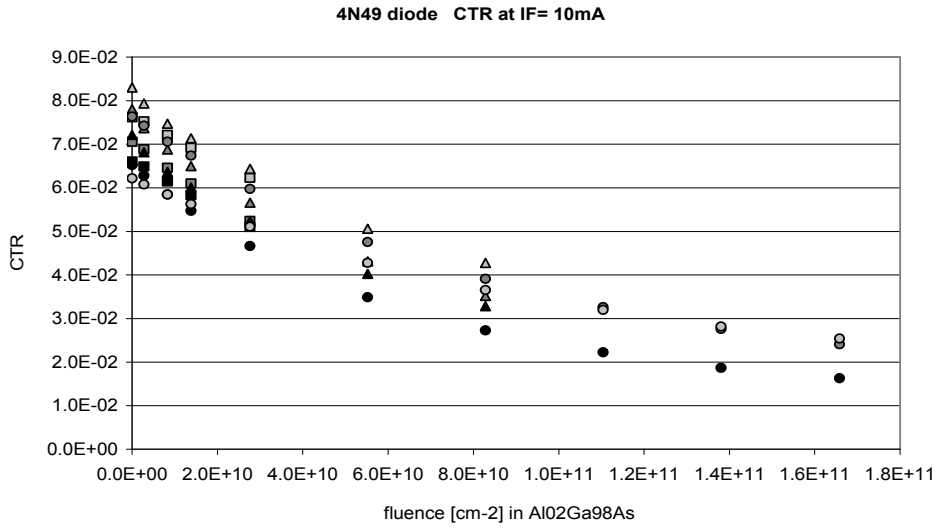
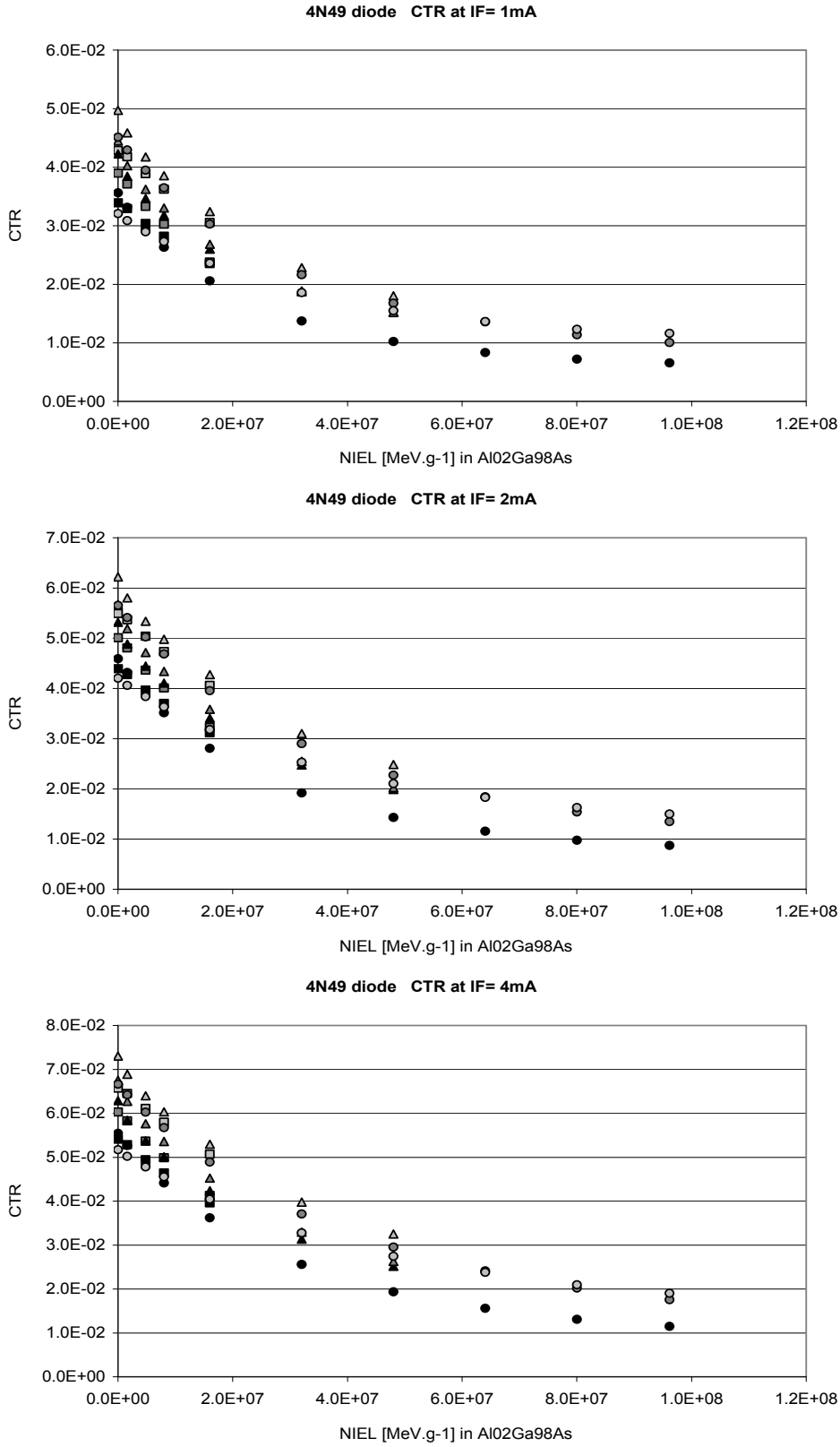
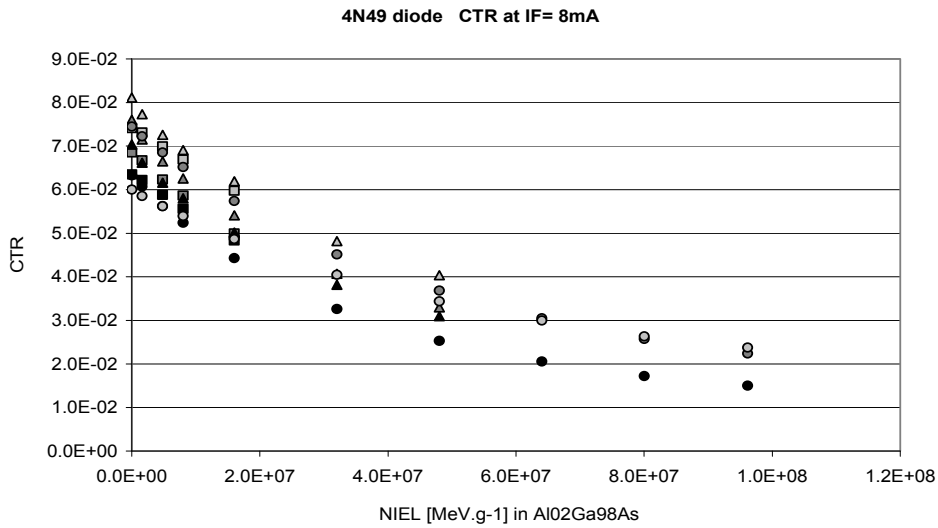

4N49 diode CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-112: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)




4N49 diode CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

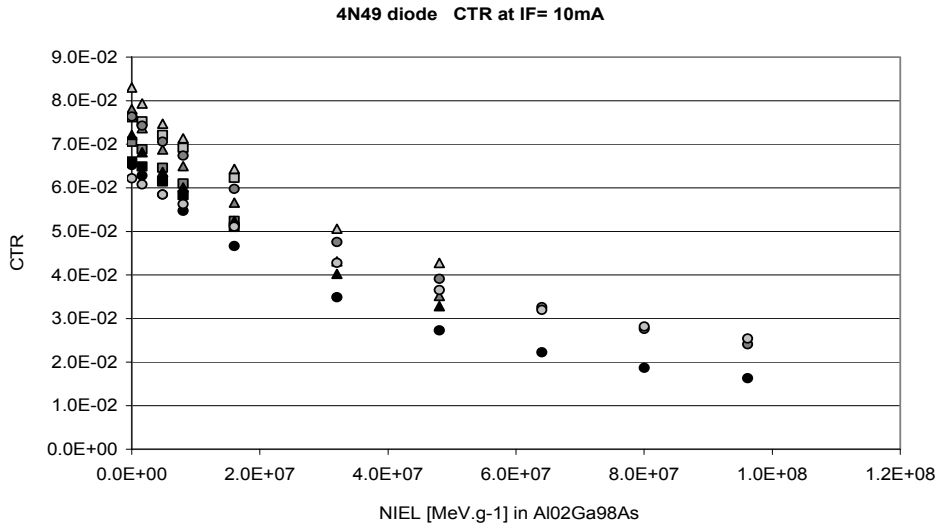
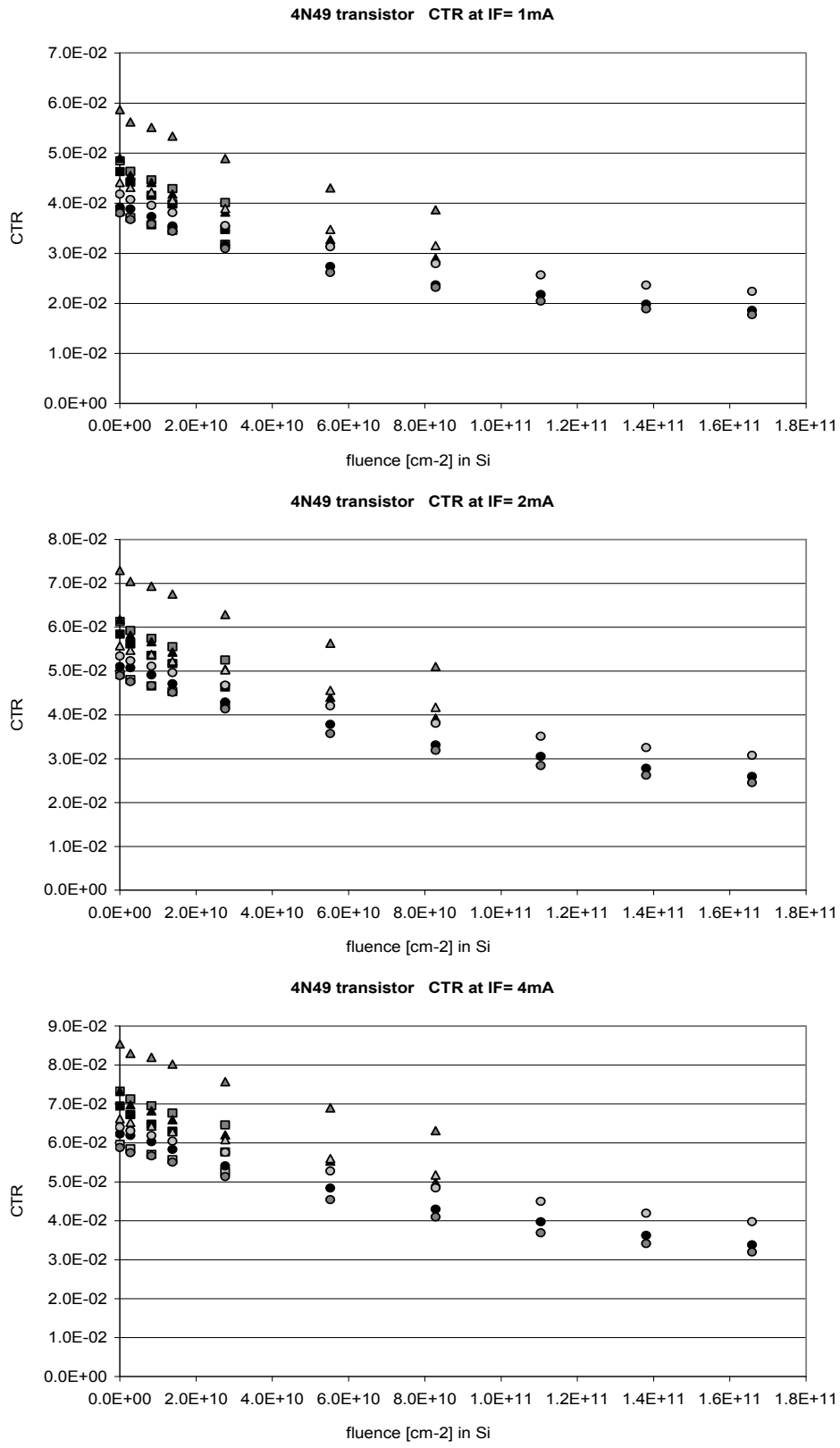
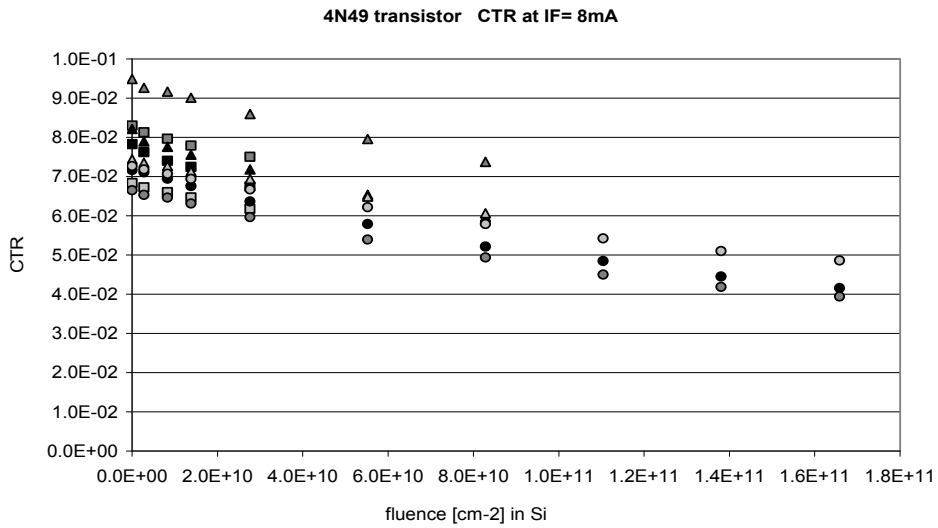

4N49 diode CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-113: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 transistor CTR at IF= 8mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

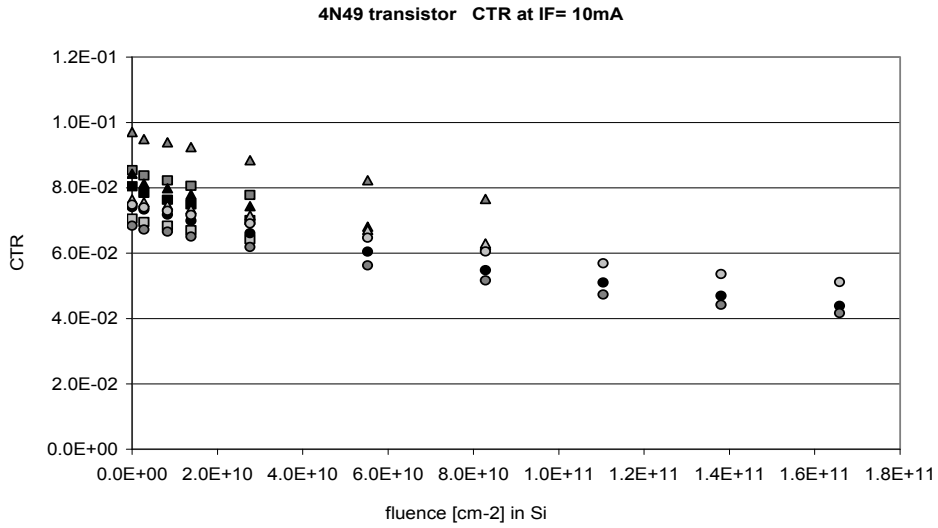
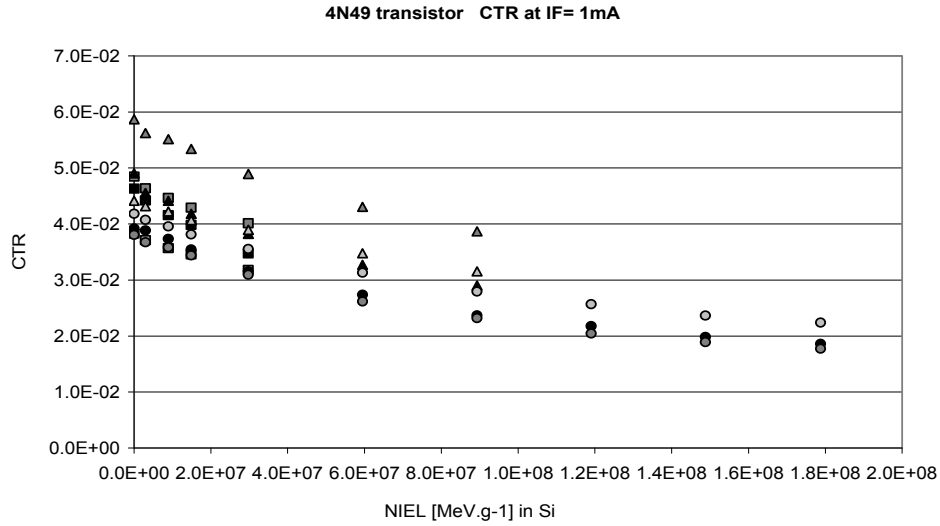
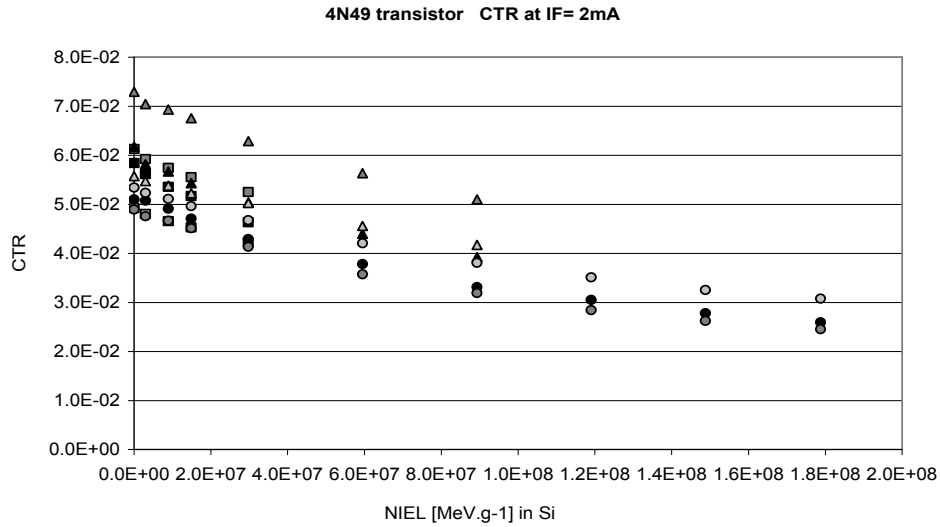
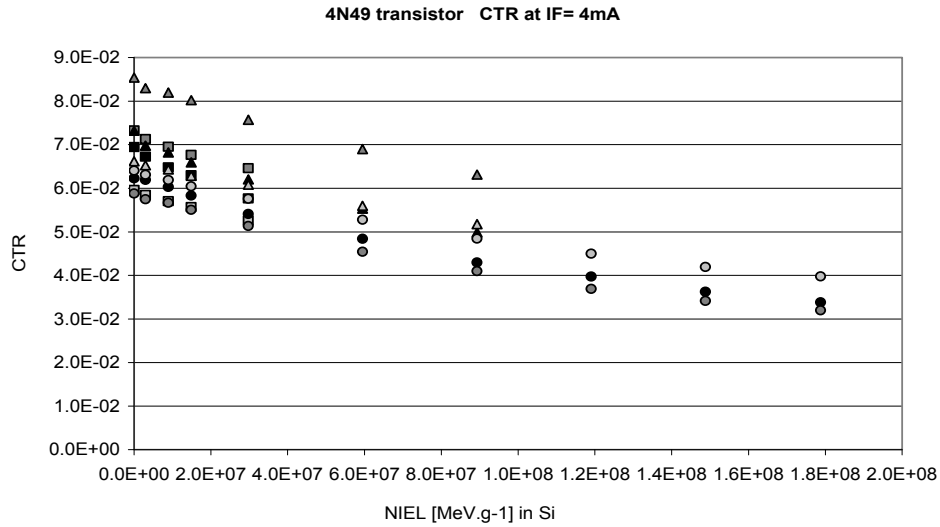
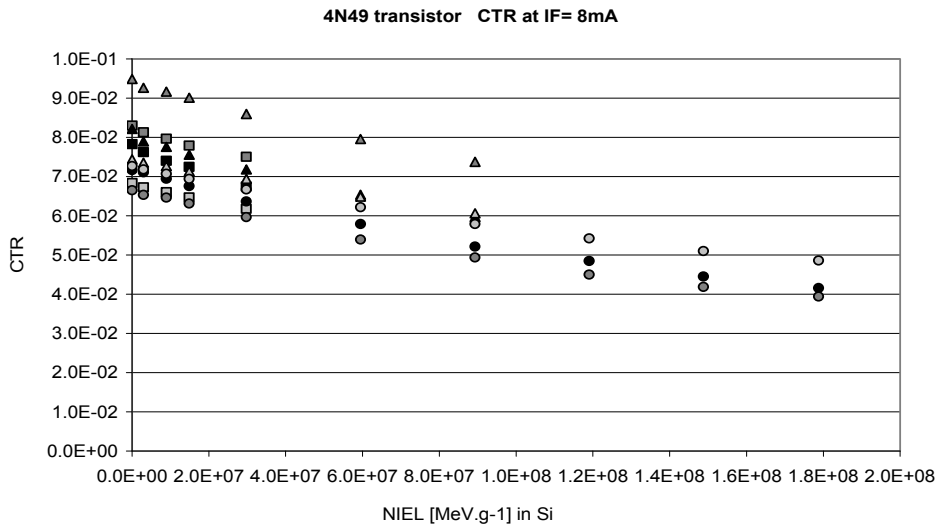

4N49 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

Fig. 12-114: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








4N49 transistor CTR at IF= 8mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

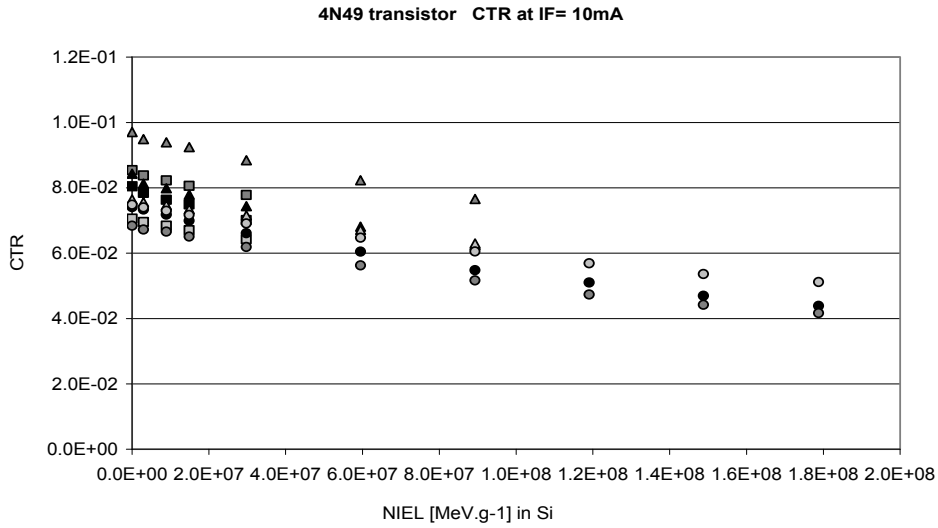
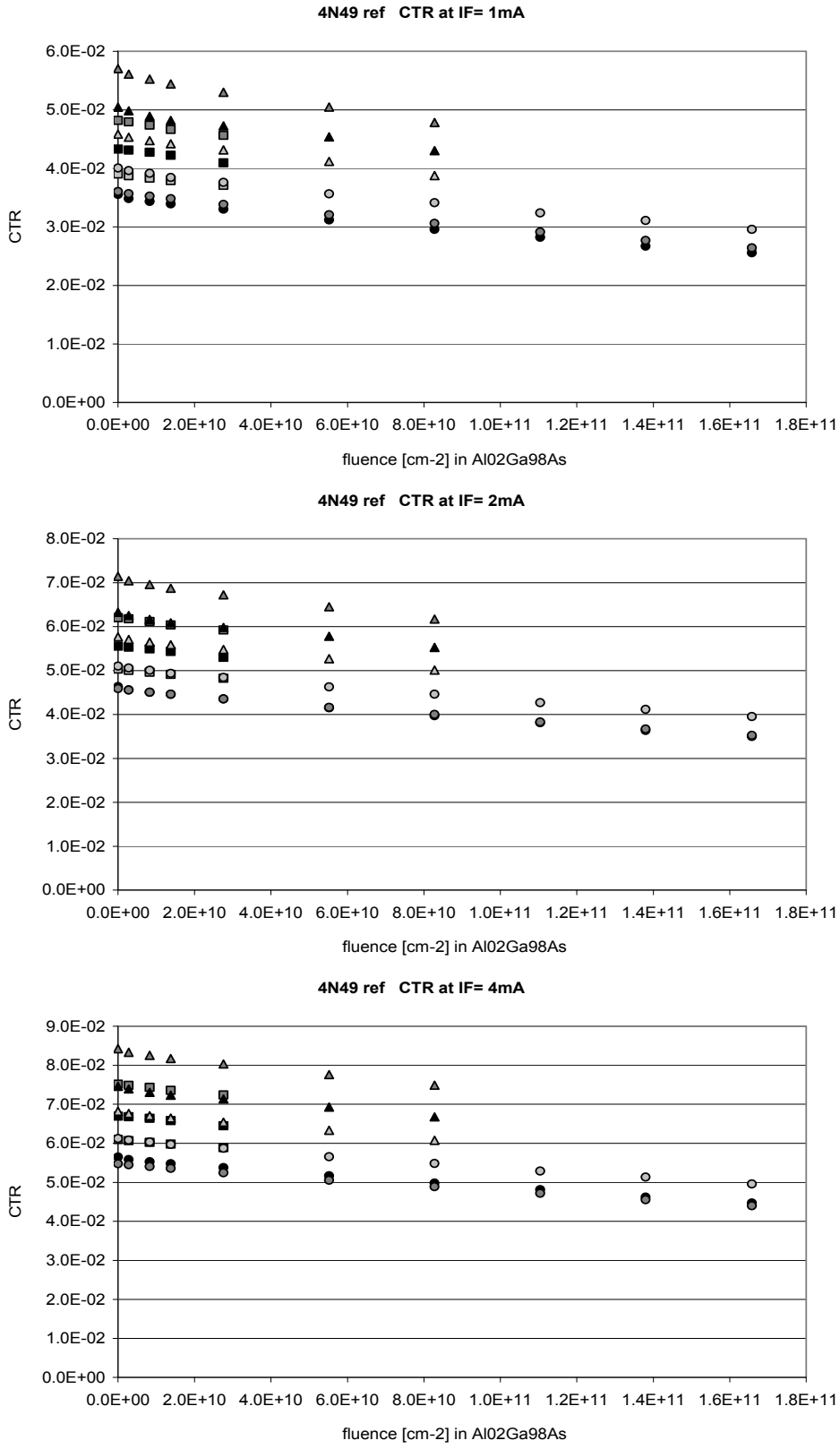
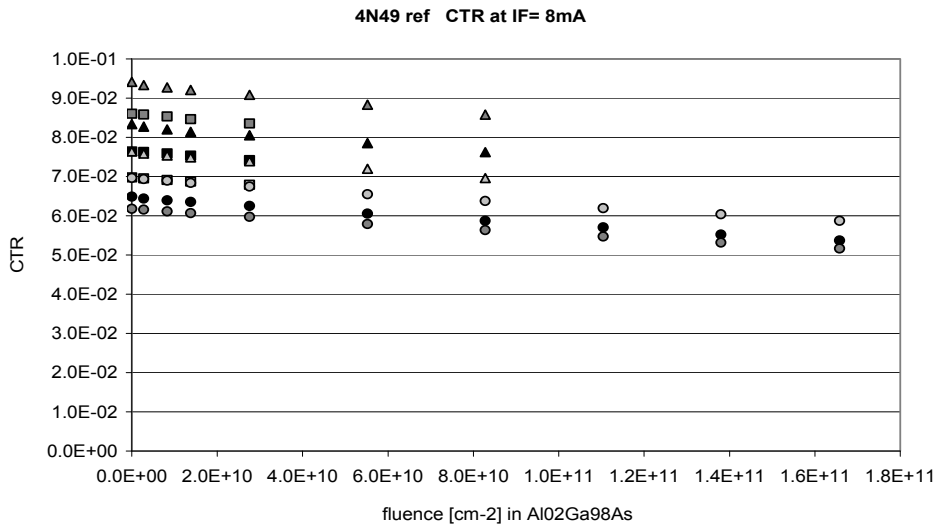

4N49 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

Fig. 12-115: 4N49 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 ref CTR at IF= 8mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

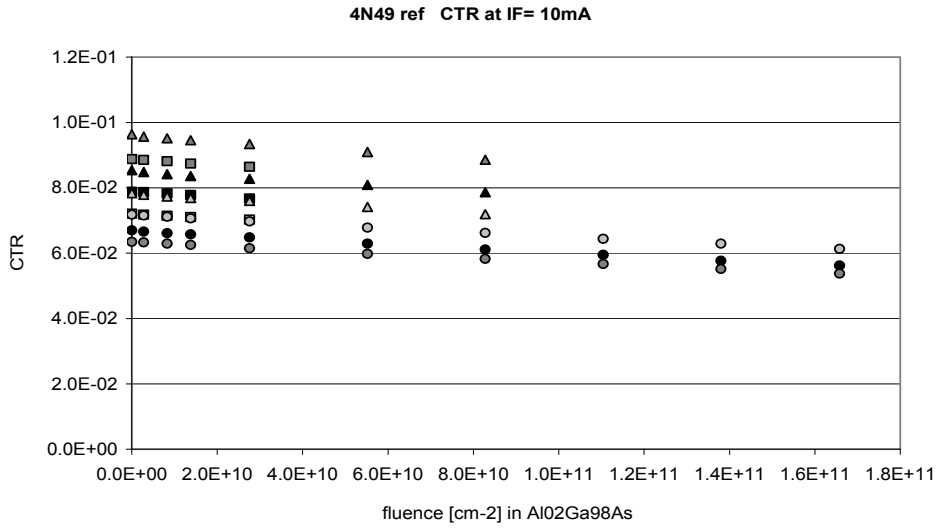
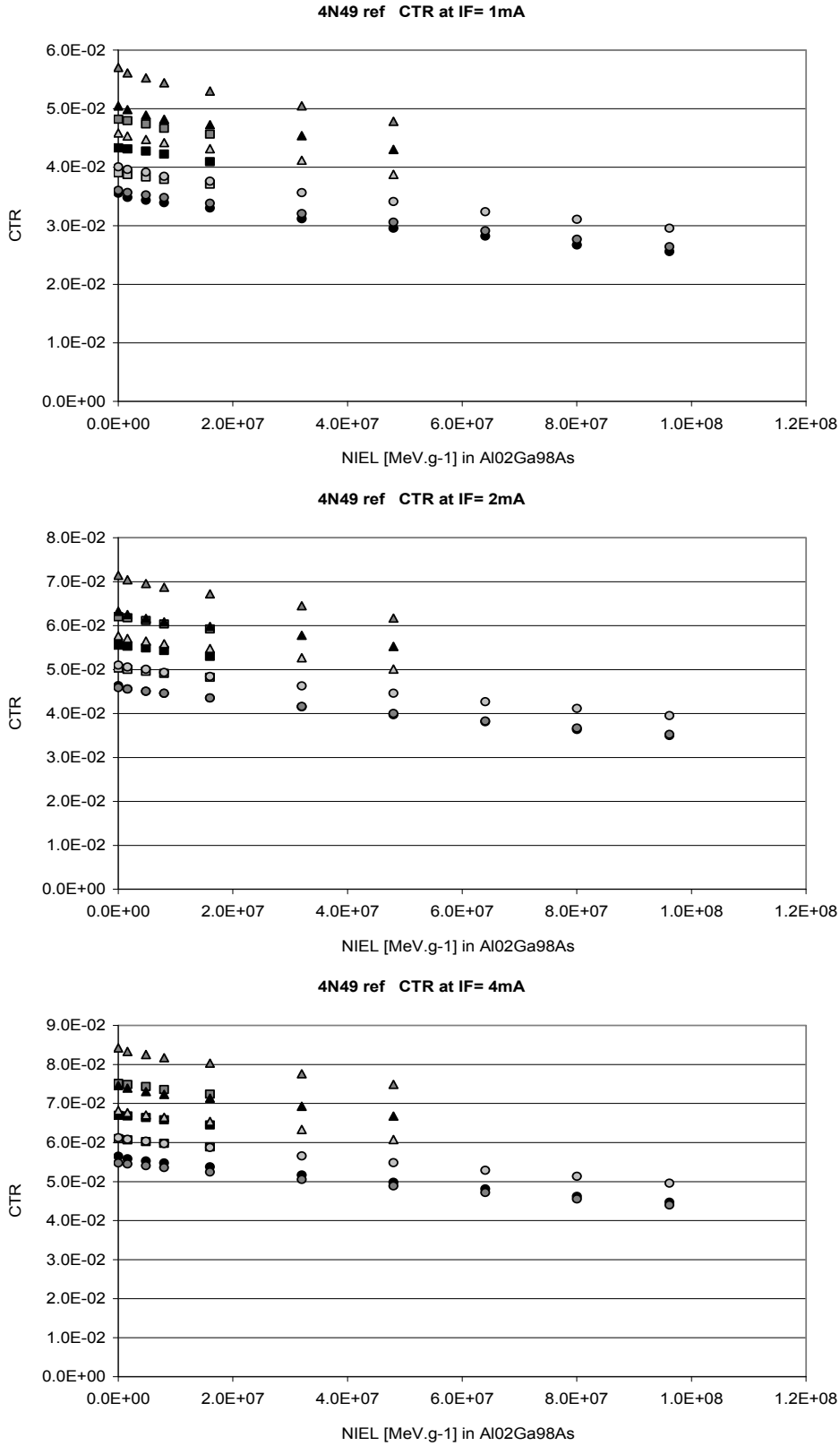
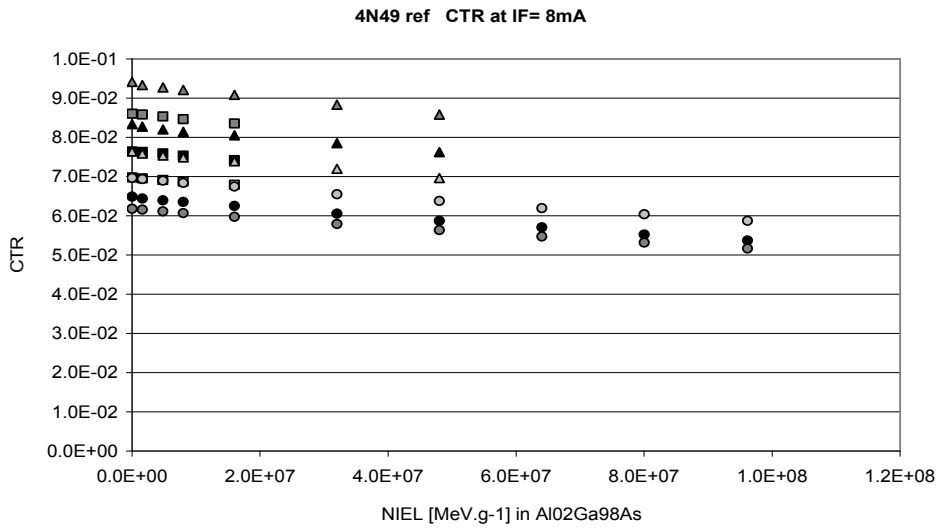

4N49 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-116: 4N49 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)




4N49 ref CTR at IF= 8mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

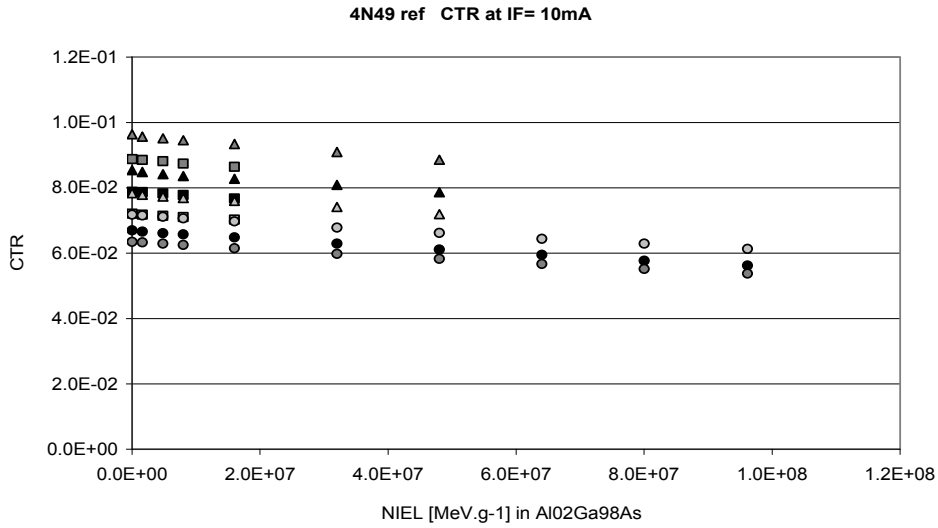
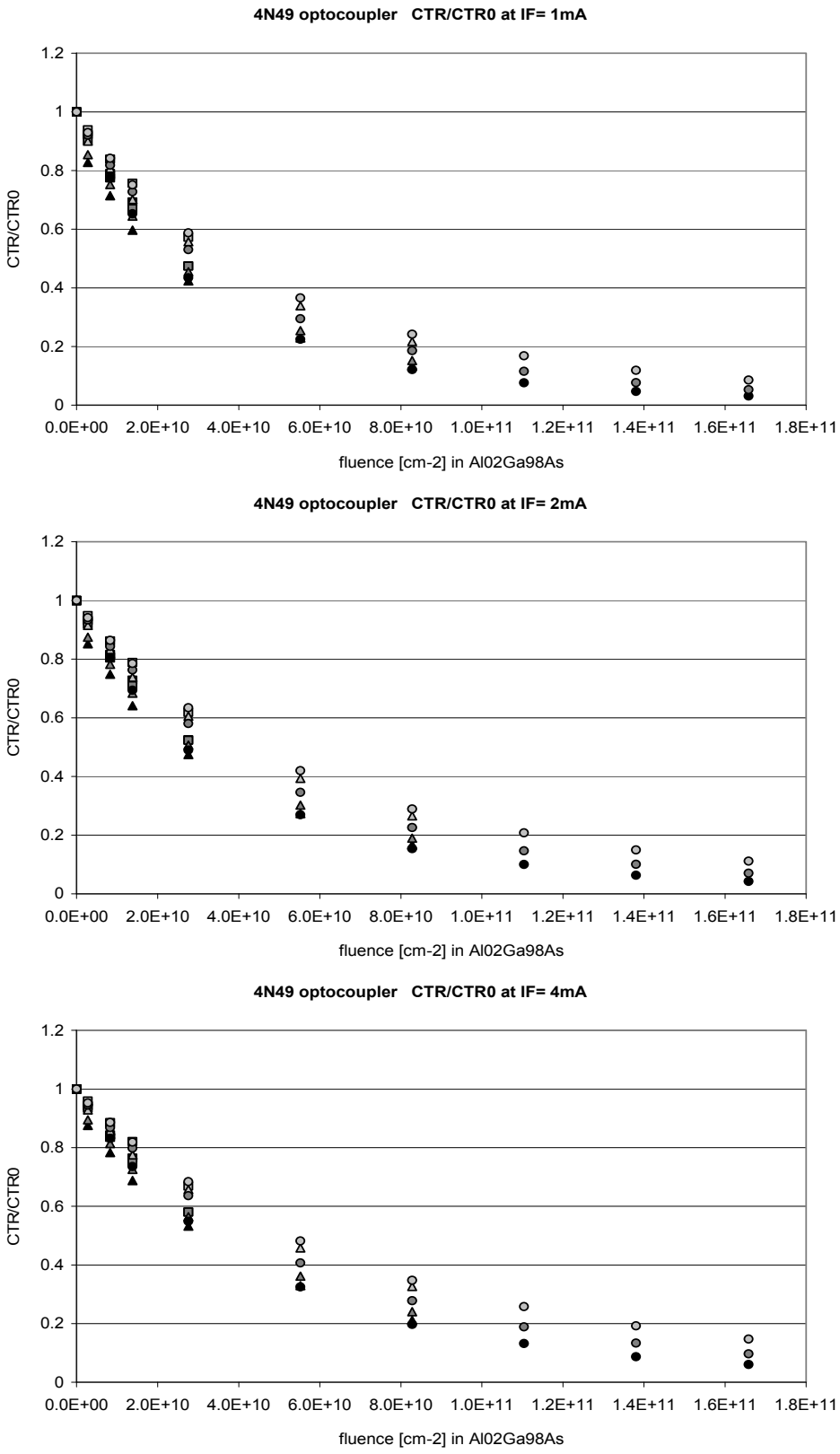
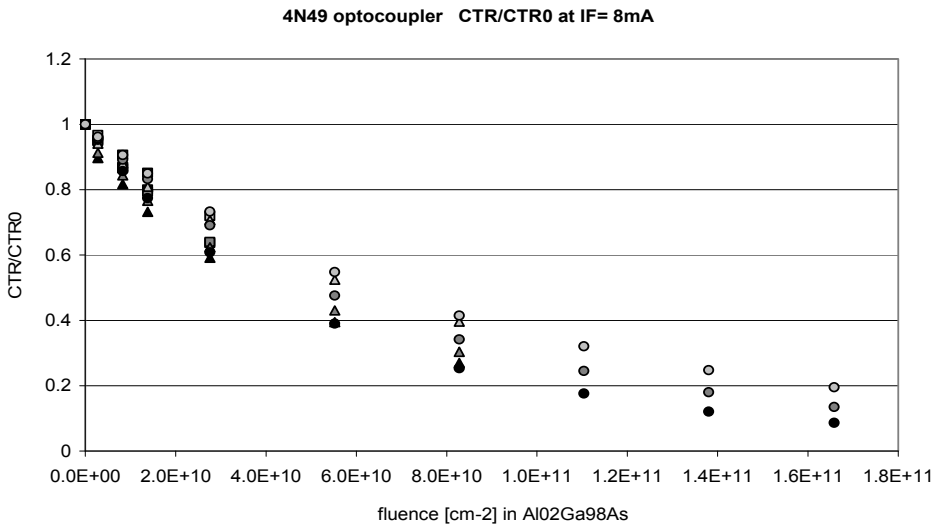

4N49 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-117: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

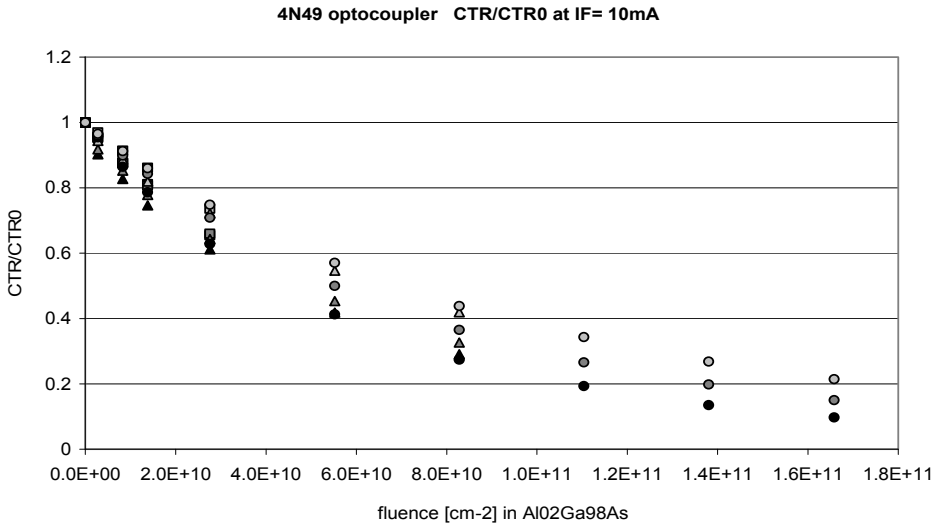
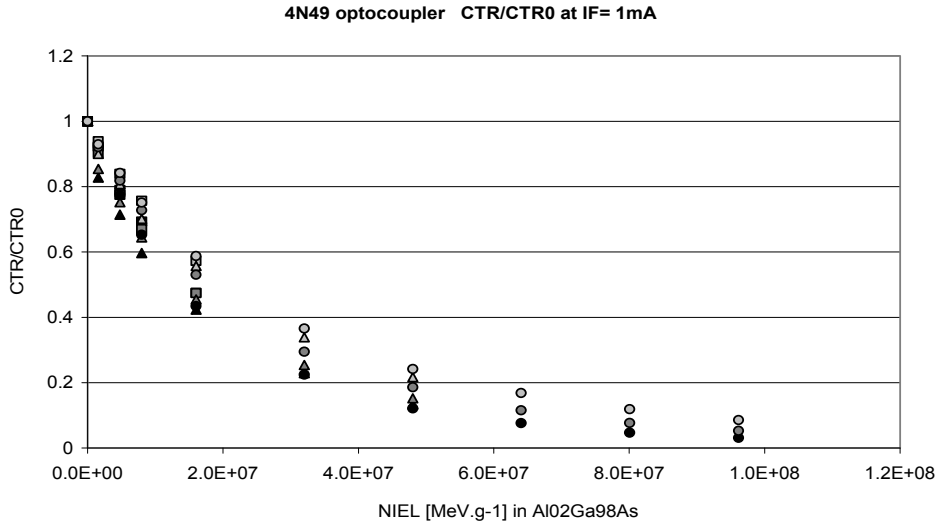
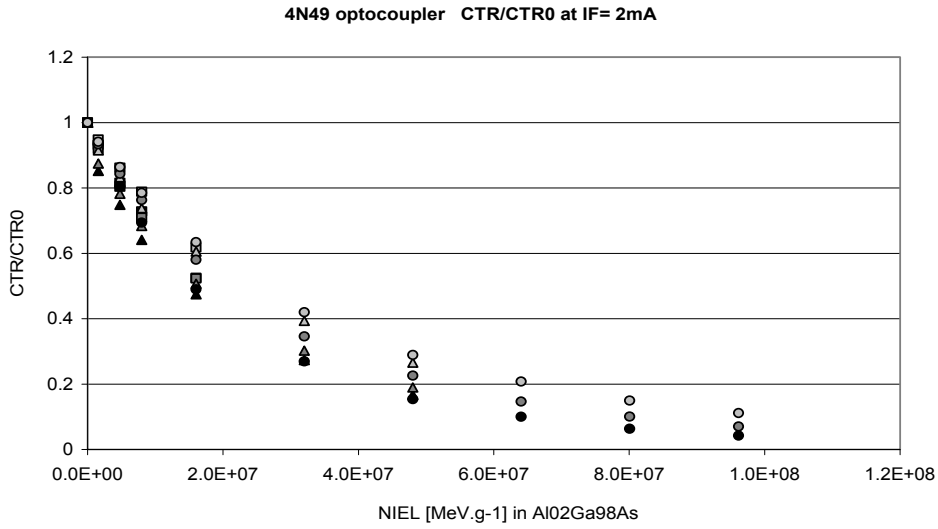
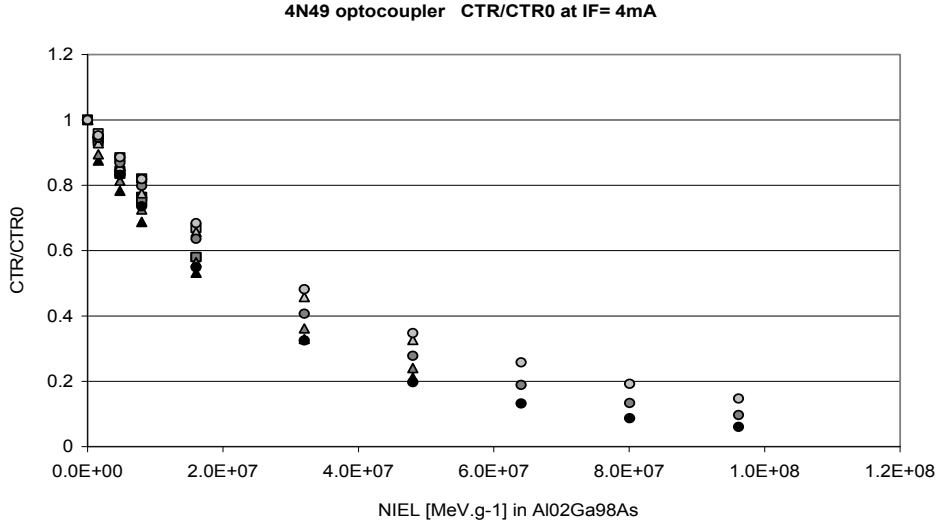
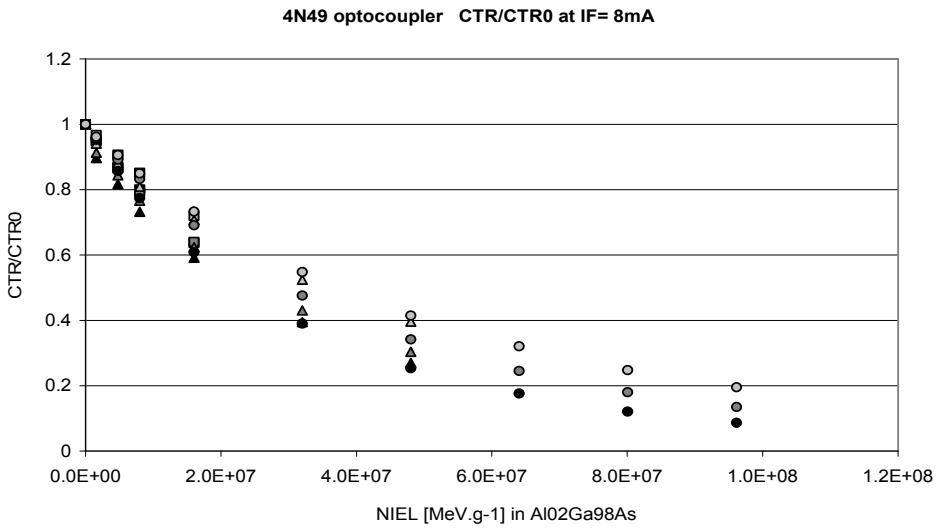

4N49 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-118: 4N49 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Al$_{0.02}$Ga$_{0.98}$As (GEANT4 TOTAL)








4N49 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

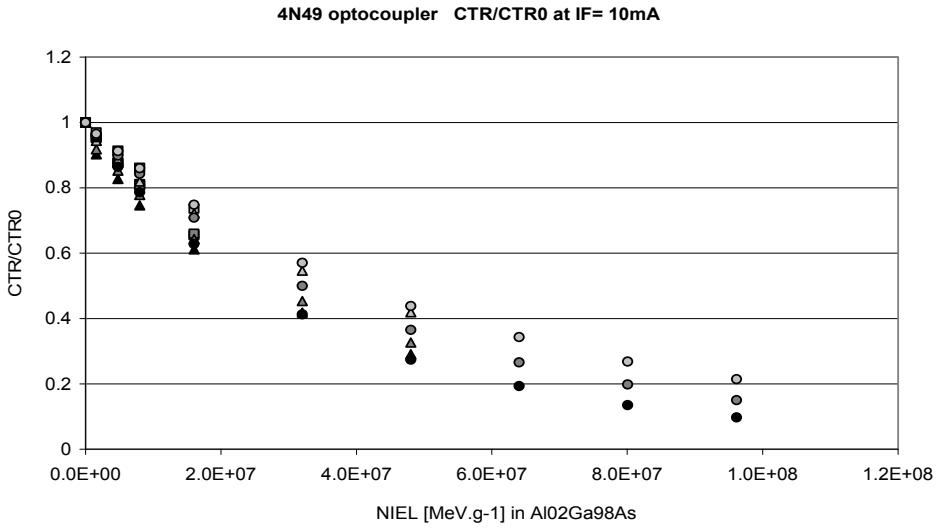
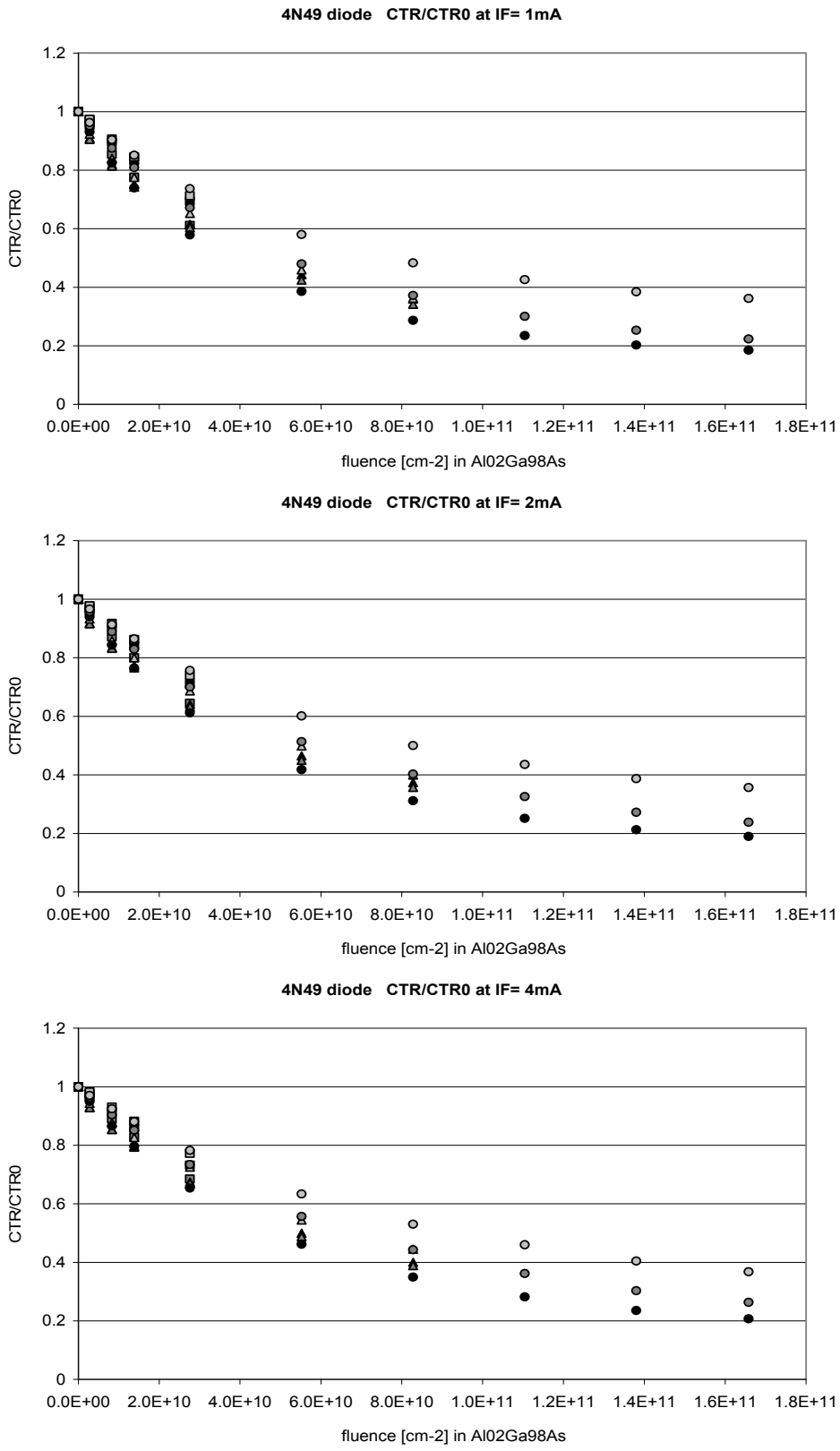
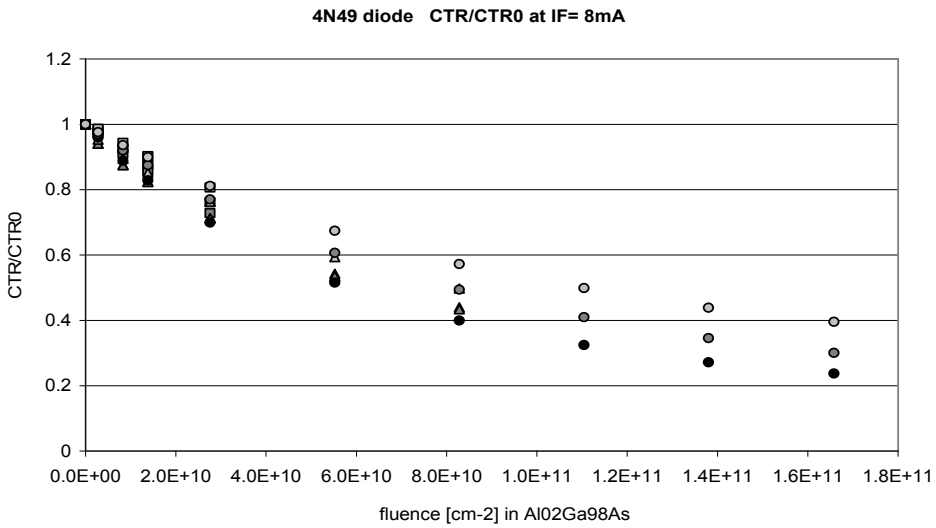

4N49 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-119: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

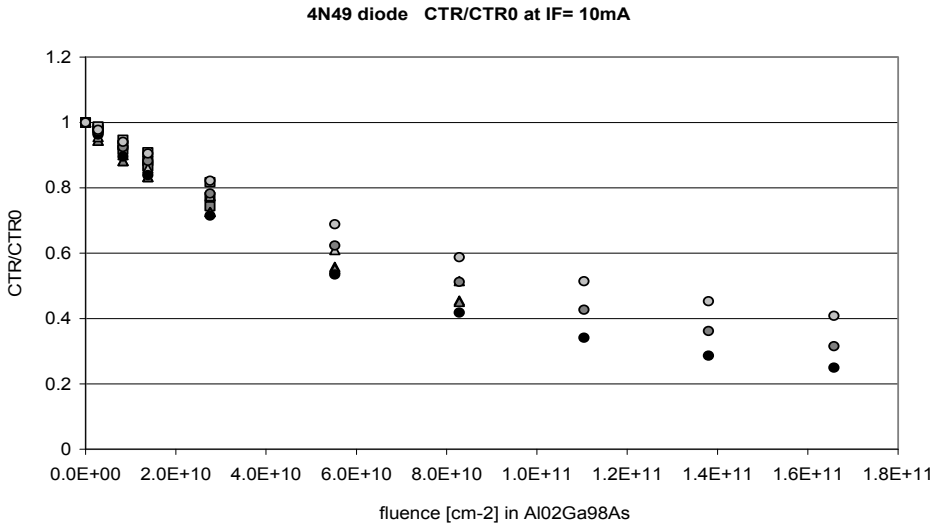
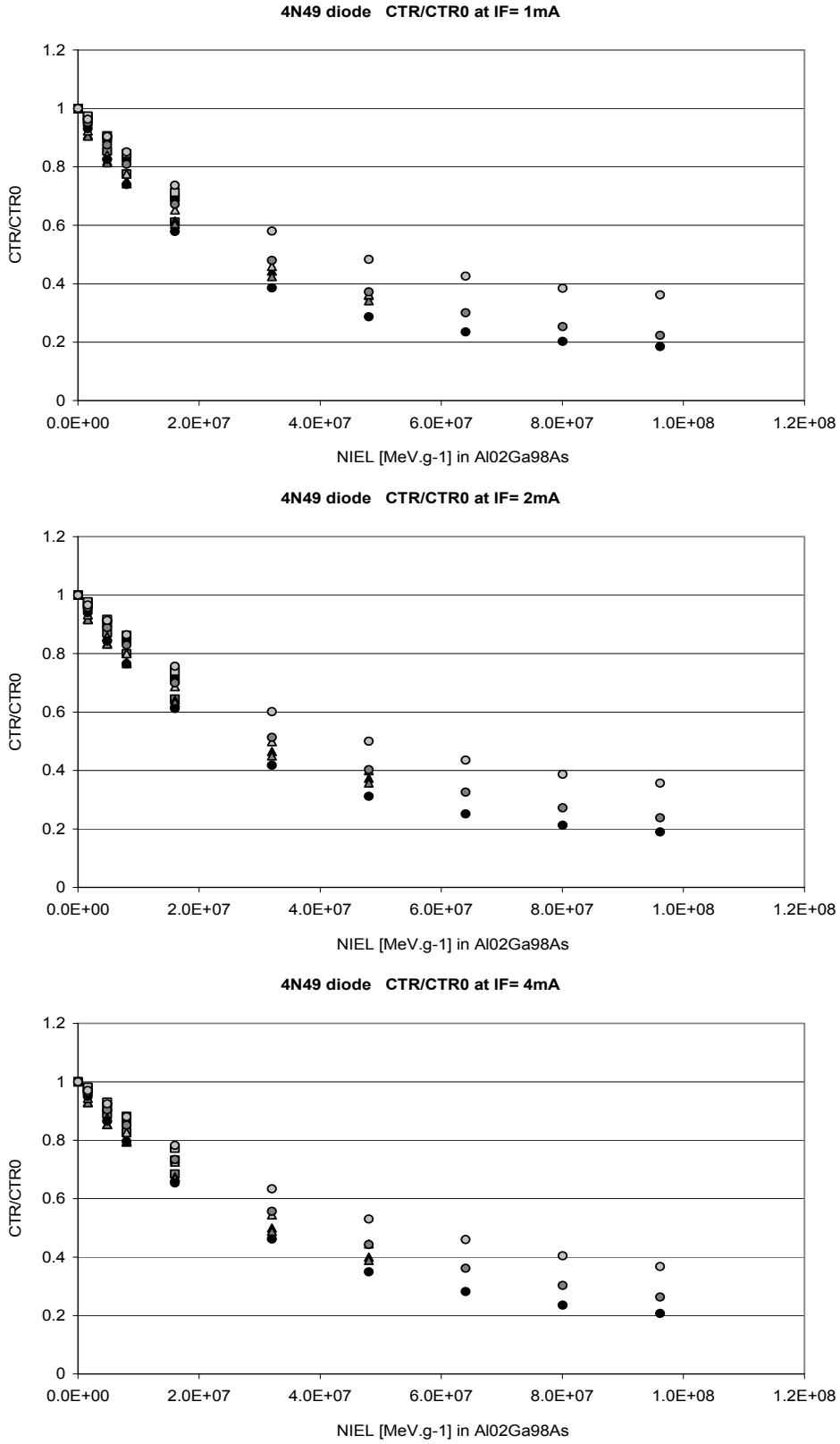
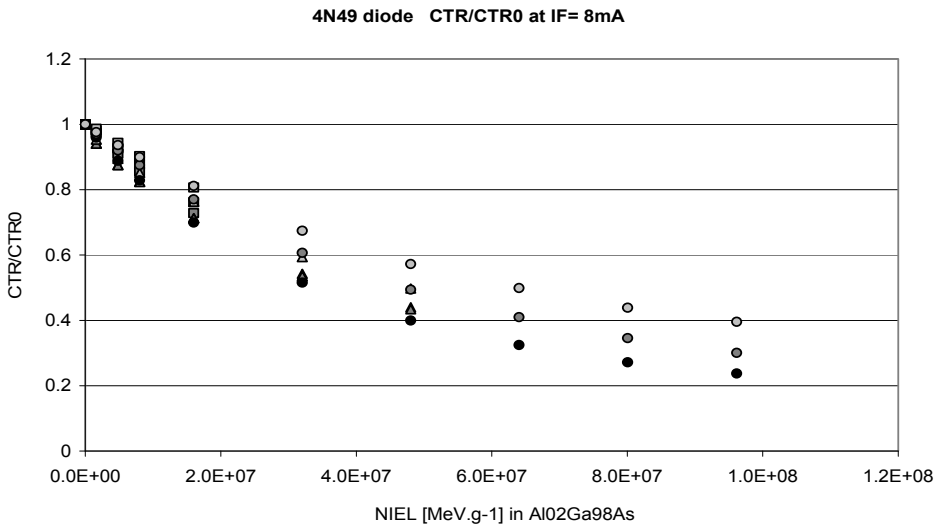

4N49 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-120: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Al$_{0.02}$Ga$_{0.98}$As (GEANT4 TOTAL)




4N49 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

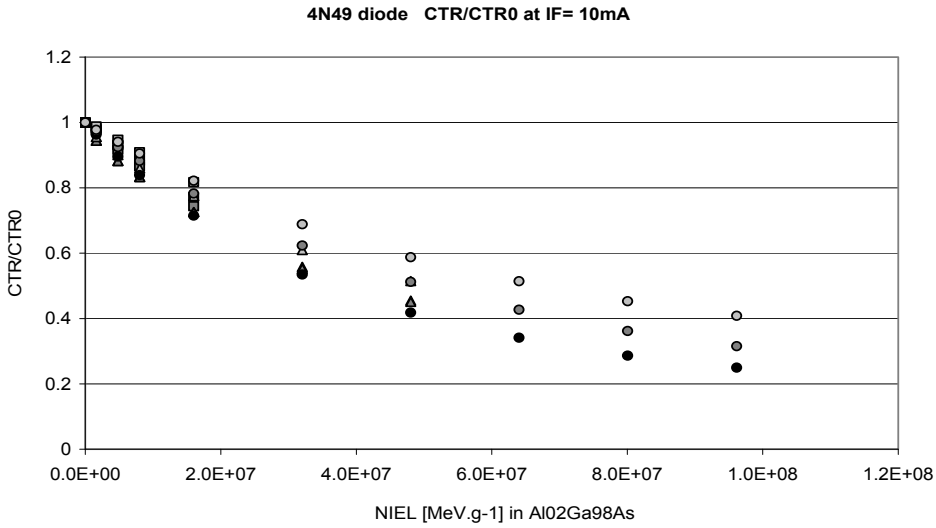
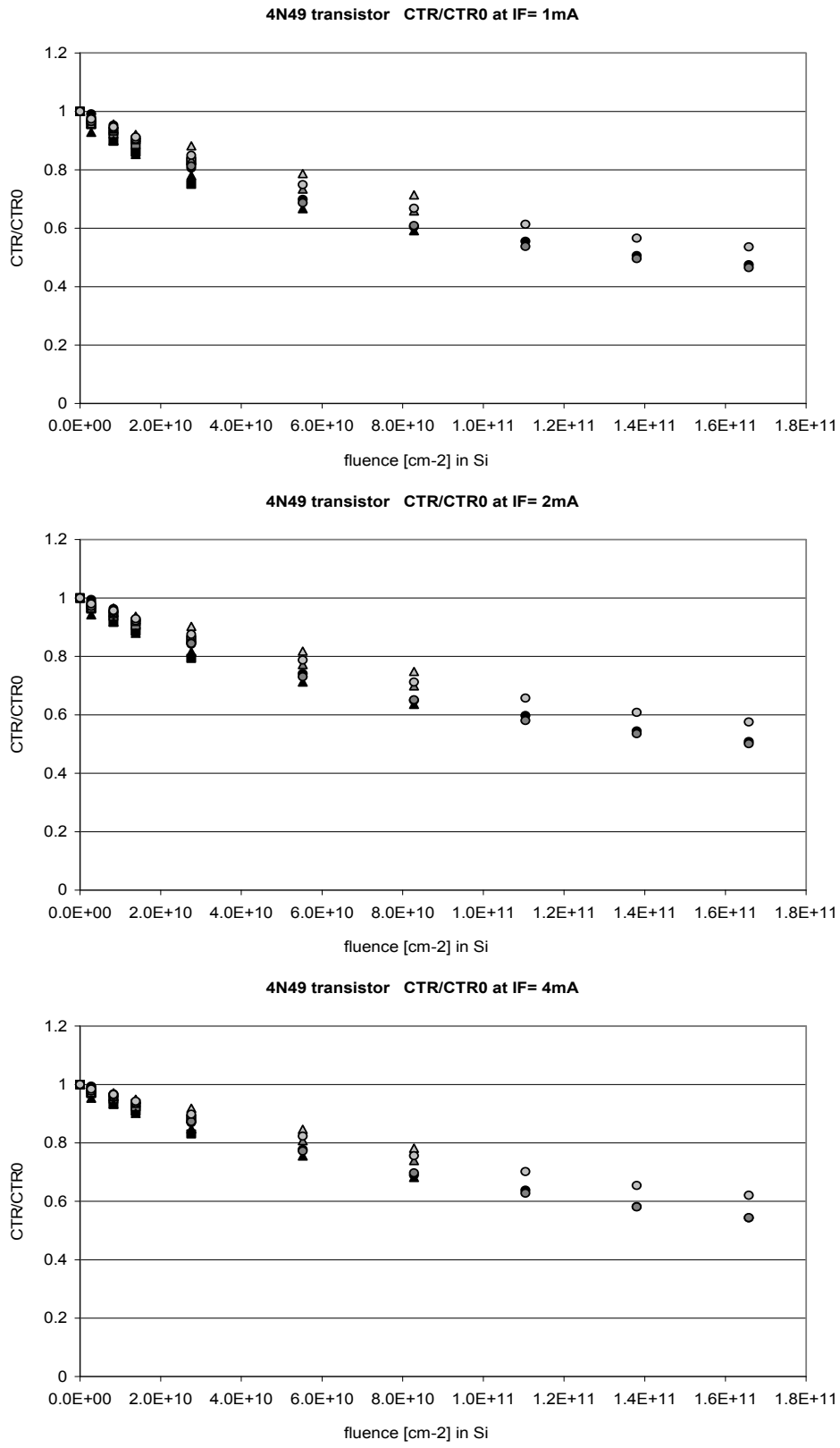
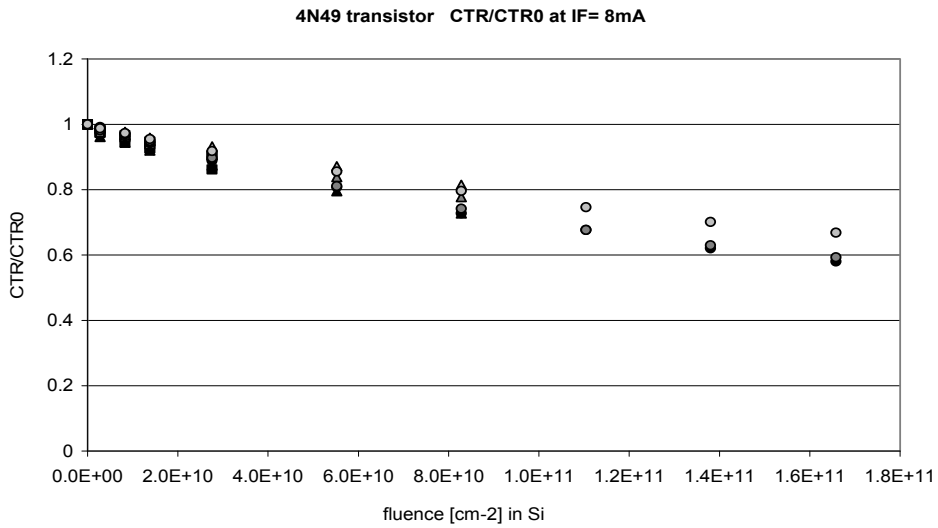

4N49 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-121: 4N49 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

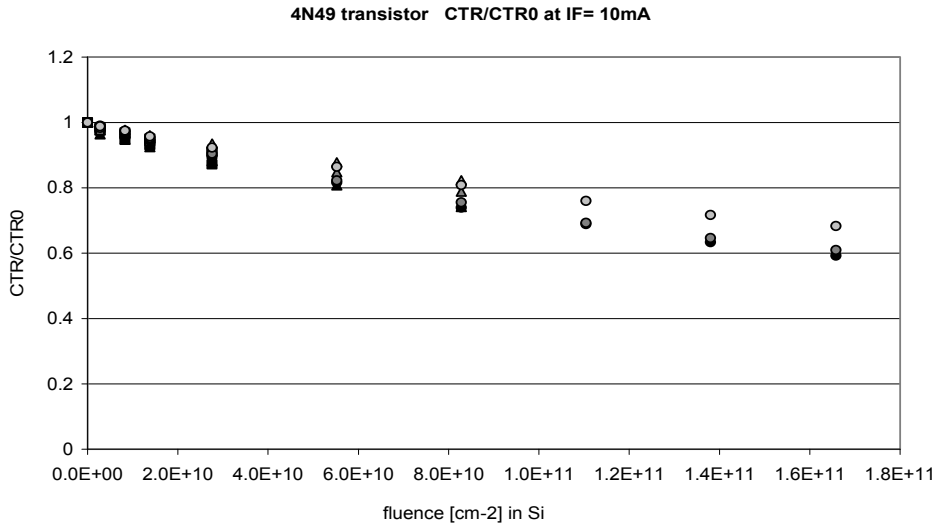
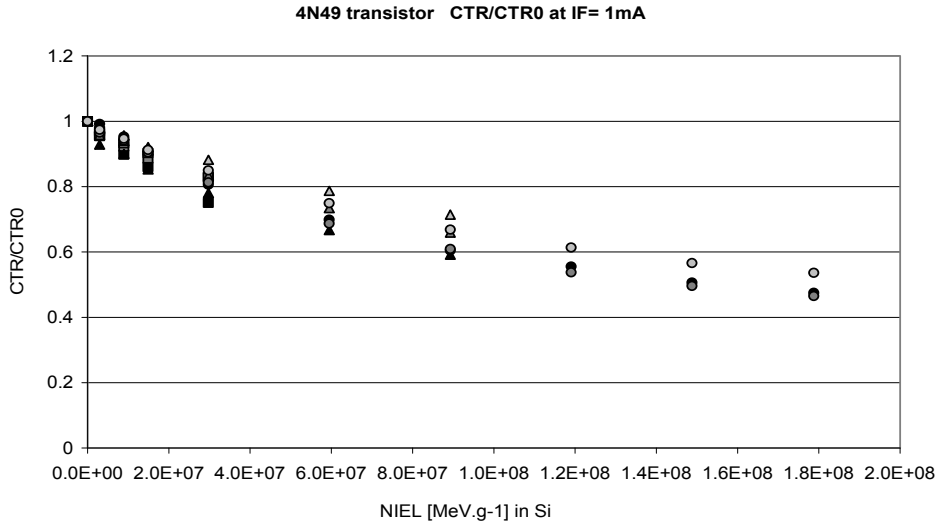
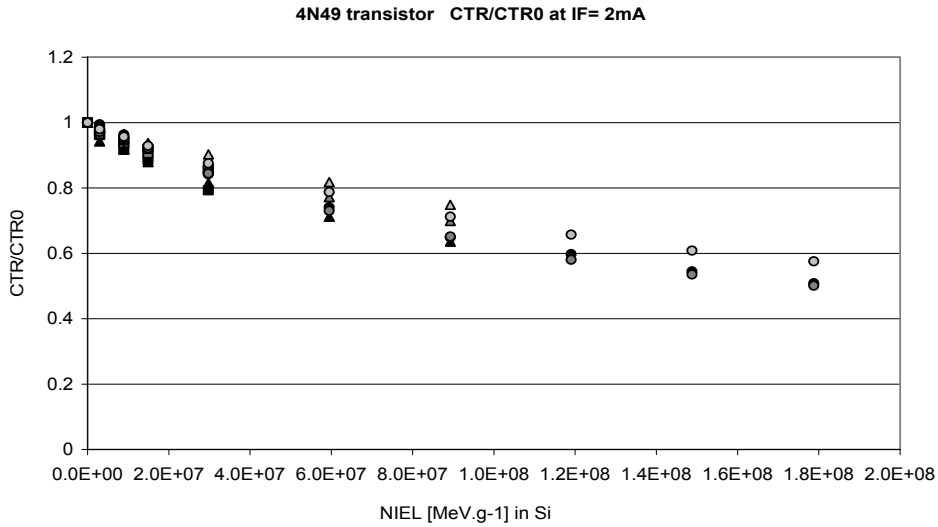
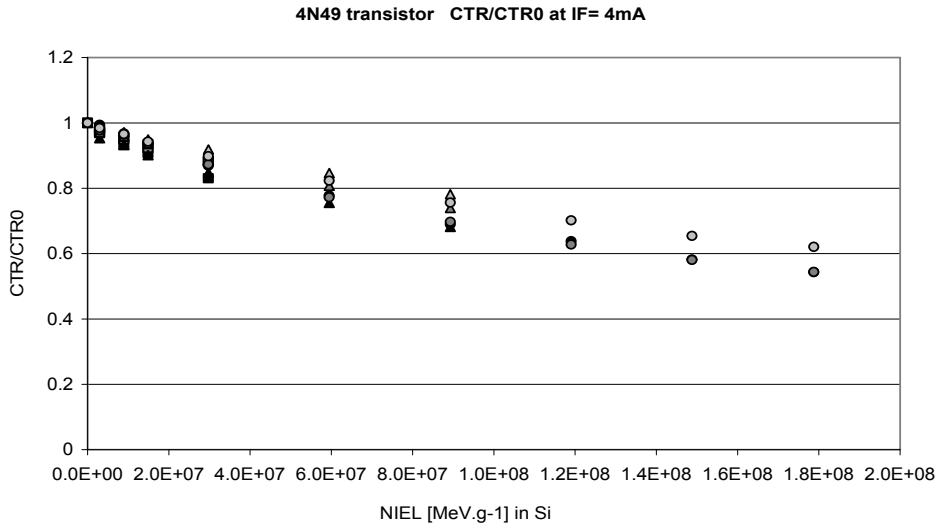
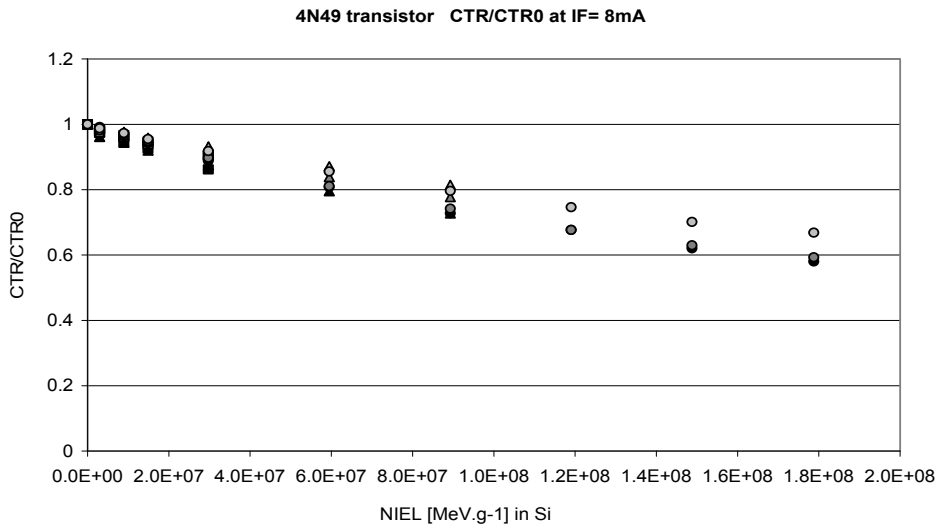

4N49 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 12-122: 4N49 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








4N49 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

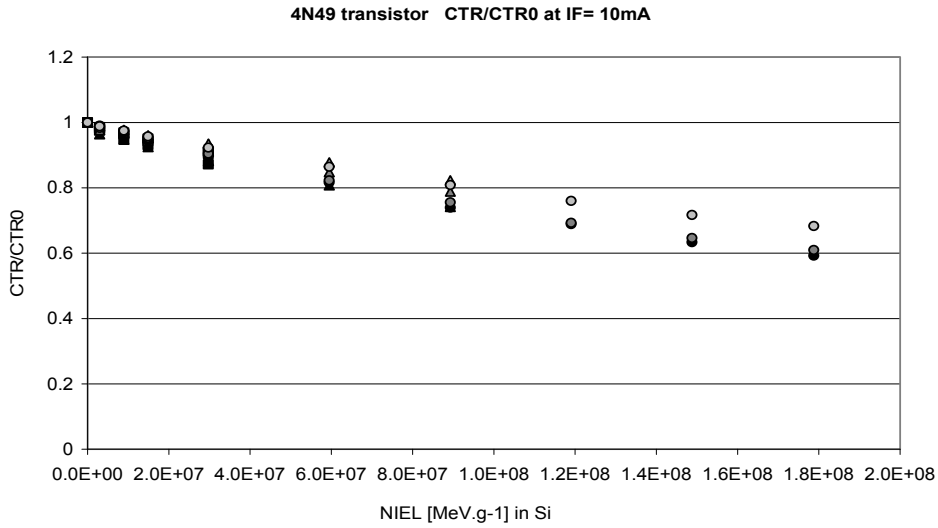
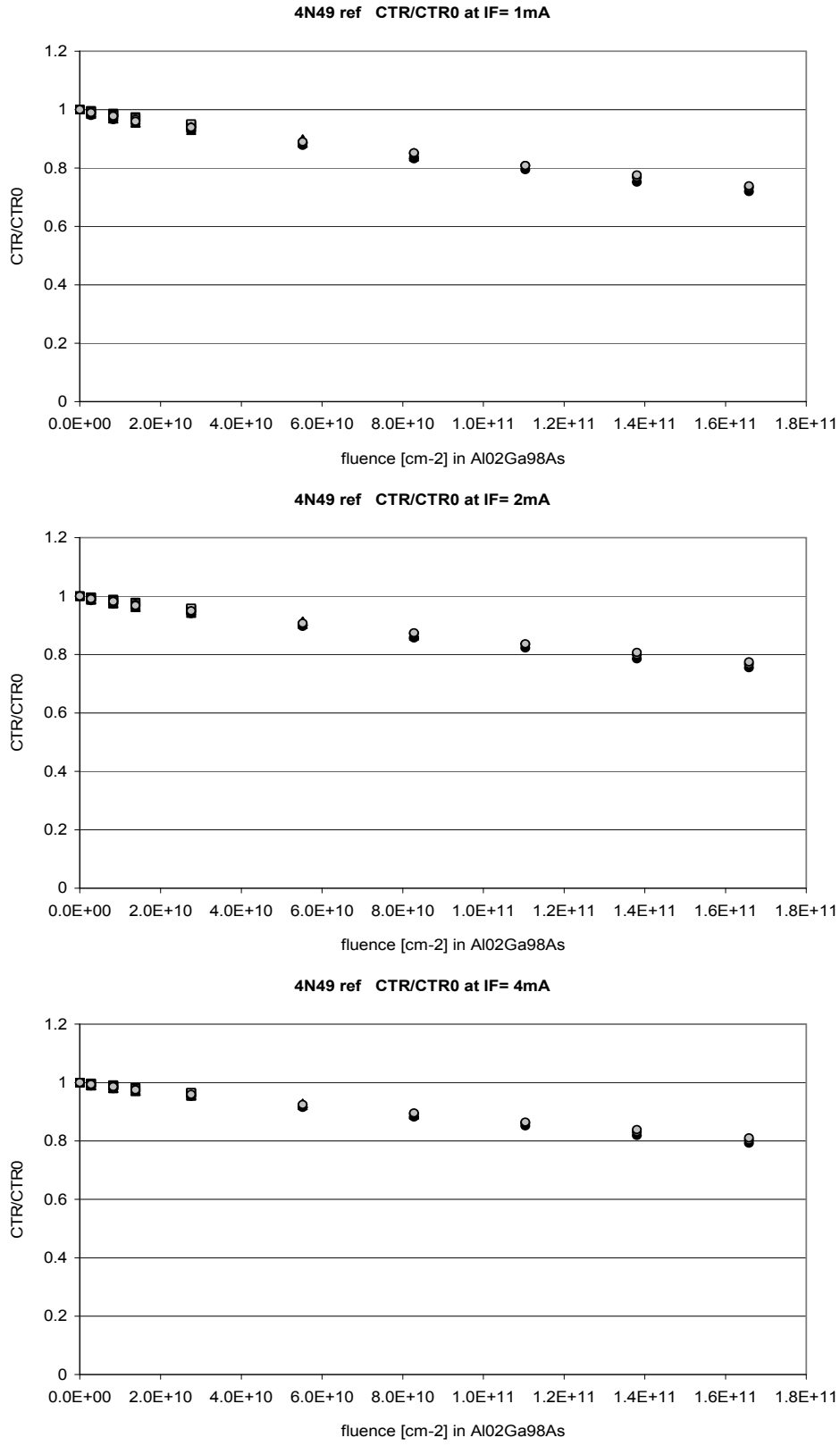
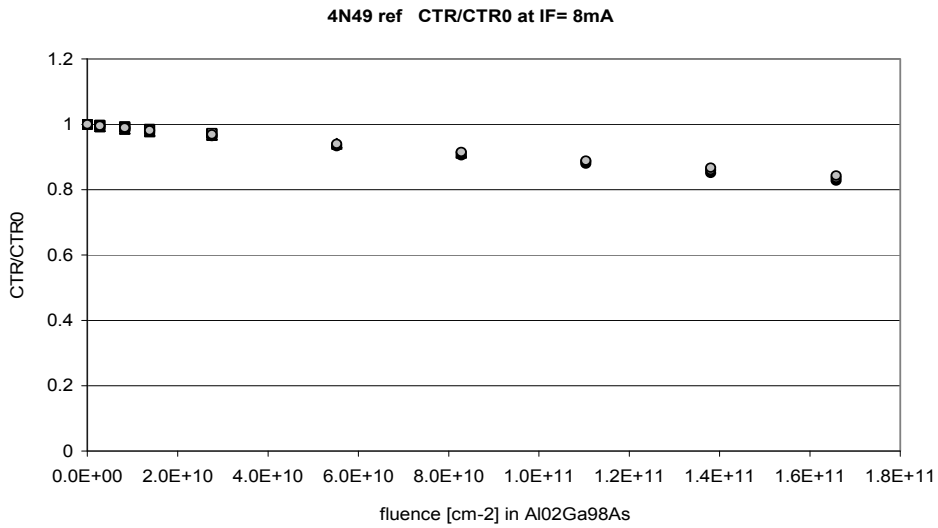

4N49 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

Fig. 12-123: 4N49 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

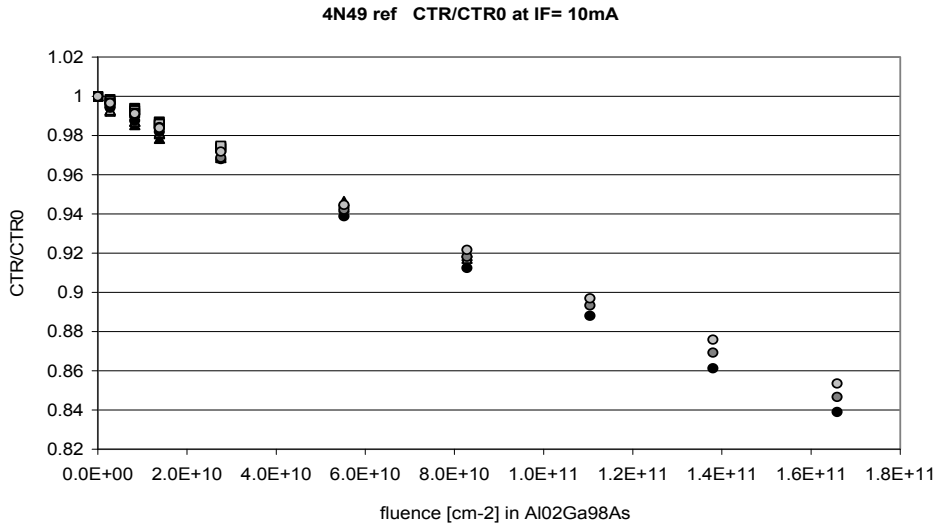
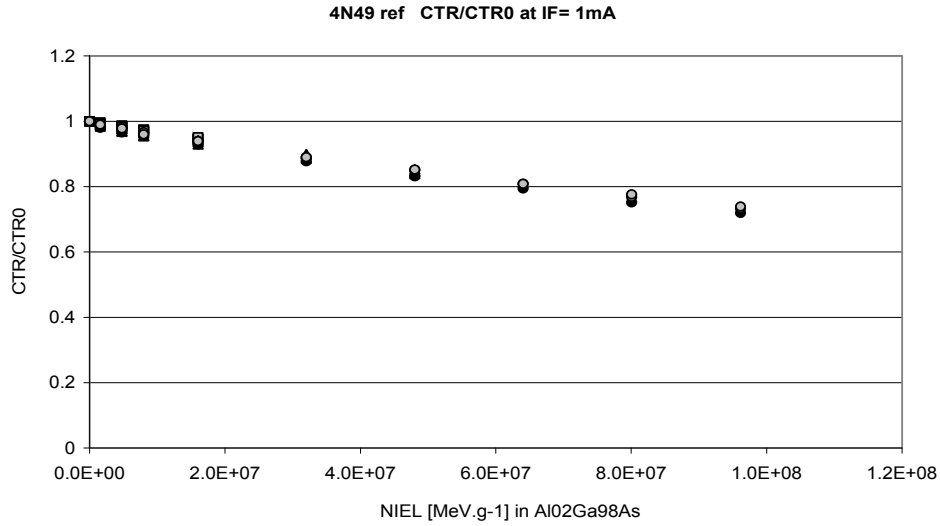
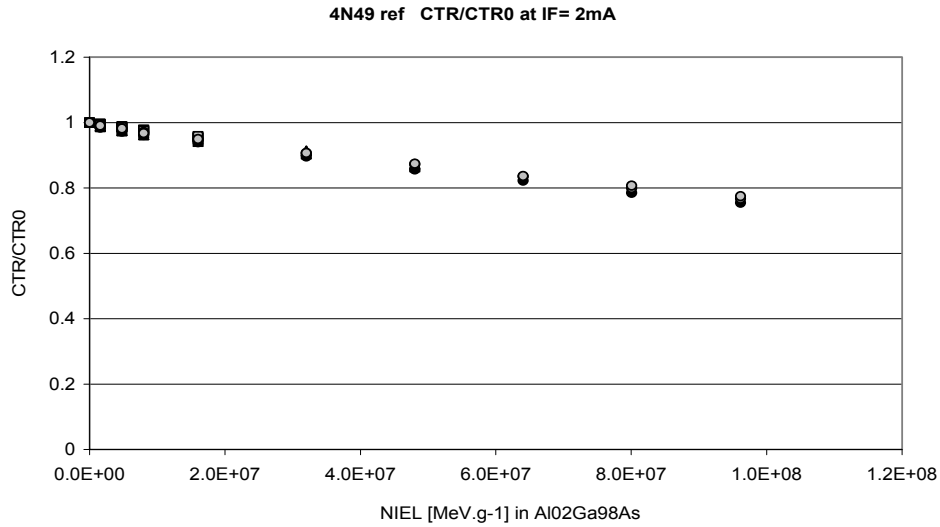
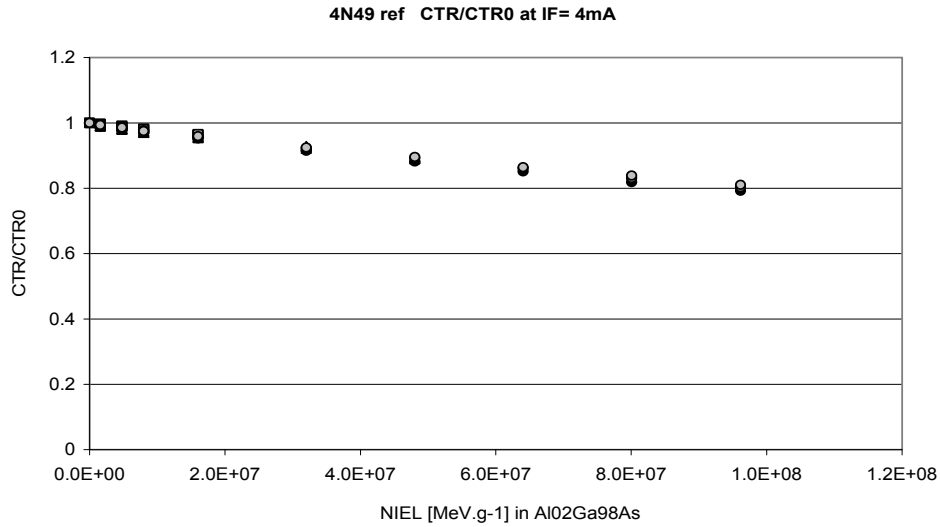
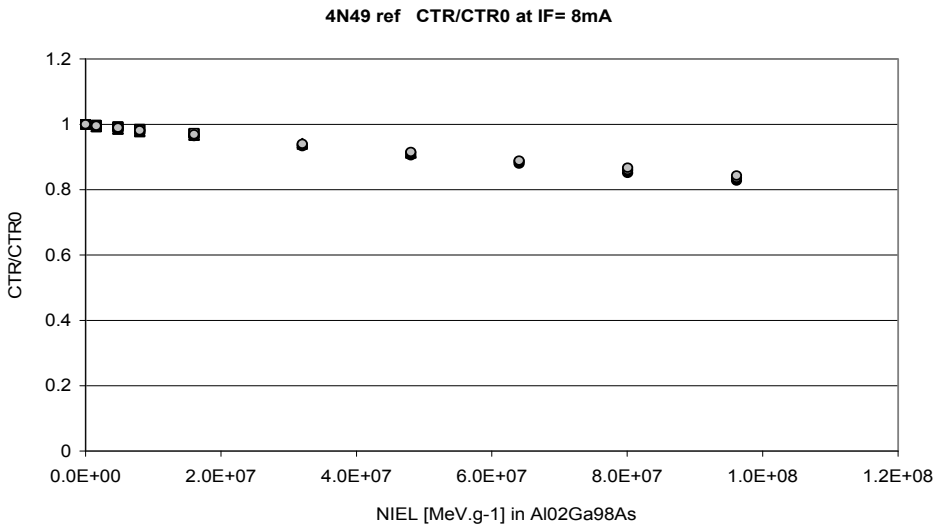

4N49 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-124: 4N49 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)








4N49 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

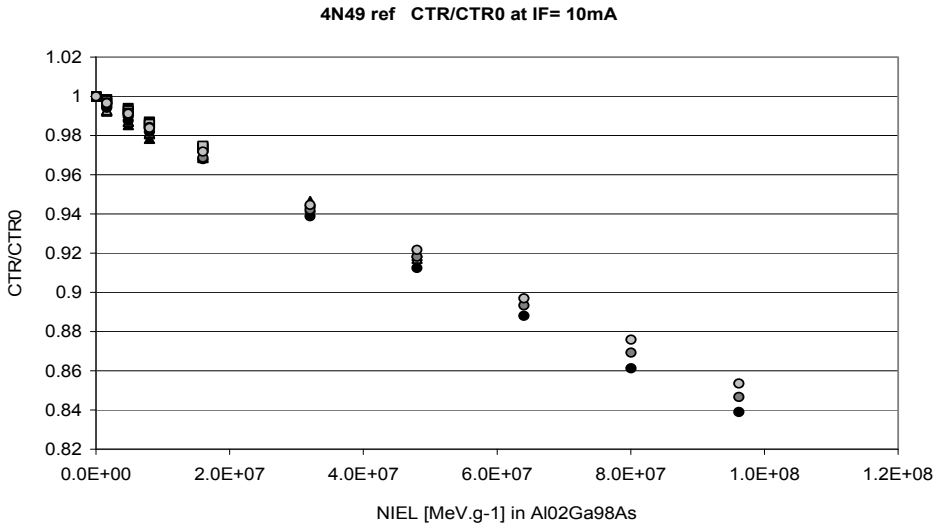
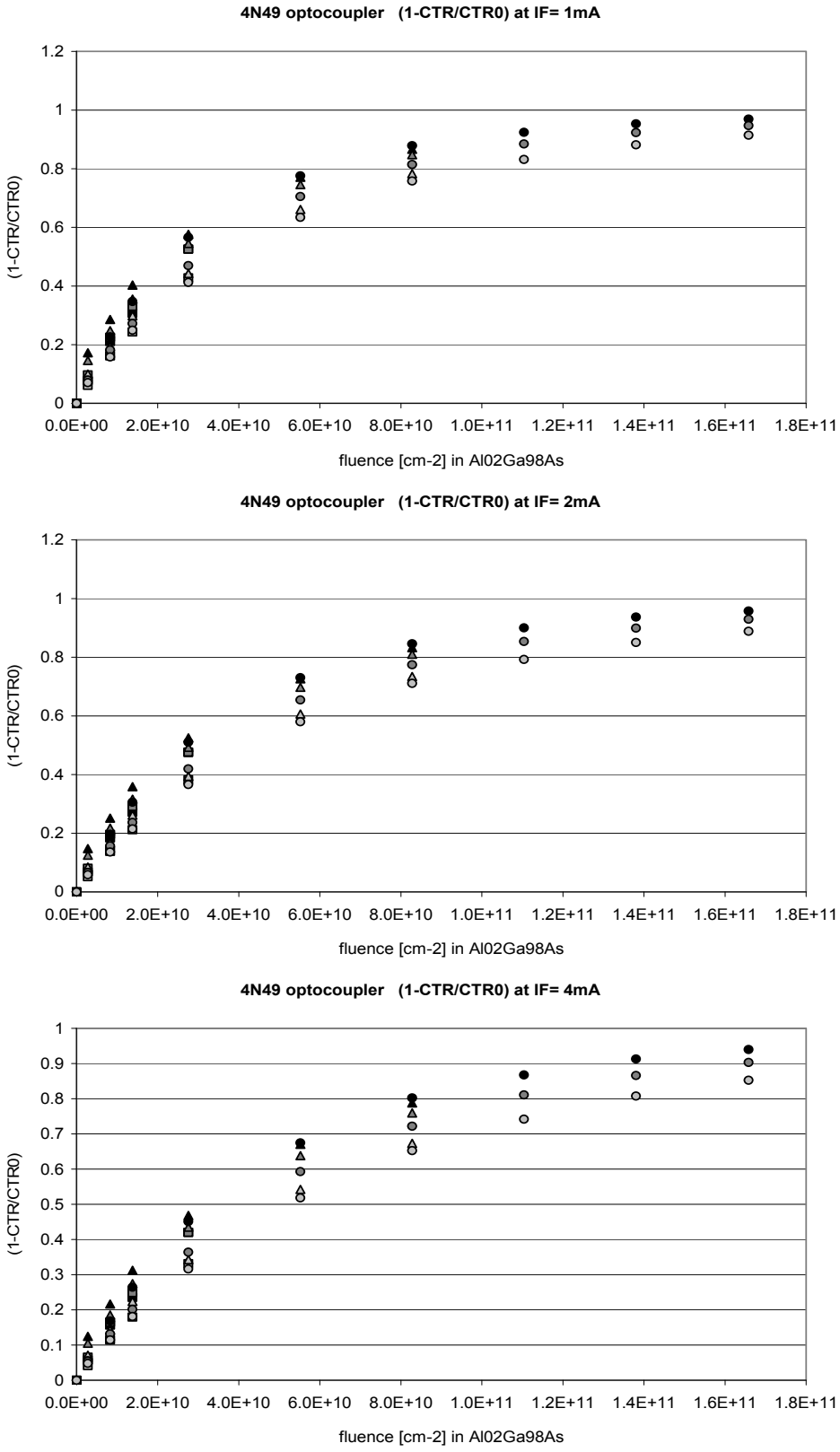
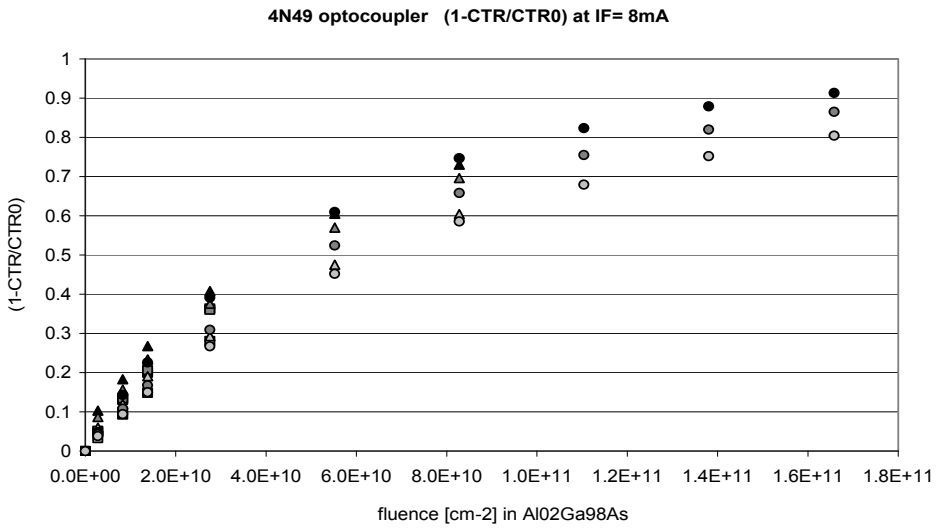

4N49 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-125: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

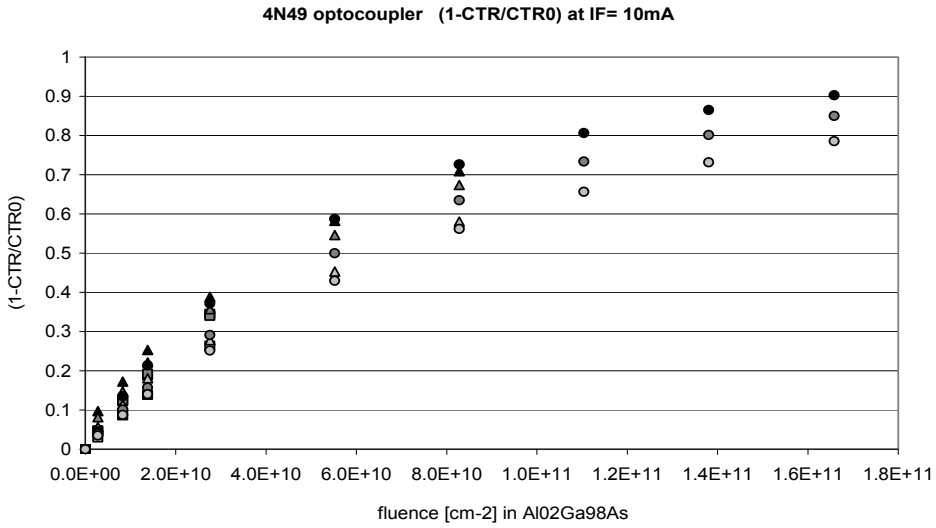
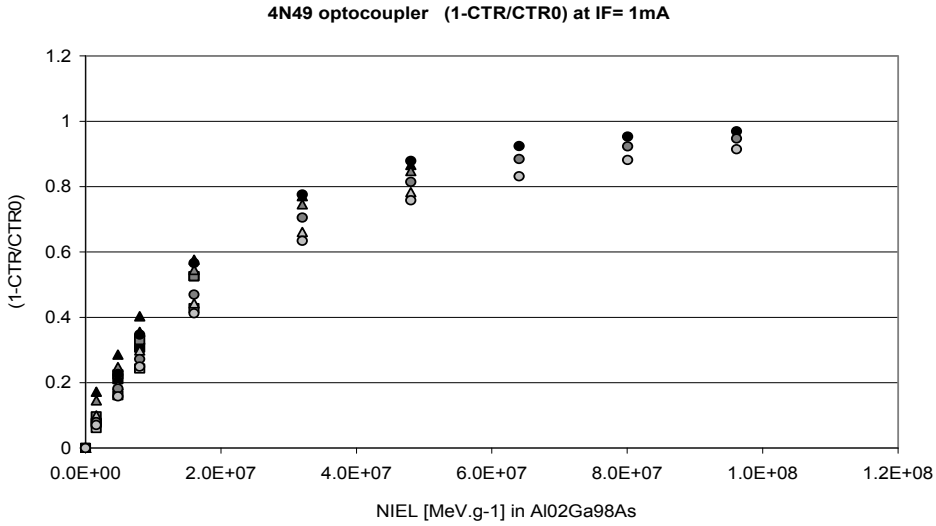
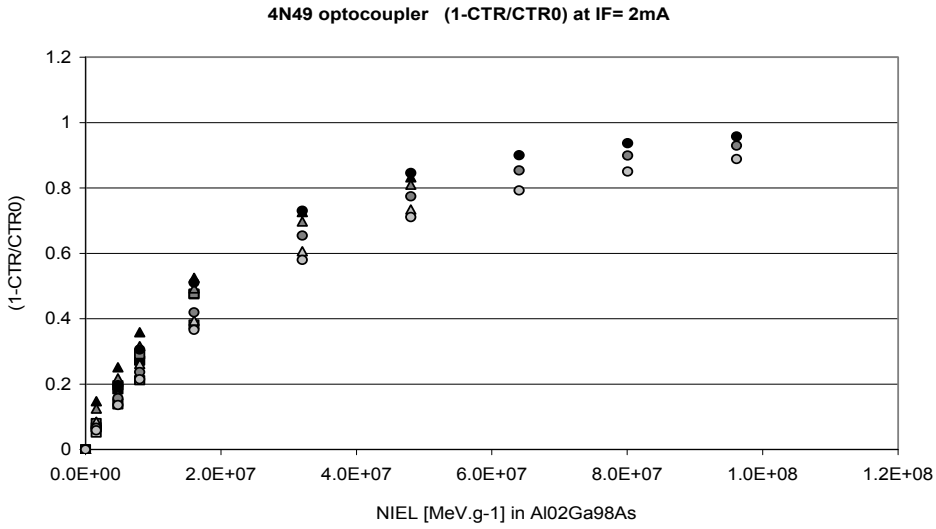
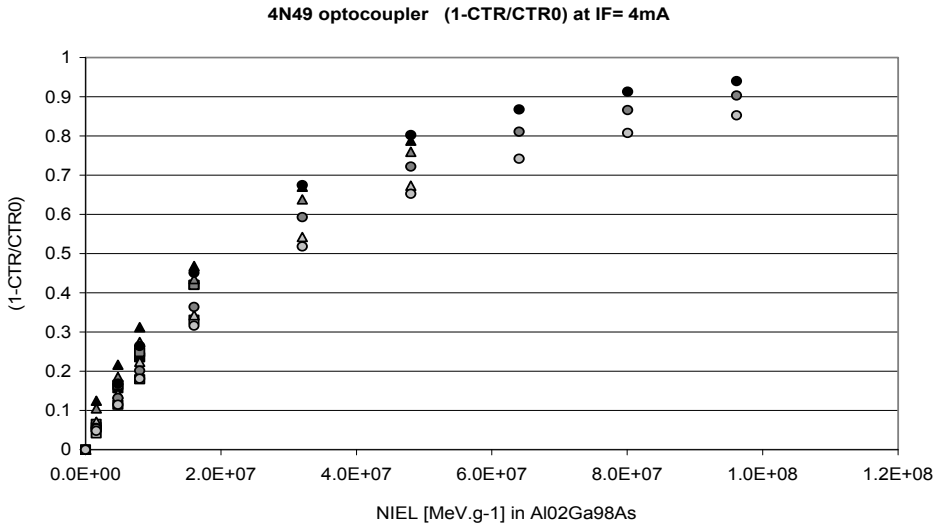
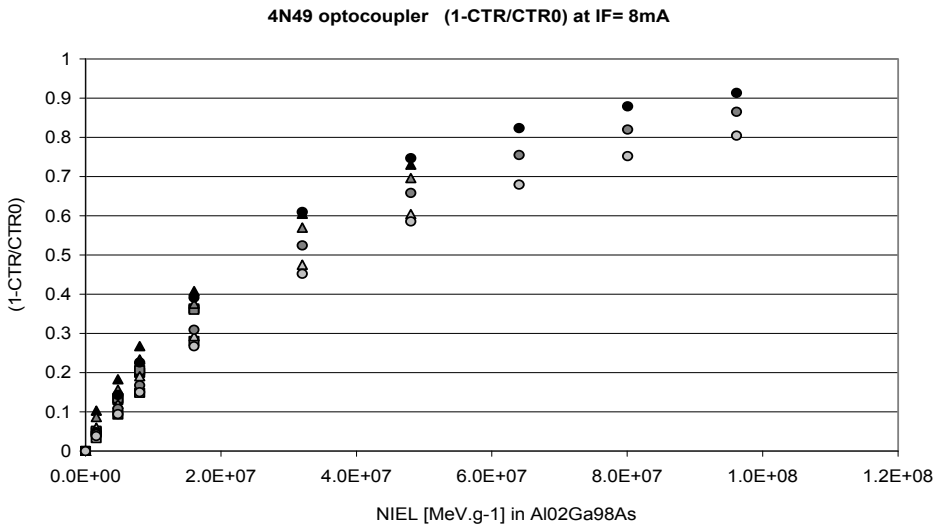

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-126: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

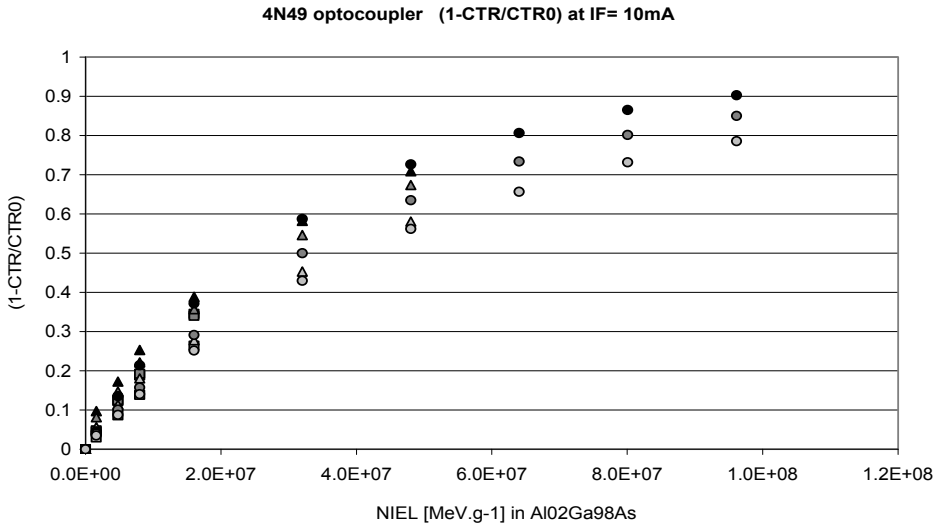
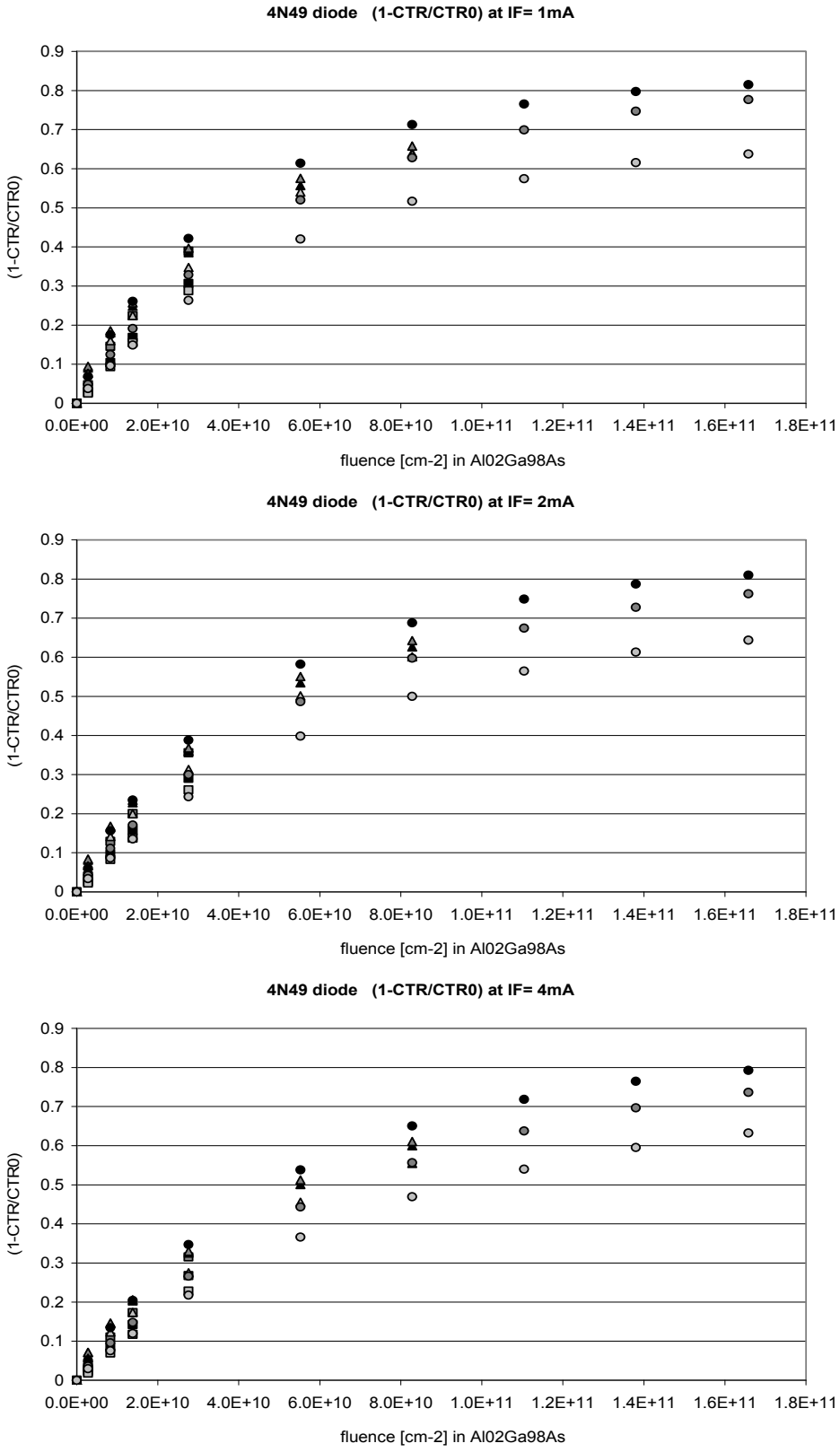
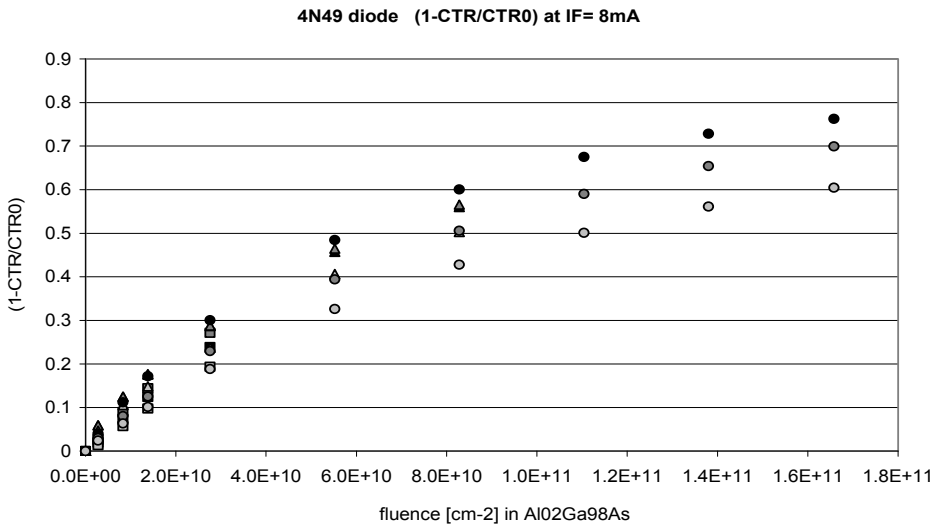

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-127: 4N49 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

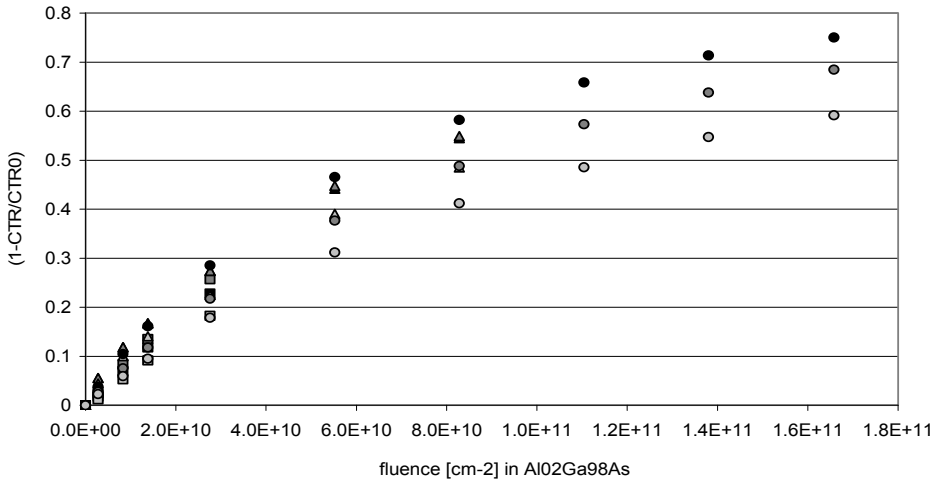
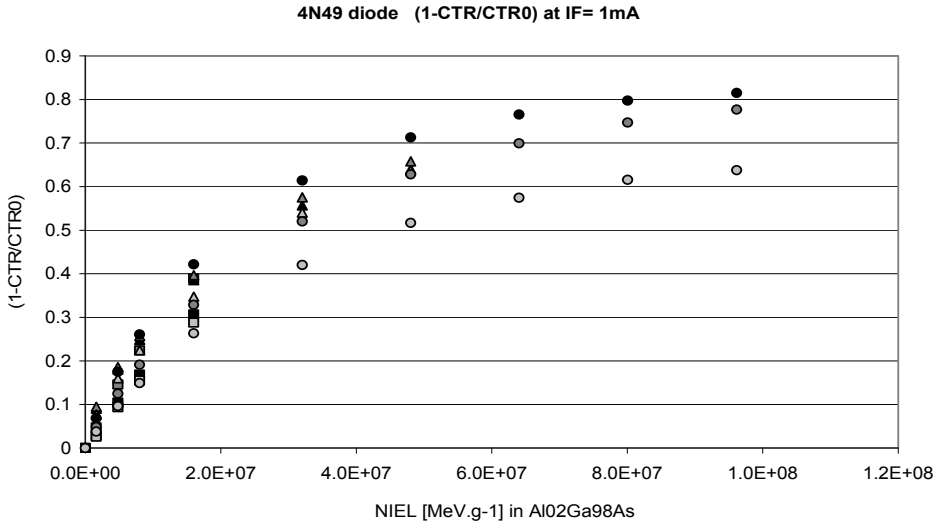
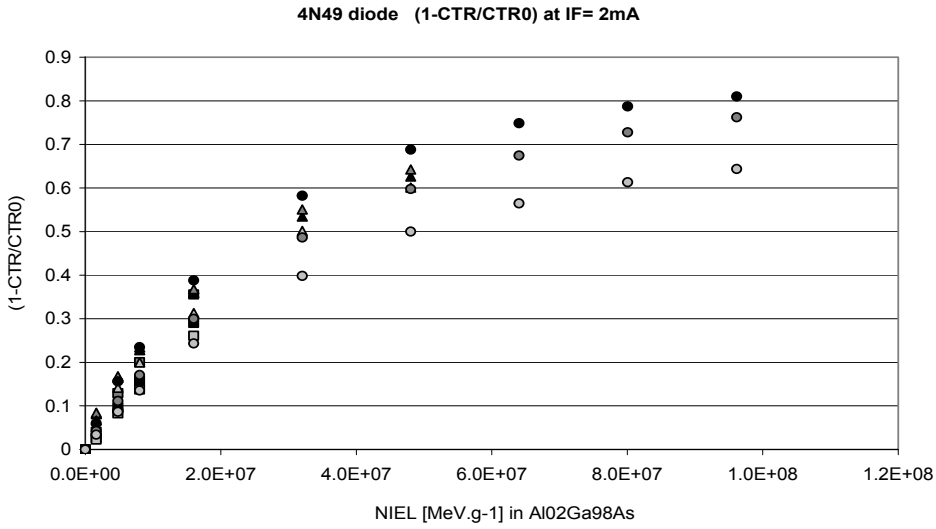
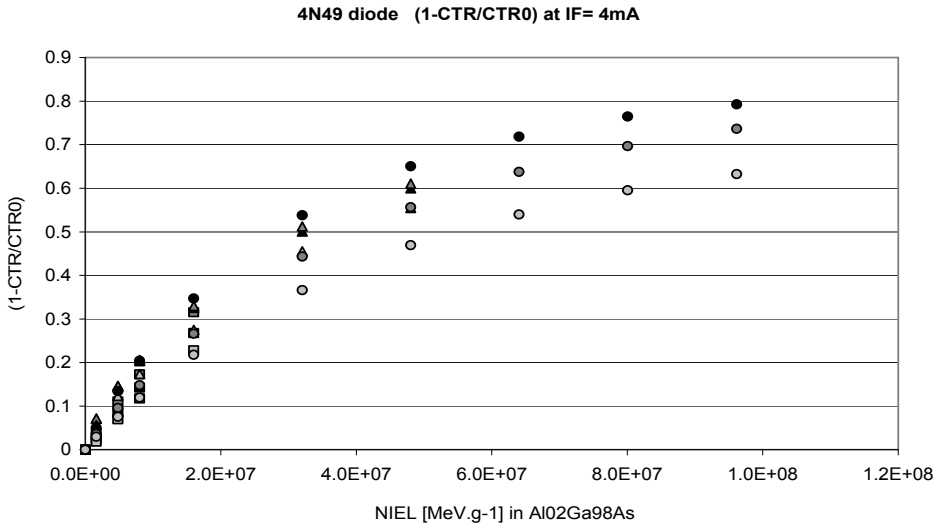
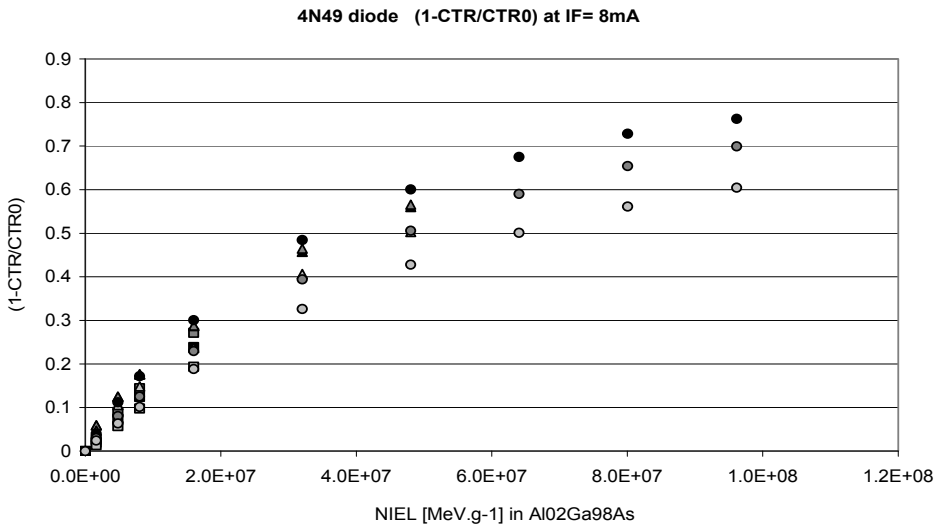

4N49 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-128: 4N49 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)








4N49 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

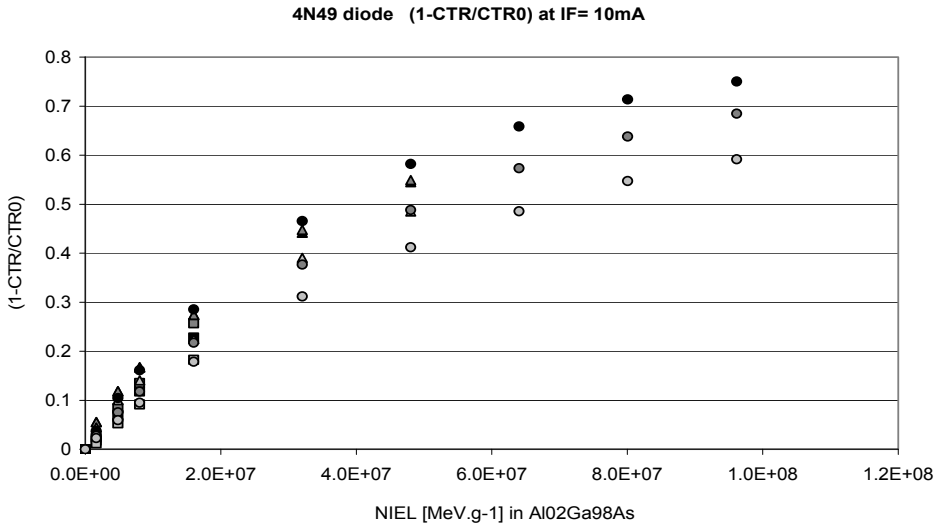
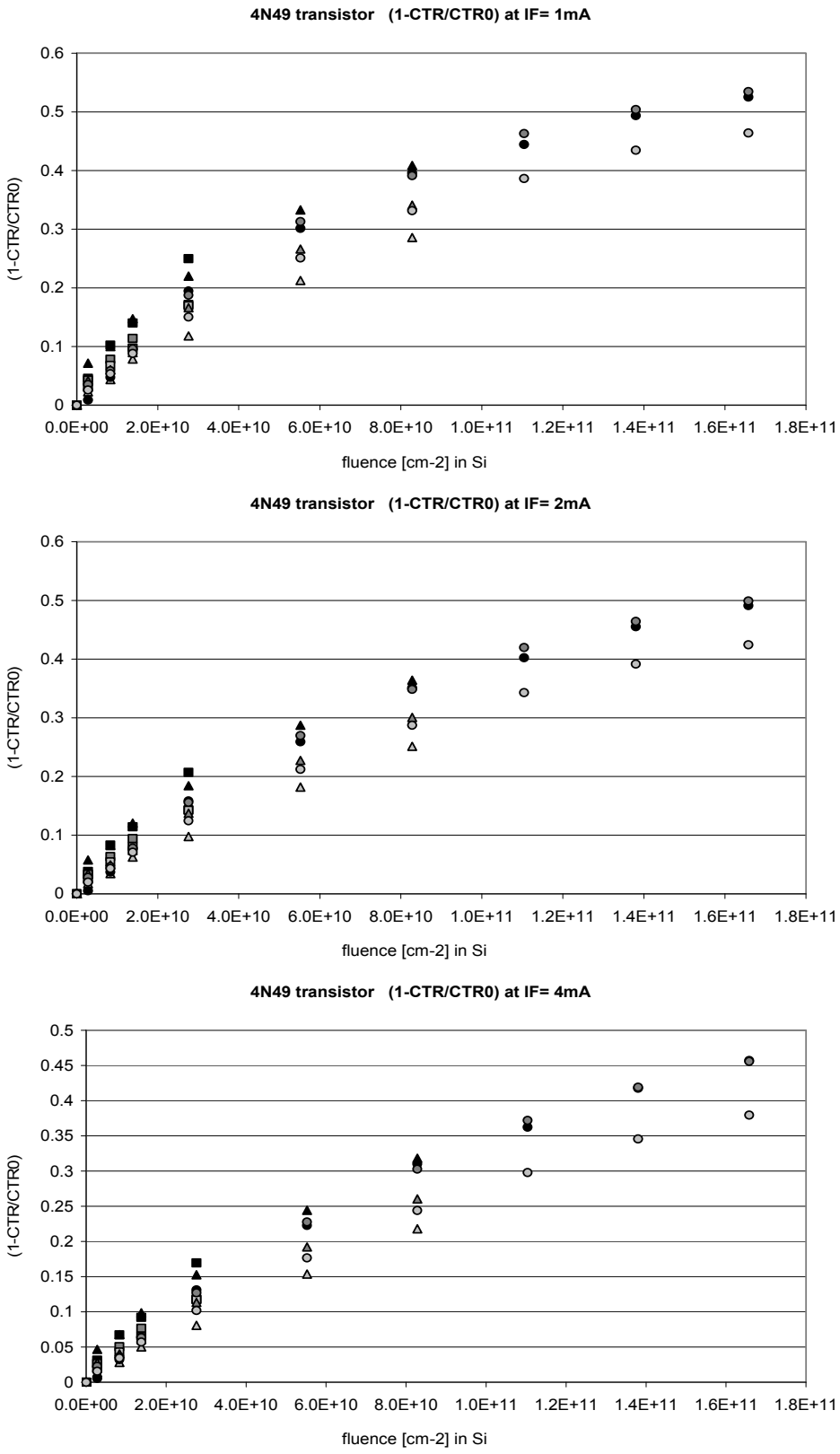
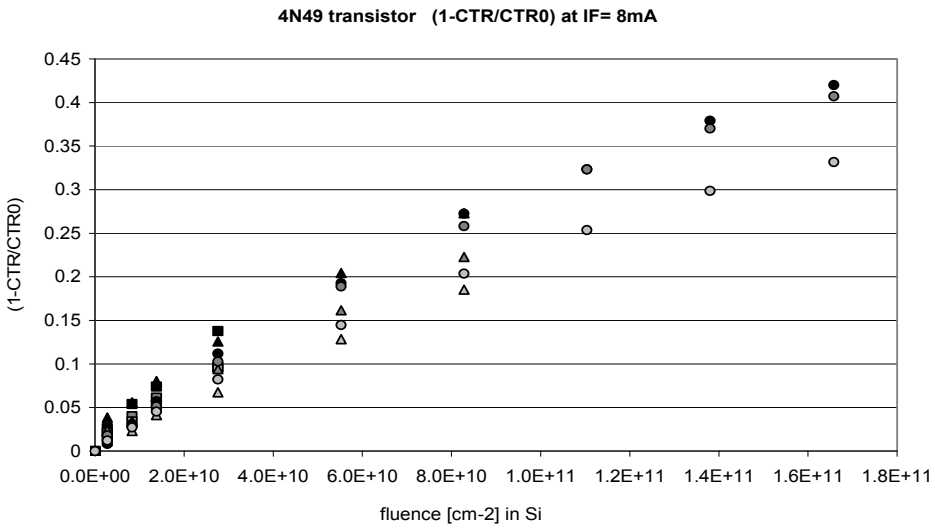

4N49 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-129: 4N49 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

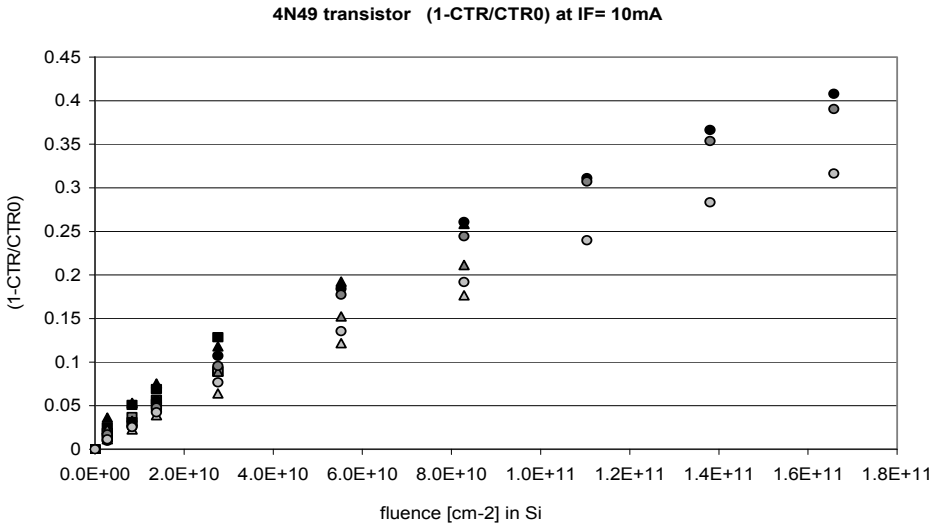
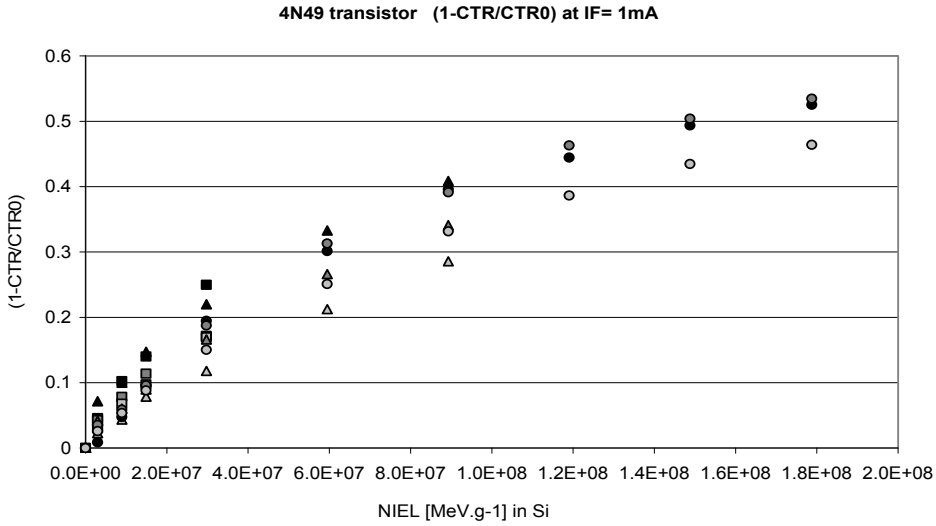
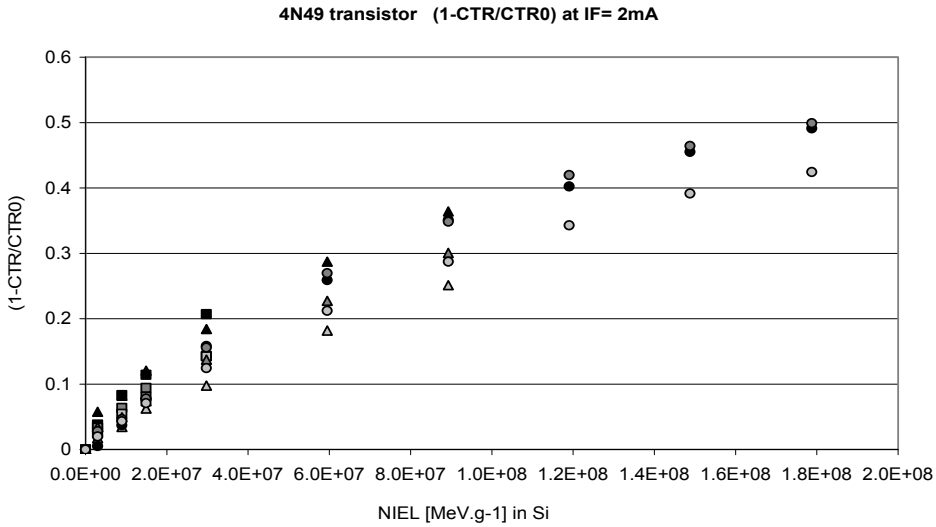
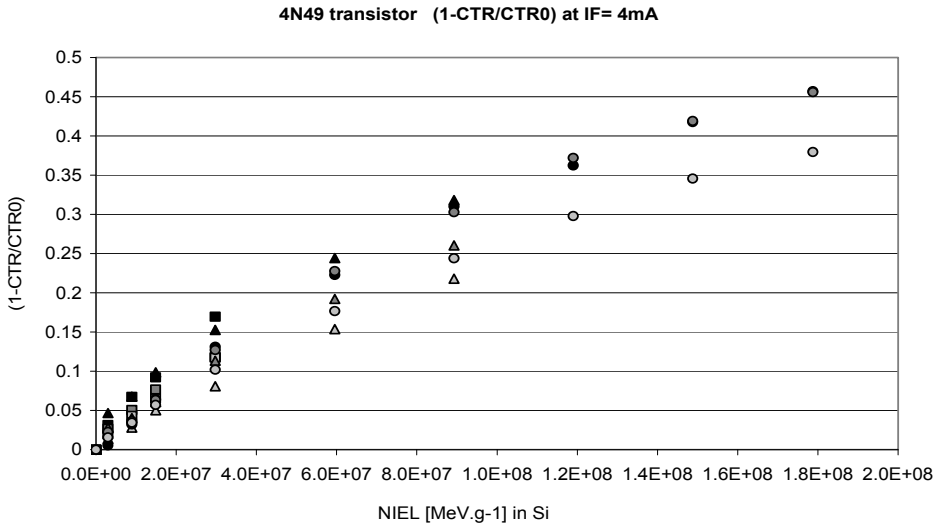
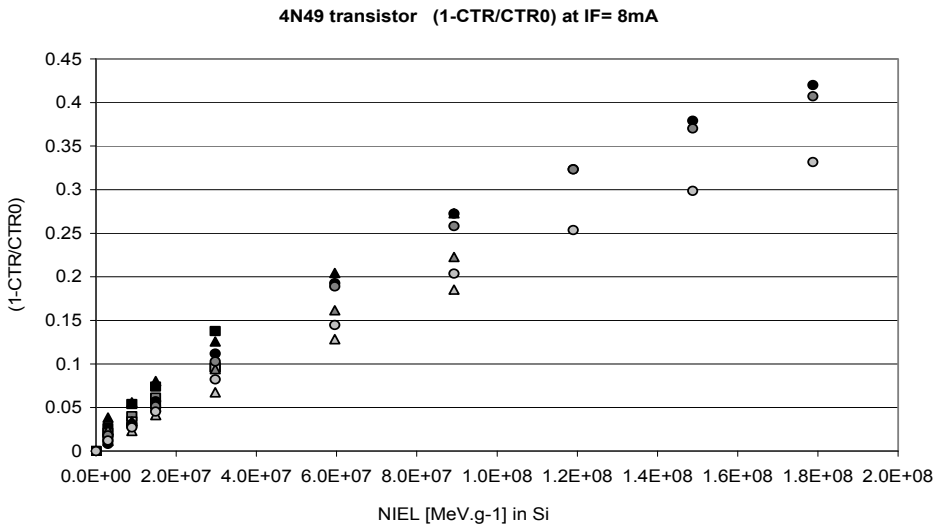

4N49 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 12-130: 4N49 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








4N49 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

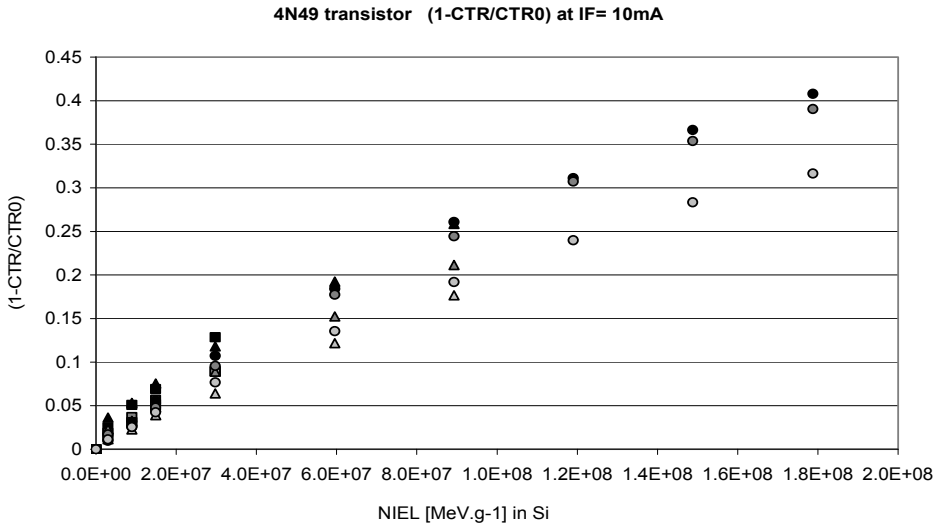
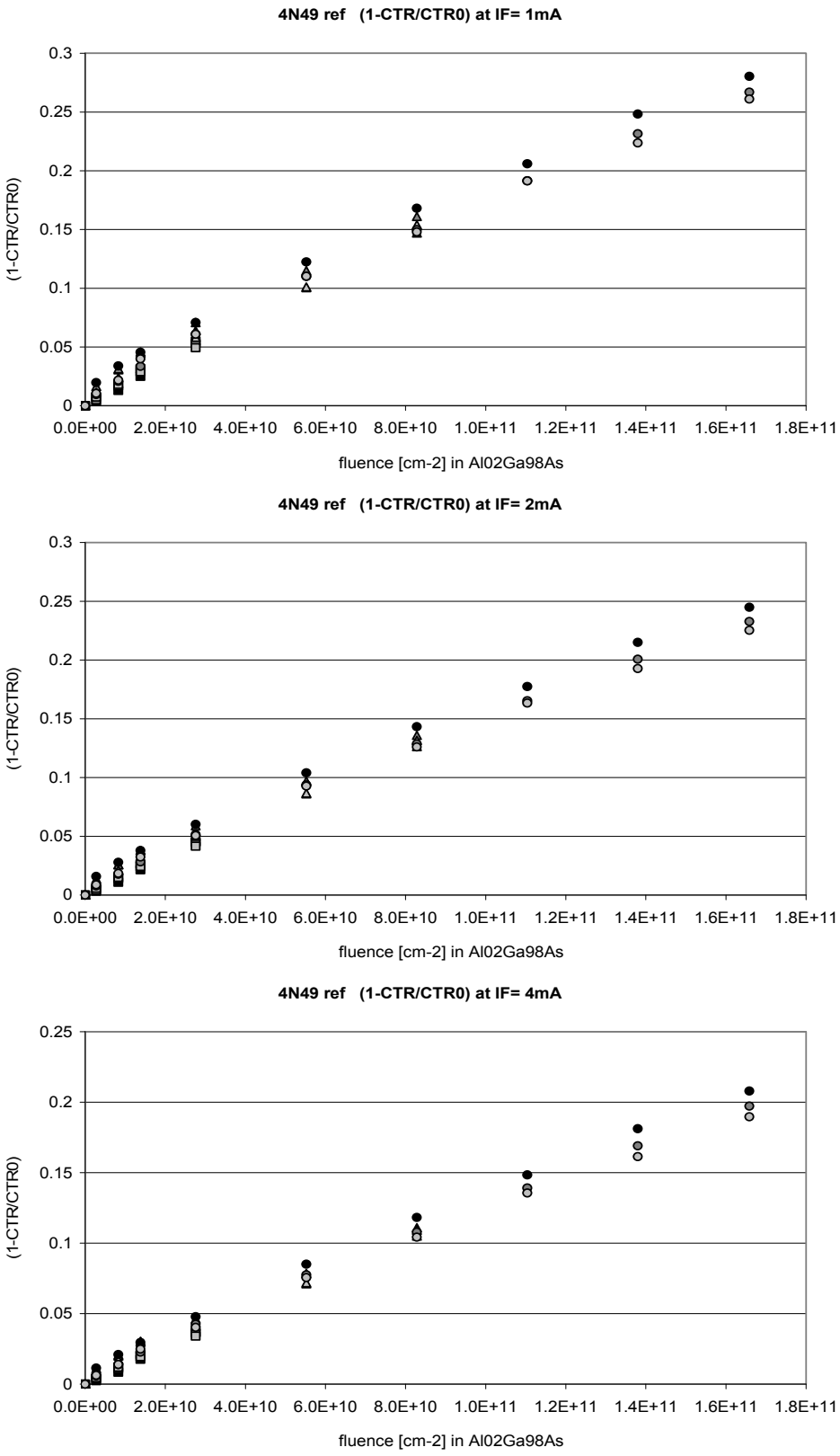
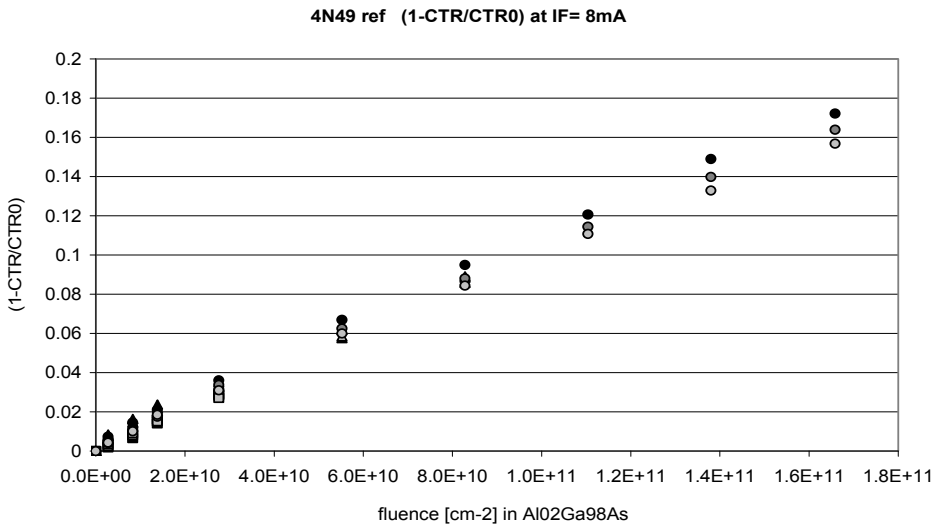

4N49 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08 2.0E+08
NIEL [MeV.g-1] in Si

Fig. 12-131: 4N49 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




4N49 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

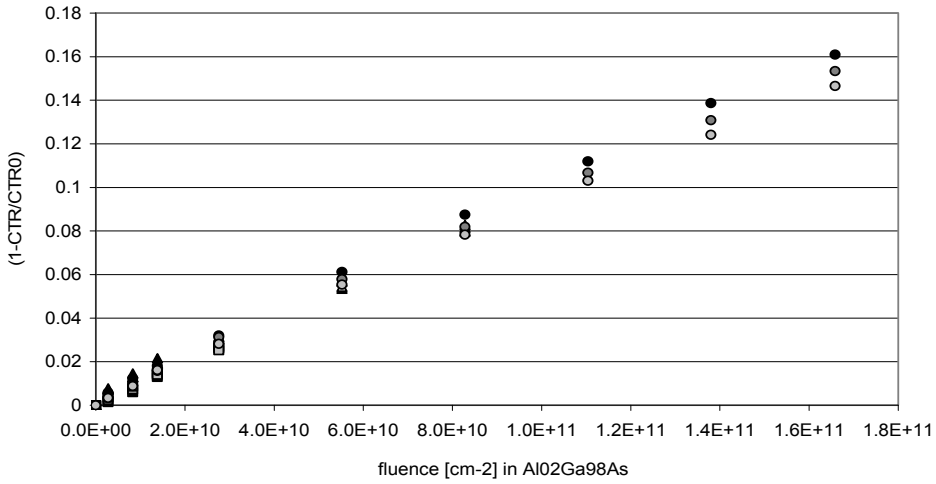
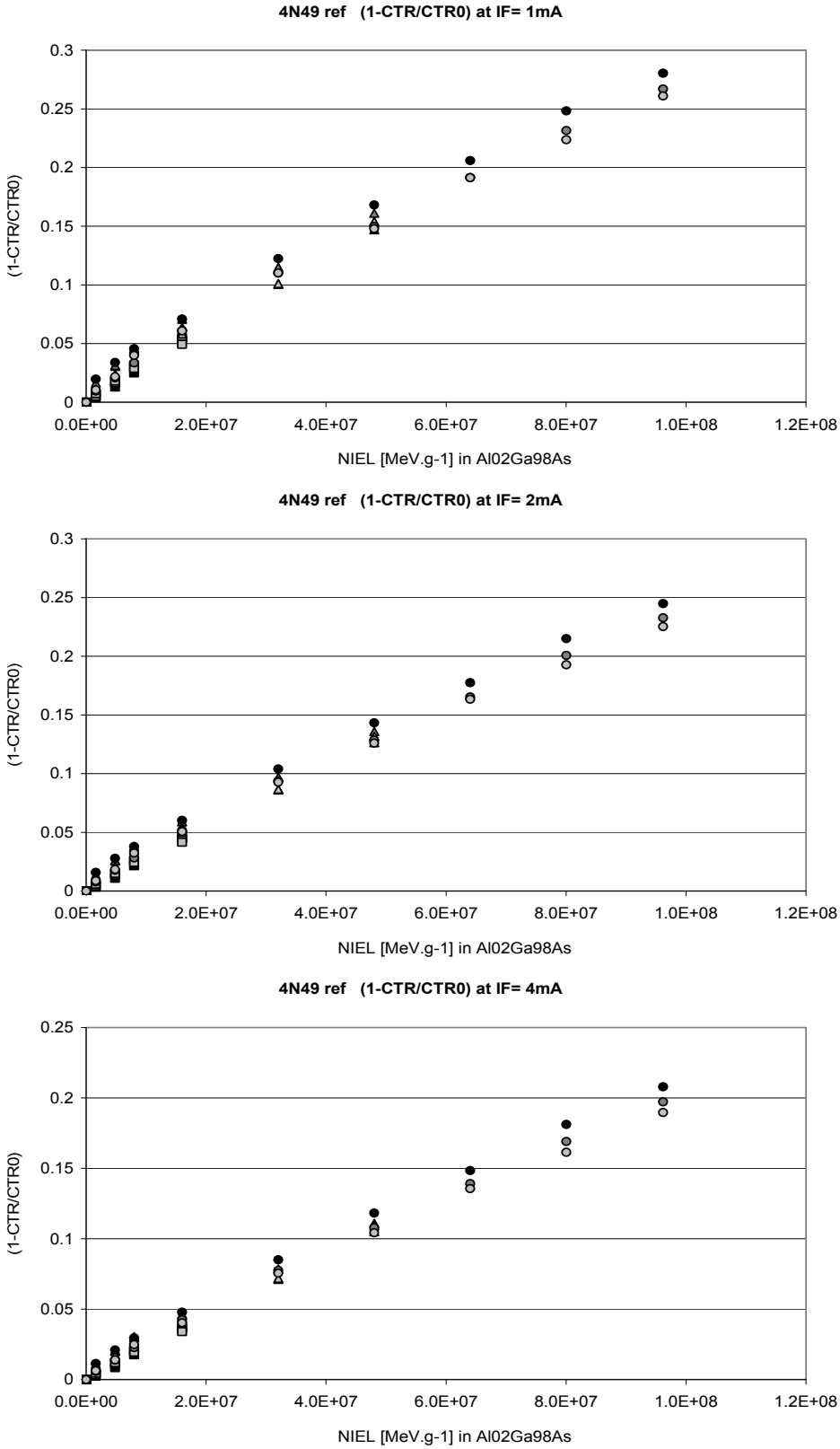
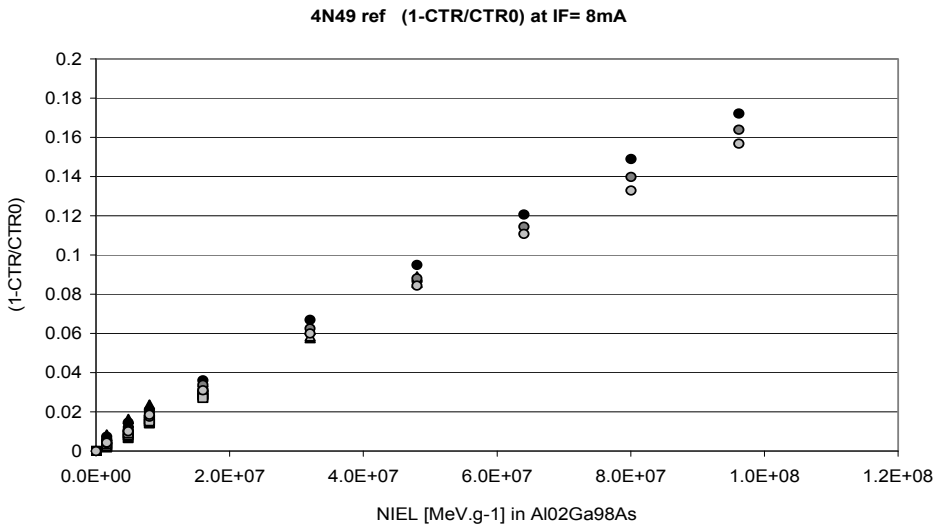

4N49 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al02Ga98As

Fig. 12-132: 4N49 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)




4N49 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

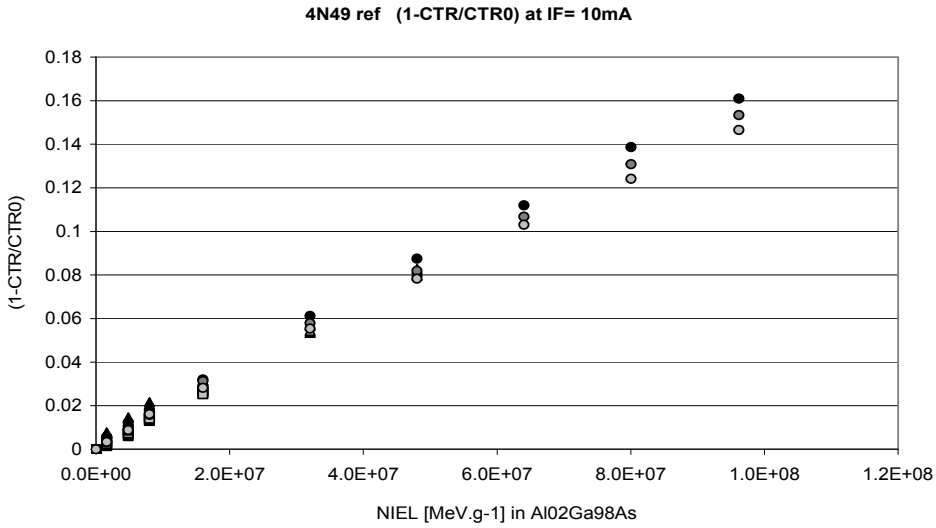
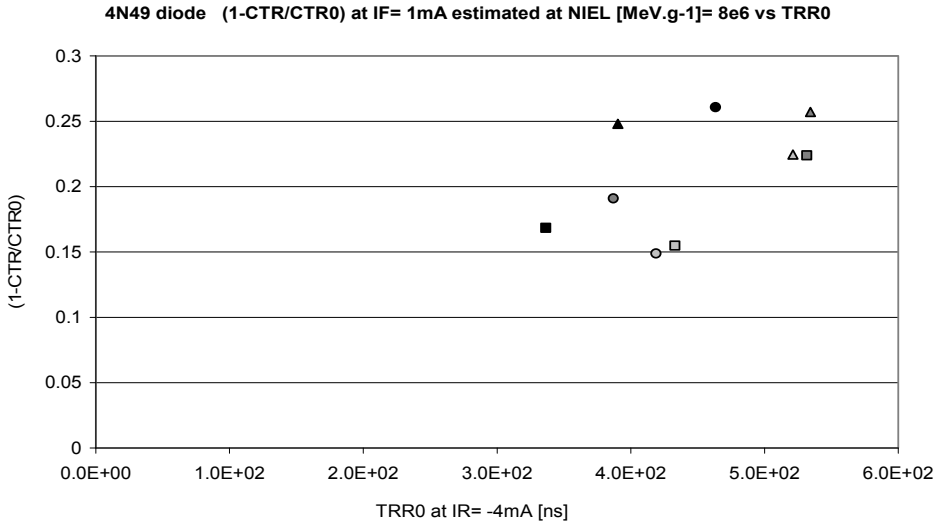
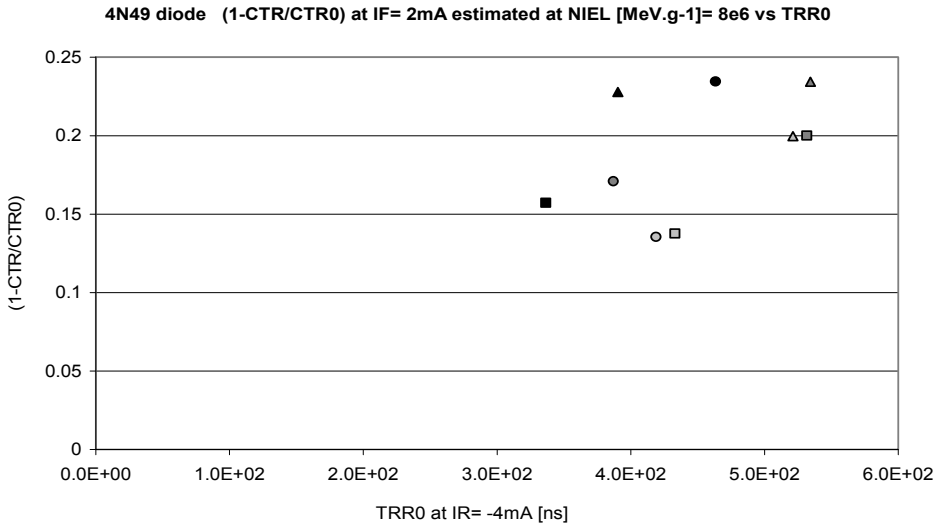
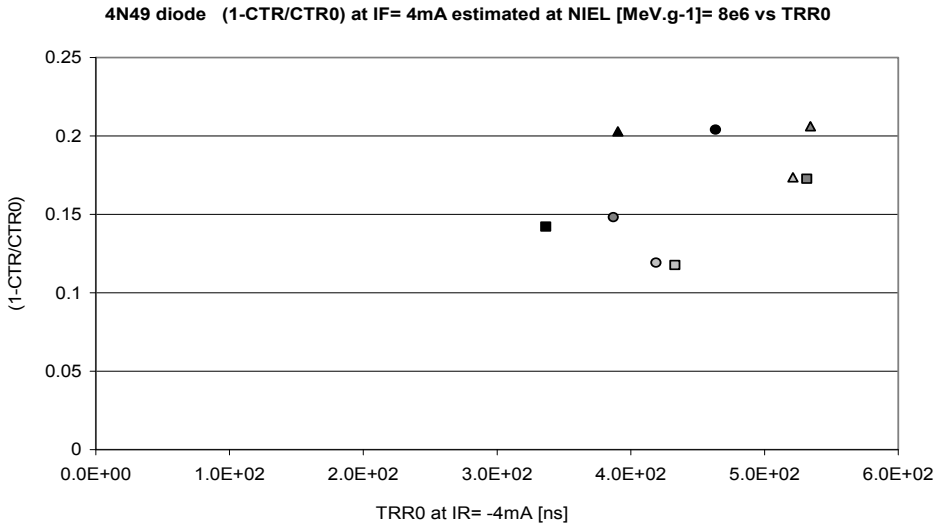
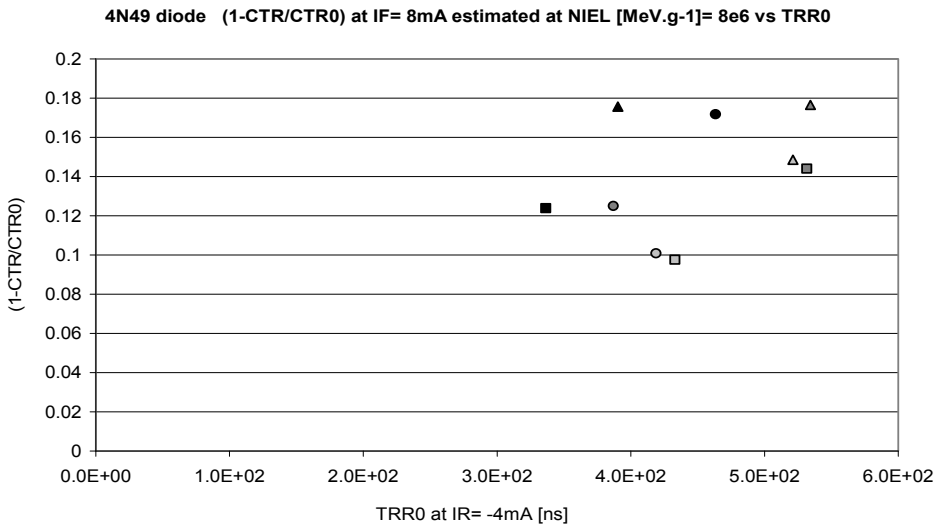

4N49 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al02Ga98As

Fig. 12-133: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
1.0E+02
2.0E+02
3.0E+02
4.0E+02
5.0E+02
6.0E+02
TRR0 at IR= -4mA [ns]

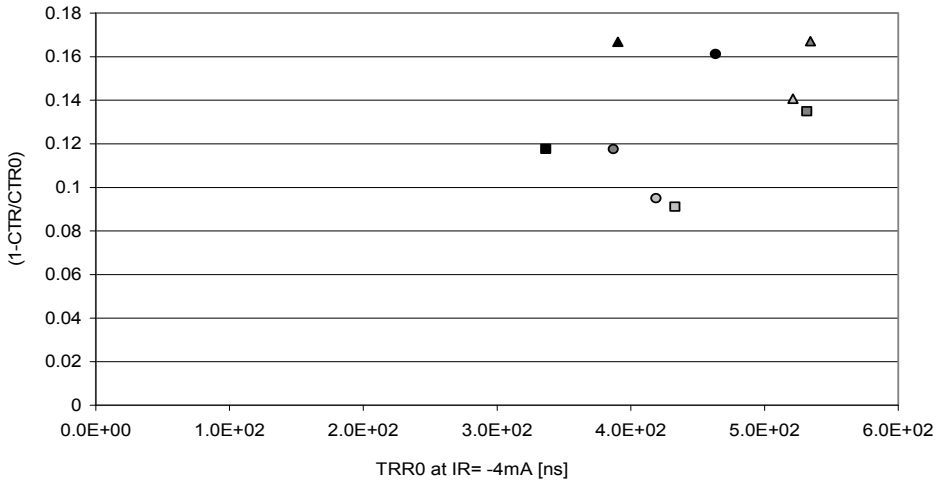

4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
1.0E+02
2.0E+02
3.0E+02
4.0E+02
5.0E+02
6.0E+02
TRR0 at IR= -4mA [ns]

Fig. 12-134: 4N49 optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

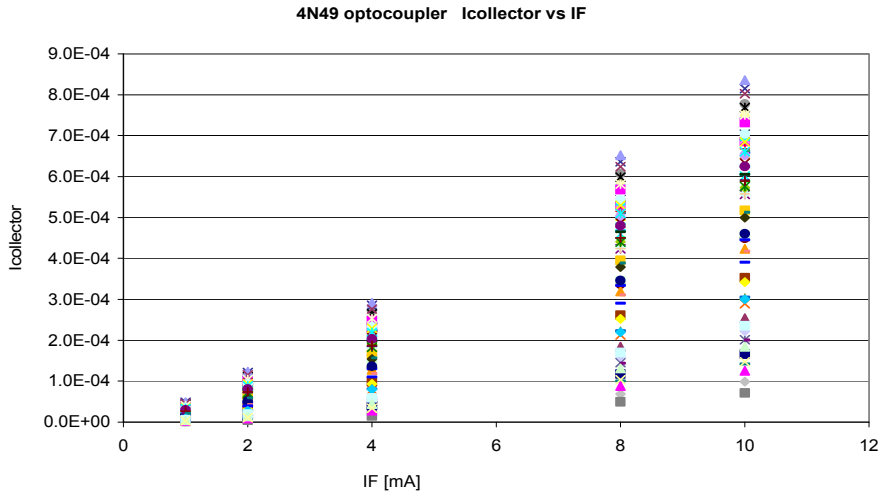


Fig. 12-135: 4N49 optocoupler irradiated: CTR for each step with respect to diode current I_F

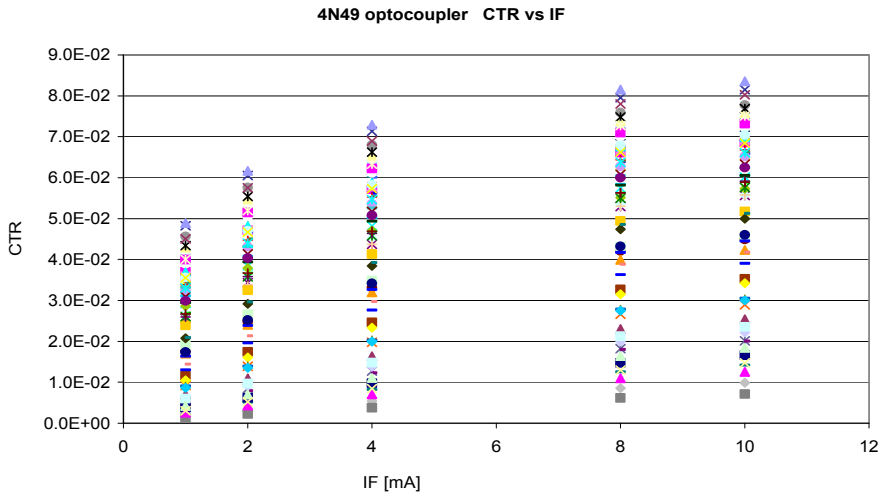


Fig. 12-136: 4N49 optocoupler irradiated: CTR/CTR_0 for each step with respect to diode current I_F

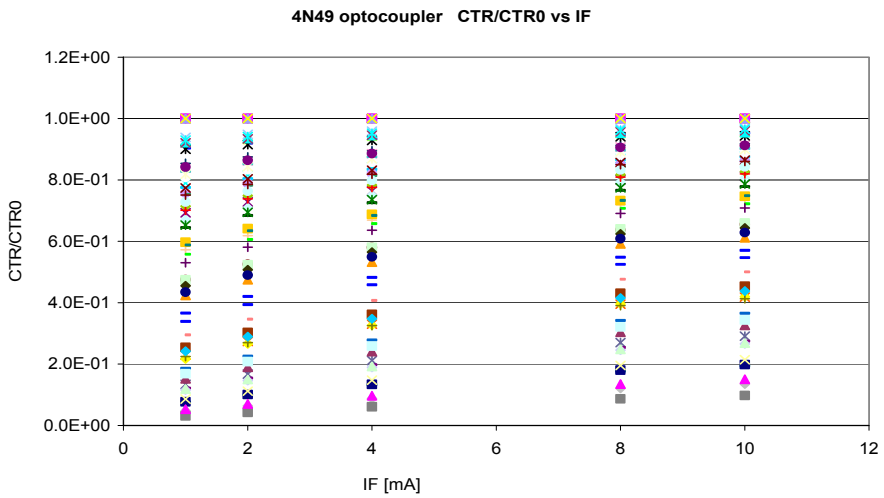


Fig. 12-137: 4N49 diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

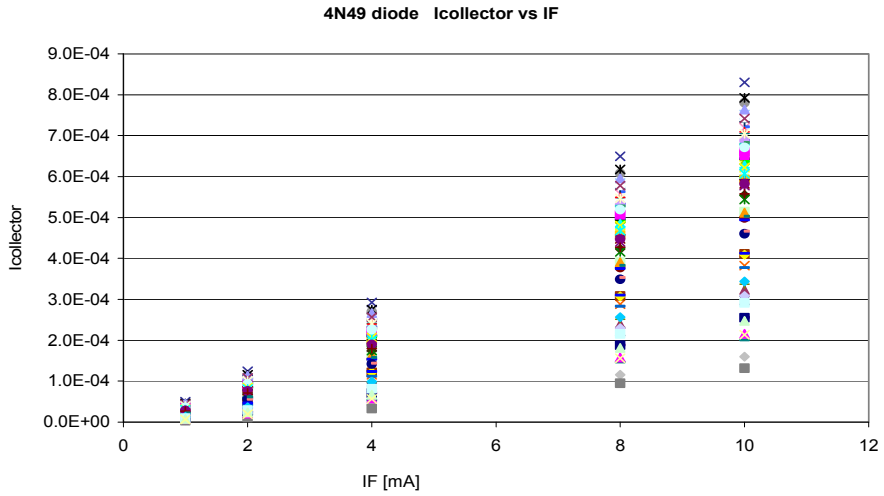


Fig. 12-138: 4N49 diode irradiated: CTR for each step with respect to diode current I_F

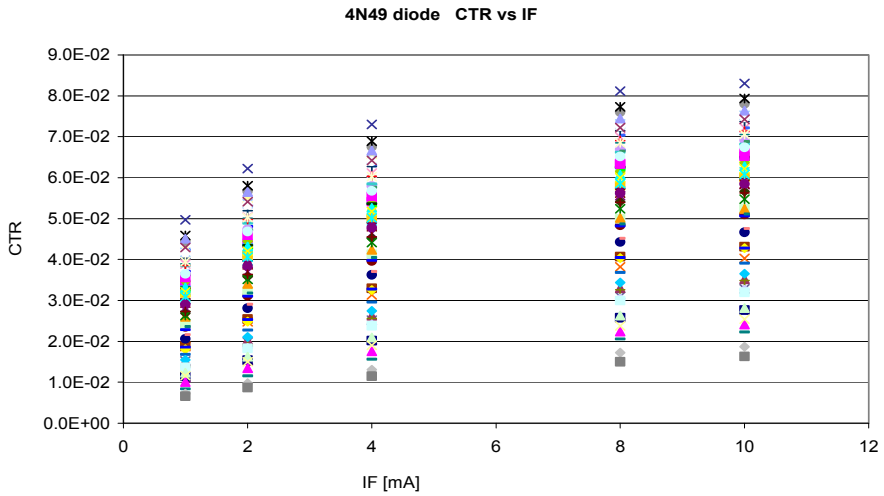


Fig. 12-139: 4N49 diode irradiated: CTR/CTR_0 for each step with respect to diode current I_F

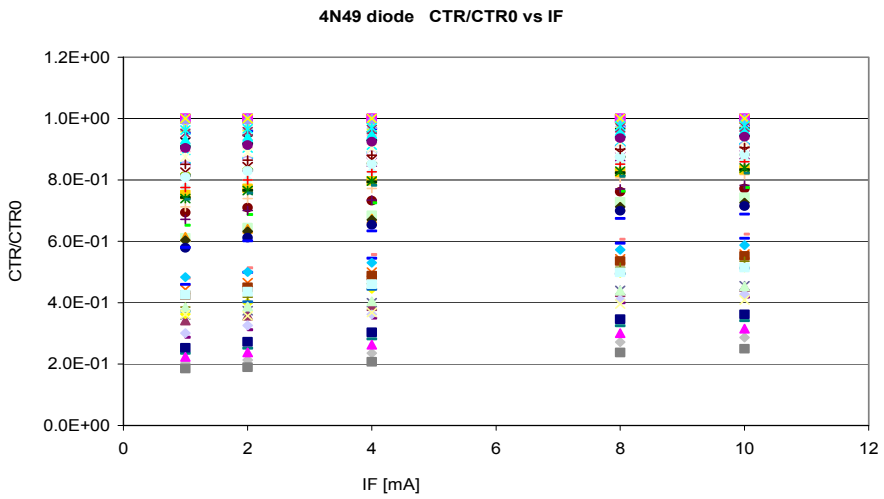


Fig. 12-140: 4N49 transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

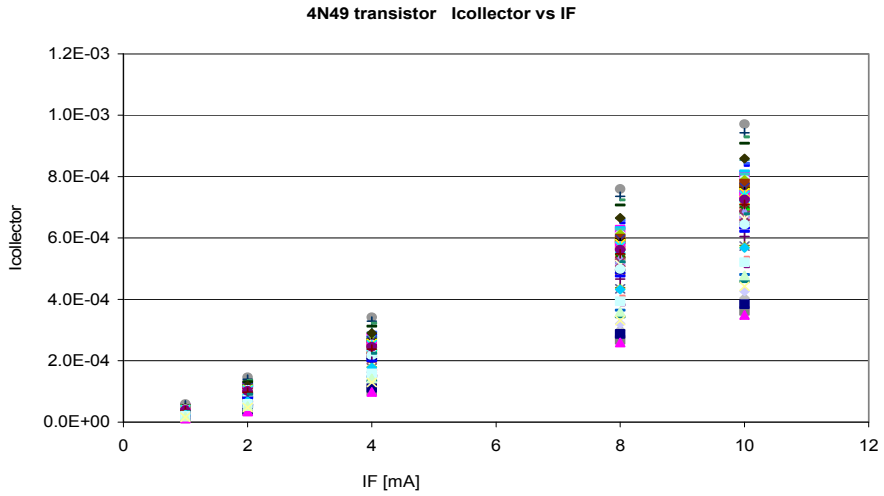


Fig. 12-141: 4N49 transistor irradiated: CTR for each step with respect to diode current I_F

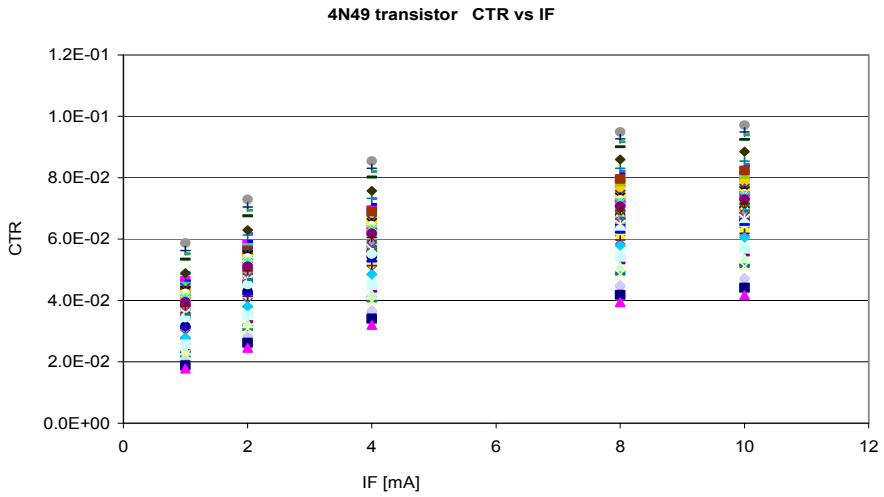


Fig. 12-142: 4N49 transistor irradiated: CTR/CTR_0 for each step with respect to diode current I_F

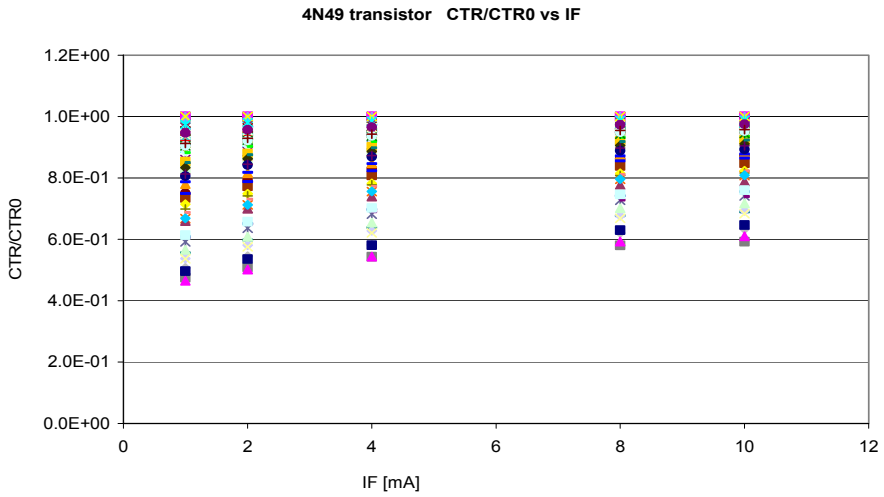


Fig. 12-143: 4N49 reference measurement: transistor collector current I_C for each step with respect to diode current I_F

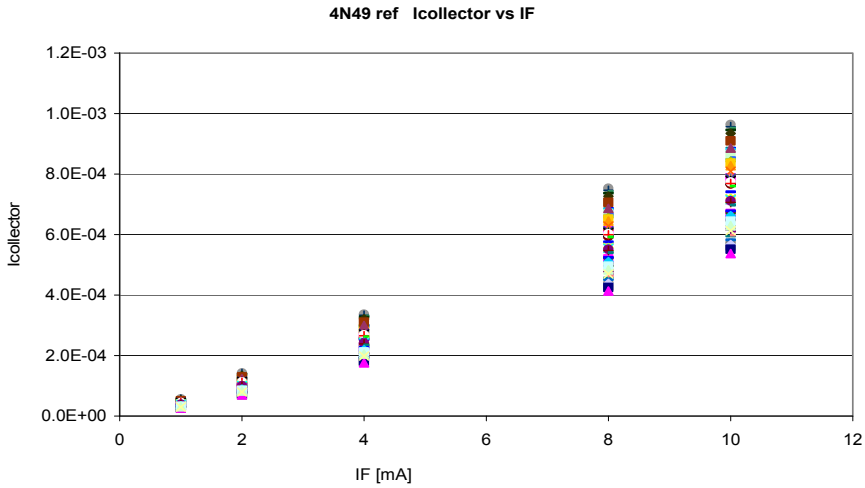


Fig. 12-144: 4N49 reference measurement: CTR for each step with respect to diode current I_F

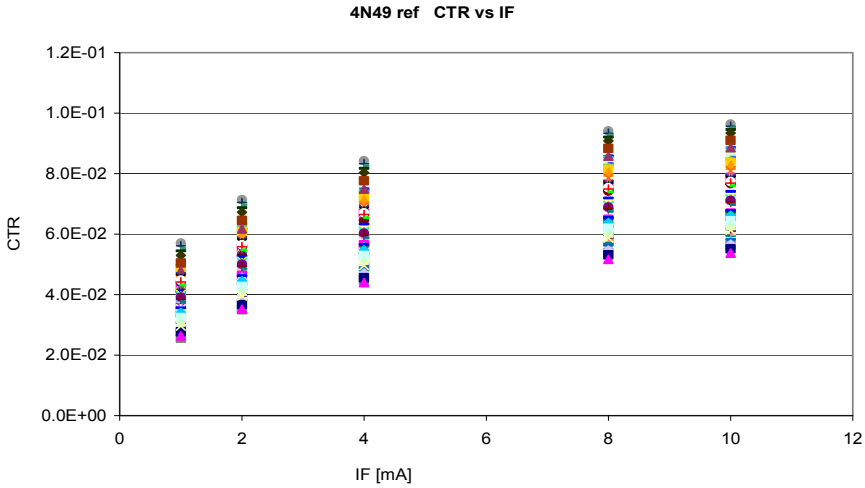


Fig. 12-145: 4N49 reference measurement: CTR/CTR_0 for each step with respect to diode current I_F

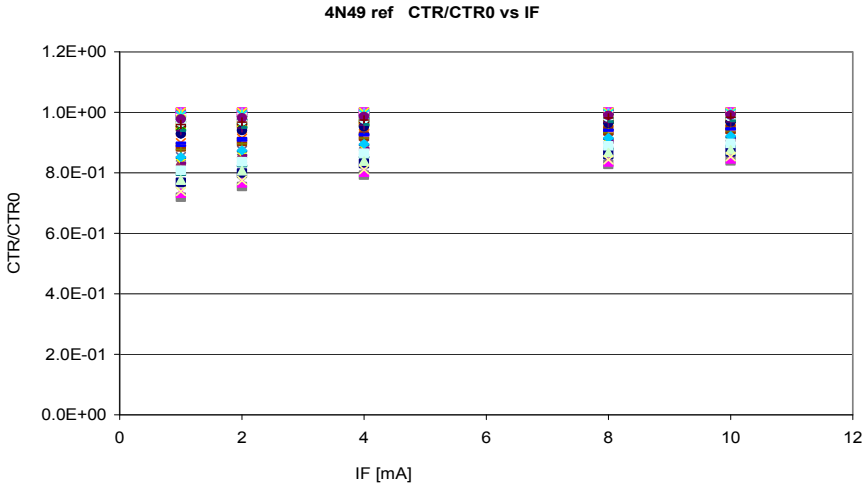


Fig. 12-146: 4N49 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA

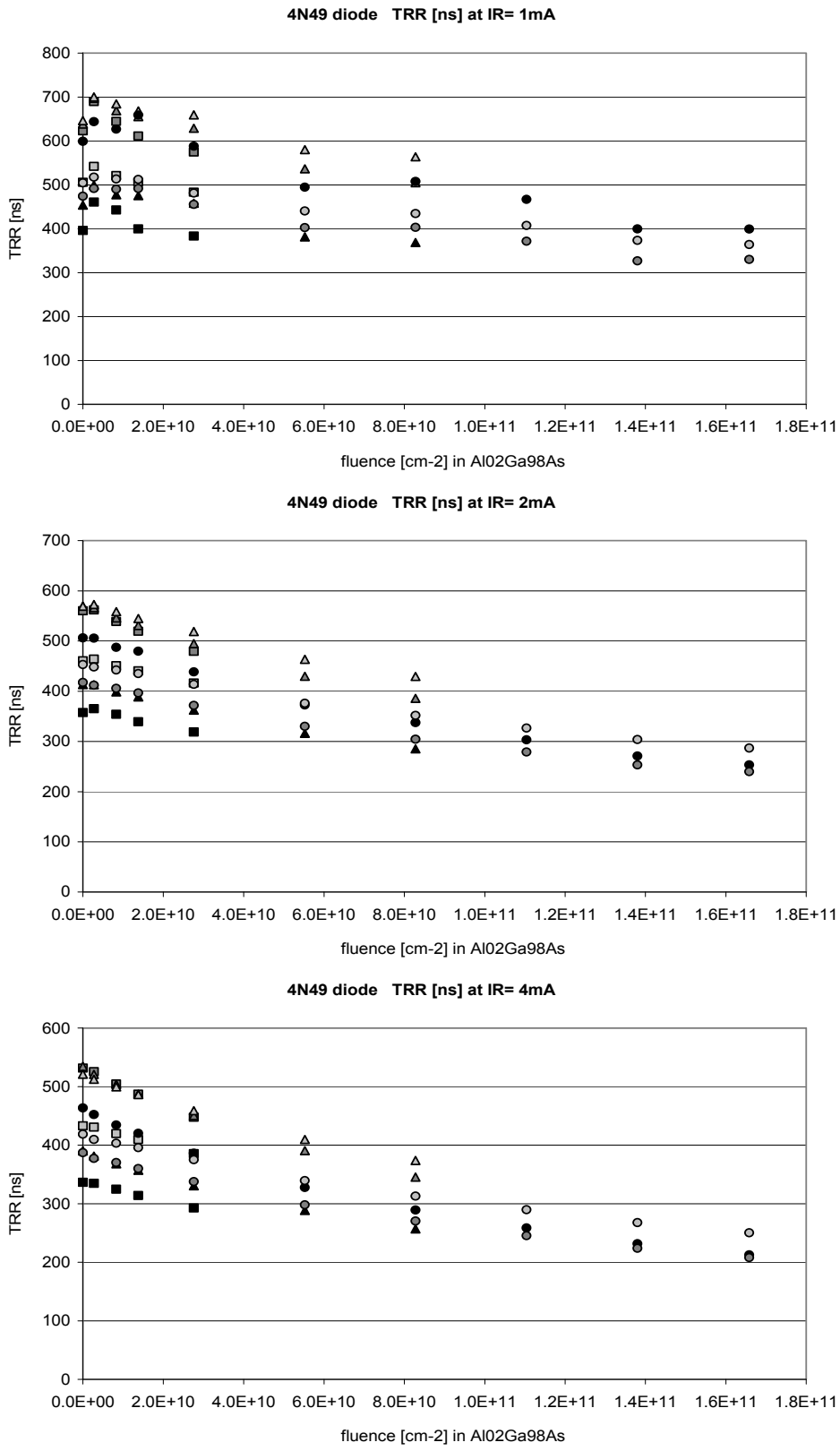
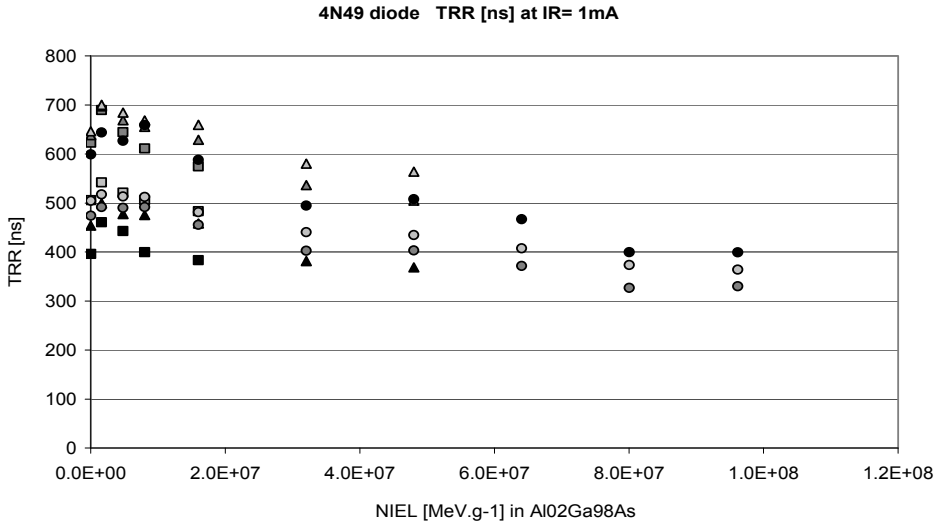
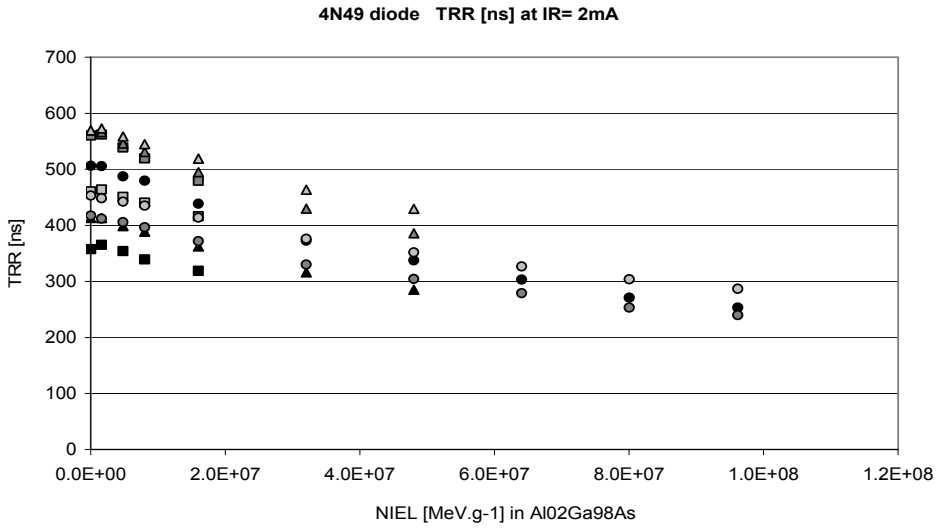


Fig. 12-147: 4N49 diode: τ_{RR} [ns] with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





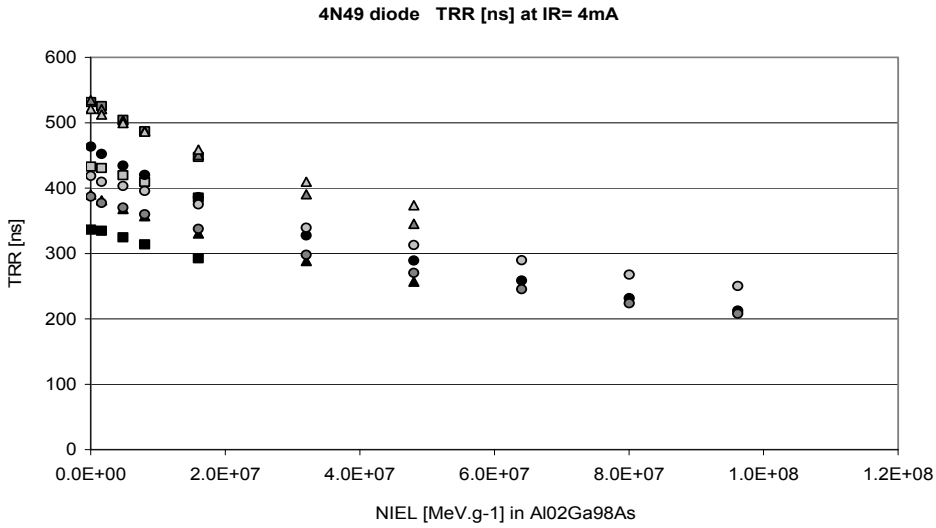


Fig. 12-148: 4N49 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA

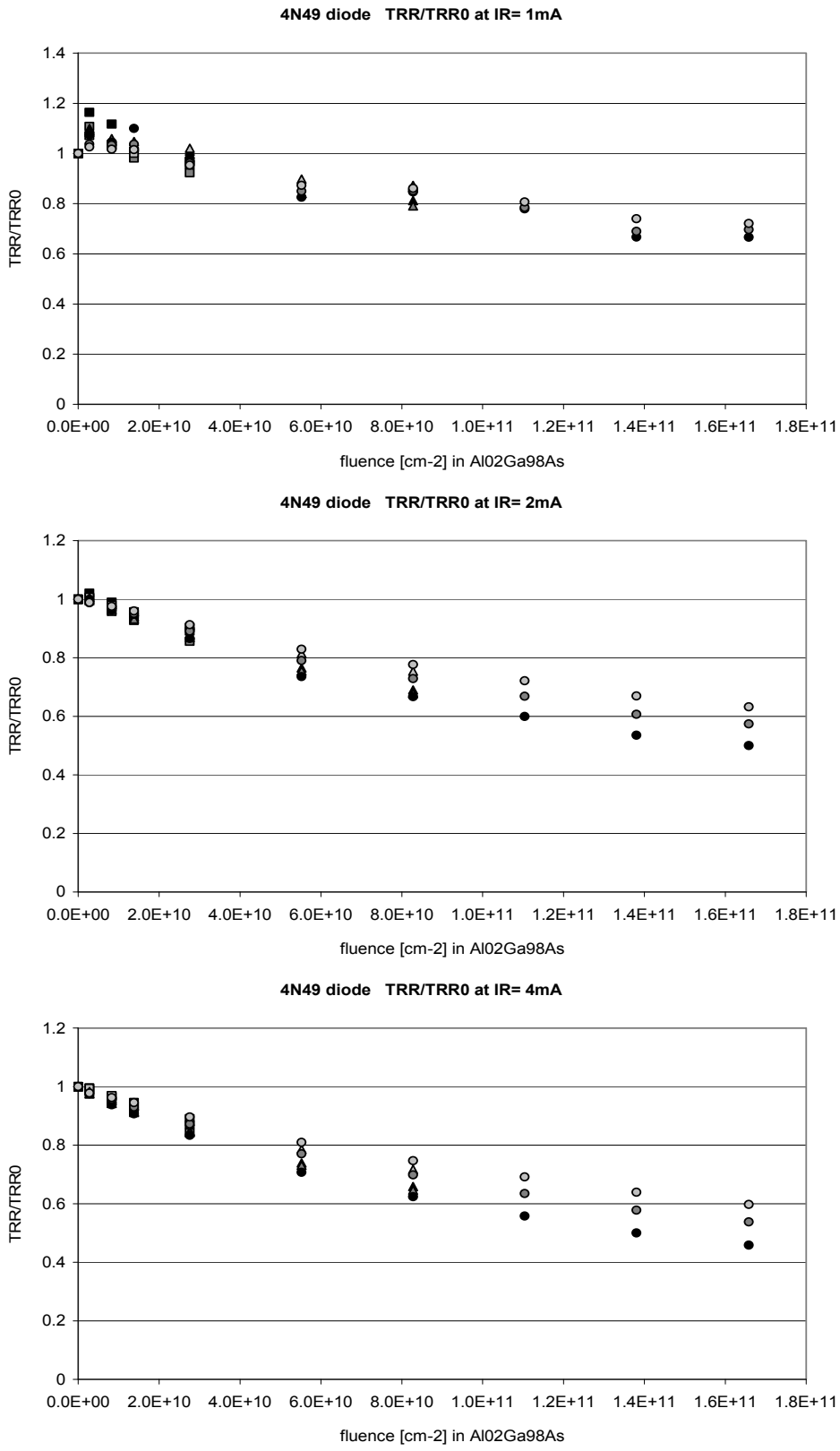


Fig. 12-149: 4N49 diode: τ_{RR}/τ_{RR0} with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA

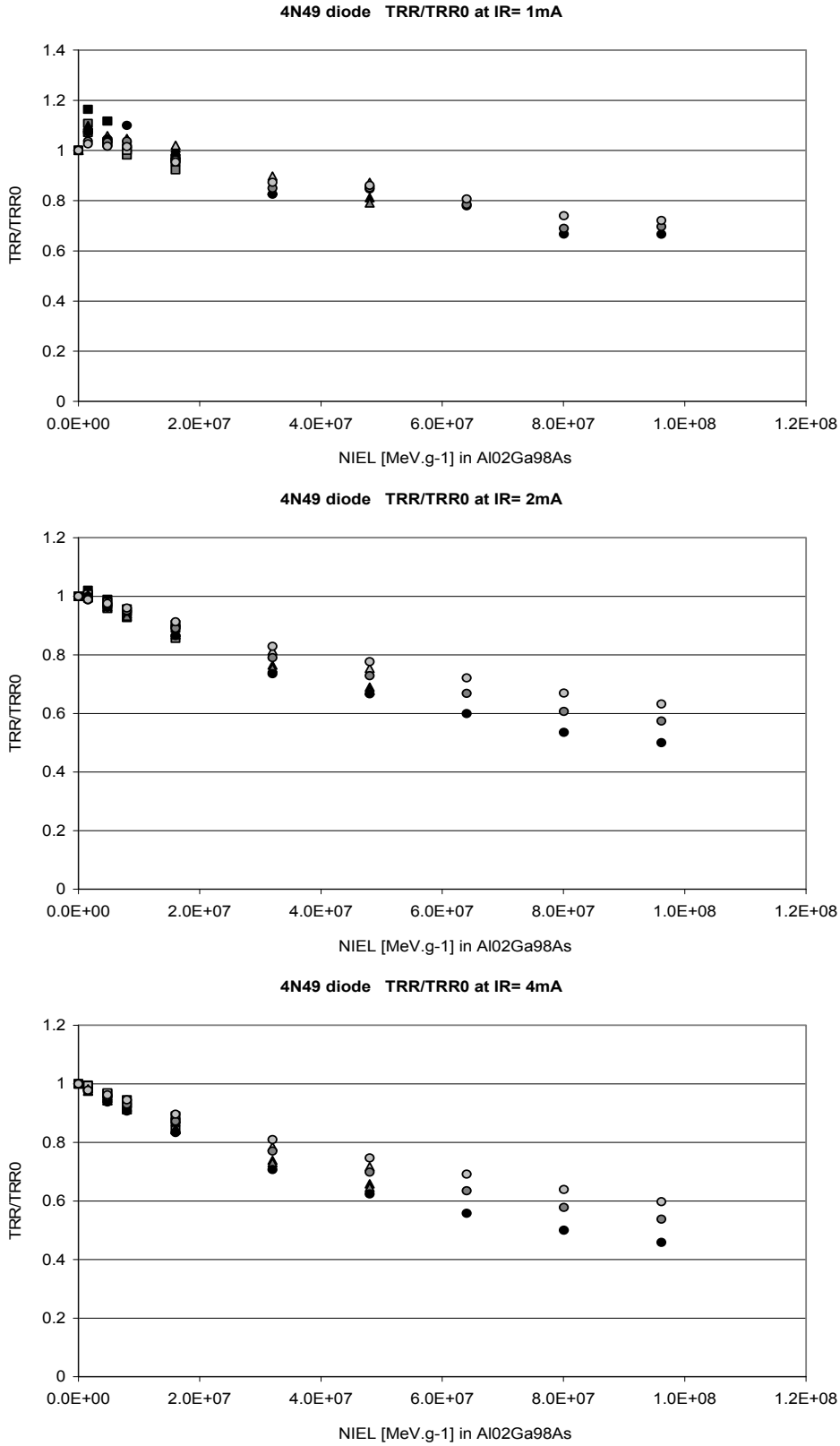


Fig. 12-150: 4N49 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA

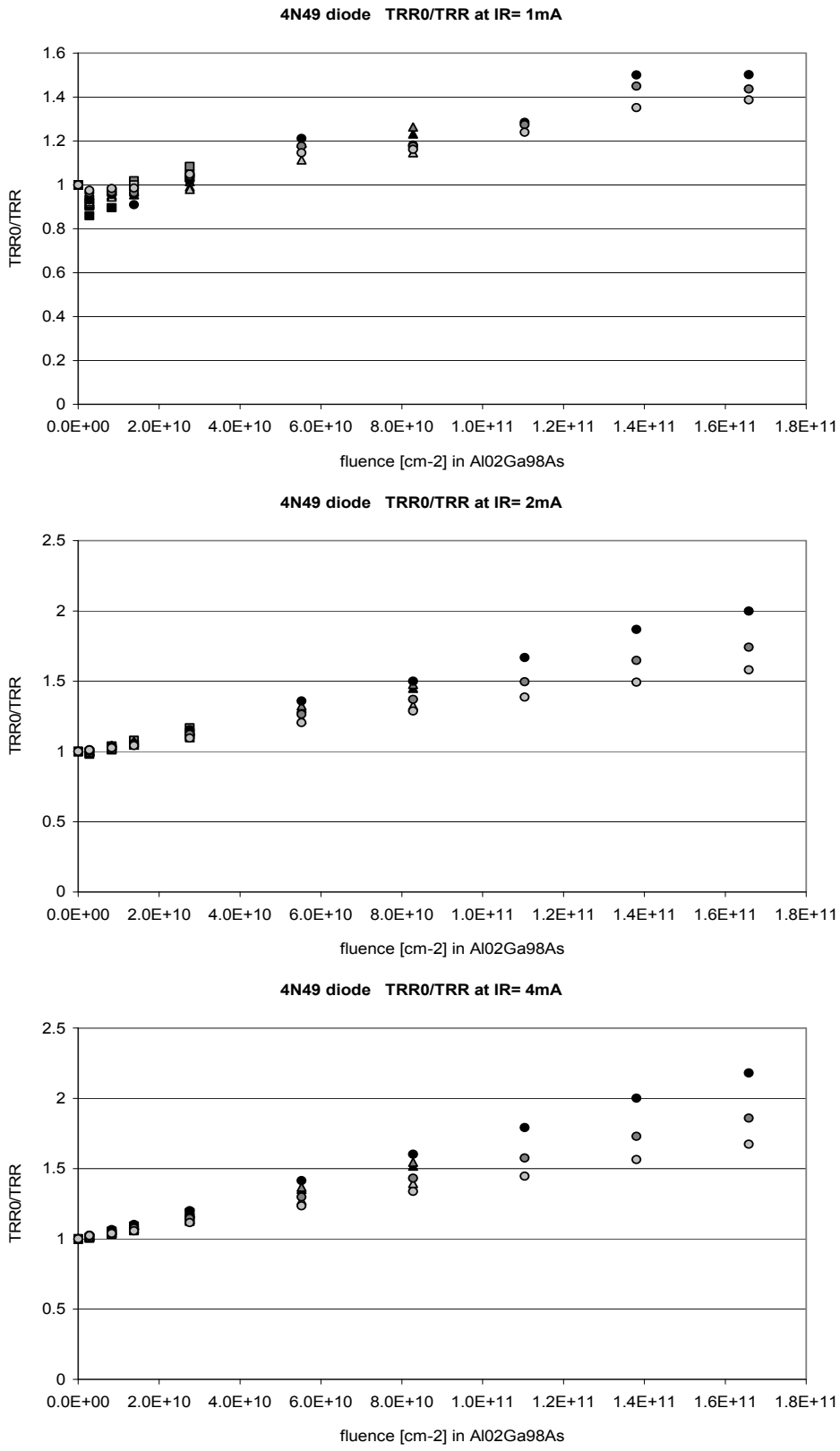


Fig. 12-151: 4N49 diode: τ_{RR0}/τ_{RR} with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA

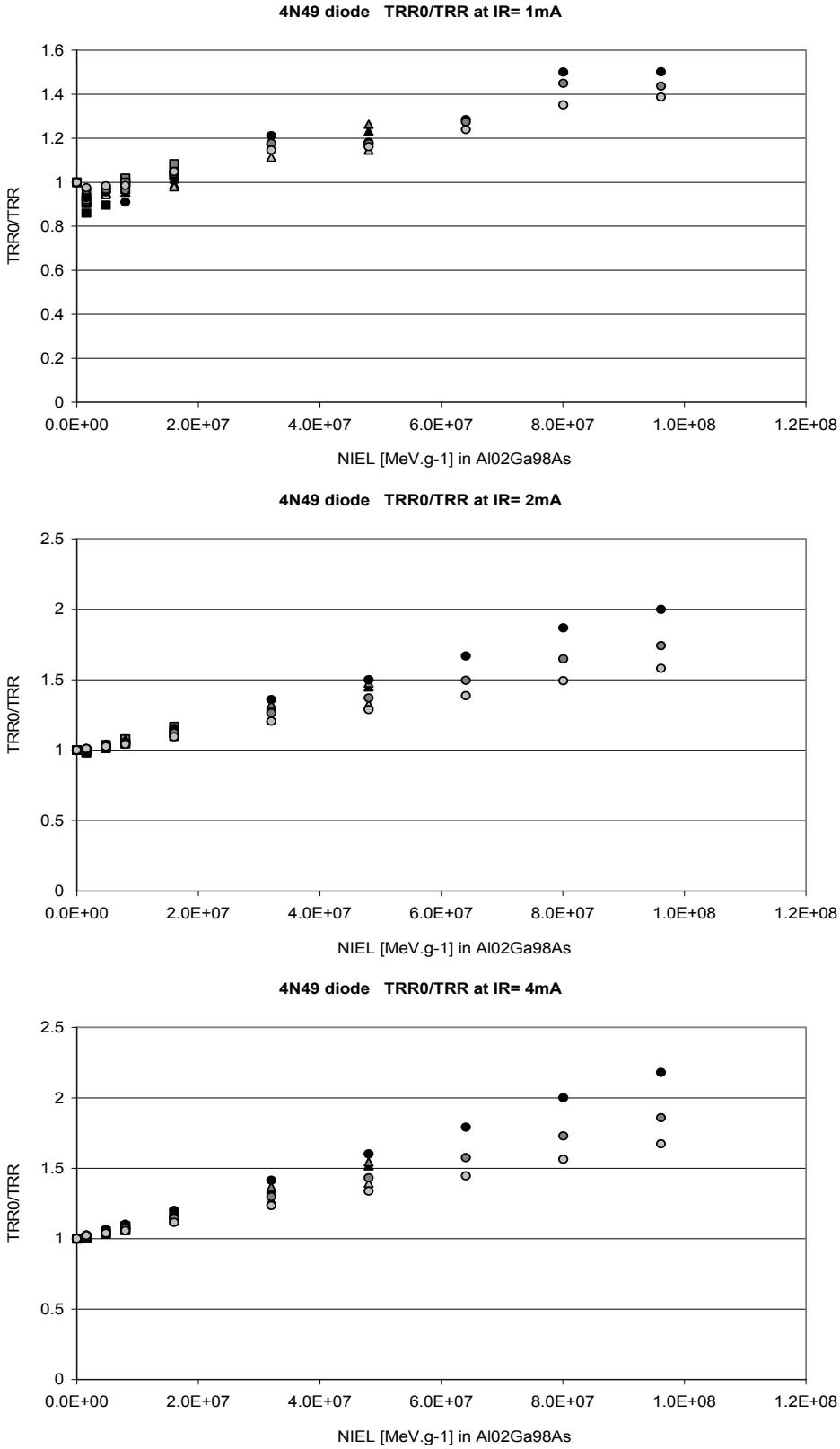
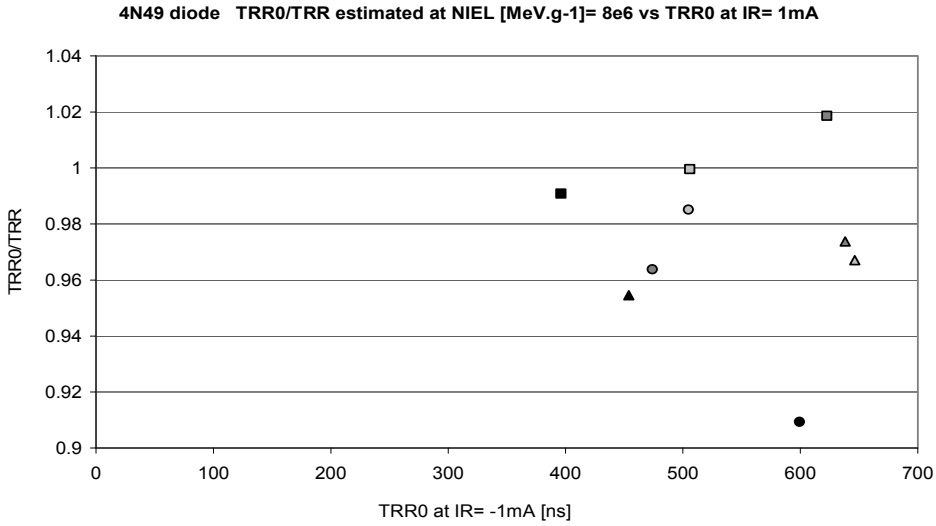
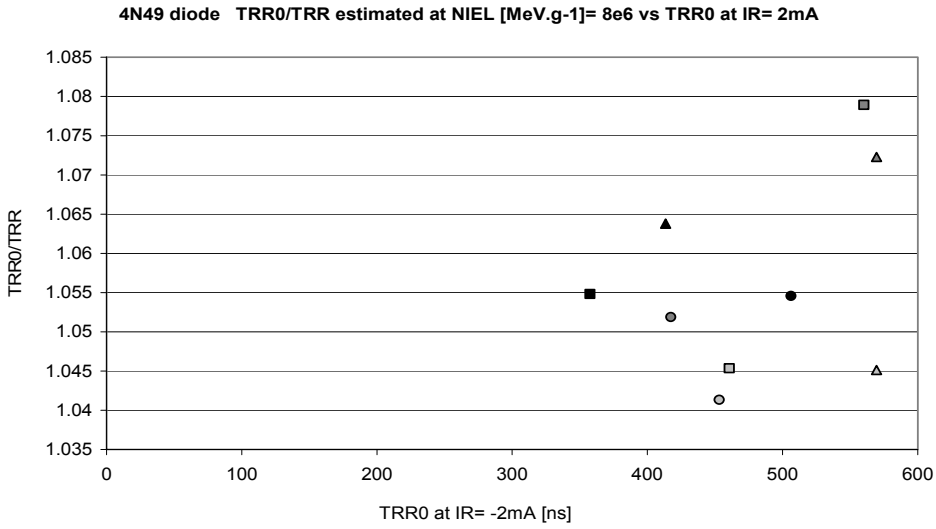


Fig. 12-152: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





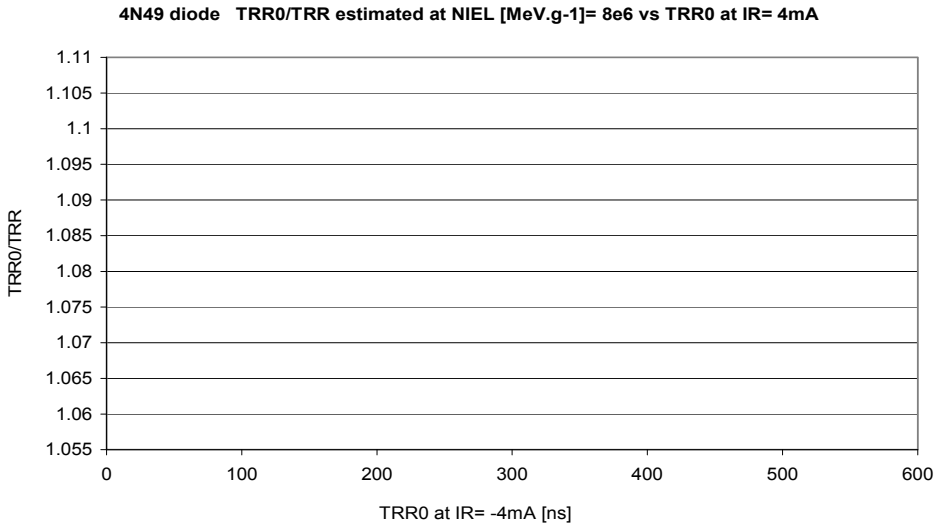


Fig. 12-153: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence

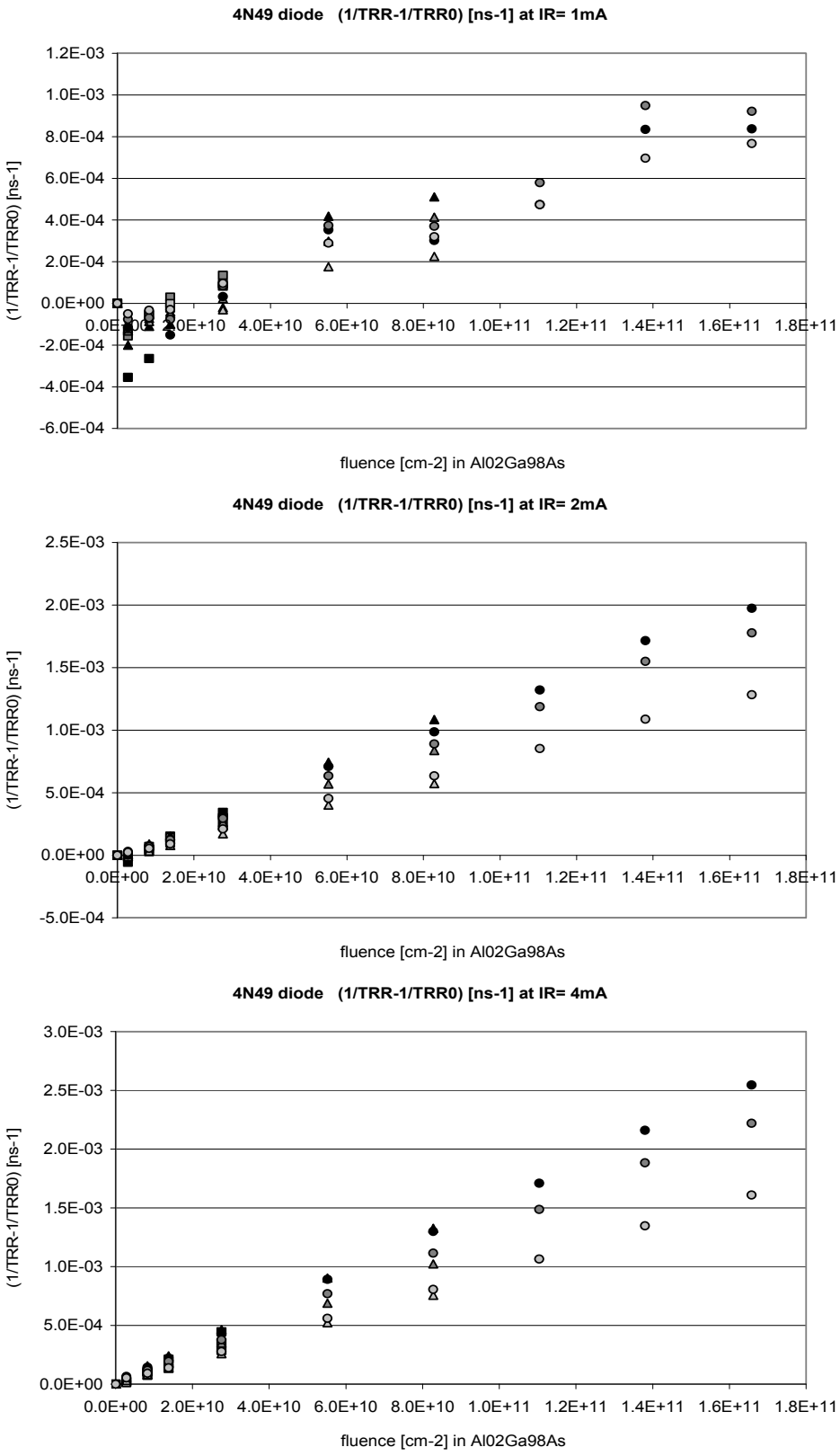


Fig. 12-154: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL in $Al_{0.02}Ga_{0.98}As$ (GEANT4 TOTAL)

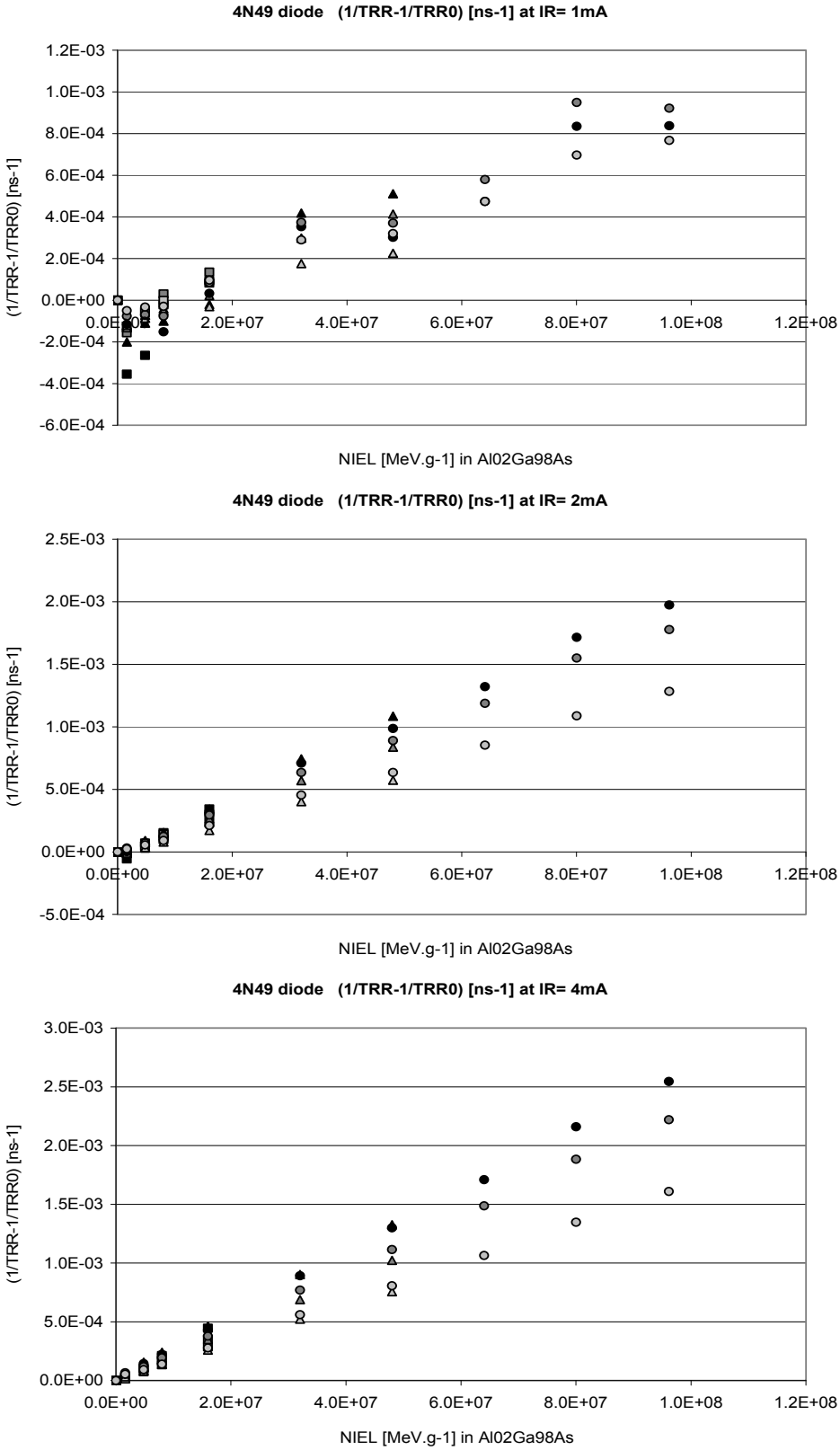


Fig. 12-155: 4N49 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}

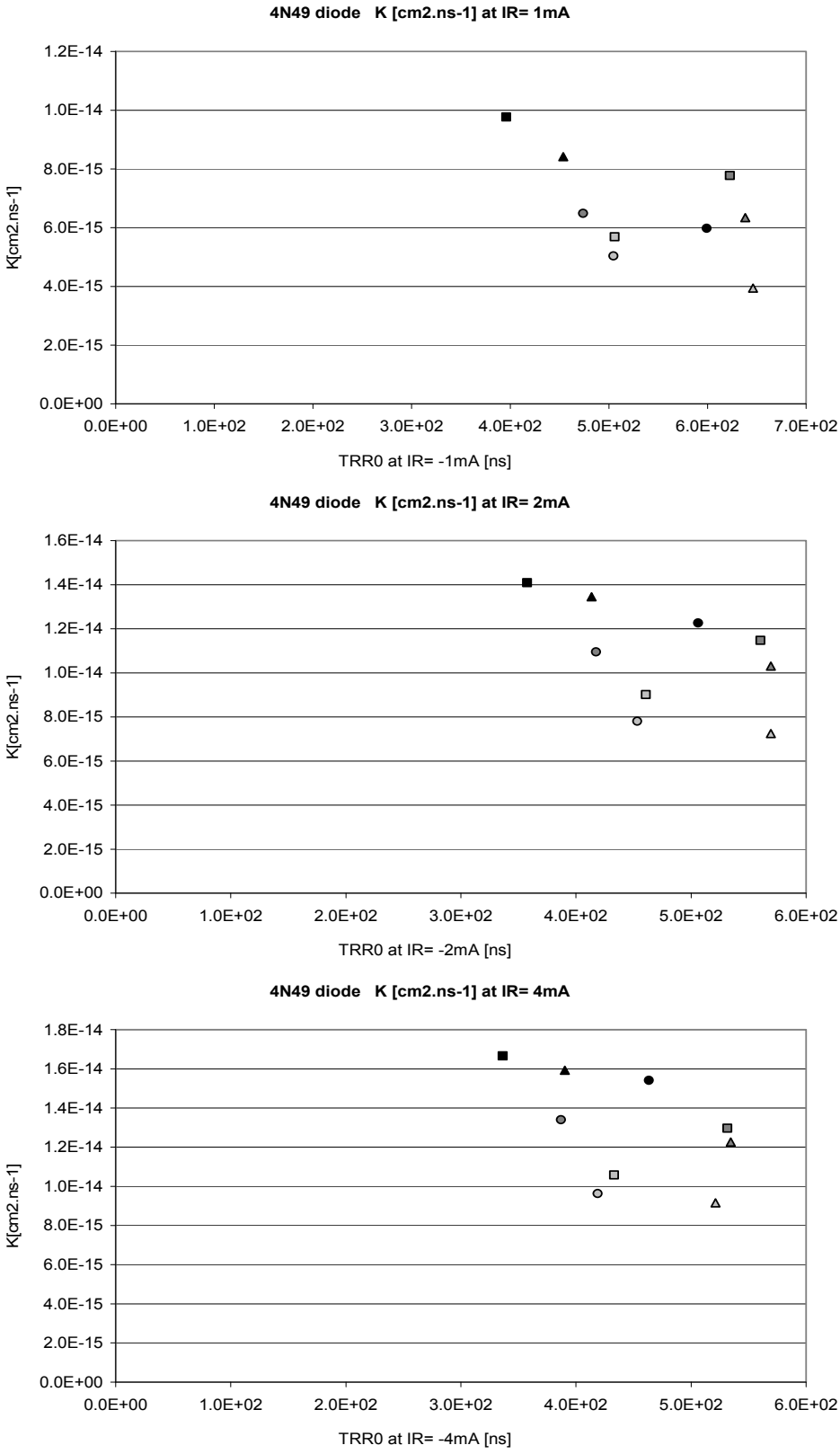


Fig. 12-156: 4N49 diode: K_{NIEL} at I_R = -1, -2, -4mA with respect to τ_{RR0}

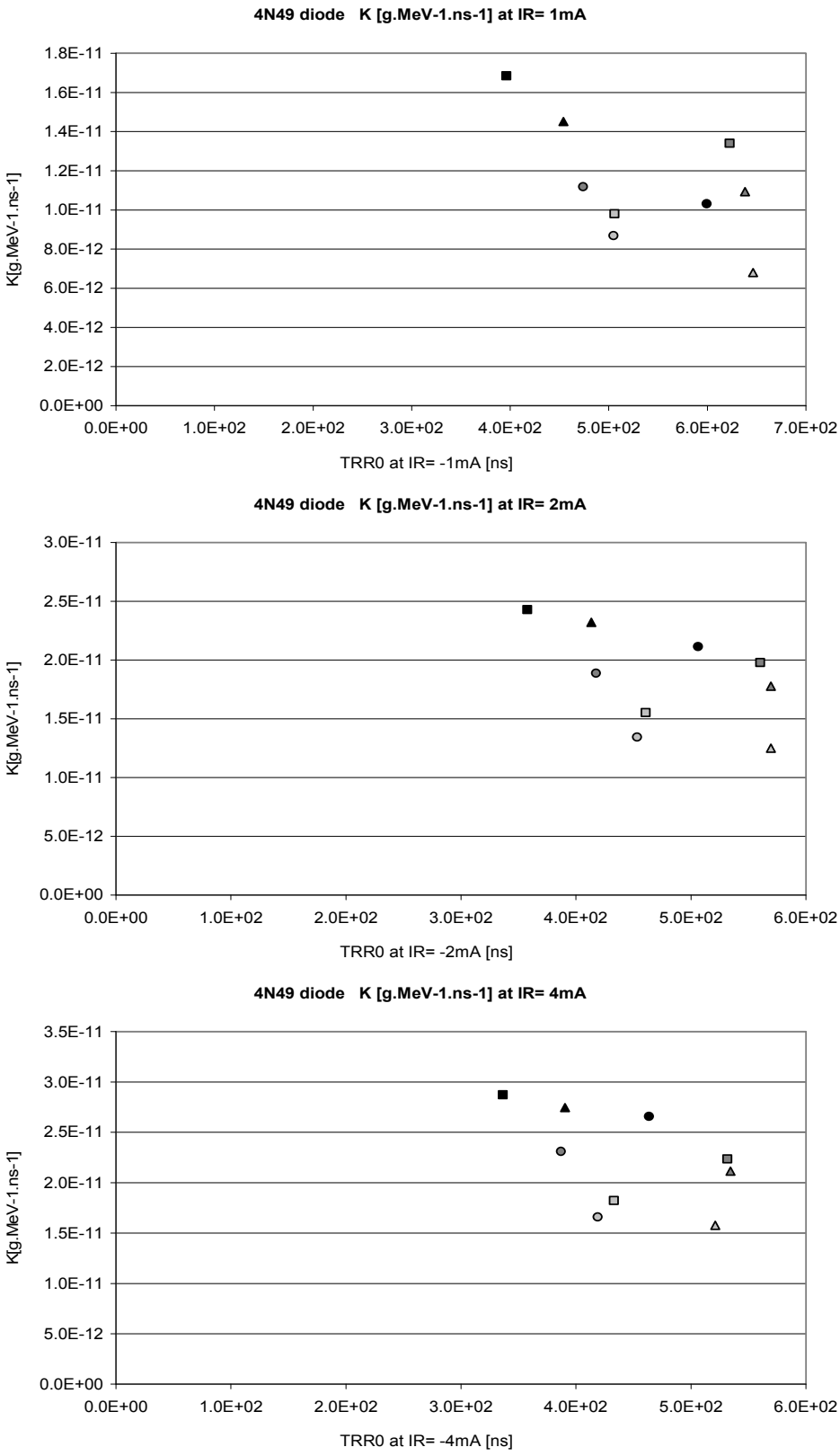
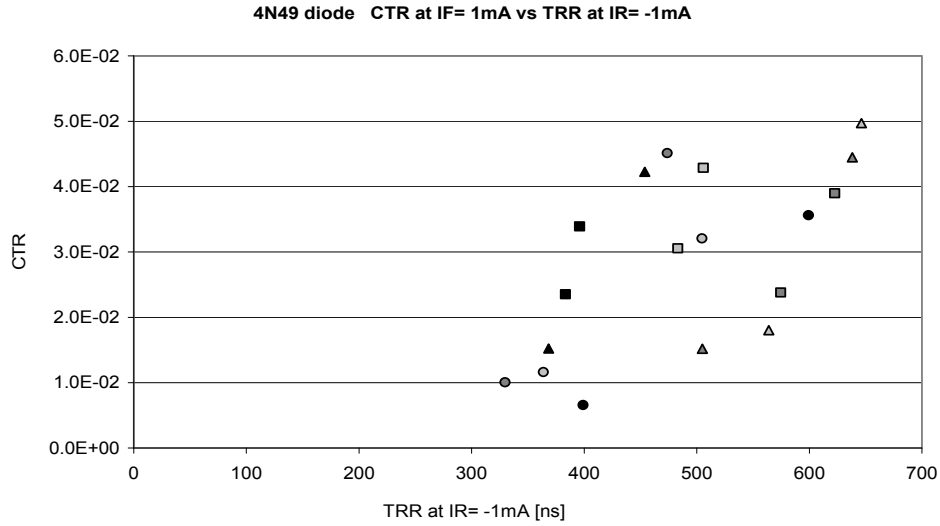
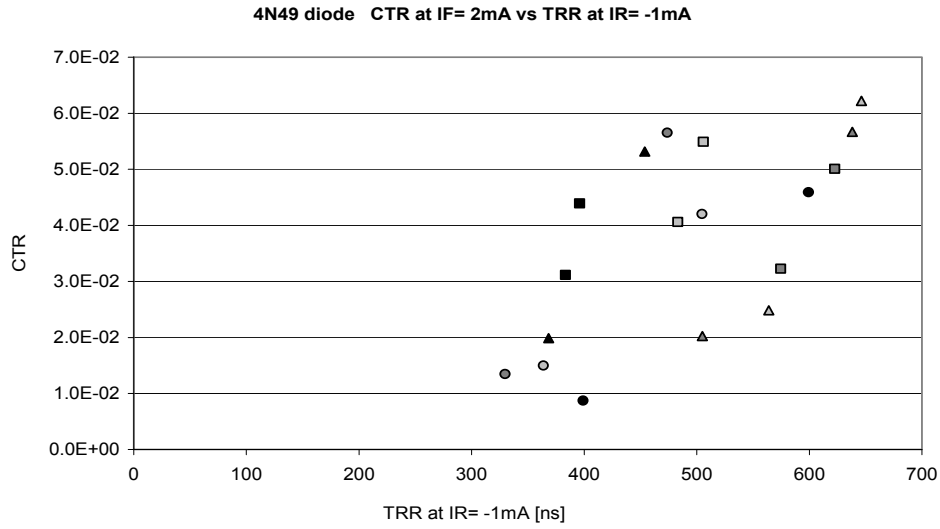
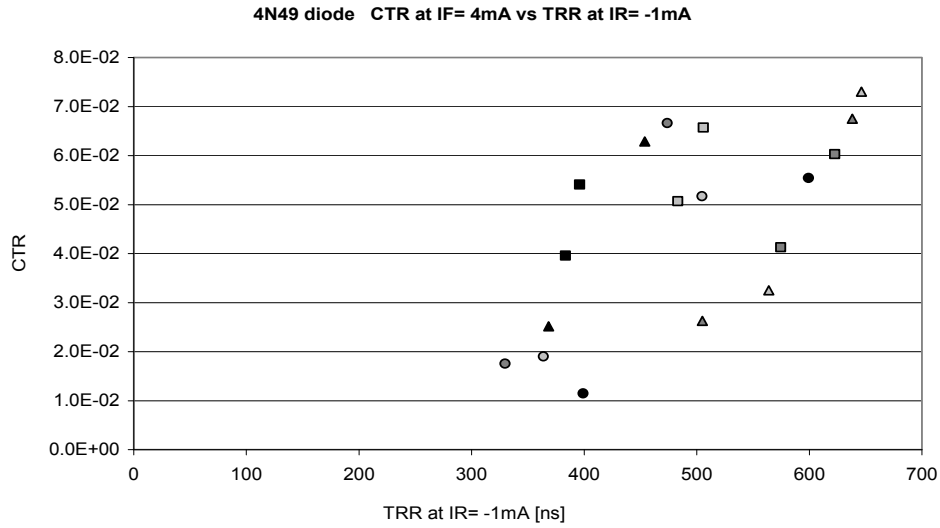
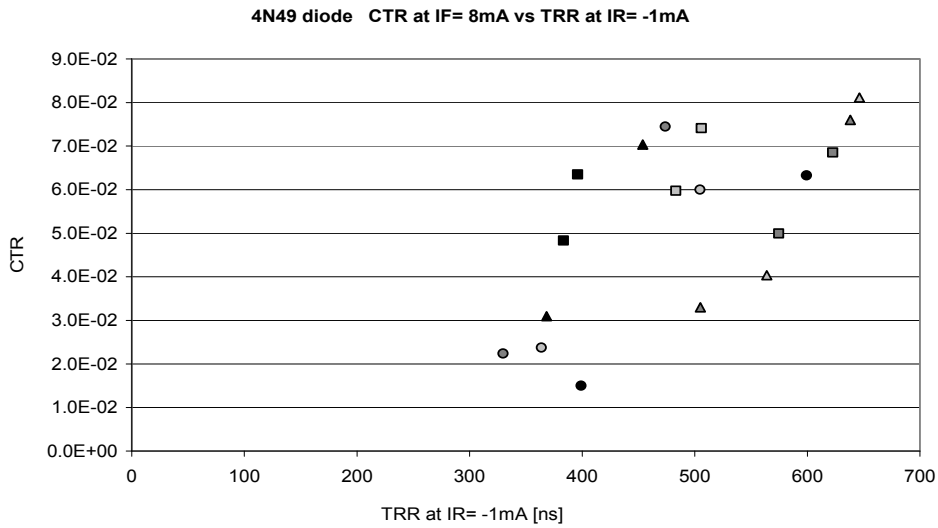


Fig. 12-157: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -1mA [ns]

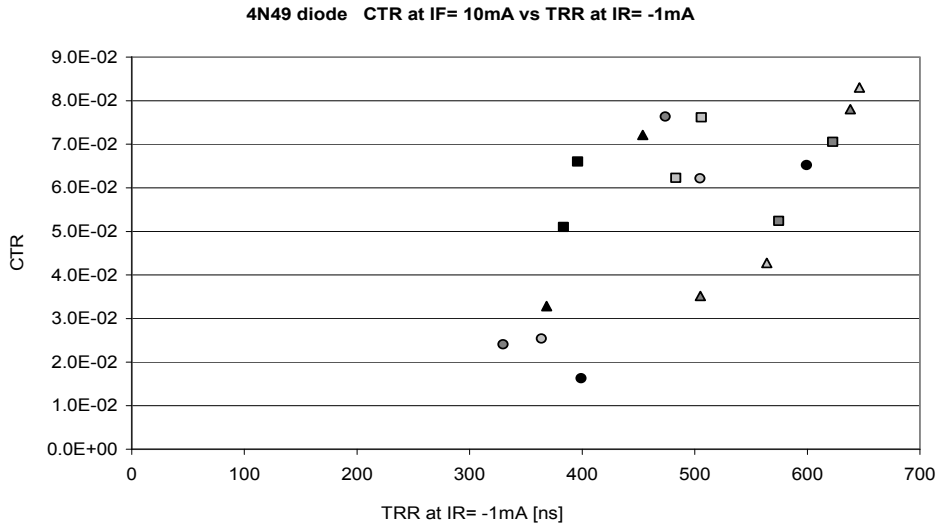
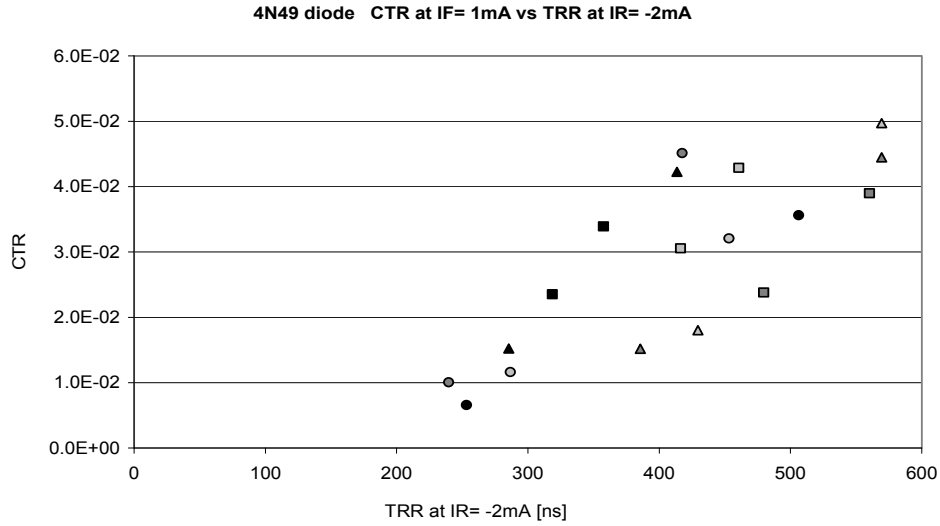
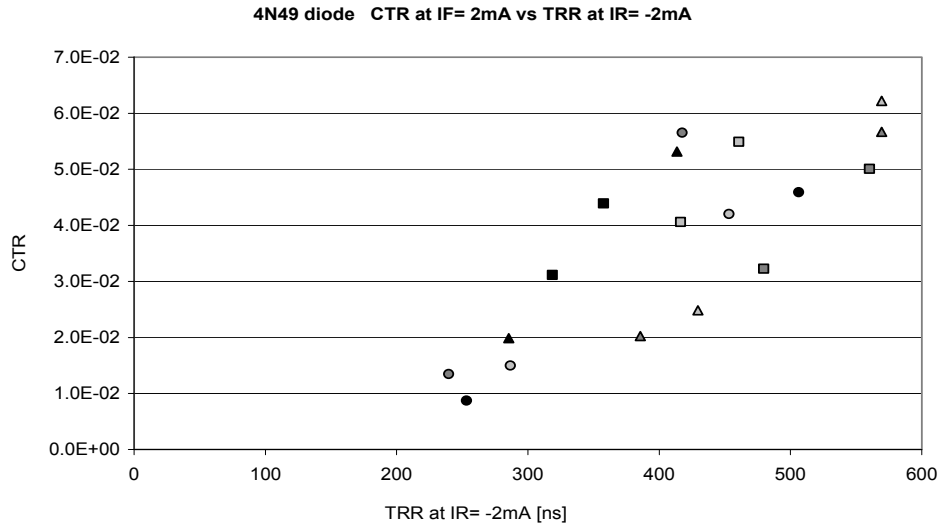
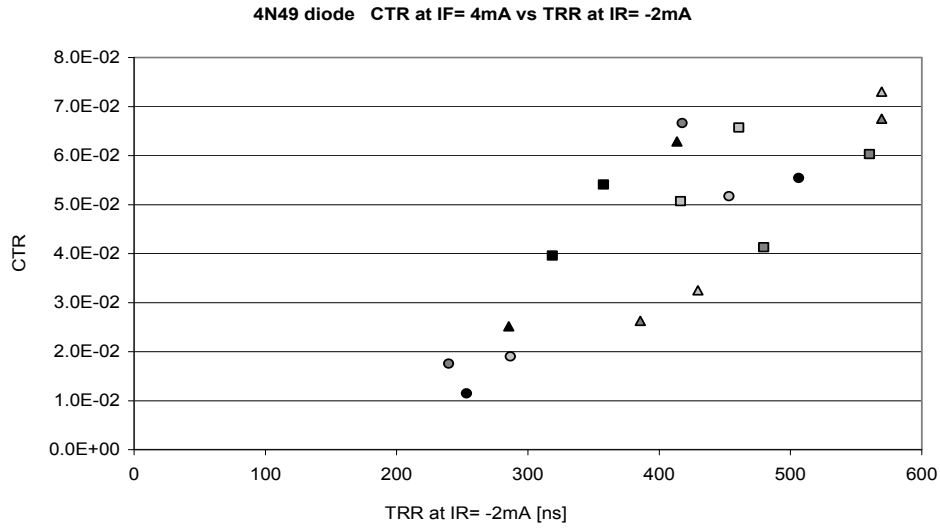
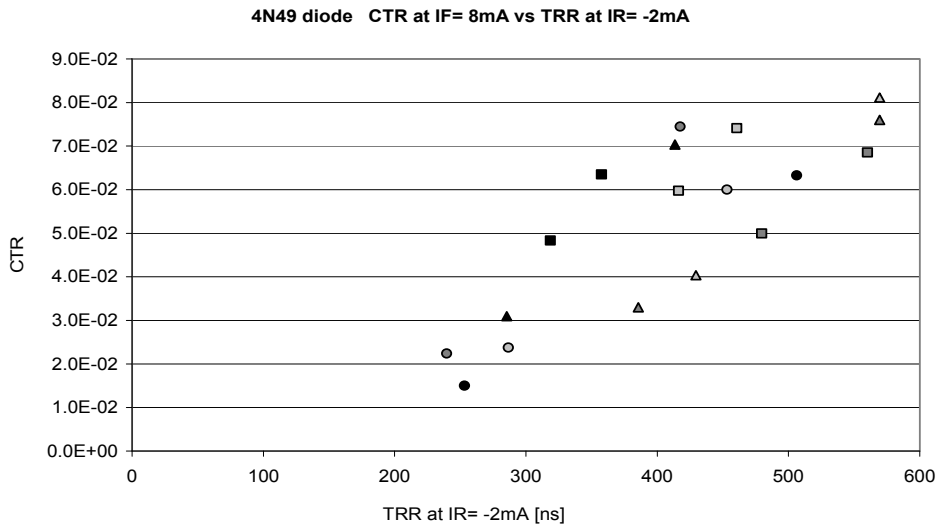

4N49 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -1mA [ns]

Fig. 12-158: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -2mA [ns]

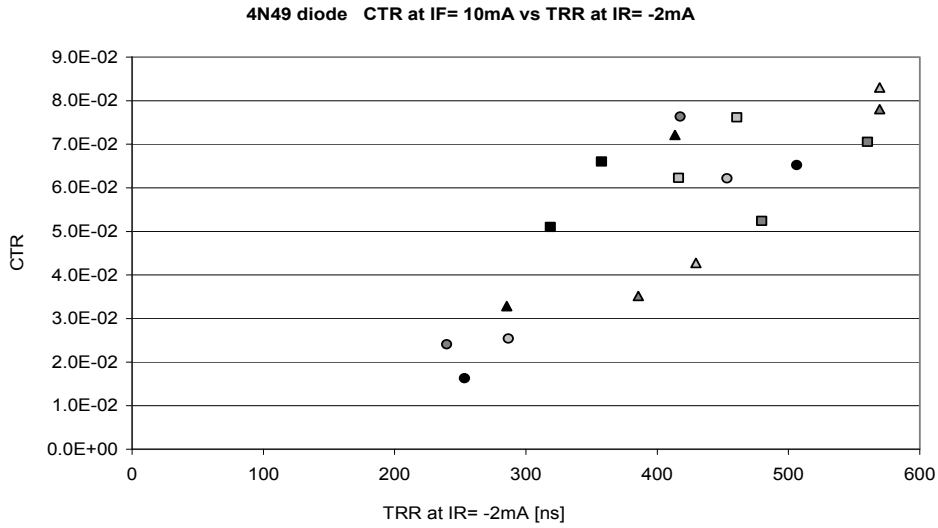
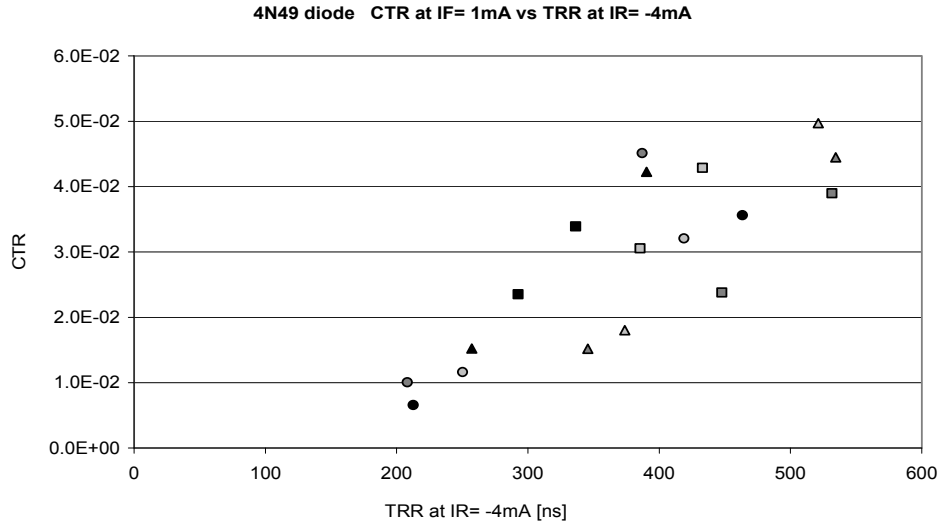
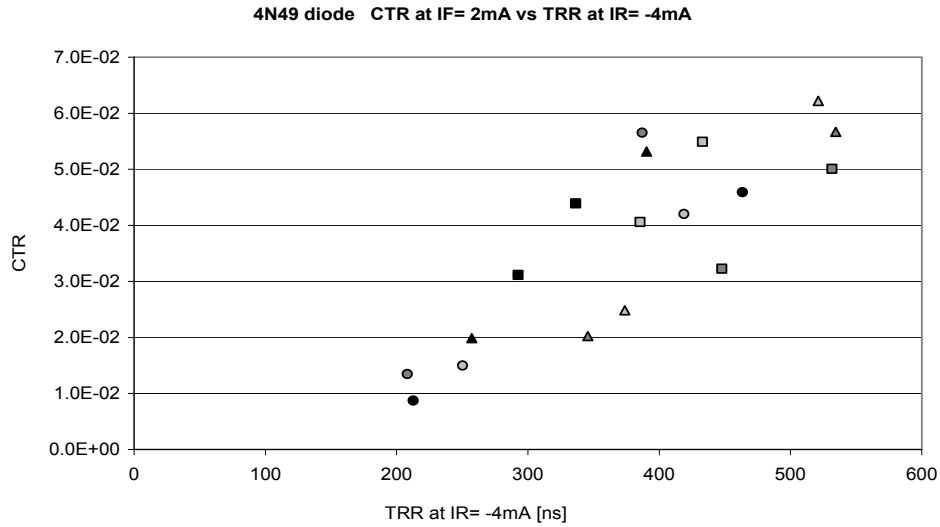
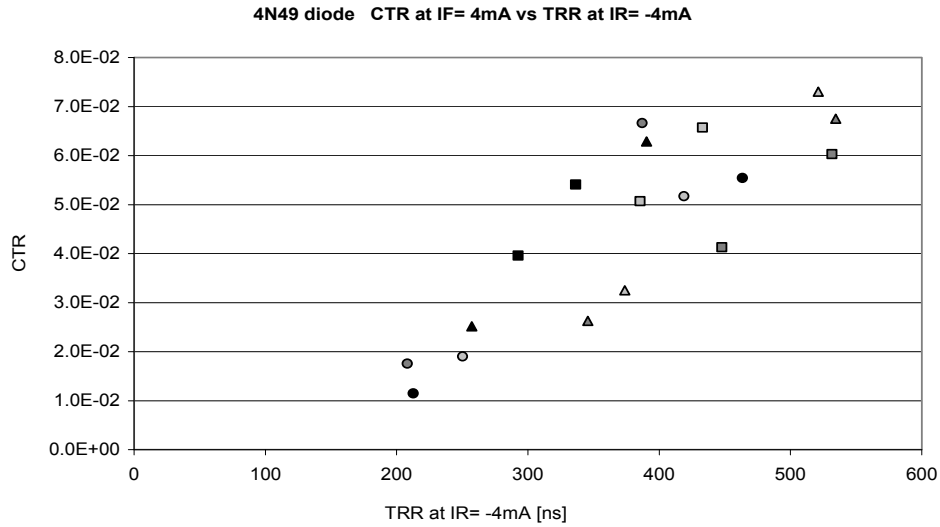
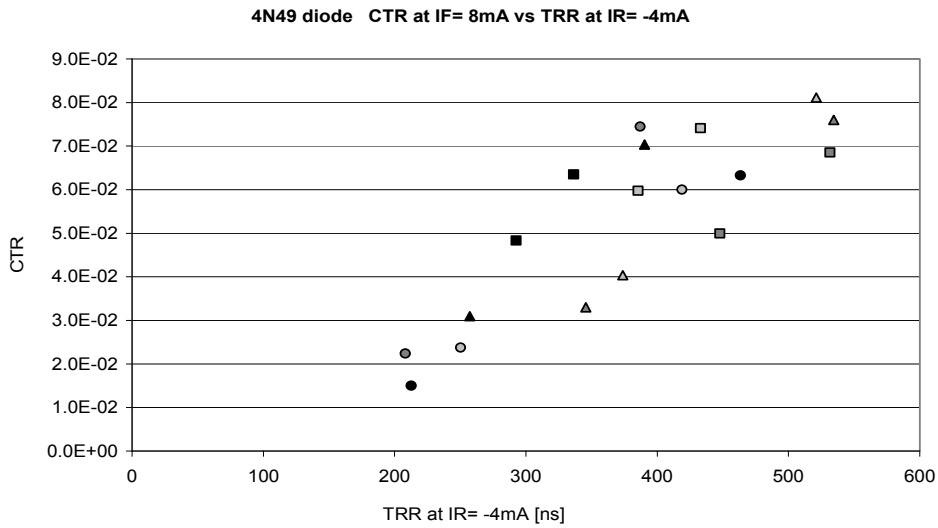

4N49 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -2mA [ns]

Fig. 12-159: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

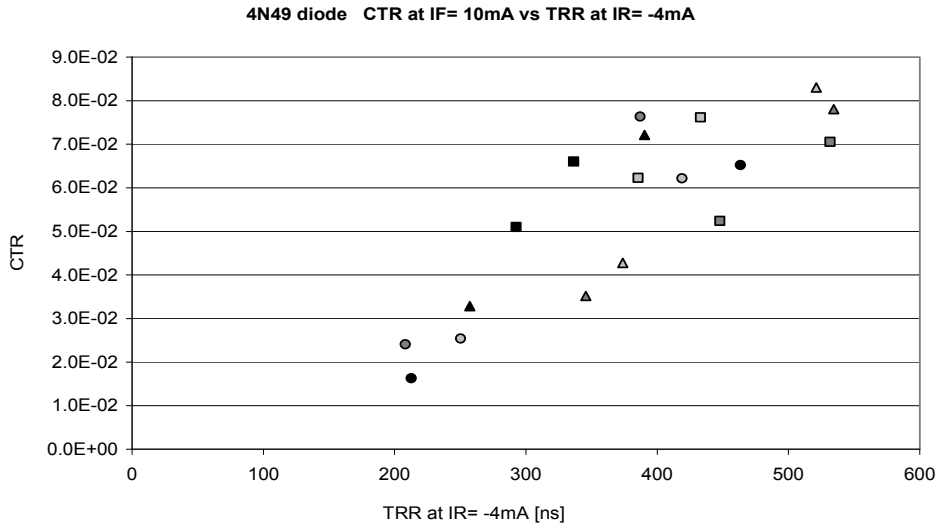
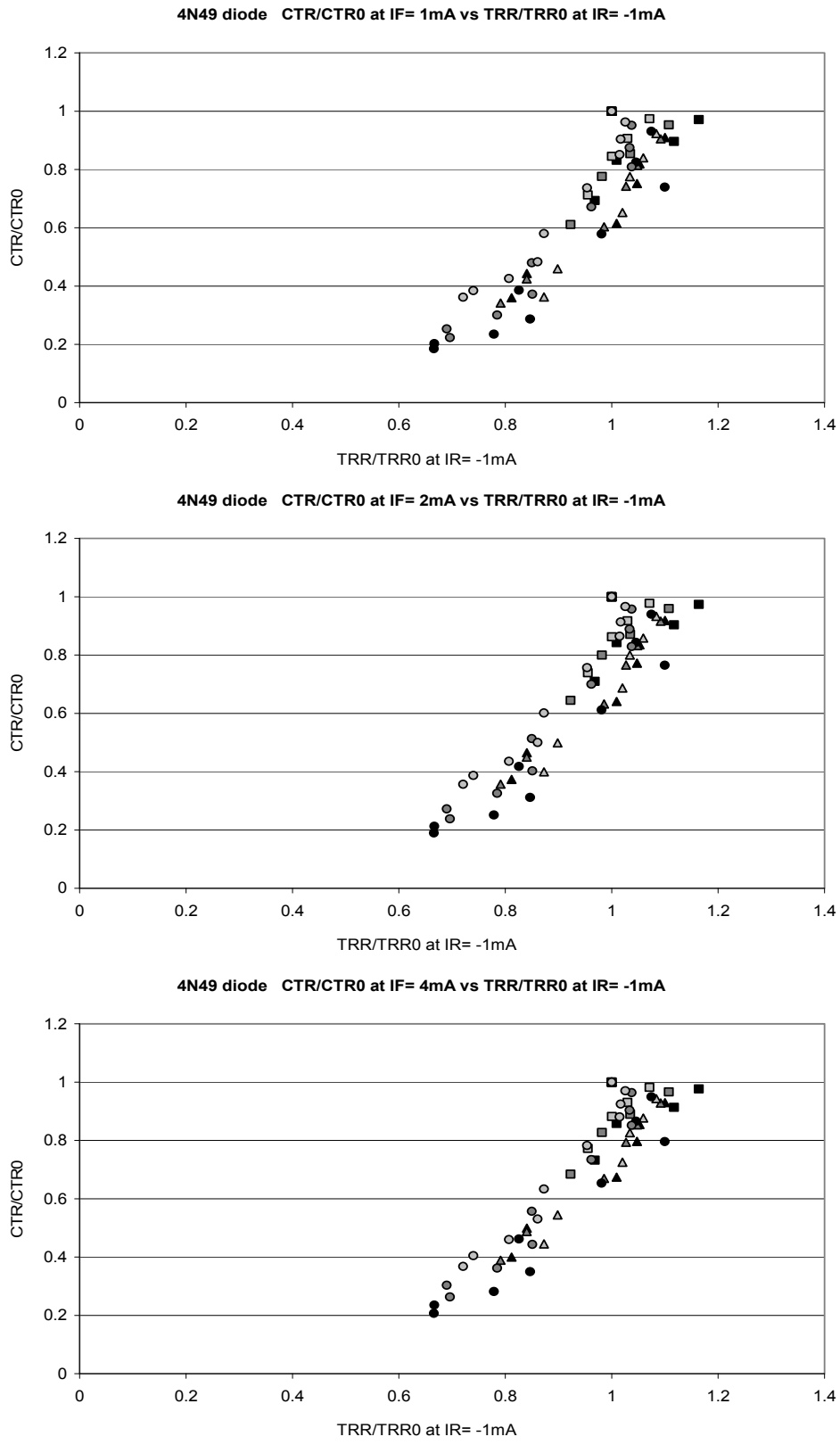
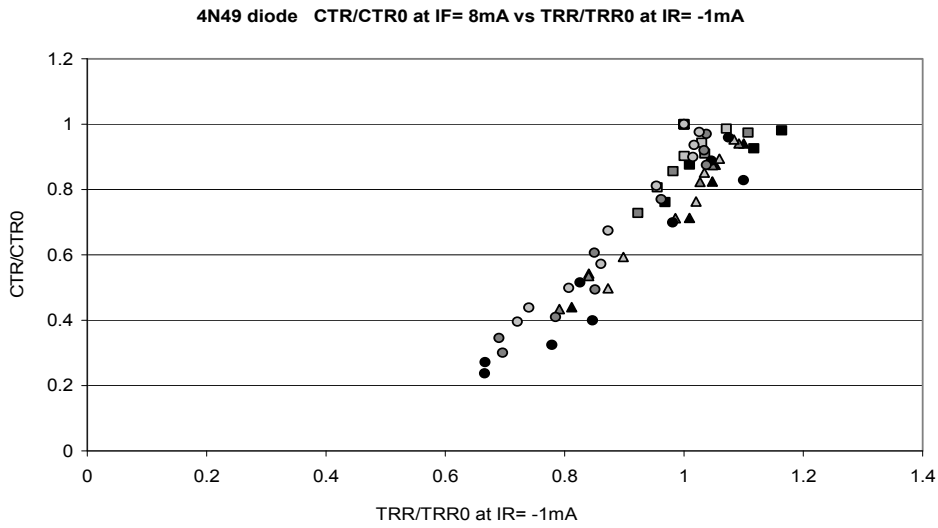

4N49 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

Fig. 12-160: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA




4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

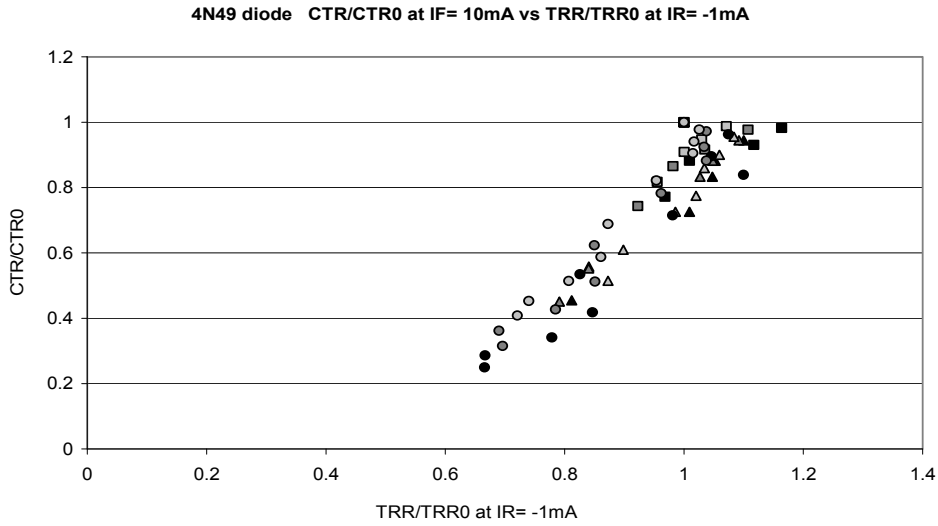
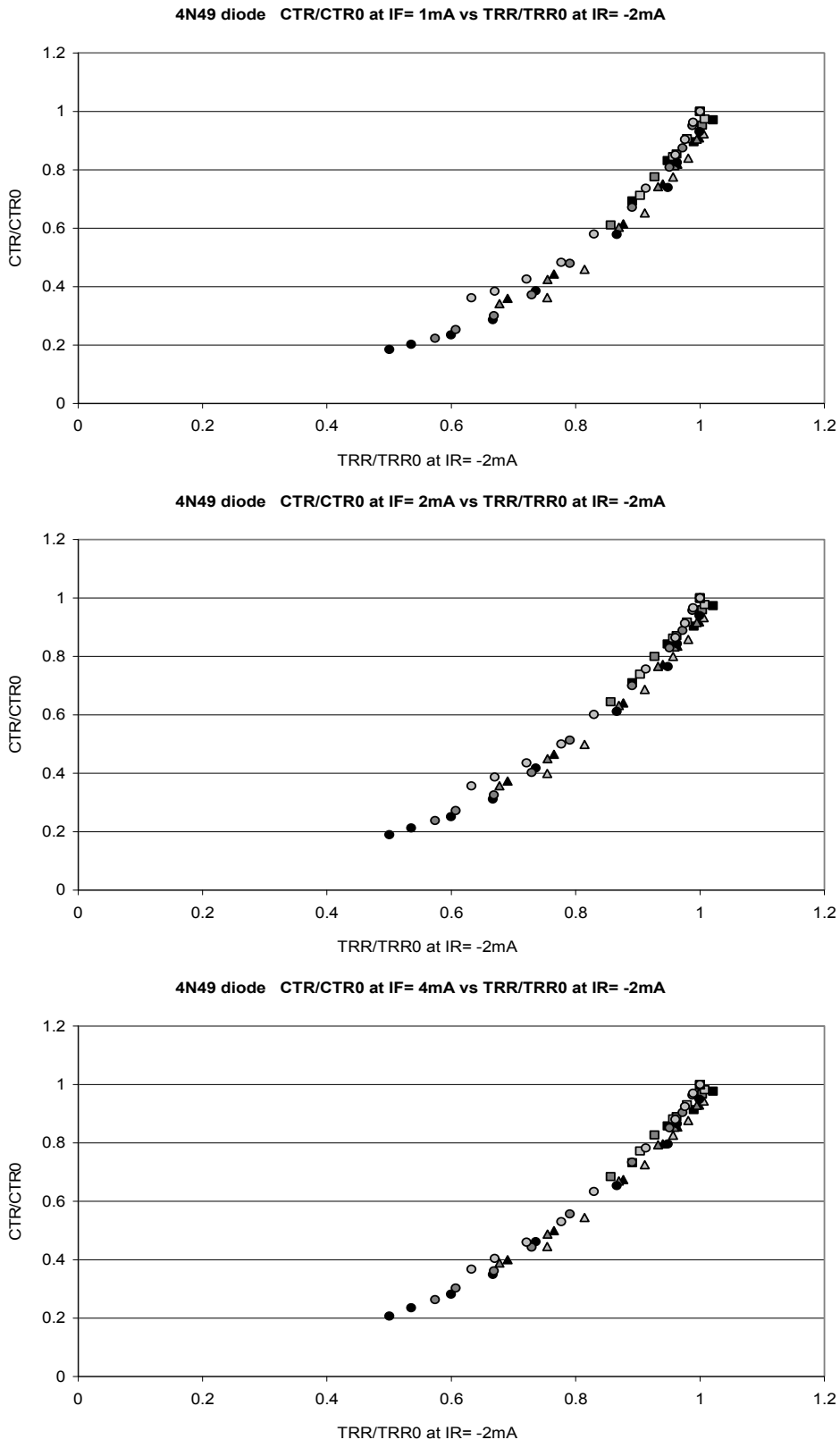
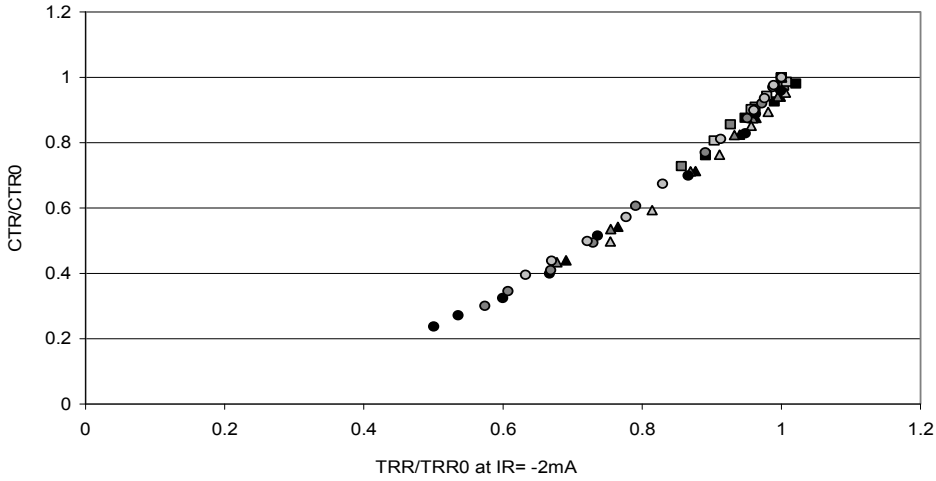

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 12-161: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA



4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA



4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA

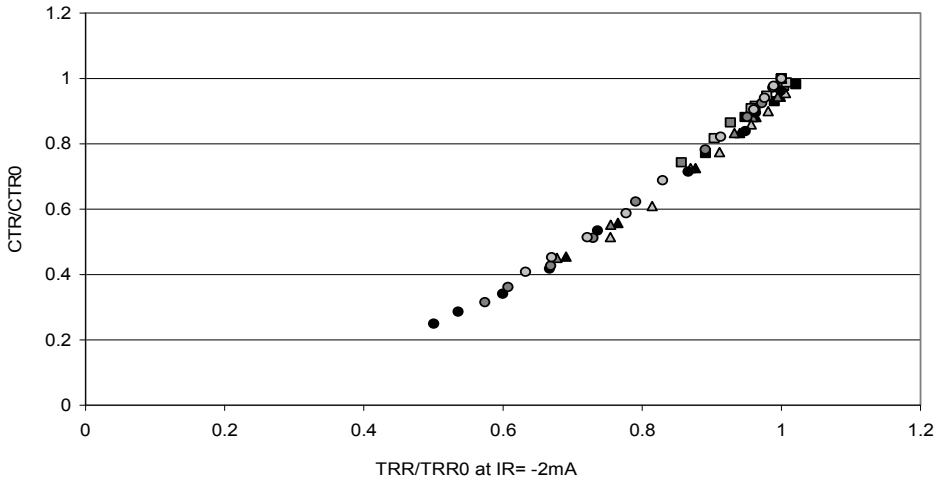
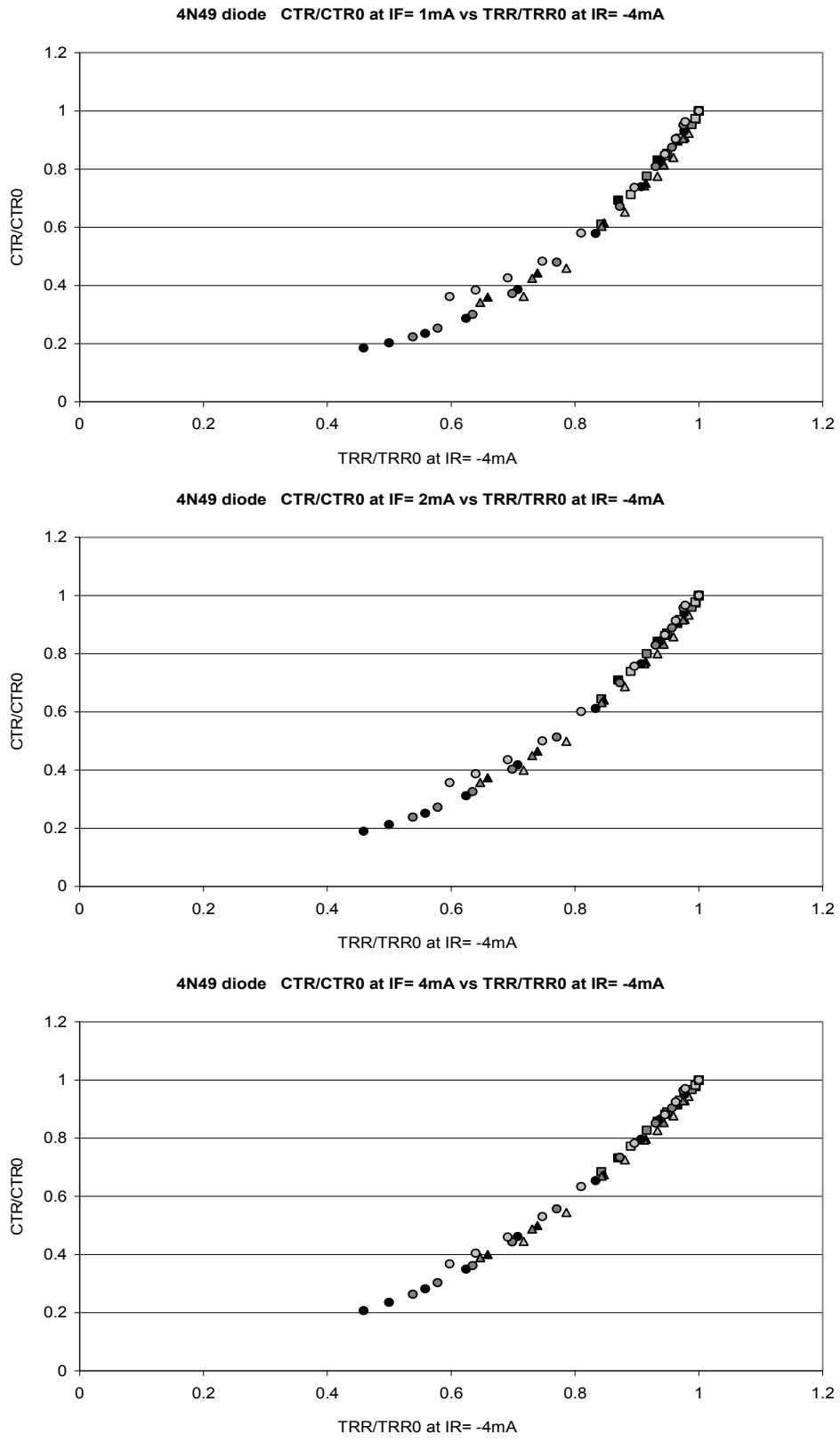
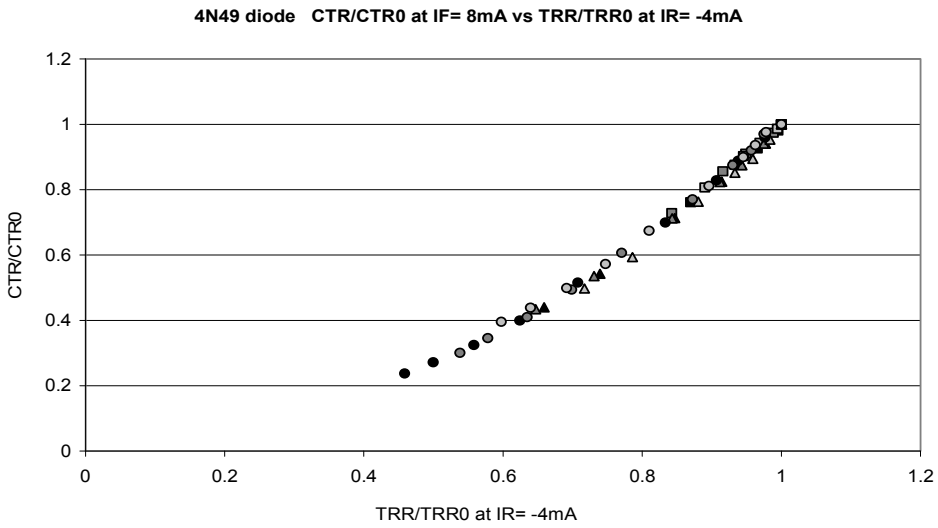


Fig. 12-162: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA




4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2

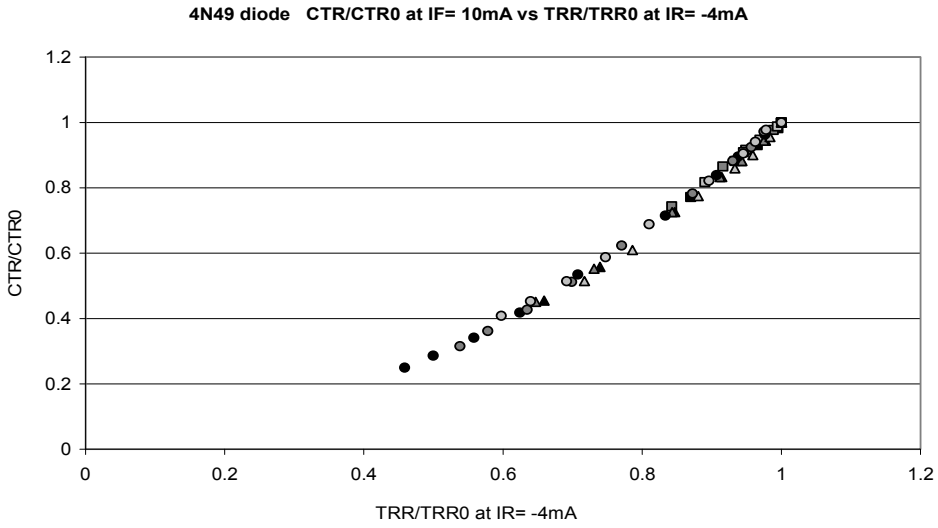
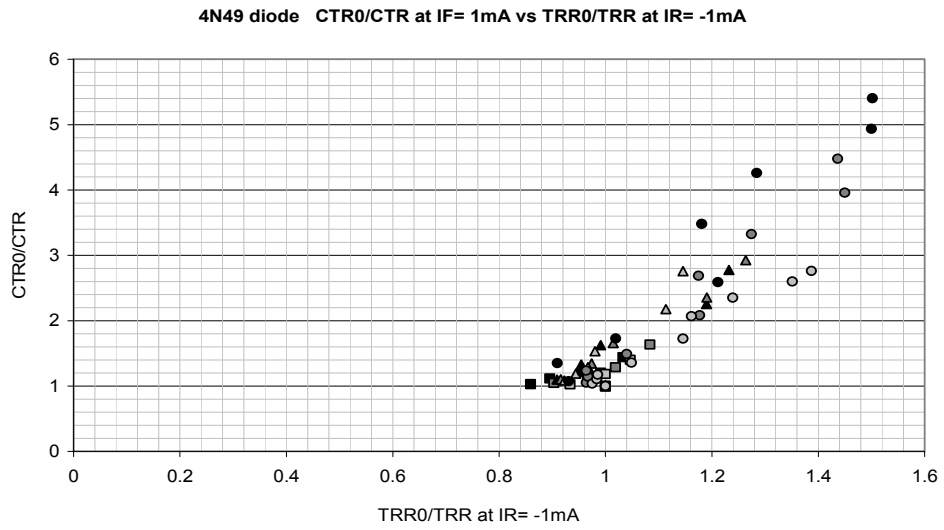
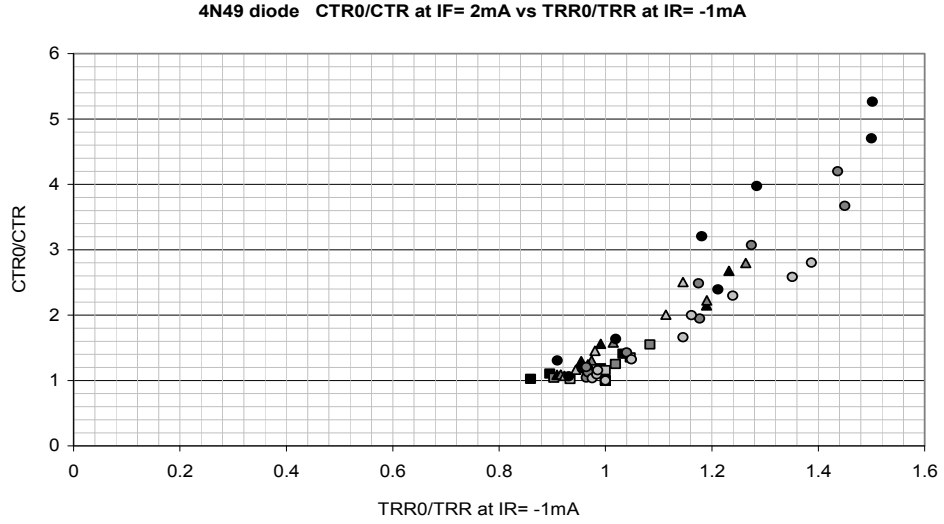
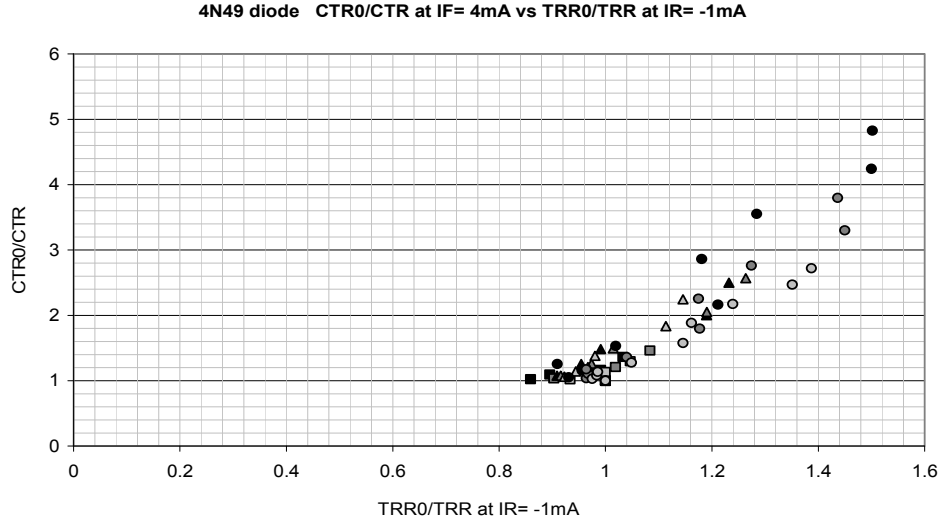
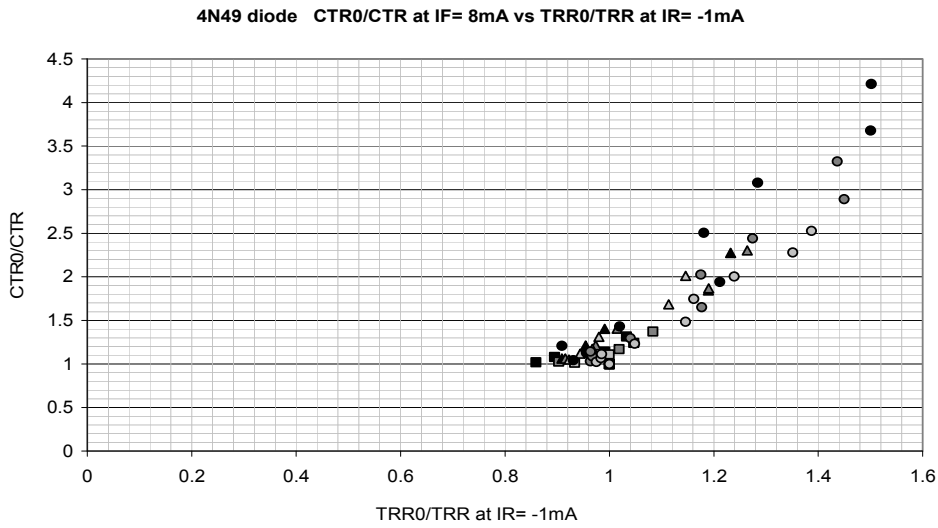

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2

Fig. 12-163: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA








4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
TRR0/TRR at IR= -1mA
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0.2
0.4
0.6
0.8
1.2
1.4
1.6

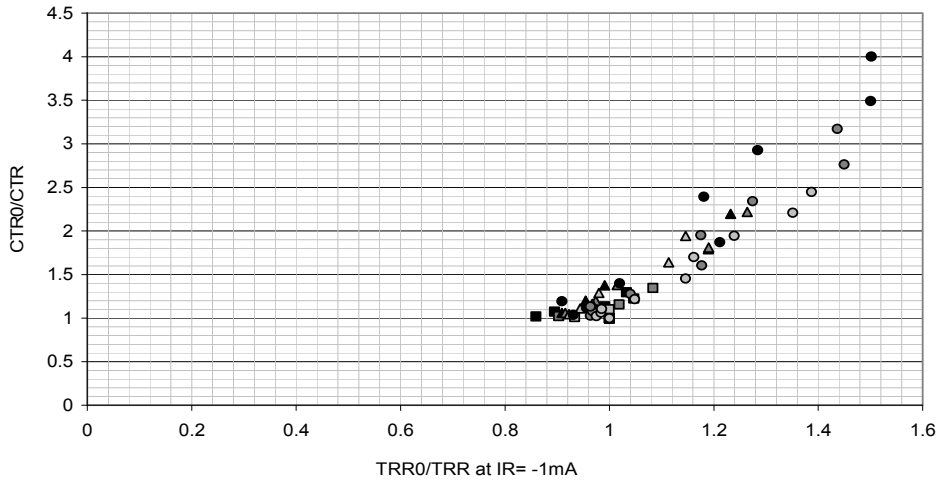
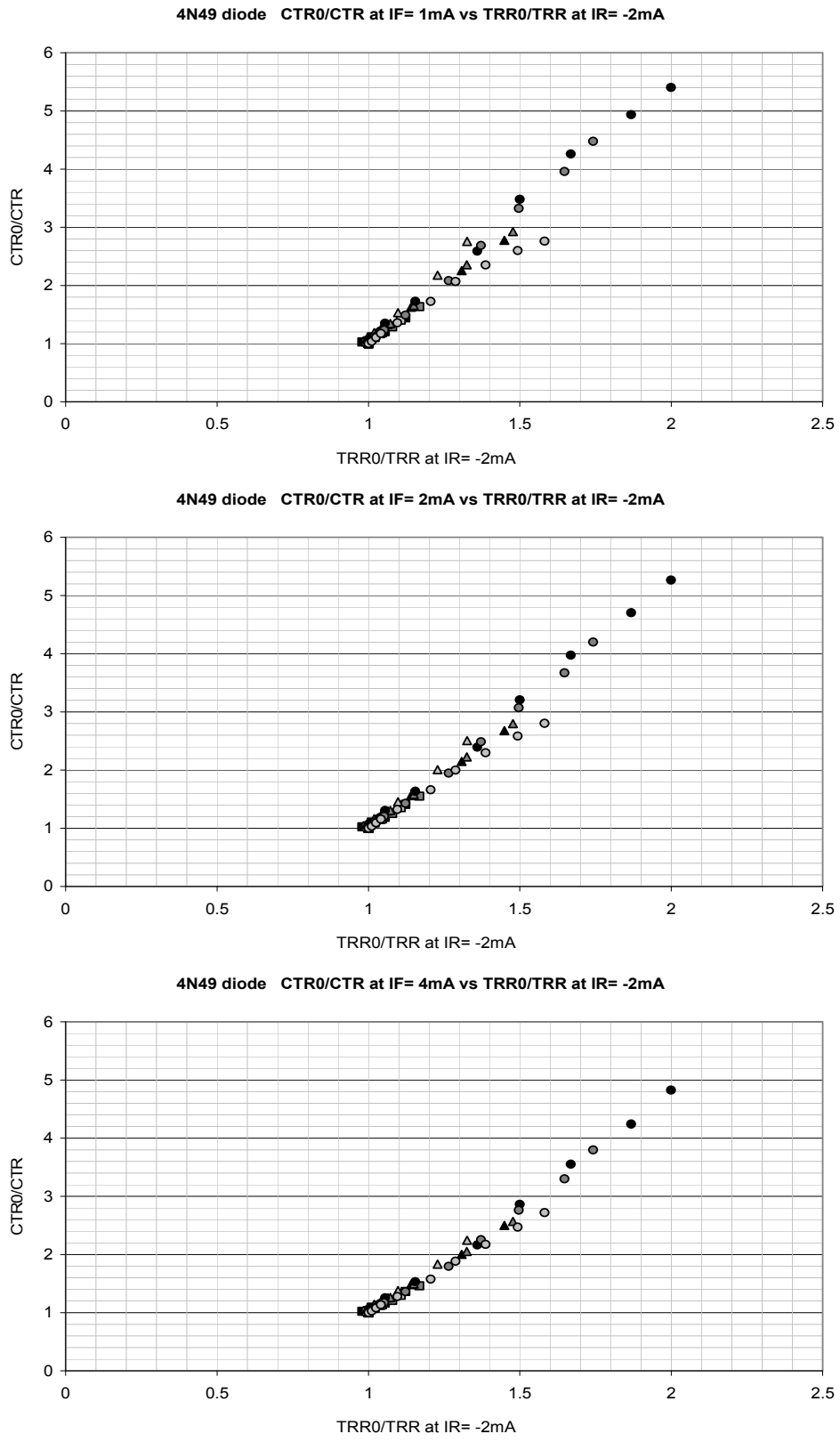
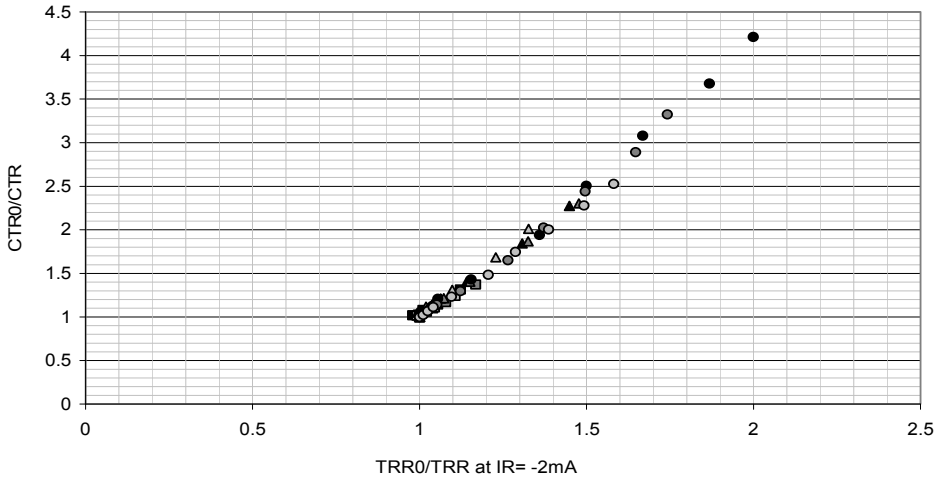

4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
TRR0/TRR at IR= -1mA
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0.2
0.4
0.6
0.8
1.2
1.4
1.6

Fig. 12-164: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

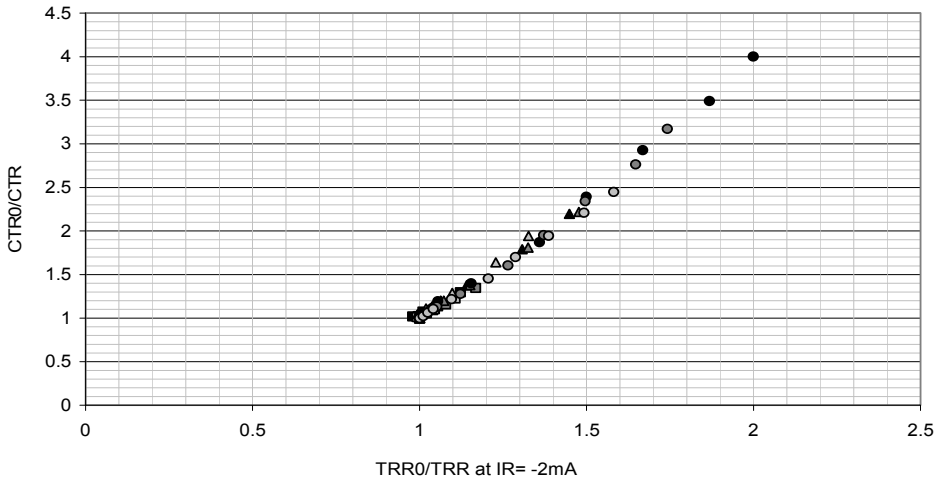
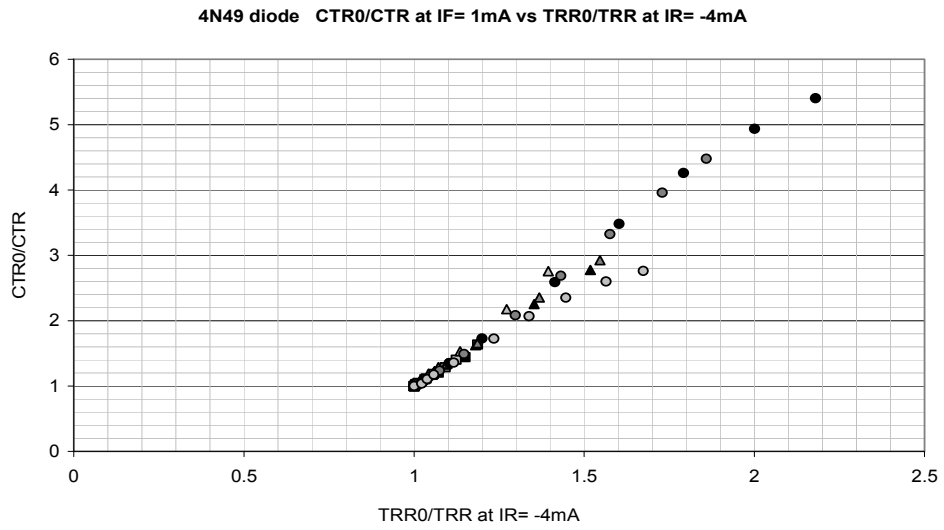
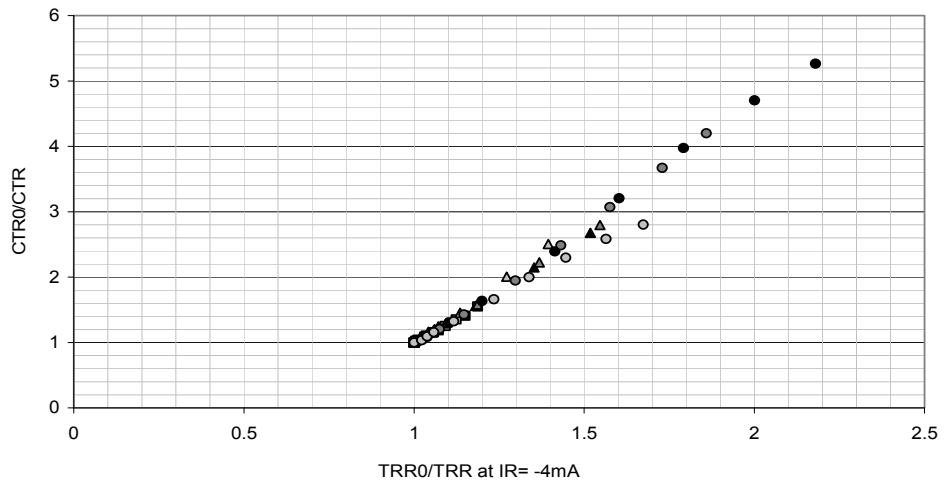
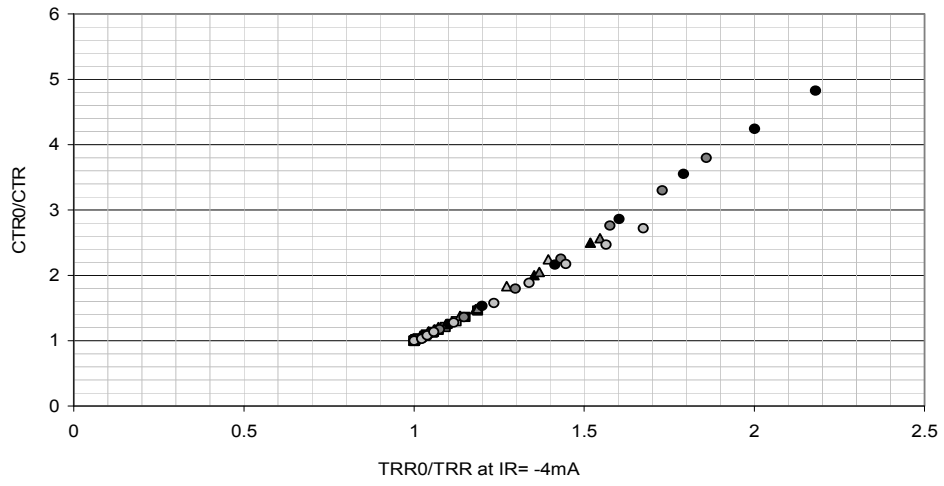


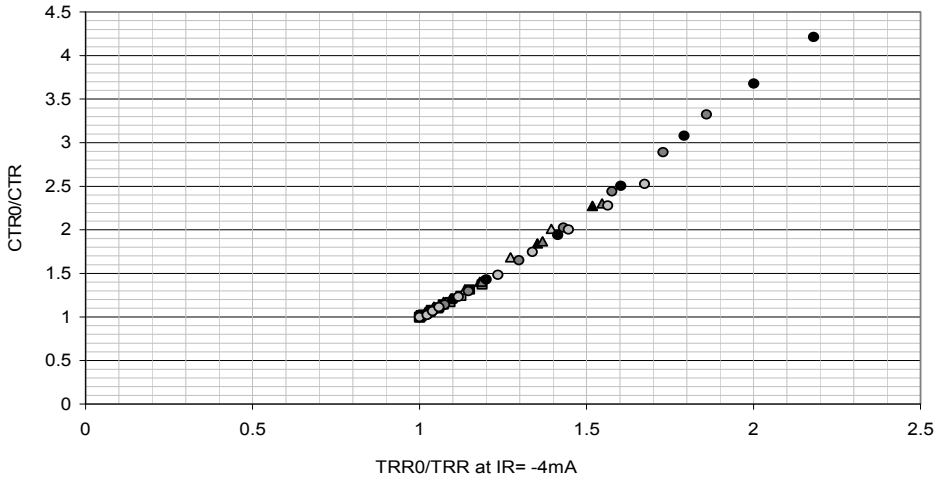
Fig. 12-165: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

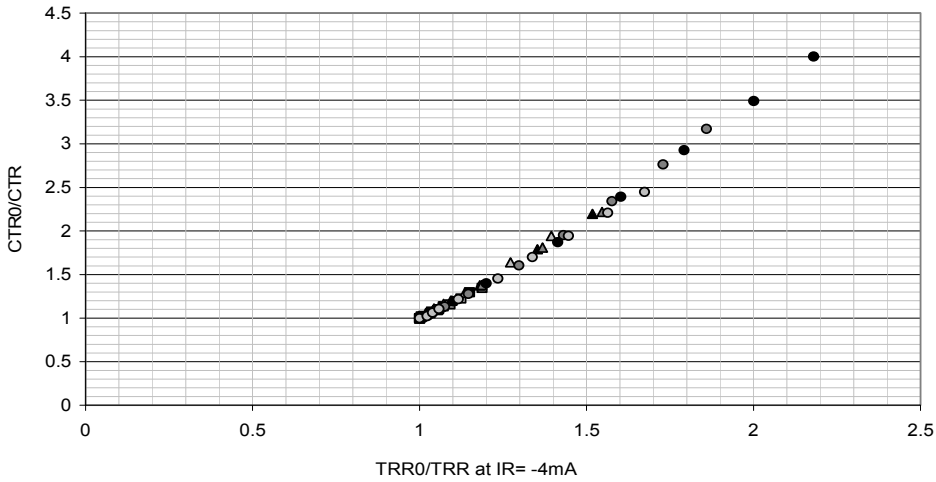
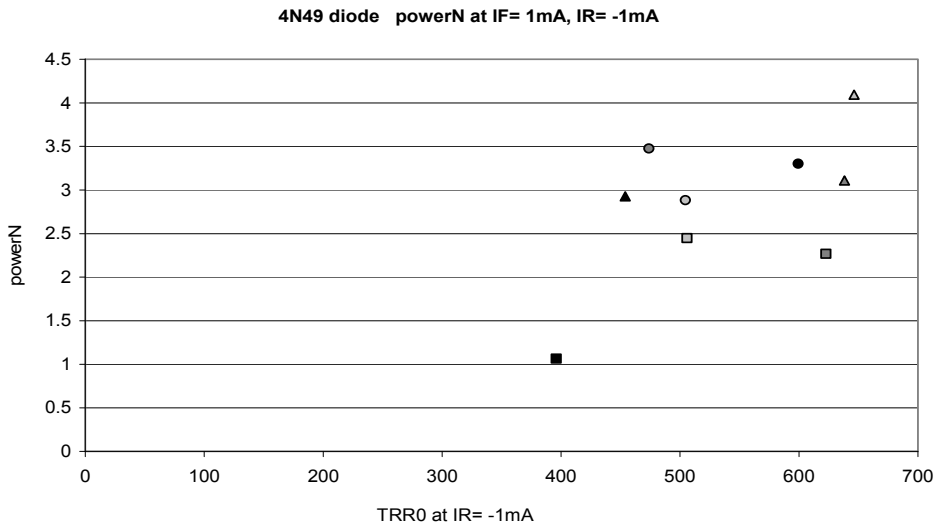
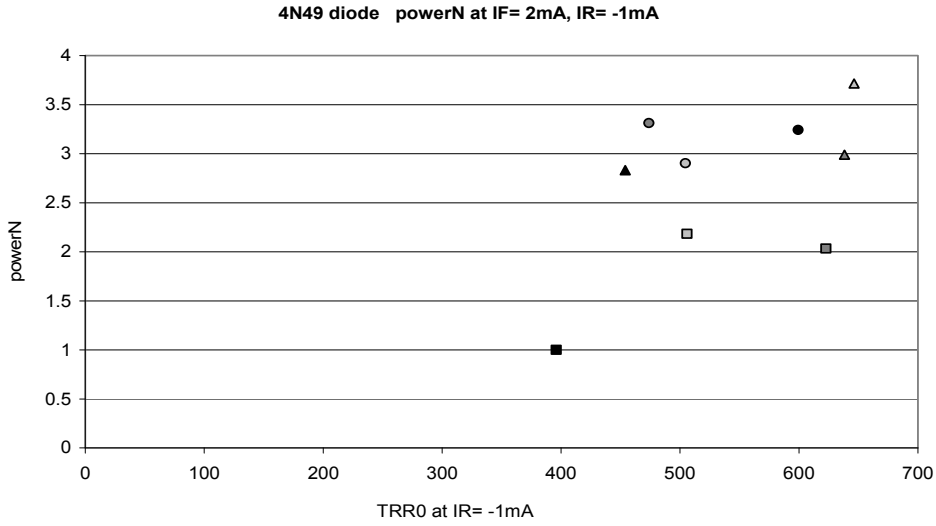
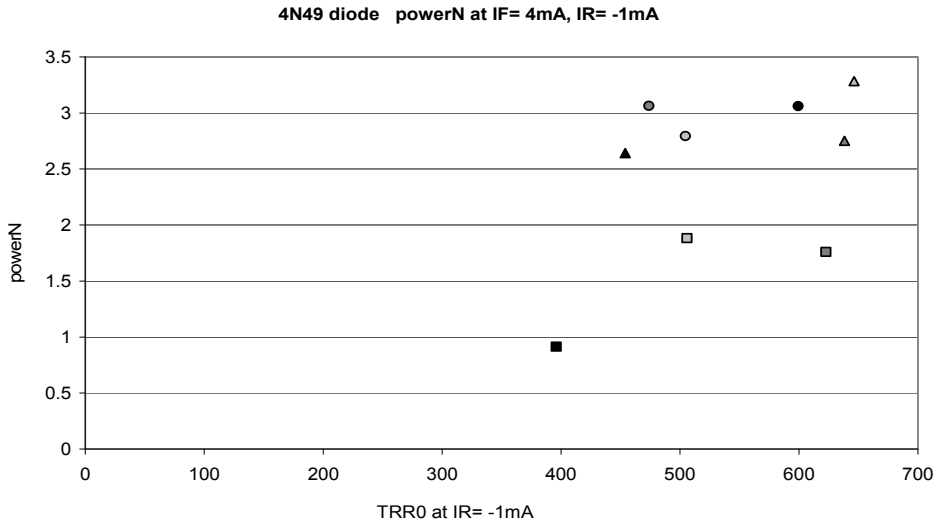
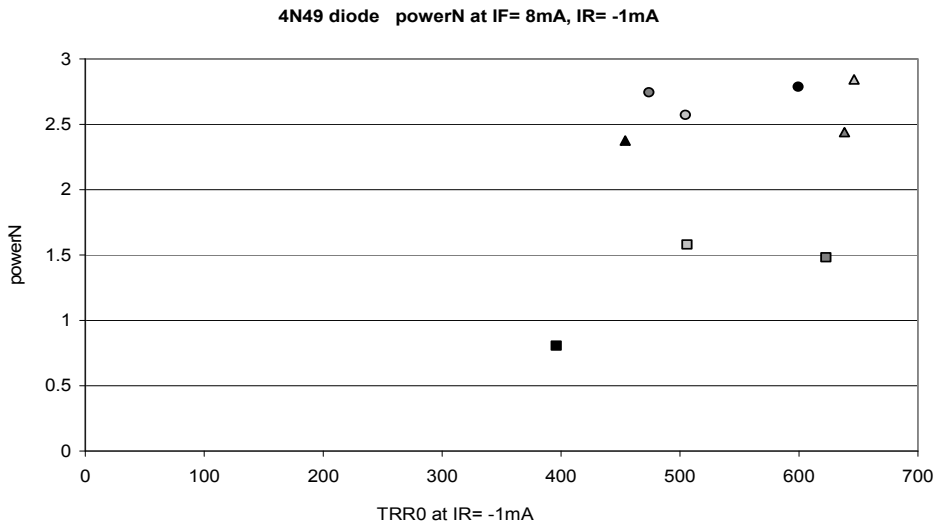


Fig. 12-166: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








4N49 diode powerN at IF= 8mA, IR= -1mA
powerN
TRR0 at IR= -1mA
0
0.5
1
1.5
2
2.5
3
0
100
200
300
400
500
600
700

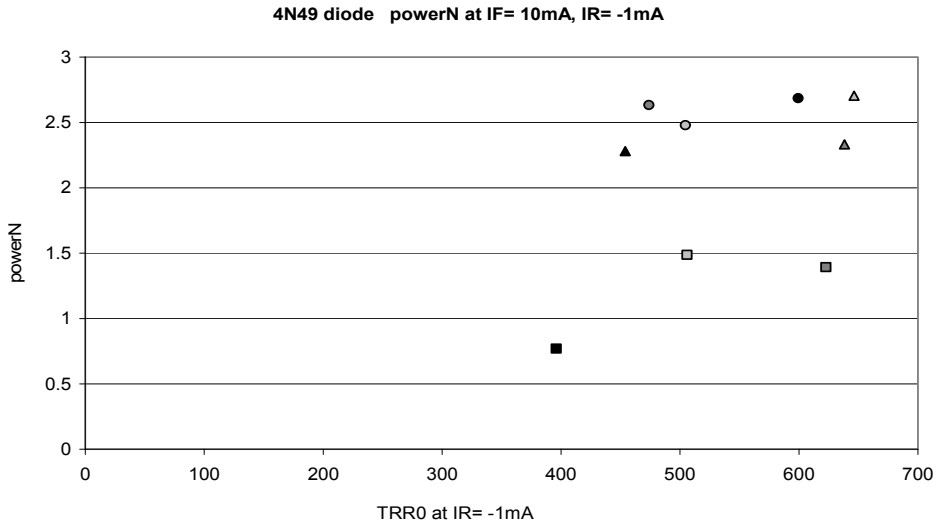
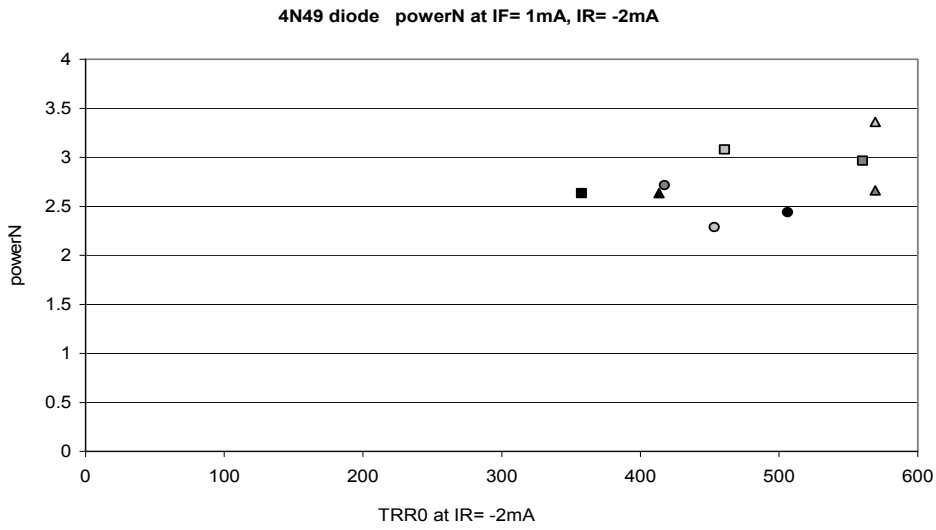
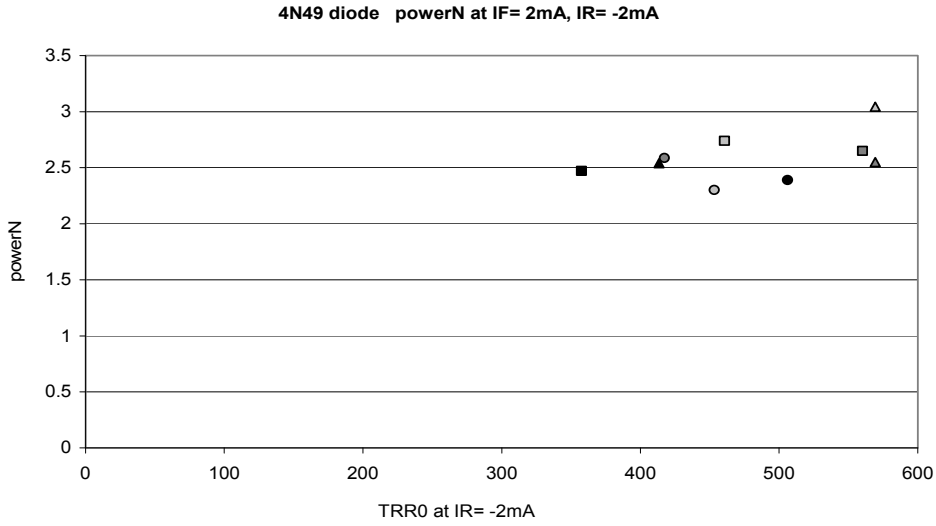
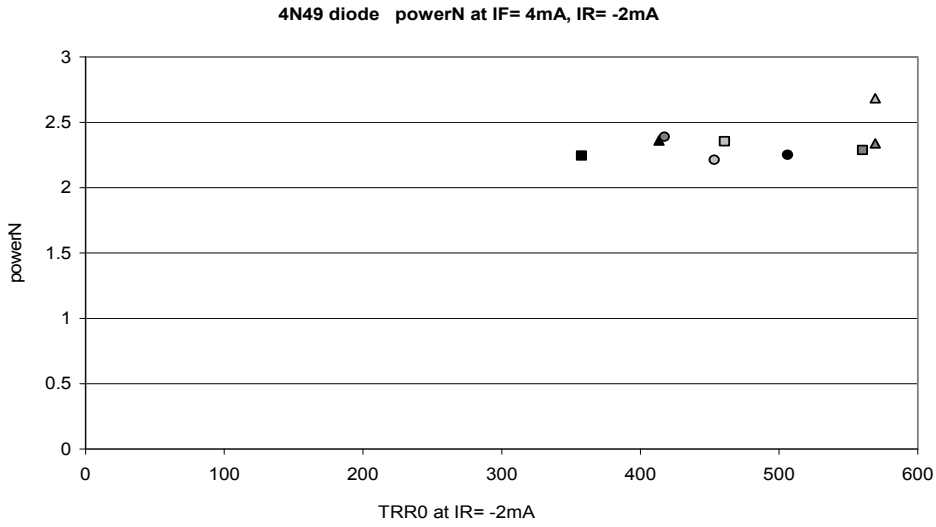
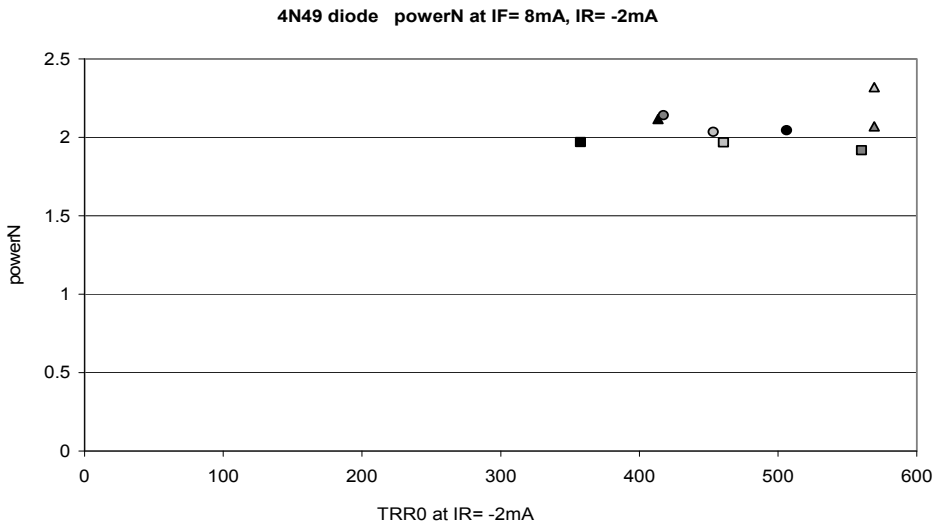

4N49 diode powerN at IF= 10mA, IR= -1mA
powerN
TRR0 at IR= -1mA
0
0.5
1
1.5
2
2.5
3
0
100
200
300
400
500
600
700

Fig. 12-167: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








4N49 diode powerN at IF= 8mA, IR= -2mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
TRR0 at IR= -2mA

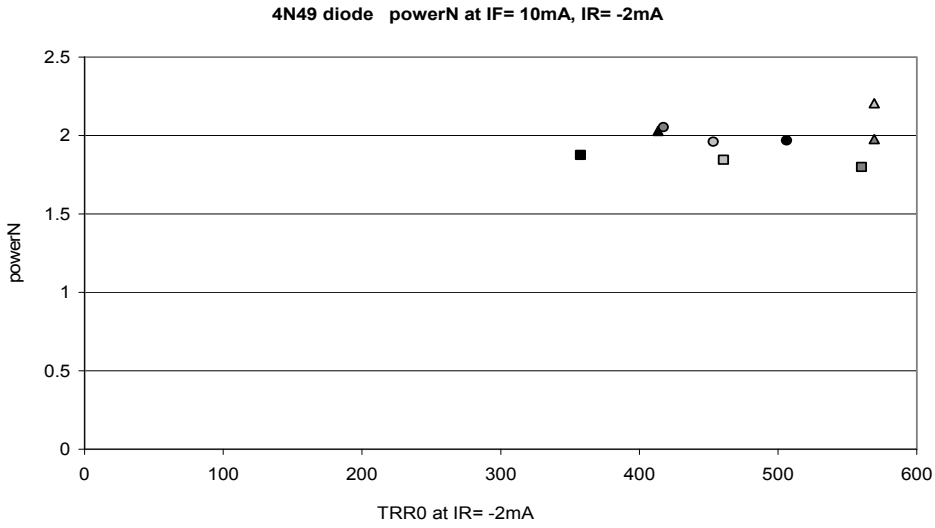
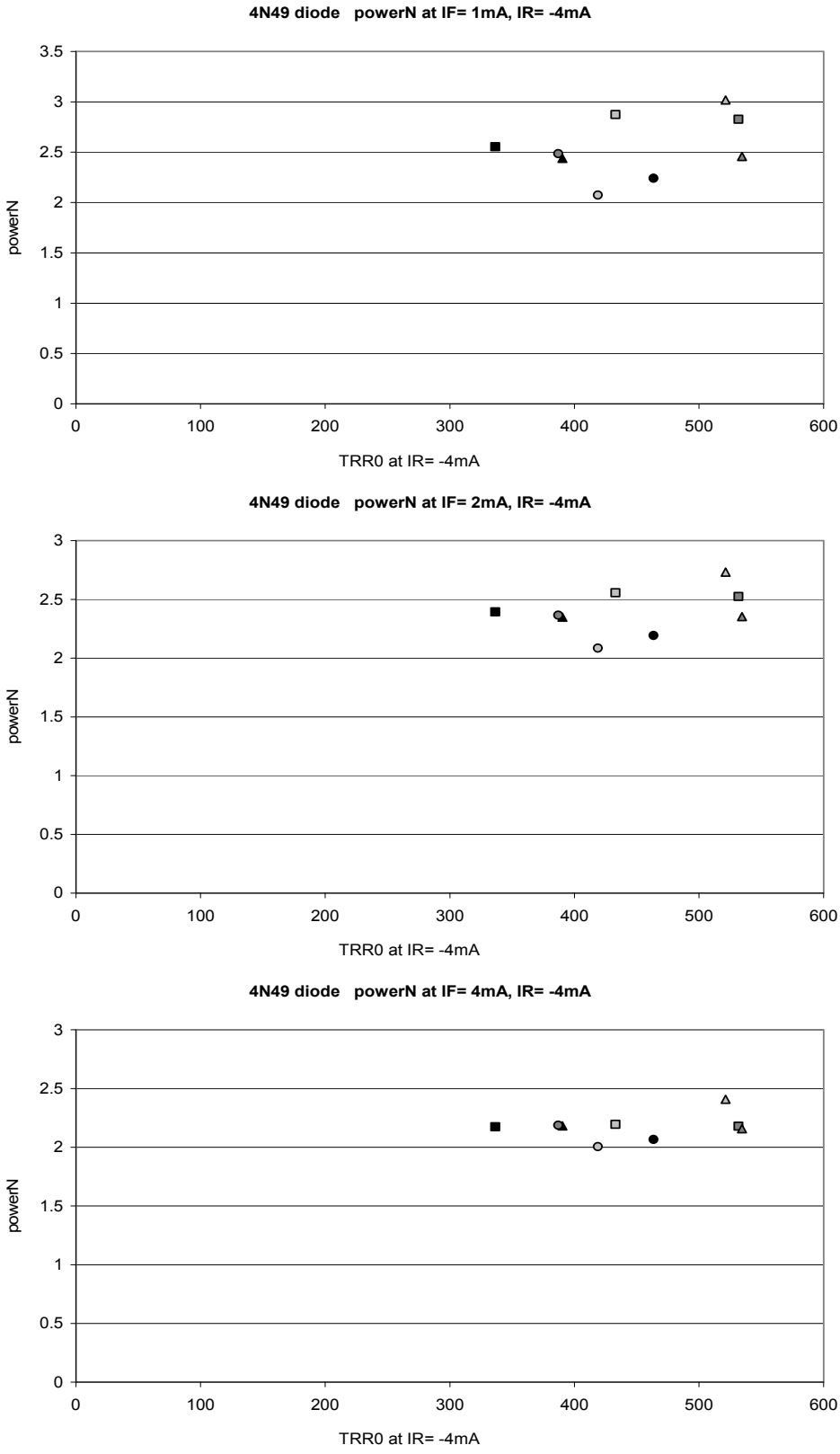
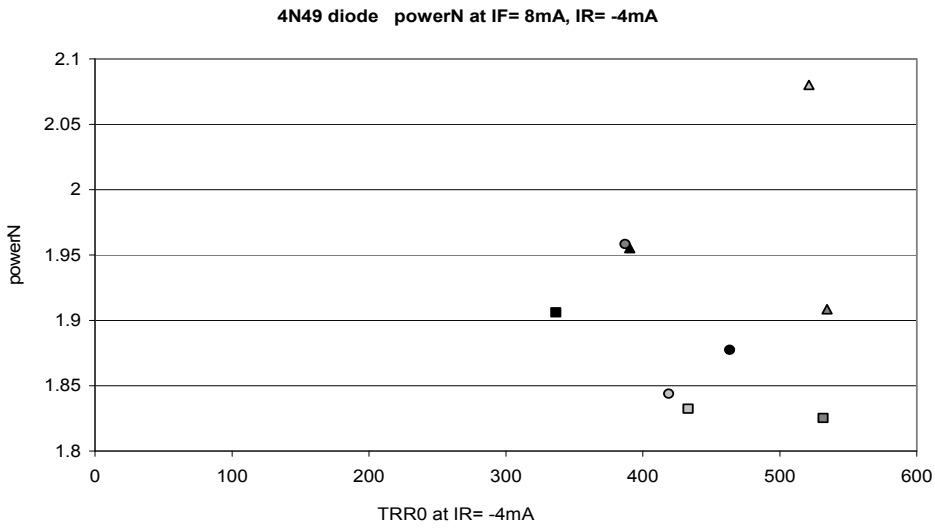
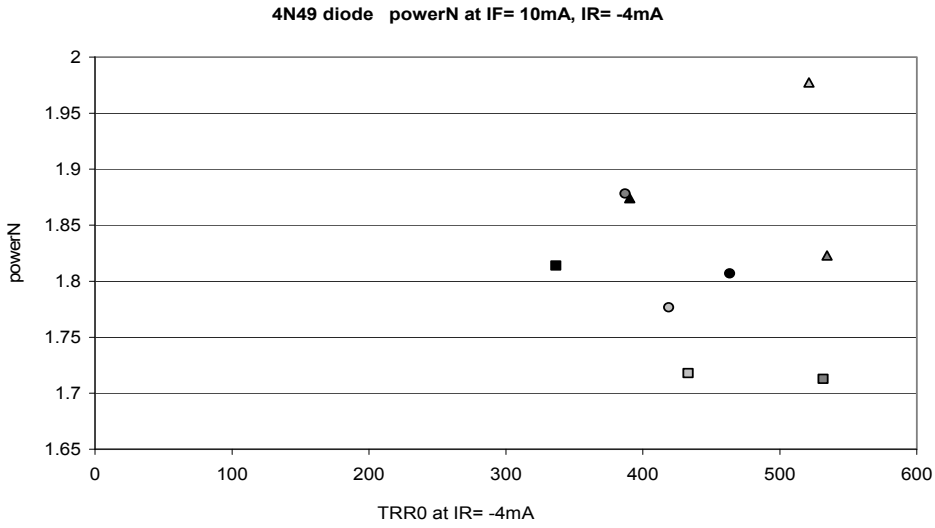

4N49 diode powerN at IF= 10mA, IR= -2mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
TRR0 at IR= -2mA

Fig. 12-168: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA

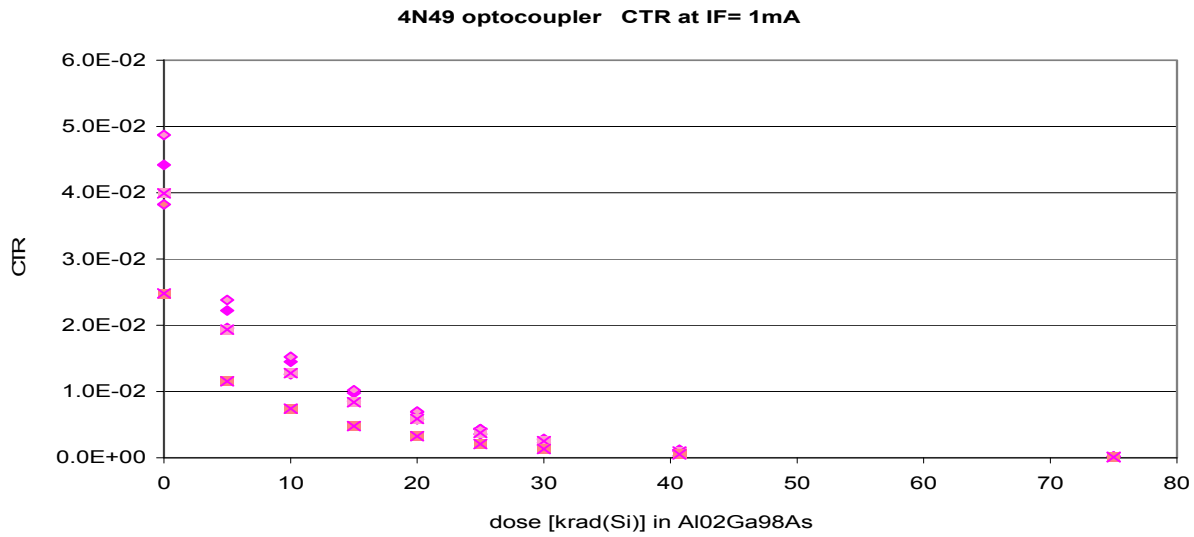


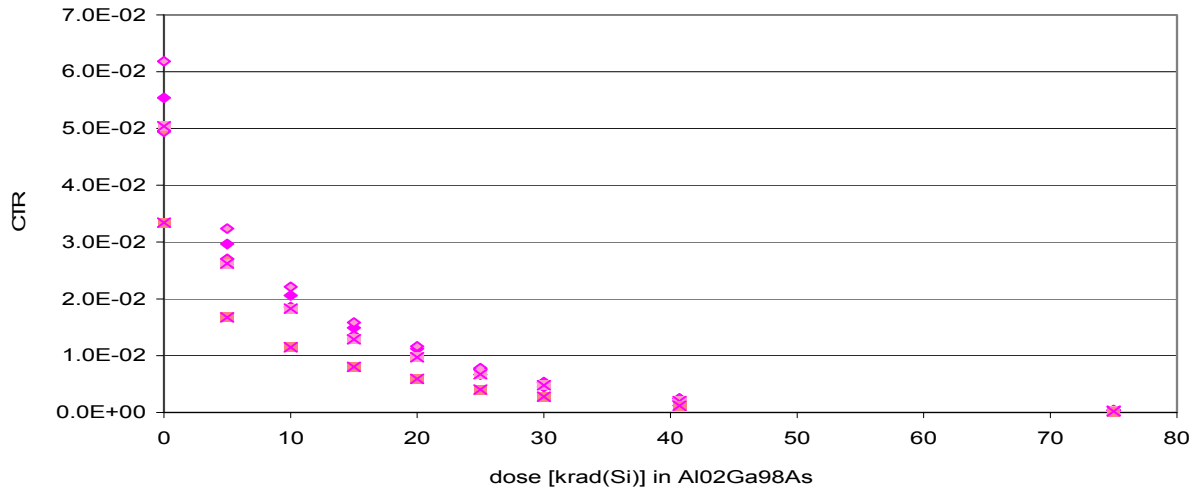

4N49 diode powerN at IF= 8mA, IR= -4mA
powerN
2.1
2.05
2
1.95
1.9
1.85
1.8
0
100
200
300
400
500
600
TRR0 at IR= -4mA

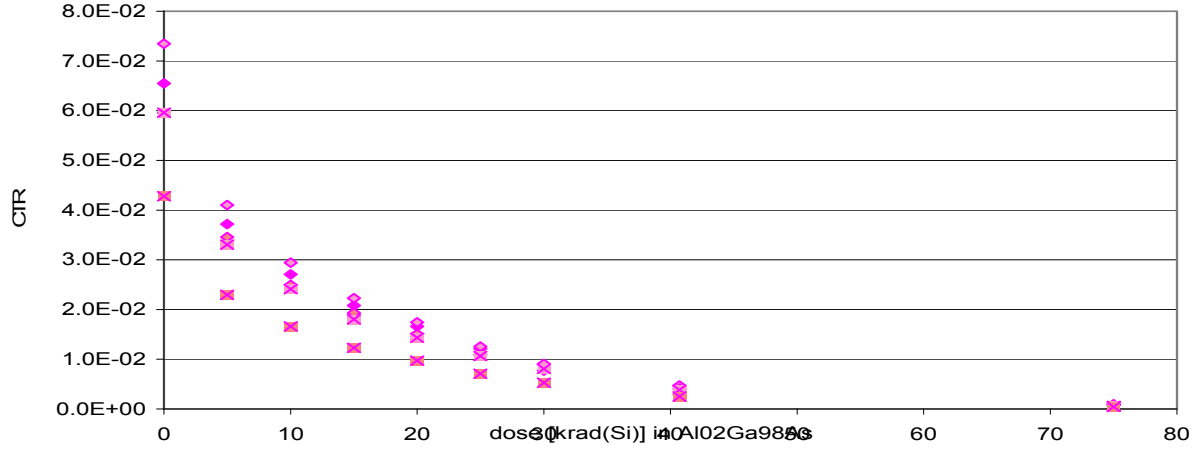

4N49 diode powerN at IF= 10mA, IR= -4mA
powerN
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
0
100
200
300
400
500
600
TRR0 at IR= -4mA

12.3 GAMMA IRRADIATION

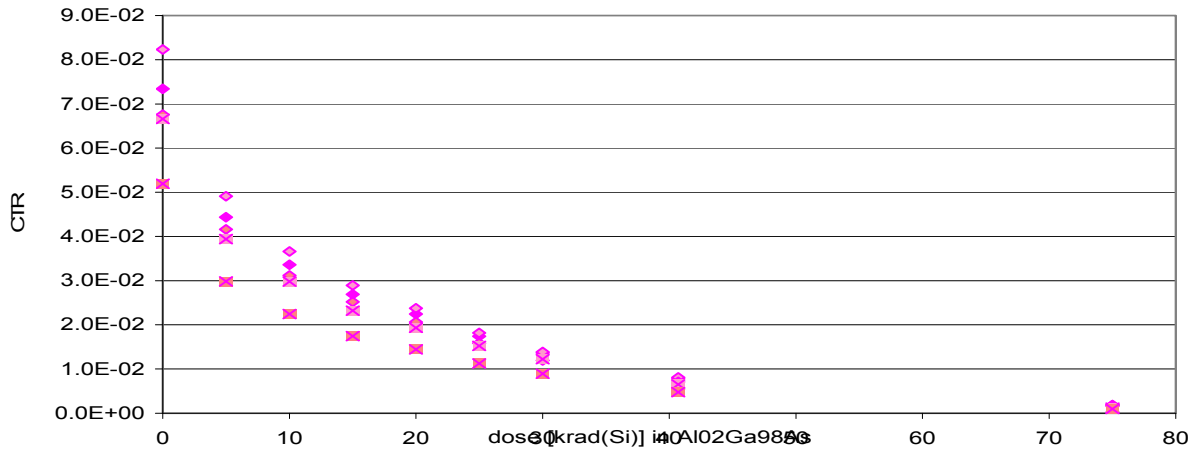
Fig. 12-169: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose







4N49 optocoupler CTR at IF= 8mA



4N49 optocoupler CTR at IF= 10mA

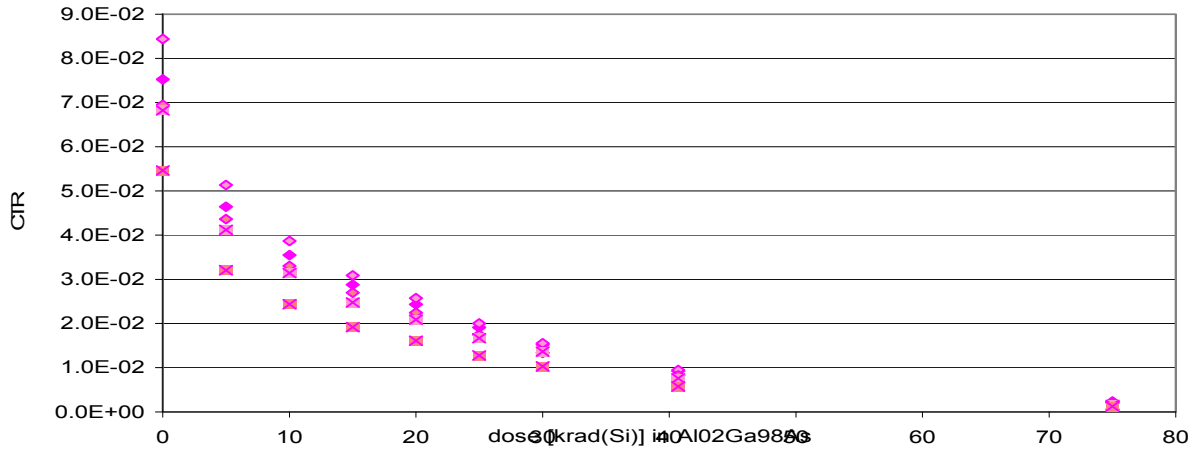
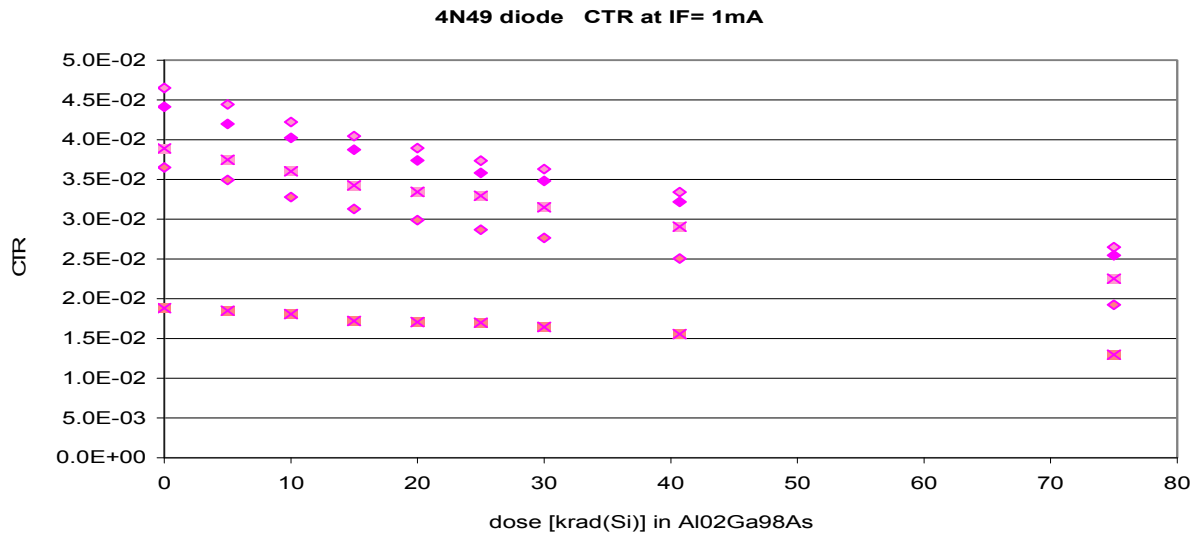
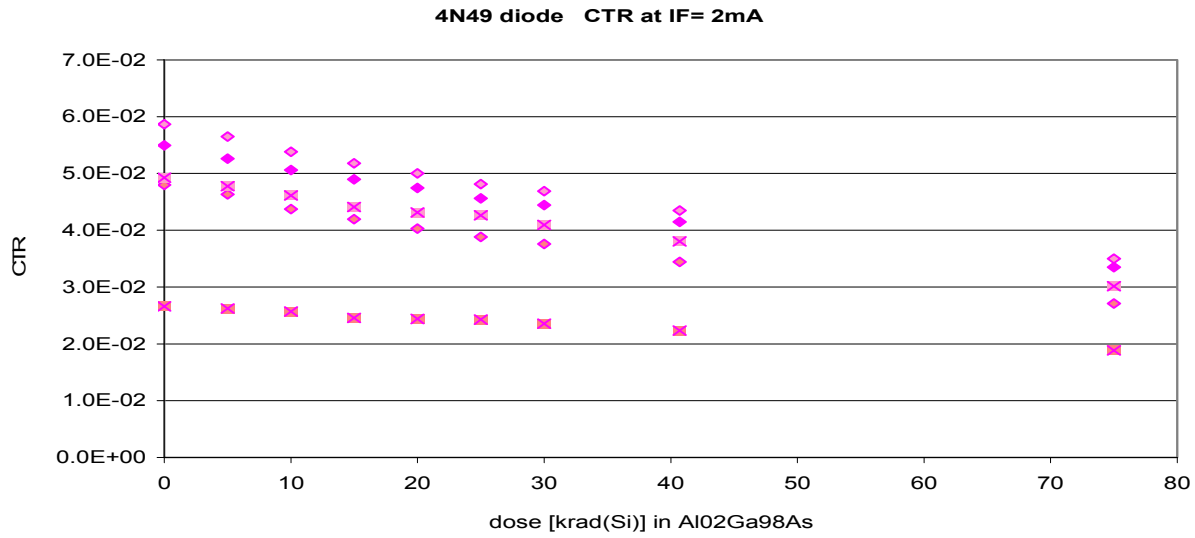
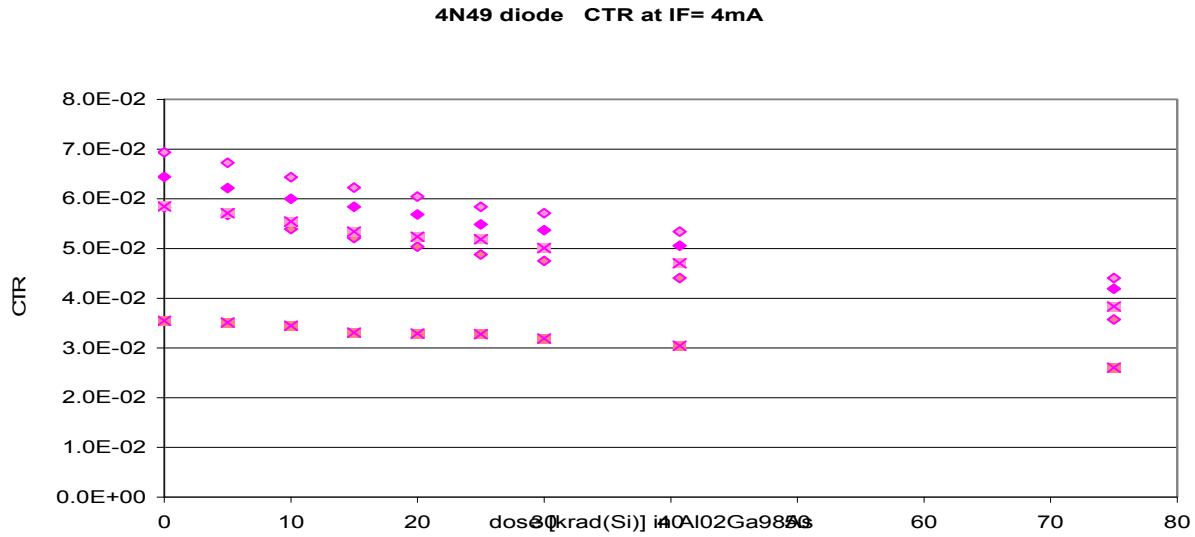


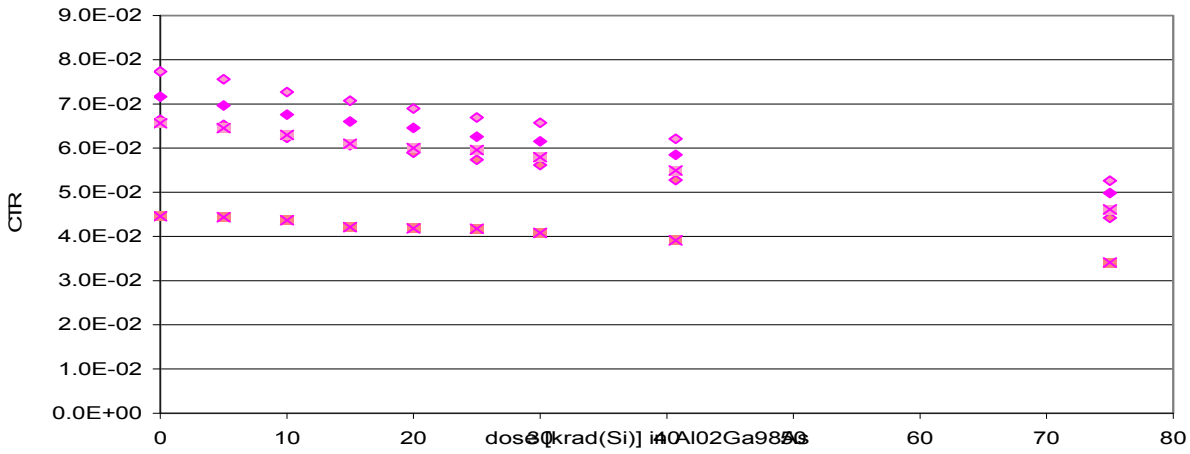
Fig. 12-170: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose







4N49 diode CTR at IF= 8mA



4N49 diode CTR at IF= 10mA

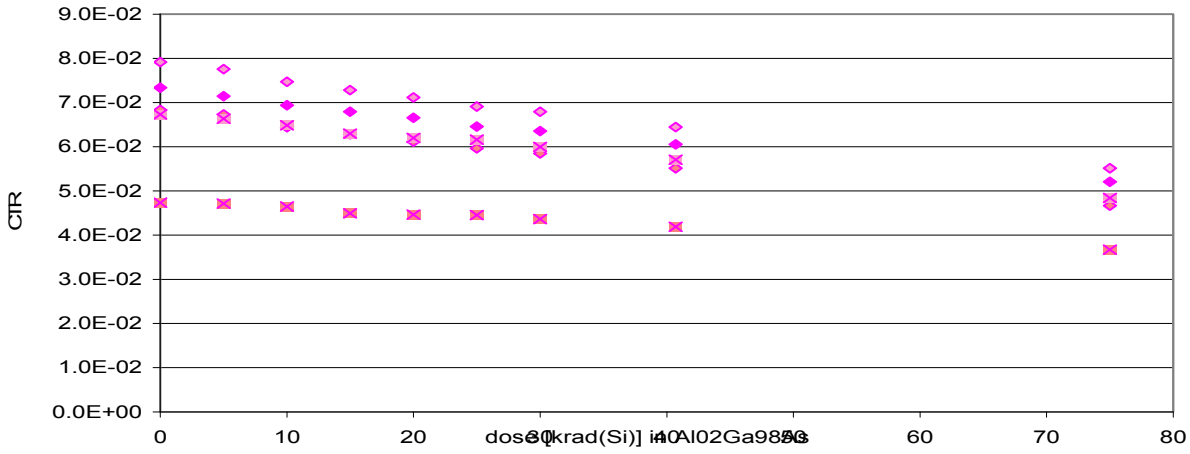
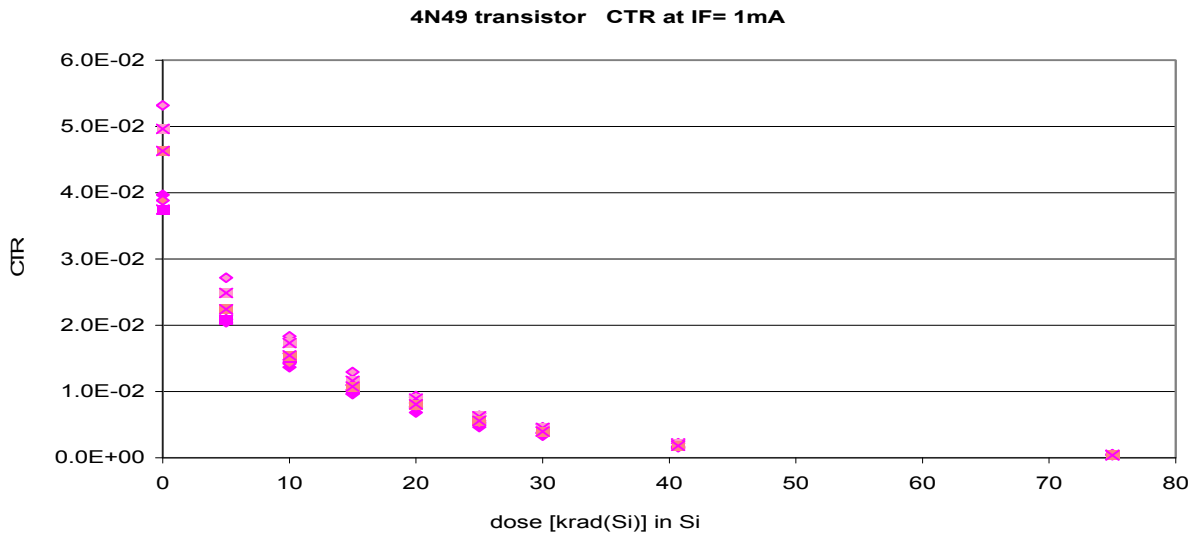
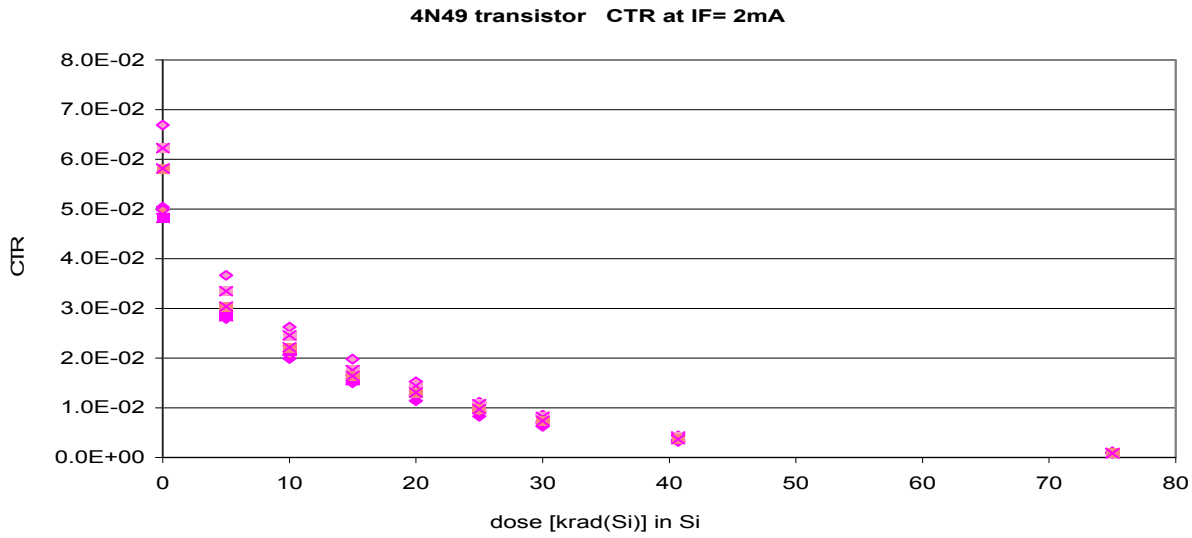
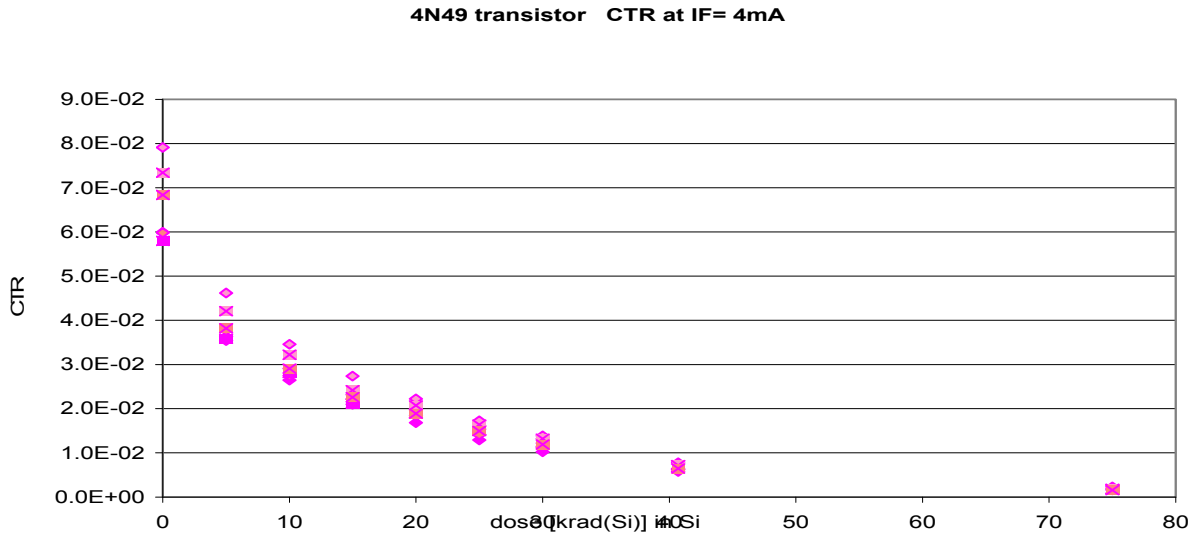


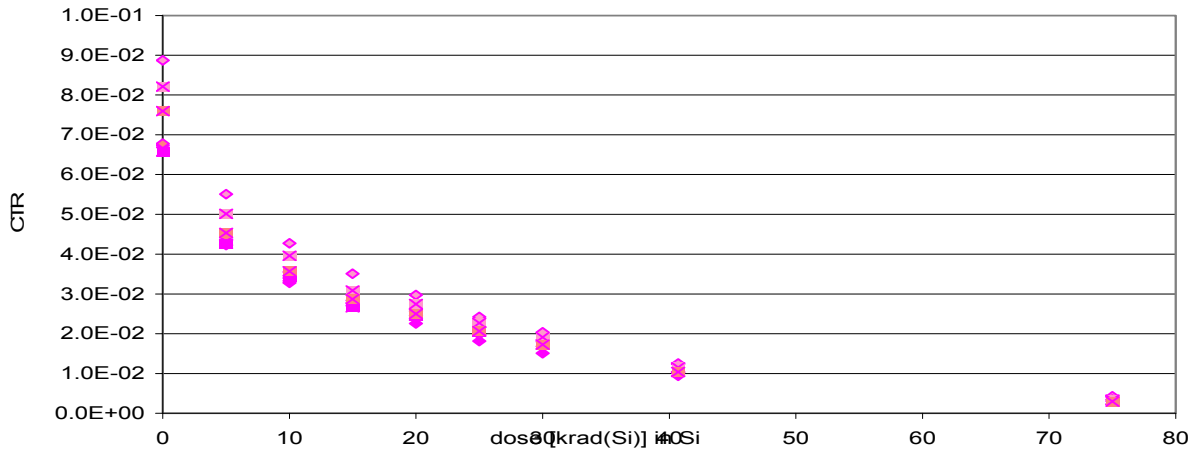
Fig. 12-171: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose







4N49 transistor CTR at IF= 8mA



4N49 transistor CTR at IF= 10mA

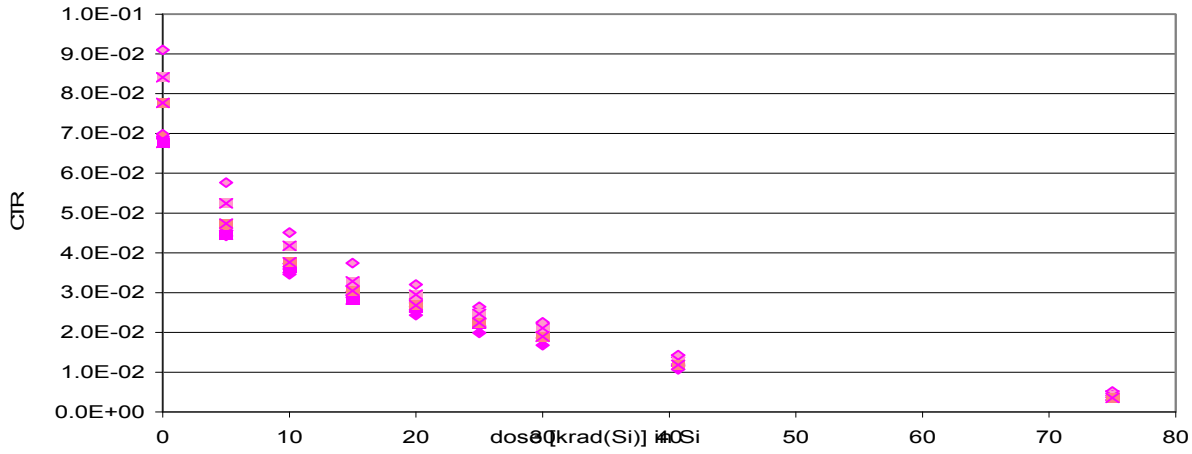
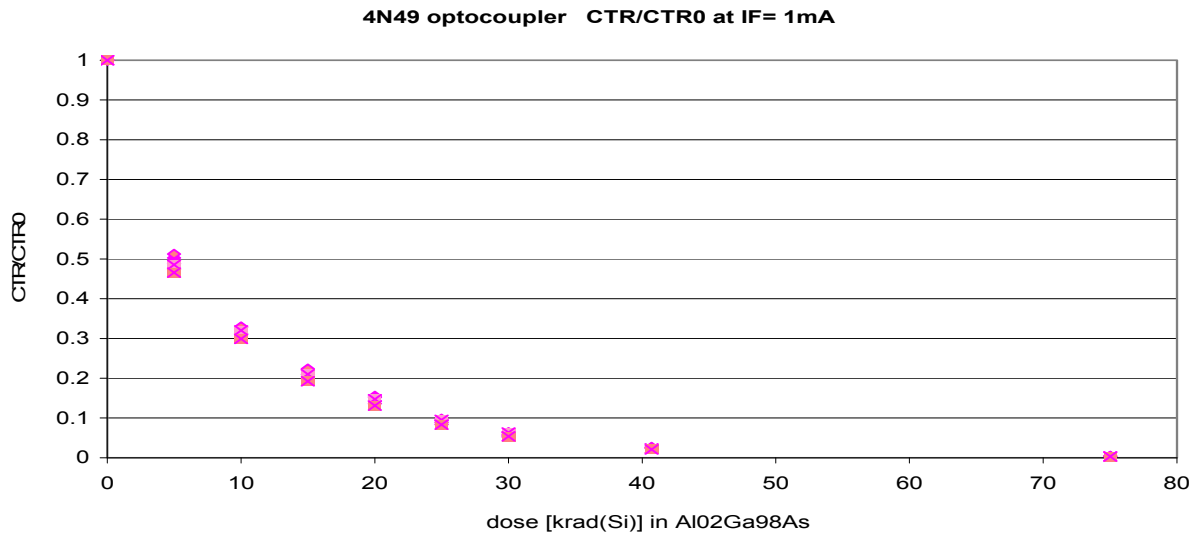
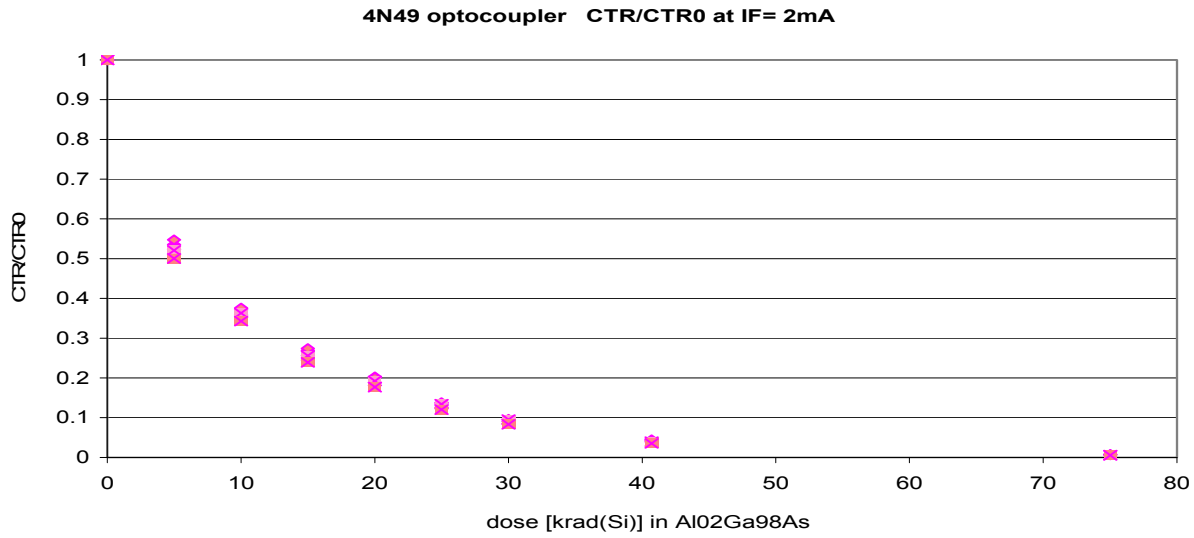
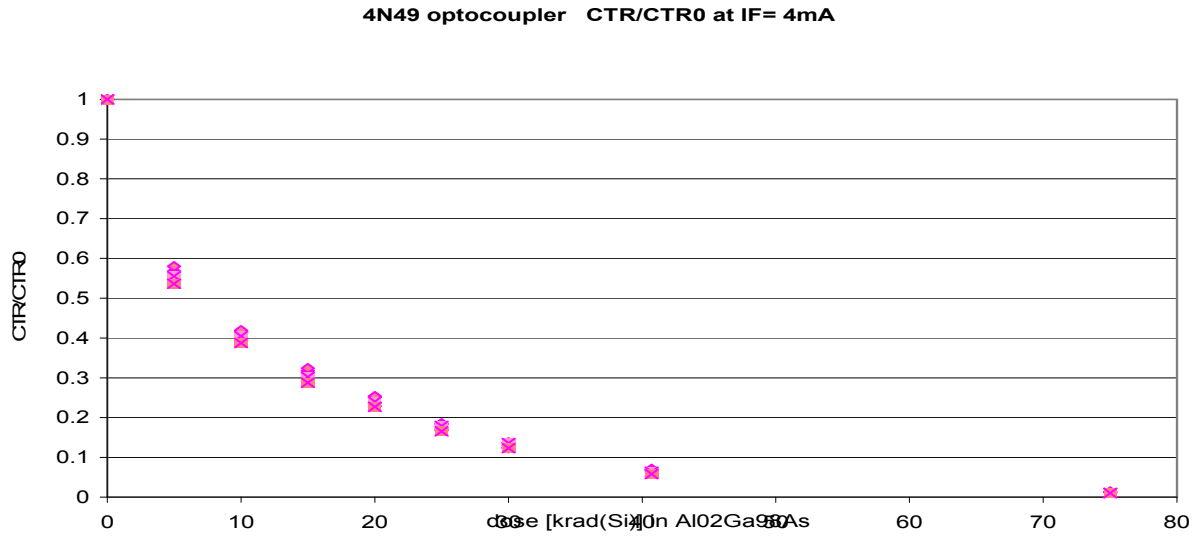


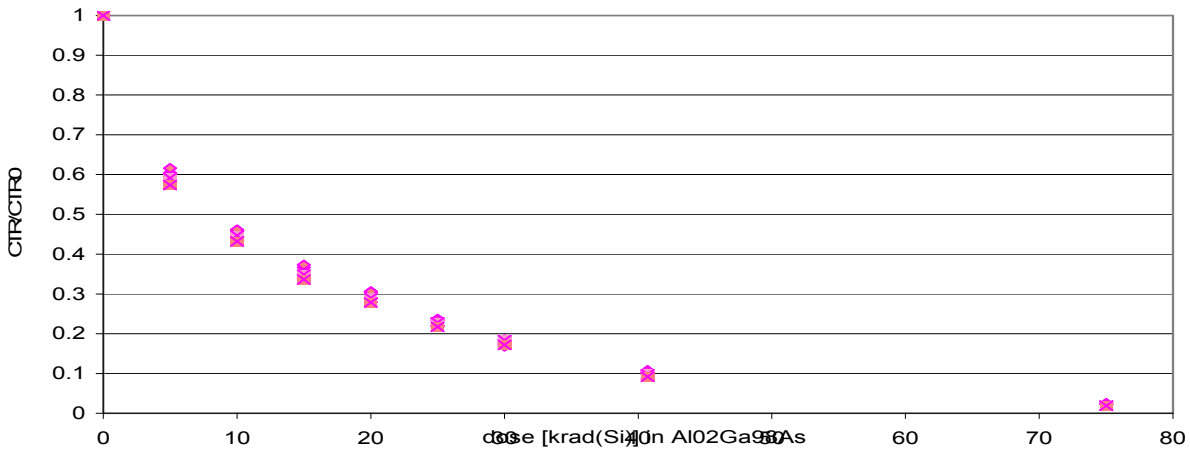
Fig. 12-172: 4N49 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose







4N49 optocoupler CTR/CTR0 at IF= 8mA



4N49 optocoupler CTR/CTR0 at IF= 10mA

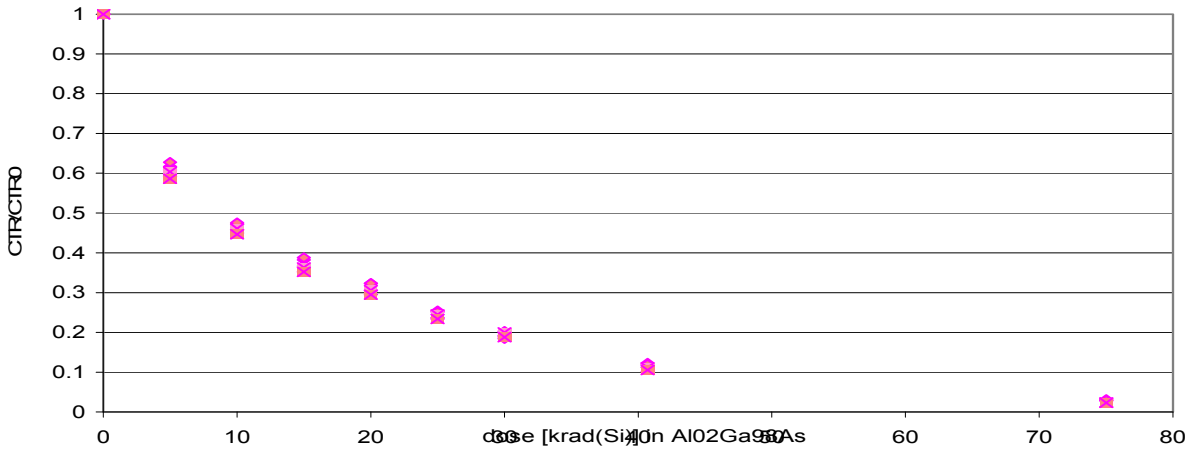
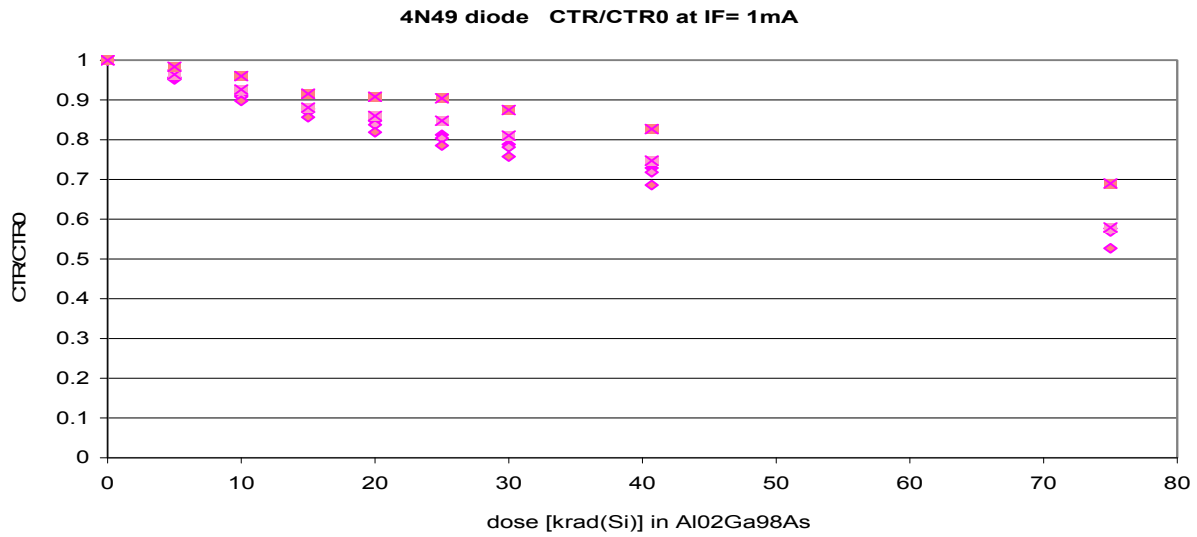
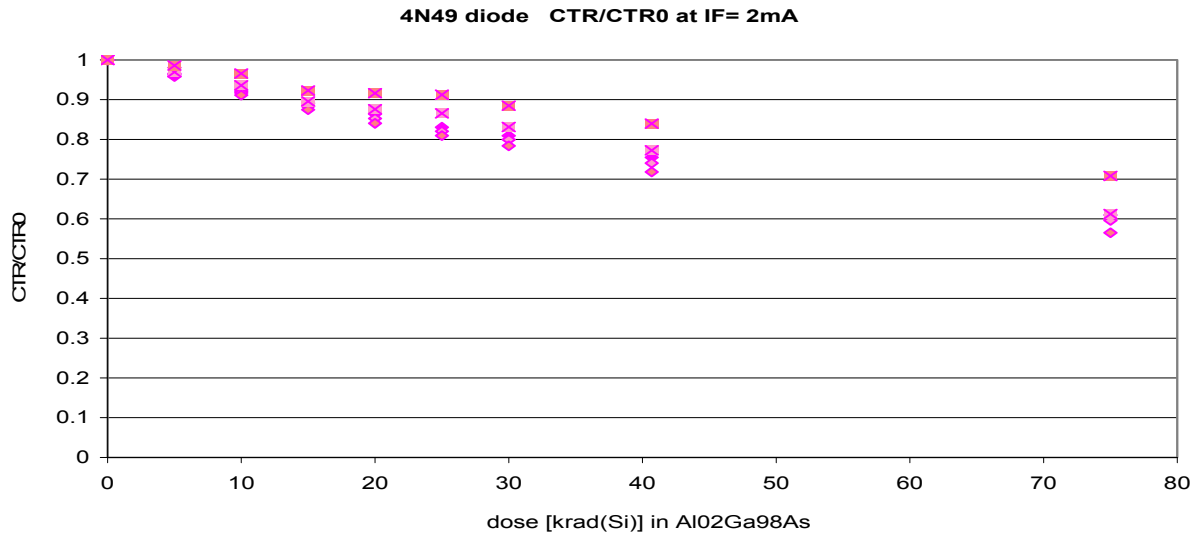
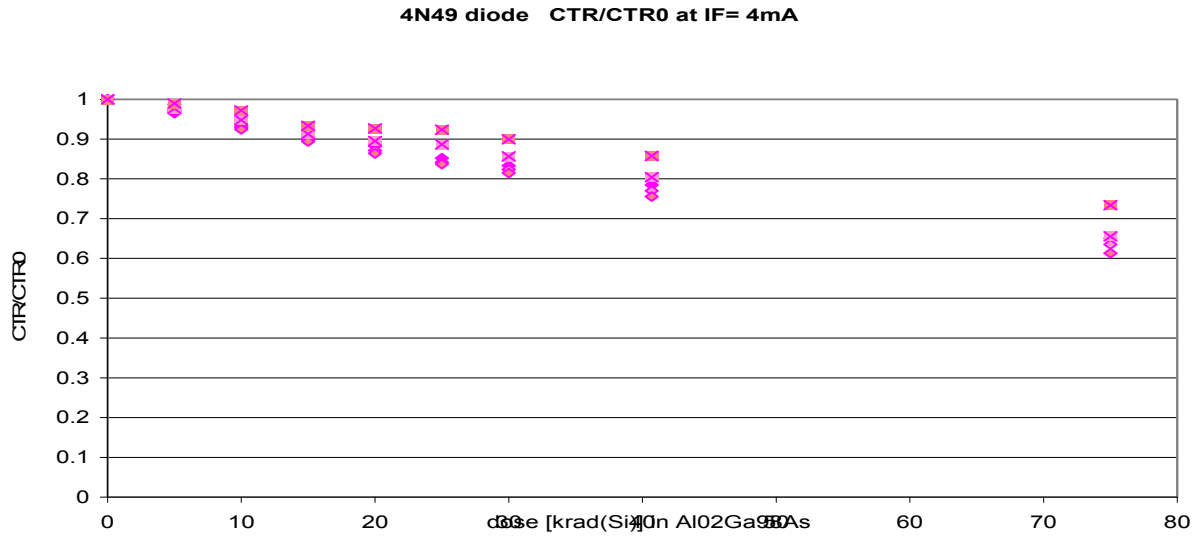
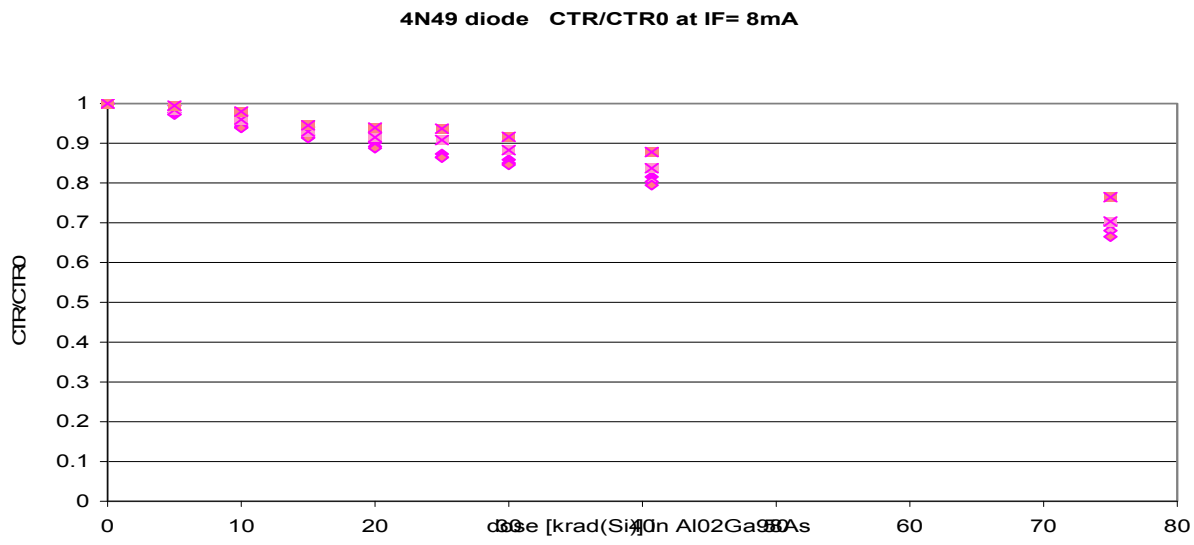


Fig. 12-173: 4N49 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80

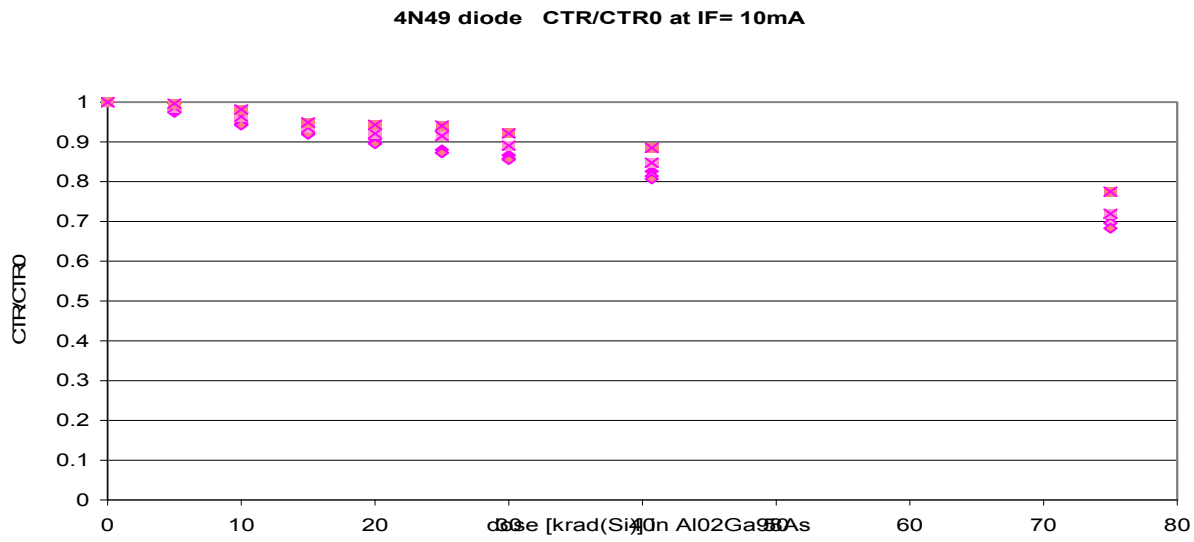
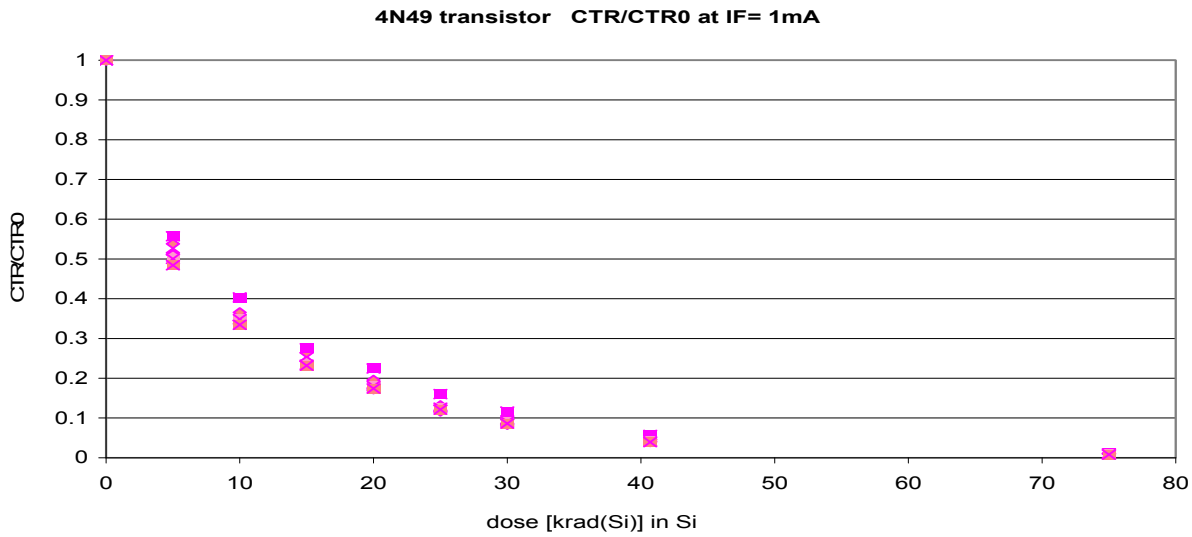
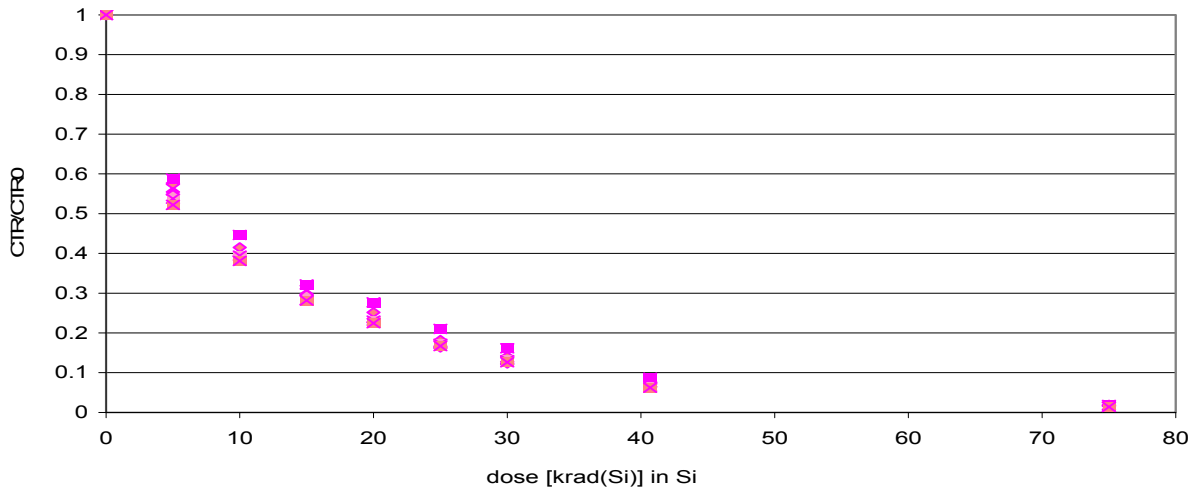
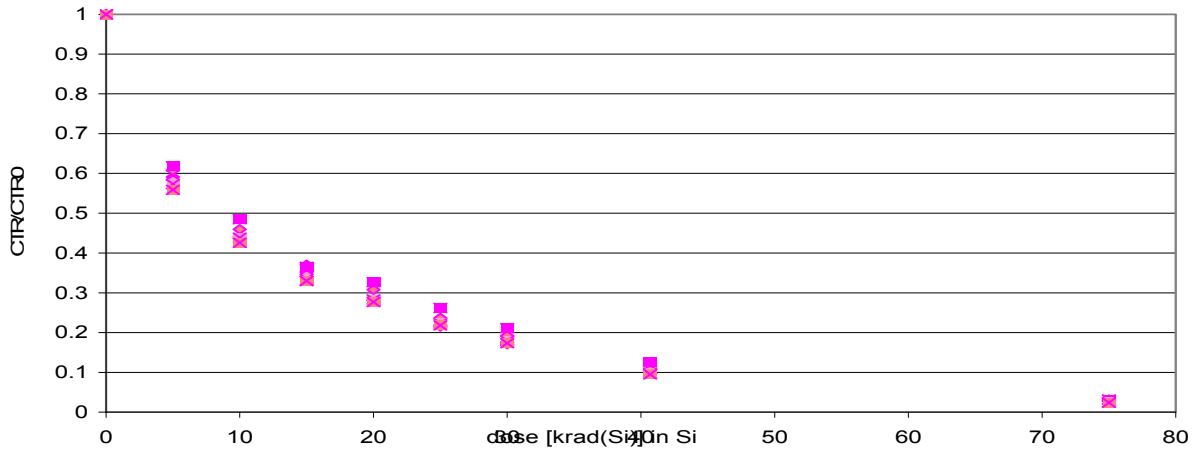

4N49 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80

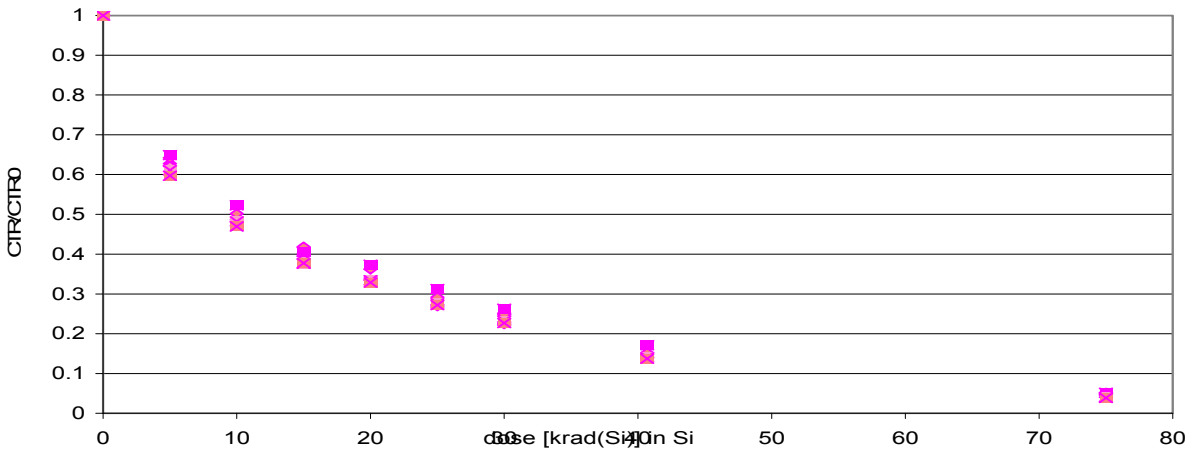
Fig. 12-174: 4N49 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose







4N49 transistor CTR/CTR0 at IF= 8mA



4N49 transistor CTR/CTR0 at IF= 10mA

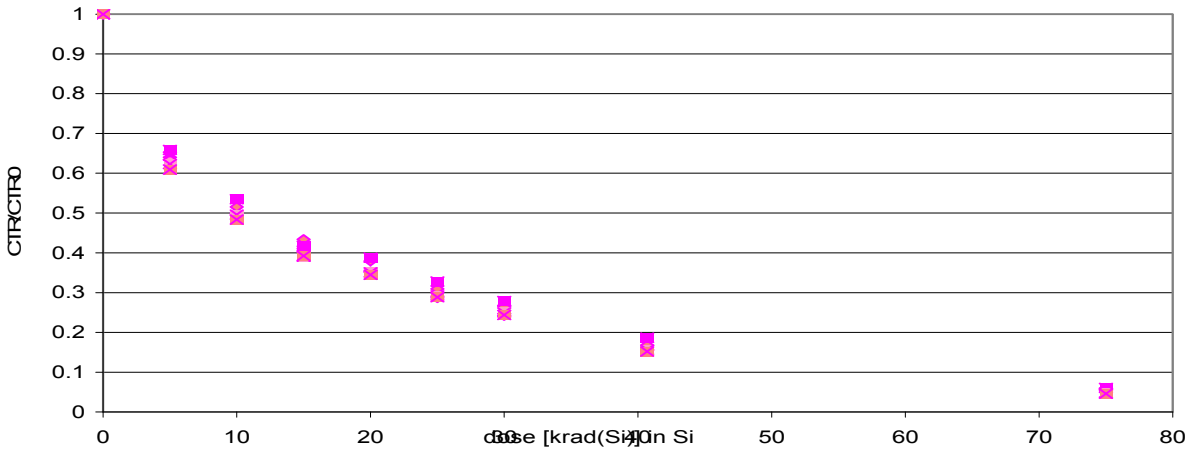
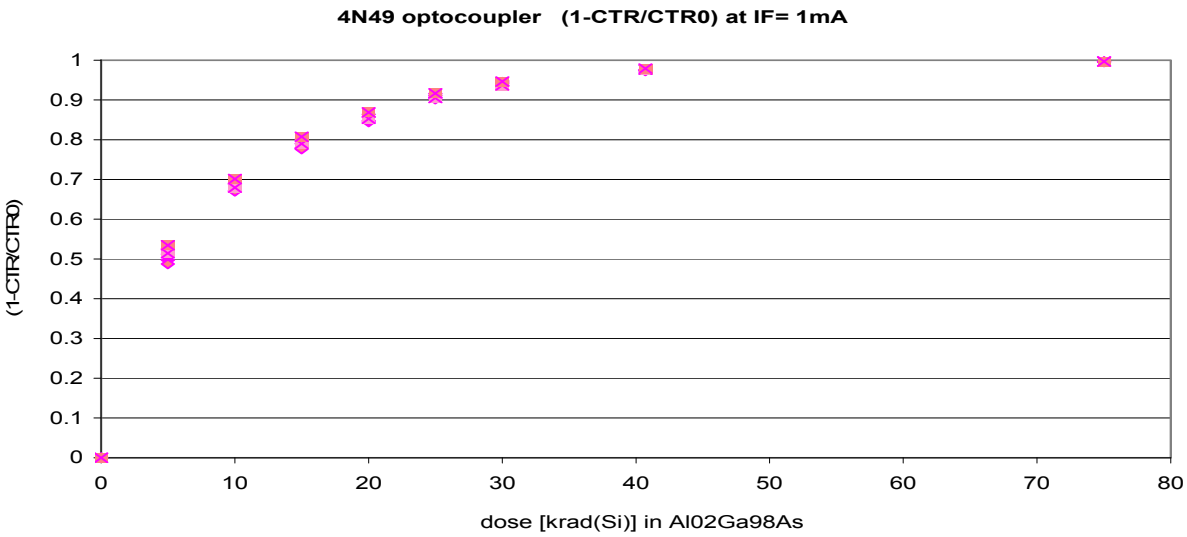
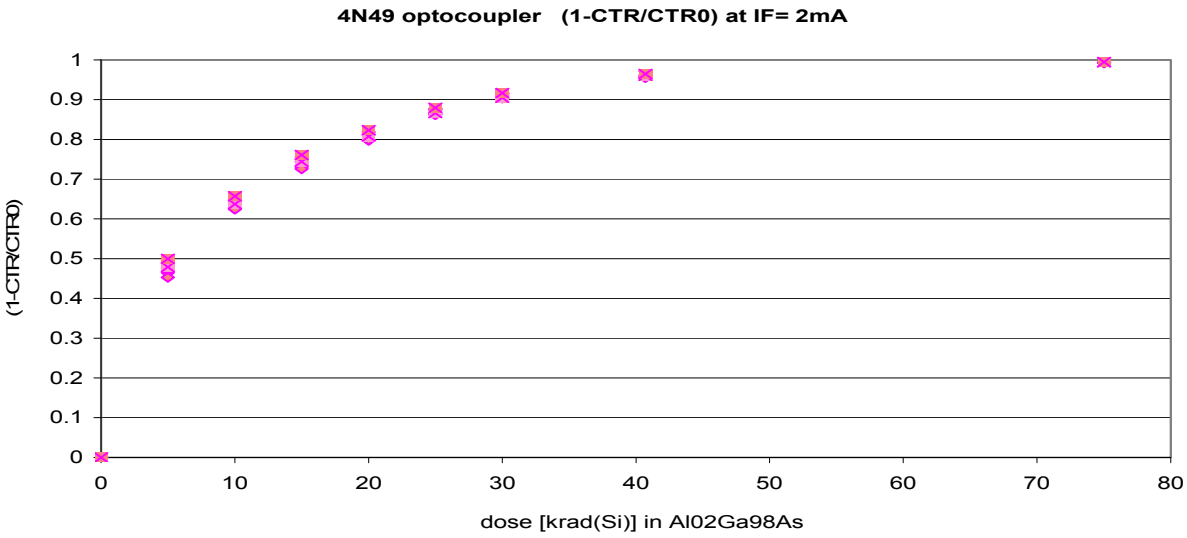
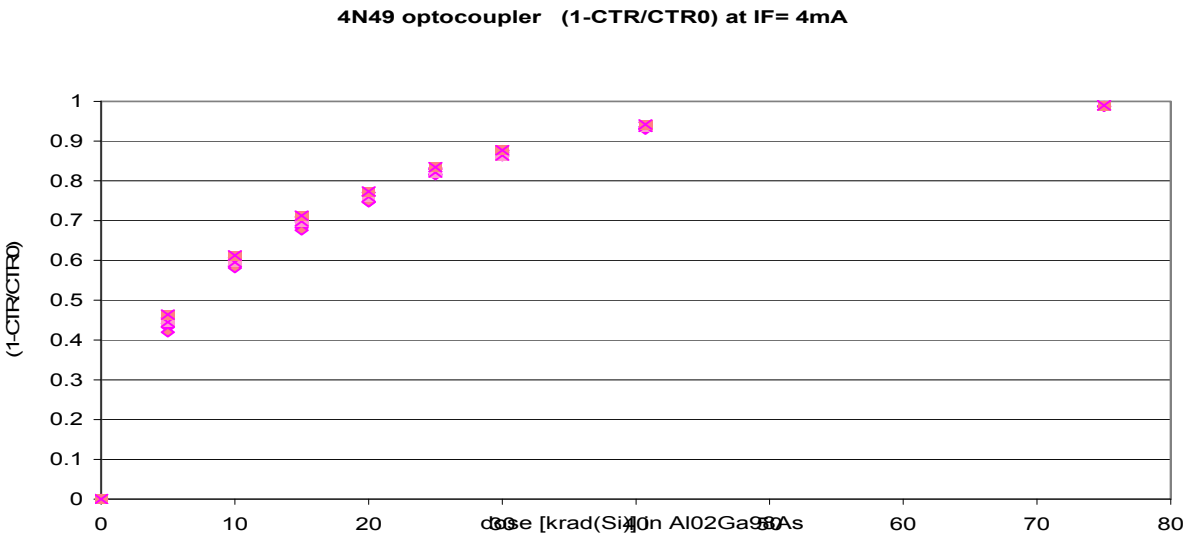


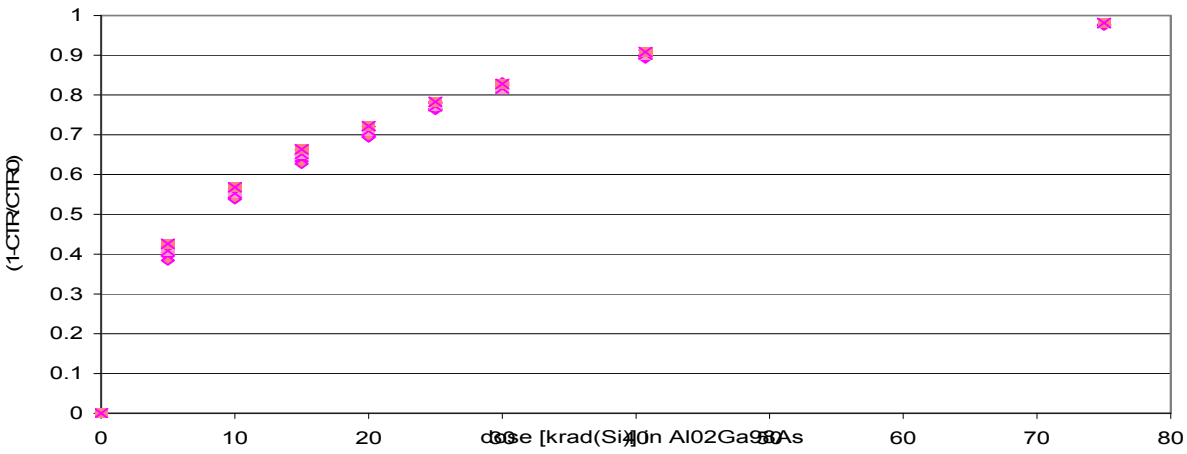
Fig. 12-175: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose







4N49 optocoupler (1-CTR/CTR0) at IF= 8mA



4N49 optocoupler (1-CTR/CTR0) at IF= 10mA

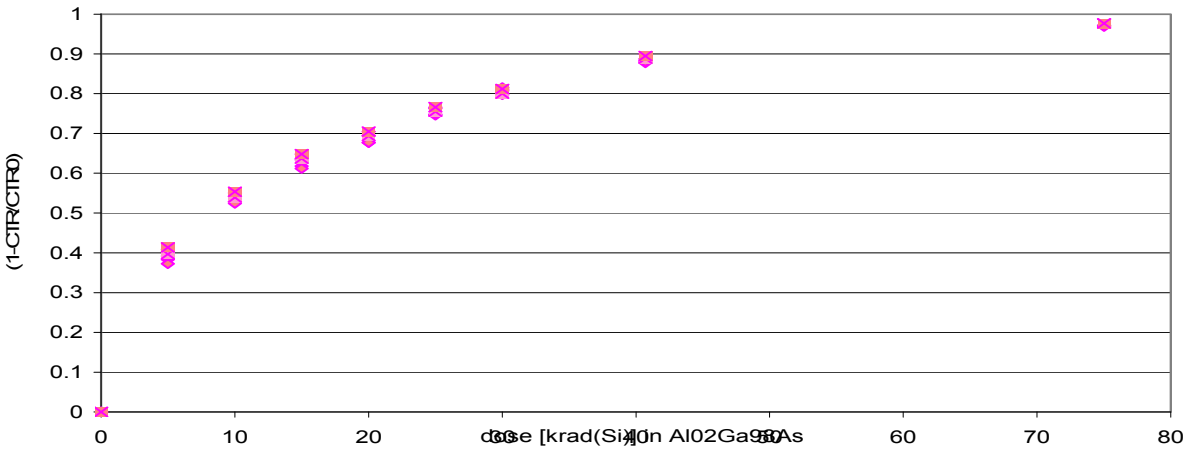
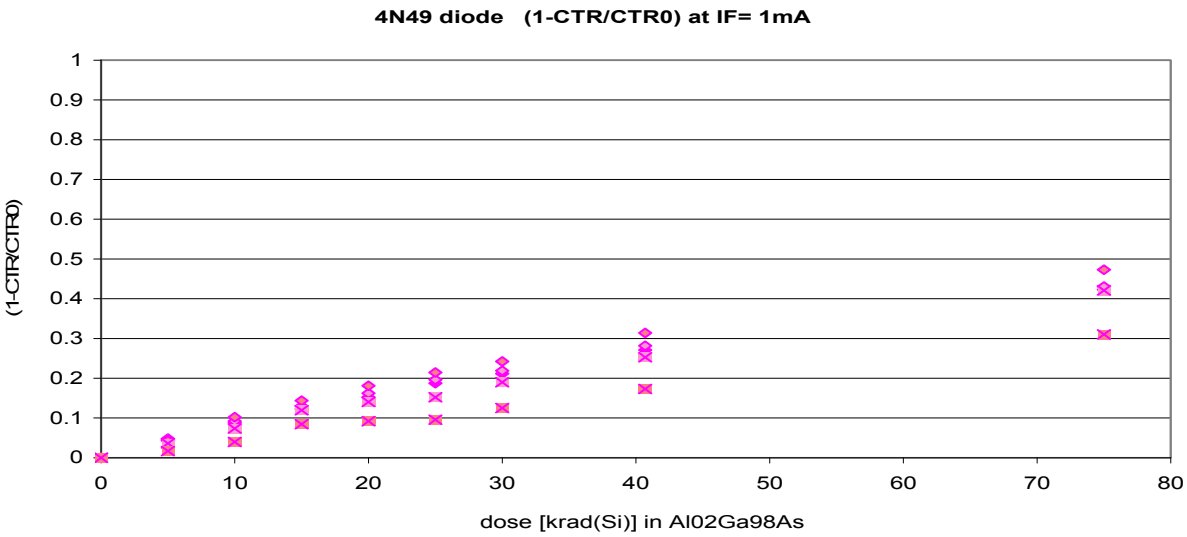
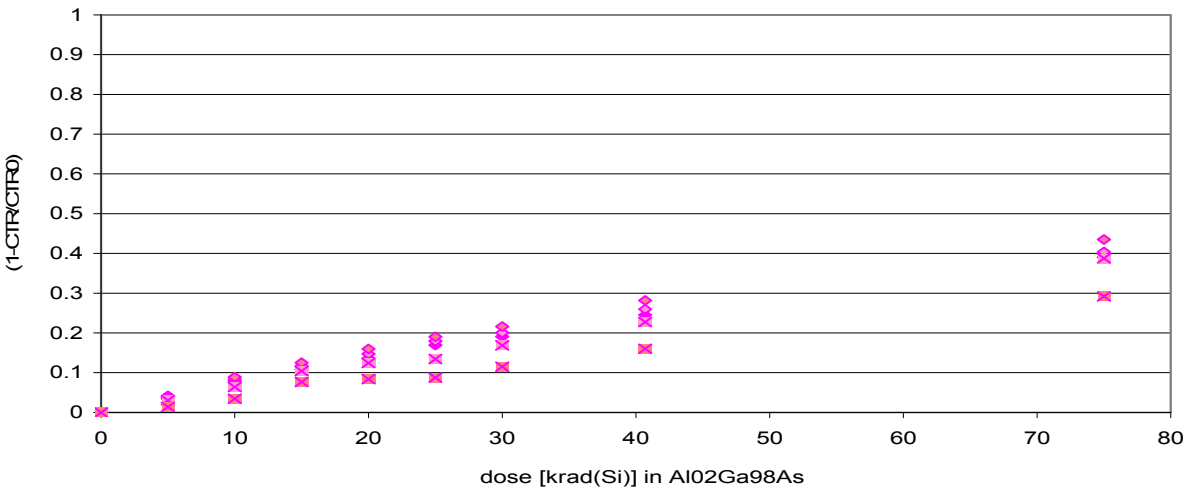
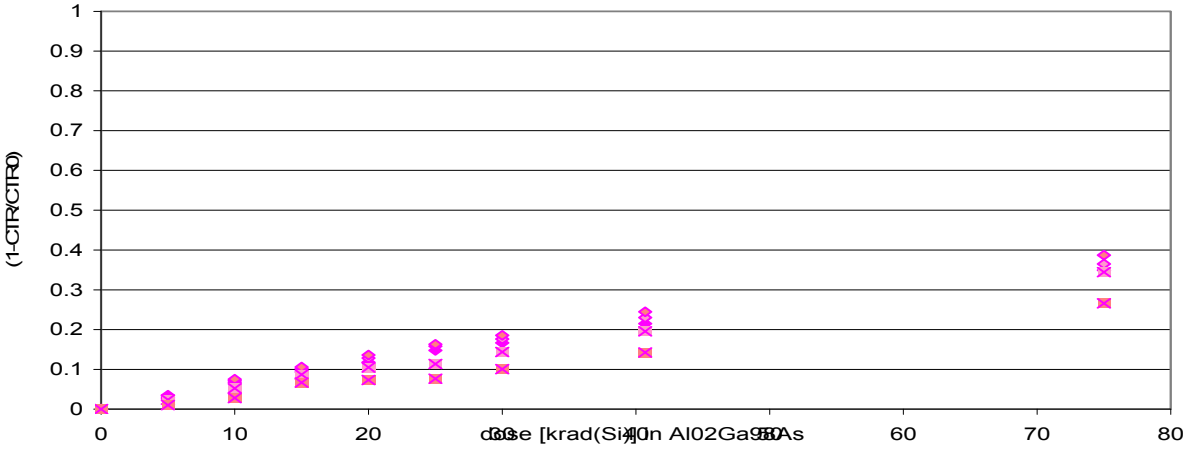


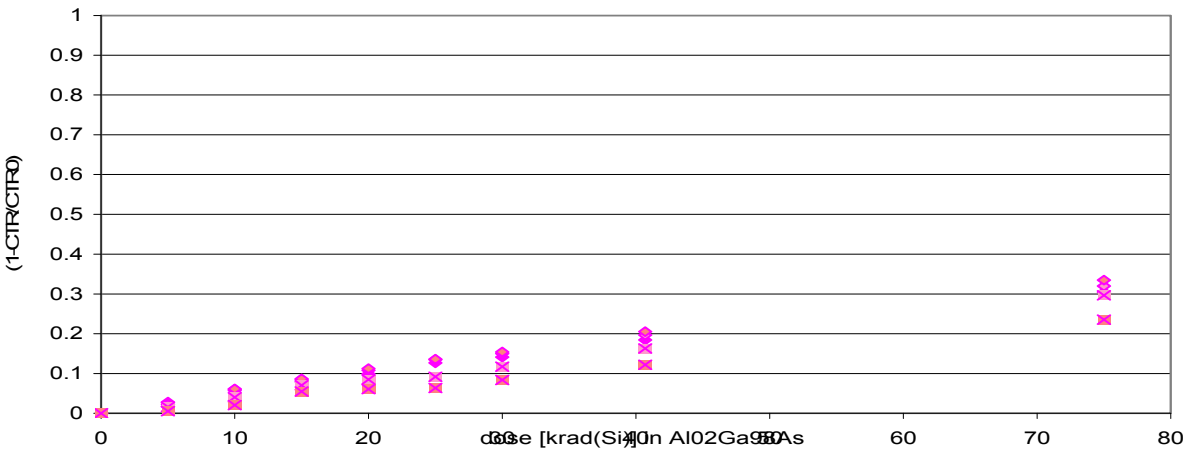
Fig. 12-176: 4N49 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose







4N49 diode (1-CTR/CTR0) at IF= 8mA



4N49 diode (1-CTR/CTR0) at IF= 10mA

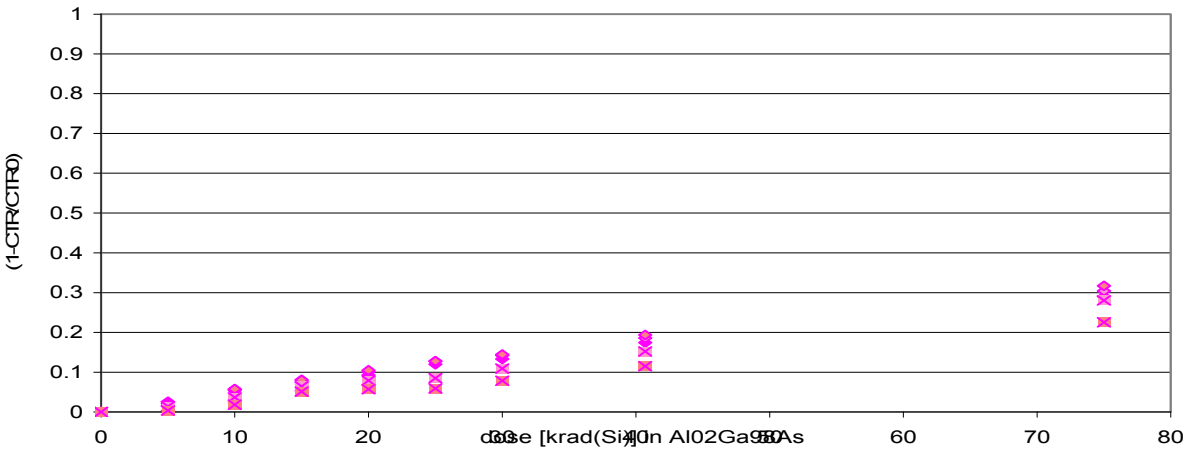
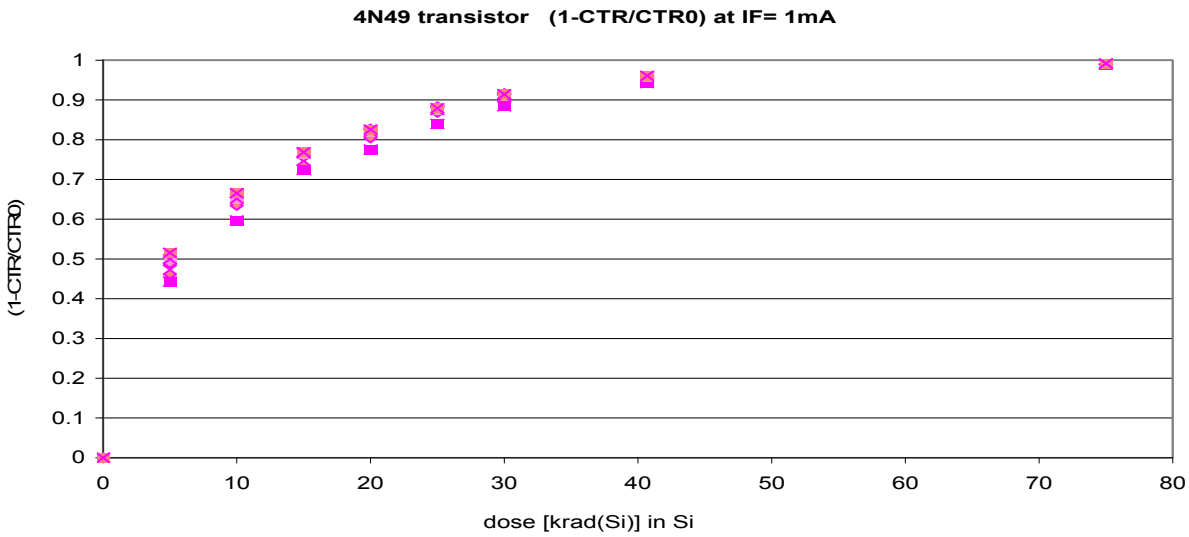
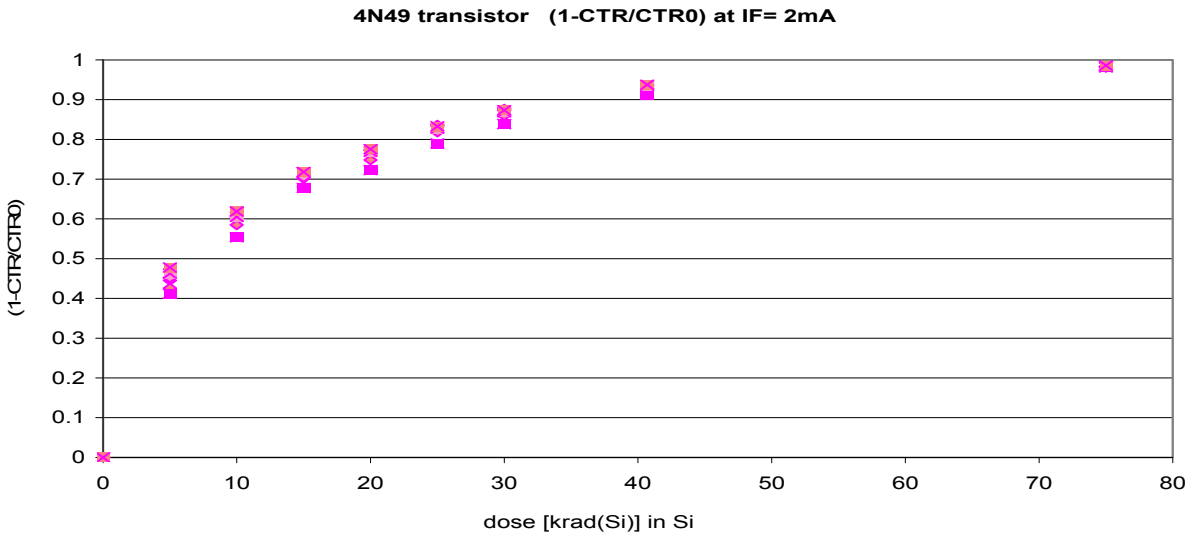
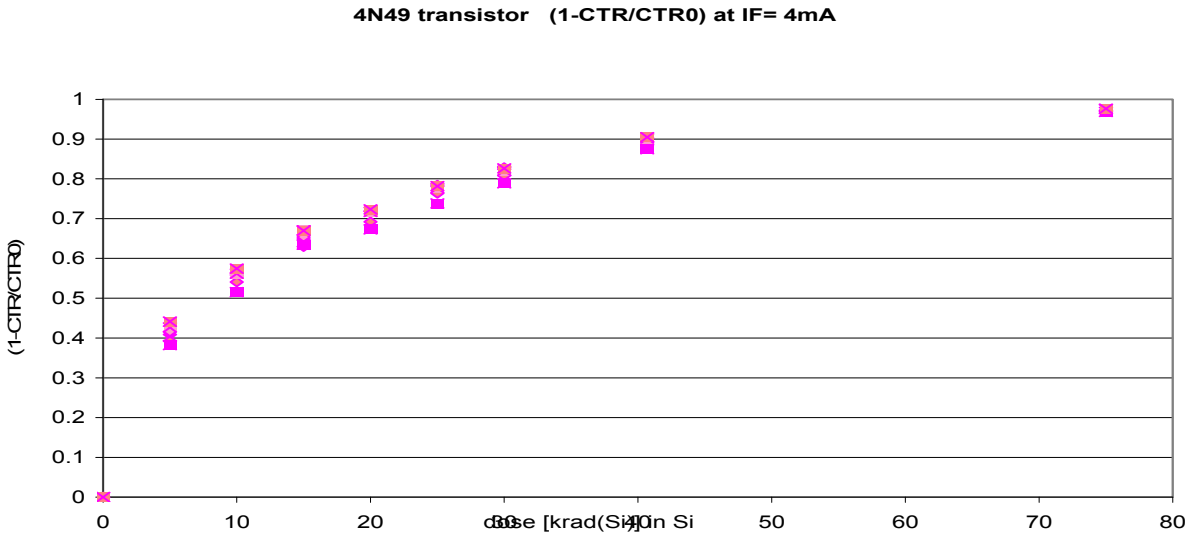


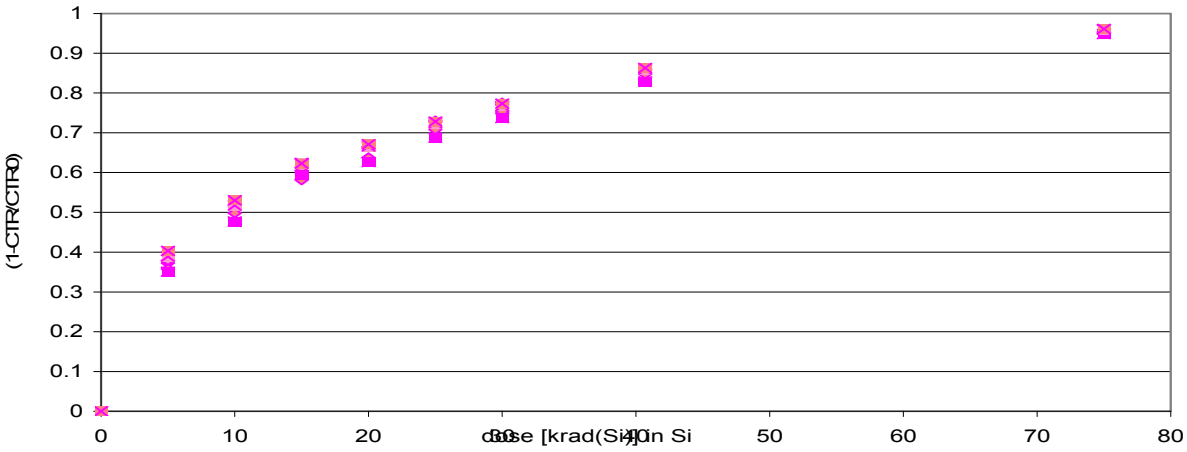
Fig. 12-177: 4N49 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose







4N49 transistor (1-CTR/CTR0) at IF= 8mA



4N49 transistor (1-CTR/CTR0) at IF= 10mA

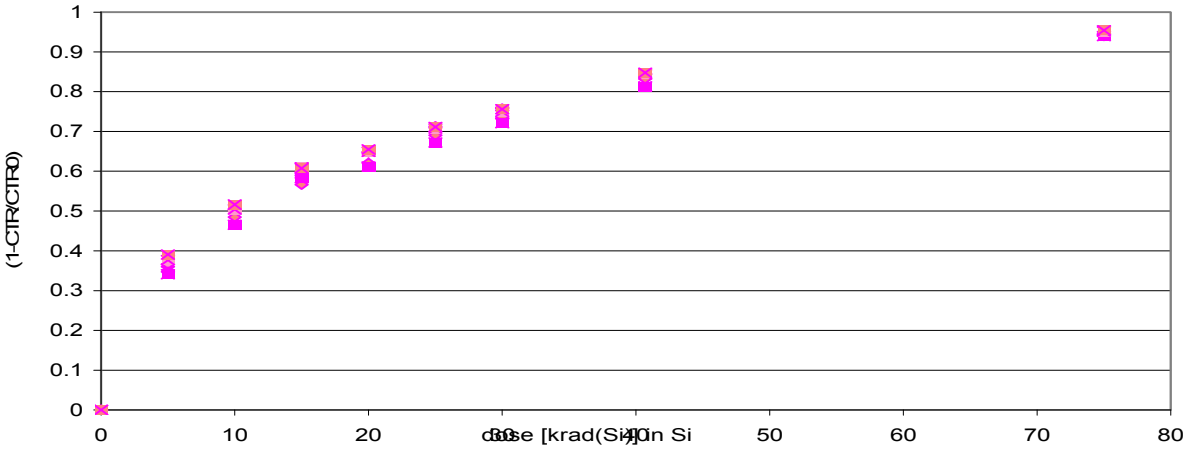
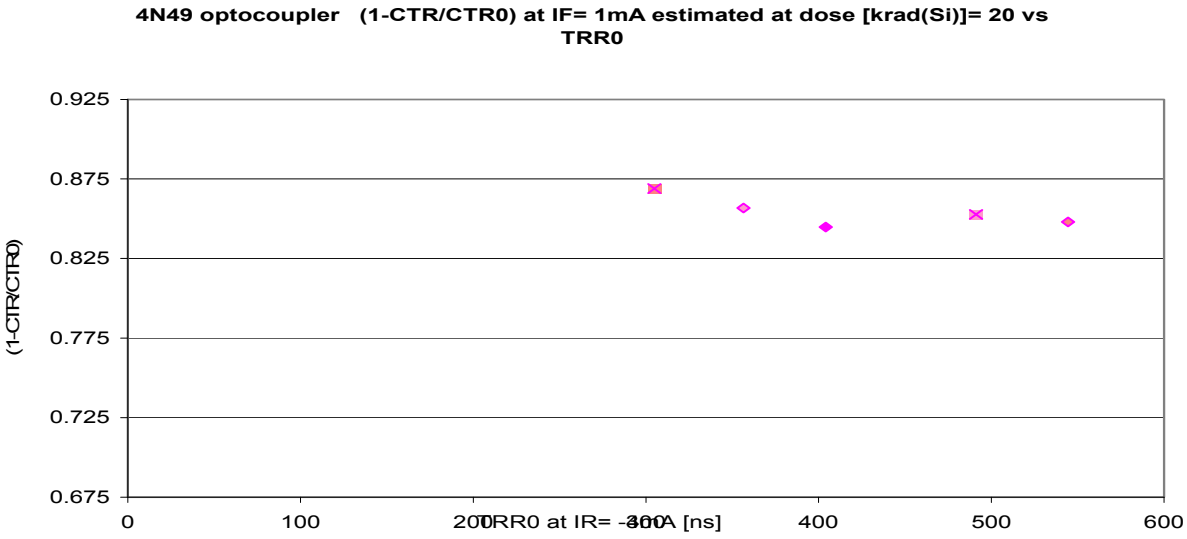
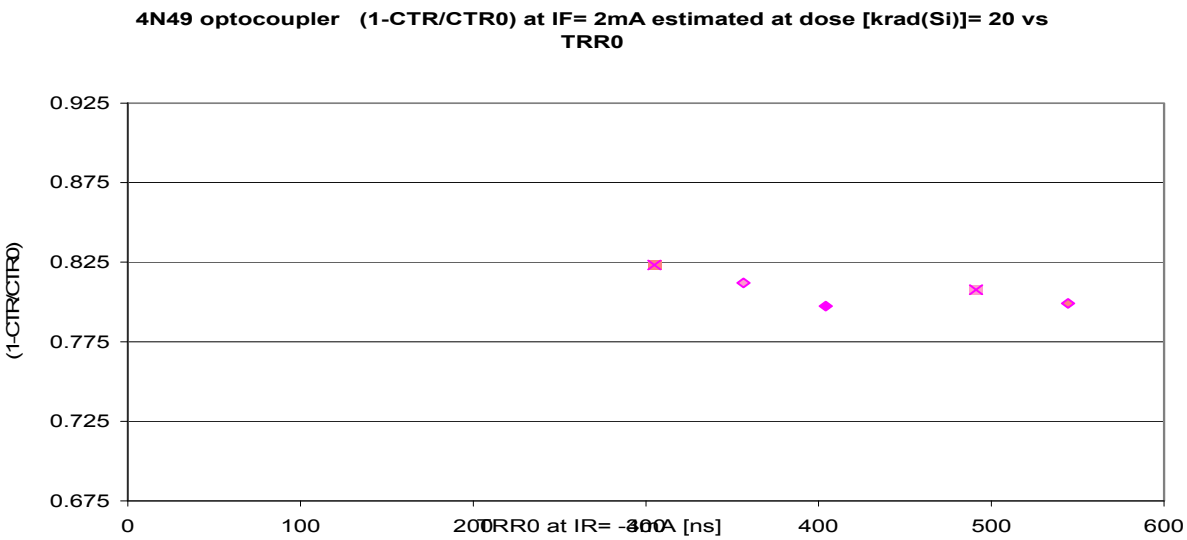
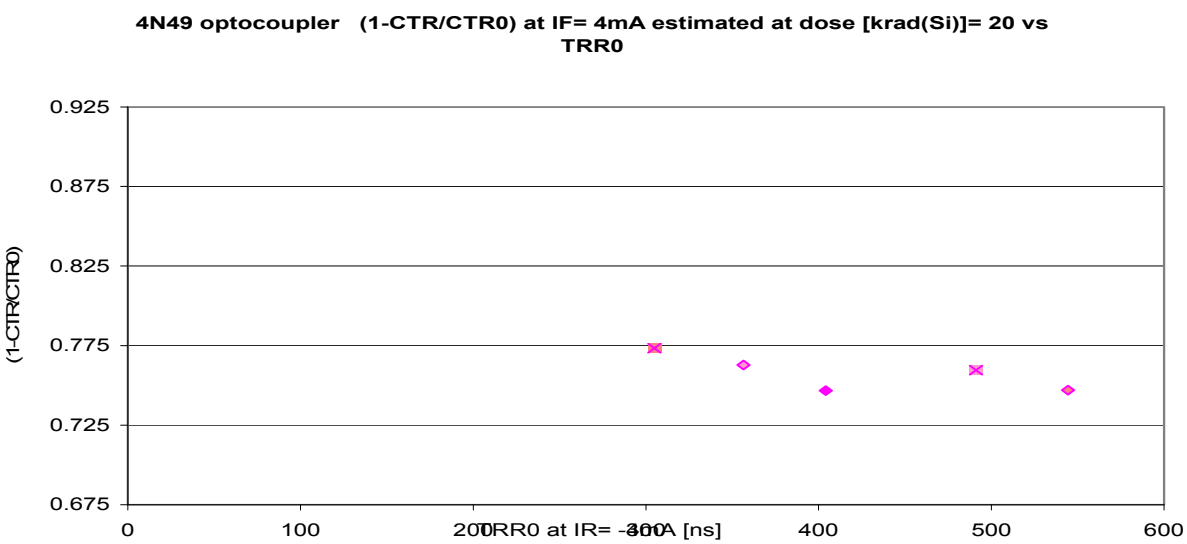
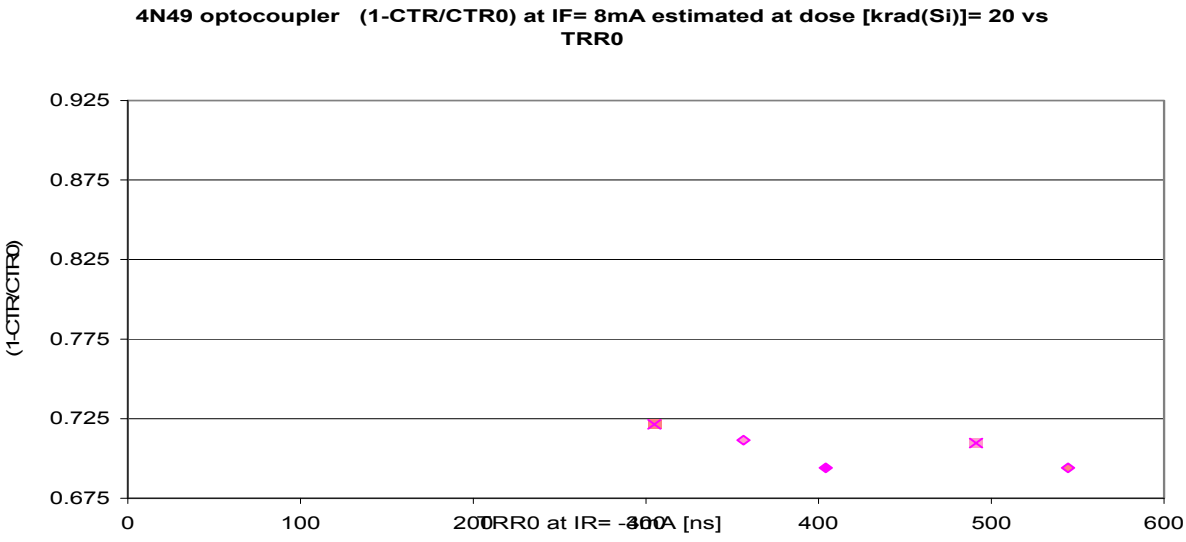


Fig. 12-178: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
0.925
0.875
0.825
0.775
0.725
0.675
(1-CTR/CTR0)
0
100
200
300
400
500
600
TRR0 at IR= -10mA [ns]

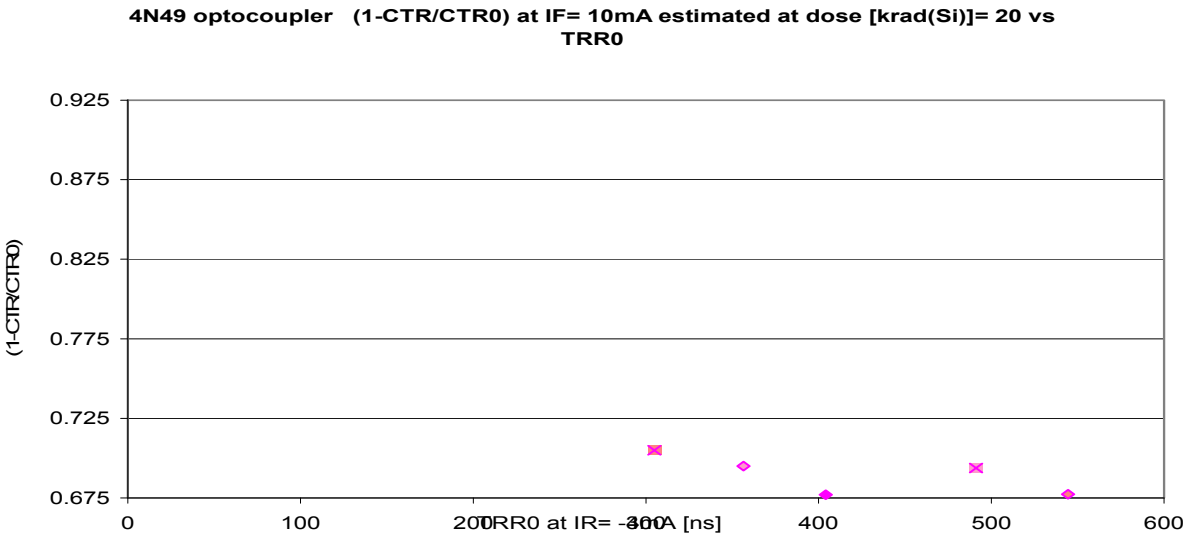
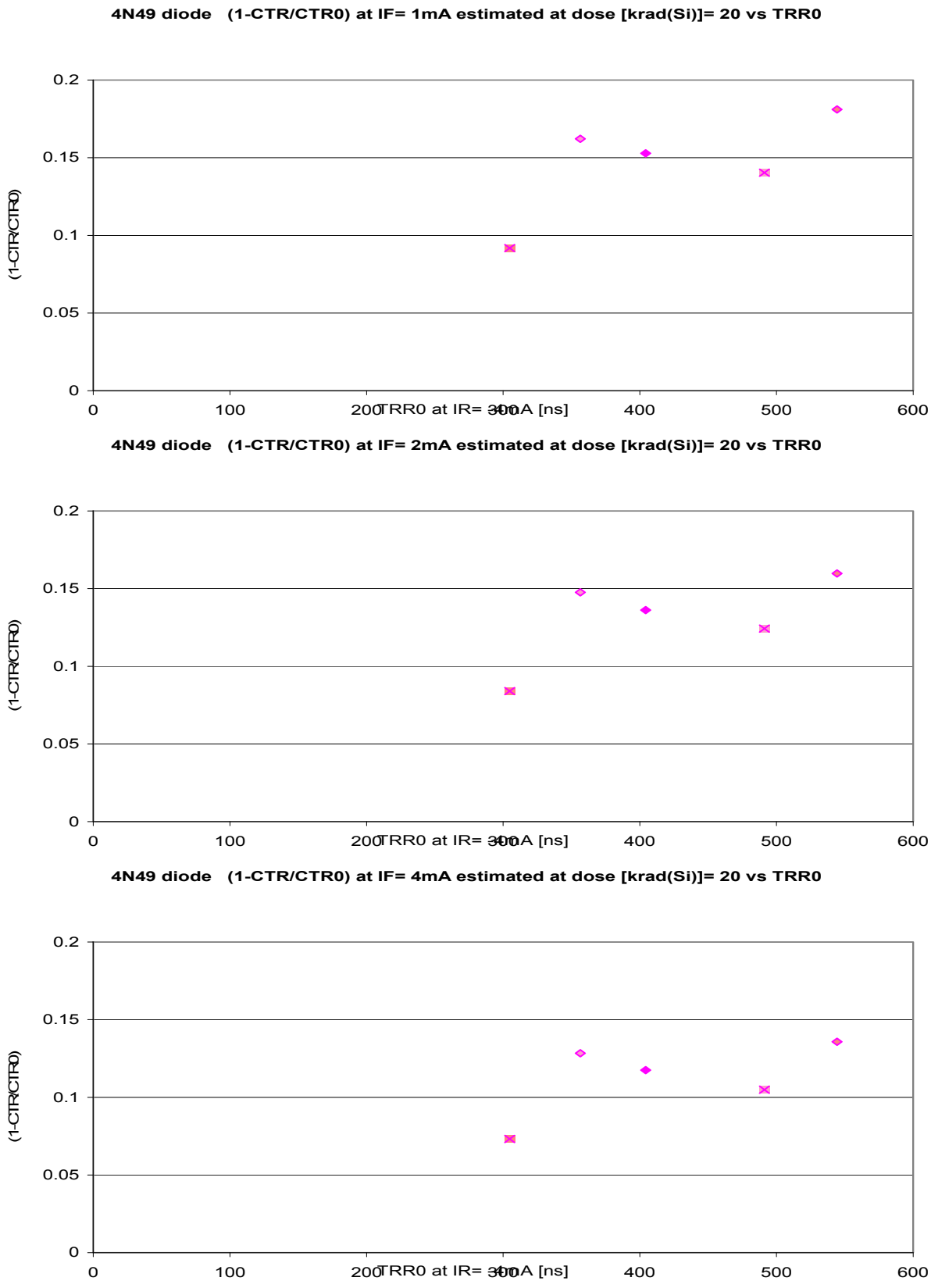
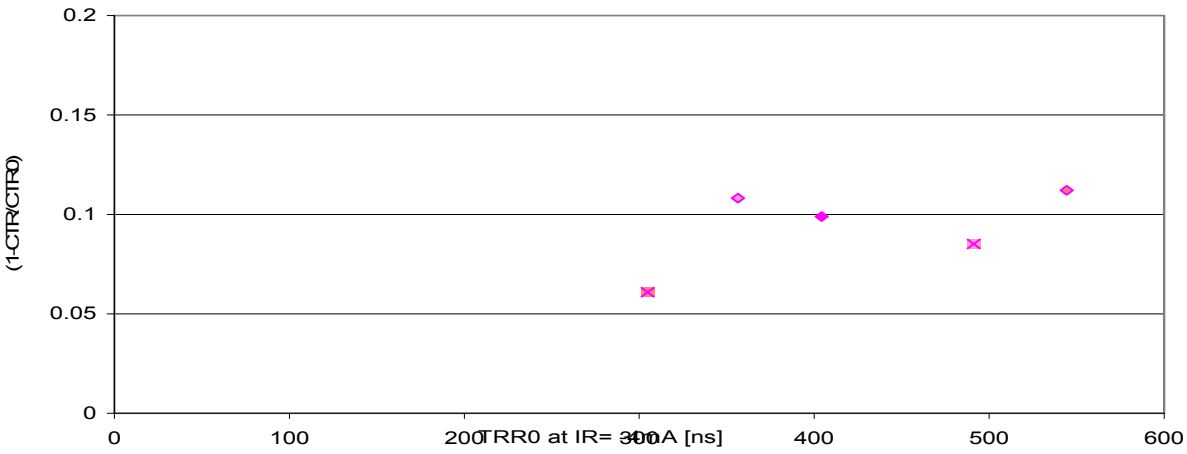

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
0.925
0.875
0.825
0.775
0.725
0.675
(1-CTR/CTR0)
0
100
200
300
400
500
600
TRR0 at IR= -10mA [ns]

Fig. 12-179: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}



4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0



4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0

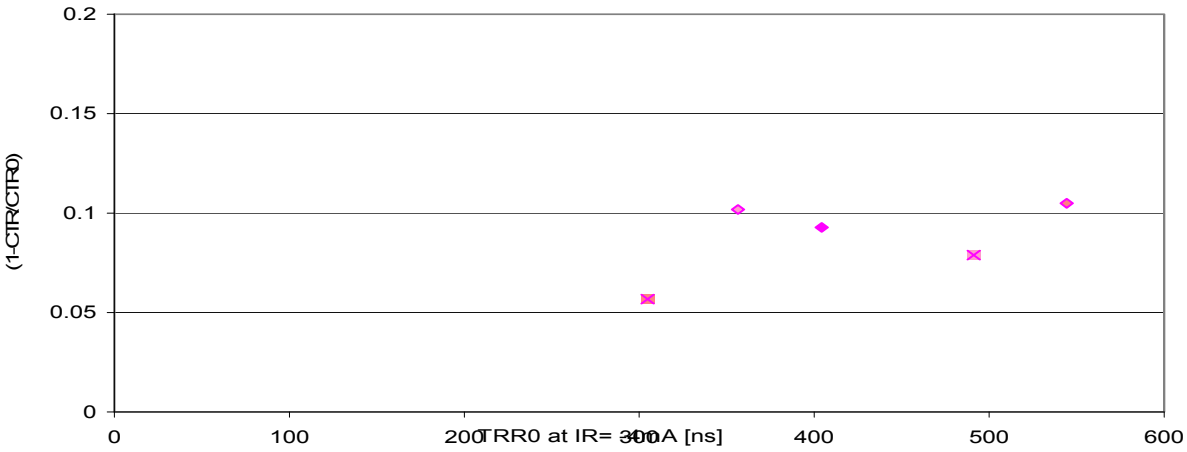
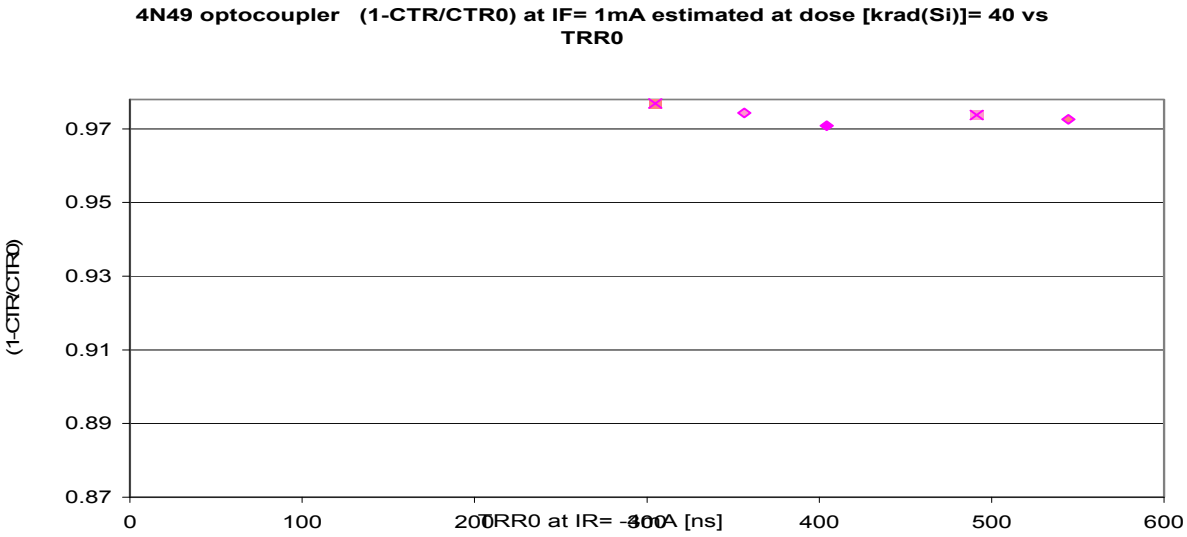
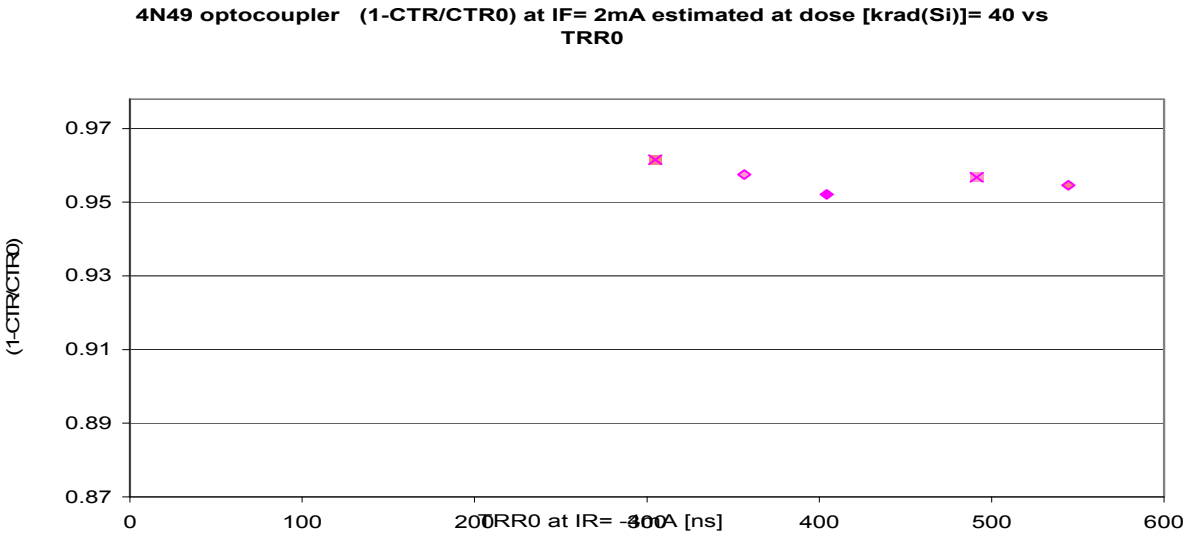
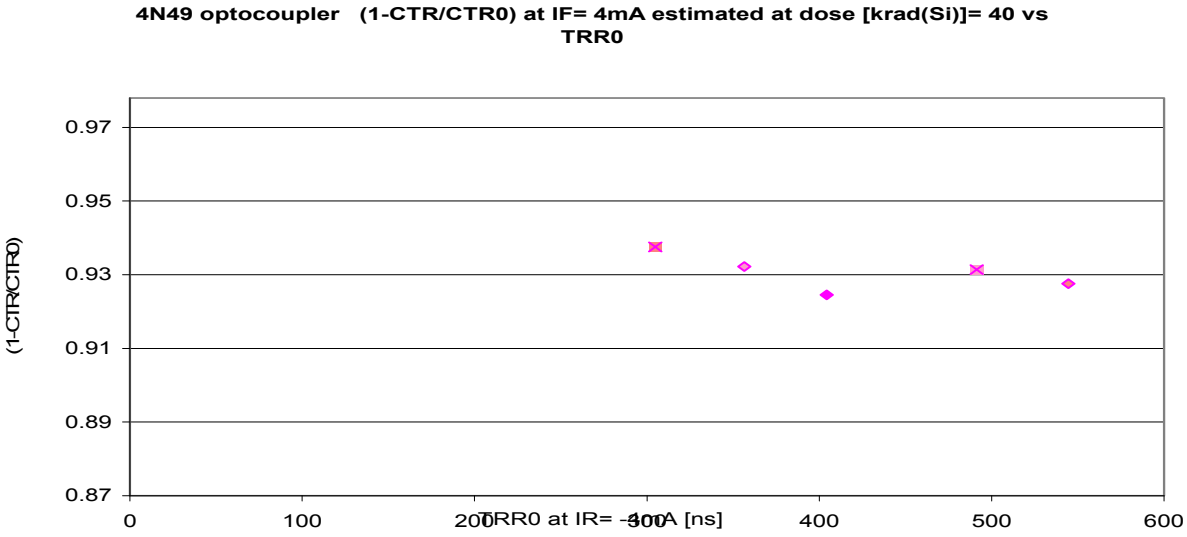


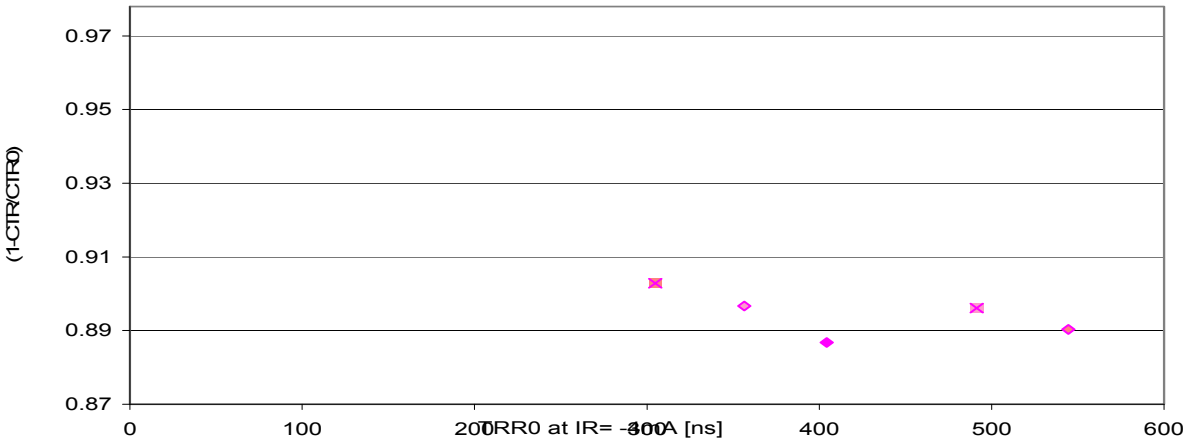
Fig. 12-180: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0



4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0

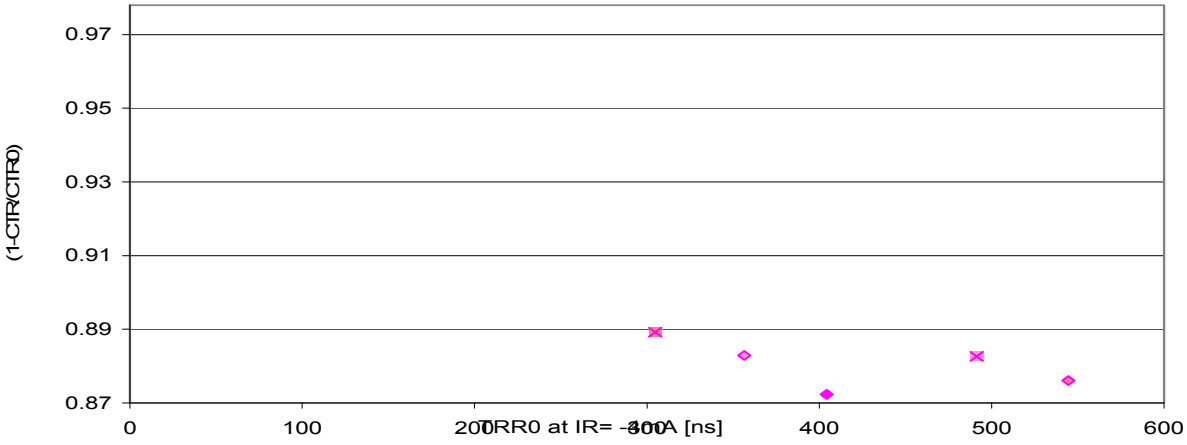
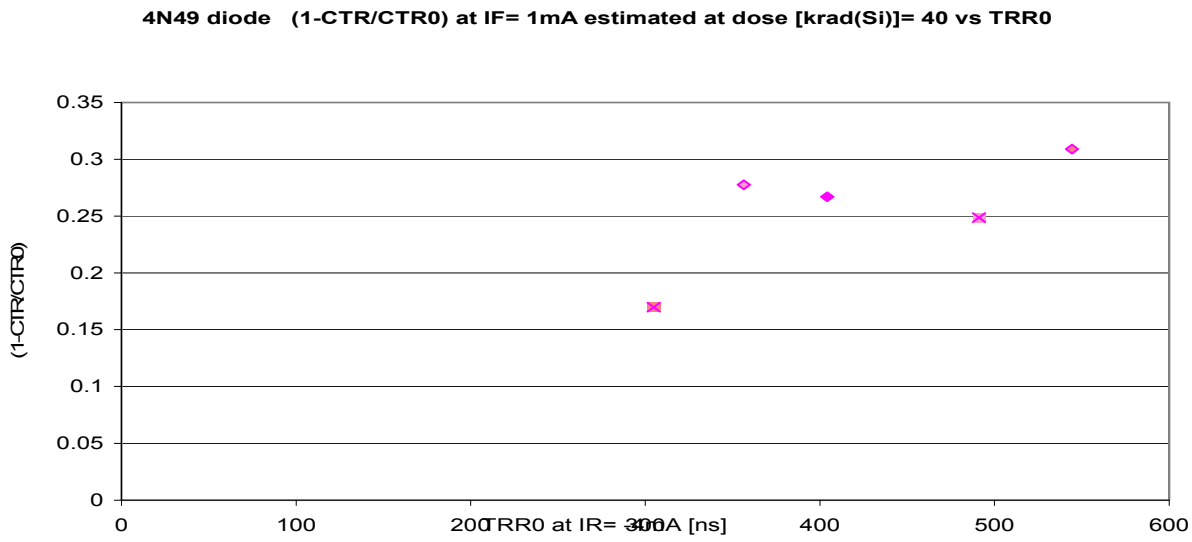
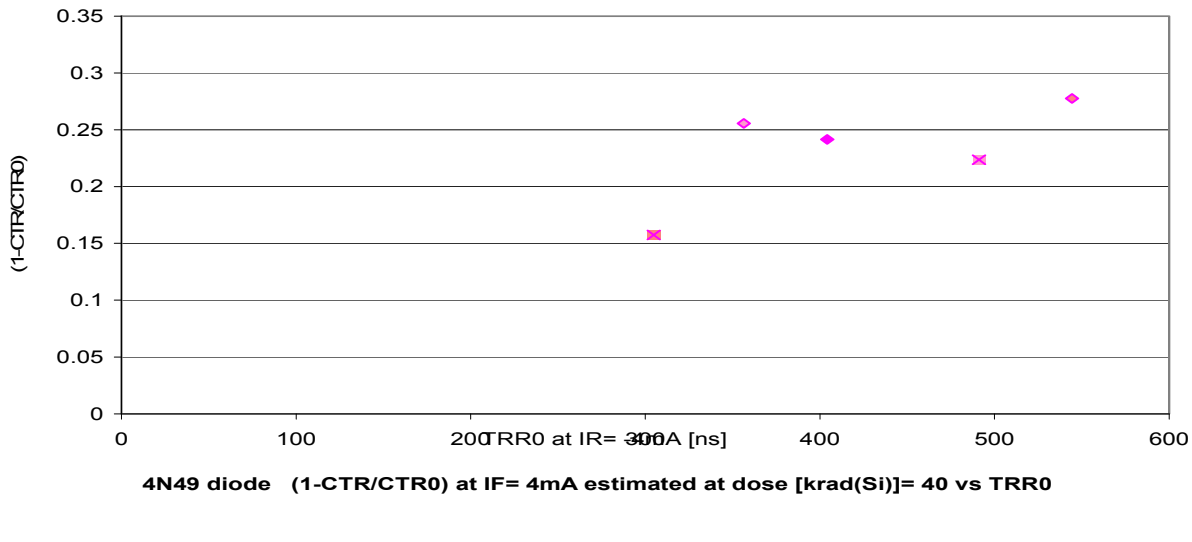
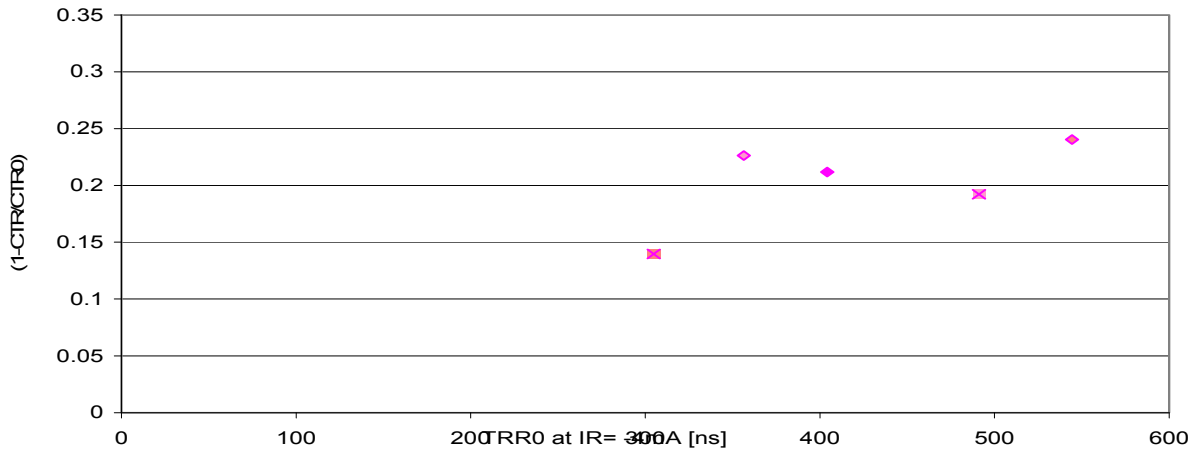


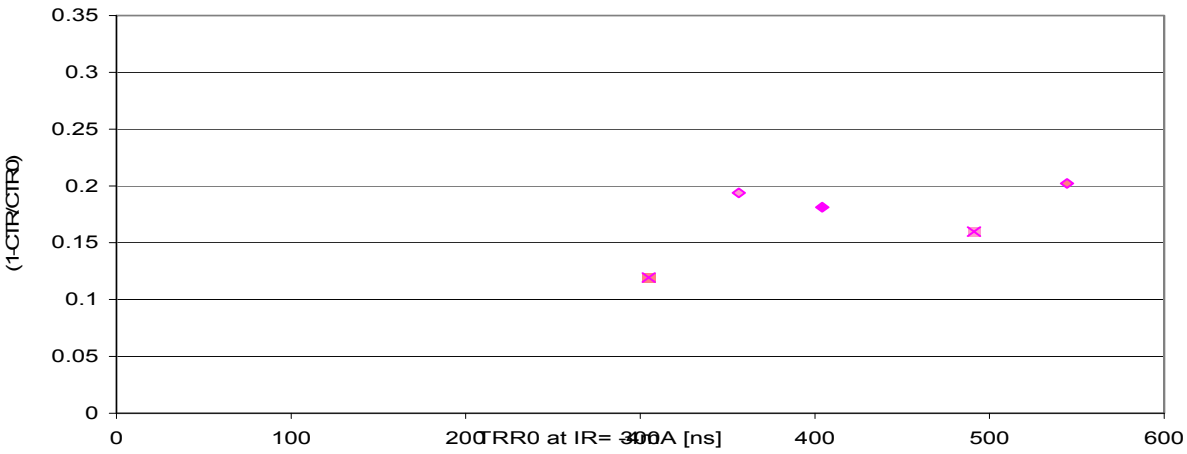
Fig. 12-181: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0



4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0

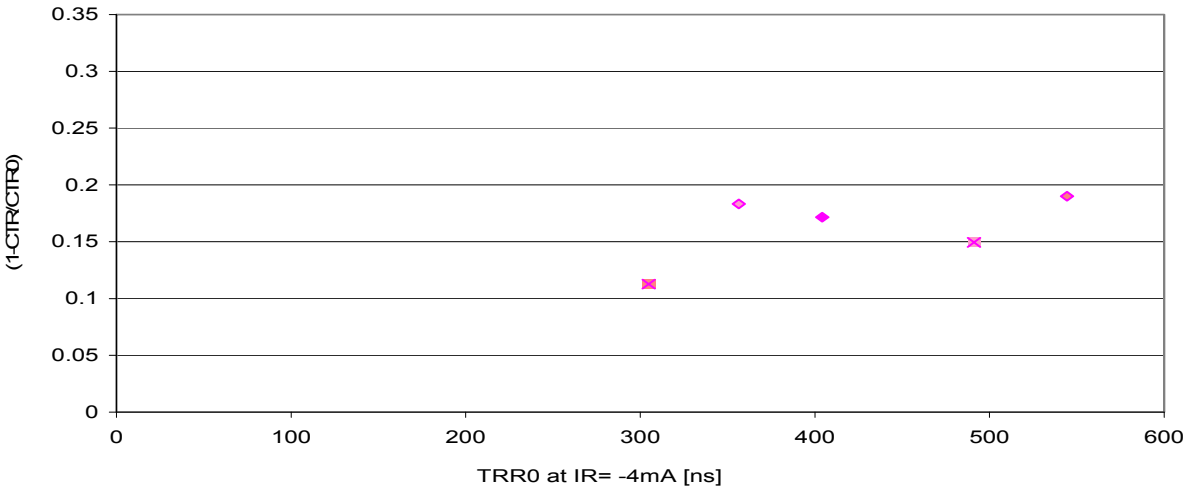
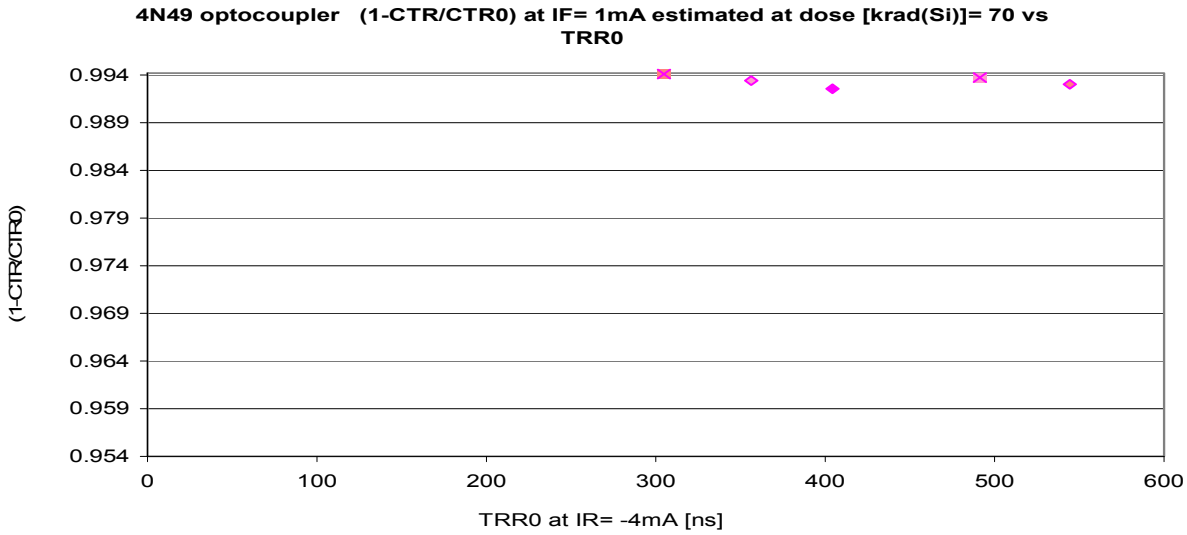
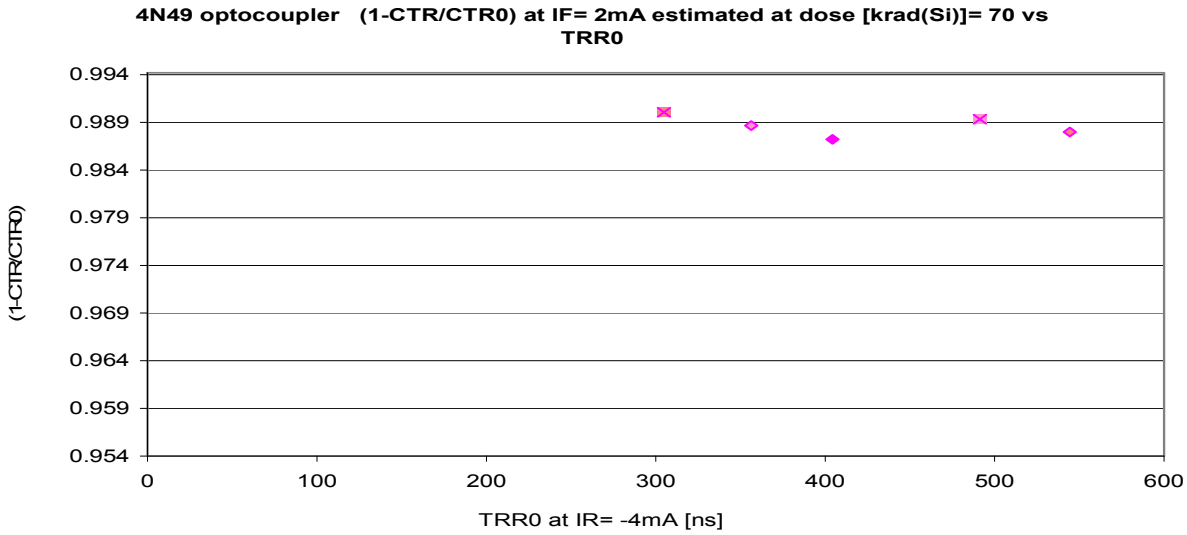
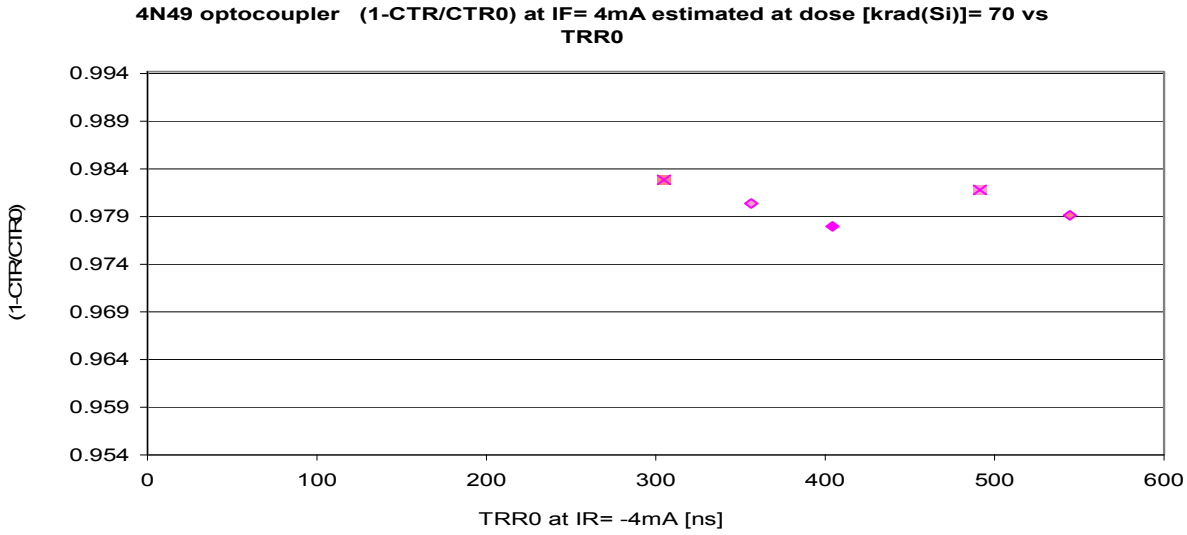
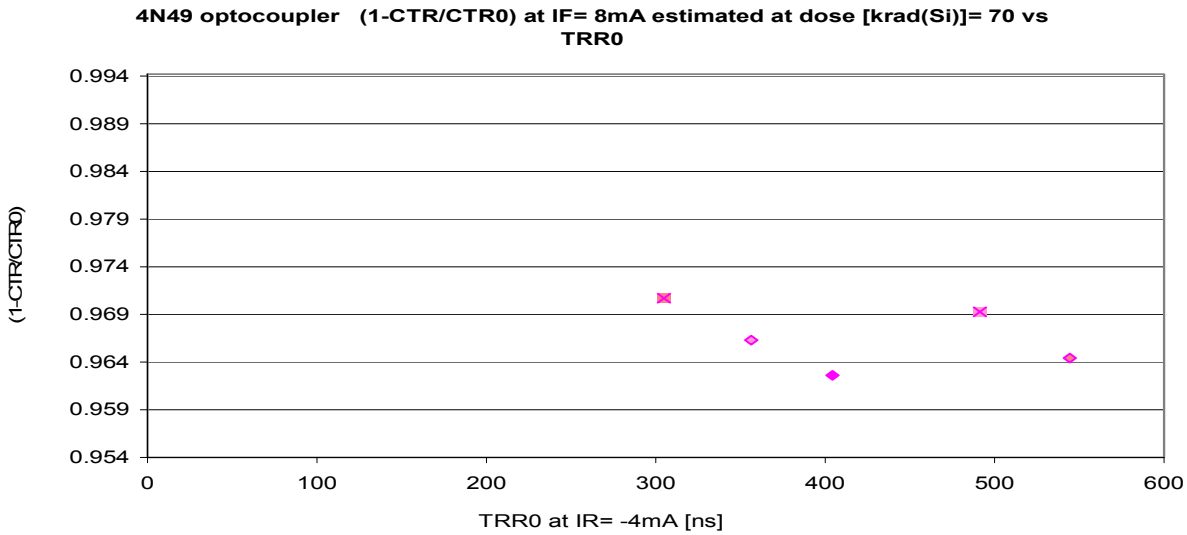


Fig. 12-182: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.994
0.989
0.984
0.979
0.974
0.969
0.964
0.959
0.954
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

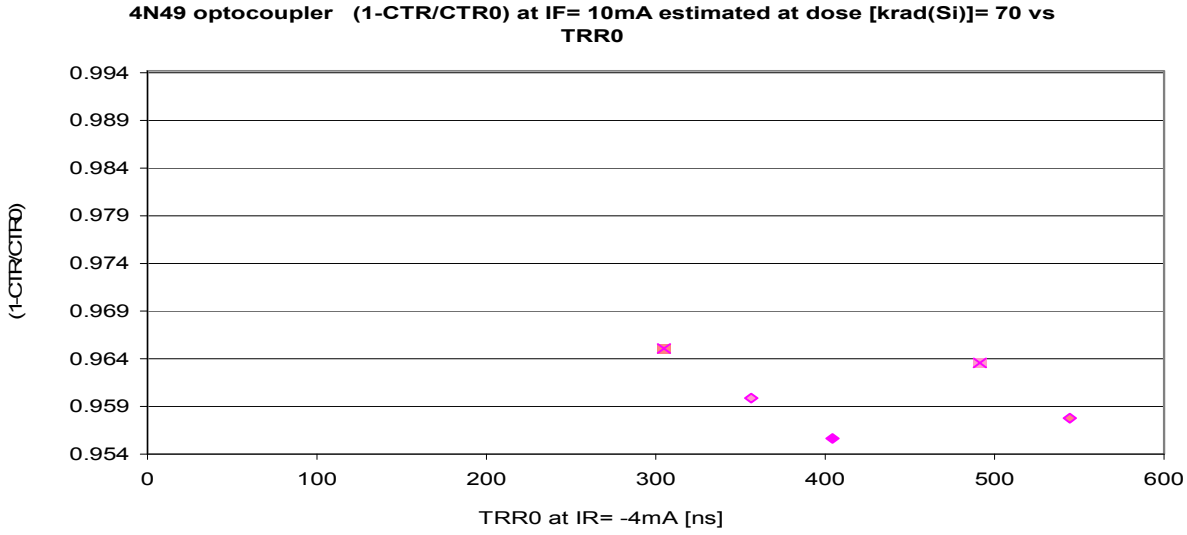
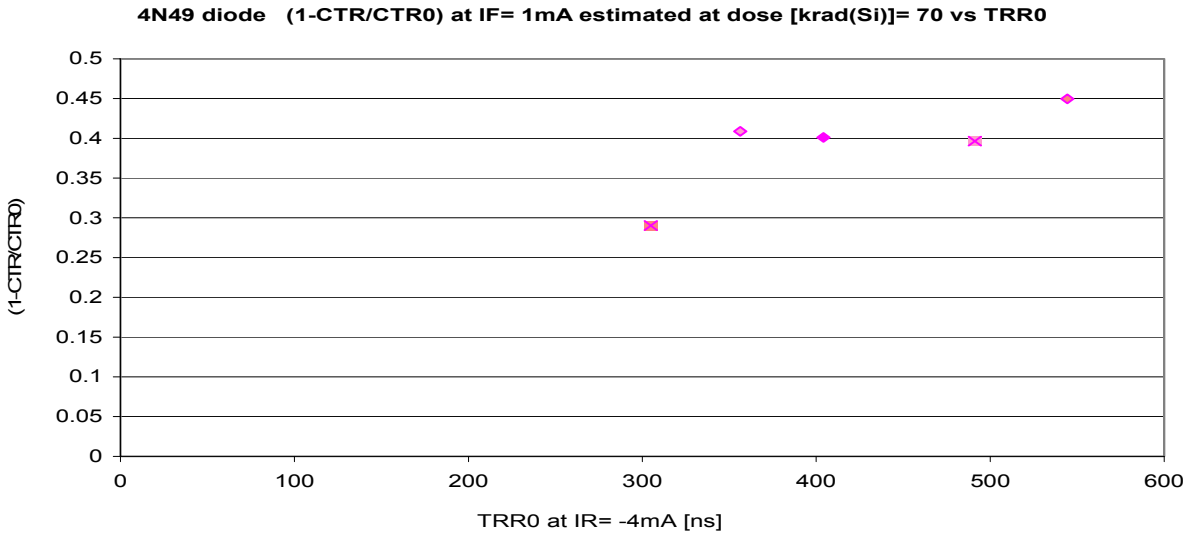
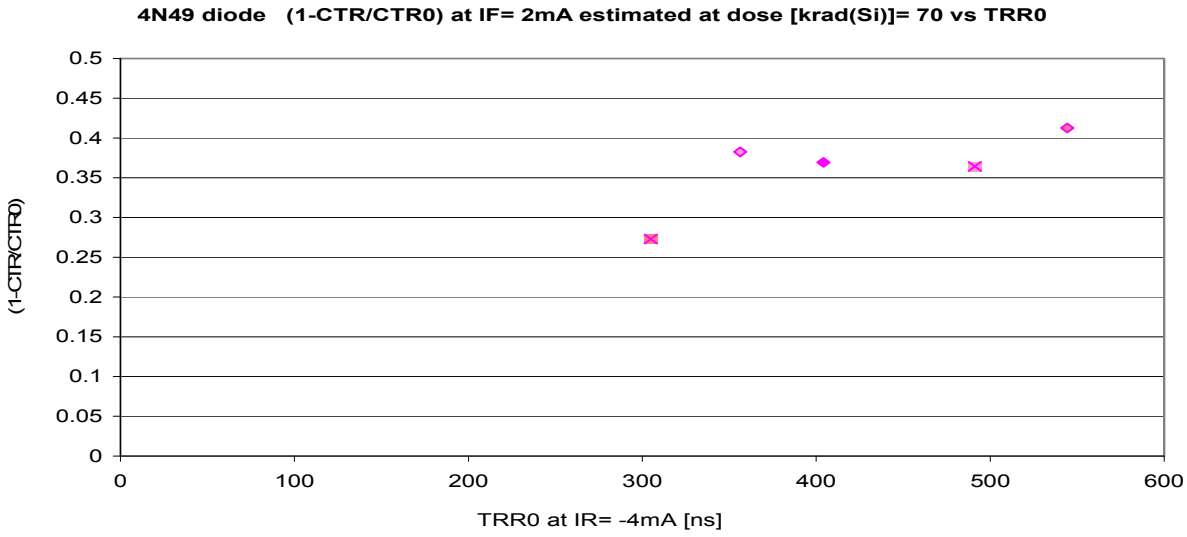
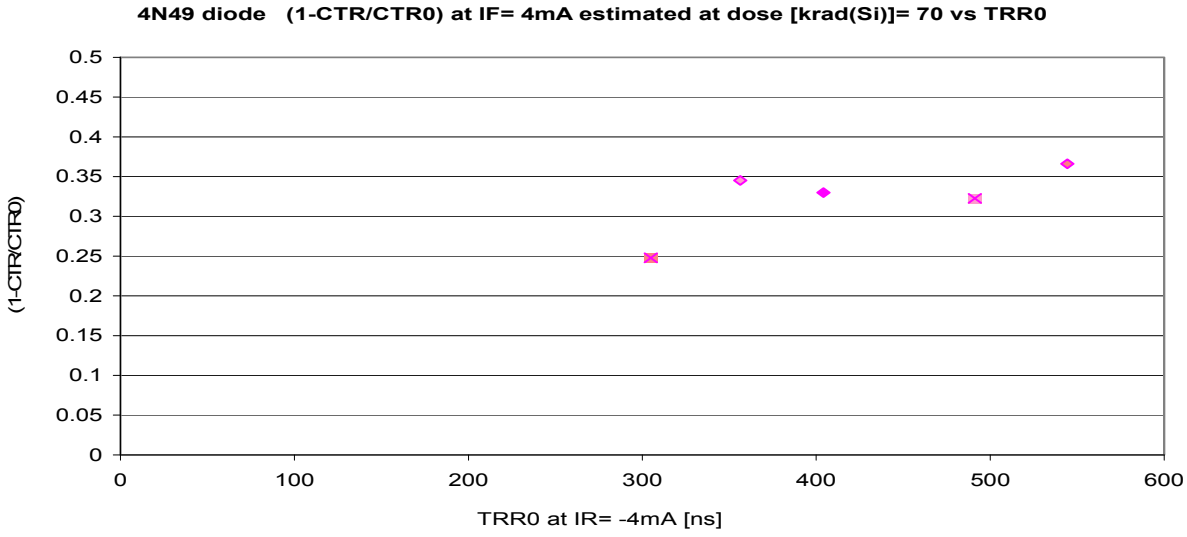
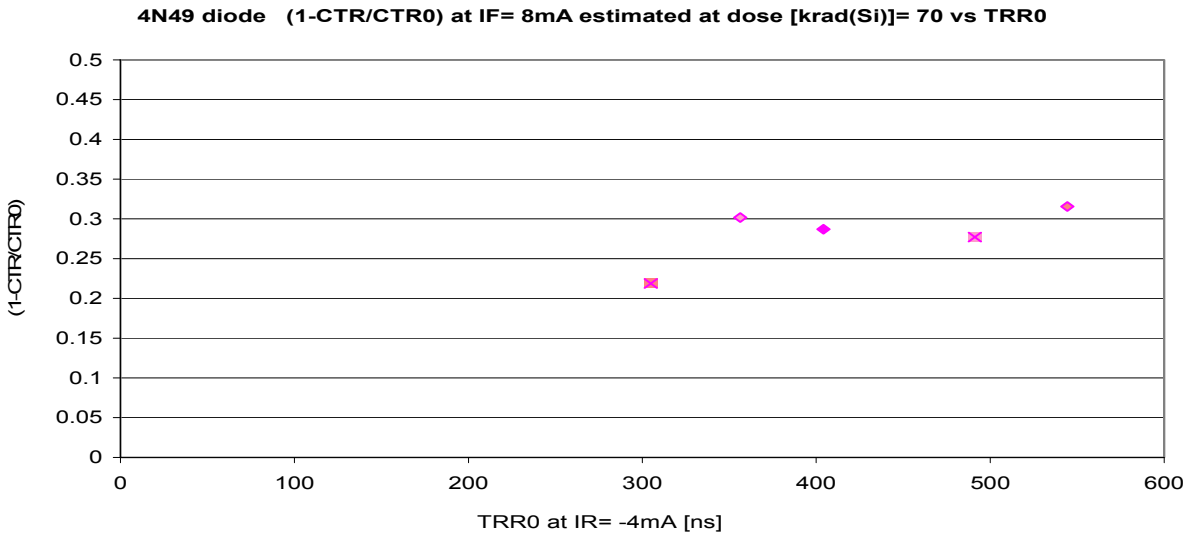

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.994
0.989
0.984
0.979
0.974
0.969
0.964
0.959
0.954
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-183: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

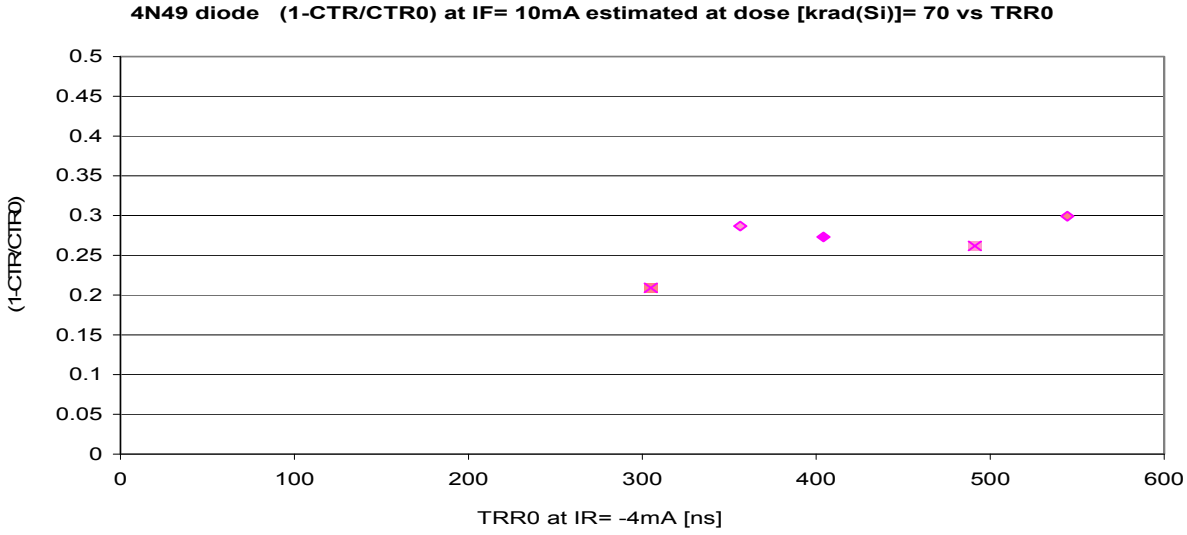

4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-184: optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

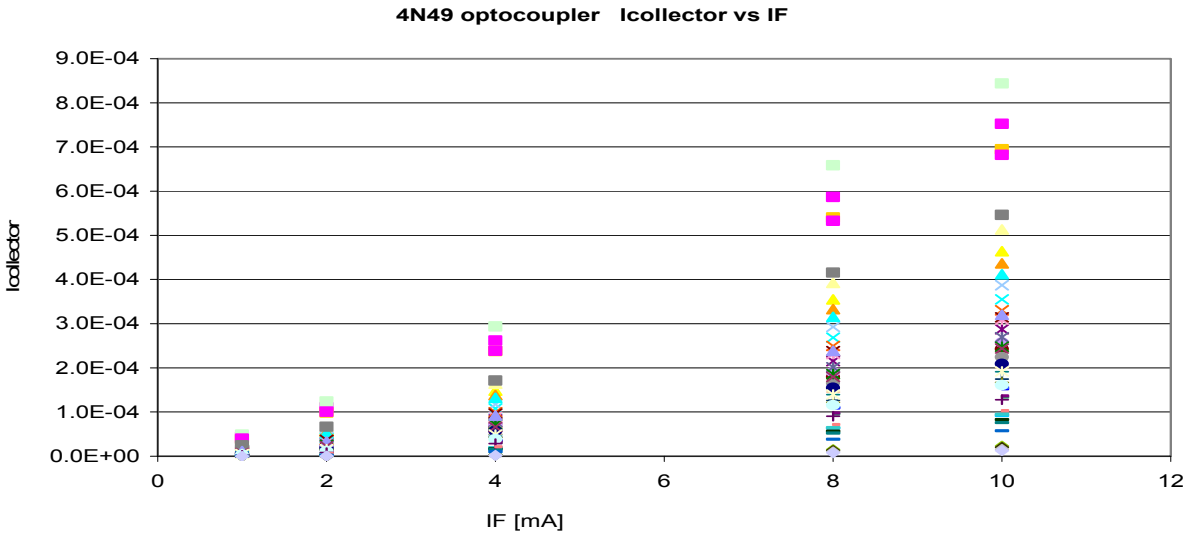


Fig. 12-185: diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

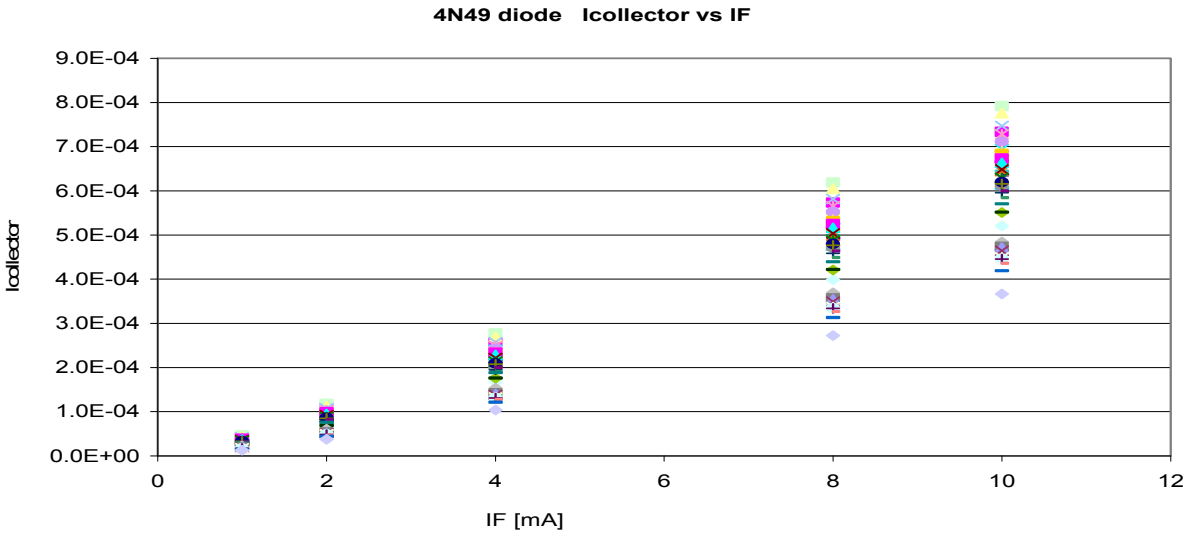


Fig. 12-186: transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

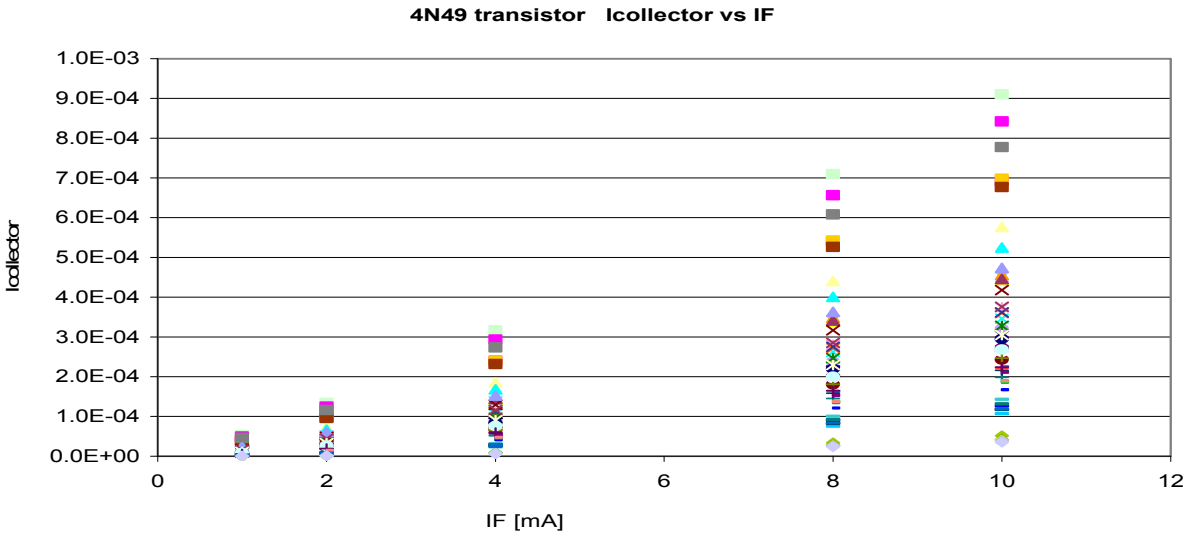


Fig. 12-187: optocoupler irradiated: CTR for each step with respect to diode current I_F

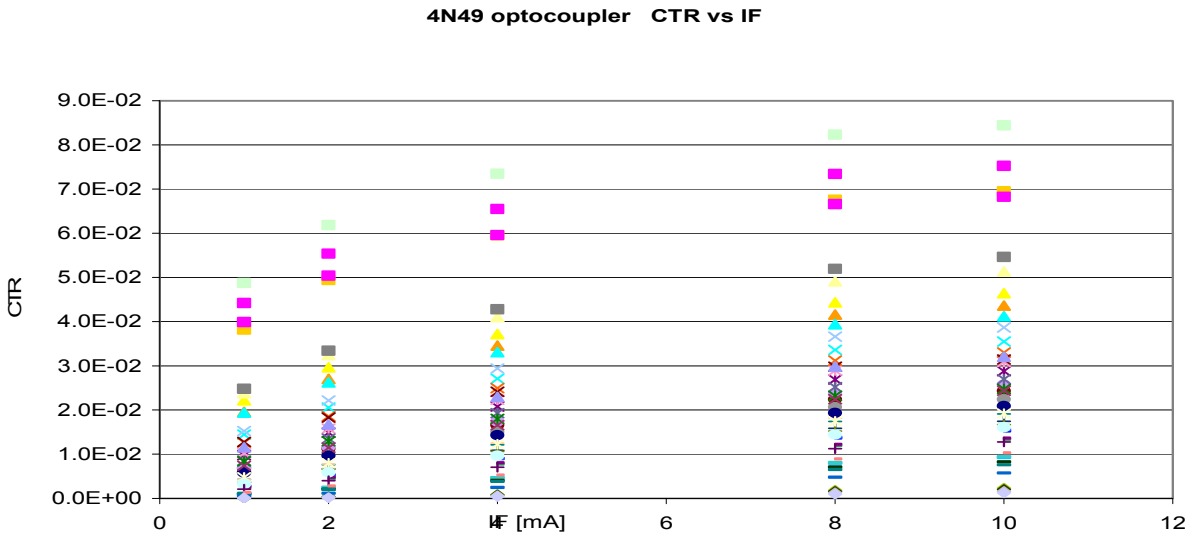


Fig. 12-188: diode irradiated: CTR for each step with respect to diode current I_F

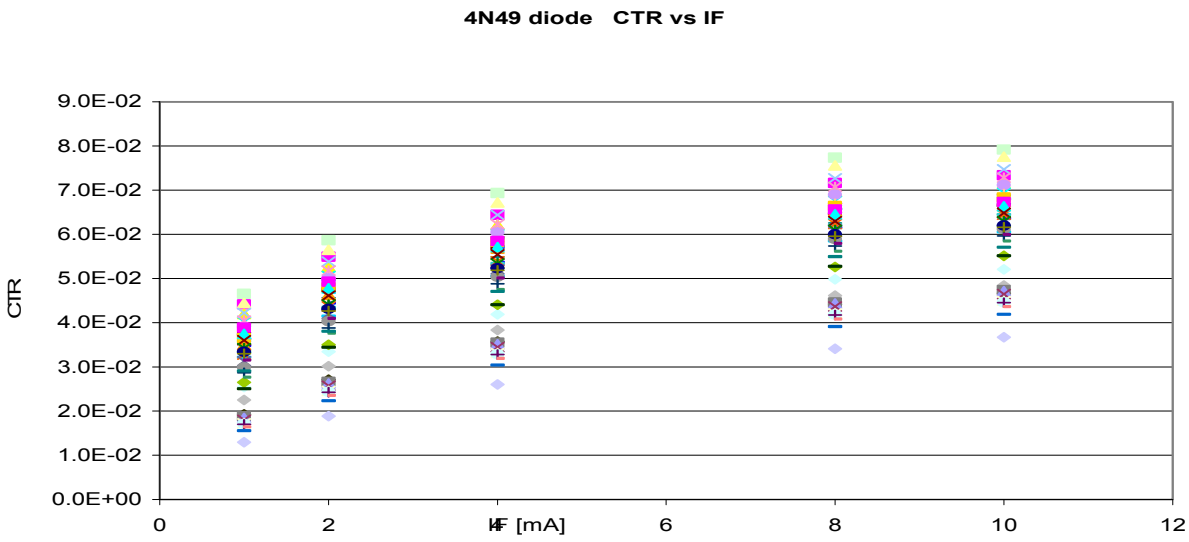


Fig. 12-189: transistor irradiated: CTR for each step with respect to diode current I_F

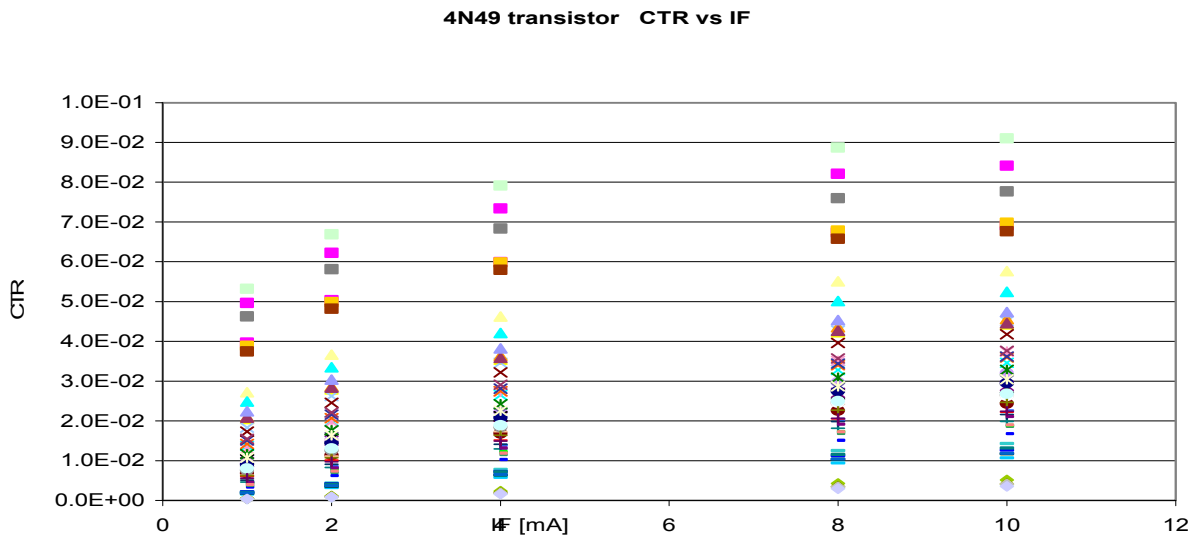


Fig. 12-190: optocoupler irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

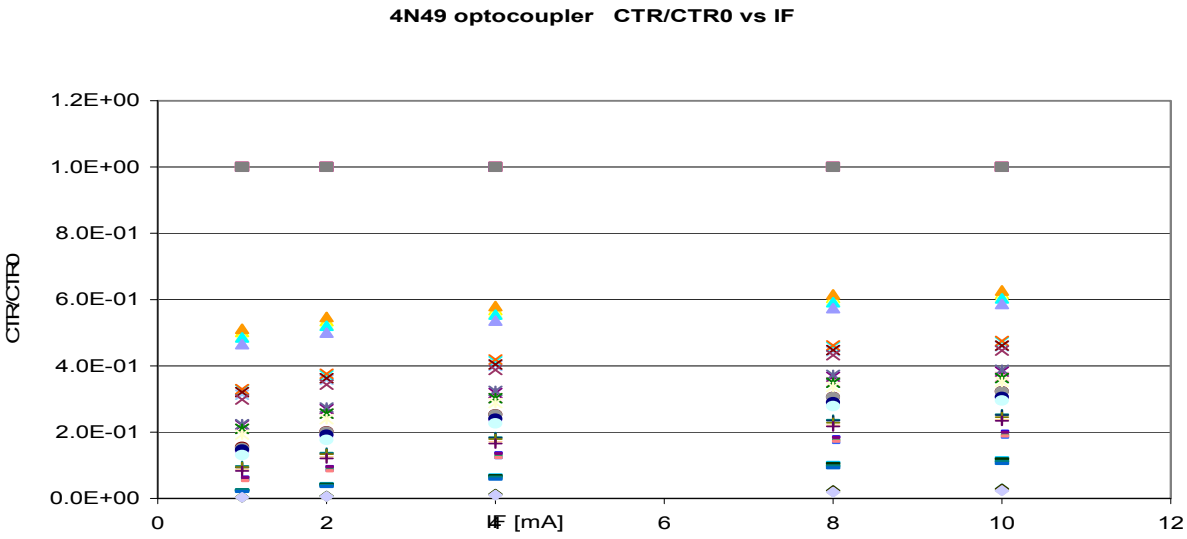


Fig. 12-191: diode irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

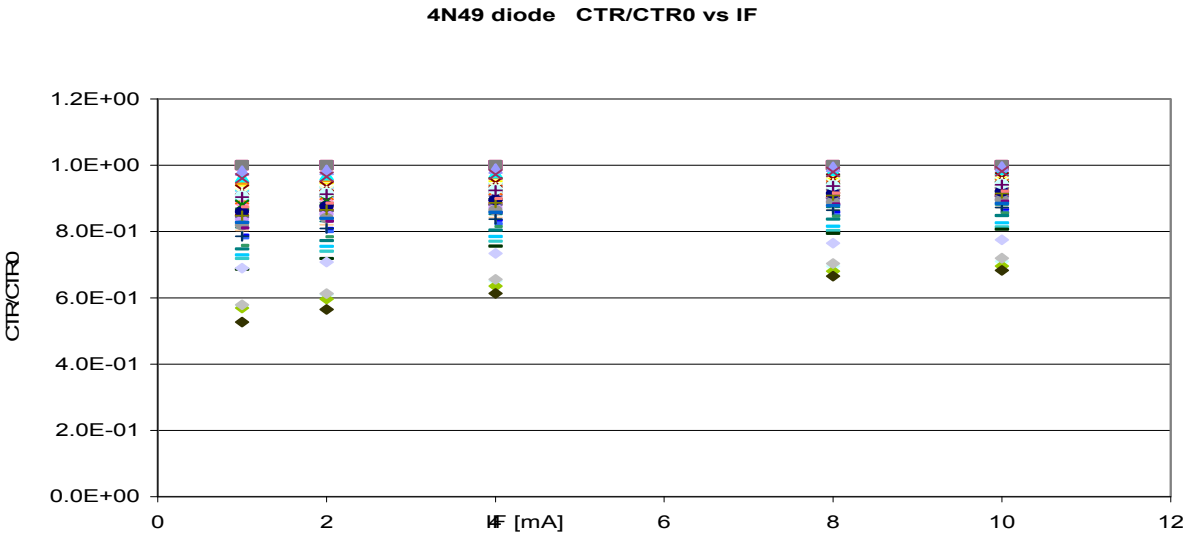


Fig. 12-192: transistor irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

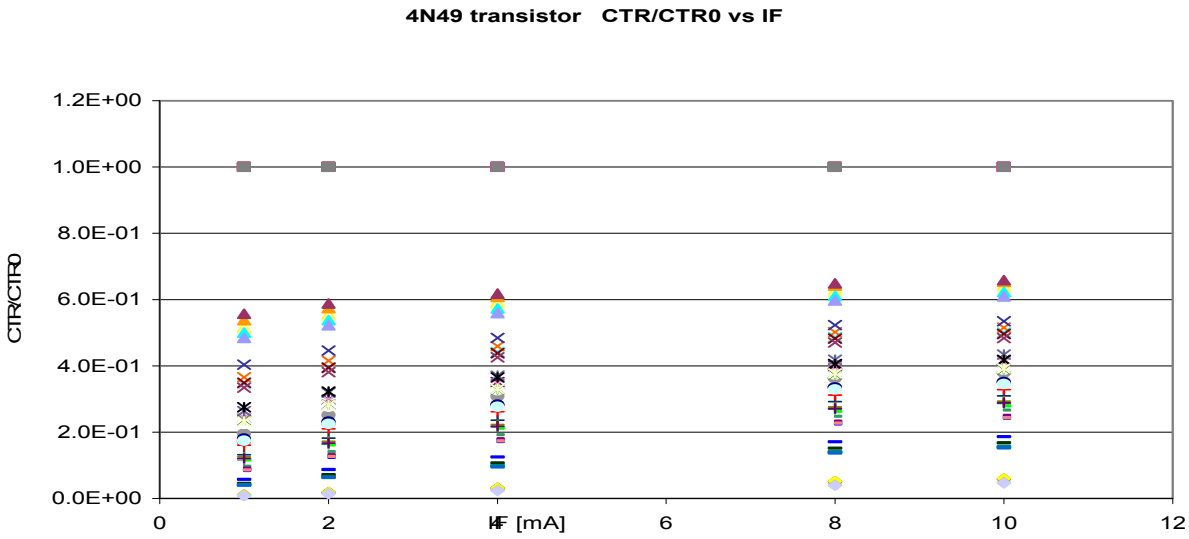
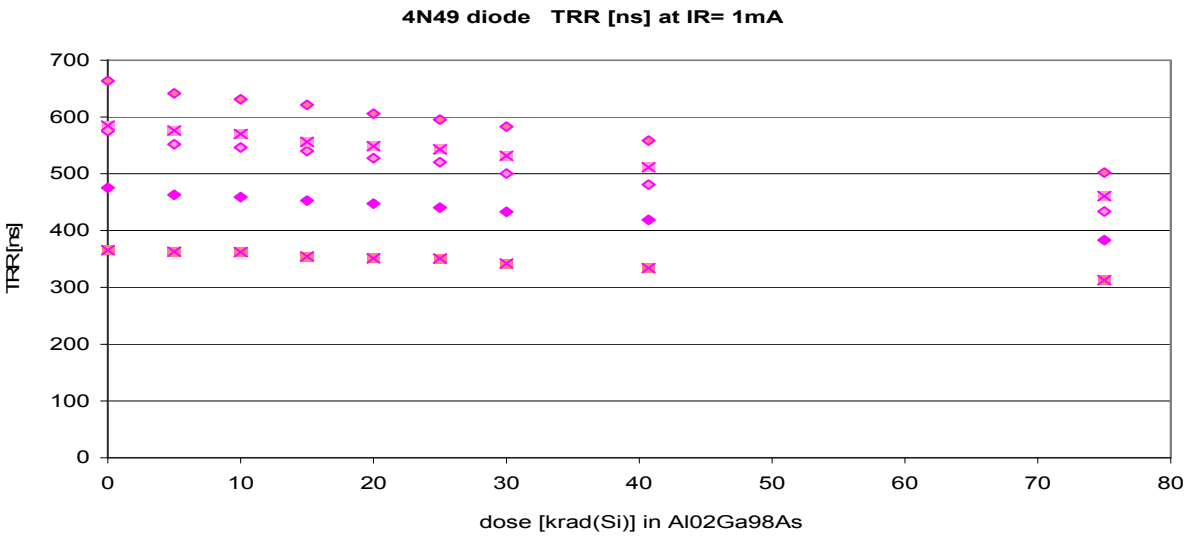
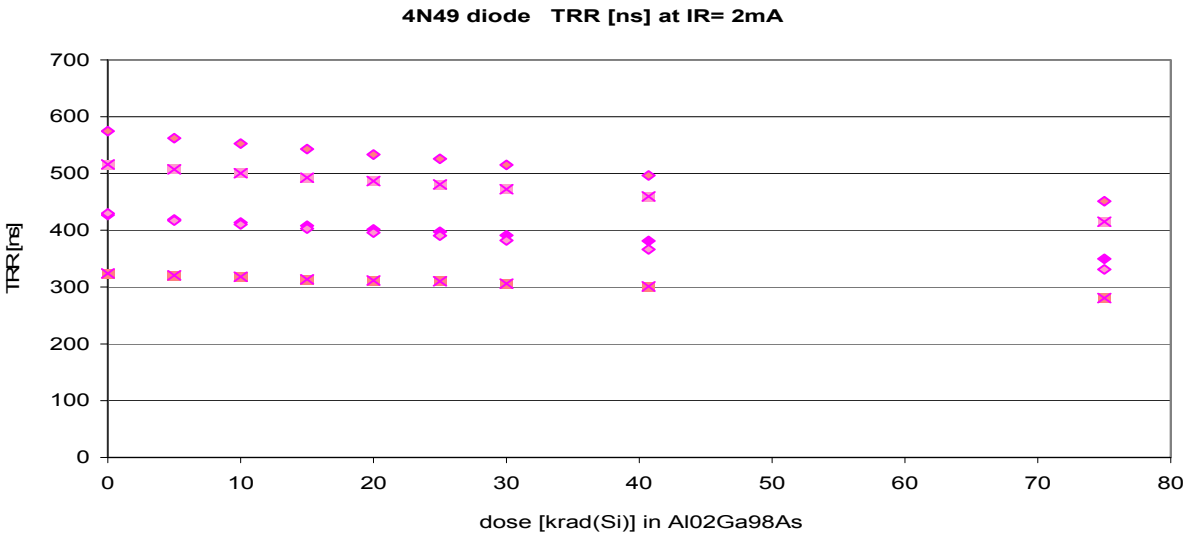


Fig. 12-193: 4N49 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





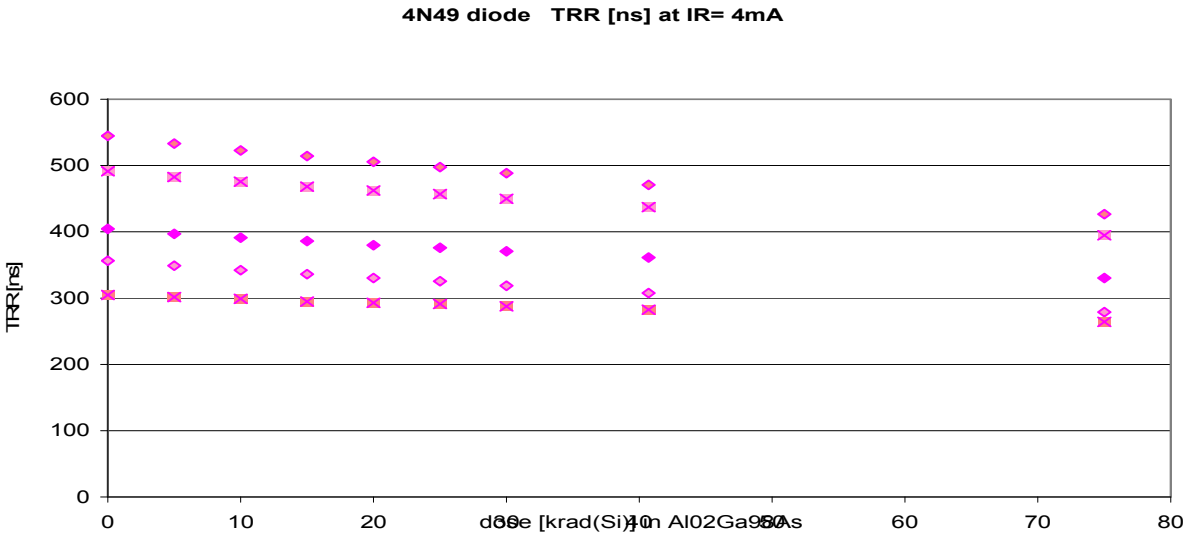


Fig. 12-194: 4N49 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA

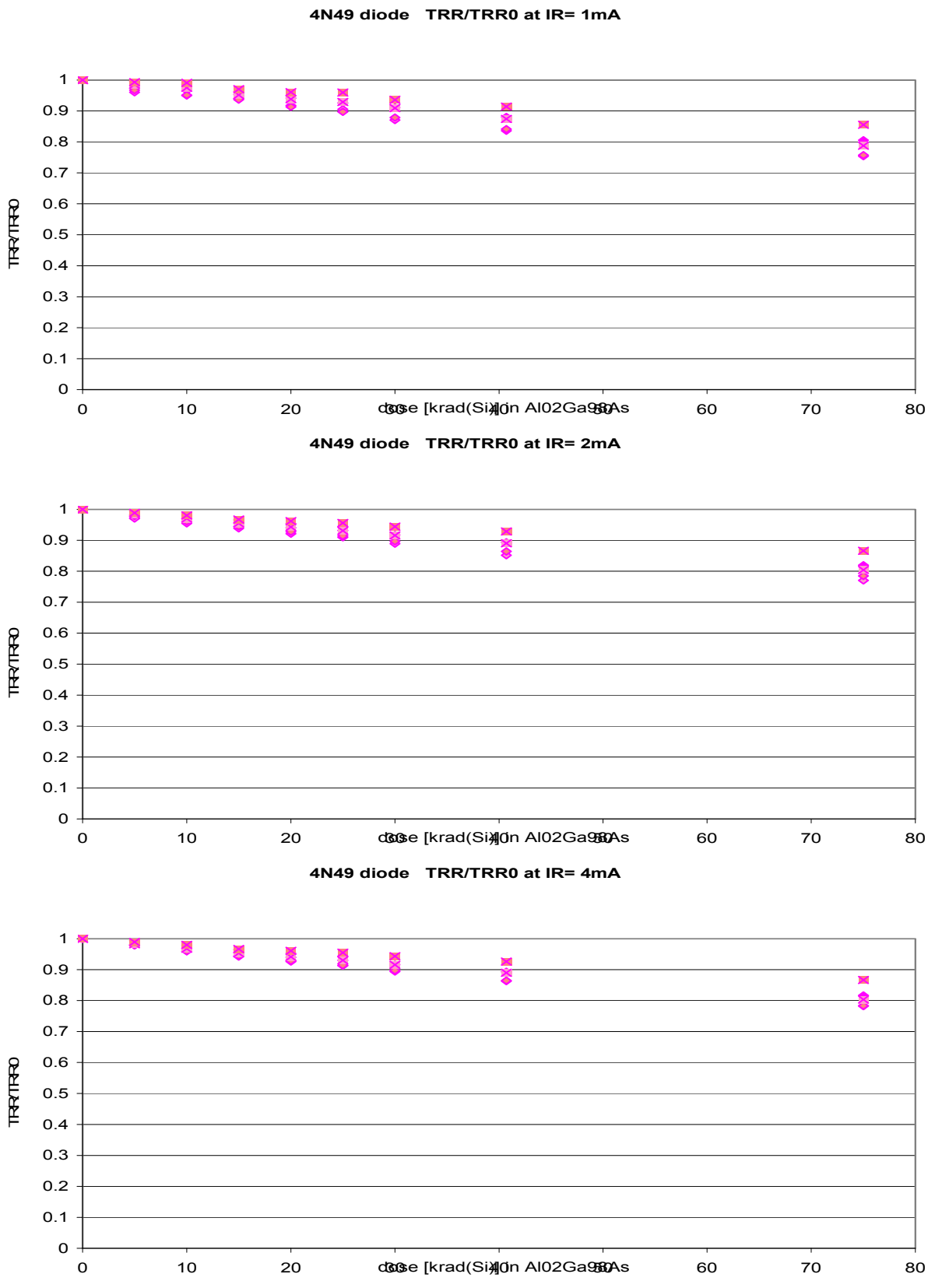


Fig. 12-195: 4N49 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA

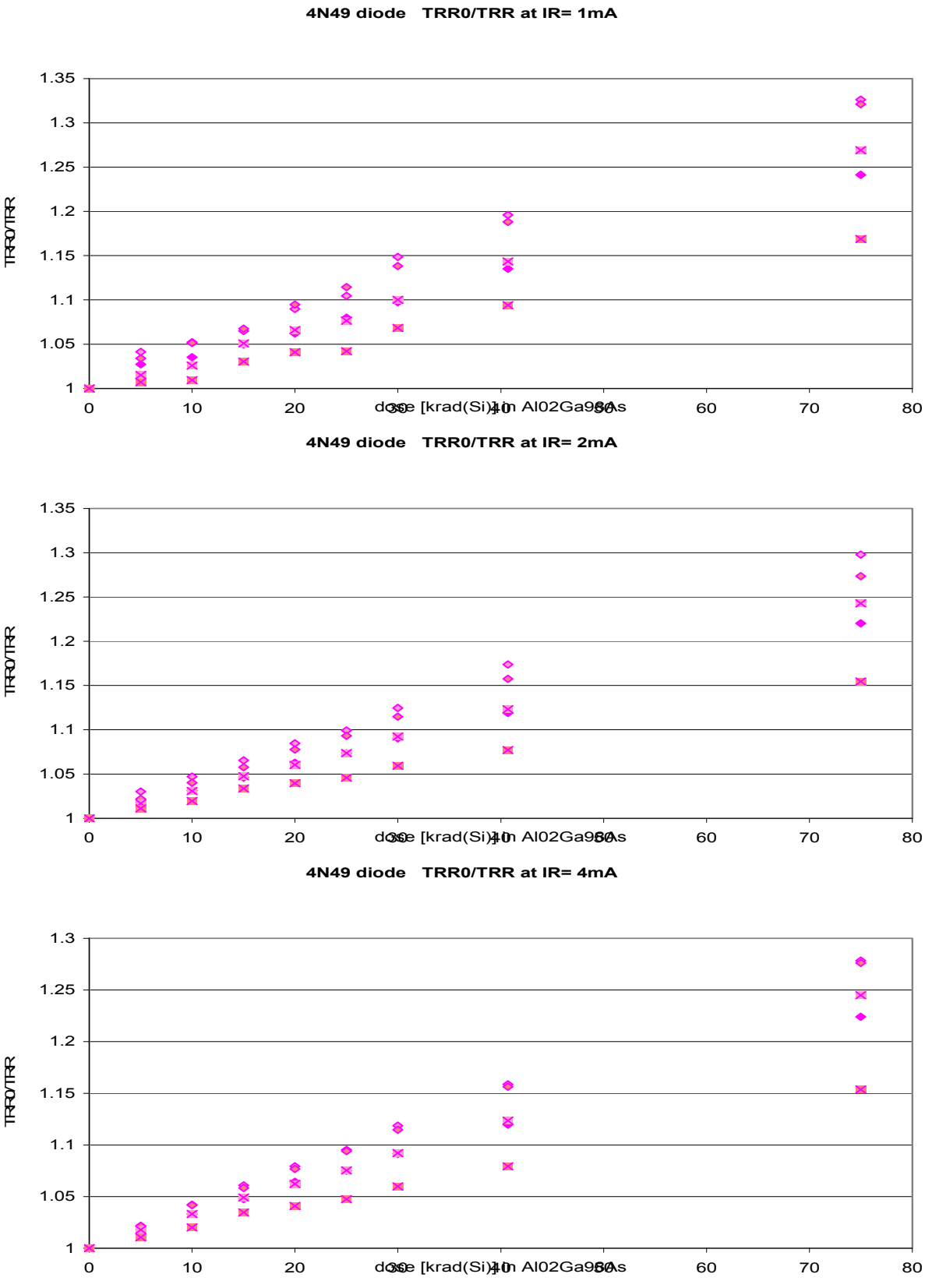


Fig. 12-196: 4N49 diode: τ_{RR0}/ τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA

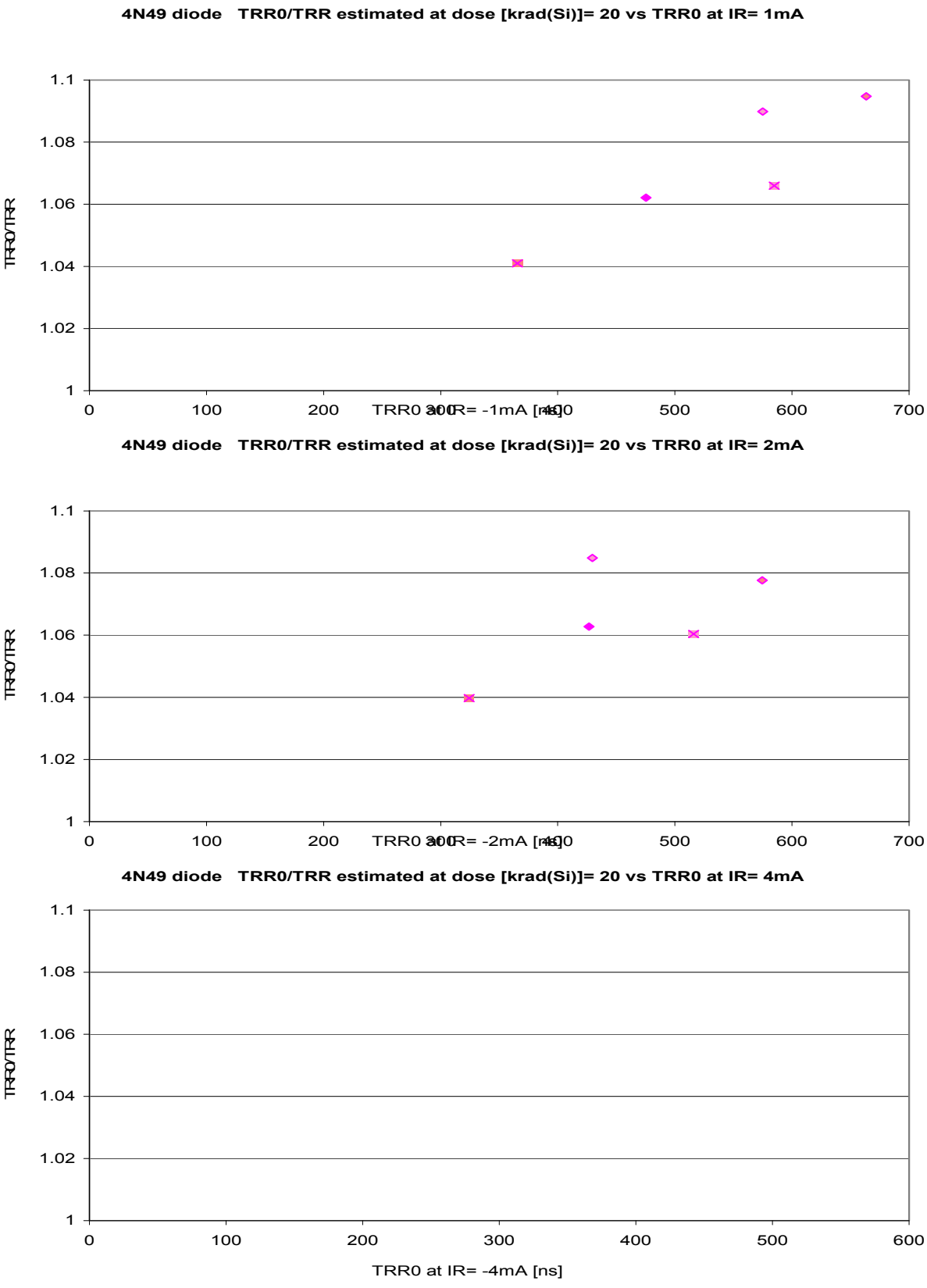


Fig. 12-197: 4N49 diode: τ_{RR0}/ τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA

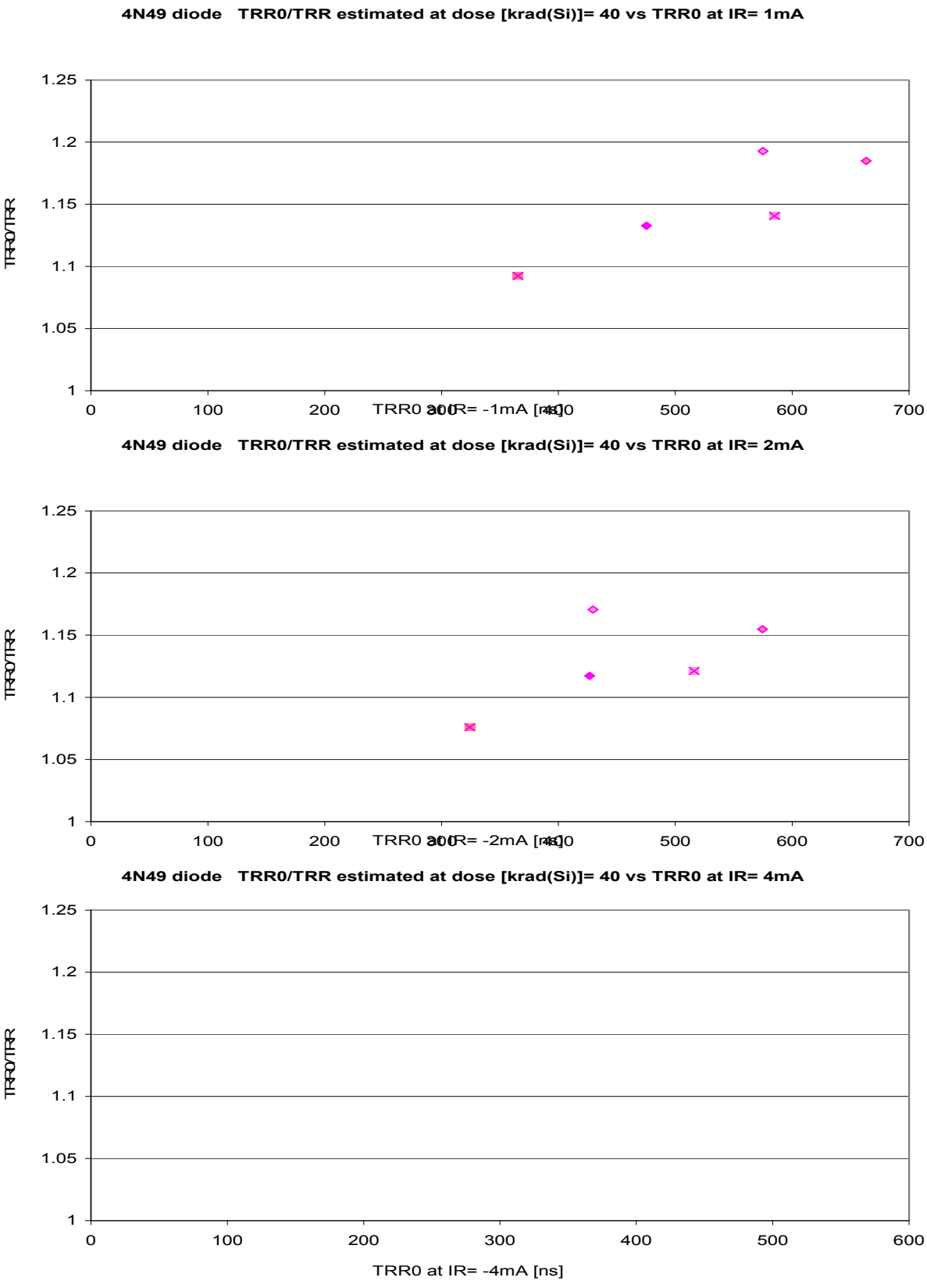
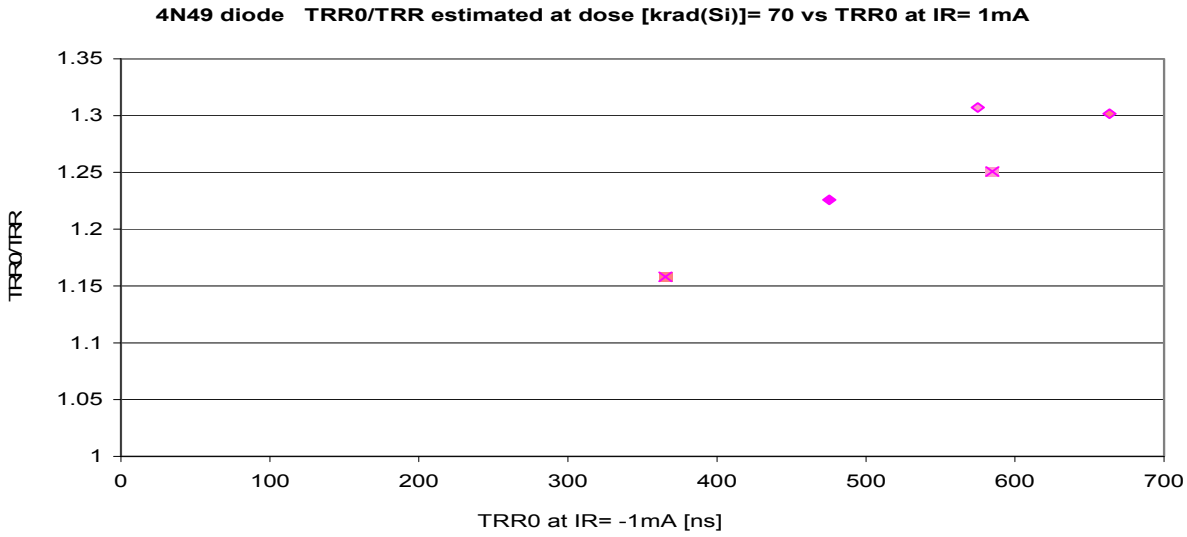
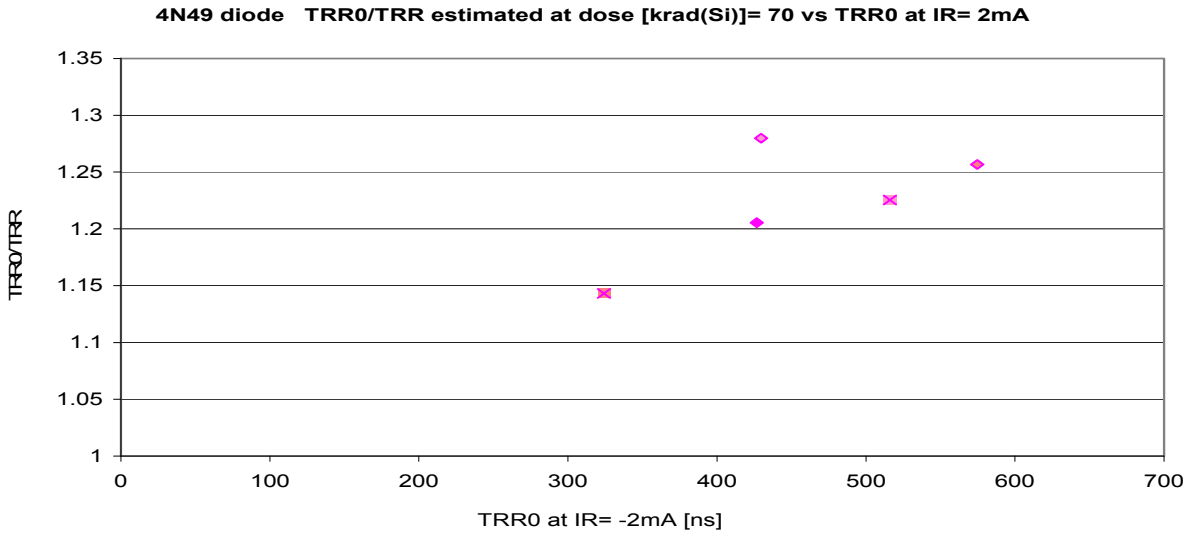


Fig. 12-198: 4N49 diode: τ_{RR0}/ τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





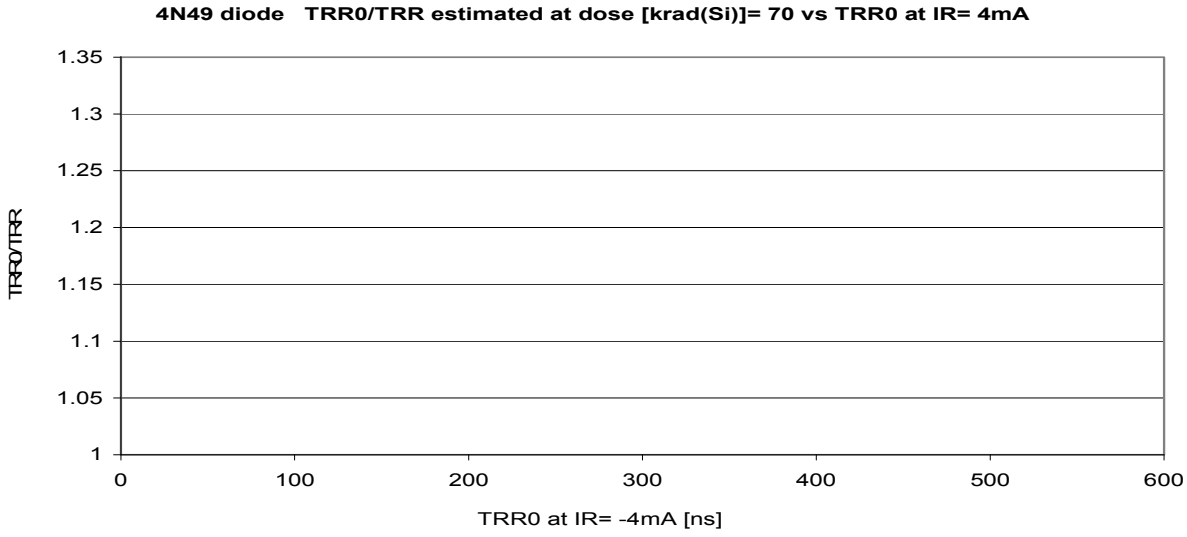
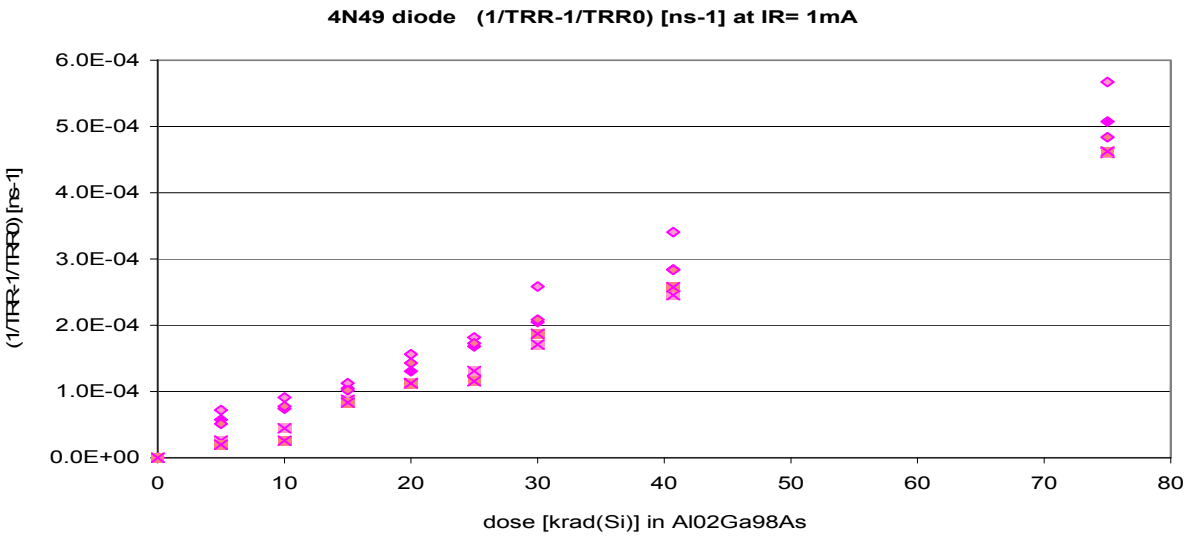
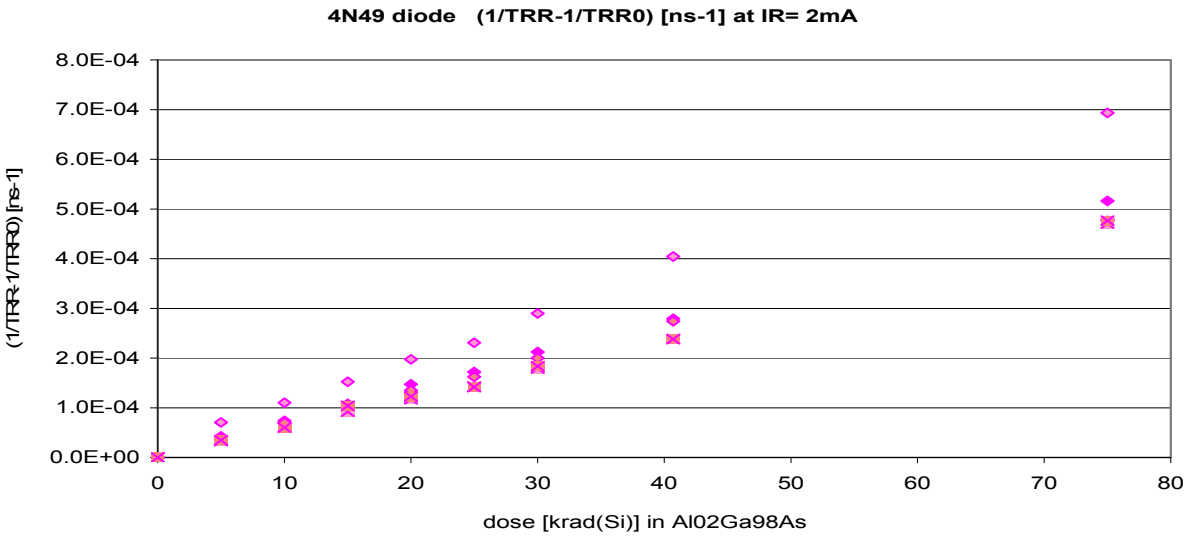


Fig. 12-199: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose





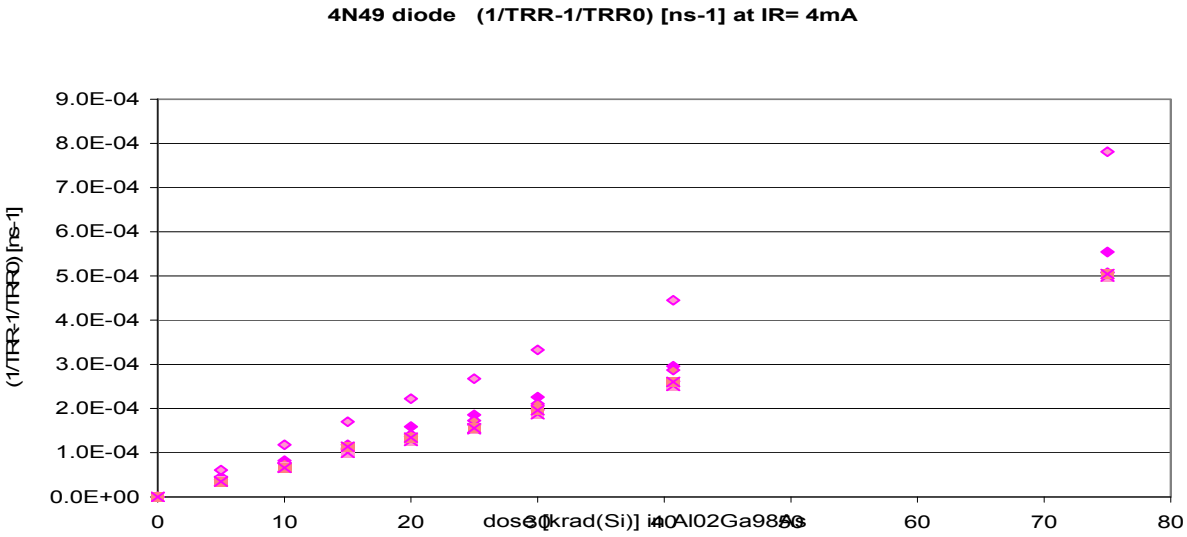


Fig. 12-200: 4N49 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}

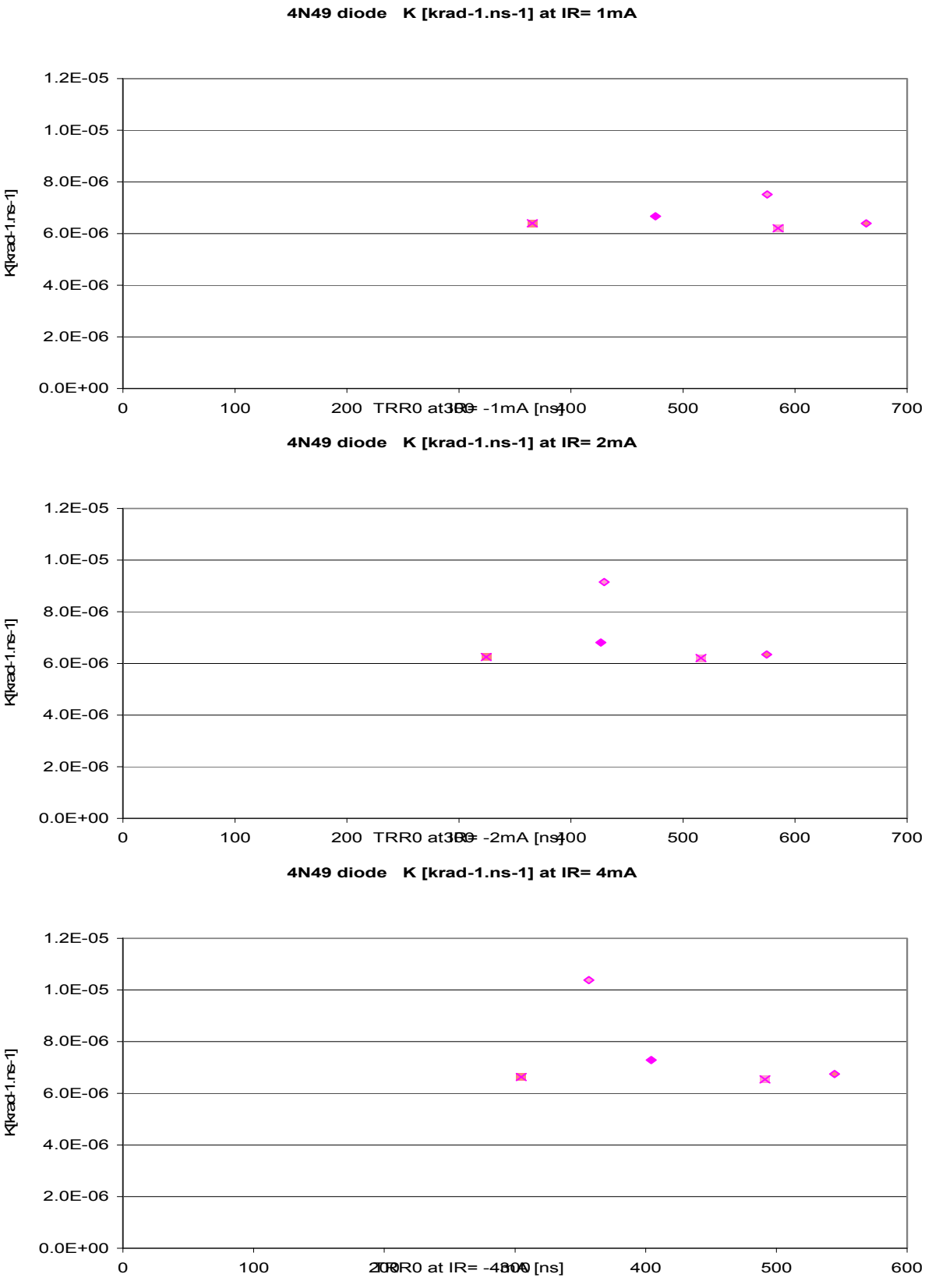
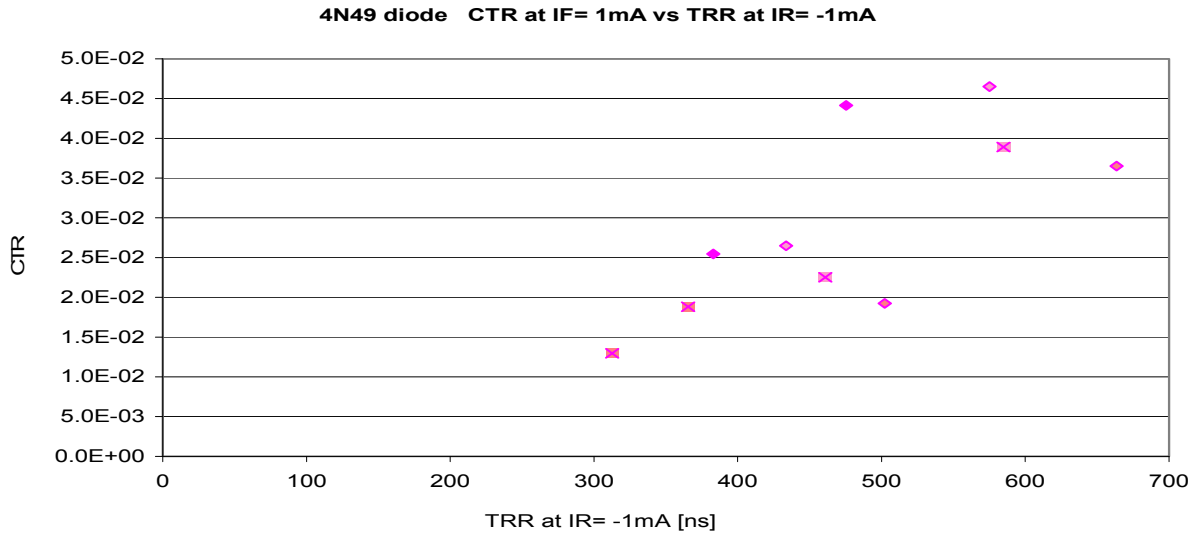
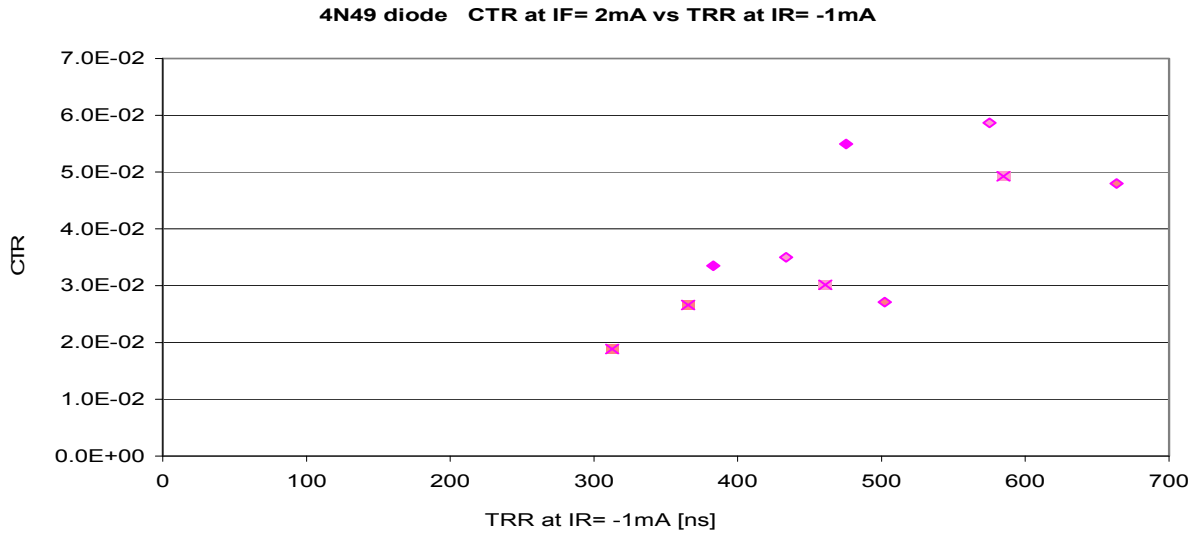
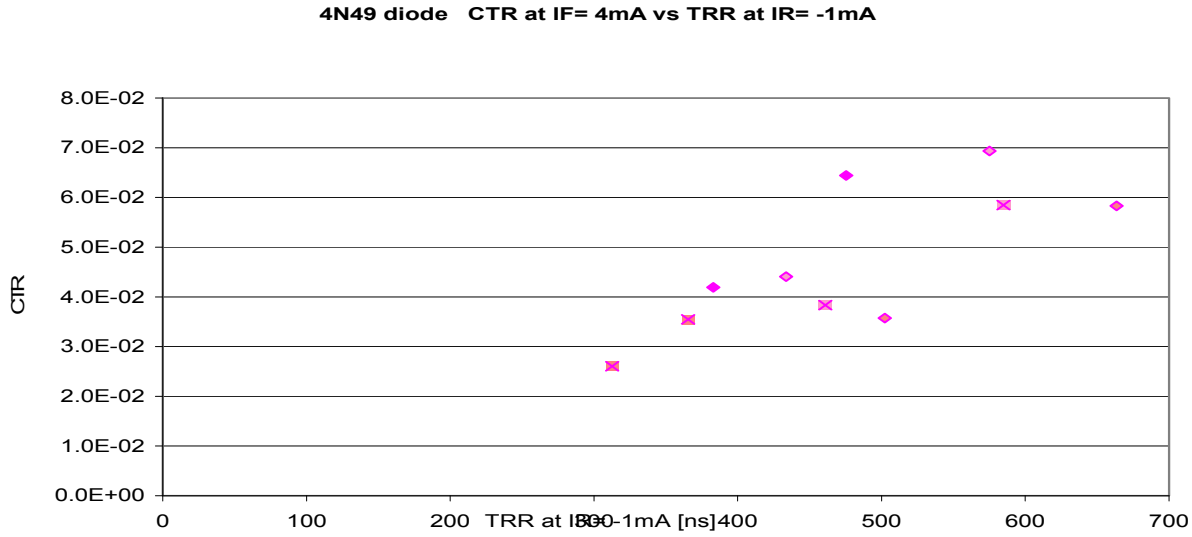


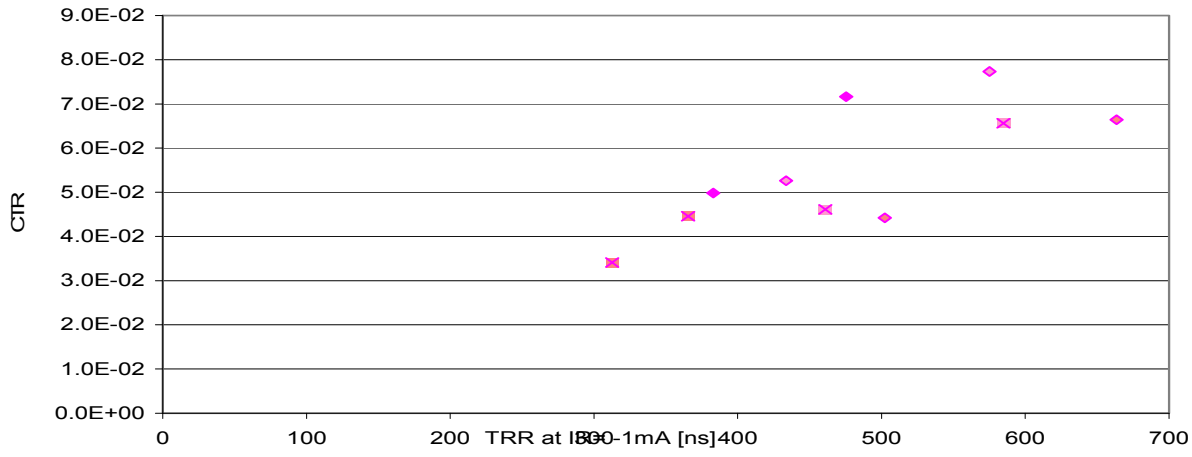
Fig. 12-201: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), and after (lower points), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA







4N49 diode CTR at IF= 8mA vs TRR at IR= -1mA



4N49 diode CTR at IF= 10mA vs TRR at IR= -1mA

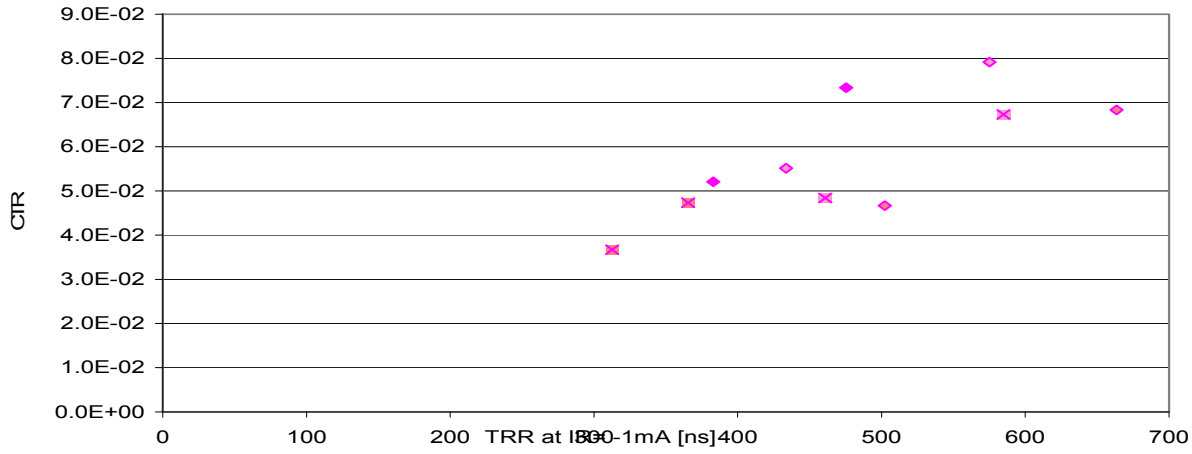
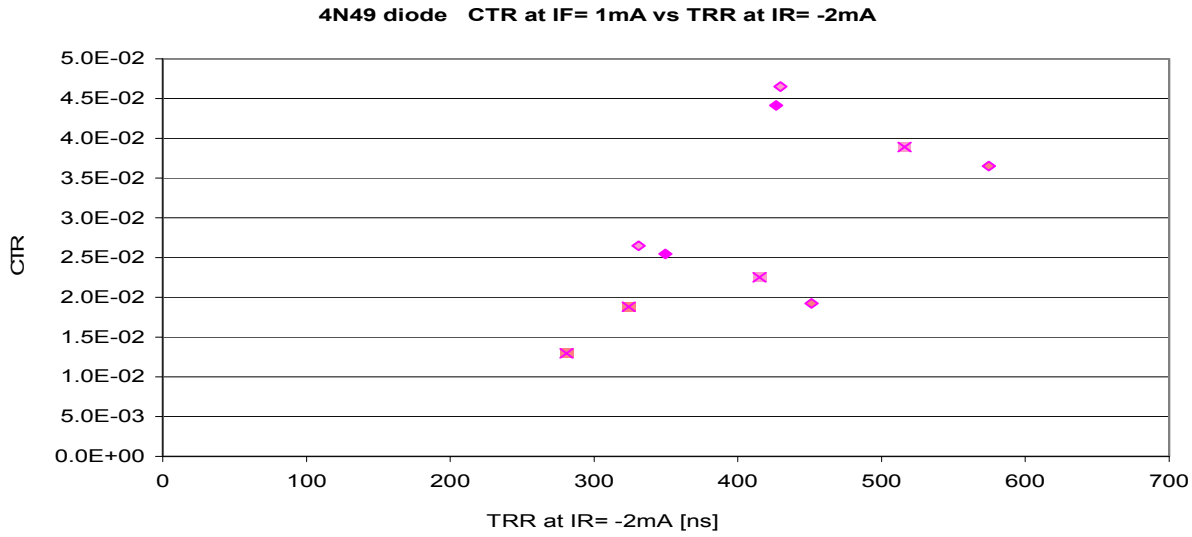
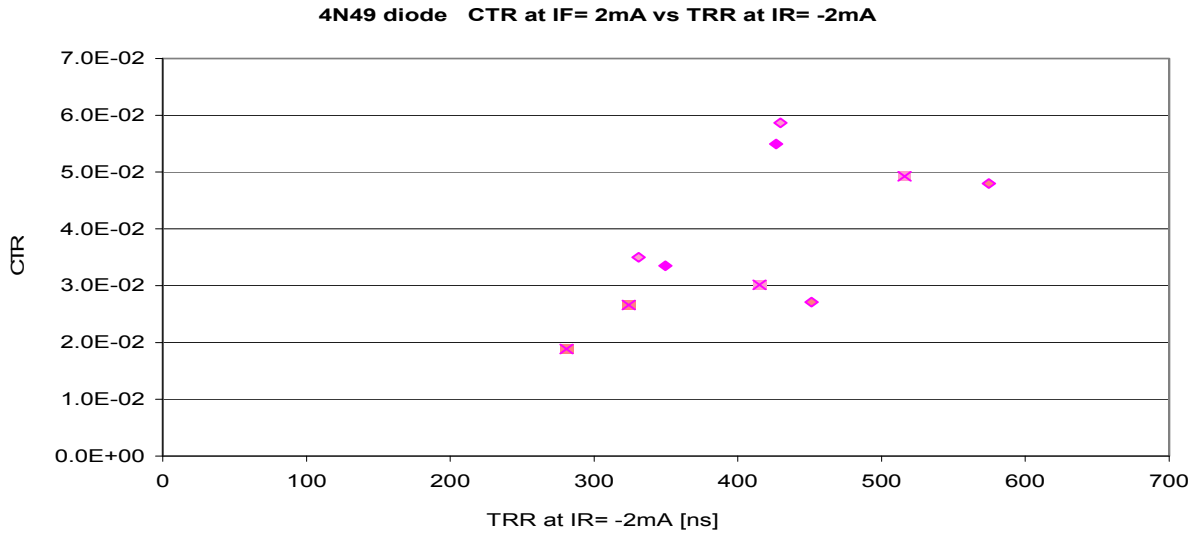
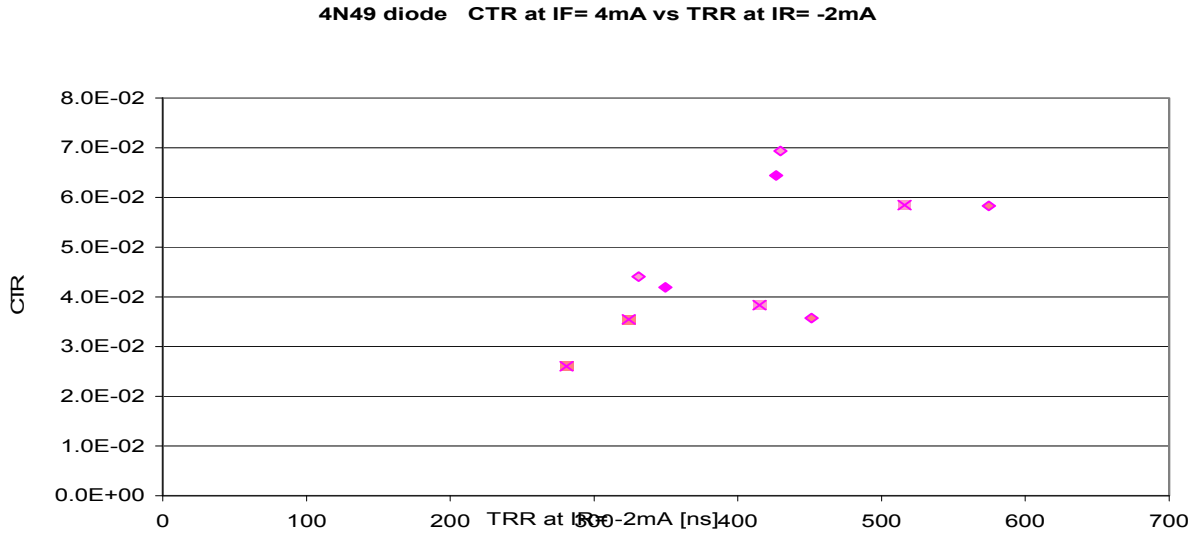


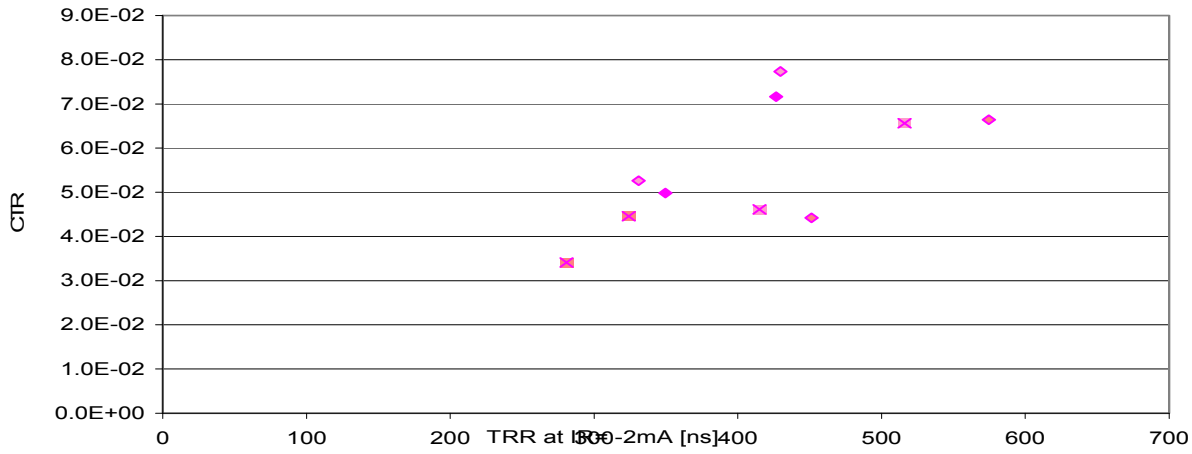
Fig. 12-202: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), and after (lower points), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA







4N49 diode CTR at IF= 8mA vs TRR at IR= -2mA



4N49 diode CTR at IF= 10mA vs TRR at IR= -2mA

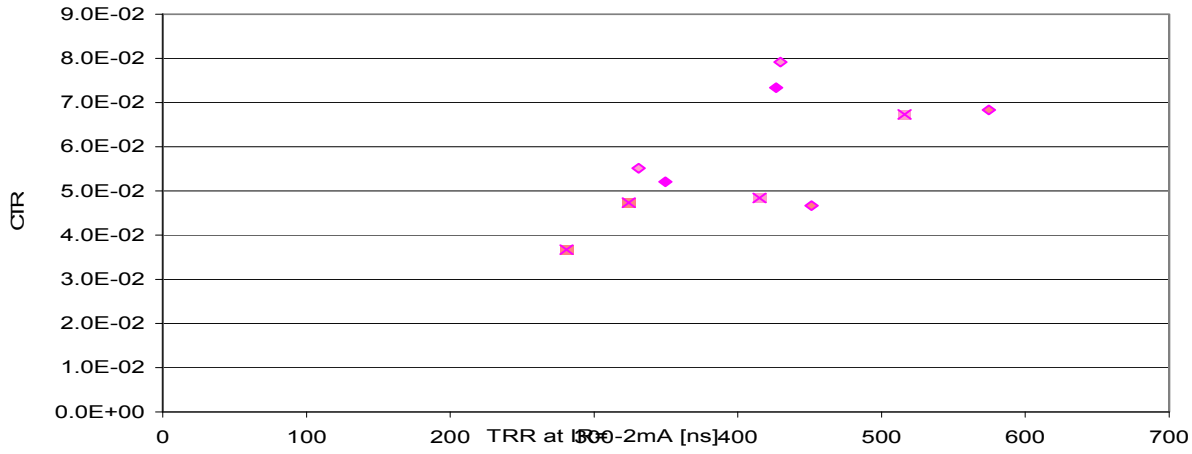
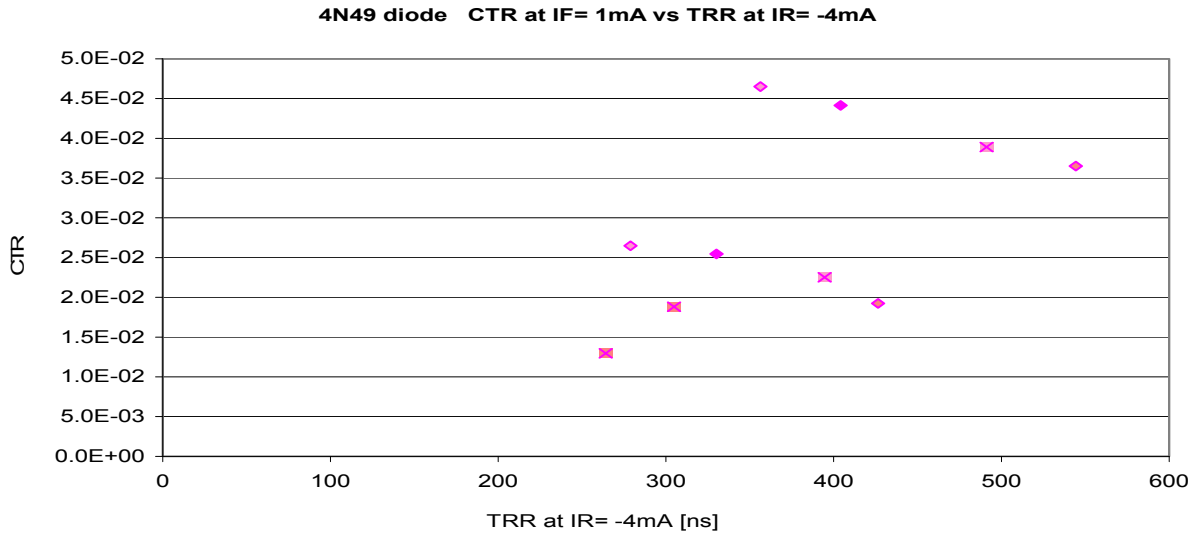
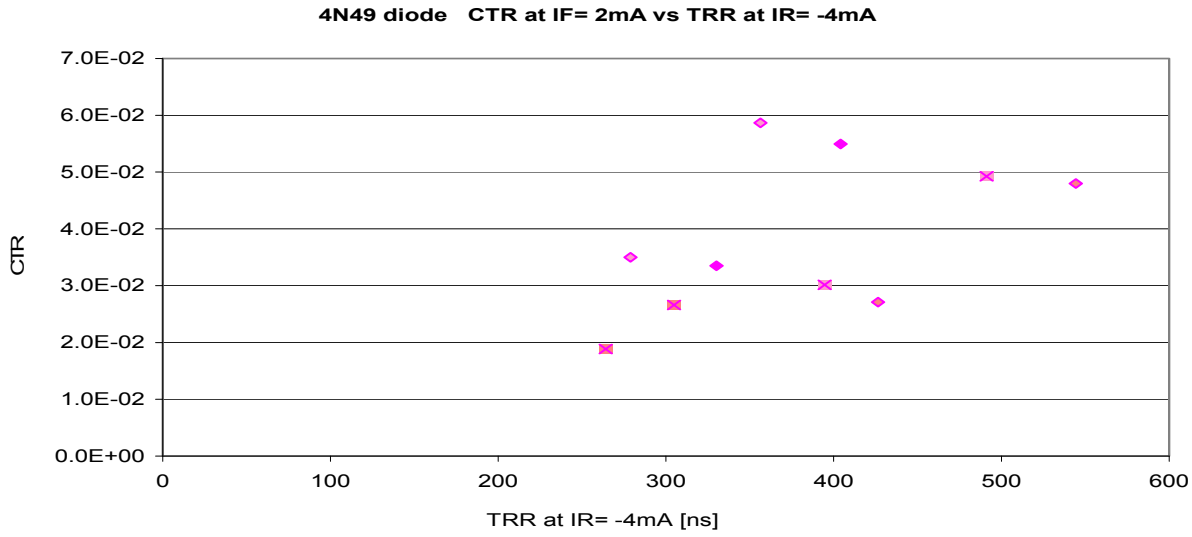
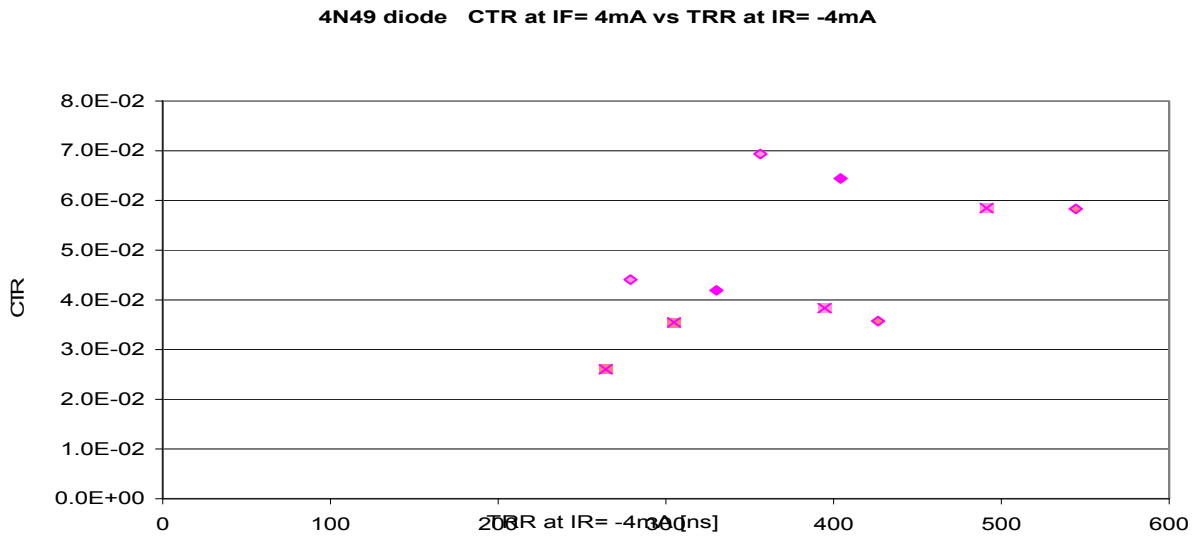
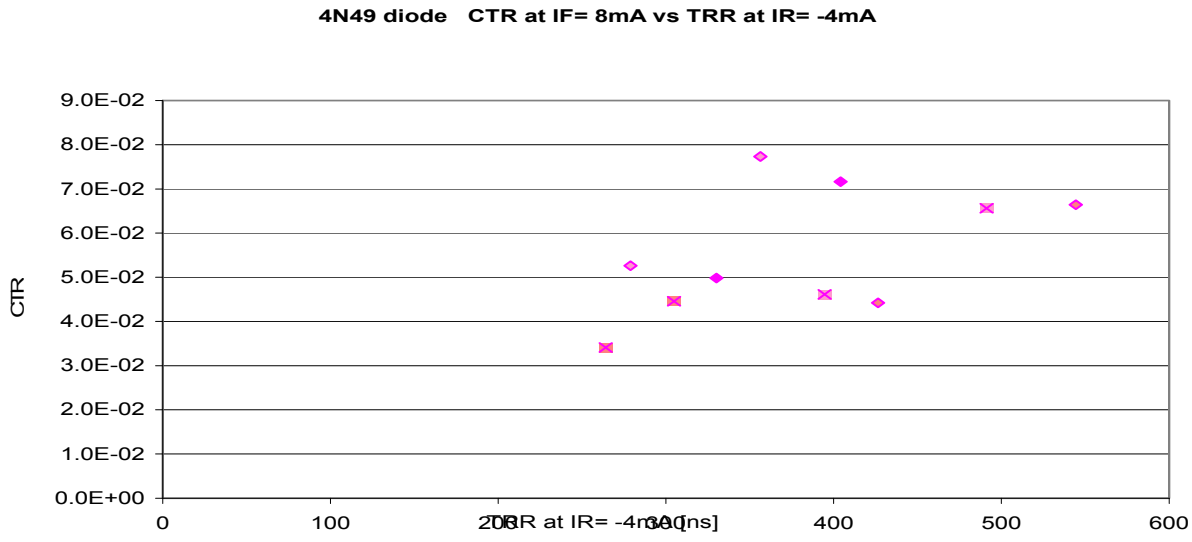


Fig. 12-203: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points), and after (lower points), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

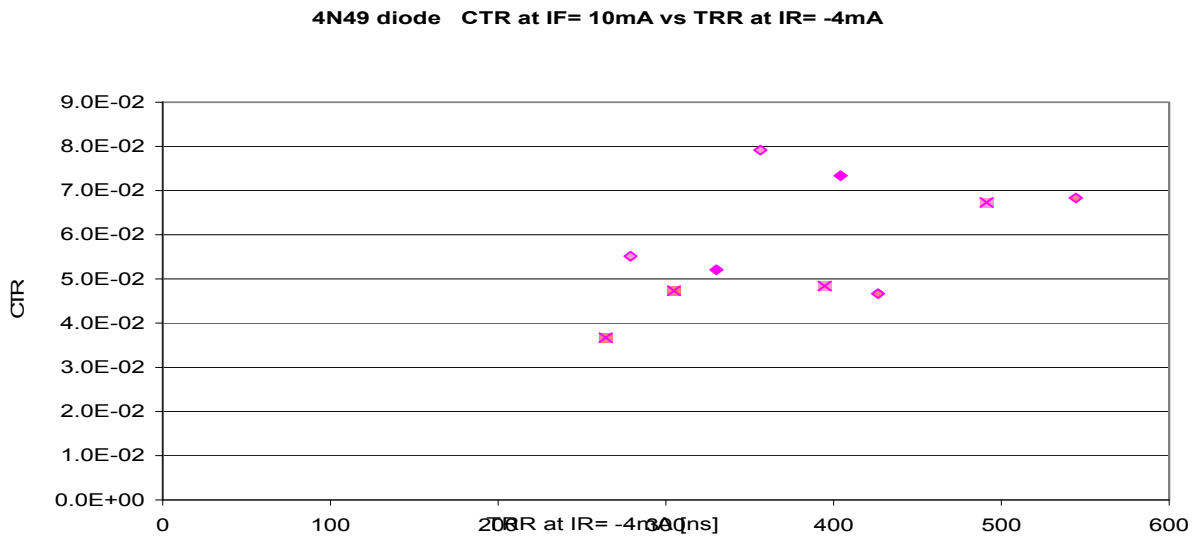
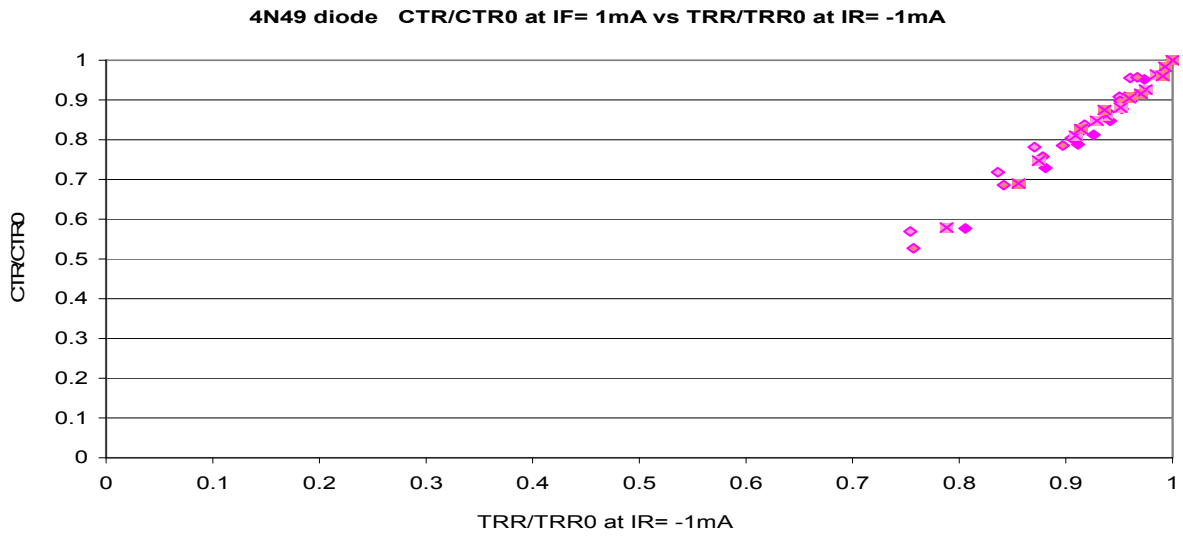
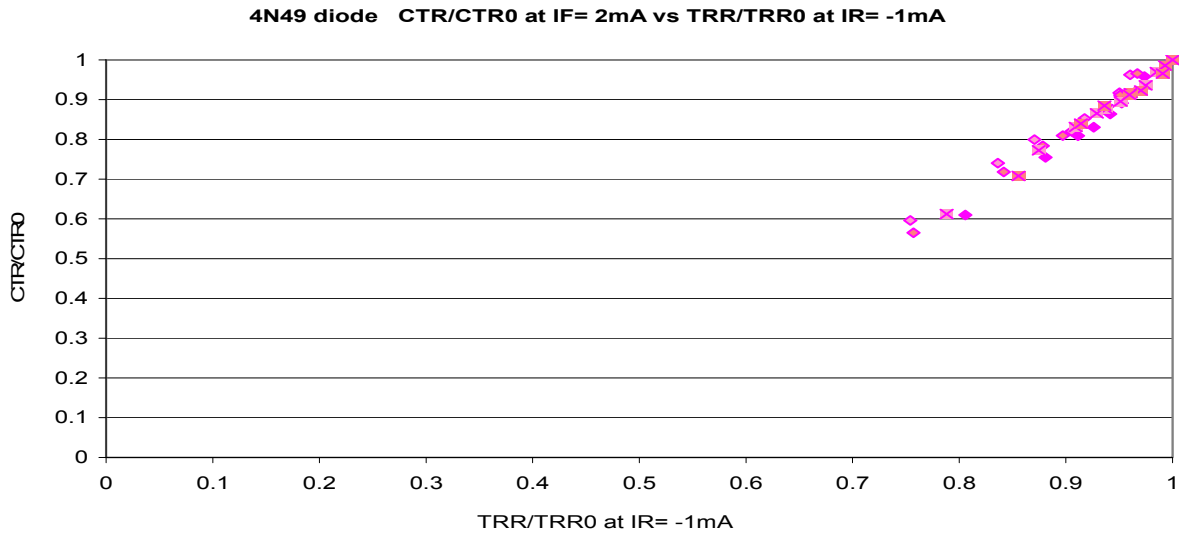
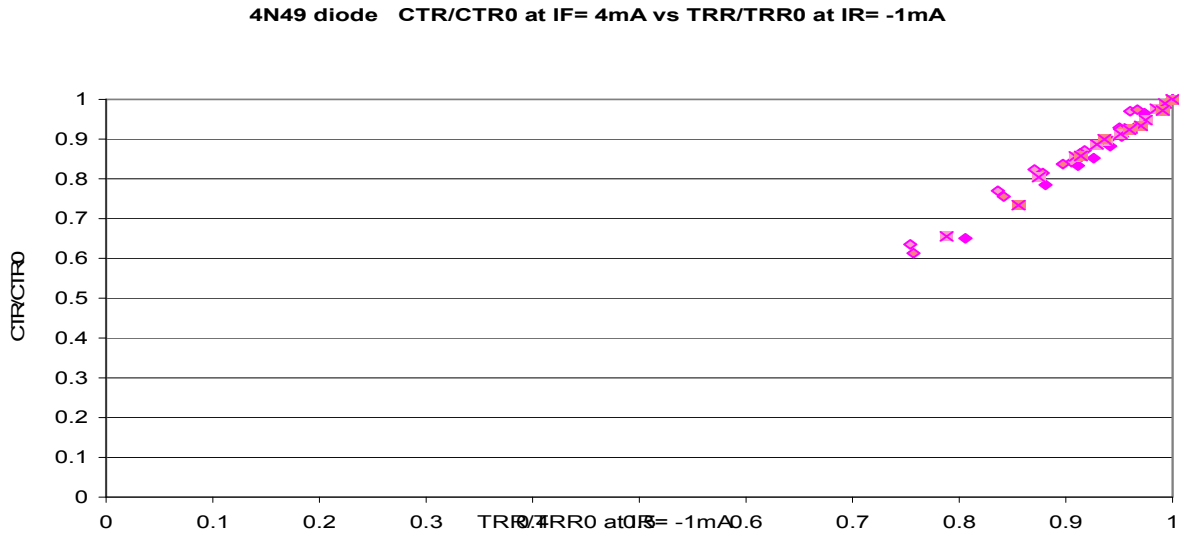

4N49 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

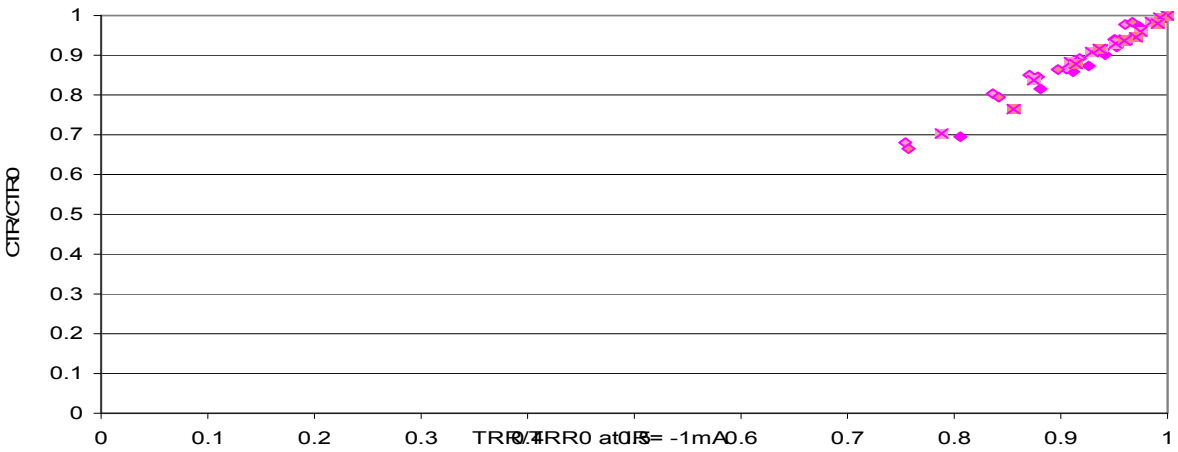
Fig. 12-204: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA



4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA

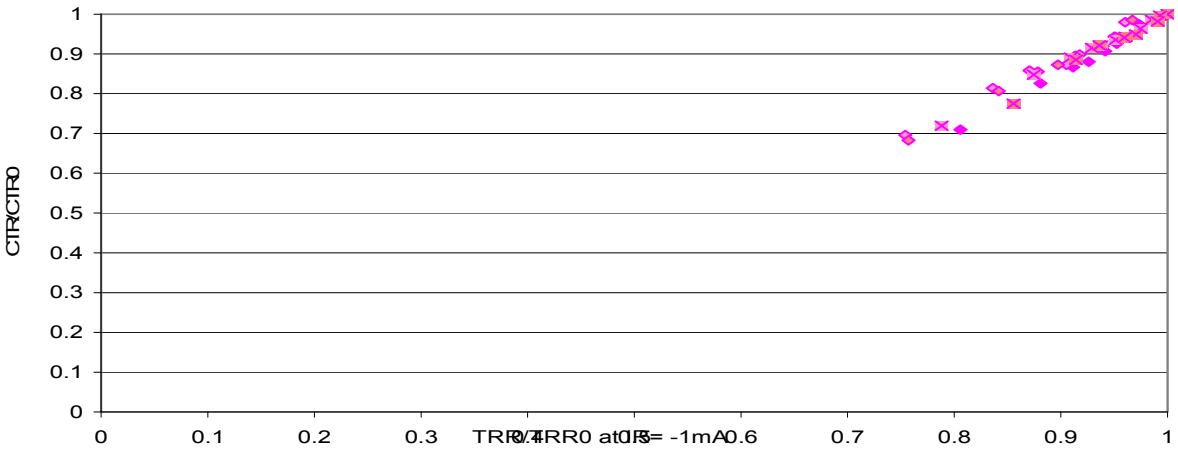
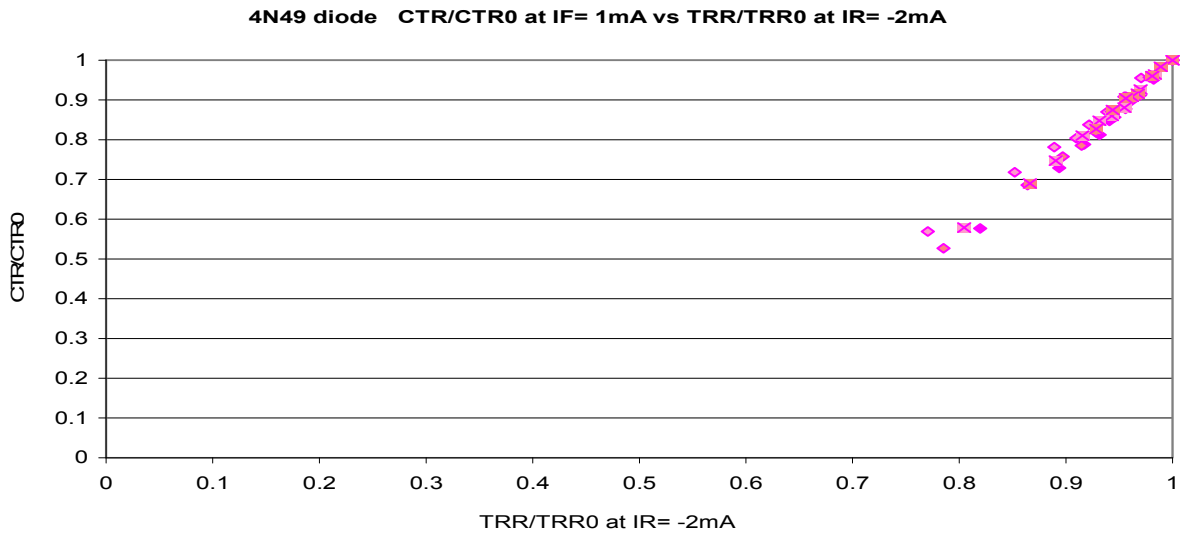
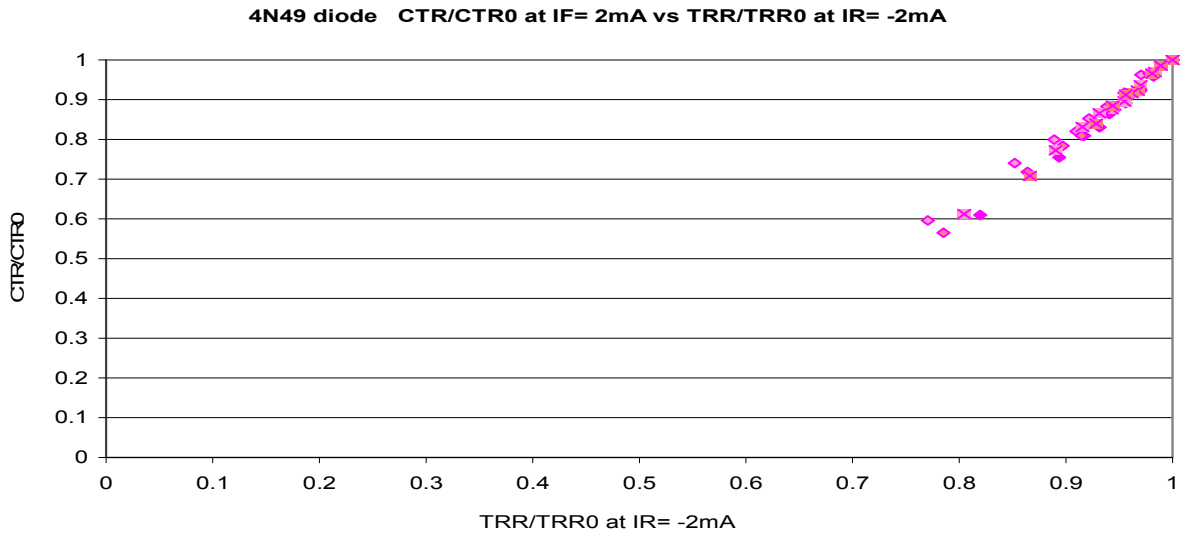
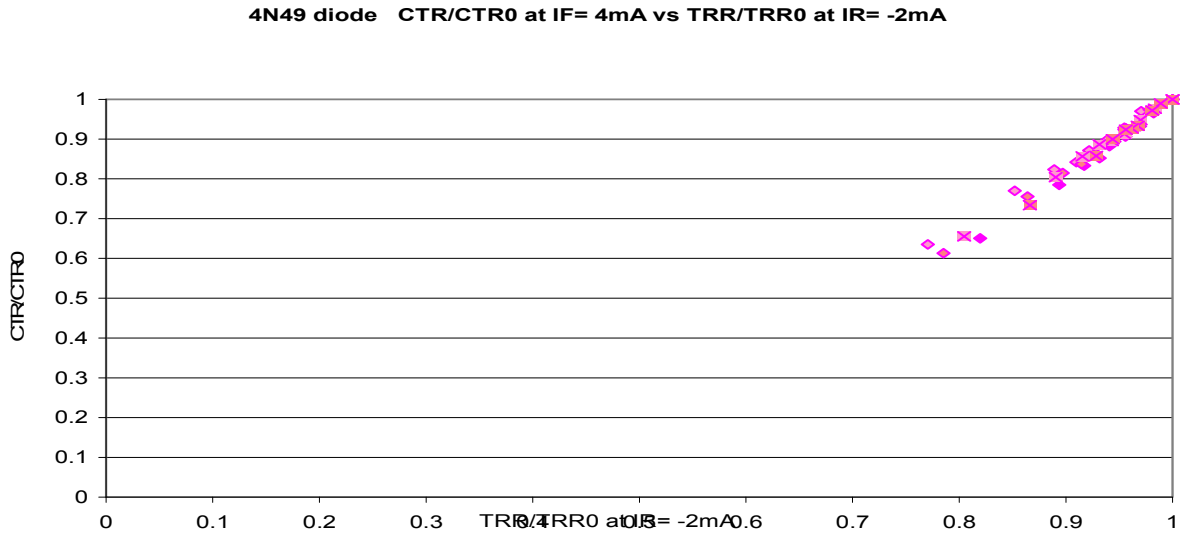


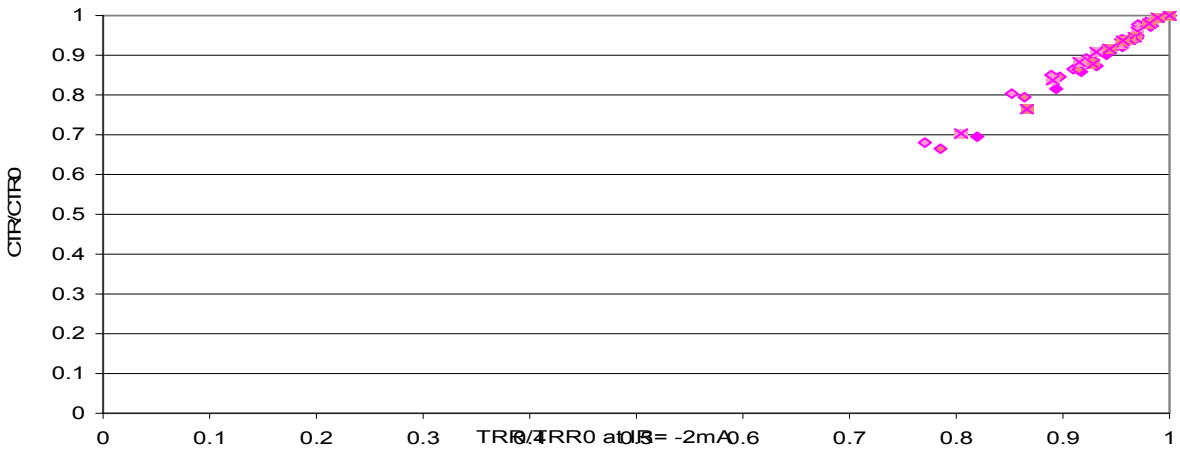
Fig. 12-205: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA







4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA



4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA

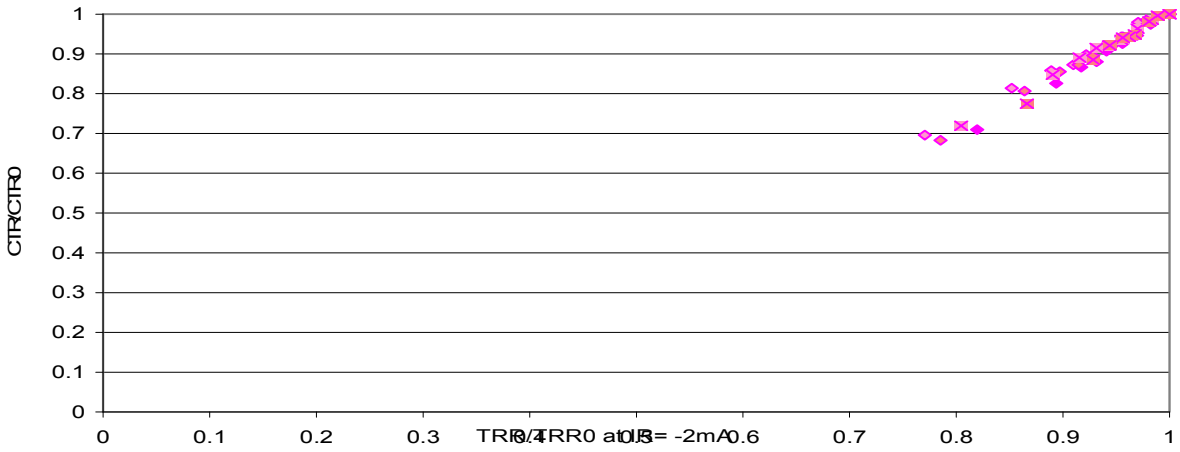
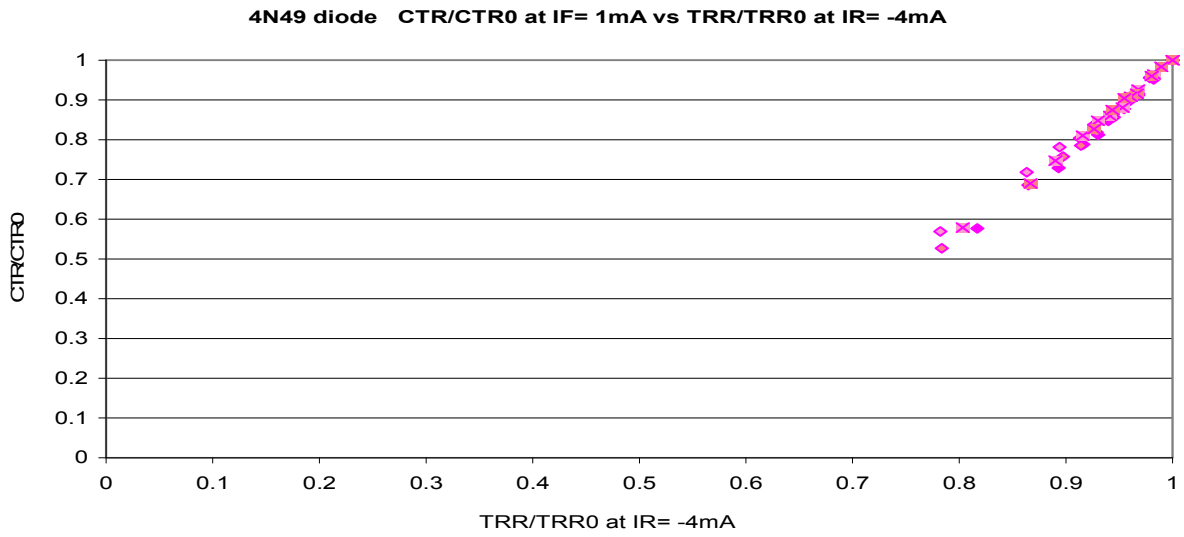
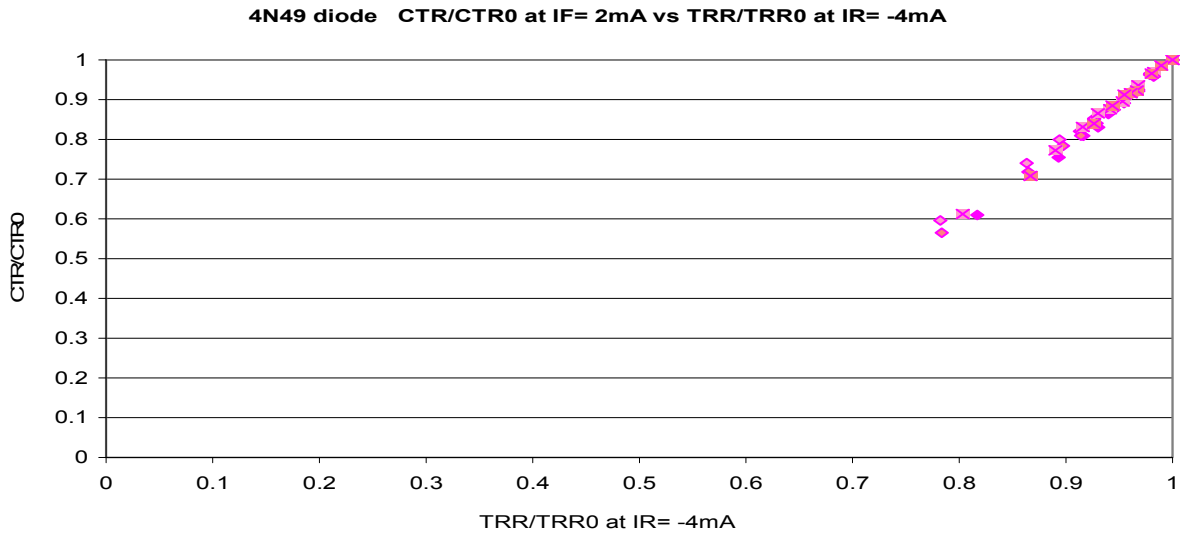
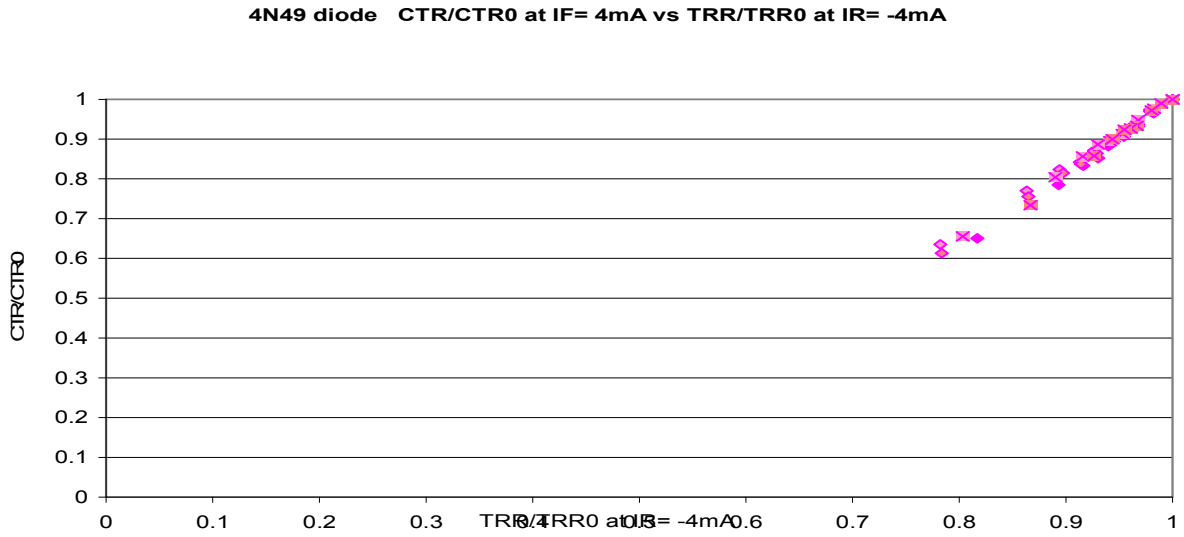
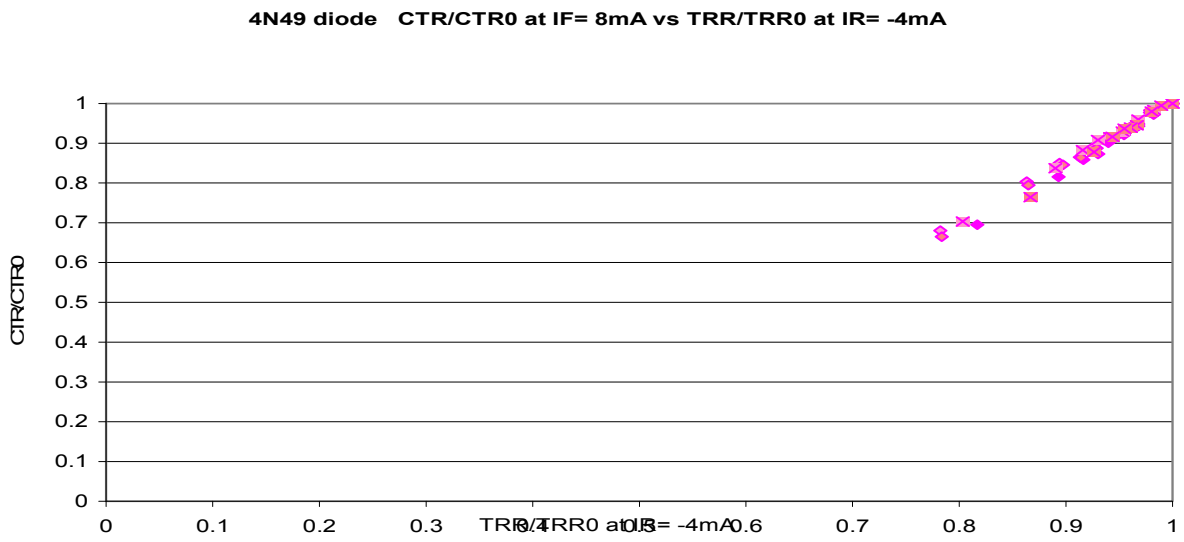


Fig. 12-206: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

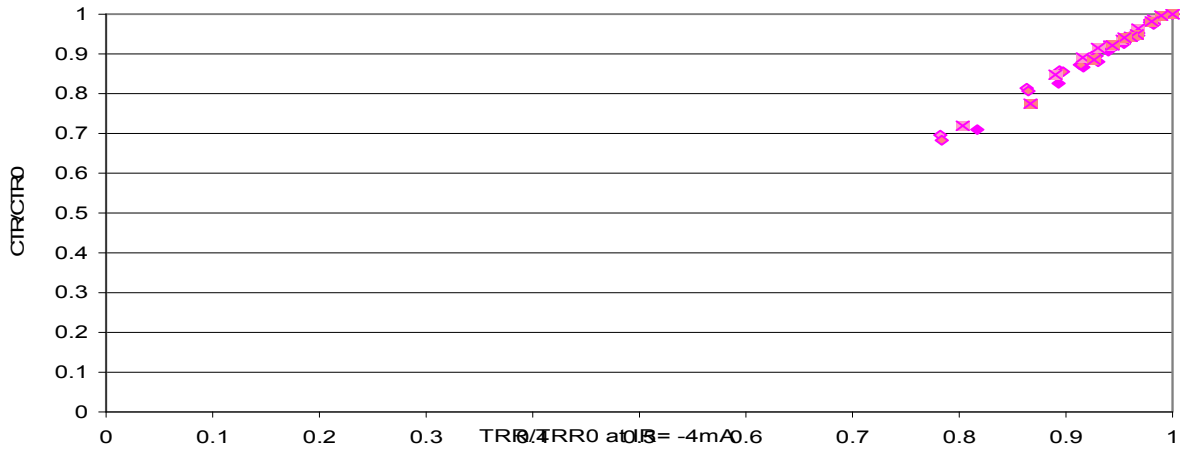
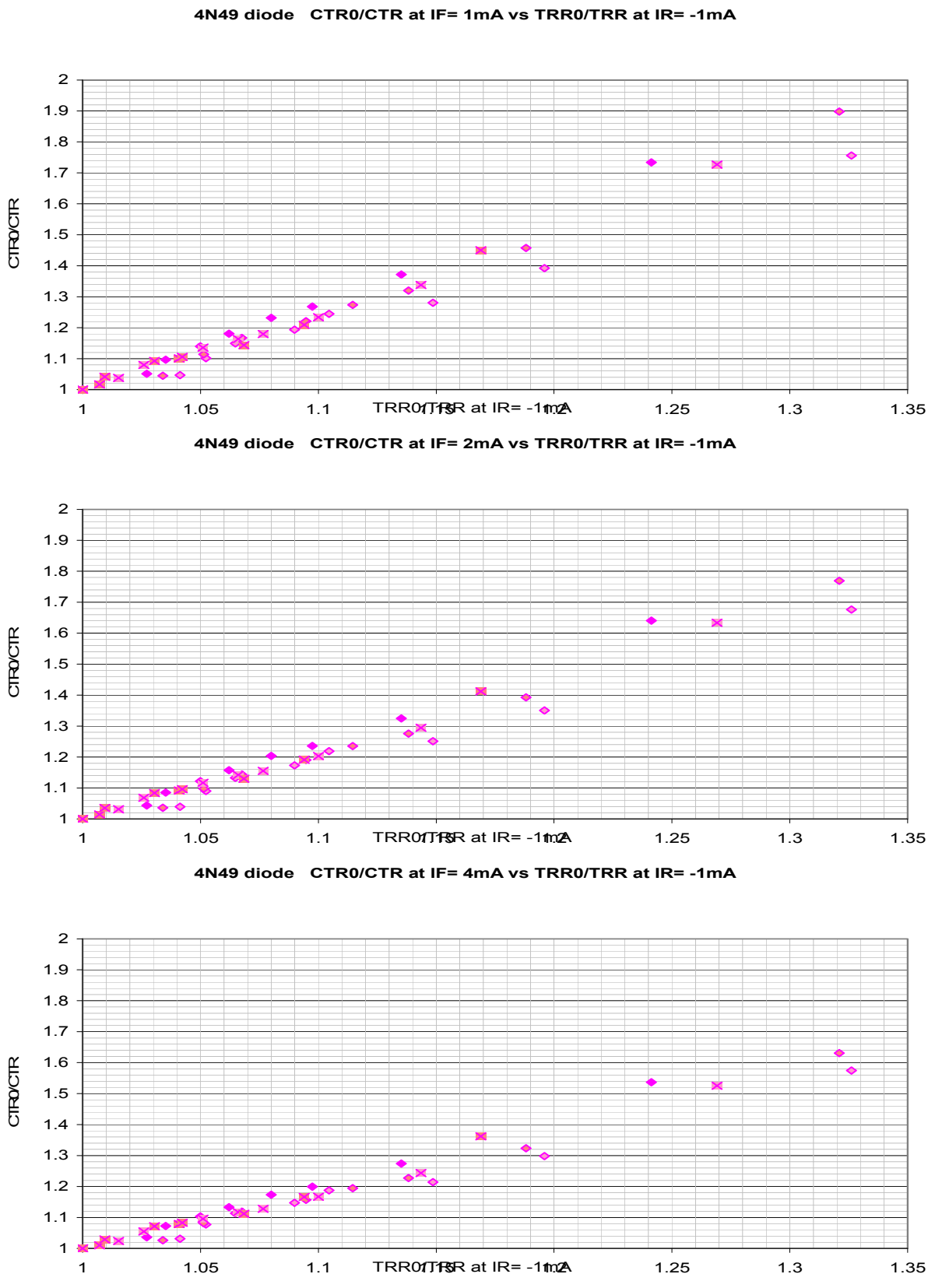
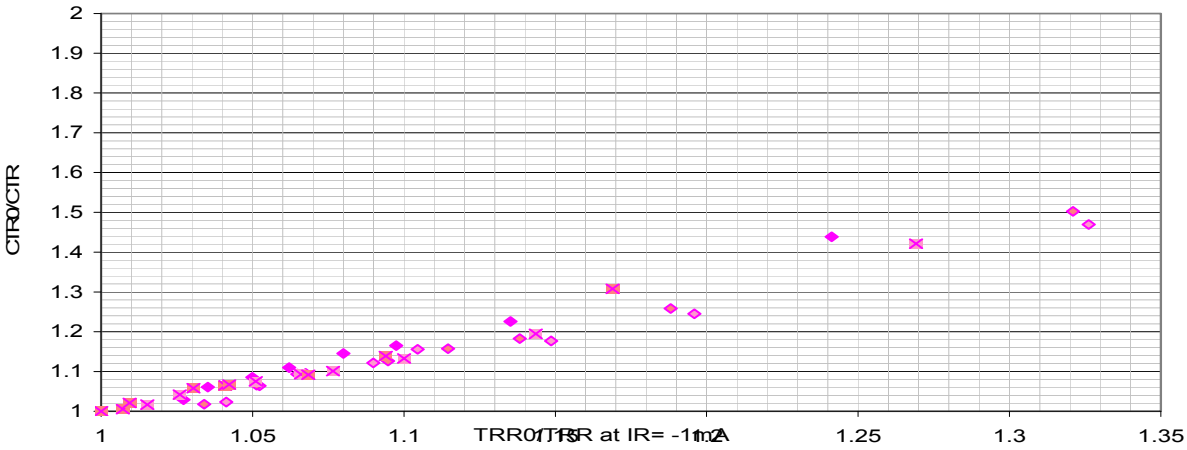

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Fig. 12-207: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA



4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA

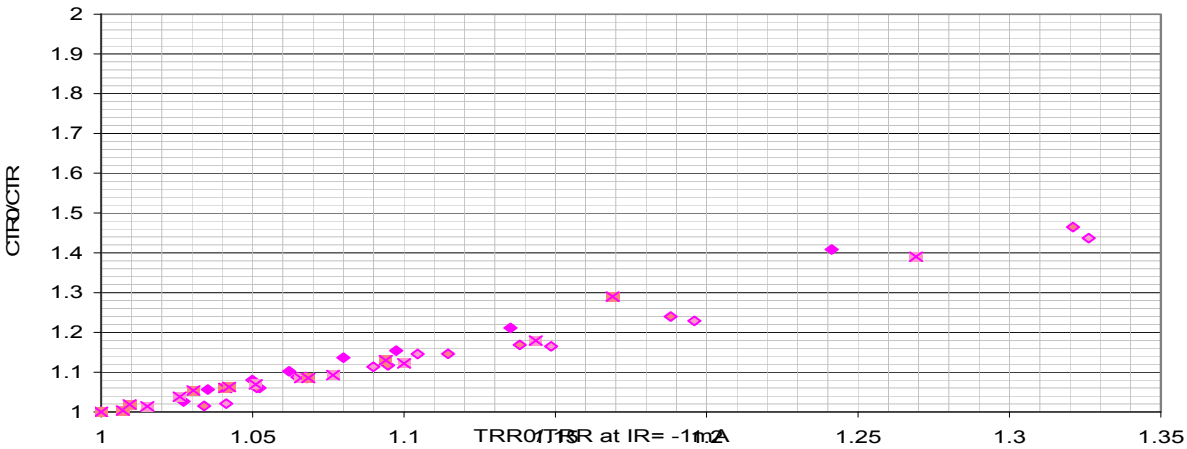
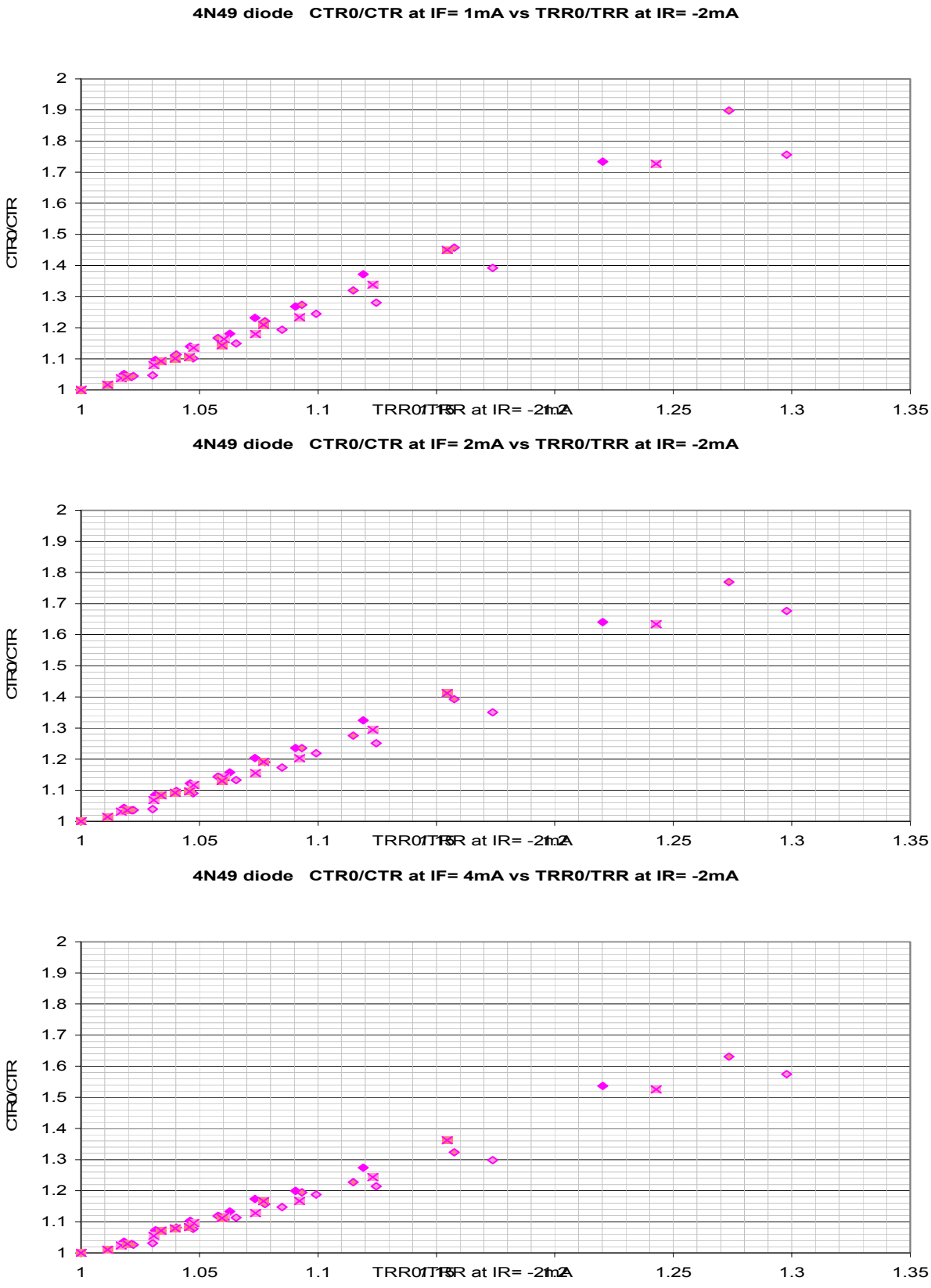
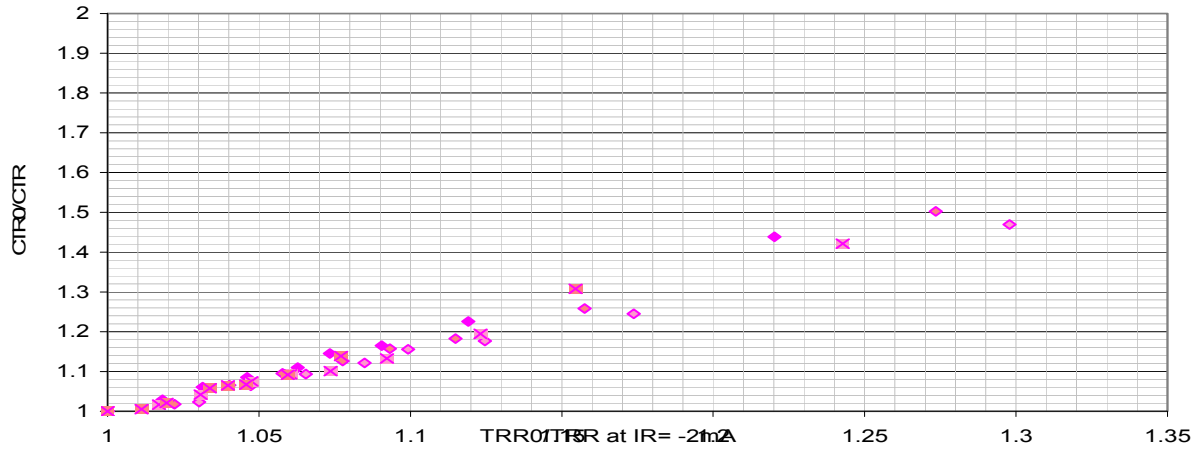


Fig. 12-208: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

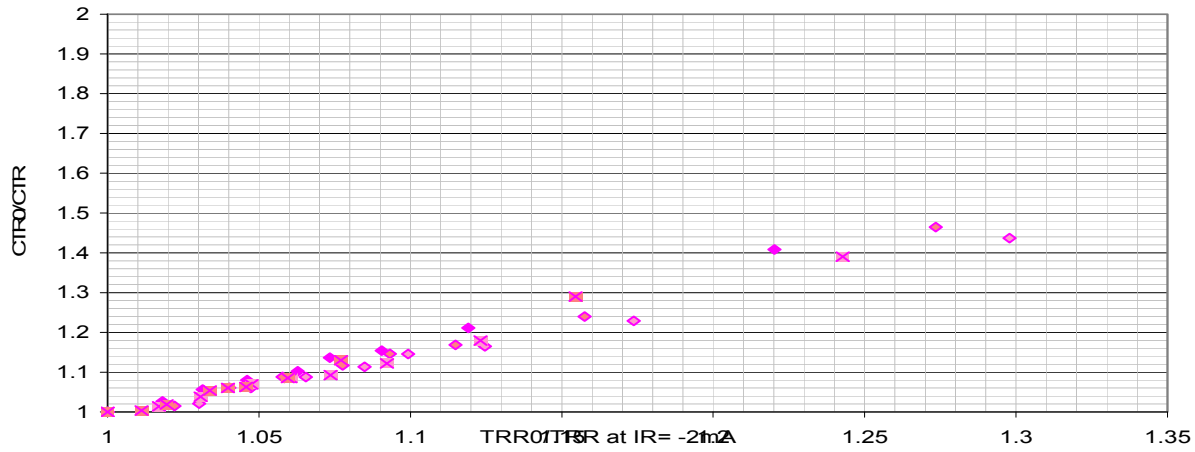
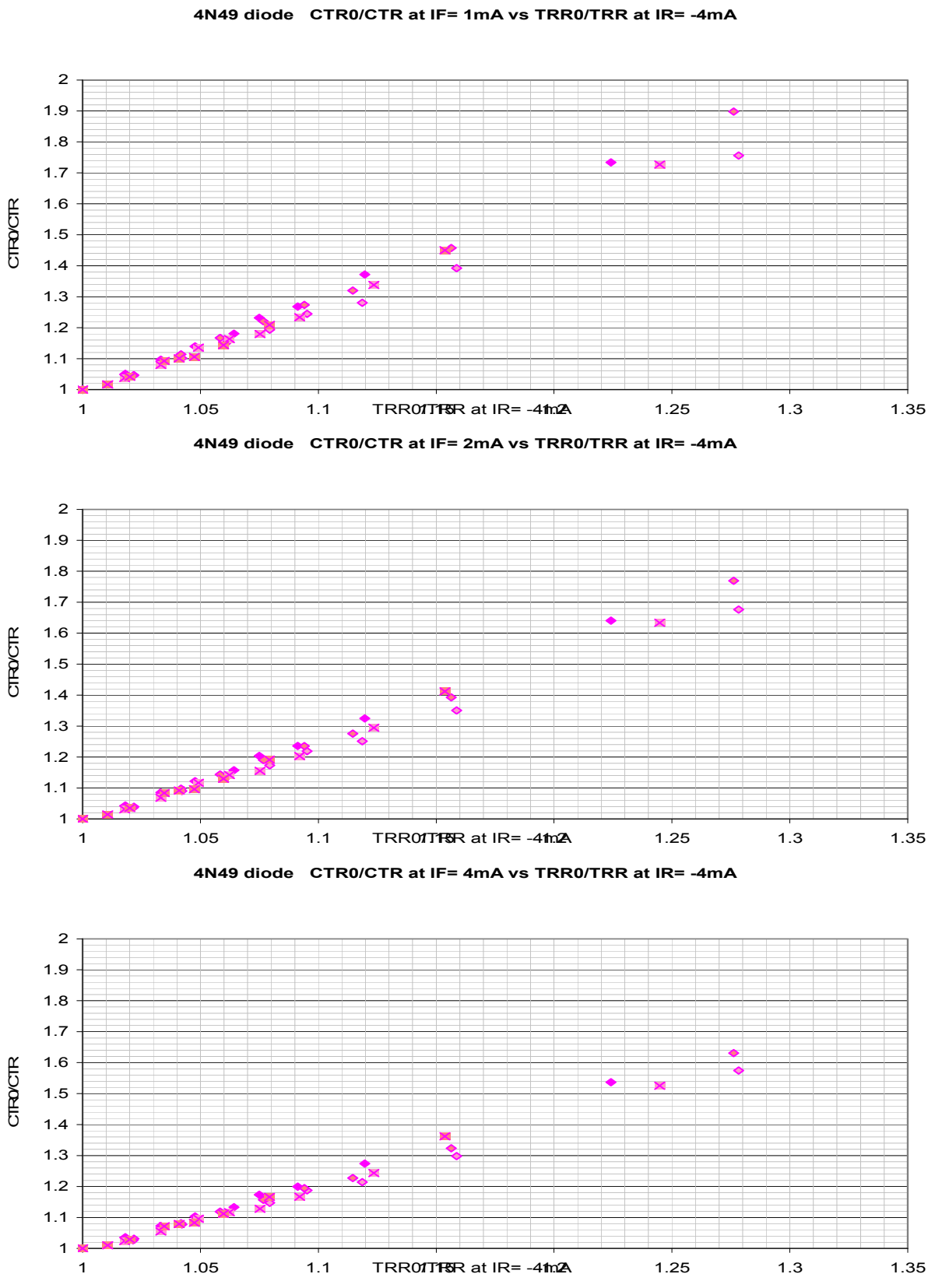
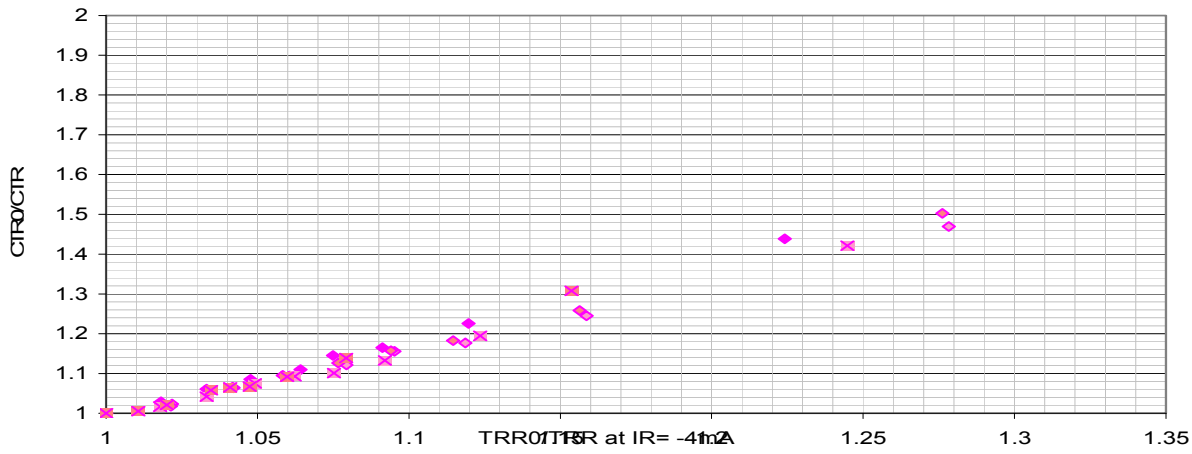


Fig. 12-209: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA



4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

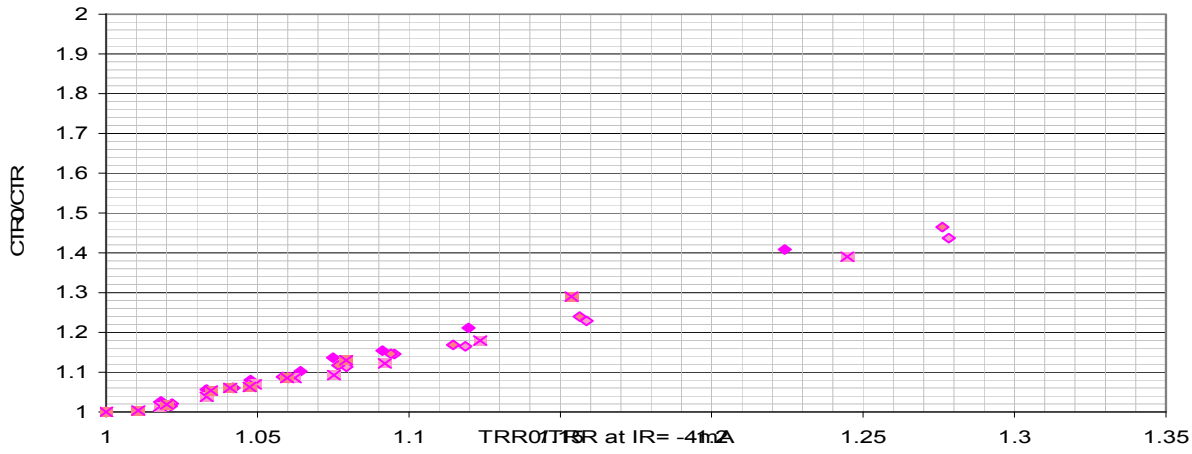
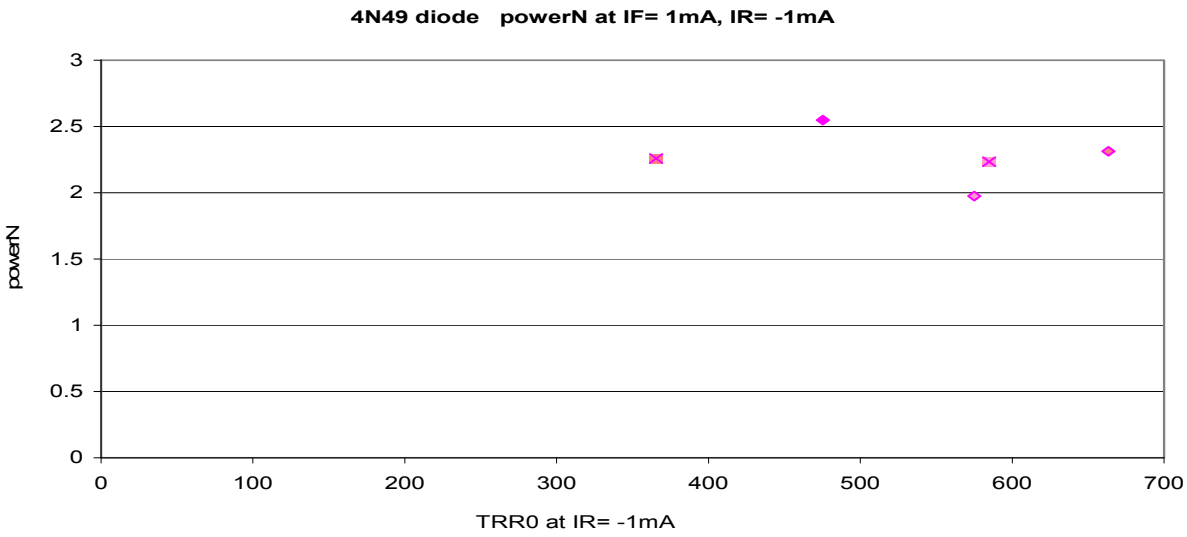
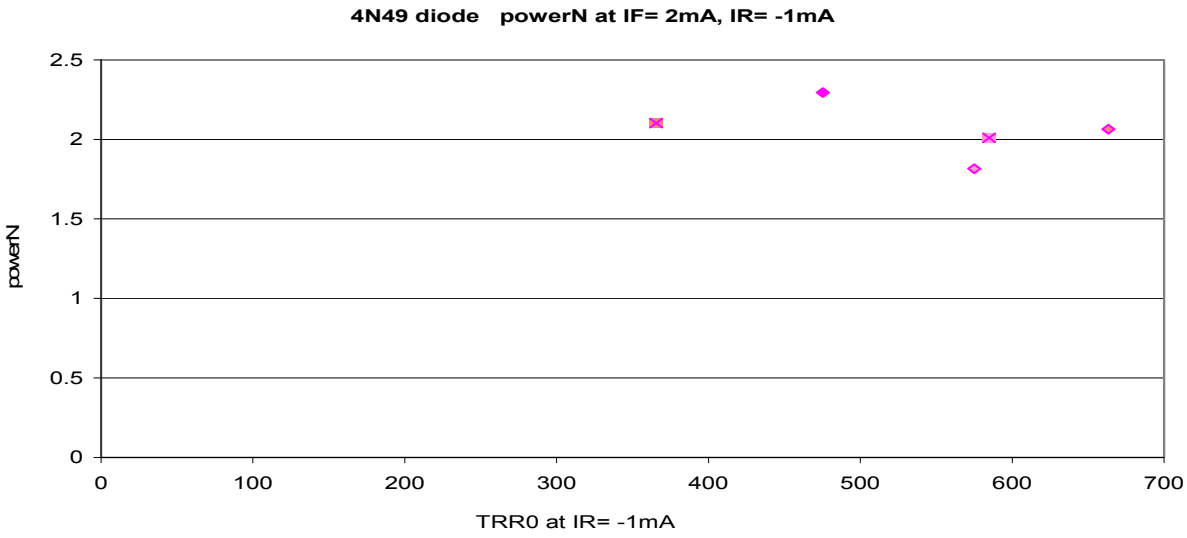
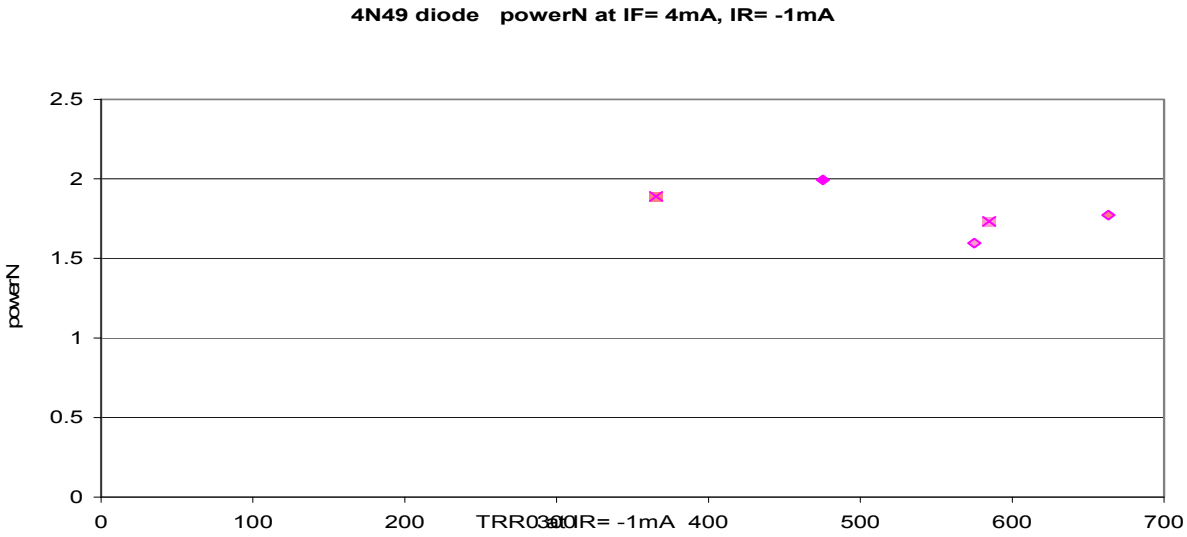
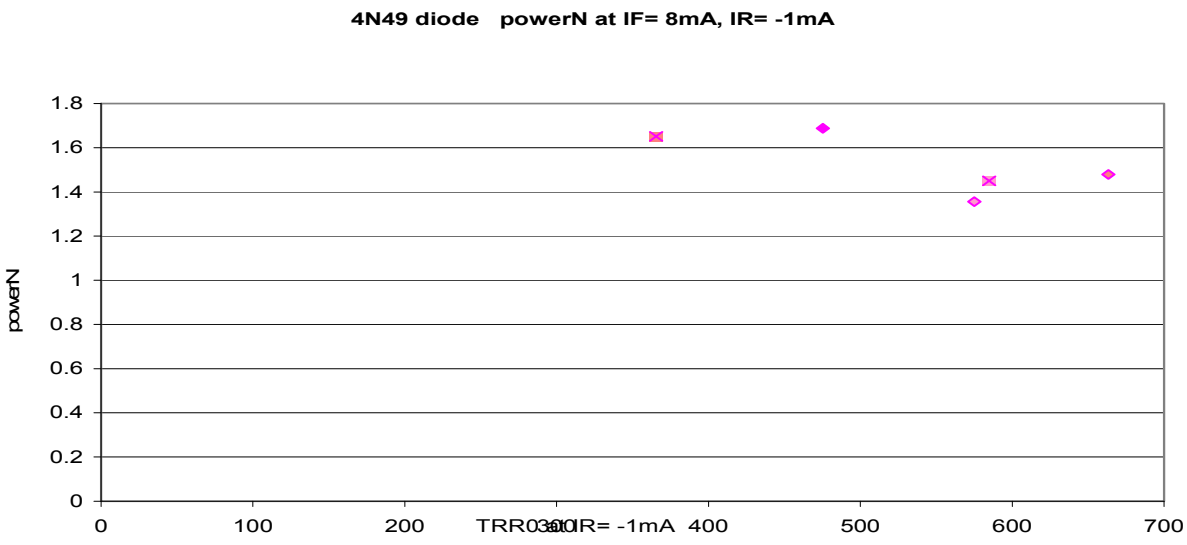


Fig. 12-210: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








4N49 diode powerN at IF= 8mA, IR= -1mA
powerN
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
TRR at IR= -1mA

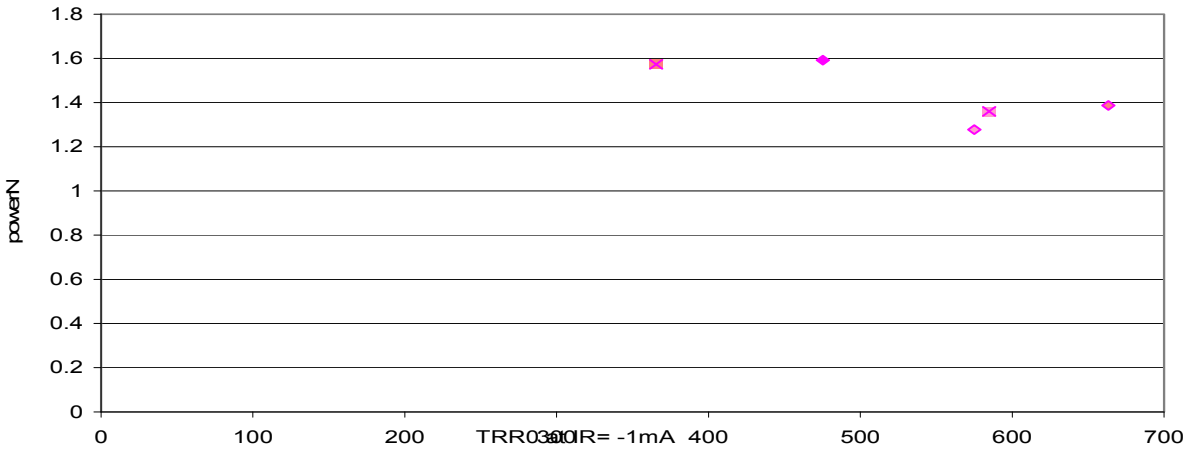
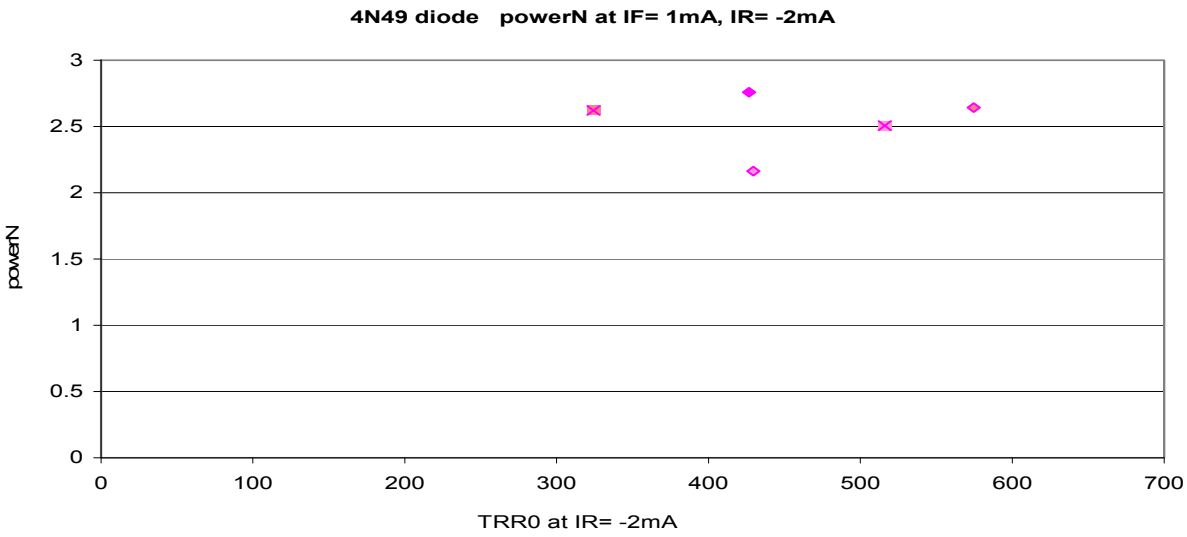
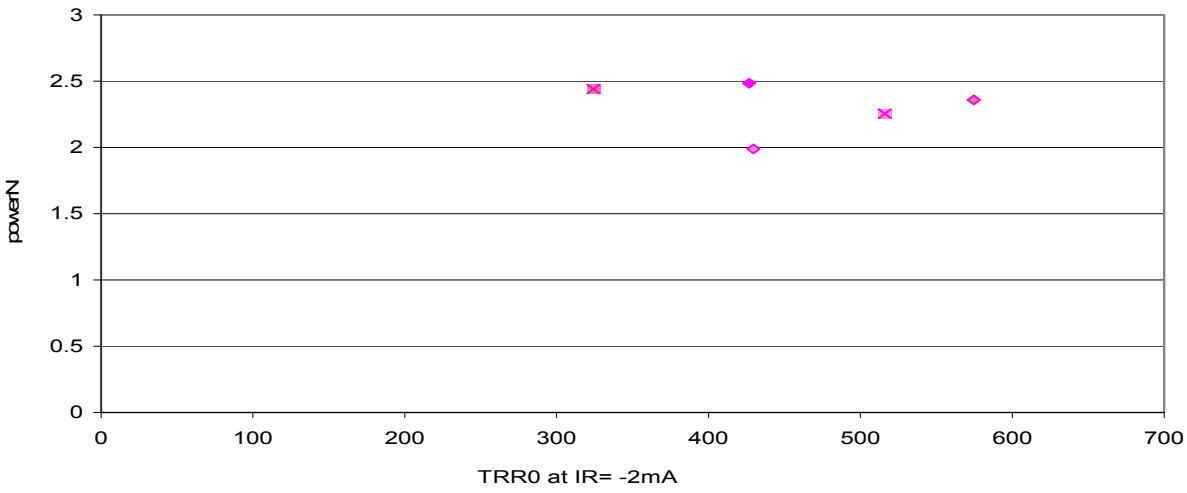
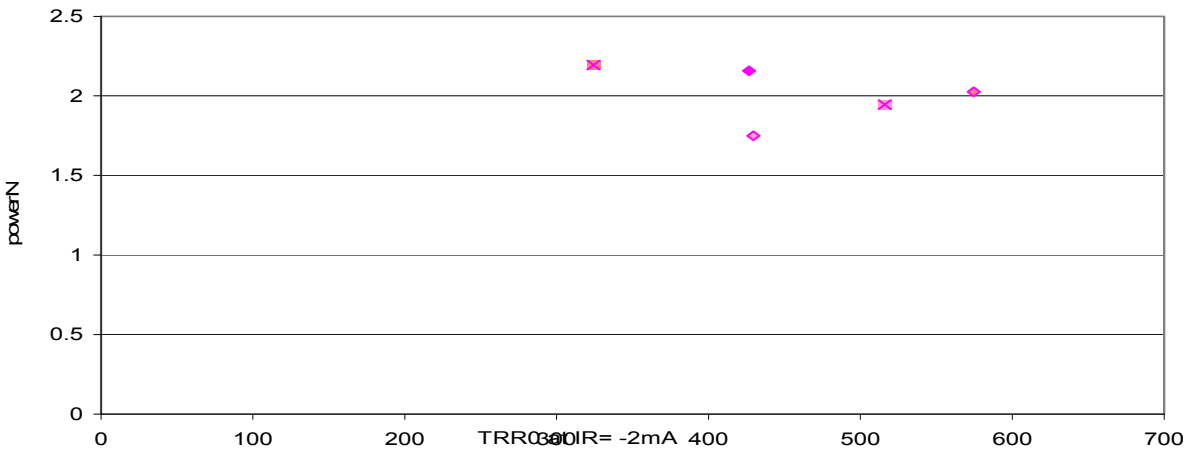
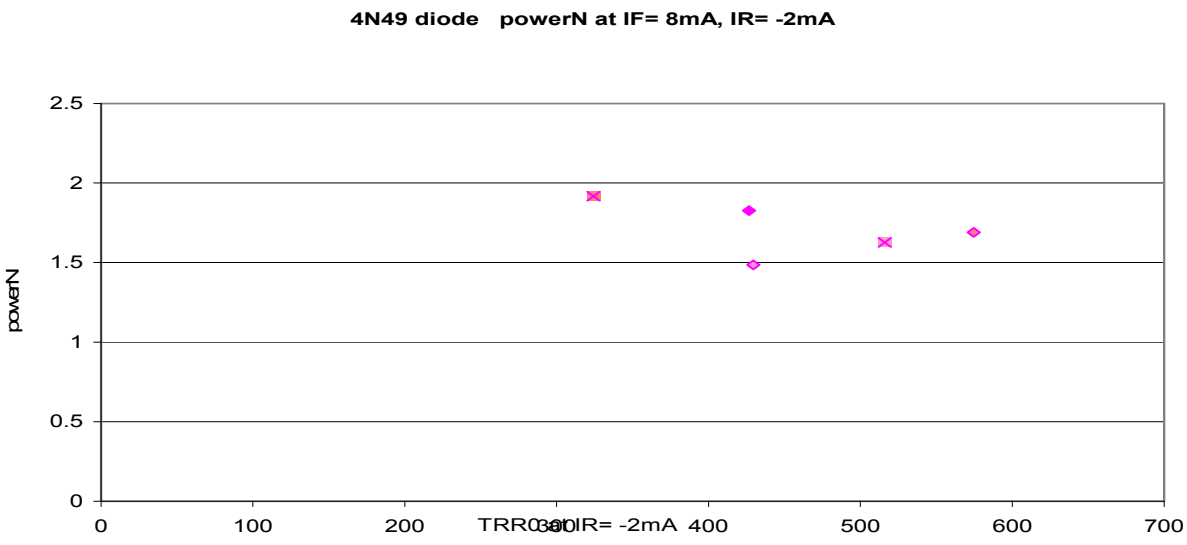

4N49 diode powerN at IF= 10mA, IR= -1mA
powerN
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
TRR at IR= -1mA

Fig. 12-211: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








4N49 diode powerN at IF= 8mA, IR= -2mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
TRR03 IR= -2mA

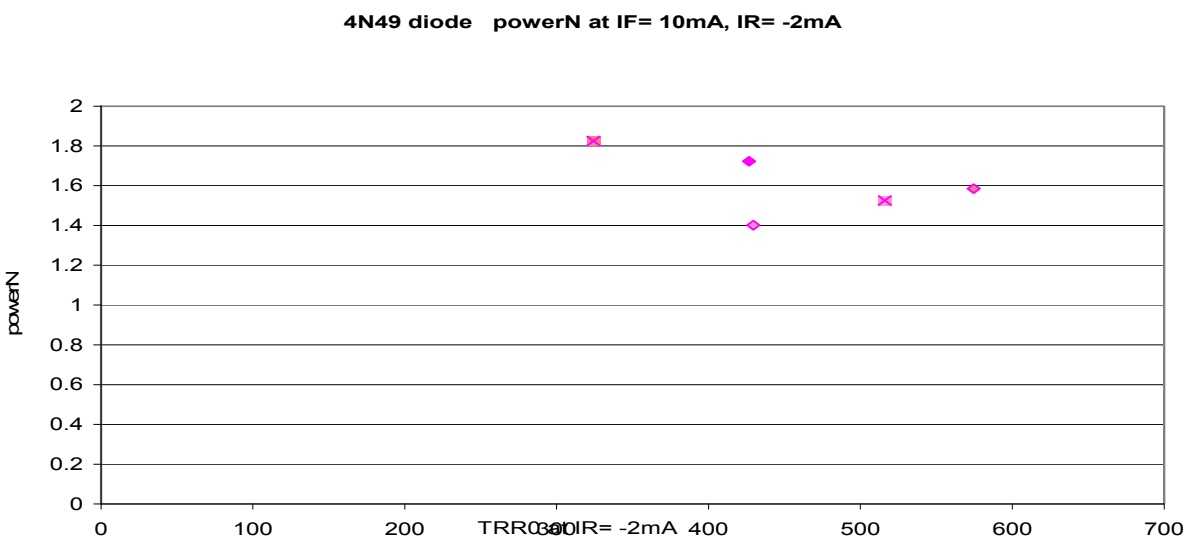
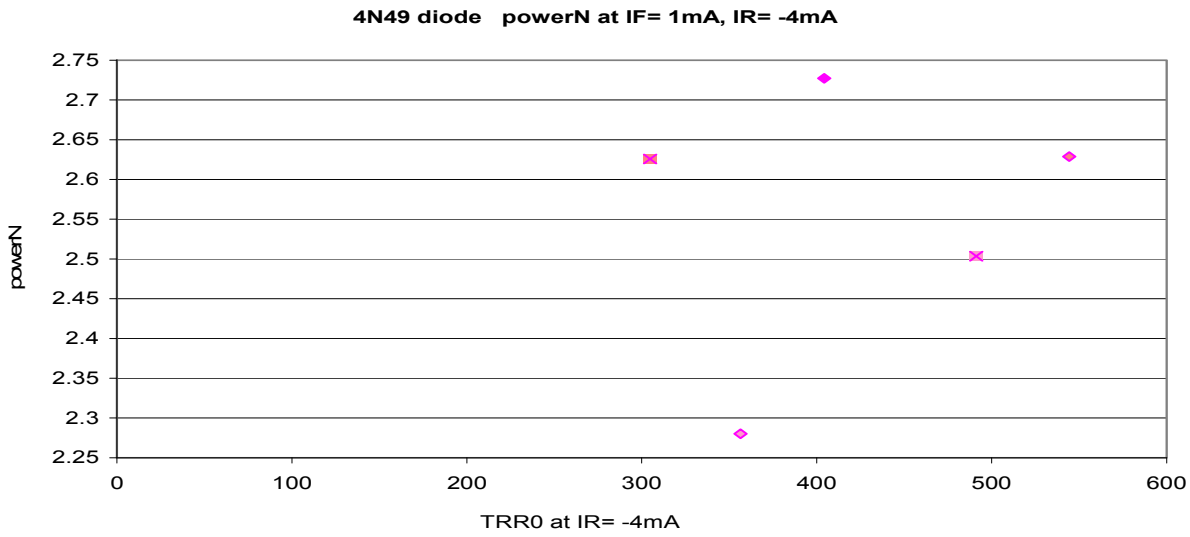
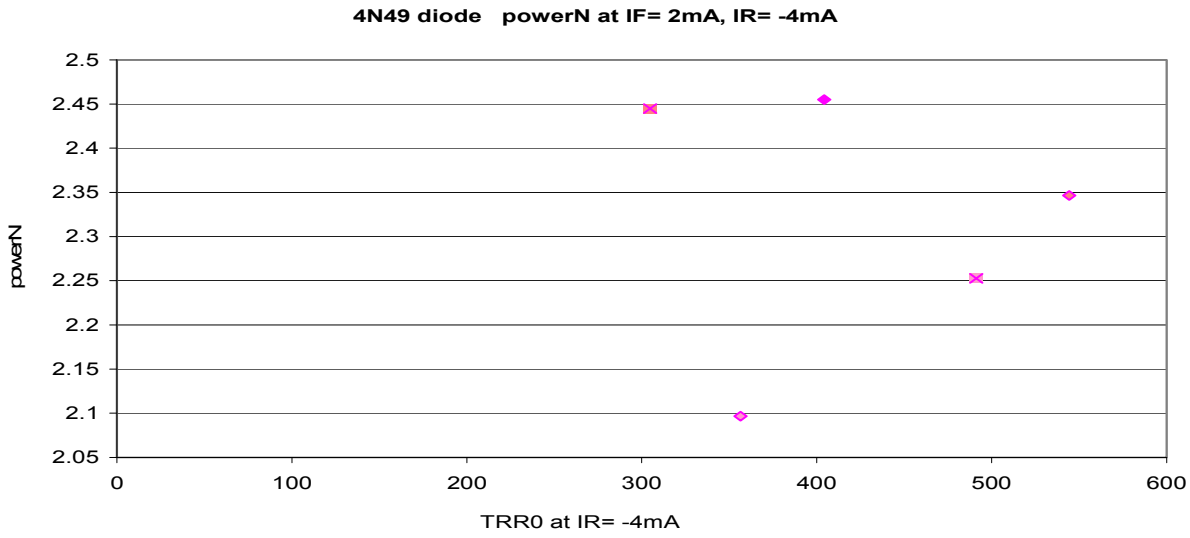
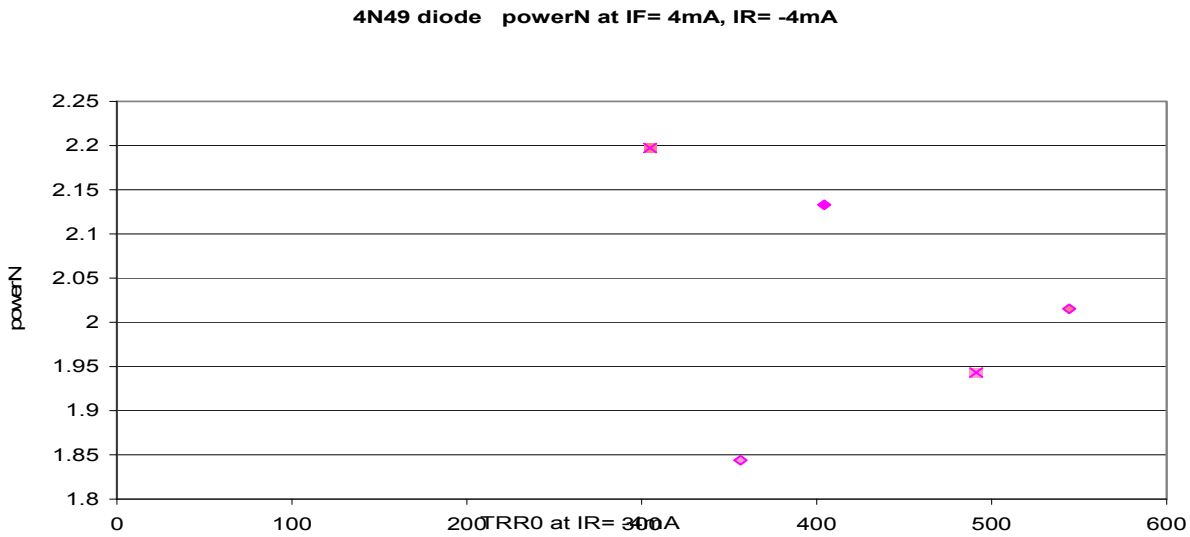
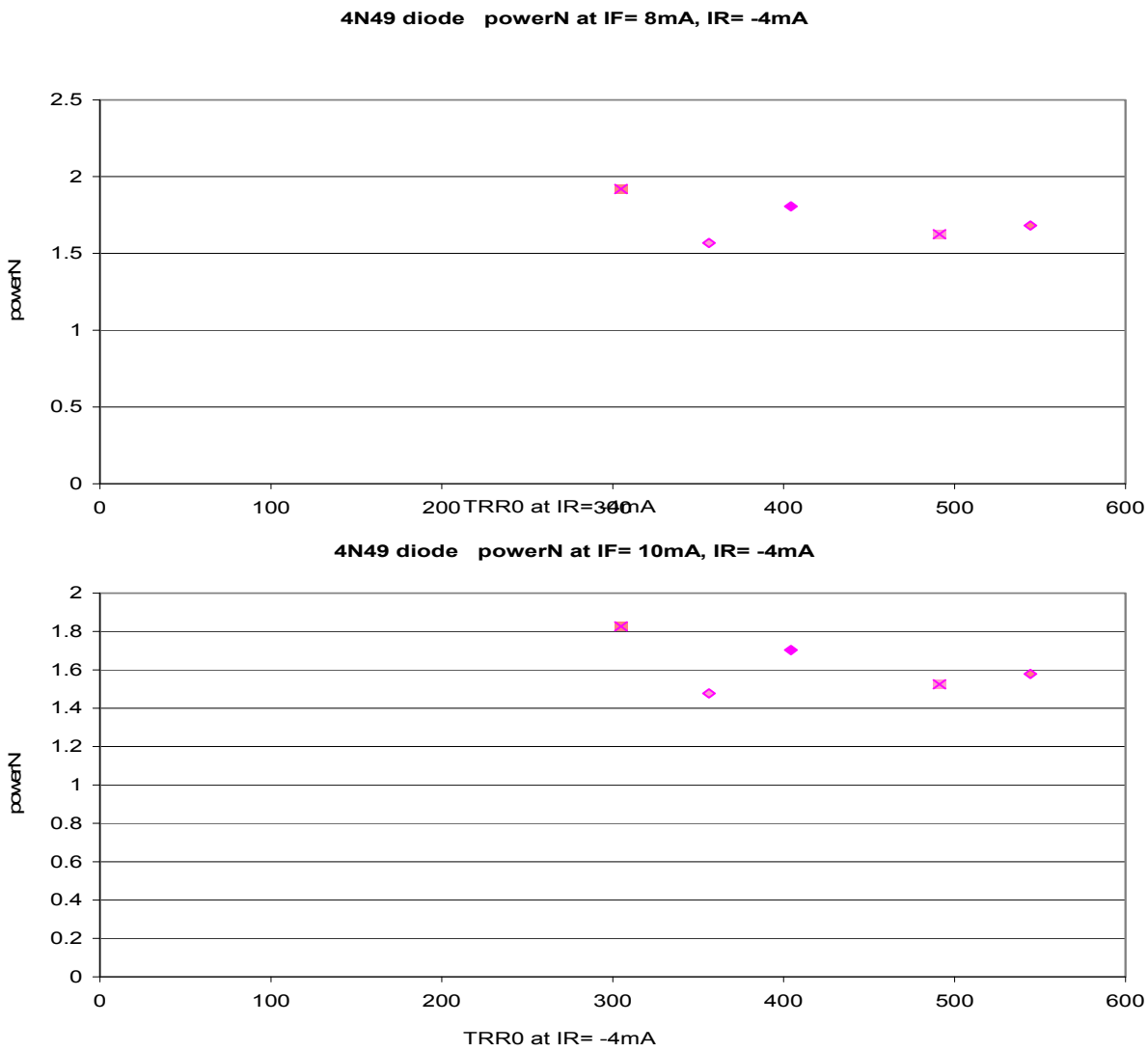

4N49 diode powerN at IF= 10mA, IR= -2mA
powerN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
TRR03 IR= -2mA

Fig. 12-212: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA





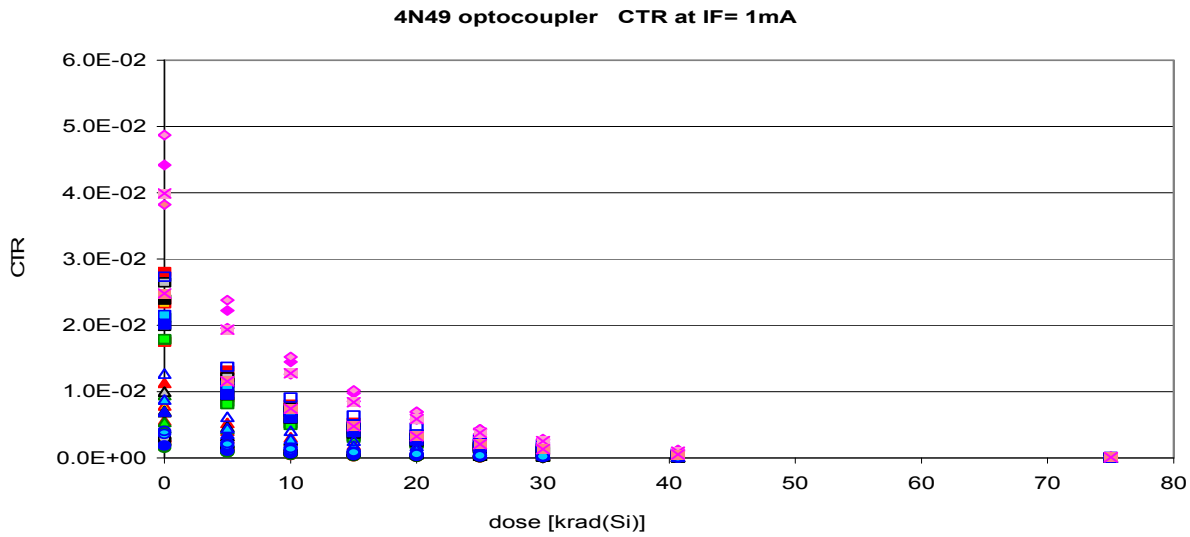


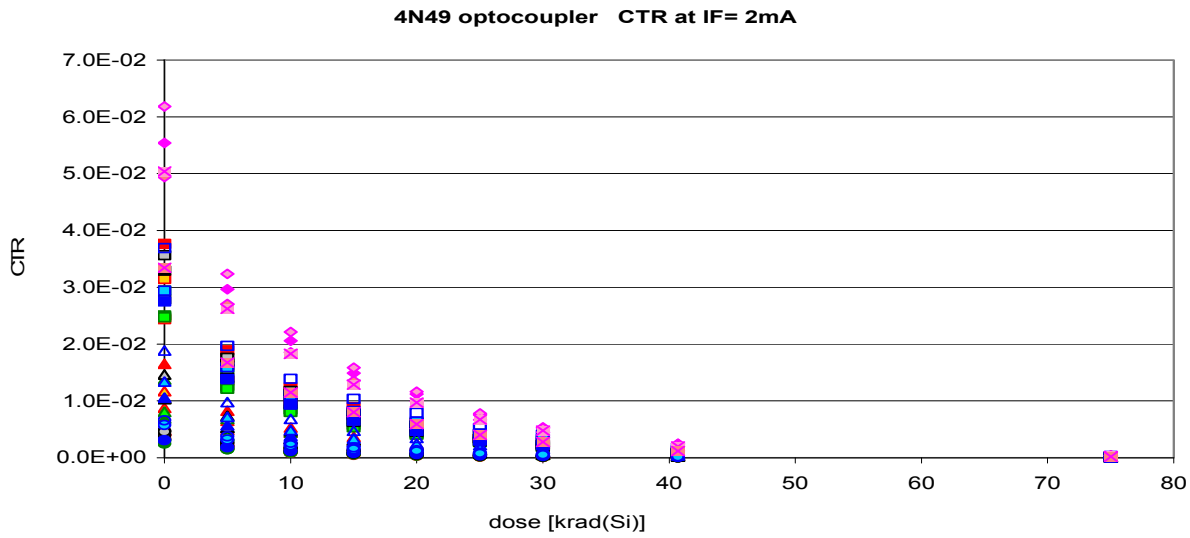

4N49 diode powerN at IF= 8mA, IR= -4mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA

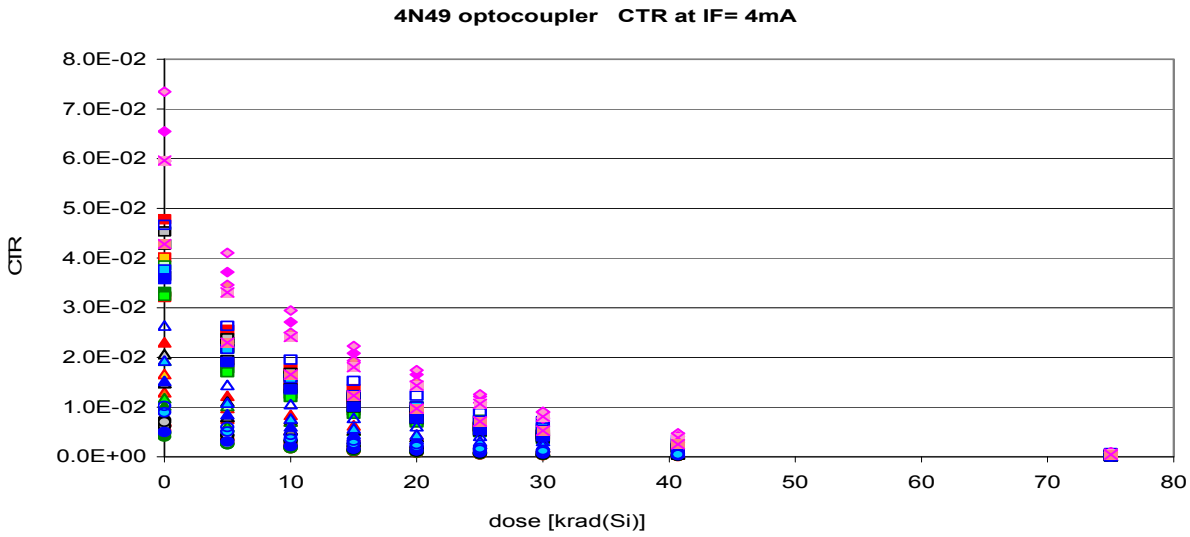
4N49 diode powerN at IF= 10mA, IR= -4mA
powerN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA

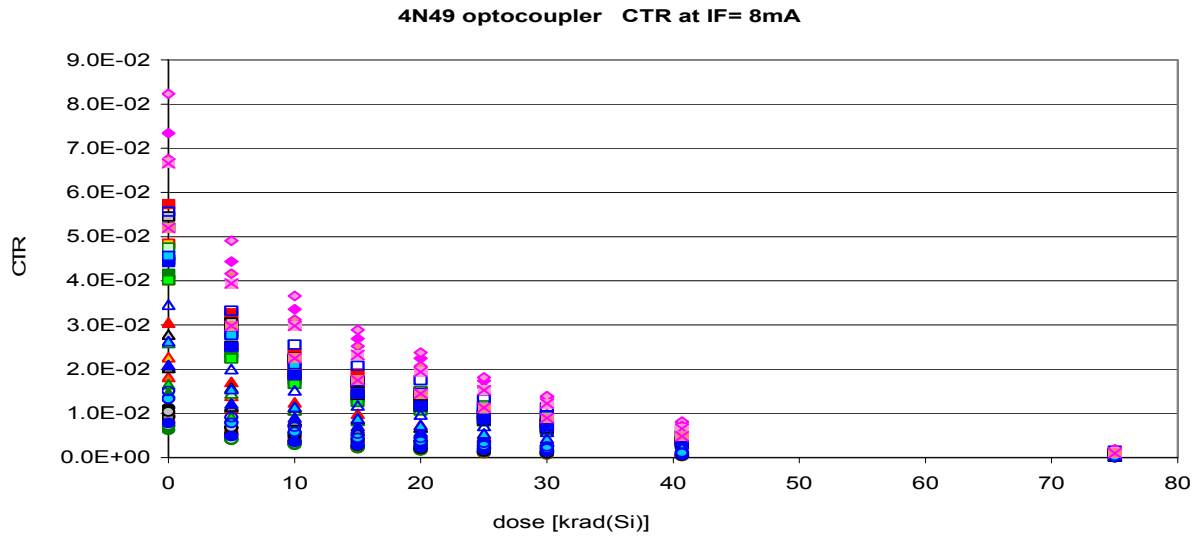
12.4 GAMMA IRRADIATION AFTER NEUTRON AND PROTON IRRADIATION

Fig. 12-213: 4N49 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 optocoupler CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

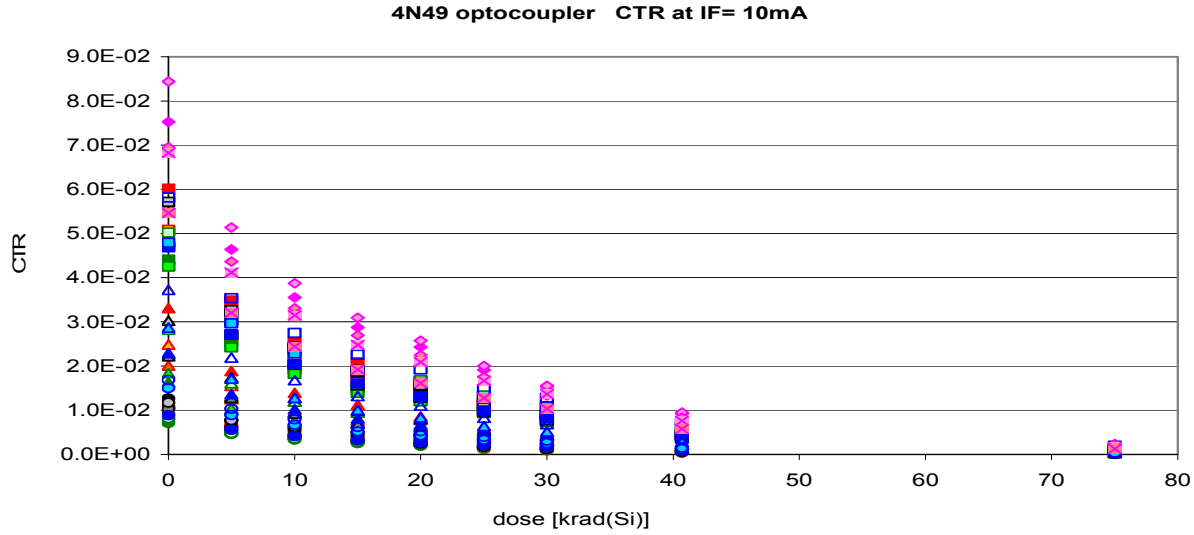
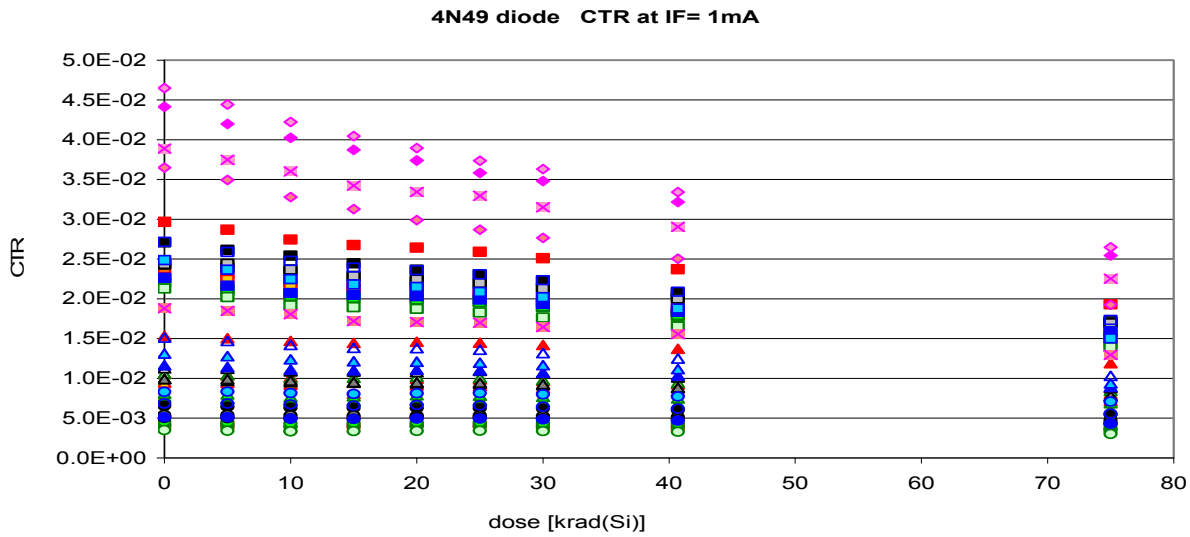
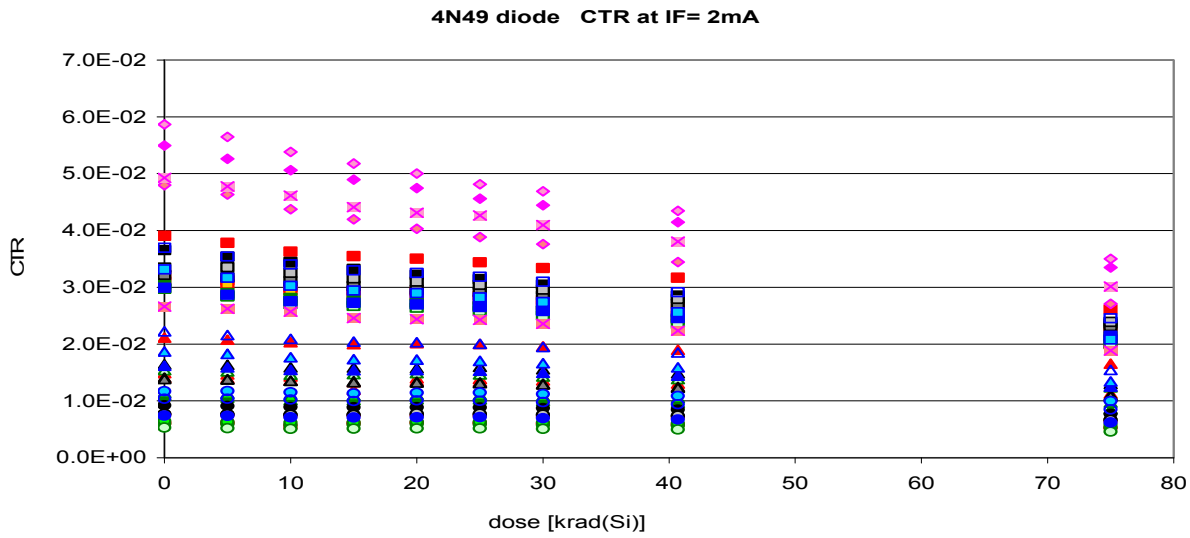
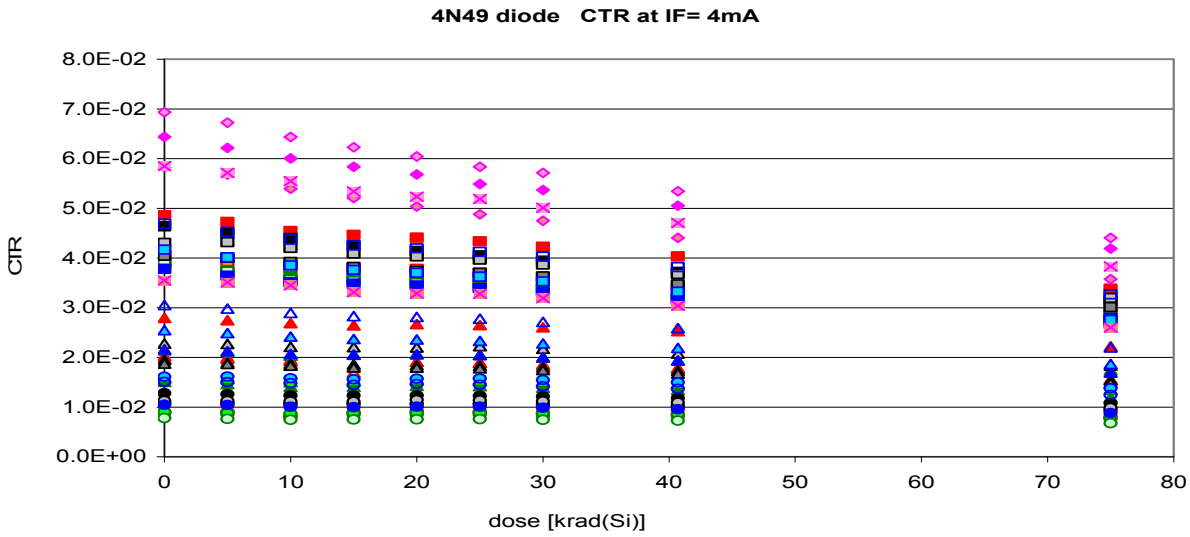
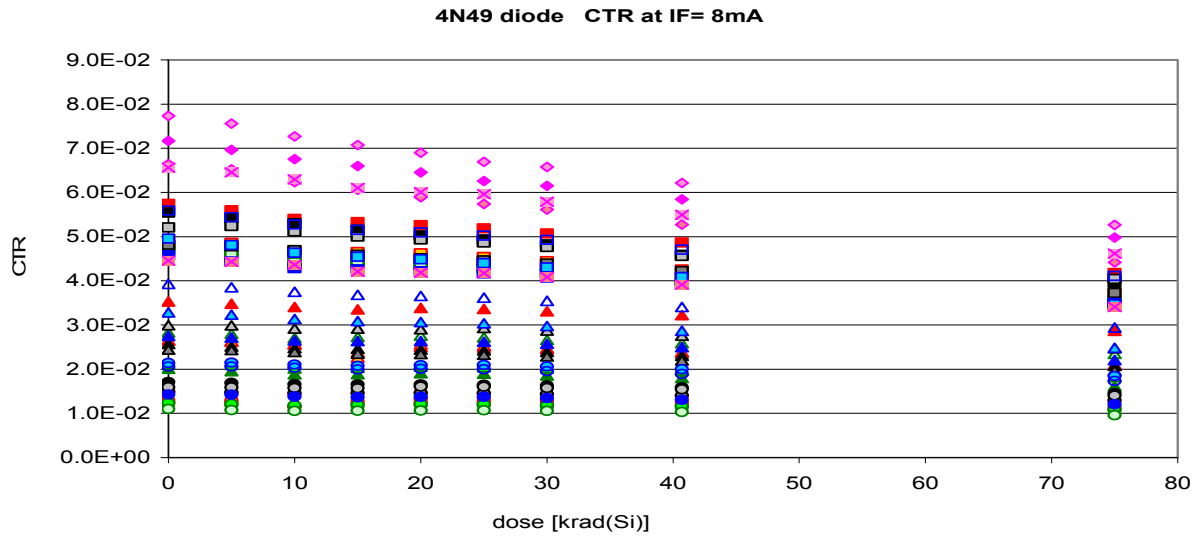

4N49 optocoupler CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-214: 4N49 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 diode CTR at IF= 8mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

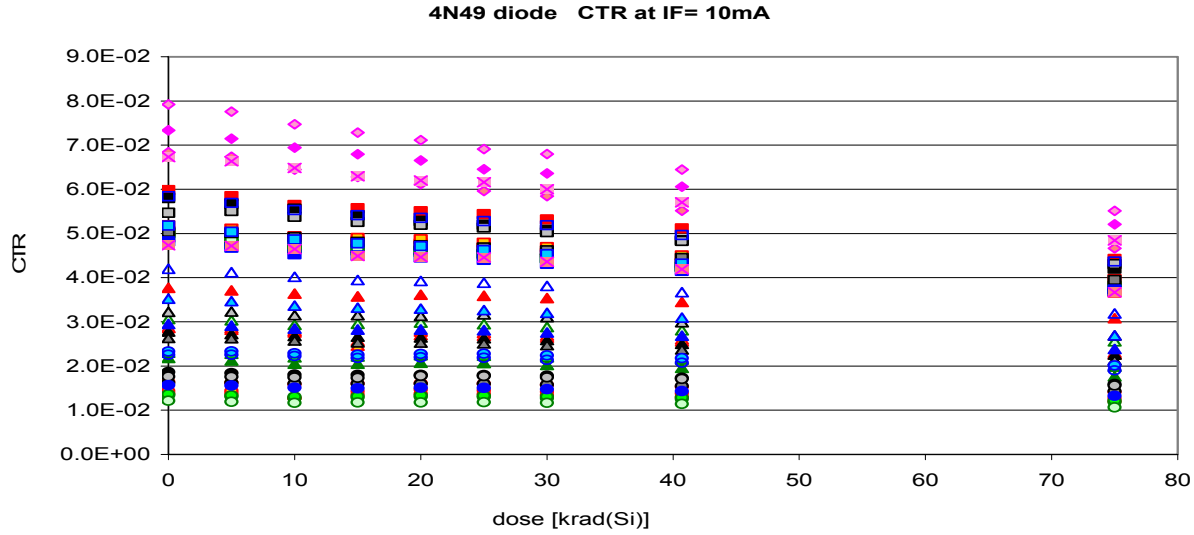
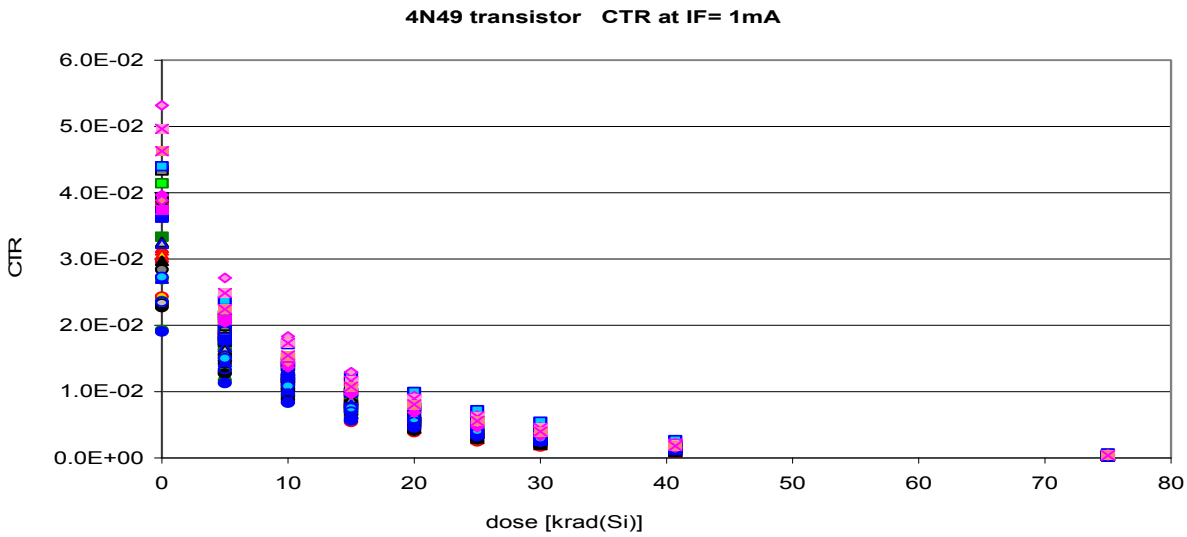
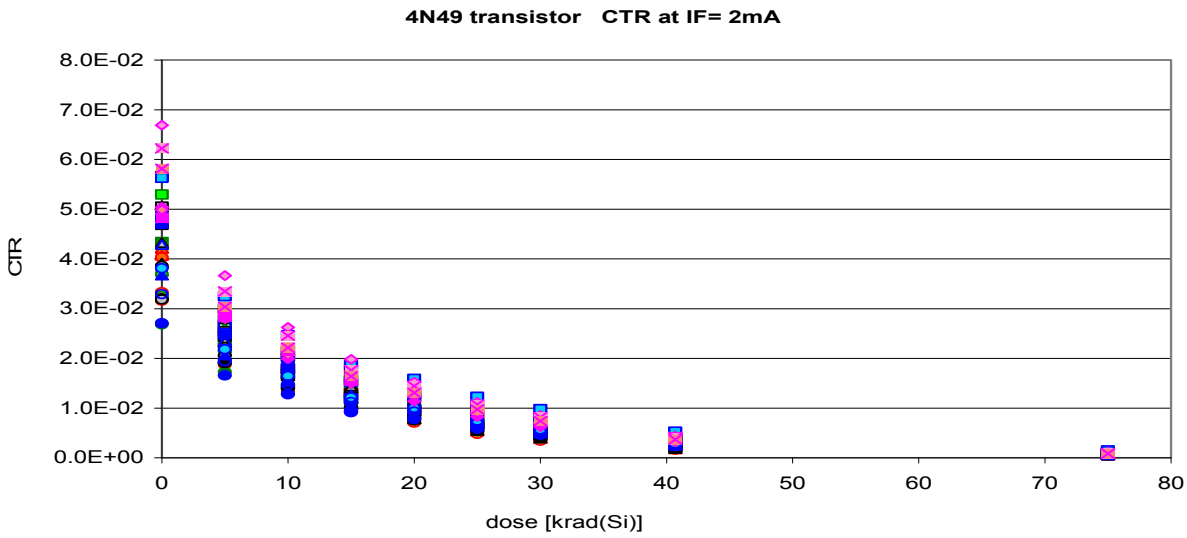
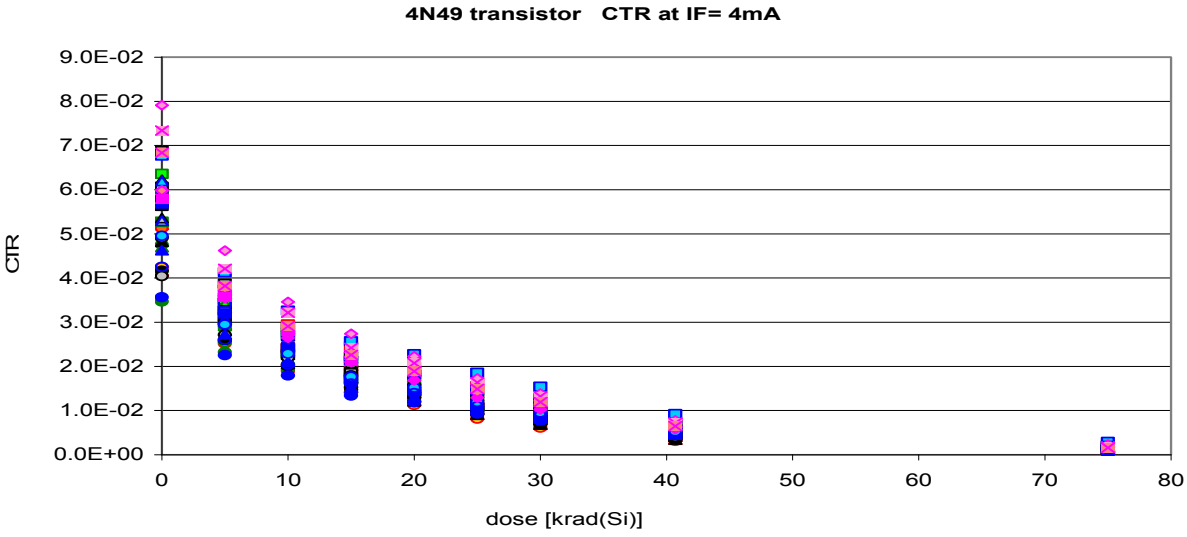
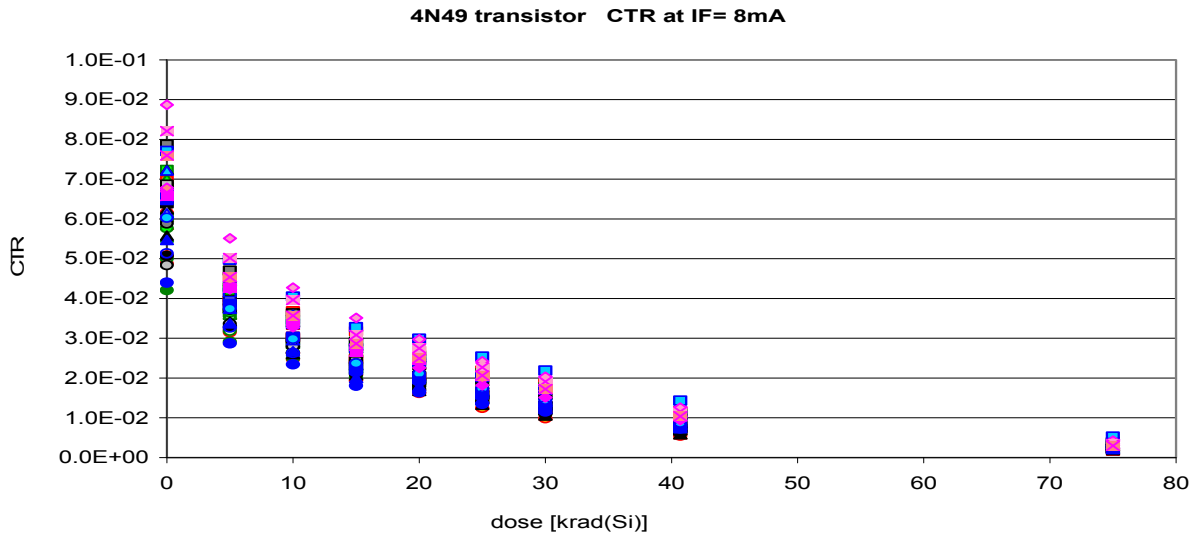

4N49 diode CTR at IF= 10mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-215: 4N49 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 transistor CTR at IF= 8mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

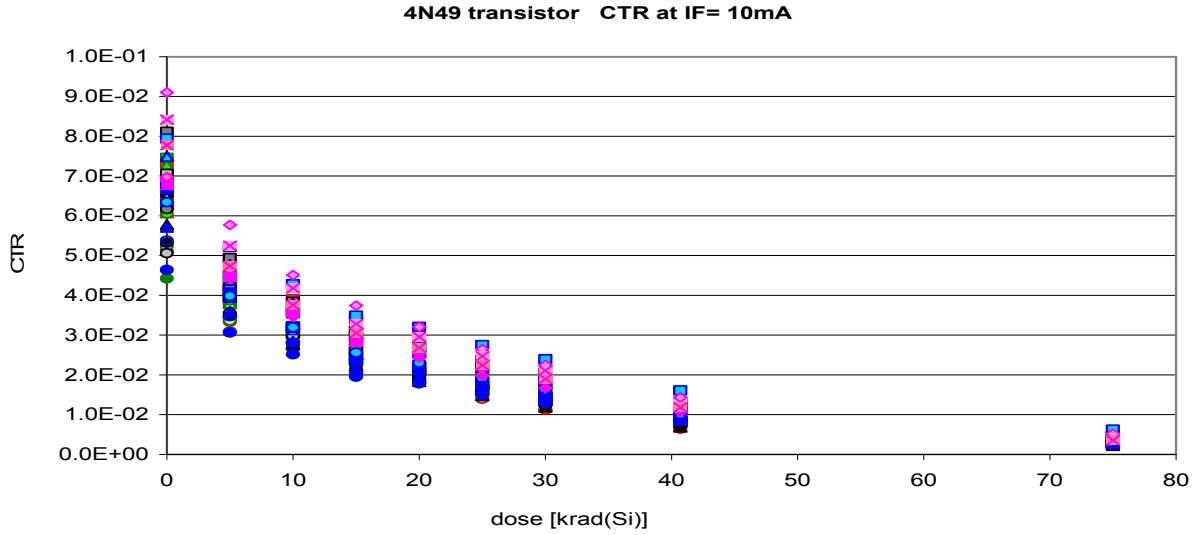
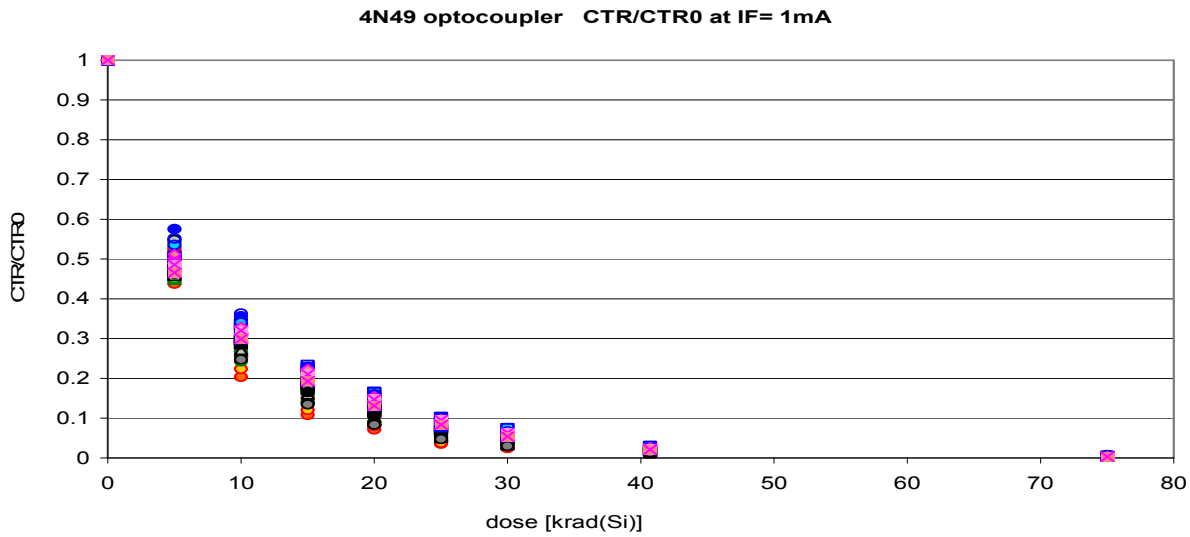
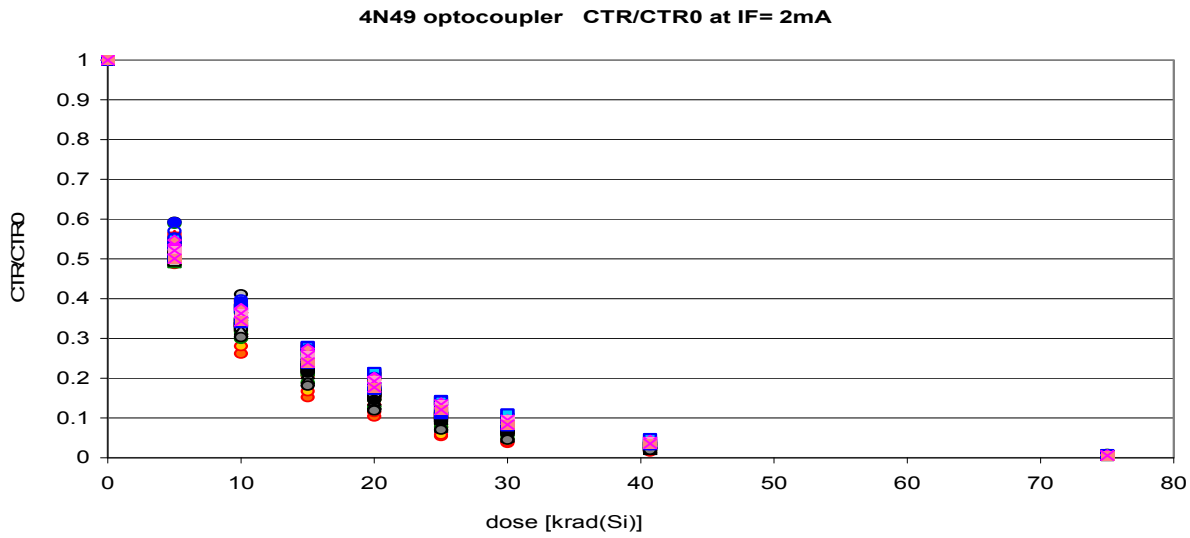
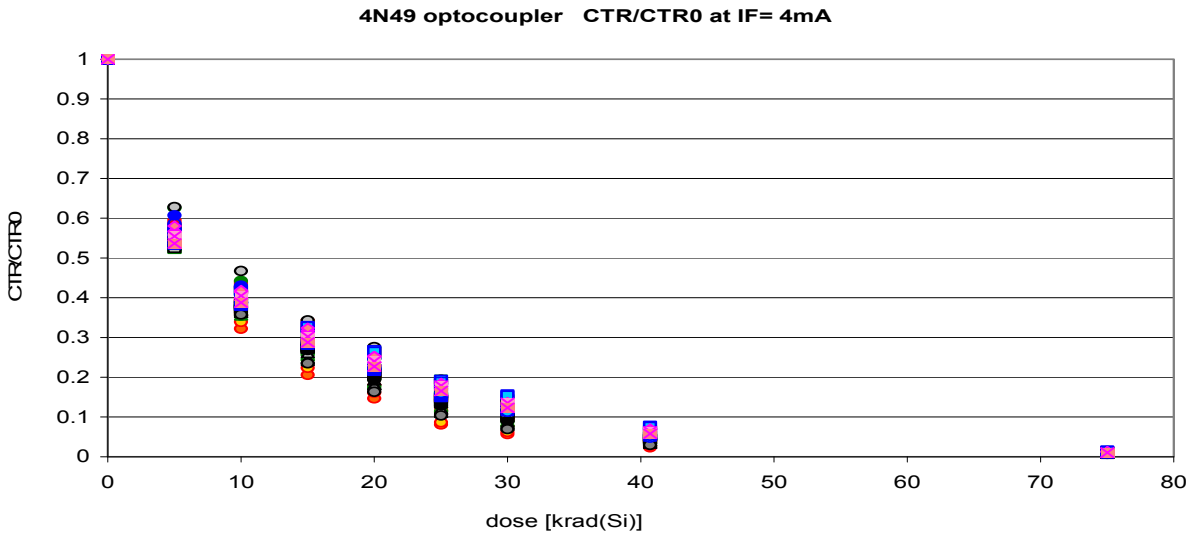
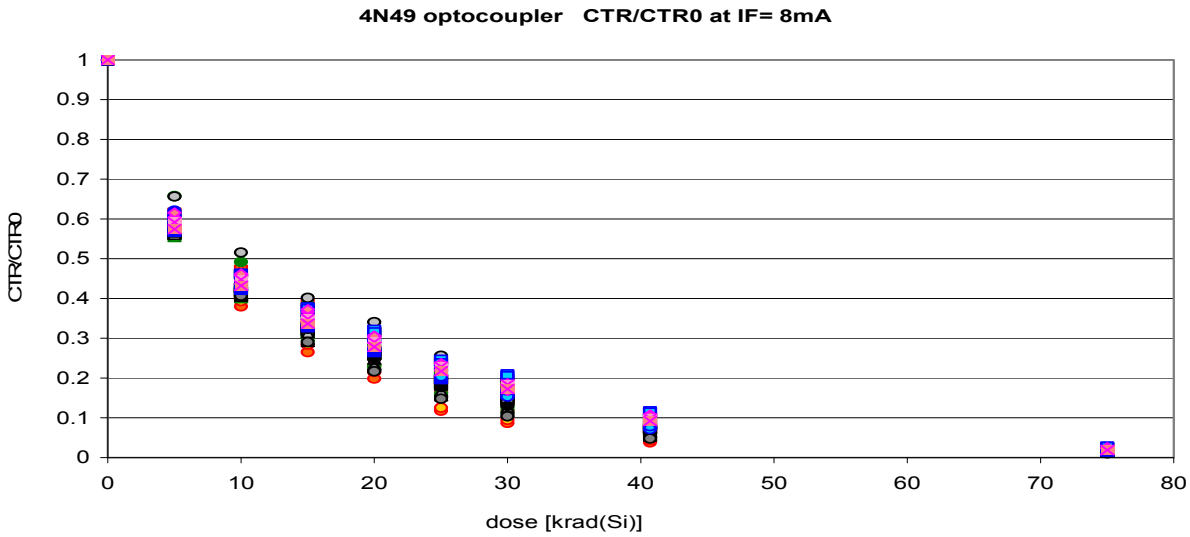

4N49 transistor CTR at IF= 10mA
CTR
1.0E-01
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-216: 4N49 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

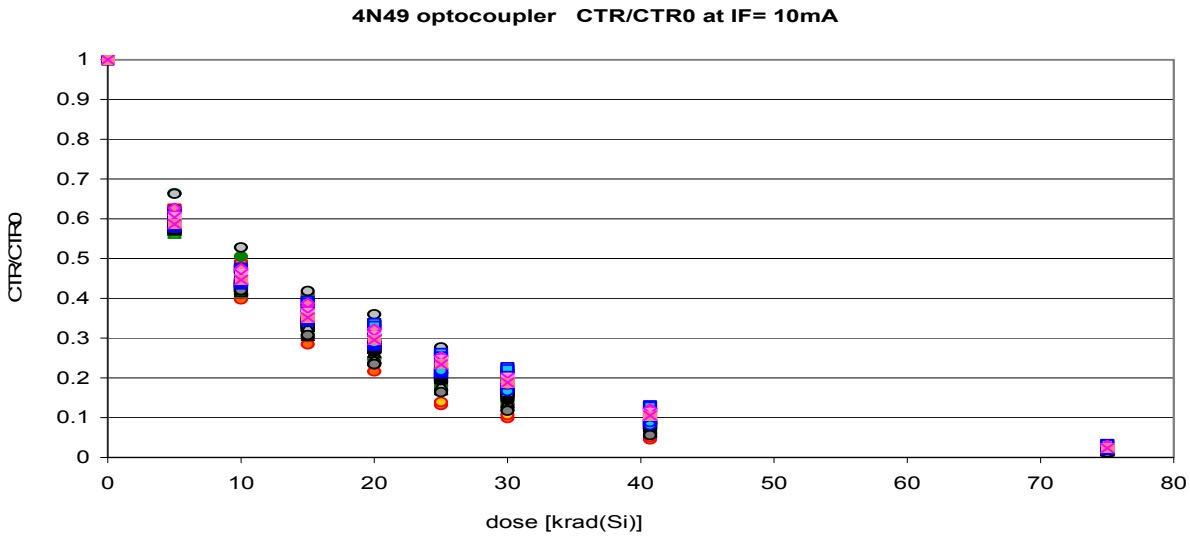
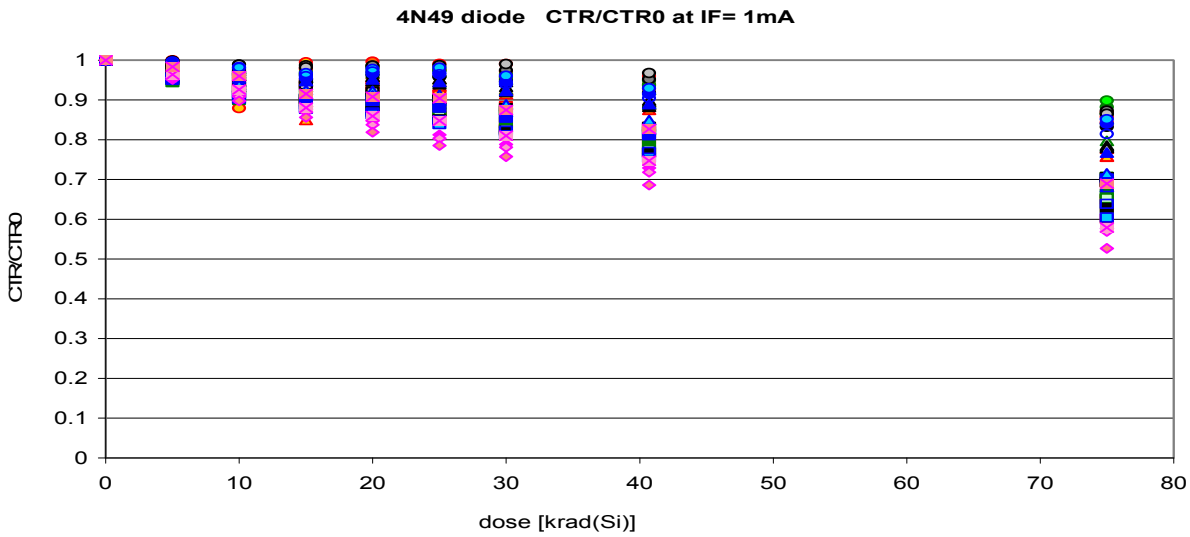
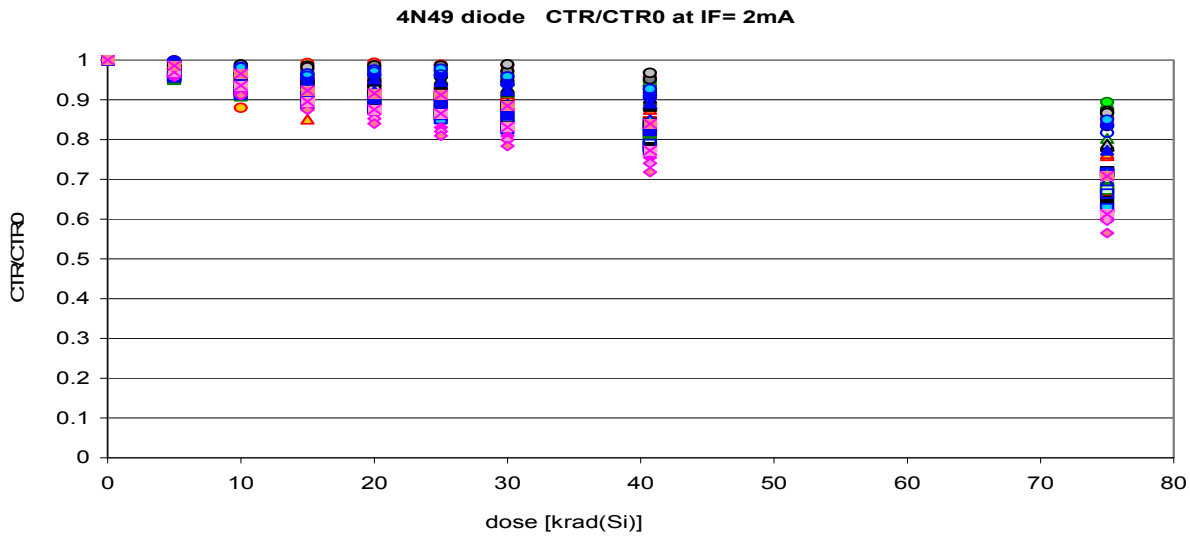
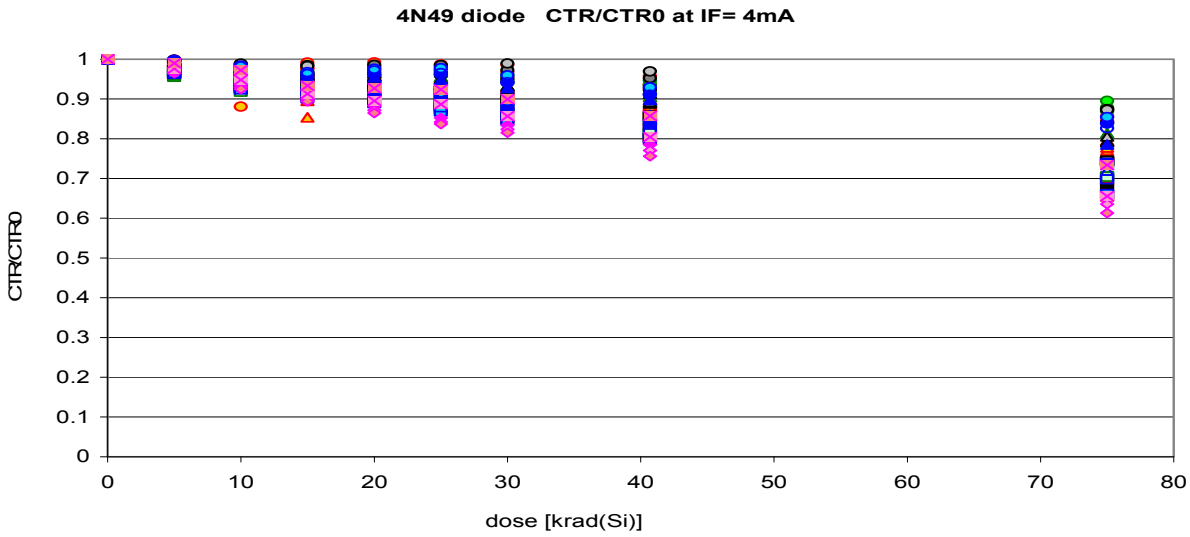
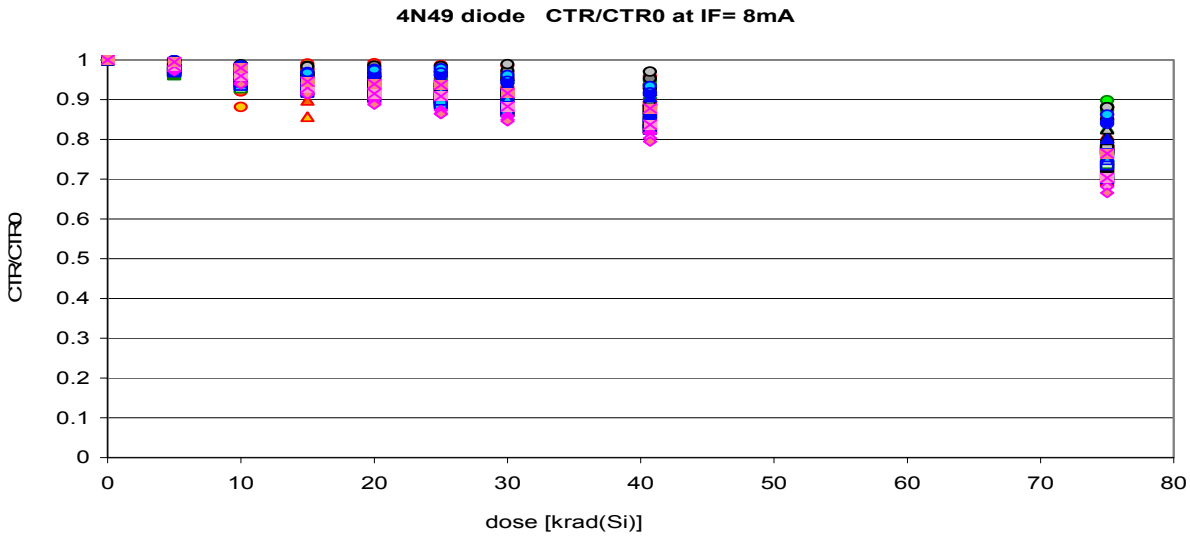

4N49 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-217: 4N49 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








4N49 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

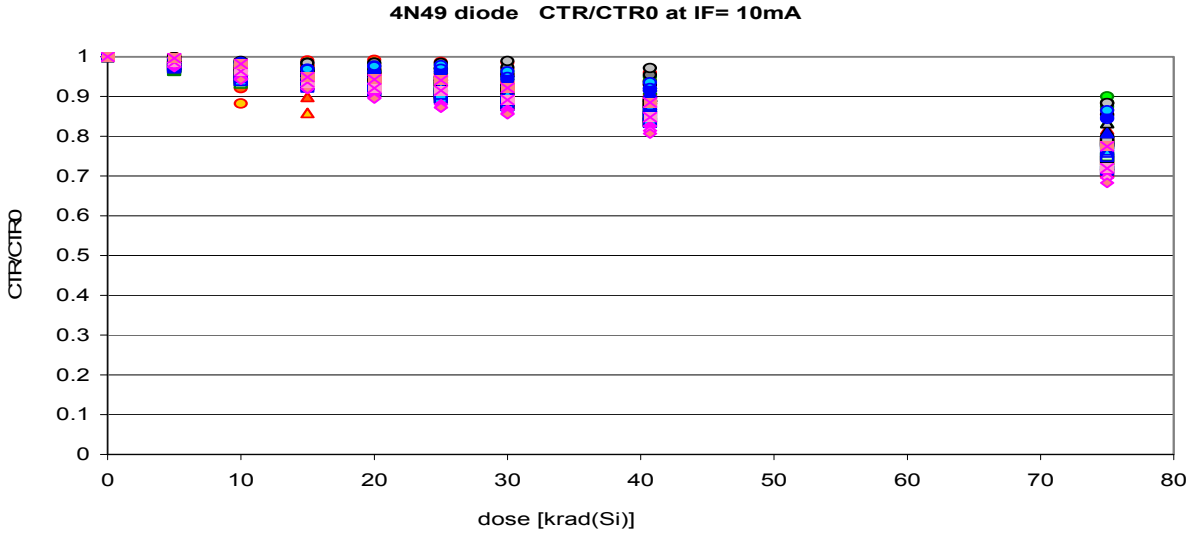
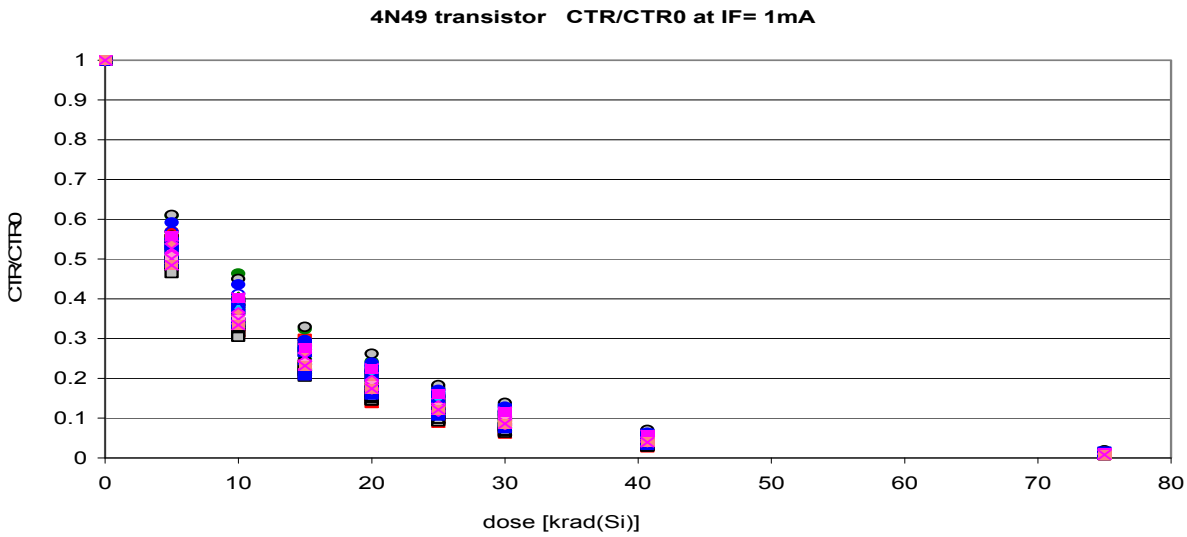
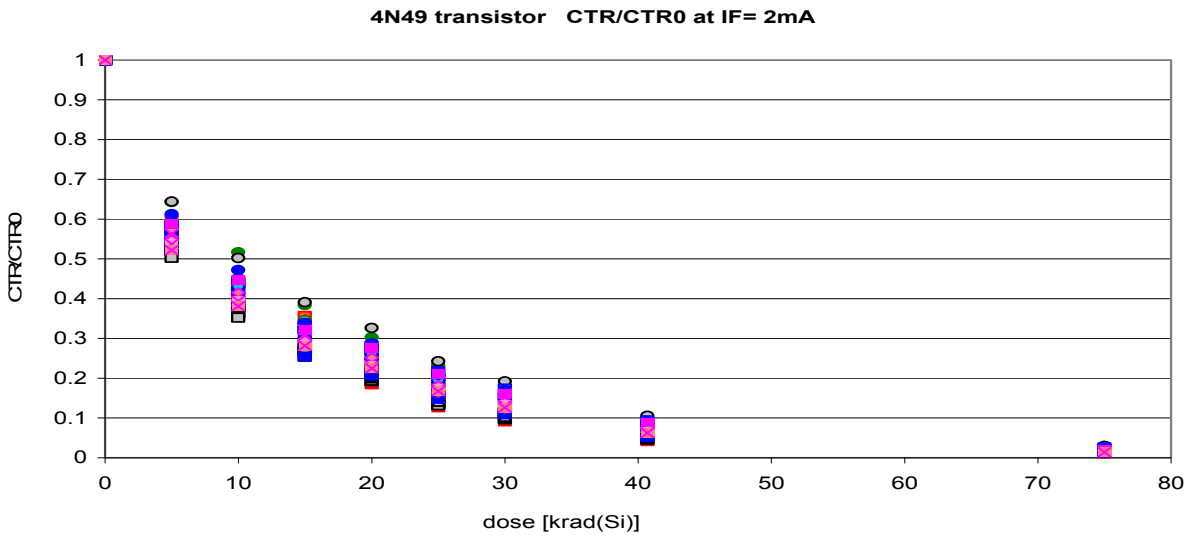
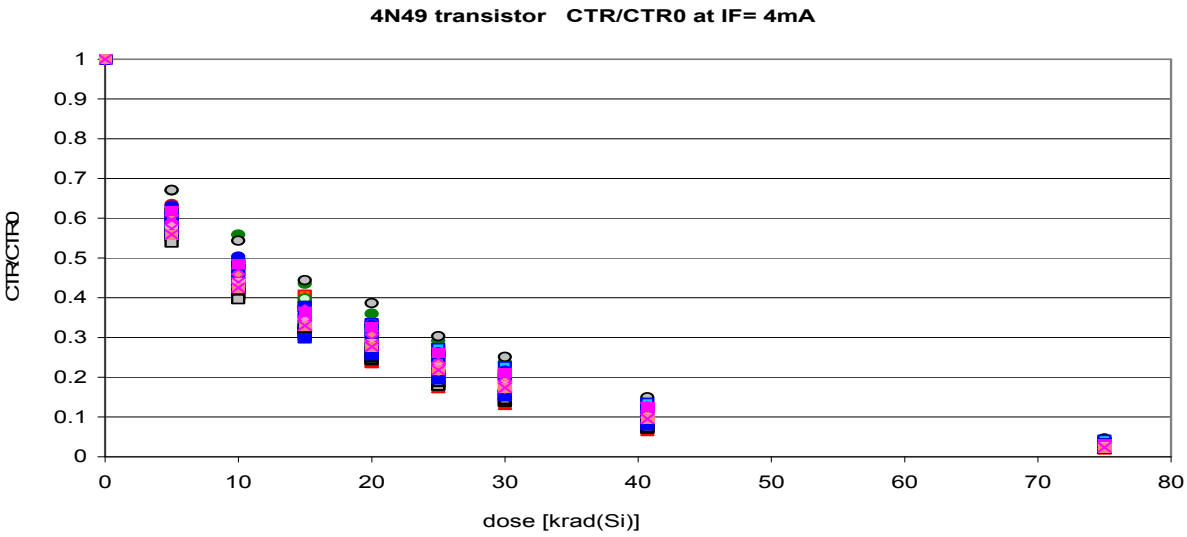
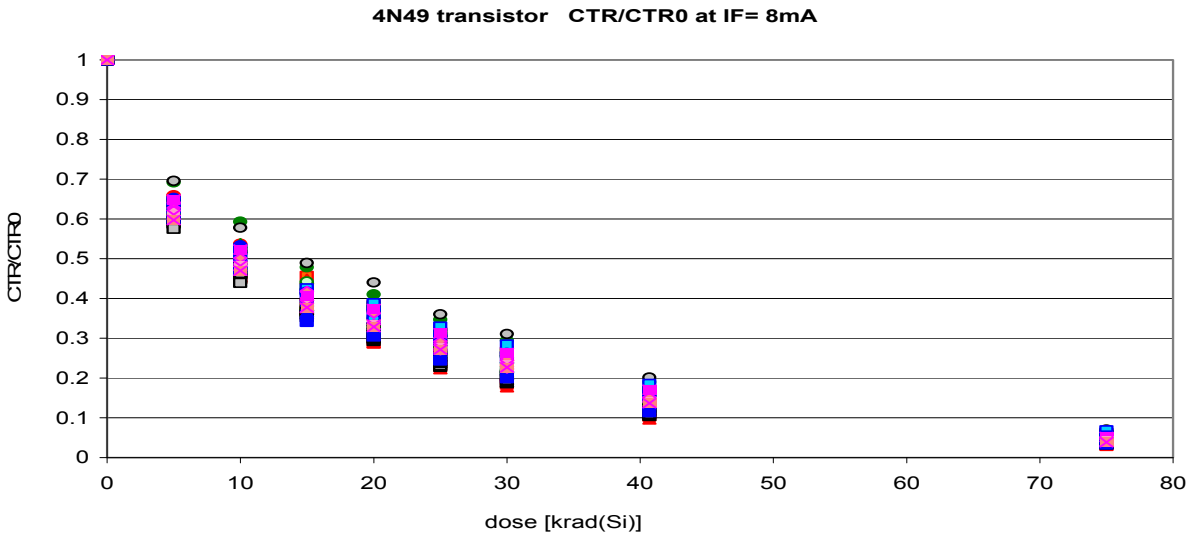

4N49 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-218: 4N49 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








4N49 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

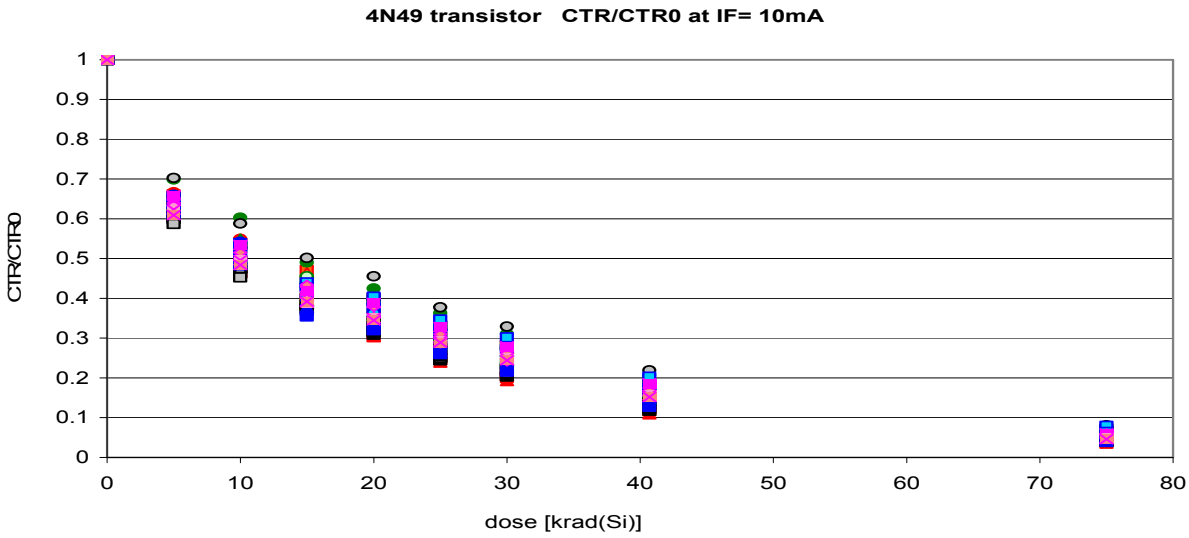
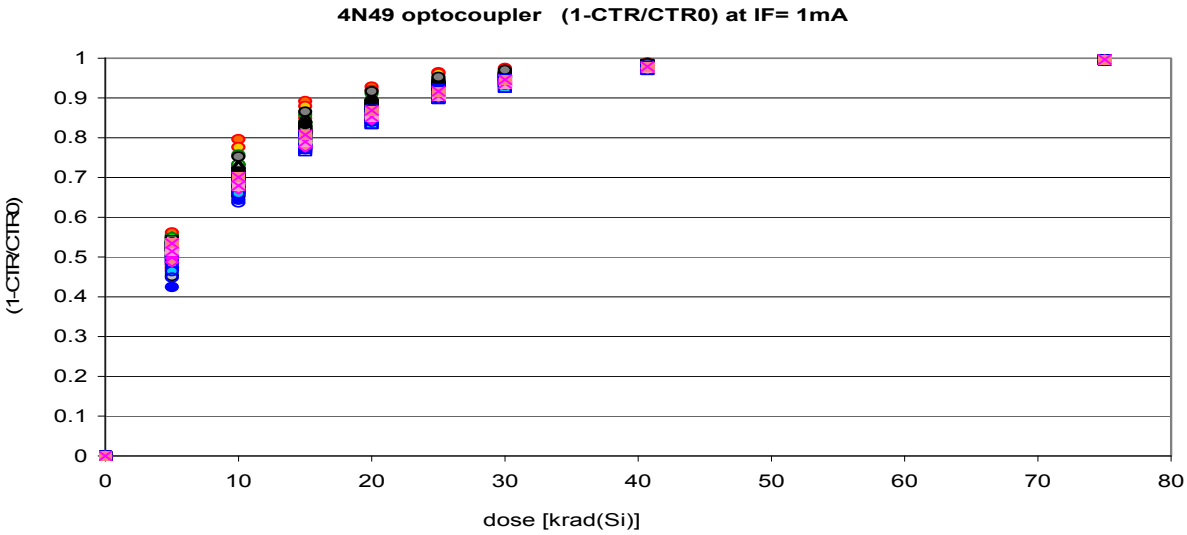
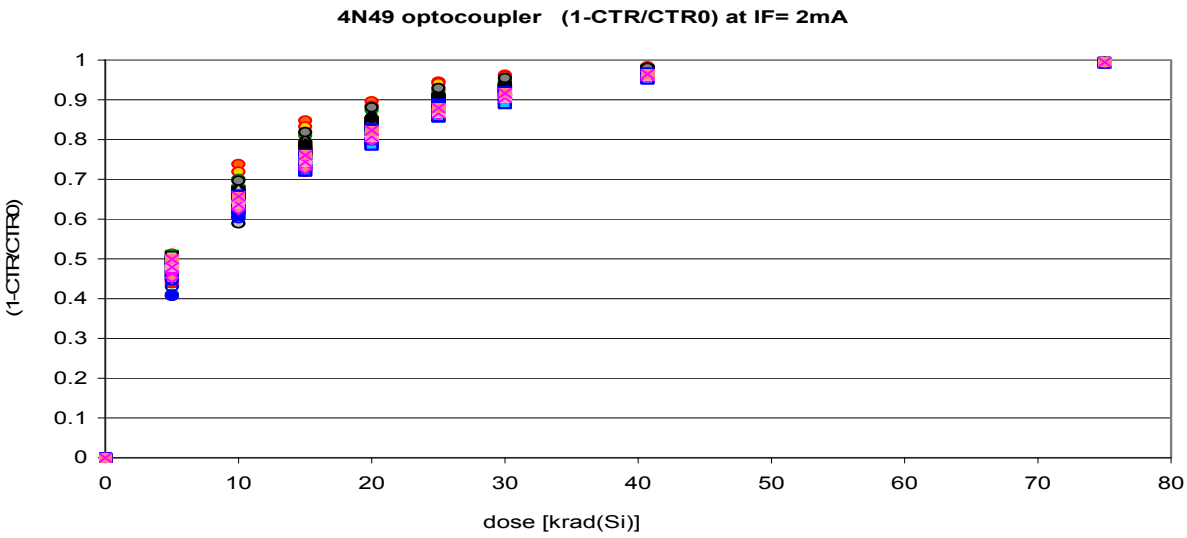
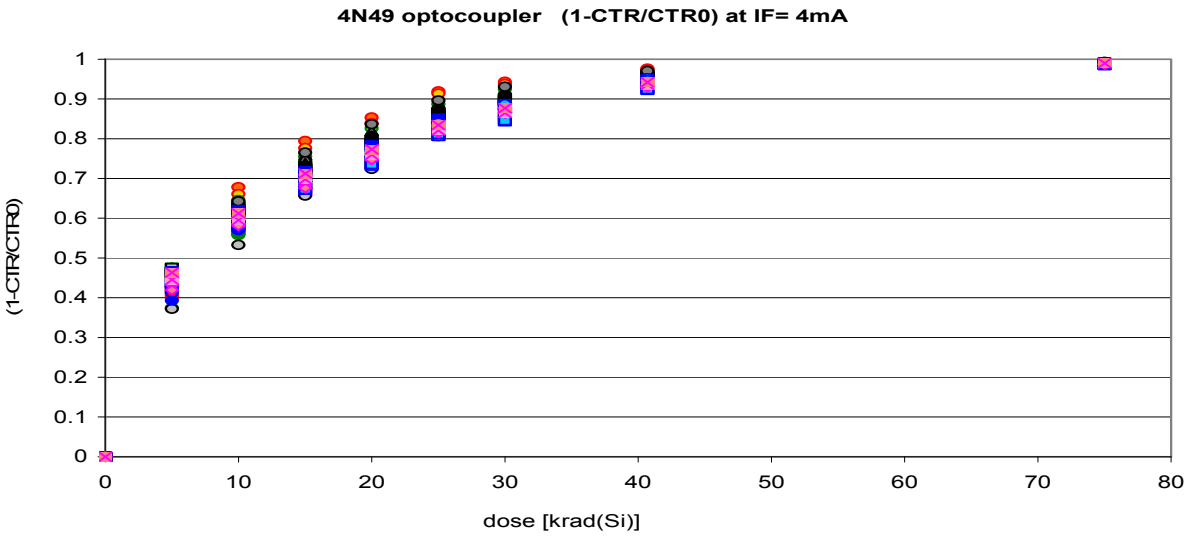
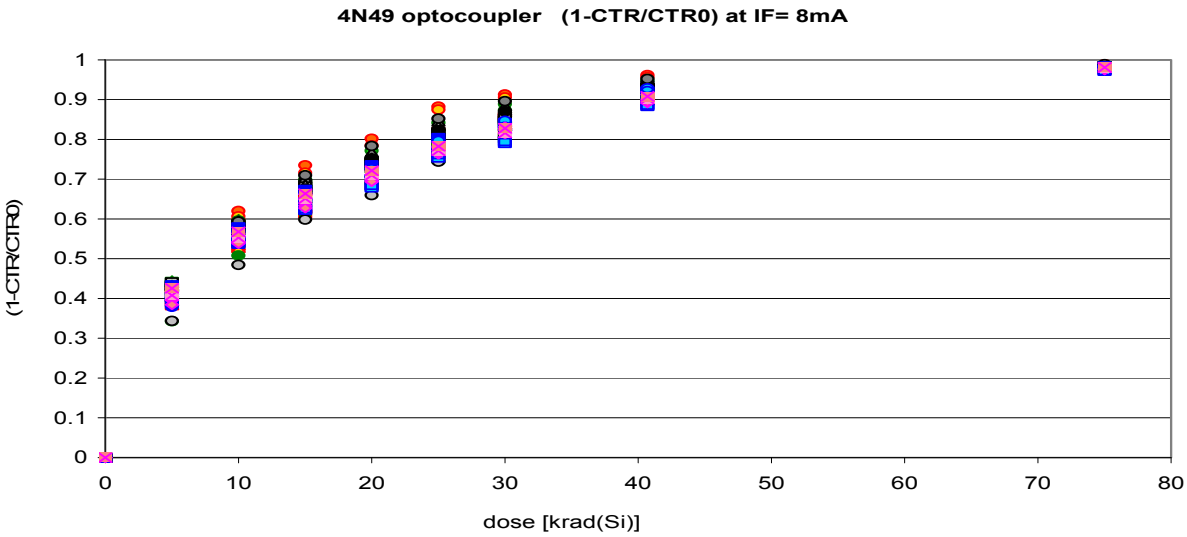

4N49 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-219: 4N49 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

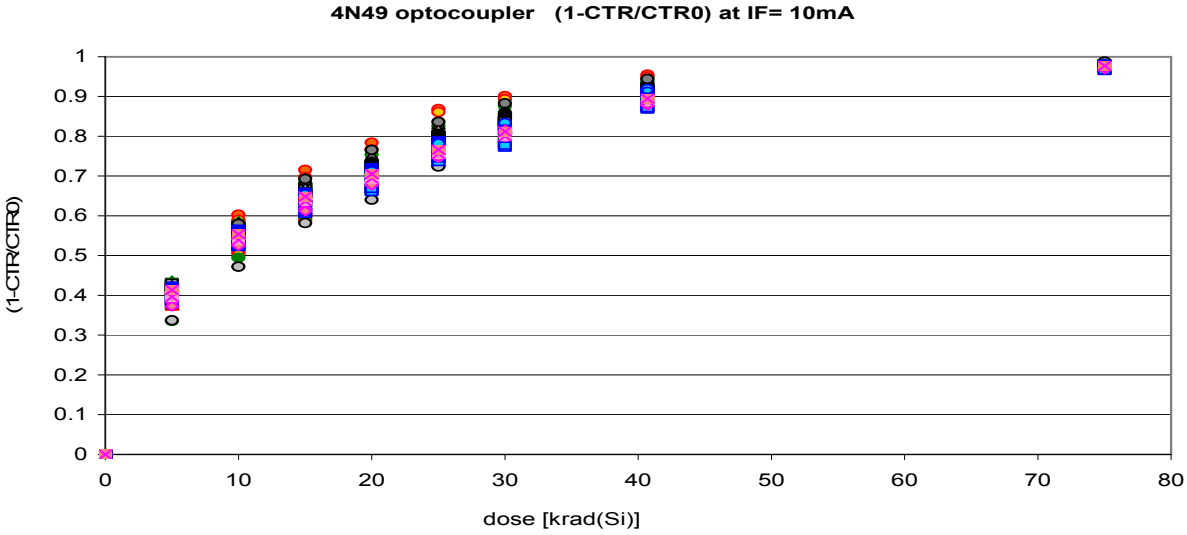
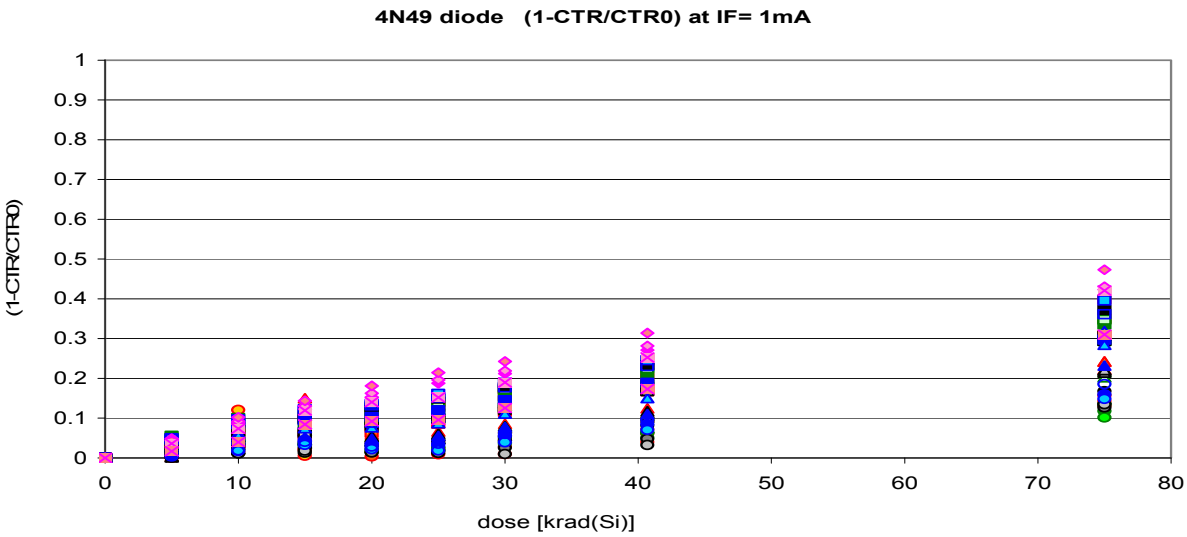
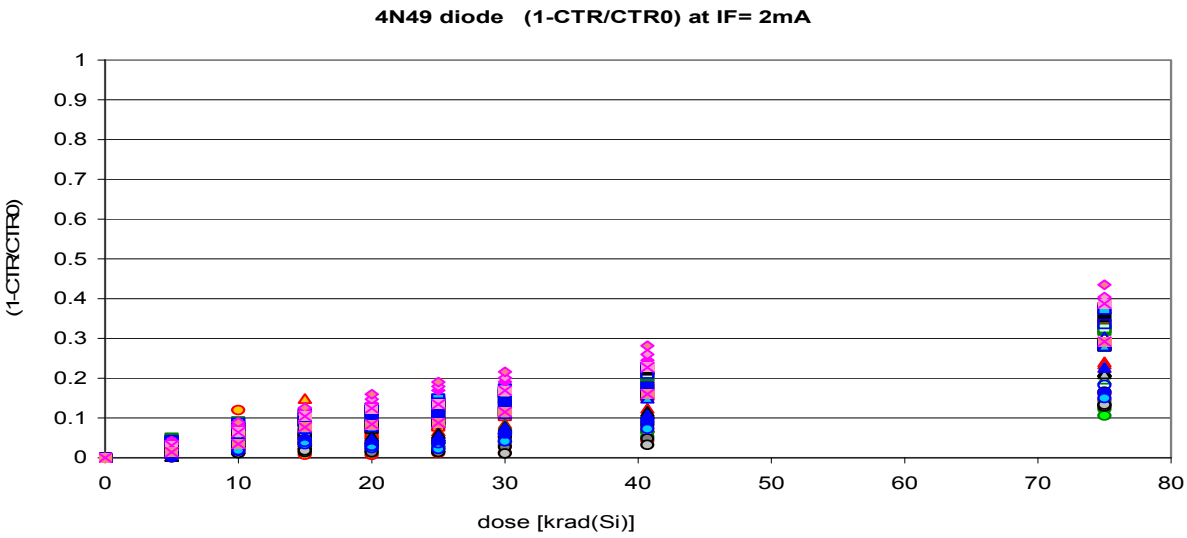
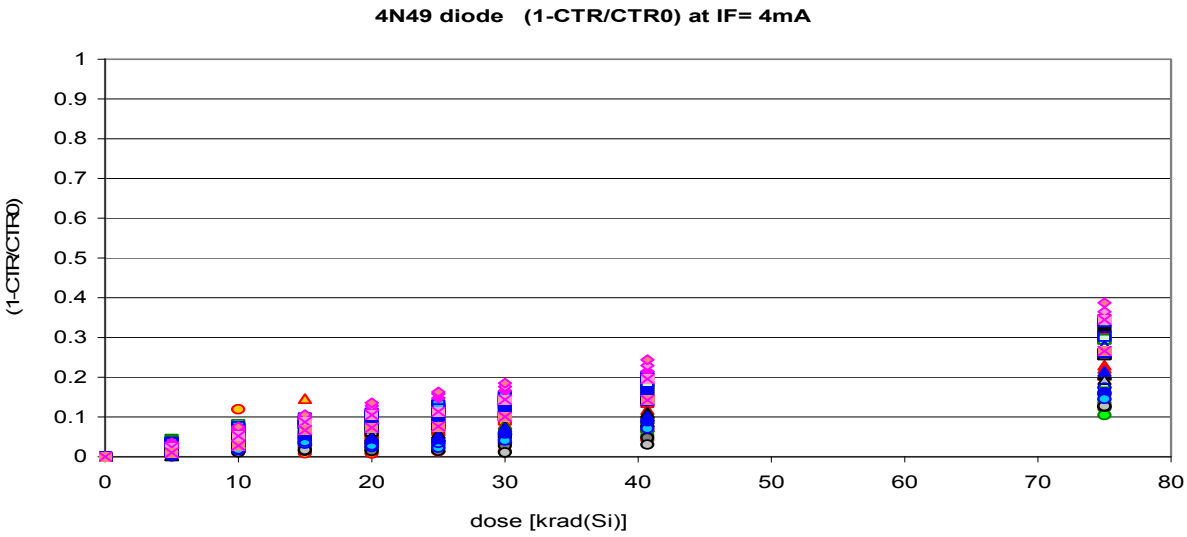
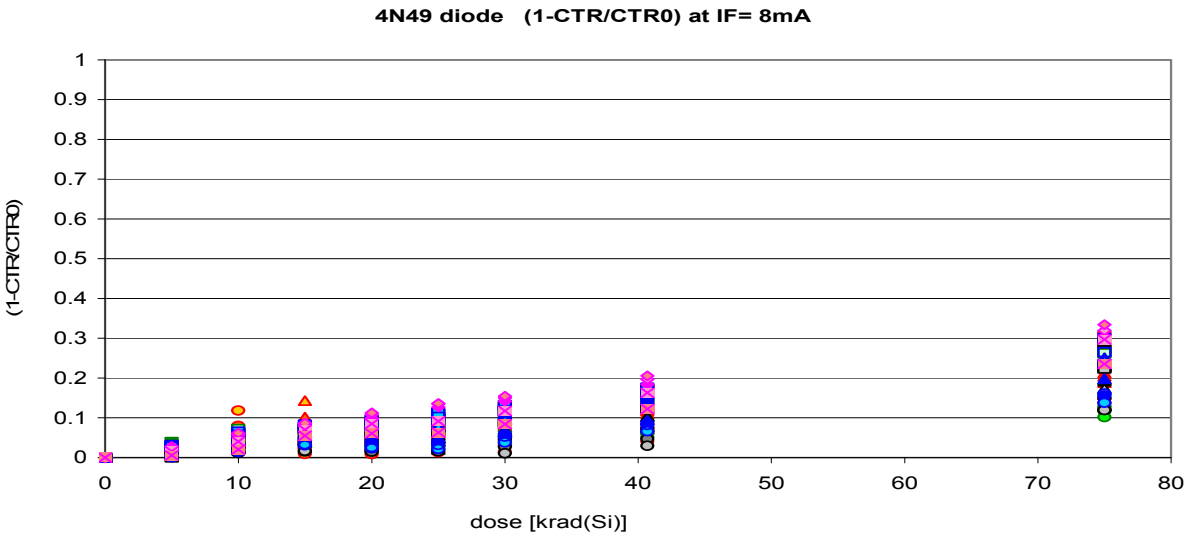

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-220: 4N49 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








4N49 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

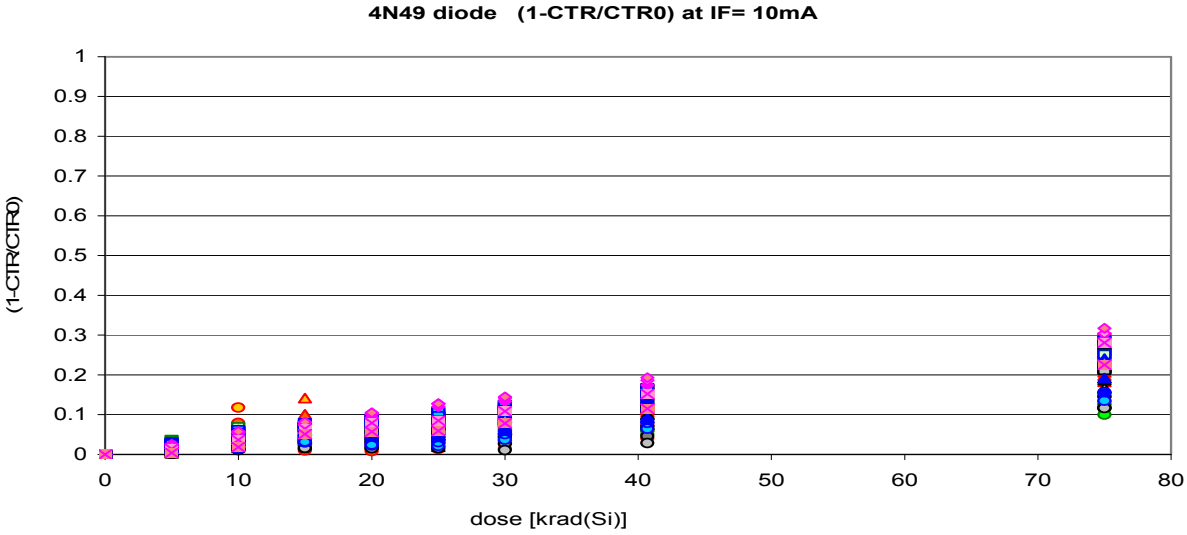
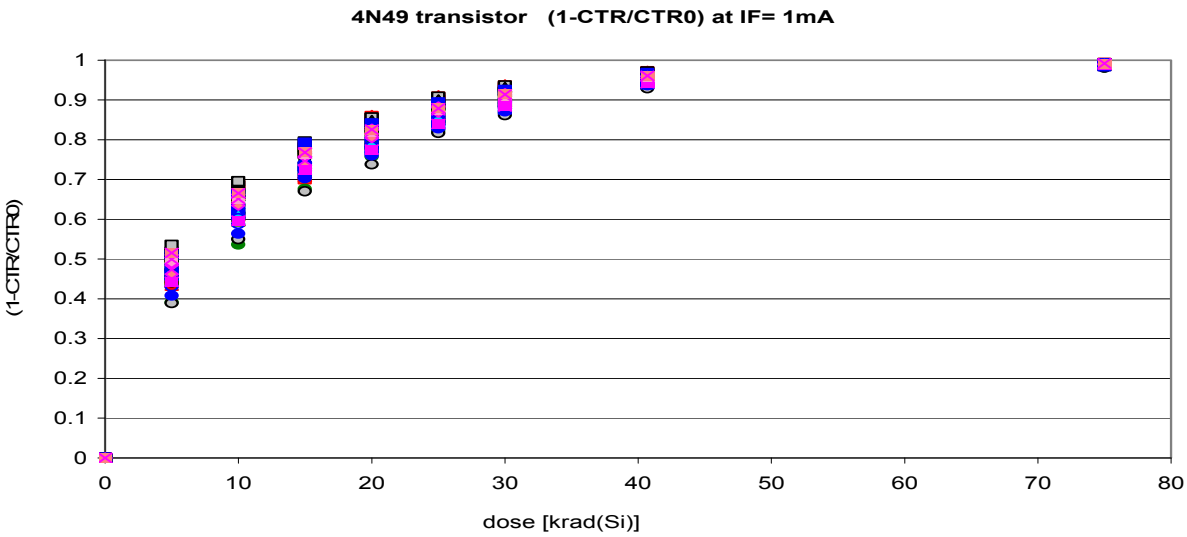
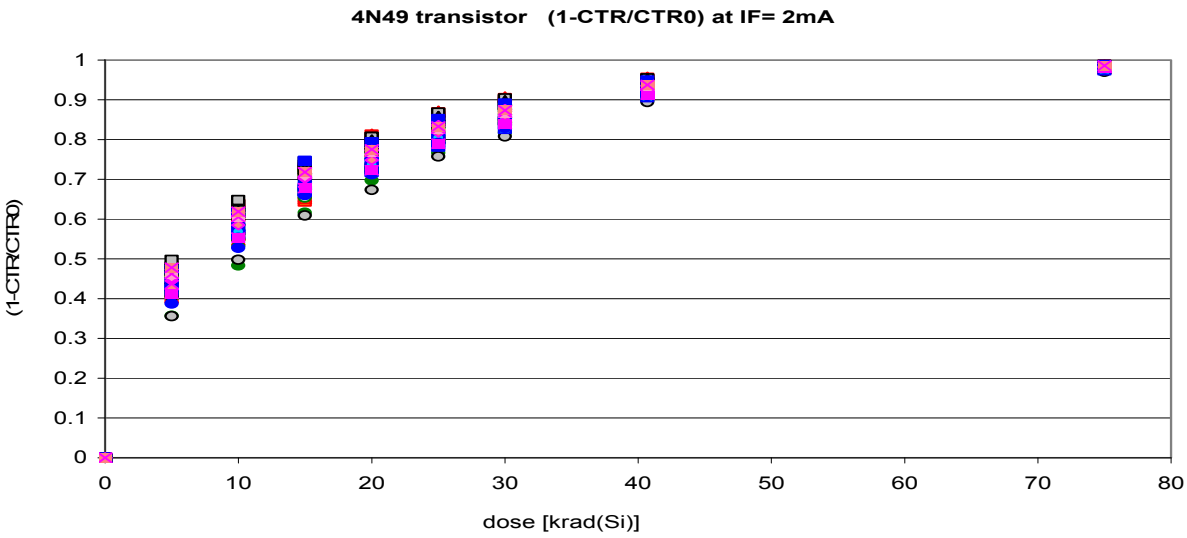
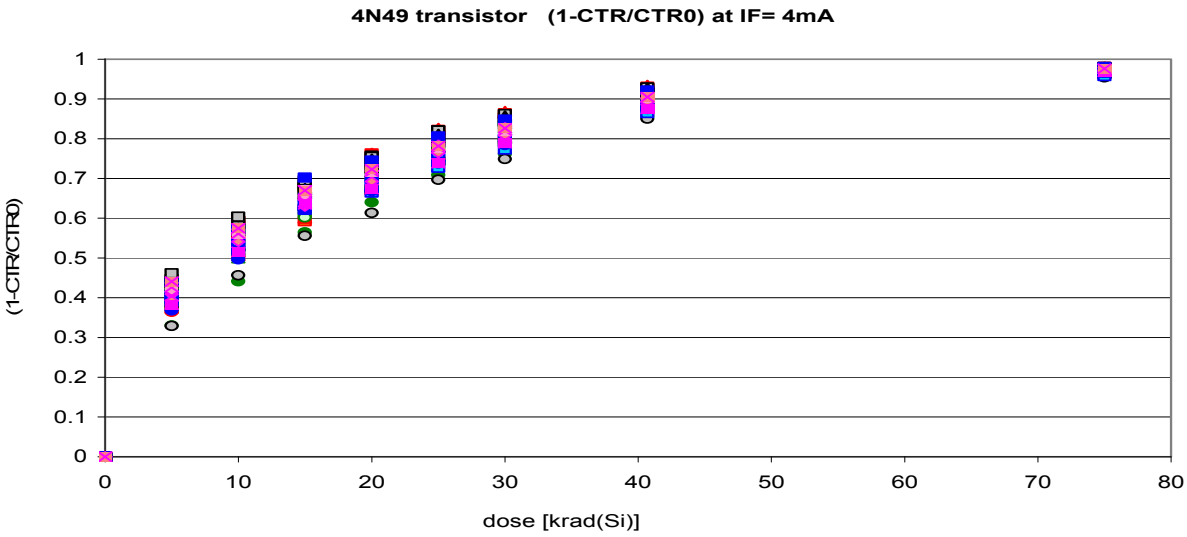
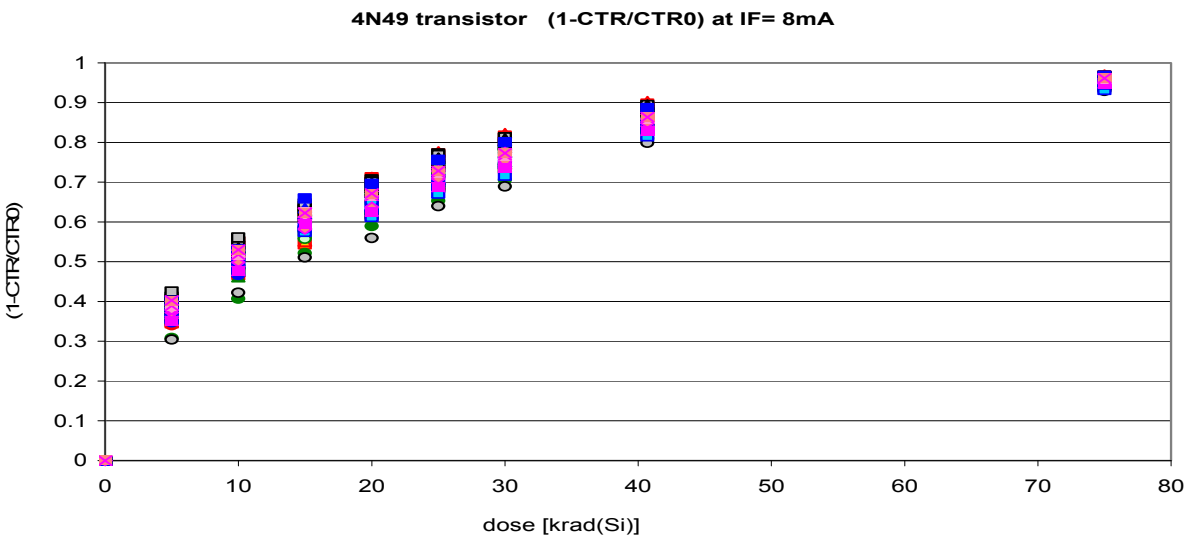

4N49 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 12-221: 4N49 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








4N49 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

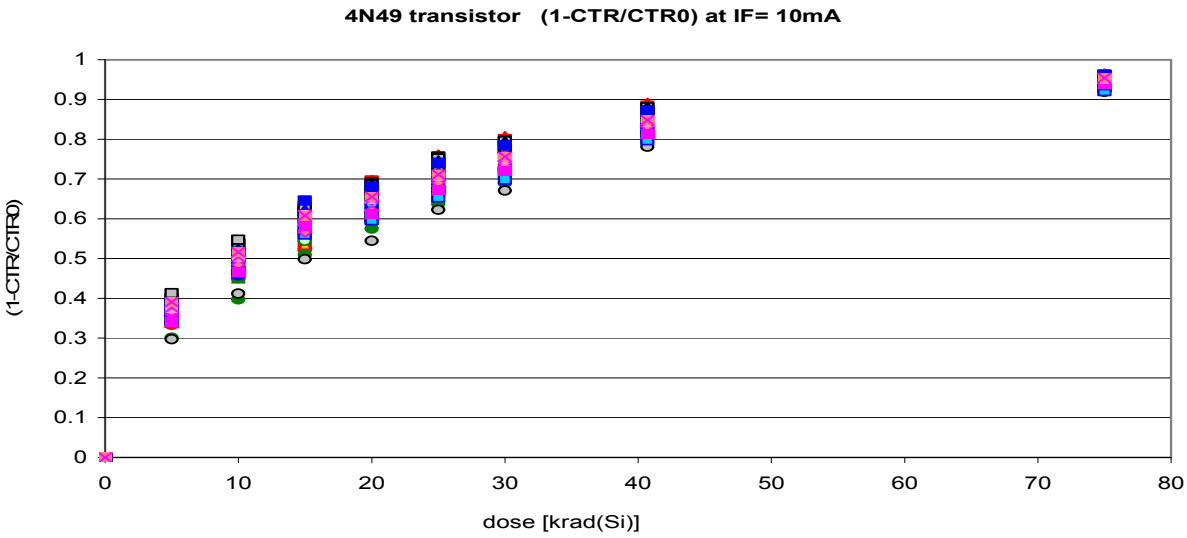
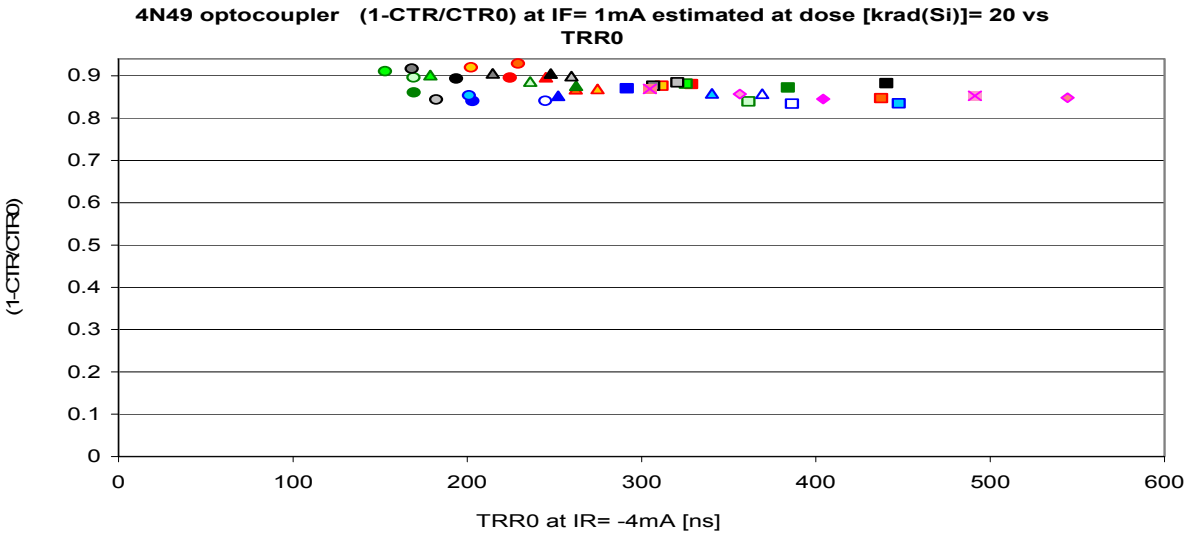
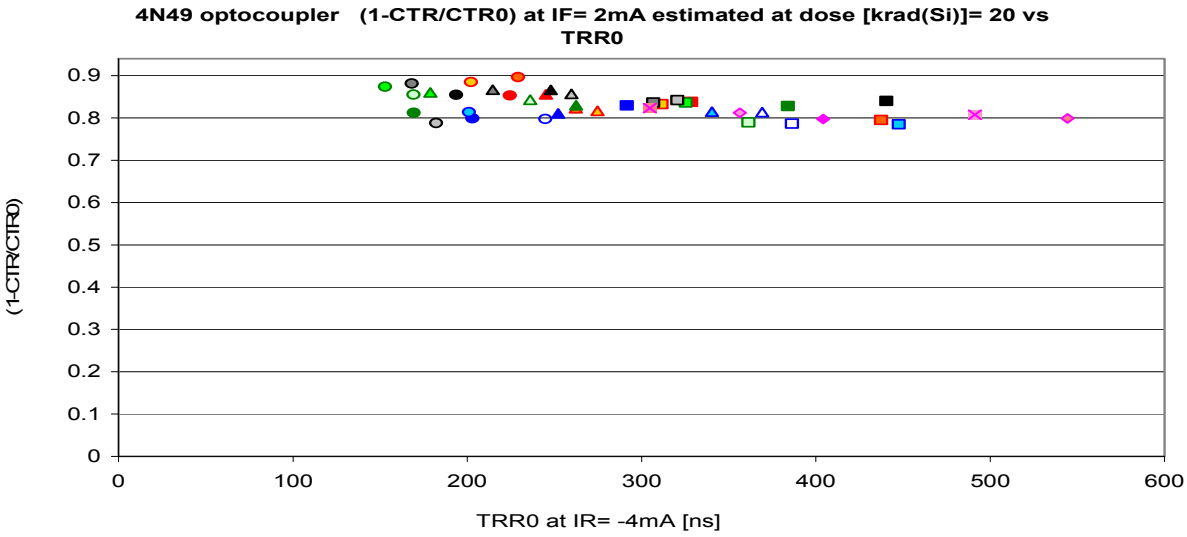
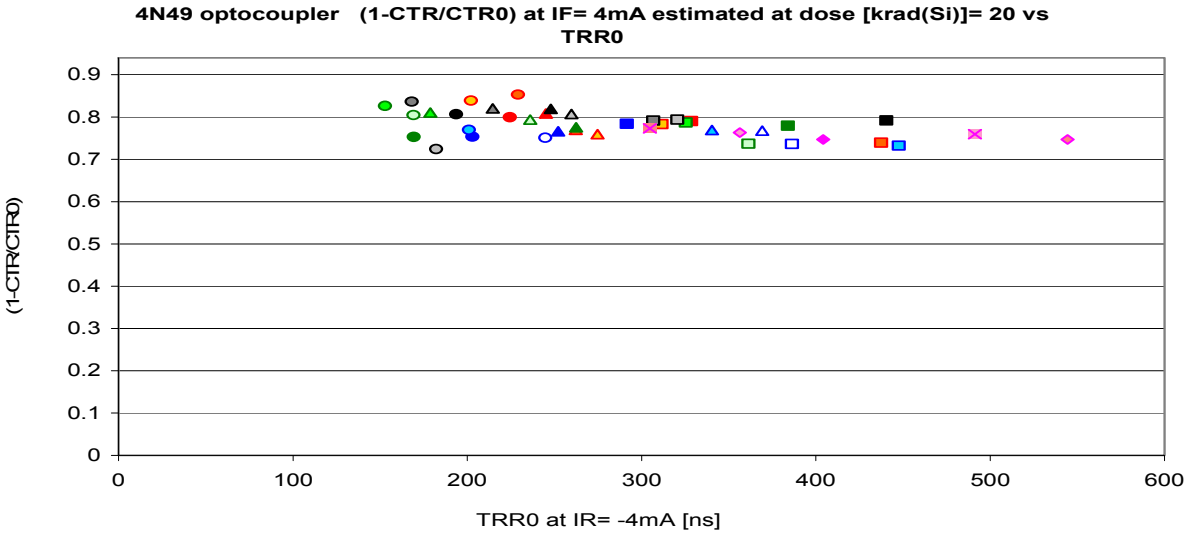
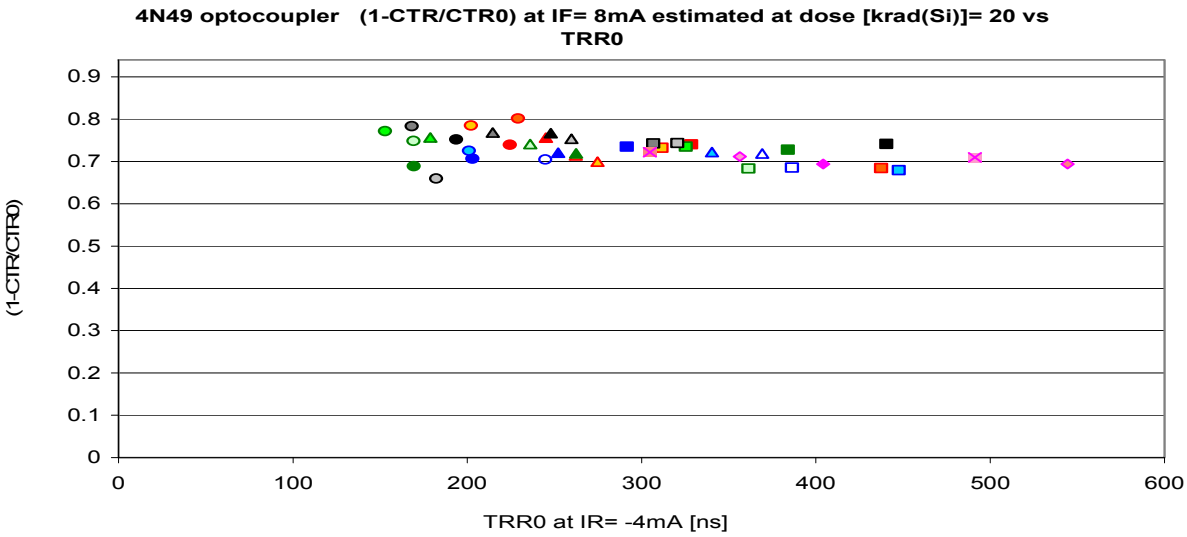

4N49 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

Fig. 12-222: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

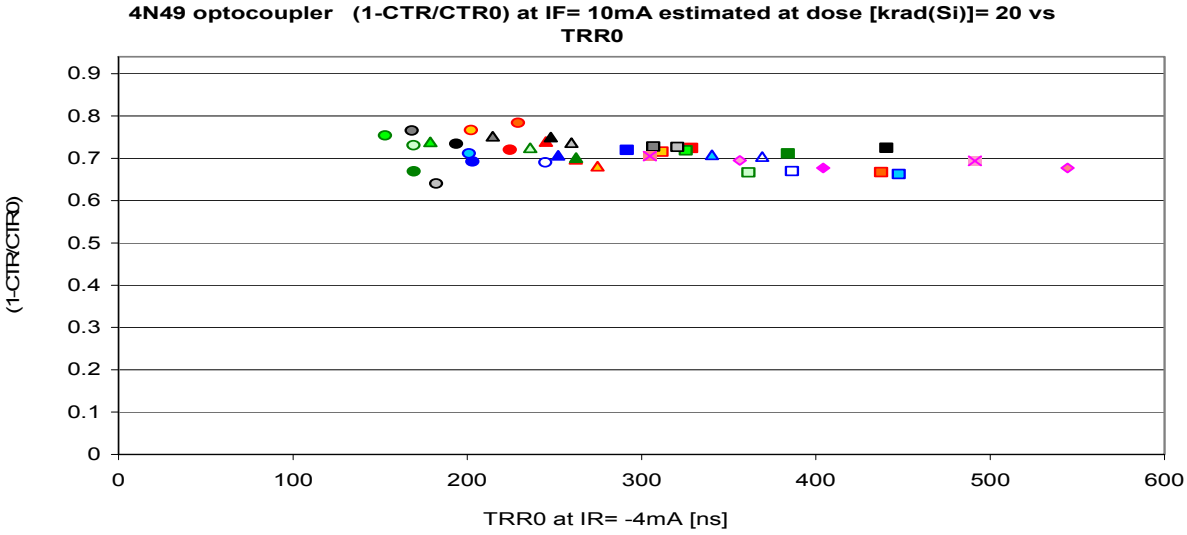
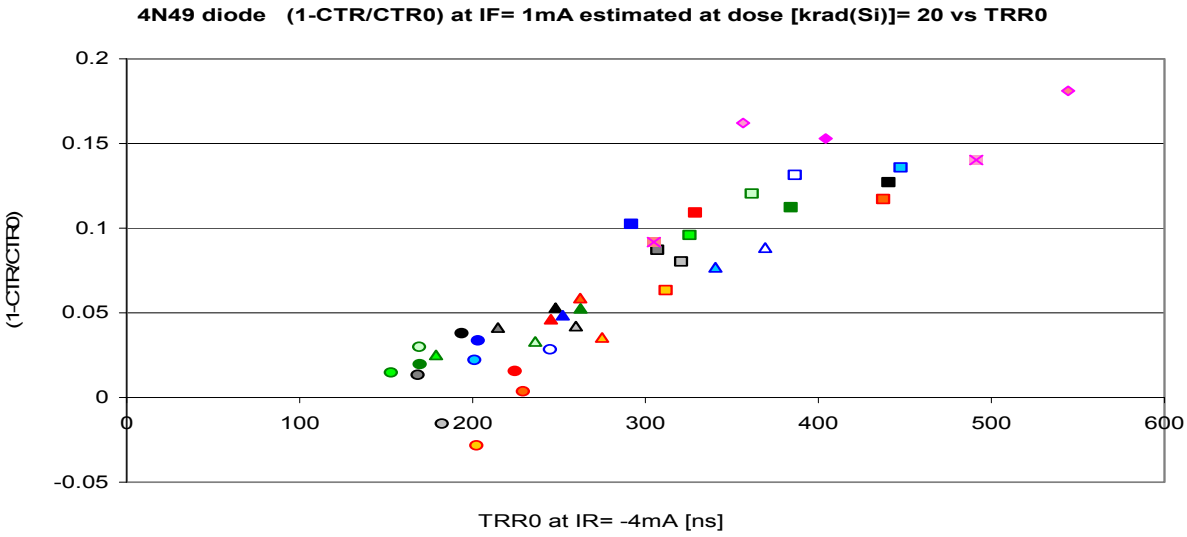
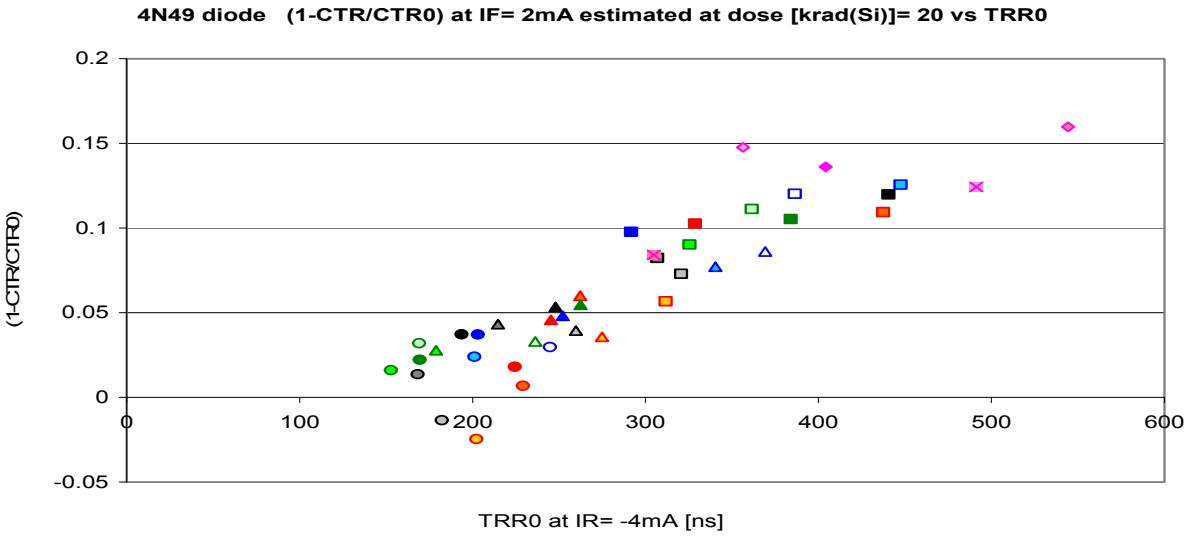
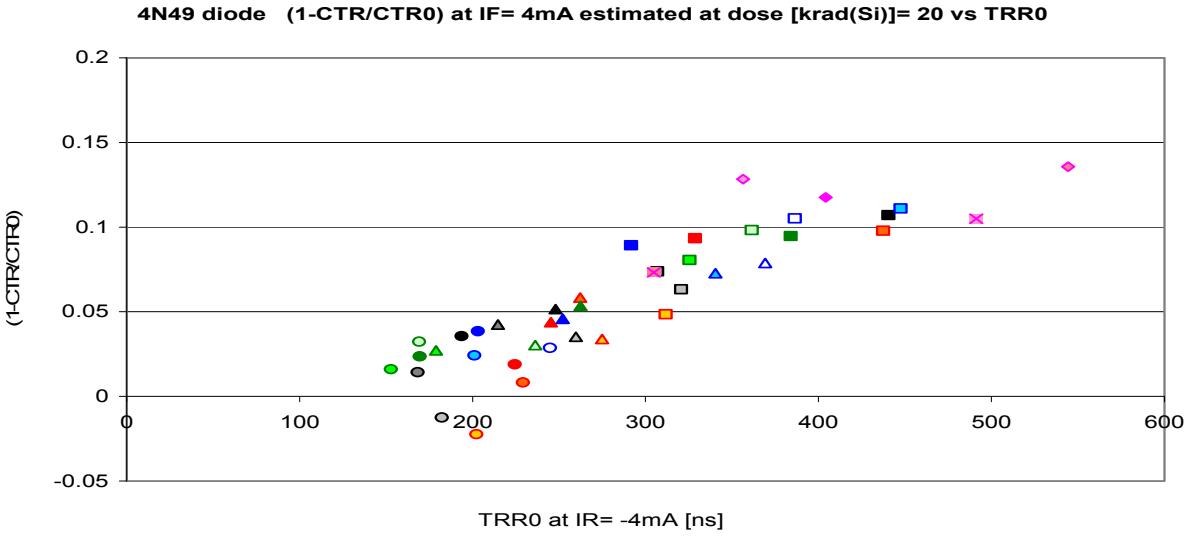
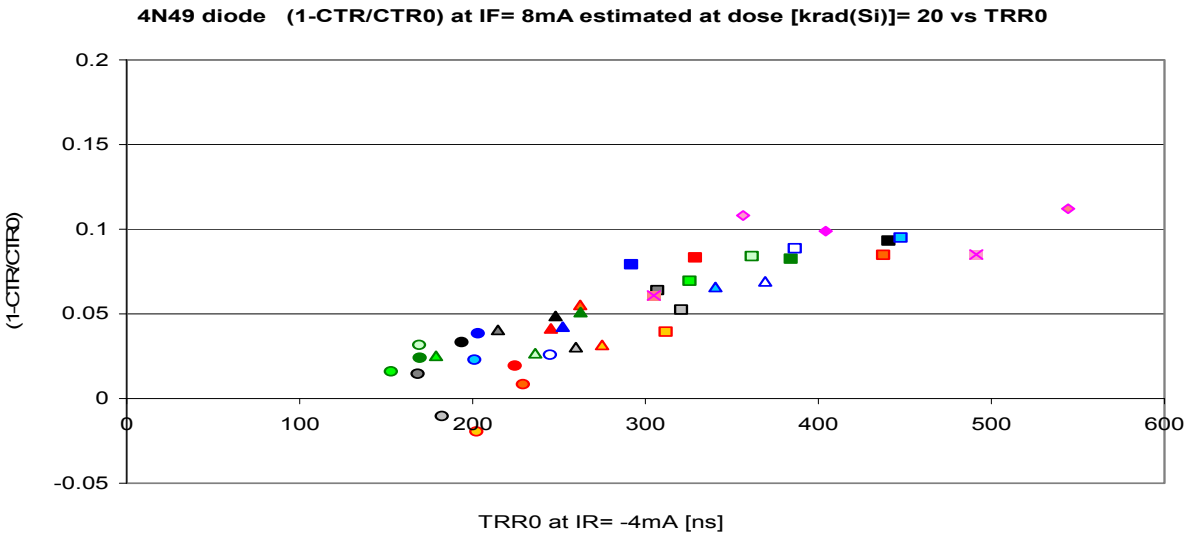

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-223: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0.2
0.15
0.1
0.05
0
-0.05
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

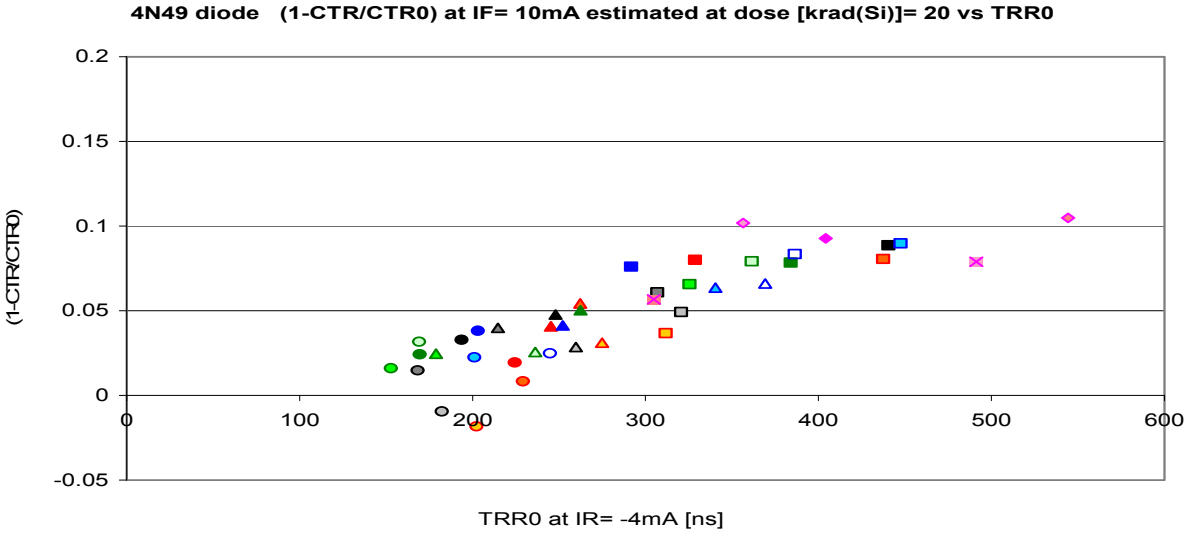
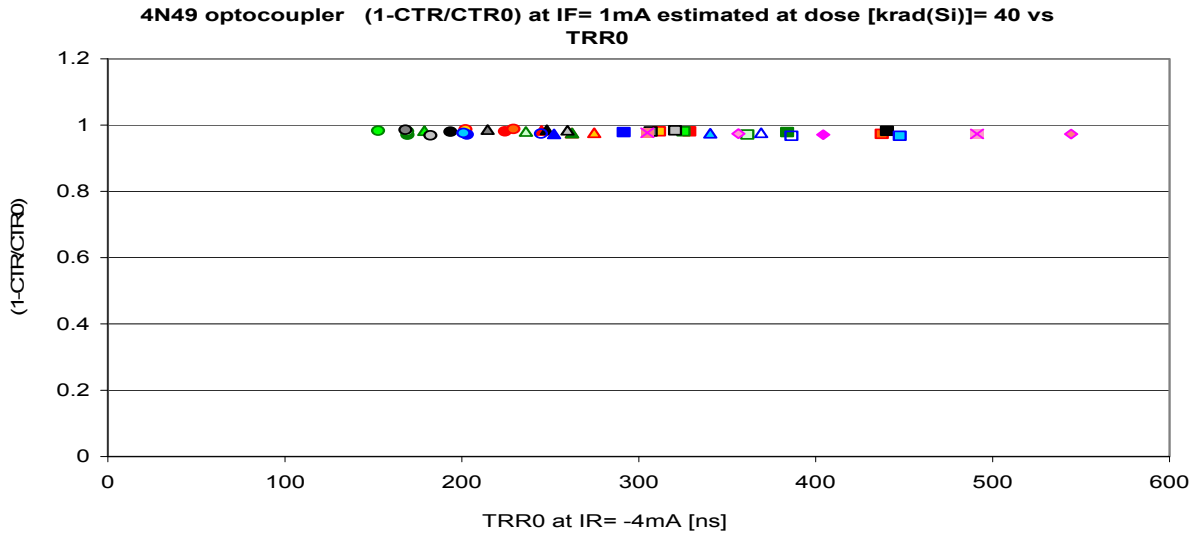
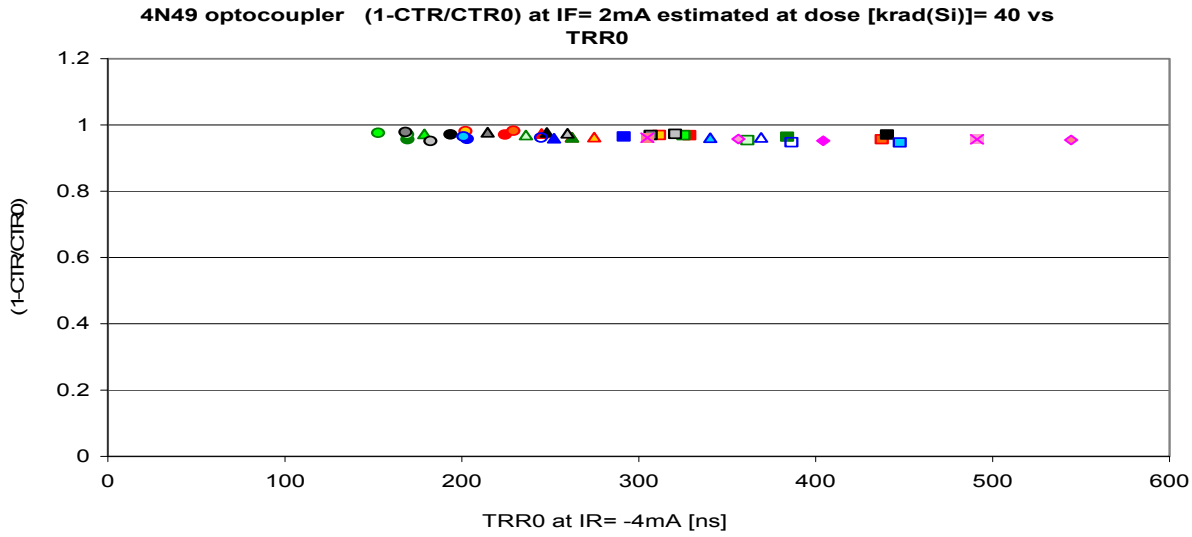
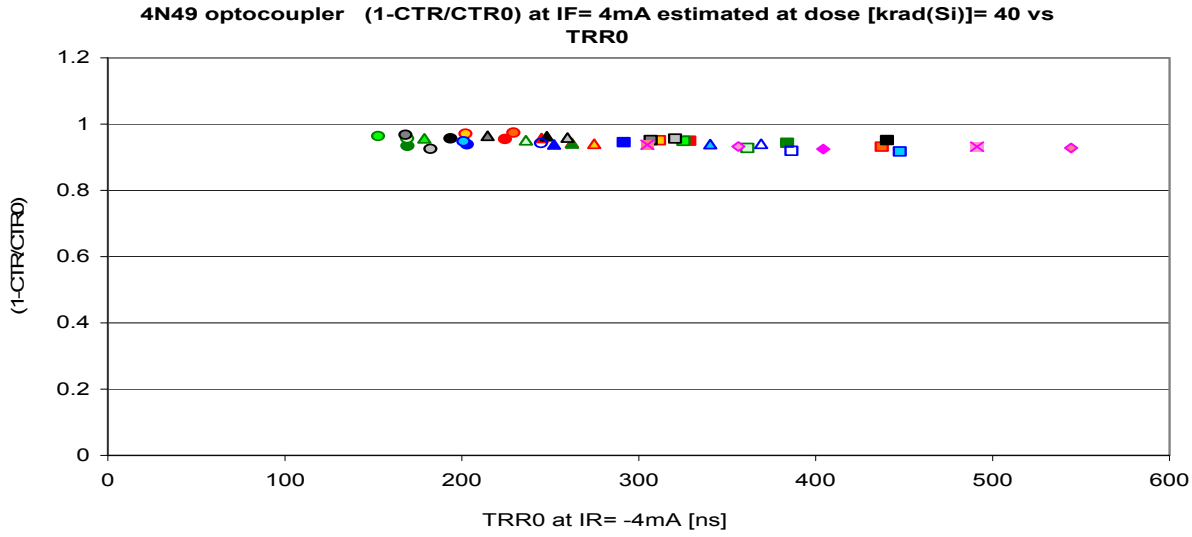
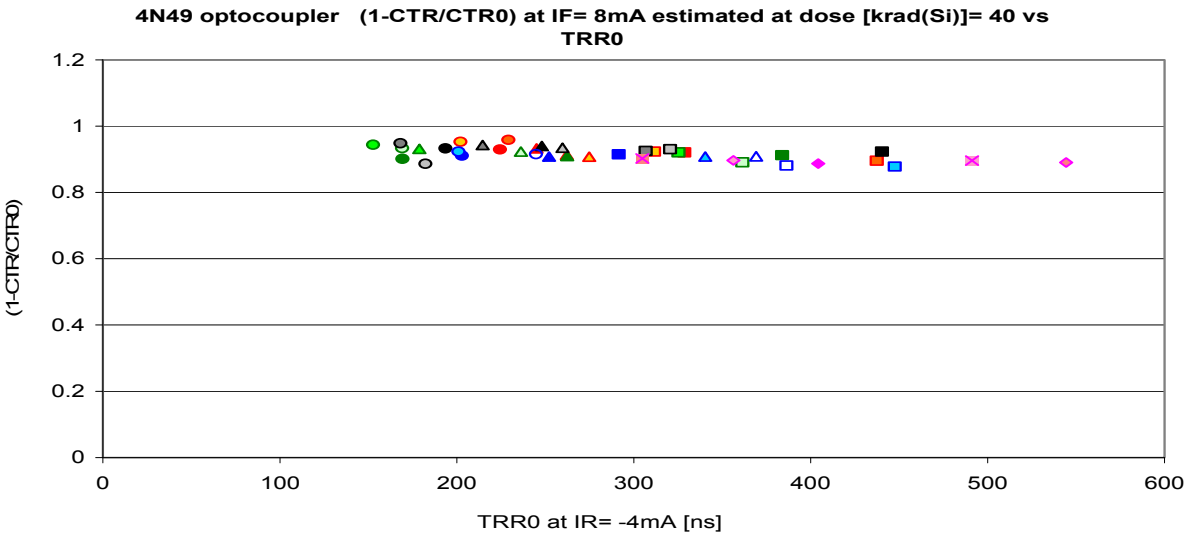

4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0.2
0.15
0.1
0.05
0
-0.05
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-224: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

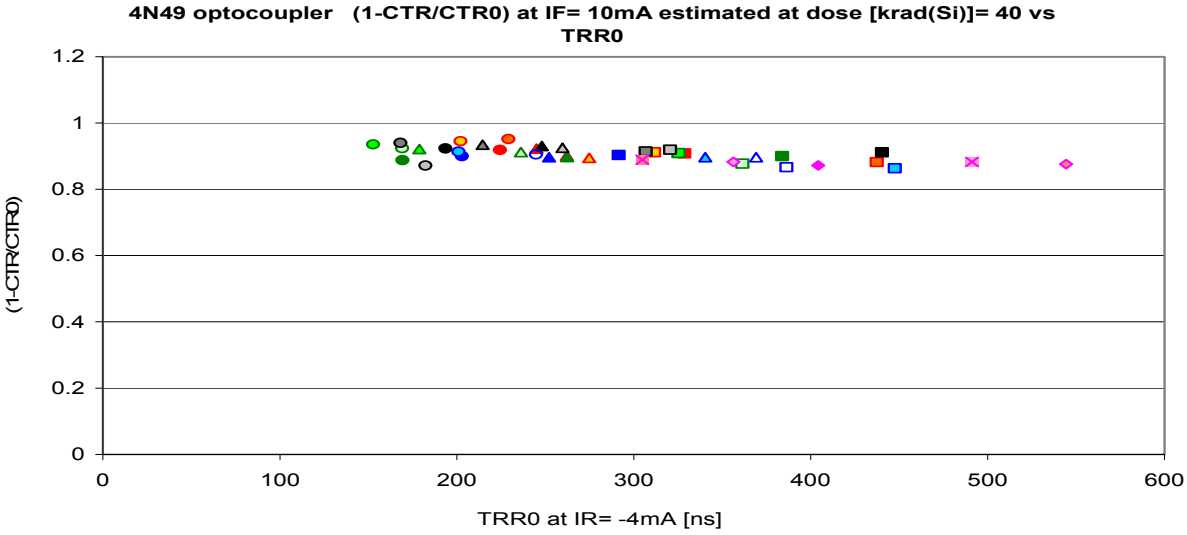
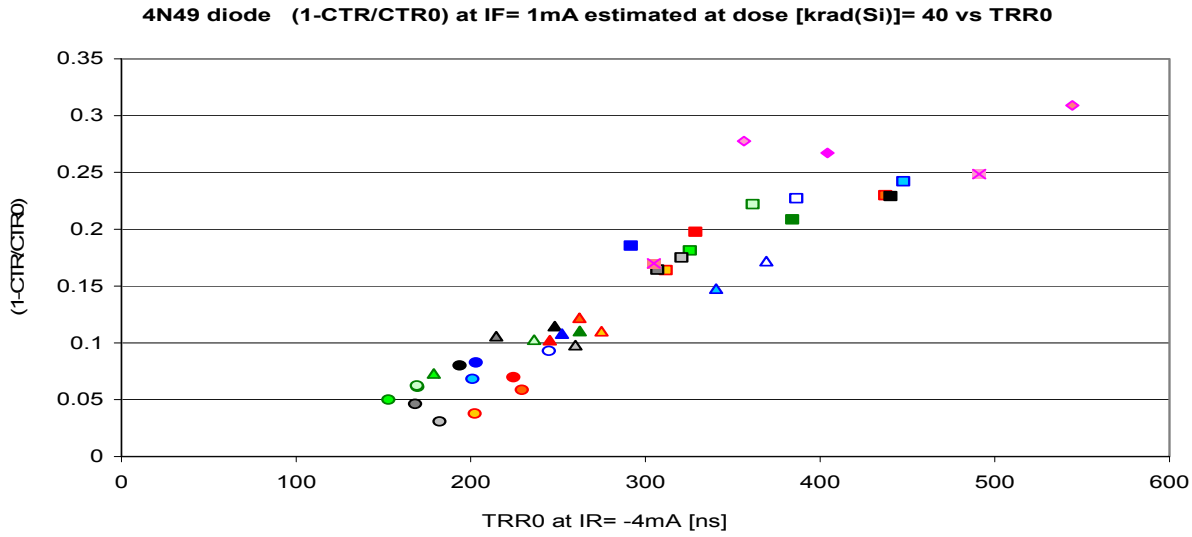
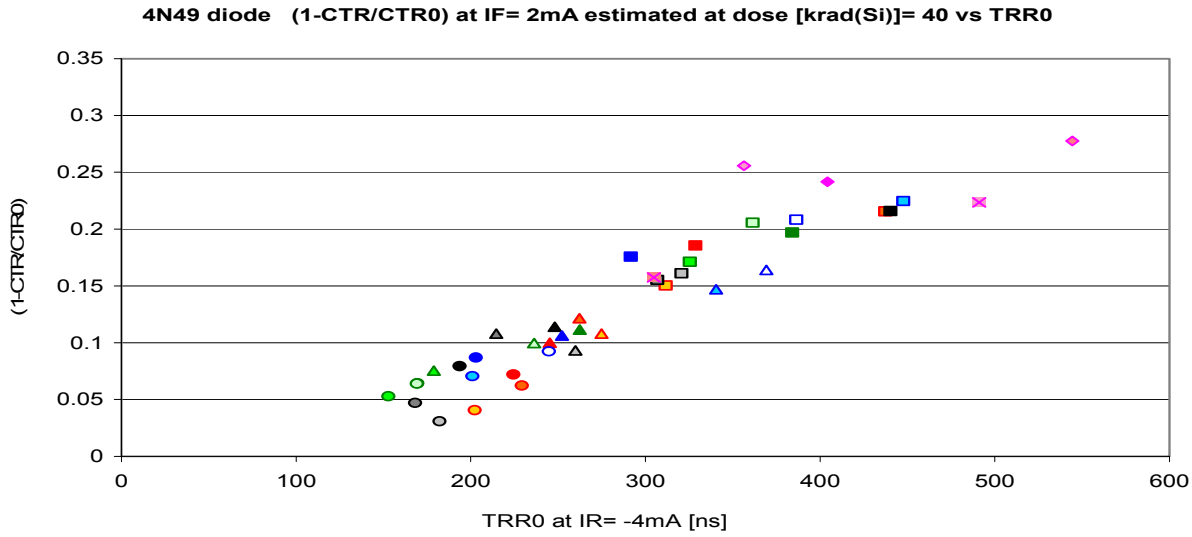
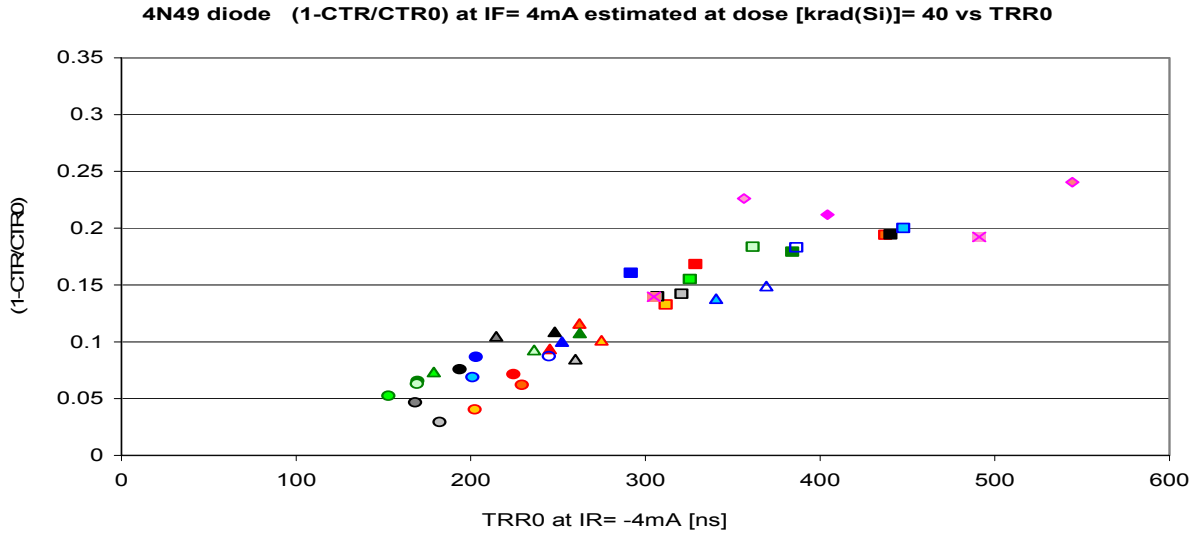

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

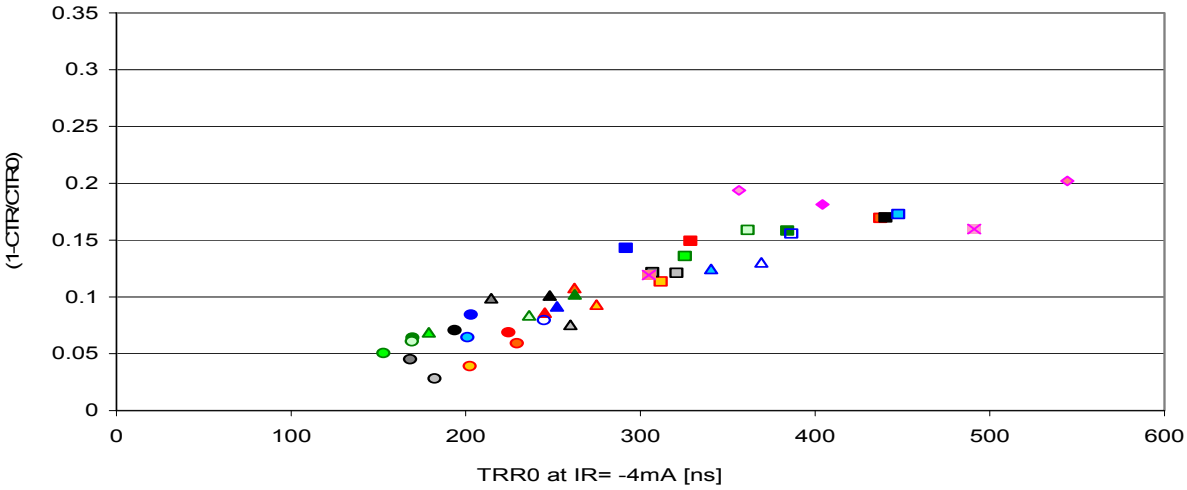
Fig. 12-225: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0



4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0

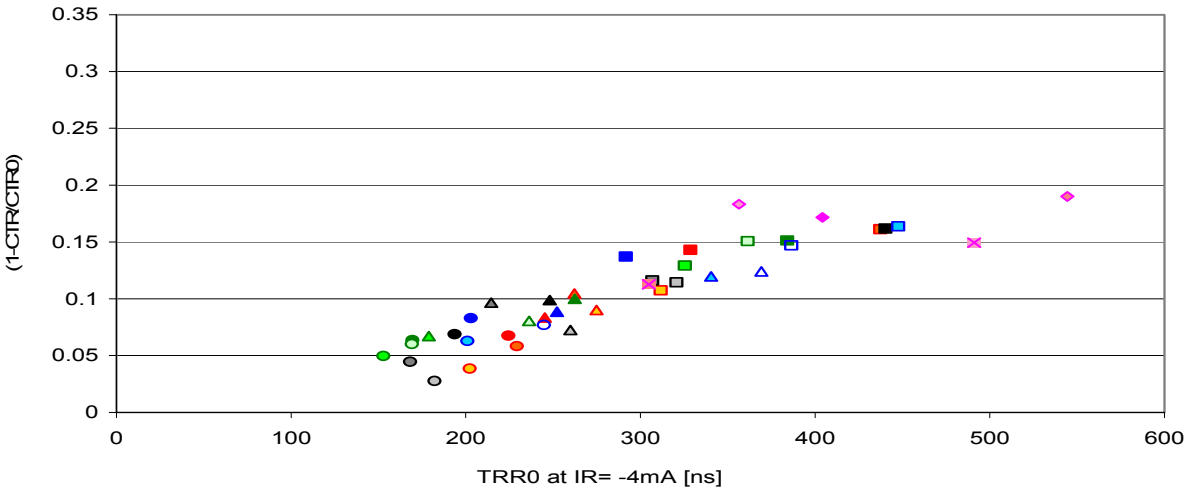
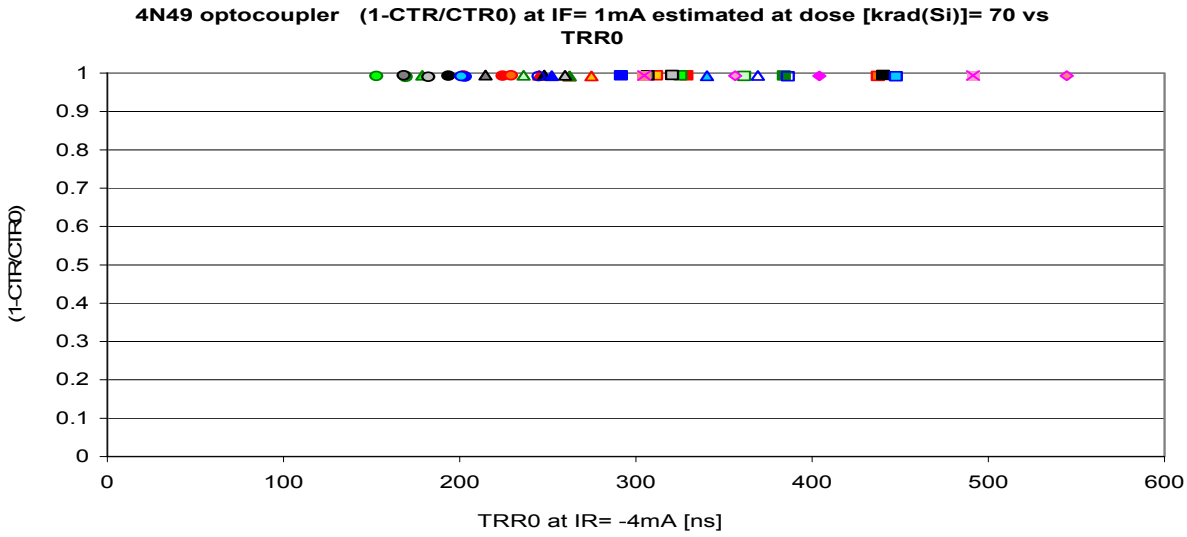
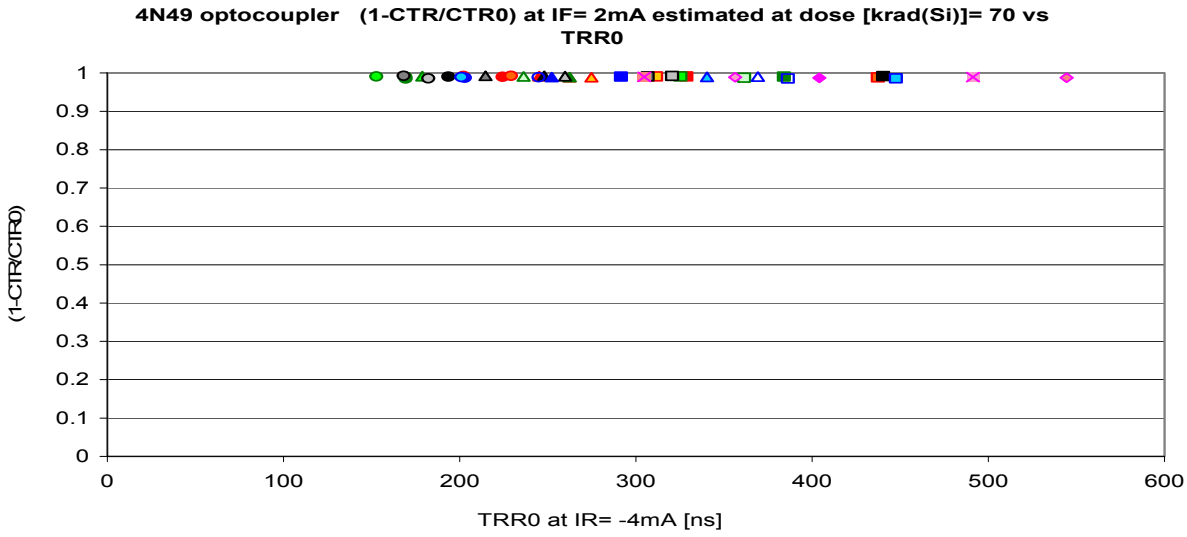
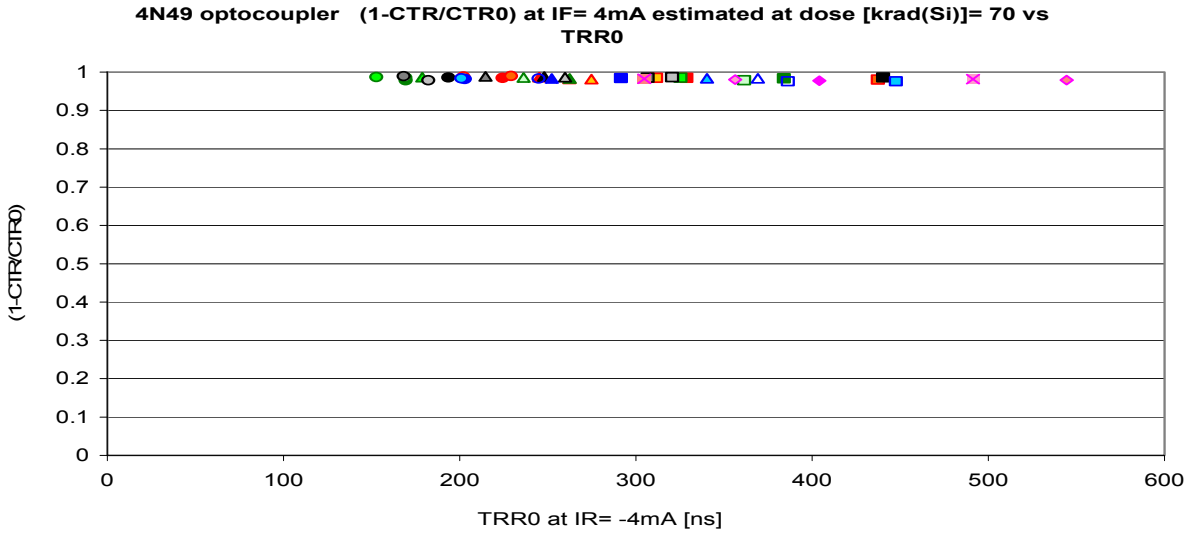
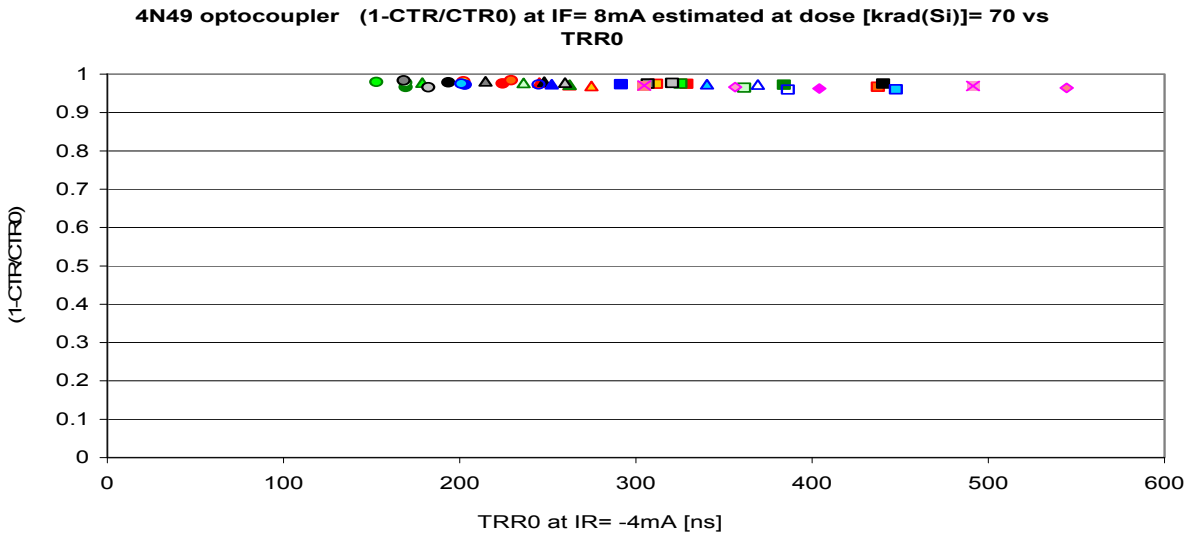


Fig. 12-226: 4N49 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

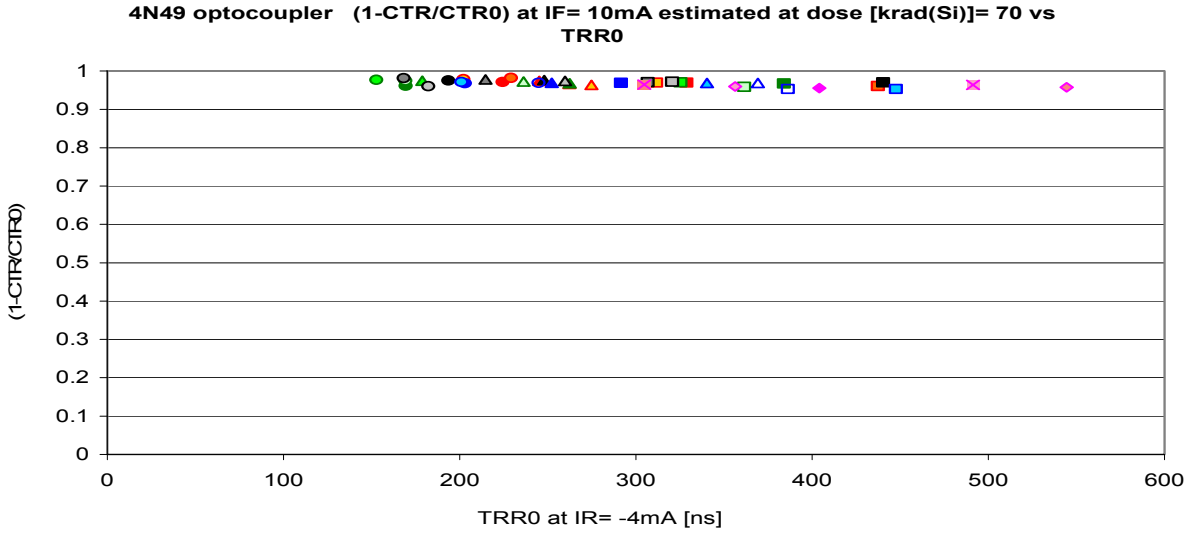
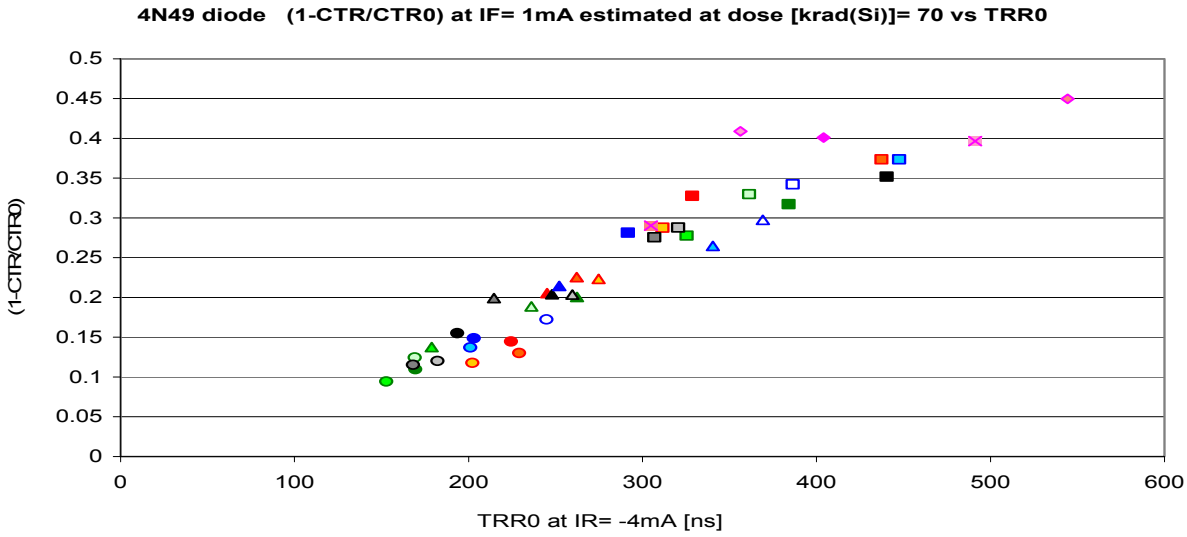
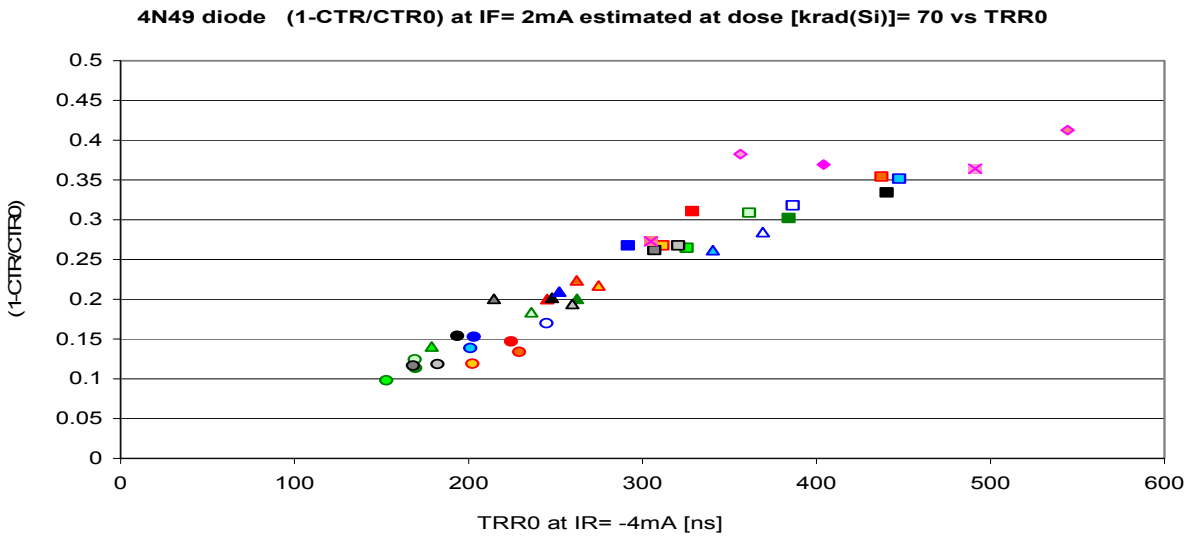
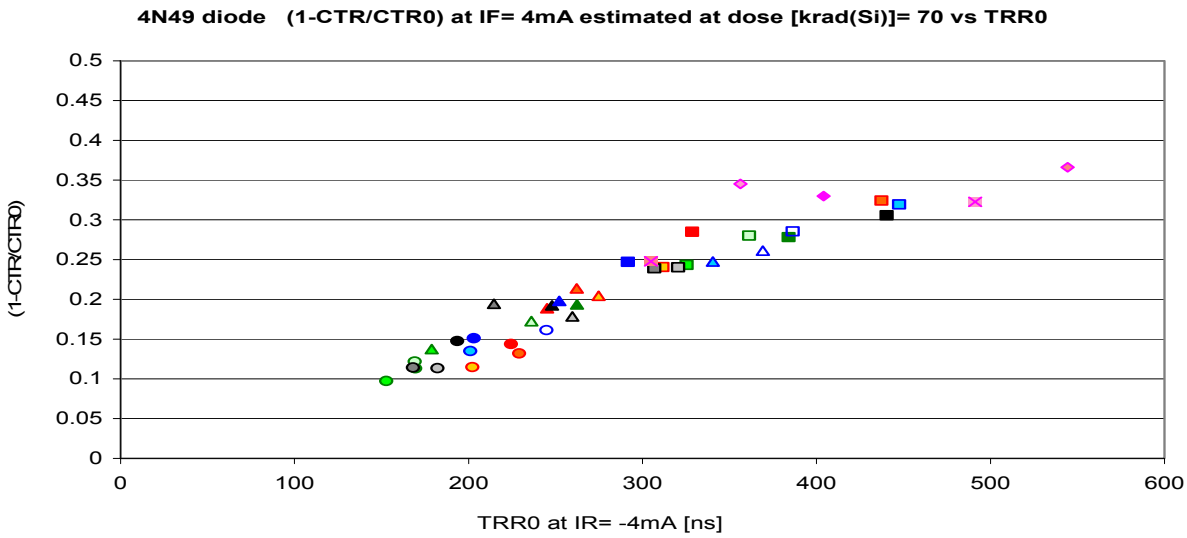
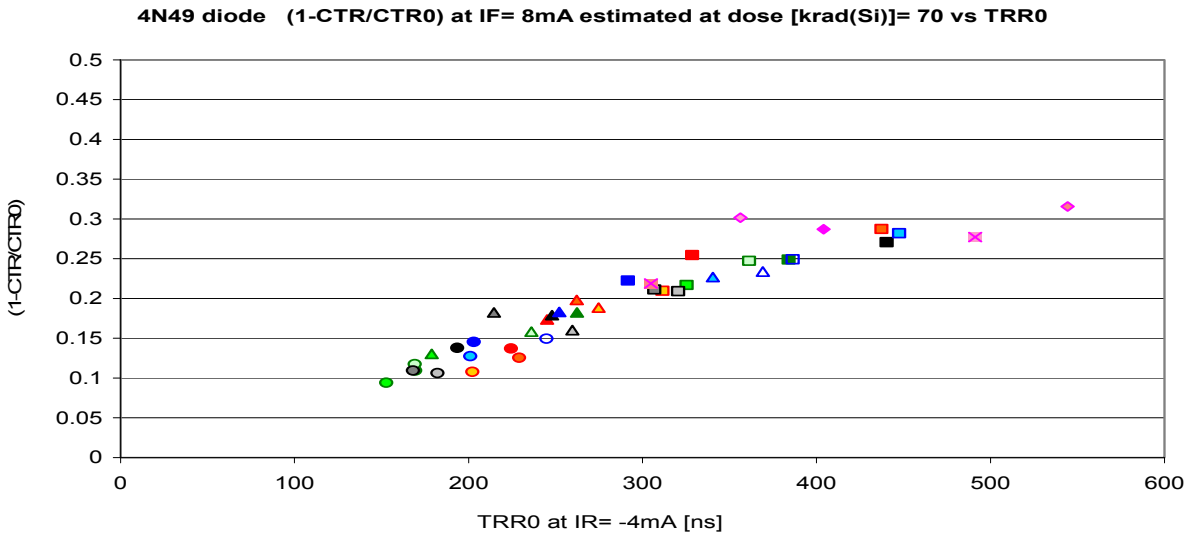

4N49 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-227: 4N49 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








4N49 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

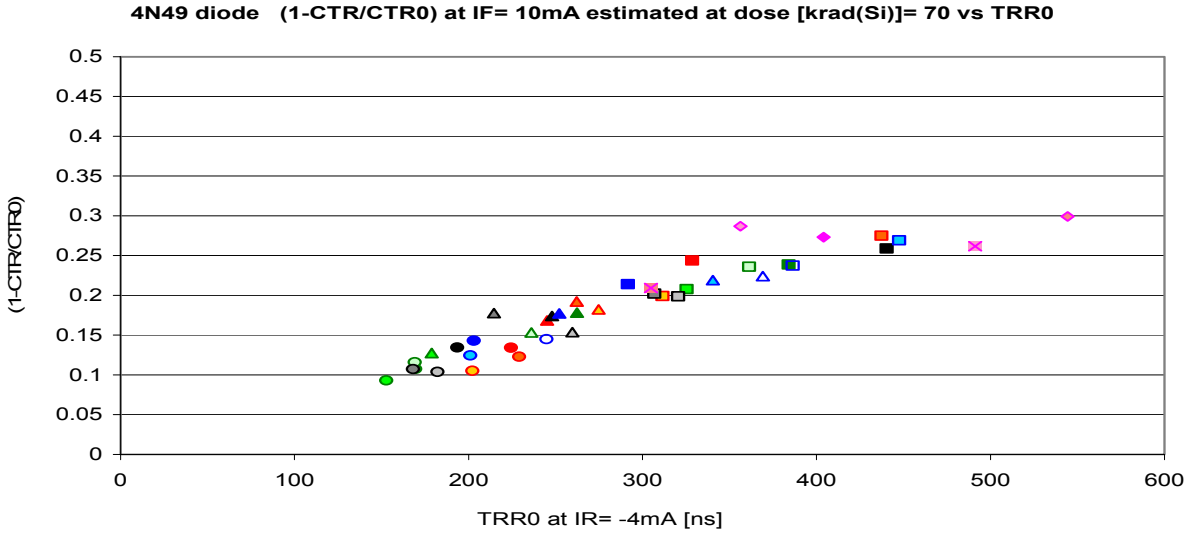
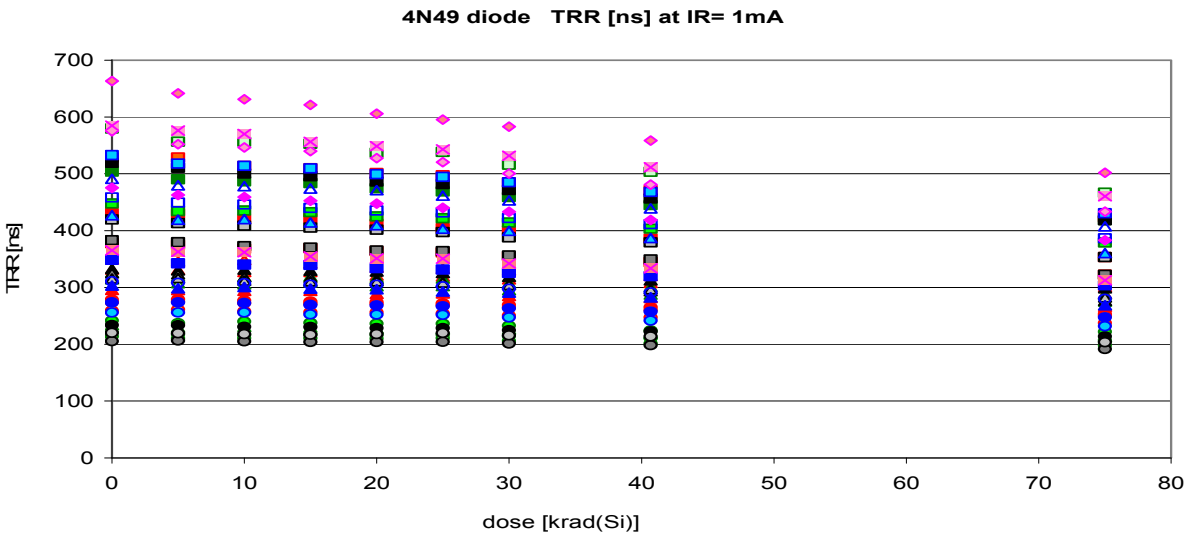
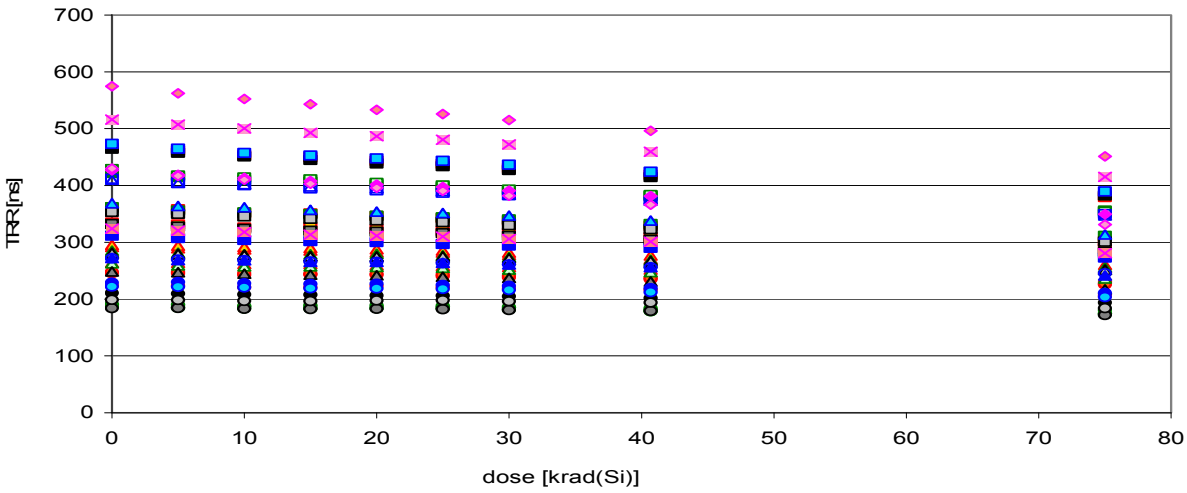

4N49 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA [ns]

Fig. 12-228: 4N49 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





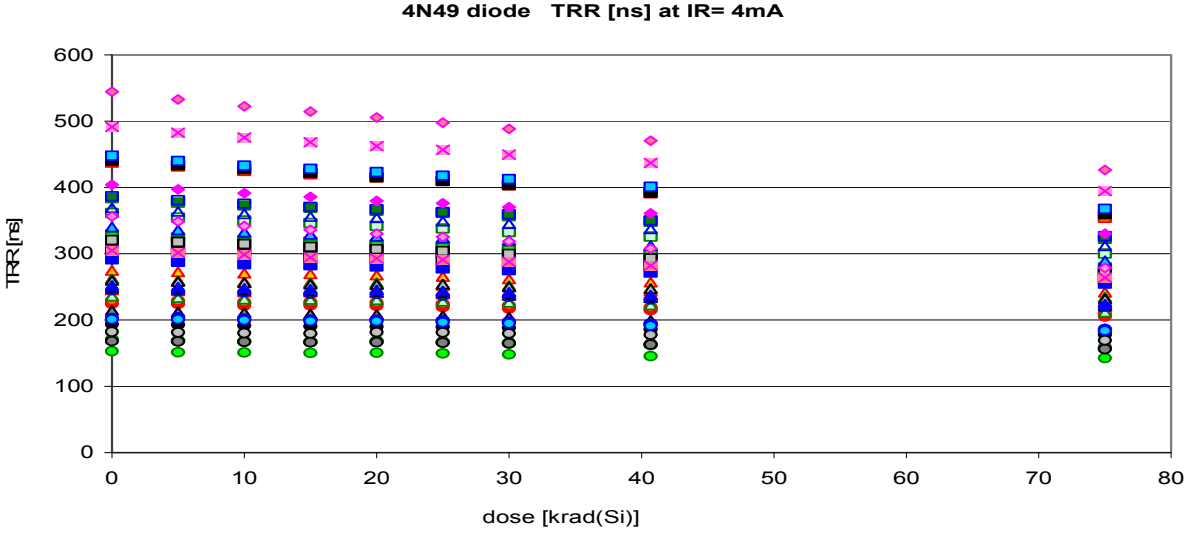
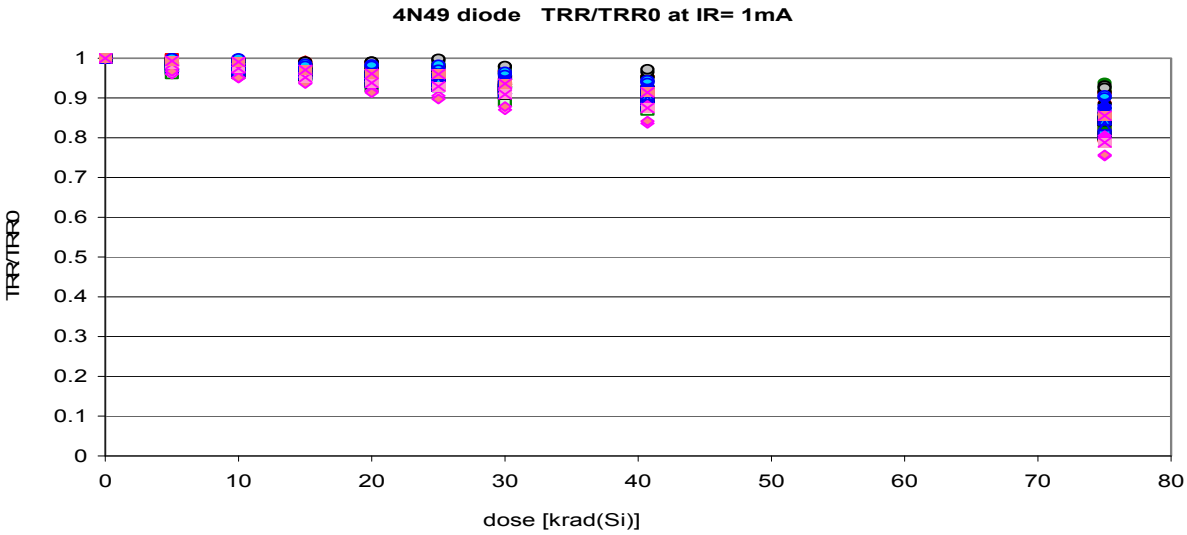
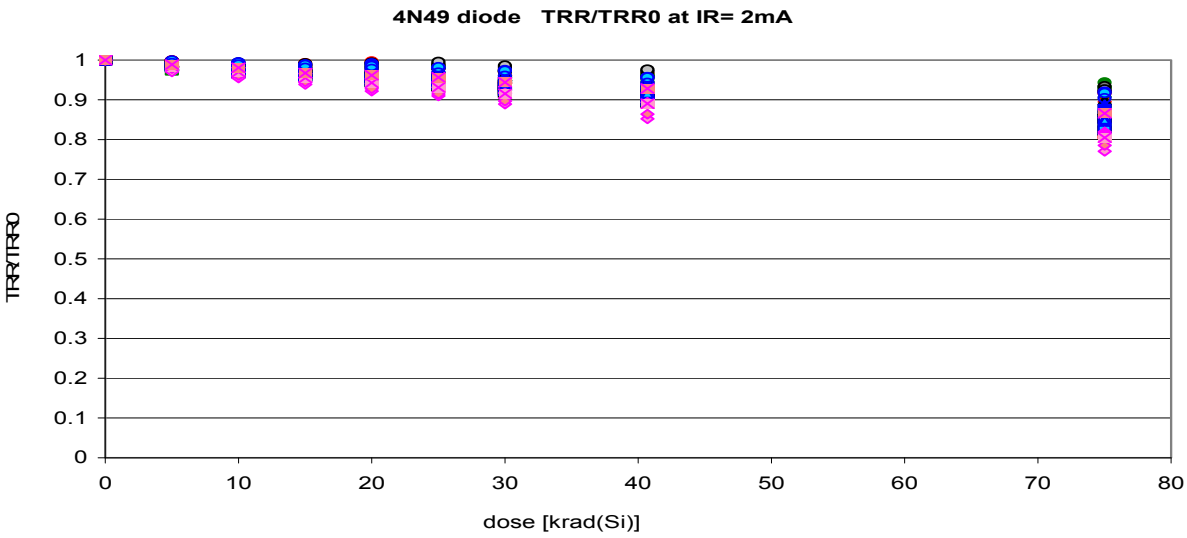


Fig. 12-229: 4N49 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA





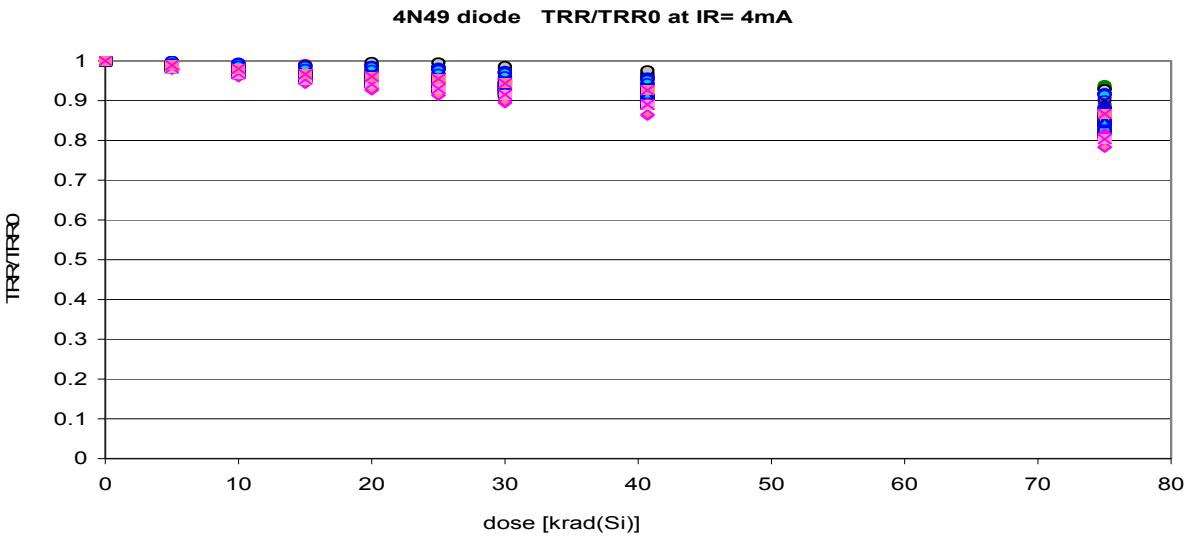
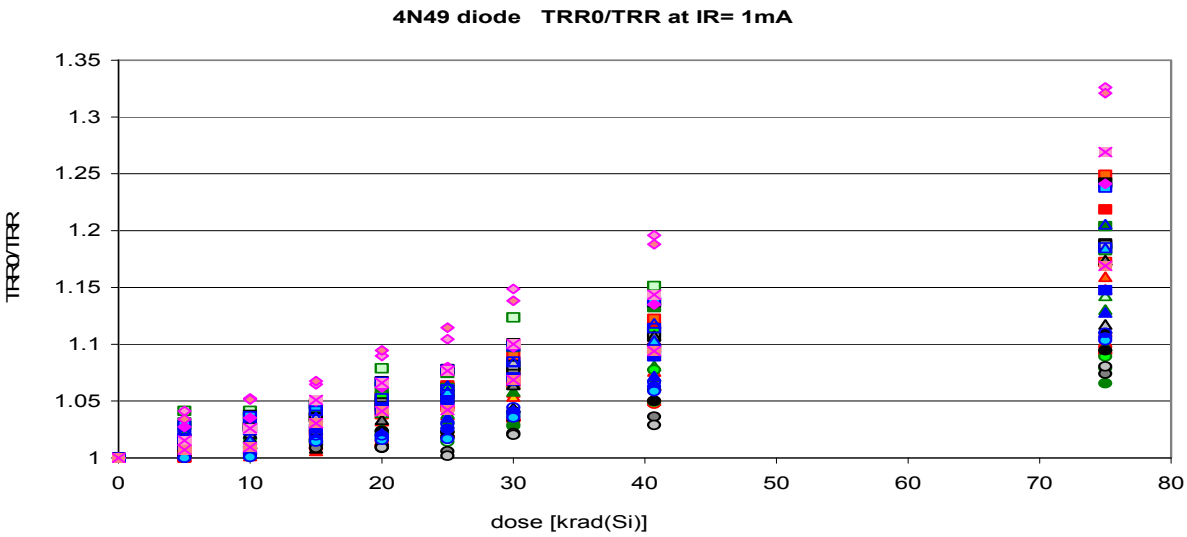
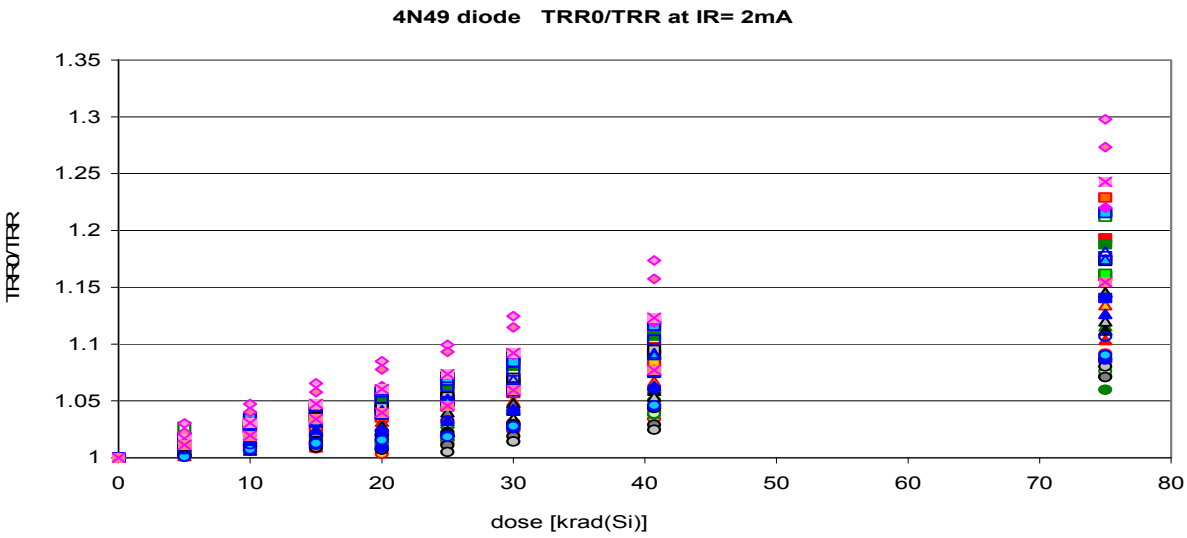


Fig. 12-230: 4N49 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





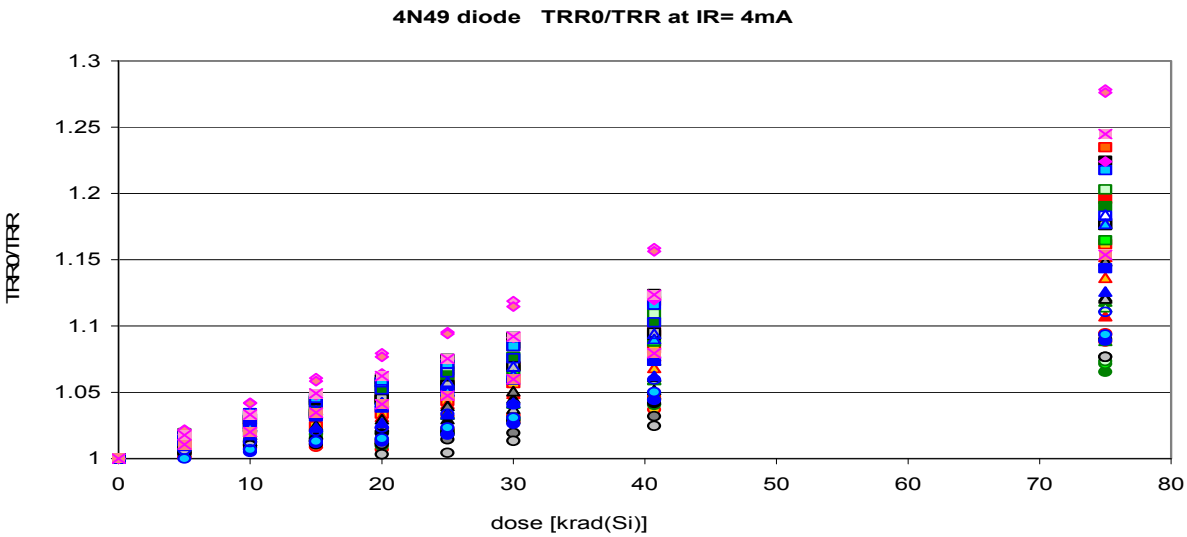
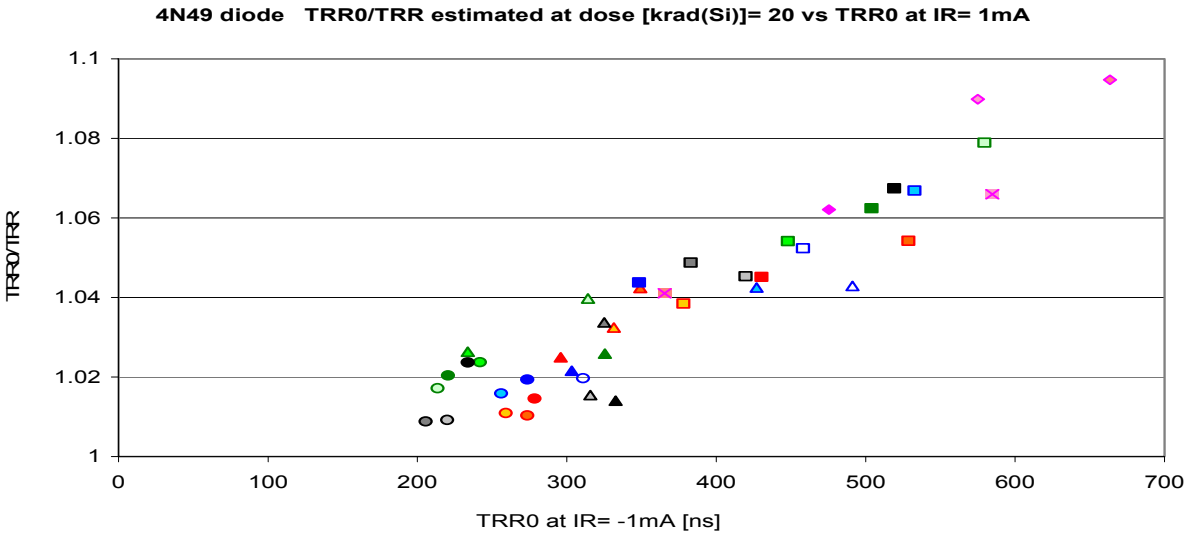
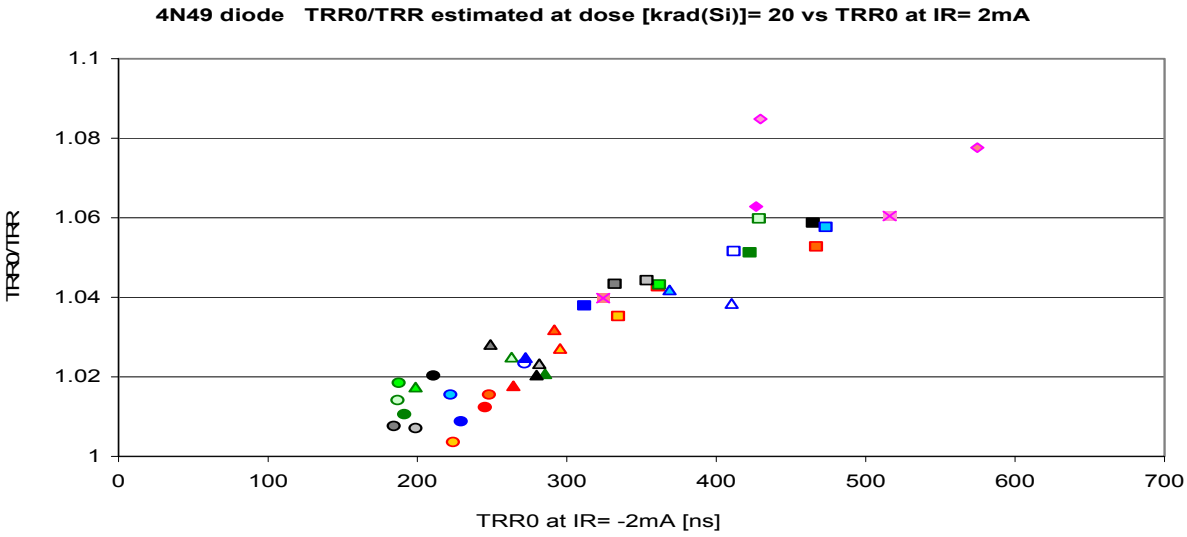


Fig. 12-231: 4N49 diode: τ_{RR0}/τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





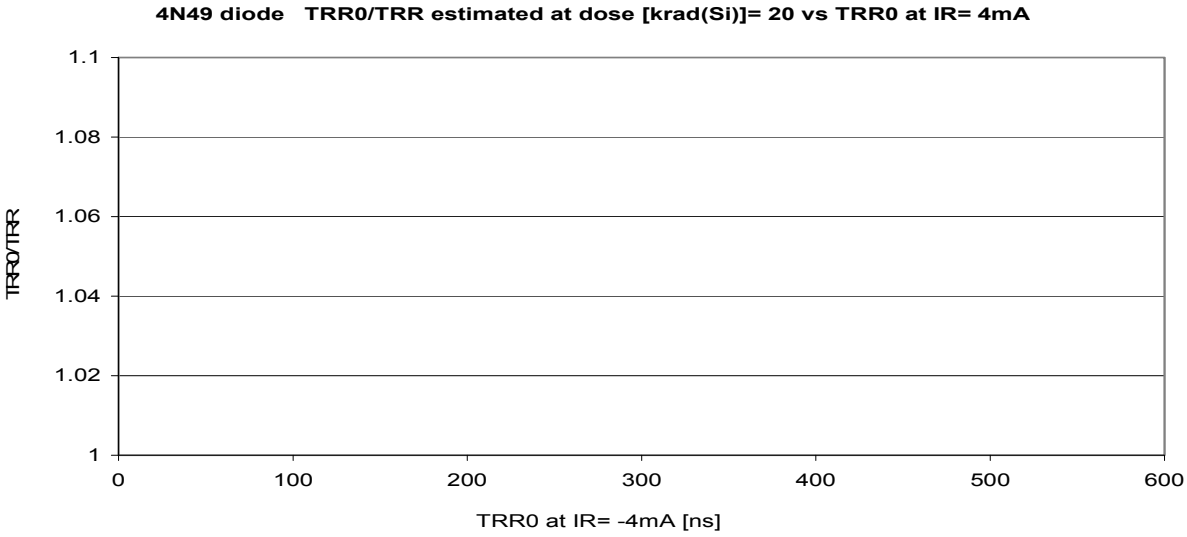
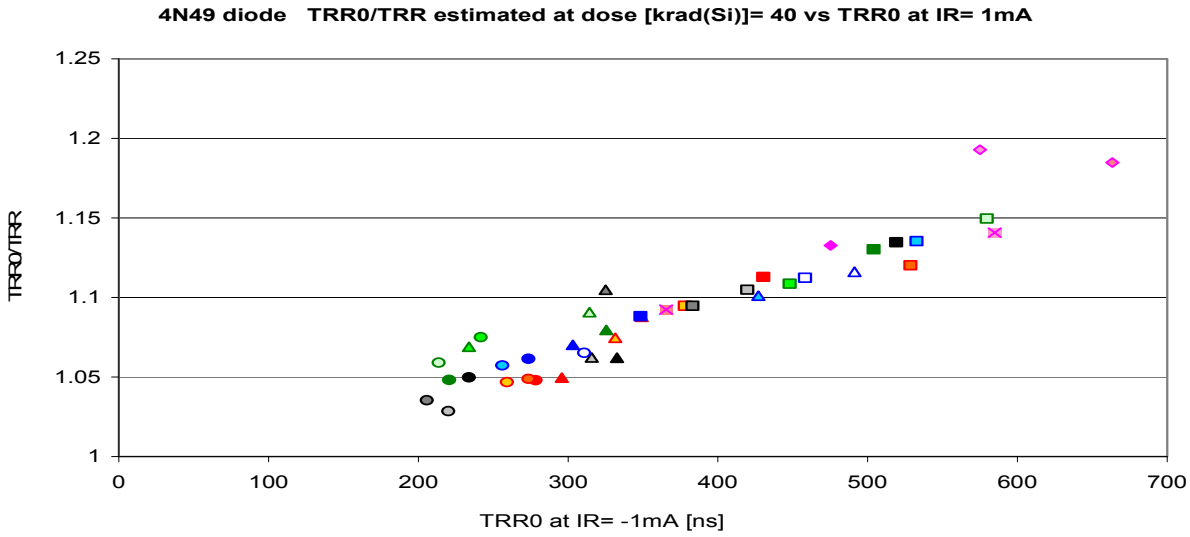
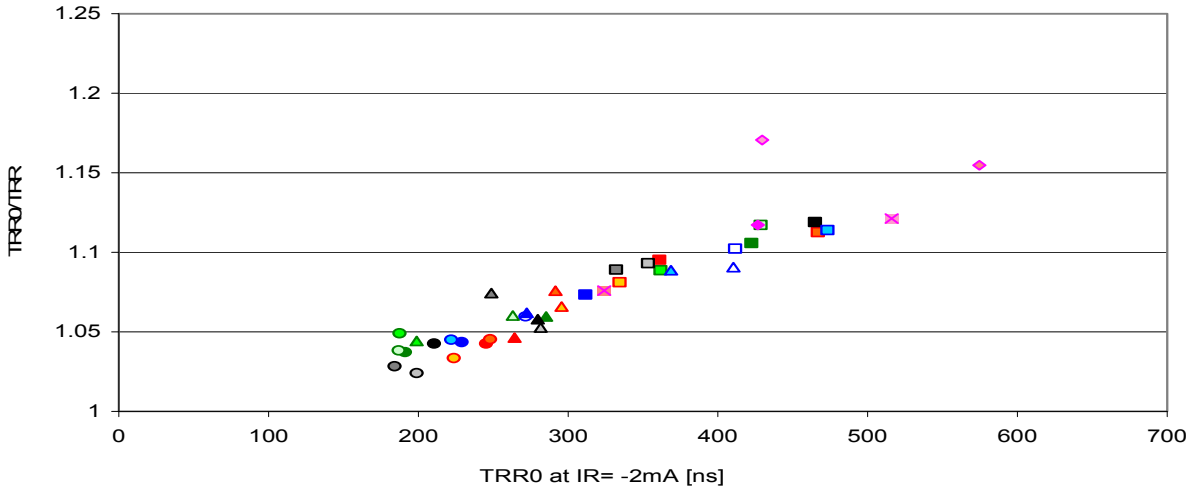


Fig. 12-232: 4N49 diode: τ_{RR0}/ τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





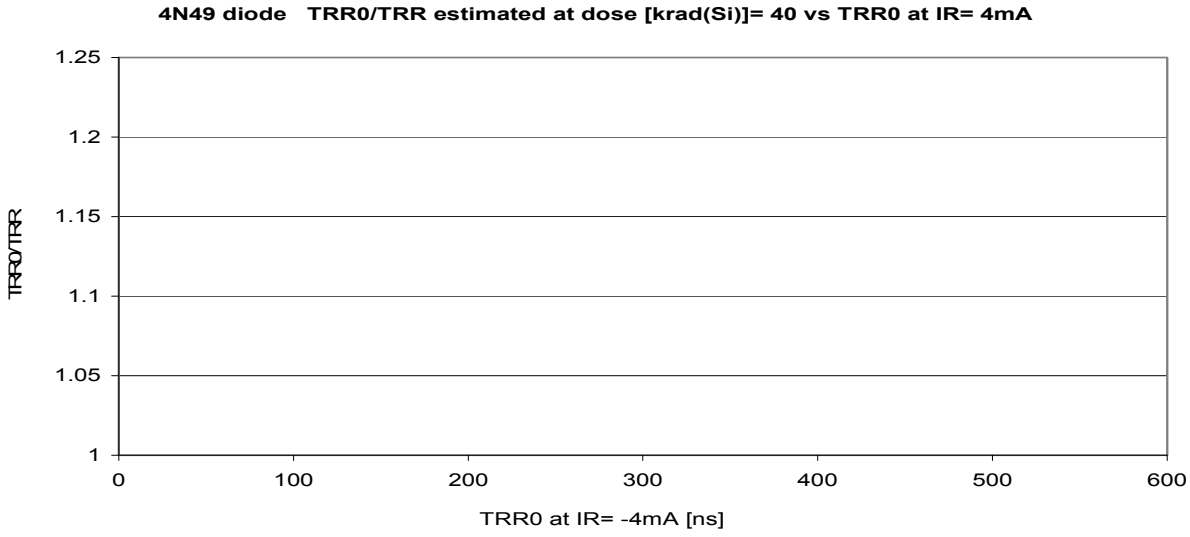
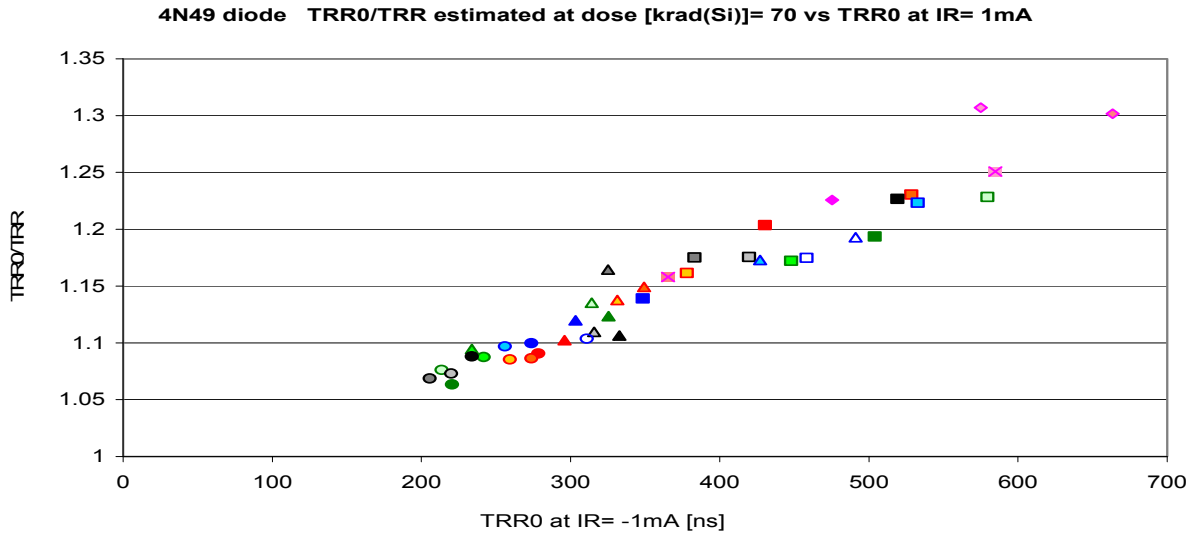
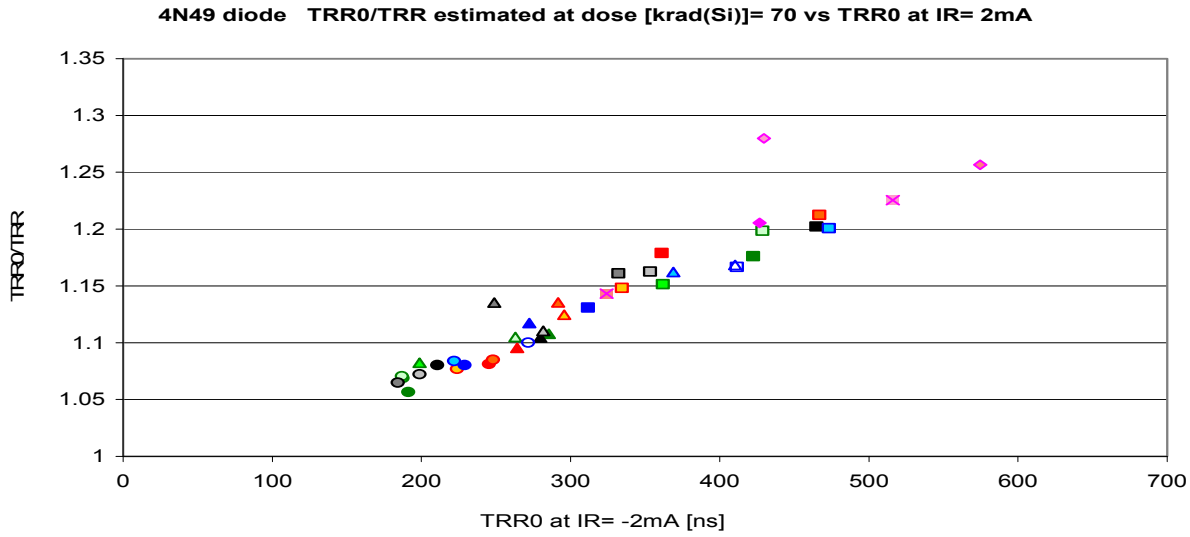


Fig. 12-233: 4N49 diode: τ_{RR0}/ τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





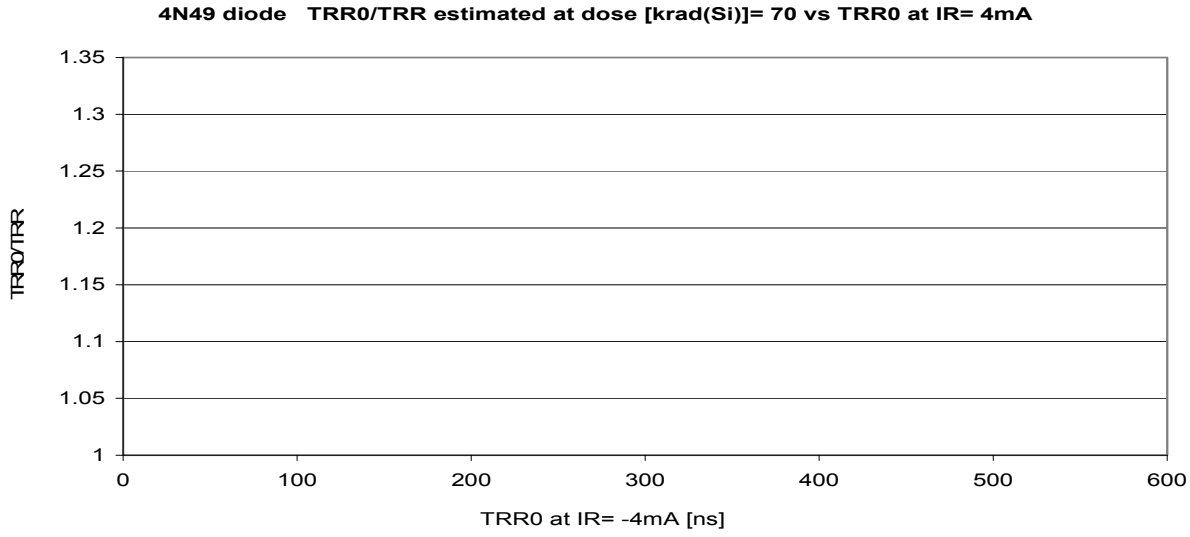
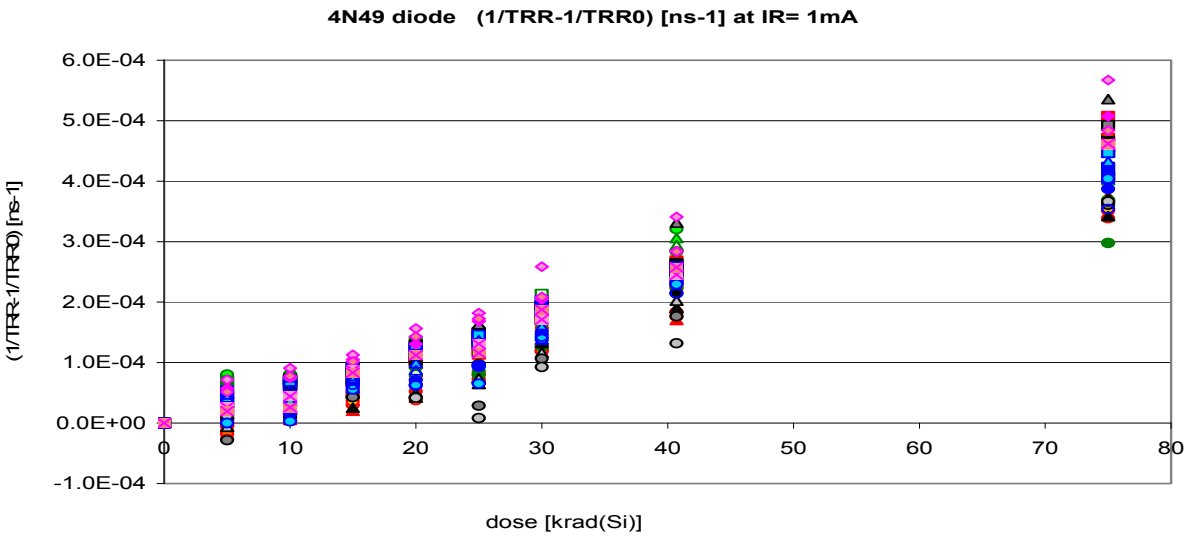
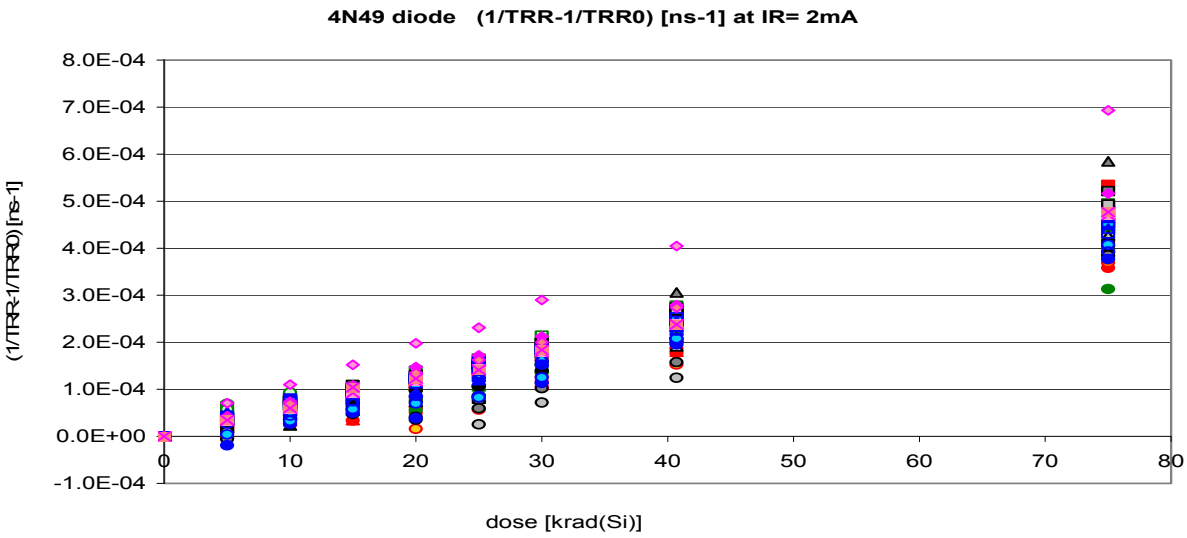


Fig. 12-234: 4N49 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose





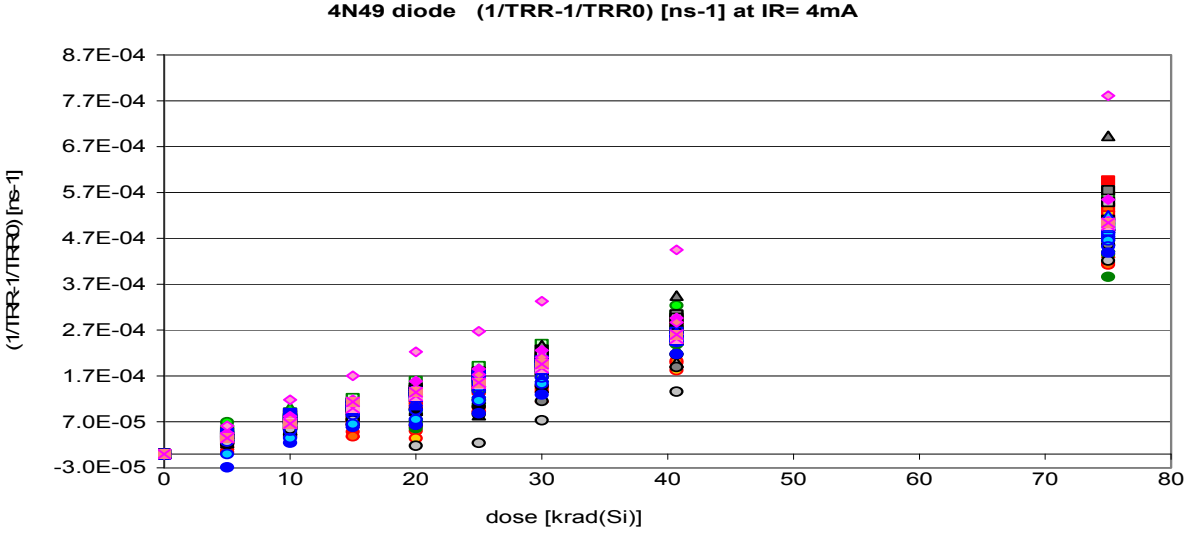
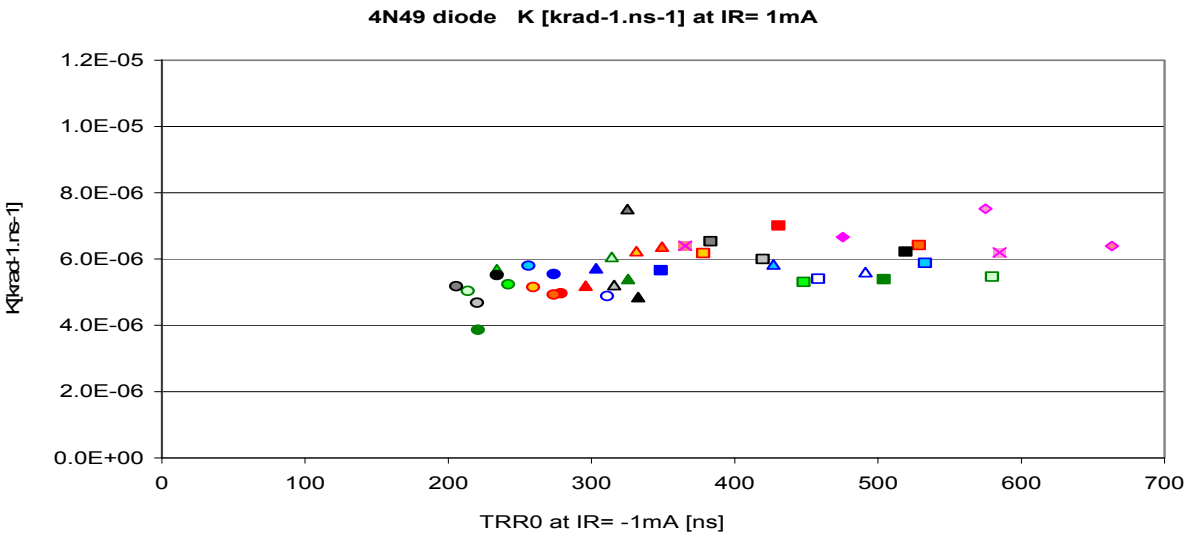
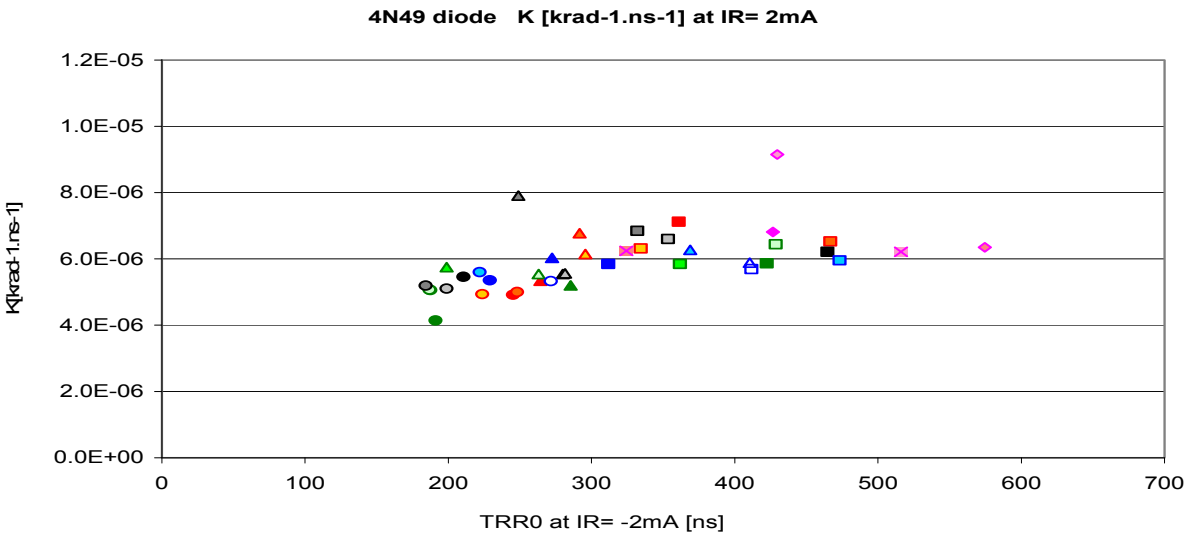


Fig. 12-235: 4N49 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}





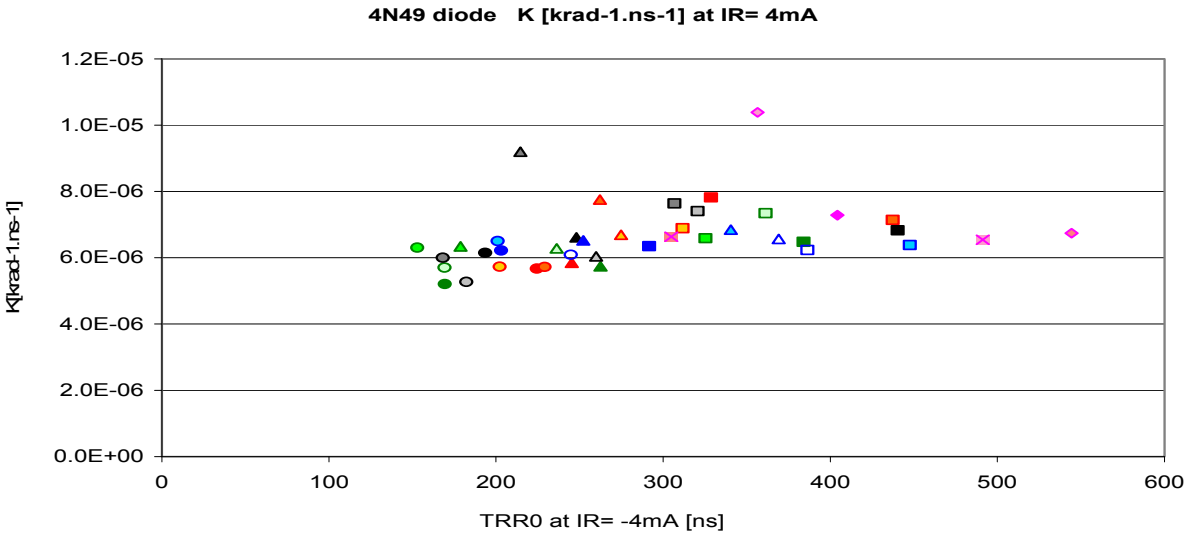
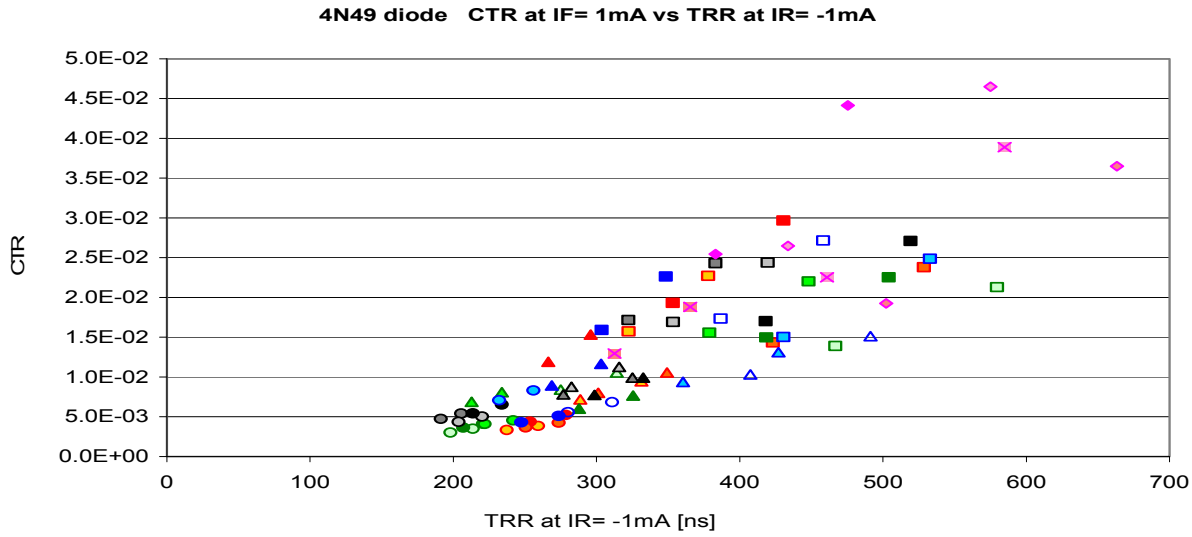
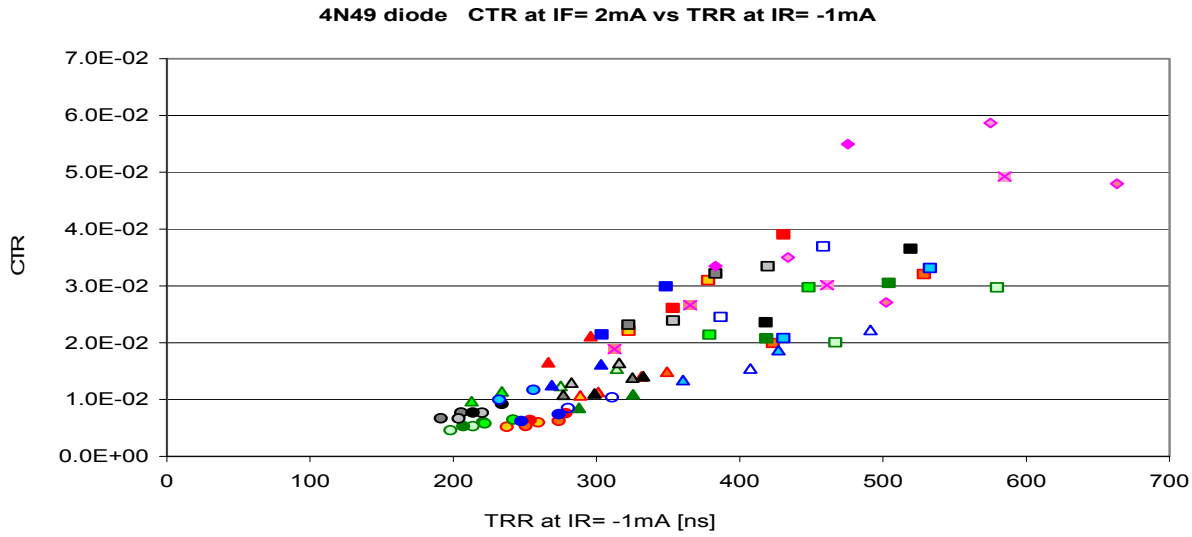
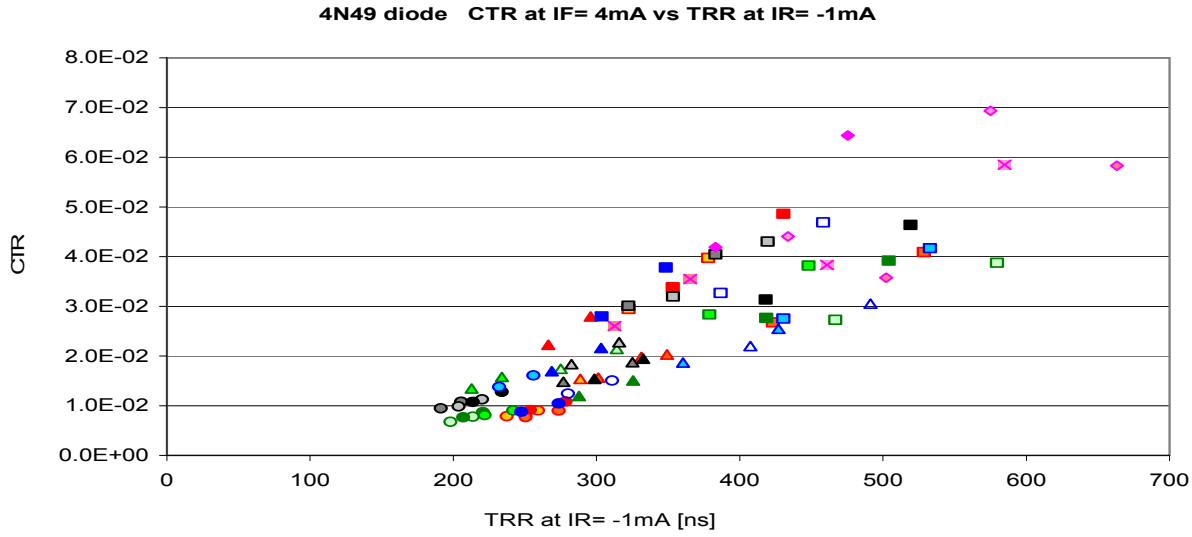
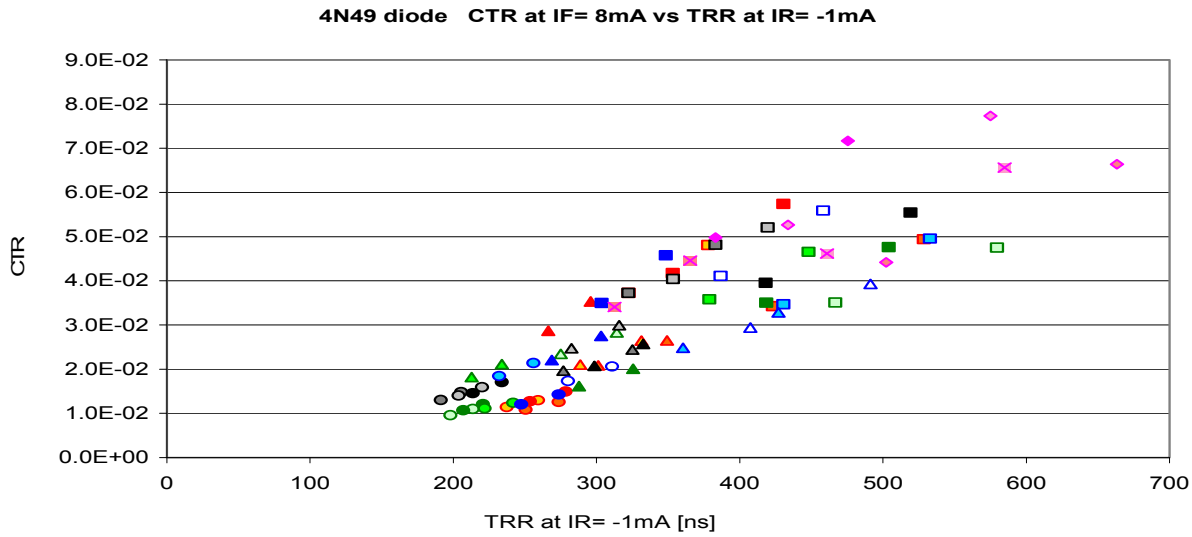


Fig. 12-236: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -1mA [ns]

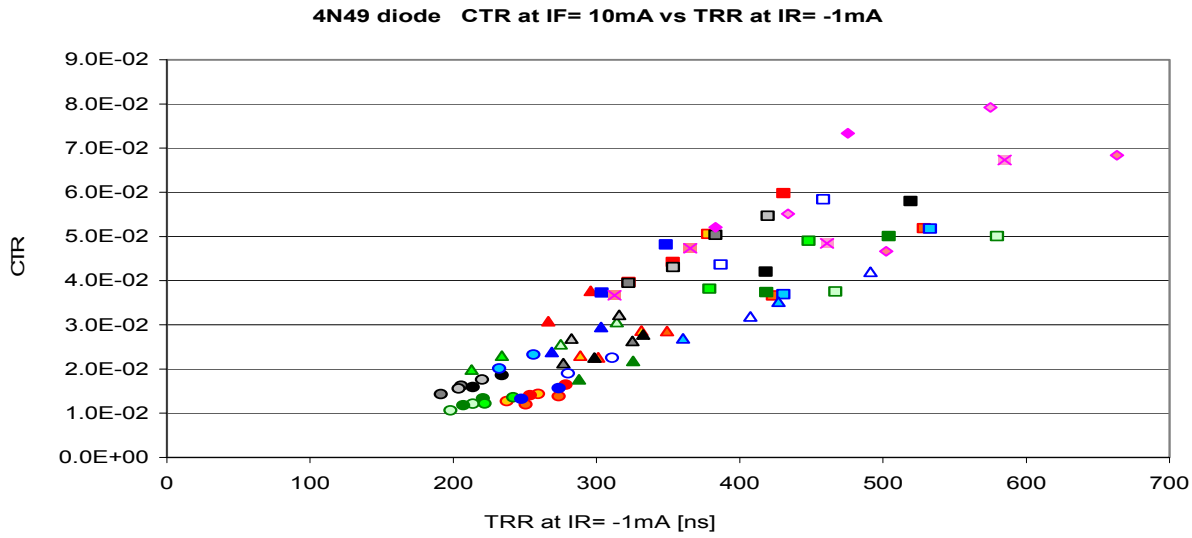
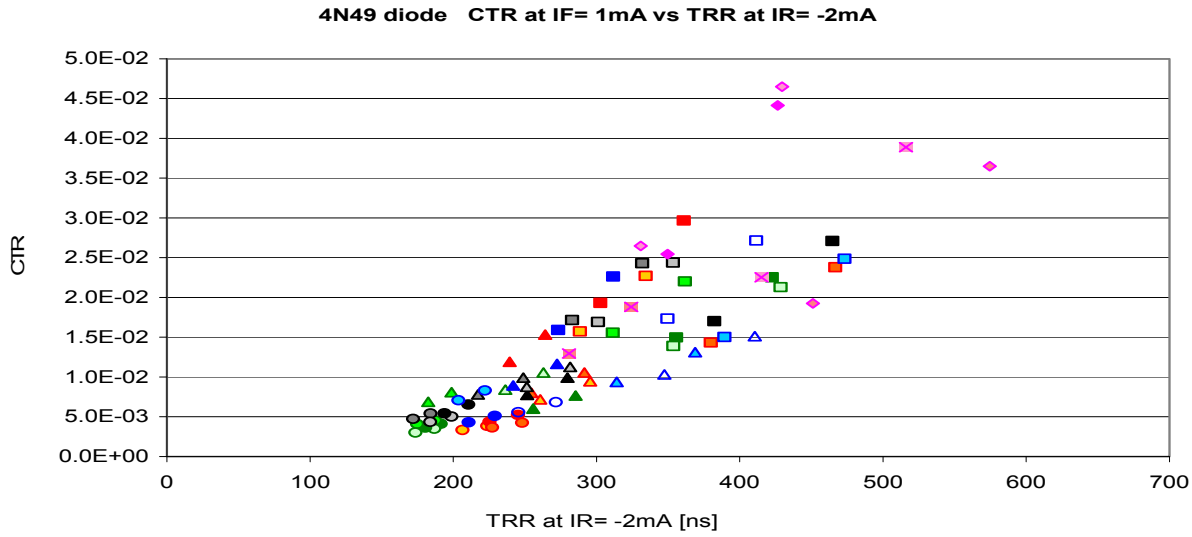
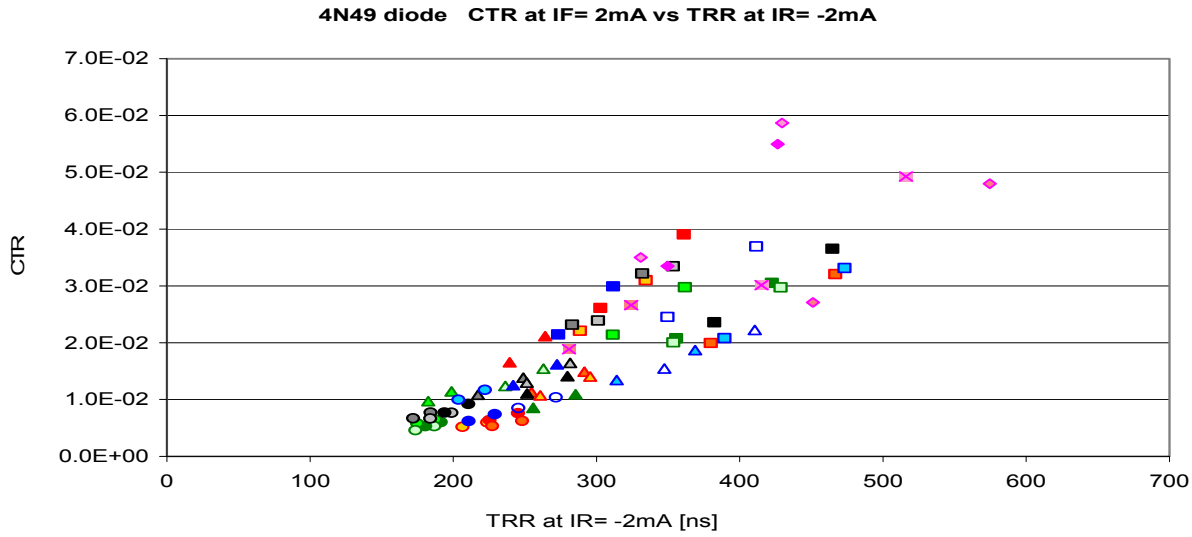
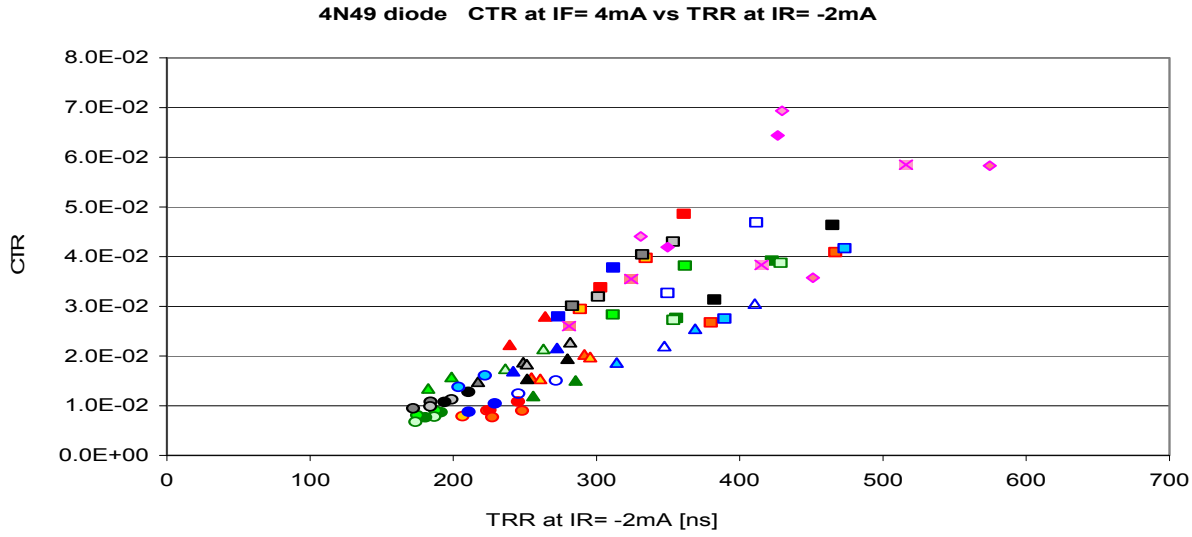
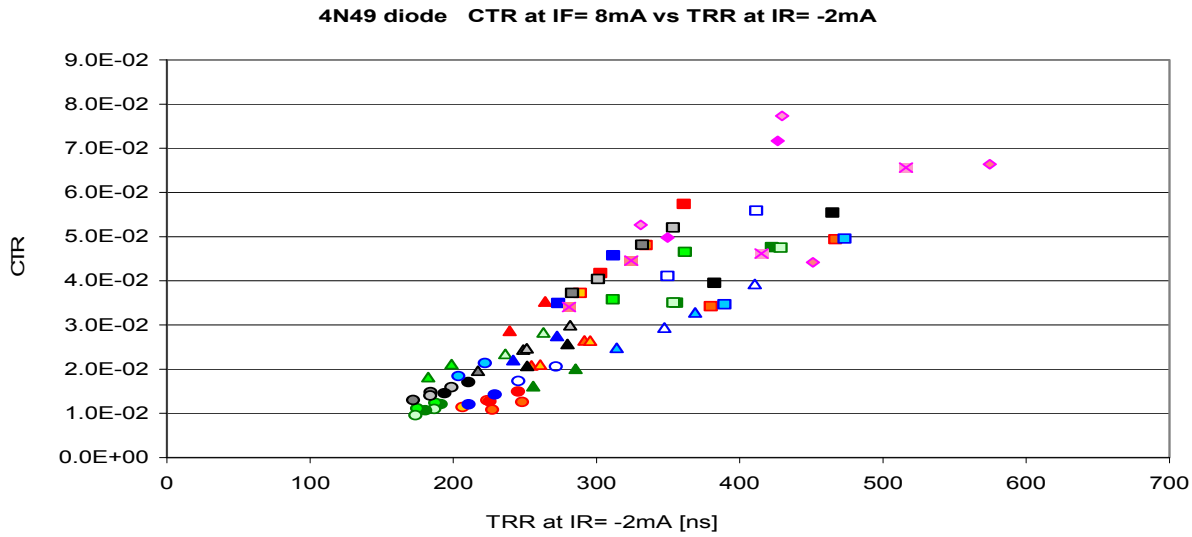

4N49 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -1mA [ns]

Fig. 12-237: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -2mA [ns]

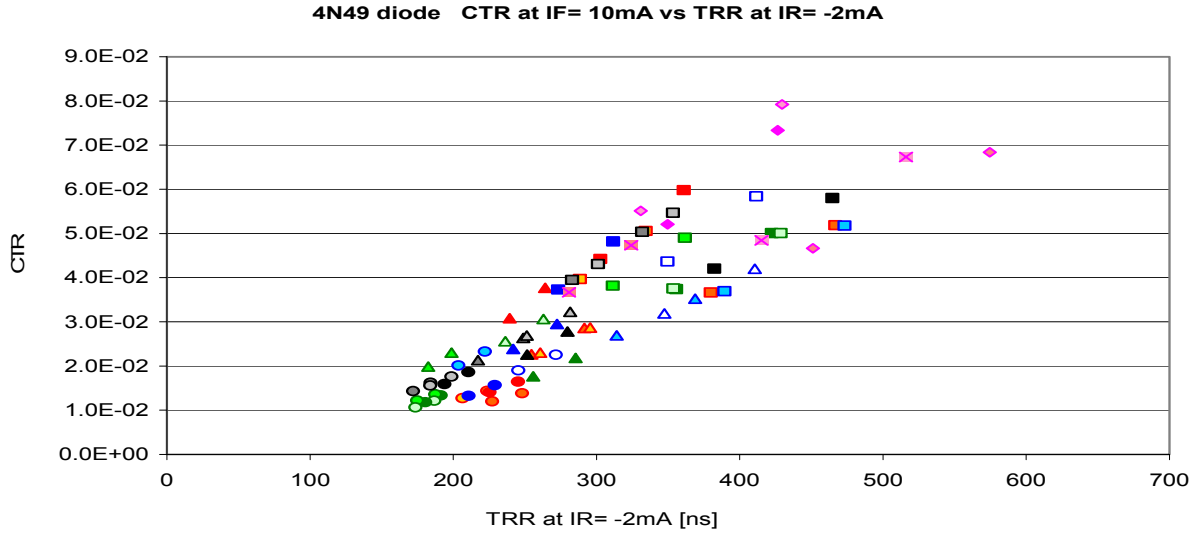
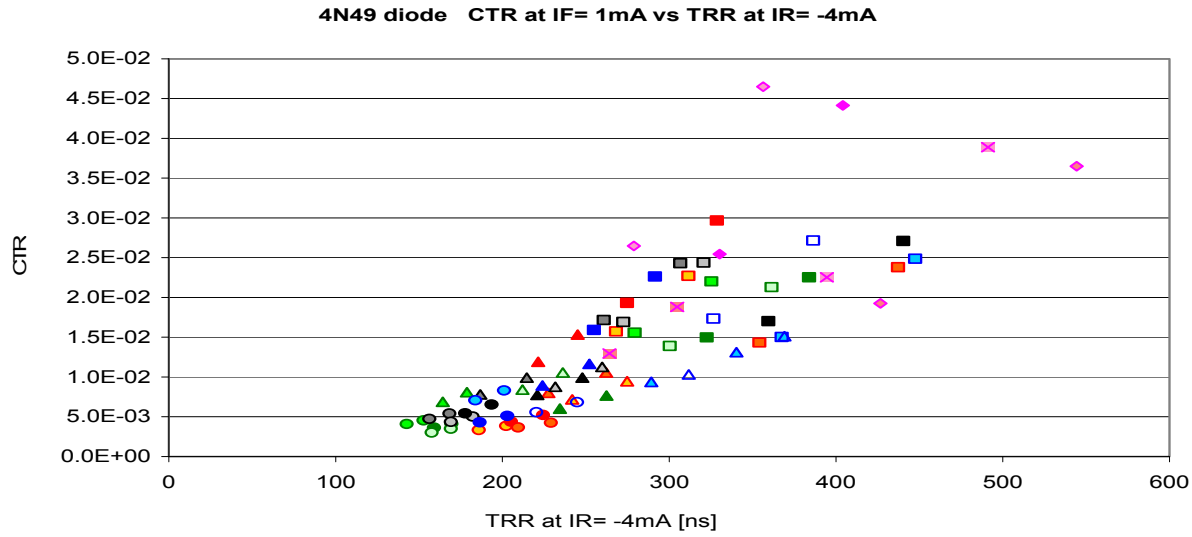
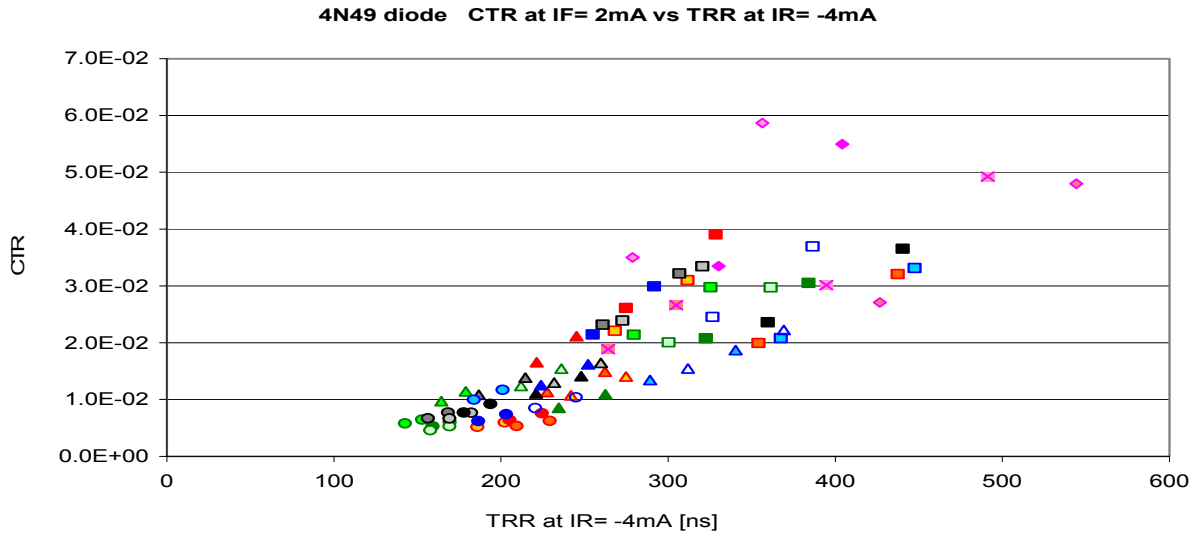
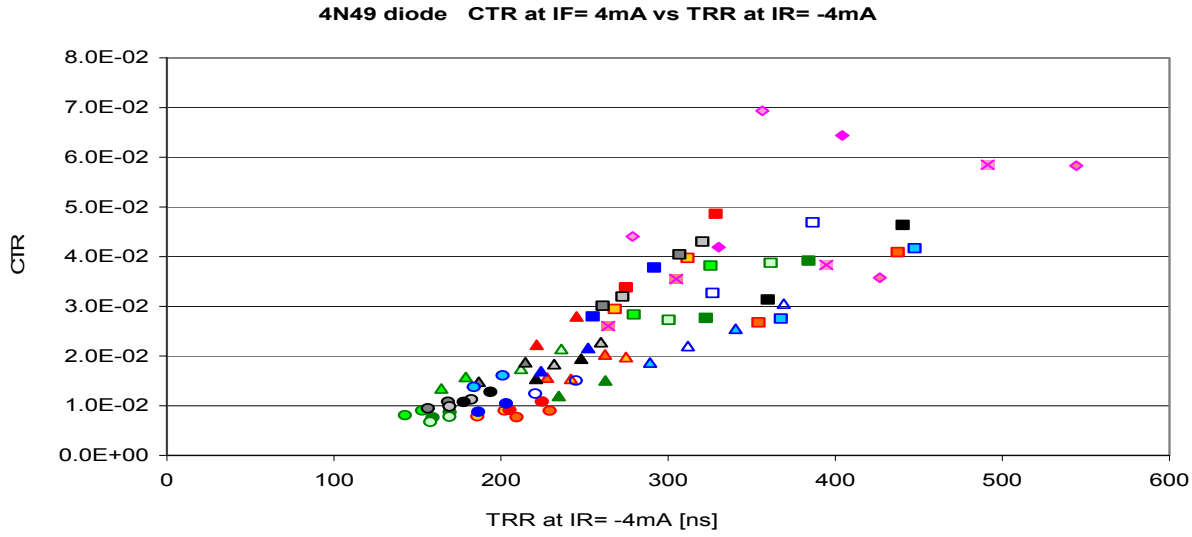
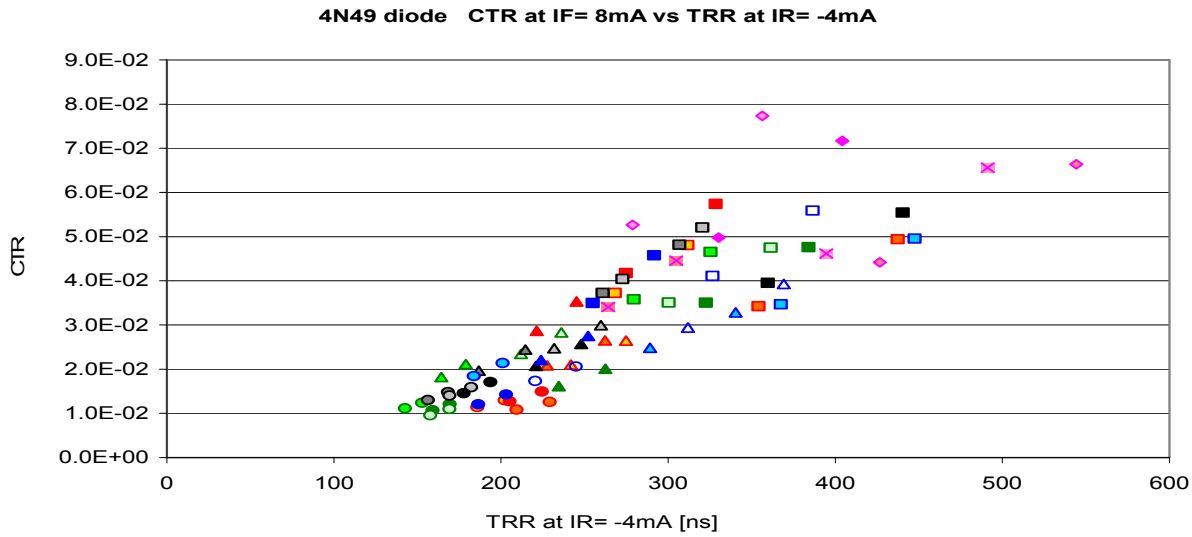

4N49 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
700
TRR at IR= -2mA [ns]

Fig. 12-238: 4N49 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








4N49 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

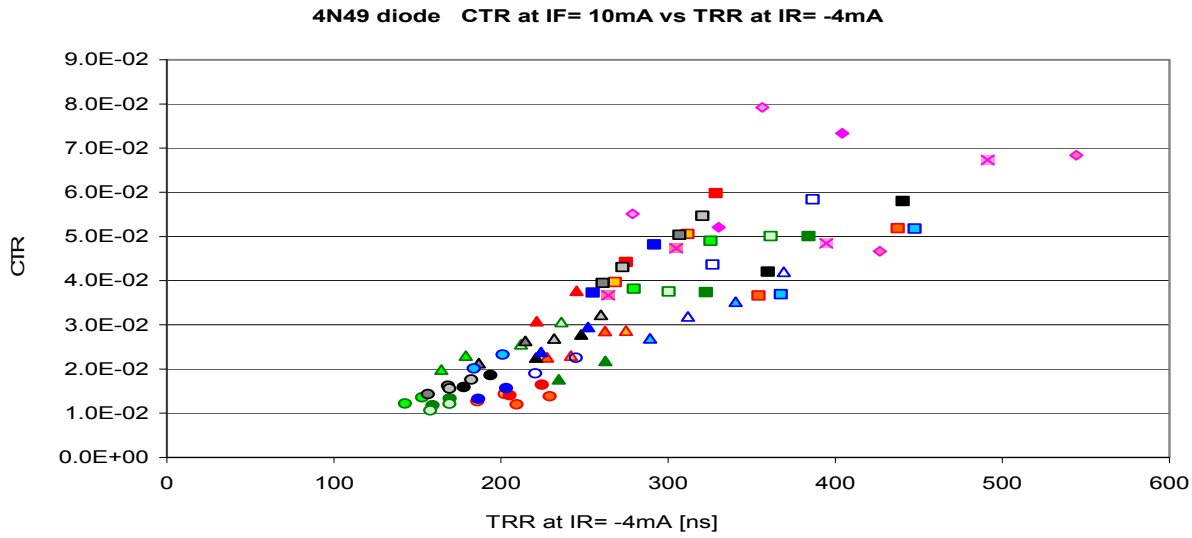
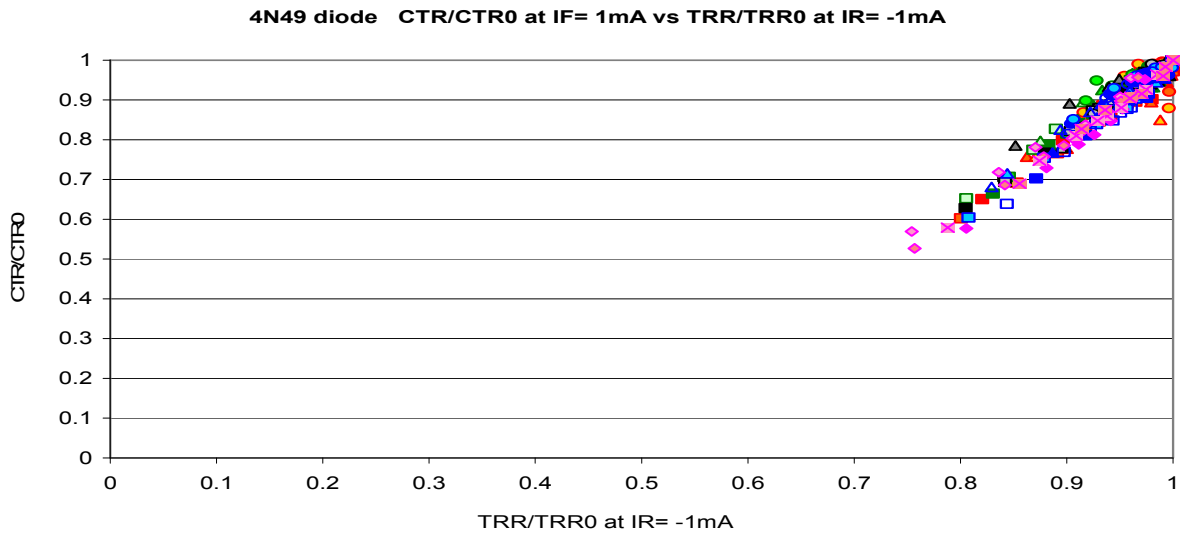
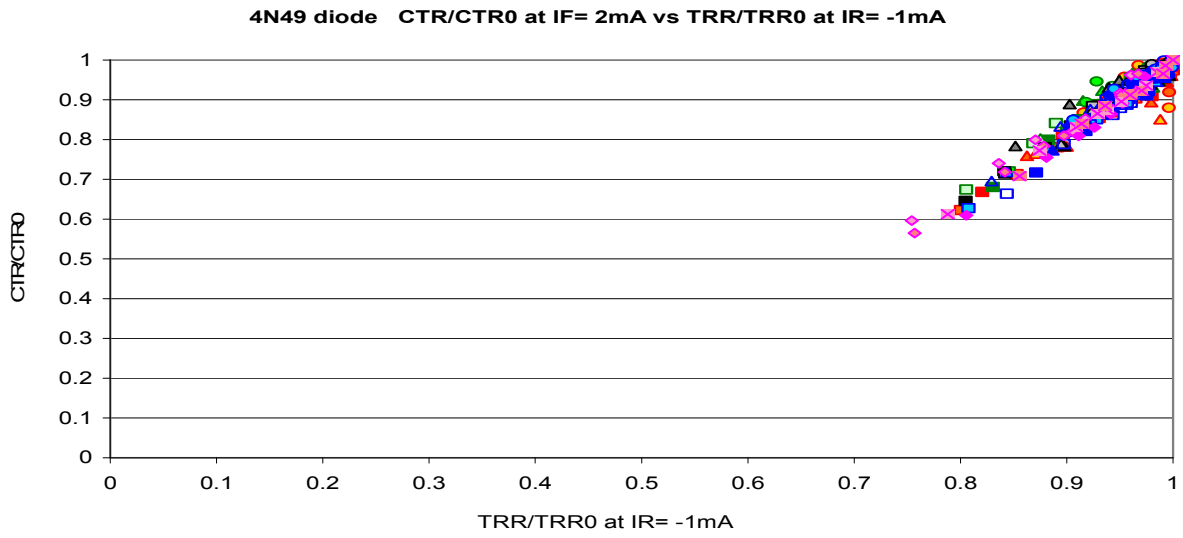
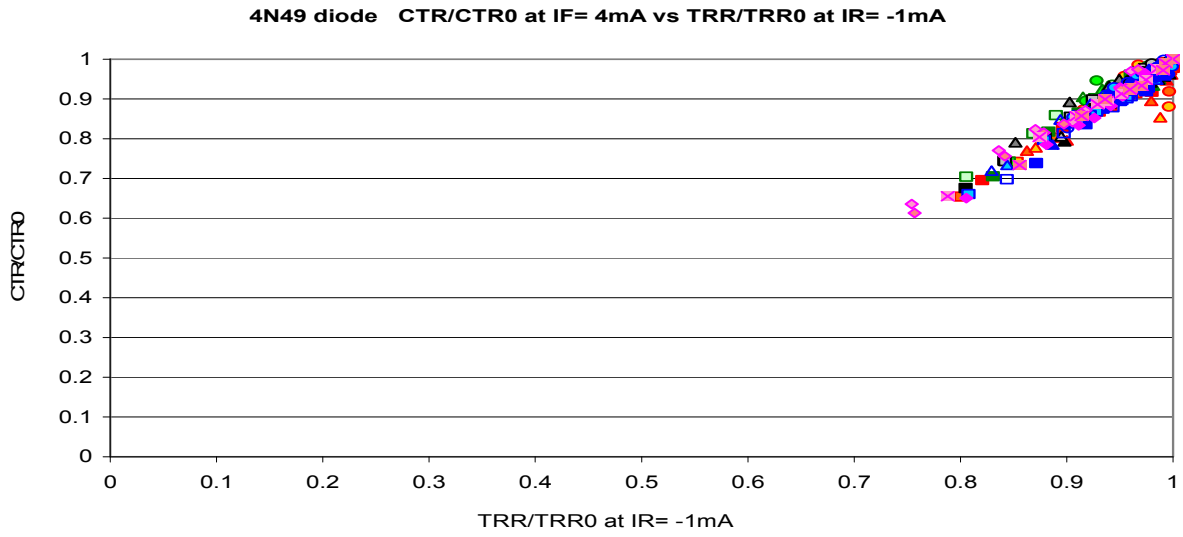
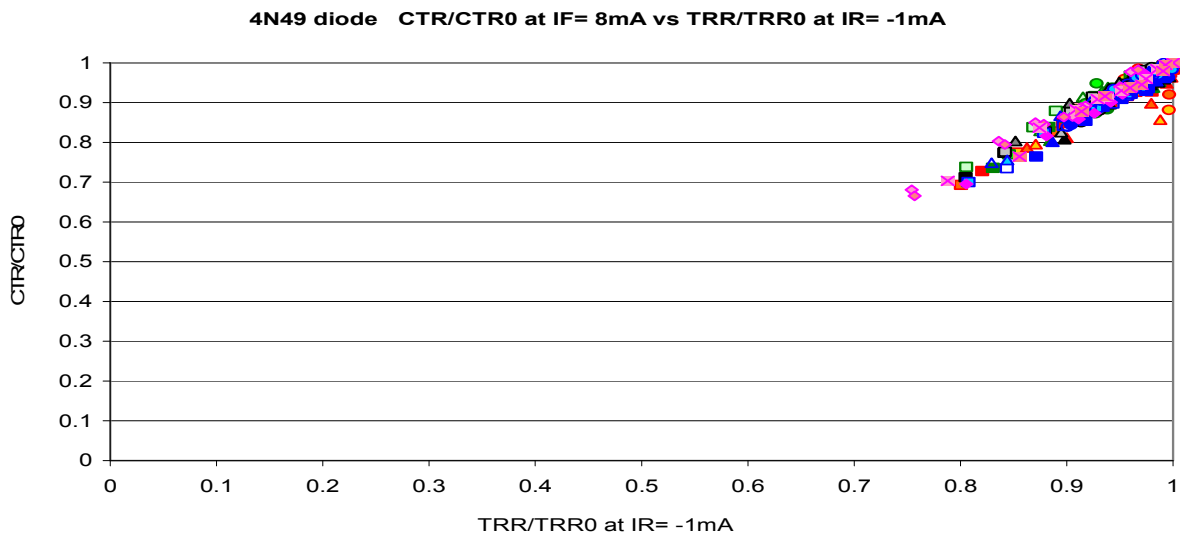

4N49 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
100
200
300
400
500
600
TRR at IR= -4mA [ns]

Fig. 12-239: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

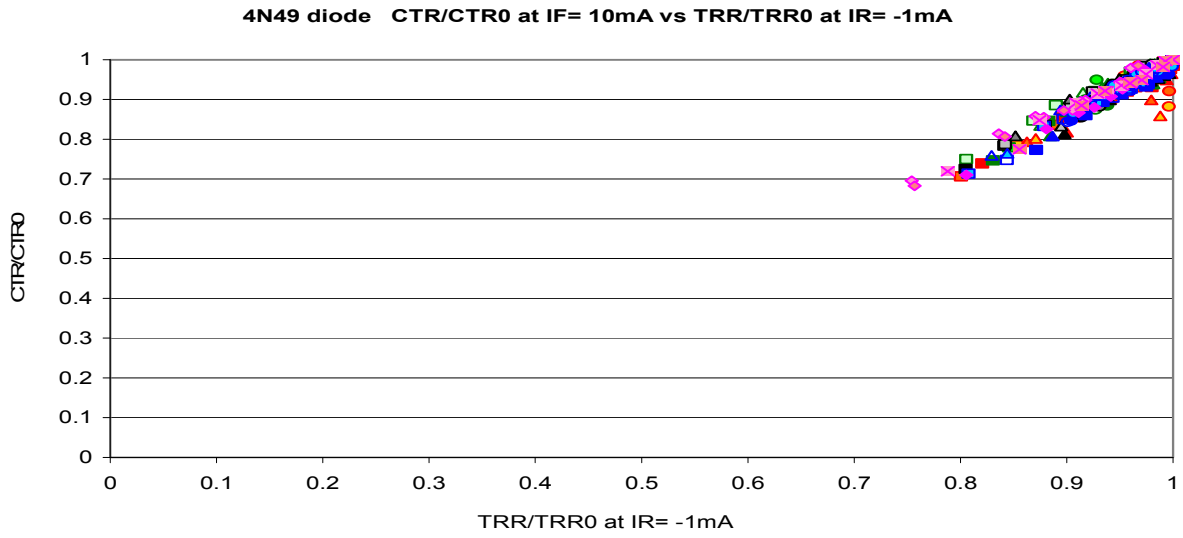
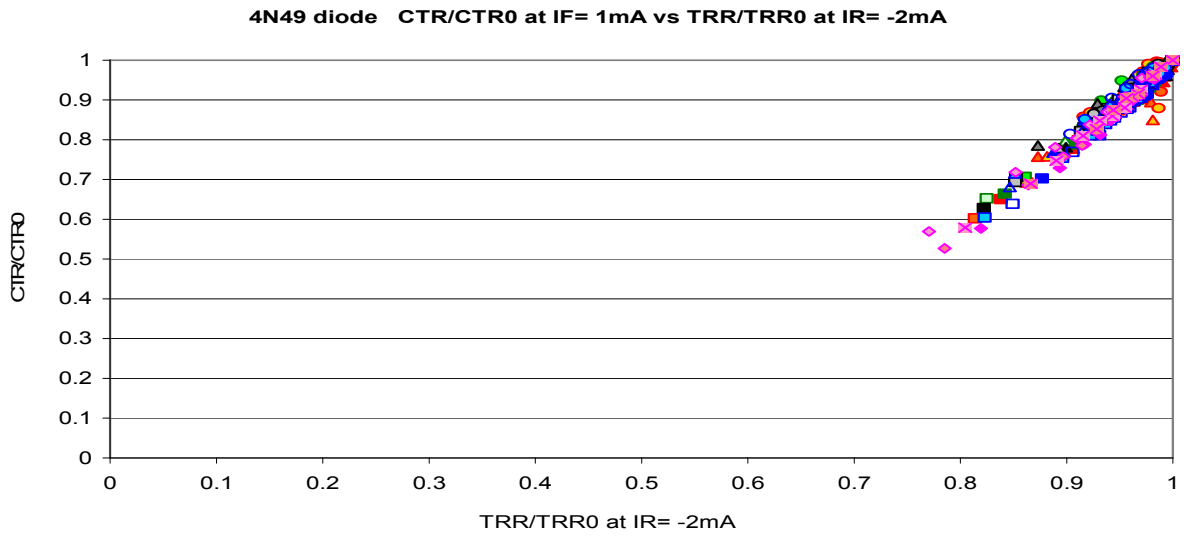
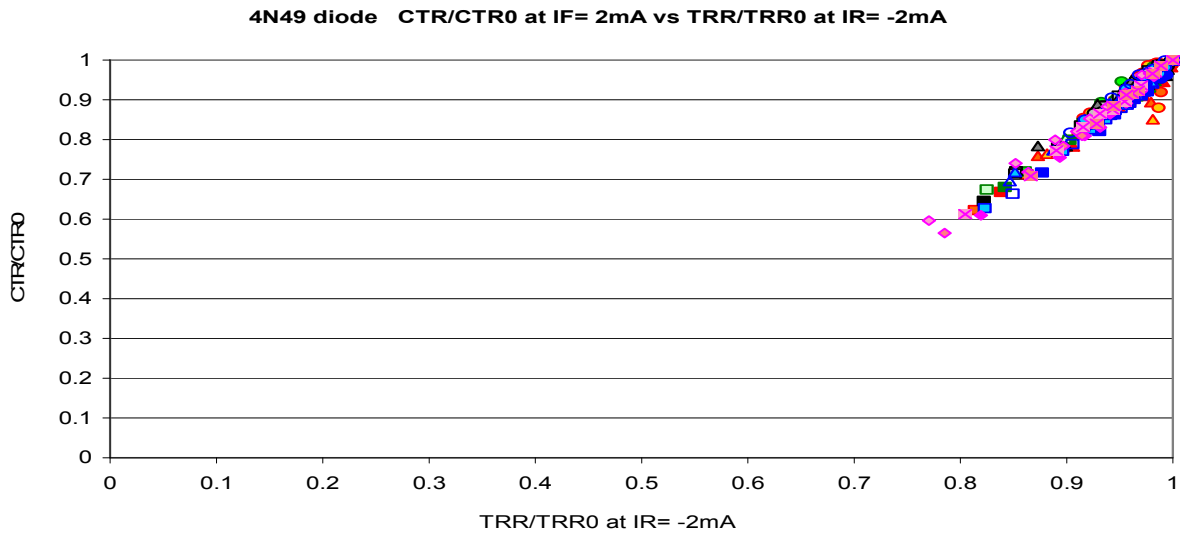
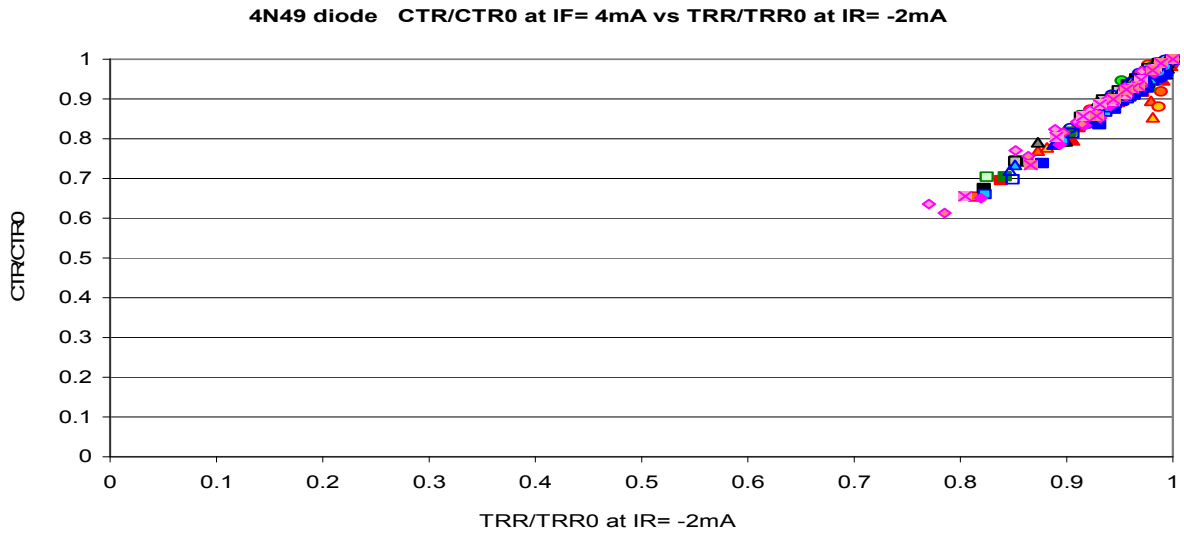
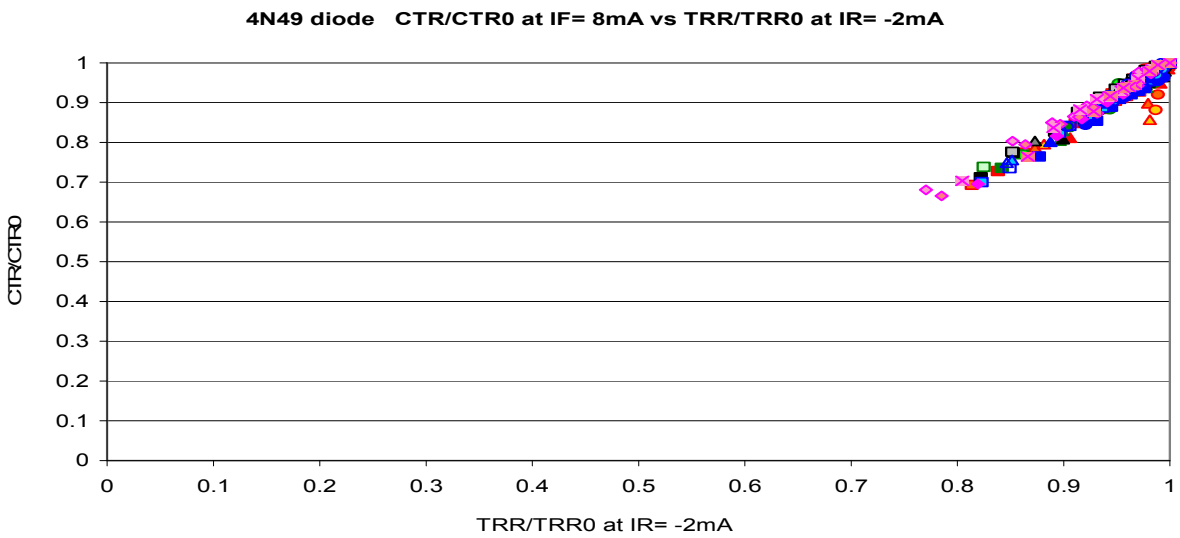

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Fig. 12-240: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
TRR/TRR0 at IR= -2mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

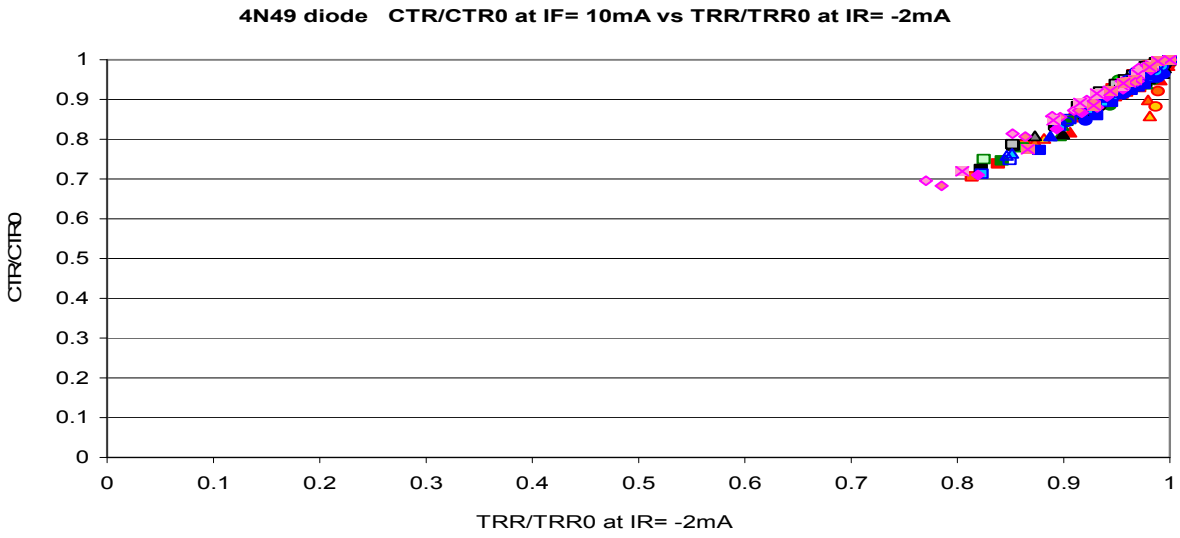
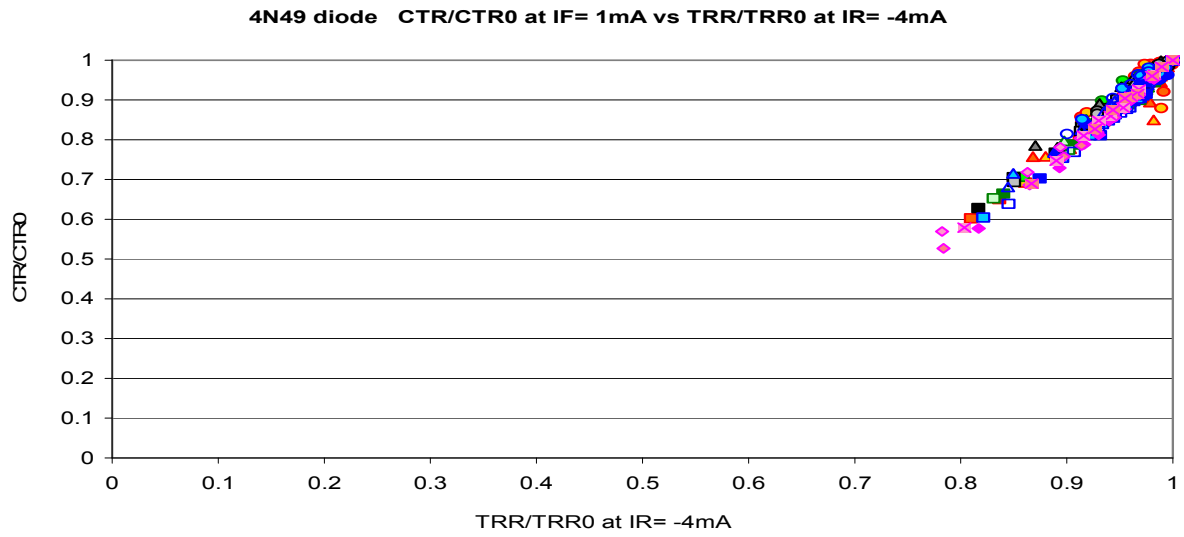
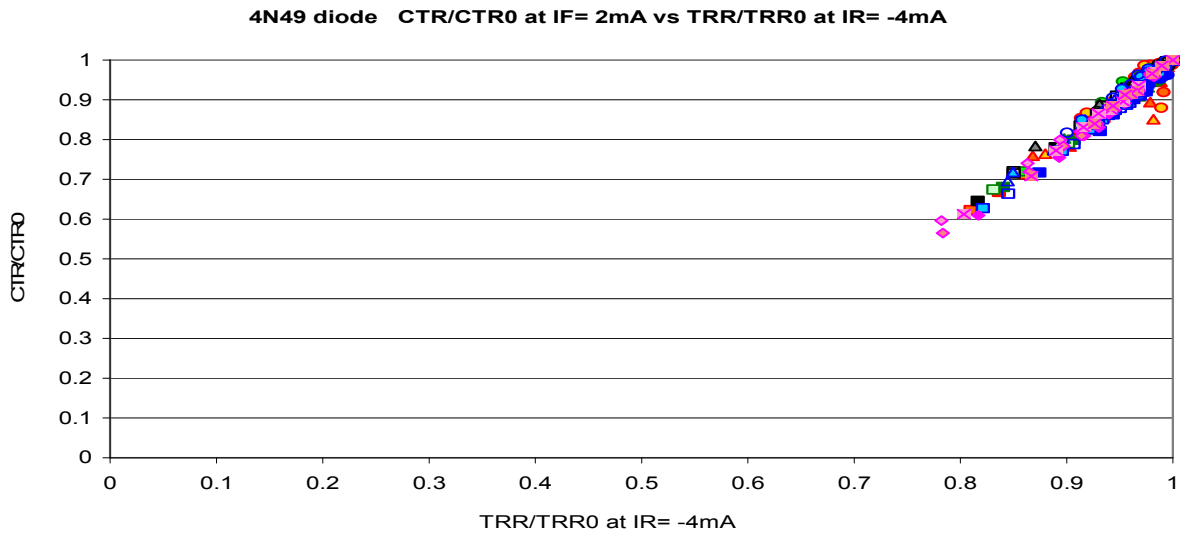
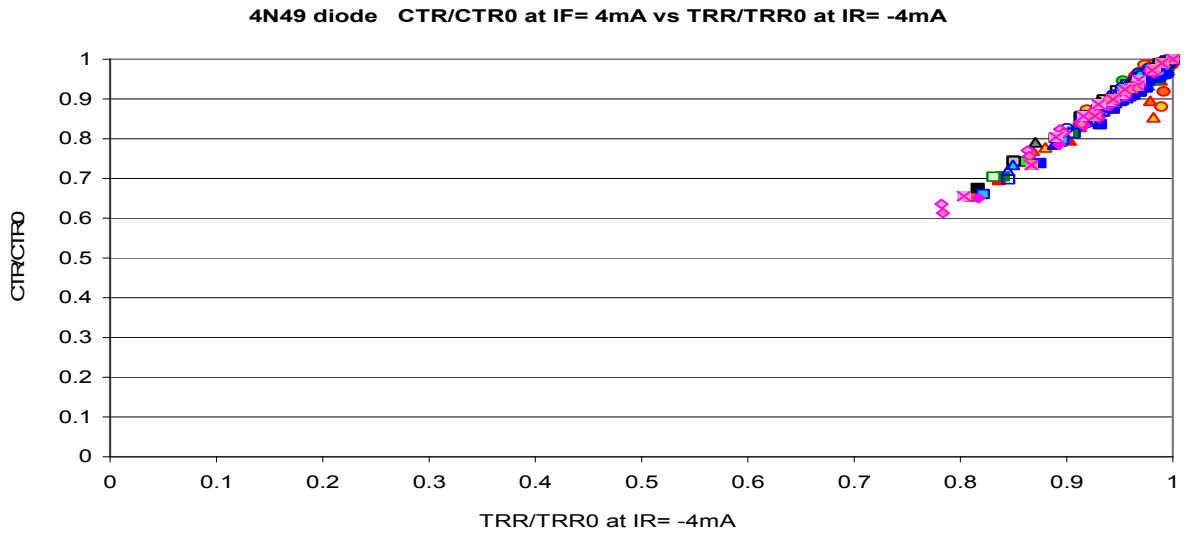
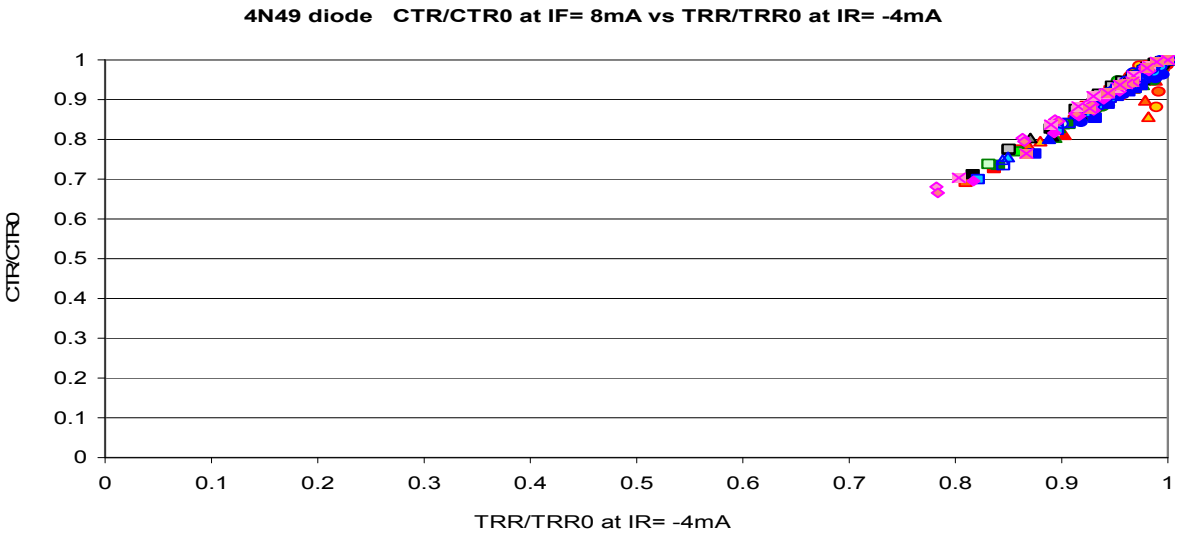

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
TRR/TRR0 at IR= -2mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Fig. 12-241: 4N49 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








4N49 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

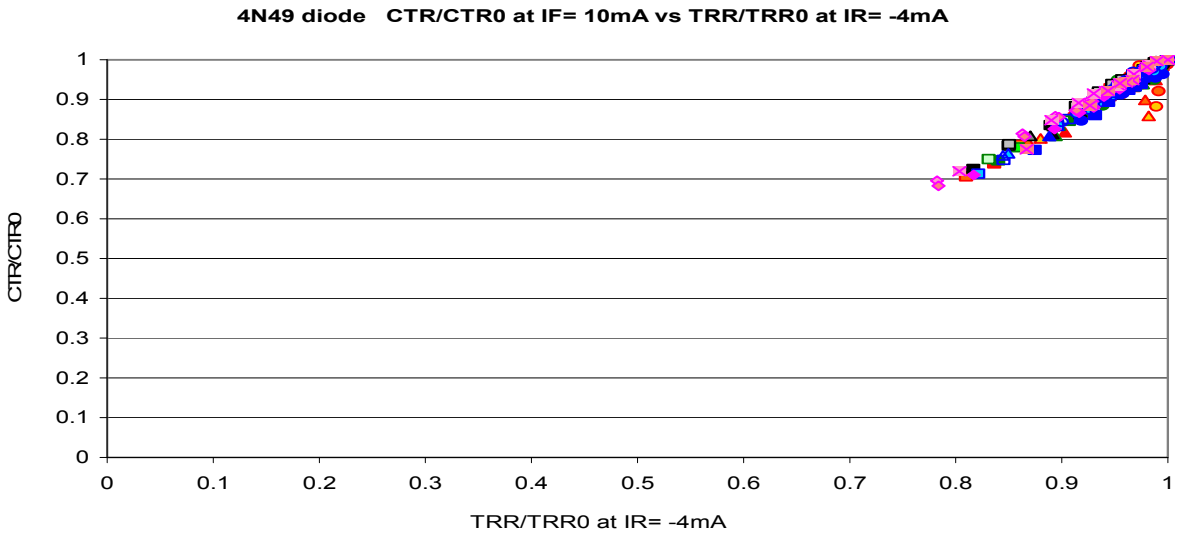
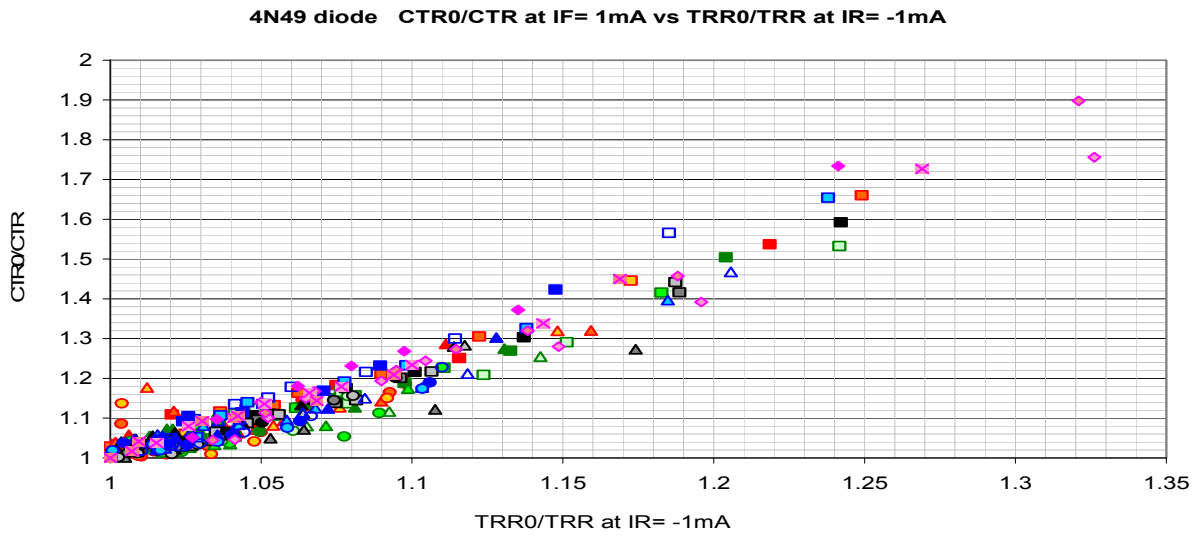
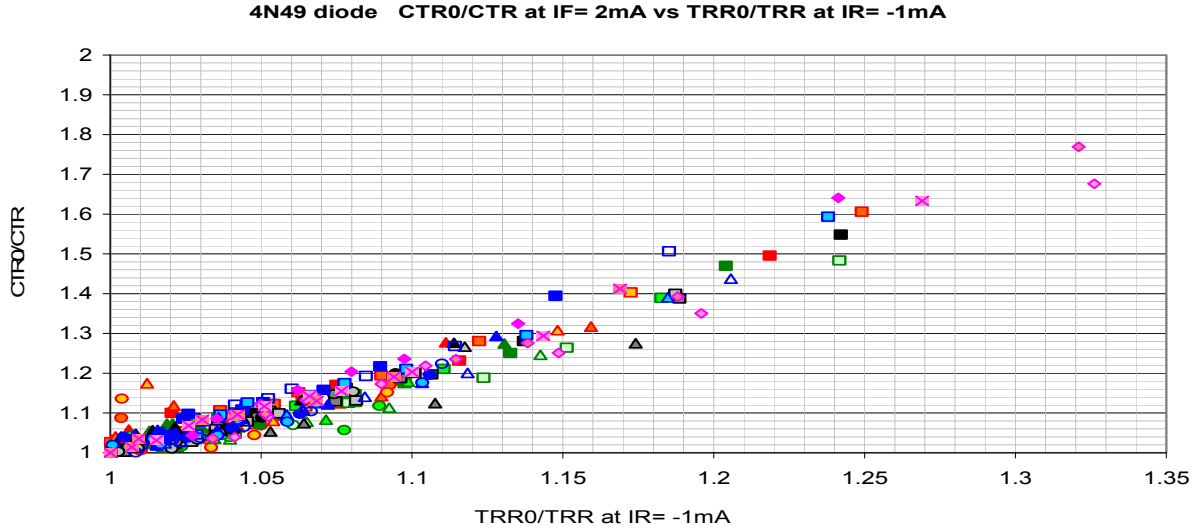
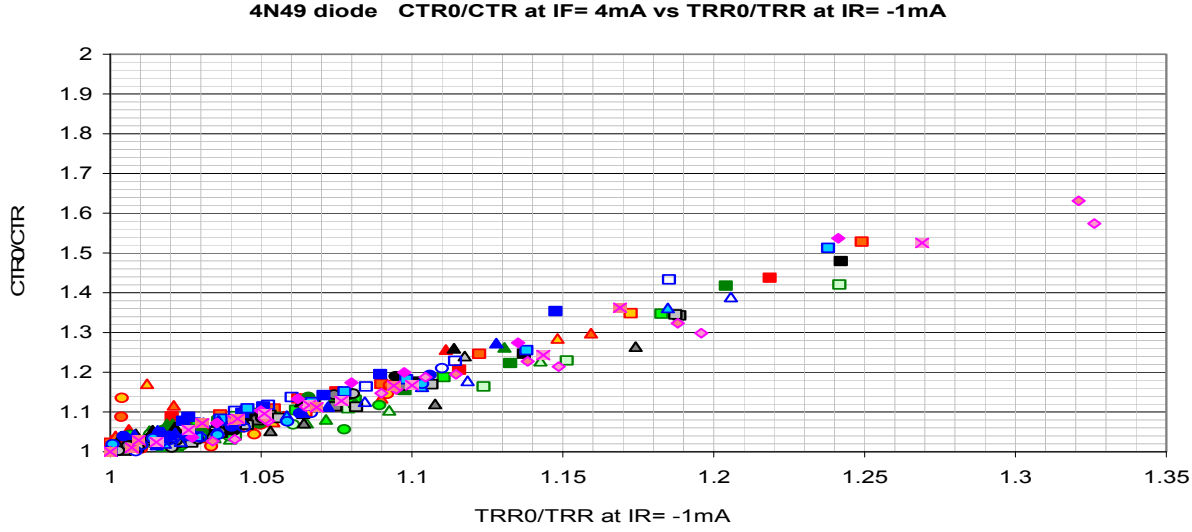

4N49 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

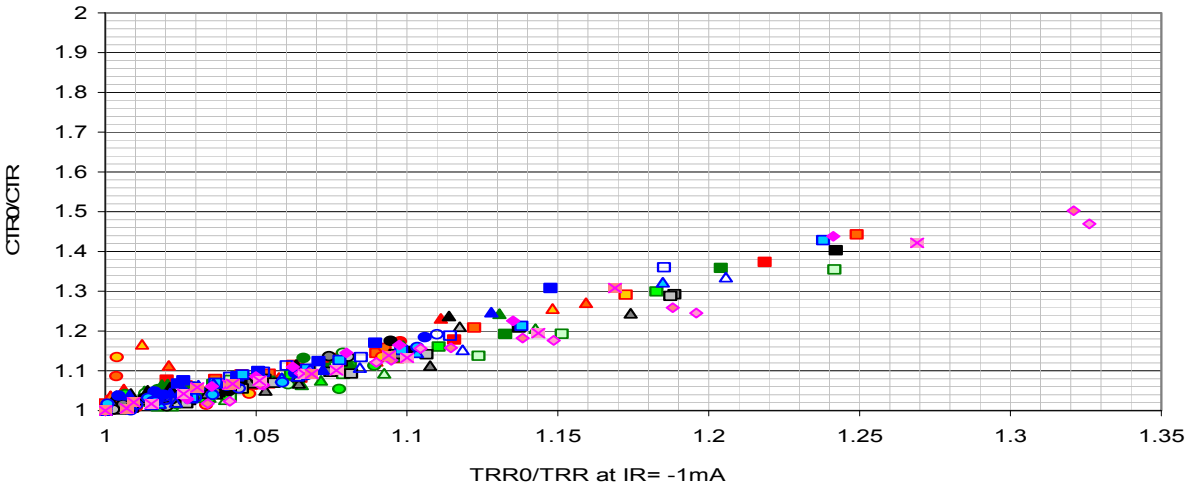
Fig. 12-242: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA







4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA

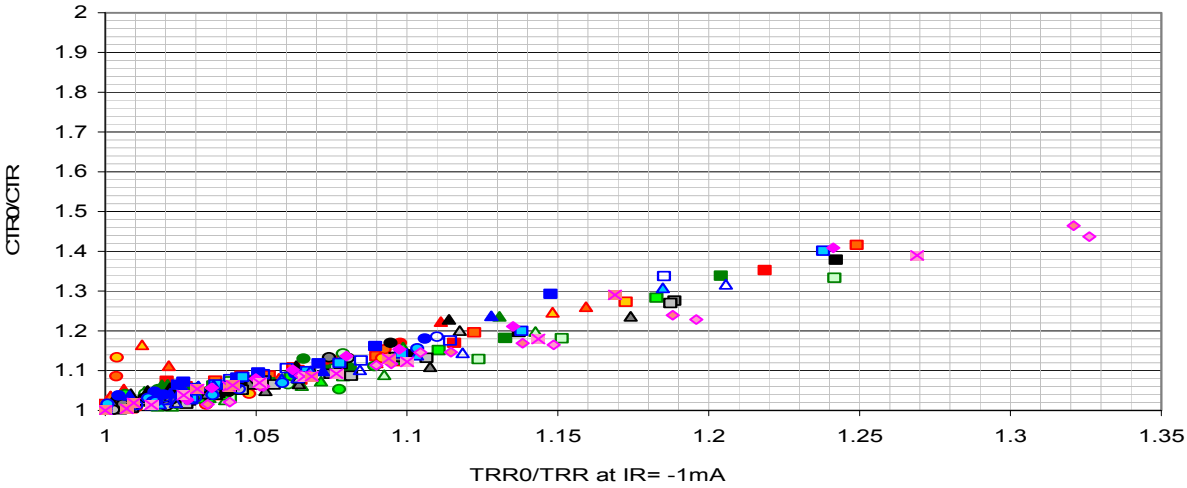
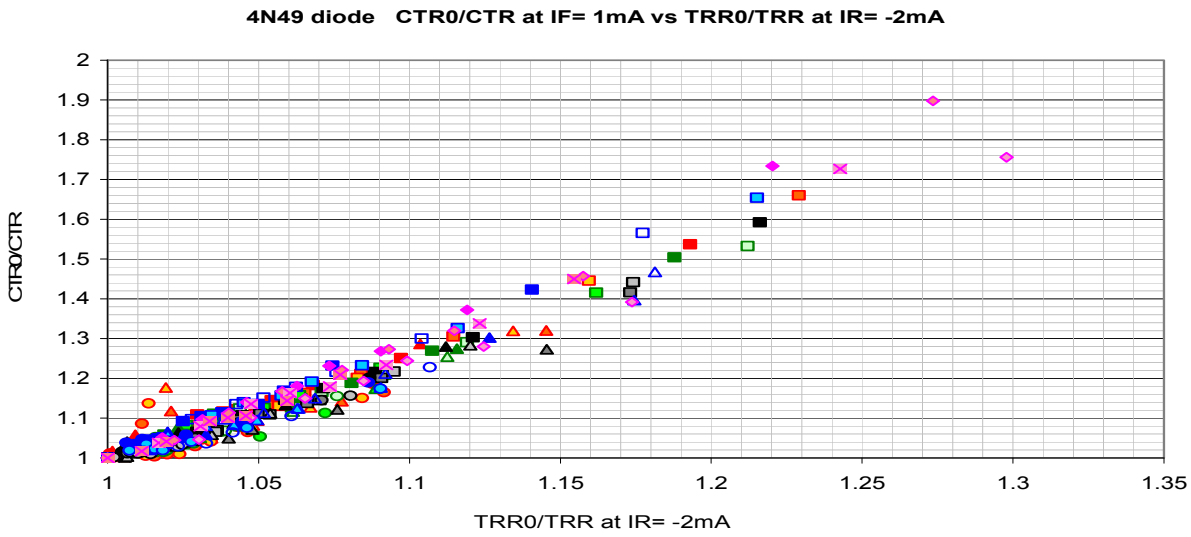
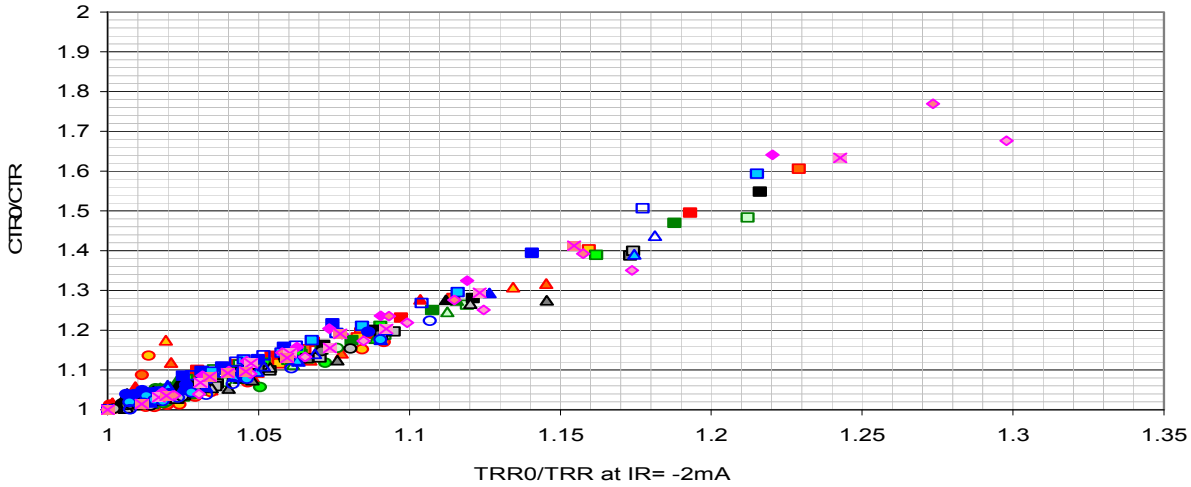
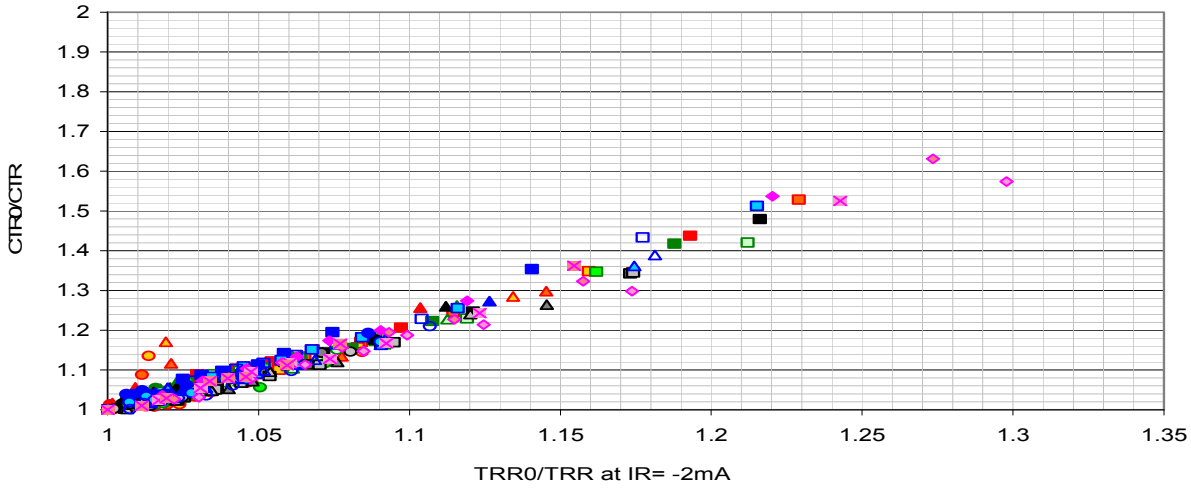


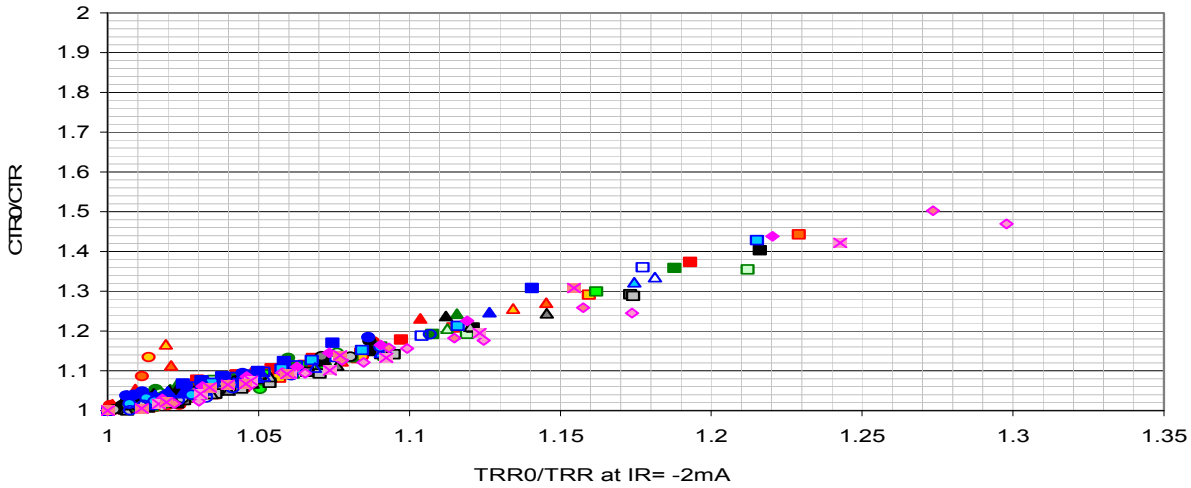
Fig. 12-243: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA







4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

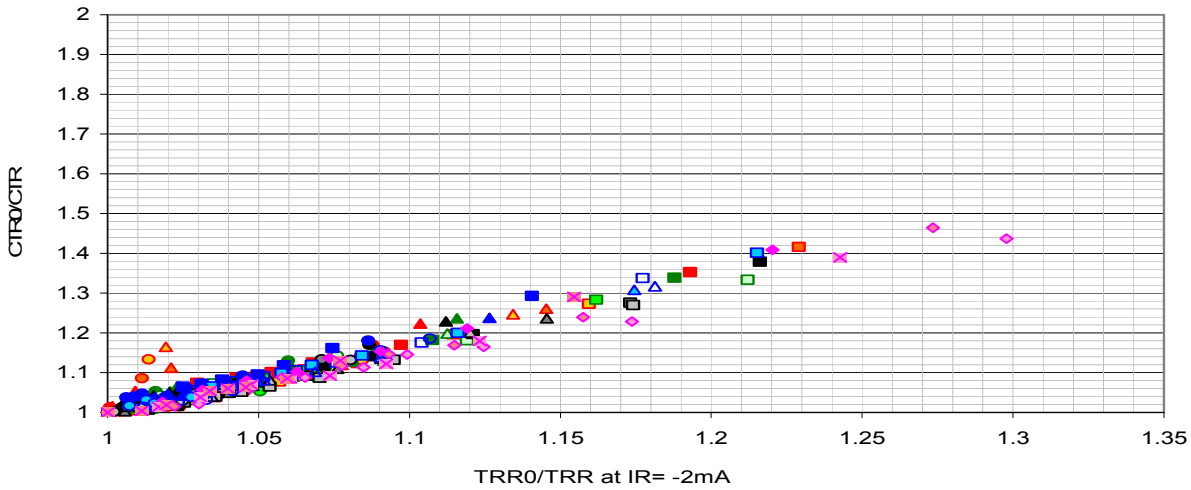
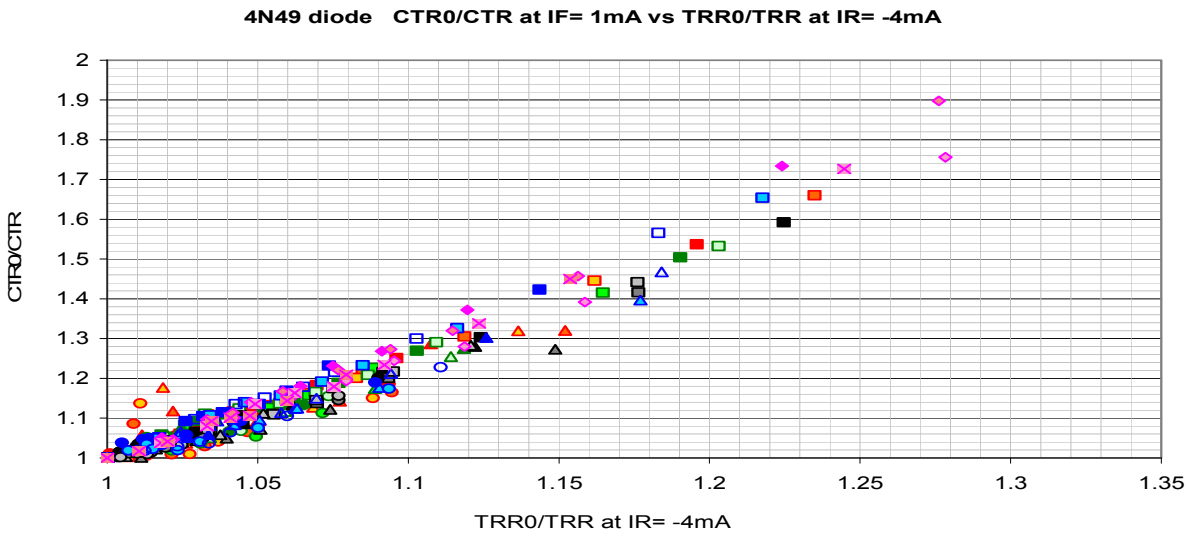
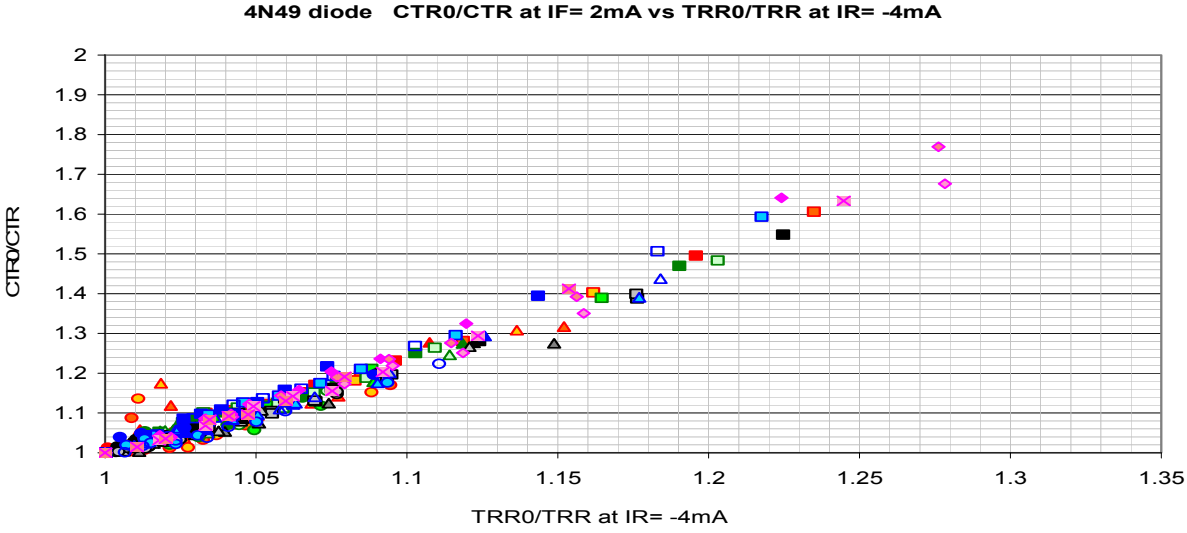
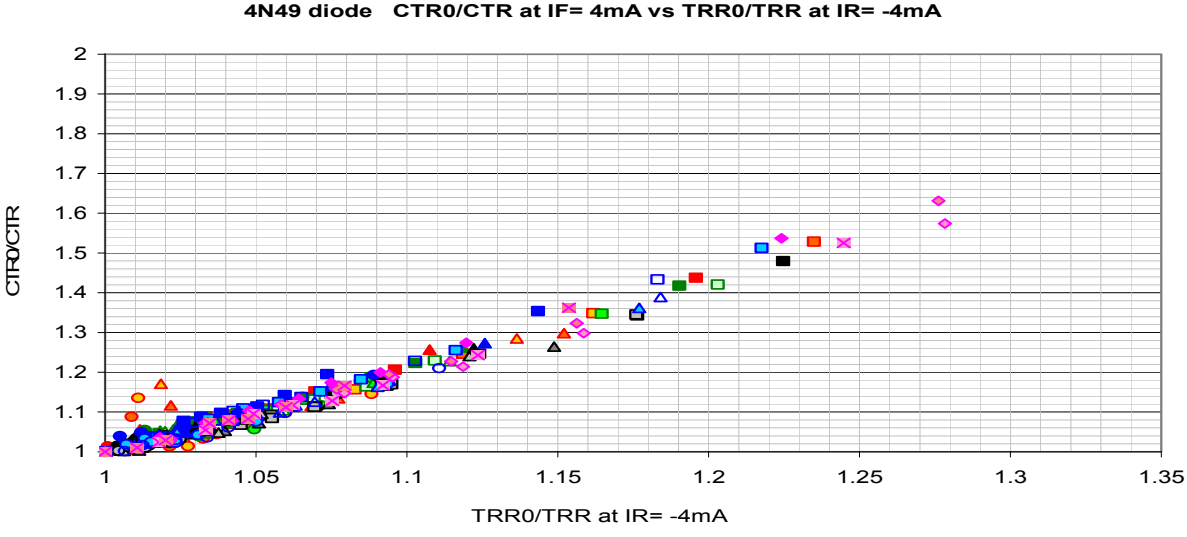


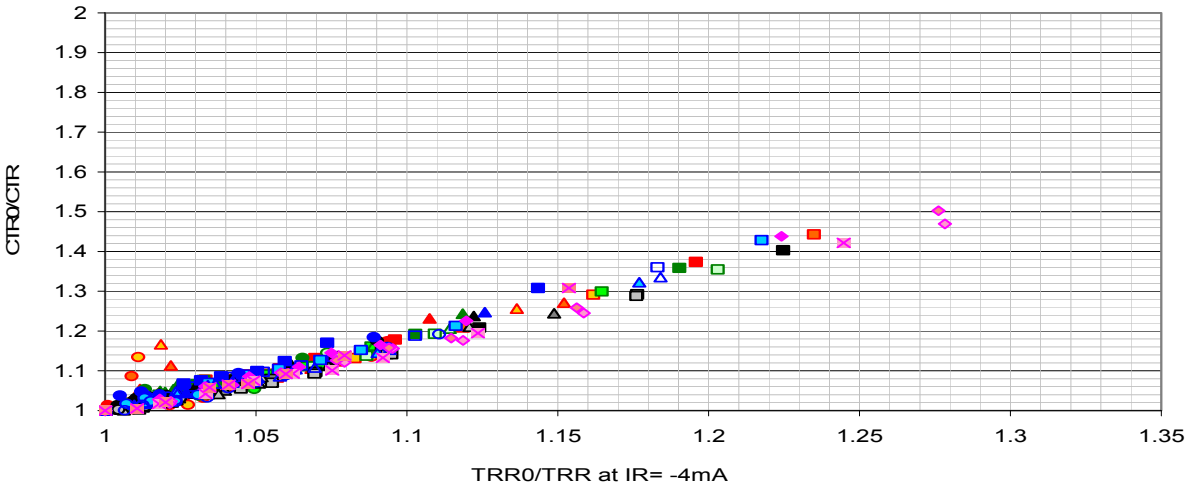
Fig. 12-244: 4N49 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







4N49 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



4N49 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

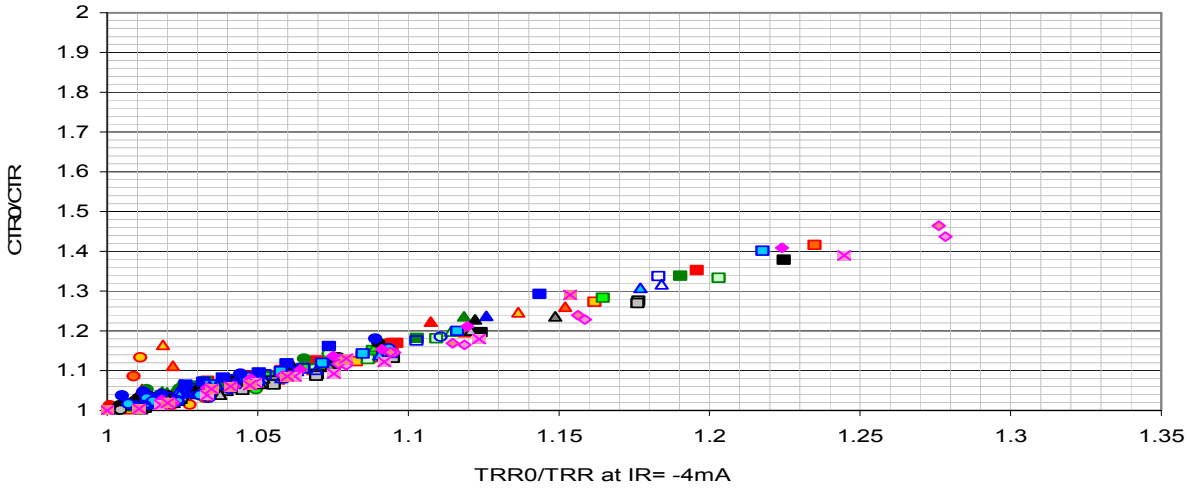
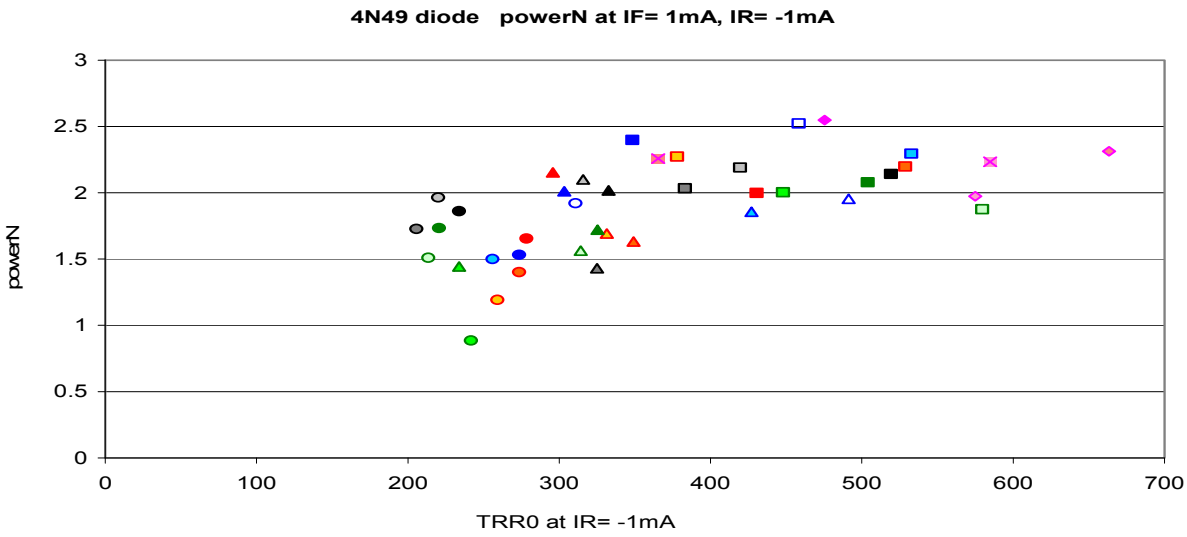
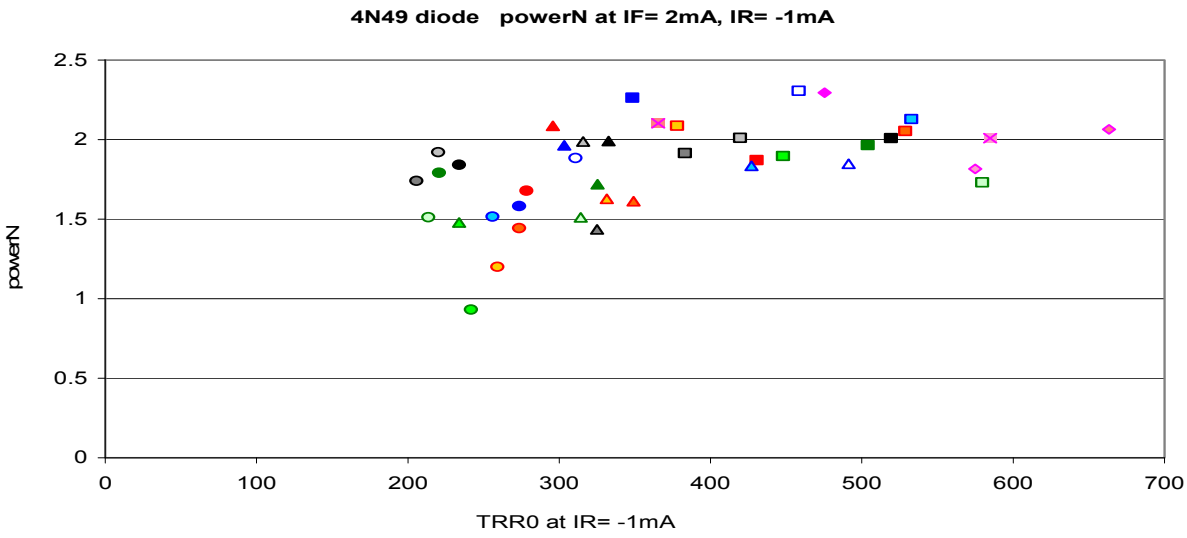
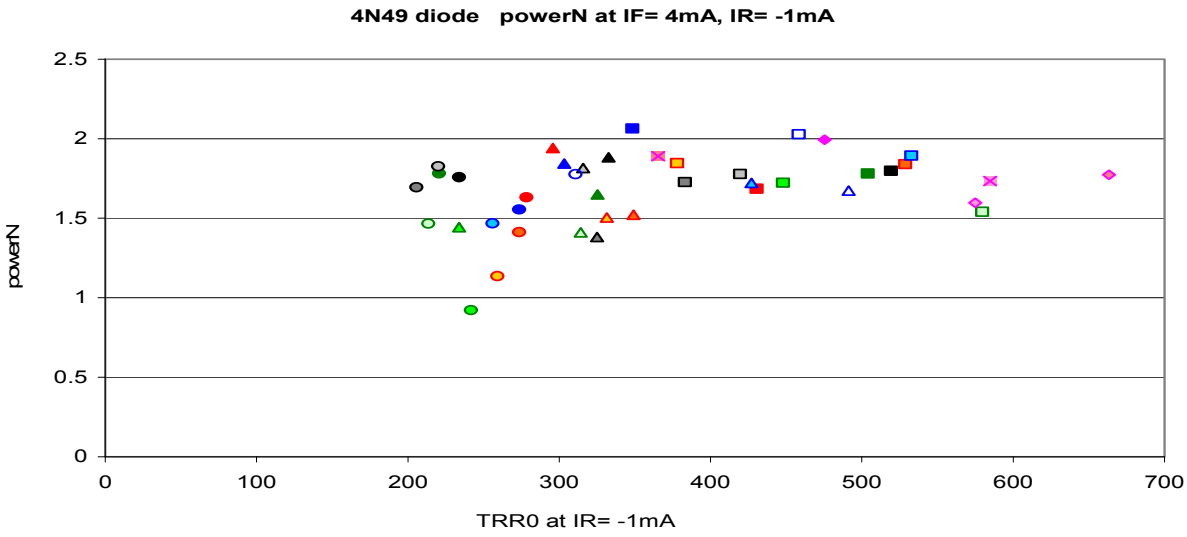
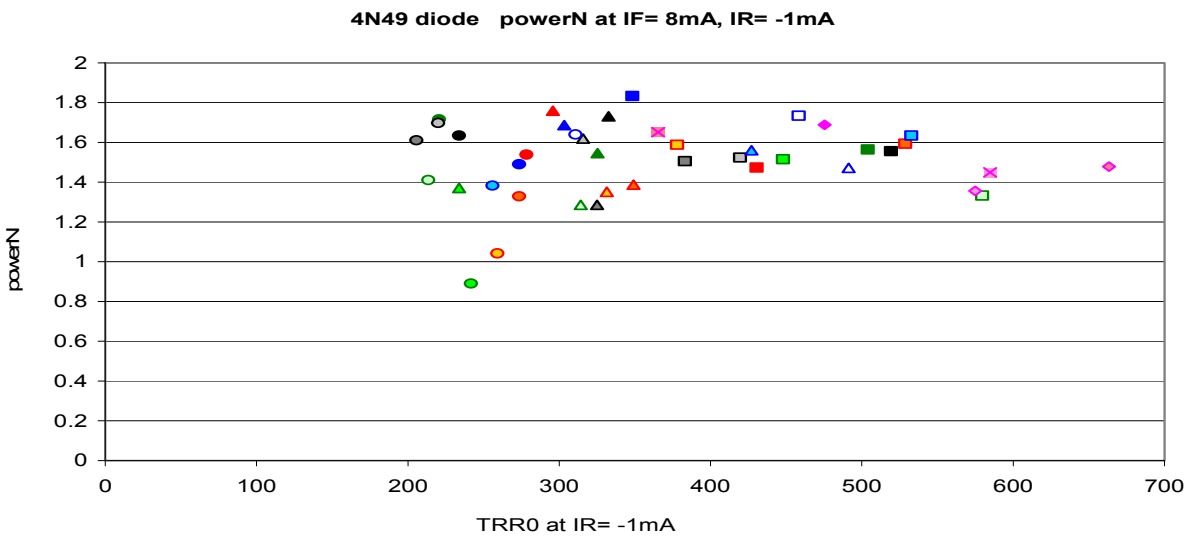


Fig. 12-245: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








4N49 diode powerN at IF= 8mA, IR= -1mA
powerN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
TRR0 at IR= -1mA

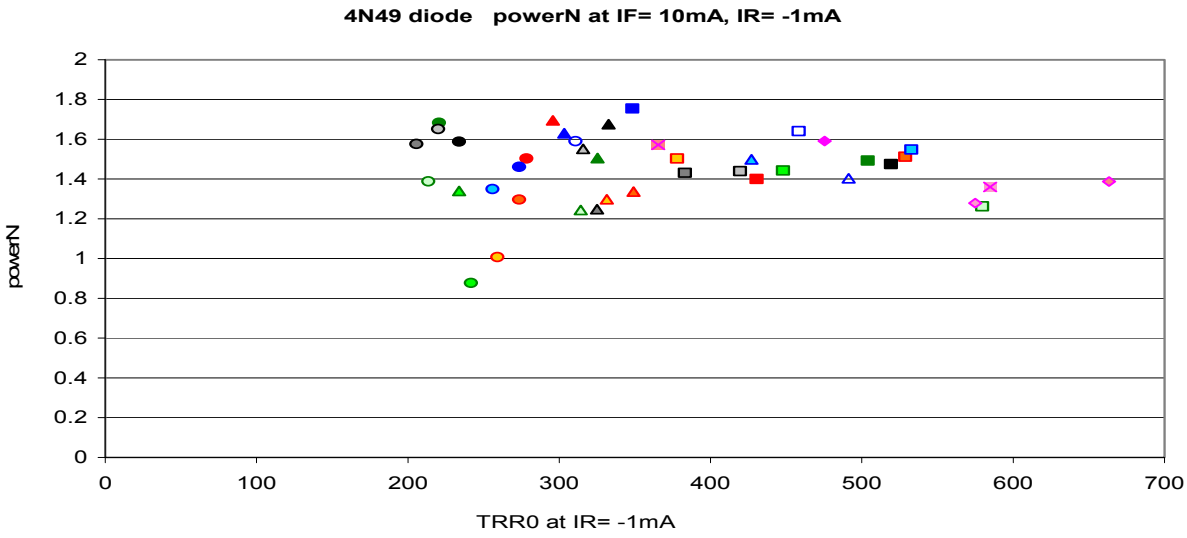
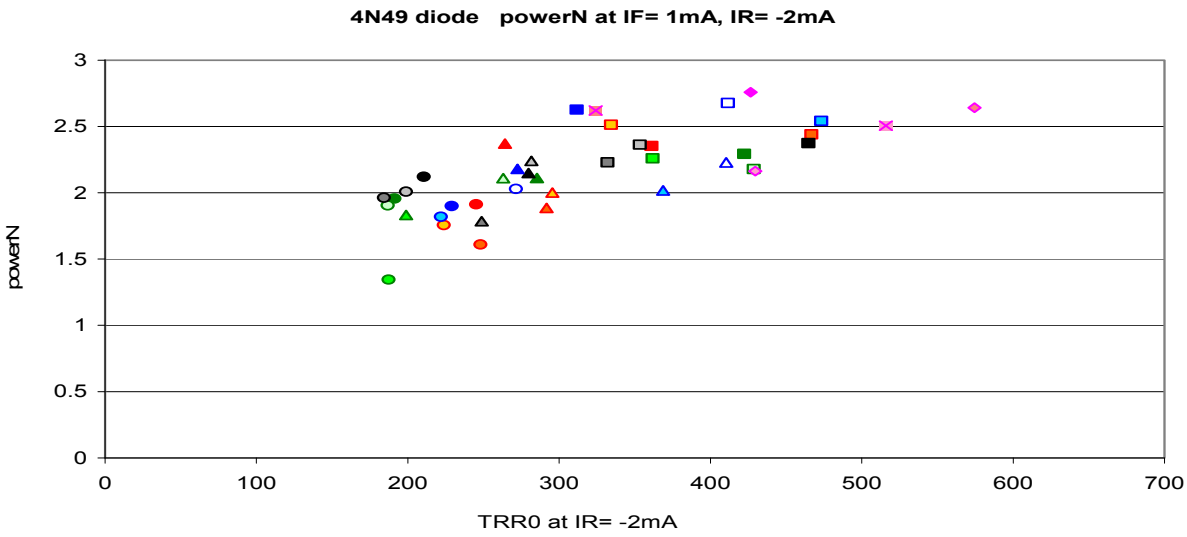
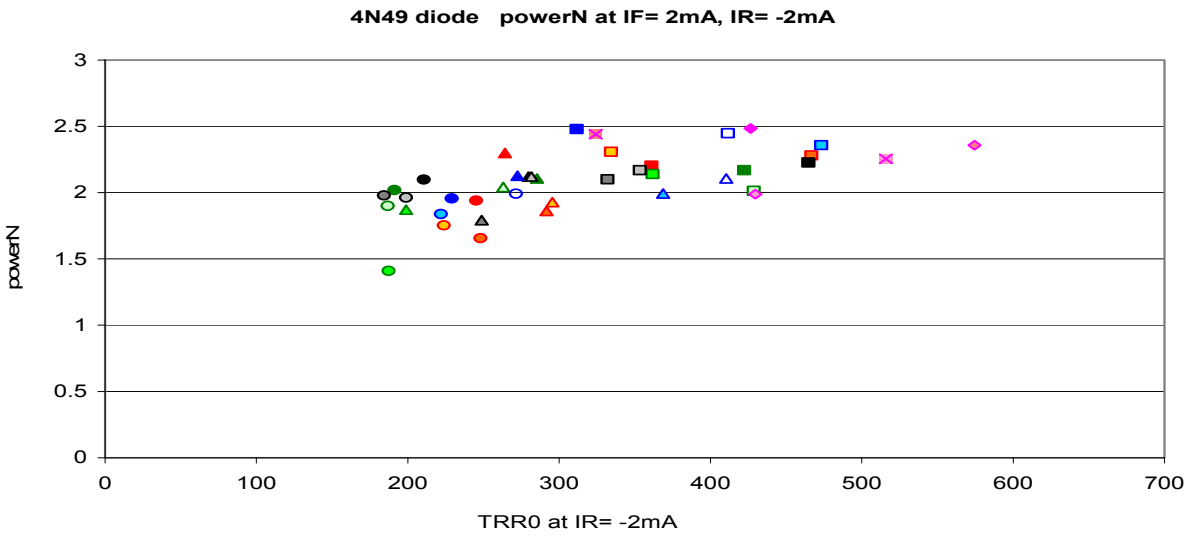
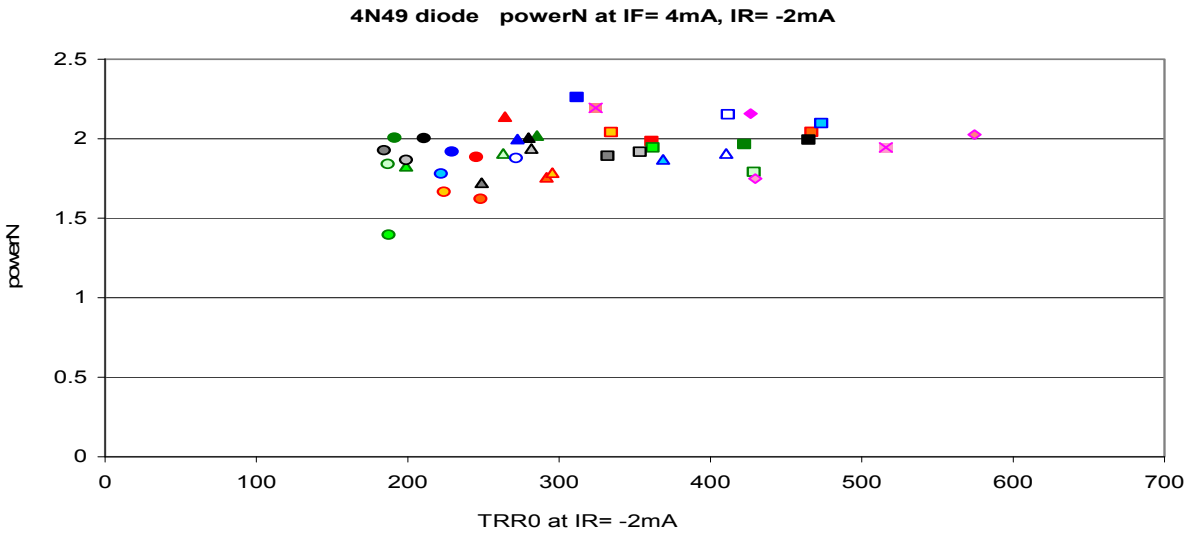
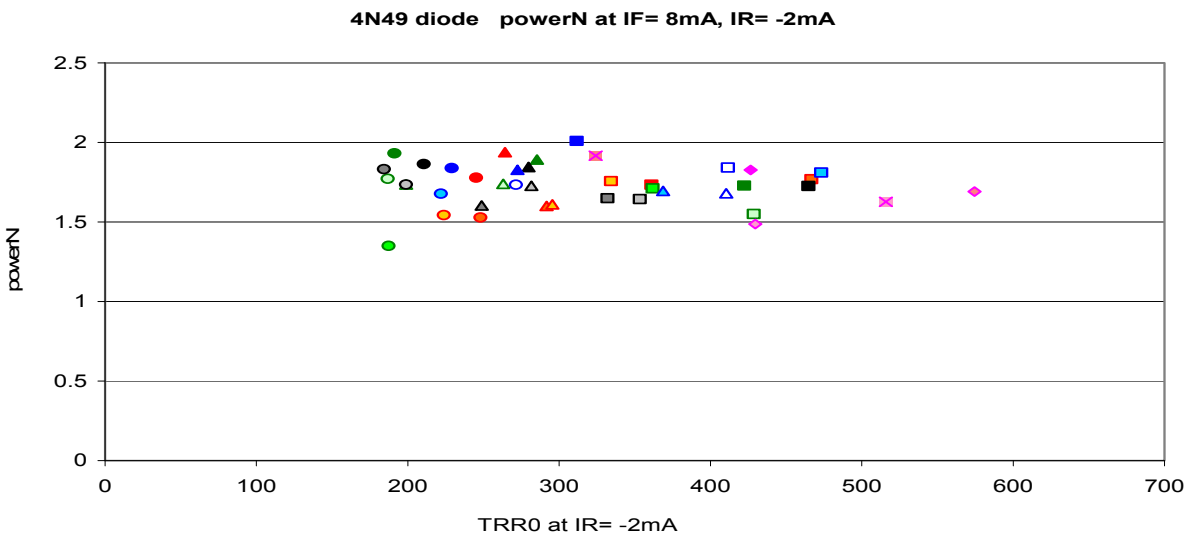

4N49 diode powerN at IF= 10mA, IR= -1mA
powerN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
TRR0 at IR= -1mA

Fig. 12-246: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








4N49 diode powerN at IF= 8mA, IR= -2mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
TRR0 at IR= -2mA

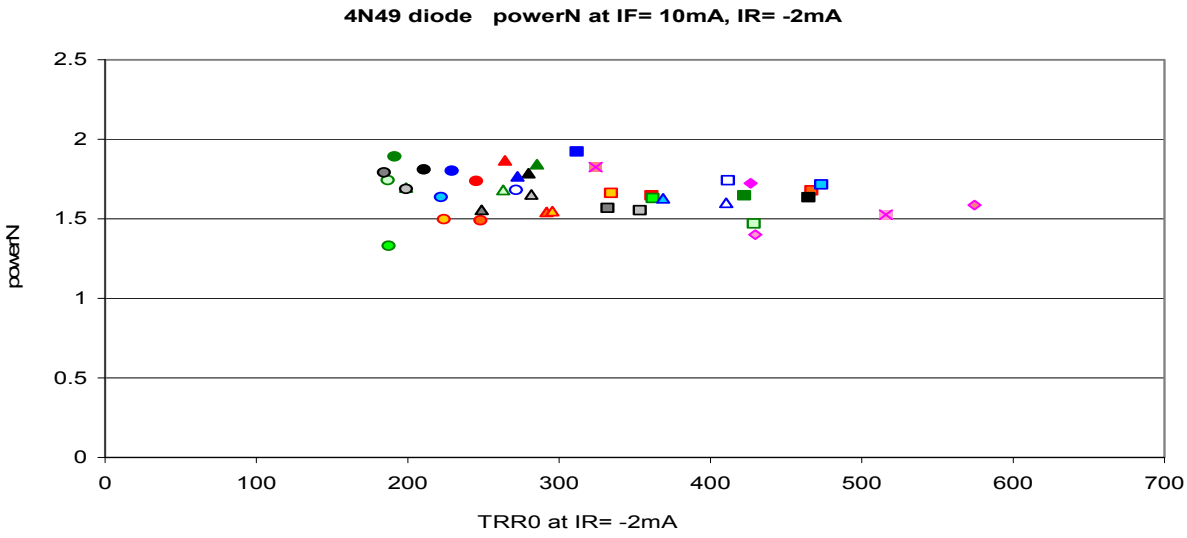
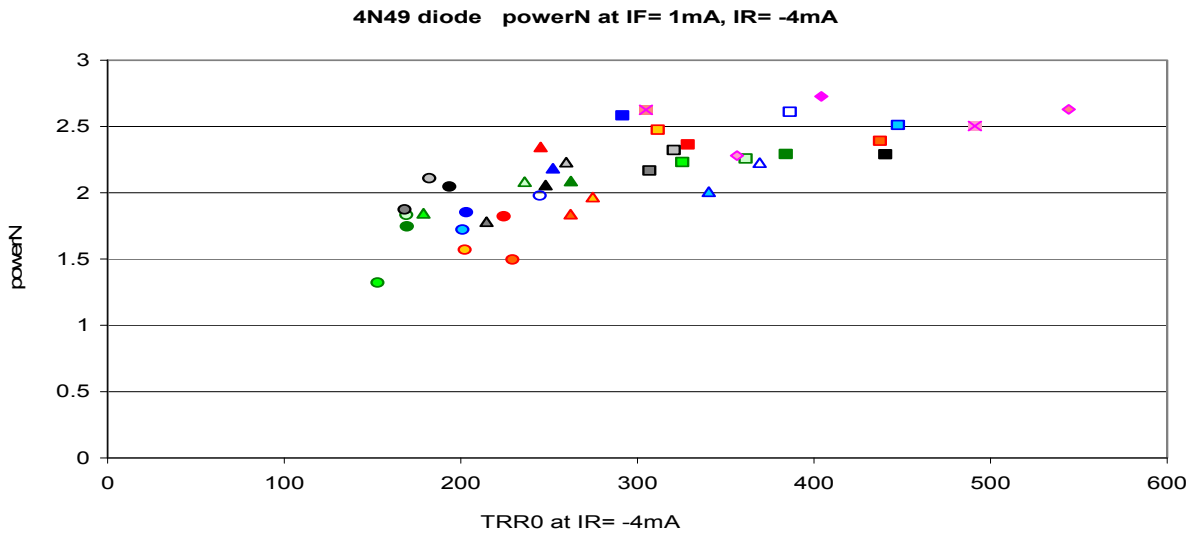
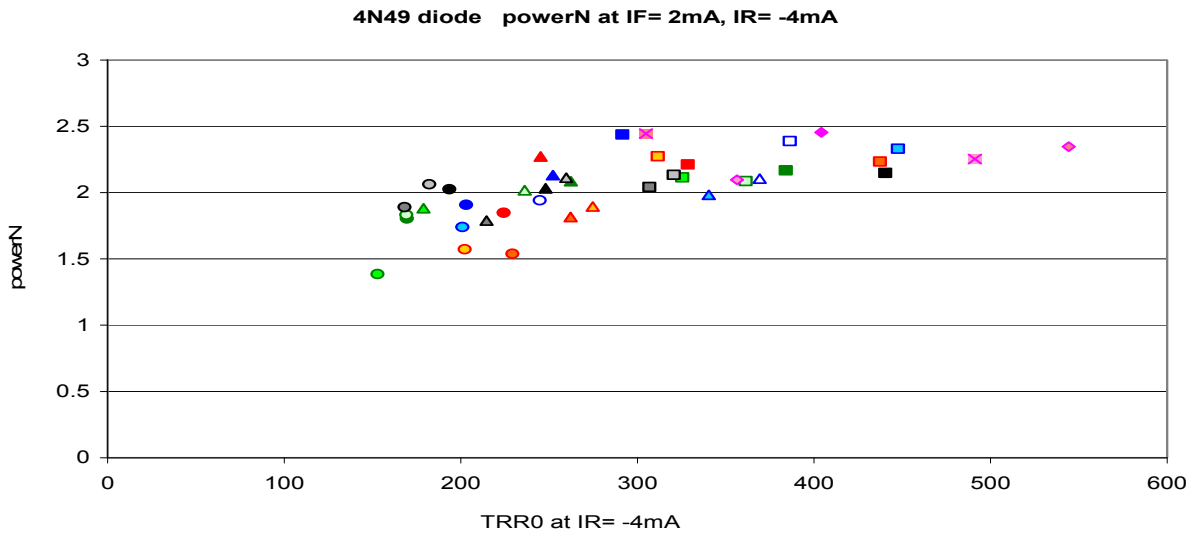
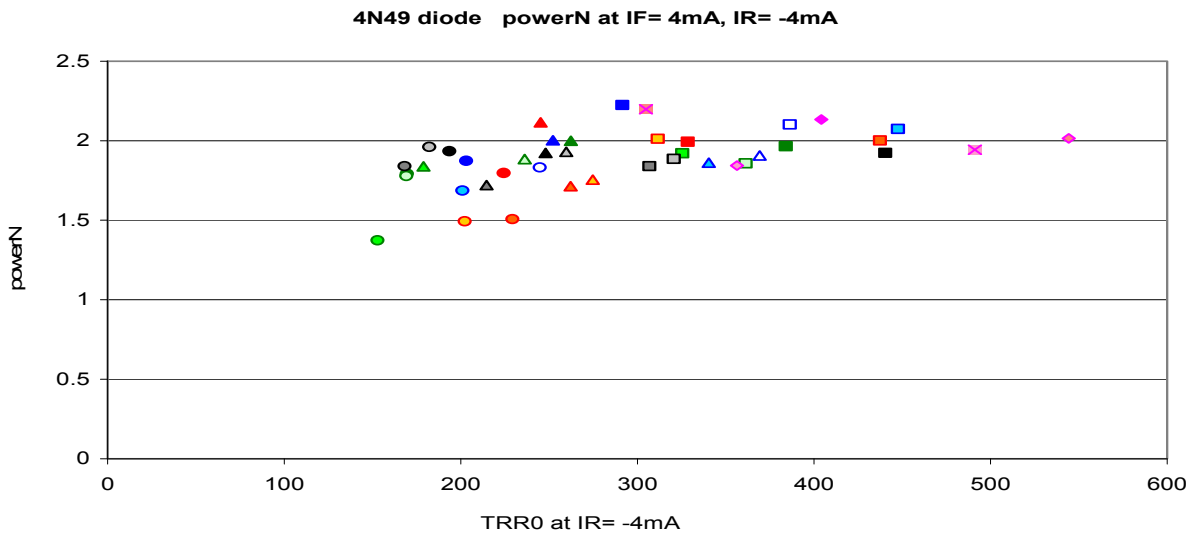
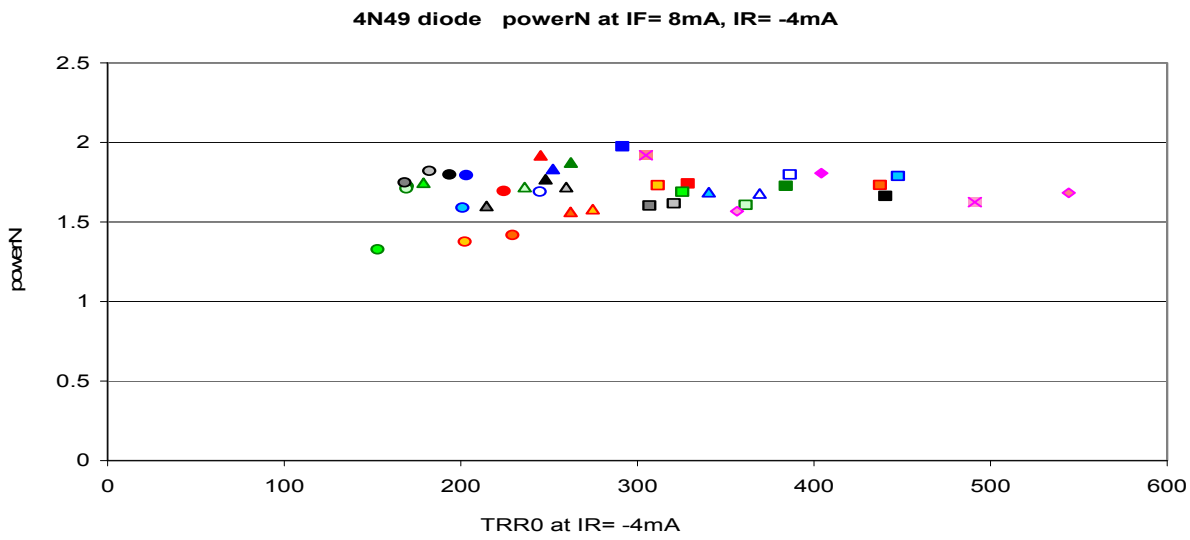

4N49 diode powerN at IF= 10mA, IR= -2mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
TRR0 at IR= -2mA

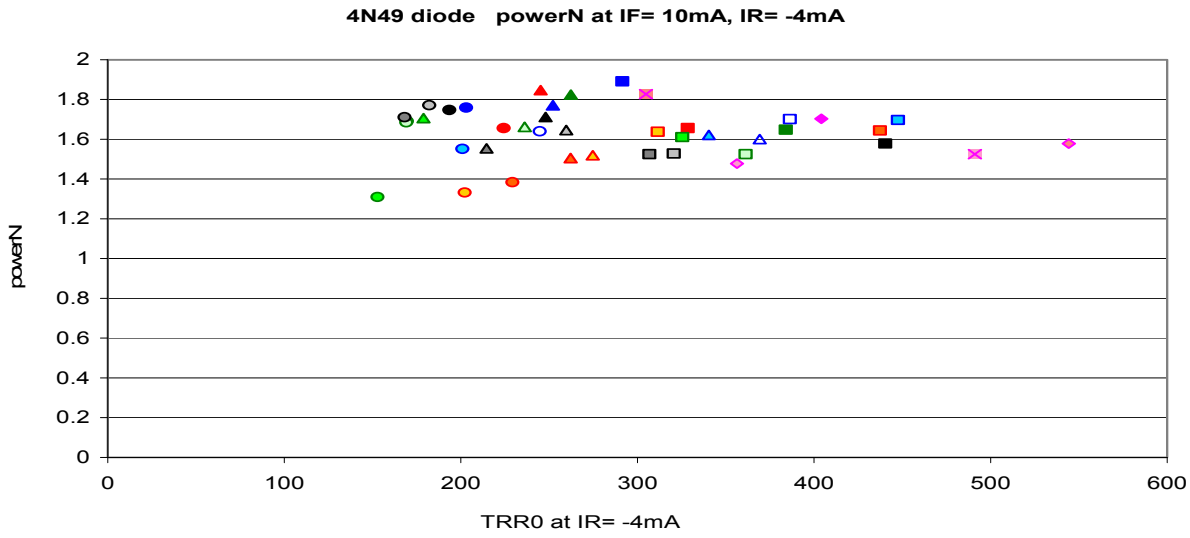
Fig. 12-247: 4N49 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA








4N49 diode powerN at IF= 8mA, IR= -4mA
powerN
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA

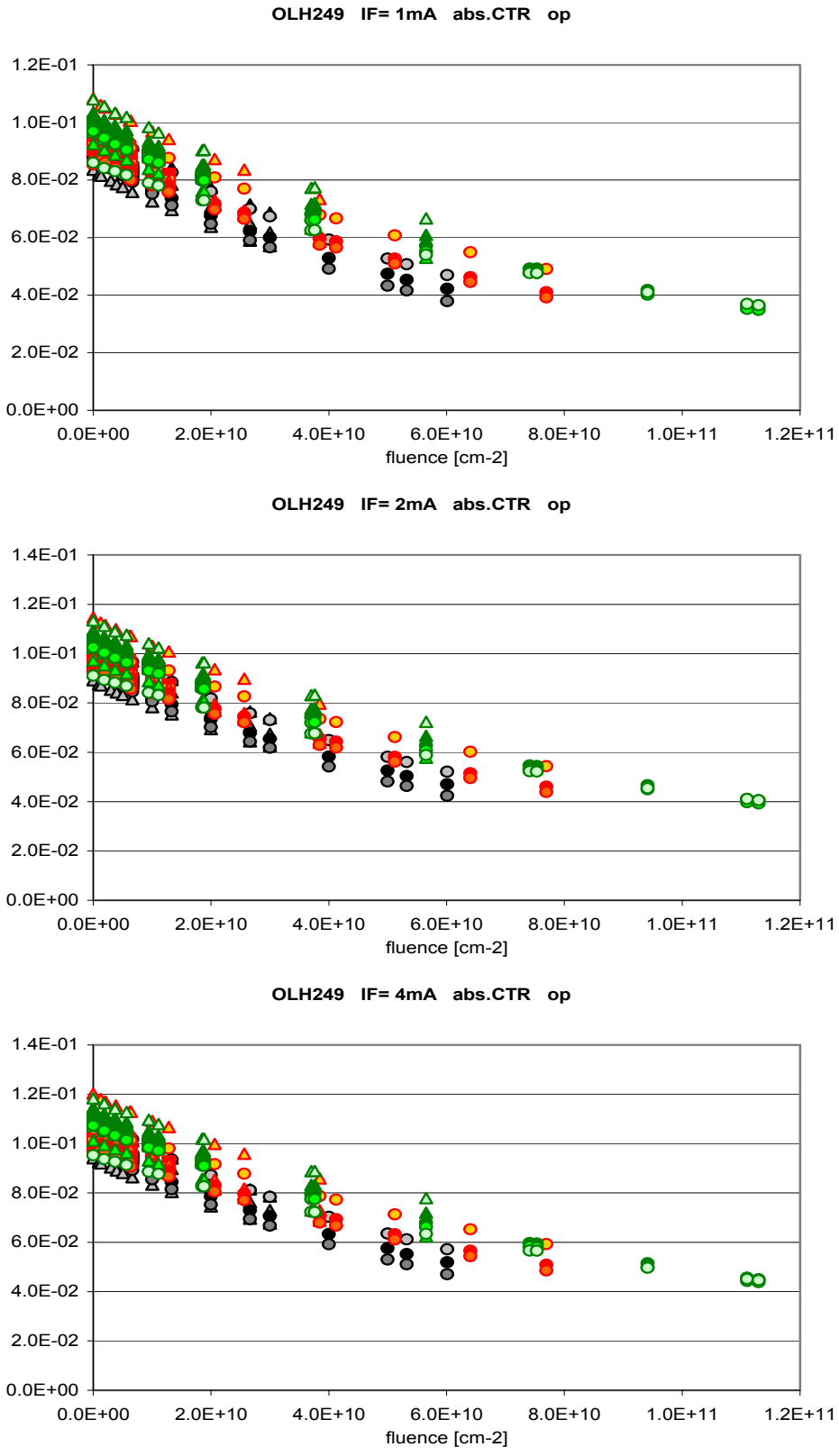

4N49 diode powerN at IF= 10mA, IR= -4mA
powerN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
TRR0 at IR= -4mA

13. APPENDIX OLH249

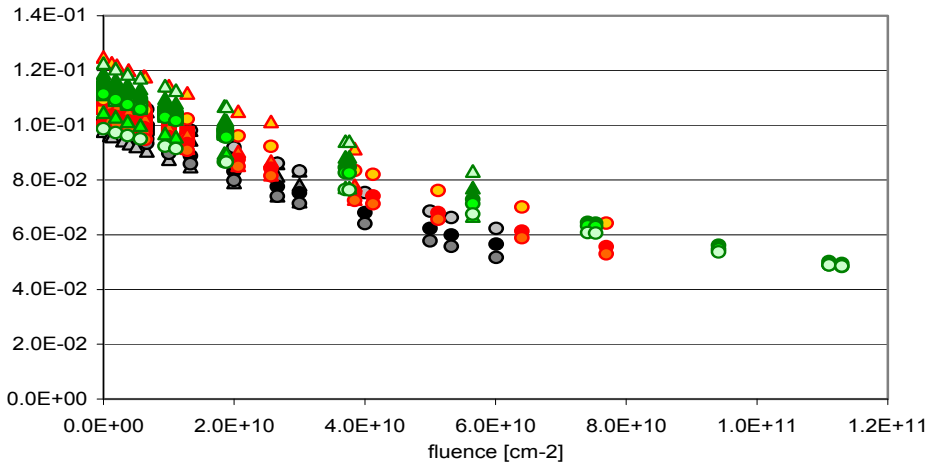
Part type	Emitter	Receiver			Package
	LED	Photodiode	Phototransistor	Output transistor	
OLH249 / ISOLINK **(DC0626)**	830 nm Double heterojunction AlGaAs **(Ref : OLQ243E)**	N/A	**0.045 inch sq (Ref : OLQ243D)**	N/A	Window can

13.1 PROTON IRRADIATION

Fig. 13-1: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

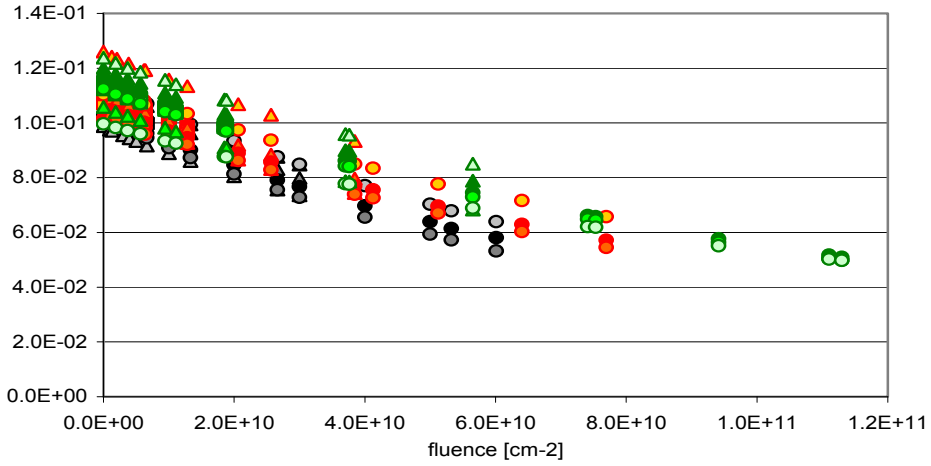
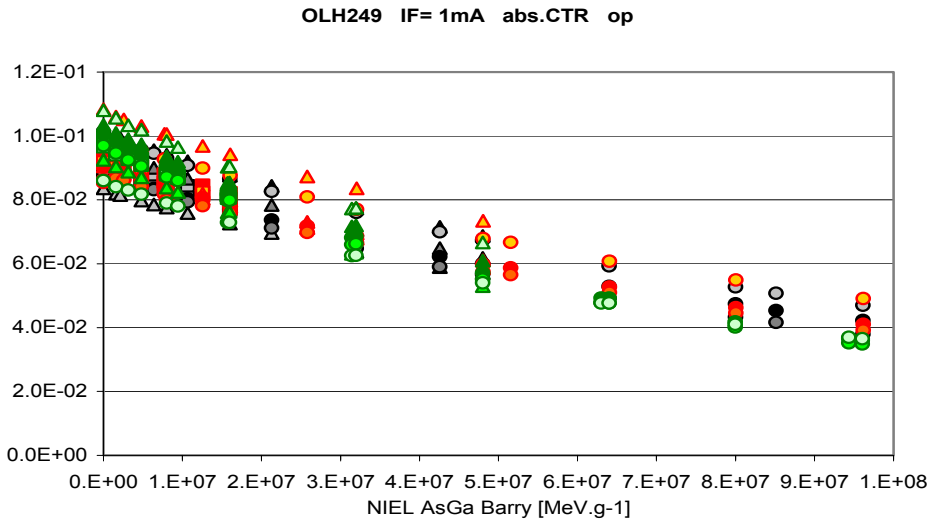
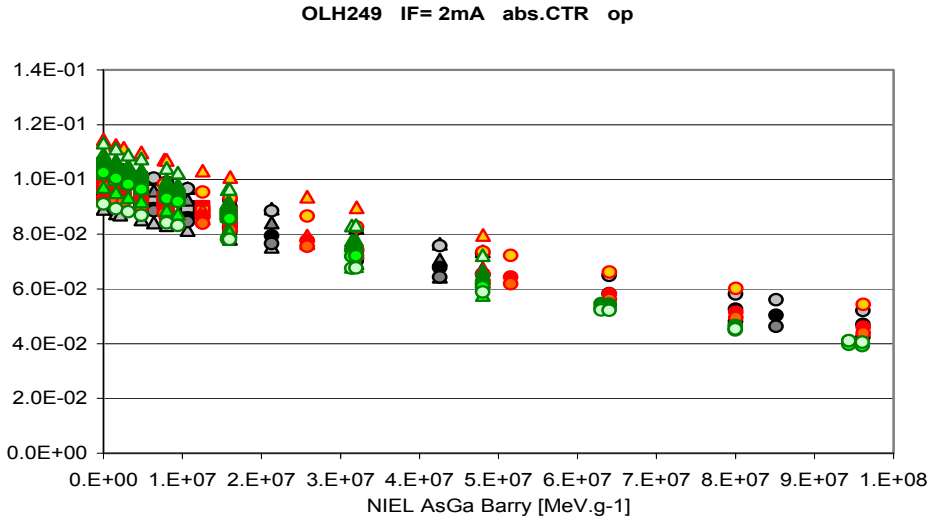
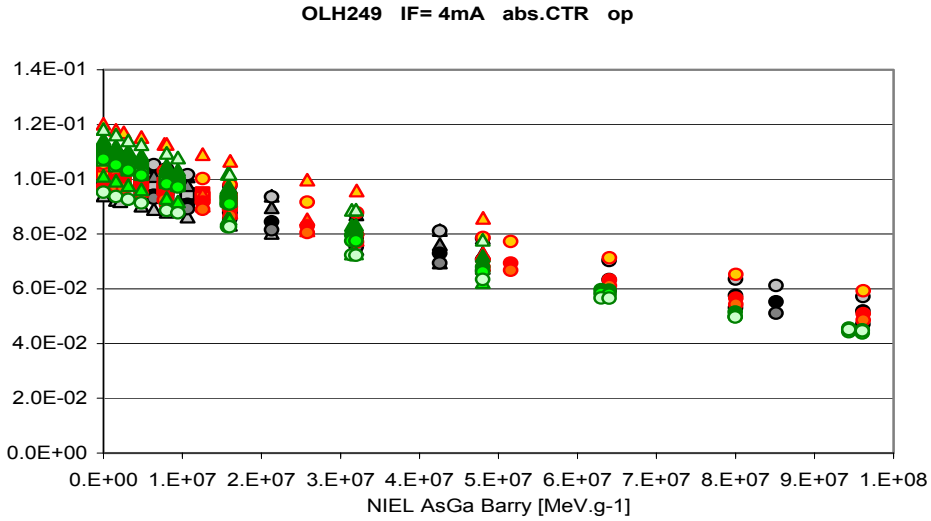


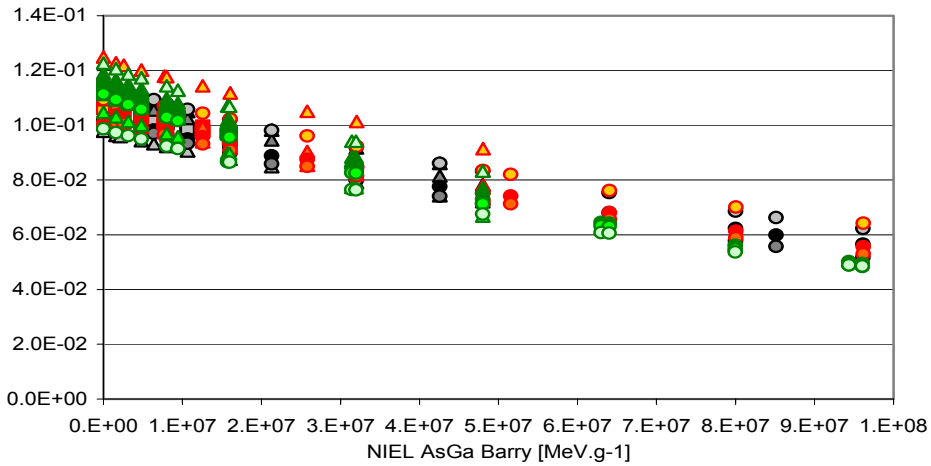
Fig. 13-2: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

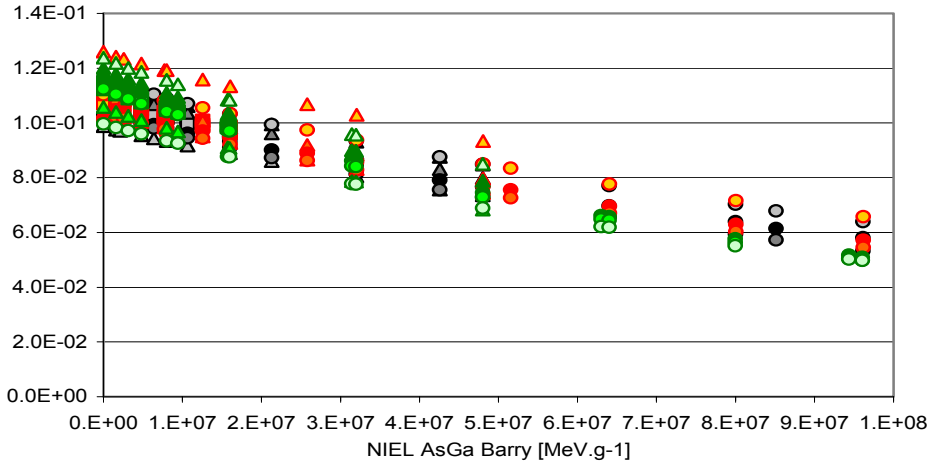
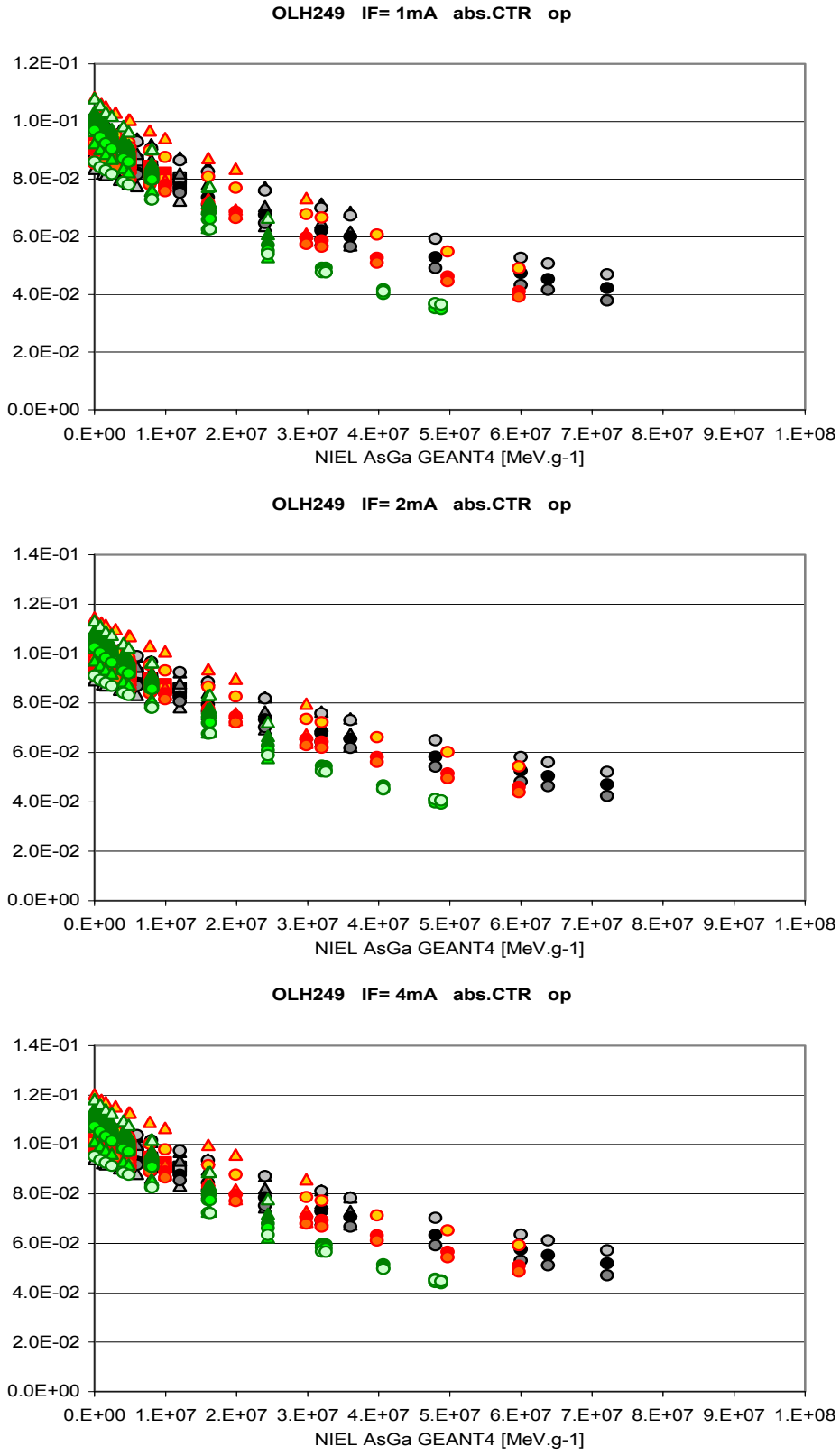
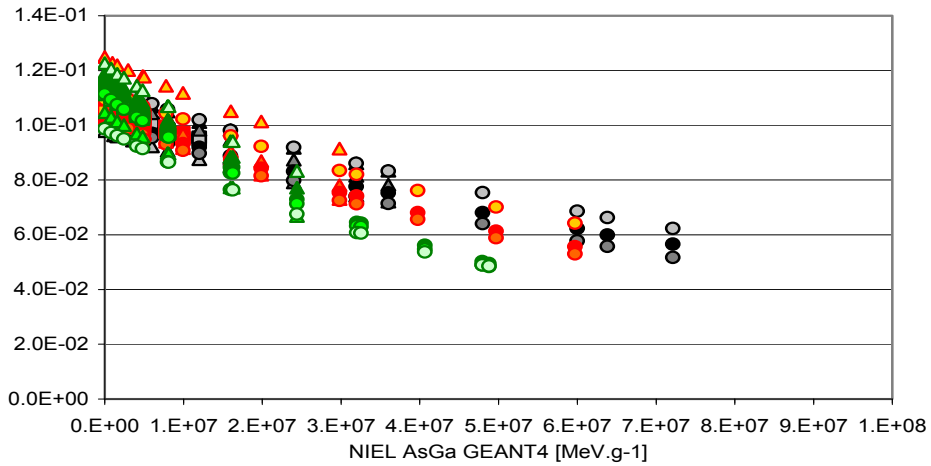


Fig. 13-3: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

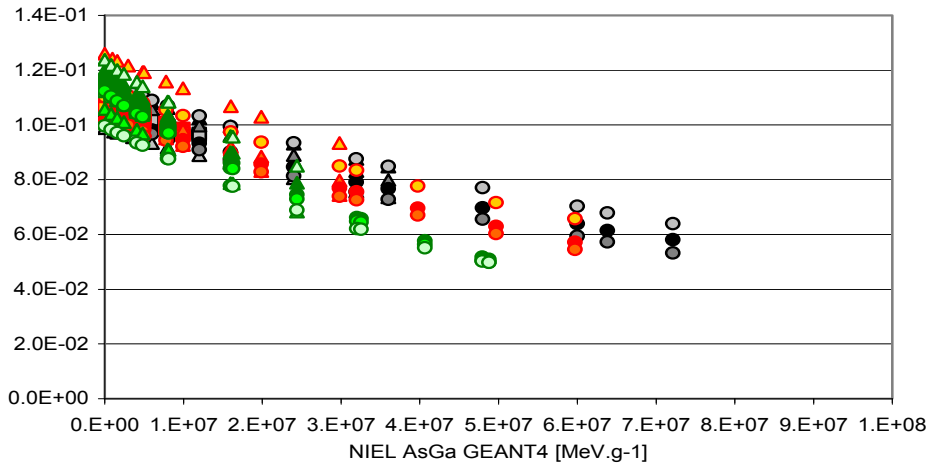
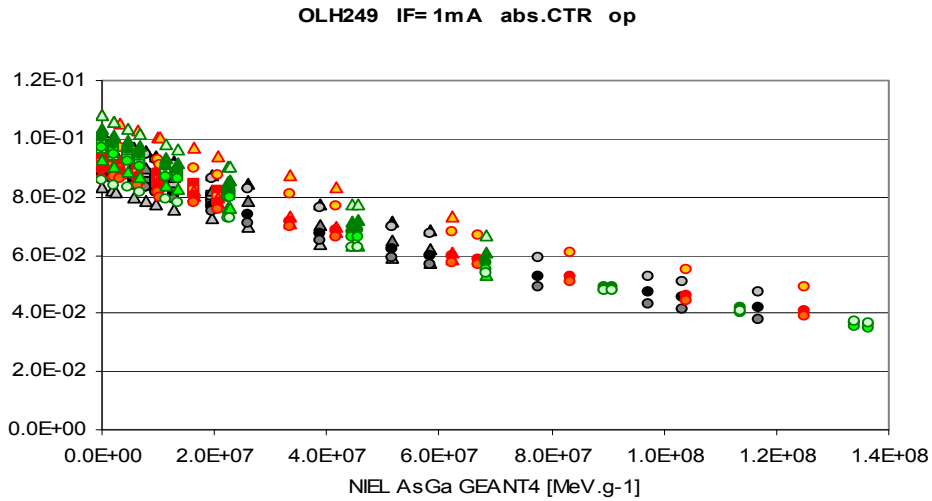
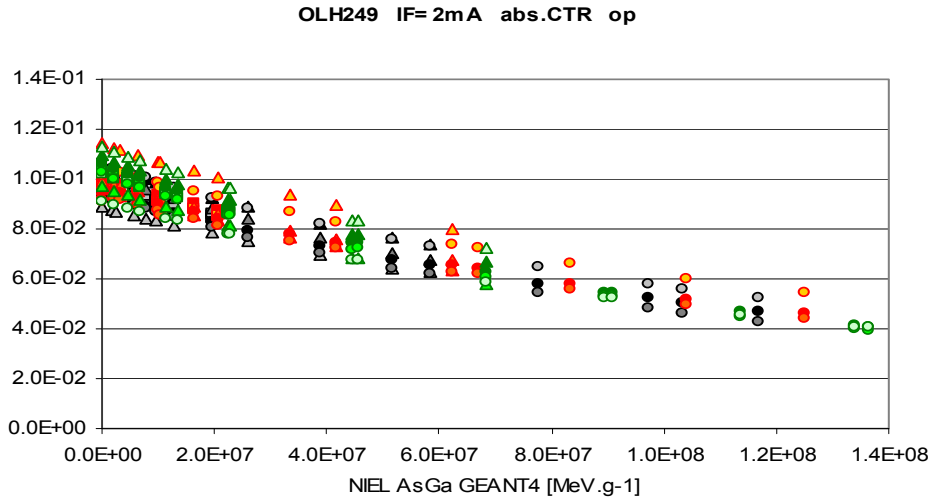
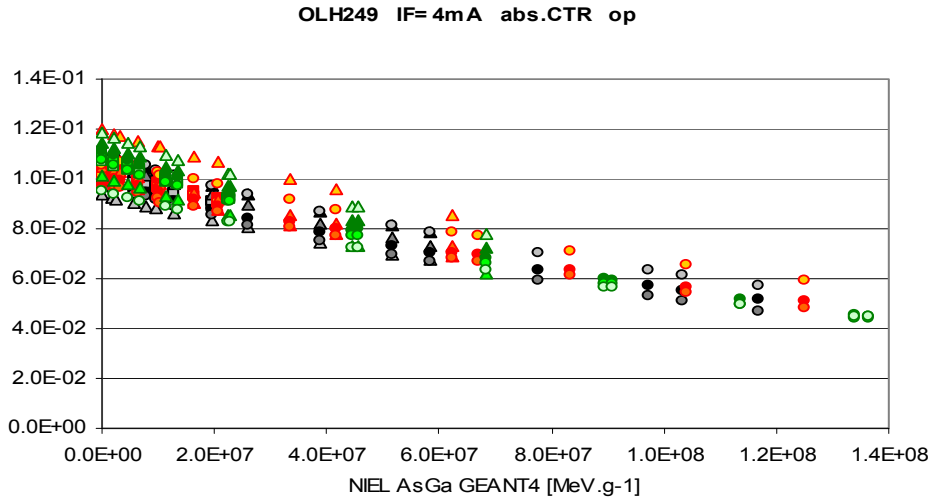


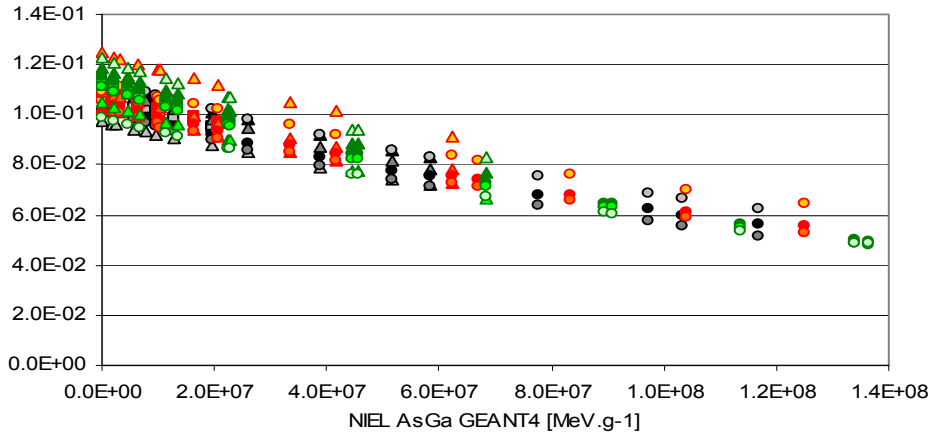
Fig. 13-4: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

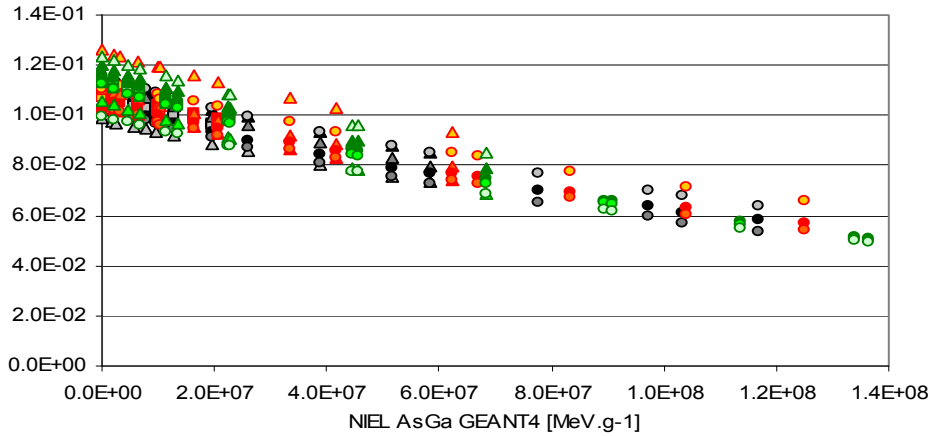
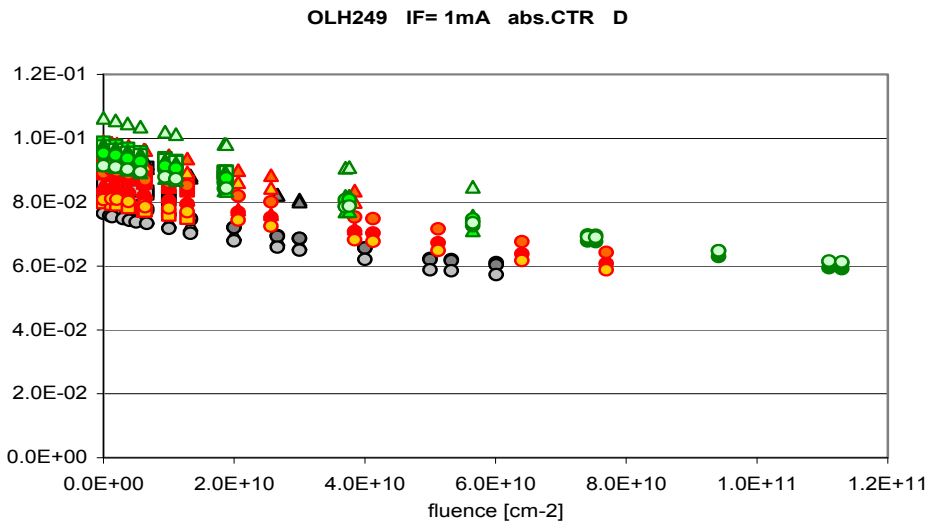
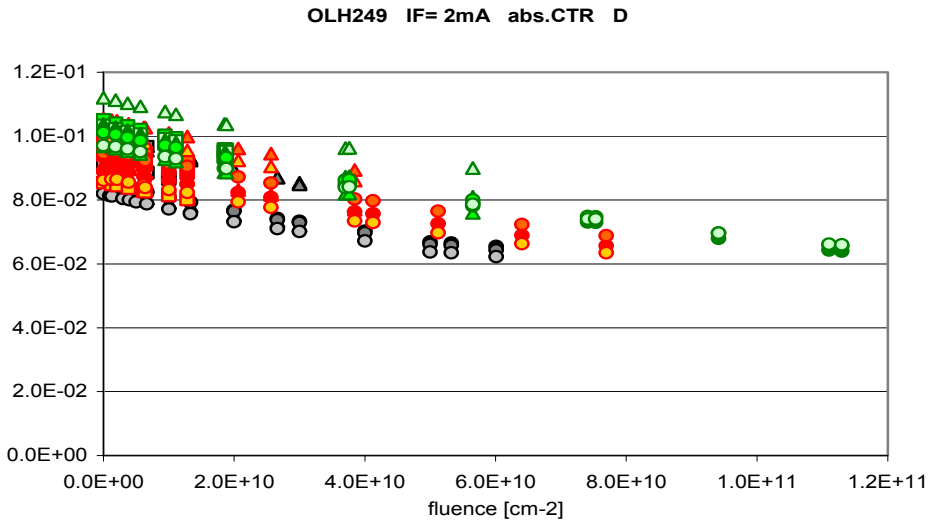
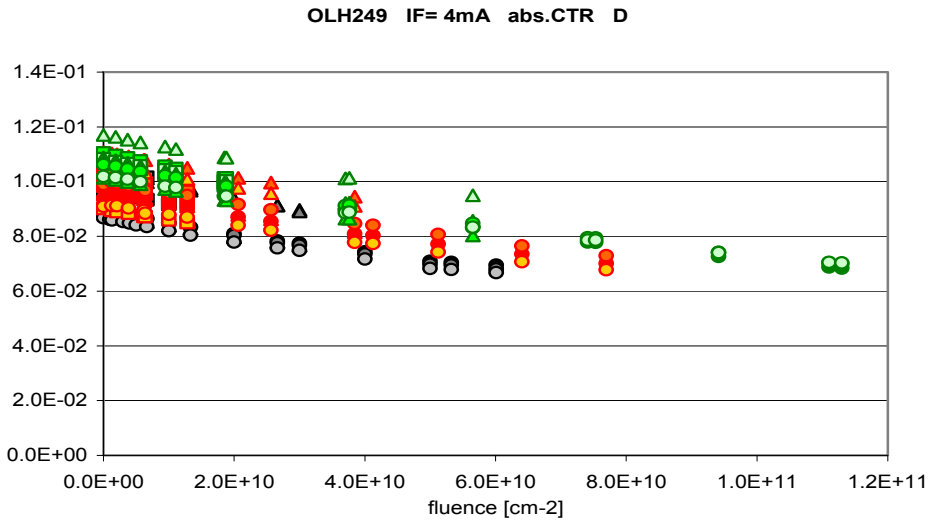


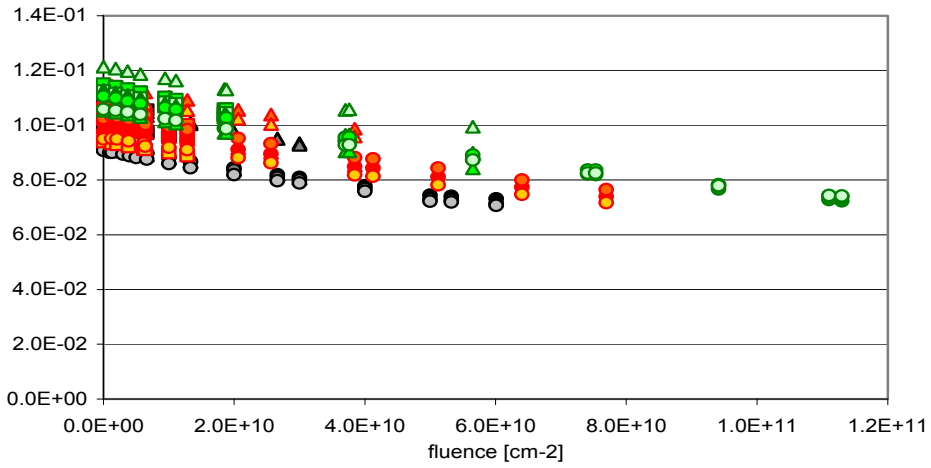
Fig. 13-5: OLH249 diode: CTR at IF= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

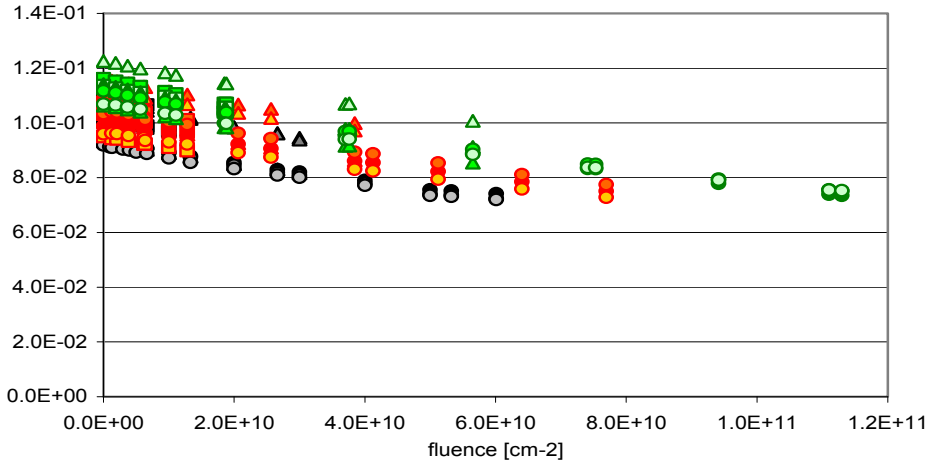
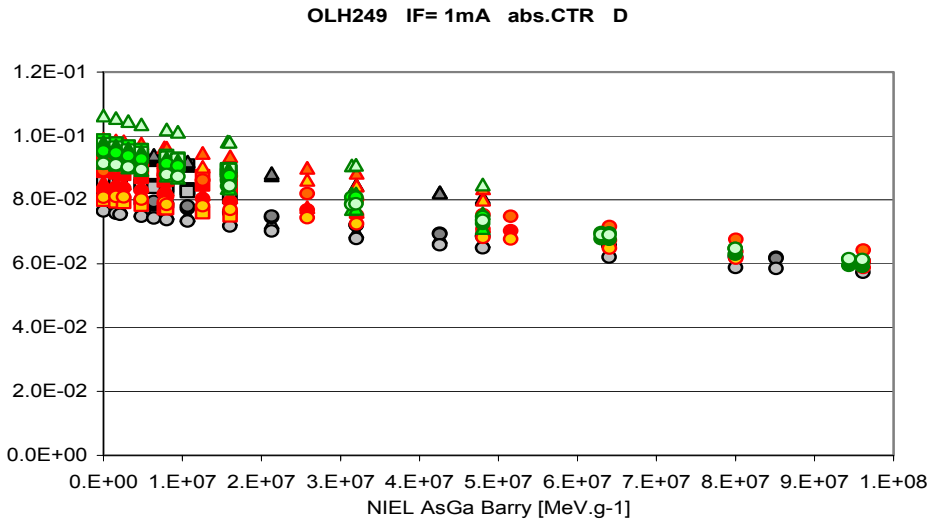
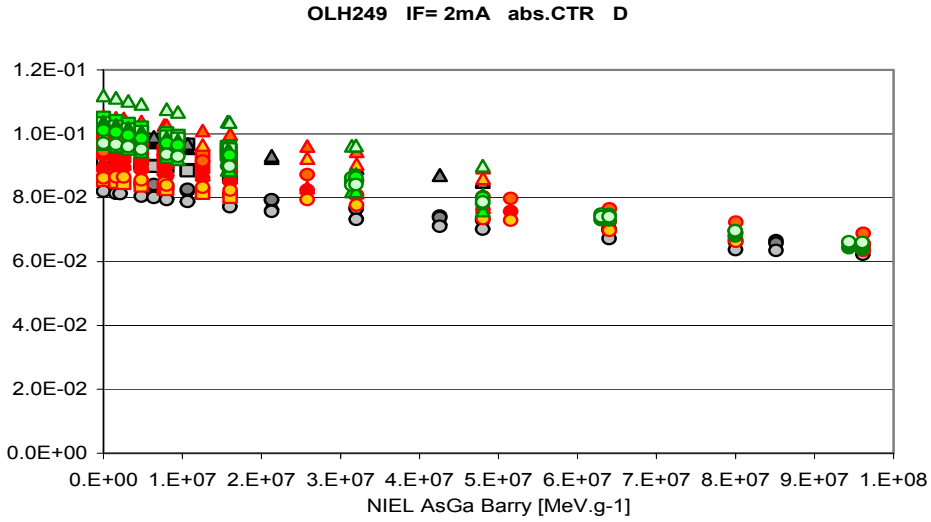
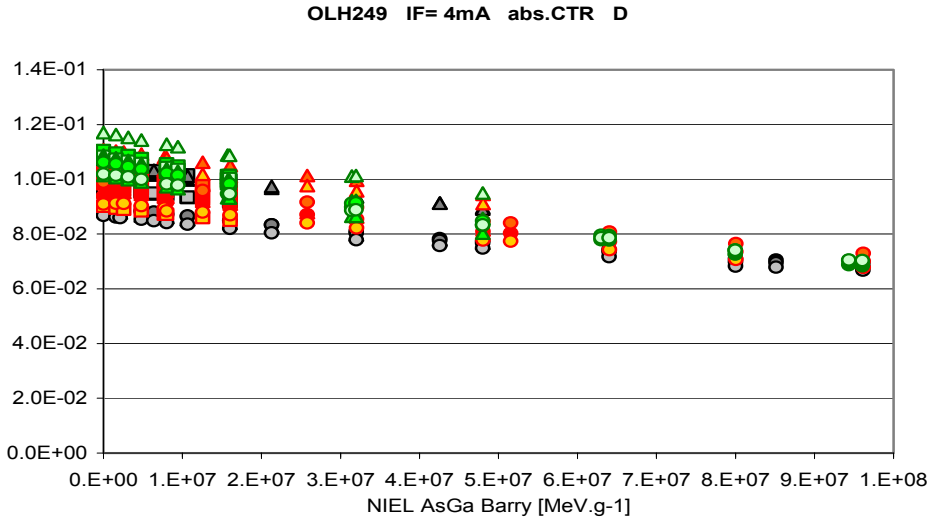


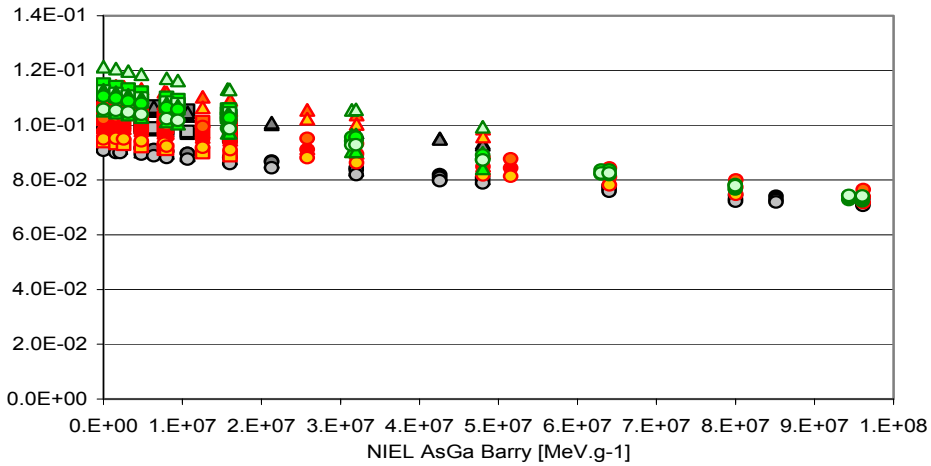
Fig. 13-6: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

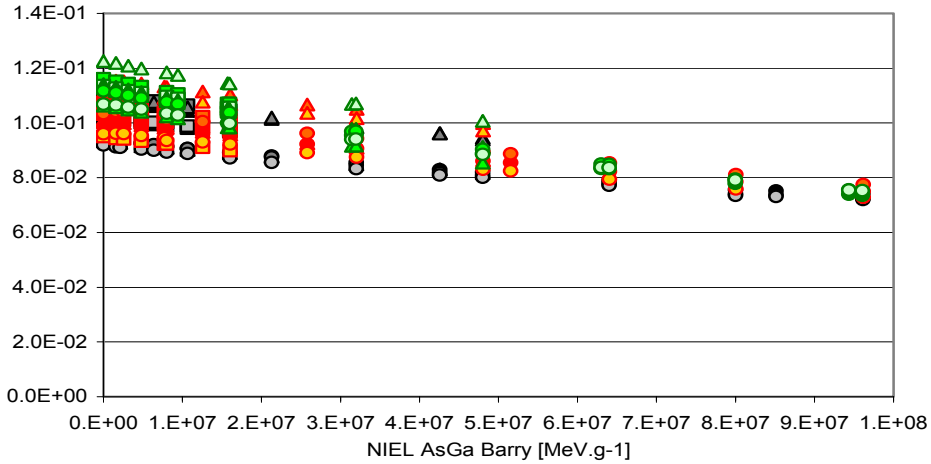
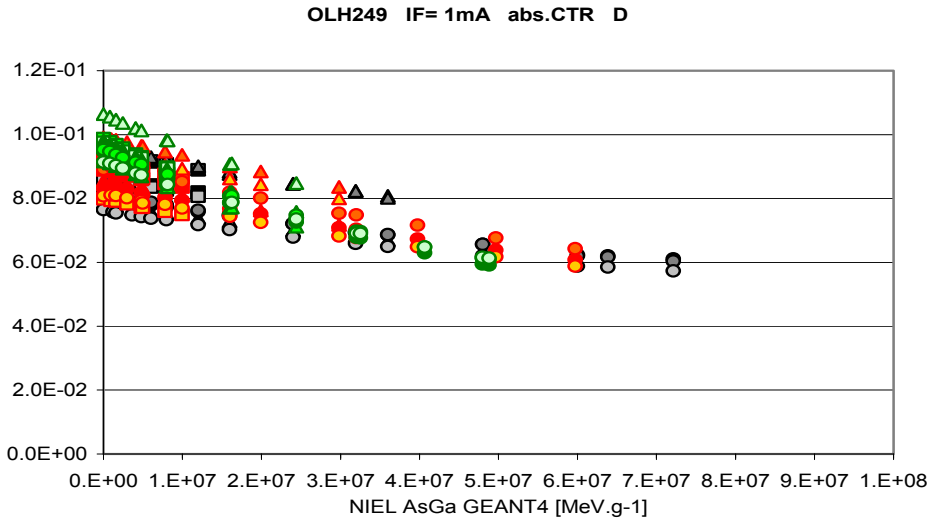
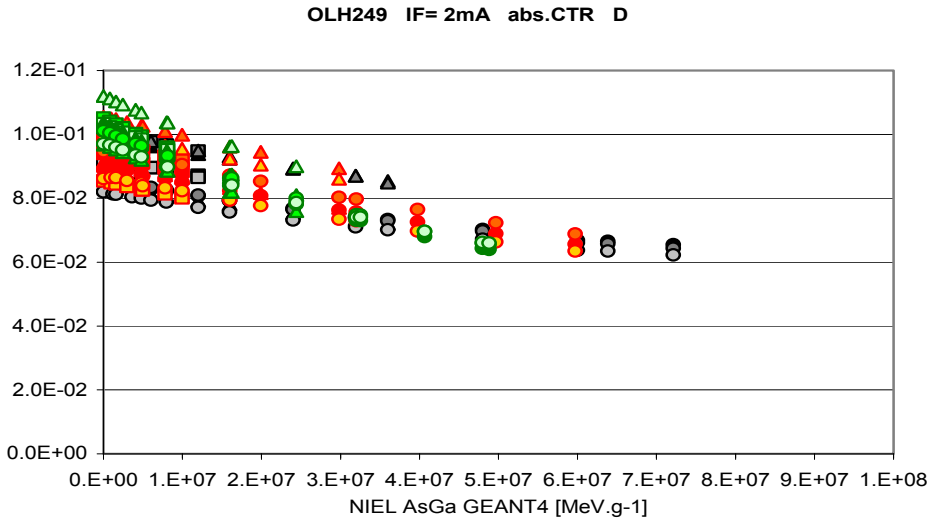
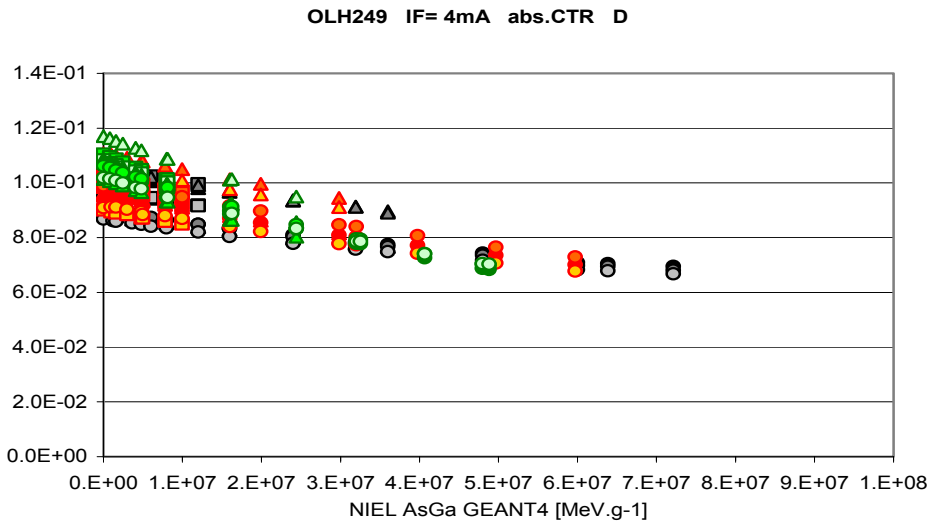


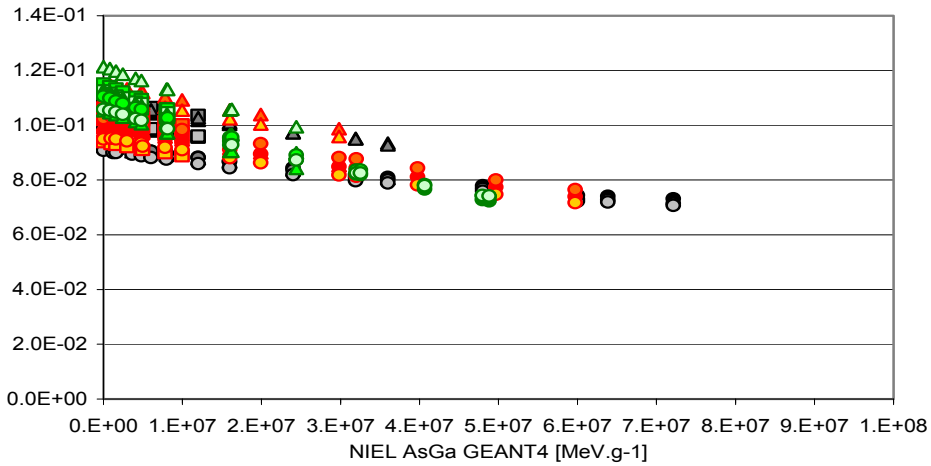
Fig. 13-7: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

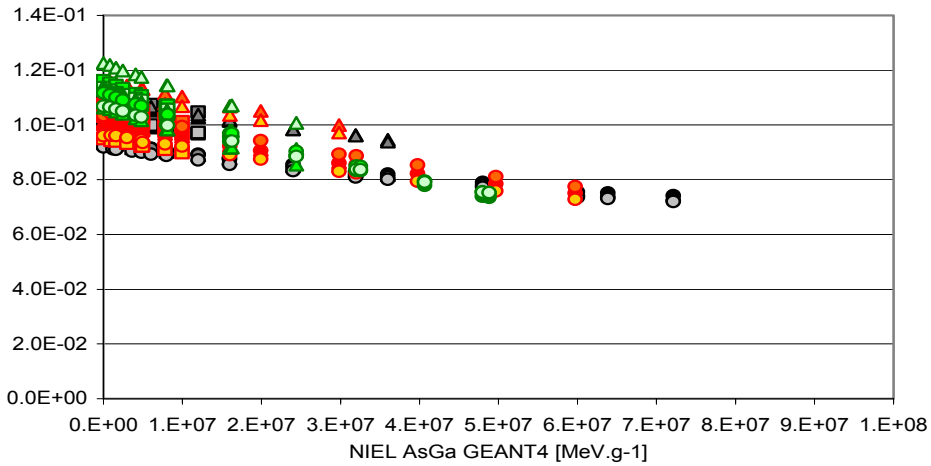
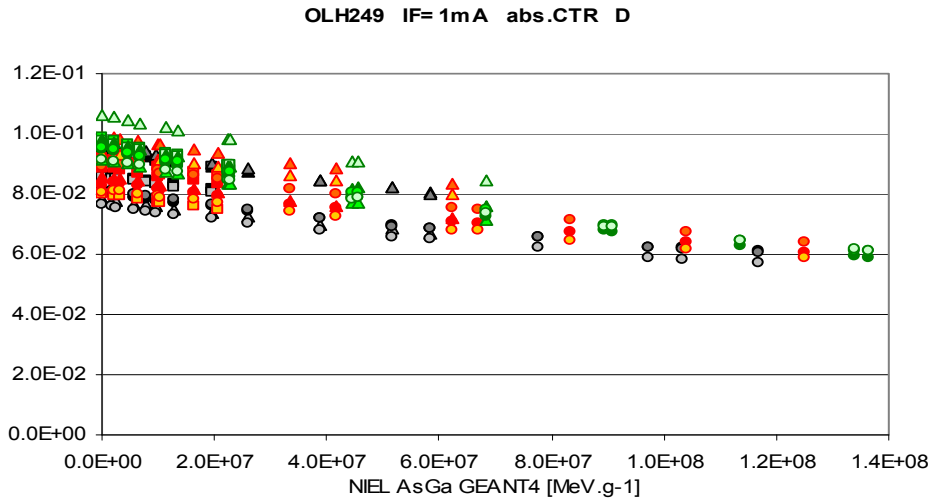
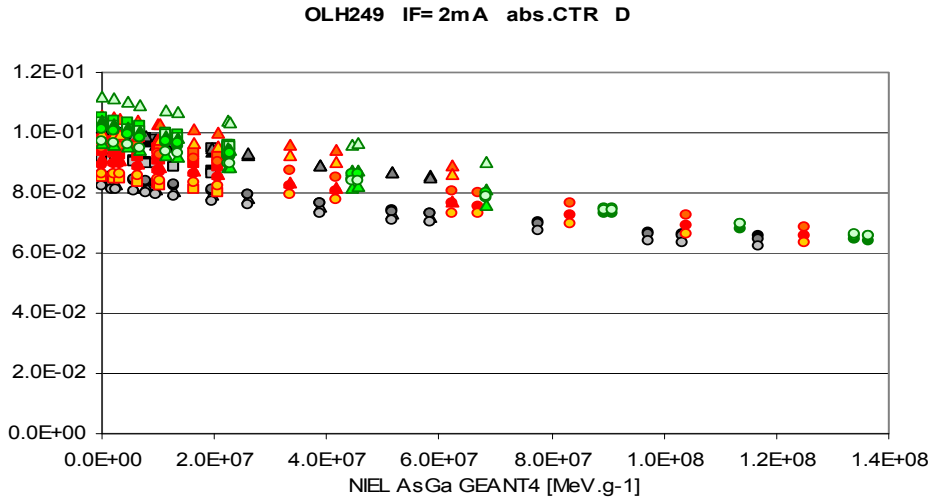
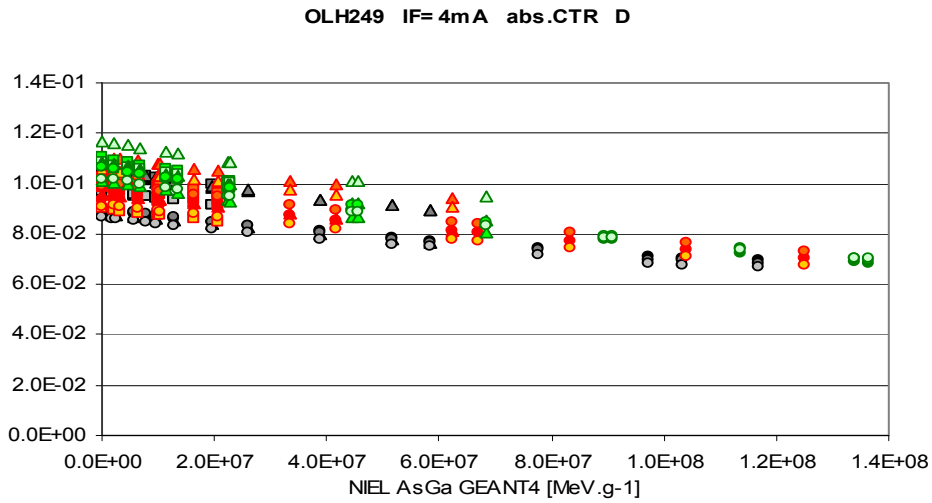


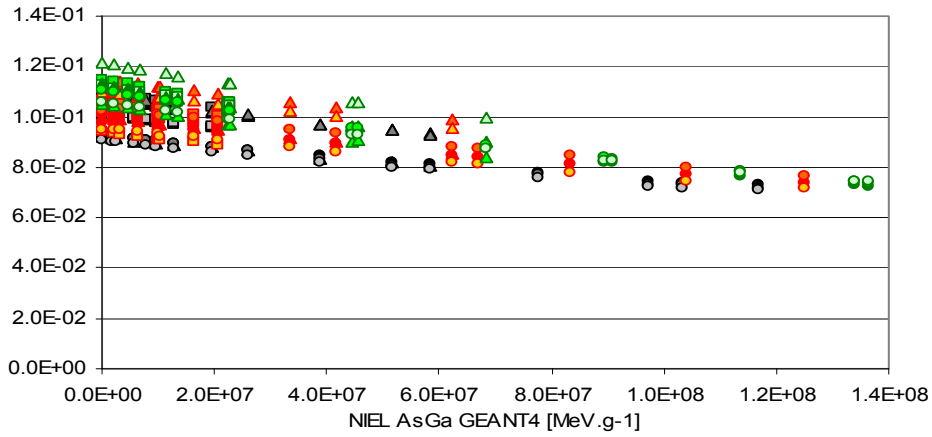
Fig. 13-8: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

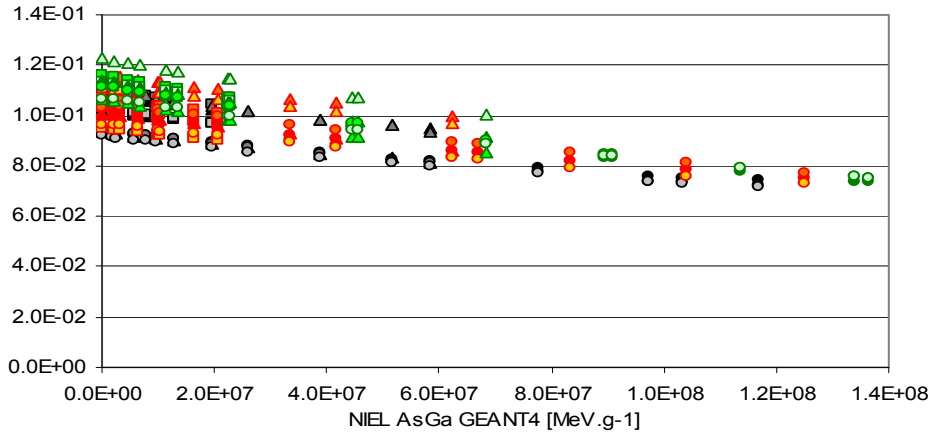
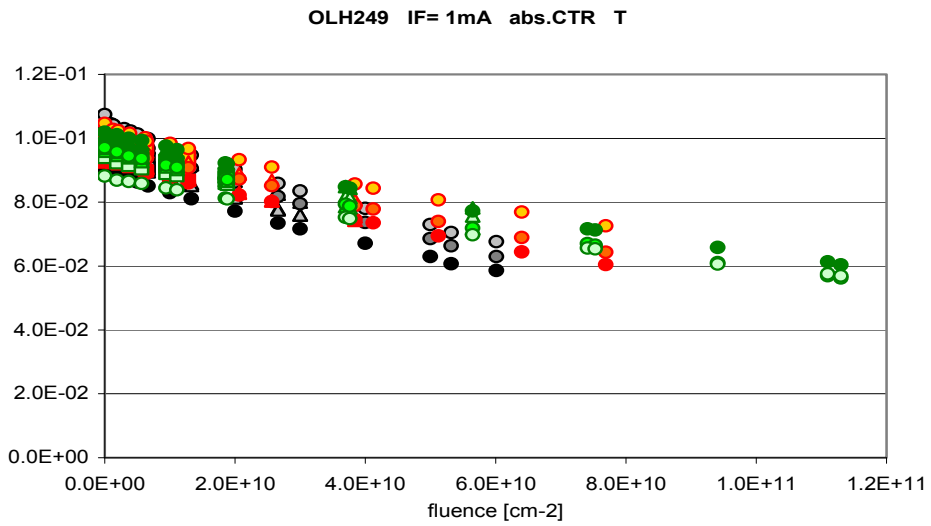
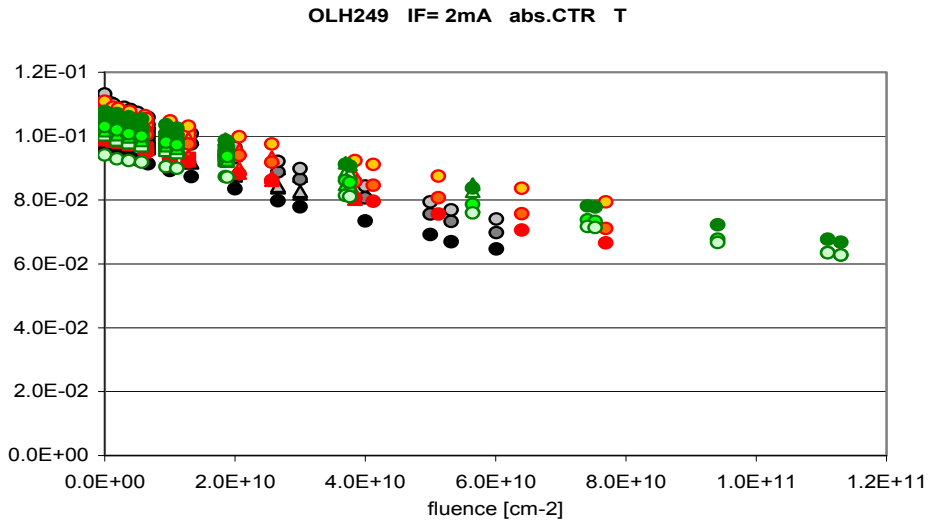
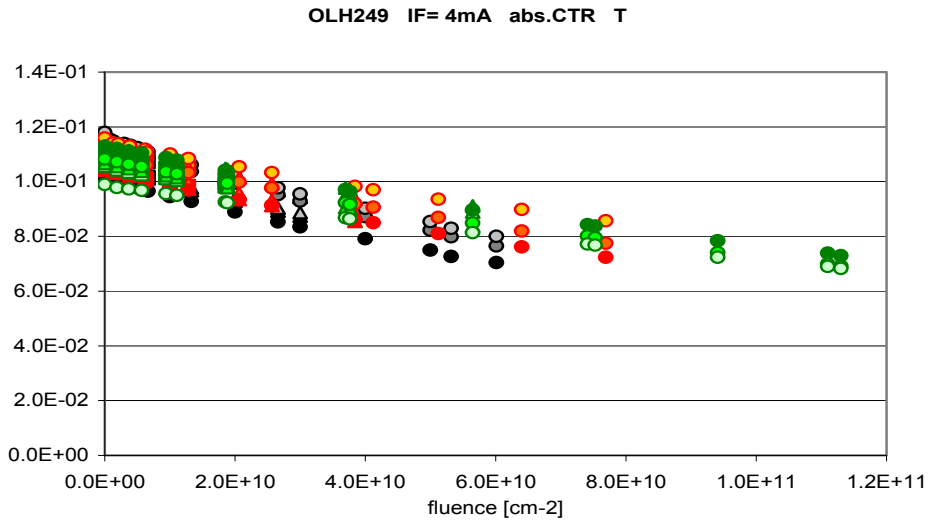


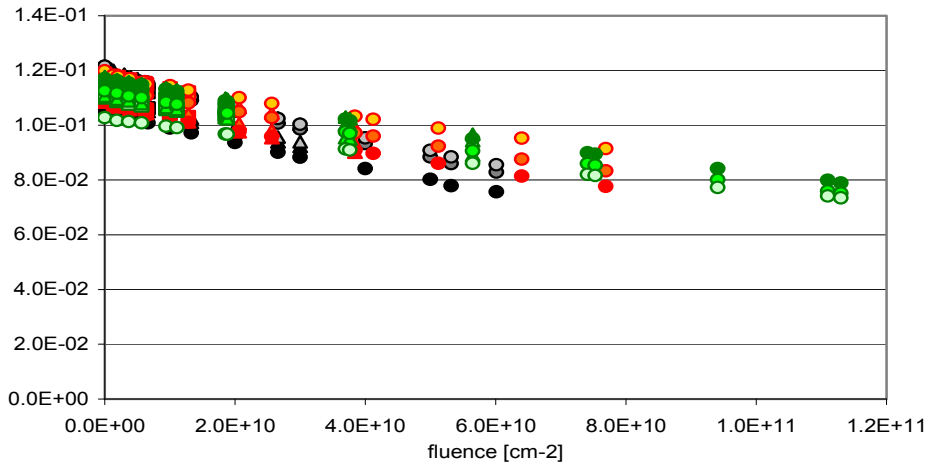
Fig. 13-9: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA abs.CTR T



OLH249 IF= 10mA abs.CTR T

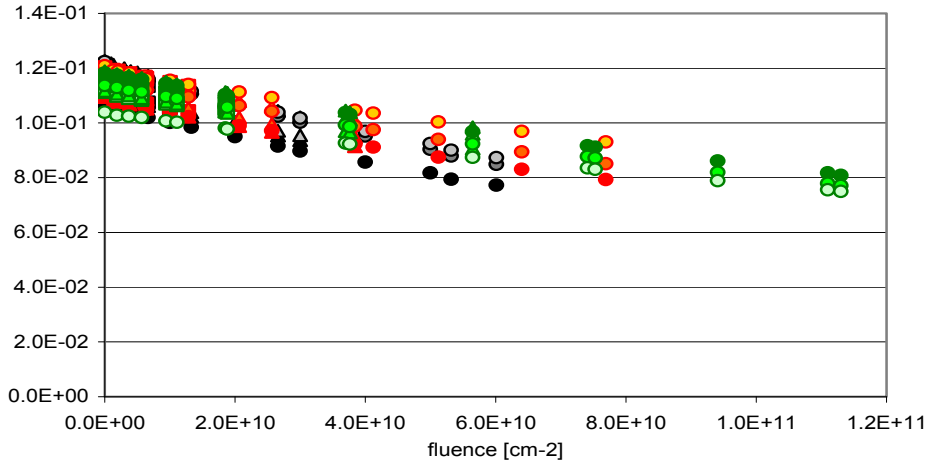
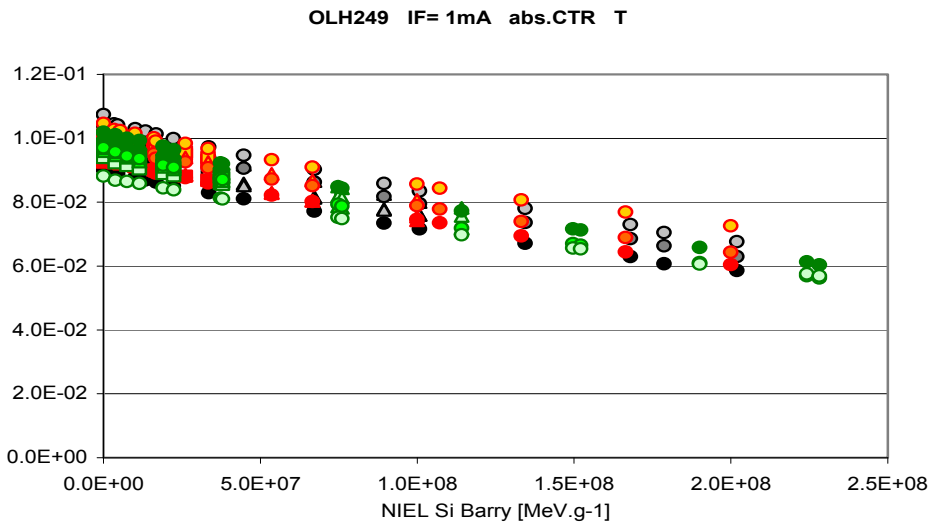
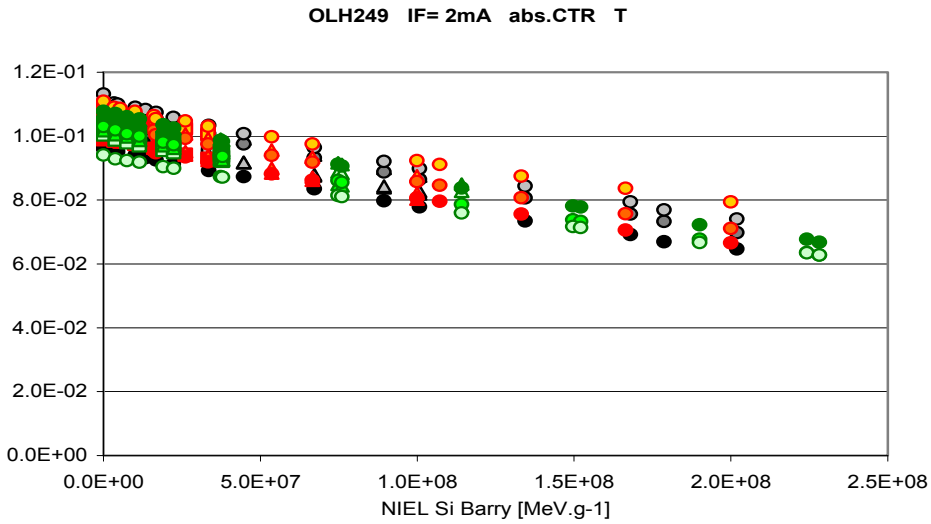
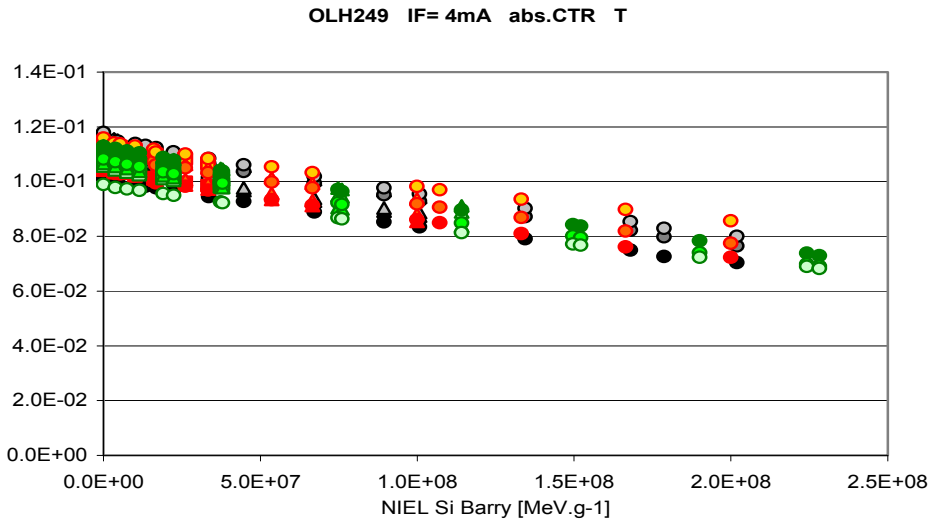
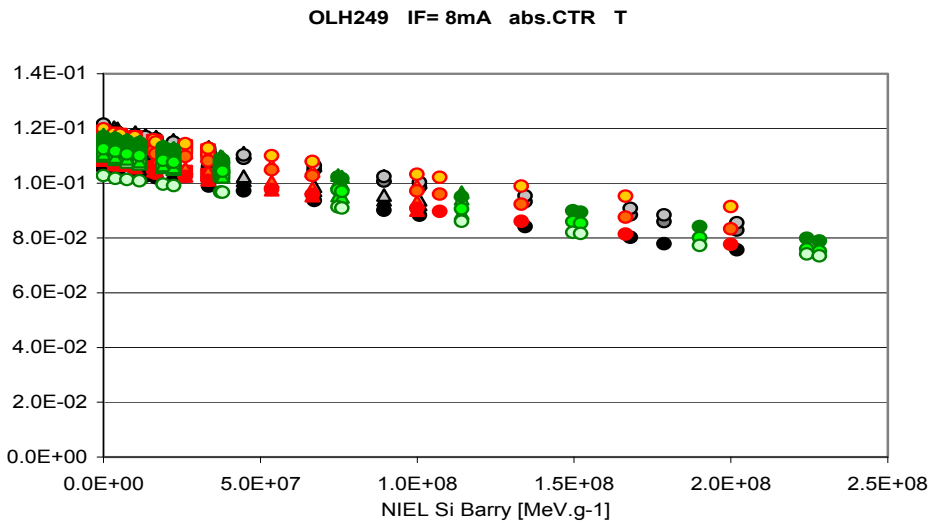


Fig. 13-10: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)








OLH249 IF= 8mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

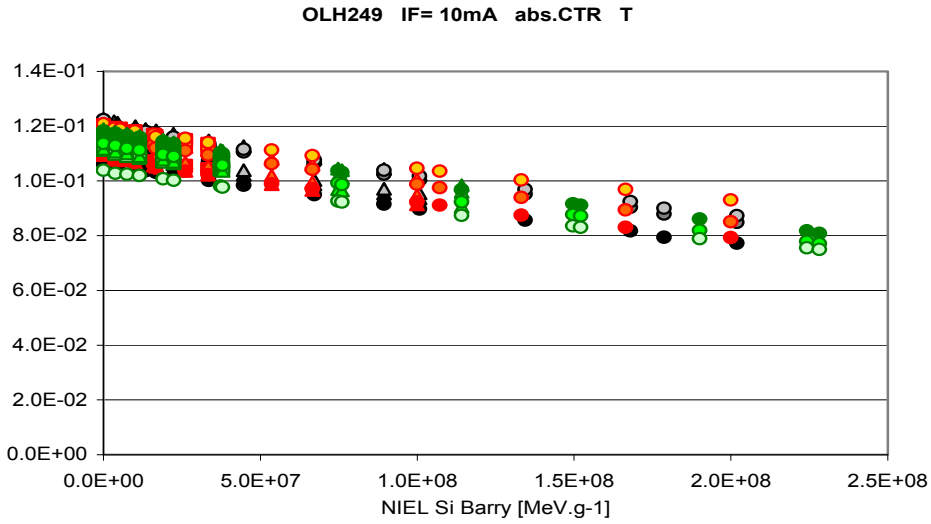
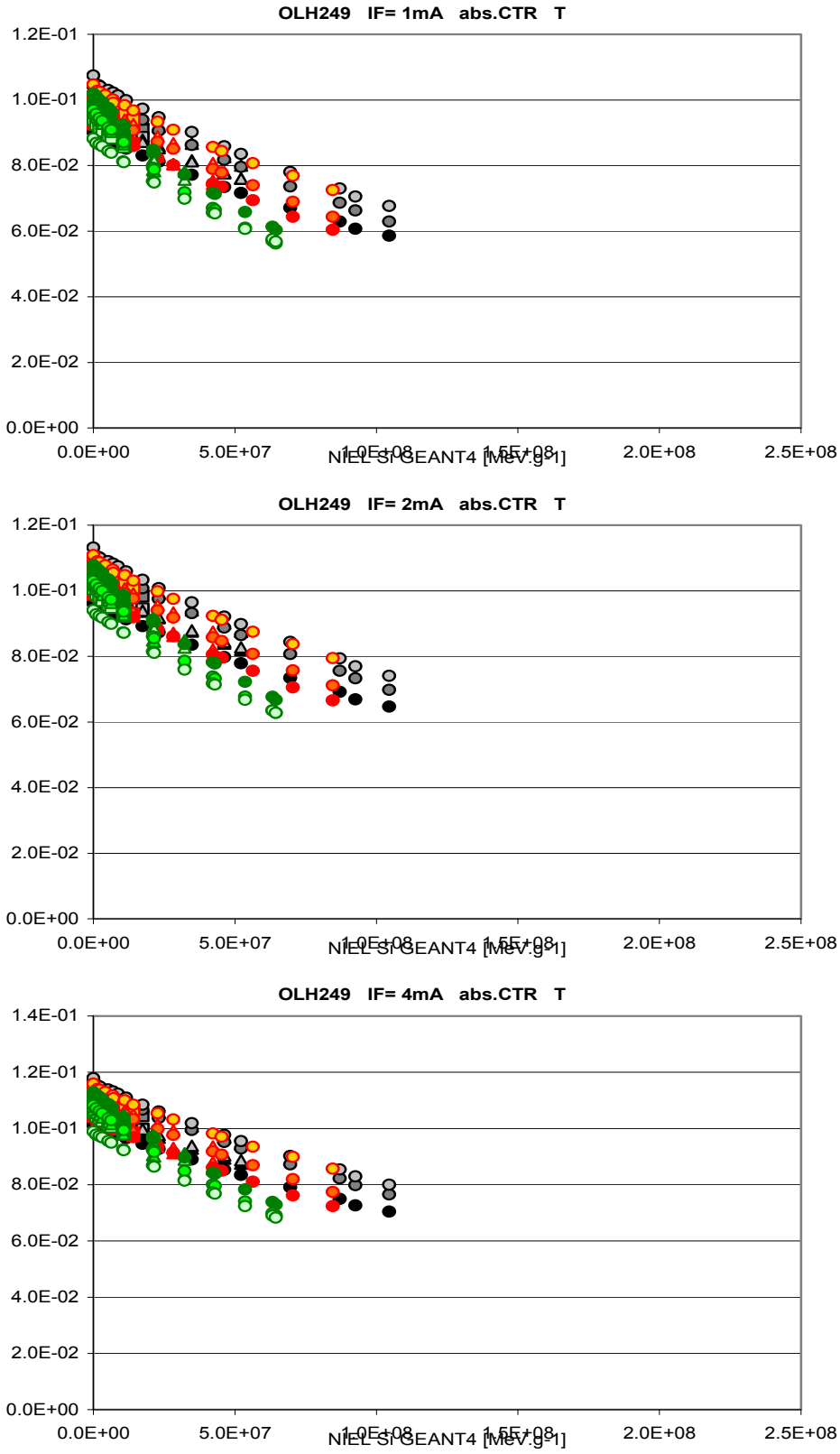
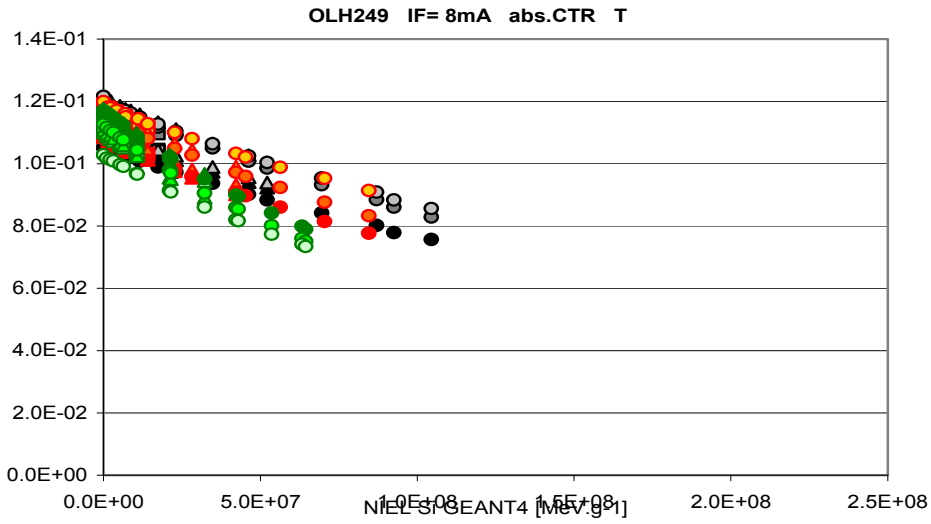

OLH249 IF= 10mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 13-11: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




OLH249 IF= 8mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

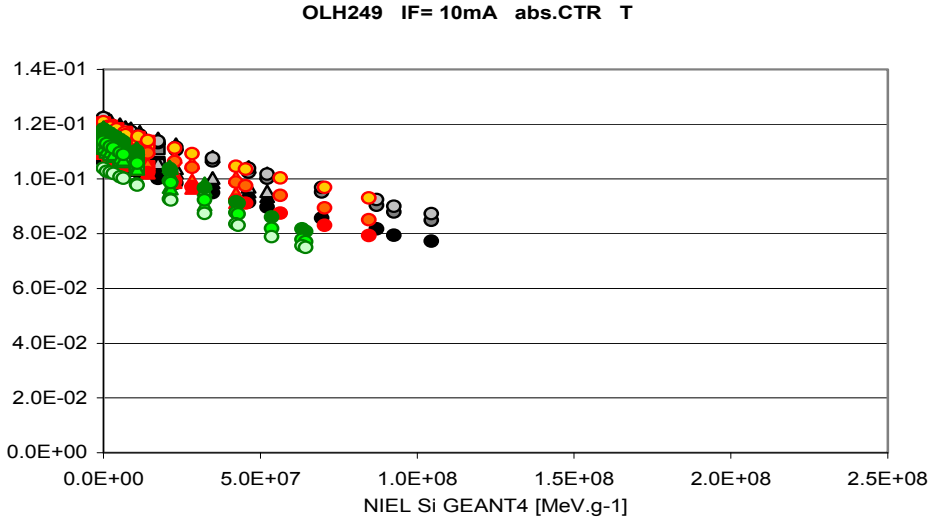
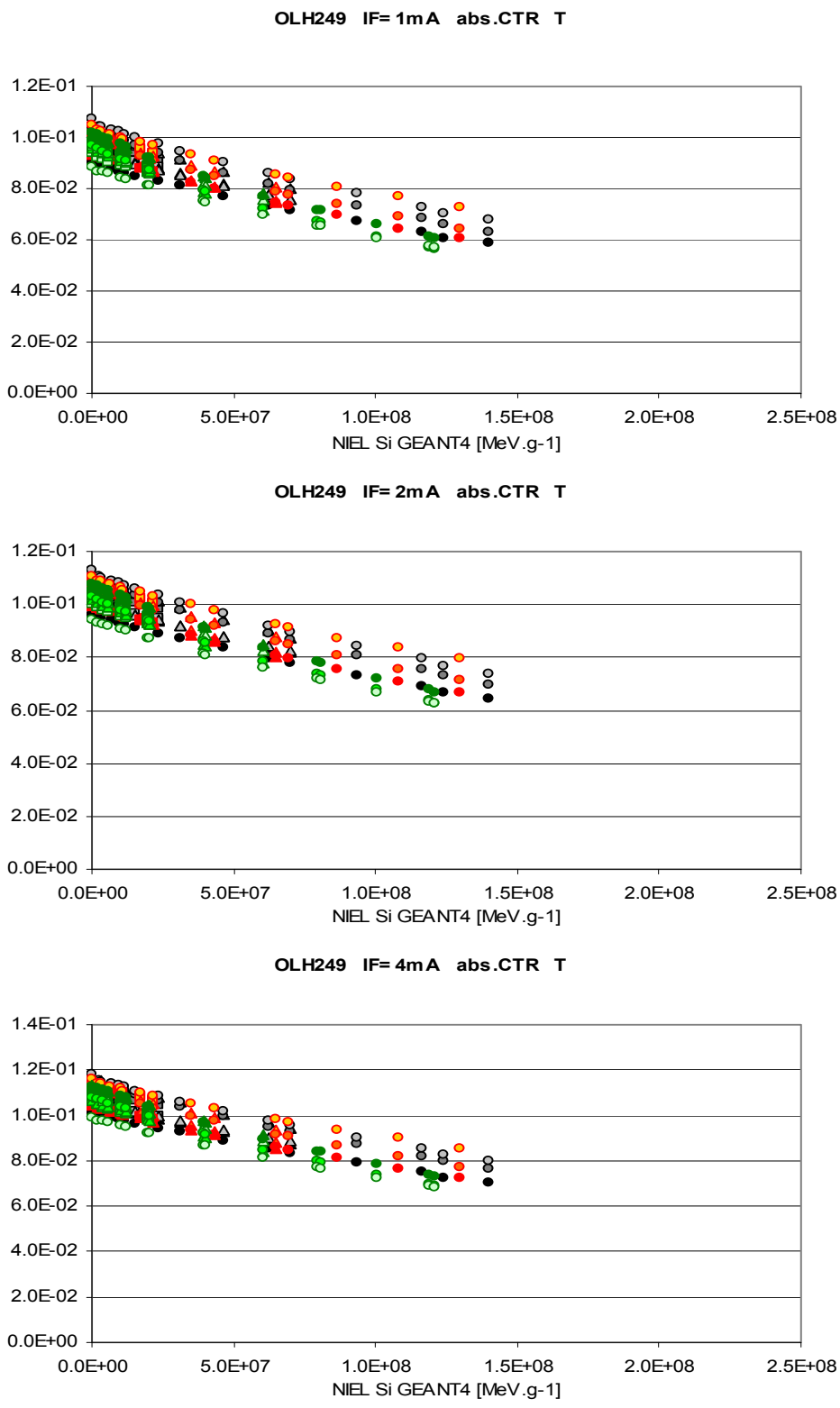
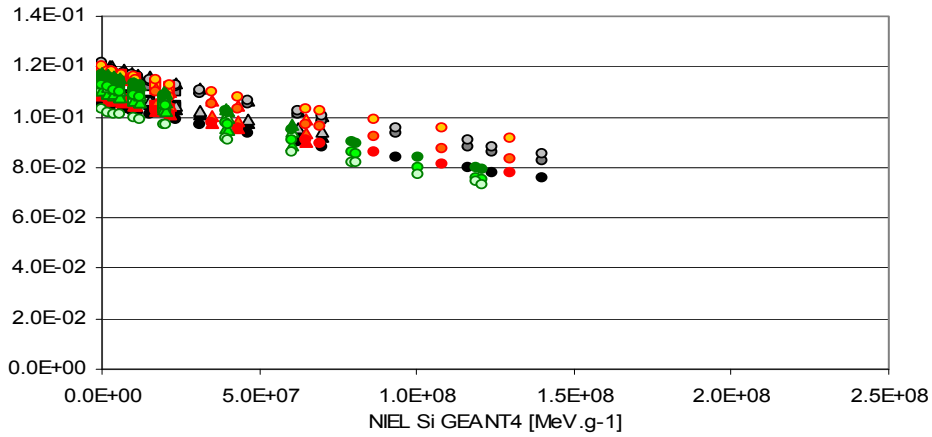

OLH249 IF= 10mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-12: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)



OLH249 IF= 8mA abs.CTR T



OLH249 IF= 10mA abs.CTR T

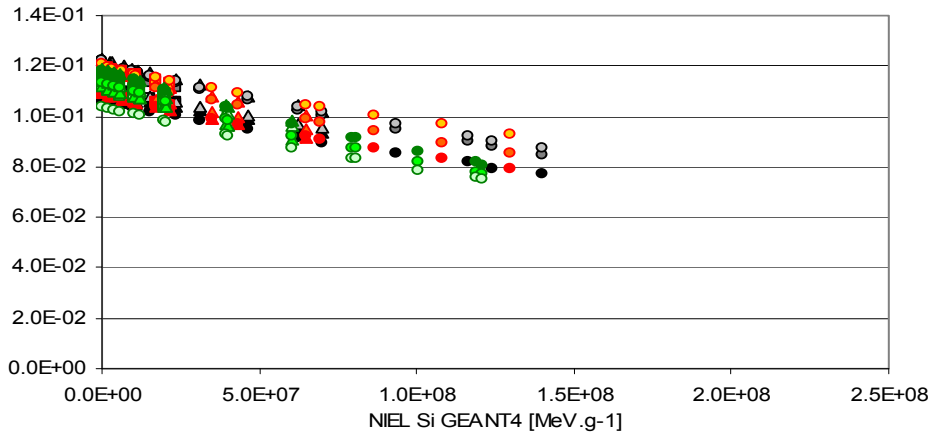
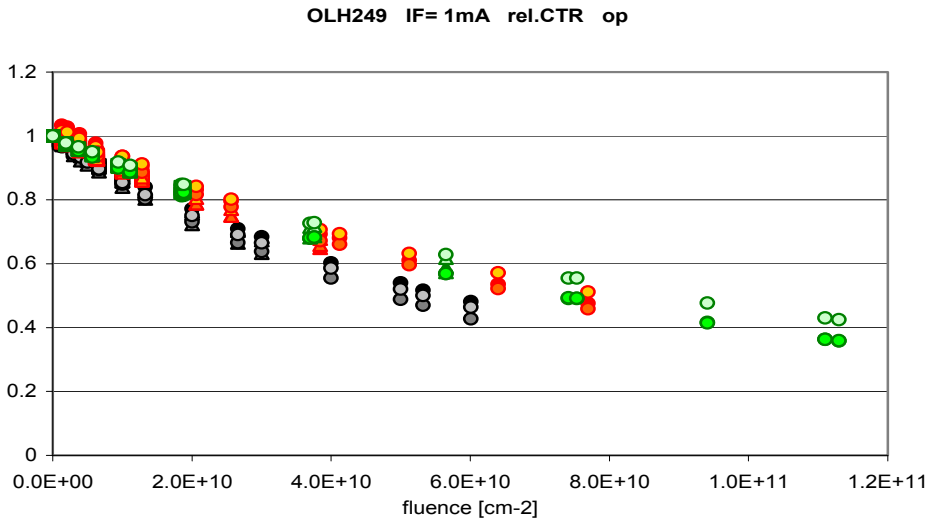
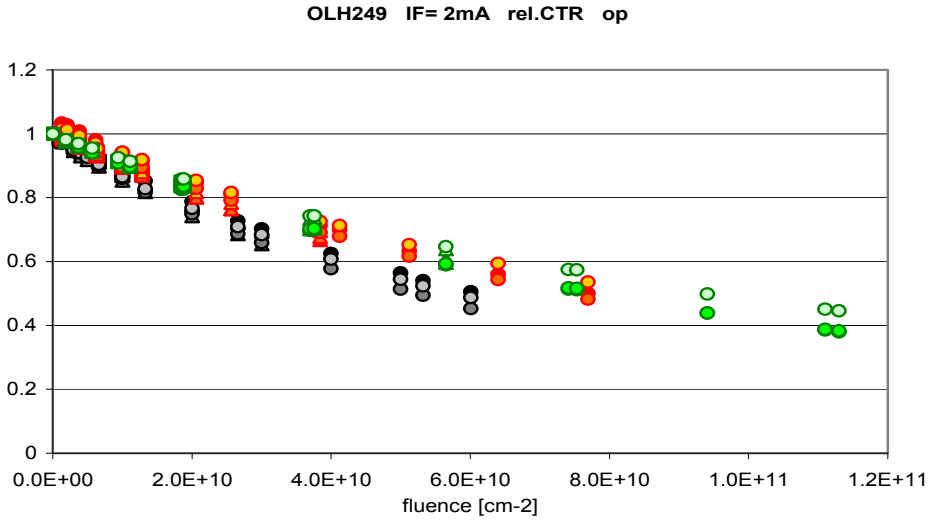
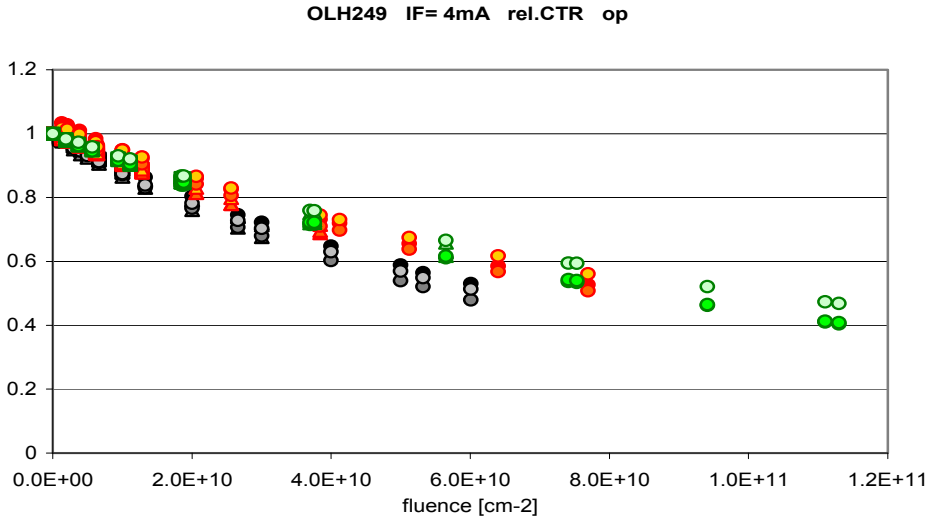


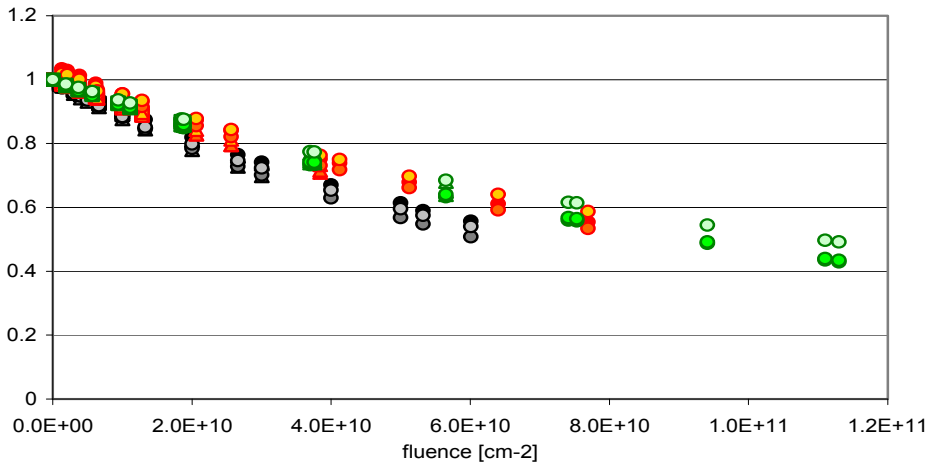
Fig. 13-13: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

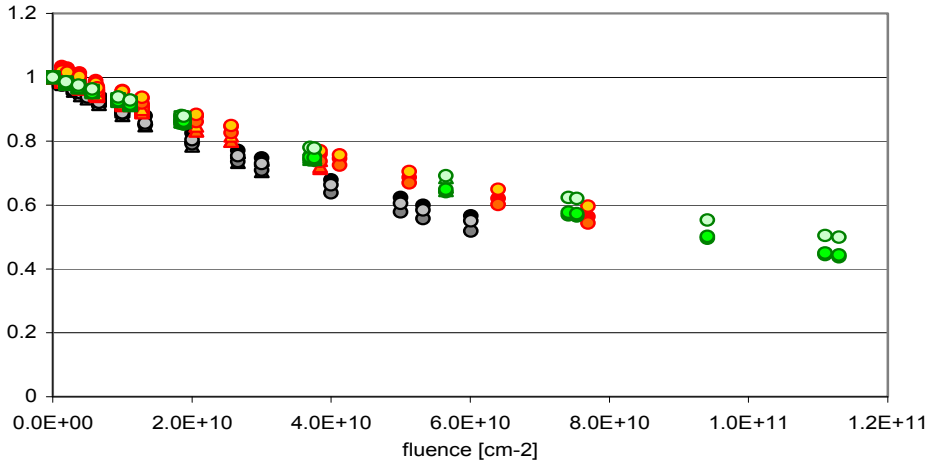
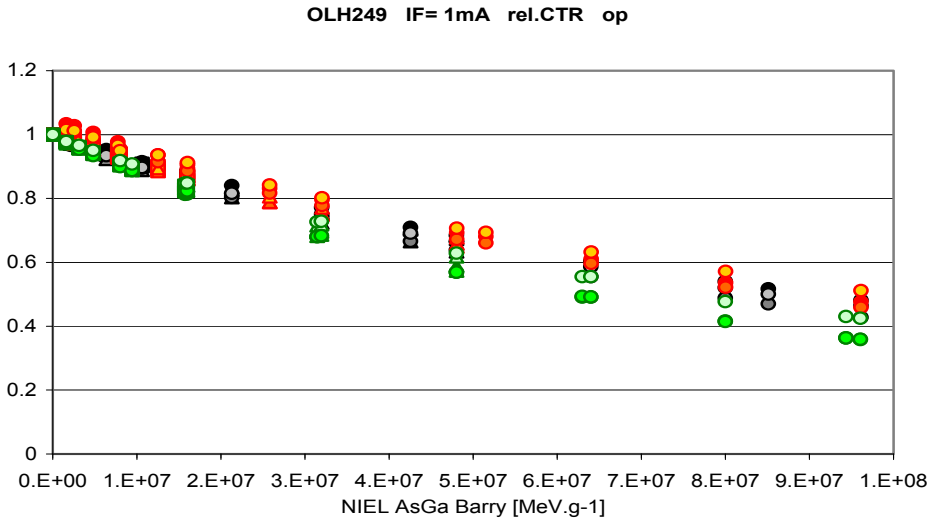
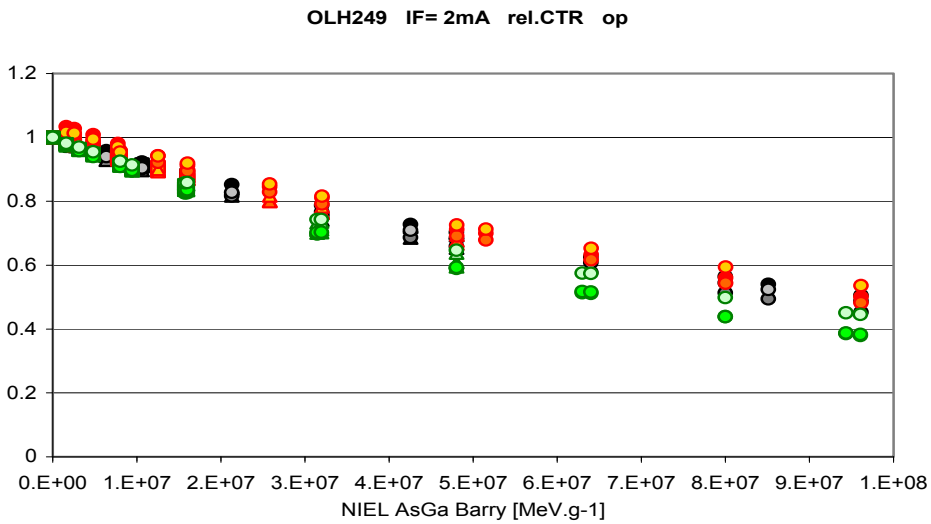
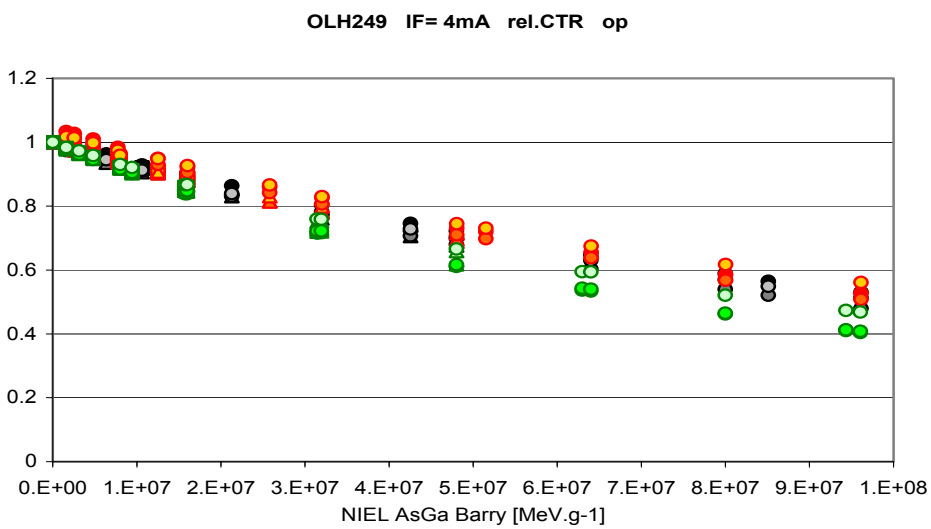


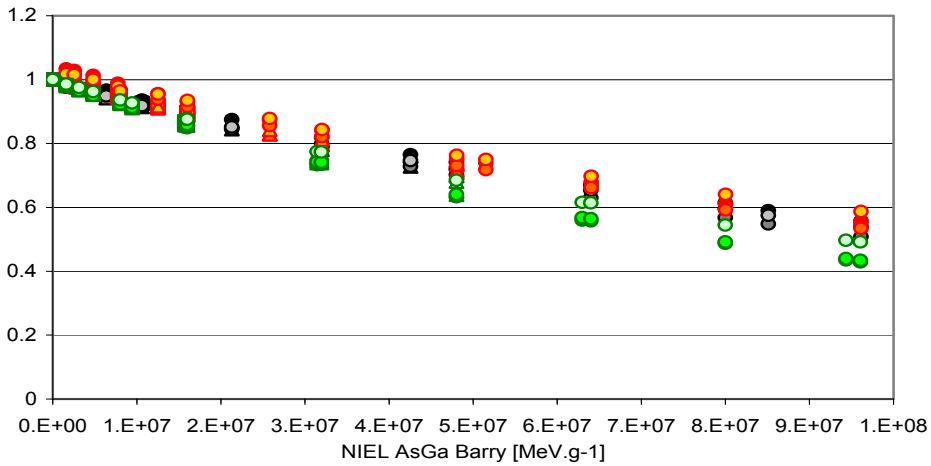
Fig. 13-14: OLH249 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

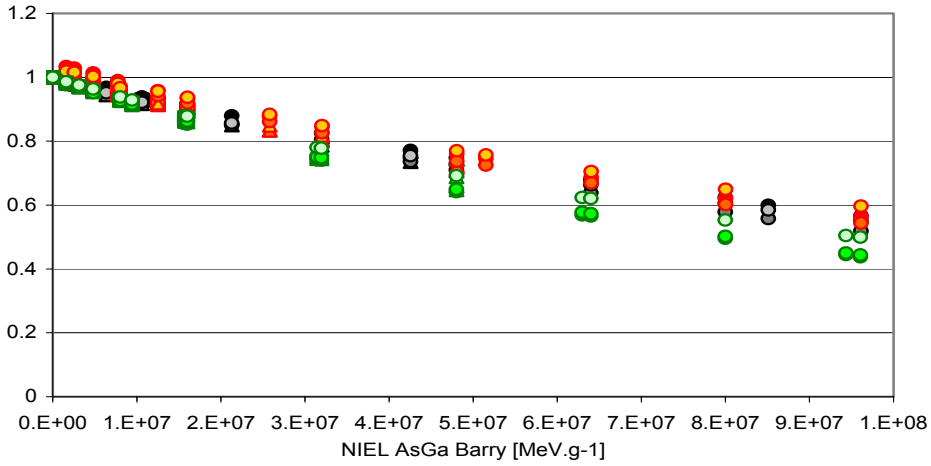
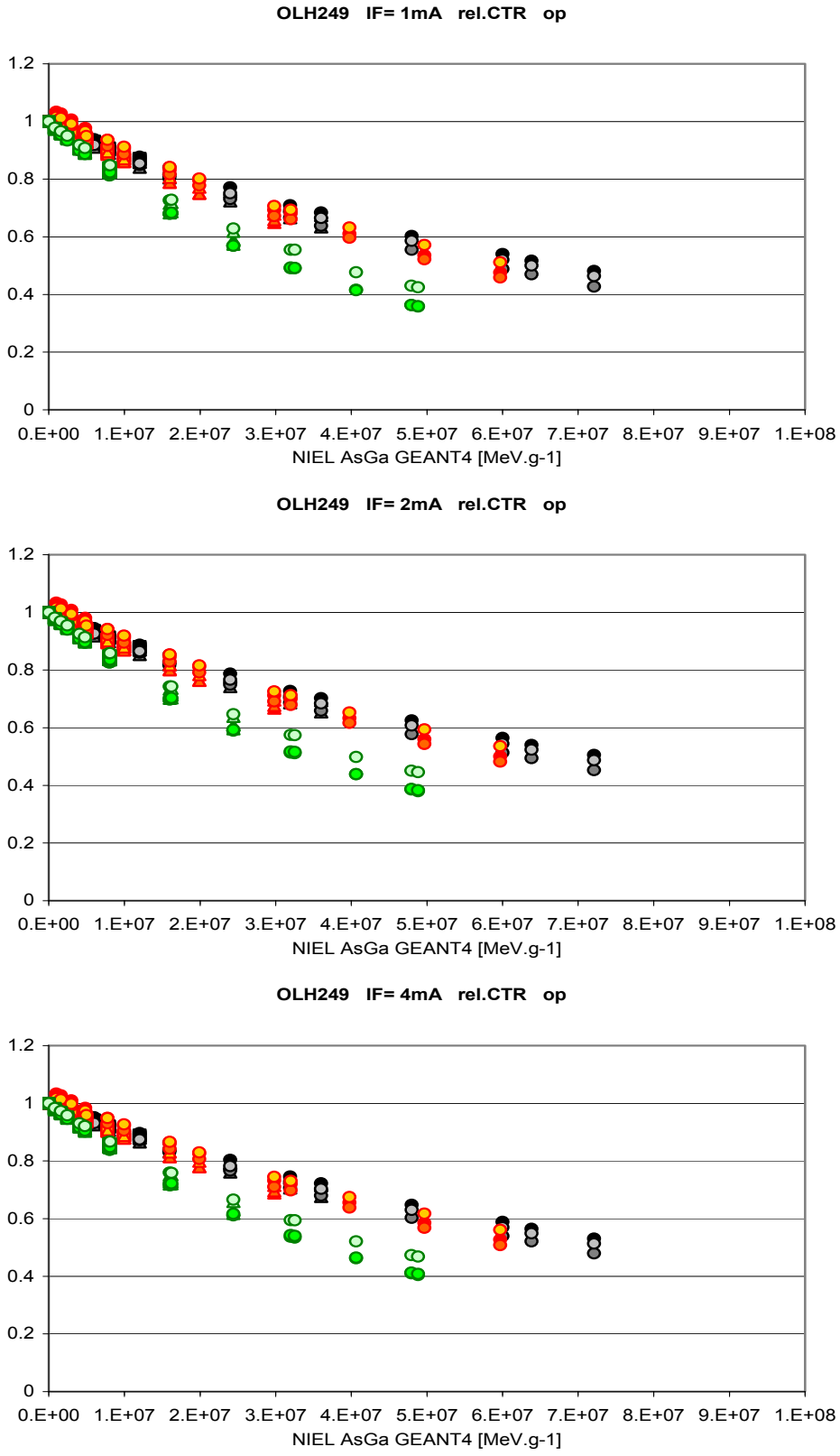
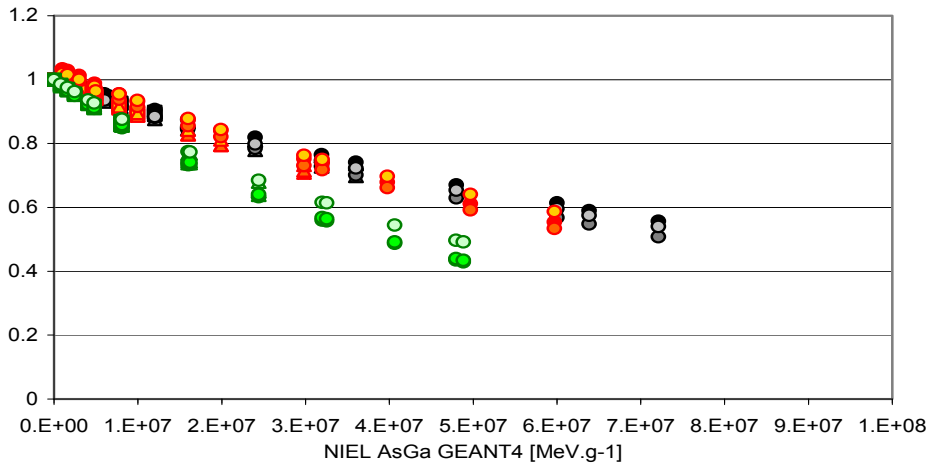


Fig. 13-15: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

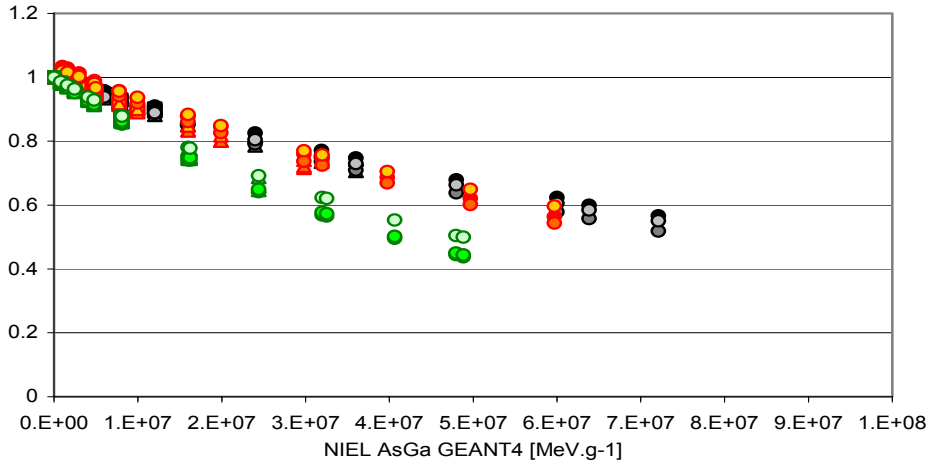
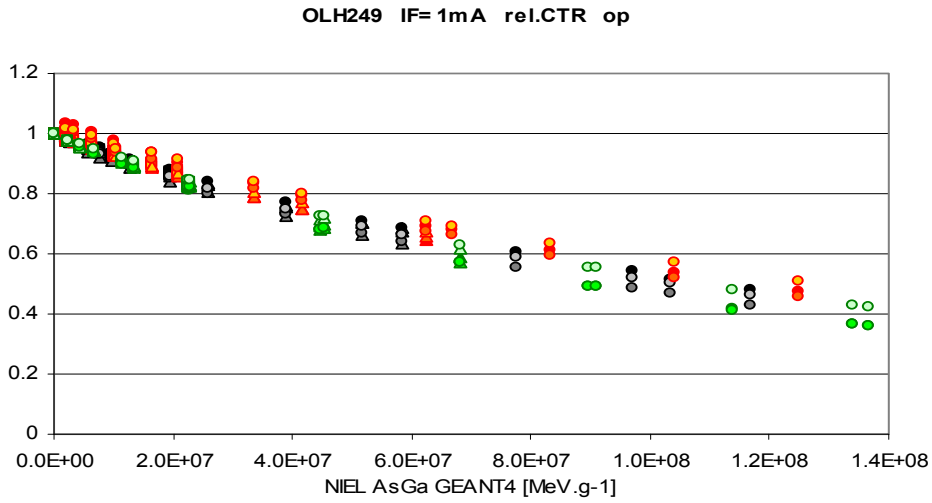
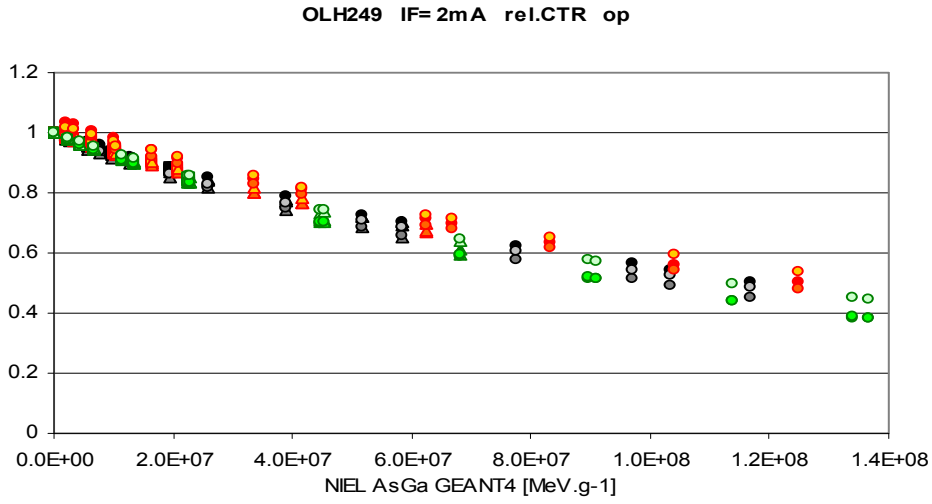
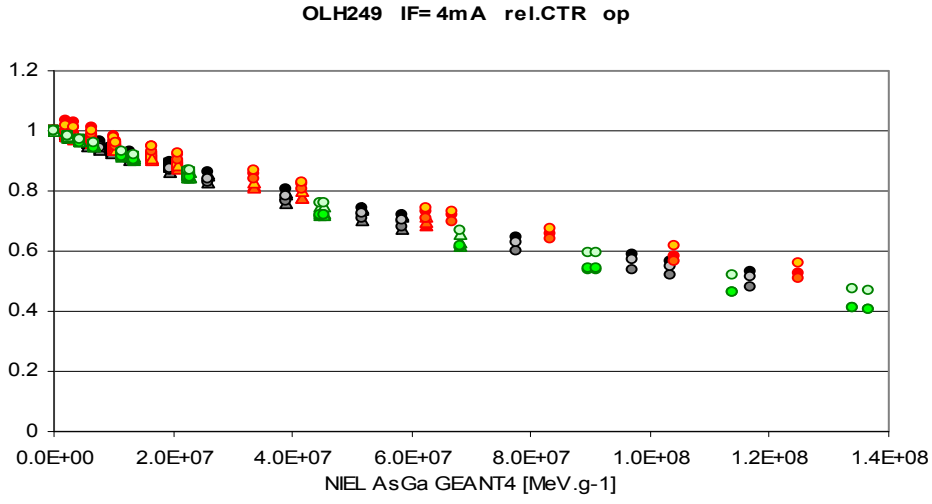
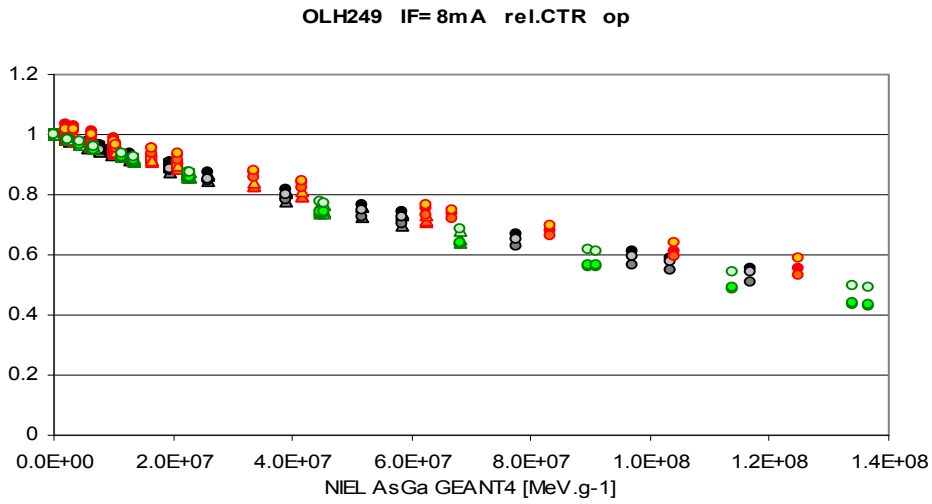


Fig. 13-16: OLH249 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)








OLH249 IF= 8mA rel.CTR op
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

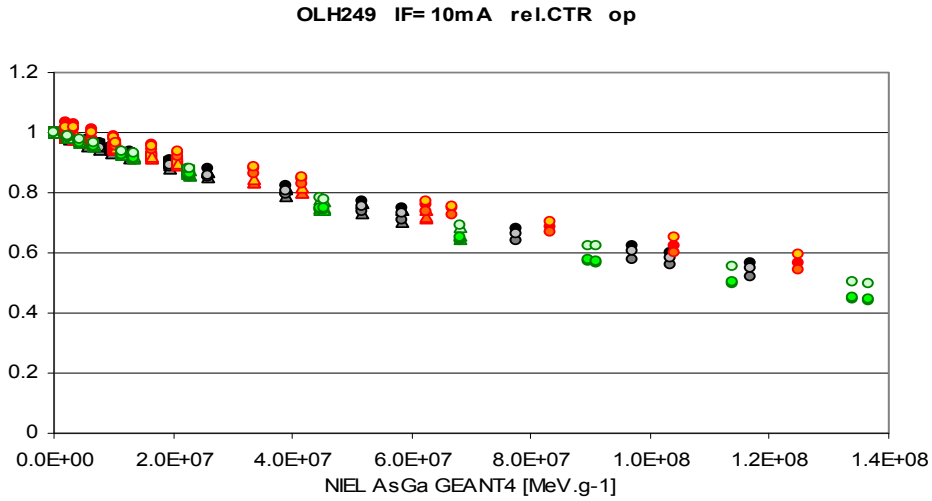
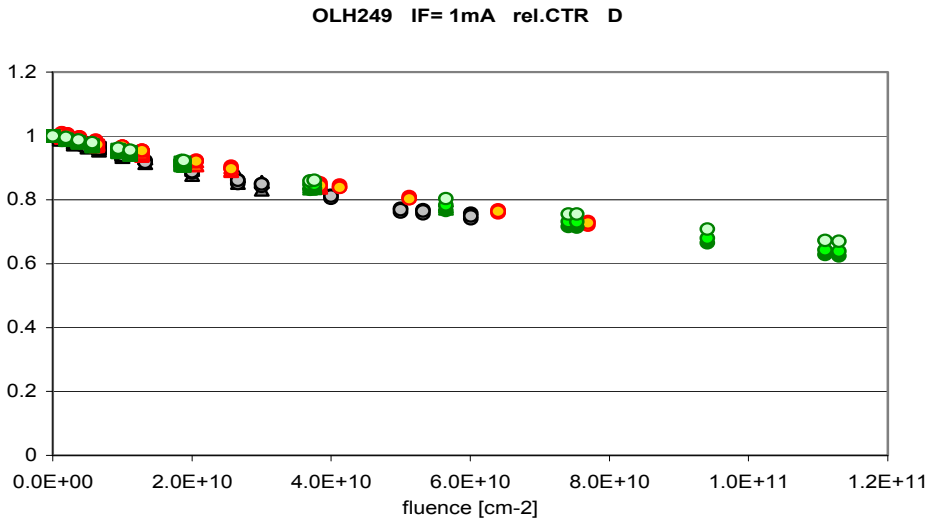
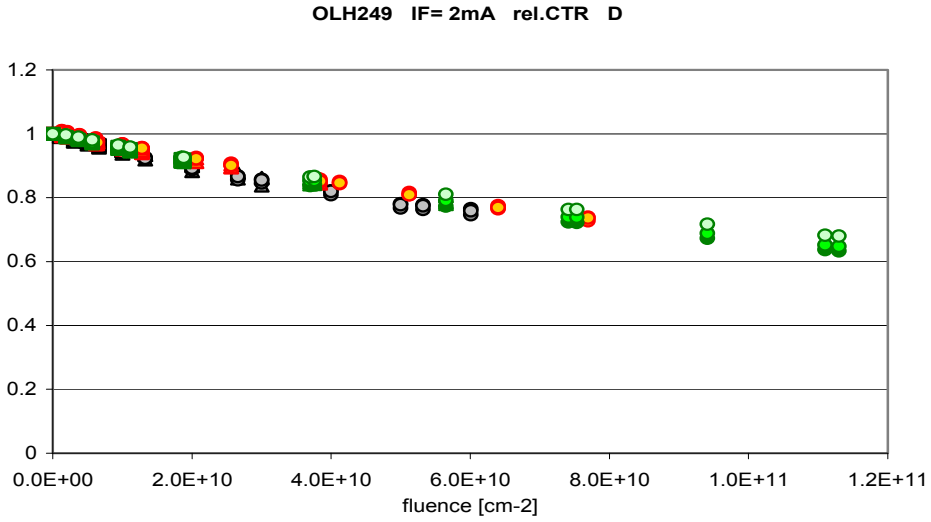
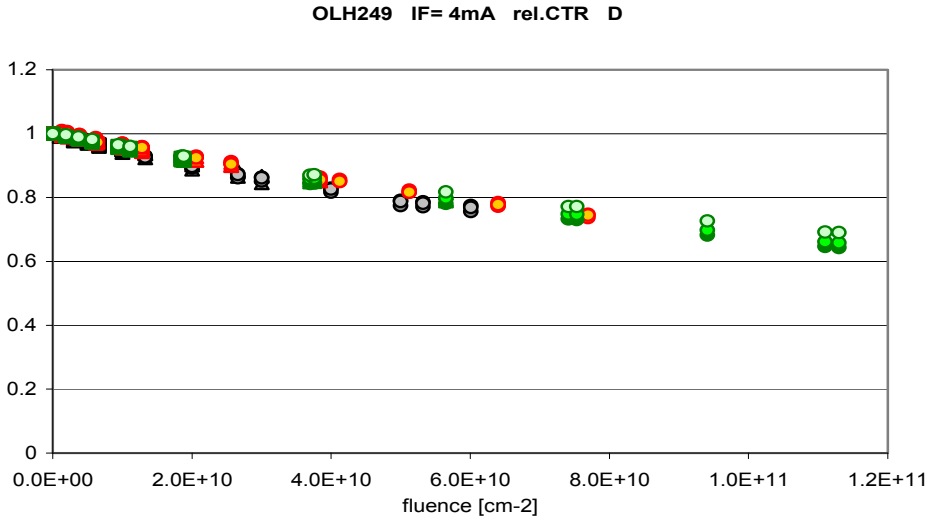

OLH249 IF= 10mA rel.CTR op
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

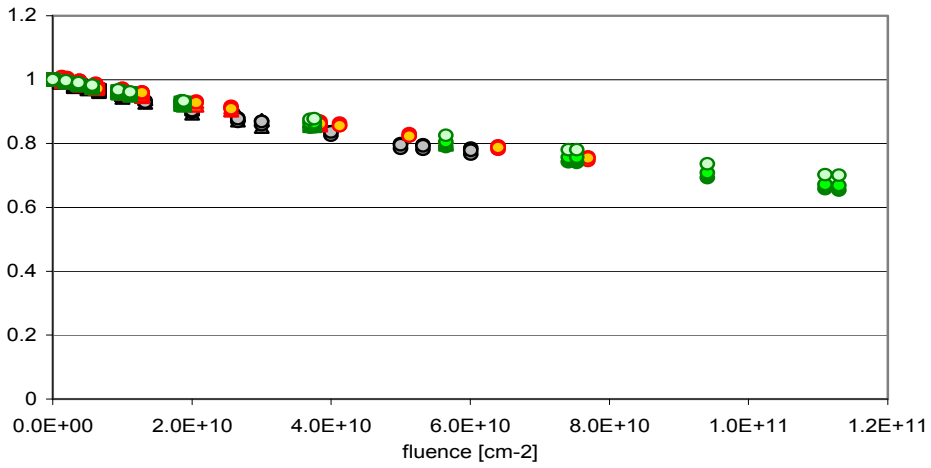
Fig. 13-17: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

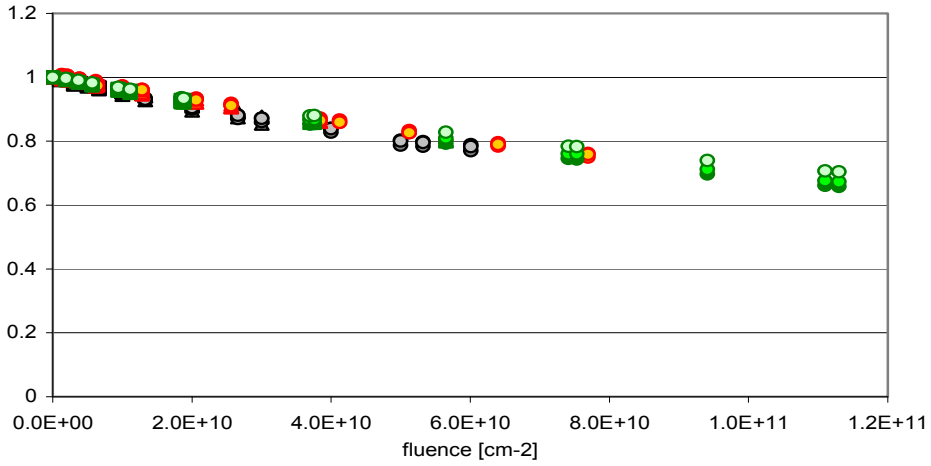
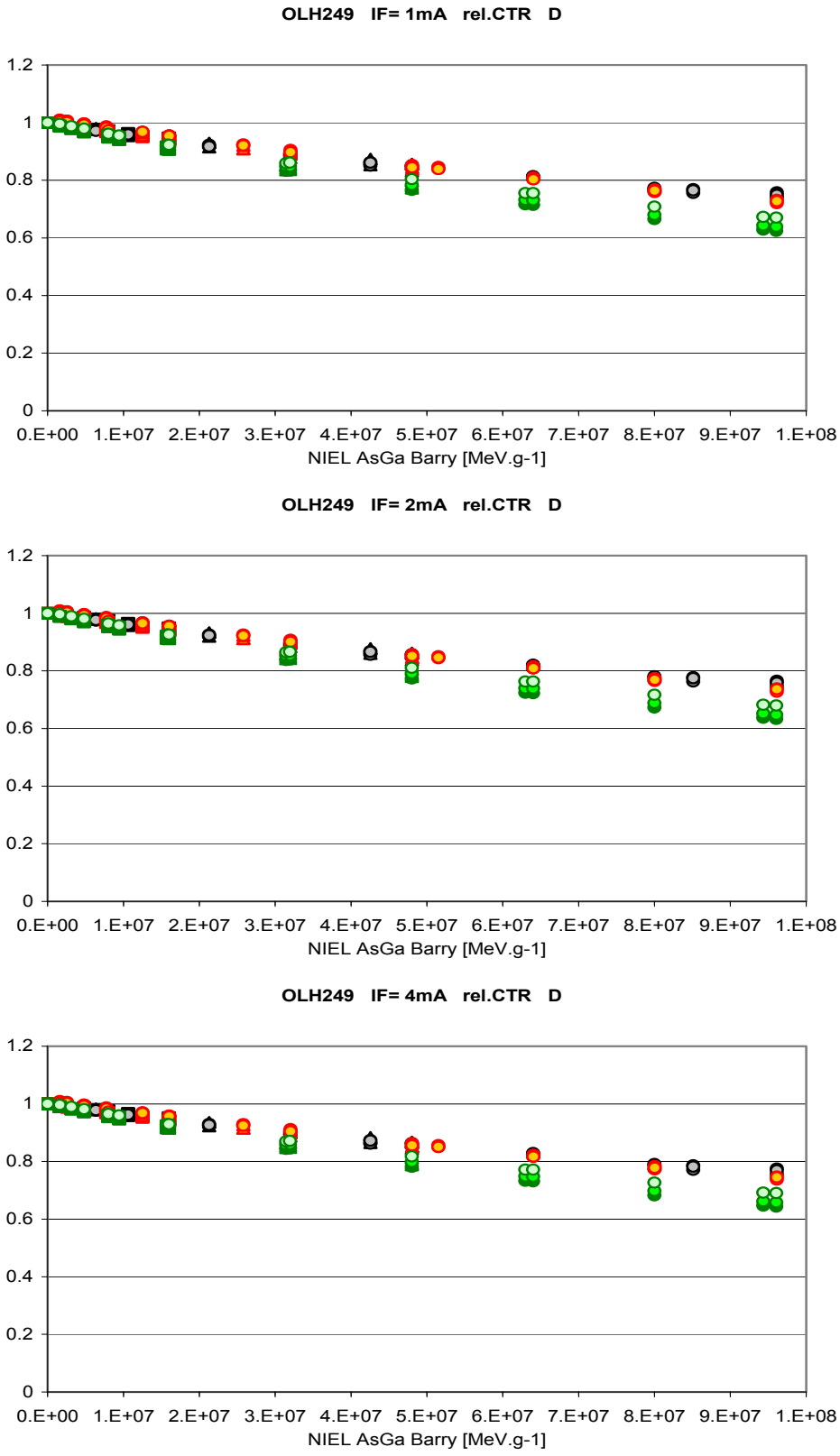
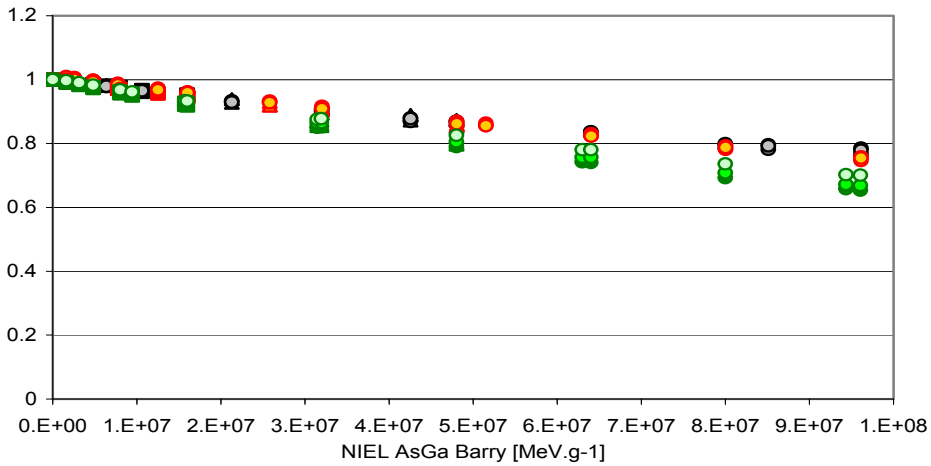


Fig. 13-18: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

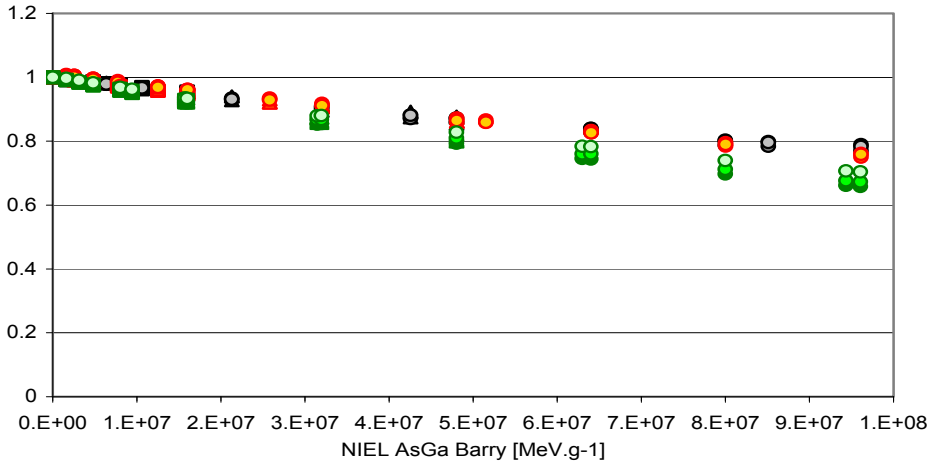
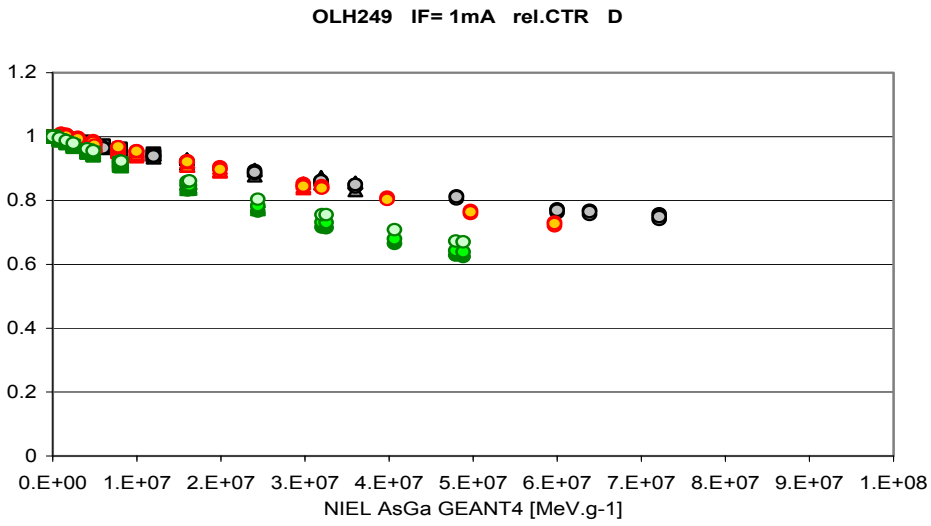
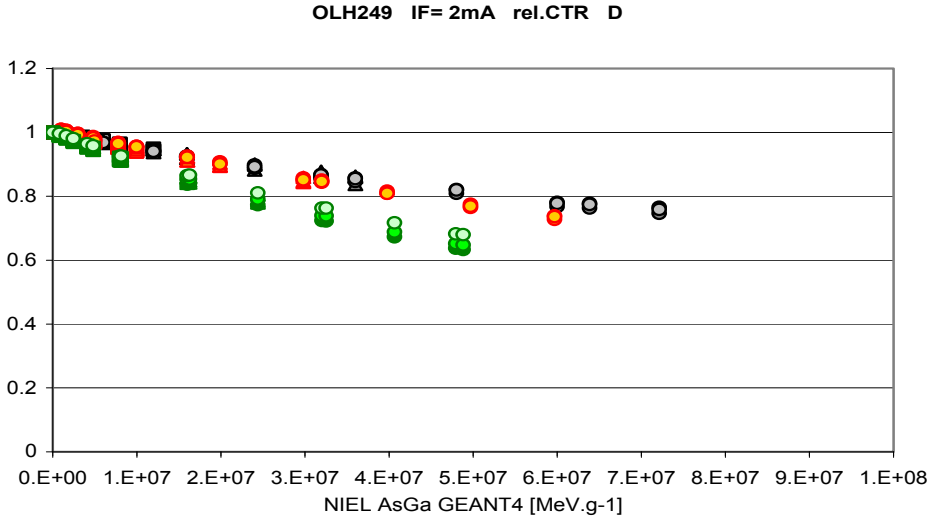
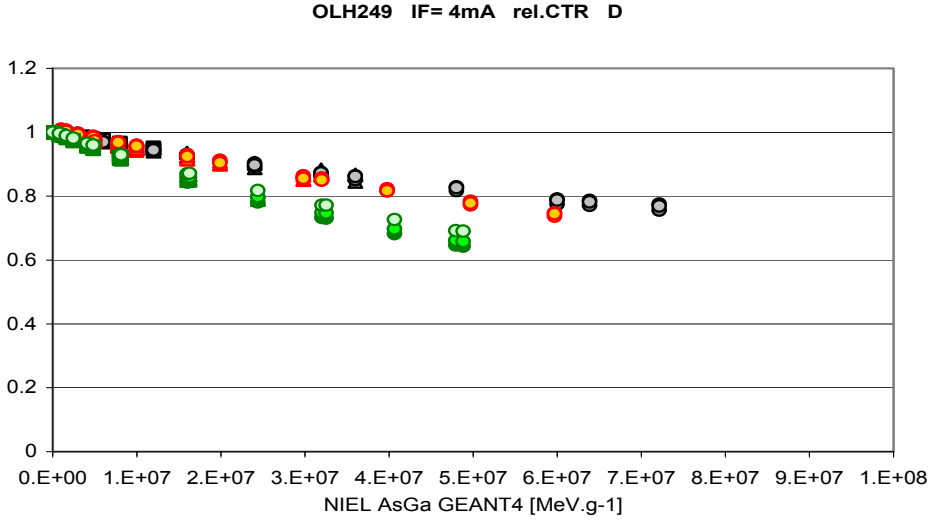


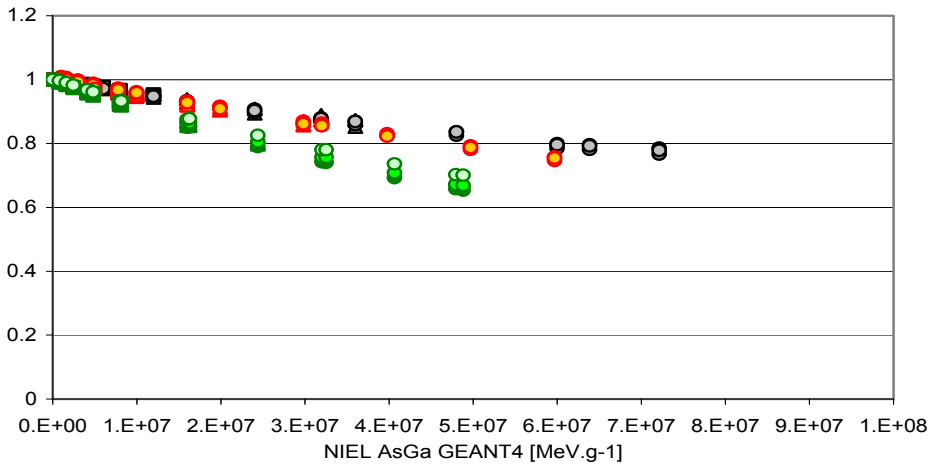
Fig. 13-19: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

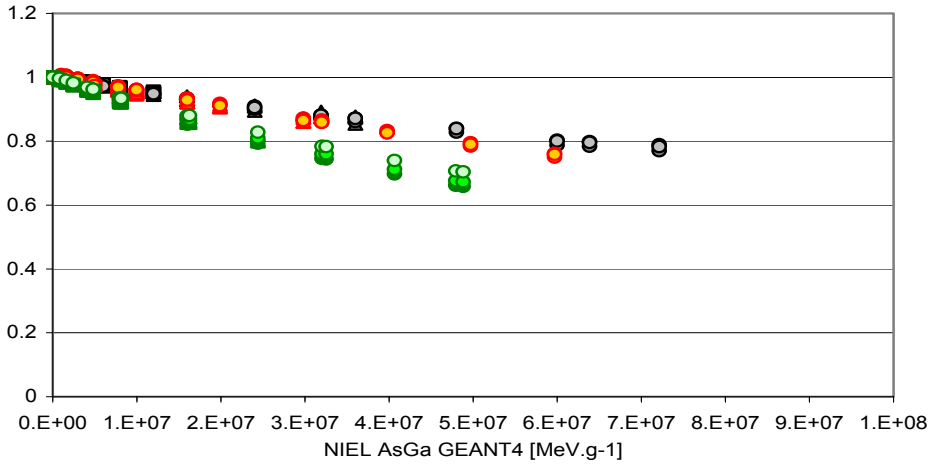
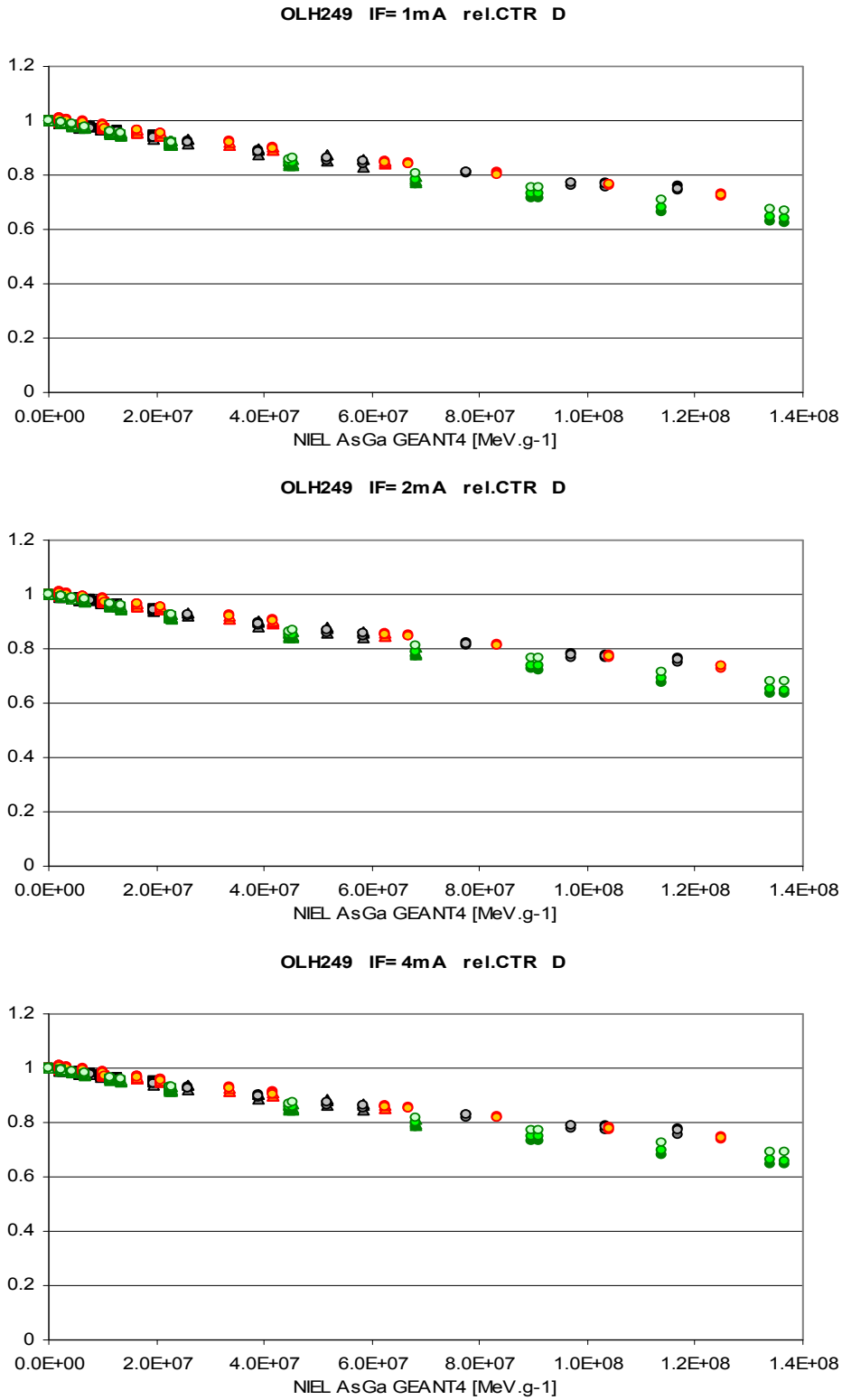
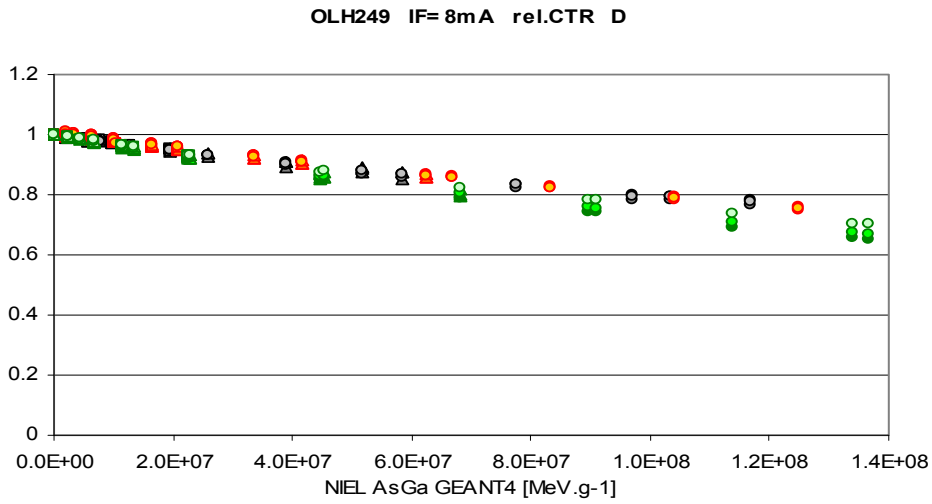


Fig. 13-20: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)




OLH249 IF= 8mA rel.CTR D
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

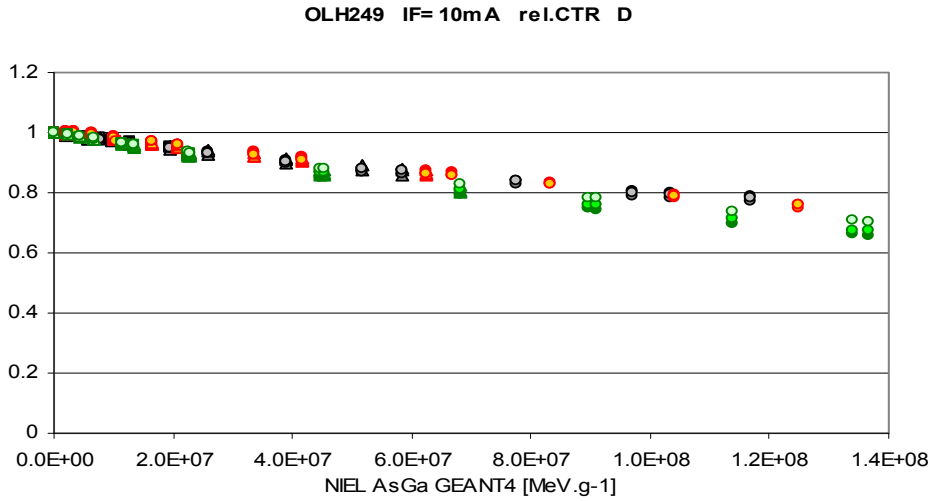
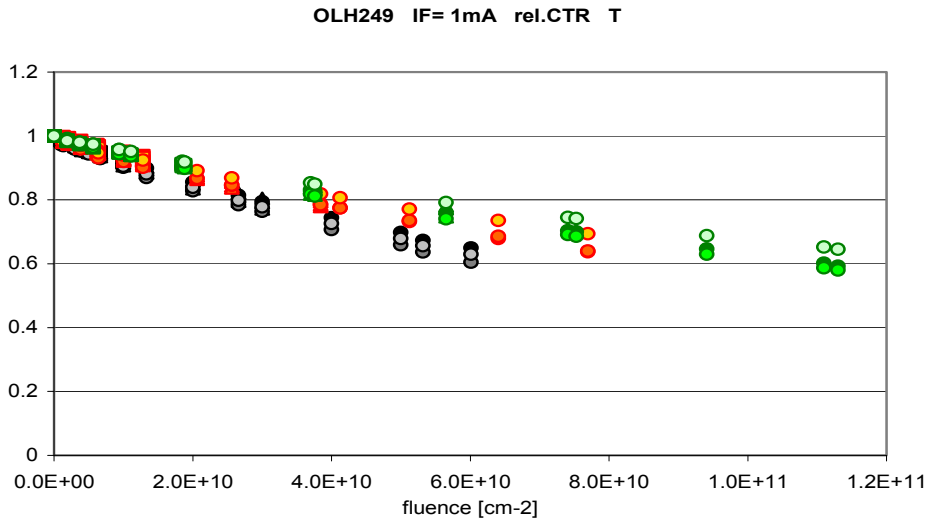
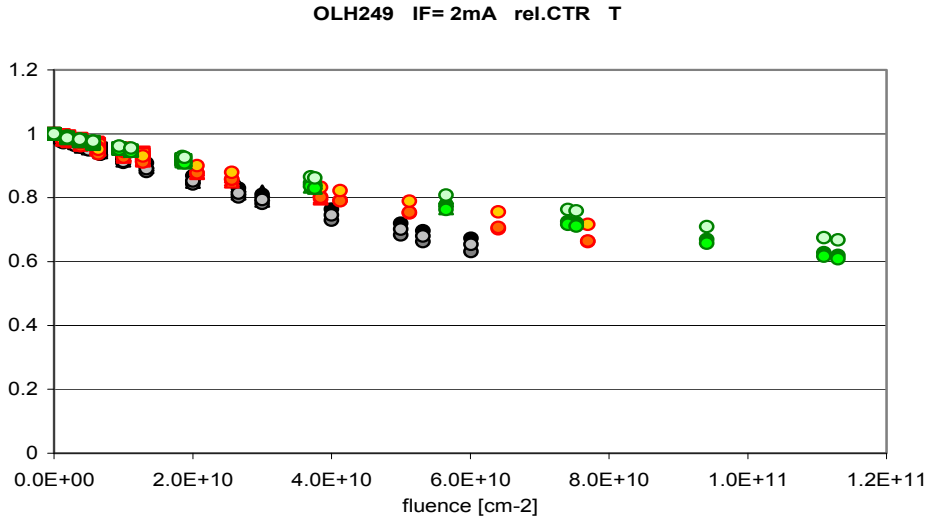
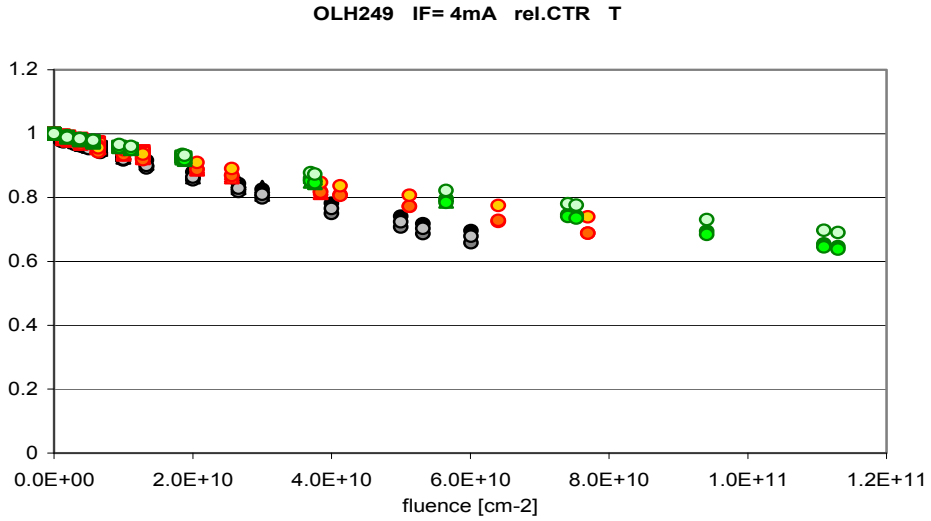

OLH249 IF= 10mA rel.CTR D
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

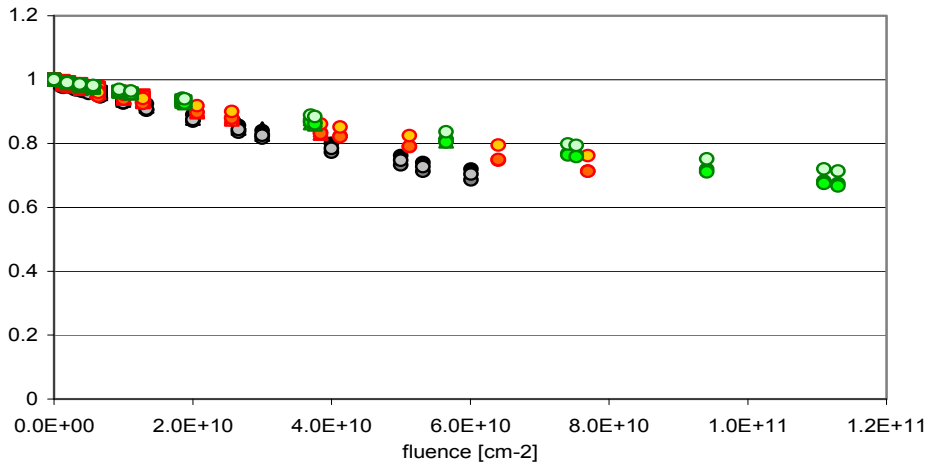
Fig. 13-21: OLH249 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR T



OLH249 IF= 10mA rel.CTR T

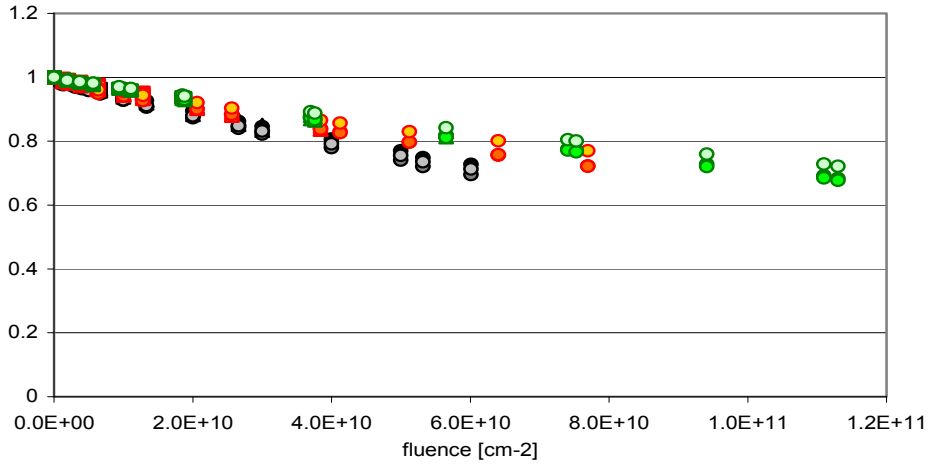
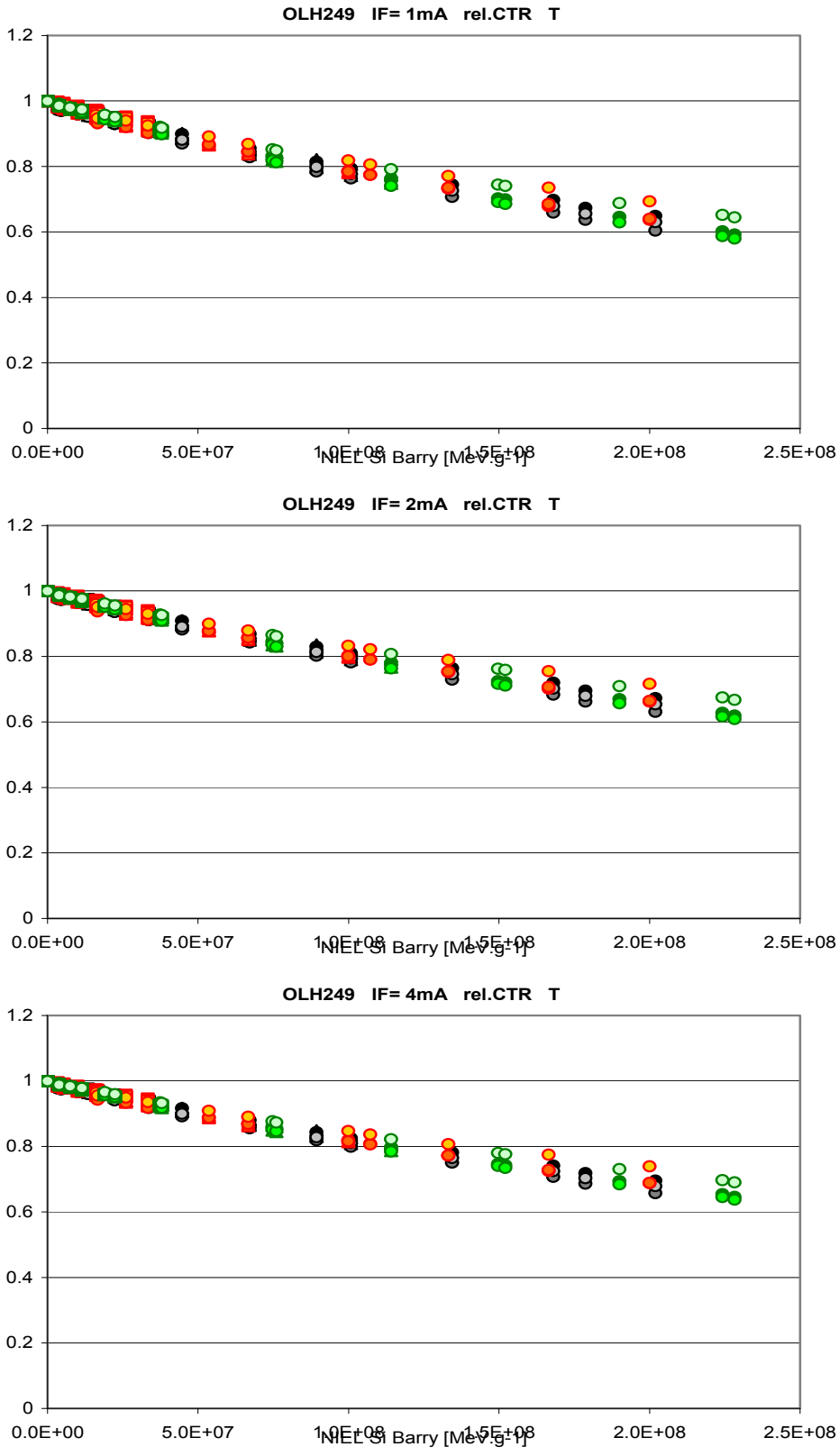
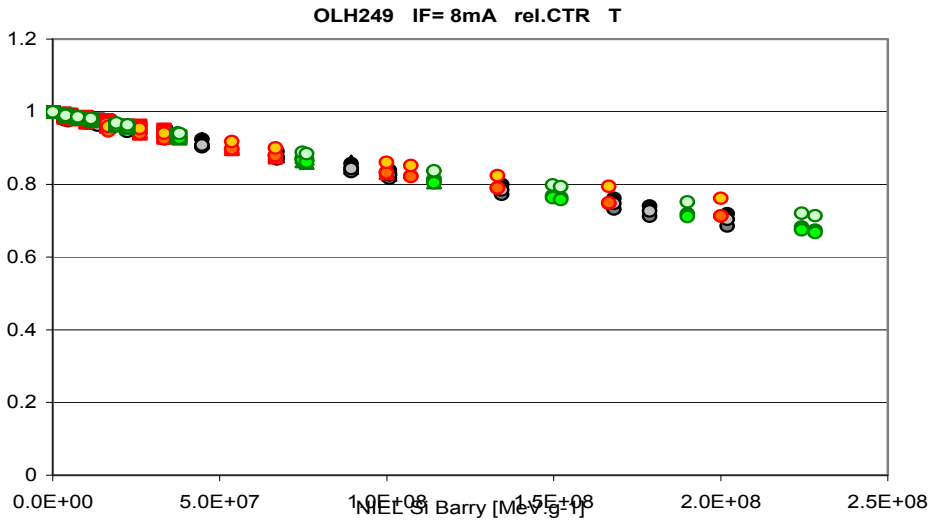


Fig. 13-22: OLH249 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)




OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

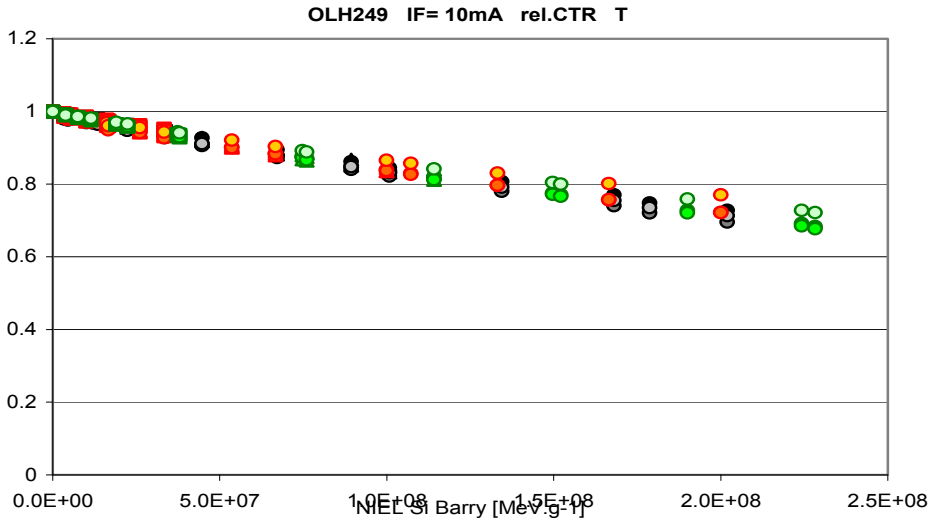
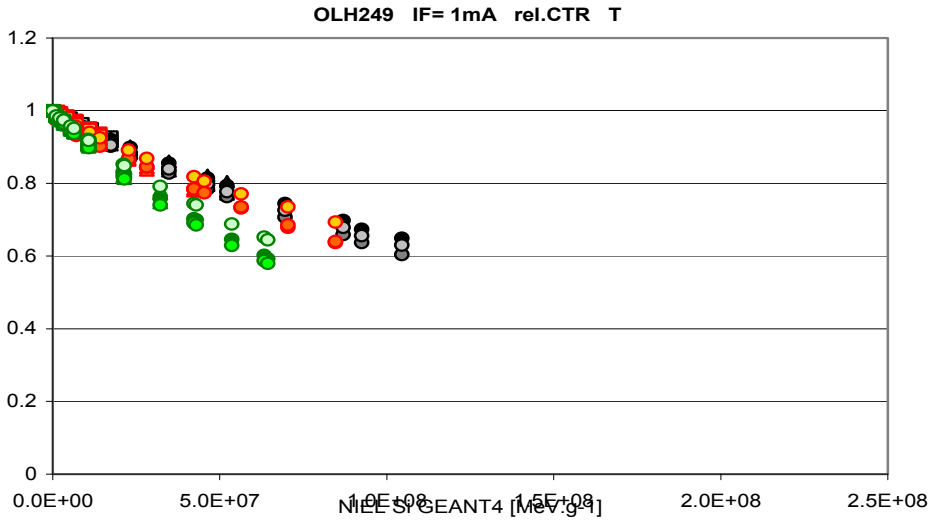
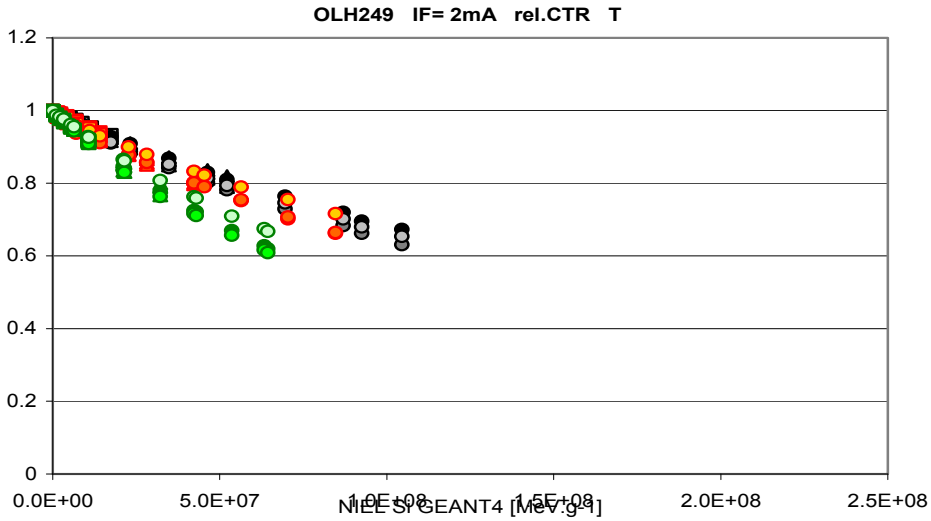
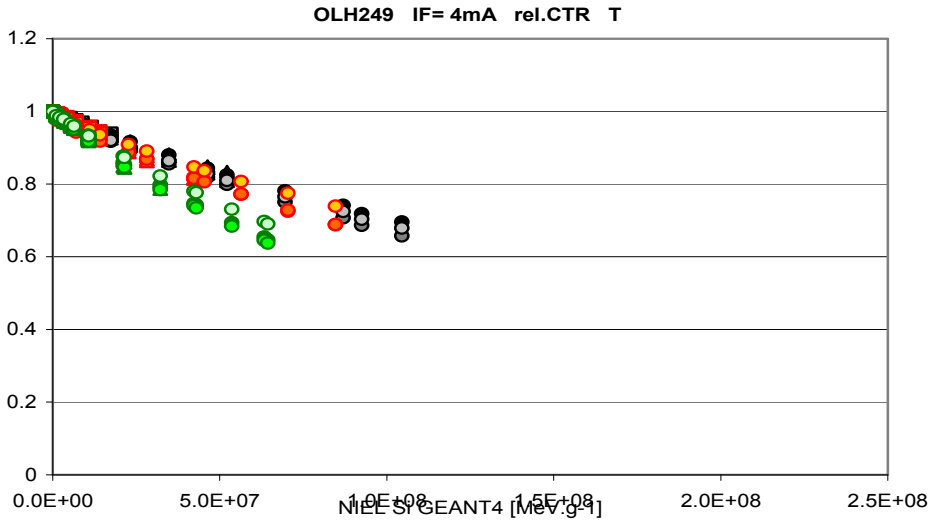
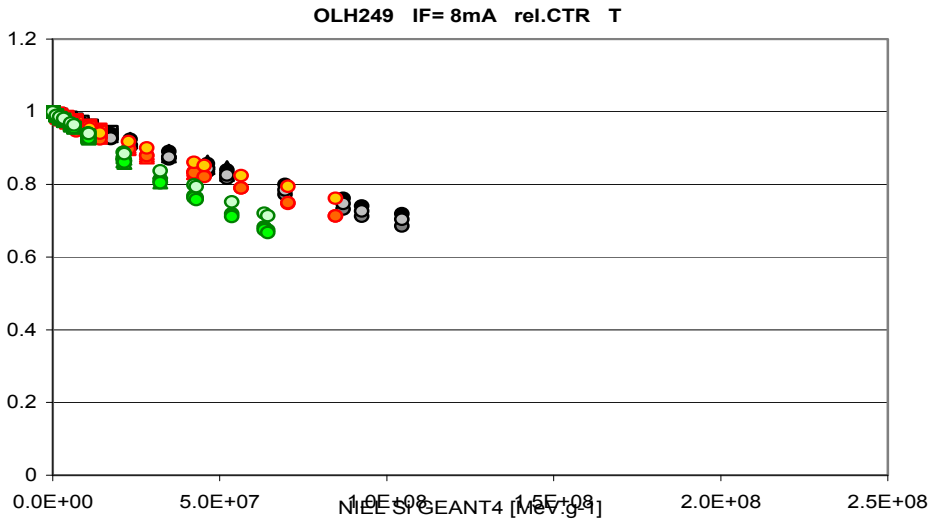

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 13-23: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)








OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

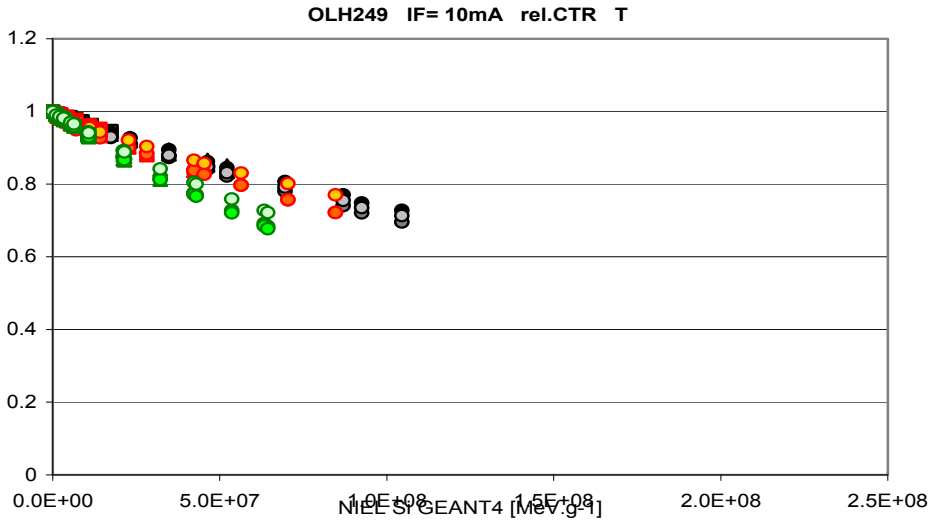
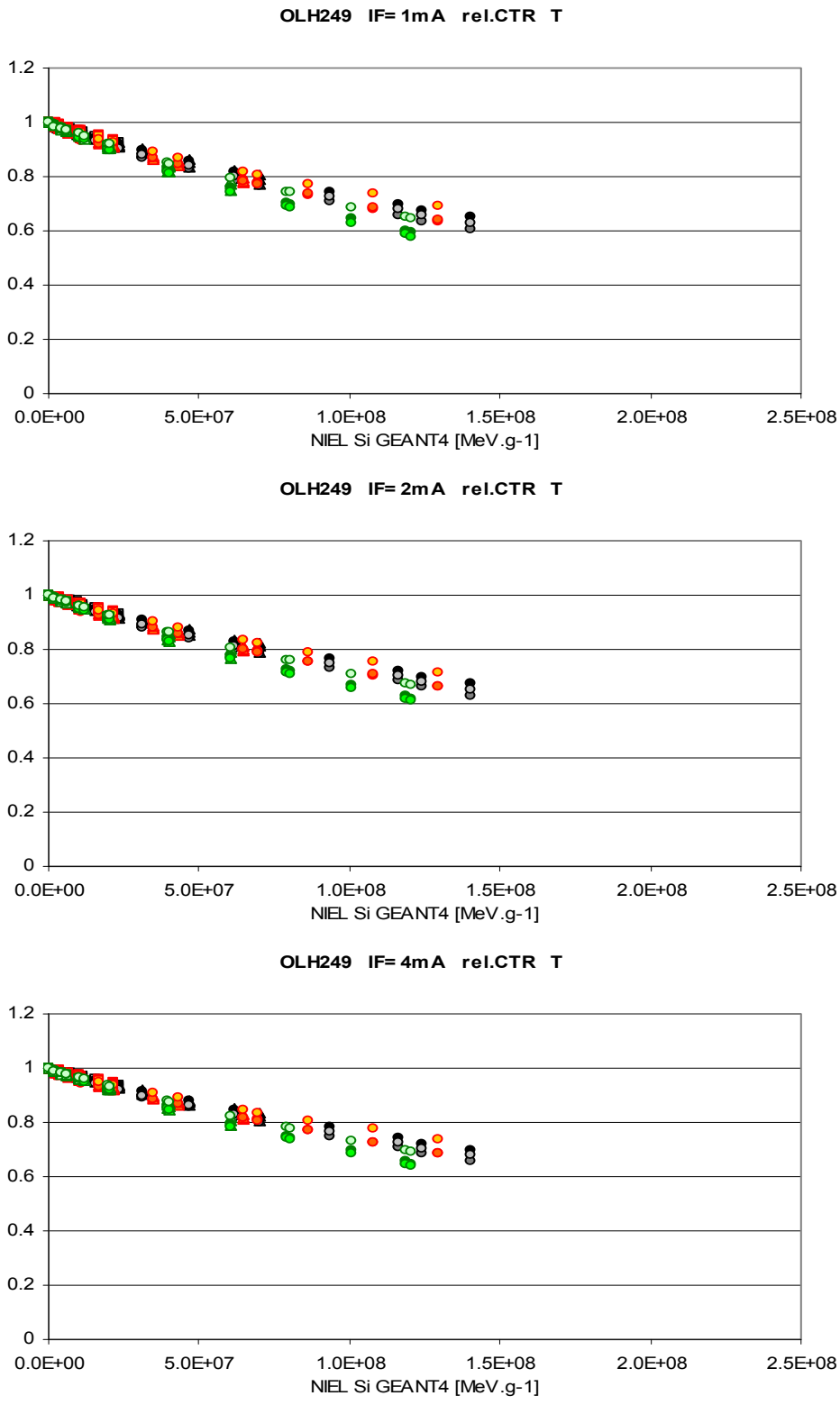
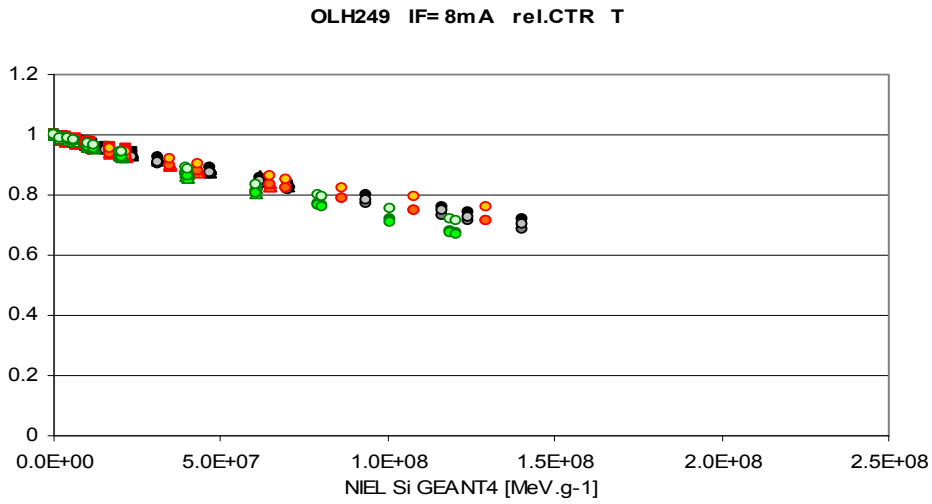

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-24: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

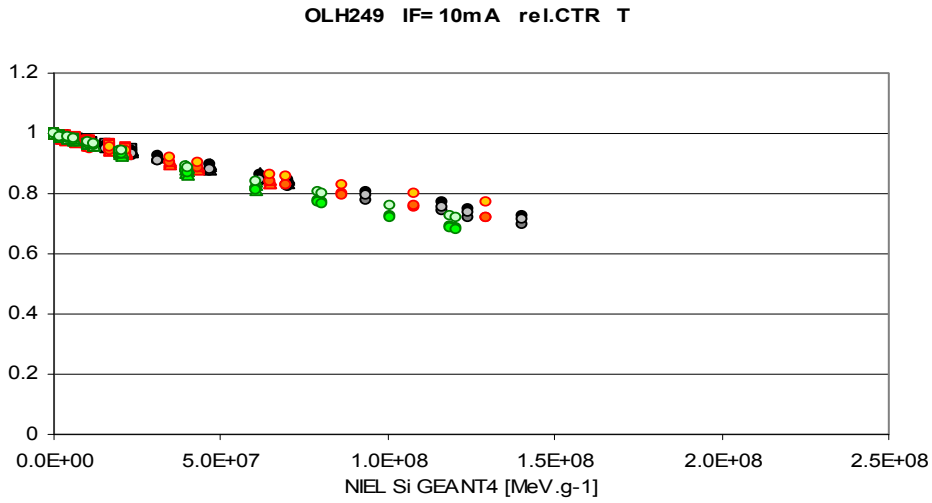
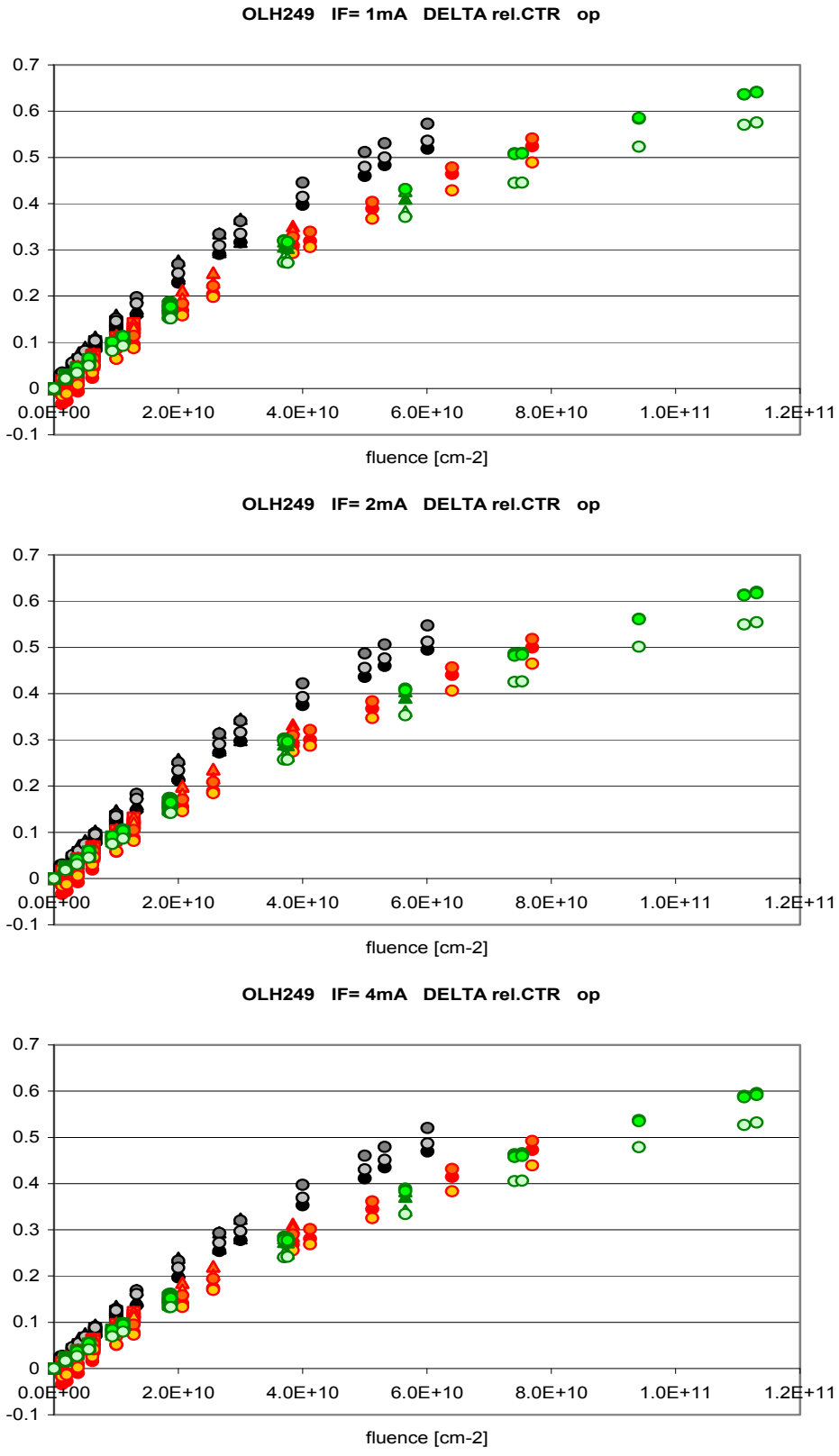
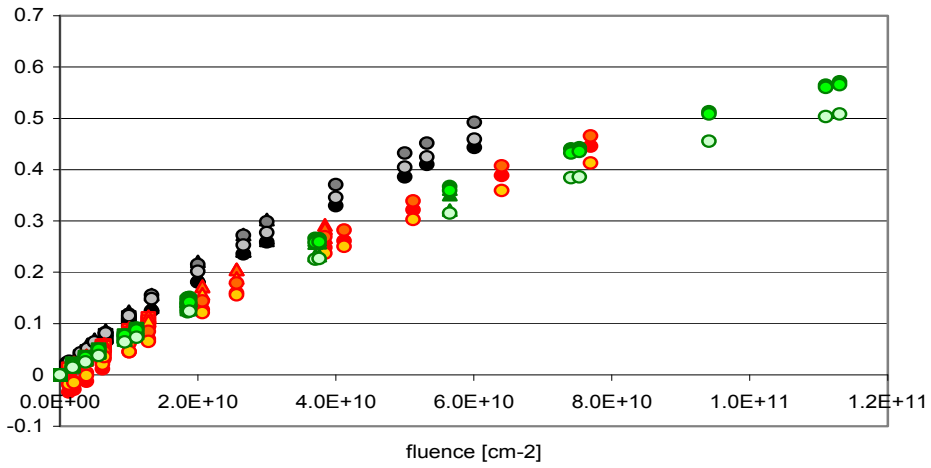

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-25: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

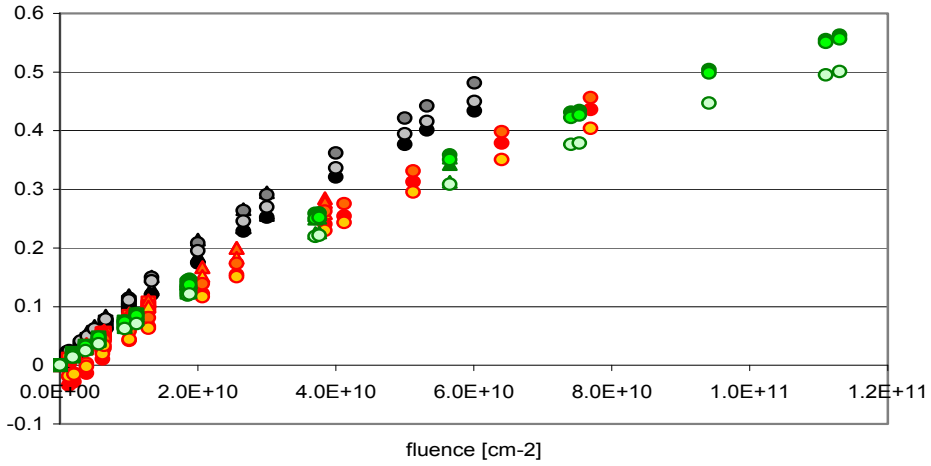
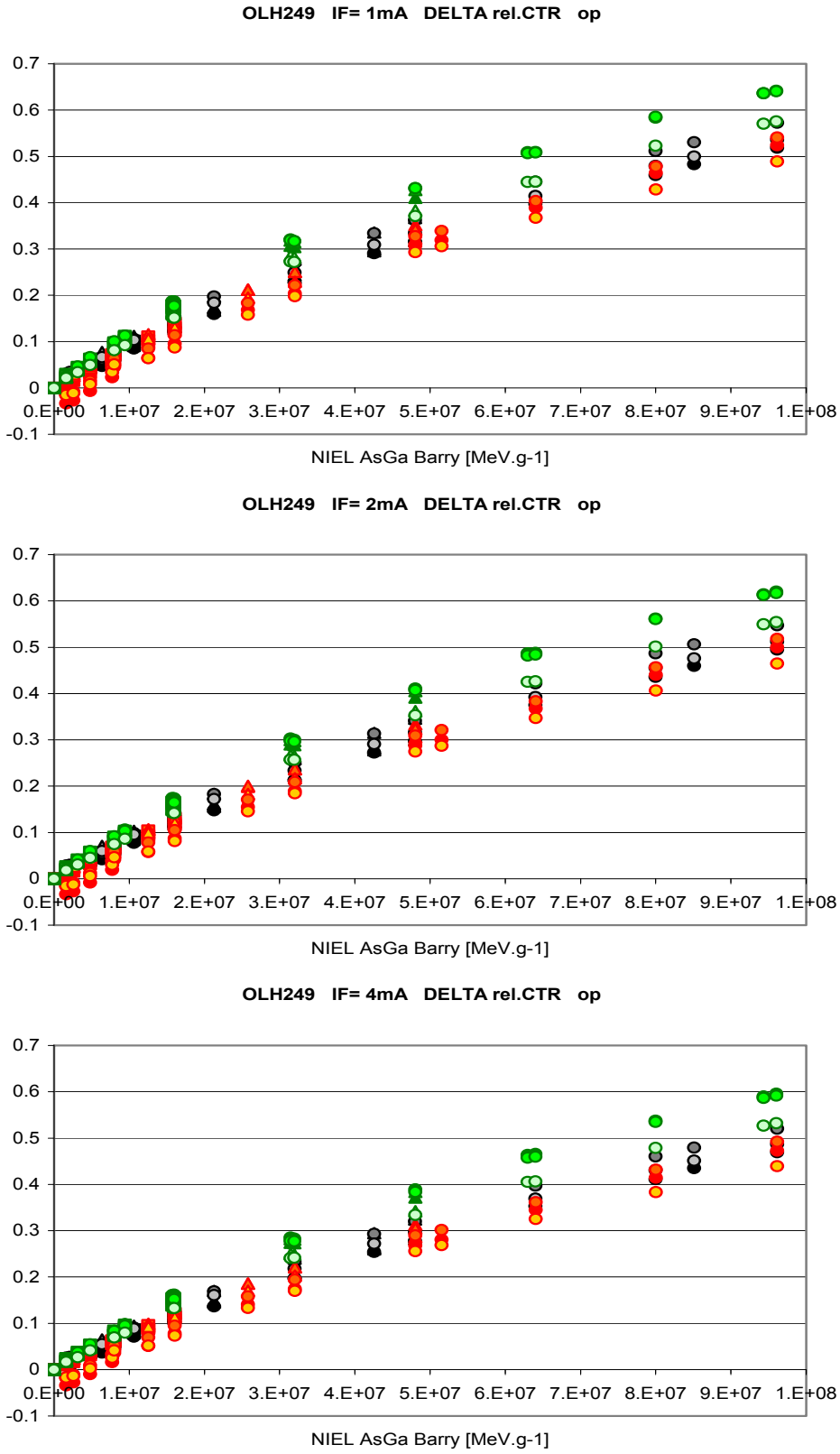
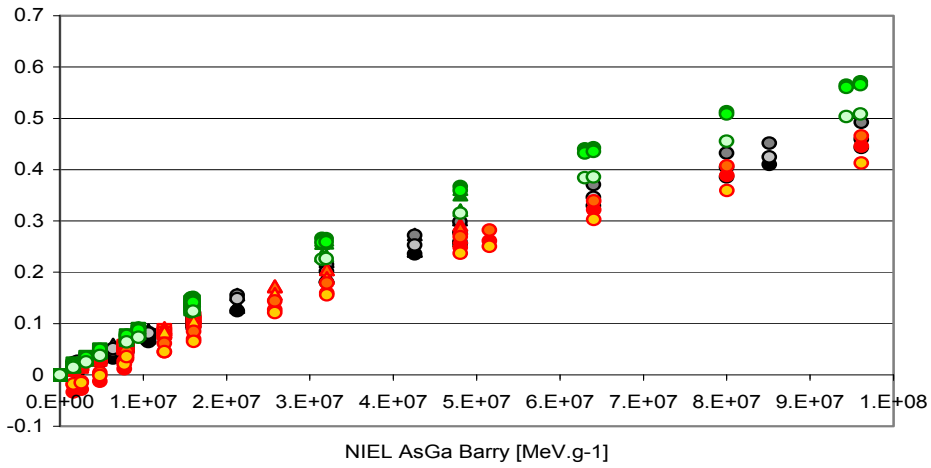


Fig. 13-26: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

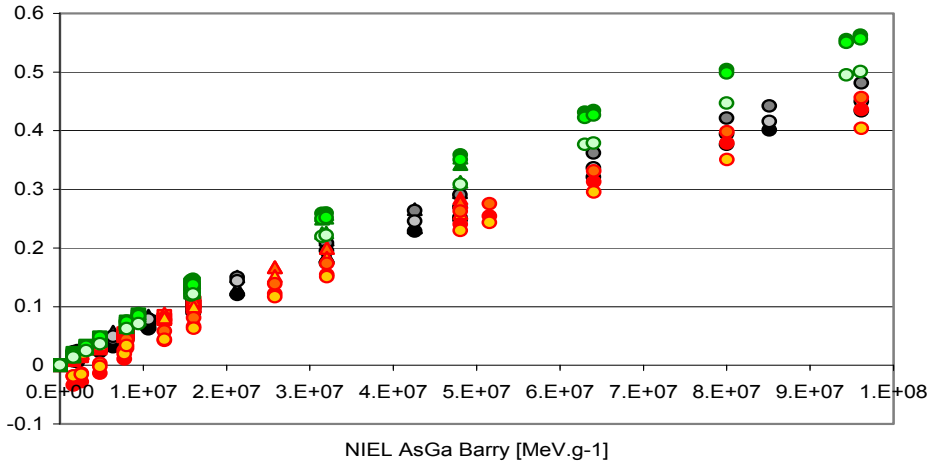
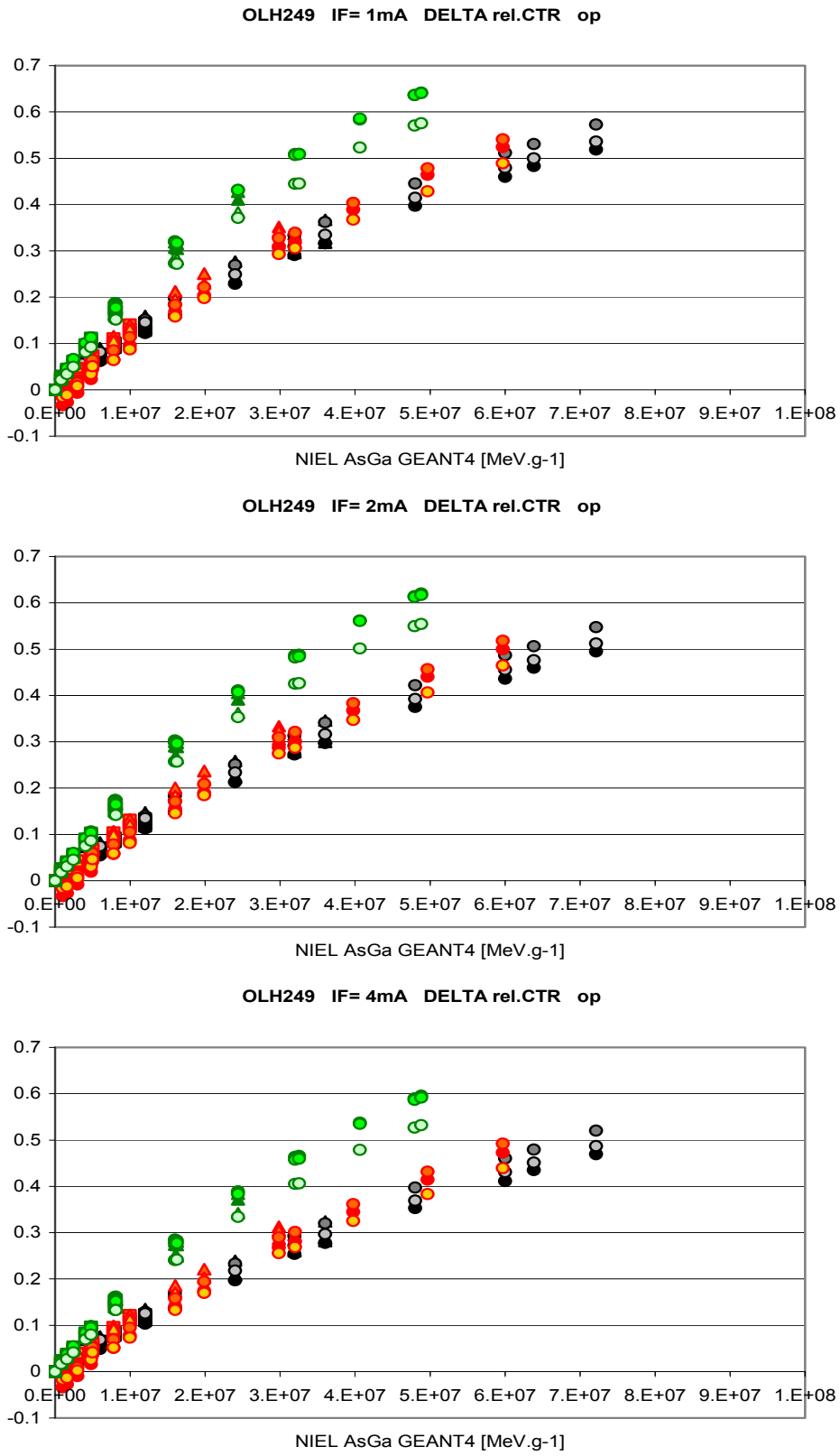
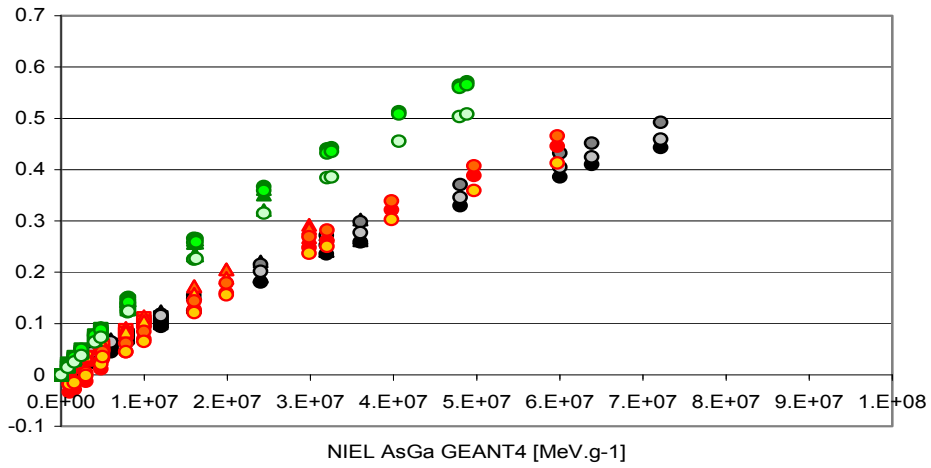


Fig. 13-27: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

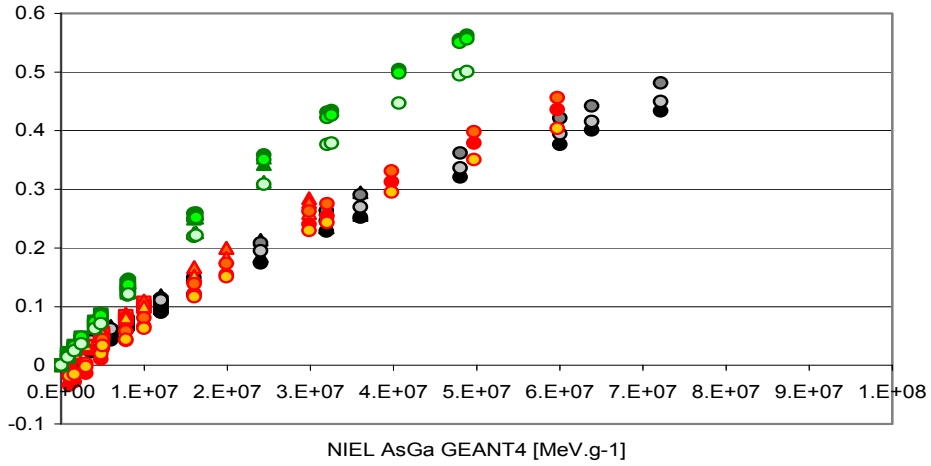
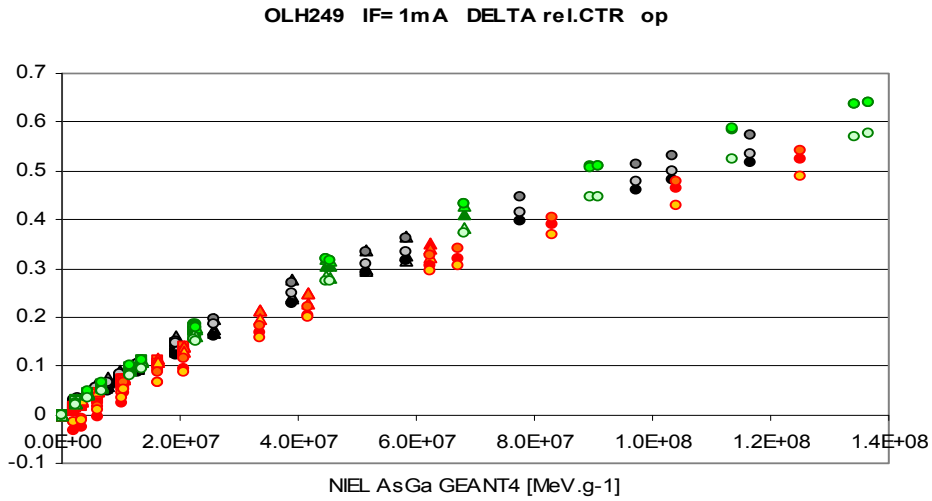
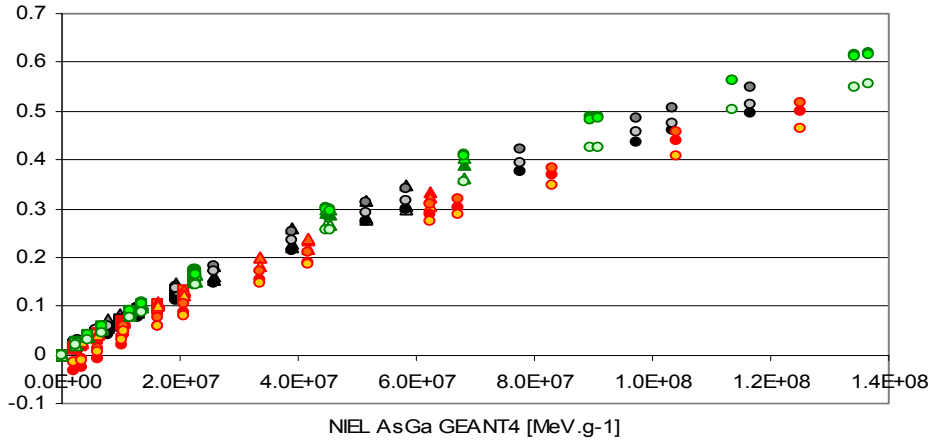
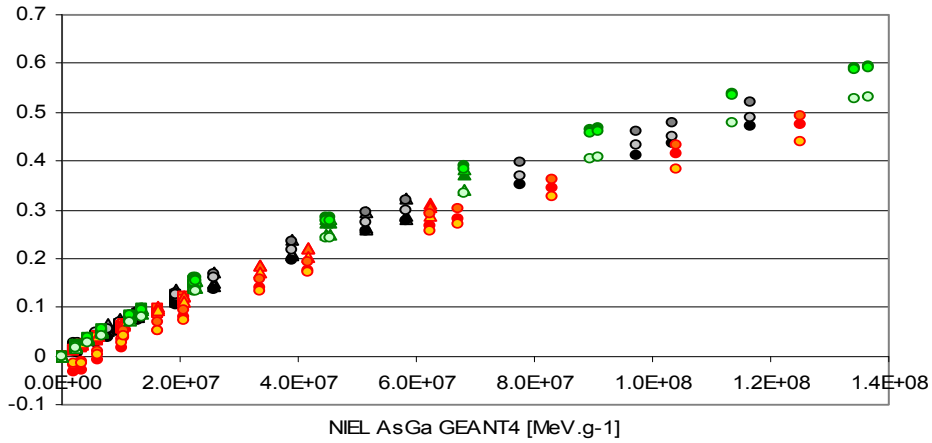


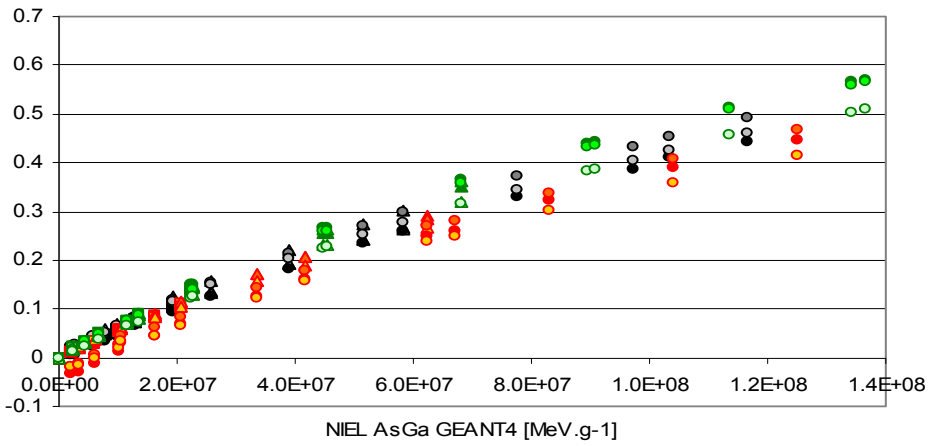
Fig. 13-28: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

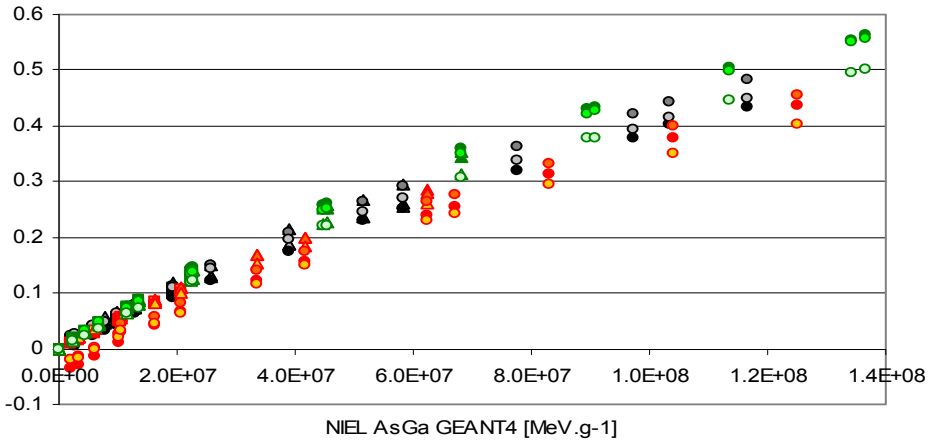
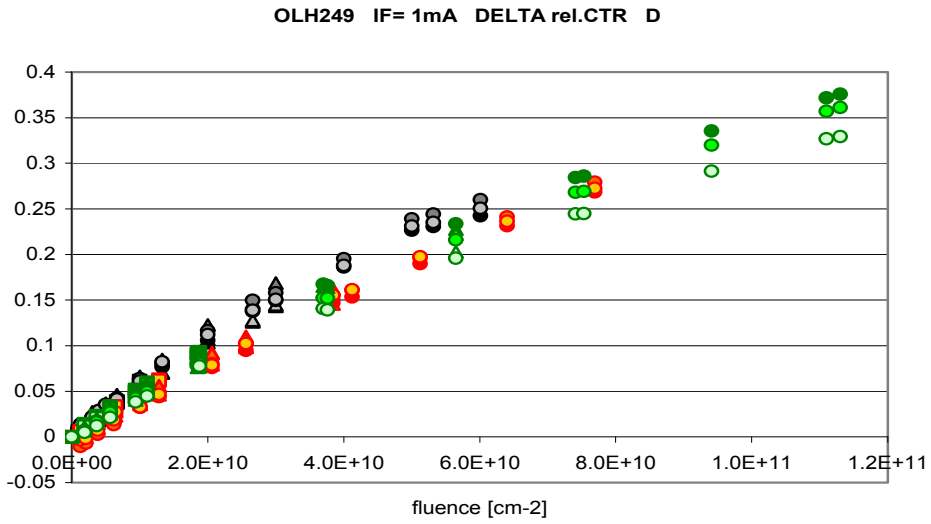
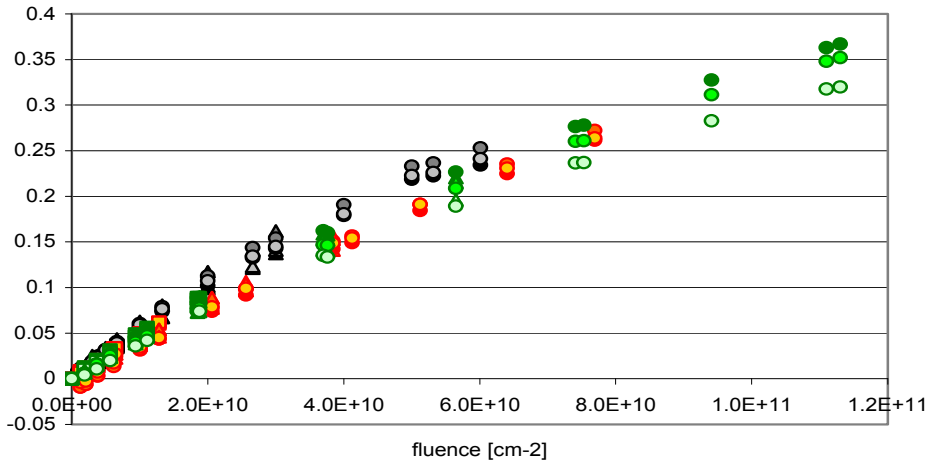
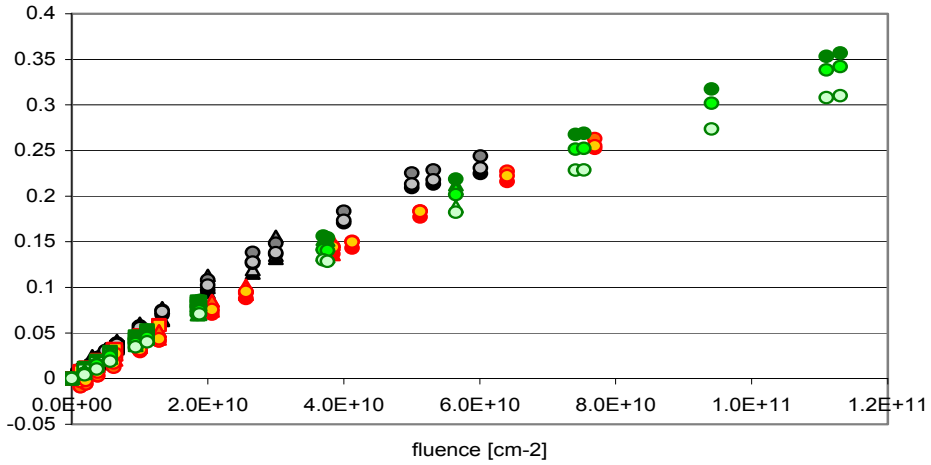


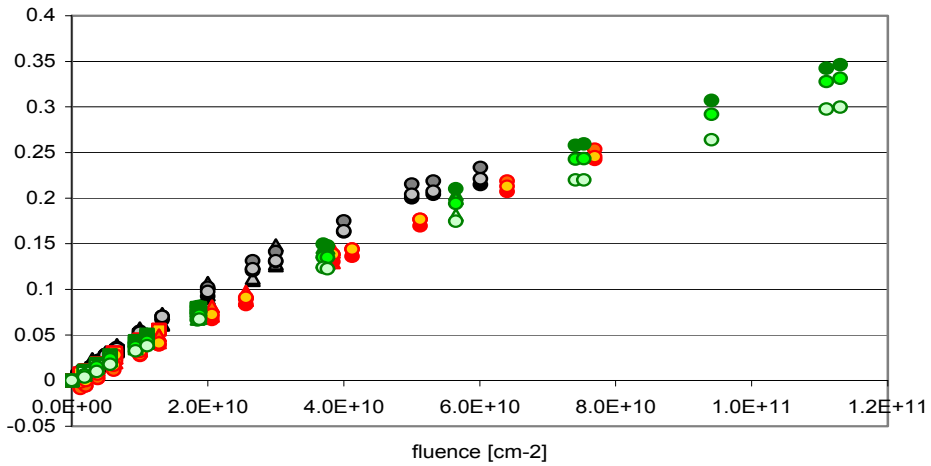
Fig. 13-29: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

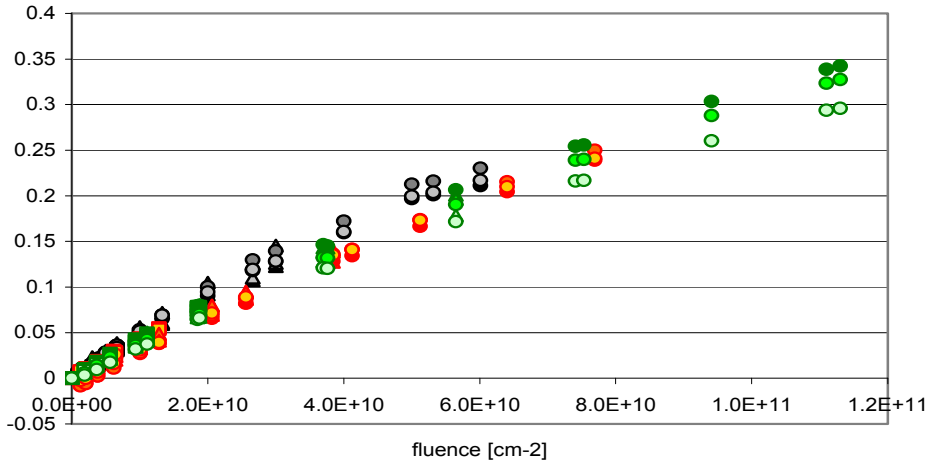
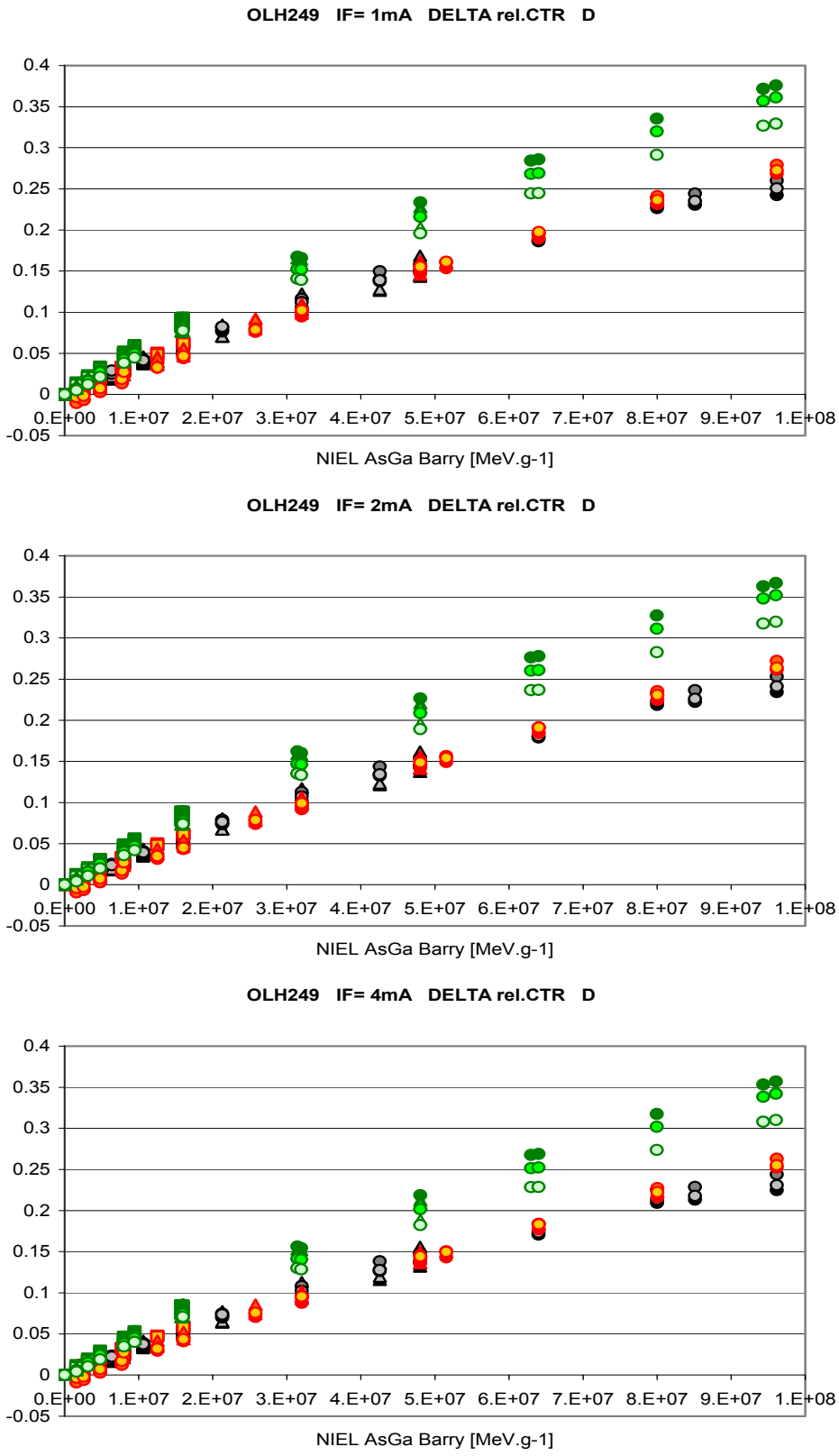
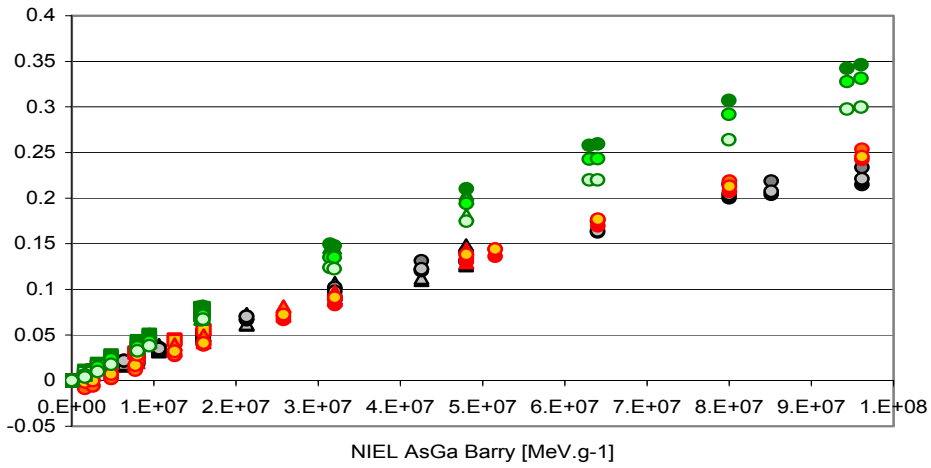


Fig. 13-30: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

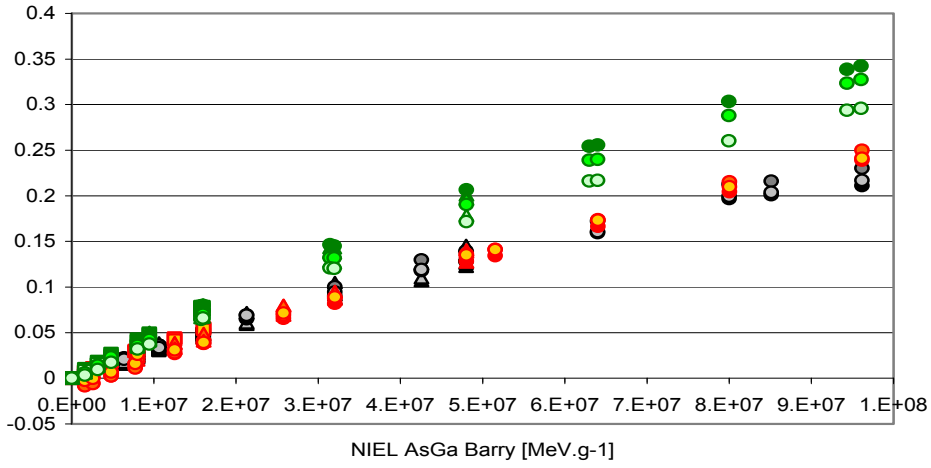
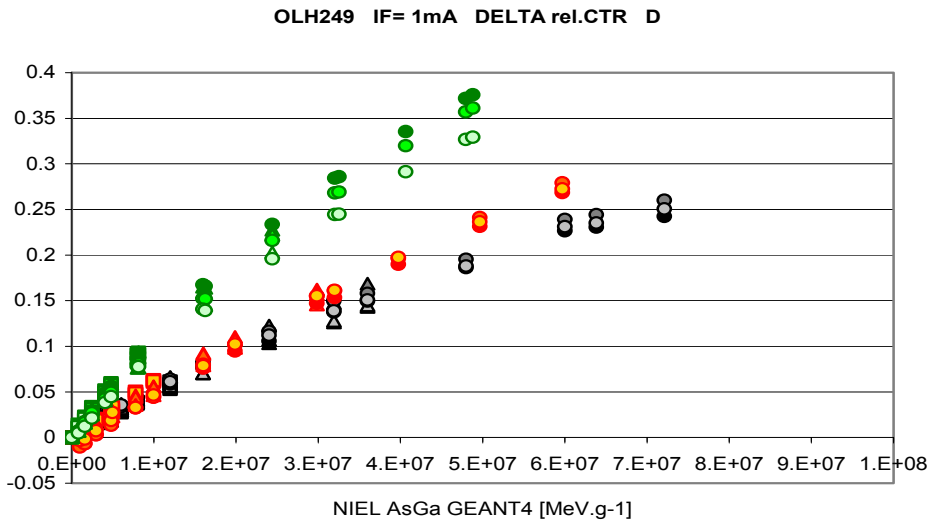
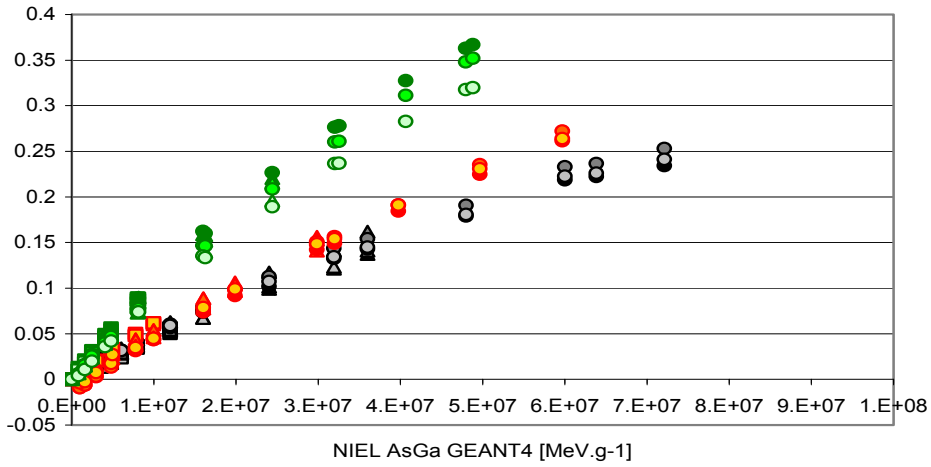
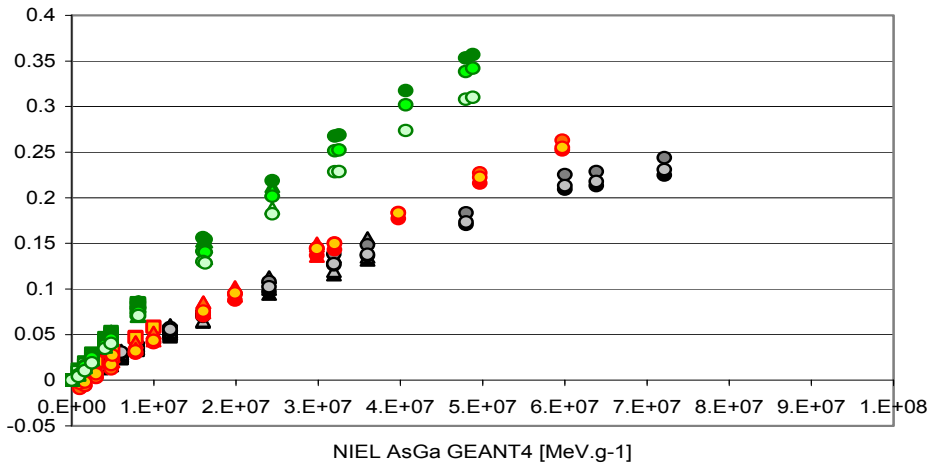


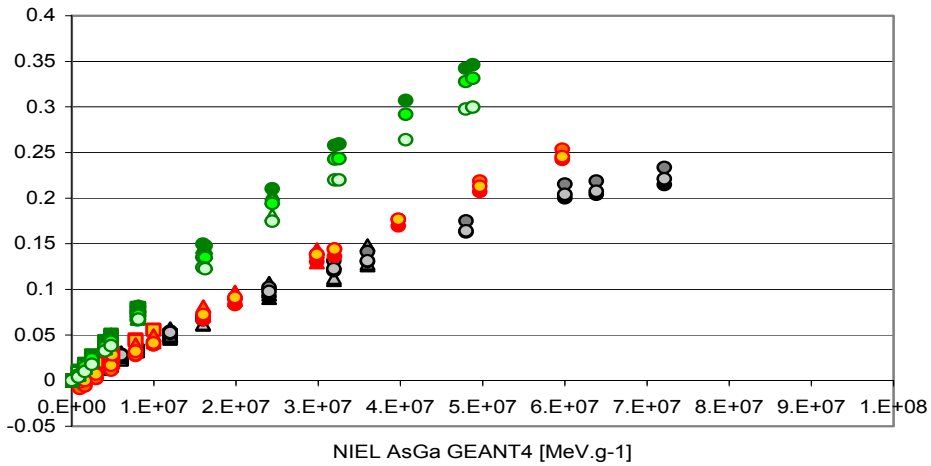
Fig. 13-31: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

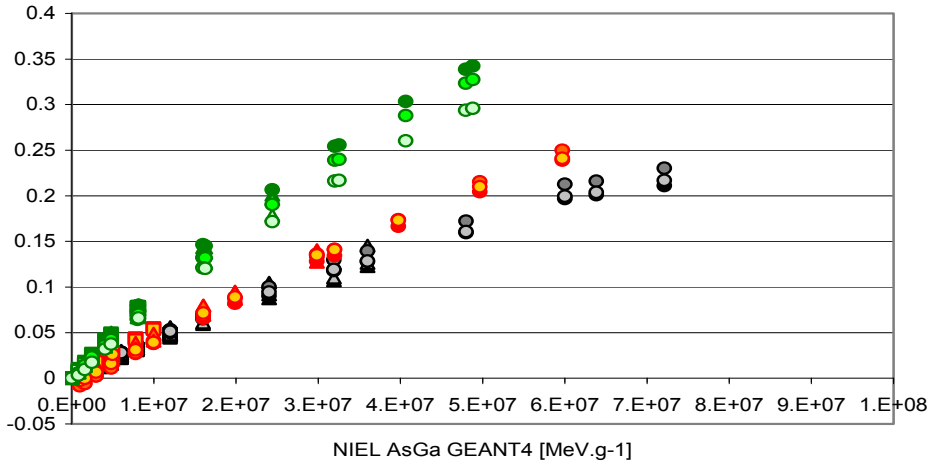
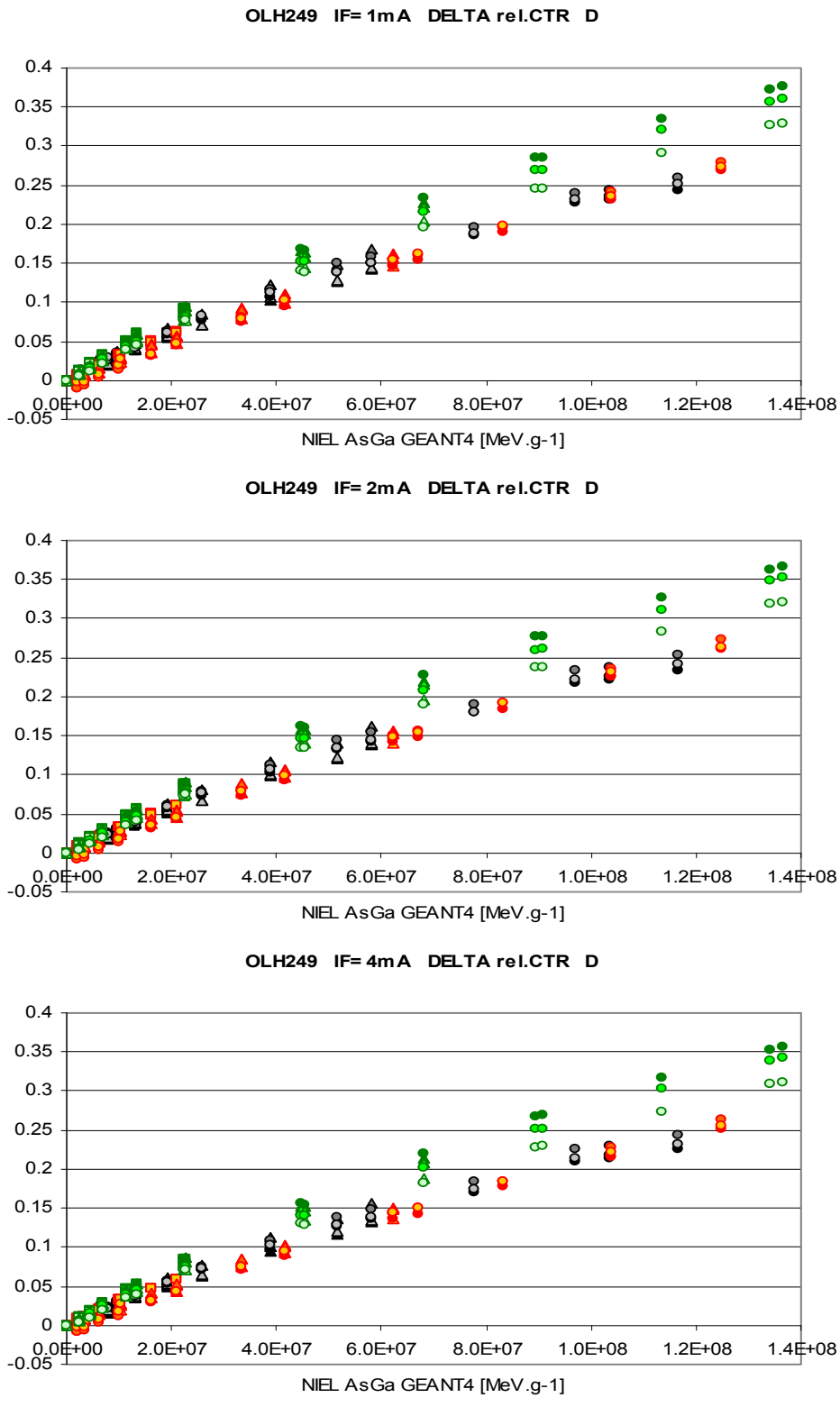
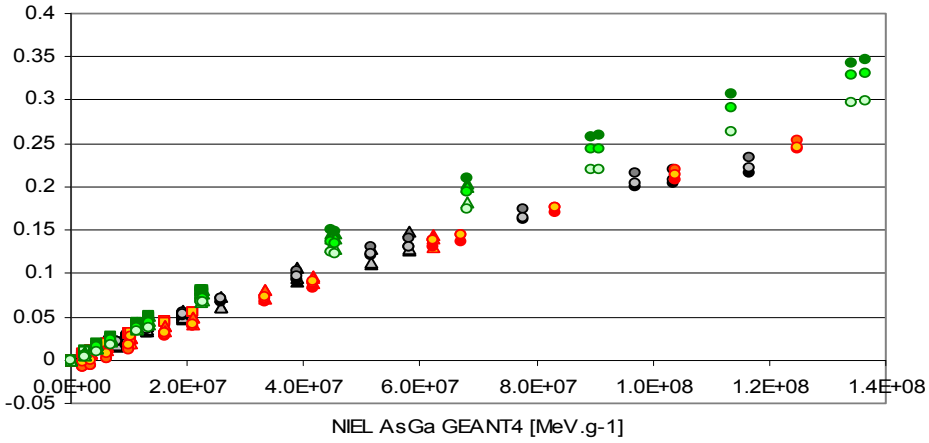


Fig. 13-32: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)



OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

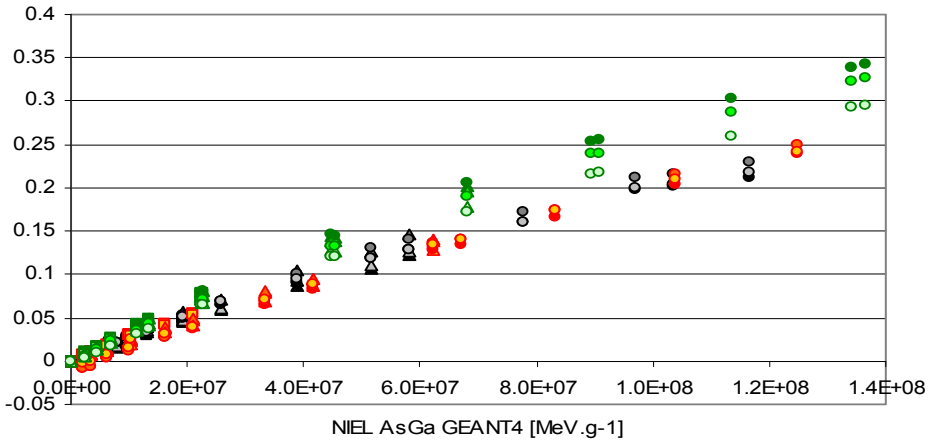
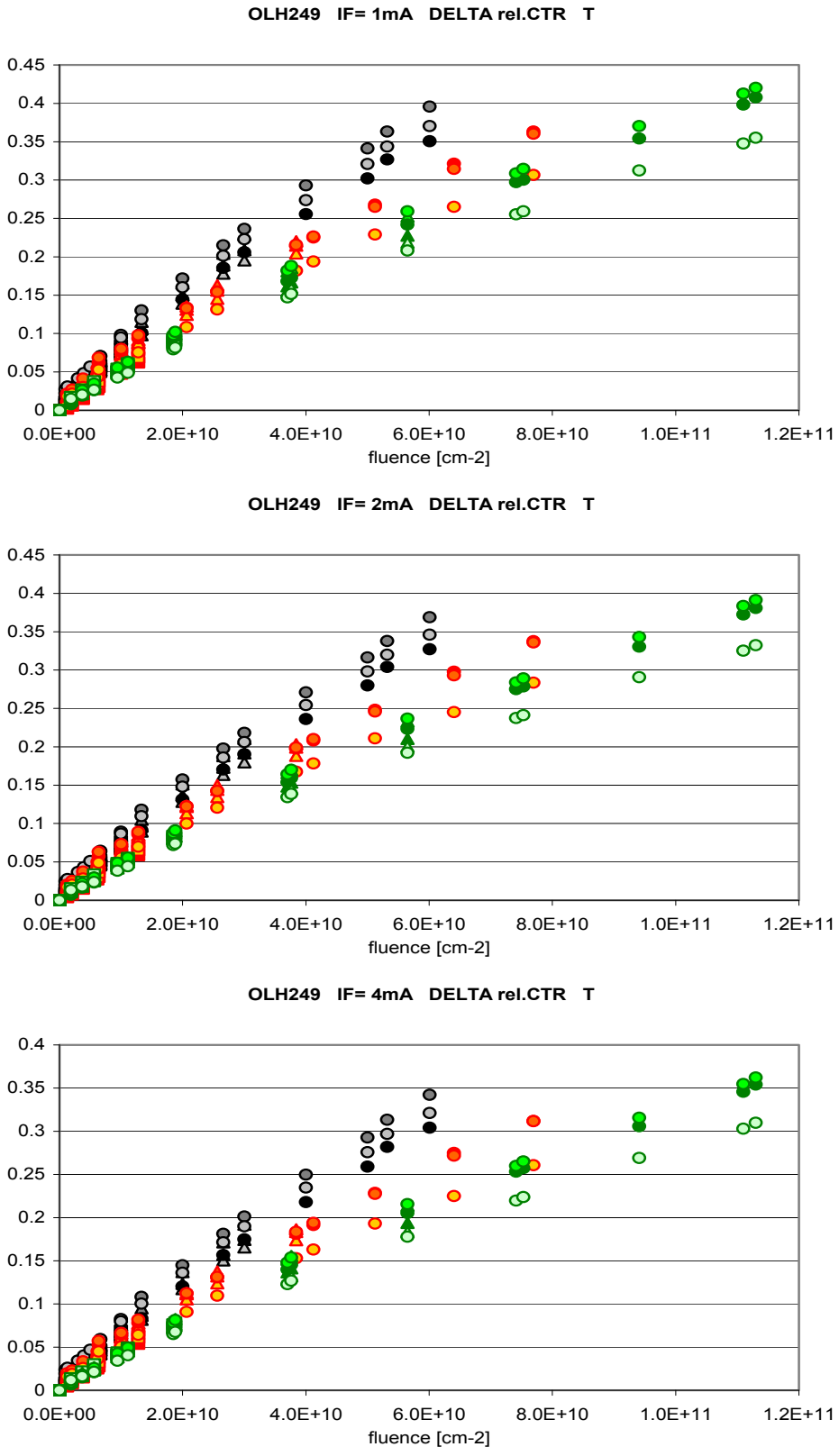
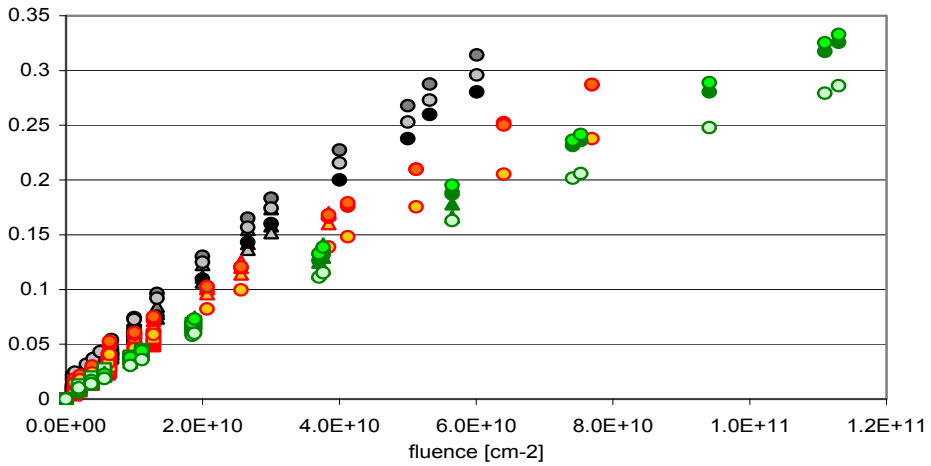


Fig. 13-33: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA DELTA rel.CTR T



OLH249 IF= 10mA DELTA rel.CTR T

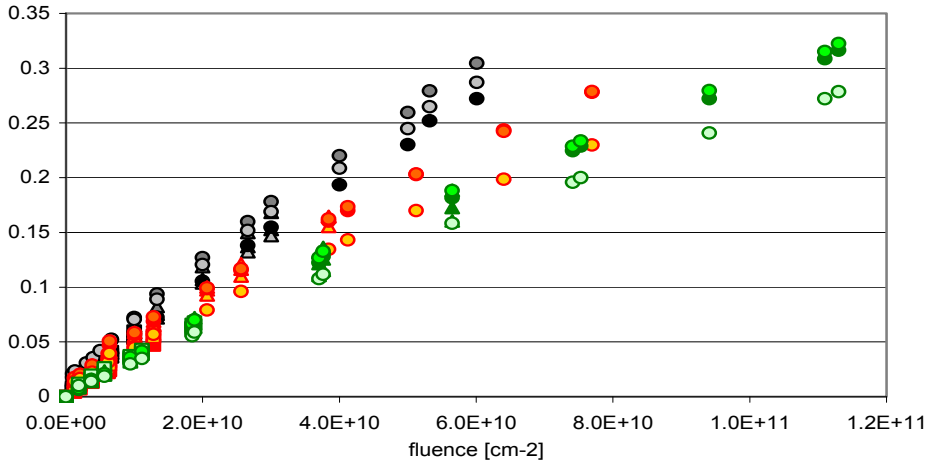
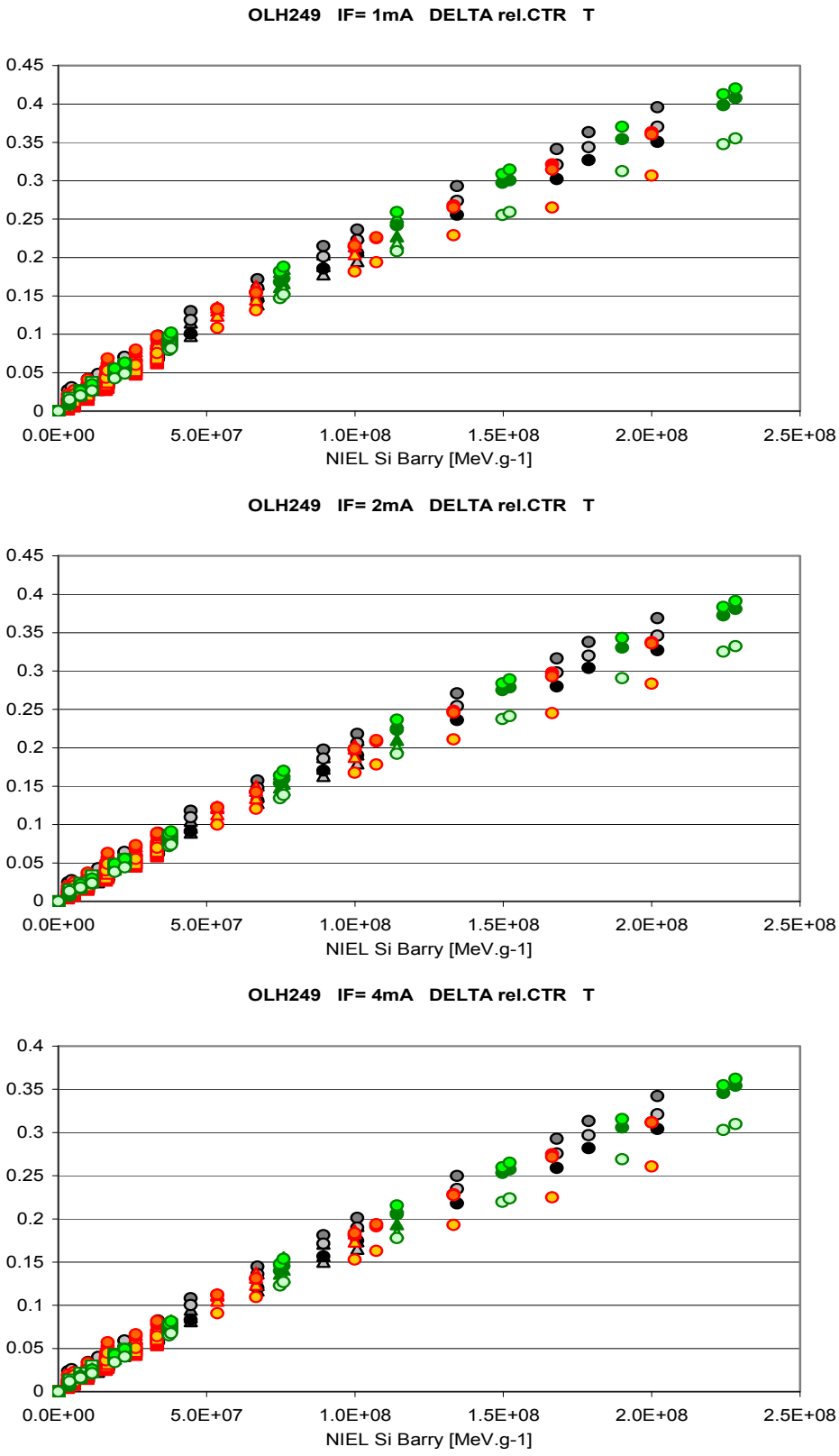
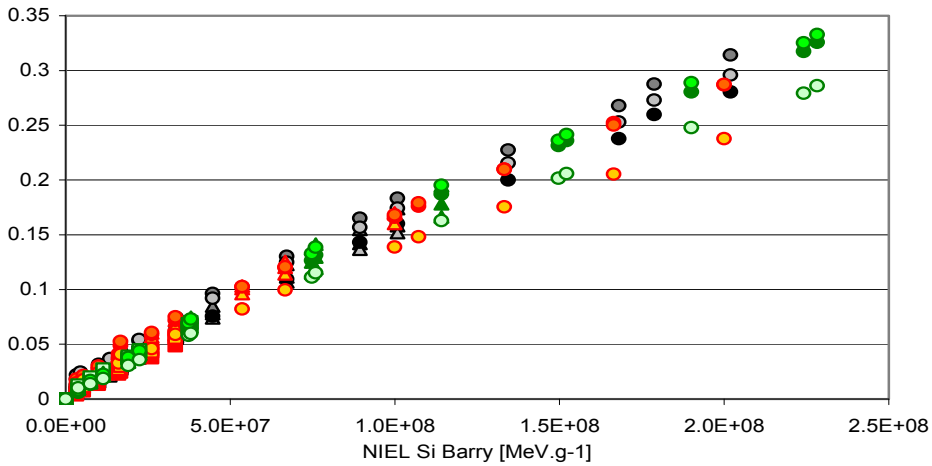


Fig. 13-34: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)



OLH249 IF= 8mA DELTA rel.CTR T



OLH249 IF= 10mA DELTA rel.CTR T

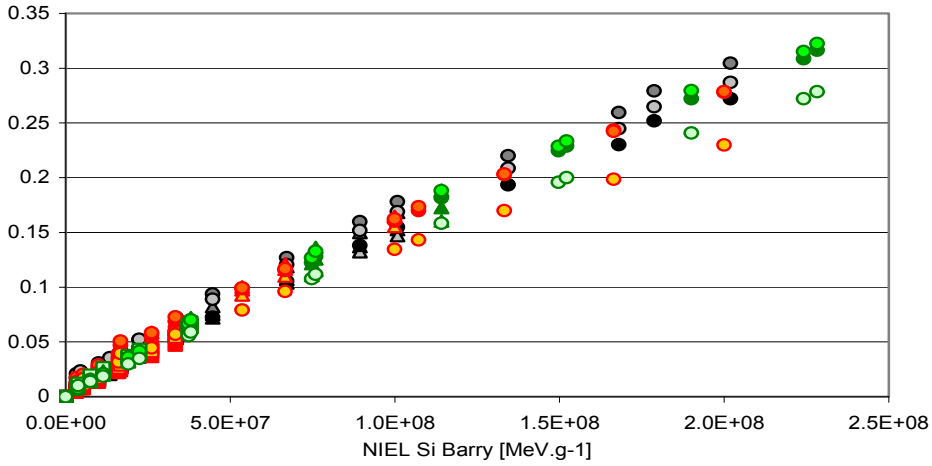
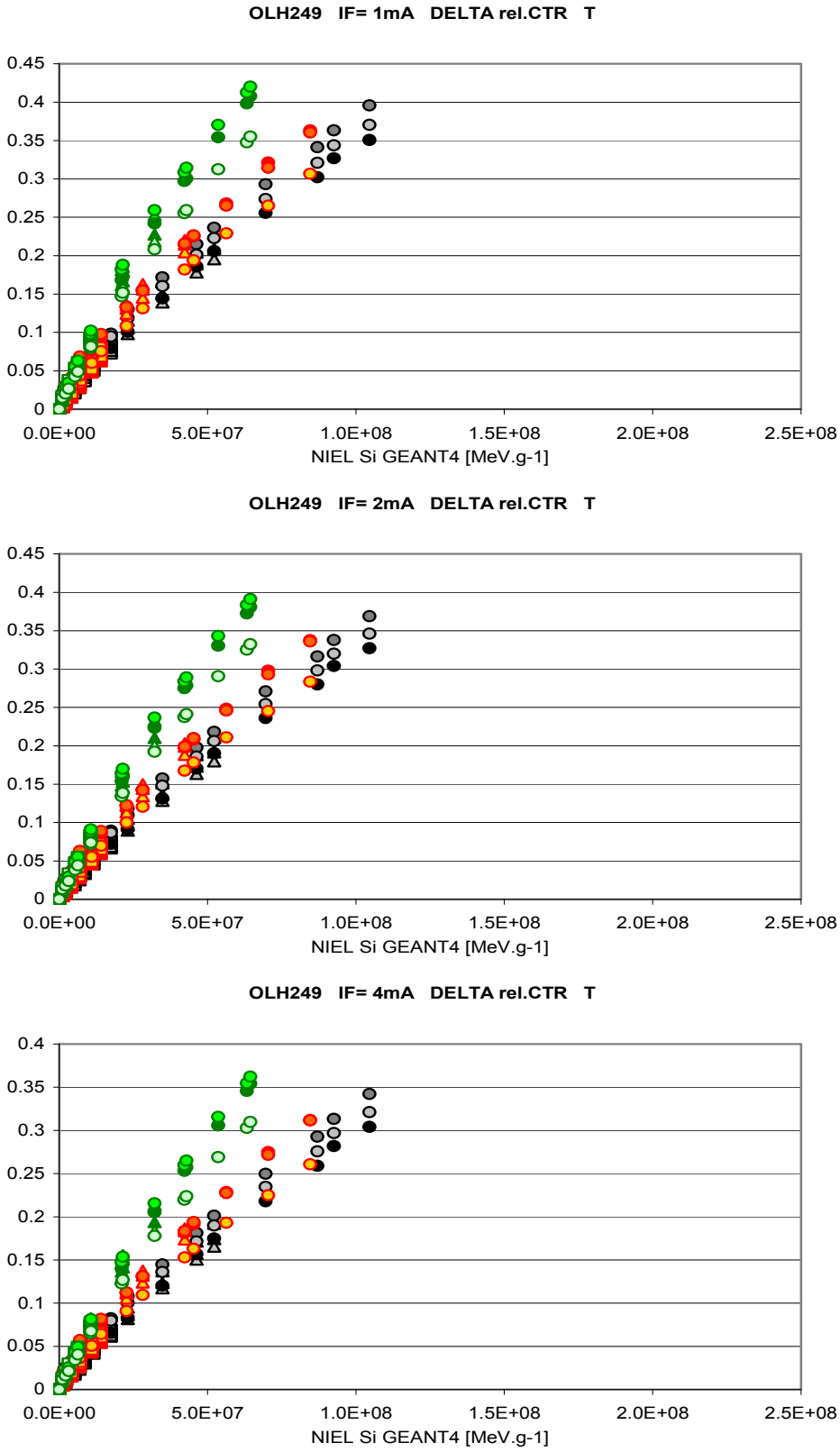
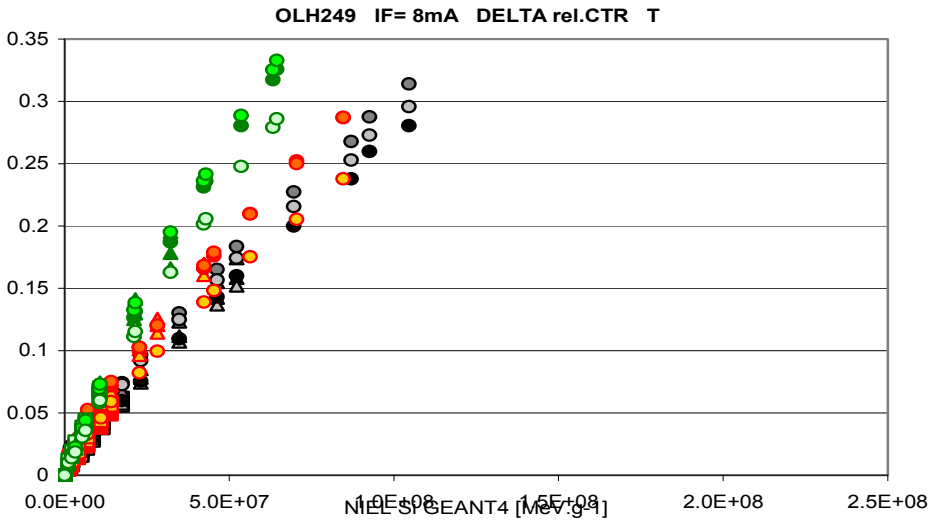


Fig. 13-35: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




OLH249 IF= 8mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

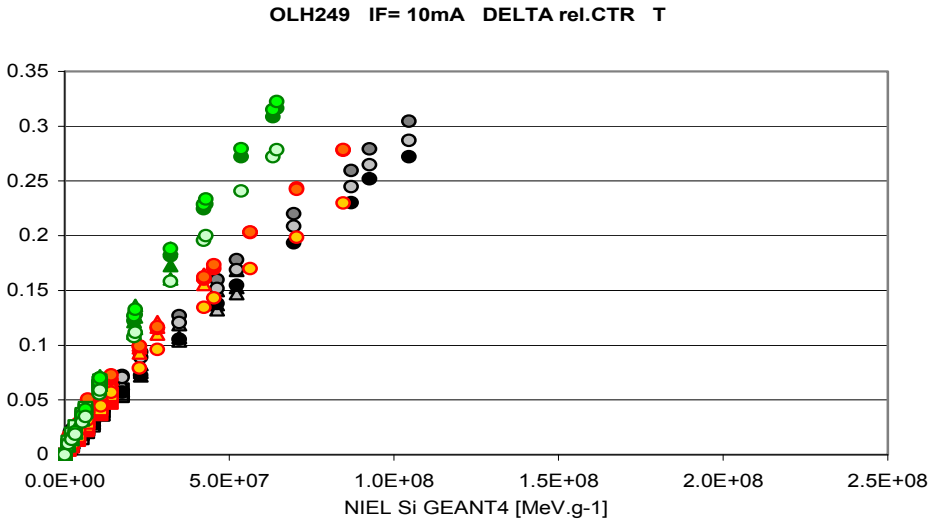
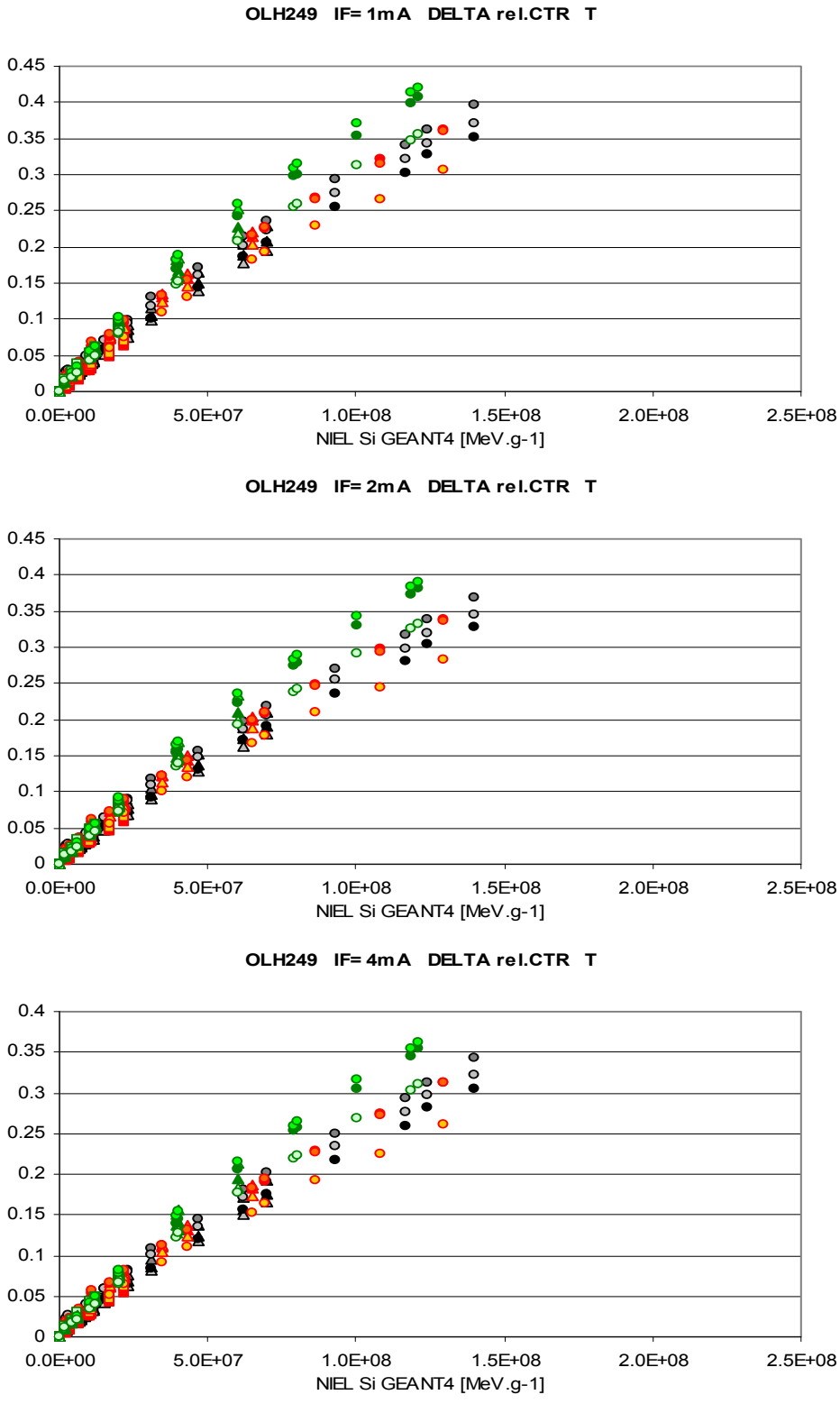
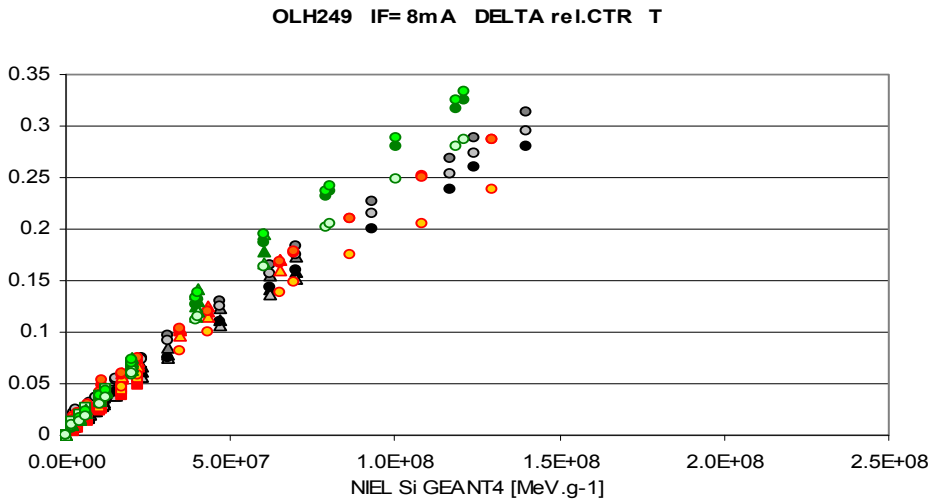

OLH249 IF= 10mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-36: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




OLH249 IF= 8mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

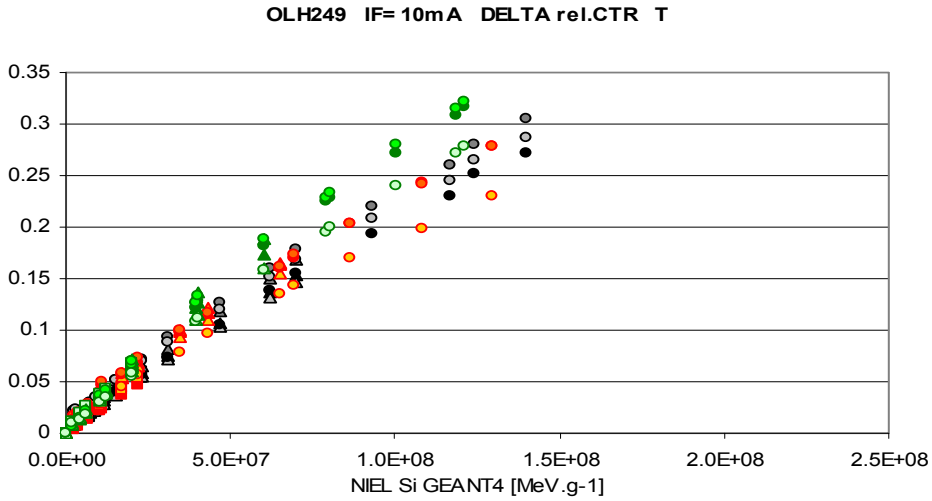
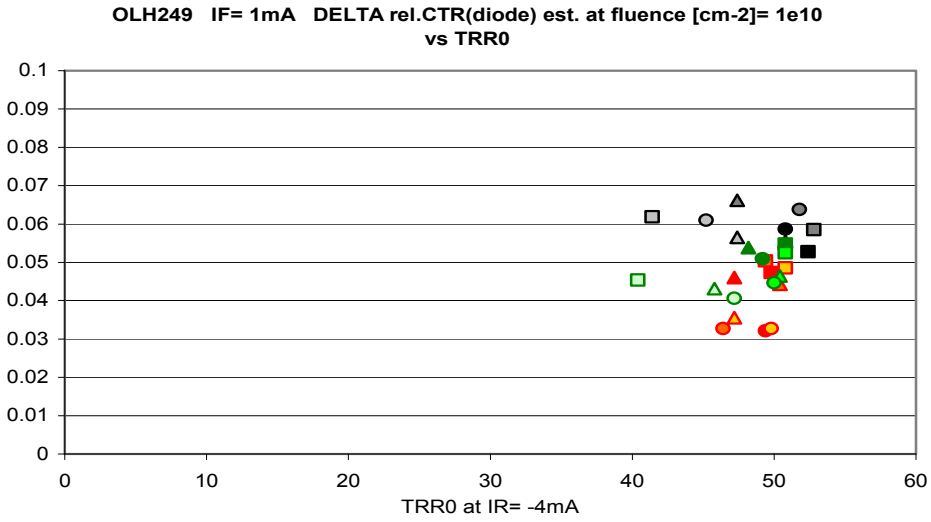
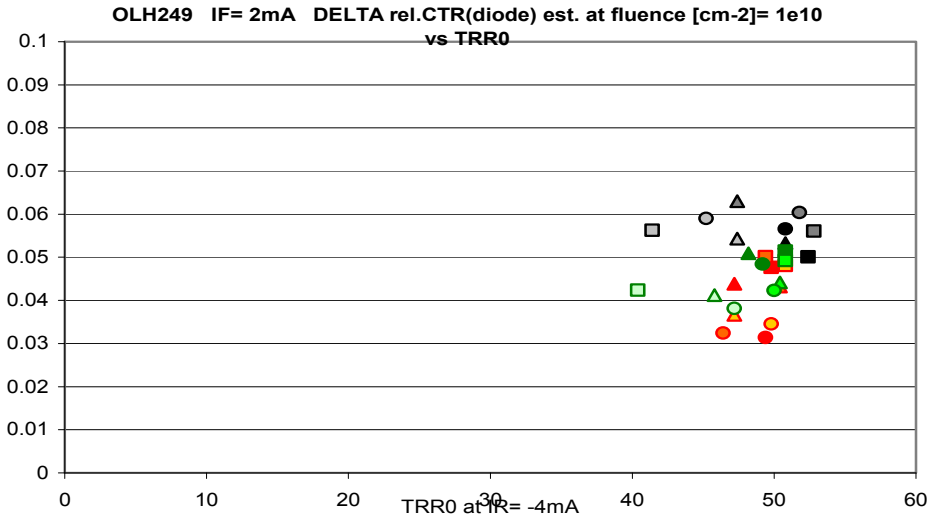
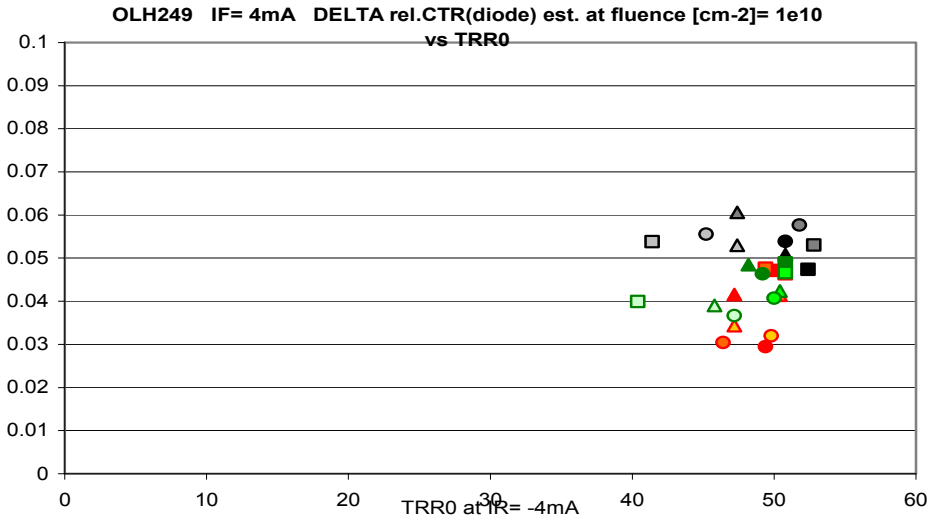
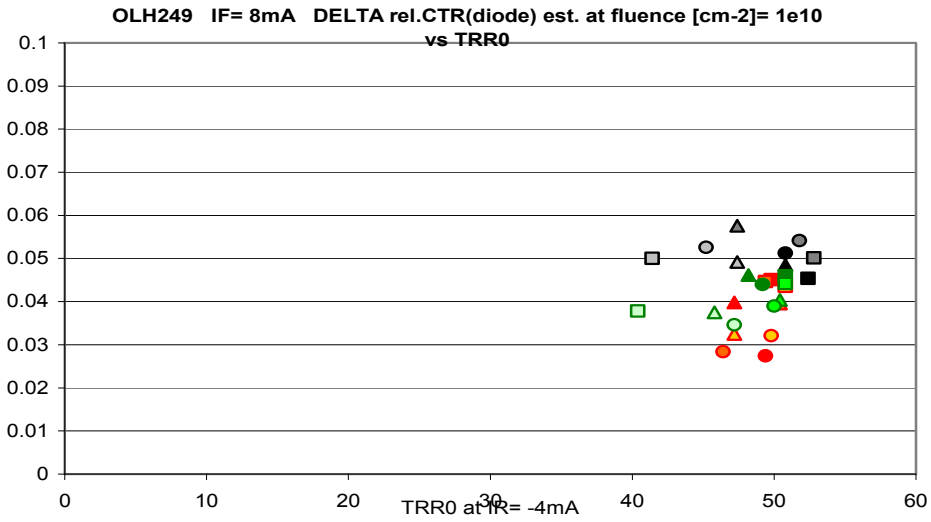

OLH249 IF= 10mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-37: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 1.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10
vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

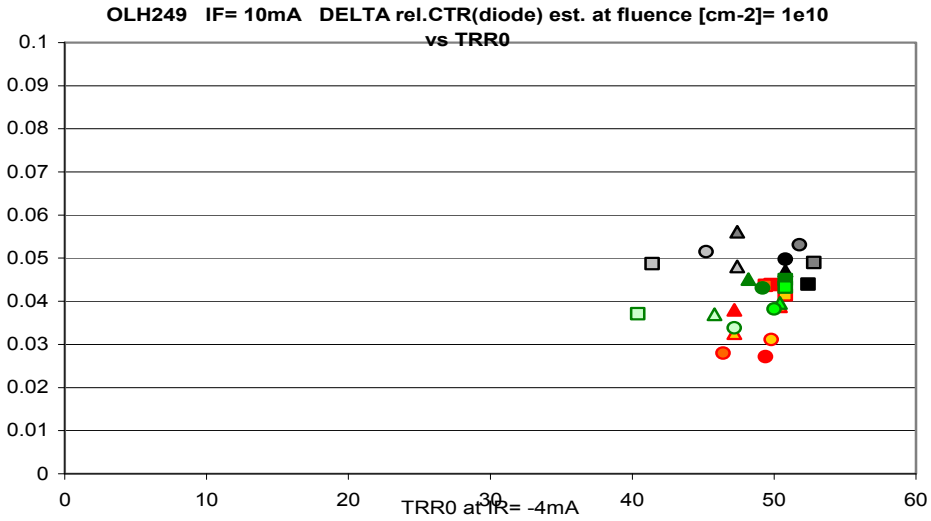
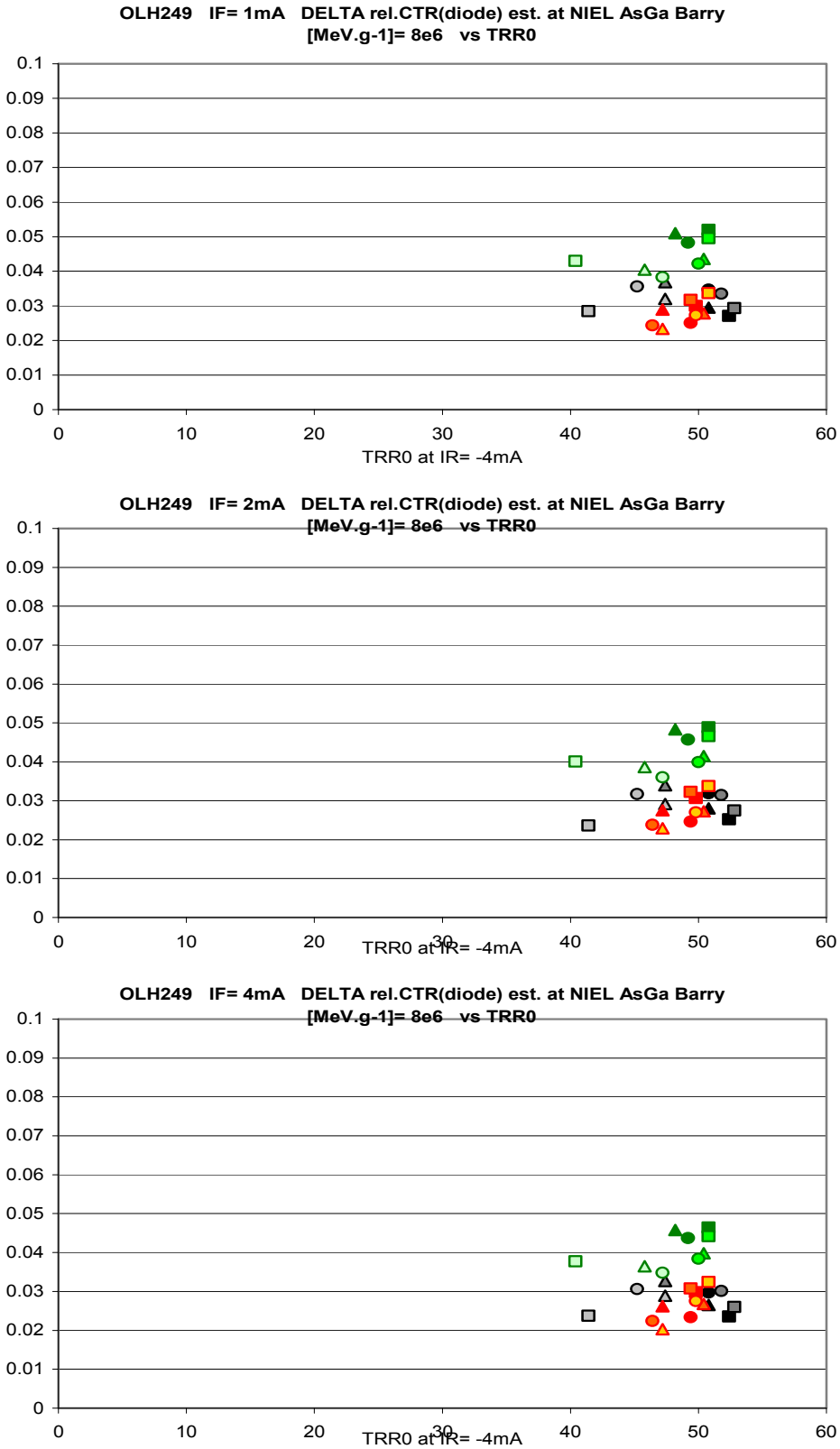
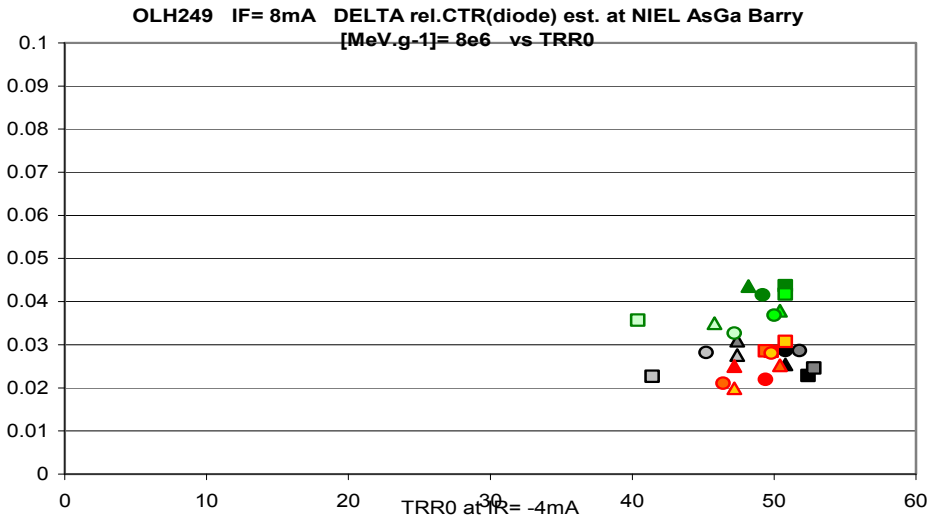

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10
vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-38: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

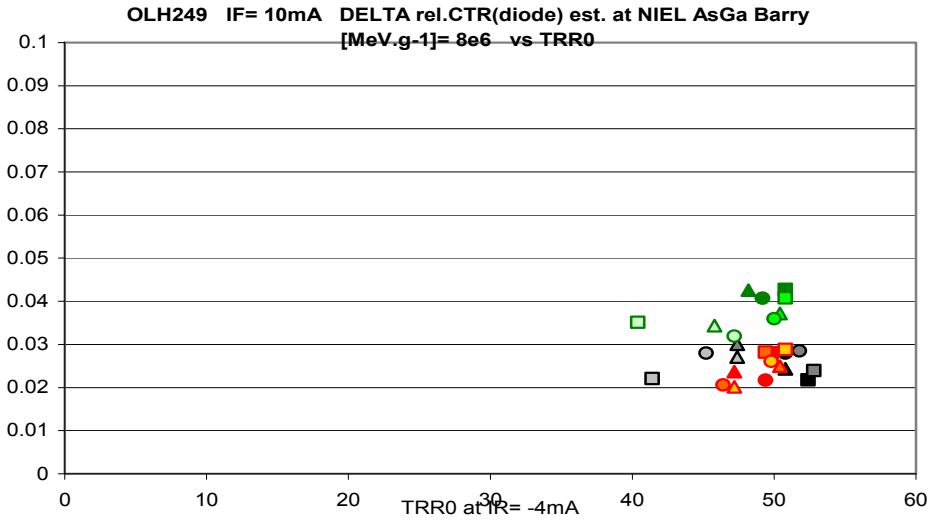
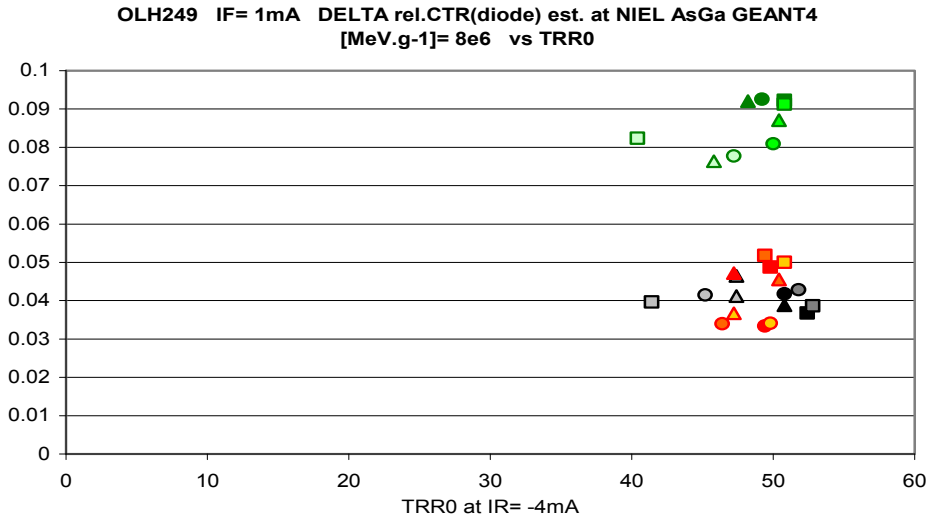
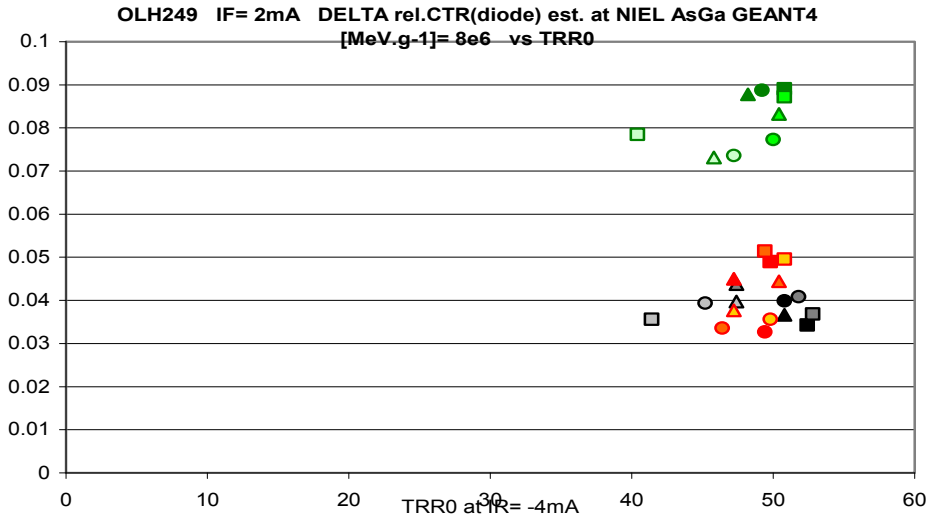
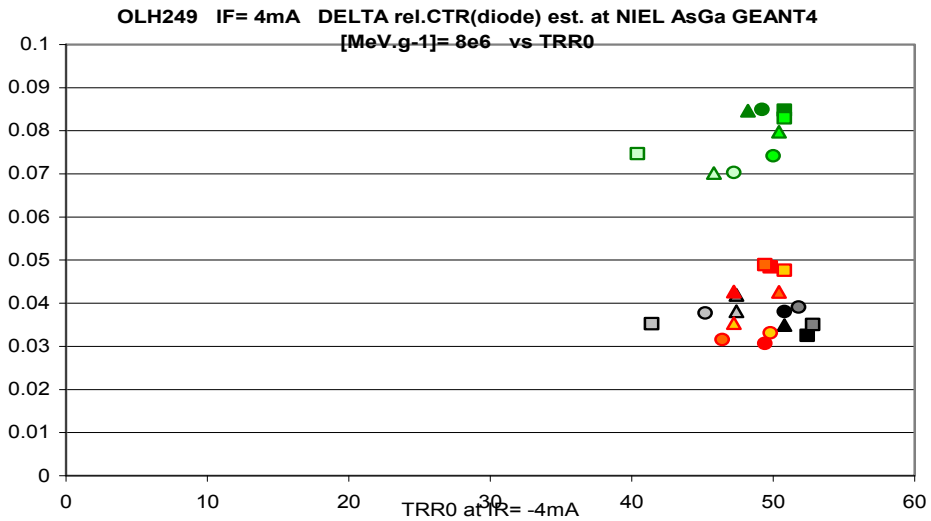
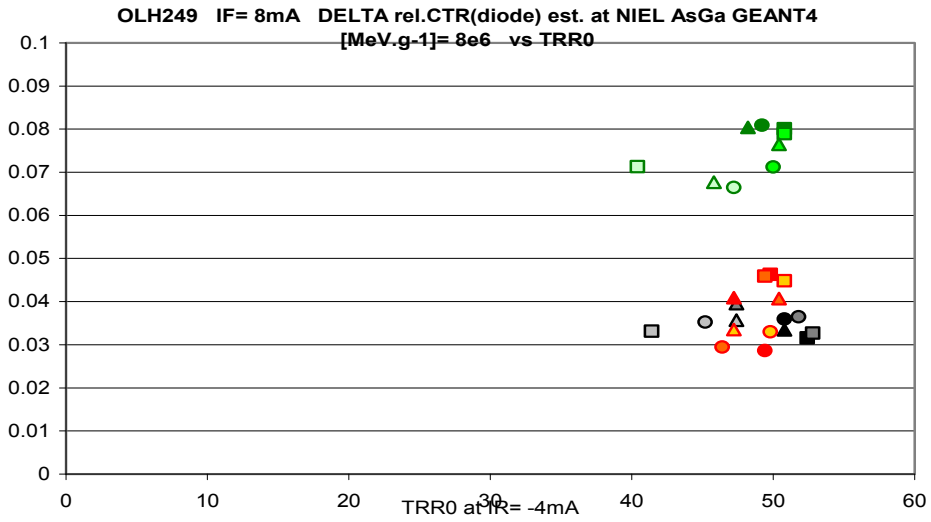

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-39: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

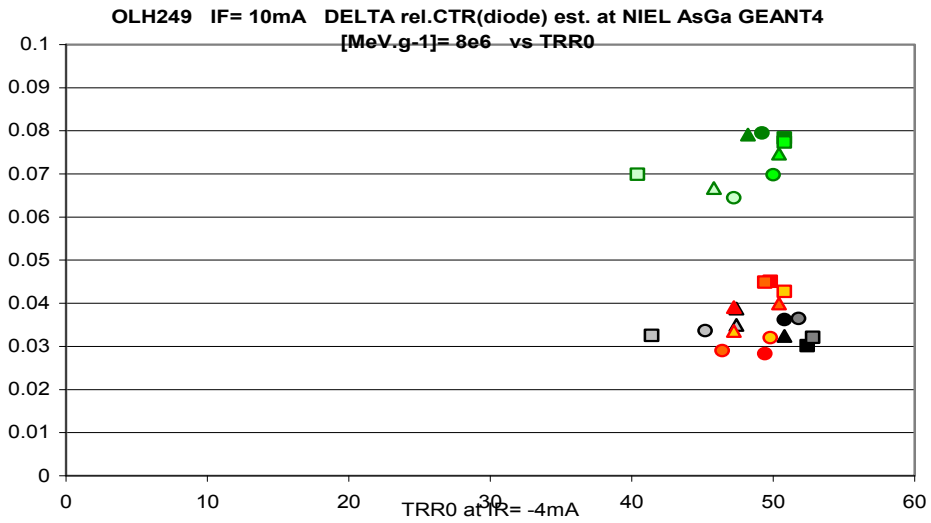
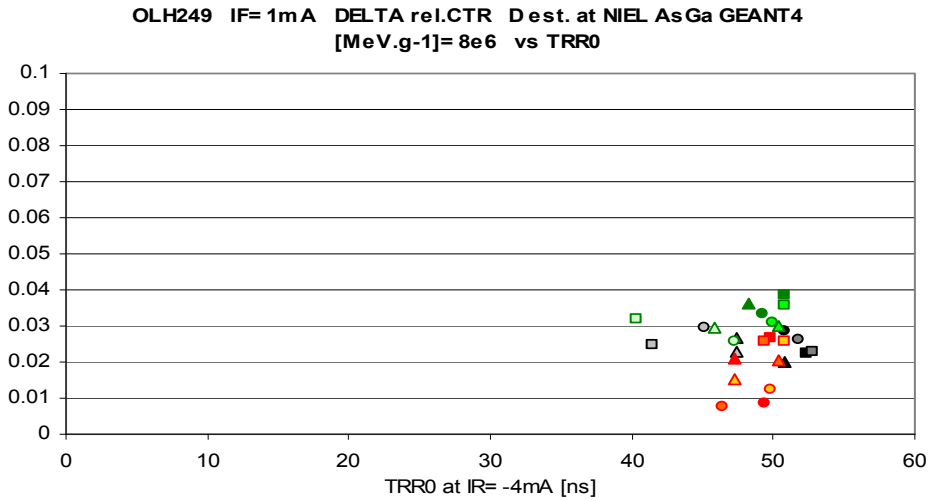
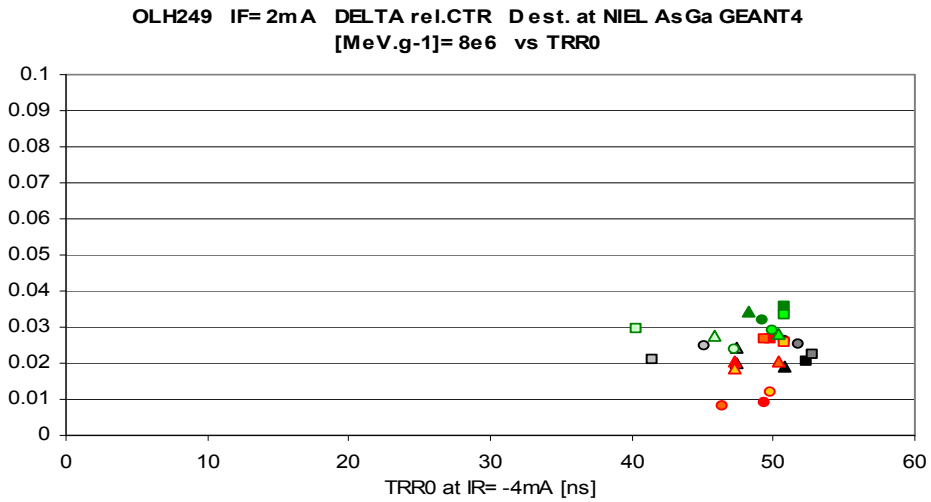
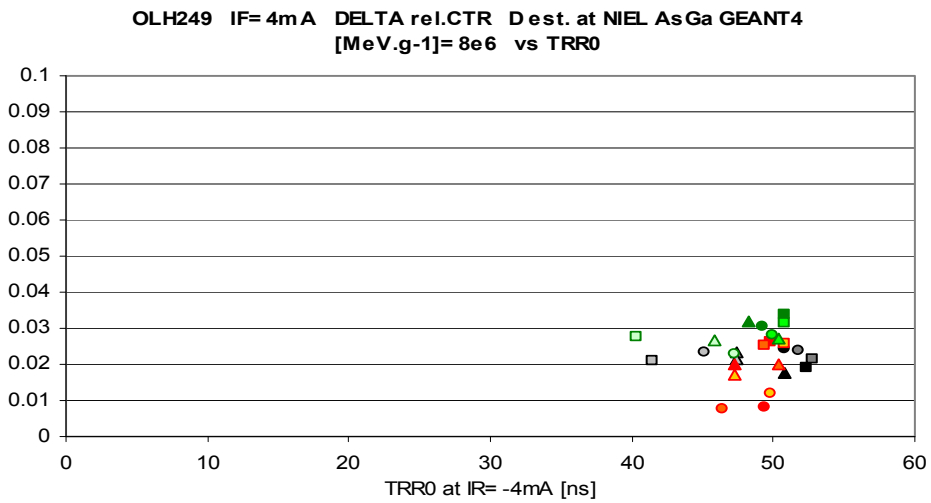
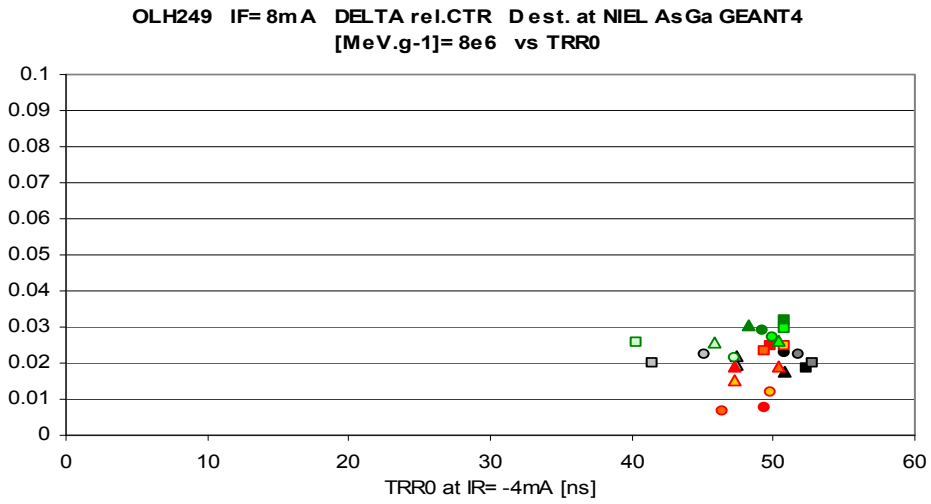

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-40: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

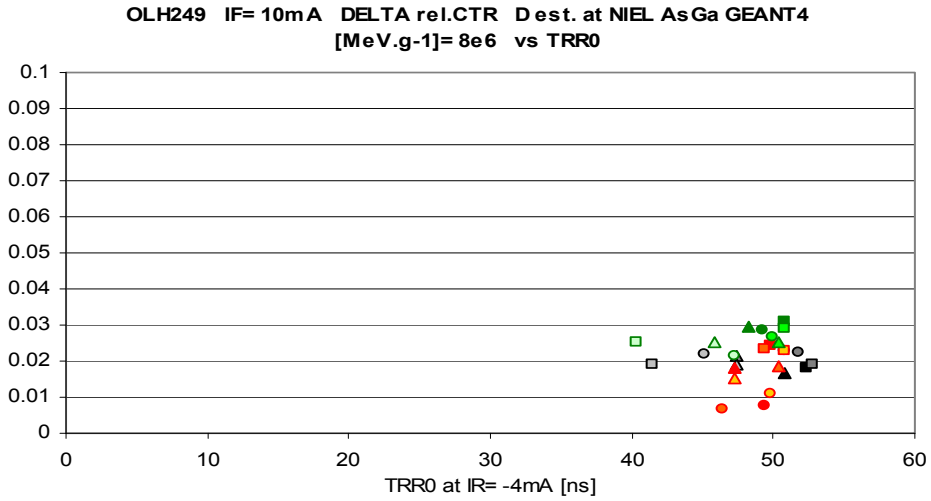
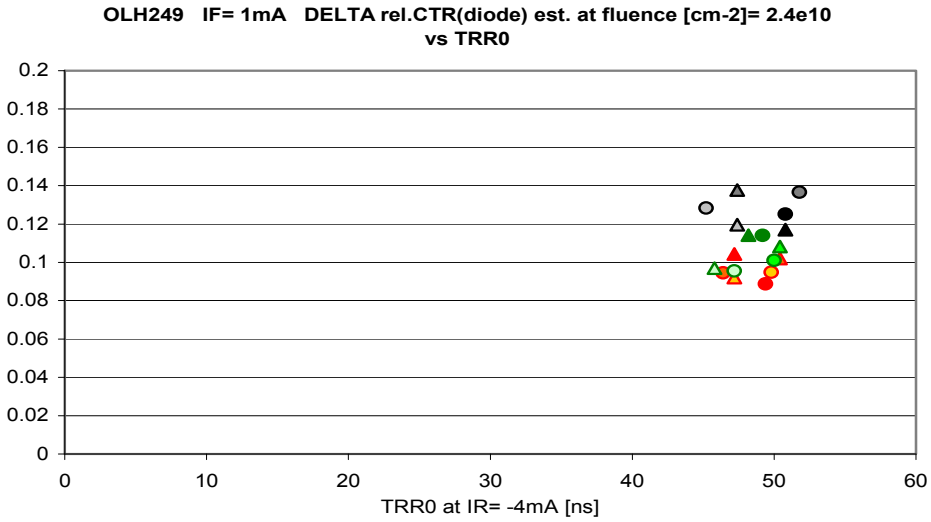
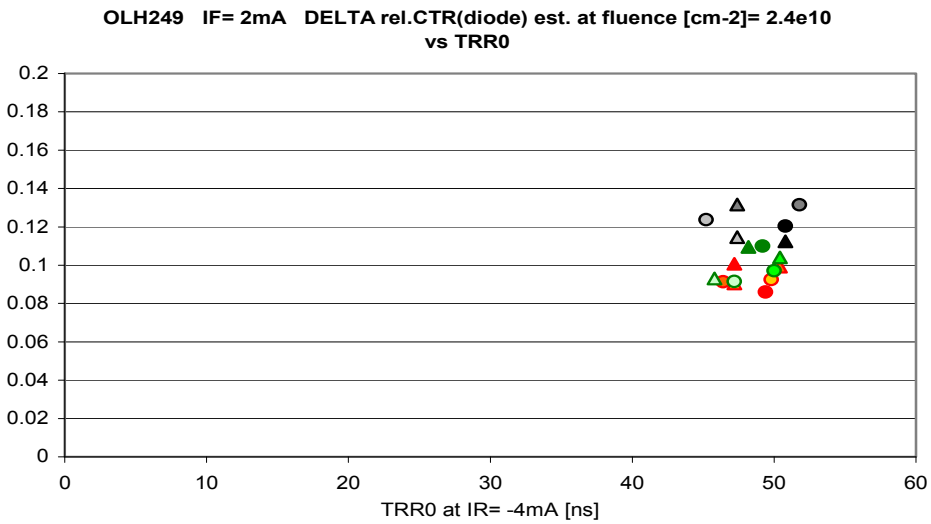
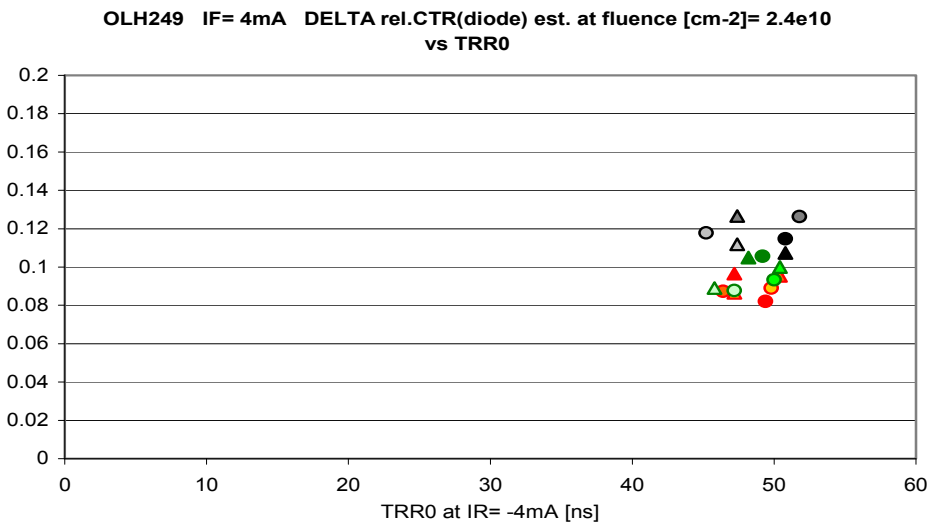
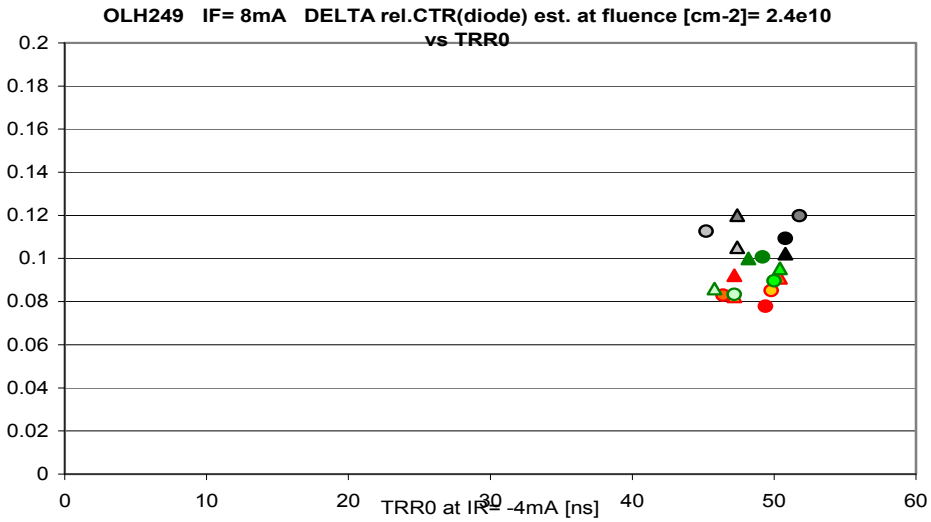

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-41: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 2.4.10^{10} cm^2 at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

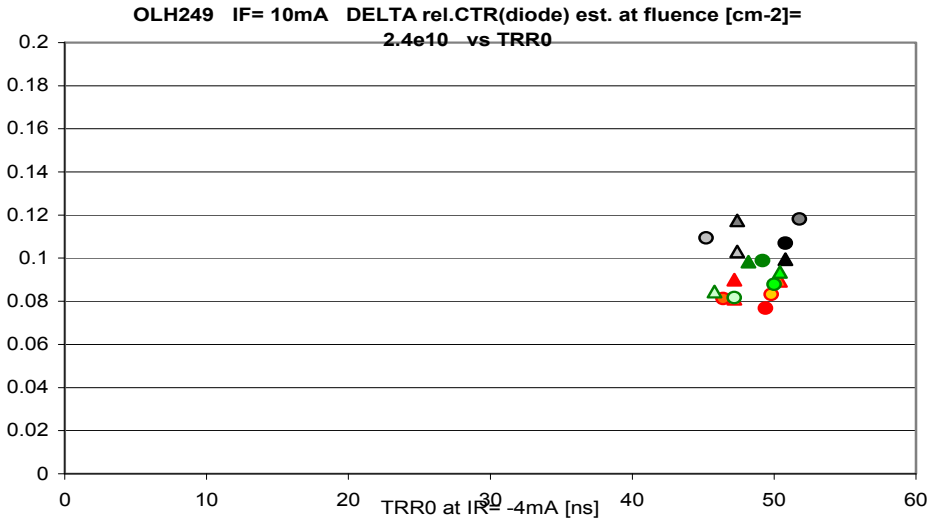
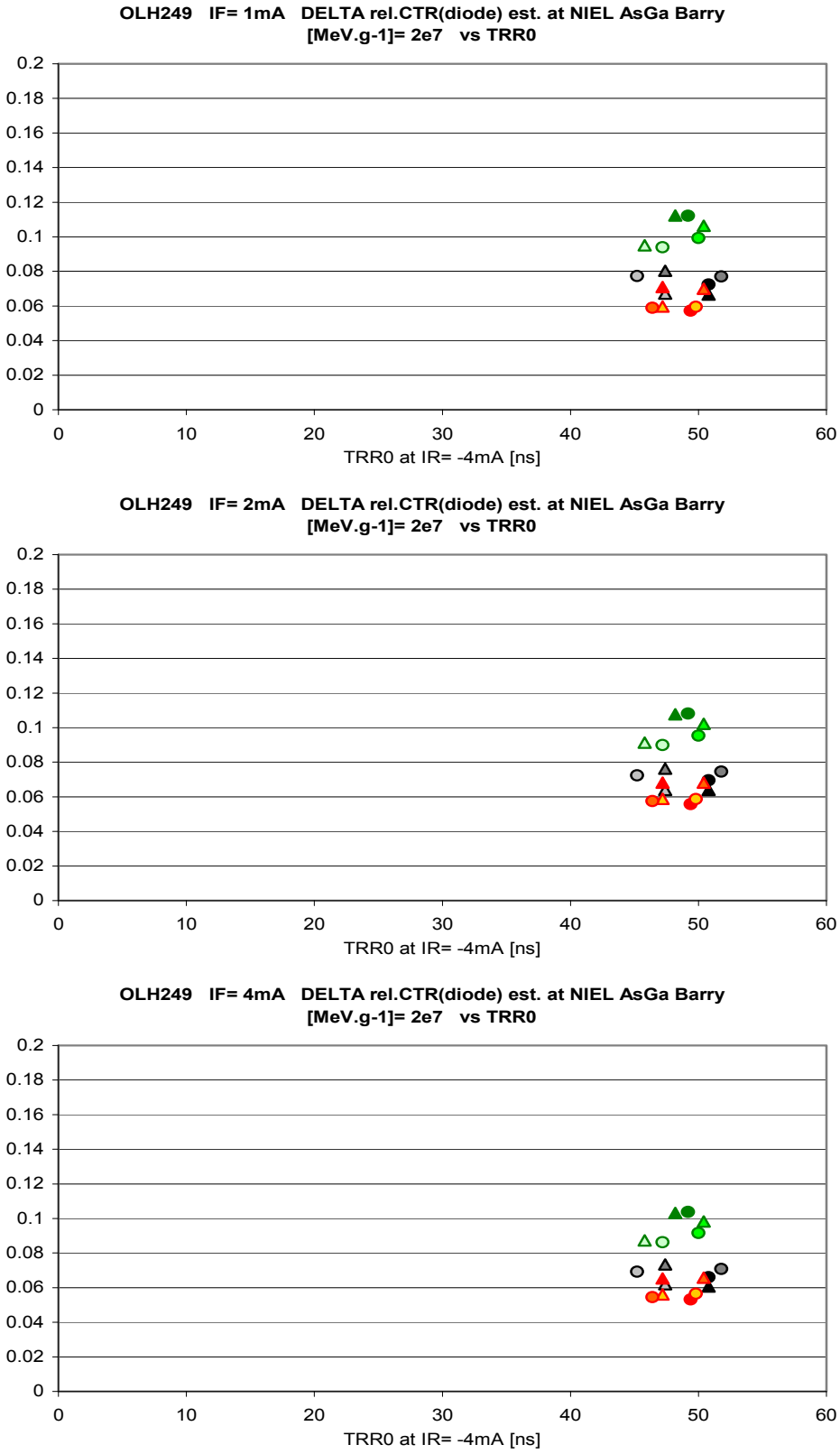
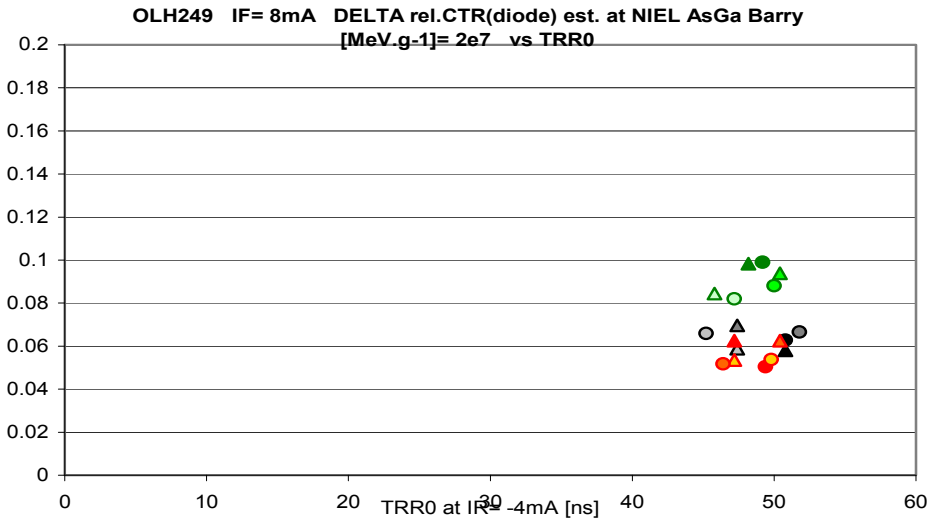

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-42: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

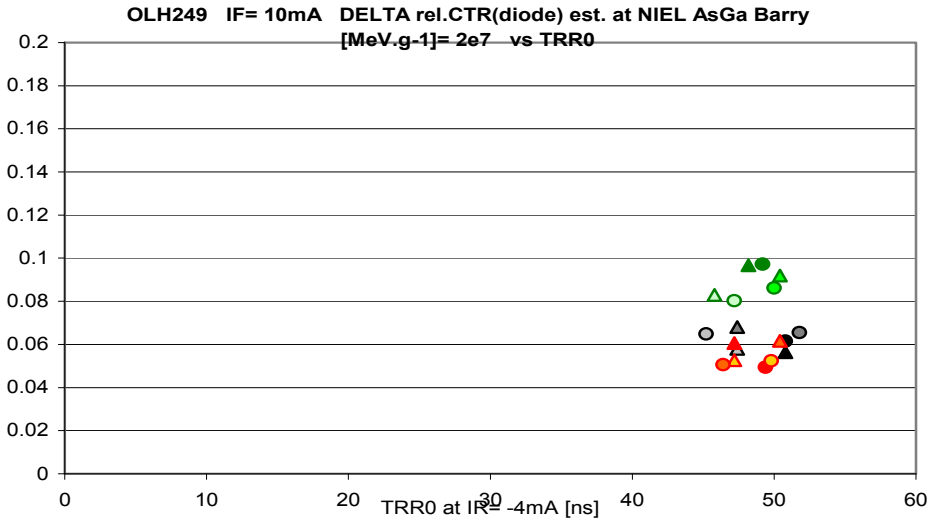
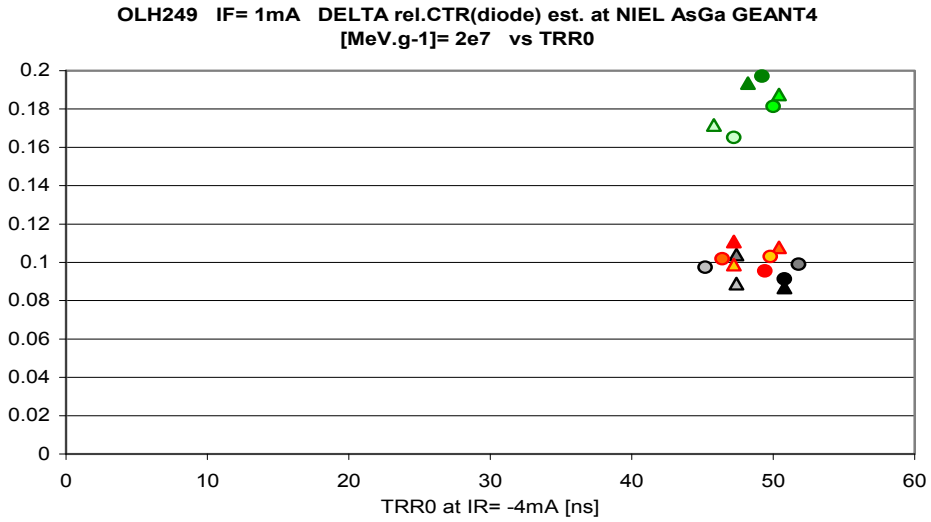
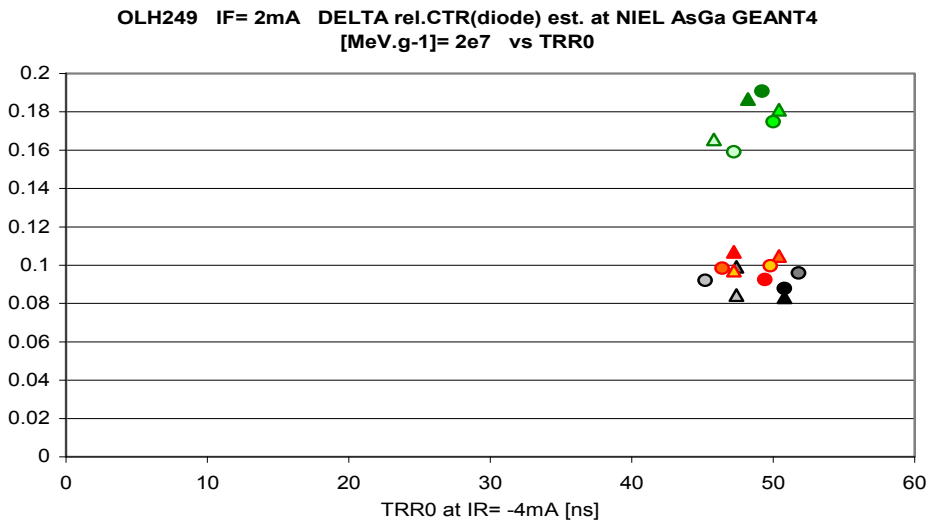
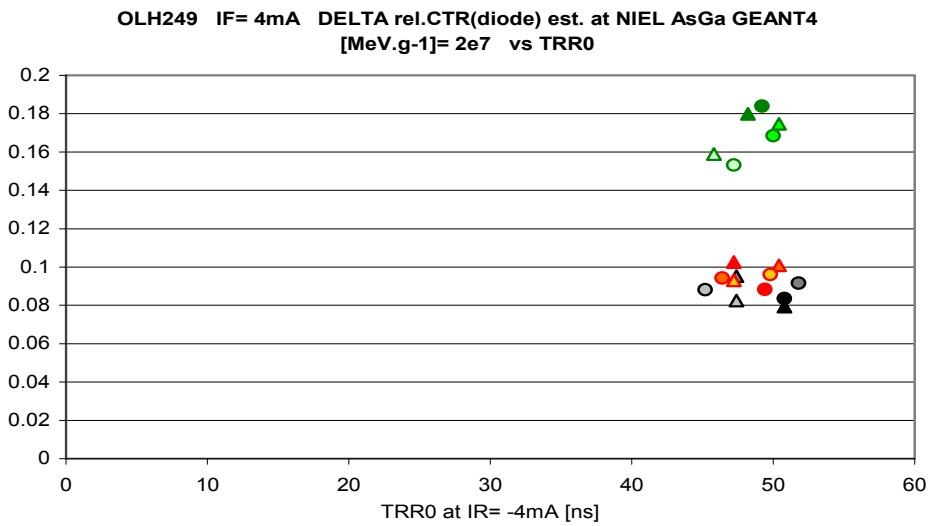
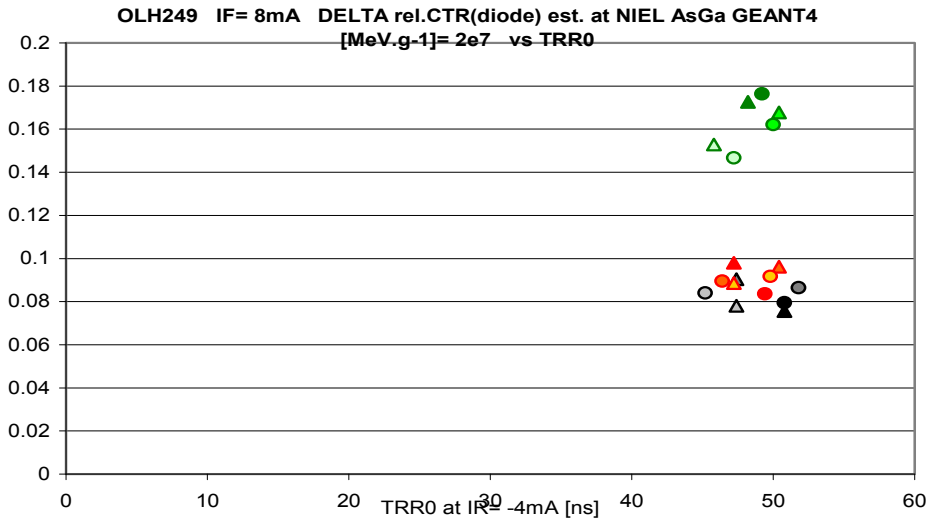

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-43: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

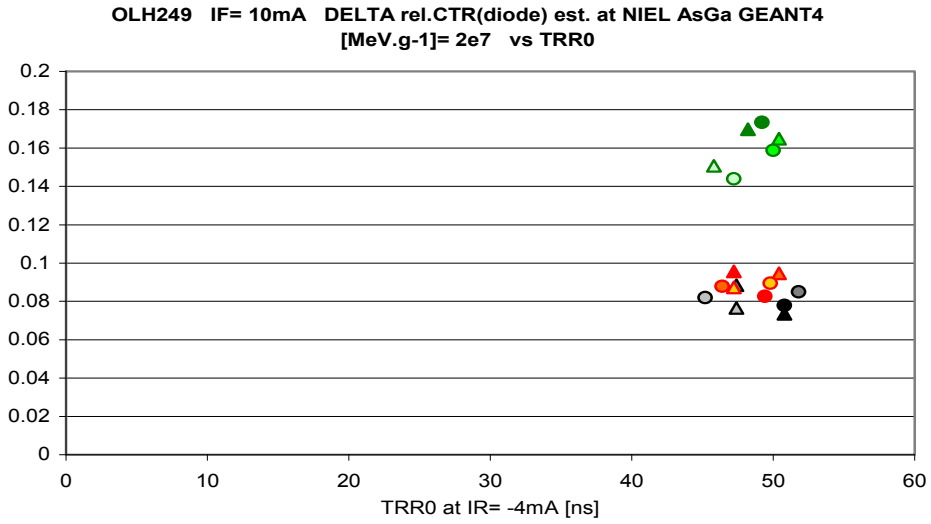
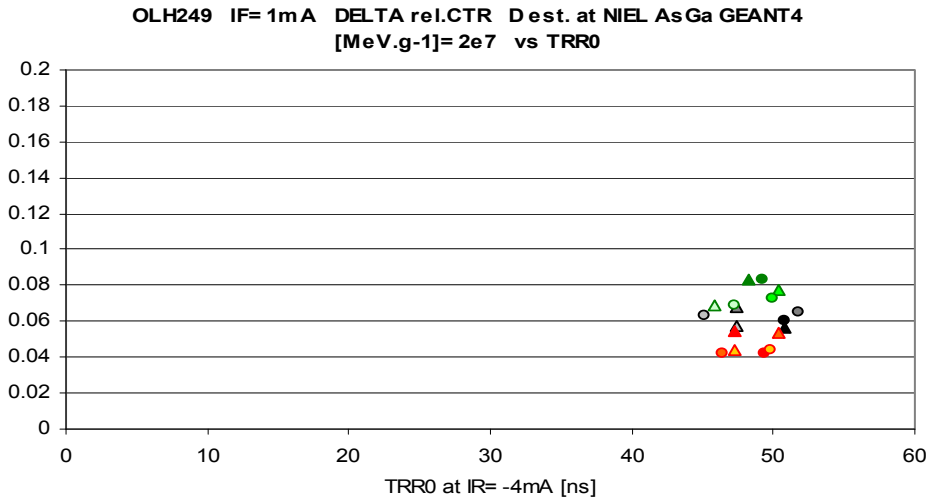
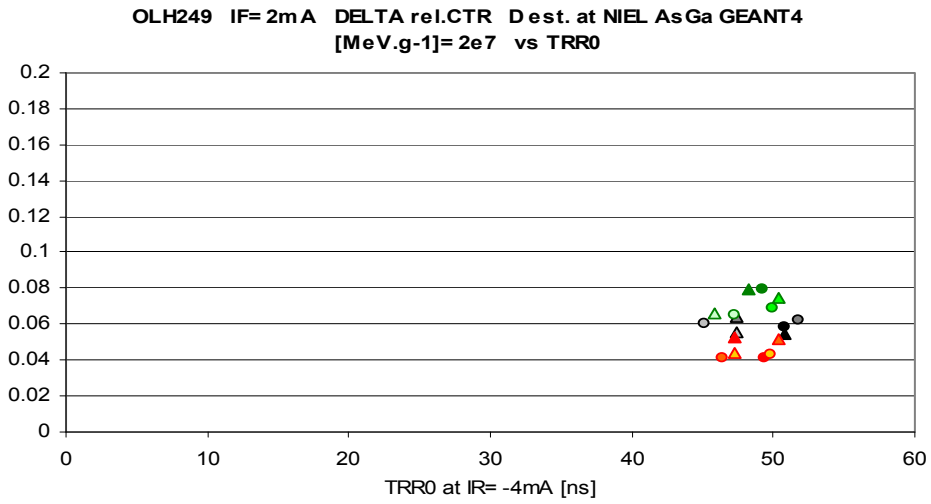
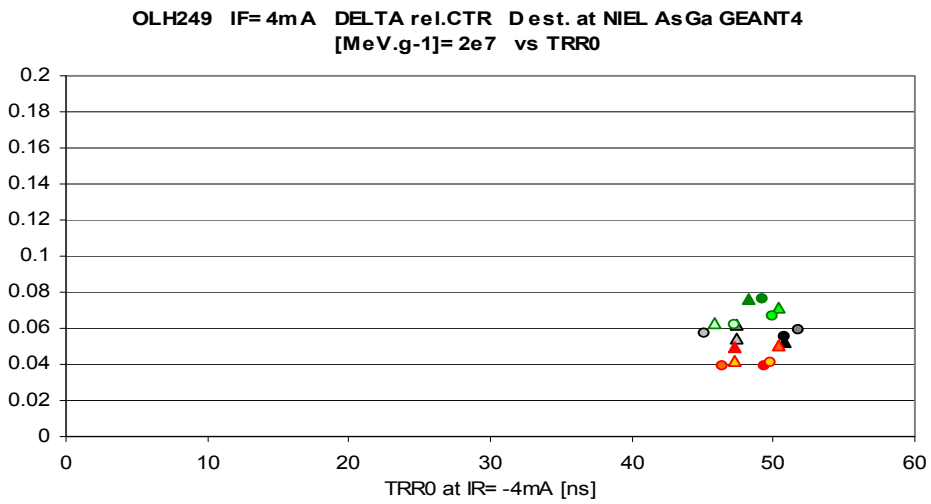
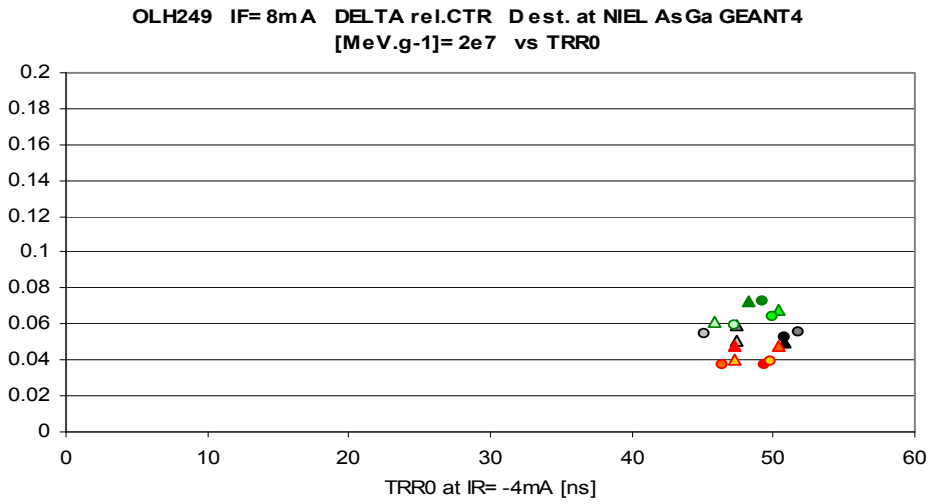

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-44: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

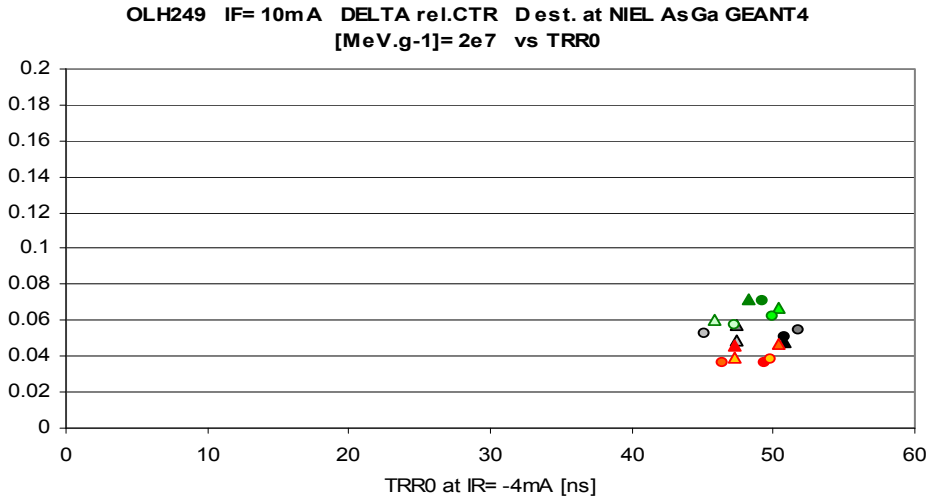
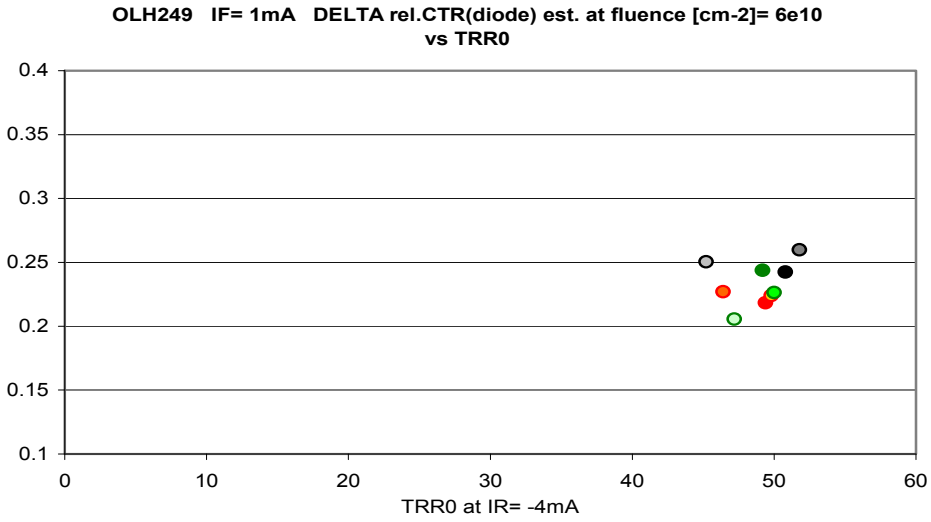
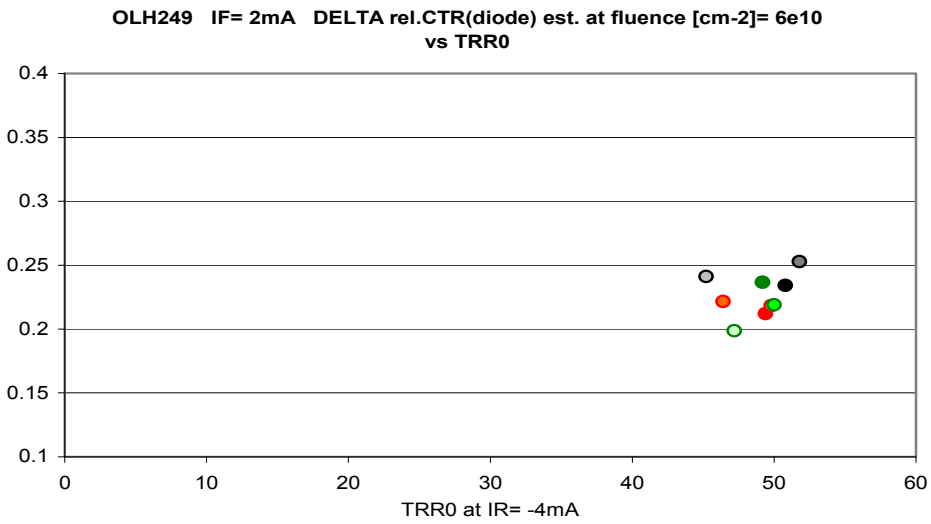
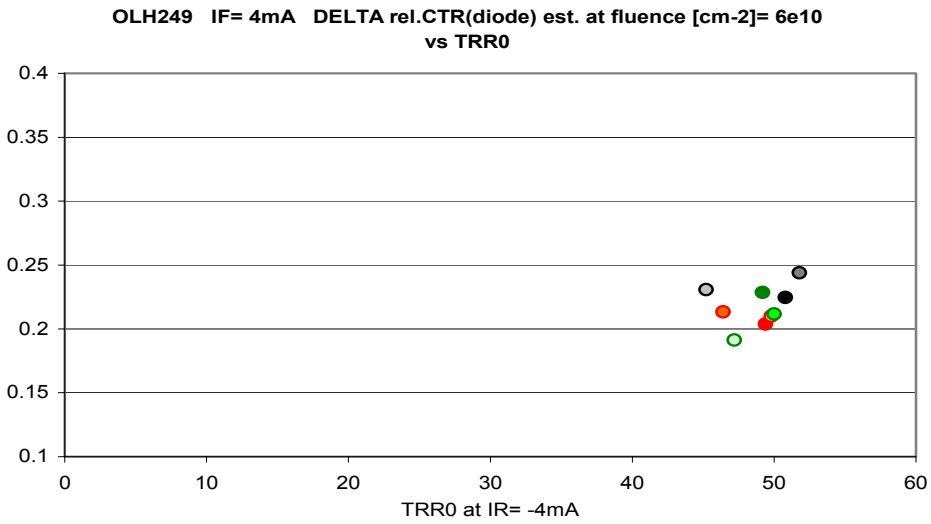
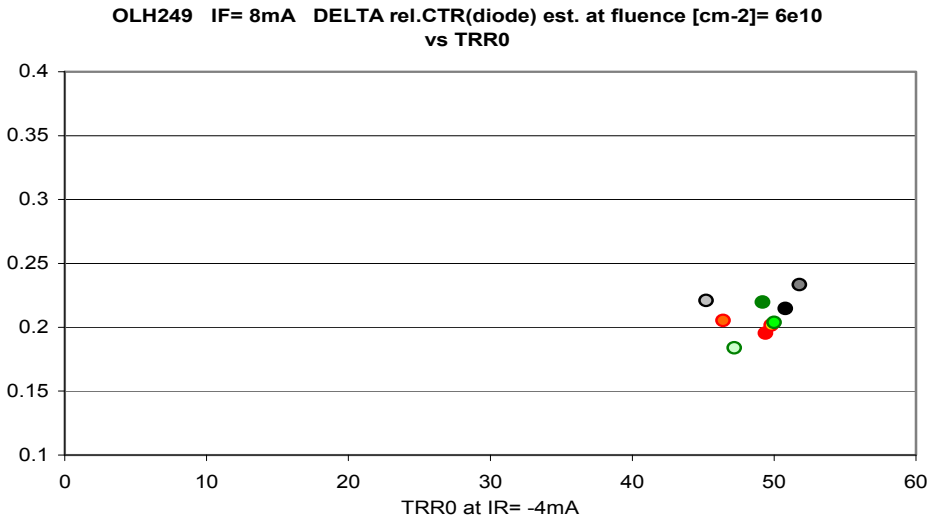

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-45: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 6.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10
vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

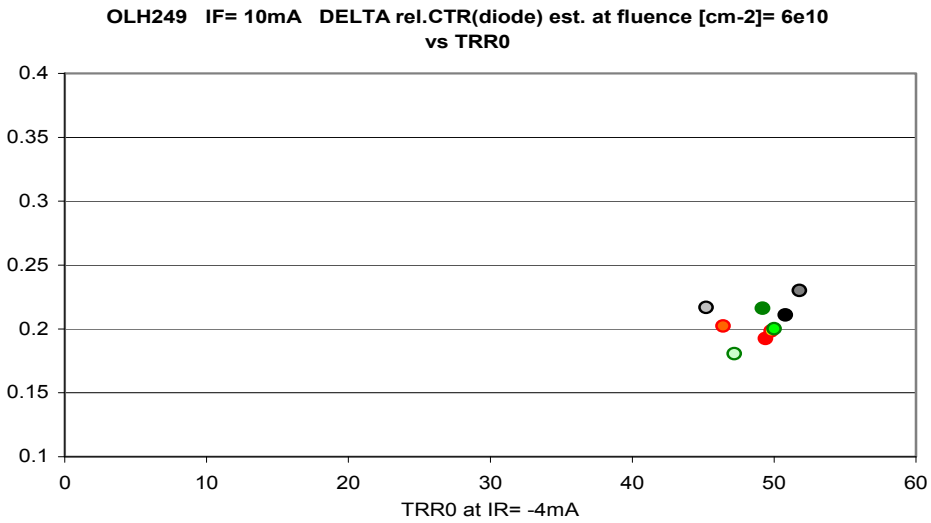
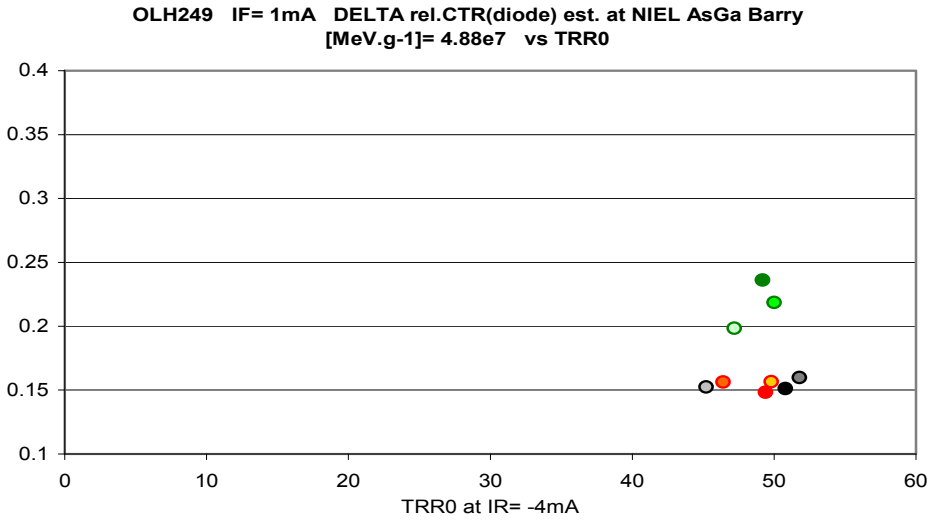
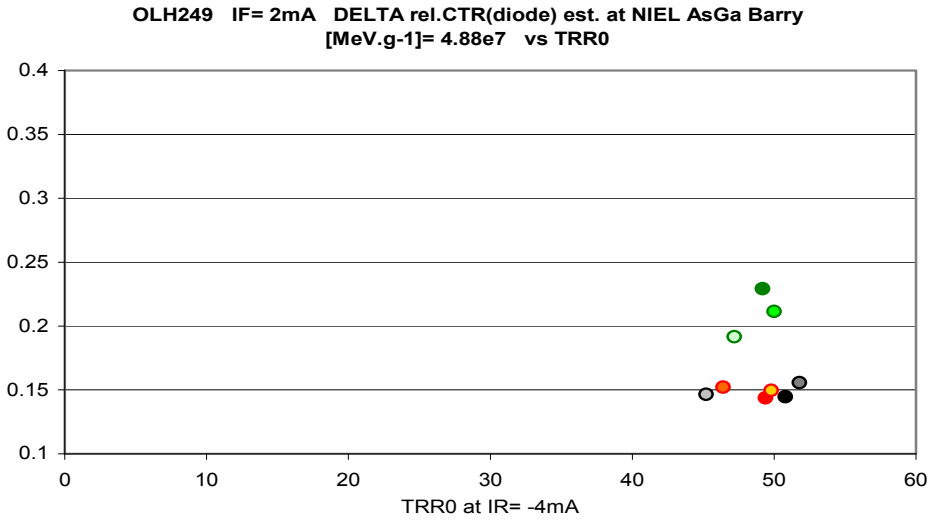
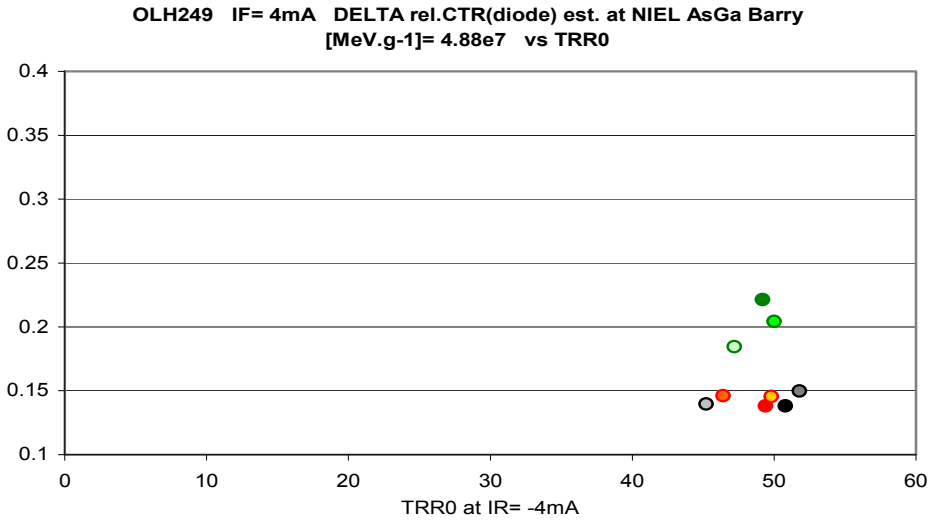
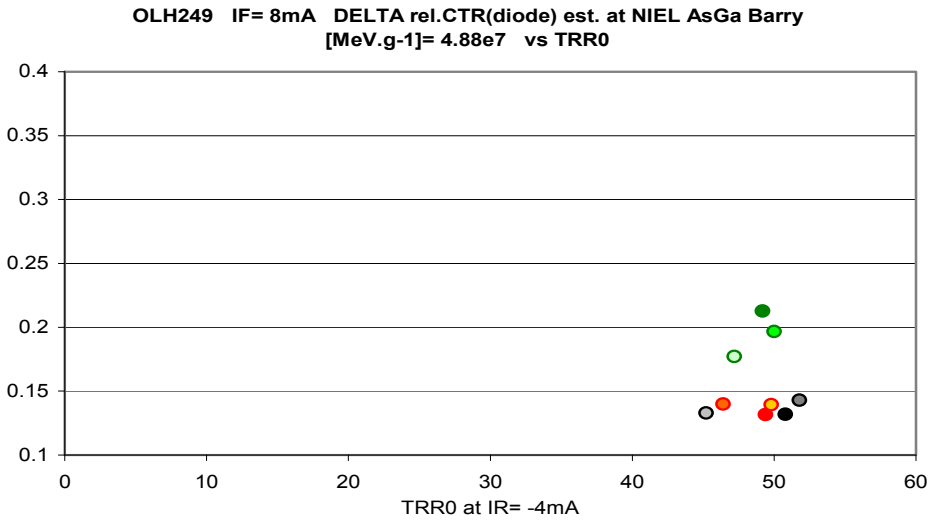

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10
vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-46: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

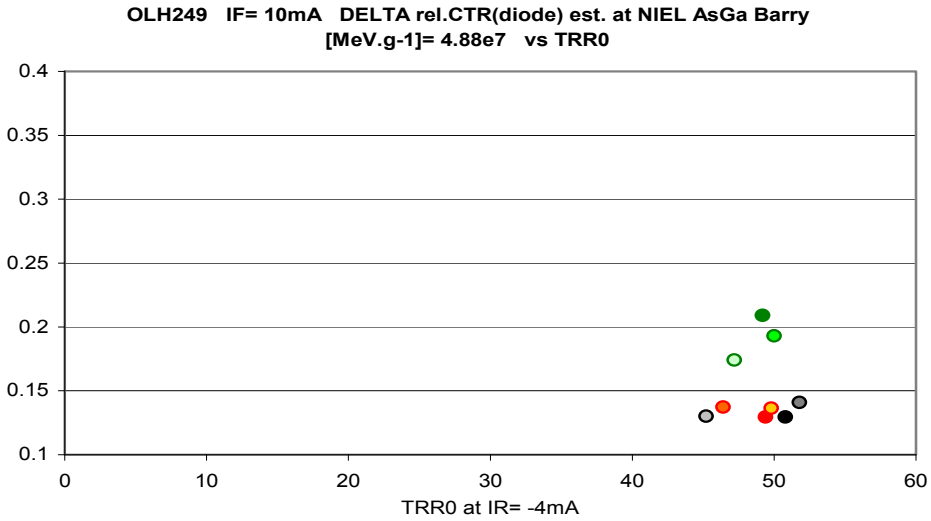
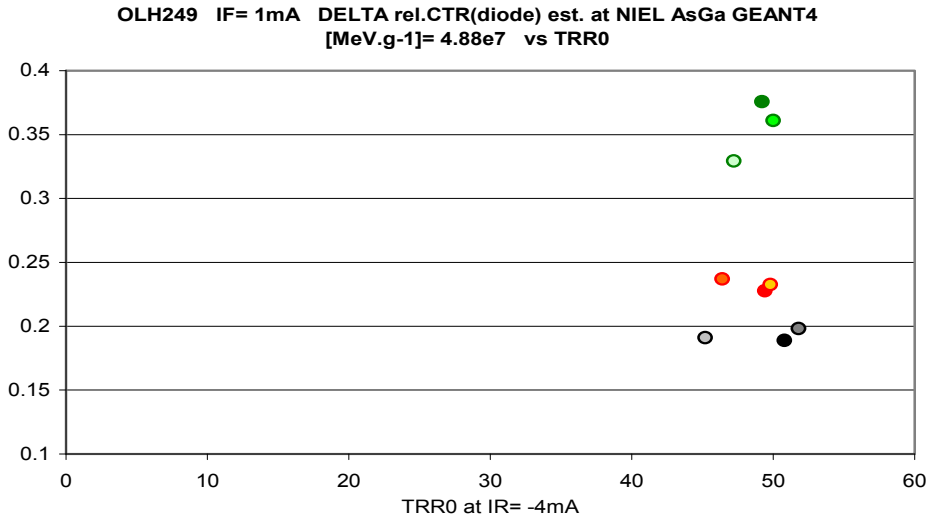
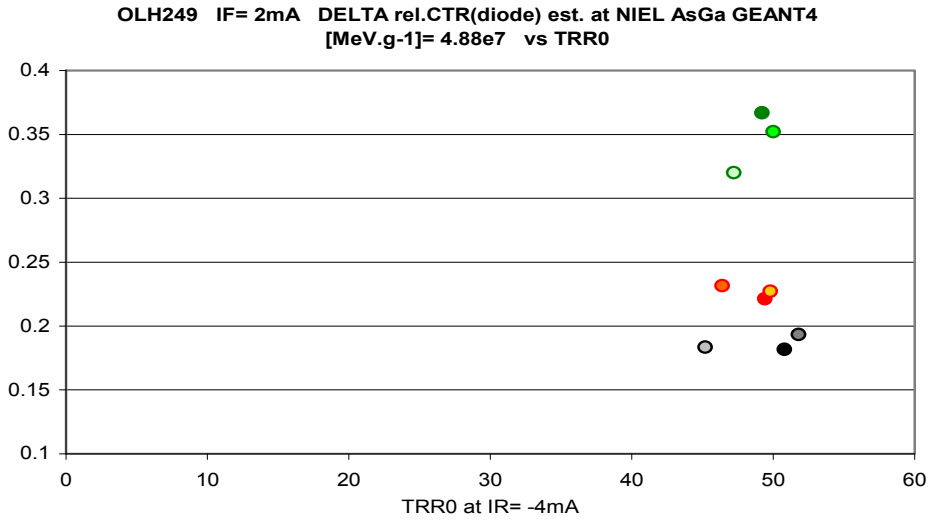
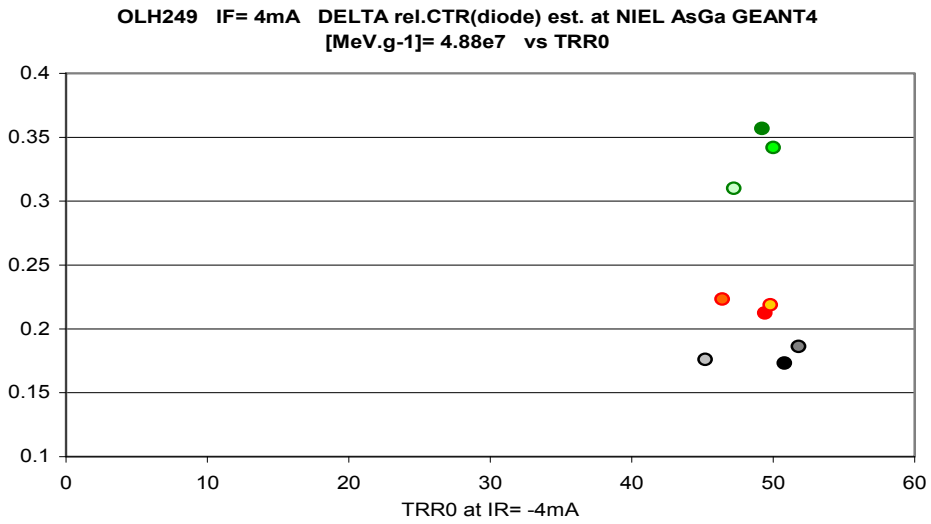
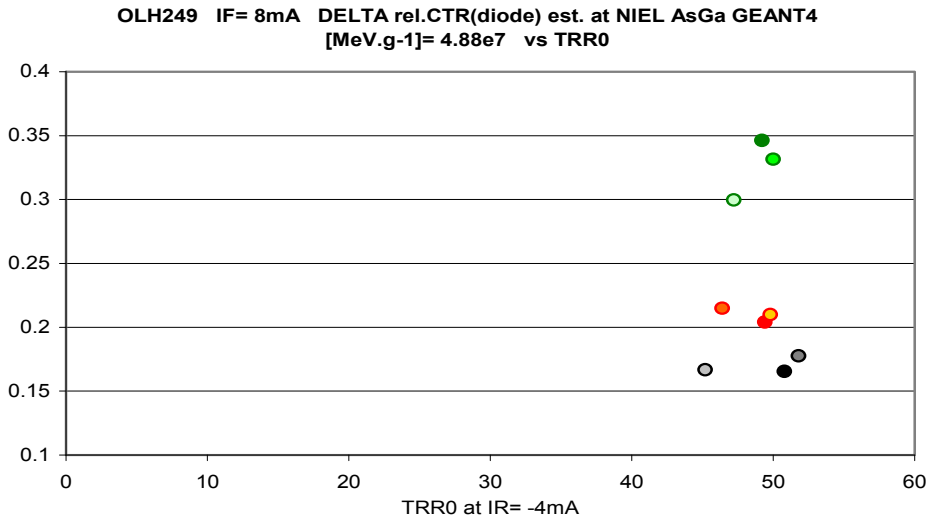

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-47: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

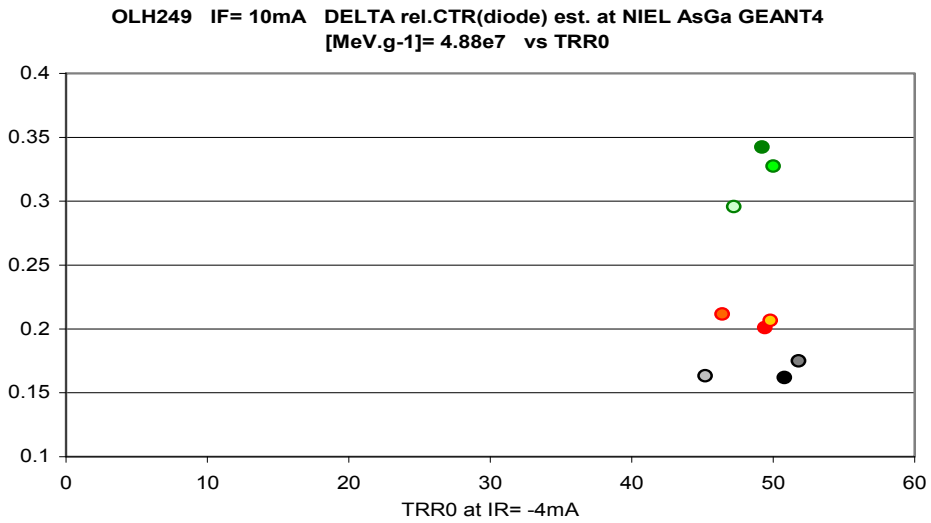
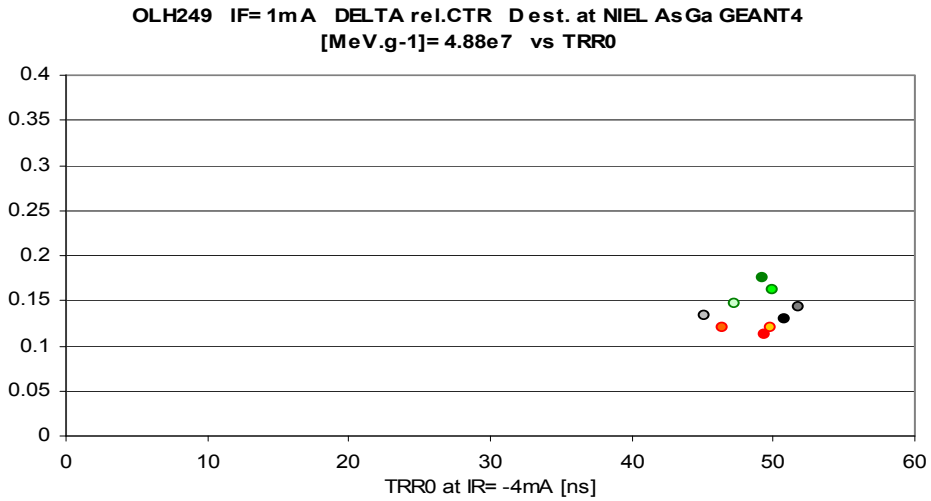
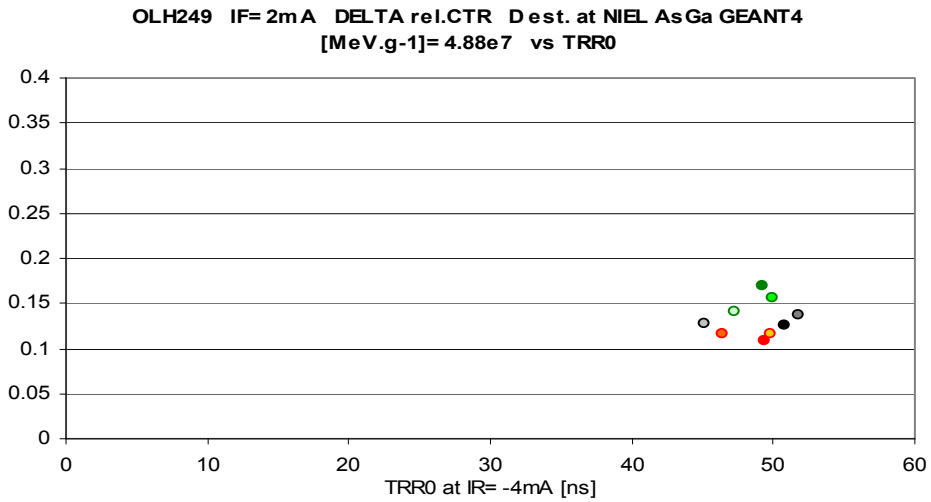
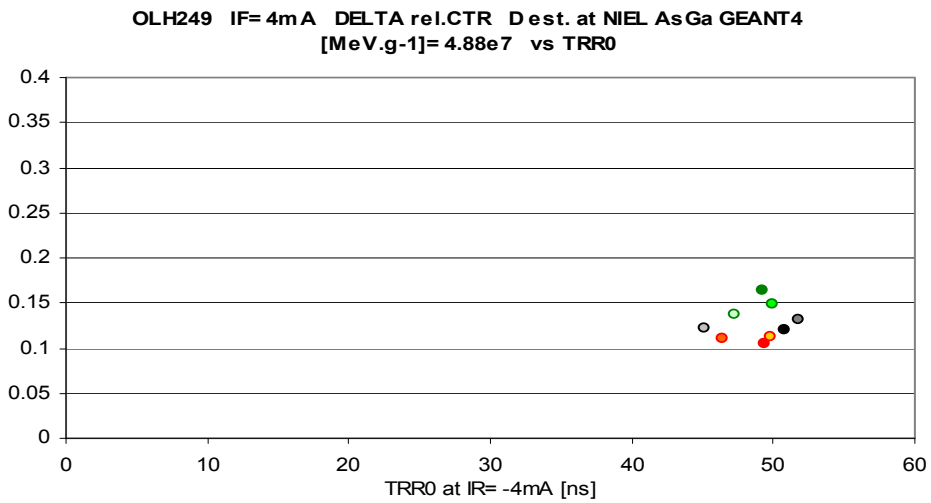
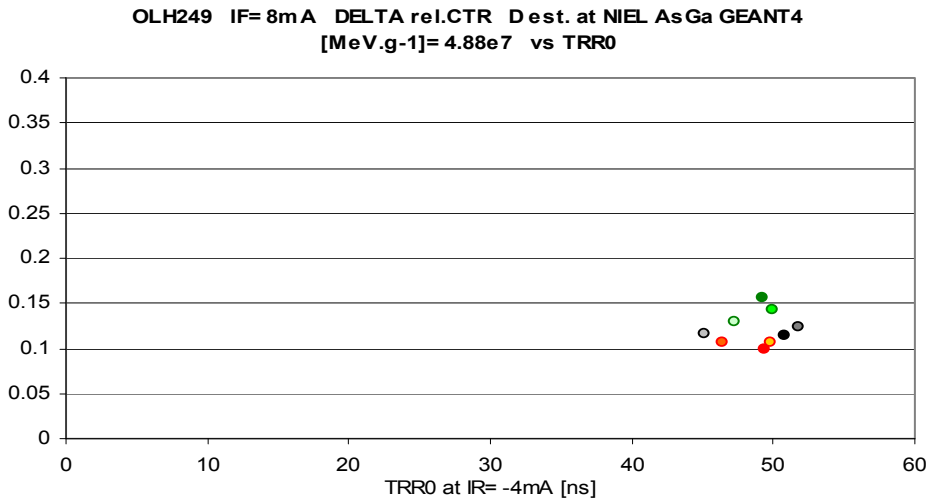

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-48: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

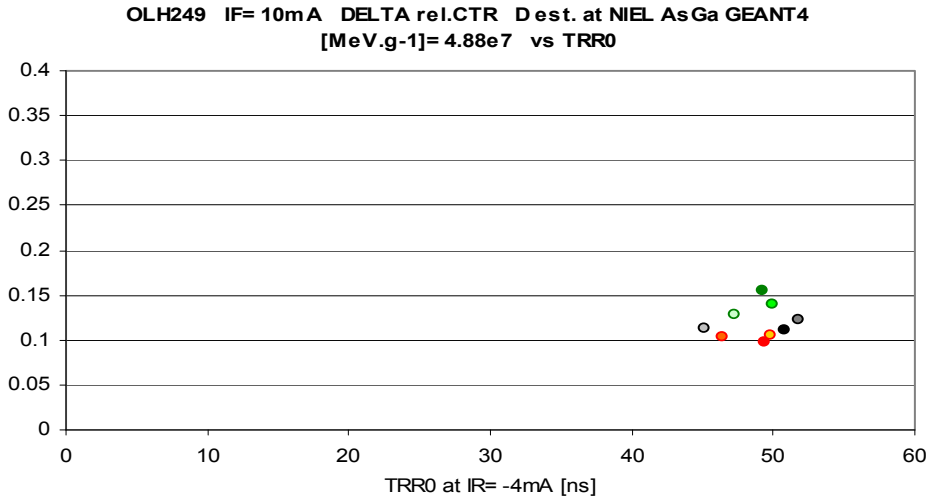
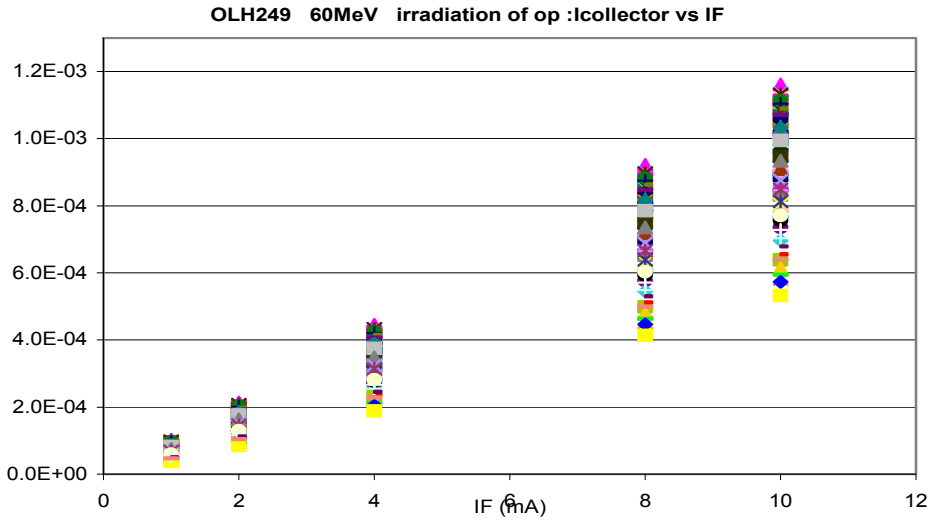
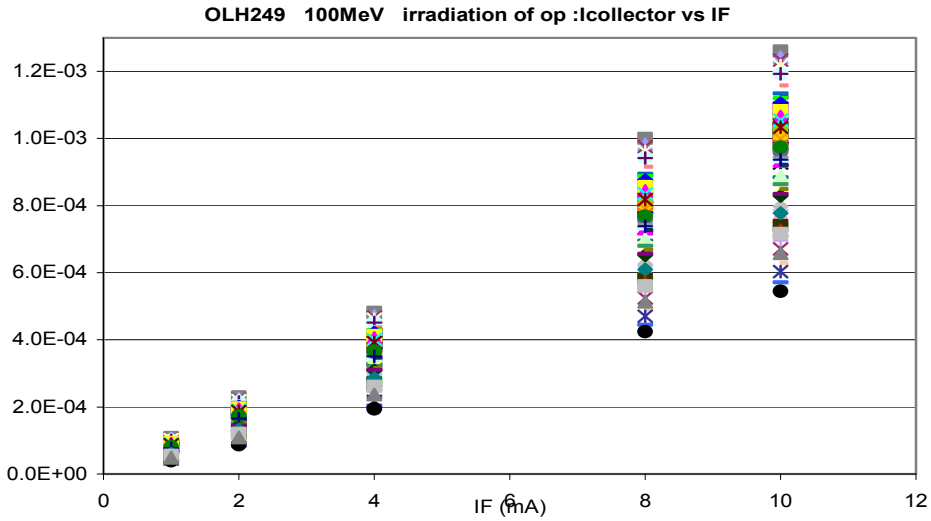

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-49: optocoupler irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to diode current I_F





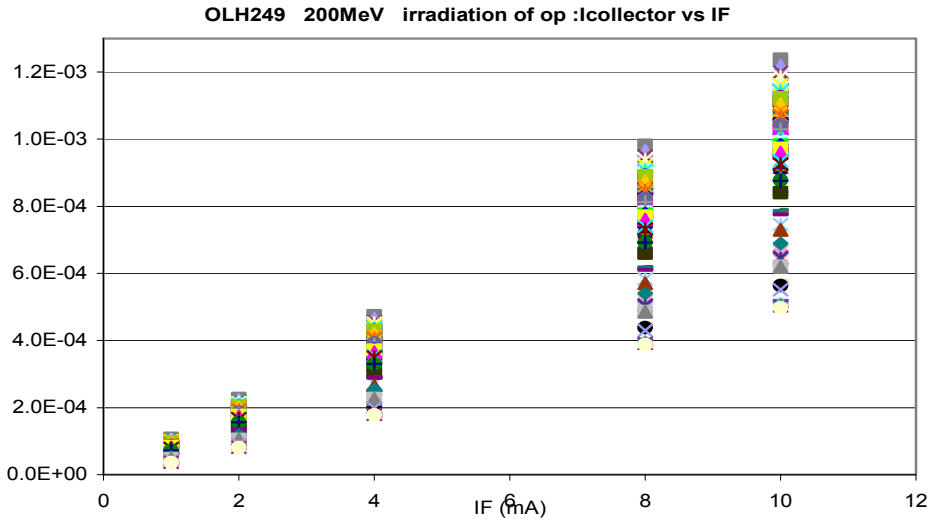
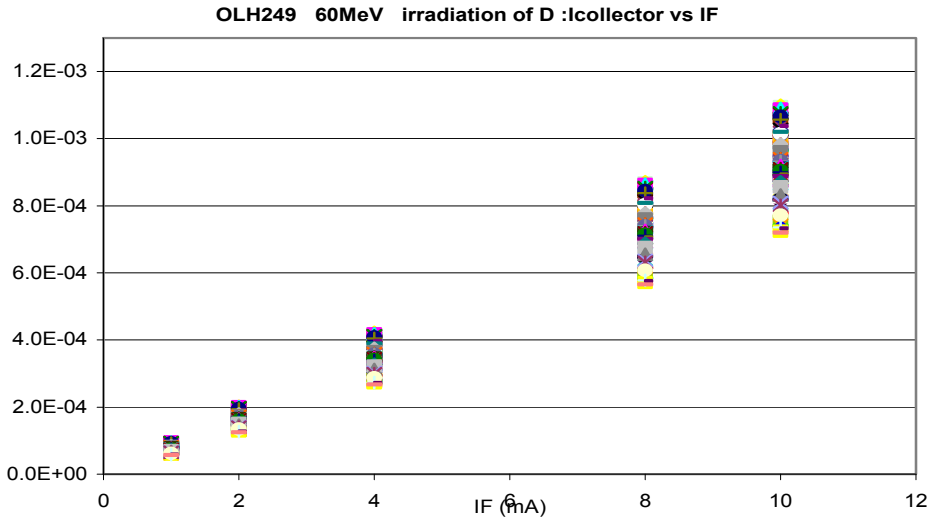
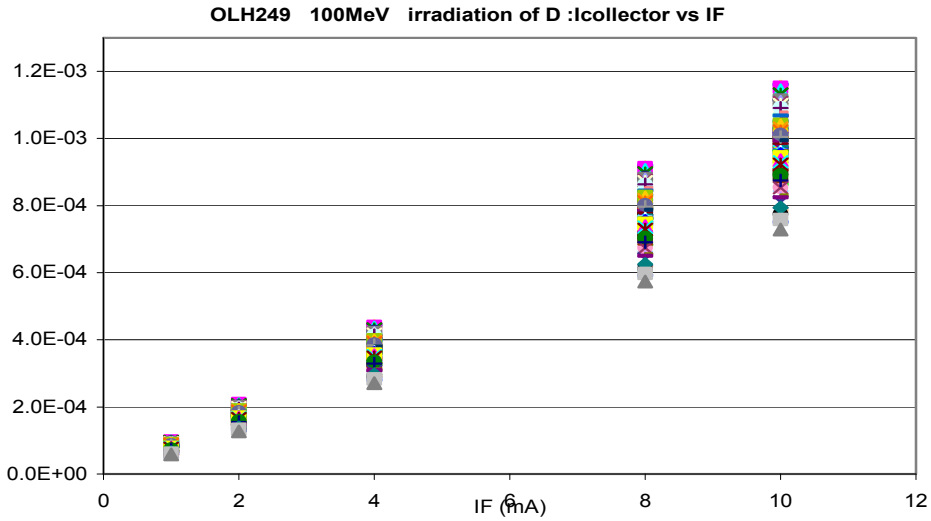


Fig. 13-50: diode irradiated at E=60, 100, 200 MeV: reference transistor collector current I_C for each step with respect to diode current I_F





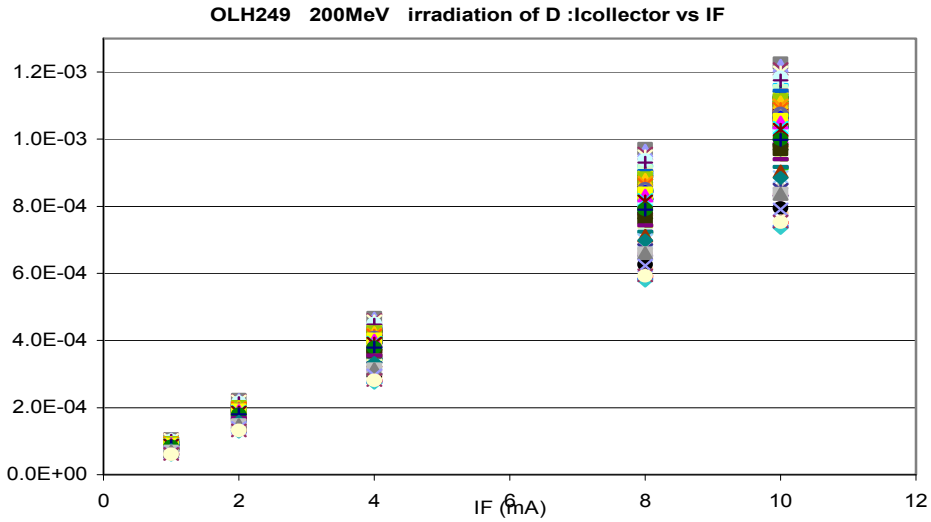


Fig. 13-51: transistor irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to reference diode current I_F

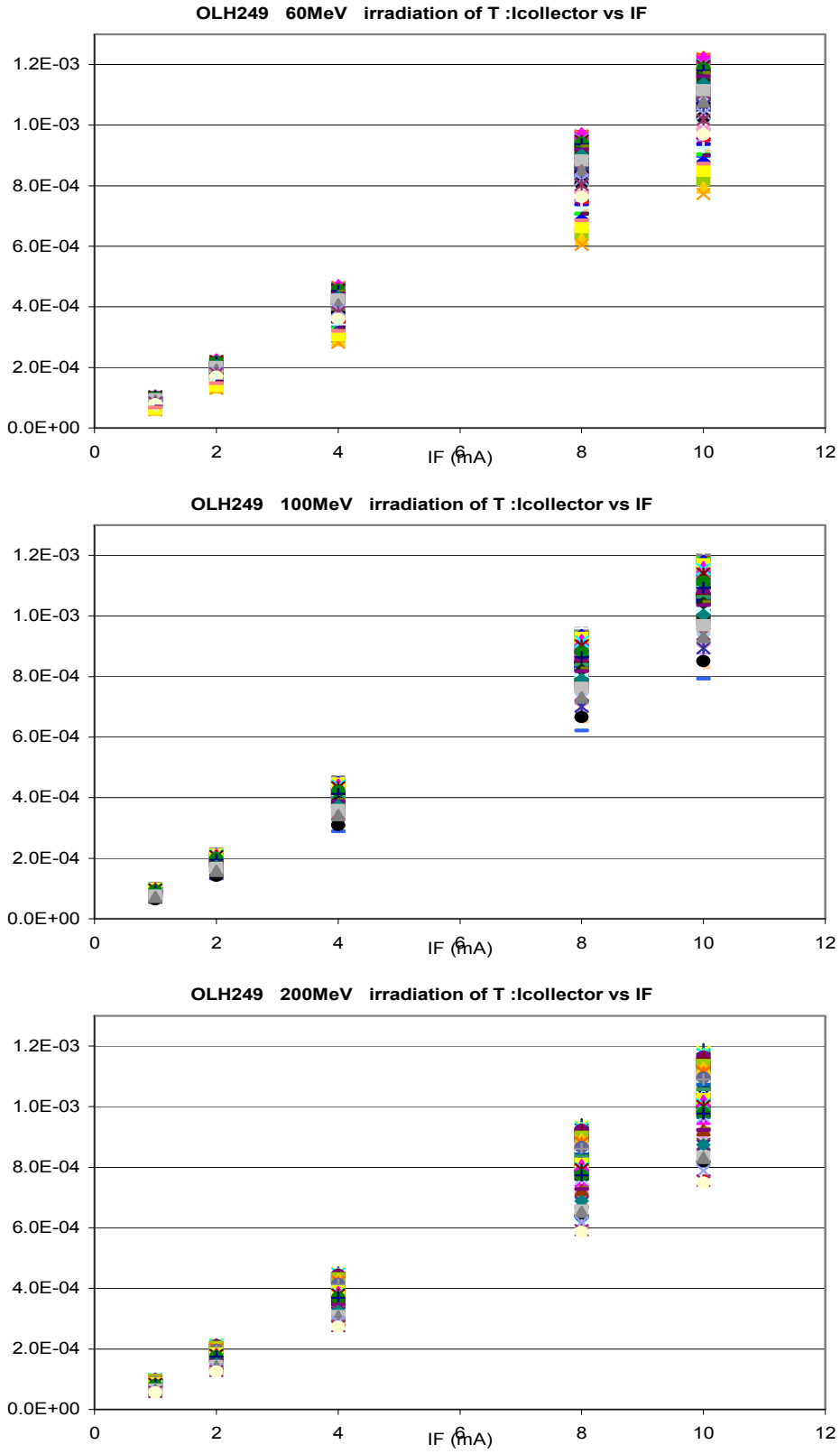


Fig. 13-52: optocoupler irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

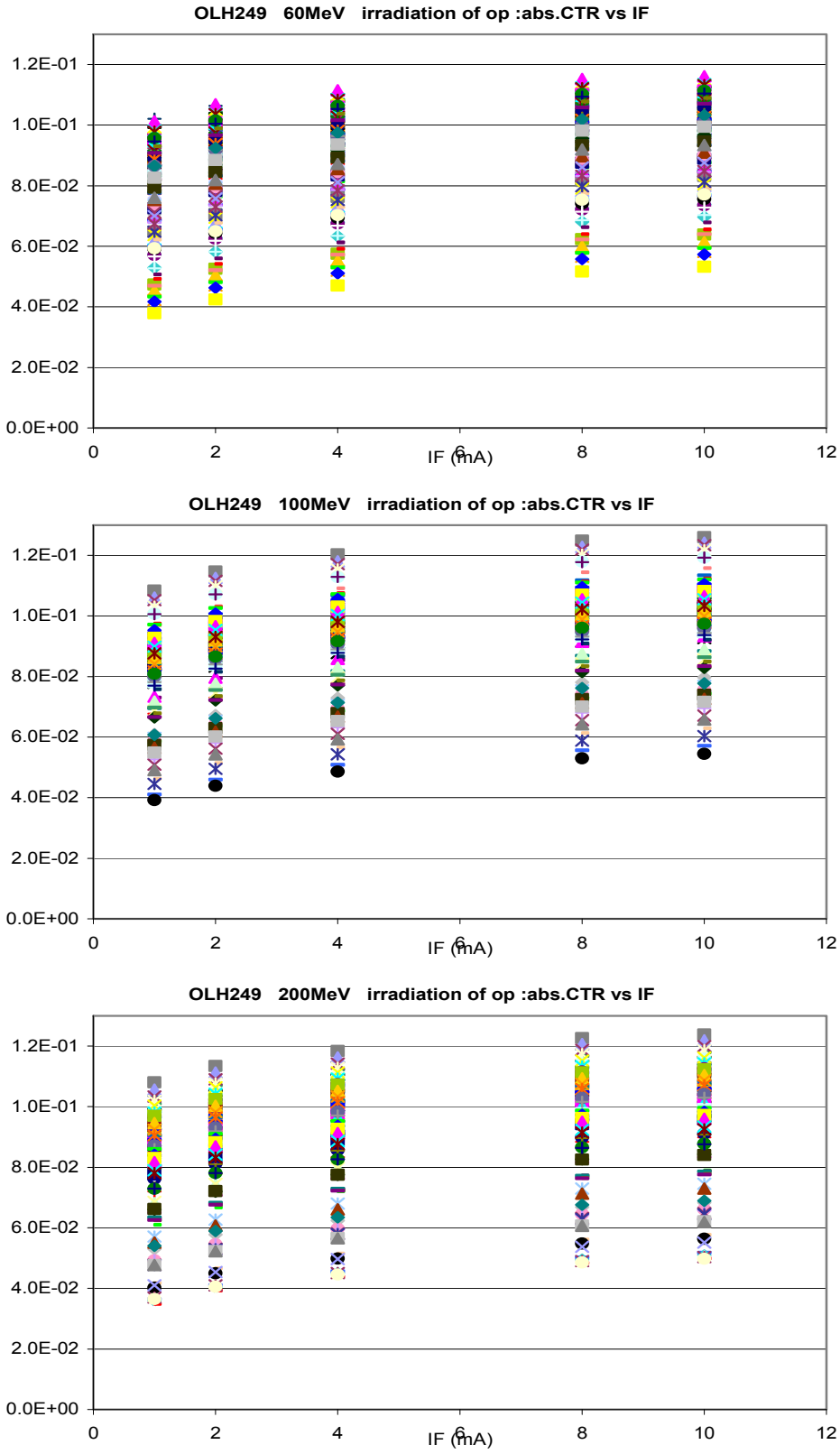


Fig. 13-53: diode irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

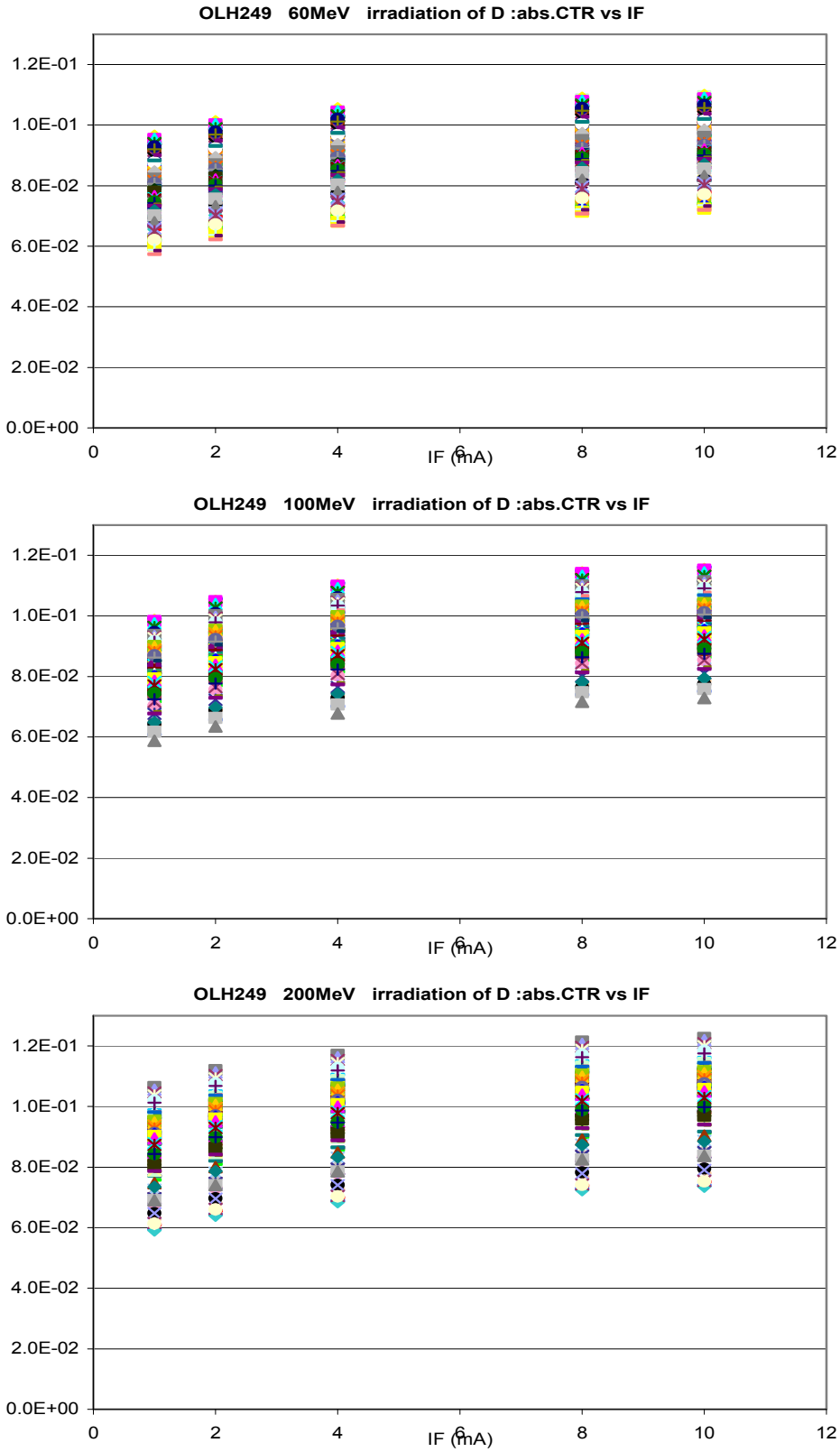


Fig. 13-54: transistor irradiated at E=60, 100, 200 MeV: CTR for each step with respect to reference diode current I_F

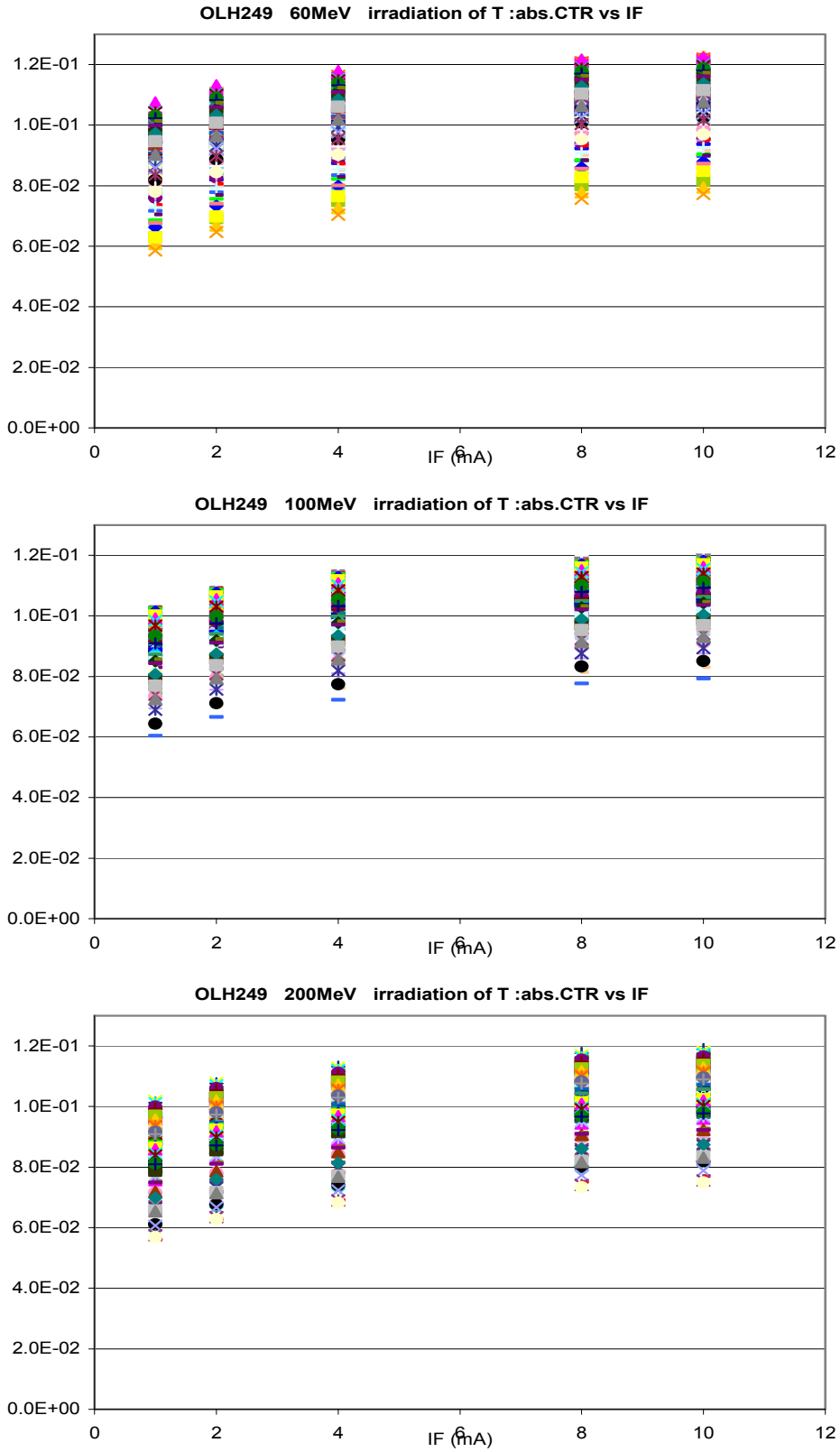


Fig. 13-55: optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

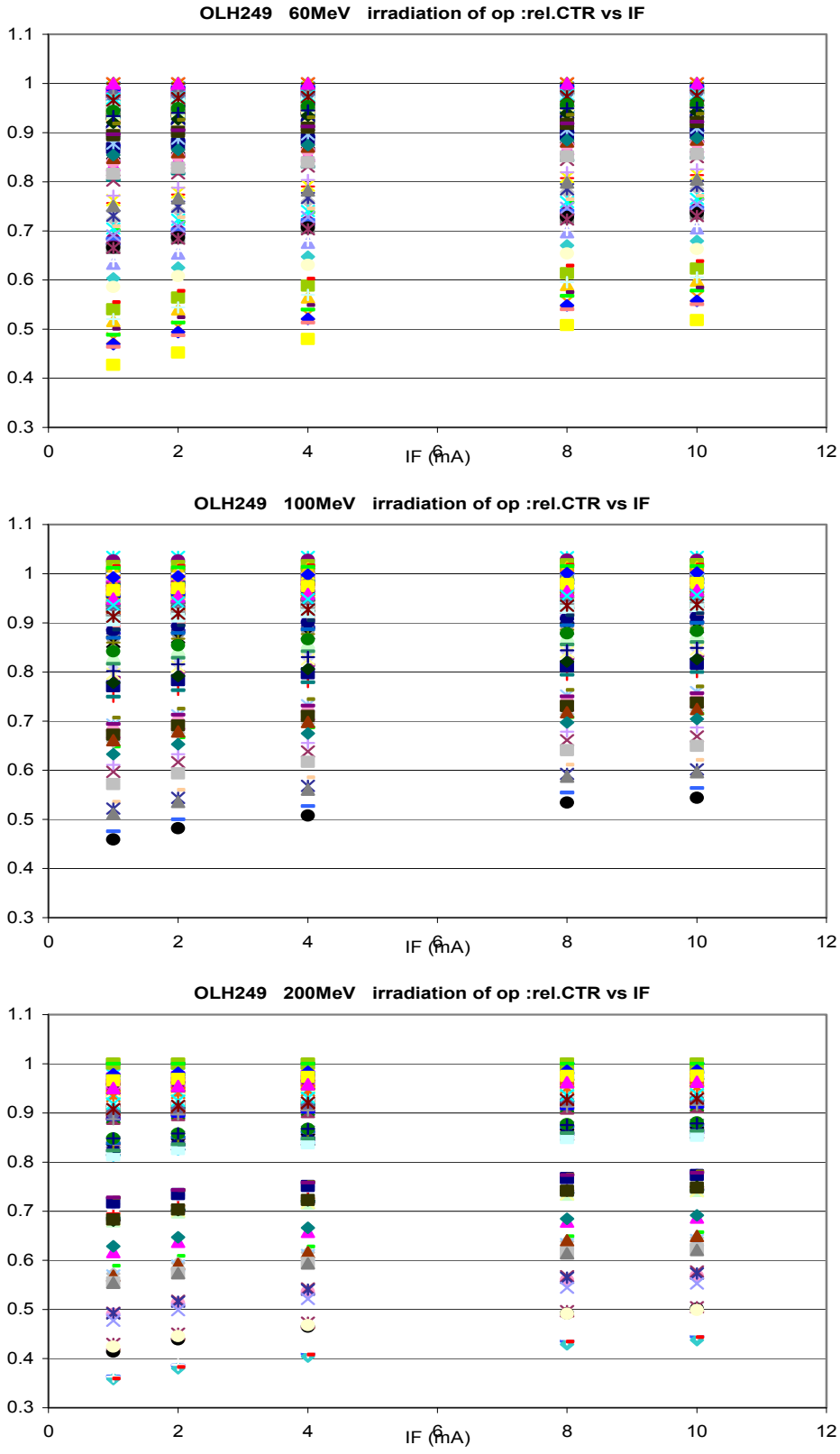


Fig. 13-56: diode irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

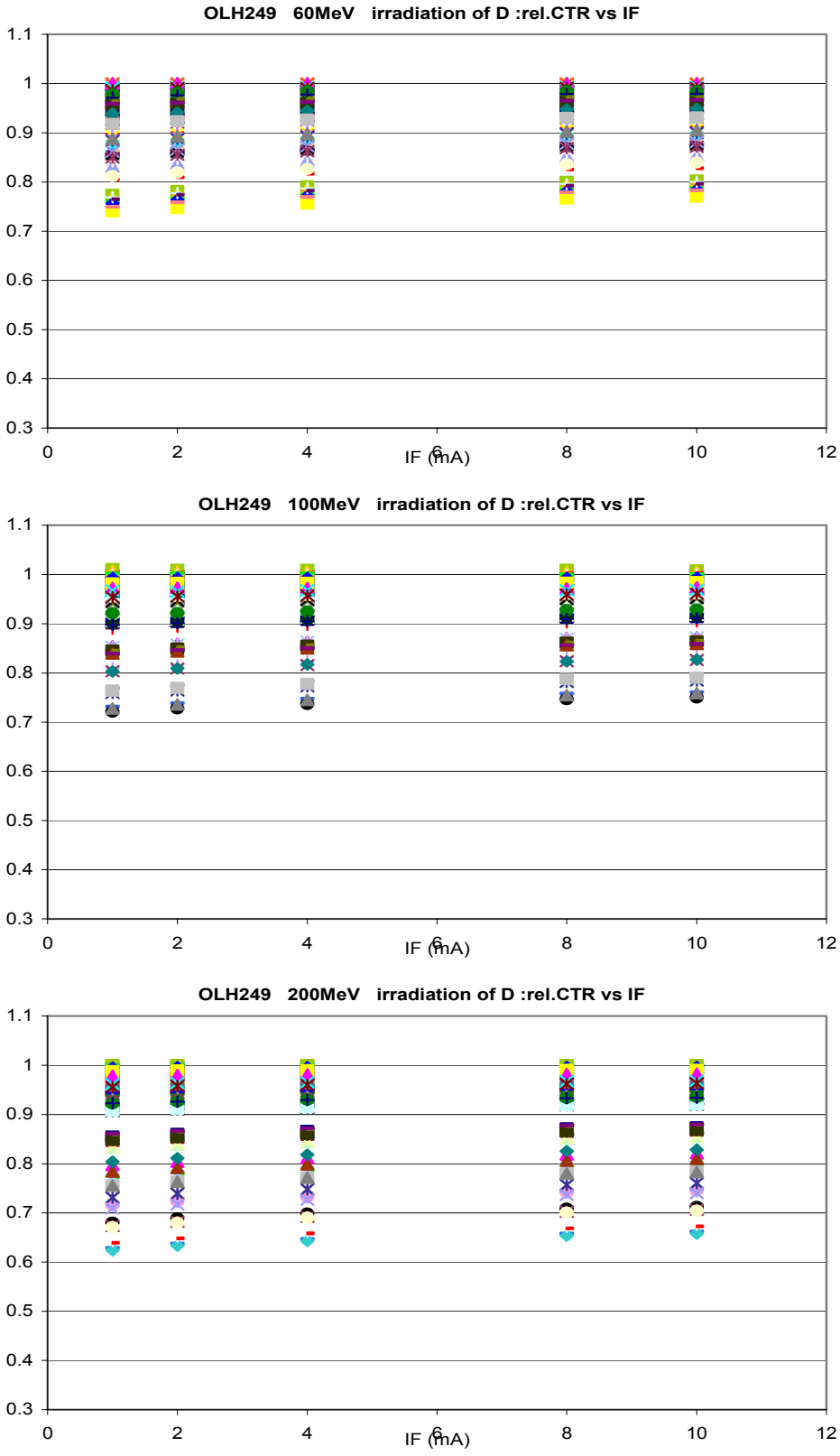


Fig. 13-57: transistor irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to reference diode current I$_F$

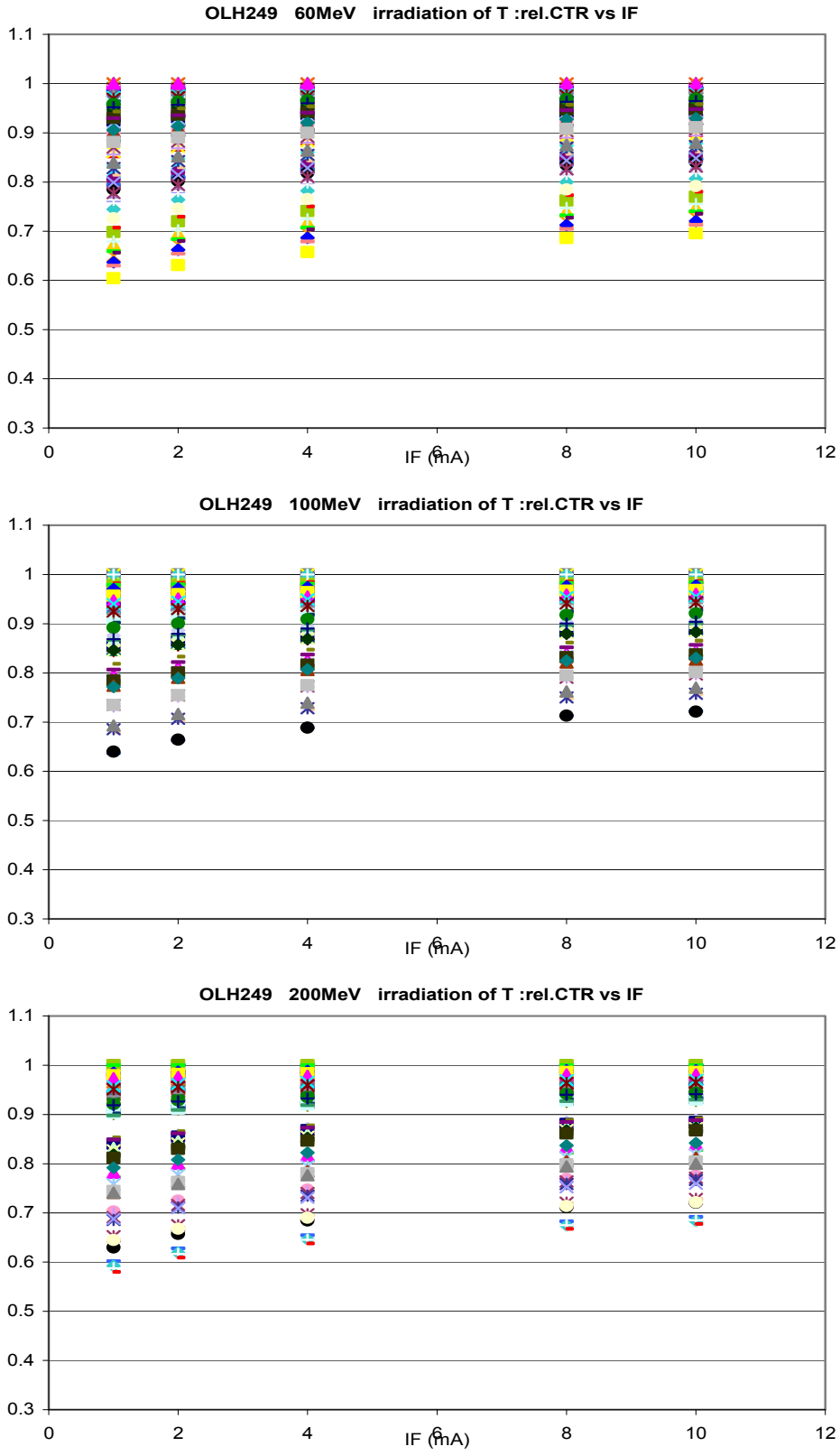
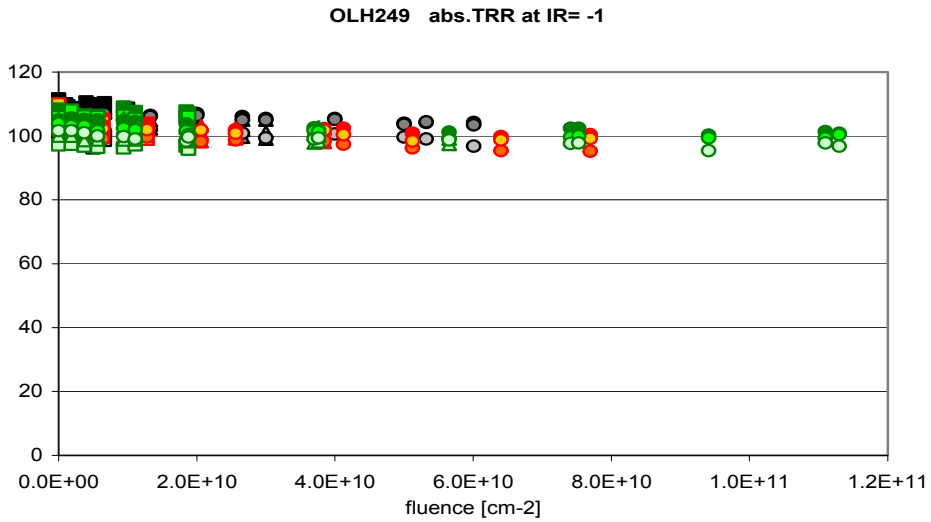
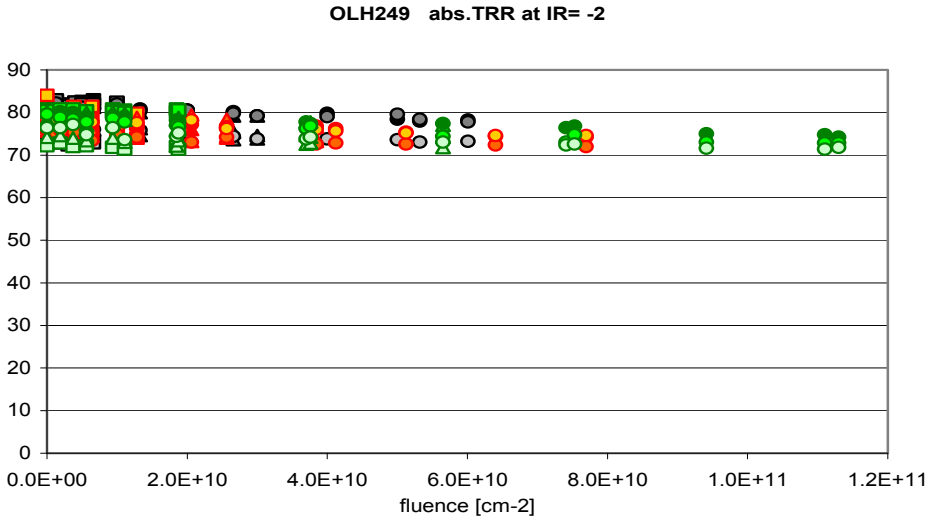


Fig. 13-58: OLH249 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA





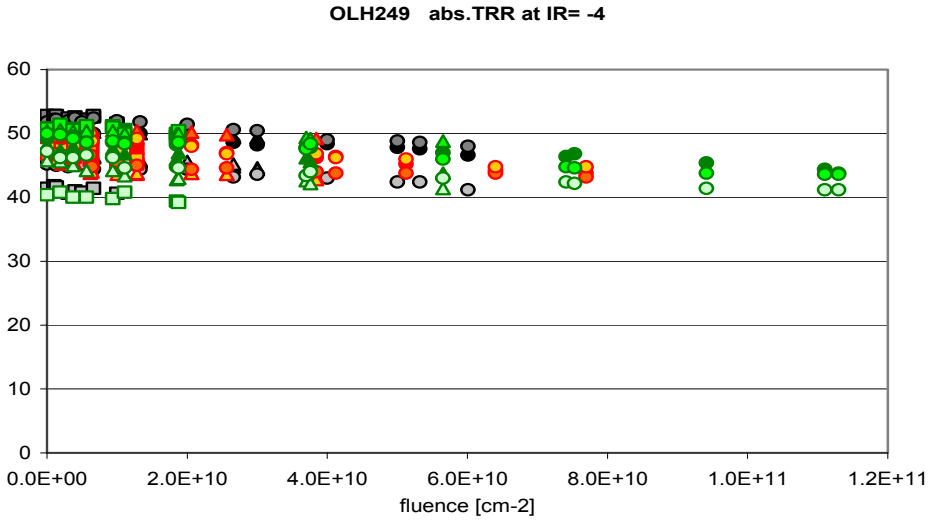
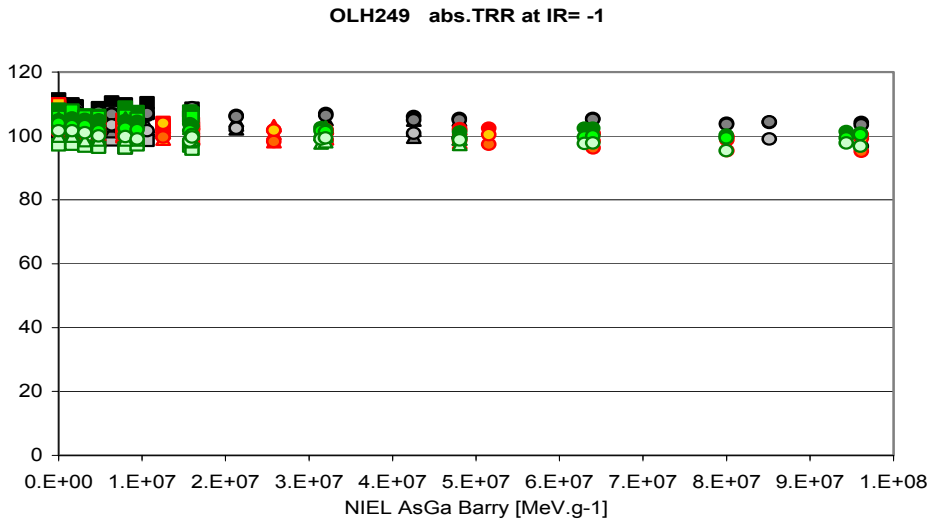
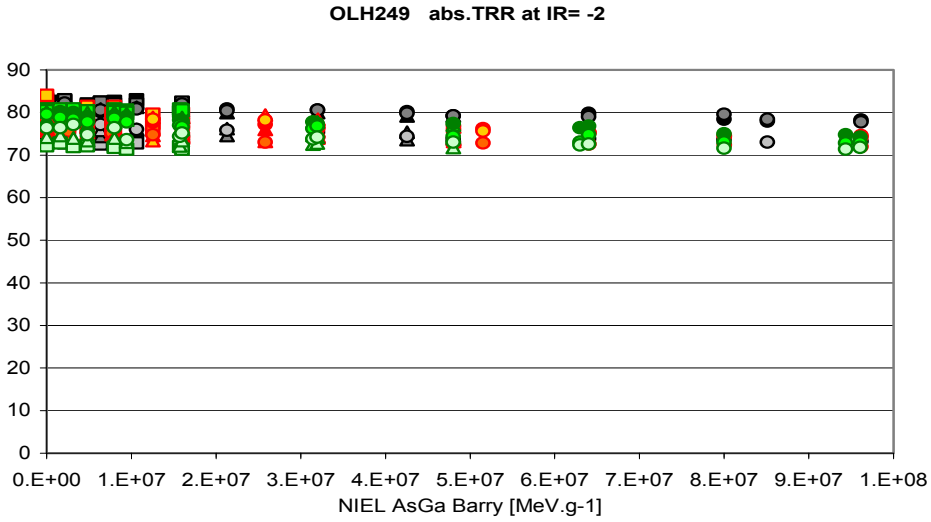


Fig. 13-59: OLH249 diode: τ_{RR} [ns] with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





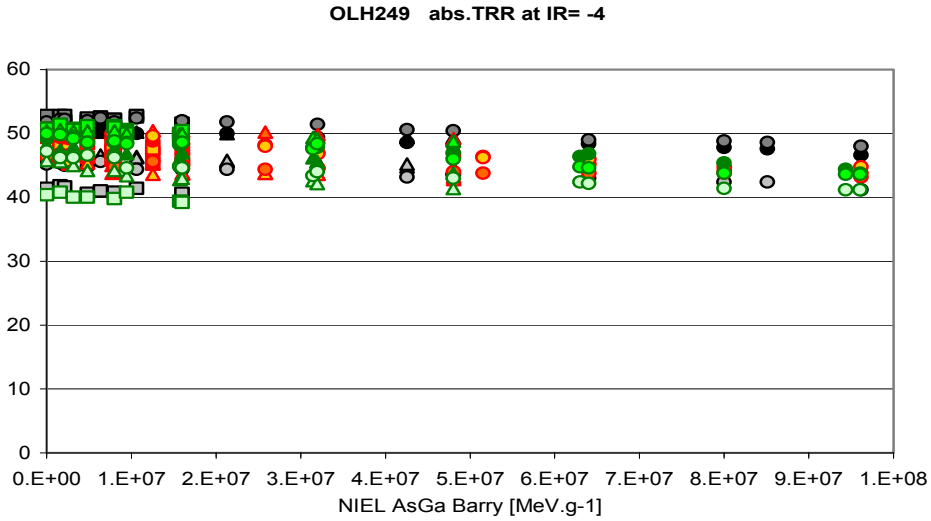
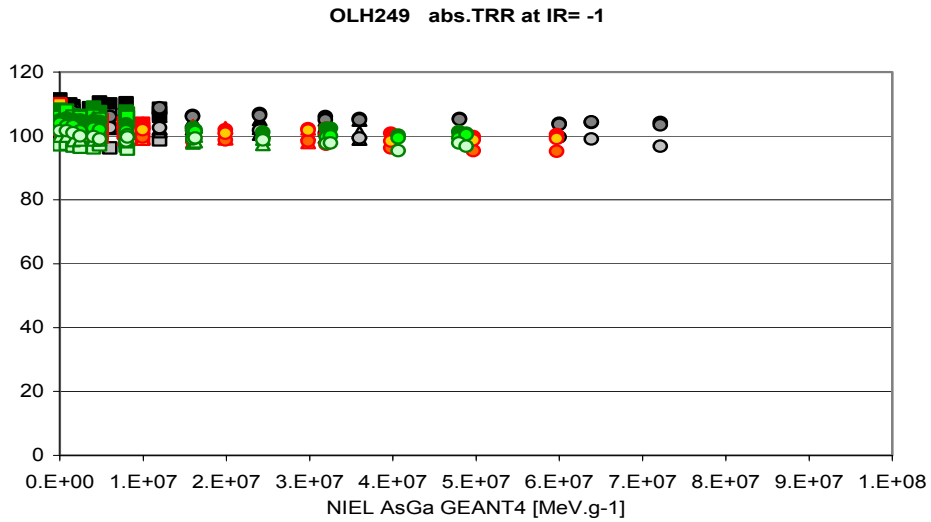
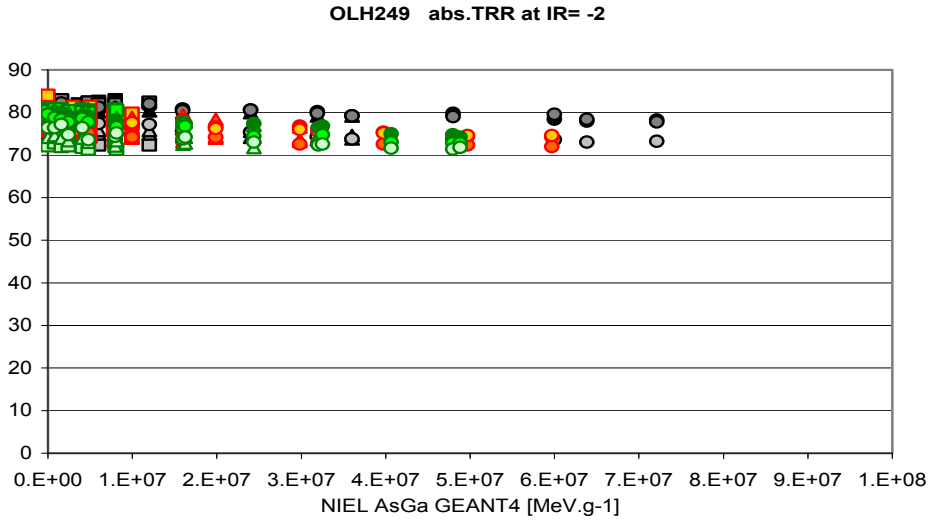


Fig. 13-60: OLH249 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





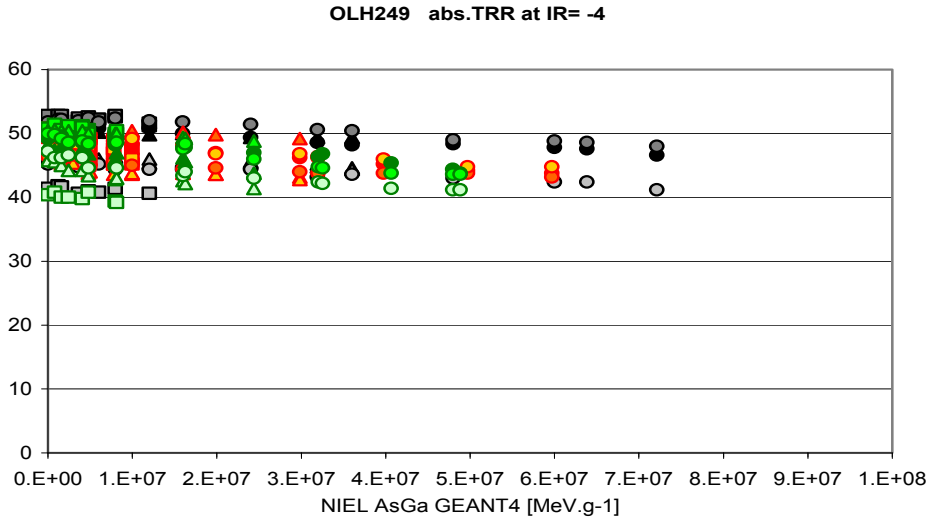
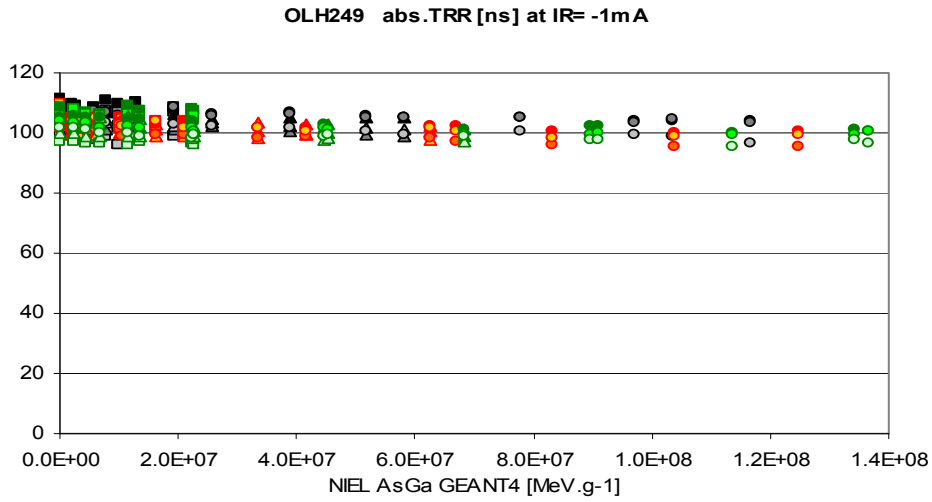
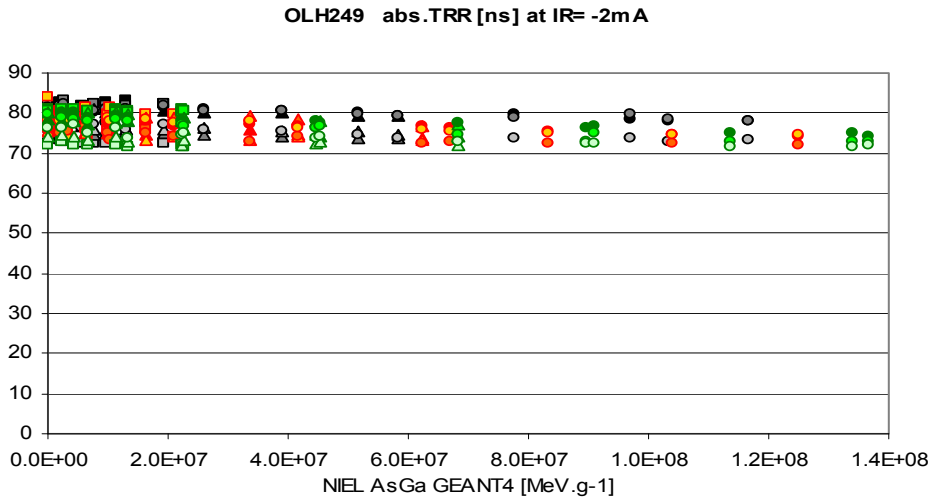


Fig. 13-61: OLH249 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





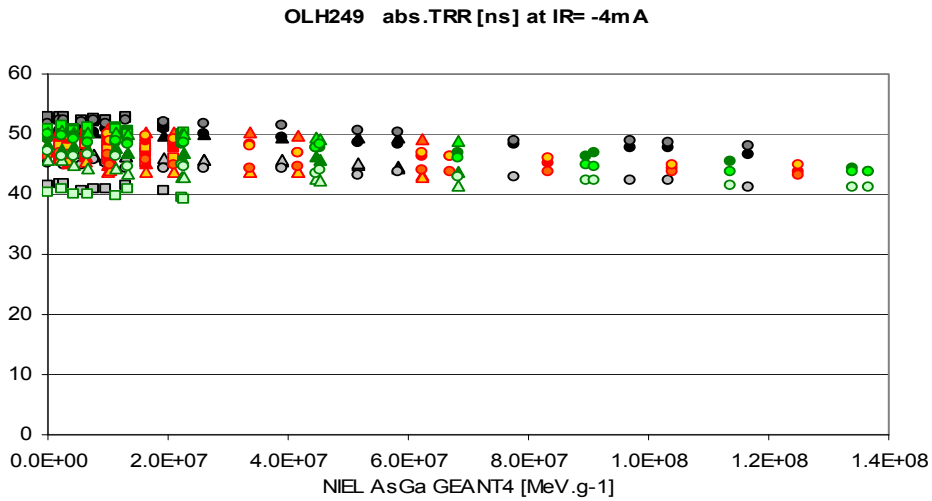


Fig. 13-62: OLH249 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA

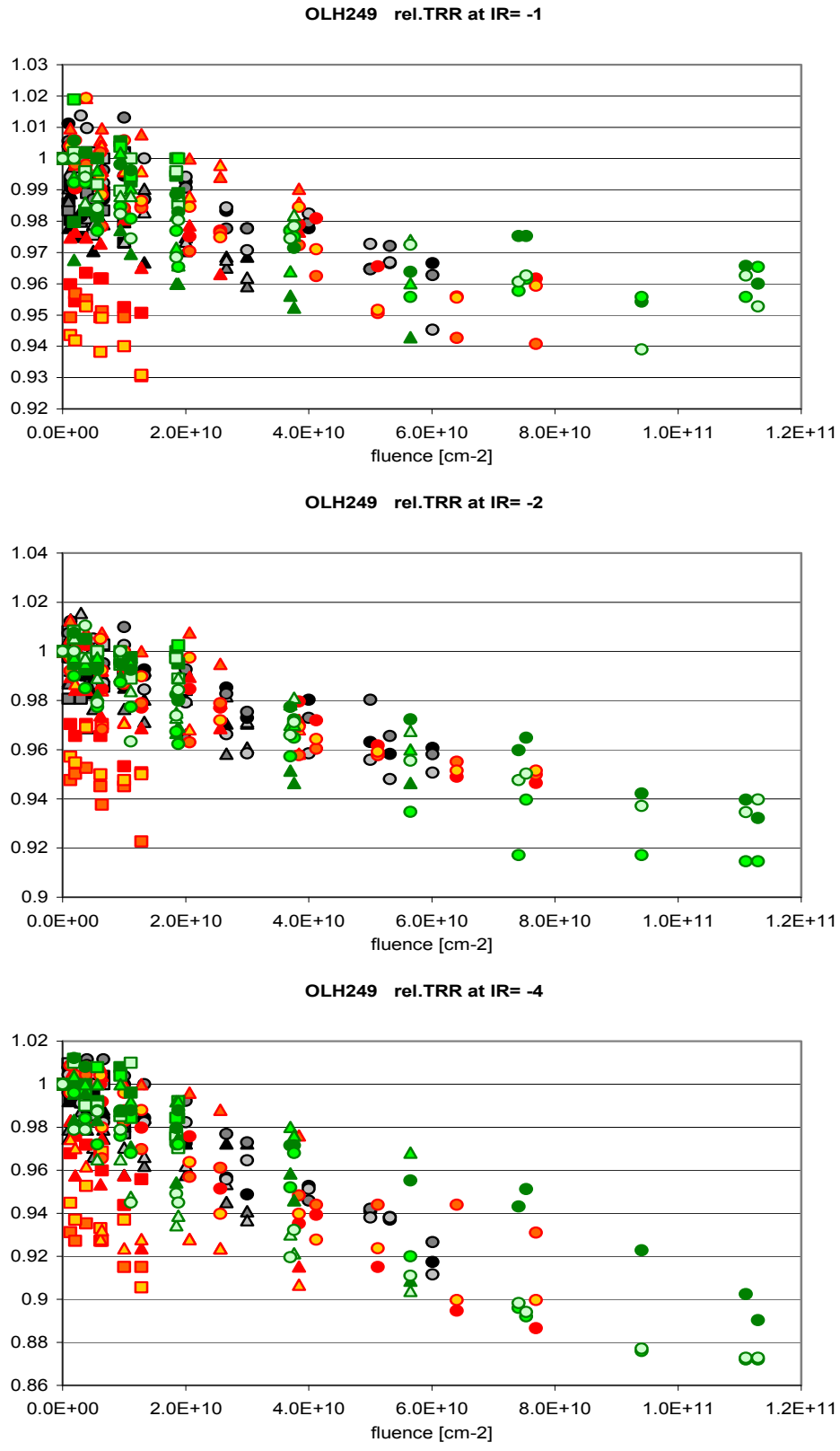
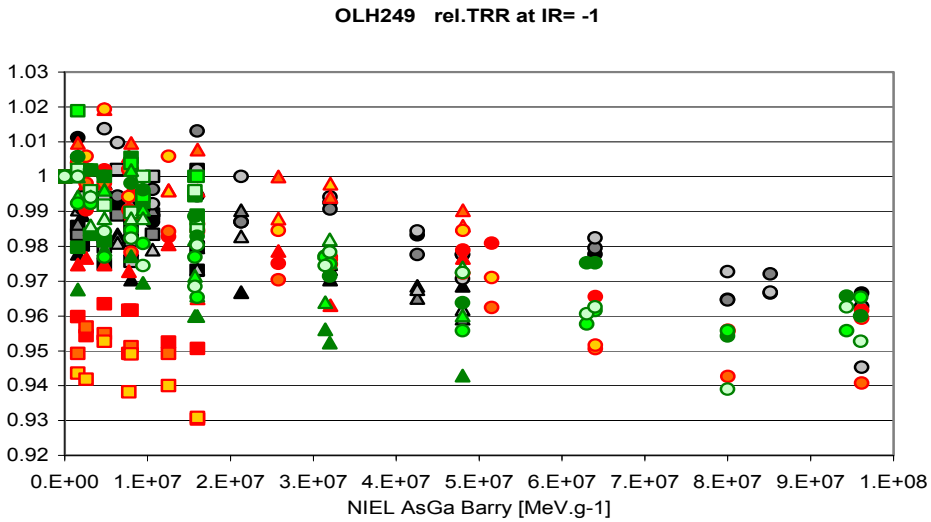
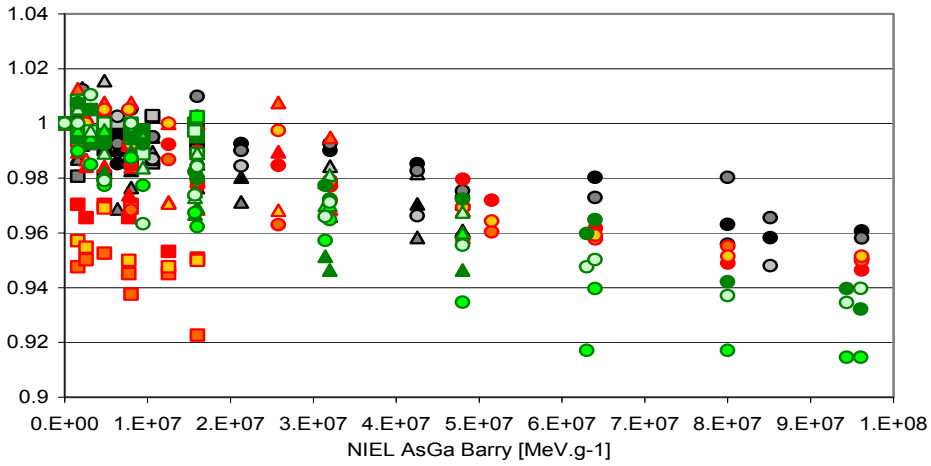


Fig. 13-63: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





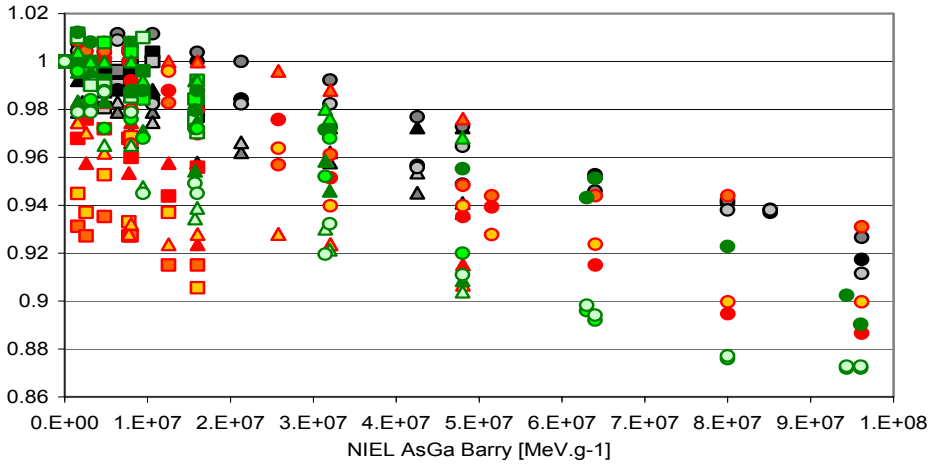


Fig. 13-64: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA

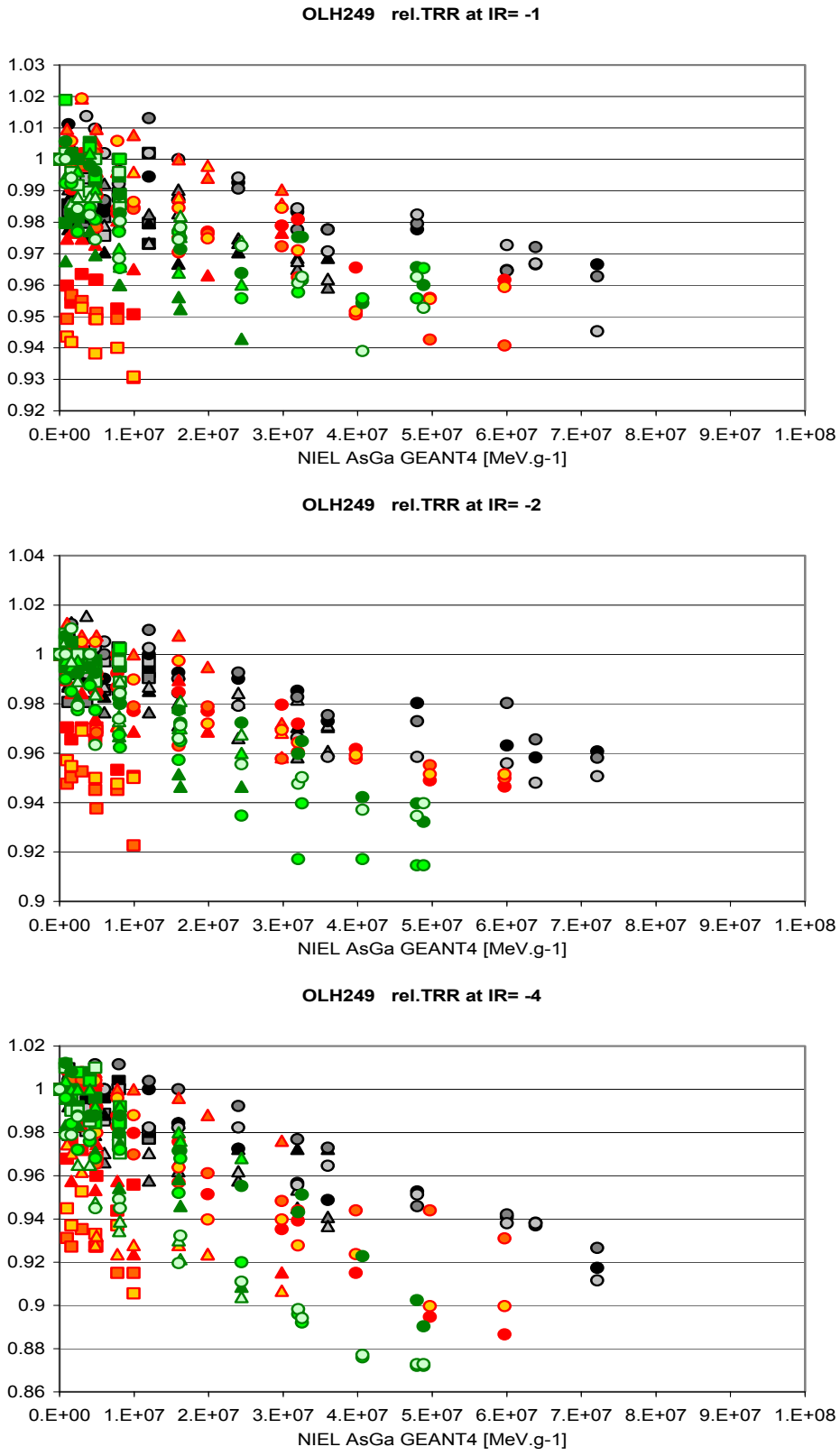
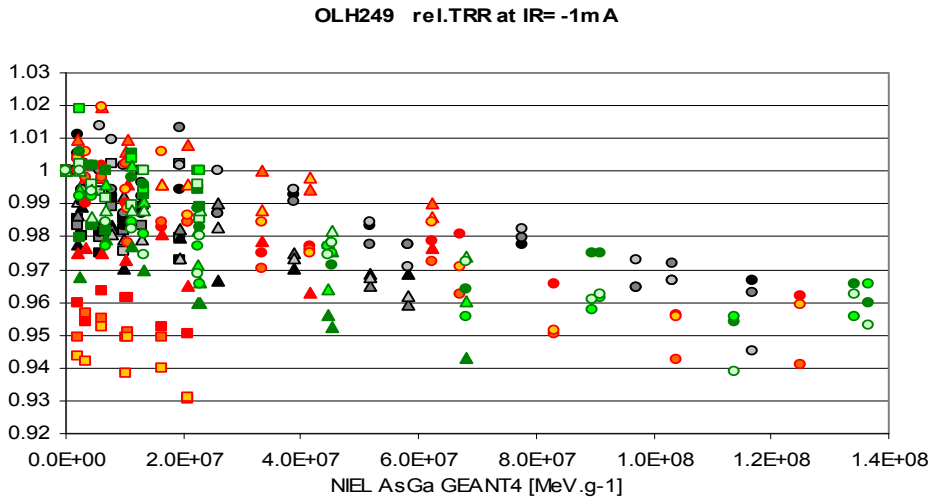
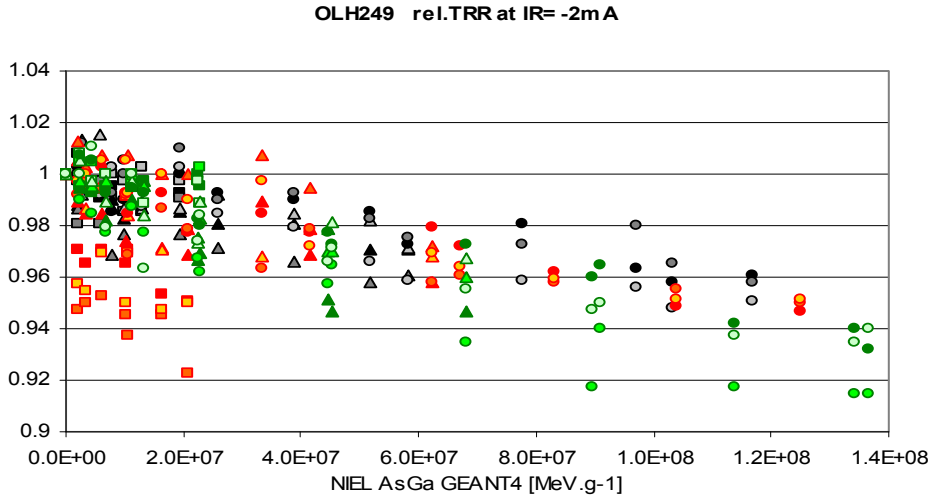


Fig. 13-65: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





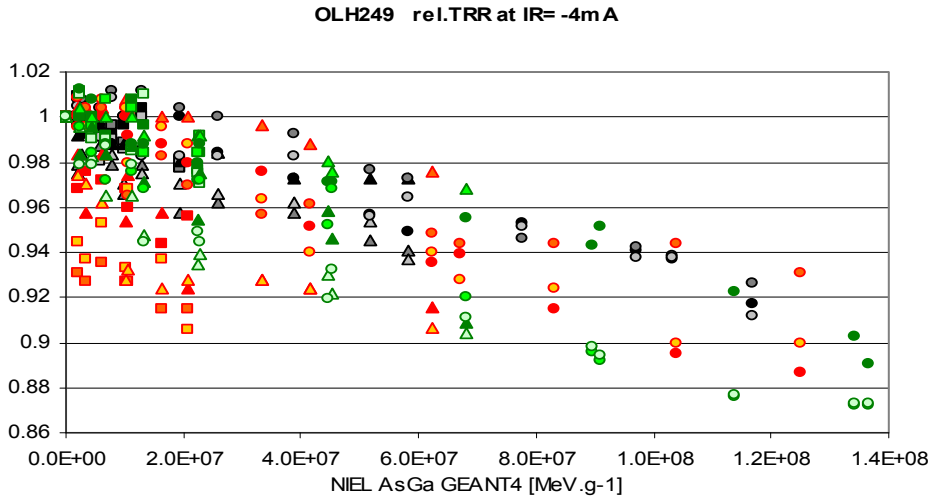
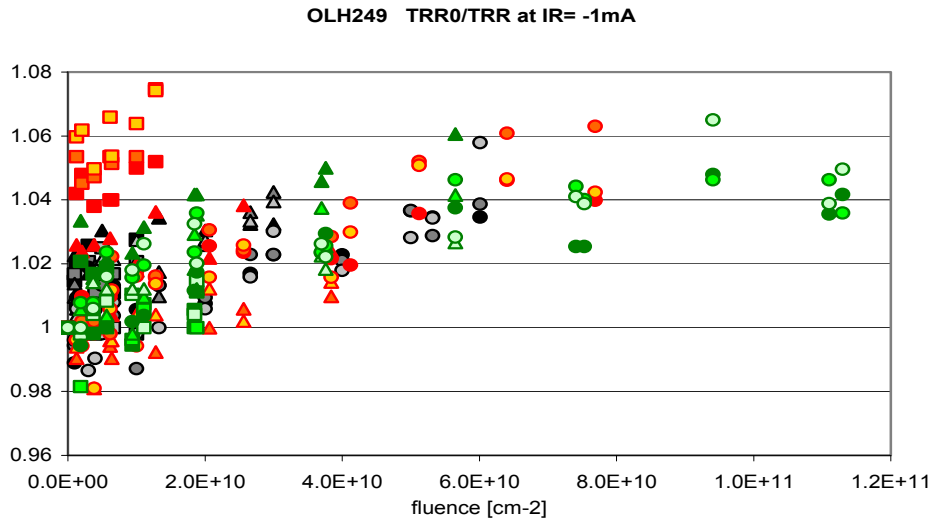
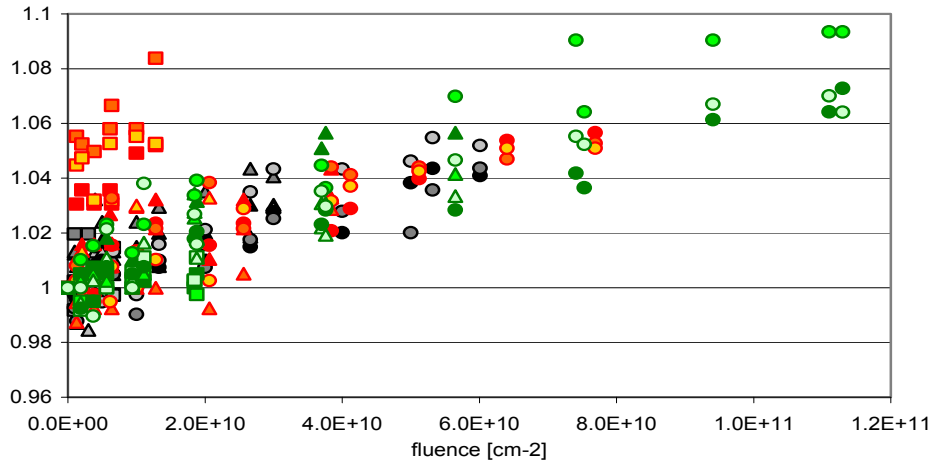


Fig. 13-66: OLH249 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





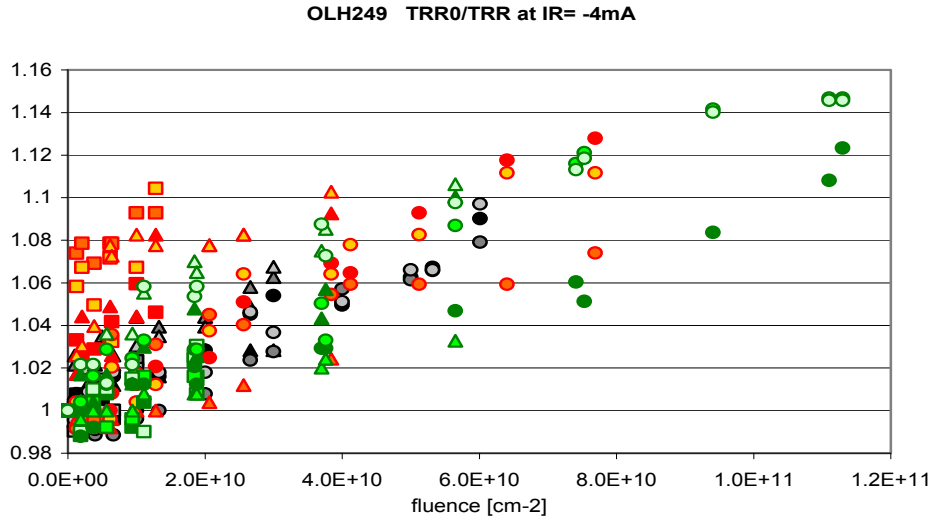
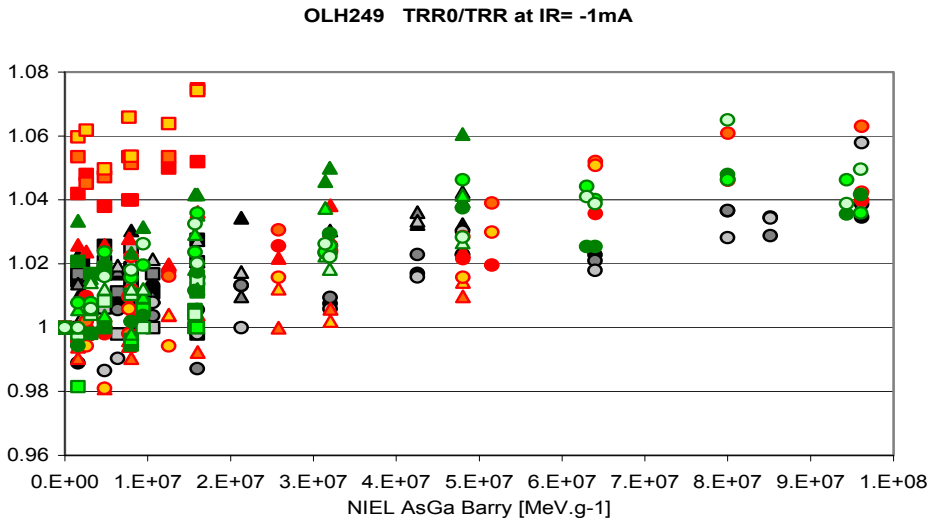
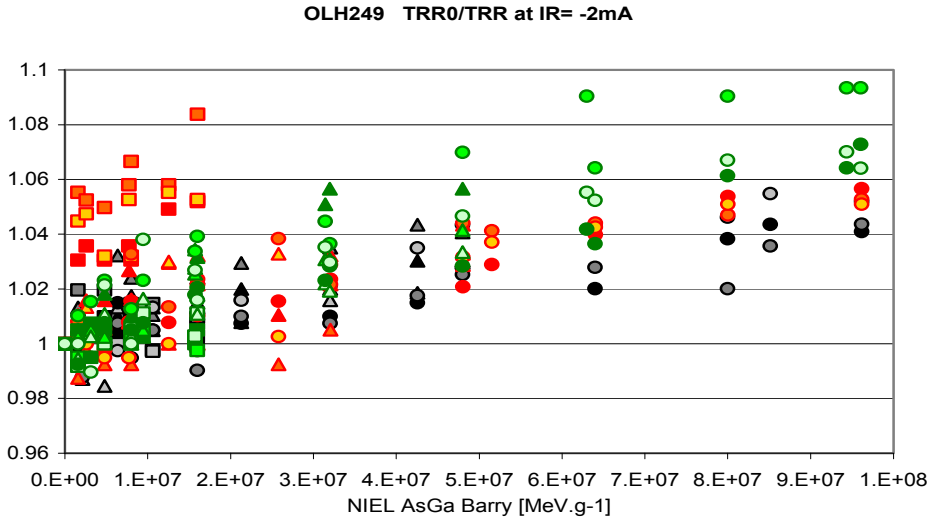


Fig. 13-67: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





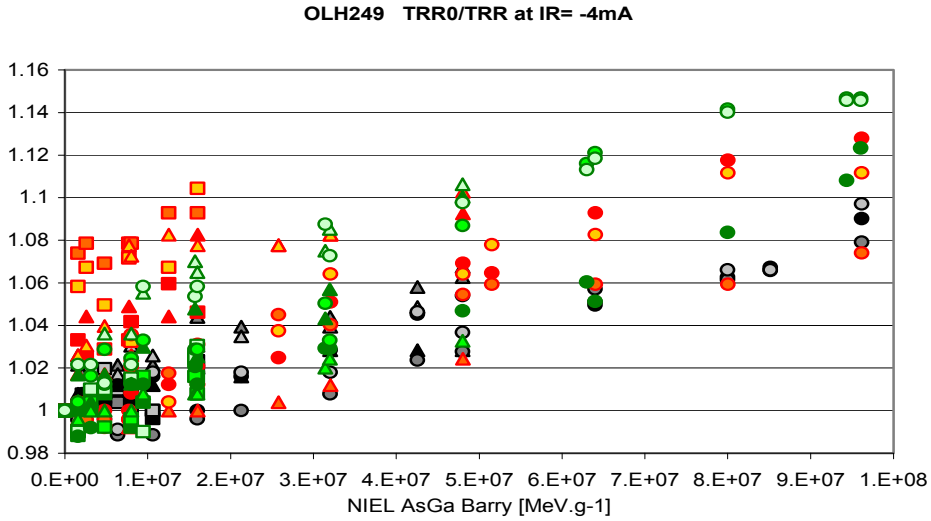
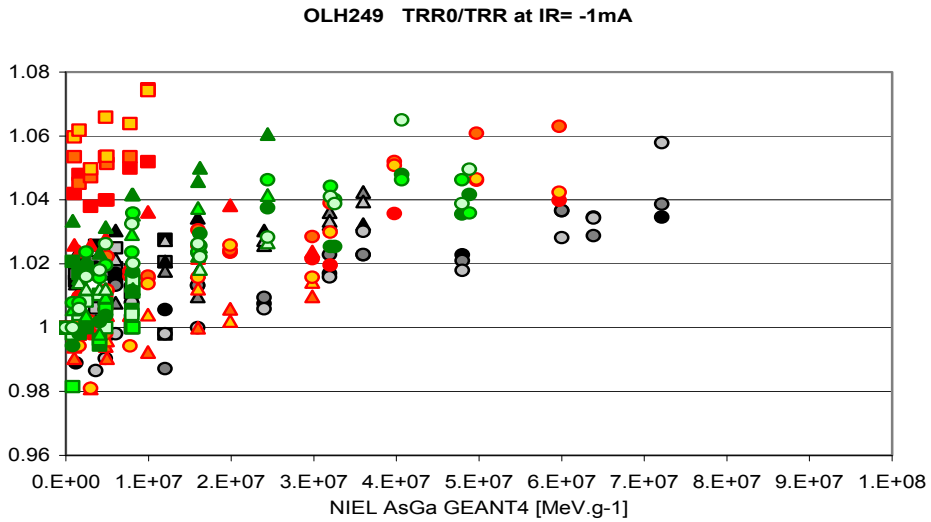
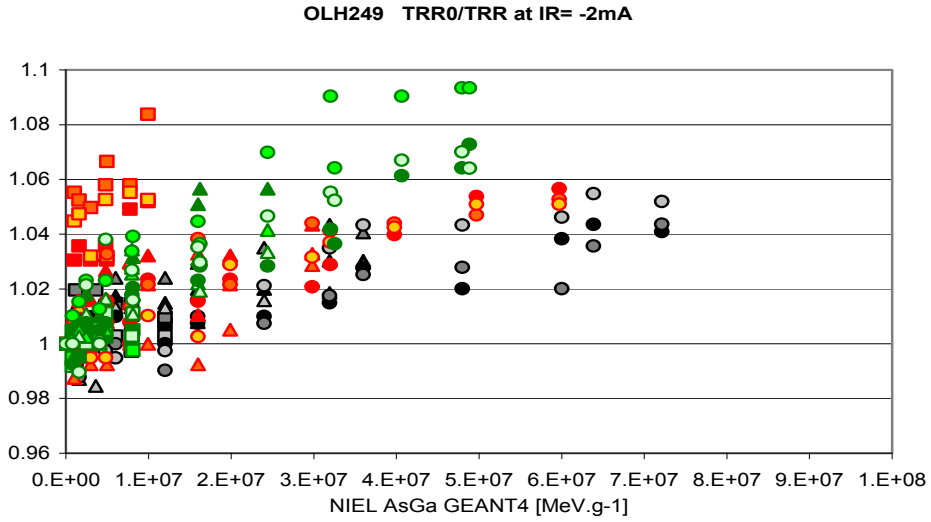


Fig. 13-68: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





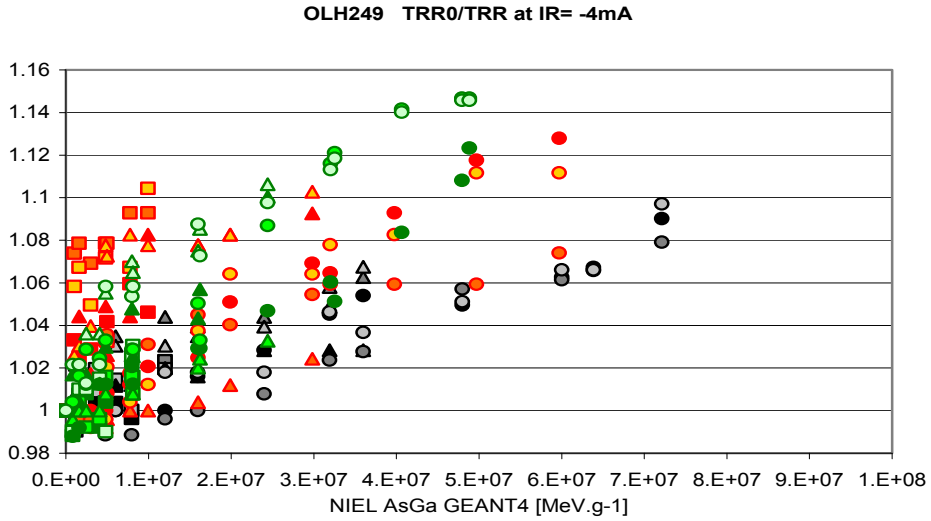
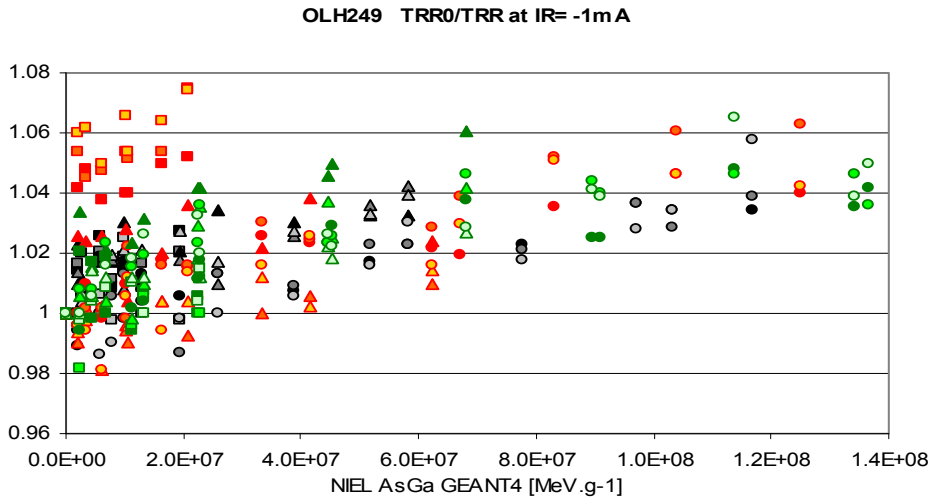
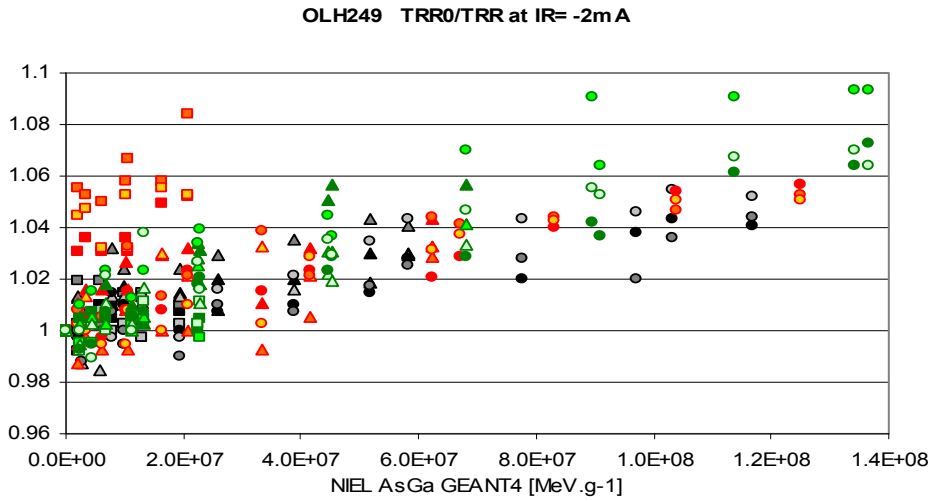


Fig. 13-69: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





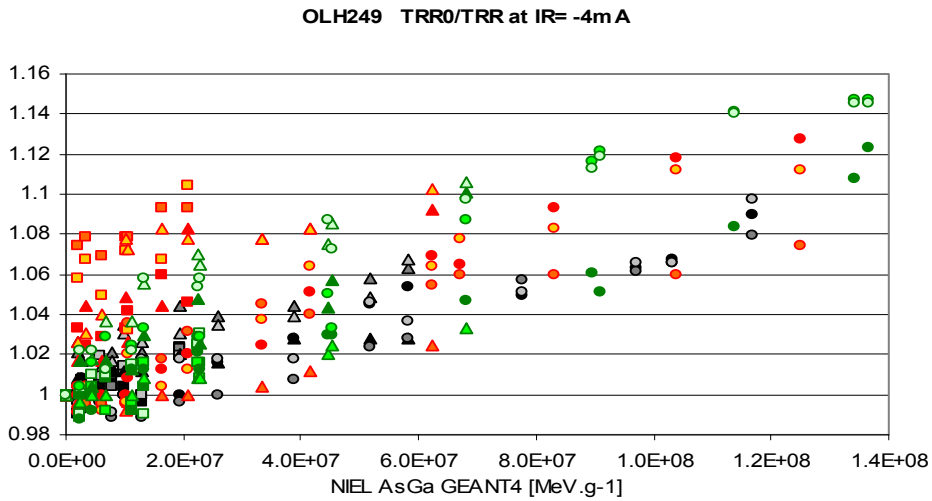


Fig. 13-70: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 1.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4 mA

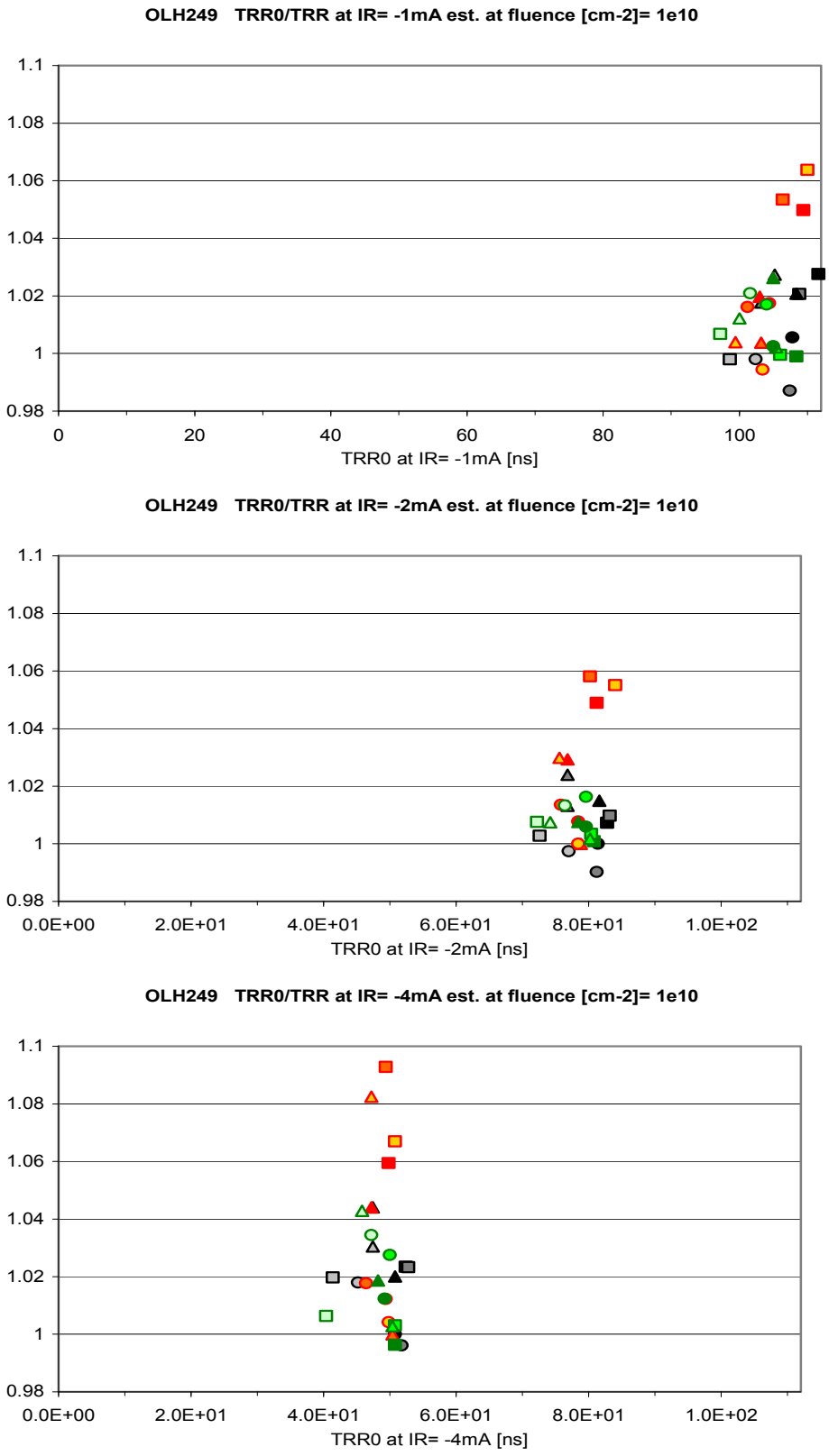
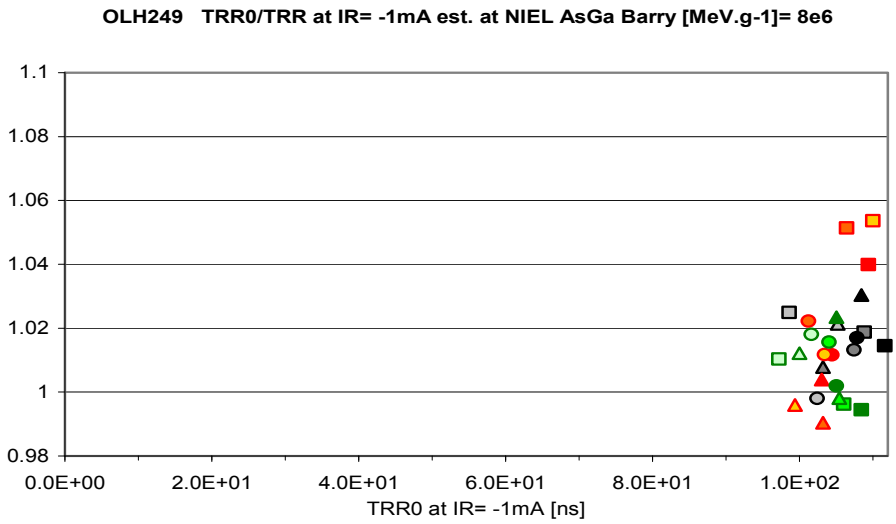
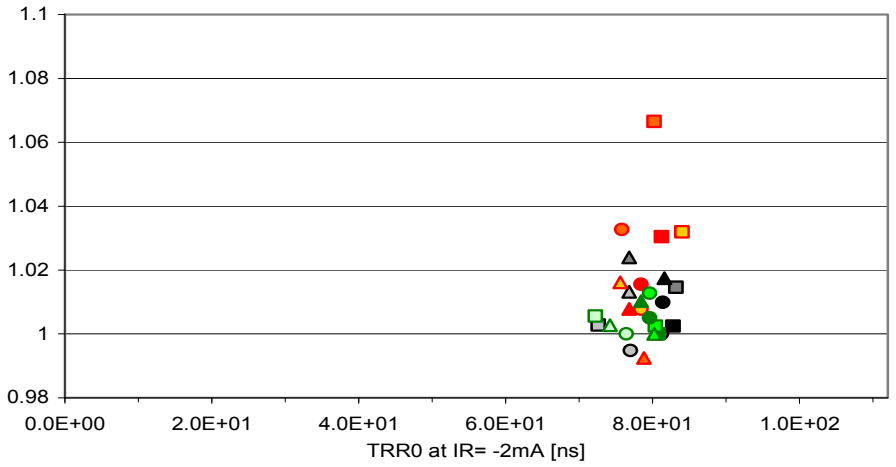


Fig. 13-71: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





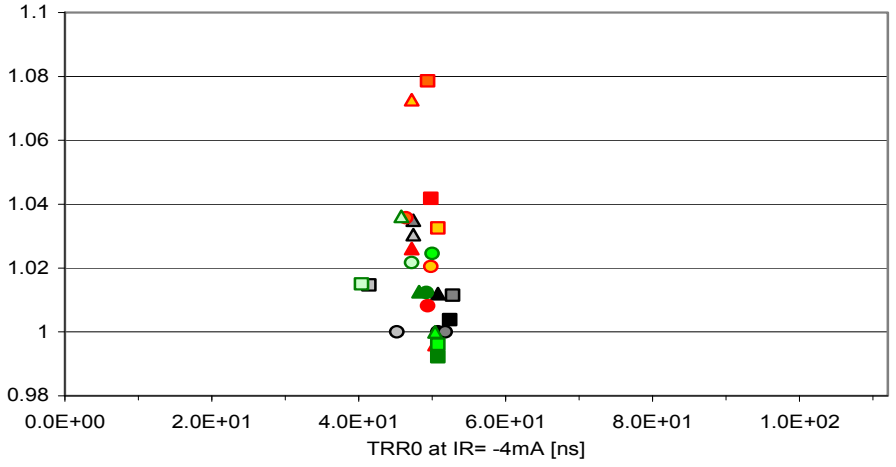


Fig. 13-72: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

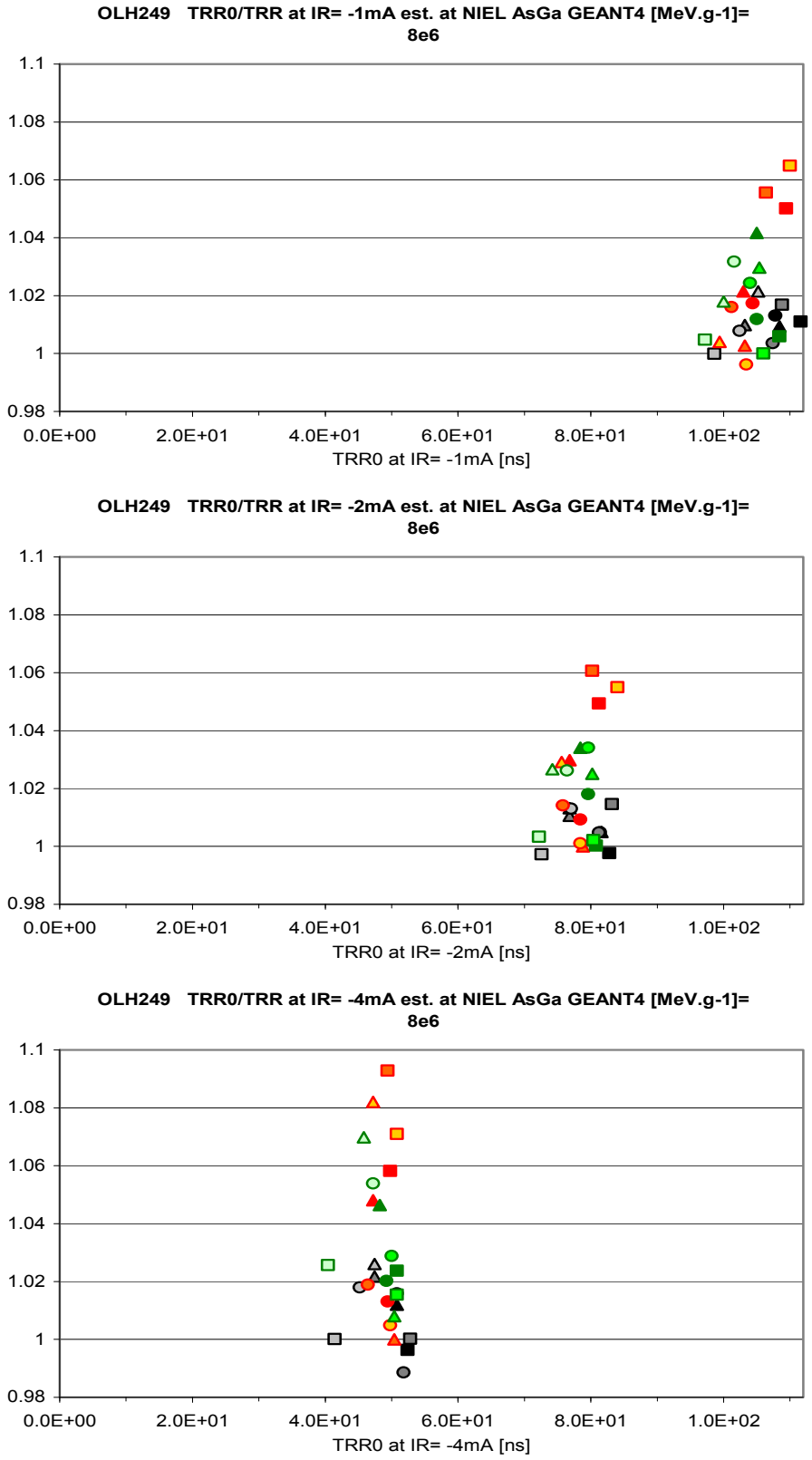
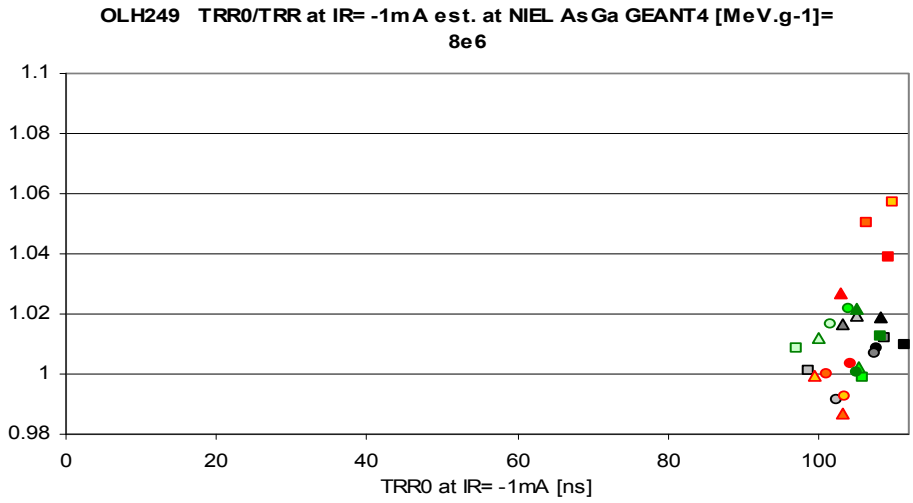
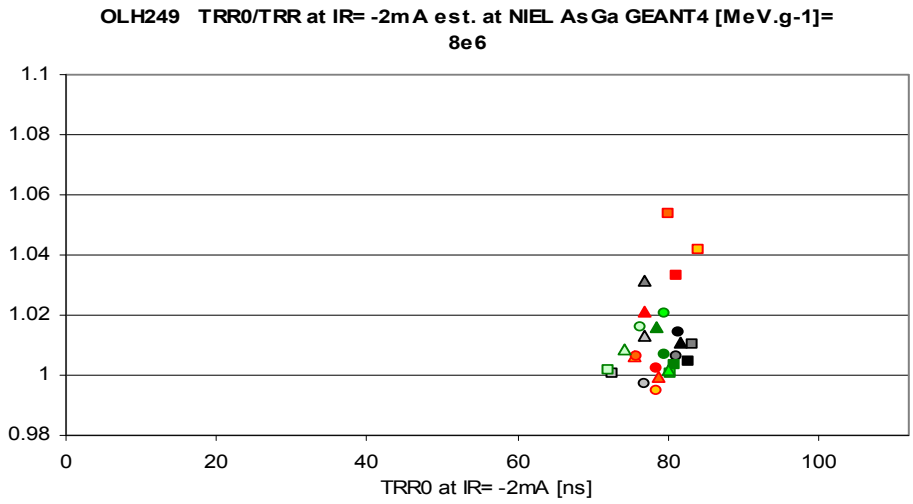


Fig. 13-73: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





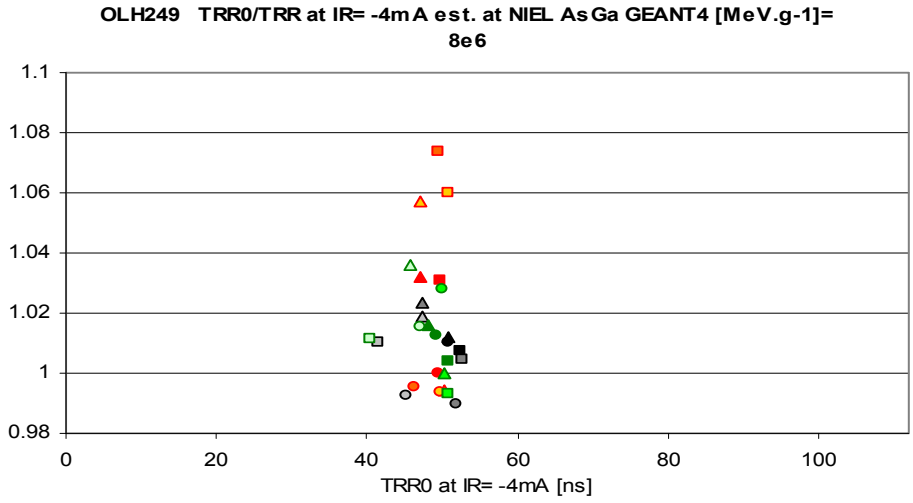


Fig. 13-74: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of $2.4.10^{10}$ cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

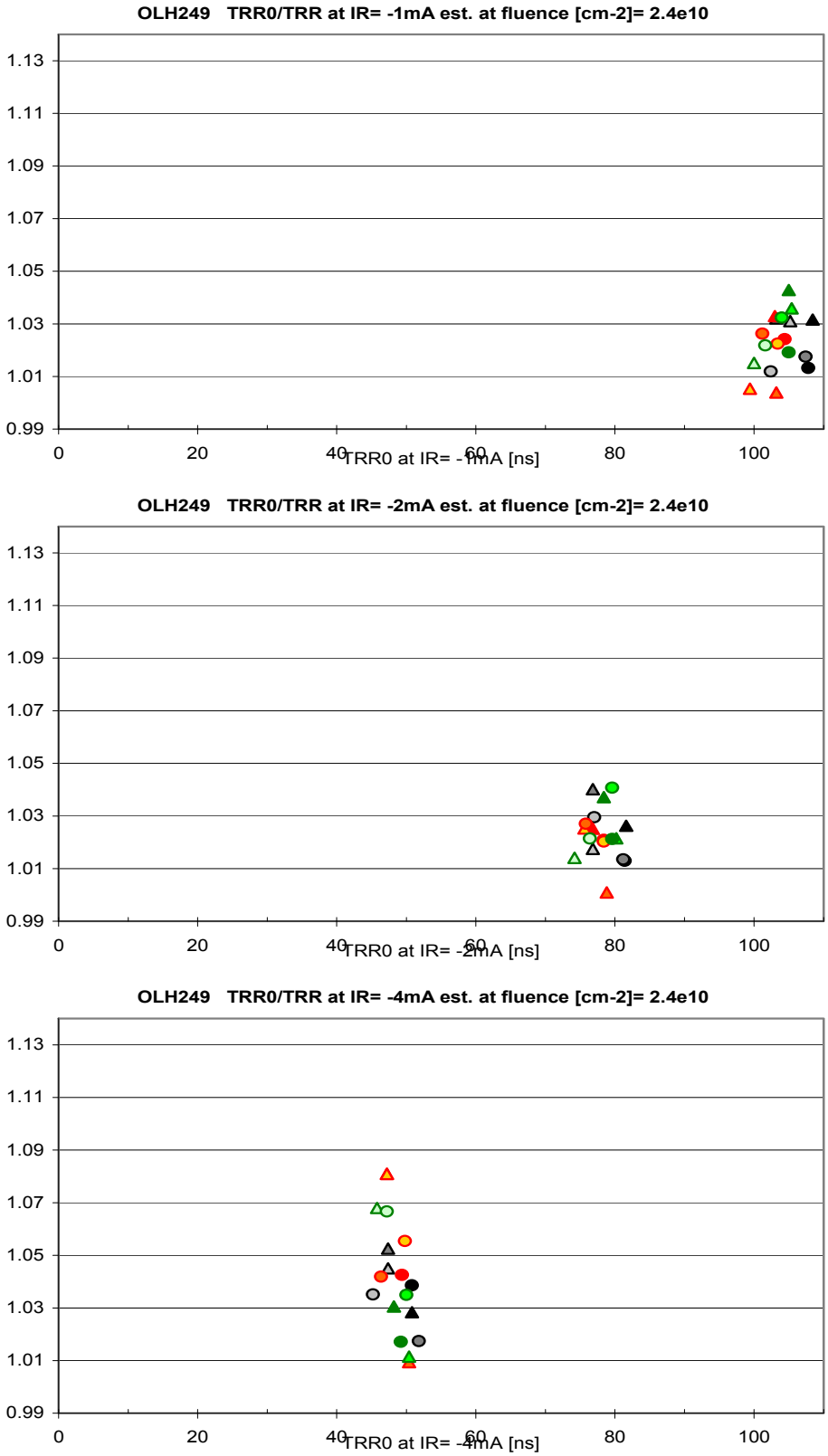
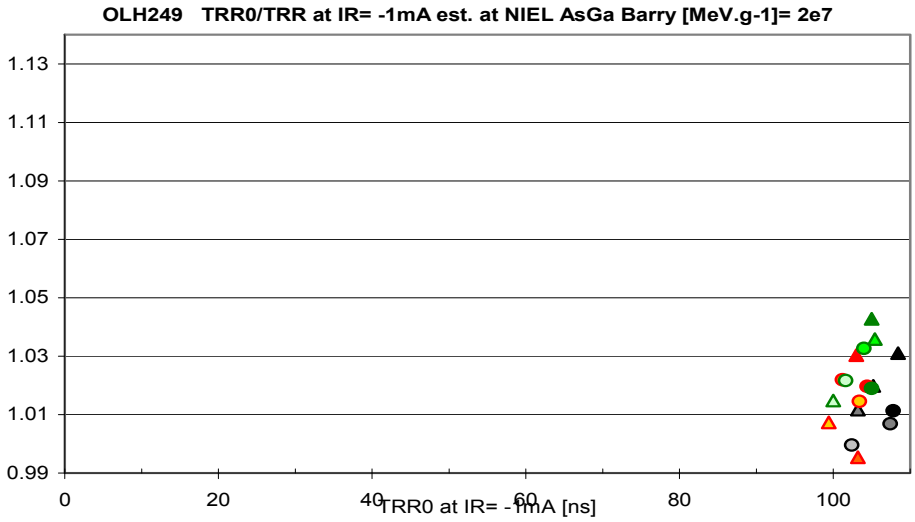
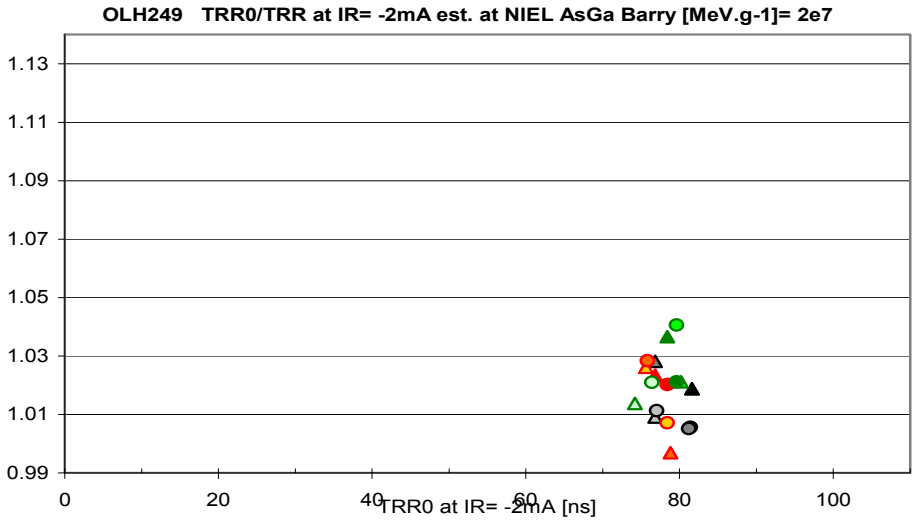


Fig. 13-75: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA





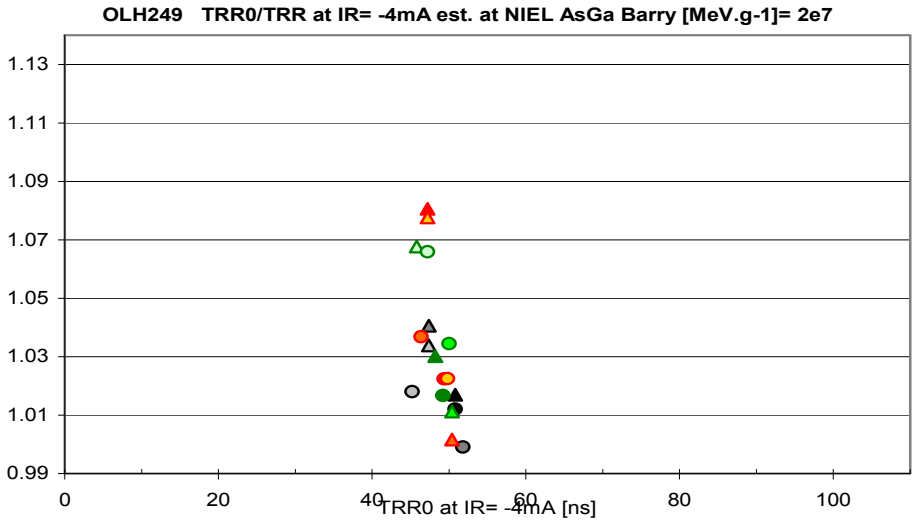


Fig. 13-76: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA

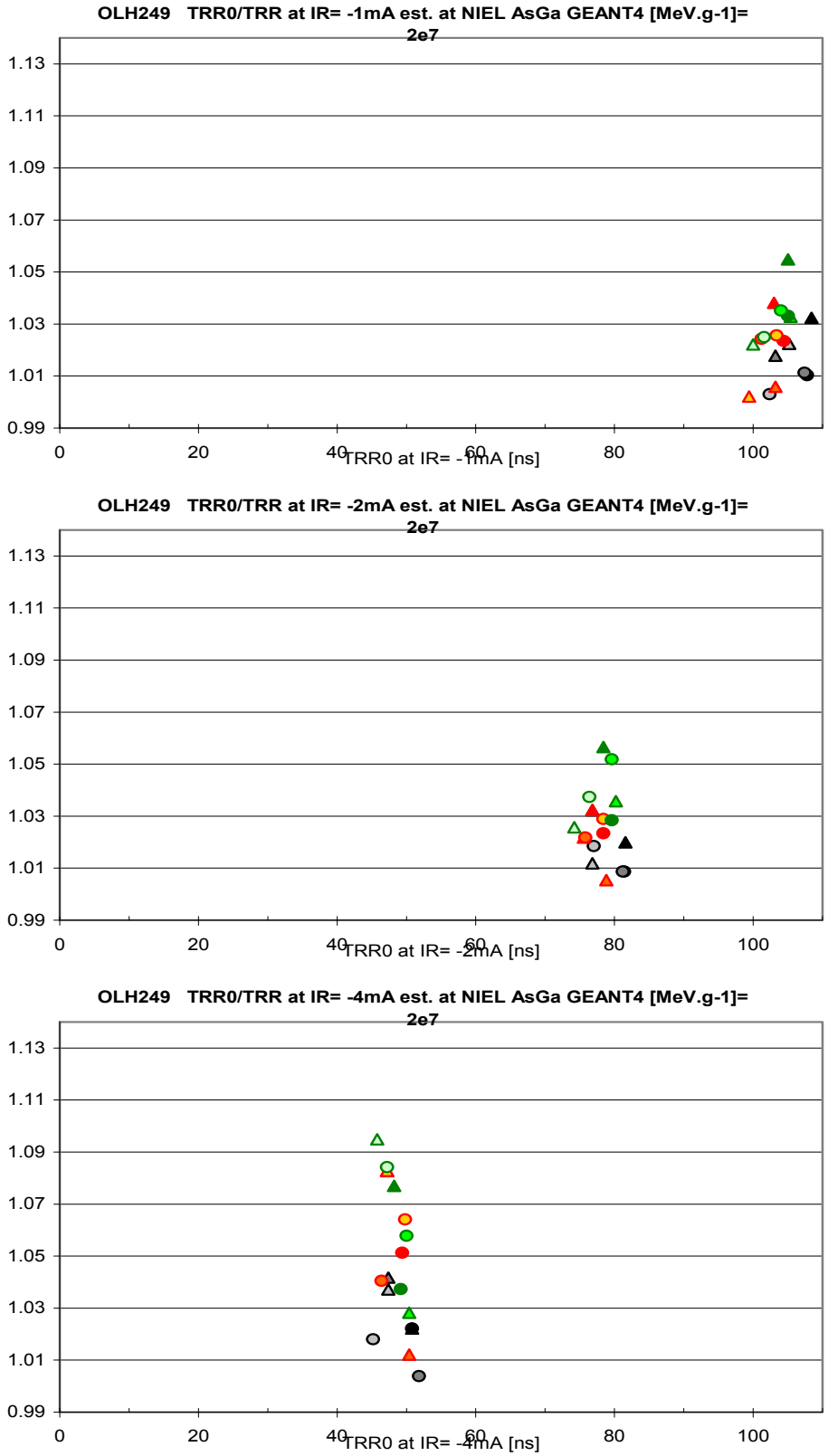
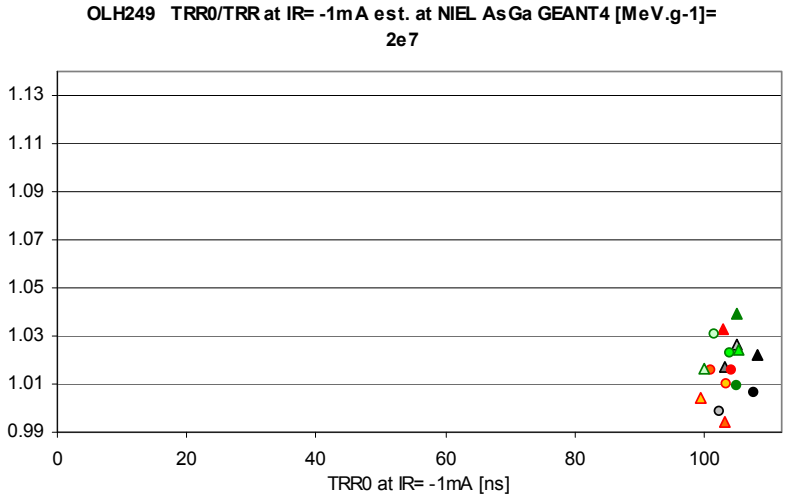
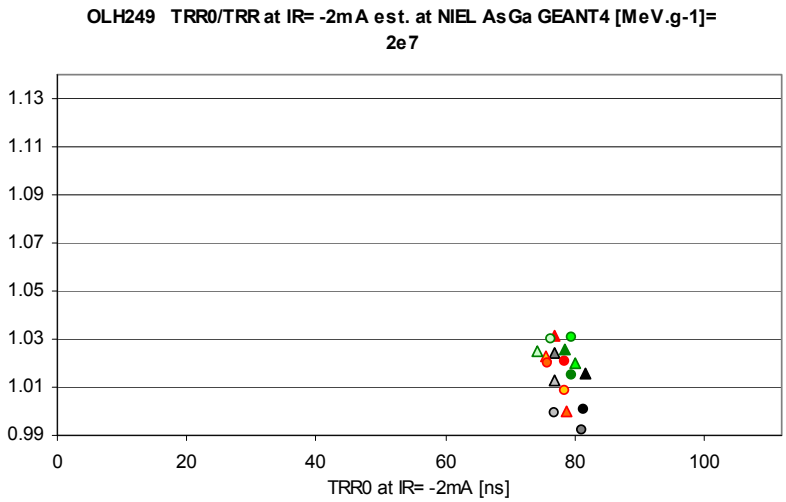


Fig. 13-77: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





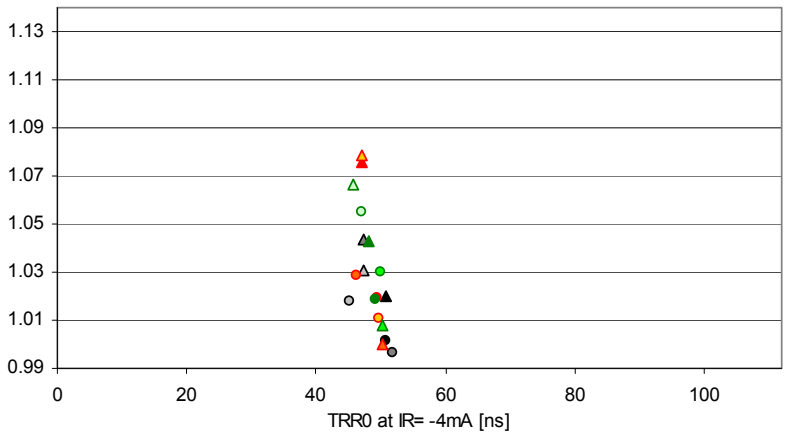


Fig. 13-78: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 6.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

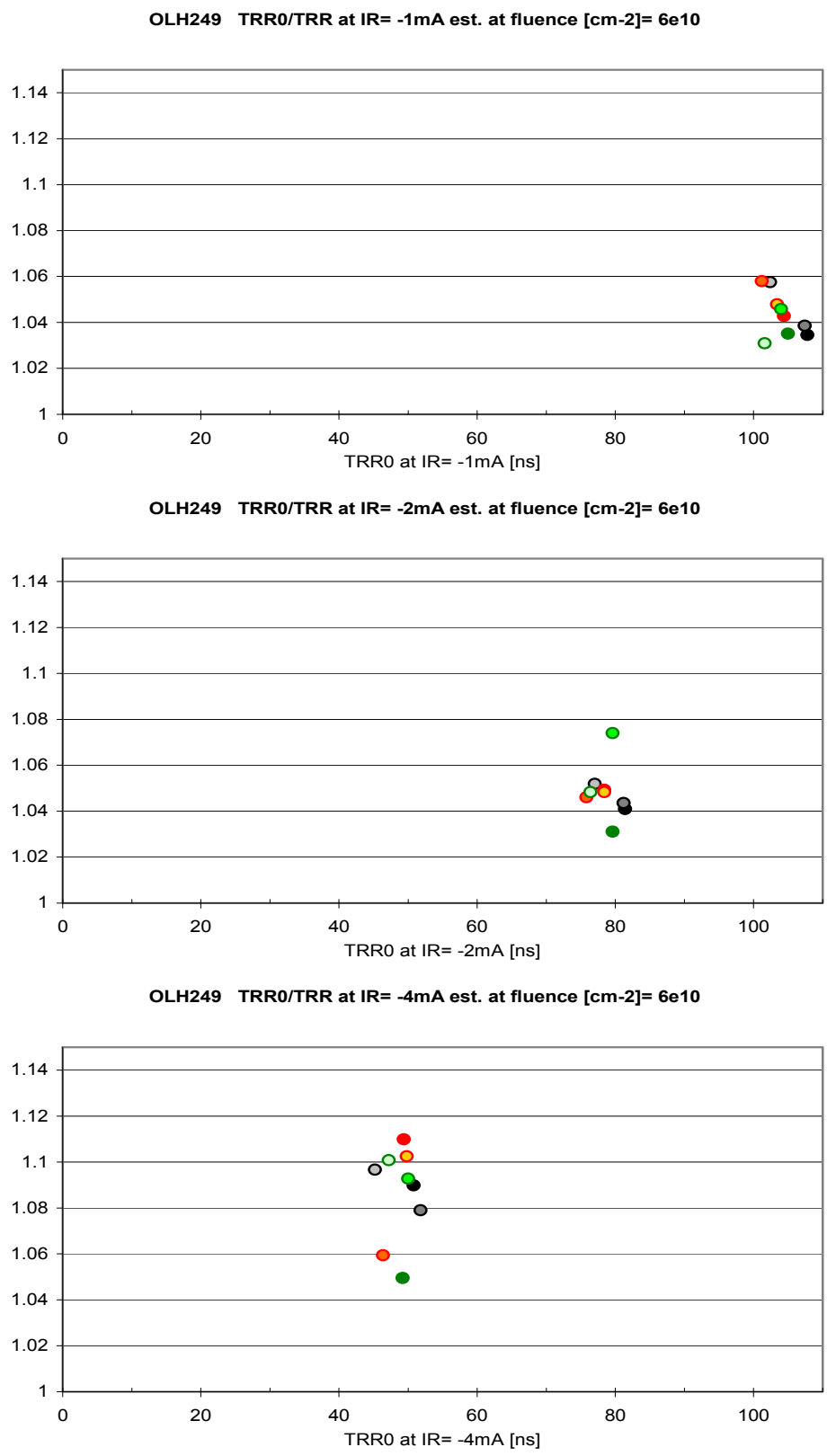


Fig. 13-79: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA

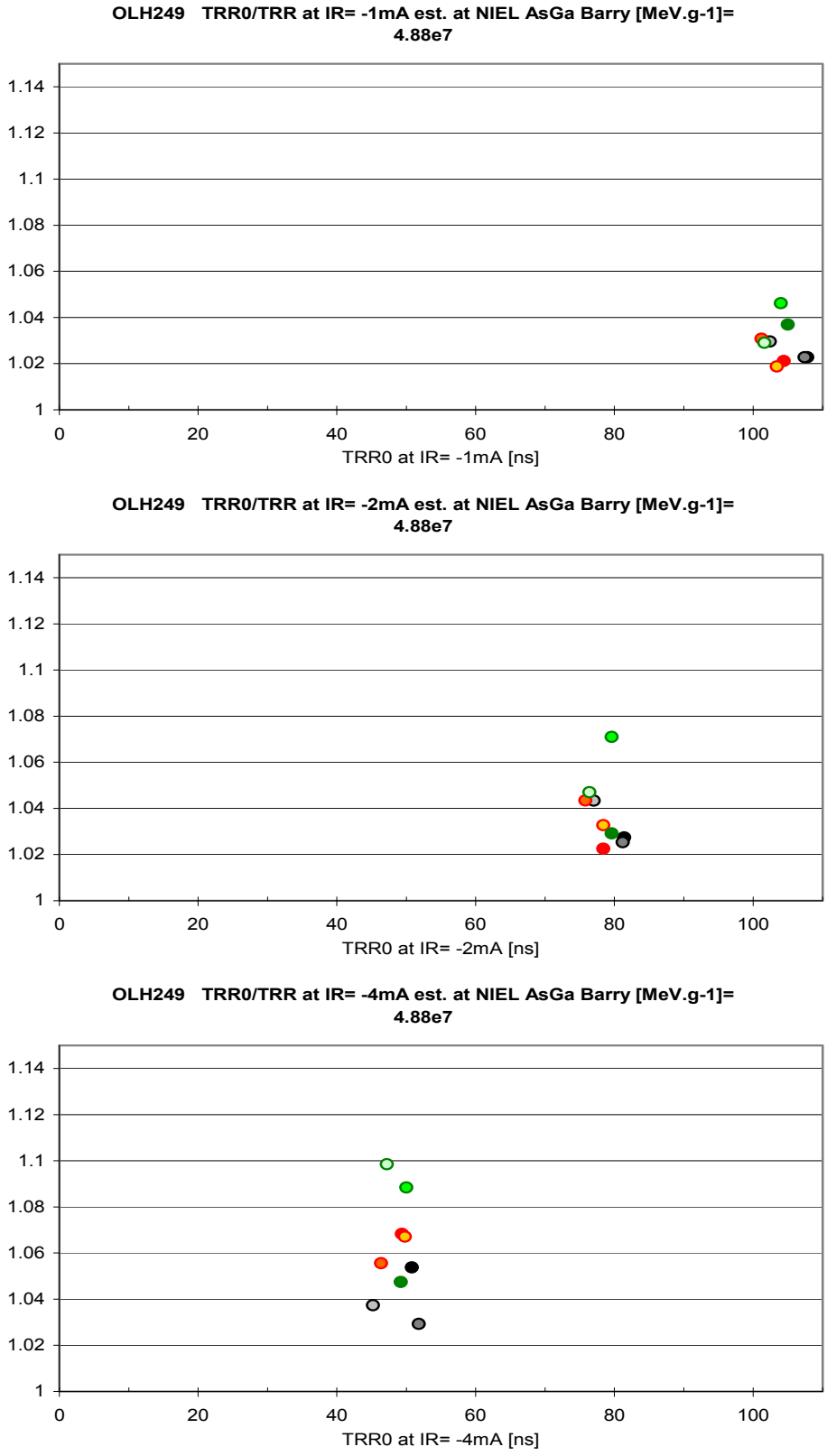
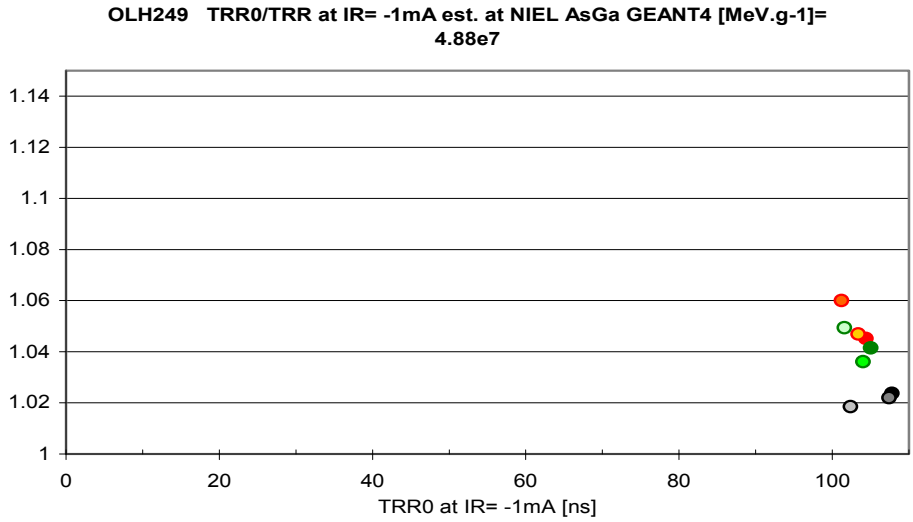
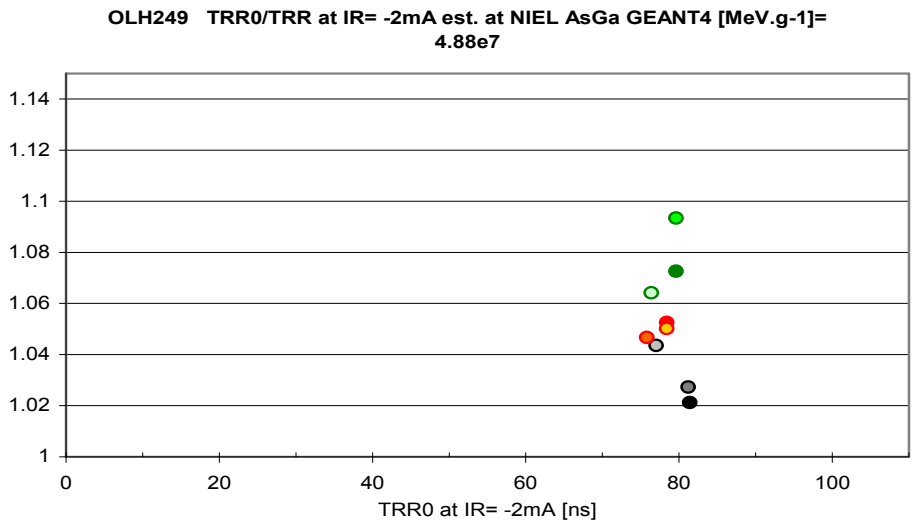


Fig. 13-80: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^7$ MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA





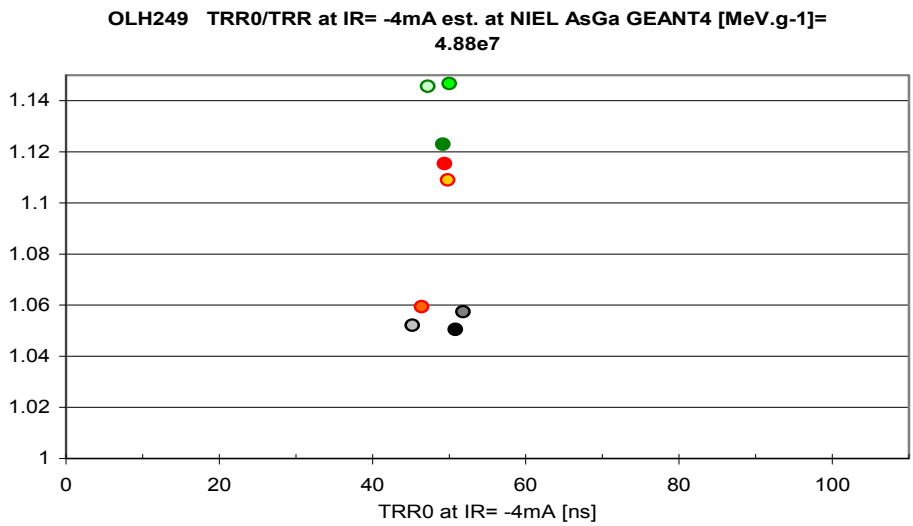
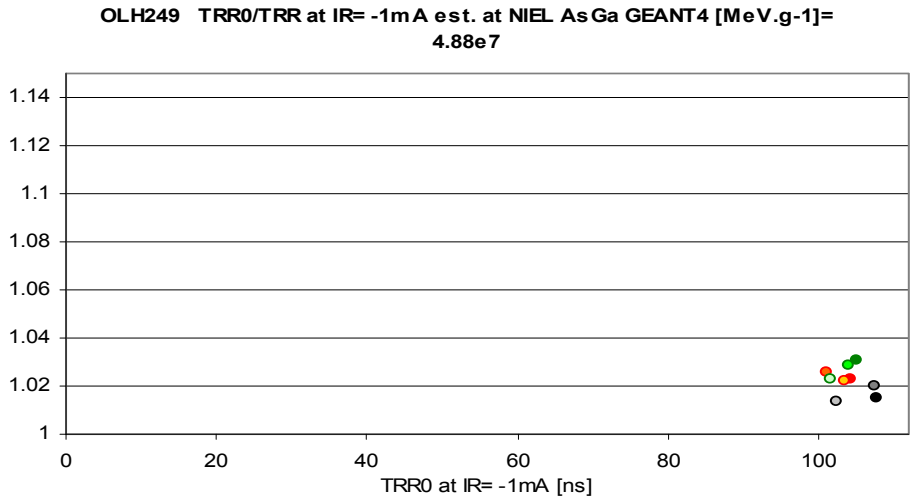
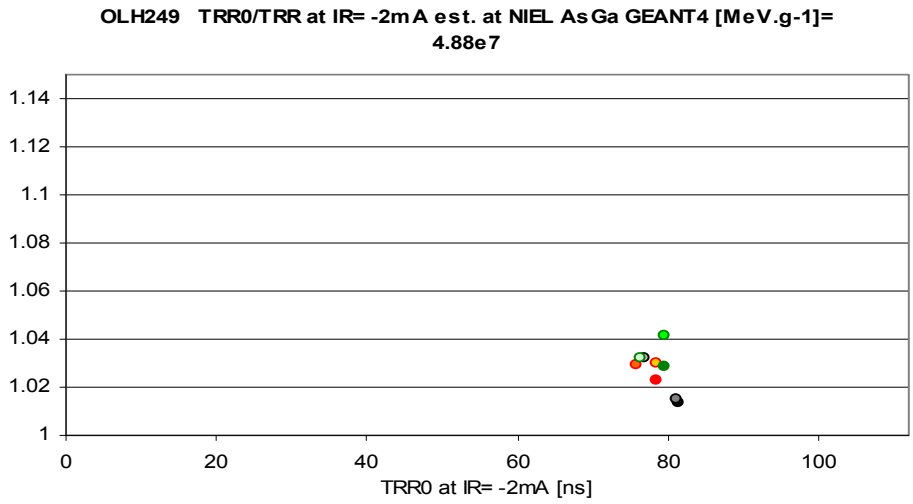


Fig. 13-81: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





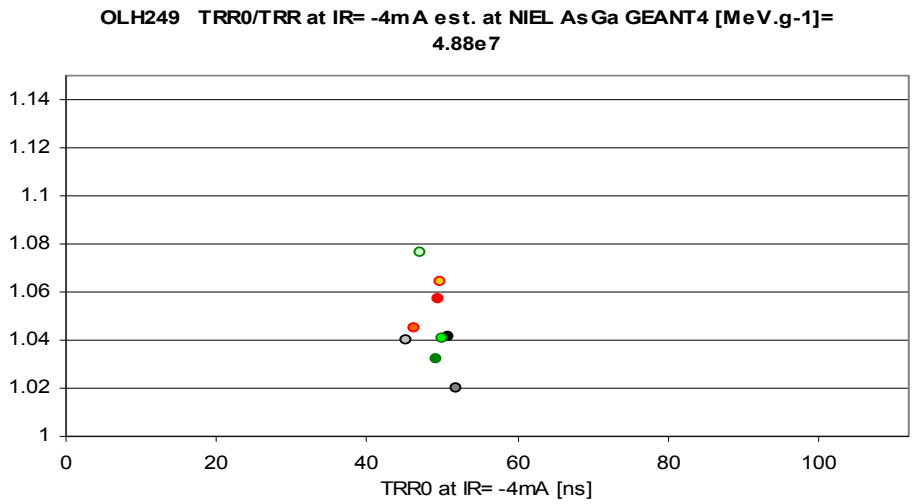


Fig. 13-82: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence

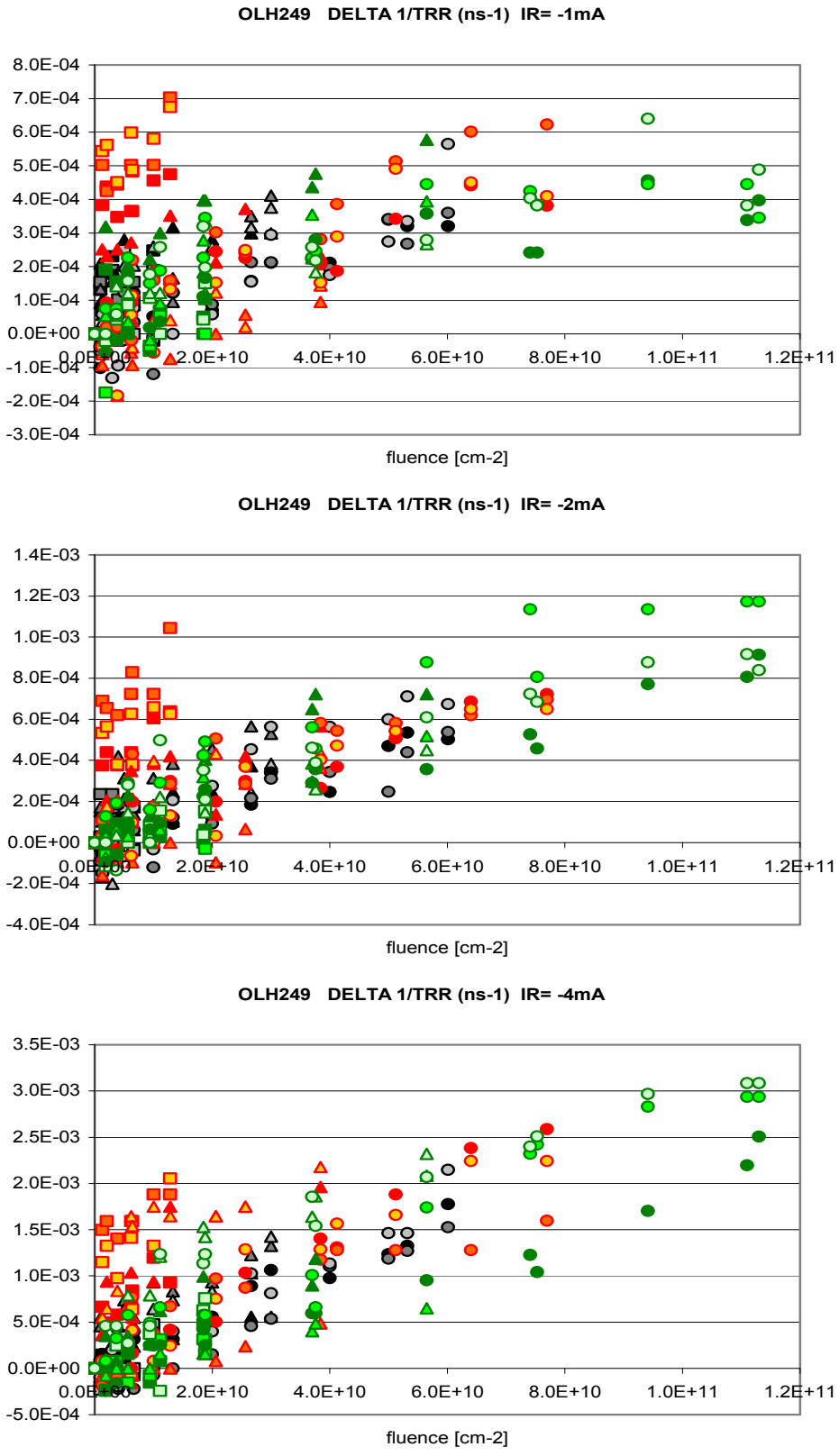
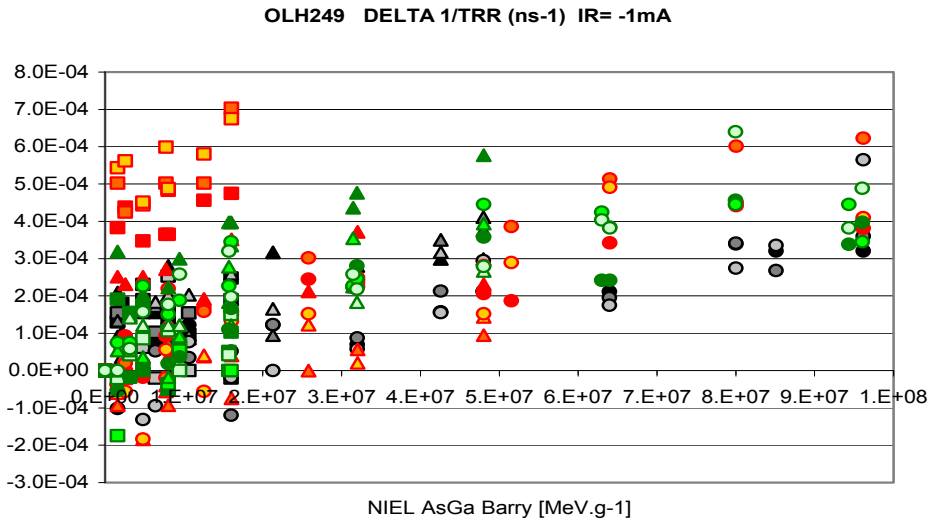
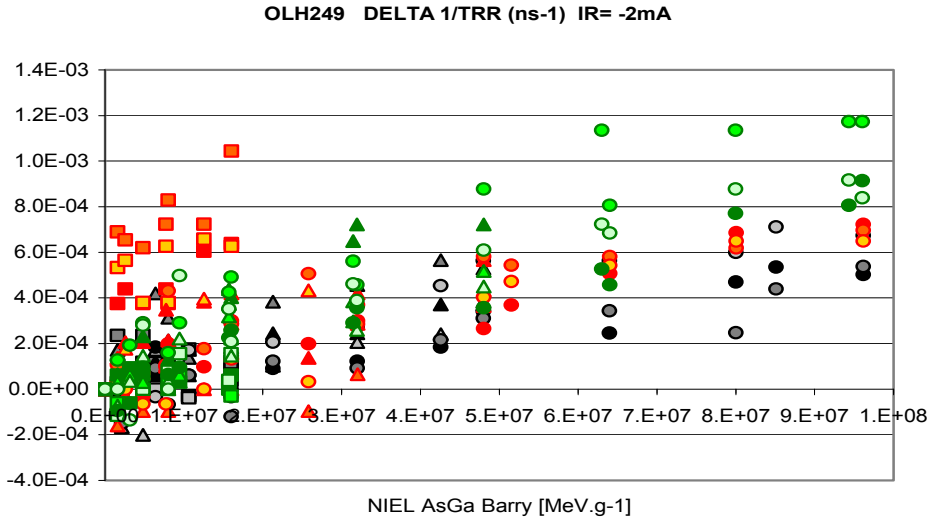


Fig. 13-83: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (Barry)





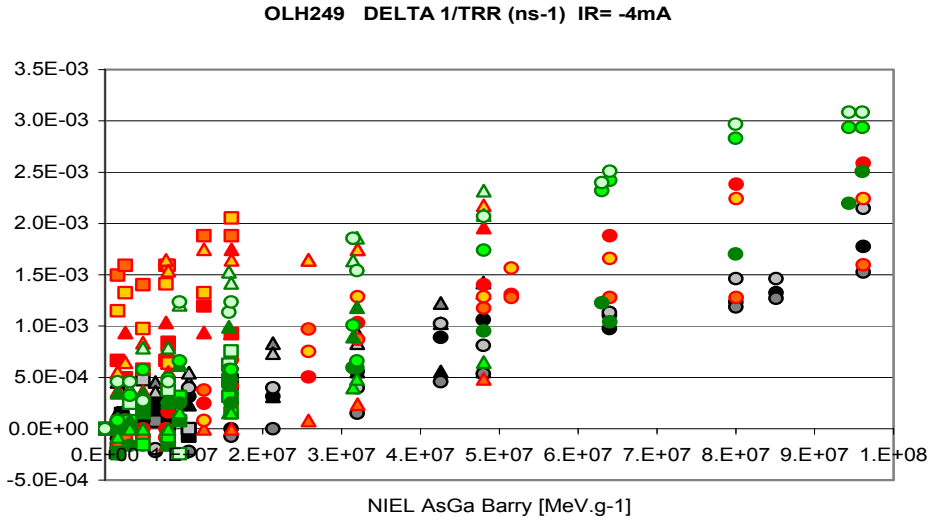


Fig. 13-84: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 ELASTIC)

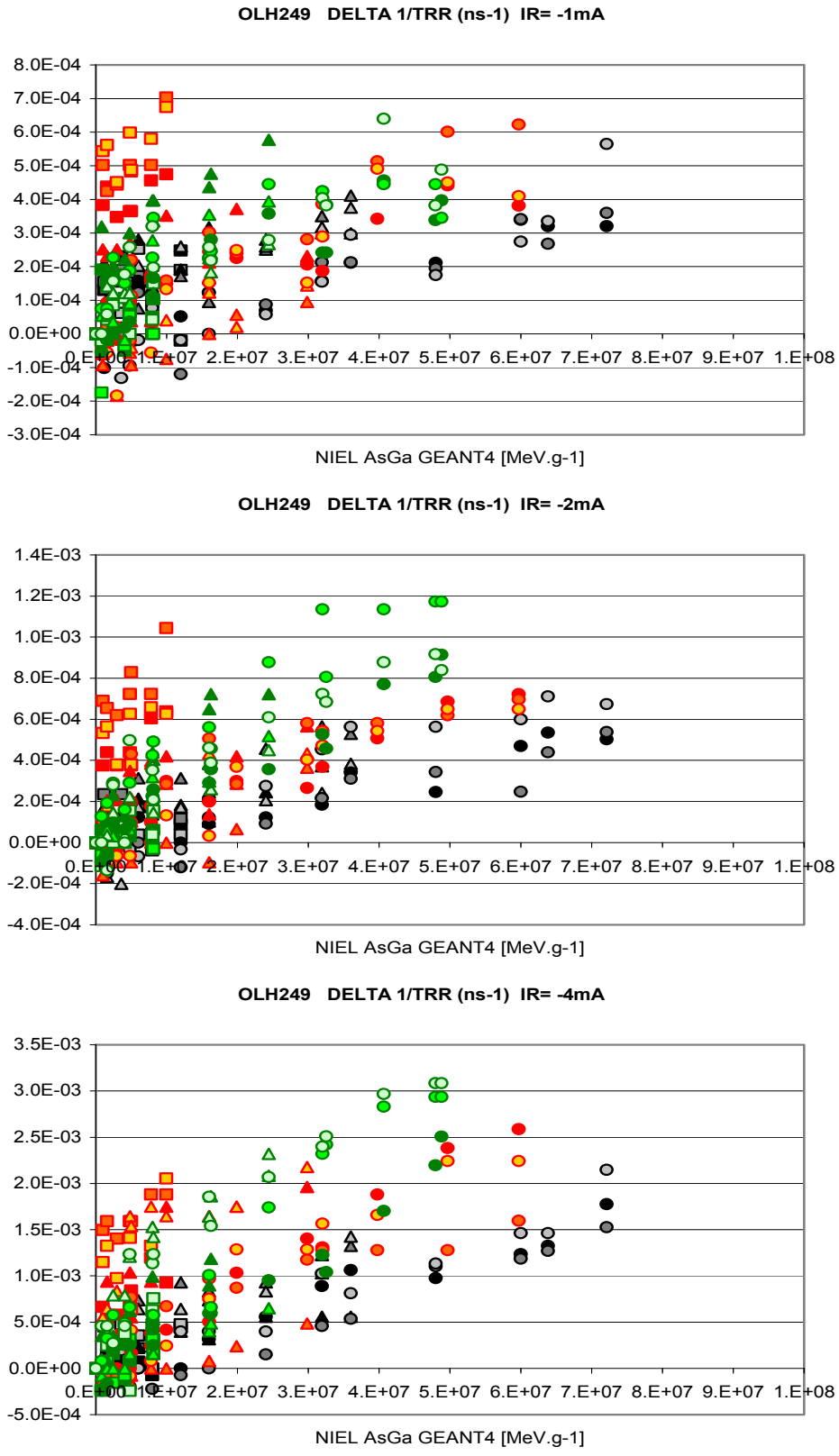
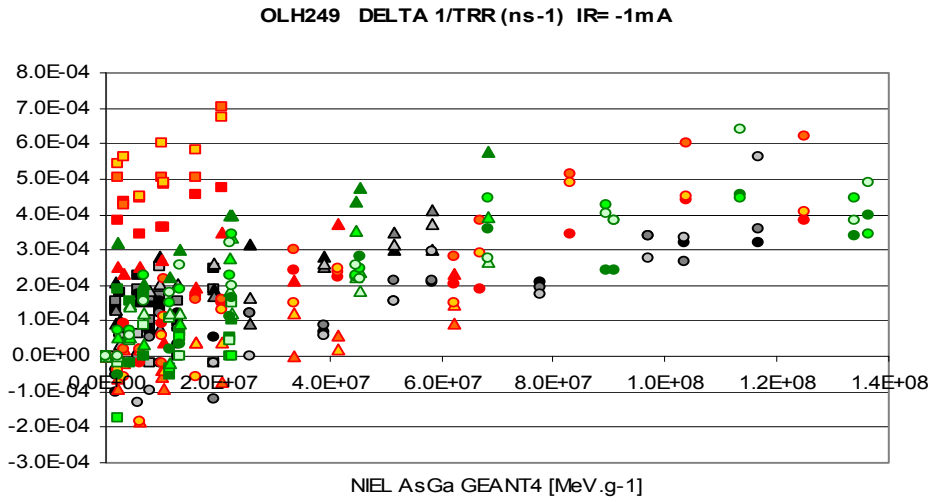
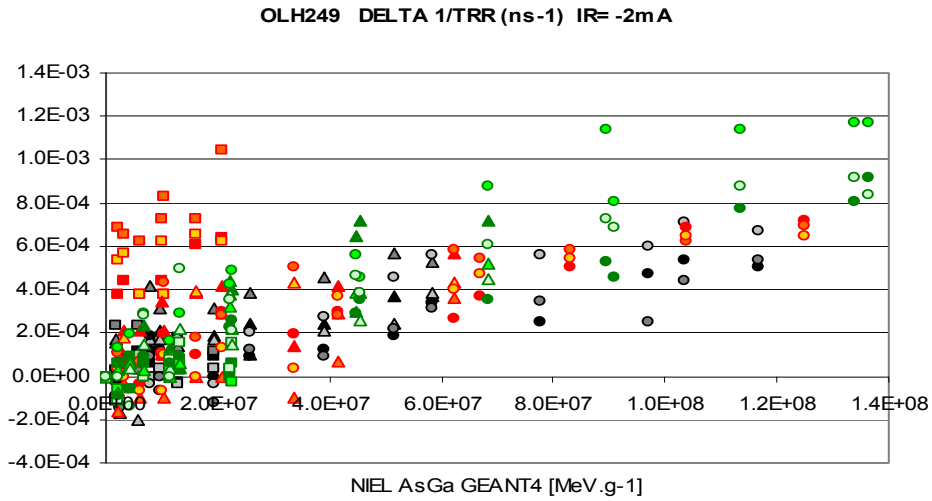


Fig. 13-85: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 TOTAL)





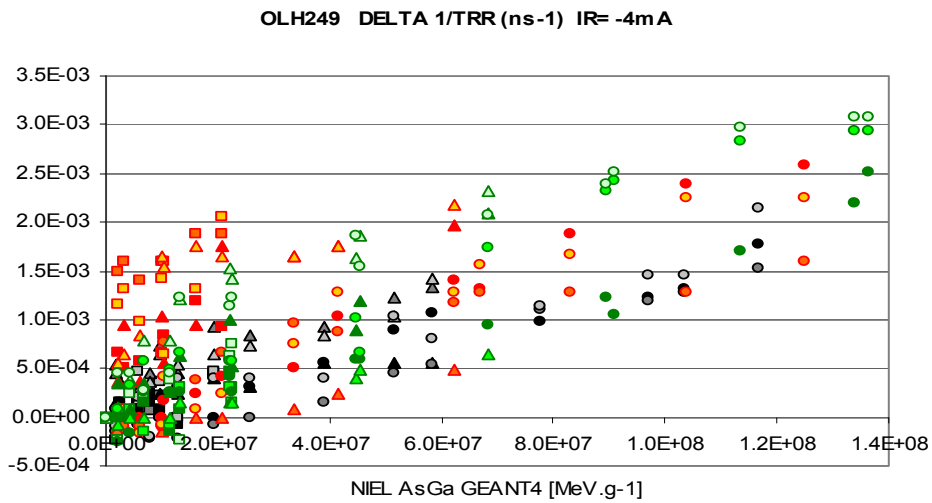
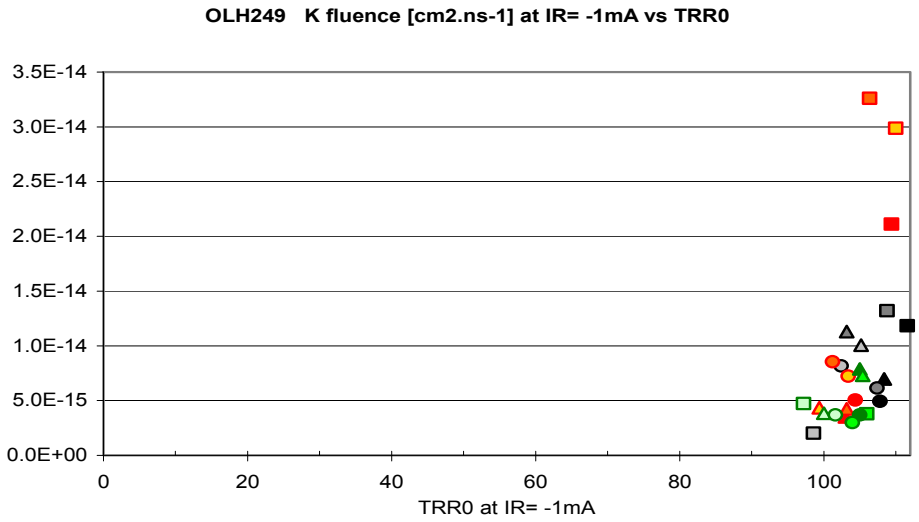
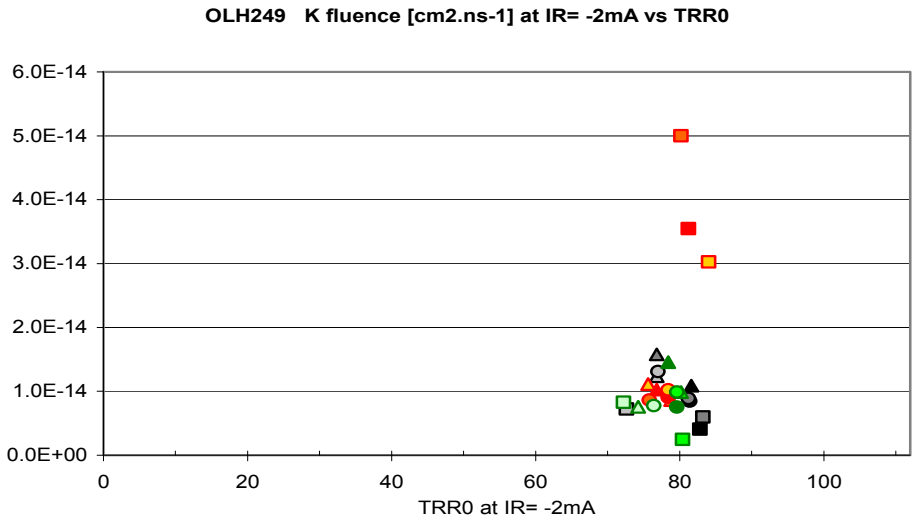


Fig. 13-86: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}





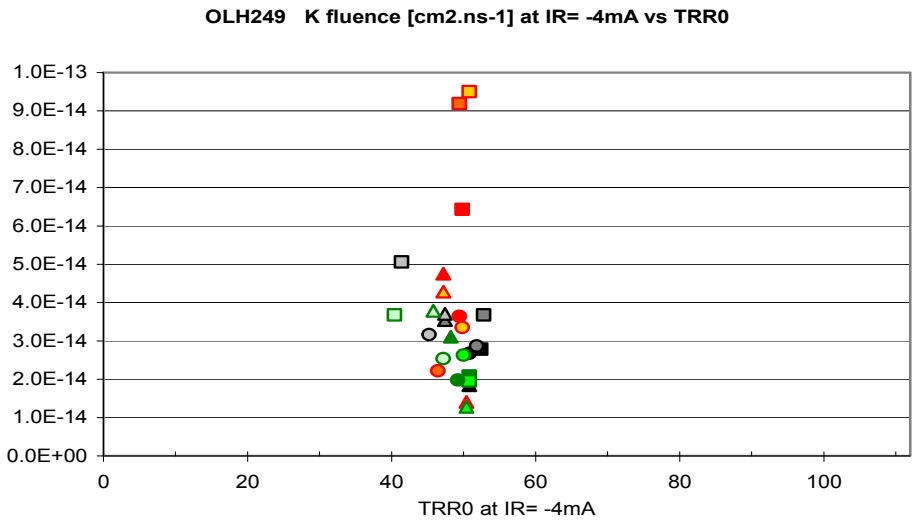
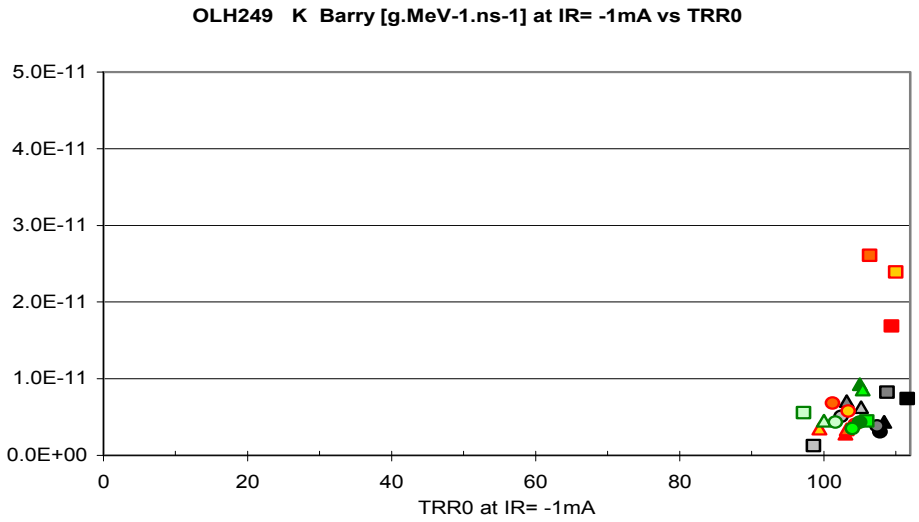
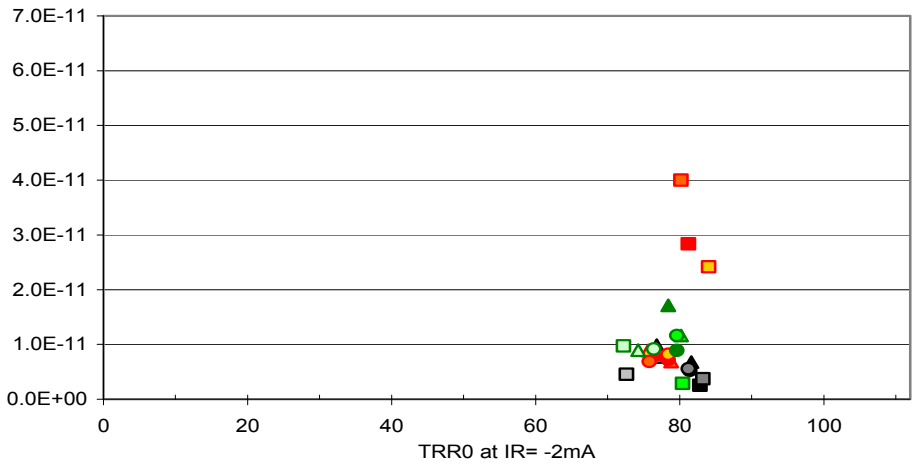


Fig. 13-87: OLH249 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to τ_{RR0}





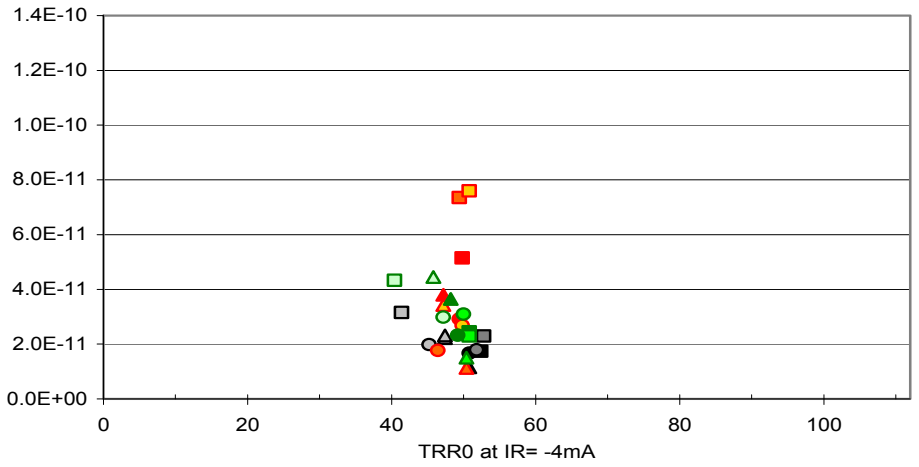
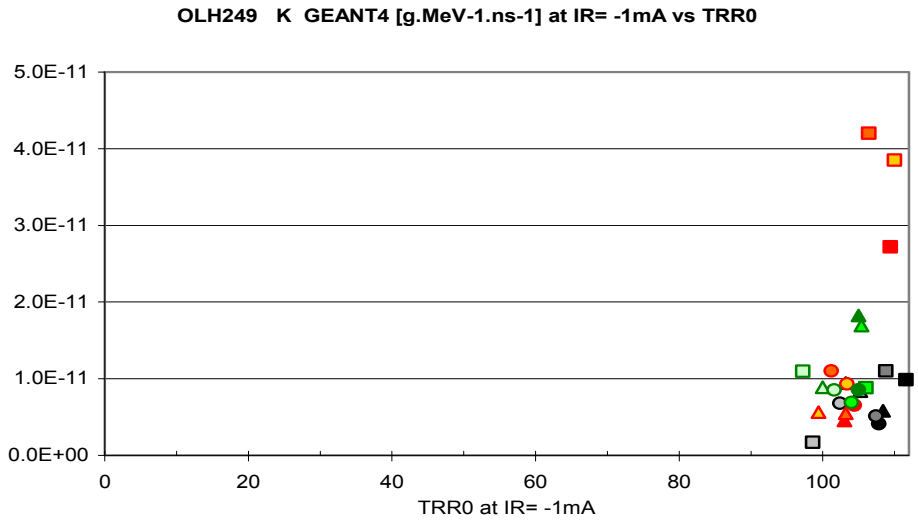
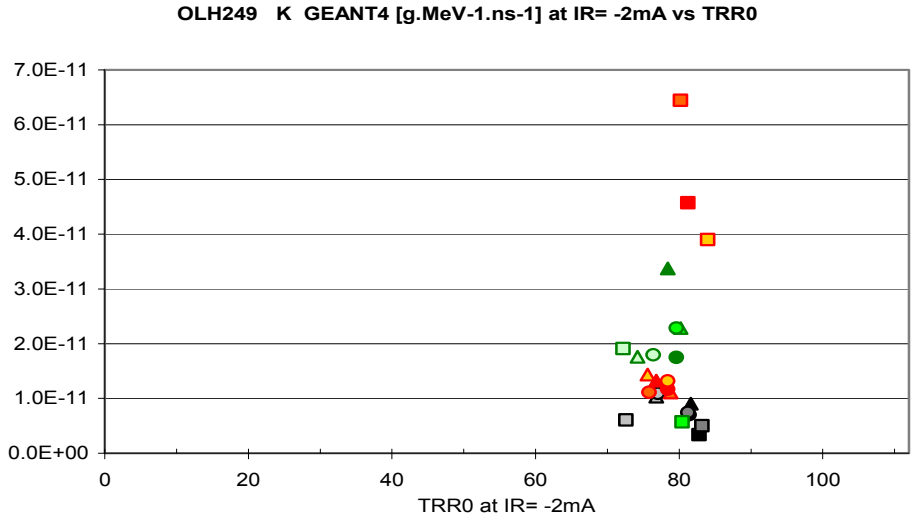


Fig. 13-88: OLH249 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}





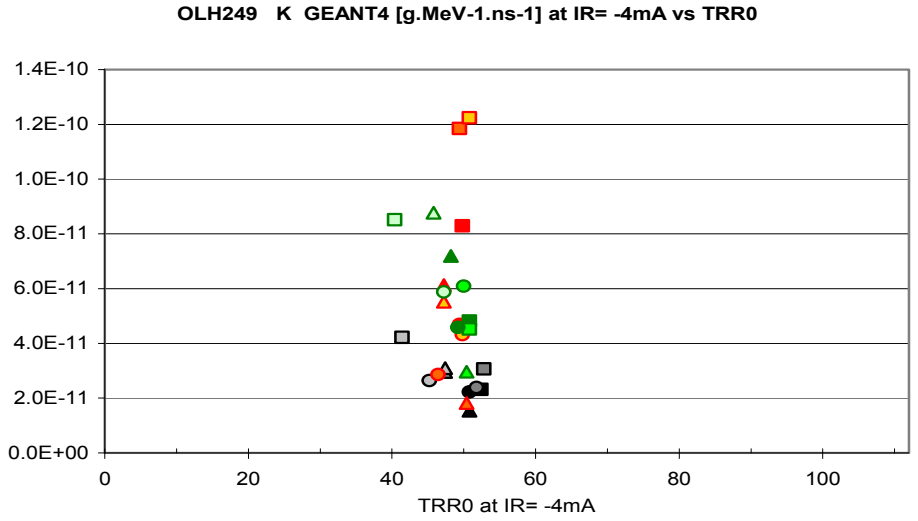
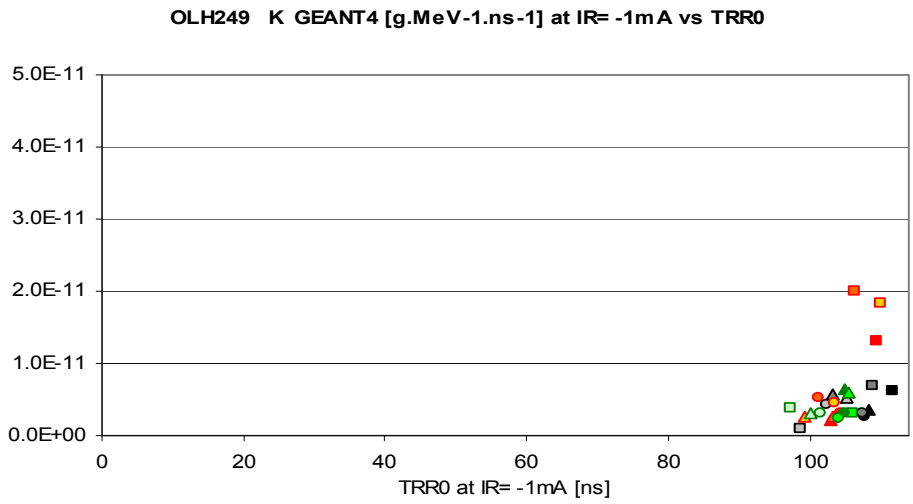
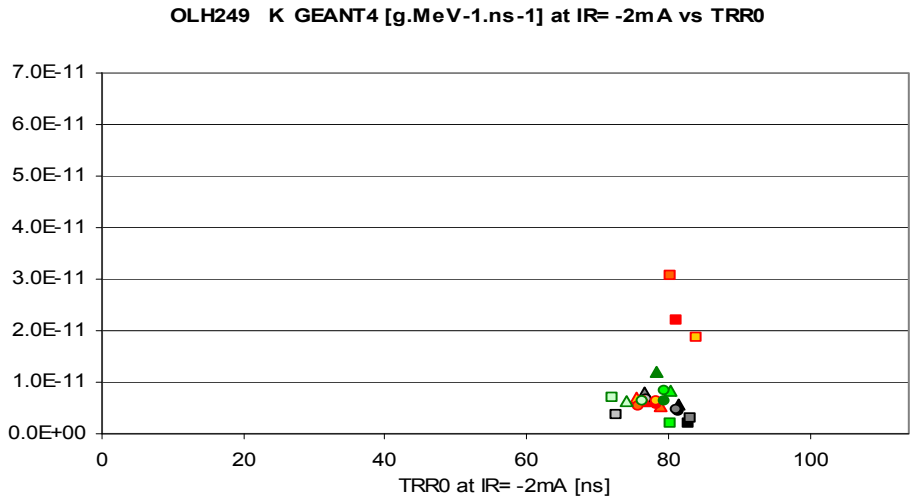


Fig. 13-89: OLH249 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}





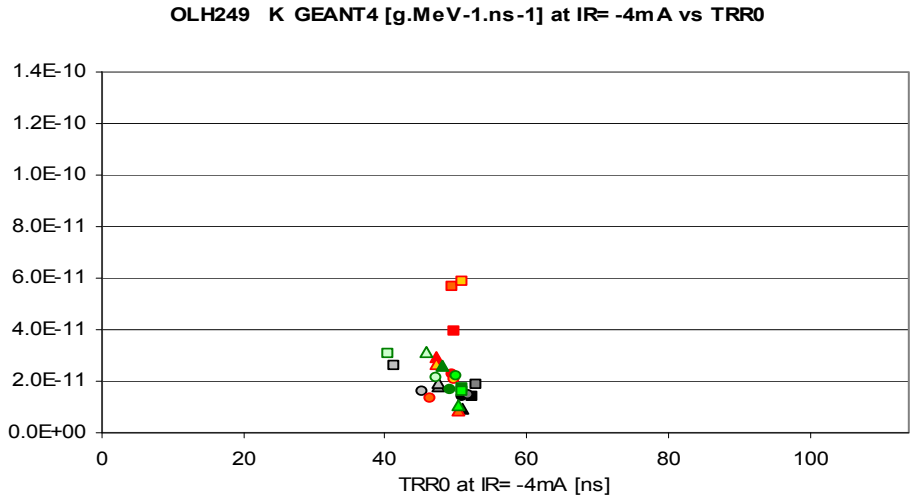


Fig. 13-90: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to energy

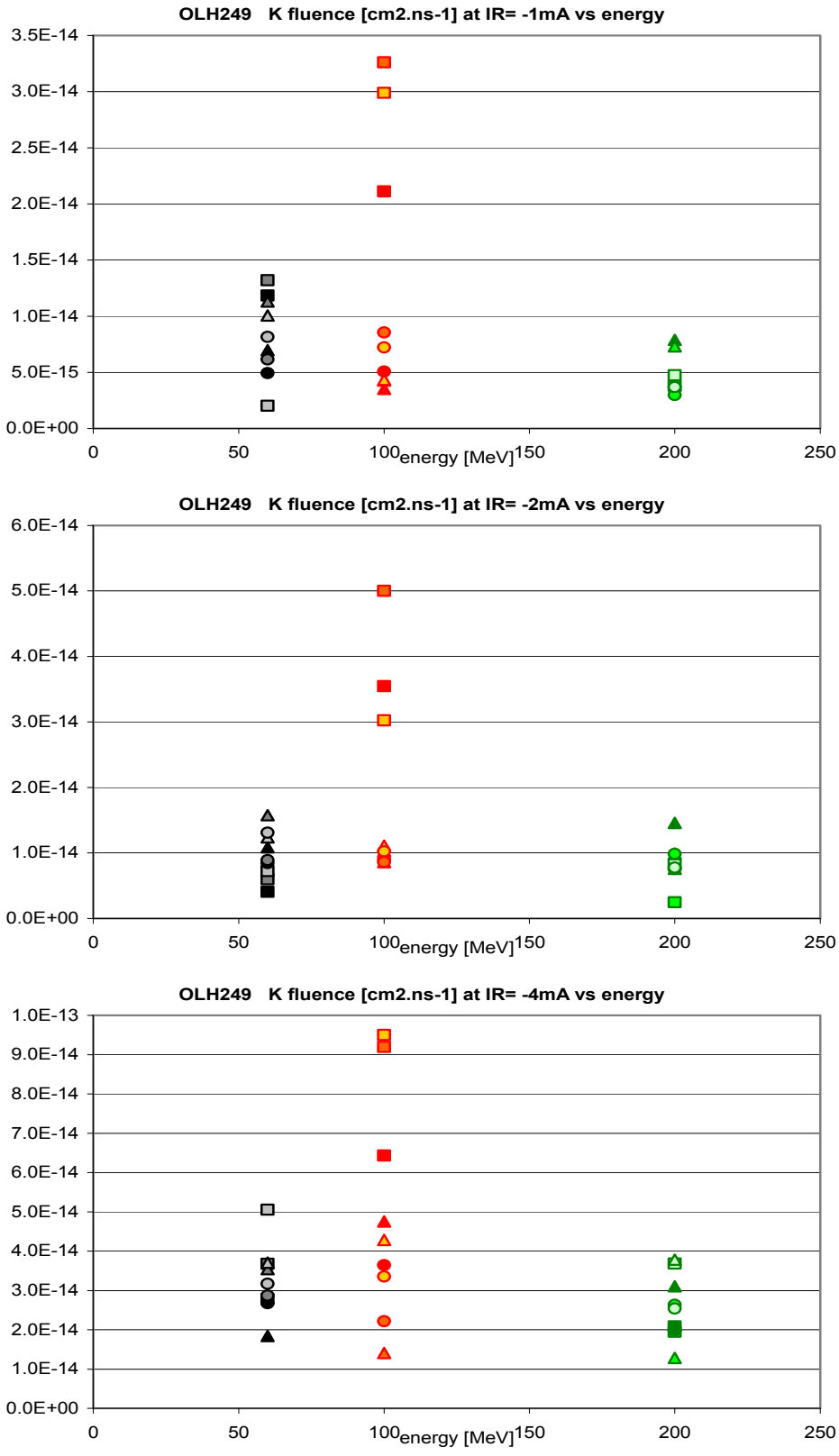


Fig. 13-91: OLH249 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to energy

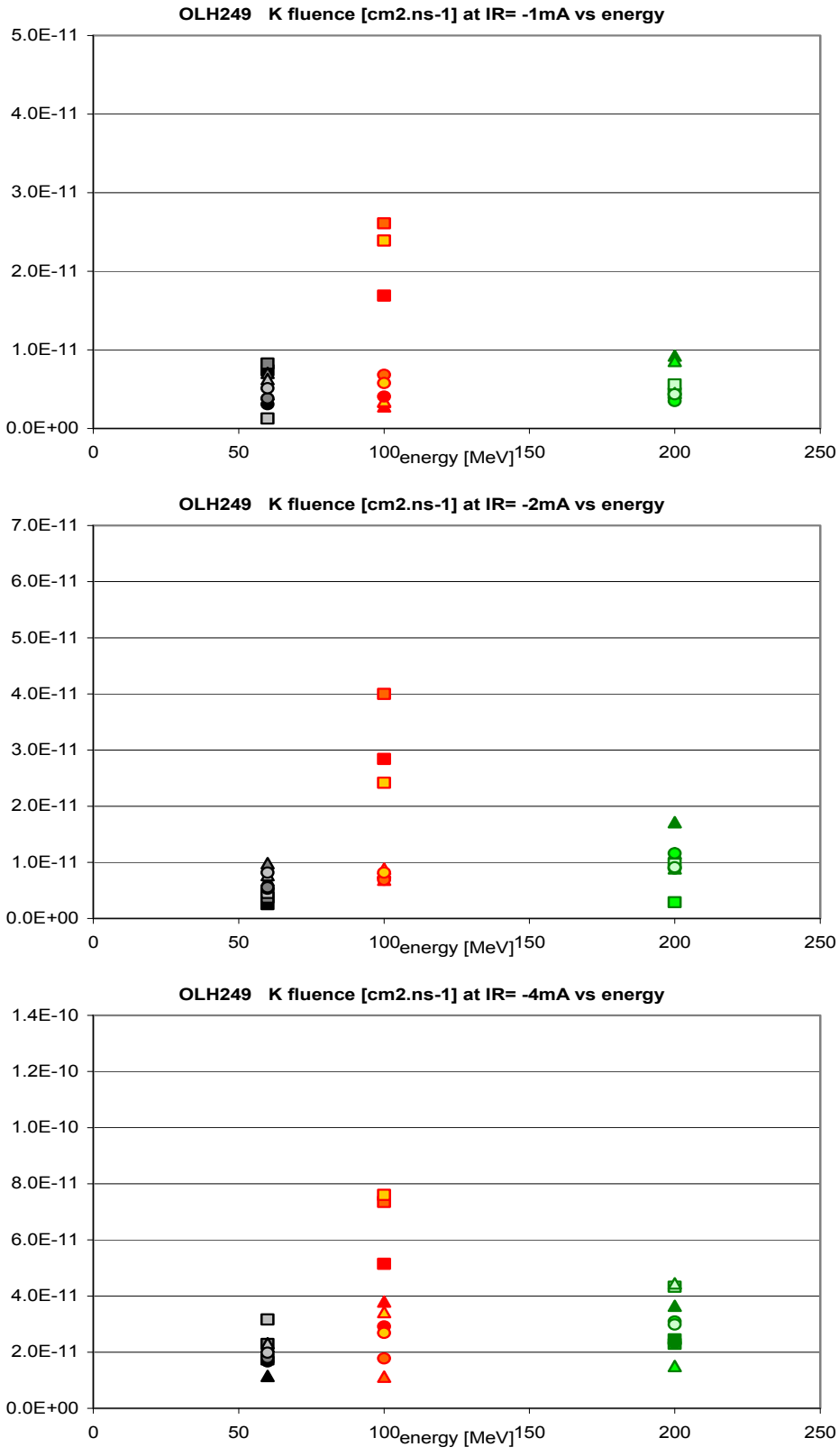


Fig. 13-92: OLH249 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to energy

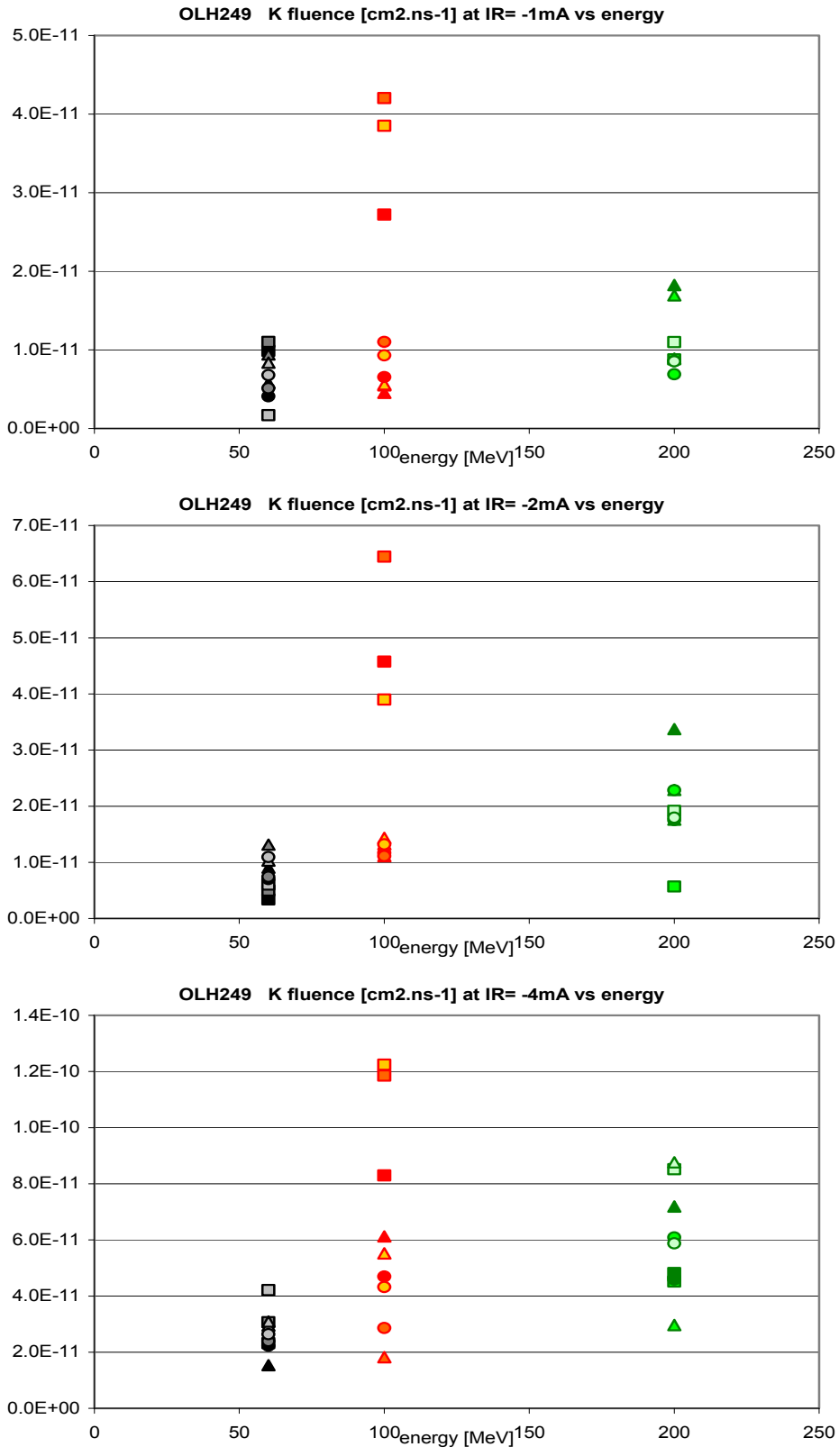
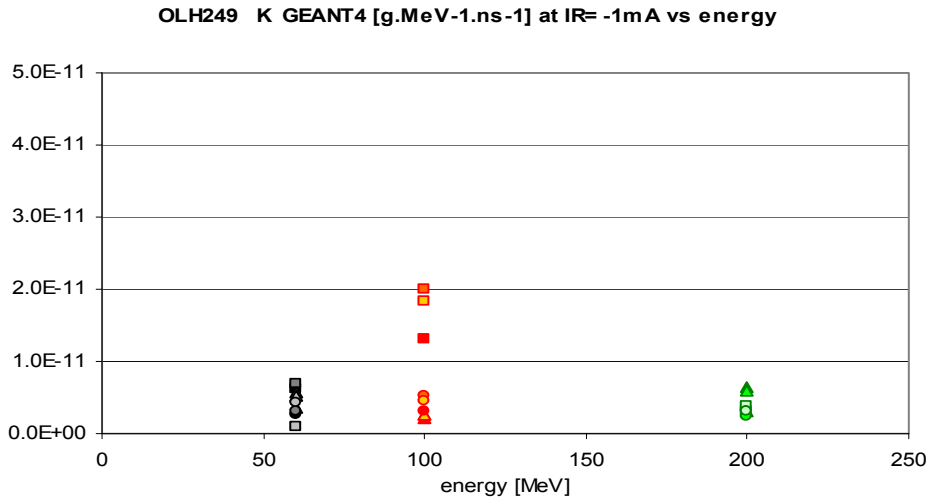
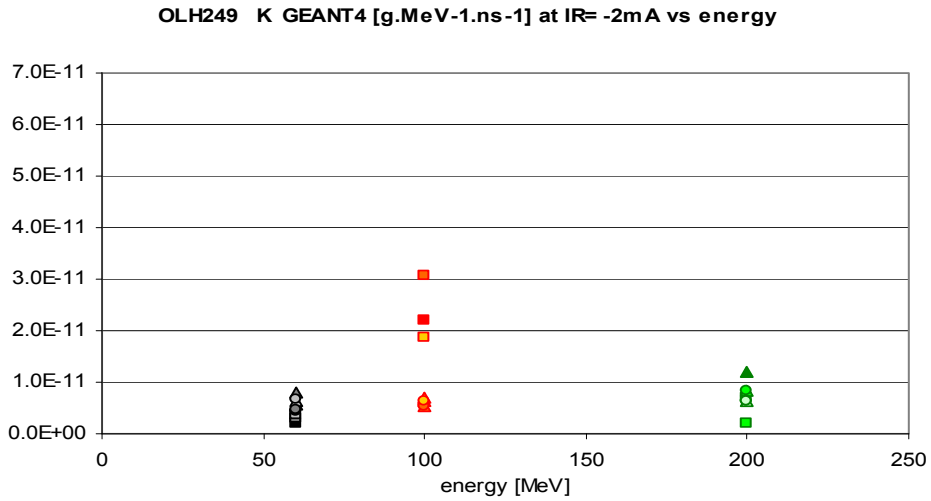


Fig. 13-93: OLH249 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to energy





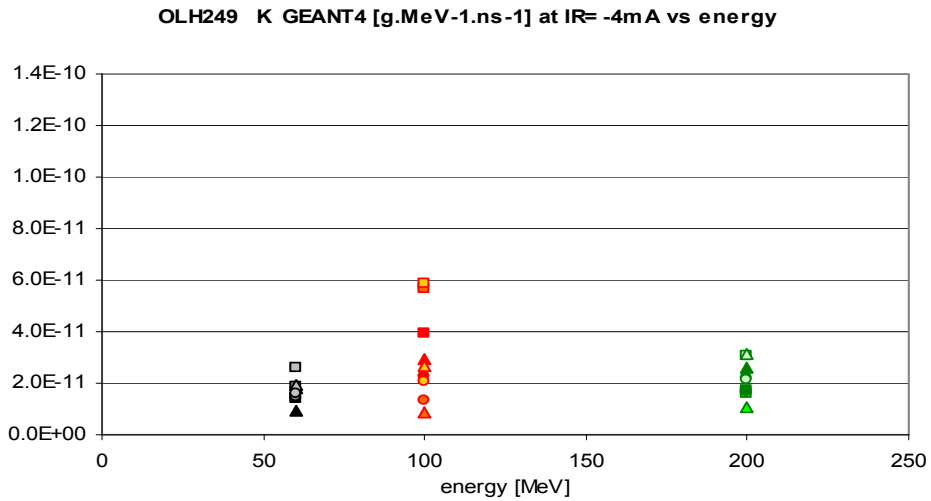
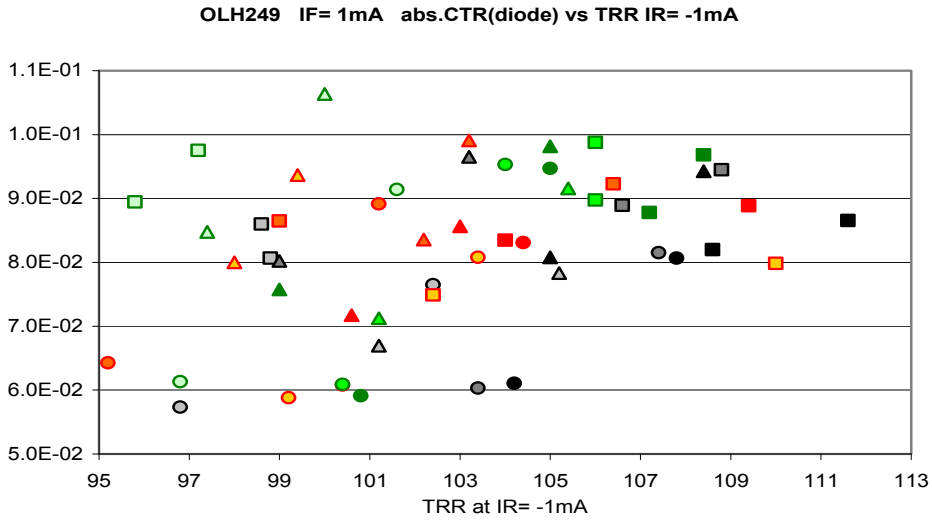
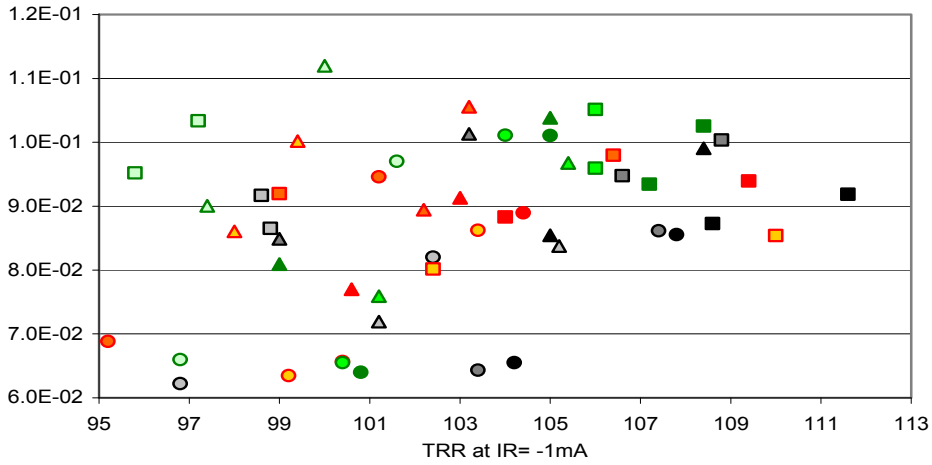
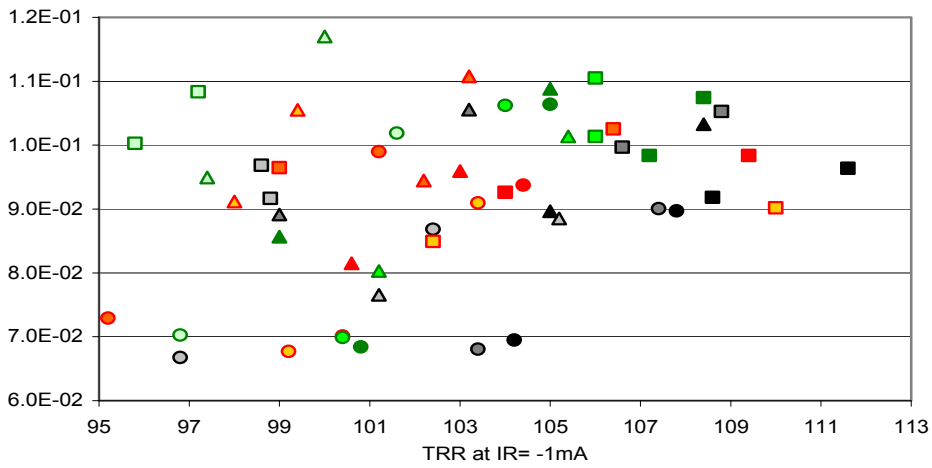
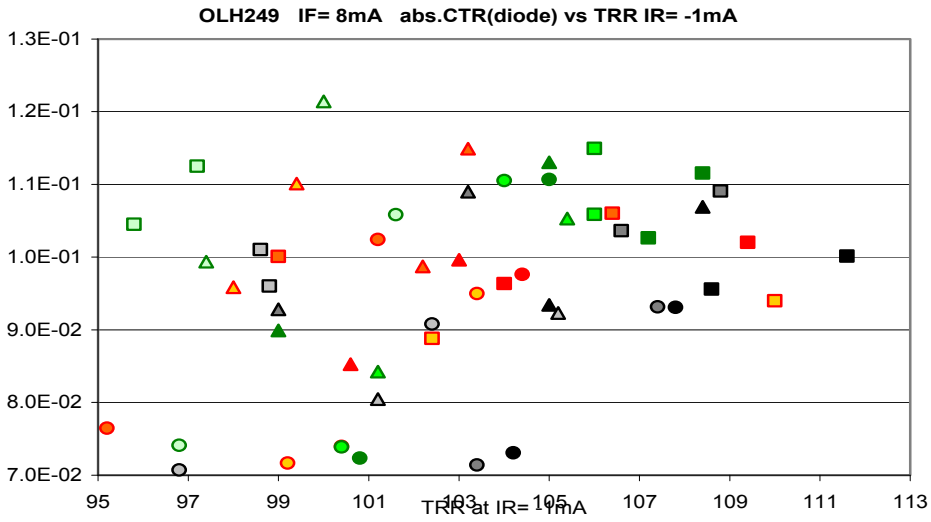


Fig. 13-94: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -1mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
95
97
99
101
103
105
107
109
111
113
TRR at IR= -1mA

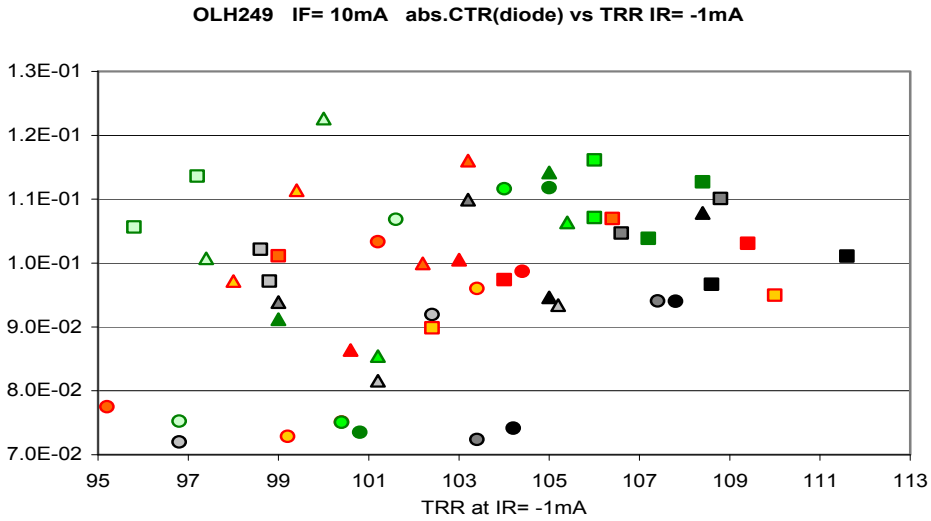
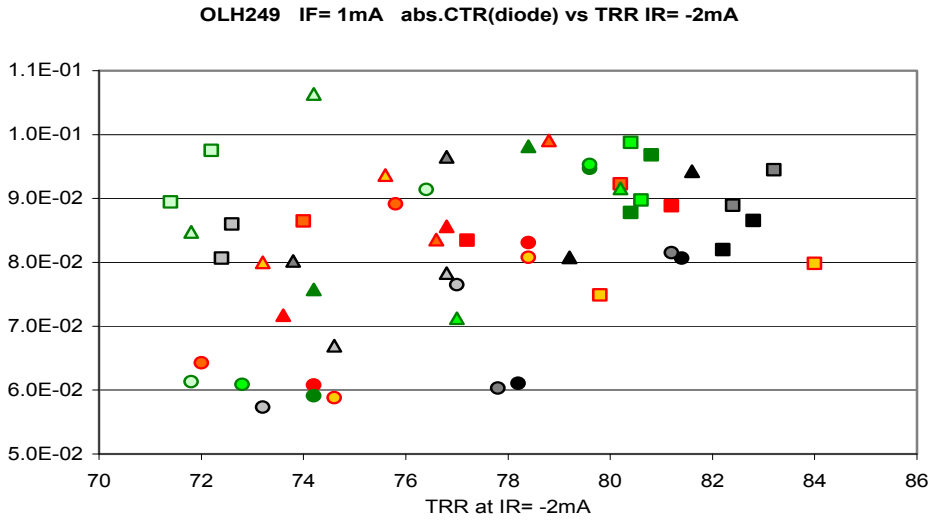
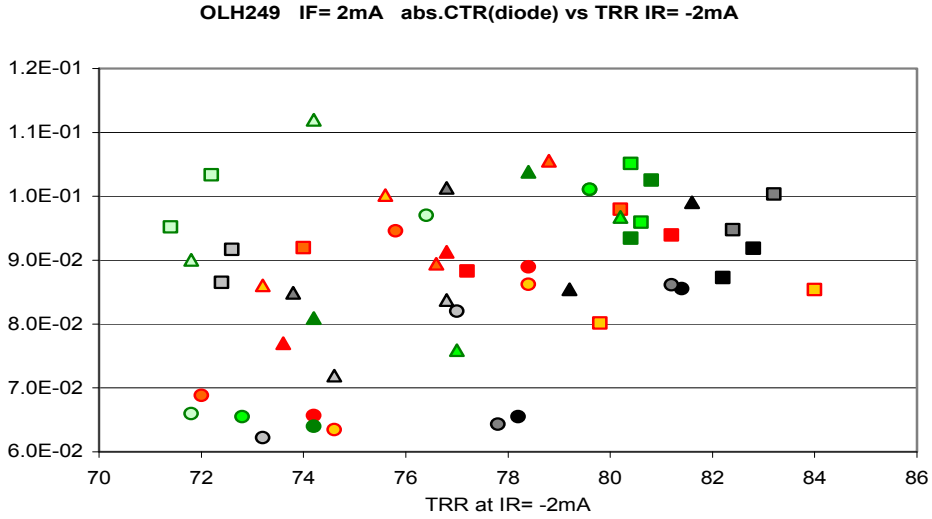
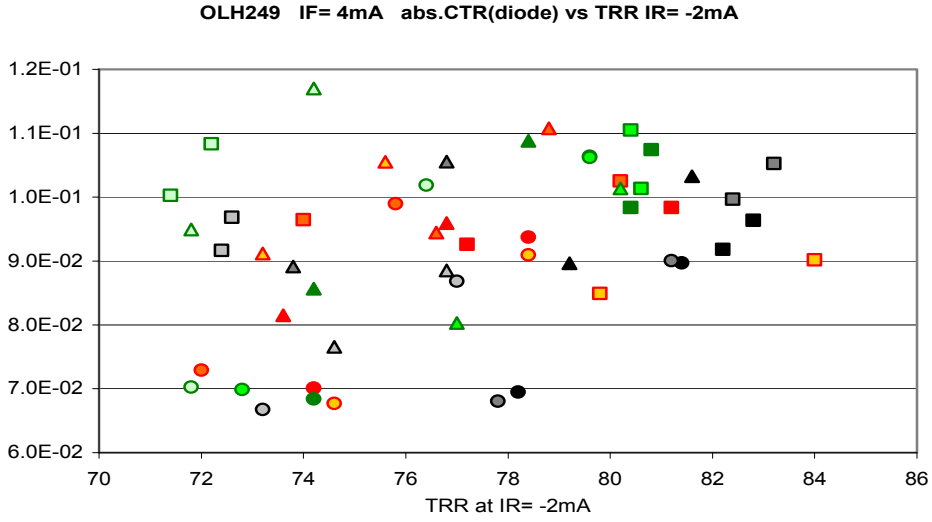
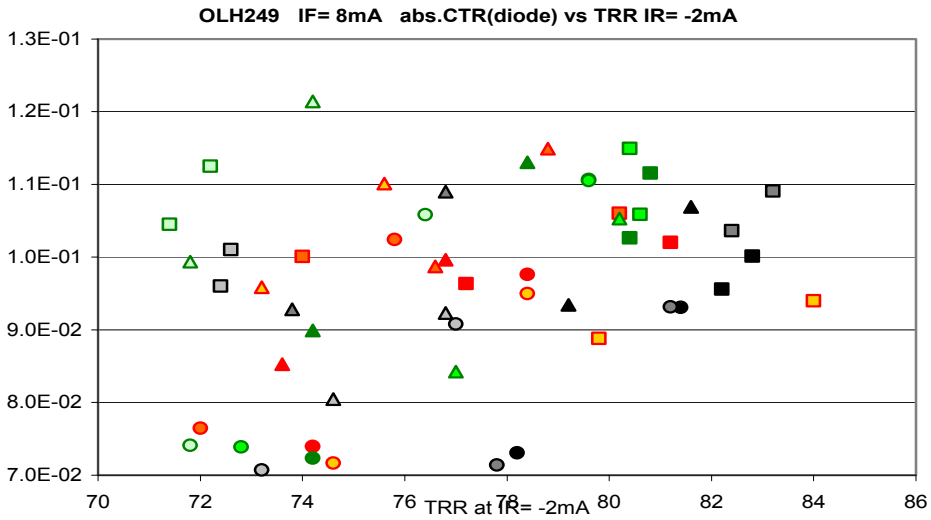

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -1mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
95
97
99
101
103
105
107
109
111
113
TRR at IR= -1mA

Fig. 13-95: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -2mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
70
72
74
76
78
80
82
84
86
TRR at IR= -2mA

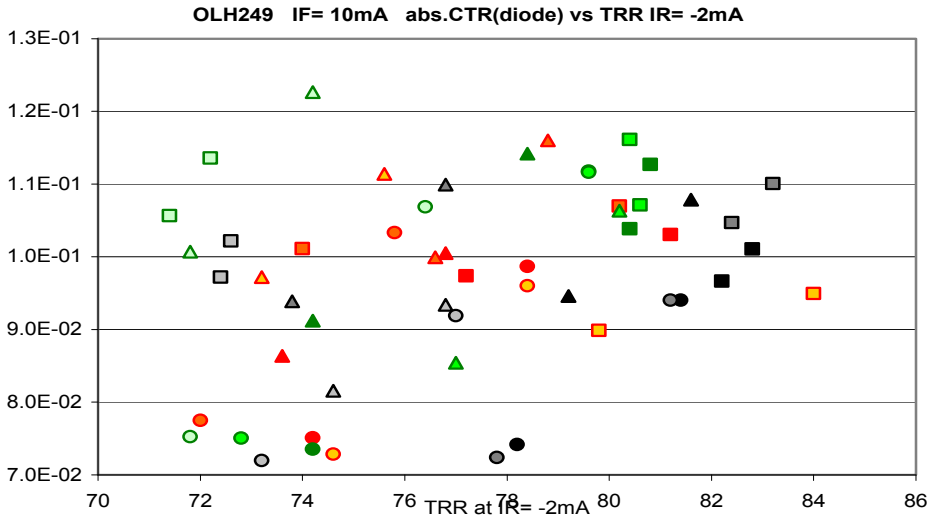
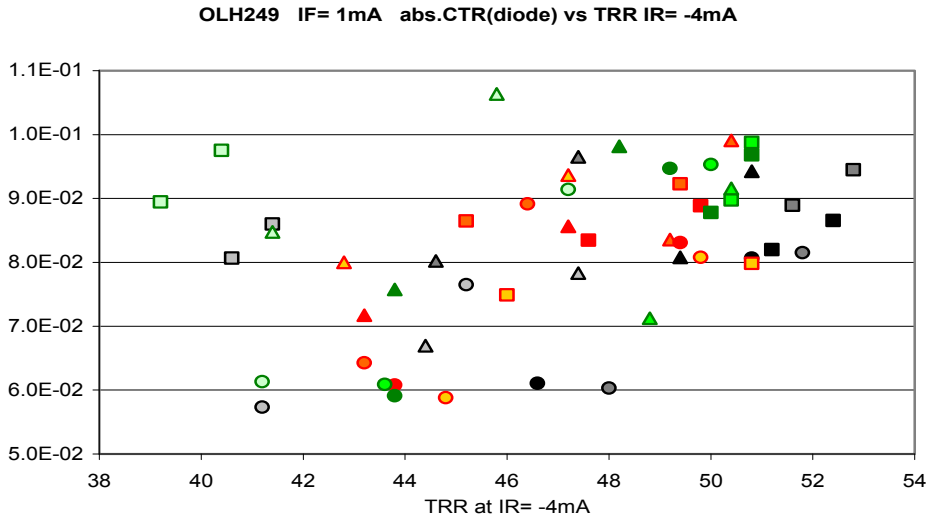
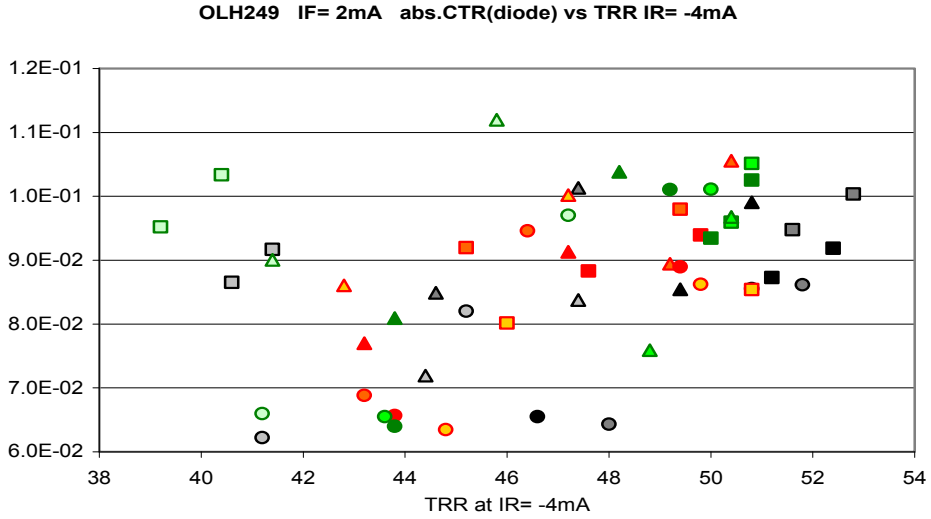
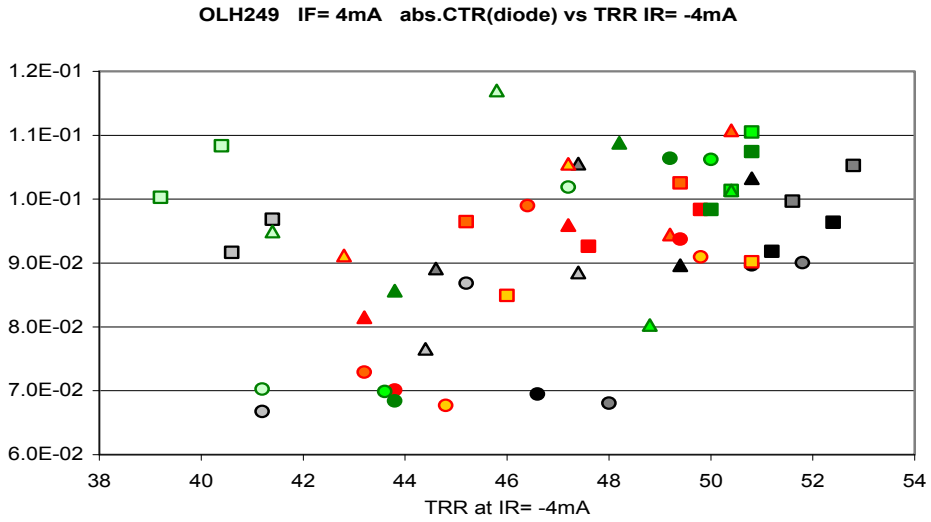
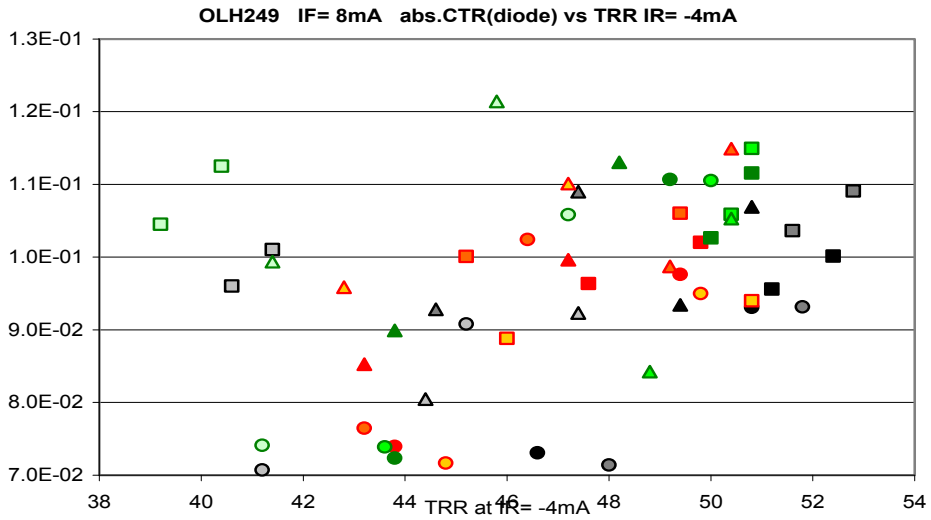

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -2mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
70
72
74
76
78
80
82
84
86
TRR at IR= -2mA

Fig. 13-96: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -4mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
38
40
42
44
46
48
50
52
54
TRR at IR= -4mA

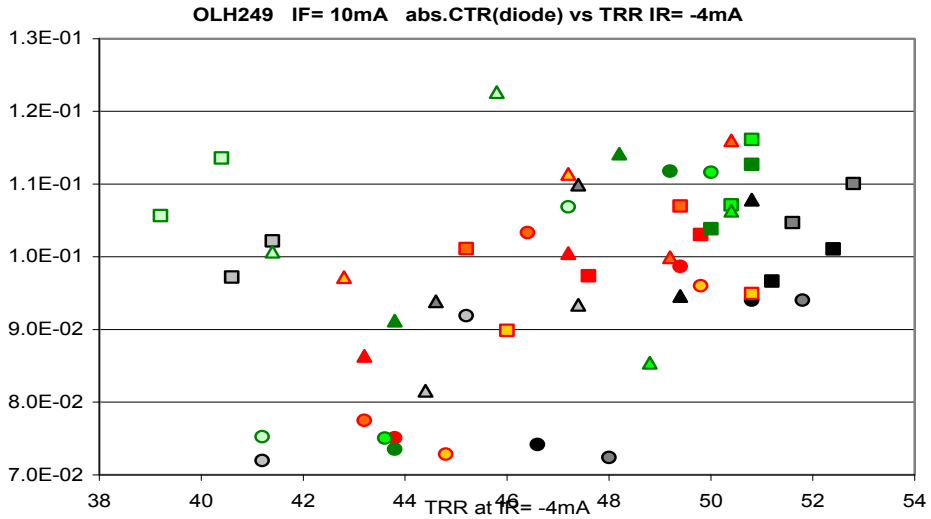
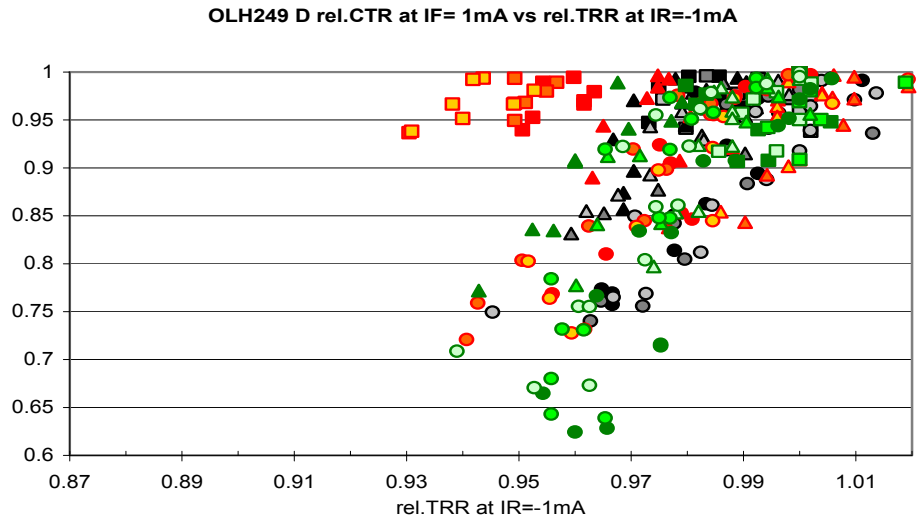
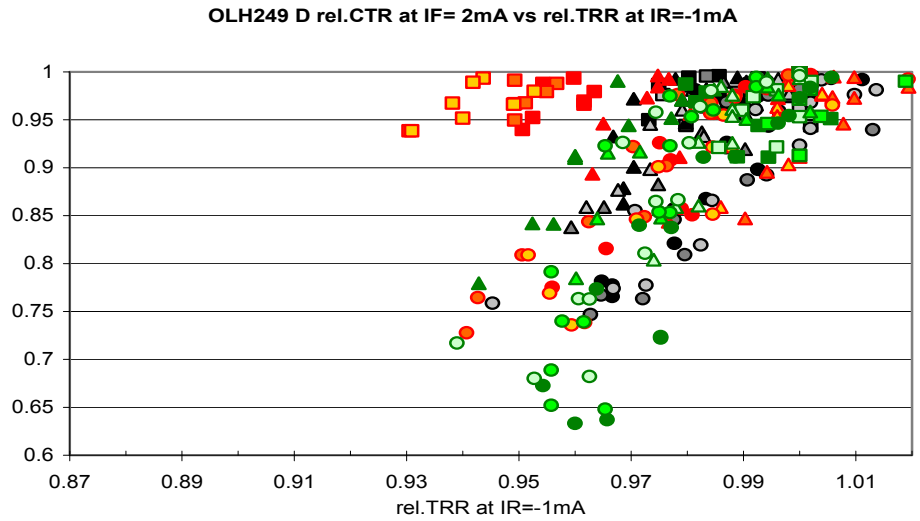
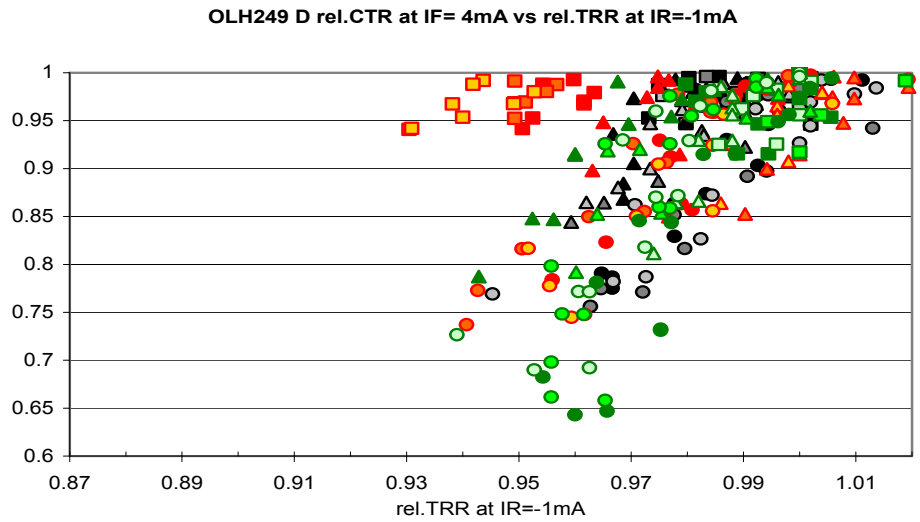

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -4mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
38
40
42
44
46
48
50
52
54
TRR at IR= -4mA

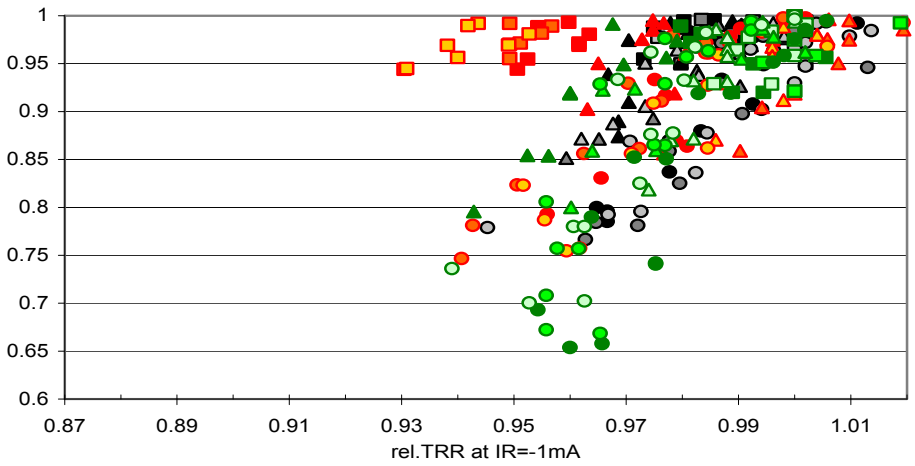
Fig. 13-97: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-1mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-1mA

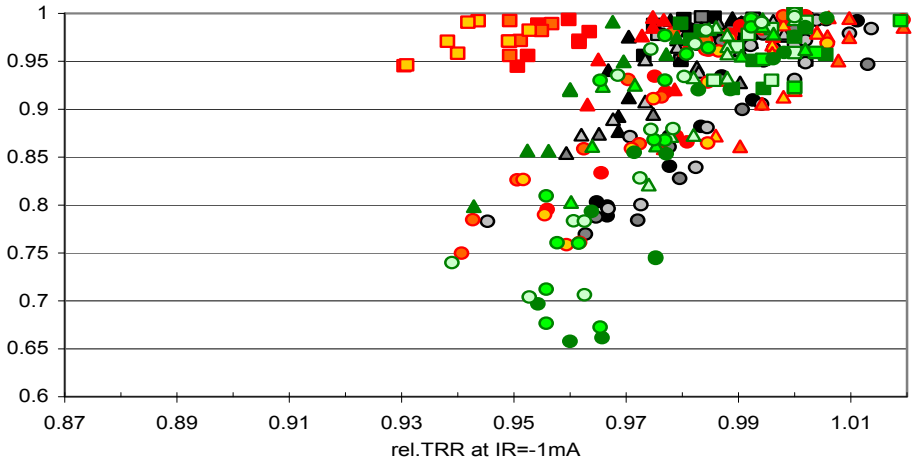
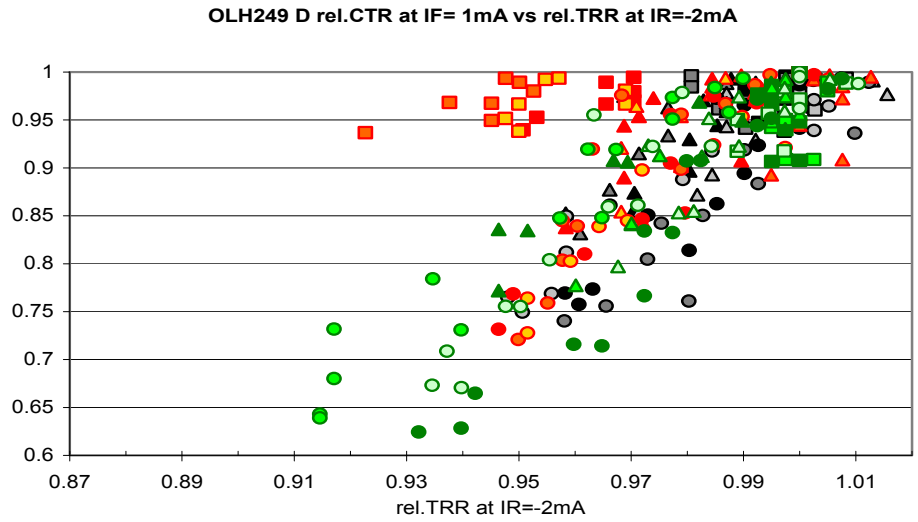
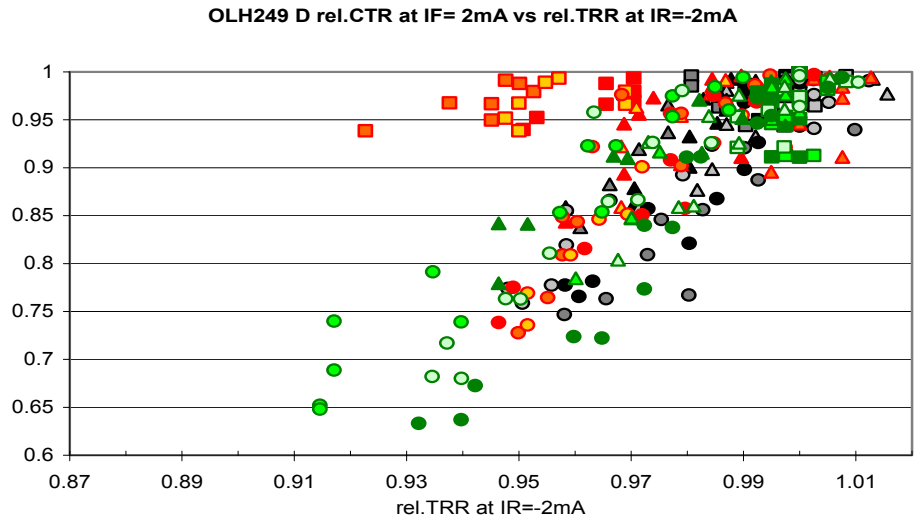
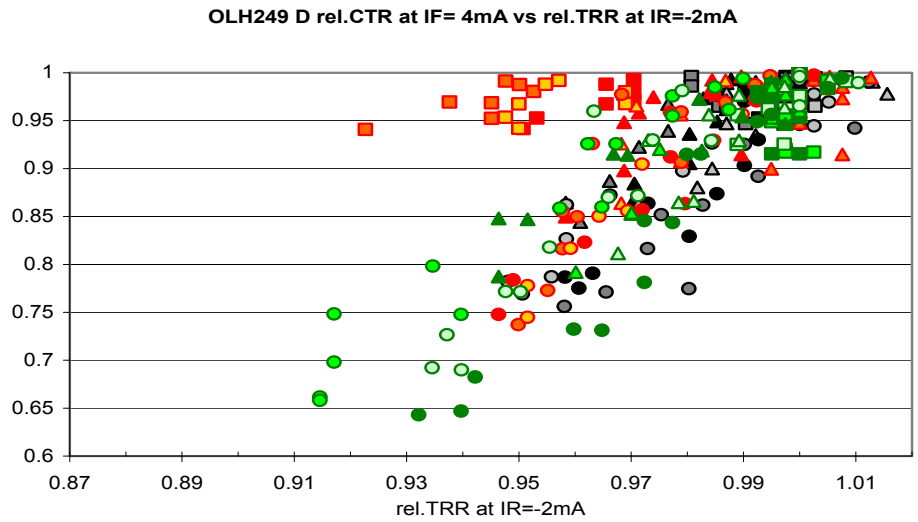


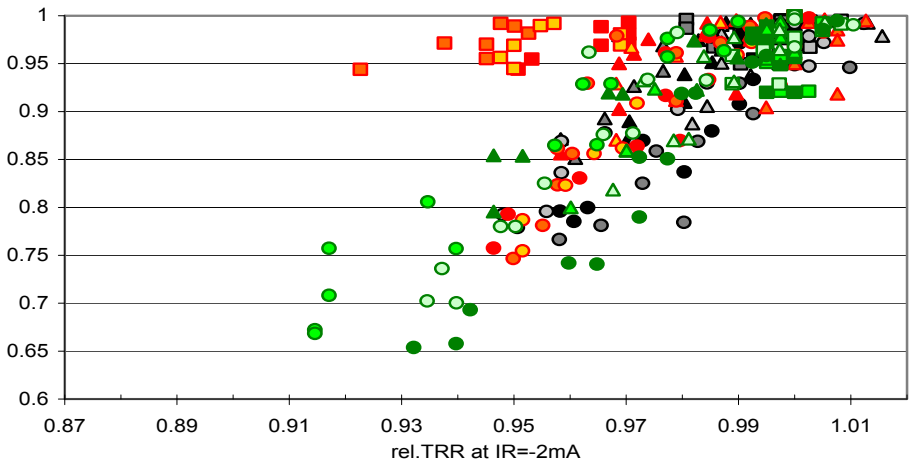
Fig. 13-98: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-2mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-2mA

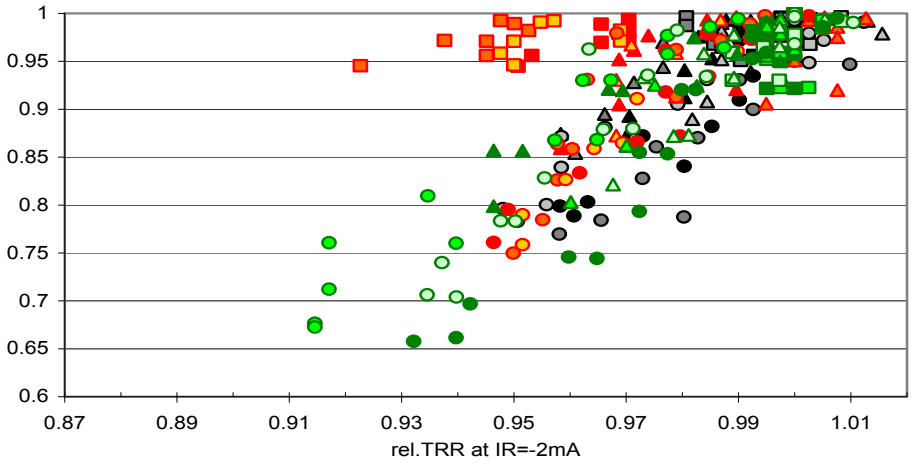
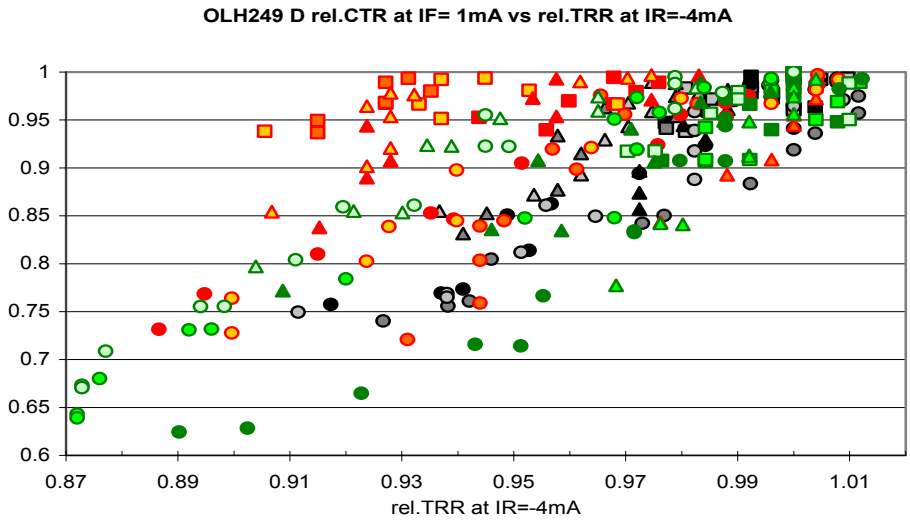
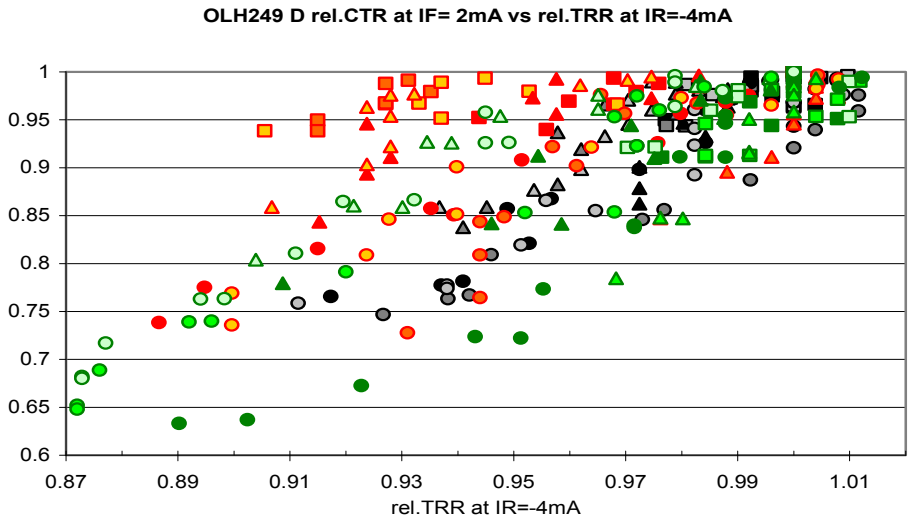
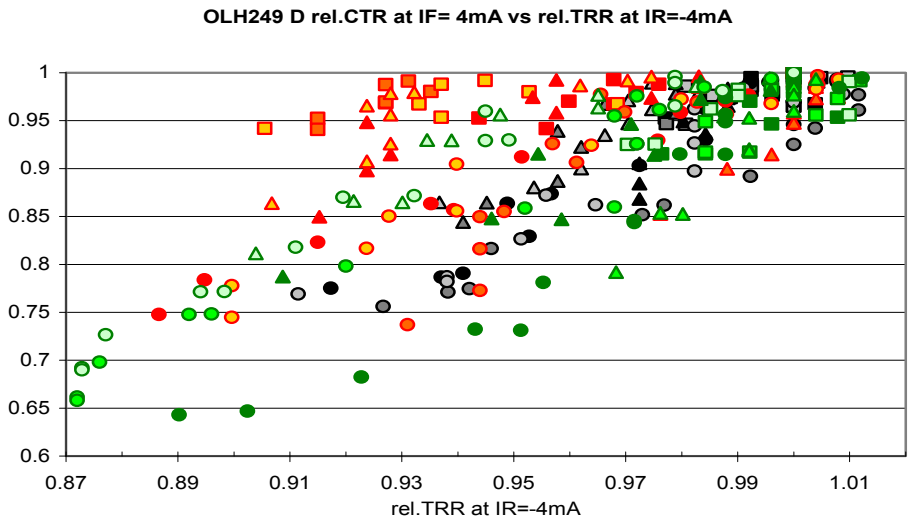


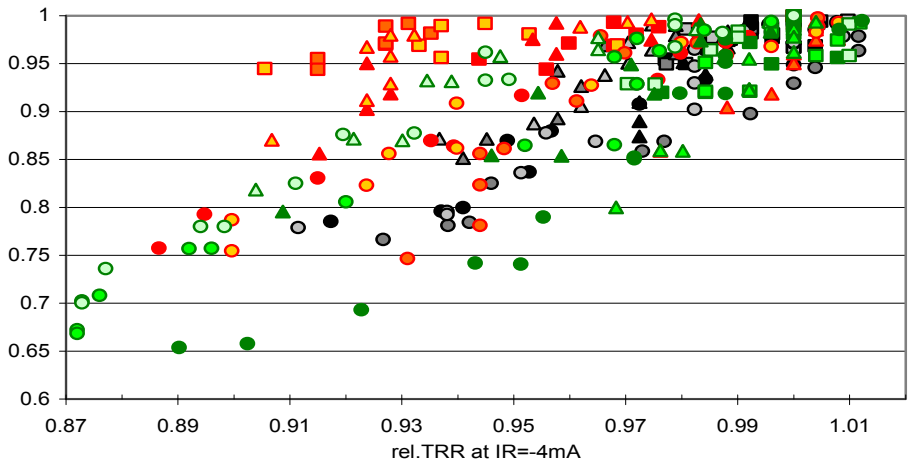
Fig. 13-99: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-4mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-4mA

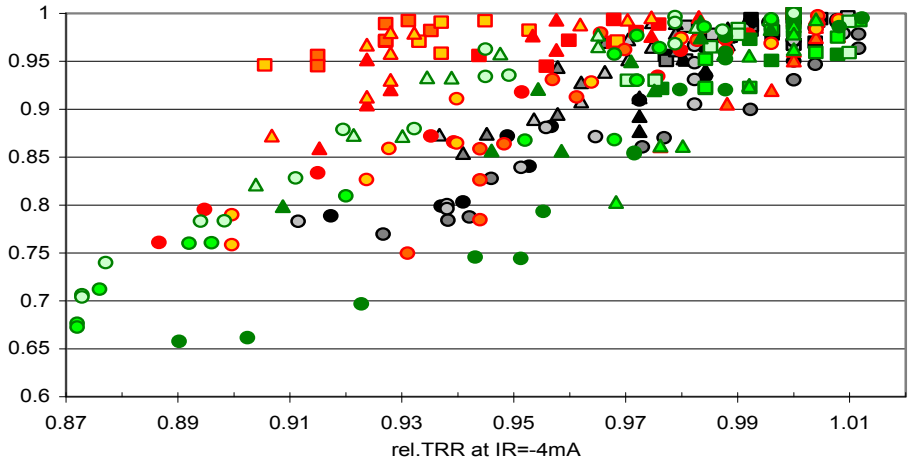
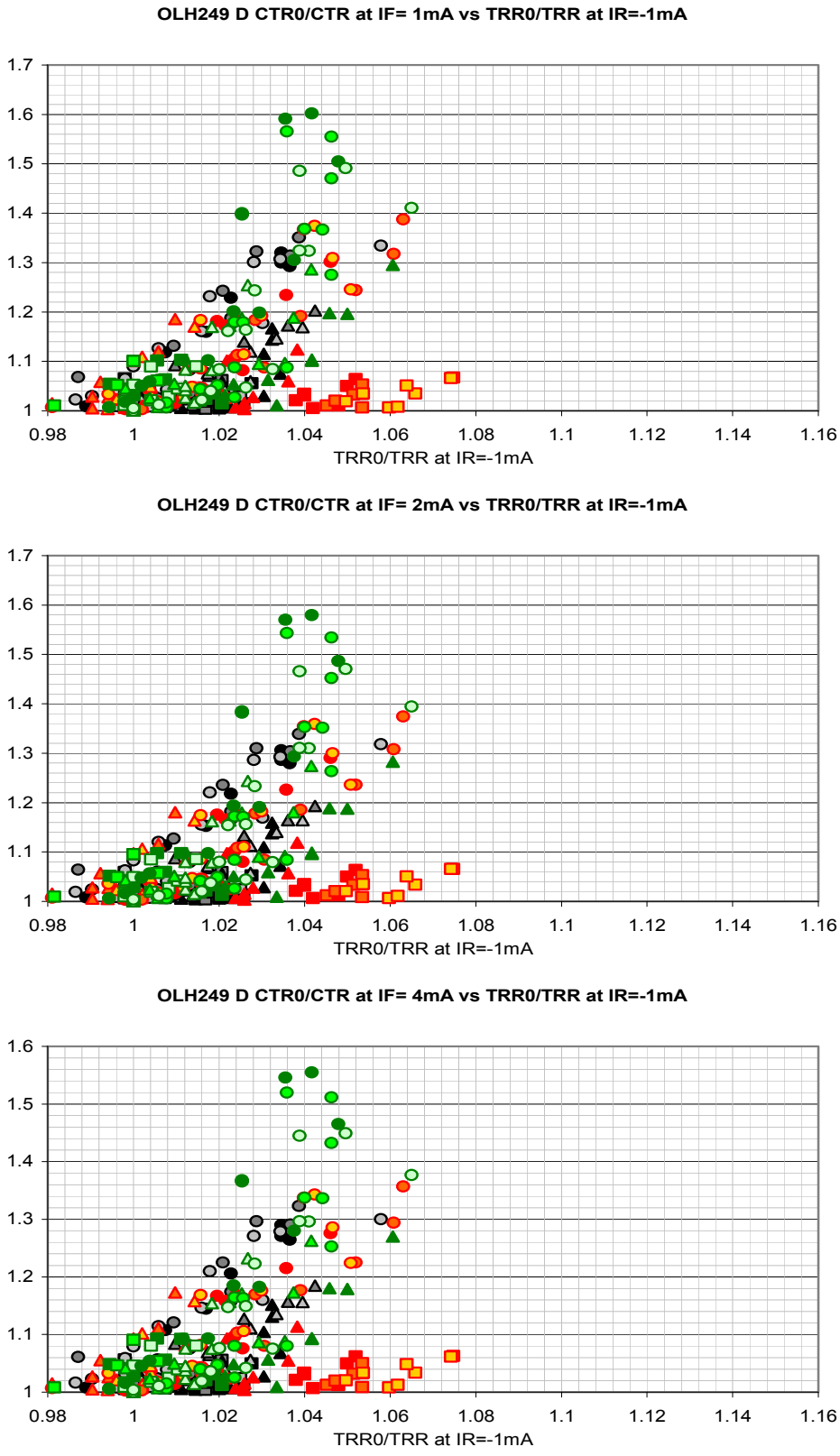
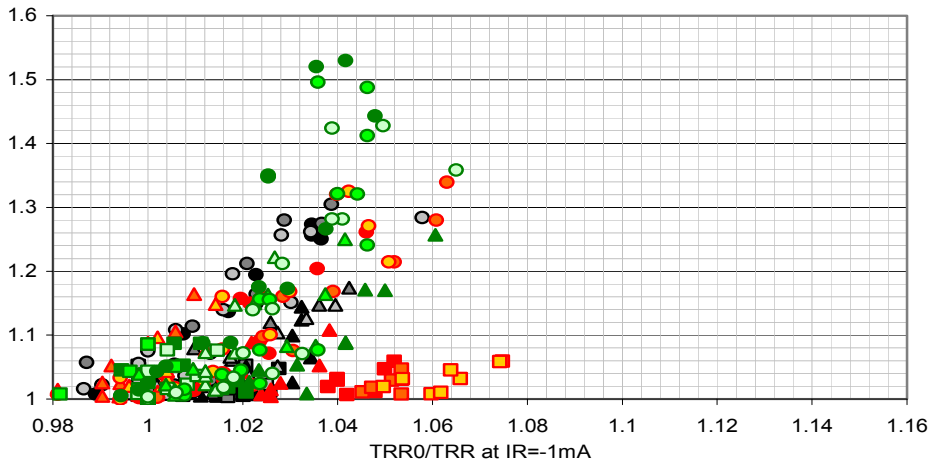


Fig. 13-100: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-1mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-1mA

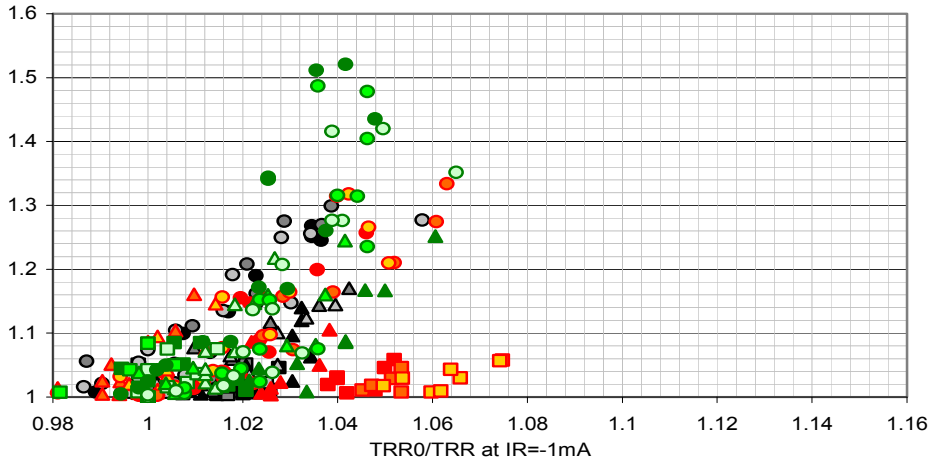
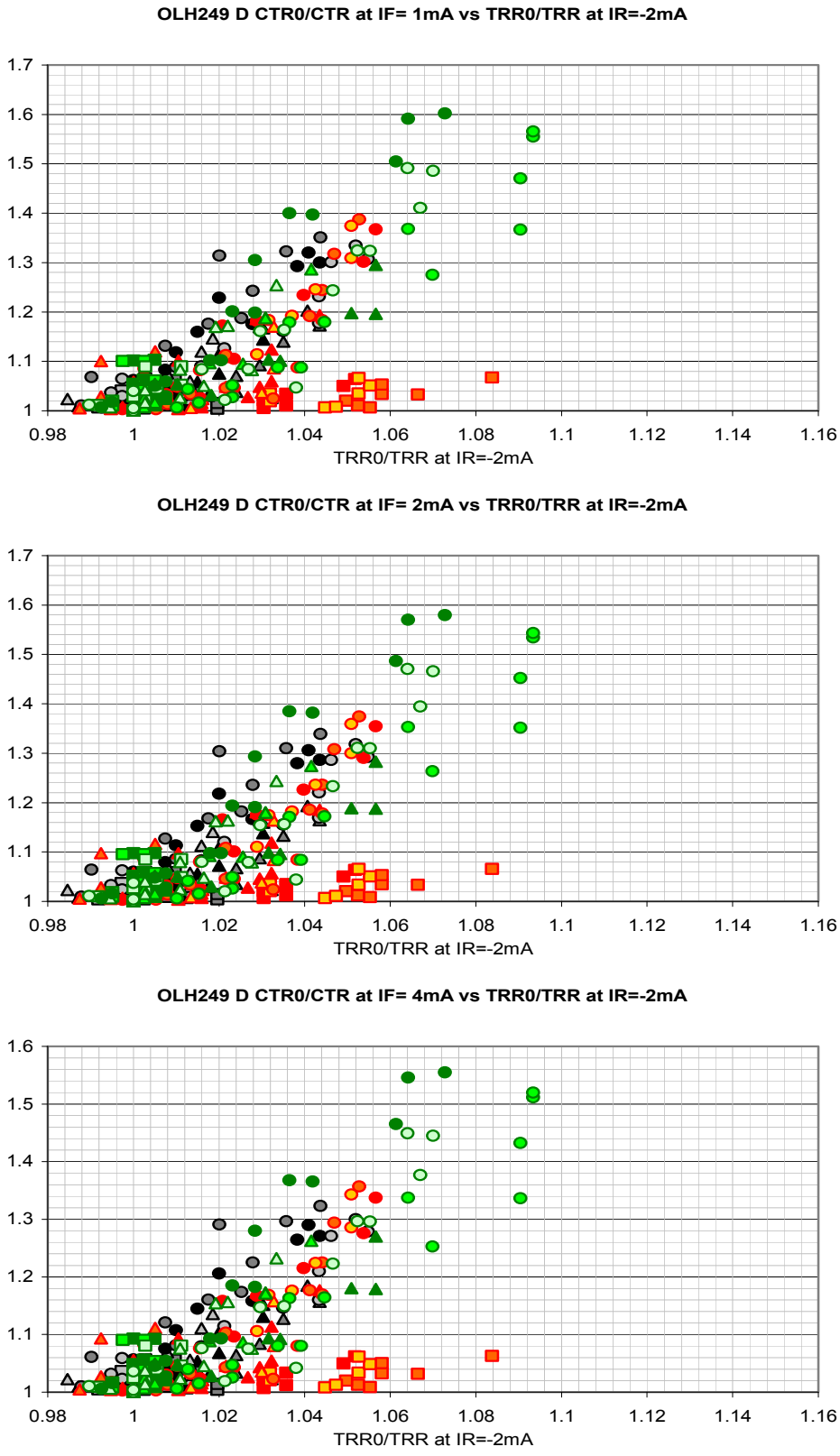
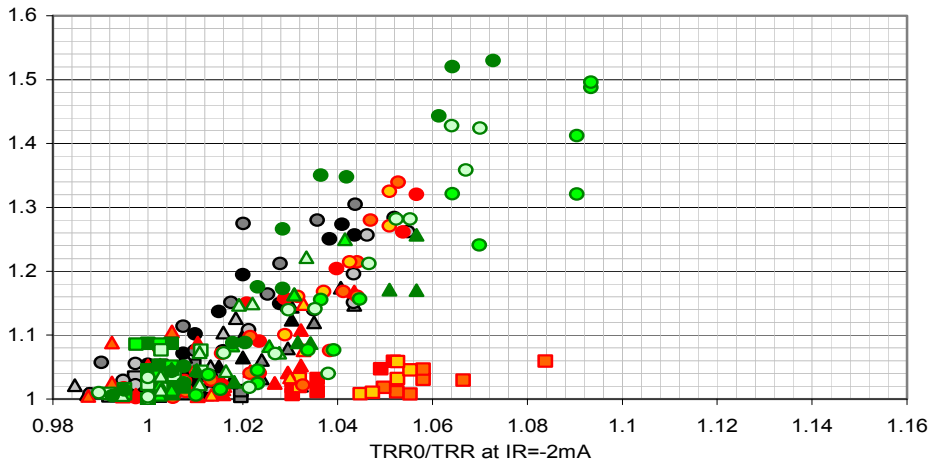


Fig. 13-101: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-2mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-2mA

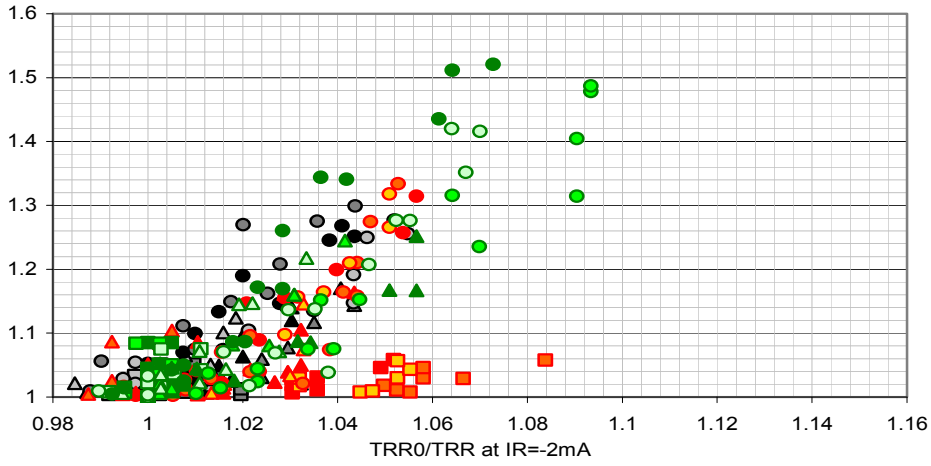
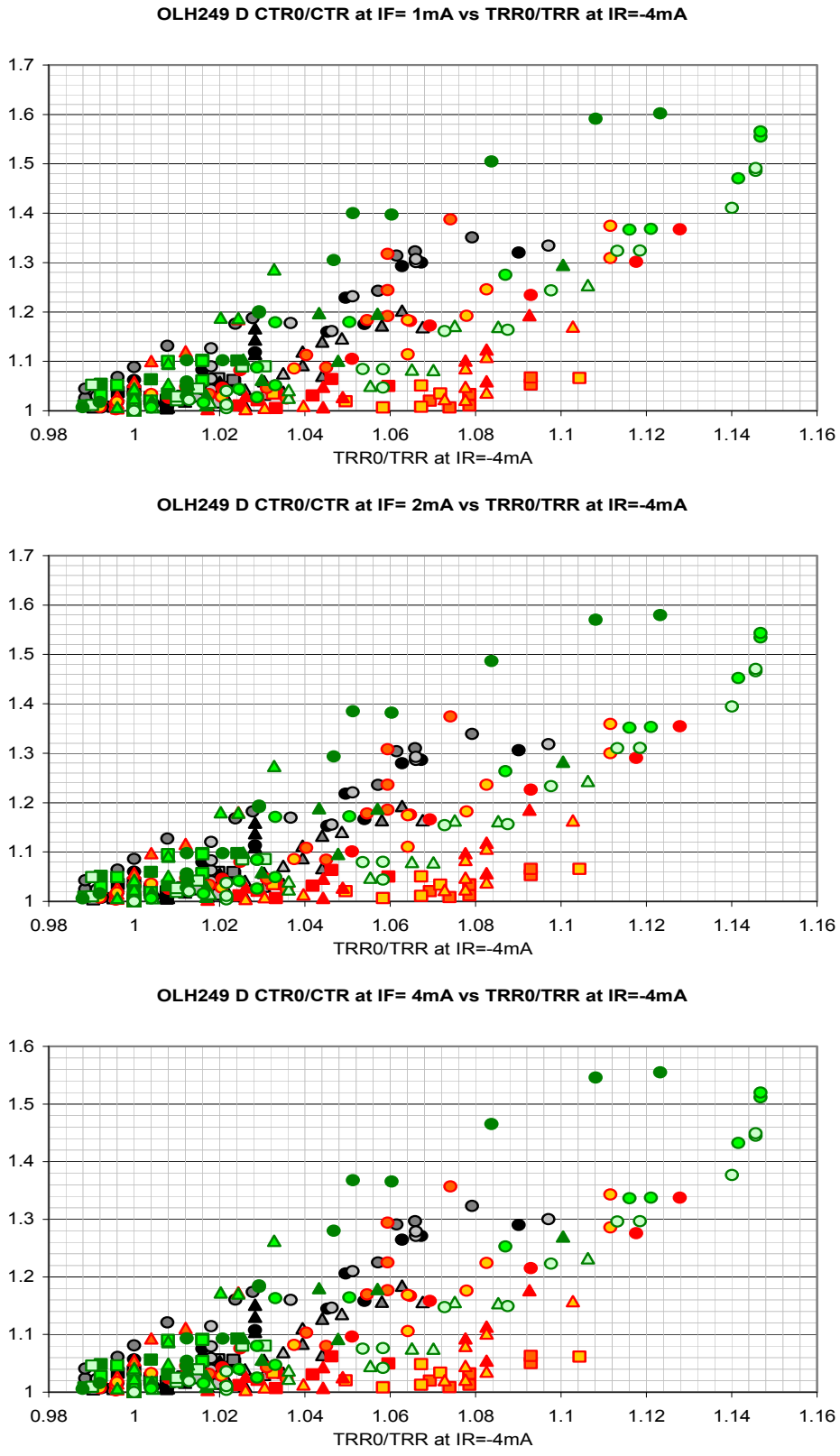
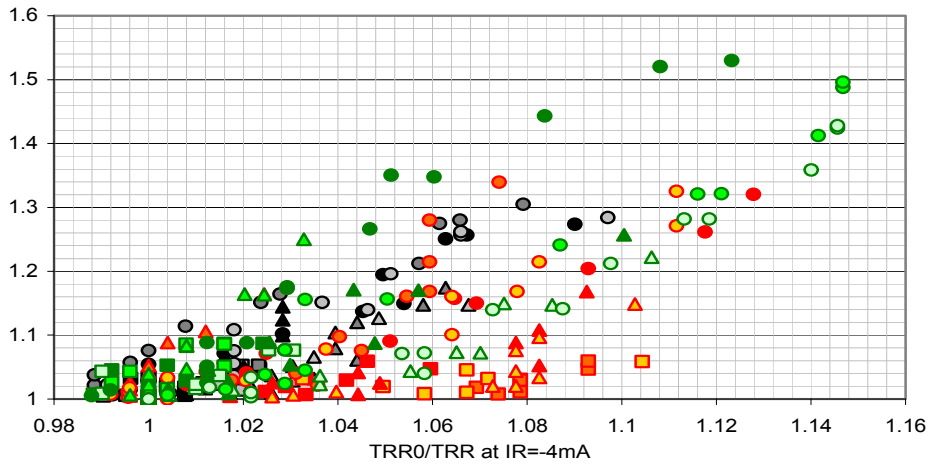


Fig. 13-102: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-4mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-4mA

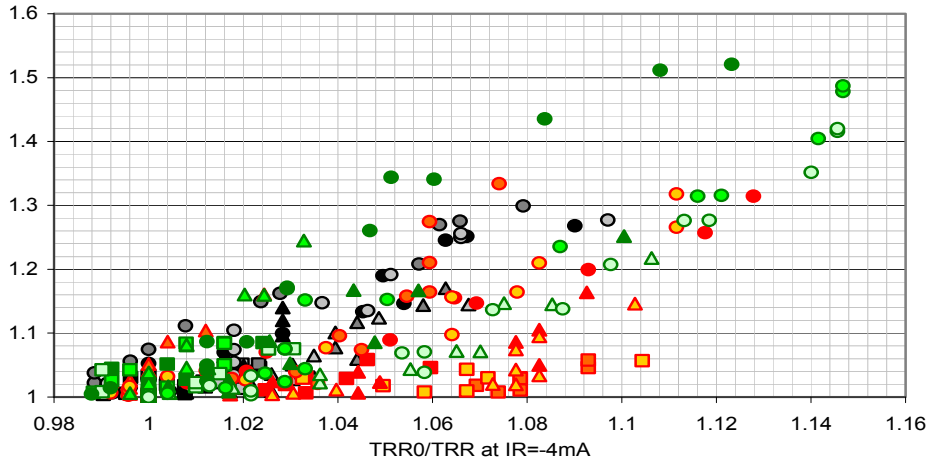
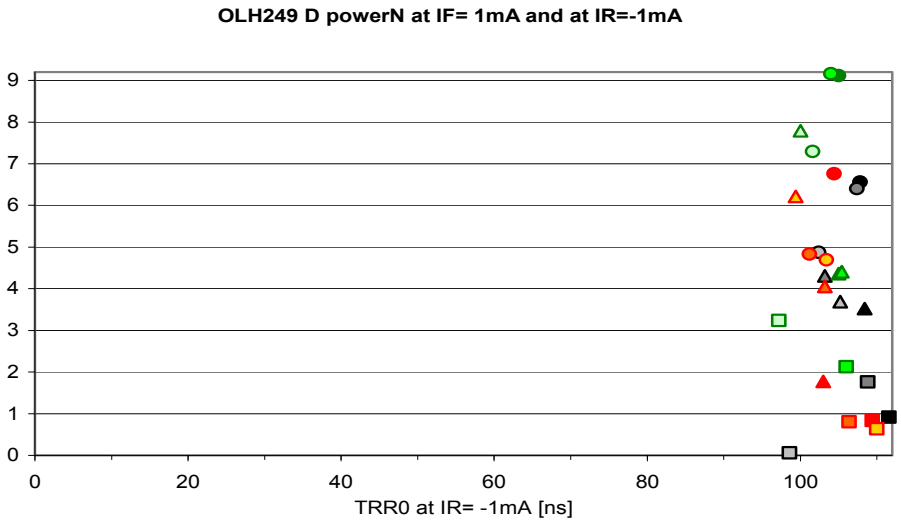
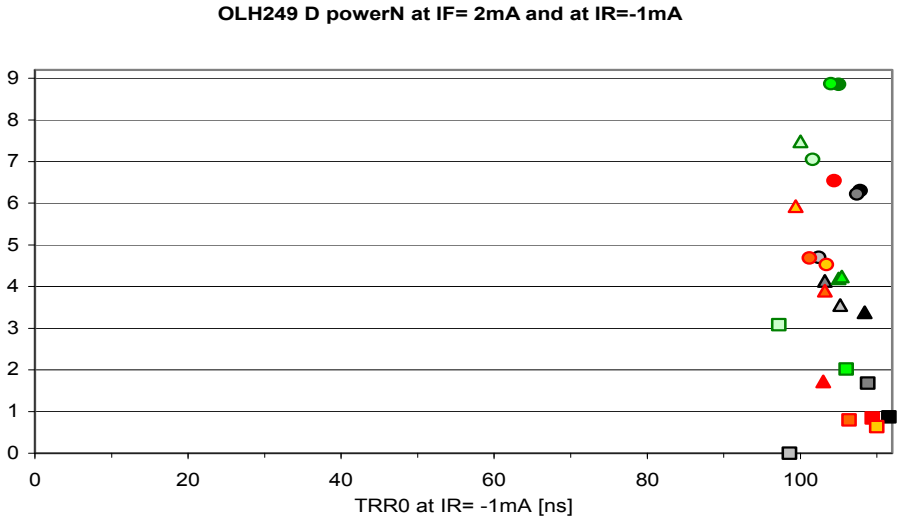
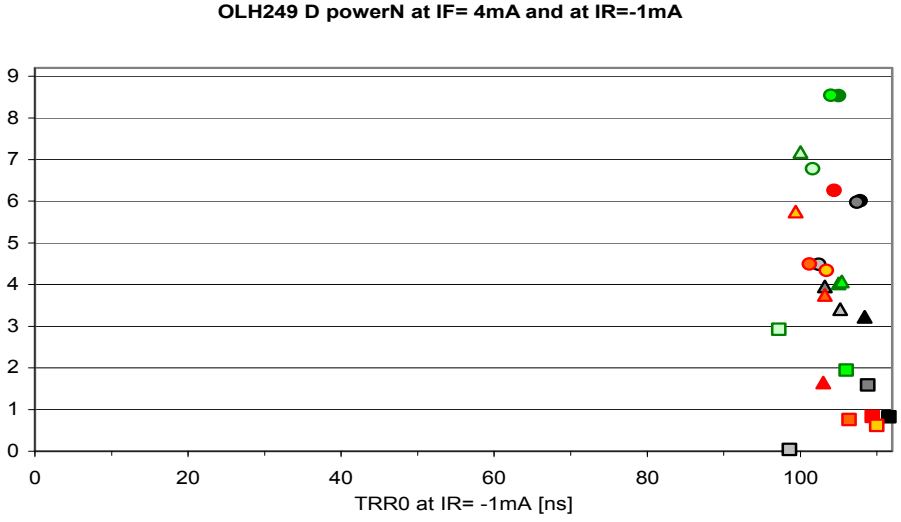


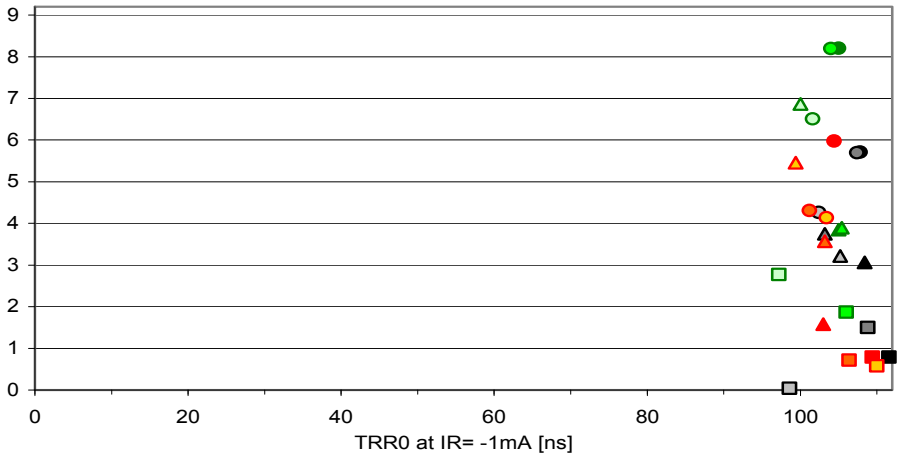
Fig. 13-103: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA







OLH249 D powerN at IF= 8mA and at IR=-1mA



OLH249 D powerN at IF= 10mA and at IR=-1mA

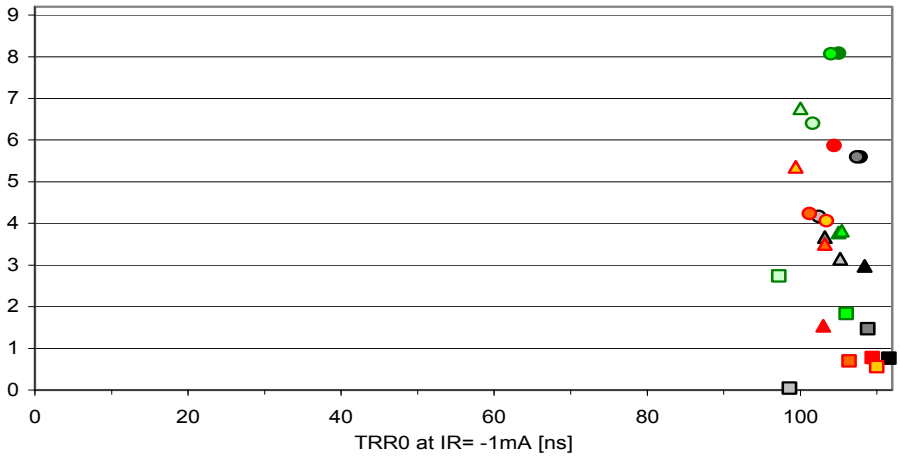
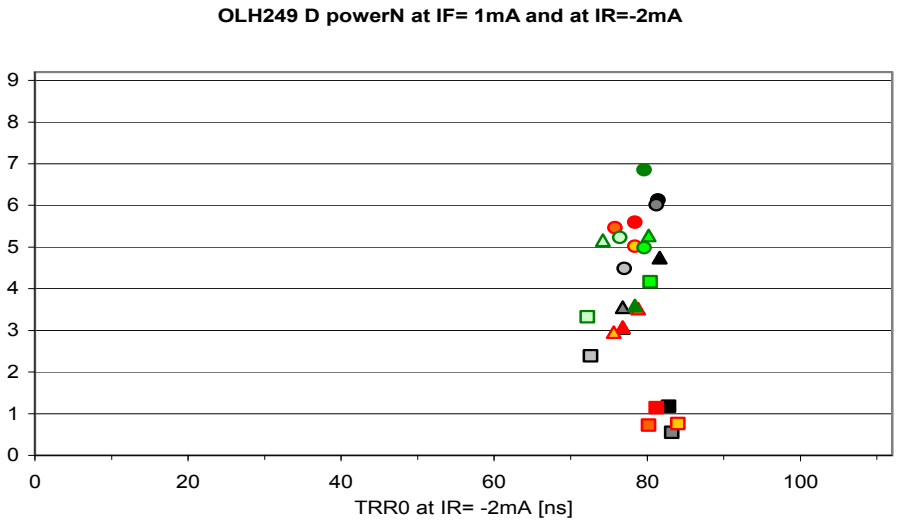
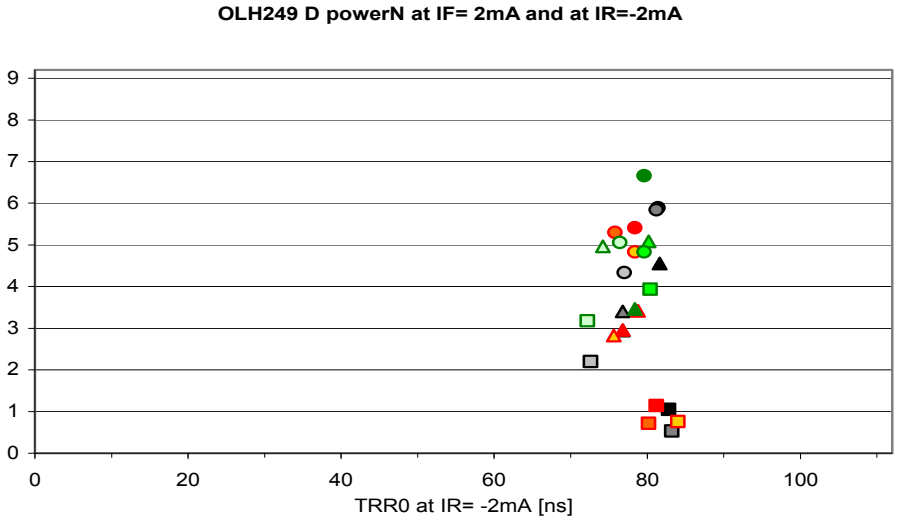
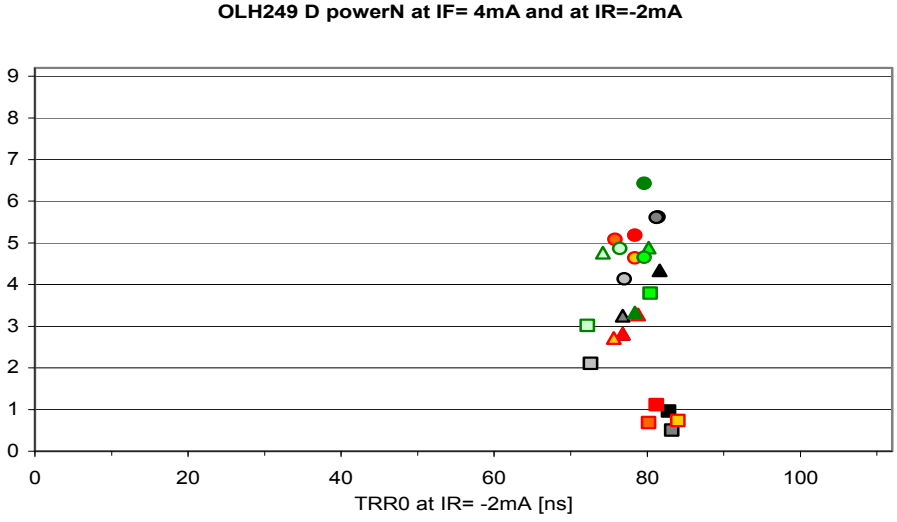


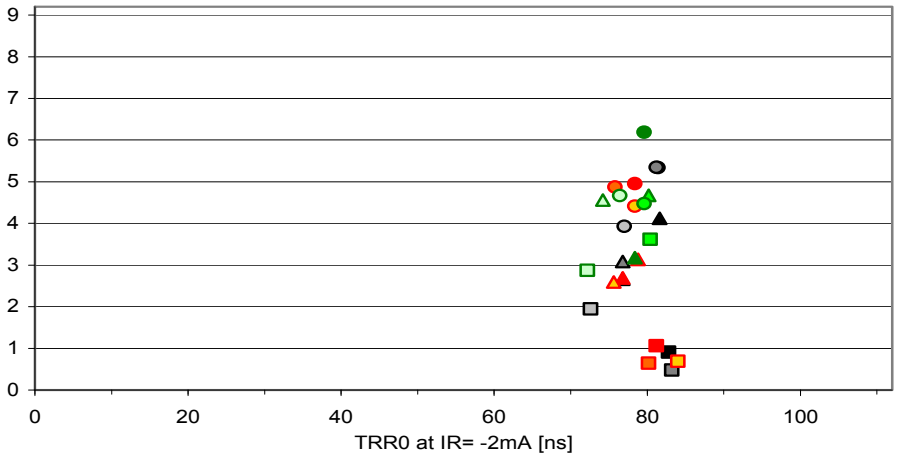
Fig. 13-104: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA







OLH249 D powerN at IF= 8mA and at IR=-2mA



OLH249 D powerN at IF= 10mA and at IR=-2mA

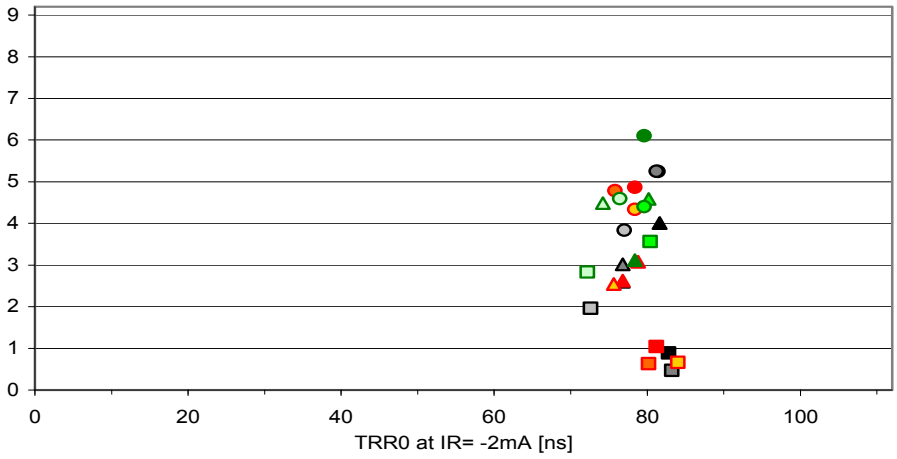
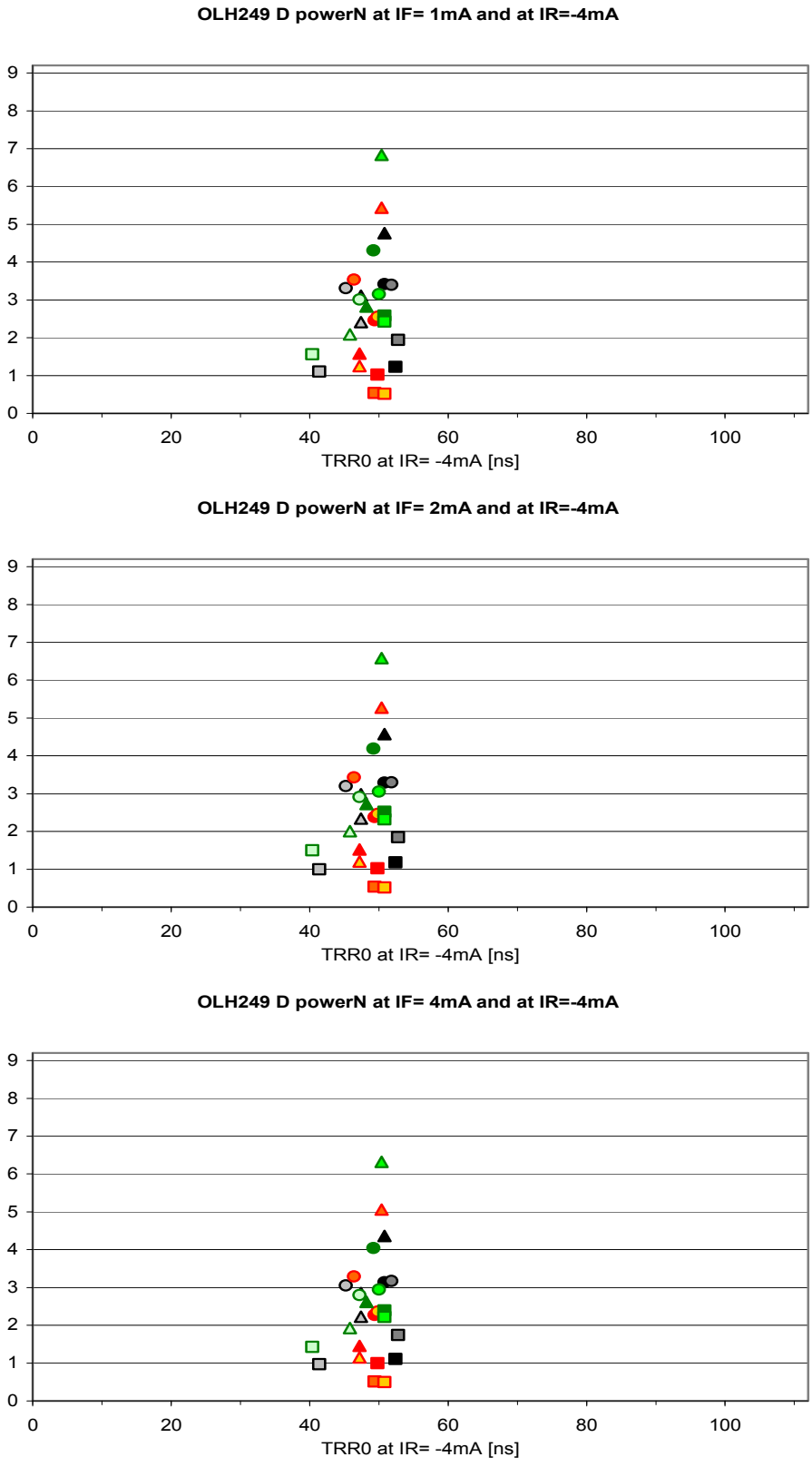
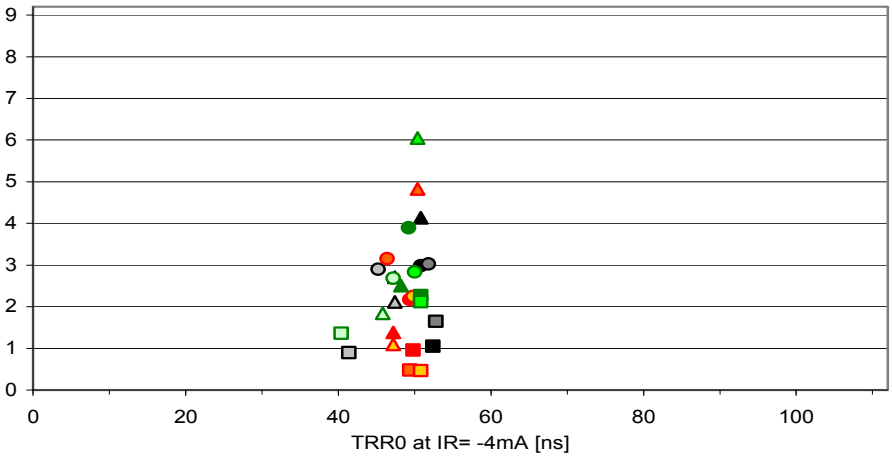


Fig. 13-105: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA



OLH249 D powerN at IF= 8mA and at IR=-4mA



OLH249 D powerN at IF= 10mA and at IR=-4mA

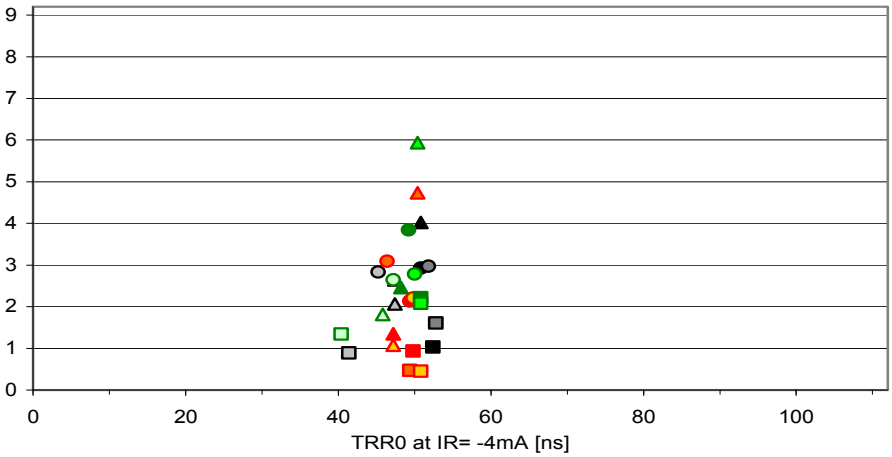
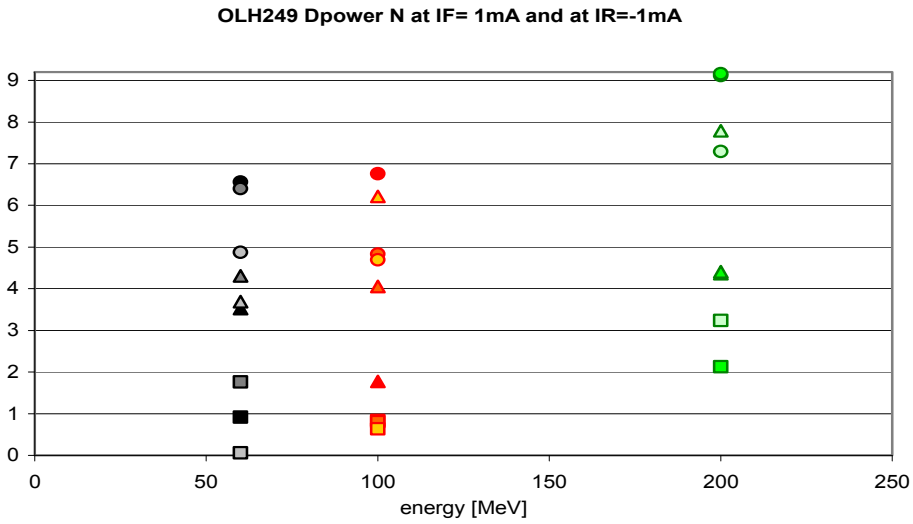
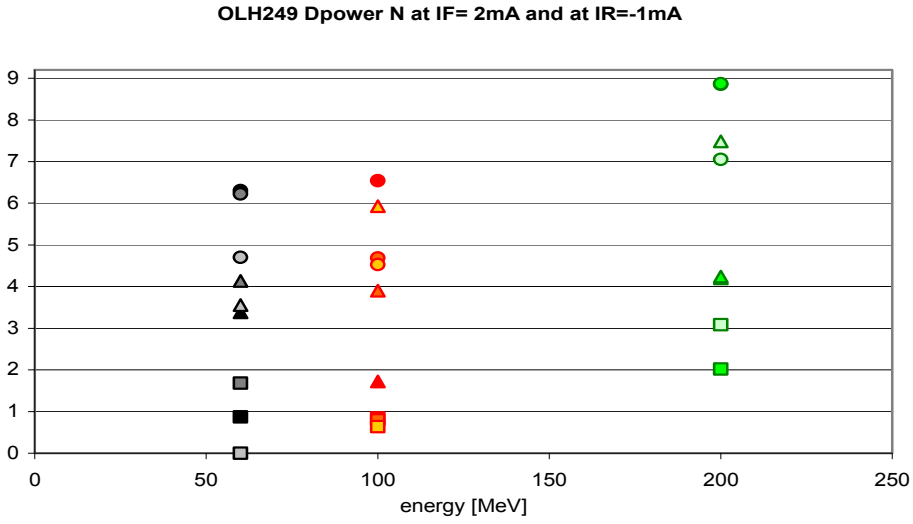
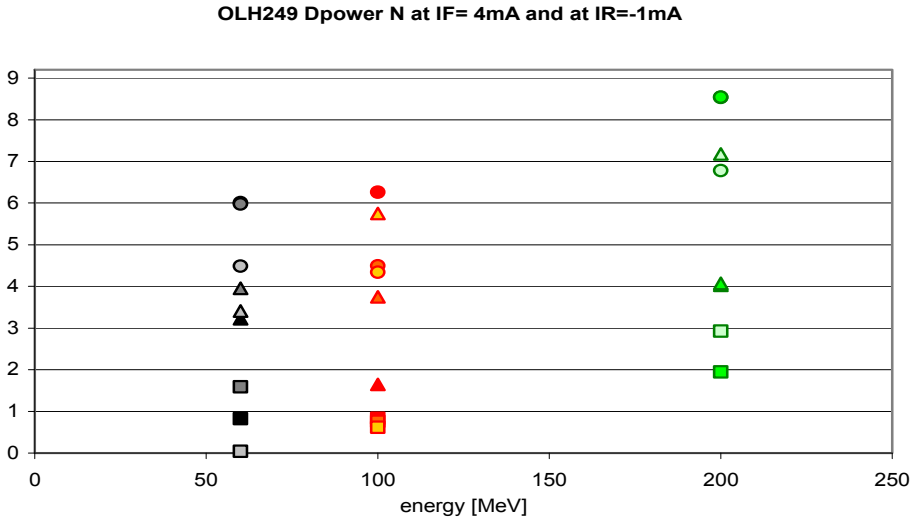
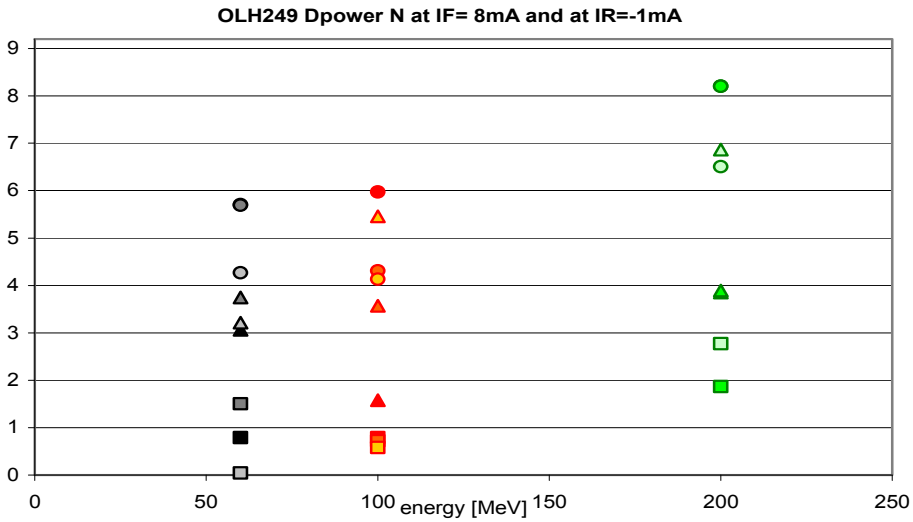


Fig. 13-106: OLH249 diode: N at I_R = -1 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy








OLH249 Dpower N at IF= 8mA and at IR=-1mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

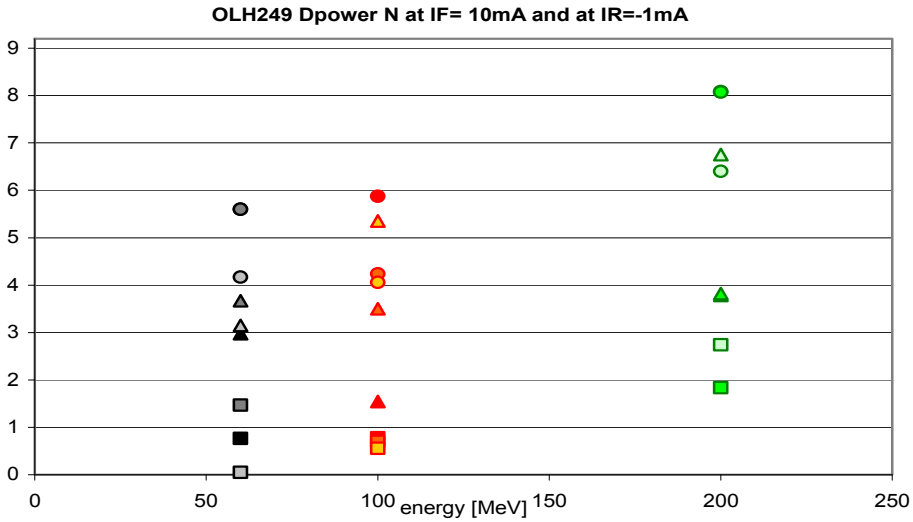
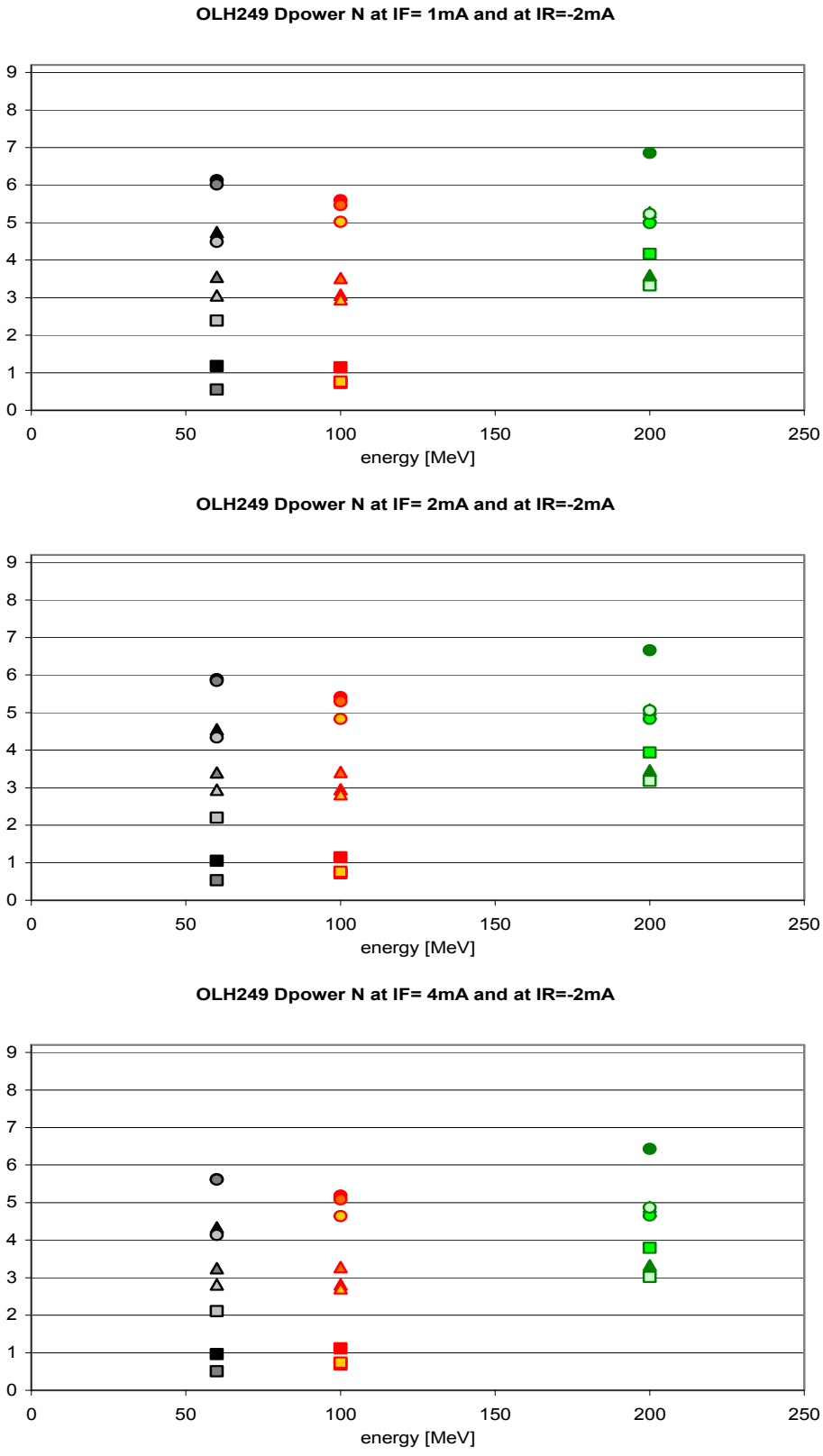
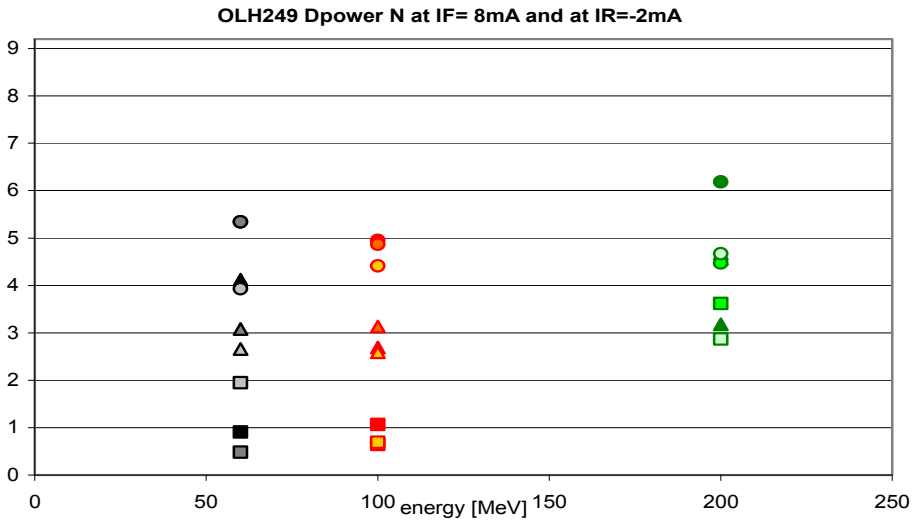

OLH249 Dpower N at IF= 10mA and at IR=-1mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

Fig. 13-107: OLH249 diode: N at I_R = -2 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy




OLH249 Dpower N at IF= 8mA and at IR=-2mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

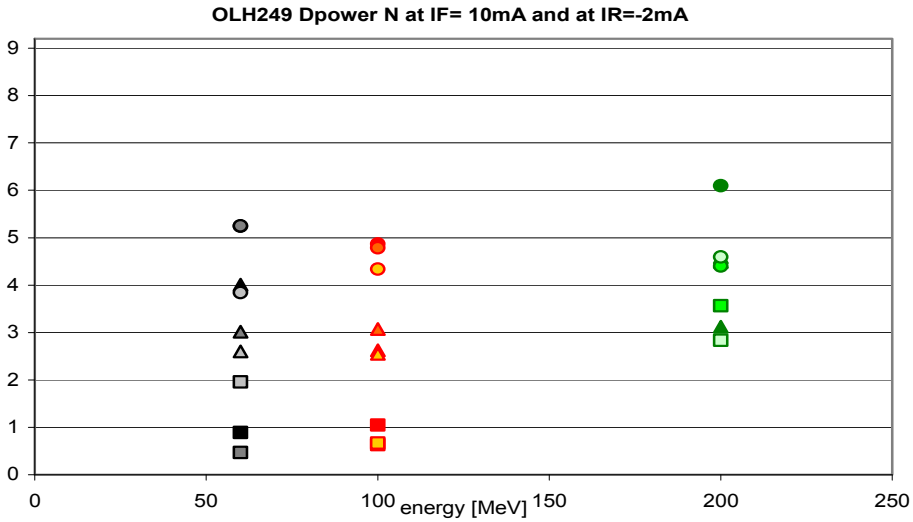
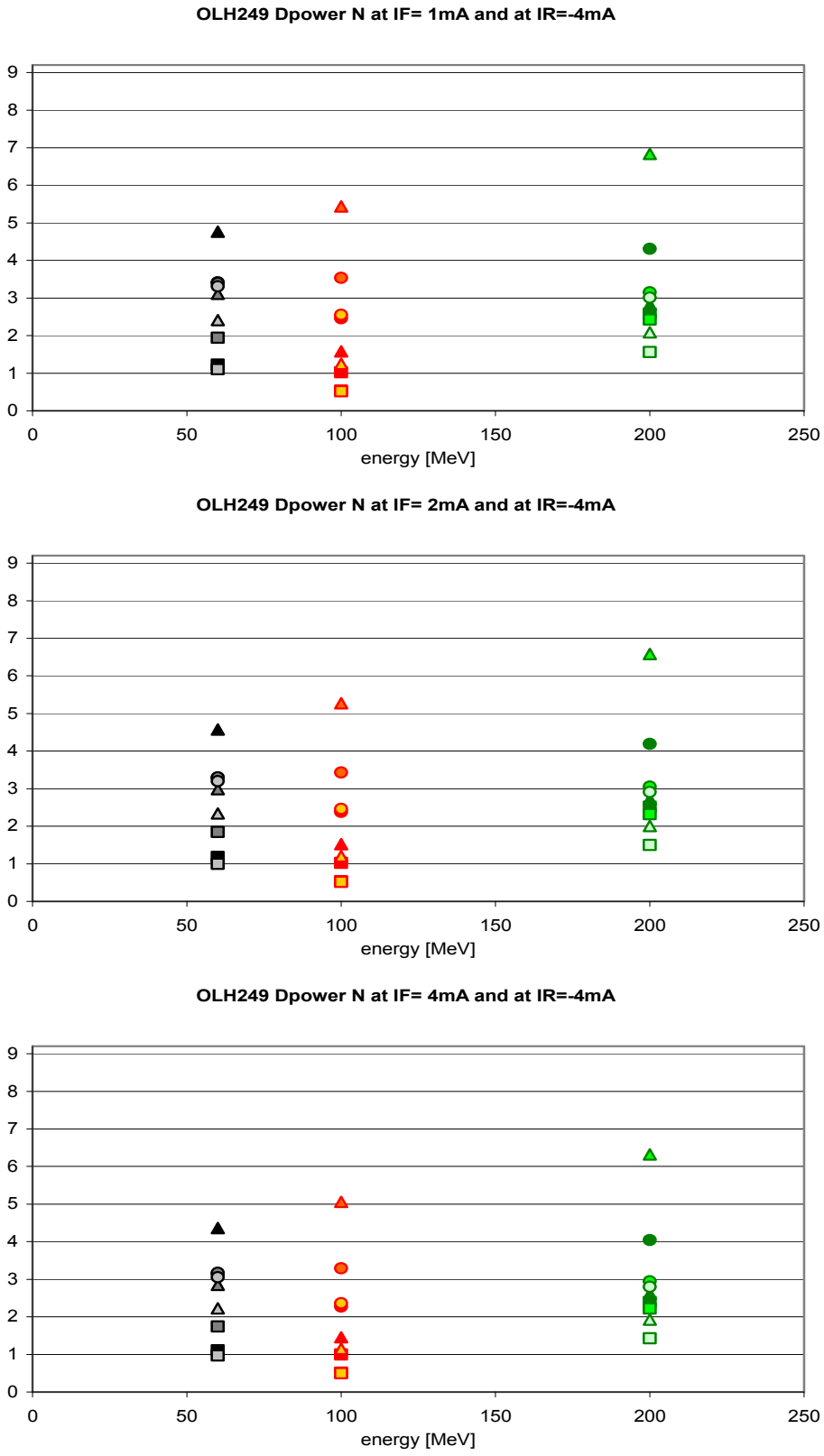
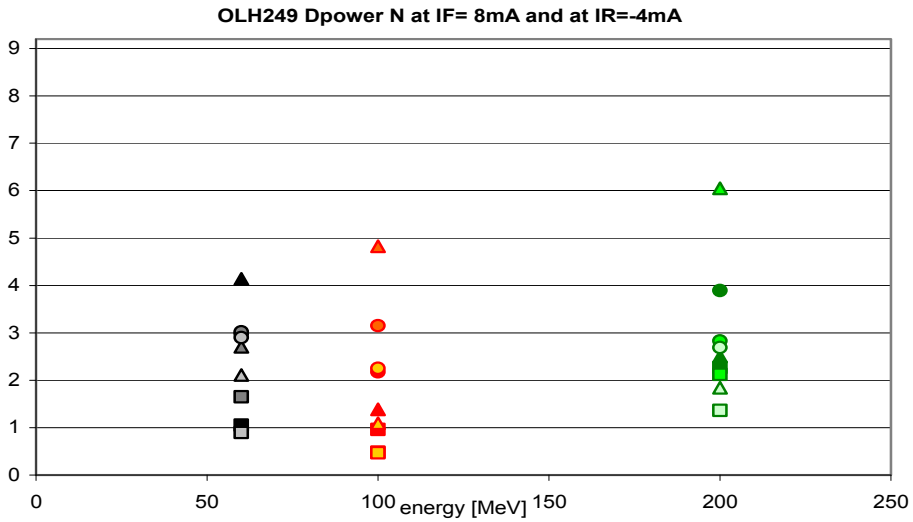
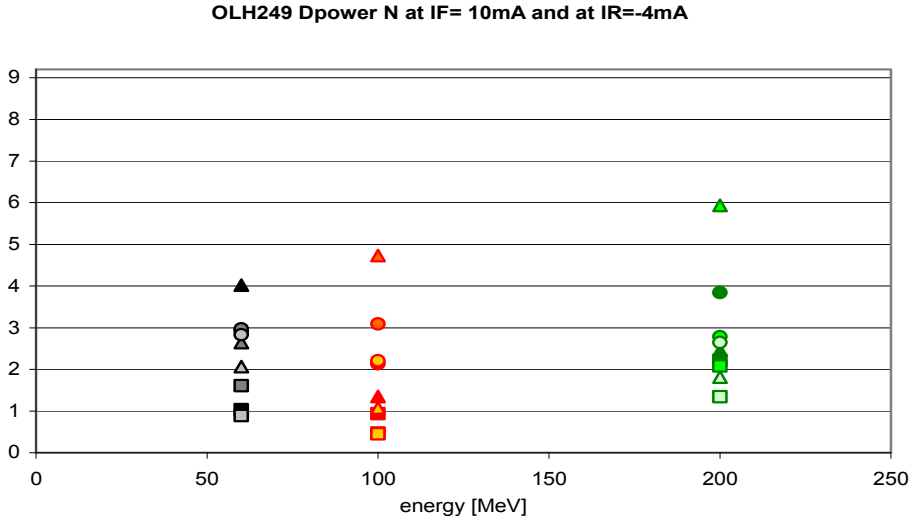

OLH249 Dpower N at IF= 10mA and at IR=-2mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

Fig. 13-108: OLH249 diode: N at I_R = -4 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy

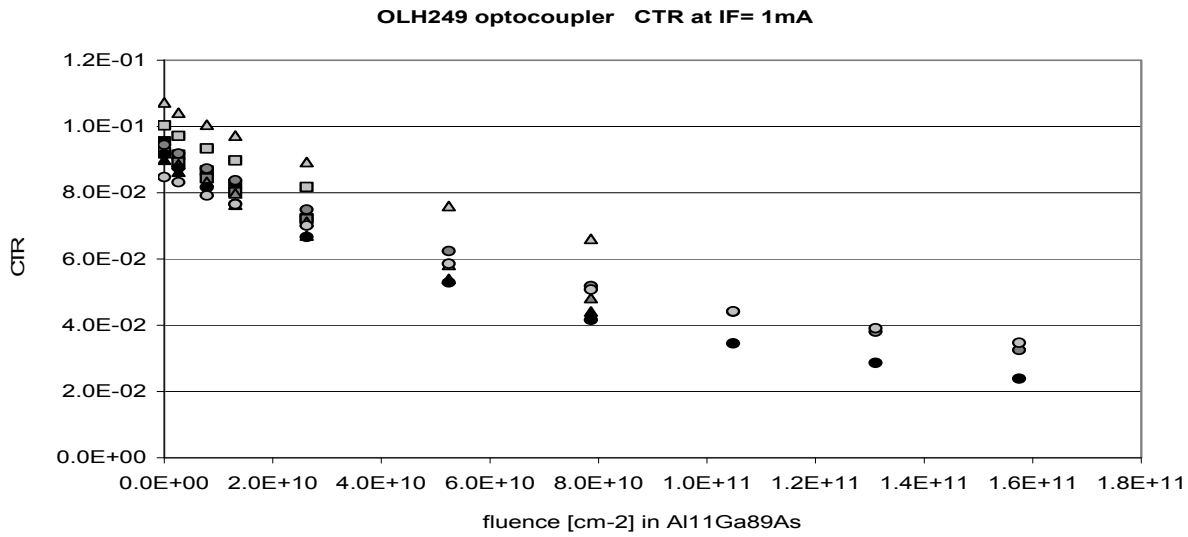


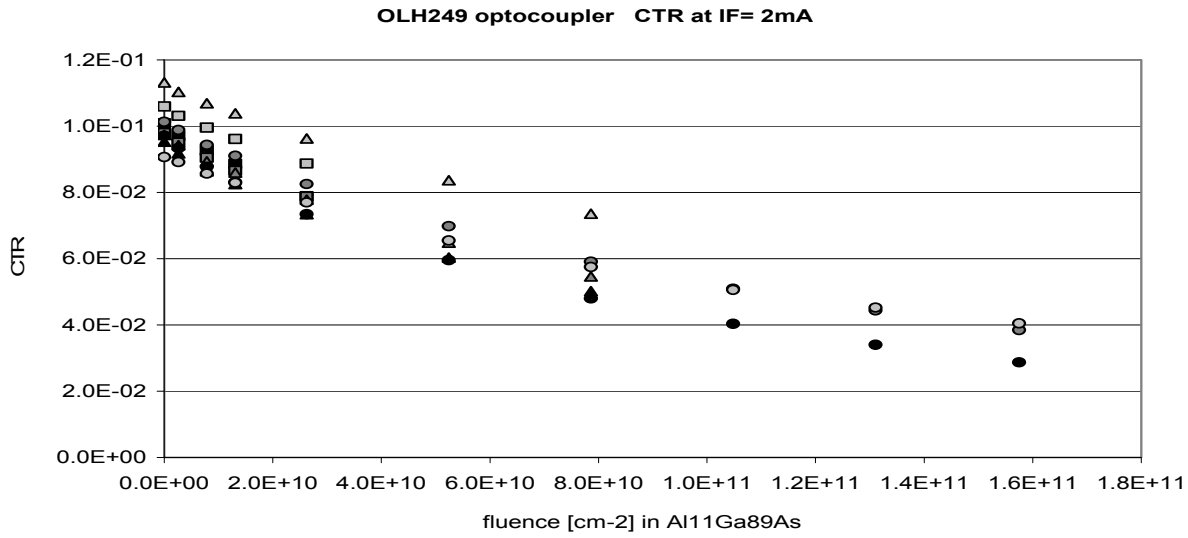

OLH249 Dpower N at IF= 8mA and at IR=-4mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

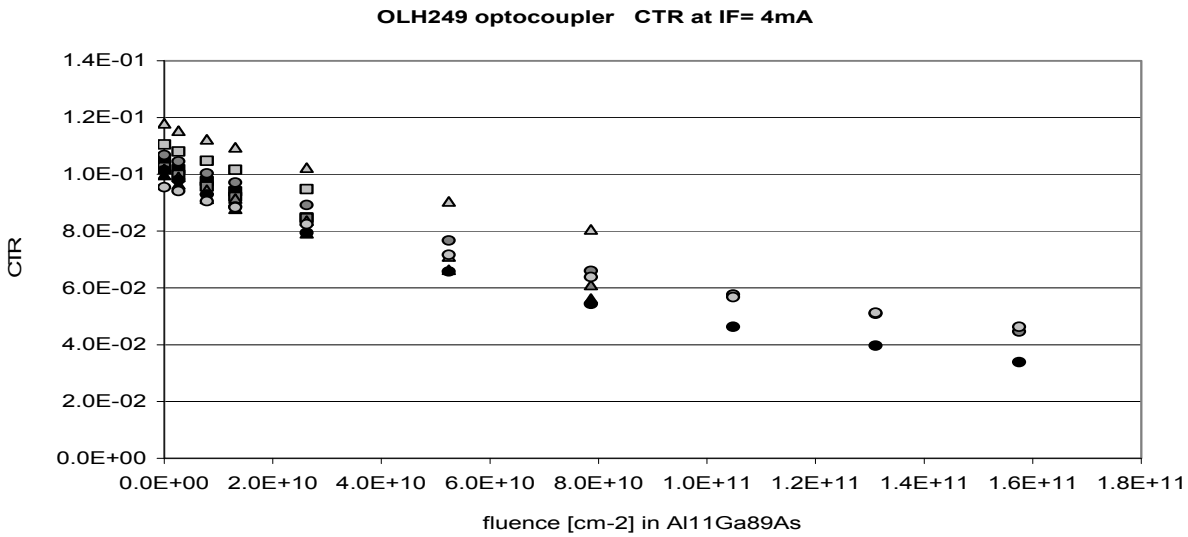

OLH249 Dpower N at IF= 10mA and at IR=-4mA
9
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
energy [MeV]

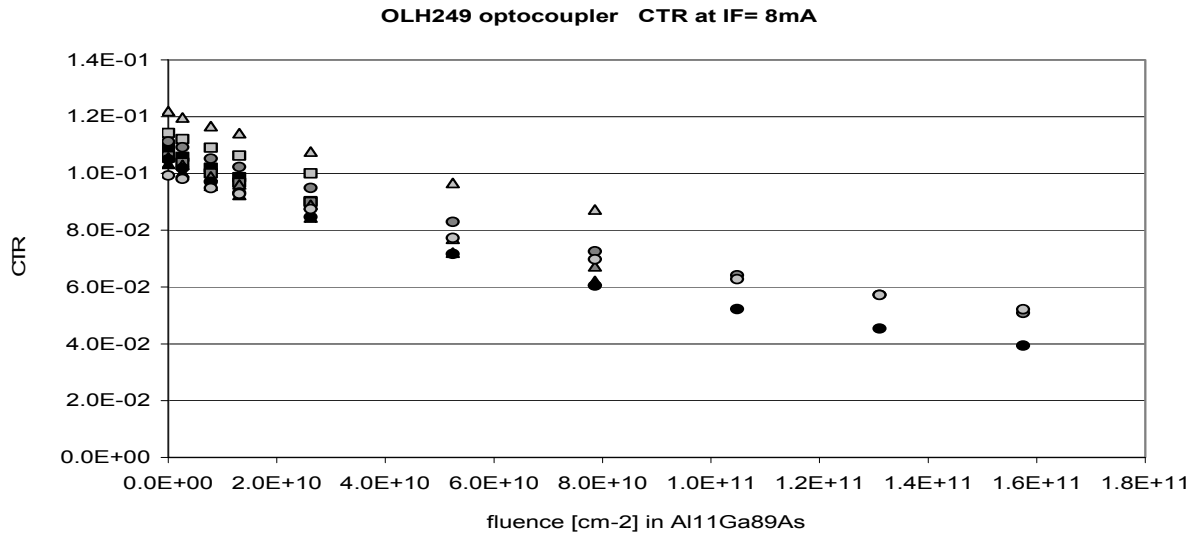
13.2 NEUTRON IRRADIATION

Fig. 13-109: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

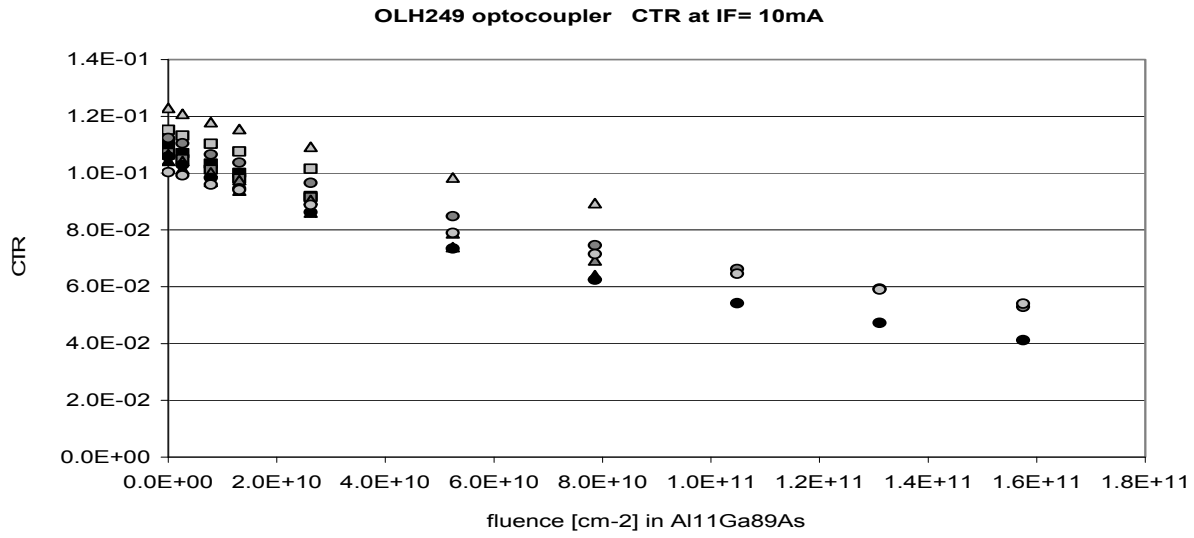
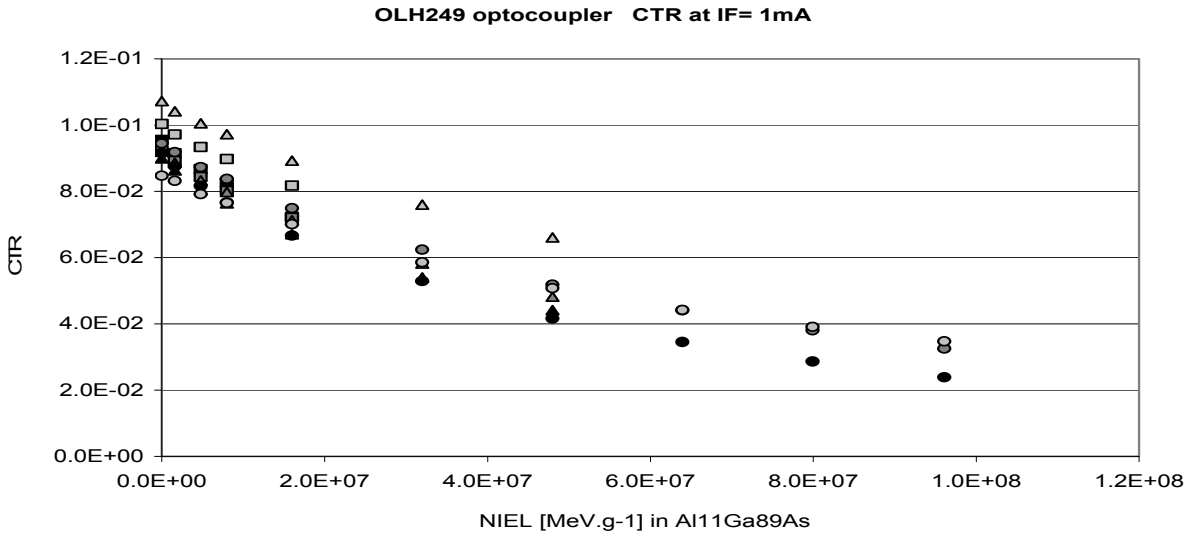
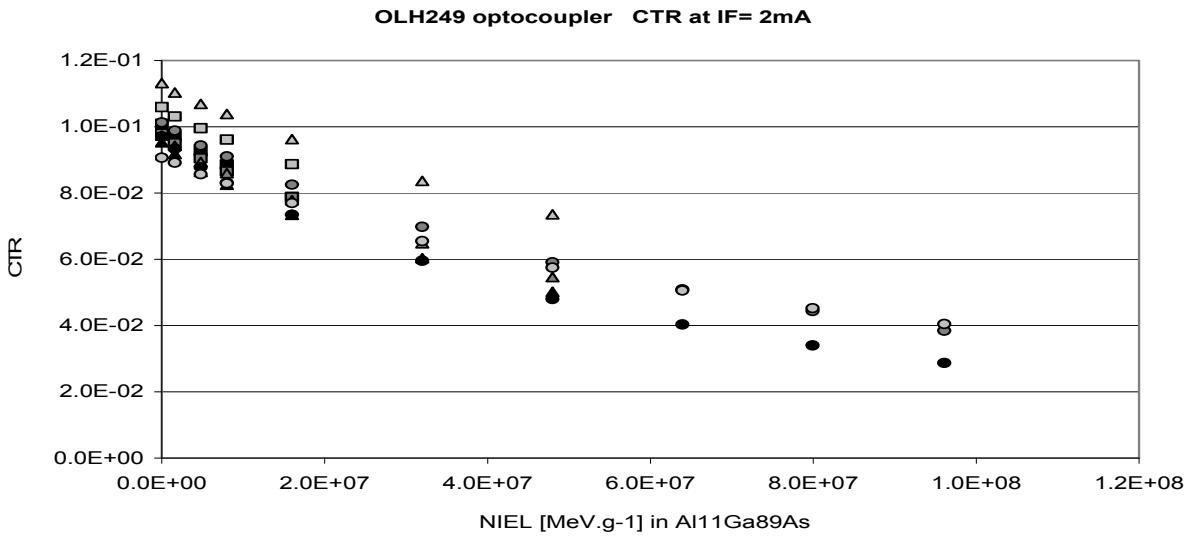
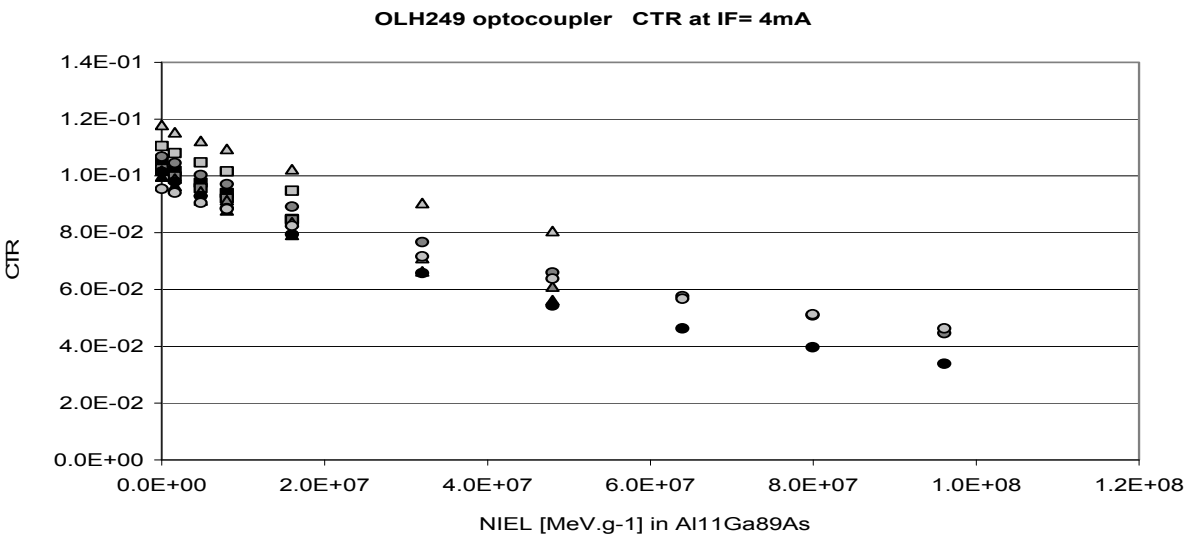
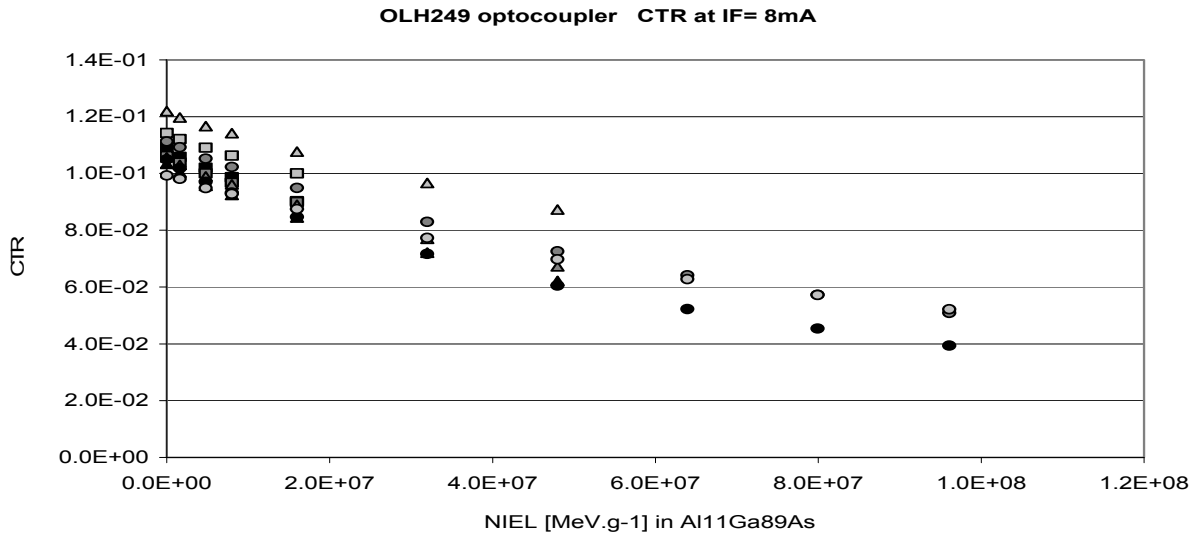

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-110: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

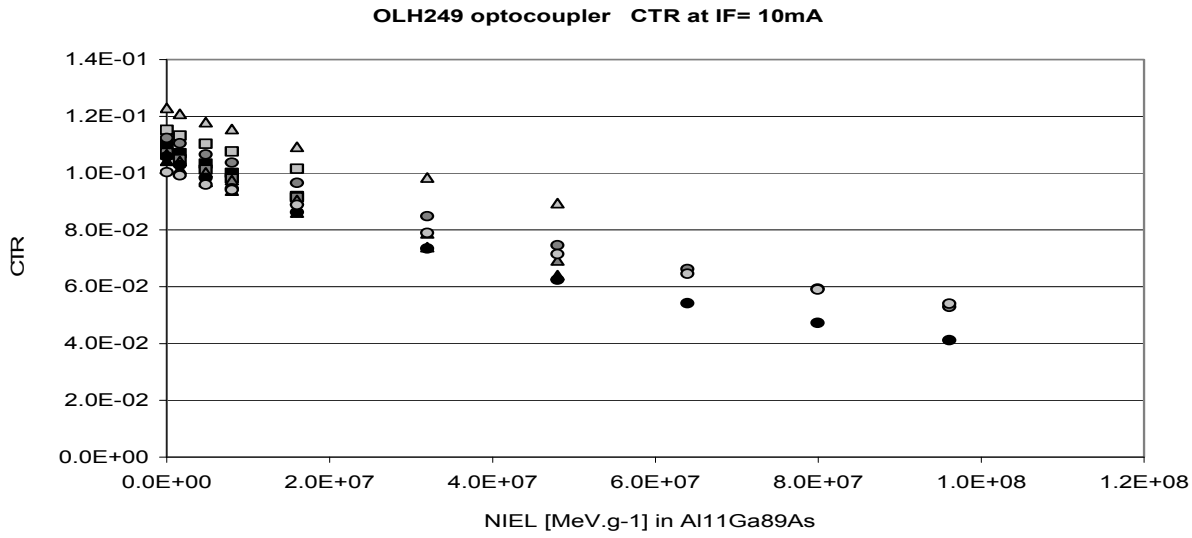
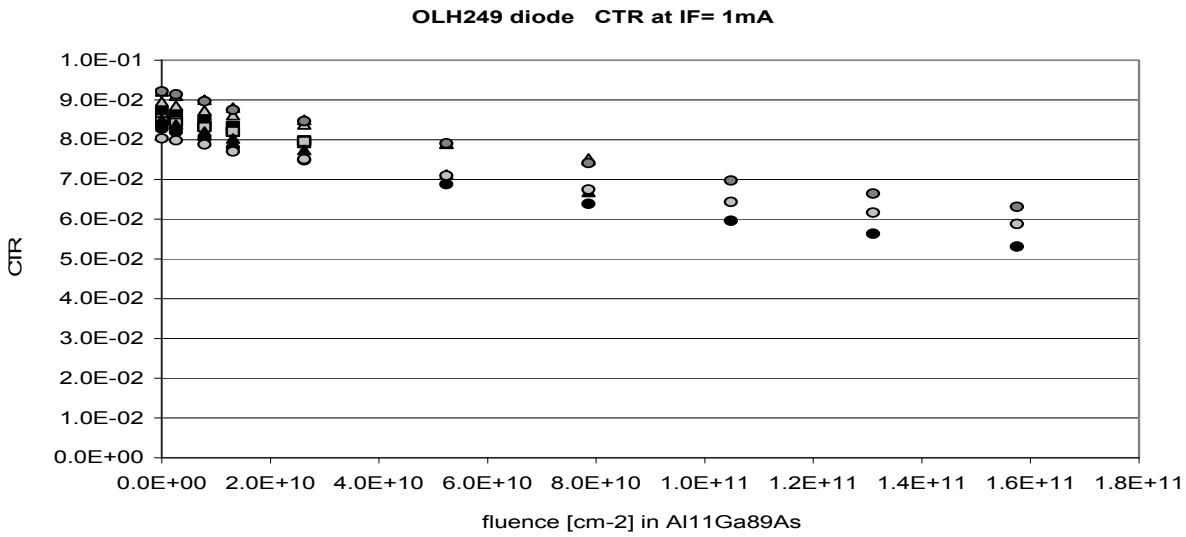
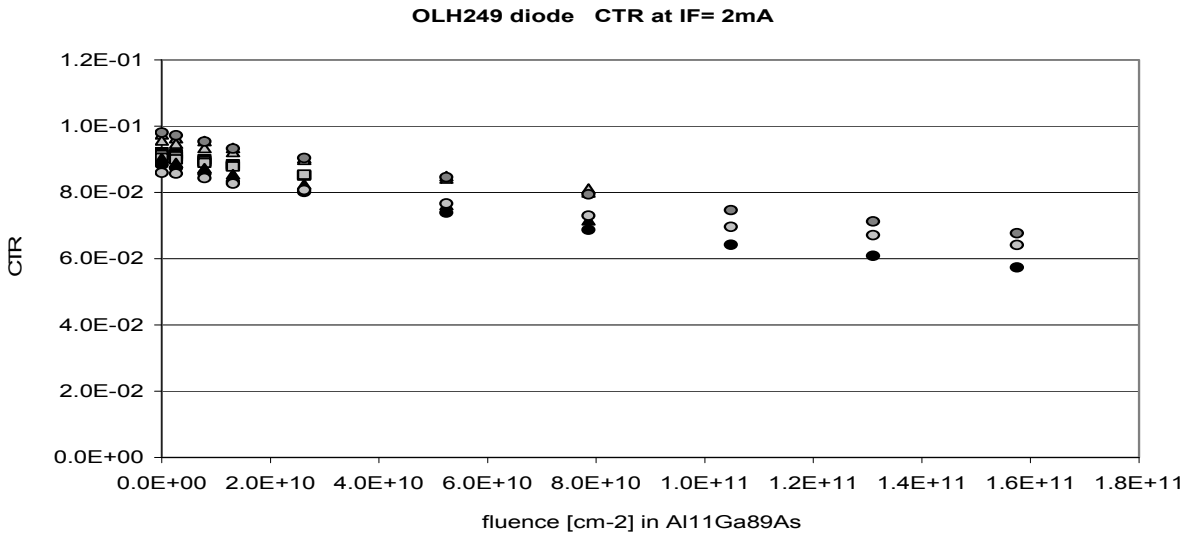
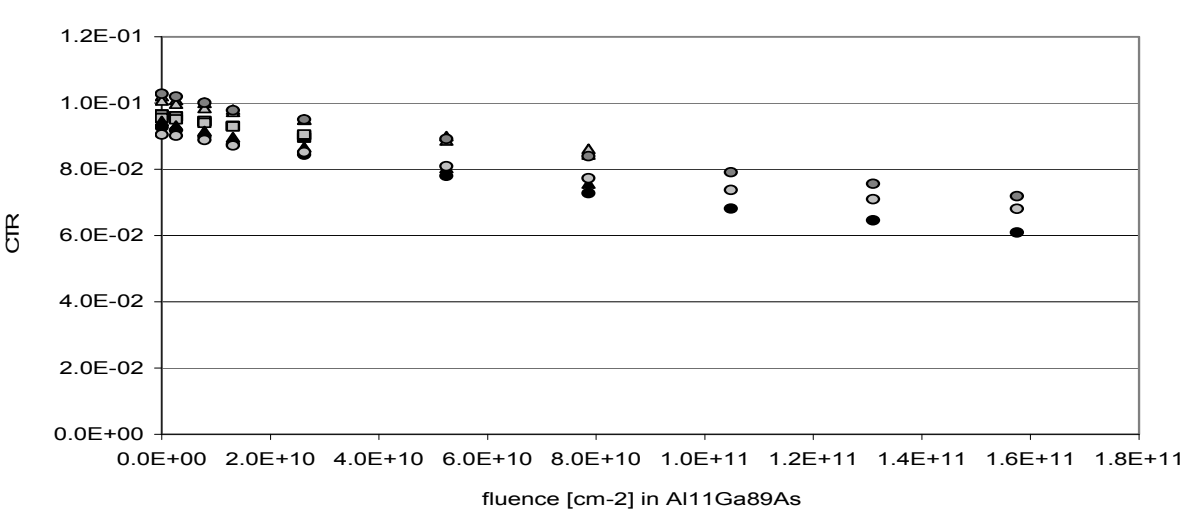
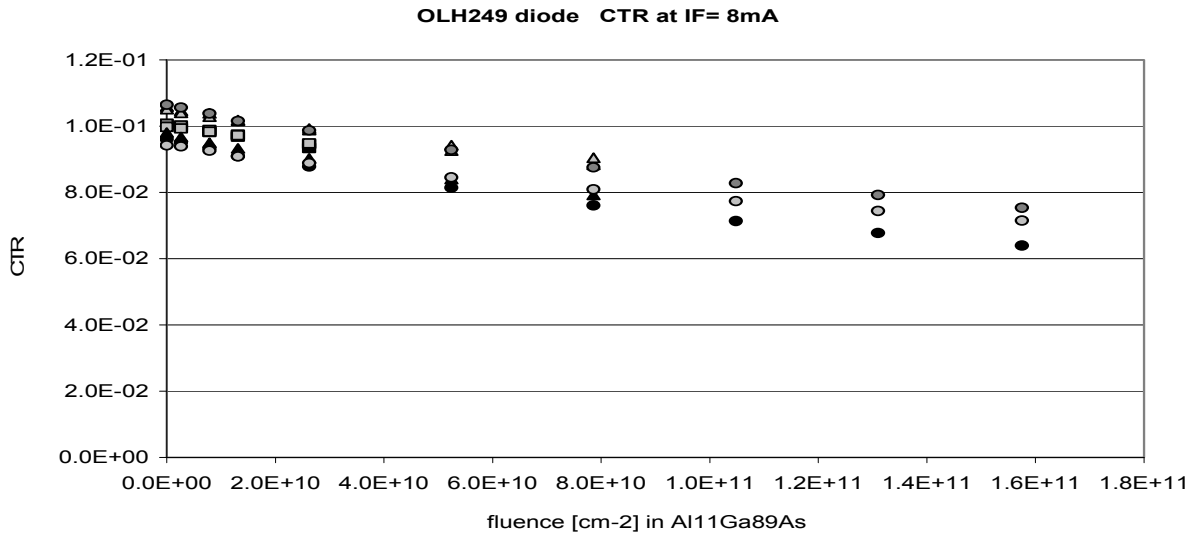

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-111: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

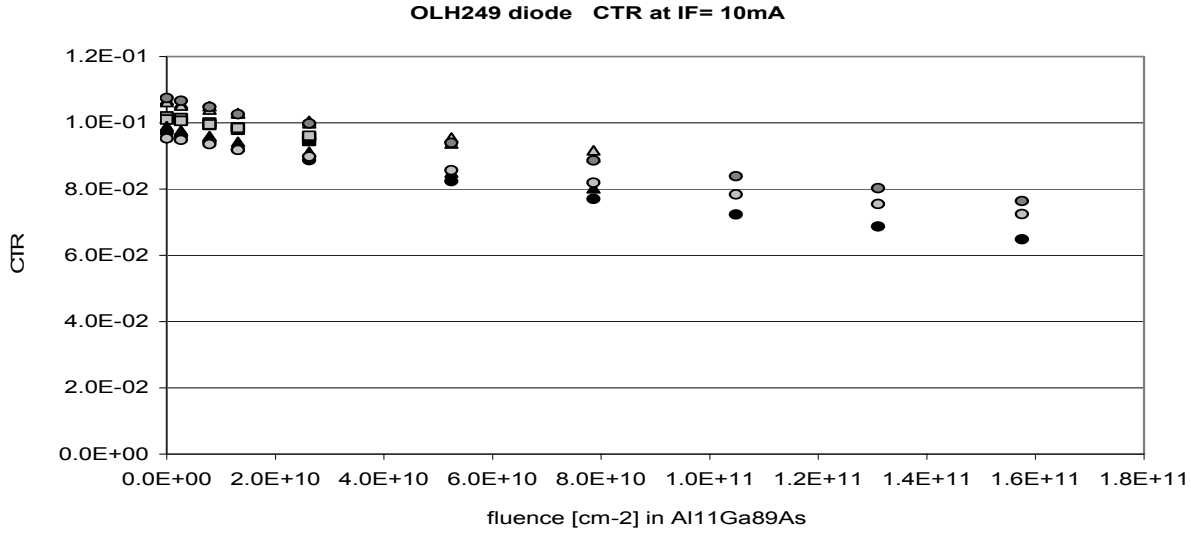
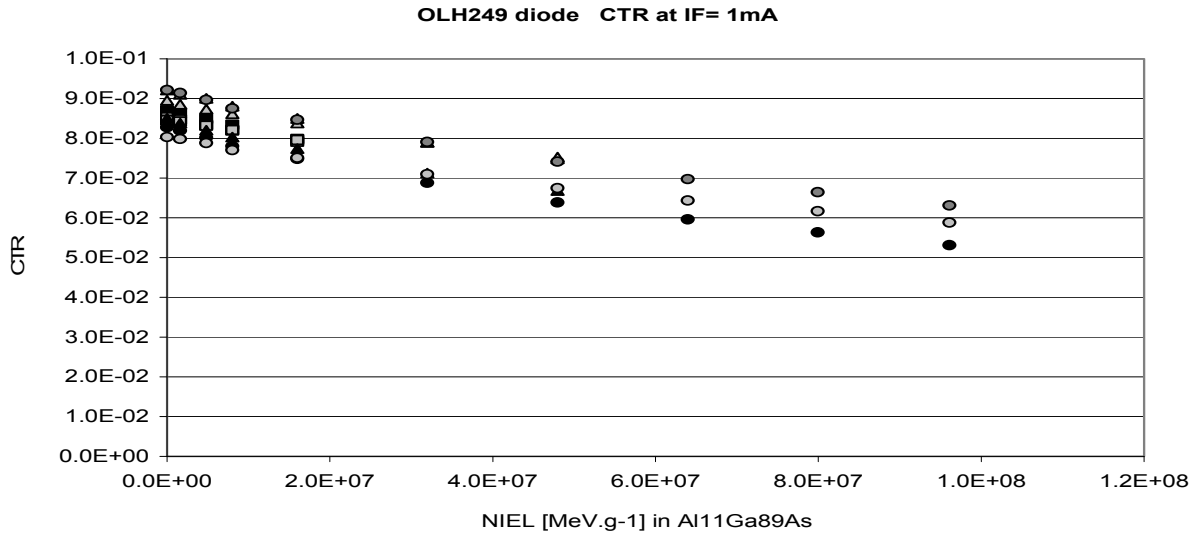
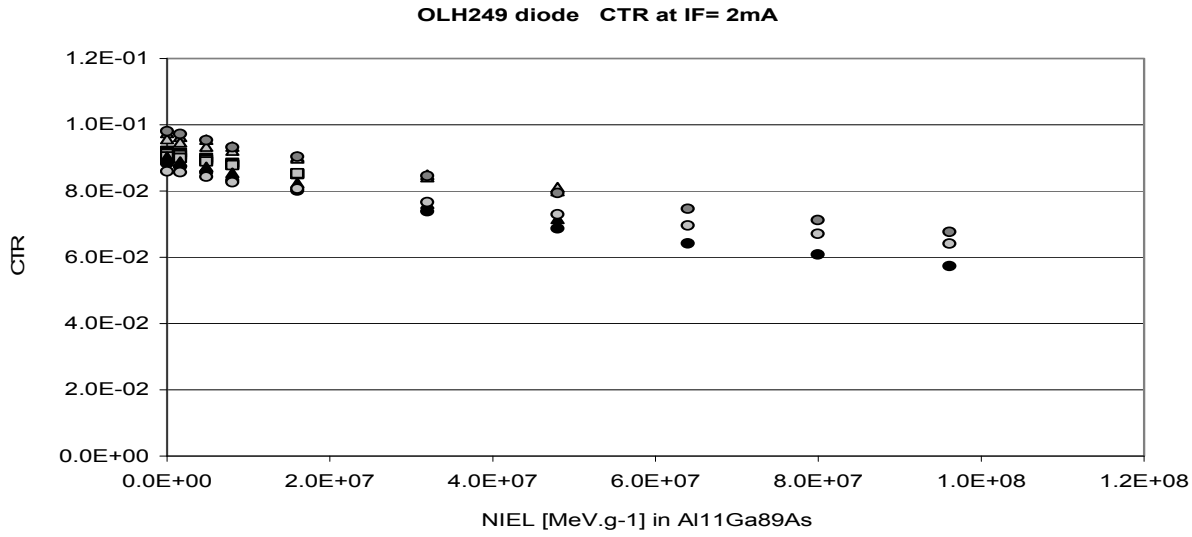
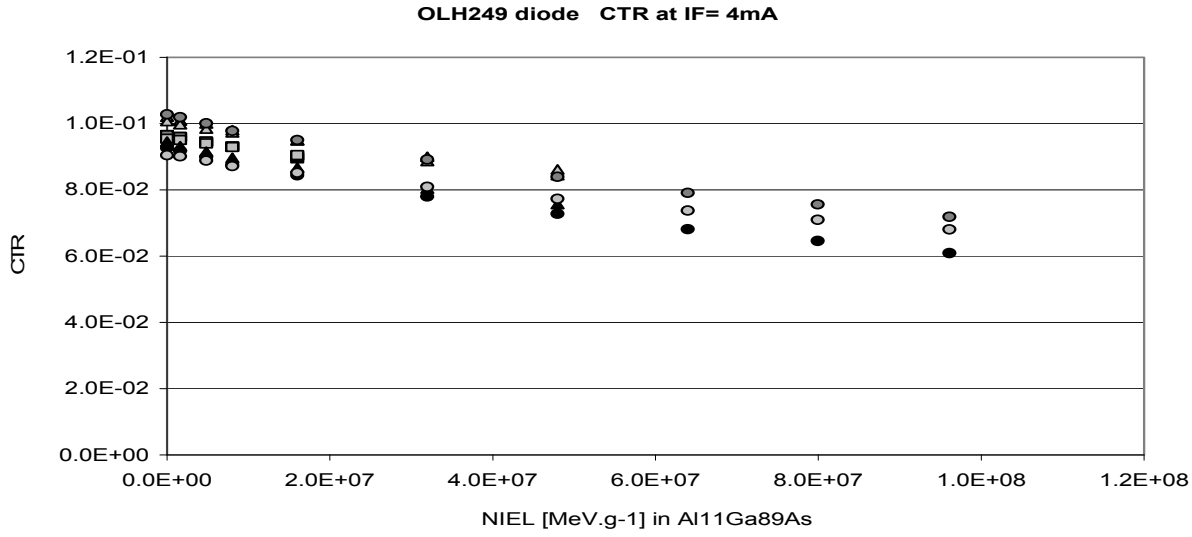
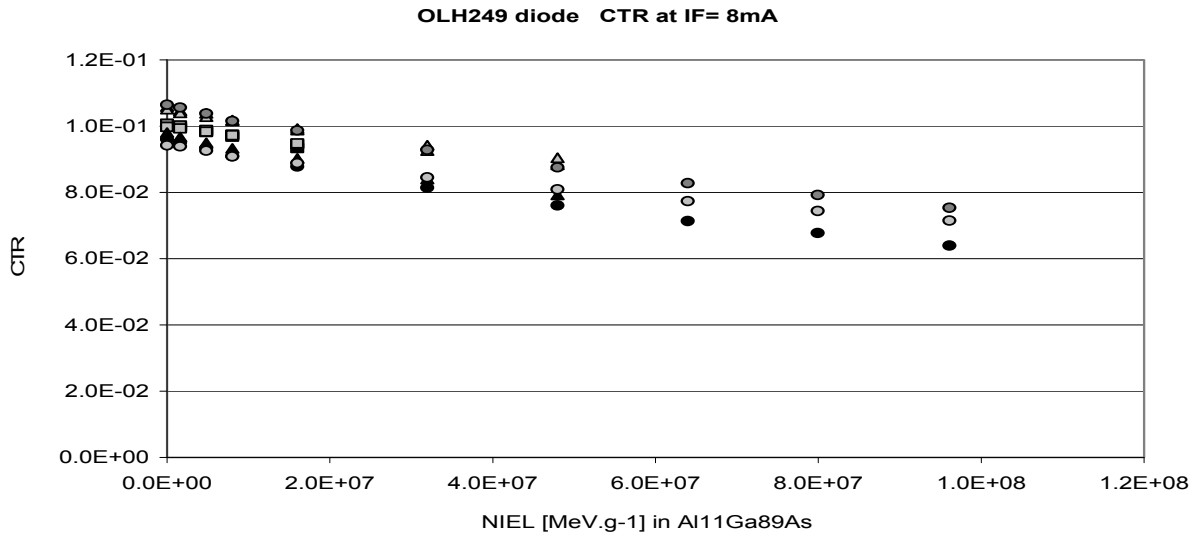

OLH249 diode CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-112: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 diode CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

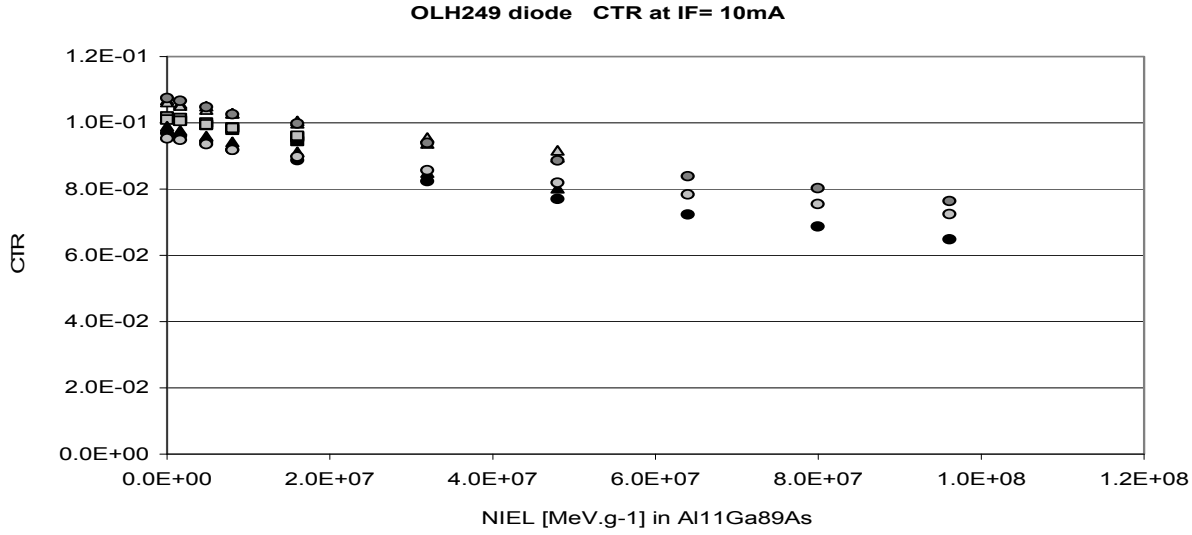
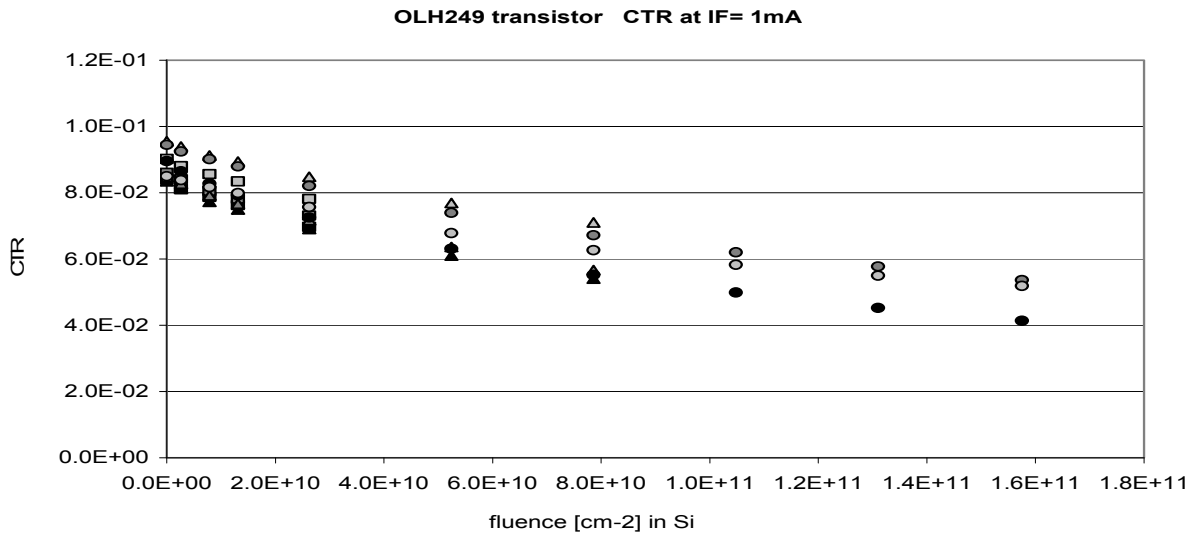
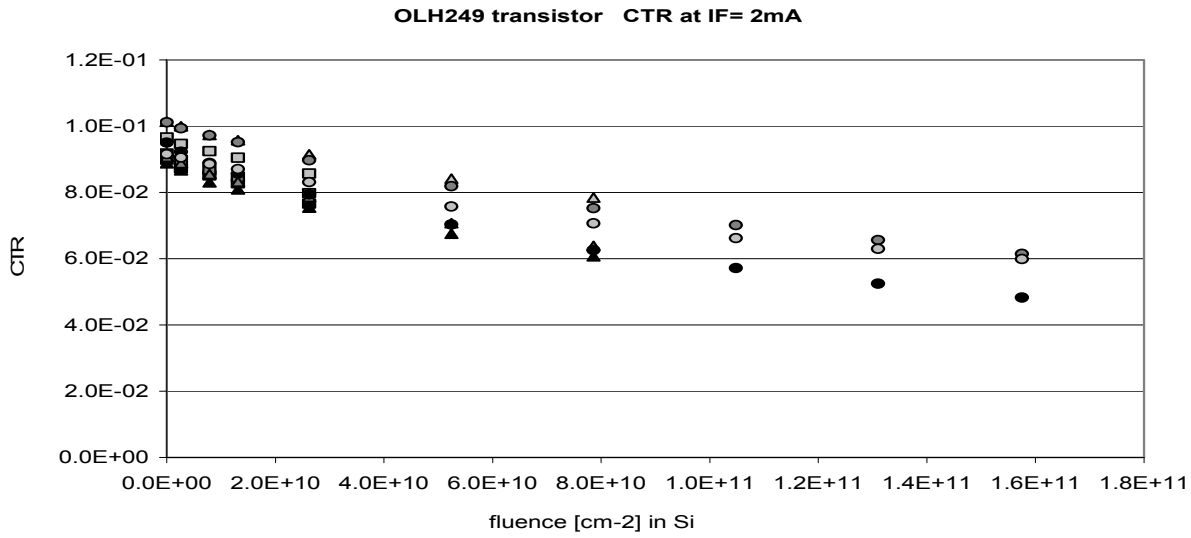
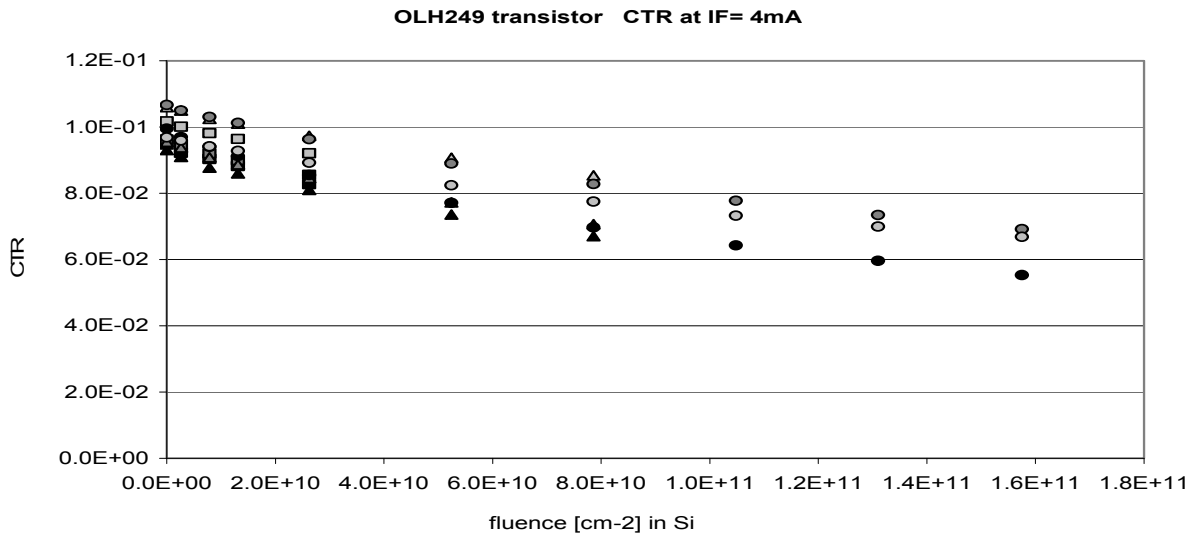
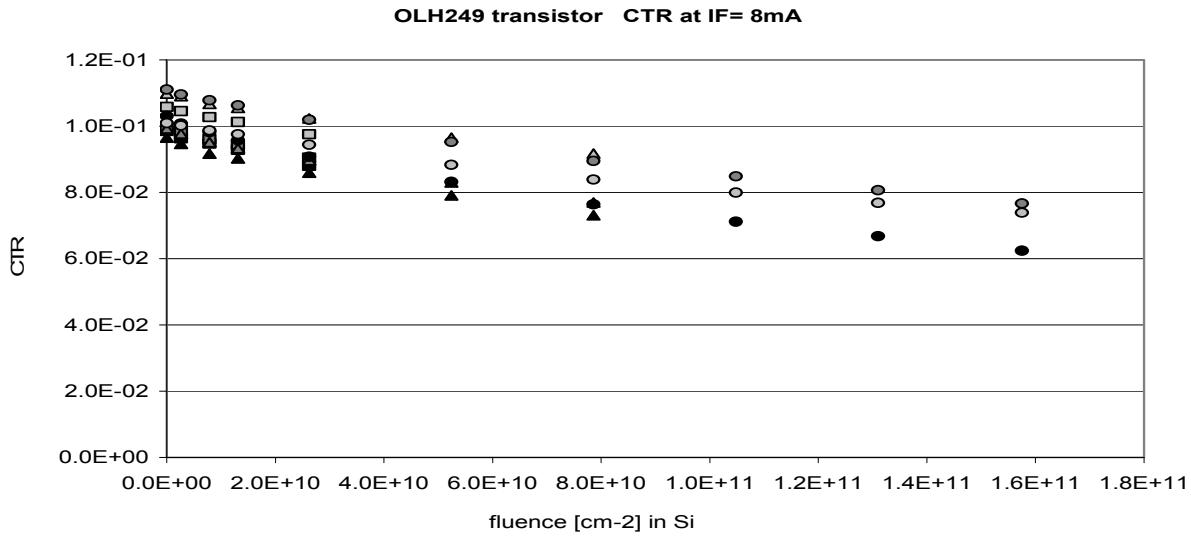

OLH249 diode CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-113: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

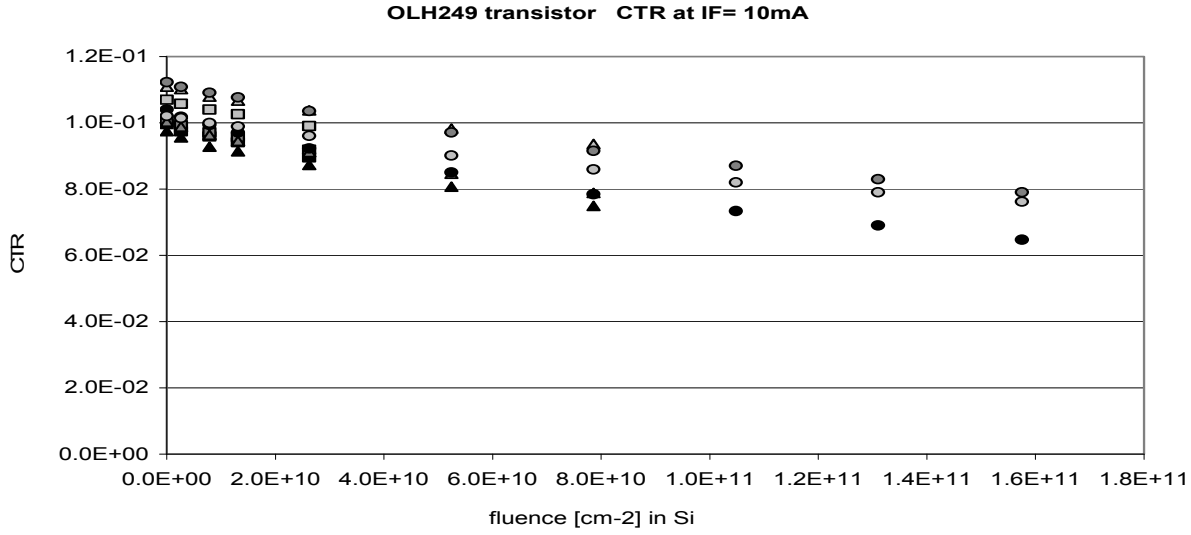
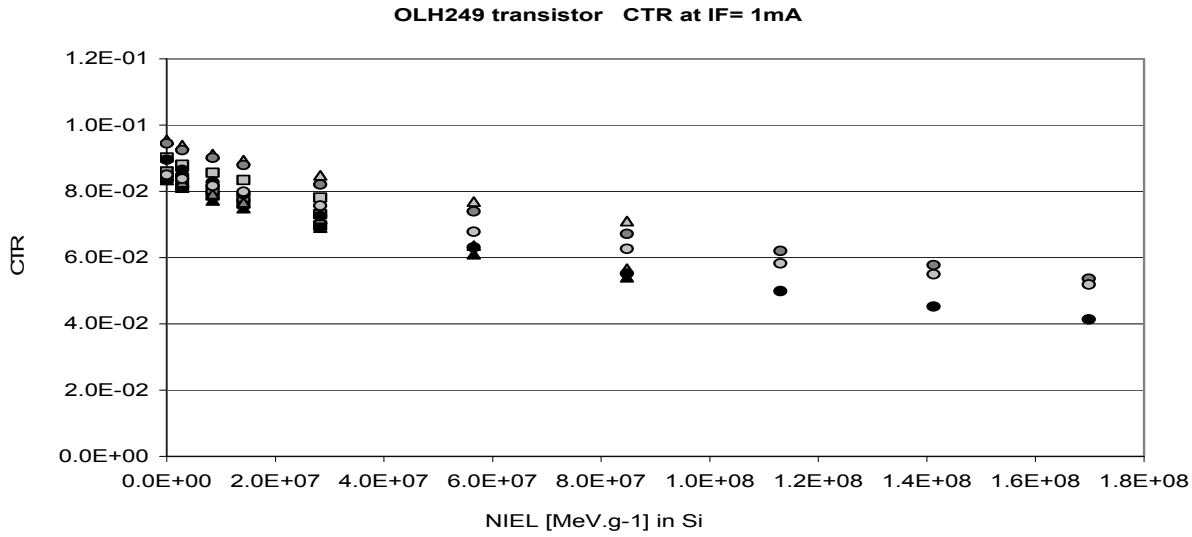
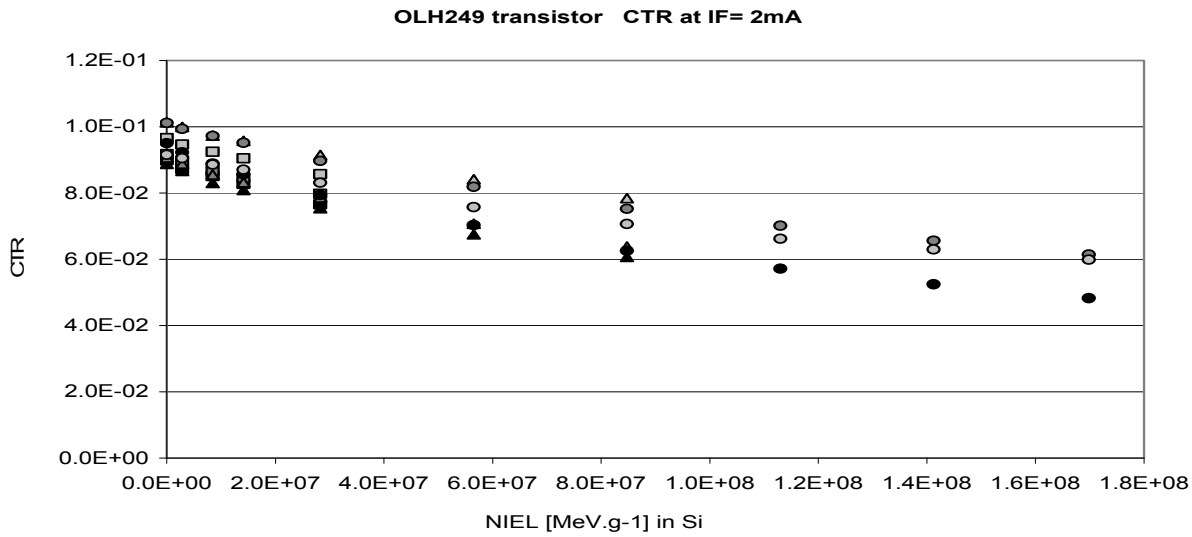
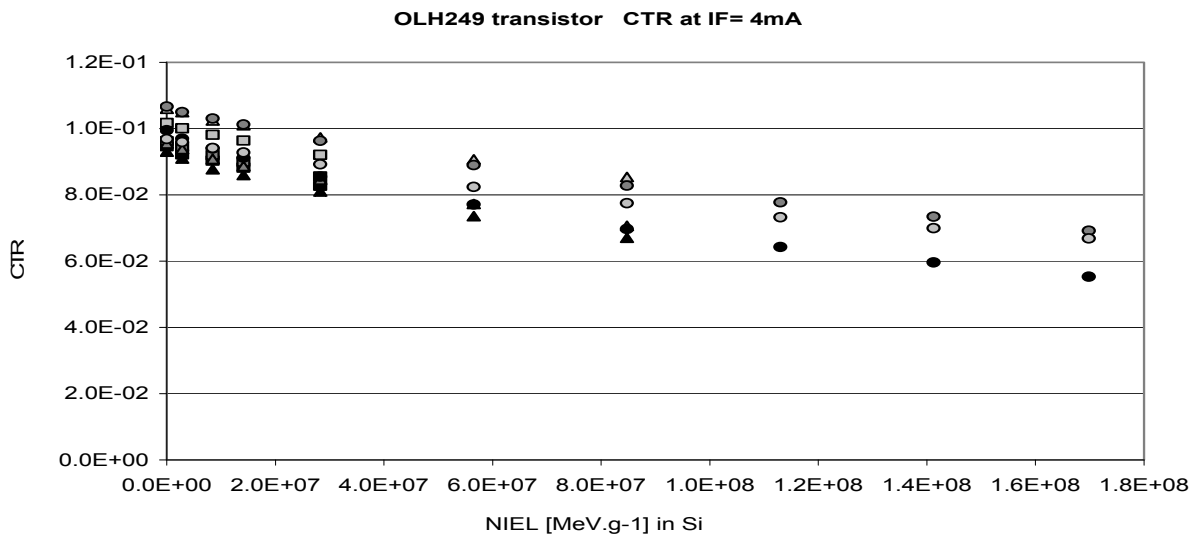
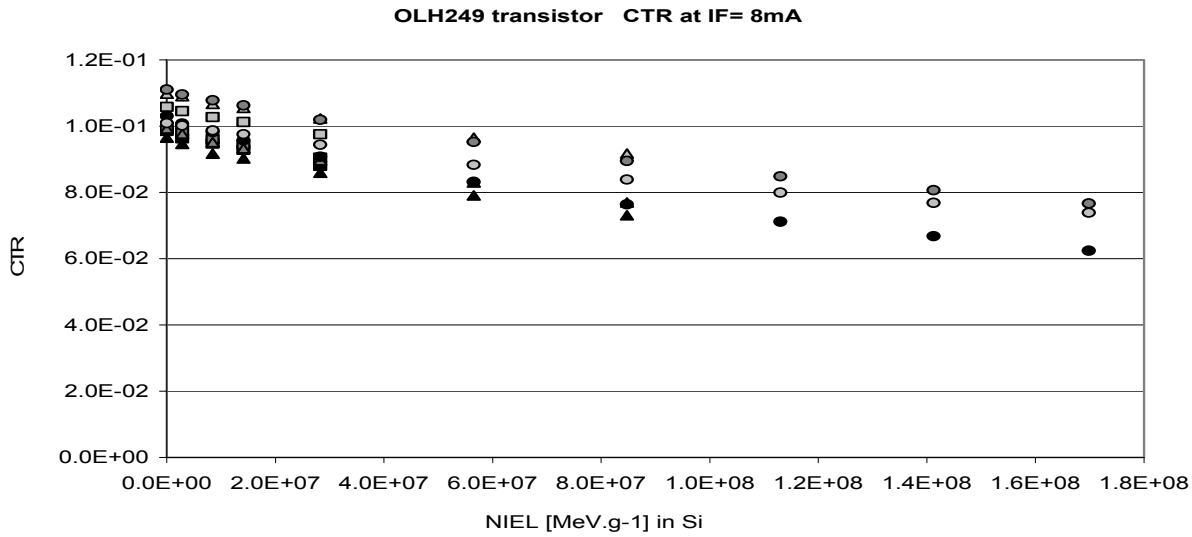

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

Fig. 13-114: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

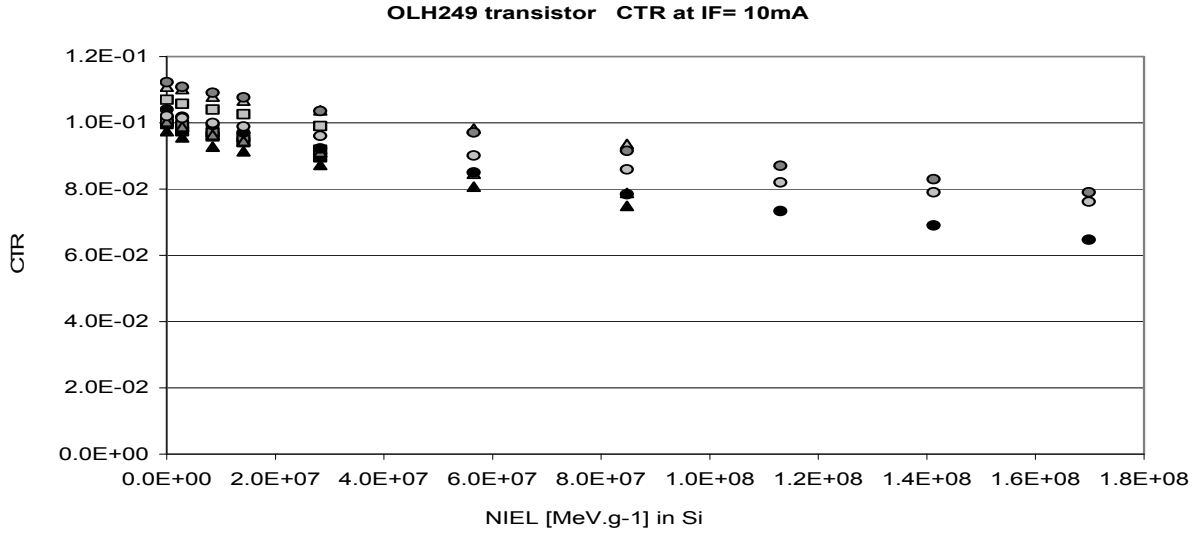
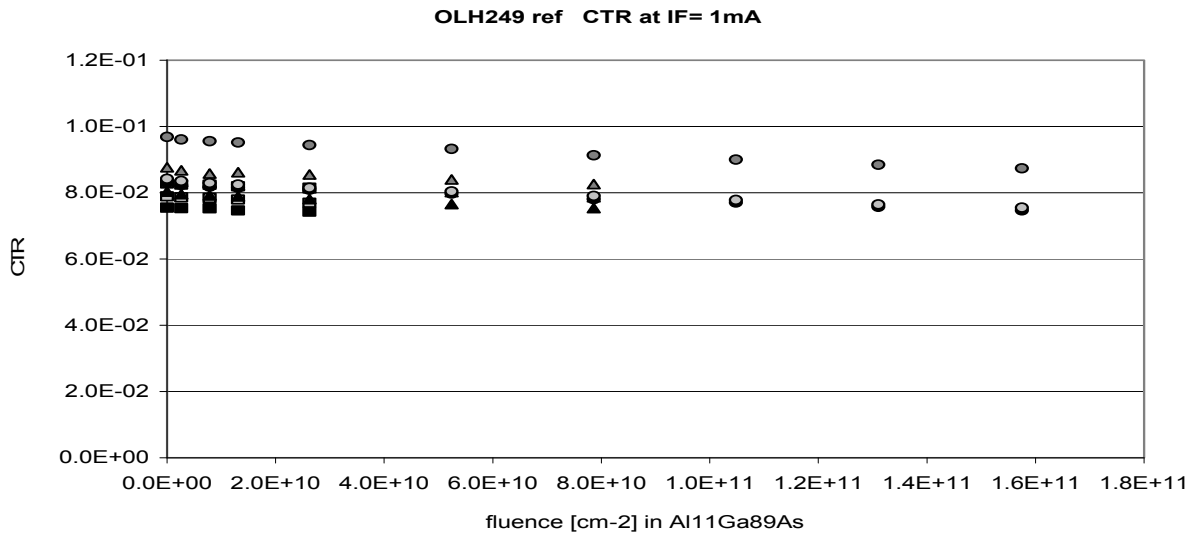
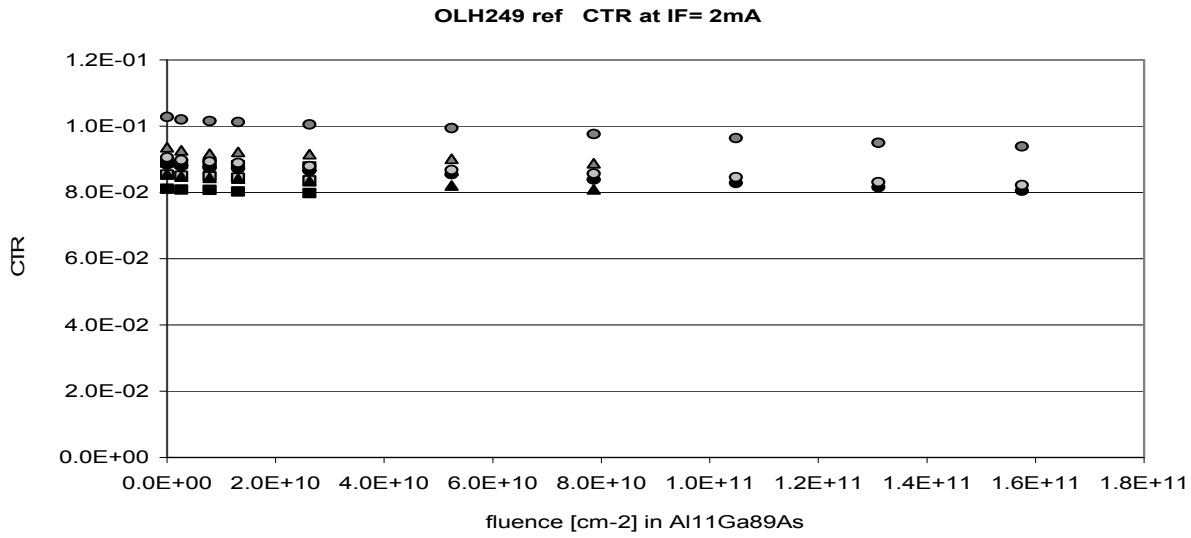
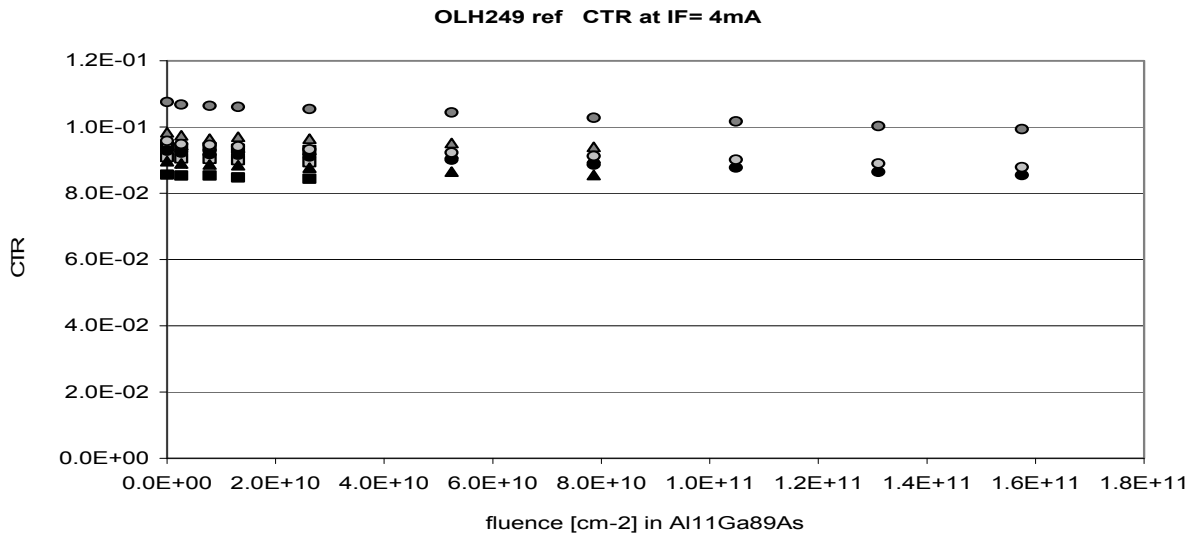
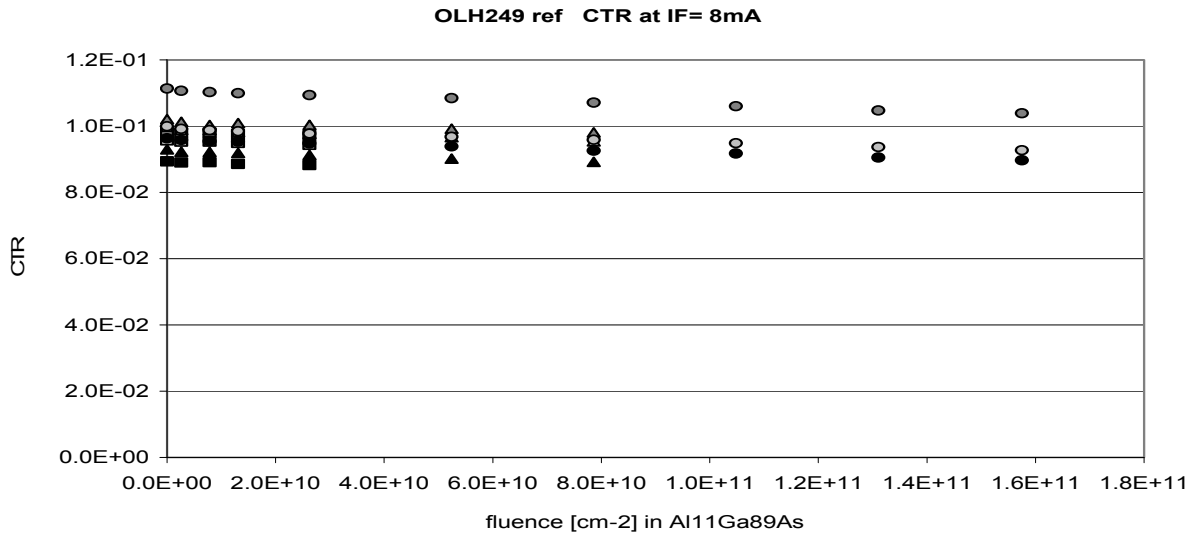

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-115: OLH249 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

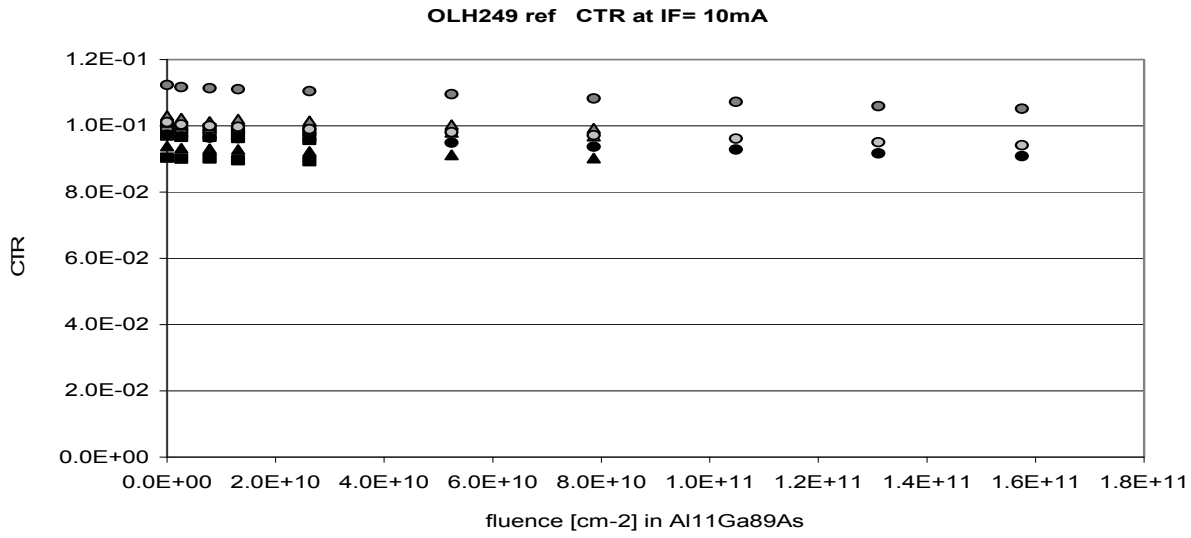
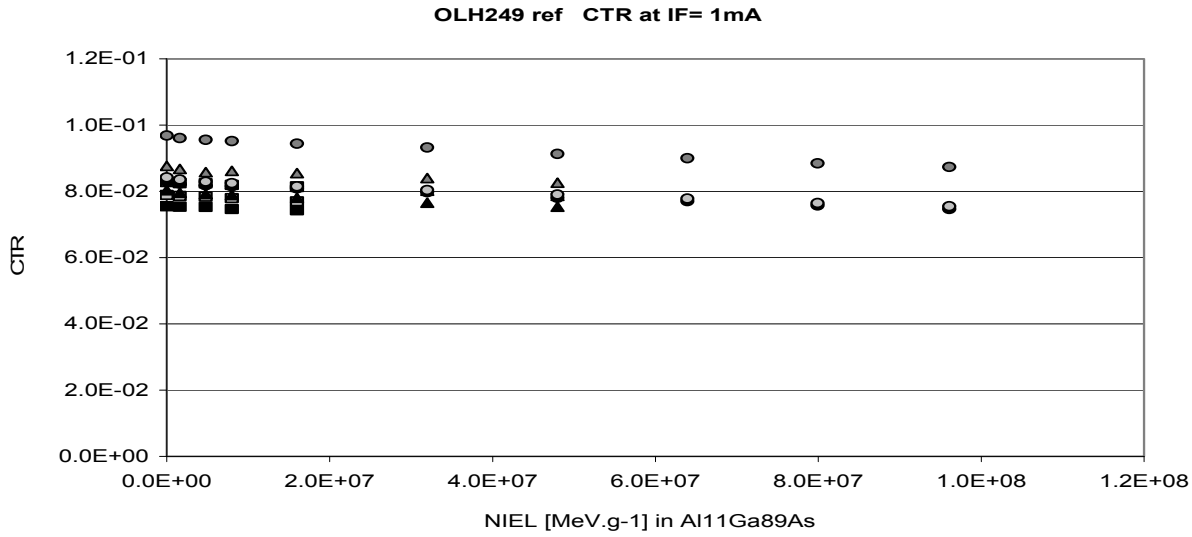
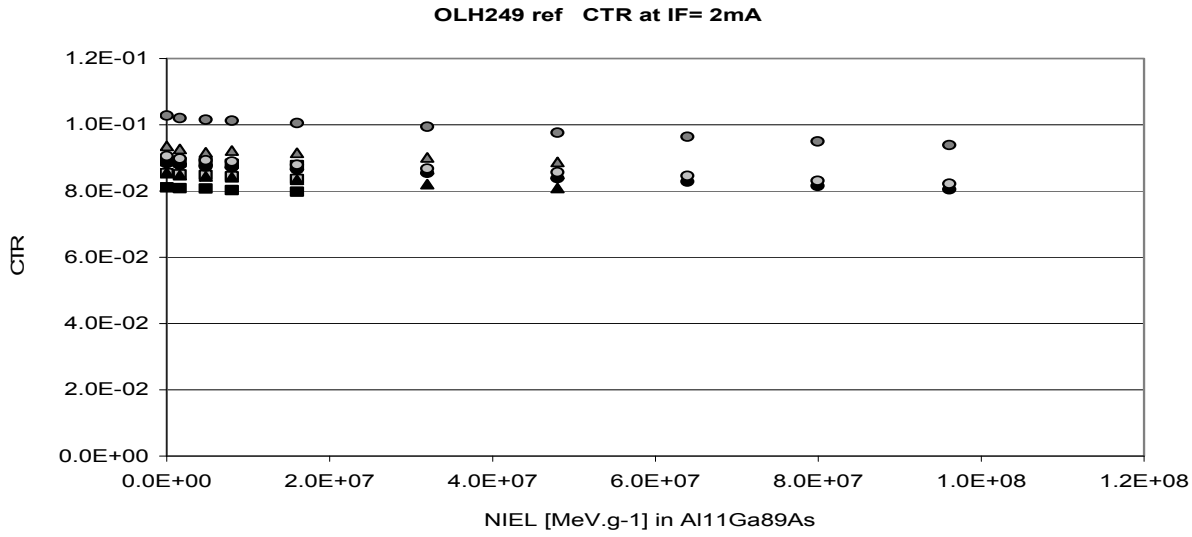
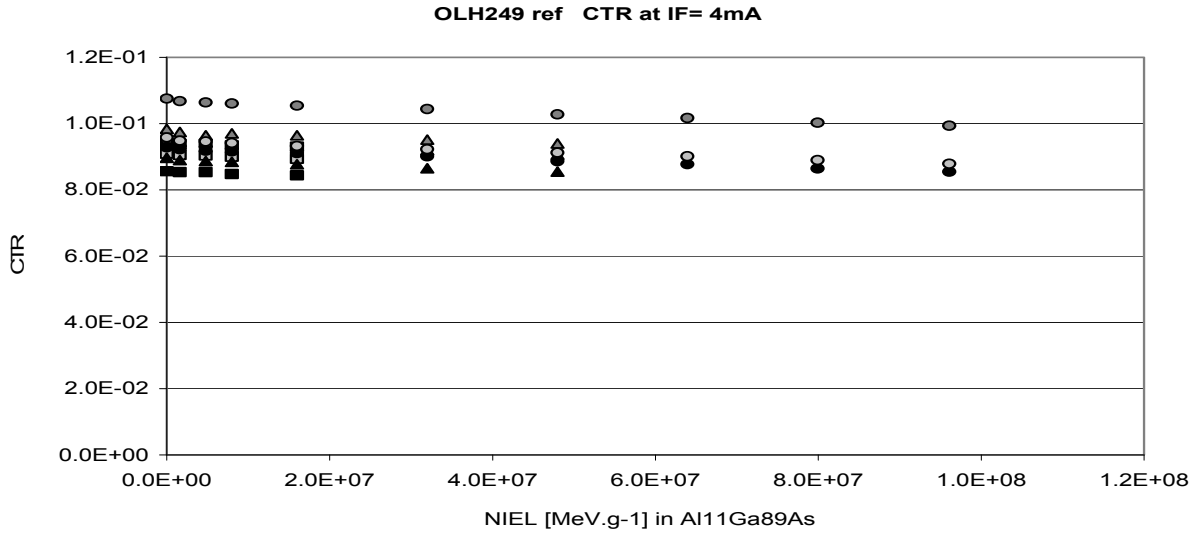
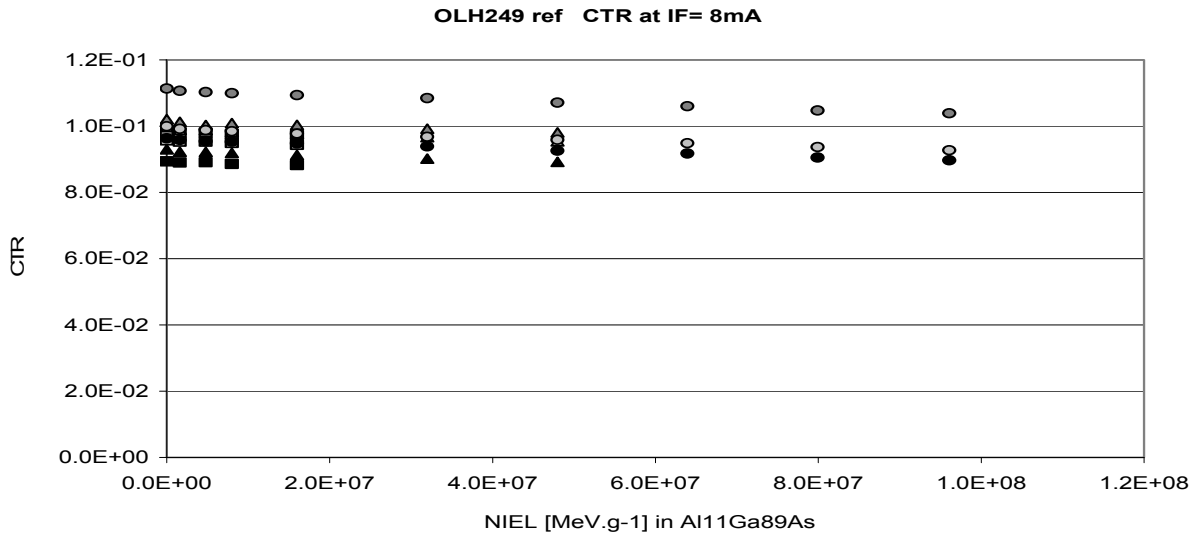

OLH249 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-116: OLH249 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

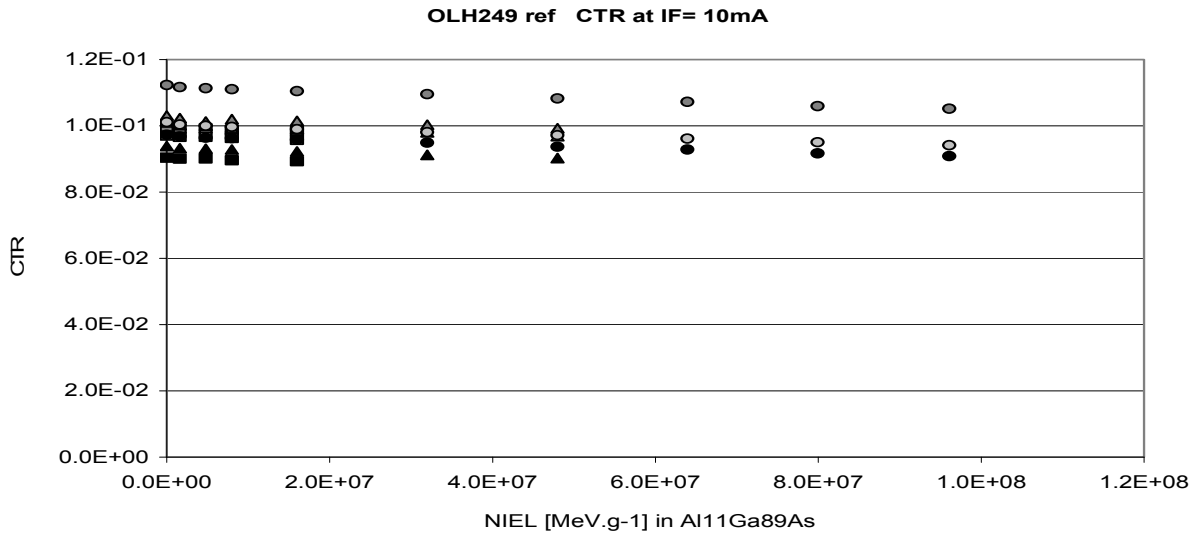
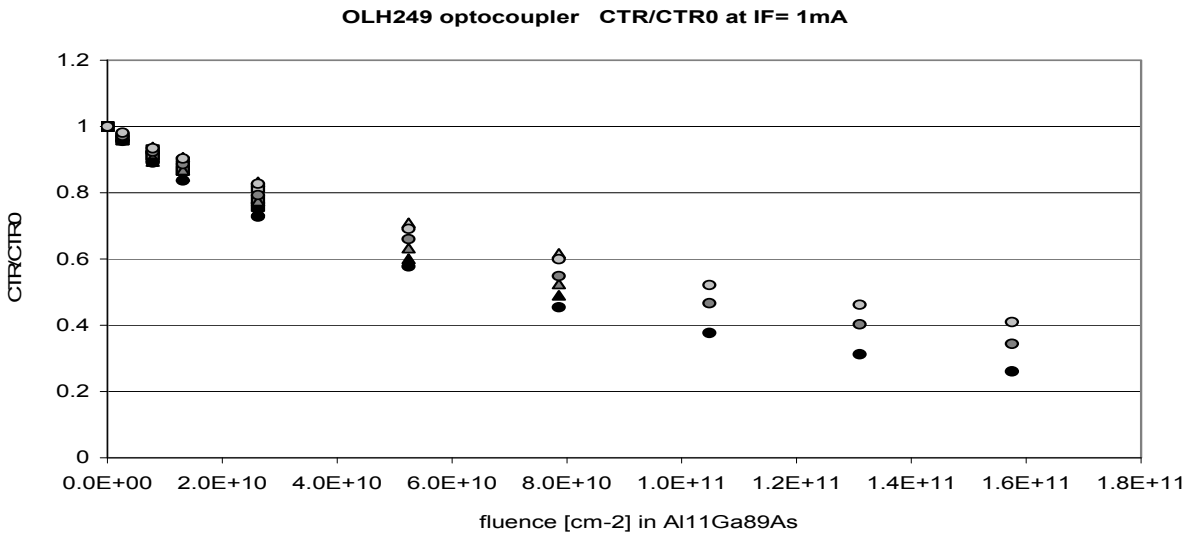
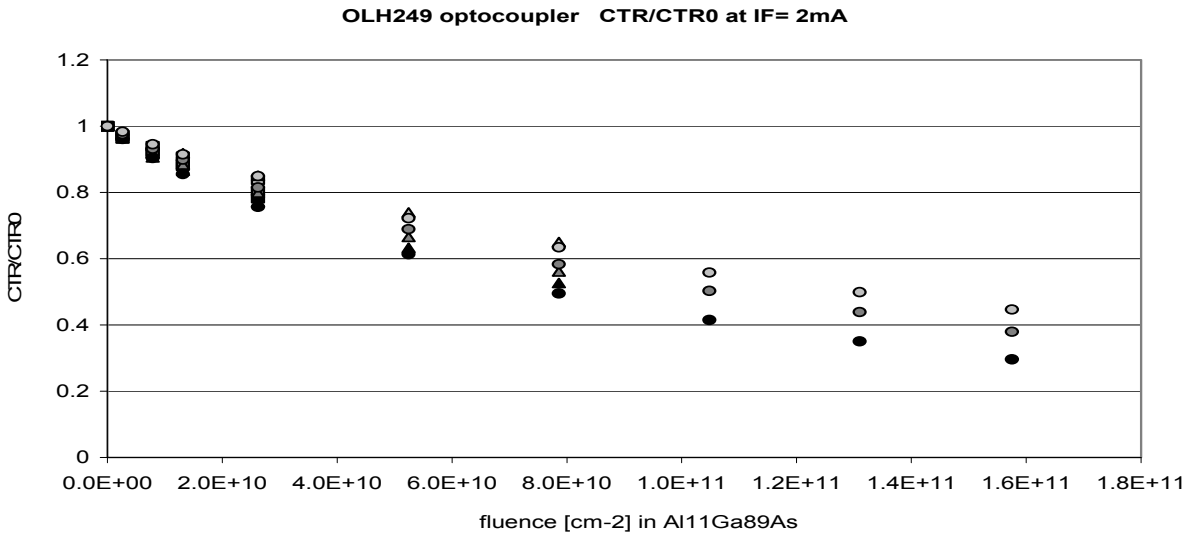
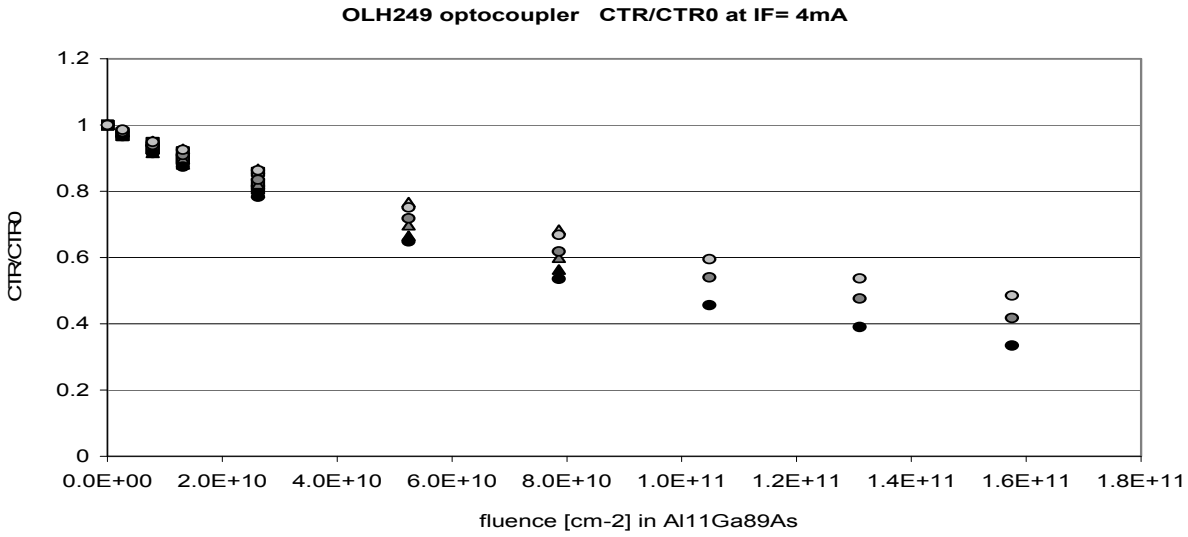
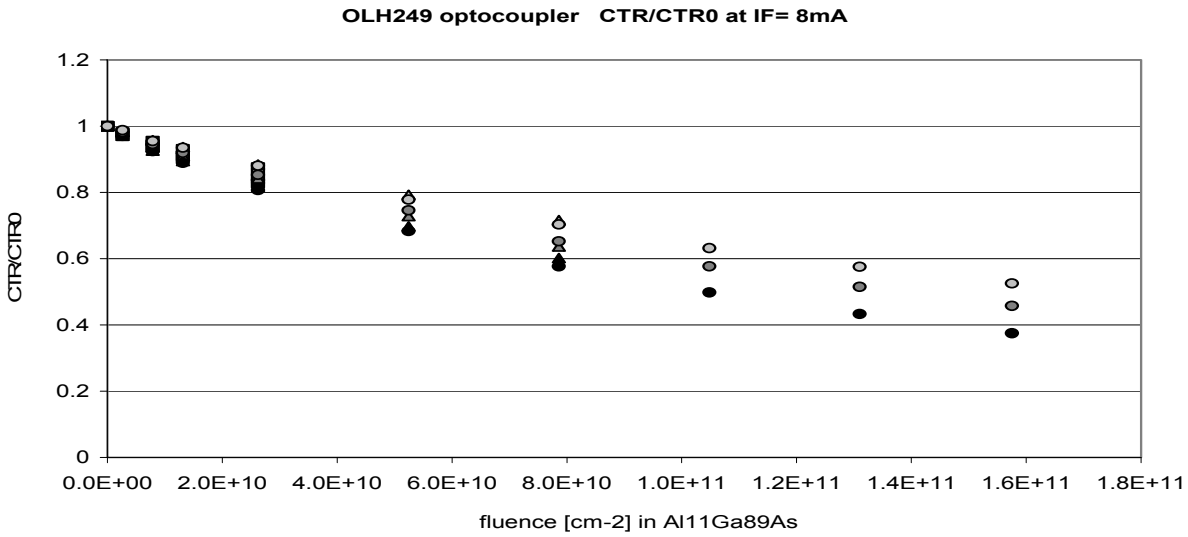

OLH249 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-117: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

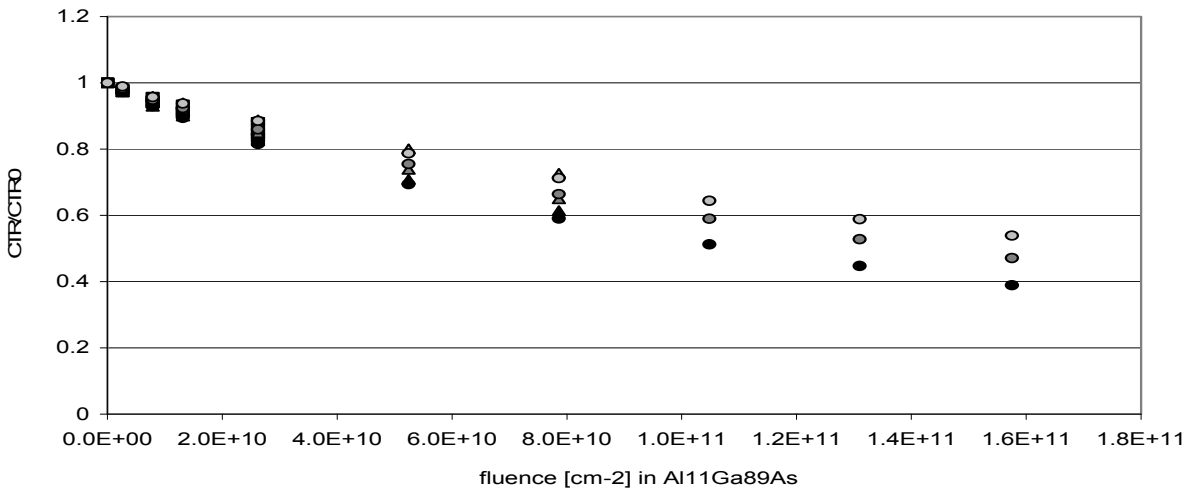
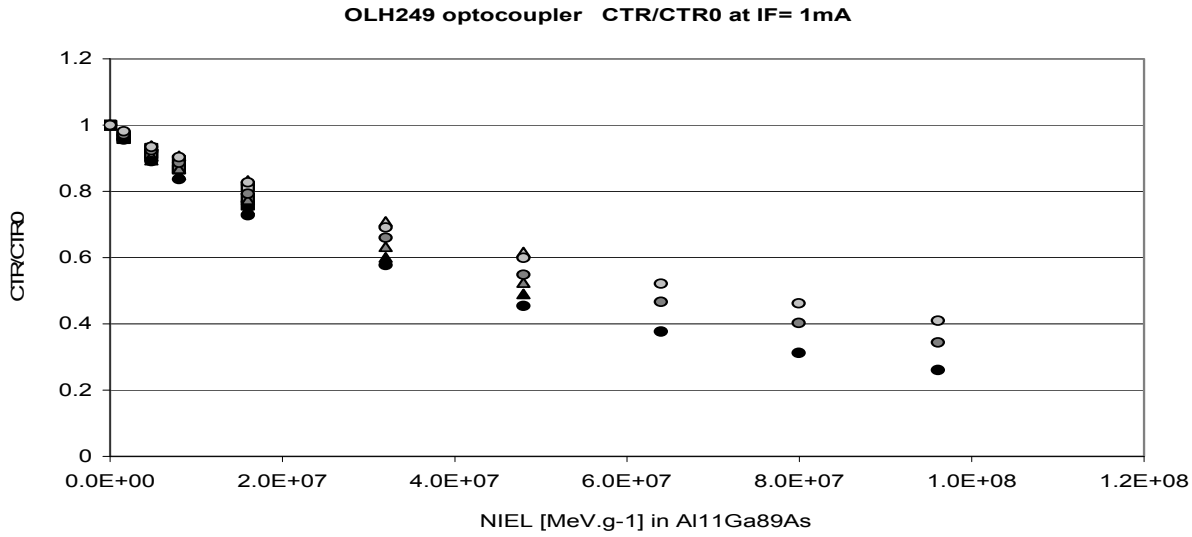
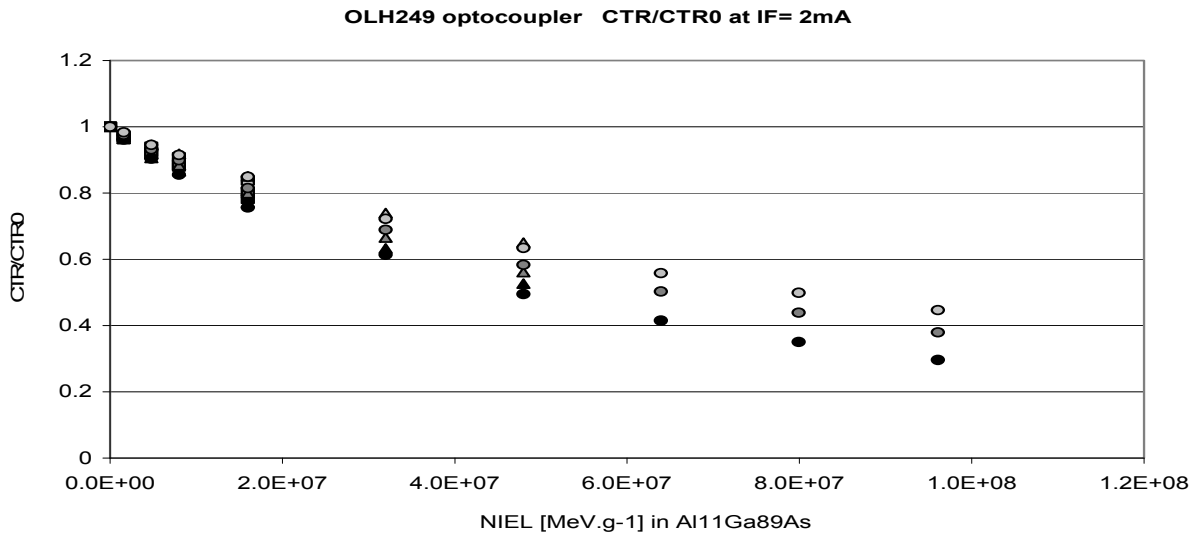
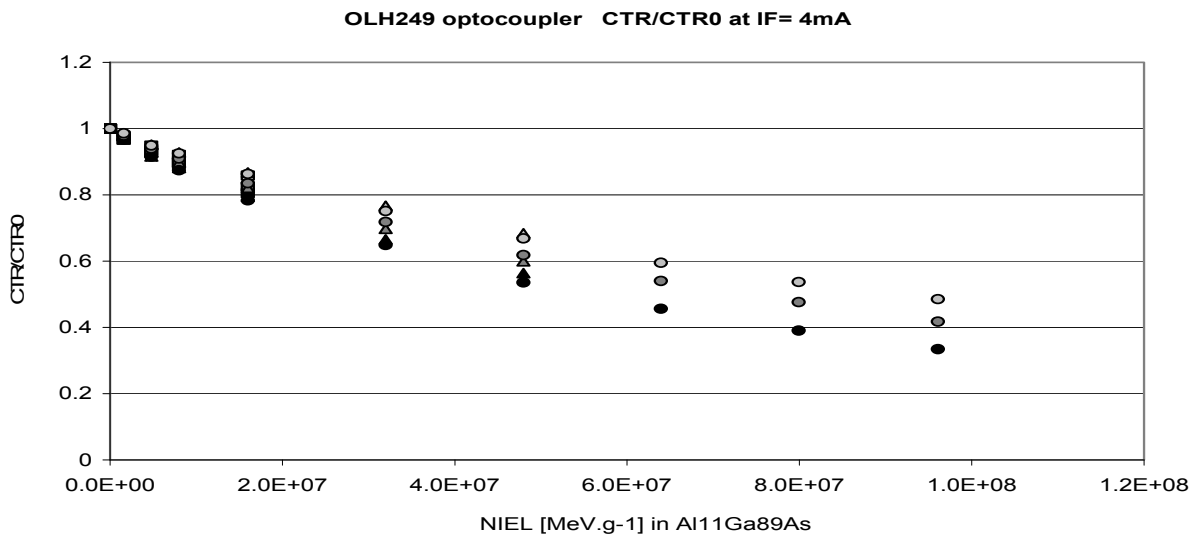

OLH249 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

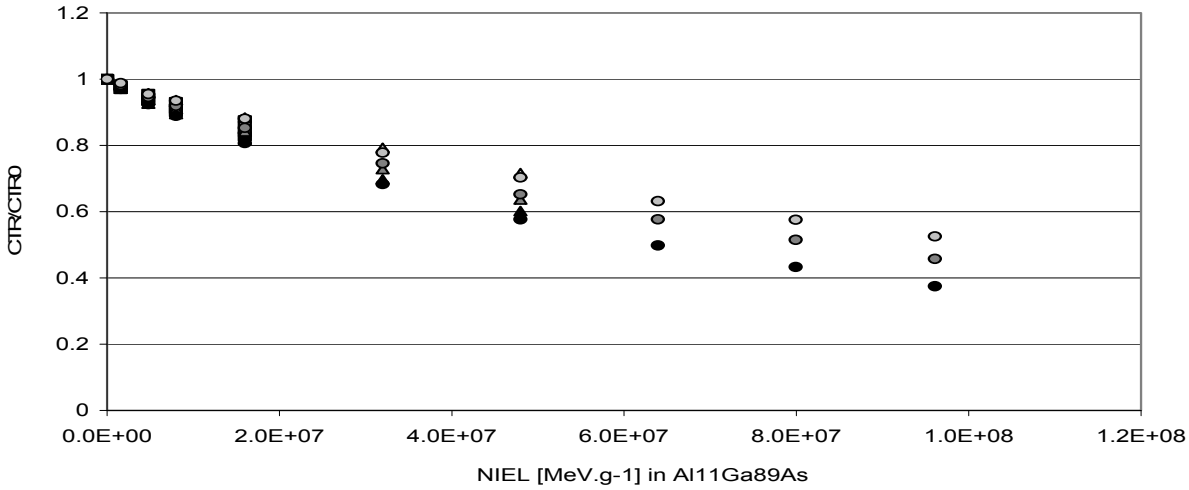
Fig. 13-118: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)







OLH249 optocoupler CTR/CTR0 at IF= 8mA



OLH249 optocoupler CTR/CTR0 at IF= 10mA

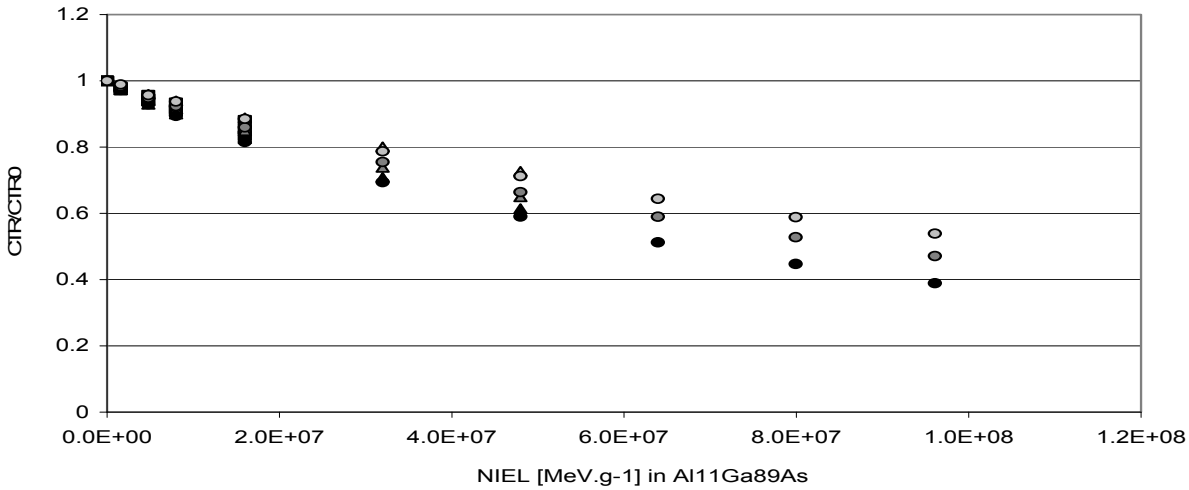
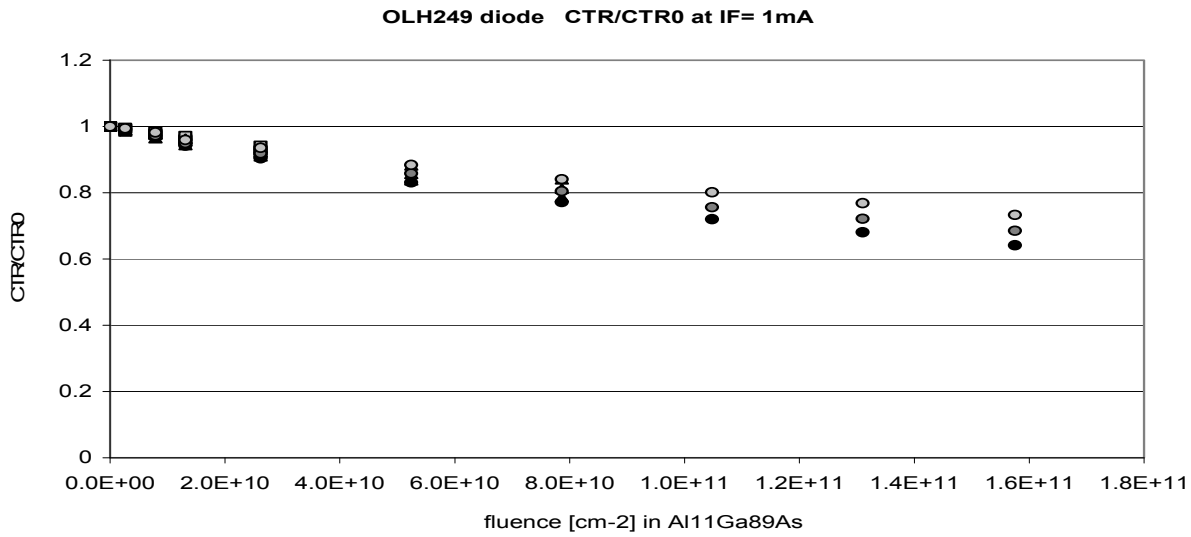
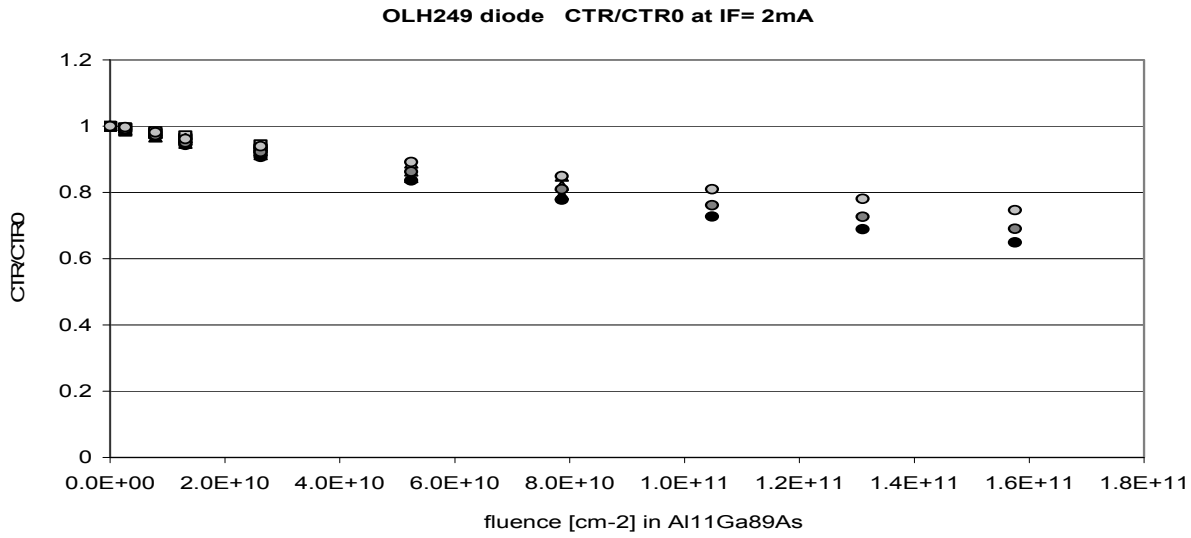
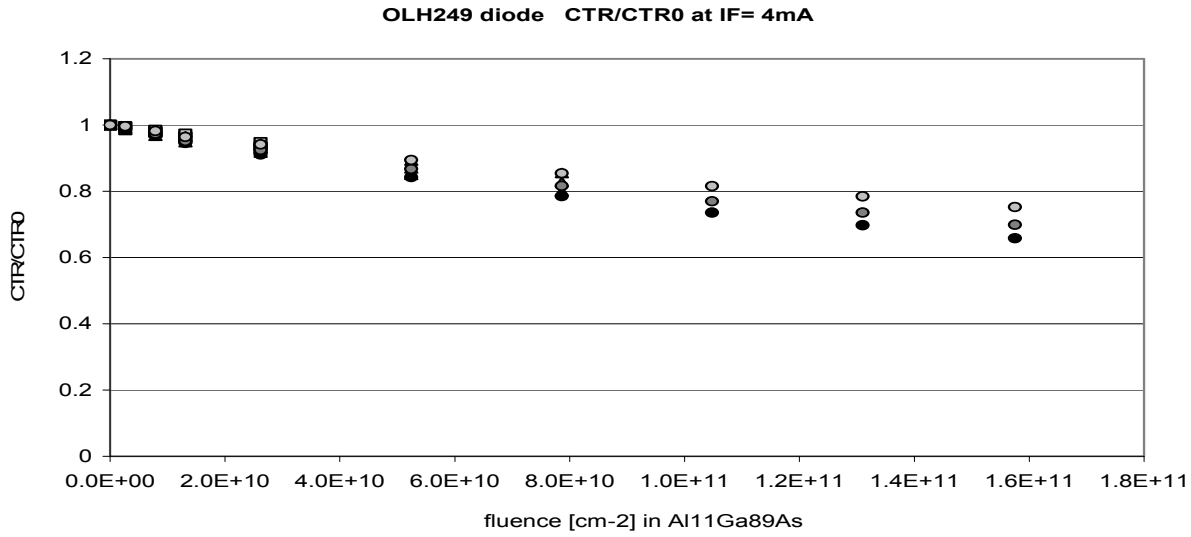
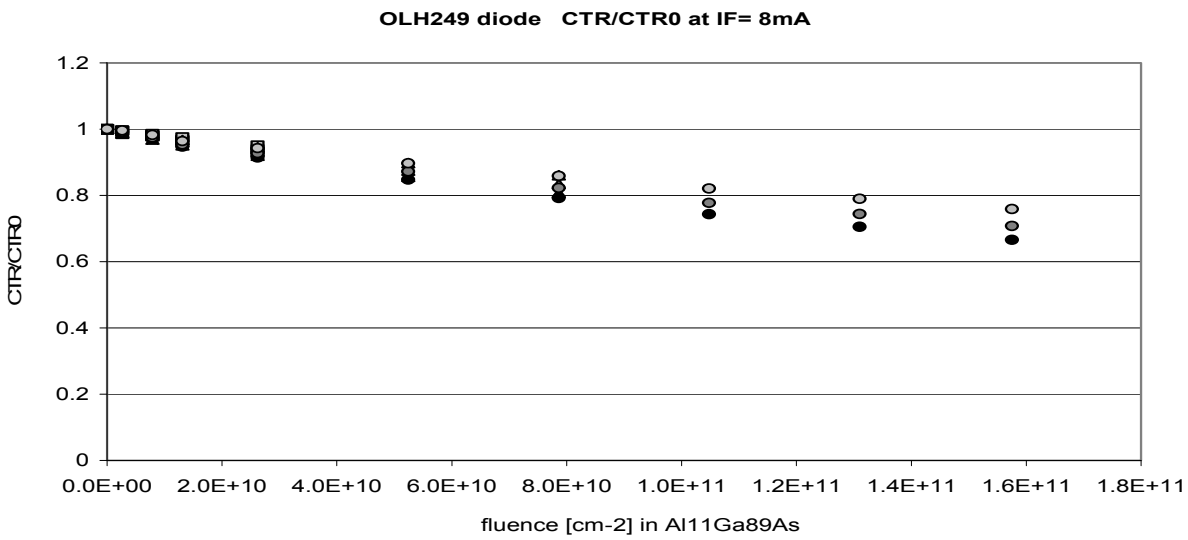


Fig. 13-119: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

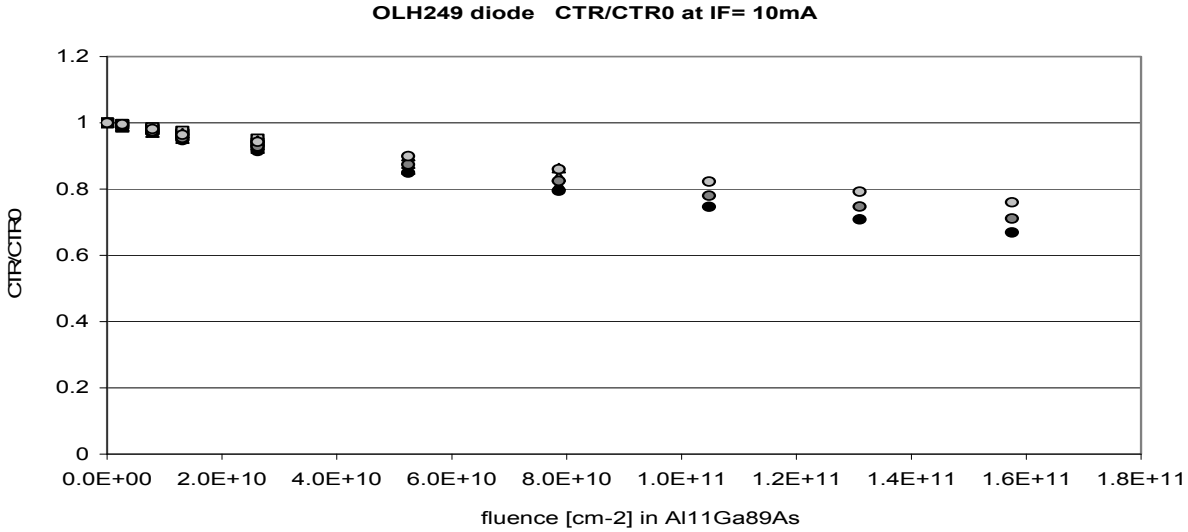
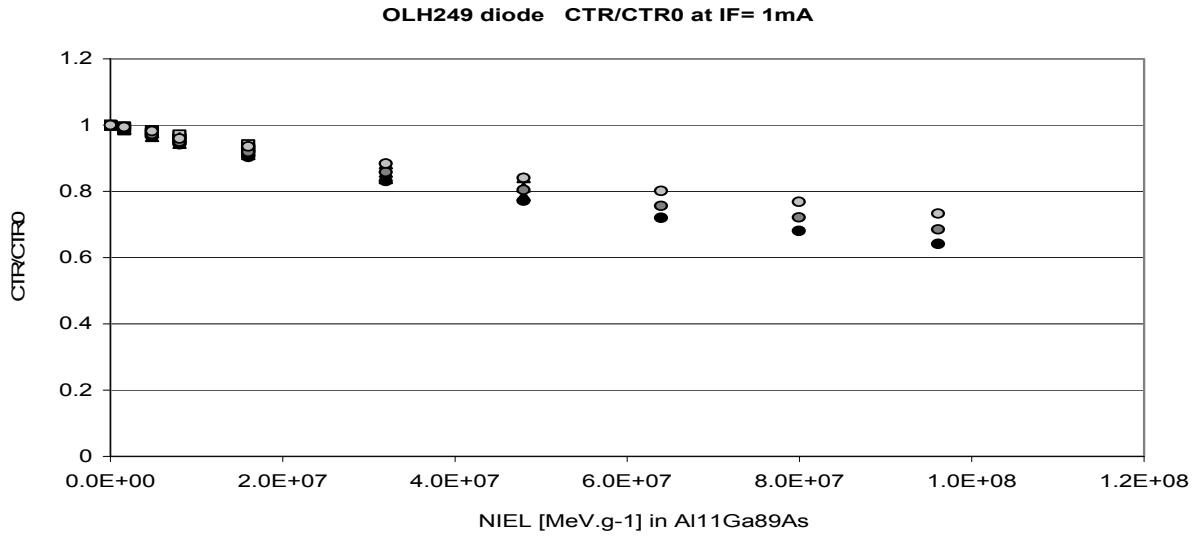
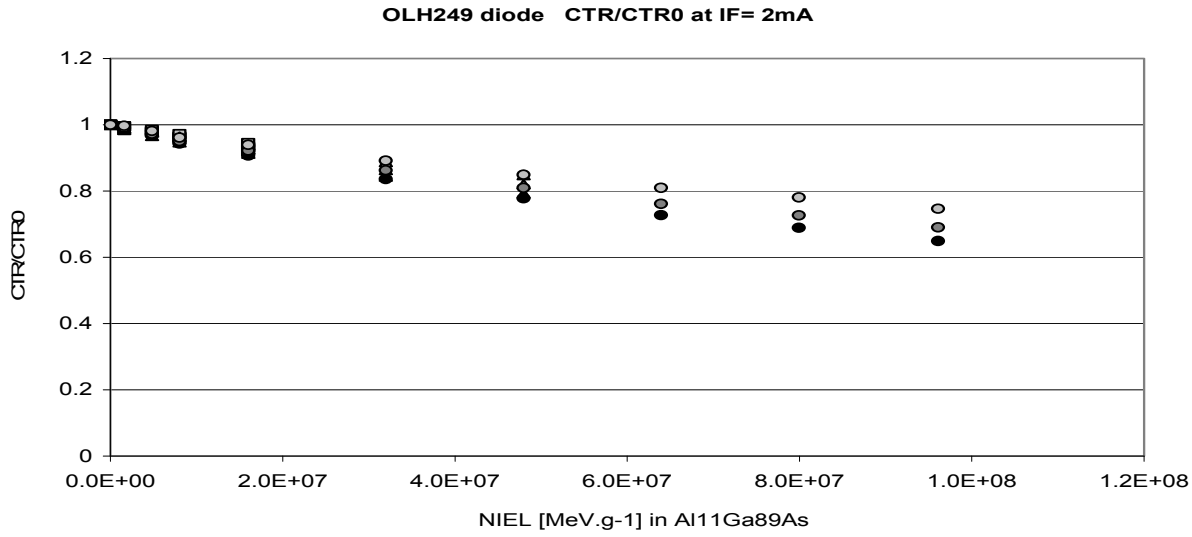
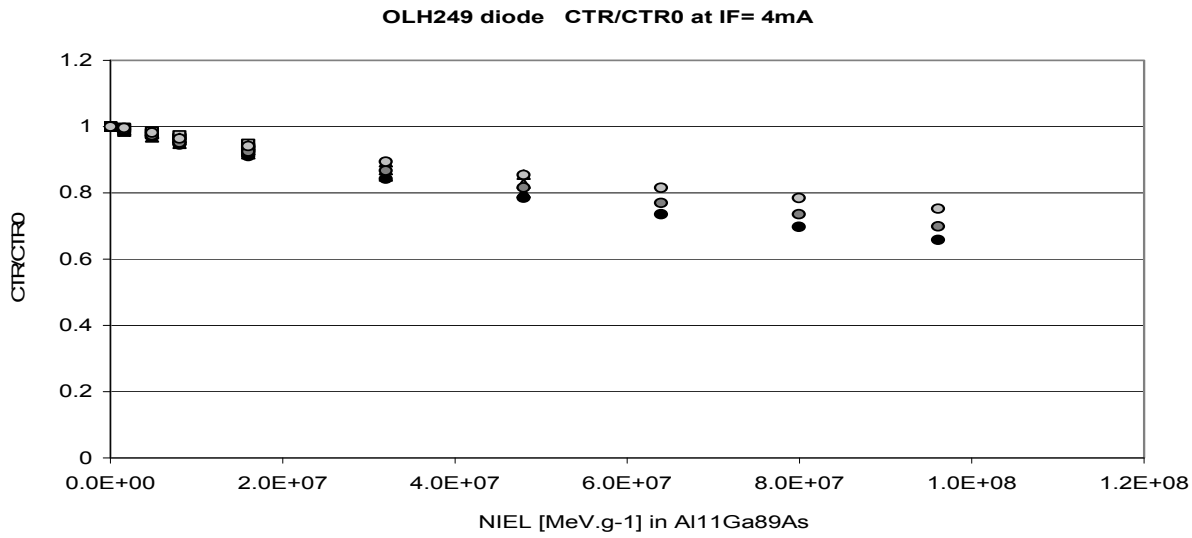
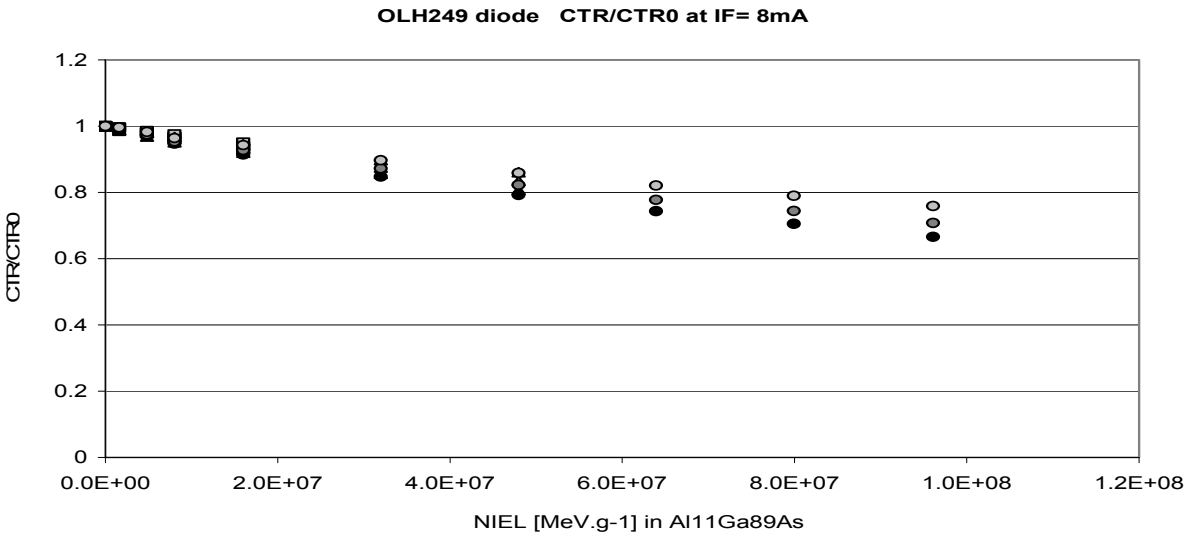

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-120: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

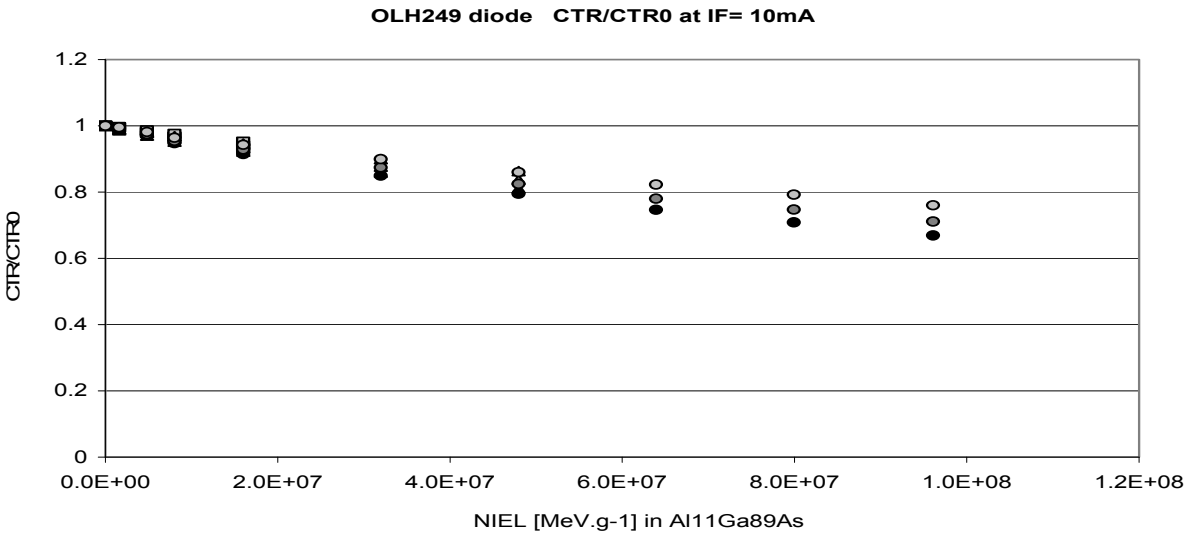
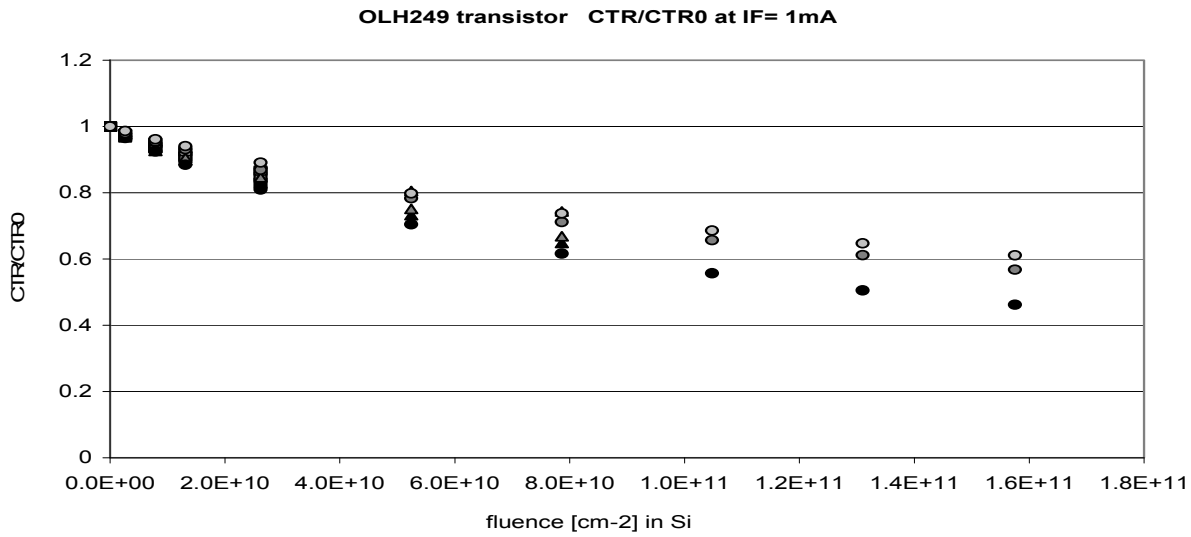
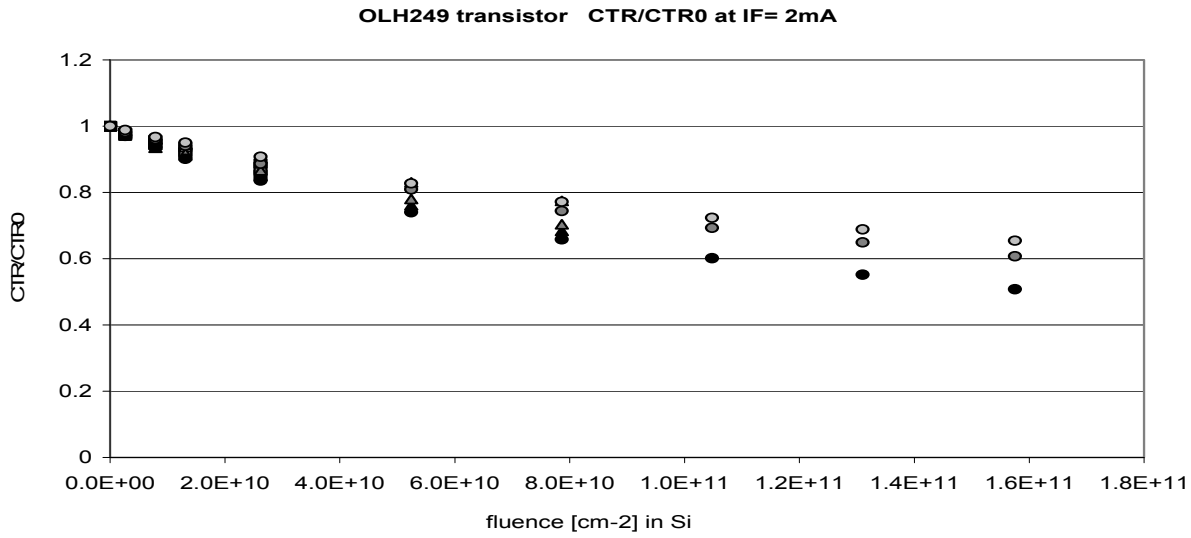
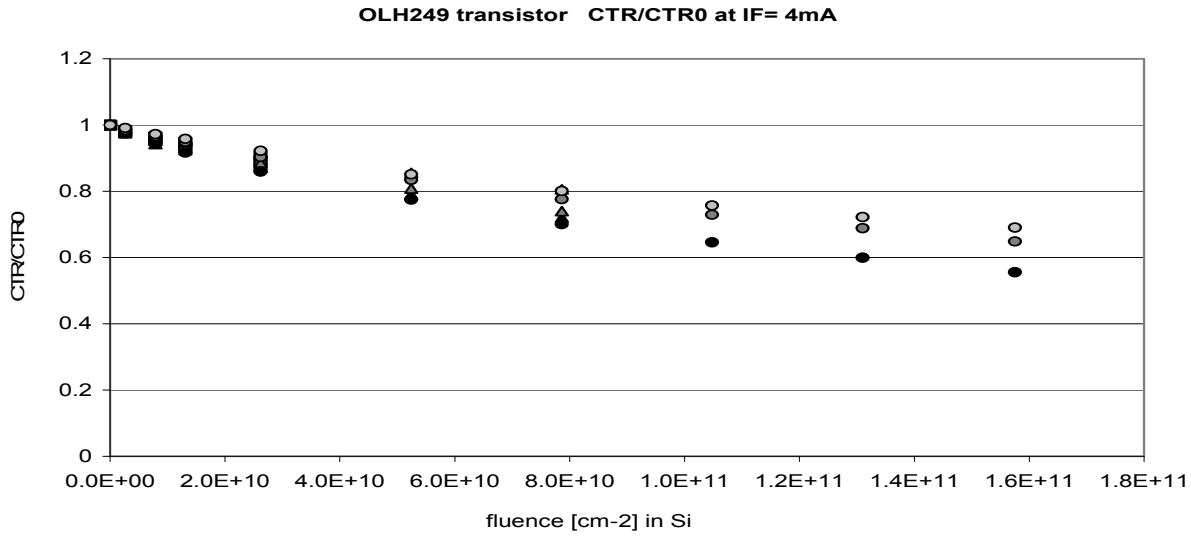
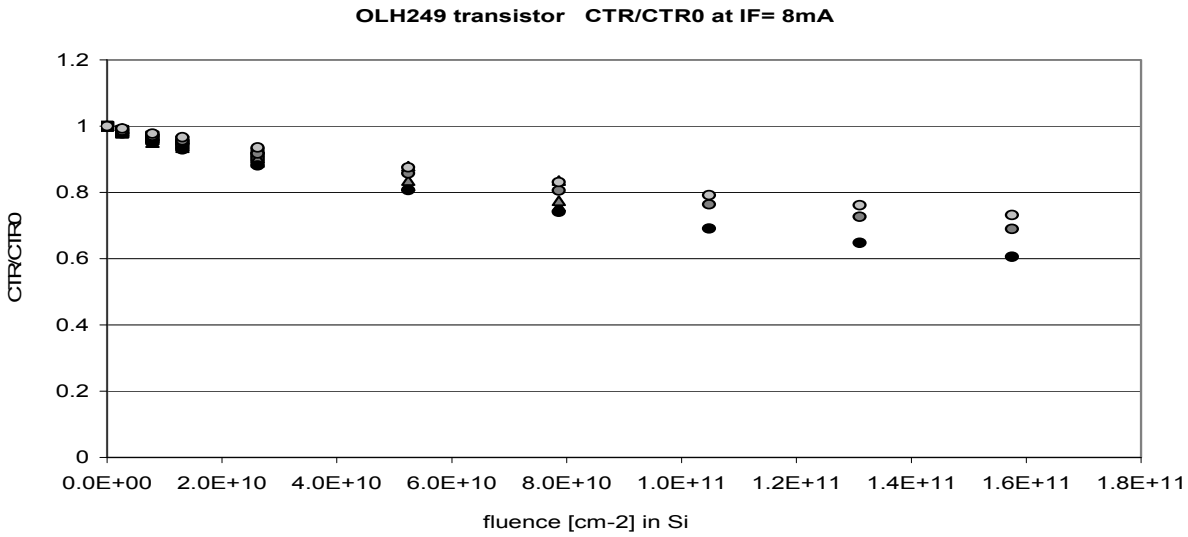

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-121: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

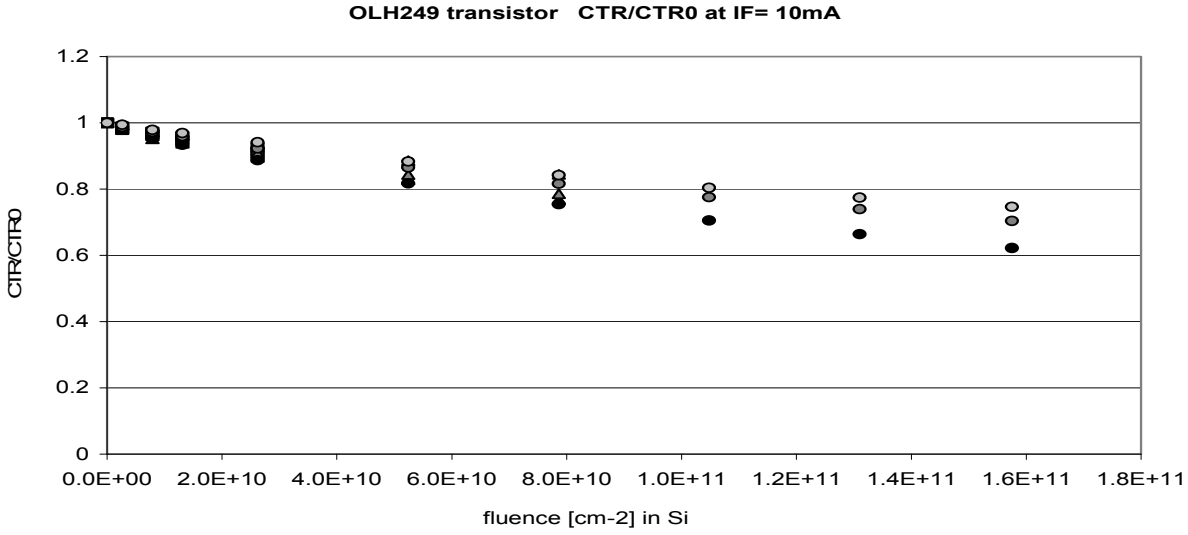
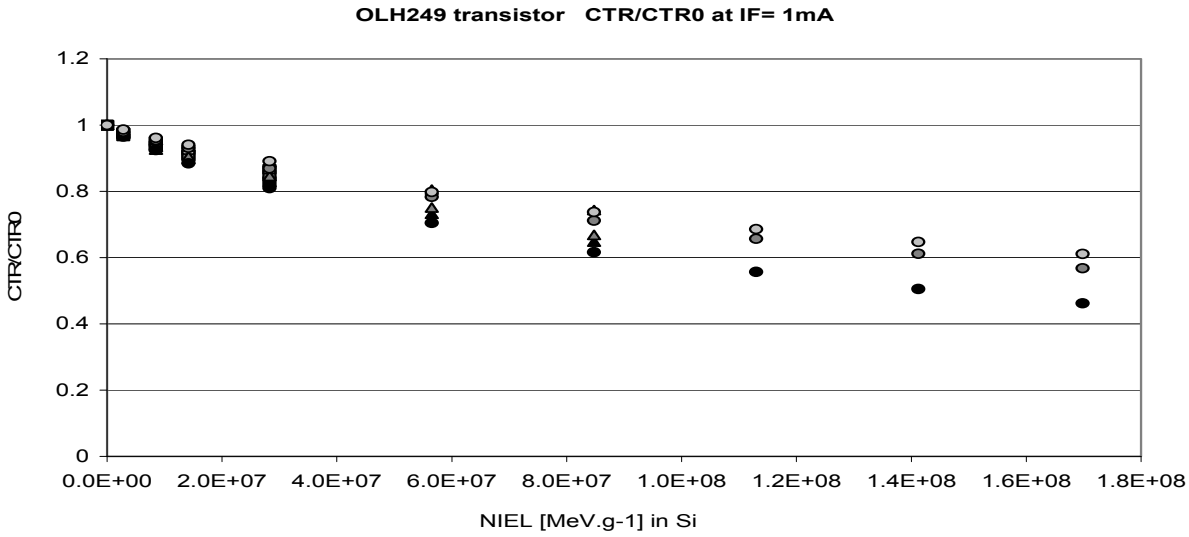
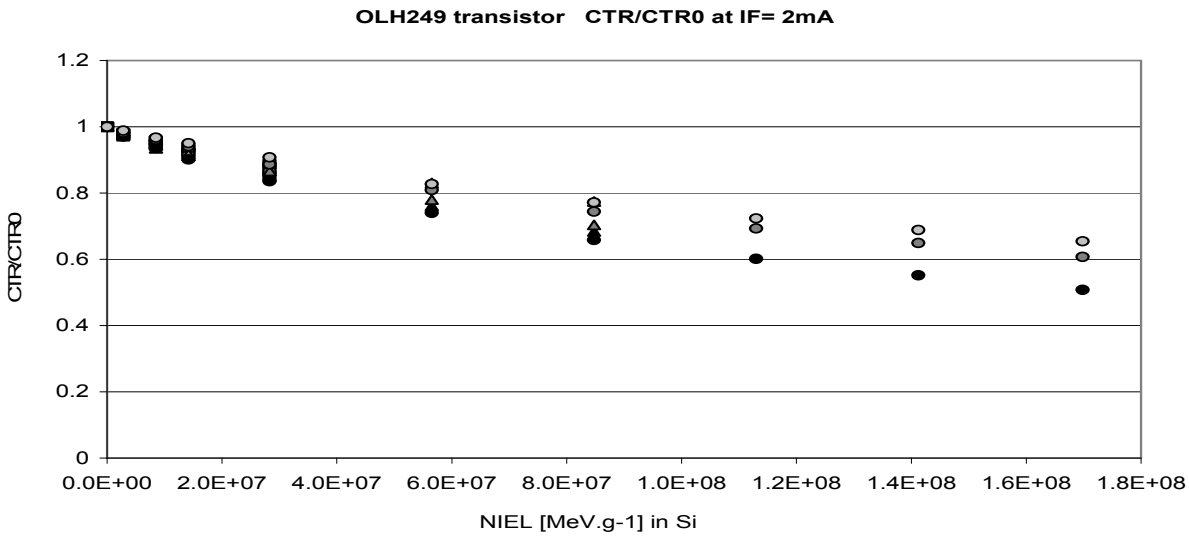
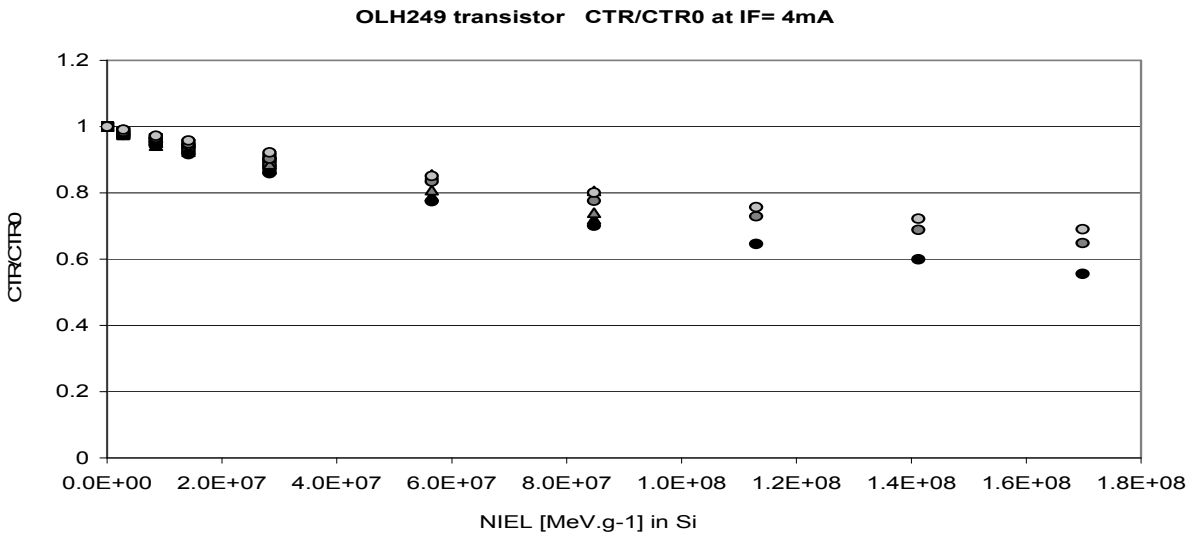
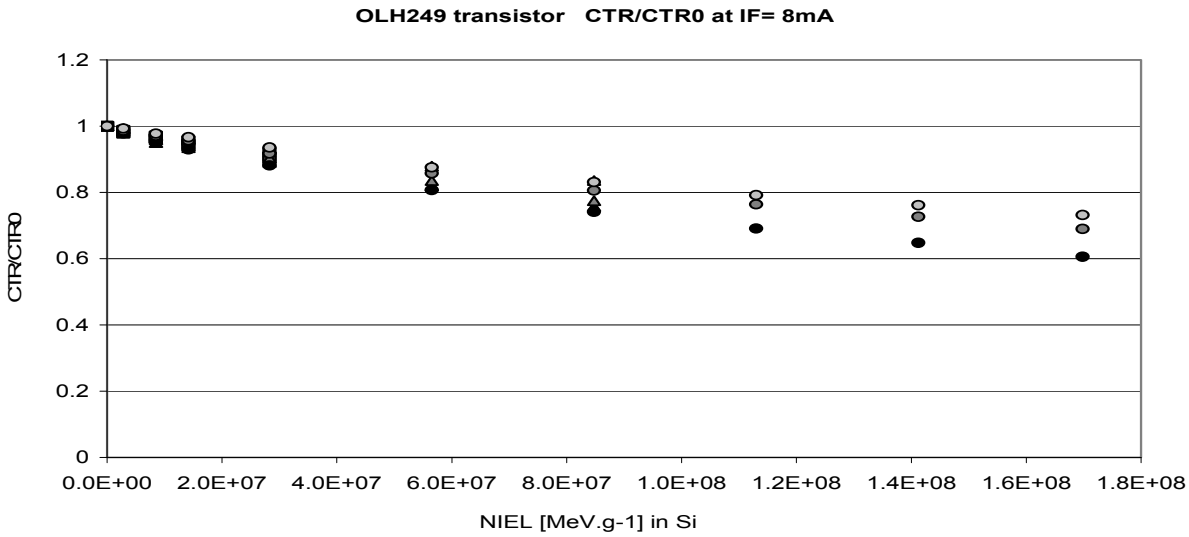

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 13-122: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

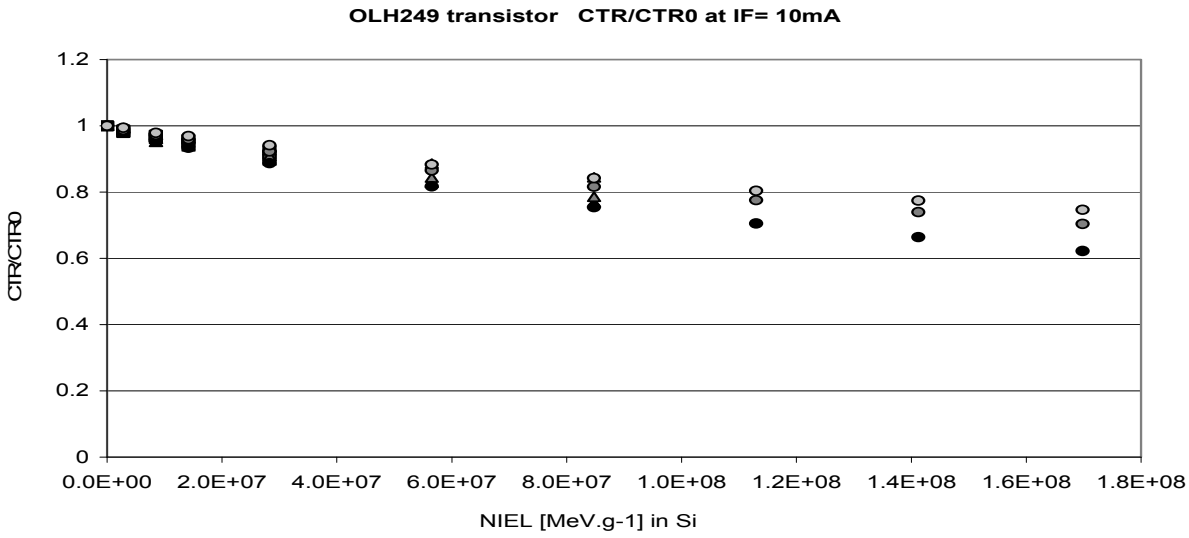
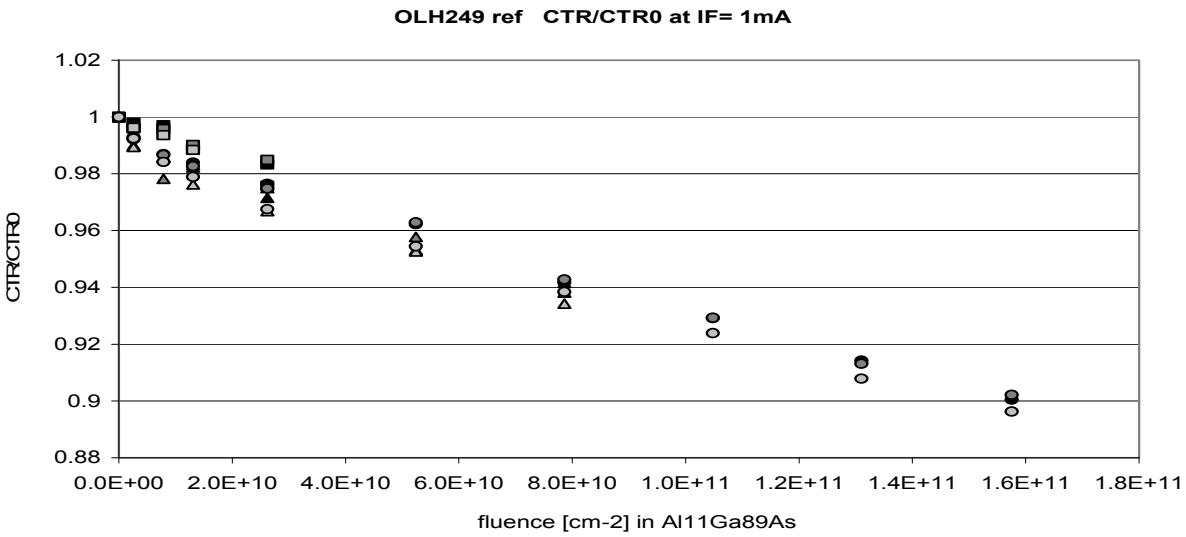
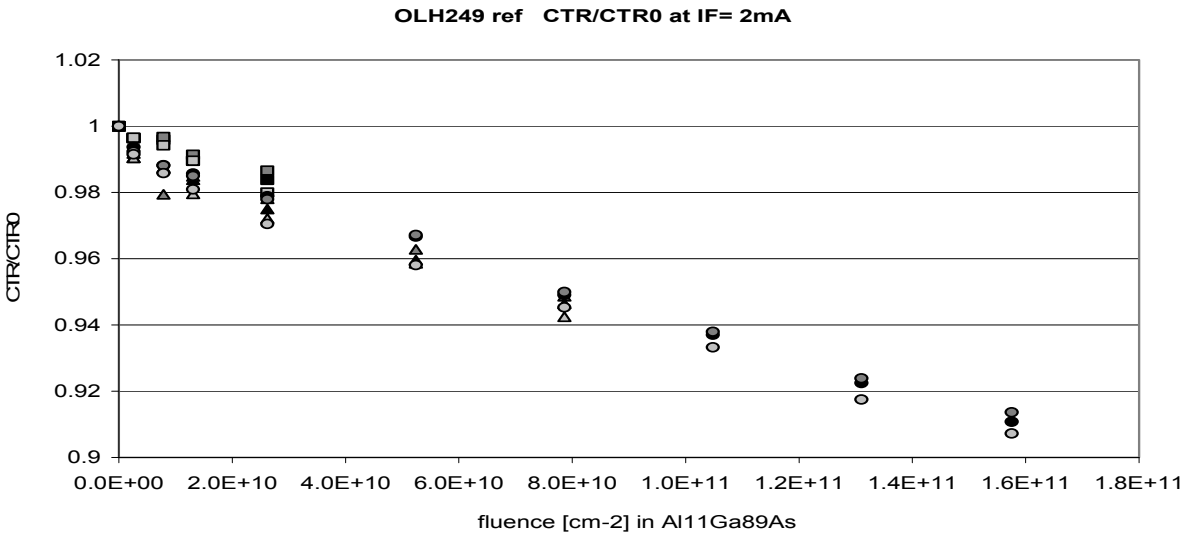
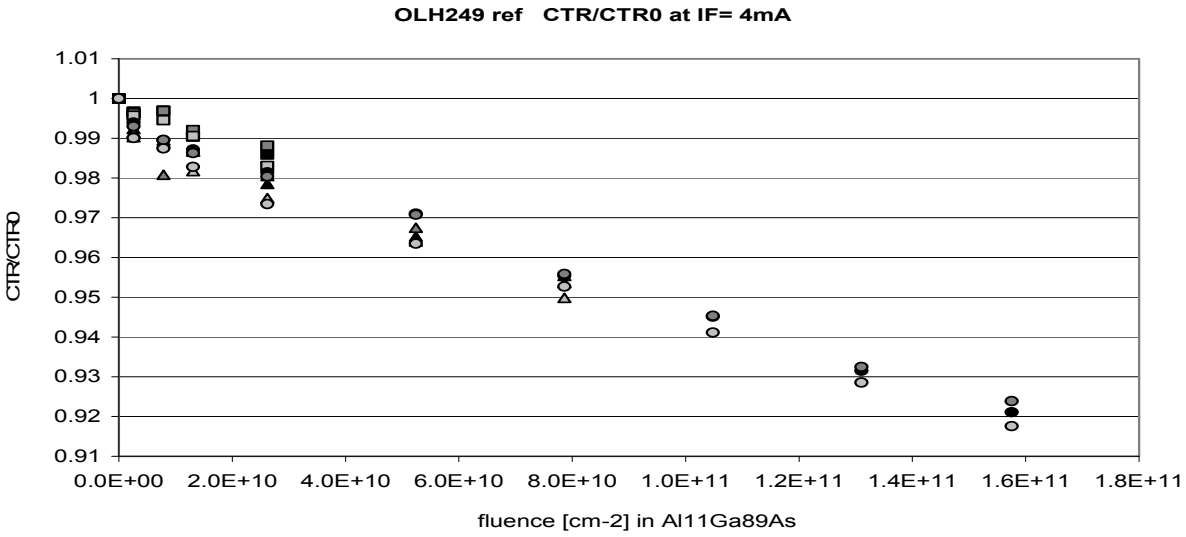
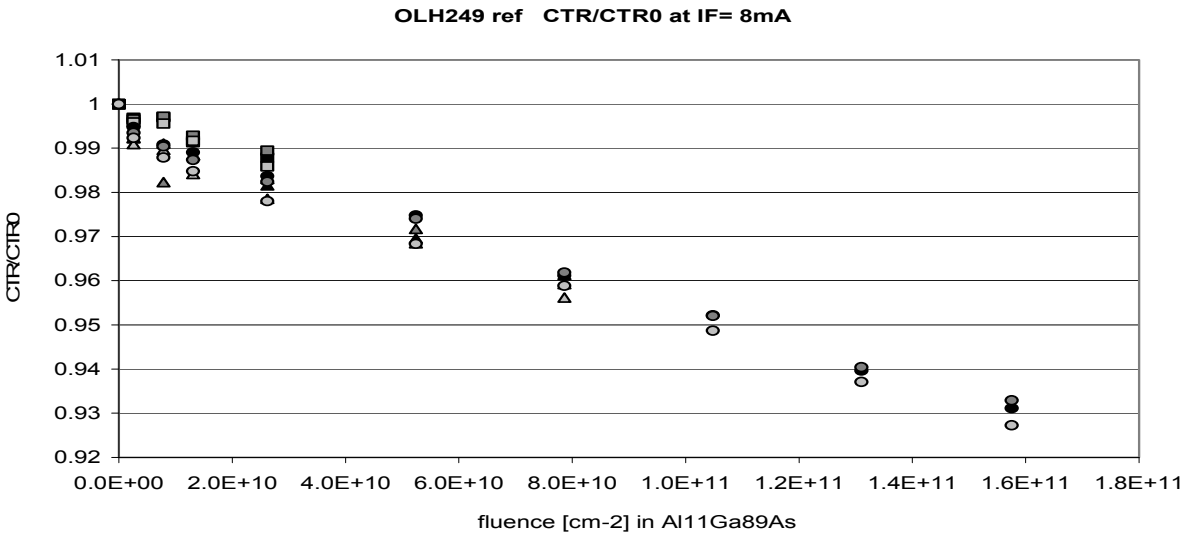

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-123: OLH249 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

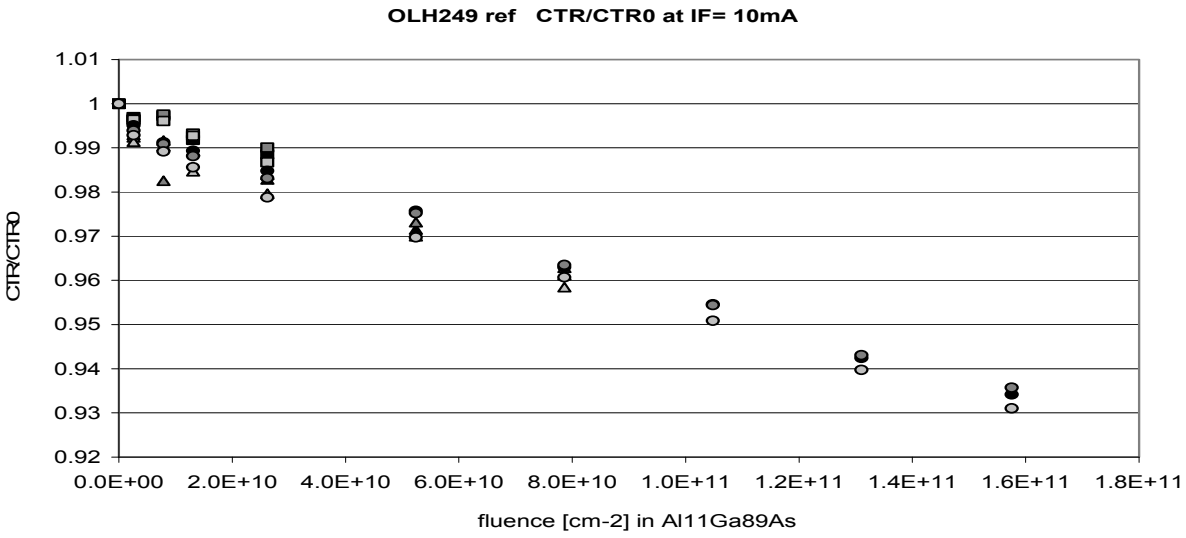
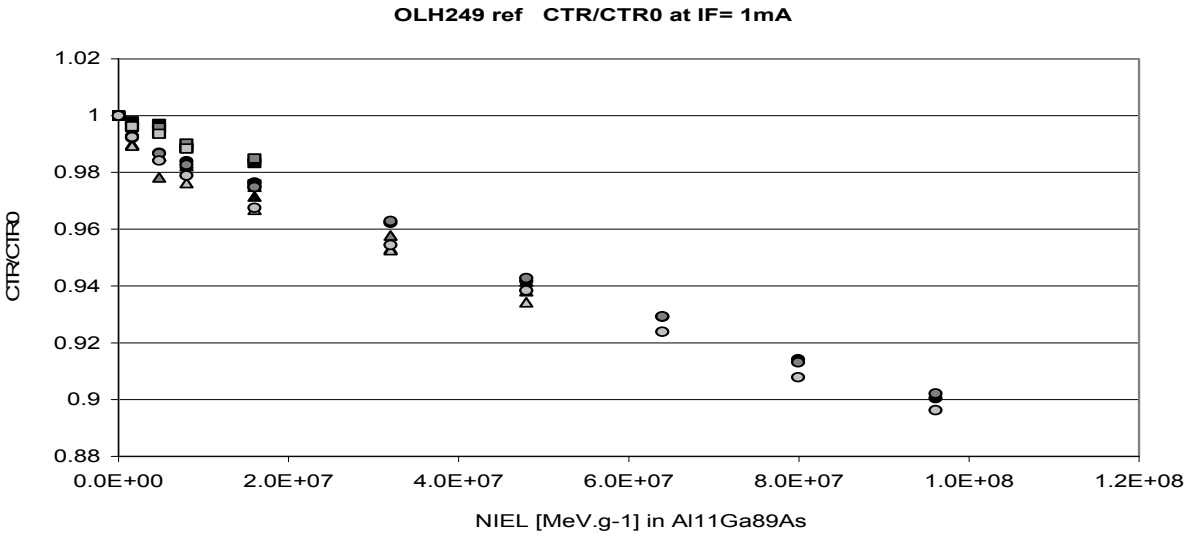
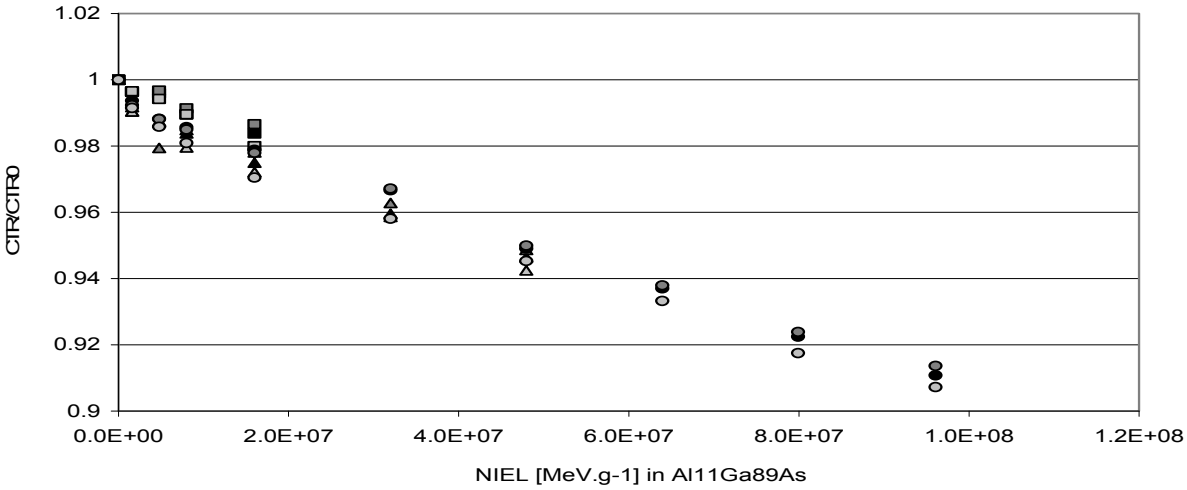
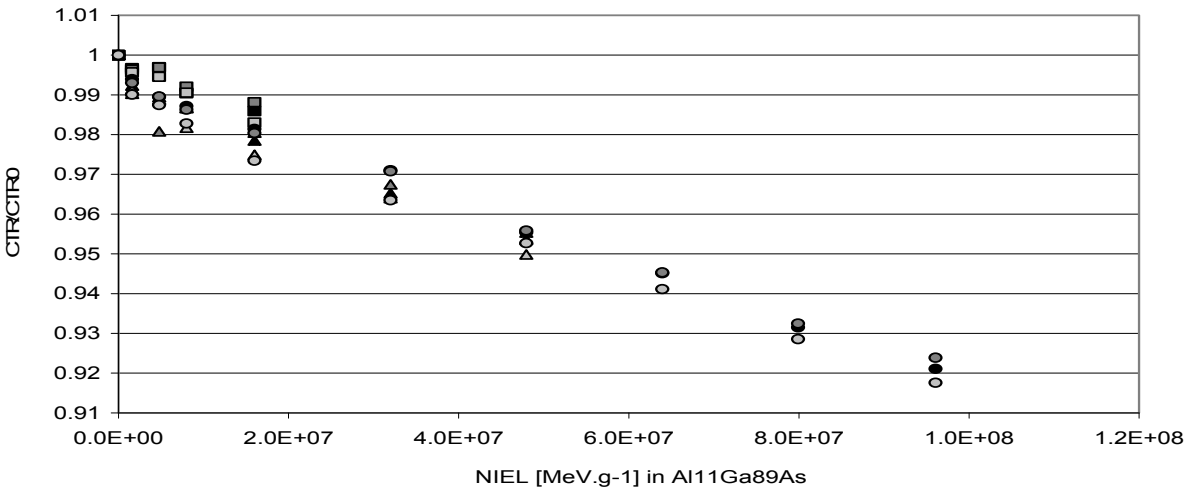
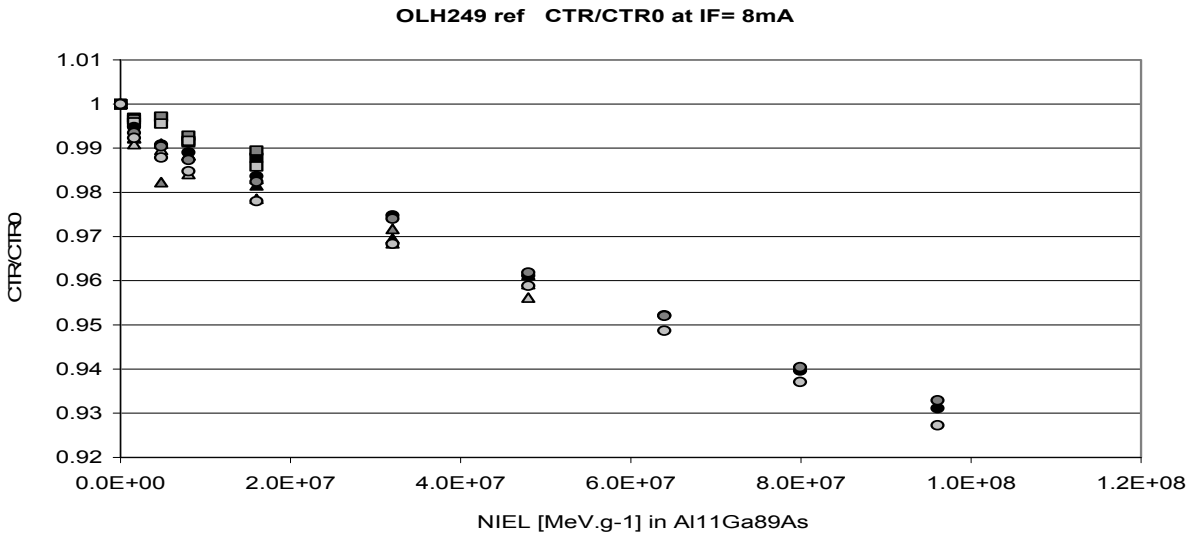

OLH249 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-124: OLH249 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

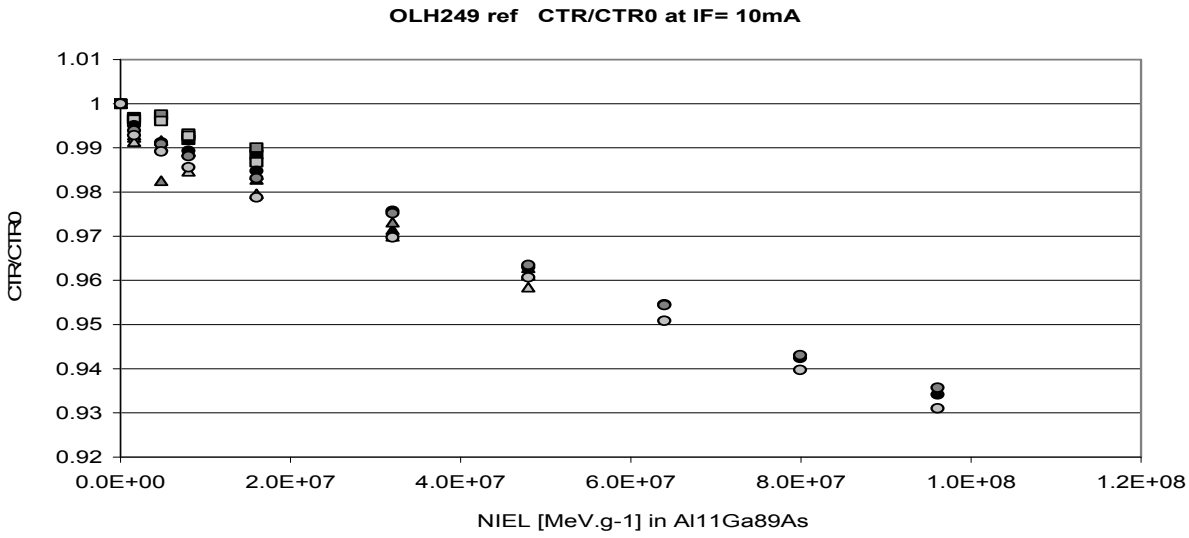
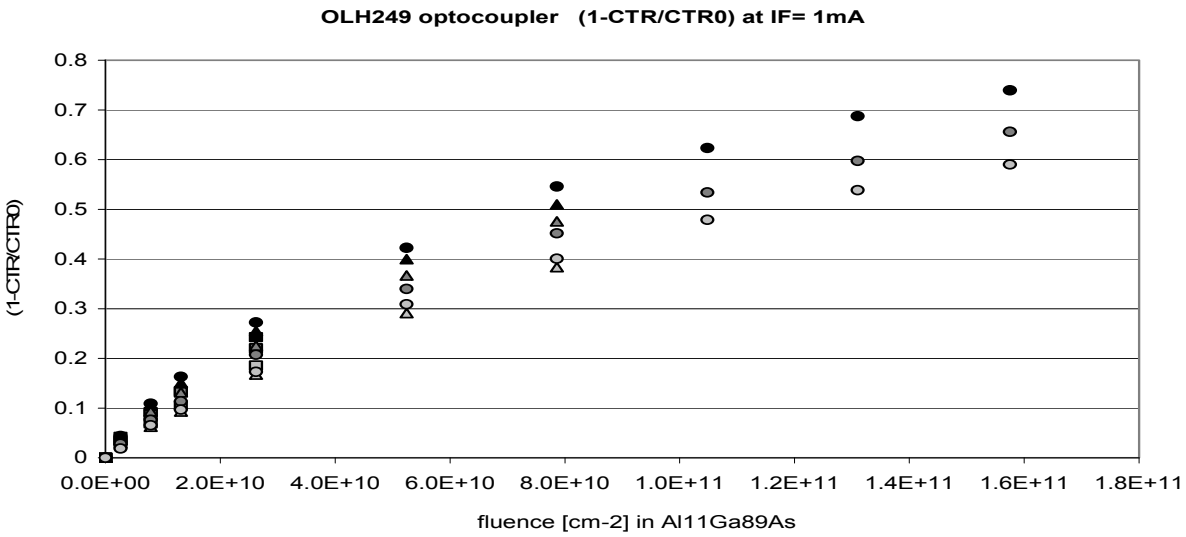
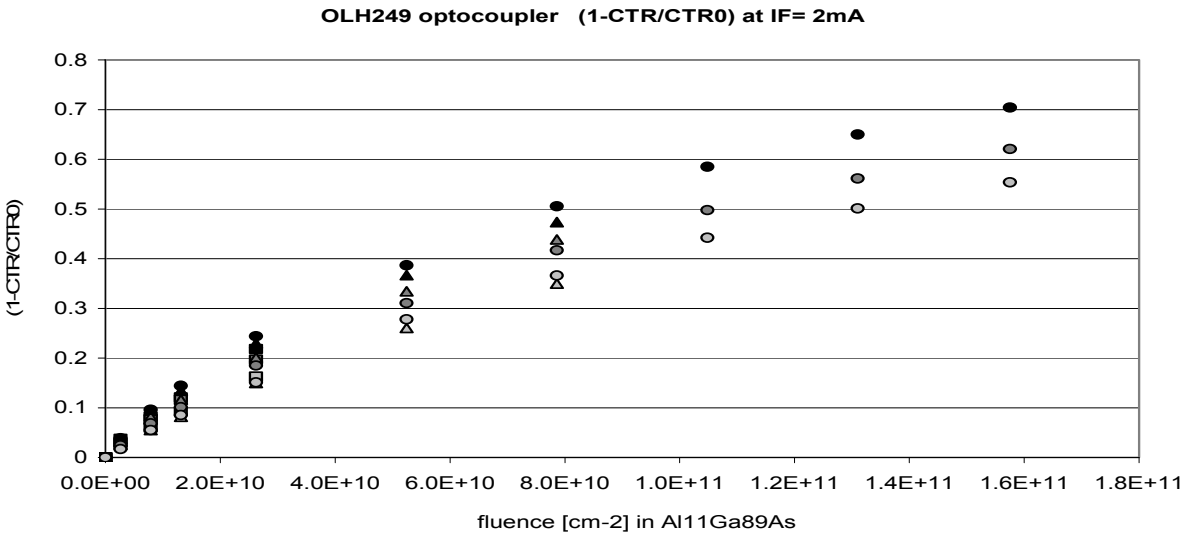
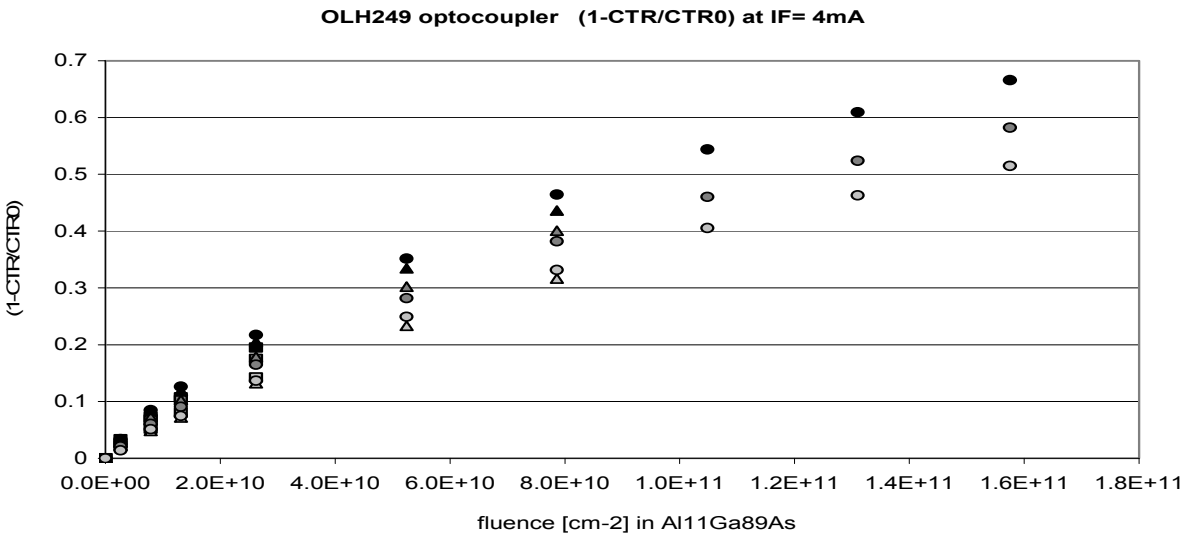
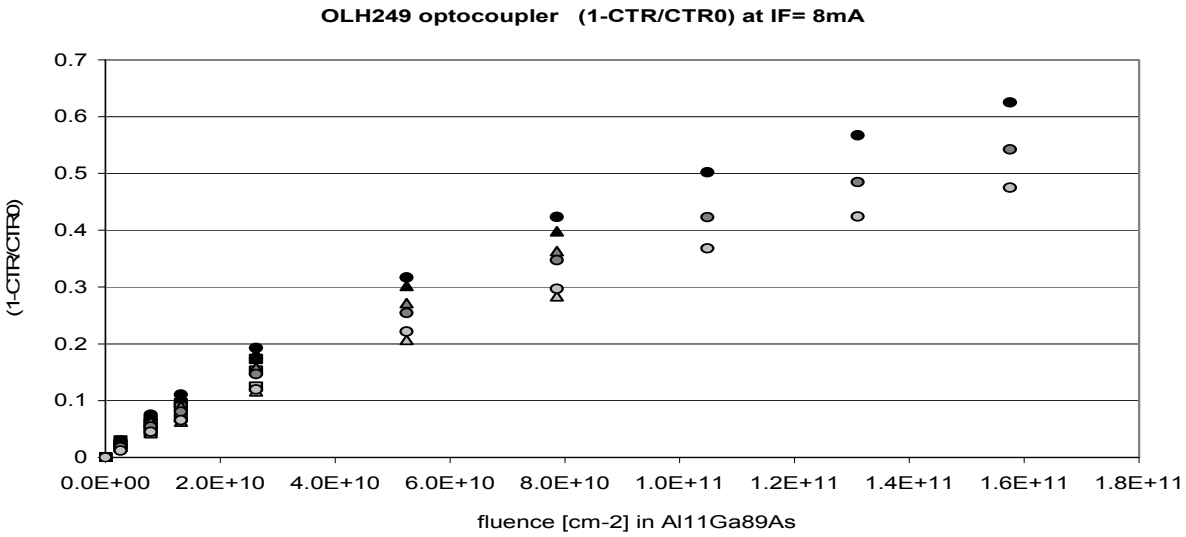

OLH249 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-125: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

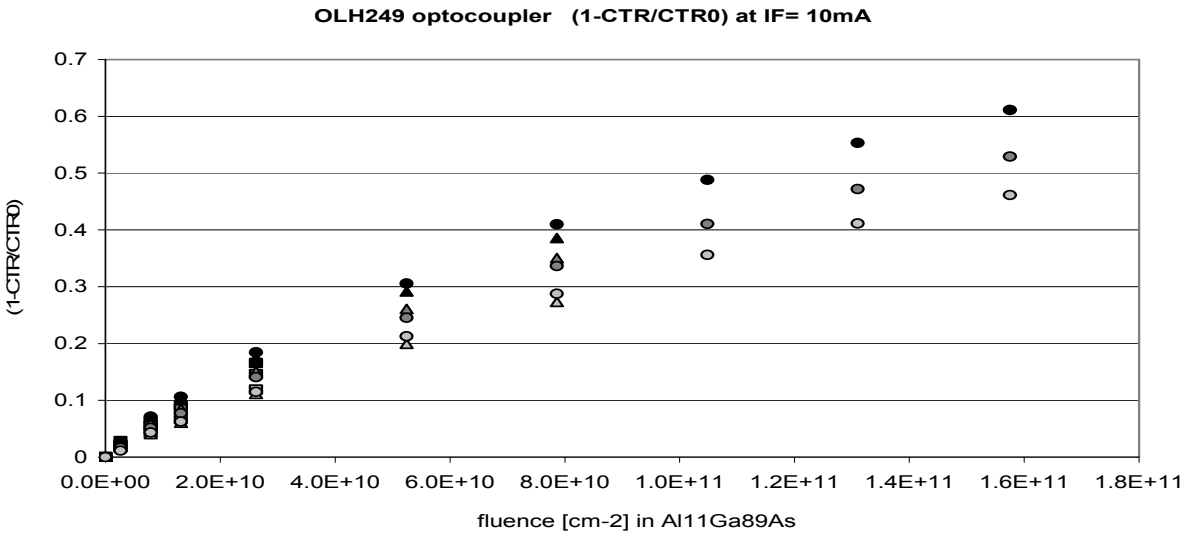
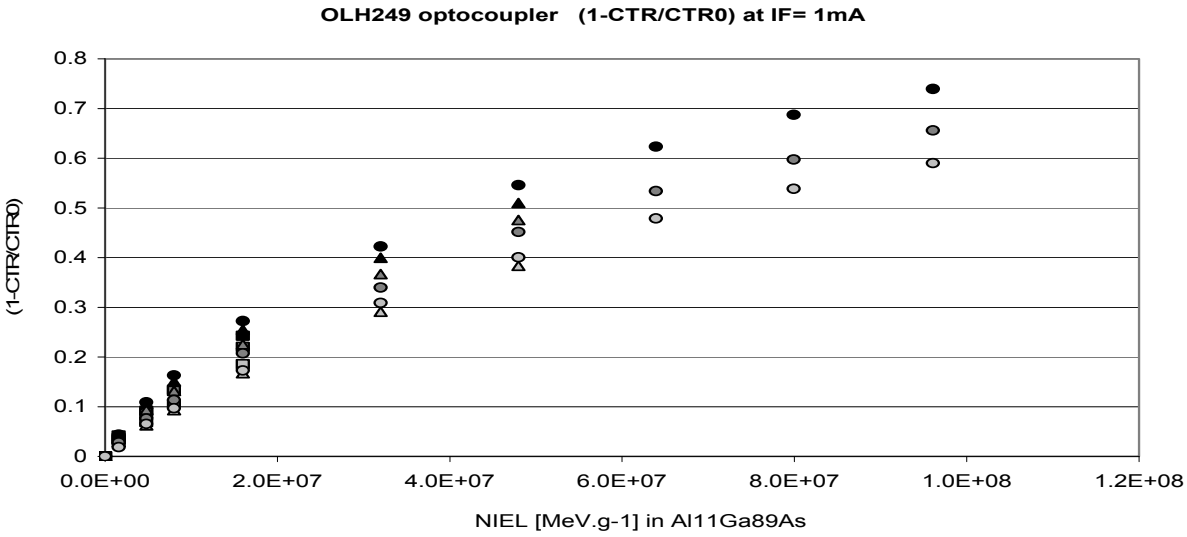
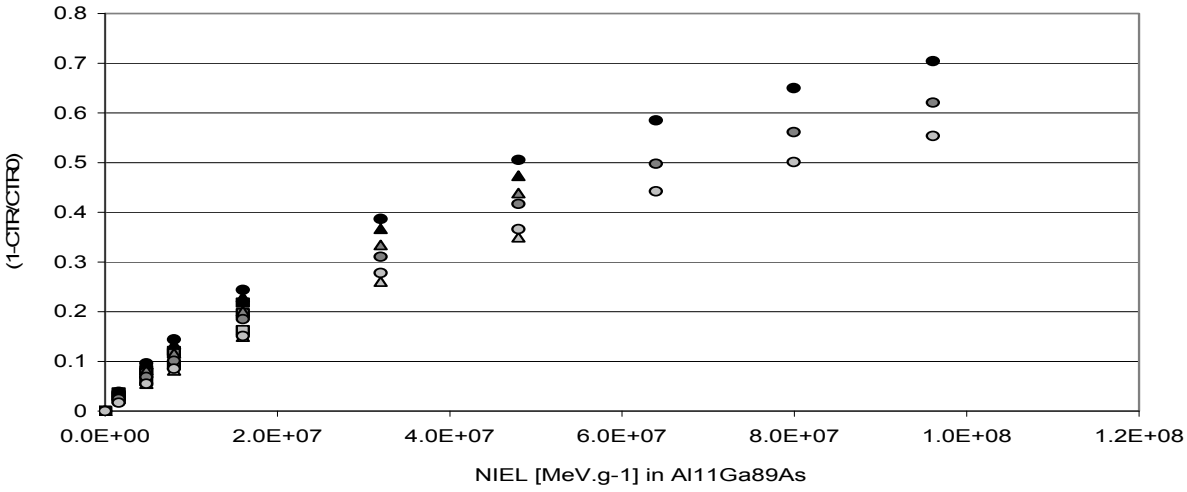
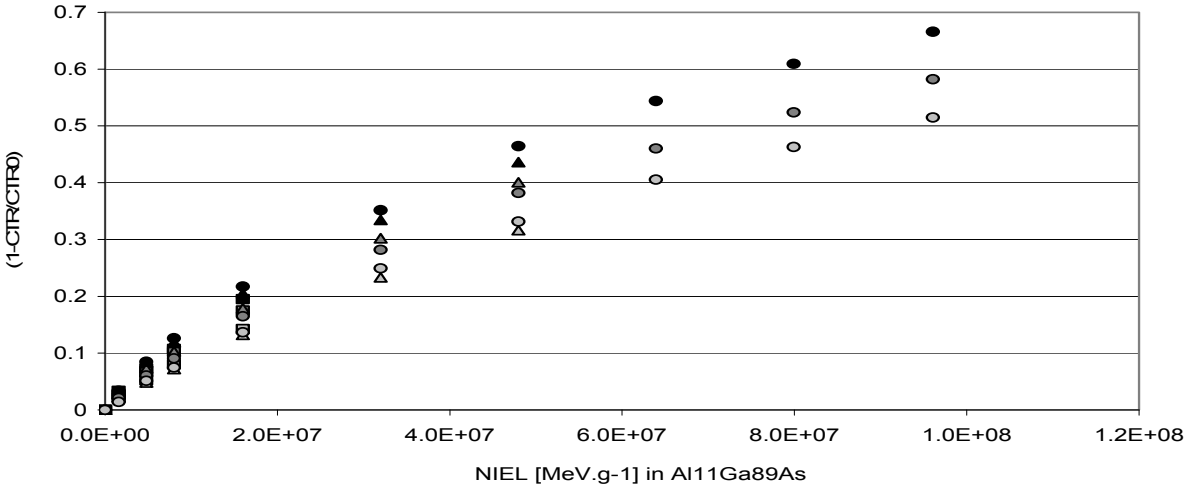
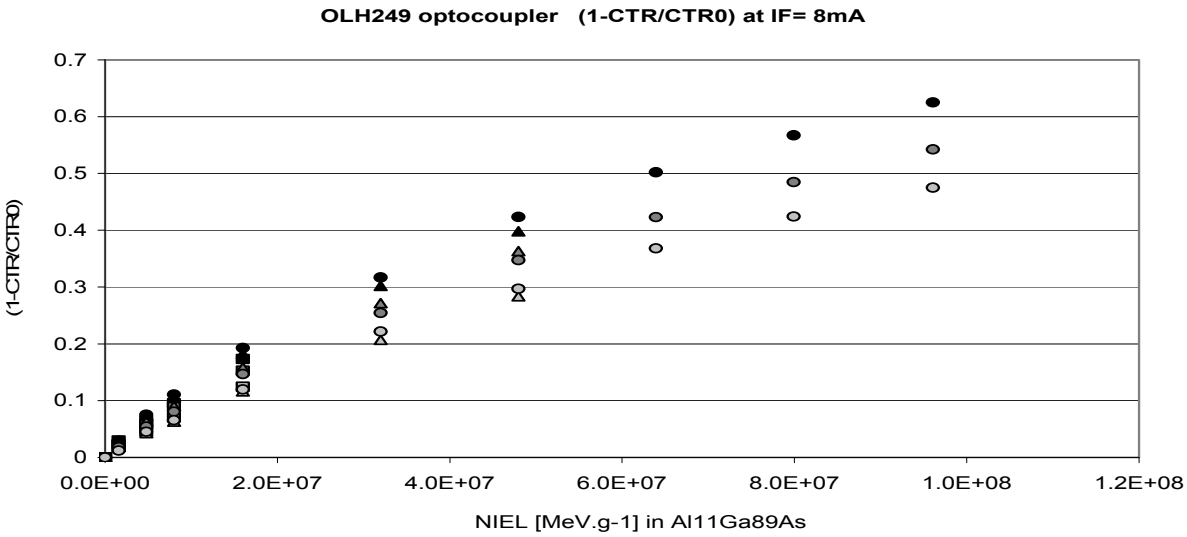

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-126: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

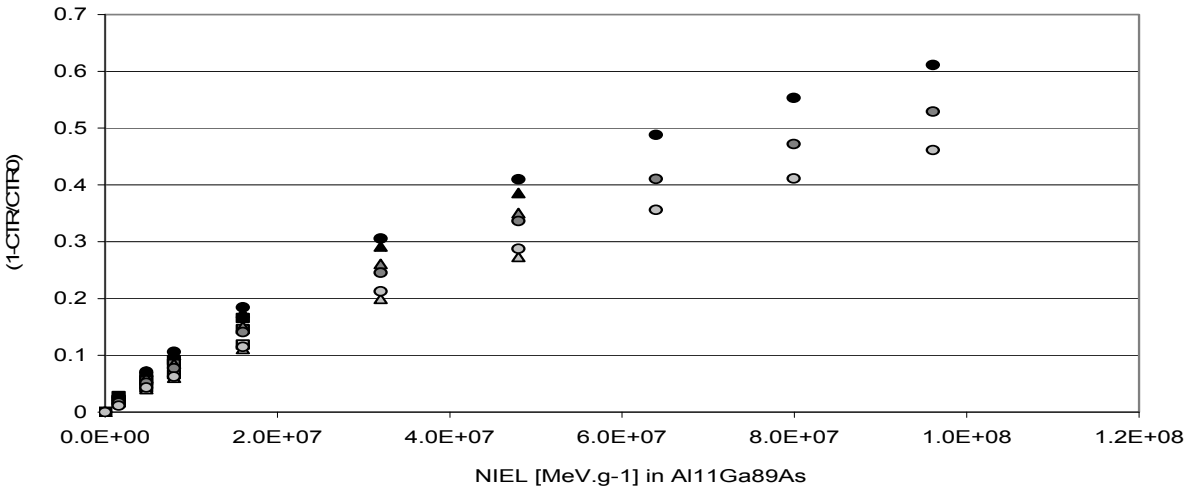
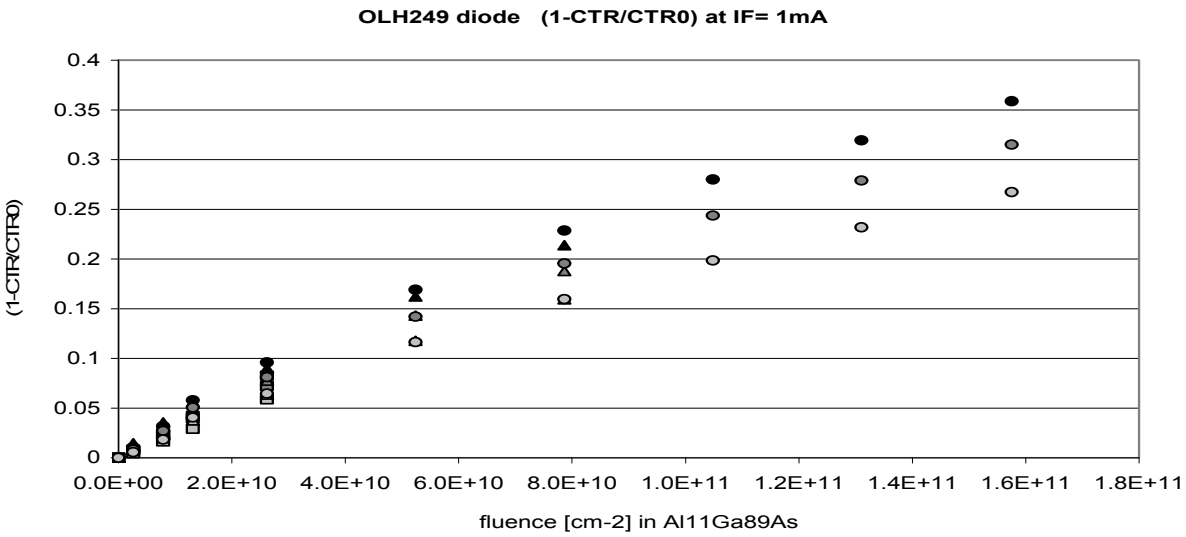
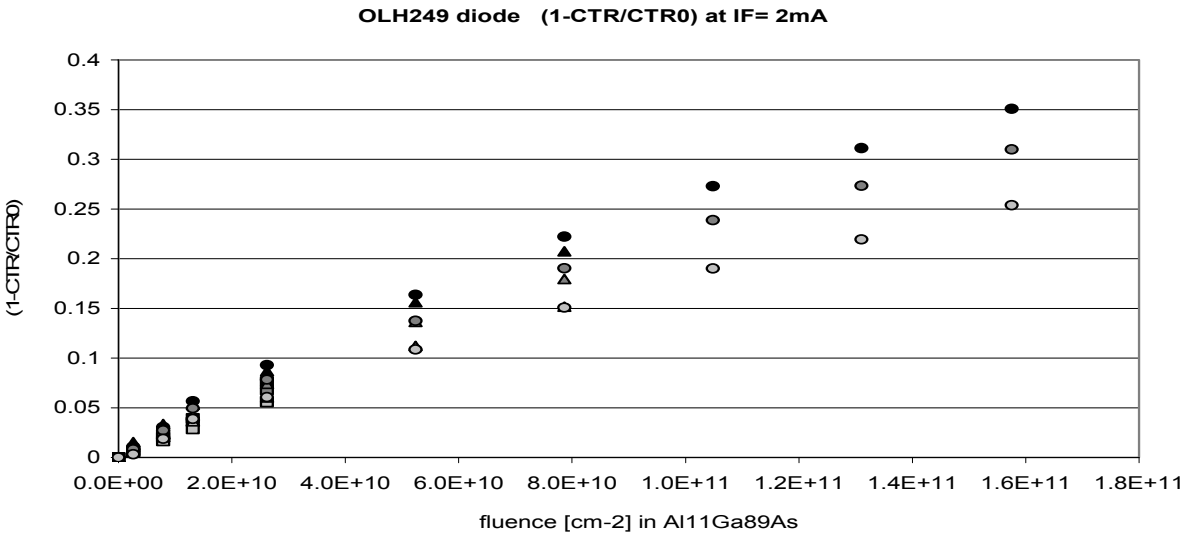
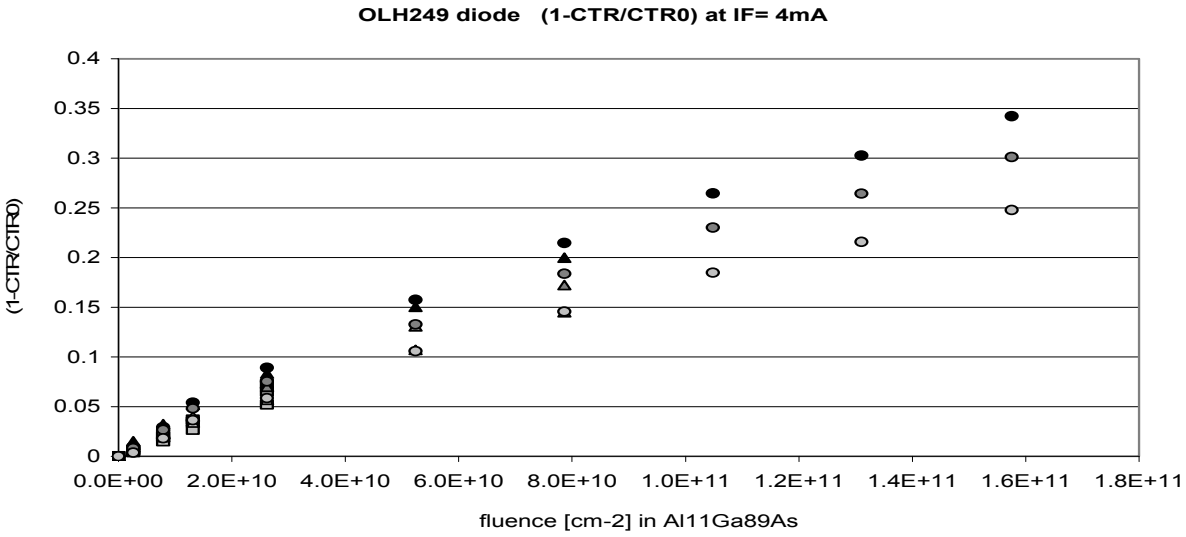
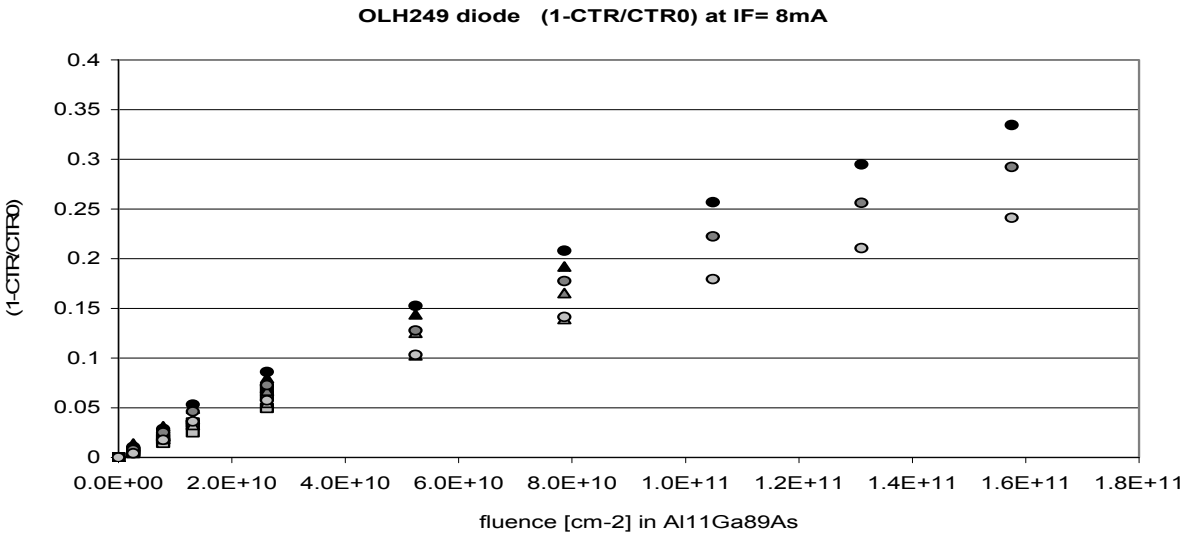

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-127: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

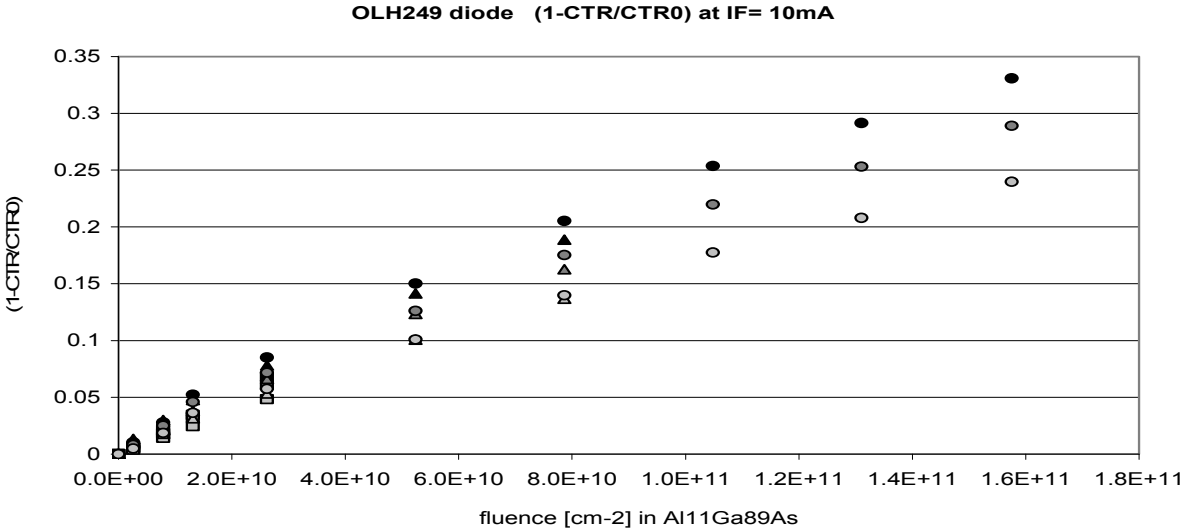
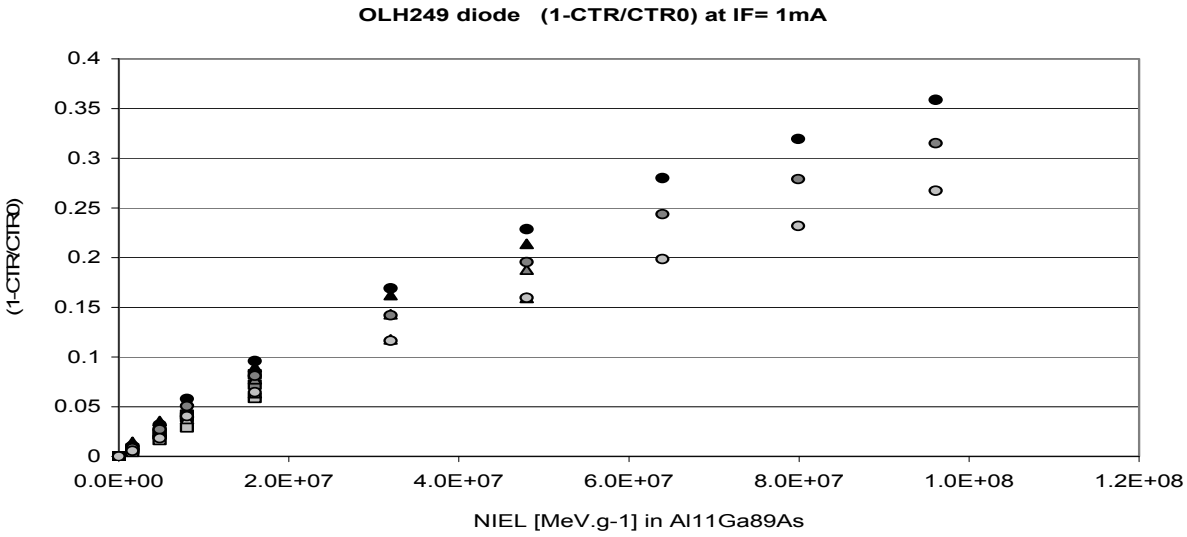
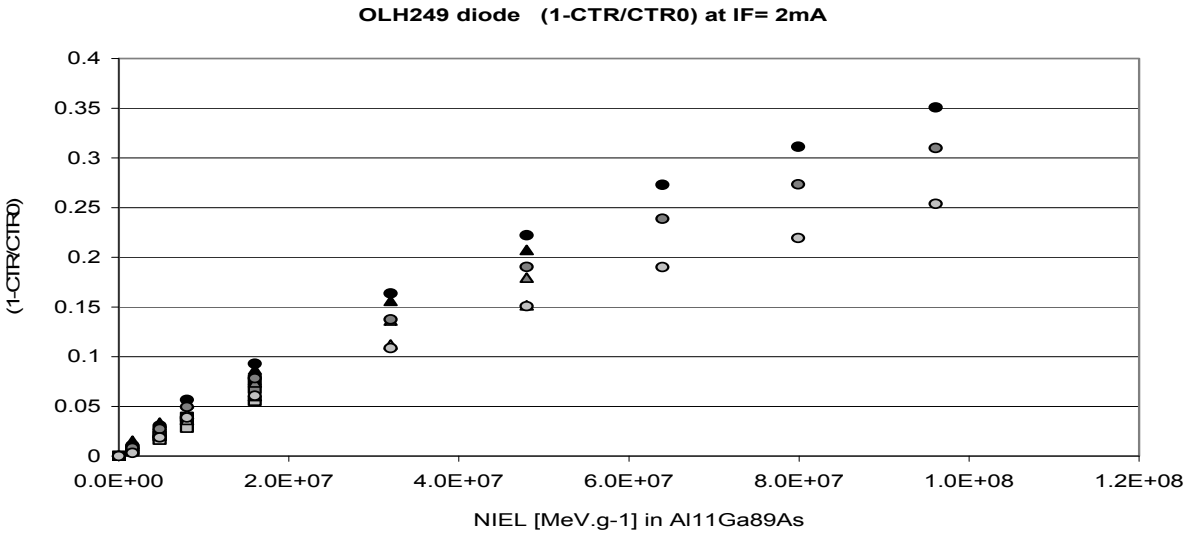
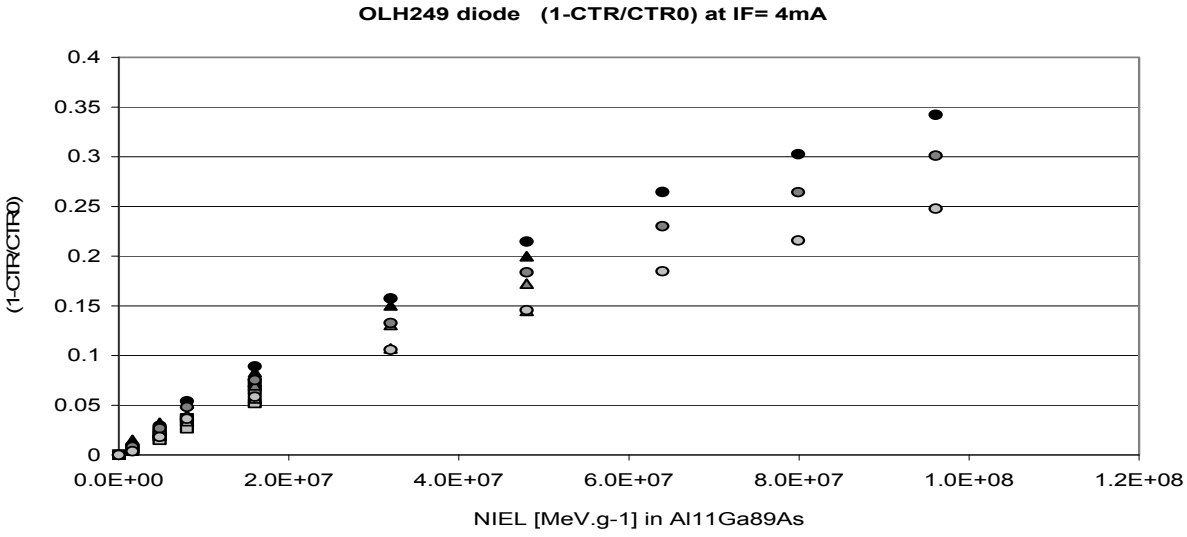
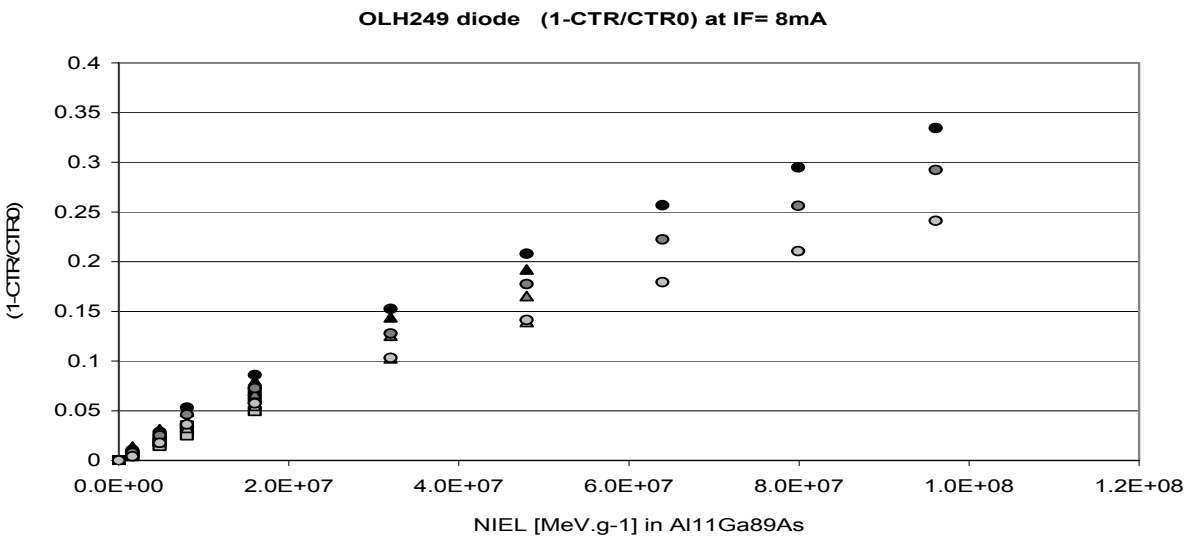

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-128: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Al$_{0.11}$Ga$_{0.89}$As (GEANT4 TOTAL)








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

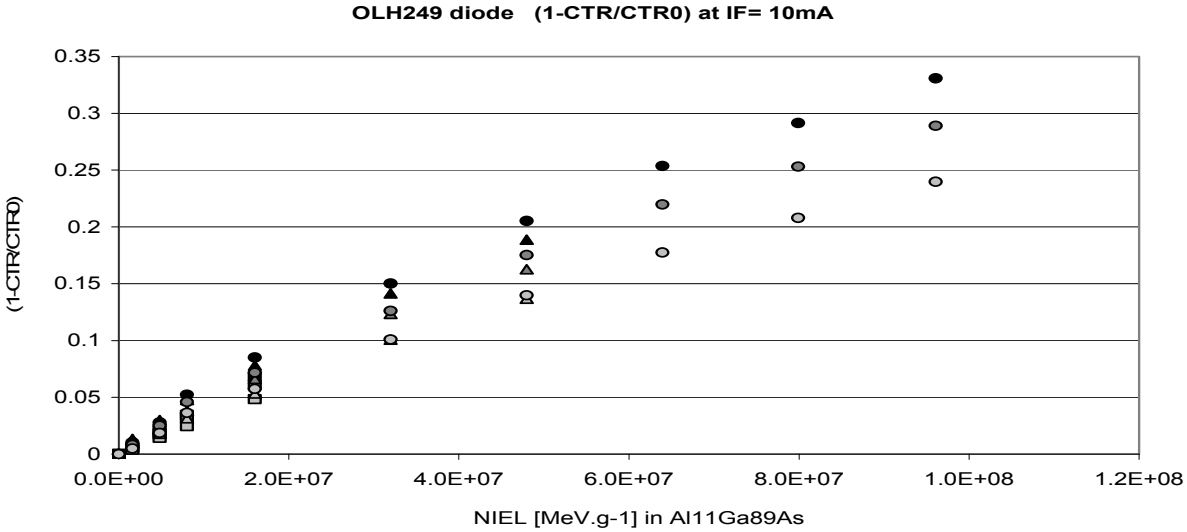
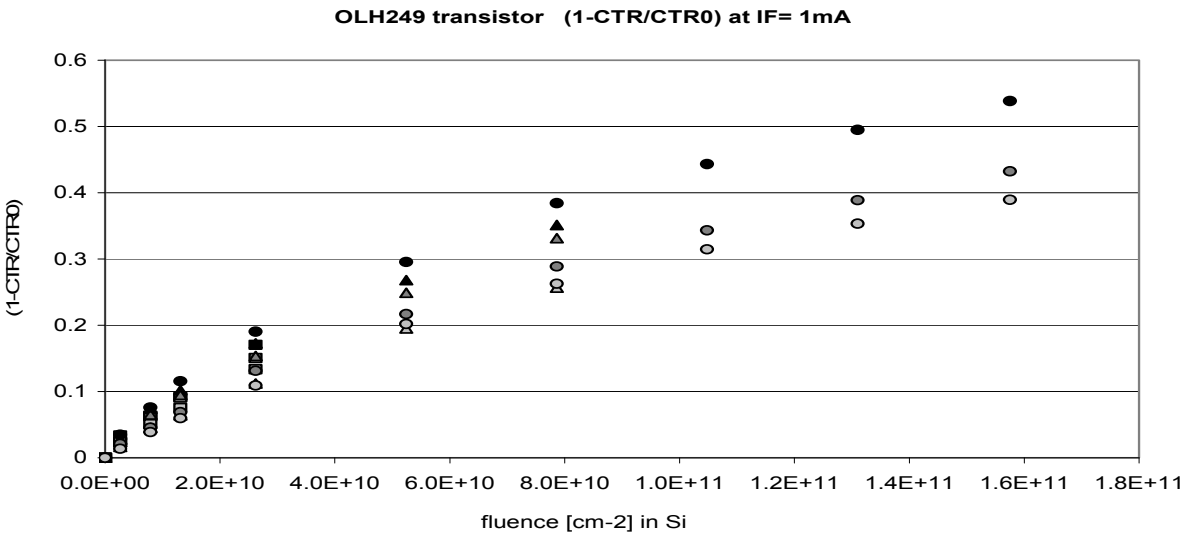
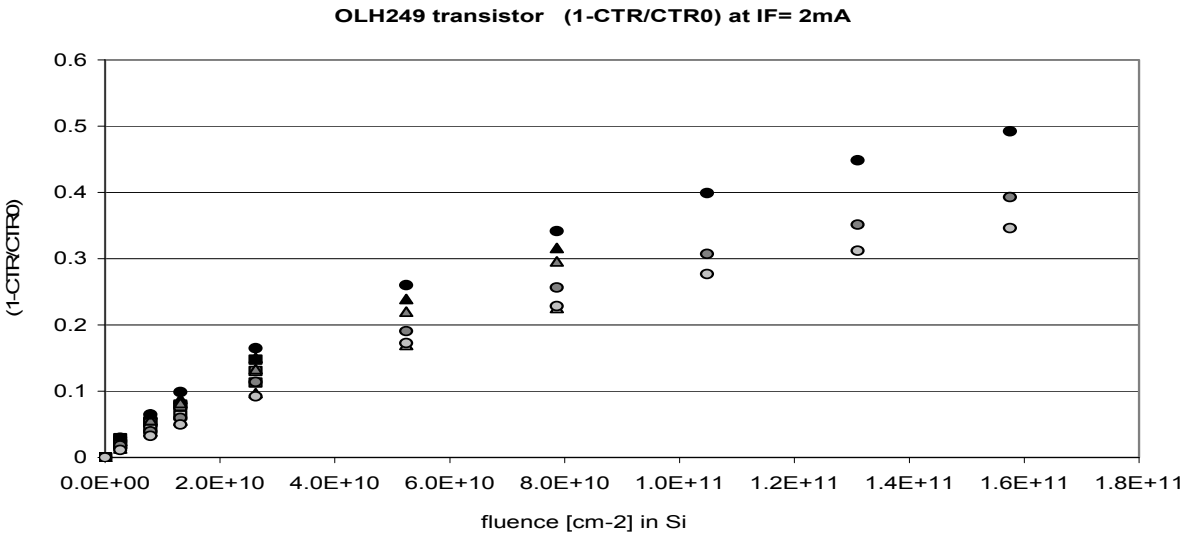
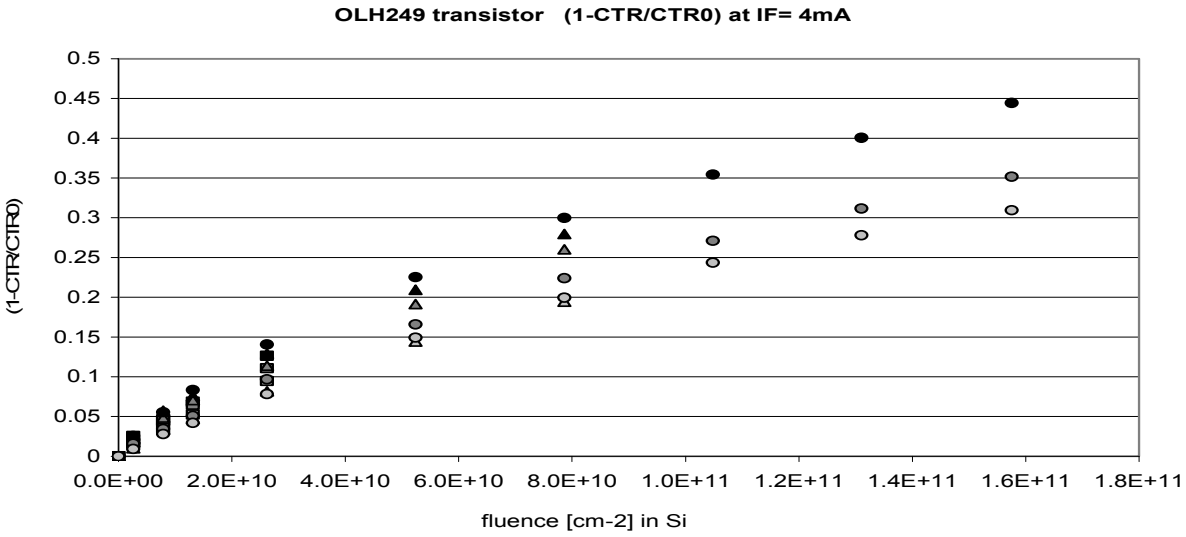
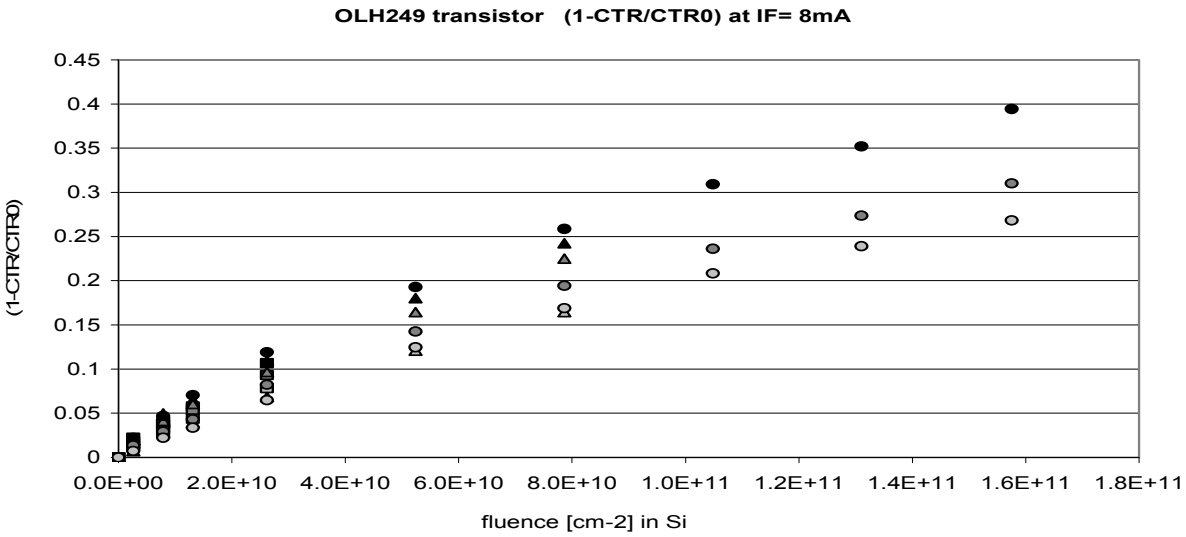

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-129: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

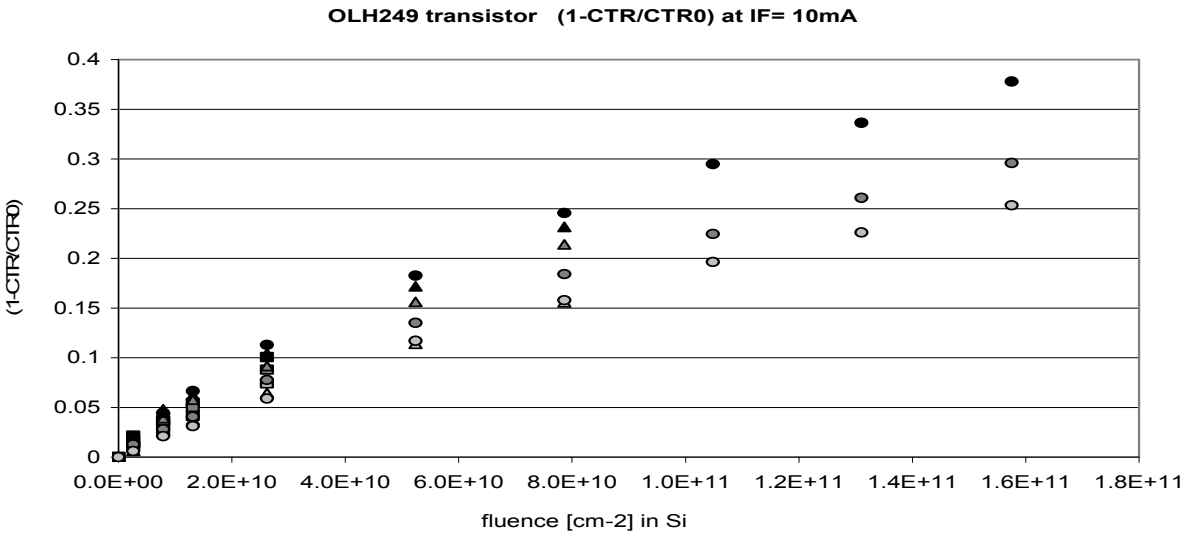
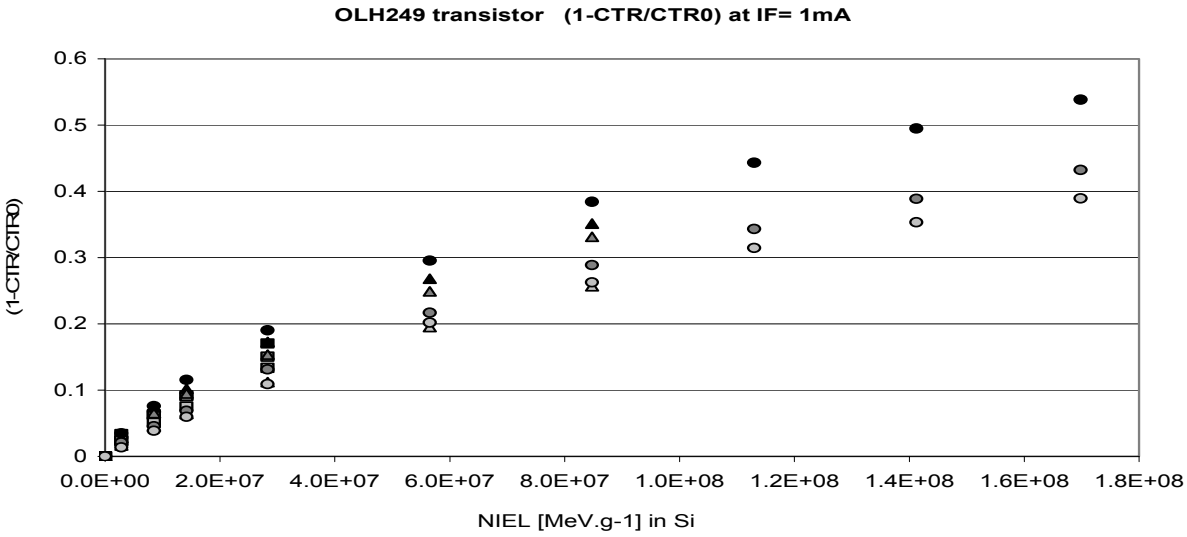
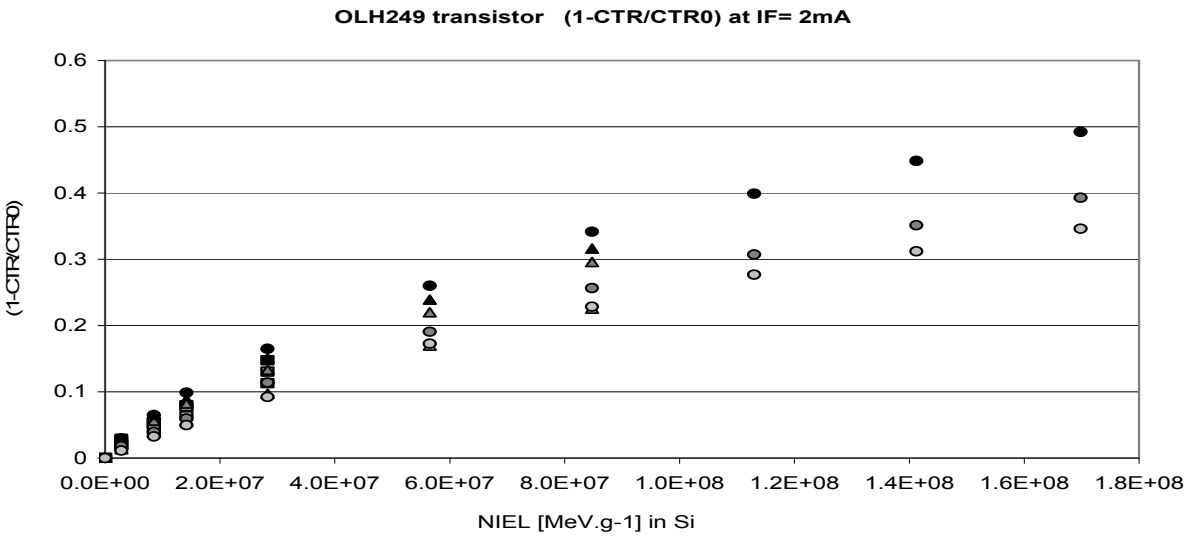
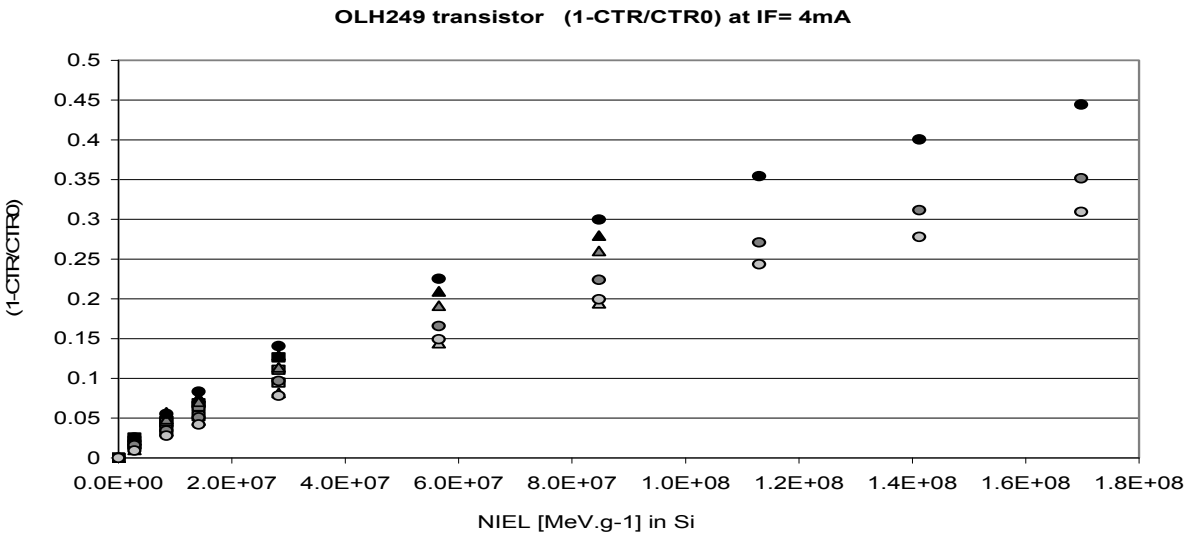
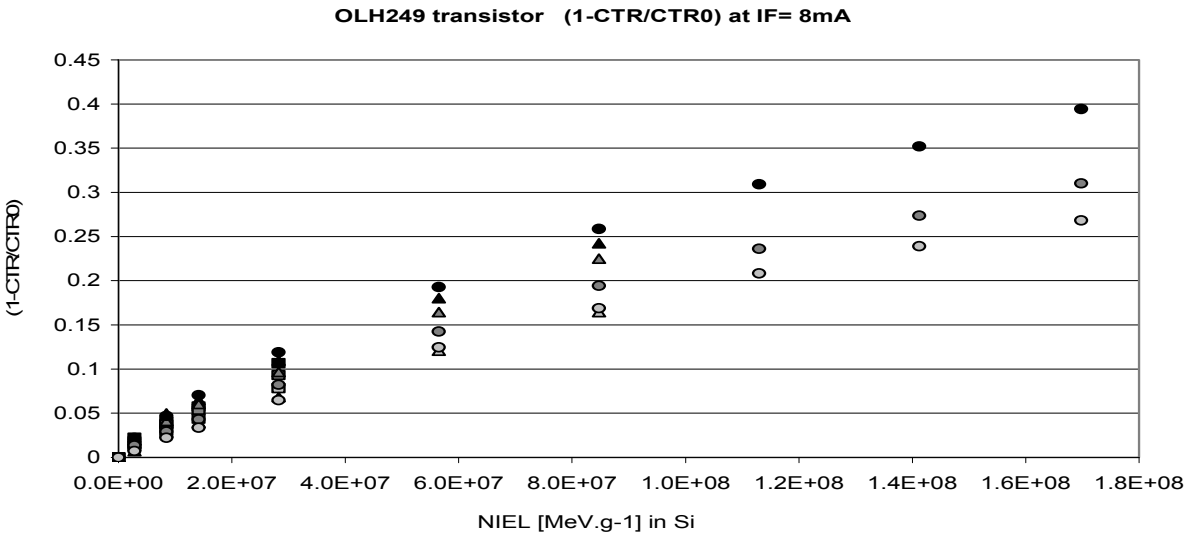

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 13-130: OLH249 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

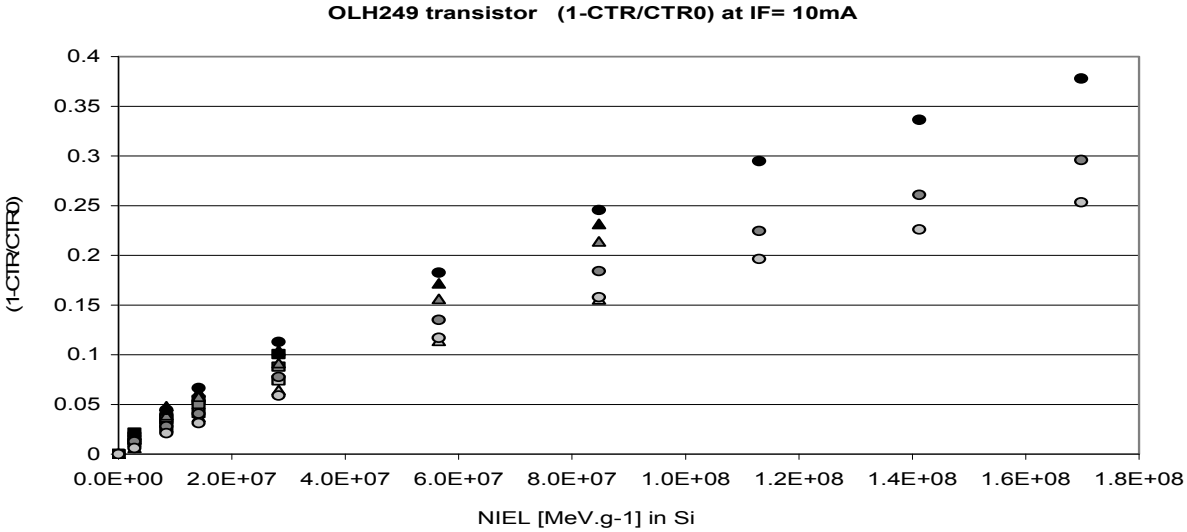
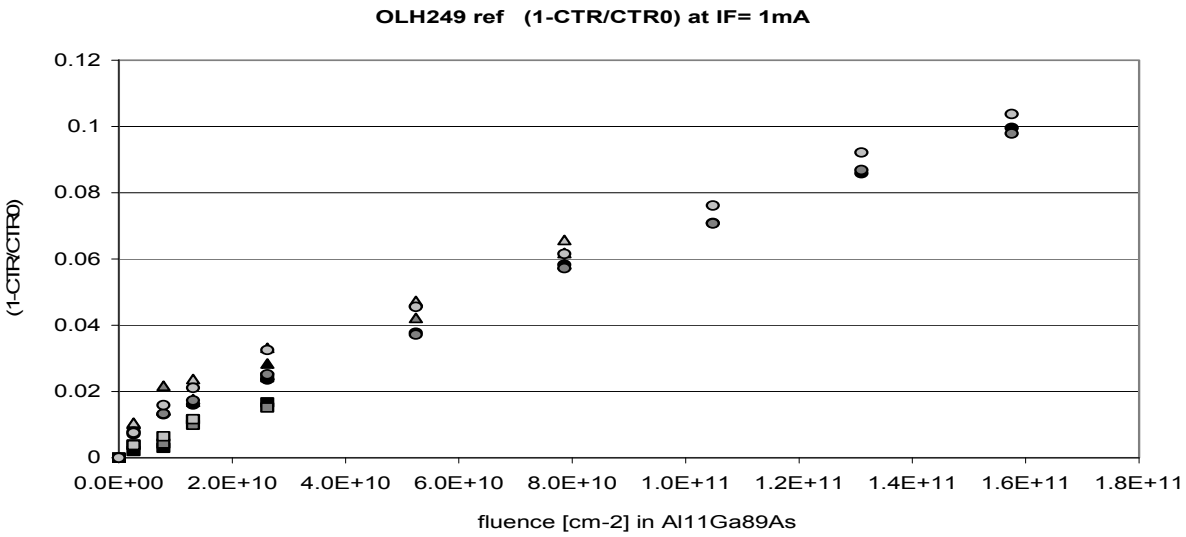
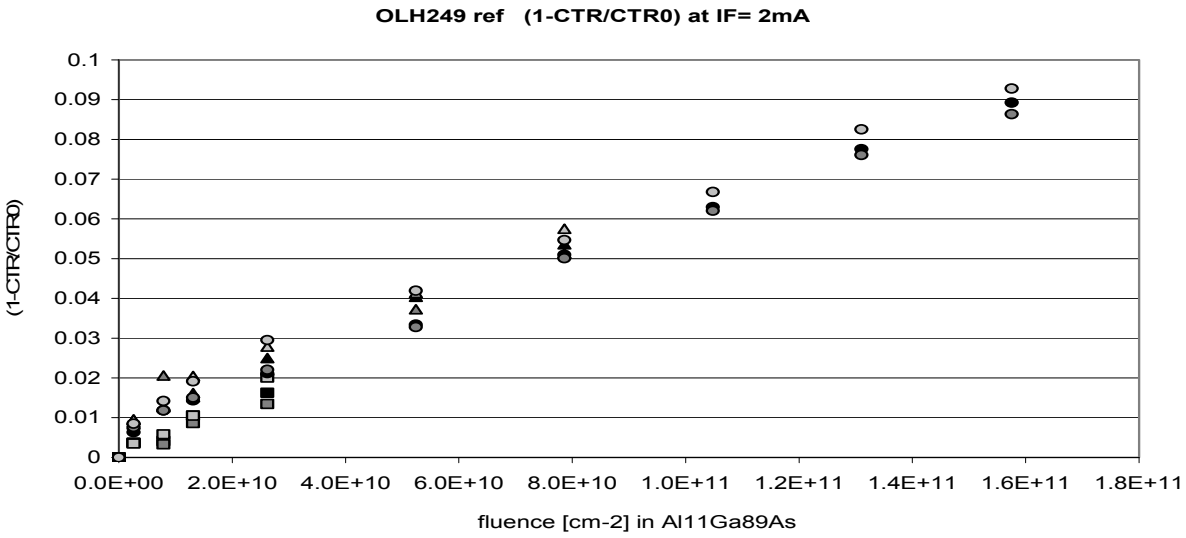
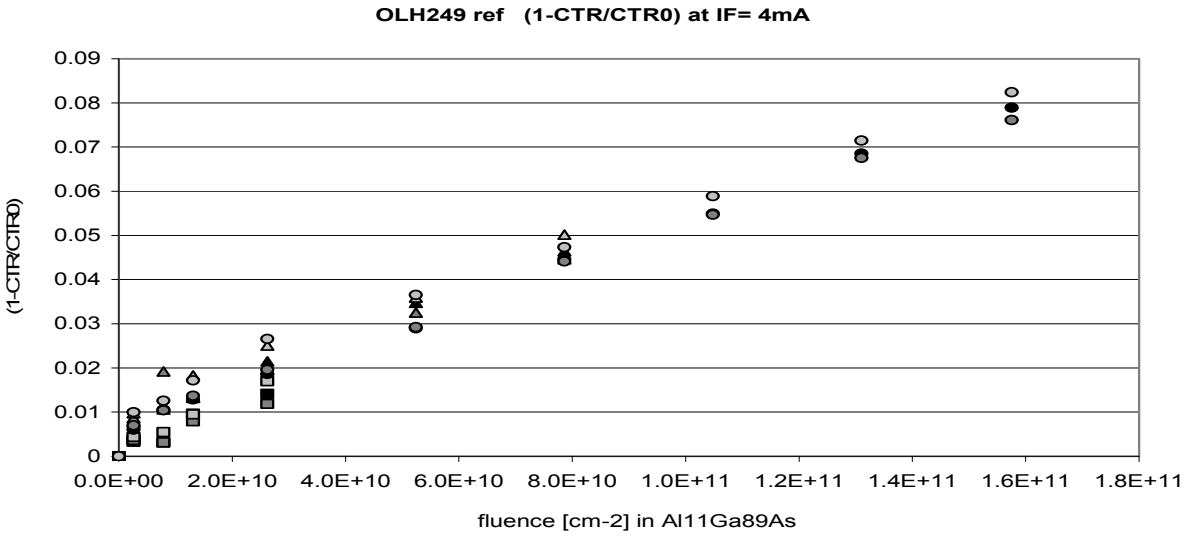
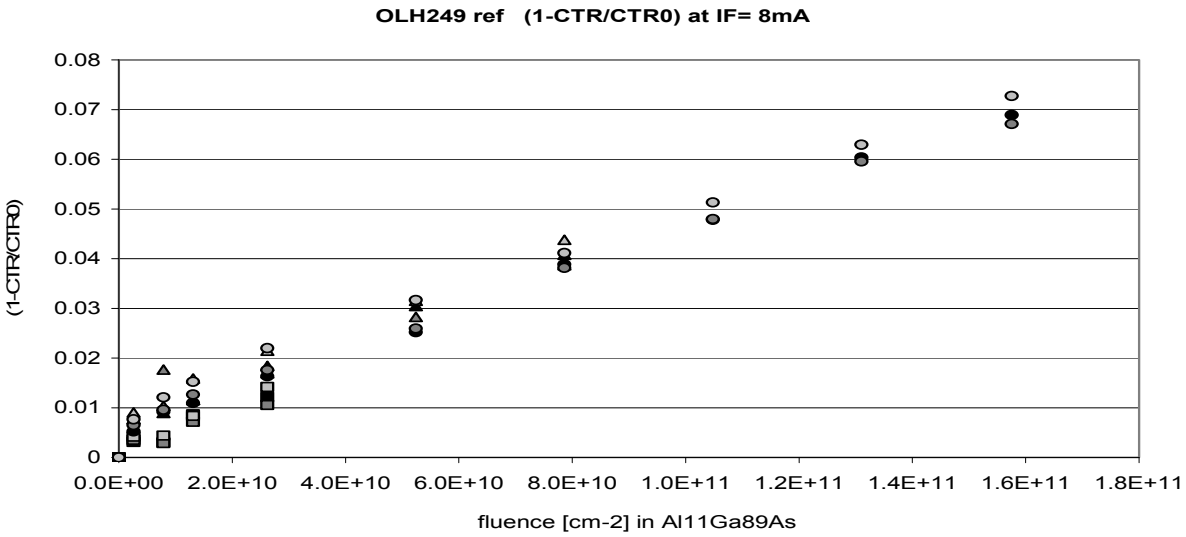

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-131: OLH249 reference: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

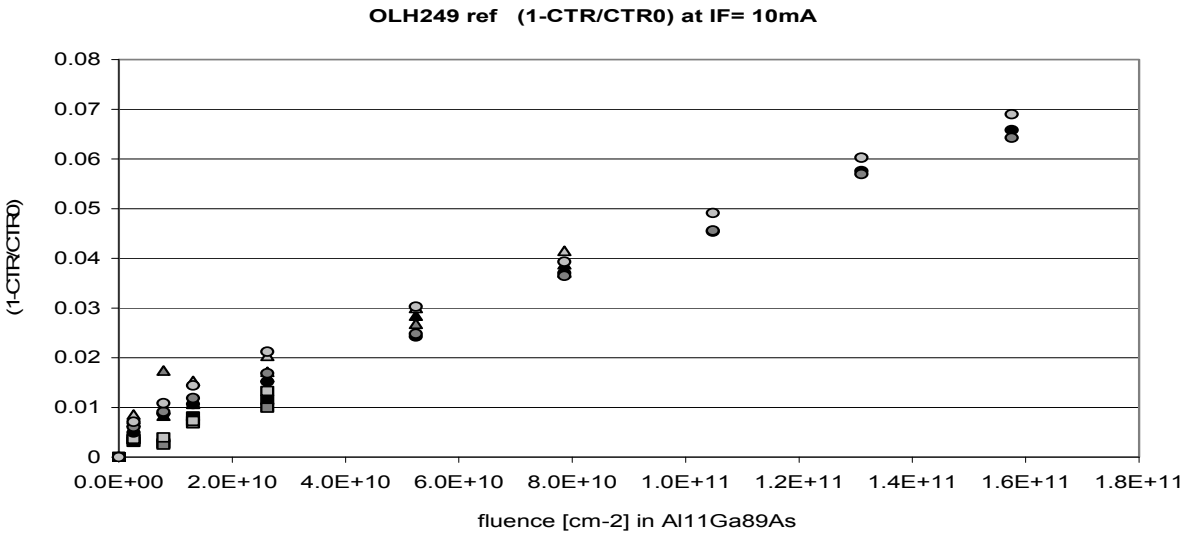
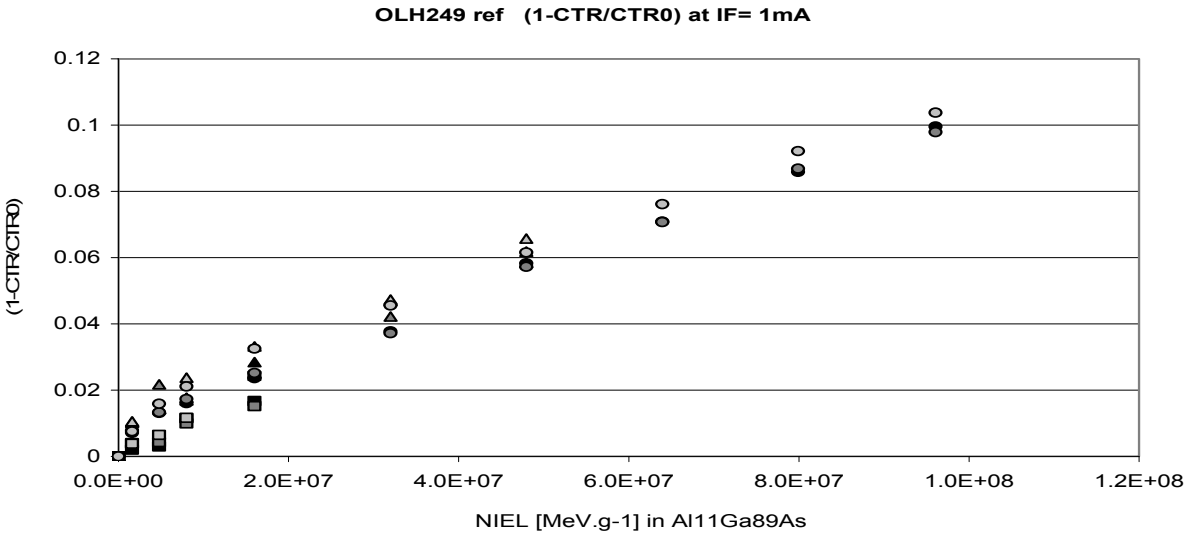
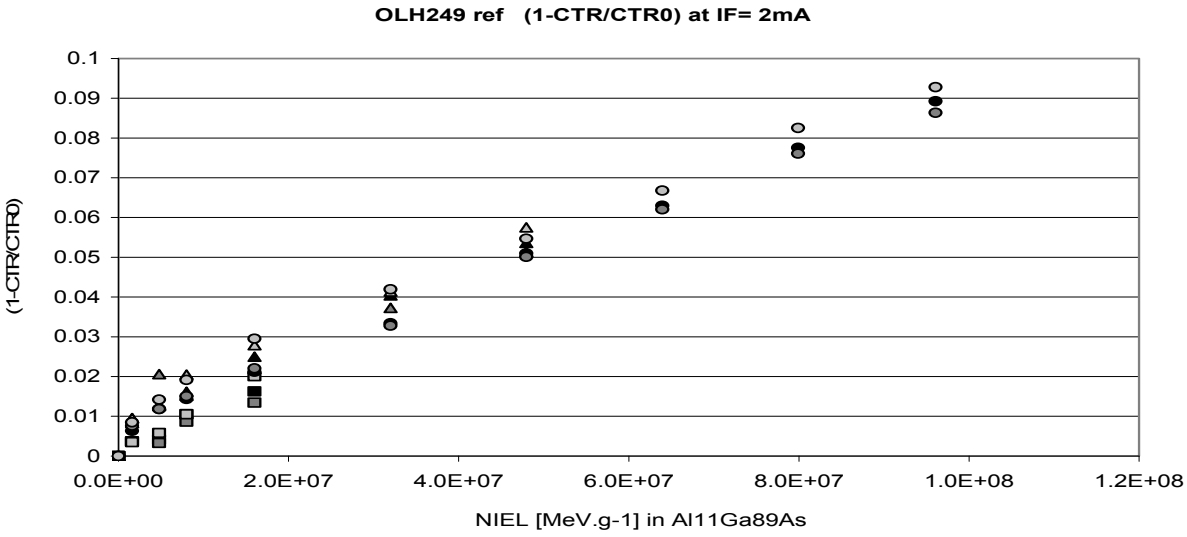
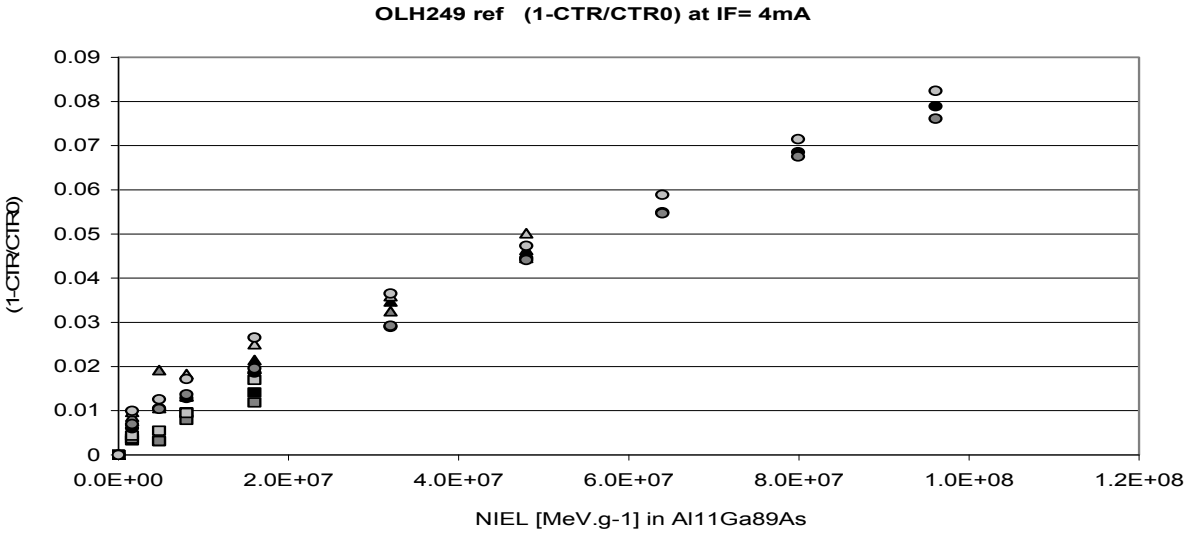
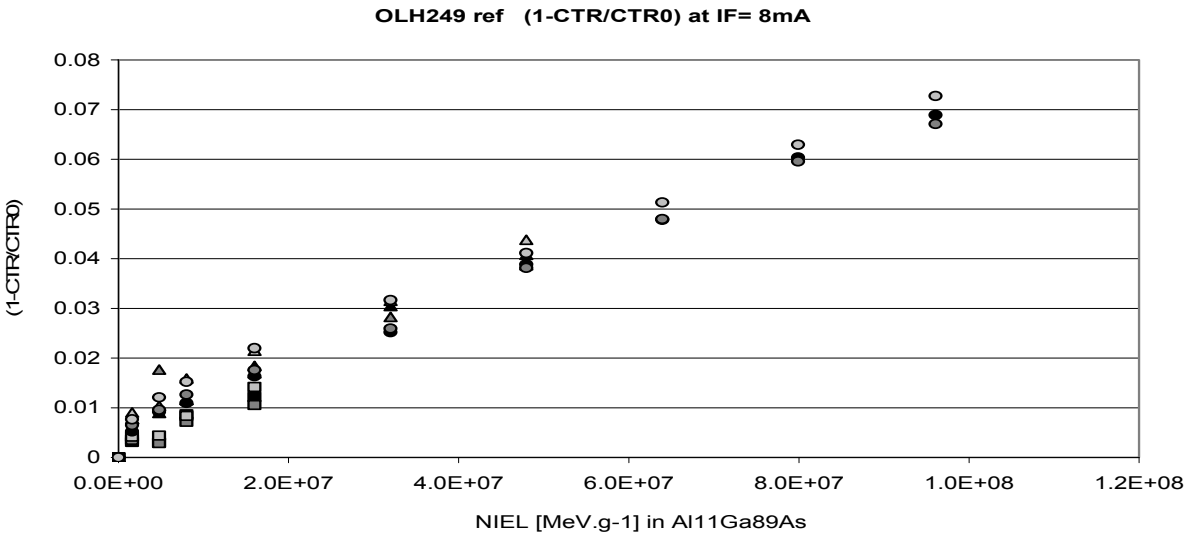

OLH249 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-132: OLH249 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

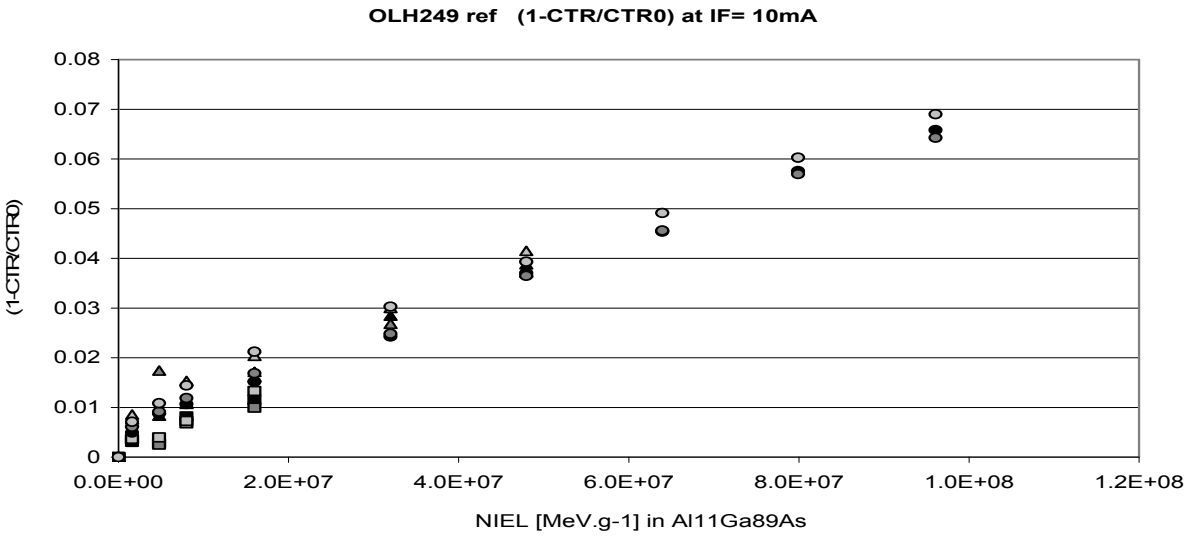
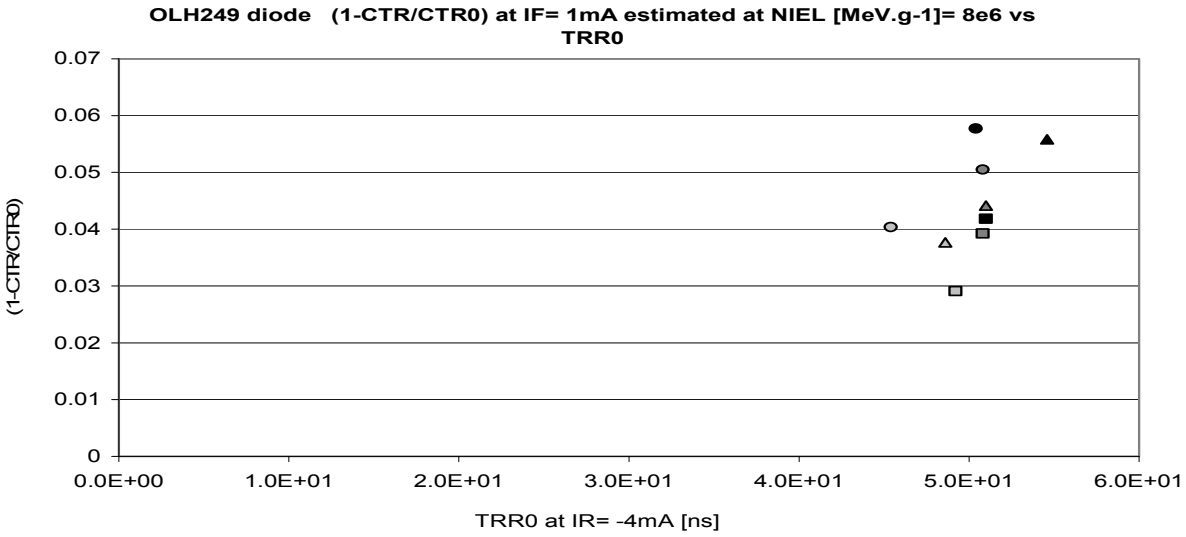
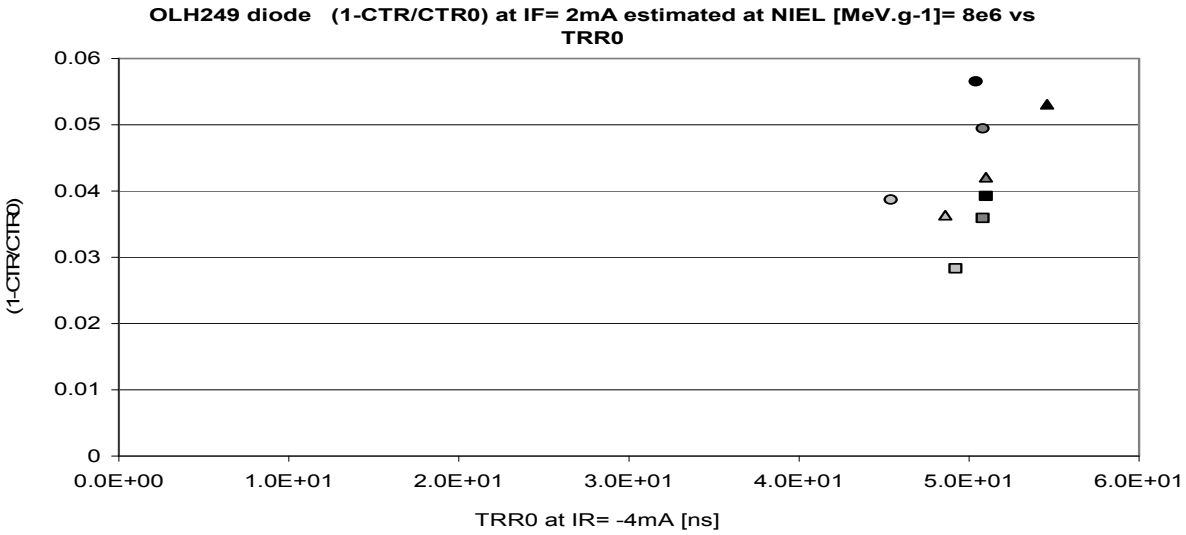
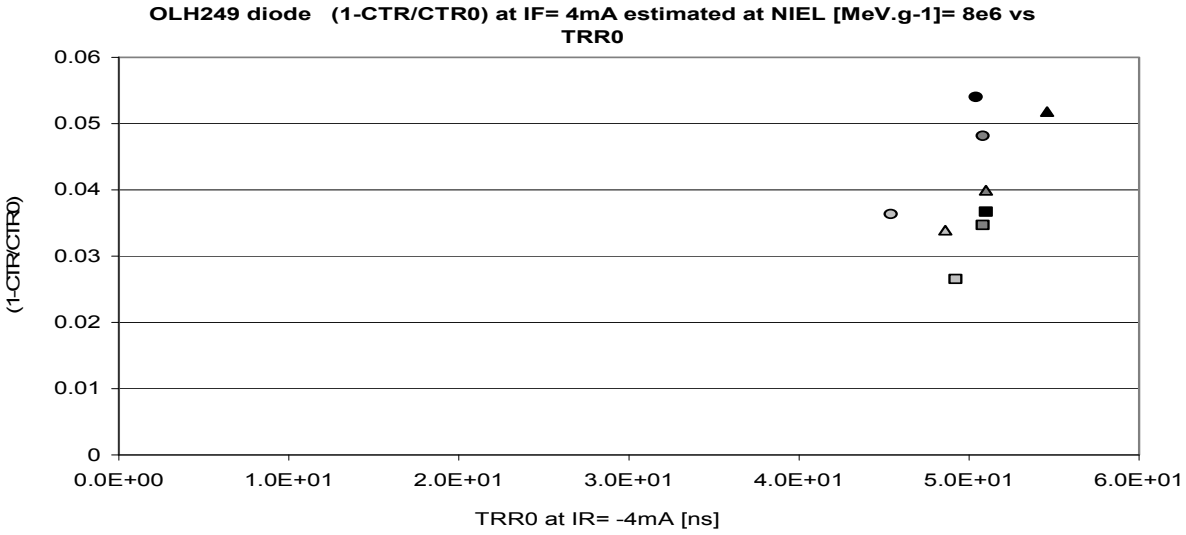
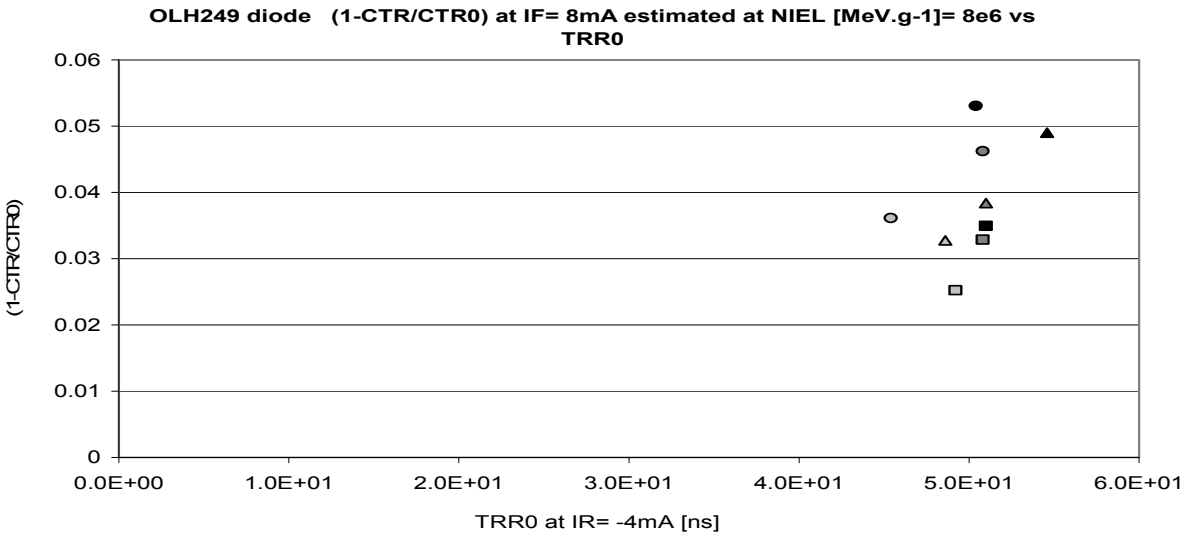

OLH249 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-133: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
1.0E+01
2.0E+01
3.0E+01
4.0E+01
5.0E+01
6.0E+01
TRR0 at IR= -4mA [ns]

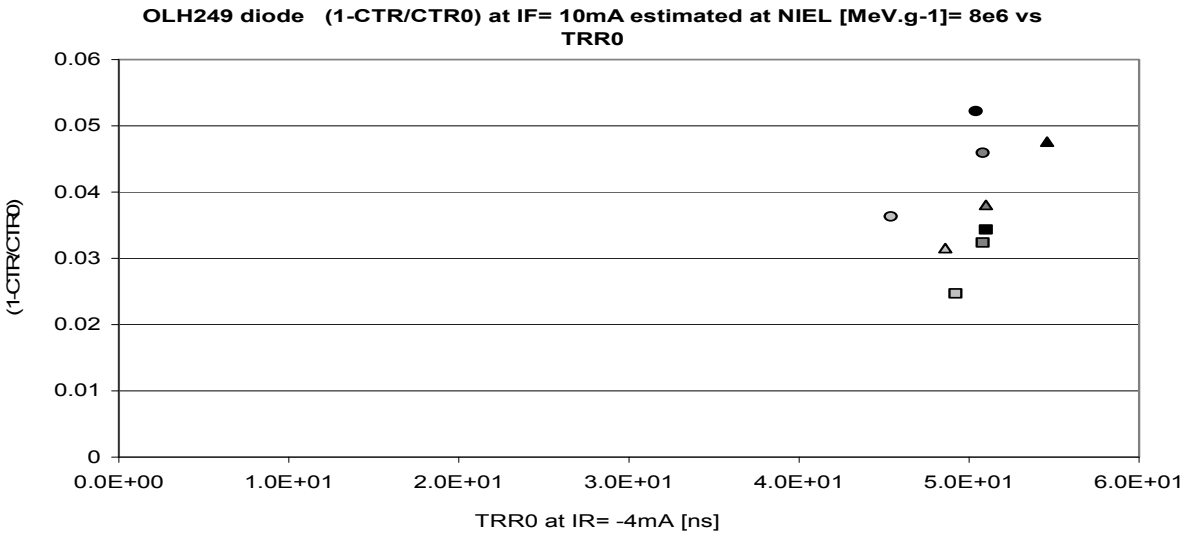

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
1.0E+01
2.0E+01
3.0E+01
4.0E+01
5.0E+01
6.0E+01
TRR0 at IR= -4mA [ns]

Fig. 13-134: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-135: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-136: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 9.6.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-137: OLH249 optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

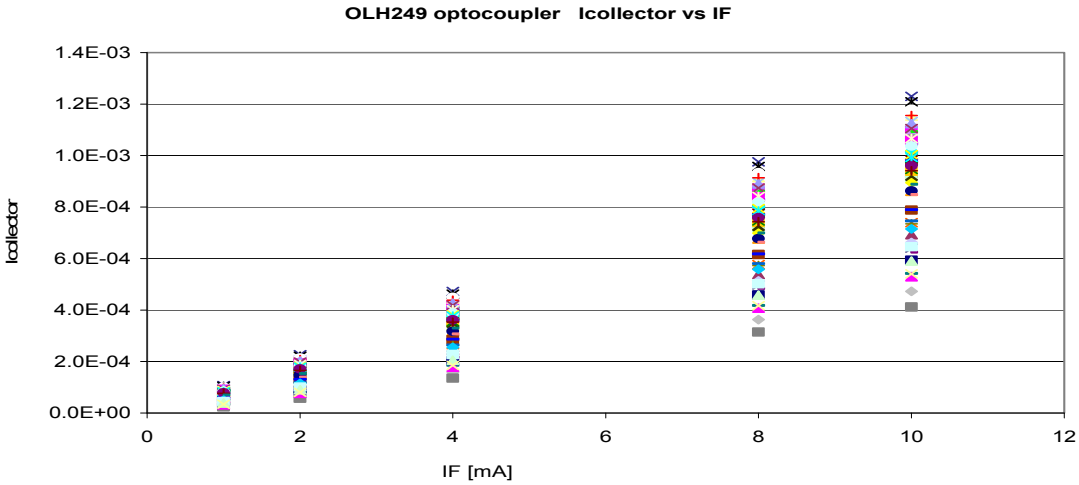


Fig. 13-138: OLH249 optocoupler irradiated: CTR for each step with respect to diode current I_F

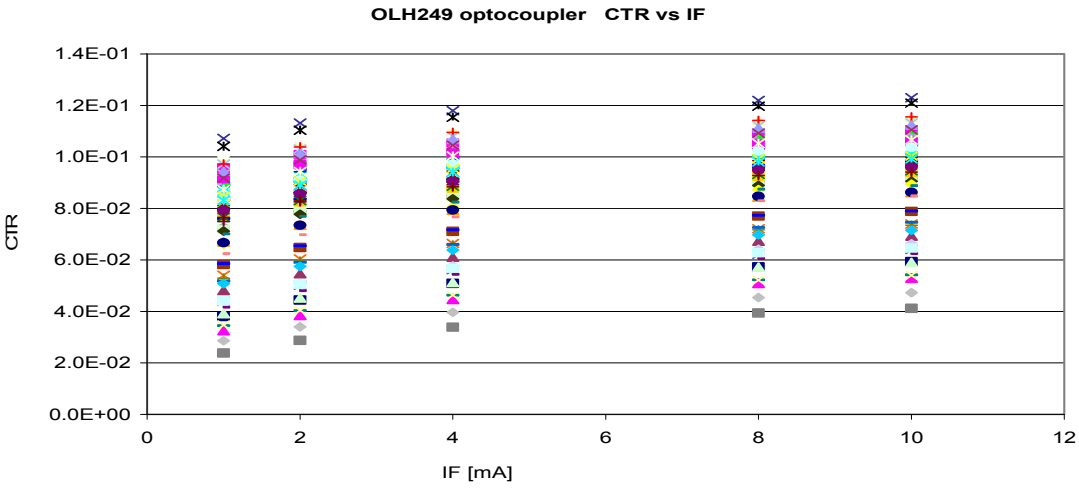


Fig. 13-139: OLH249 optocoupler irradiated: CTR/CTR_0 for each step with respect to diode current I_F

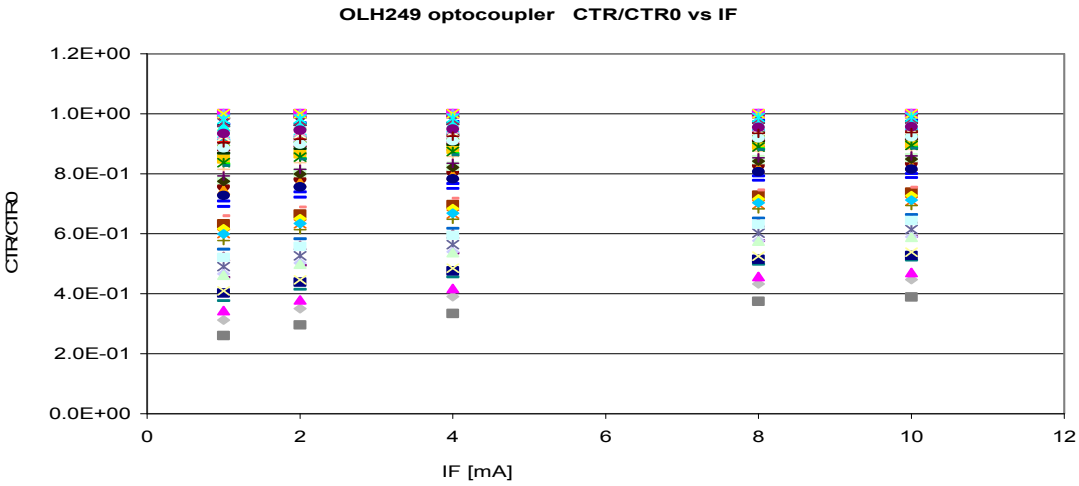


Fig. 13-140: OLH249 diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

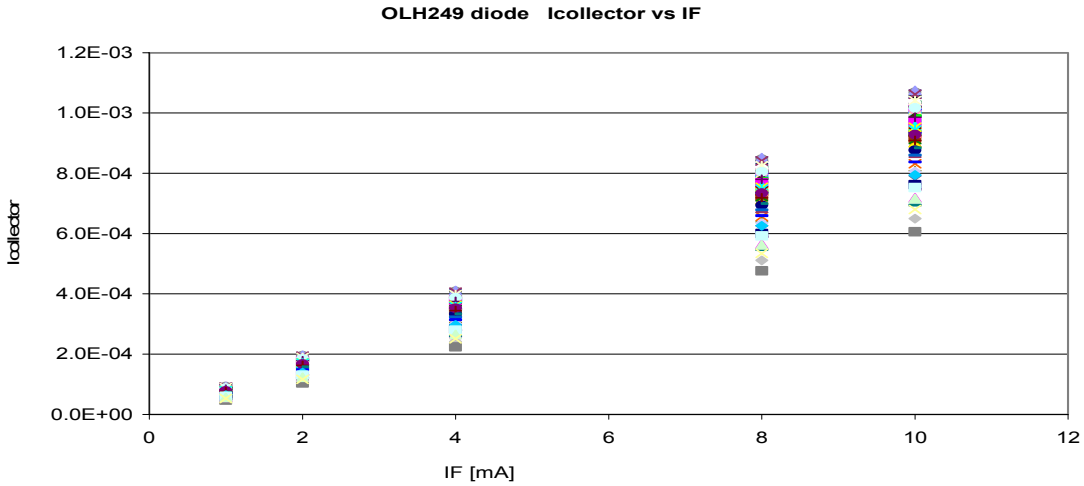


Fig. 13-141: OLH249 diode irradiated: CTR for each step with respect to diode current I_F

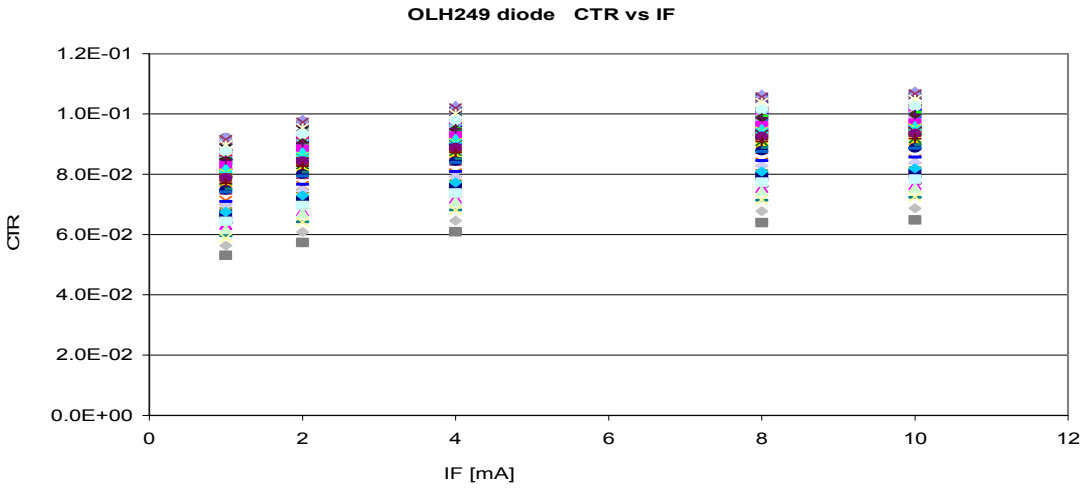


Fig. 13-142: OLH249 diode irradiated: CTR/CTR_0 for each step with respect to diode current I_F

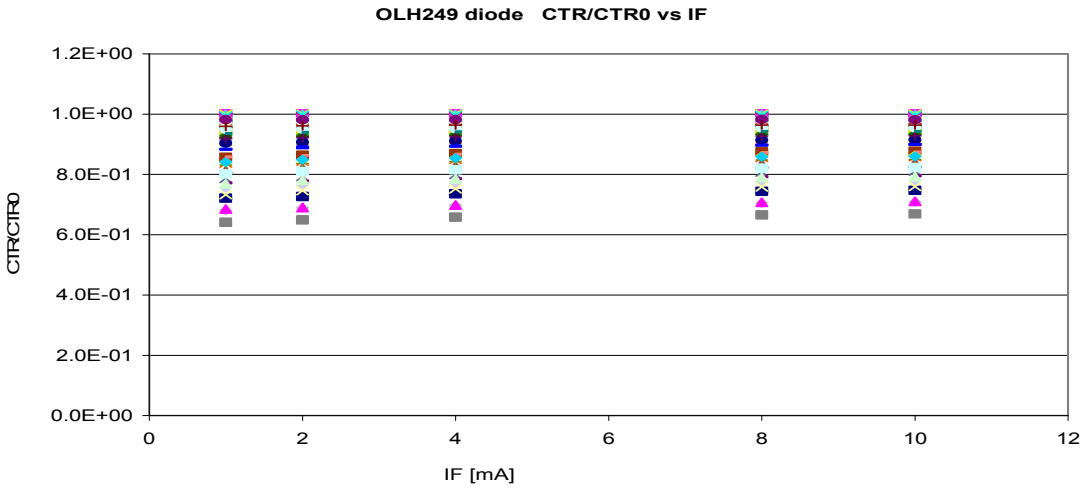


Fig. 13-143: OLH249 transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

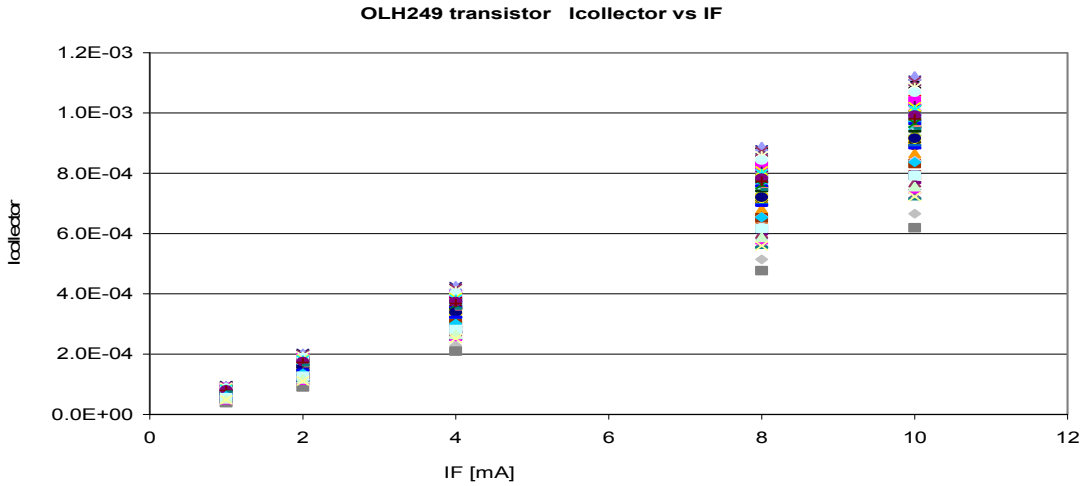


Fig. 13-144: OLH249 transistor irradiated: CTR for each step with respect to diode current I_F

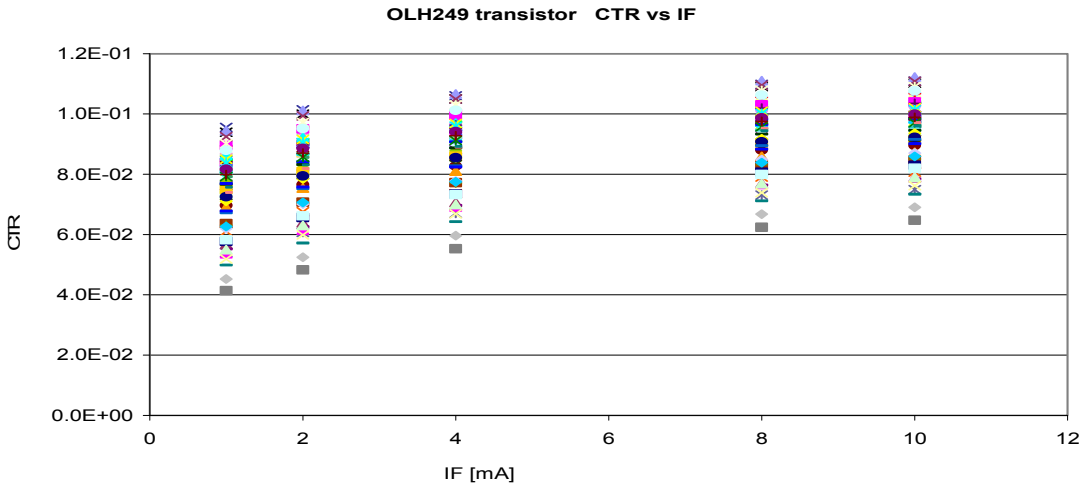


Fig. 13-145: OLH249 transistor irradiated: CTR/CTR_0 for each step with respect to diode current I_F

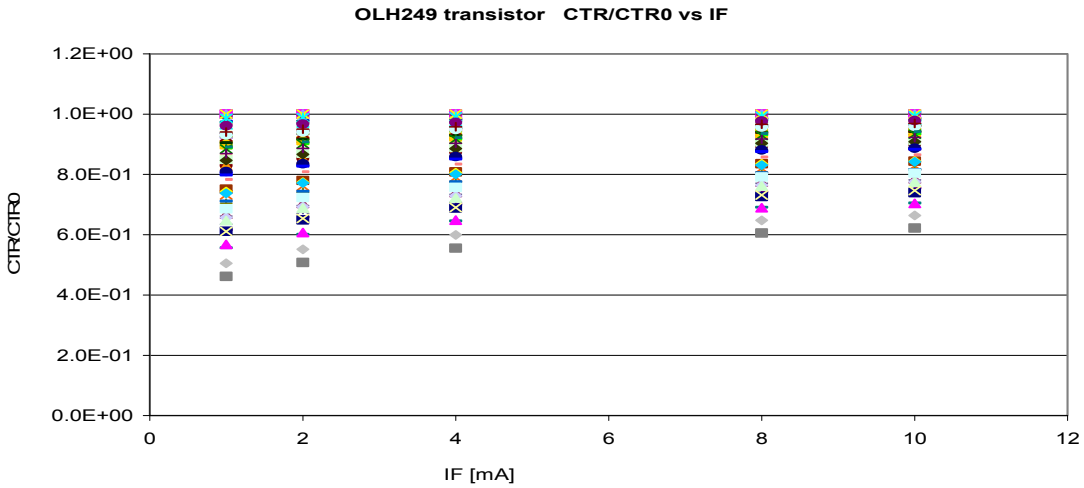


Fig. 13-146: OLH249 reference measurement: transistor collector current I_C for each step with respect to diode current I_F

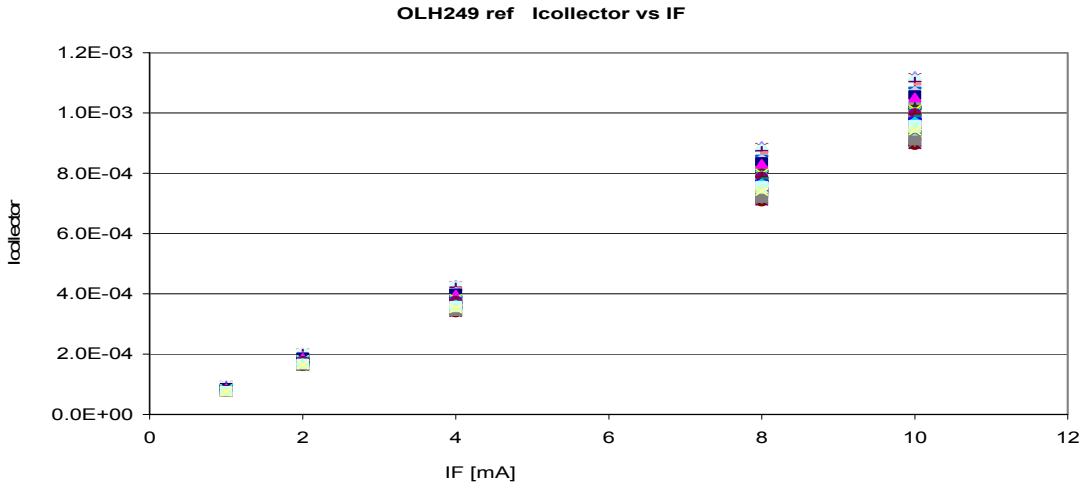


Fig. 13-147: OLH249 reference measurement: CTR for each step with respect to diode current I_F

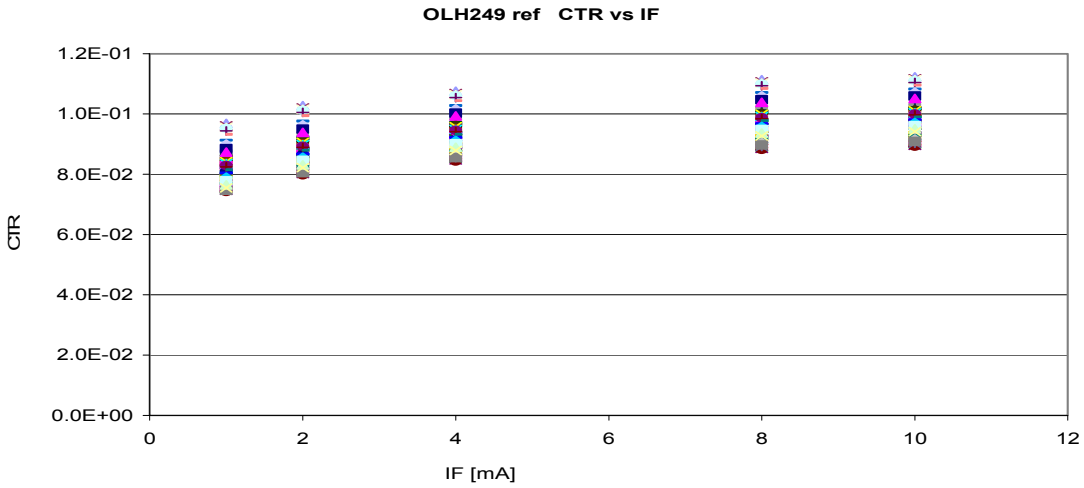


Fig. 13-148: OLH249 reference measurement: CTR/CTR_0 for each step with respect to diode current I_F

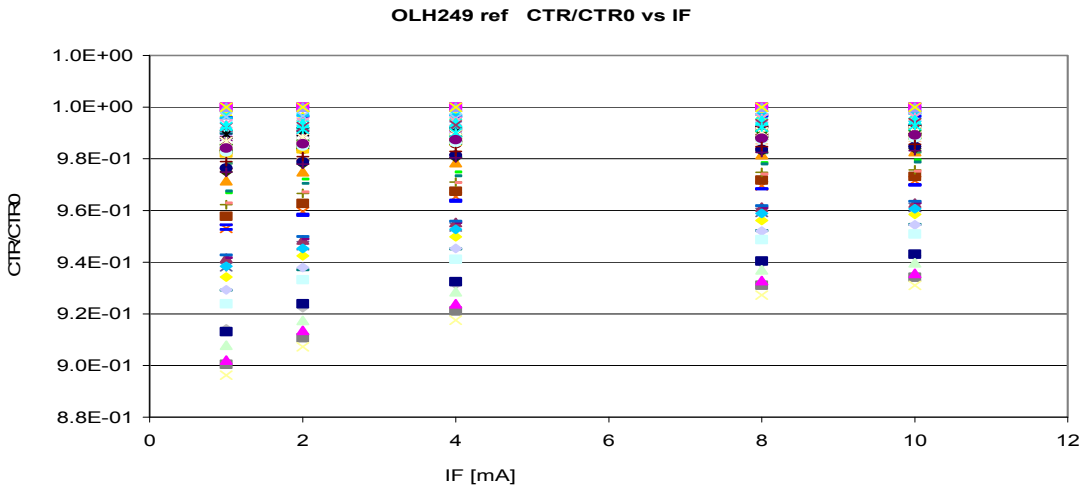
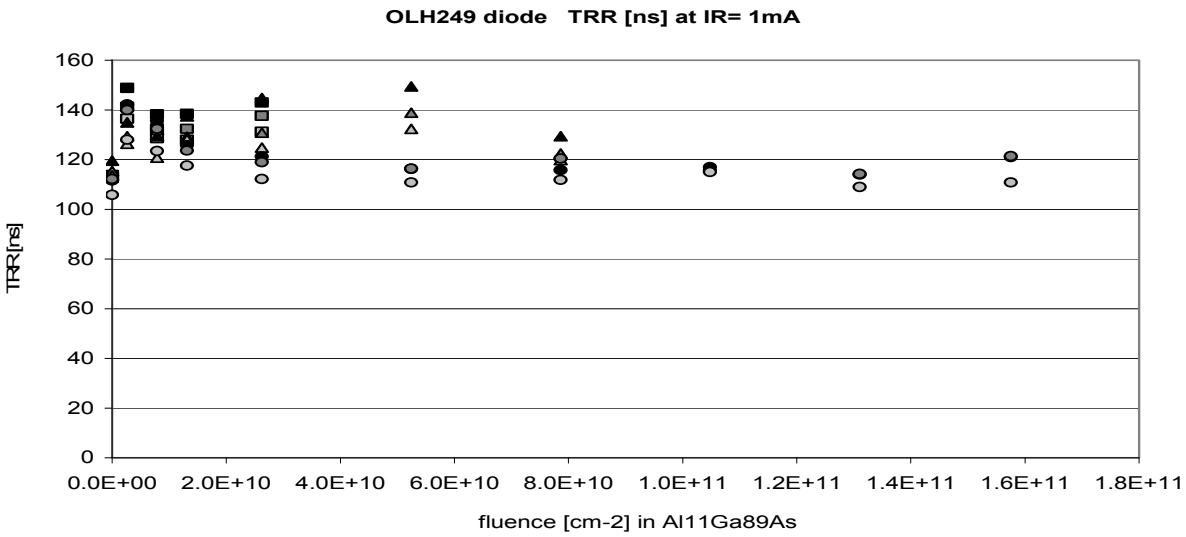
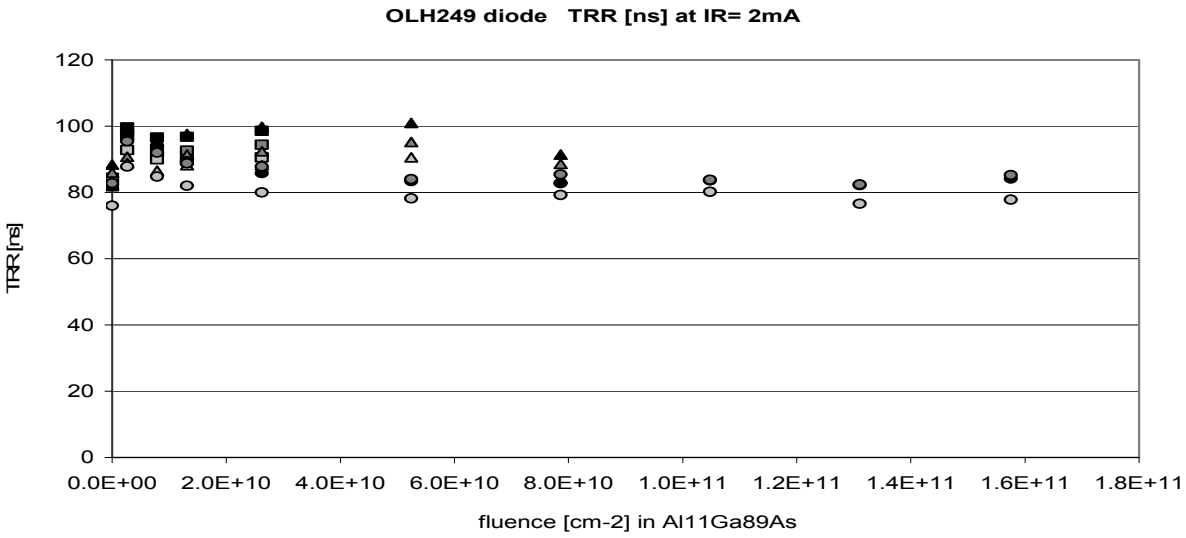


Fig. 13-149: OLH249 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA





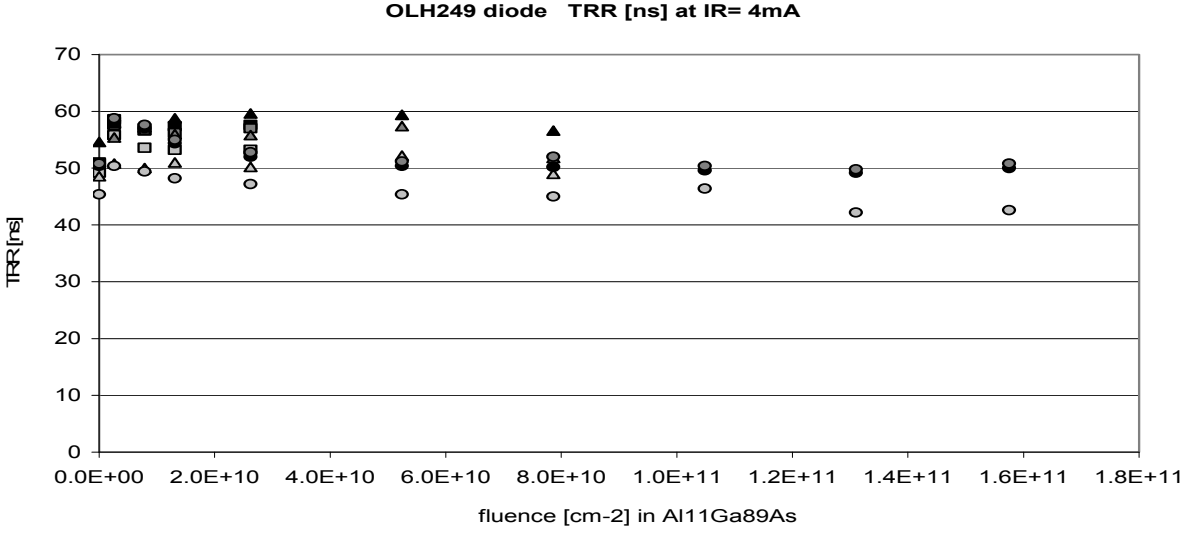
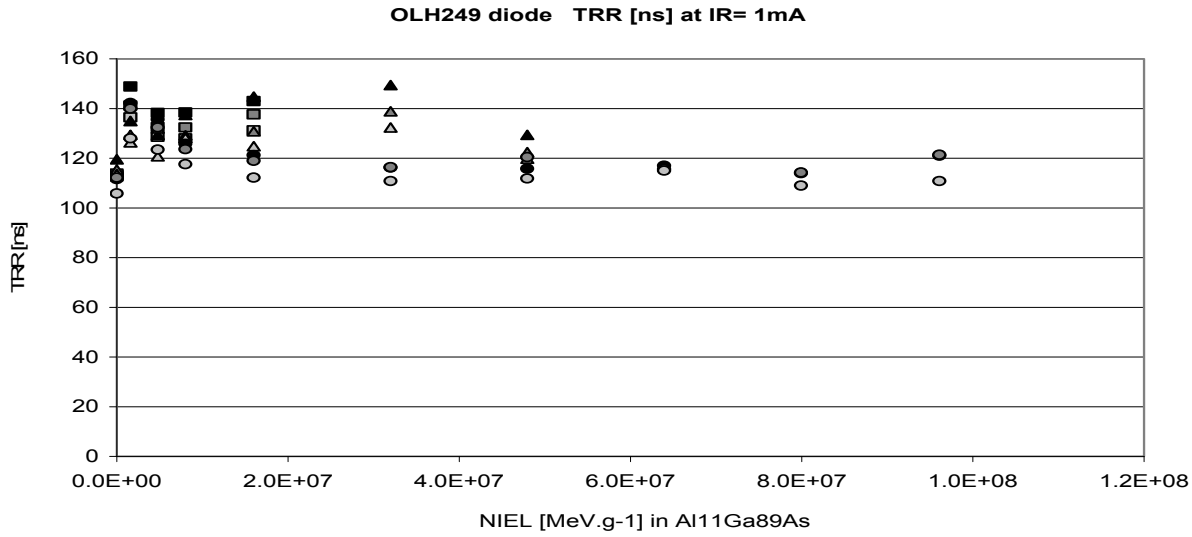
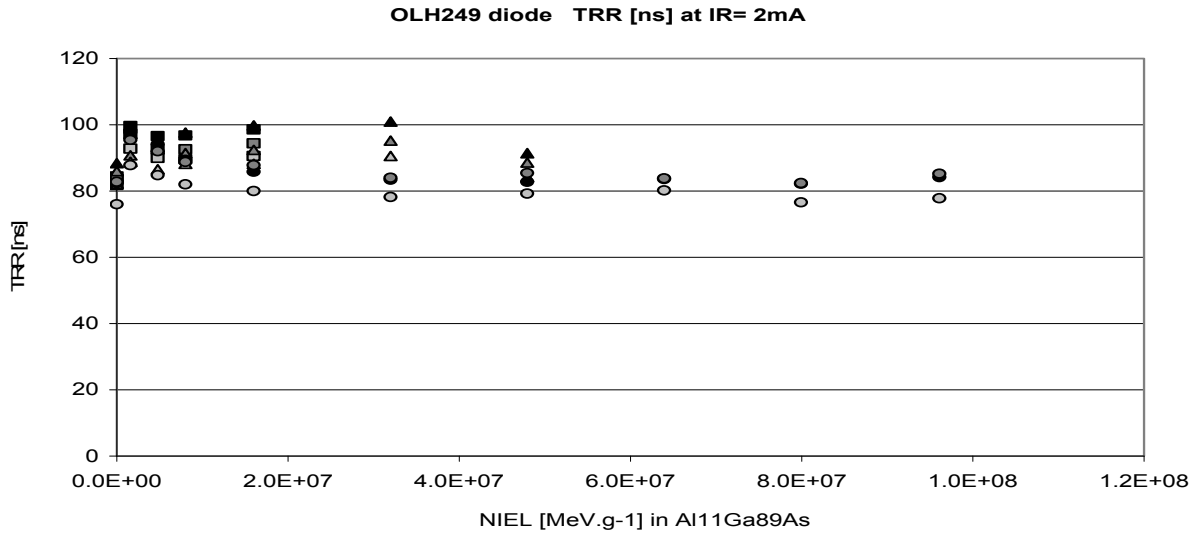


Fig. 13-150: OLH249 diode: τ_{RR} [ns] with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





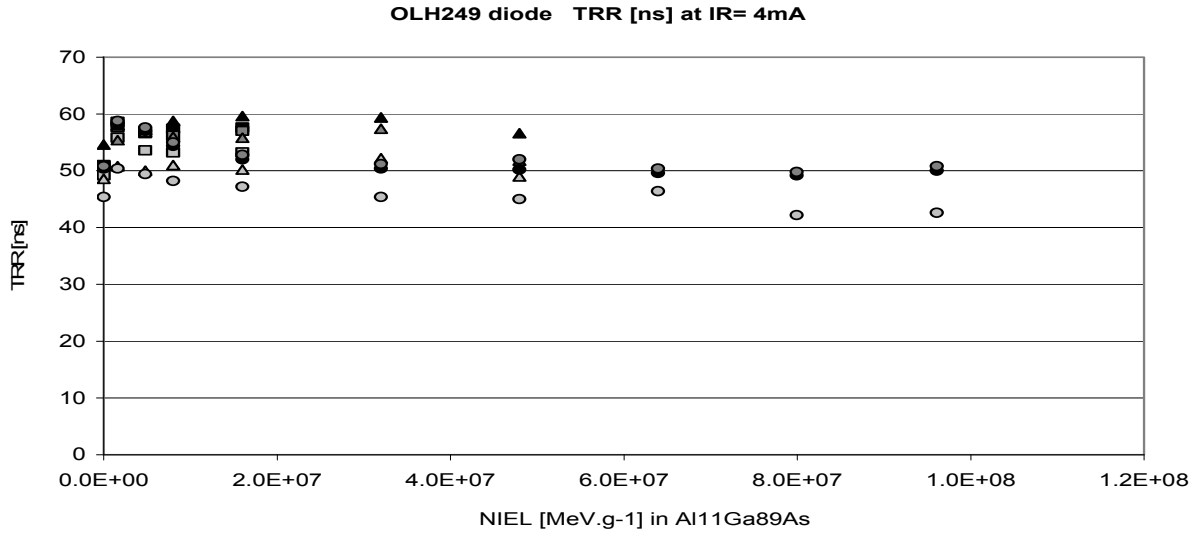
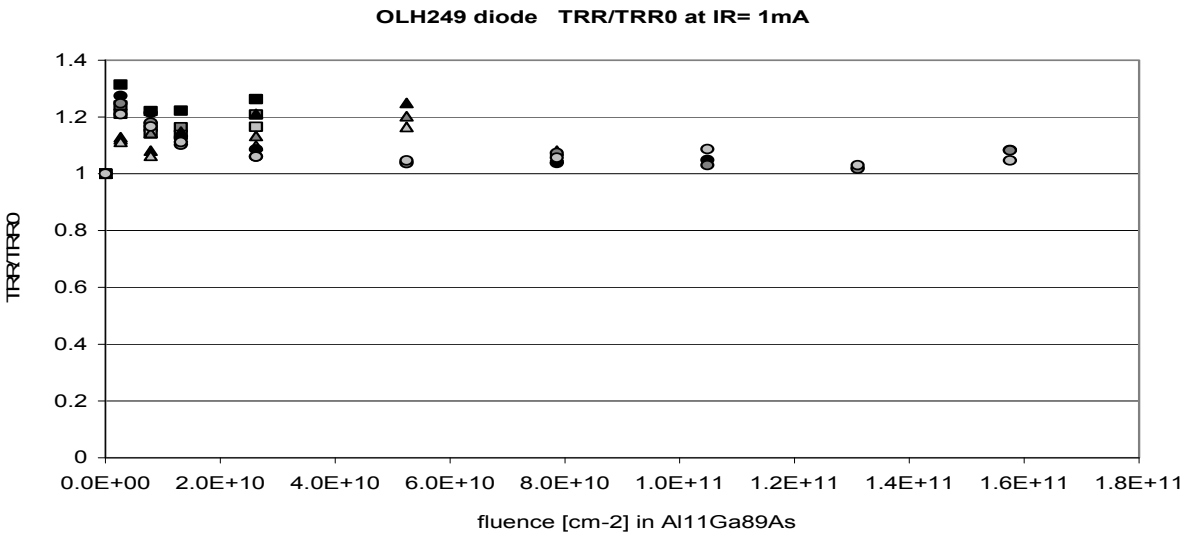
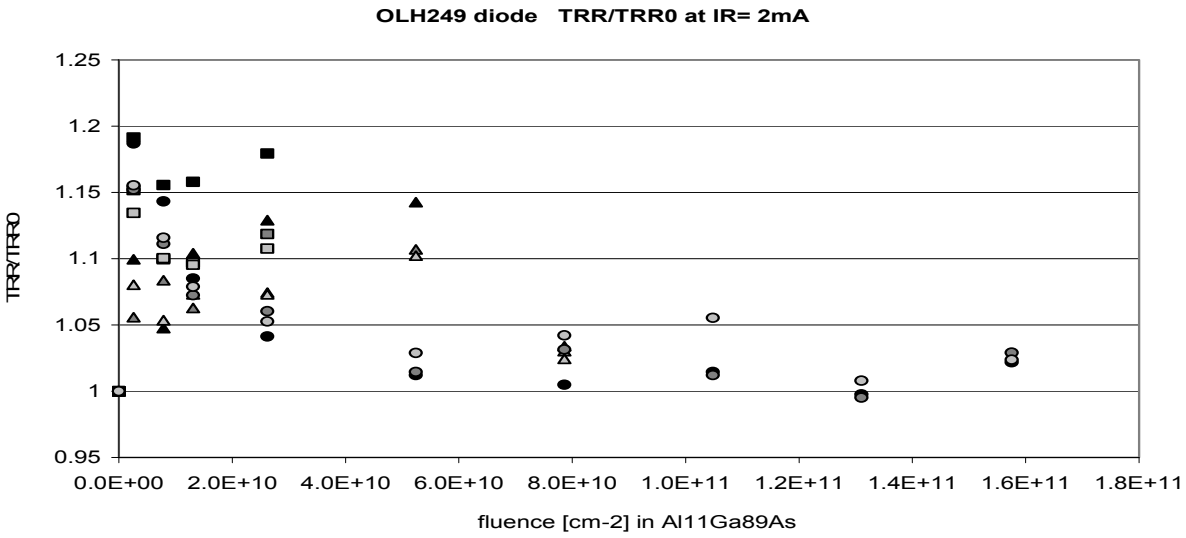


Fig. 13-151: OLH249 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA





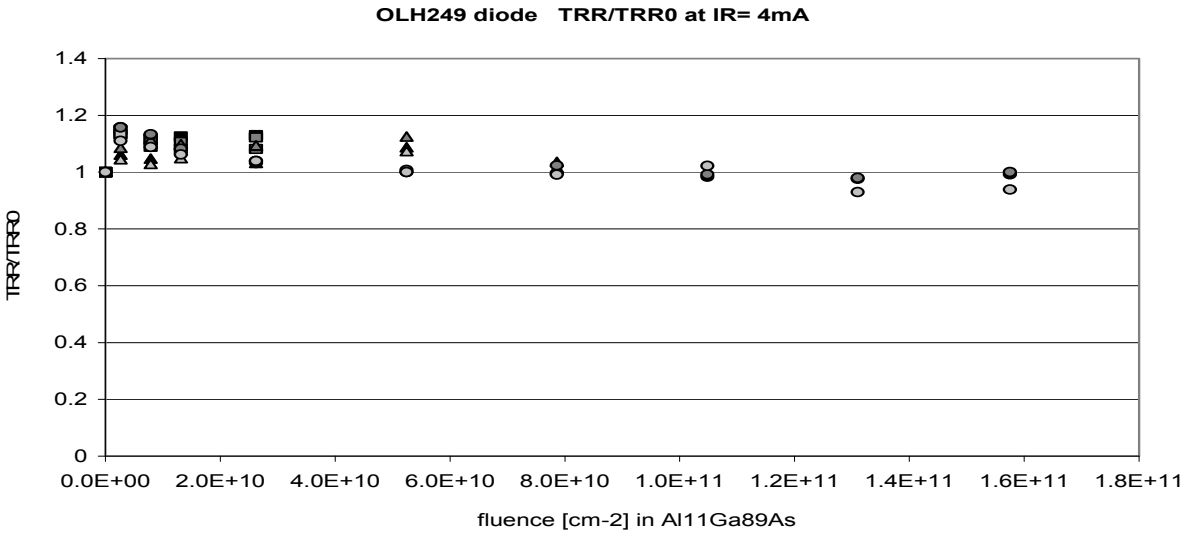
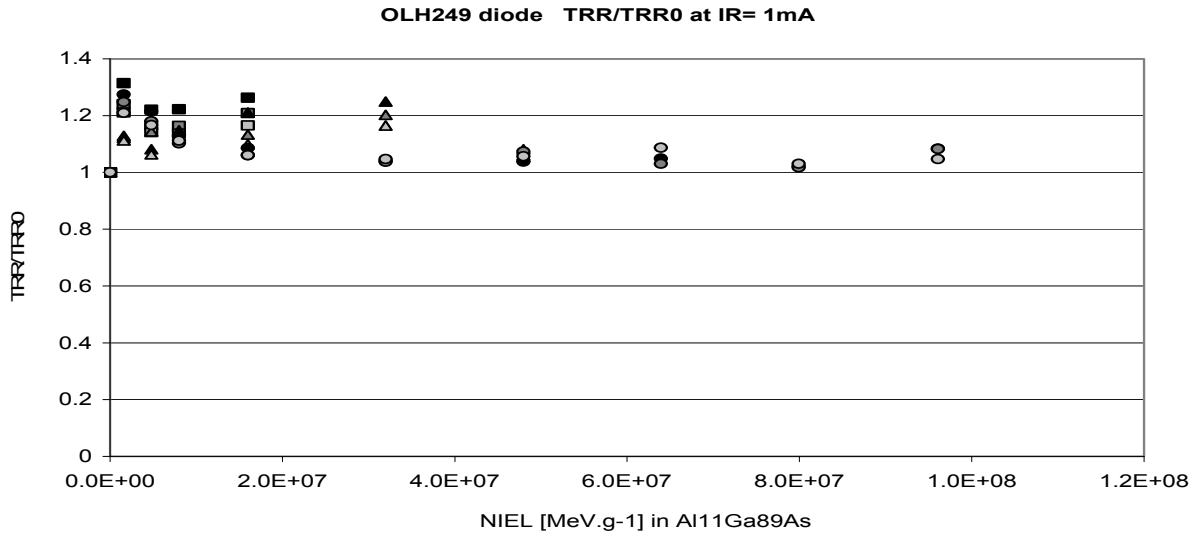
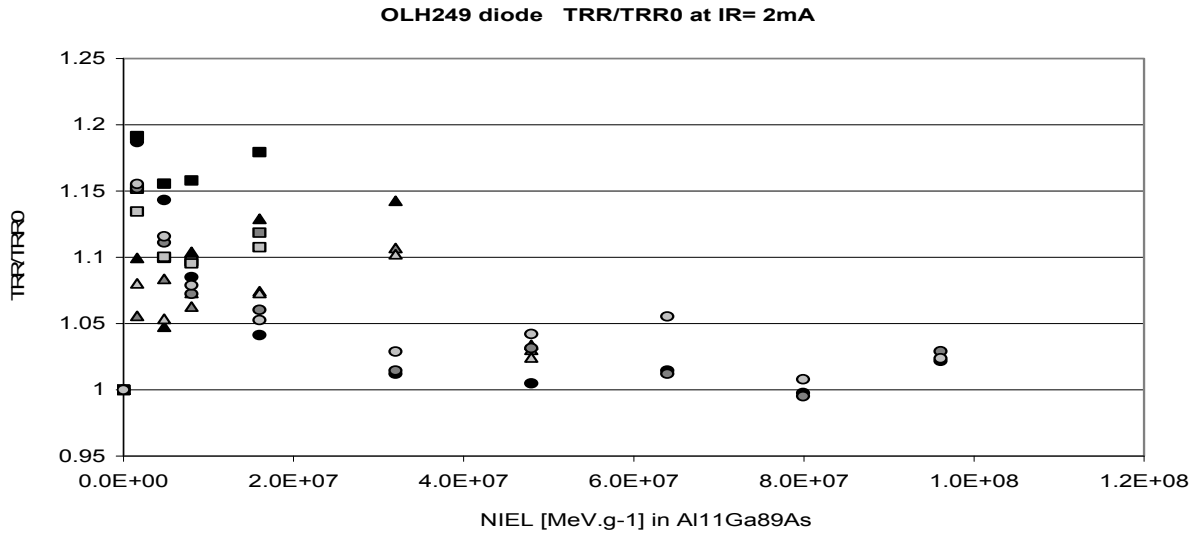


Fig. 13-152: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





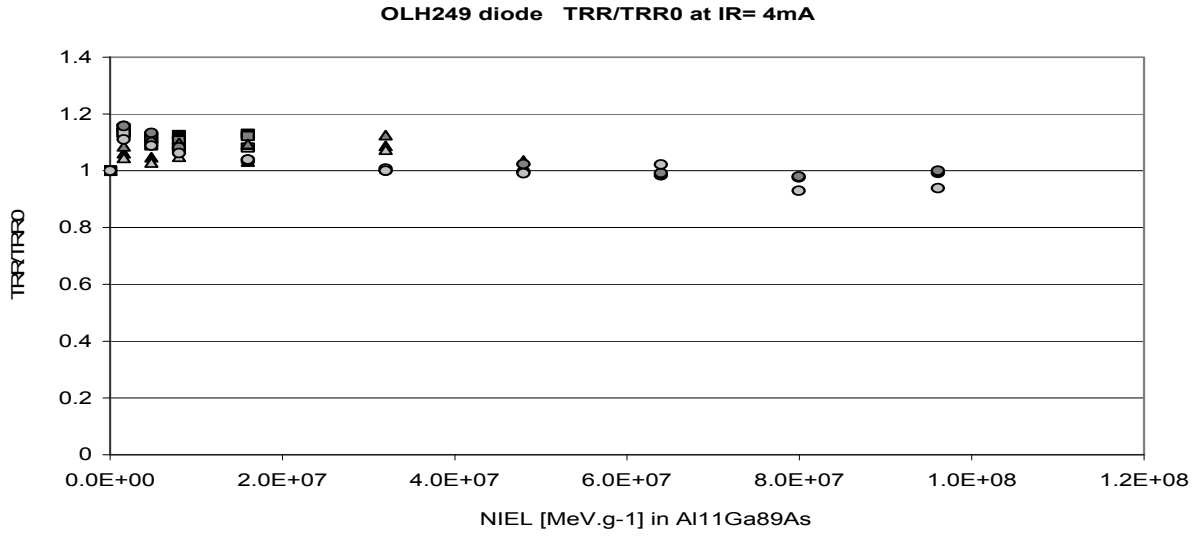
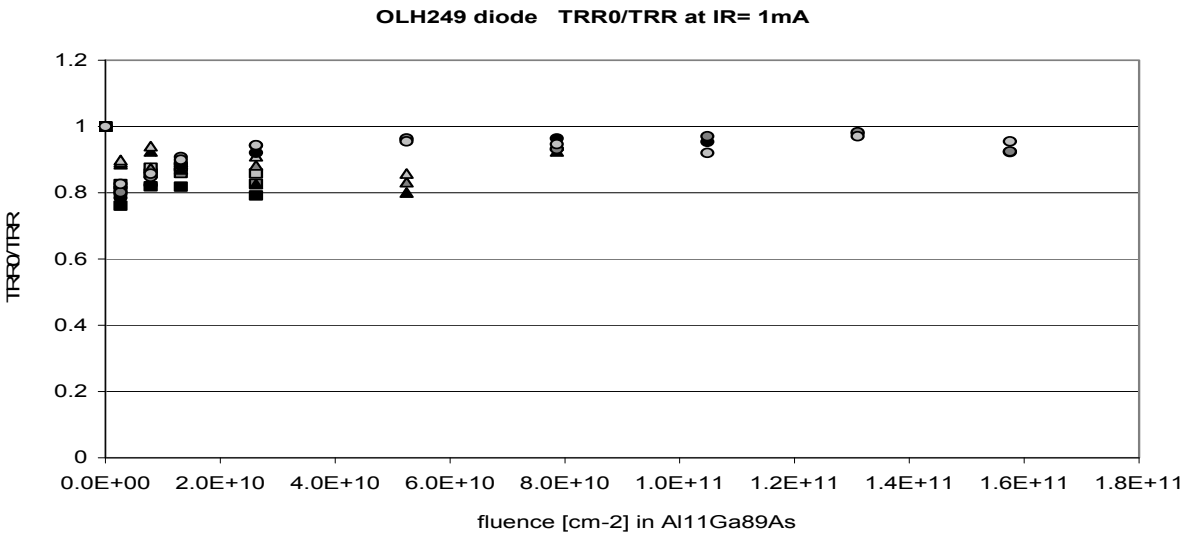
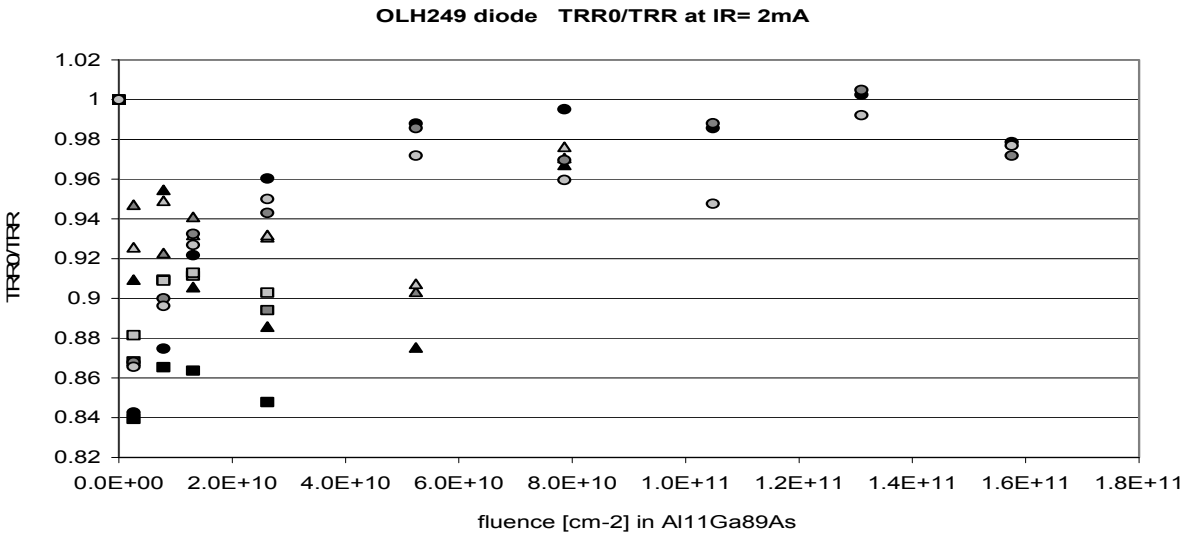


Fig. 13-153: OLH249 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





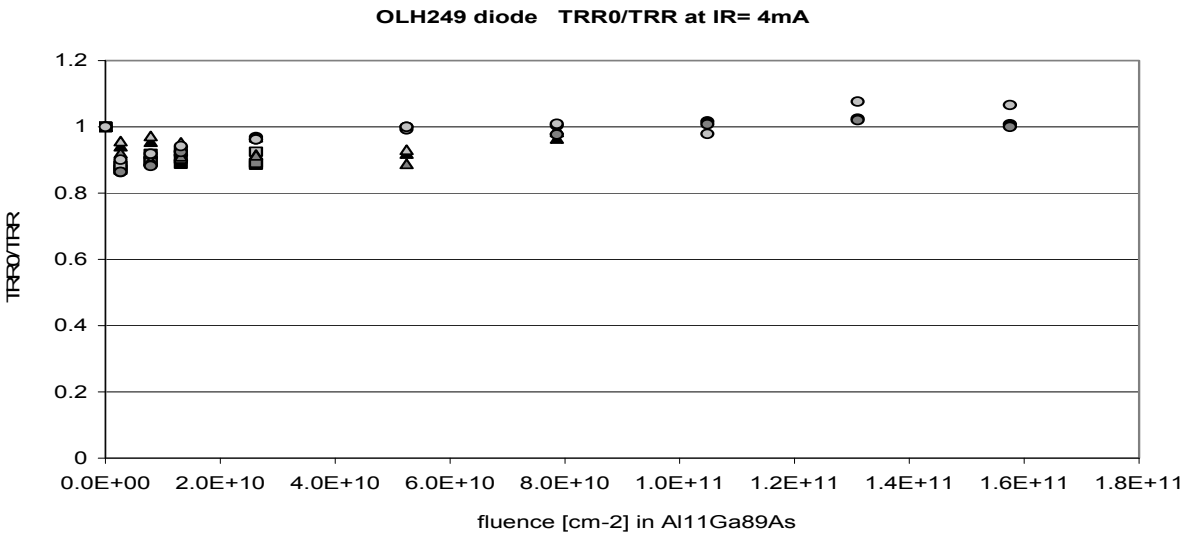
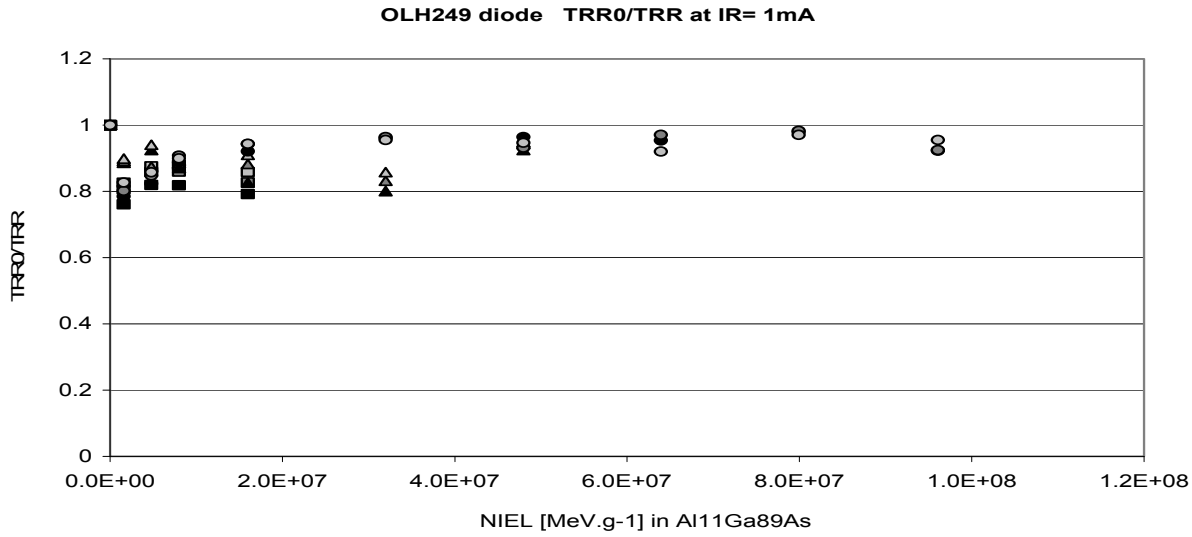
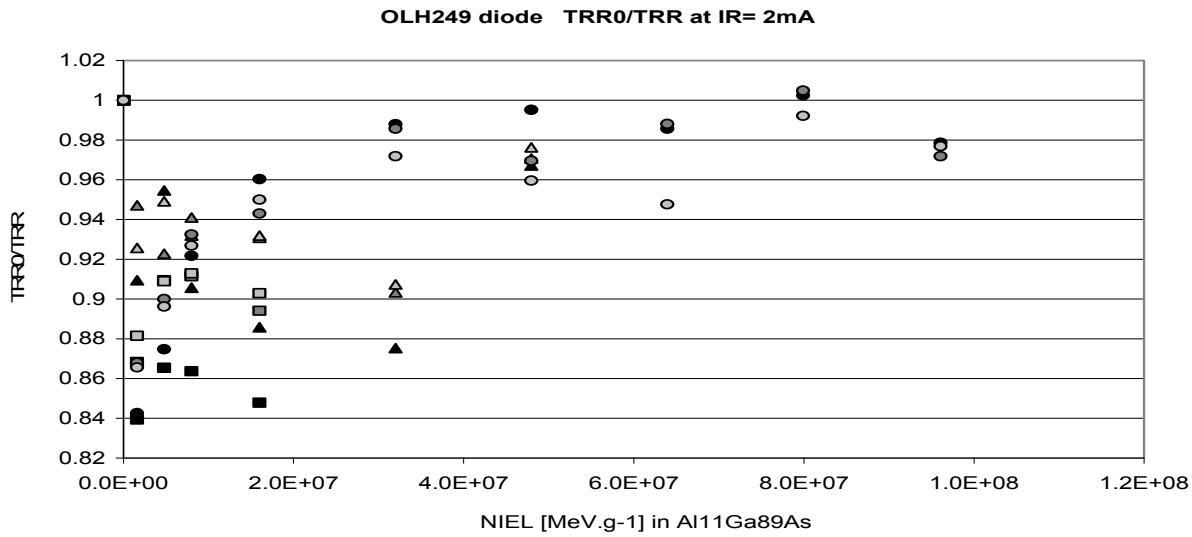


Fig. 13-154: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





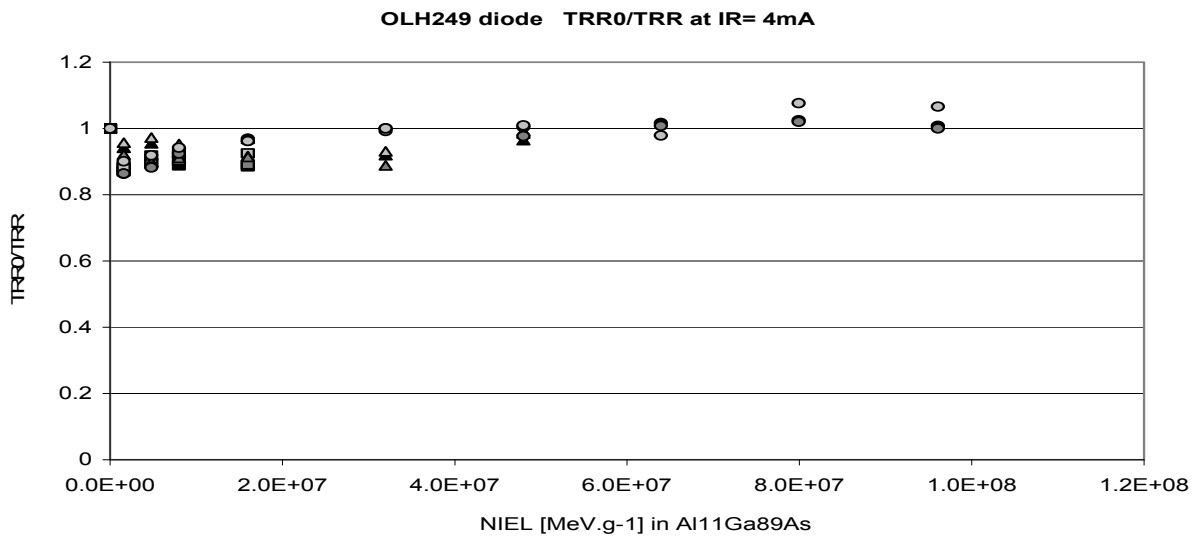
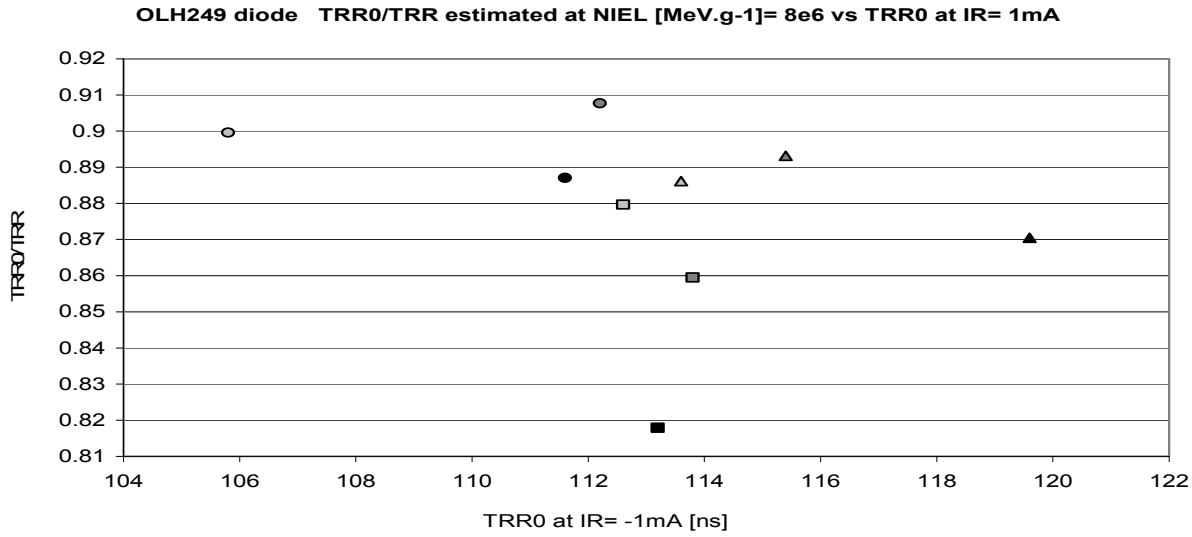
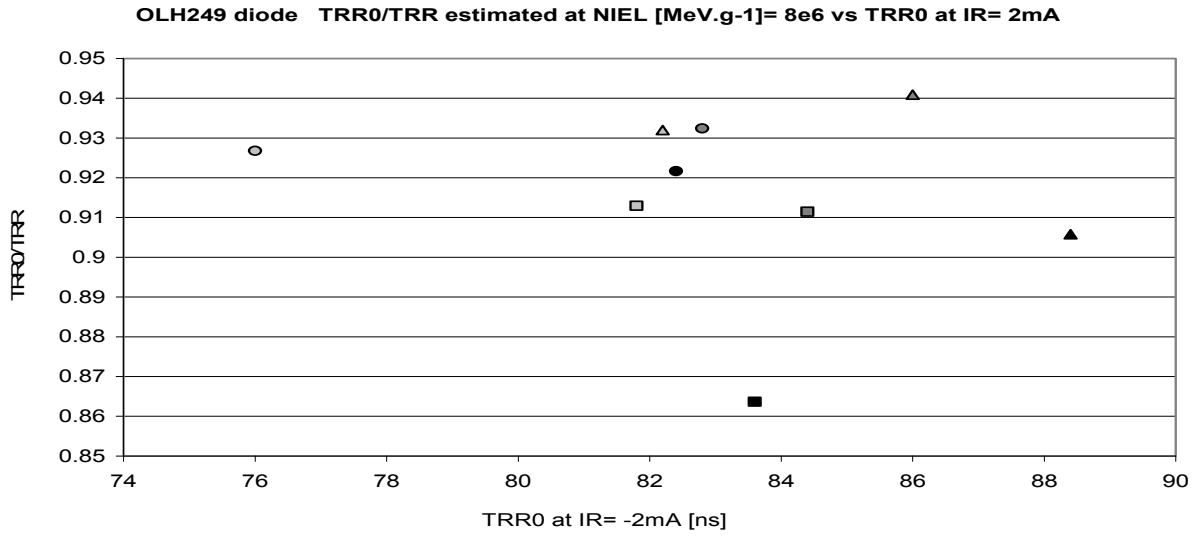


Fig. 13-155: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





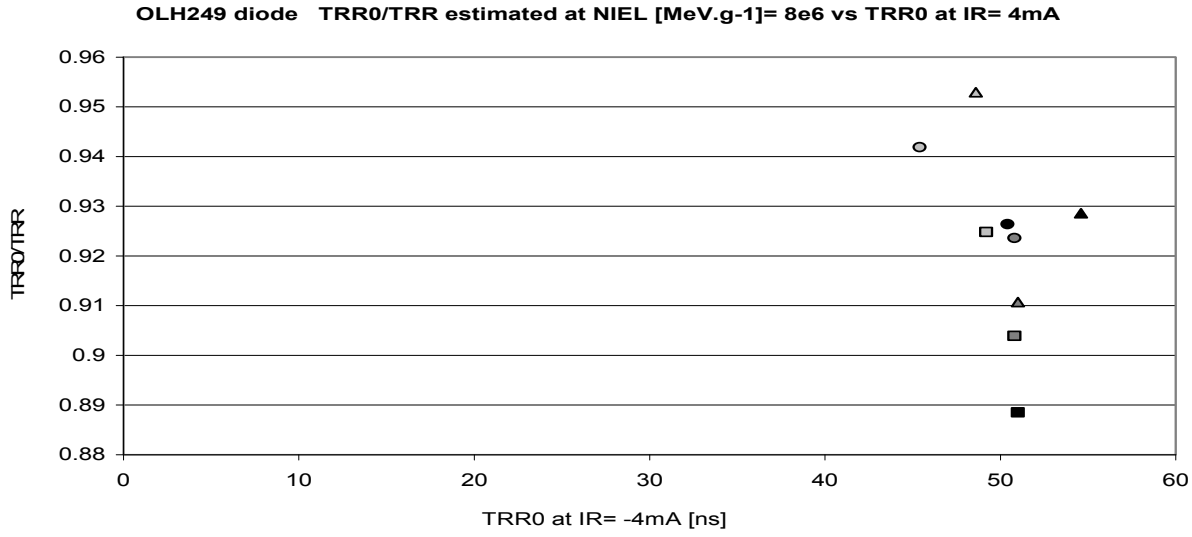
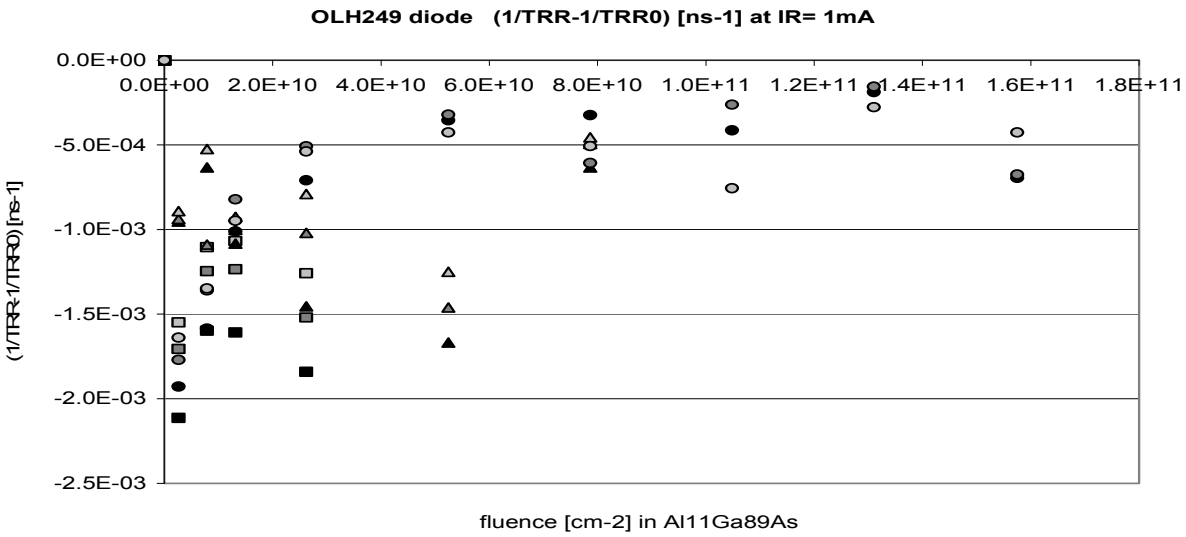
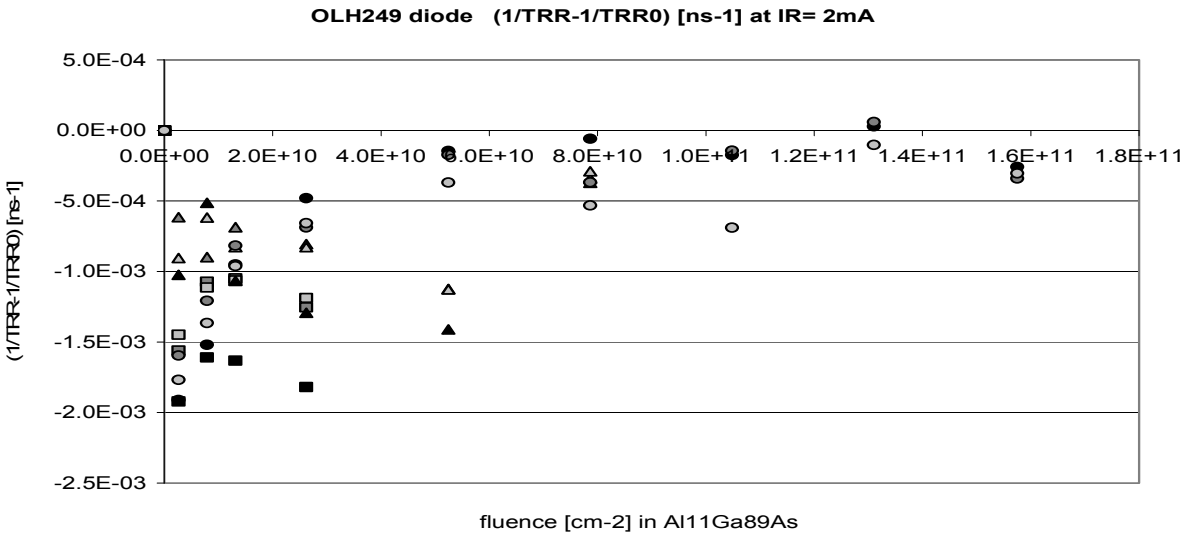


Fig. 13-156: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence





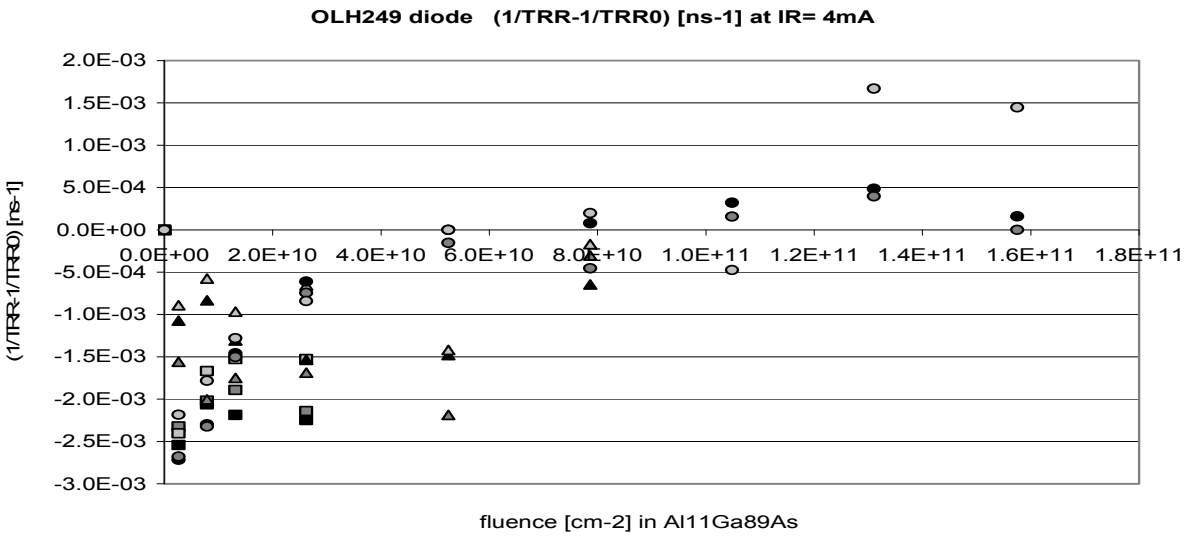
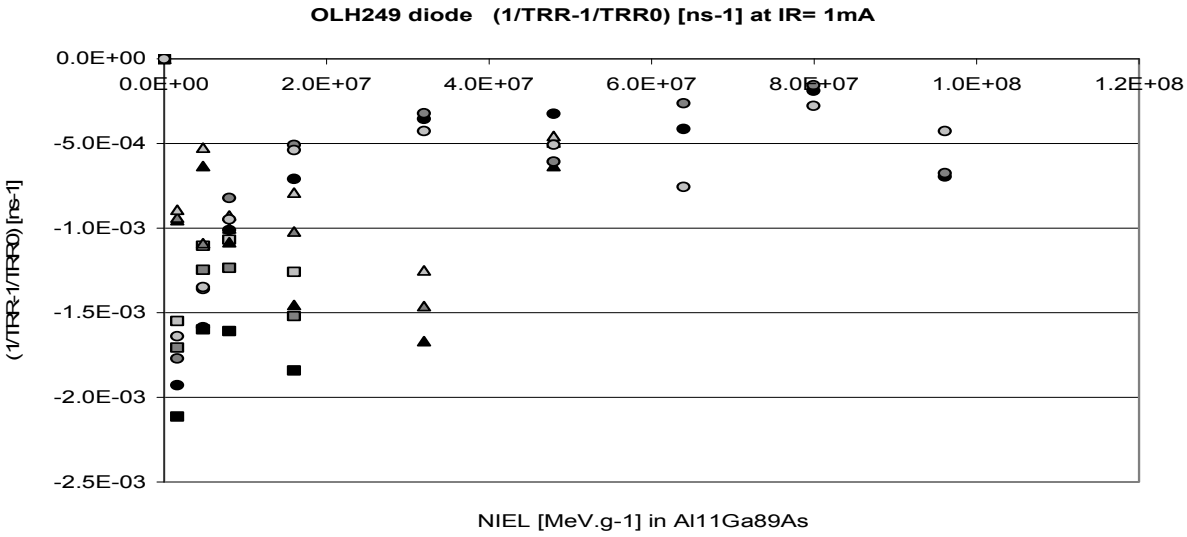
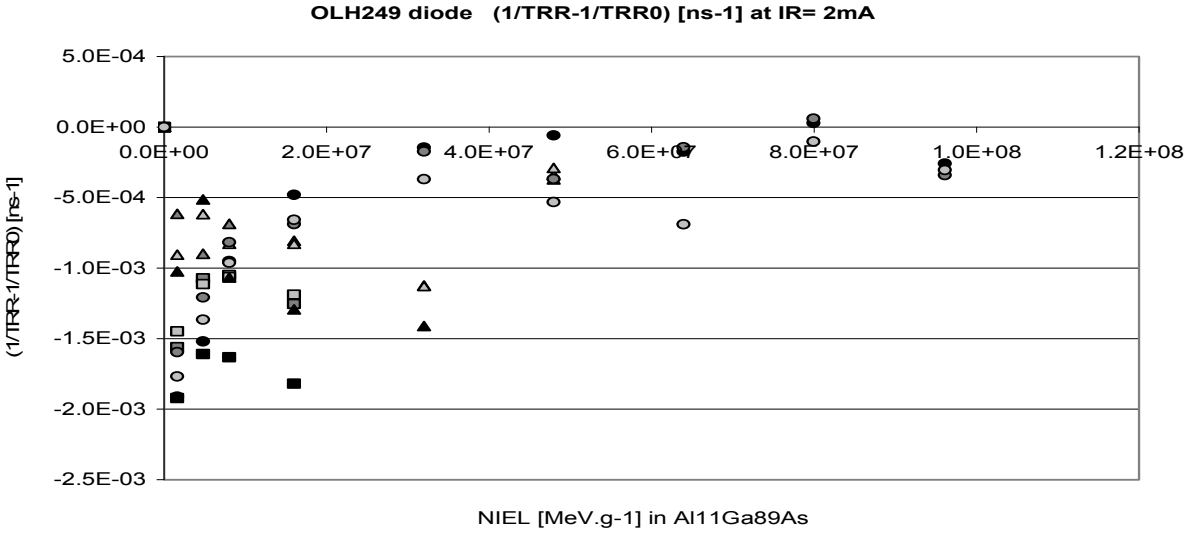


Fig. 13-157: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)





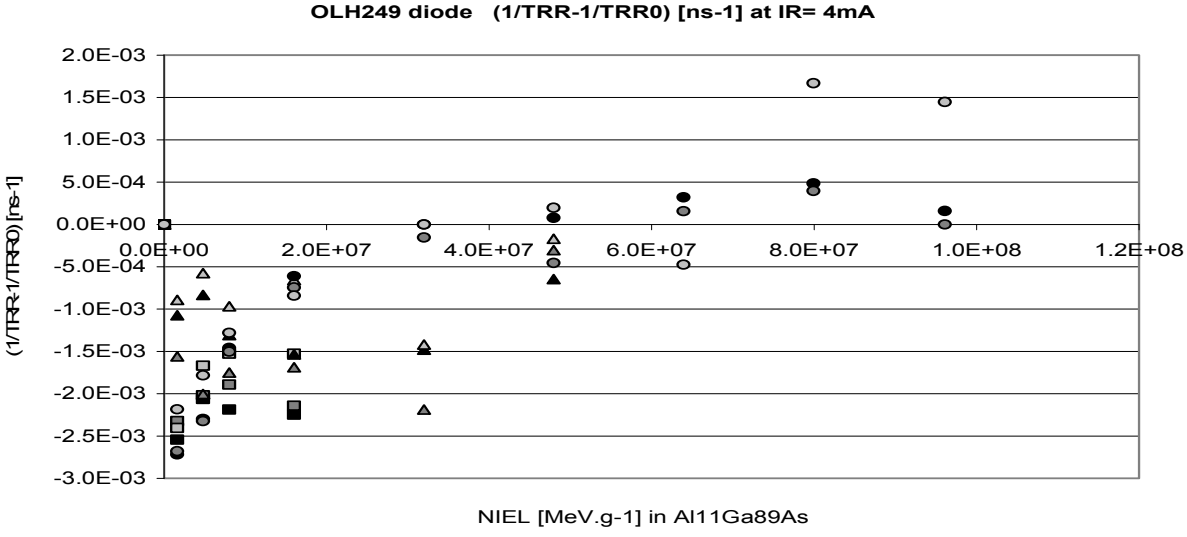


Fig. 13-158: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}

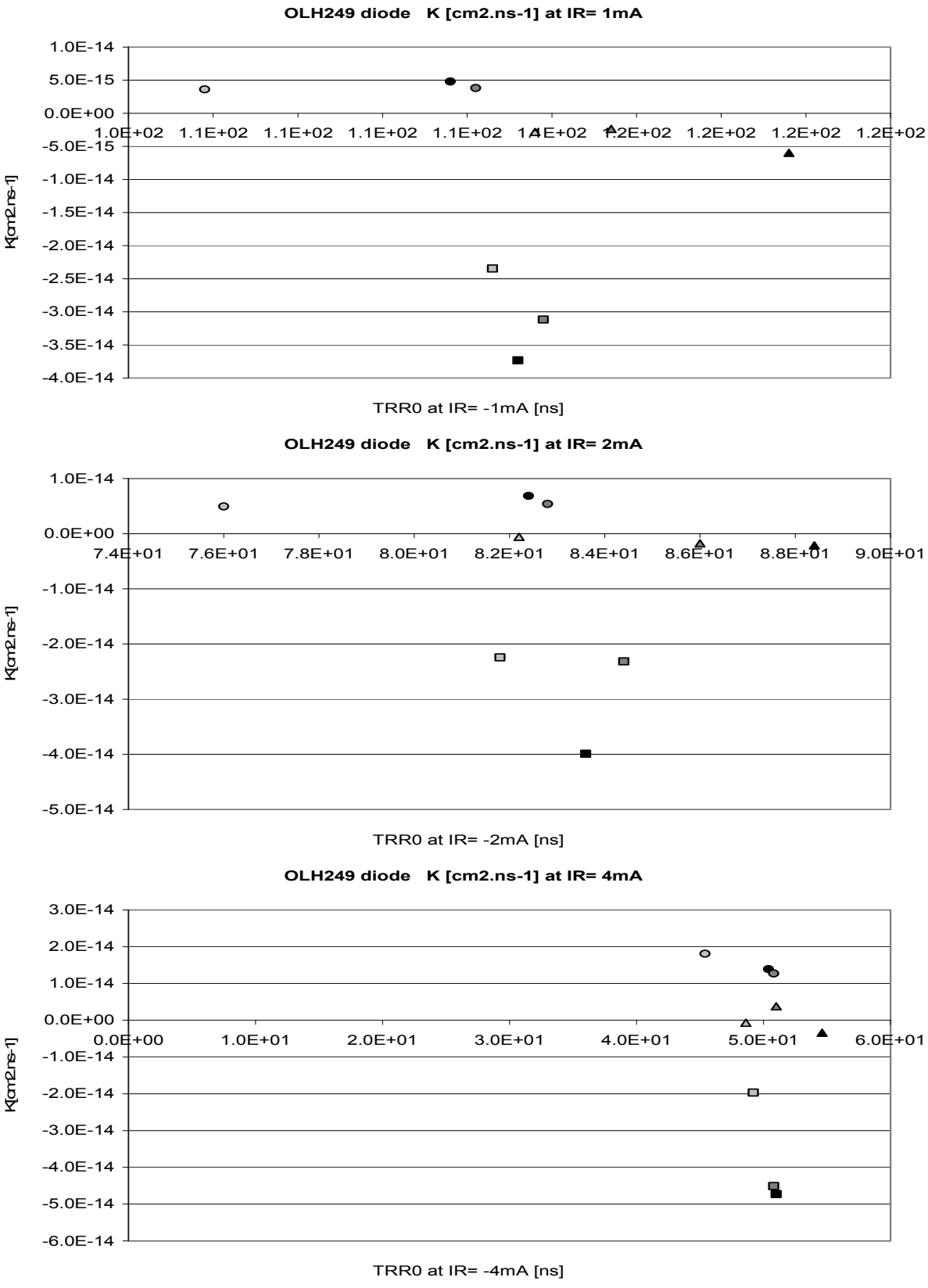
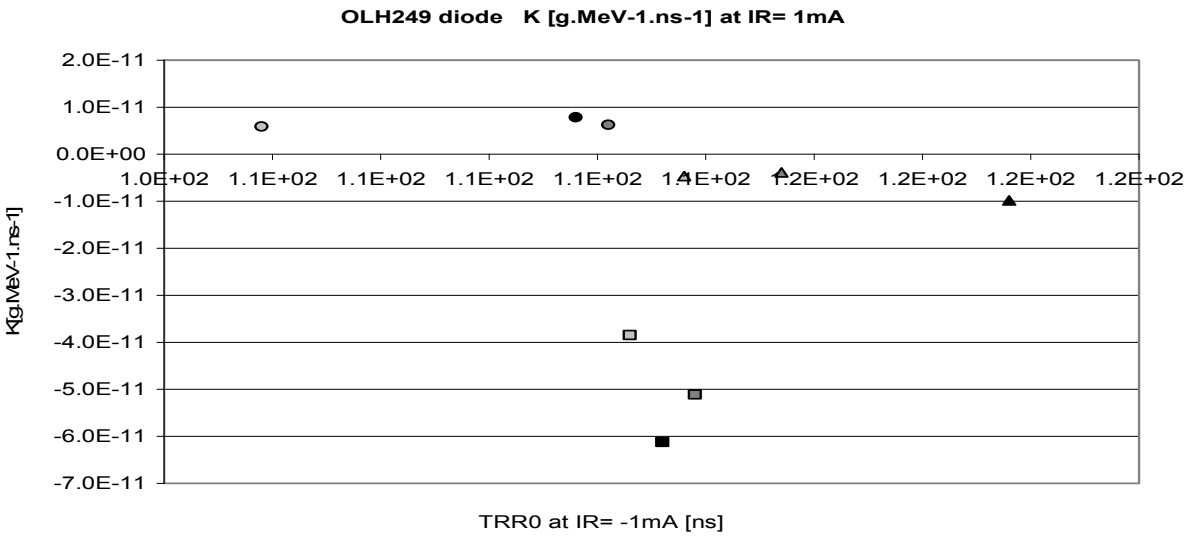
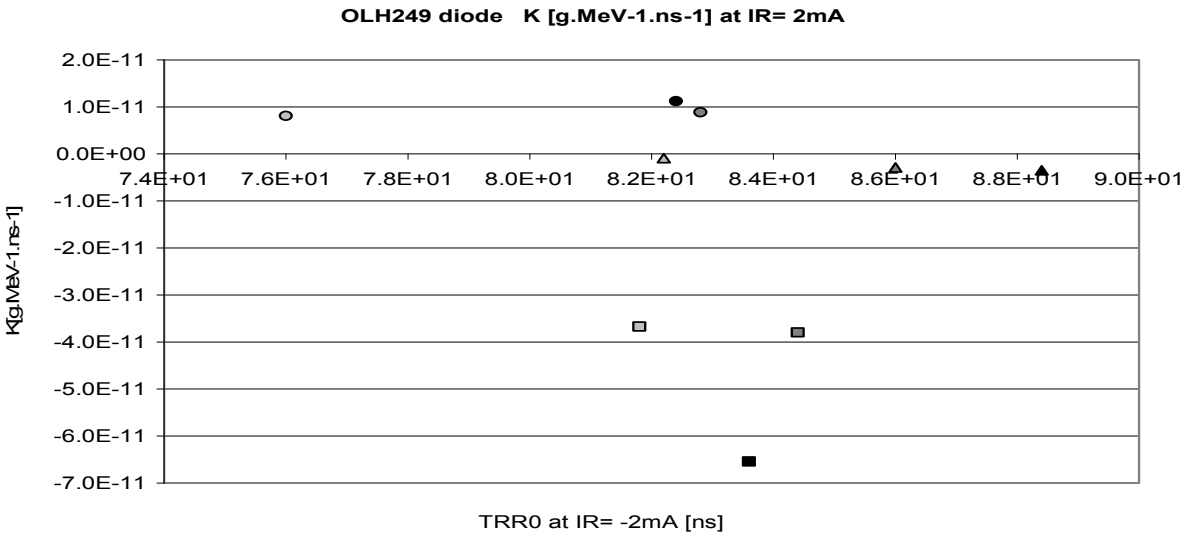


Fig. 13-159: OLH249 diode: K_{NIEL} at I_R = -1, -2, -4mA with respect to τ_{RR0}





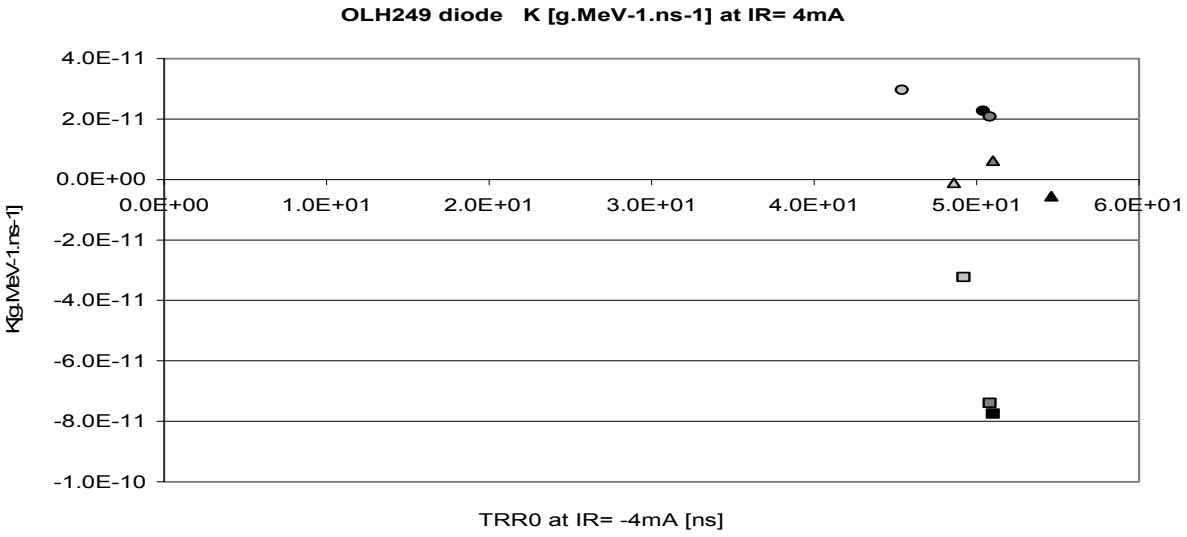
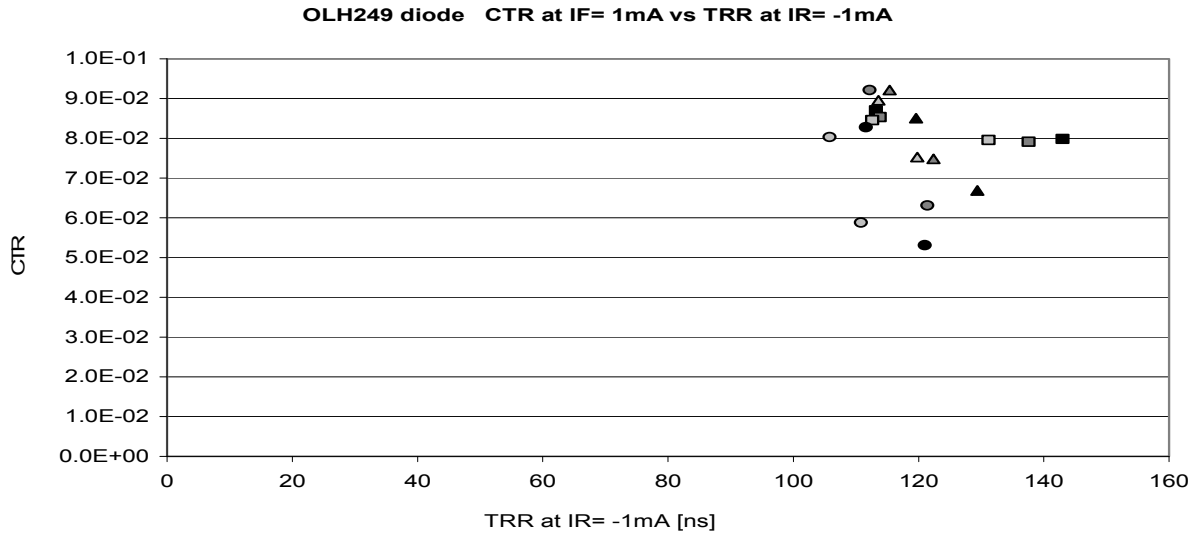
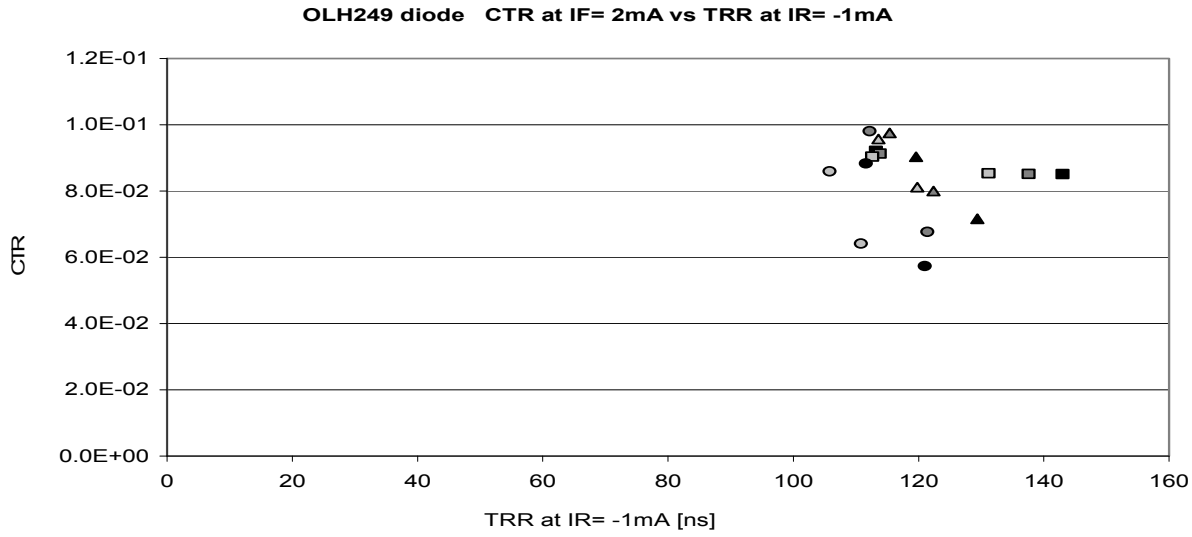
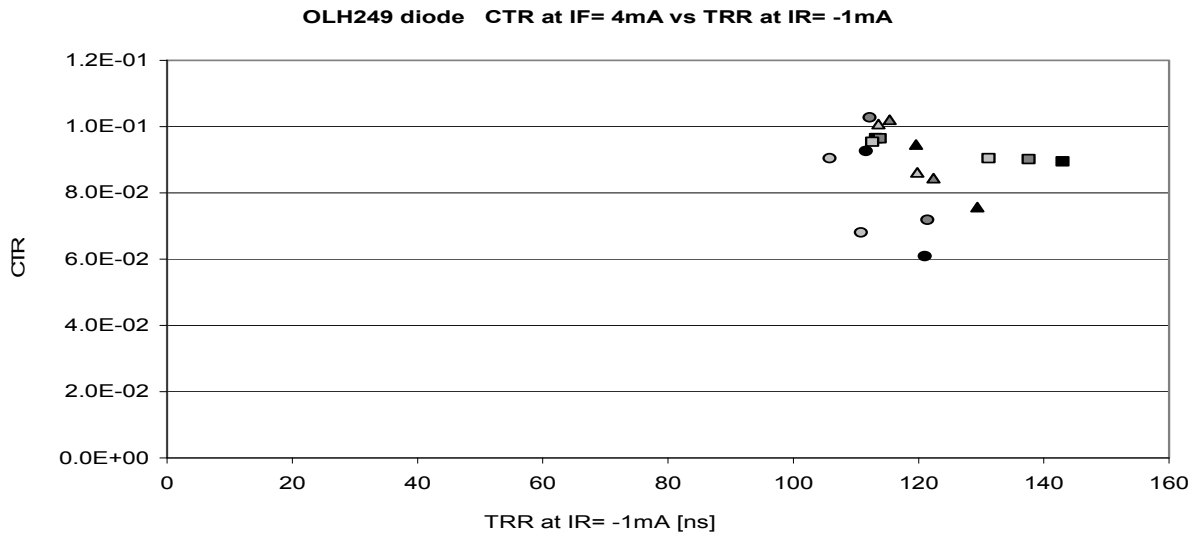
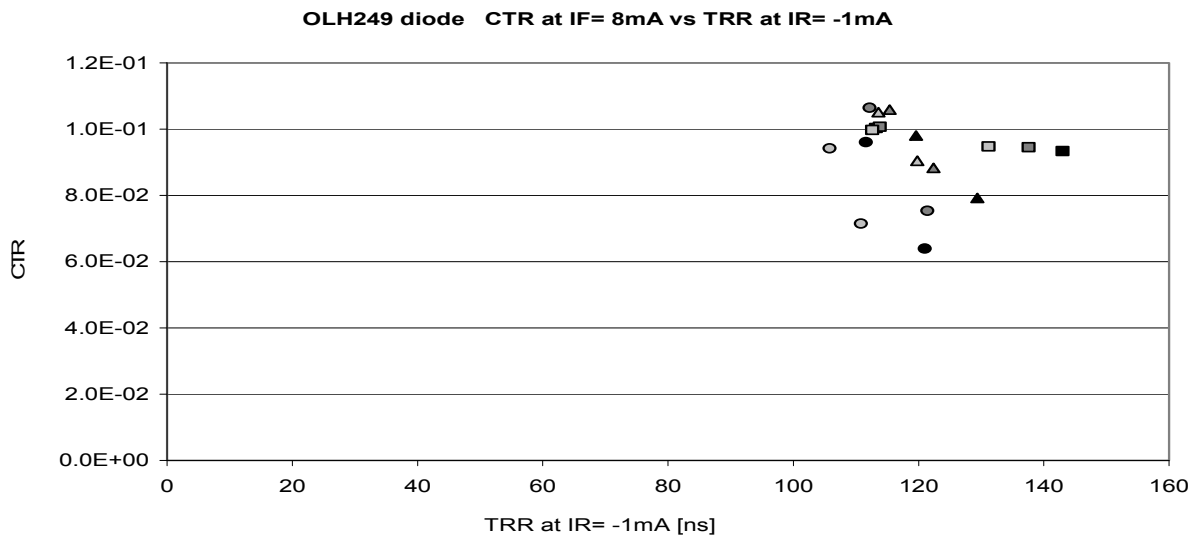


Fig. 13-160: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
140
160
TRR at IR= -1mA [ns]

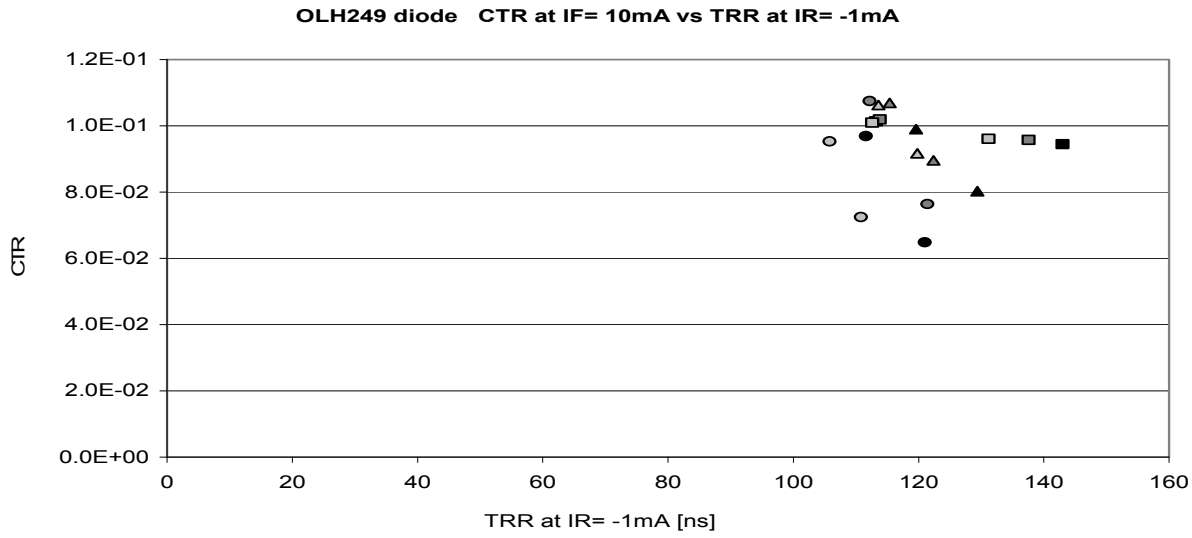
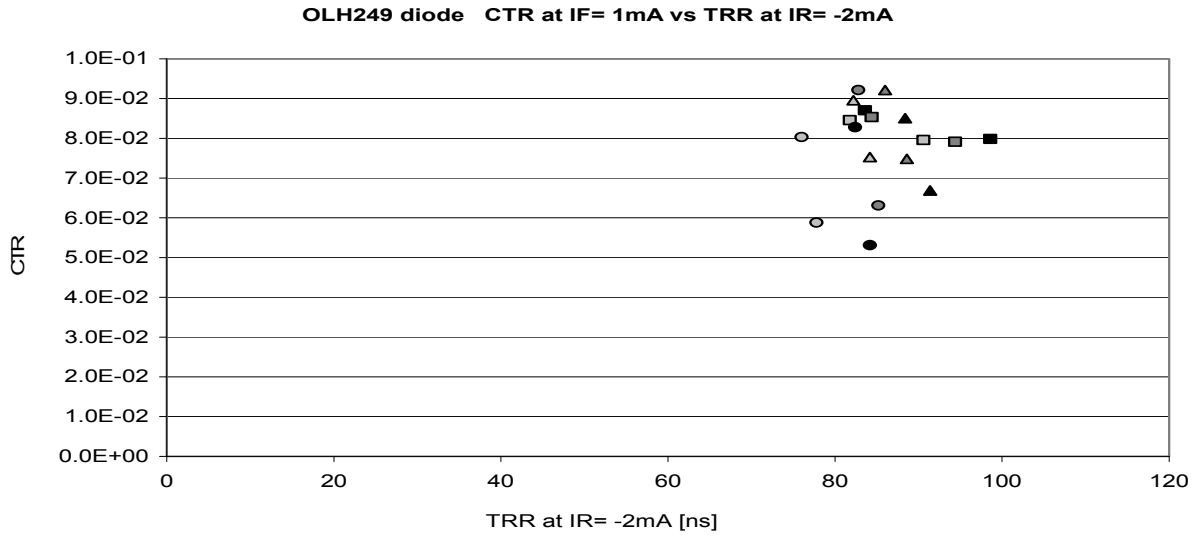
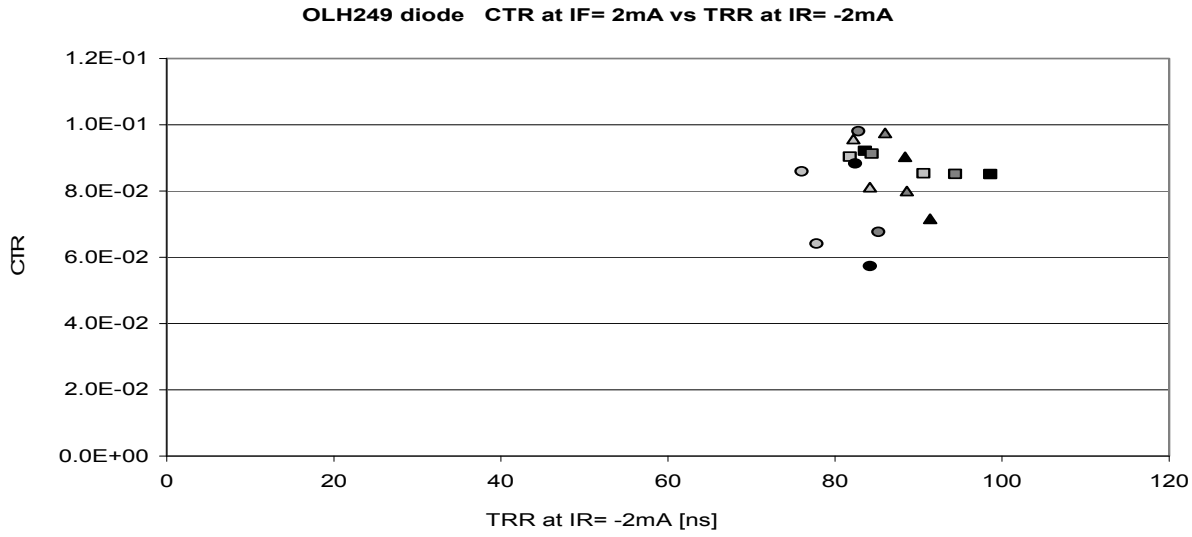
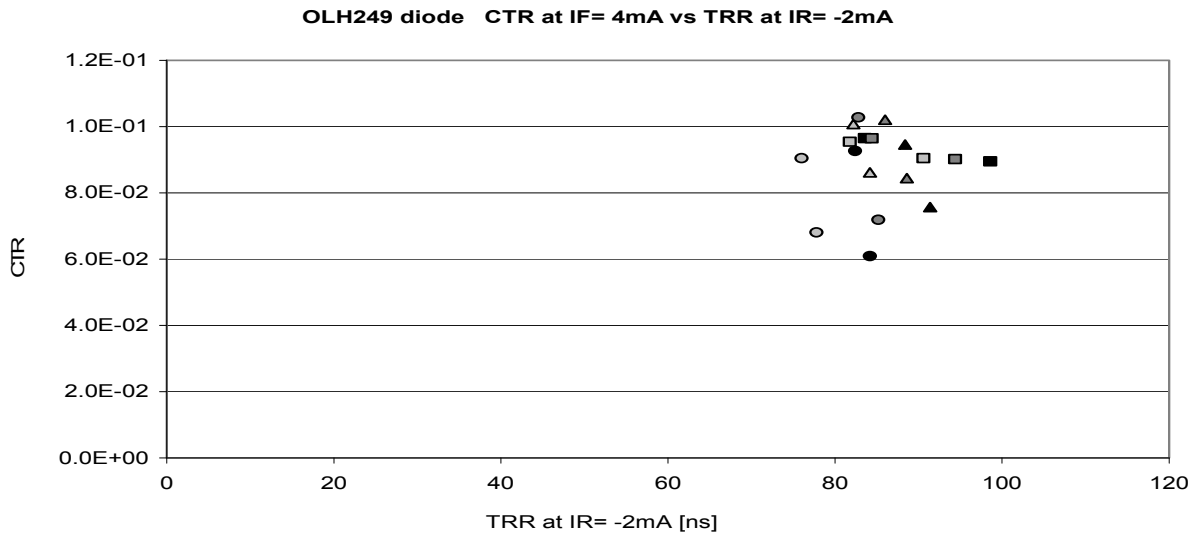
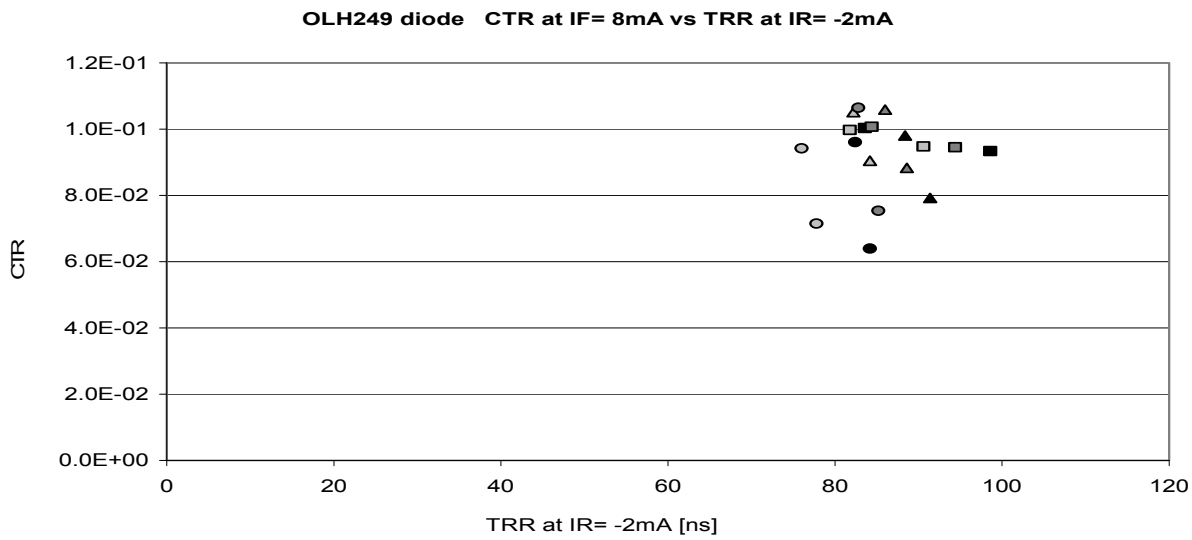

OLH249 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
140
160
TRR at IR= -1mA [ns]

Fig. 13-161: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
TRR at IR= -2mA [ns]

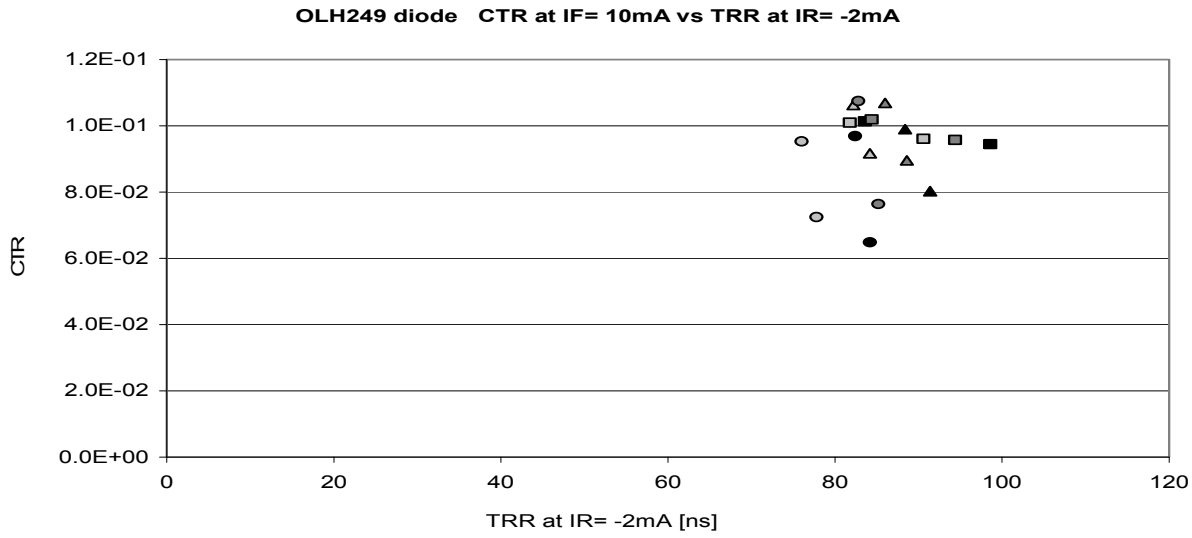
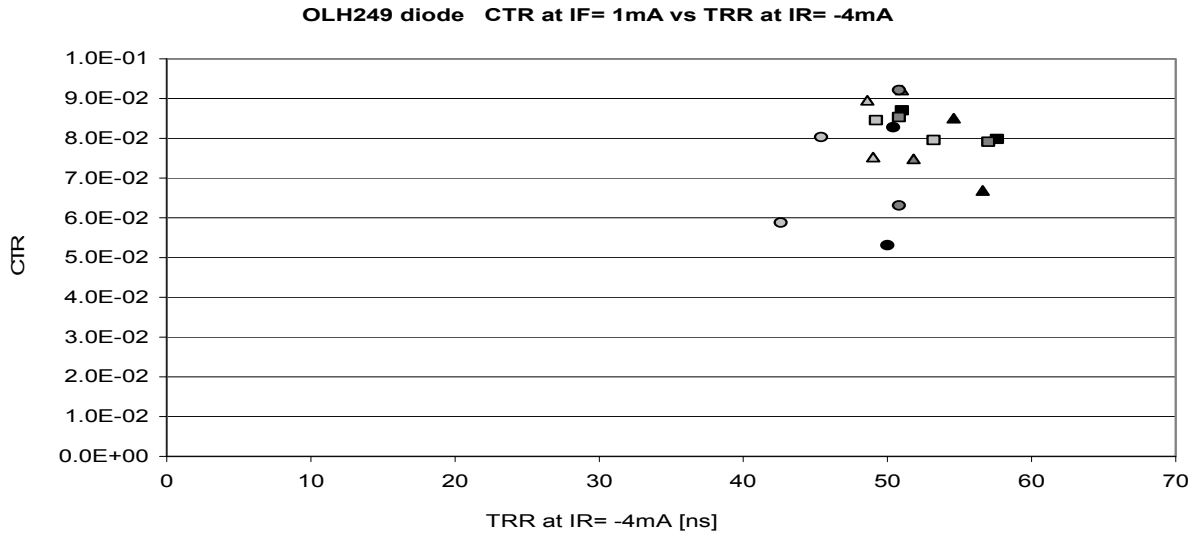
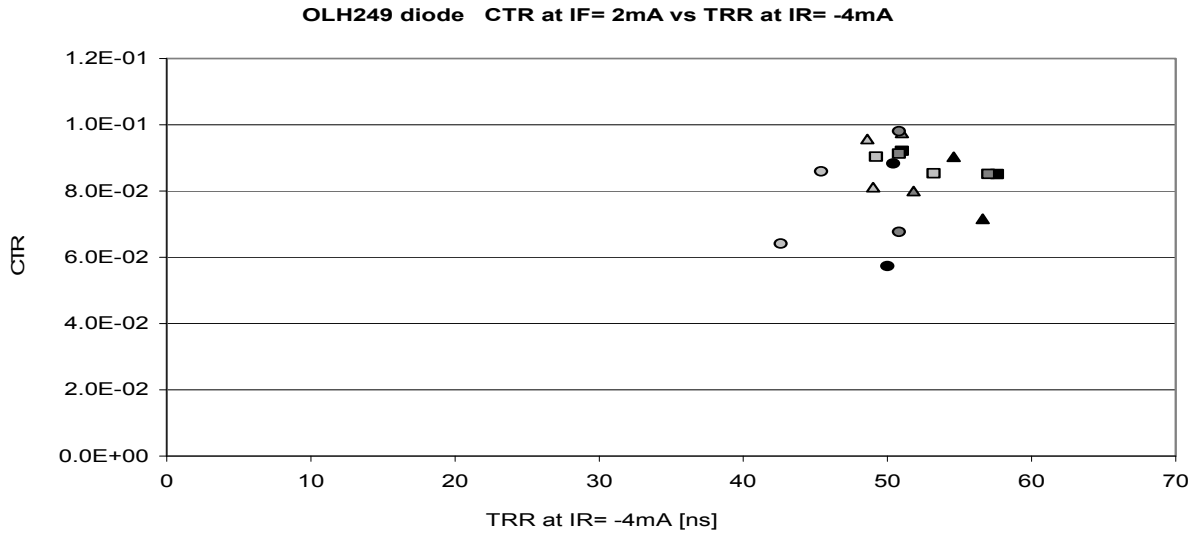
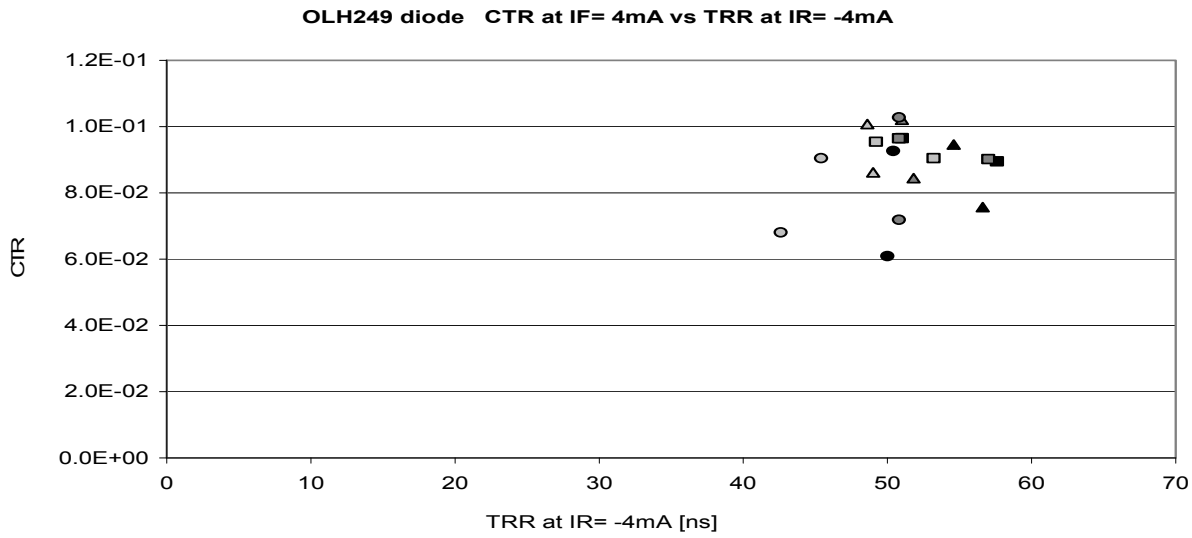
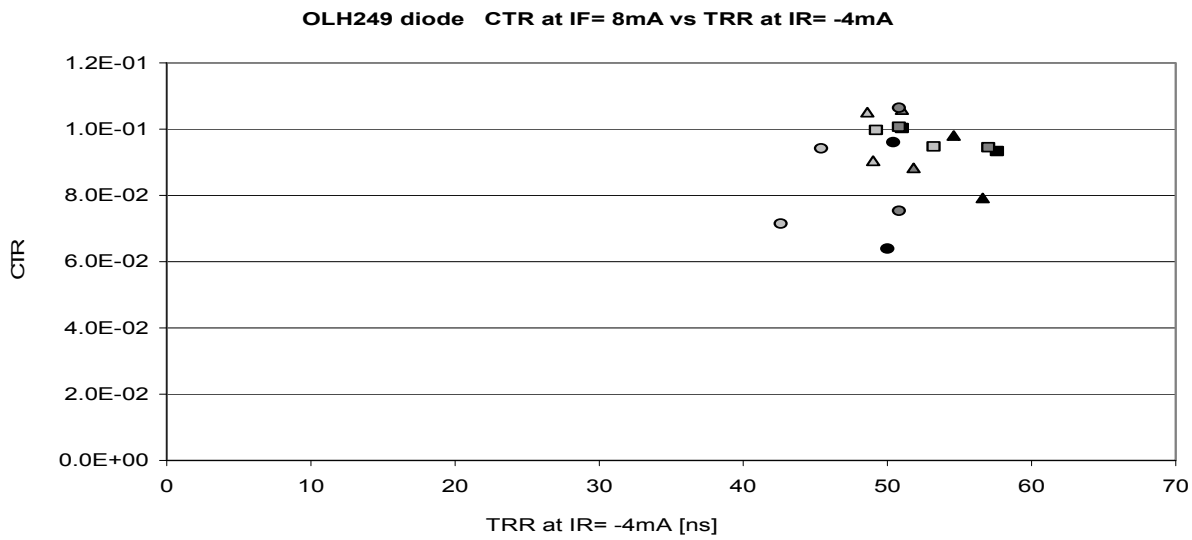

OLH249 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
TRR at IR= -2mA [ns]

Fig. 13-162: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -4mA [ns]

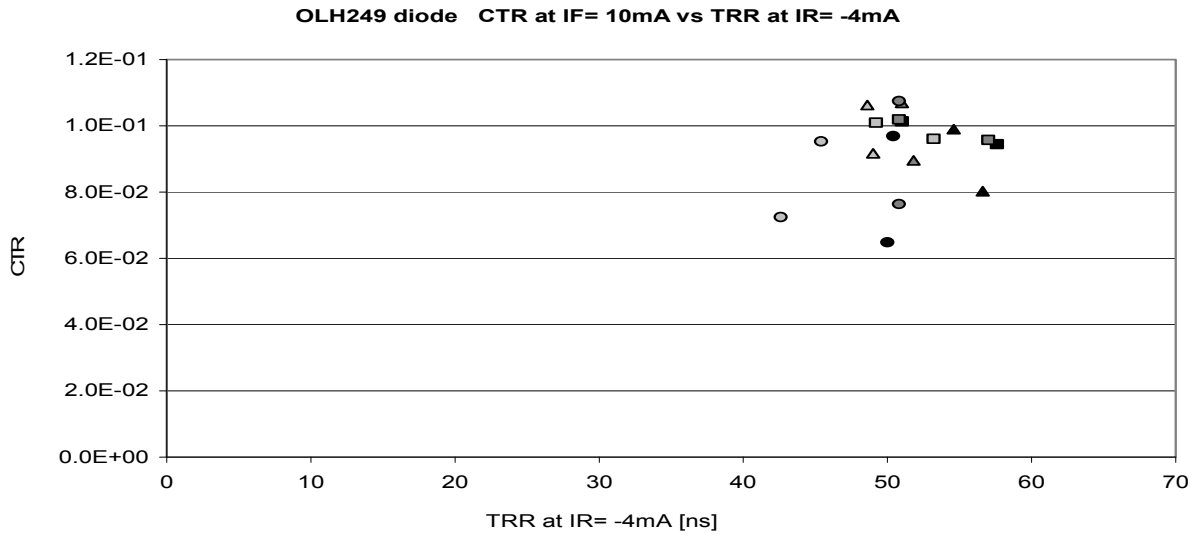
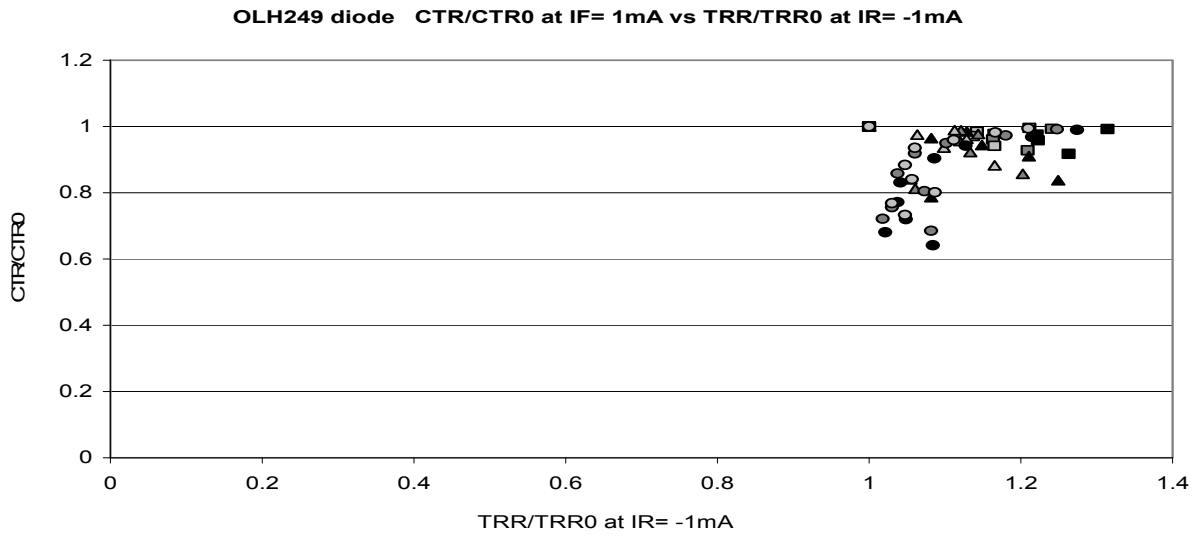
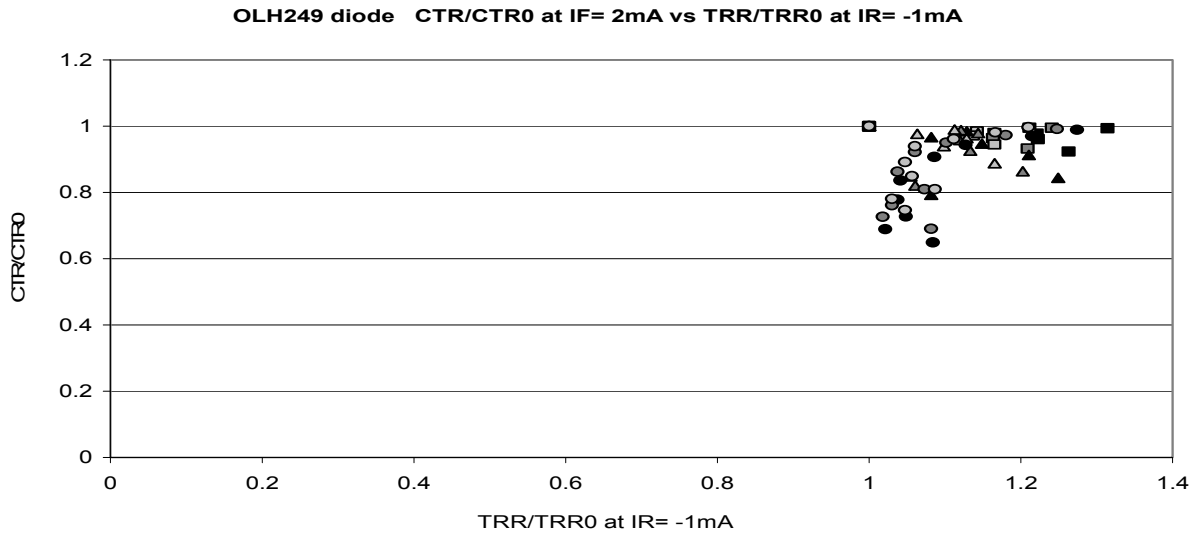
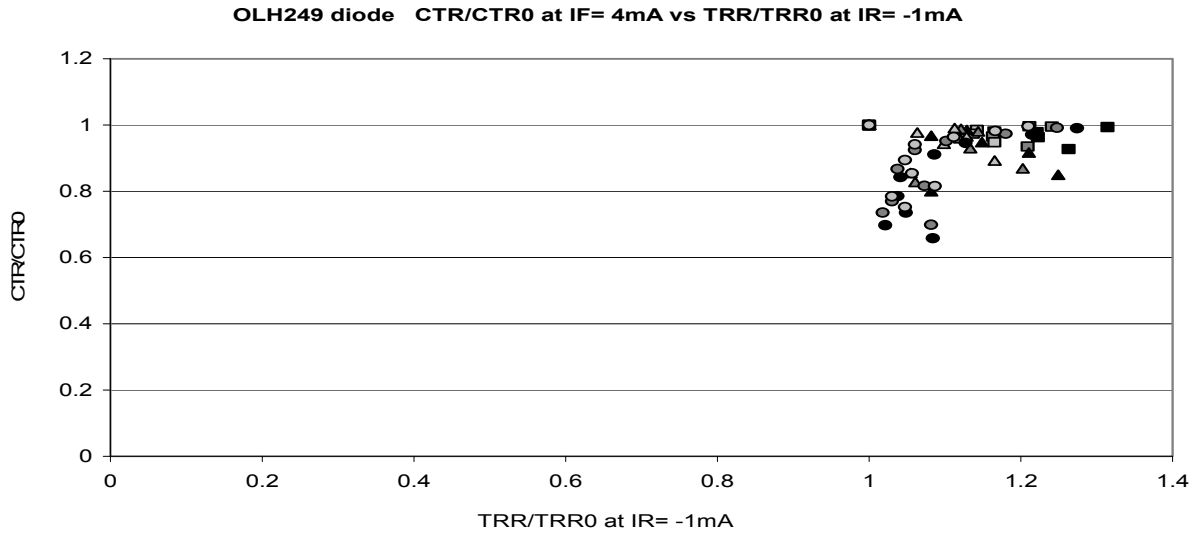
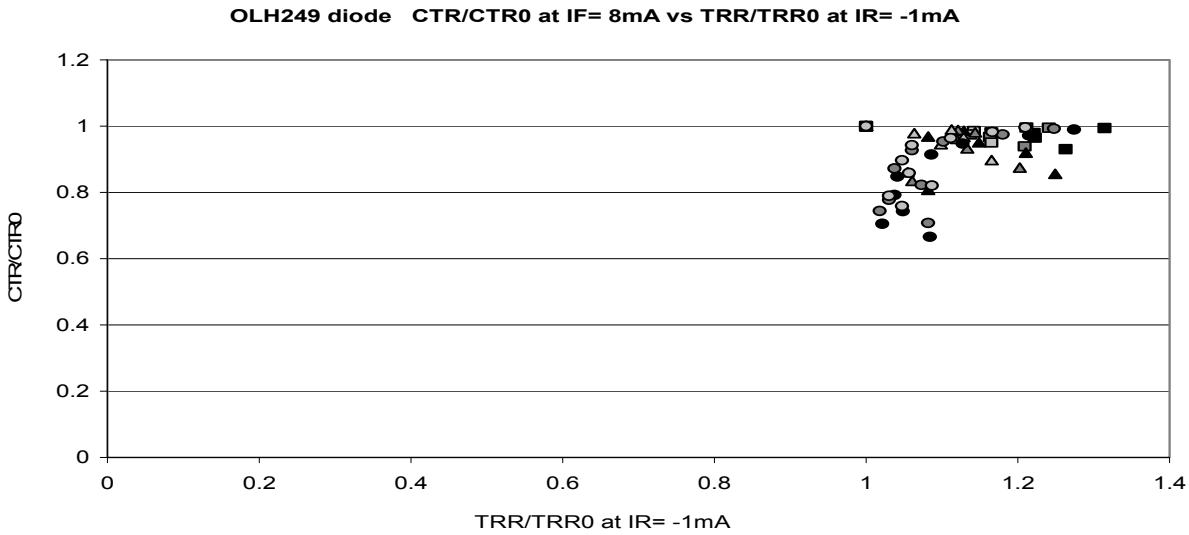

OLH249 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -4mA [ns]

Fig. 13-163: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

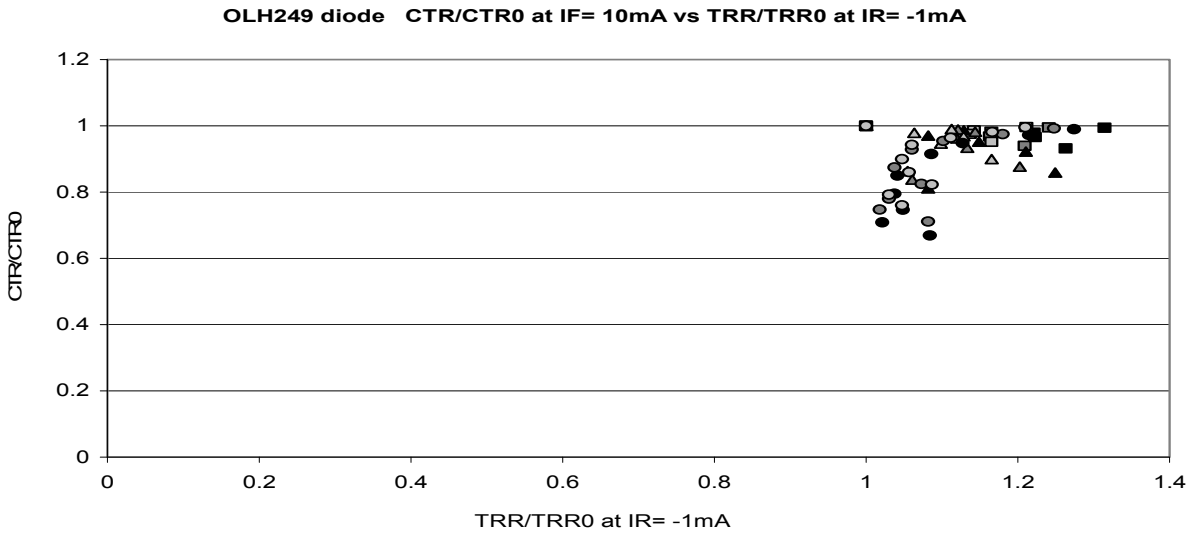
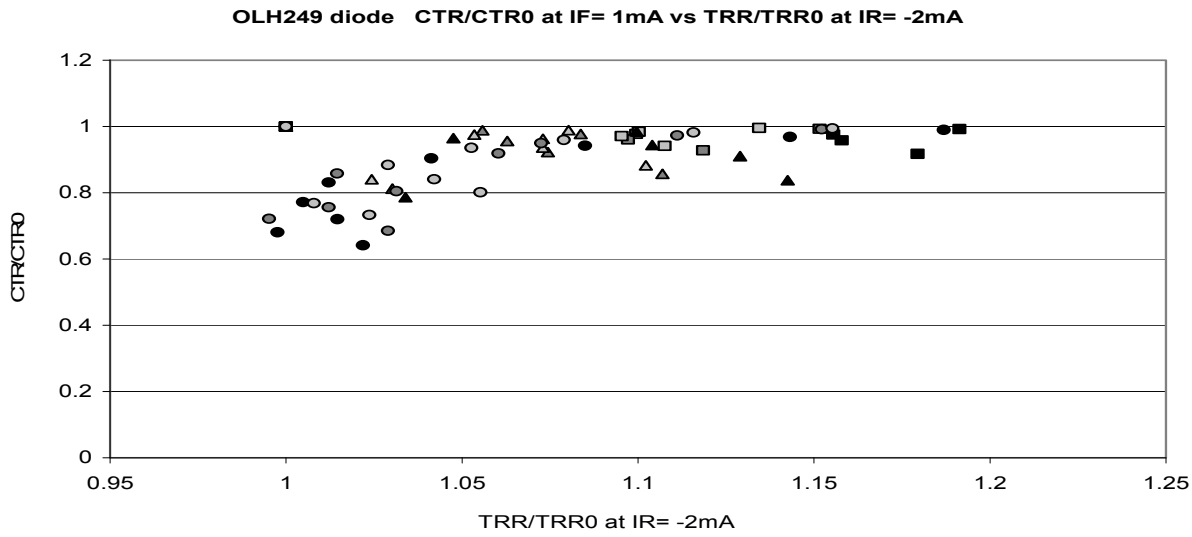
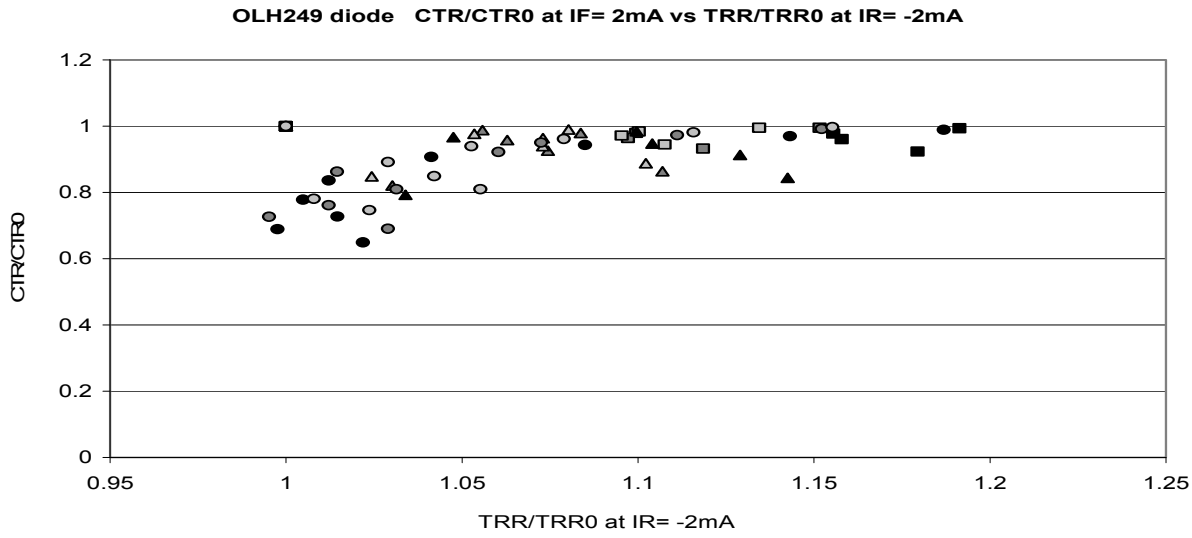
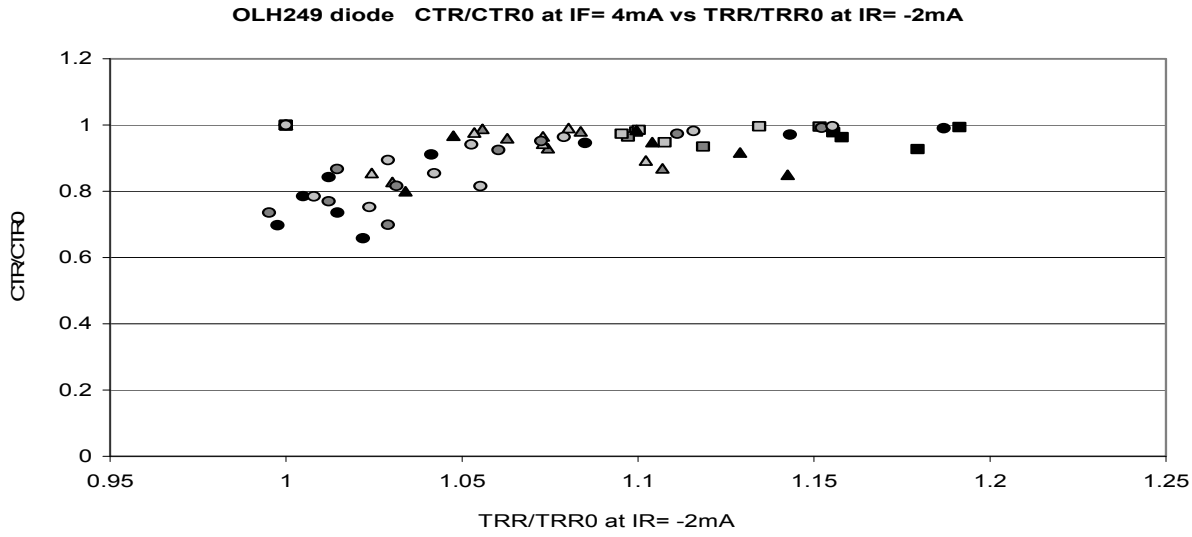
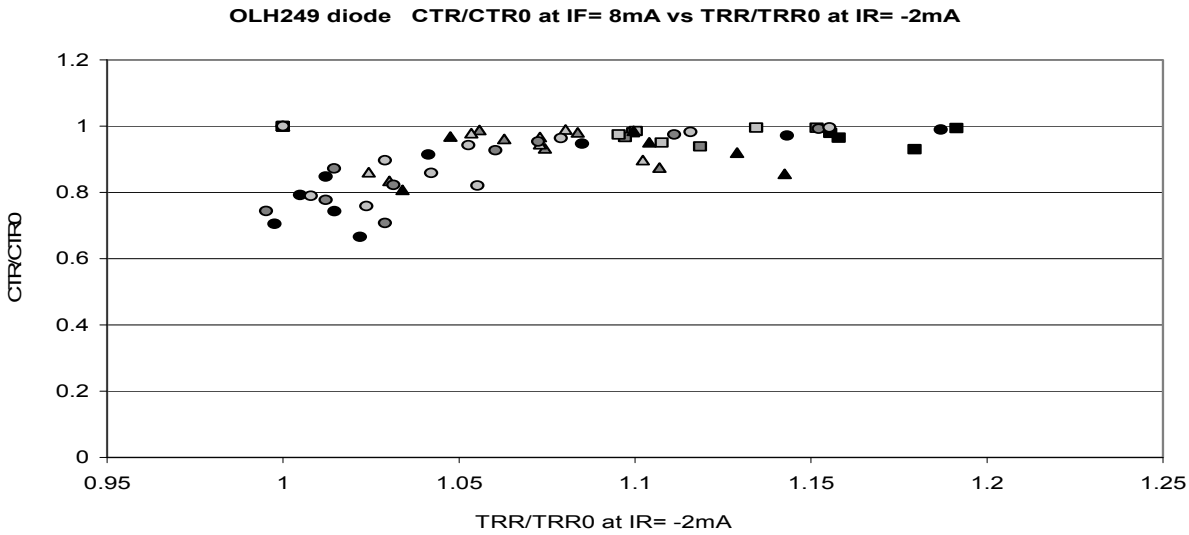

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 13-164: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.95
1
1.05
1.1
1.15
1.2
1.25
TRR/TRR0 at IR= -2mA

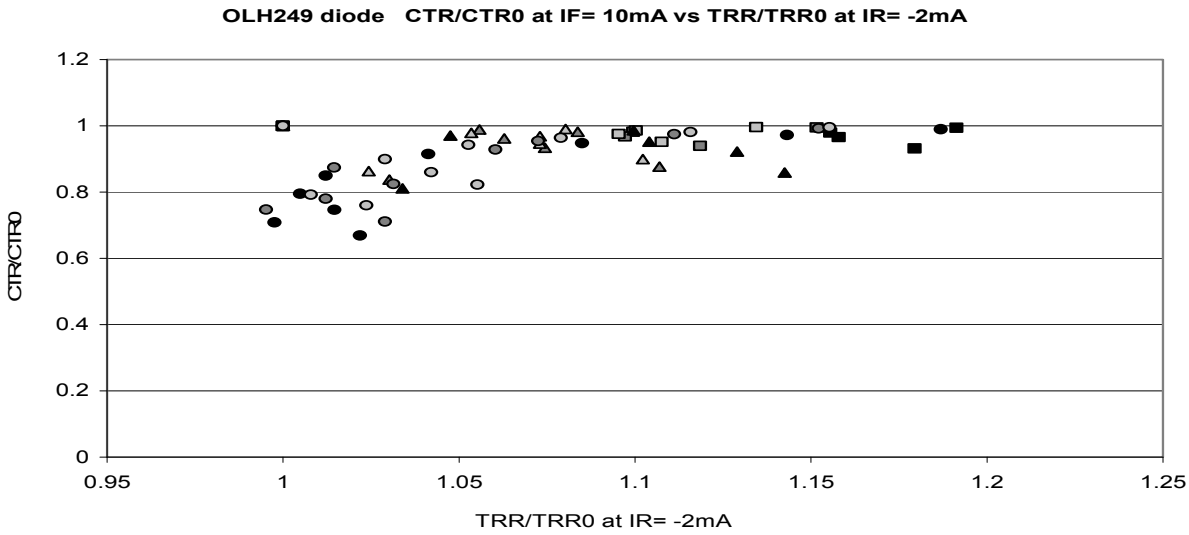
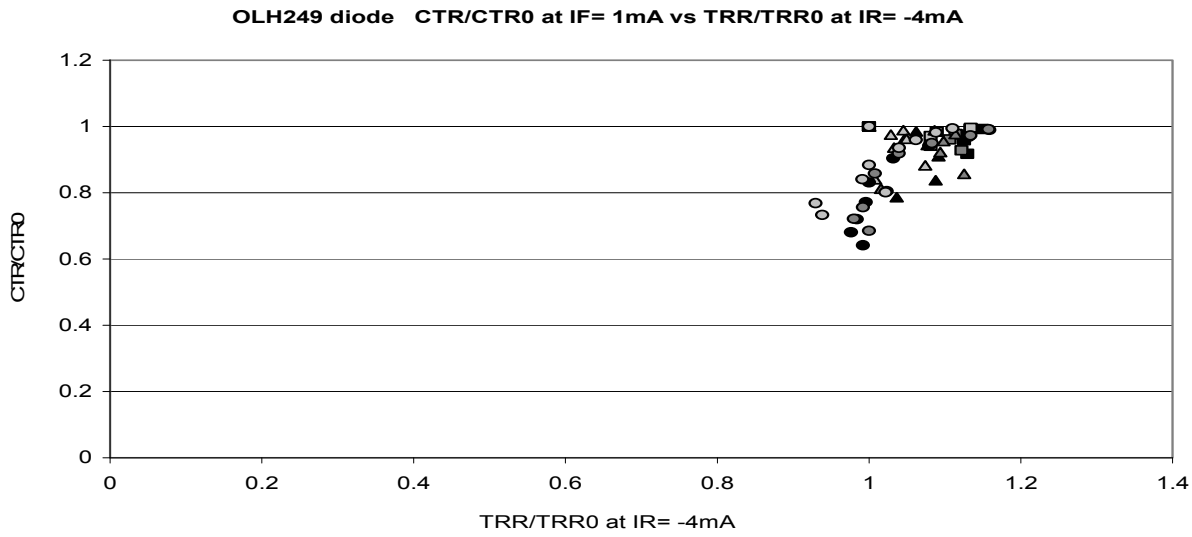
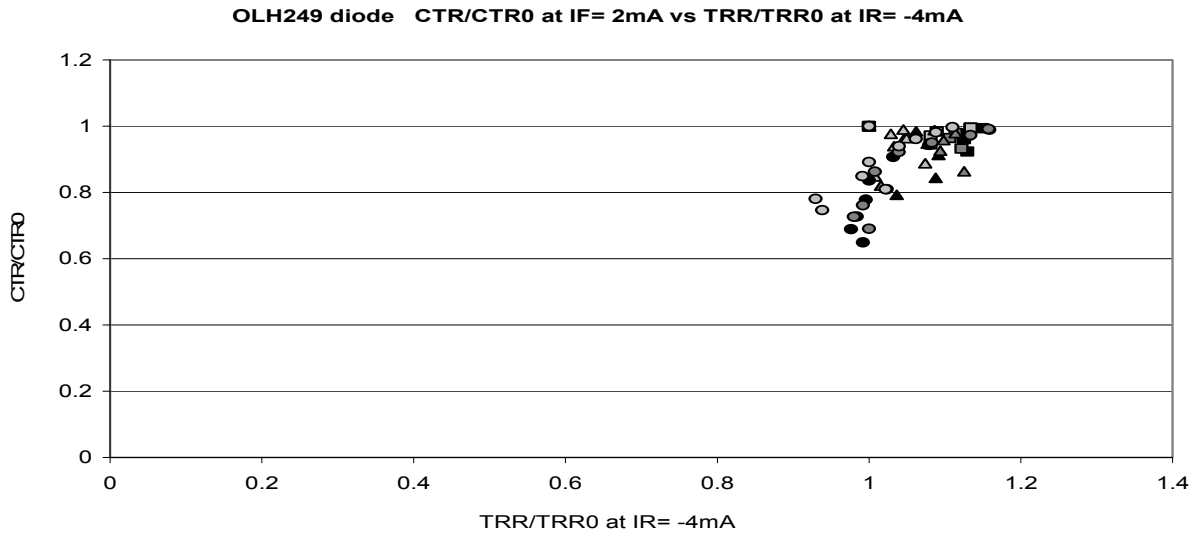
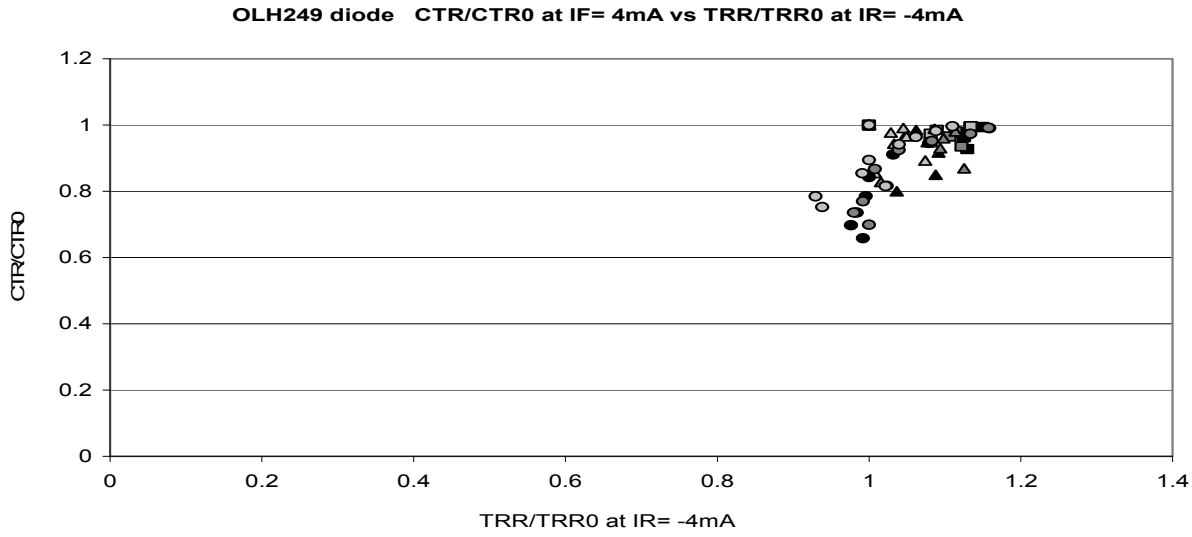
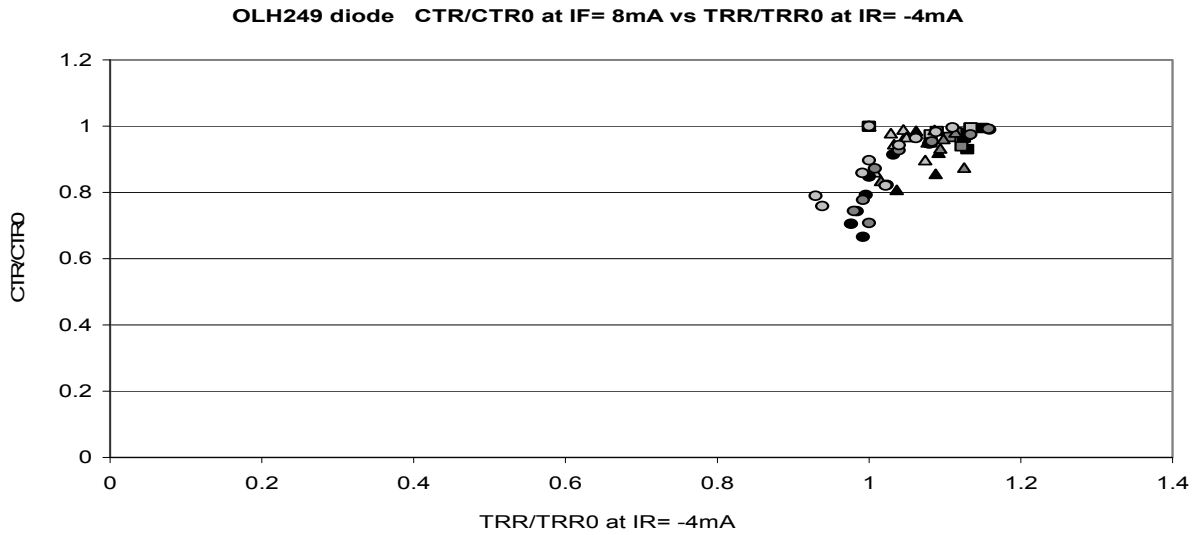

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.95
1
1.05
1.1
1.15
1.2
1.25
TRR/TRR0 at IR= -2mA

Fig. 13-165: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

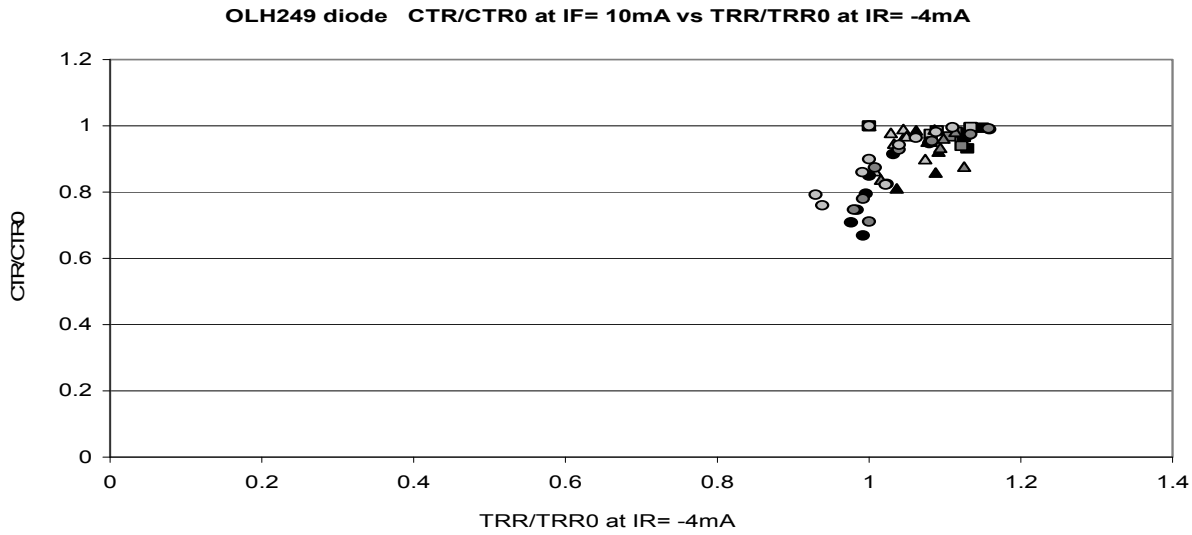
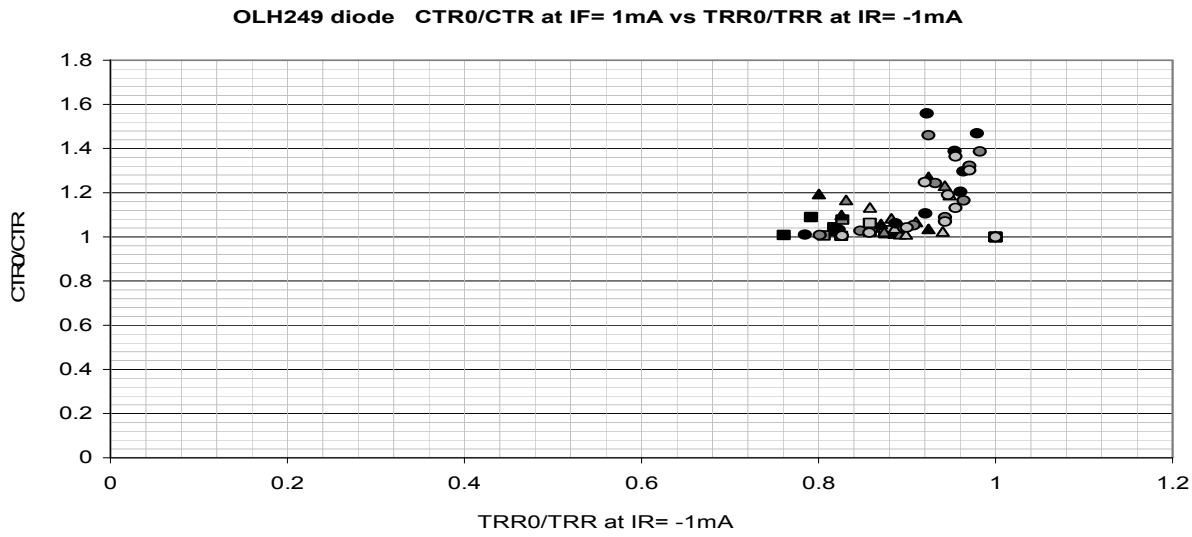
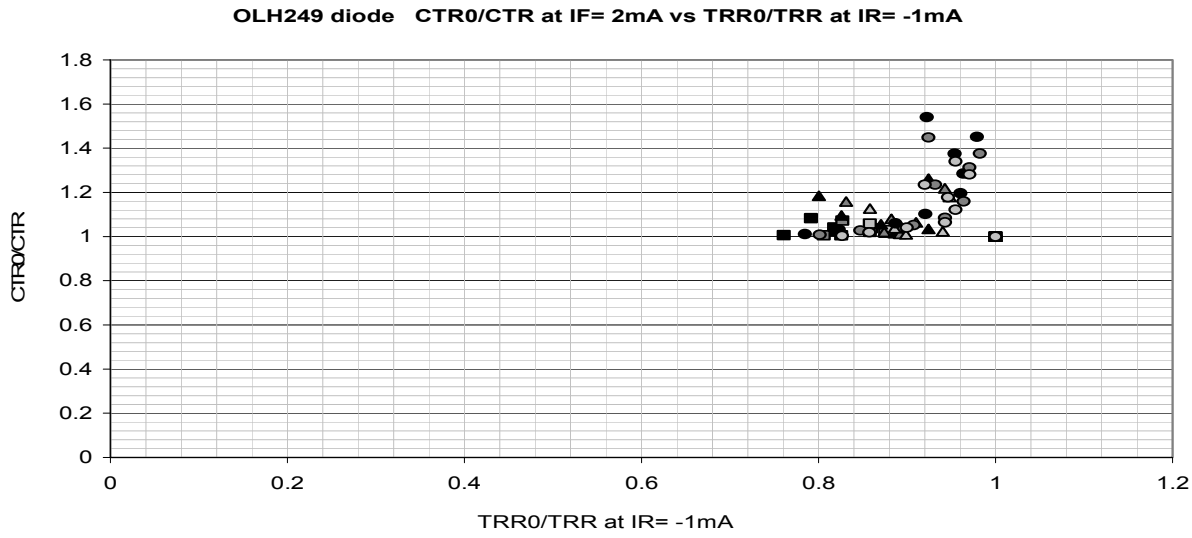
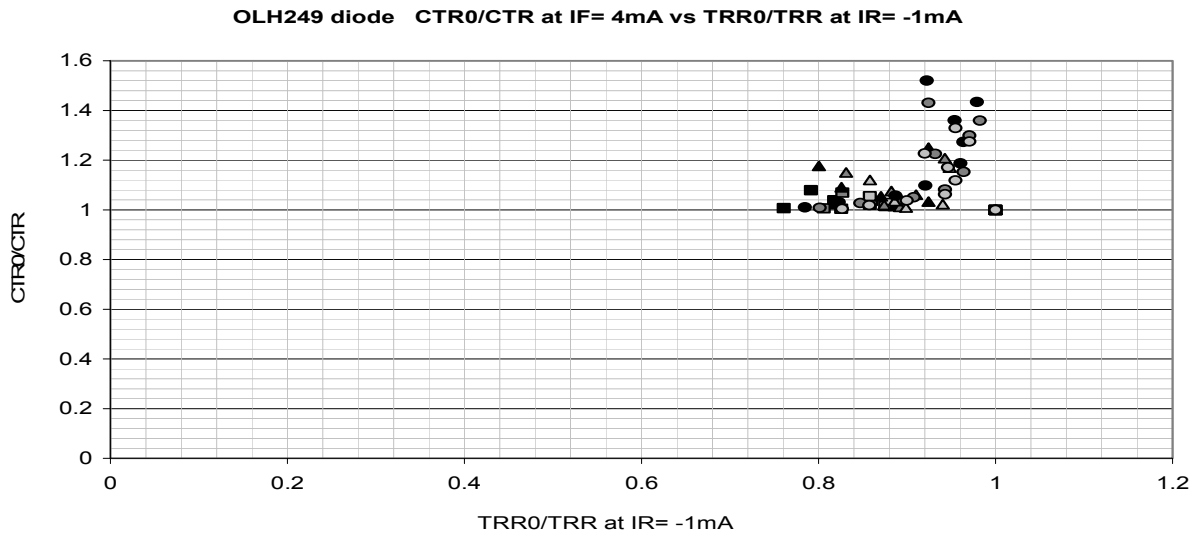
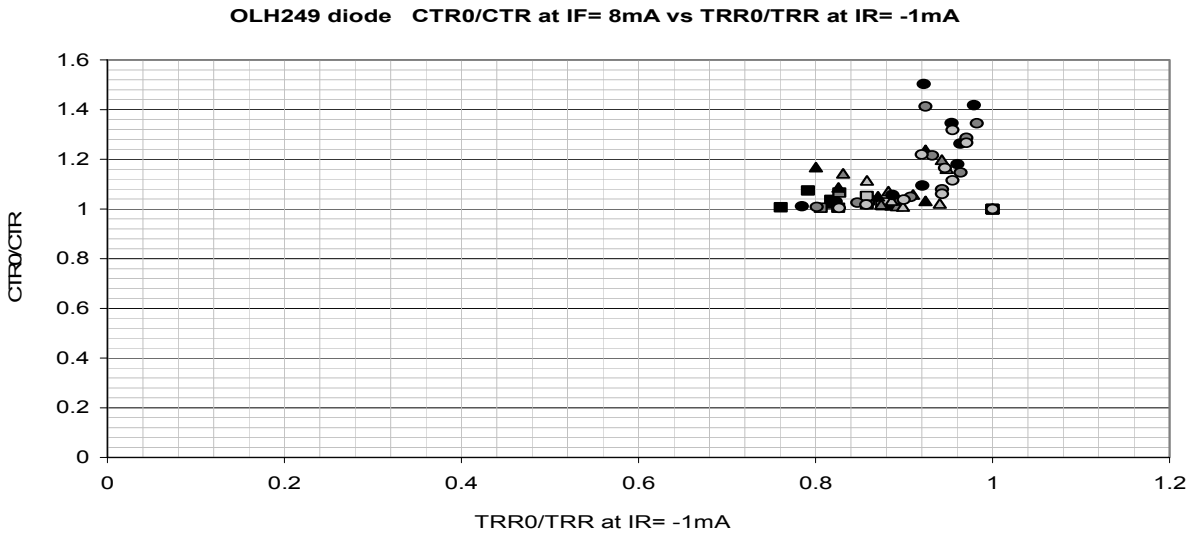

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 13-166: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
TRR0/TRR at IR= -1mA

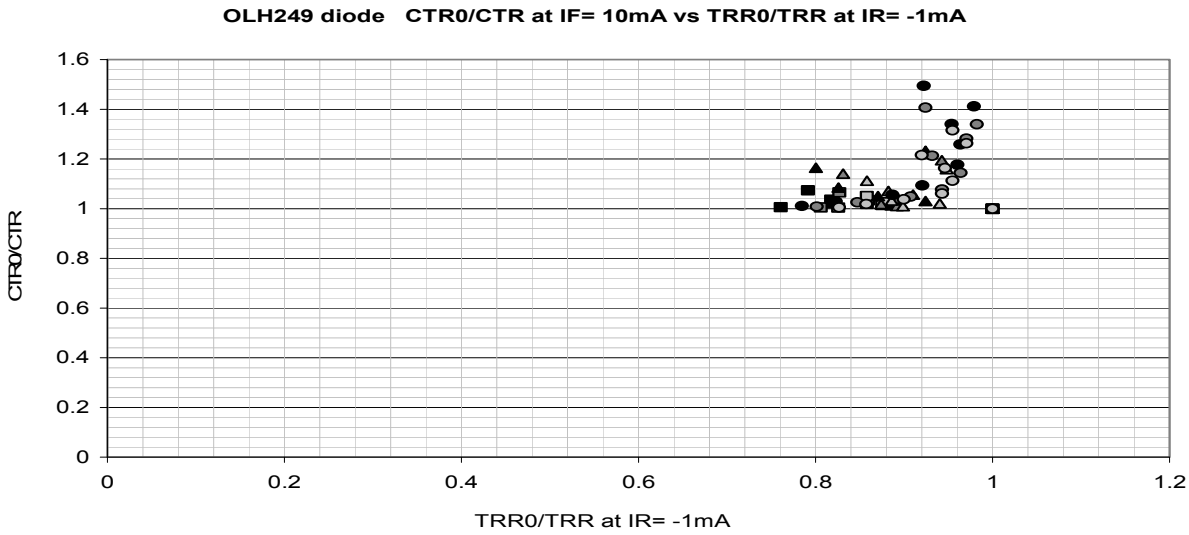
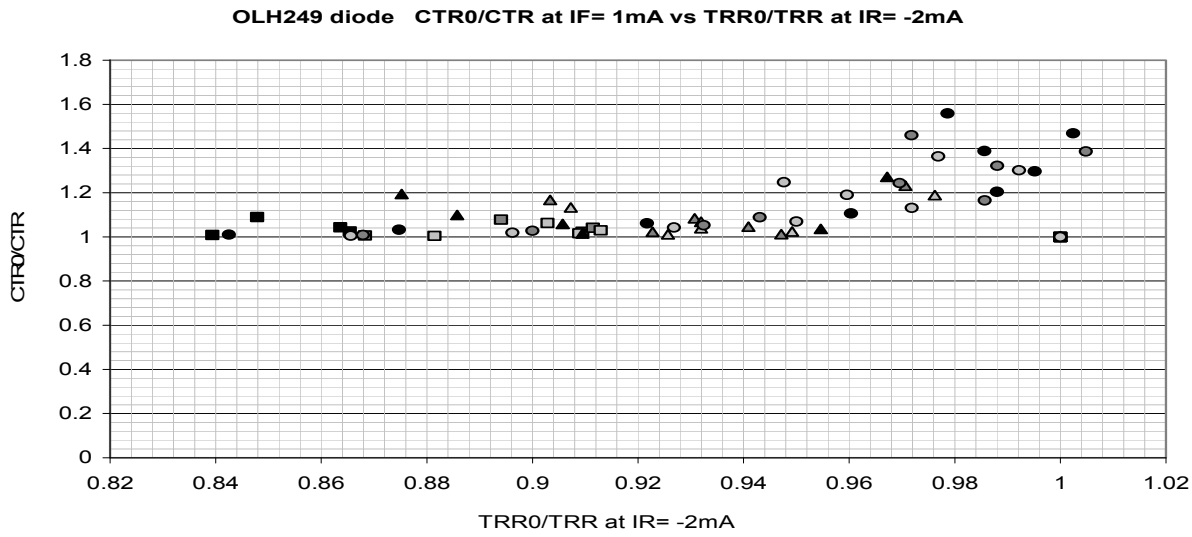
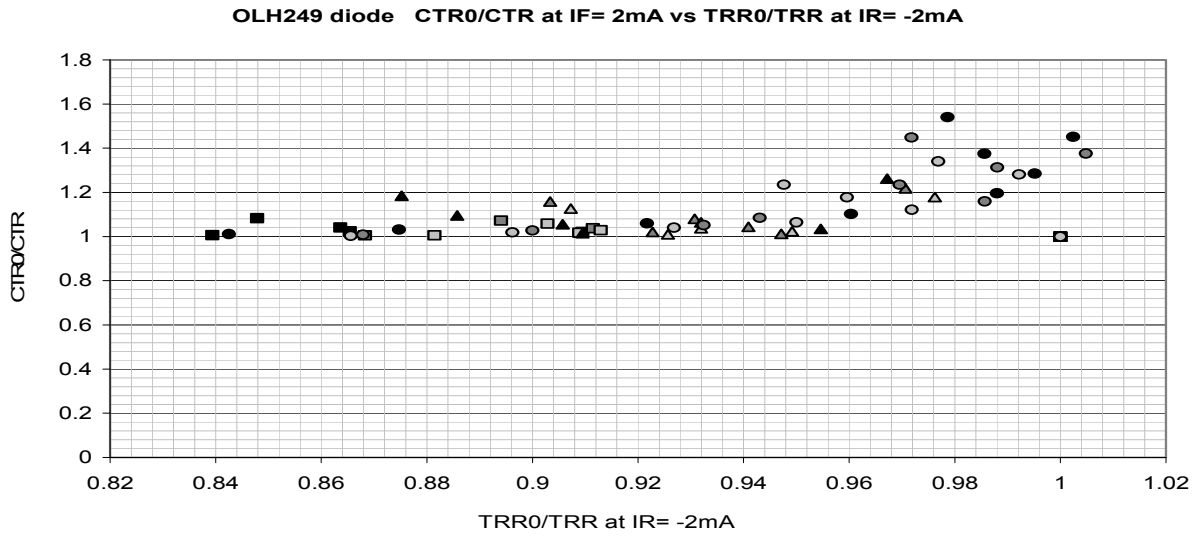
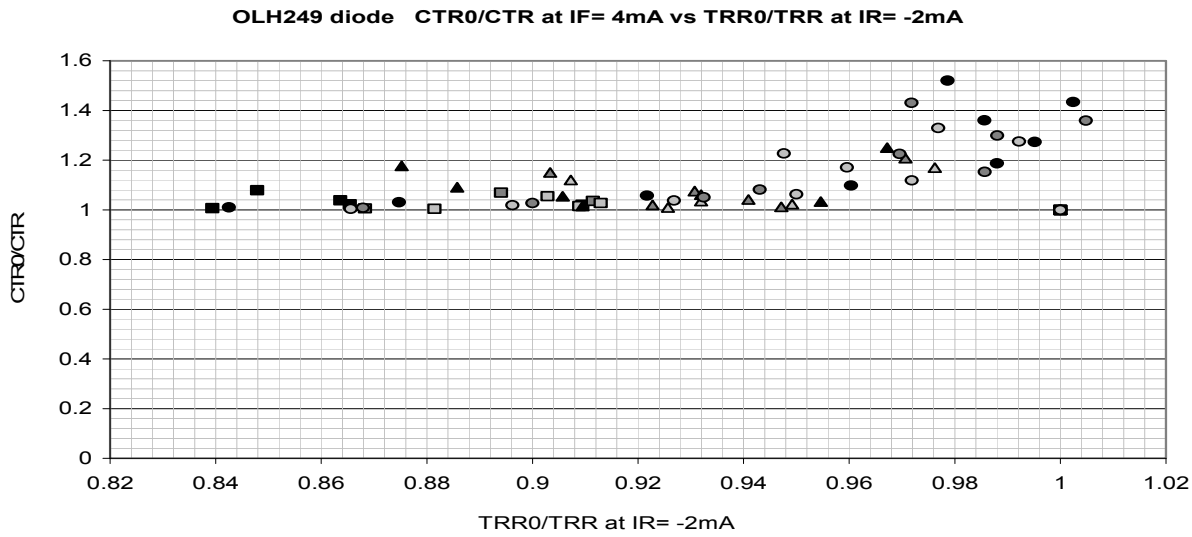
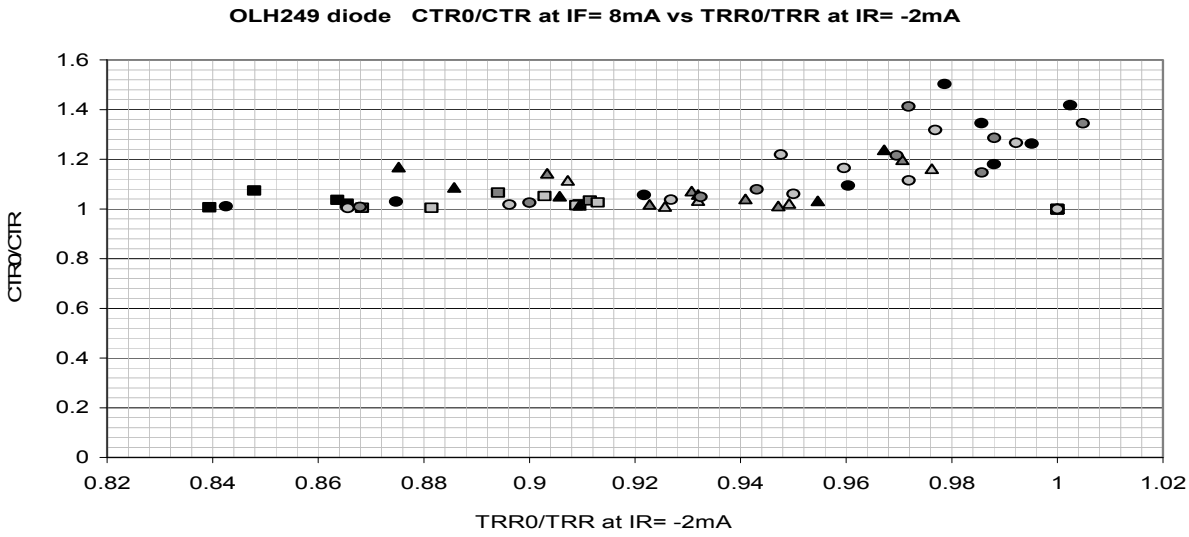

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
TRR0/TRR at IR= -1mA

Fig. 13-167: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
TRR0/TRR at IR= -2mA

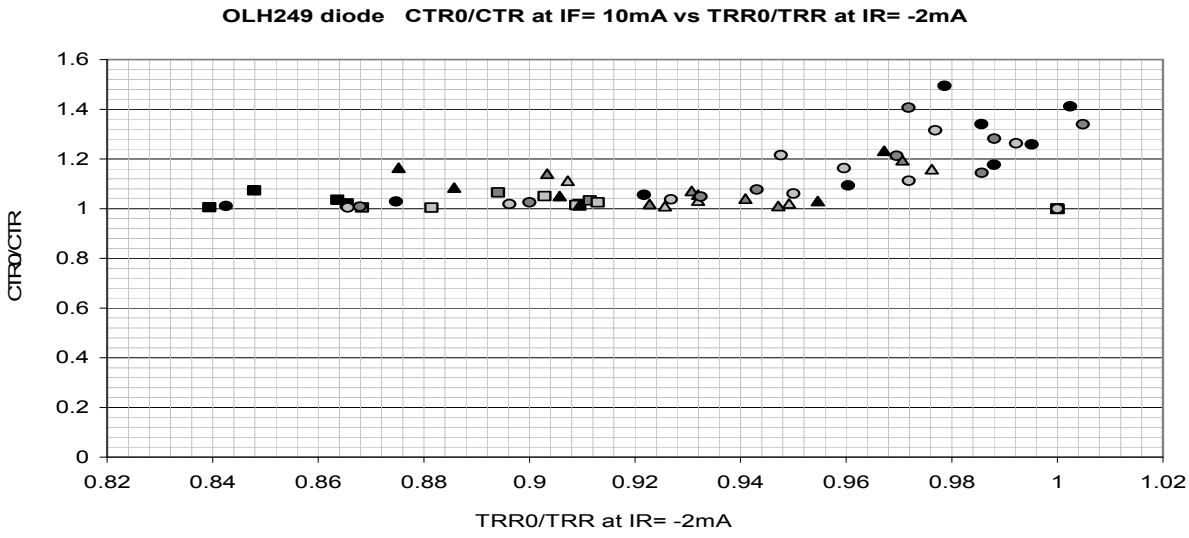
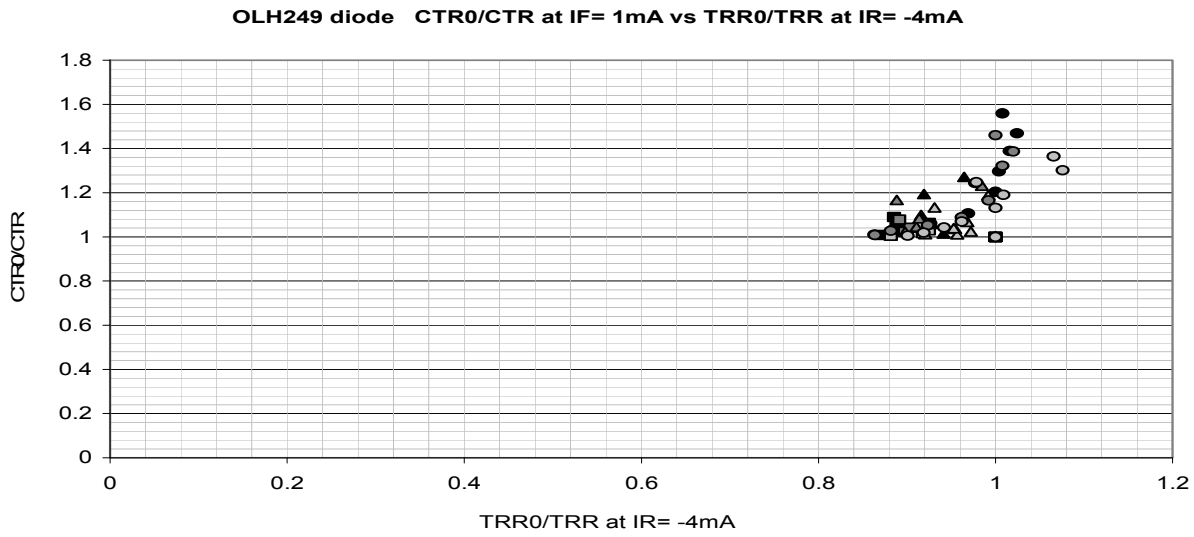
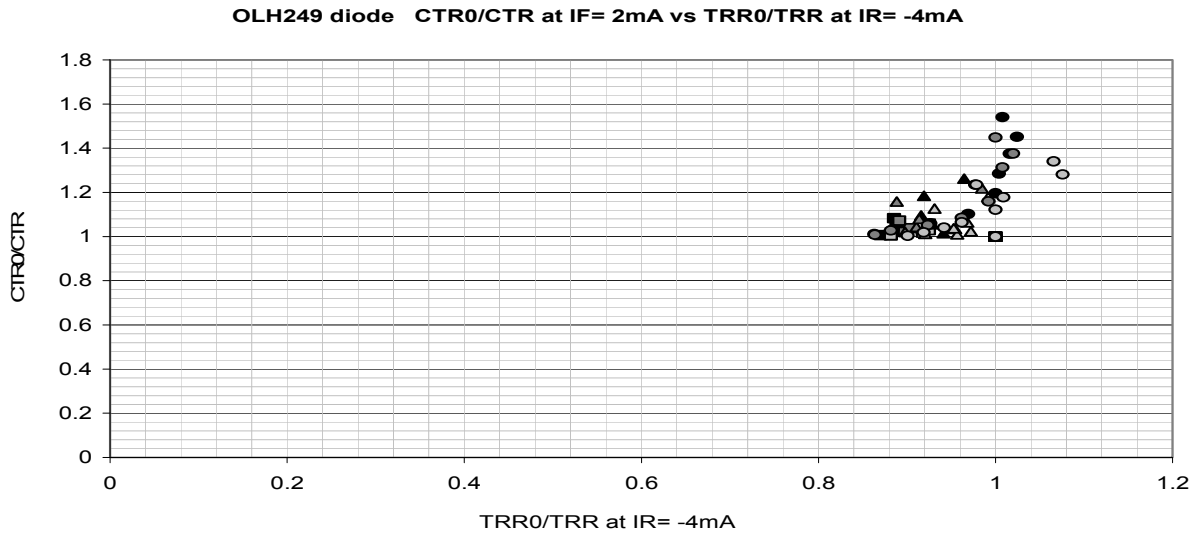
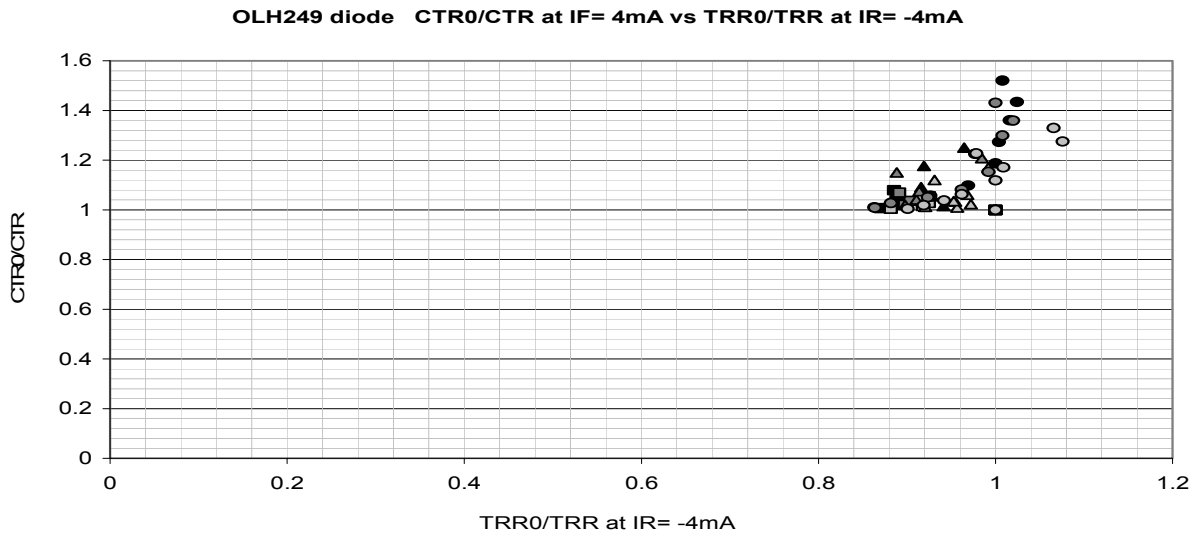
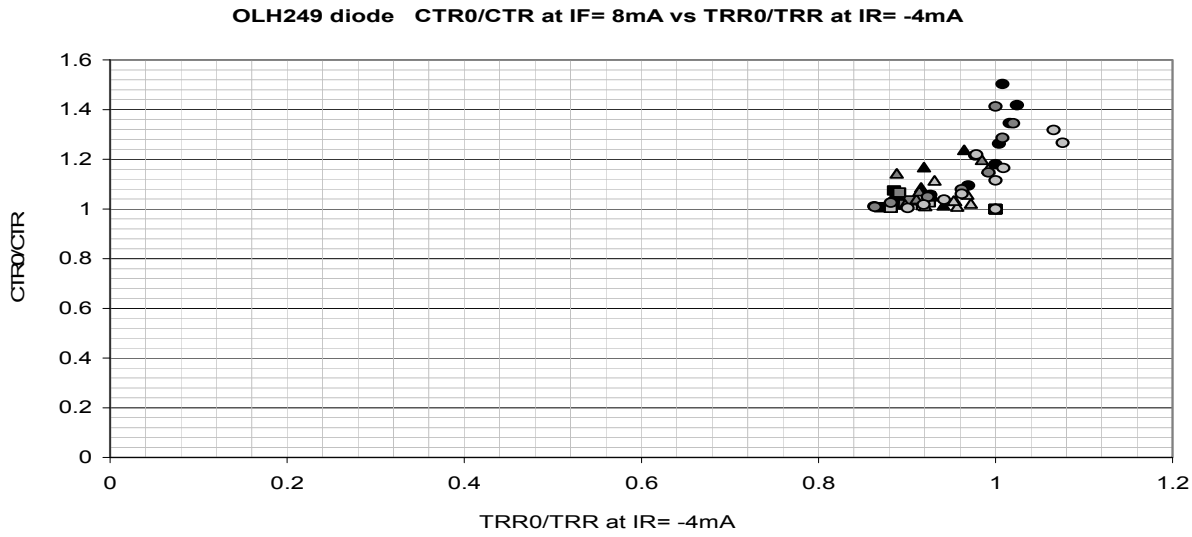

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
TRR0/TRR at IR= -2mA

Fig. 13-168: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
TRR0/TRR at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

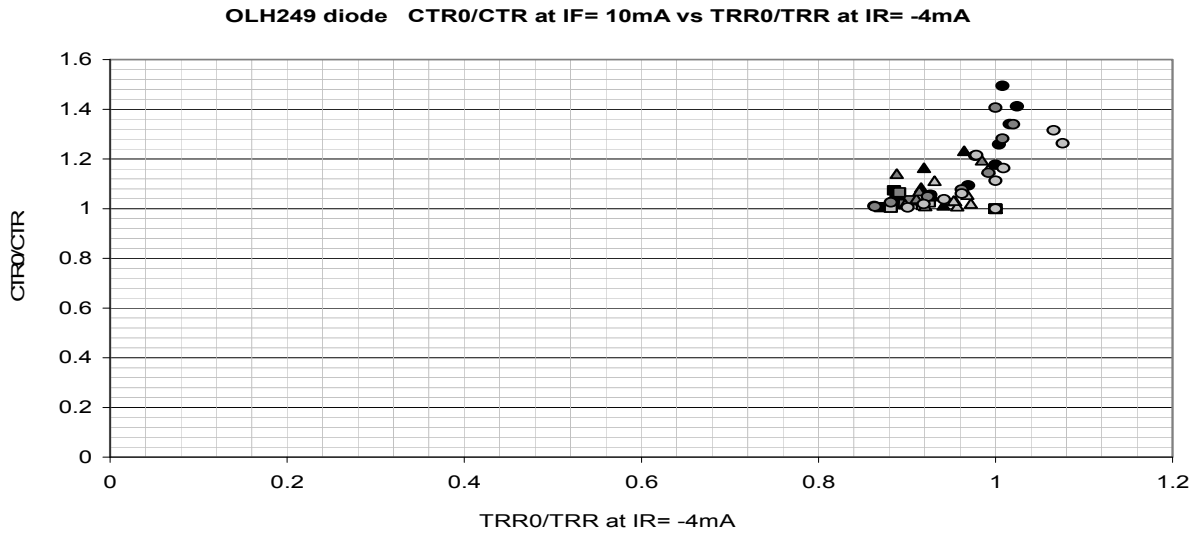
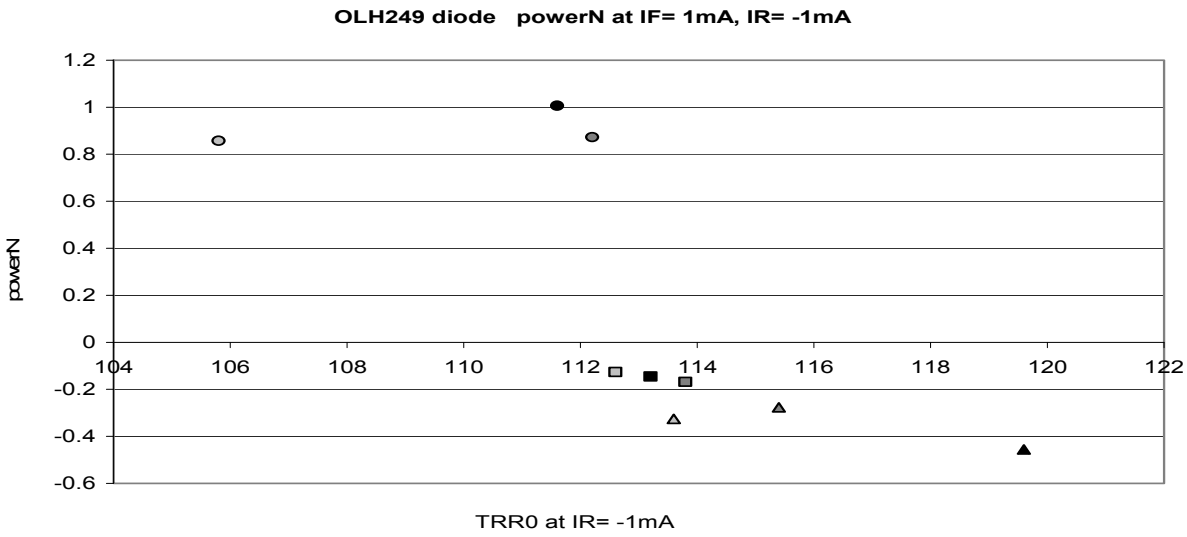
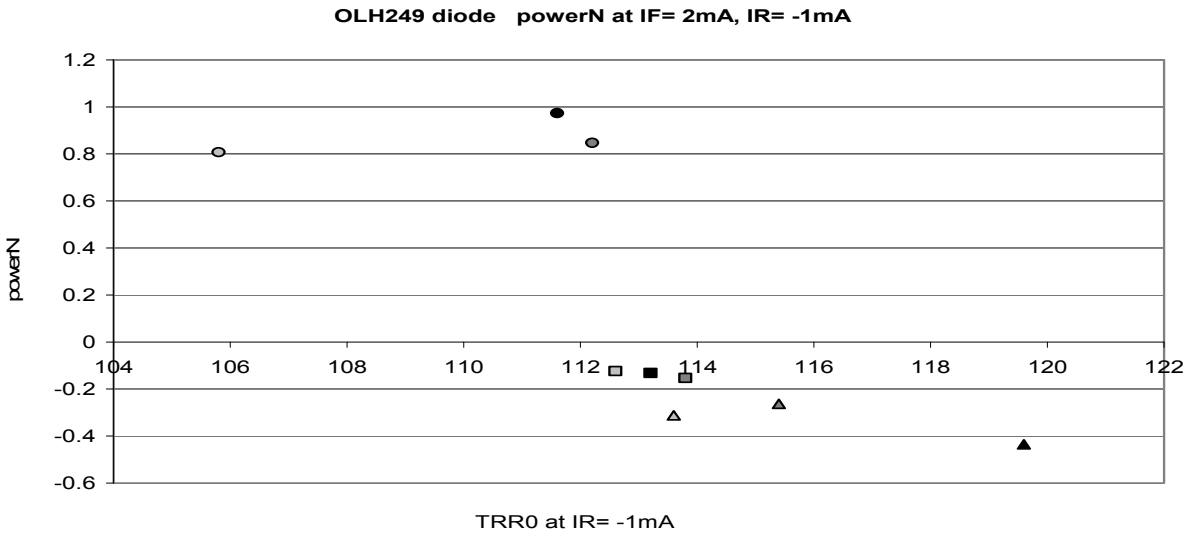
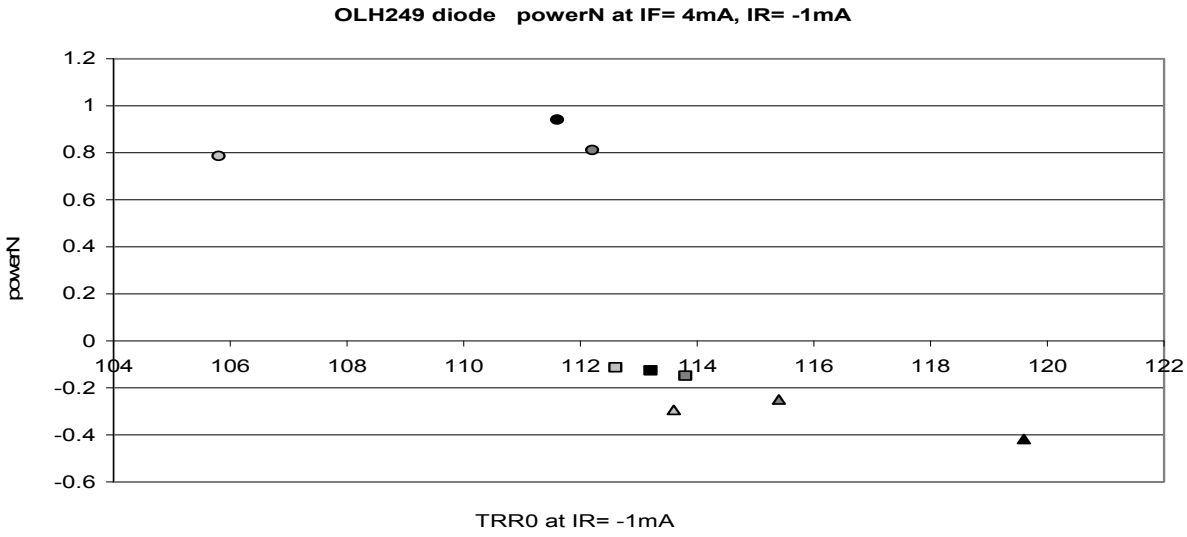
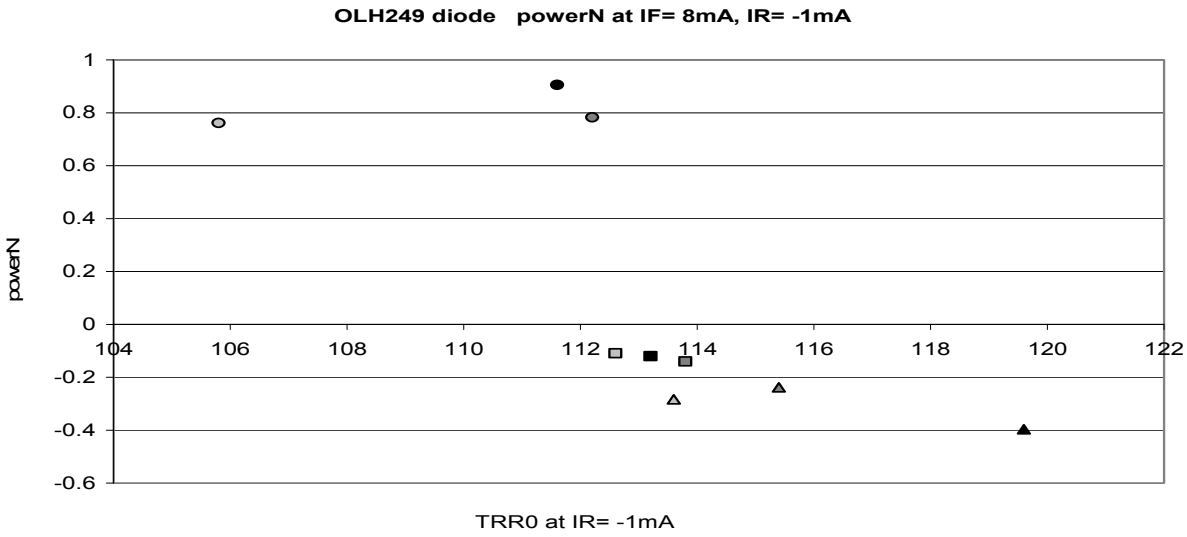

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
TRR0/TRR at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

Fig. 13-169: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








OLH249 diode powerN at IF= 8mA, IR= -1mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
104
106
108
110
112
114
116
118
120
122
TRR0 at IR= -1mA

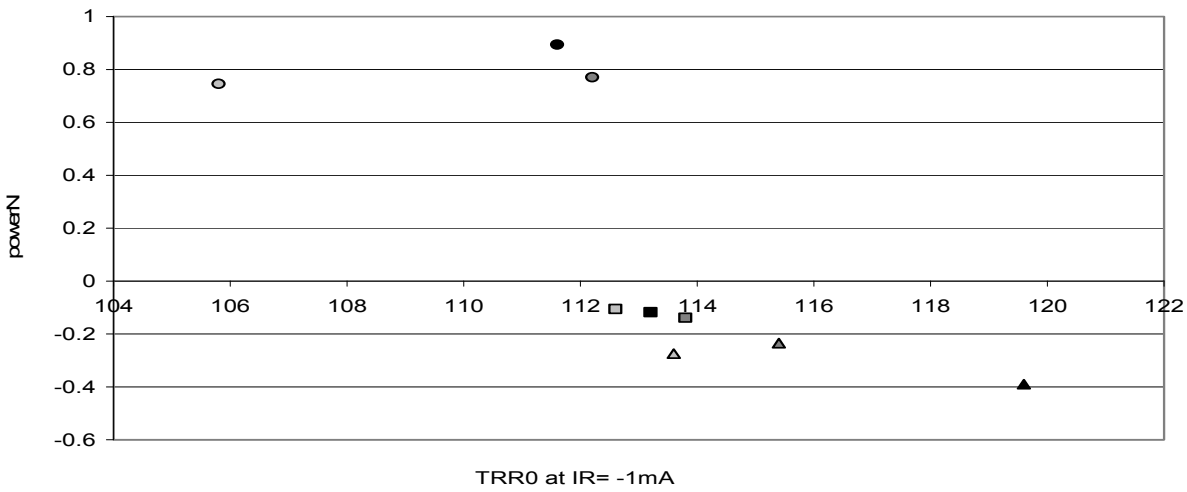
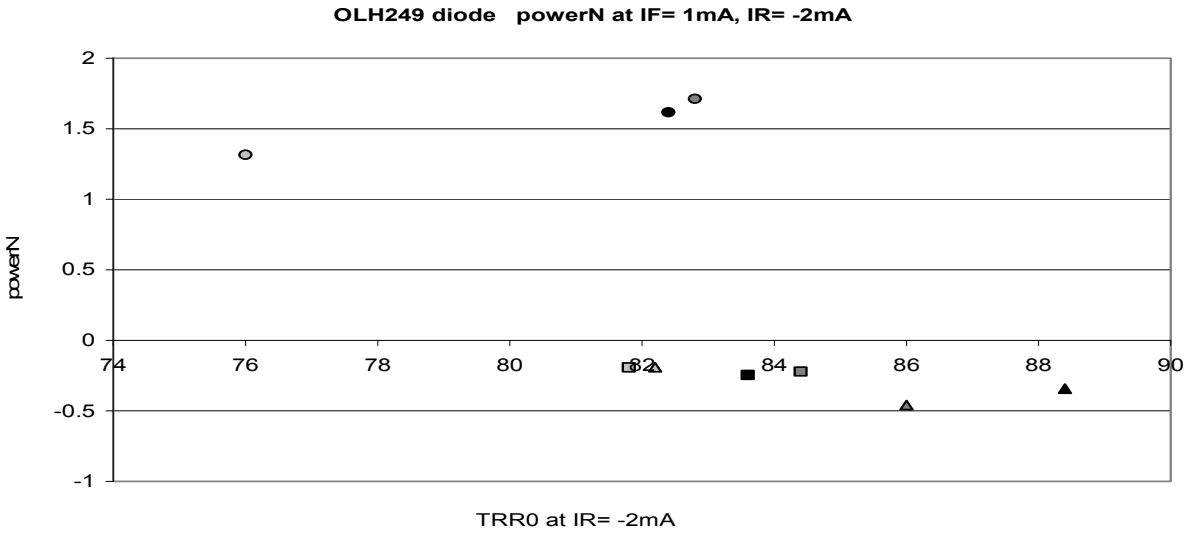
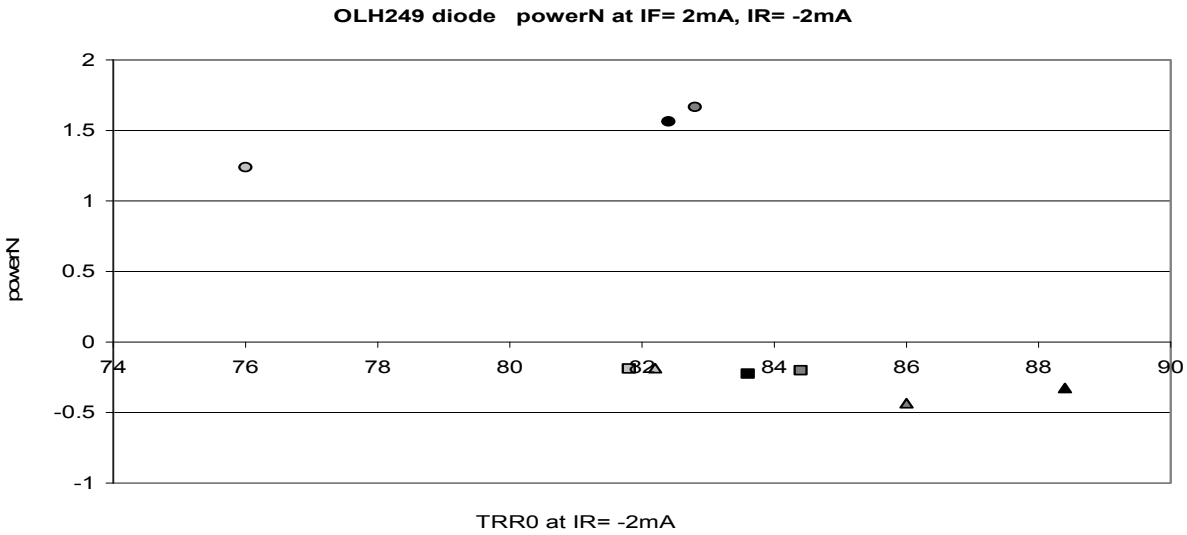
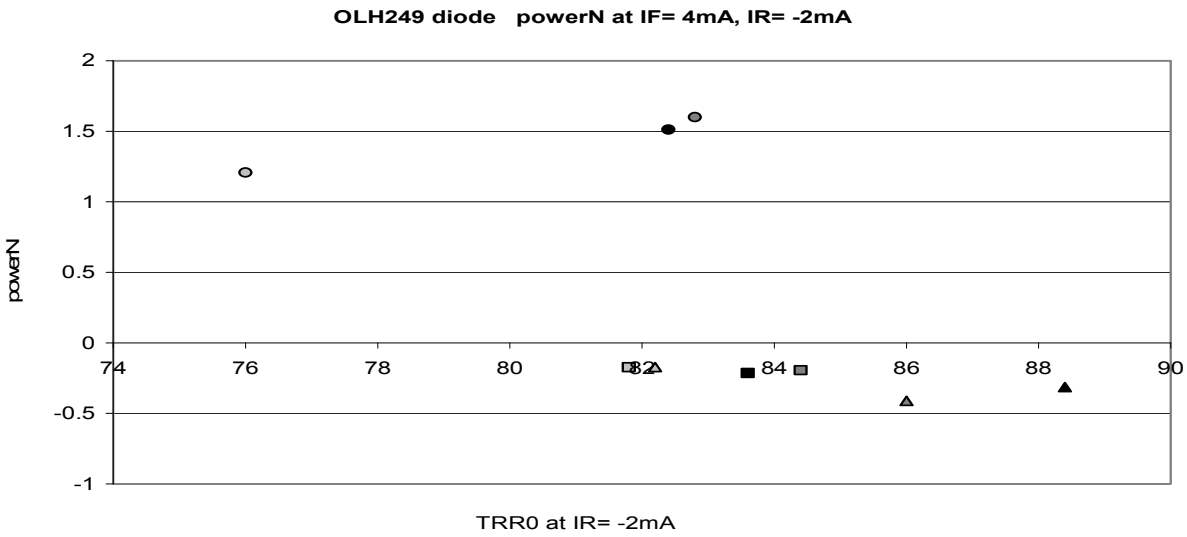
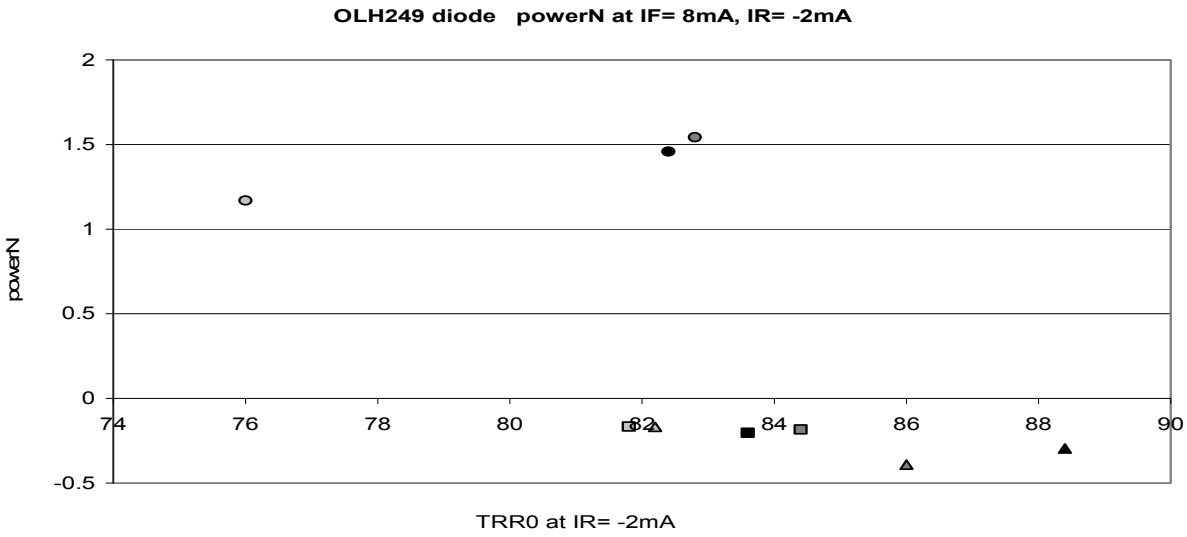

OLH249 diode powerN at IF= 10mA, IR= -1mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
104
106
108
110
112
114
116
118
120
122
TRR0 at IR= -1mA

Fig. 13-170: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








OLH249 diode powerN at IF= 8mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
74
76
78
80
82
84
86
88
90
TRR0 at IR= -2mA

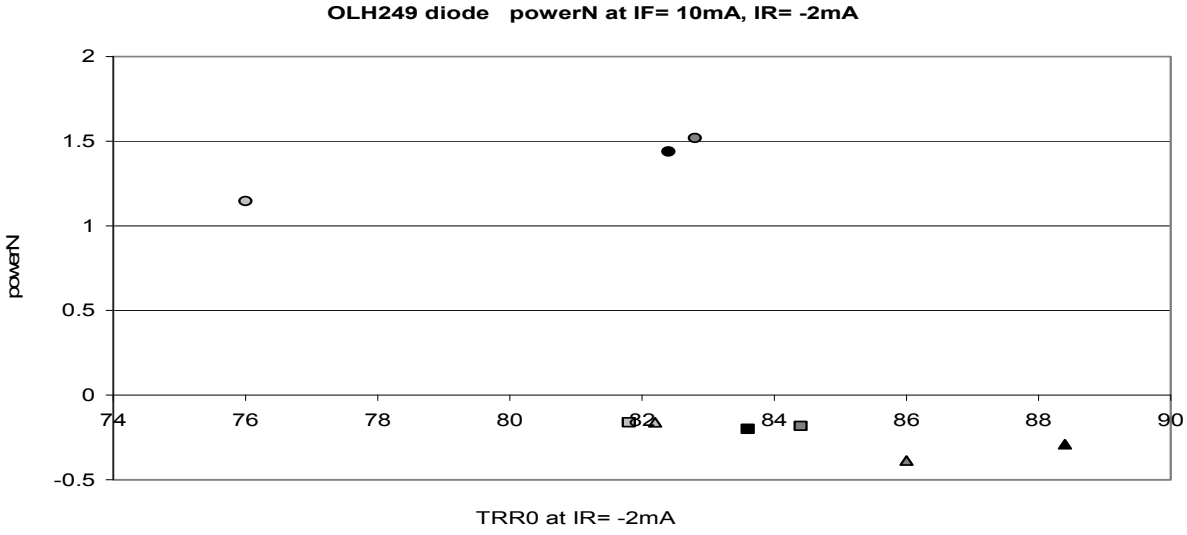
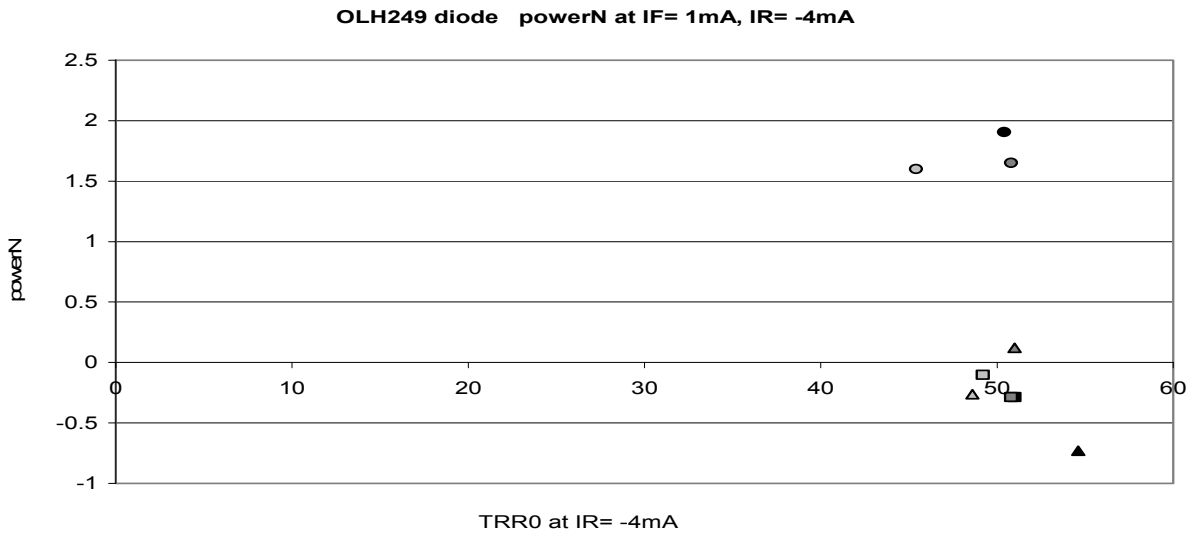
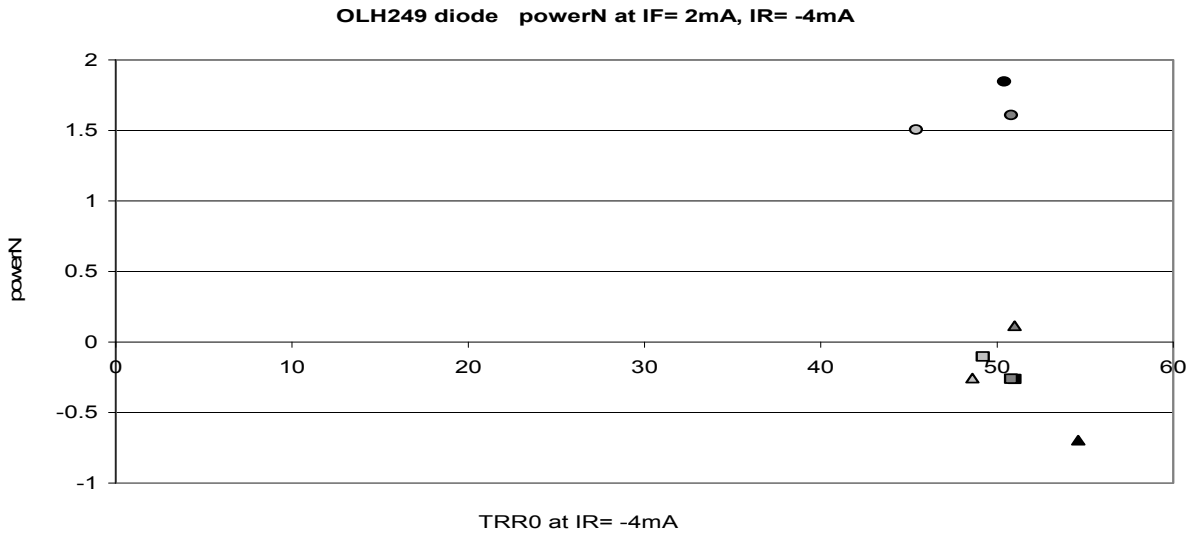
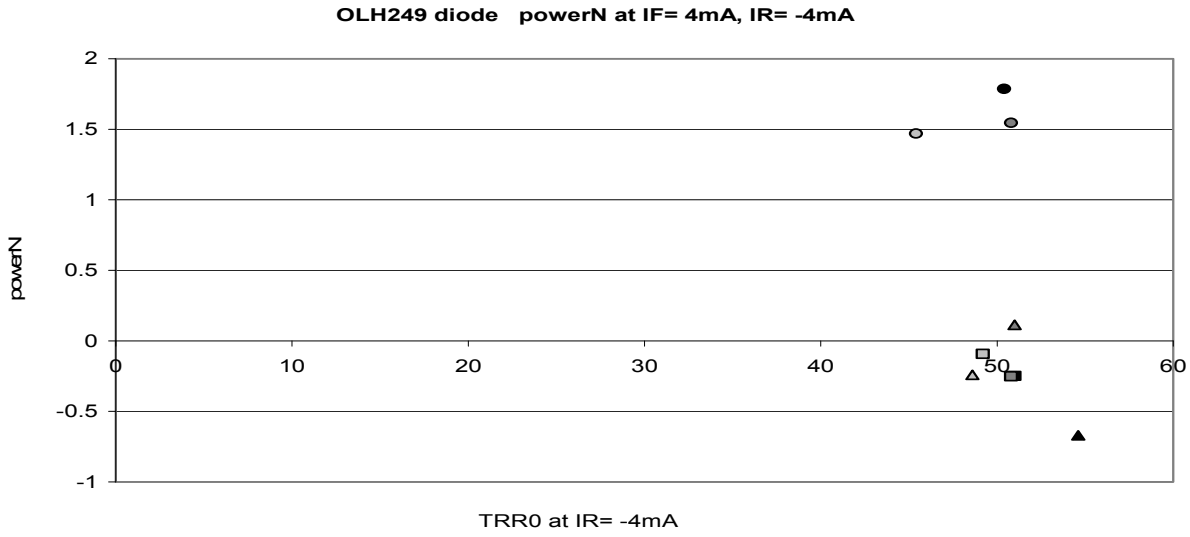
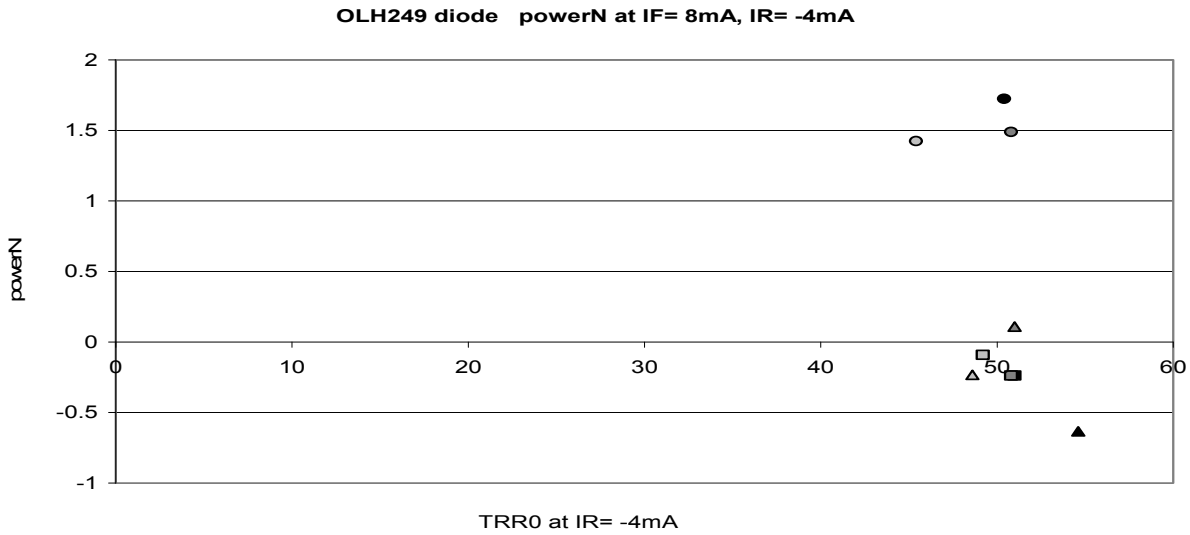

OLH249 diode powerN at IF= 10mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
74
76
78
80
82
84
86
88
90
TRR0 at IR= -2mA

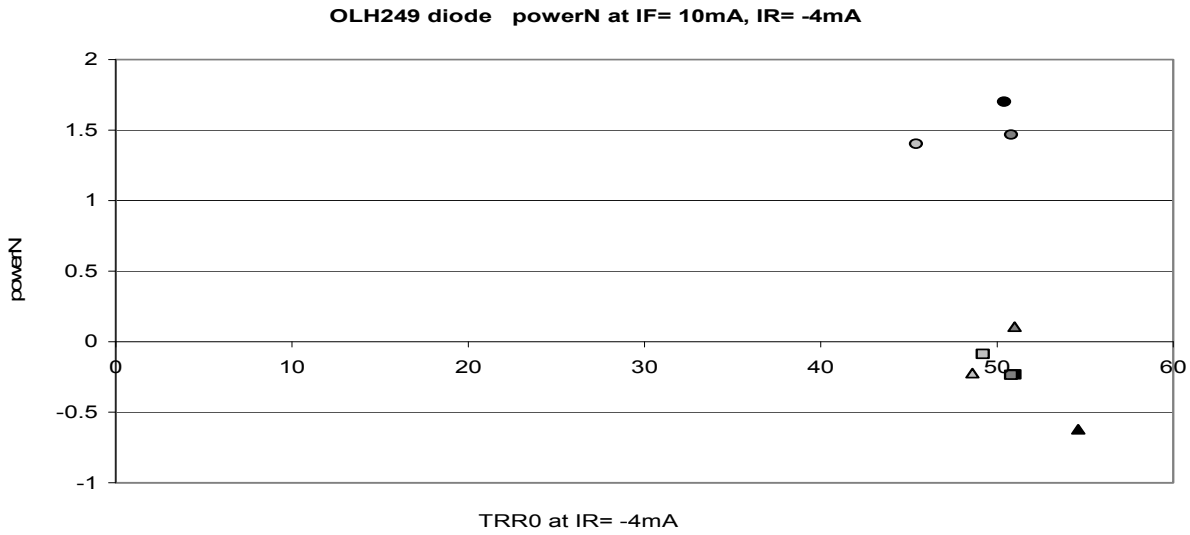
Fig. 13-171: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA





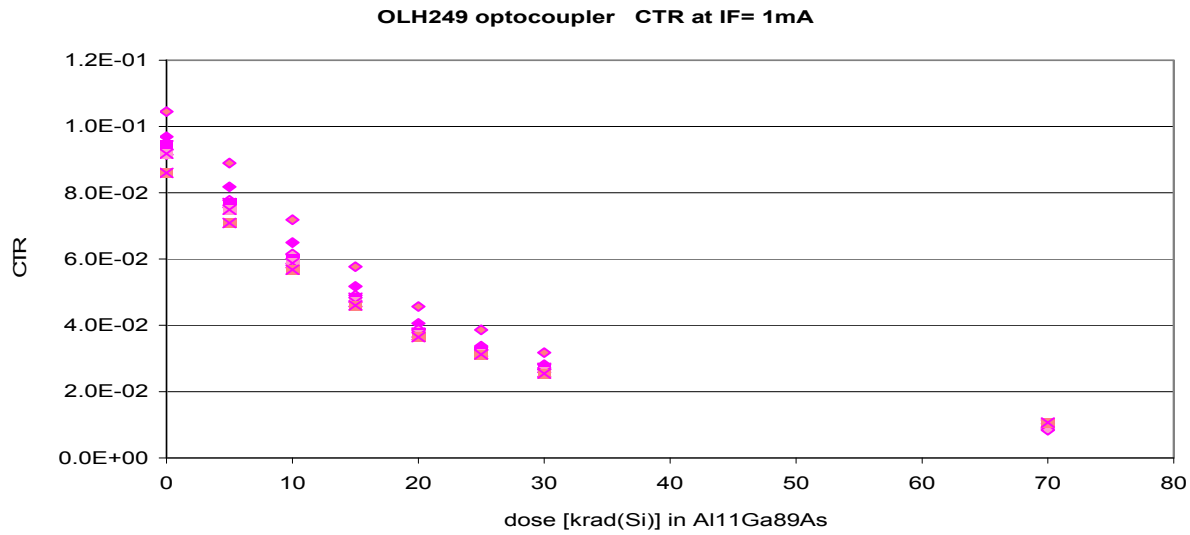


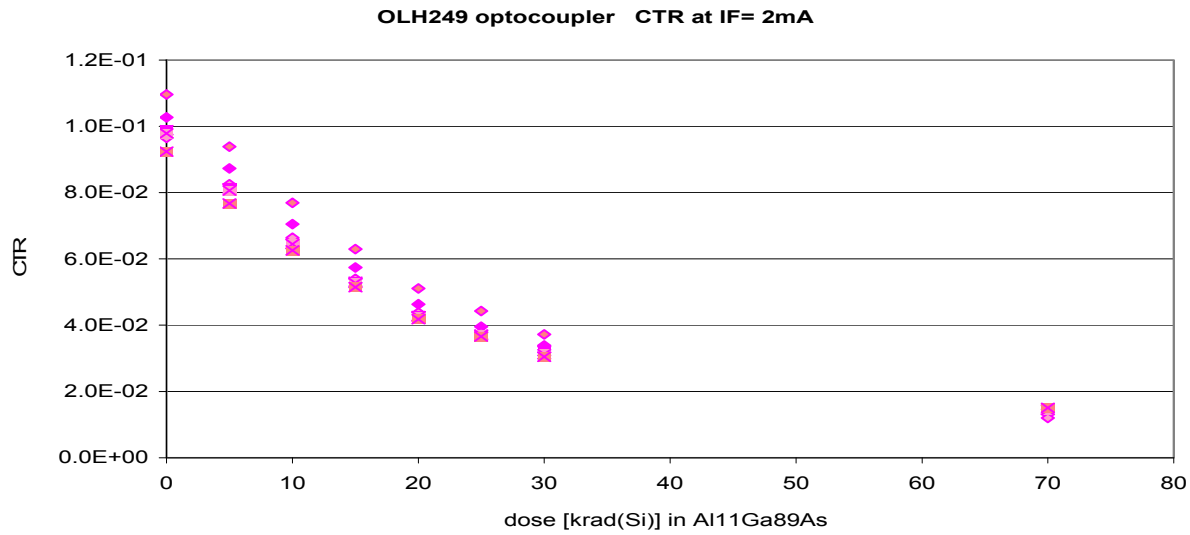

OLH249 diode powerN at IF= 8mA, IR= -4mA
powerN
2
1.5
1
0.5
0
-0.5
-1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

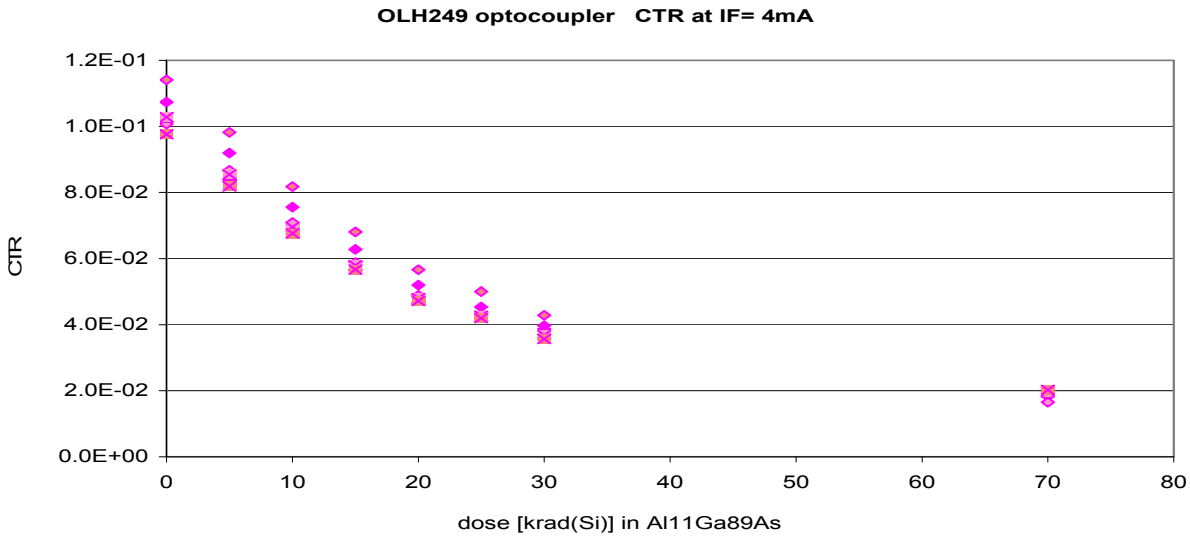

OLH249 diode powerN at IF= 10mA, IR= -4mA
powerN
2
1.5
1
0.5
0
-0.5
-1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

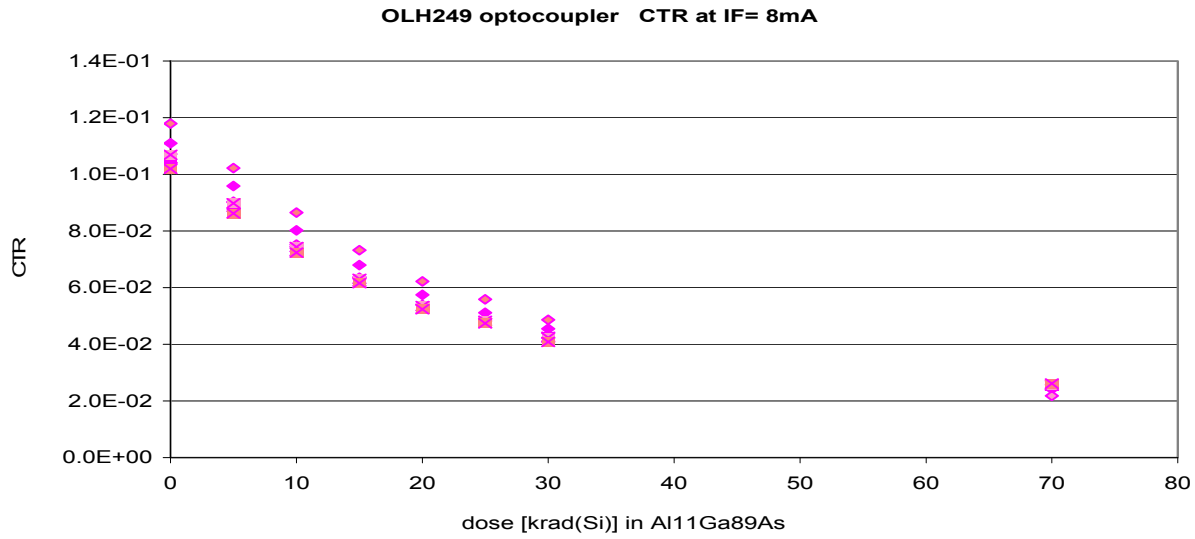
13.3 GAMMA IRRADIATION

Fig. 13-172: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

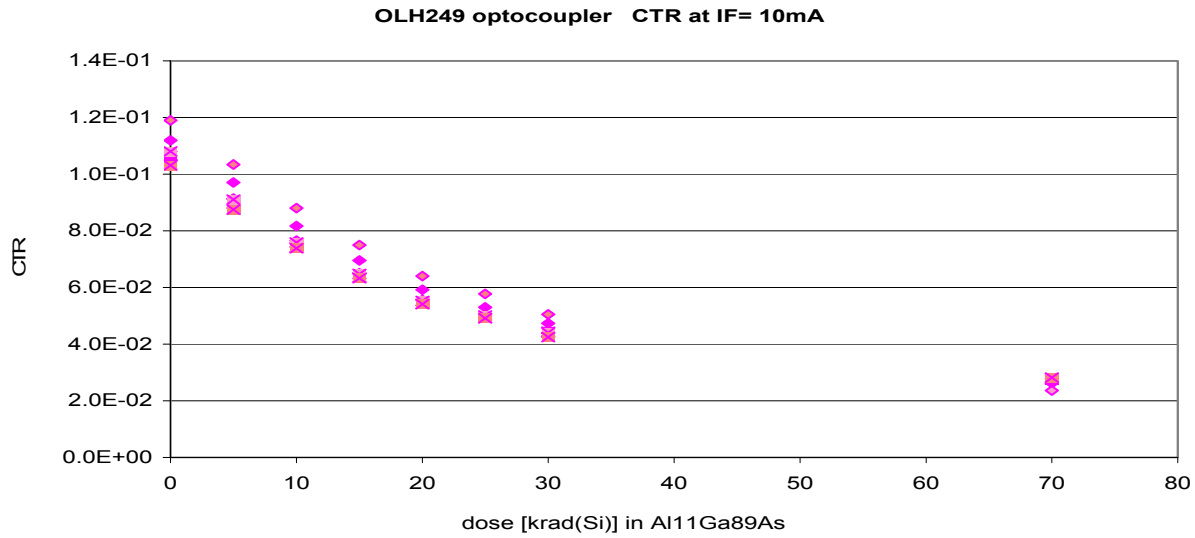
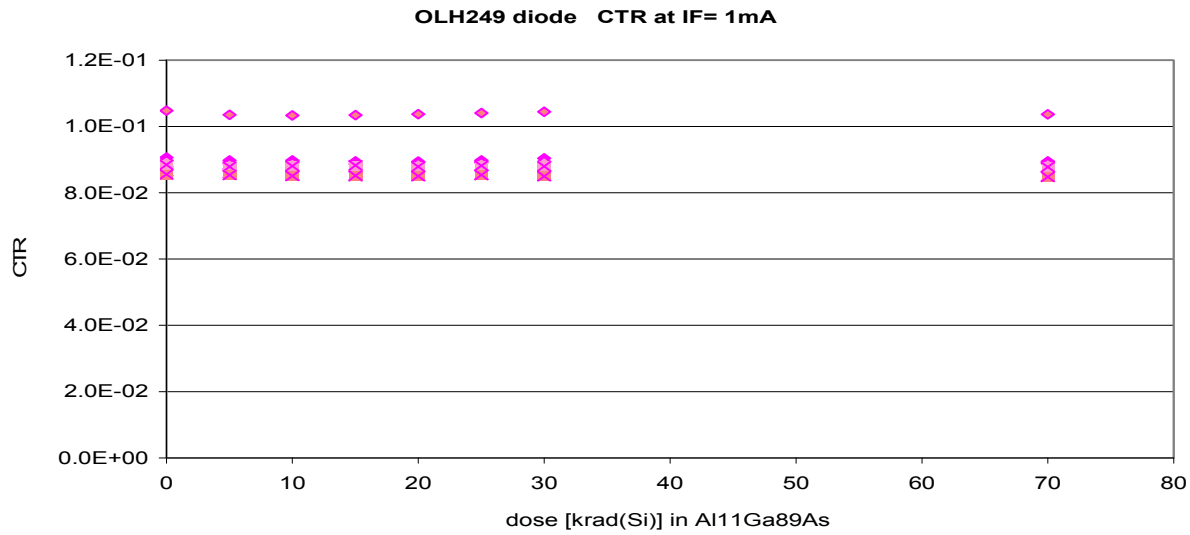
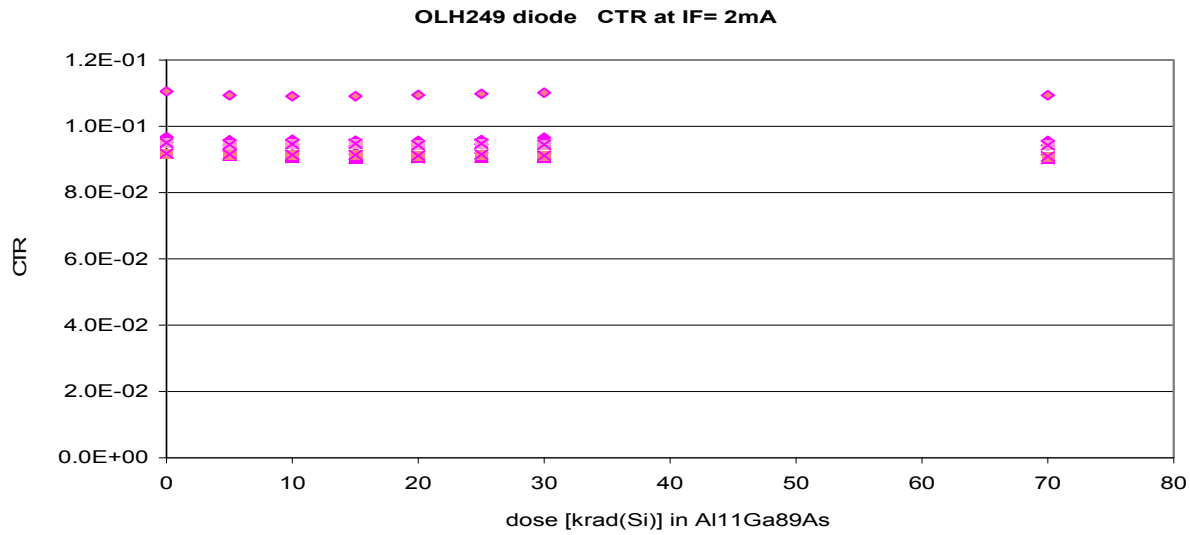
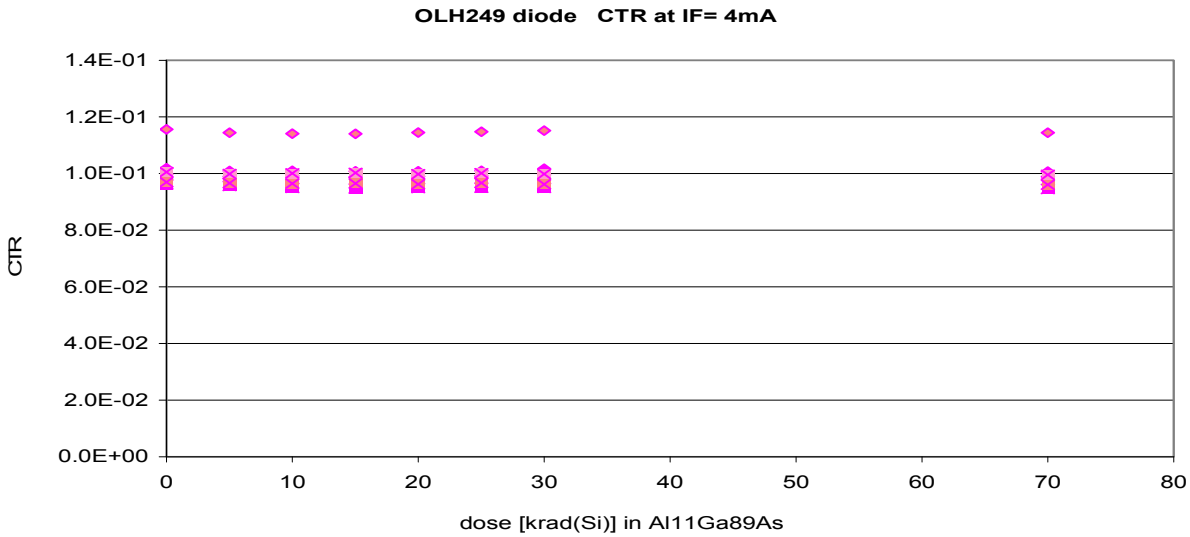
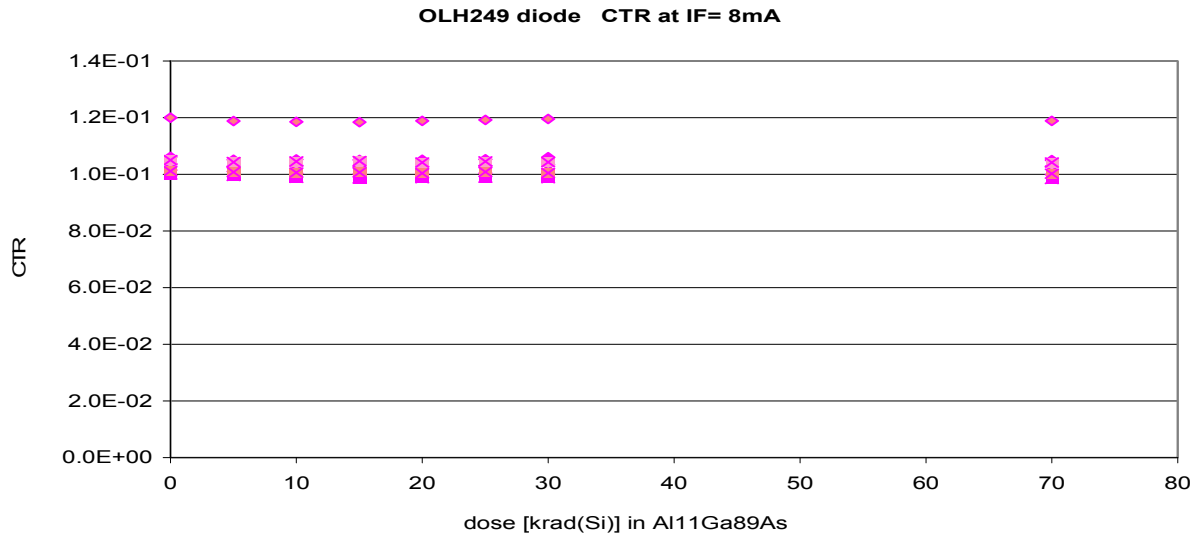

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-173: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

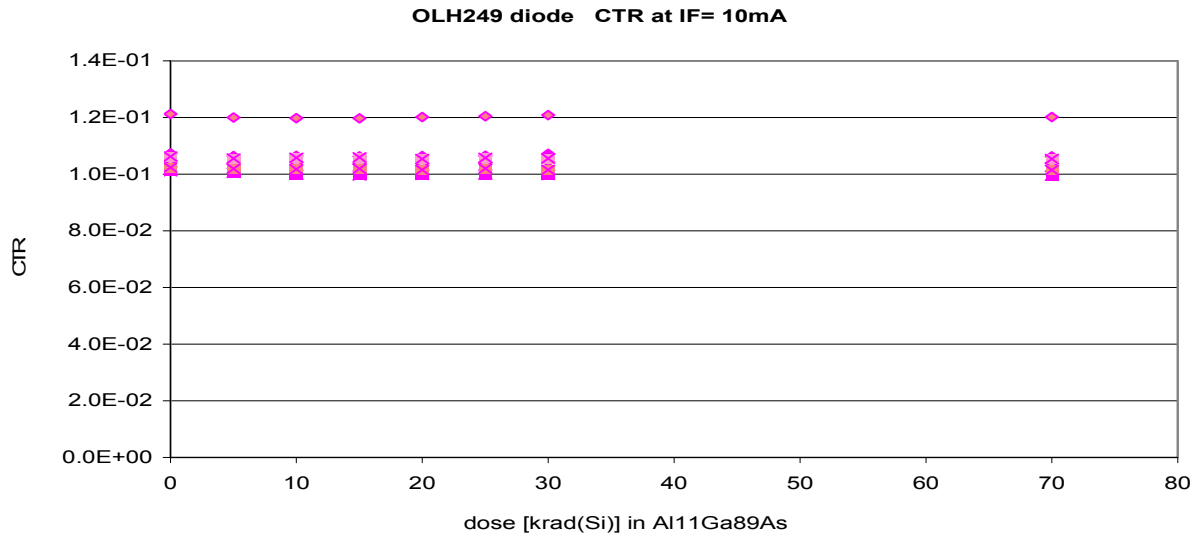
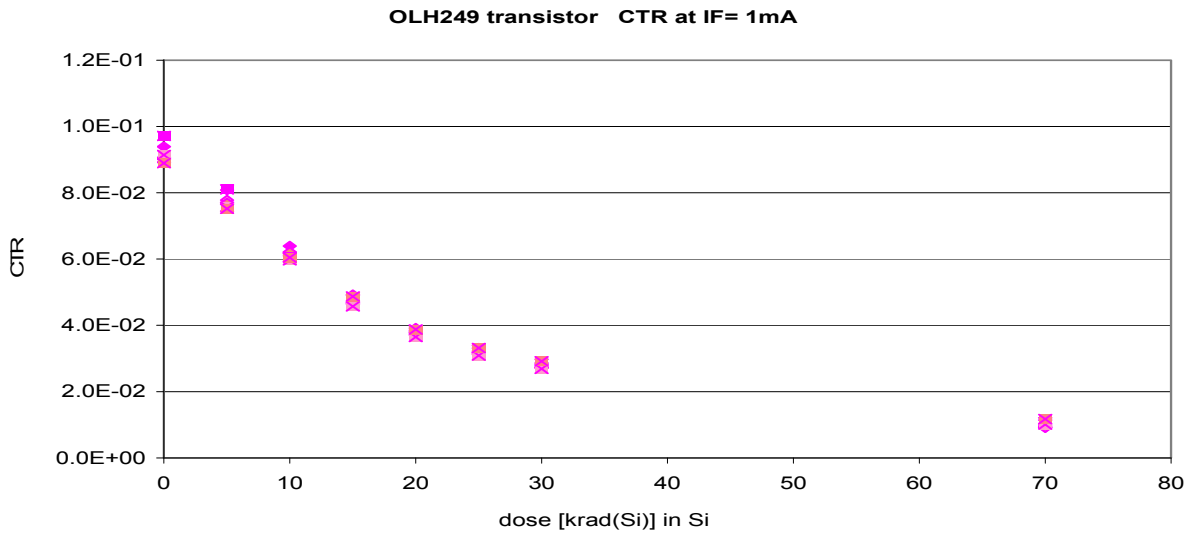
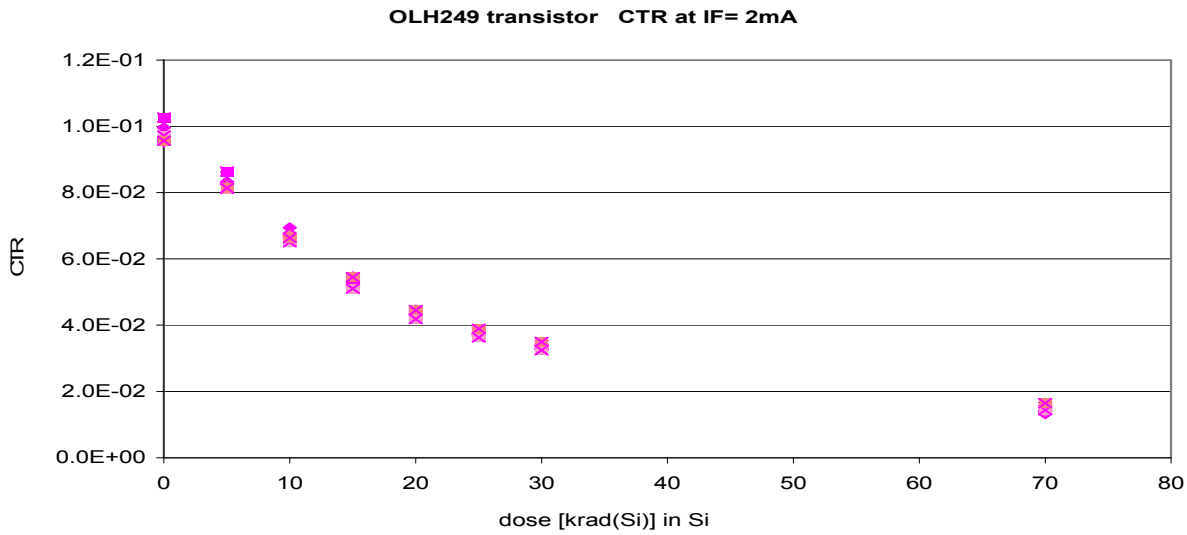
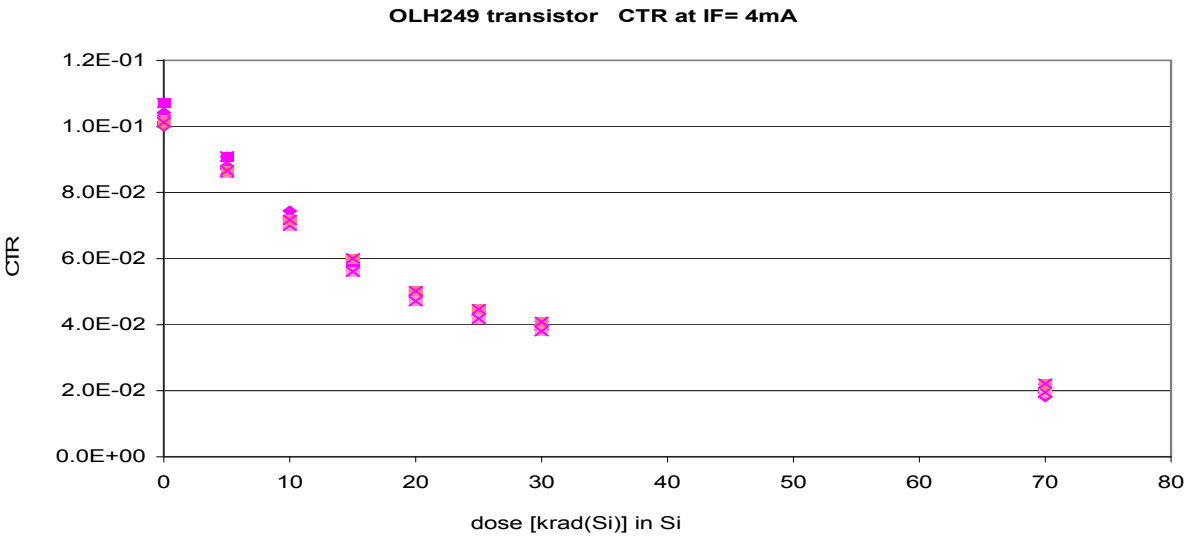
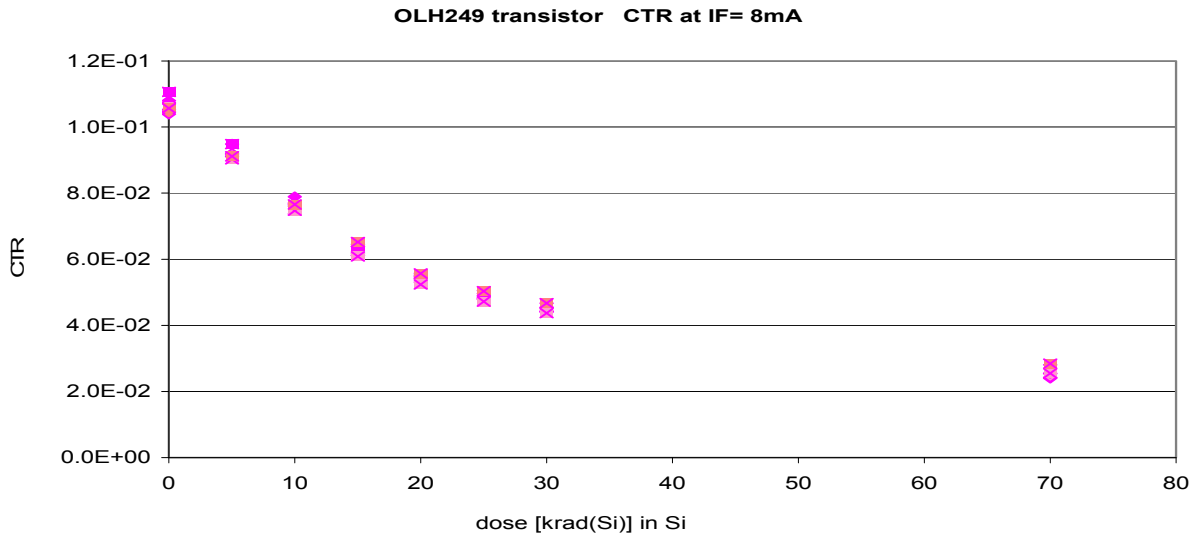

OLH249 diode CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-174: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

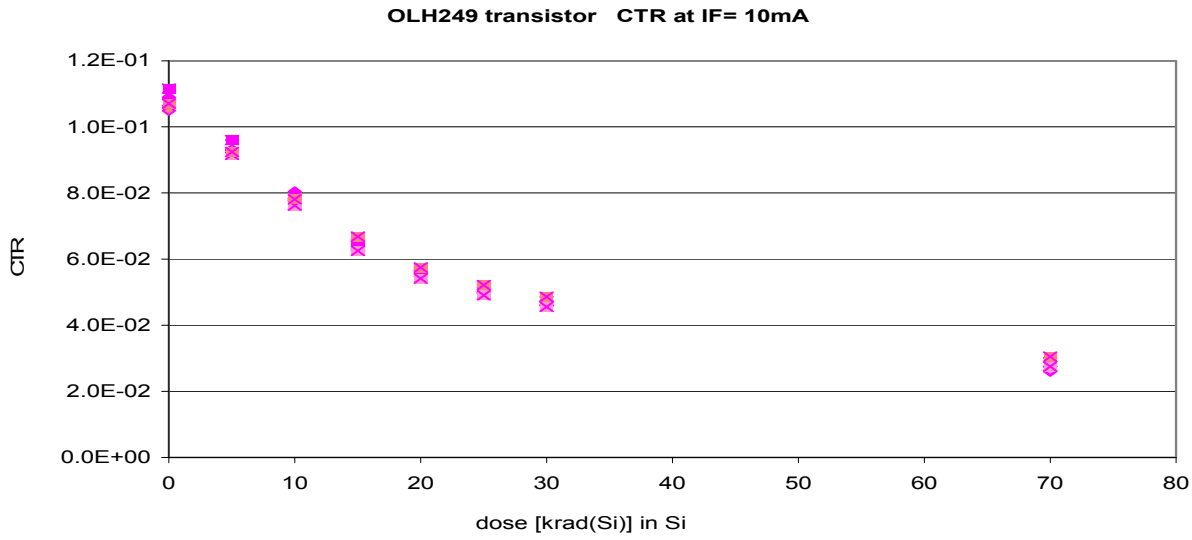
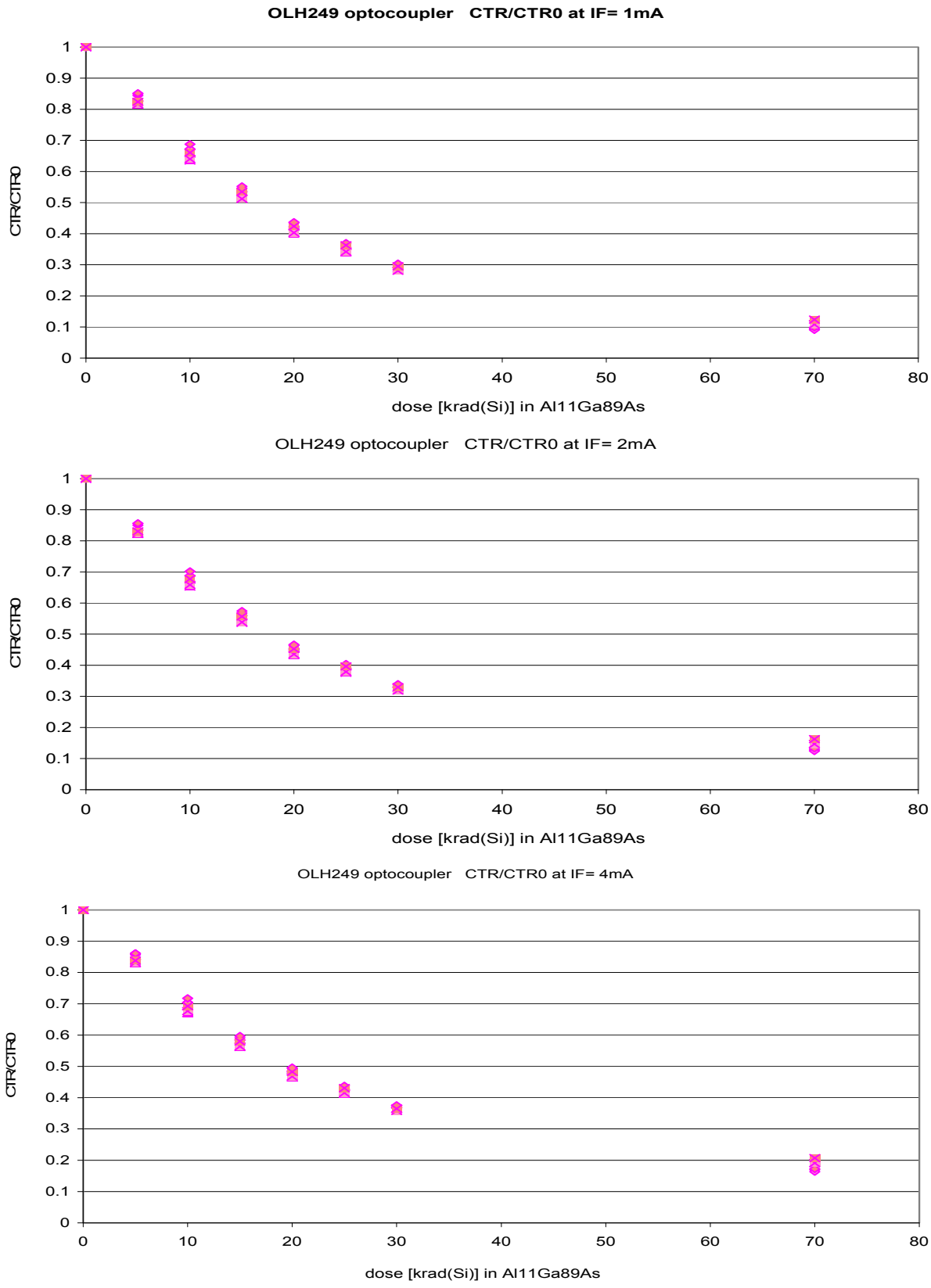
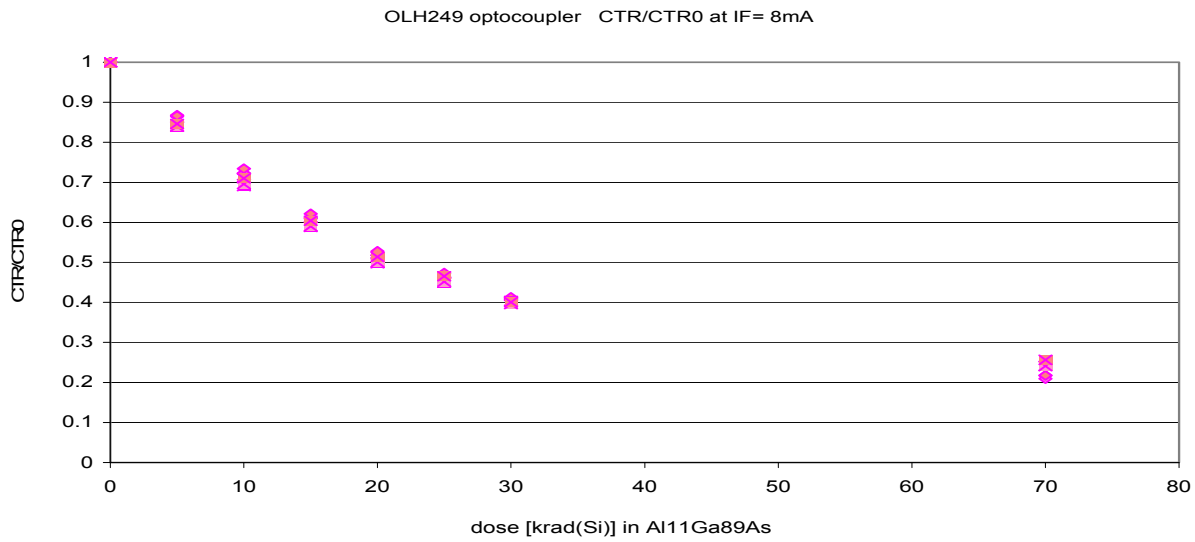

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 13-175: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose




OLH249 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

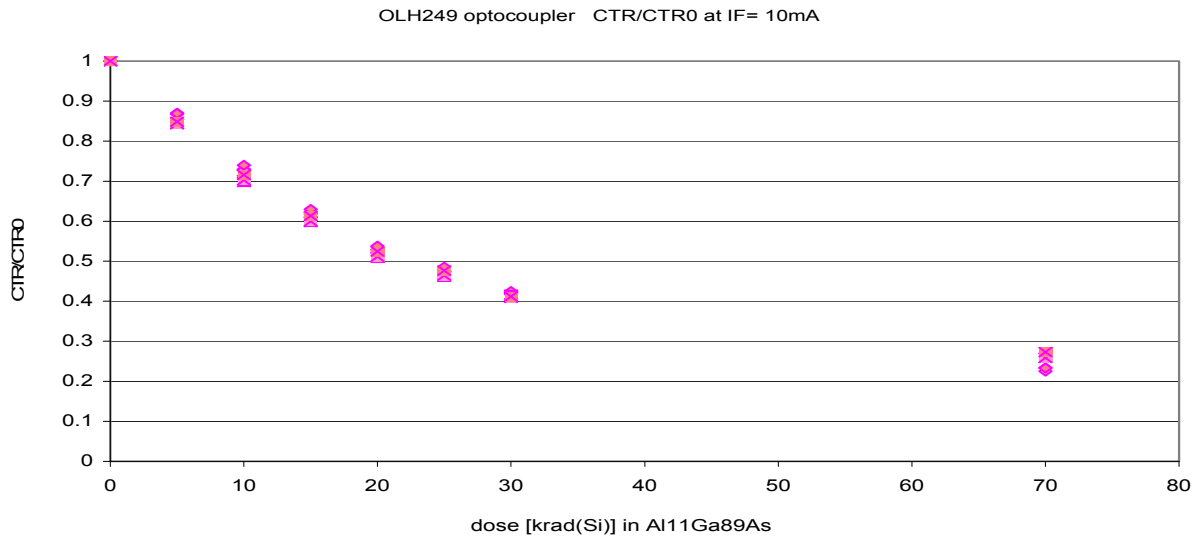
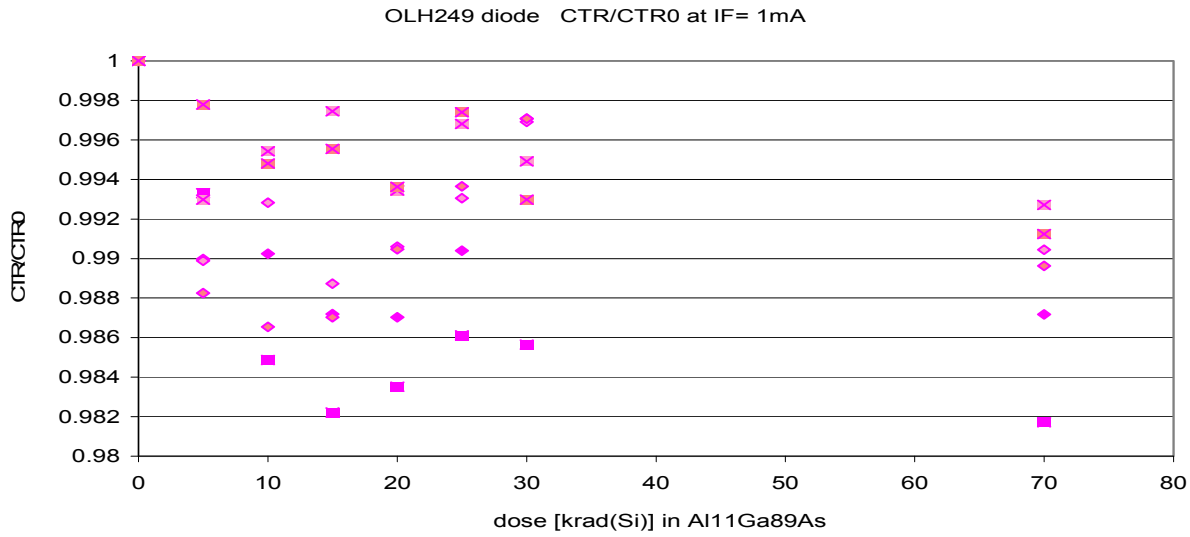
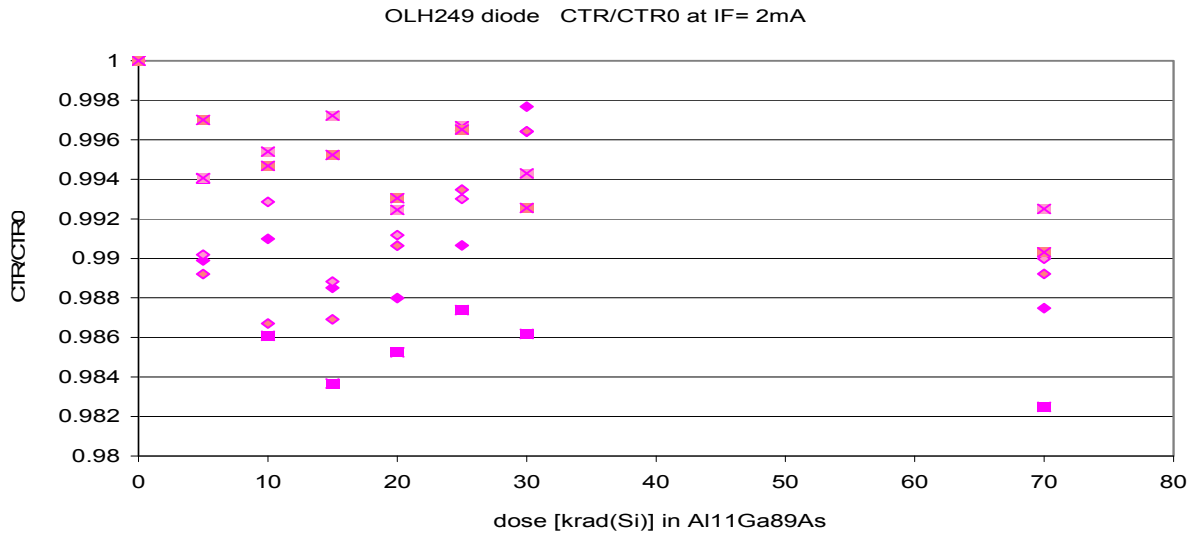
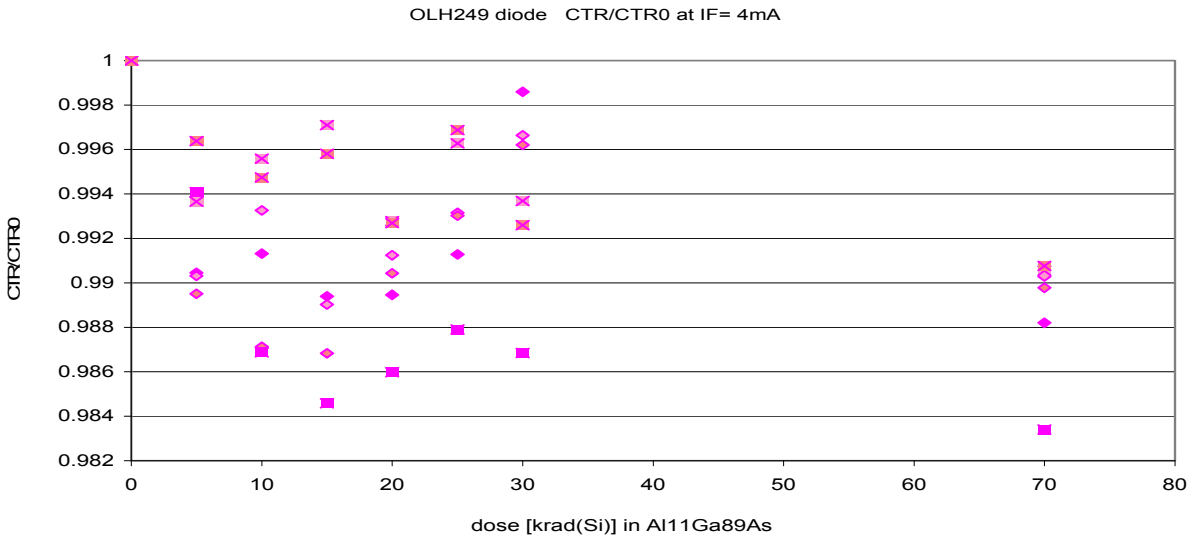
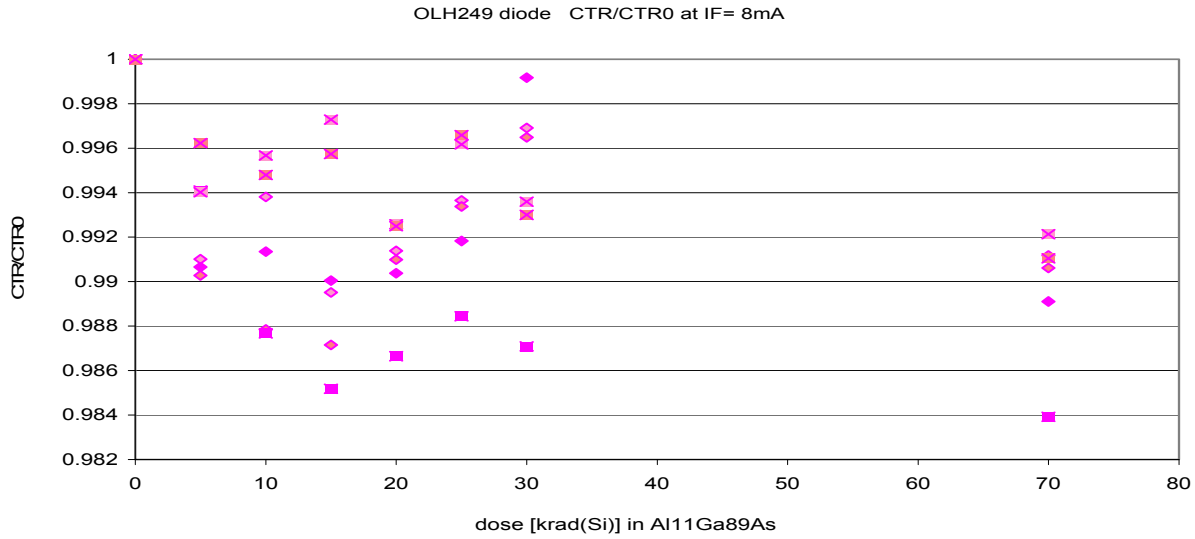

OLH249 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-176: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

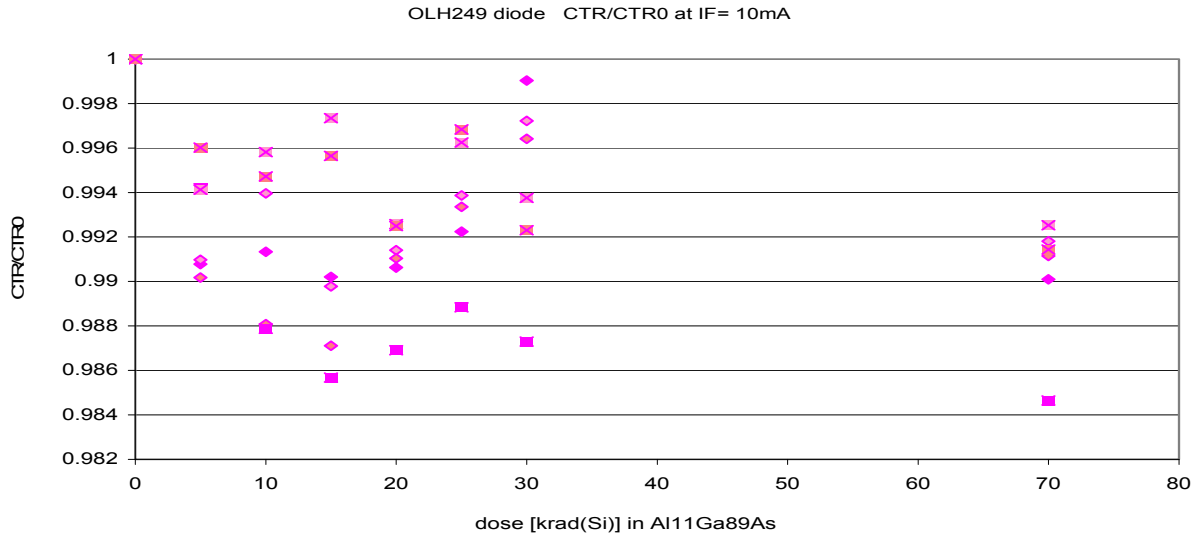
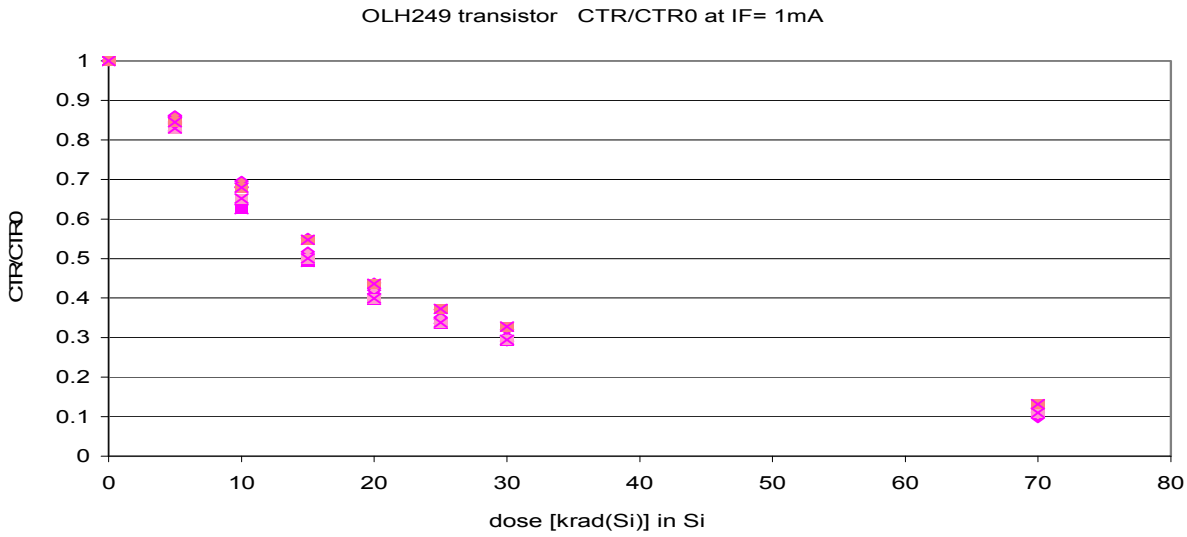
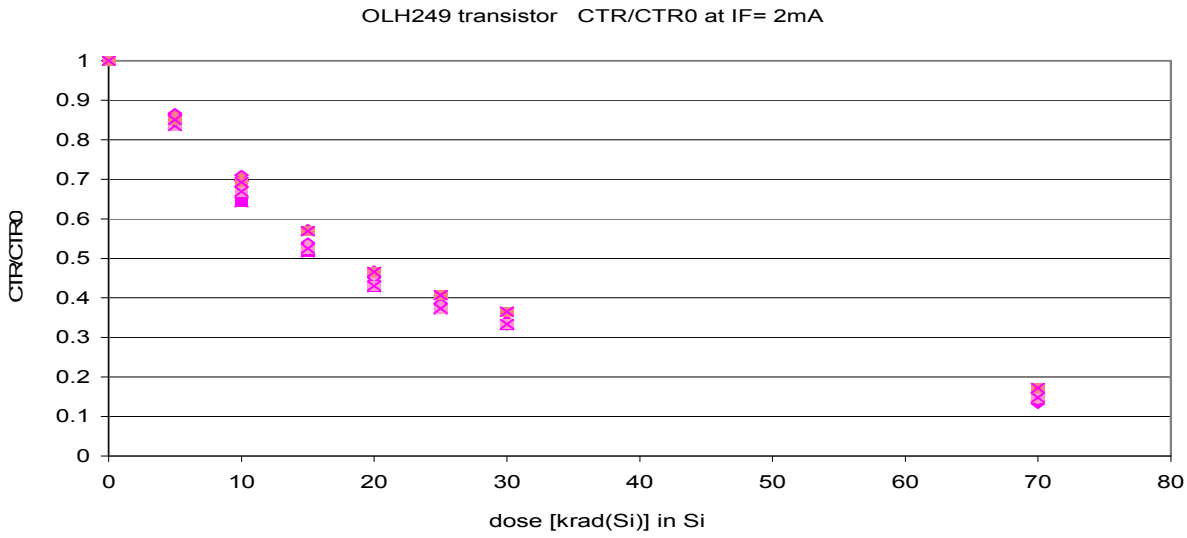
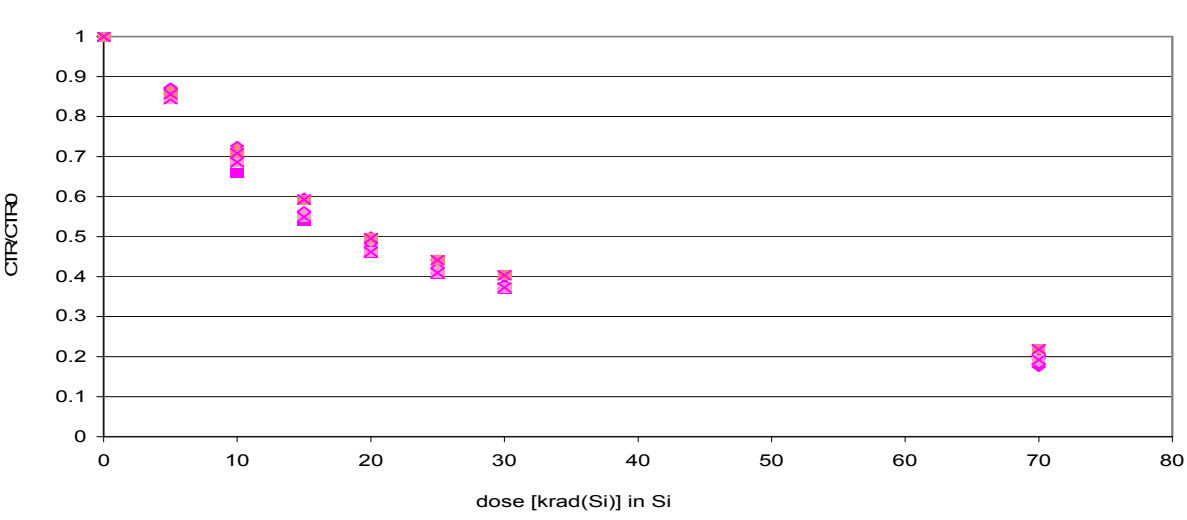
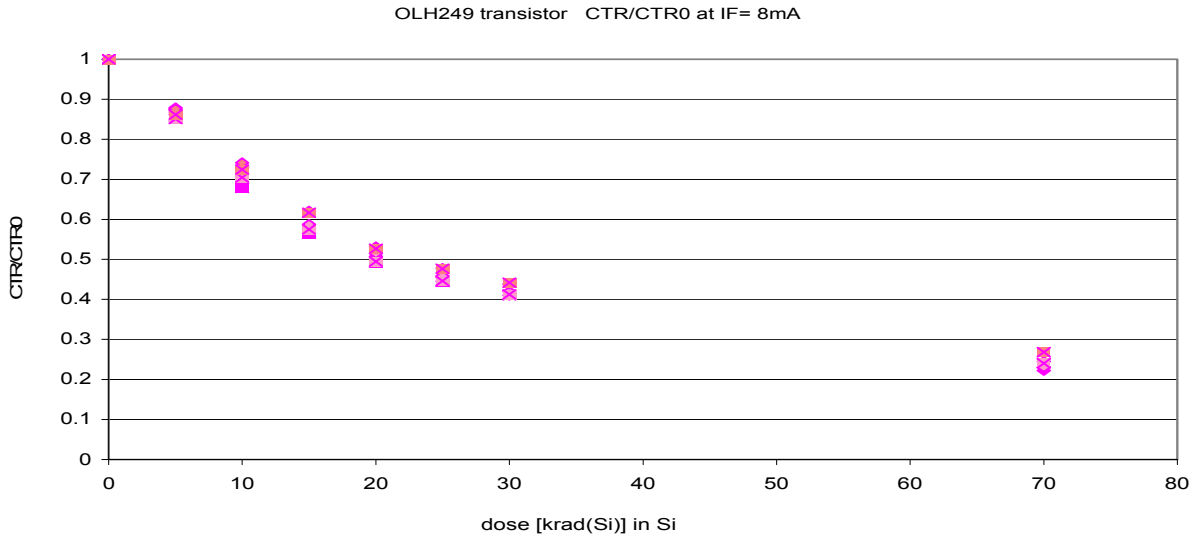

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-177: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

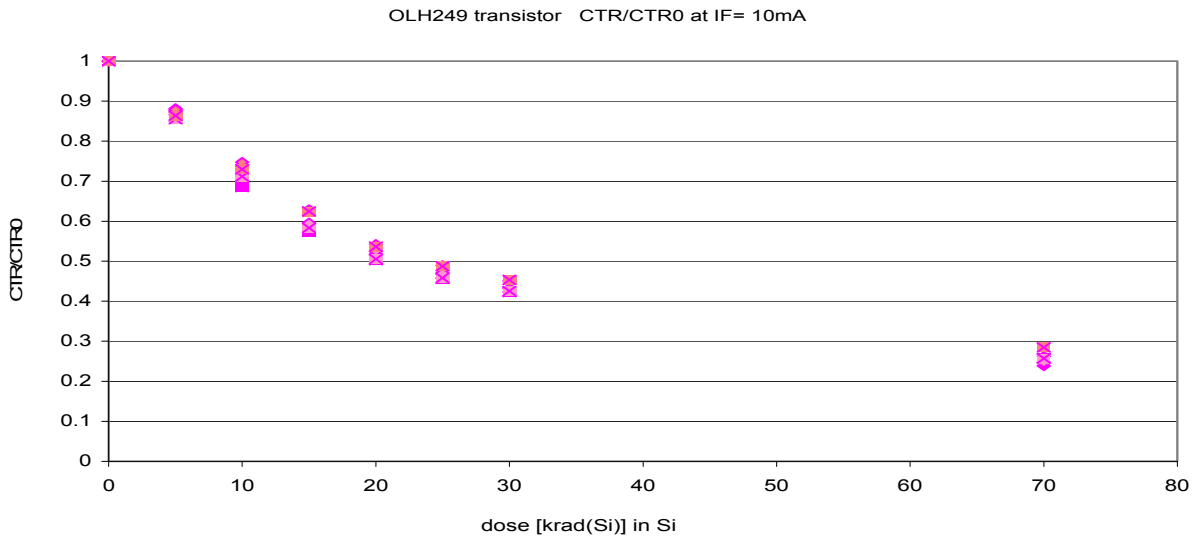
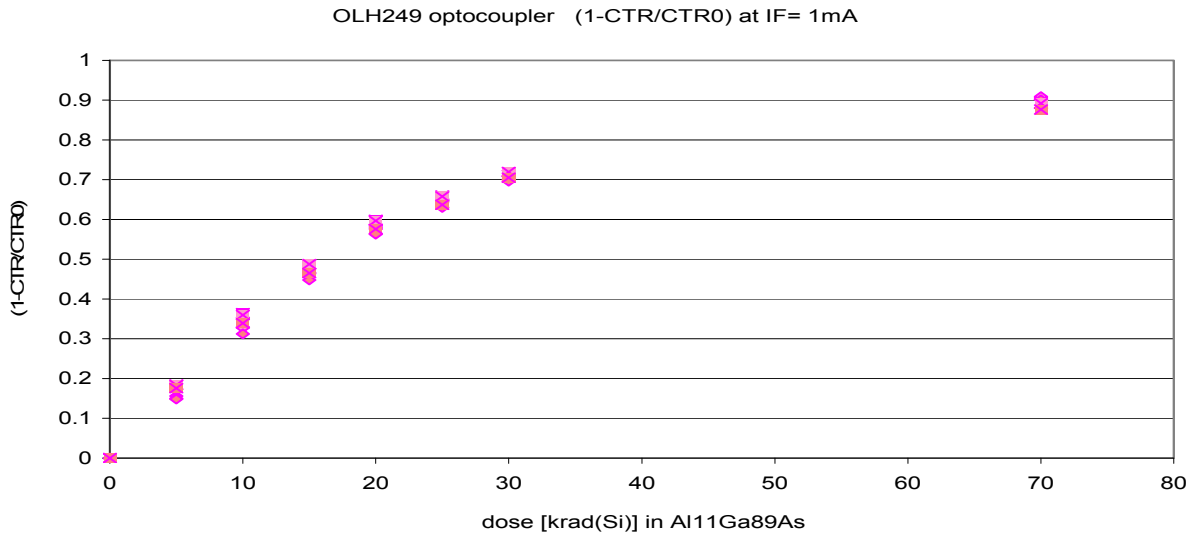
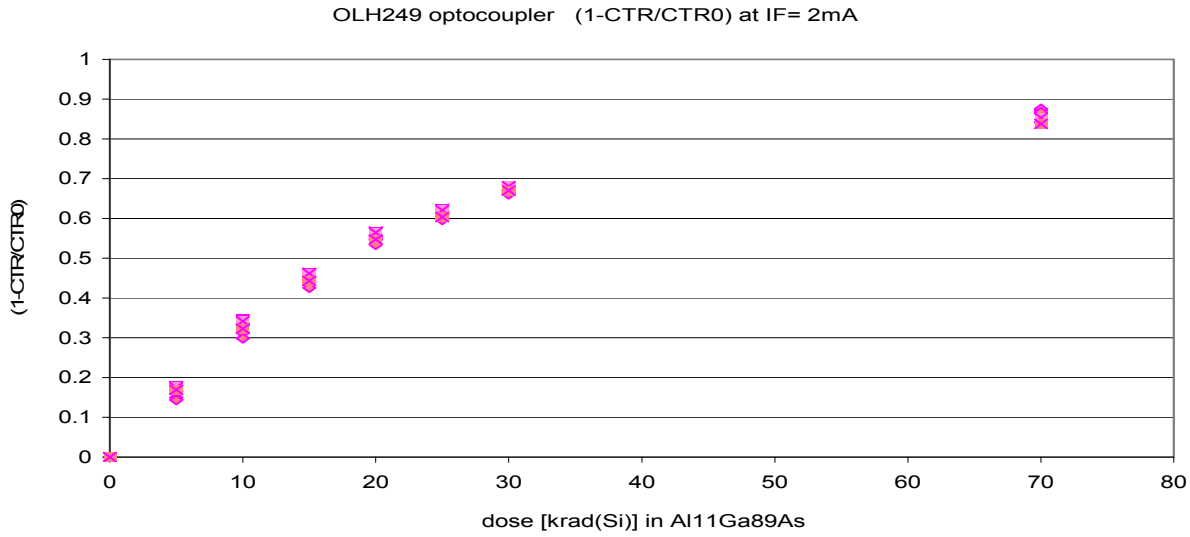
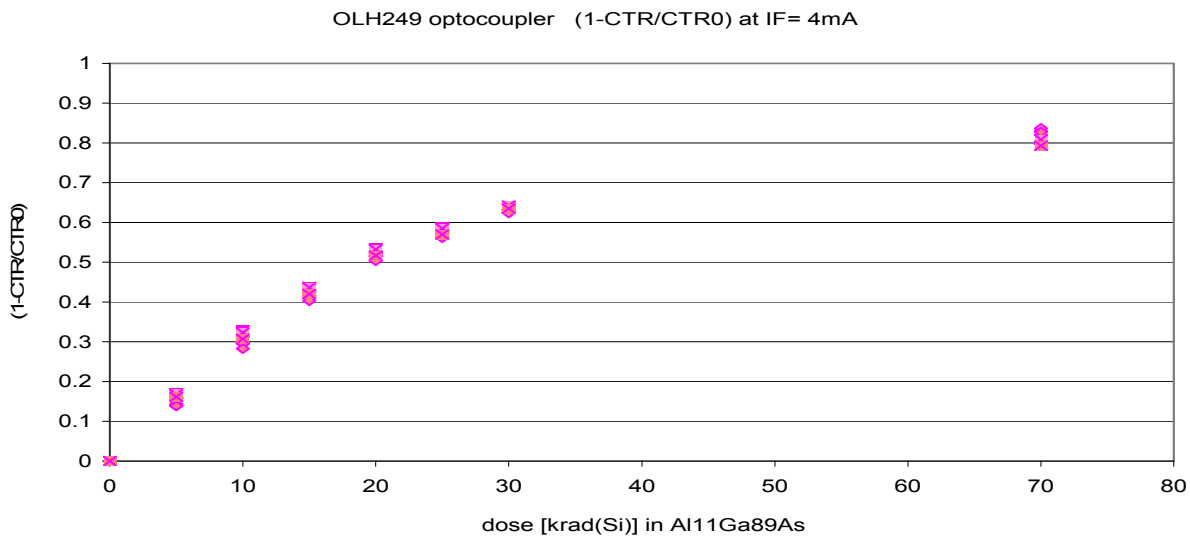
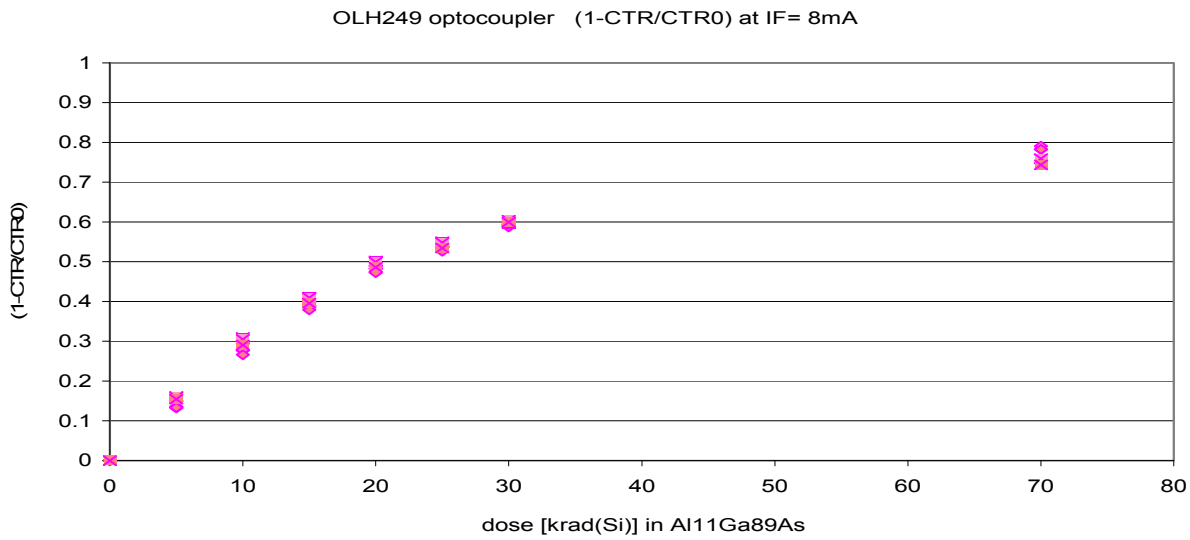

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 13-178: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

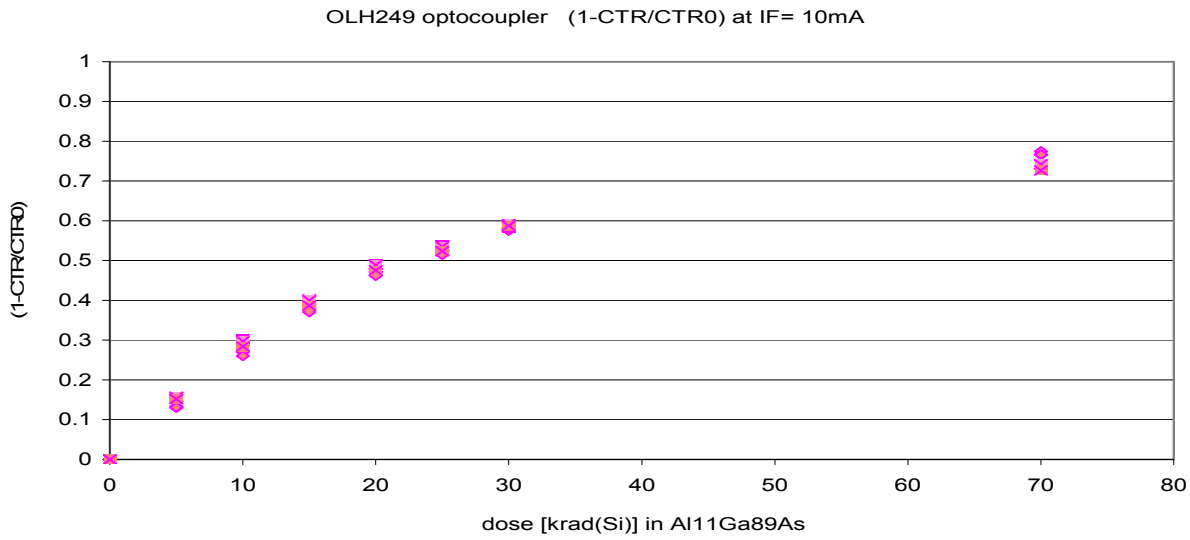
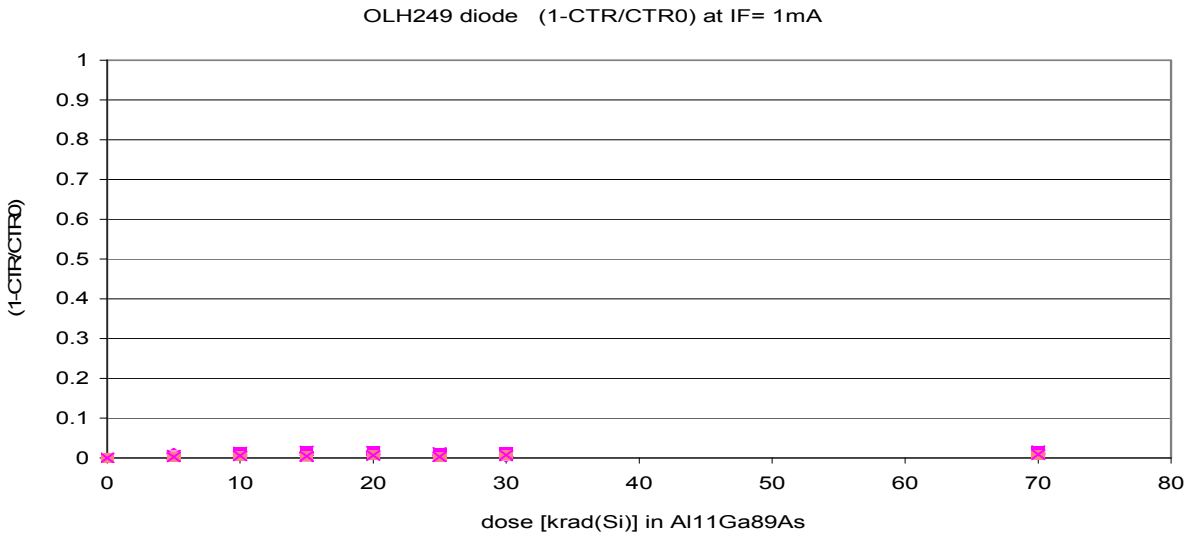
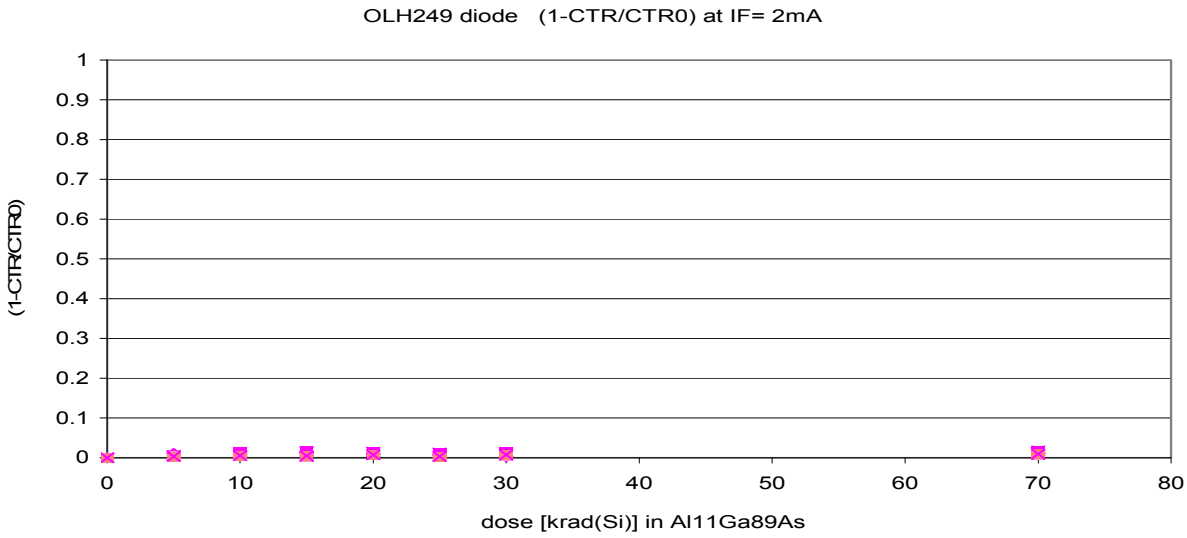
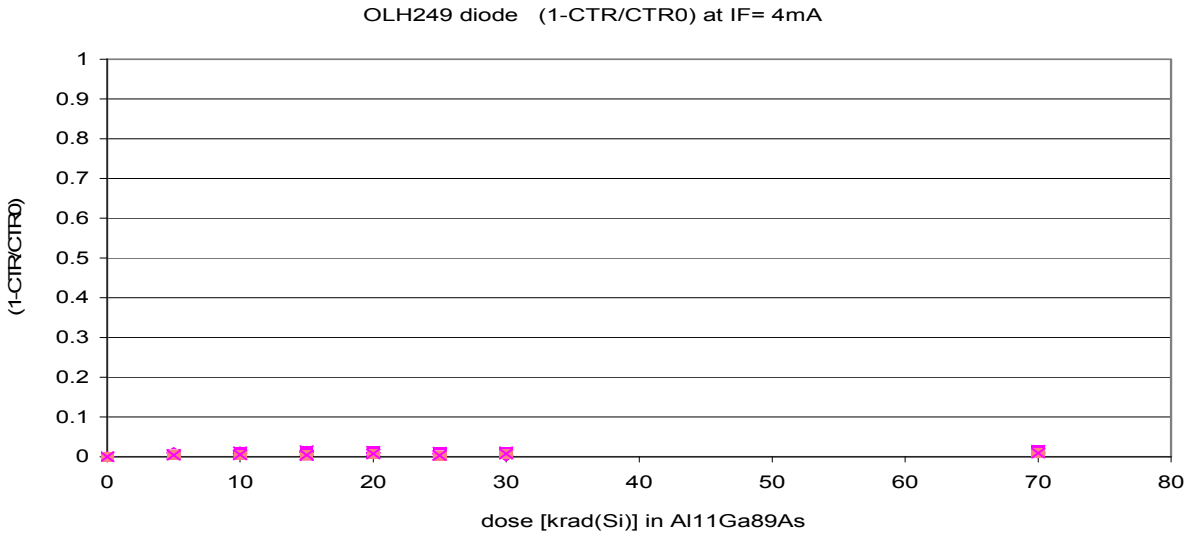
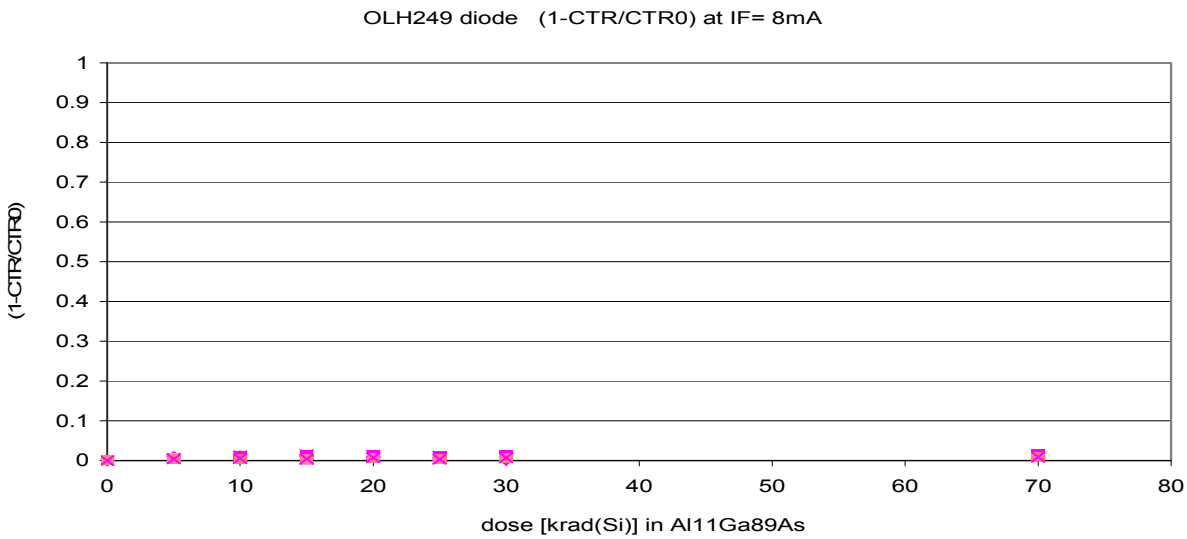

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-179: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

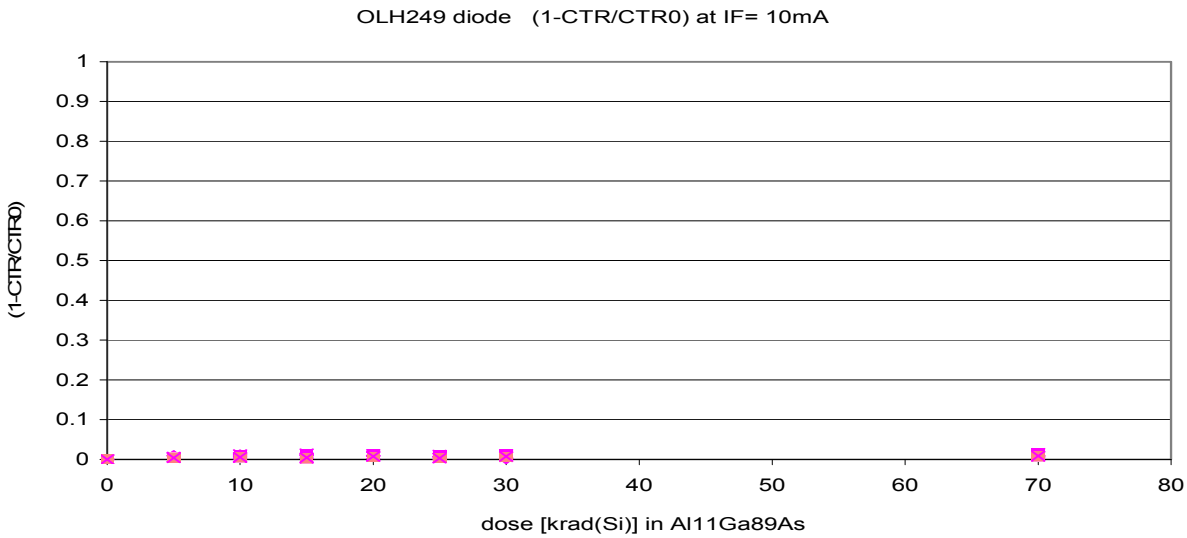
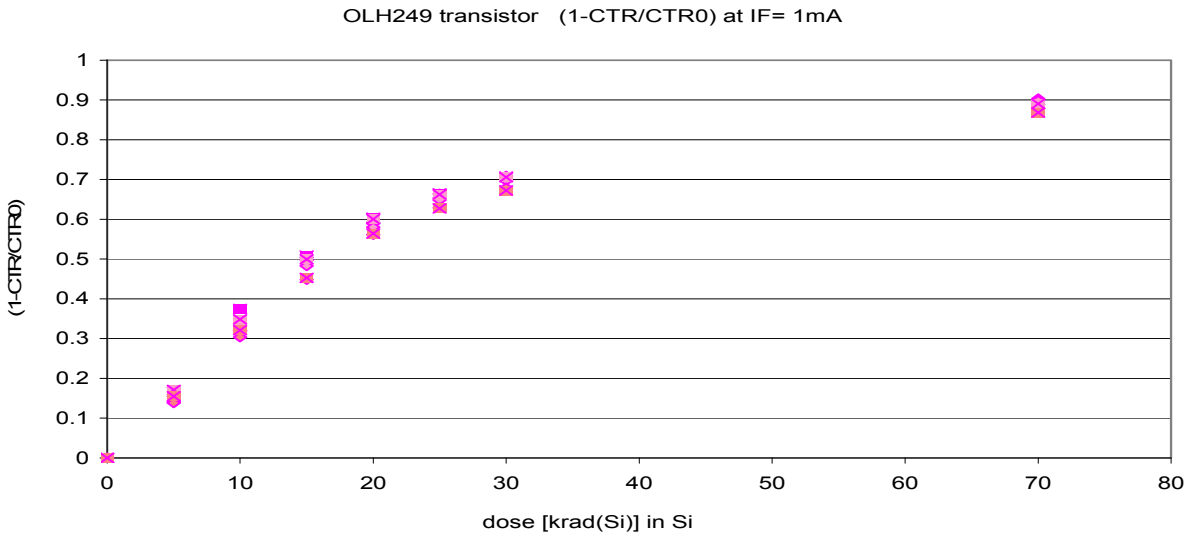
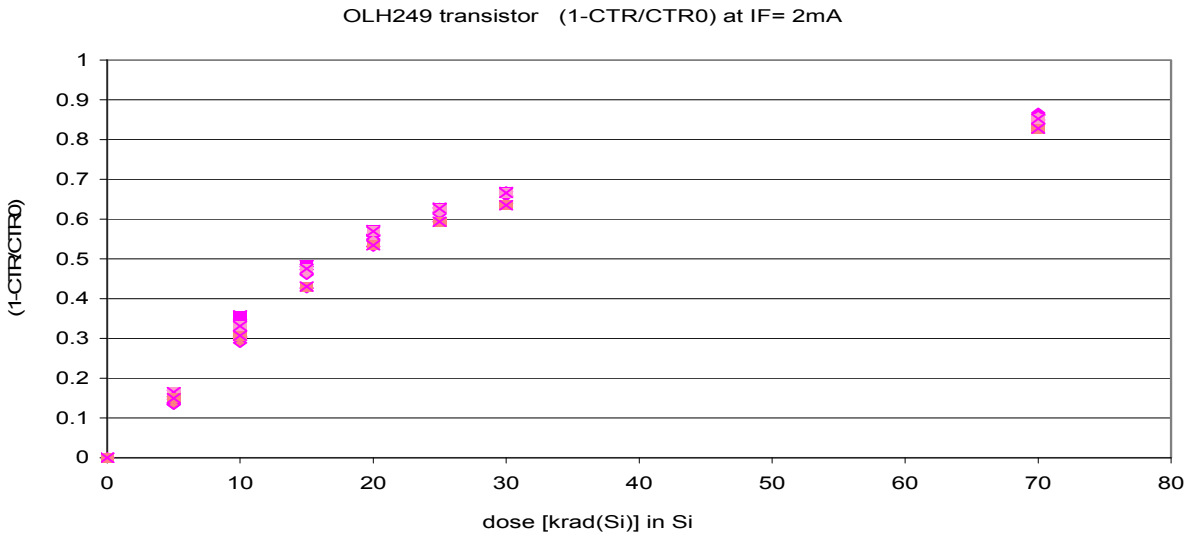
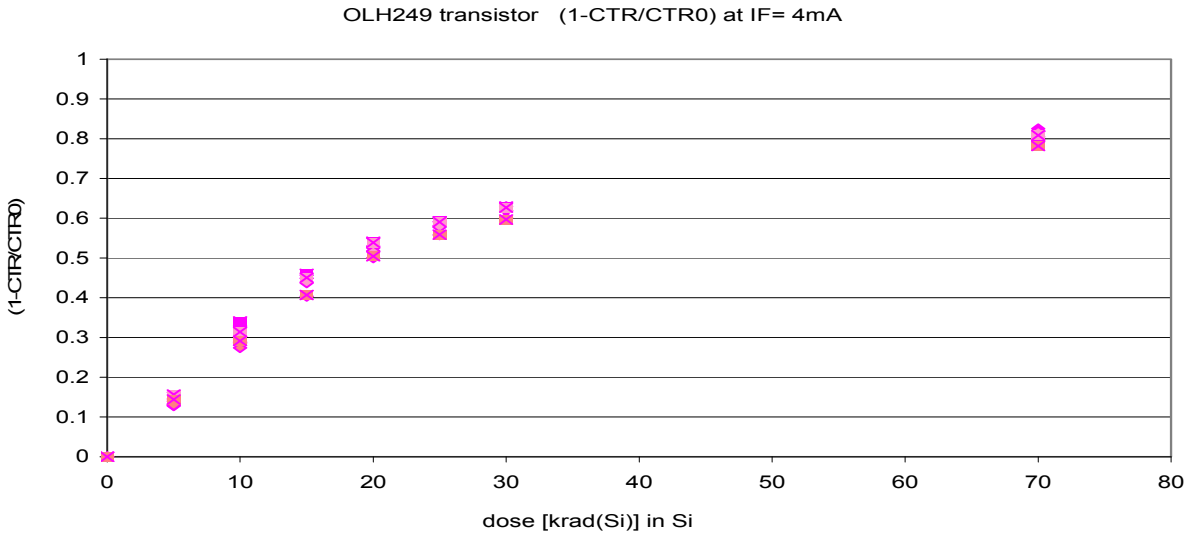

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-180: OLH249 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose





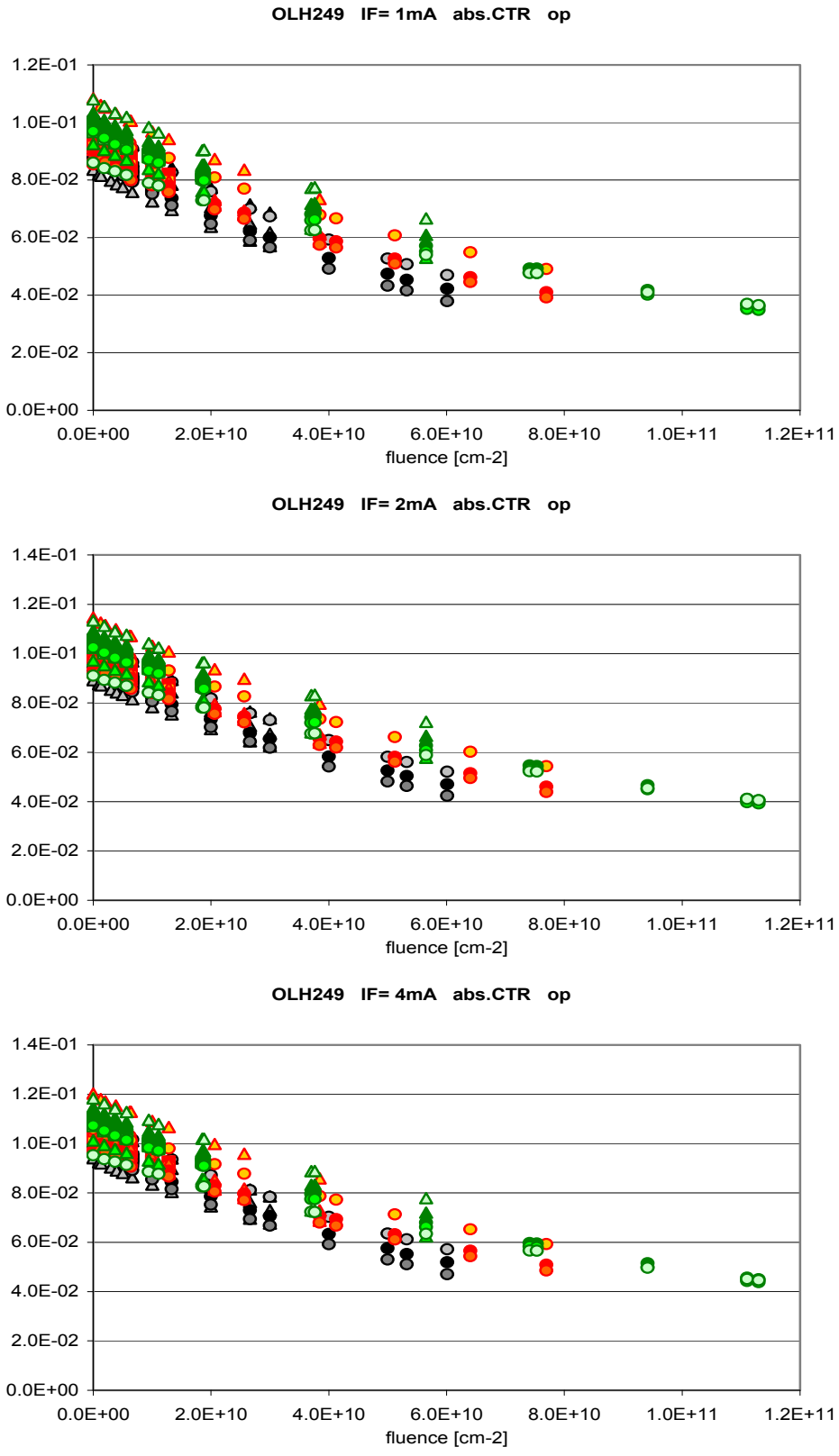


13. APPENDIX OLH249

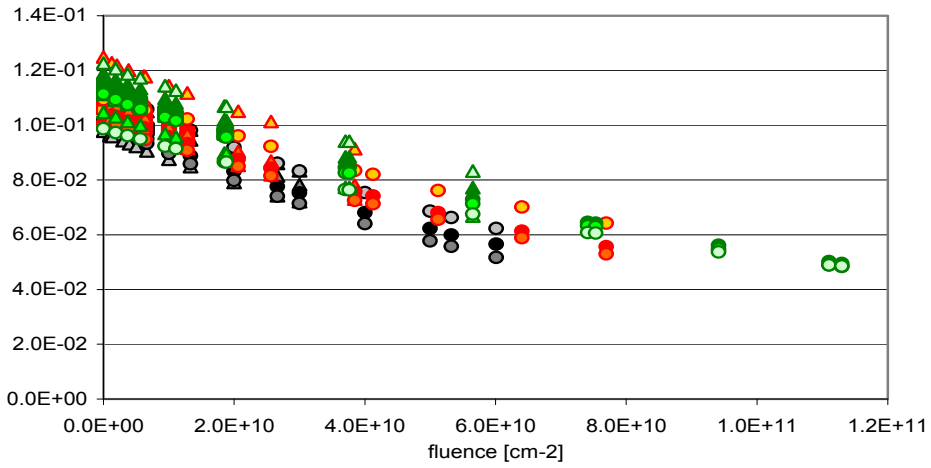
Part type	Emitter	Receiver			Package
	LED	Photodiode	Phototransistor	Output transistor	
OLH249 / ISOLINK **(DC0626)**	830 nm Double heterojunction AlGaAs **(Ref : OLQ243E)**	N/A	**0.045 inch sq (Ref : OLQ243D)**	N/A	Window can

13.1 PROTON IRRADIATION

Fig. 13-1: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

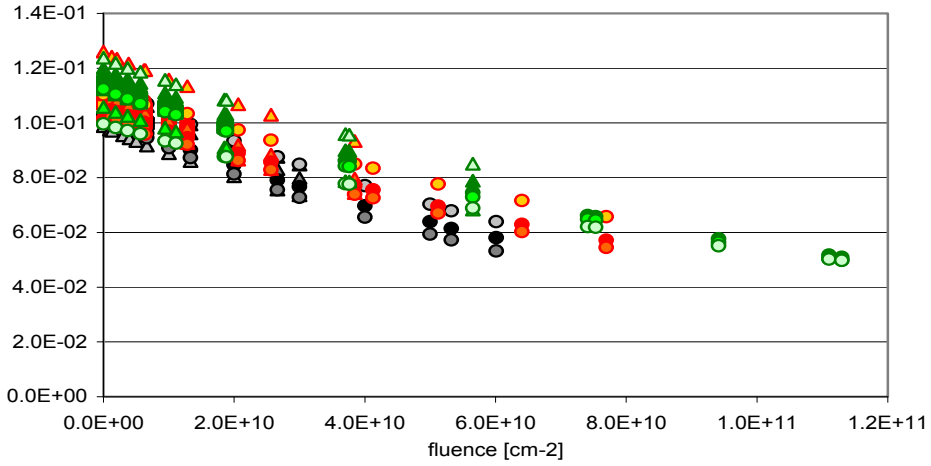
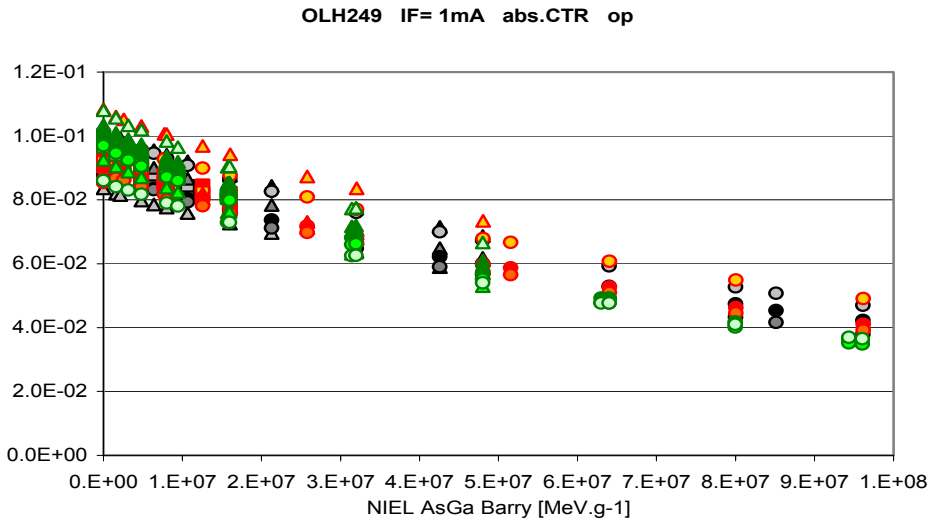
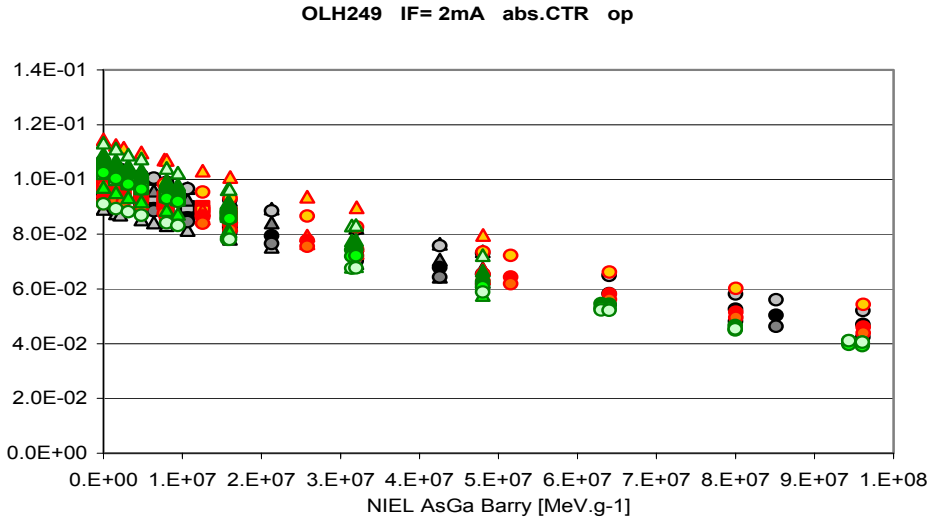
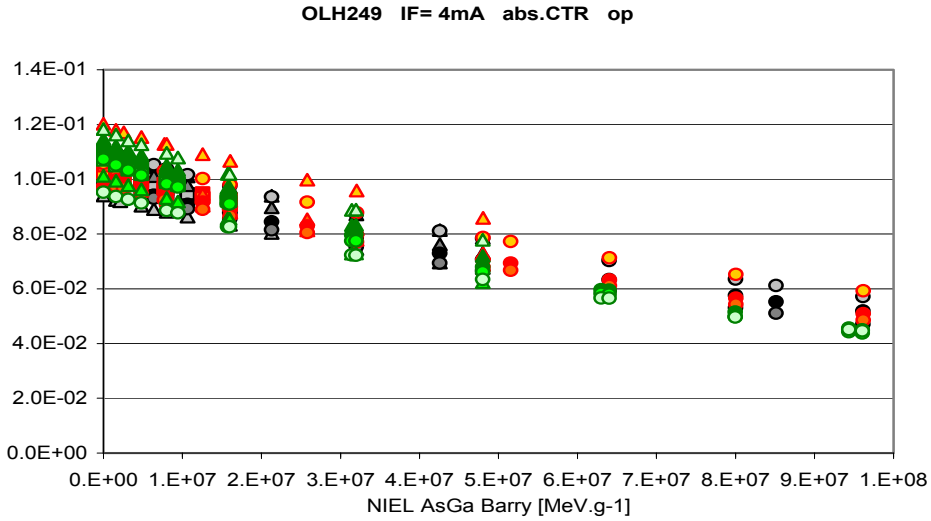


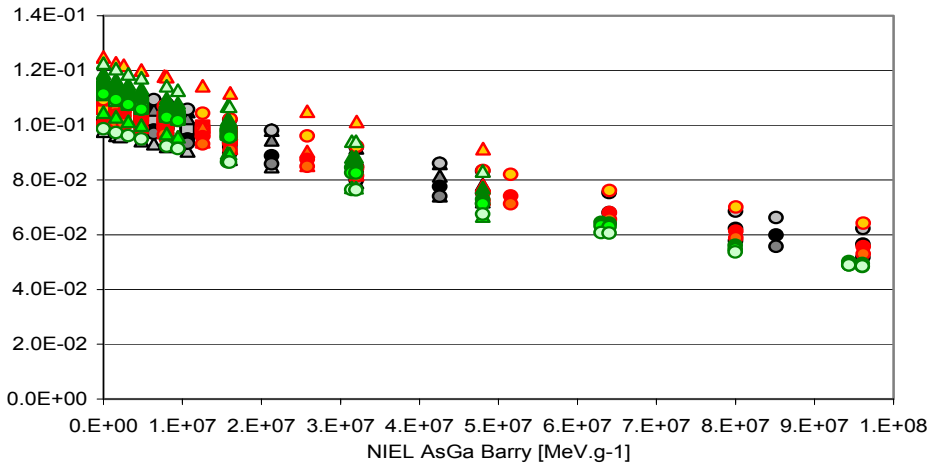
Fig. 13-2: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

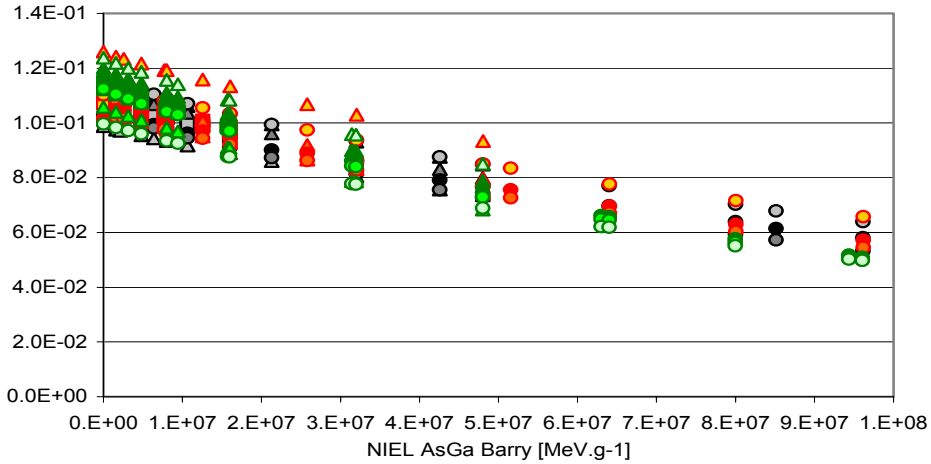
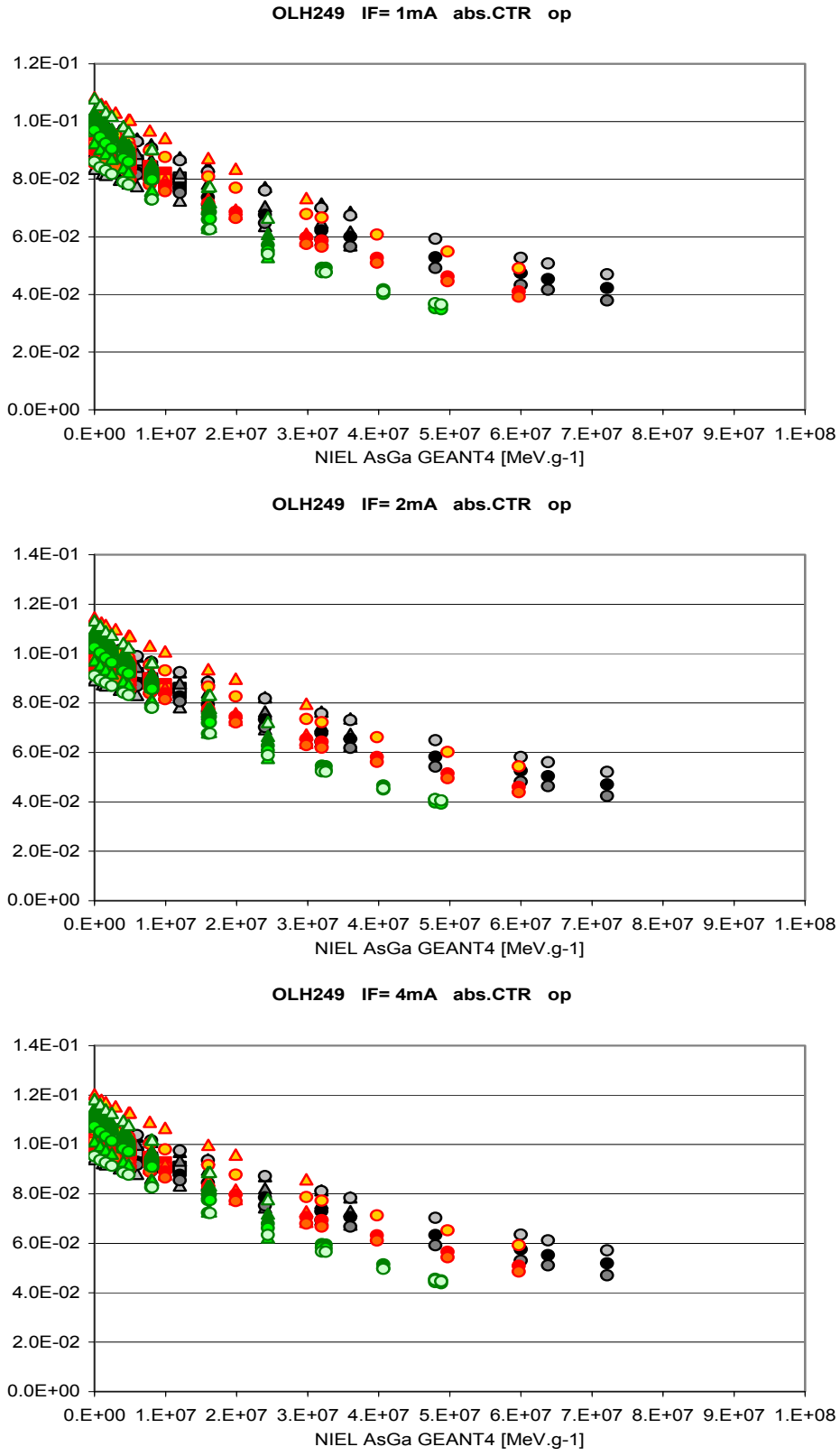
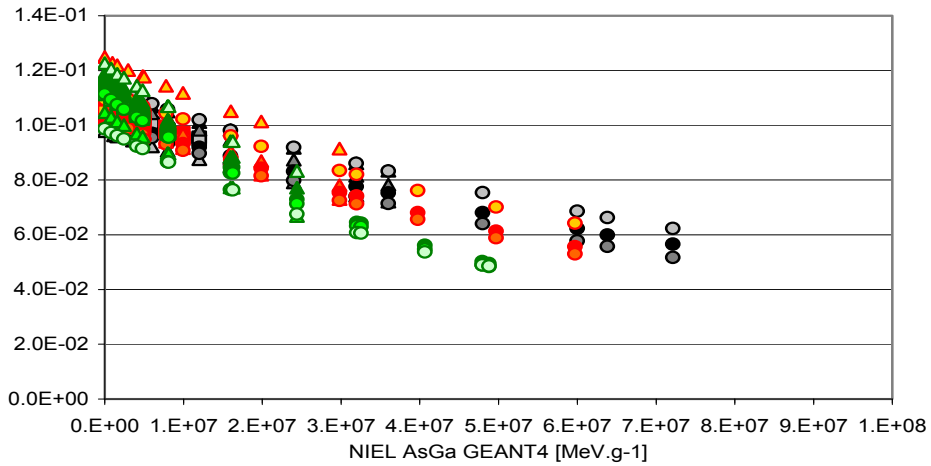


Fig. 13-3: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

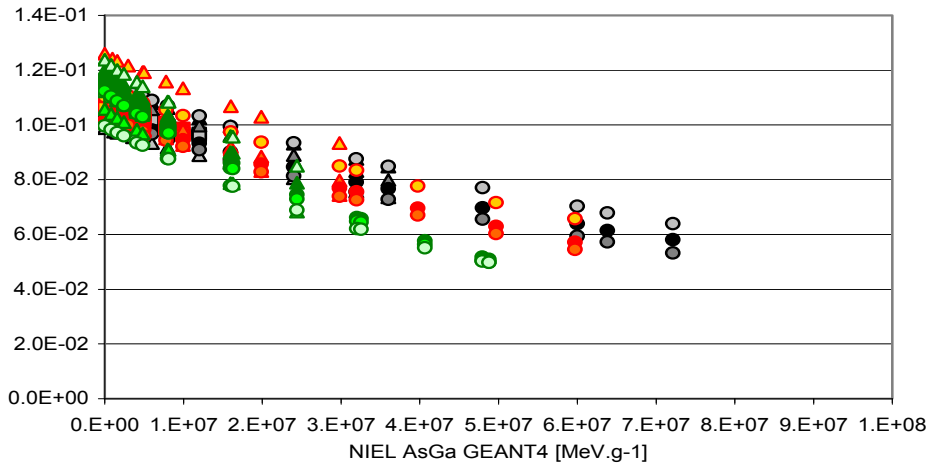
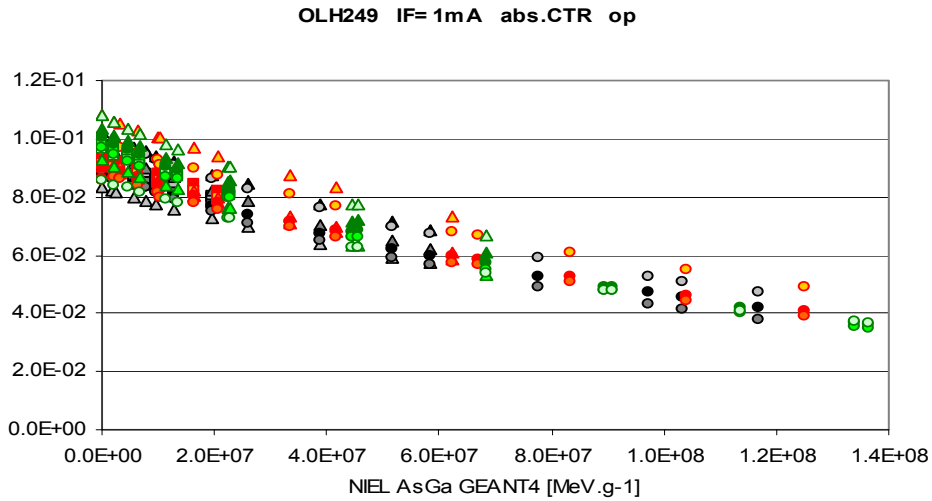
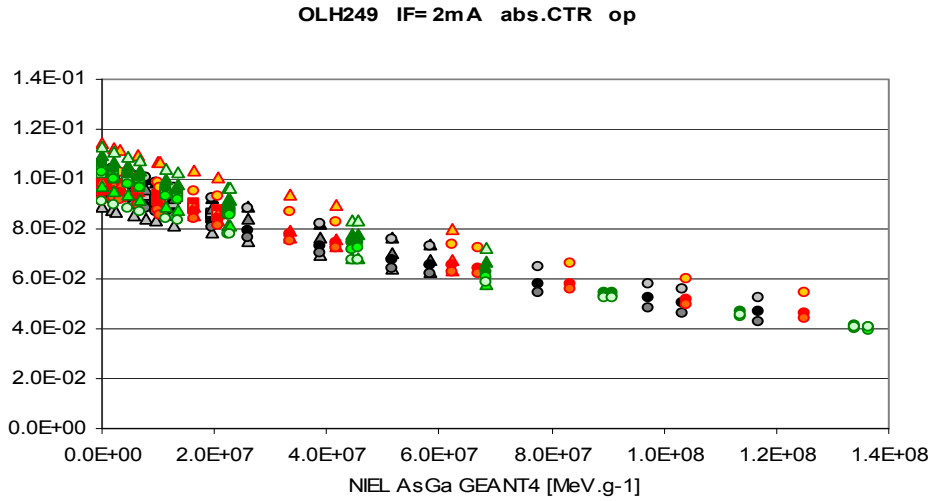
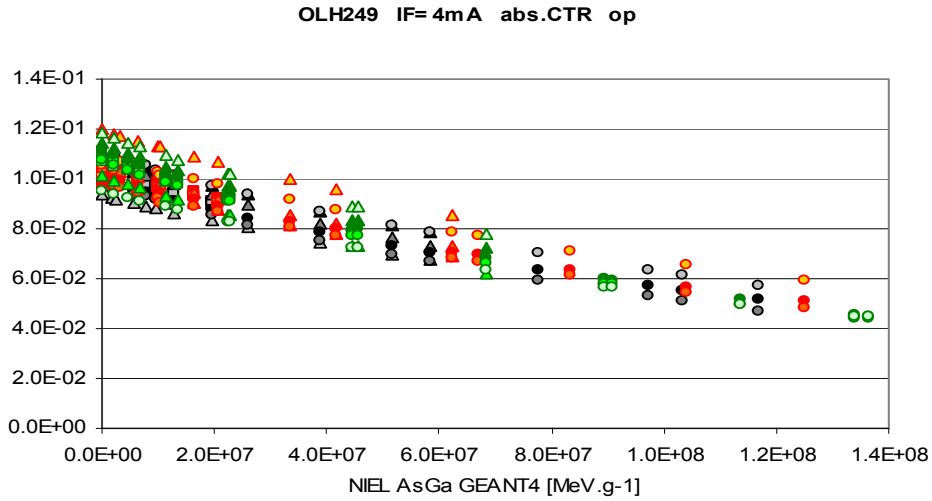


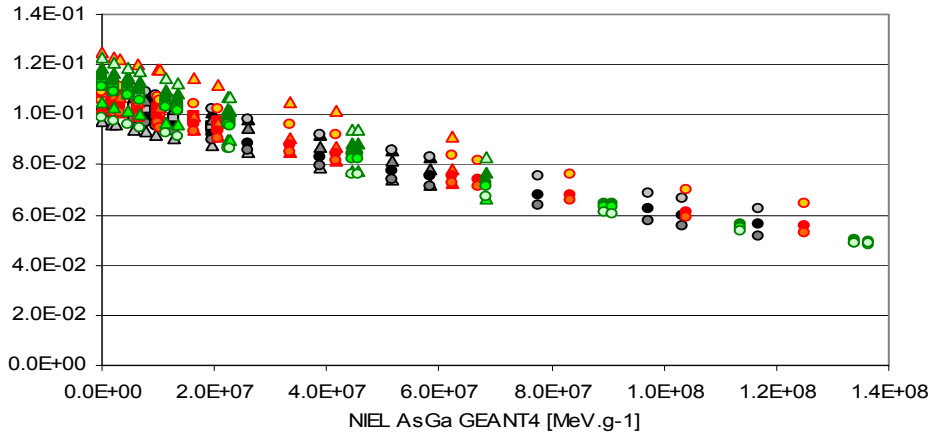
Fig. 13-4: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA abs.CTR op



OLH249 IF= 10mA abs.CTR op

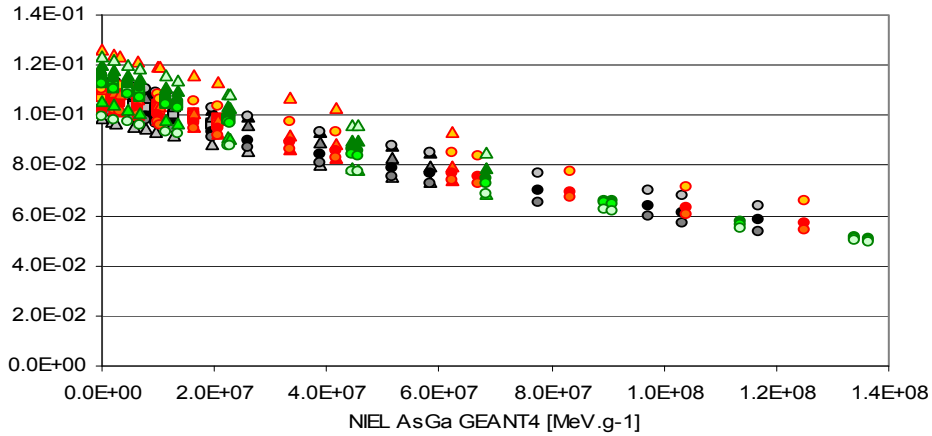
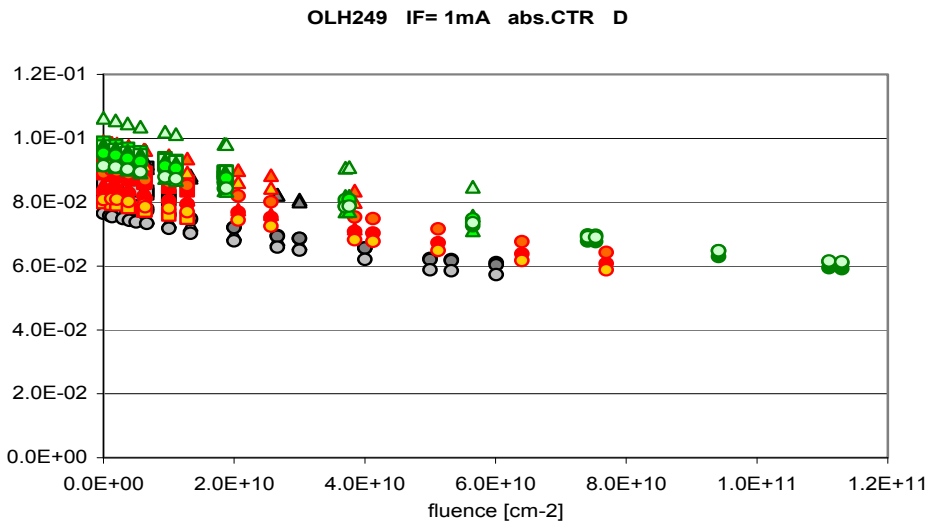
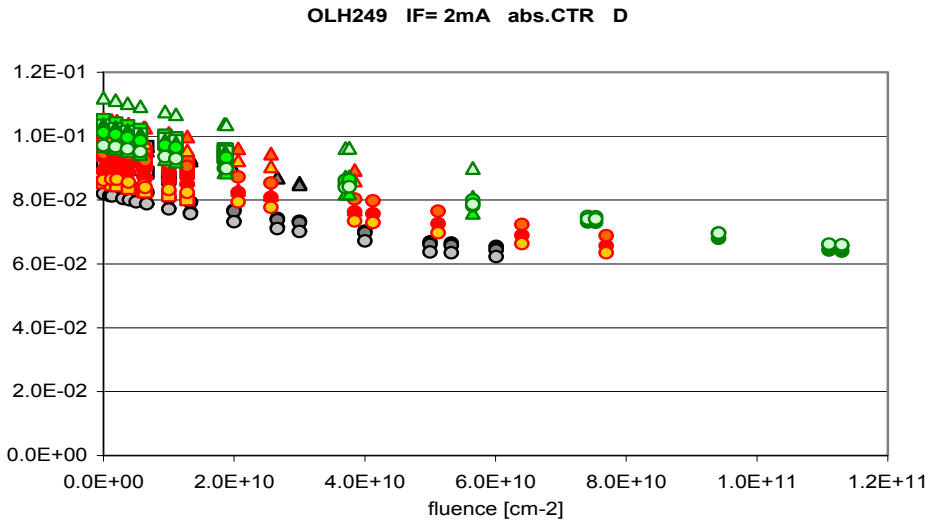
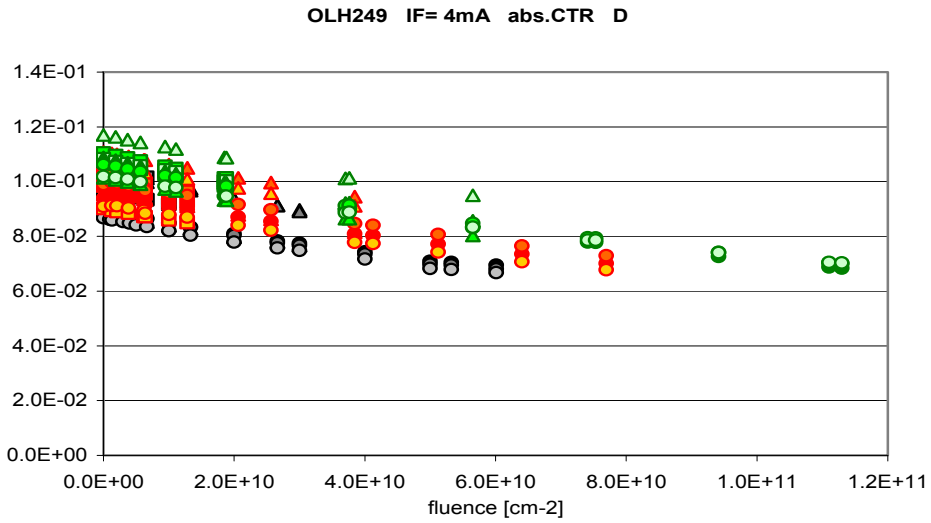


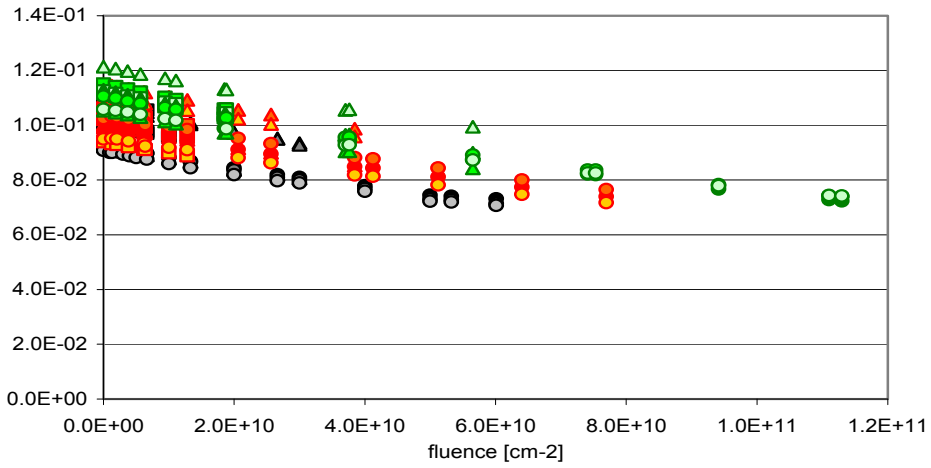
Fig. 13-5: OLH249 diode: CTR at IF= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

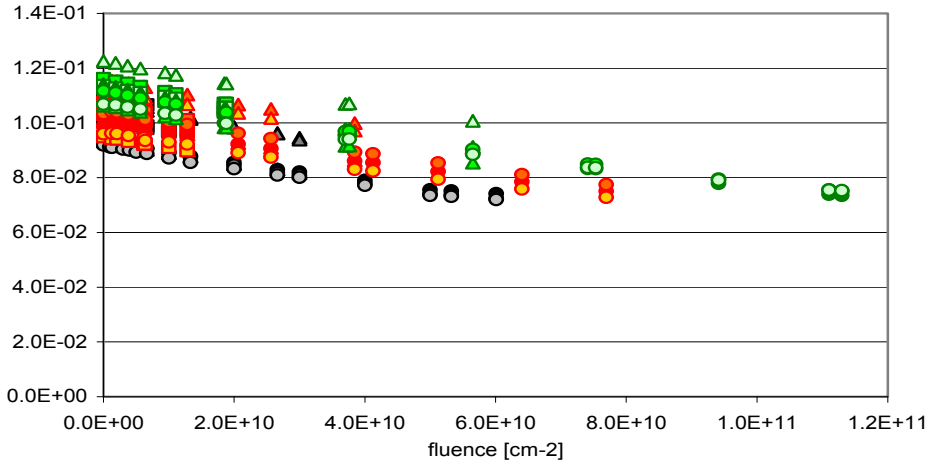
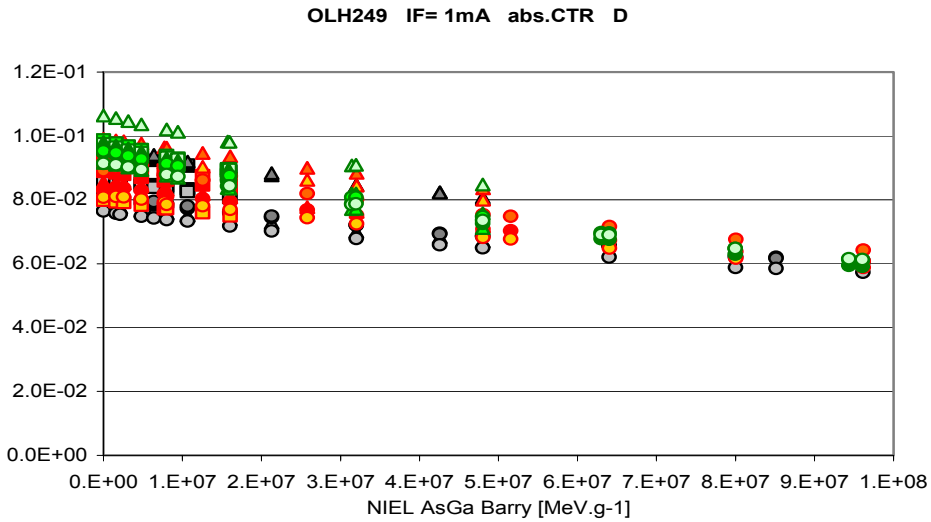
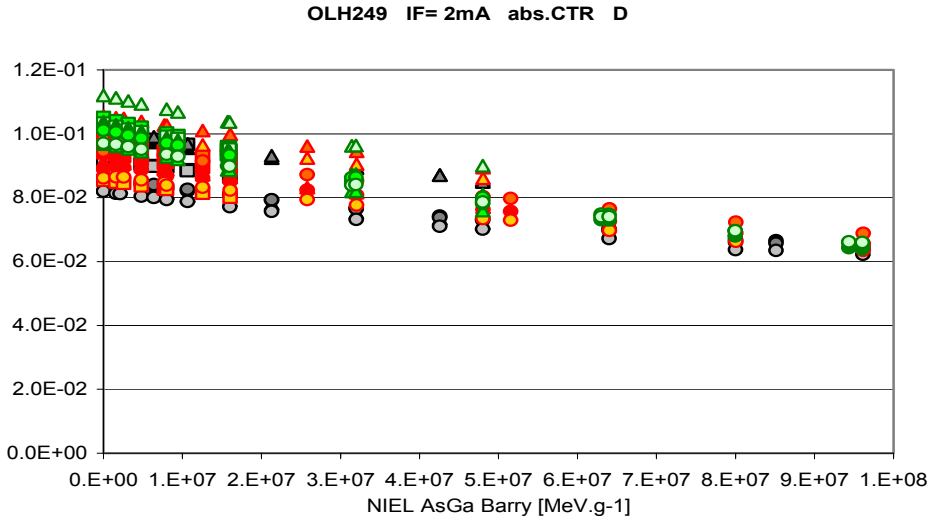
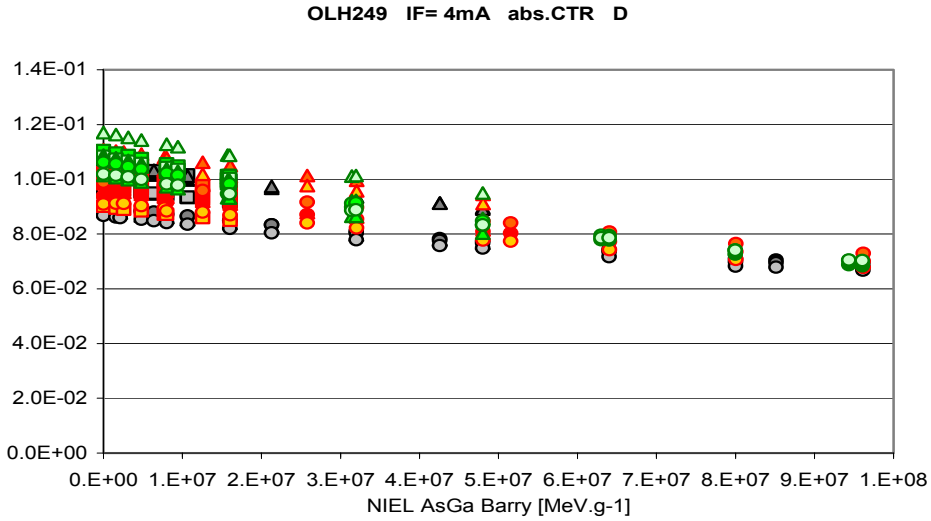


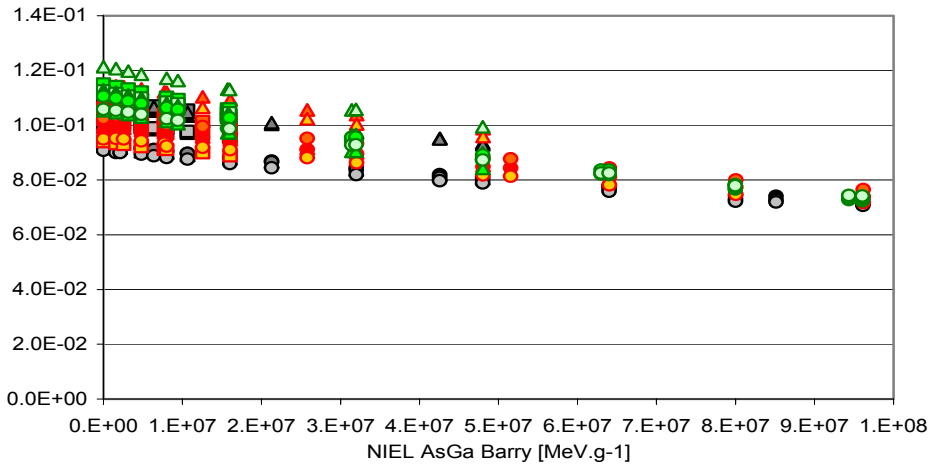
Fig. 13-6: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

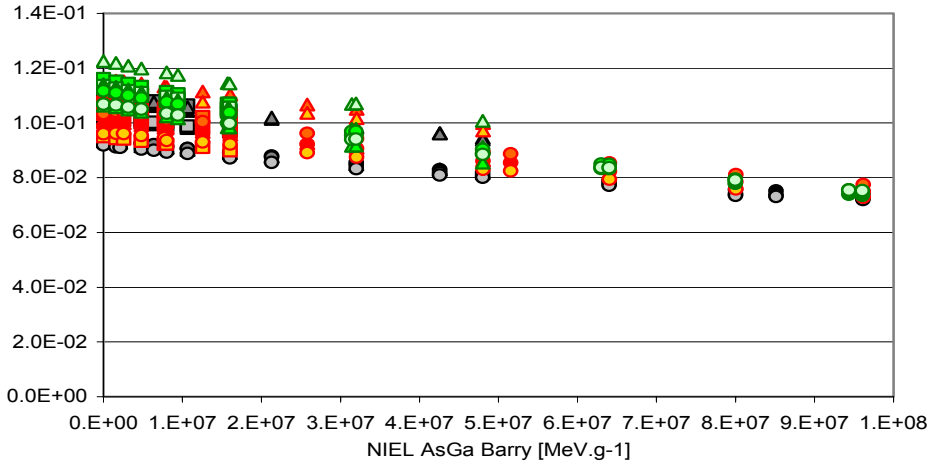
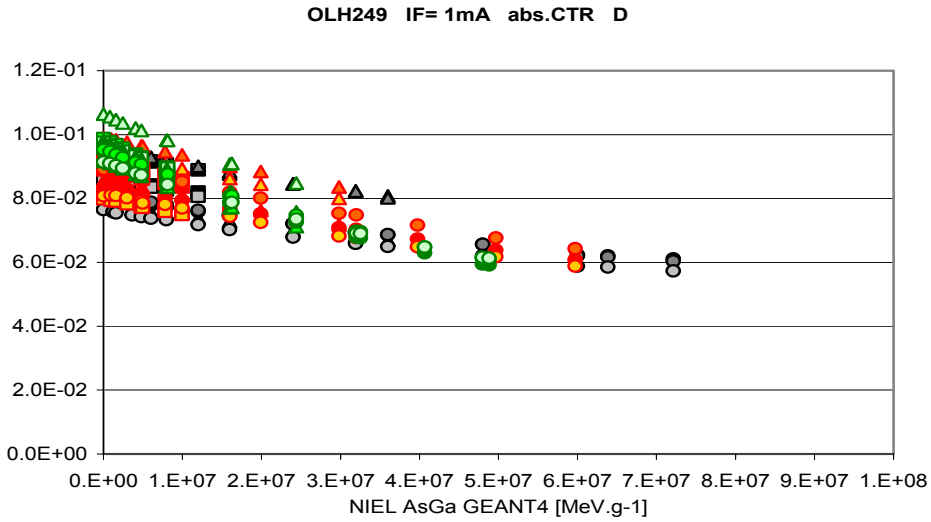
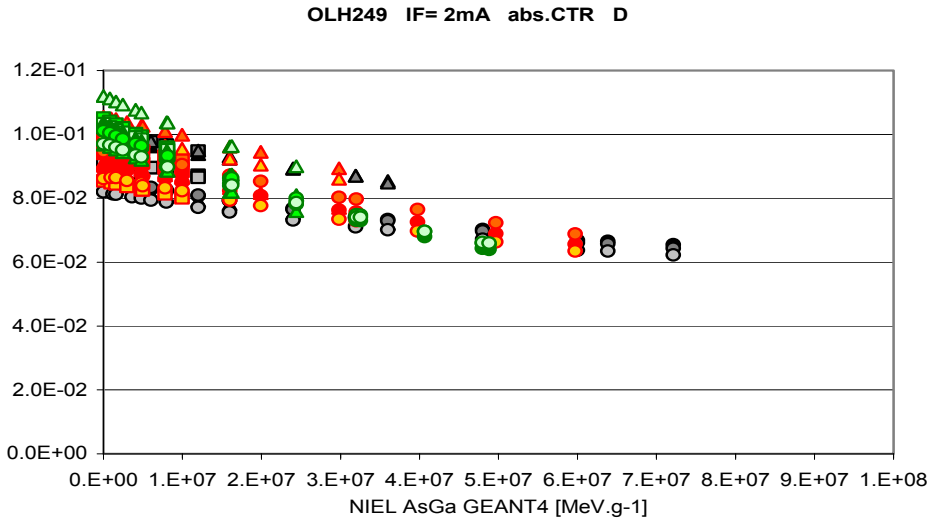
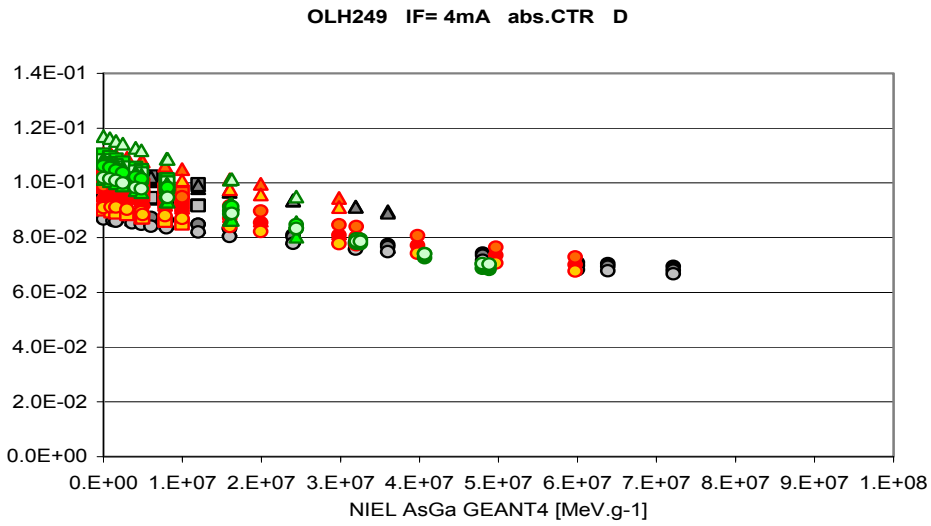


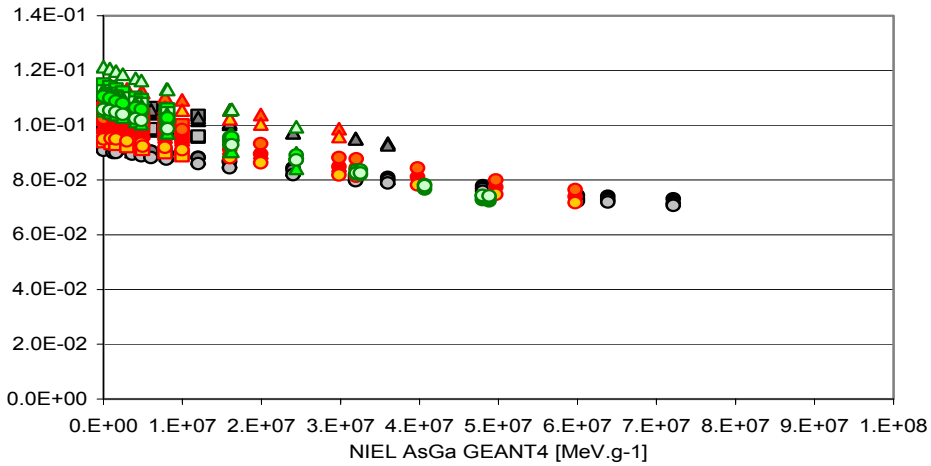
Fig. 13-7: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

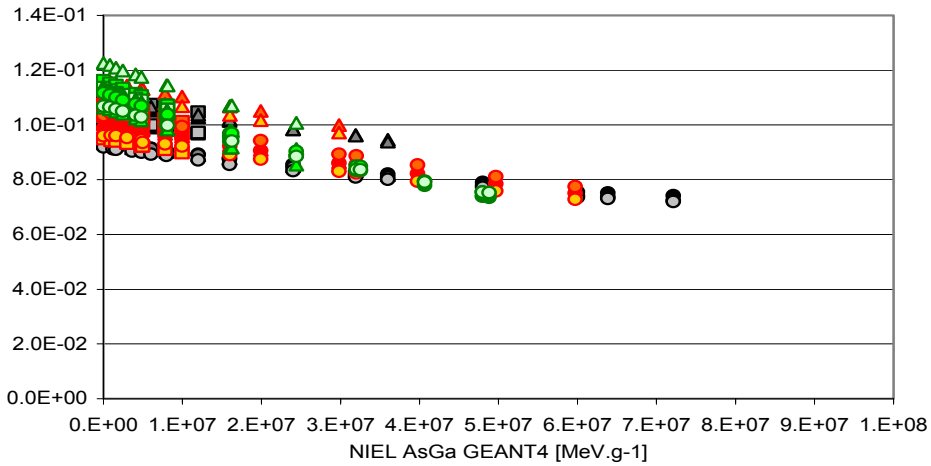
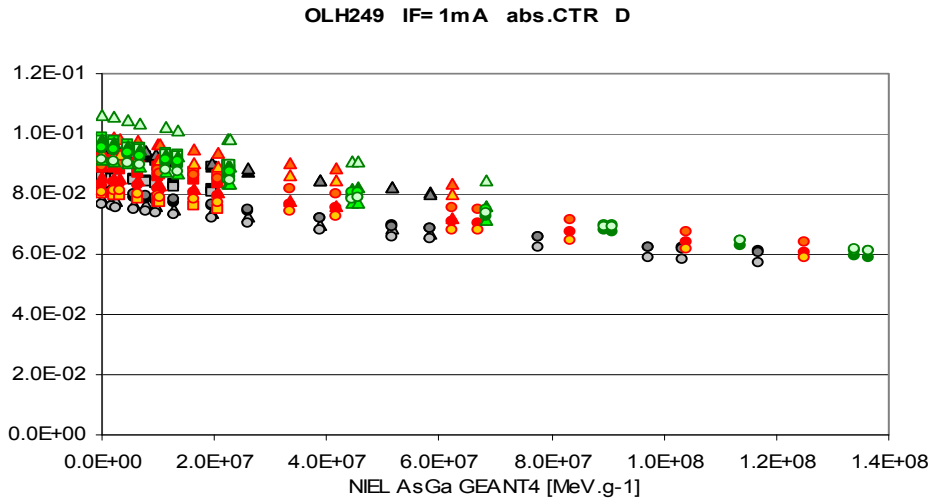
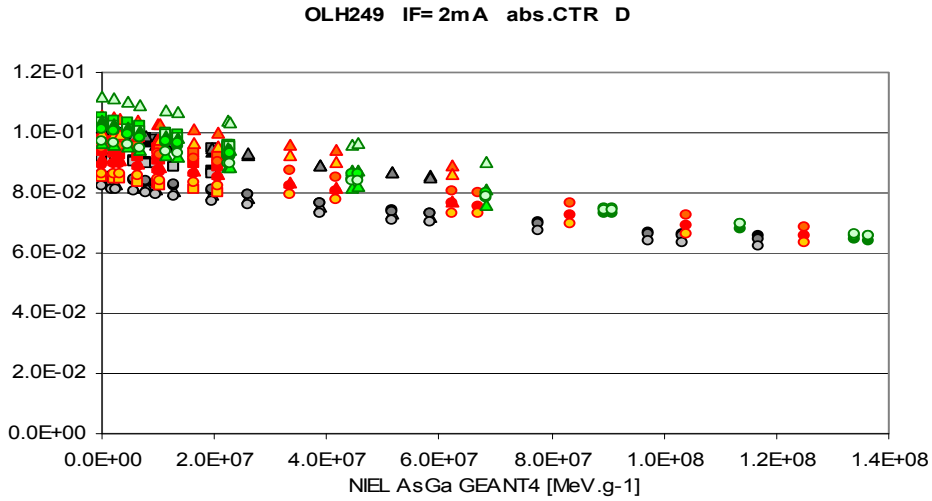
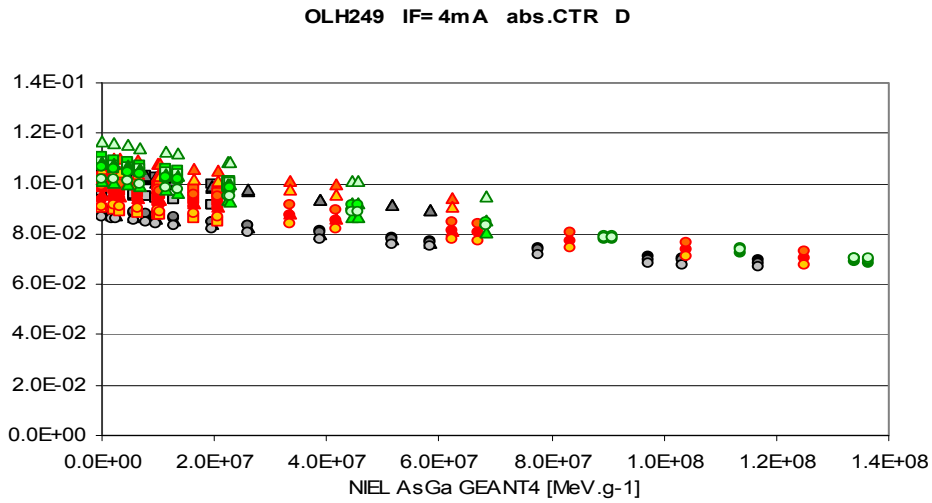


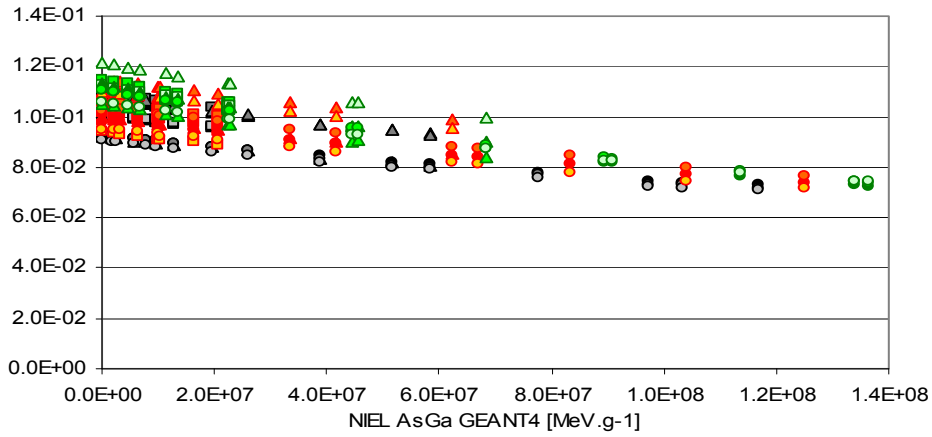
Fig. 13-8: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA abs.CTR D



OLH249 IF= 10mA abs.CTR D

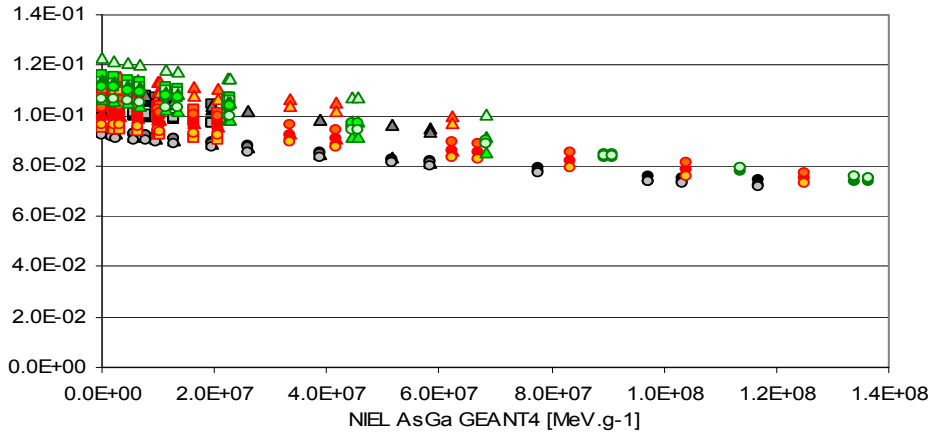
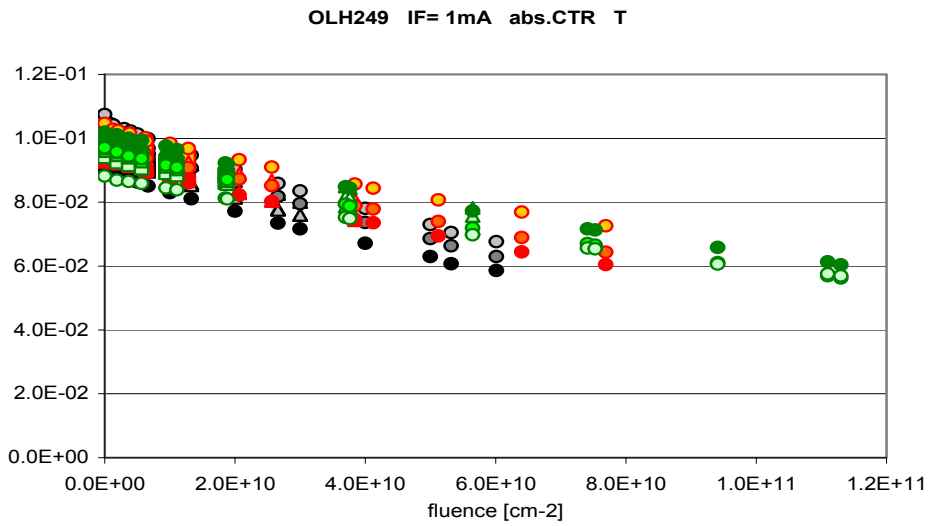
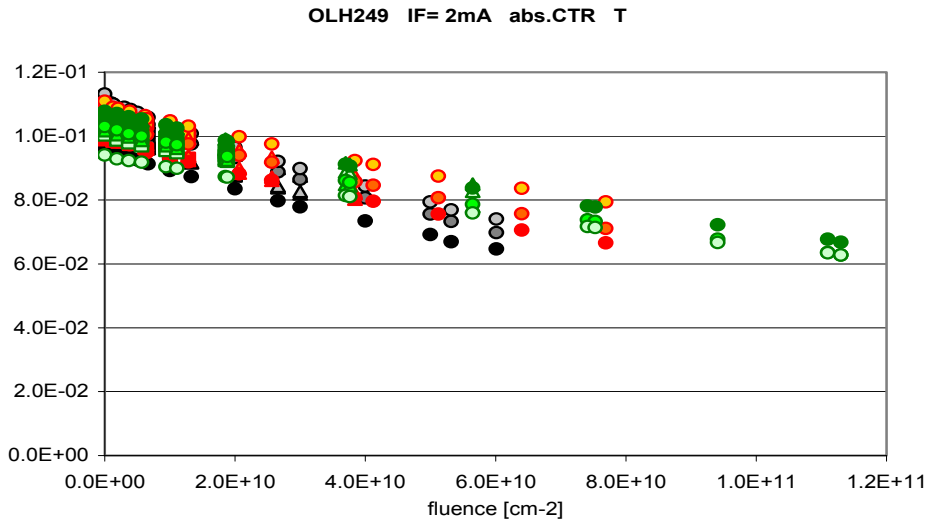
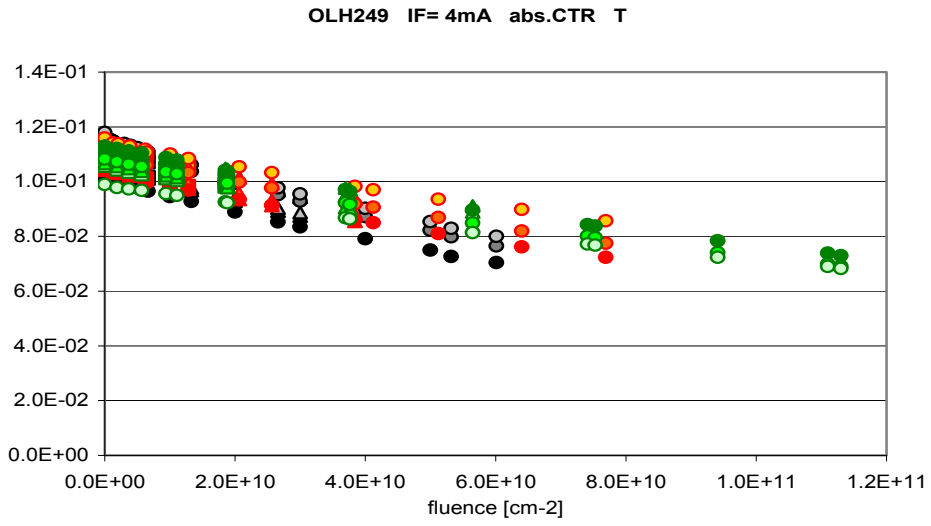


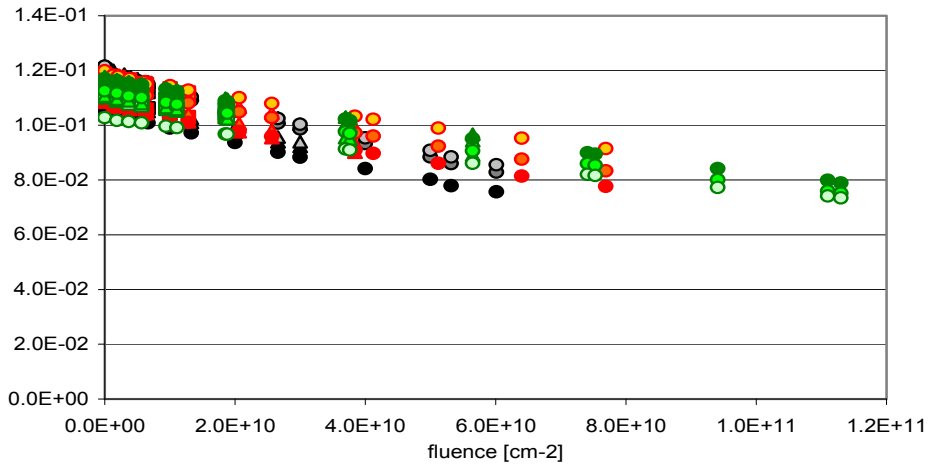
Fig. 13-9: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA abs.CTR T



OLH249 IF= 10mA abs.CTR T

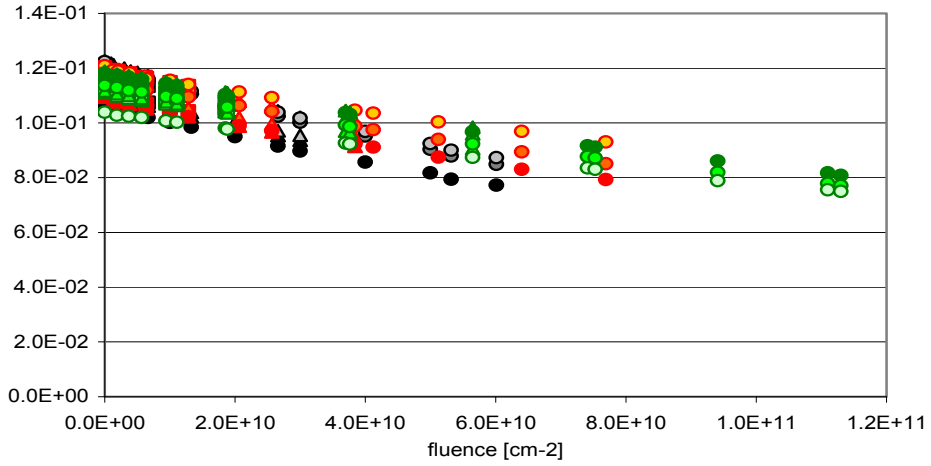
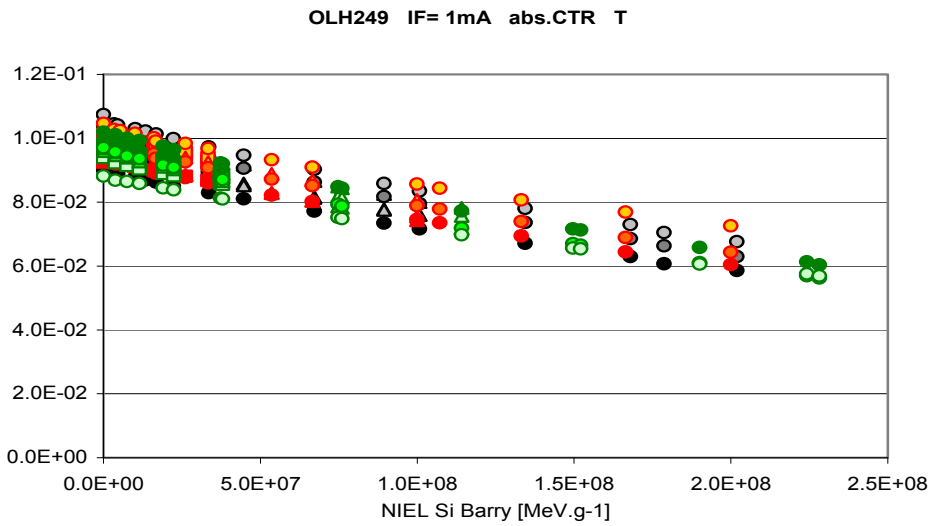
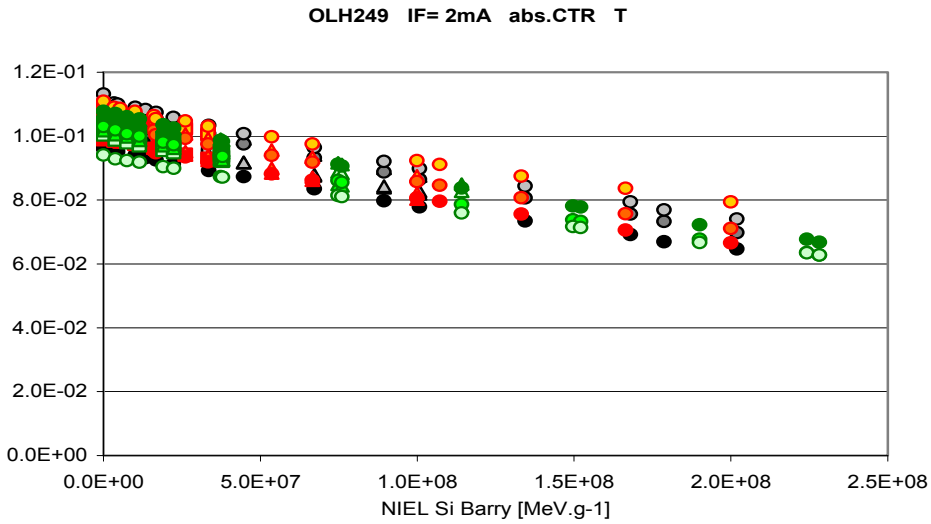
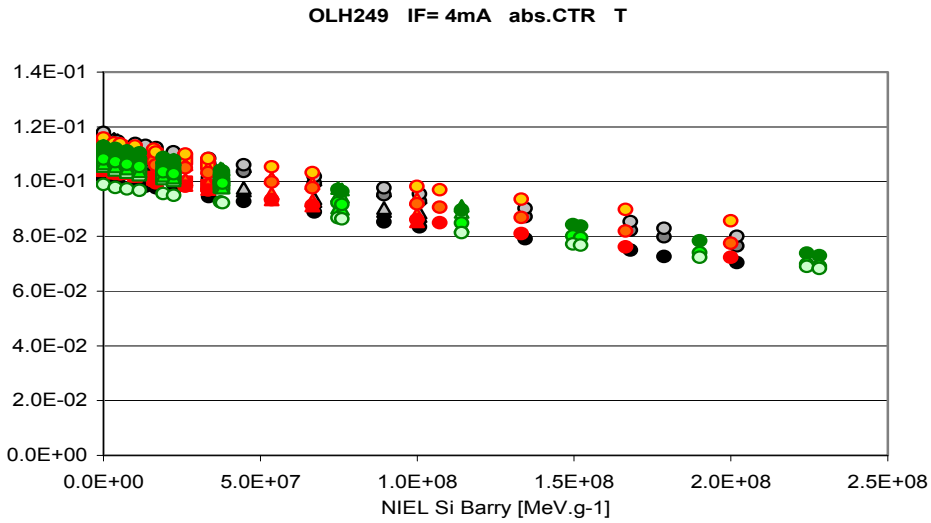
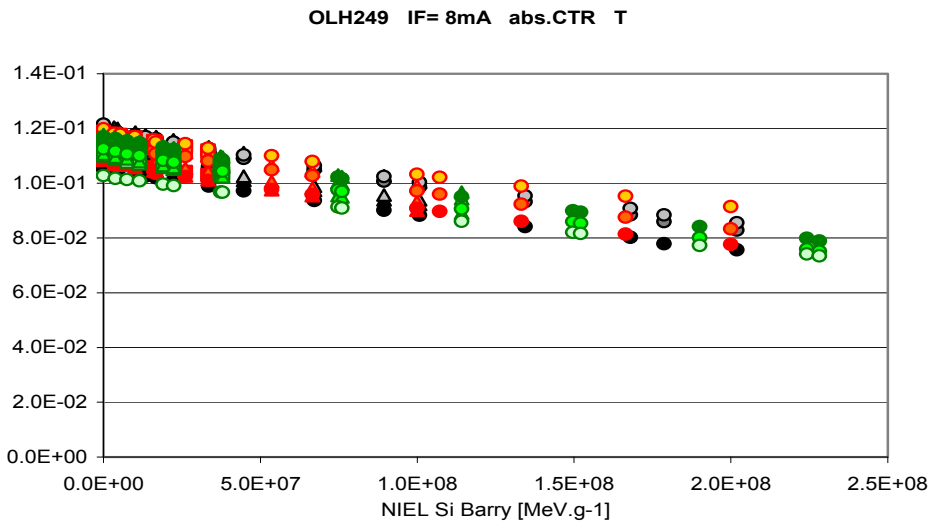


Fig. 13-10: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)








OLH249 IF= 8mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

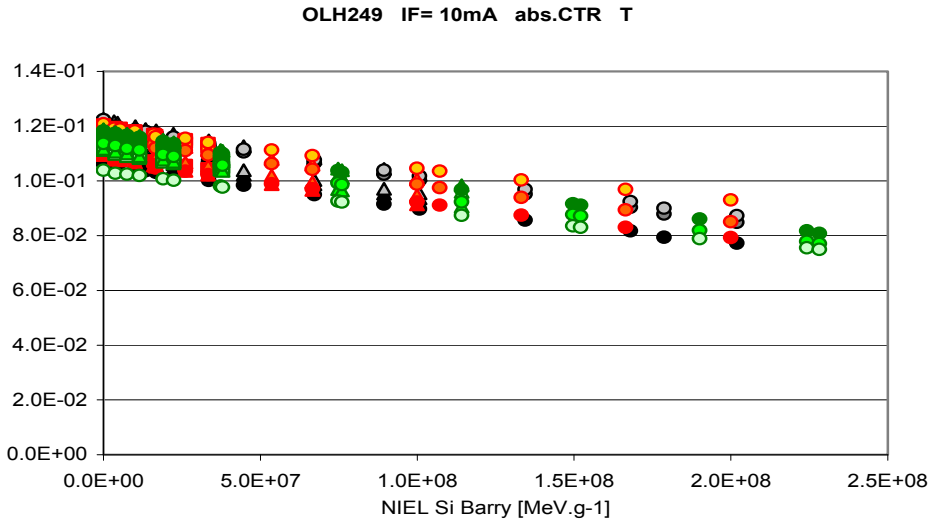
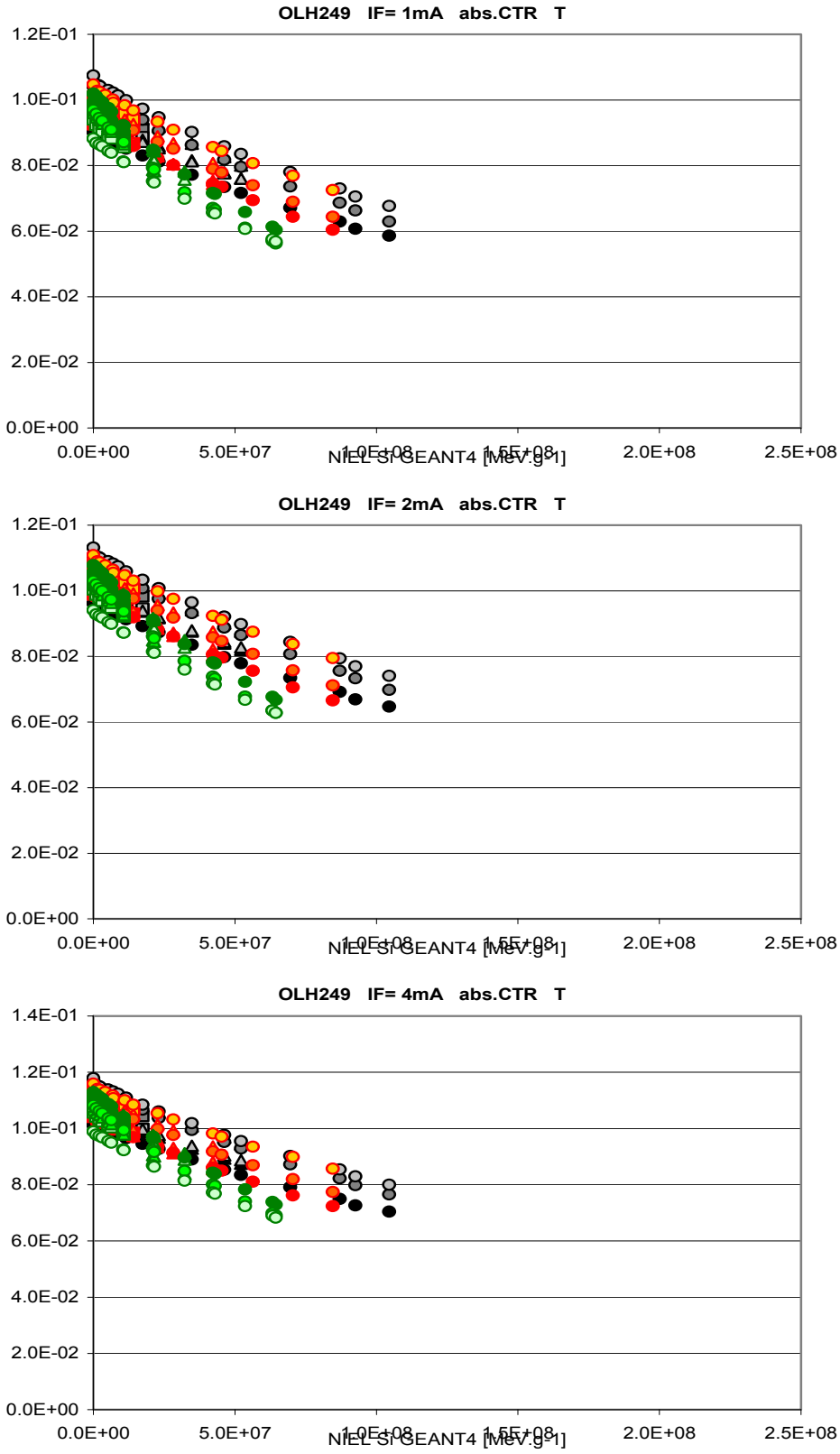
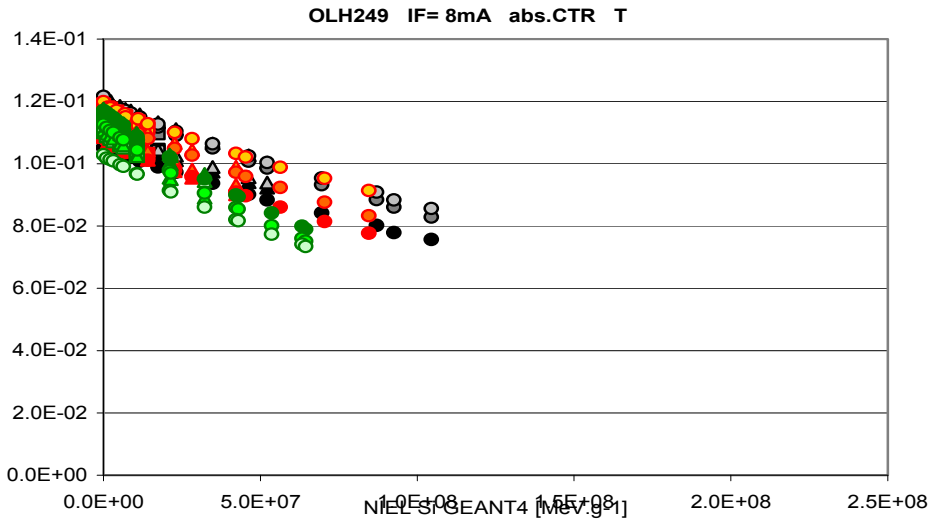

OLH249 IF= 10mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 13-11: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




OLH249 IF= 8mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

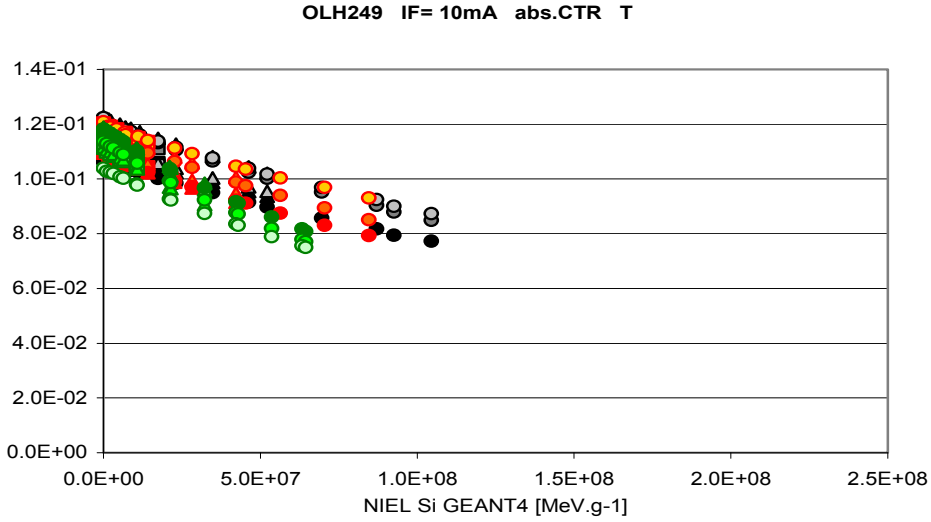
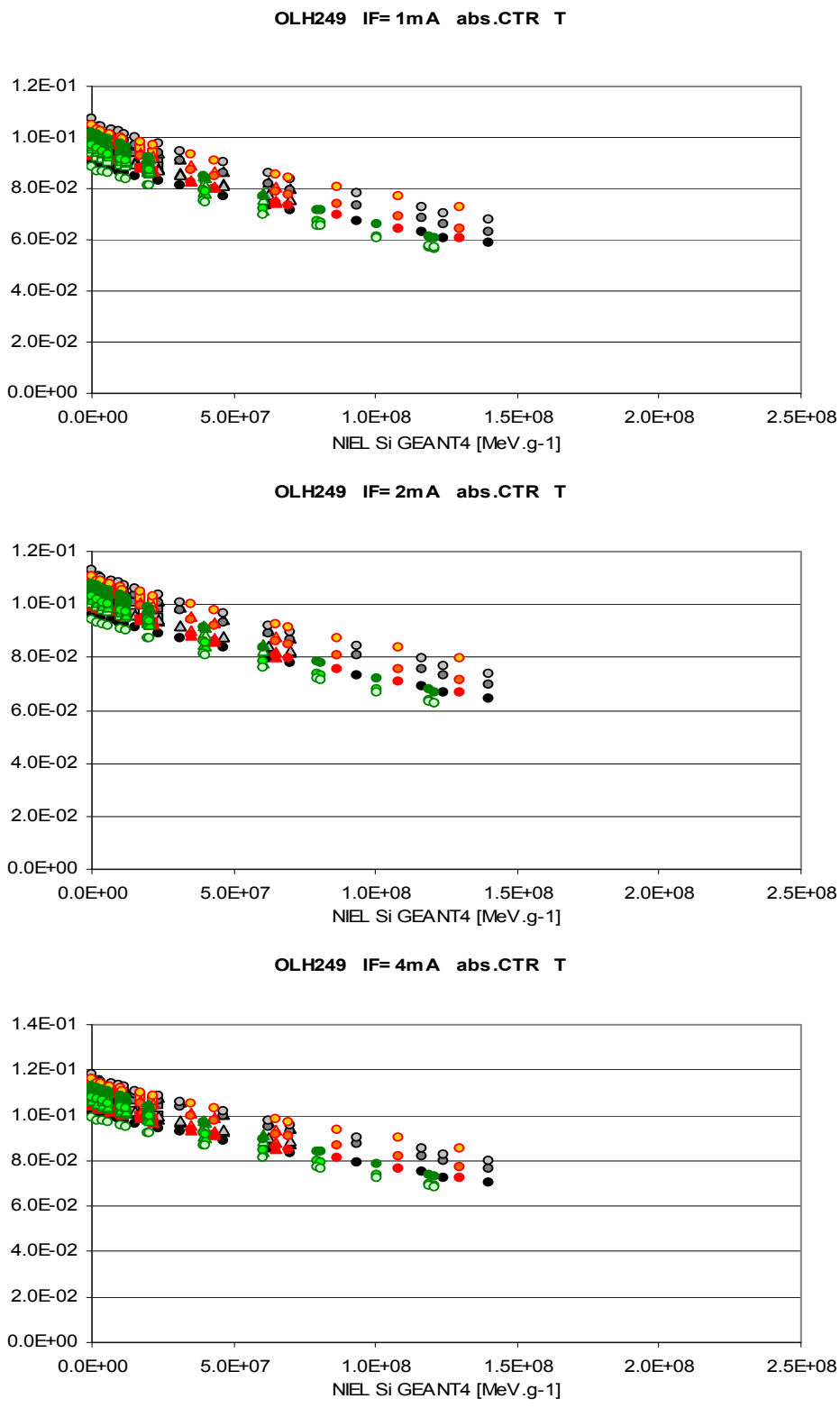
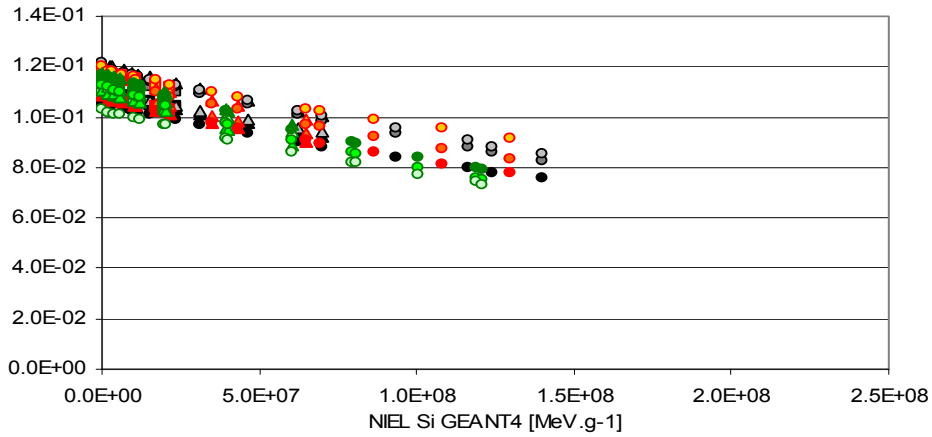

OLH249 IF= 10mA abs.CTR T
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-12: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)



OLH249 IF= 8mA abs.CTR T



OLH249 IF= 10mA abs.CTR T

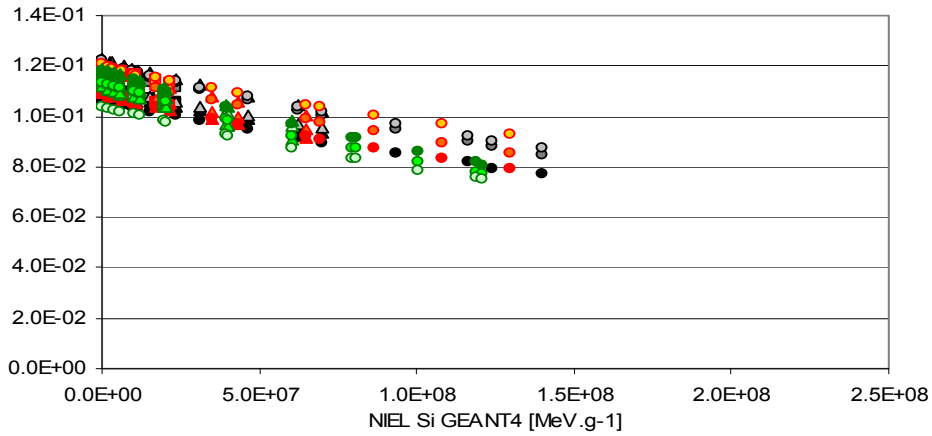
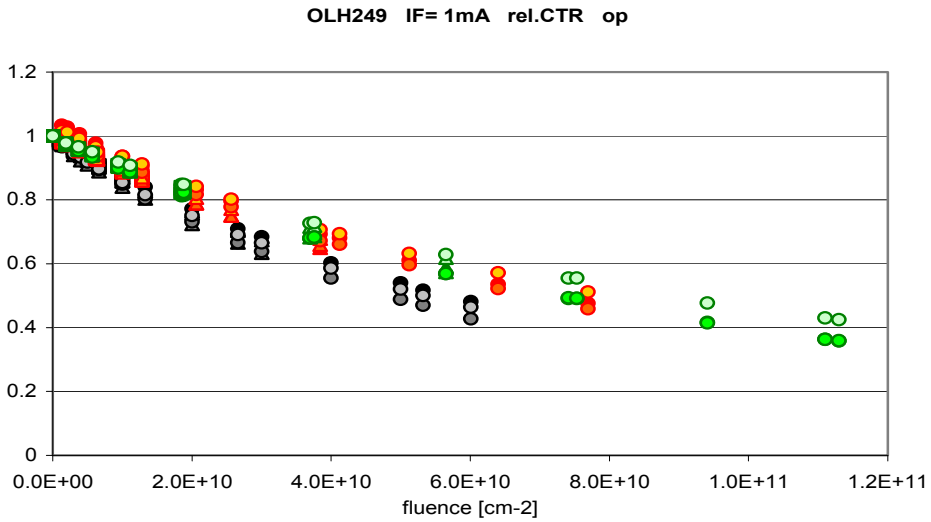
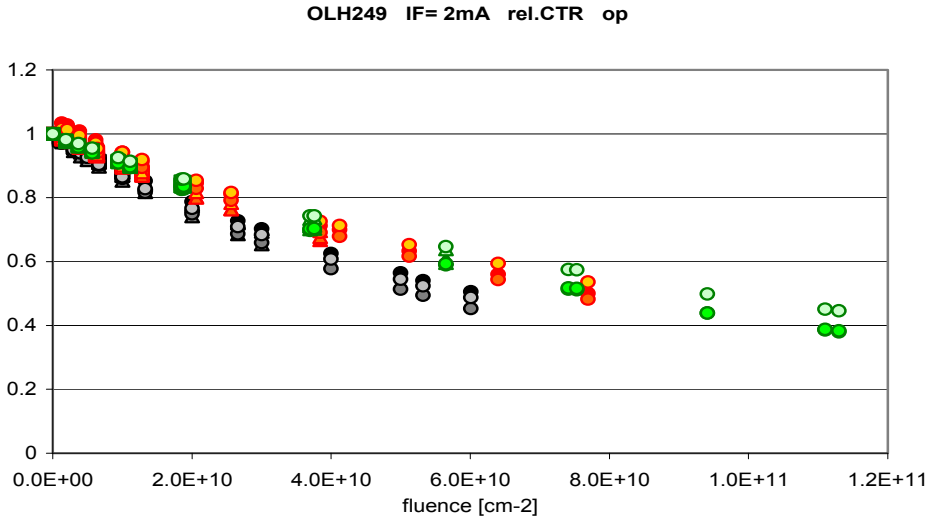
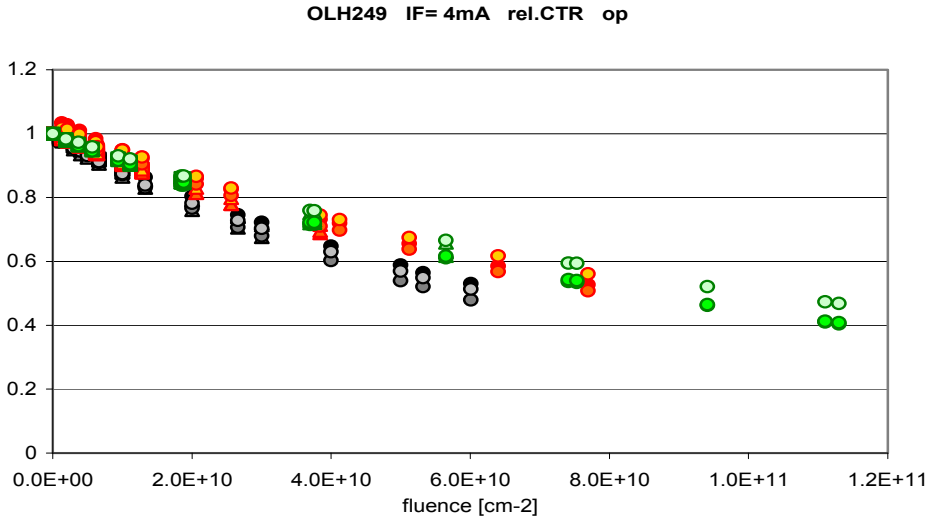


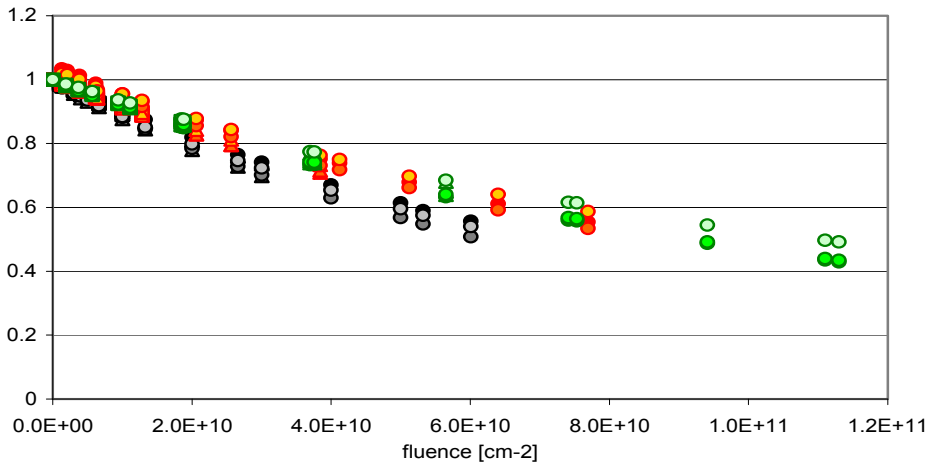
Fig. 13-13: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

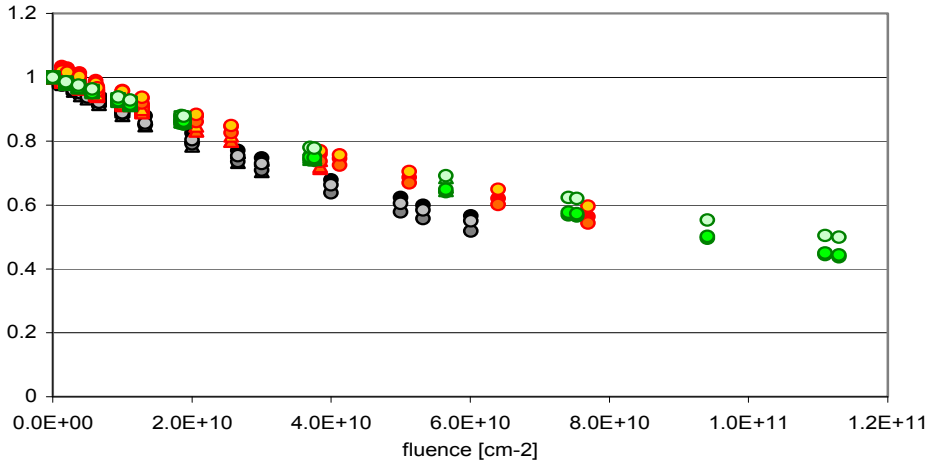
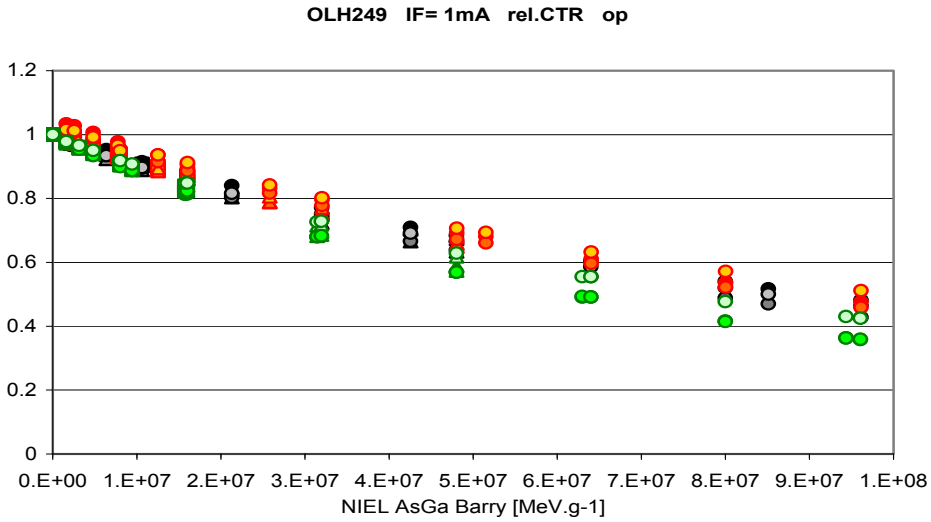
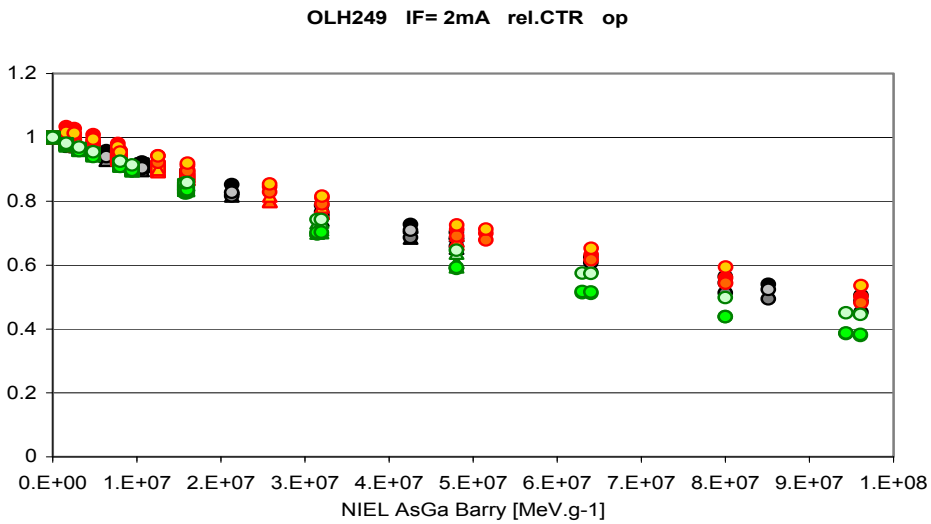
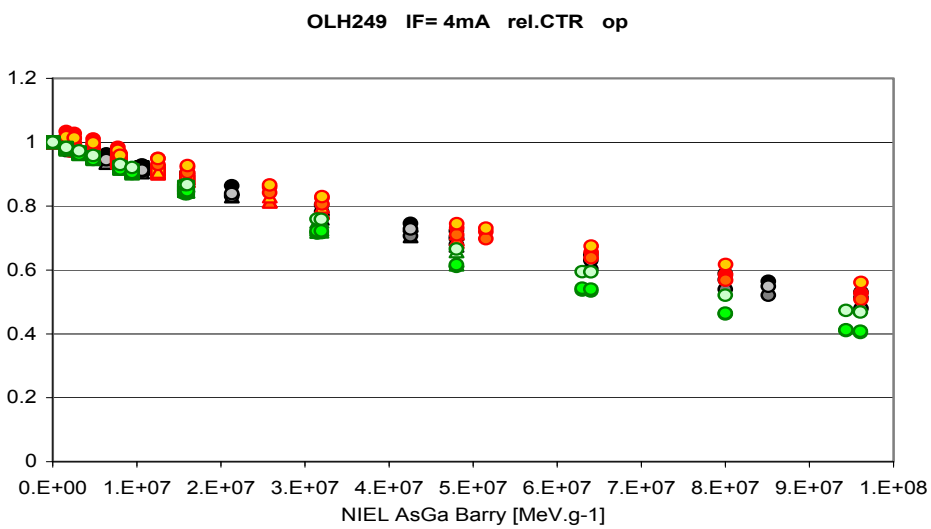


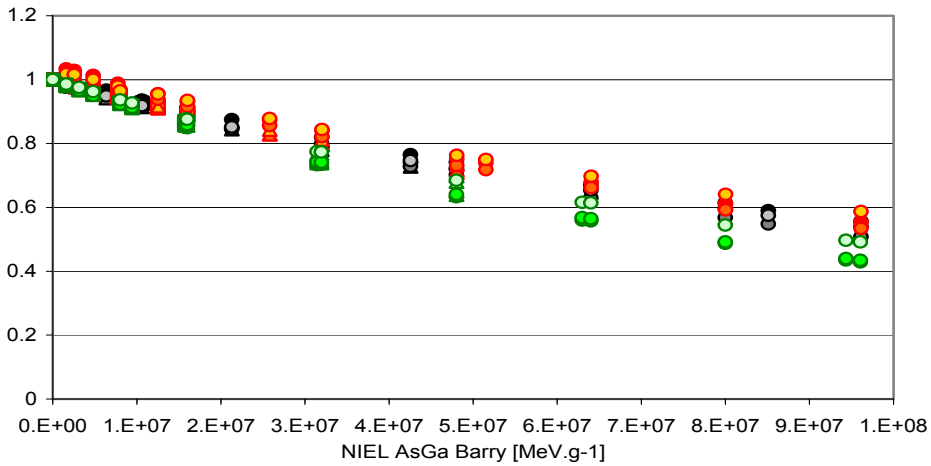
Fig. 13-14: OLH249 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)







OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

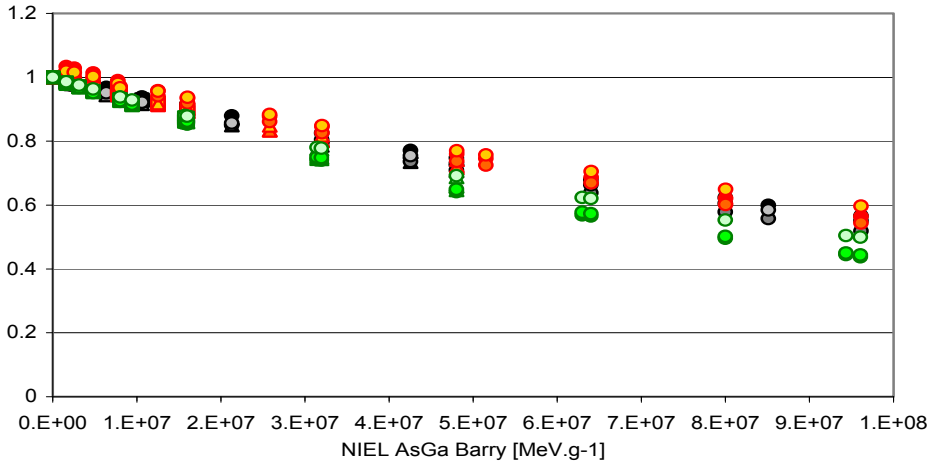
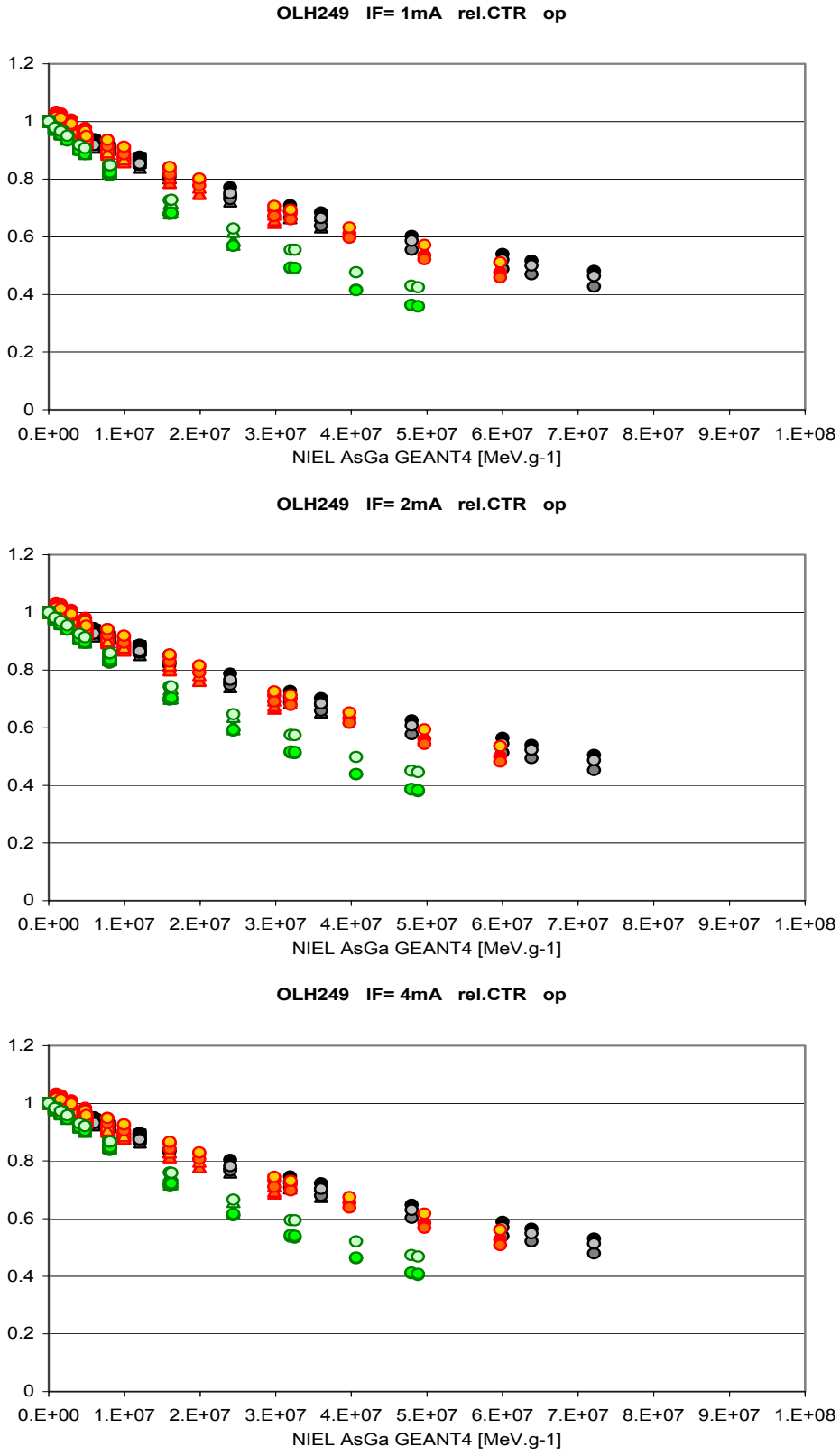
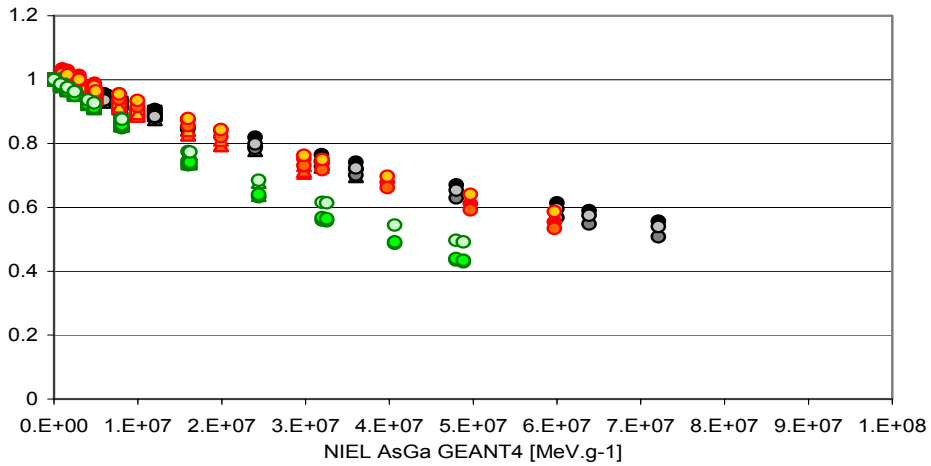


Fig. 13-15: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA rel.CTR op



OLH249 IF= 10mA rel.CTR op

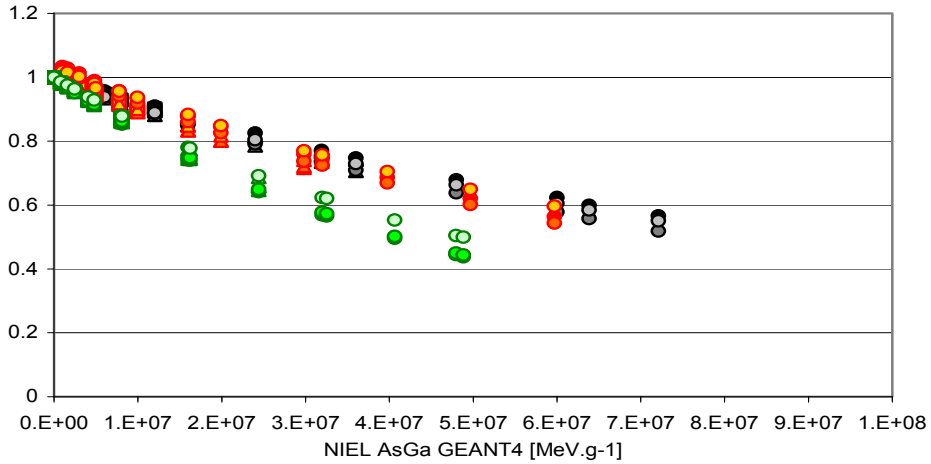
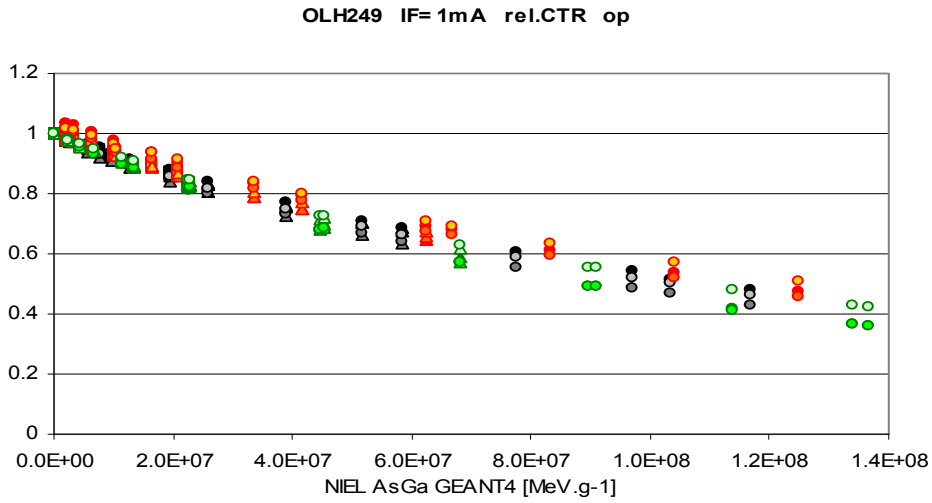
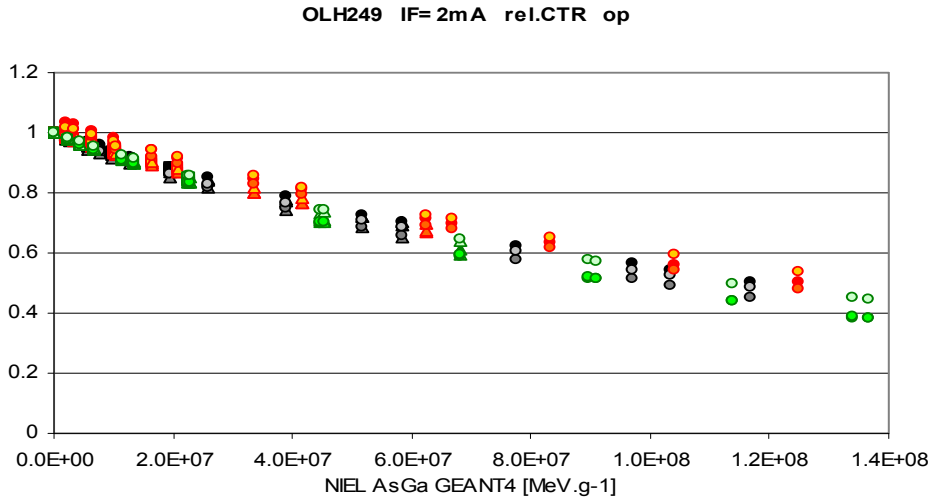
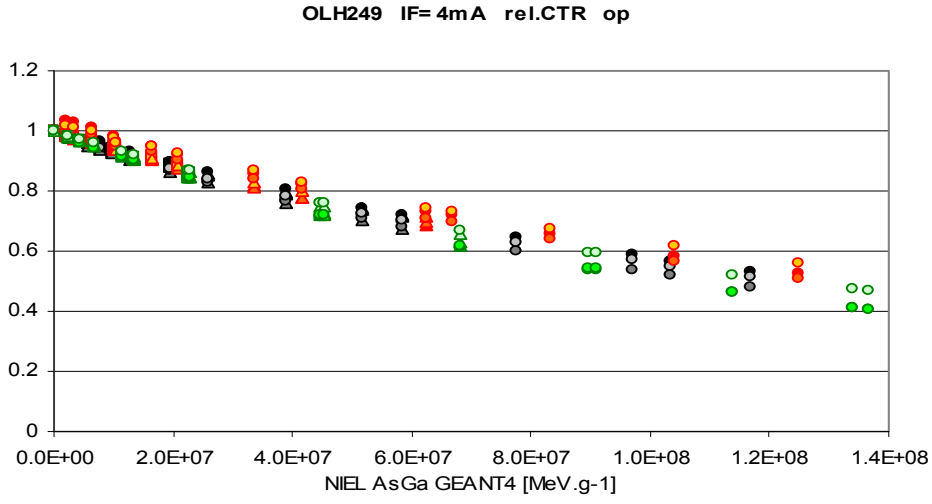
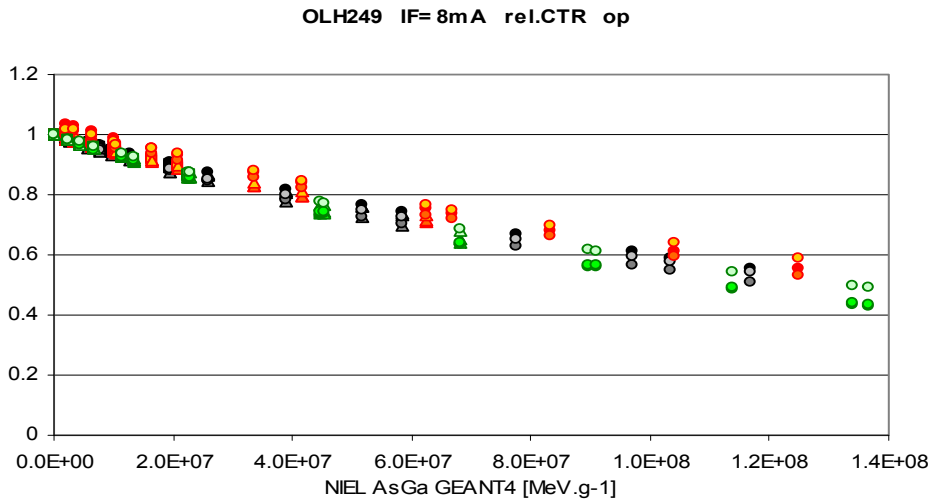


Fig. 13-16: OLH249 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)








OLH249 IF= 8mA rel.CTR op
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

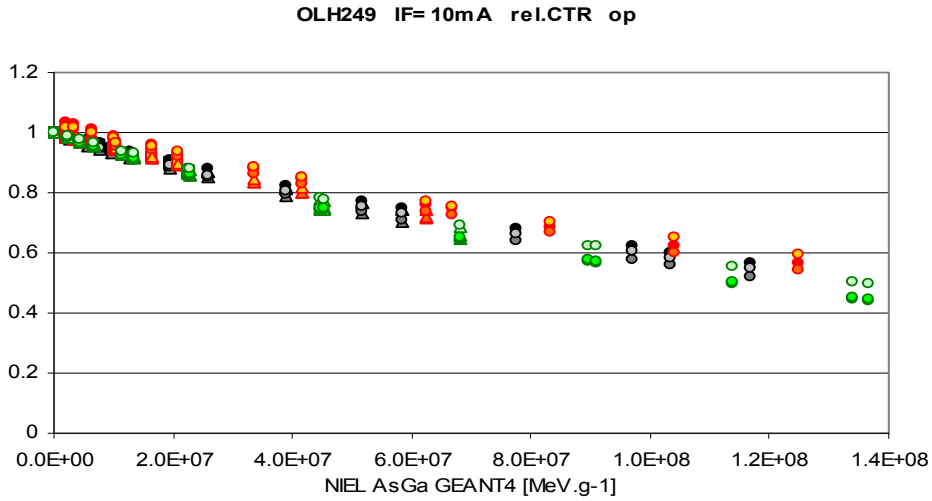
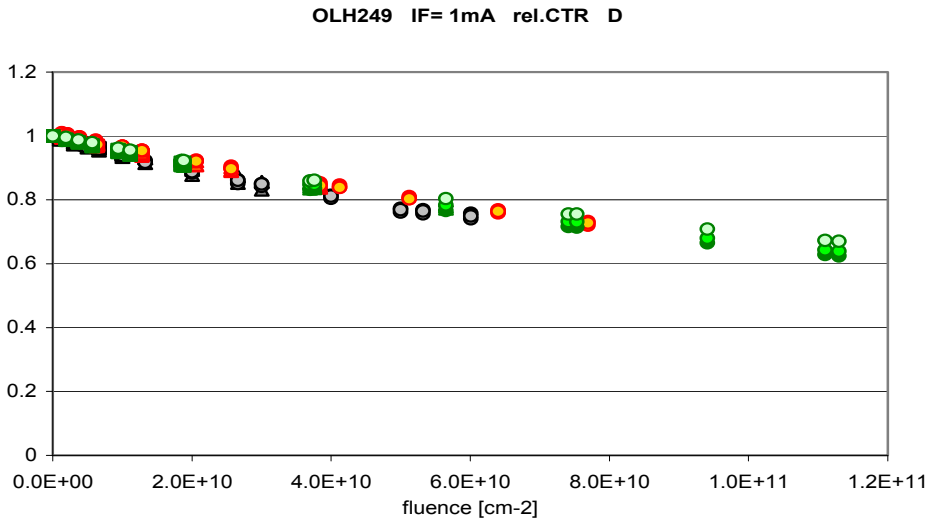
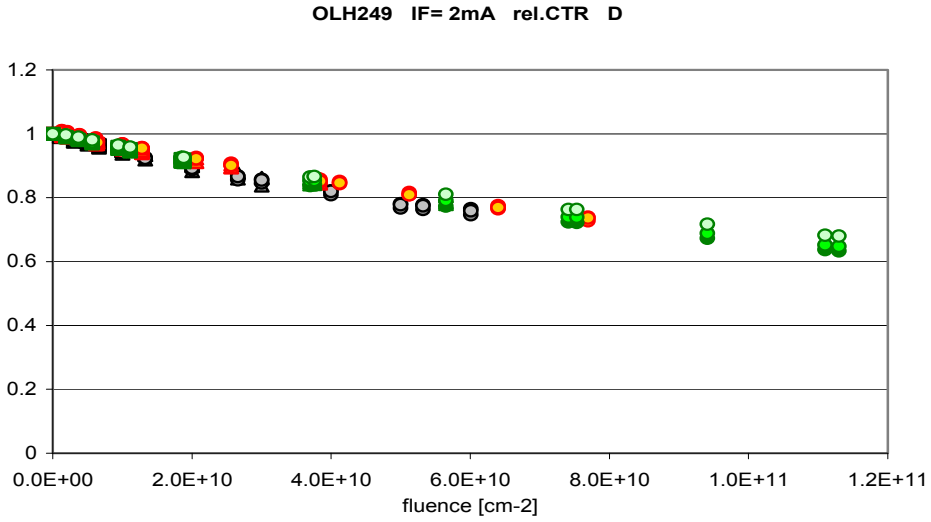
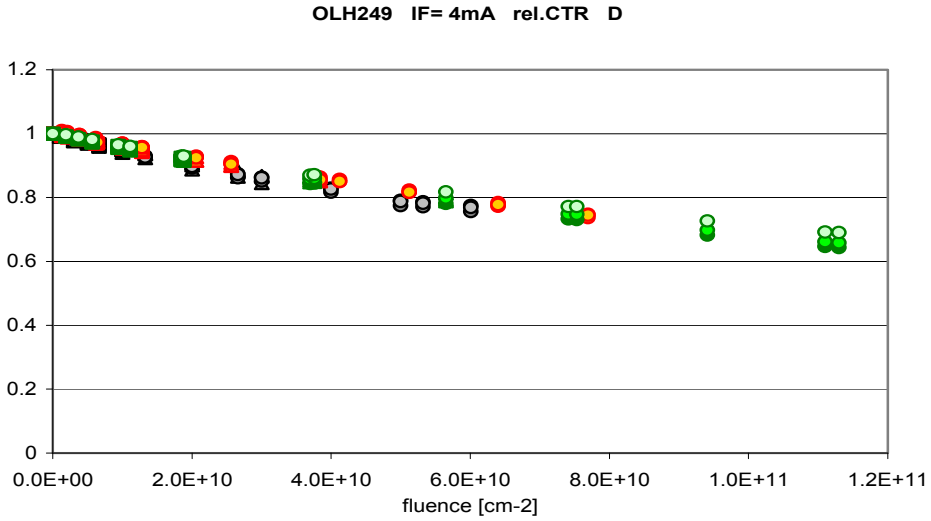

OLH249 IF= 10mA rel.CTR op
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

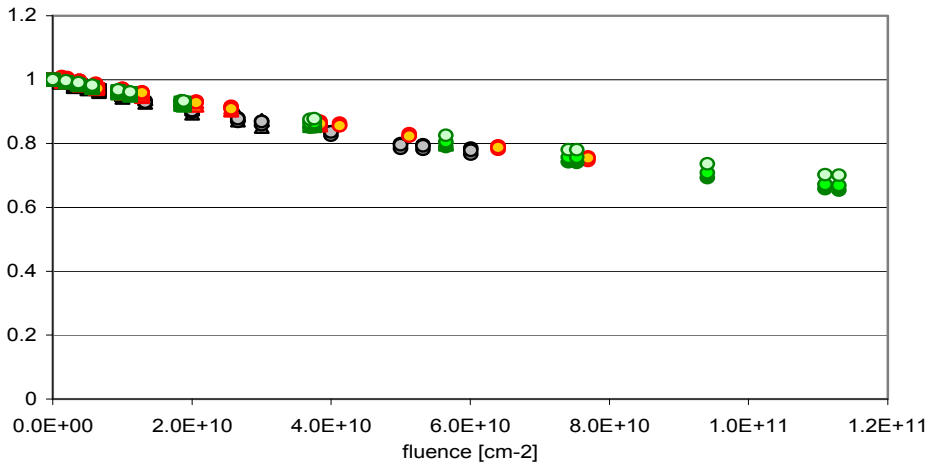
Fig. 13-17: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

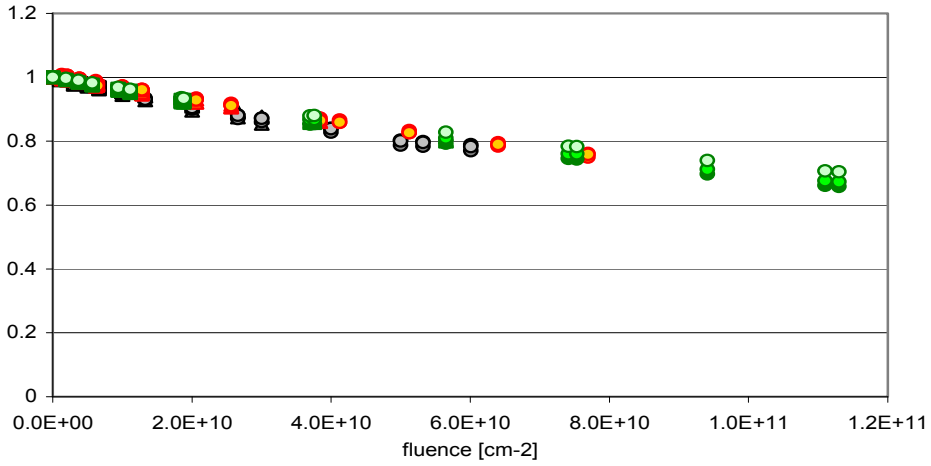
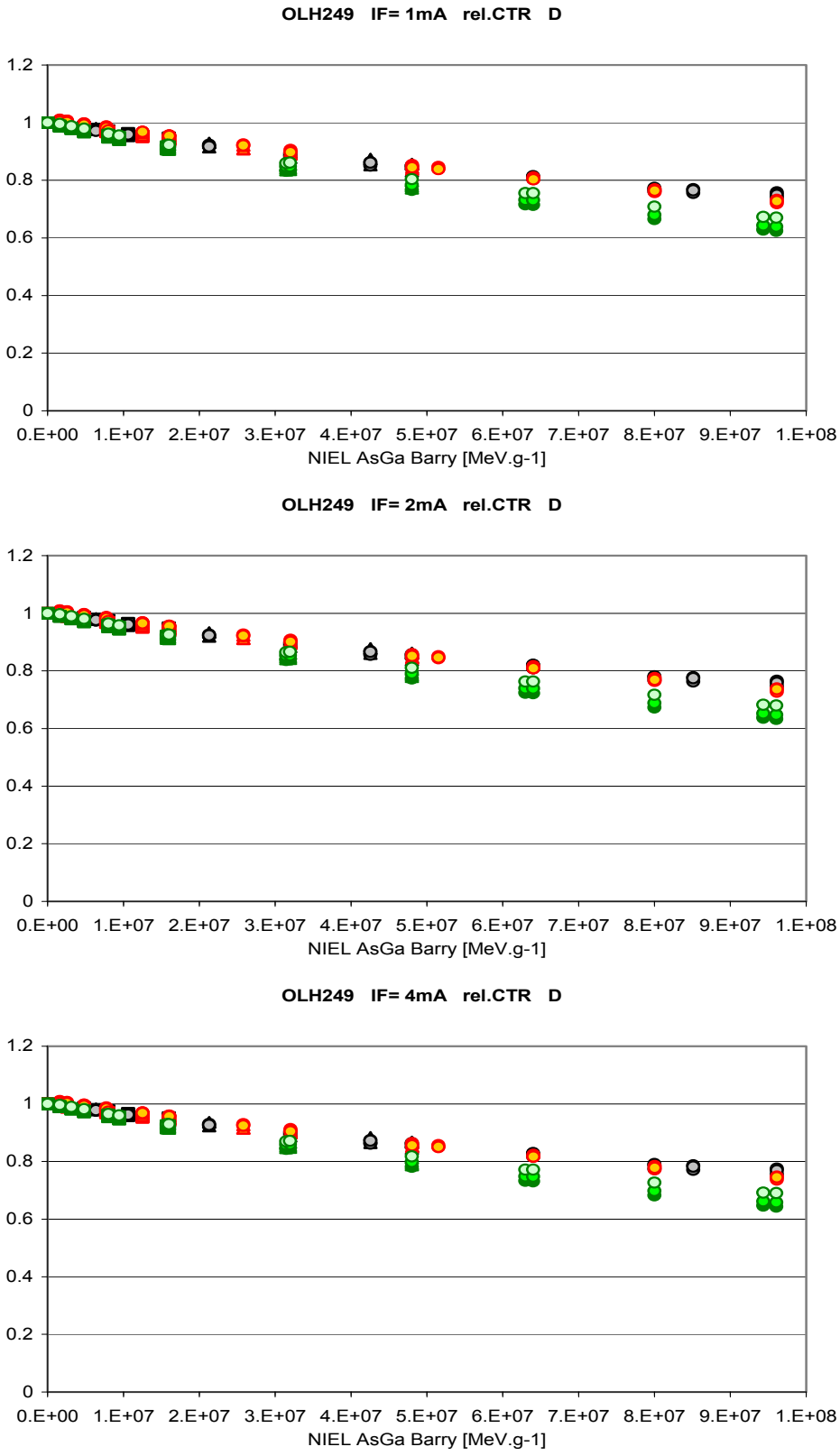
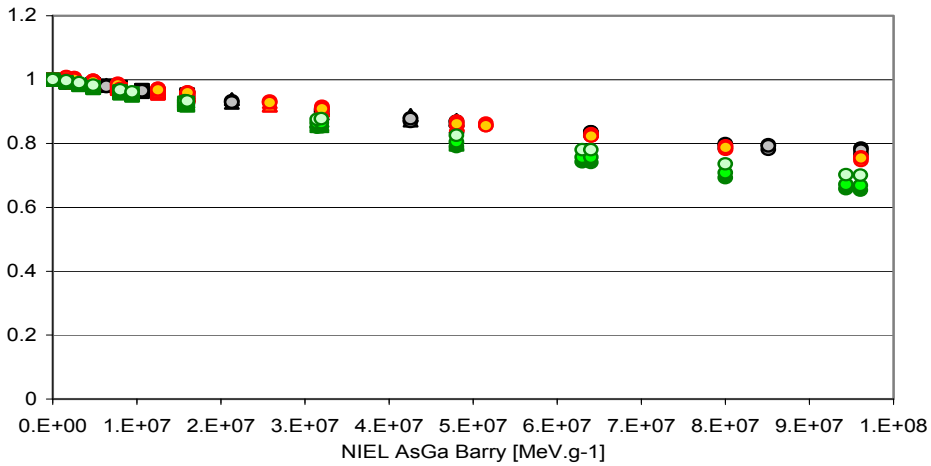


Fig. 13-18: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

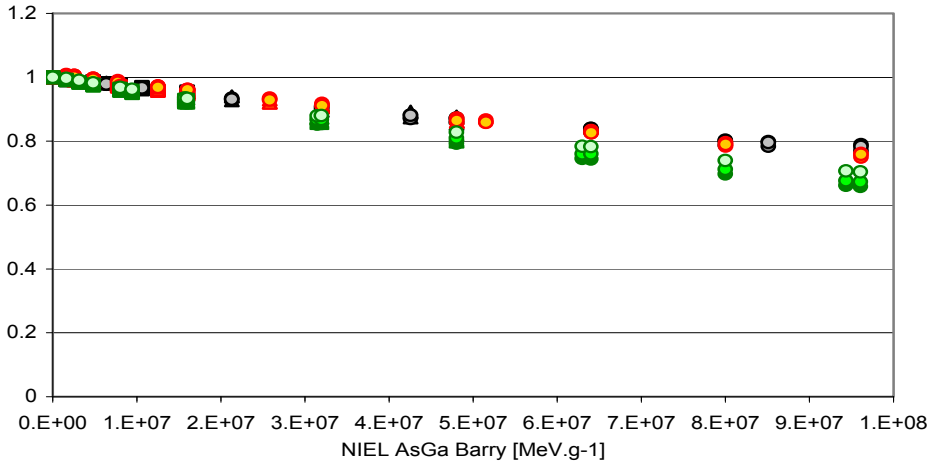
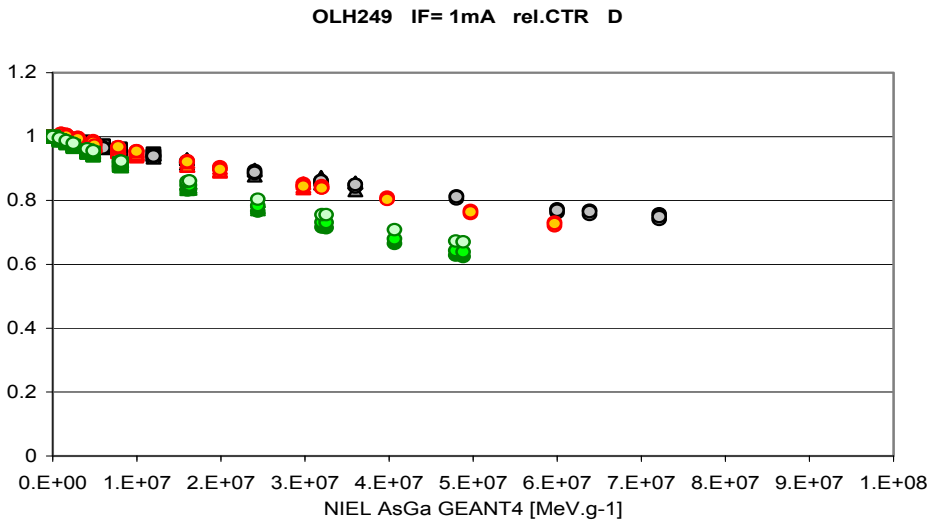
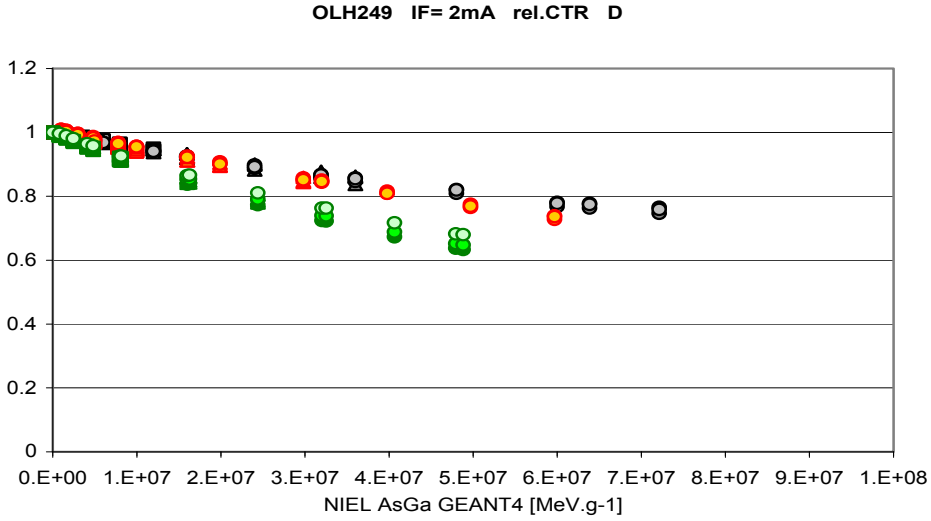
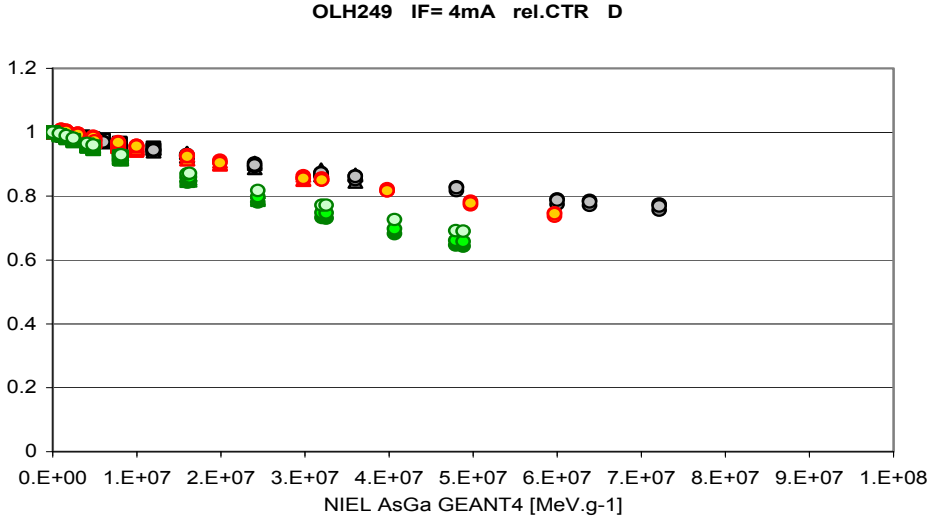


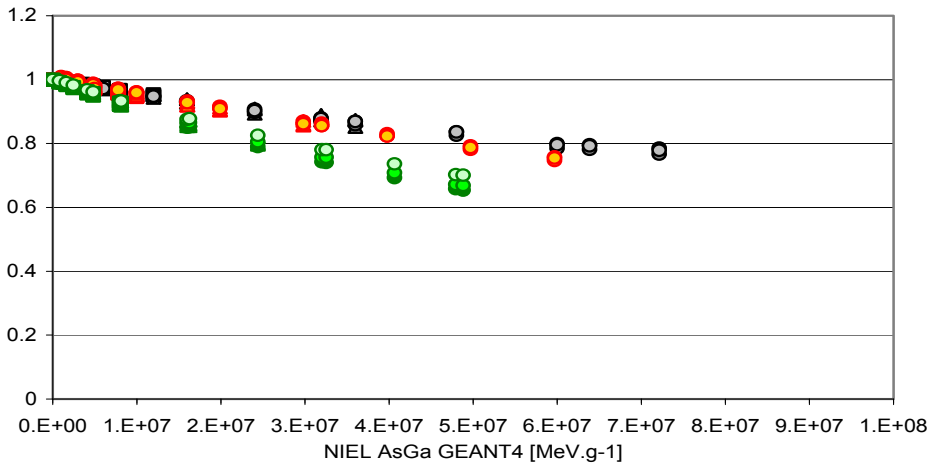
Fig. 13-19: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA rel.CTR D



OLH249 IF= 10mA rel.CTR D

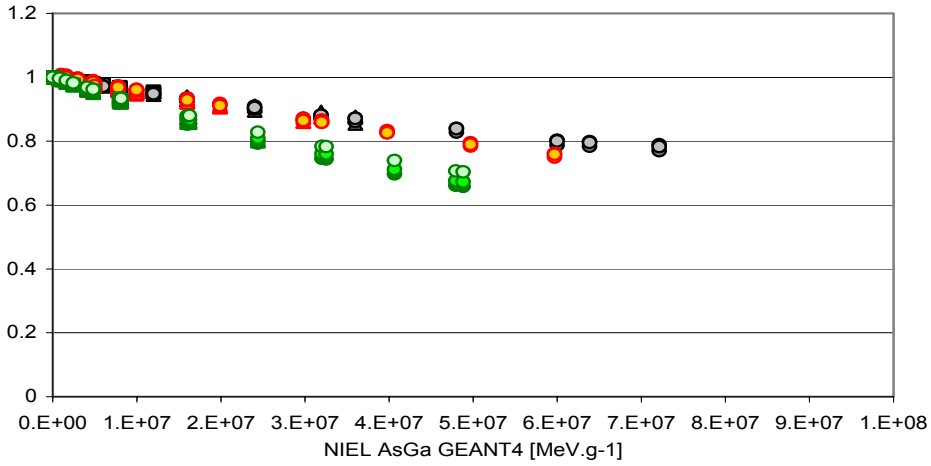
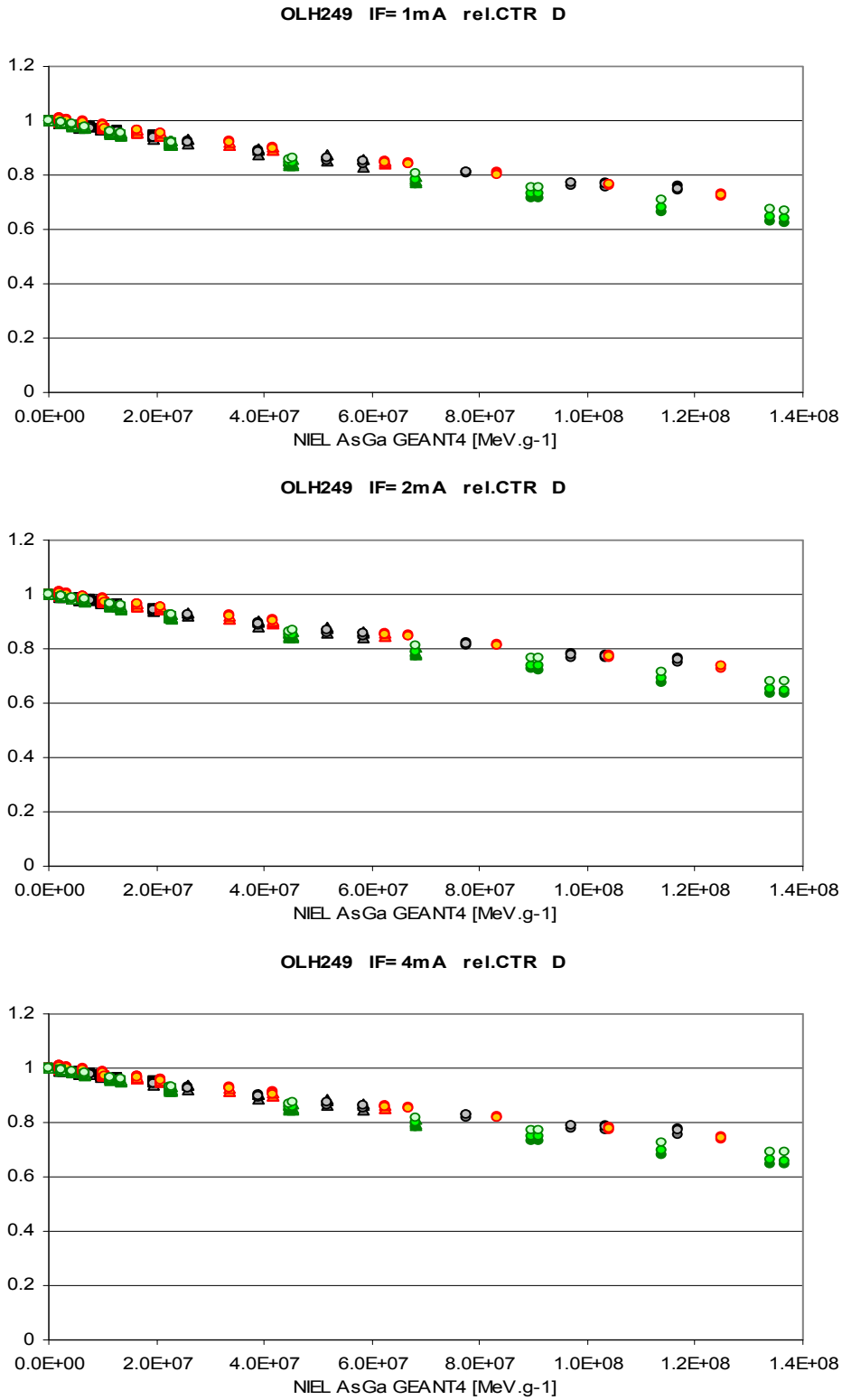
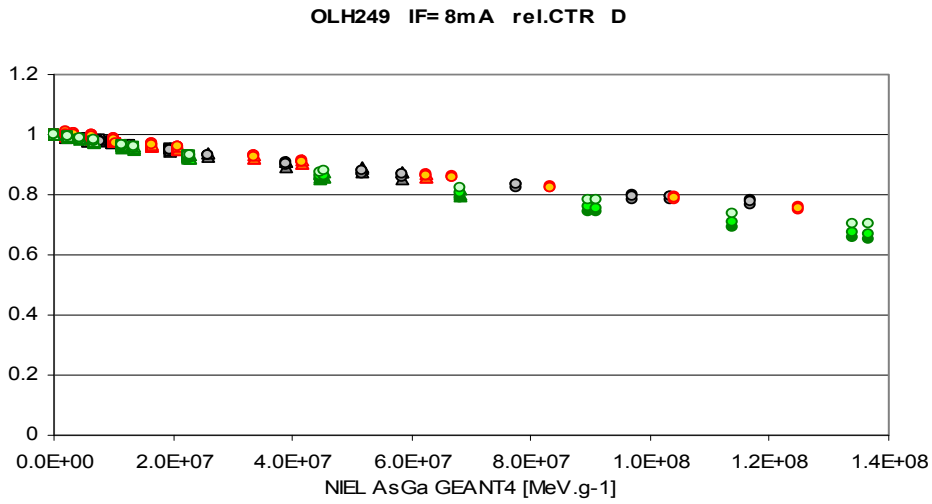


Fig. 13-20: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)




OLH249 IF= 8mA rel.CTR D
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

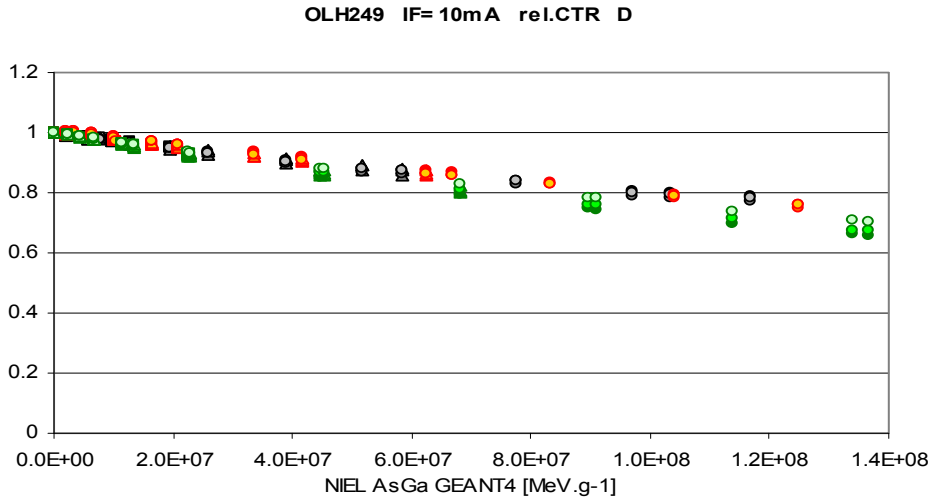
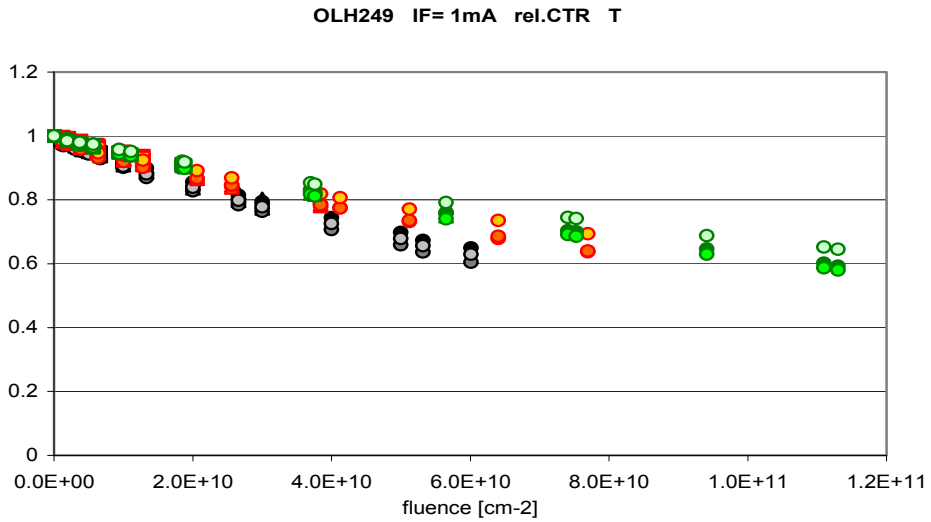
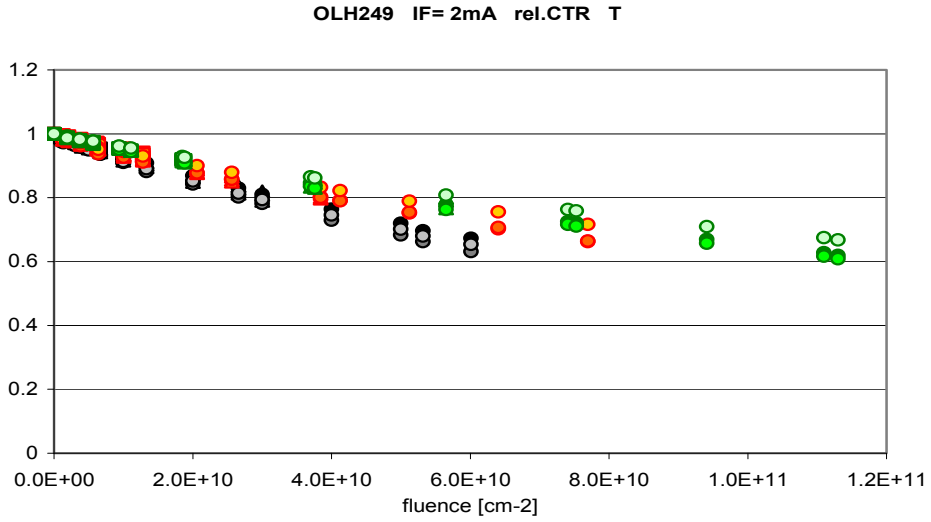
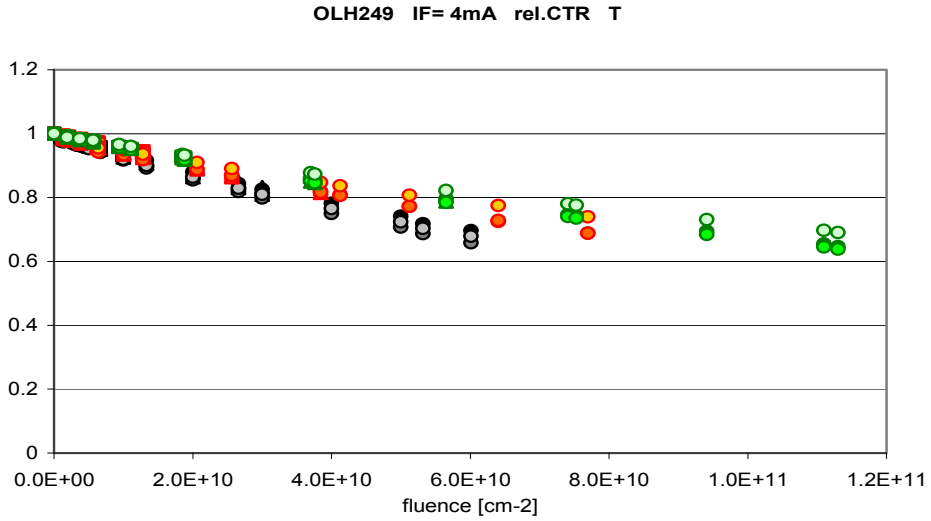

OLH249 IF= 10mA rel.CTR D
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

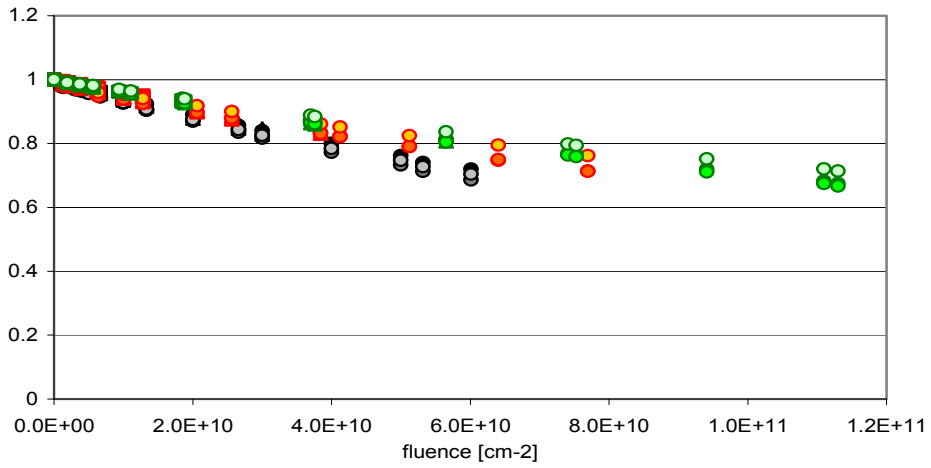
Fig. 13-21: OLH249 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA rel.CTR T



OLH249 IF= 10mA rel.CTR T

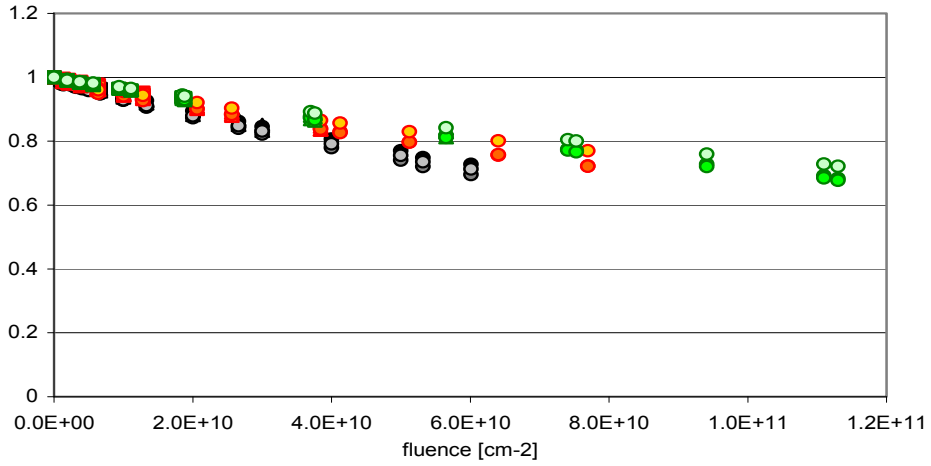
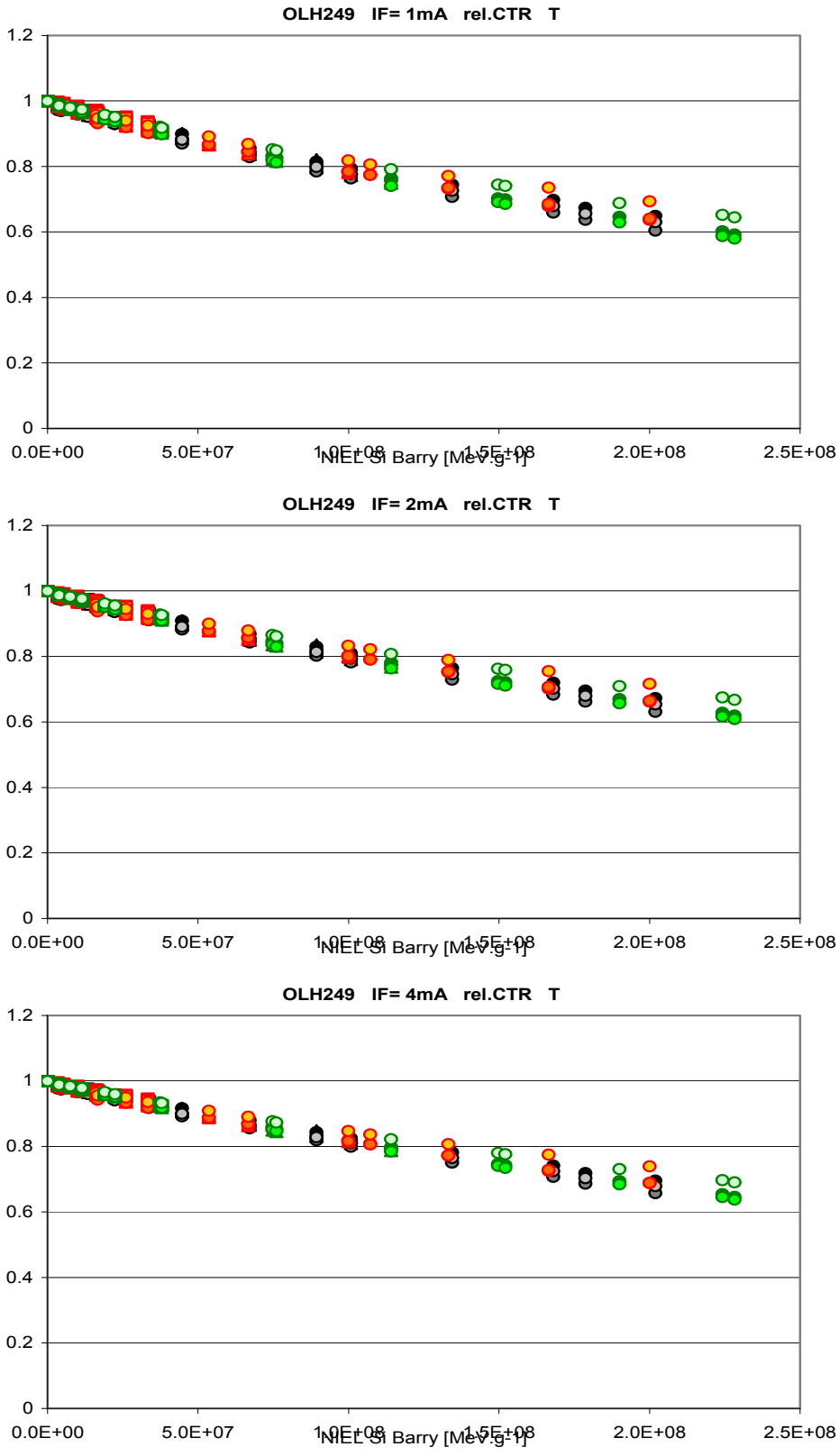
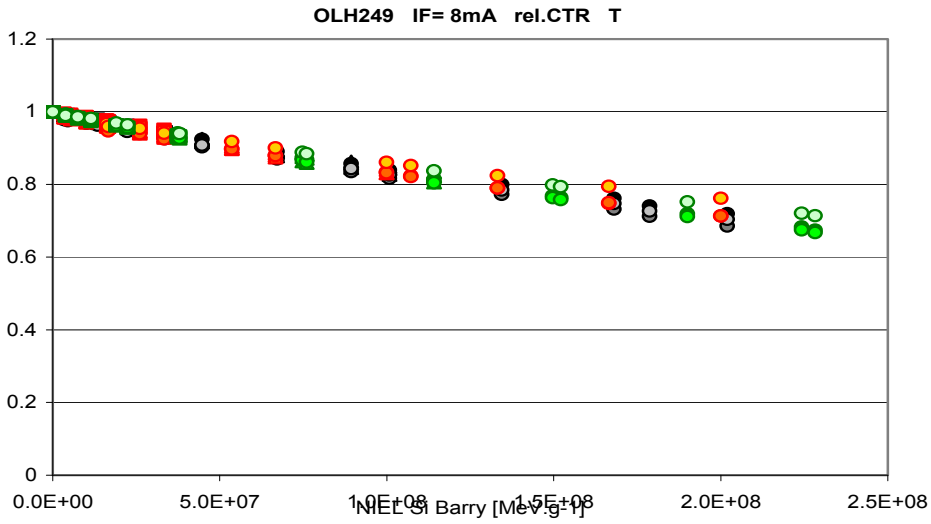


Fig. 13-22: OLH249 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)




OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

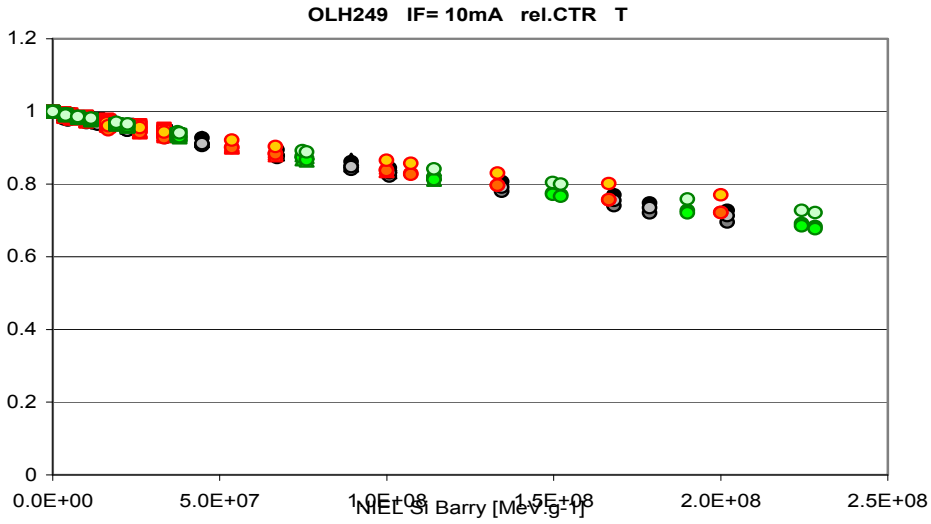
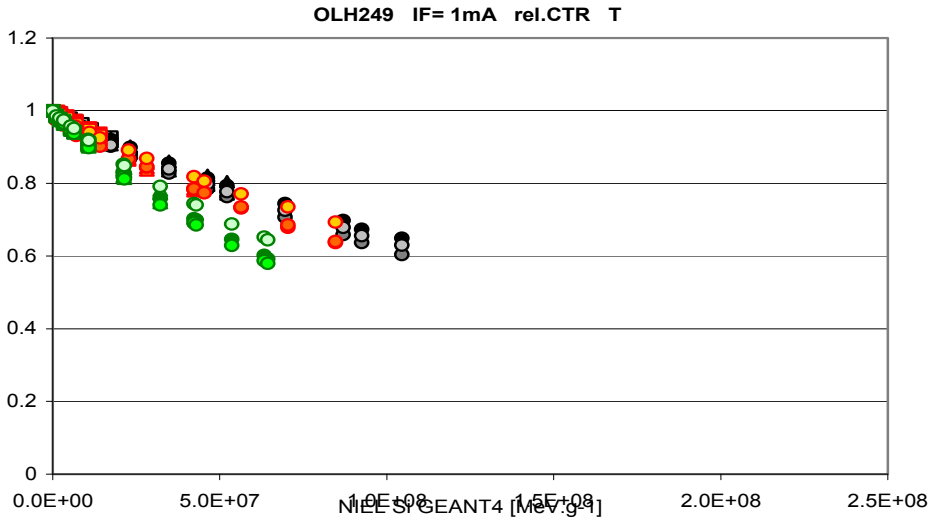
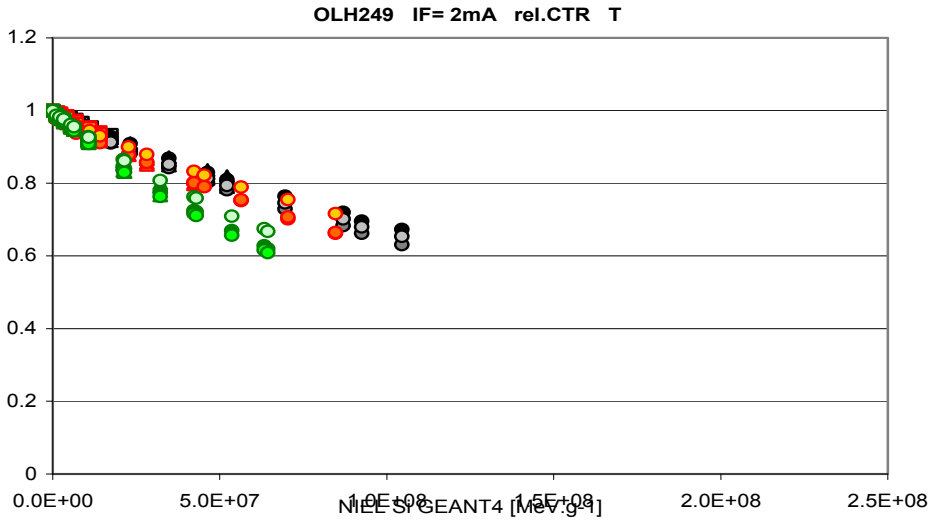
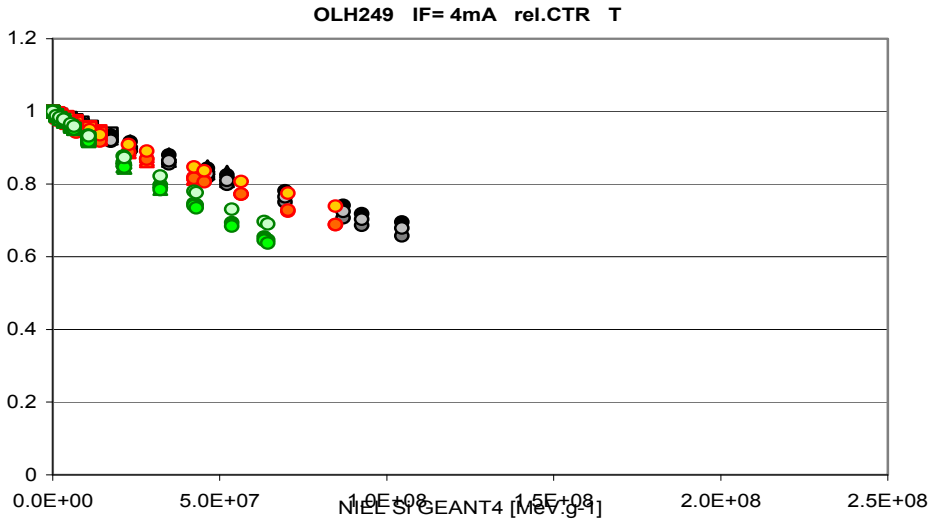
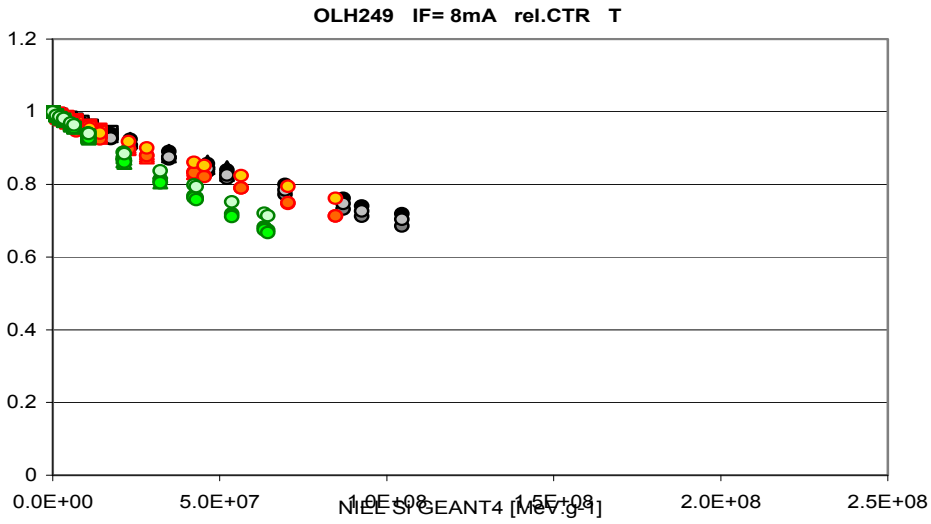

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 13-23: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)








OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

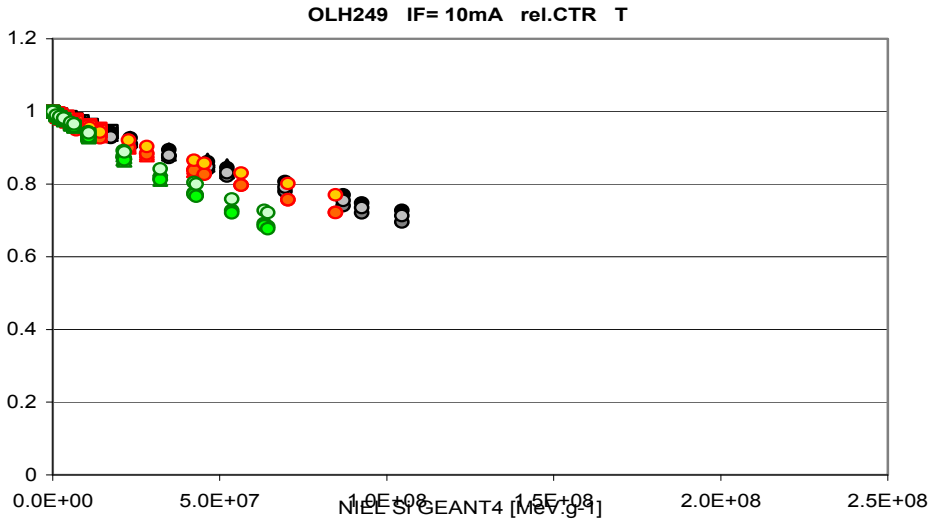
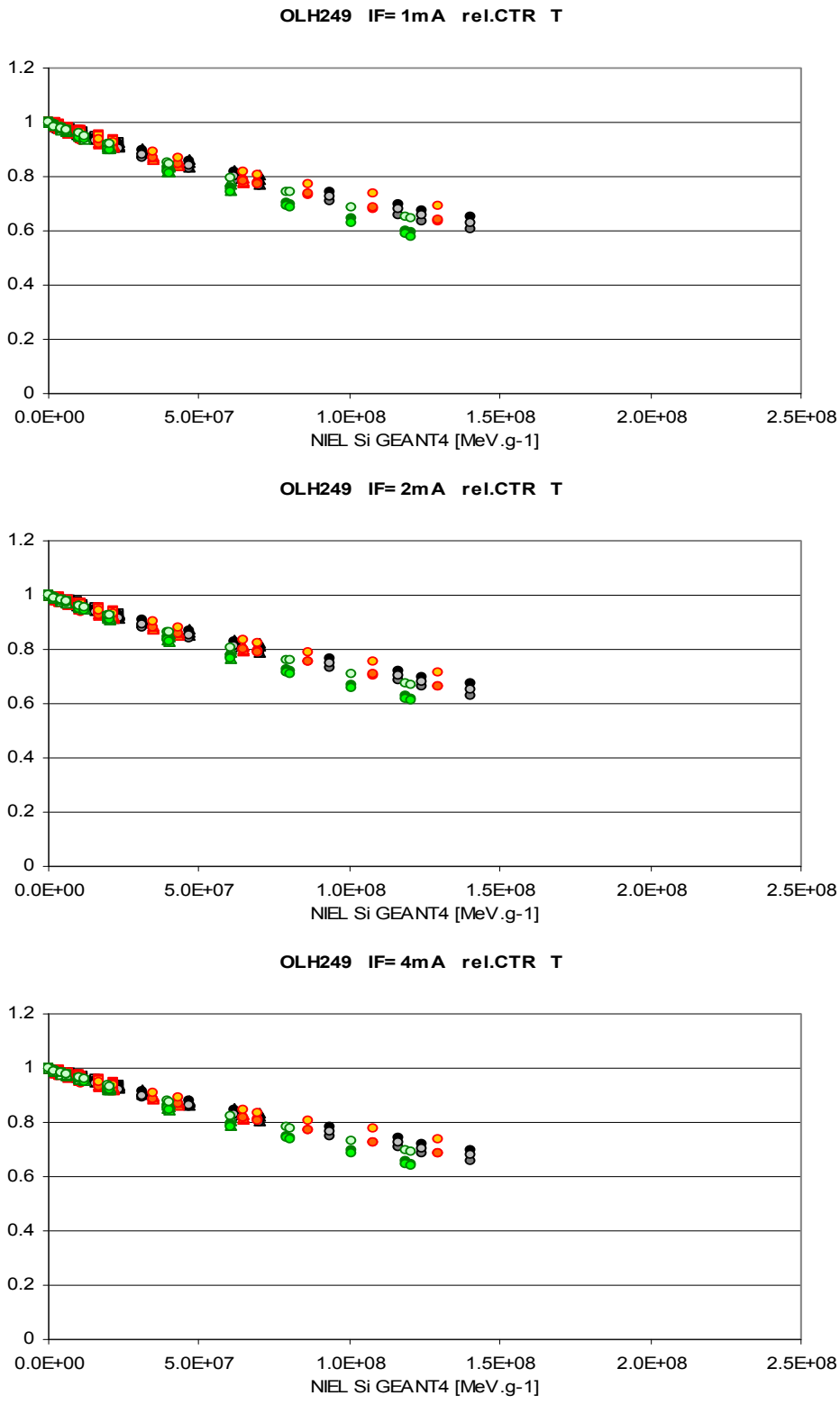
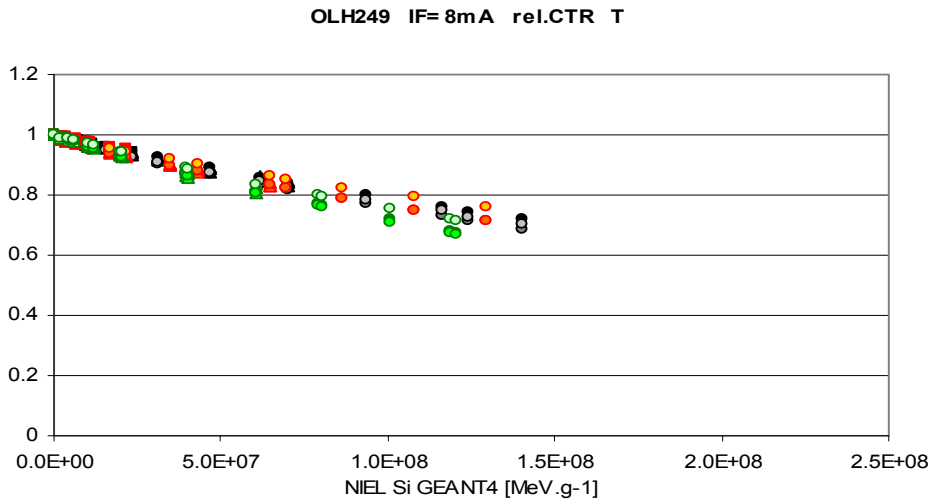

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-24: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




OLH249 IF= 8mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

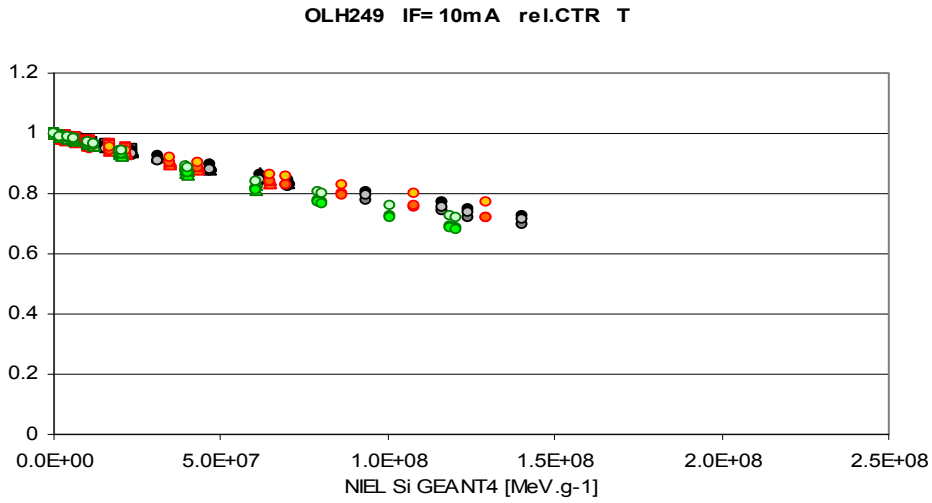
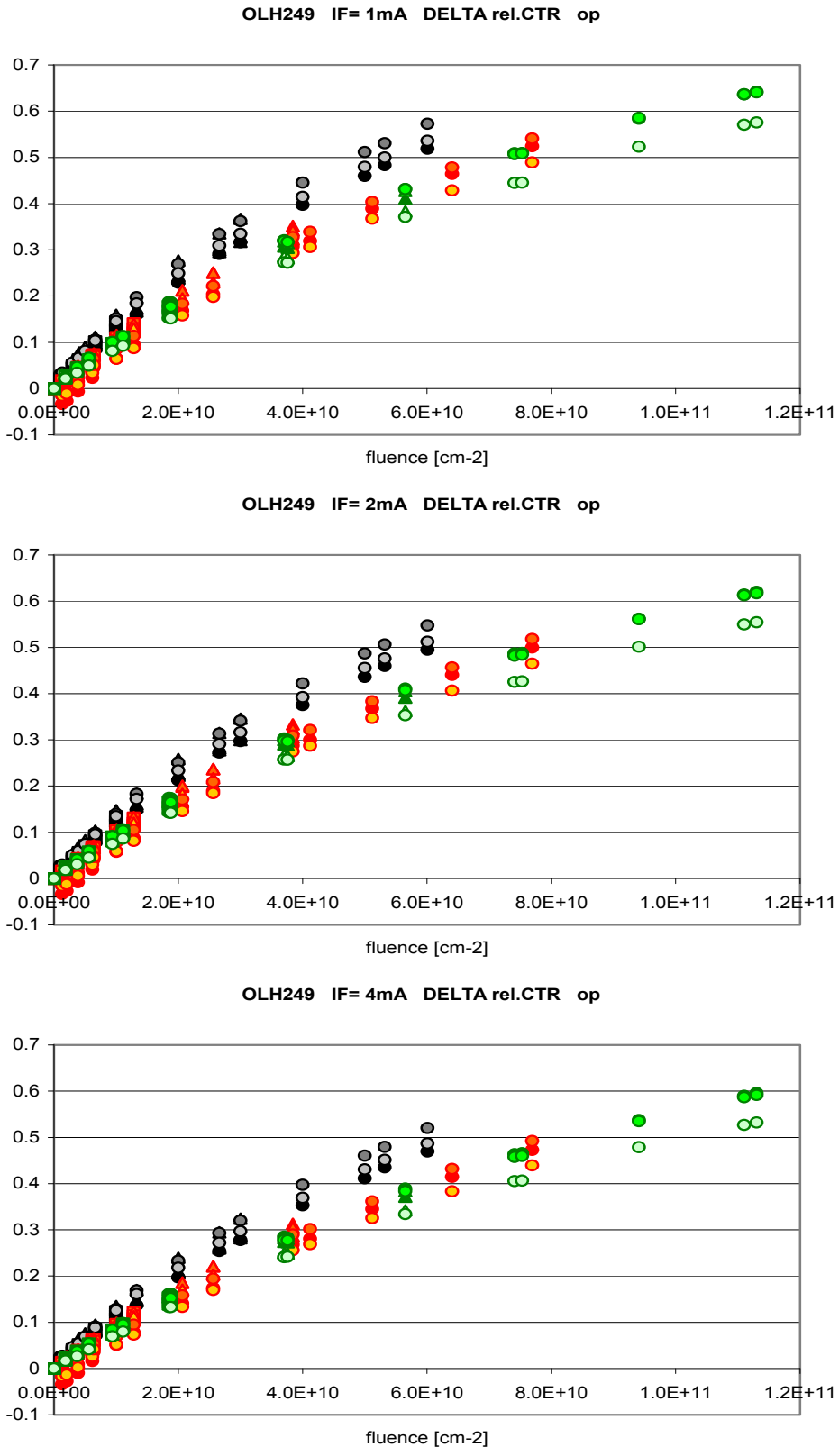
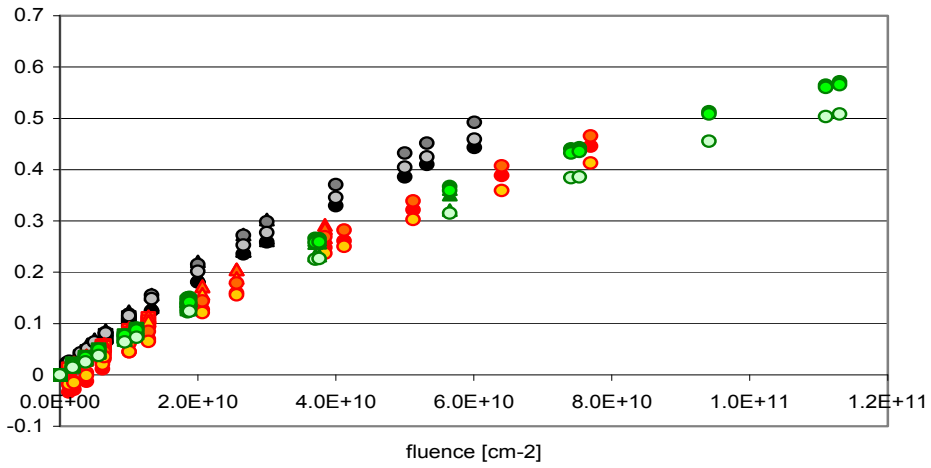

OLH249 IF= 10mA rel.CTR T
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-25: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

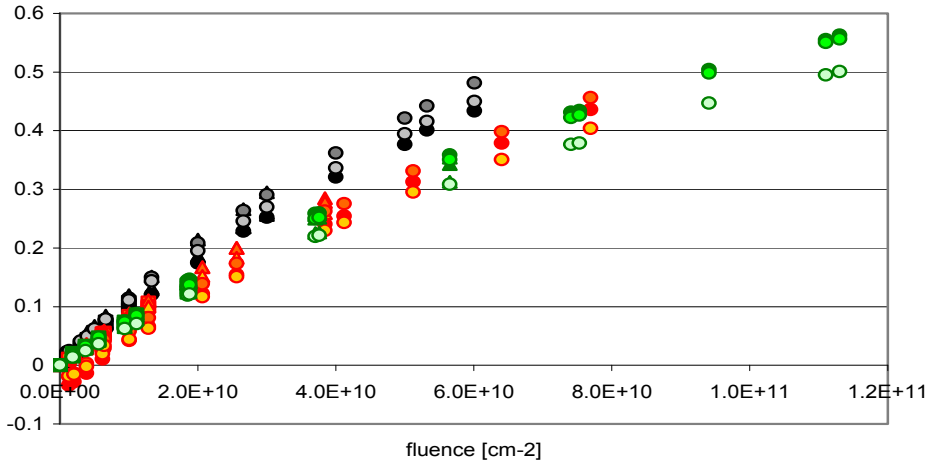
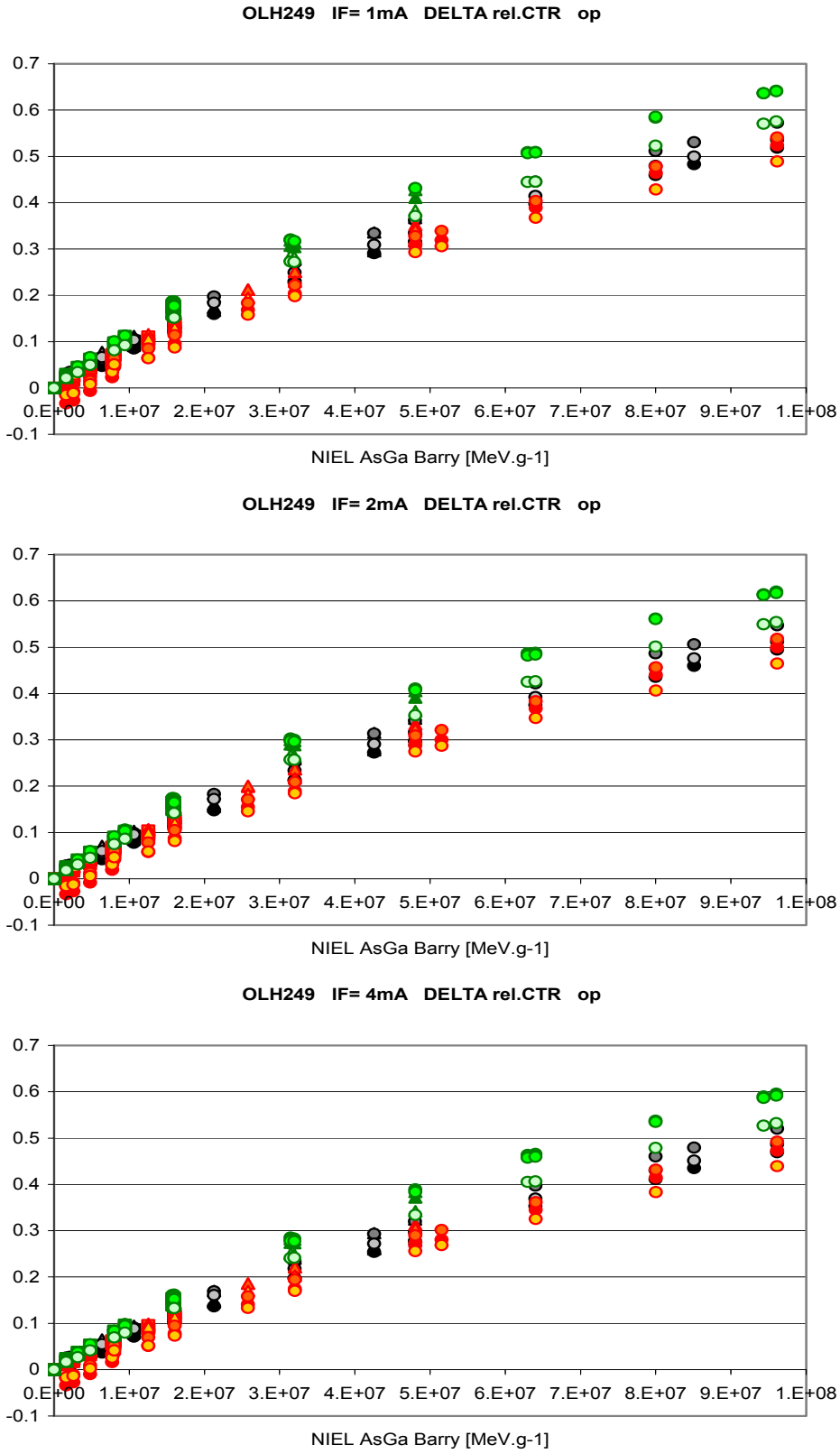
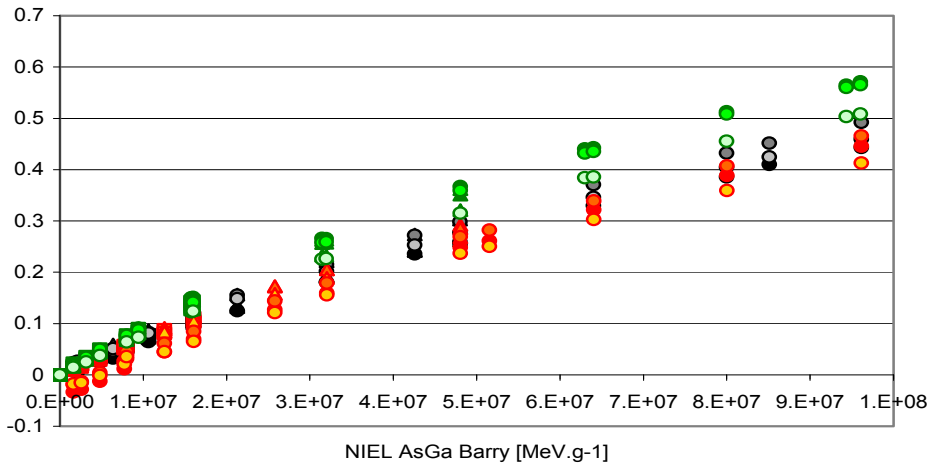


Fig. 13-26: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

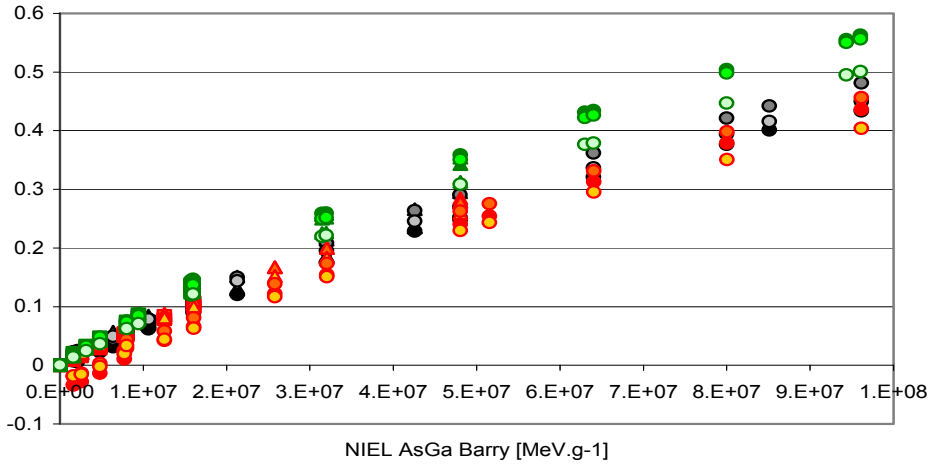
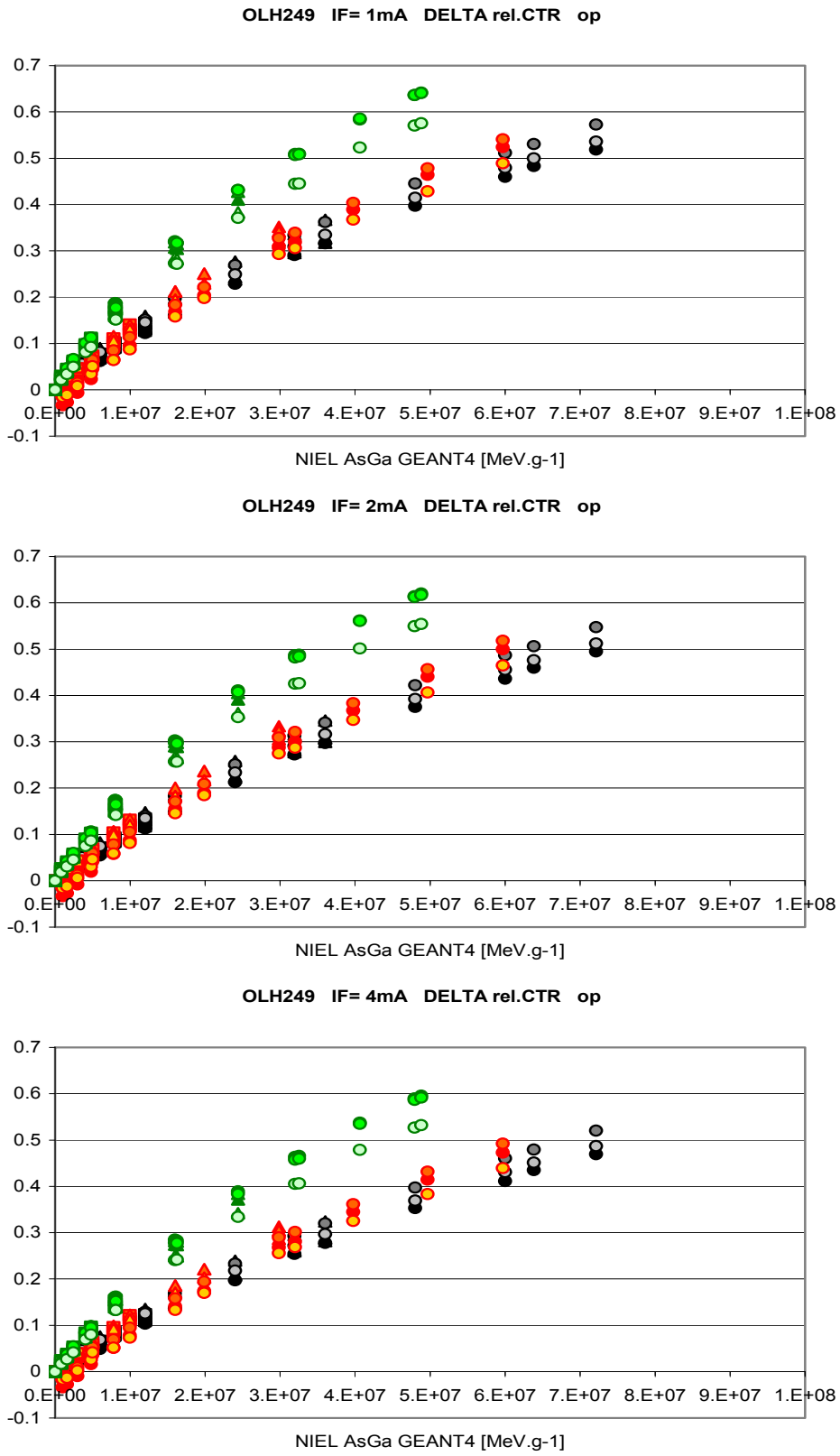
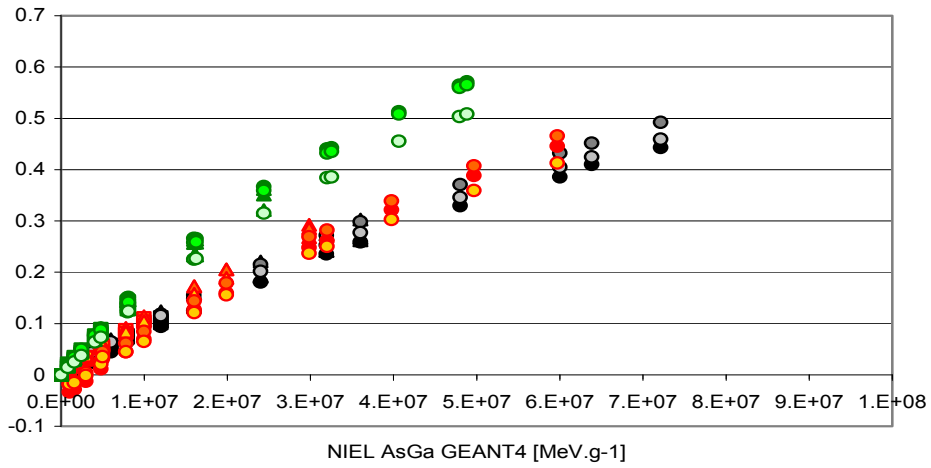


Fig. 13-27: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)



OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

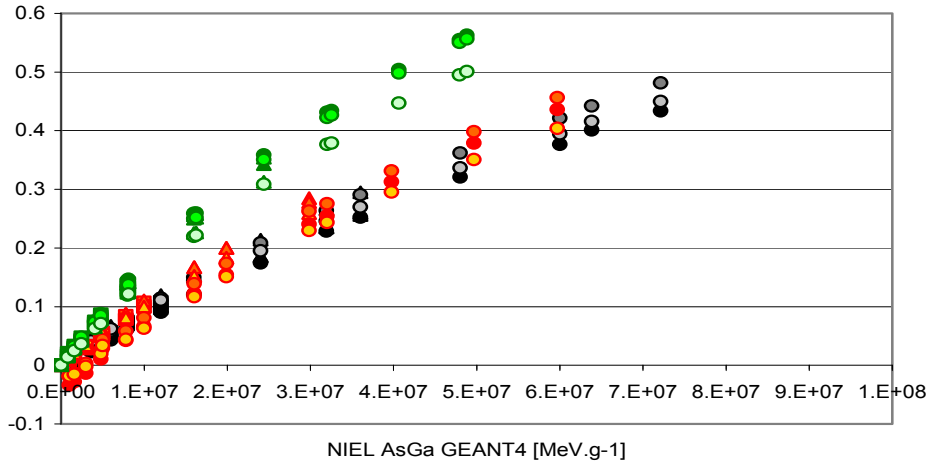
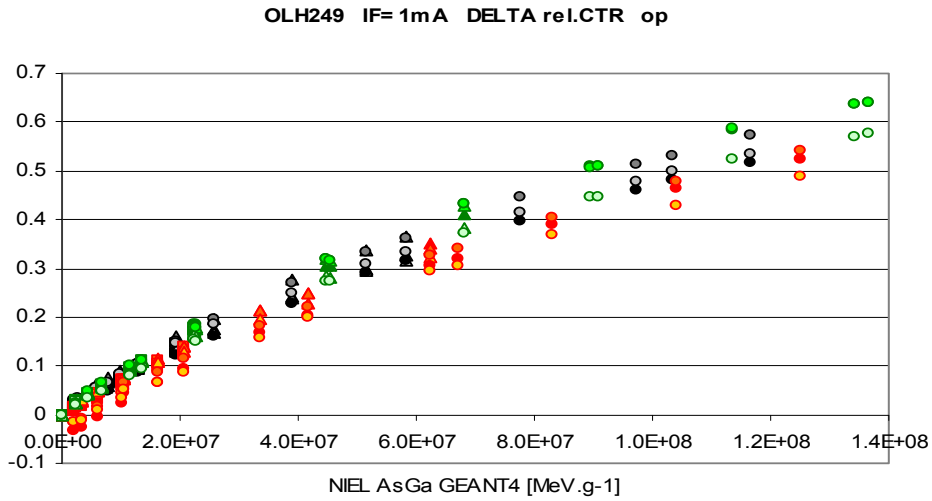
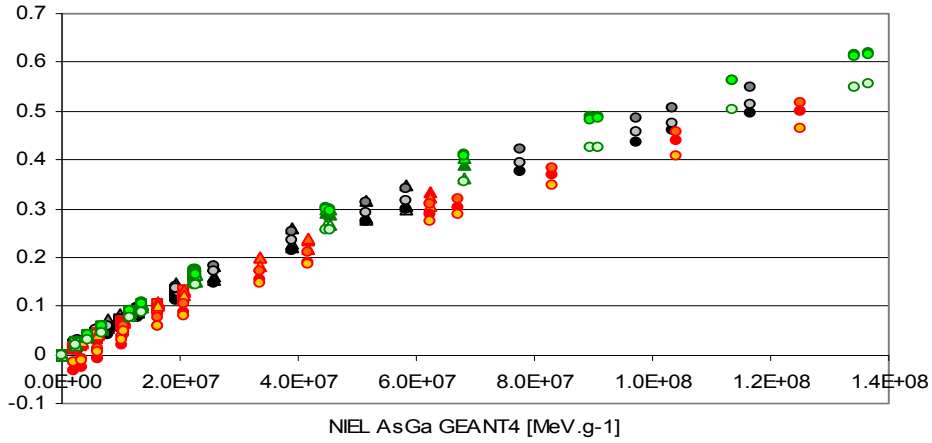
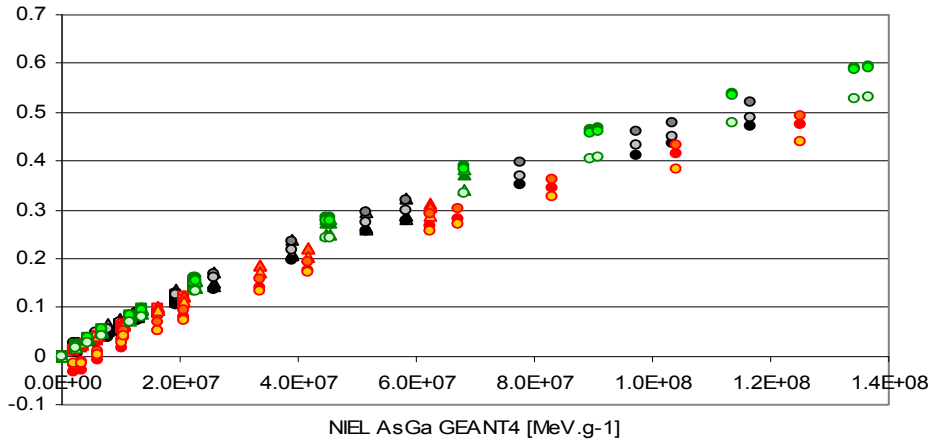


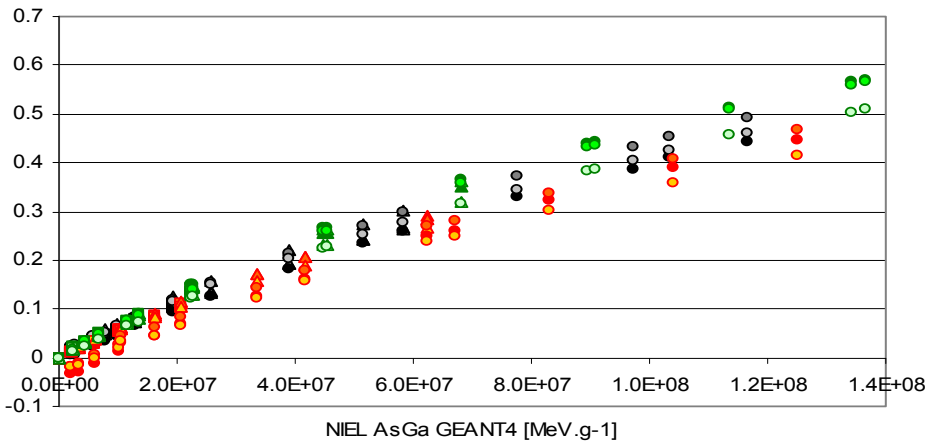
Fig. 13-28: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







OLH249 IF= 8mA DELTA rel.CTR op



OLH249 IF= 10mA DELTA rel.CTR op

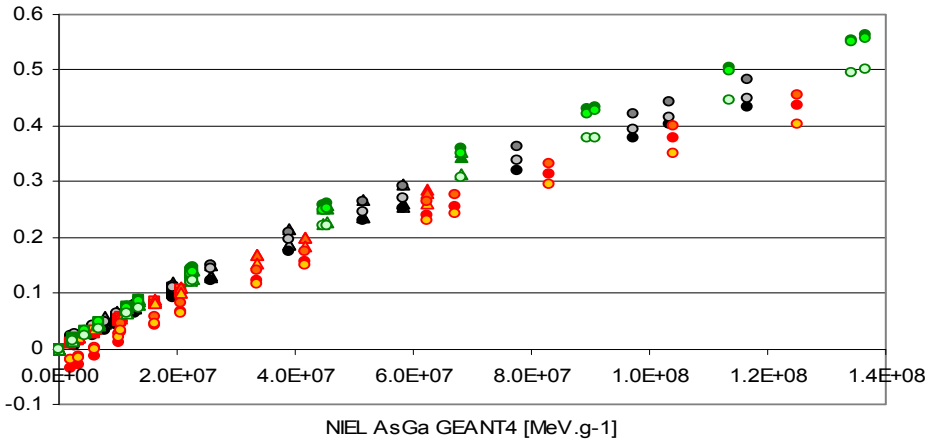
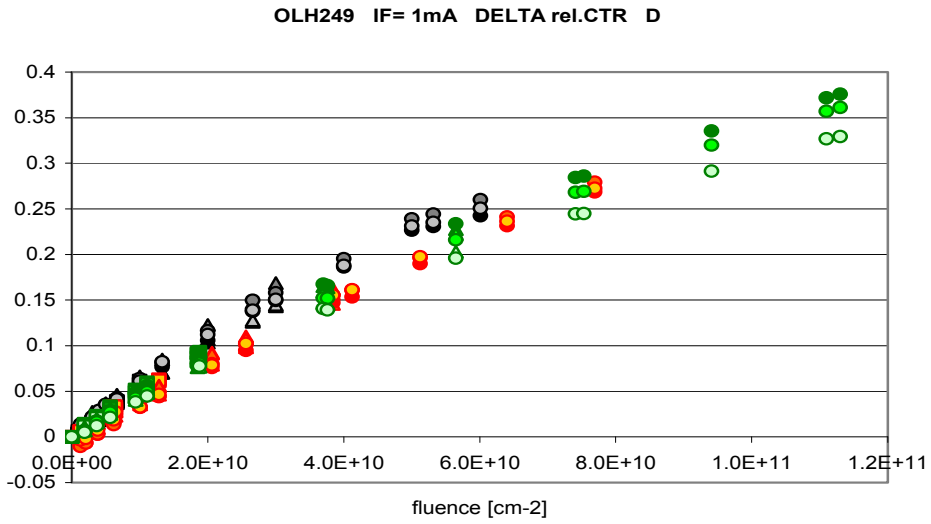
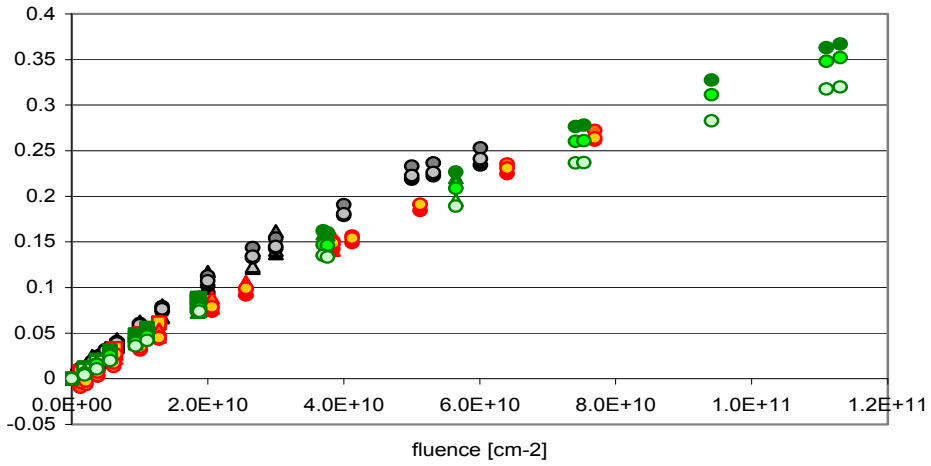
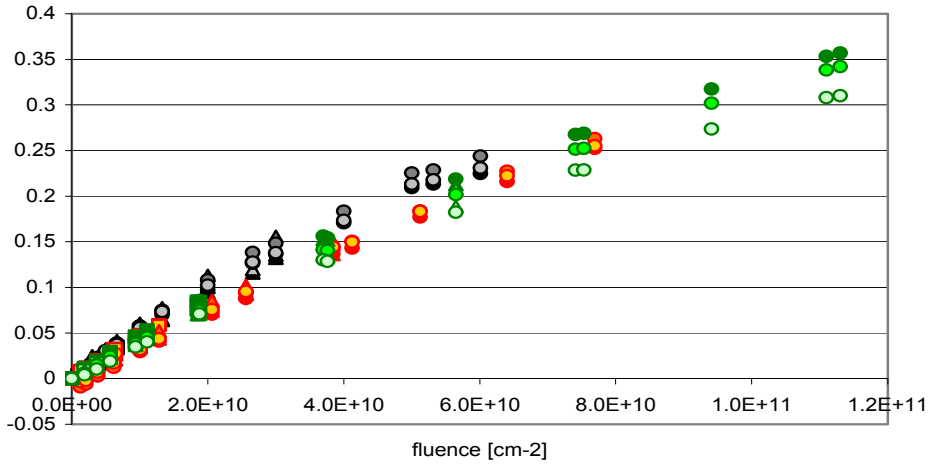


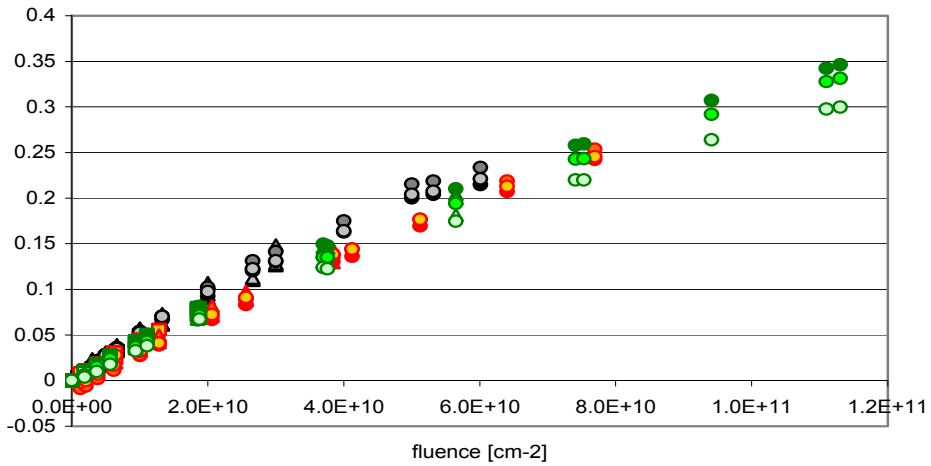
Fig. 13-29: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence







OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

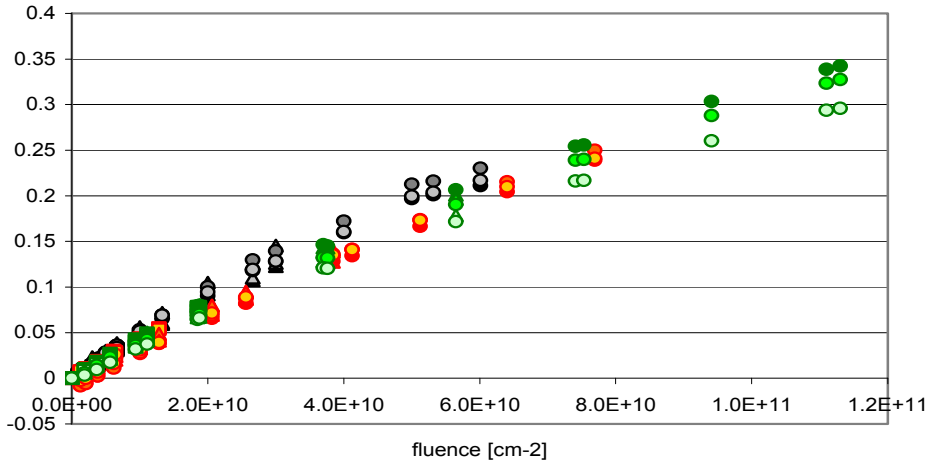
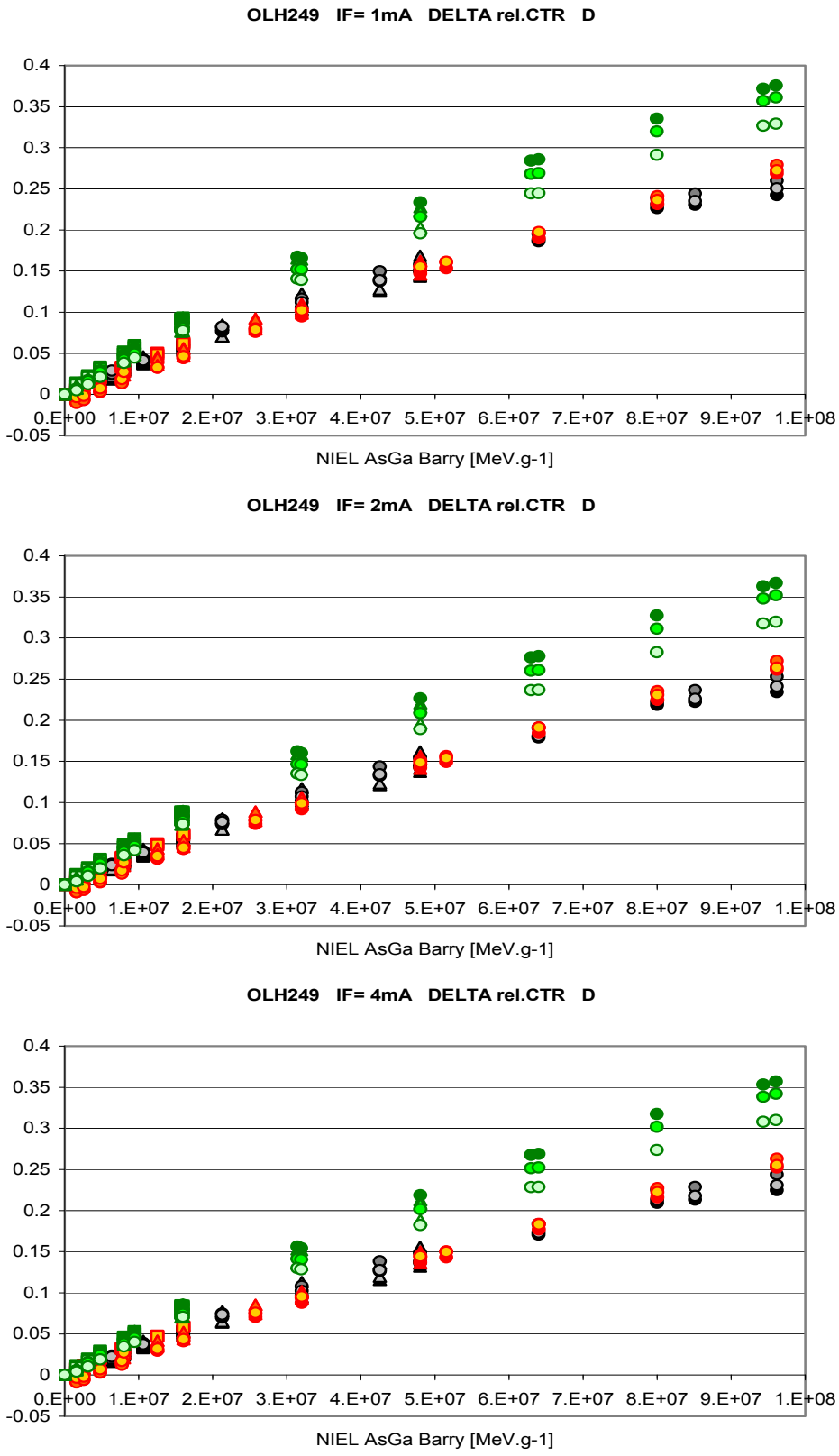
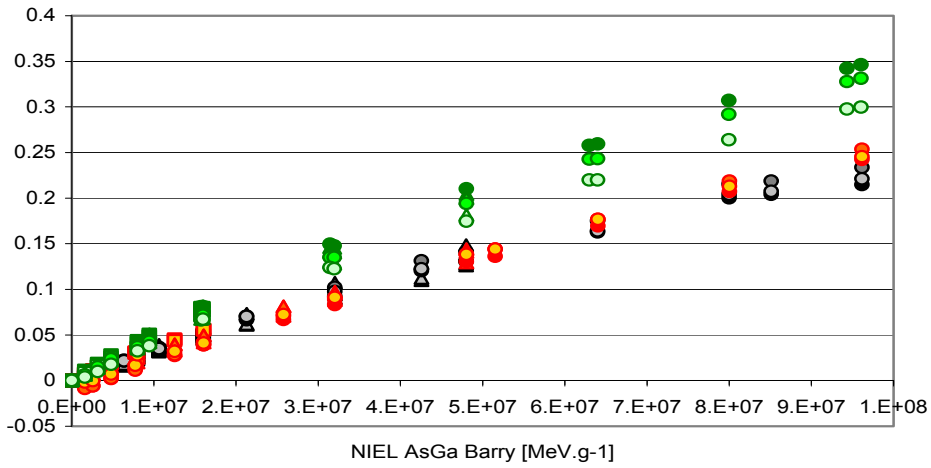


Fig. 13-30: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)



OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

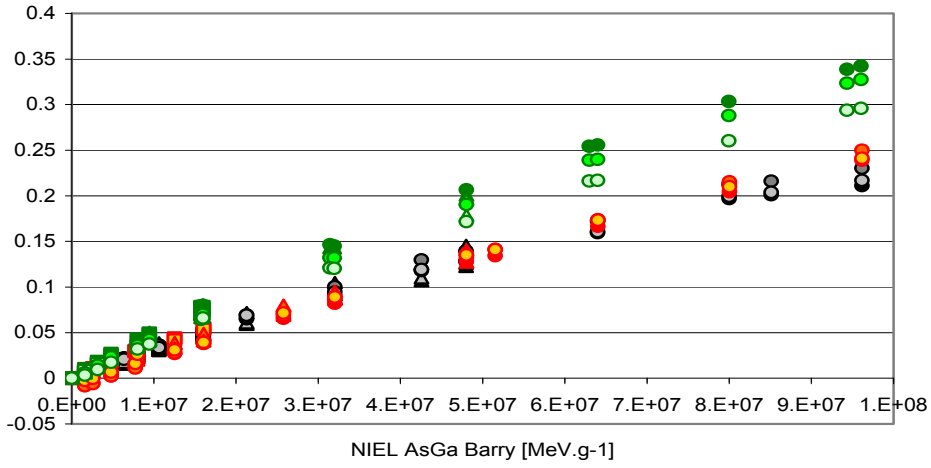
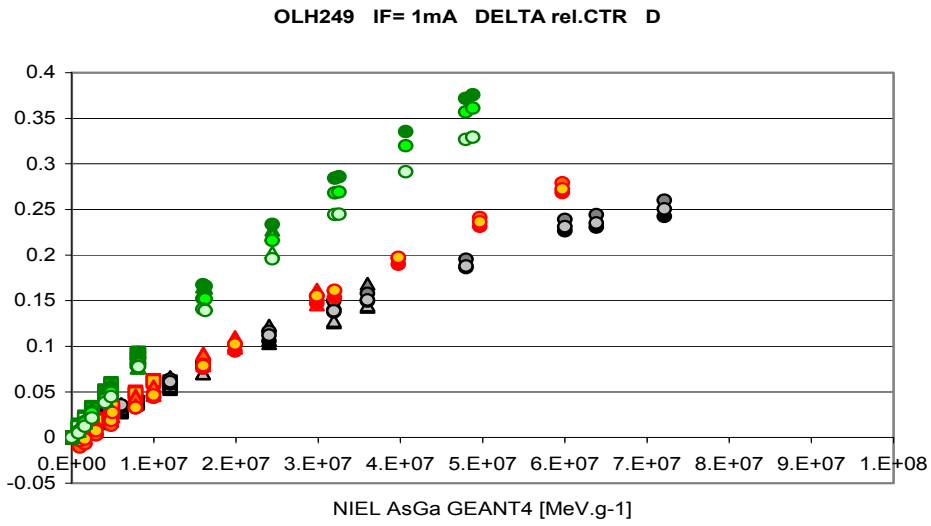
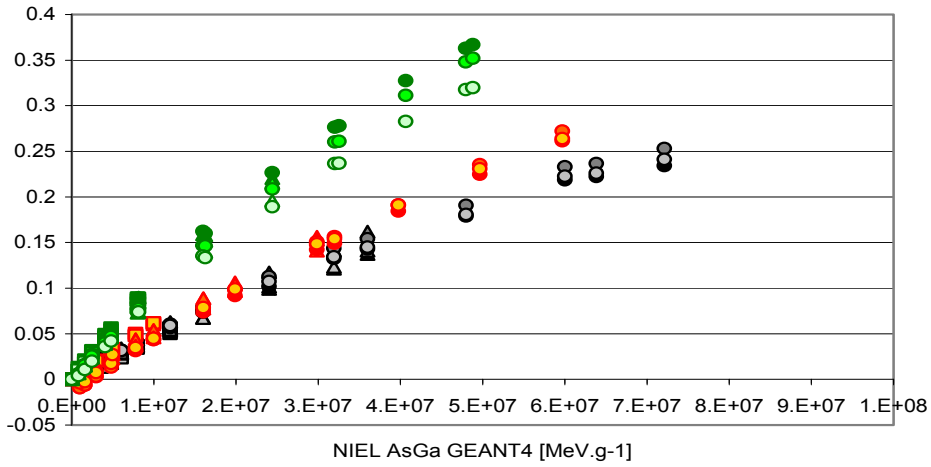
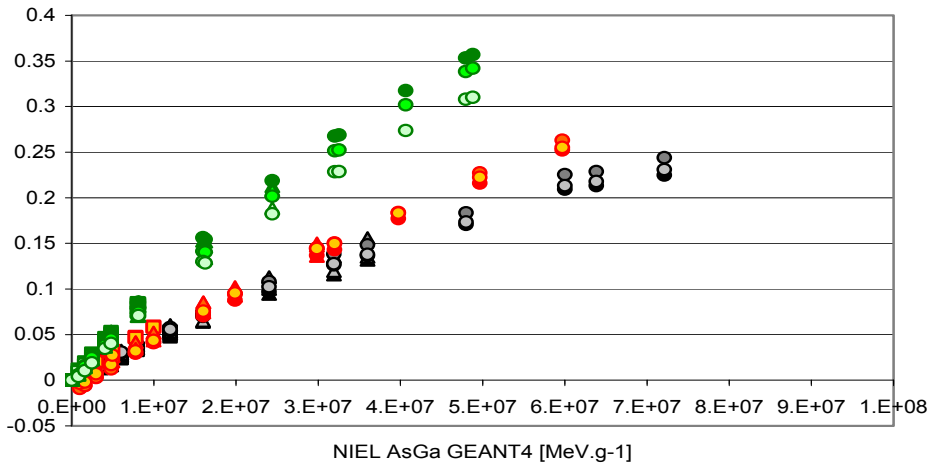


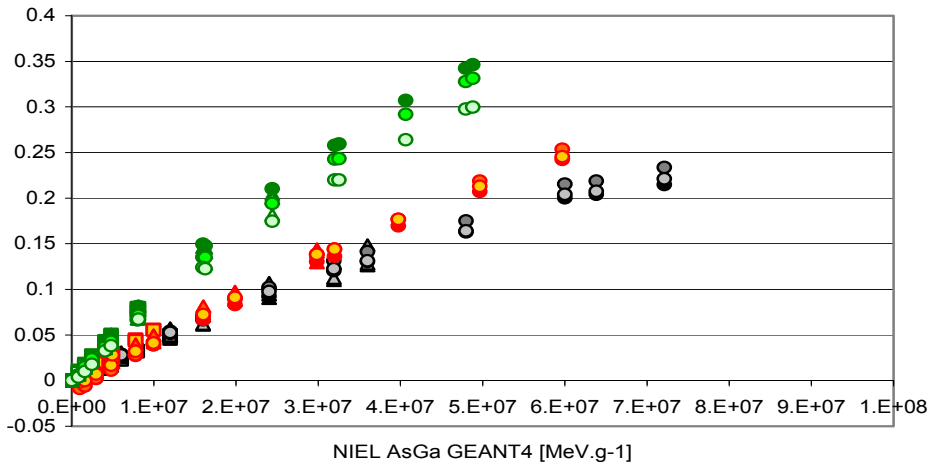
Fig. 13-31: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)







OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

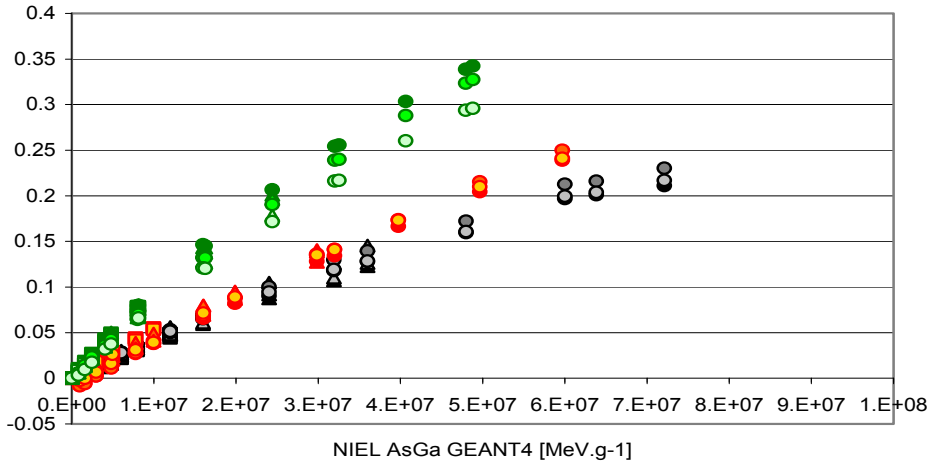
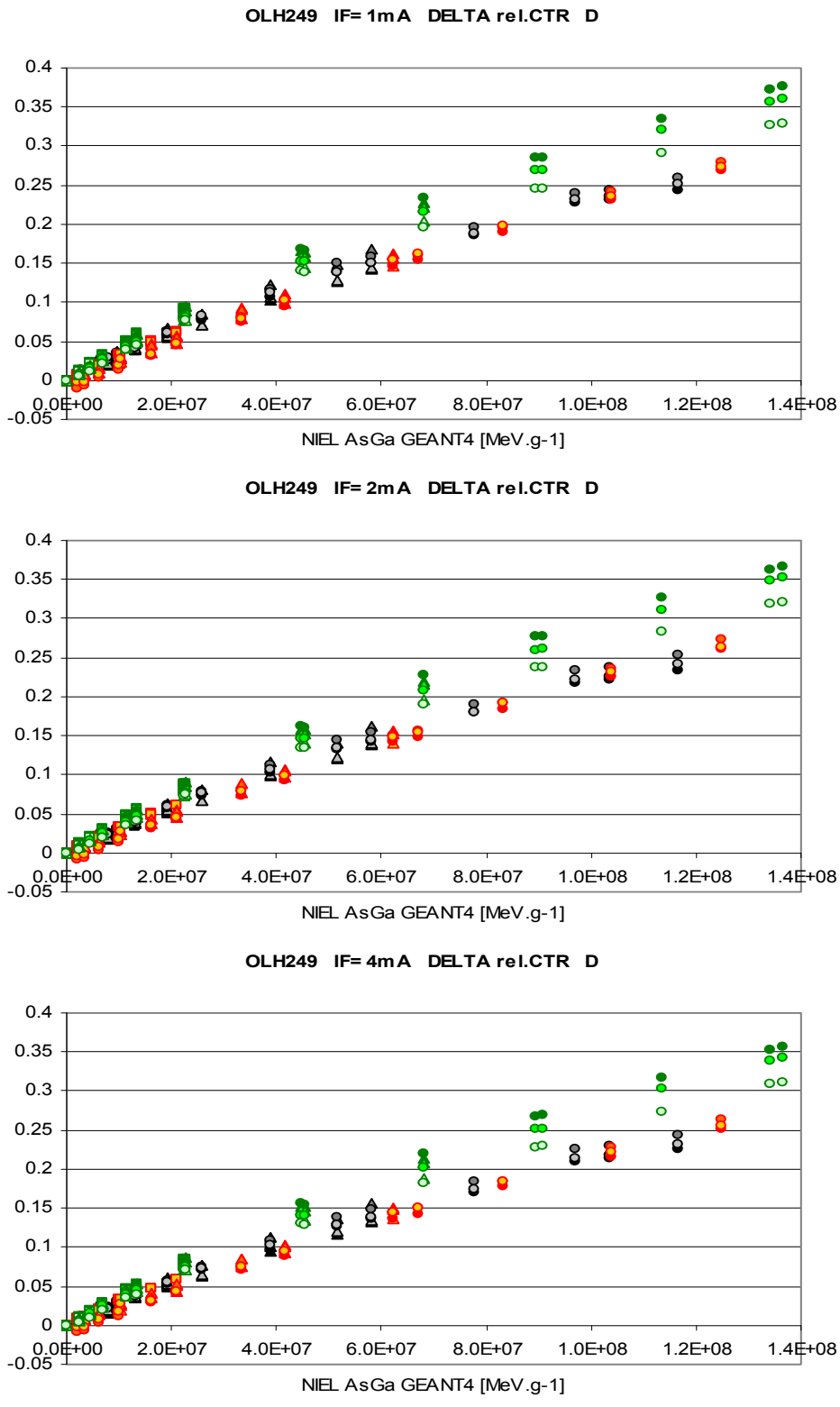
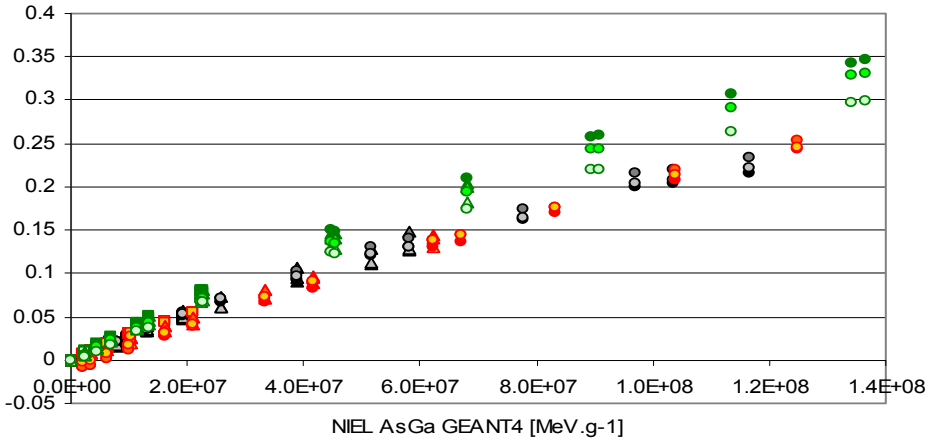


Fig. 13-32: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)



OLH249 IF= 8mA DELTA rel.CTR D



OLH249 IF= 10mA DELTA rel.CTR D

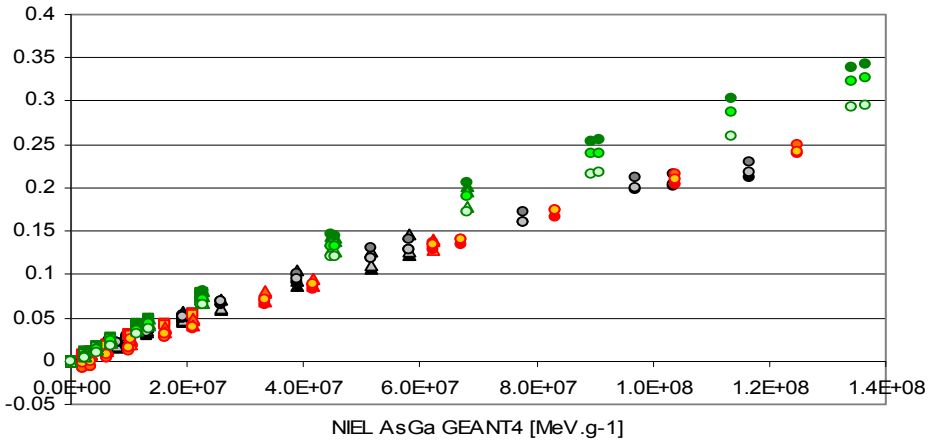
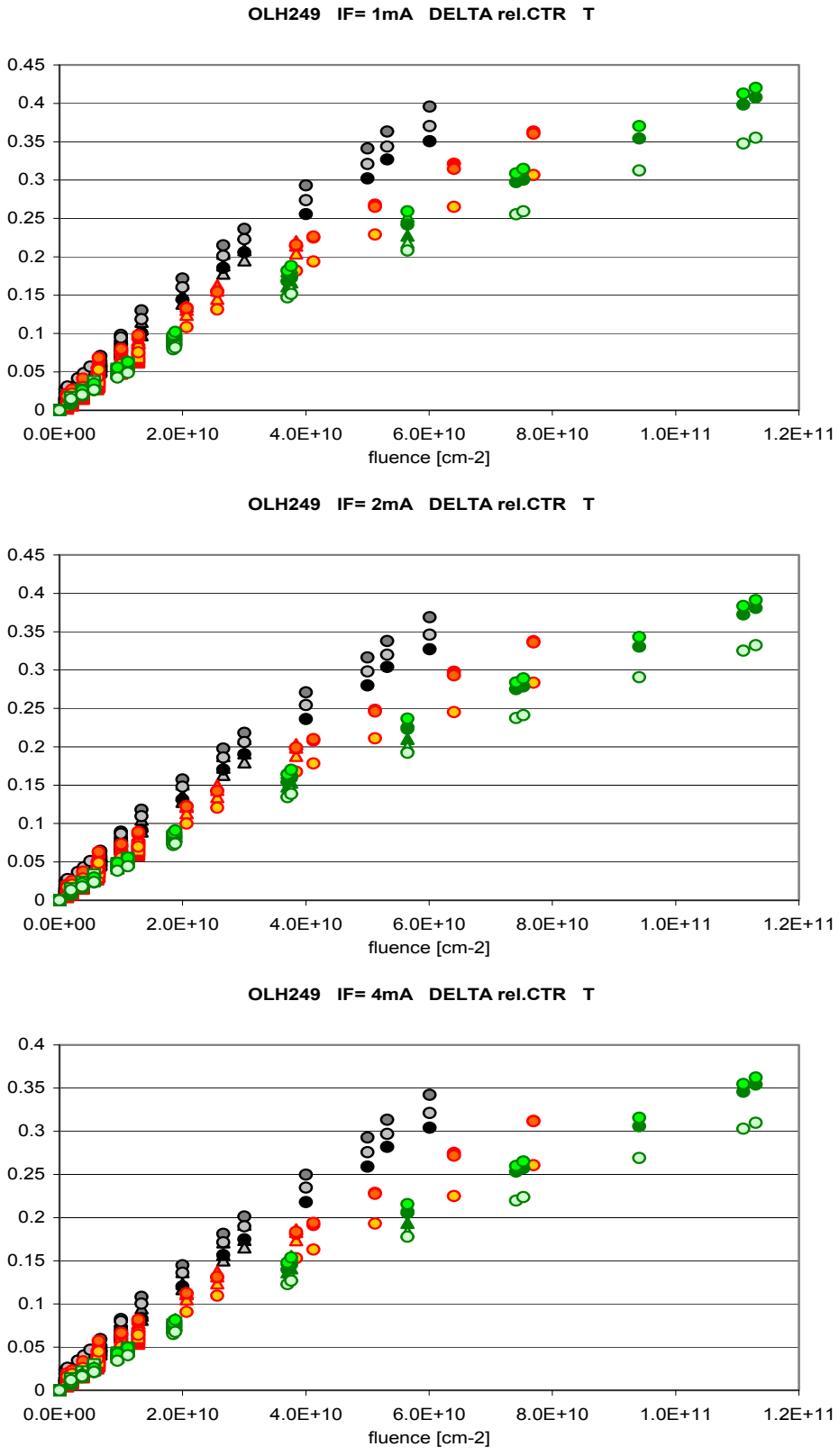
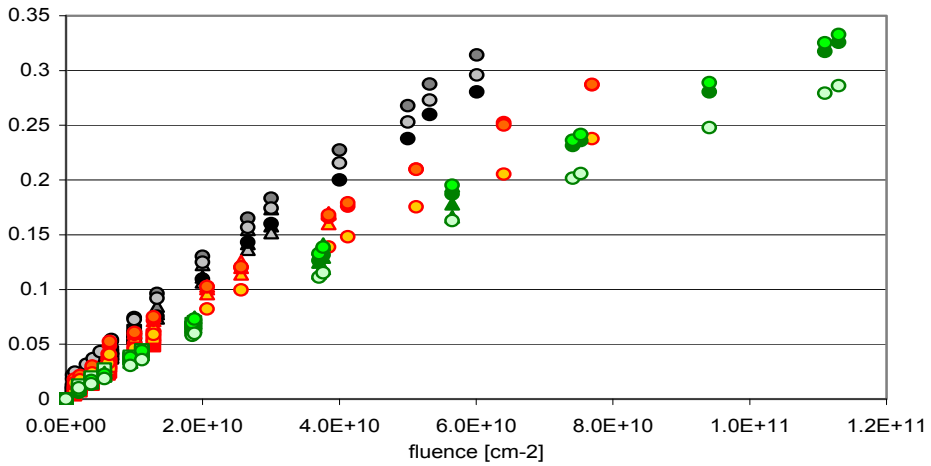


Fig. 13-33: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence



OLH249 IF= 8mA DELTA rel.CTR T



OLH249 IF= 10mA DELTA rel.CTR T

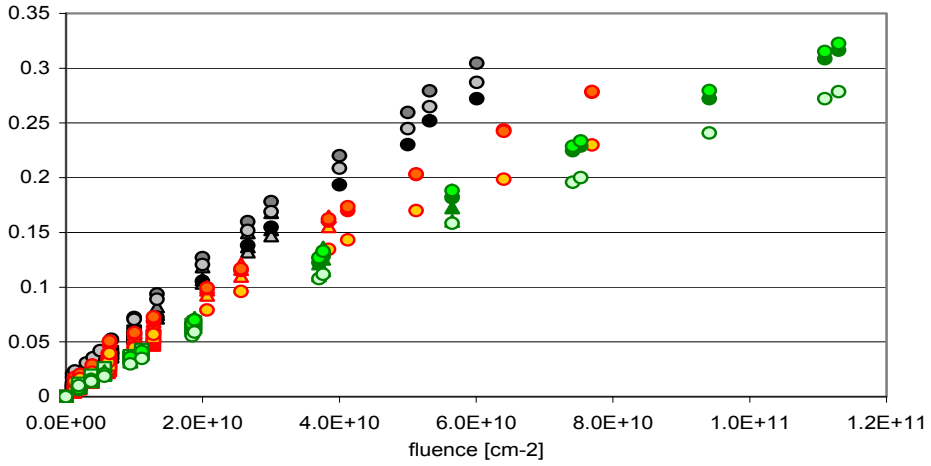
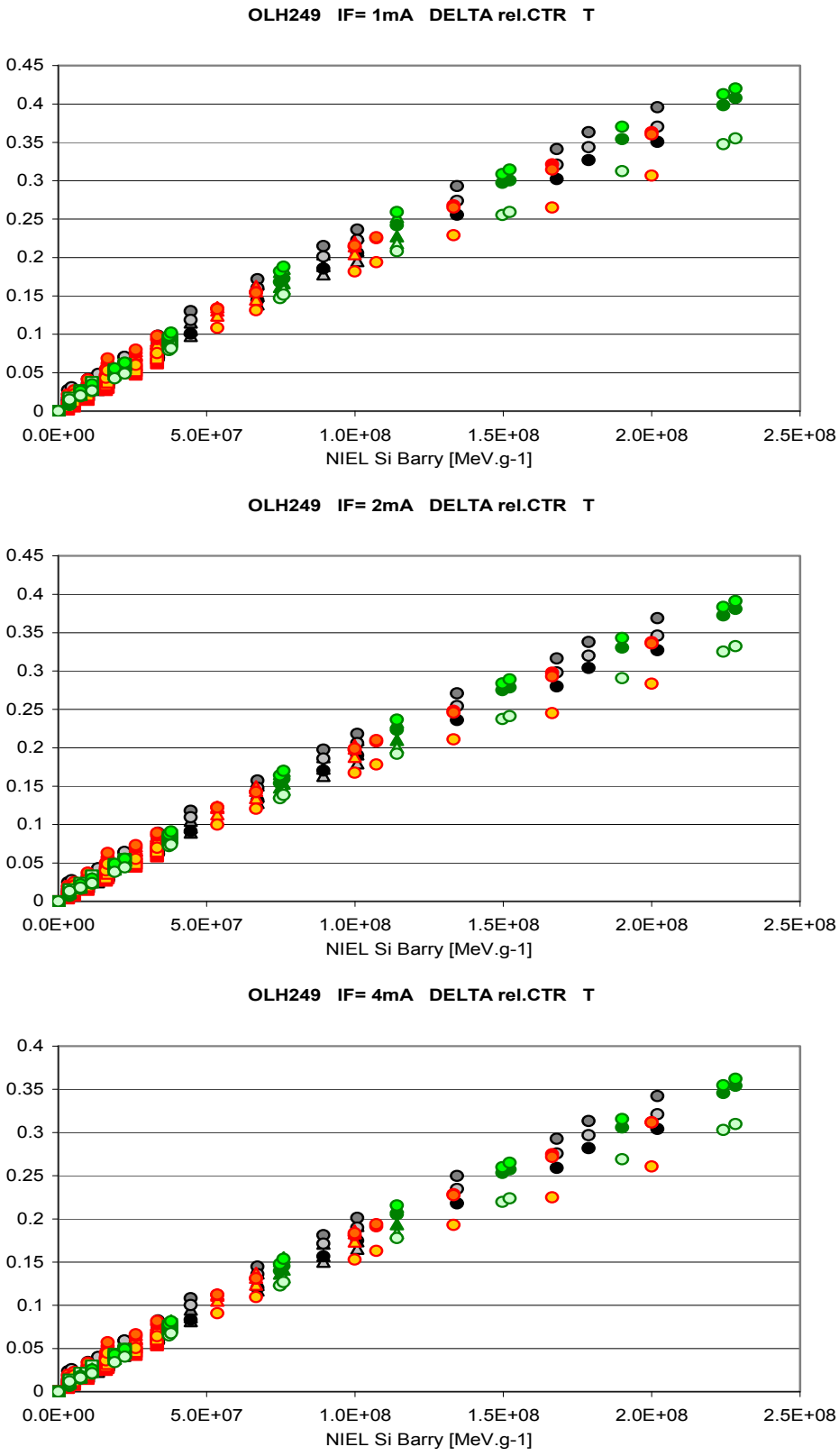
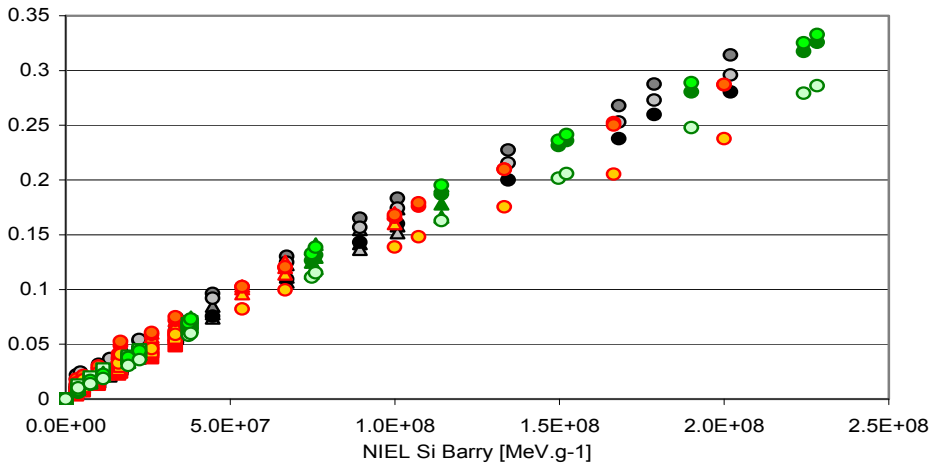


Fig. 13-34: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)



OLH249 IF= 8mA DELTA rel.CTR T



OLH249 IF= 10mA DELTA rel.CTR T

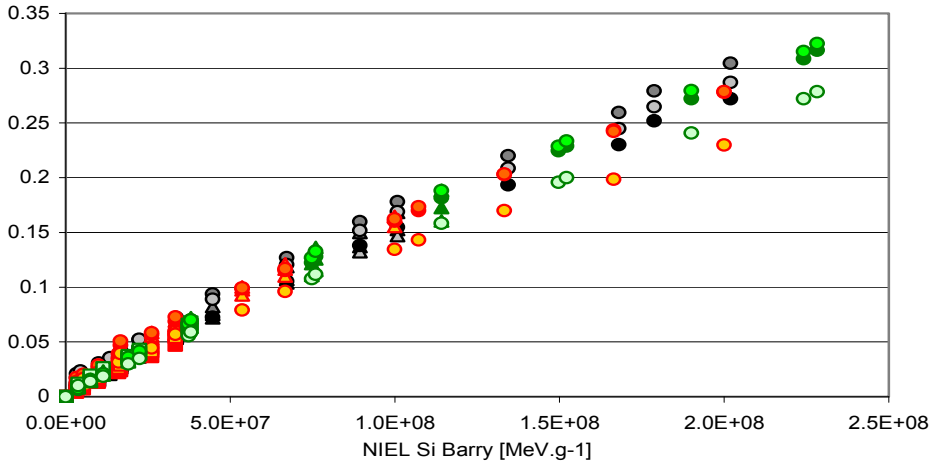
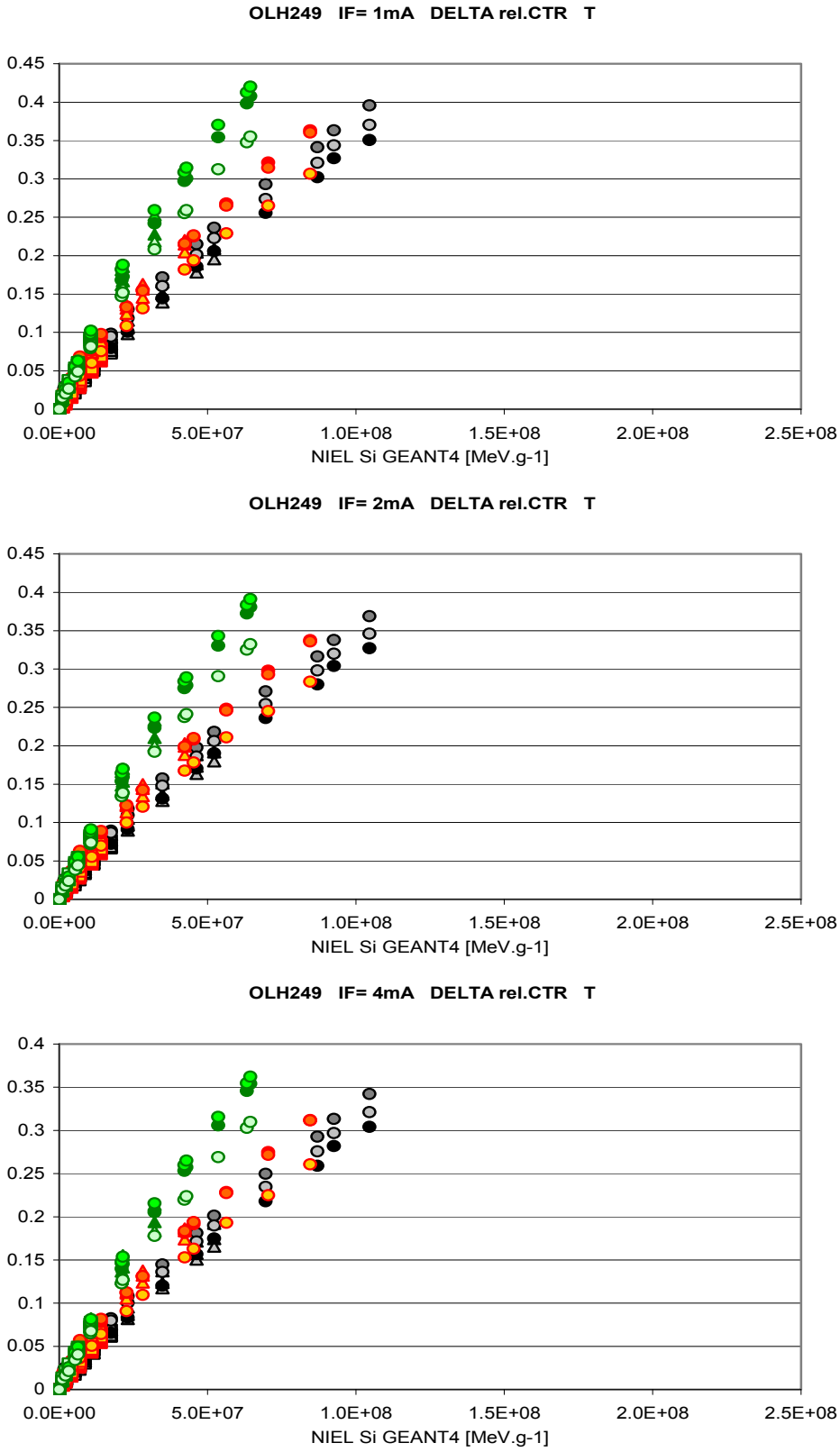
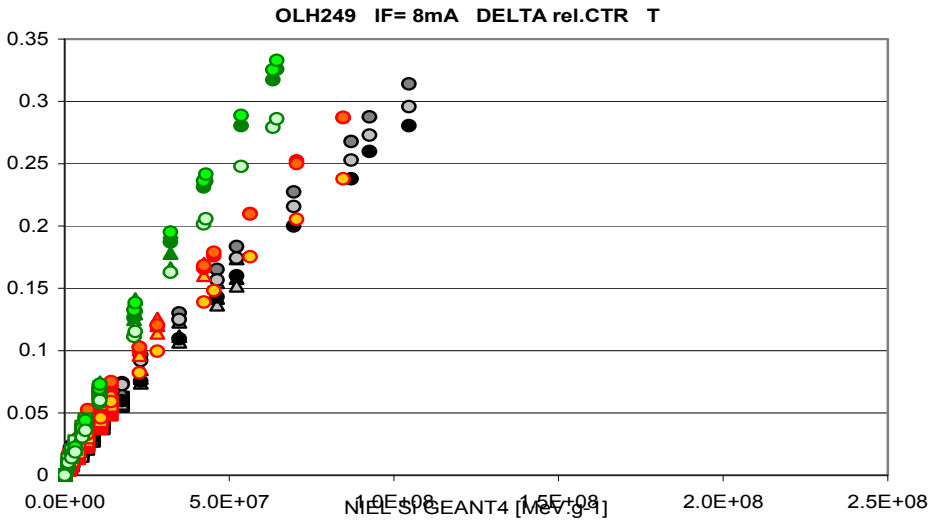


Fig. 13-35: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




OLH249 IF= 8mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

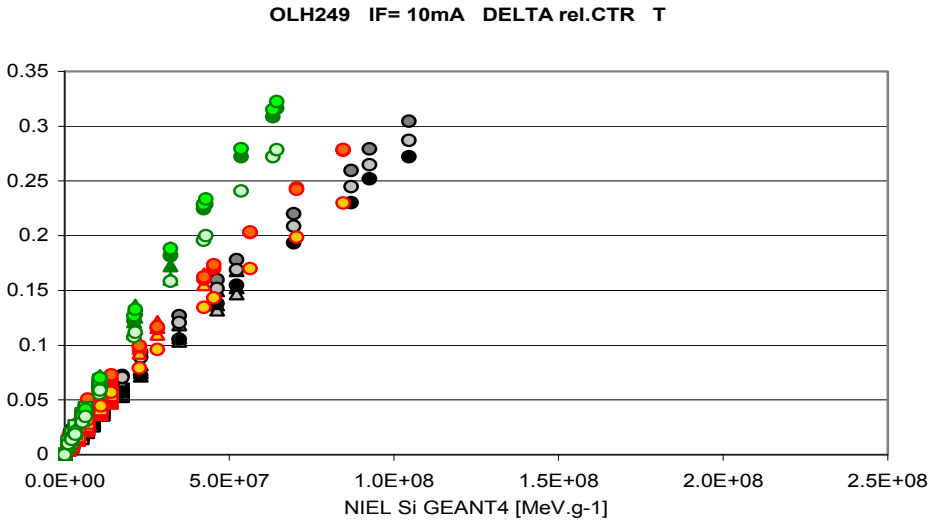
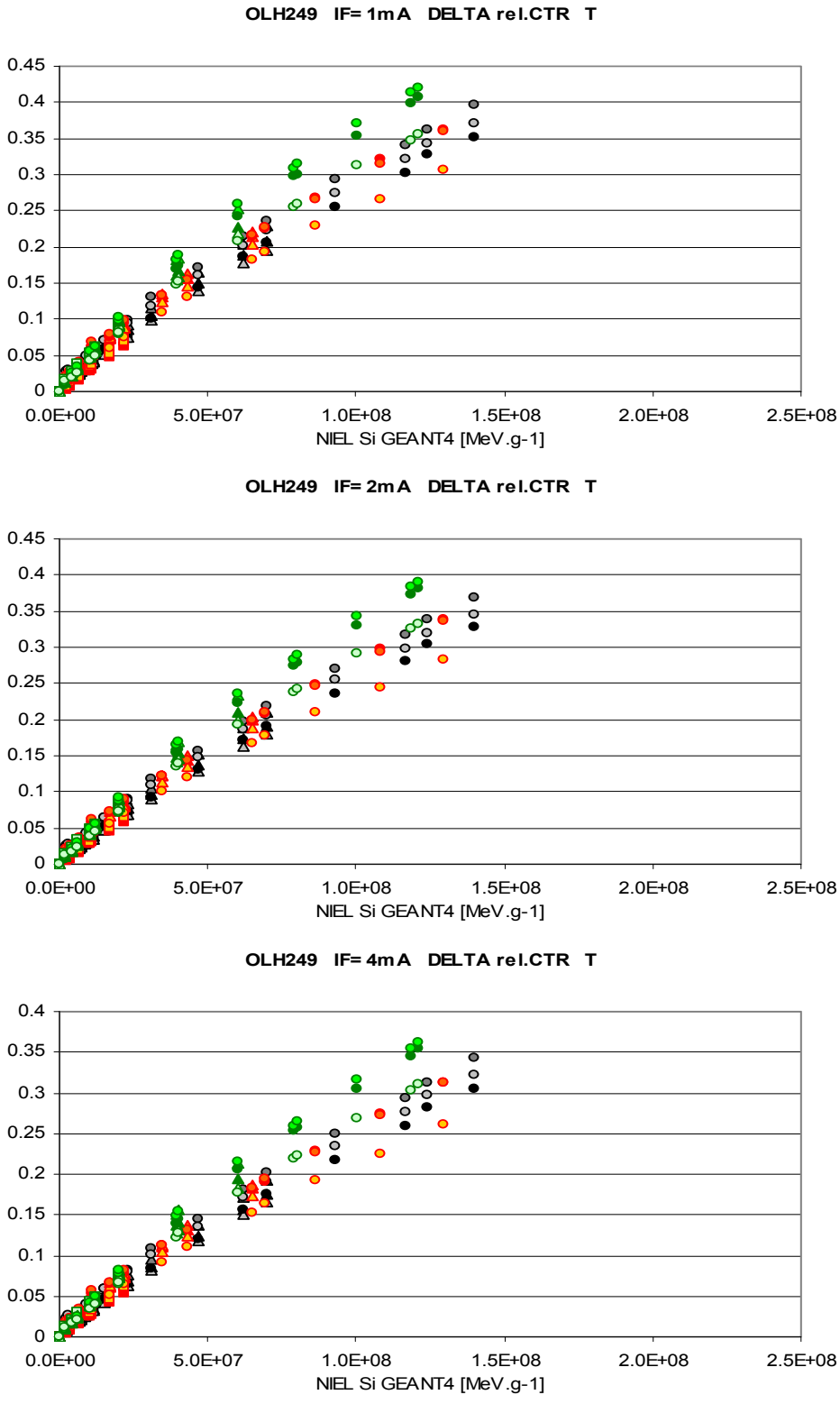
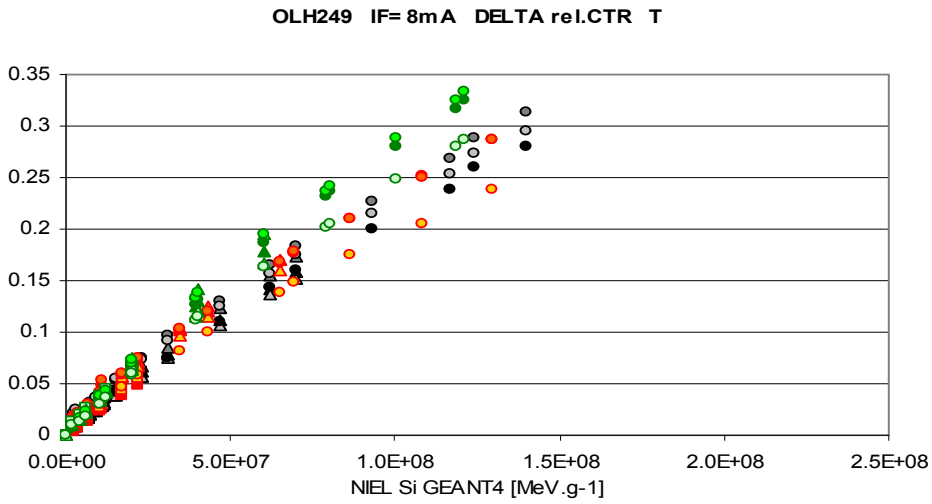

OLH249 IF= 10mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-36: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




OLH249 IF= 8mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

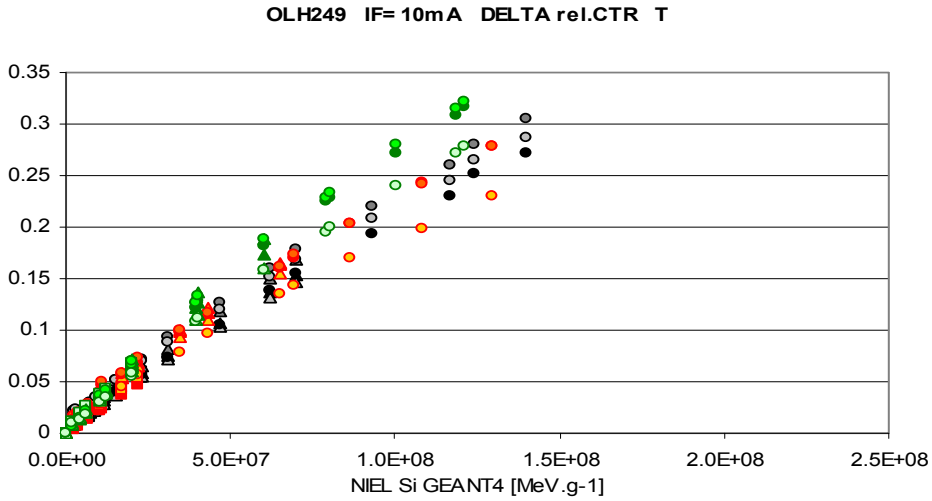
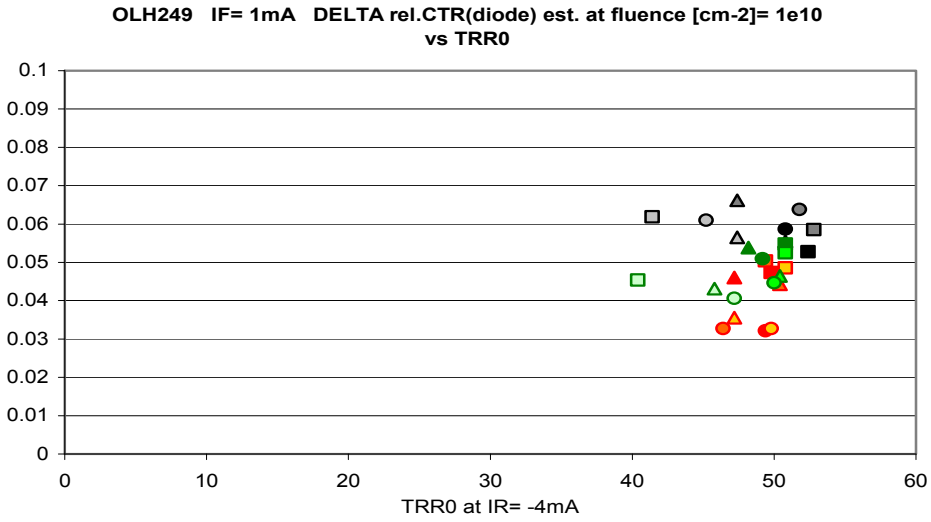
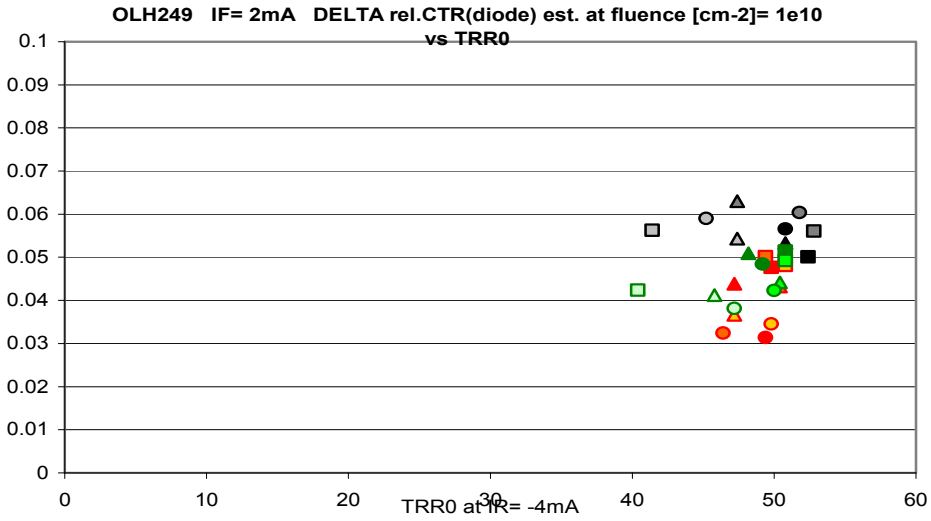
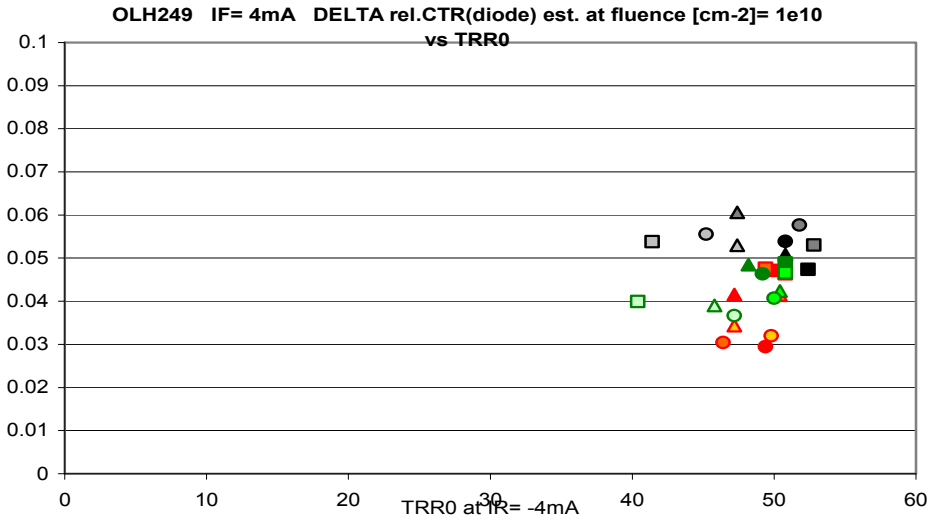
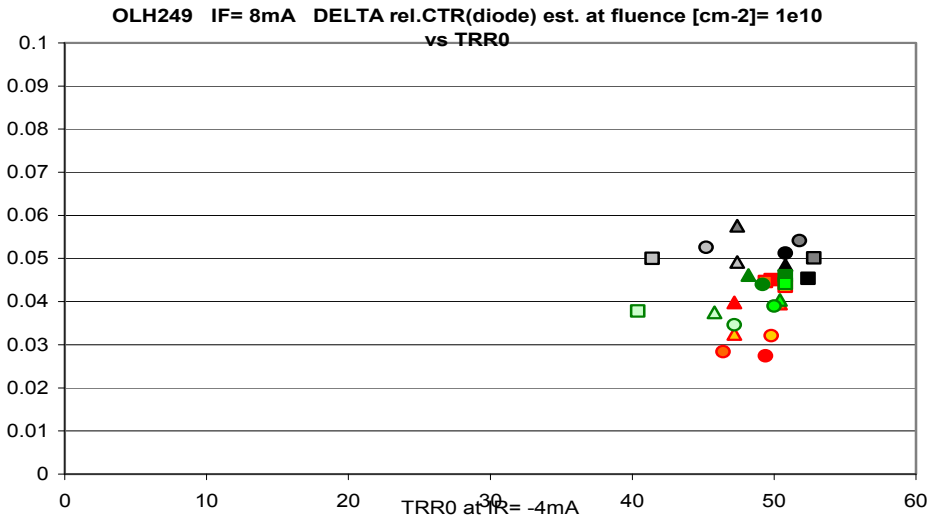

OLH249 IF= 10mA DELTA rel.CTR T
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 13-37: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 1.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10
vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

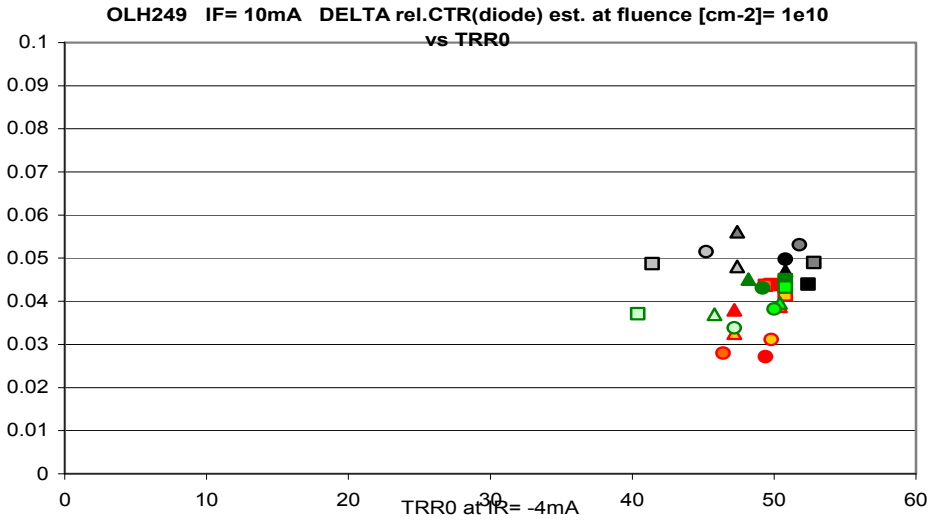
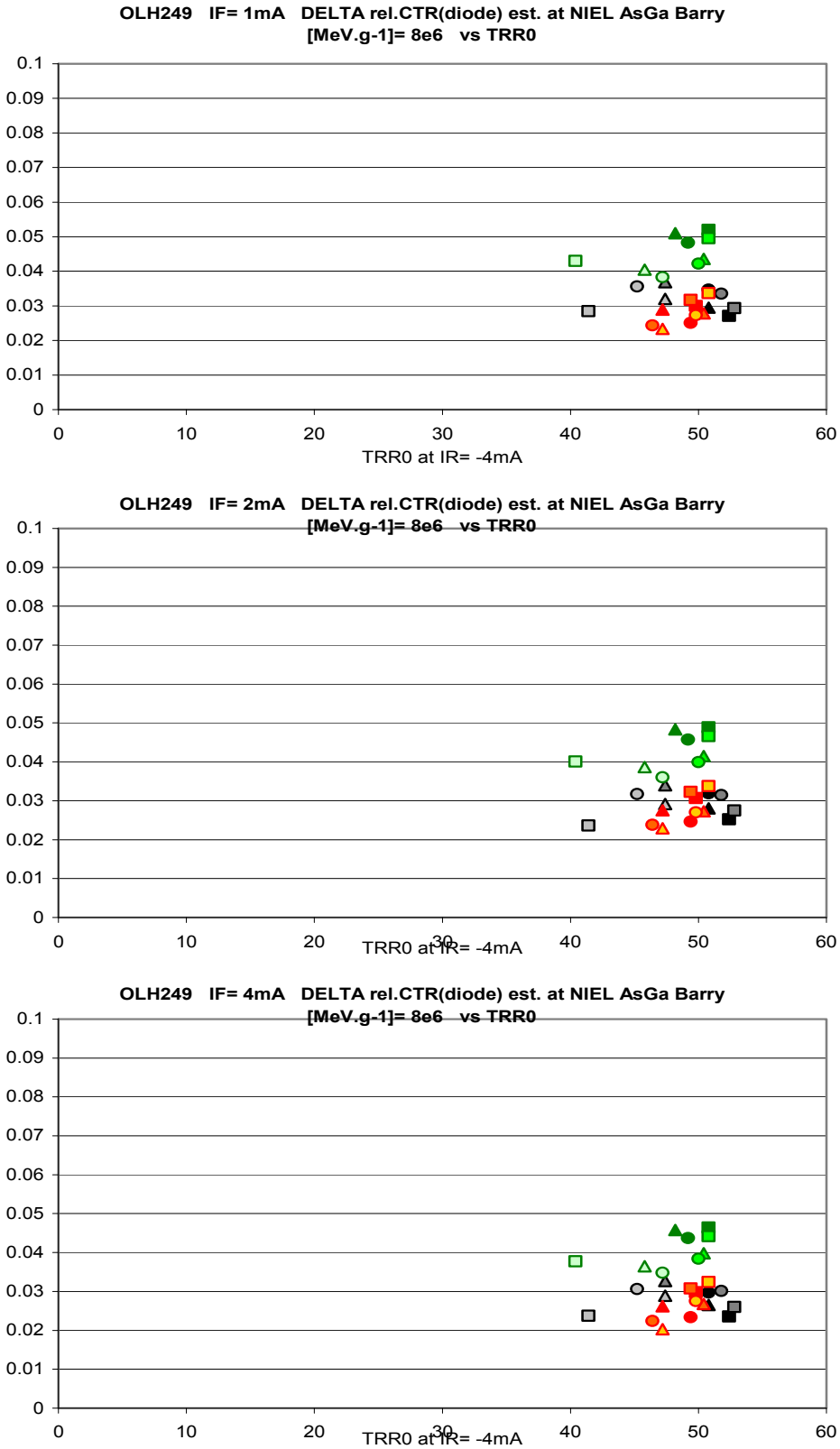
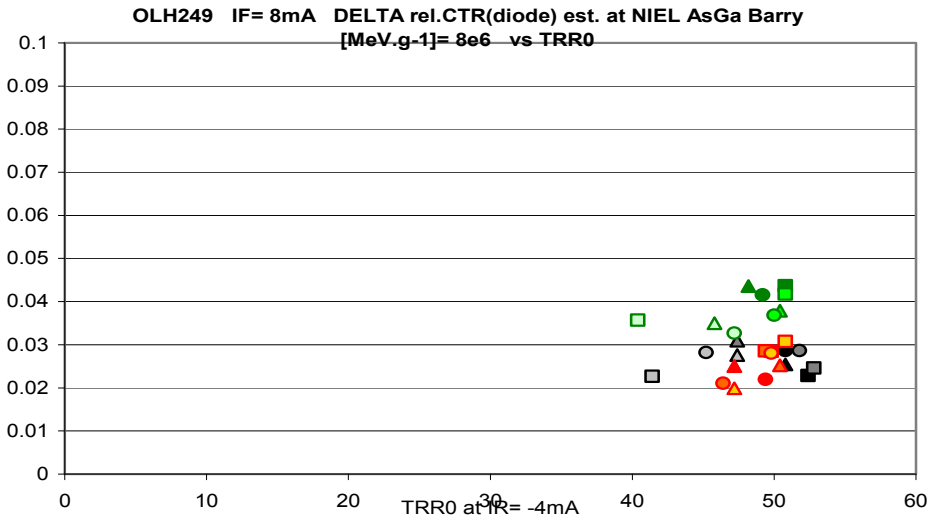

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10
vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-38: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

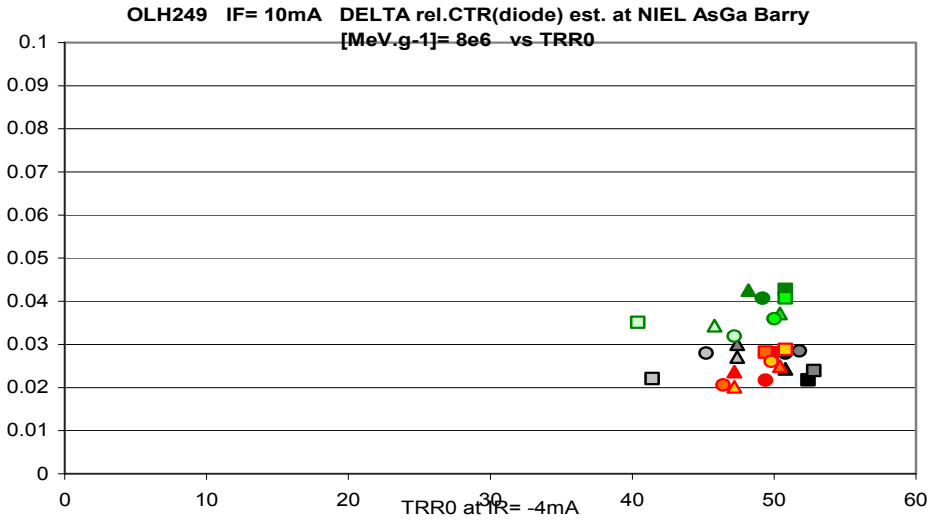
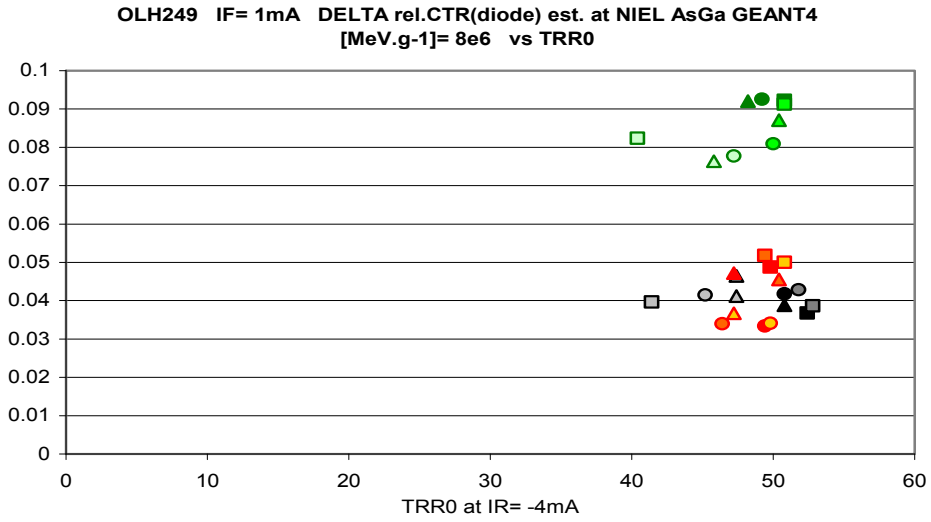
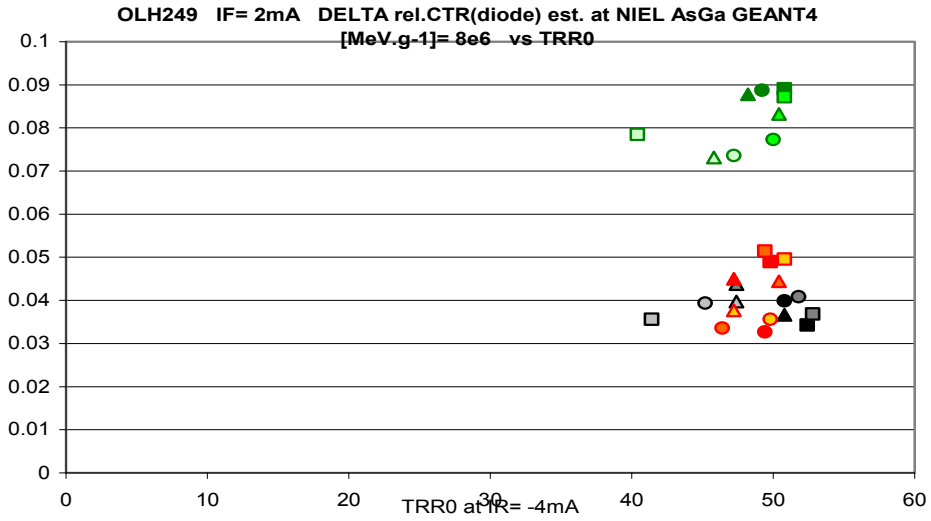
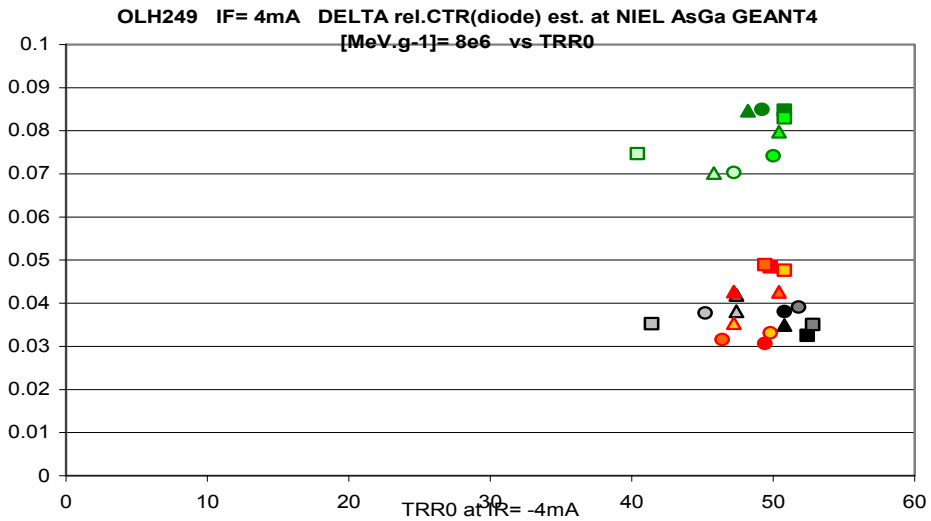
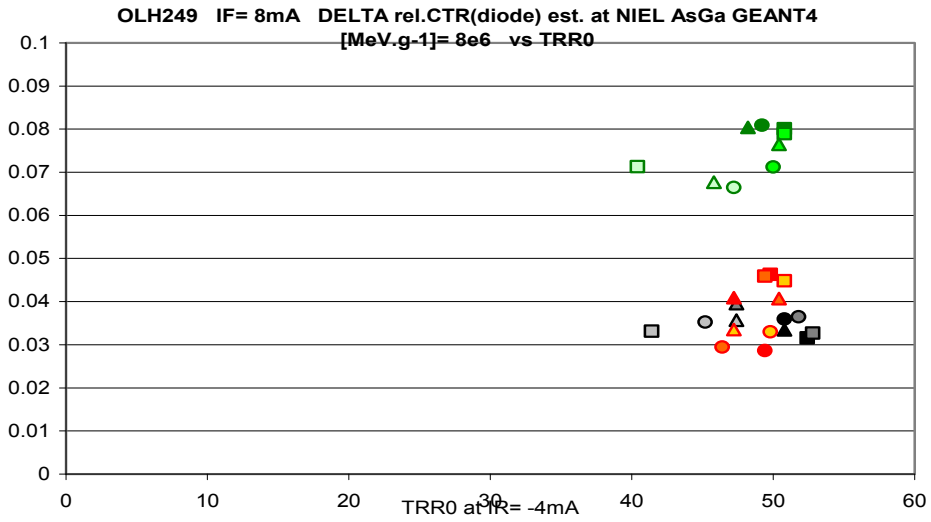

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-39: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

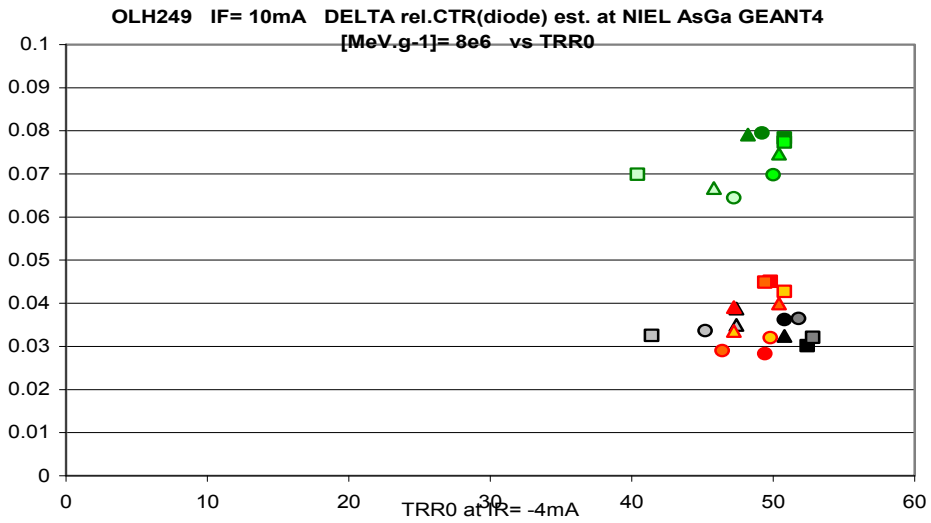
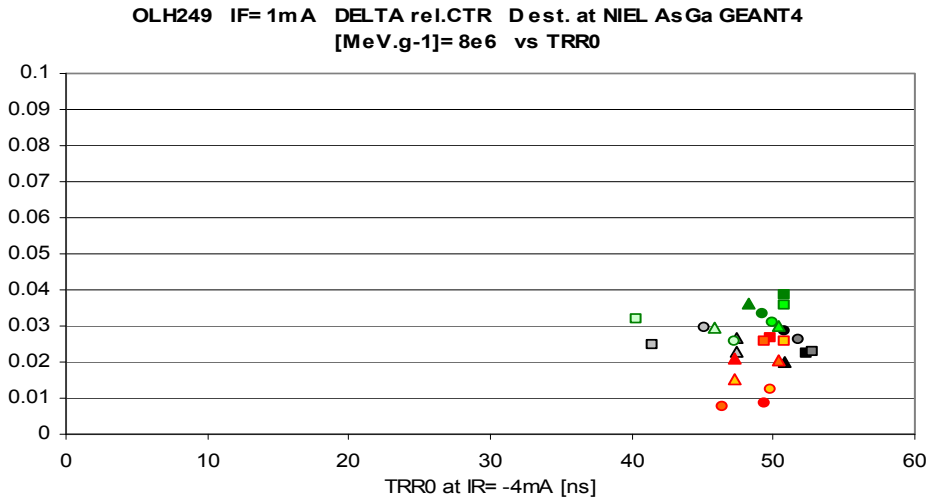
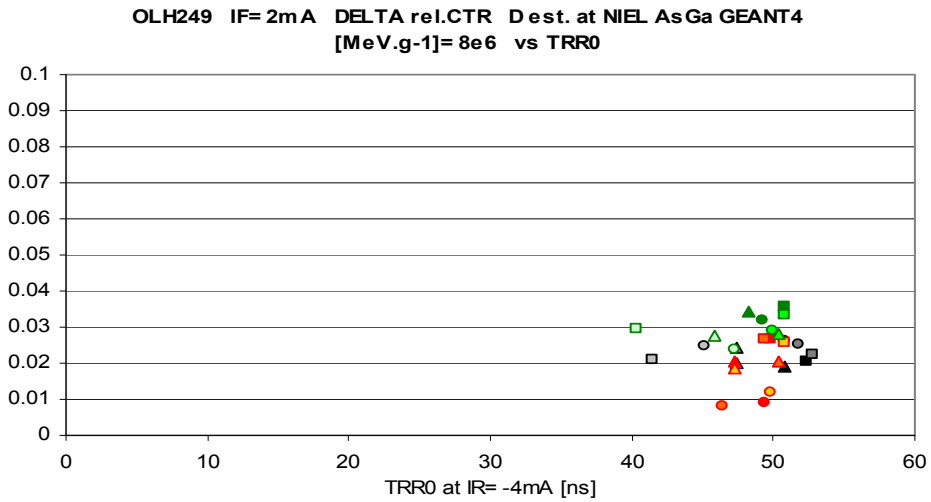
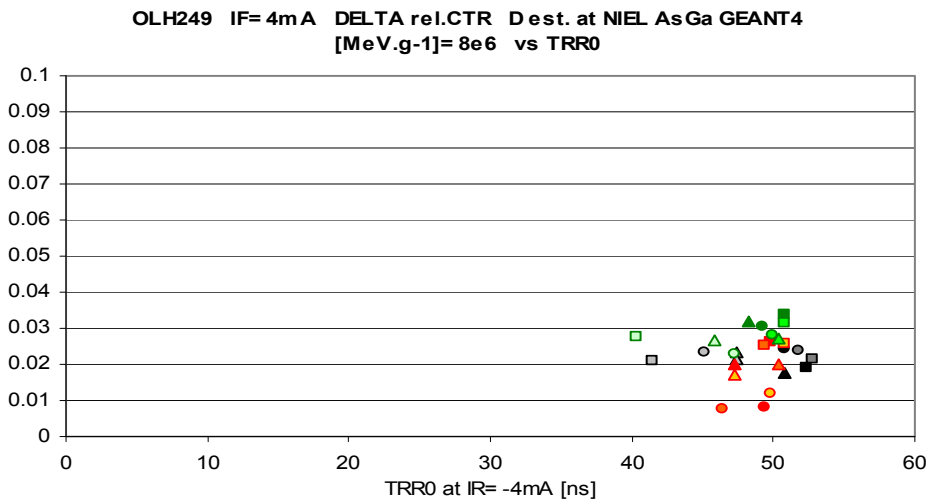
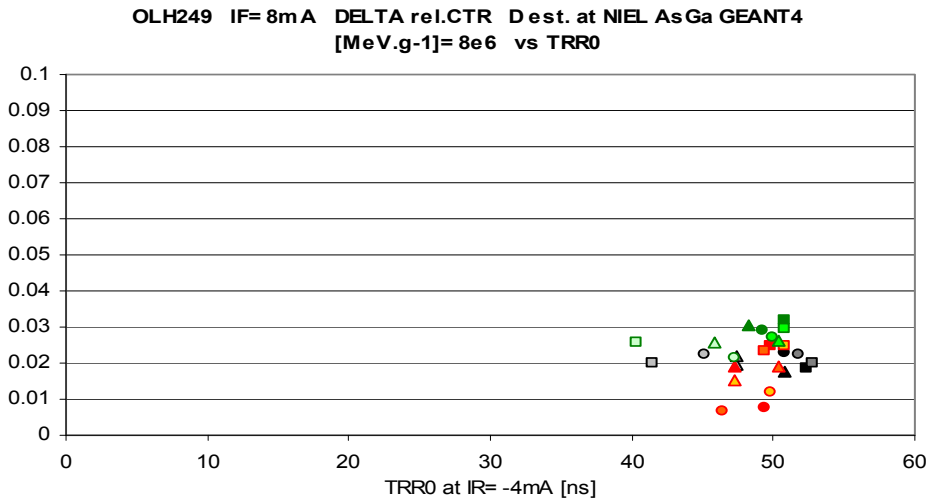

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-40: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

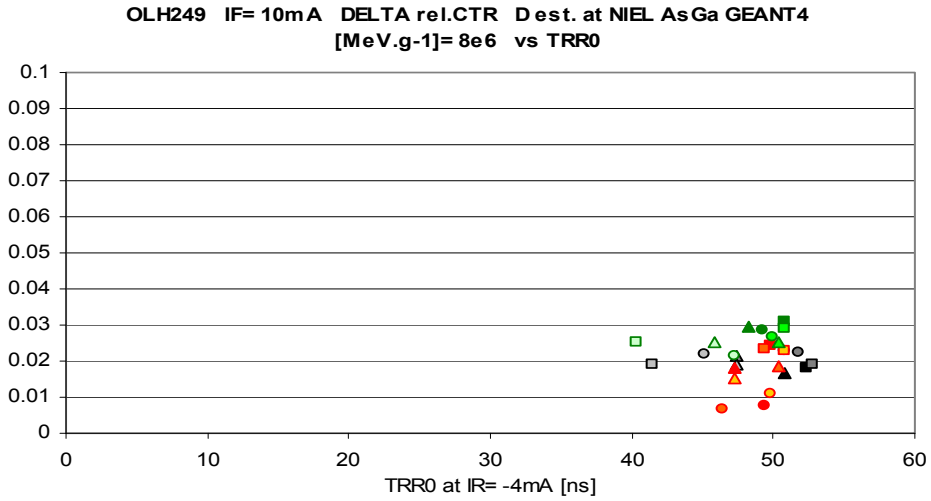
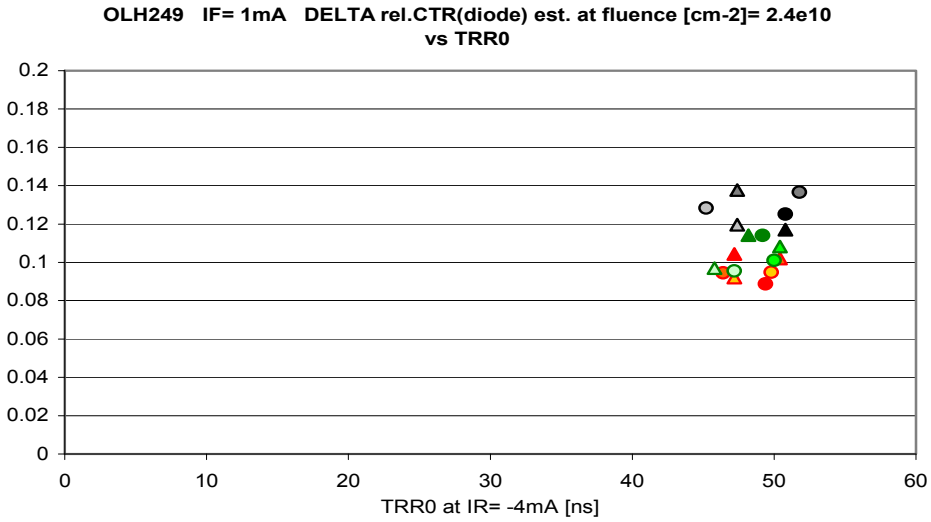
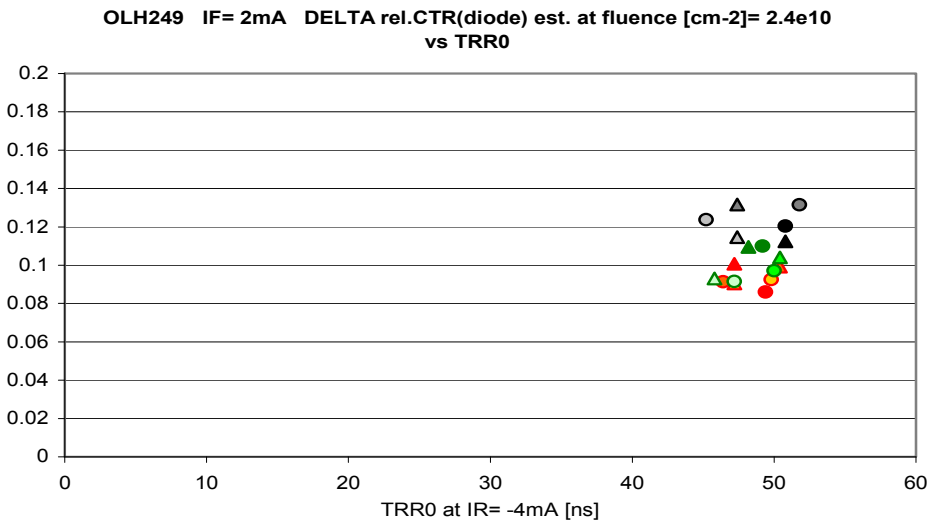
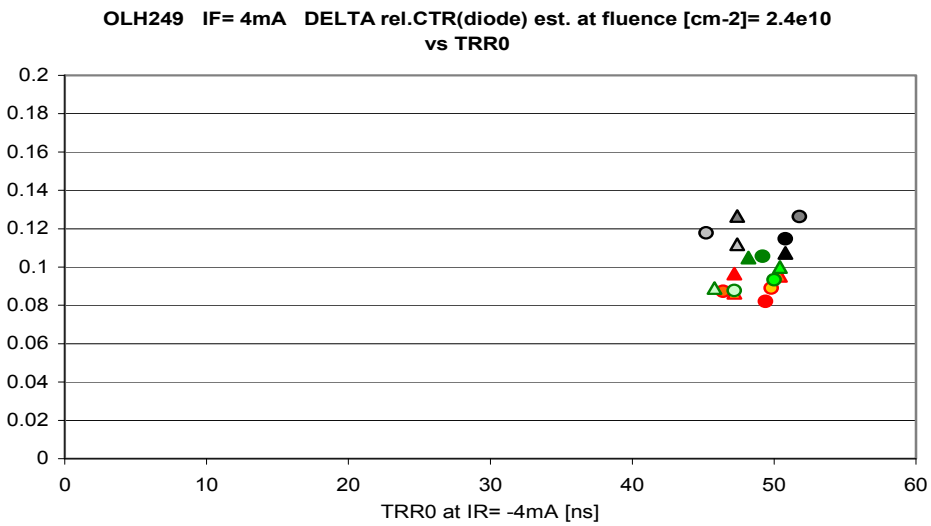
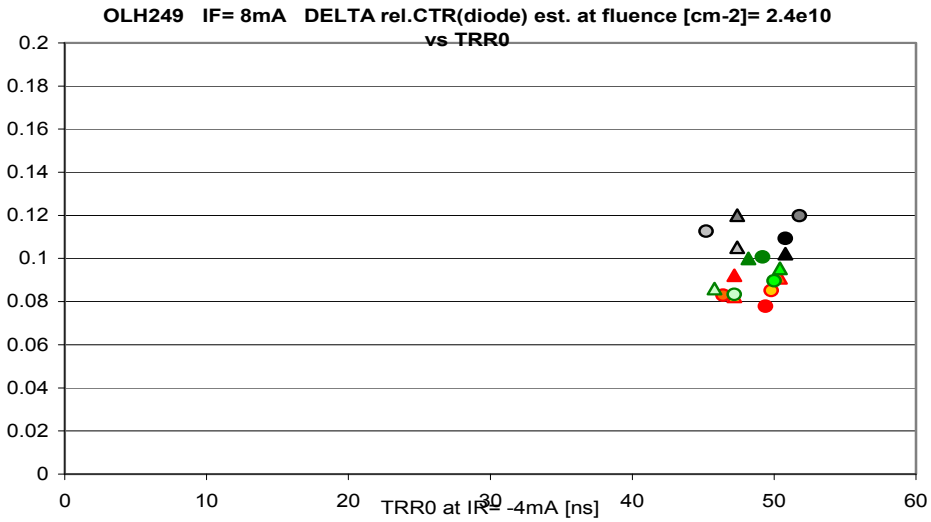

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-41: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 2.4.10^{10} cm^2 at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

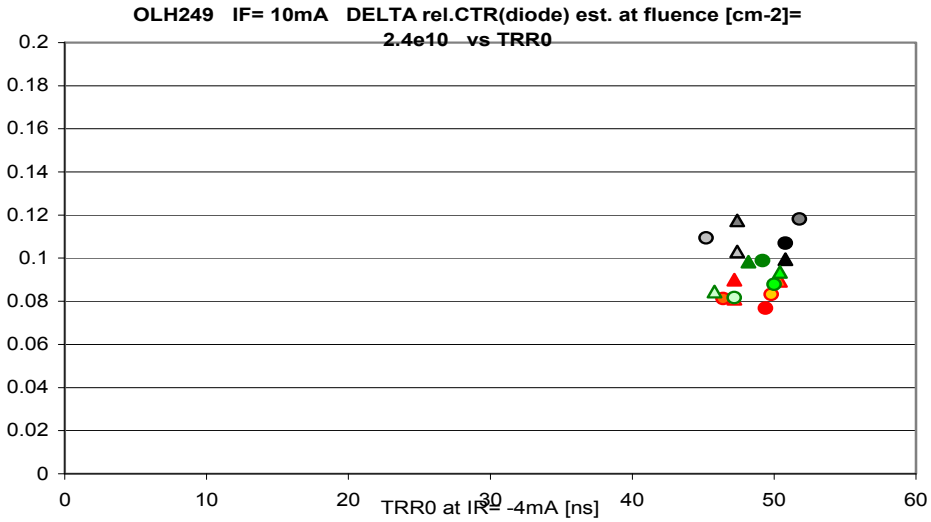
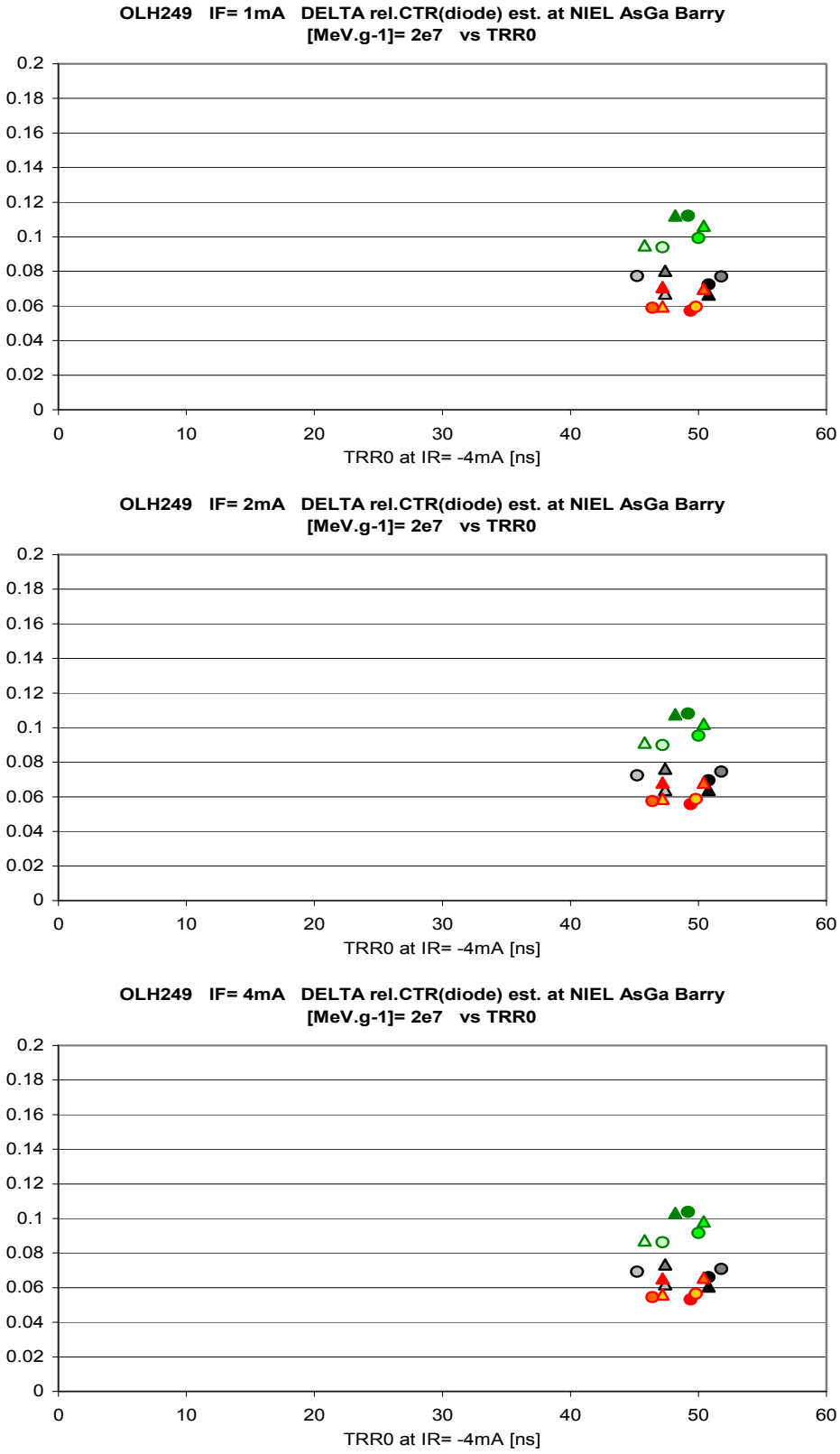
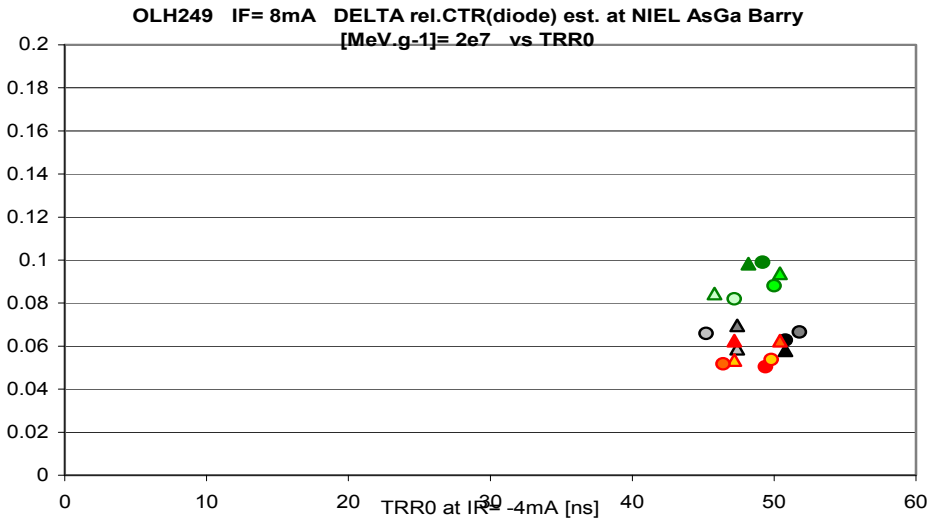

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-42: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

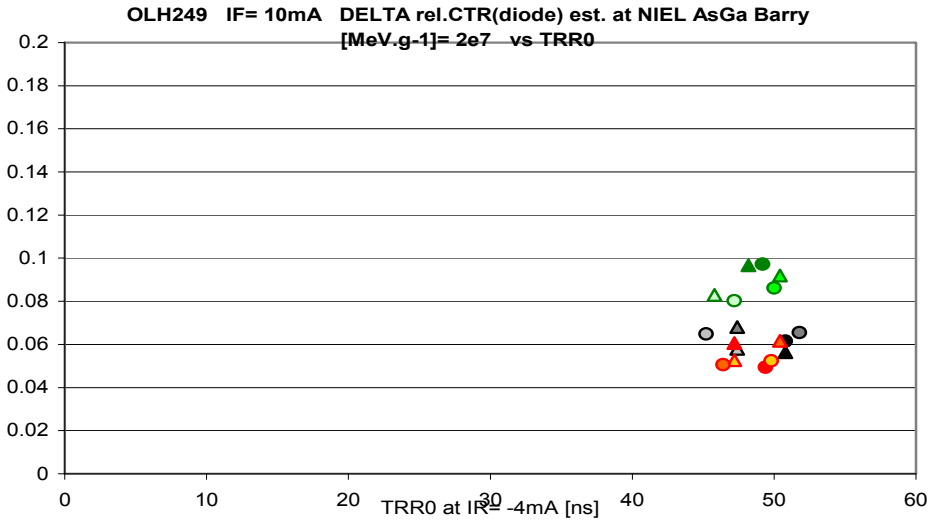
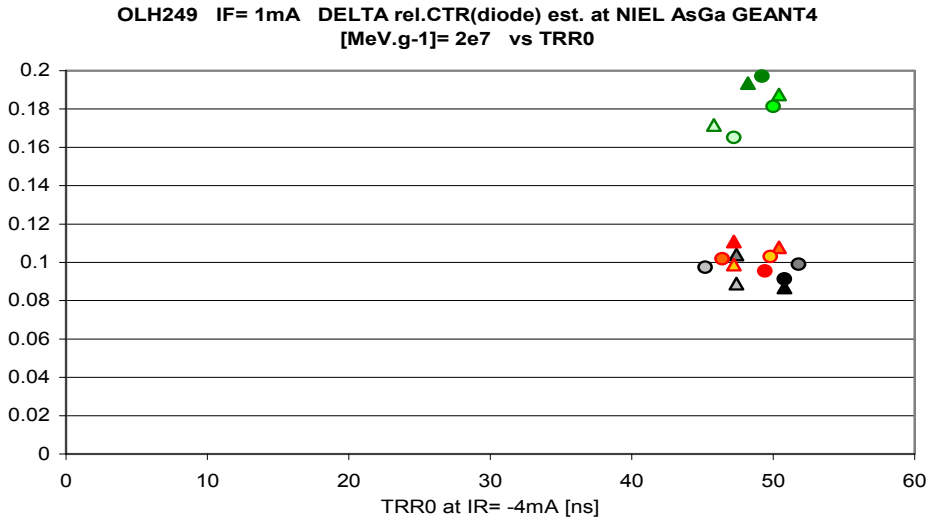
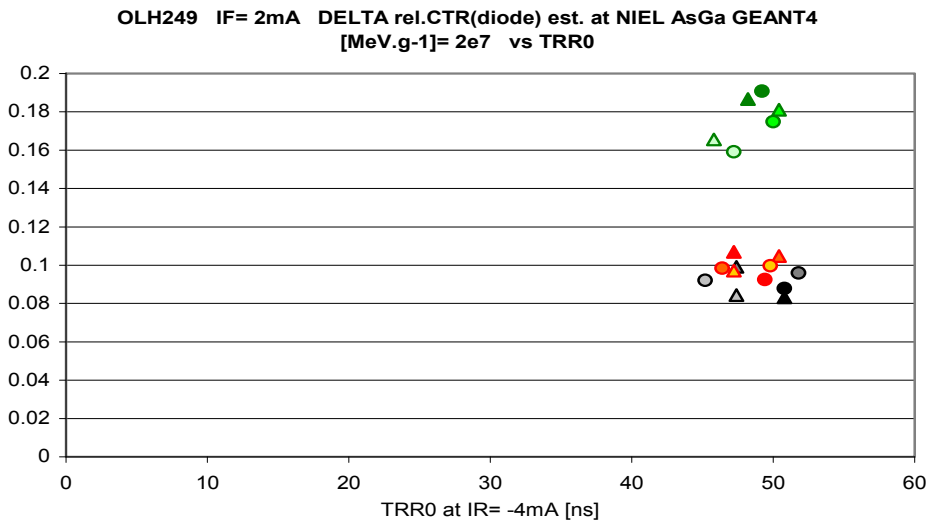
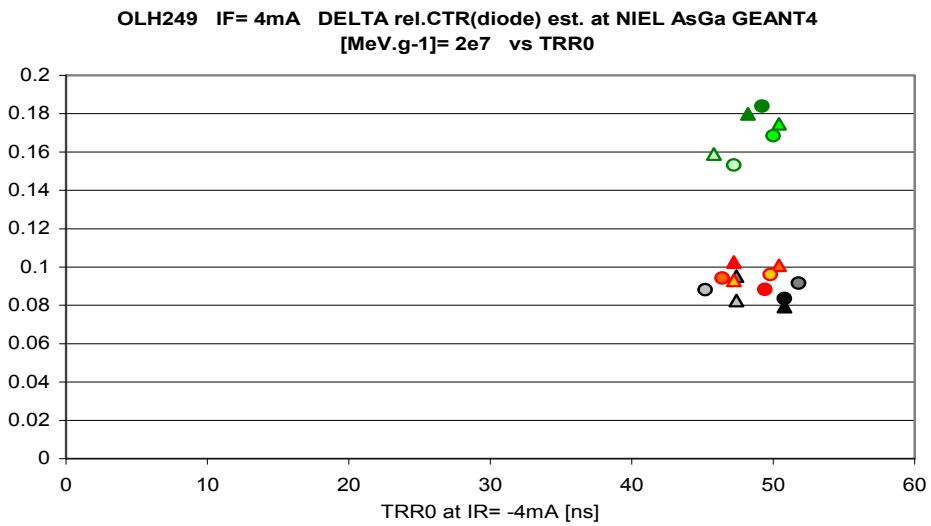
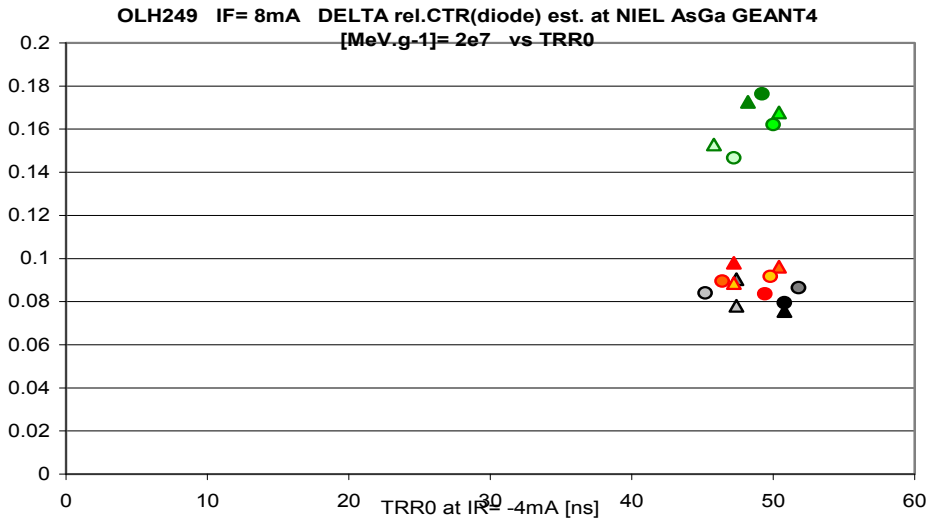

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-43: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

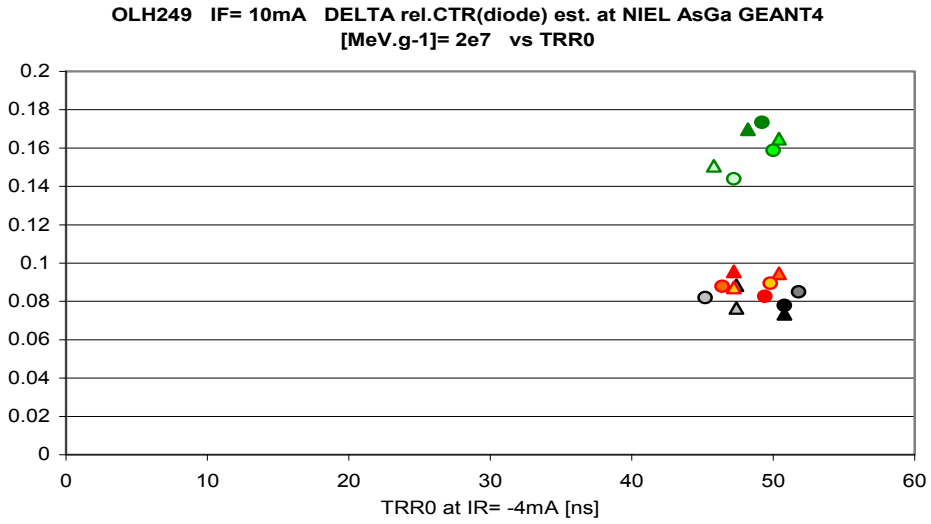
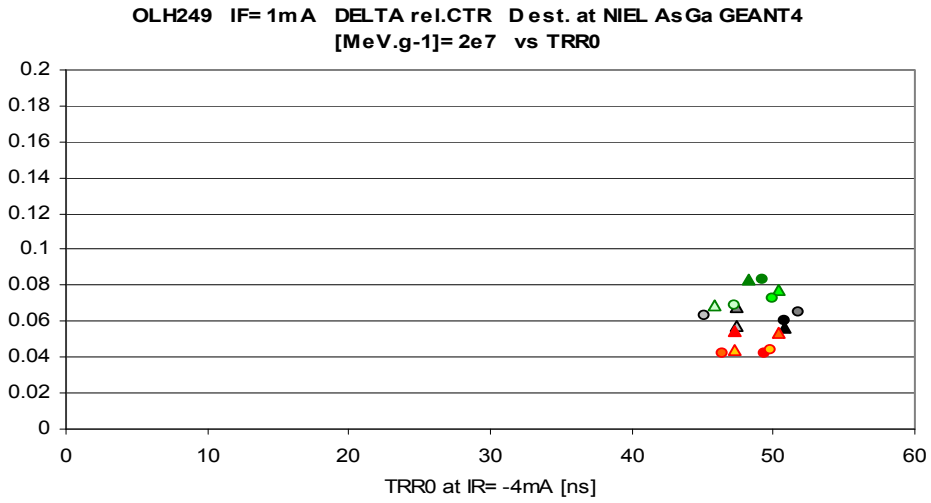
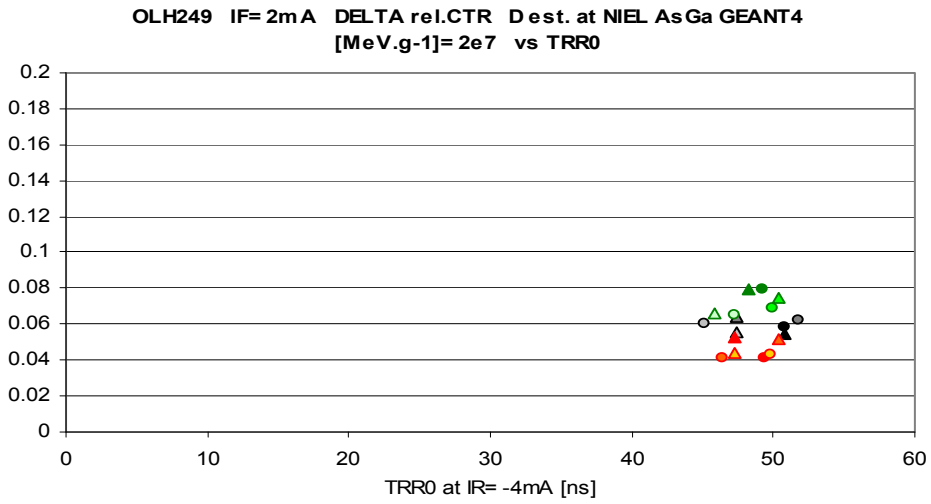
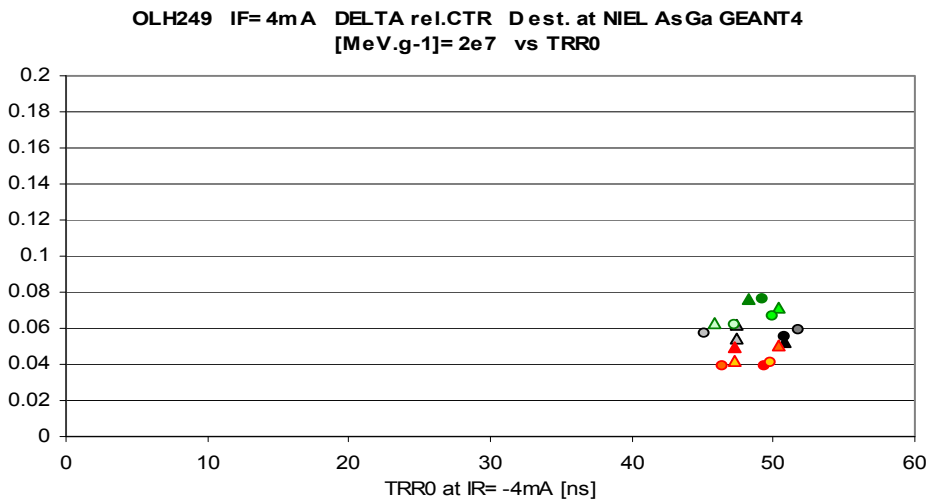
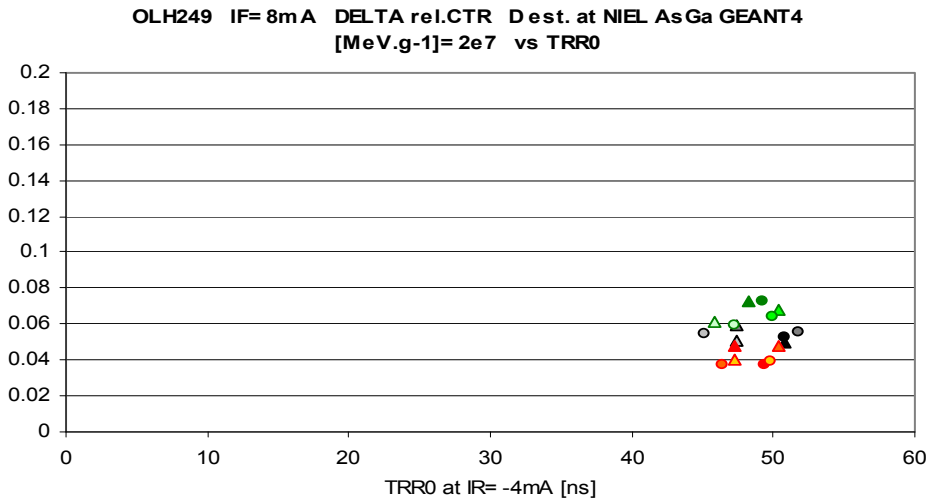

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-44: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

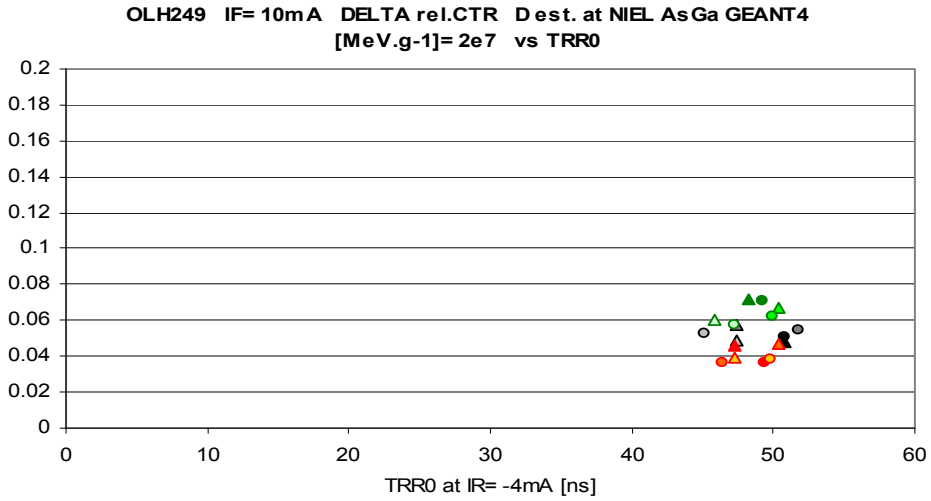
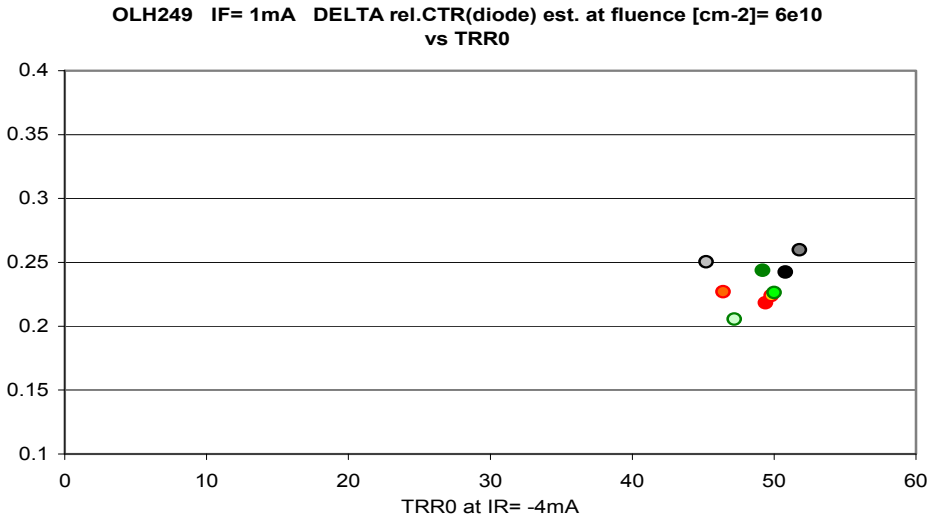
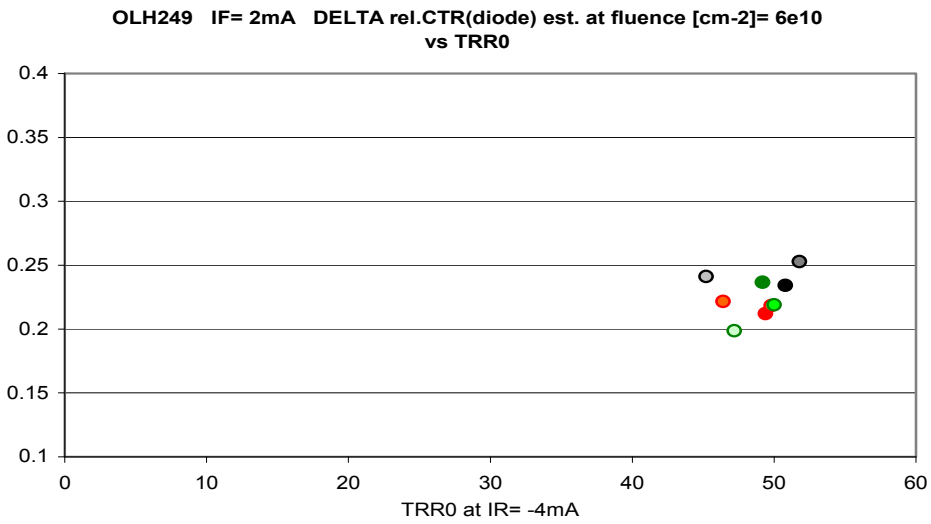
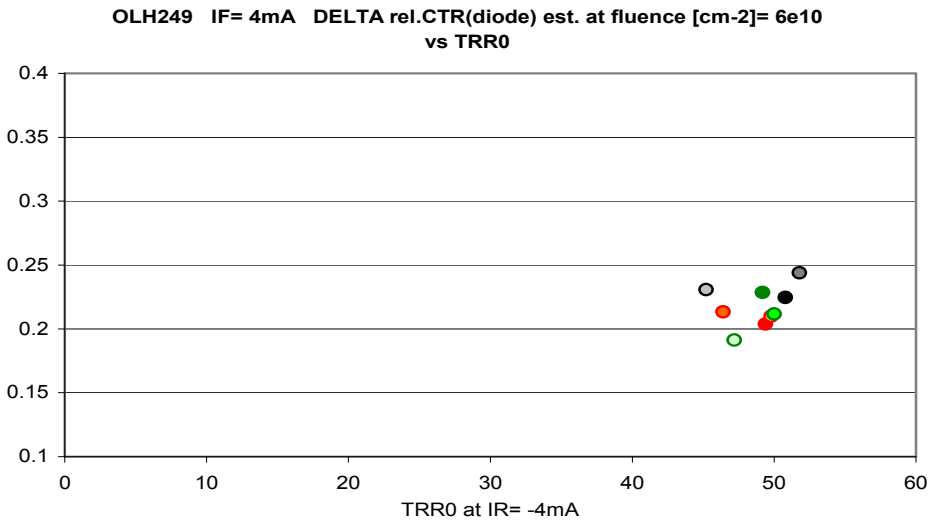
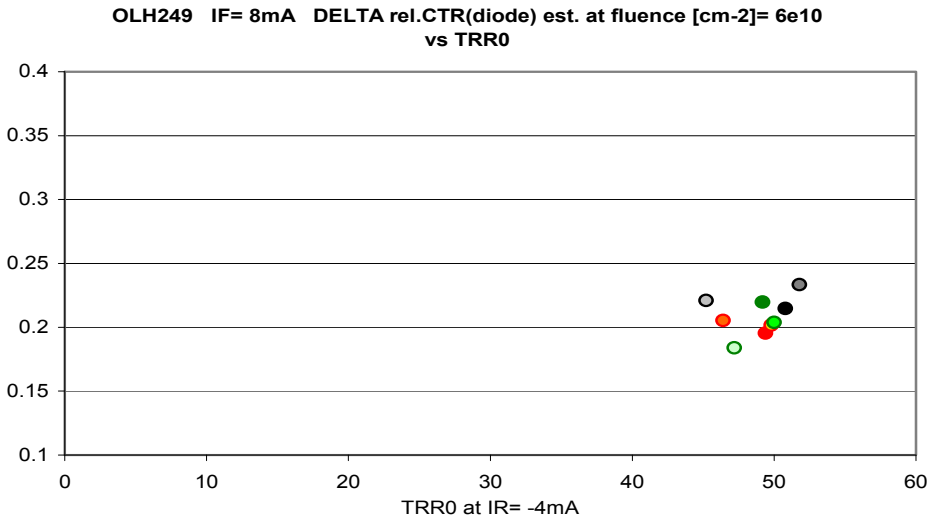

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-45: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 6.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10
vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

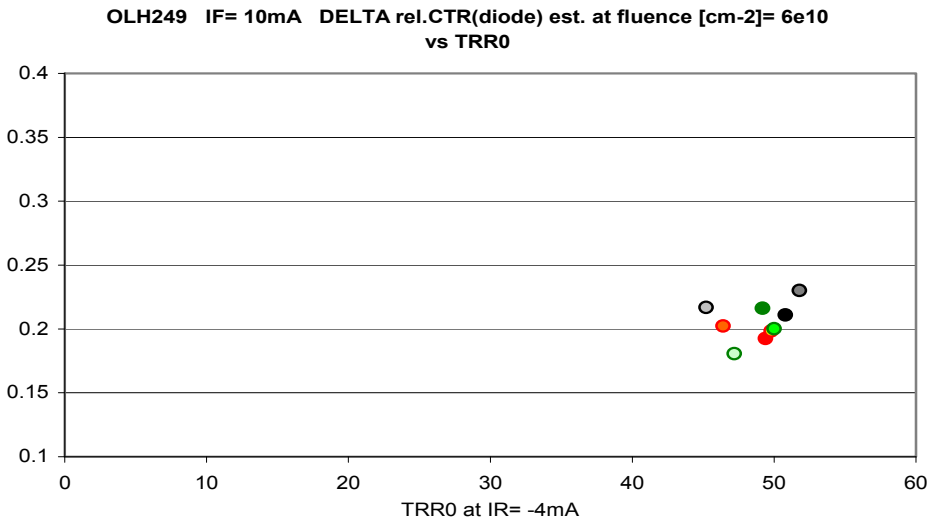
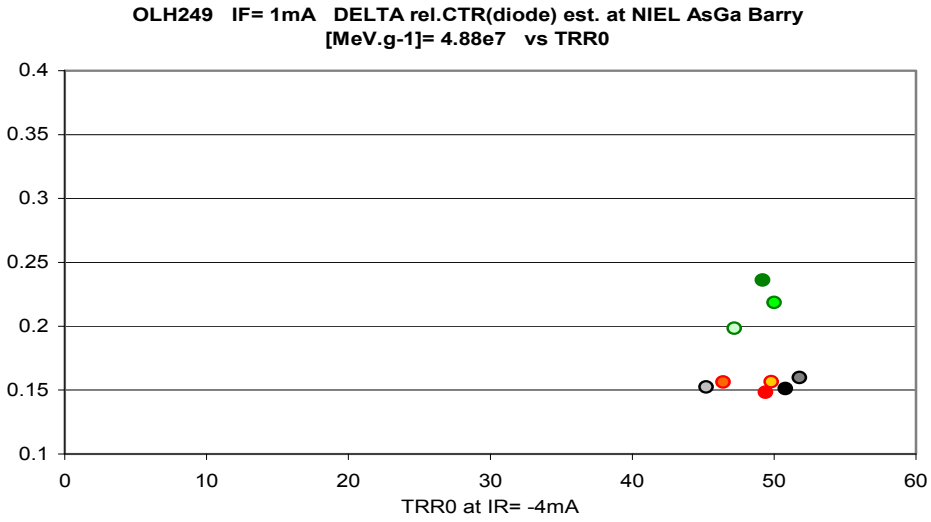
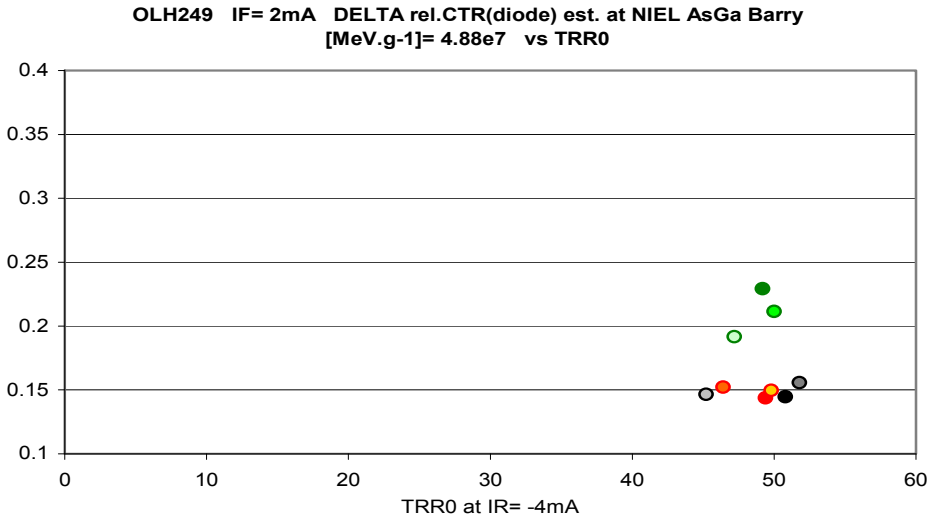
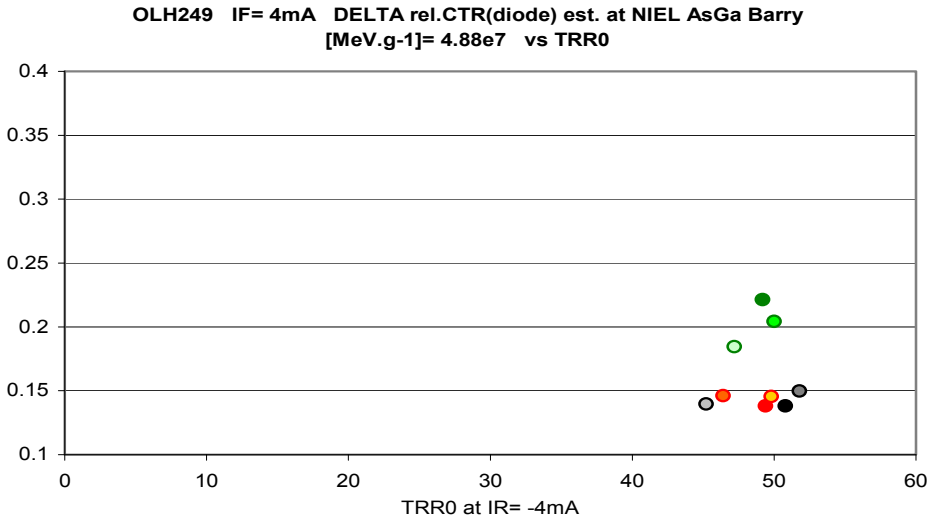
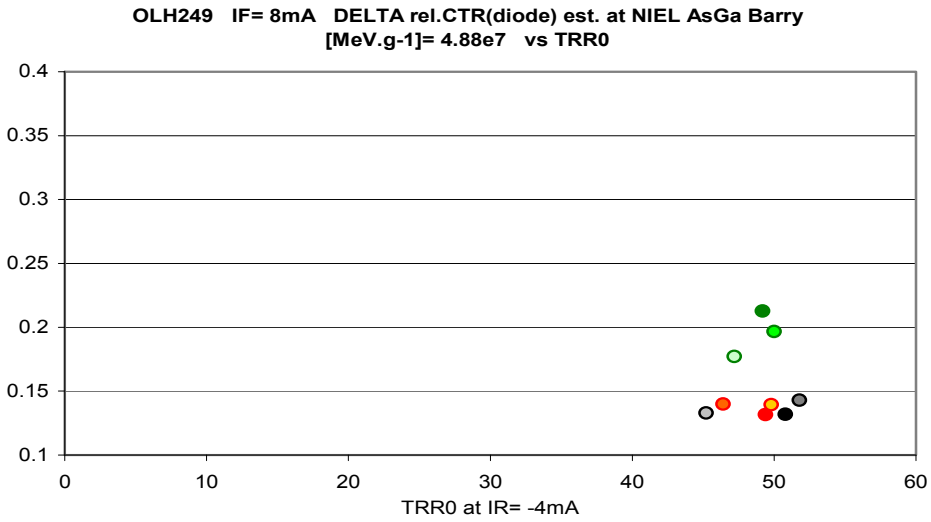

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10
vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-46: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

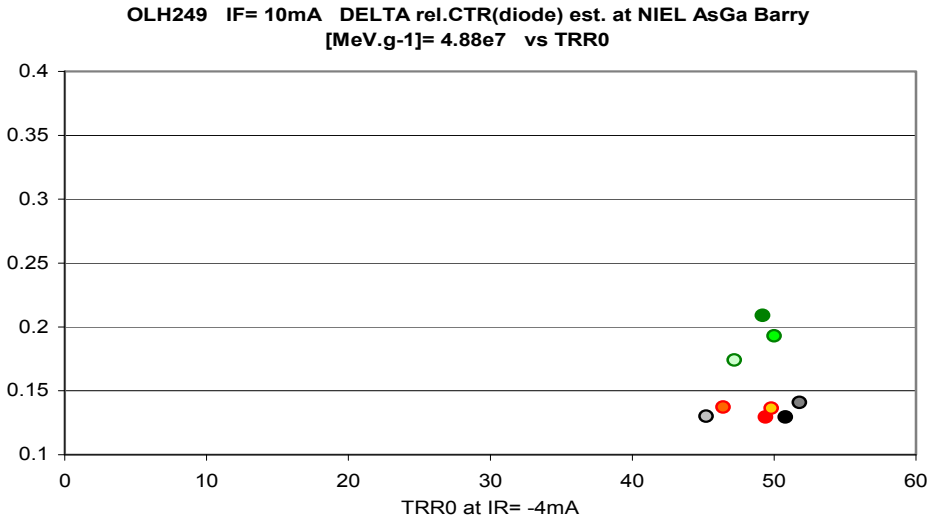
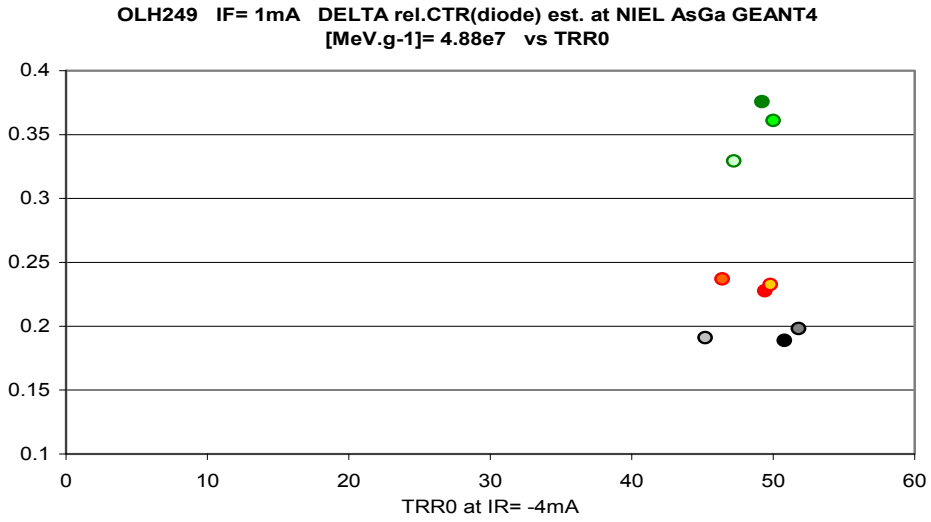
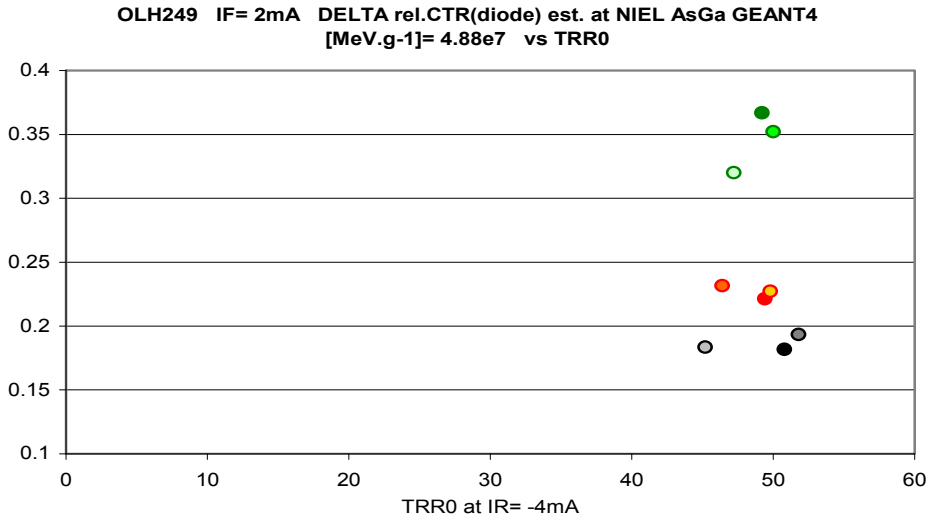
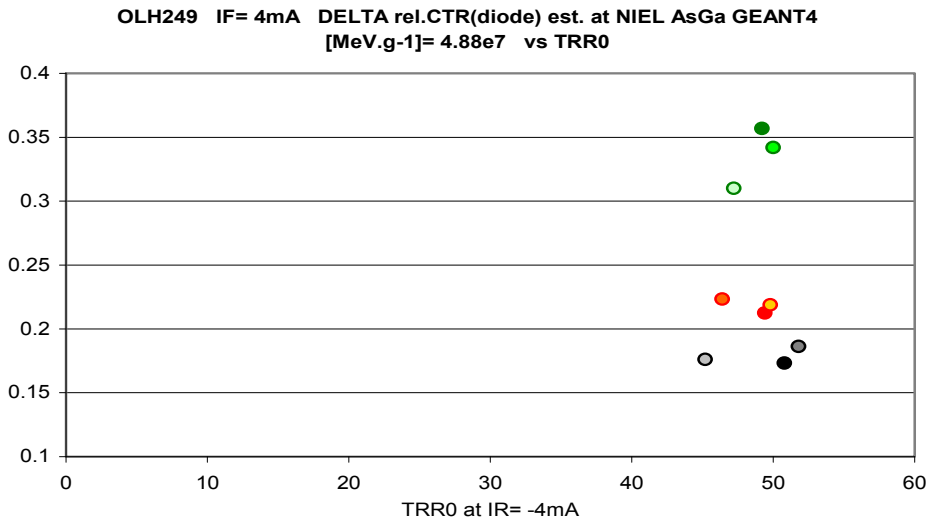
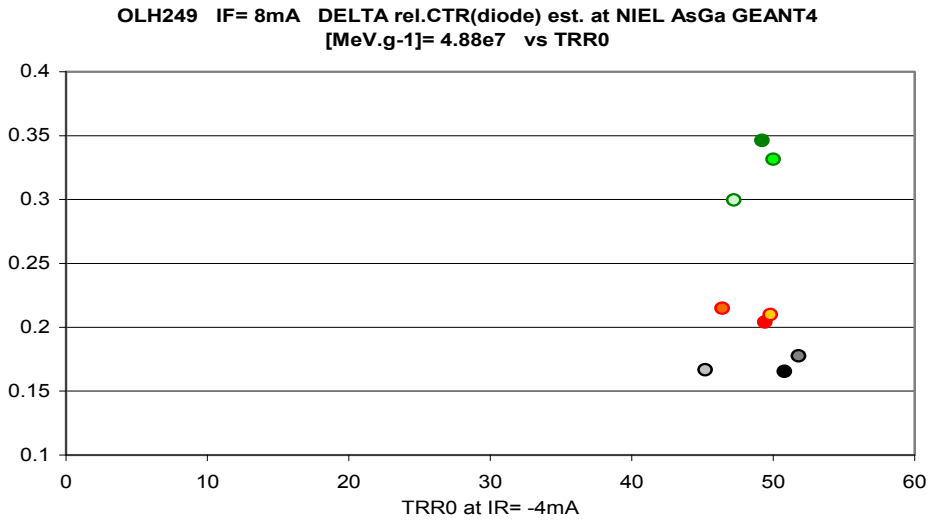

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-47: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

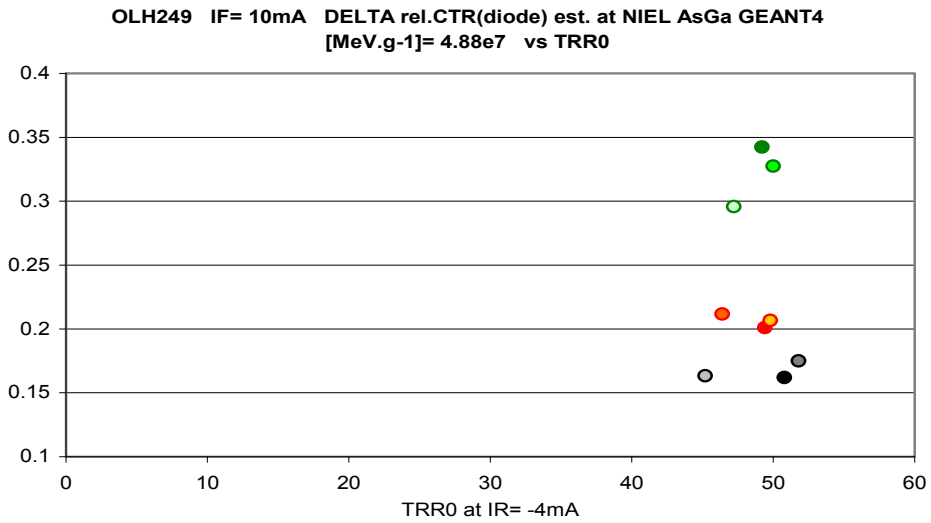
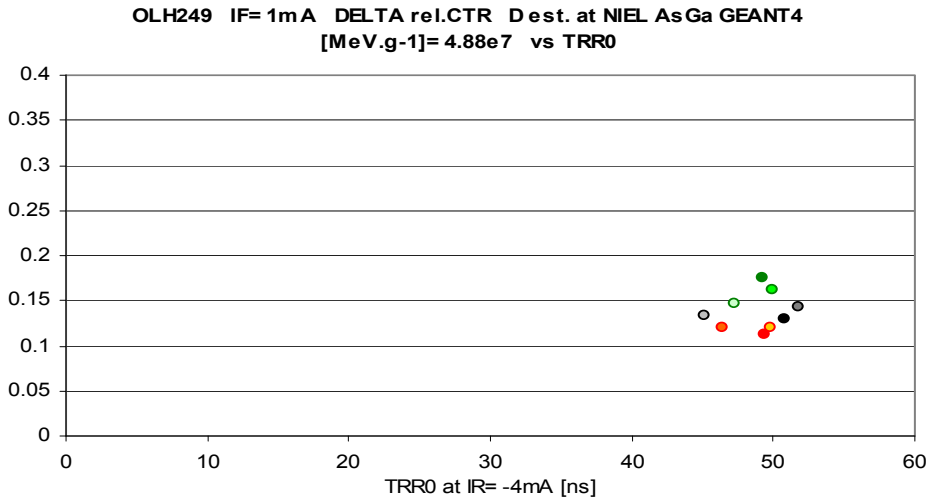
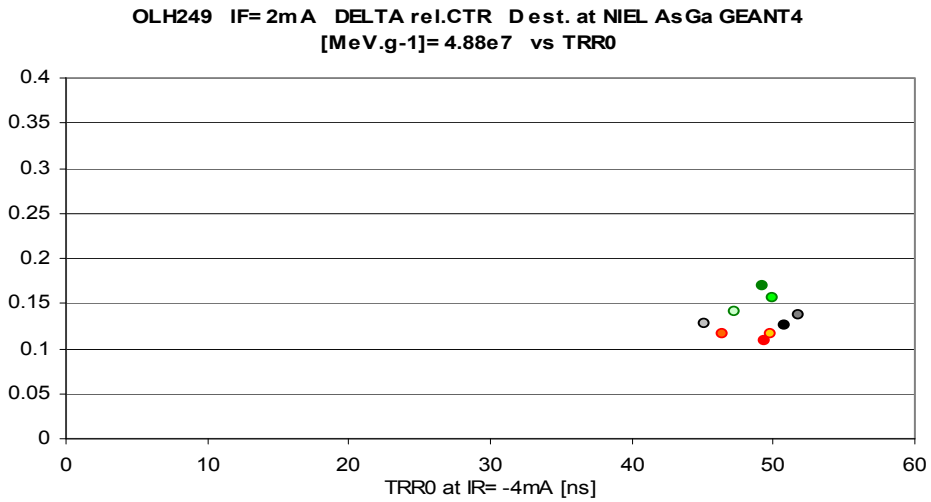
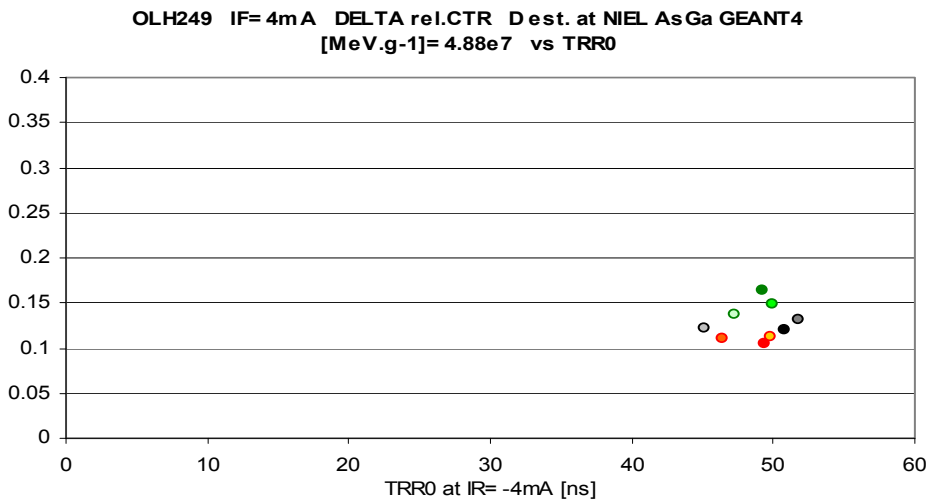
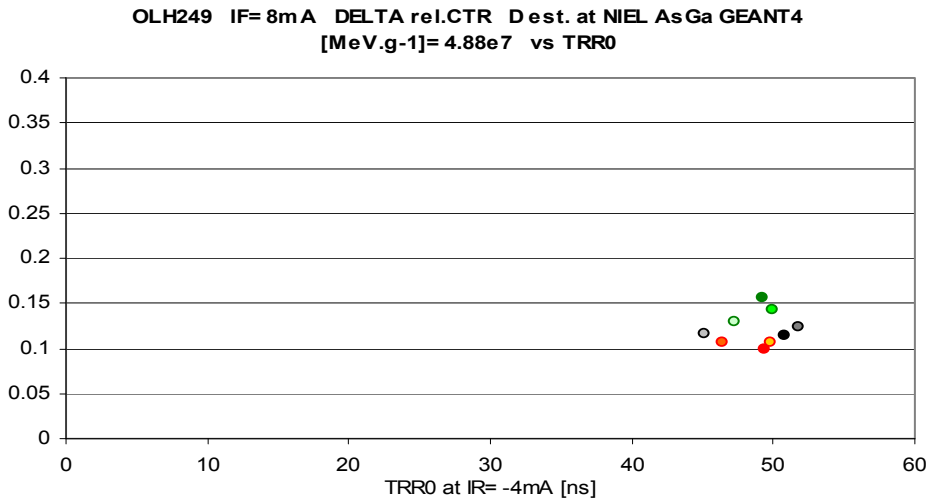

OLH249 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

Fig. 13-48: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

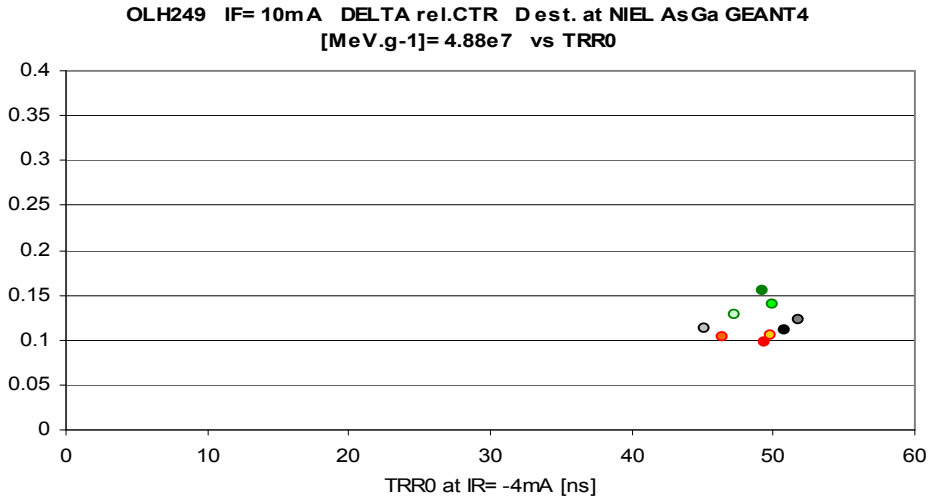
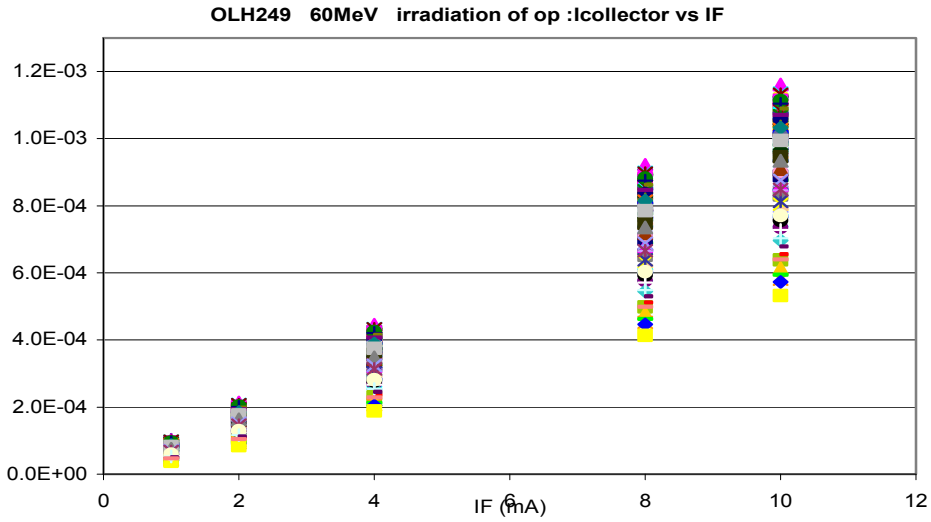
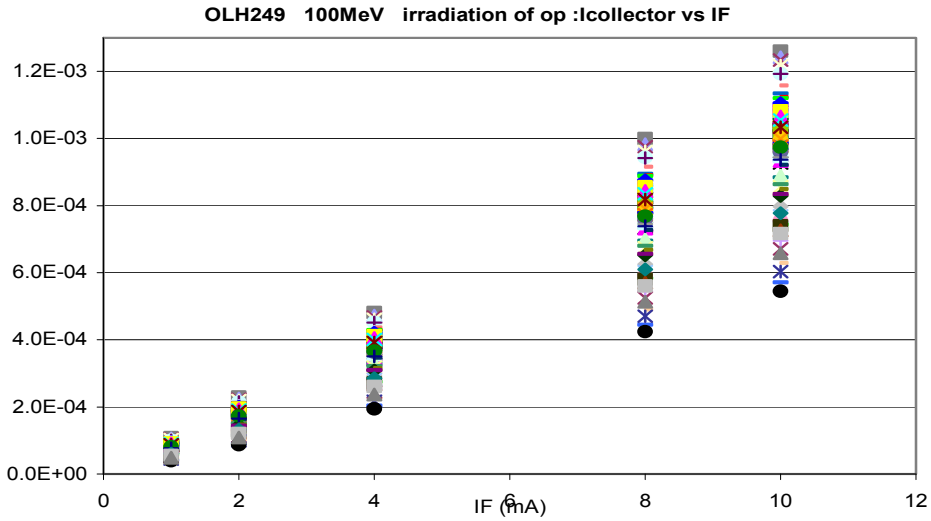

OLH249 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 4.88e7 vs TRR0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-49: optocoupler irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to diode current I_F





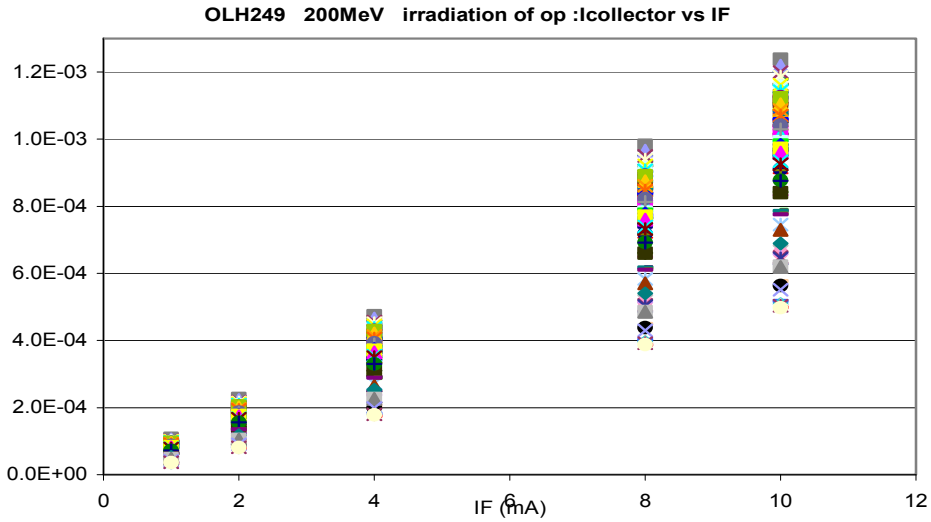
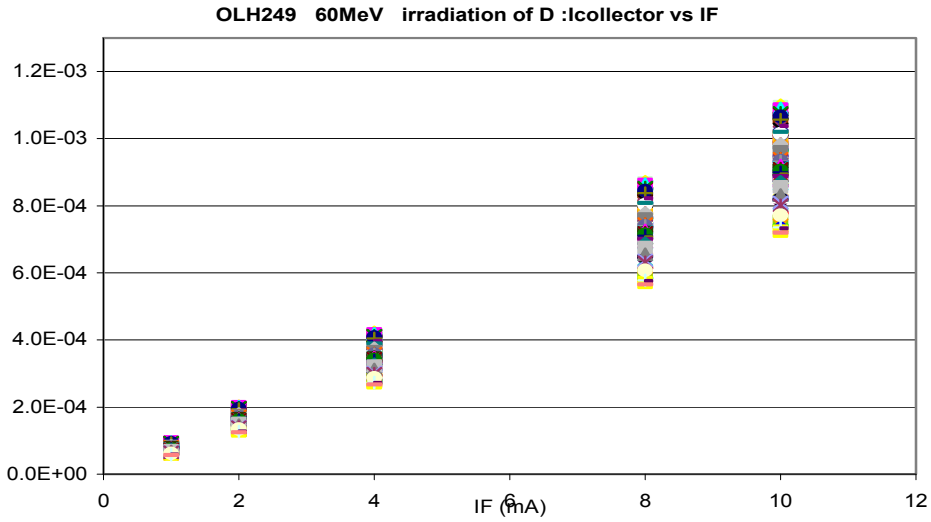
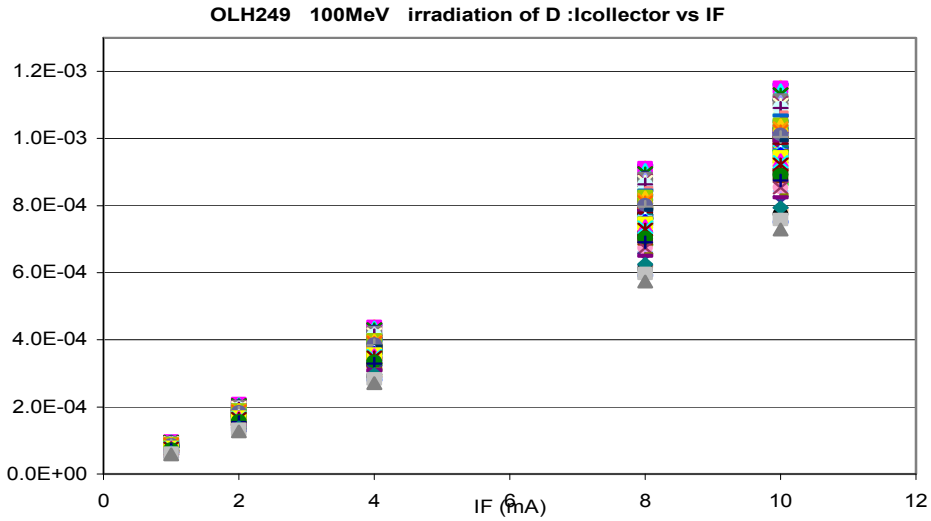


Fig. 13-50: diode irradiated at E=60, 100, 200 MeV: reference transistor collector current I_C for each step with respect to diode current I_F





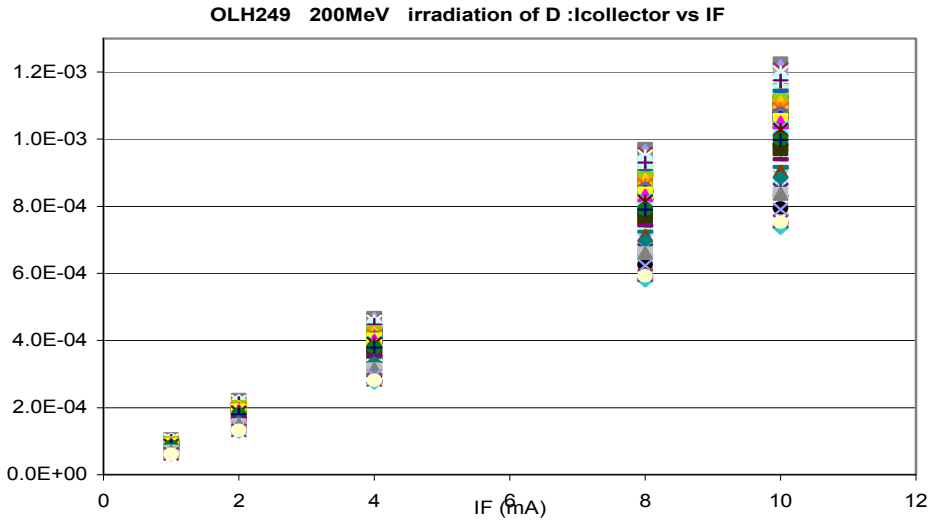


Fig. 13-51: transistor irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to reference diode current I_F

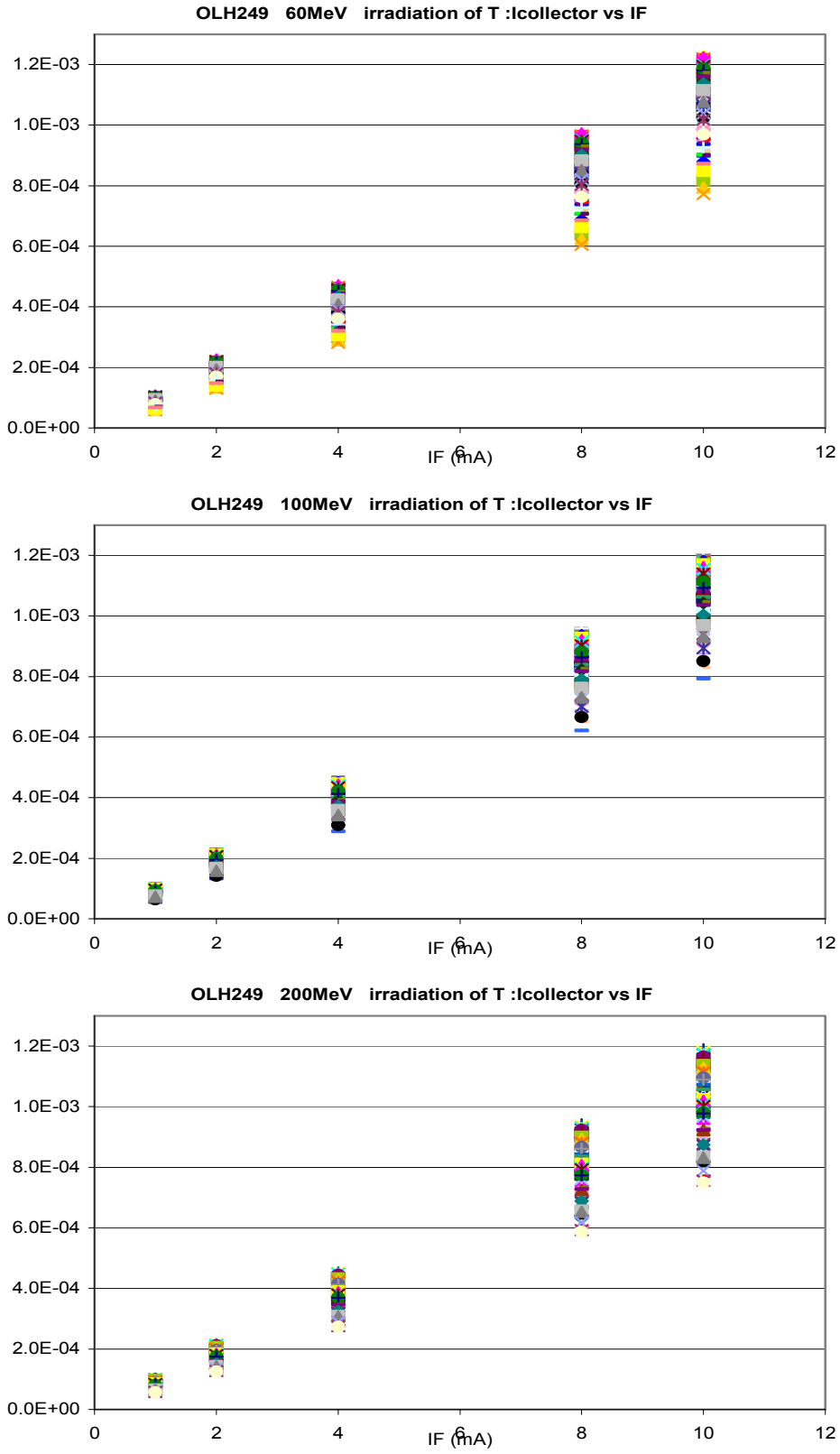


Fig. 13-52: optocoupler irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

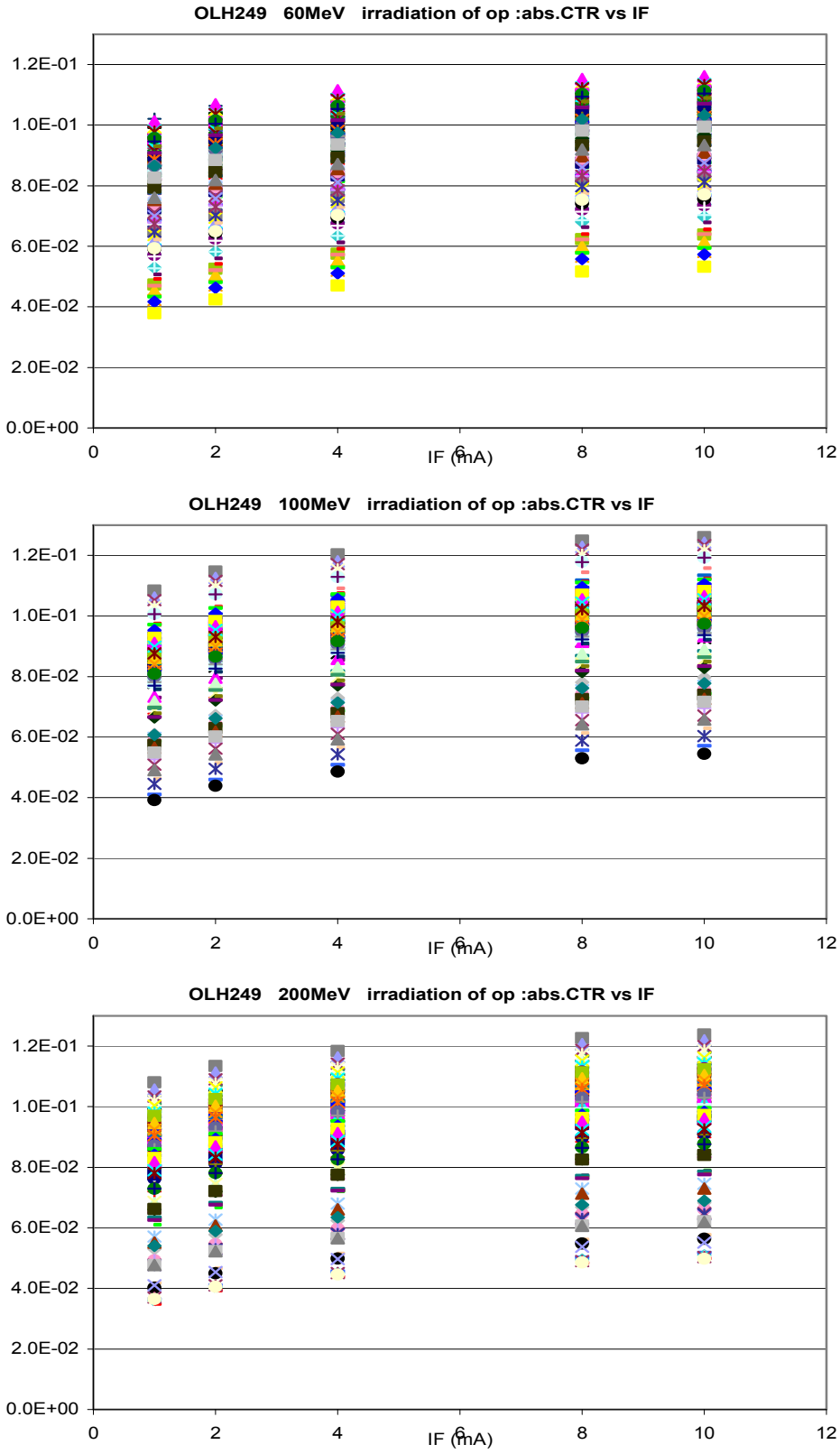


Fig. 13-53: diode irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

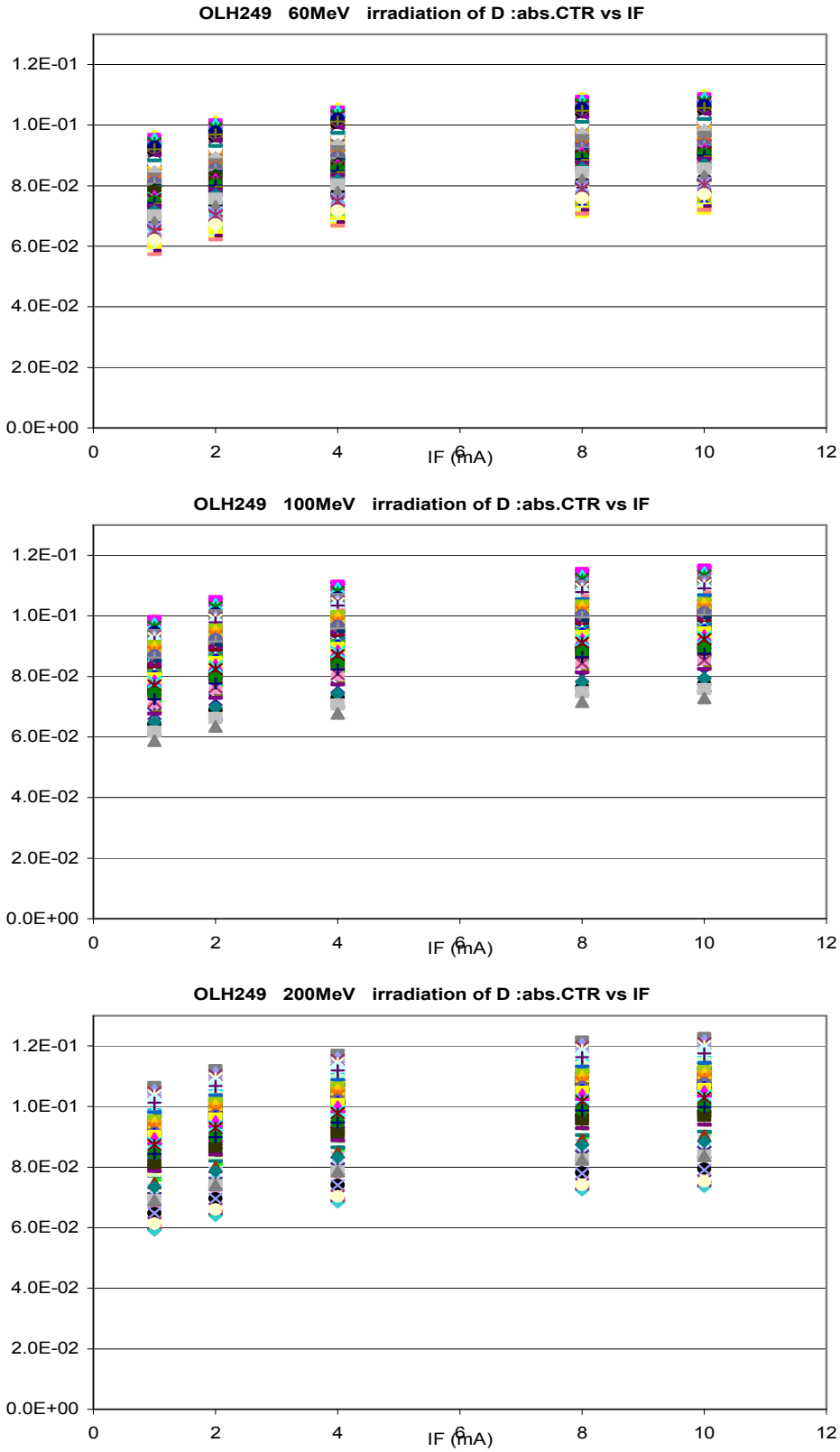


Fig. 13-54: transistor irradiated at E=60, 100, 200 MeV: CTR for each step with respect to reference diode current I_F

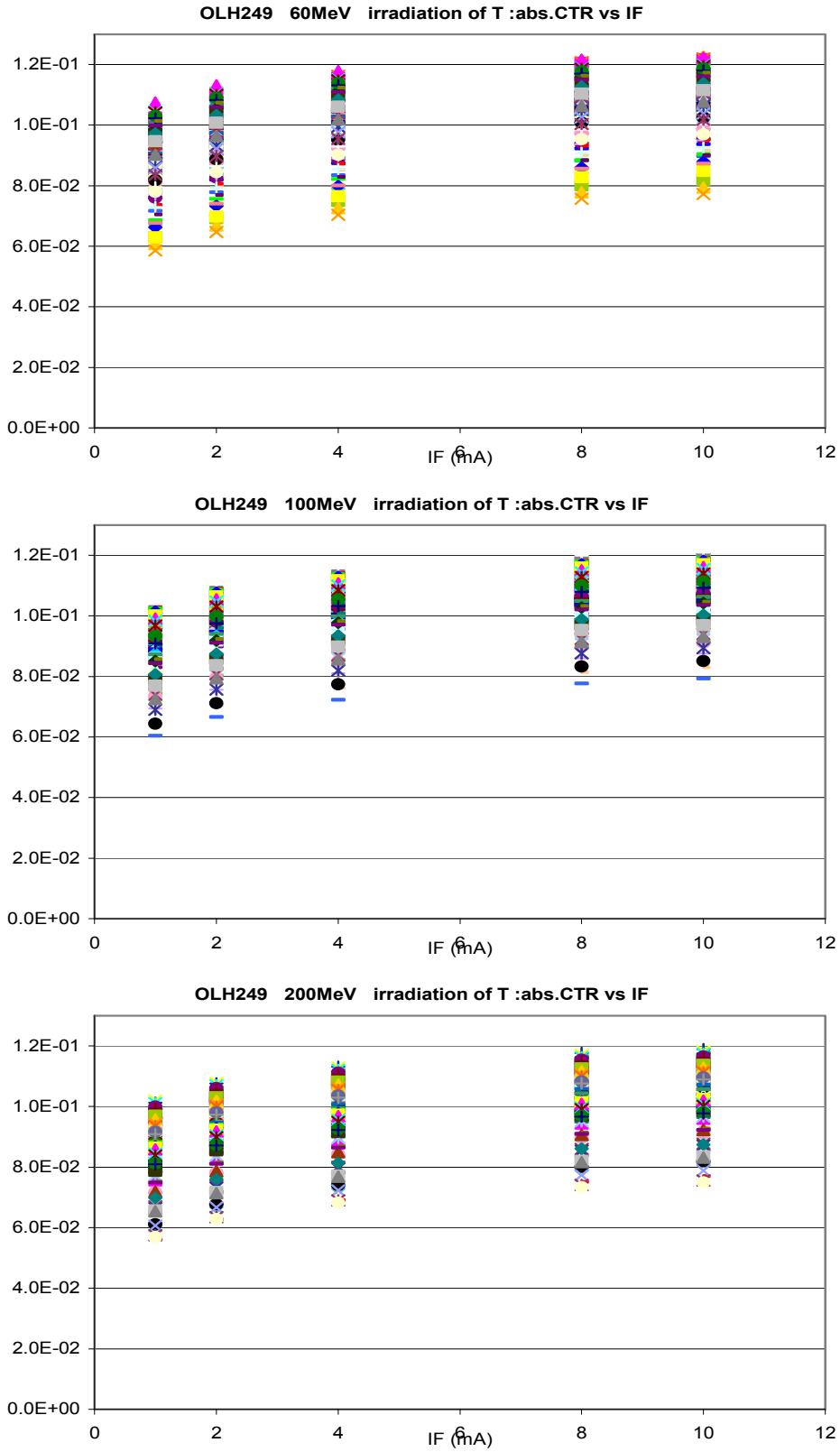


Fig. 13-55: optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

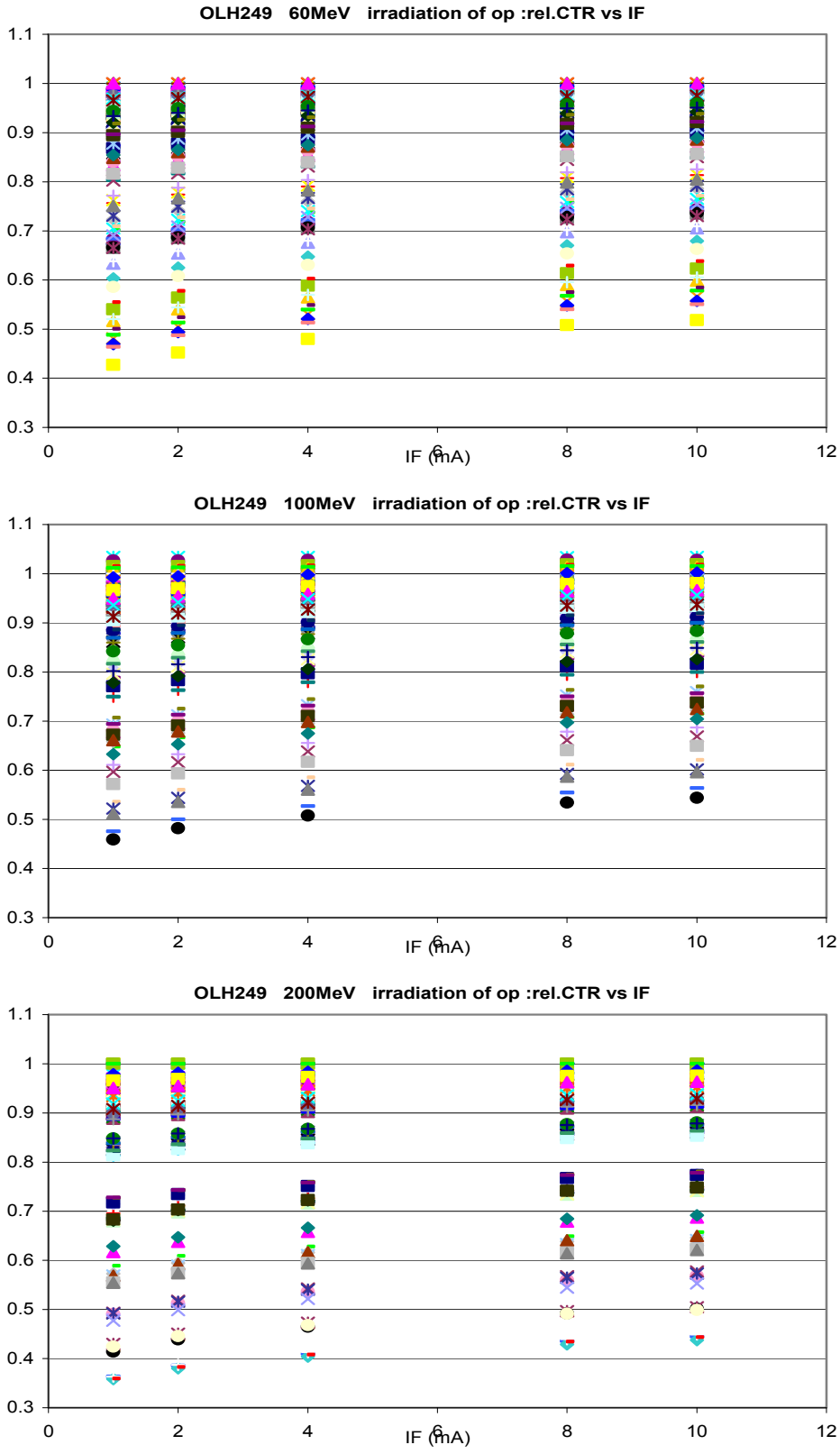


Fig. 13-56: diode irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

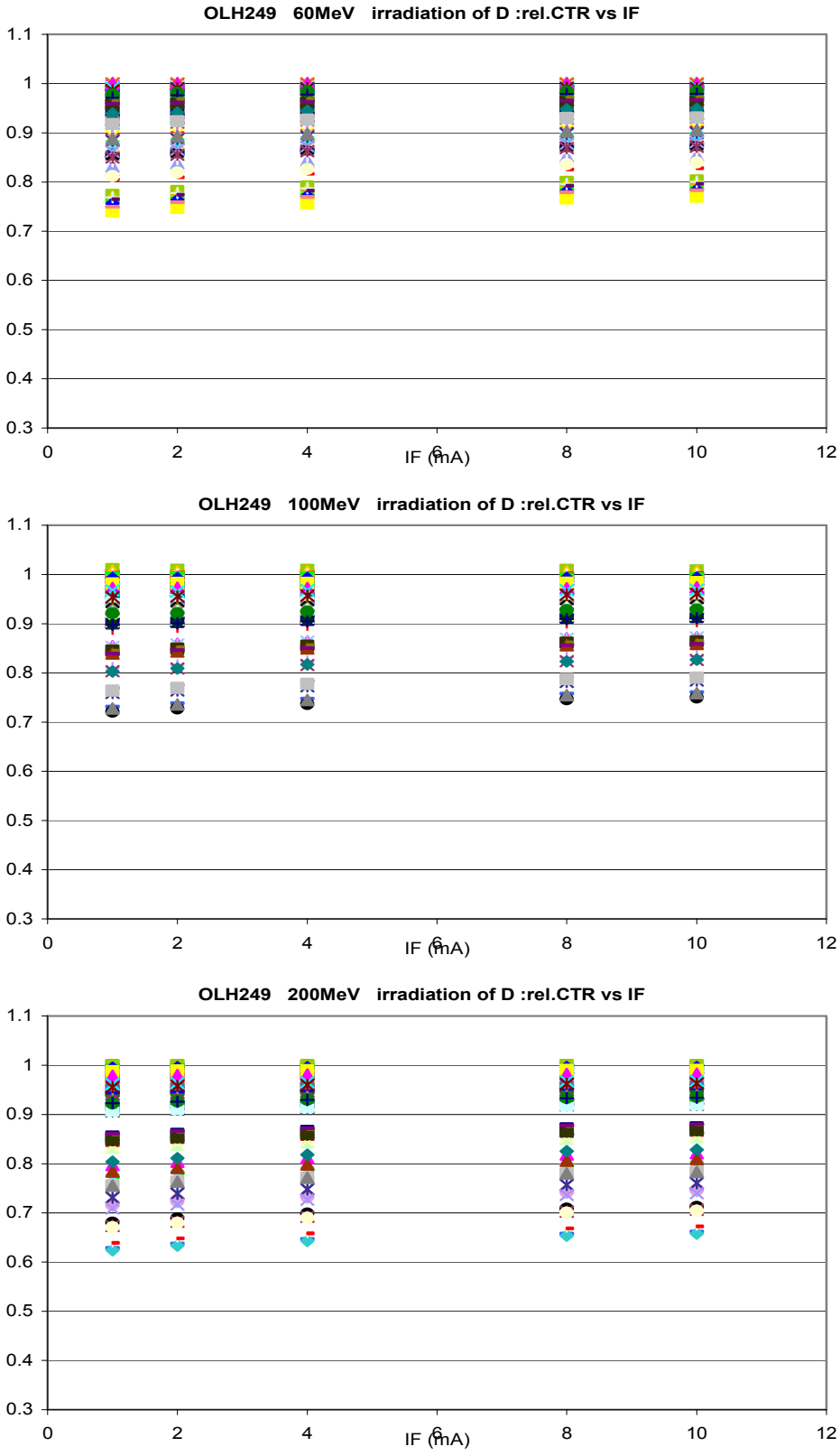


Fig. 13-57: transistor irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to reference diode current I$_F$

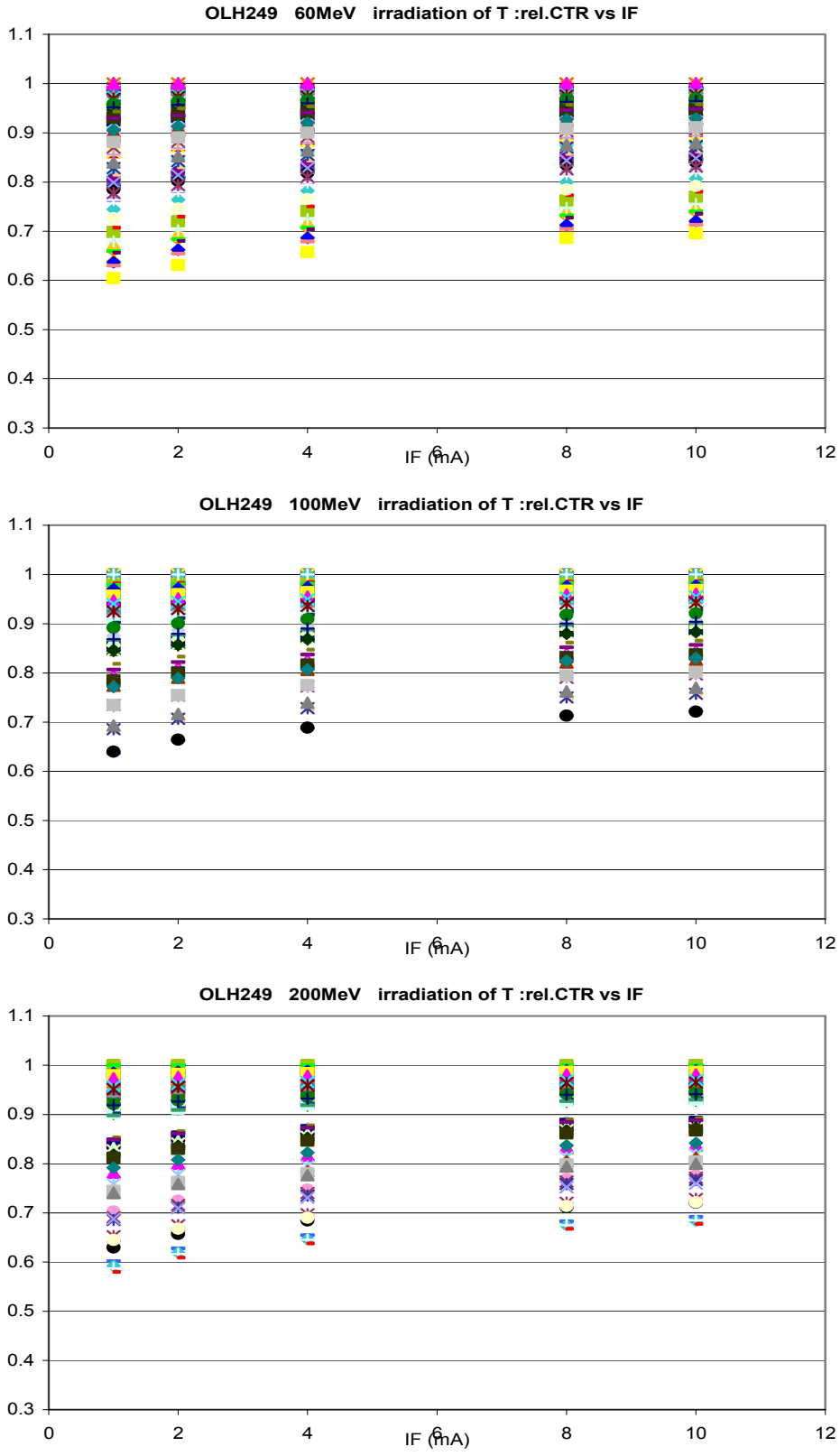
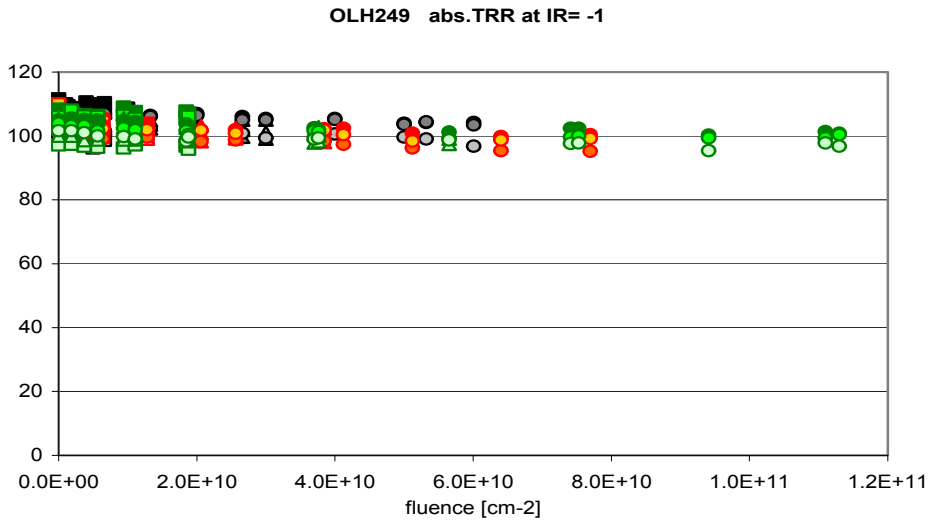
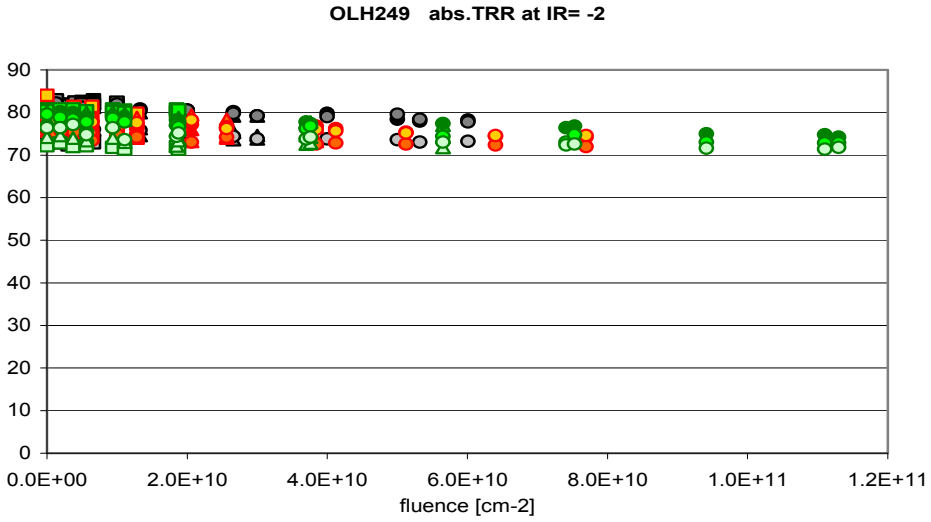


Fig. 13-58: OLH249 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA





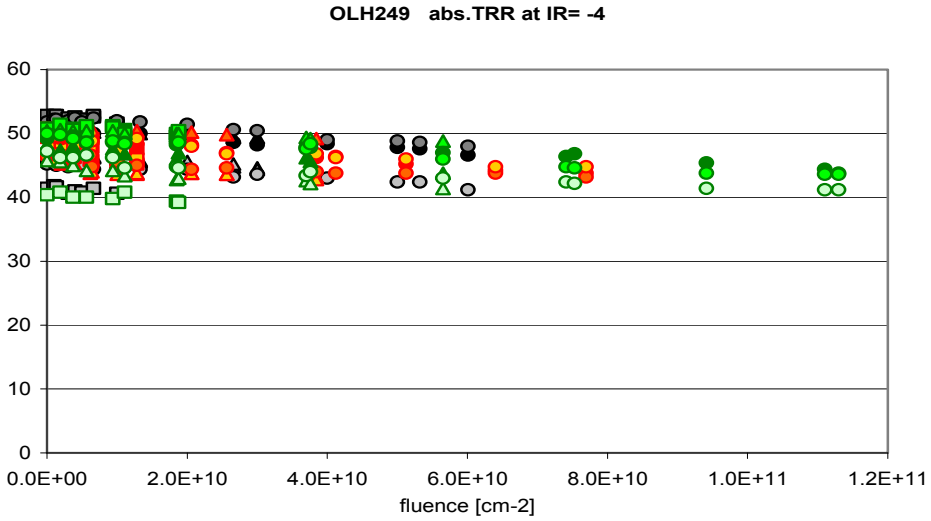
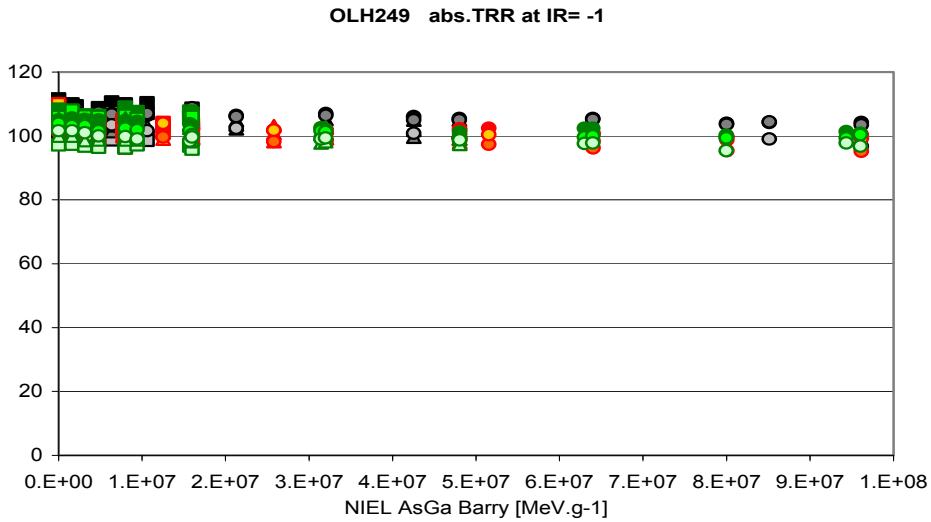
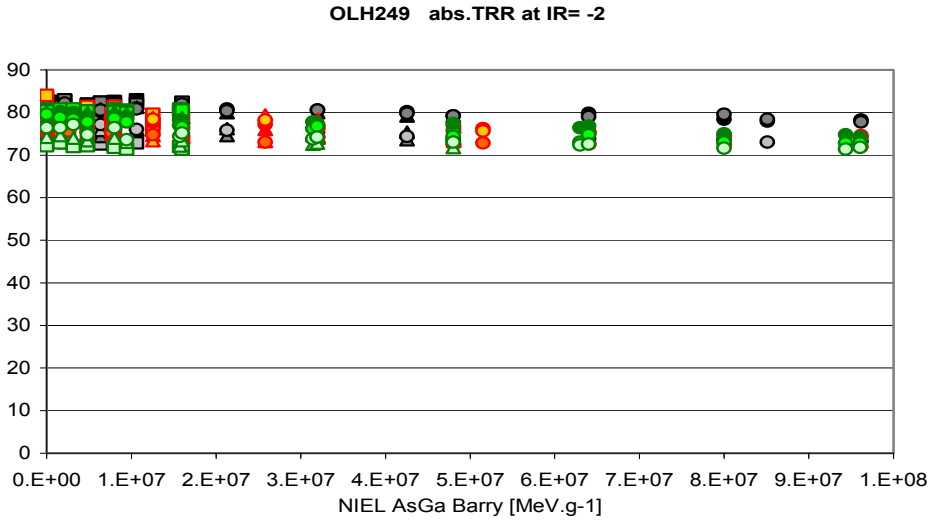


Fig. 13-59: OLH249 diode: τ_{RR} [ns] with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





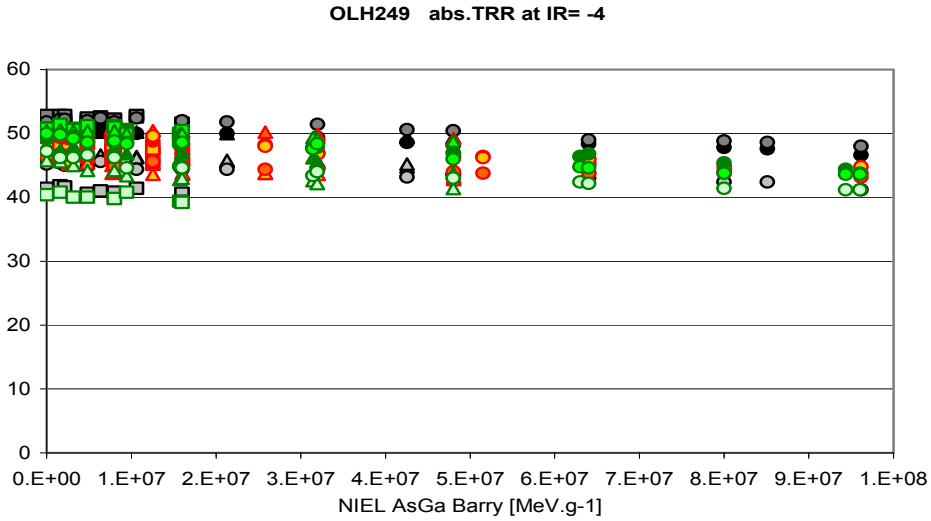
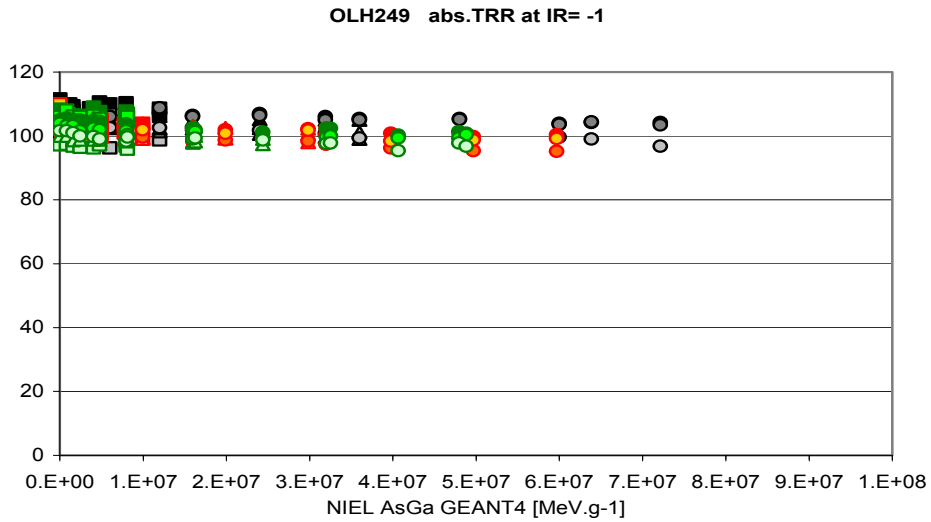
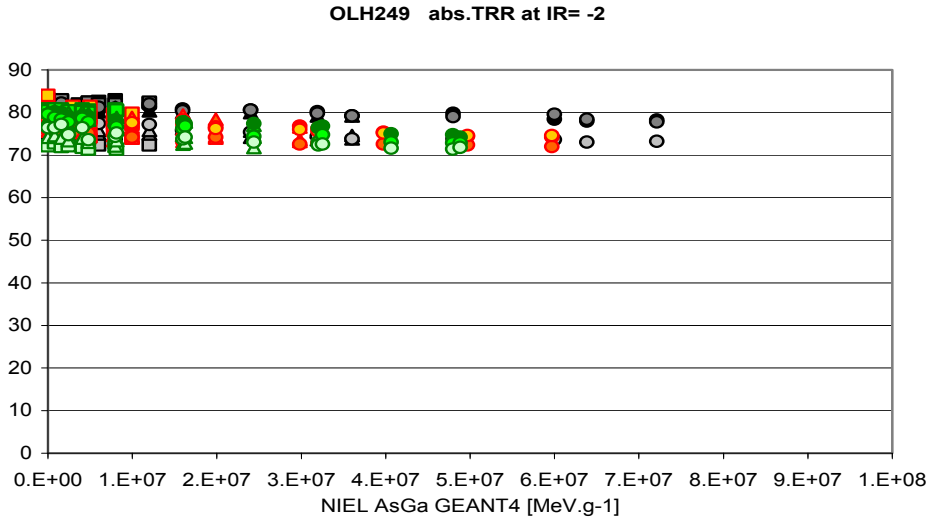


Fig. 13-60: OLH249 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





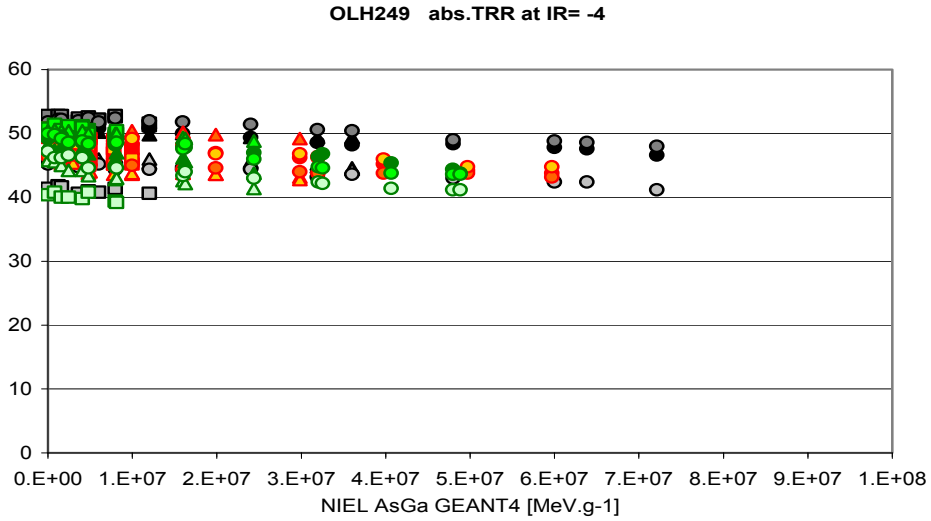
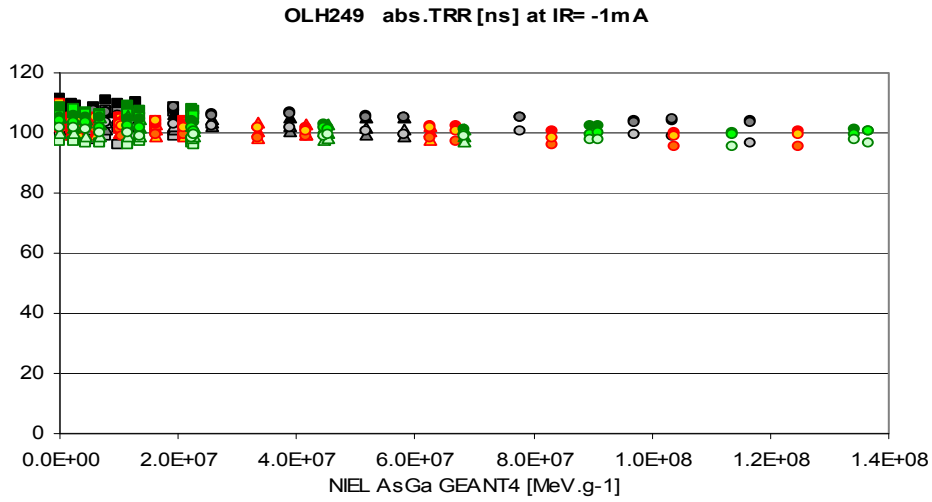
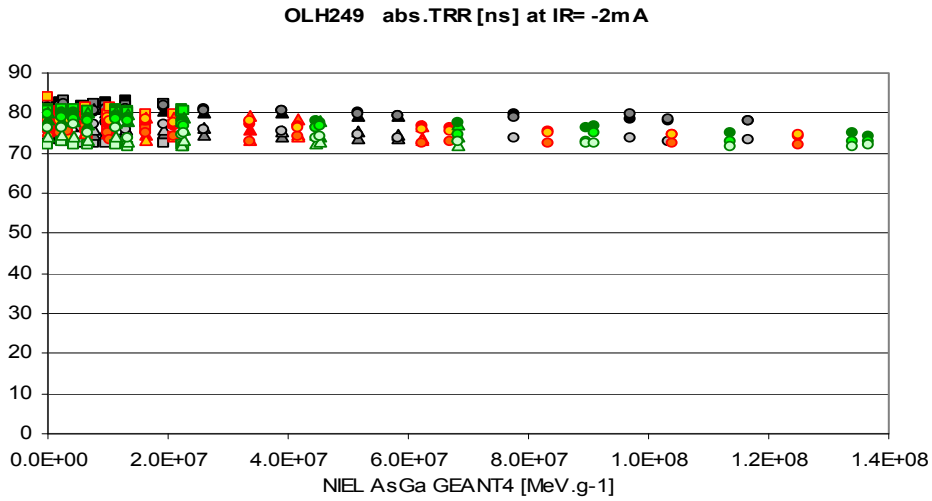


Fig. 13-61: OLH249 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





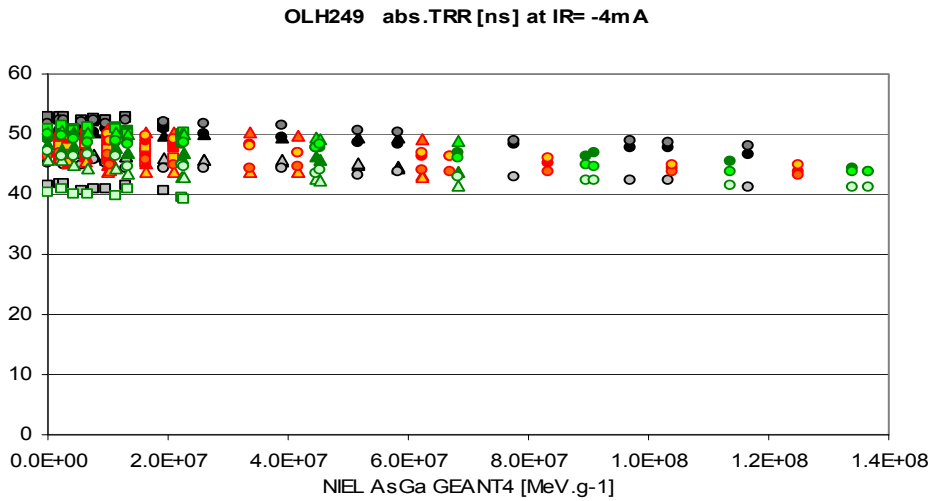


Fig. 13-62: OLH249 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA

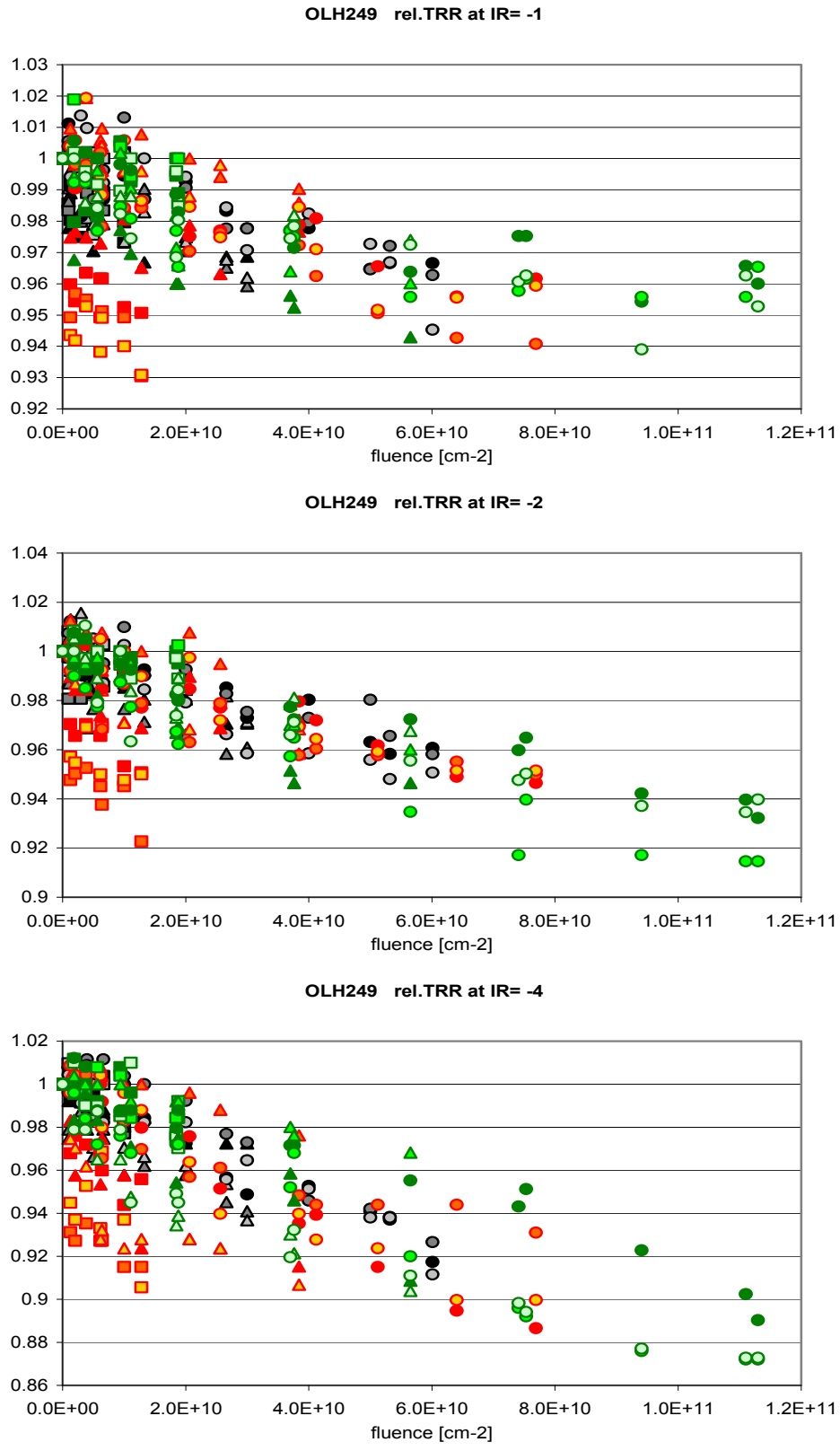
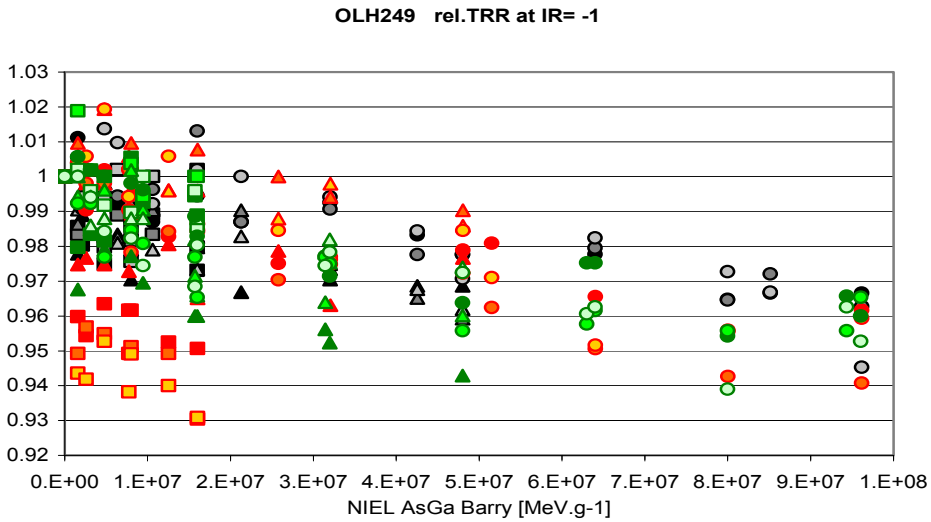
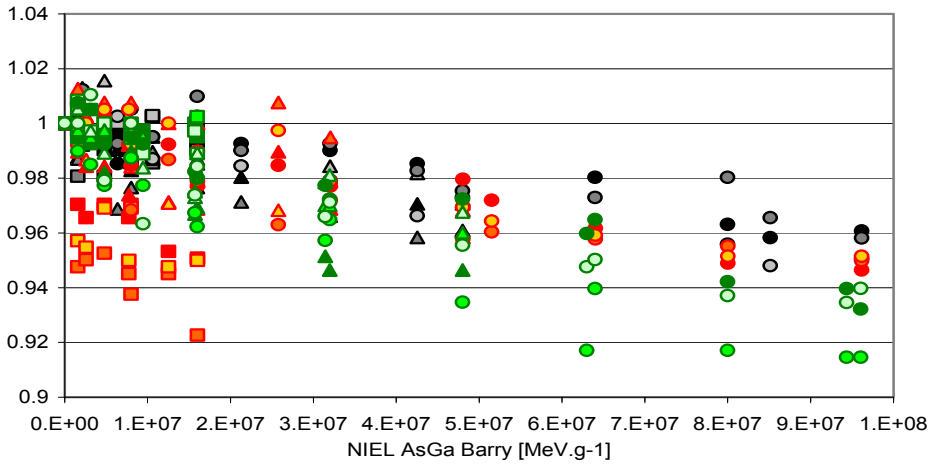


Fig. 13-63: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





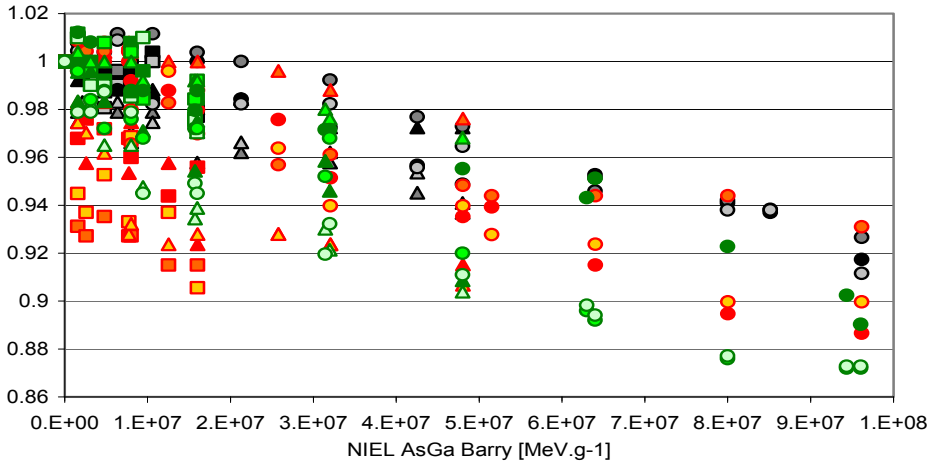


Fig. 13-64: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA

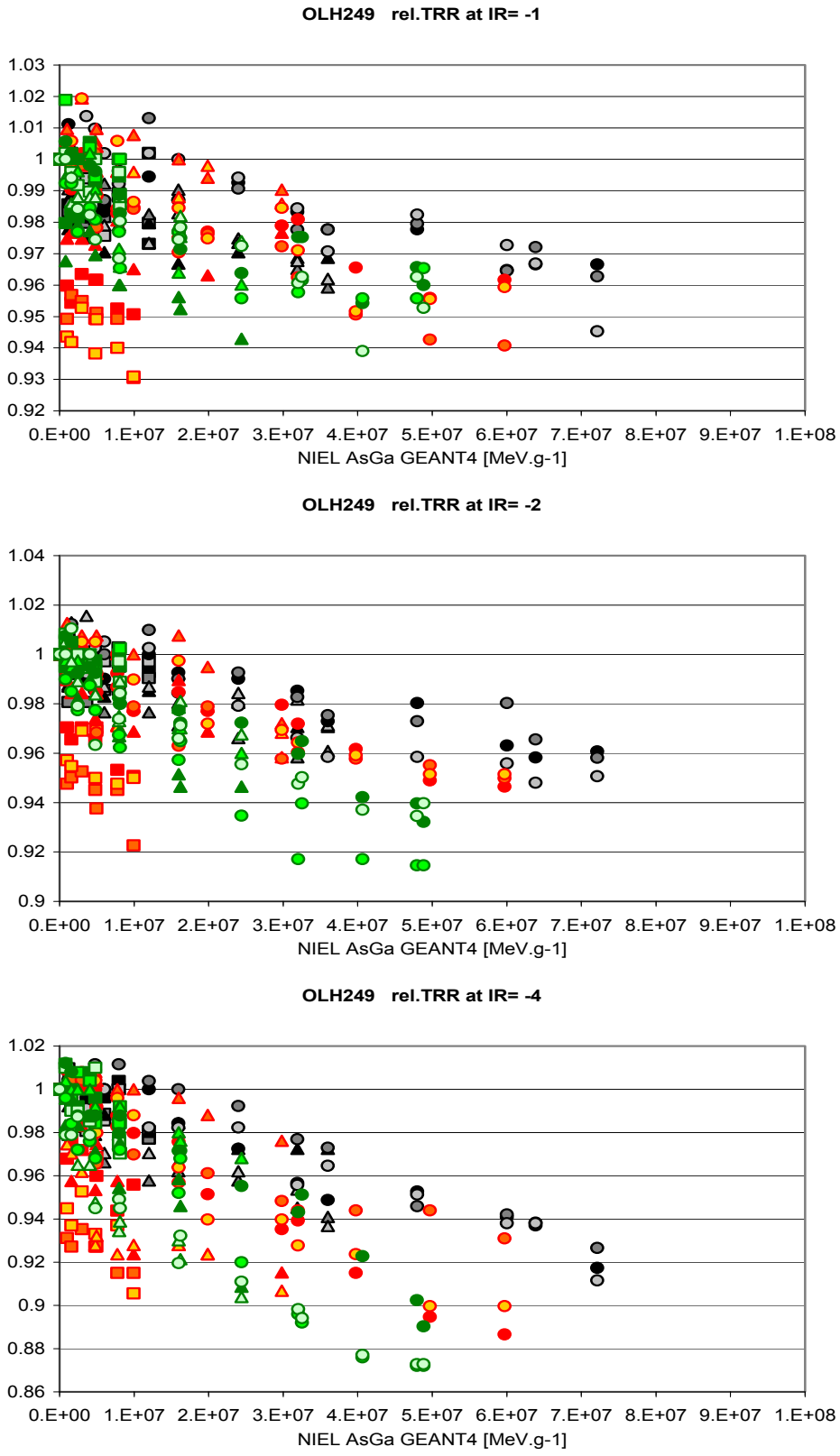
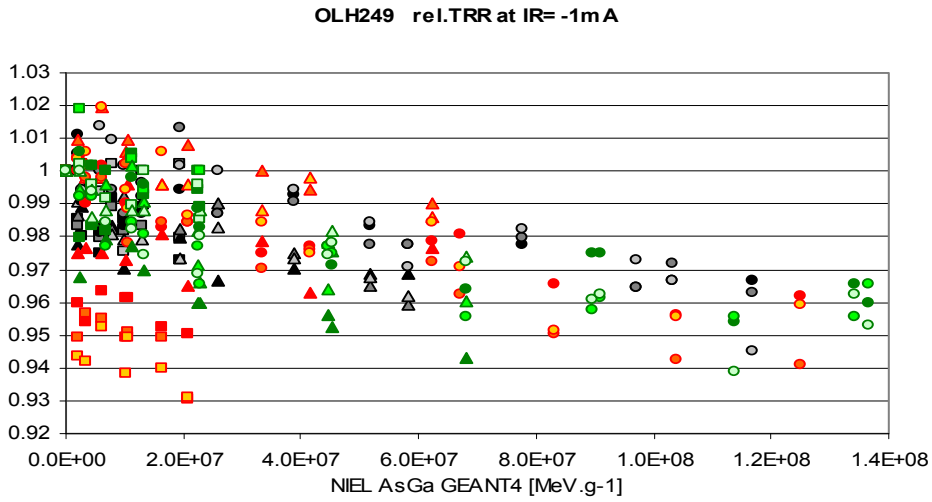
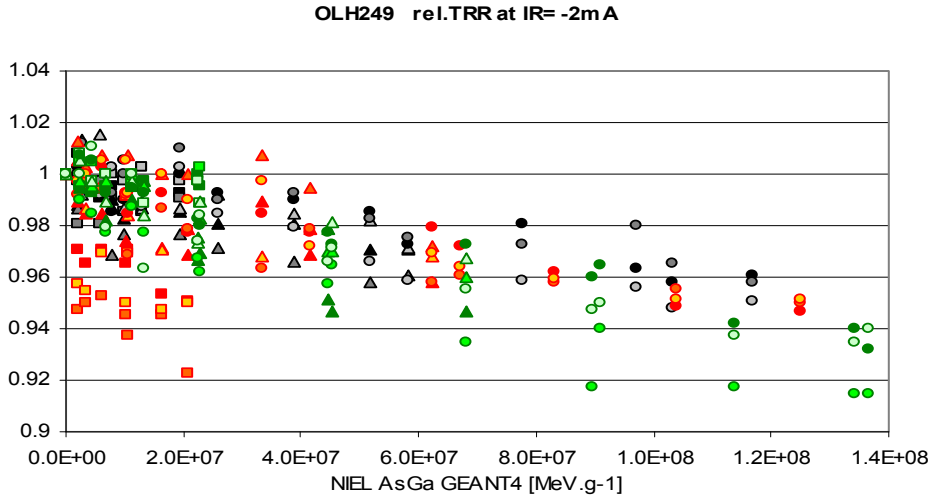


Fig. 13-65: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





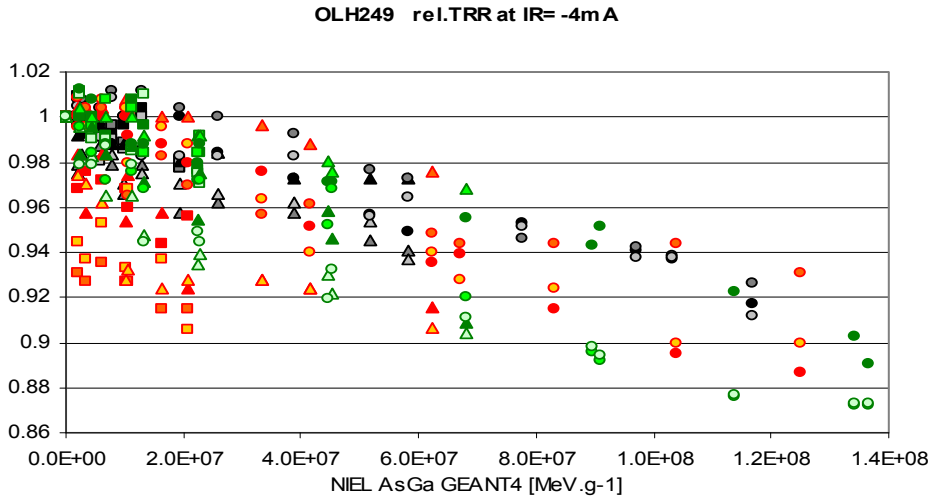
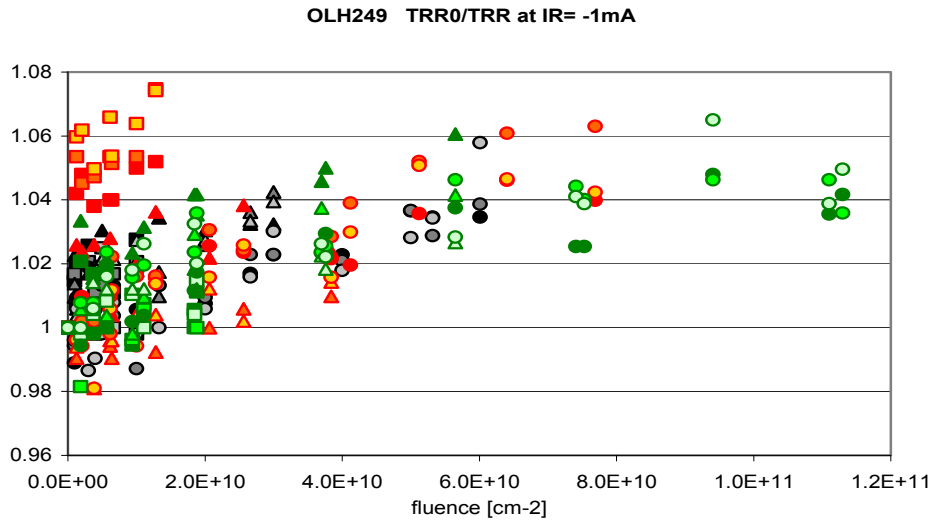
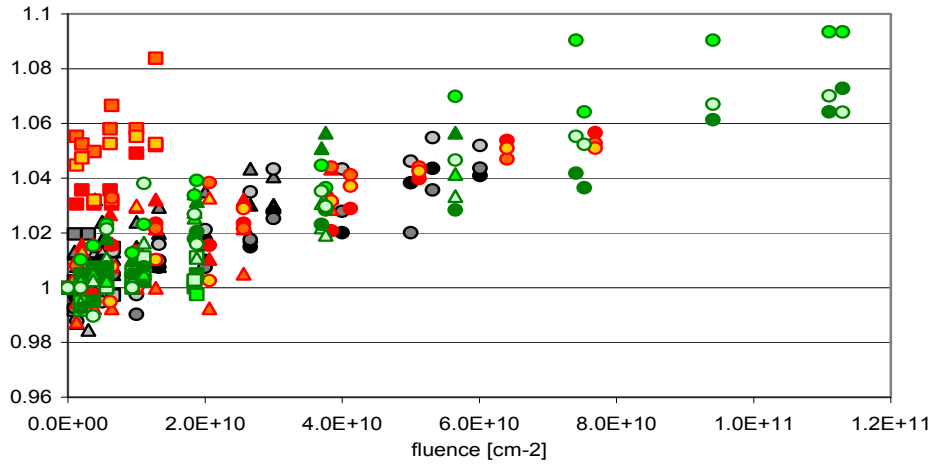


Fig. 13-66: OLH249 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





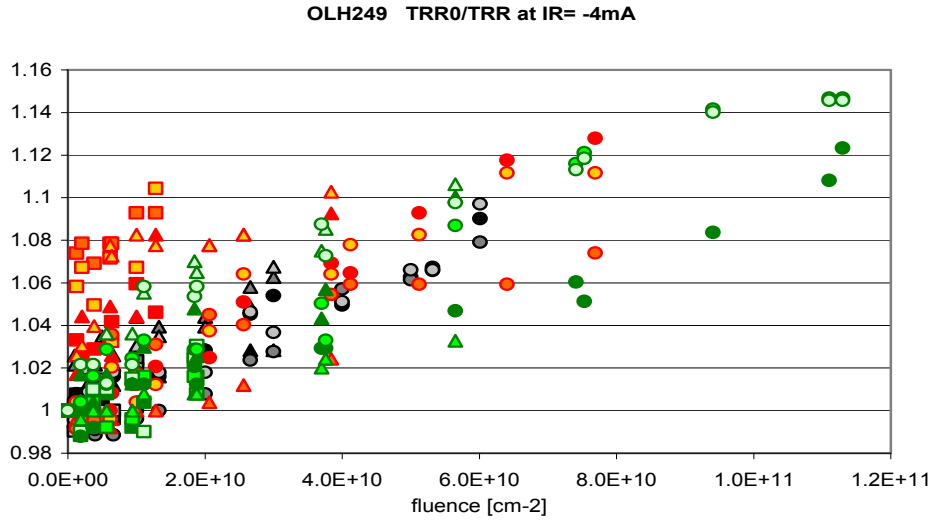
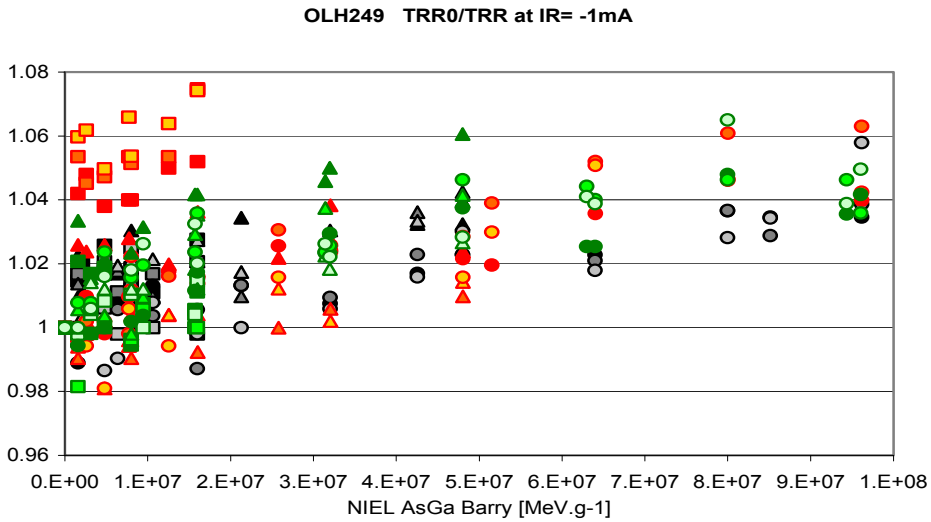
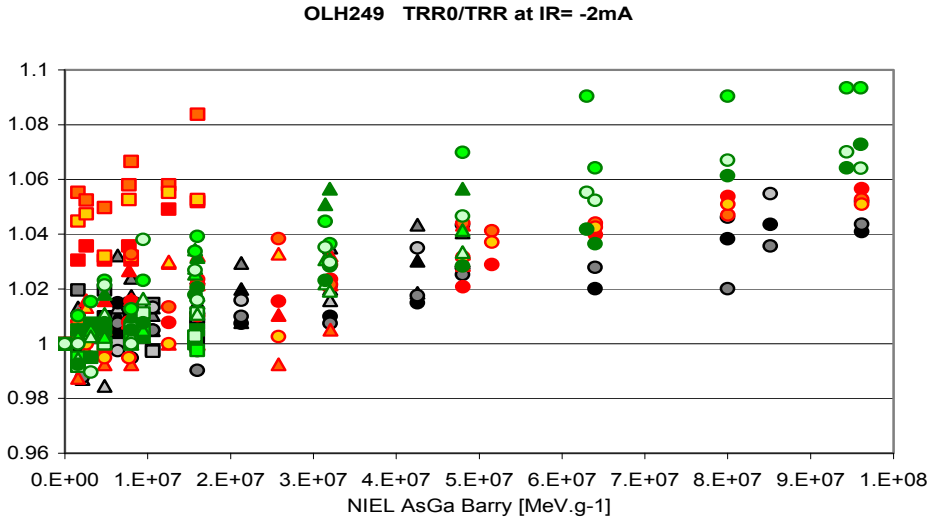


Fig. 13-67: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





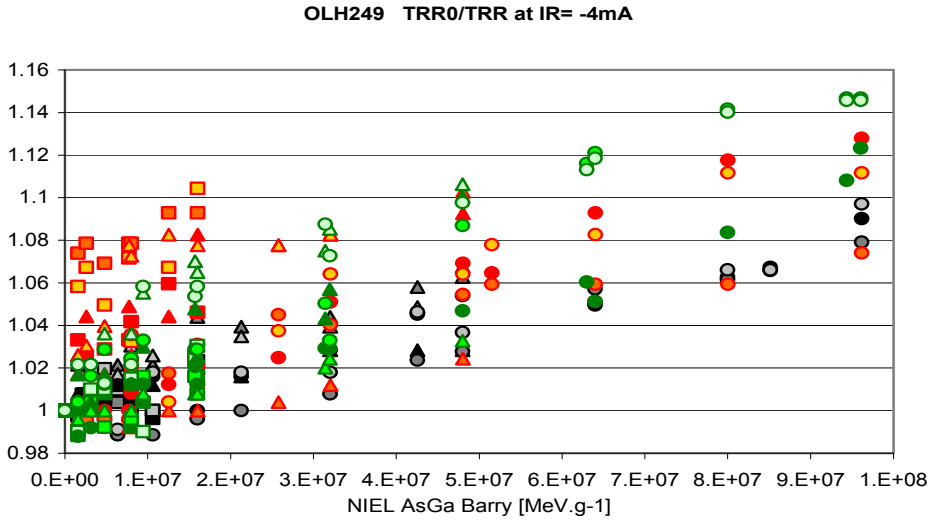
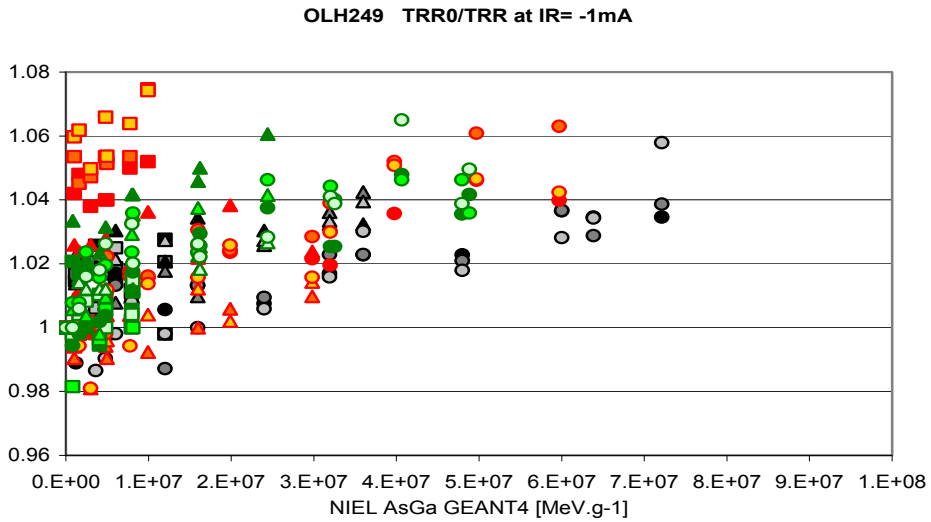
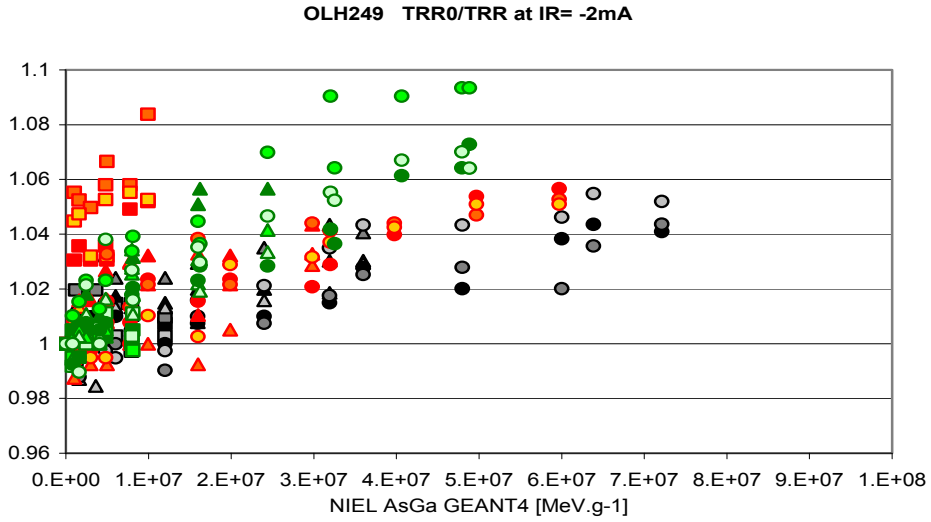


Fig. 13-68: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





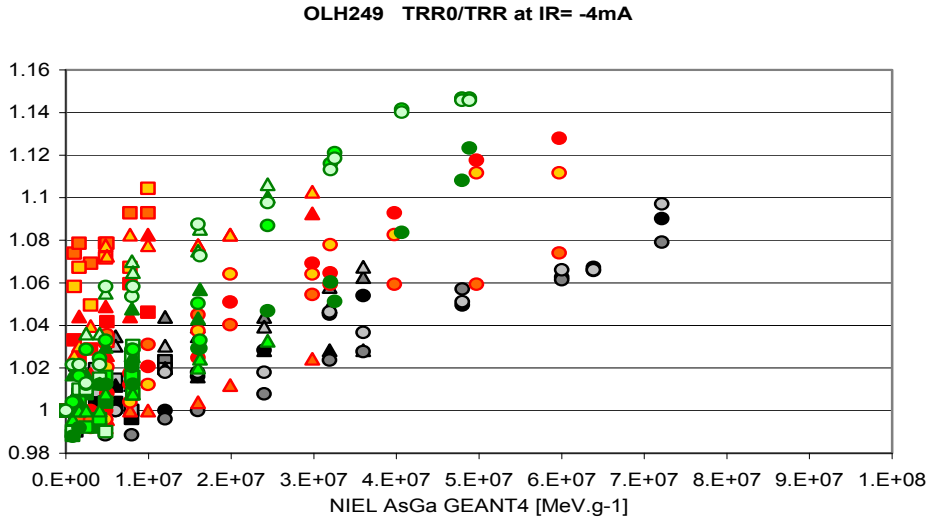
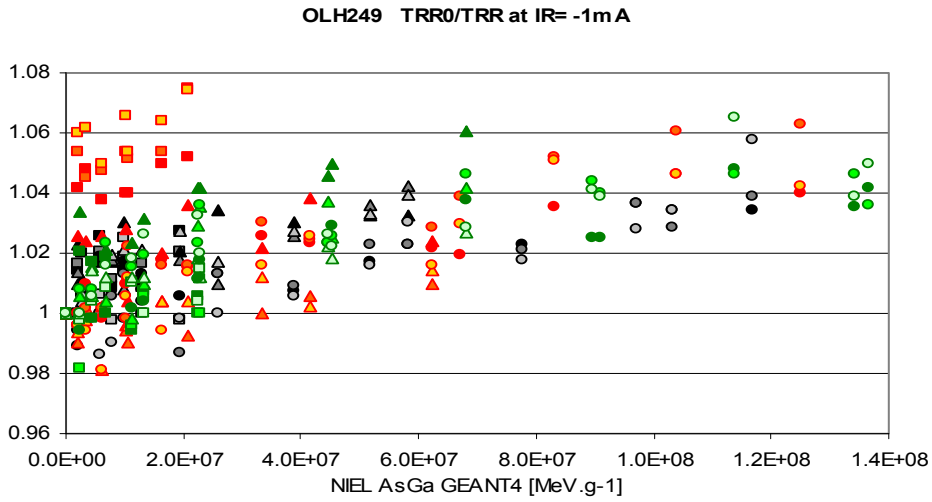
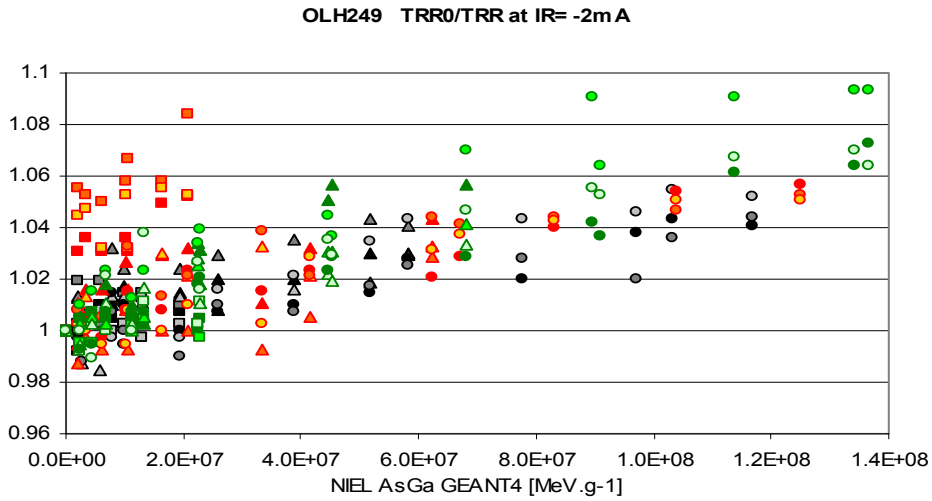


Fig. 13-69: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





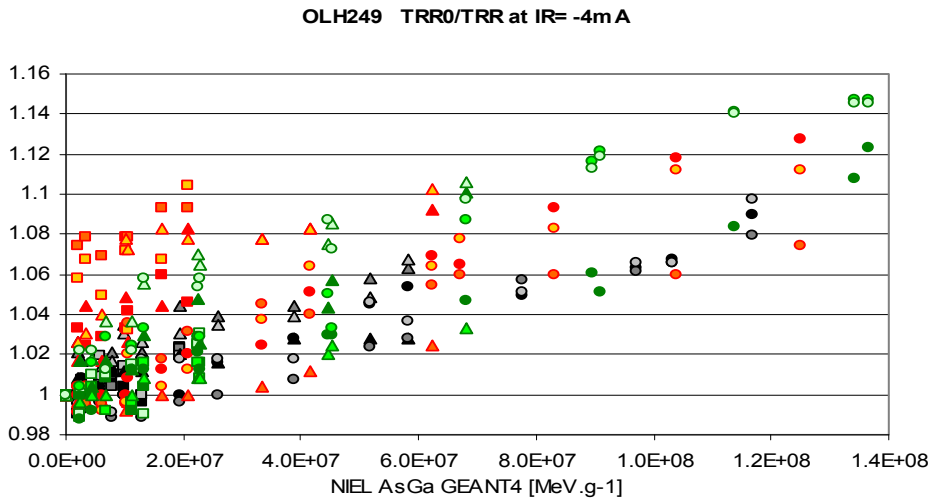


Fig. 13-70: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 1.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4 mA

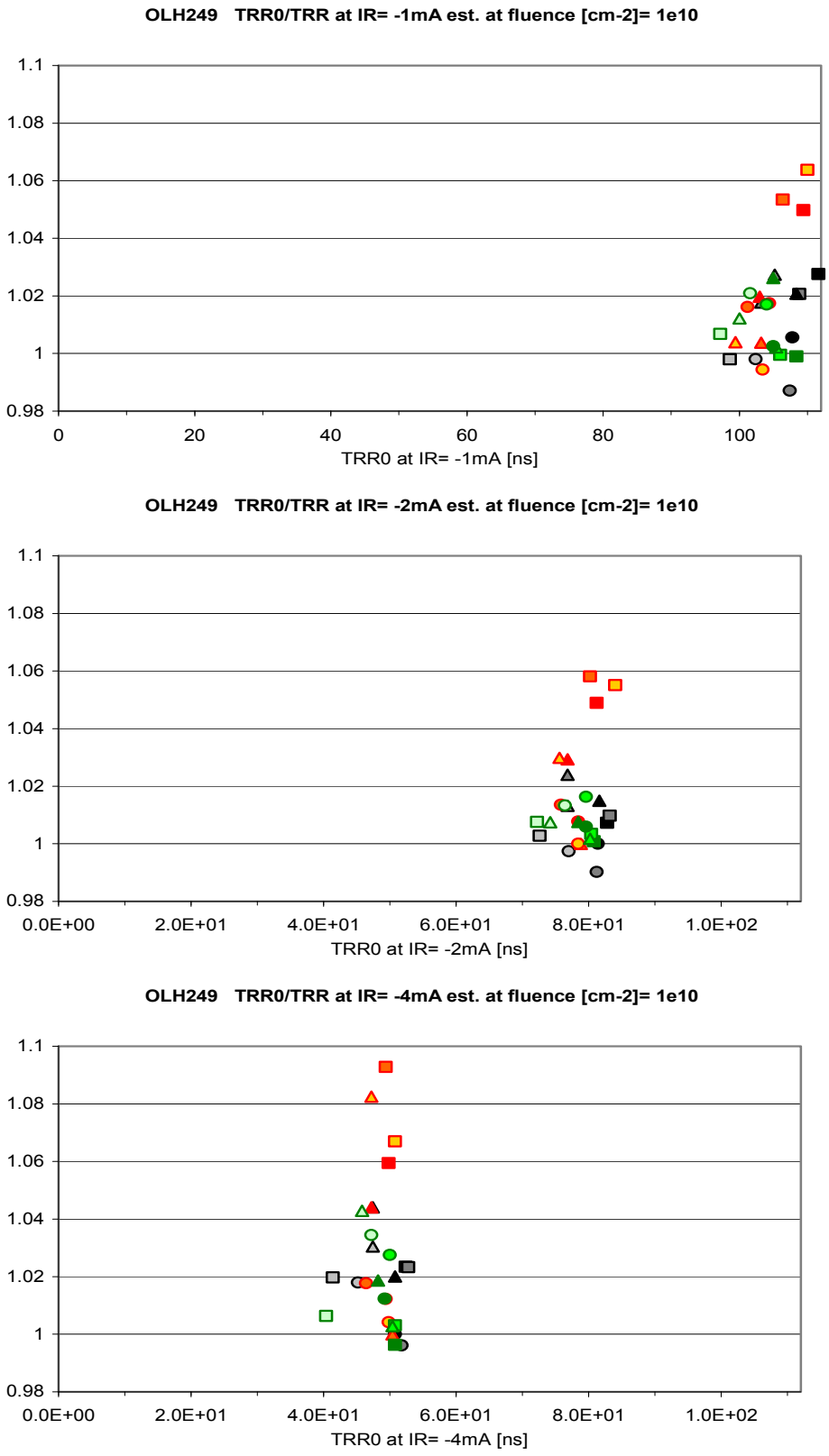
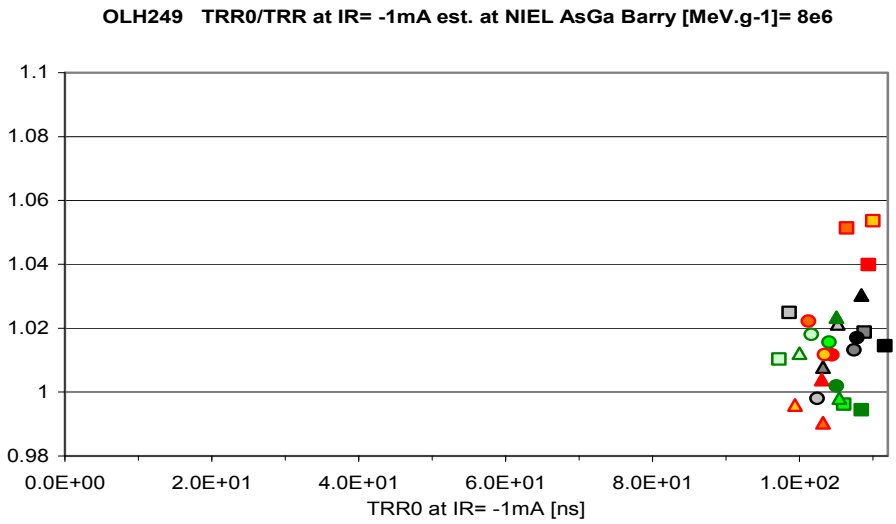
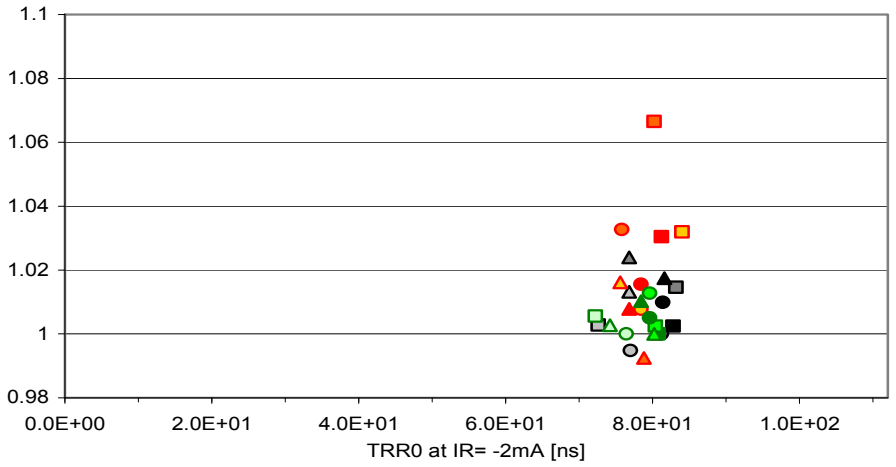


Fig. 13-71: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





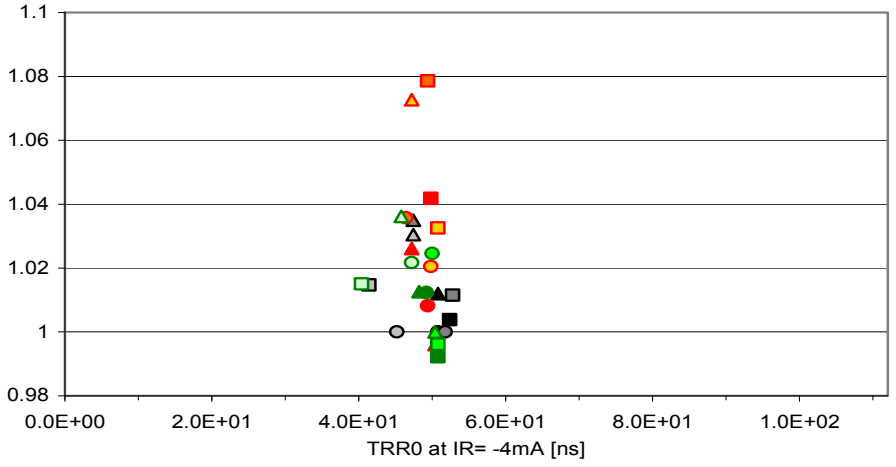


Fig. 13-72: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

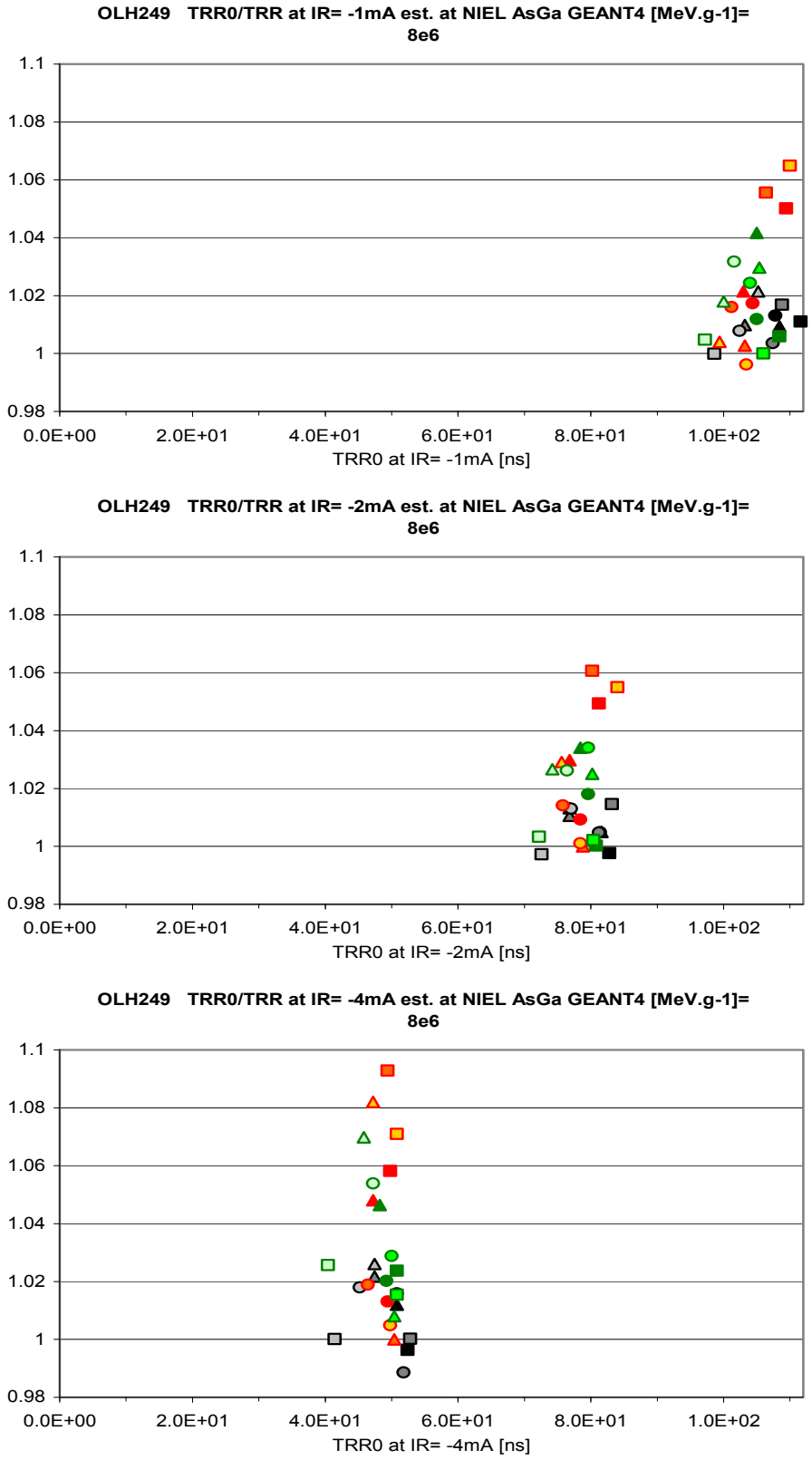
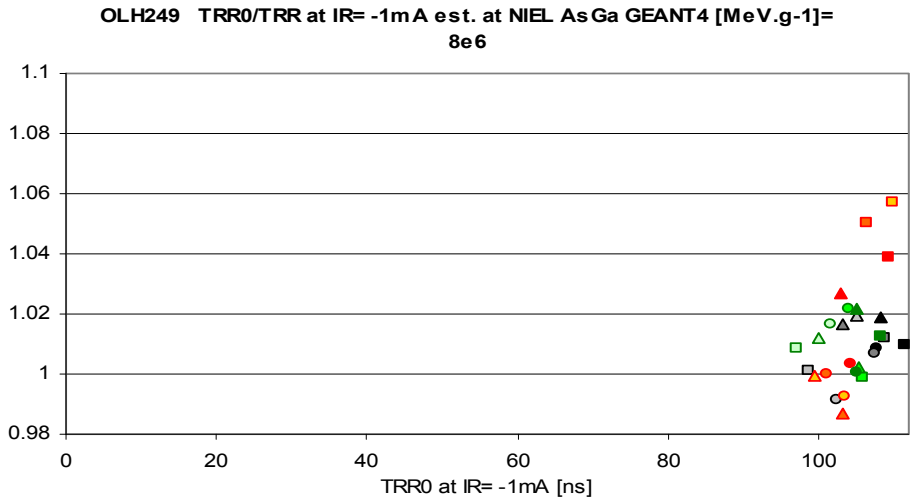
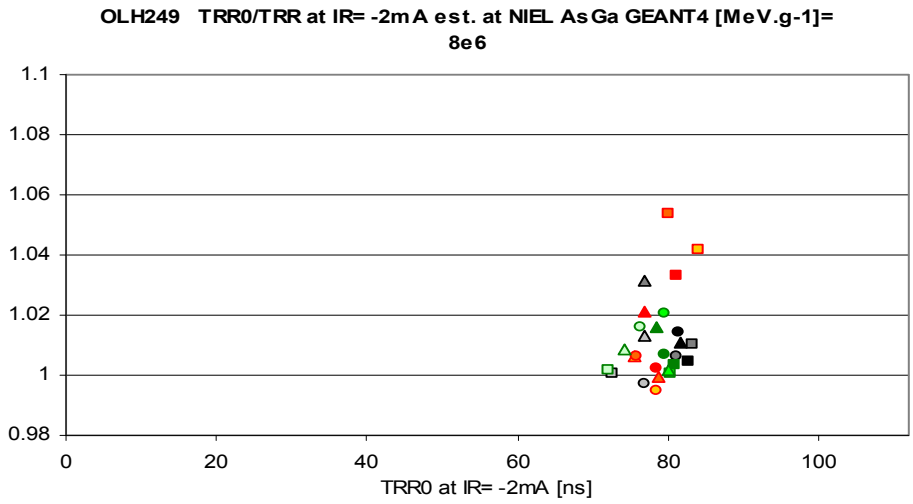


Fig. 13-73: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





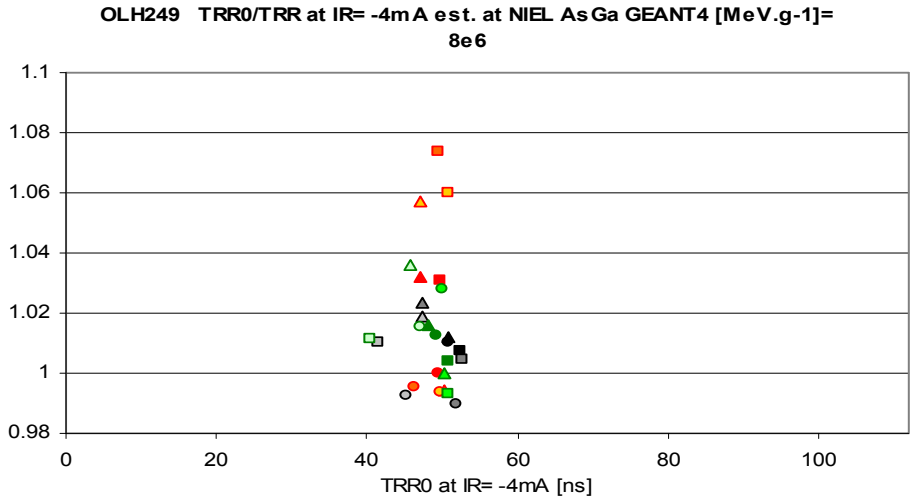


Fig. 13-74: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of $2.4.10^{10}$ cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

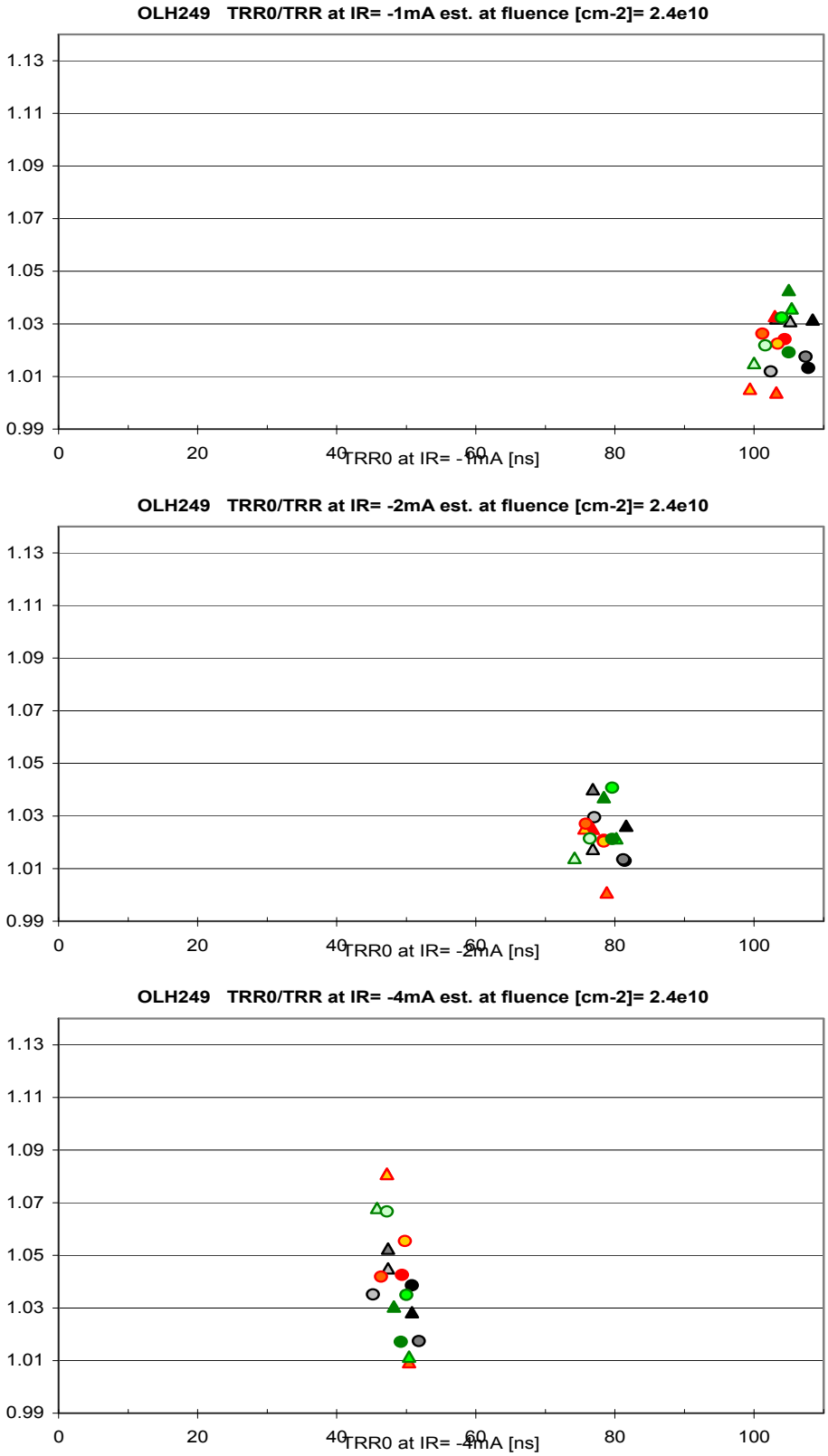
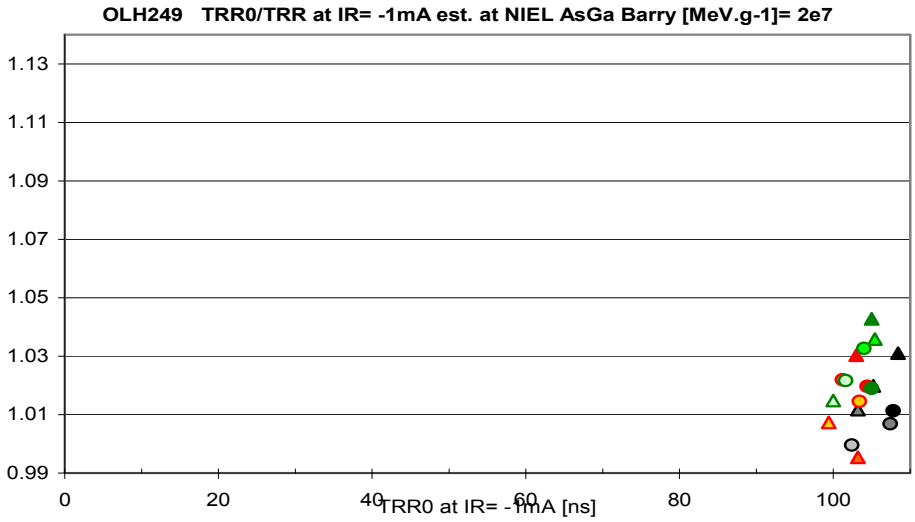
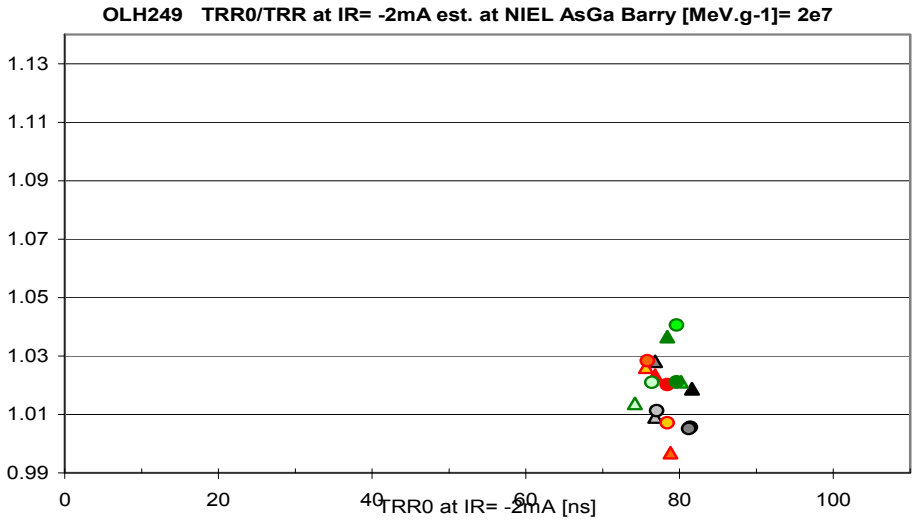


Fig. 13-75: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA





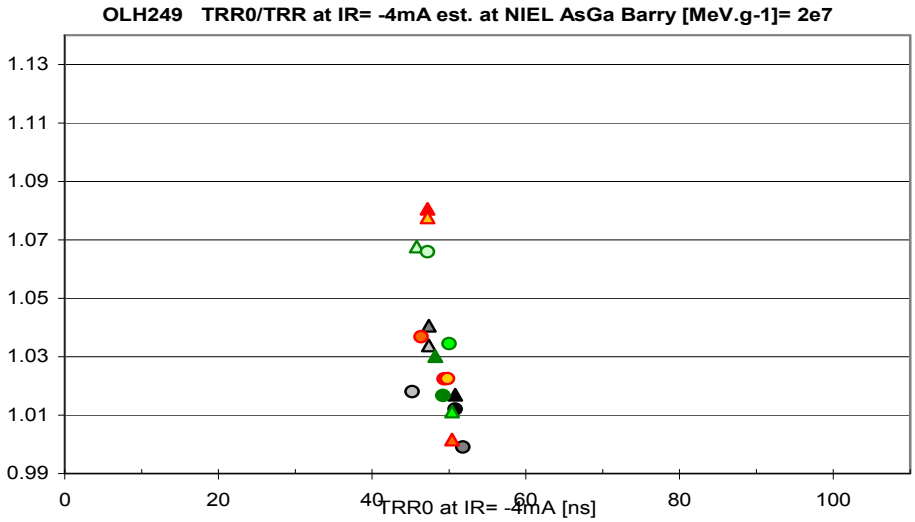


Fig. 13-76: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA

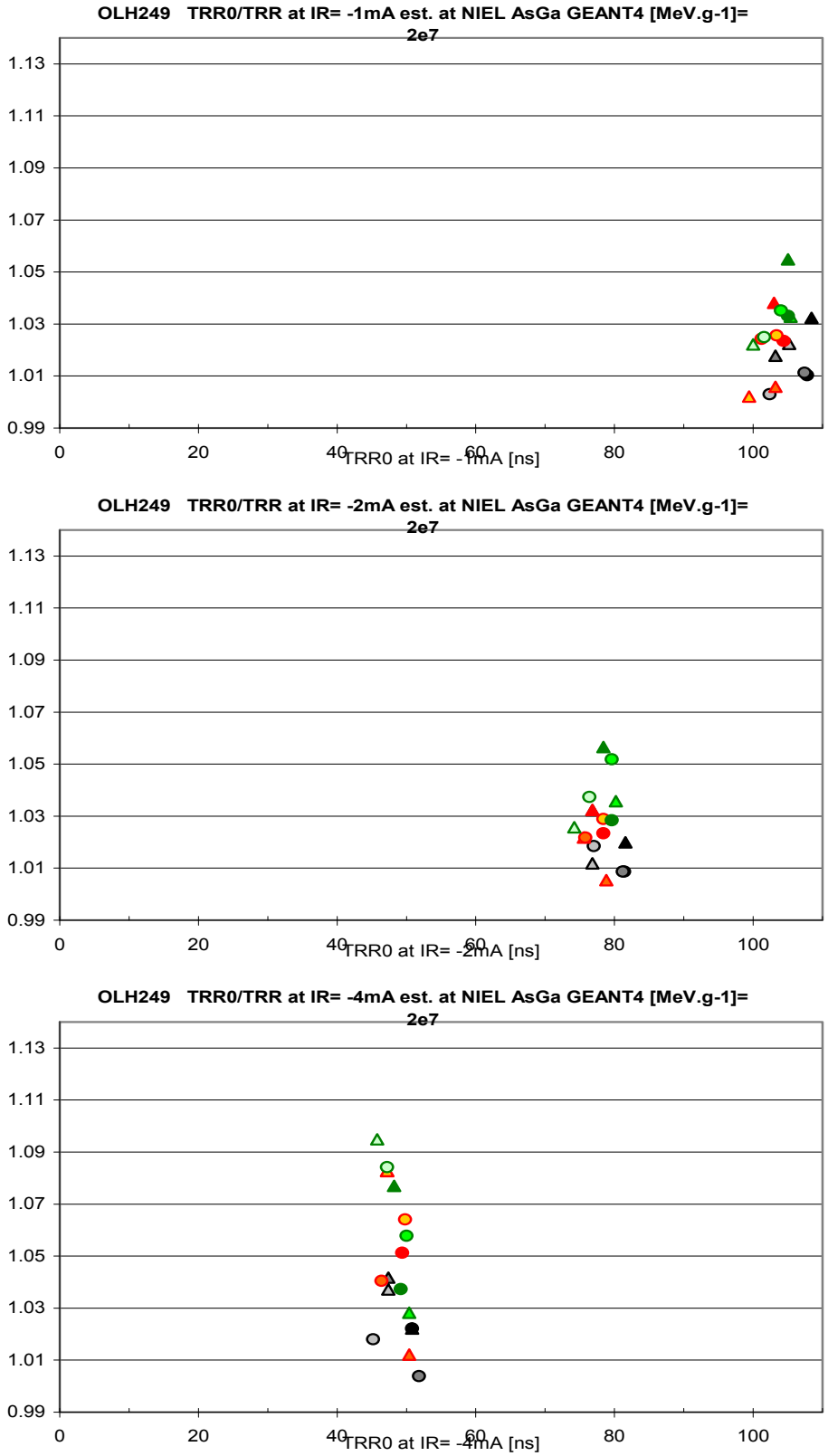
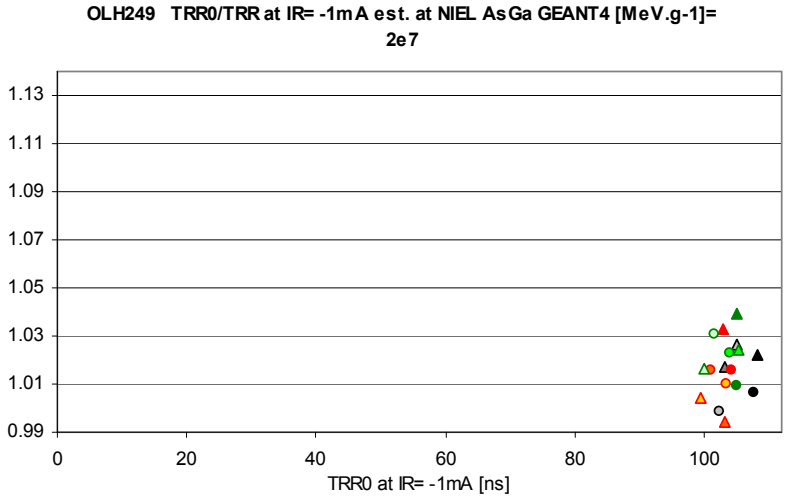
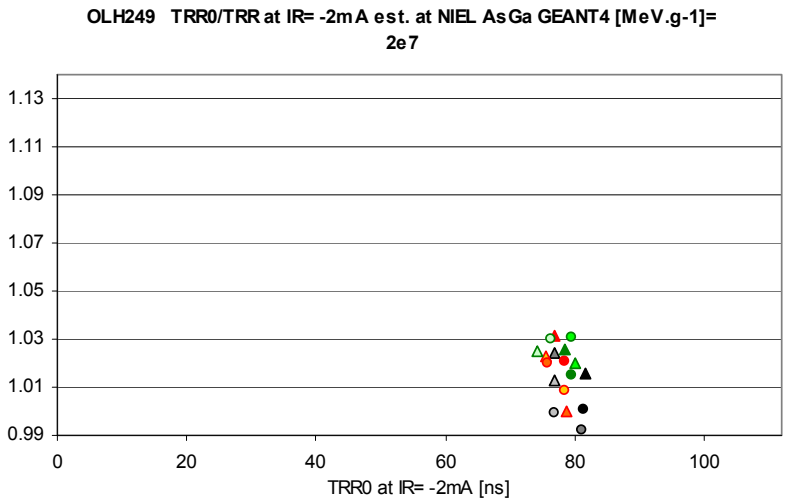


Fig. 13-77: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





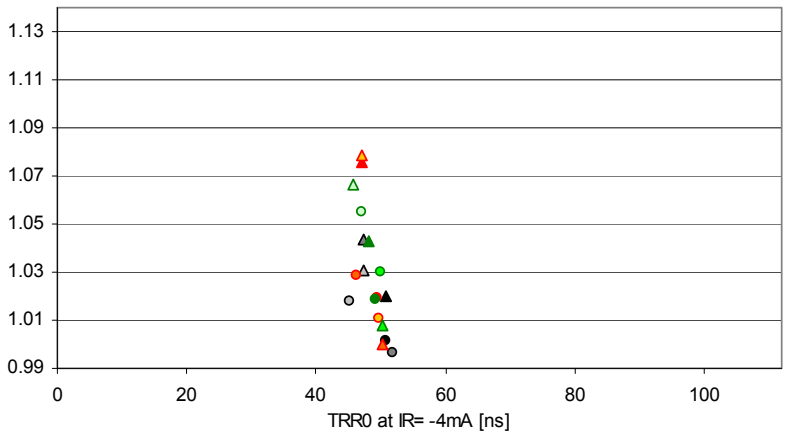


Fig. 13-78: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 6.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

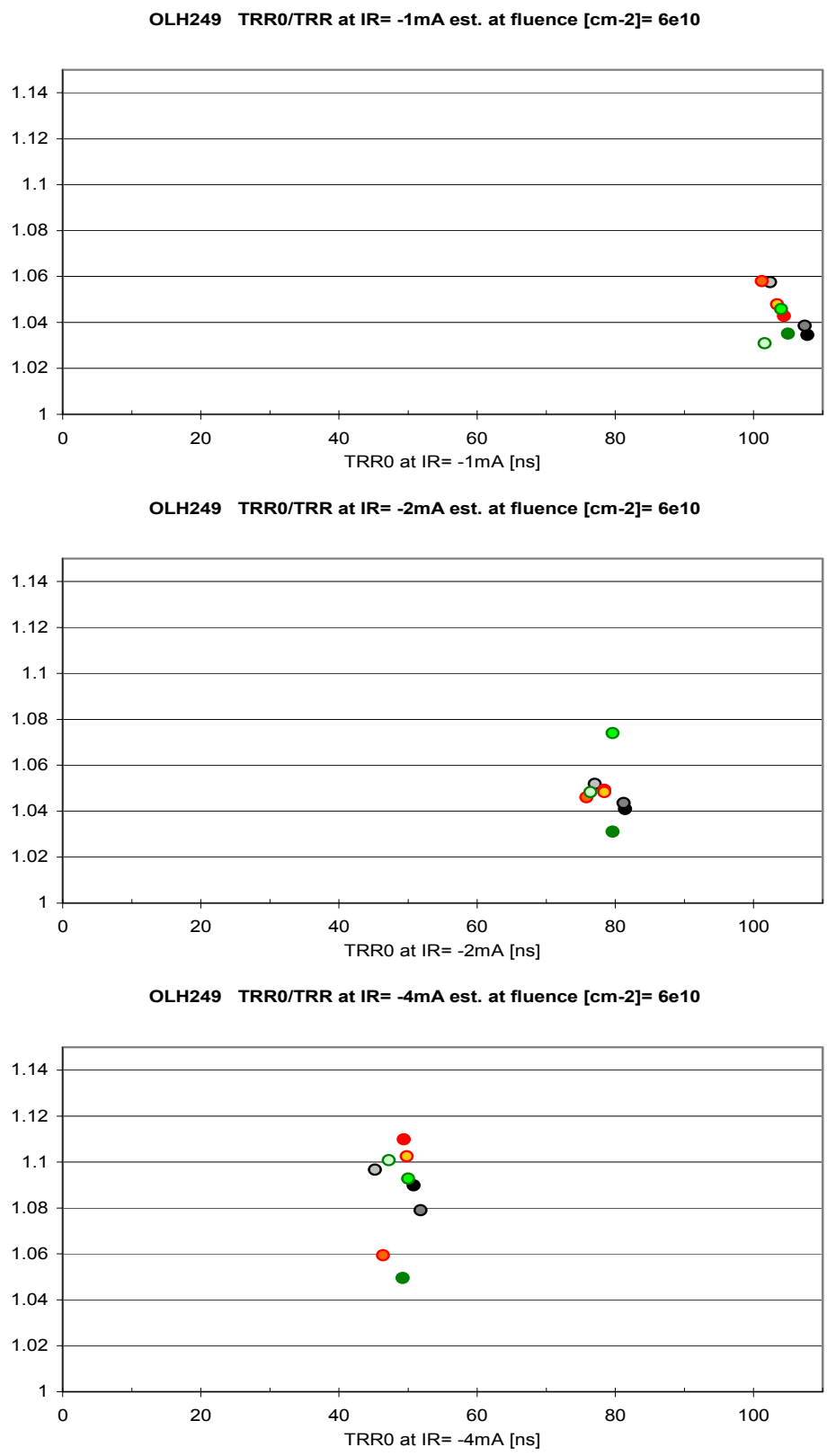


Fig. 13-79: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA

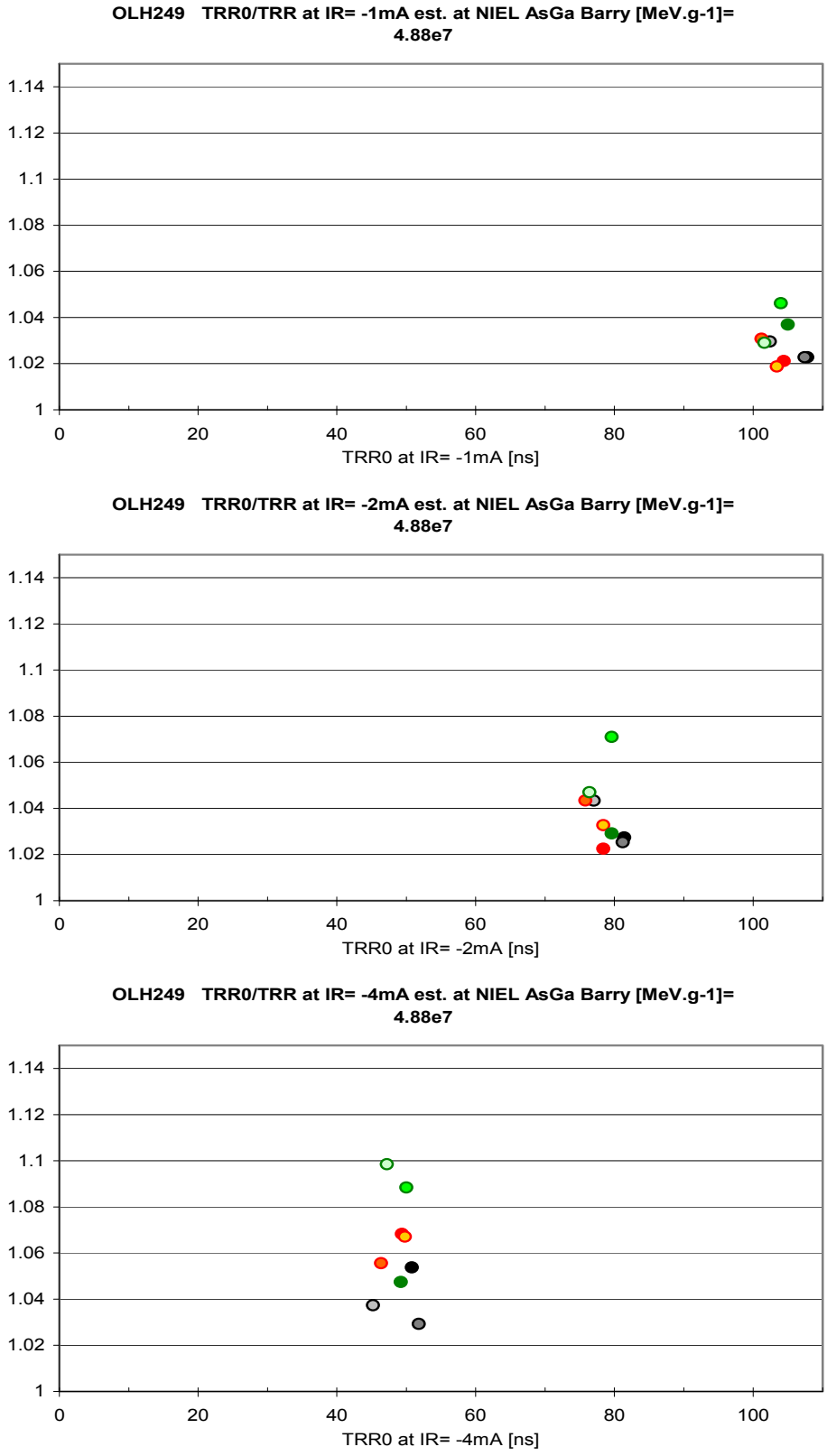
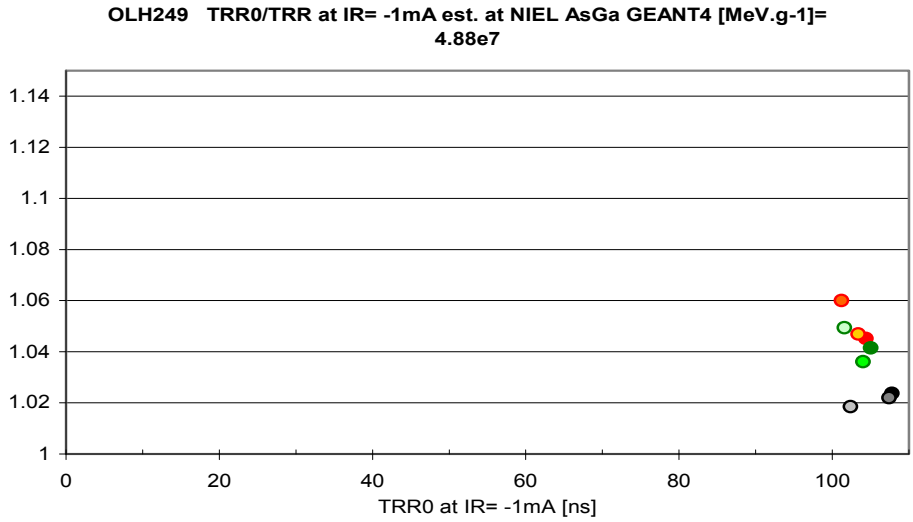
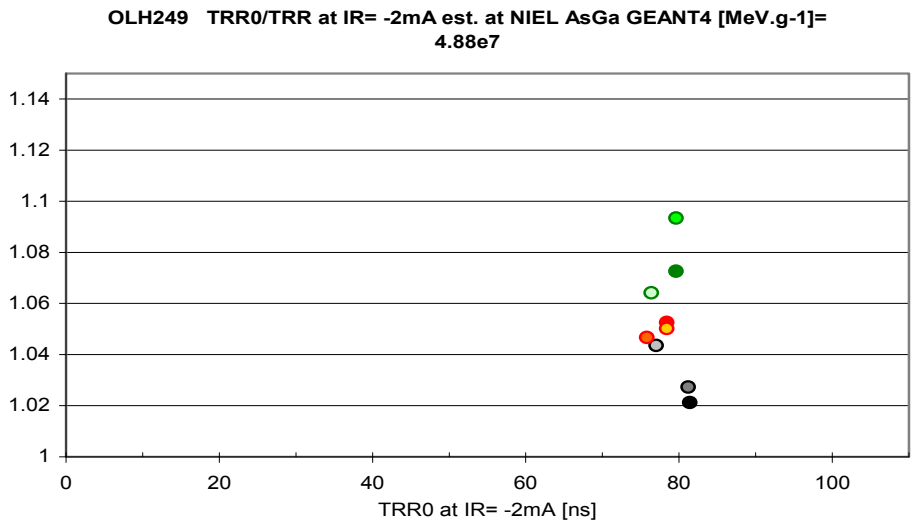


Fig. 13-80: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^7$ MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA





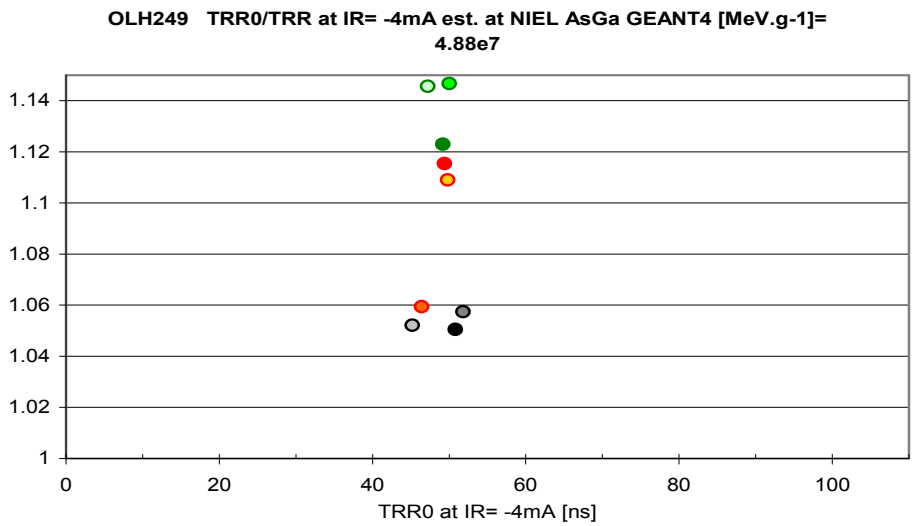
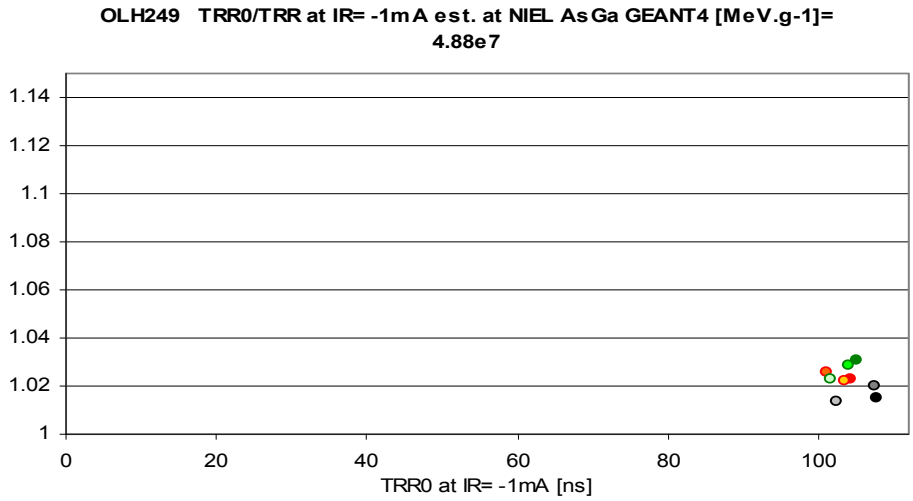
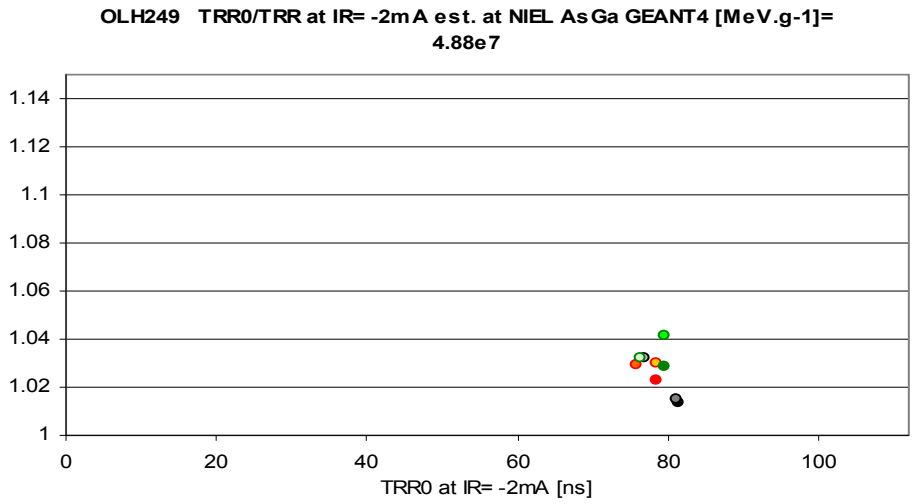


Fig. 13-81: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





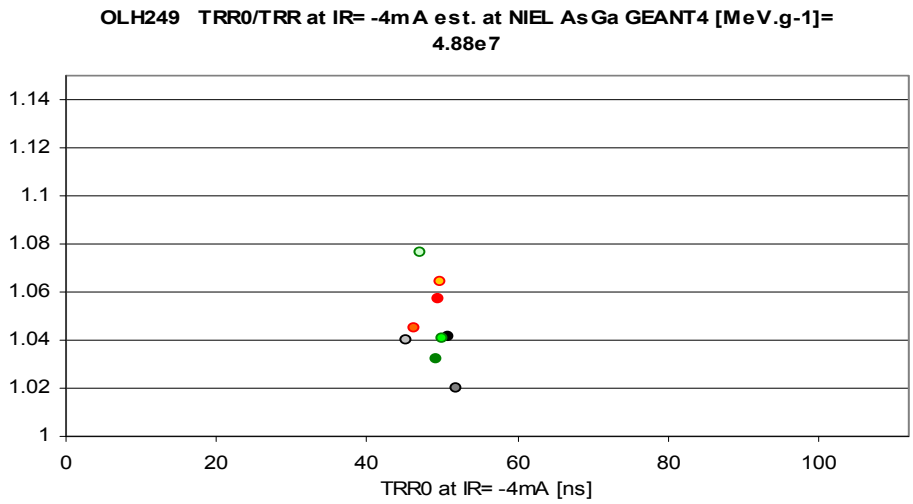


Fig. 13-82: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence

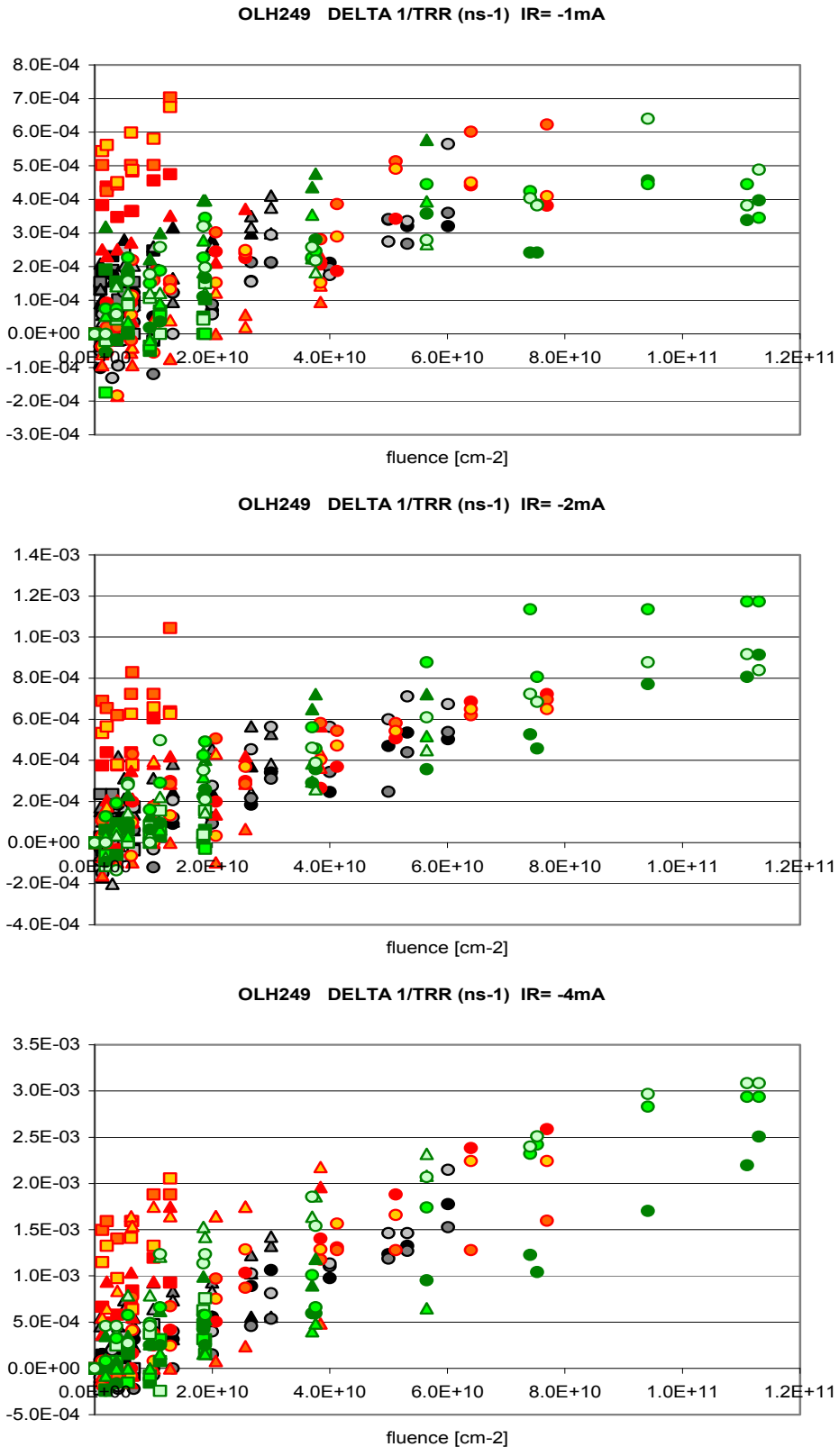
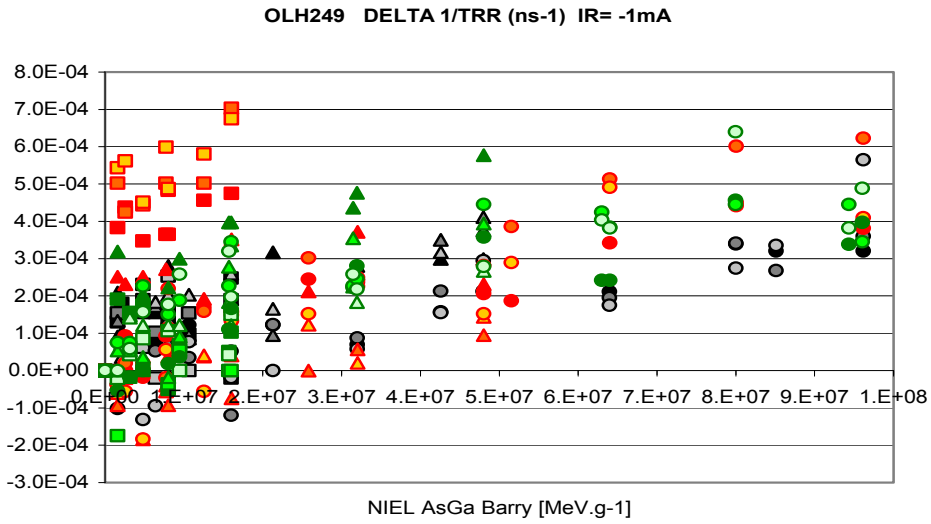
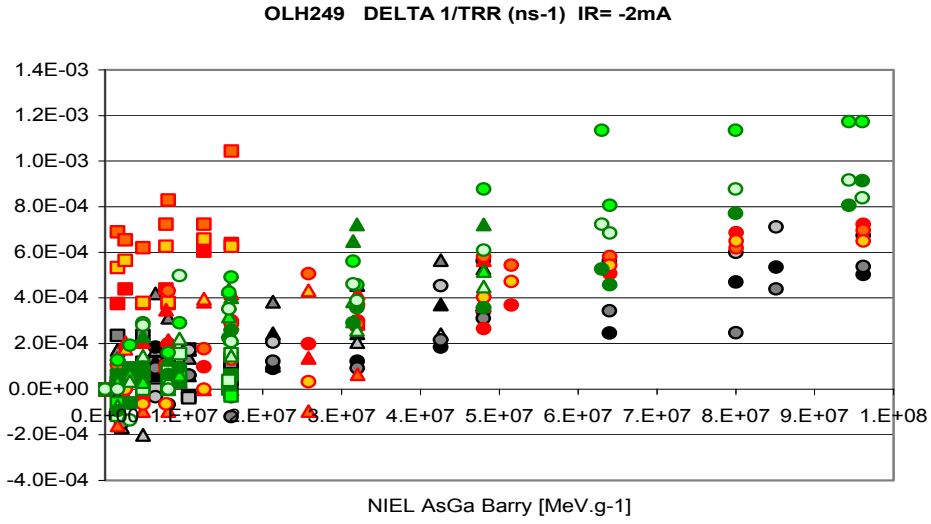


Fig. 13-83: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (Barry)





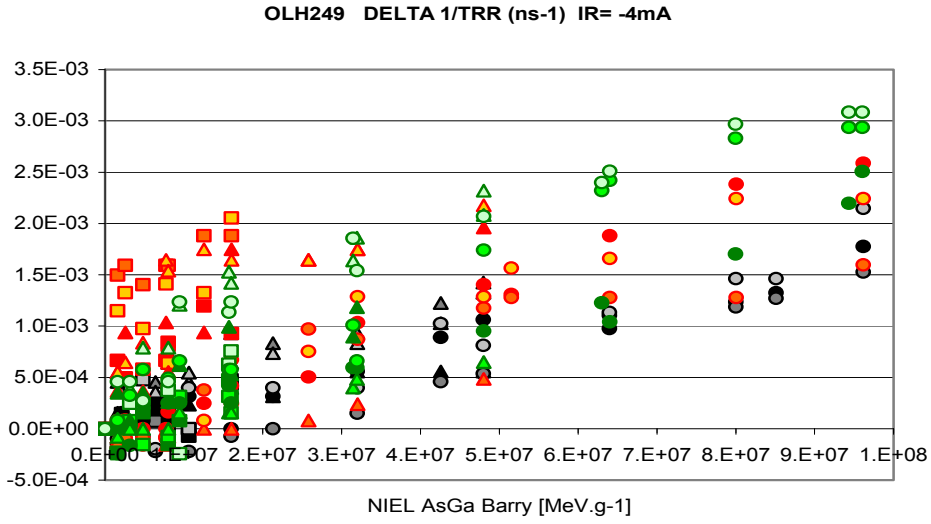


Fig. 13-84: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 ELASTIC)

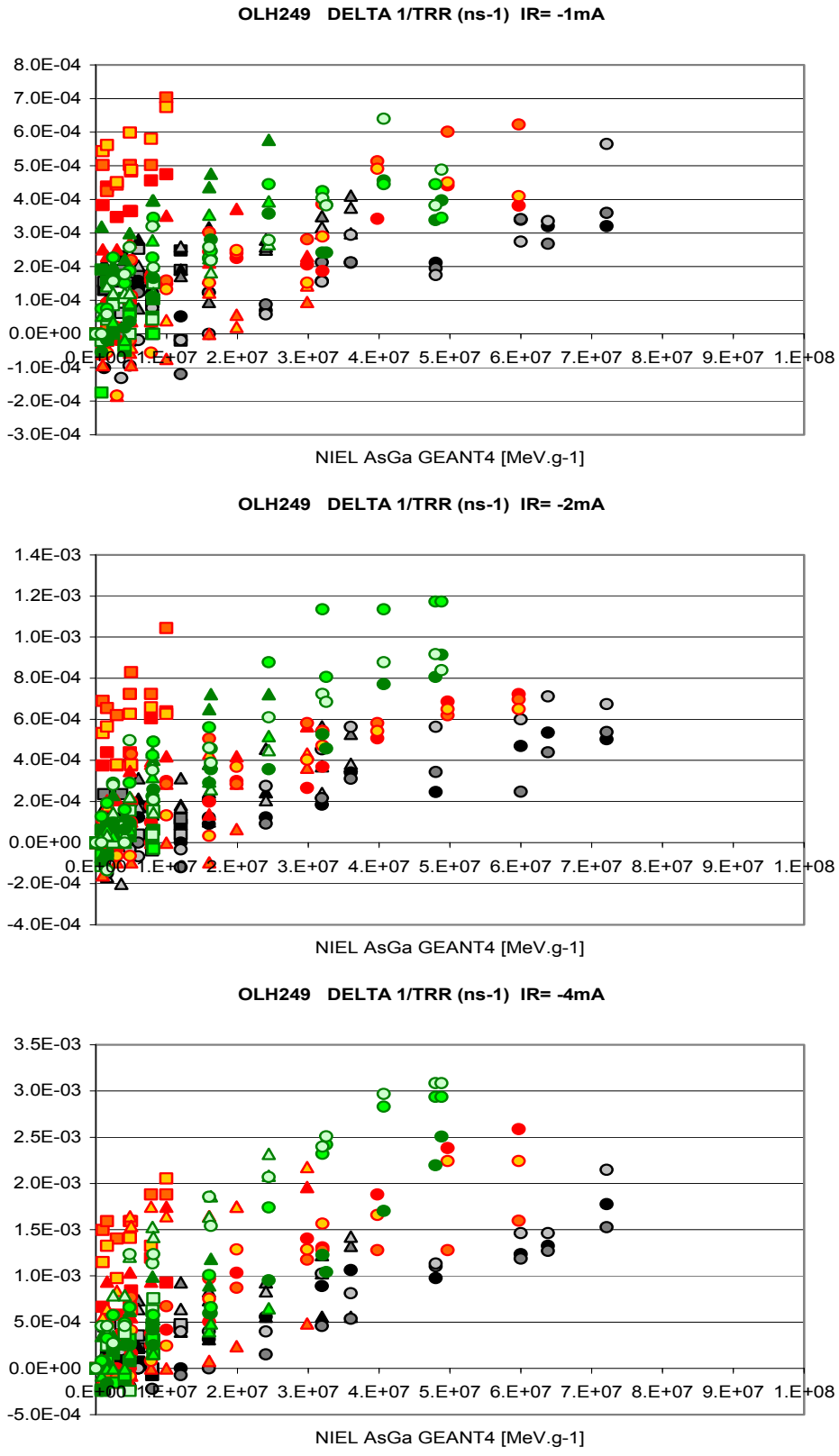
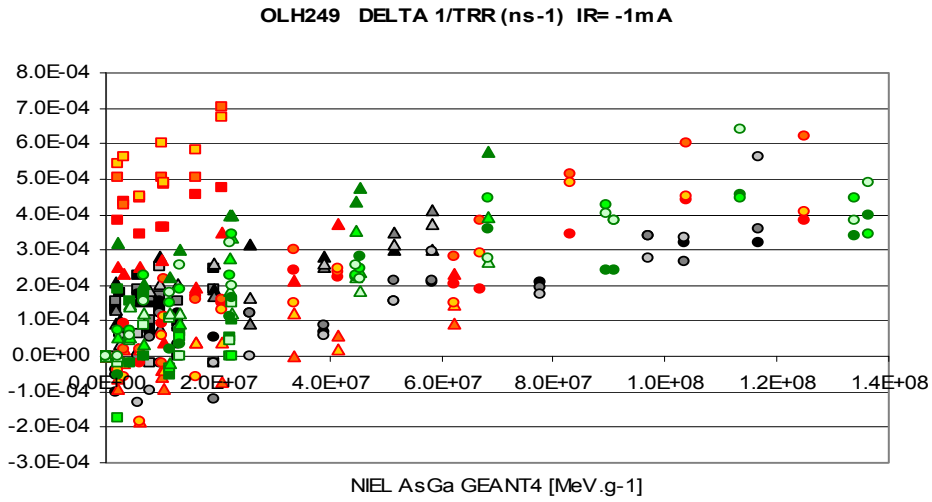
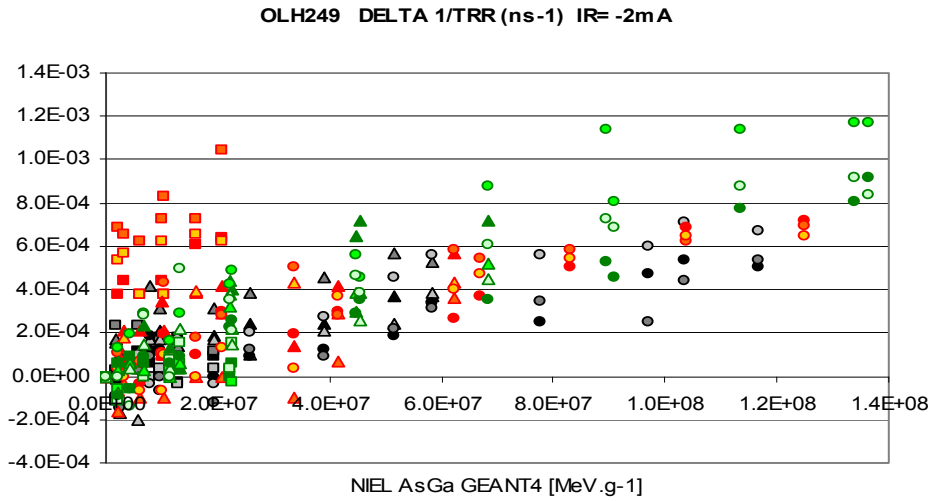


Fig. 13-85: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 TOTAL)





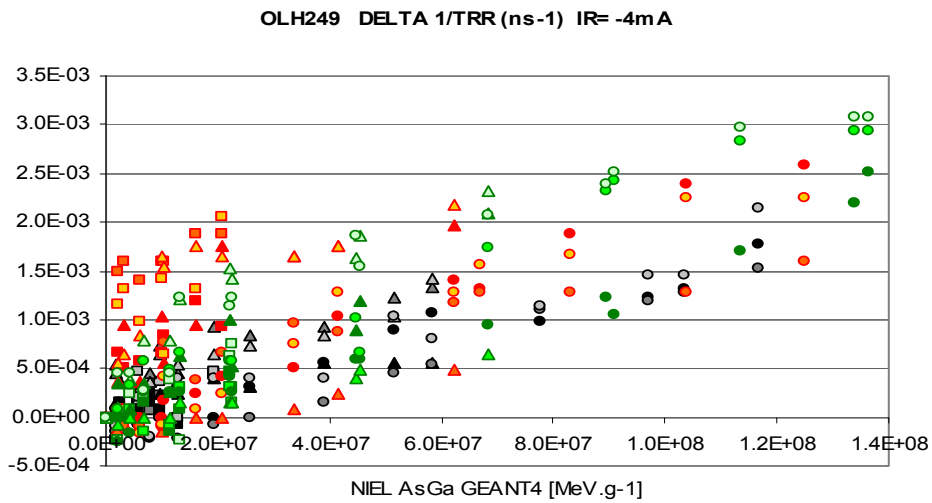
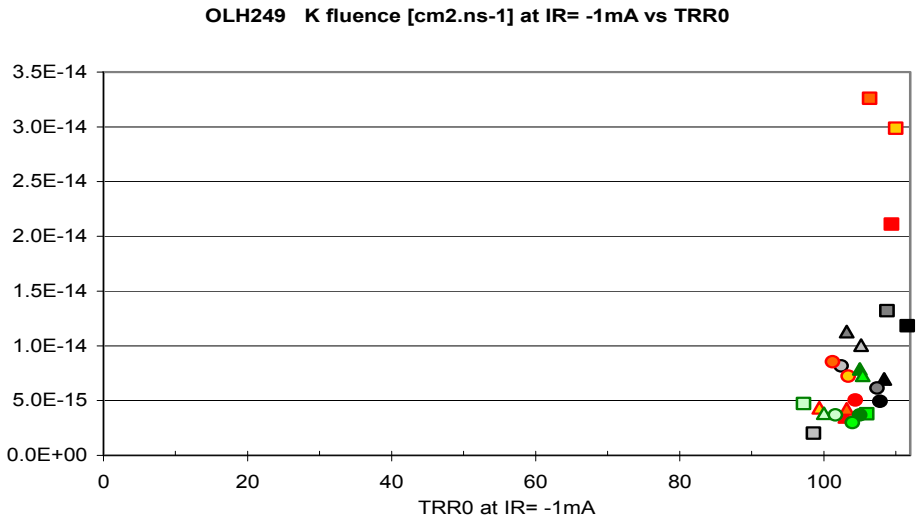
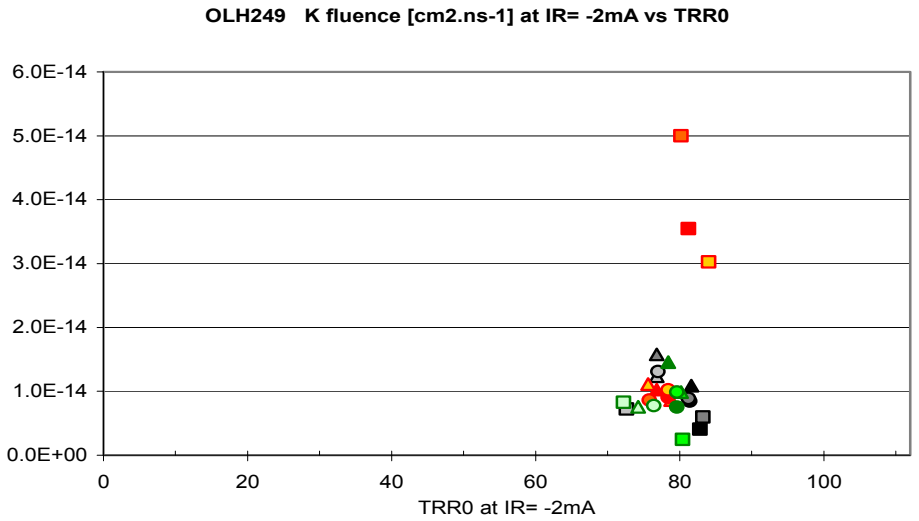


Fig. 13-86: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}





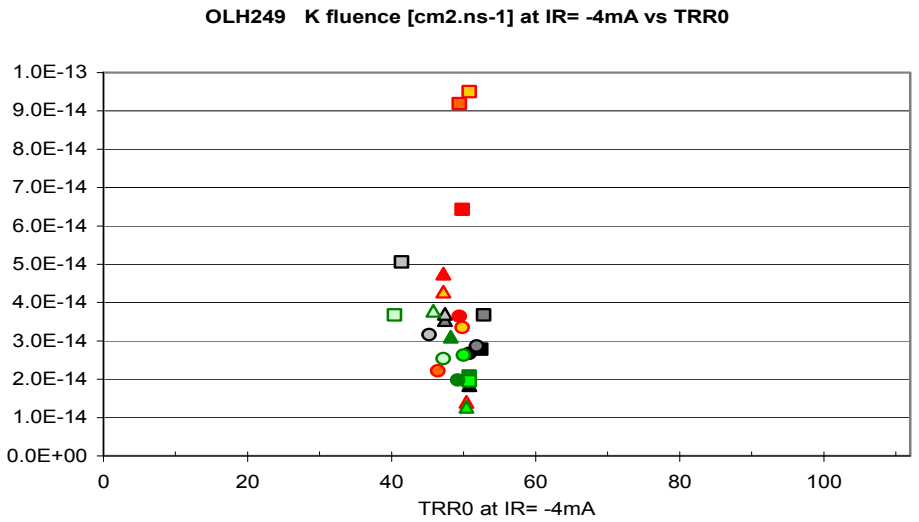
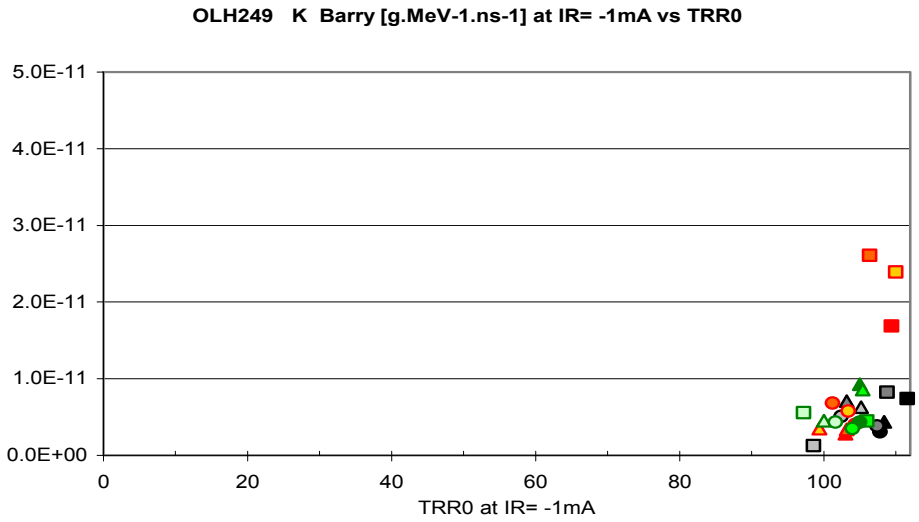
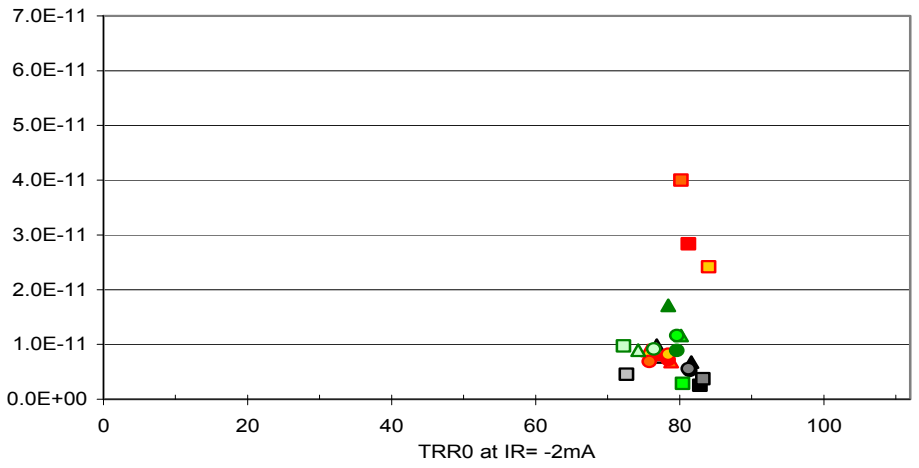


Fig. 13-87: OLH249 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to τ_{RR0}





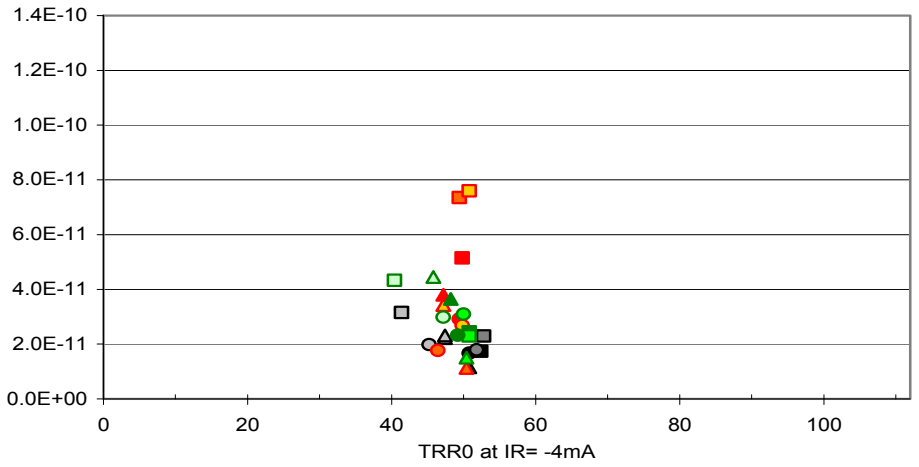
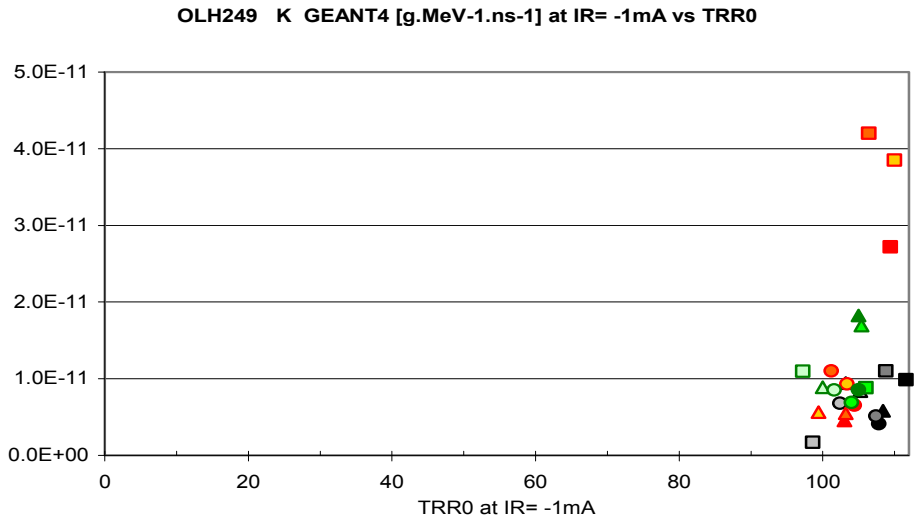
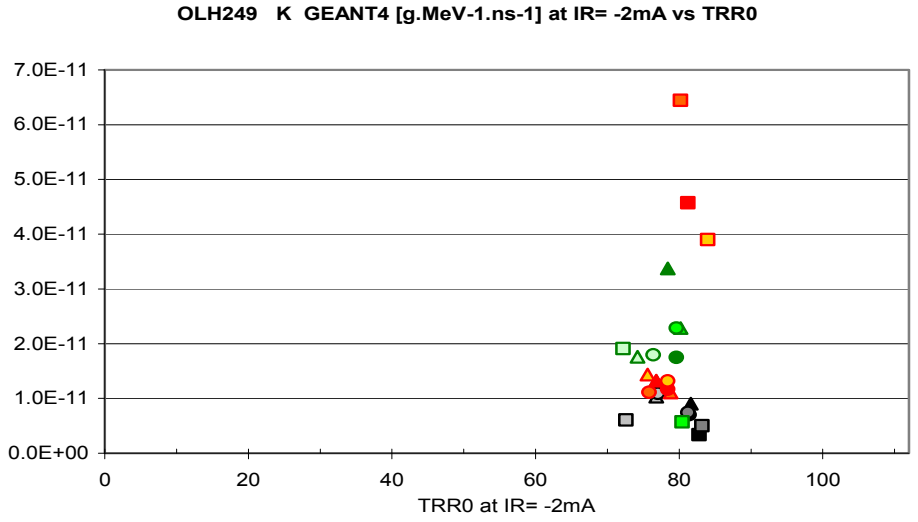


Fig. 13-88: OLH249 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}





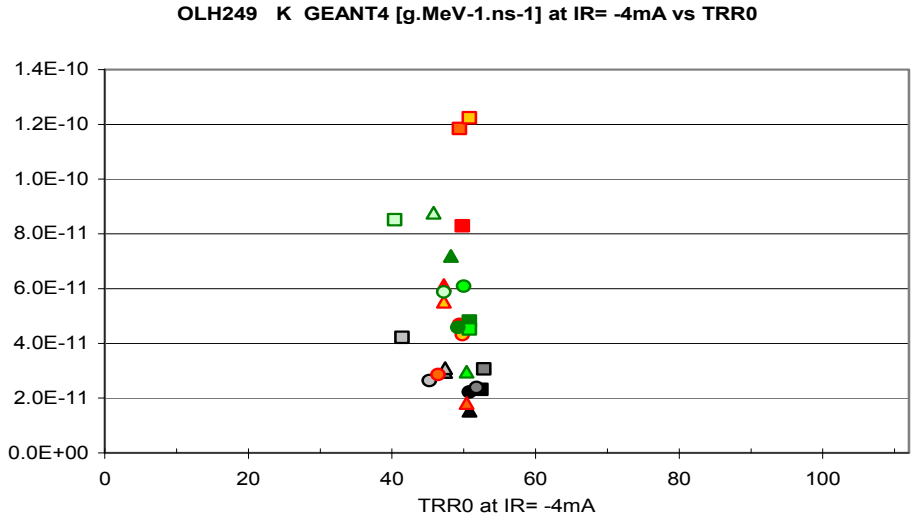
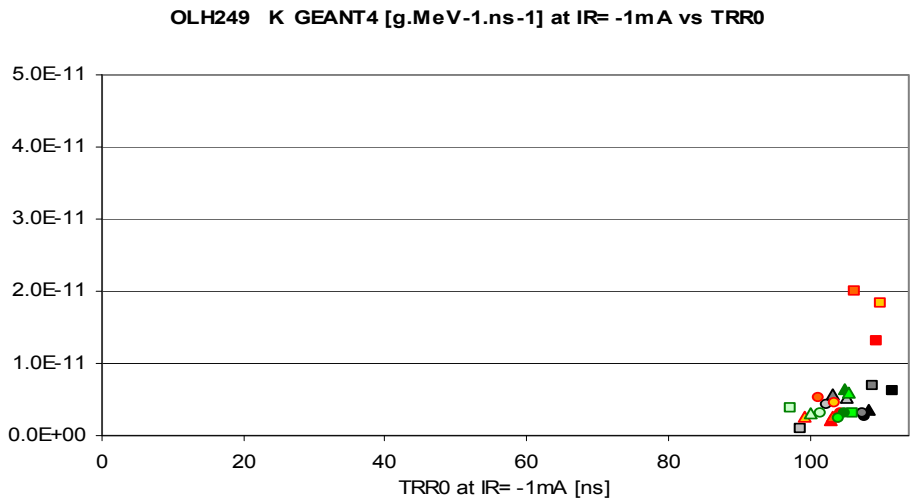
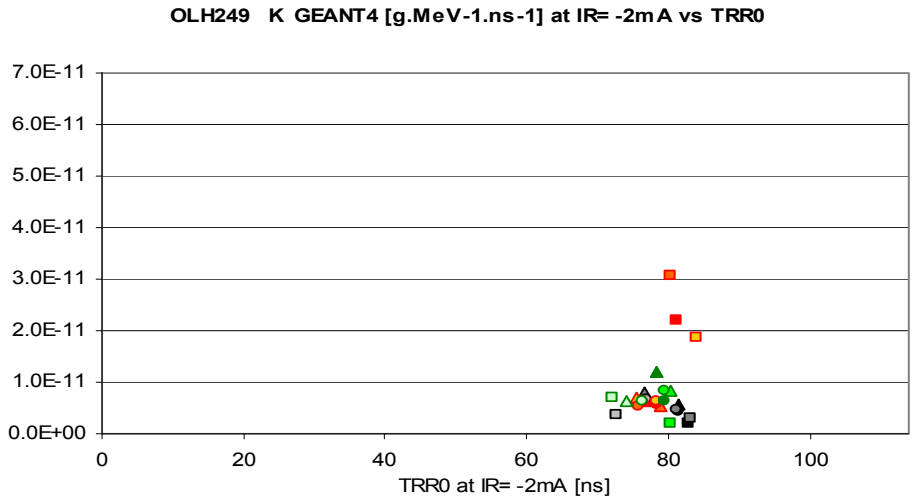


Fig. 13-89: OLH249 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}





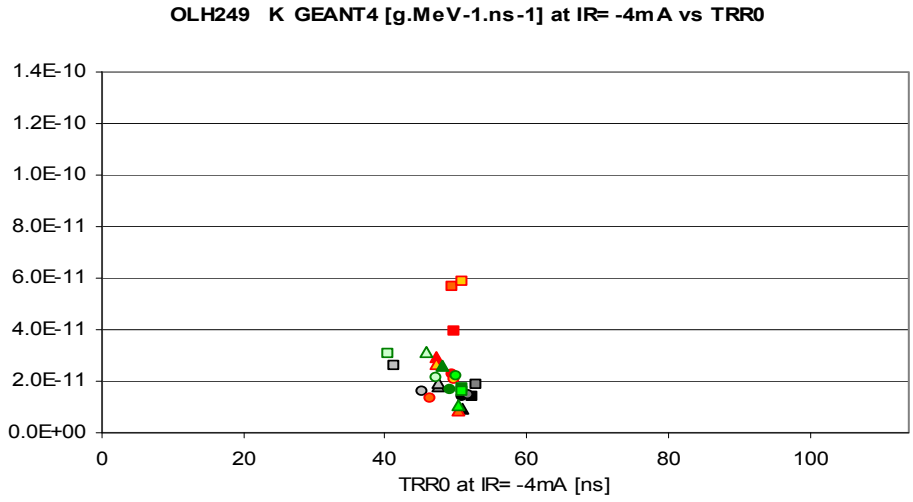


Fig. 13-90: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to energy

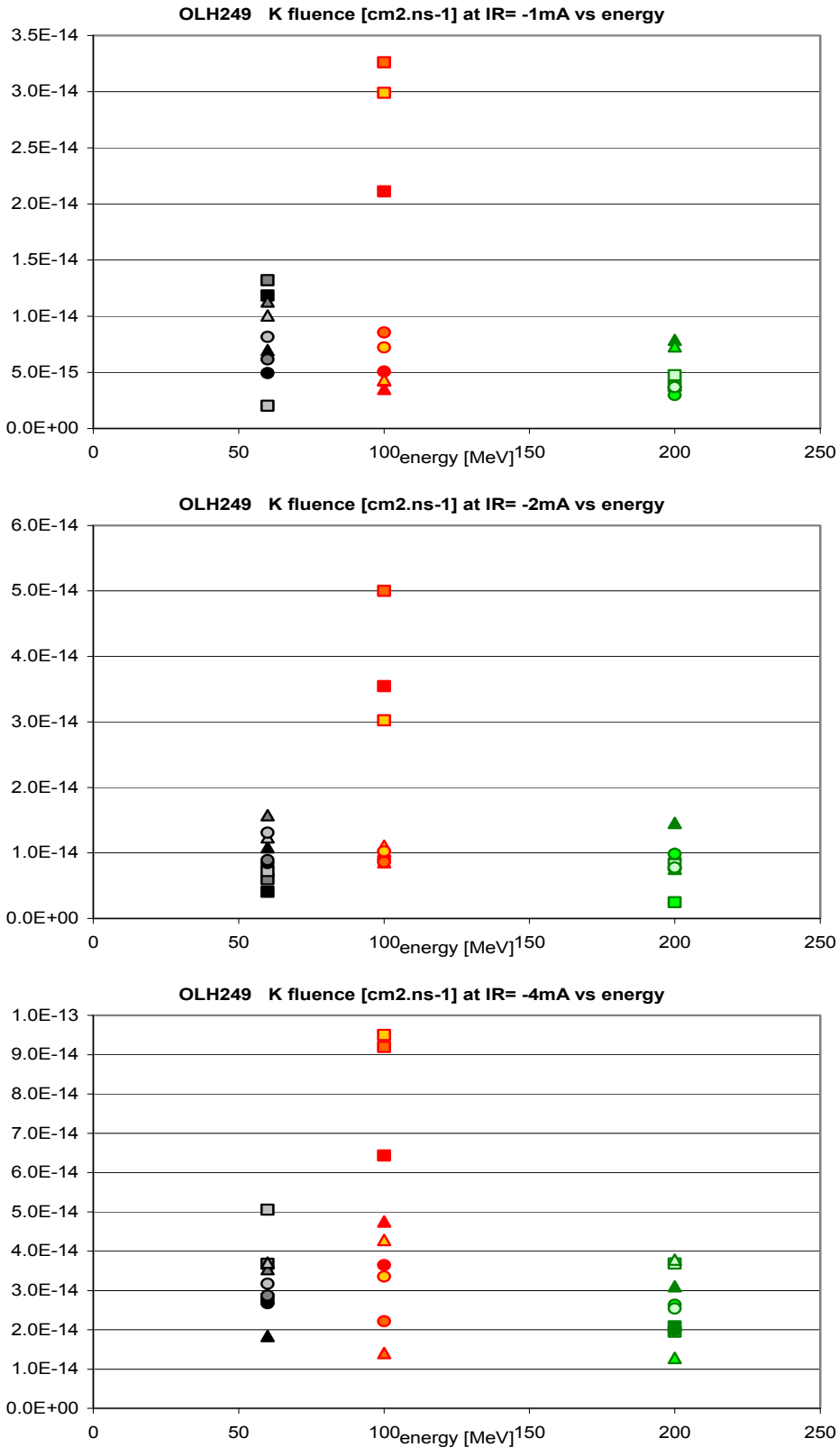


Fig. 13-91: OLH249 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to energy

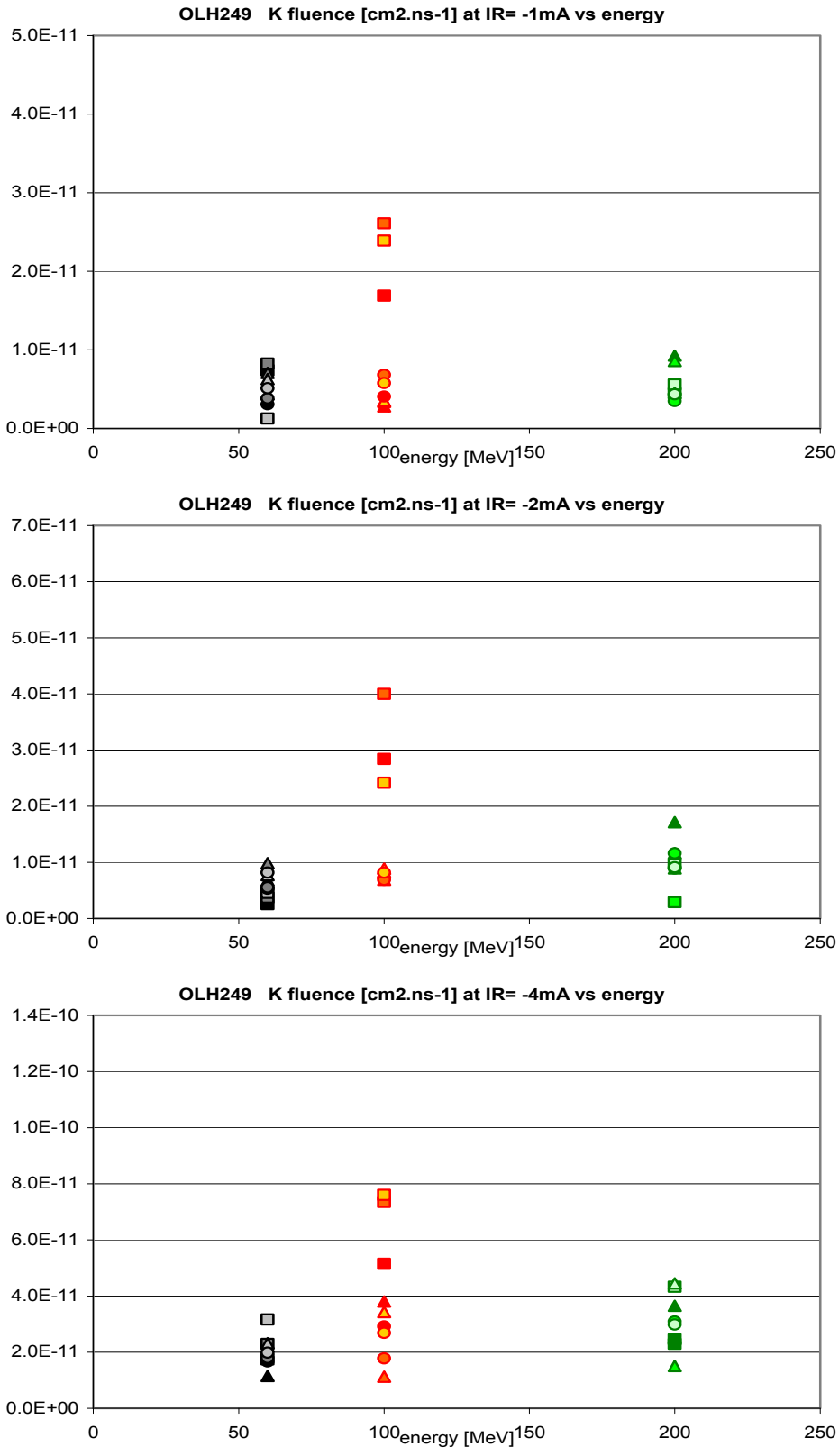


Fig. 13-92: OLH249 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to energy

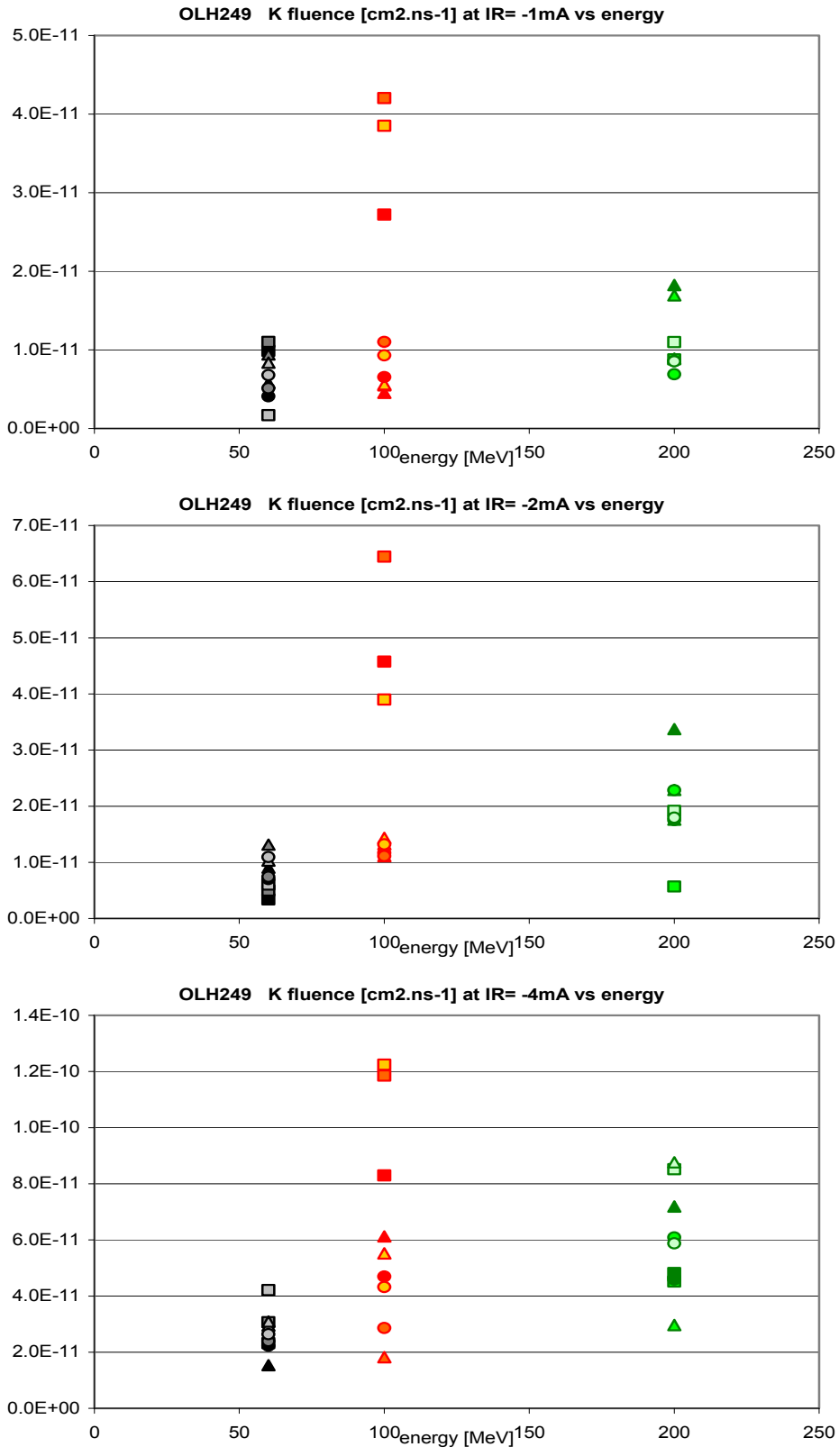
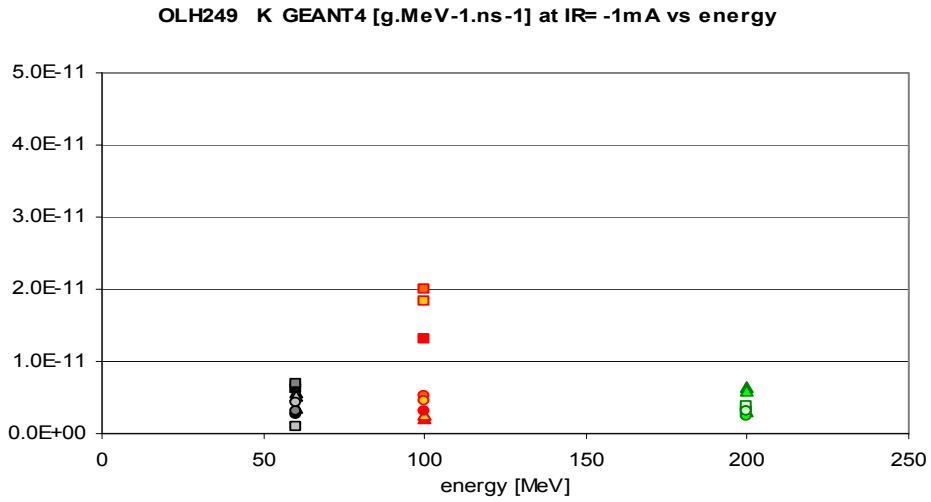
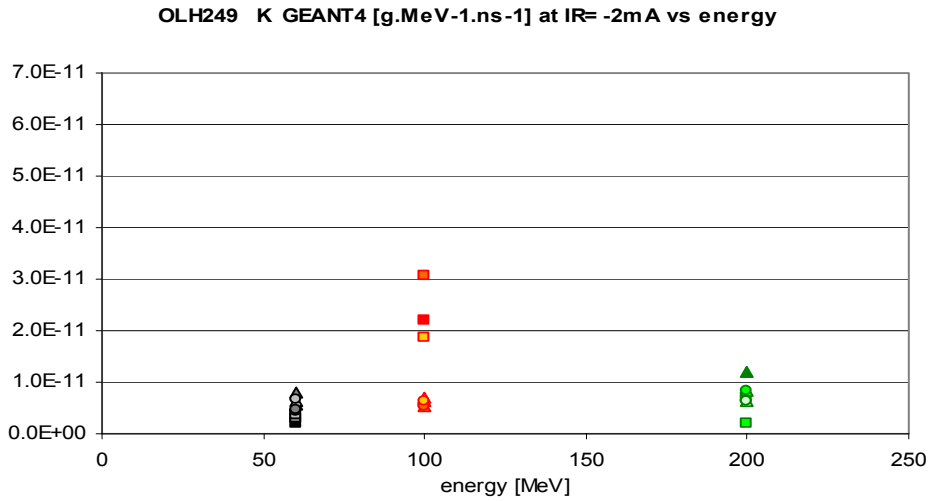


Fig. 13-93: OLH249 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to energy





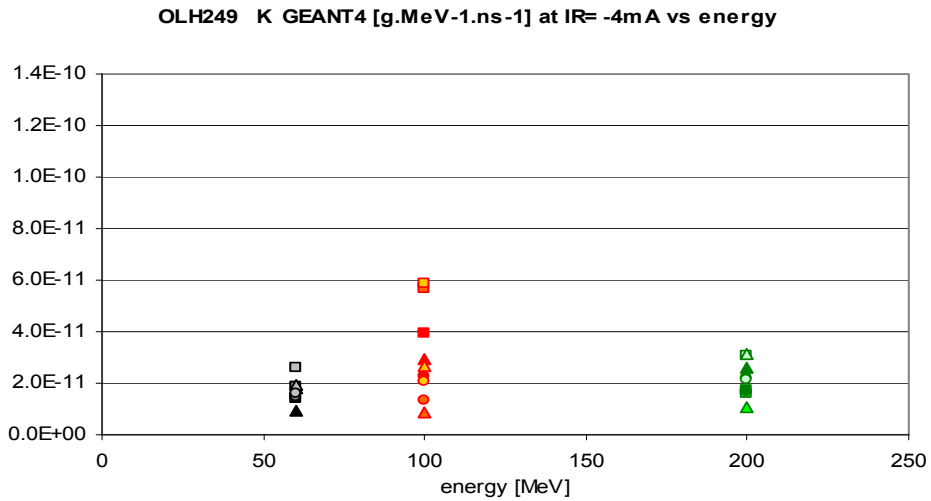
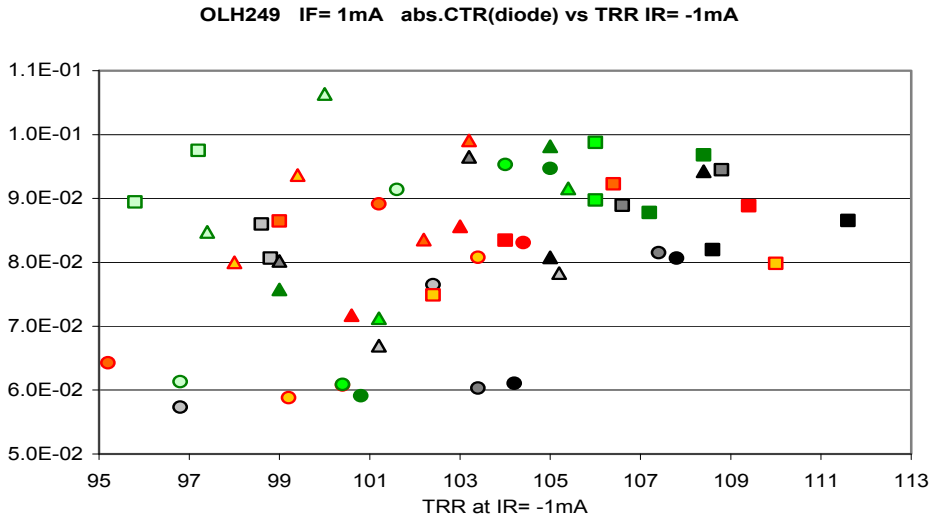
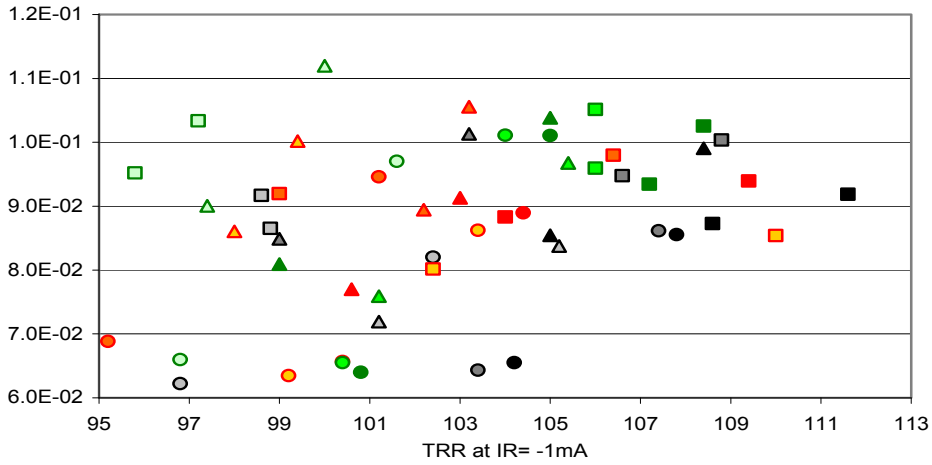
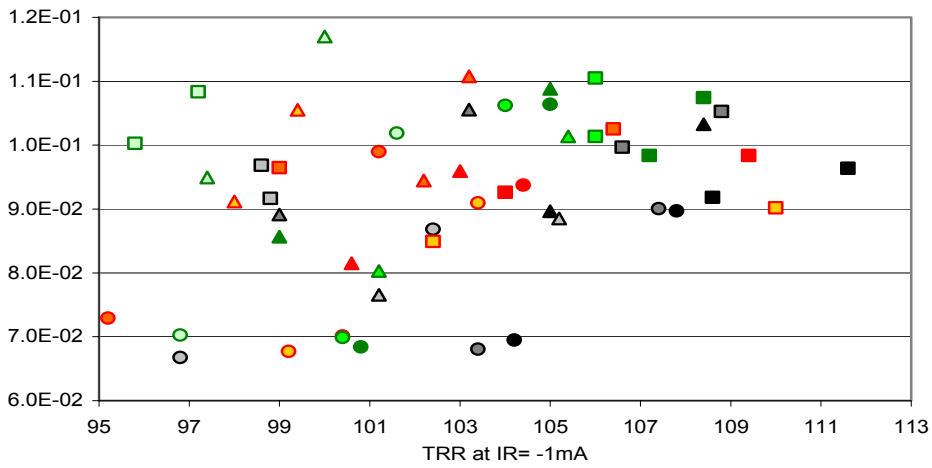
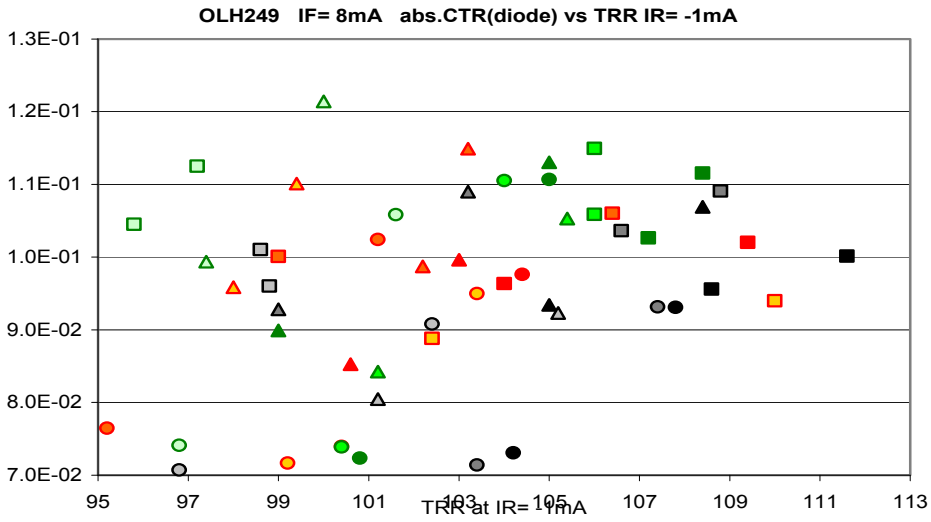


Fig. 13-94: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -1mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
95
97
99
101
103
105
107
109
111
113
TRR at IR= -1mA

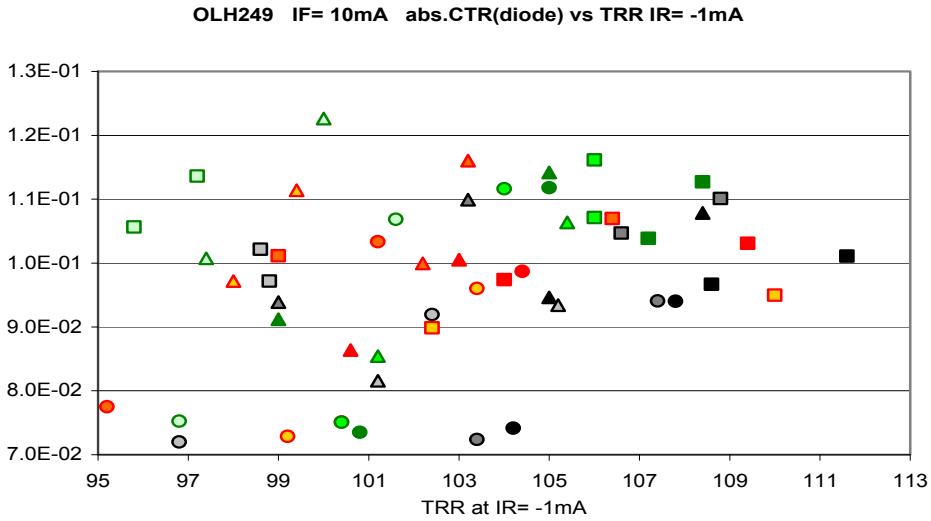
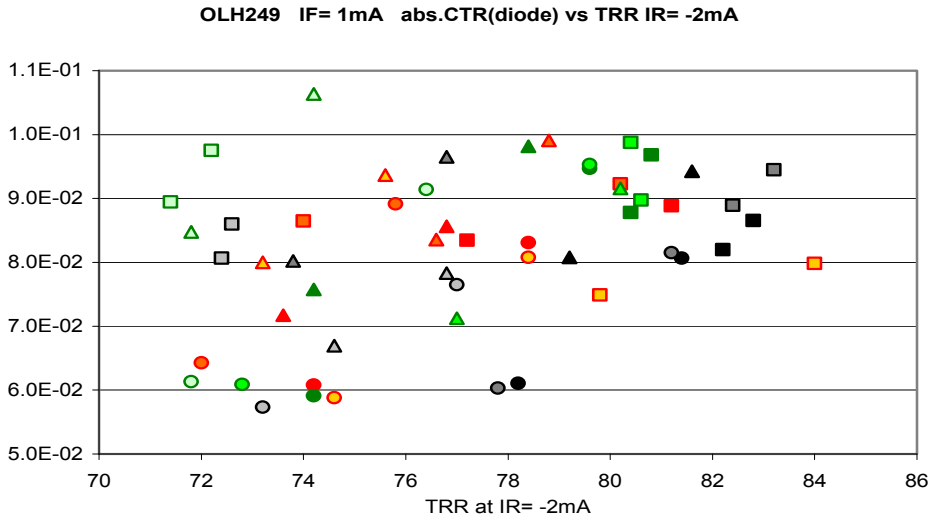
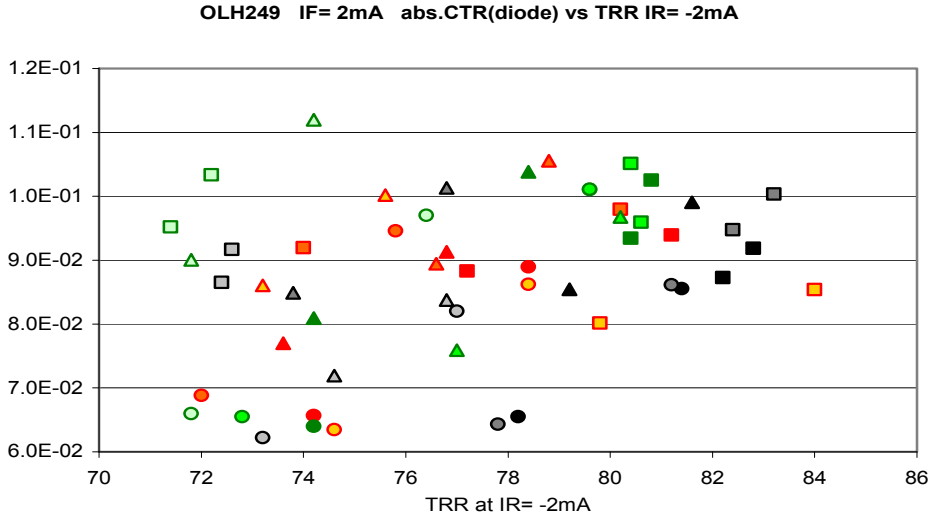
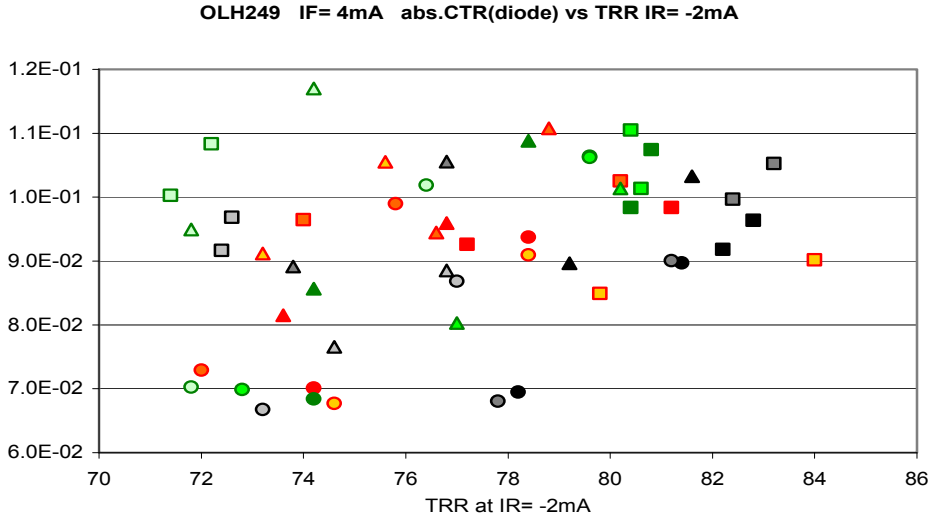
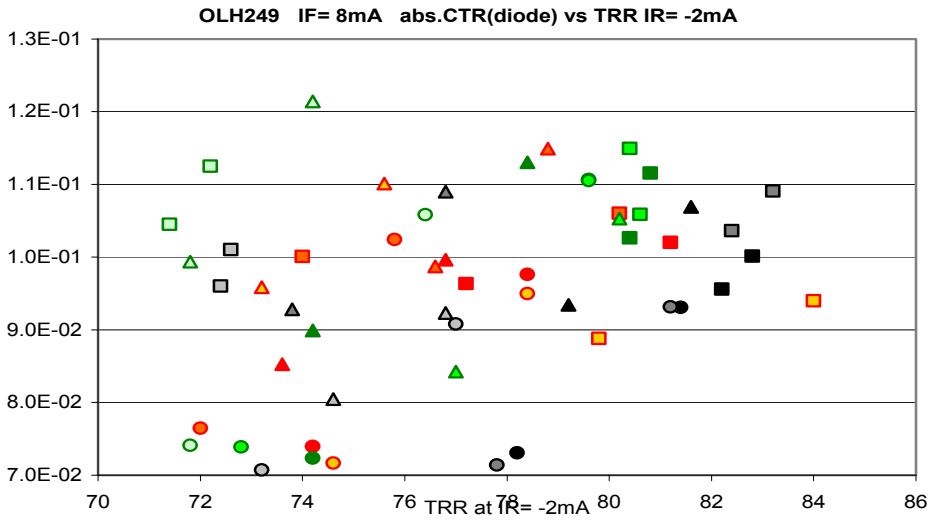

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -1mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
95
97
99
101
103
105
107
109
111
113
TRR at IR= -1mA

Fig. 13-95: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -2mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
70
72
74
76
78
80
82
84
86
TRR at IR= -2mA

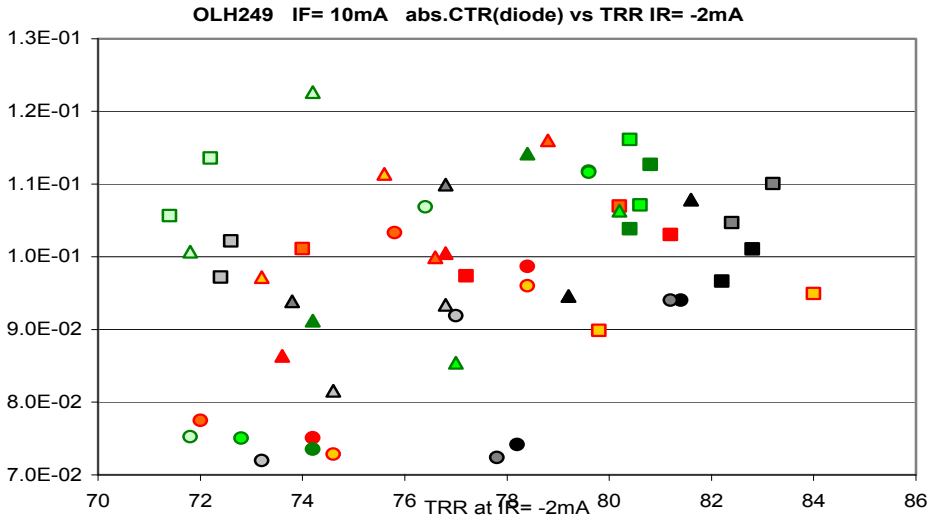
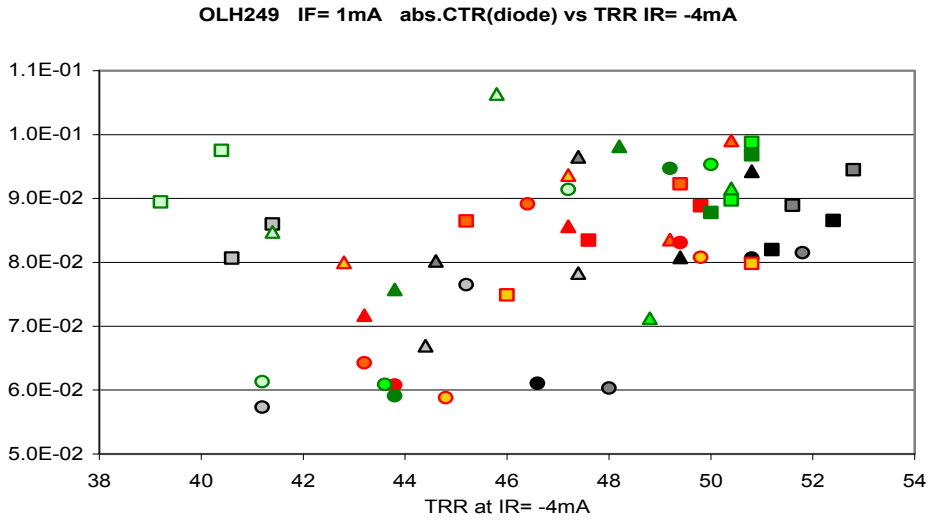
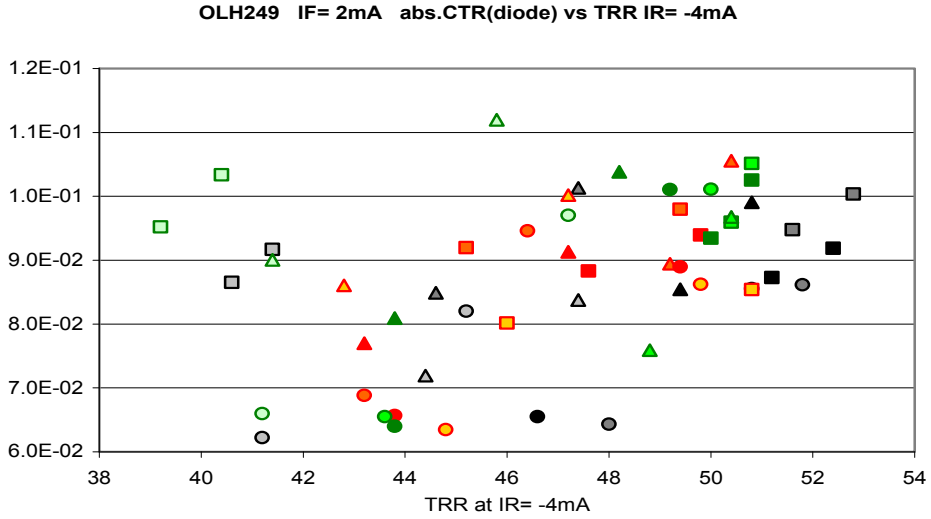
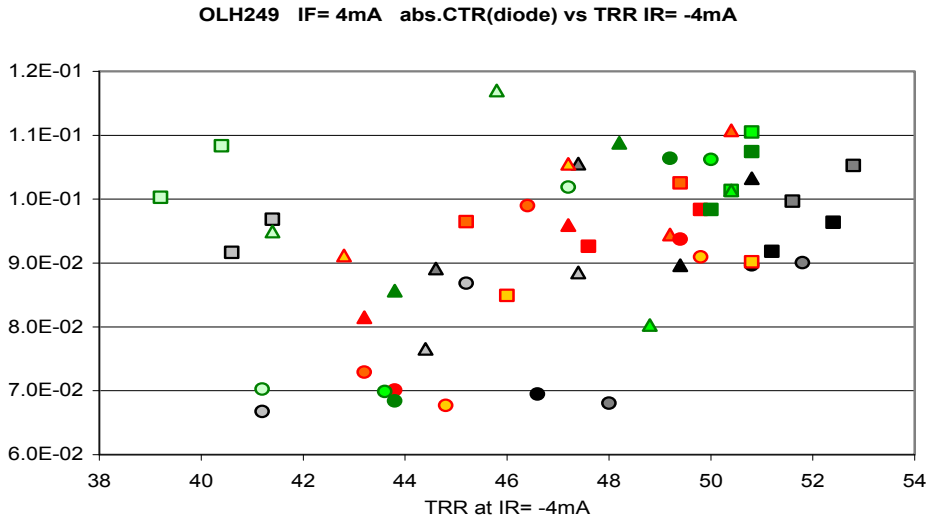
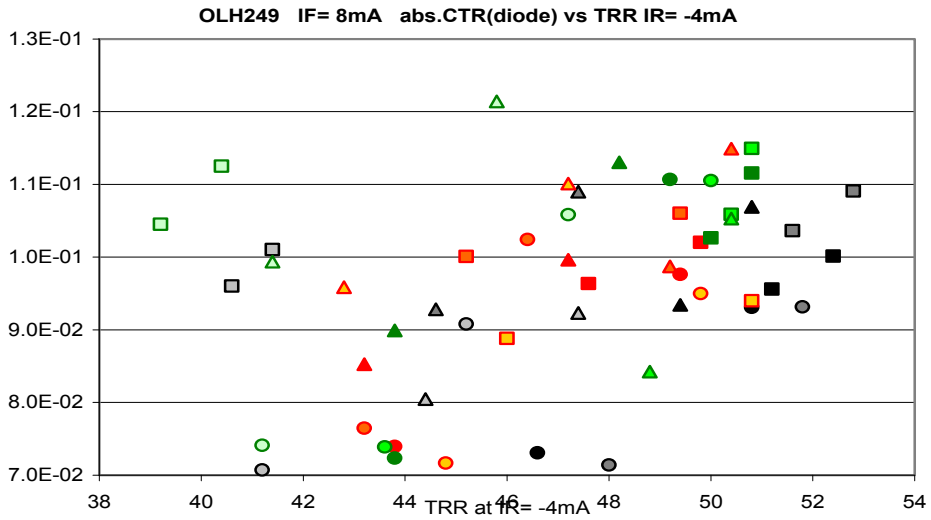

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -2mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
70
72
74
76
78
80
82
84
86
TRR at IR= -2mA

Fig. 13-96: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 IF= 8mA abs.CTR(diode) vs TRR IR= -4mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
38
40
42
44
46
48
50
52
54
TRR at IR= -4mA

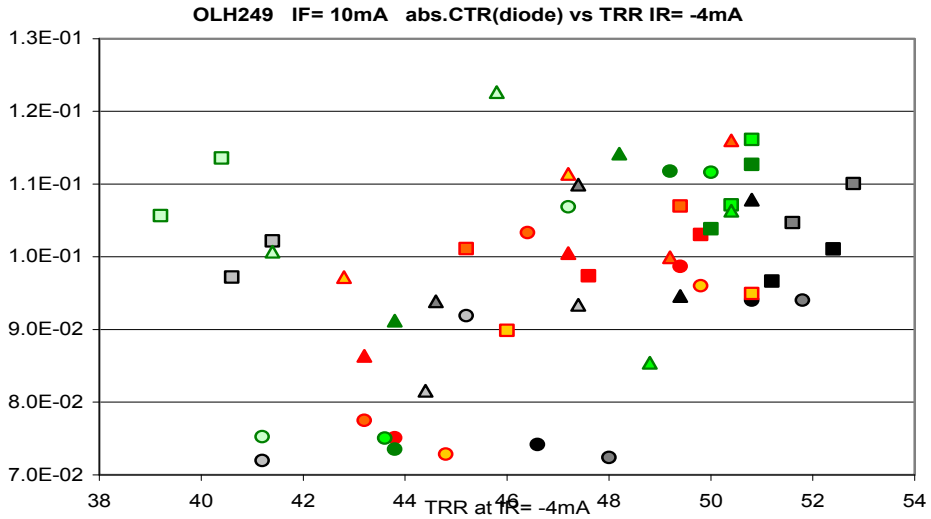
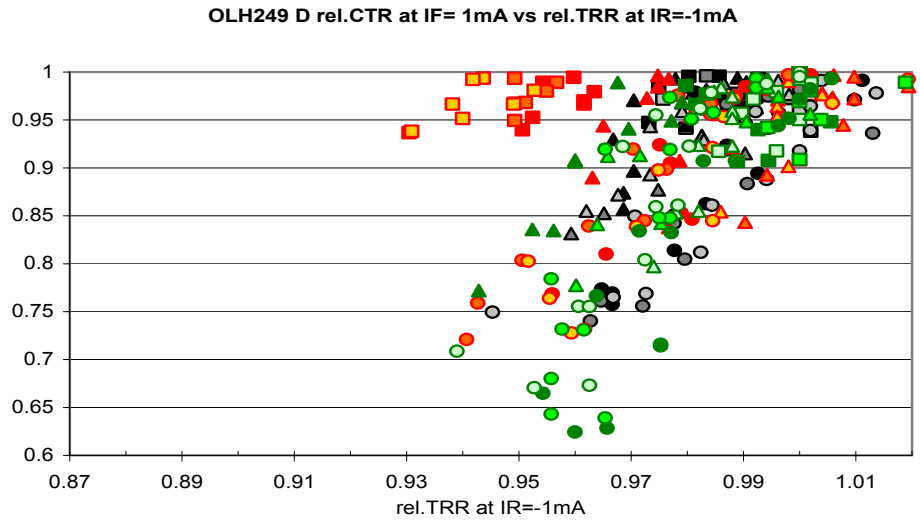
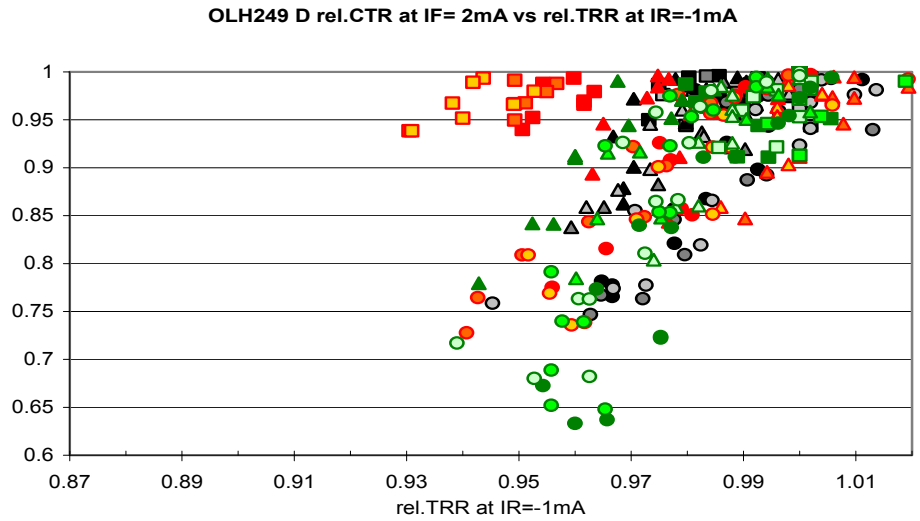
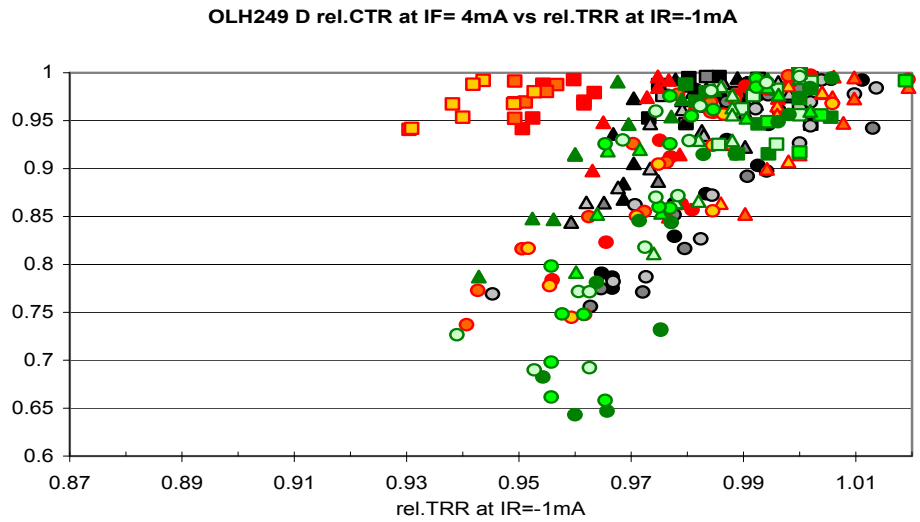

OLH249 IF= 10mA abs.CTR(diode) vs TRR IR= -4mA
1.3E-01
1.2E-01
1.1E-01
1.0E-01
9.0E-02
8.0E-02
7.0E-02
38
40
42
44
46
48
50
52
54
TRR at IR= -4mA

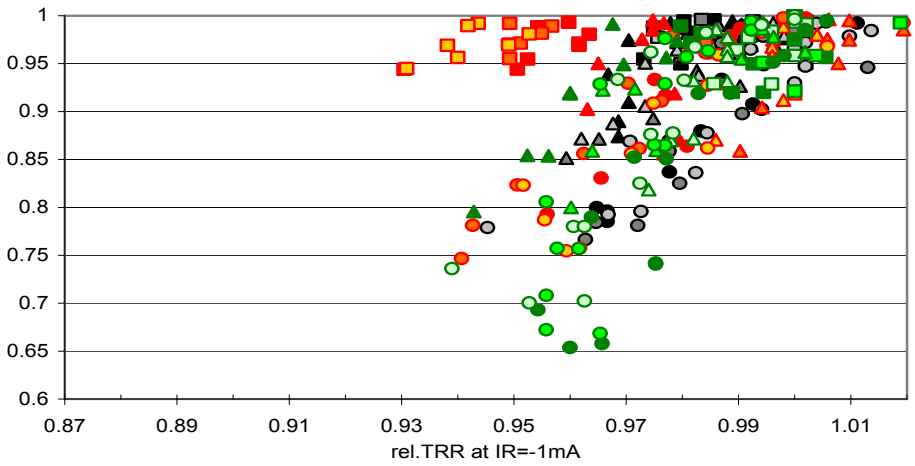
Fig. 13-97: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-1mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-1mA

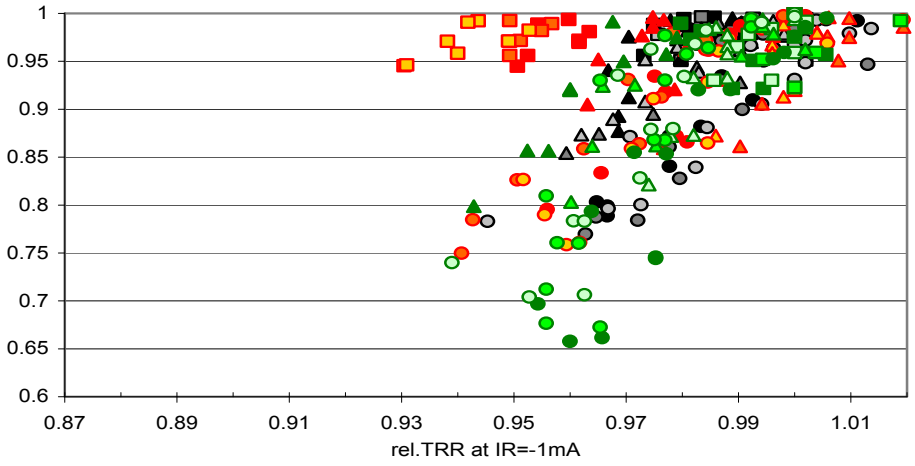
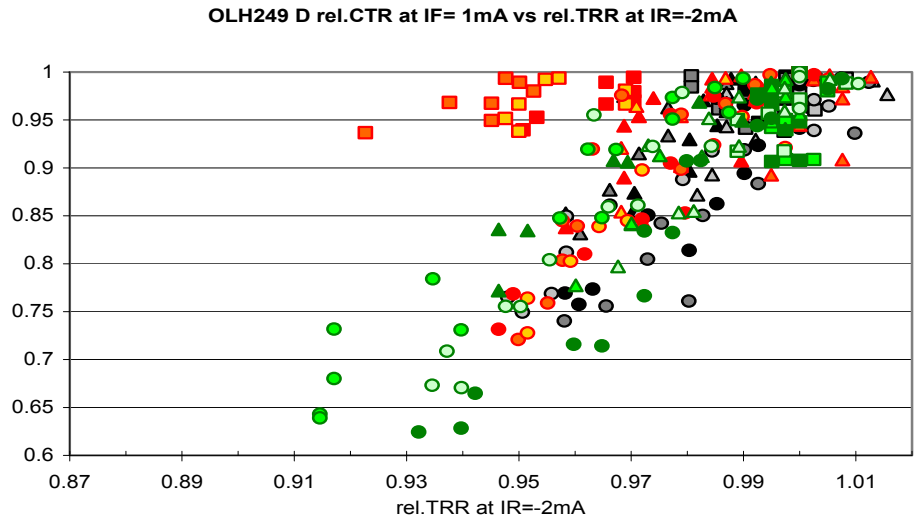
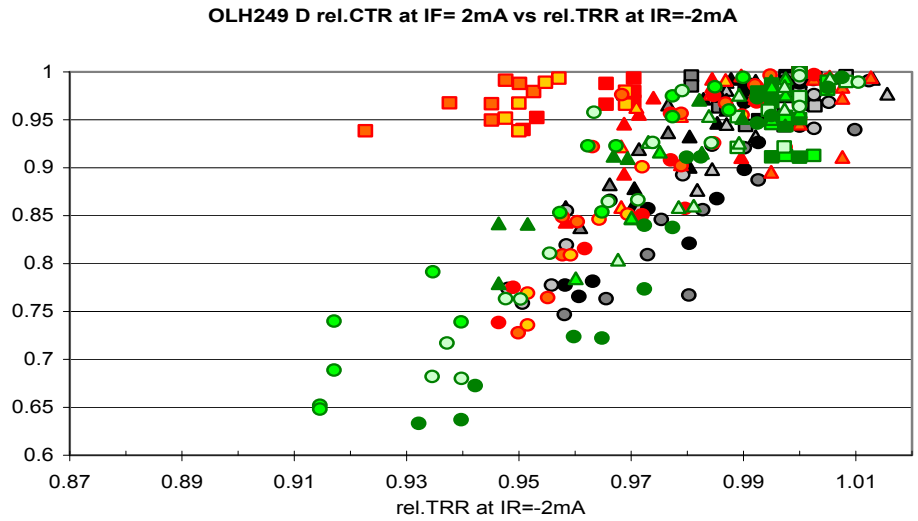
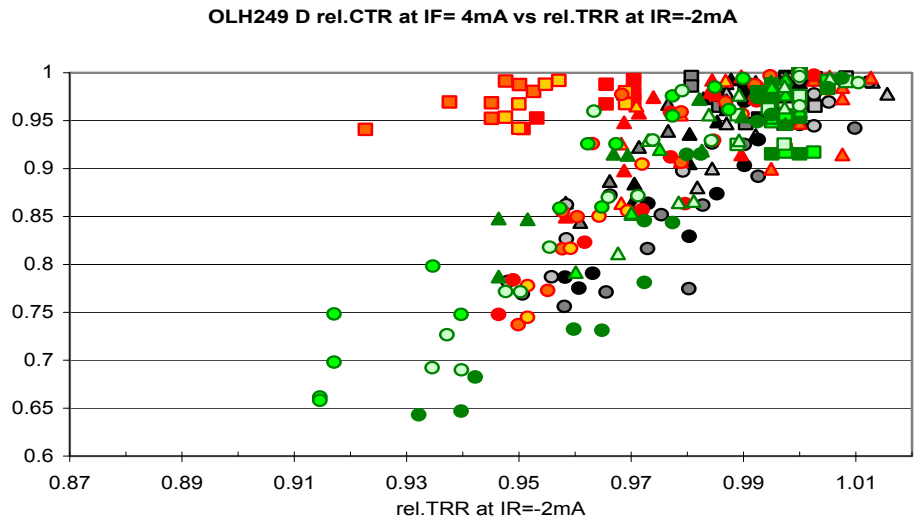


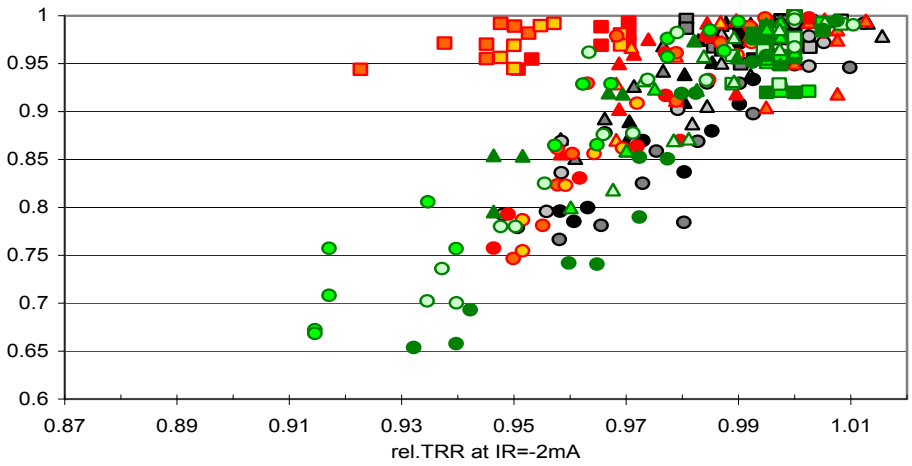
Fig. 13-98: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-2mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-2mA

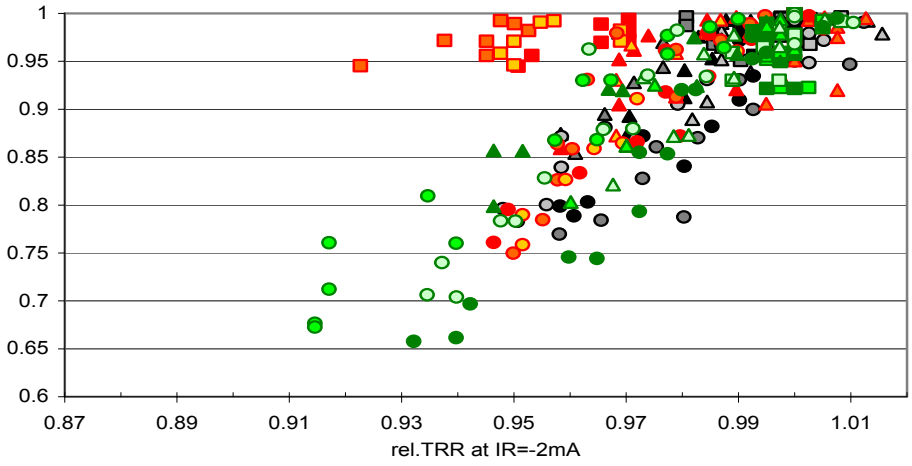
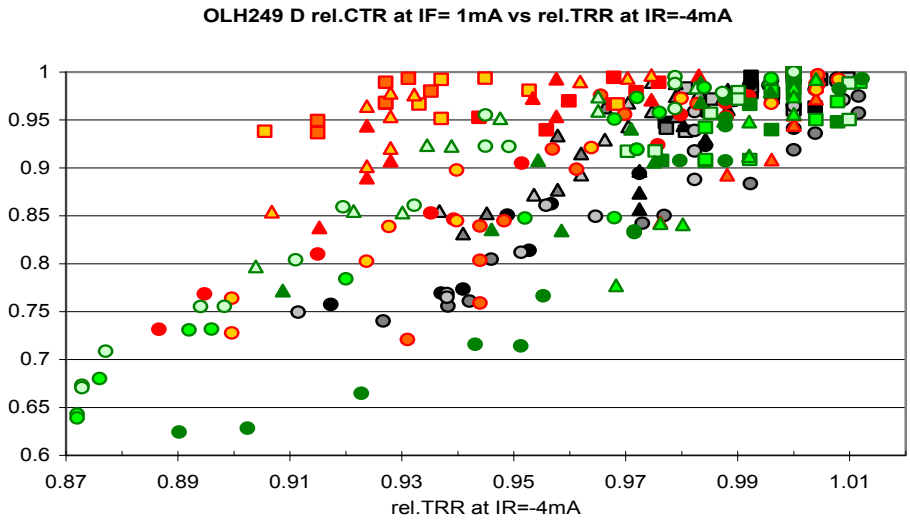
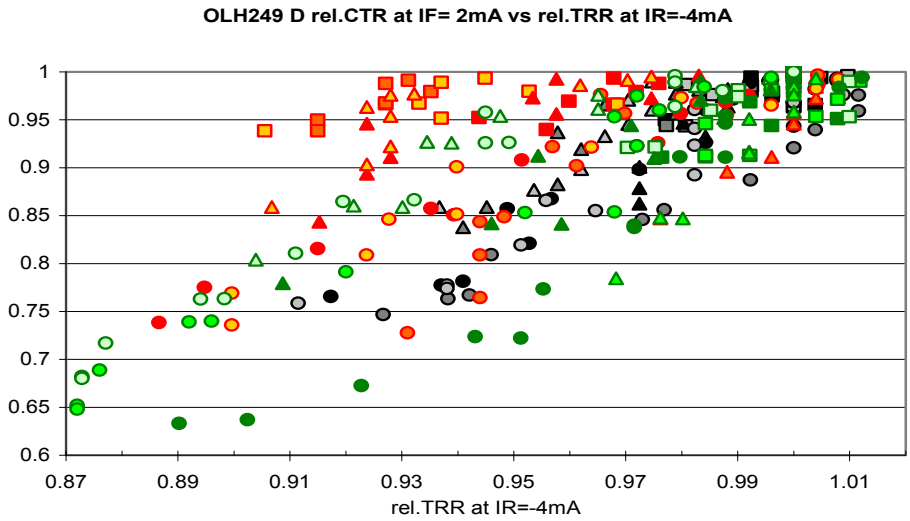
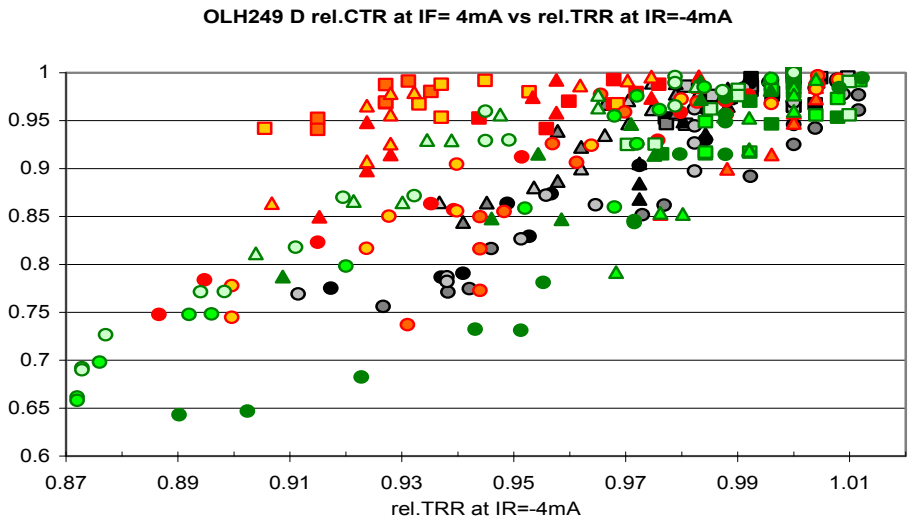


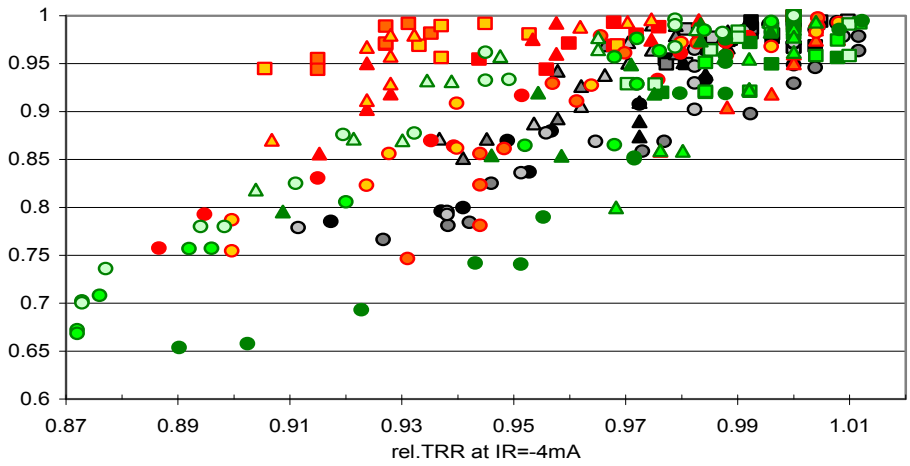
Fig. 13-99: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA







OLH249 D rel.CTR at IF= 8mA vs rel.TRR at IR=-4mA



OLH249 D rel.CTR at IF= 10mA vs rel.TRR at IR=-4mA

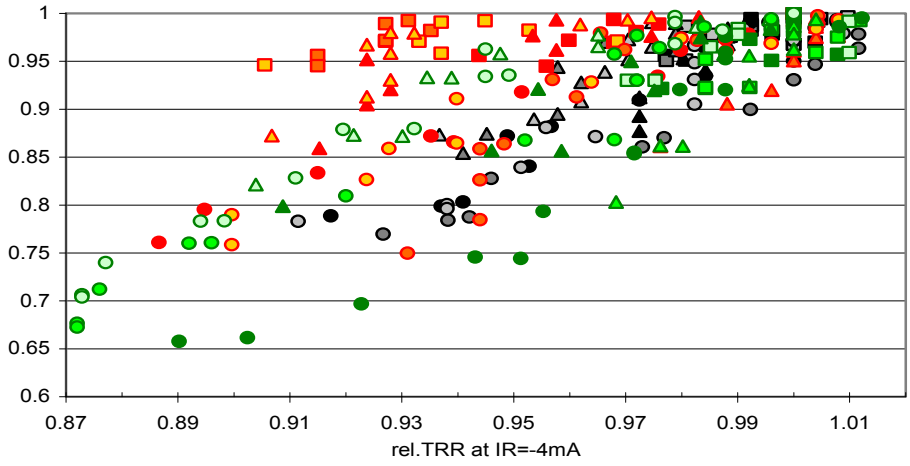
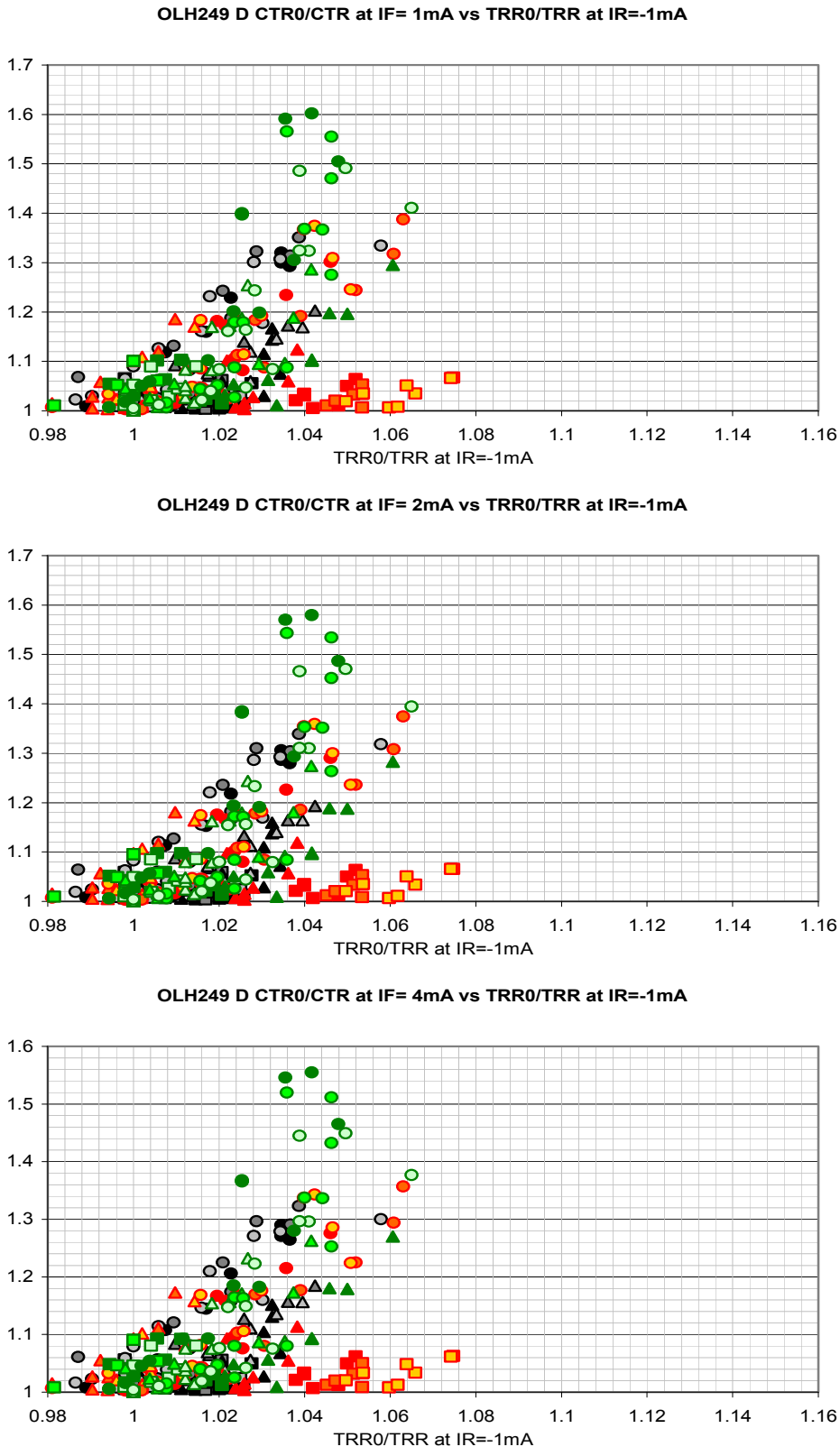
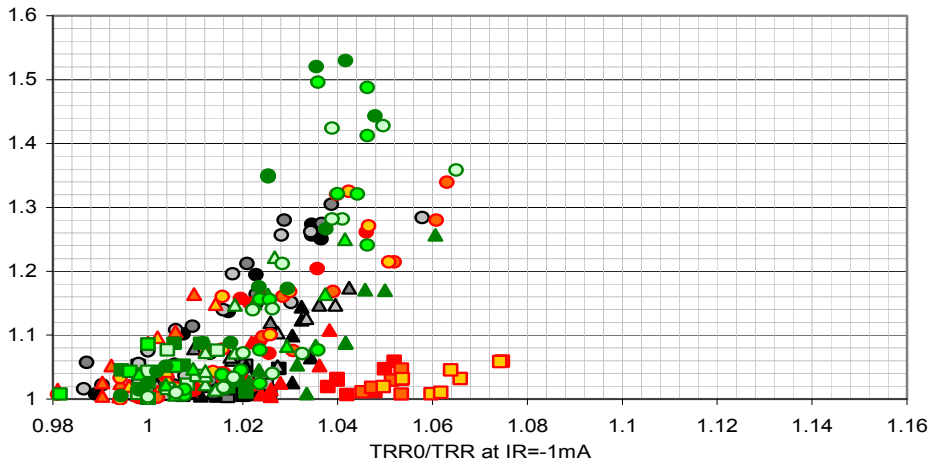


Fig. 13-100: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-1mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-1mA

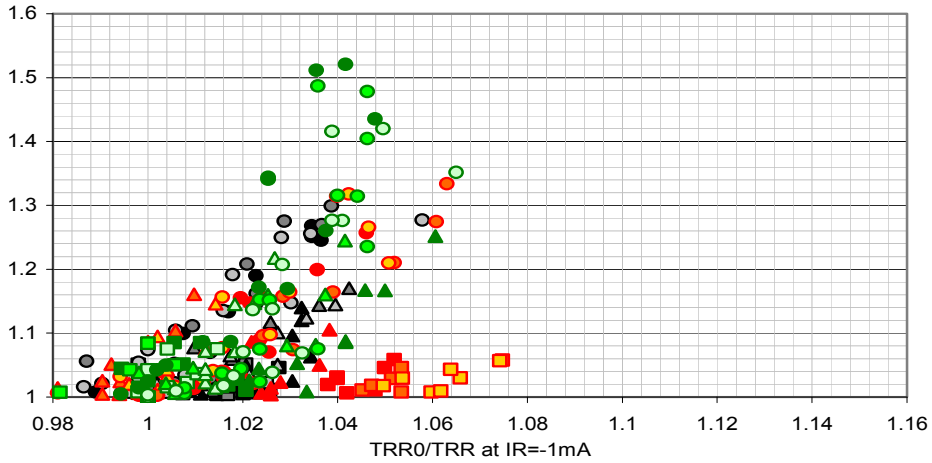
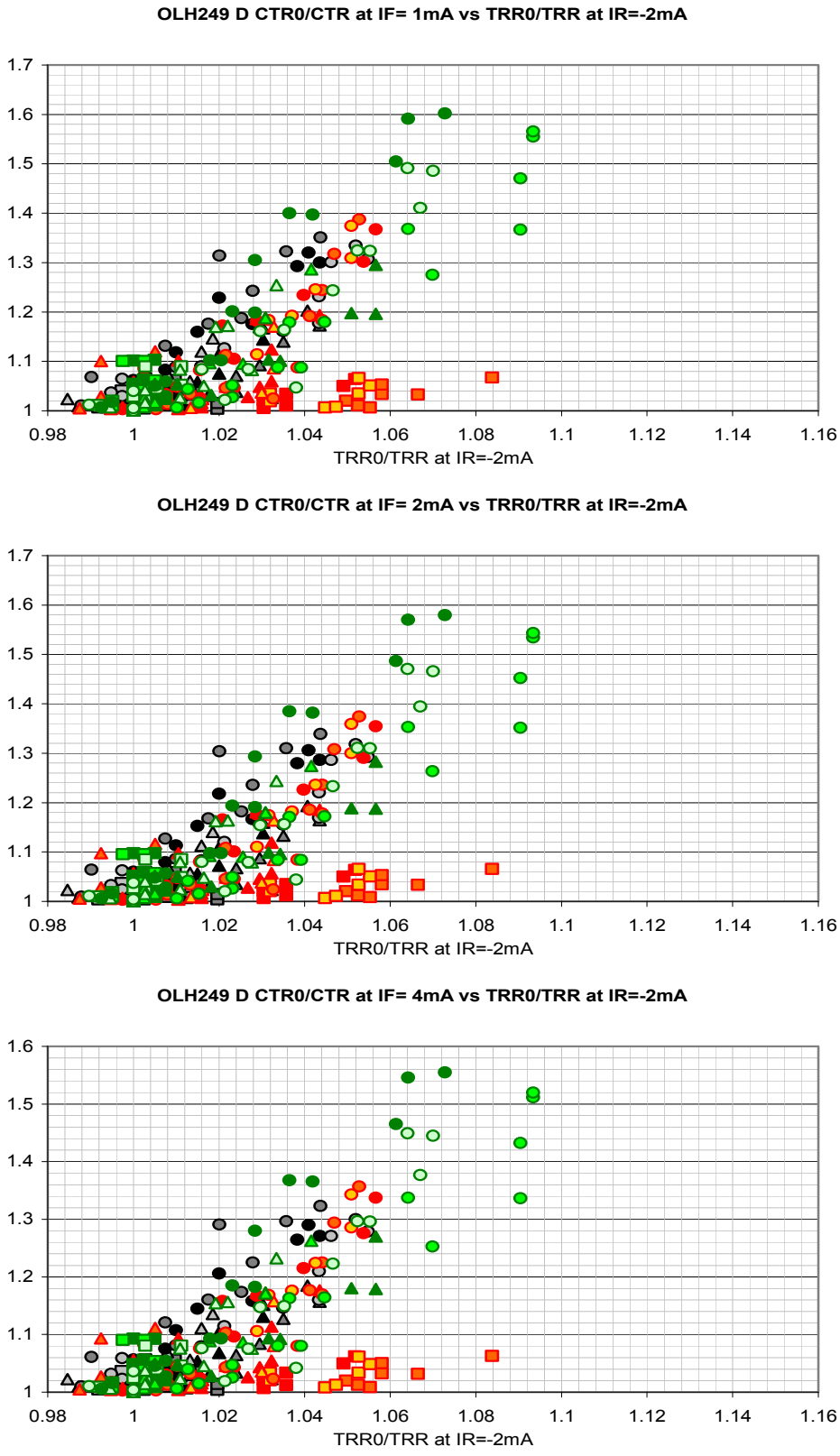
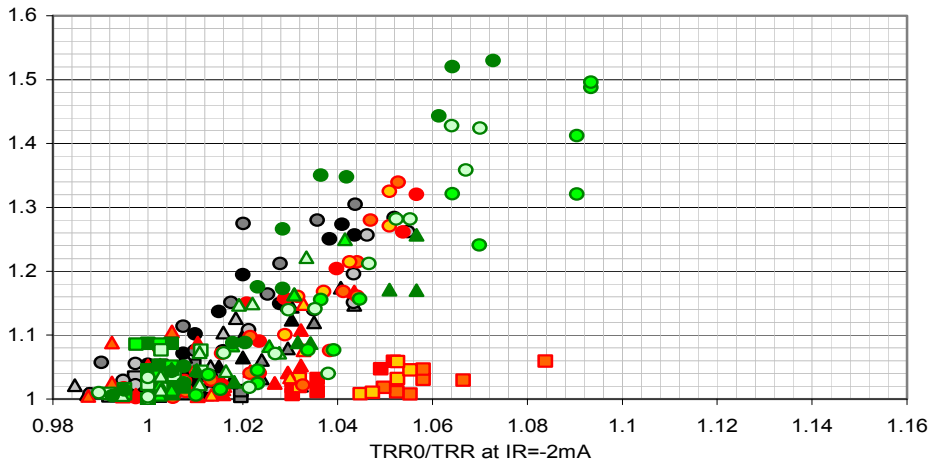


Fig. 13-101: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-2mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-2mA

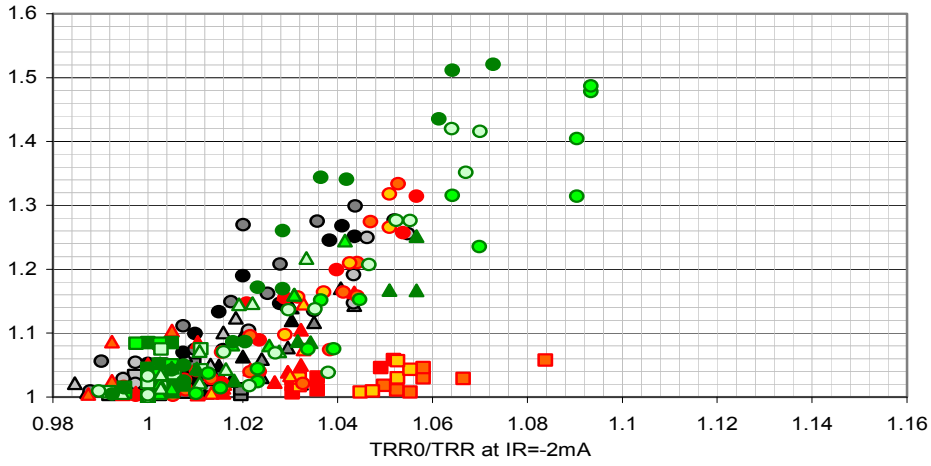
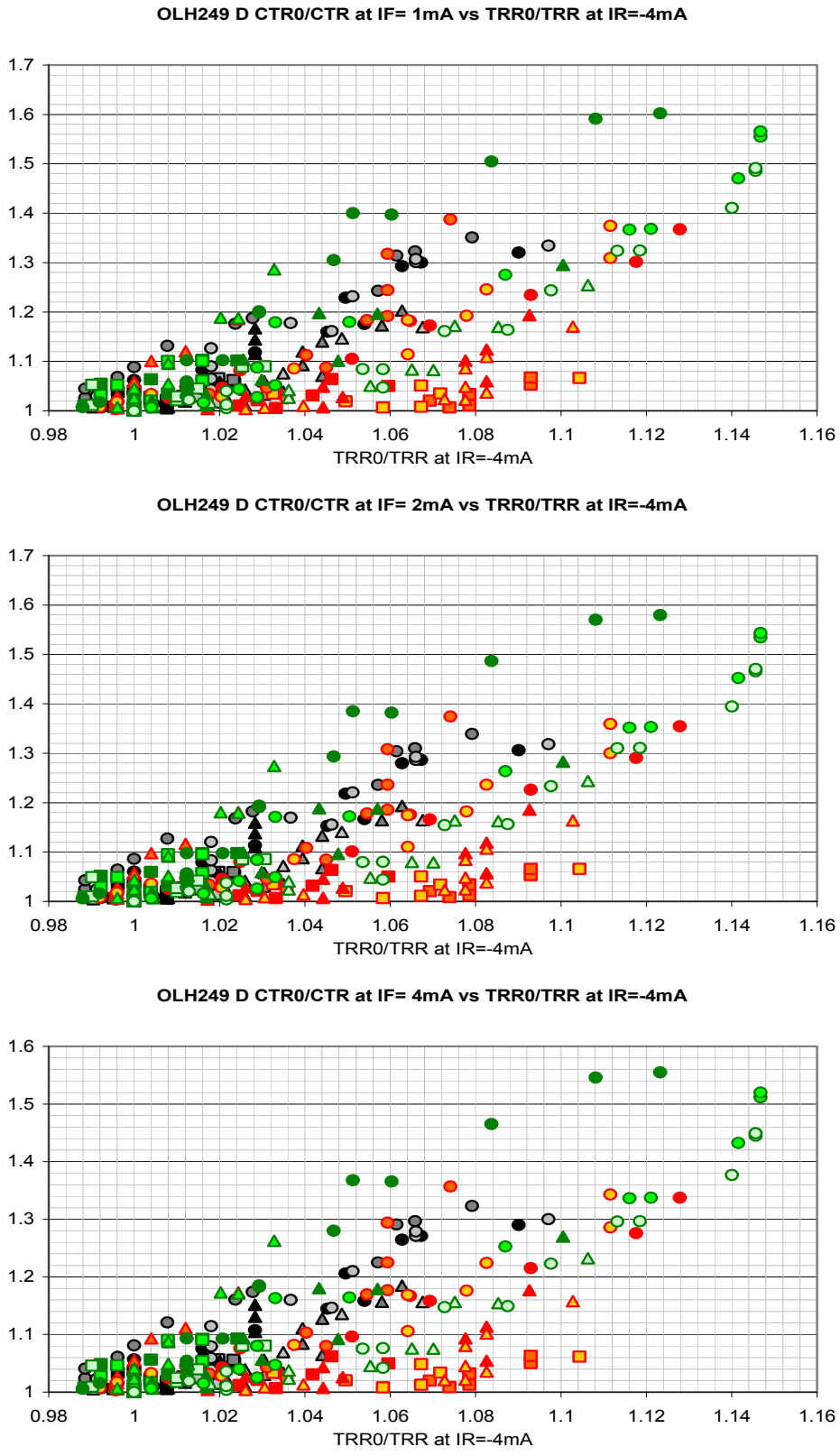
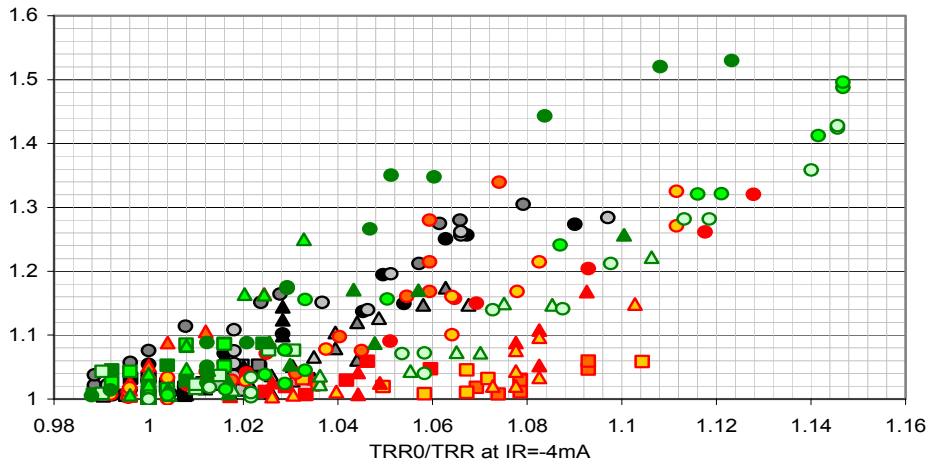


Fig. 13-102: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA



OLH249 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-4mA



OLH249 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-4mA

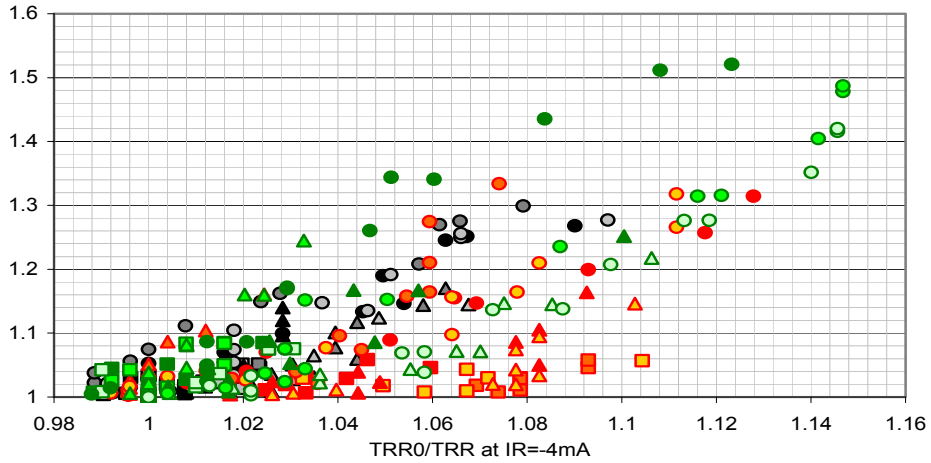
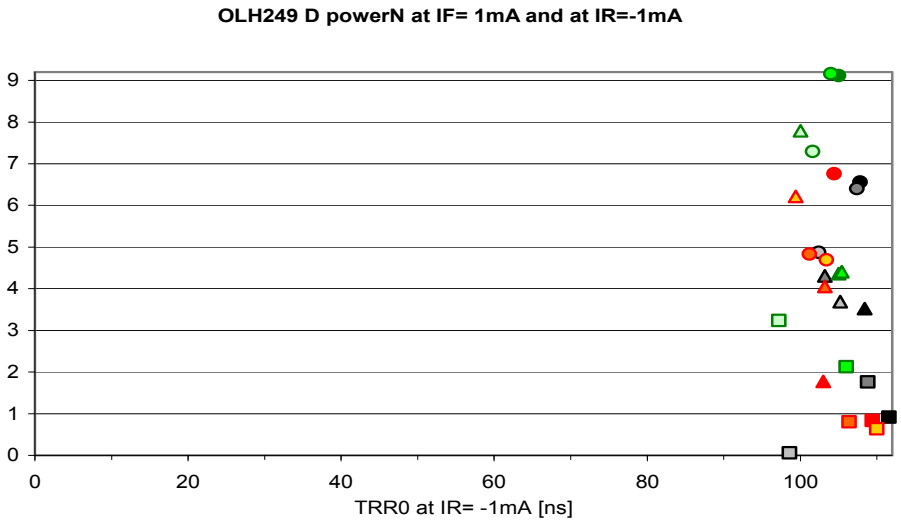
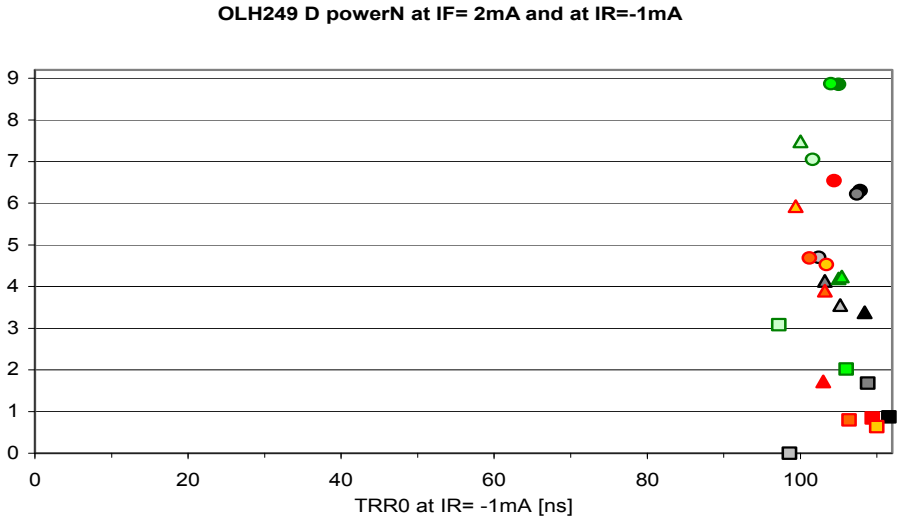
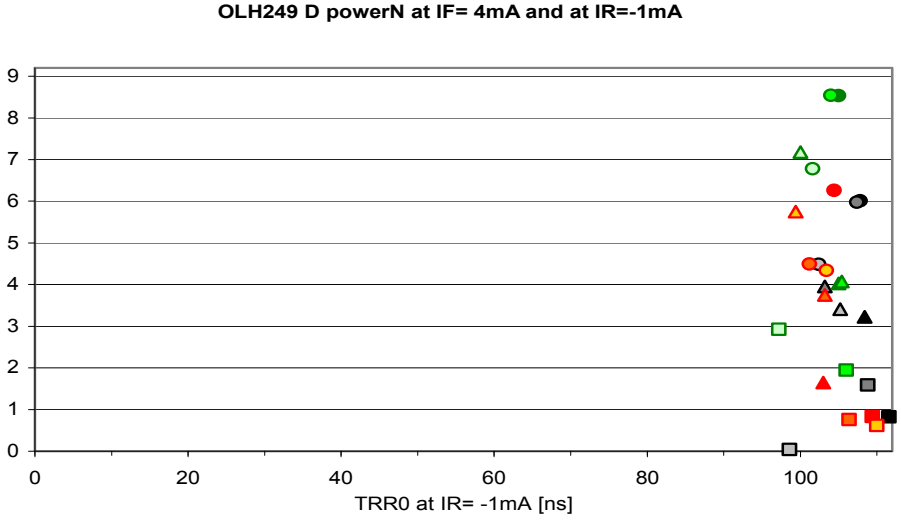


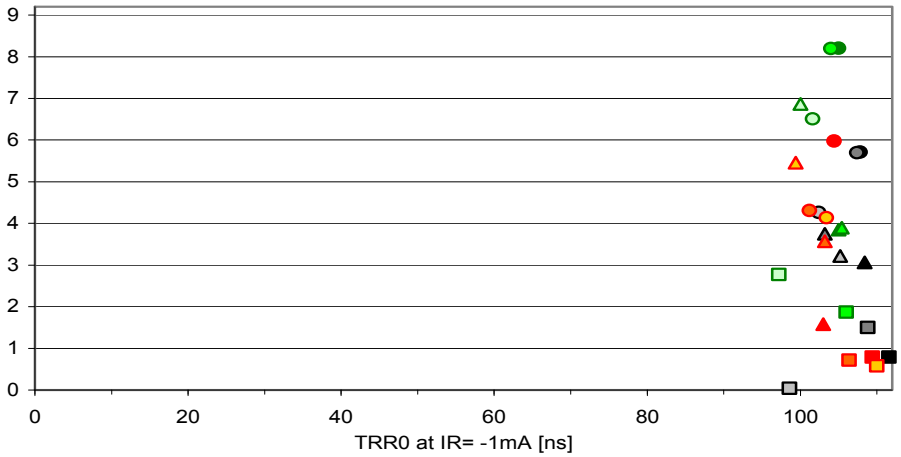
Fig. 13-103: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA







OLH249 D powerN at IF= 8mA and at IR=-1mA



OLH249 D powerN at IF= 10mA and at IR=-1mA

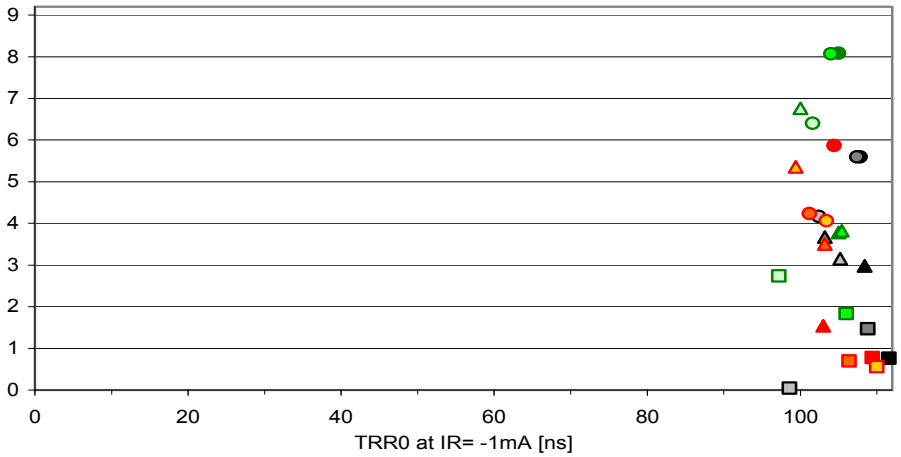
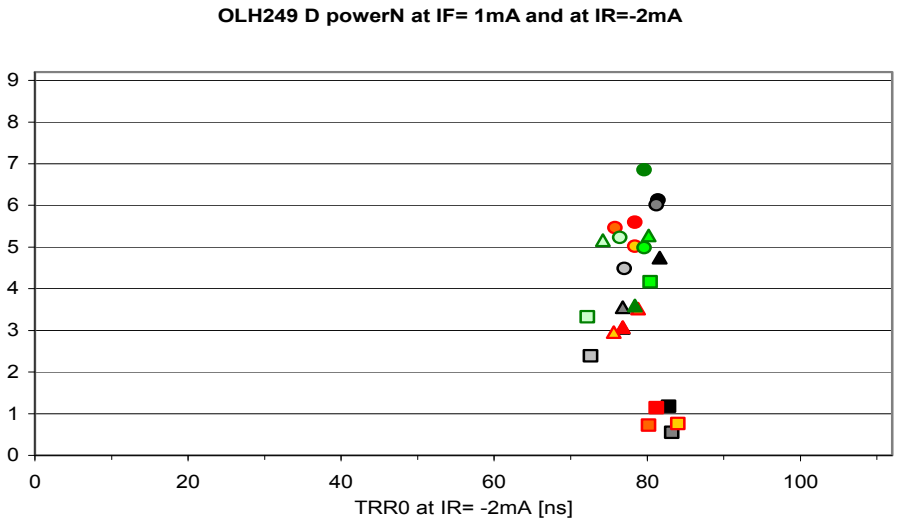
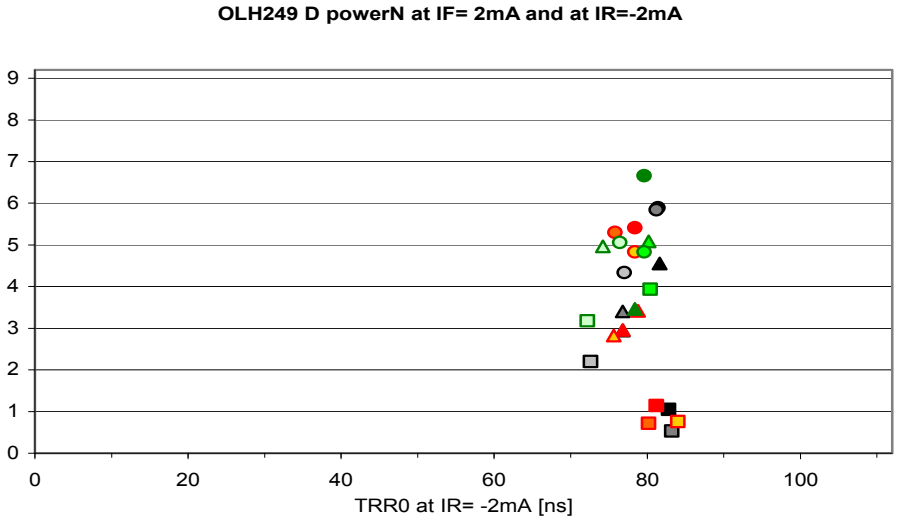
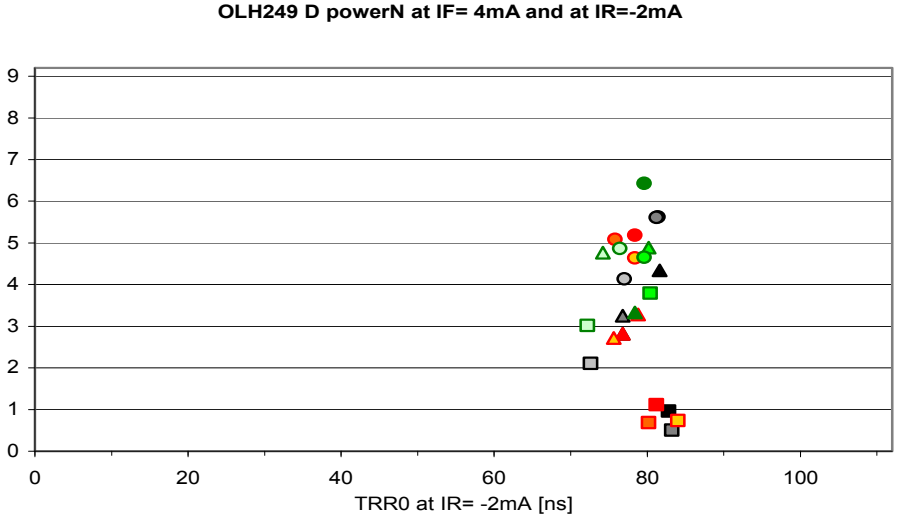


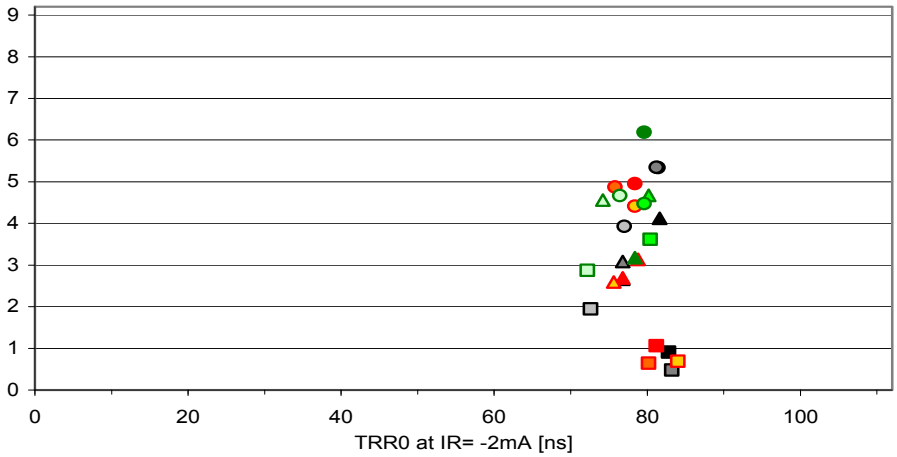
Fig. 13-104: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA







OLH249 D powerN at IF= 8mA and at IR=-2mA



OLH249 D powerN at IF= 10mA and at IR=-2mA

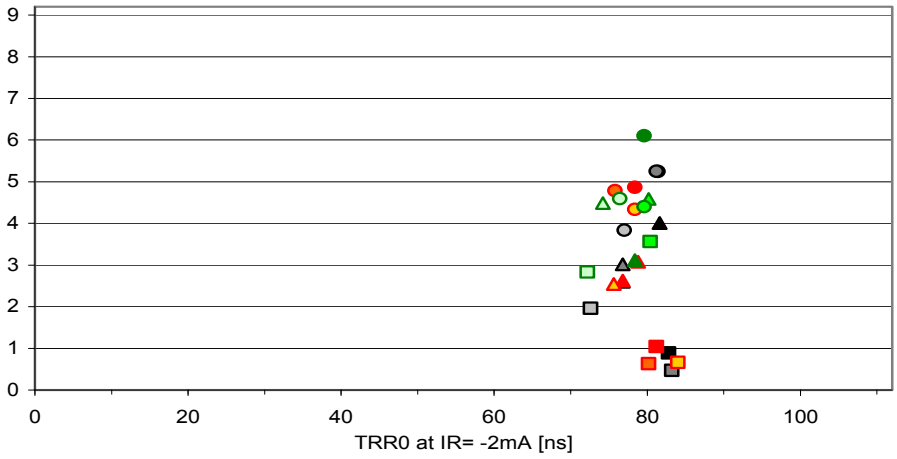
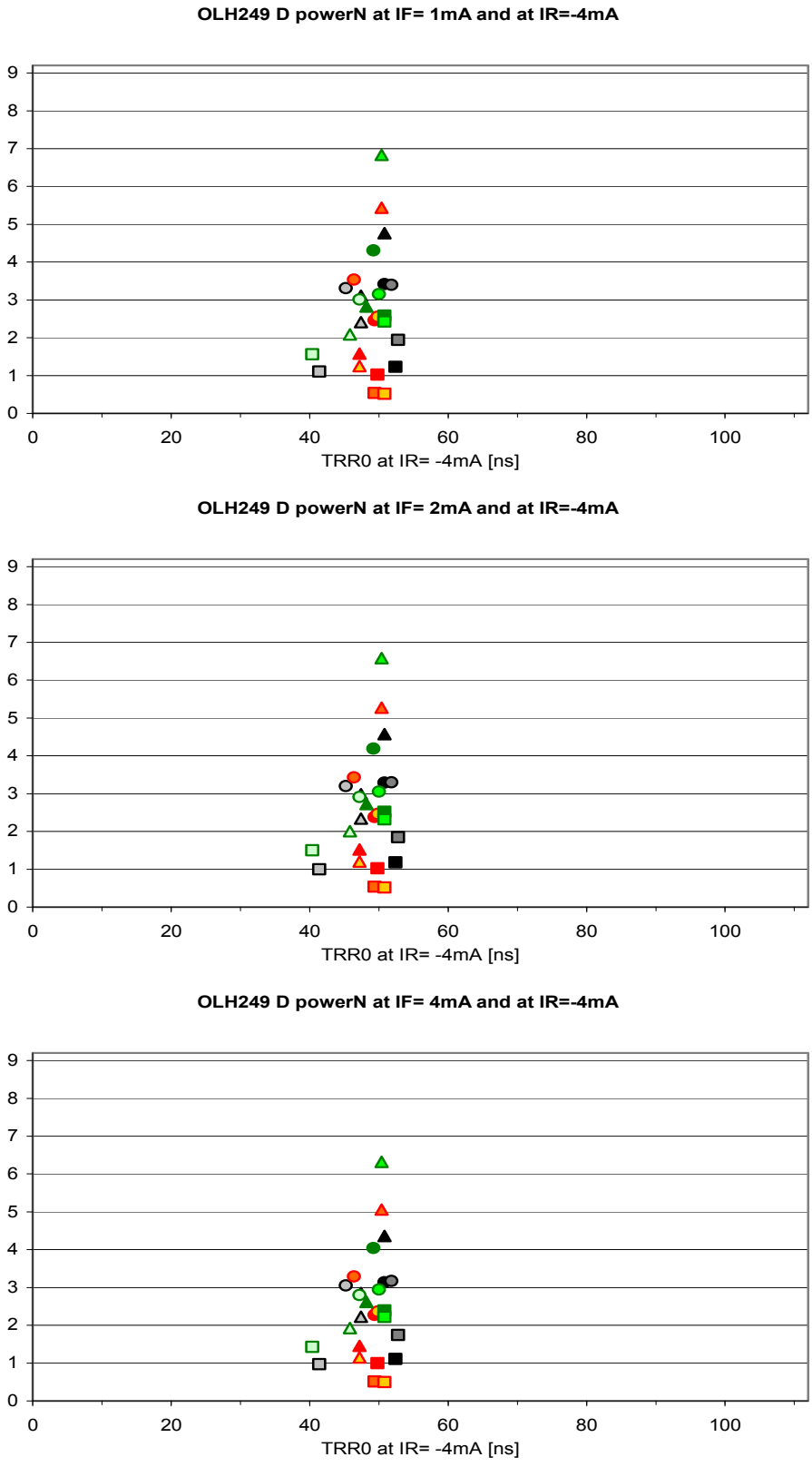
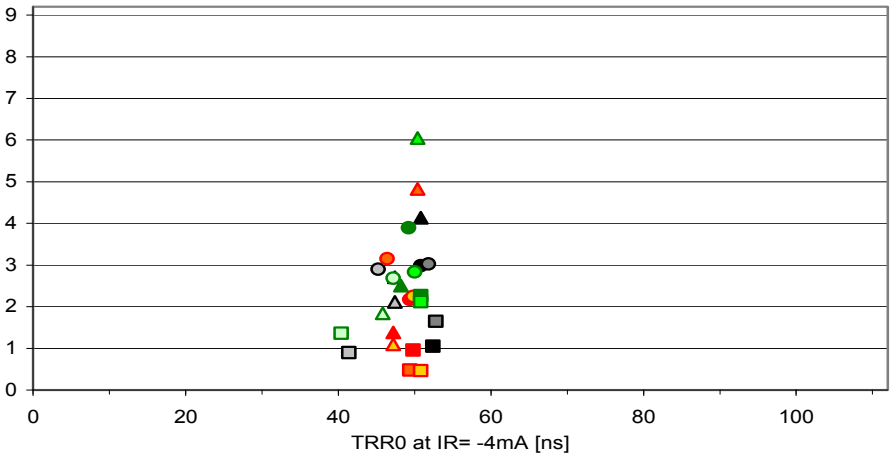


Fig. 13-105: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA



OLH249 D powerN at IF= 8mA and at IR=-4mA



OLH249 D powerN at IF= 10mA and at IR=-4mA

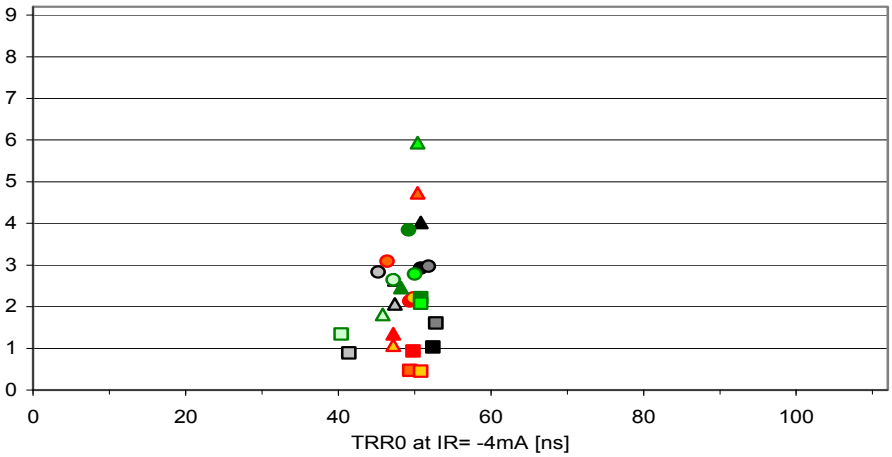
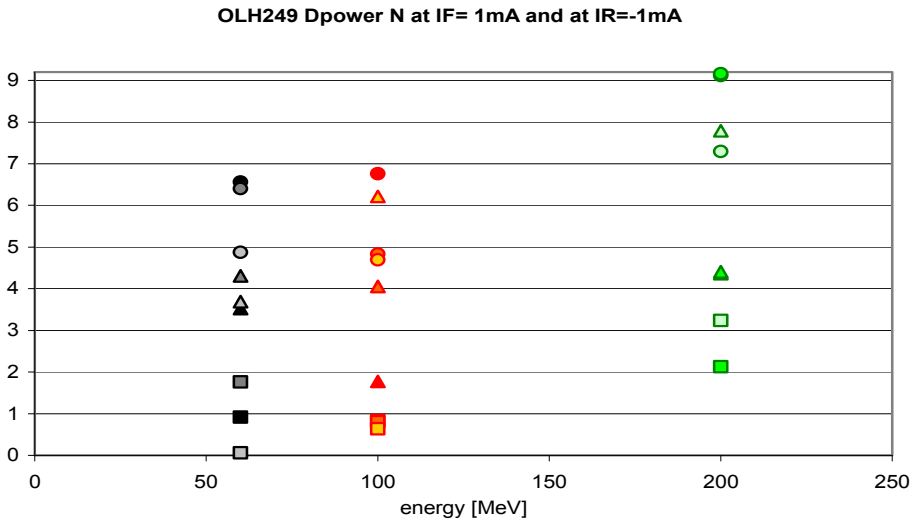
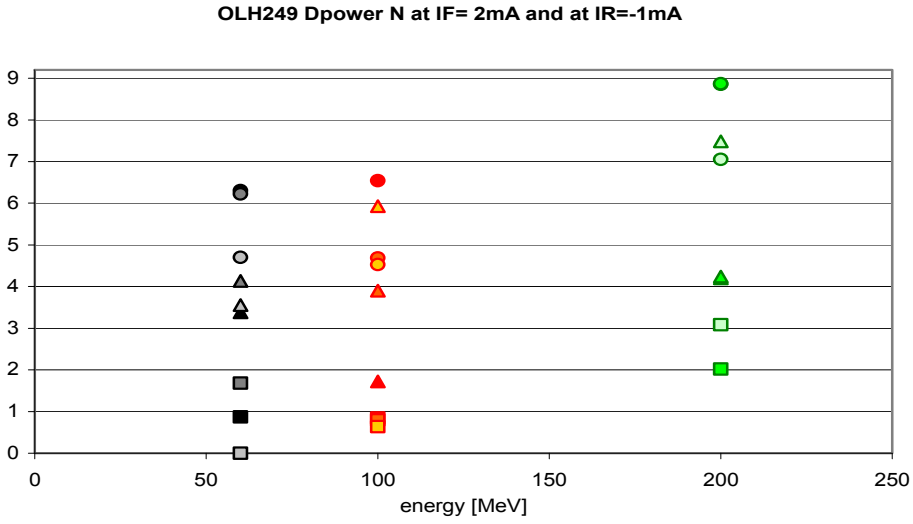
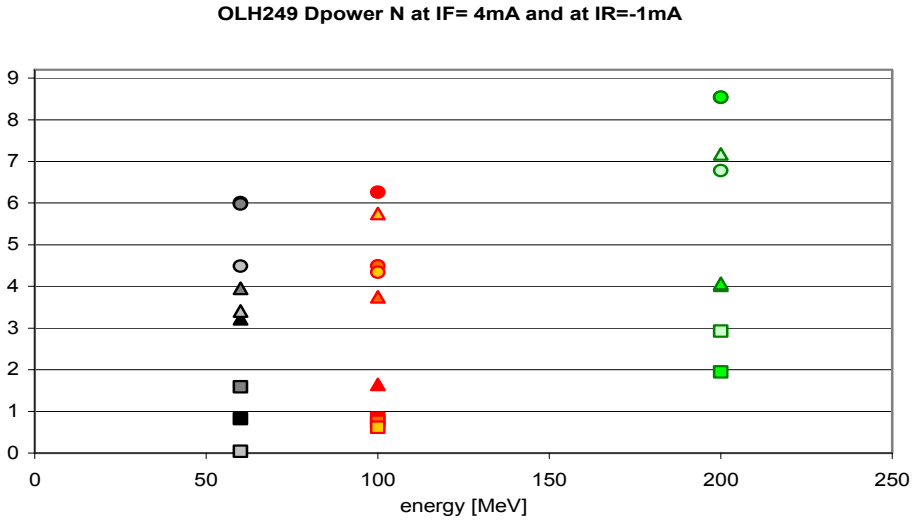
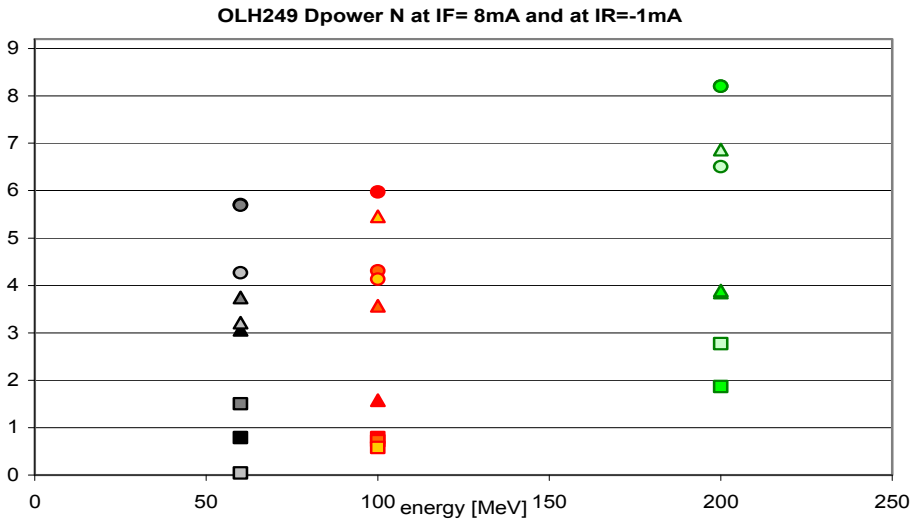


Fig. 13-106: OLH249 diode: N at I_R = -1 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy








OLH249 Dpower N at IF= 8mA and at IR=-1mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

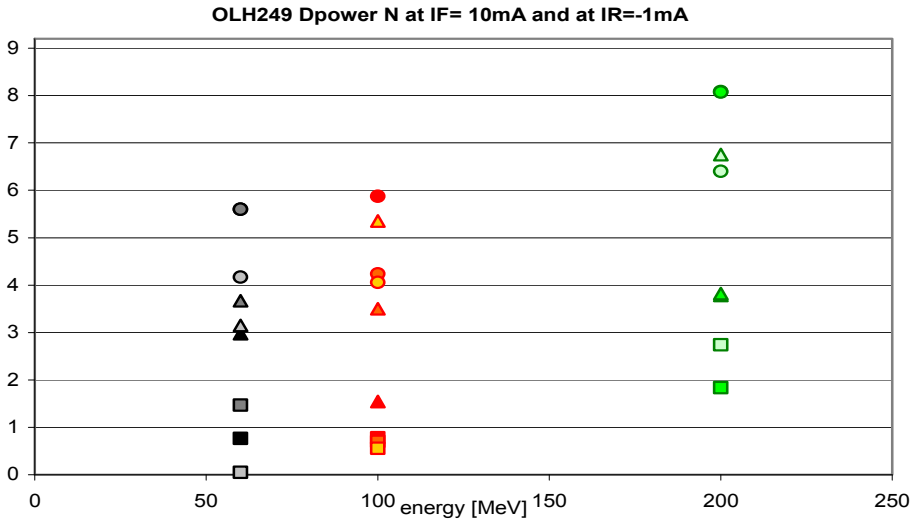
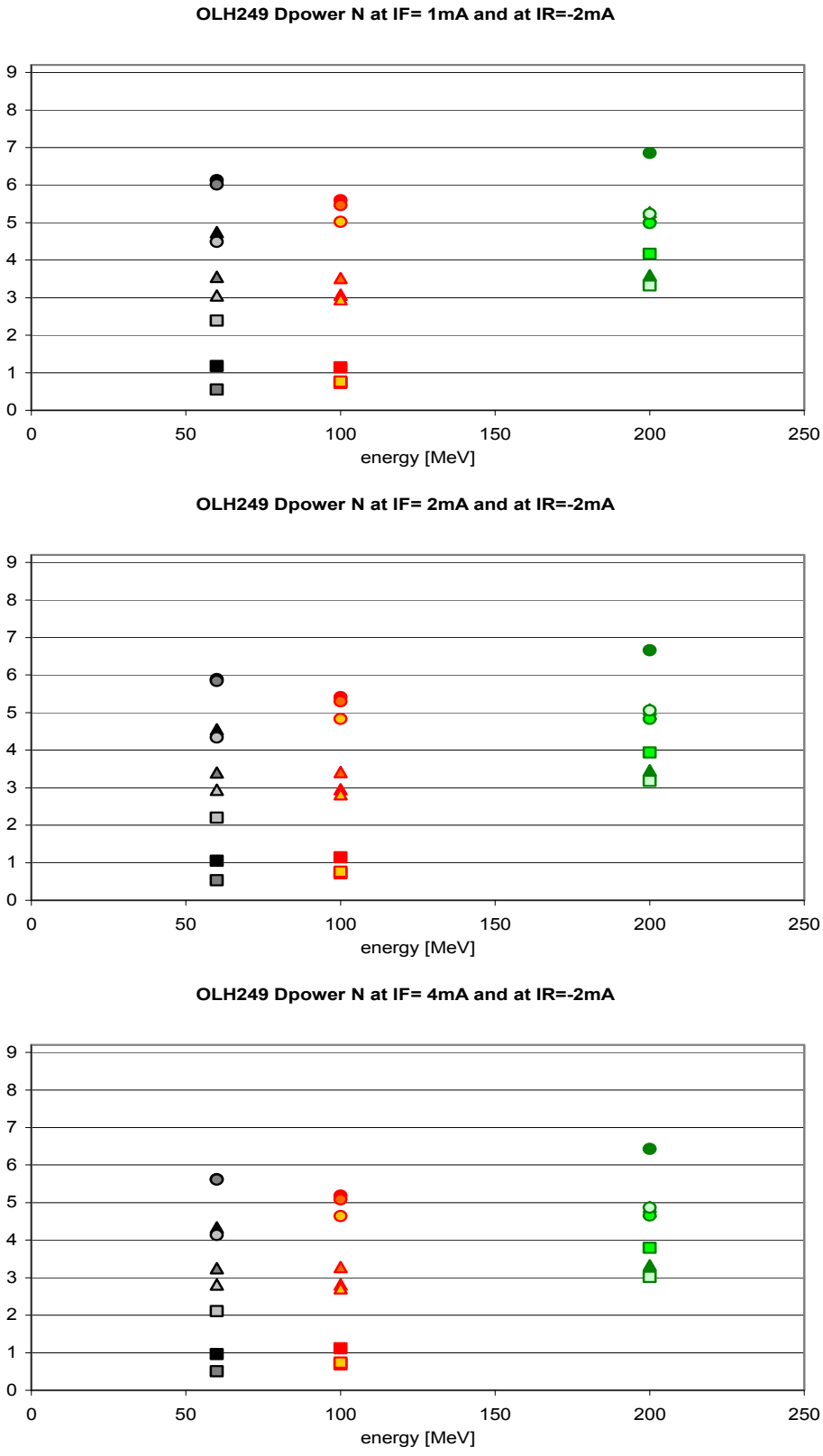
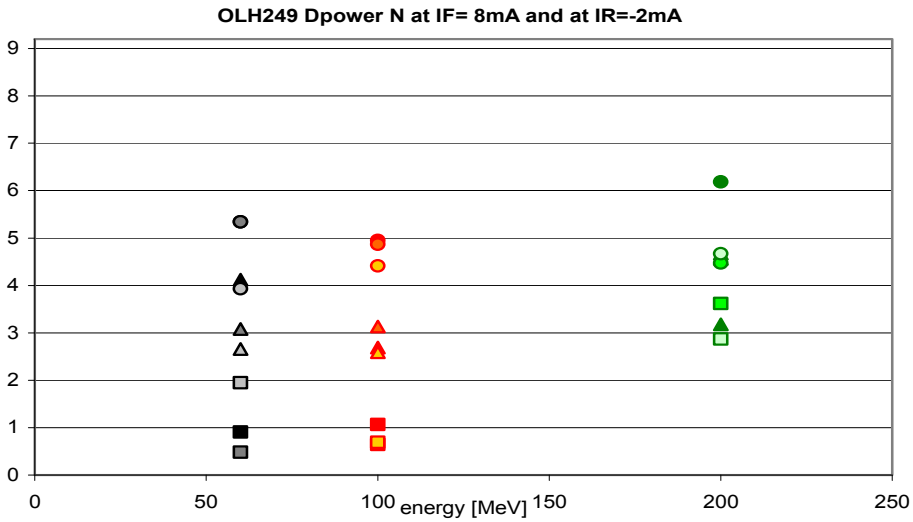

OLH249 Dpower N at IF= 10mA and at IR=-1mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

Fig. 13-107: OLH249 diode: N at I_R = -2 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy




OLH249 Dpower N at IF= 8mA and at IR=-2mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

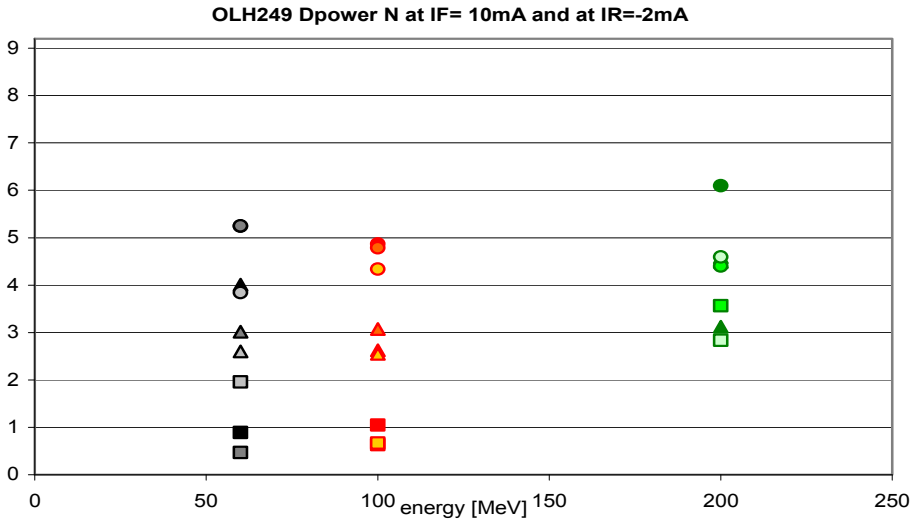
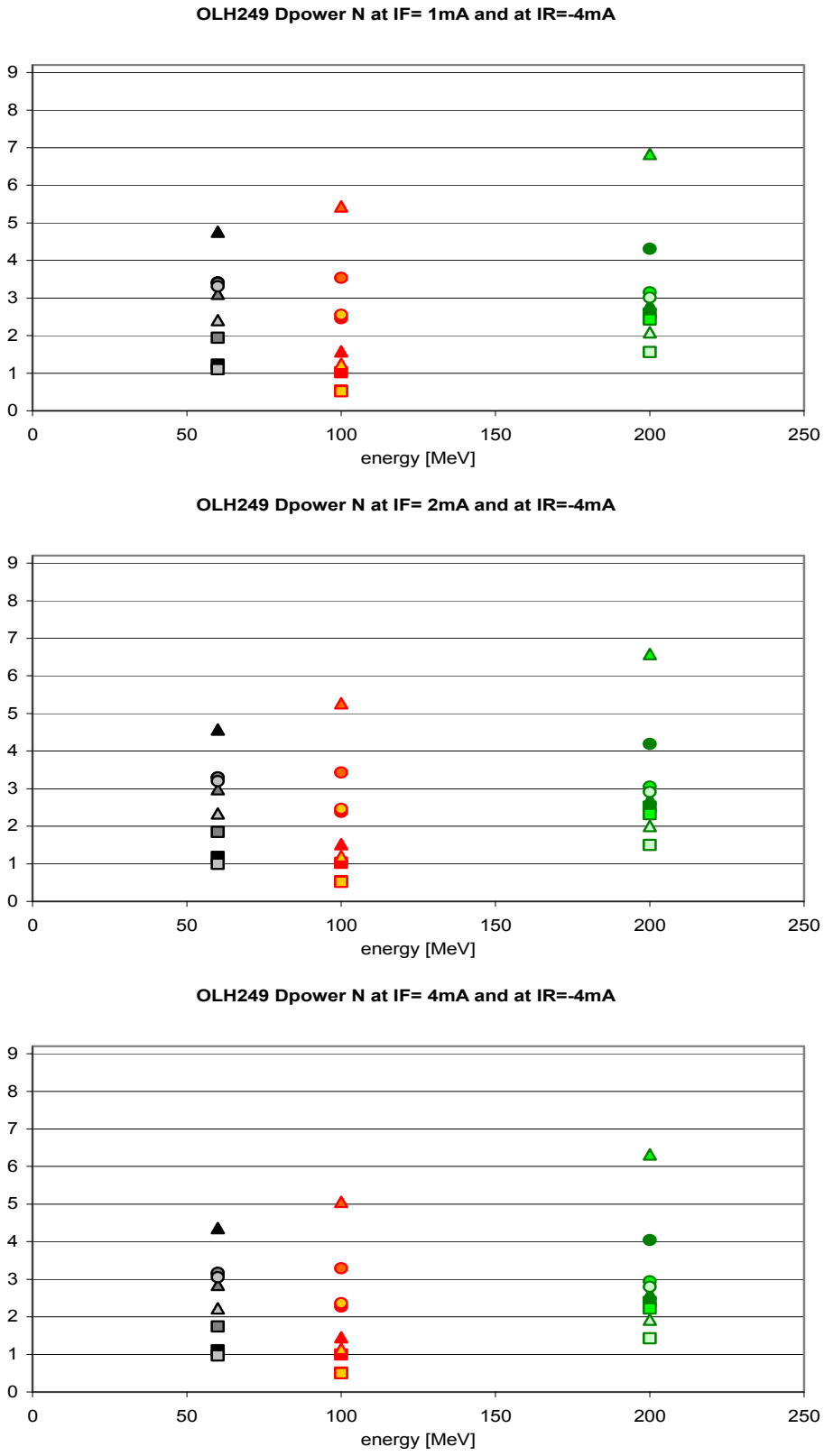
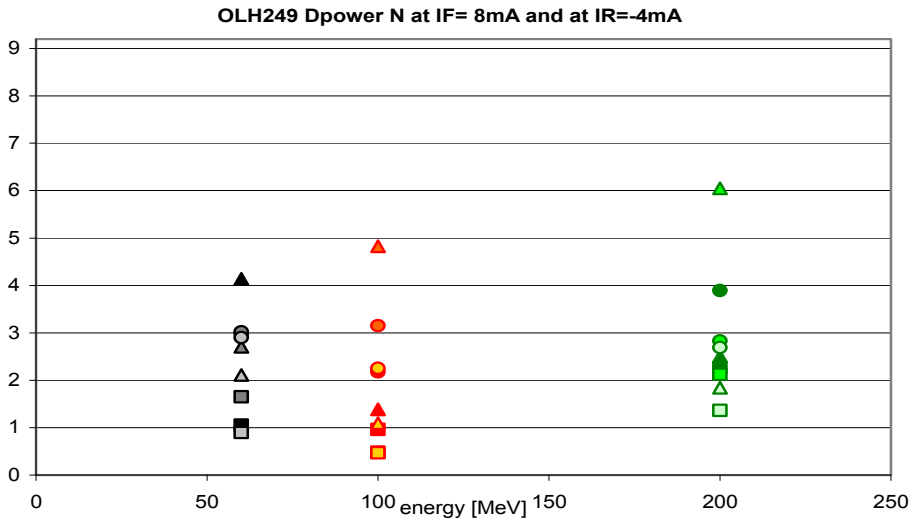
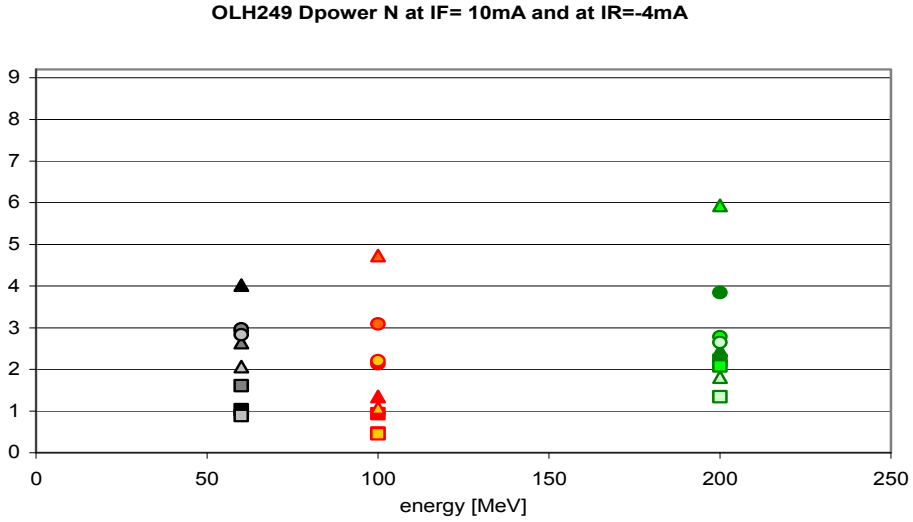

OLH249 Dpower N at IF= 10mA and at IR=-2mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

Fig. 13-108: OLH249 diode: N at I_R = -4 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy

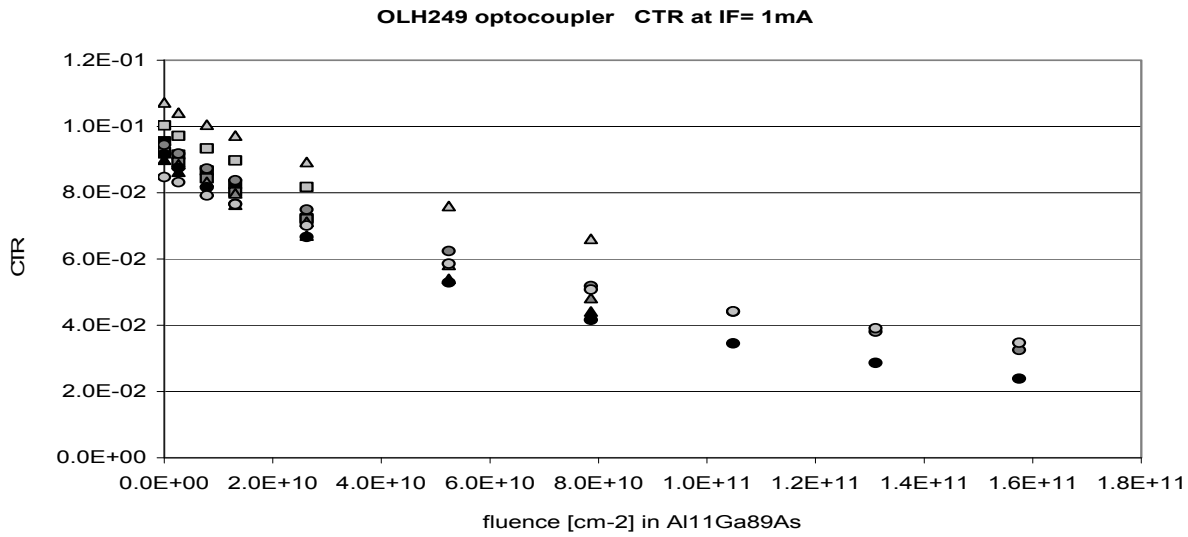


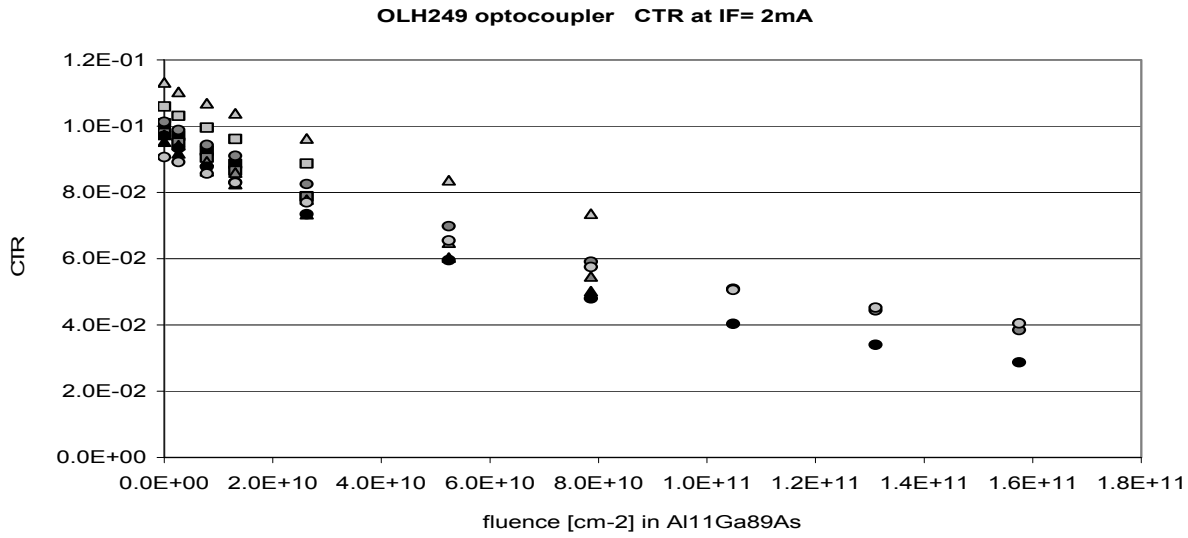

OLH249 Dpower N at IF= 8mA and at IR=-4mA
9
8
7
6
5
4
3
2
1
0
0
50
100
energy [MeV]
150
200
250

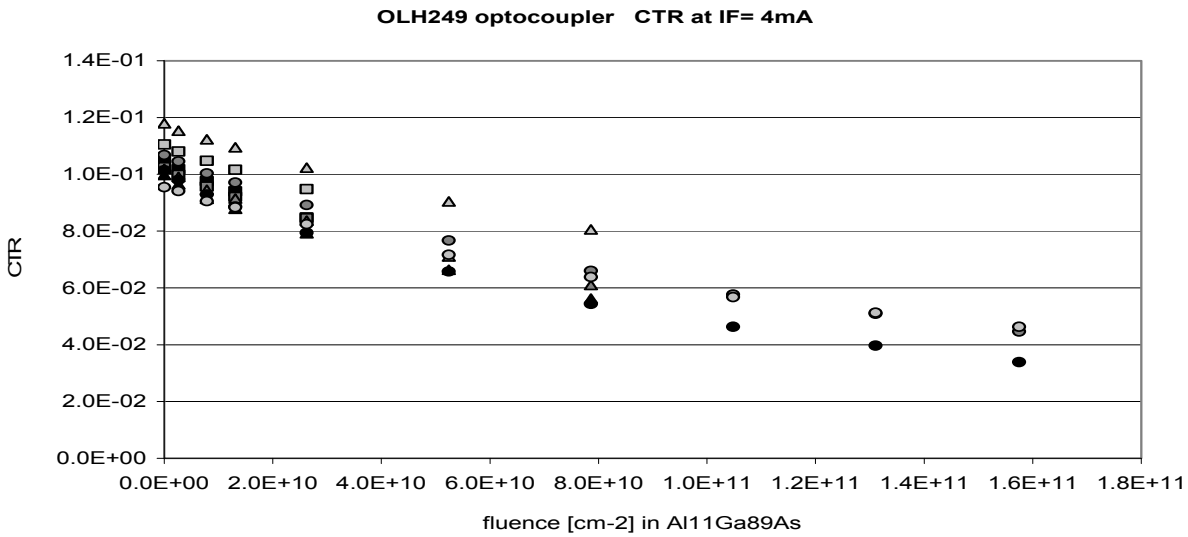

OLH249 Dpower N at IF= 10mA and at IR=-4mA
9
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
energy [MeV]

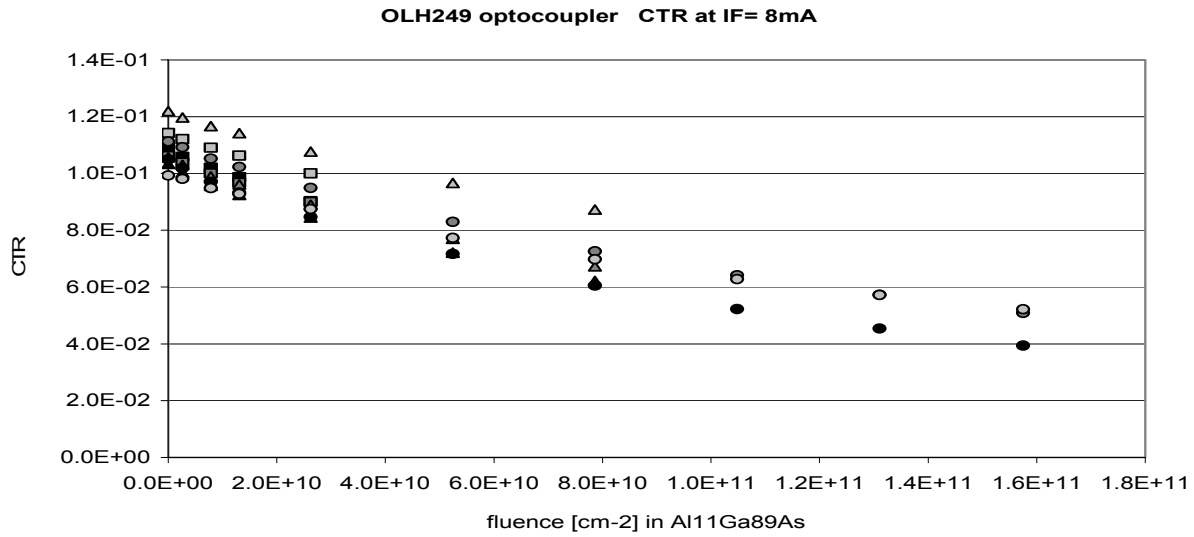
13.2 NEUTRON IRRADIATION

Fig. 13-109: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

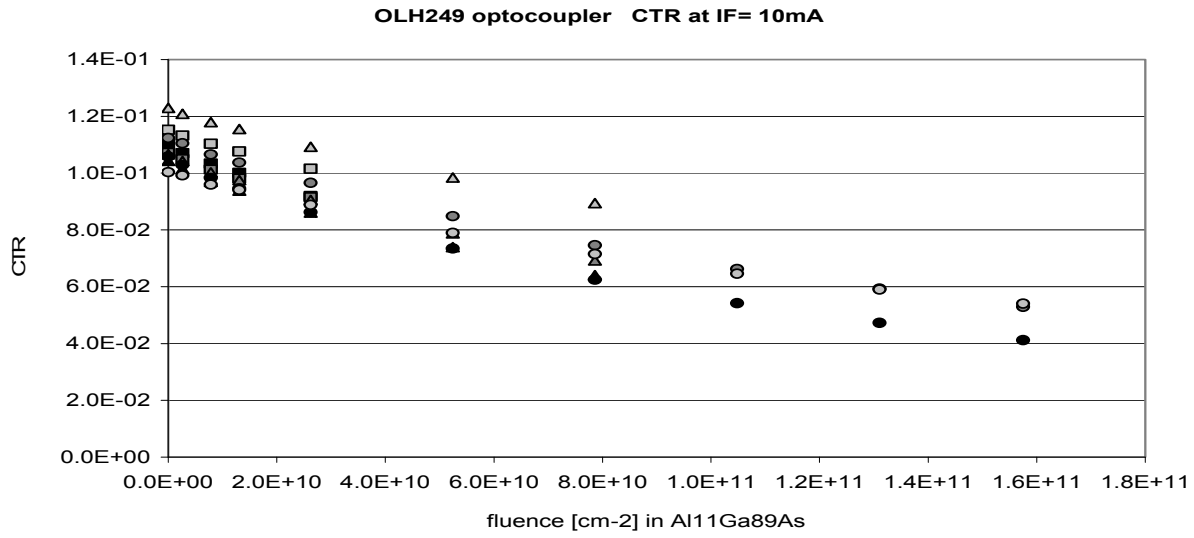
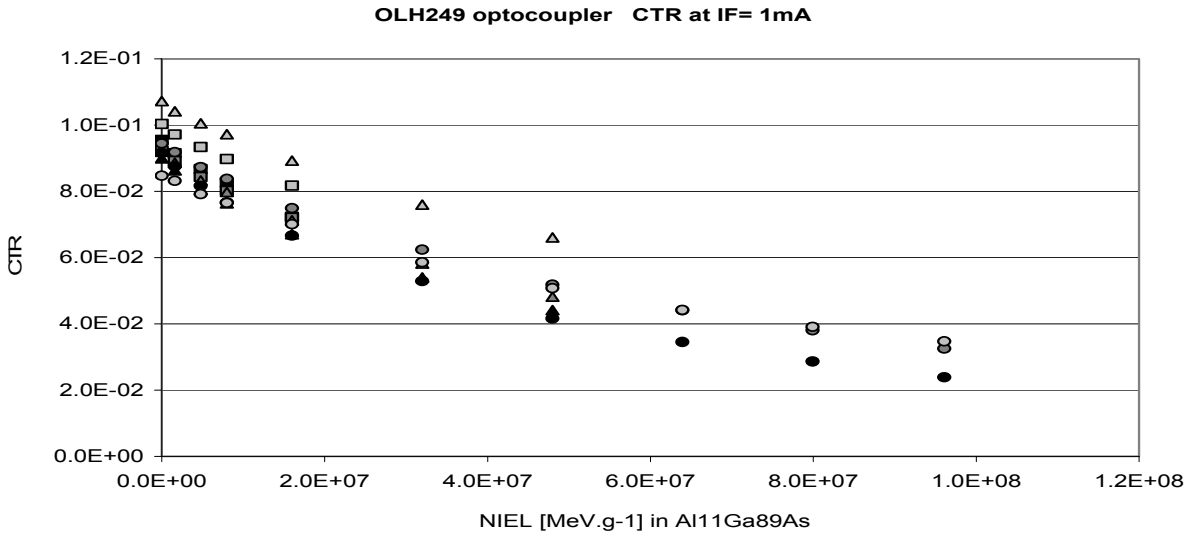
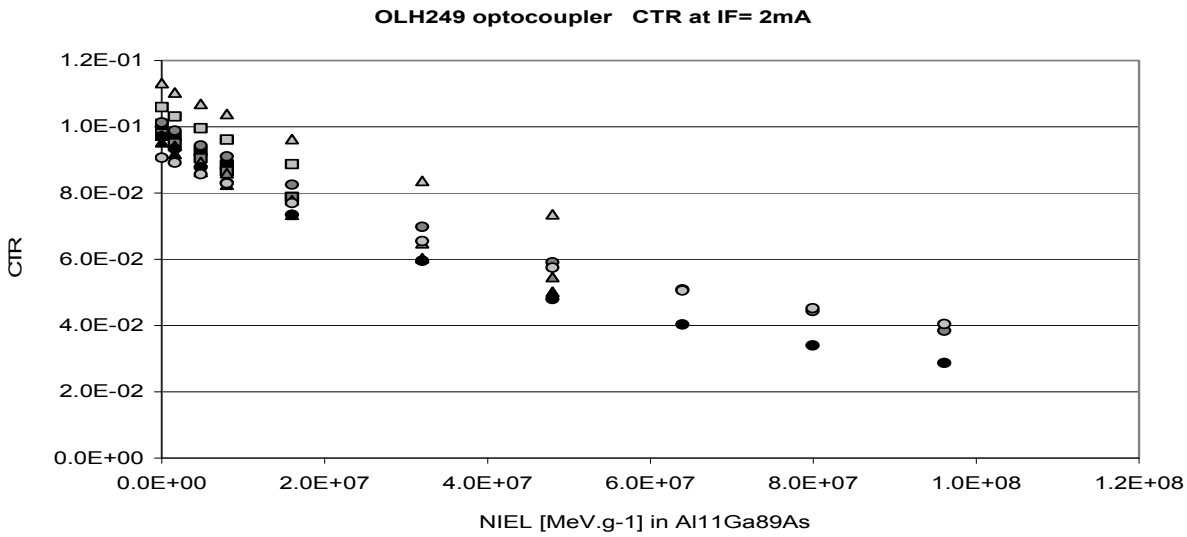
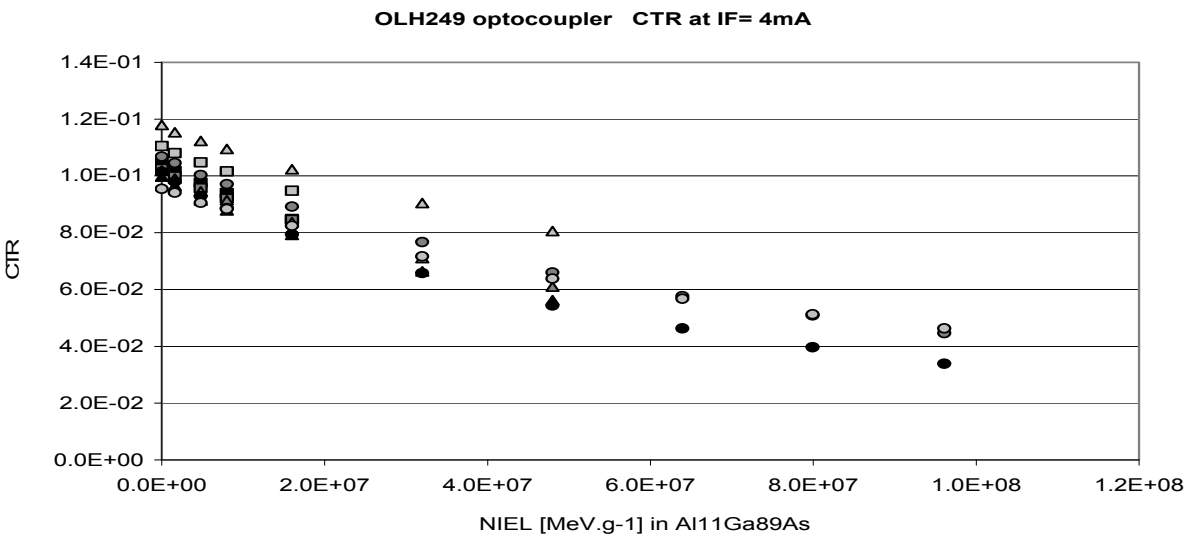
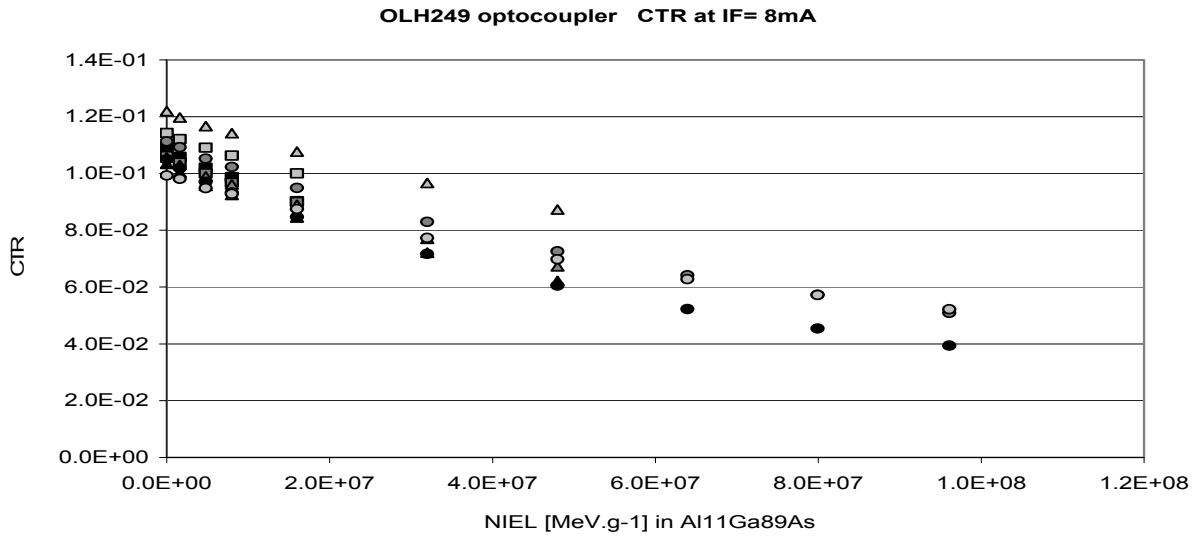

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-110: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

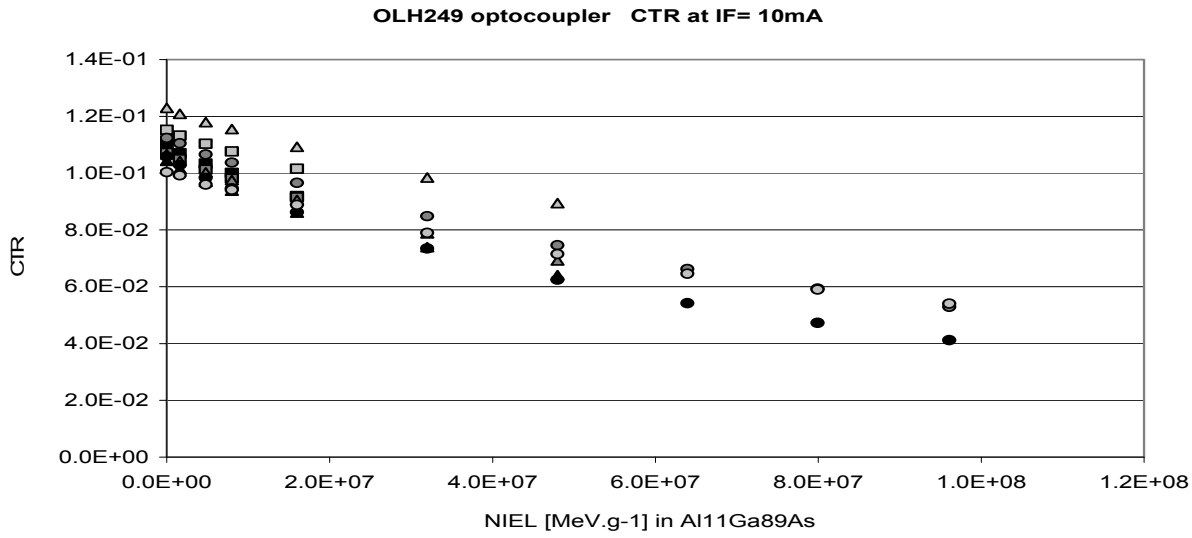
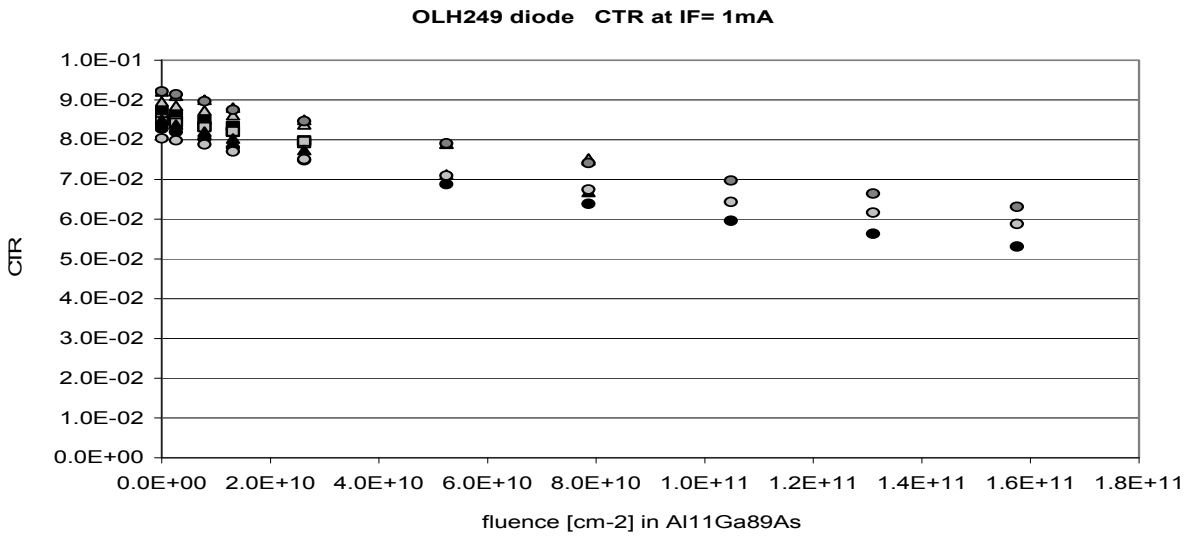
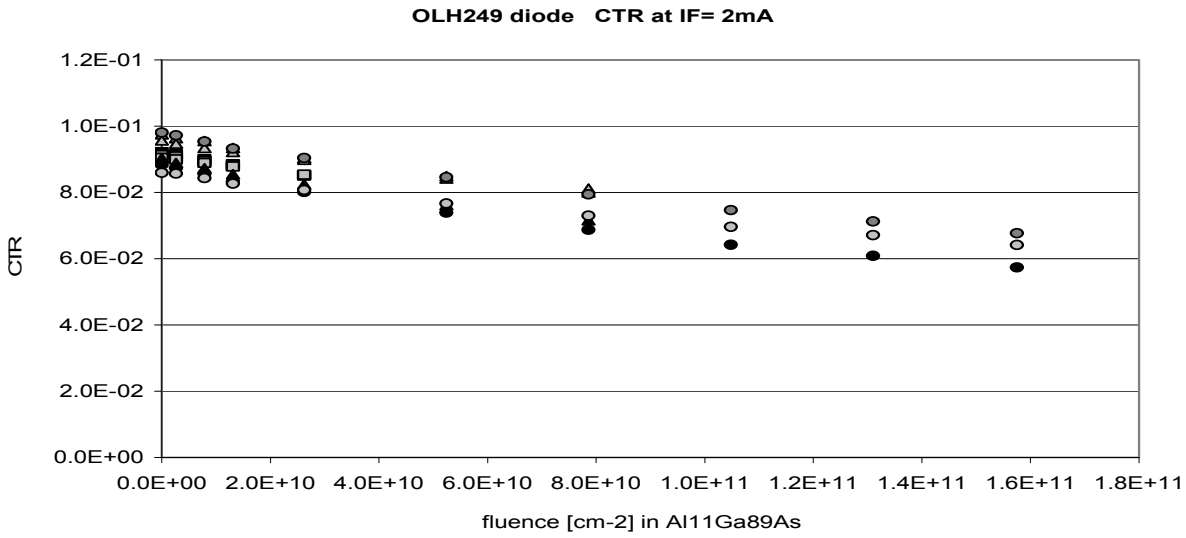
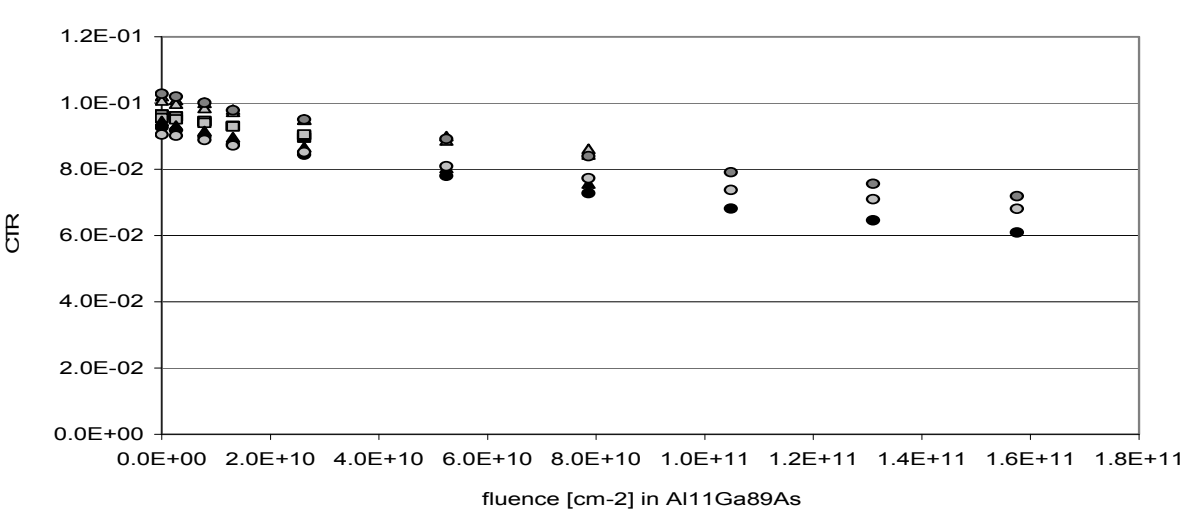
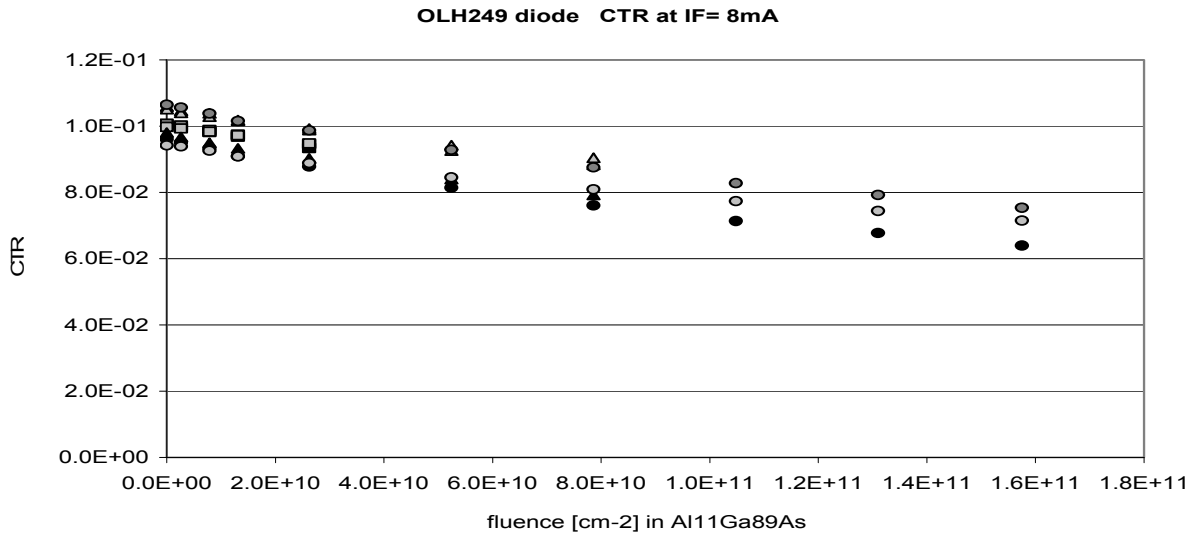

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-111: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

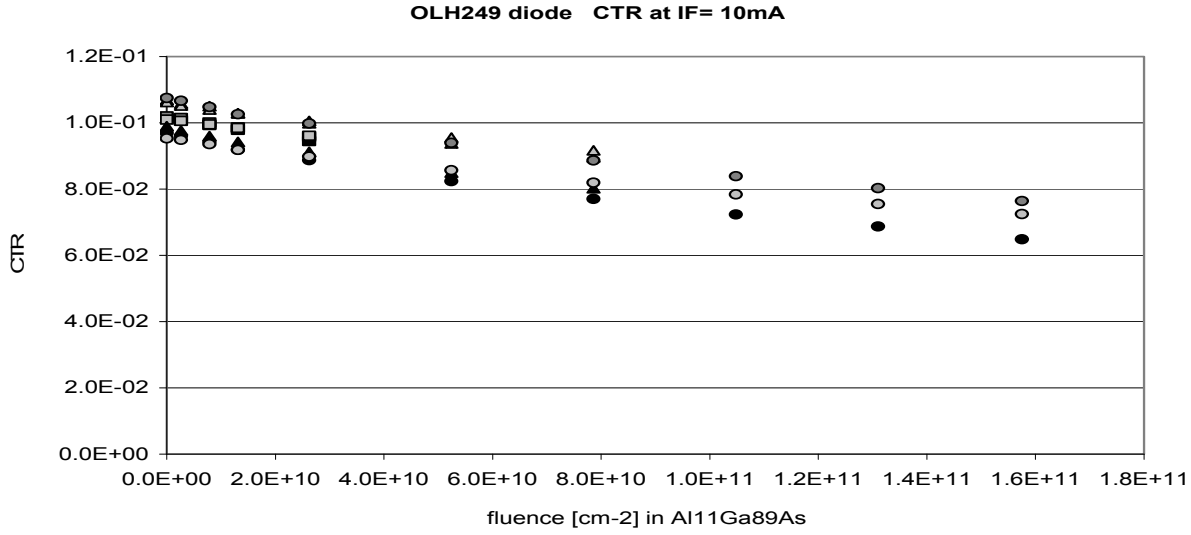
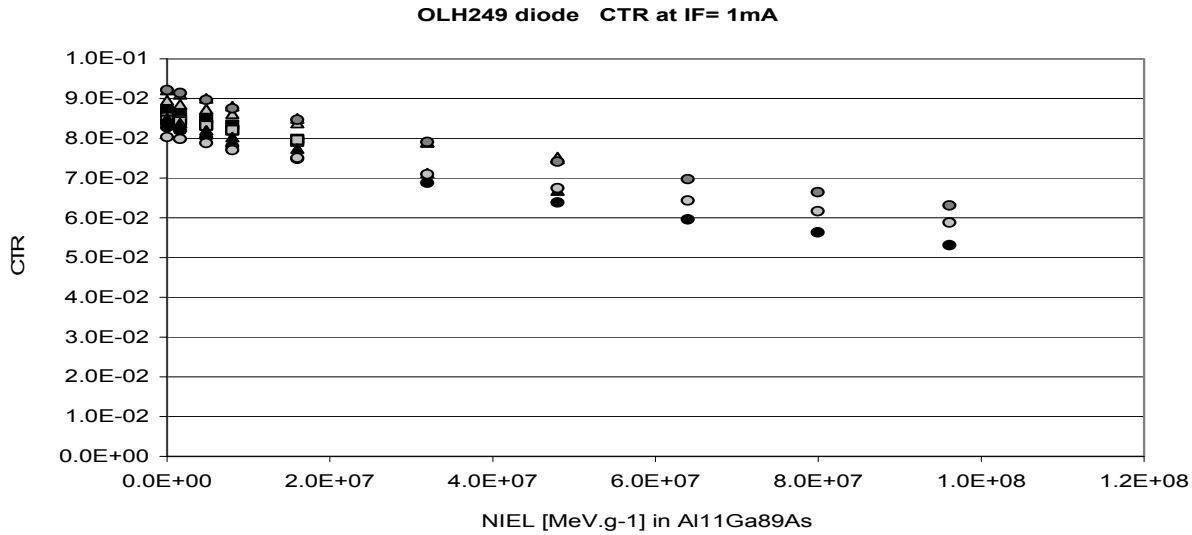
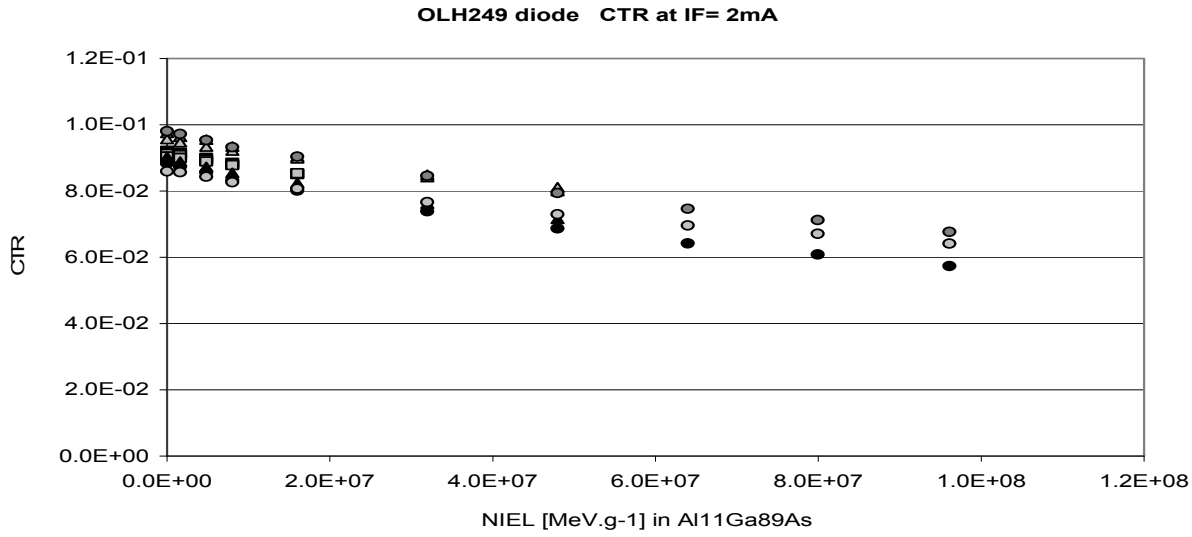
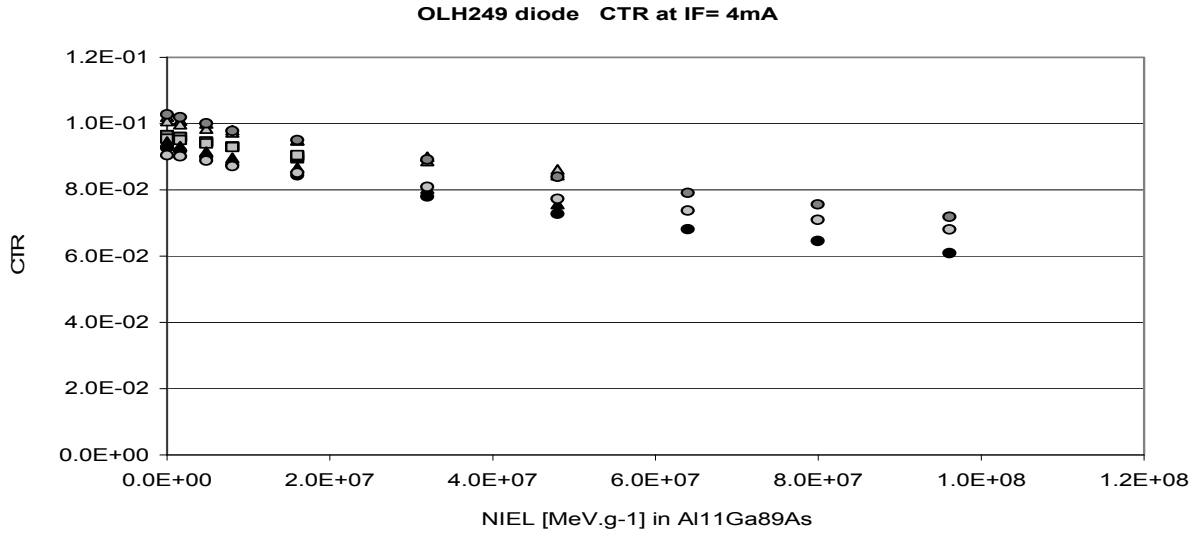
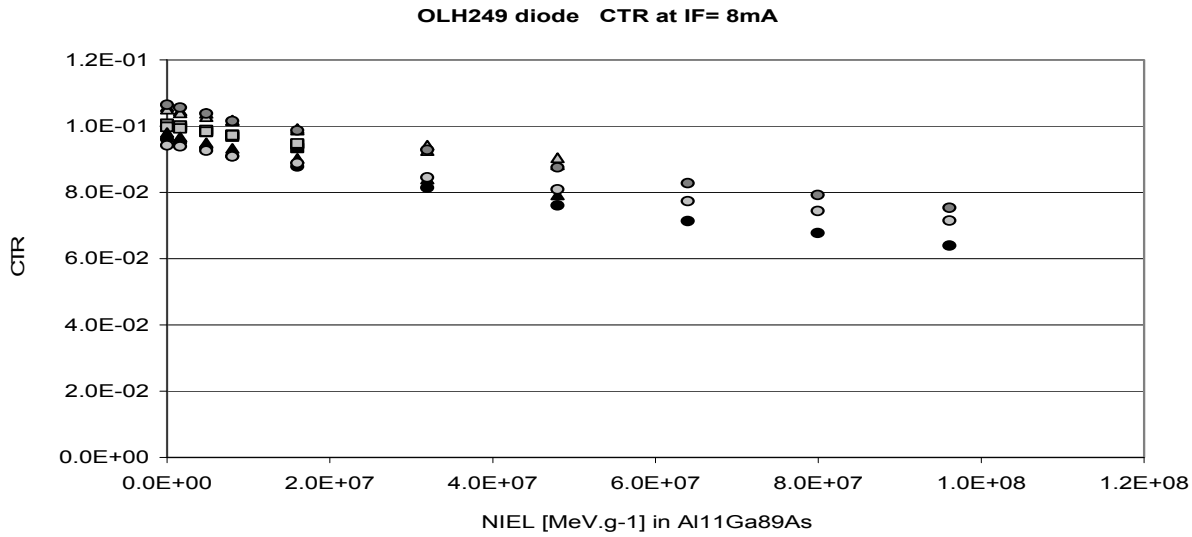

OLH249 diode CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-112: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 diode CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

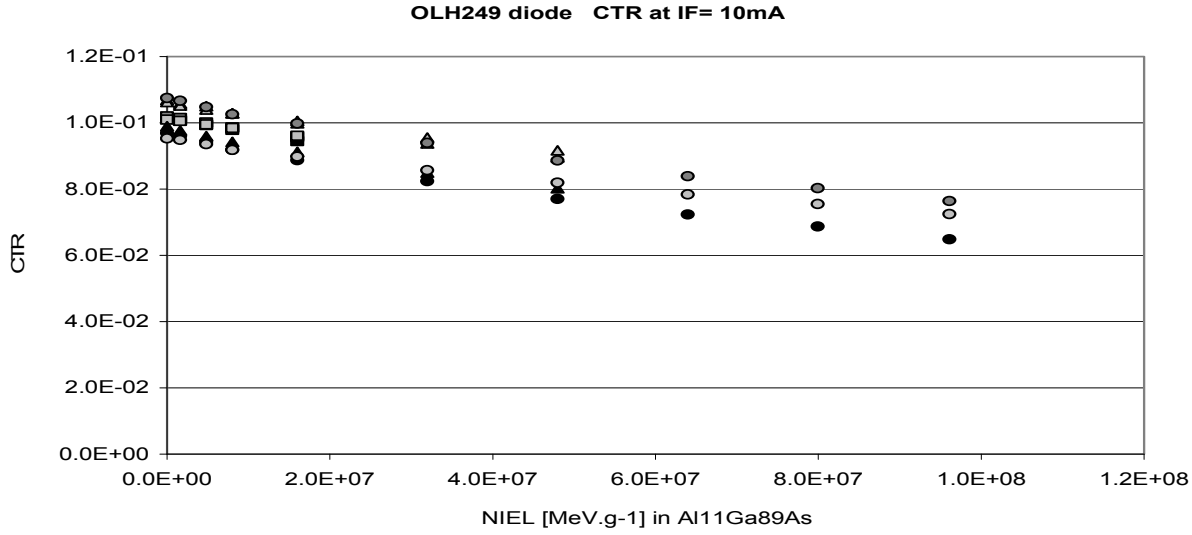
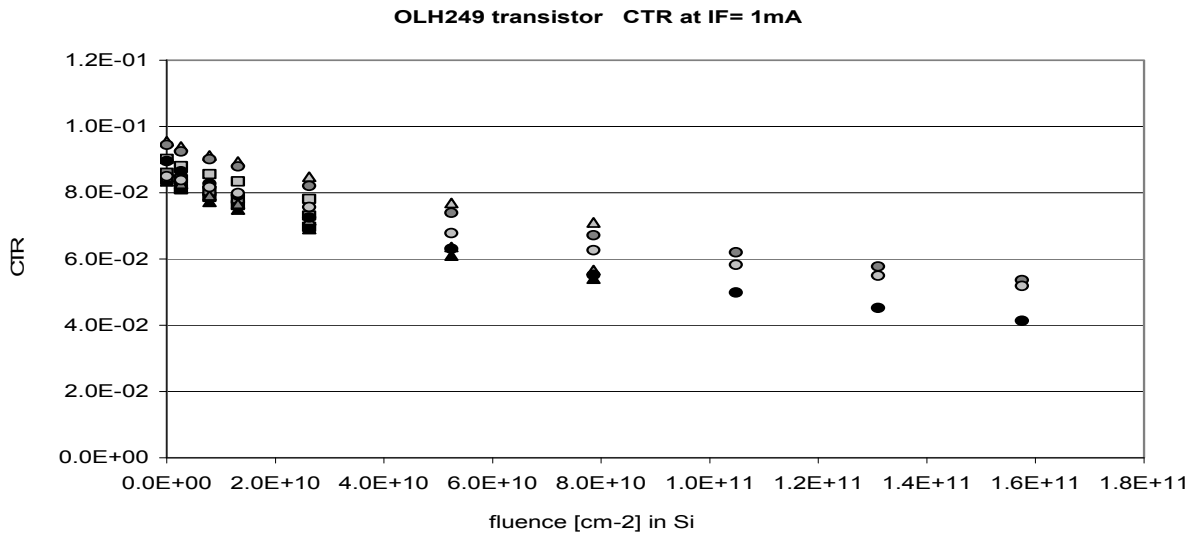
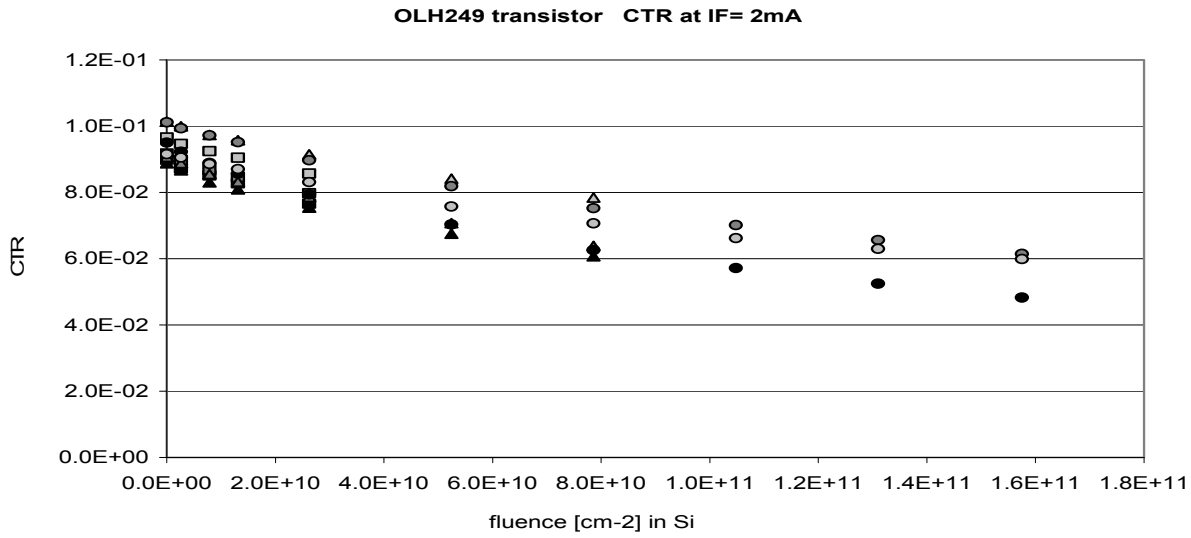
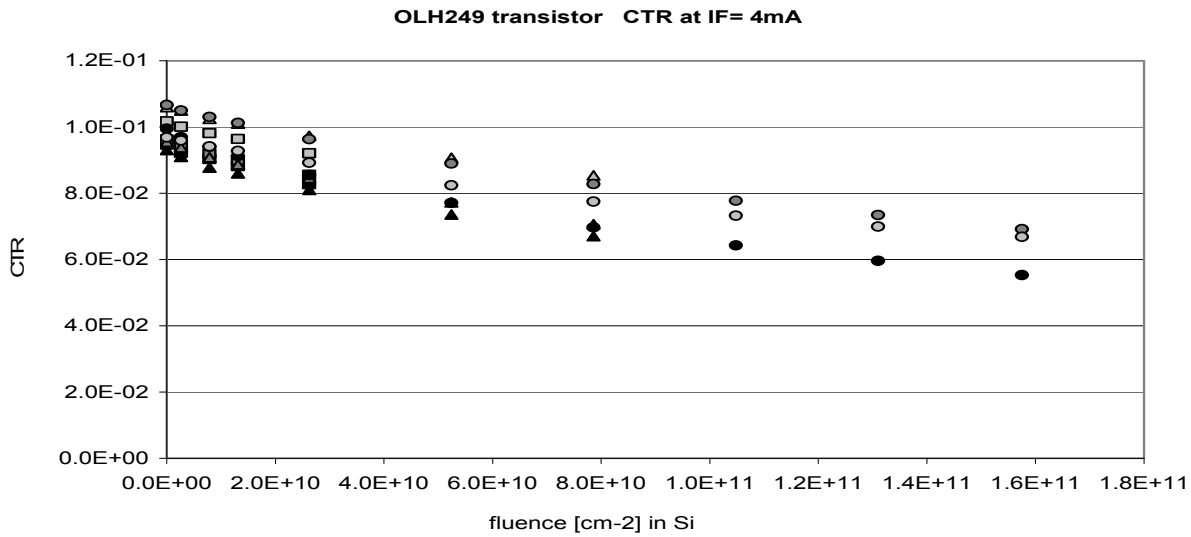
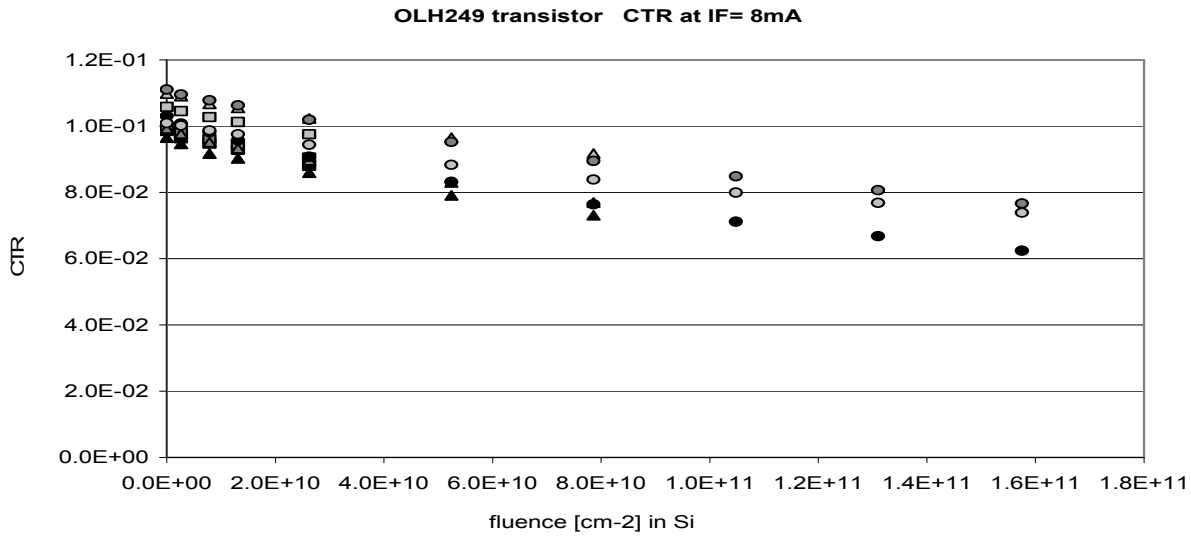

OLH249 diode CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-113: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

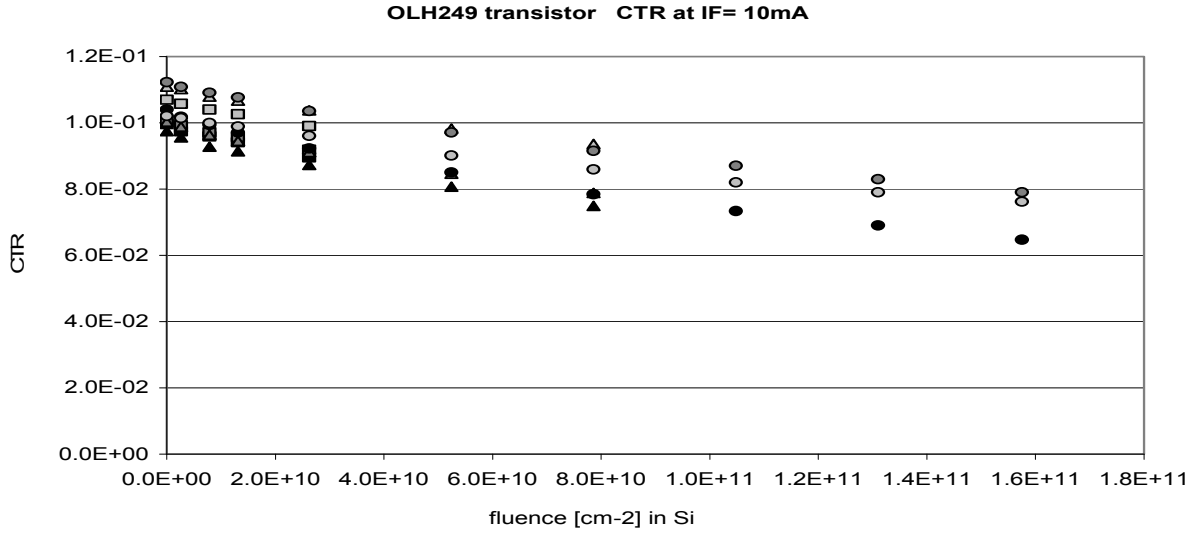
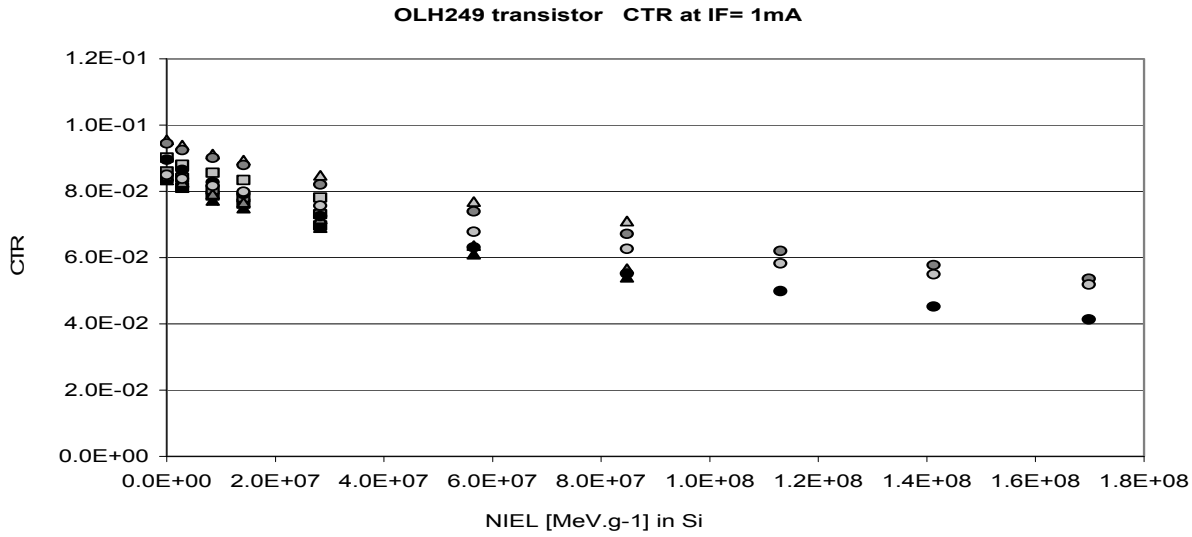
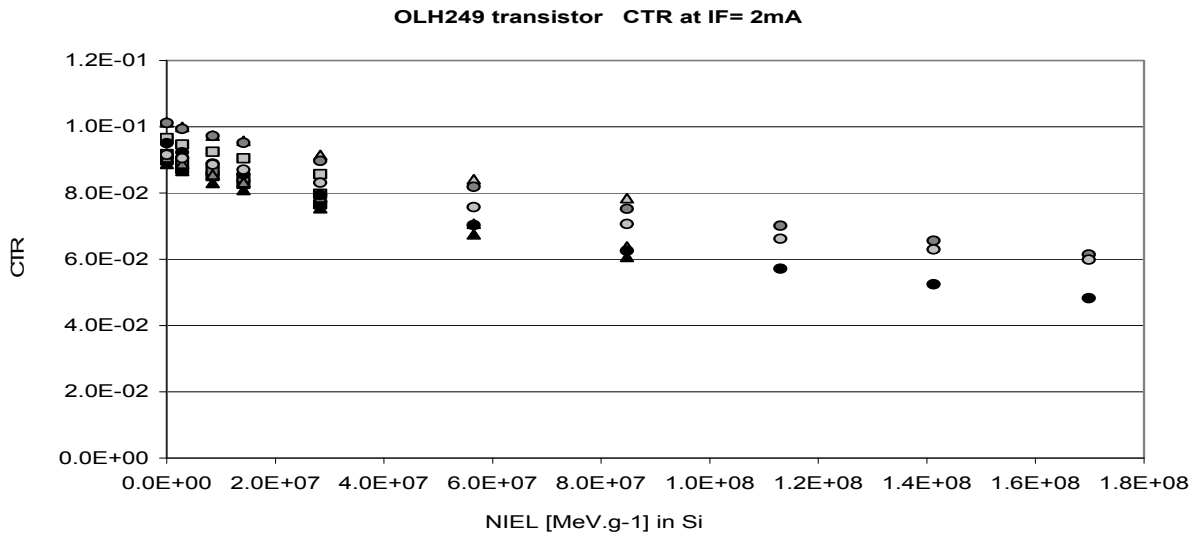
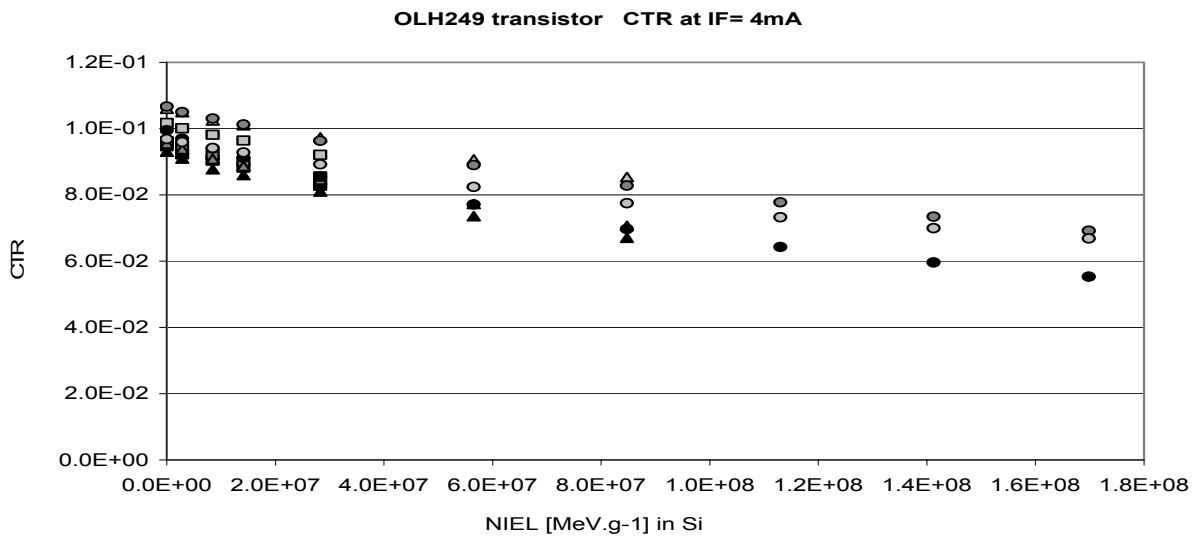
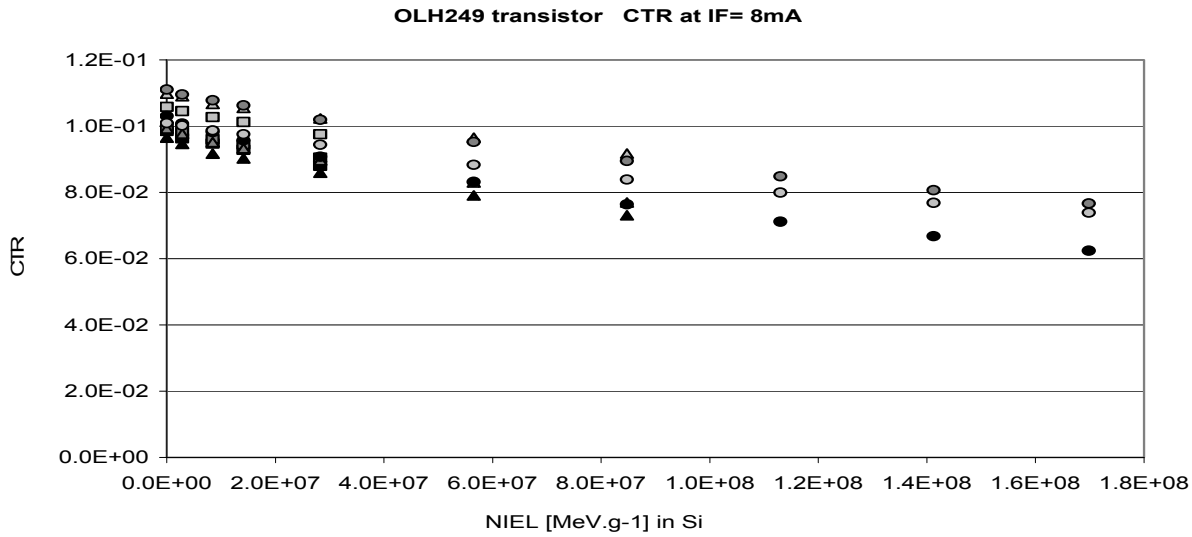

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Si

Fig. 13-114: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

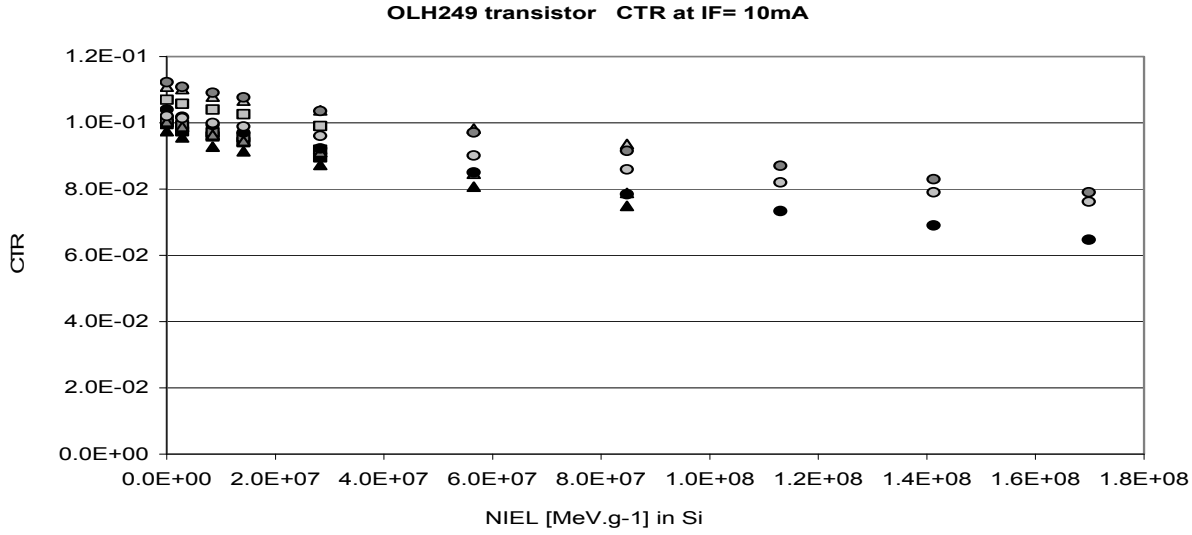
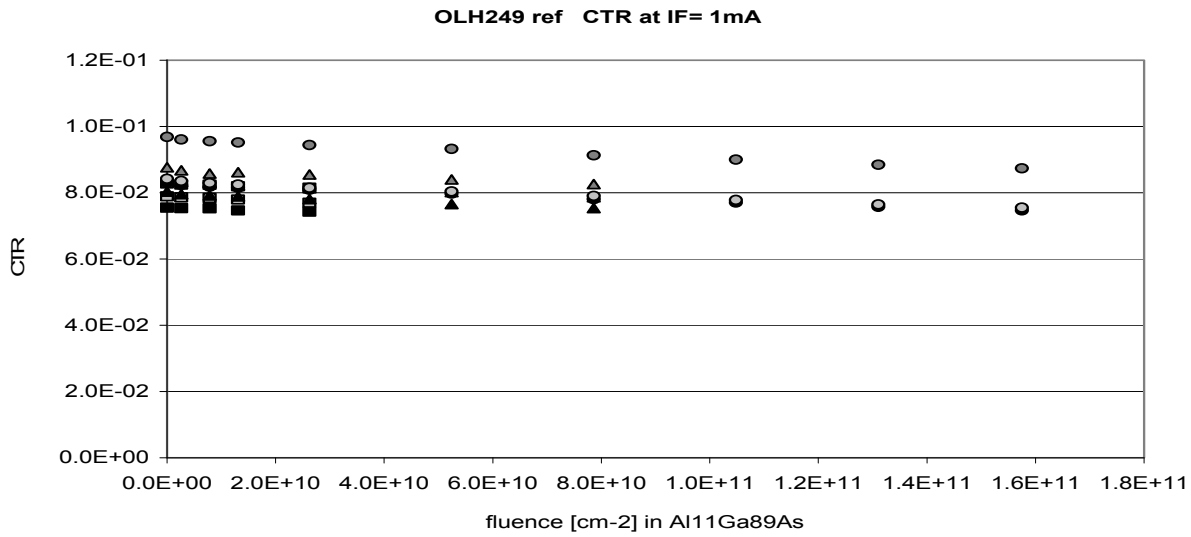
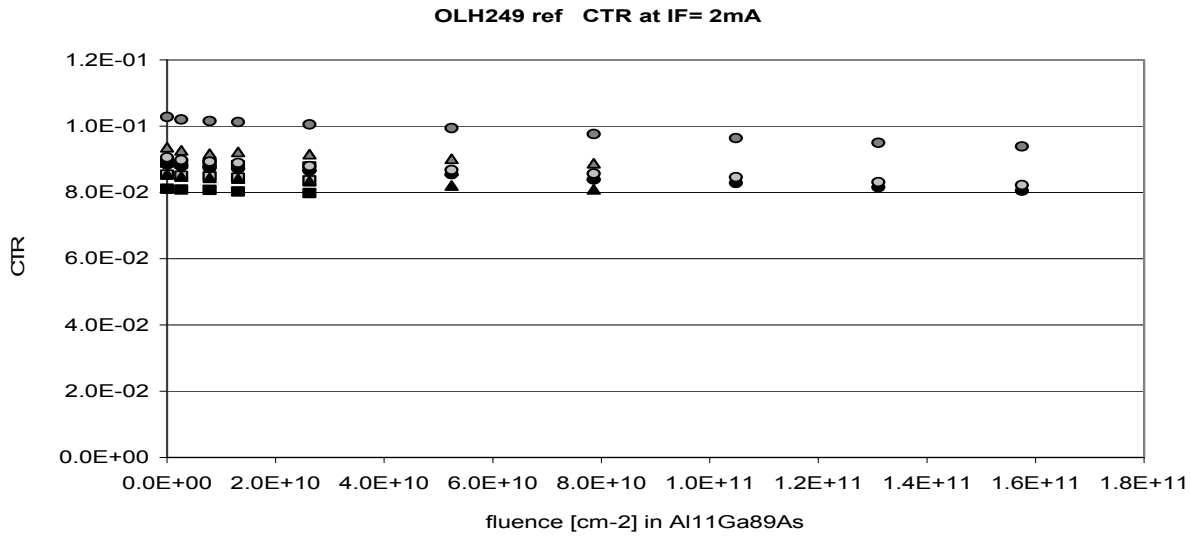
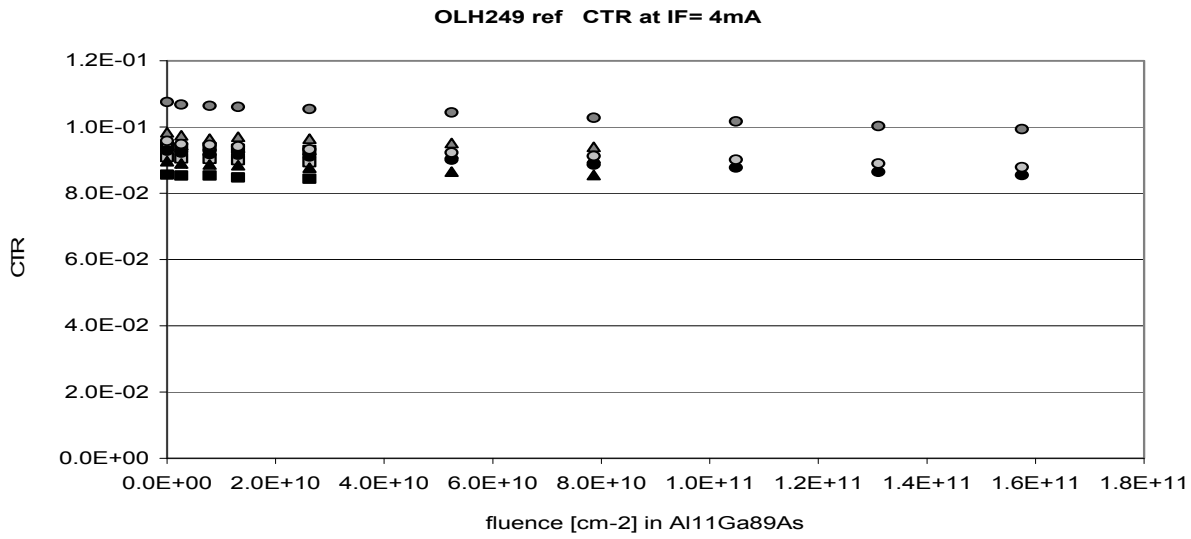
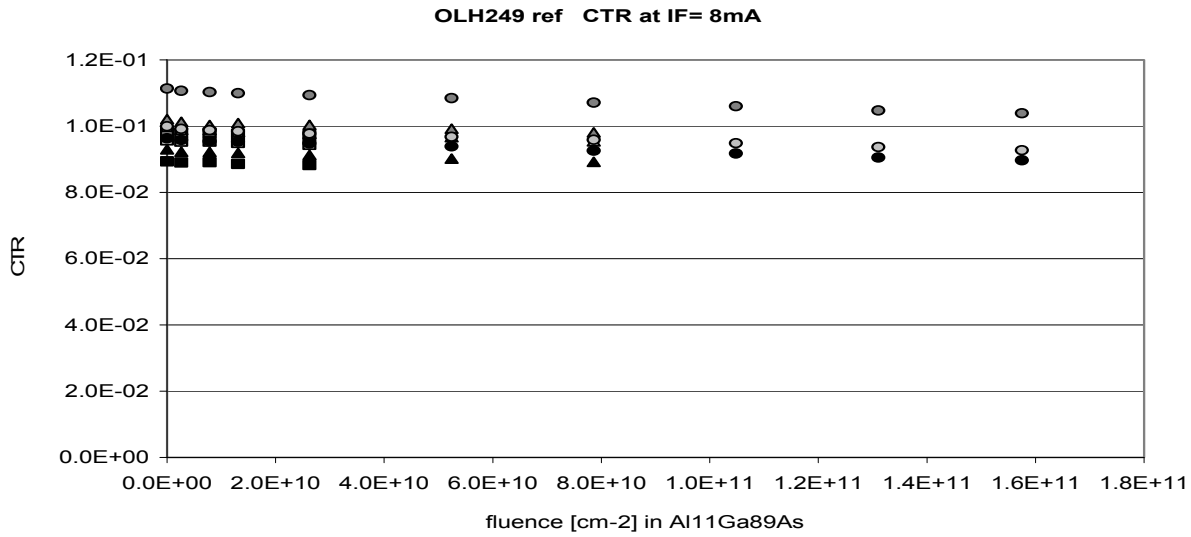

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-115: OLH249 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

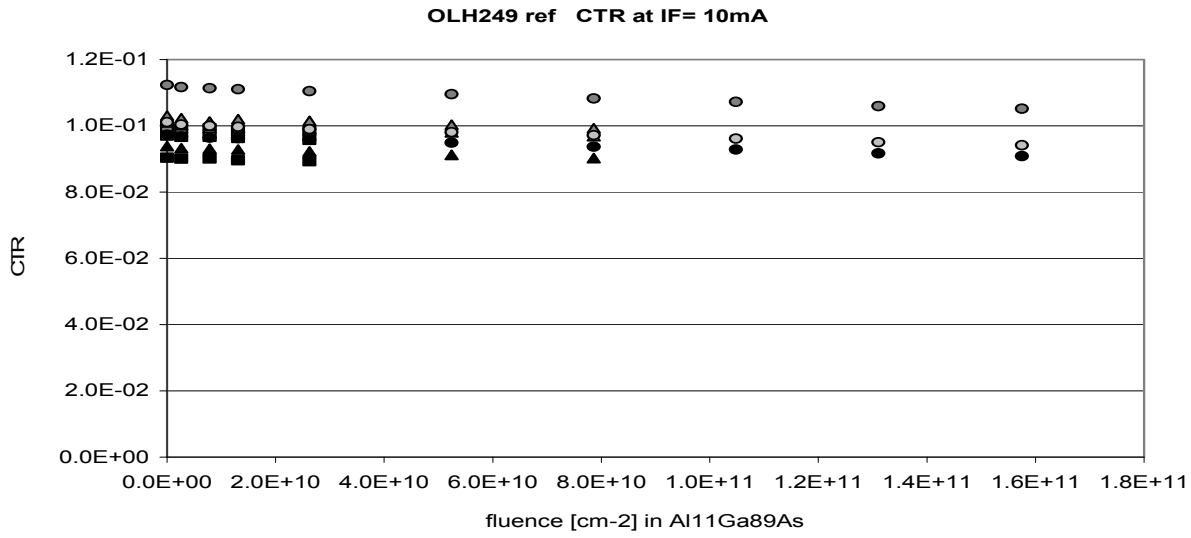
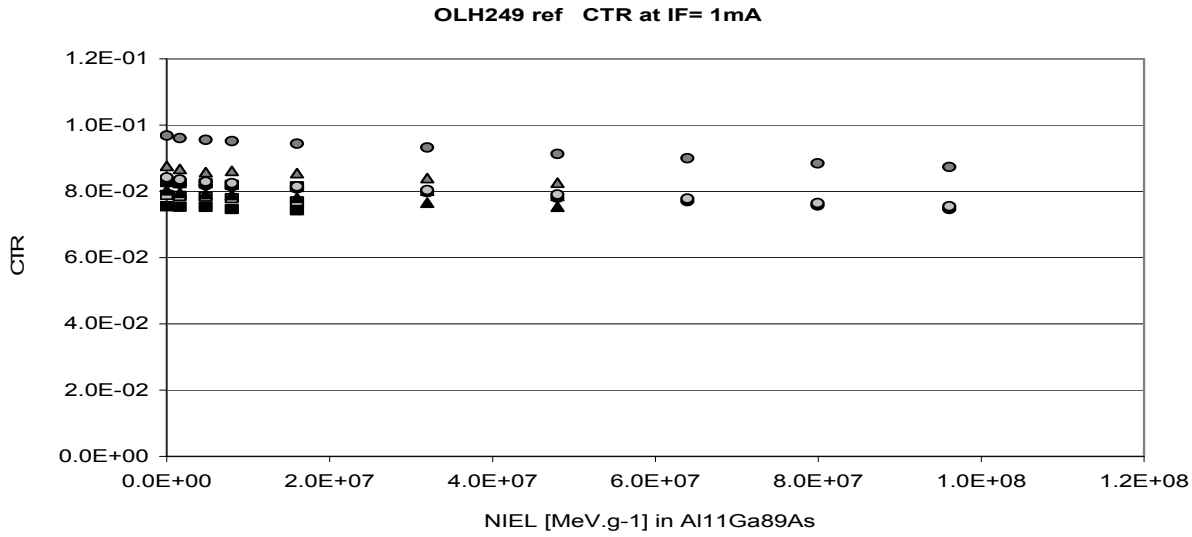
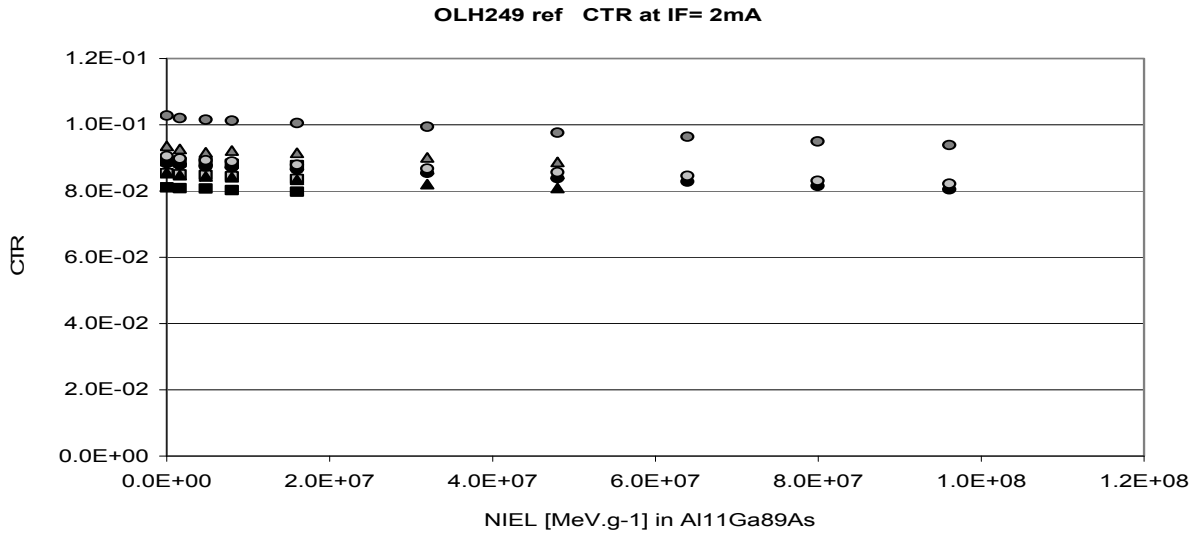
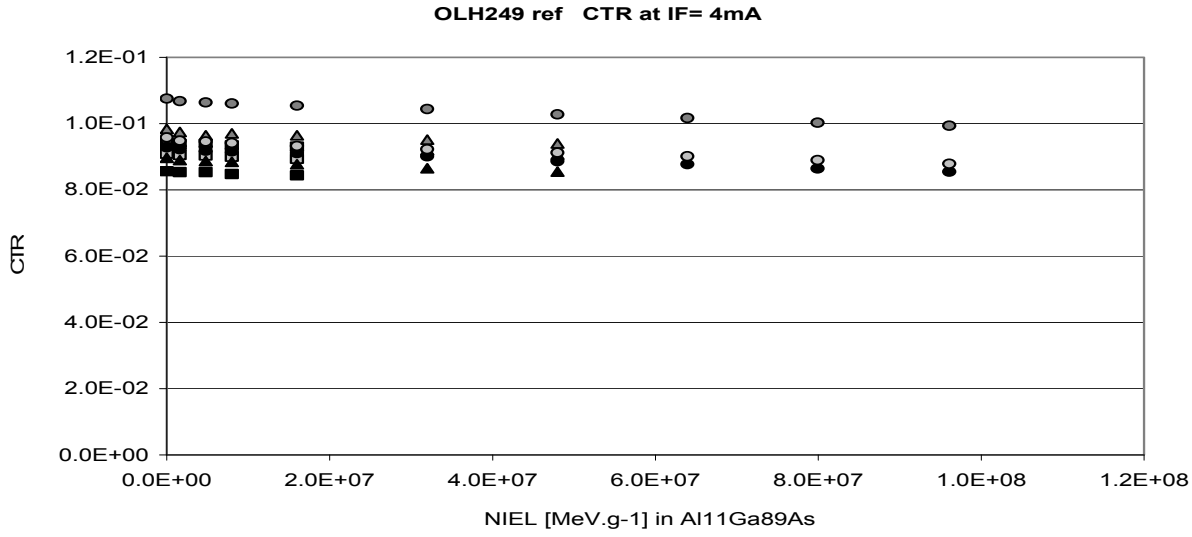
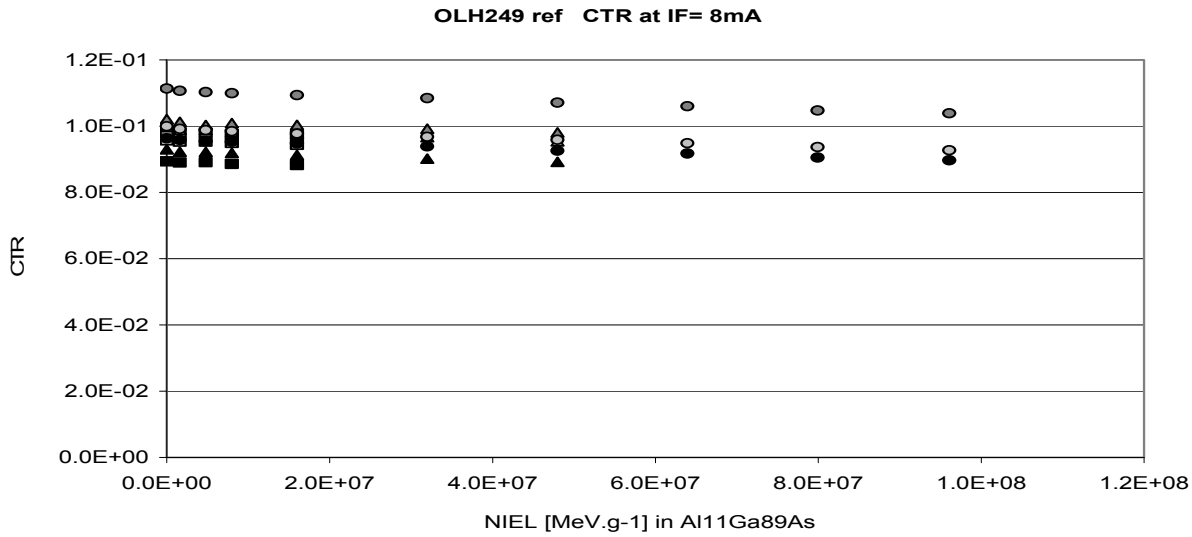

OLH249 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00 2.0E+10 4.0E+10 6.0E+10 8.0E+10 1.0E+11 1.2E+11 1.4E+11 1.6E+11 1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-116: OLH249 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

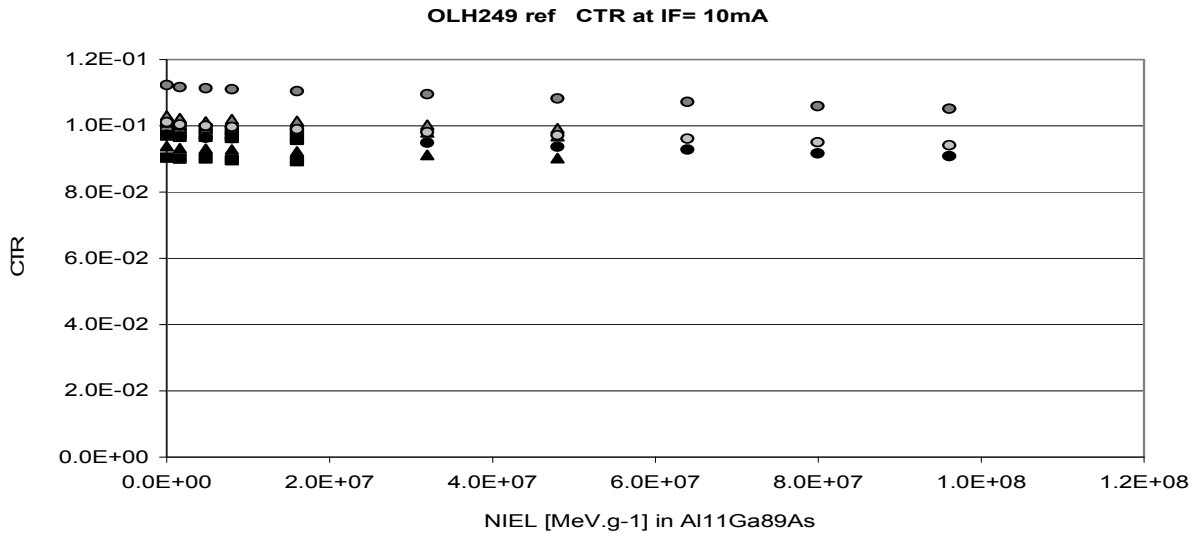
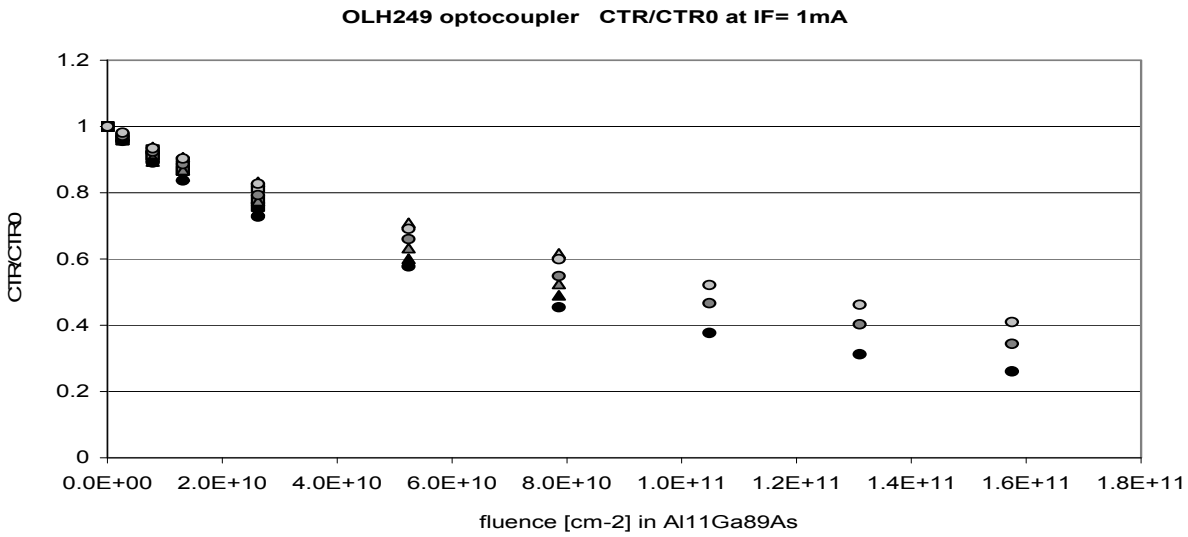
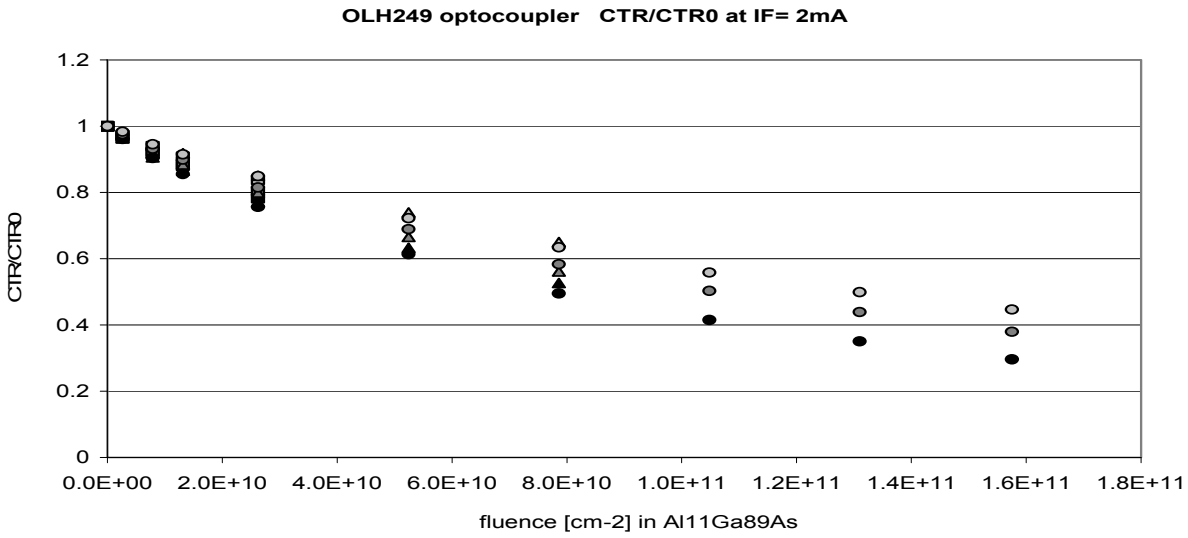
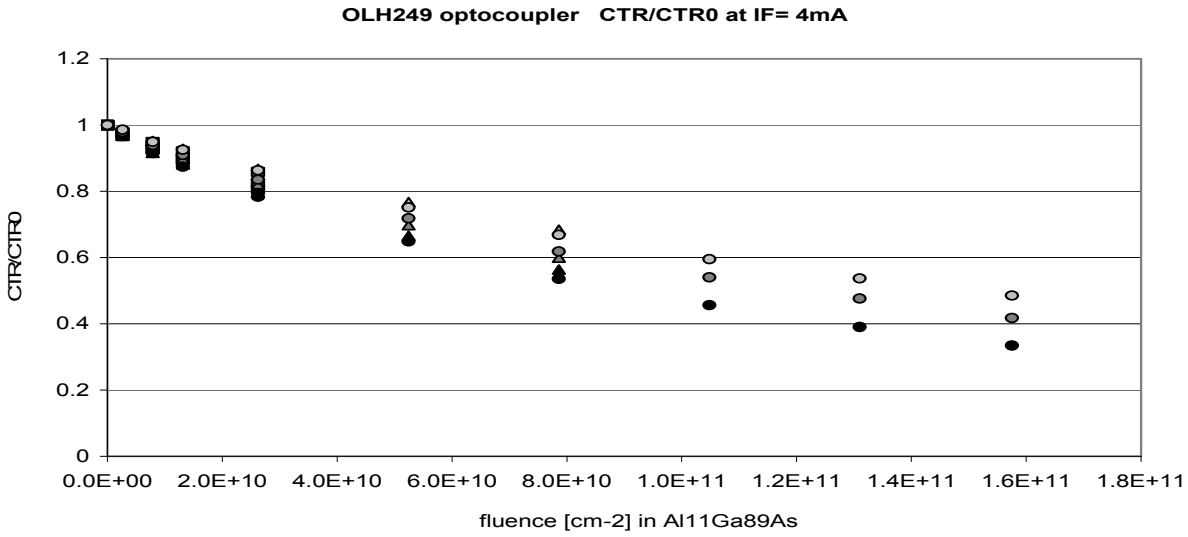
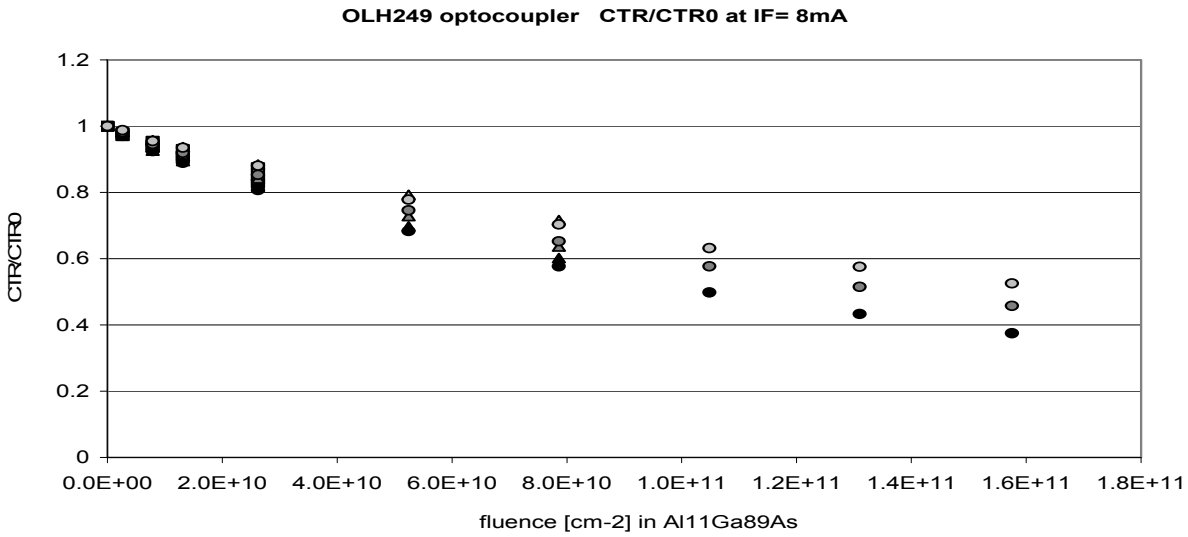

OLH249 ref CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-117: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

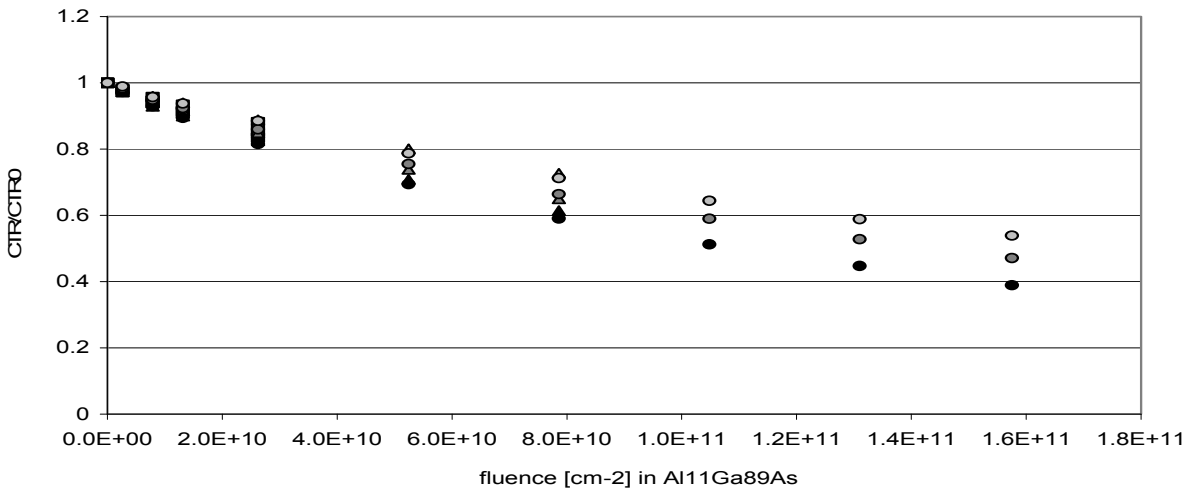
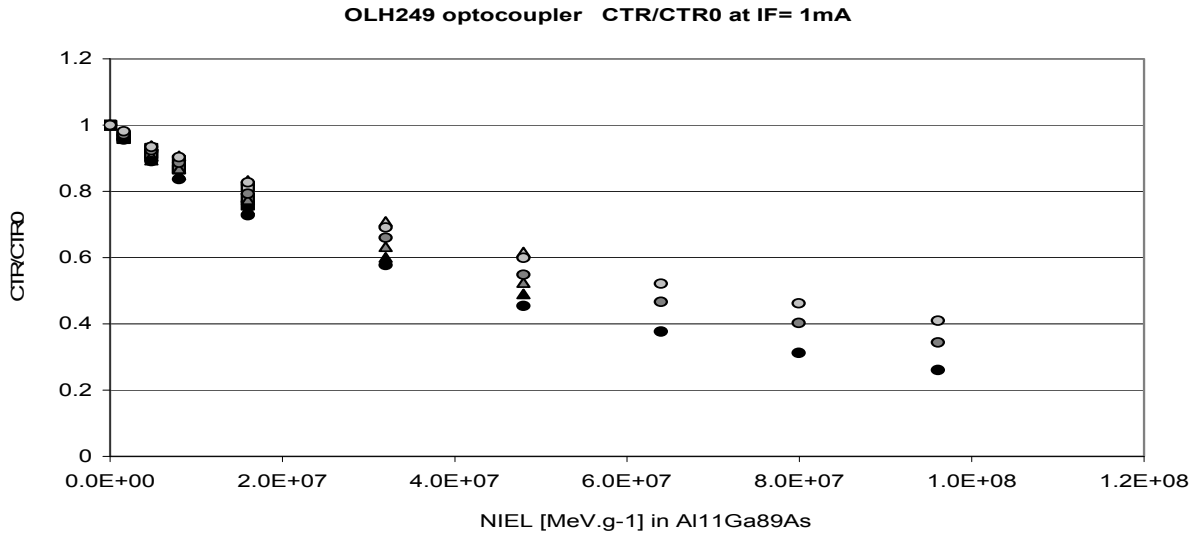
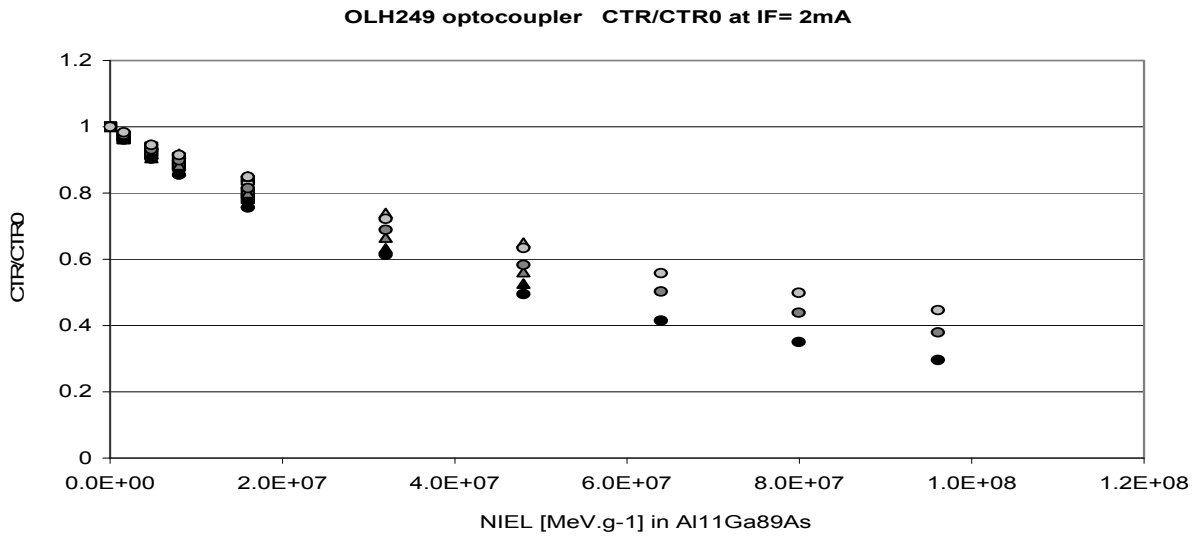
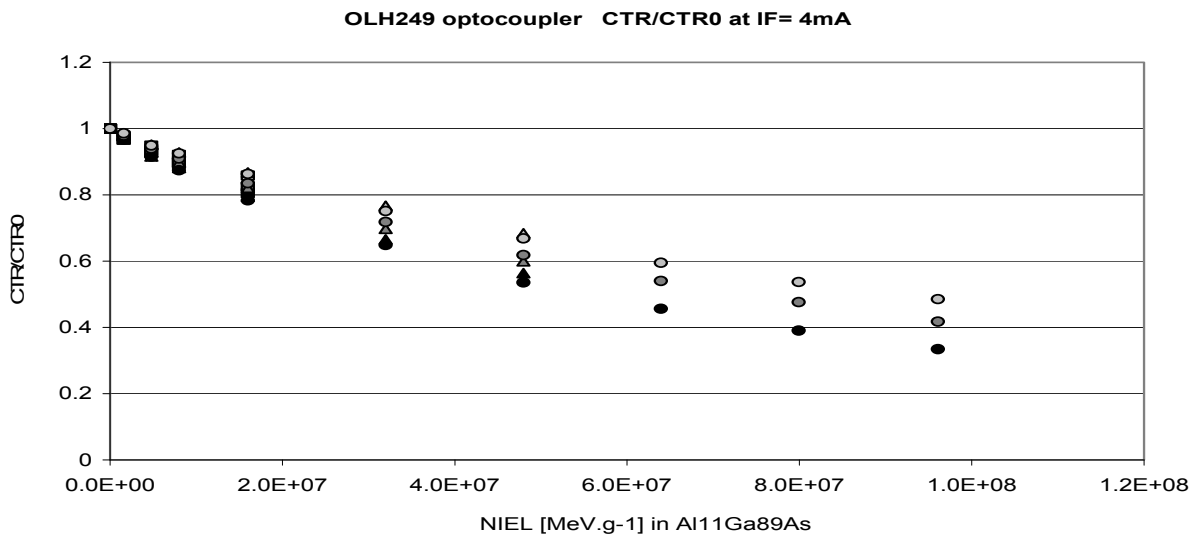

OLH249 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

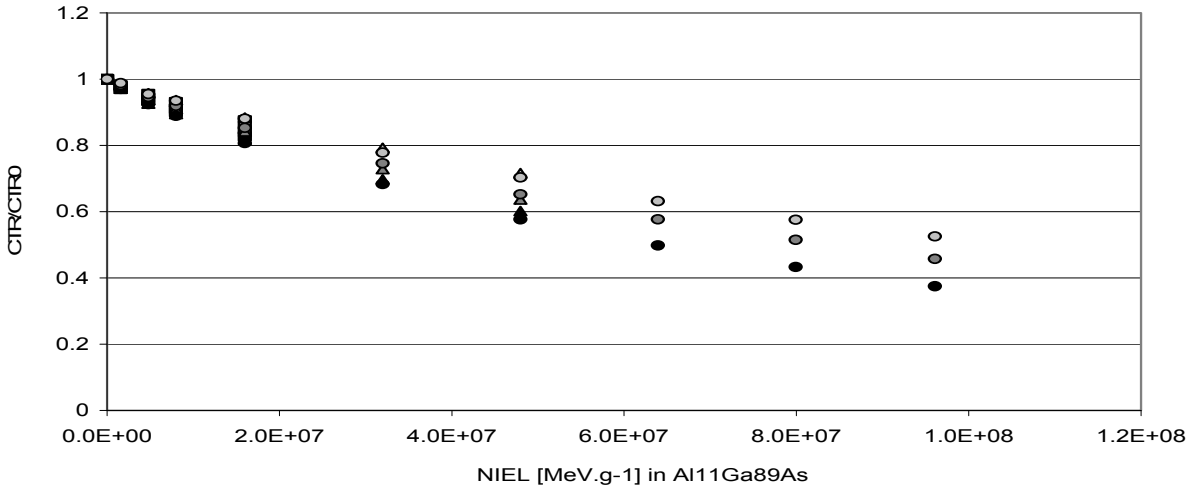
Fig. 13-118: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)







OLH249 optocoupler CTR/CTR0 at IF= 8mA



OLH249 optocoupler CTR/CTR0 at IF= 10mA

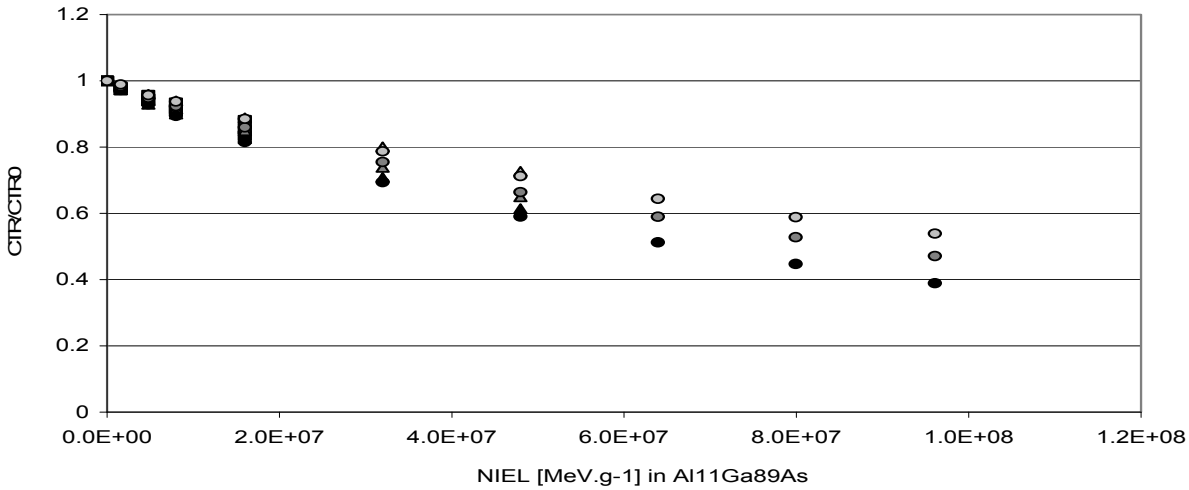
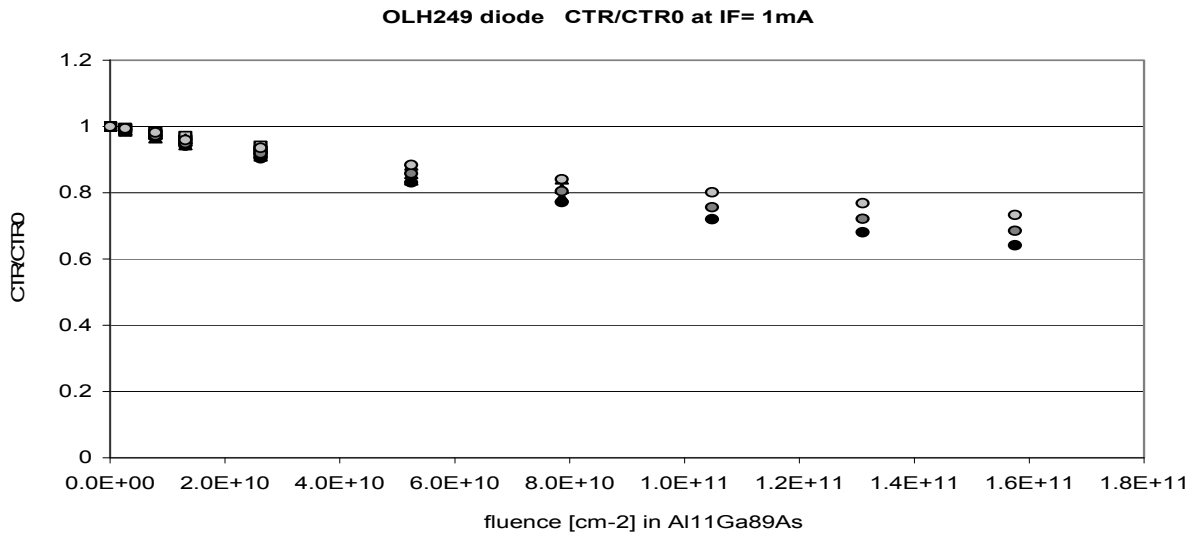
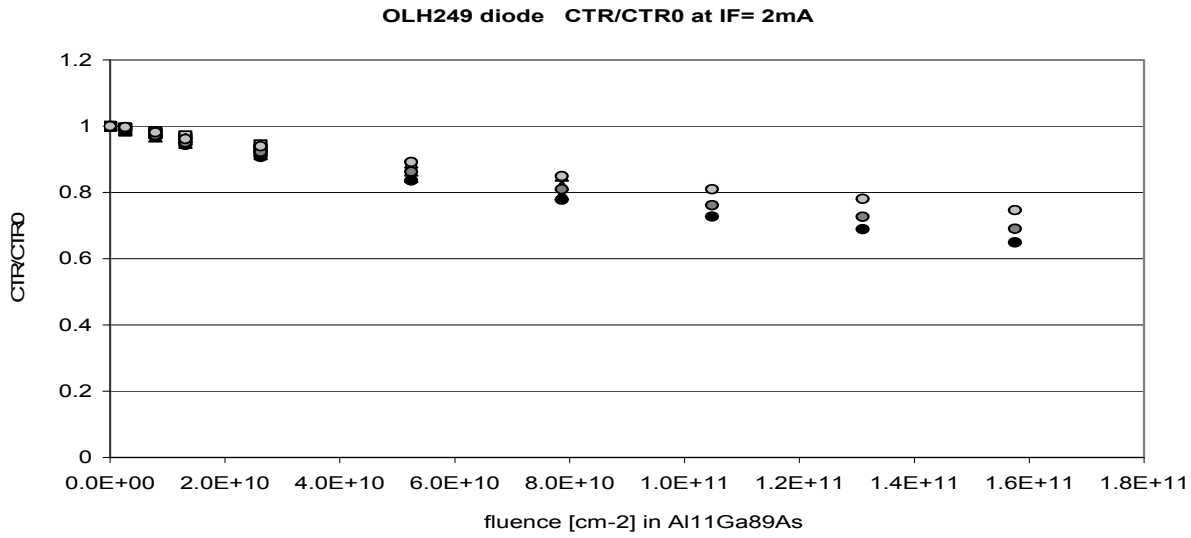
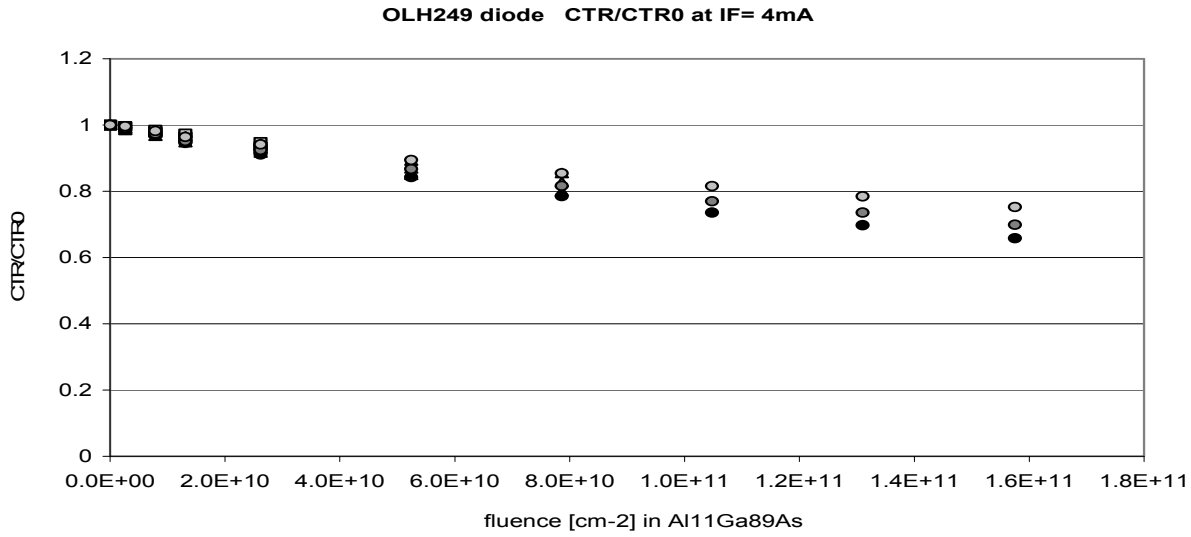
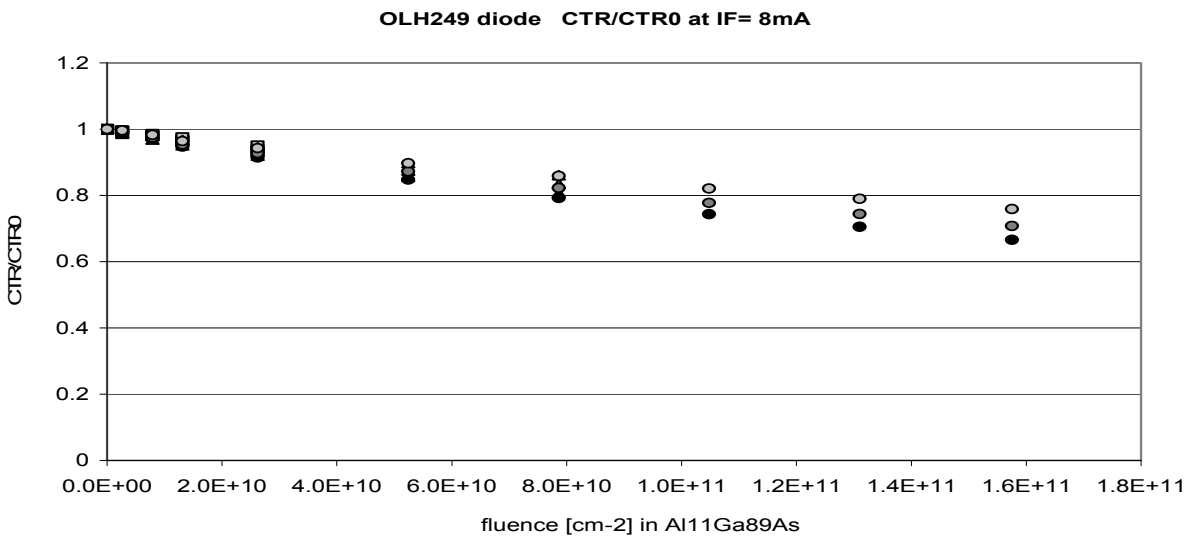


Fig. 13-119: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

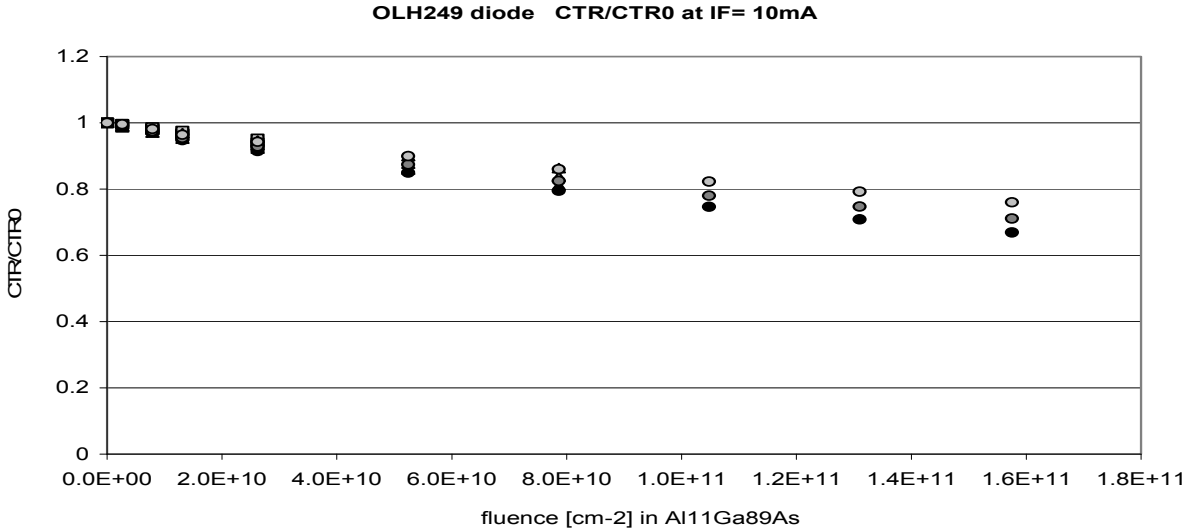
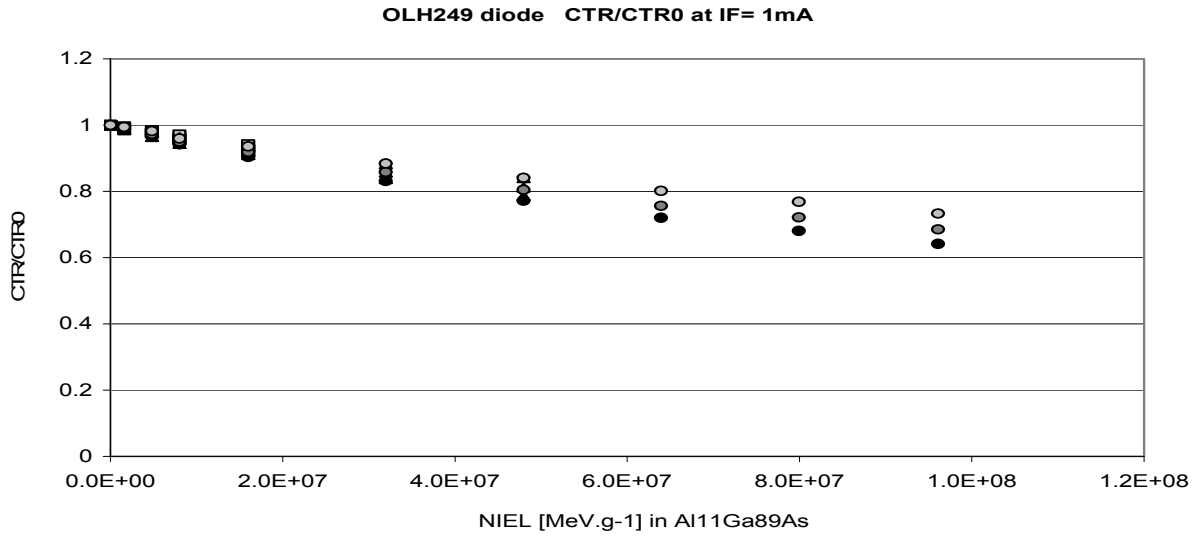
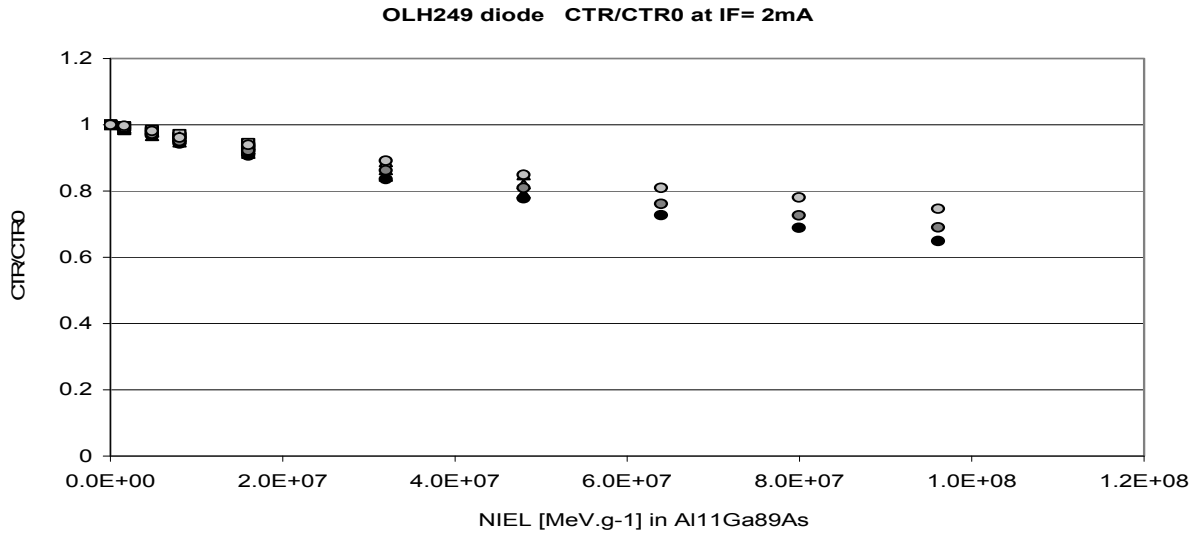
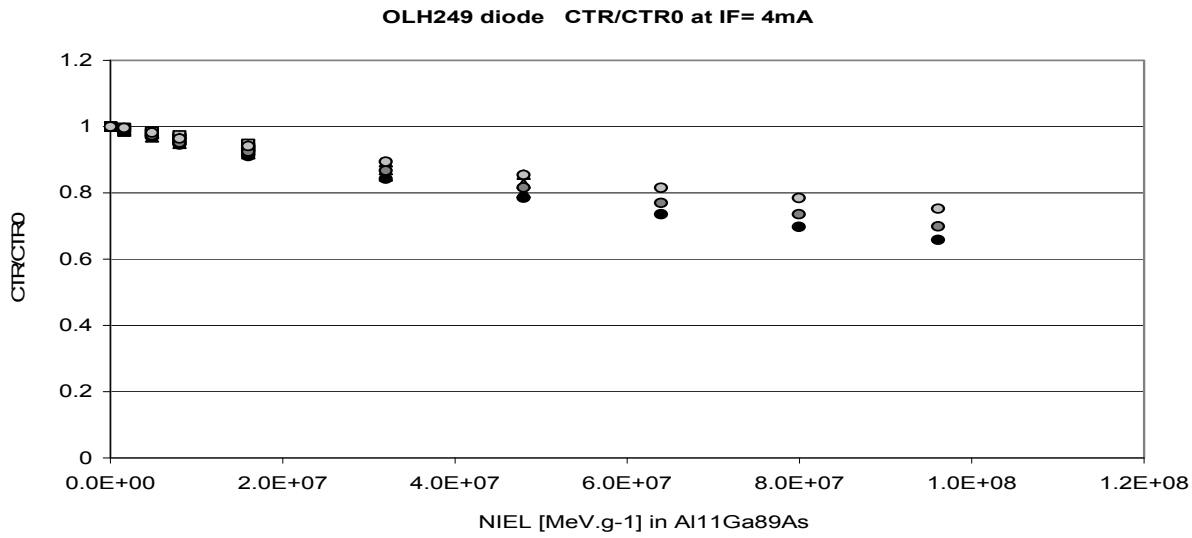
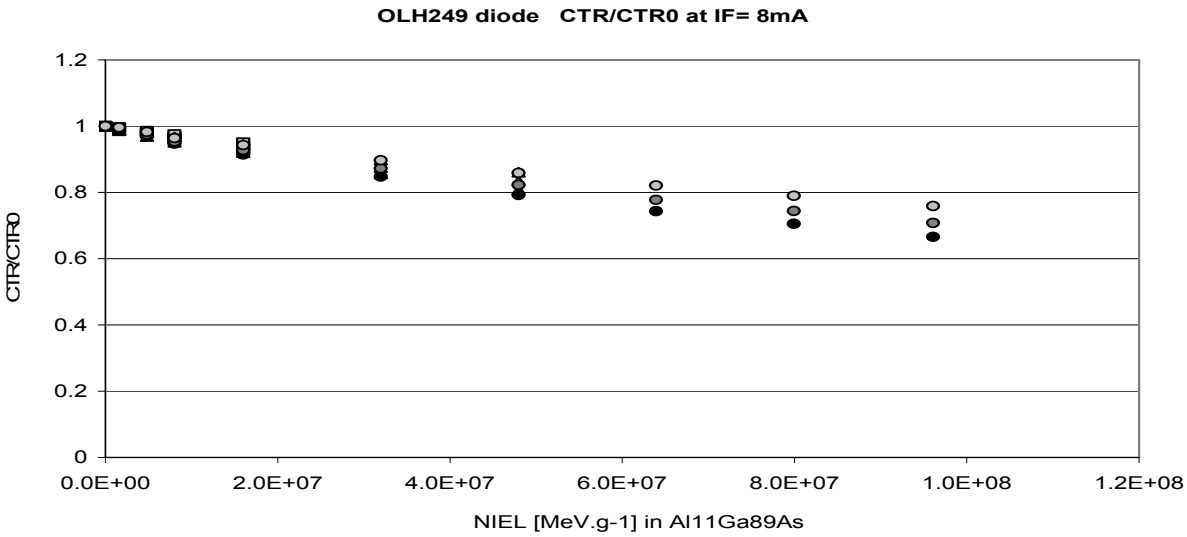

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-120: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

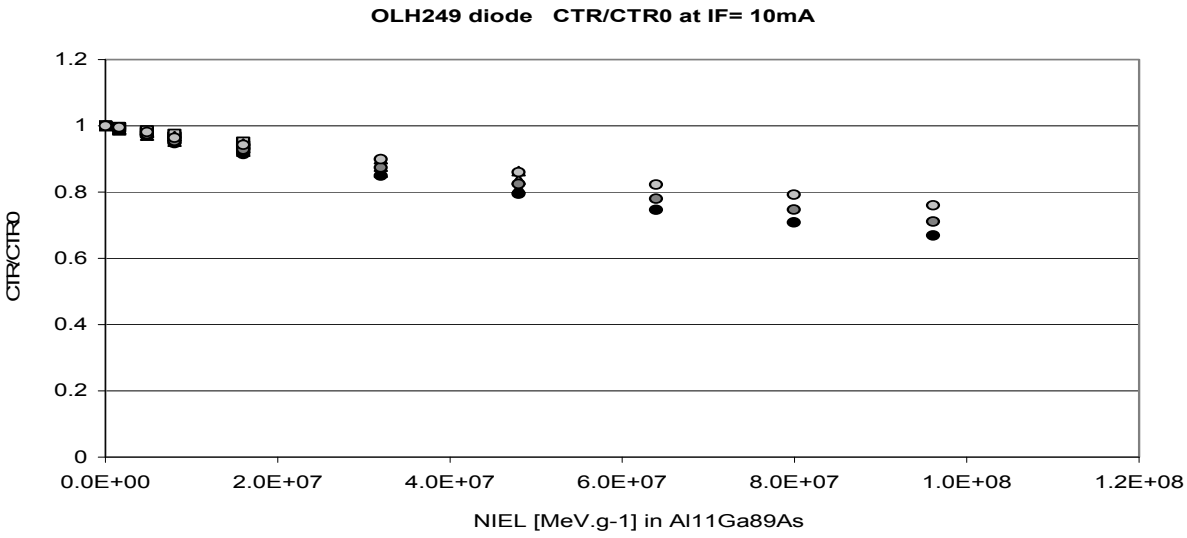
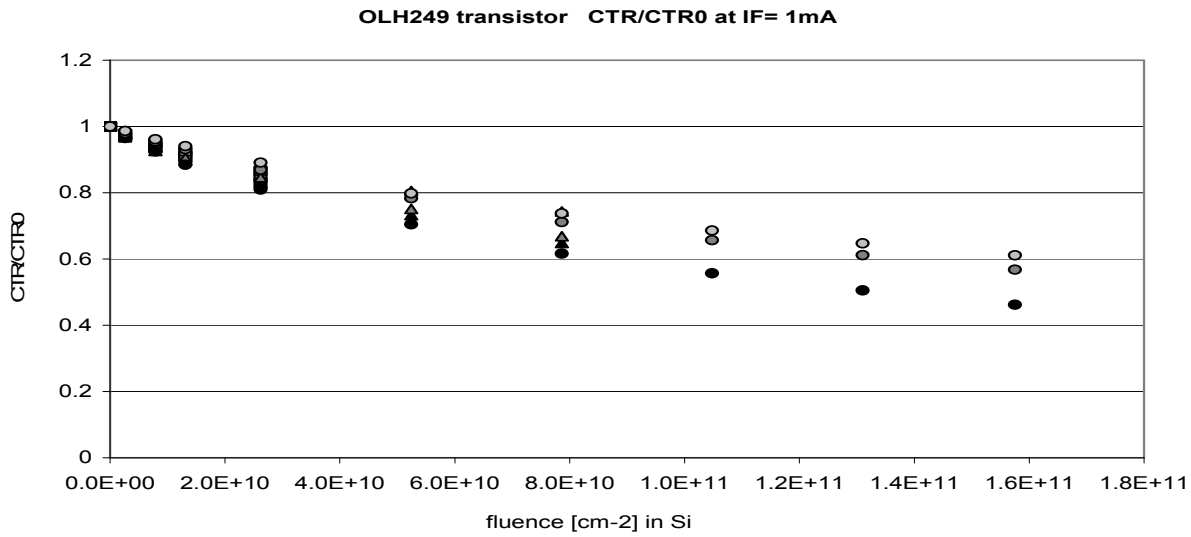
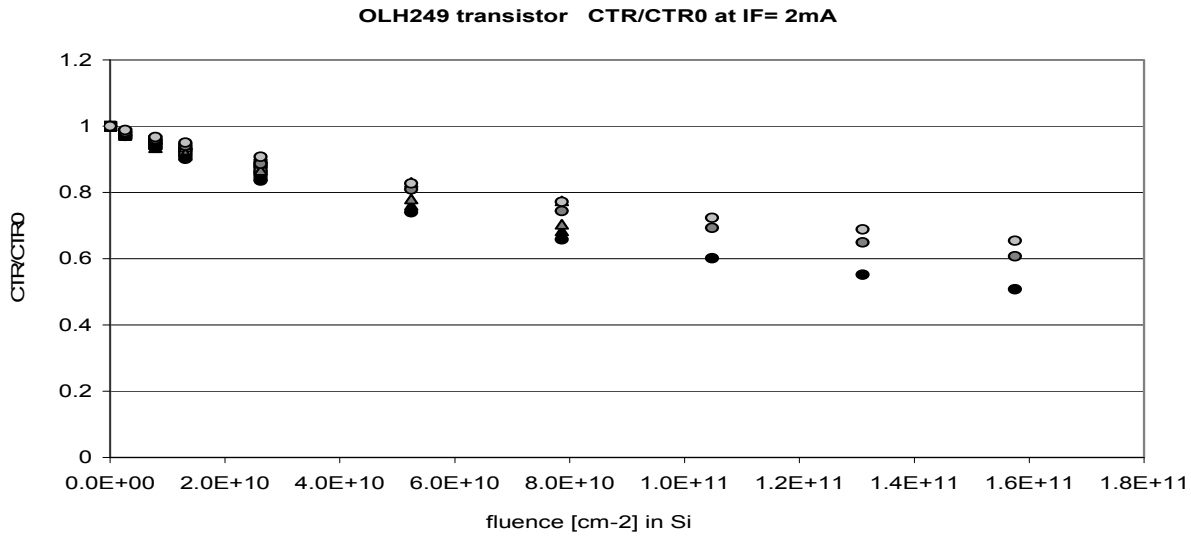
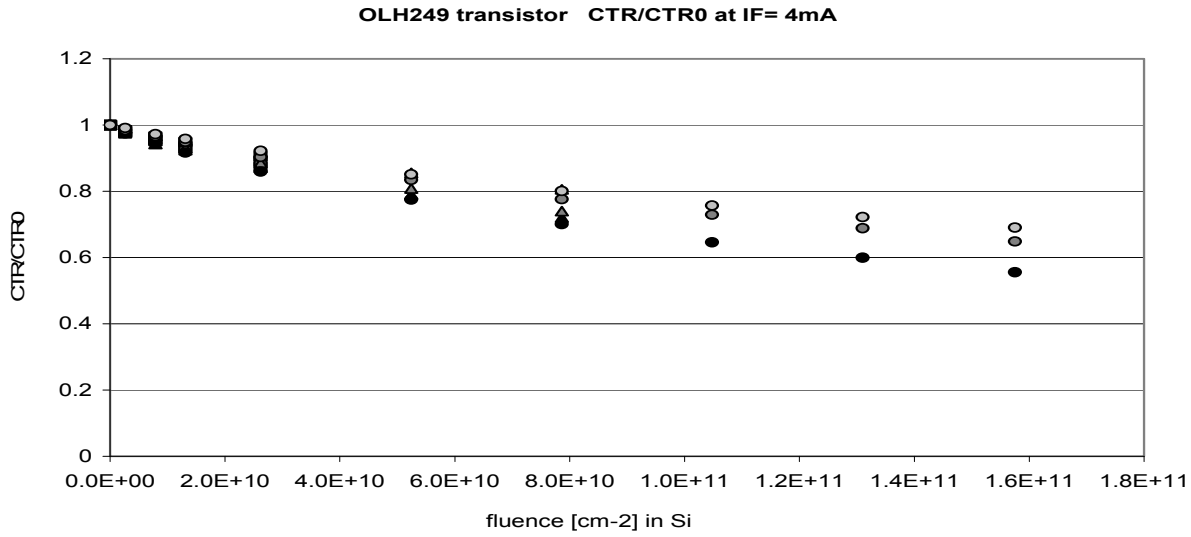
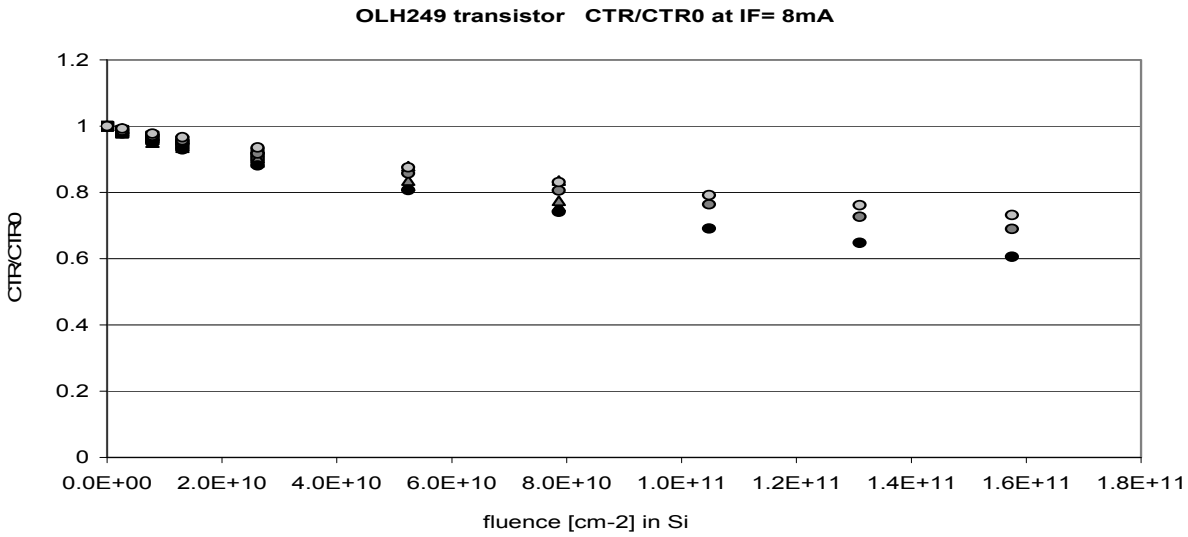

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-121: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

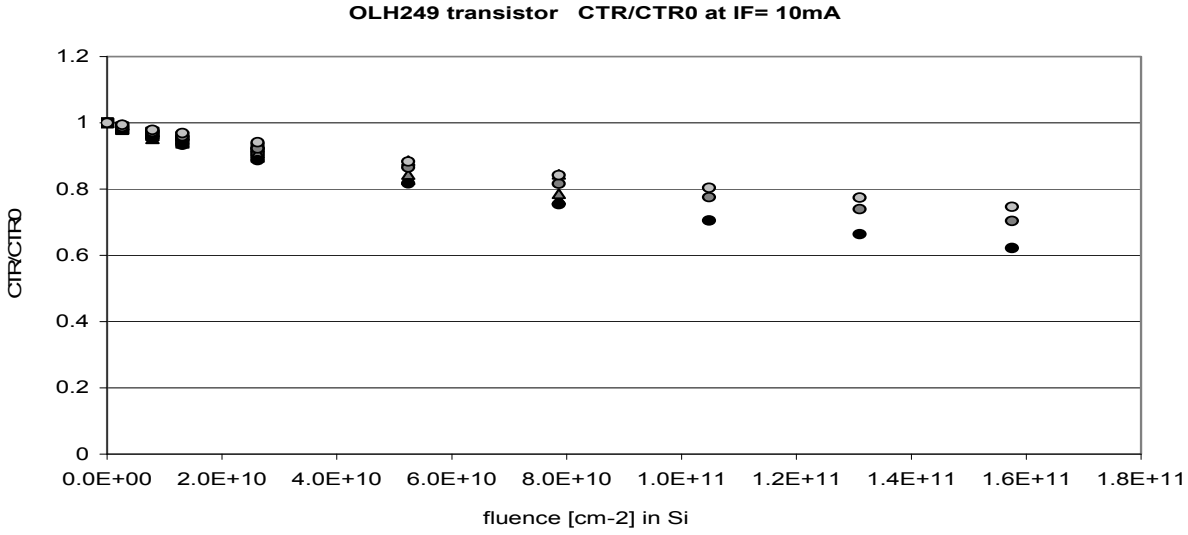
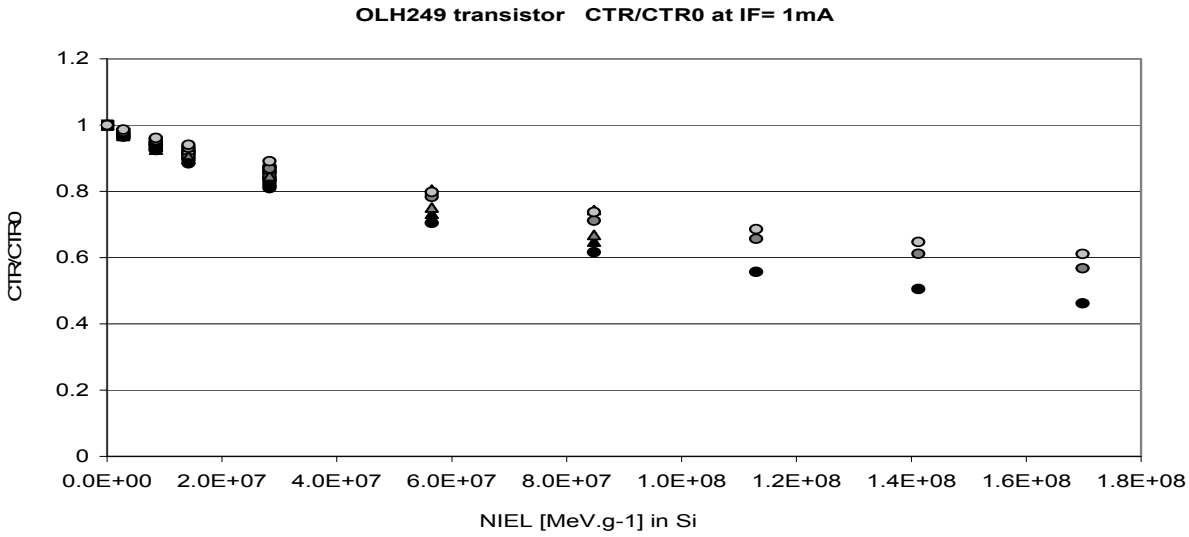
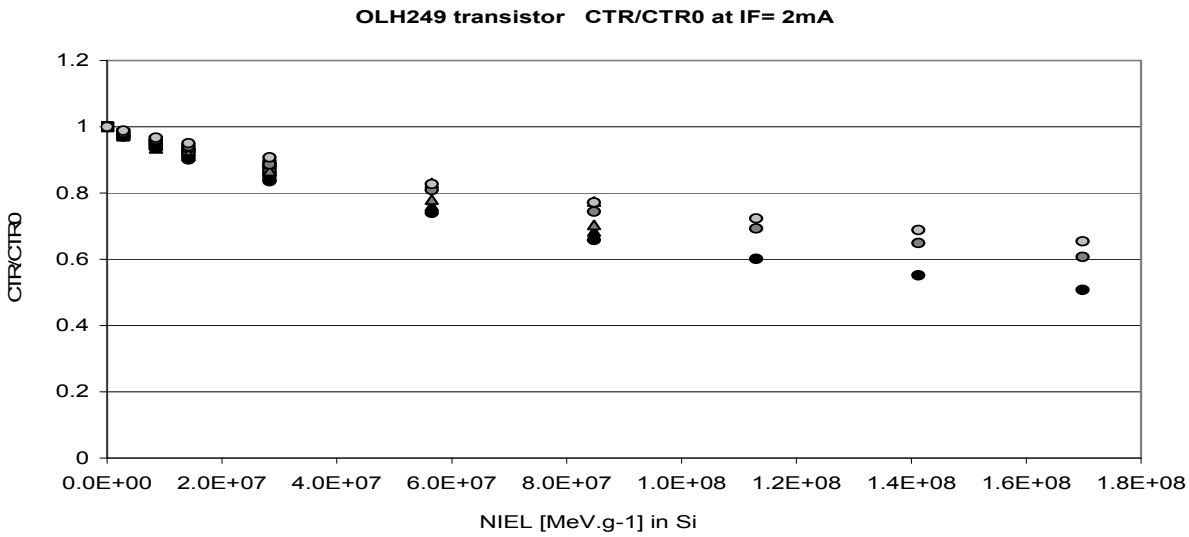
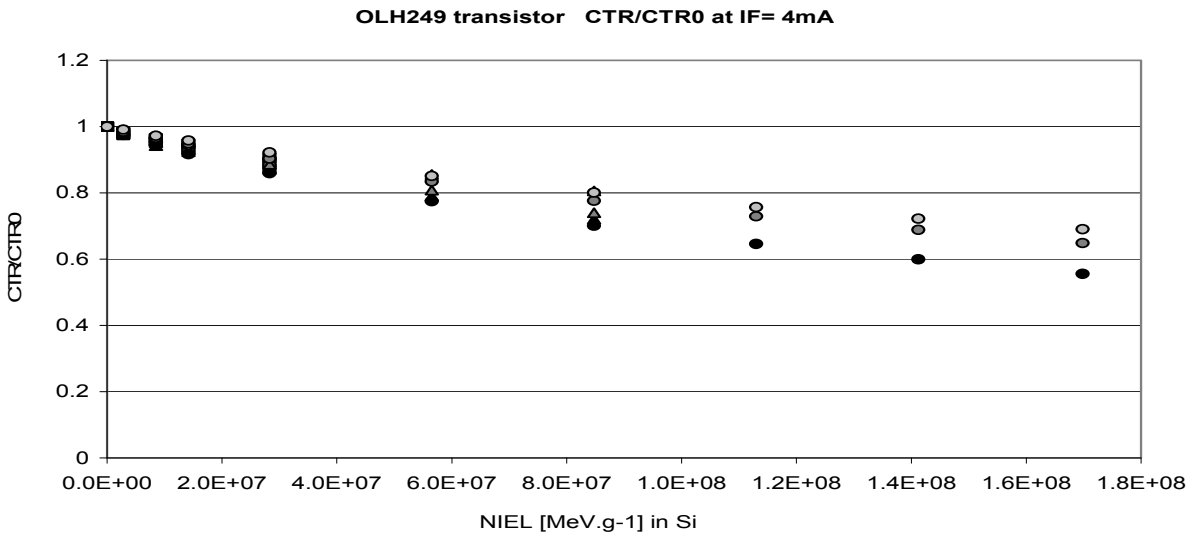
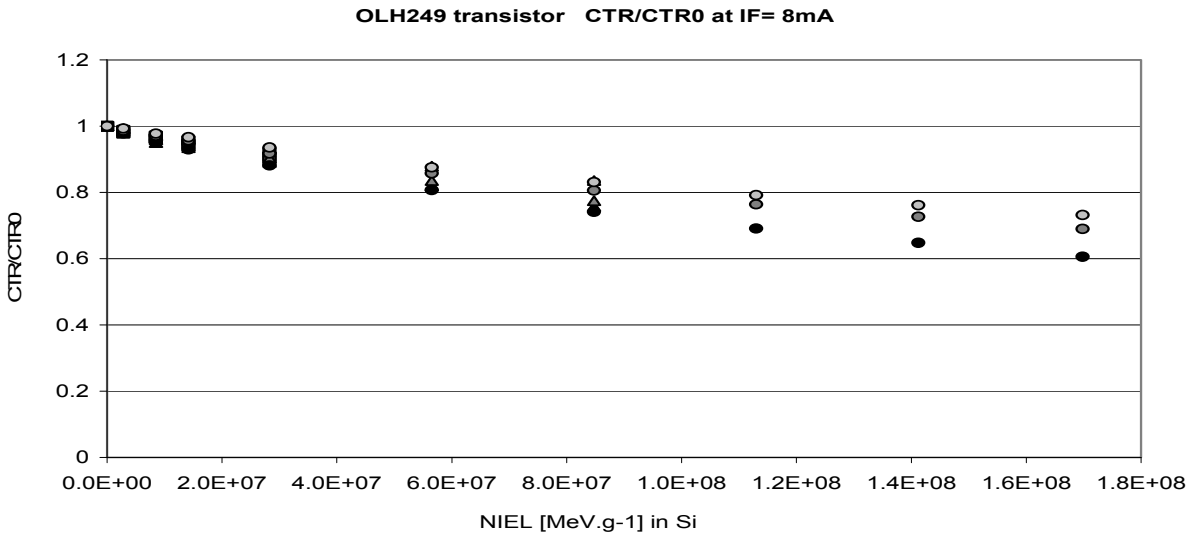

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 13-122: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

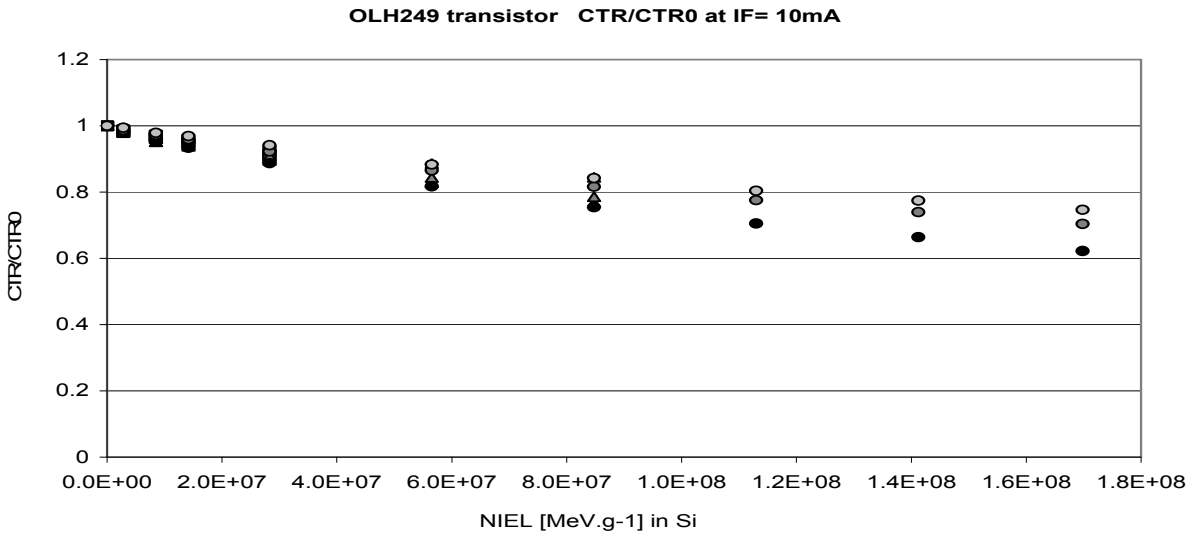
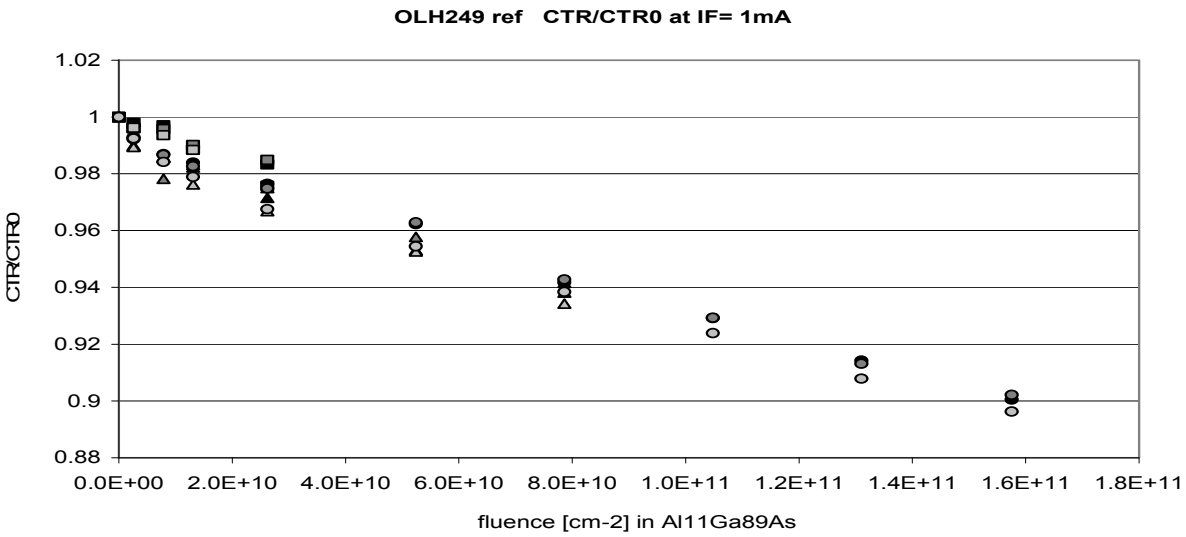
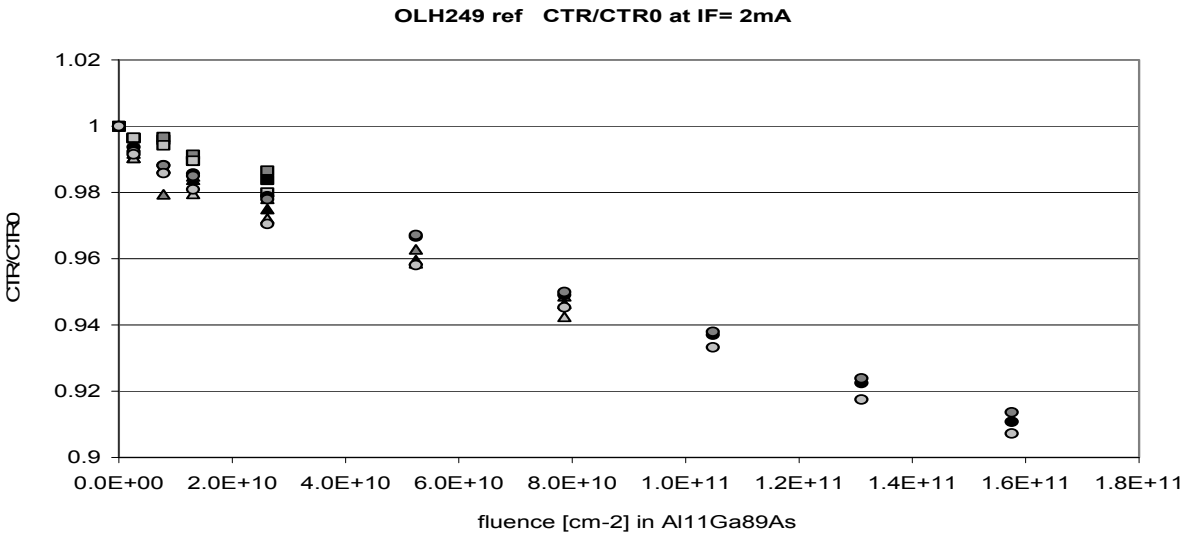
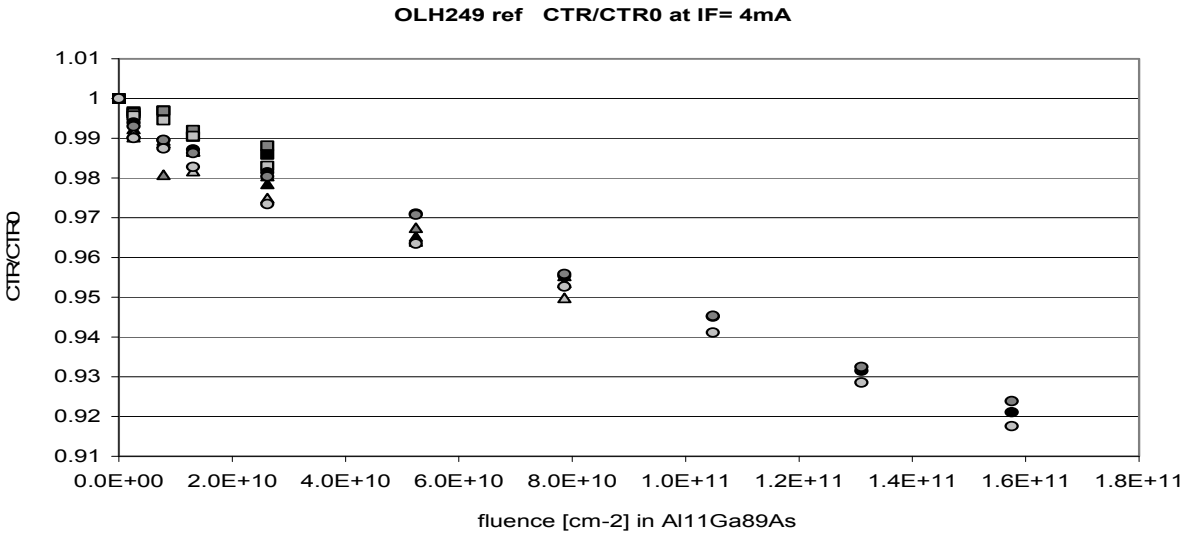
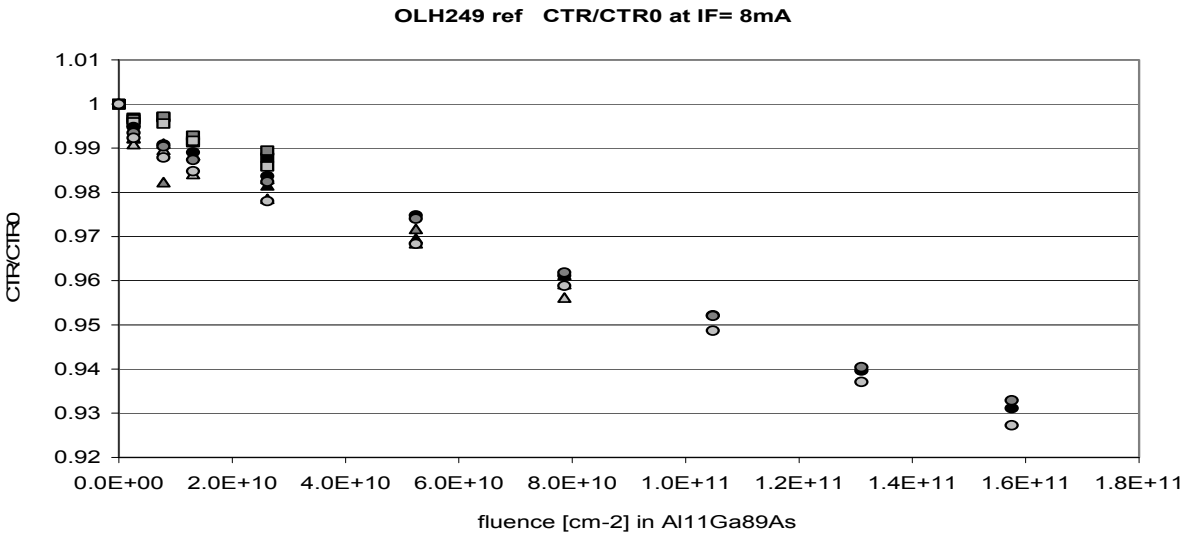

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-123: OLH249 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

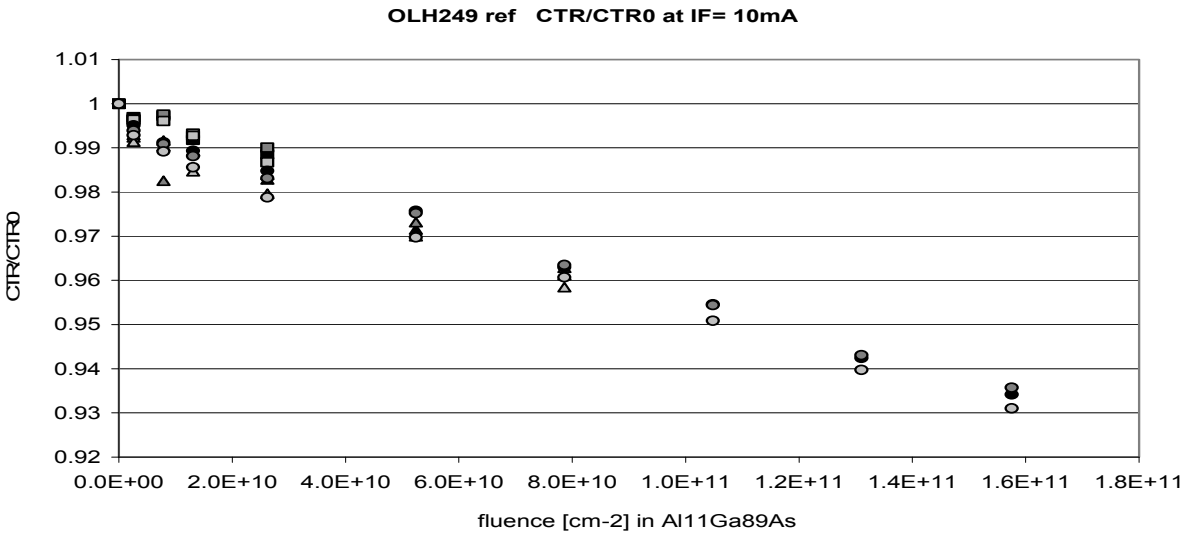
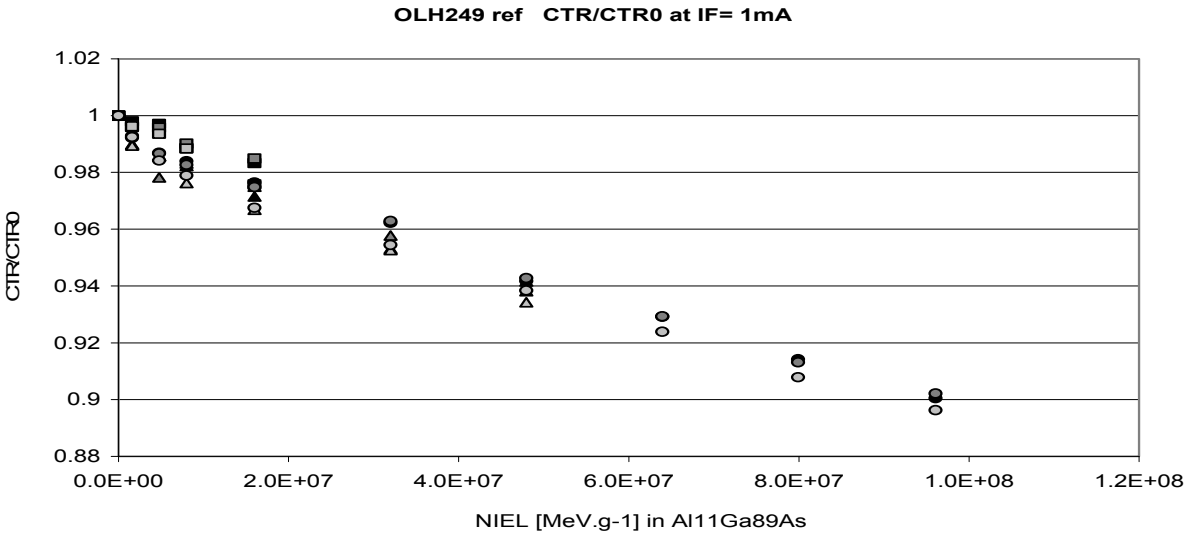
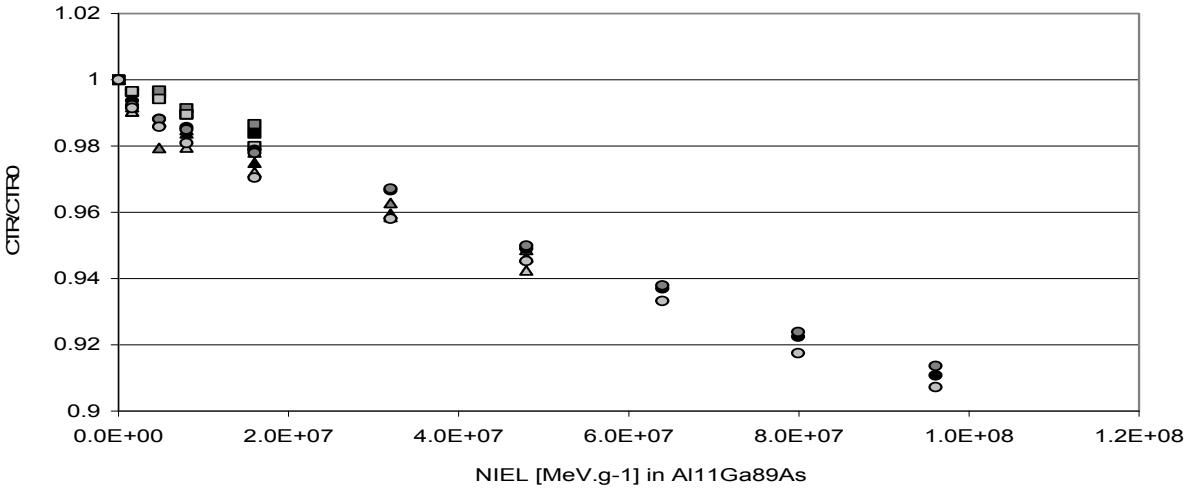
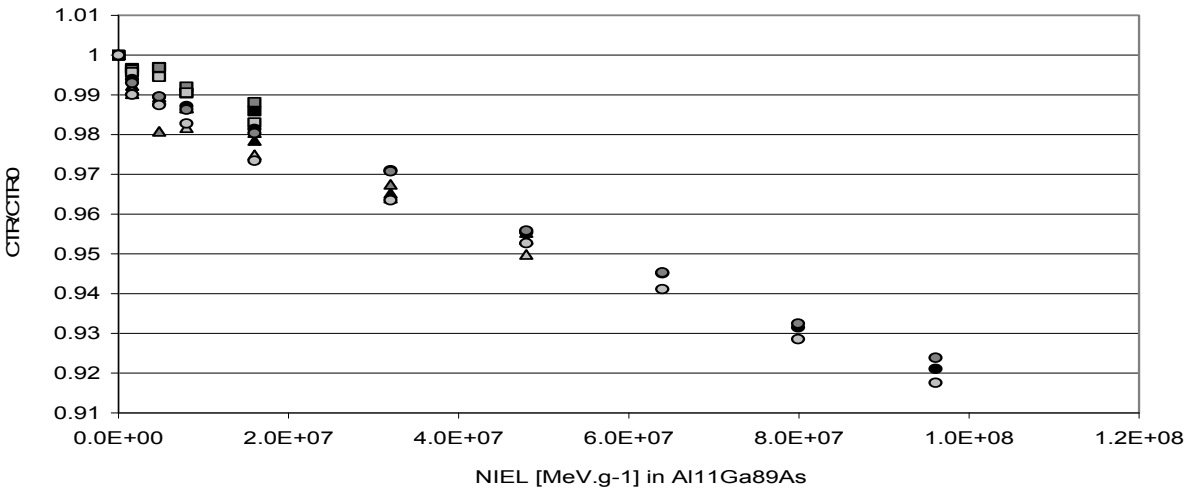
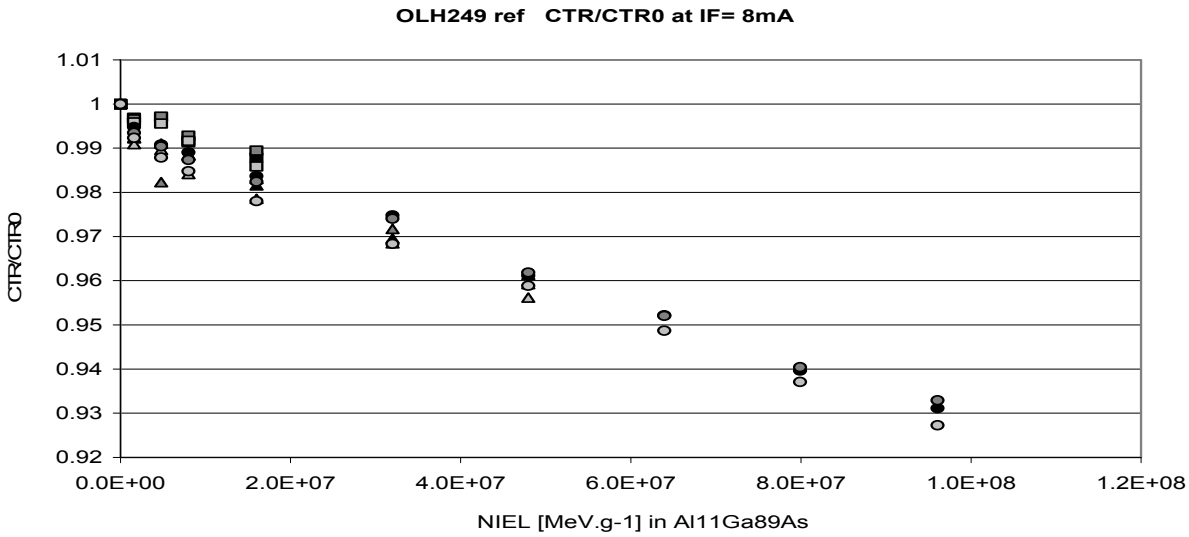

OLH249 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-124: OLH249 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

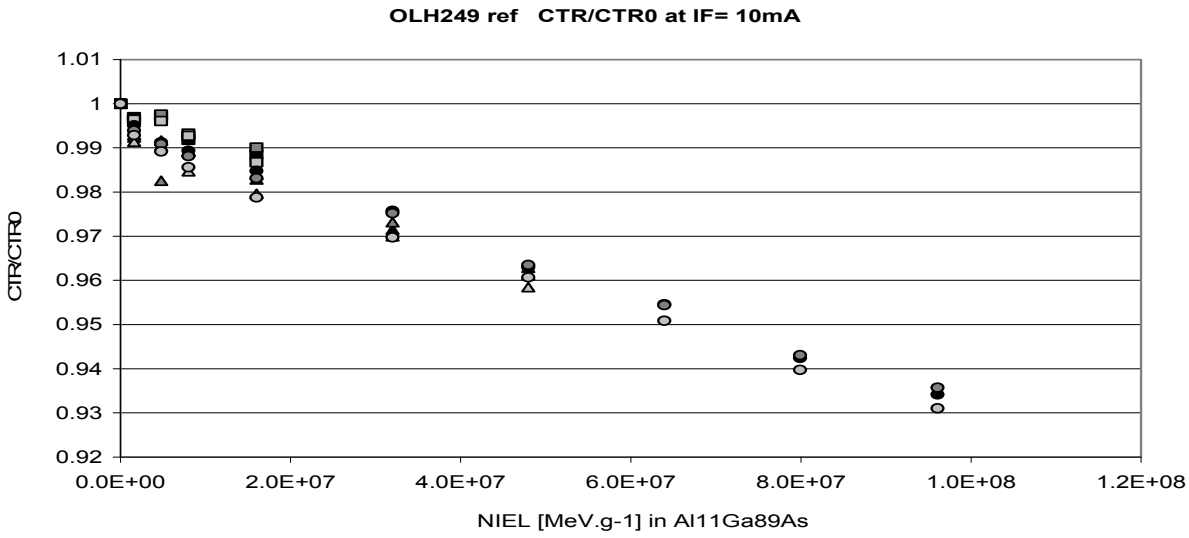
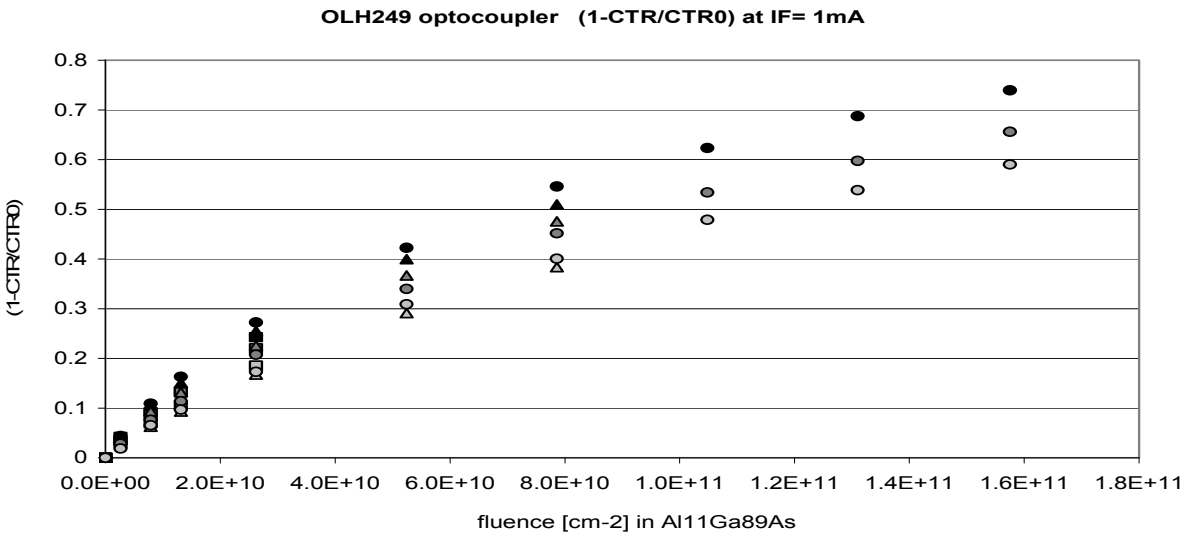
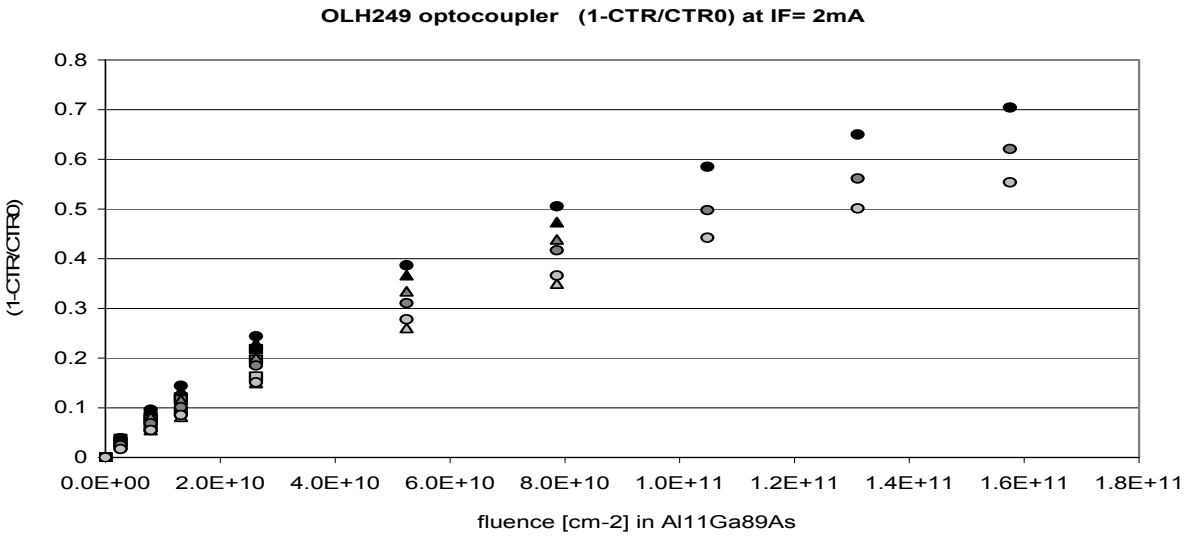
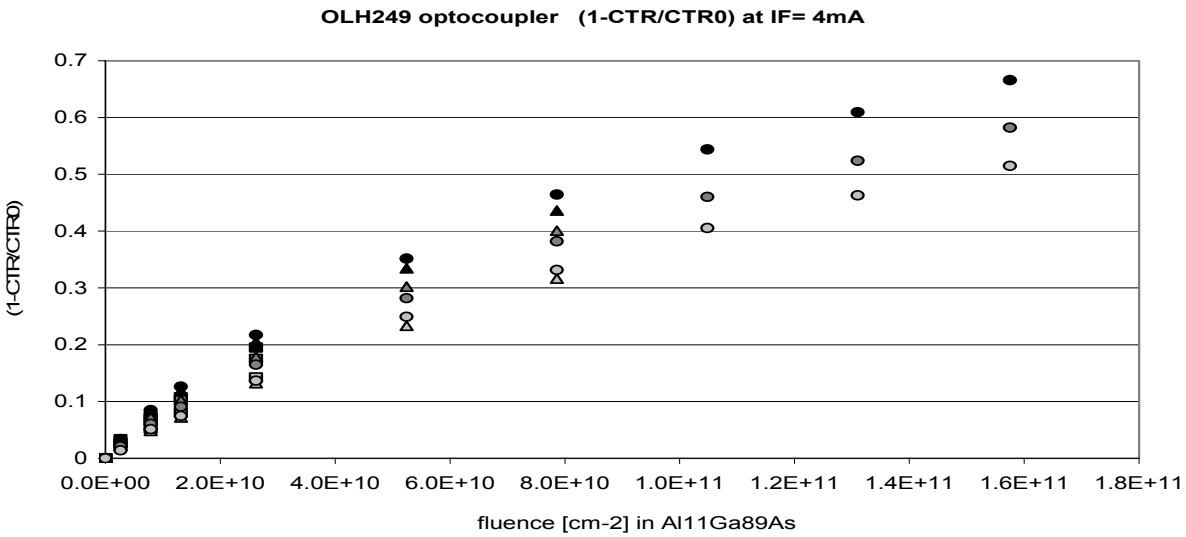
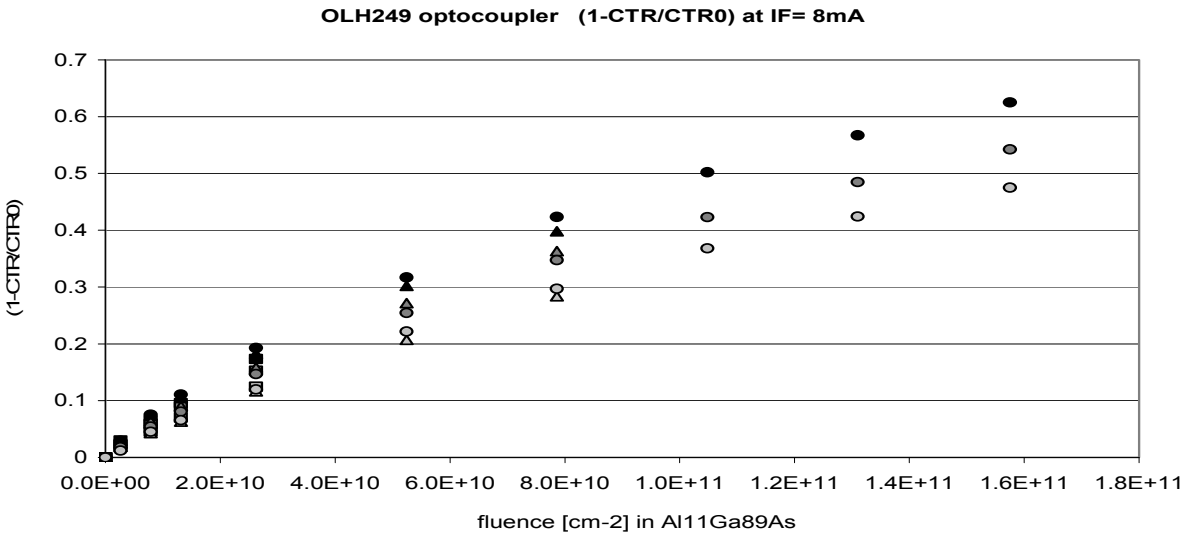

OLH249 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-125: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

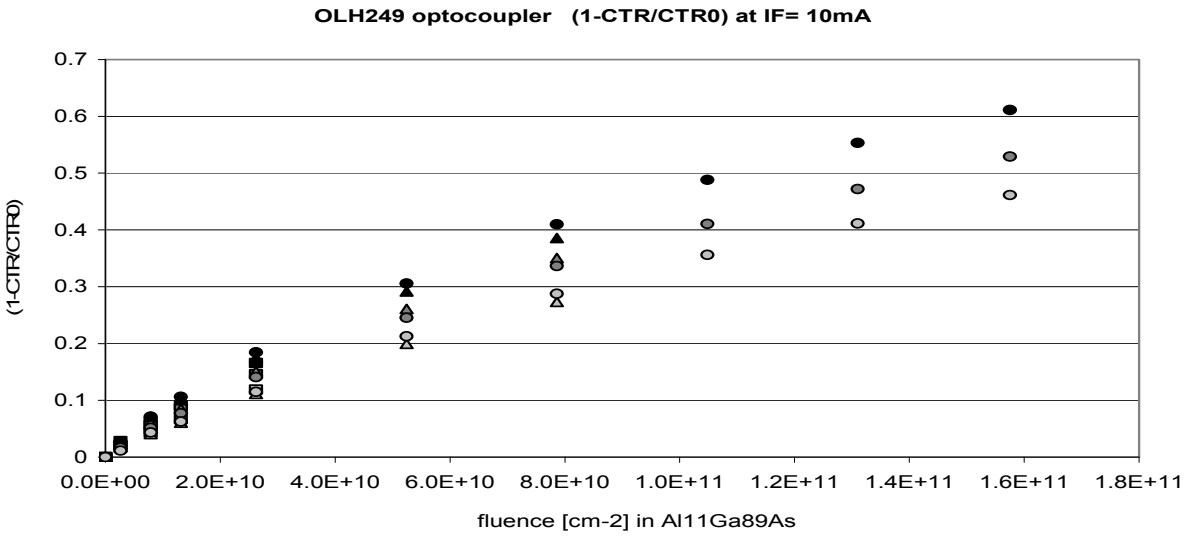
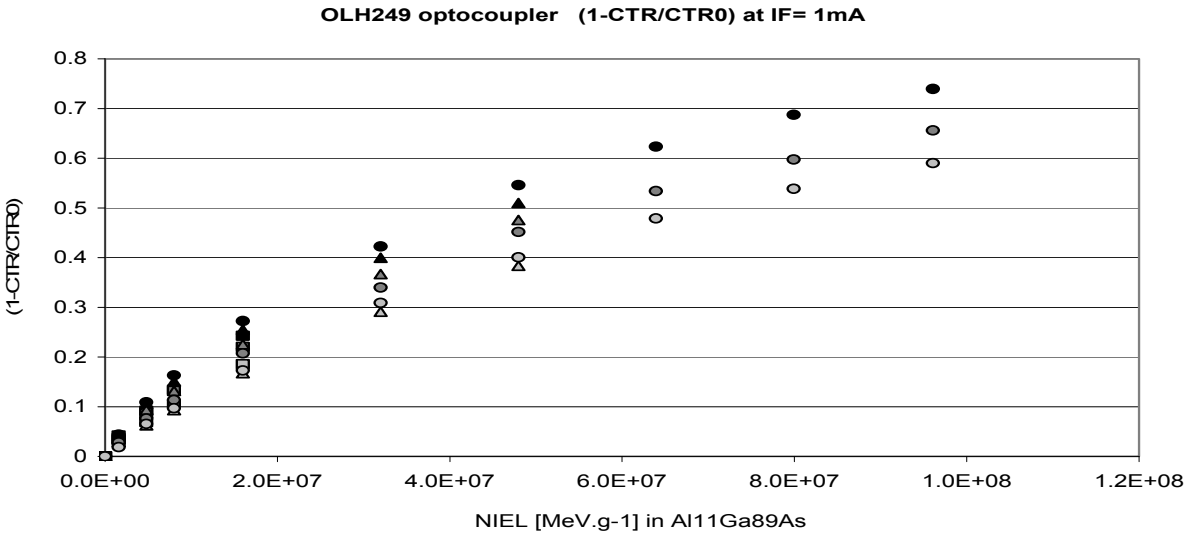
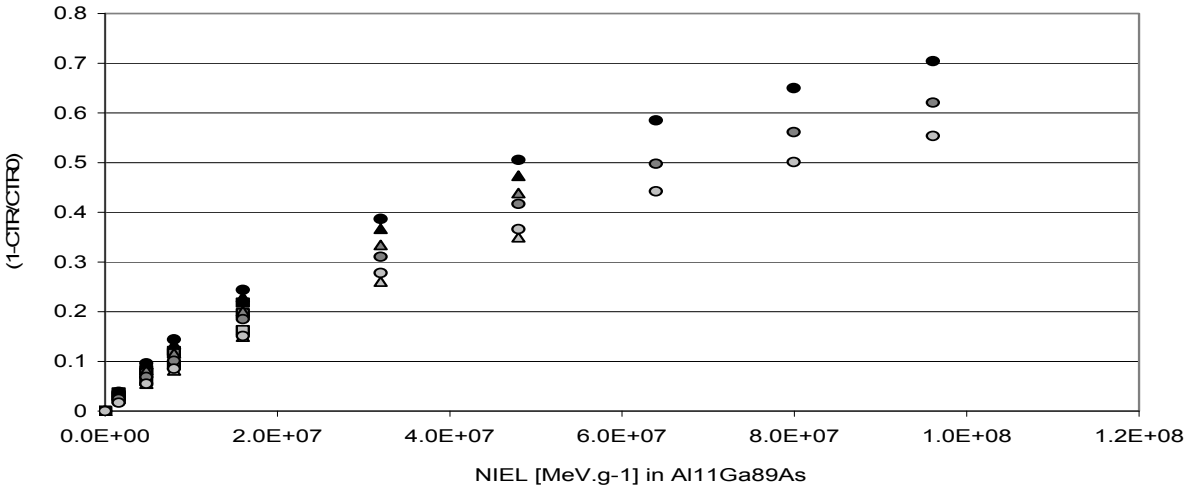
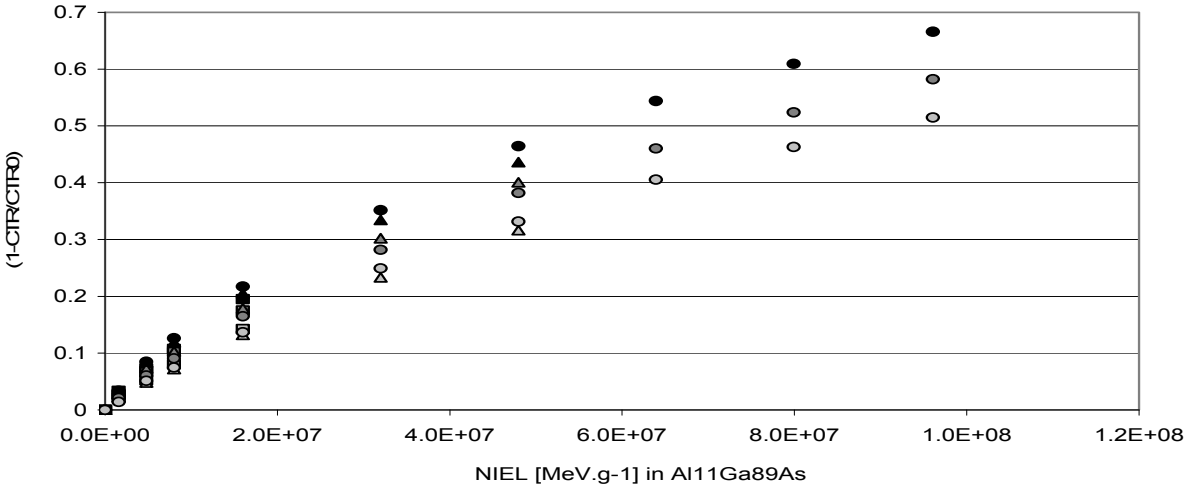
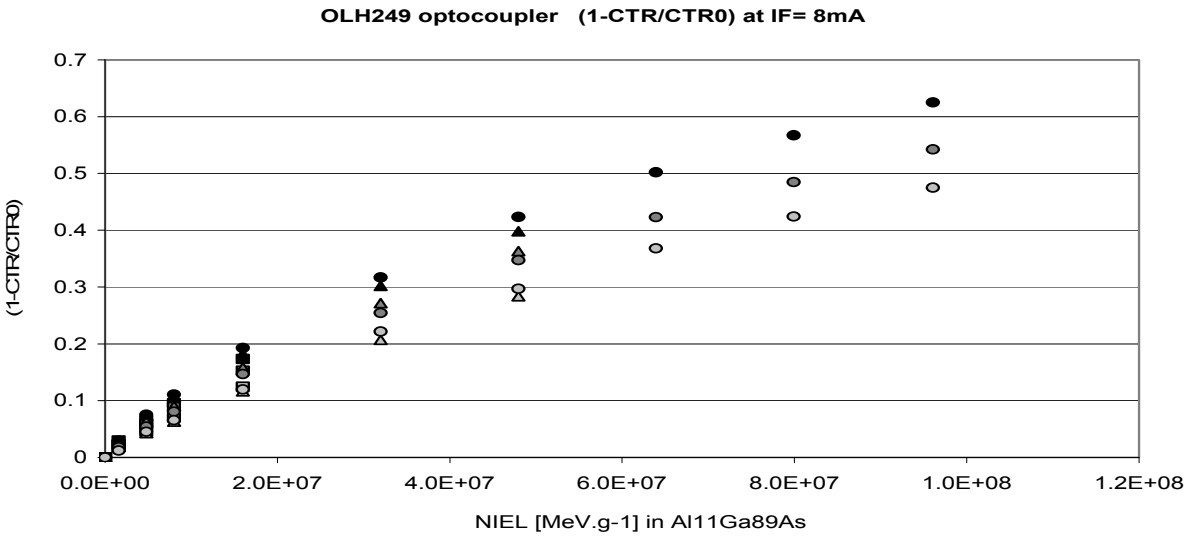

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-126: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

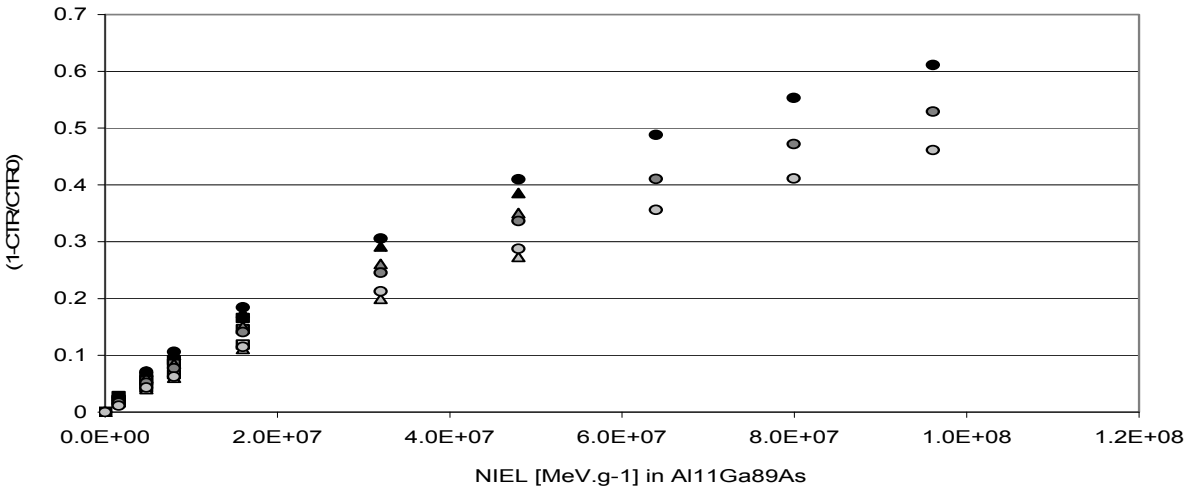
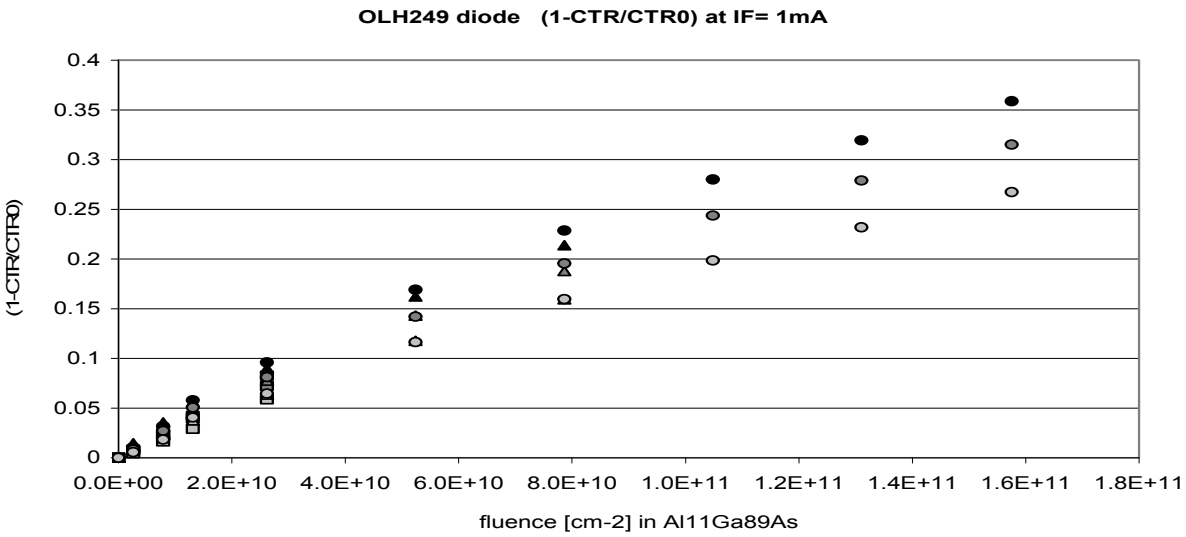
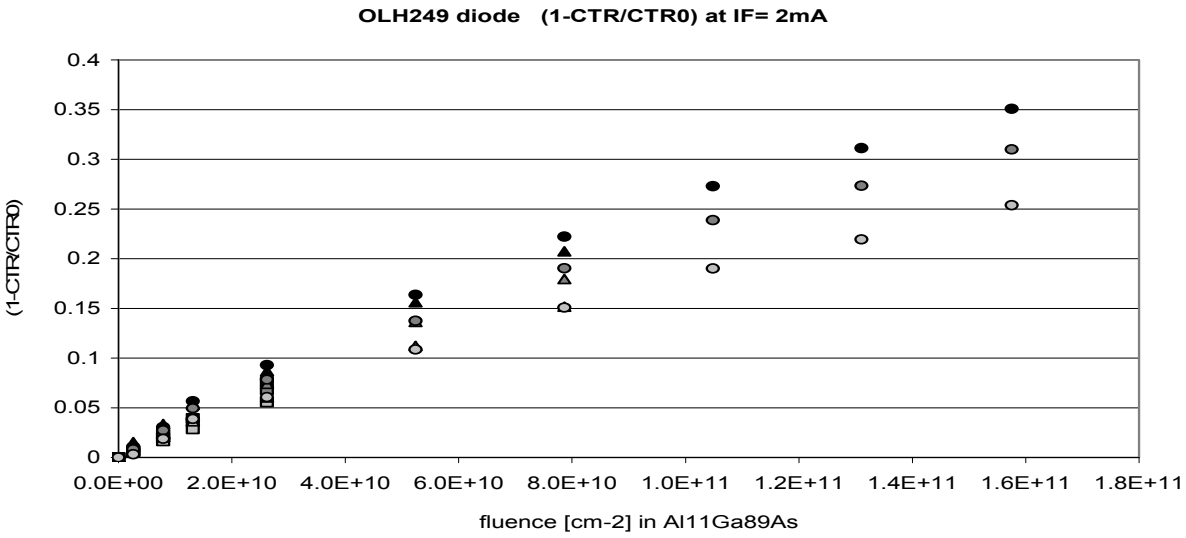
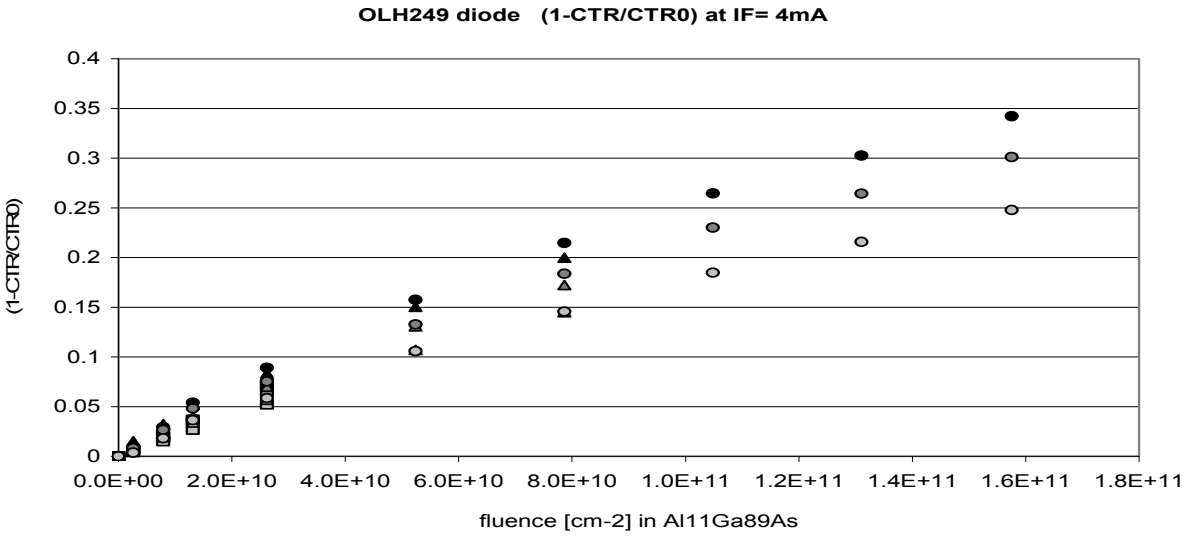
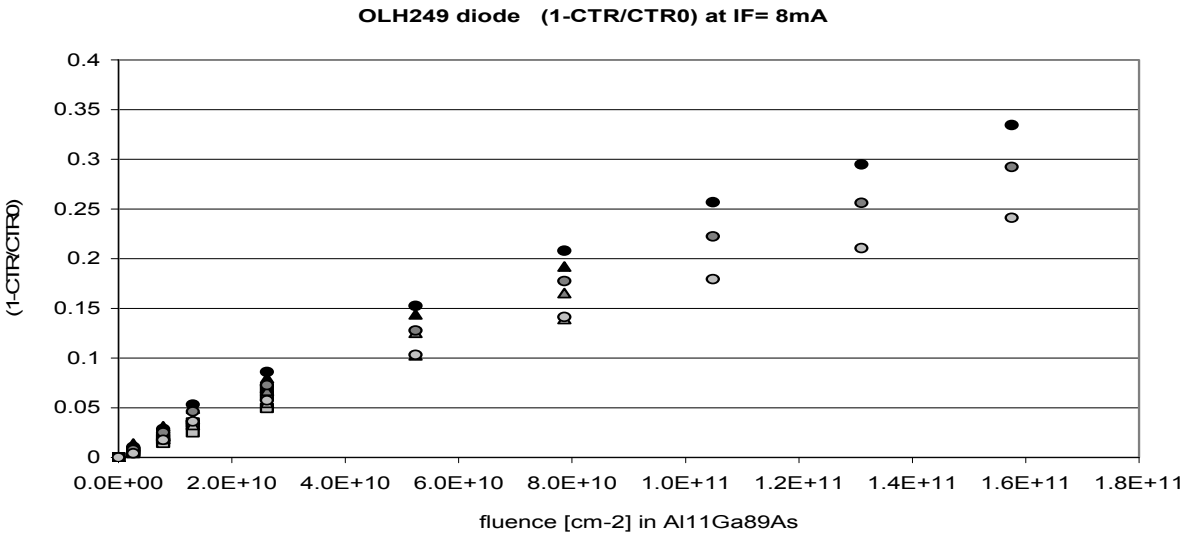

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-127: OLH249 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

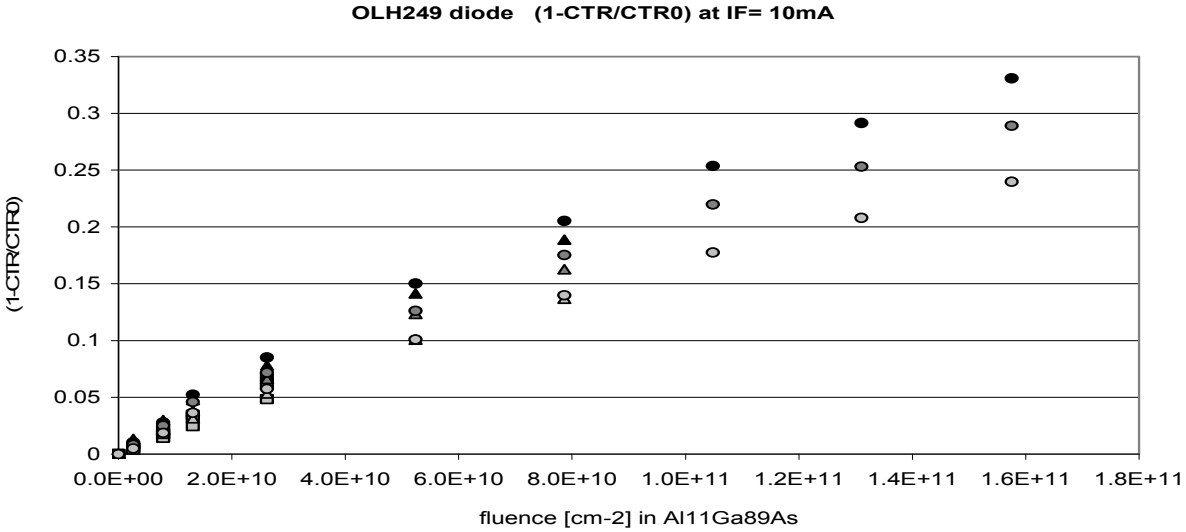
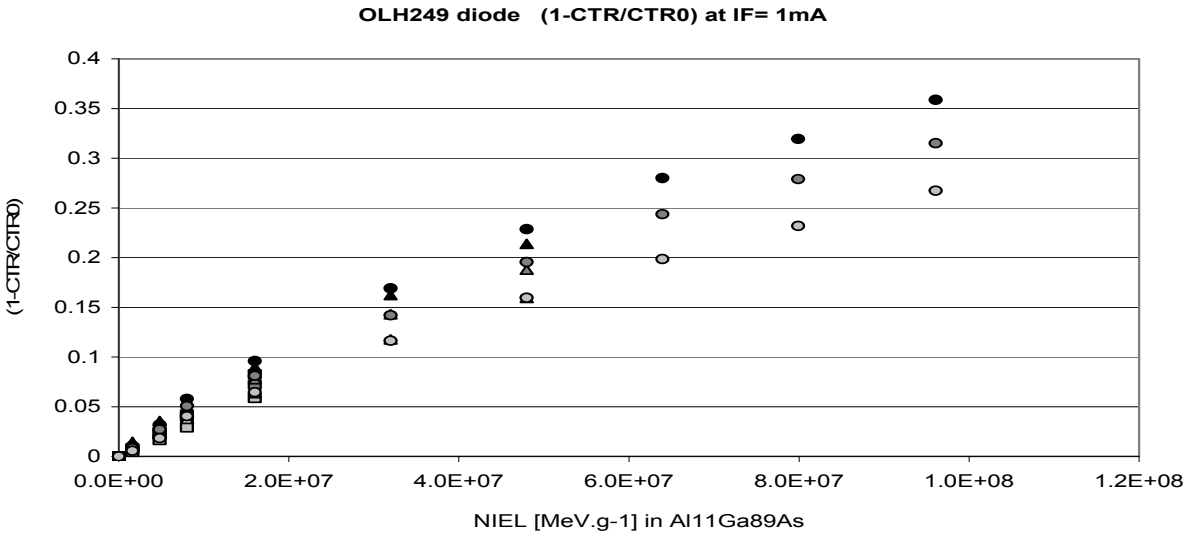
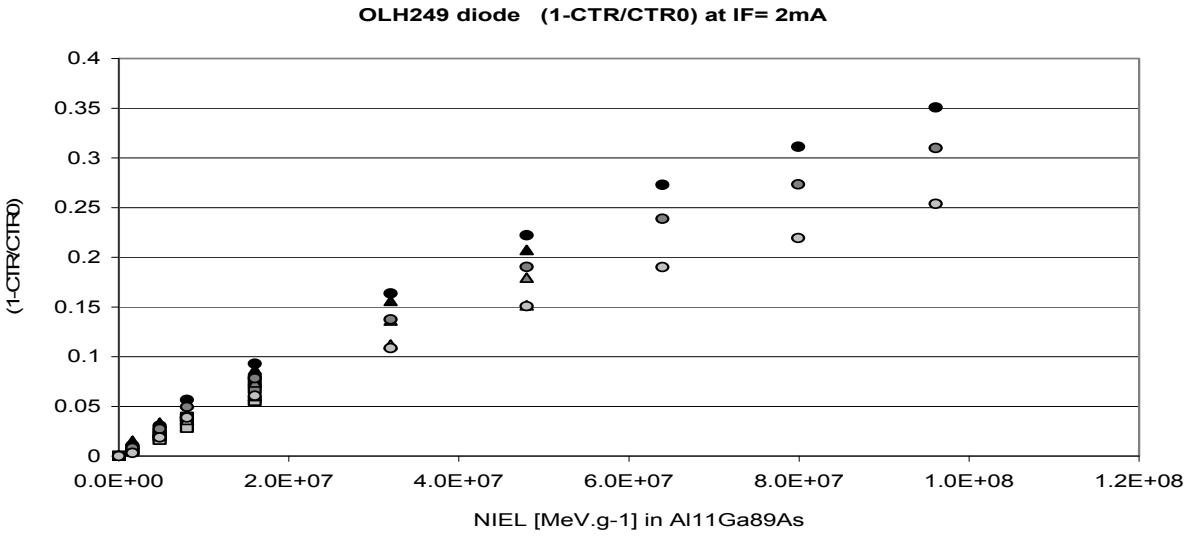
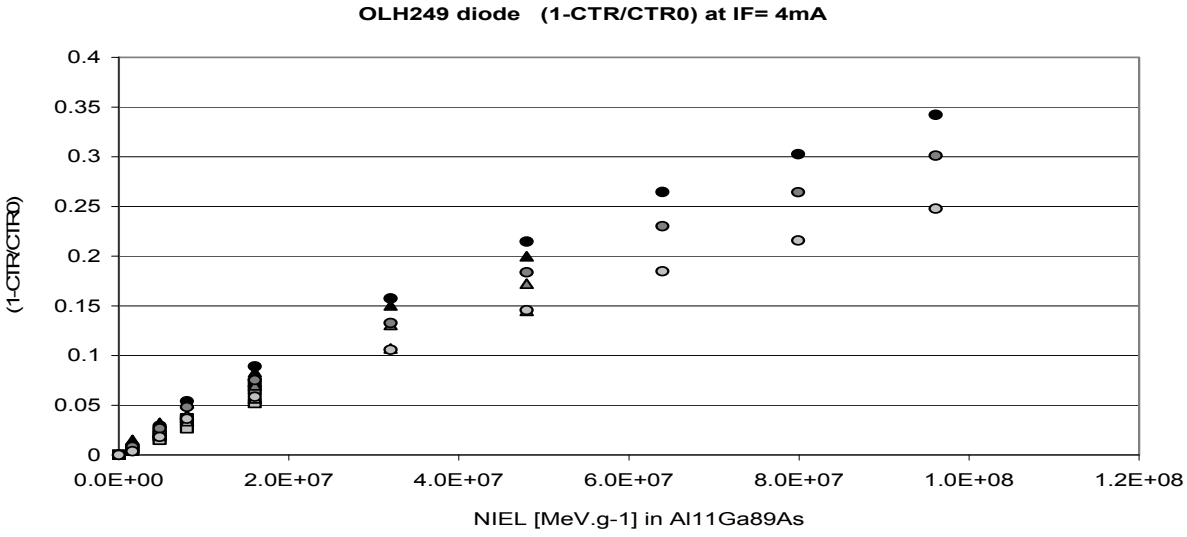
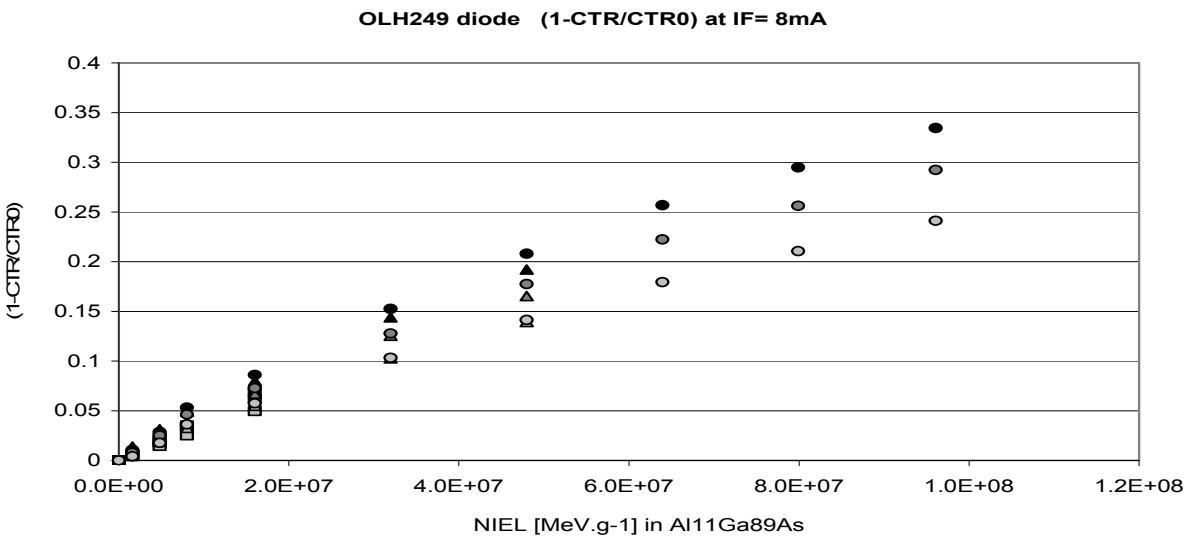

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-128: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Al$_{0.11}$Ga$_{0.89}$As (GEANT4 TOTAL)








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

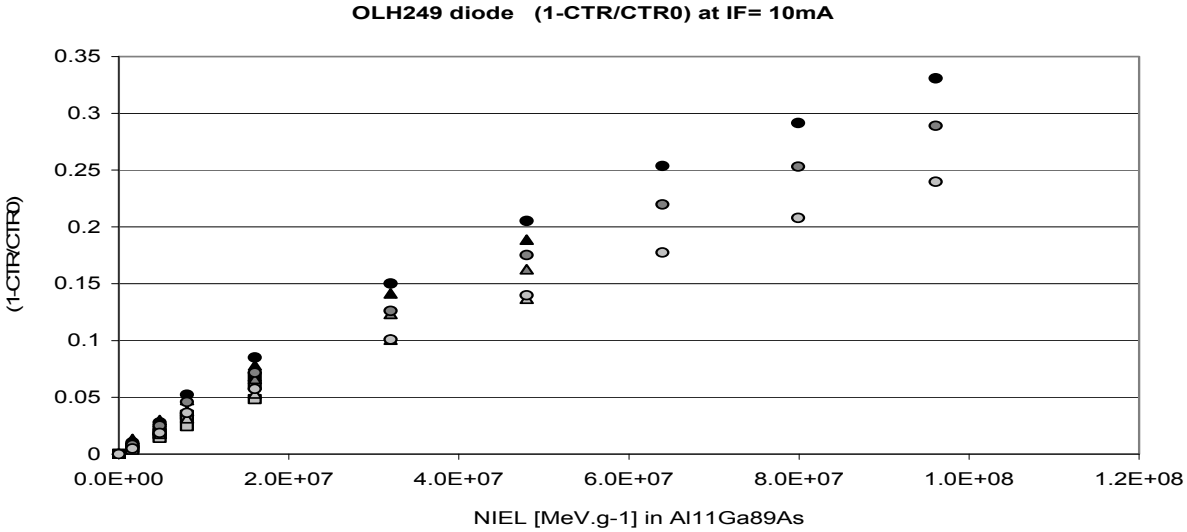
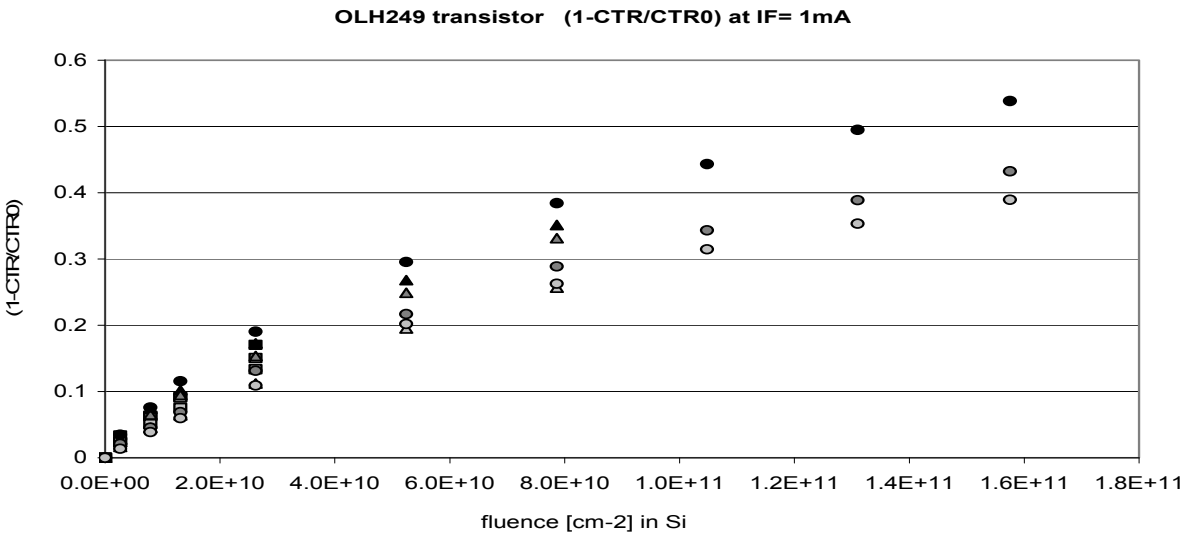
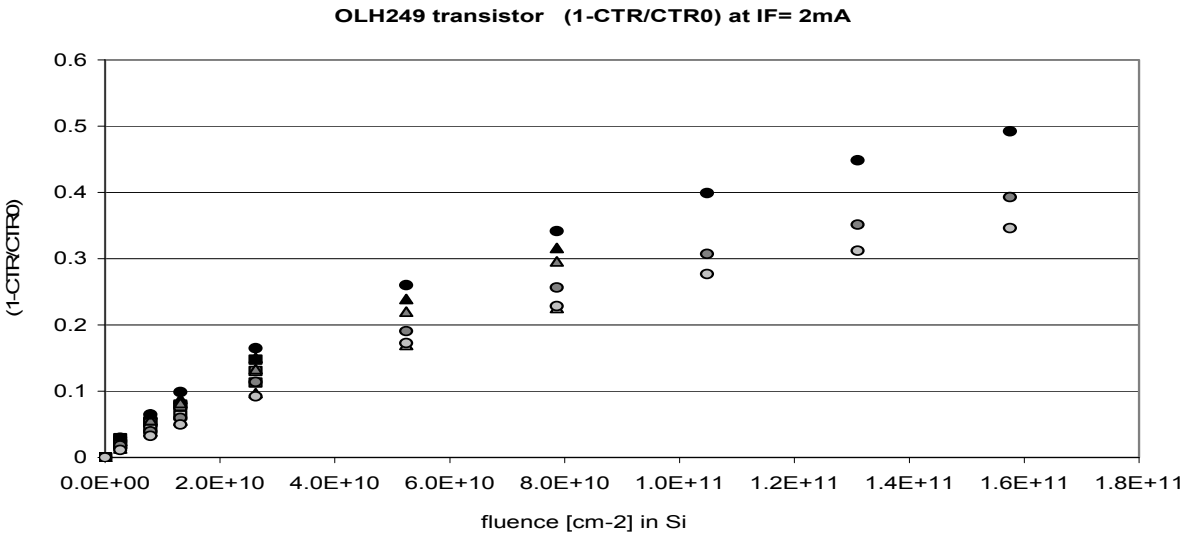
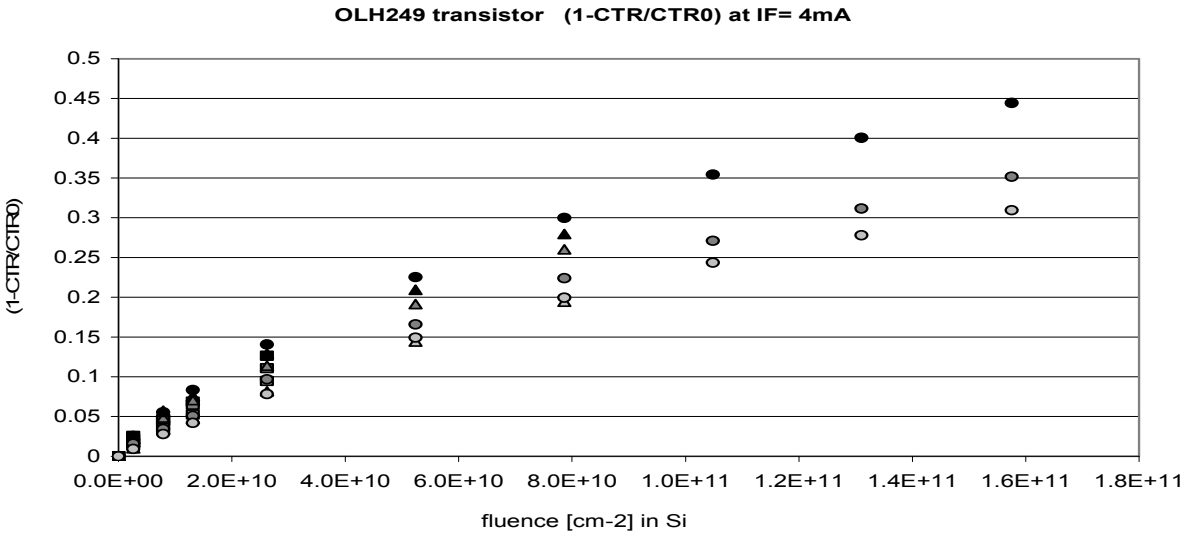
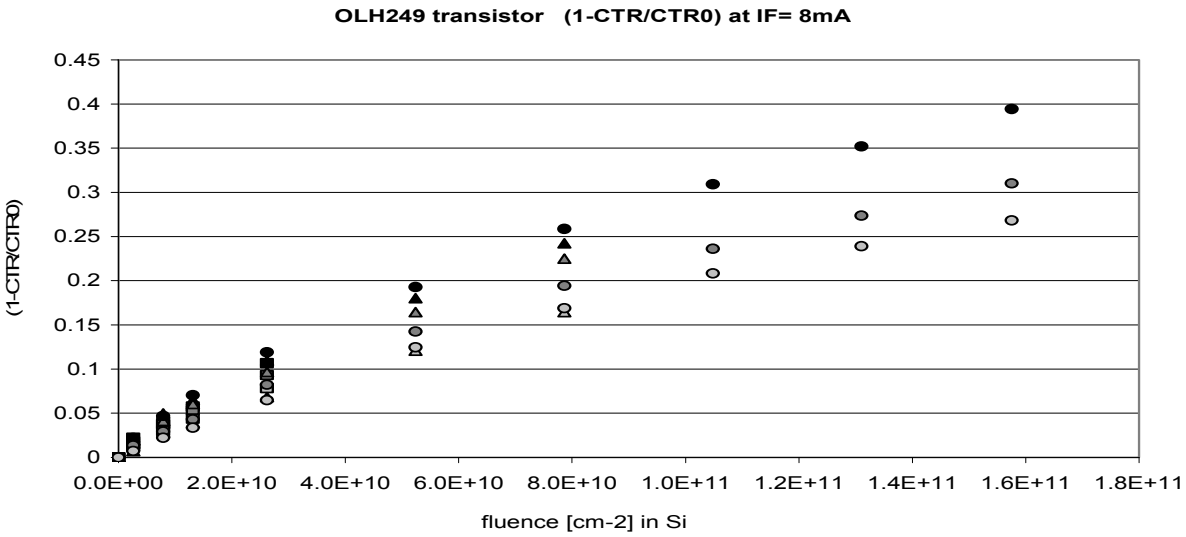

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-129: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

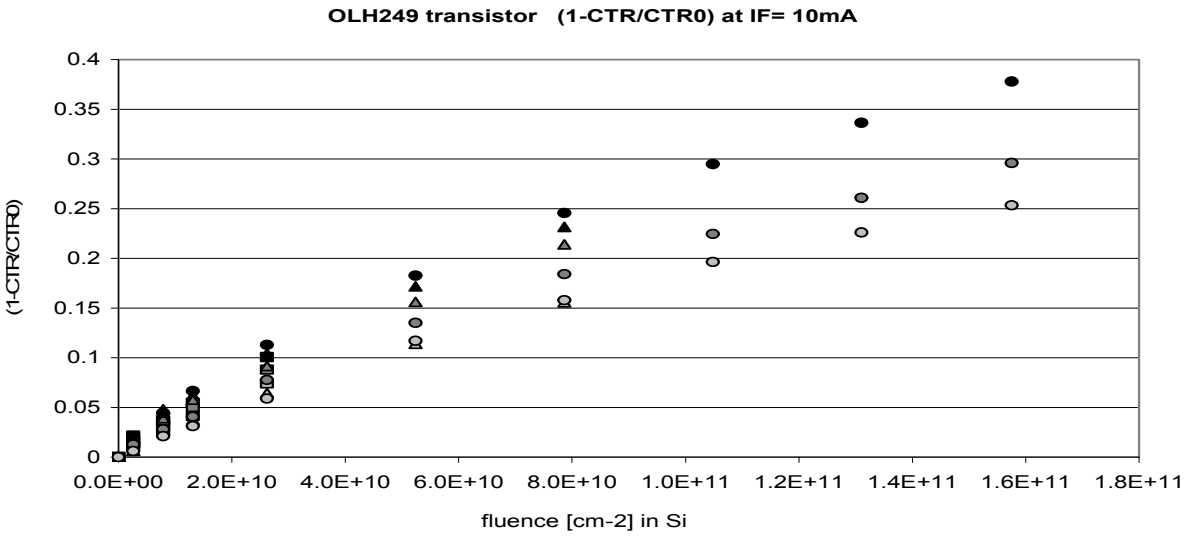
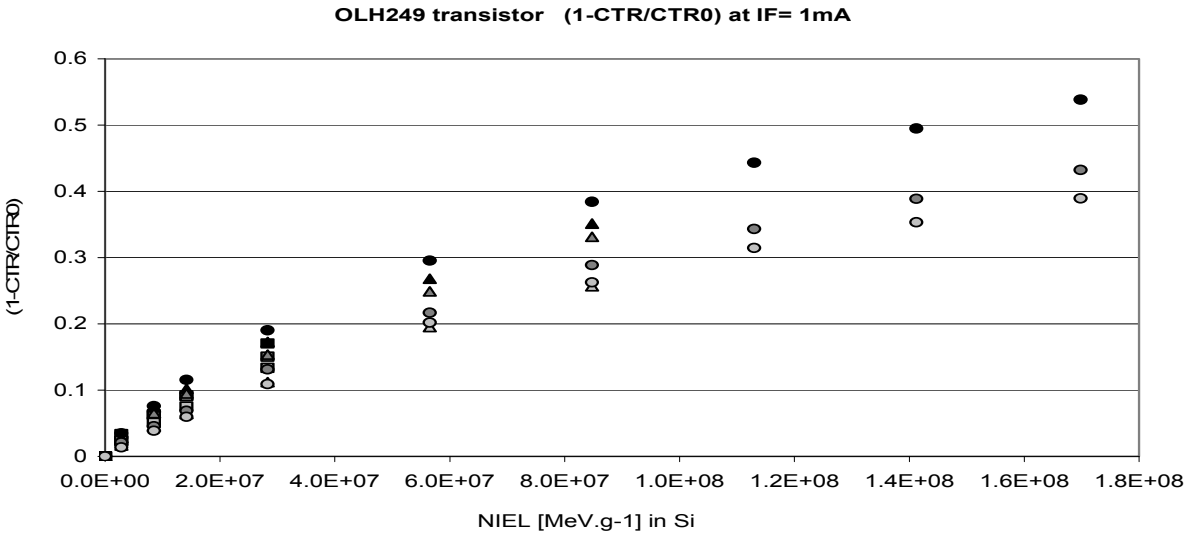
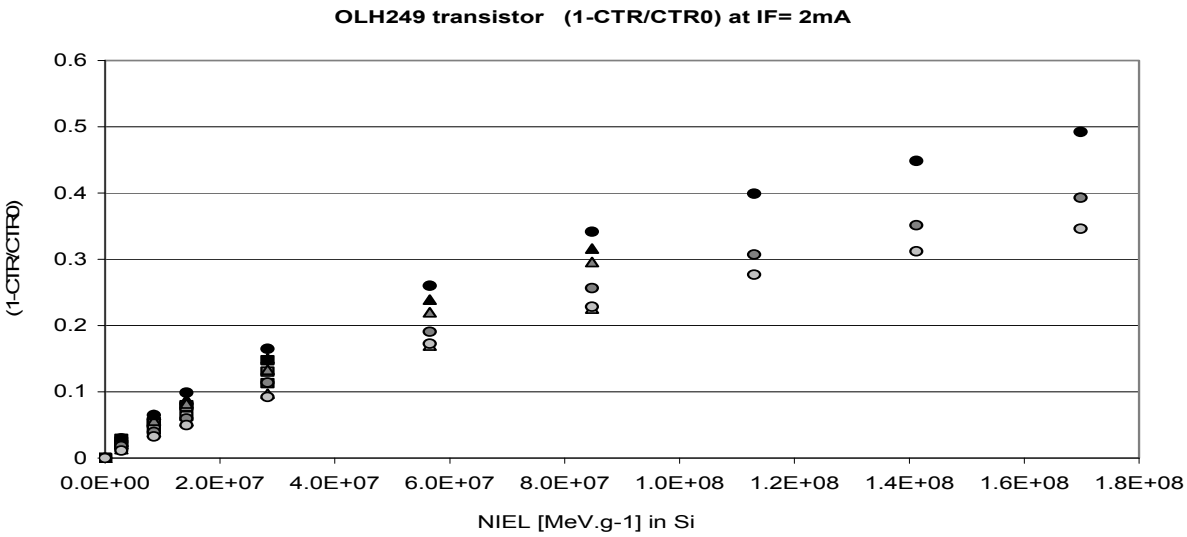
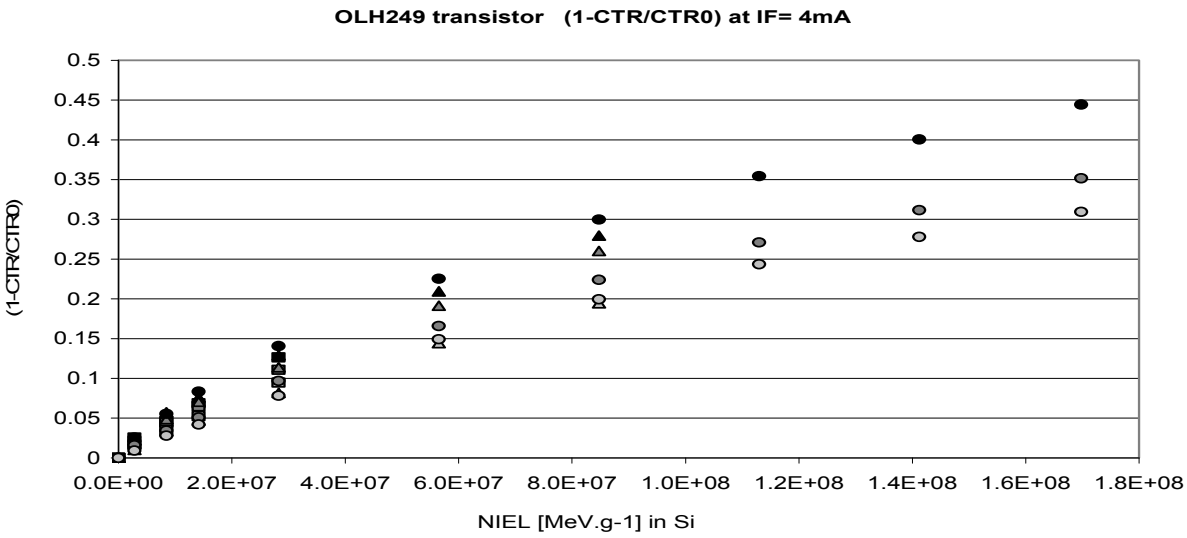
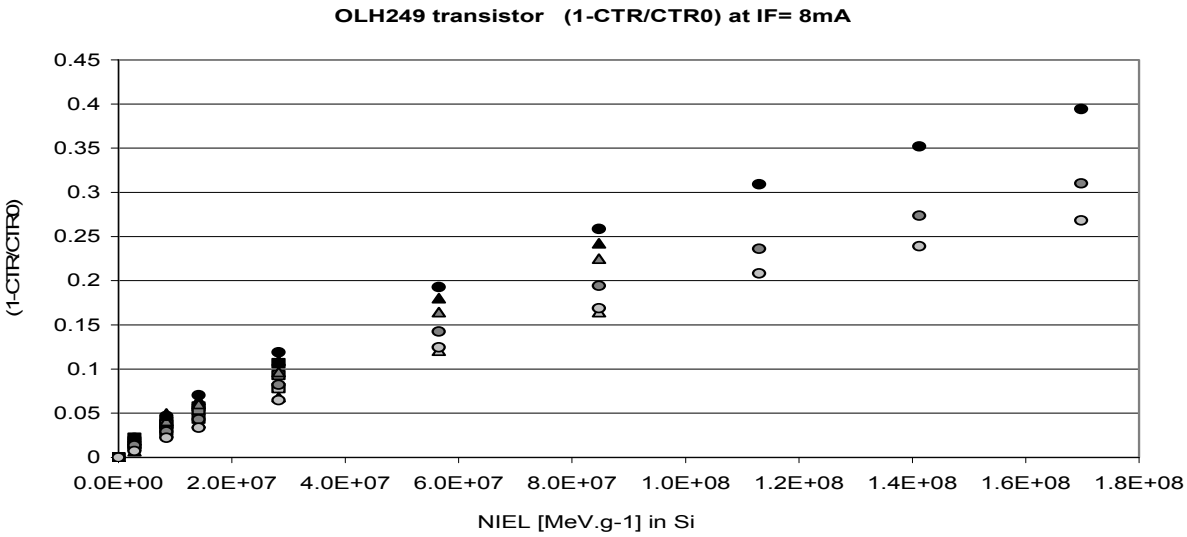

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Si

Fig. 13-130: OLH249 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

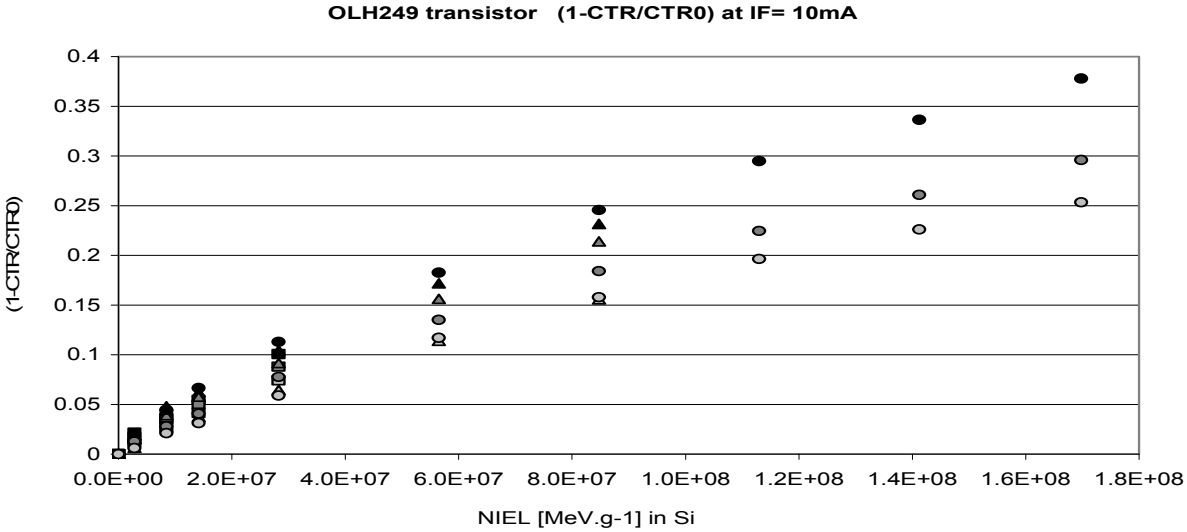
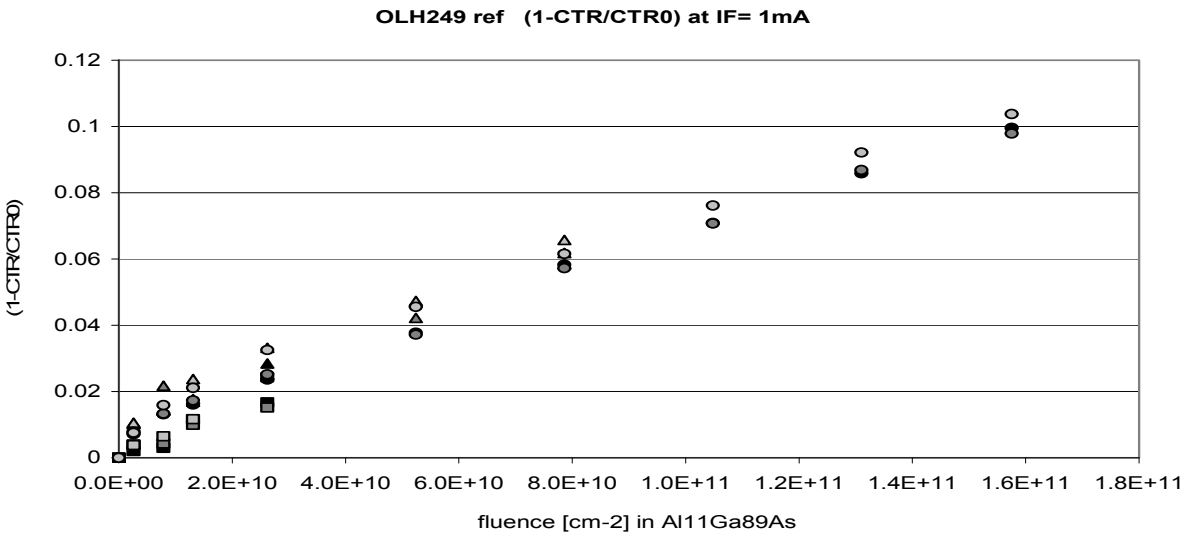
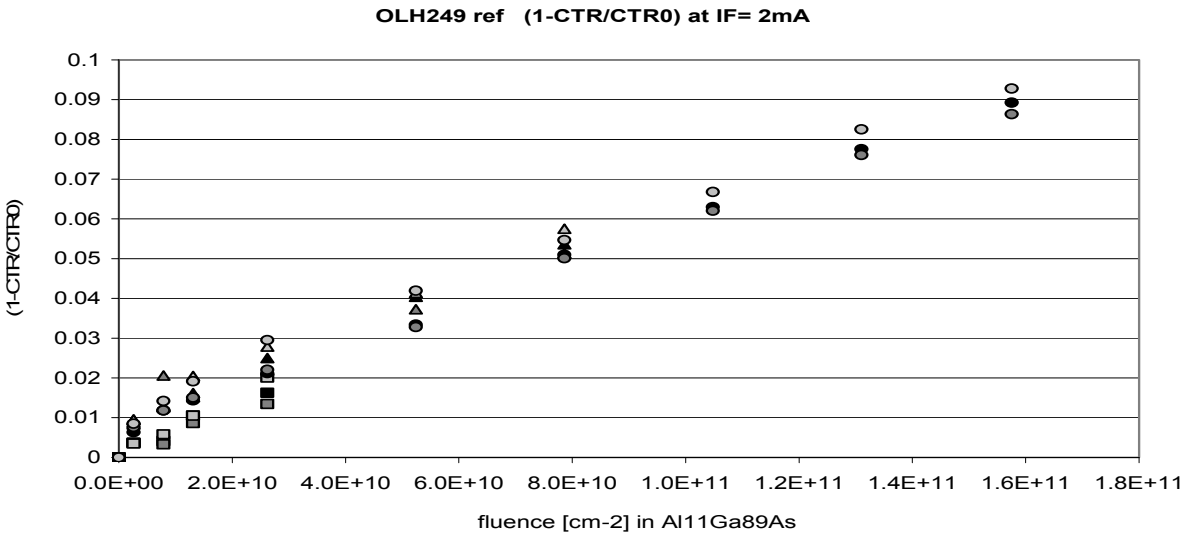
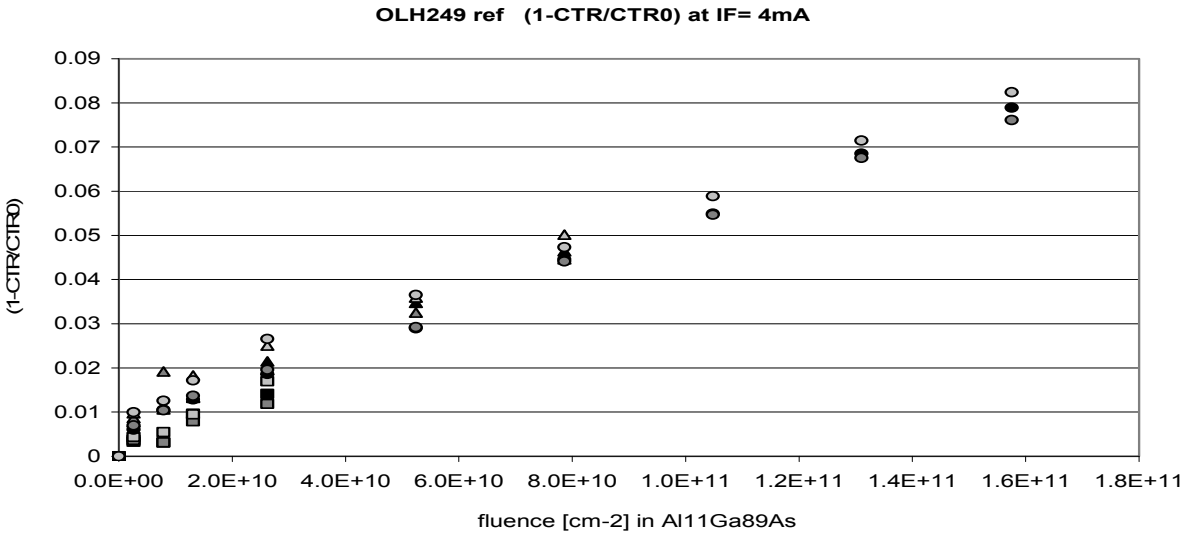
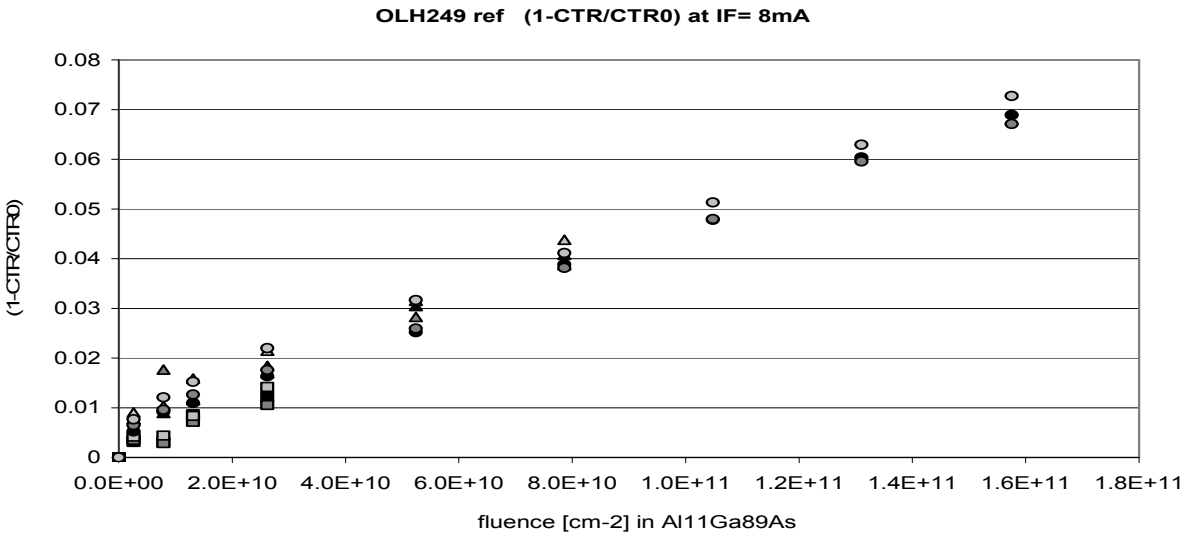

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 13-131: OLH249 reference: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence








OLH249 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

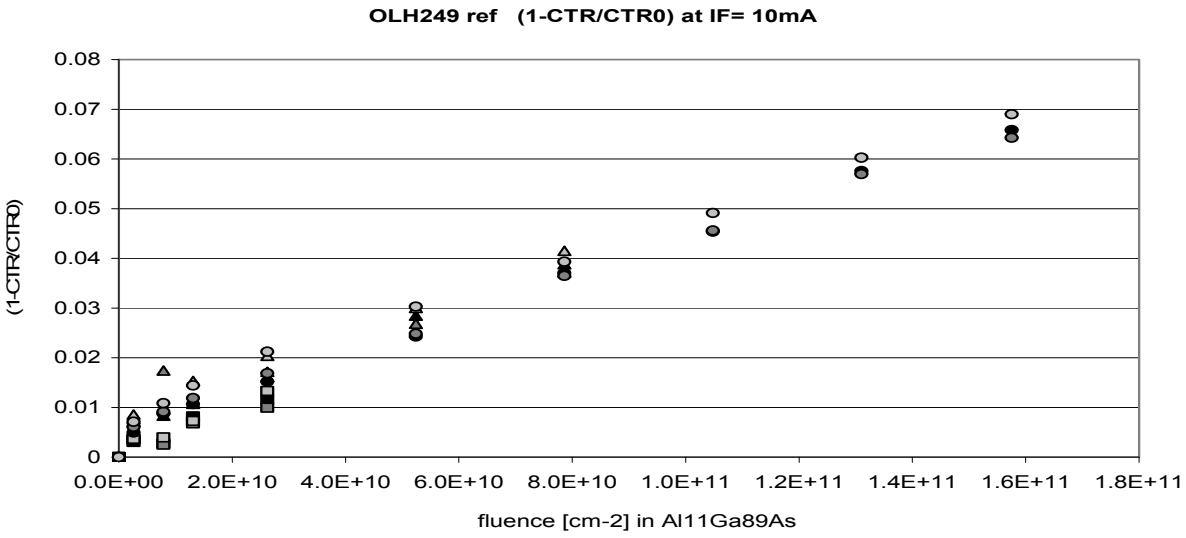
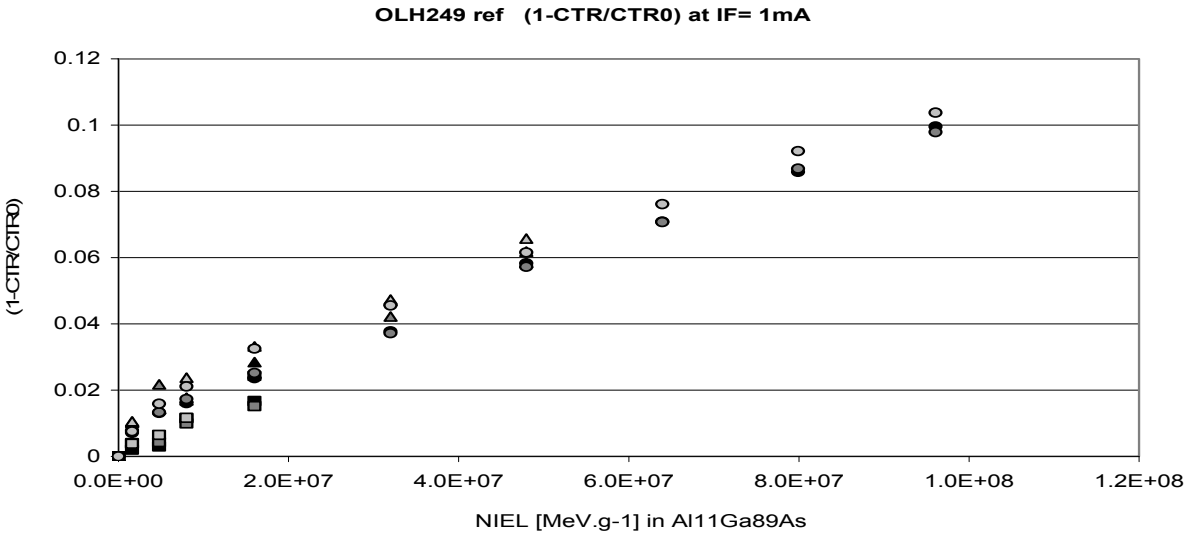
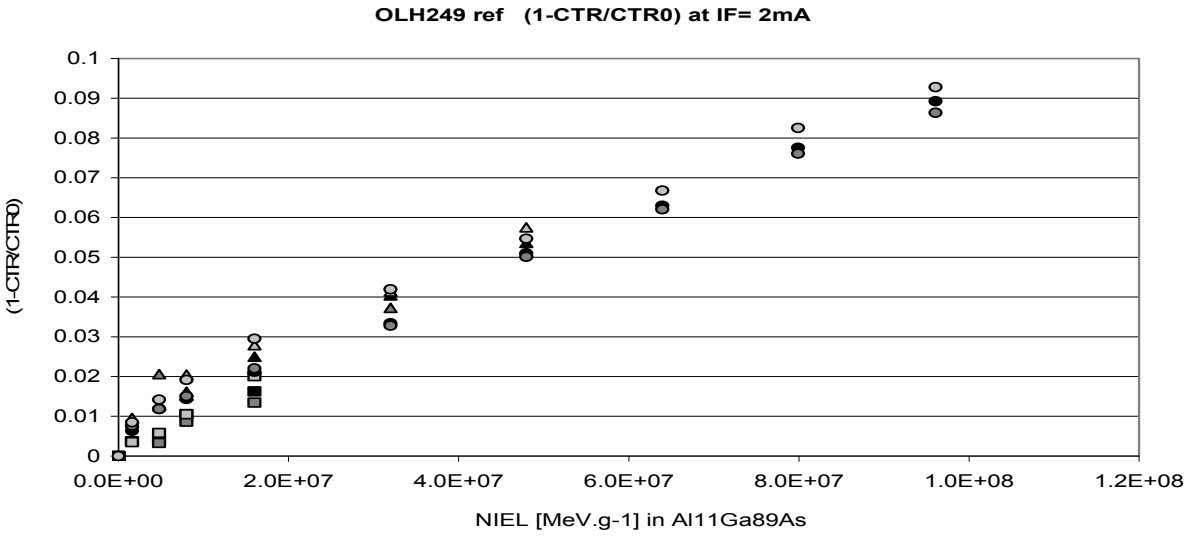
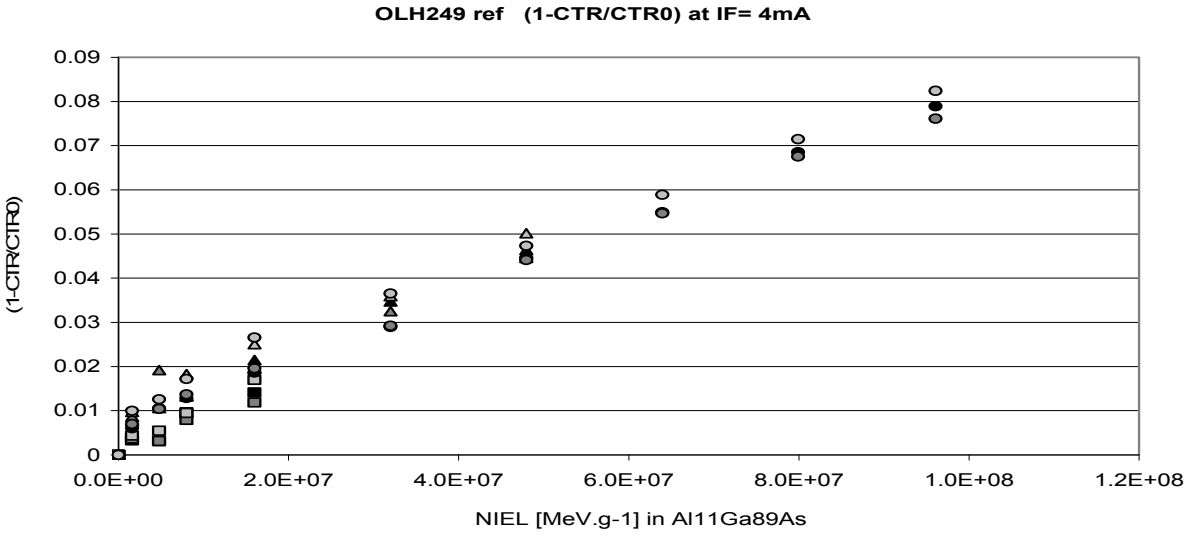
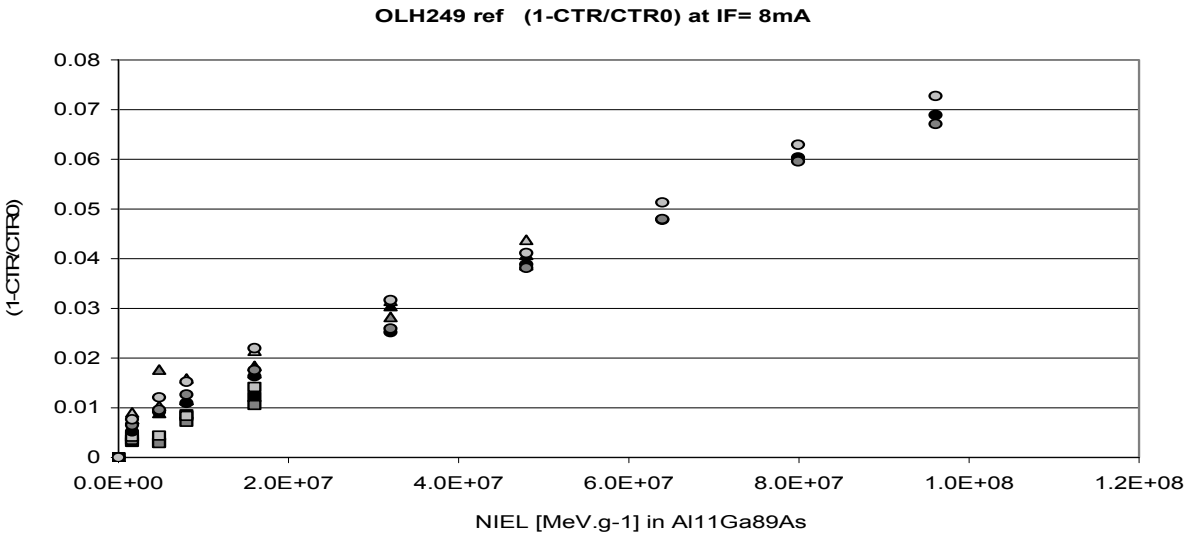

OLH249 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
1.8E+11
fluence [cm-2] in Al11Ga89As

Fig. 13-132: OLH249 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)








OLH249 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

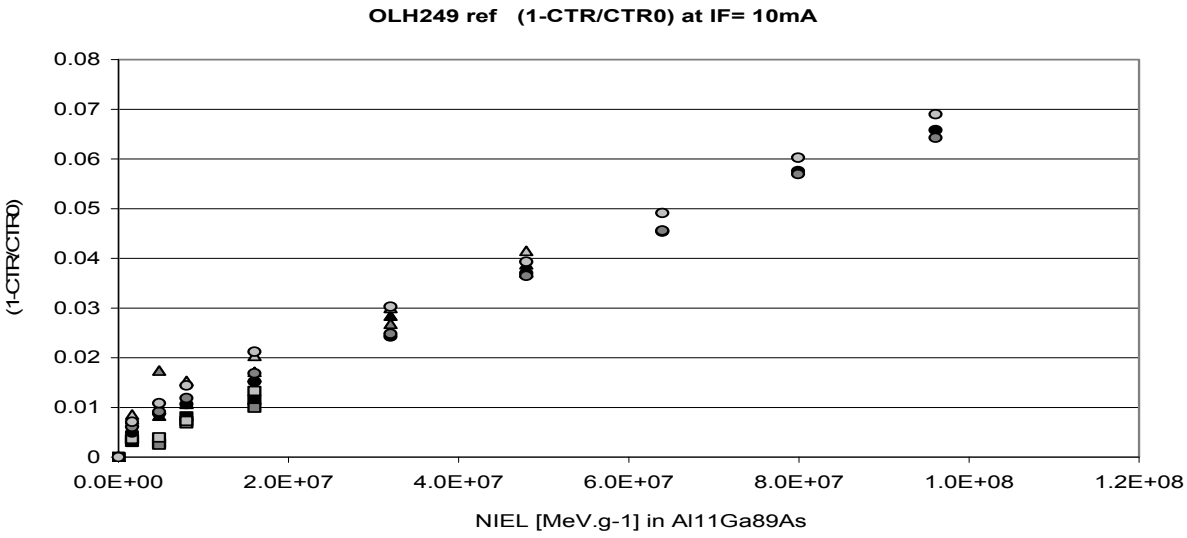
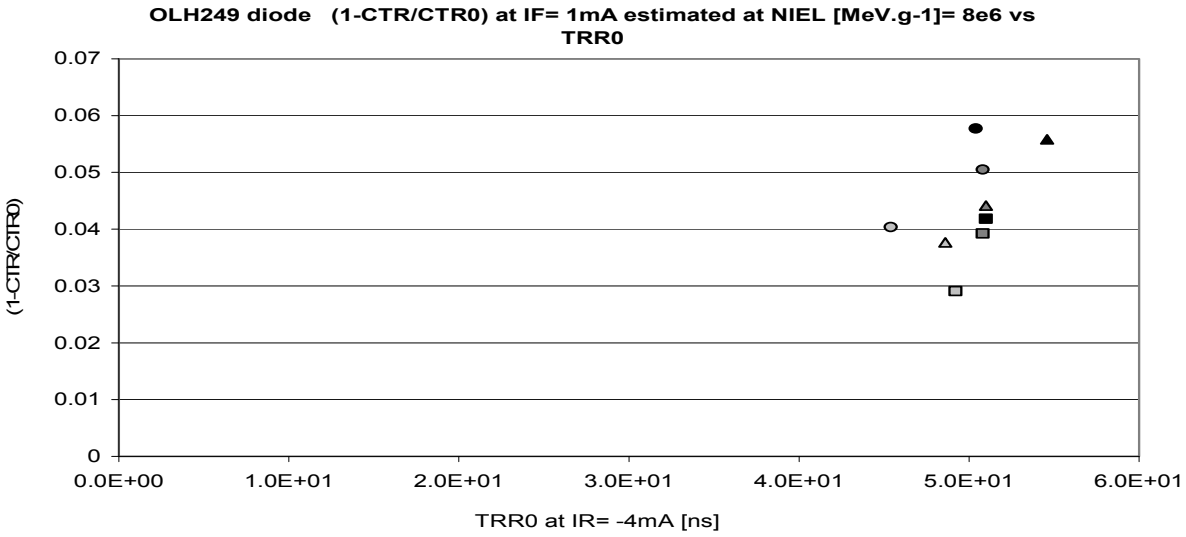
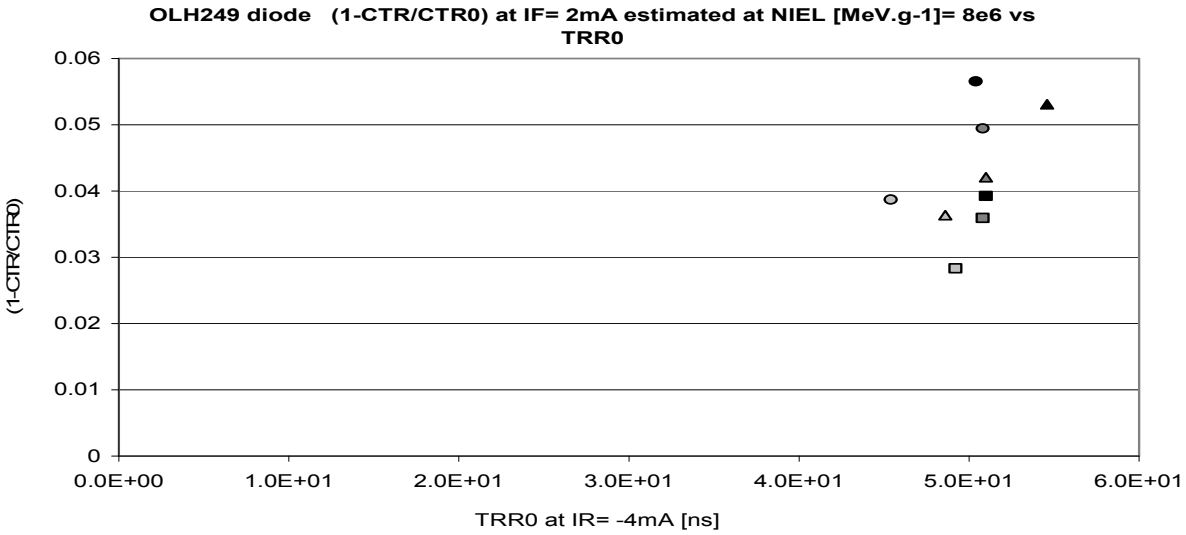
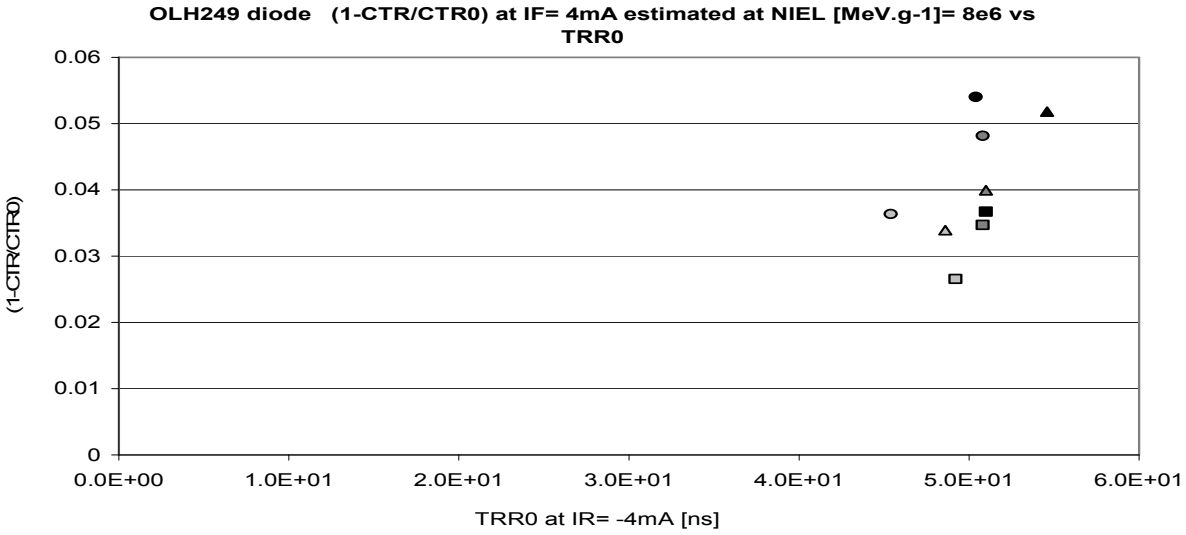
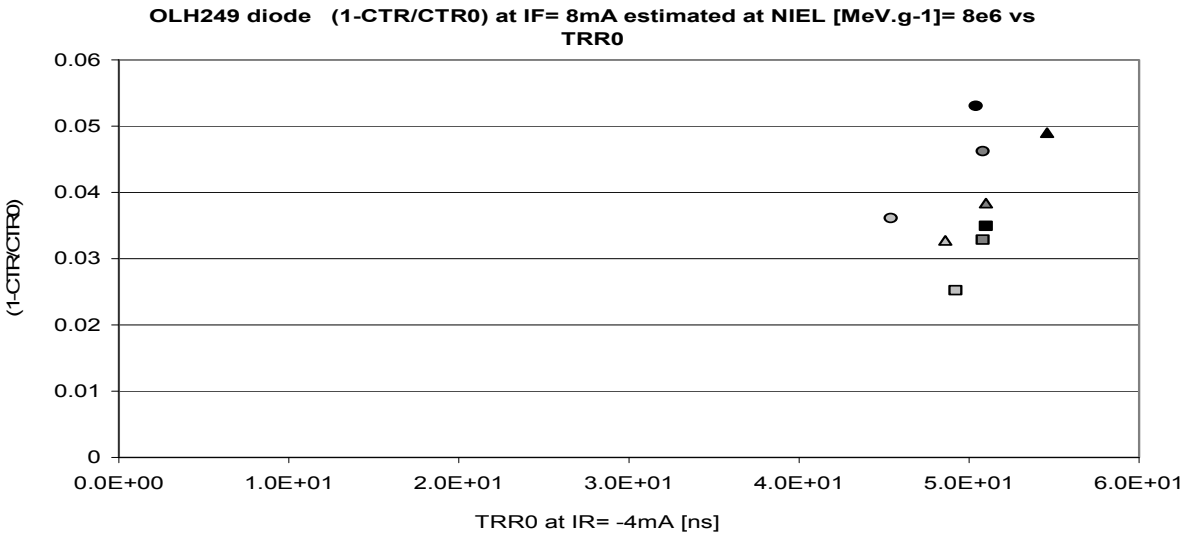

OLH249 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al11Ga89As

Fig. 13-133: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
1.0E+01
2.0E+01
3.0E+01
4.0E+01
5.0E+01
6.0E+01
TRR0 at IR= -4mA [ns]

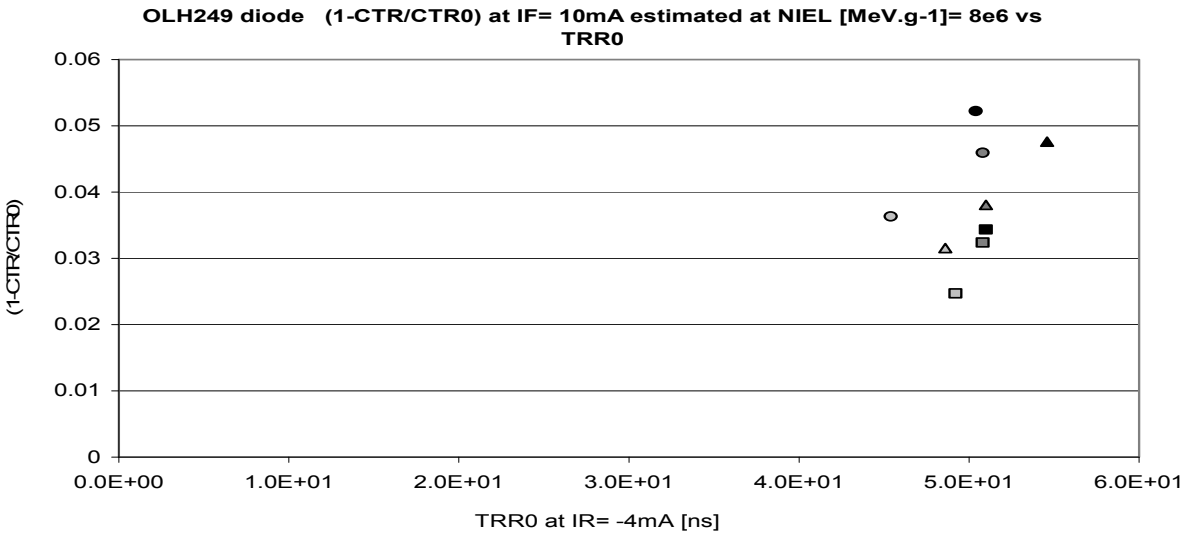

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
1.0E+01
2.0E+01
3.0E+01
4.0E+01
5.0E+01
6.0E+01
TRR0 at IR= -4mA [ns]

Fig. 13-134: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-135: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-136: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 9.6.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 13-137: OLH249 optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

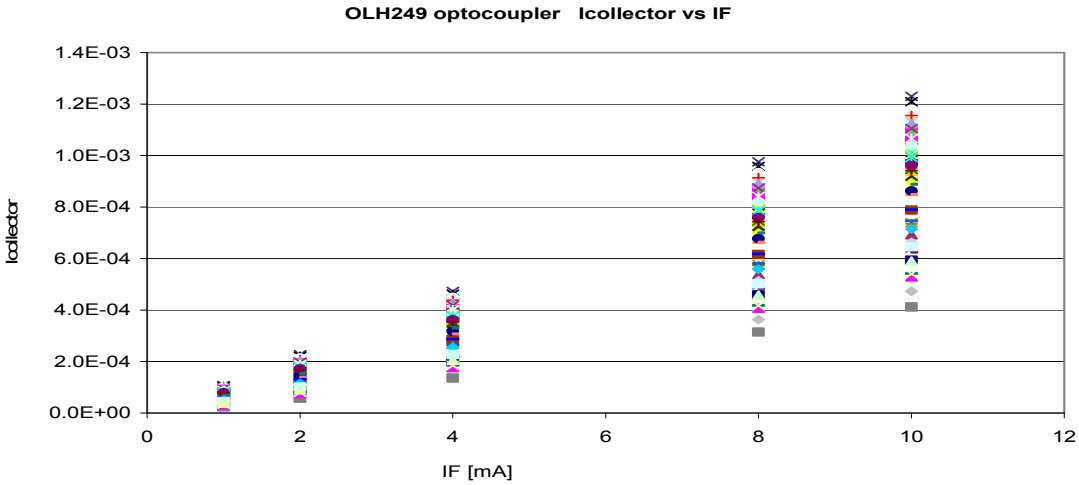


Fig. 13-138: OLH249 optocoupler irradiated: CTR for each step with respect to diode current I_F

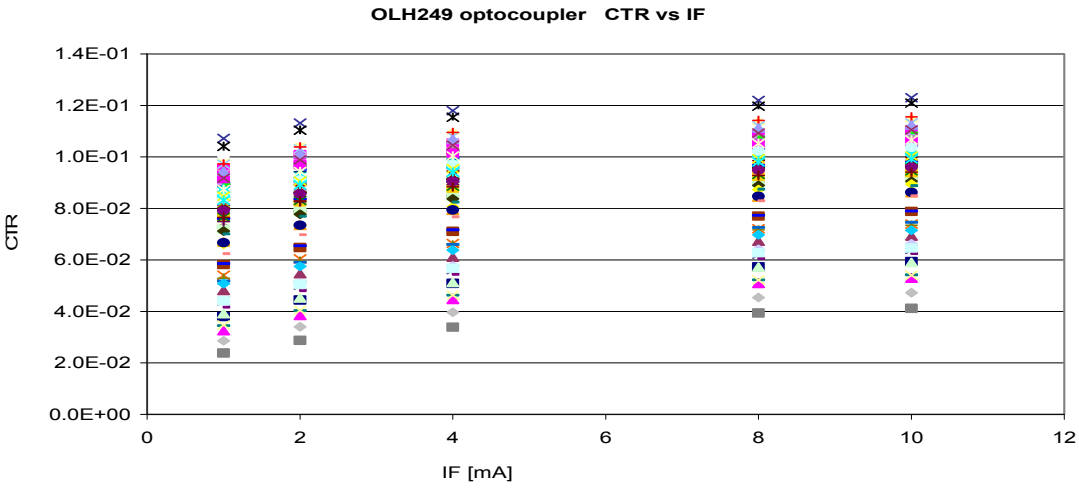


Fig. 13-139: OLH249 optocoupler irradiated: CTR/CTR_0 for each step with respect to diode current I_F

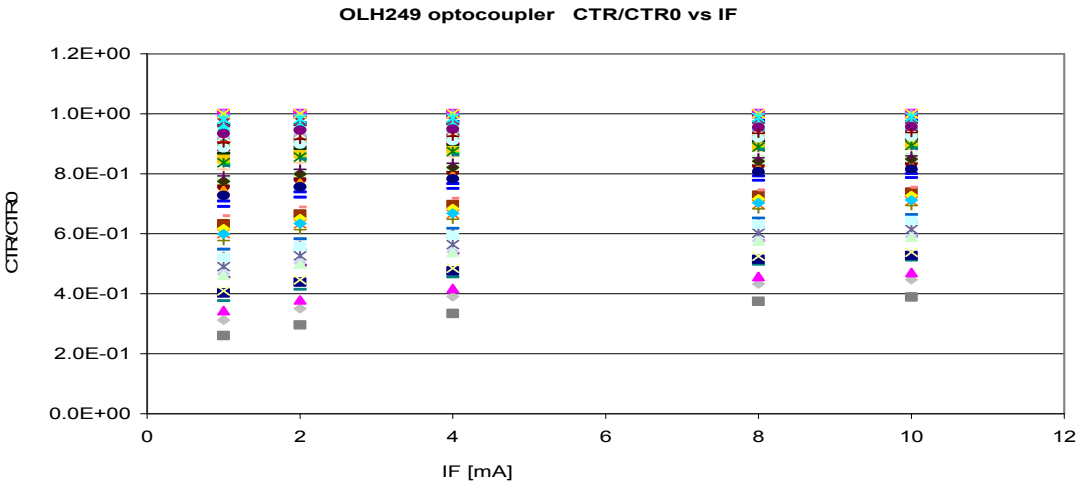


Fig. 13-140: OLH249 diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

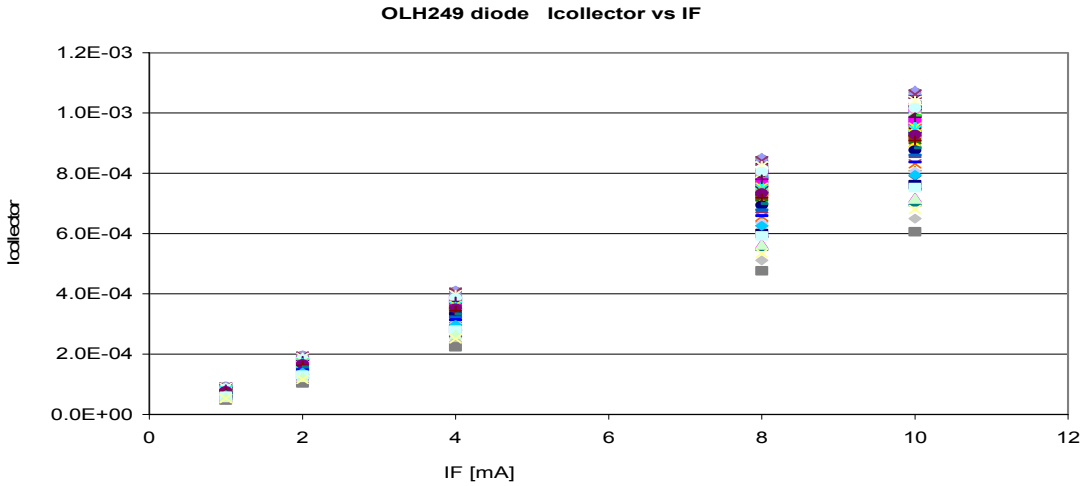


Fig. 13-141: OLH249 diode irradiated: CTR for each step with respect to diode current I_F

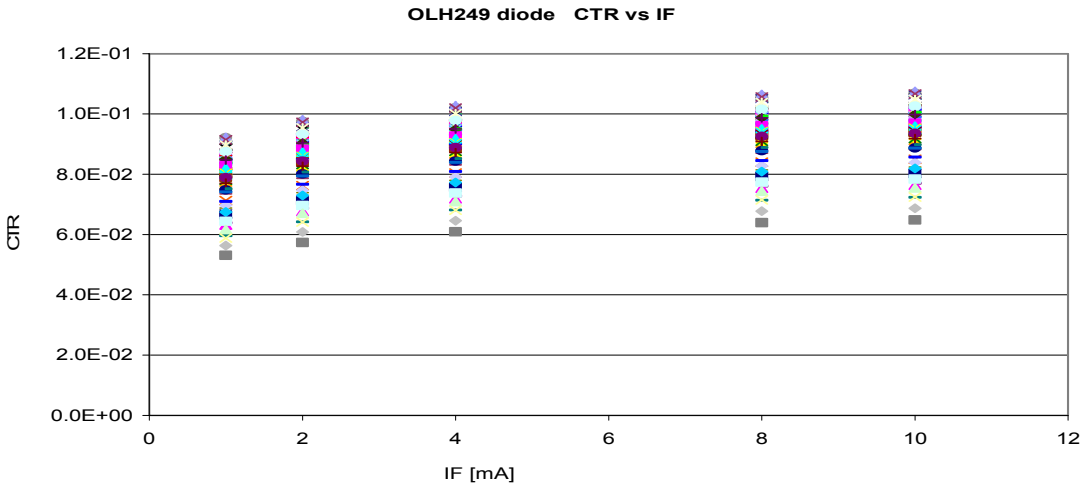


Fig. 13-142: OLH249 diode irradiated: CTR/CTR_0 for each step with respect to diode current I_F

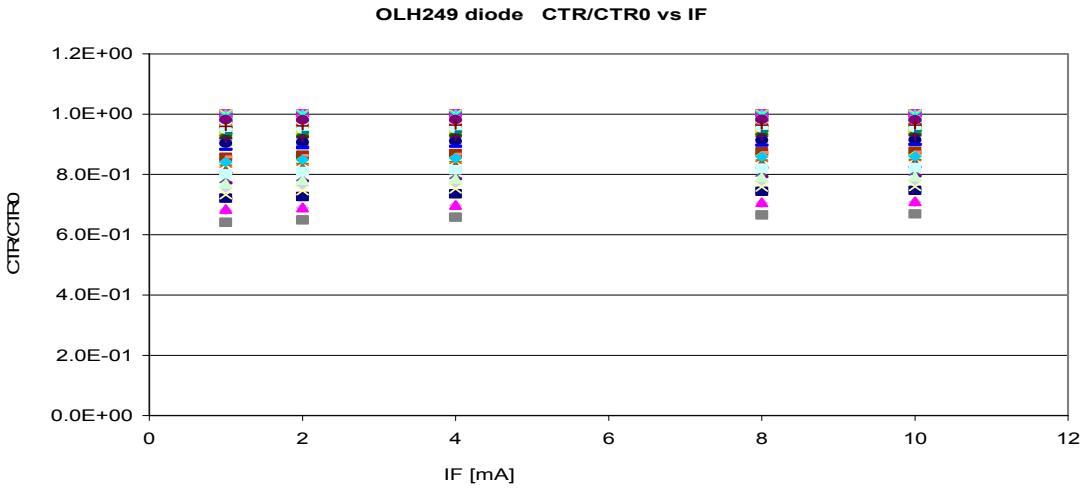


Fig. 13-143: OLH249 transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

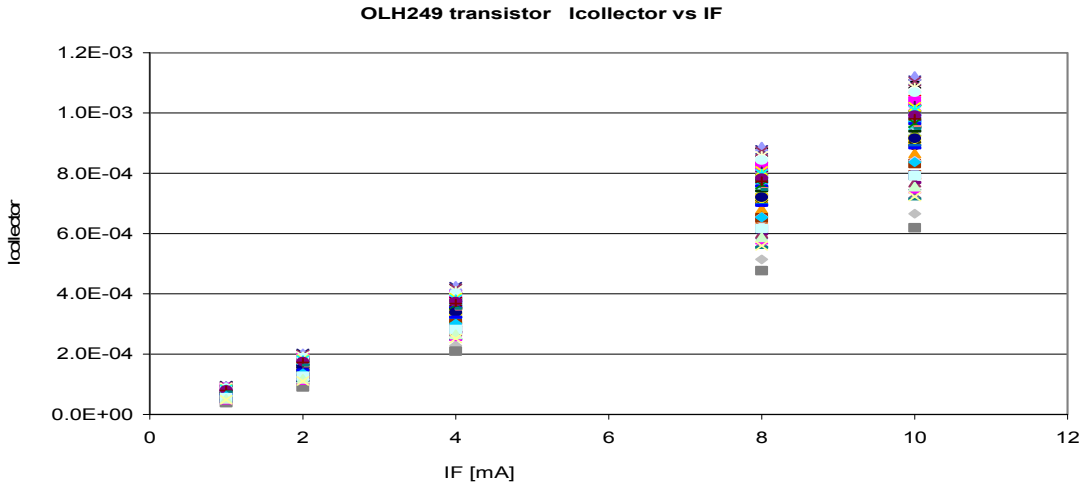


Fig. 13-144: OLH249 transistor irradiated: CTR for each step with respect to diode current I_F

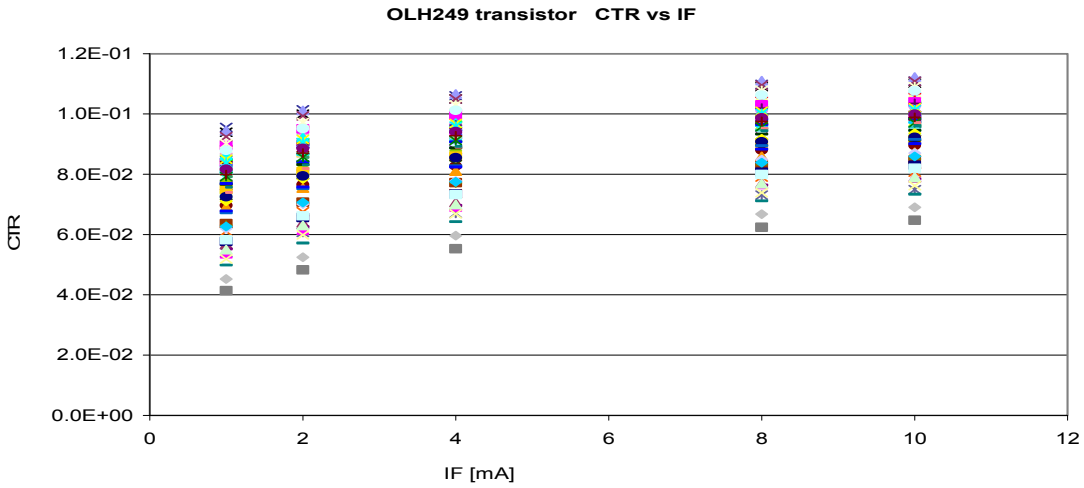


Fig. 13-145: OLH249 transistor irradiated: CTR/CTR_0 for each step with respect to diode current I_F

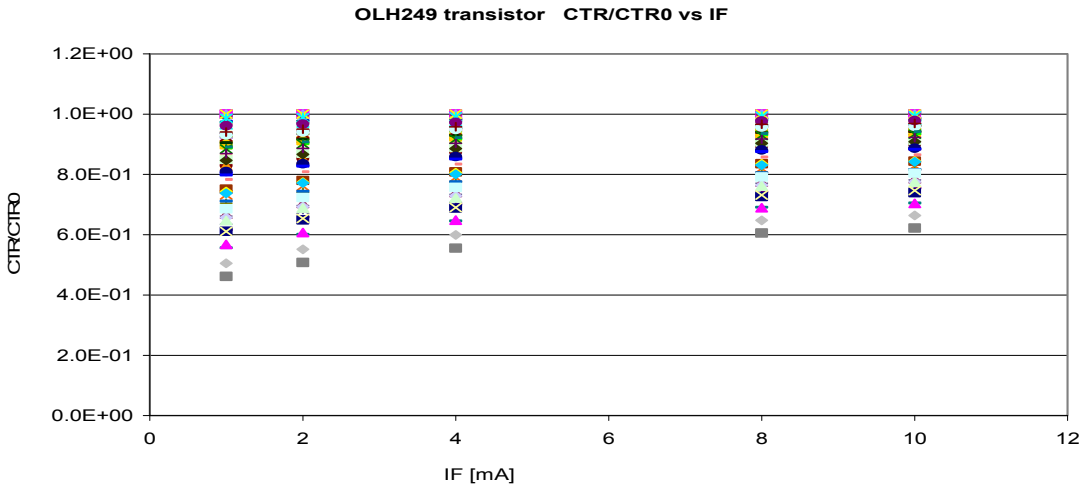


Fig. 13-146: OLH249 reference measurement: transistor collector current I_C for each step with respect to diode current I_F

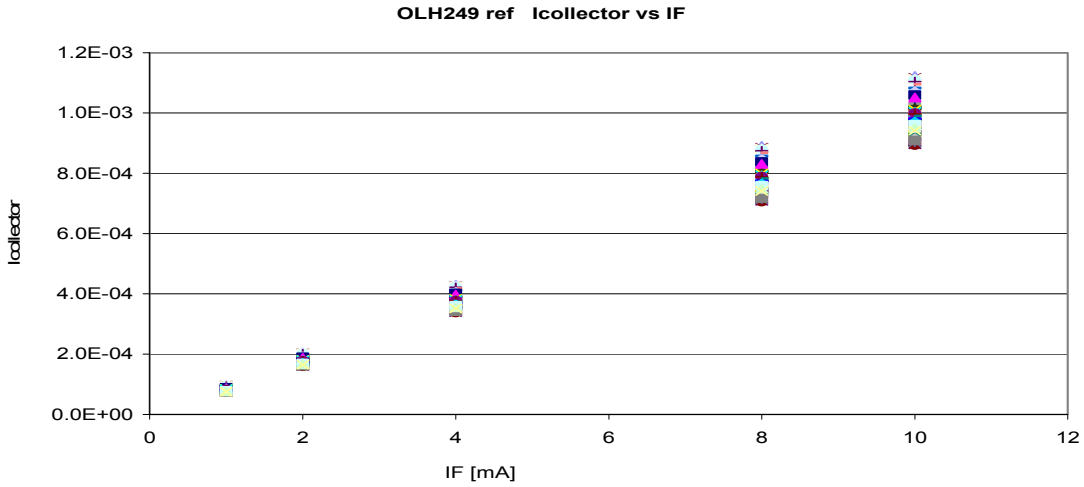


Fig. 13-147: OLH249 reference measurement: CTR for each step with respect to diode current I_F

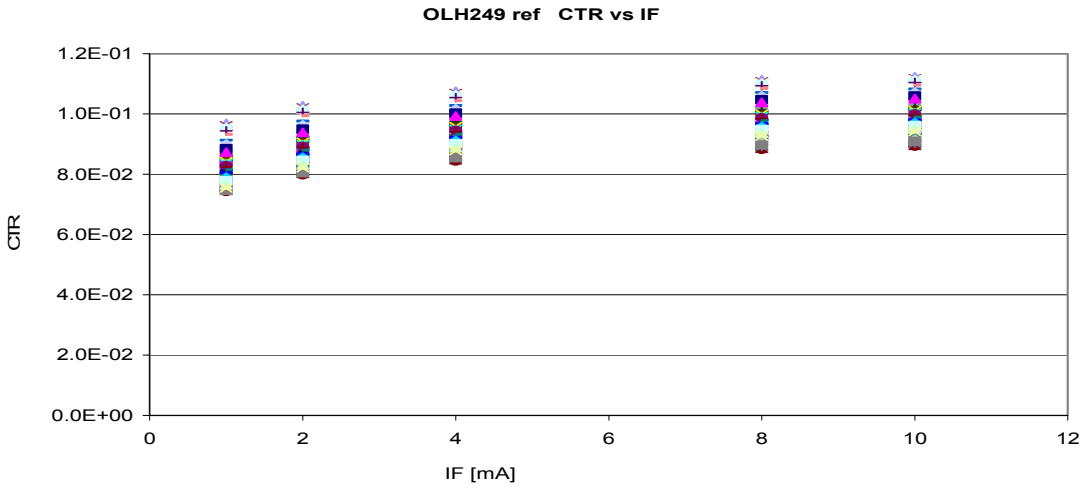


Fig. 13-148: OLH249 reference measurement: CTR/CTR_0 for each step with respect to diode current I_F

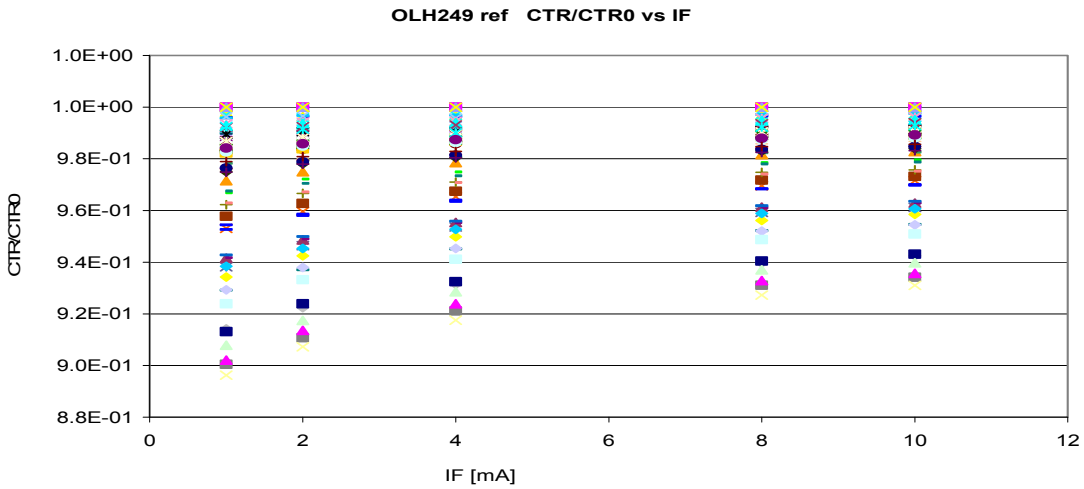
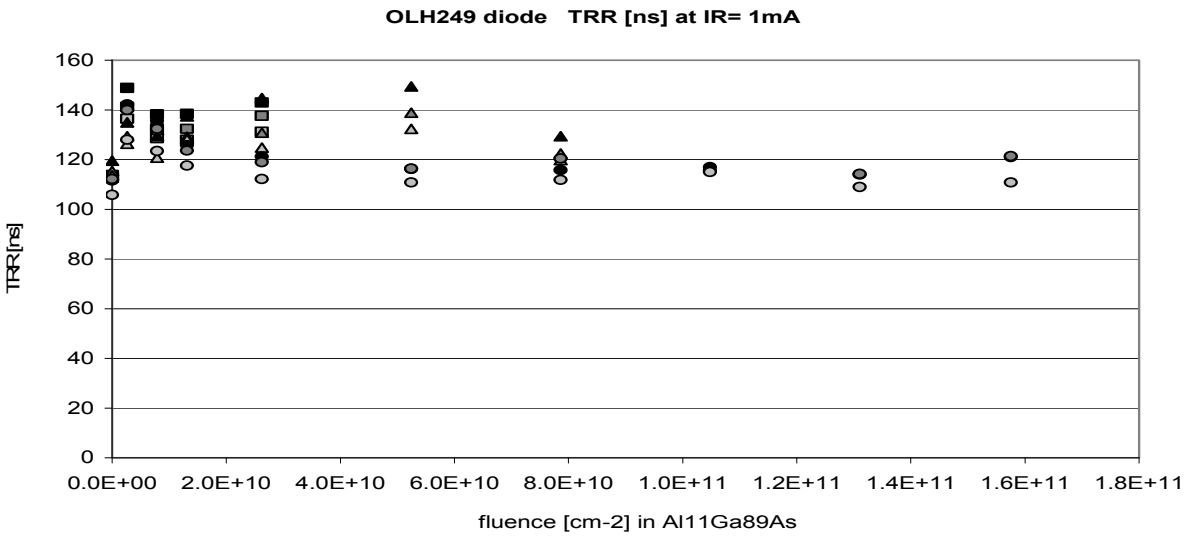
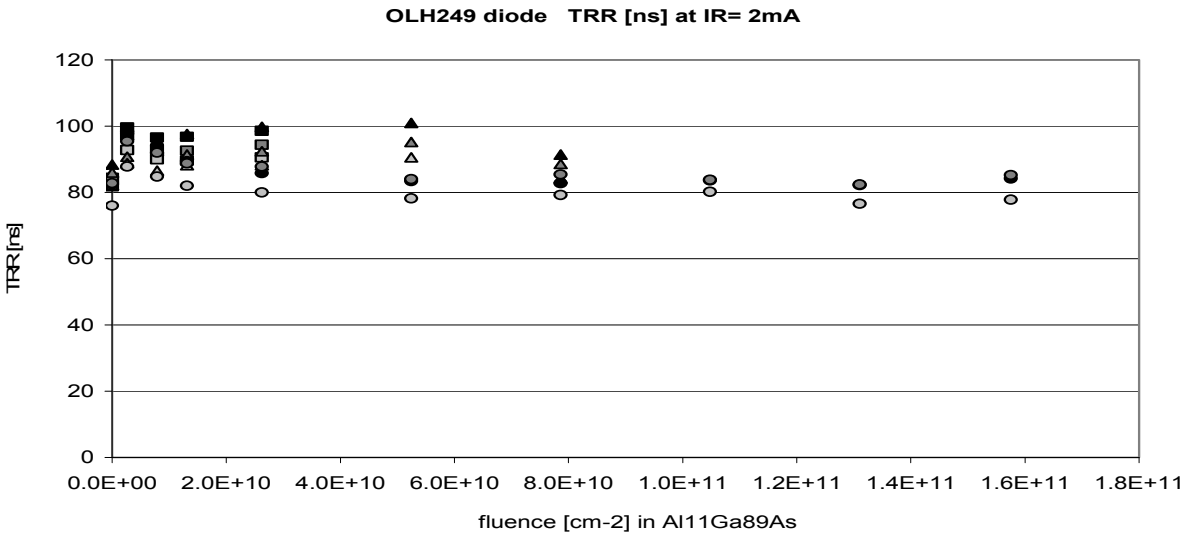


Fig. 13-149: OLH249 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA





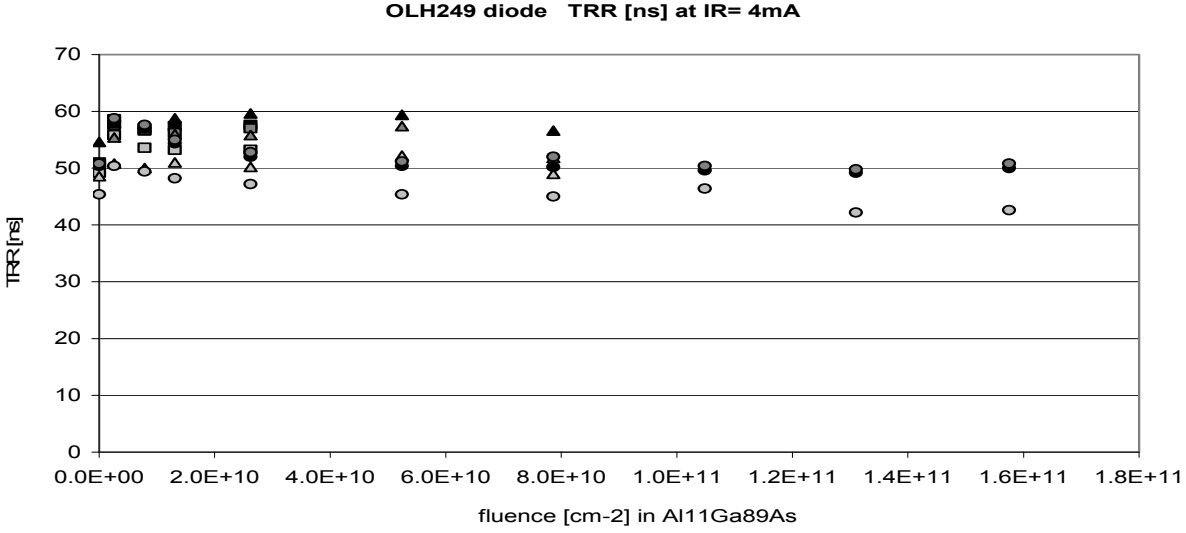
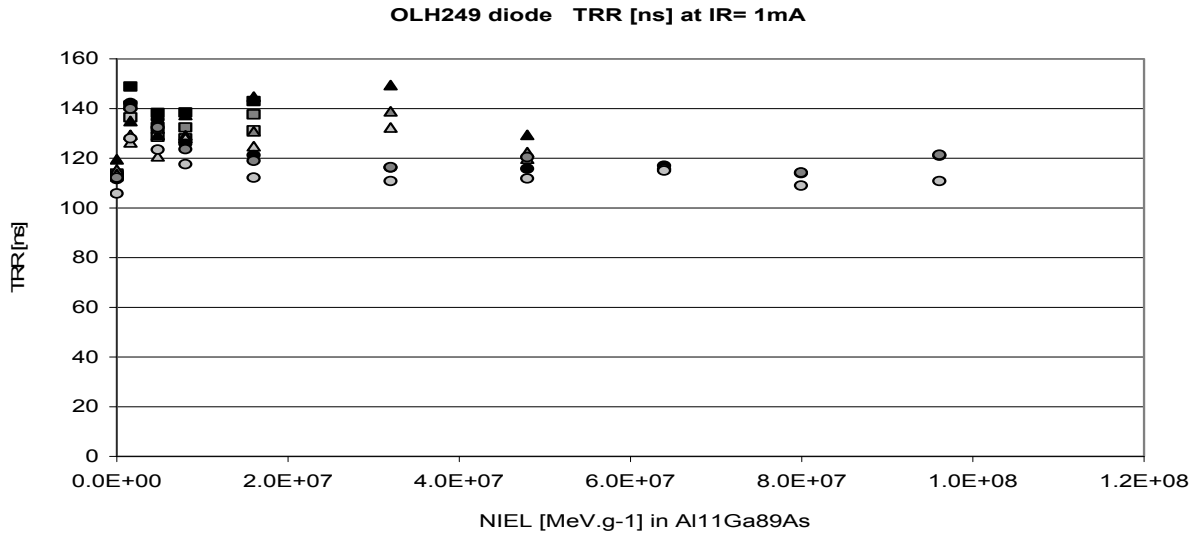
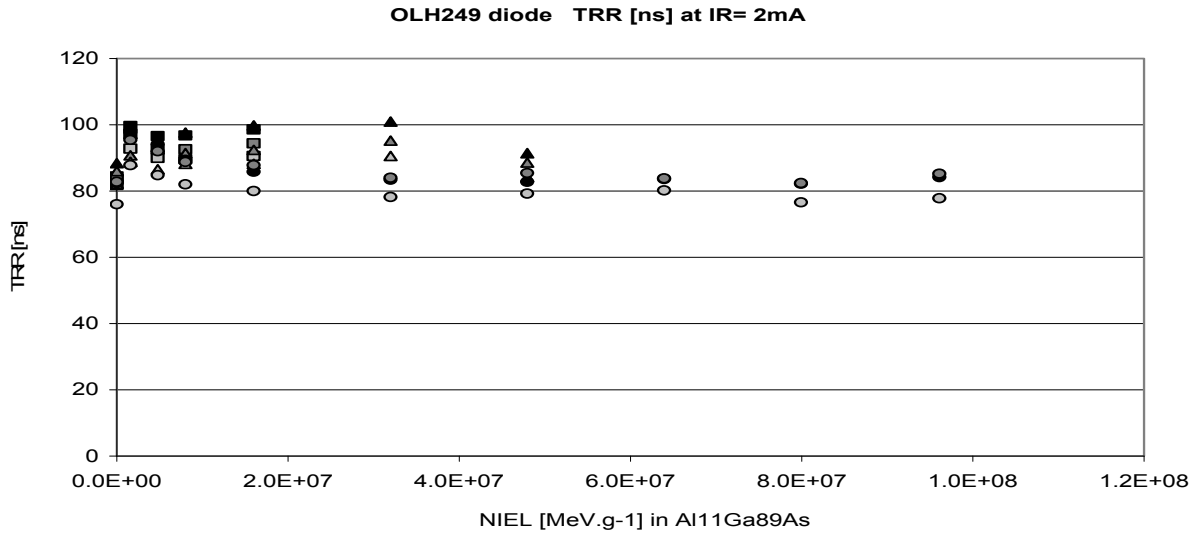


Fig. 13-150: OLH249 diode: τ_{RR} [ns] with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





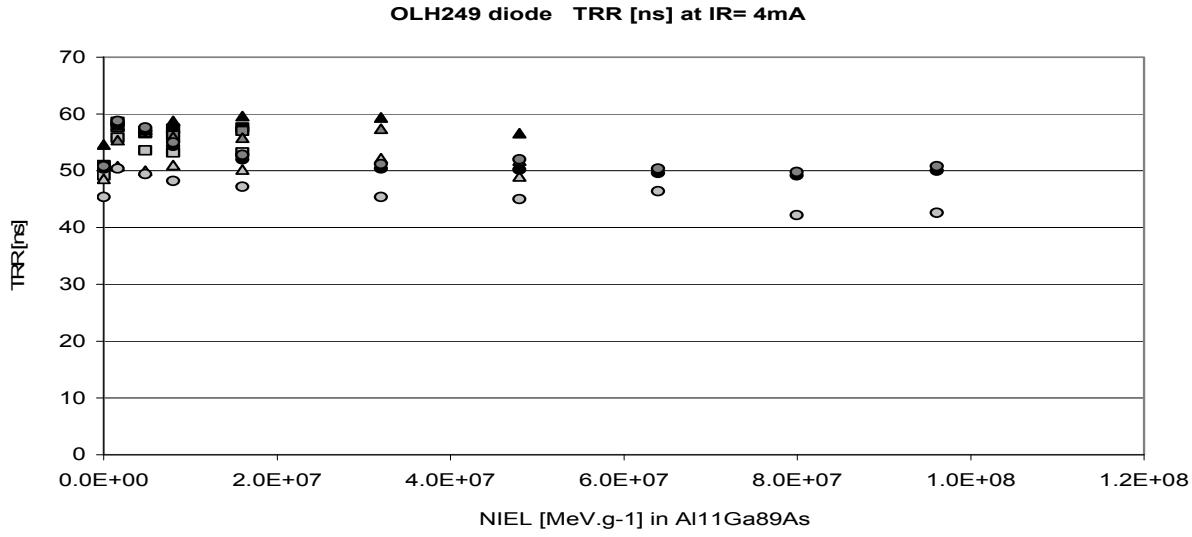
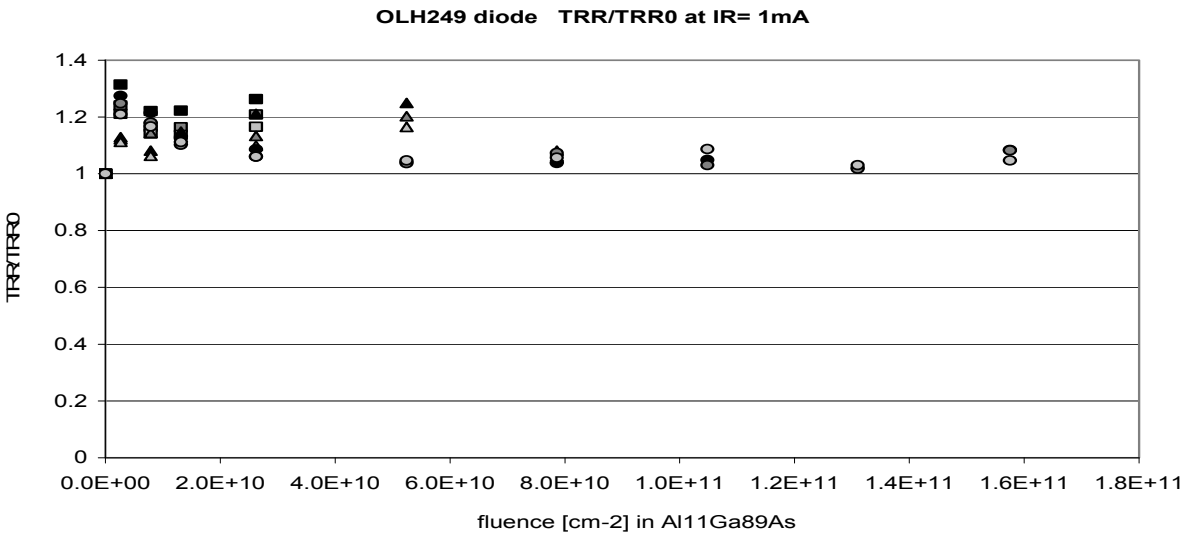
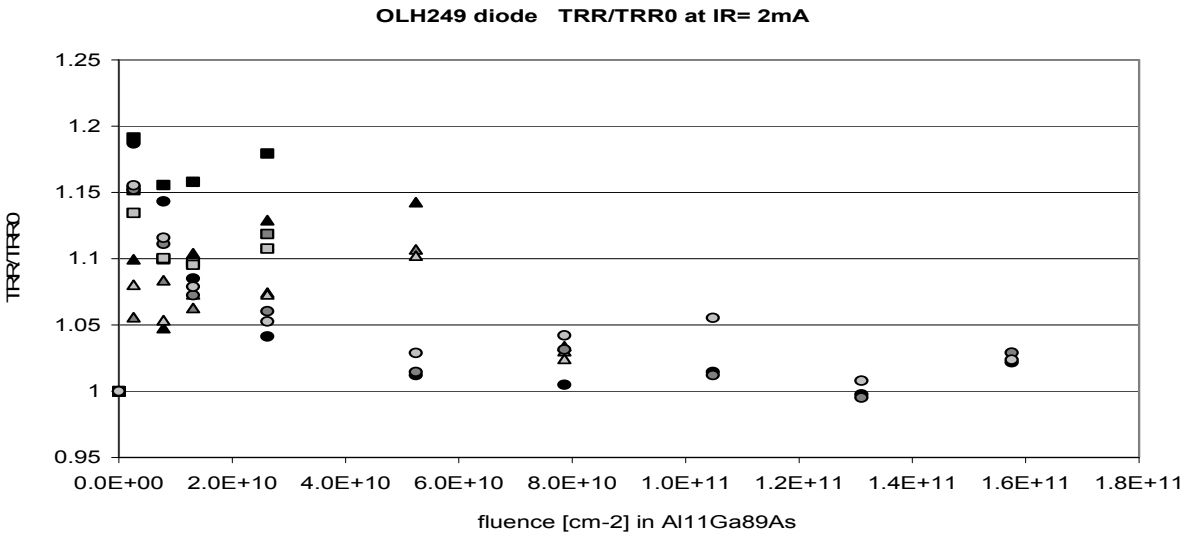


Fig. 13-151: OLH249 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA





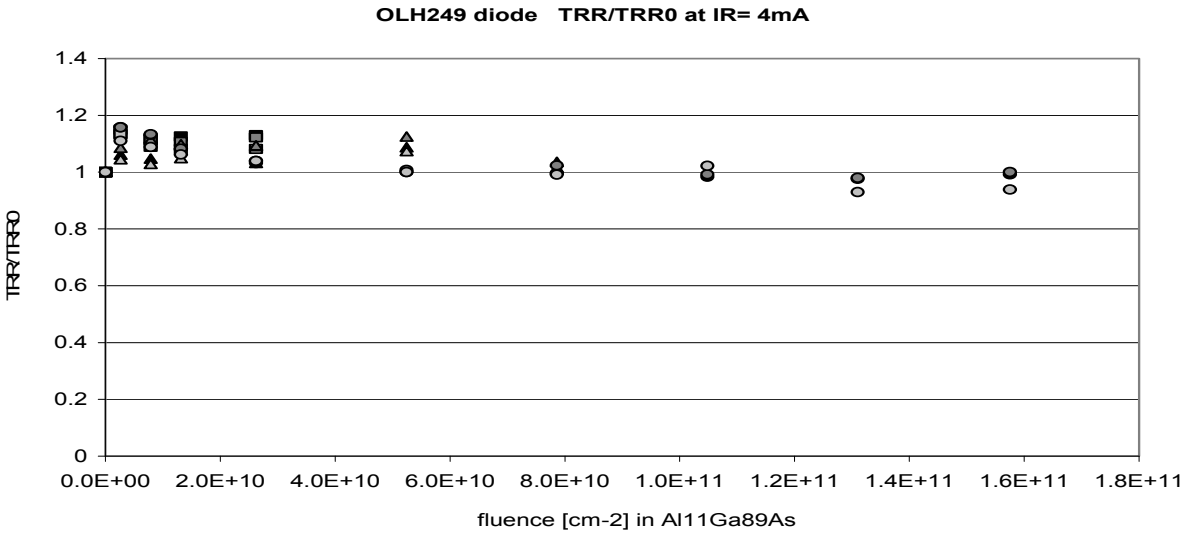
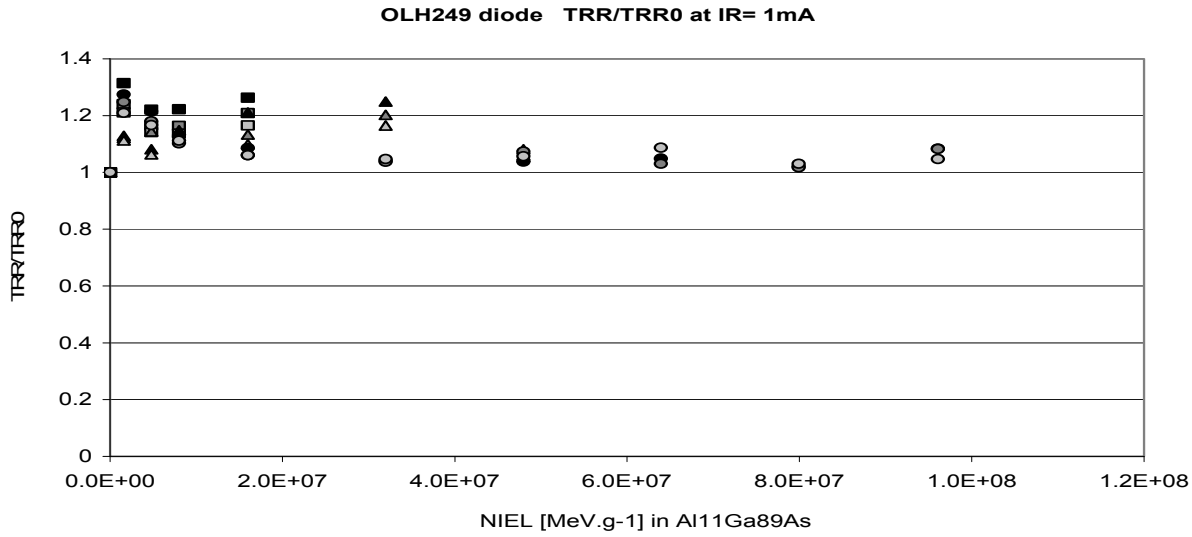
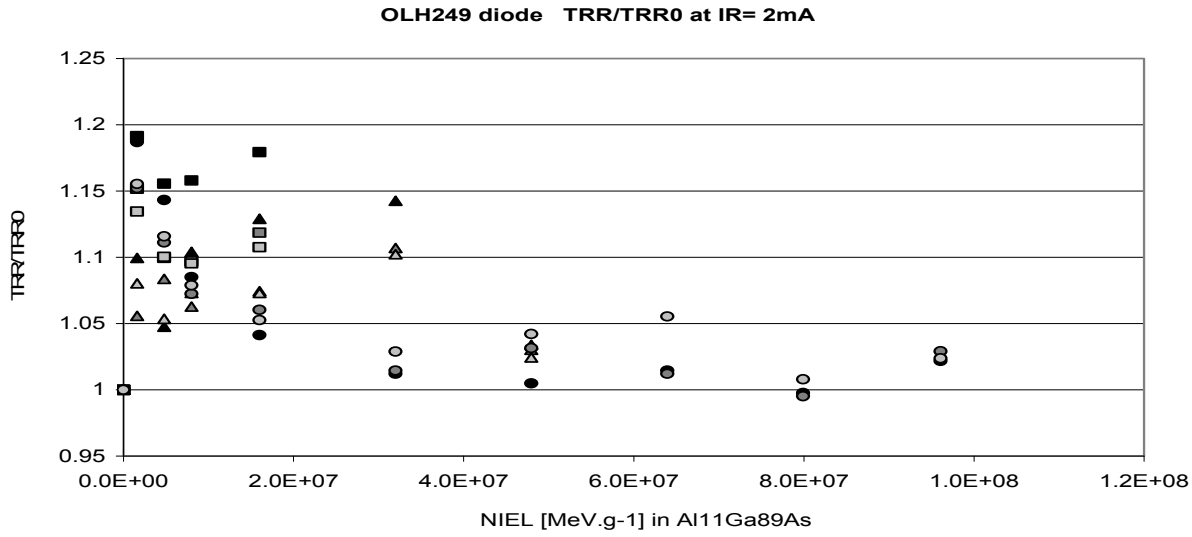


Fig. 13-152: OLH249 diode: τ_{RR}/τ_{RR0} with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





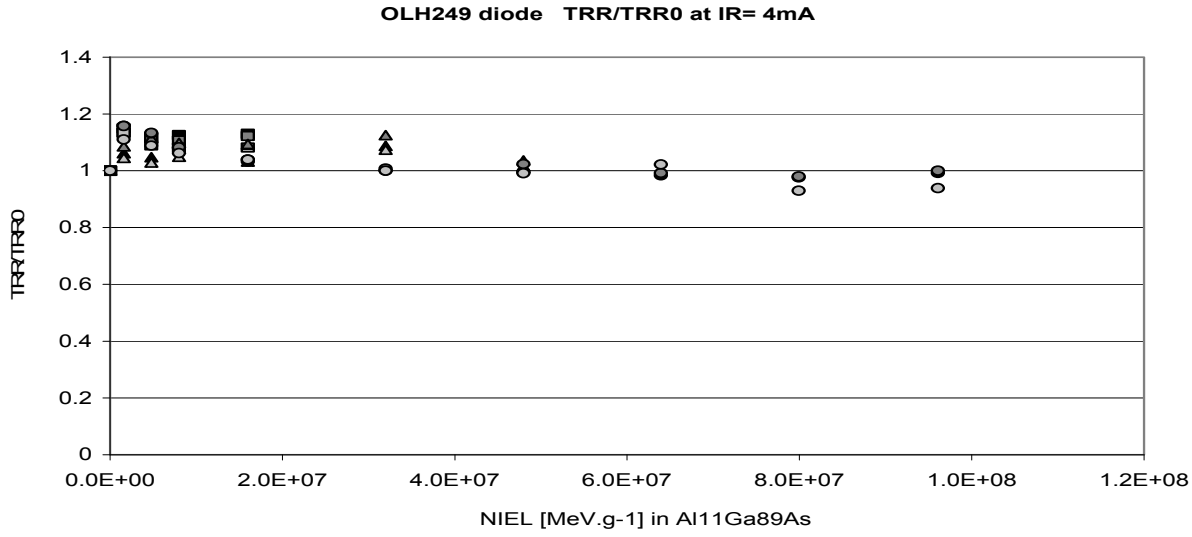
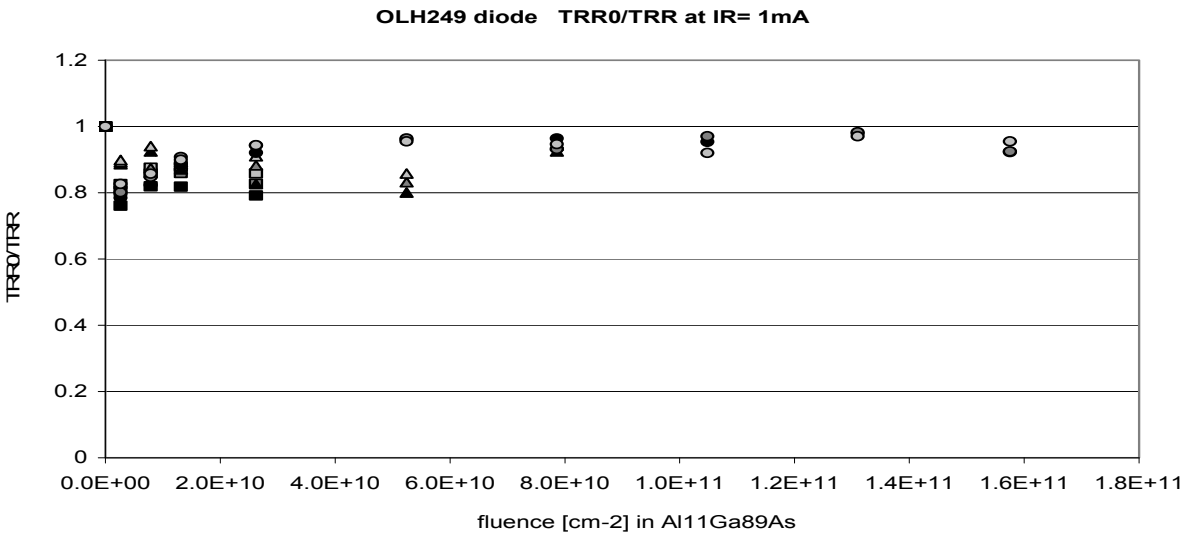
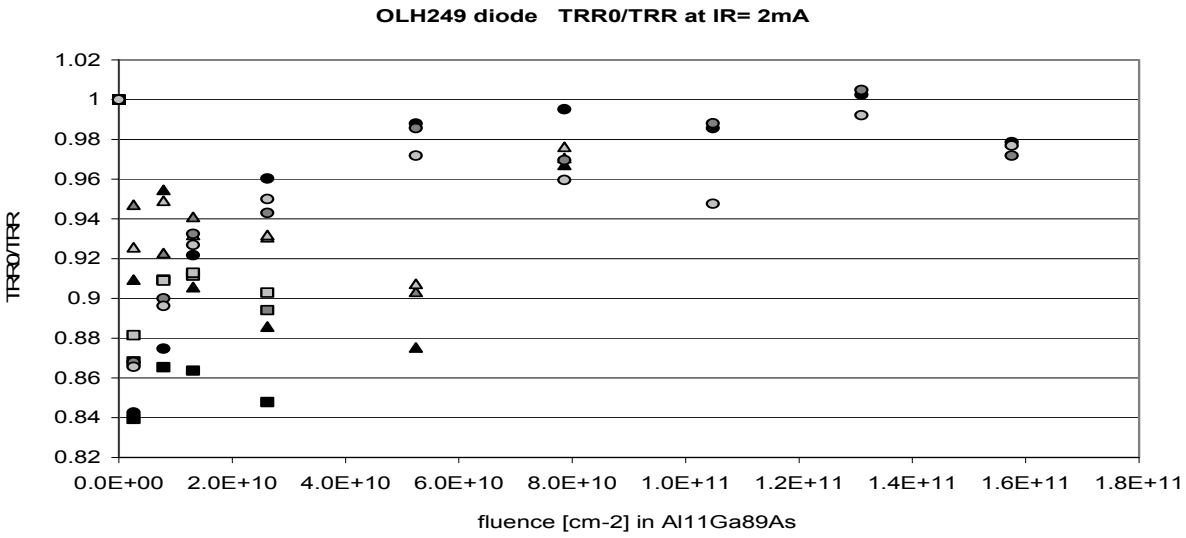


Fig. 13-153: OLH249 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





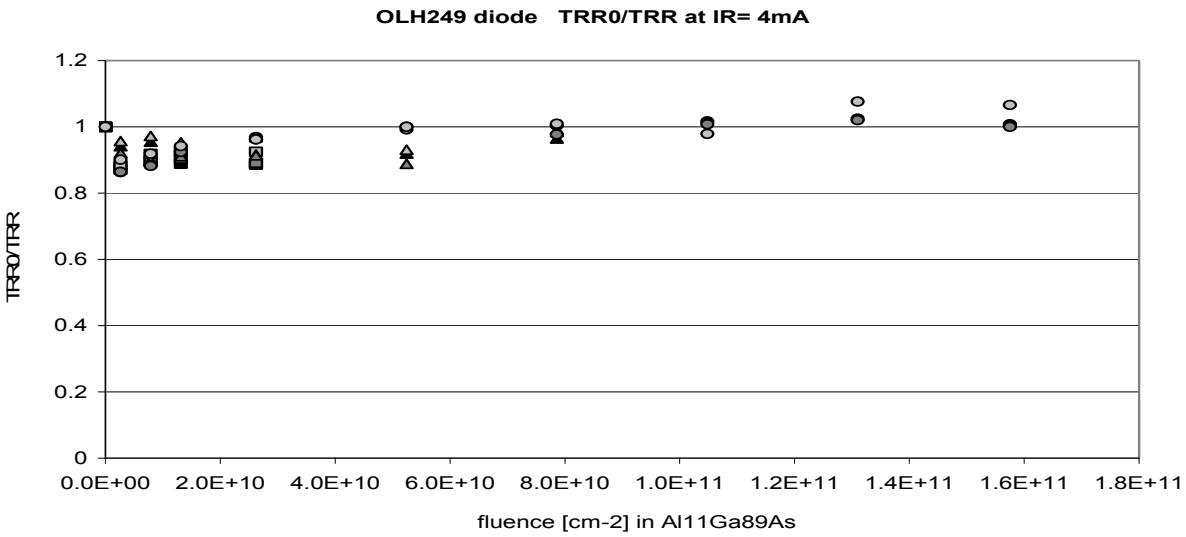
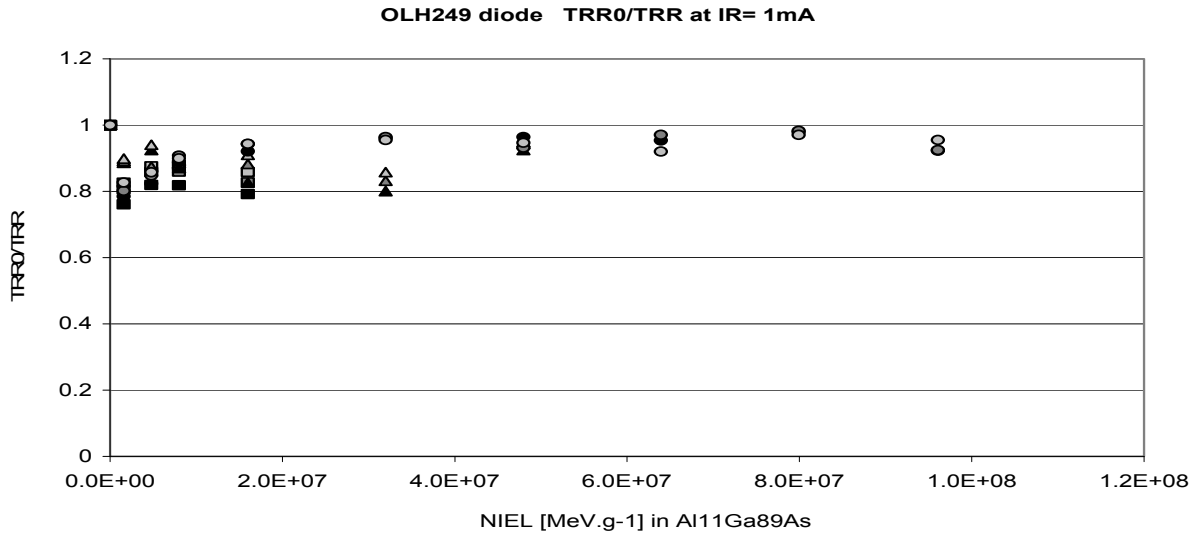
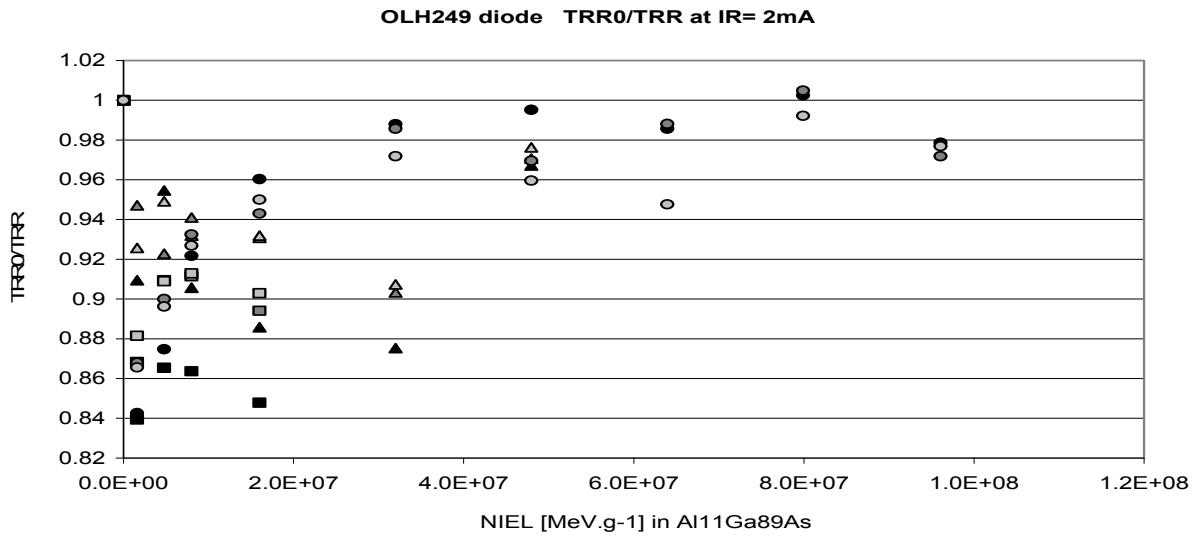


Fig. 13-154: OLH249 diode: τ_{RR0}/τ_{RR} with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





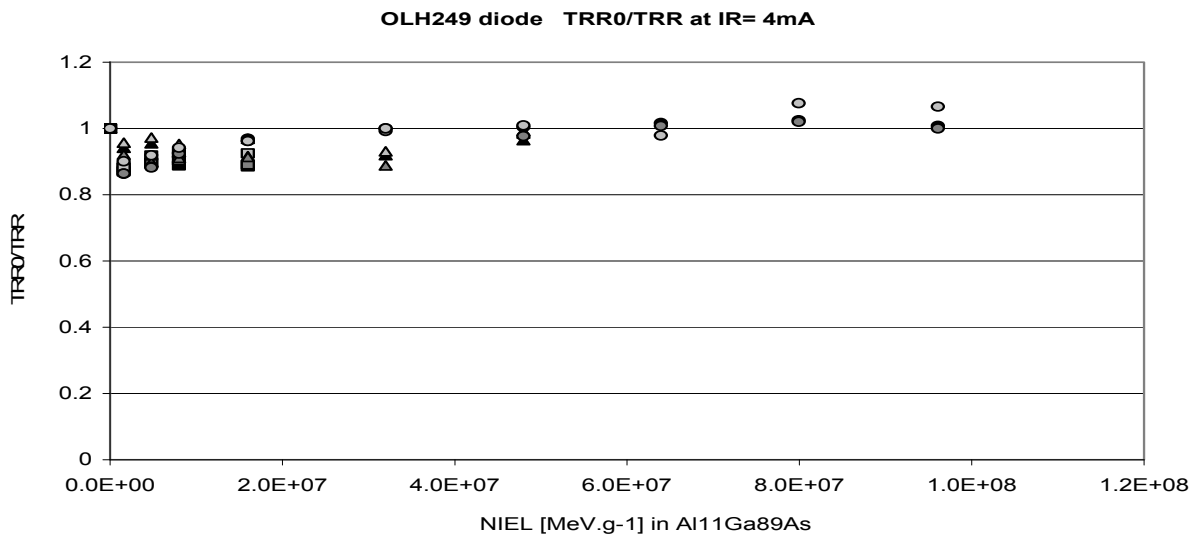
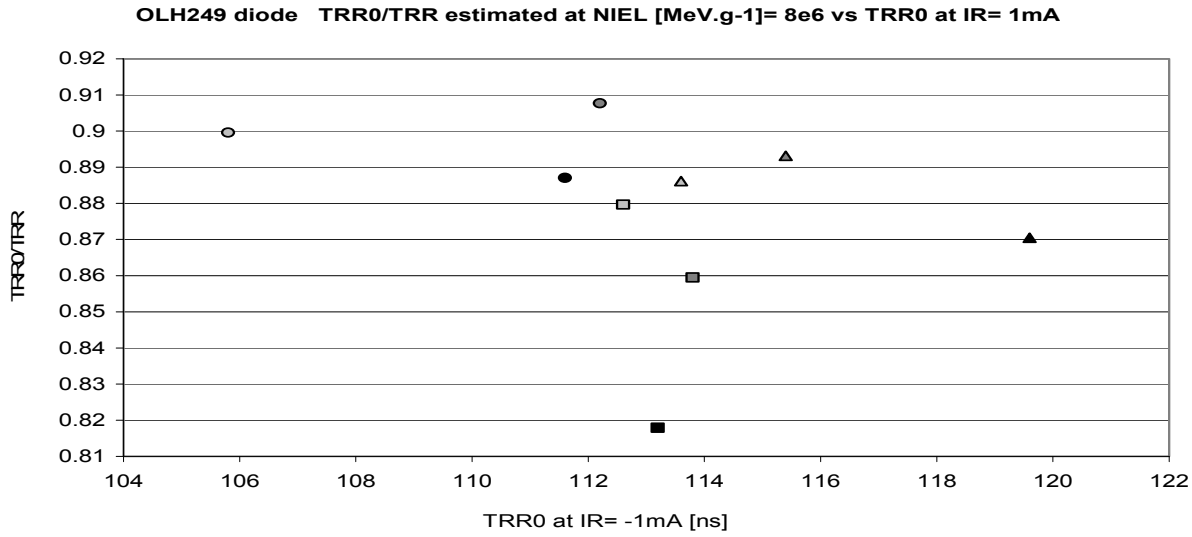
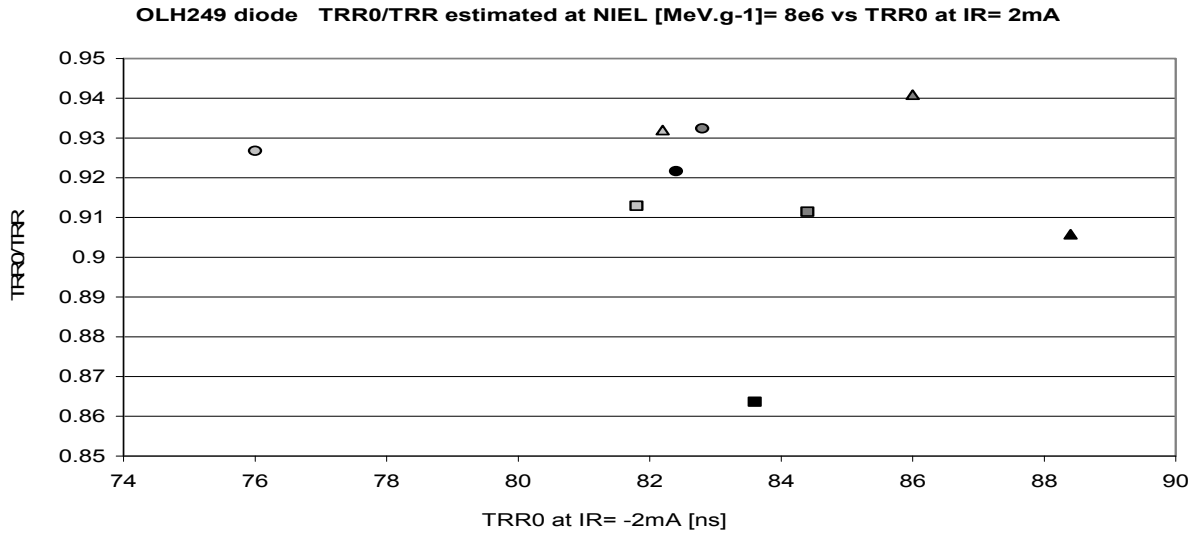


Fig. 13-155: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





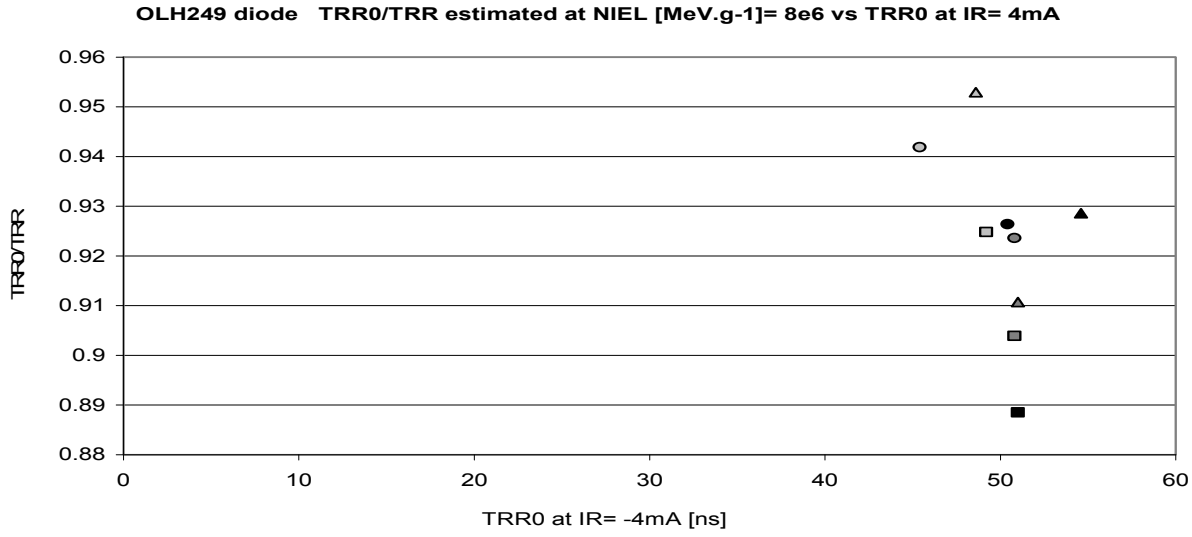
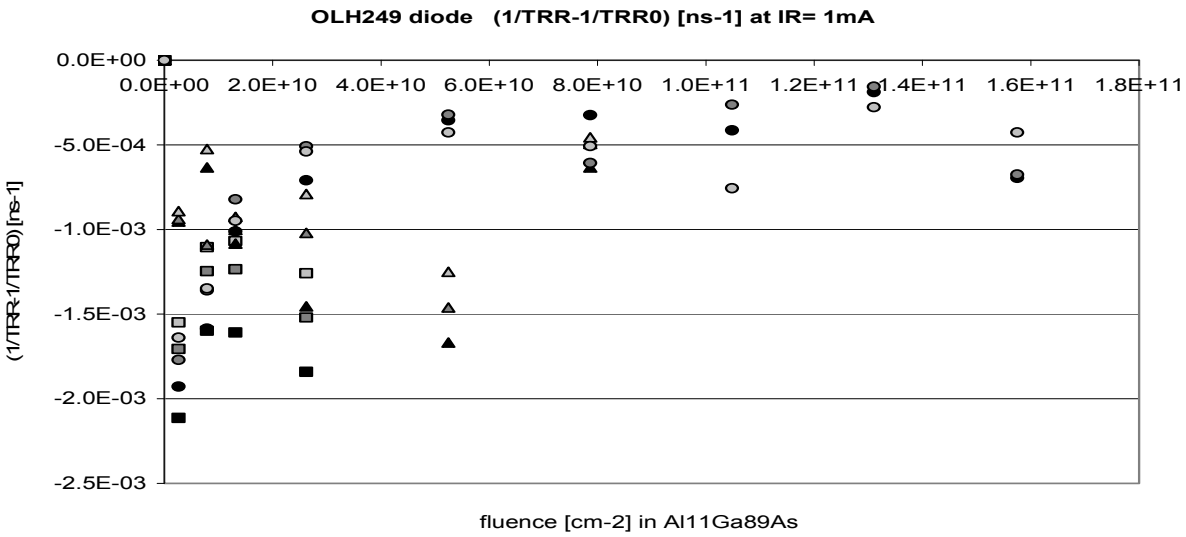
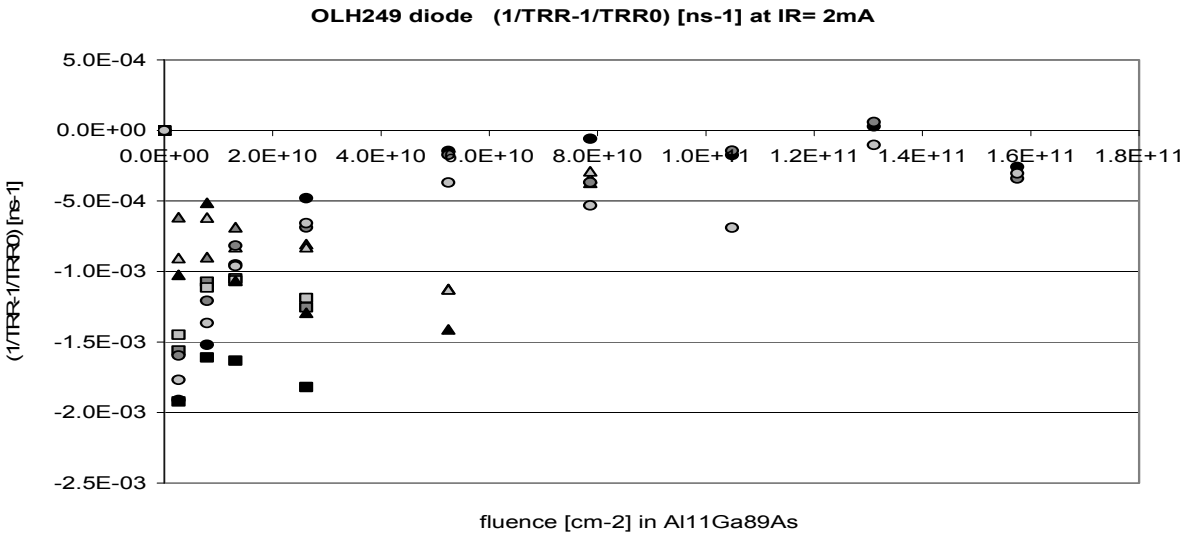


Fig. 13-156: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence





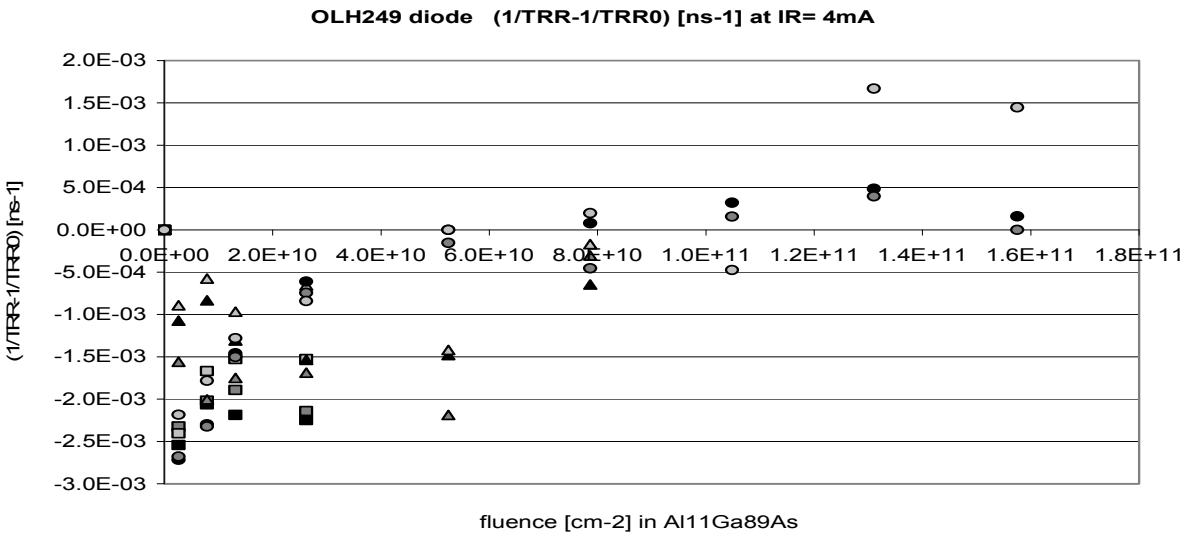
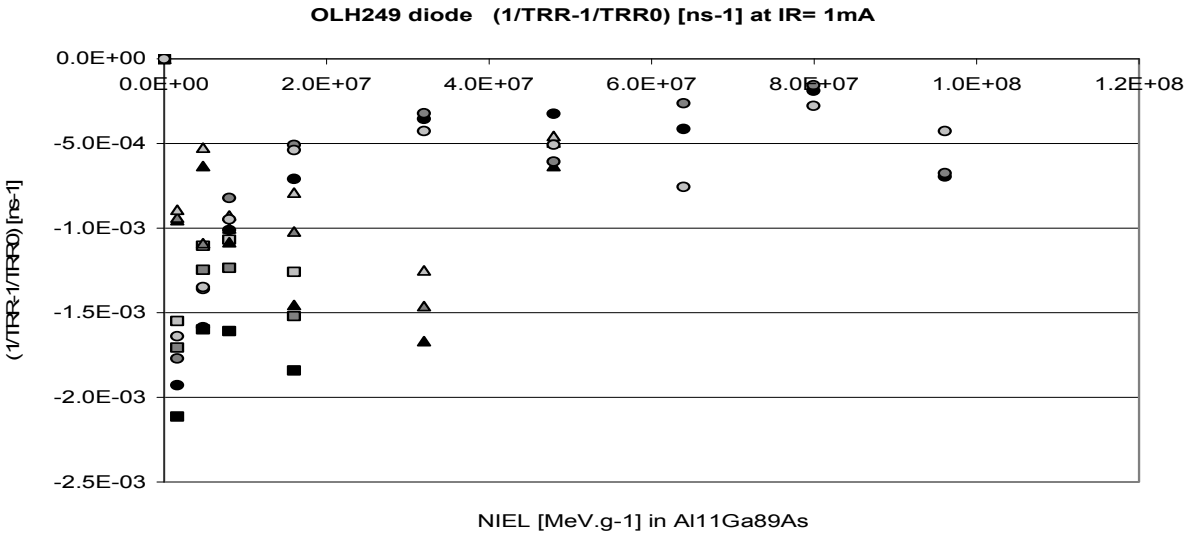
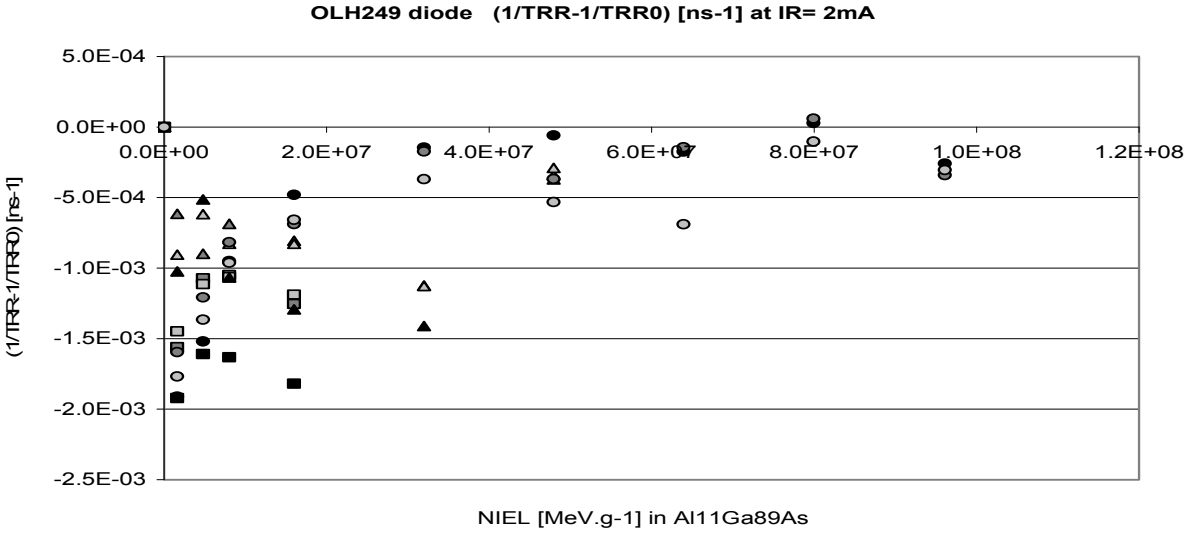


Fig. 13-157: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL in $Al_{0.11}Ga_{0.89}As$ (GEANT4 TOTAL)





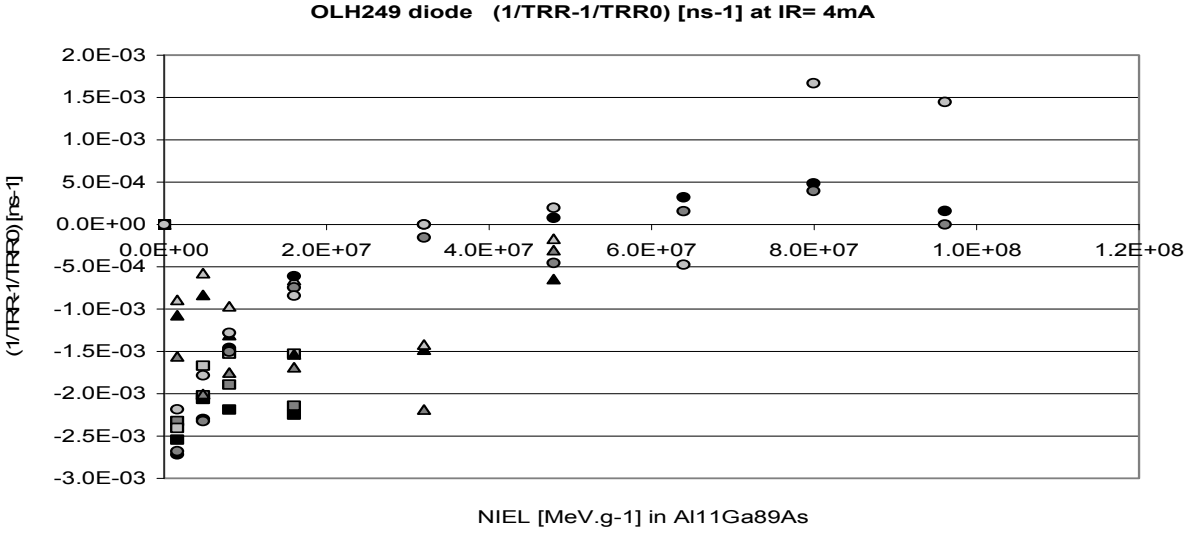


Fig. 13-158: OLH249 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}

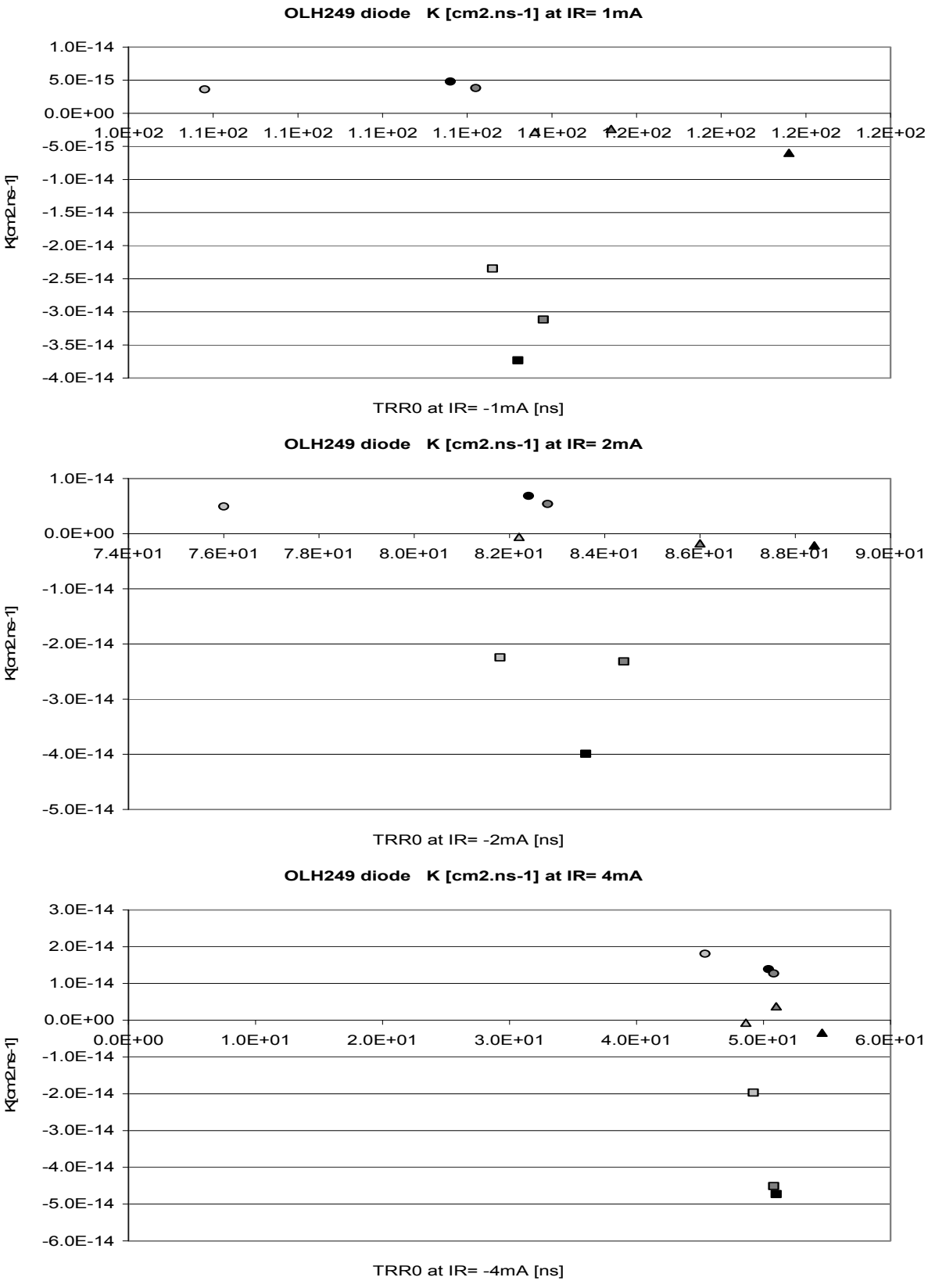
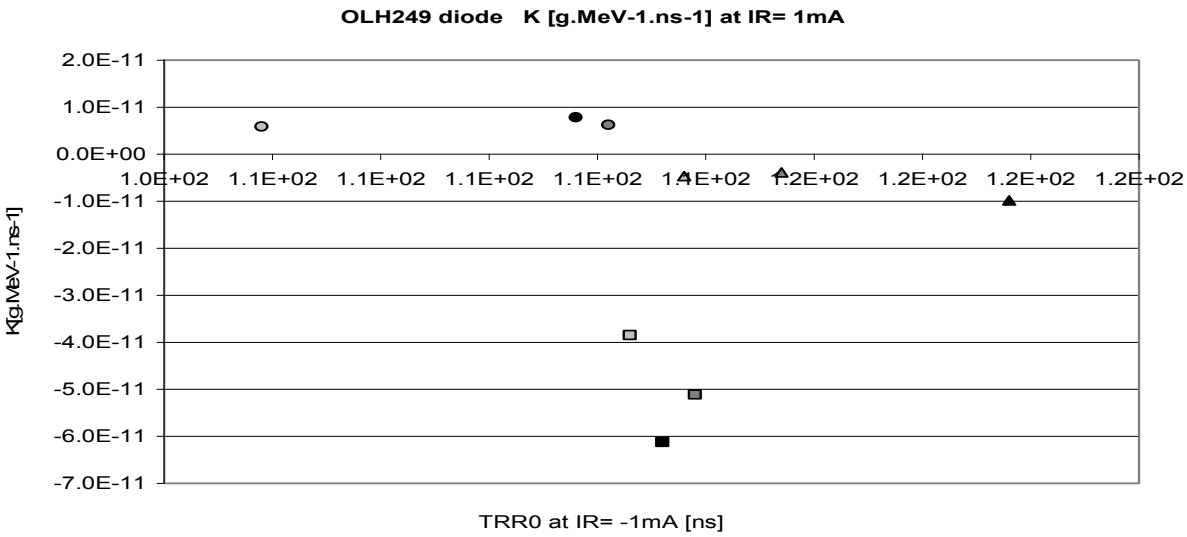
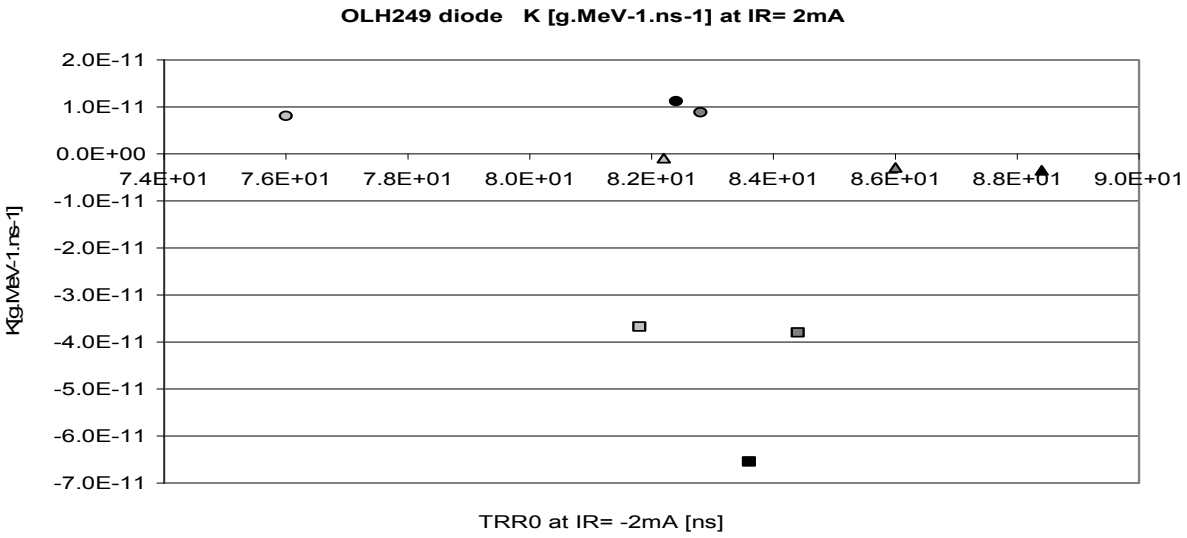


Fig. 13-159: OLH249 diode: K_{NIEL} at I_R = -1, -2, -4mA with respect to τ_{RR0}





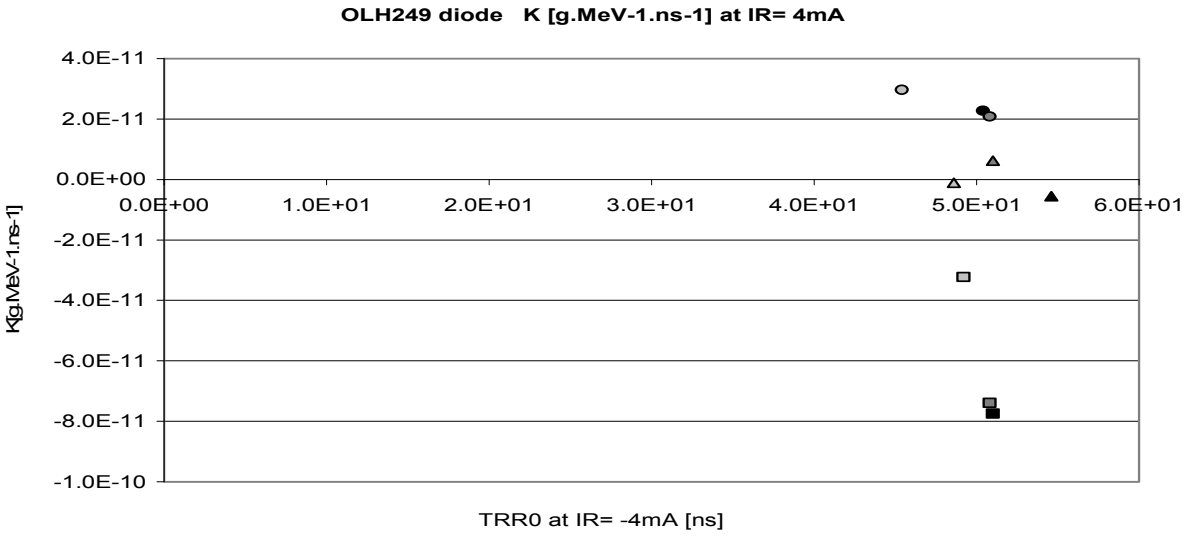
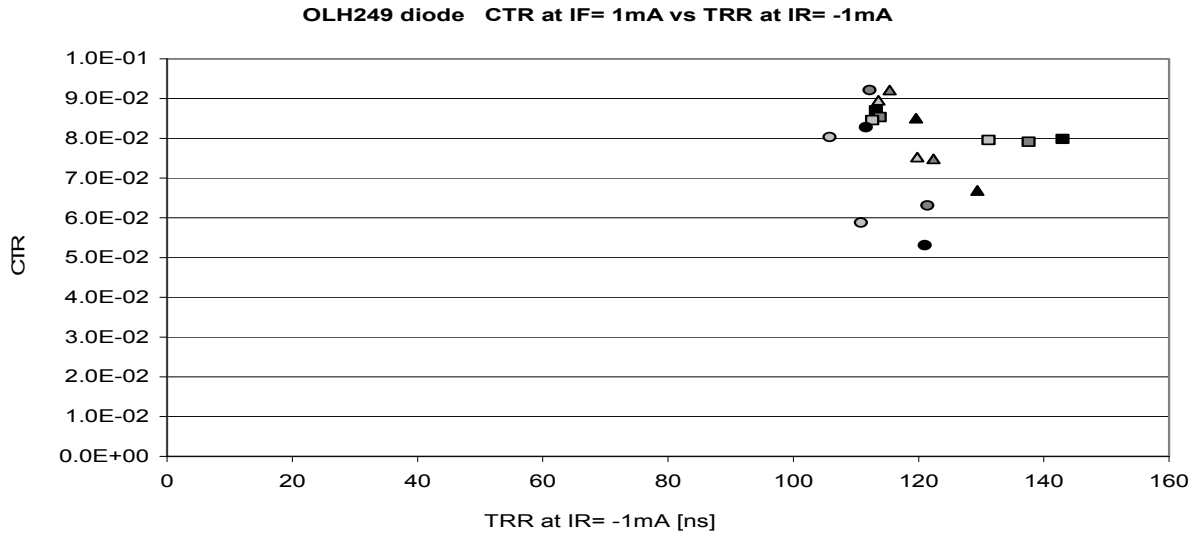
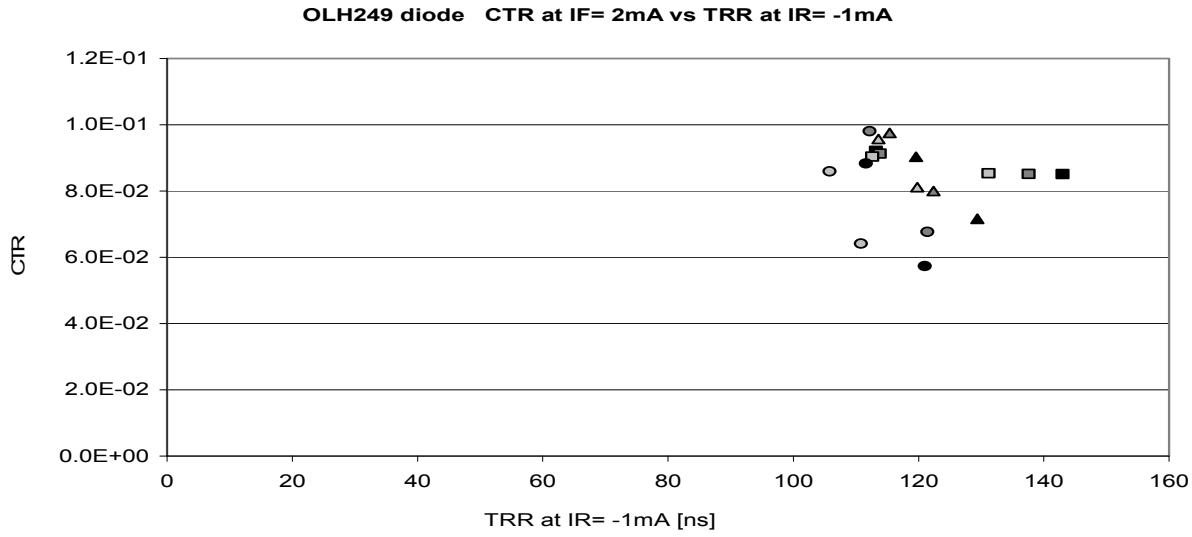
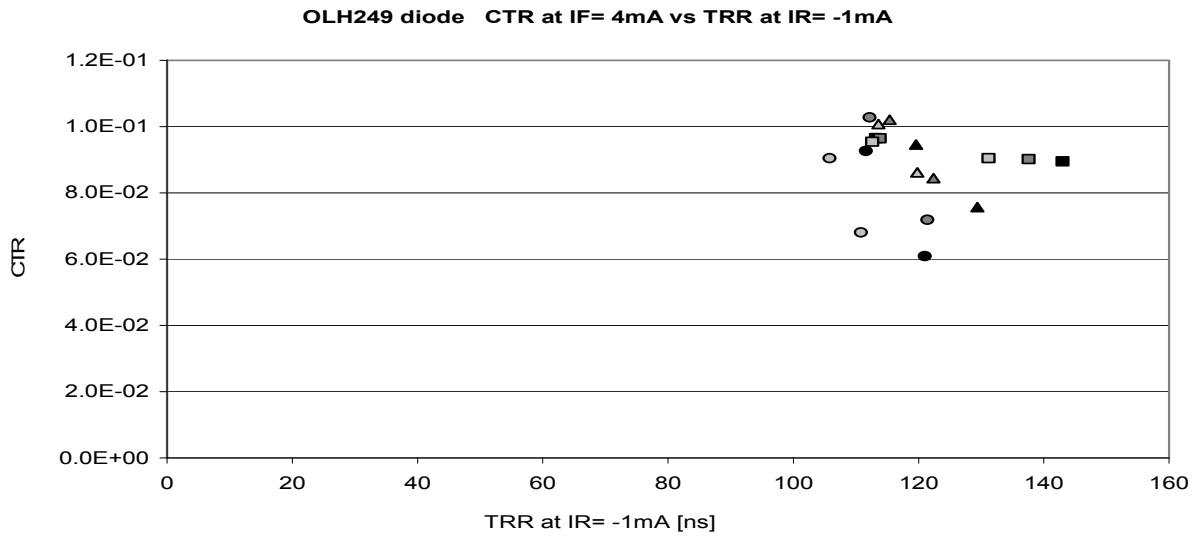
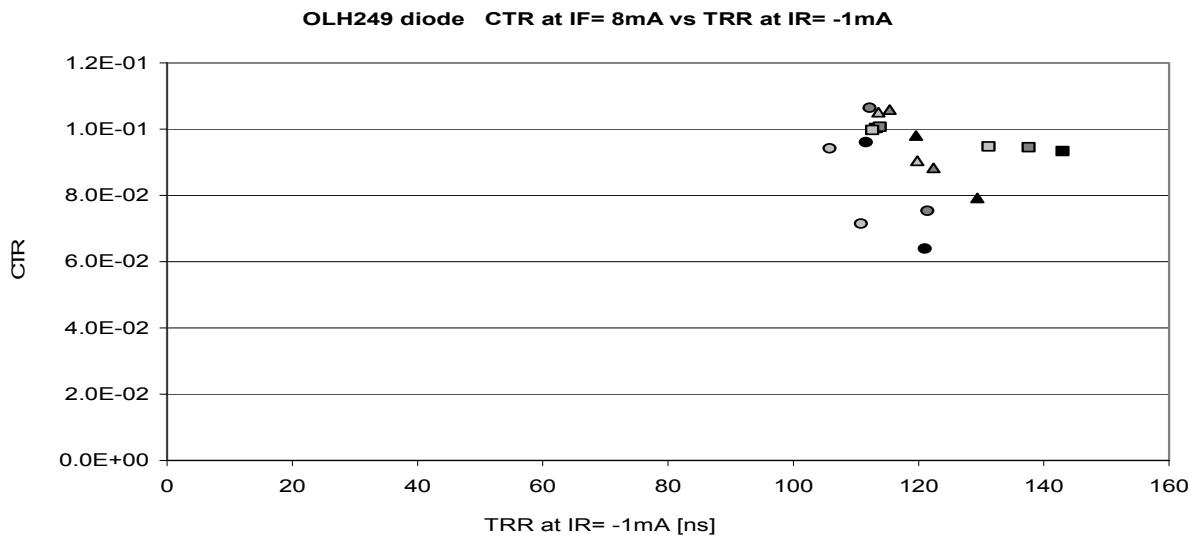


Fig. 13-160: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
140
160
TRR at IR= -1mA [ns]

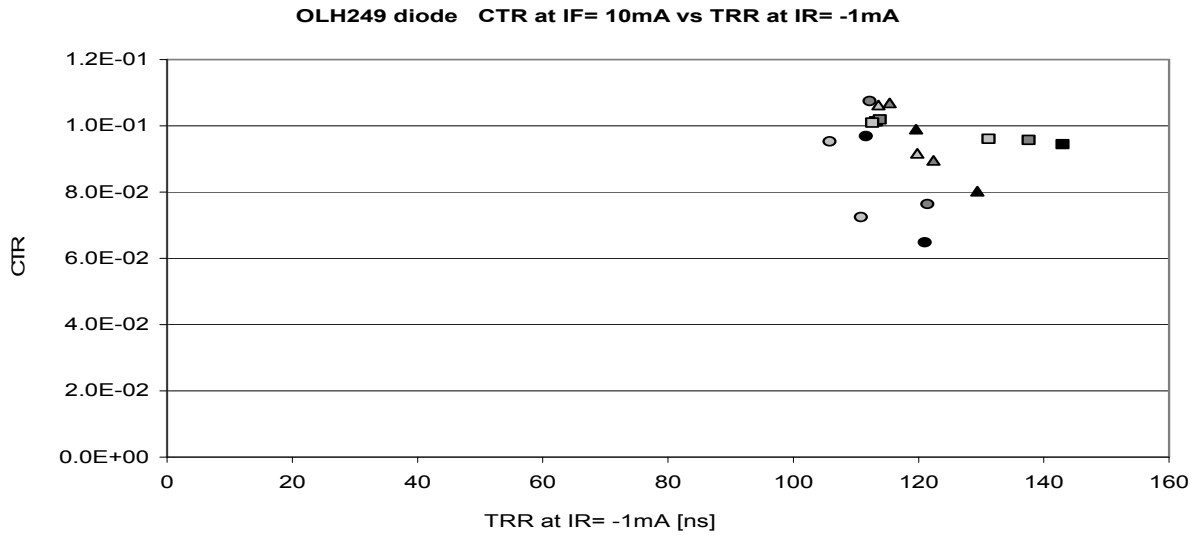
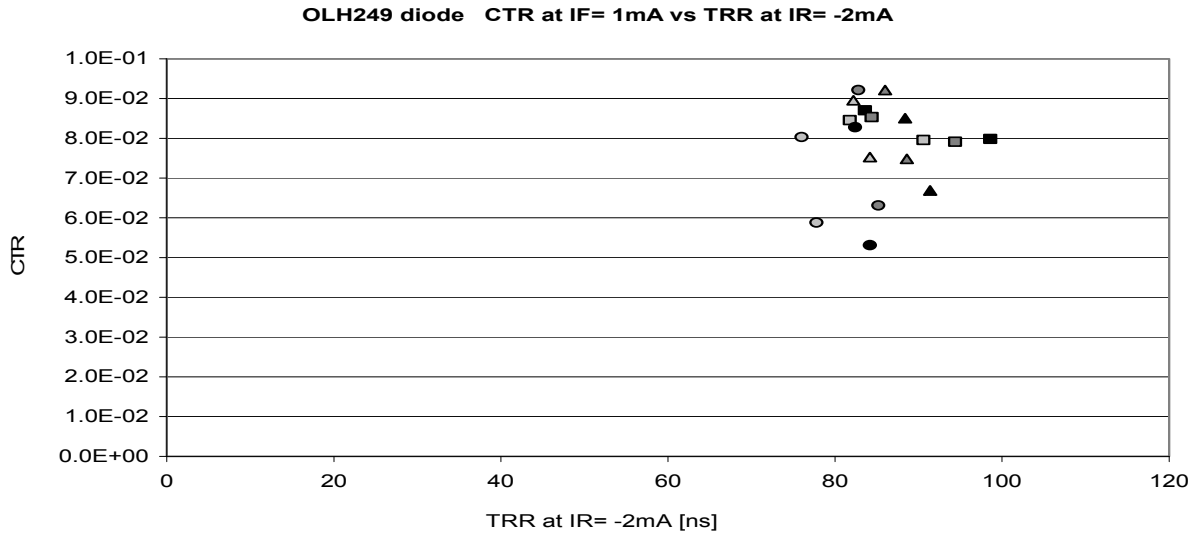
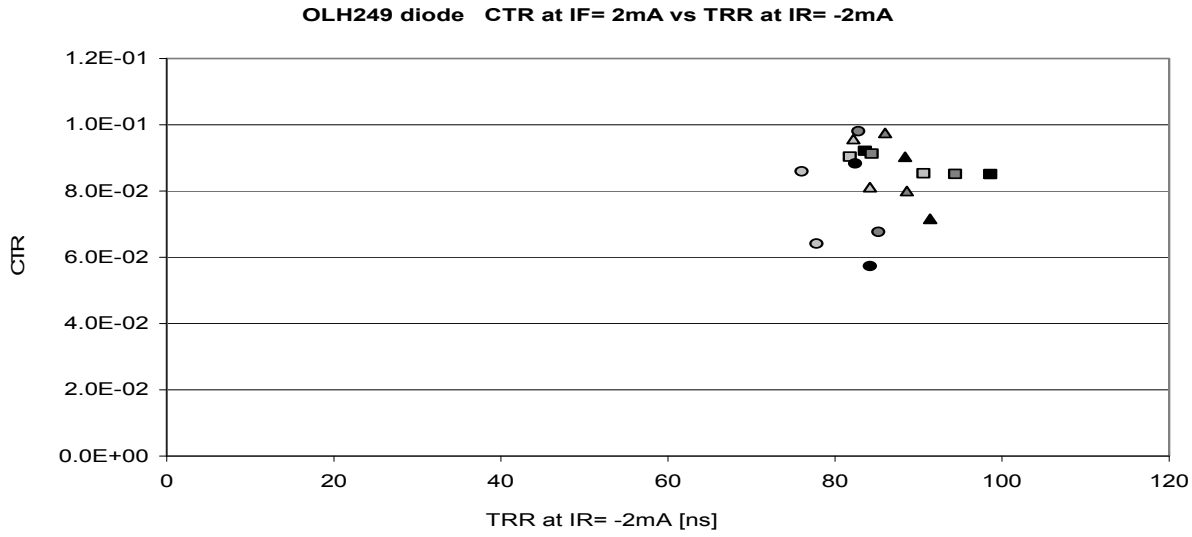
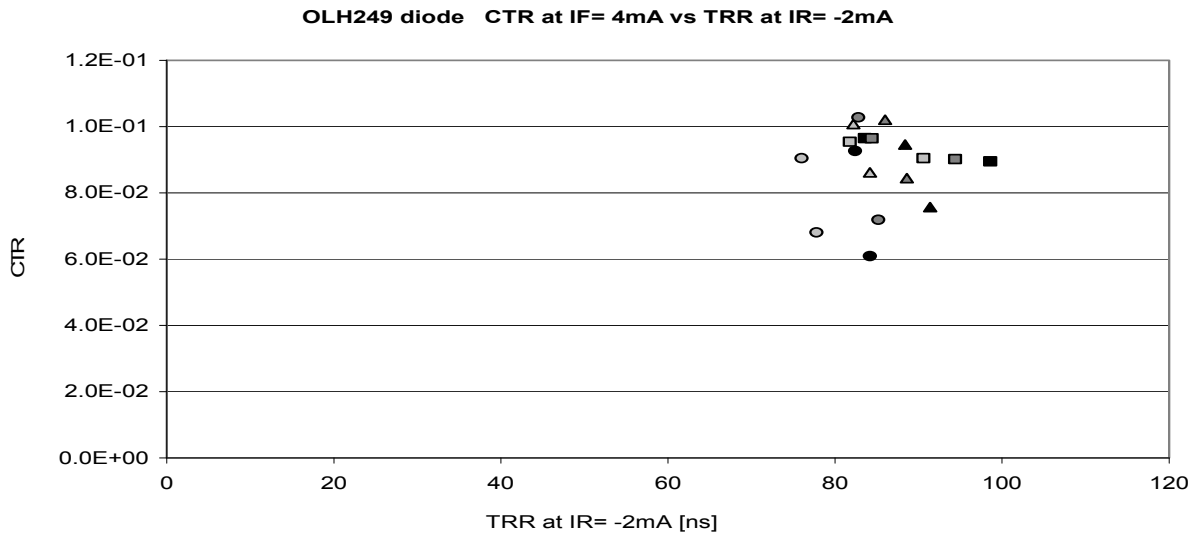
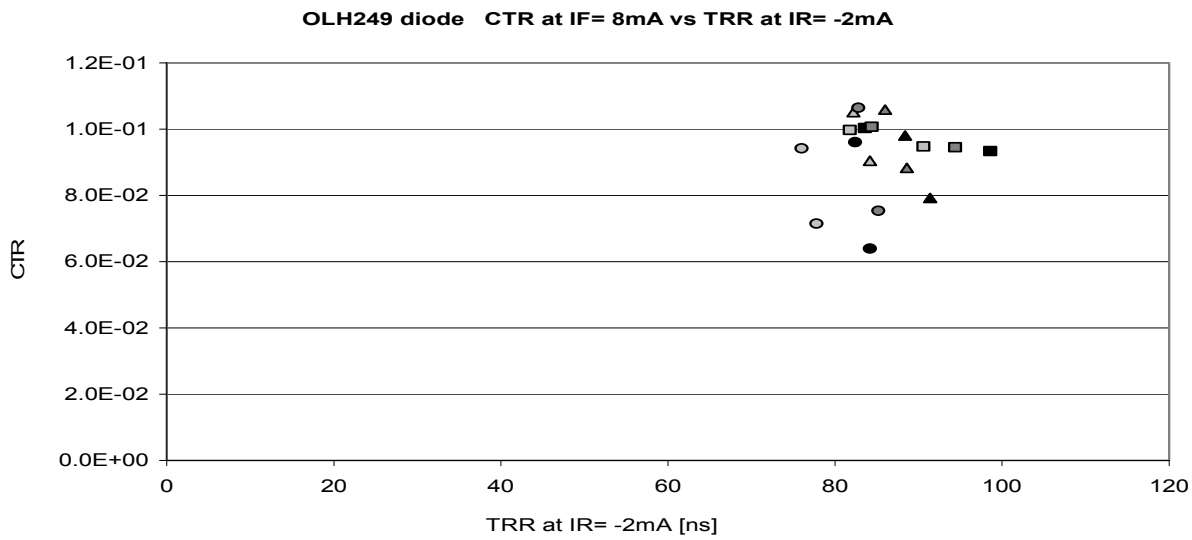

OLH249 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
140
160
TRR at IR= -1mA [ns]

Fig. 13-161: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
TRR at IR= -2mA [ns]

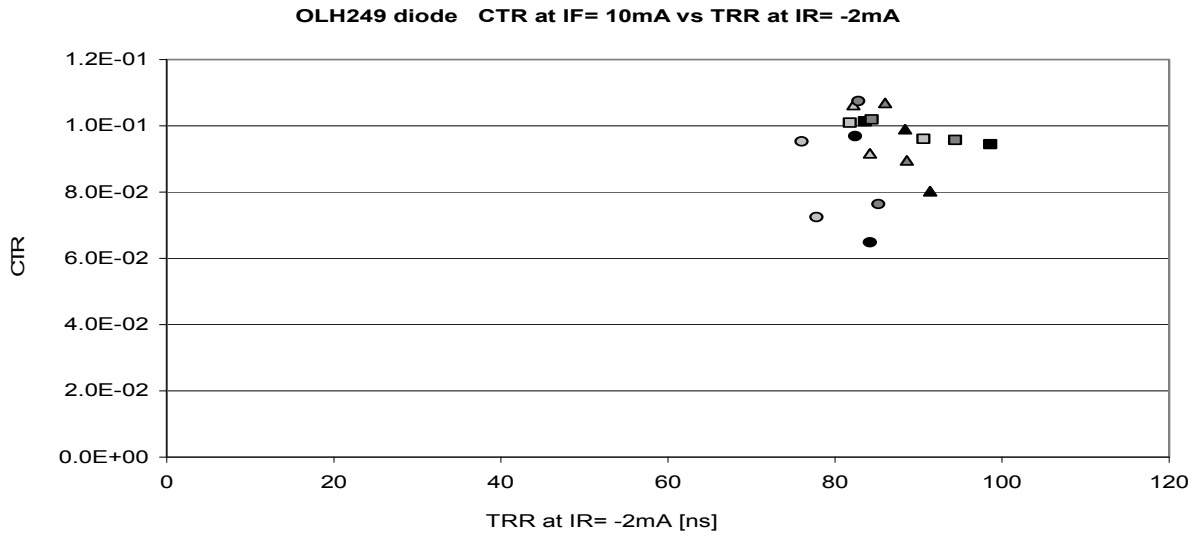
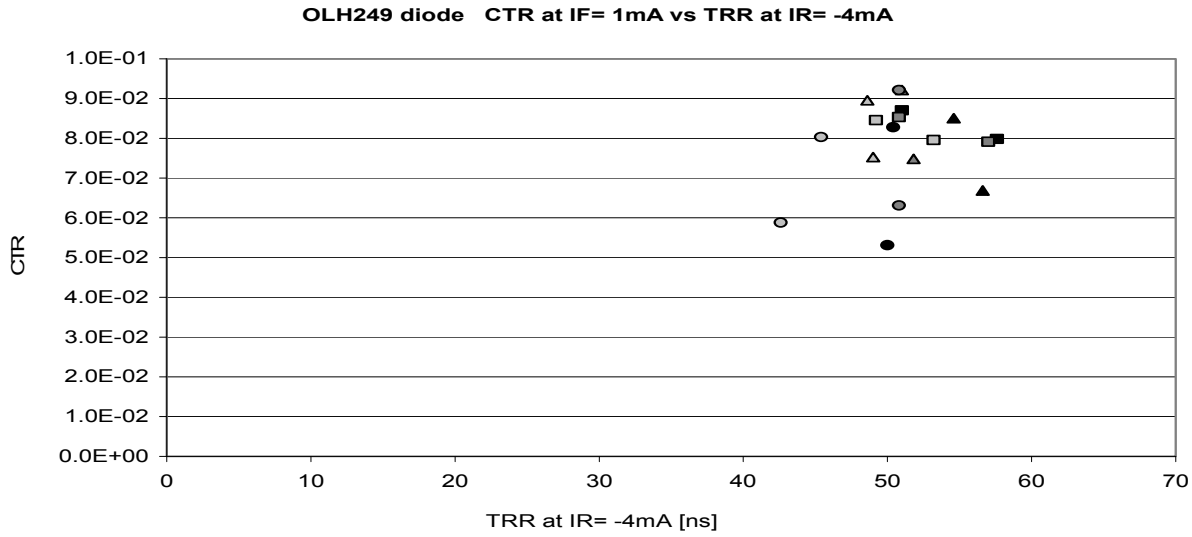
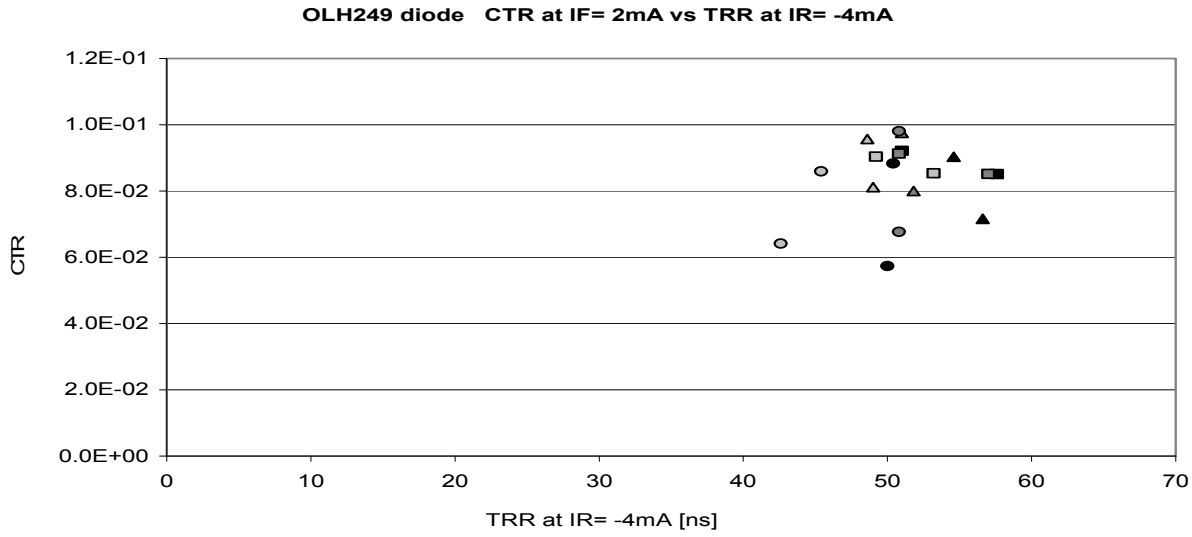
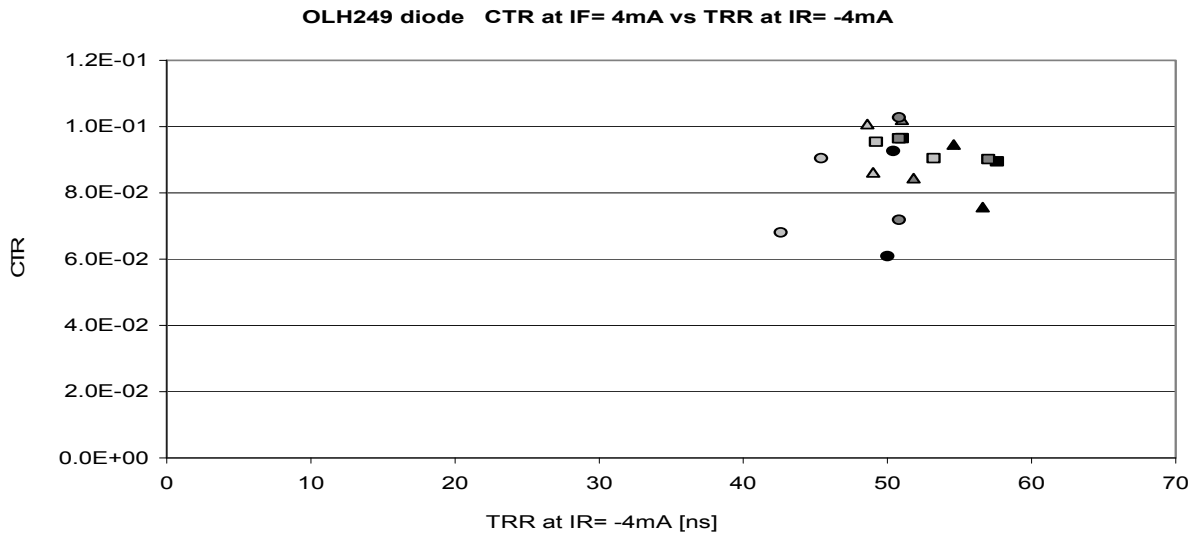
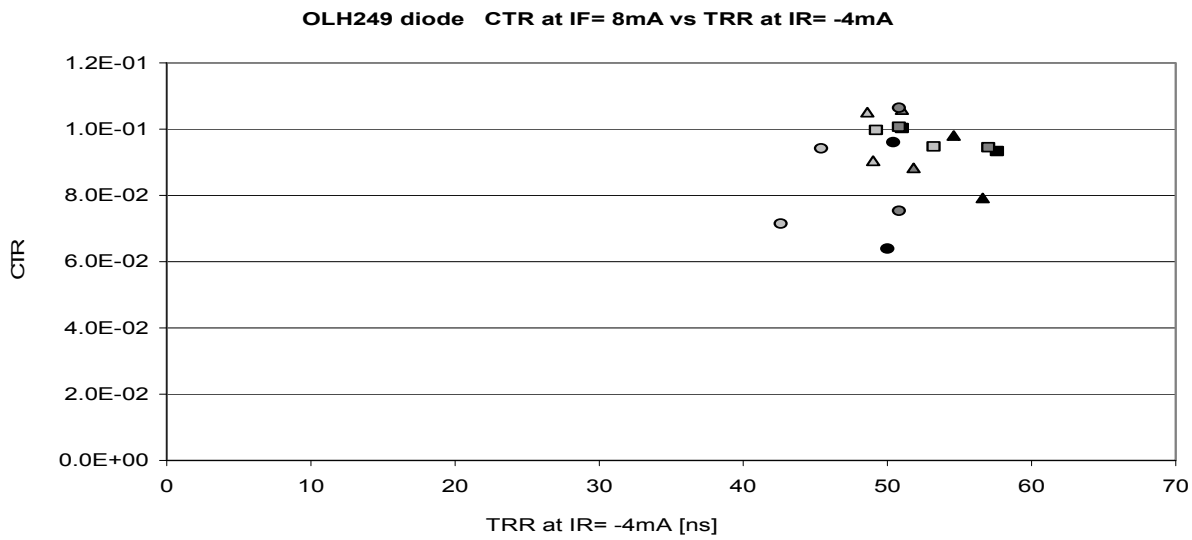

OLH249 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
20
40
60
80
100
120
TRR at IR= -2mA [ns]

Fig. 13-162: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -4mA [ns]

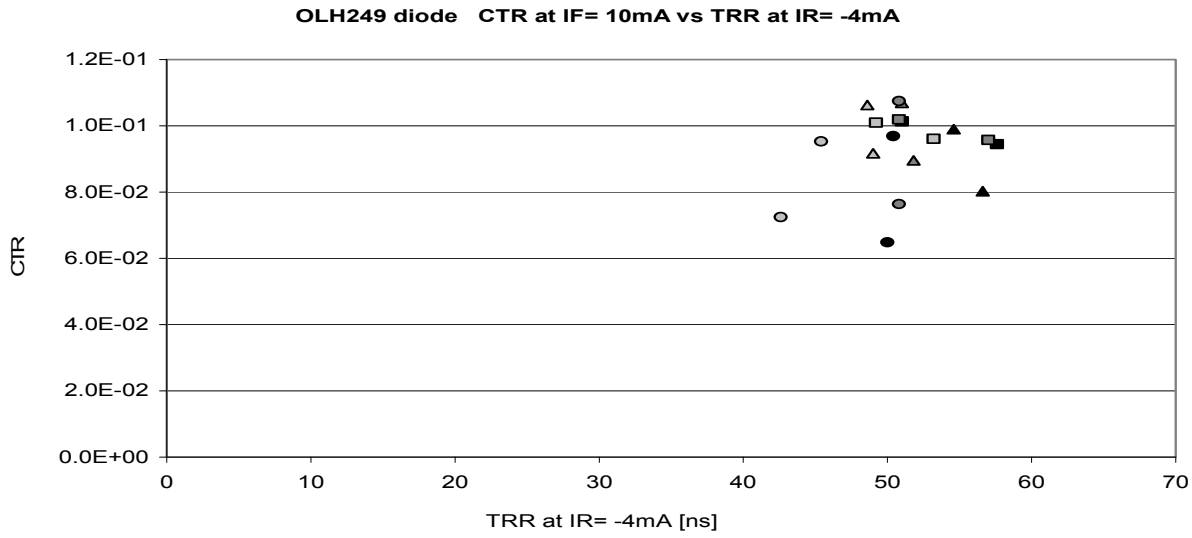
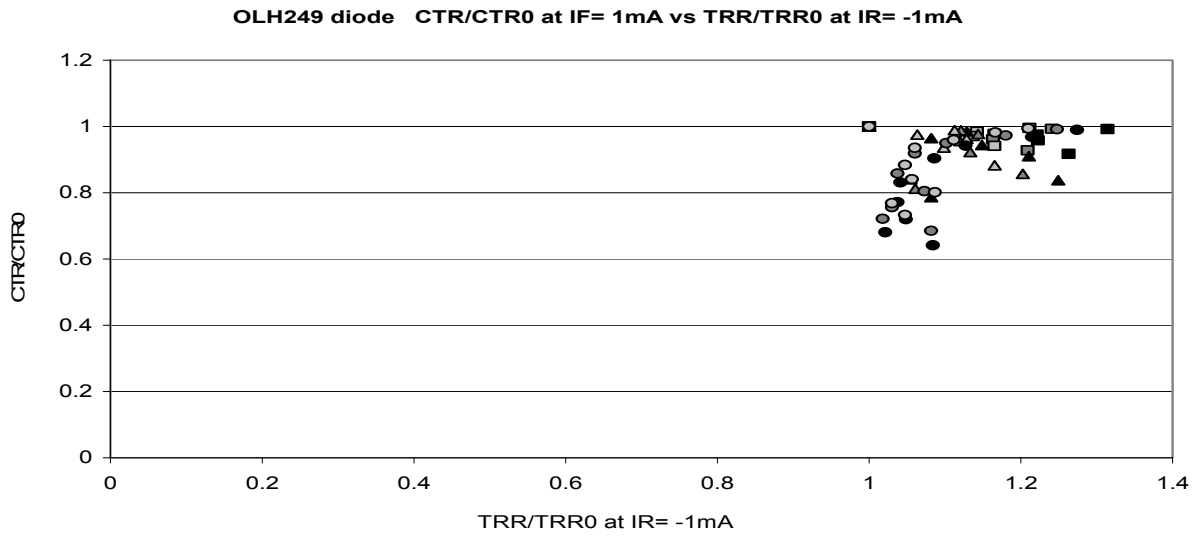
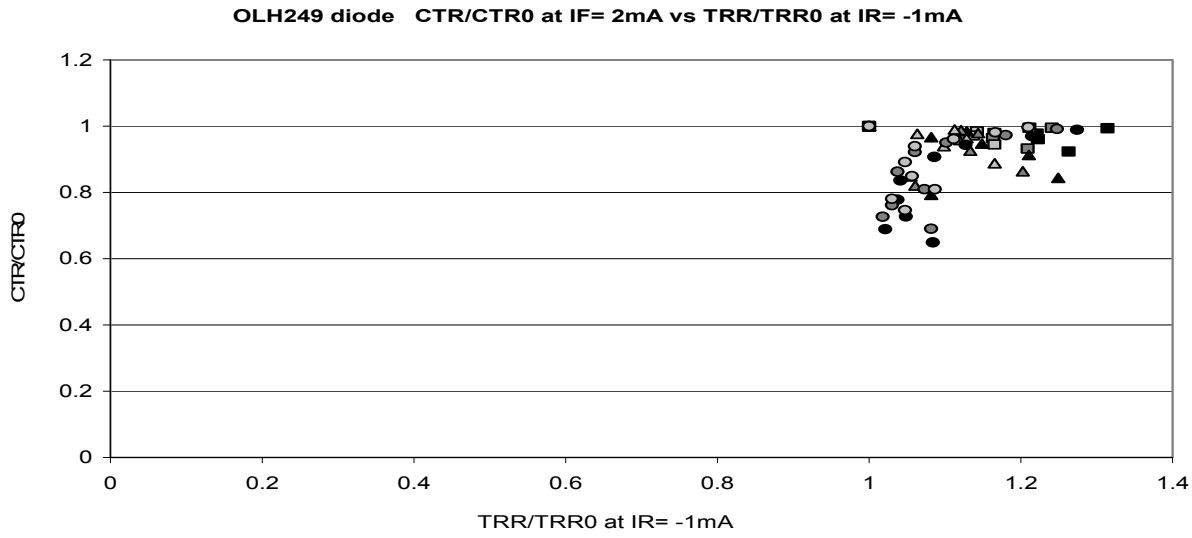
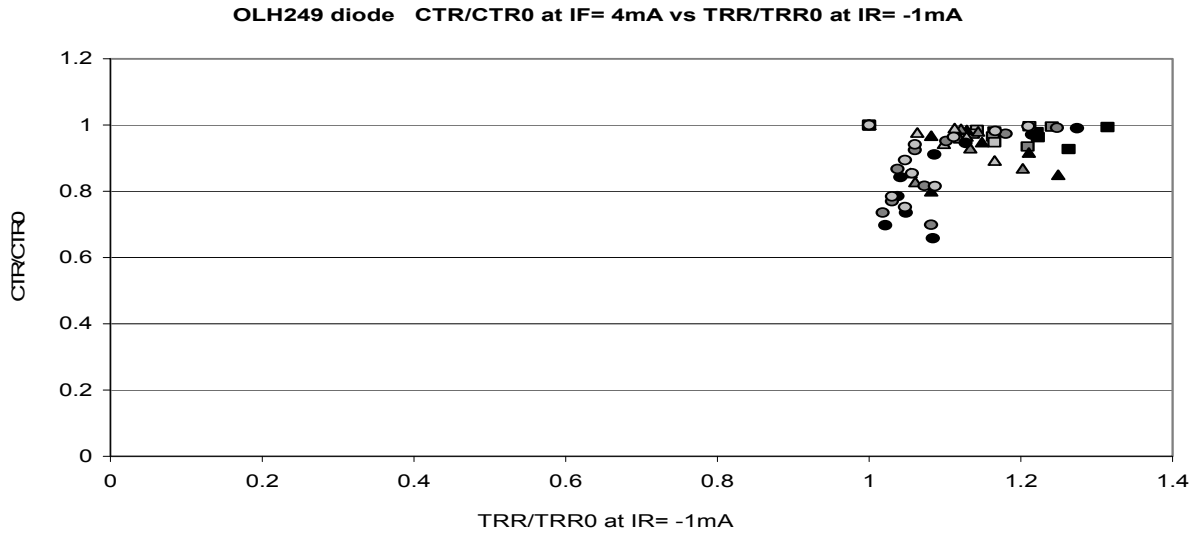
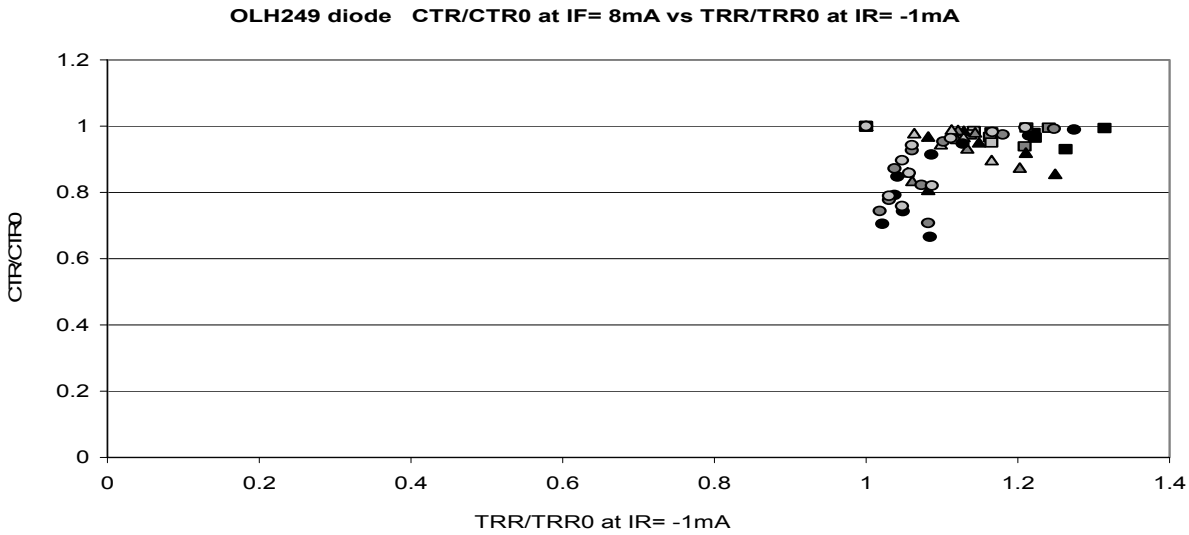

OLH249 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -4mA [ns]

Fig. 13-163: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

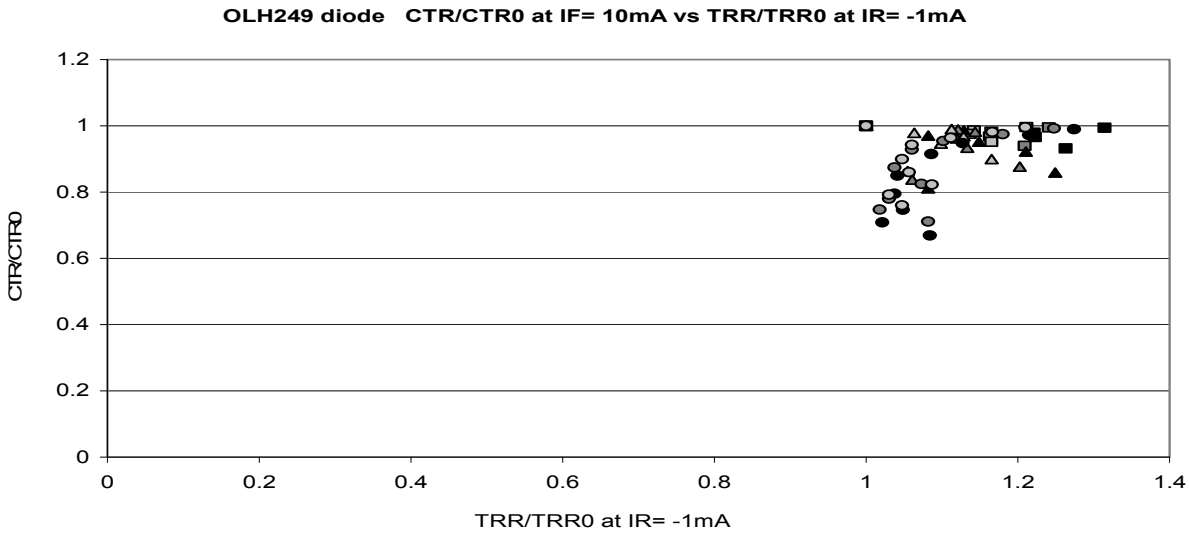
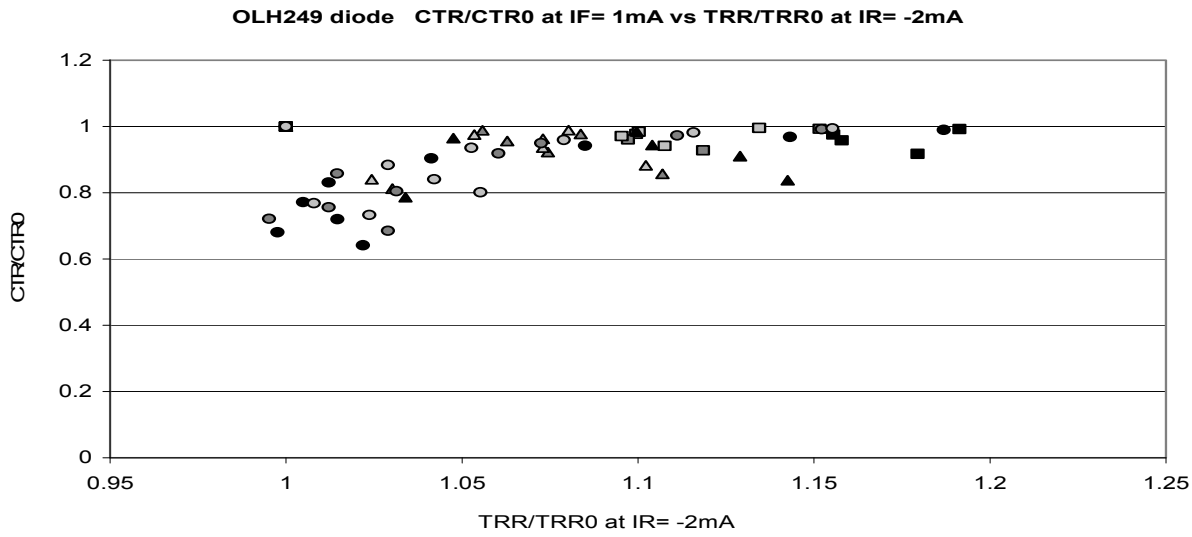
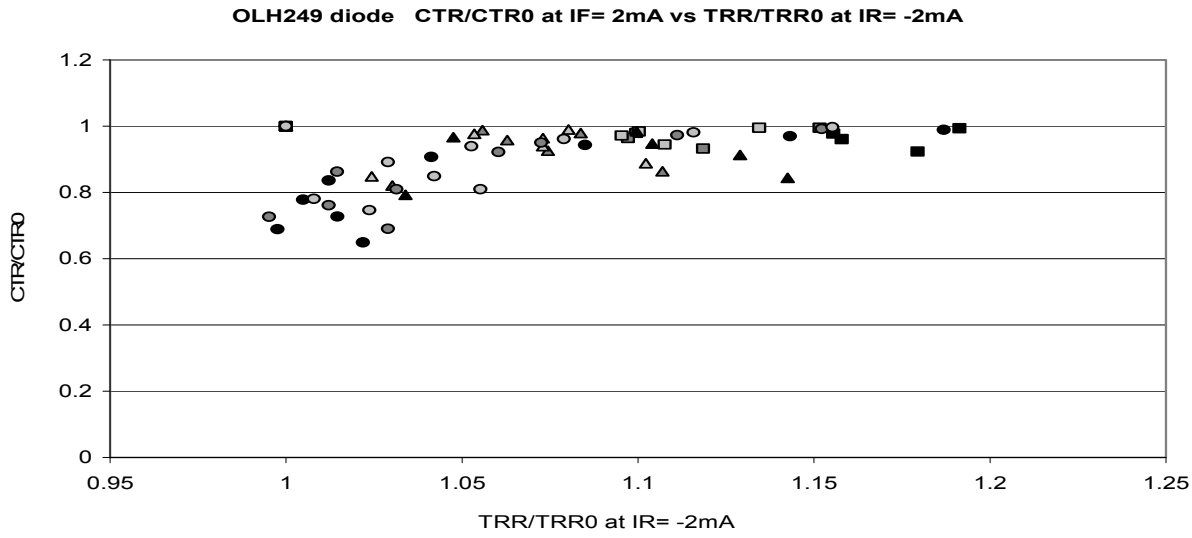
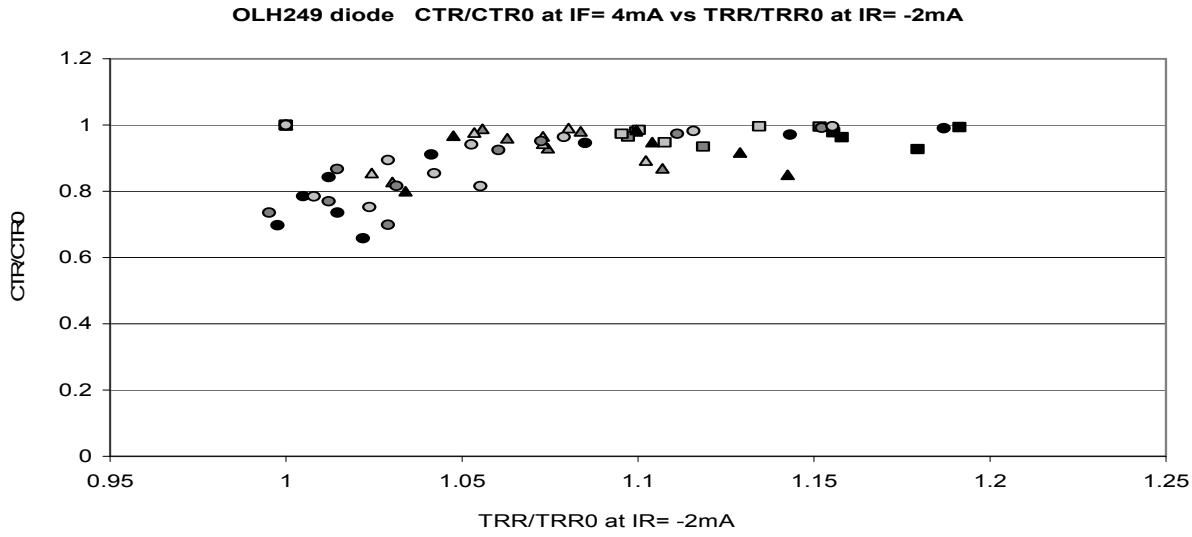
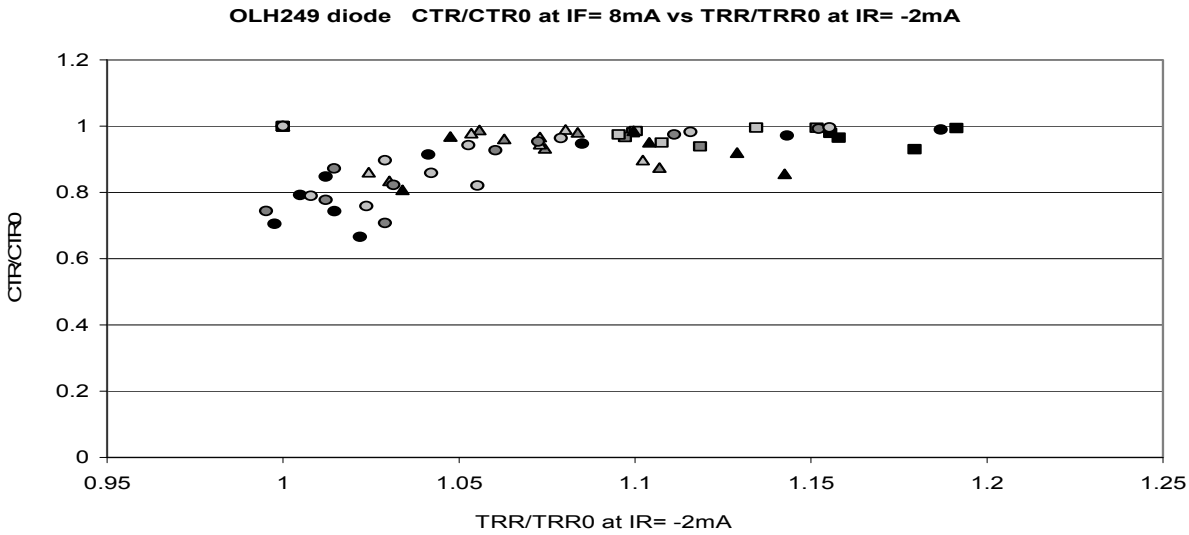

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 13-164: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.95
1
1.05
1.1
1.15
1.2
1.25
TRR/TRR0 at IR= -2mA

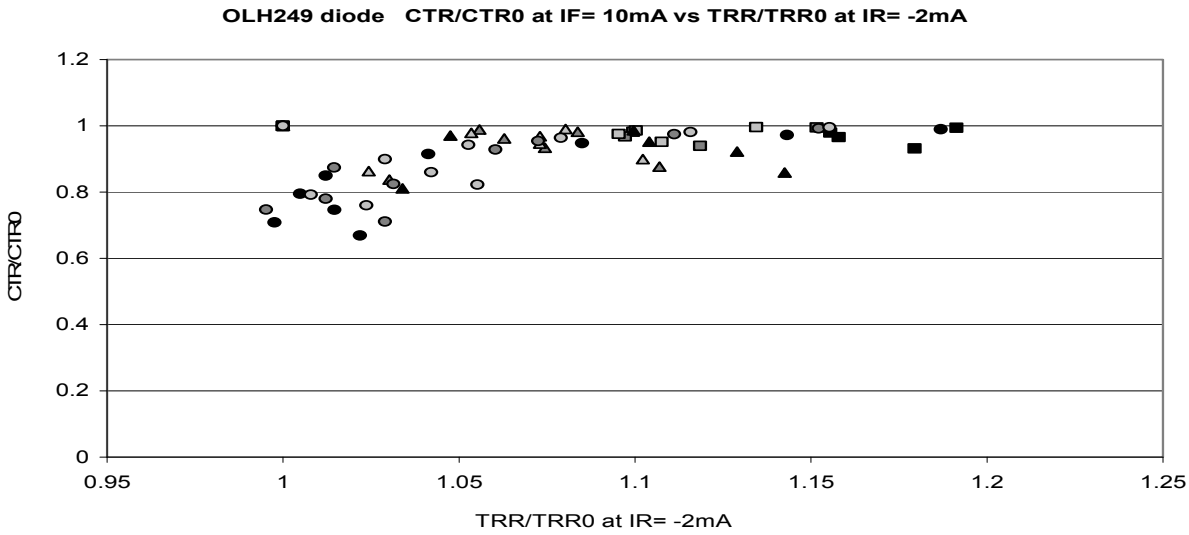
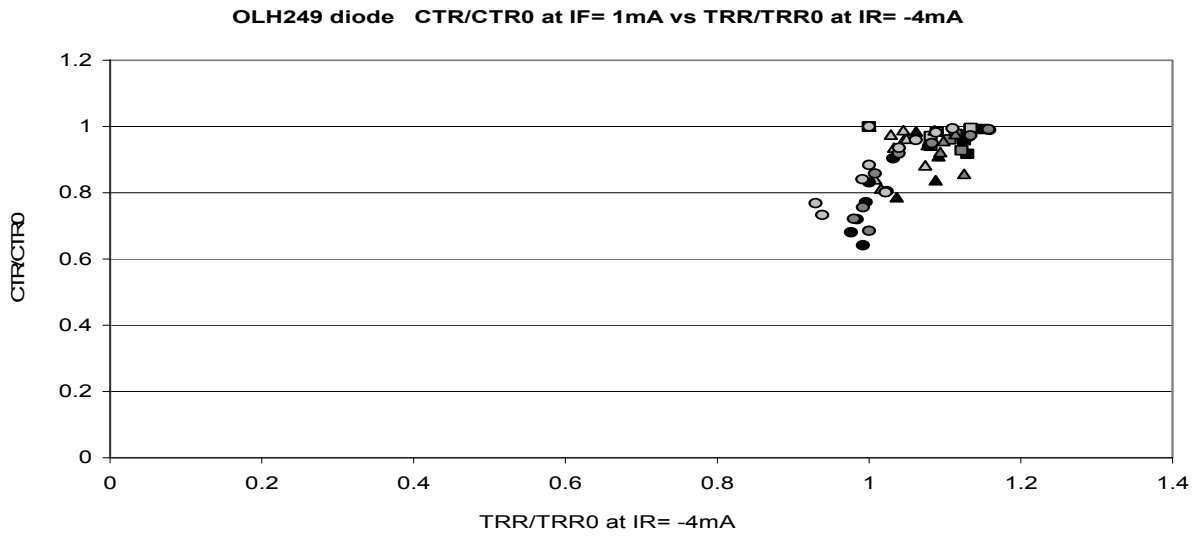
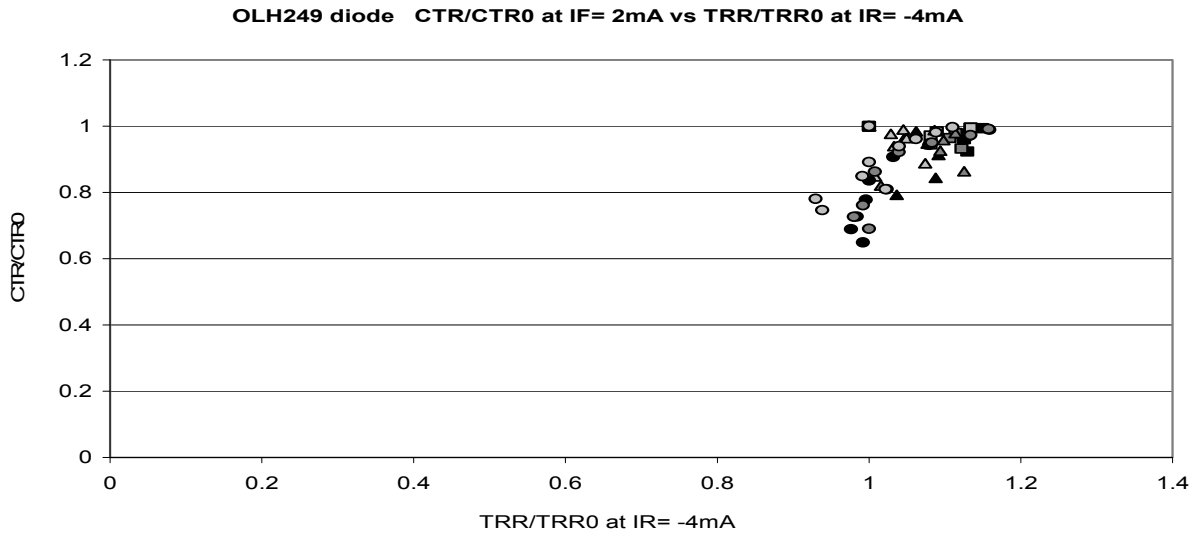
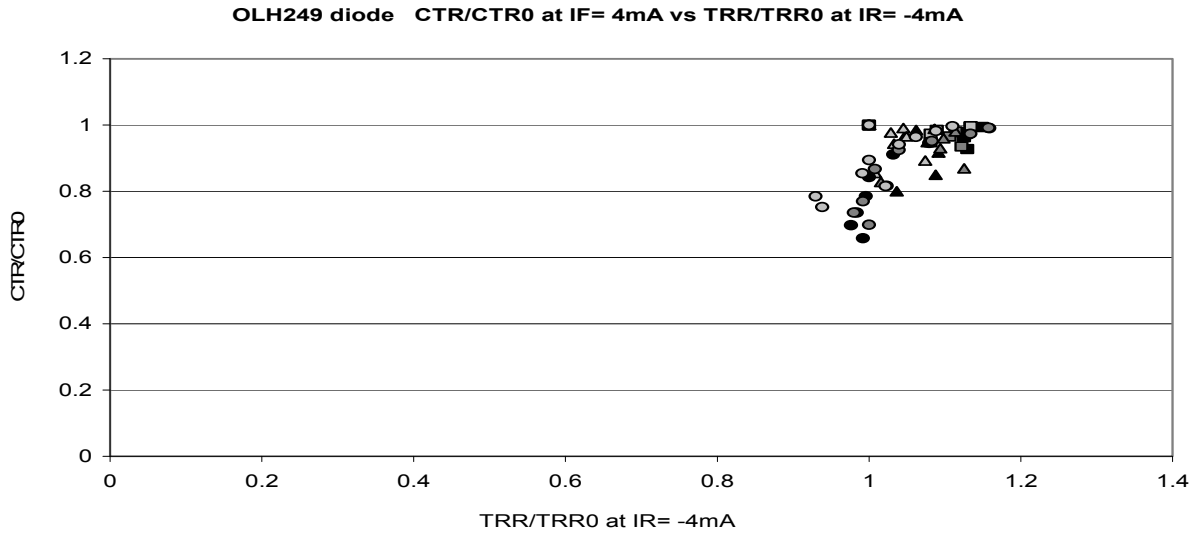
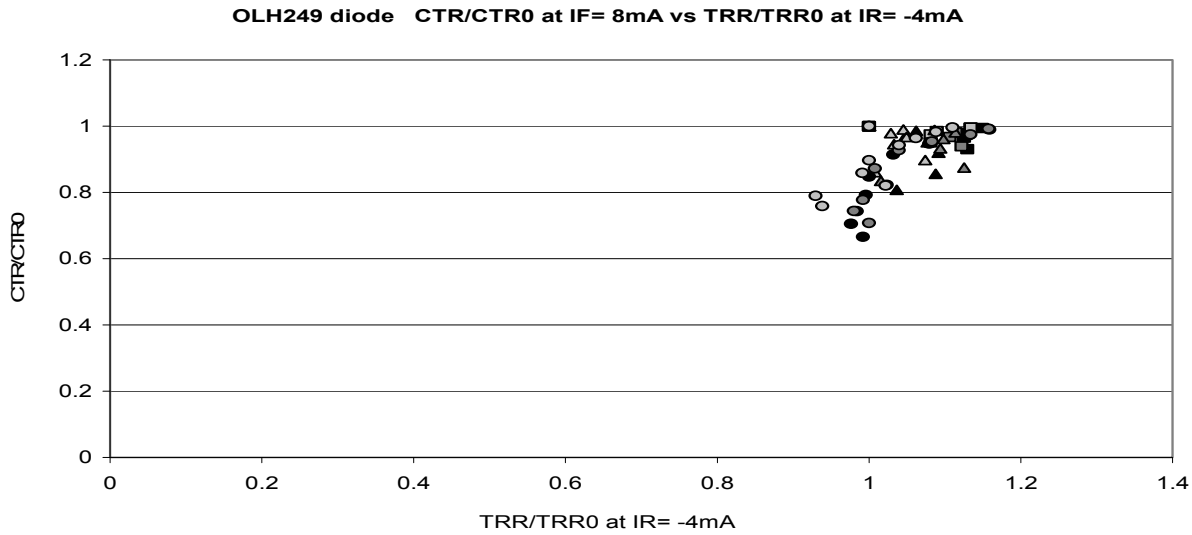

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.95
1
1.05
1.1
1.15
1.2
1.25
TRR/TRR0 at IR= -2mA

Fig. 13-165: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

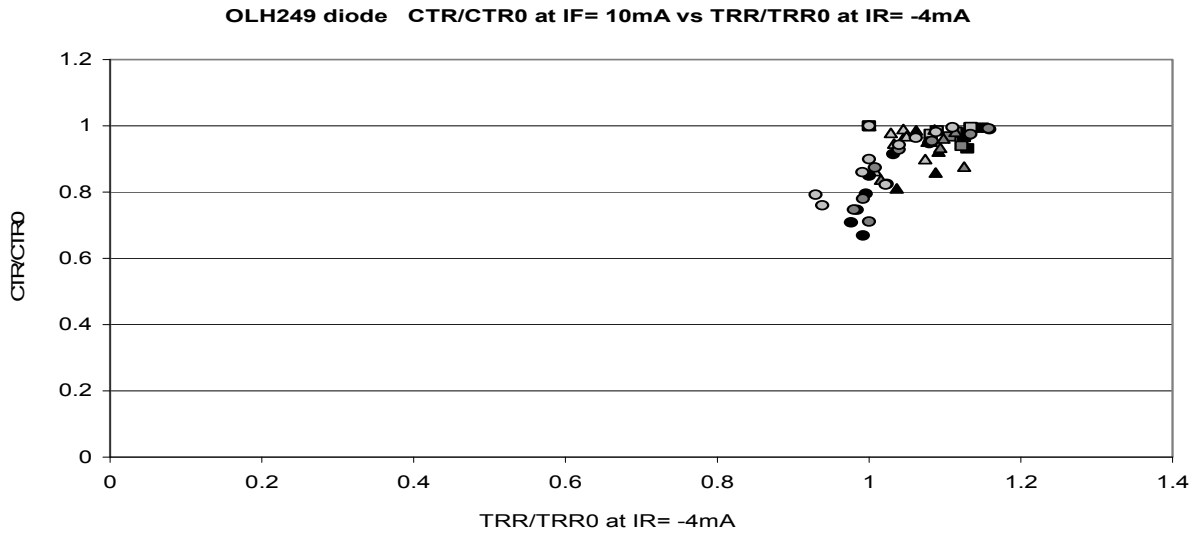
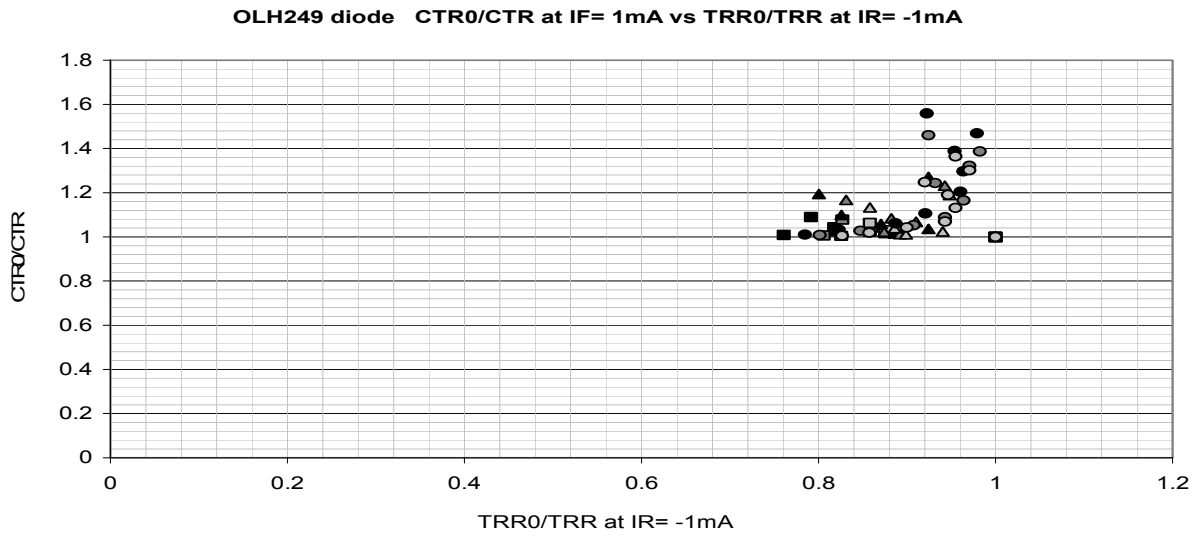
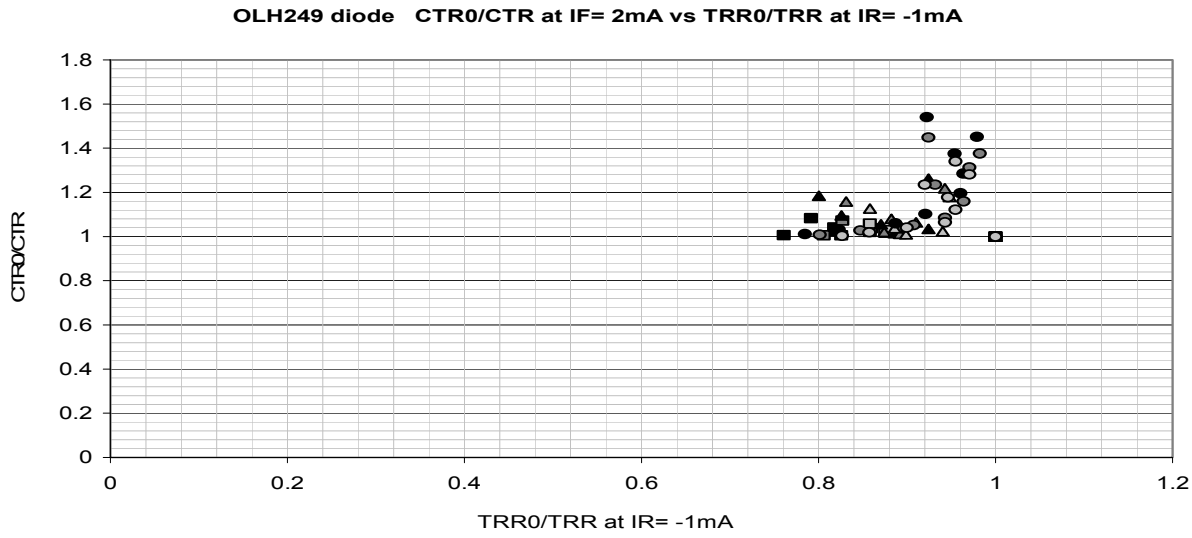
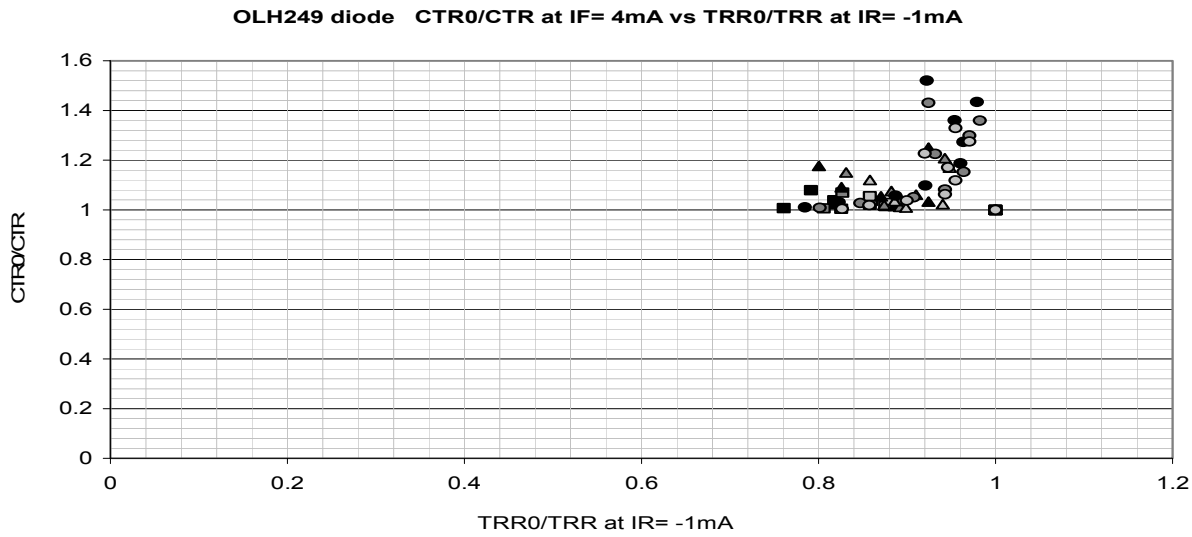
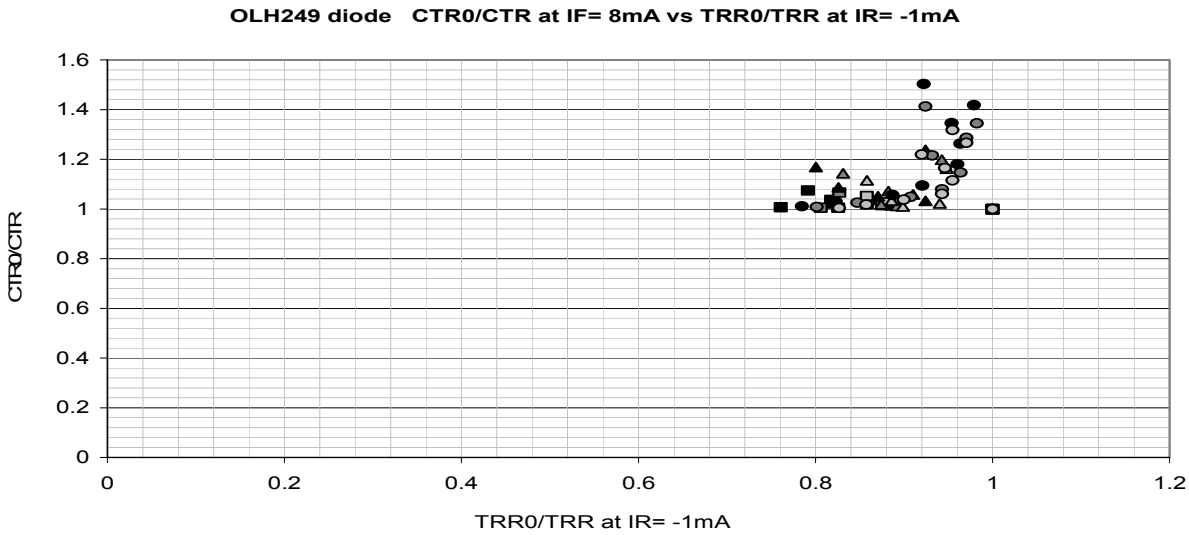

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 13-166: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
TRR0/TRR at IR= -1mA

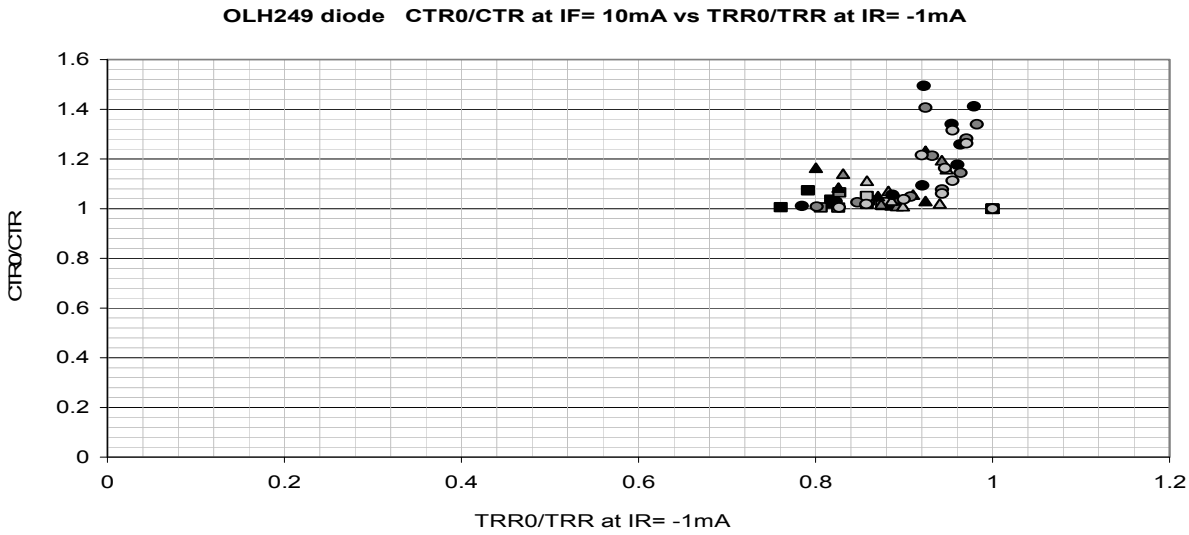
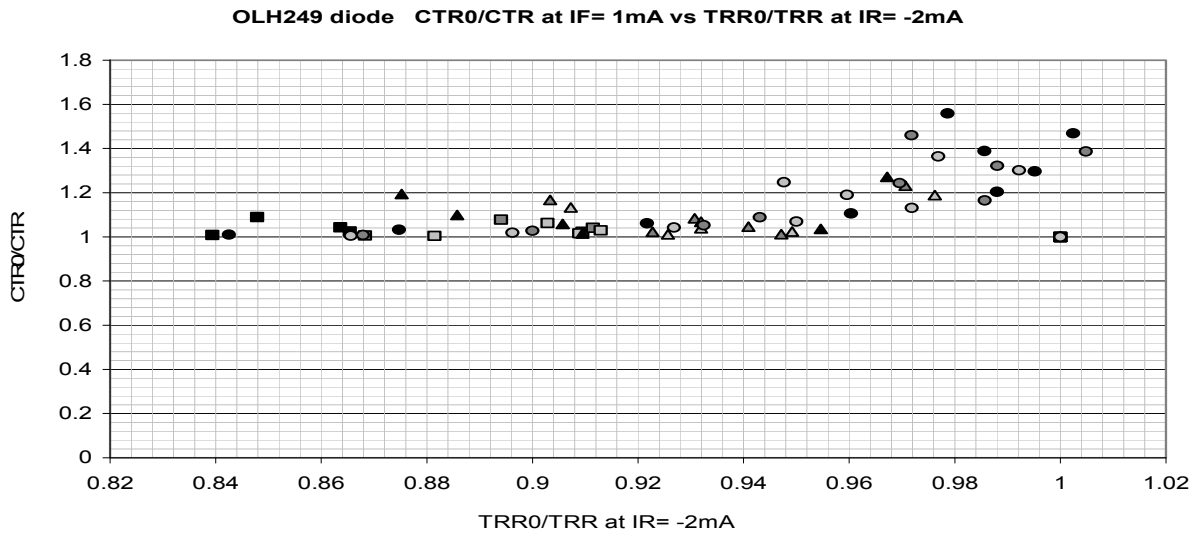
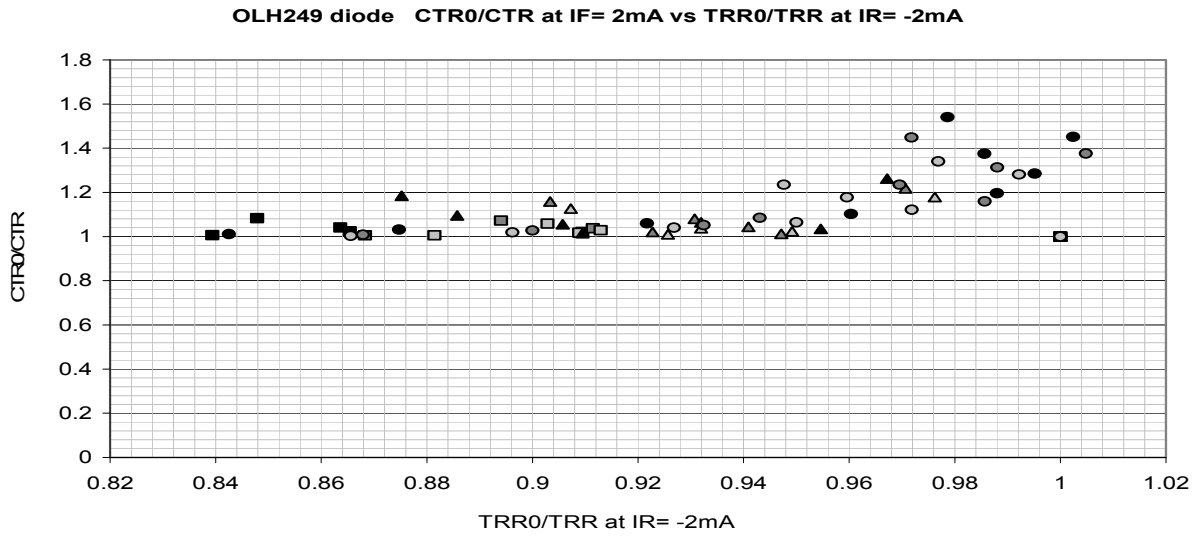
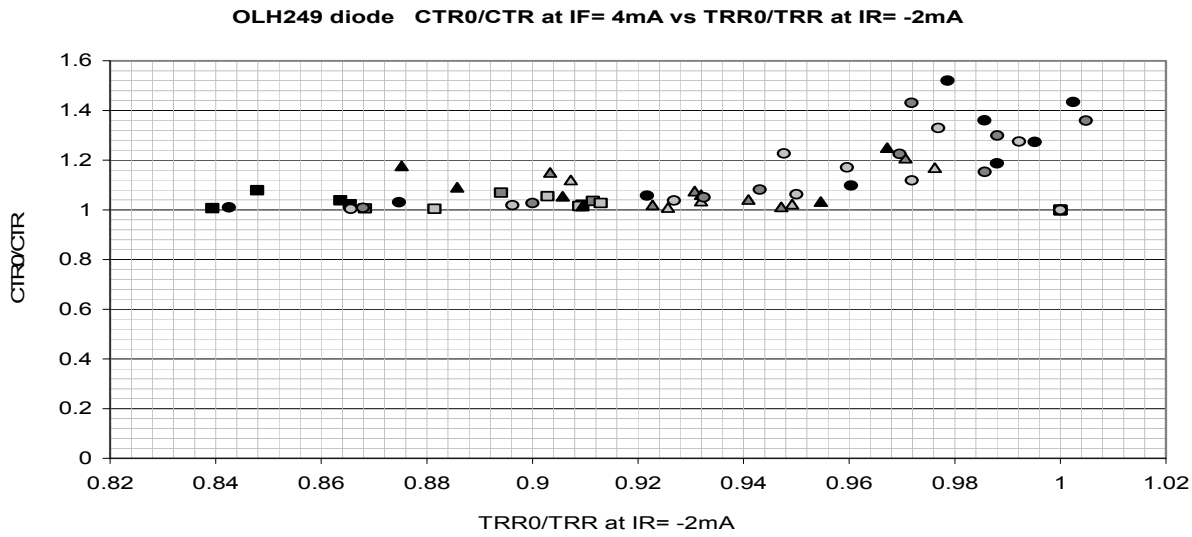
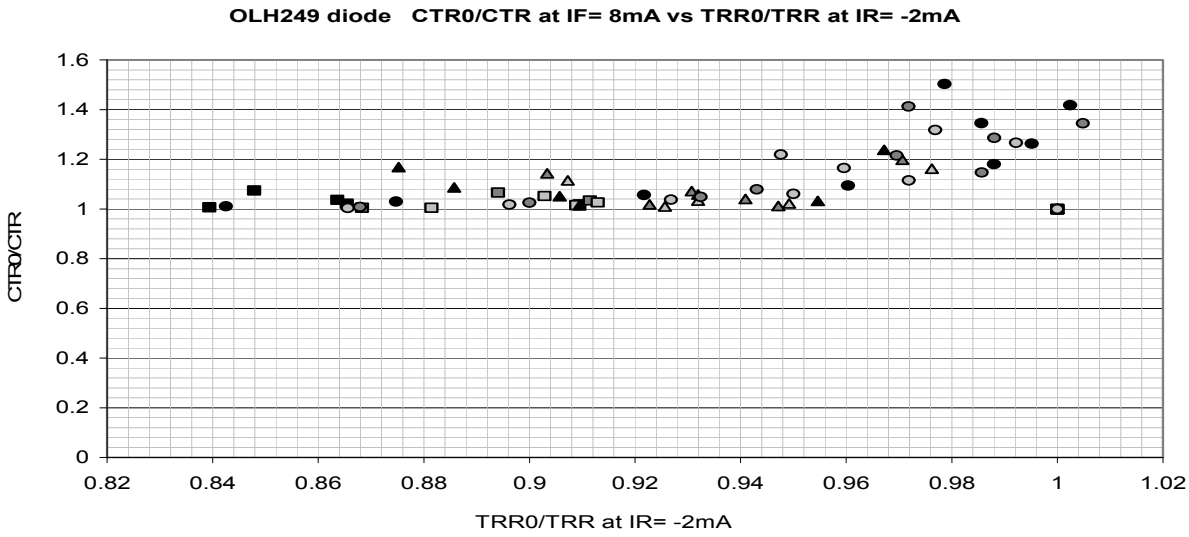

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
TRR0/TRR at IR= -1mA

Fig. 13-167: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
TRR0/TRR at IR= -2mA

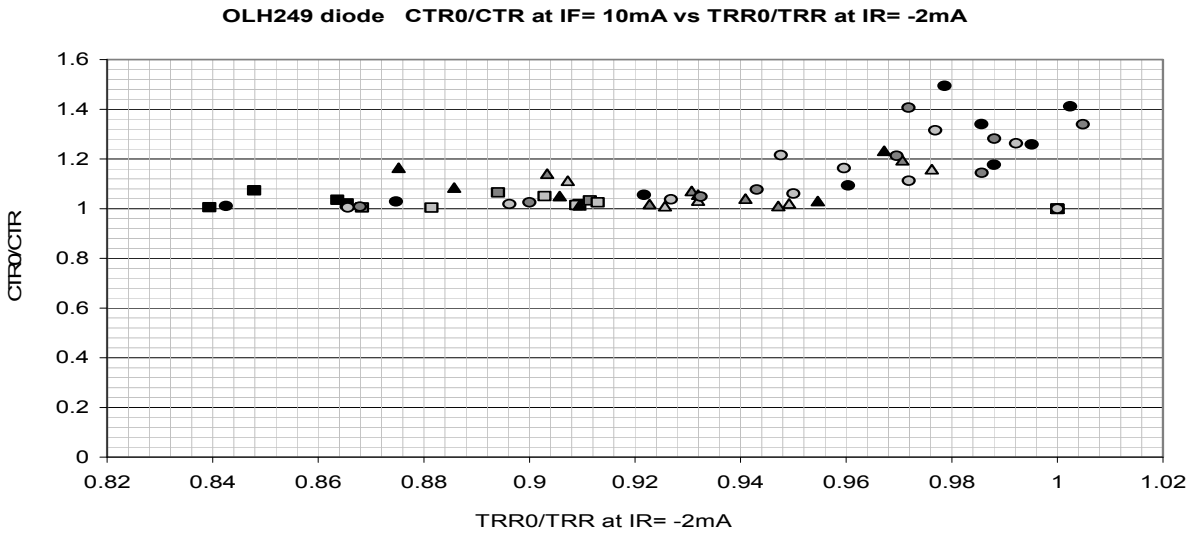
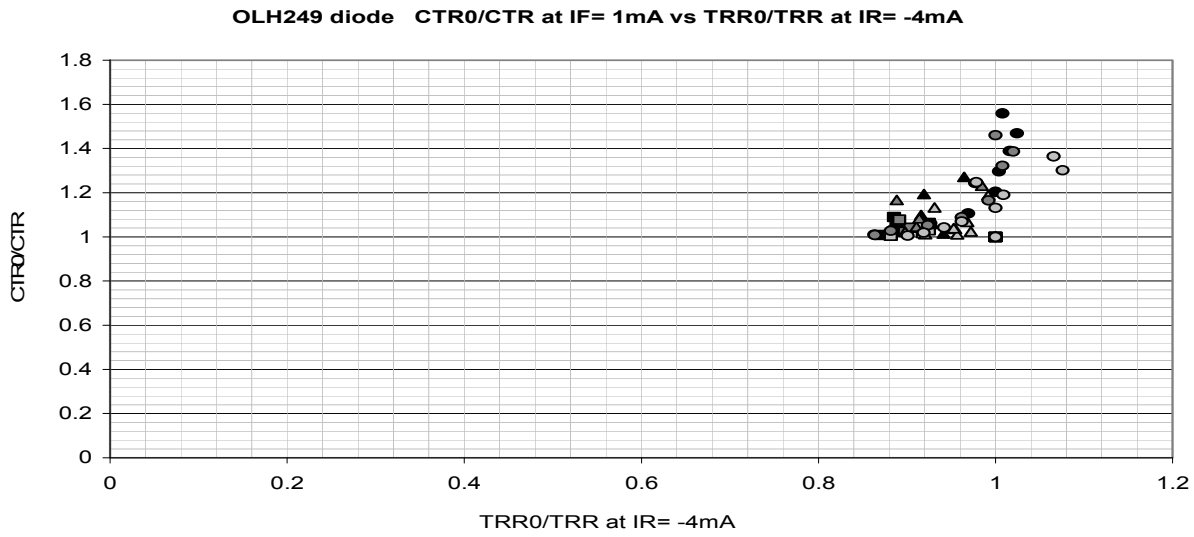
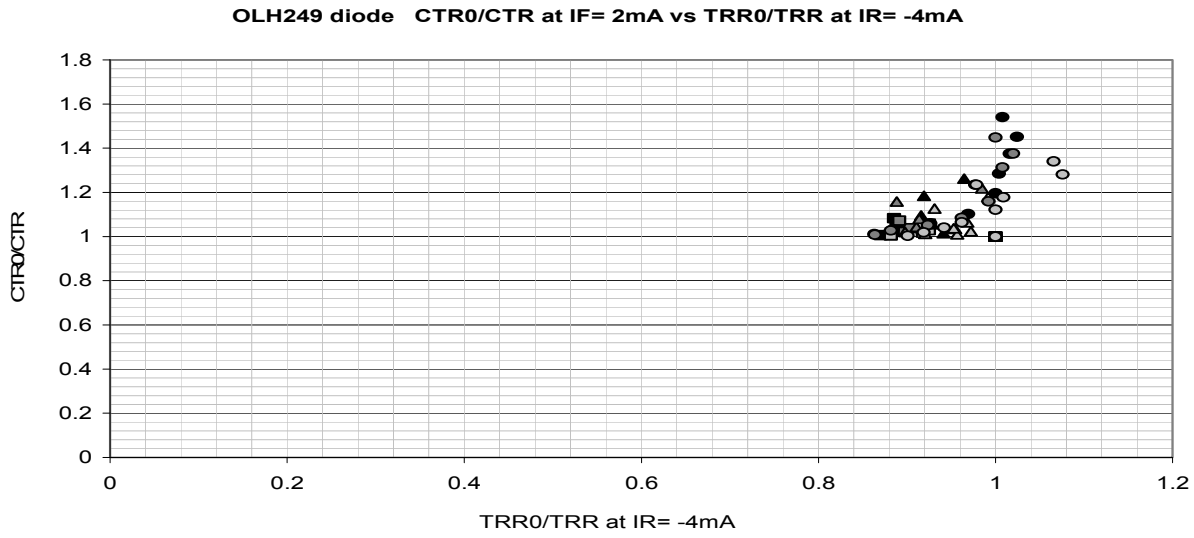
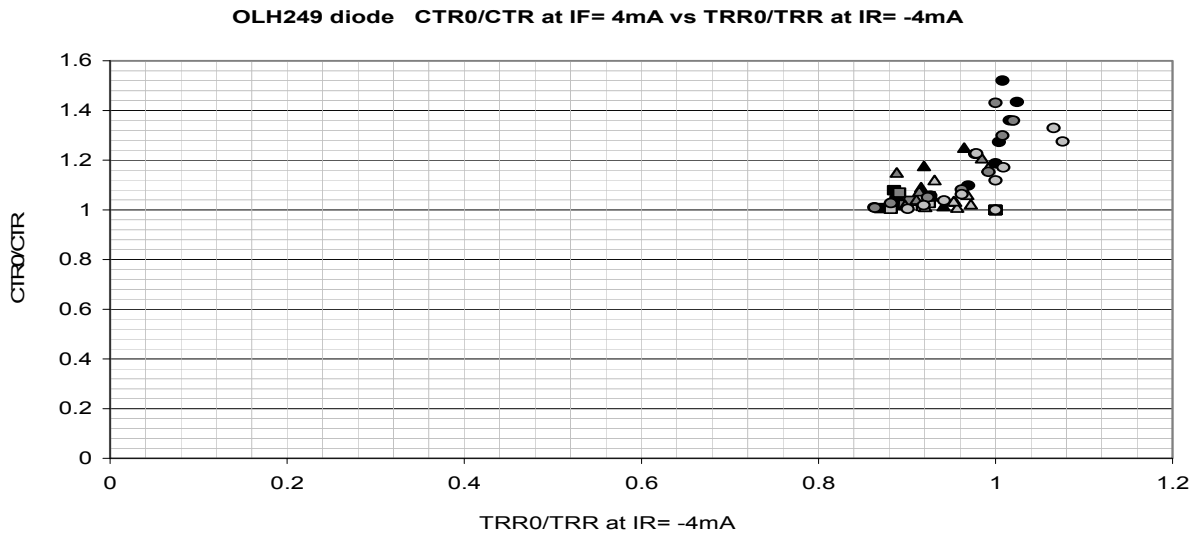
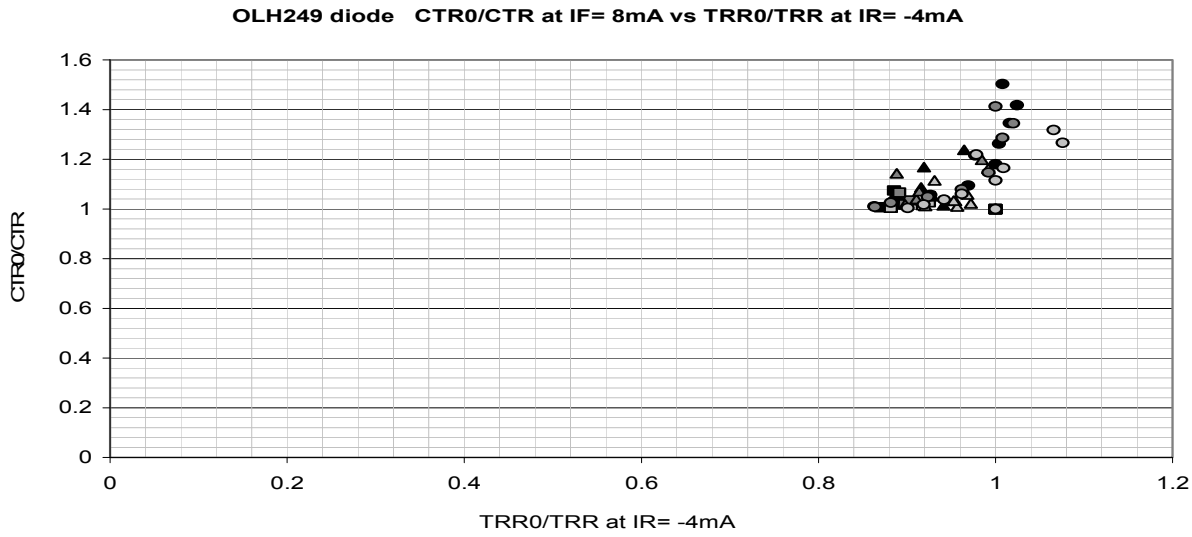

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
TRR0/TRR at IR= -2mA

Fig. 13-168: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA








OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
TRR0/TRR at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

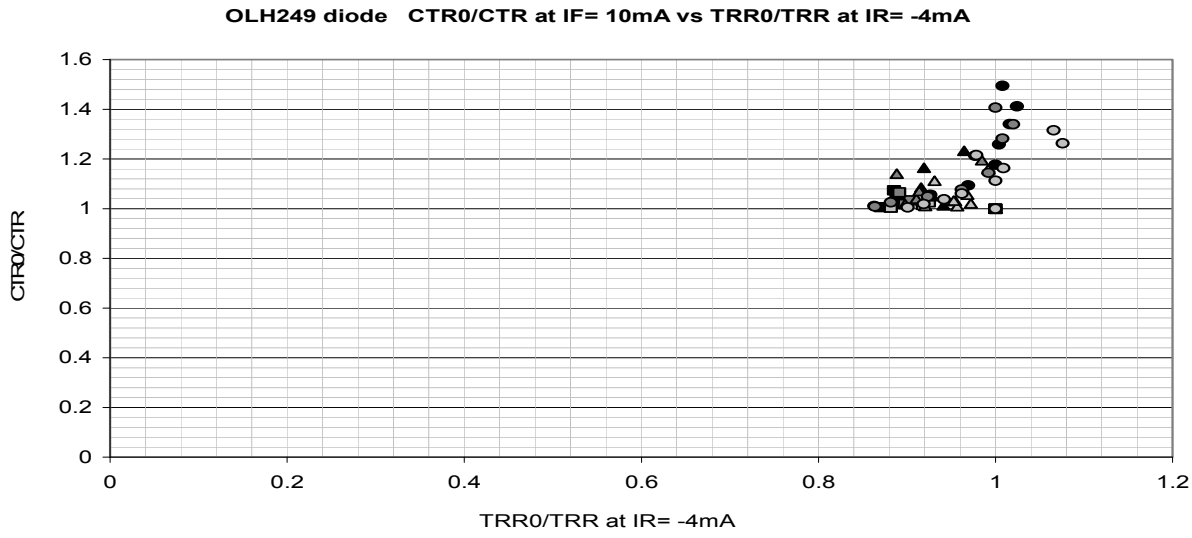
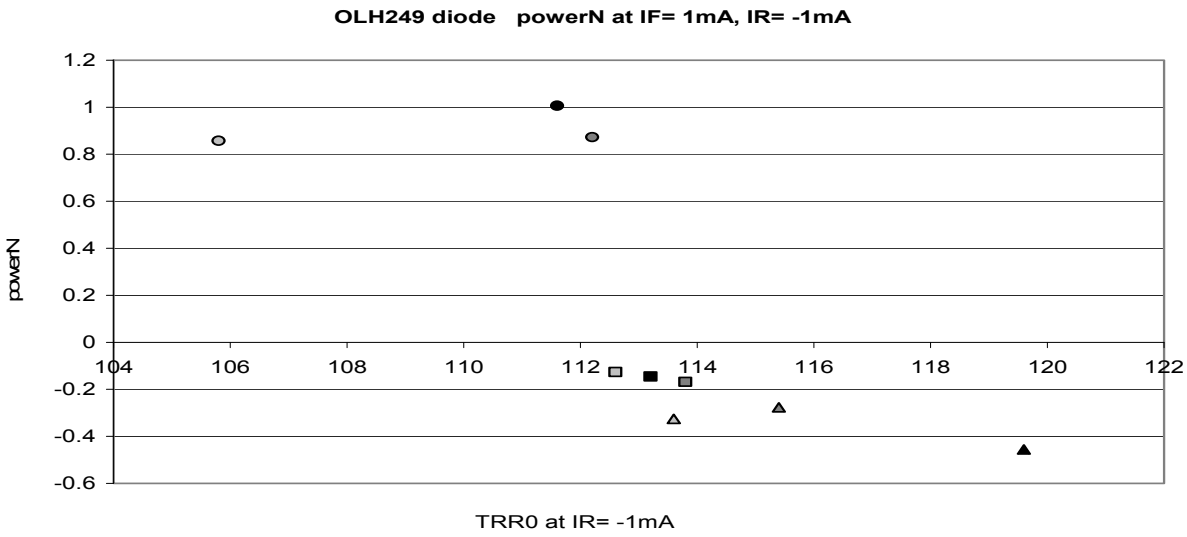
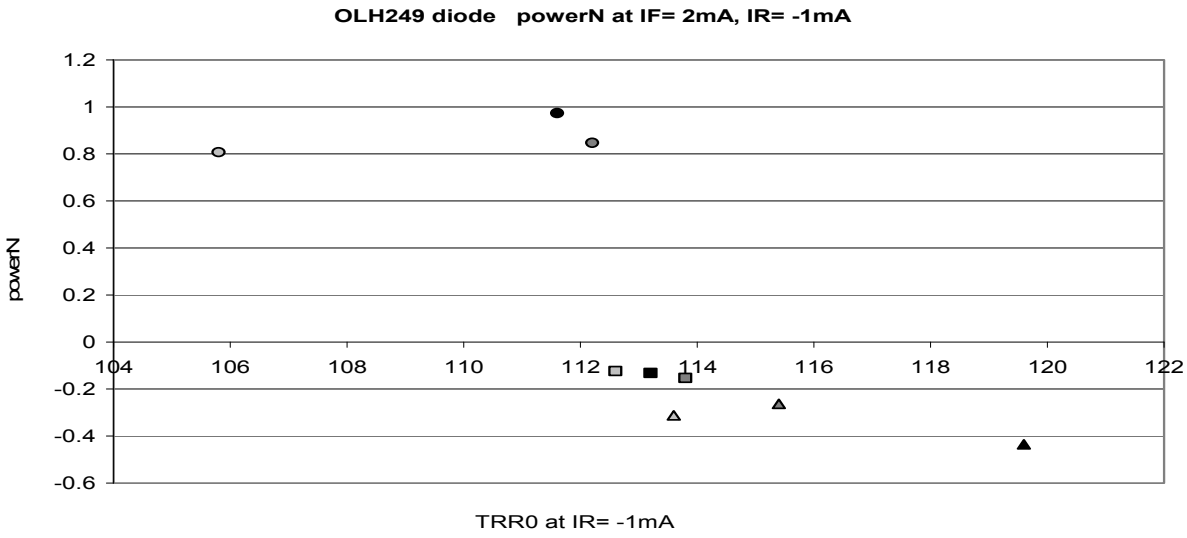
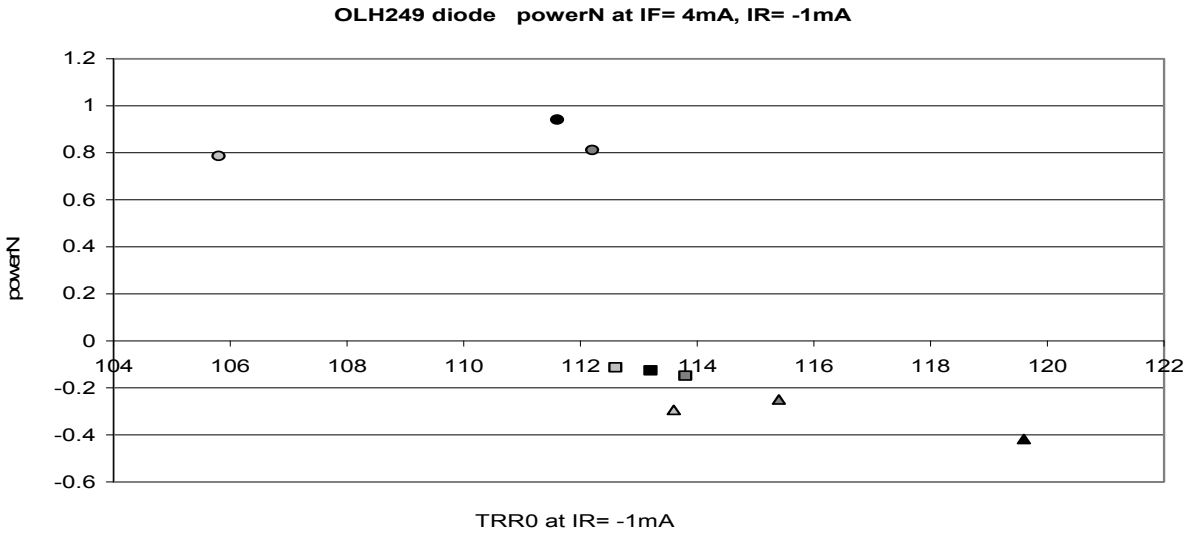
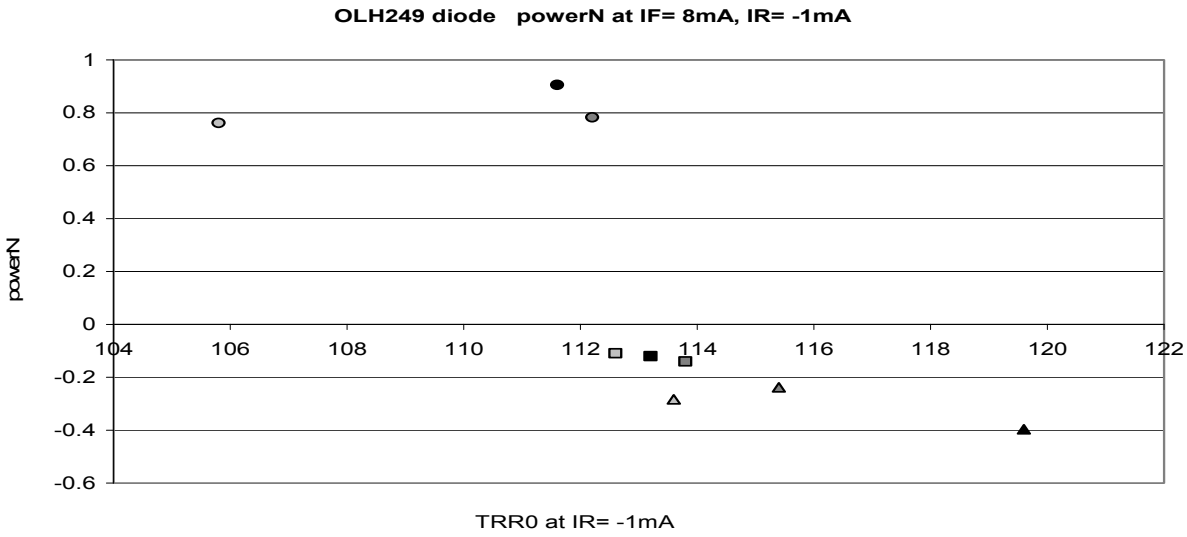

OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
TRR0/TRR at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

Fig. 13-169: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








OLH249 diode powerN at IF= 8mA, IR= -1mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
104
106
108
110
112
114
116
118
120
122
TRR0 at IR= -1mA

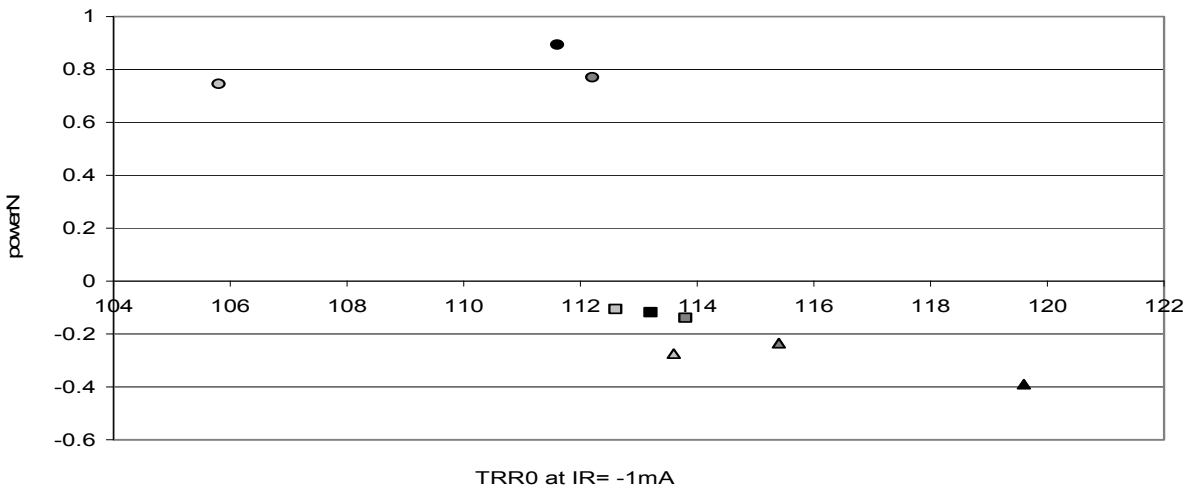
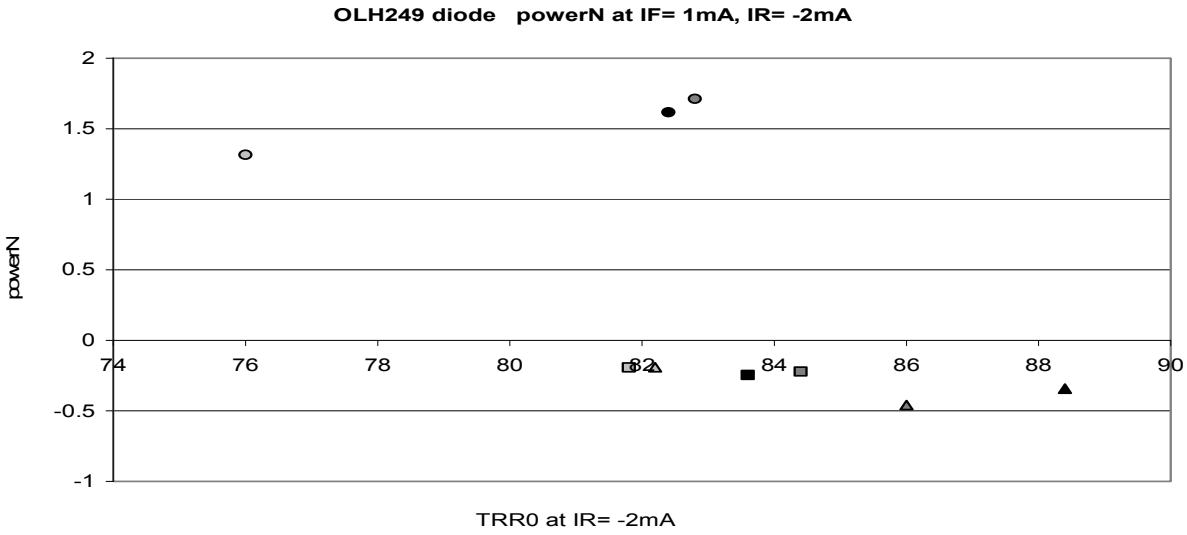
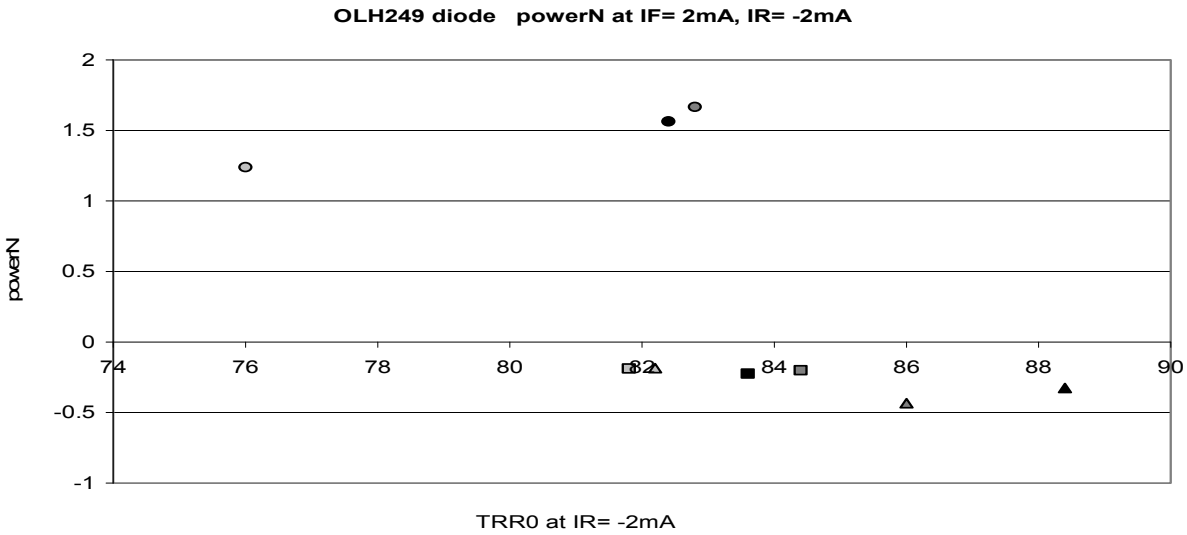
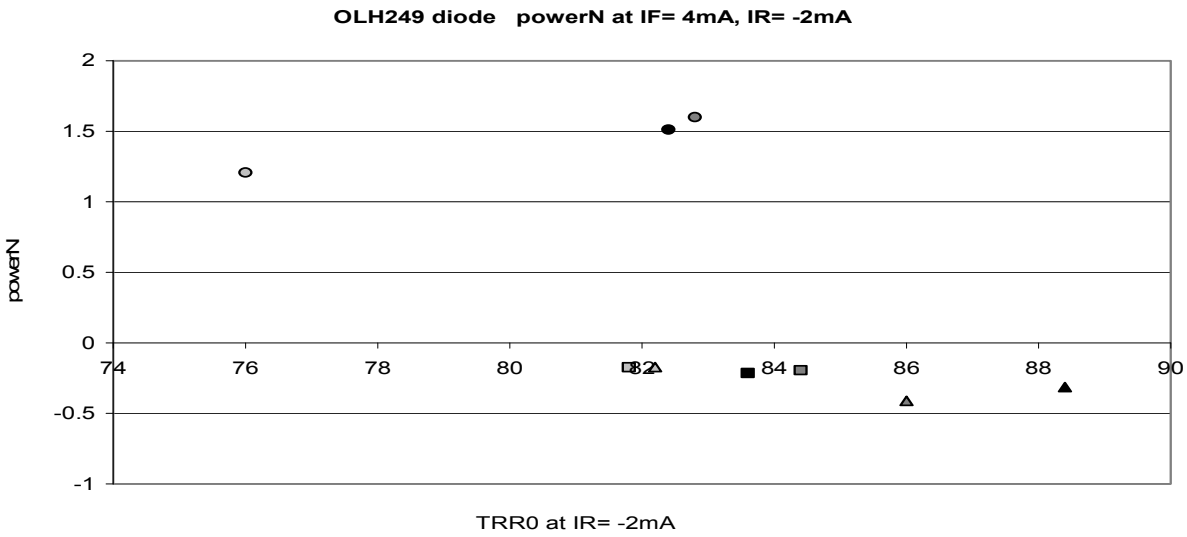
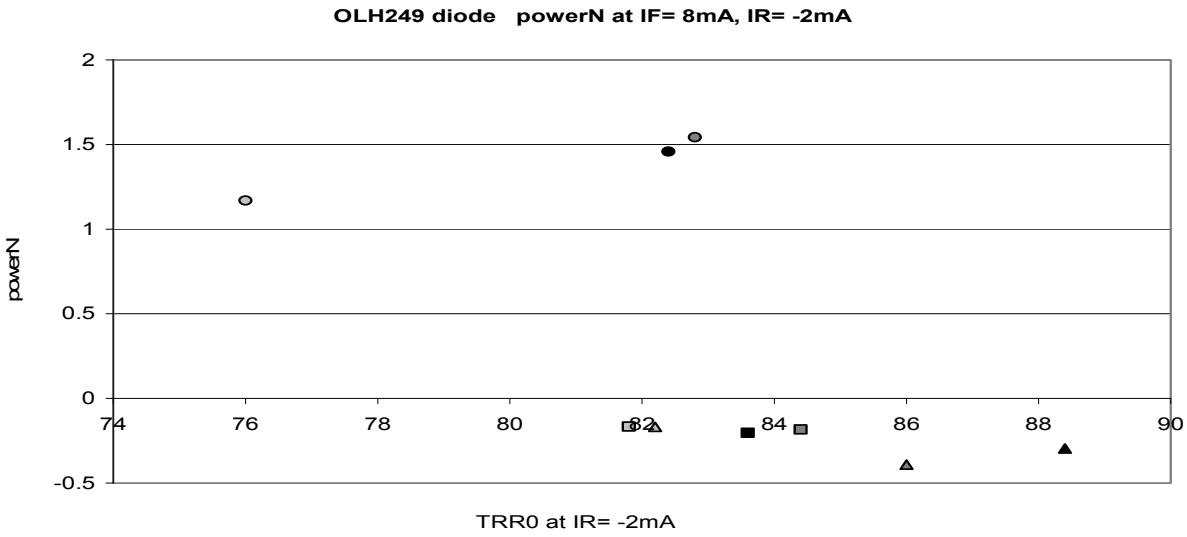

OLH249 diode powerN at IF= 10mA, IR= -1mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
104
106
108
110
112
114
116
118
120
122
TRR0 at IR= -1mA

Fig. 13-170: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








OLH249 diode powerN at IF= 8mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
74
76
78
80
82
84
86
88
90
TRR0 at IR= -2mA

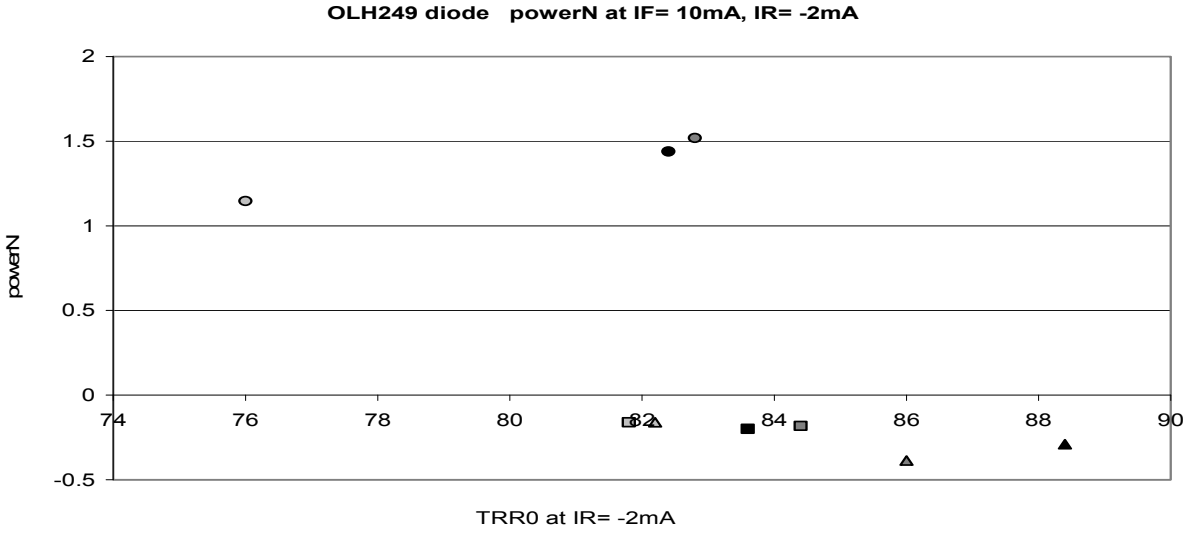
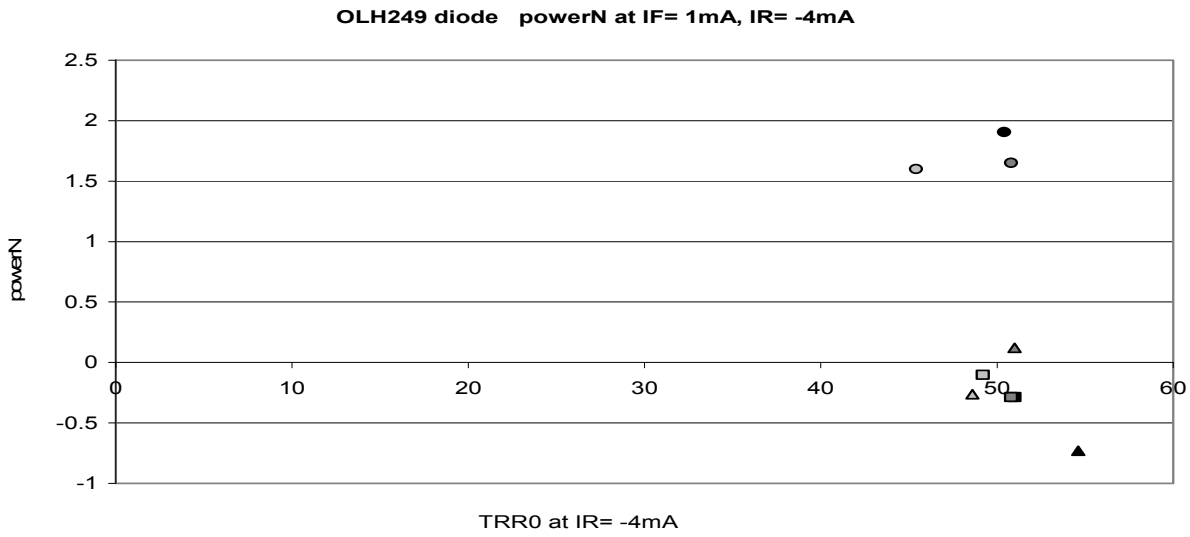
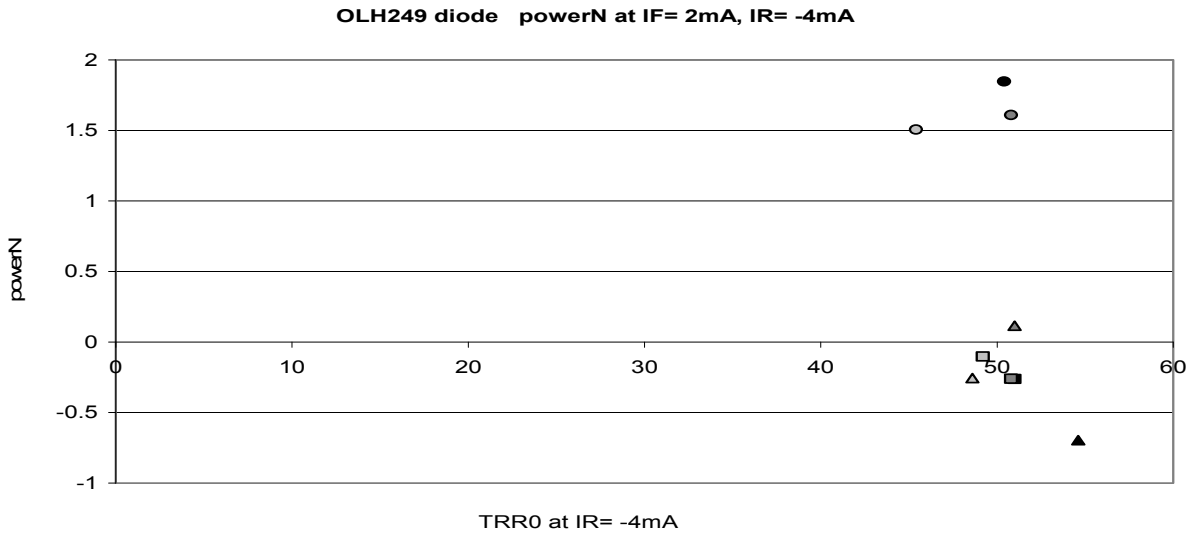
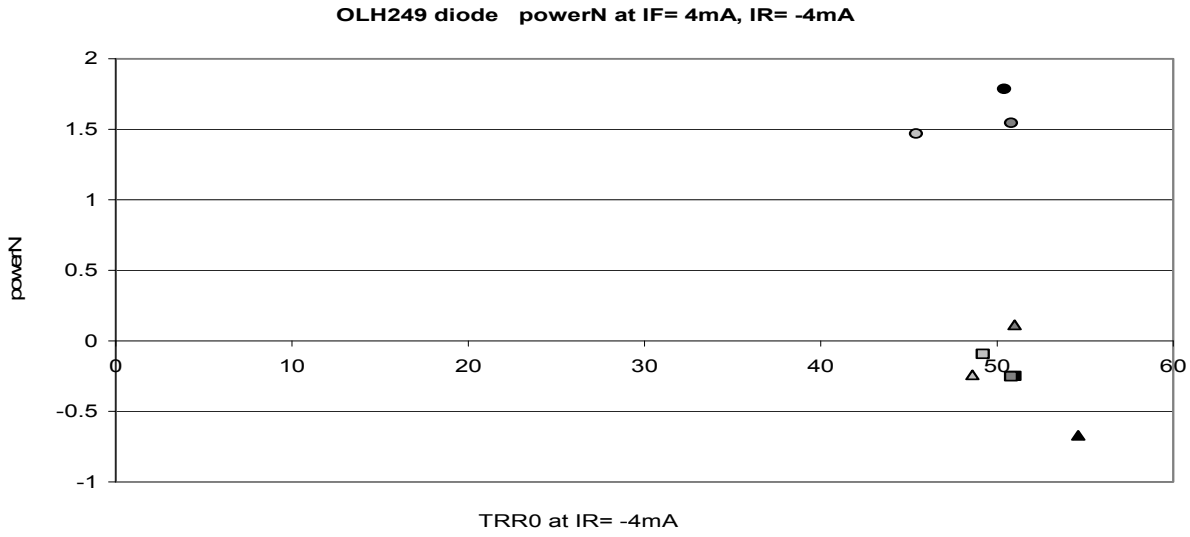
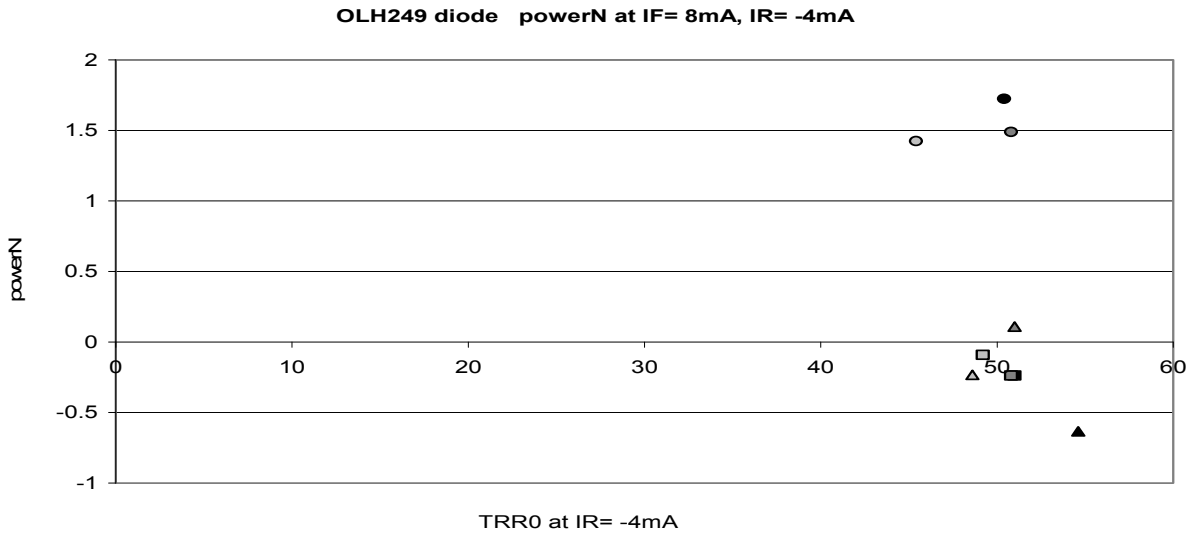

OLH249 diode powerN at IF= 10mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
74
76
78
80
82
84
86
88
90
TRR0 at IR= -2mA

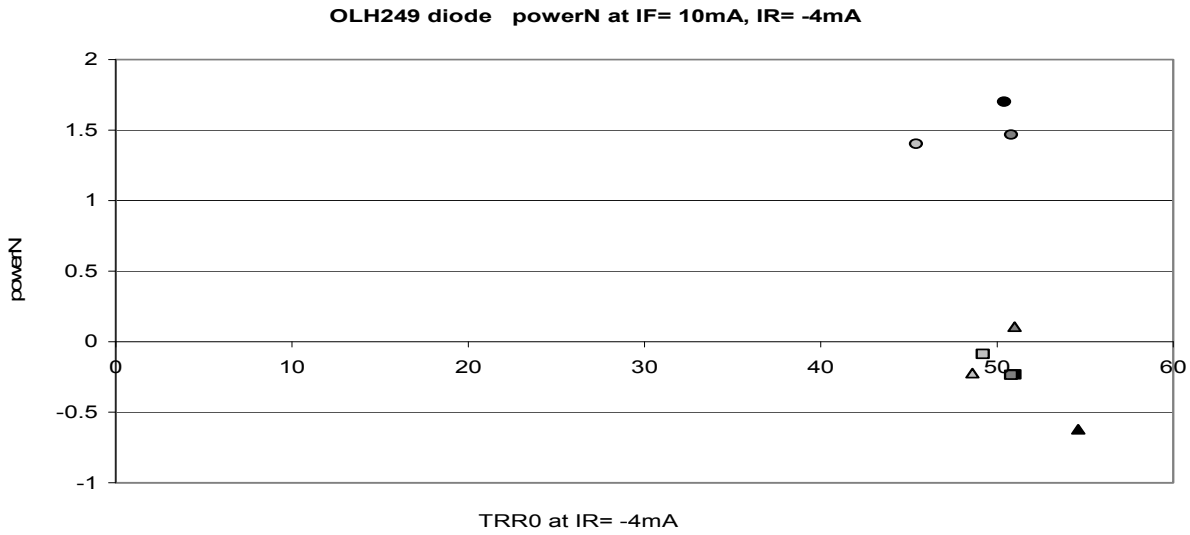
Fig. 13-171: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA





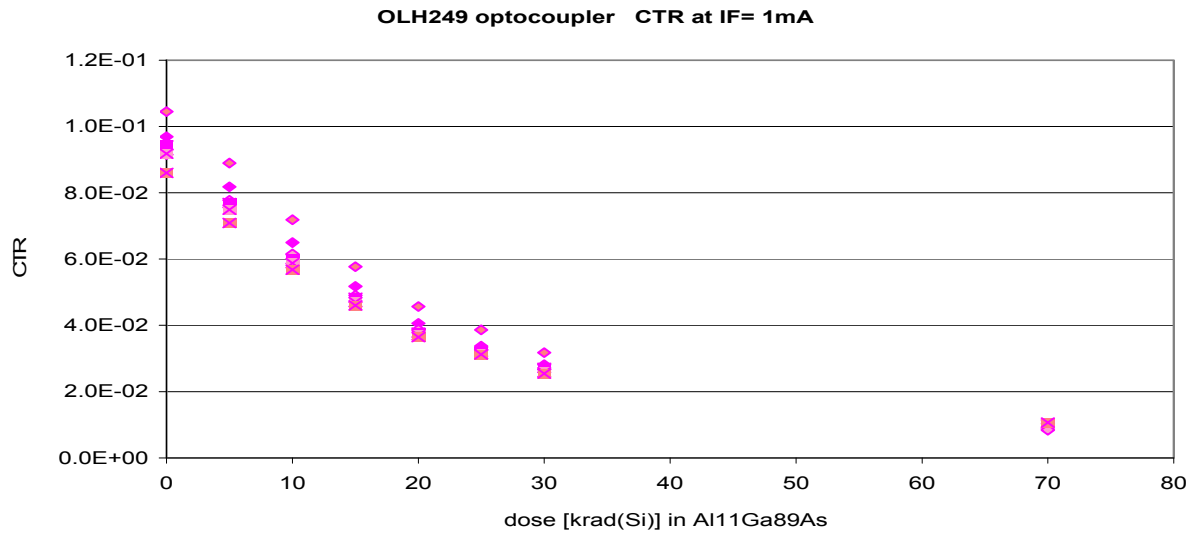


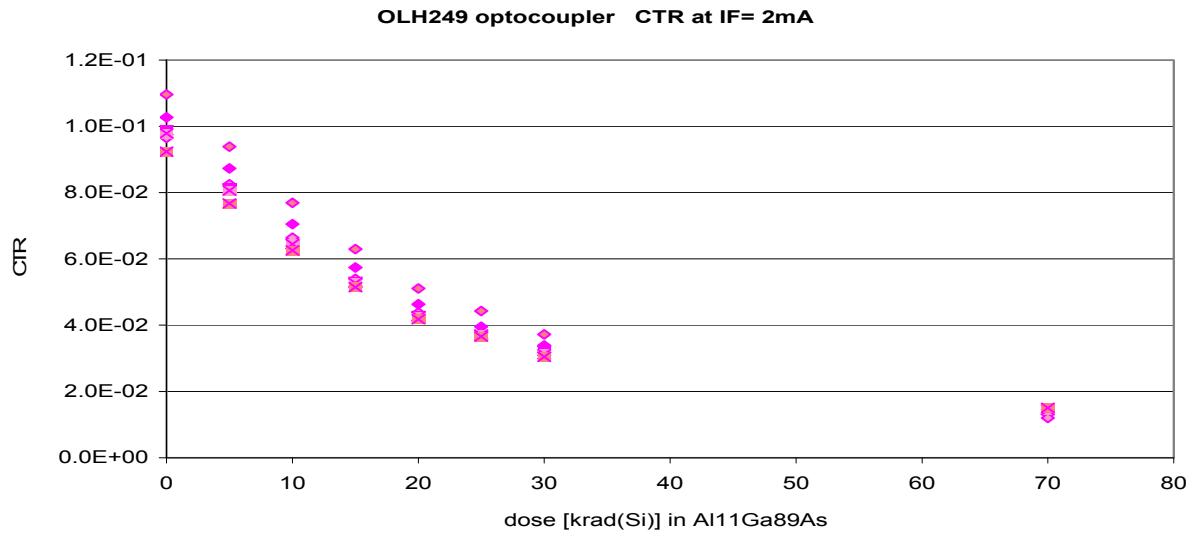

OLH249 diode powerN at IF= 8mA, IR= -4mA
powerN
2
1.5
1
0.5
0
-0.5
-1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

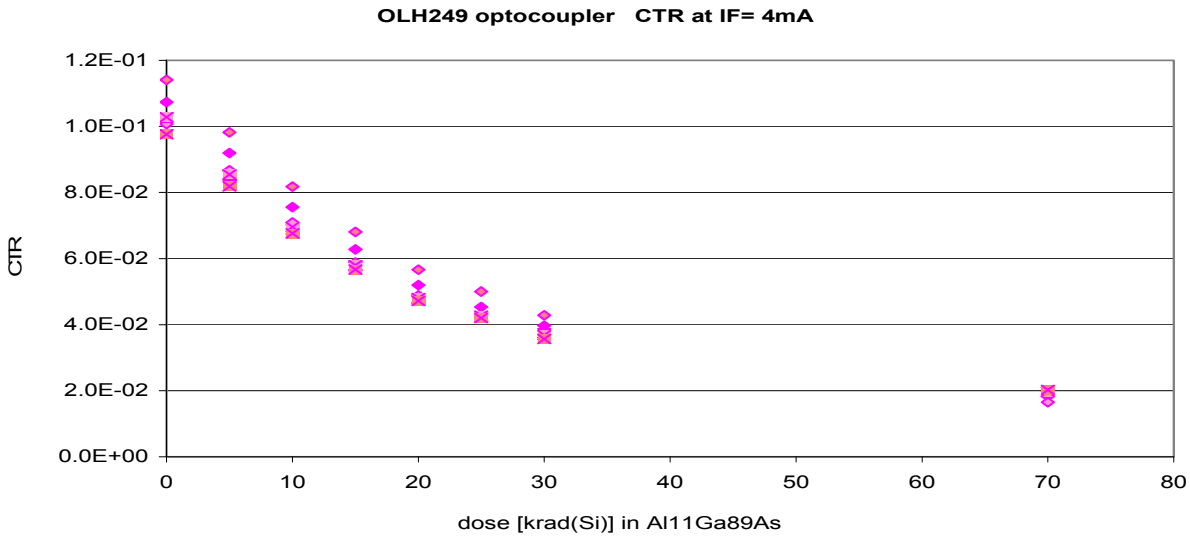

OLH249 diode powerN at IF= 10mA, IR= -4mA
powerN
2
1.5
1
0.5
0
-0.5
-1
0
10
20
30
40
50
60
TRR0 at IR= -4mA

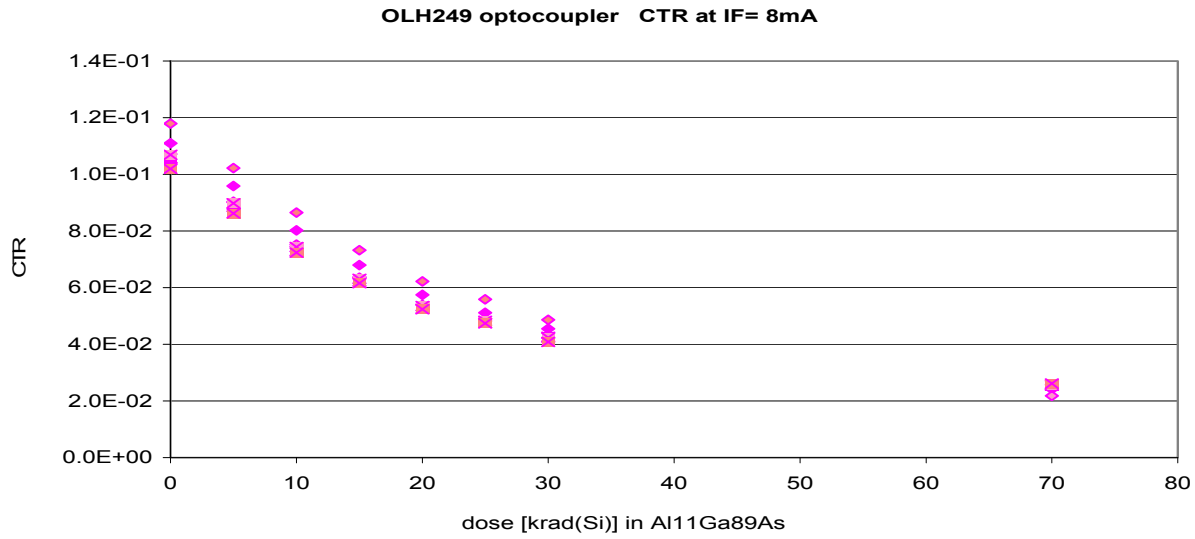
13.3 GAMMA IRRADIATION

Fig. 13-172: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

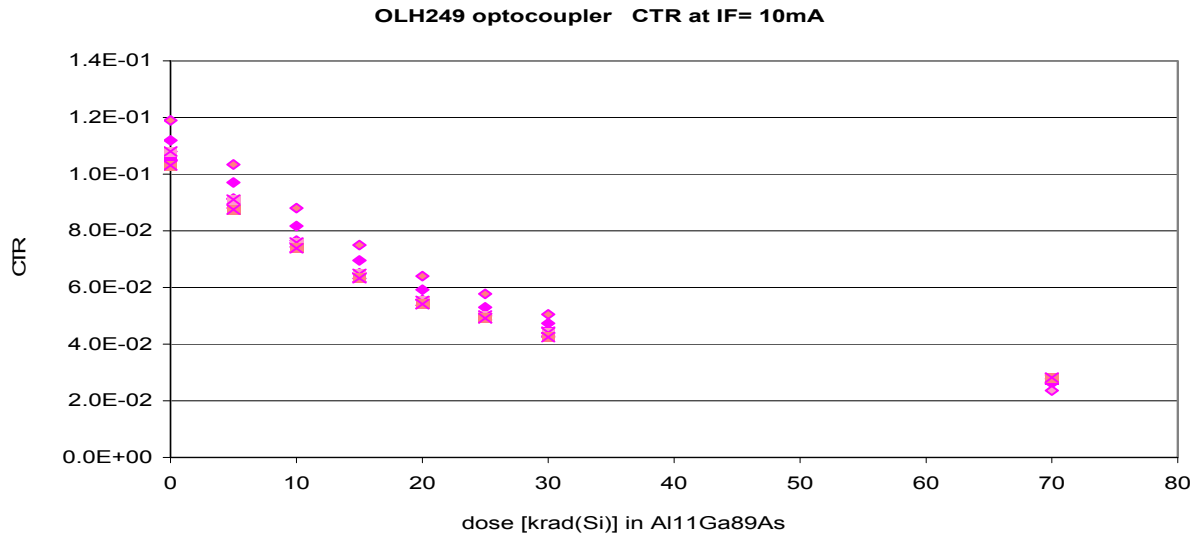
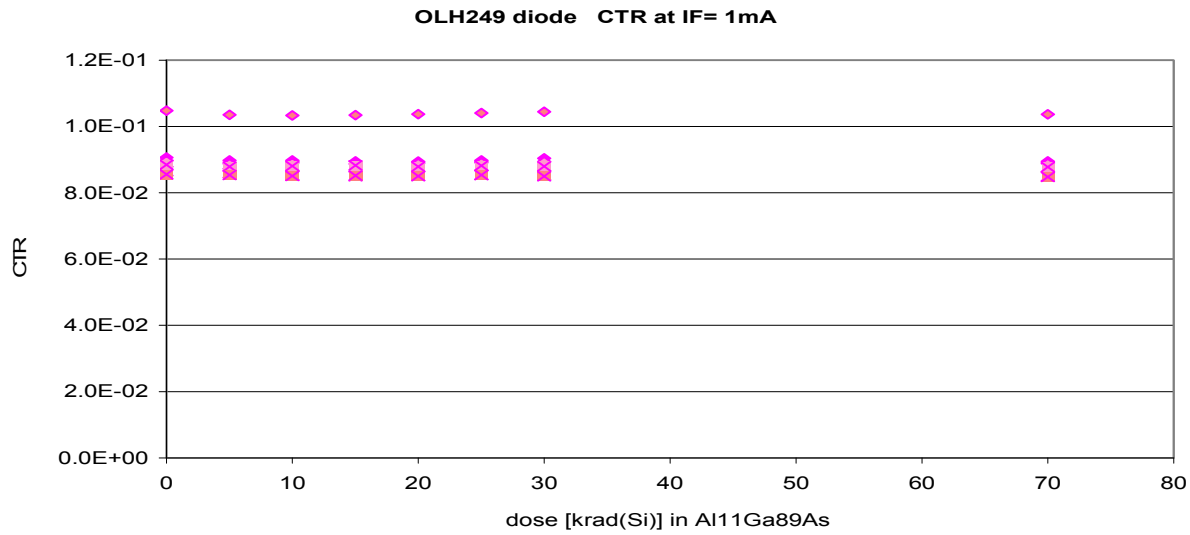
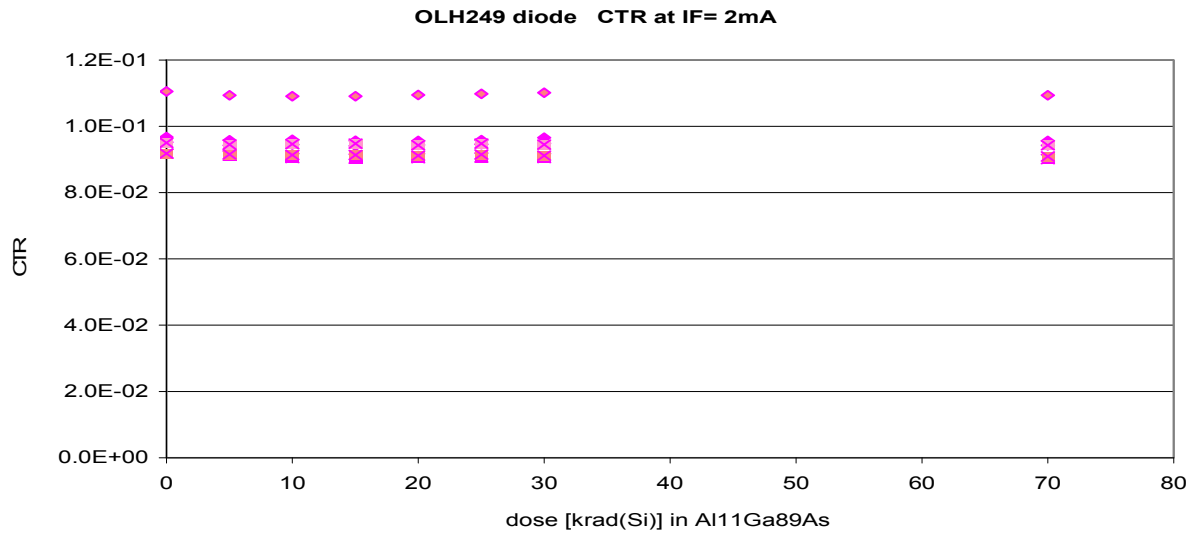
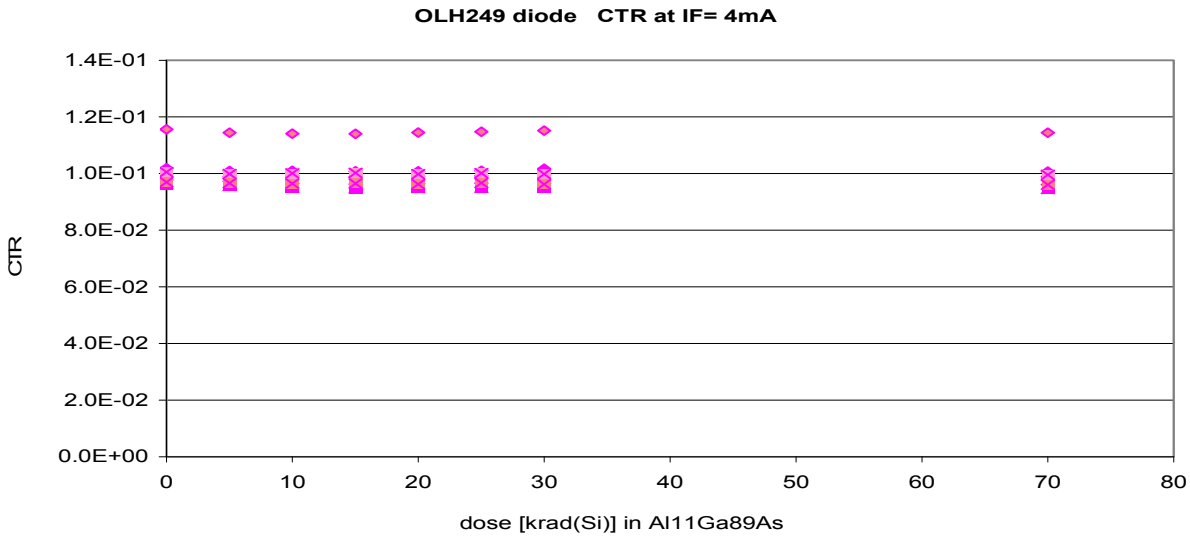
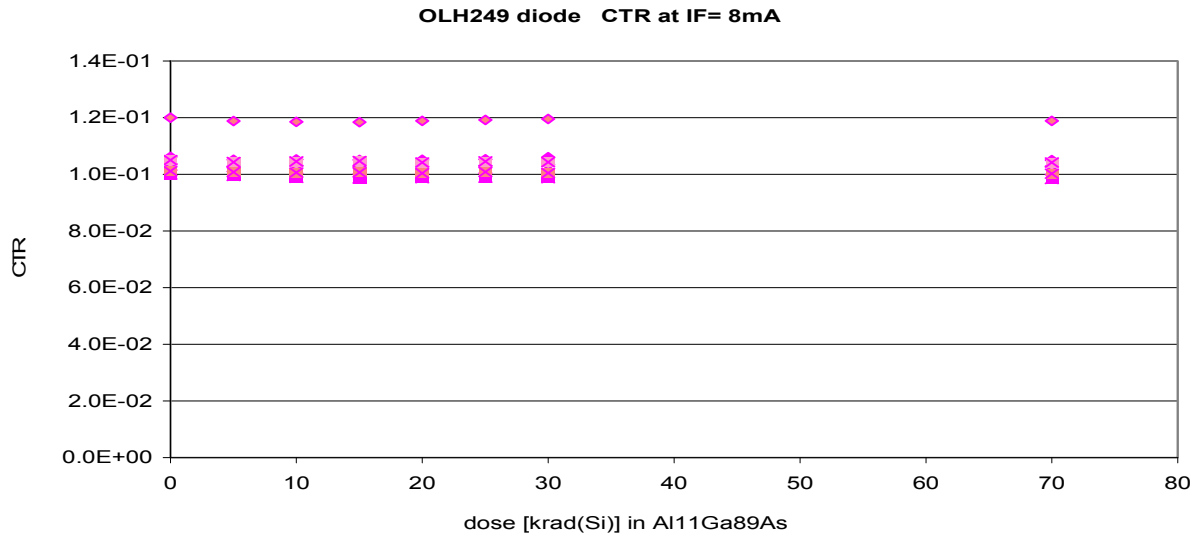

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-173: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

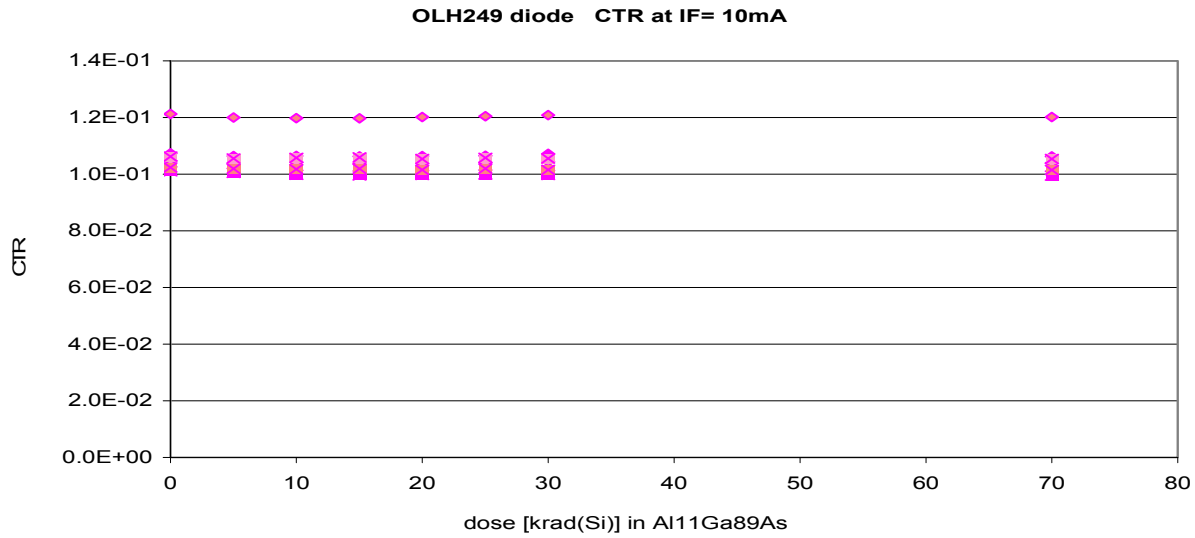
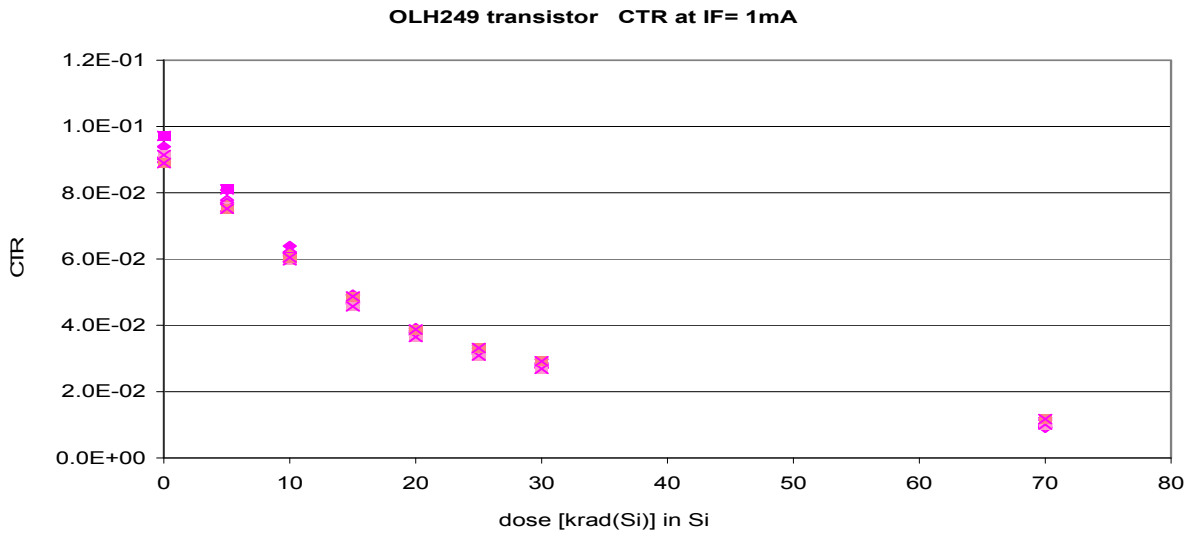
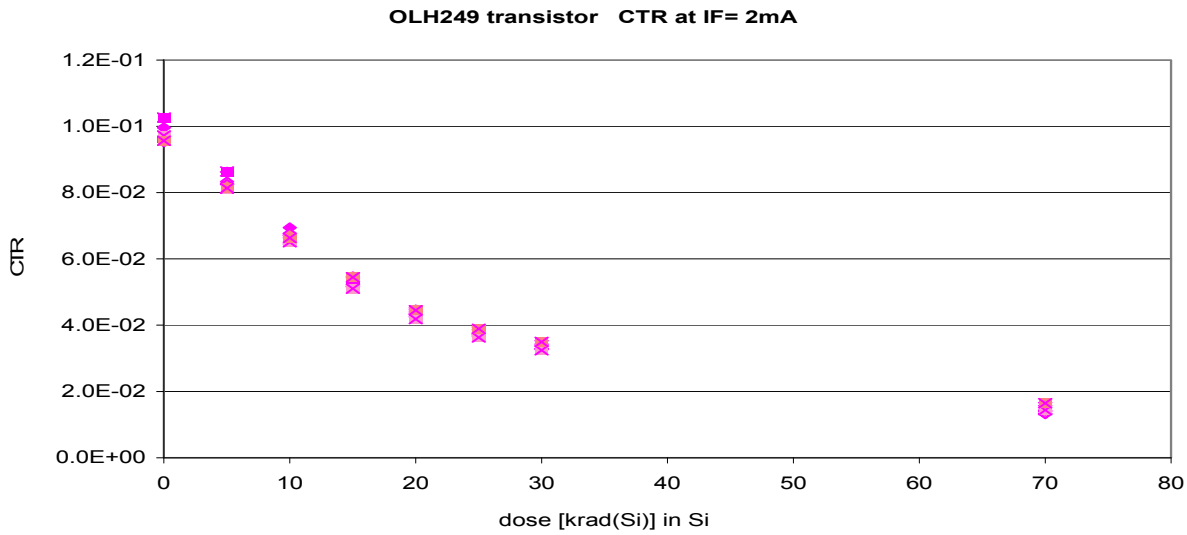
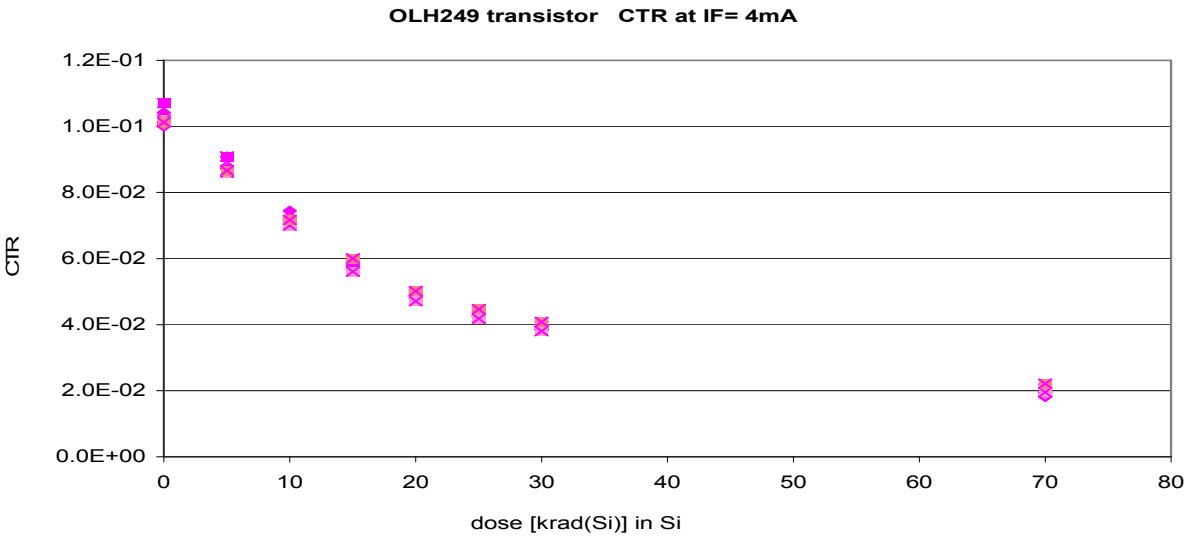
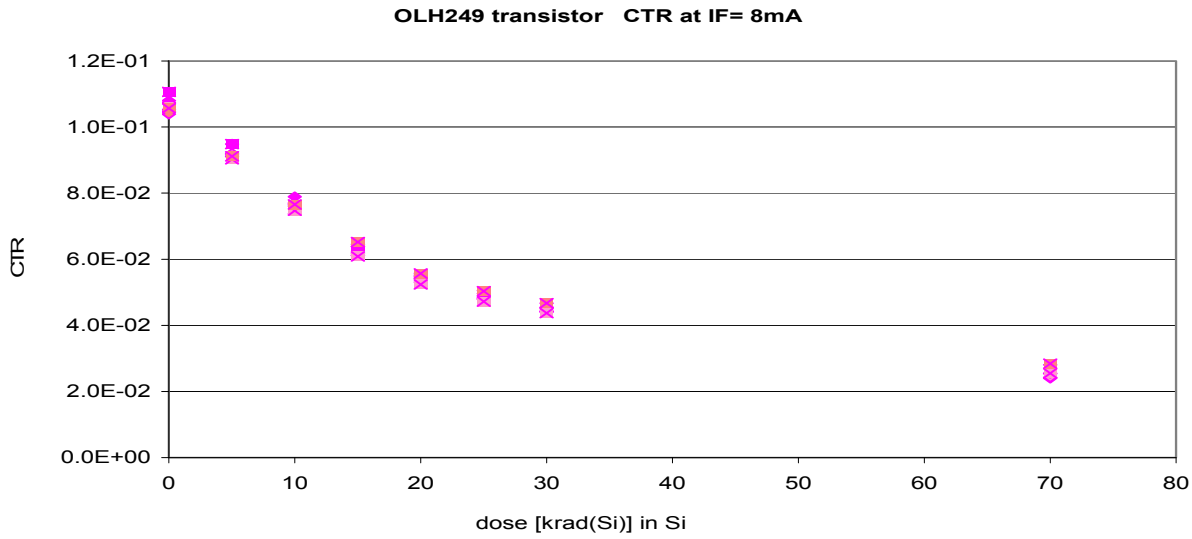

OLH249 diode CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-174: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

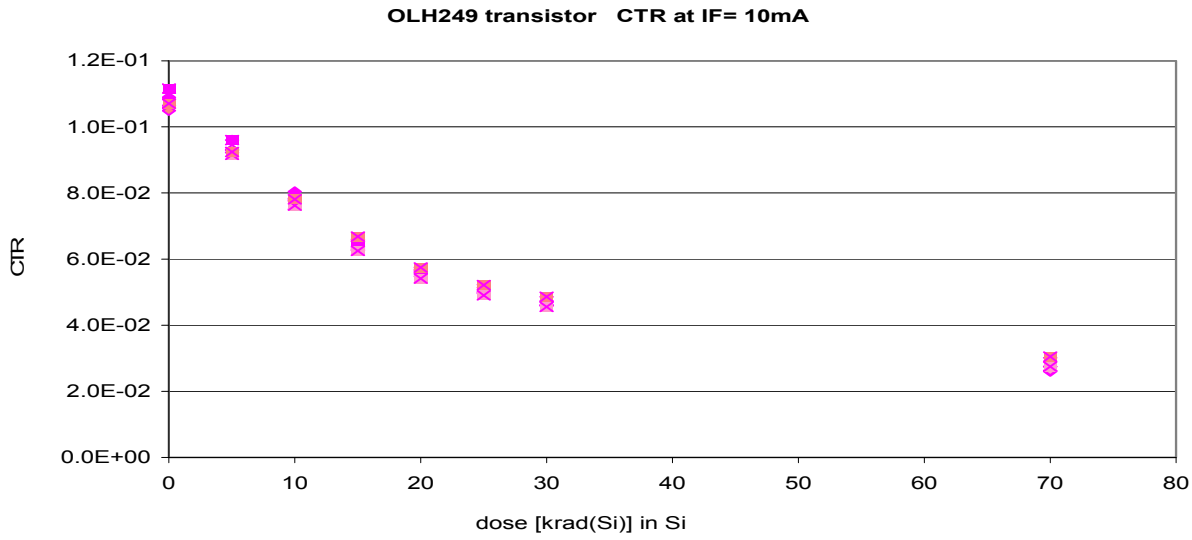
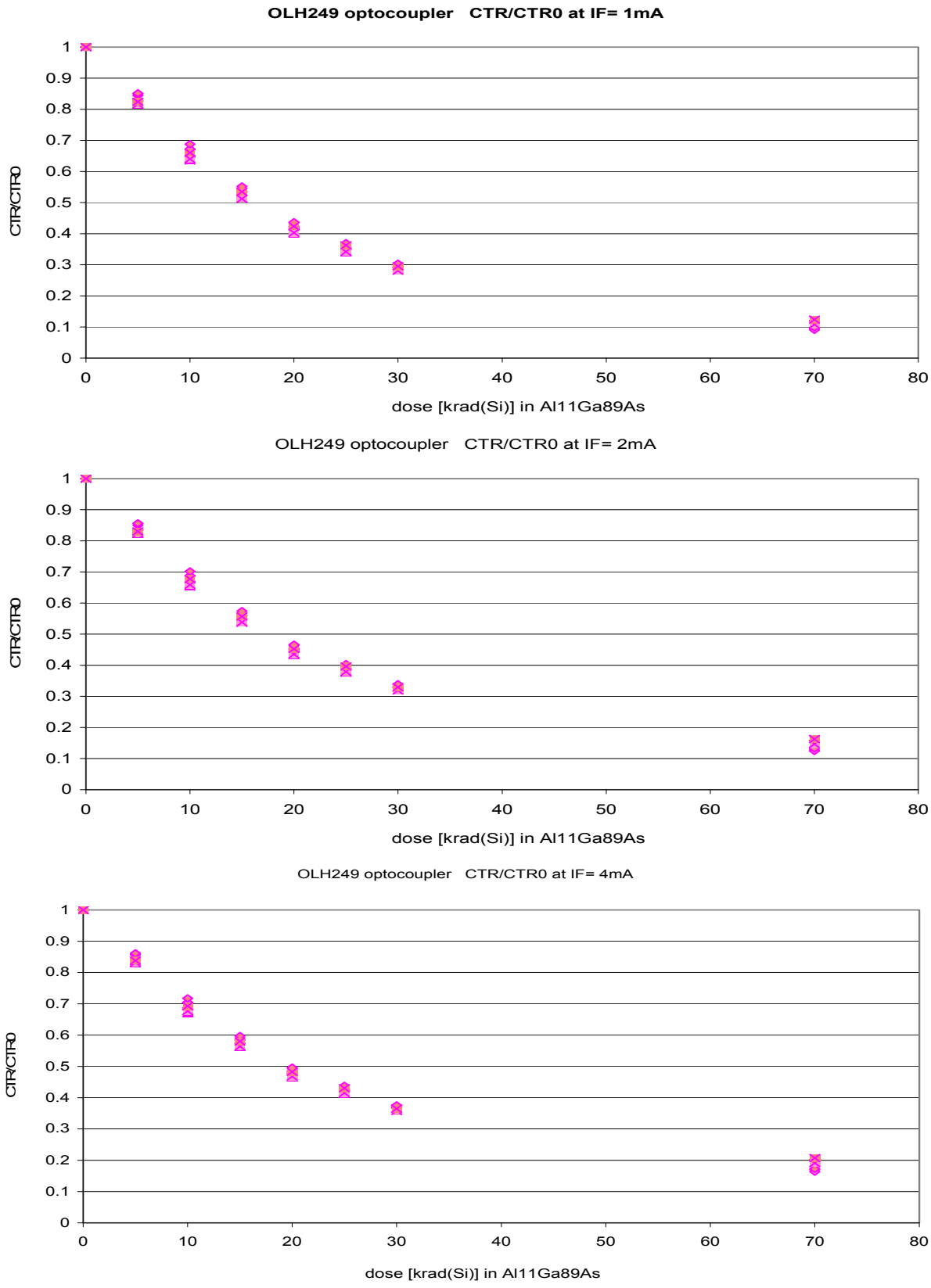
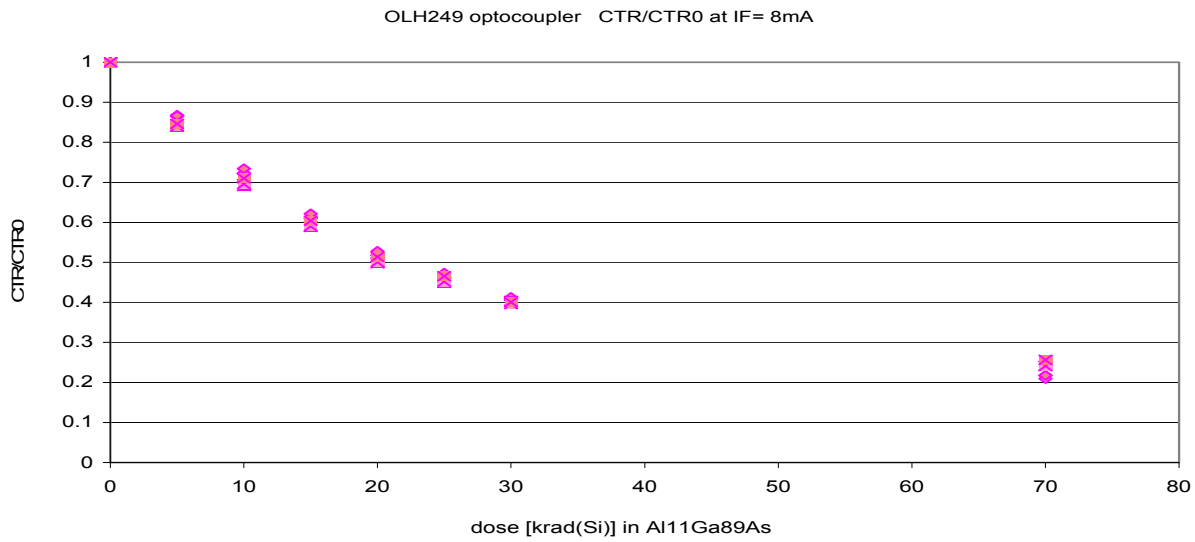

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 13-175: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose




OLH249 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

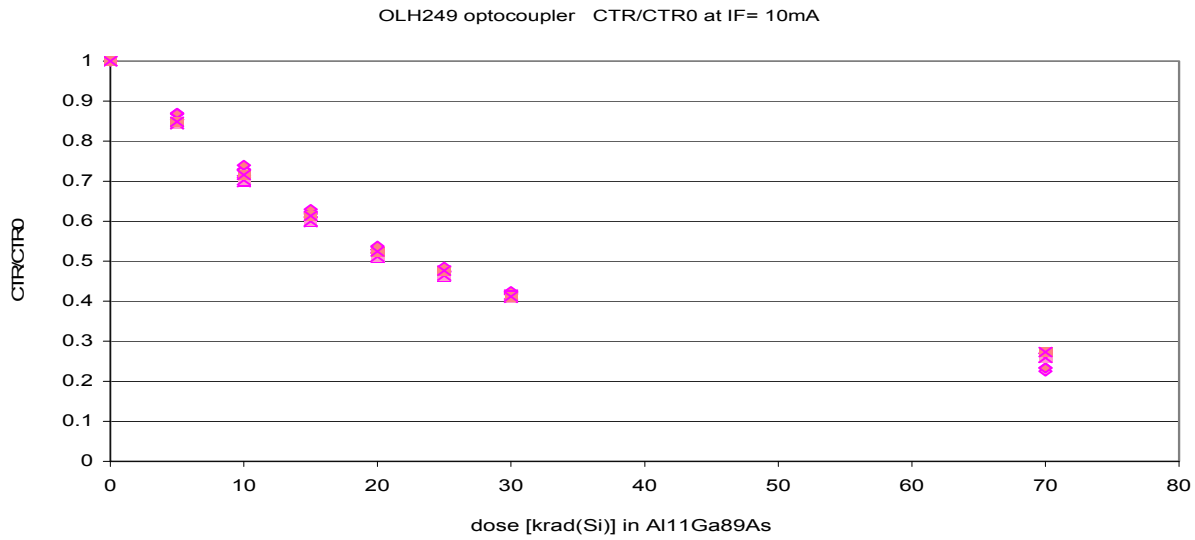
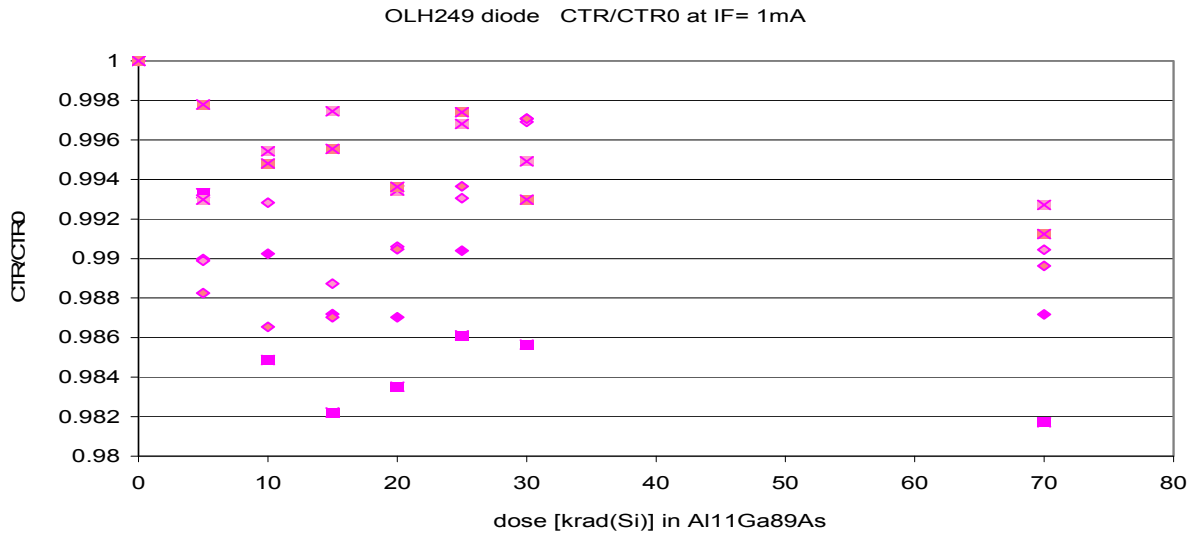
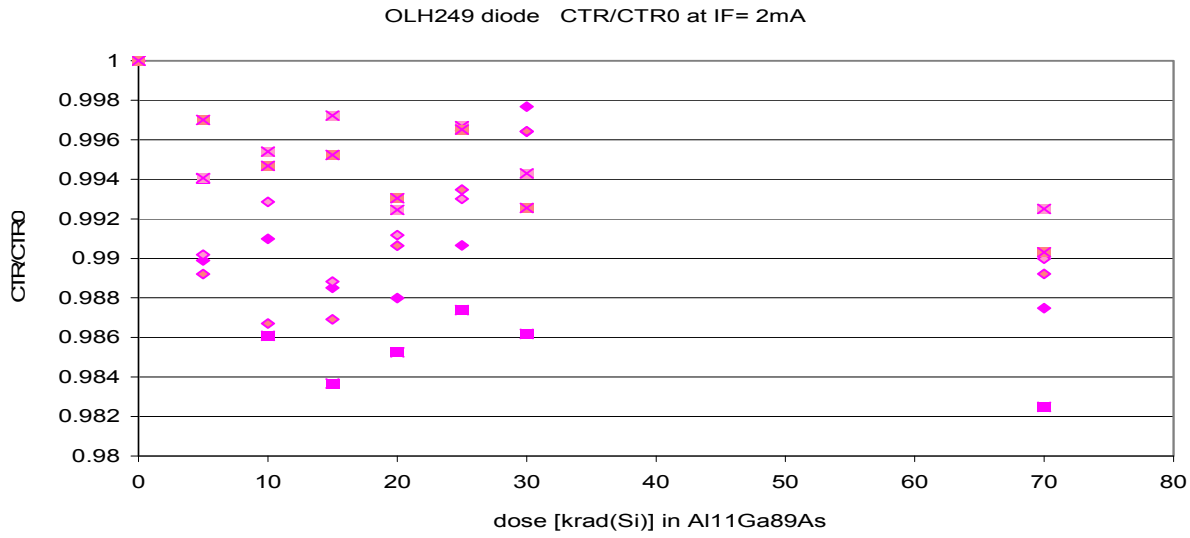
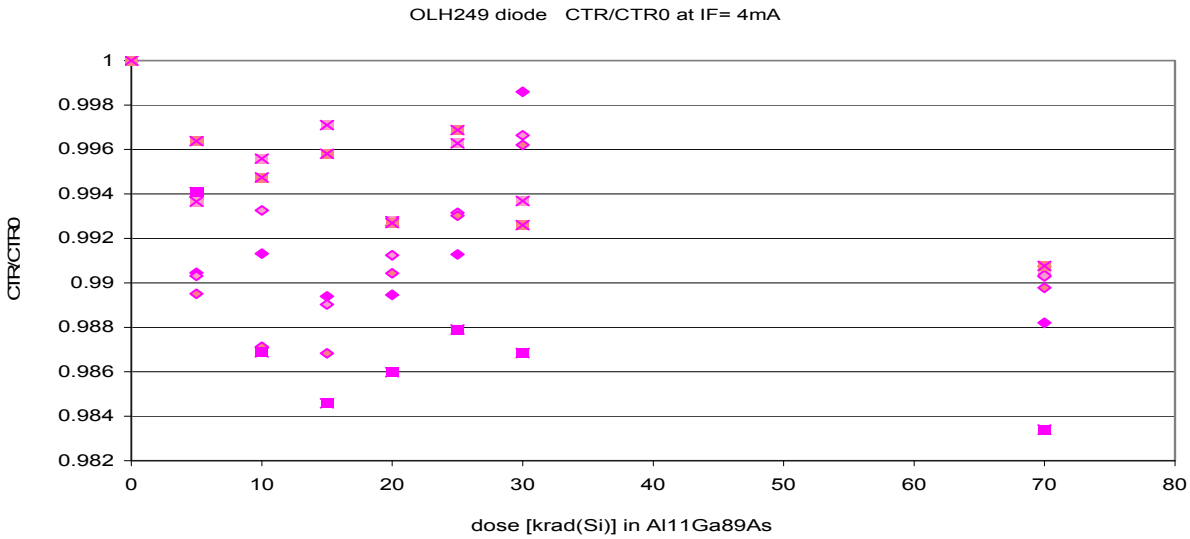
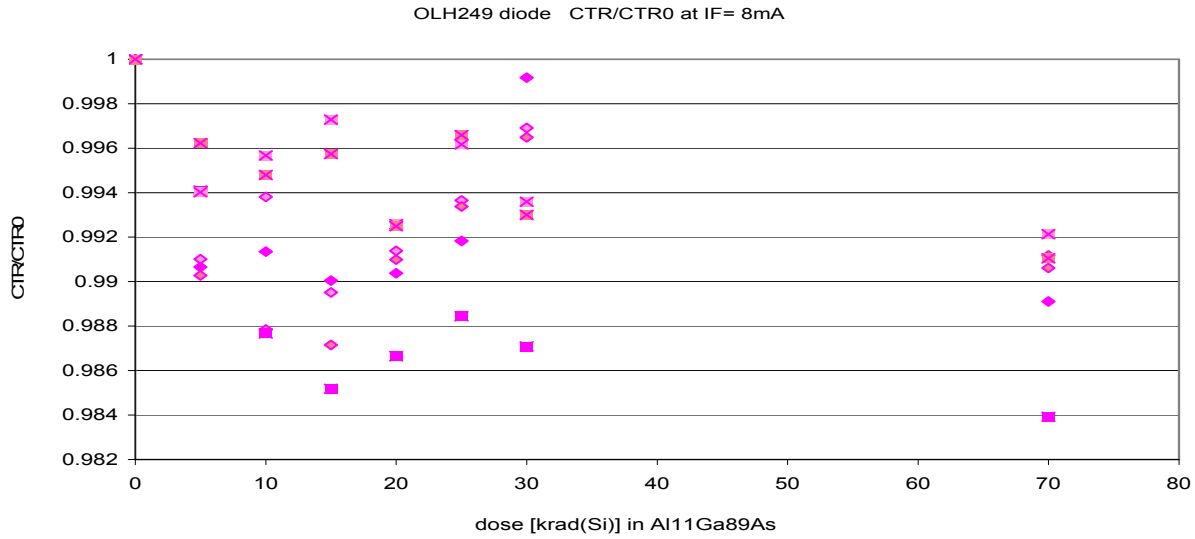

OLH249 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-176: OLH249 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

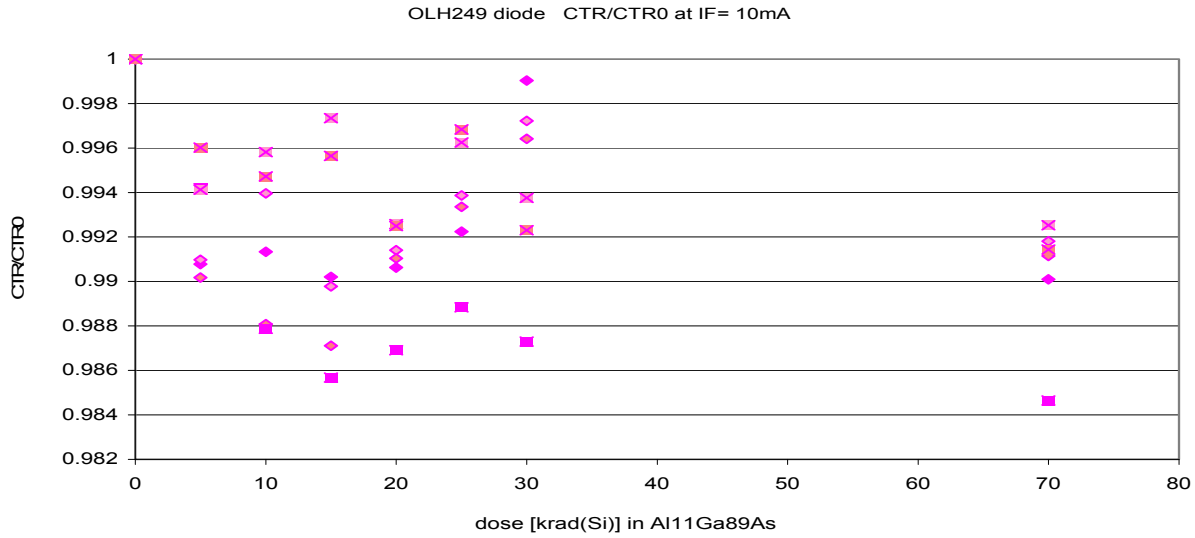
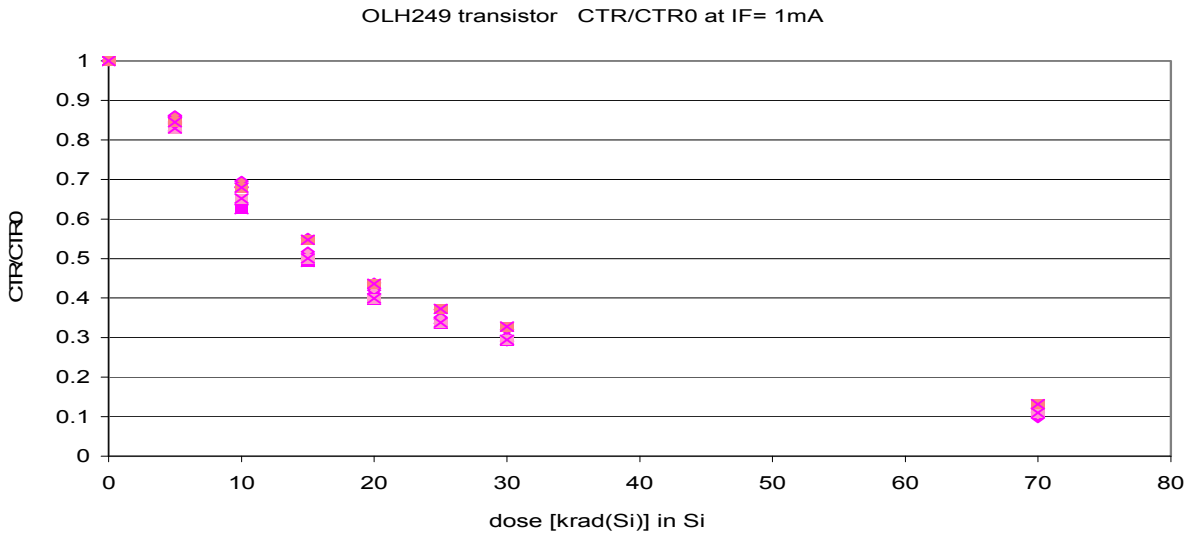
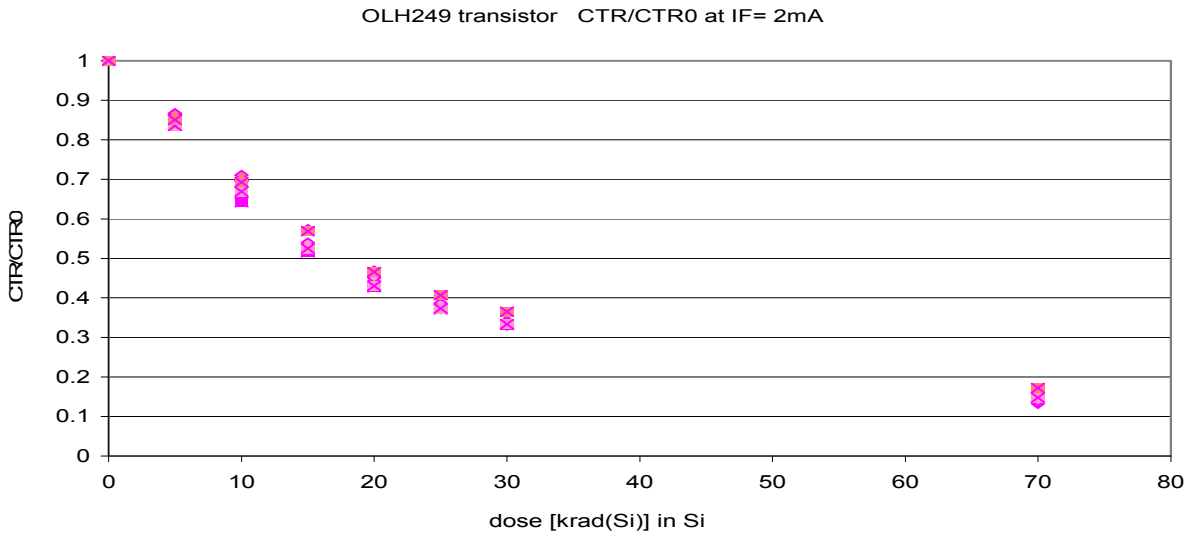
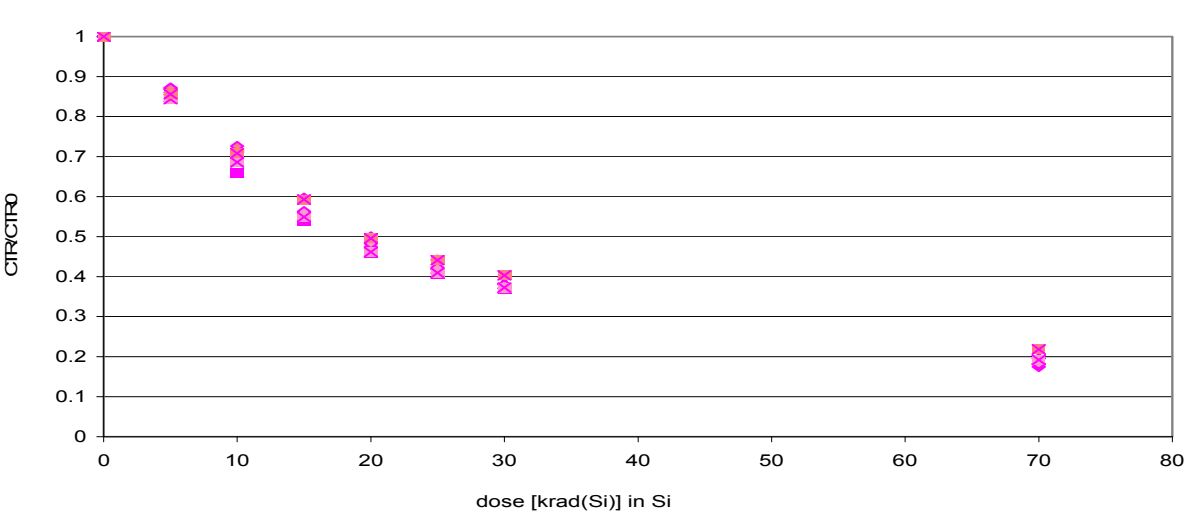
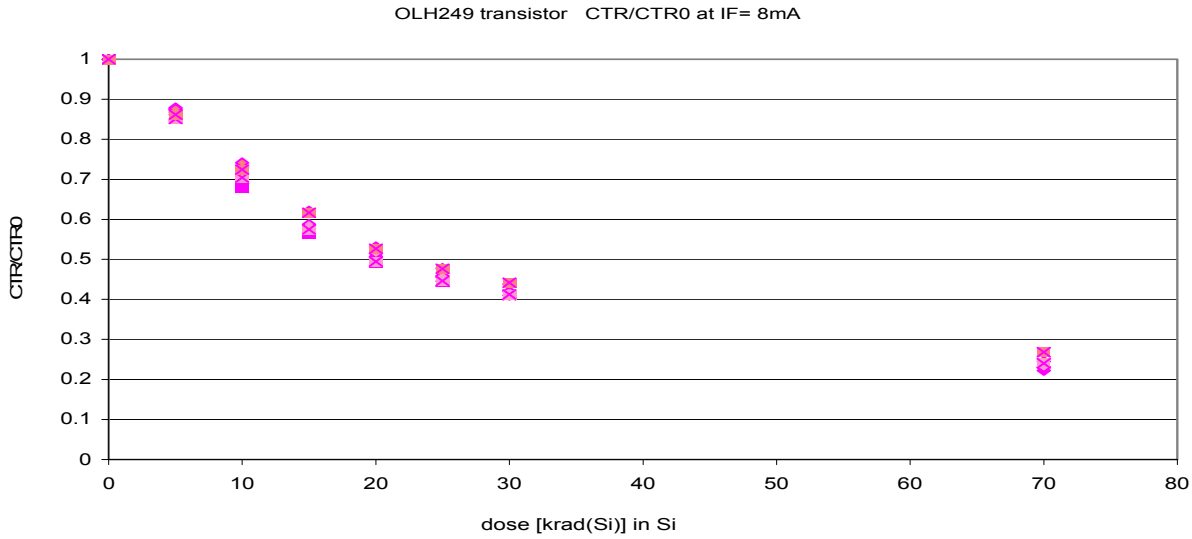

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-177: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

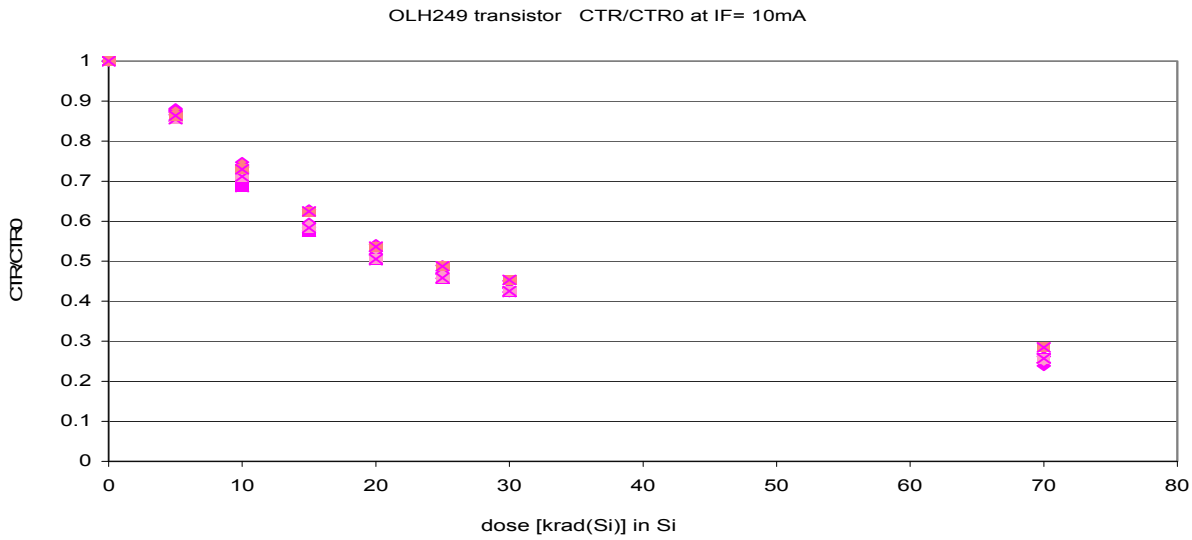
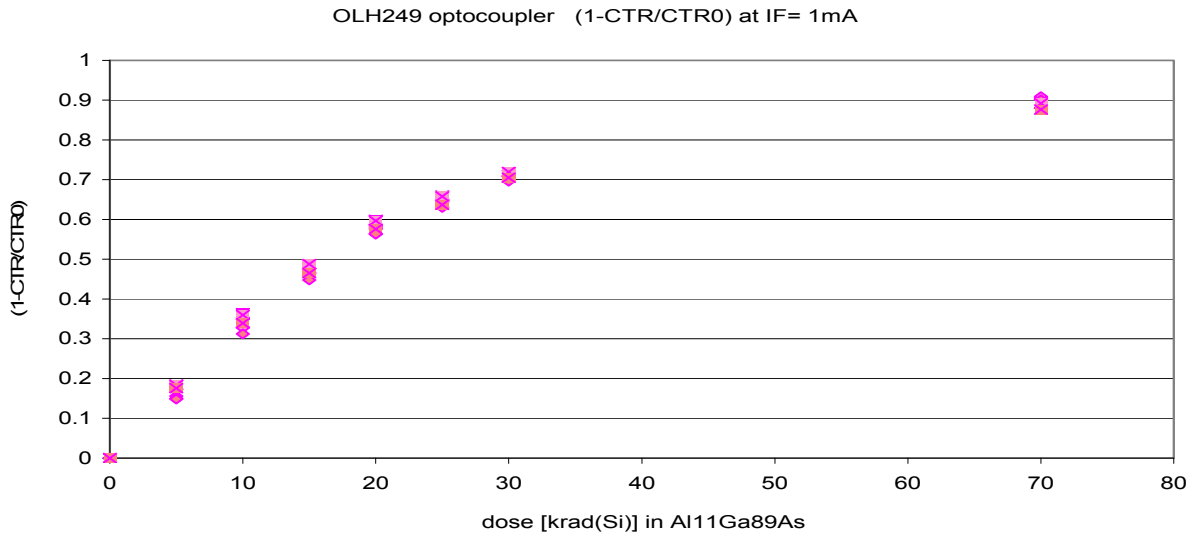
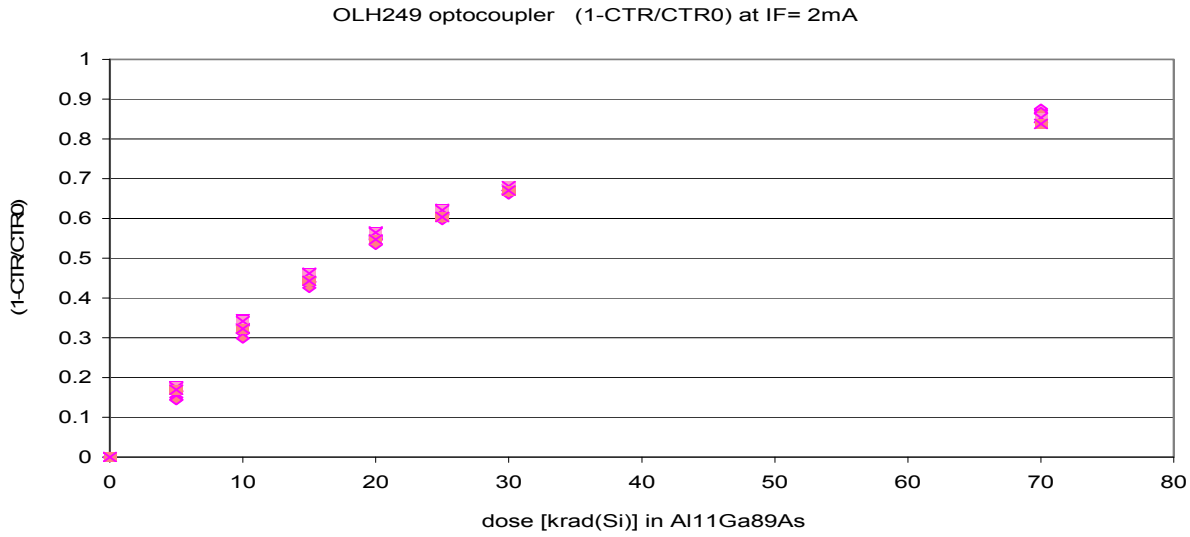
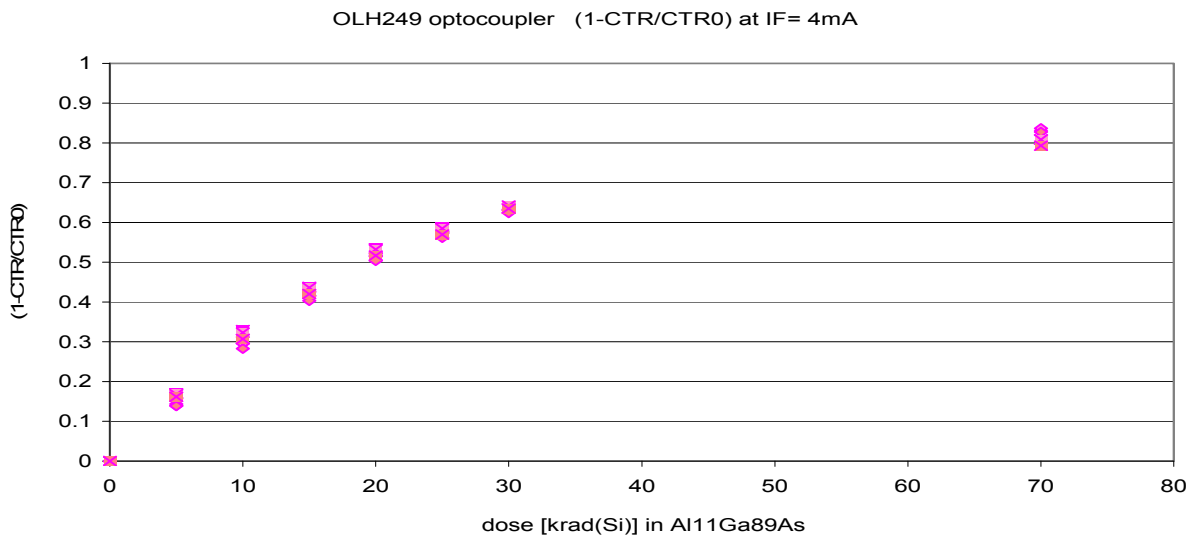
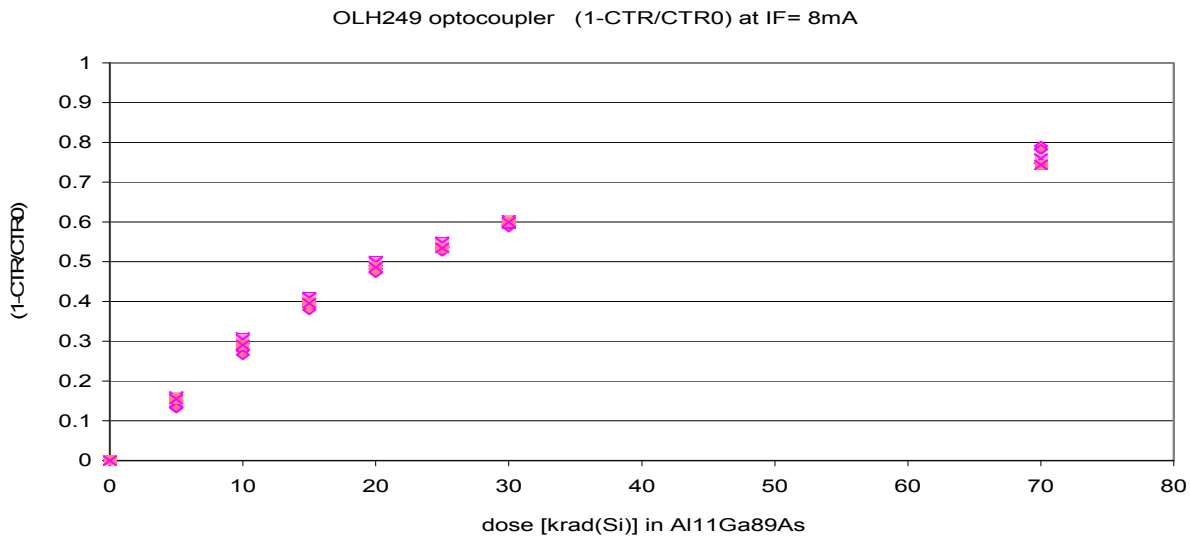

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 13-178: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

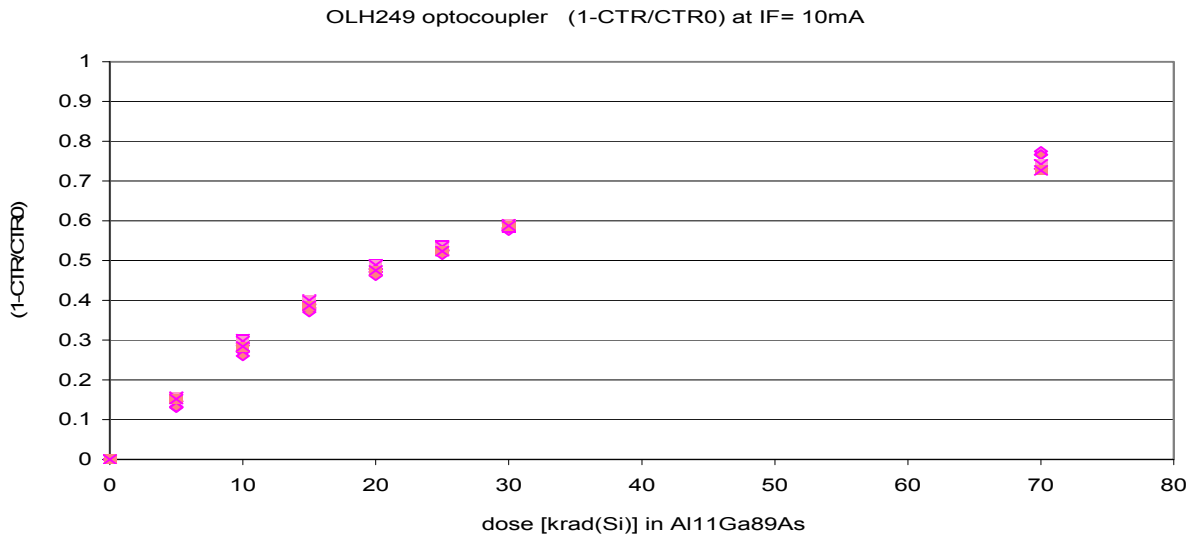
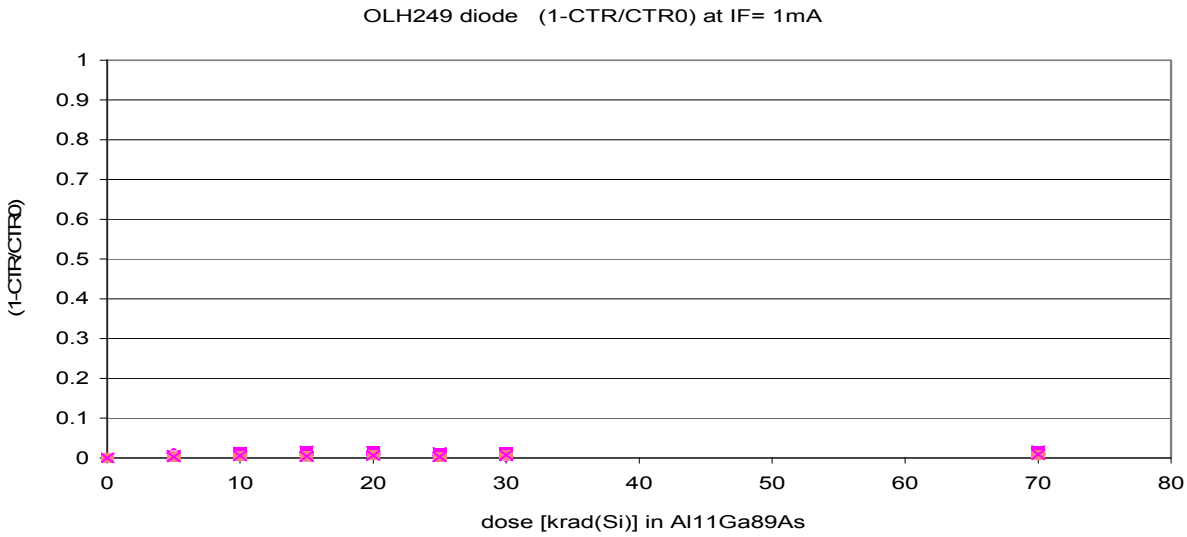
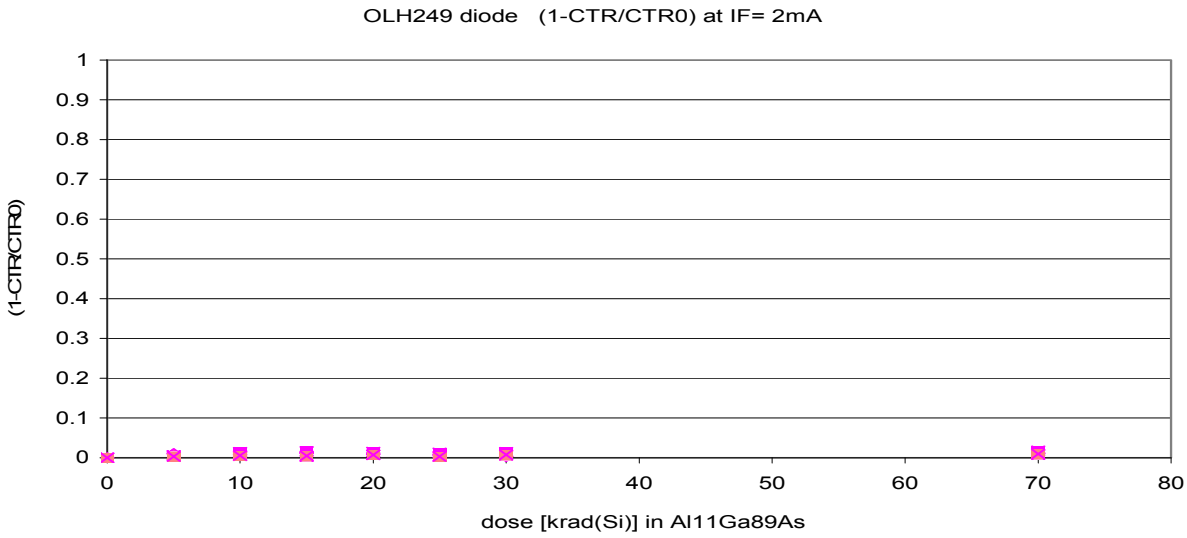
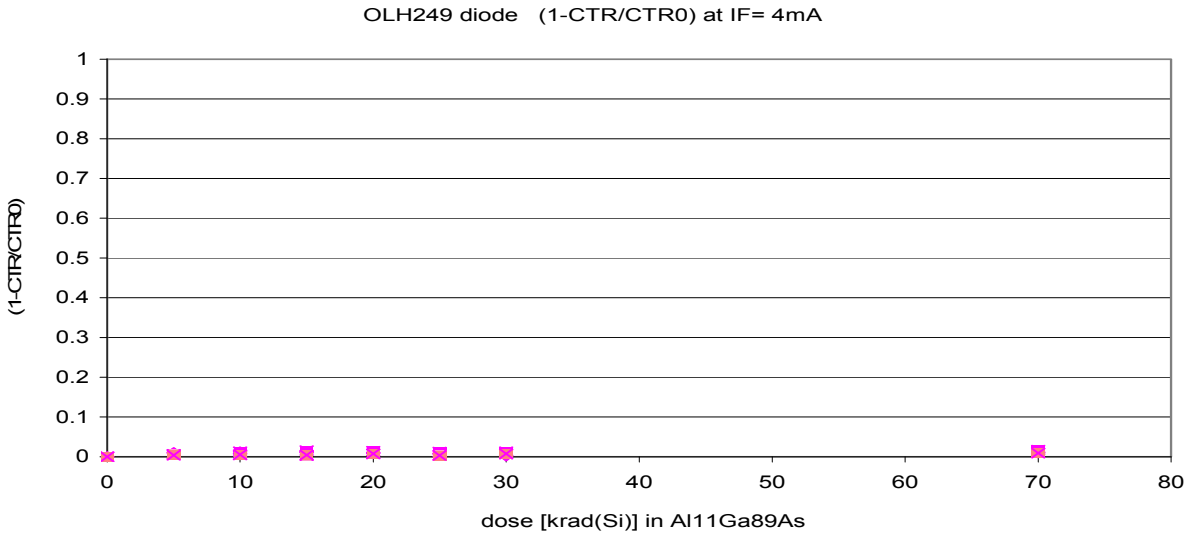
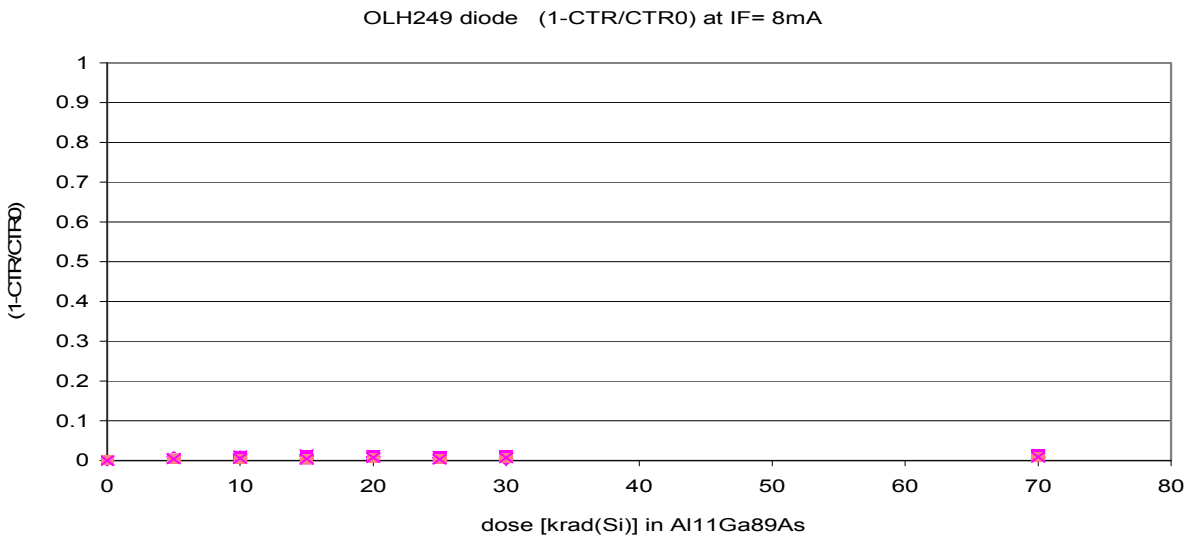

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-179: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

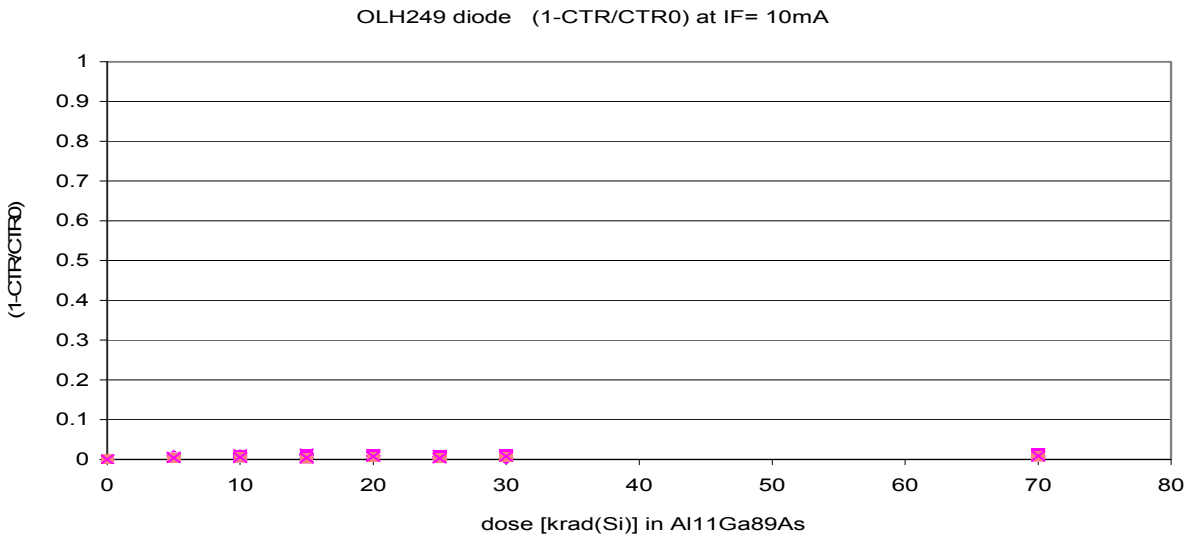
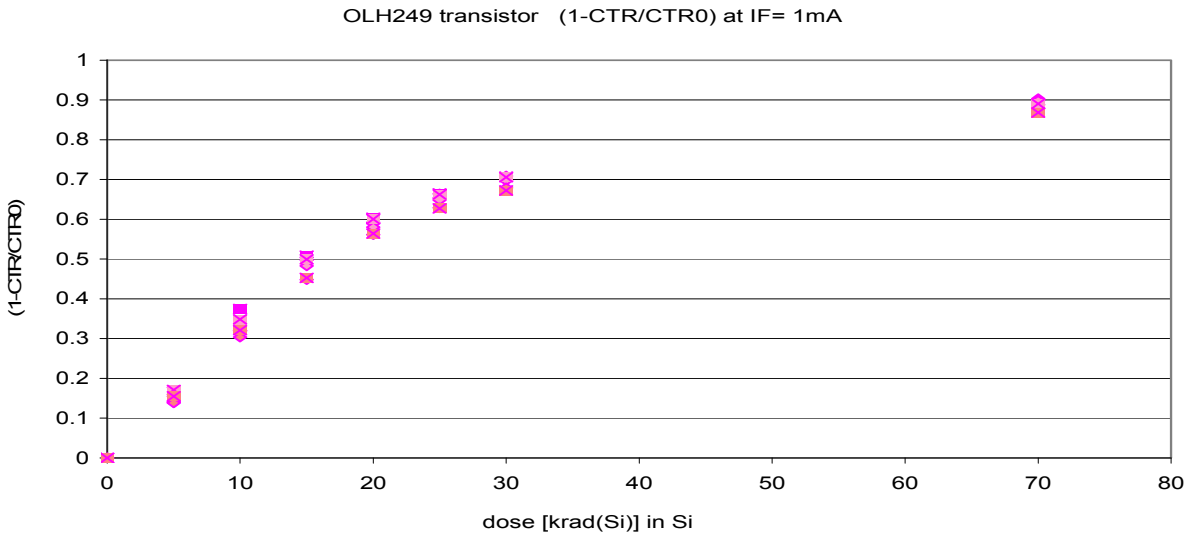
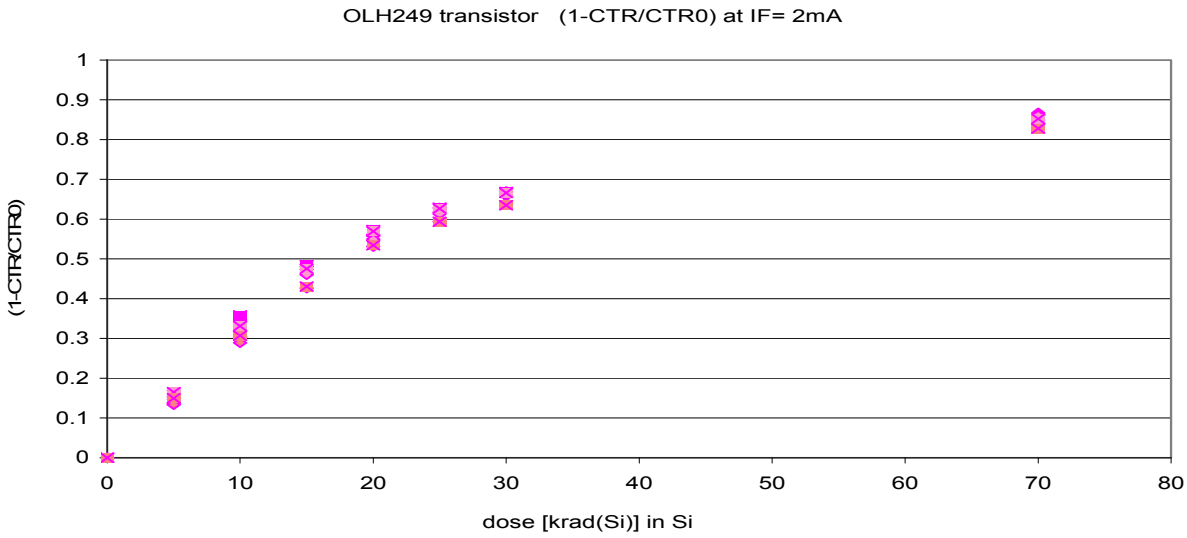
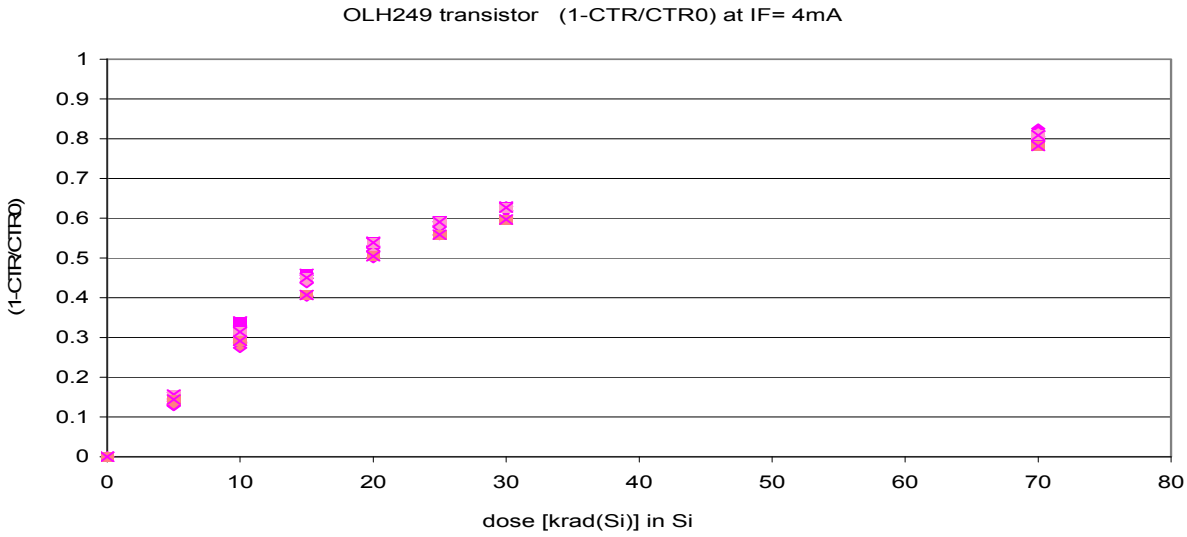
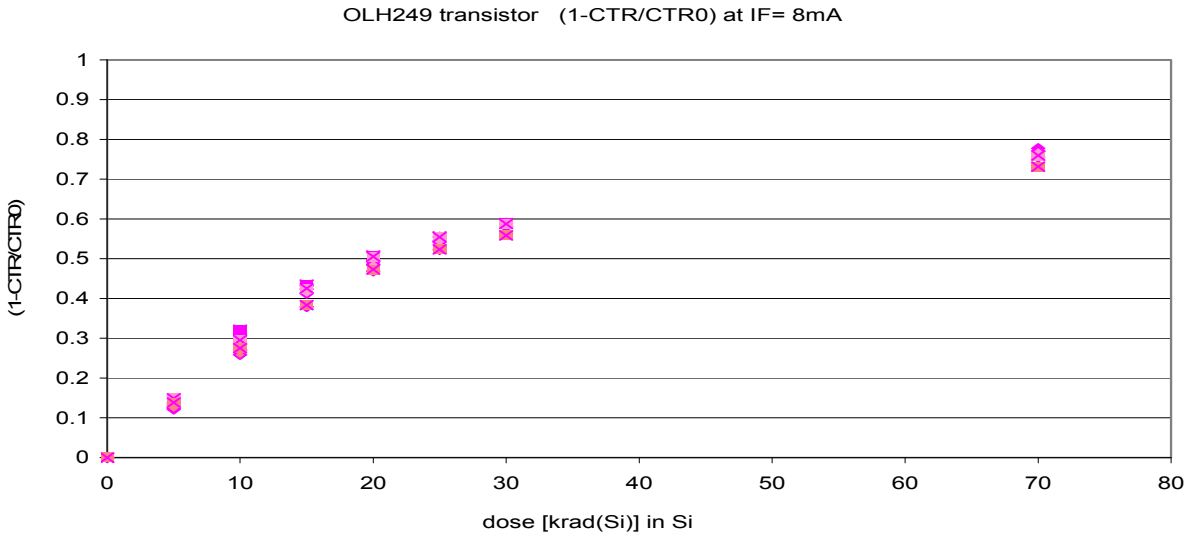

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al11Ga89As

Fig. 13-180: OLH249 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

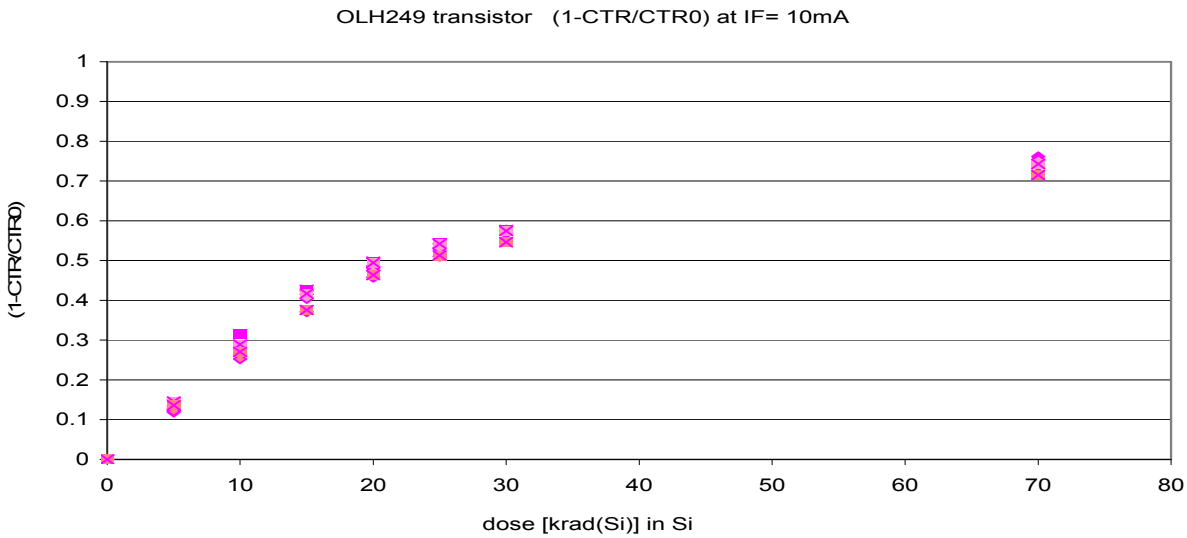
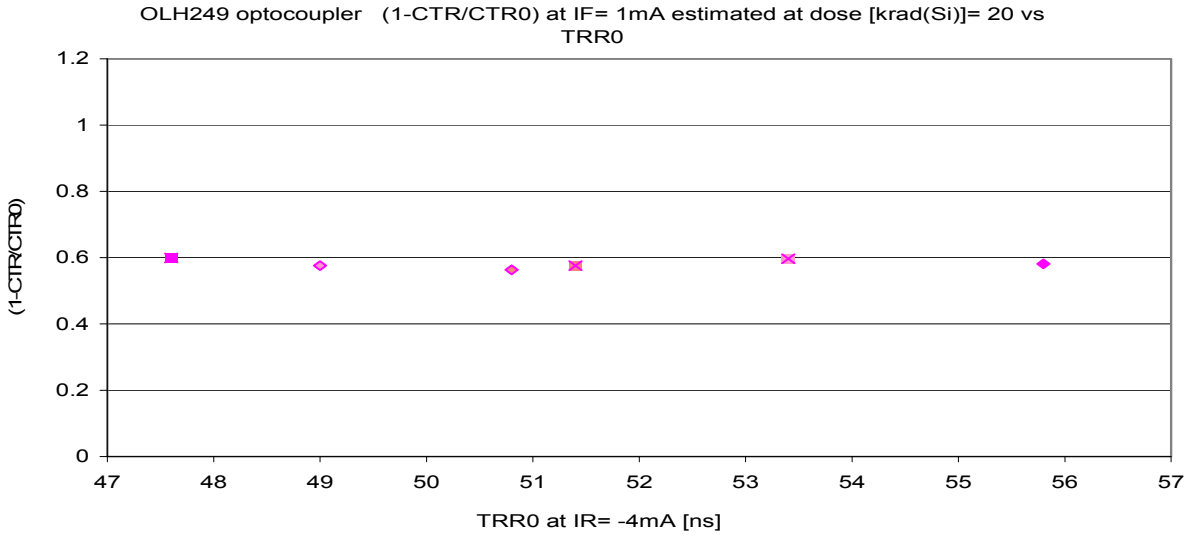
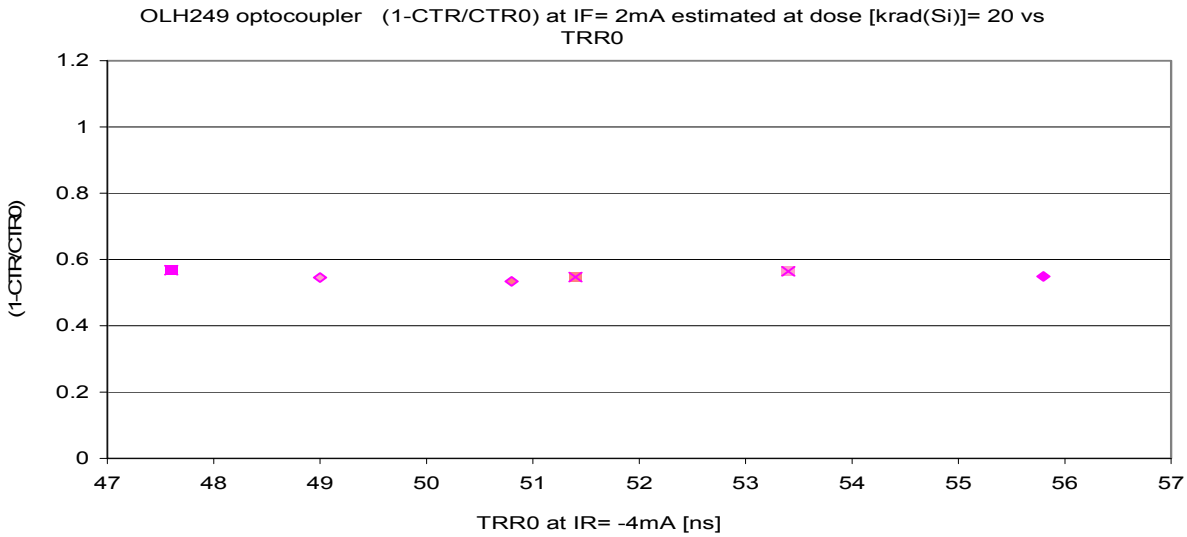
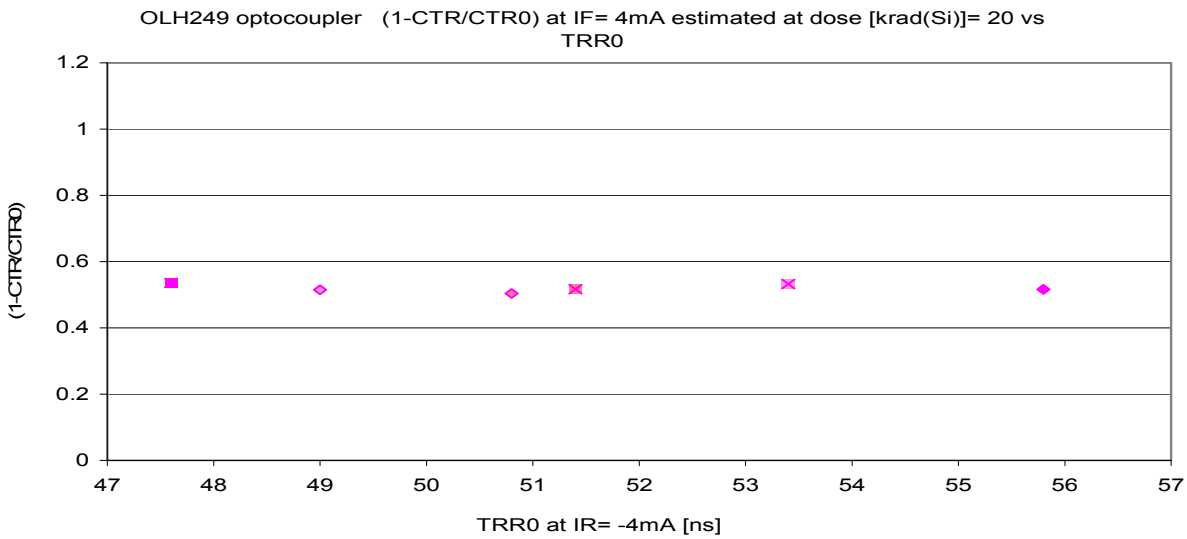
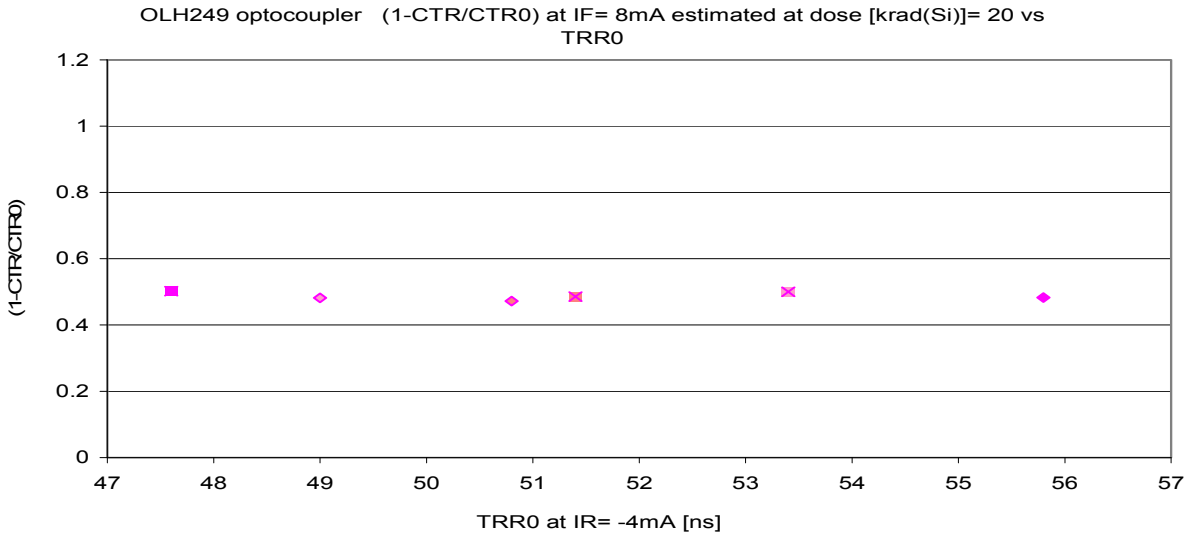

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 13-181: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

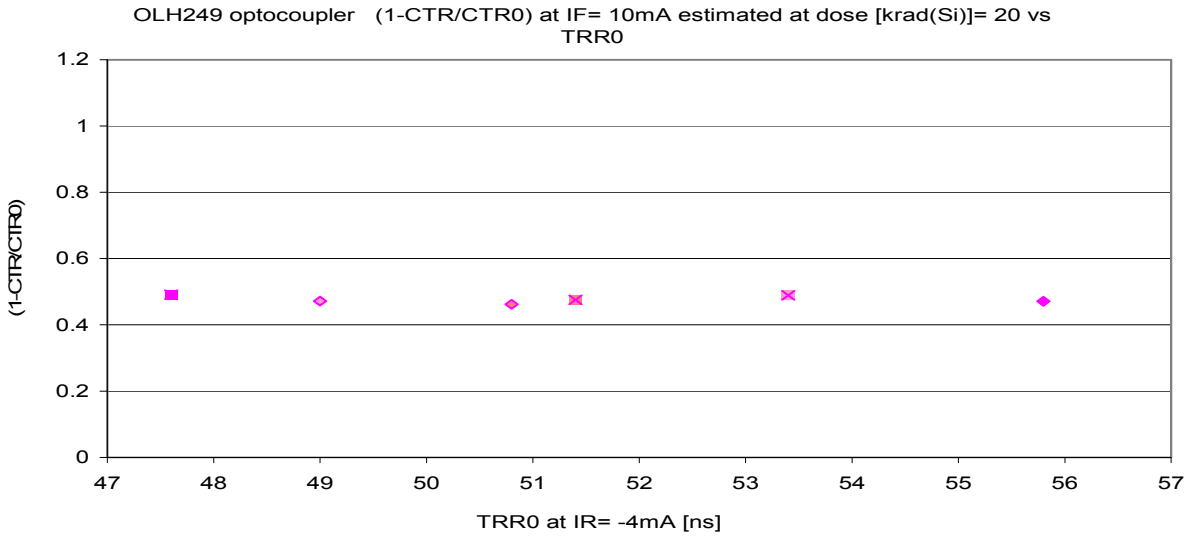
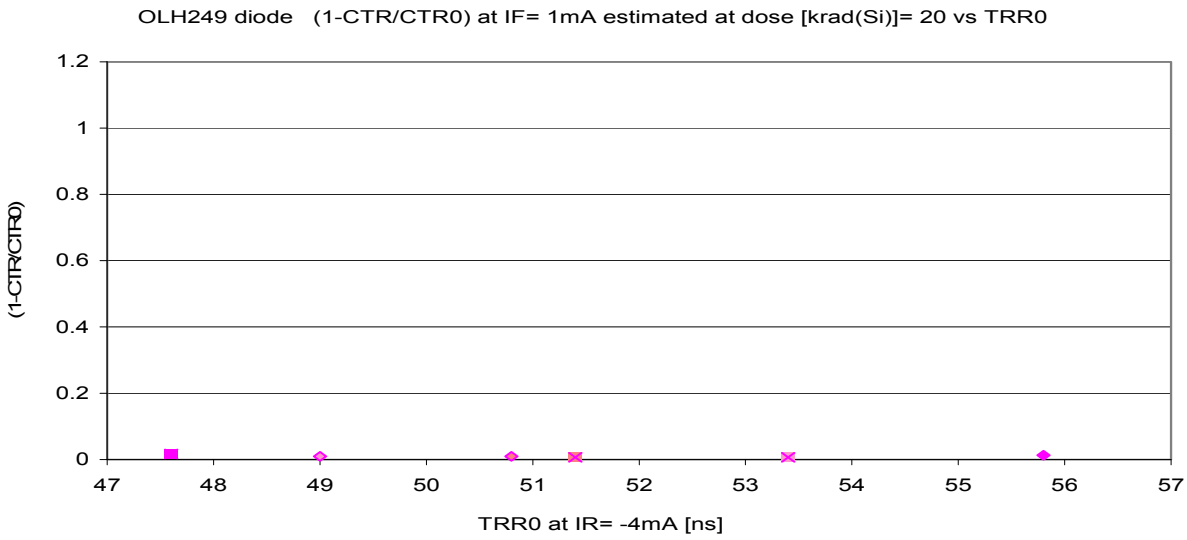
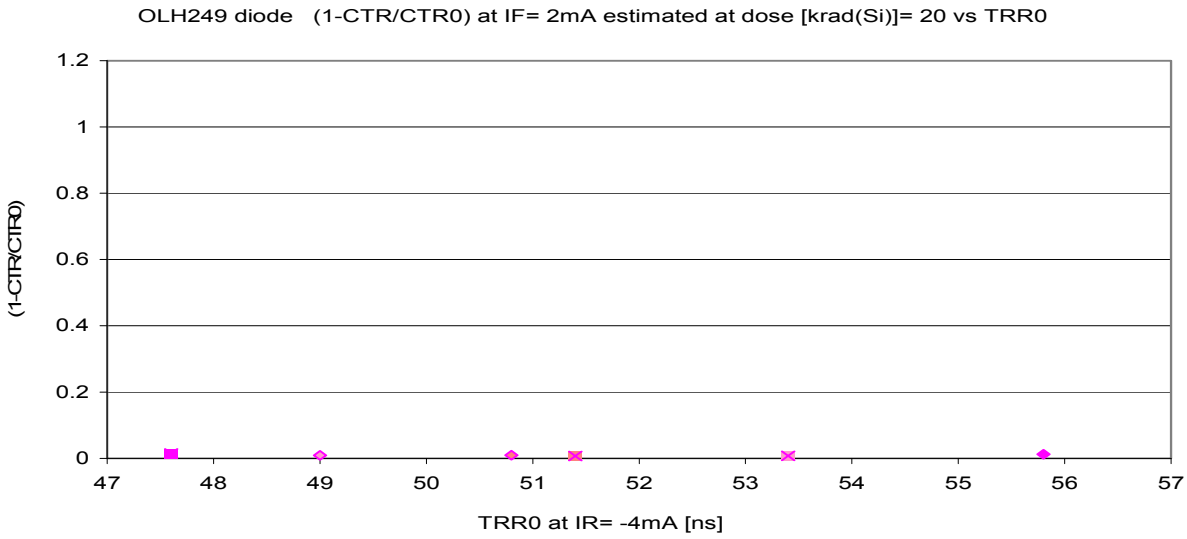
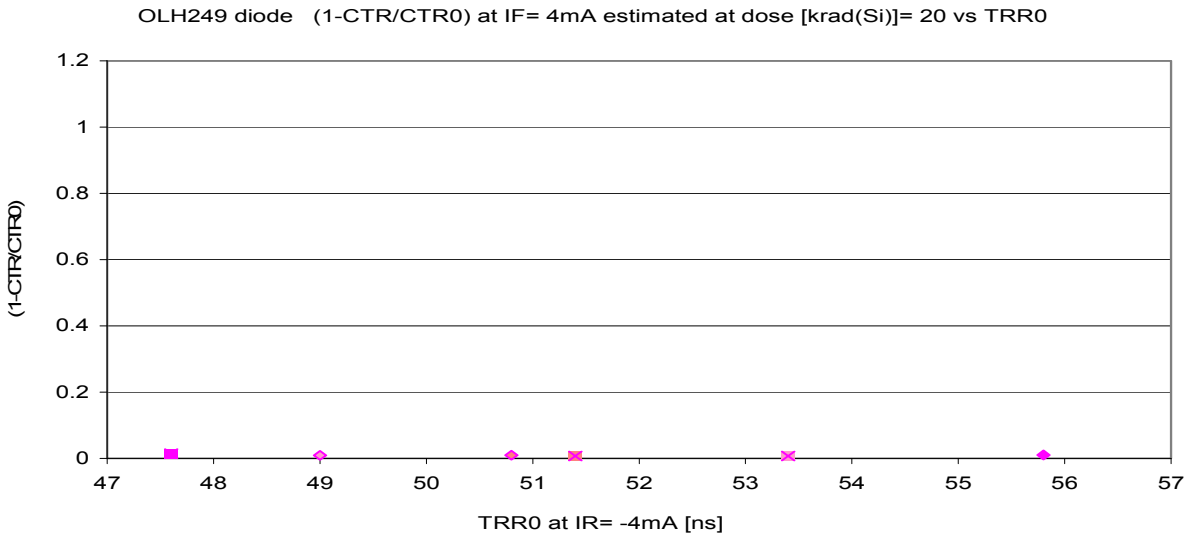
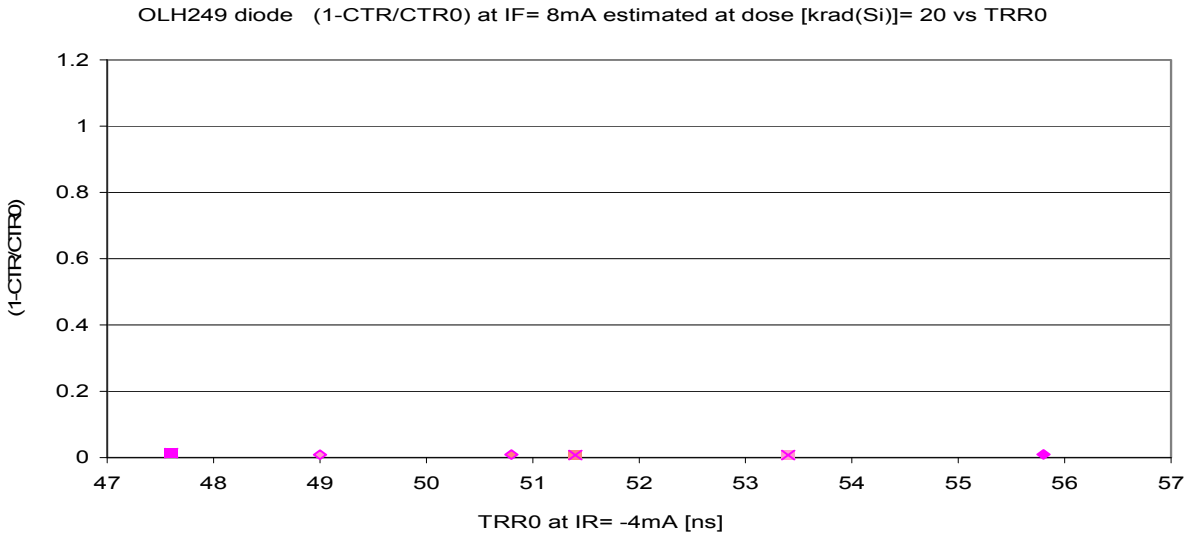

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

Fig. 13-182: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

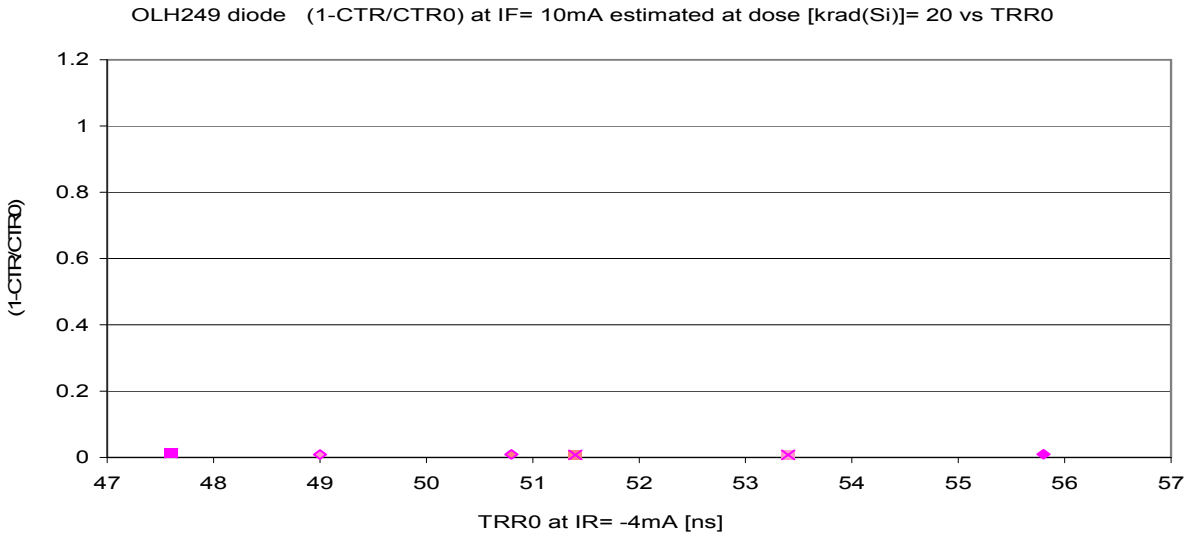
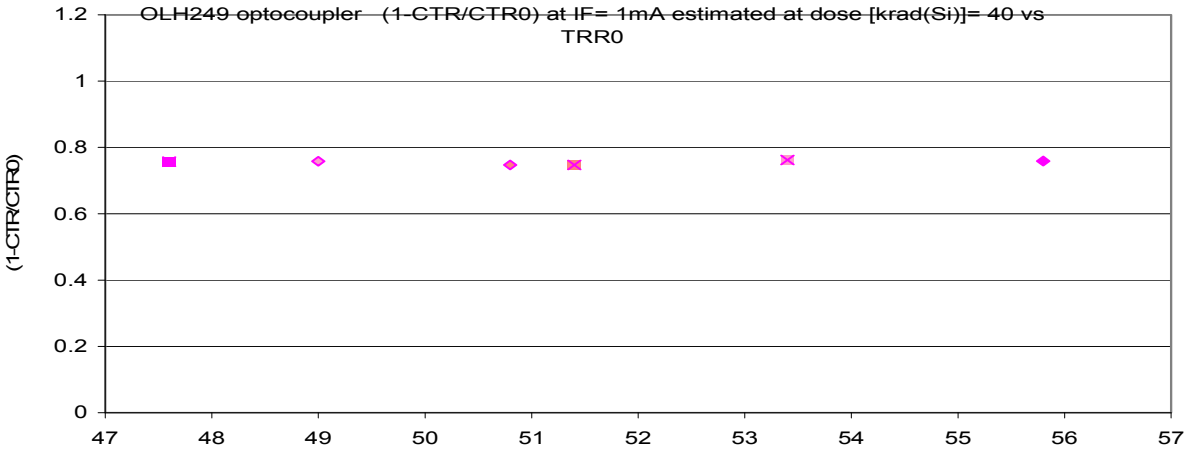
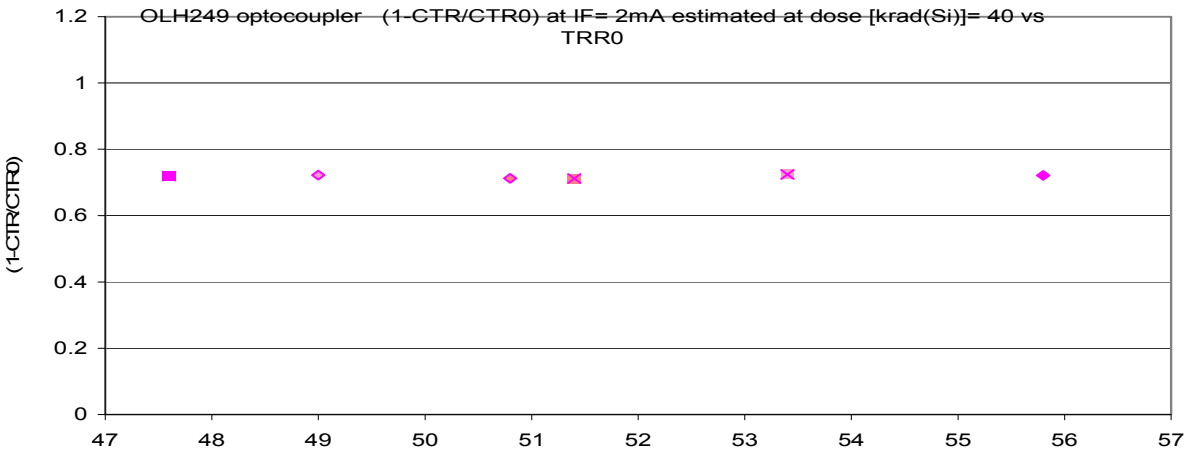
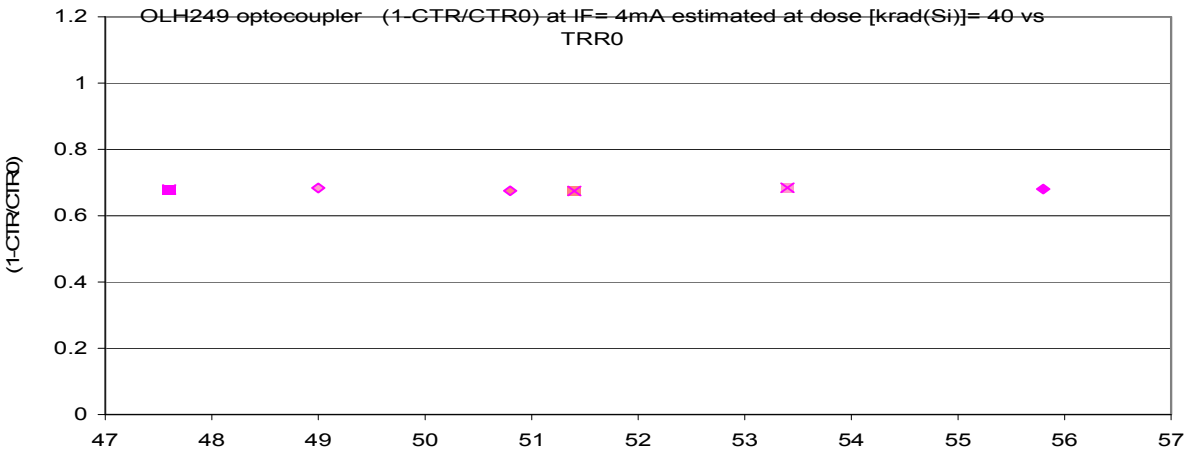
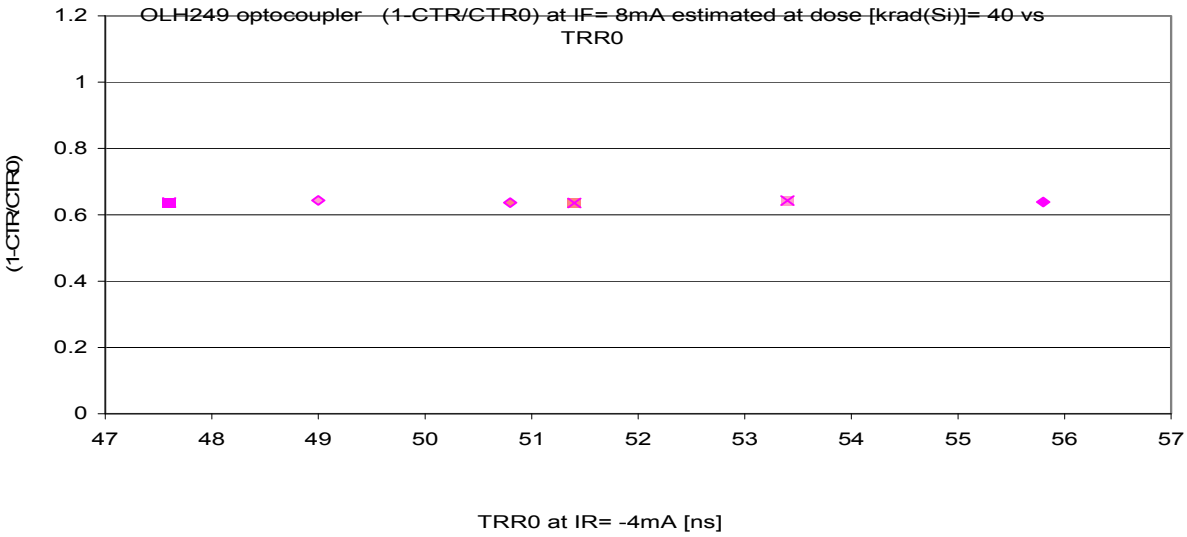

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

Fig. 13-183: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

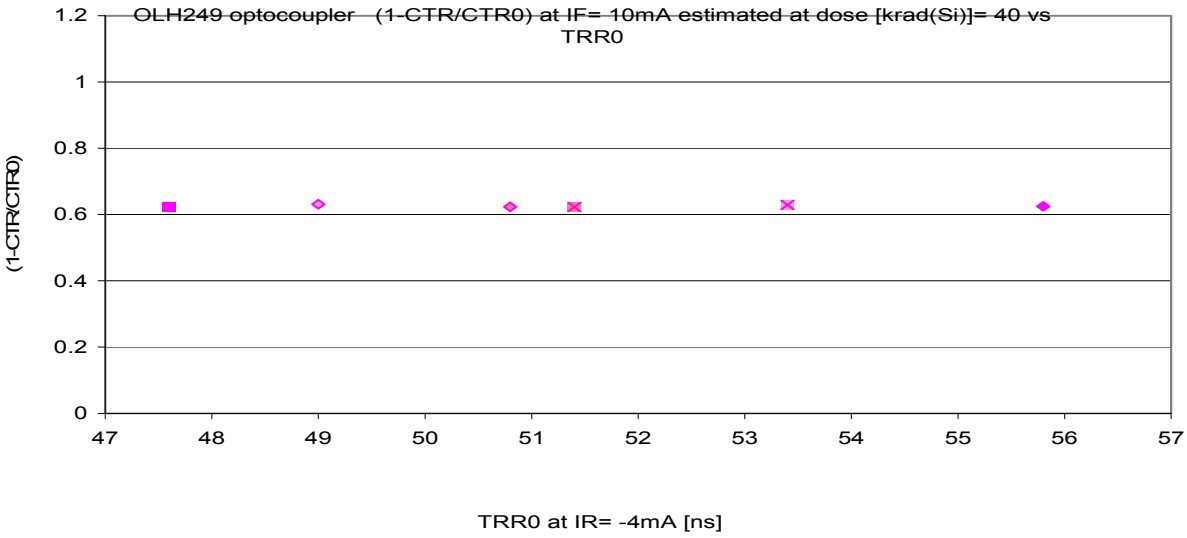
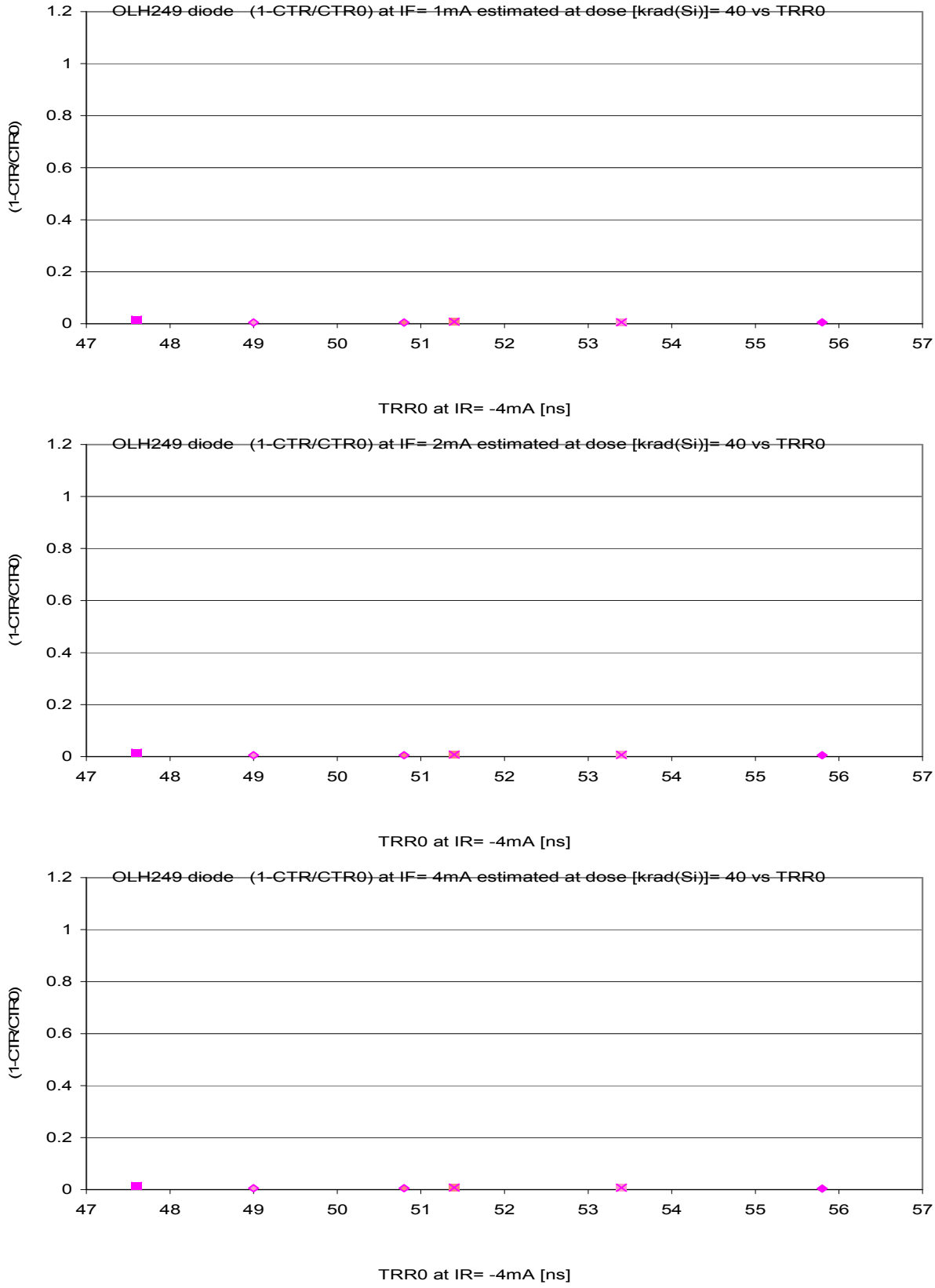
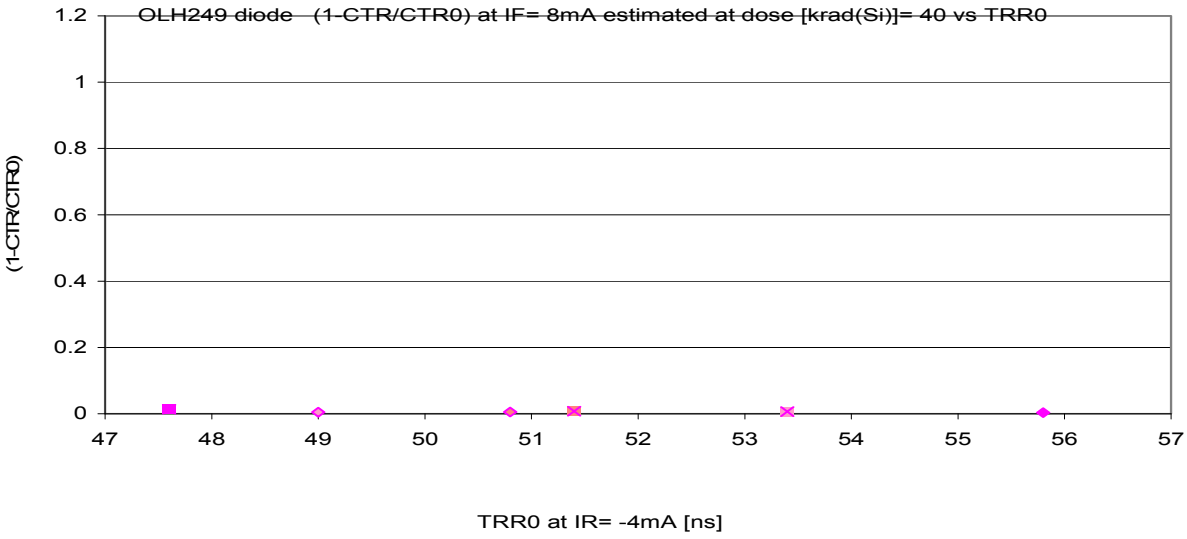

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

Fig. 13-184: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}




OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

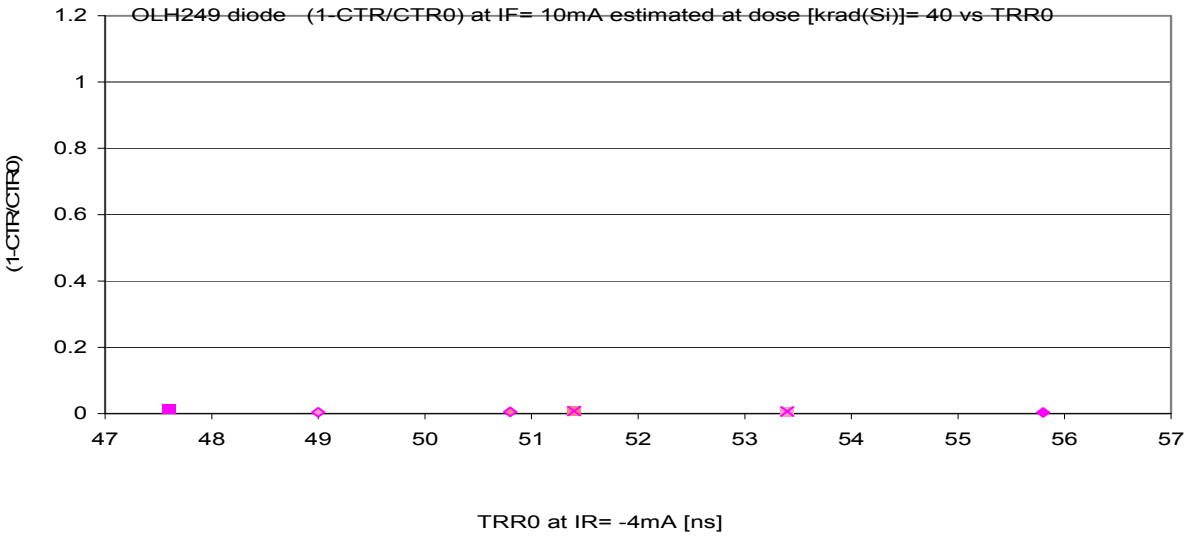
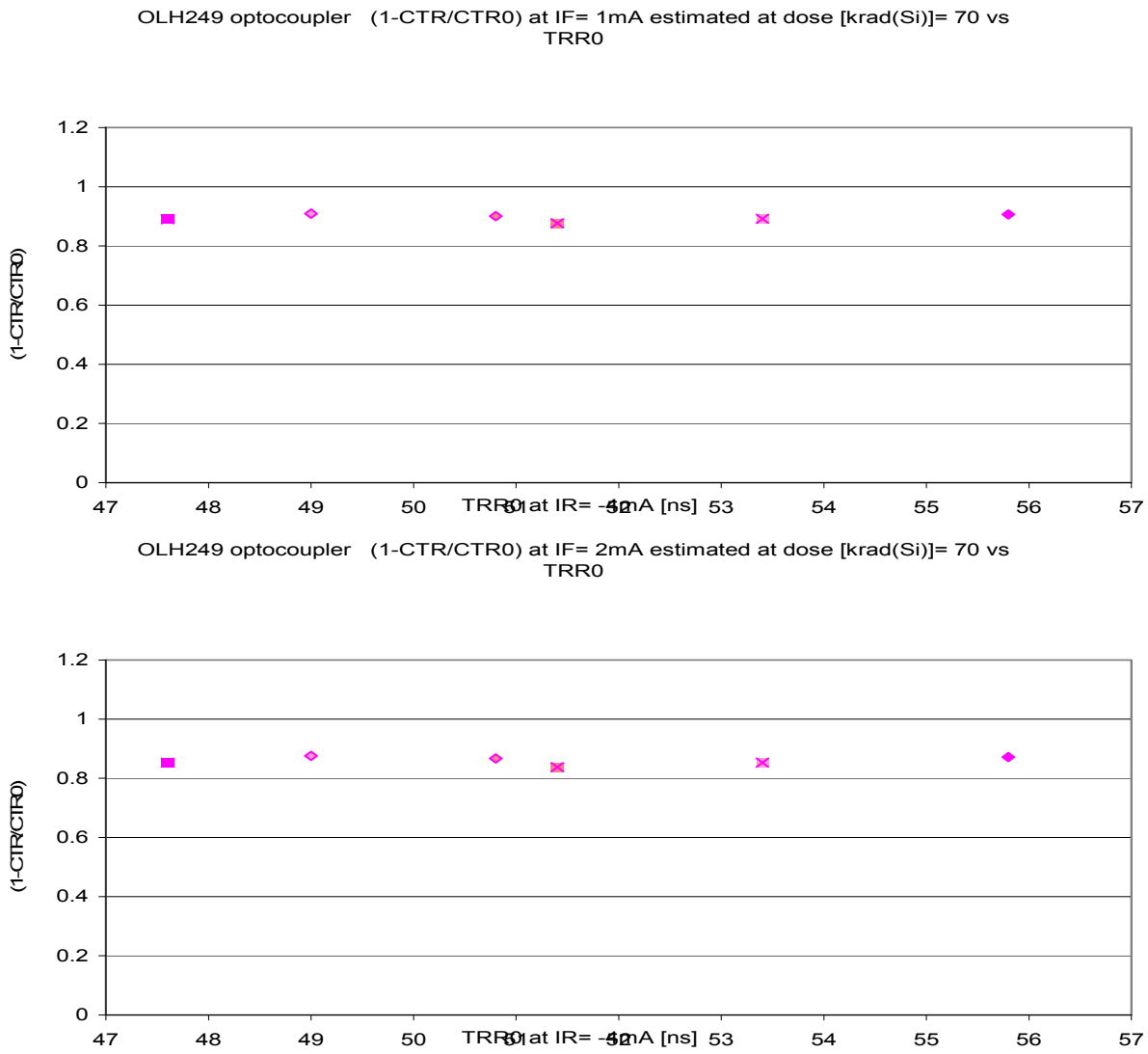
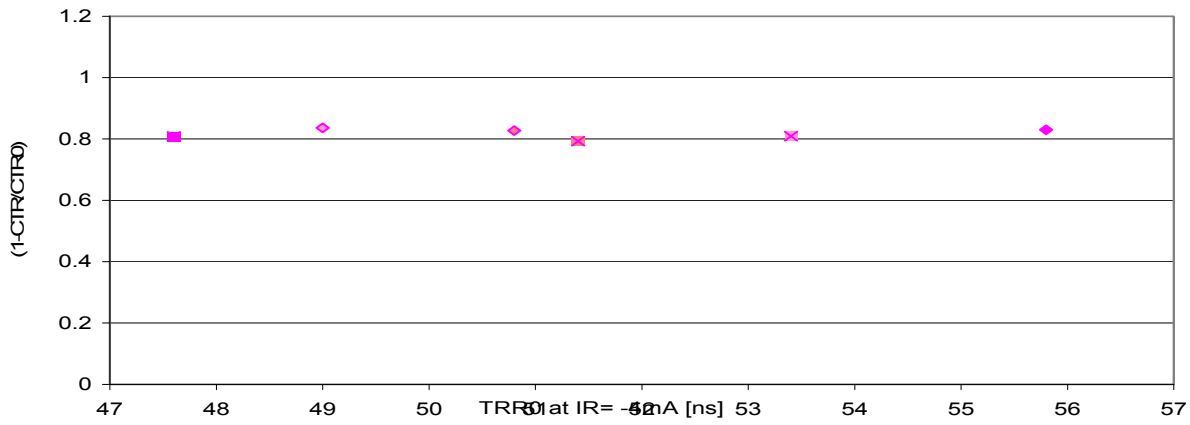

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA [ns]

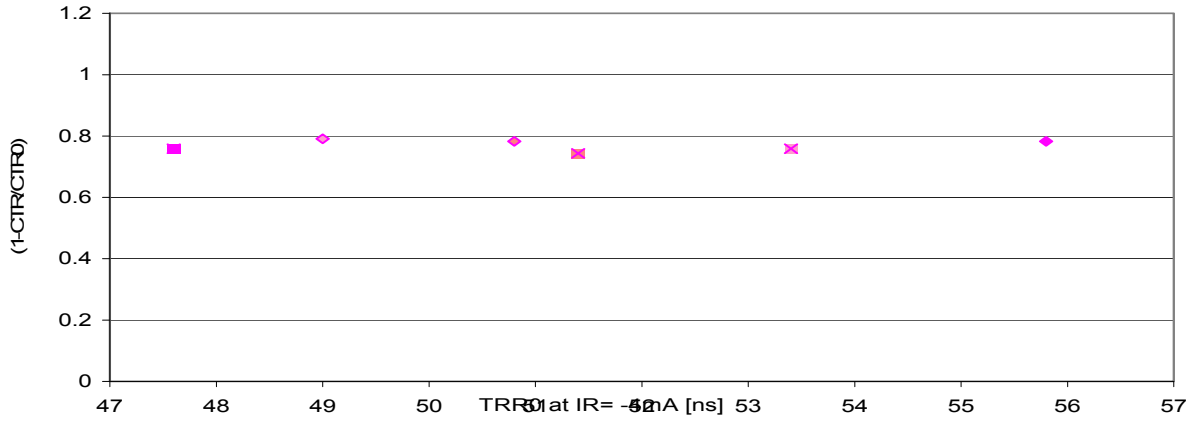
Fig. 13-185: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}



OLH249 optocoupler (1-CTR/CTR0) at IF= 4mA estimated at dose [krad(Si)]= 70 vs TRR0



OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0



OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0

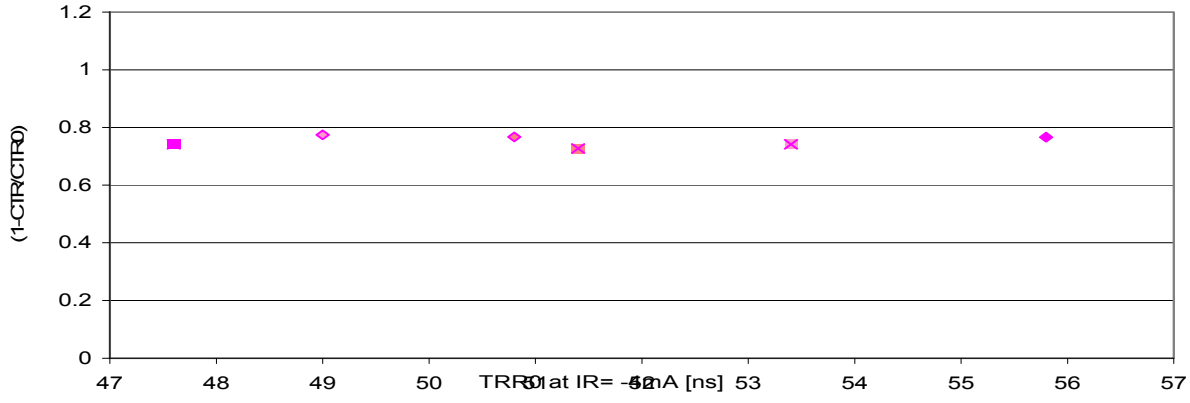
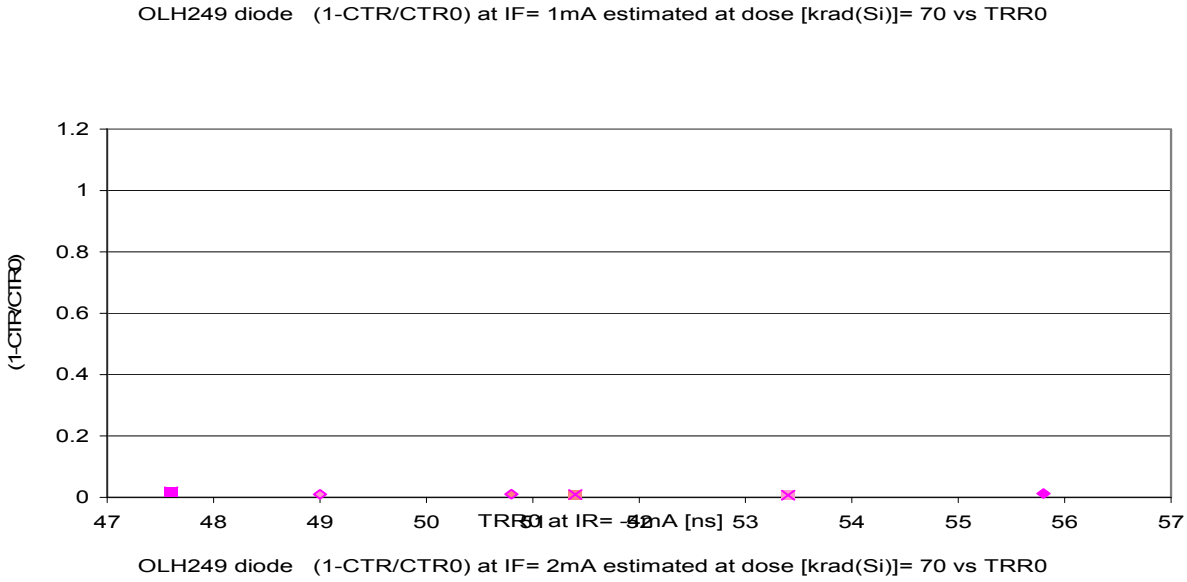
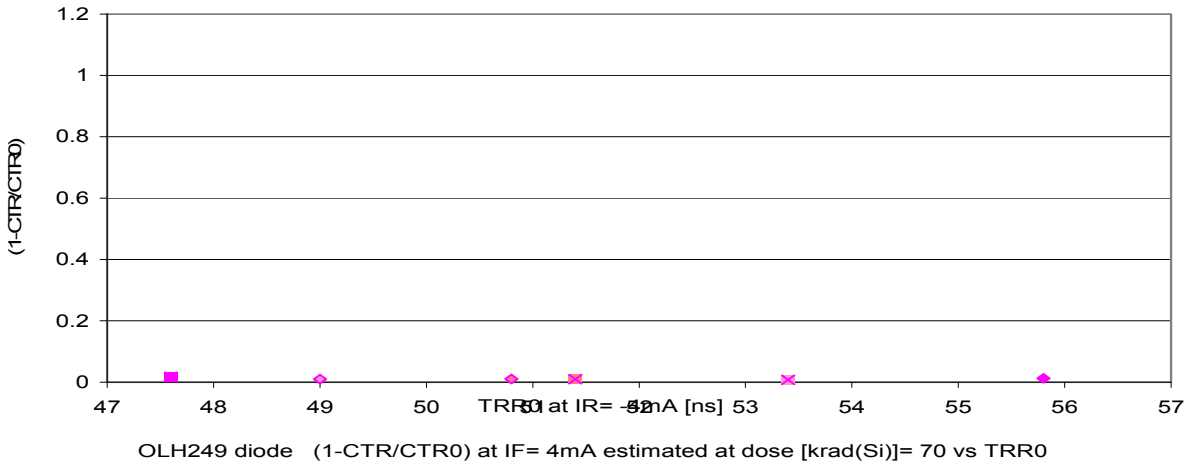
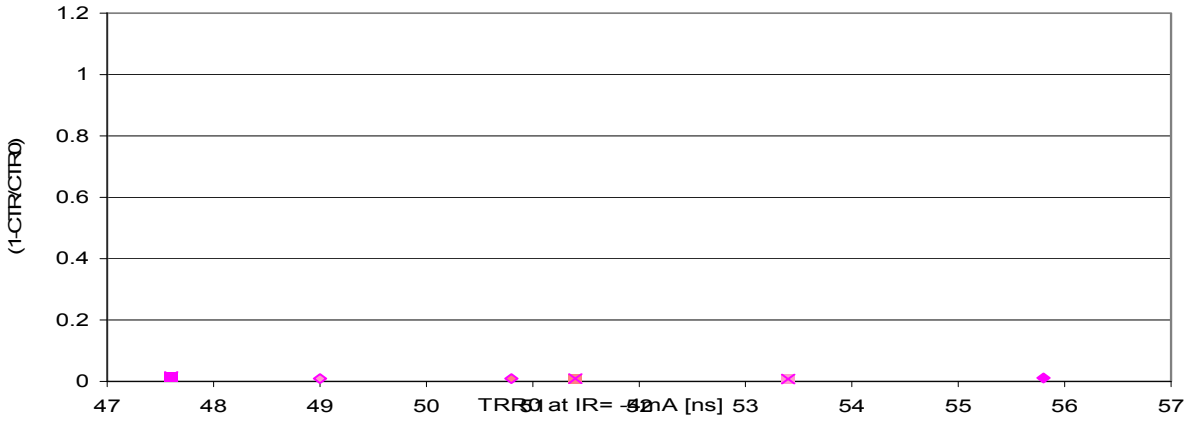


Fig. 13-186: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}





OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0



OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0

Fig. 13-187: optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

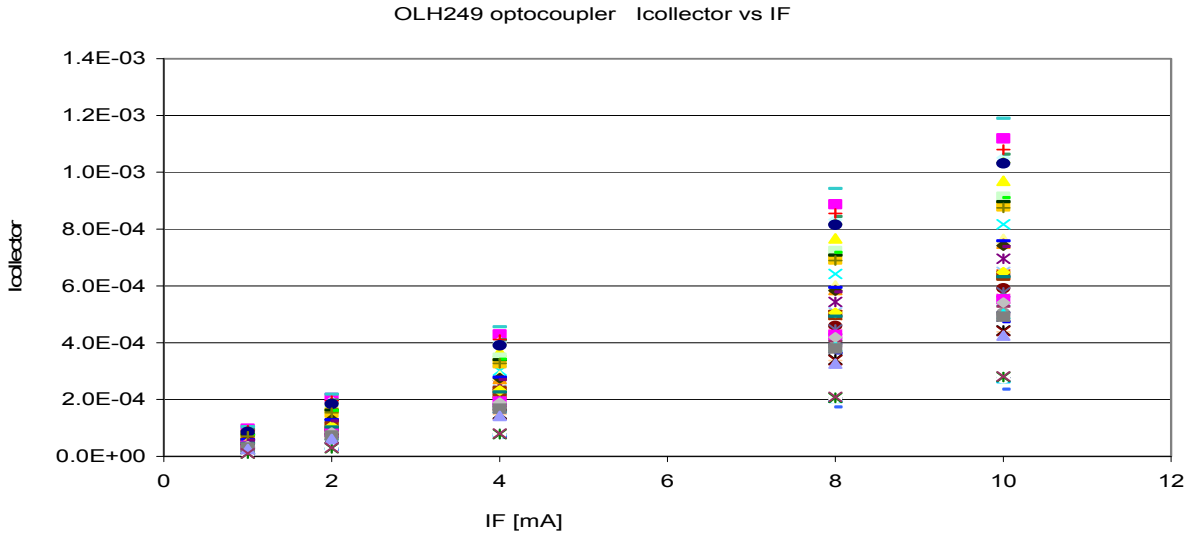


Fig. 13-188: diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

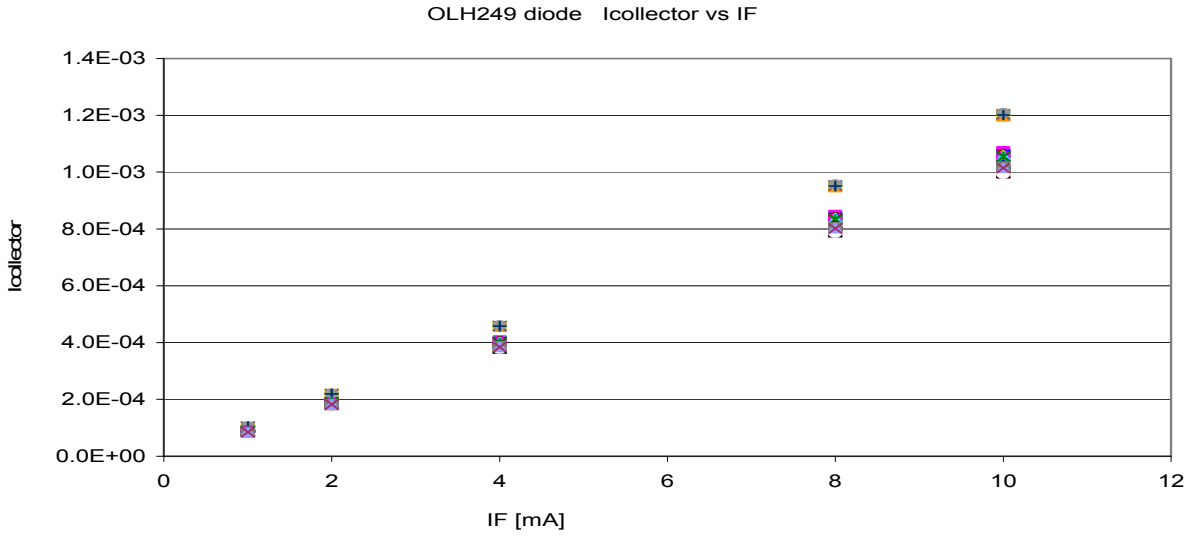


Fig. 13-189: transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

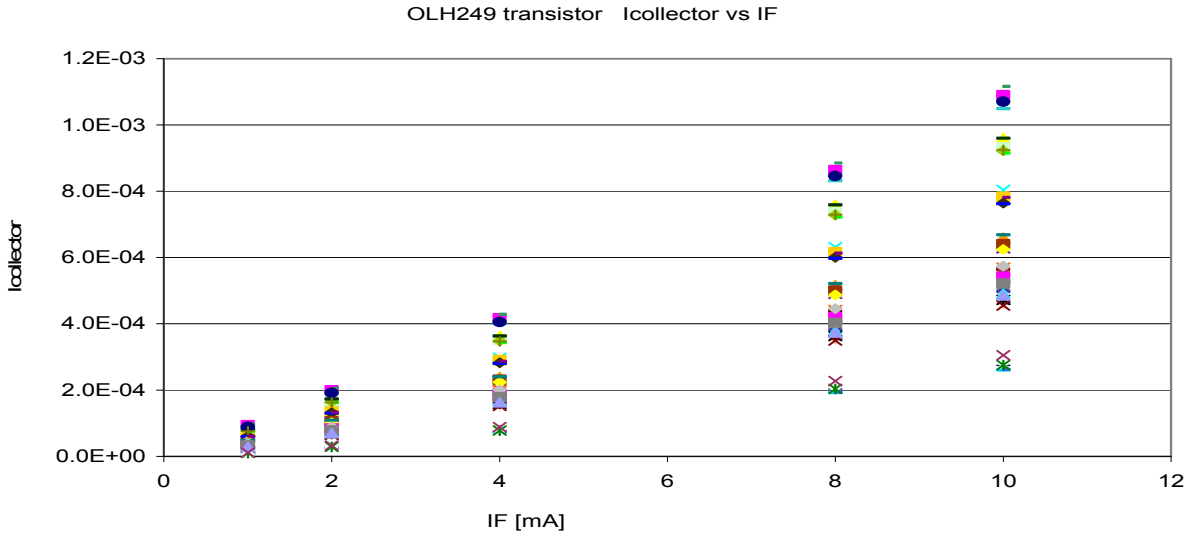


Fig. 13-190: optocoupler irradiated: CTR for each step with respect to diode current I_F

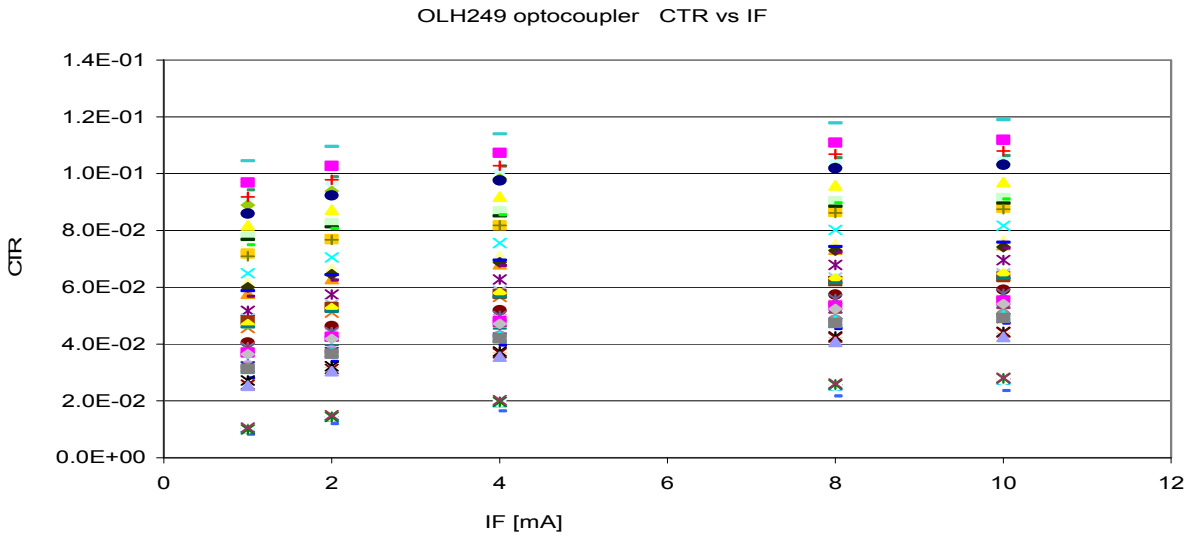


Fig. 13-191: diode irradiated: CTR for each step with respect to diode current I_F

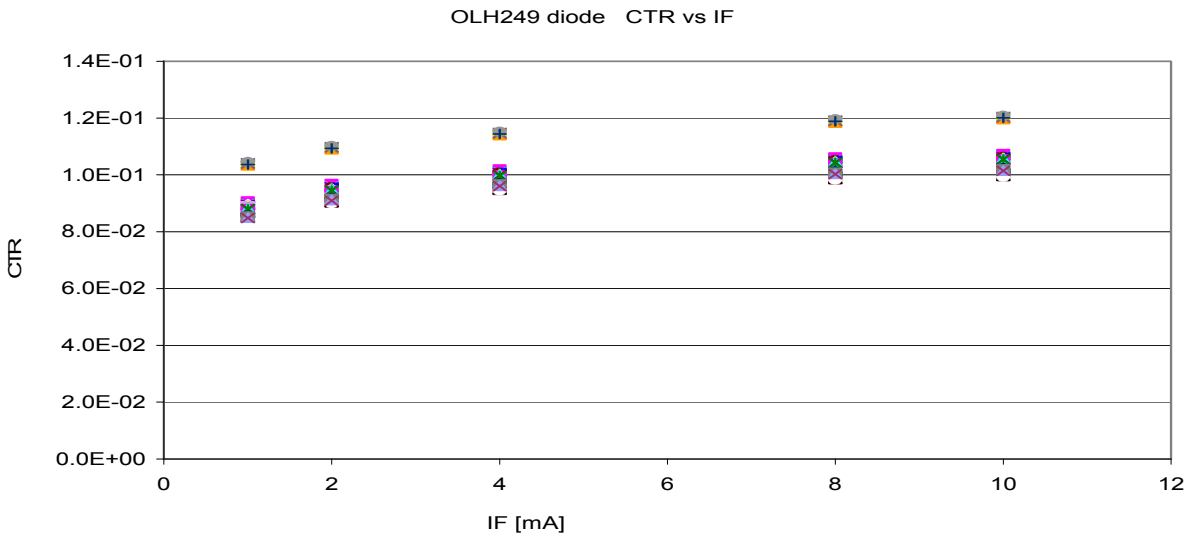


Fig. 13-192: transistor irradiated: CTR for each step with respect to diode current I_F

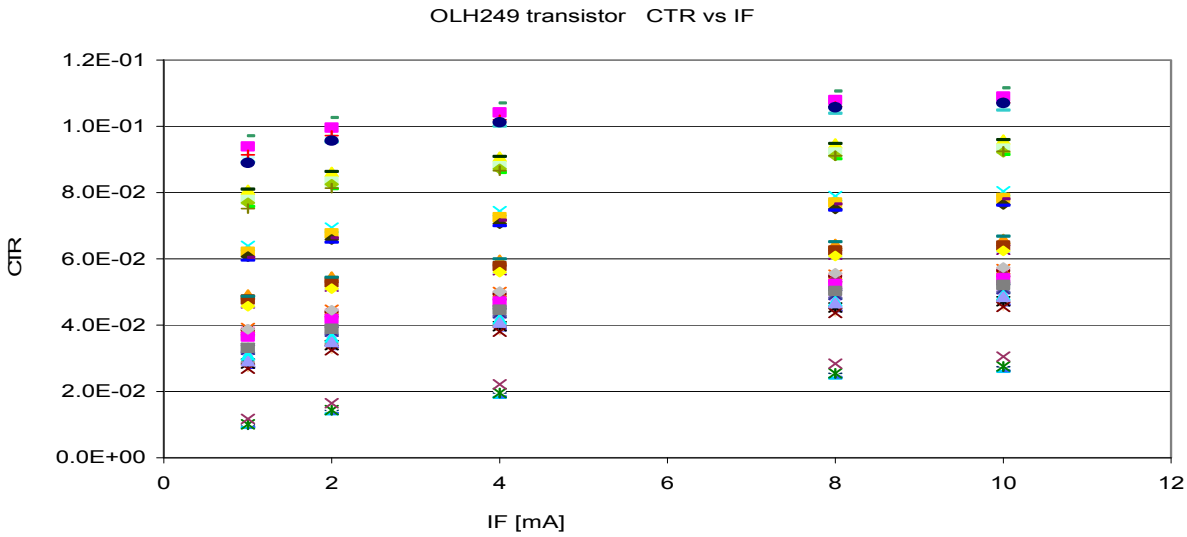


Fig. 13-193: optocoupler irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

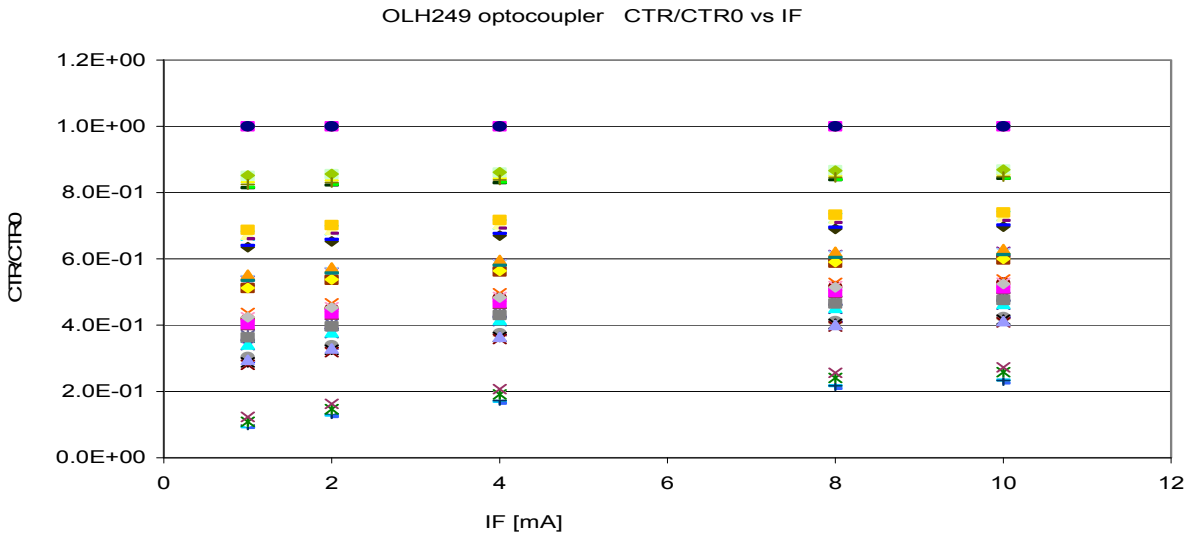


Fig. 13-194: diode irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

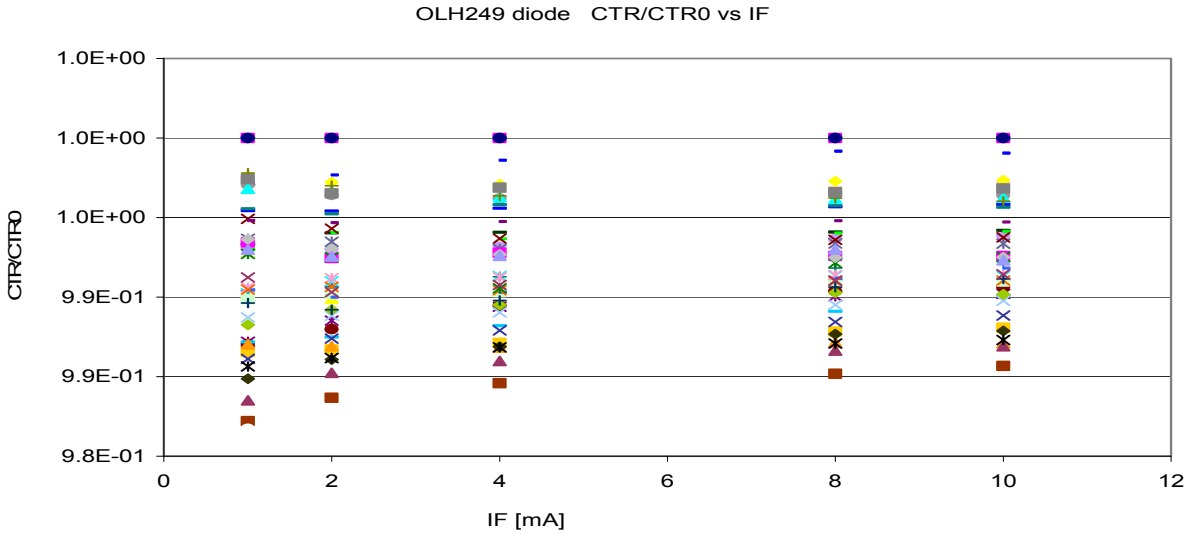


Fig. 13-195: transistor irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

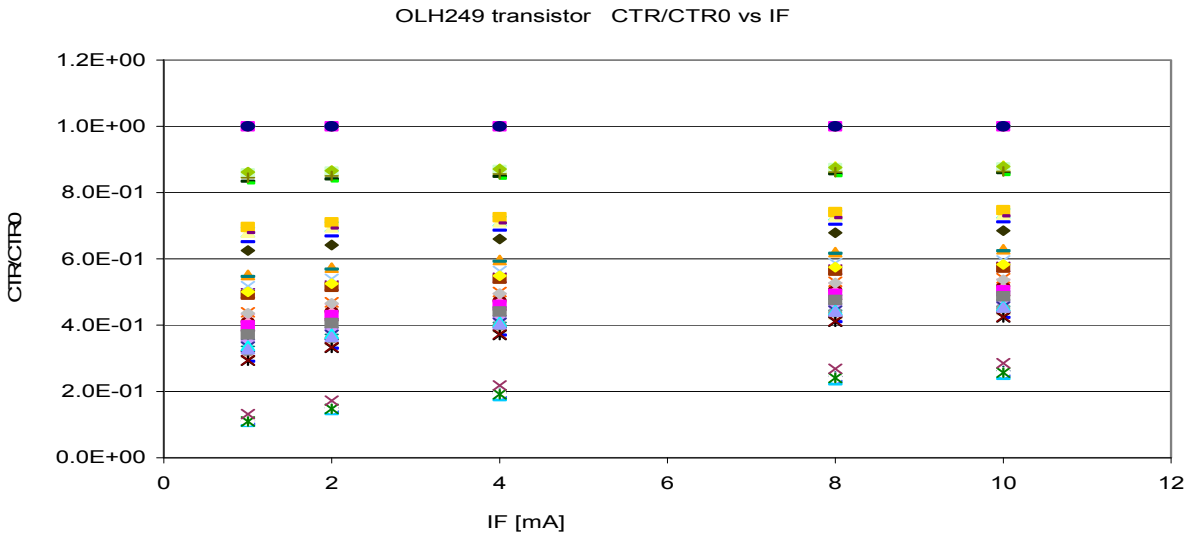


Fig. 13-196: OLH249 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA

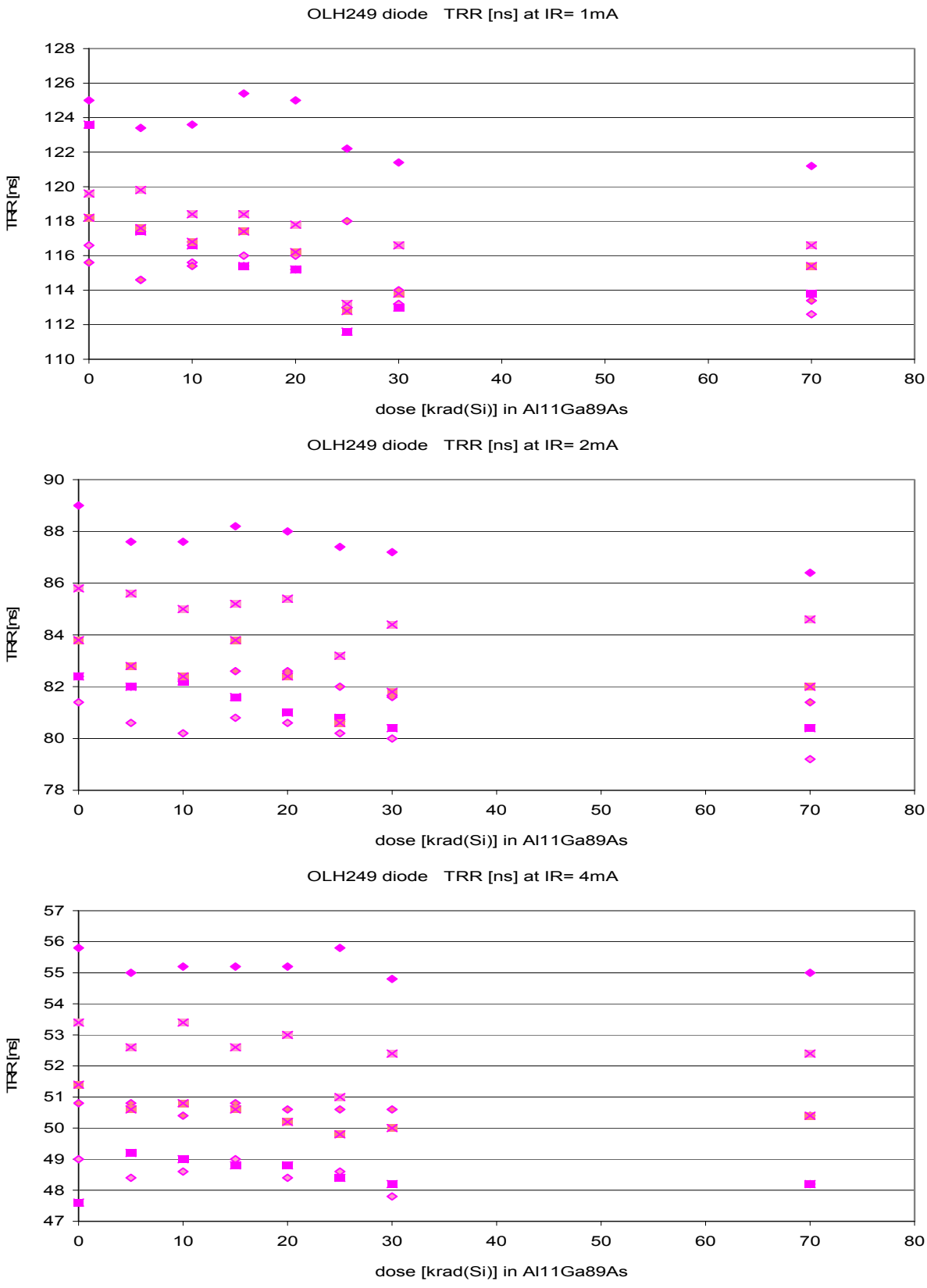
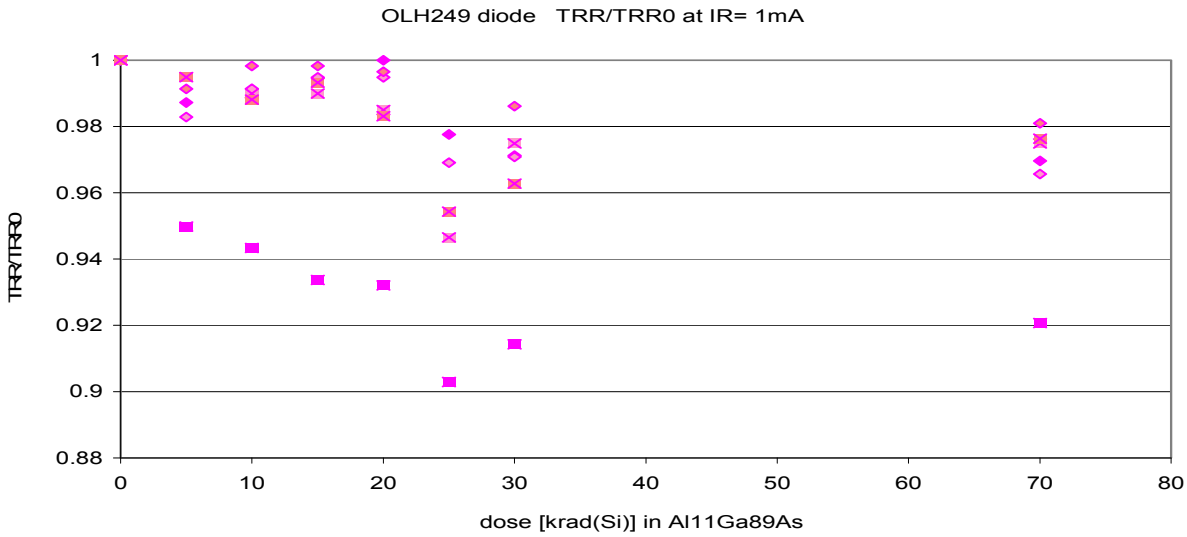
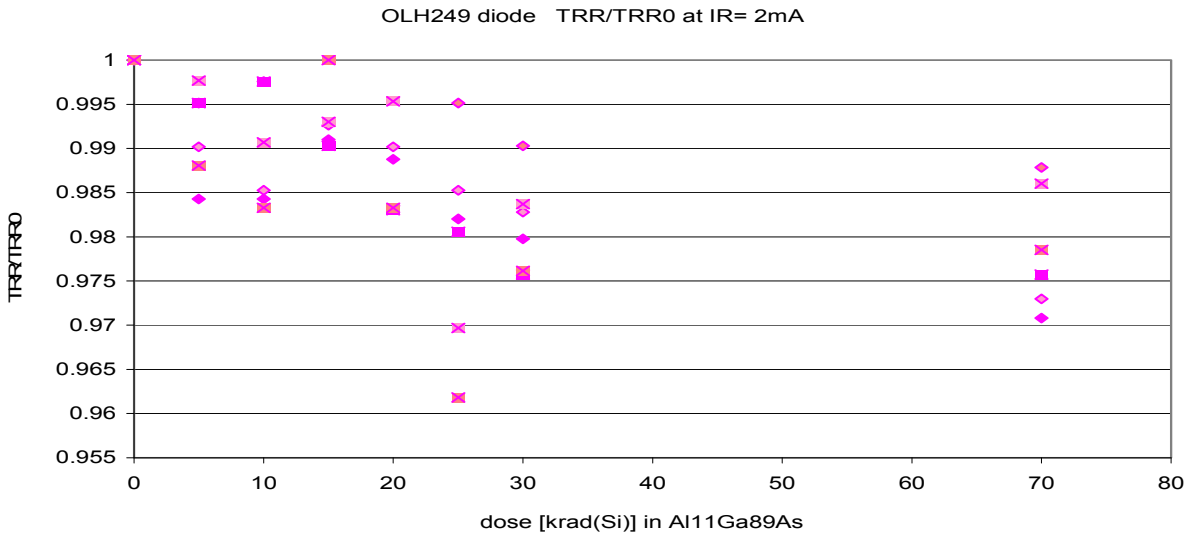


Fig. 13-197: OLH249 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA





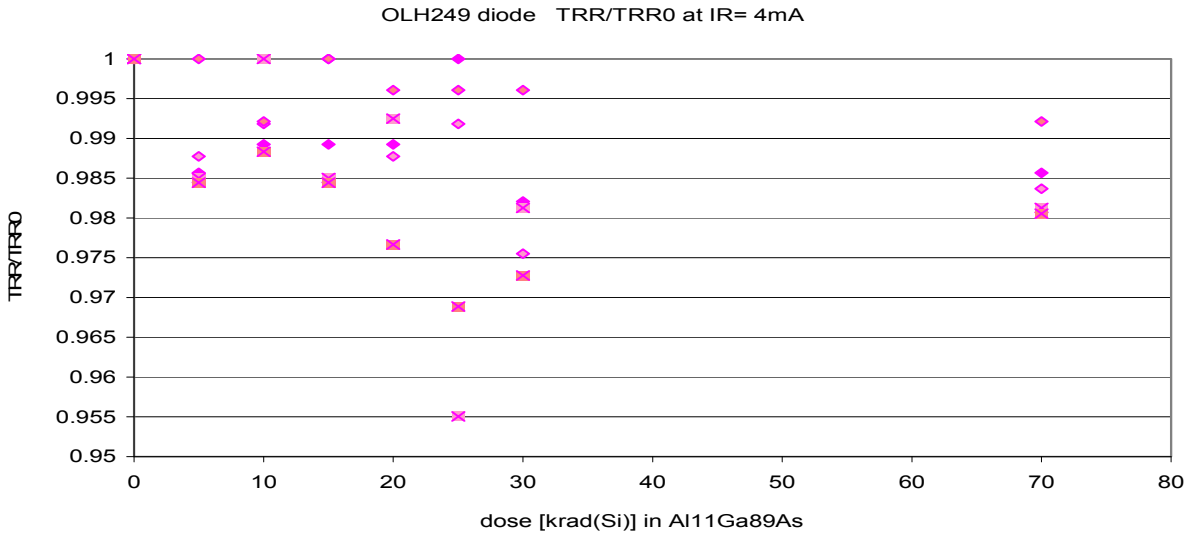
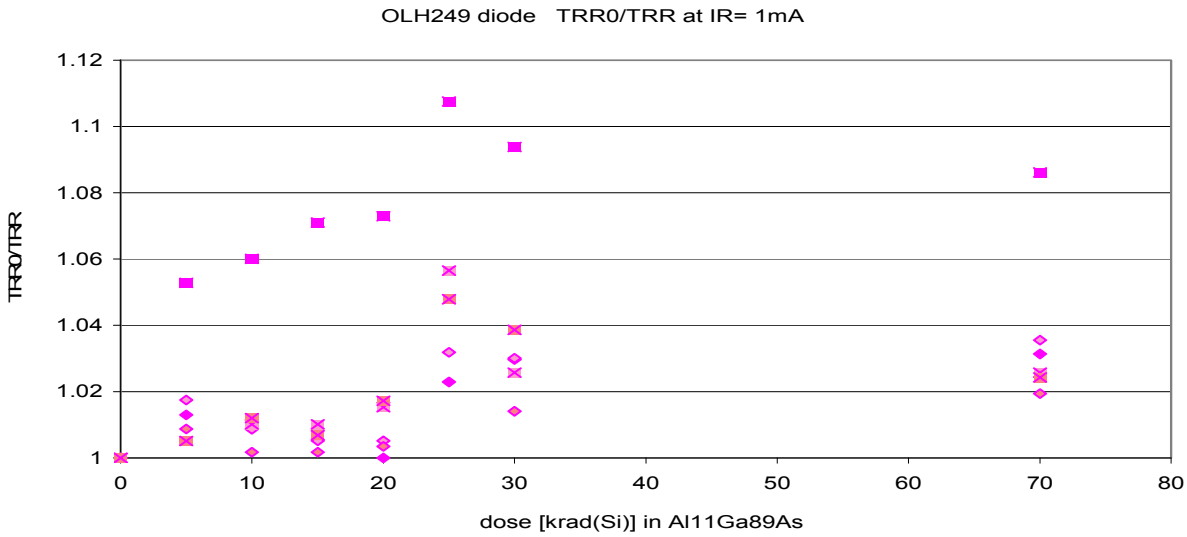
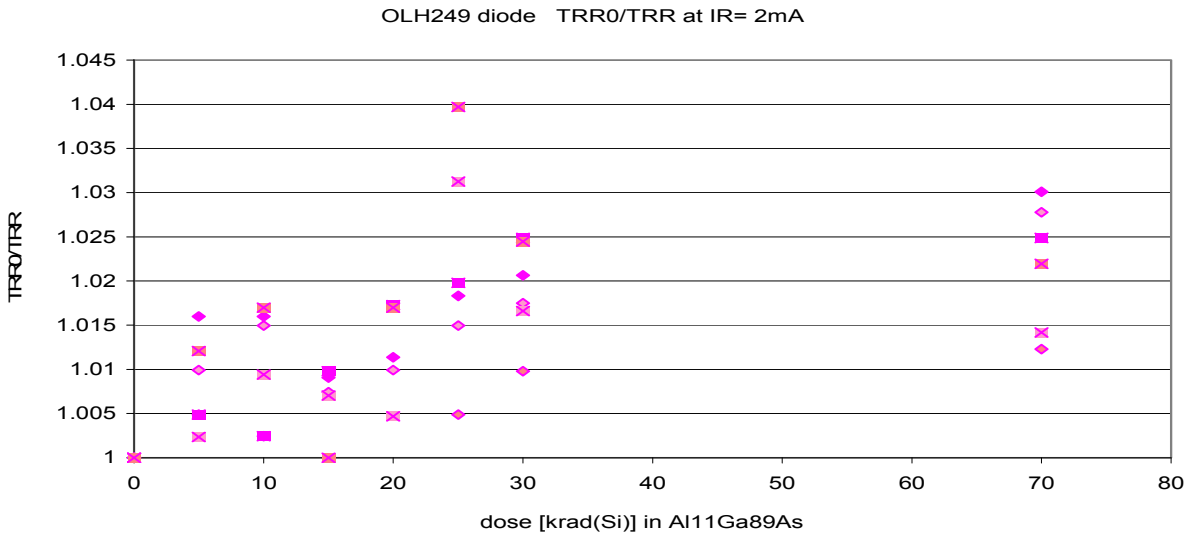


Fig. 13-198: OLH249 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





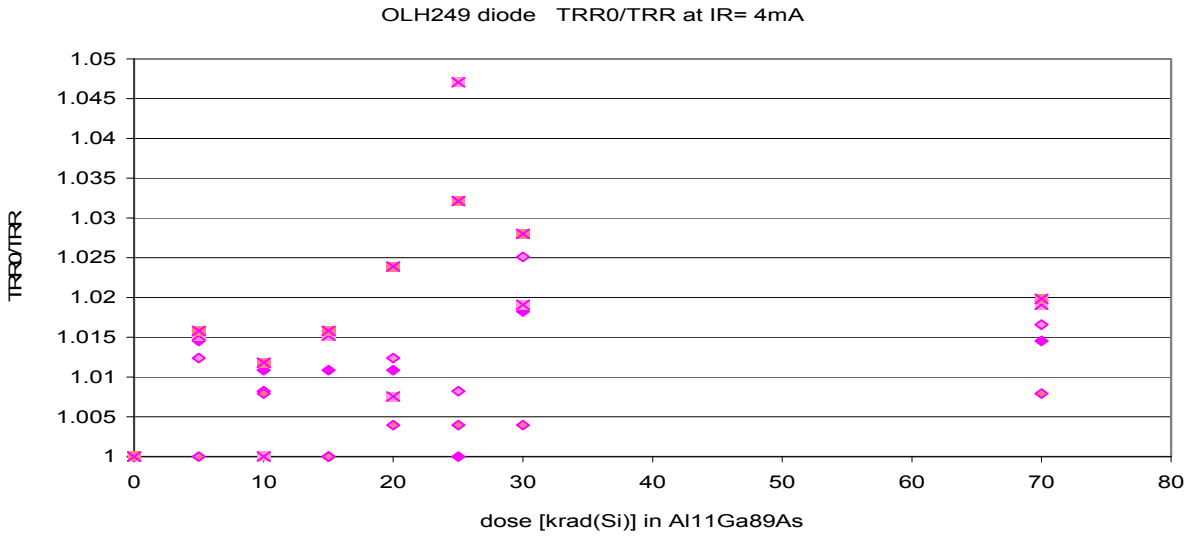
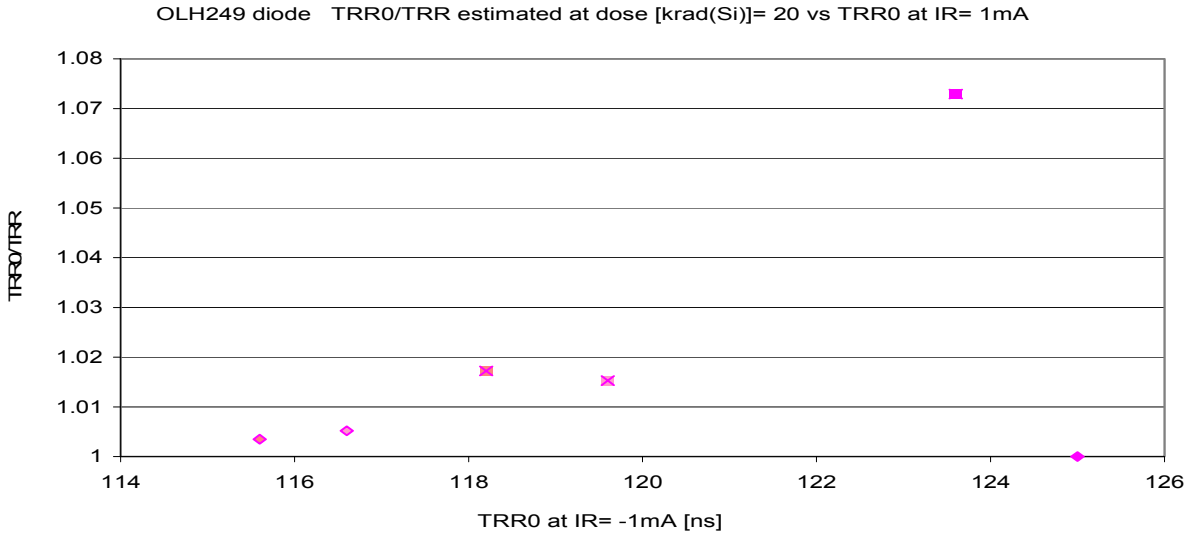
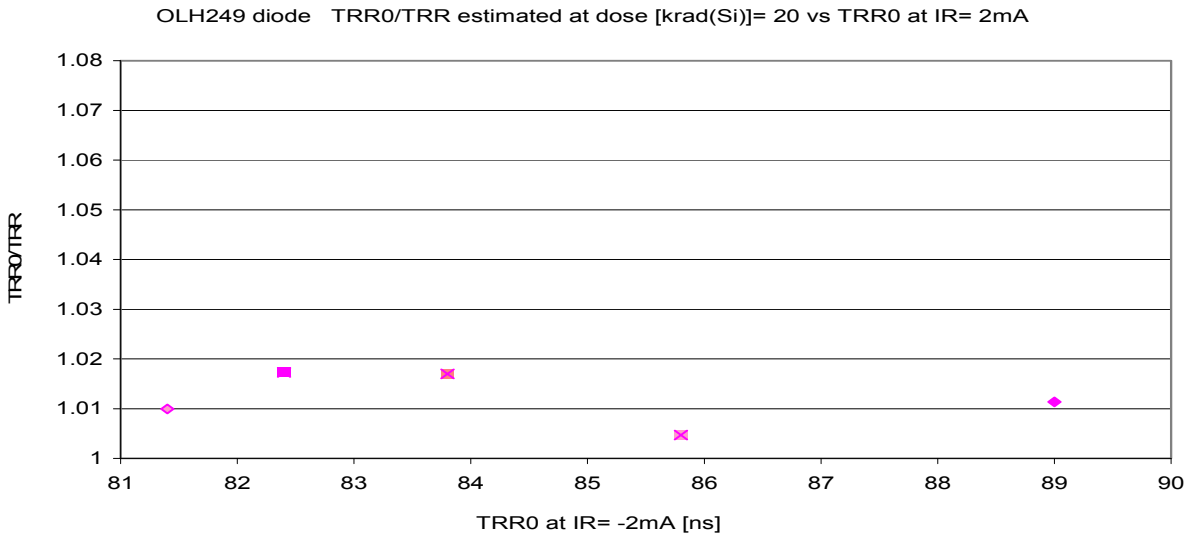


Fig. 13-199: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





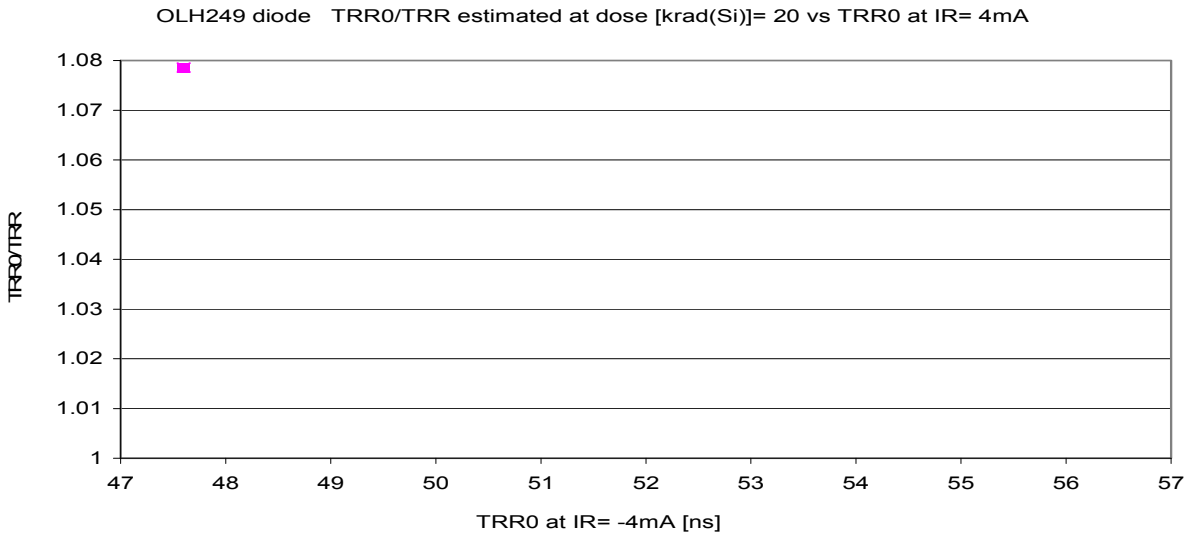
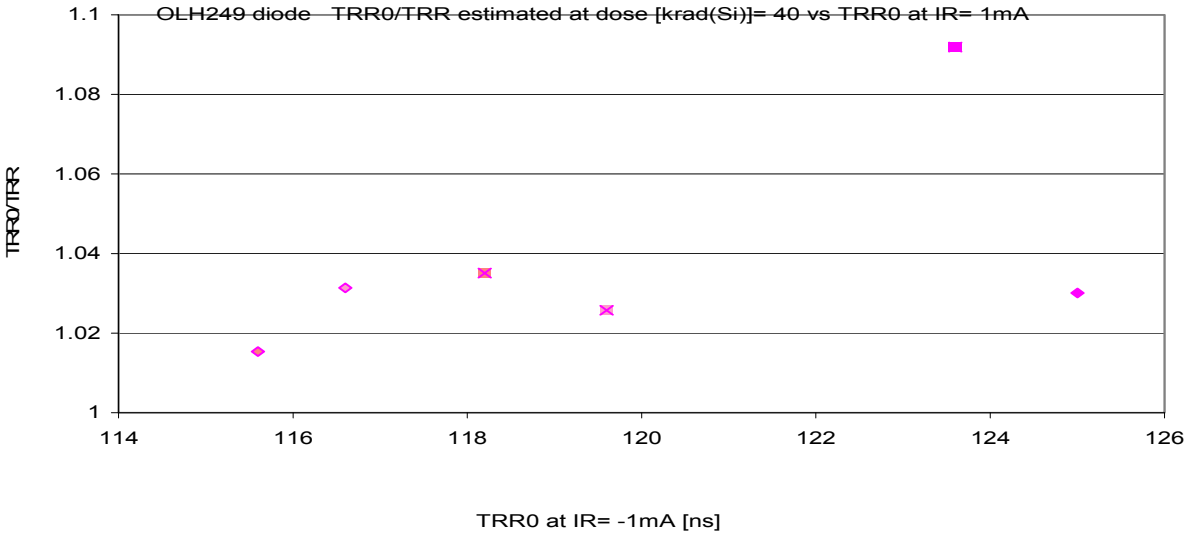
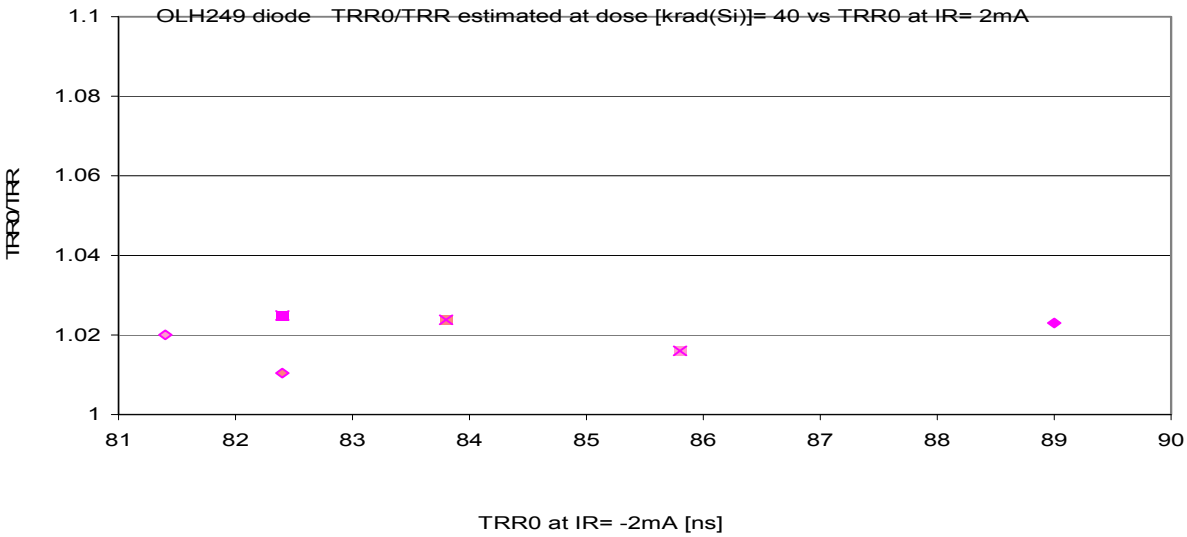


Fig. 13-200: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





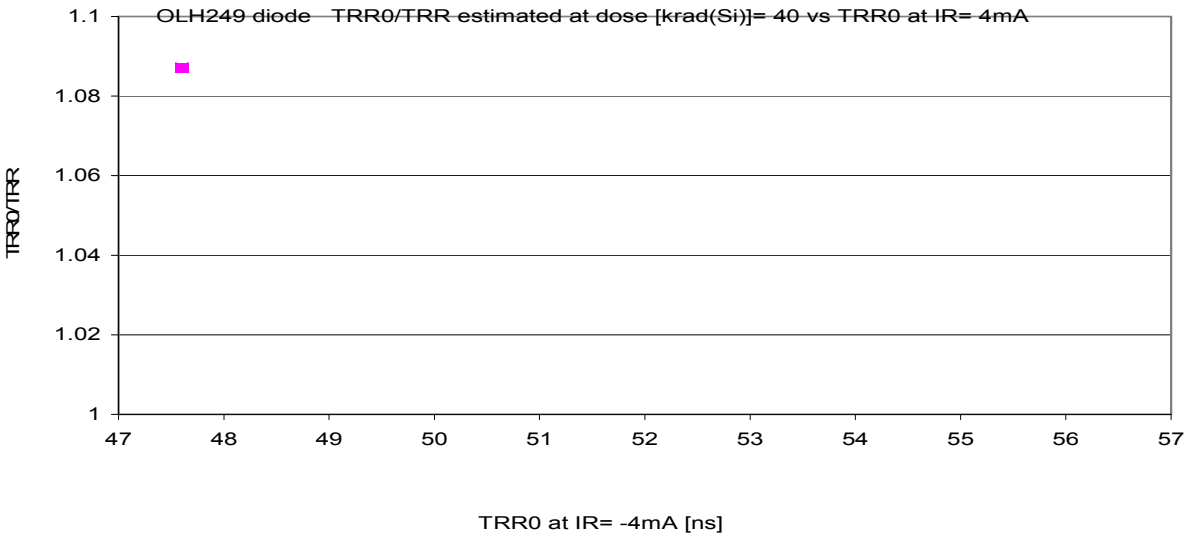
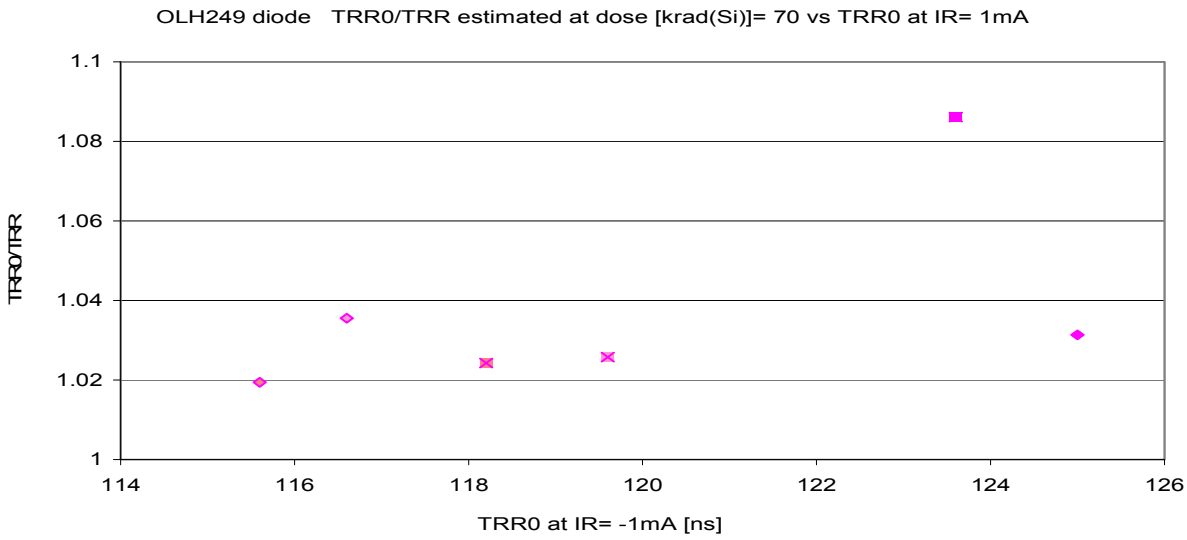
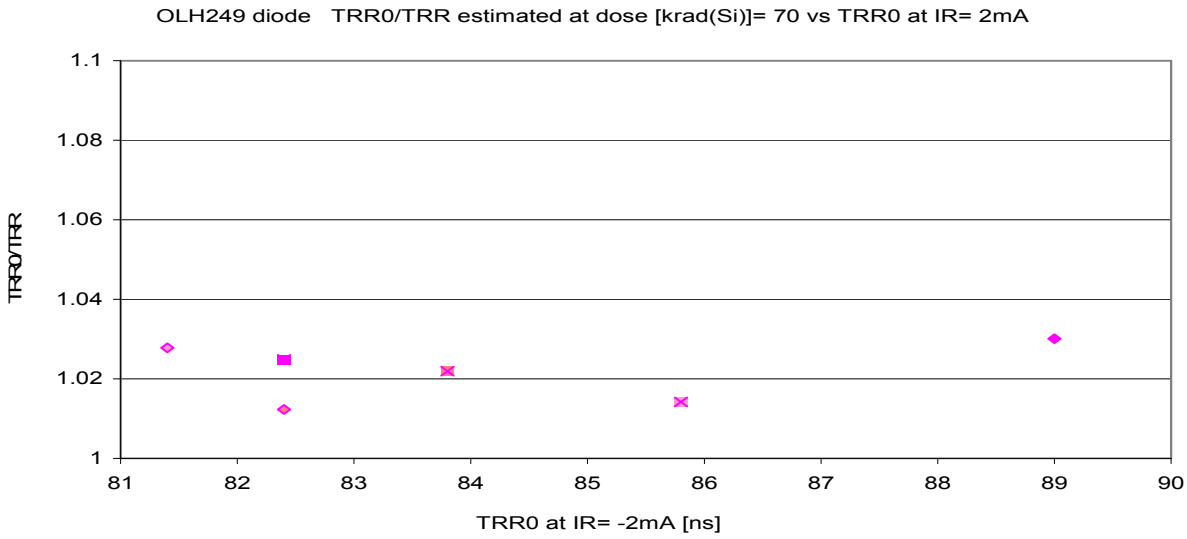


Fig. 13-201: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





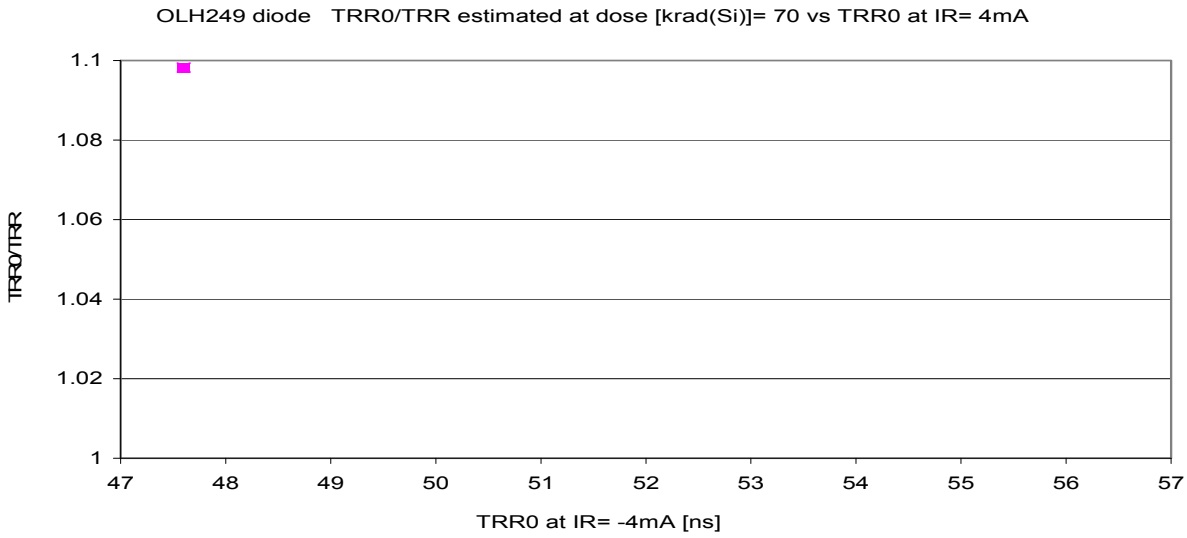


Fig. 13-202: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose

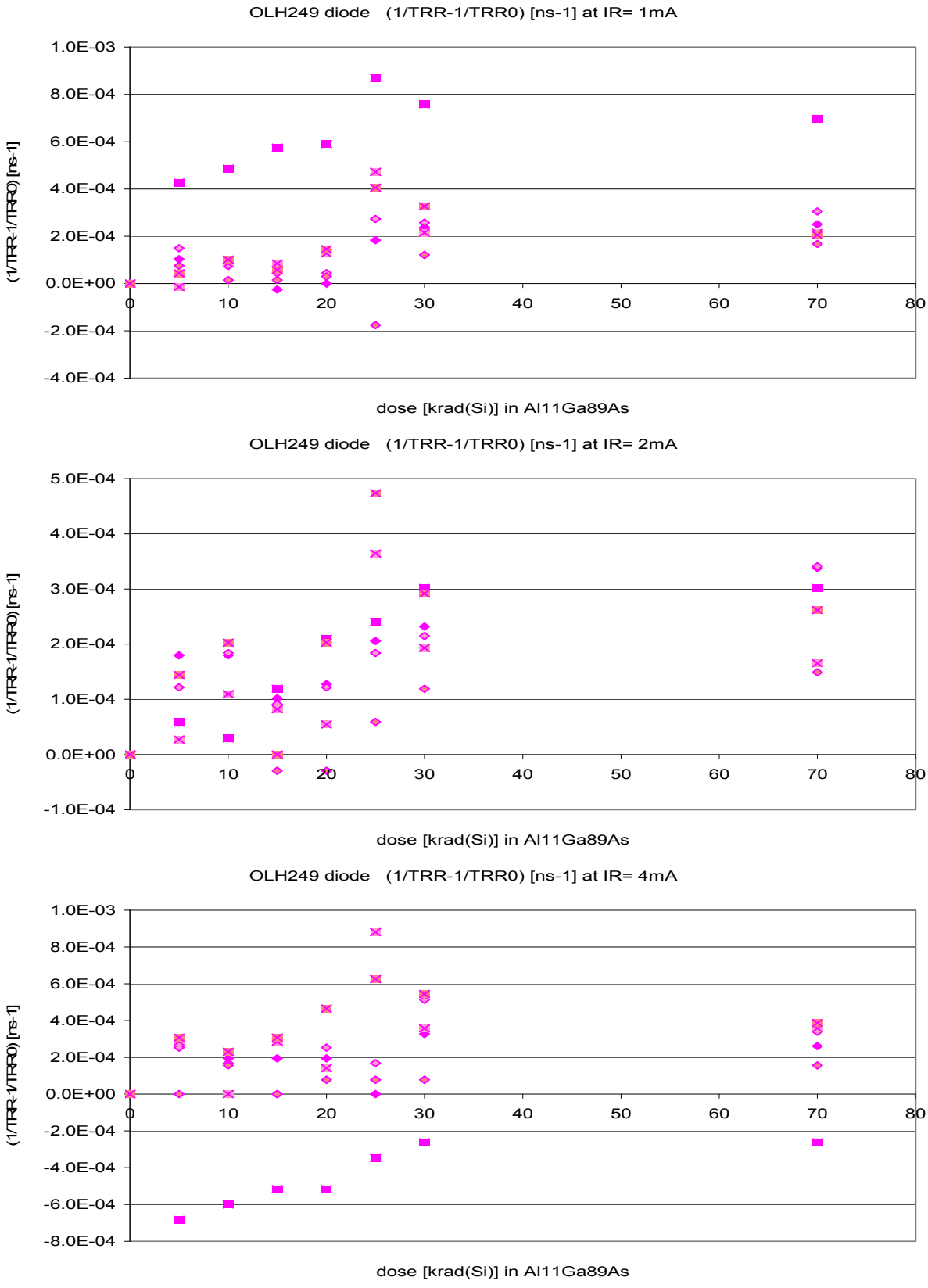
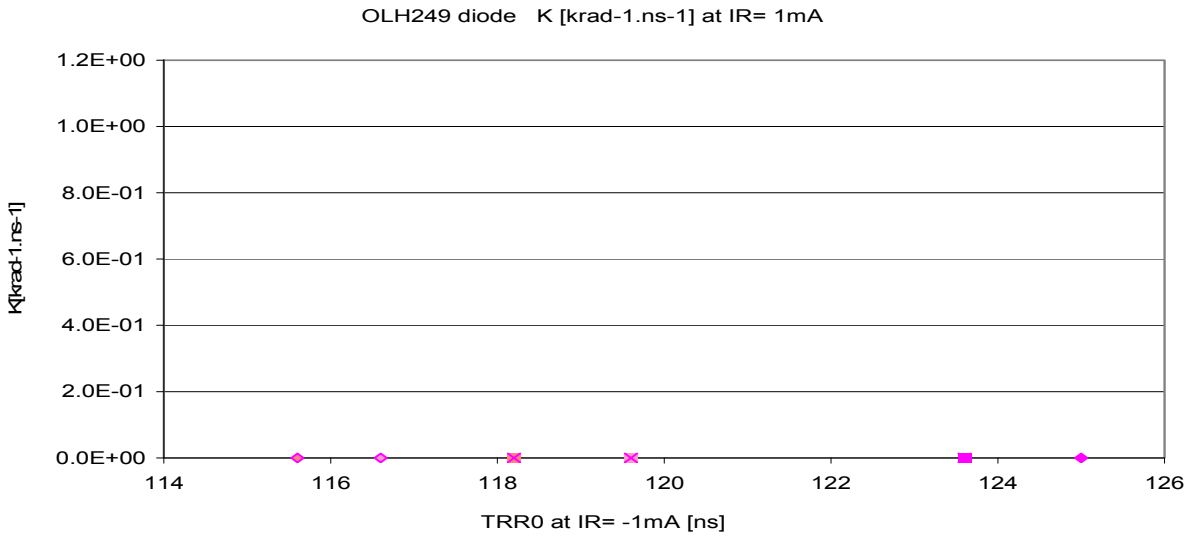
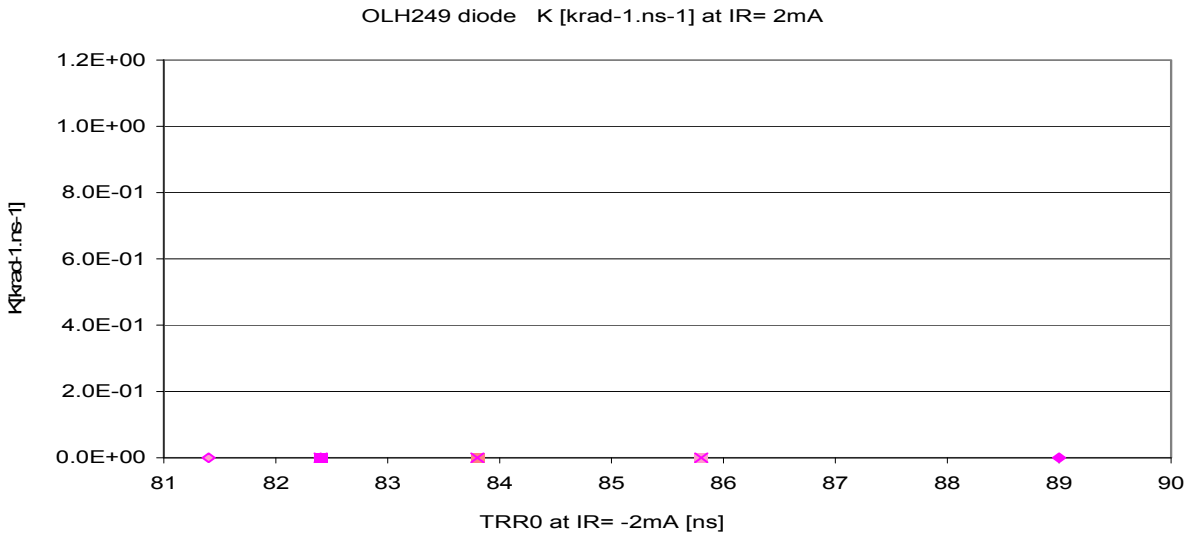


Fig. 13-203: OLH249 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}





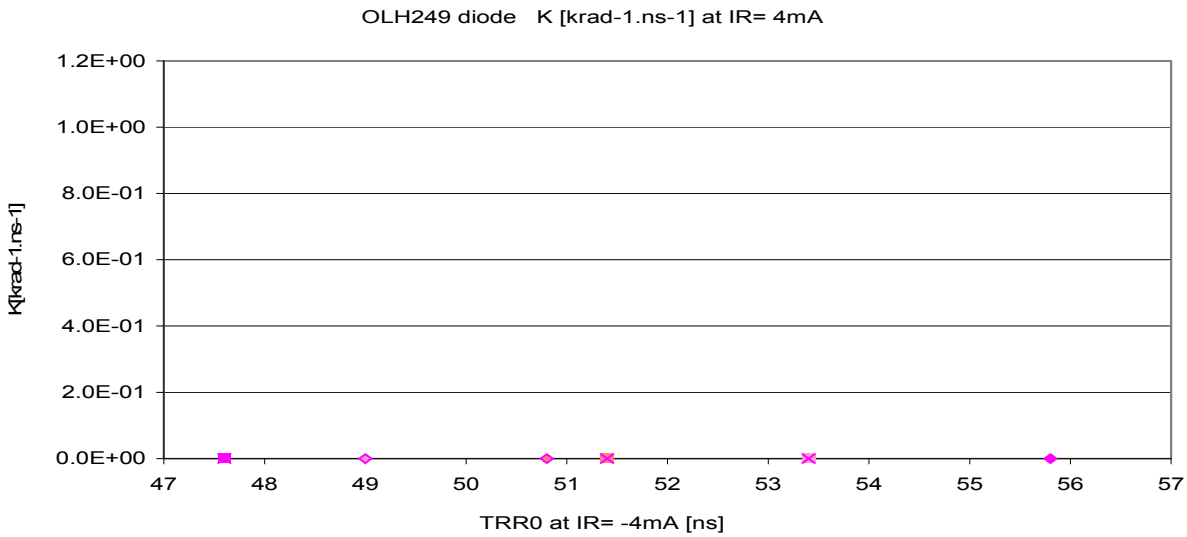
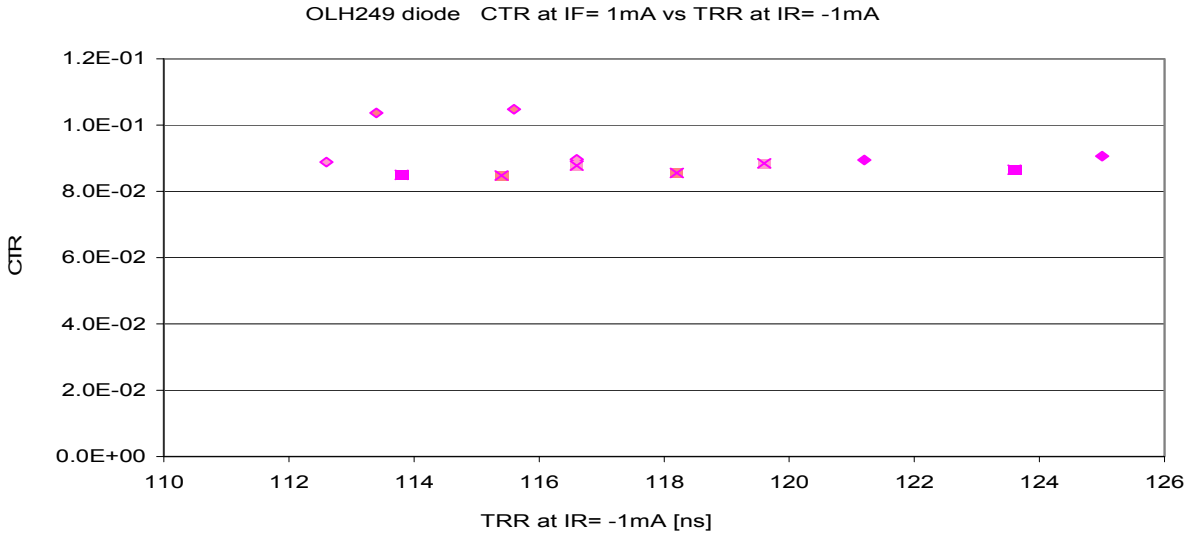
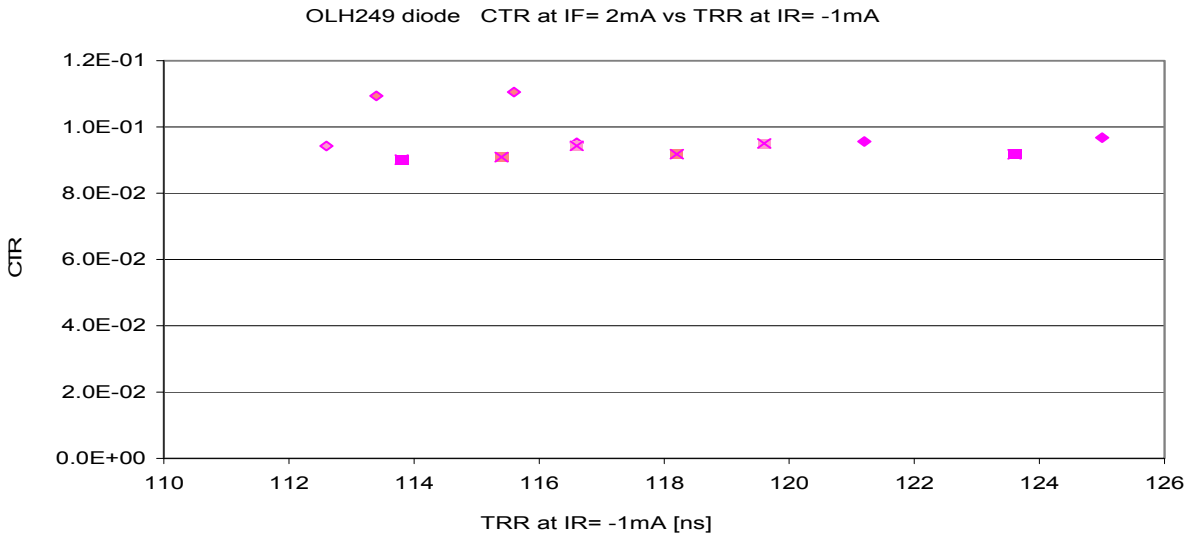
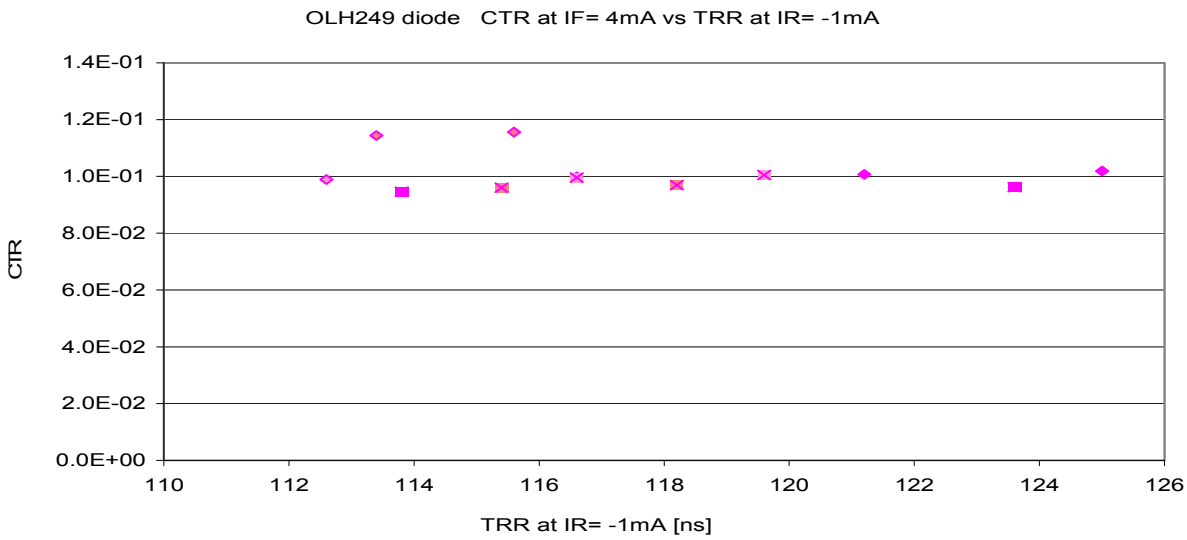
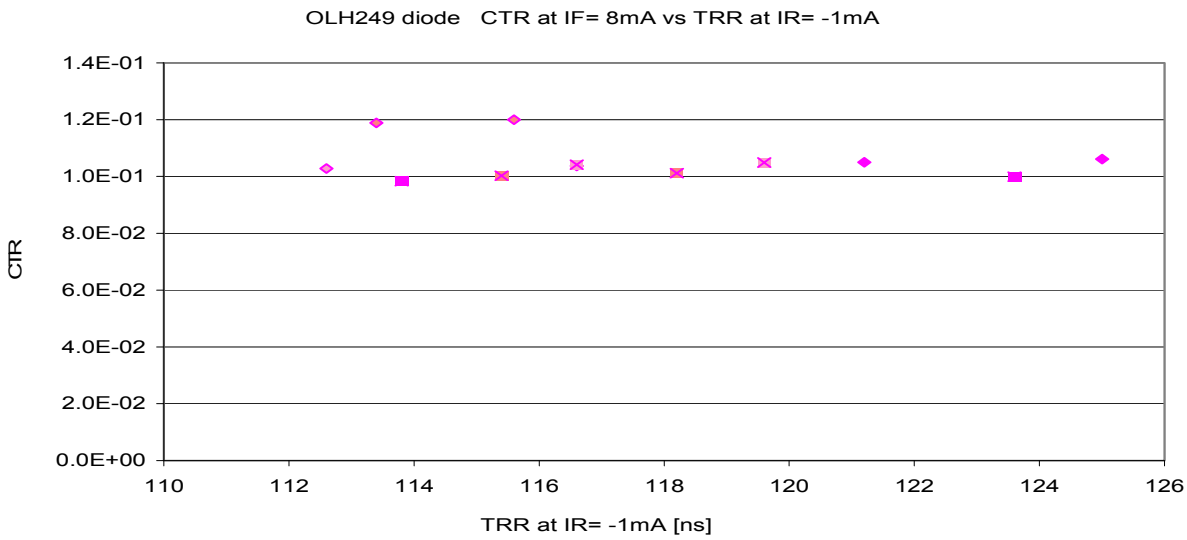


Fig. 13-204: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
110
112
114
116
118
120
122
124
126
TRR at IR= -1mA [ns]

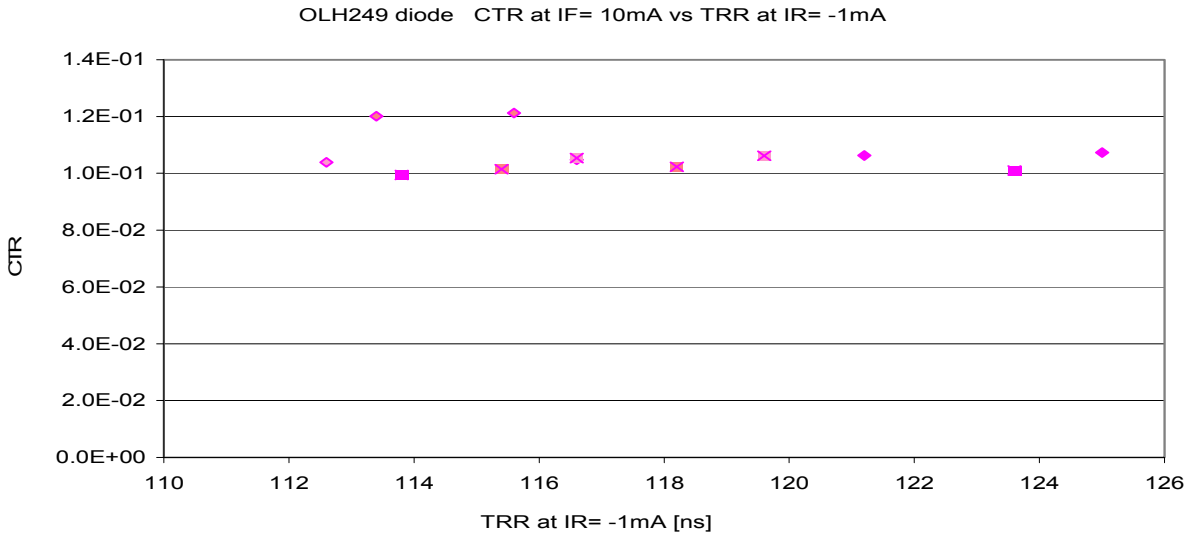
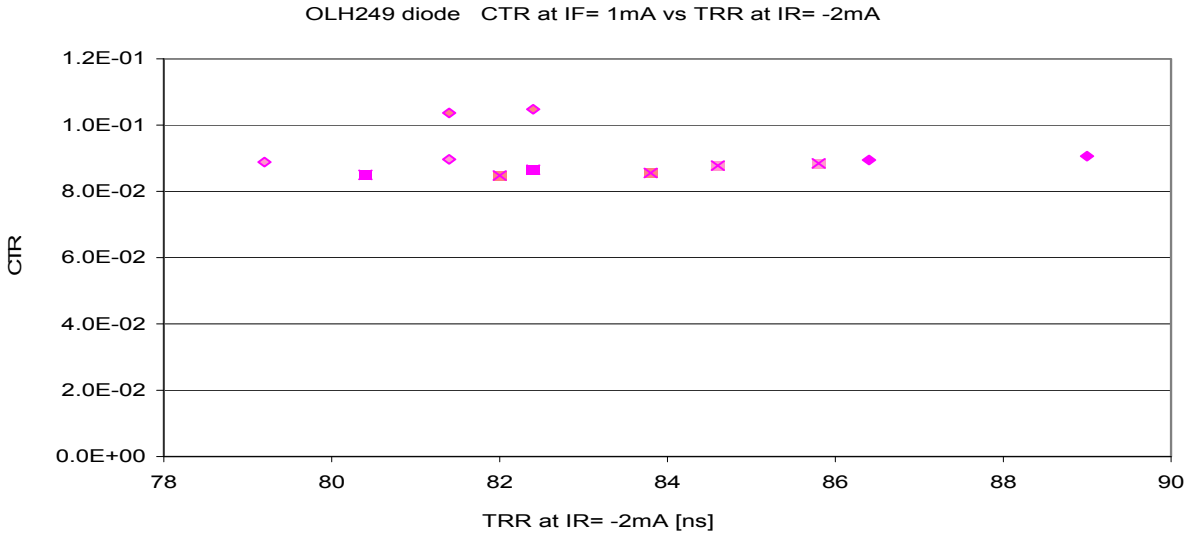
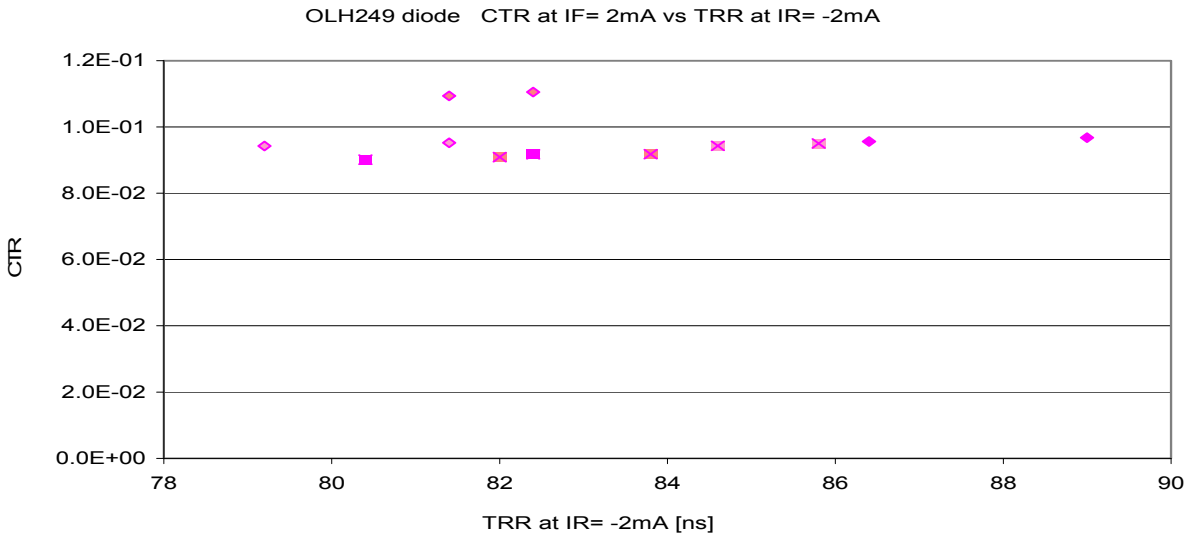
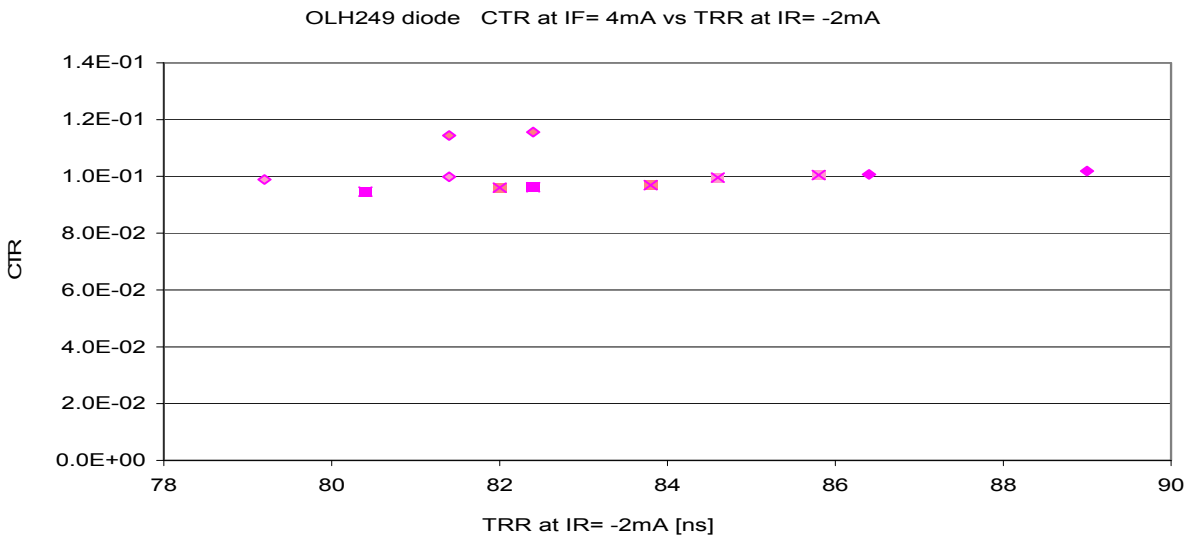
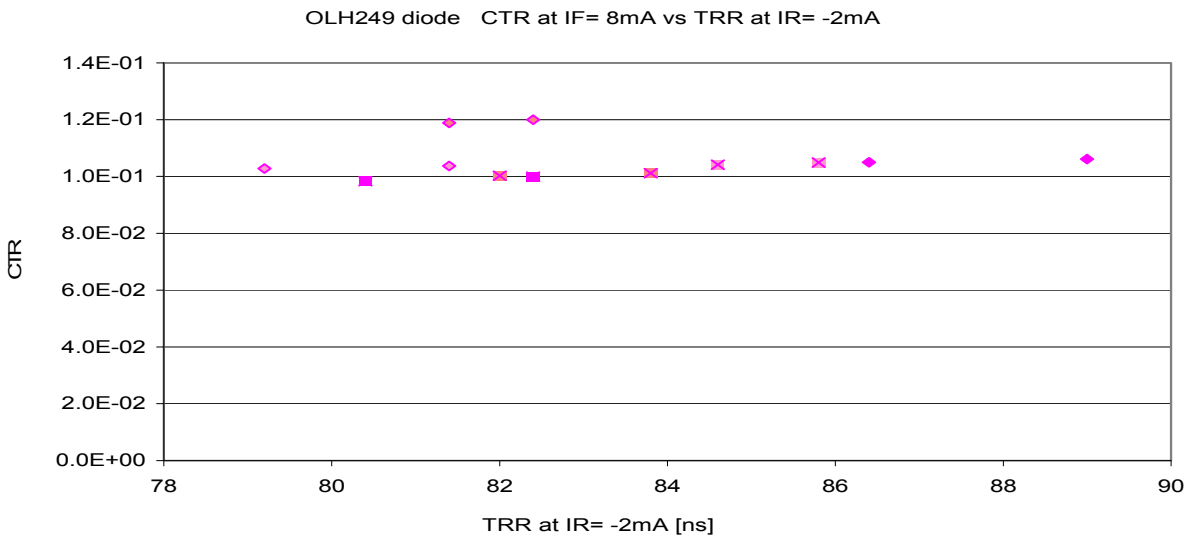

OLH249 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
110
112
114
116
118
120
122
124
126
TRR at IR= -1mA [ns]

Fig. 13-205: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
78
80
82
84
86
88
90
TRR at IR= -2mA [ns]

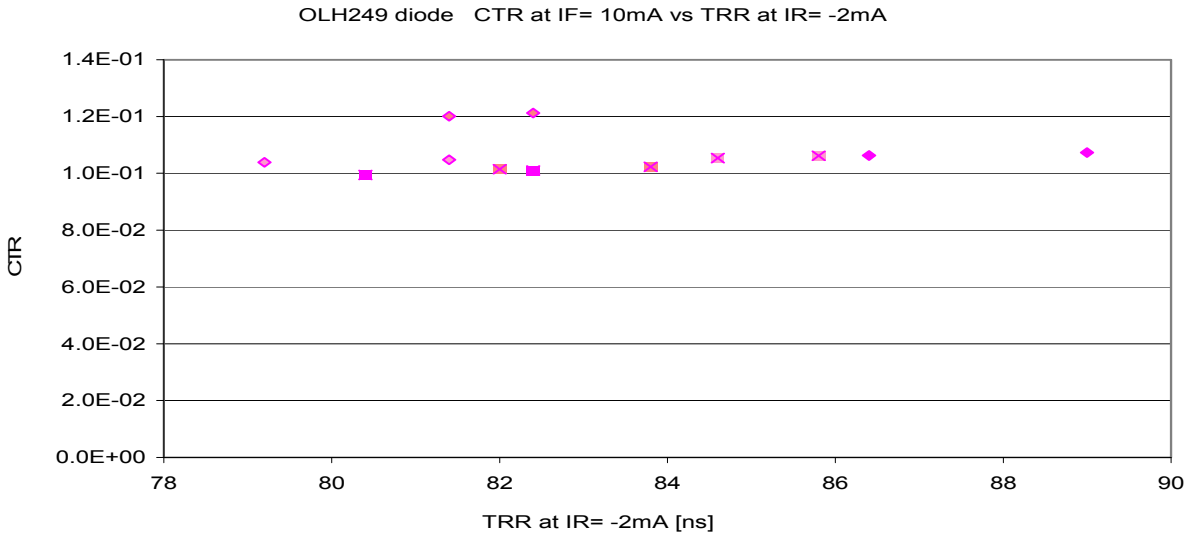
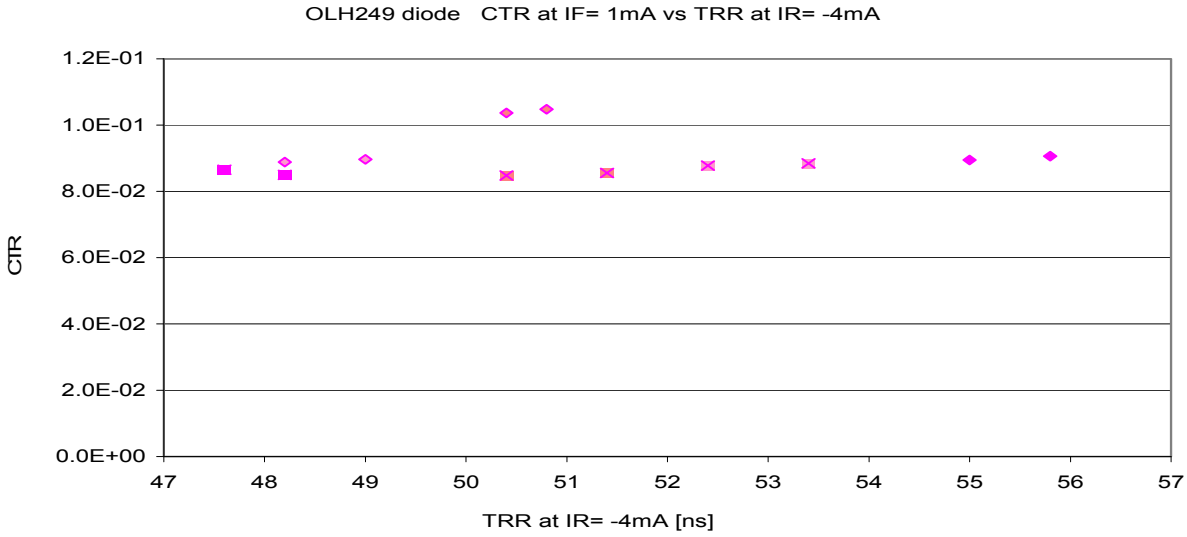
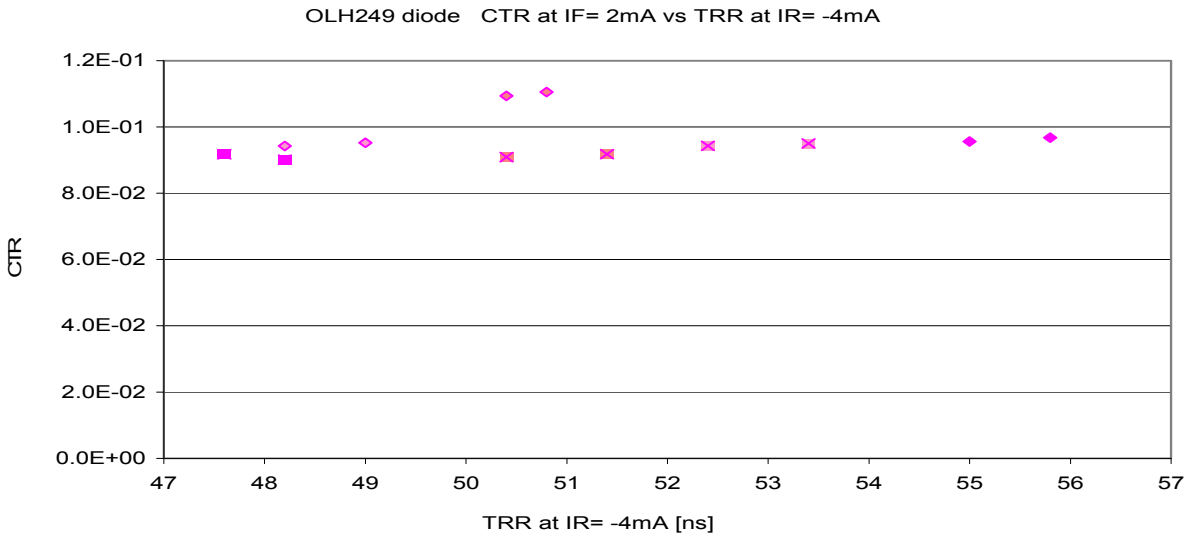
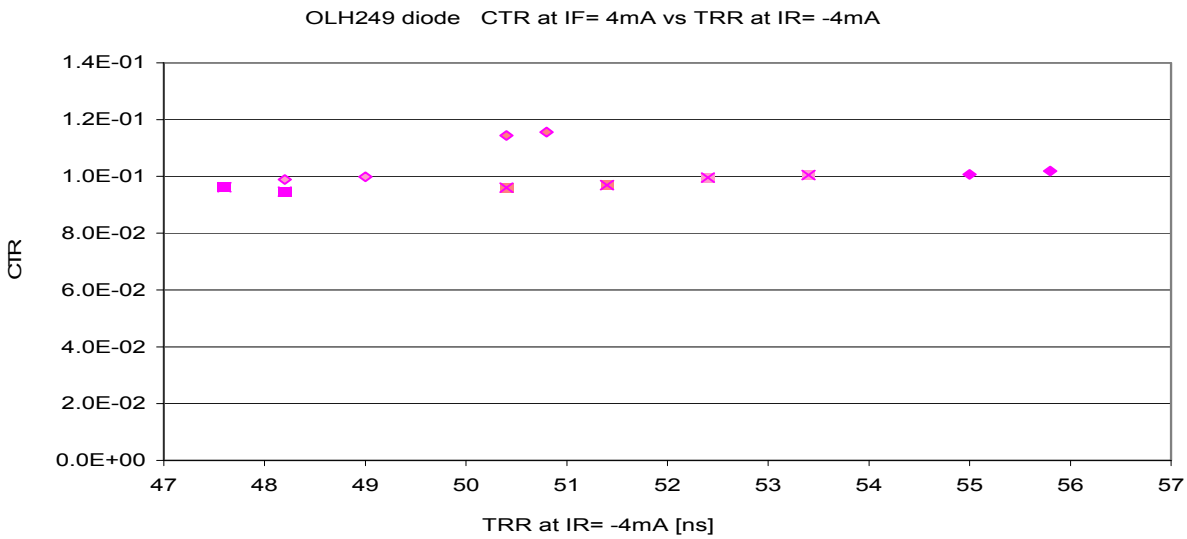
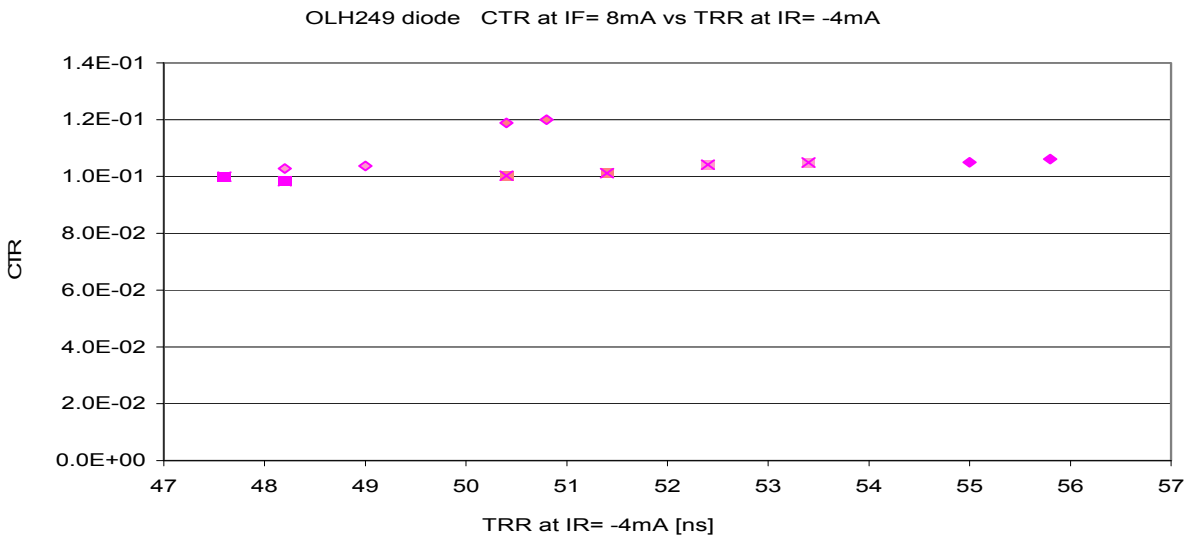

OLH249 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
78
80
82
84
86
88
90
TRR at IR= -2mA [ns]

Fig. 13-206: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








OLH249 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
47
48
49
50
51
52
53
54
55
56
57
TRR at IR= -4mA [ns]

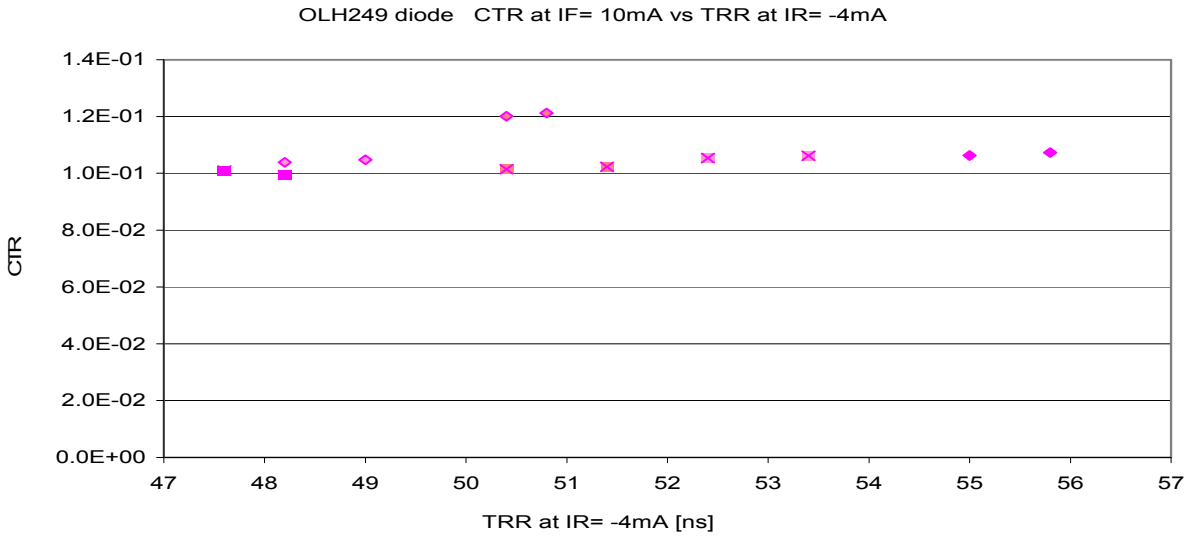
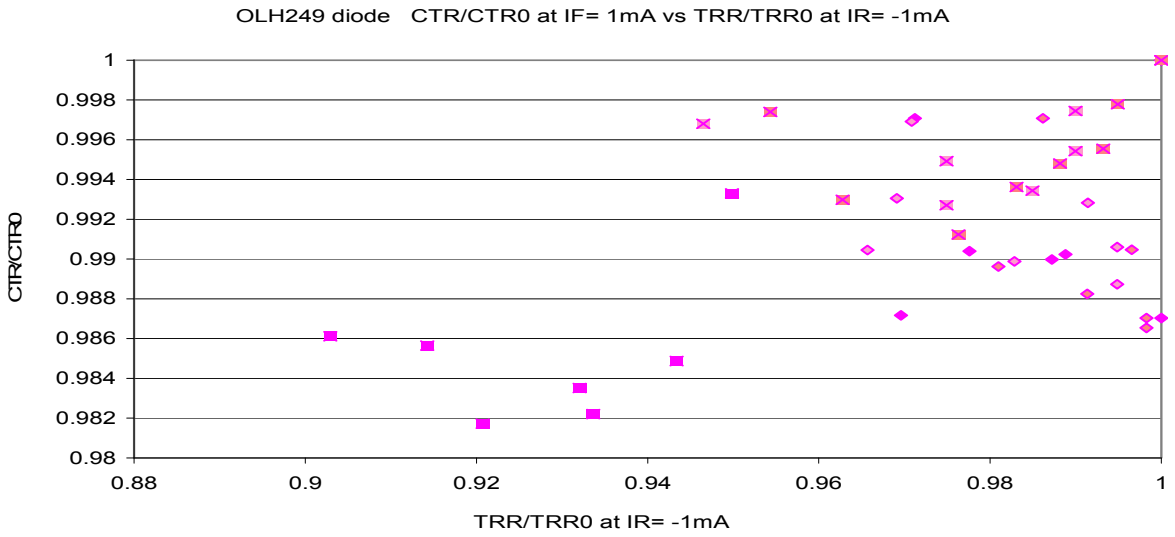
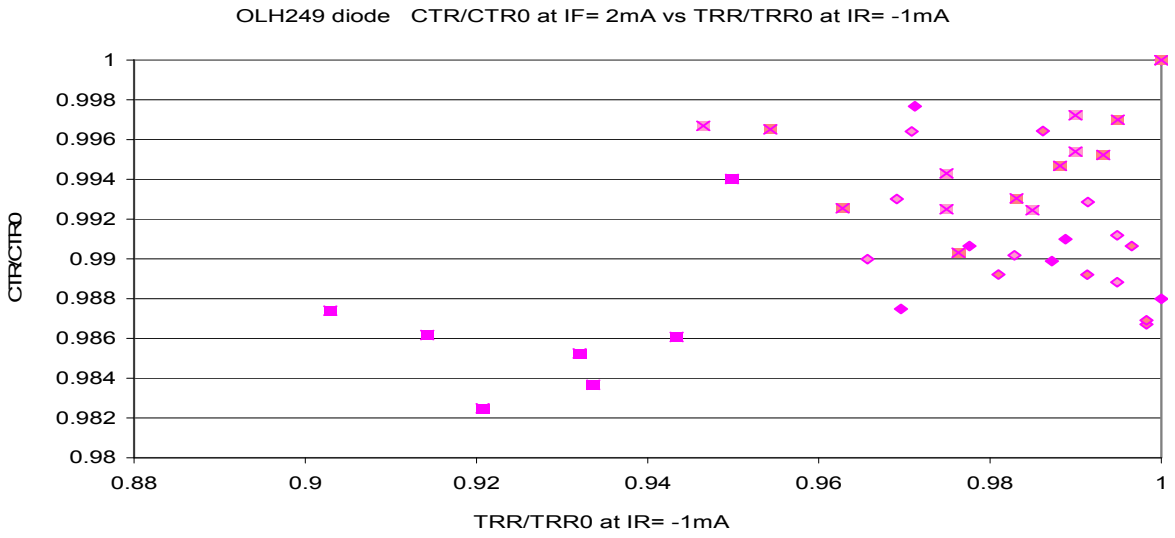
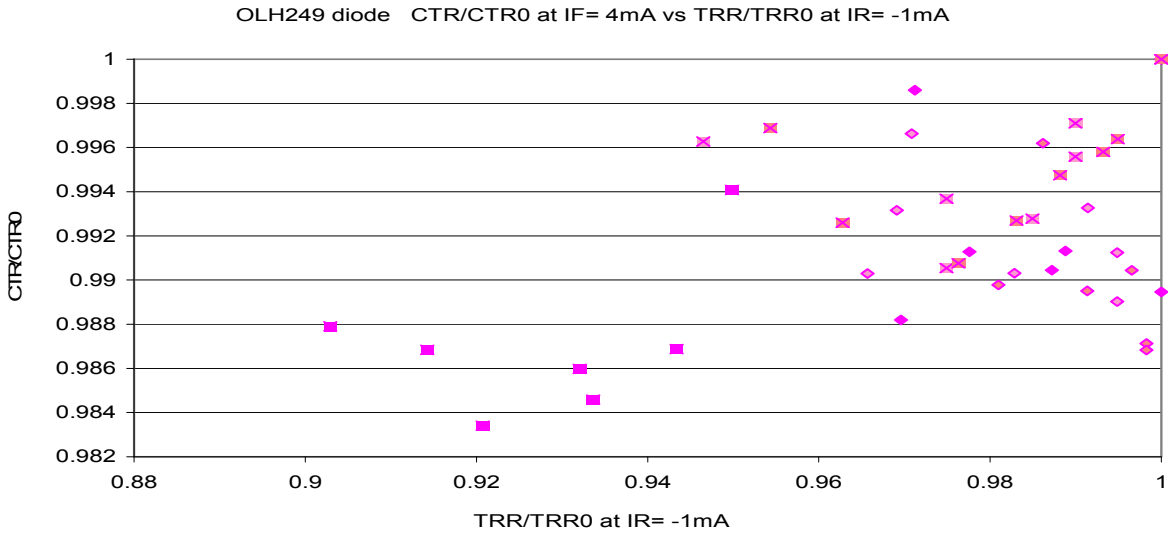
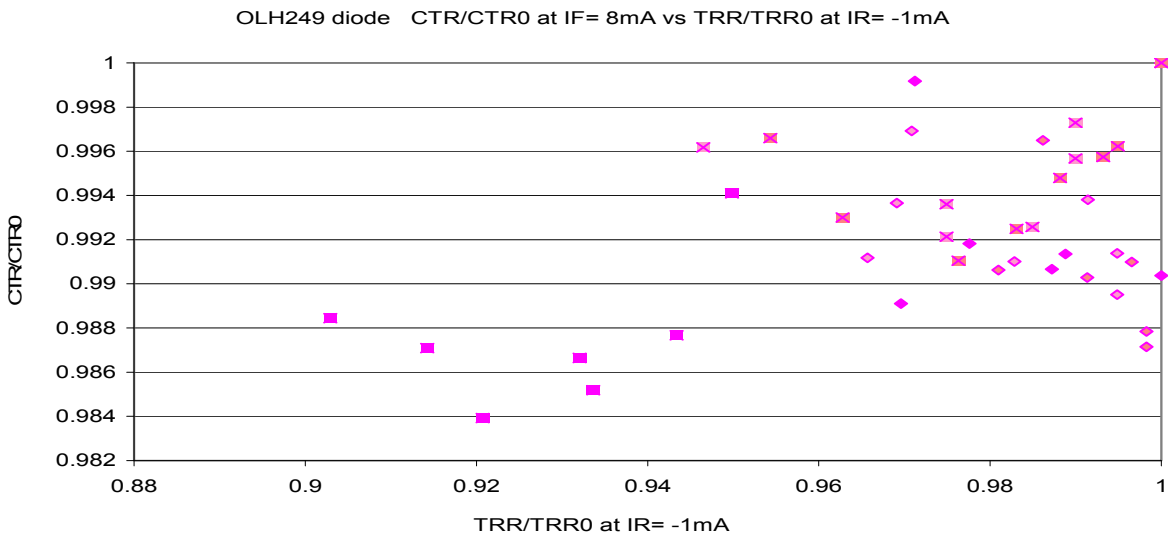

OLH249 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
47
48
49
50
51
52
53
54
55
56
57
TRR at IR= -4mA [ns]

Fig. 13-207: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.88
0.9
0.92
0.94
0.96
0.98
1
TRR/TRR0 at IR= -1mA

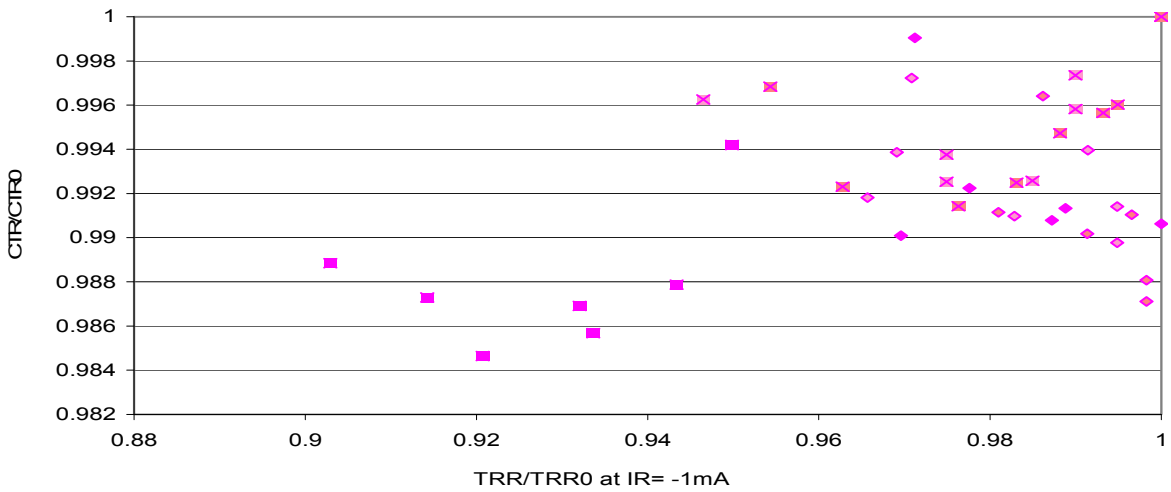
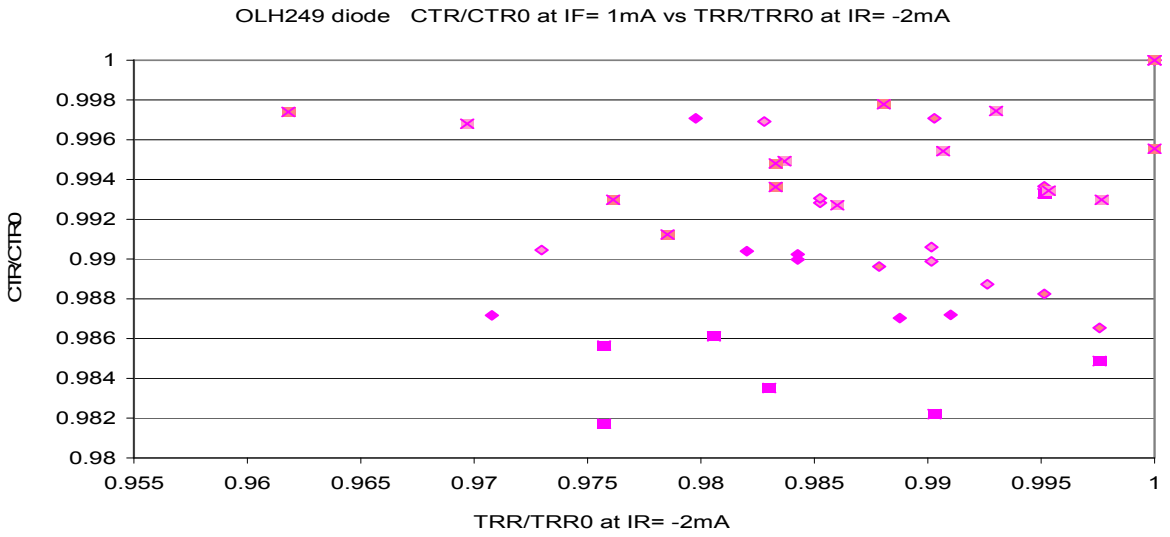
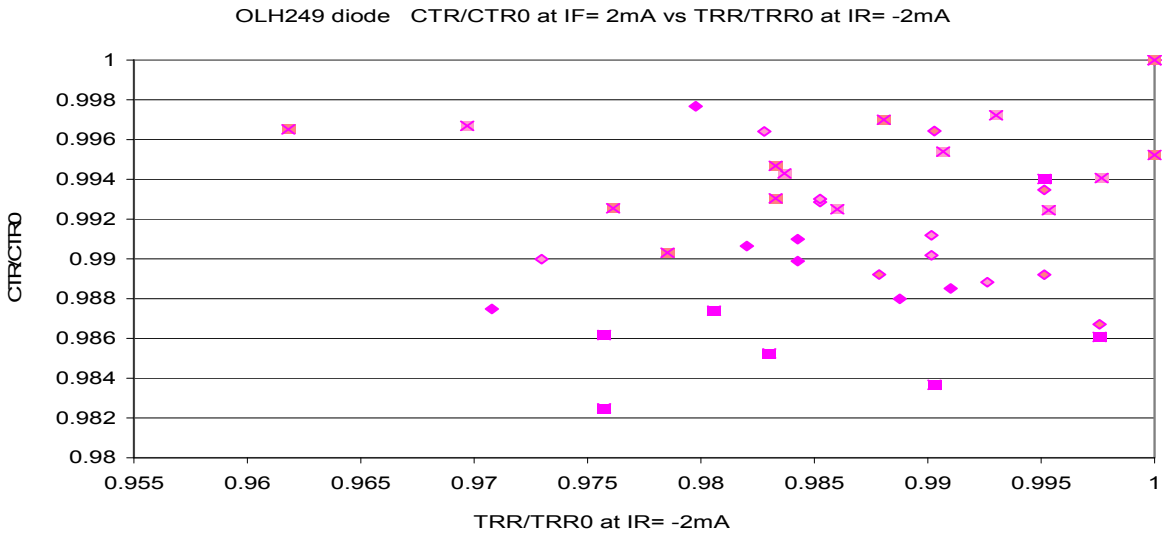
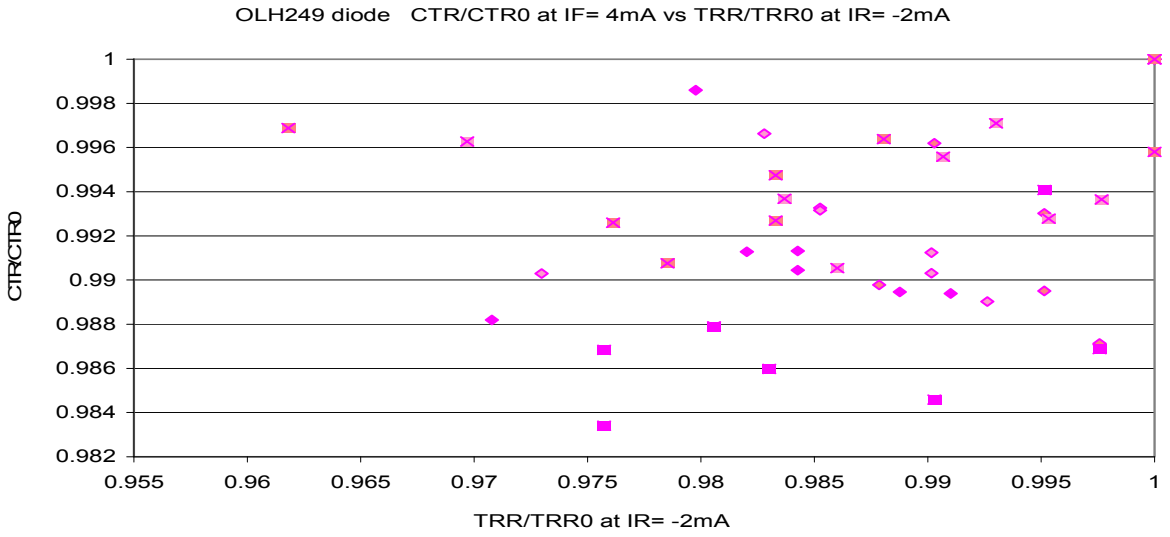
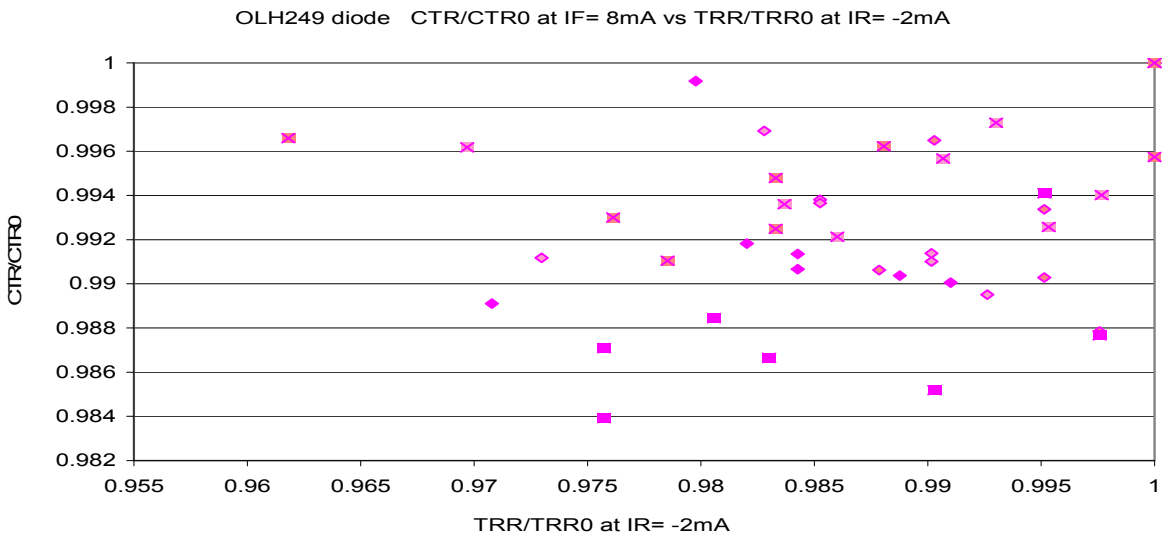

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.88
0.9
0.92
0.94
0.96
0.98
1
TRR/TRR0 at IR= -1mA

Fig. 13-208: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -2mA

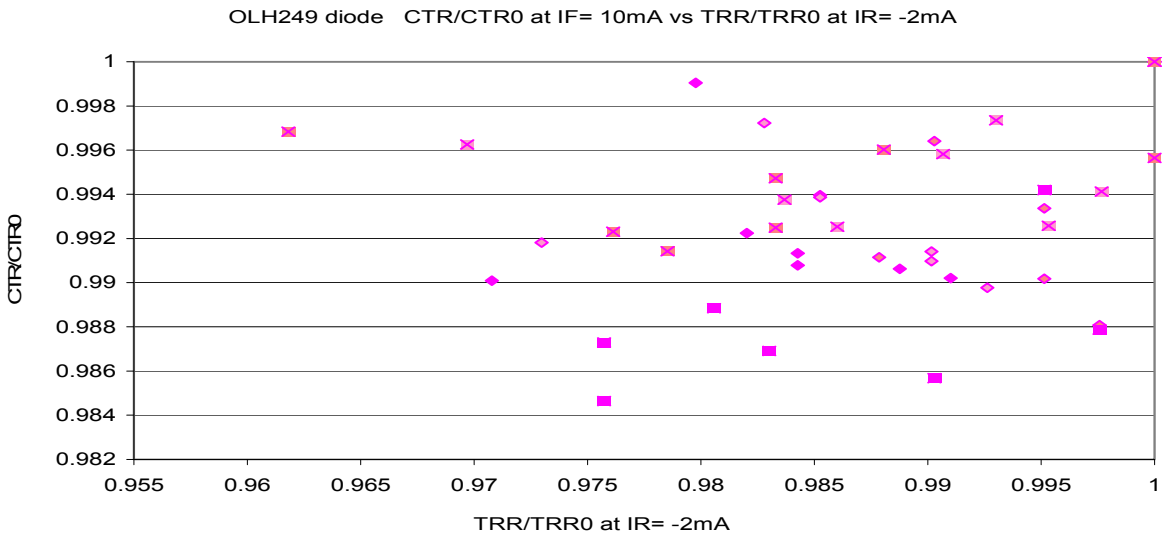
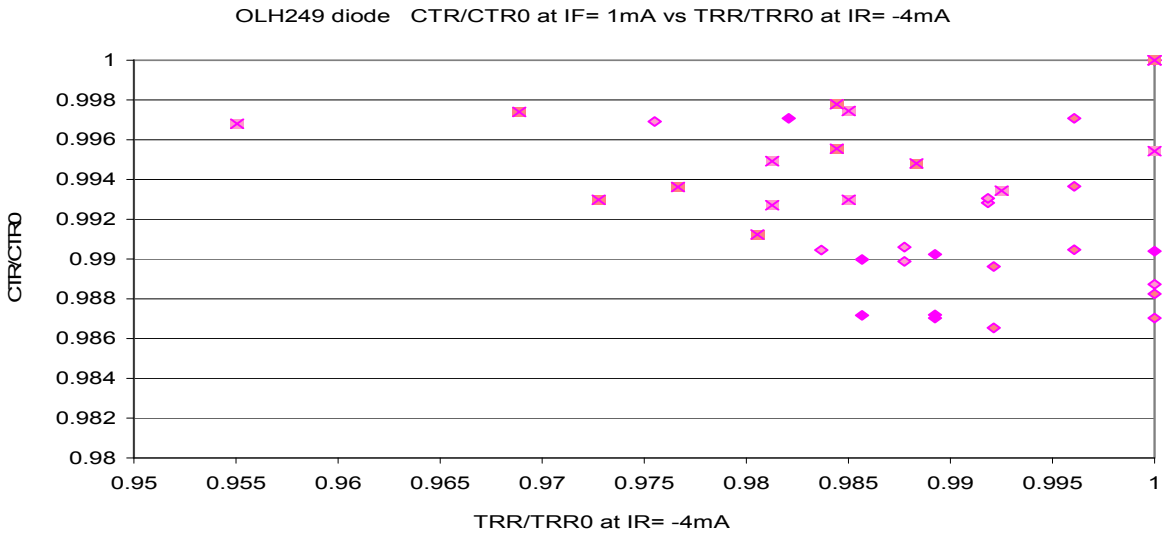
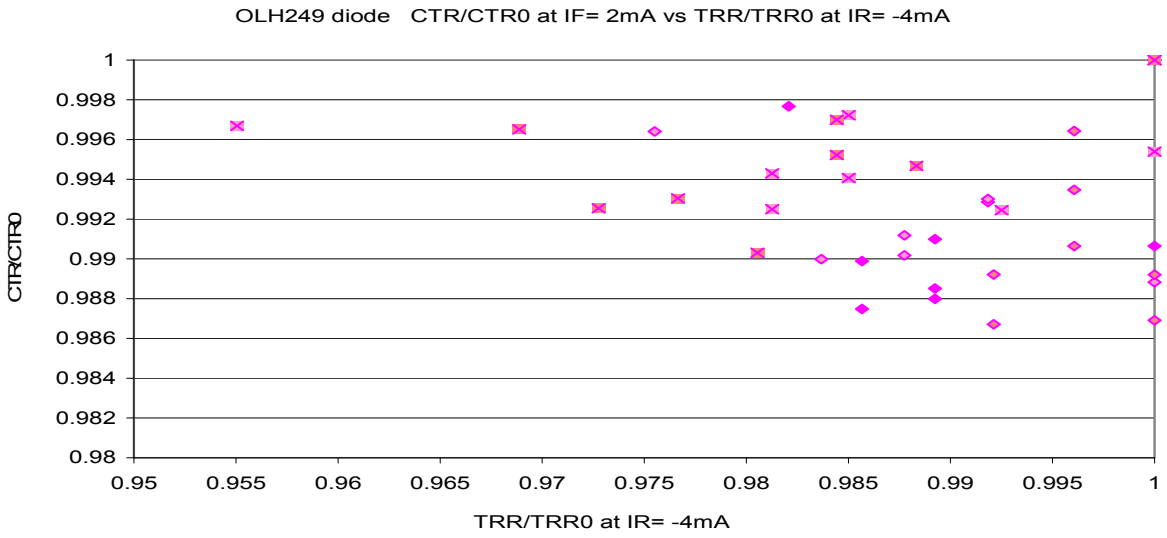
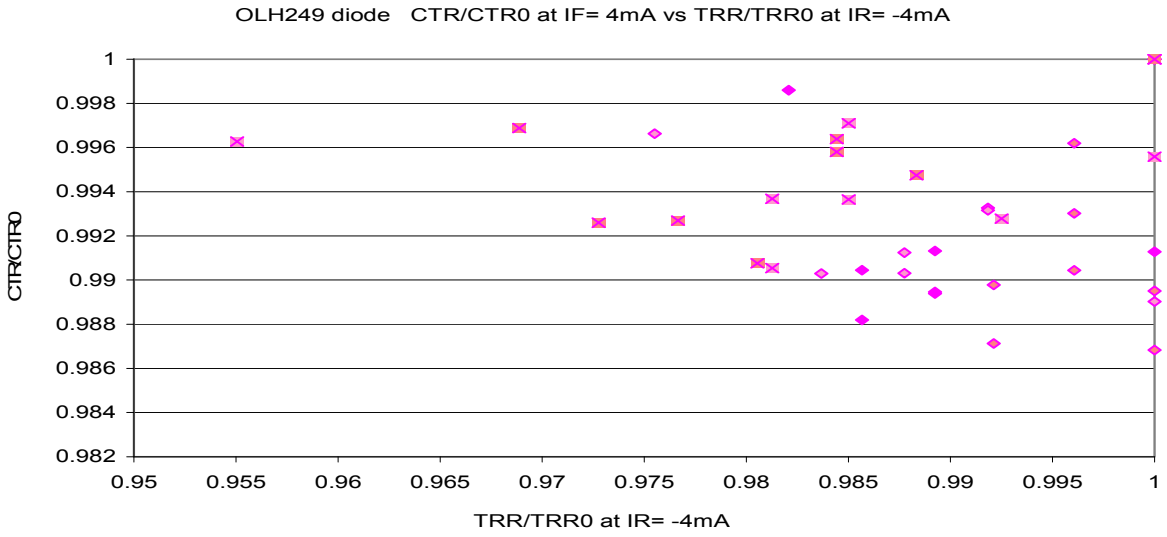
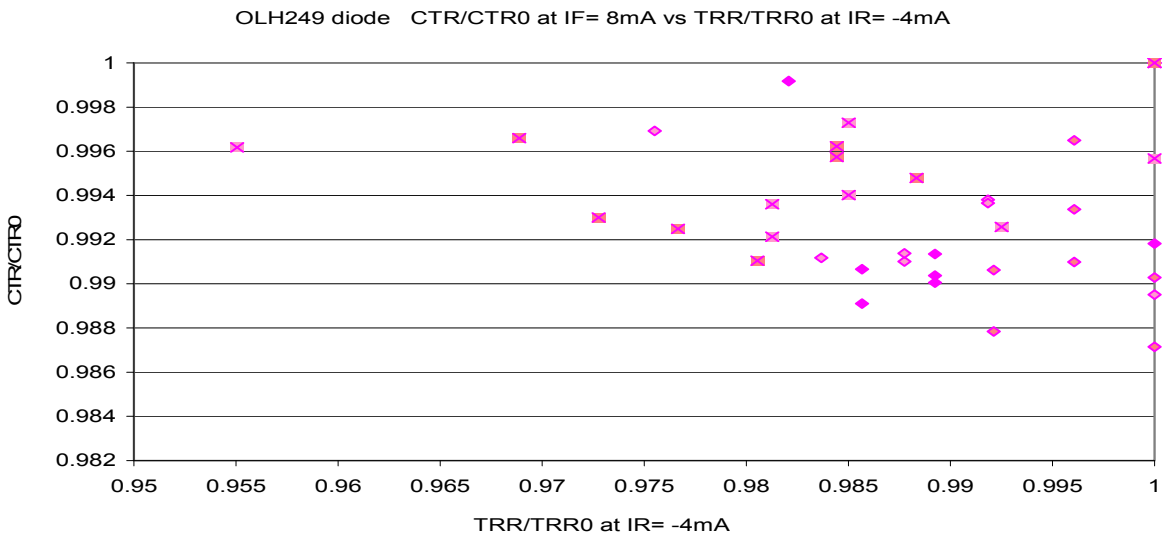

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -2mA

Fig. 13-209: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.95
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -4mA

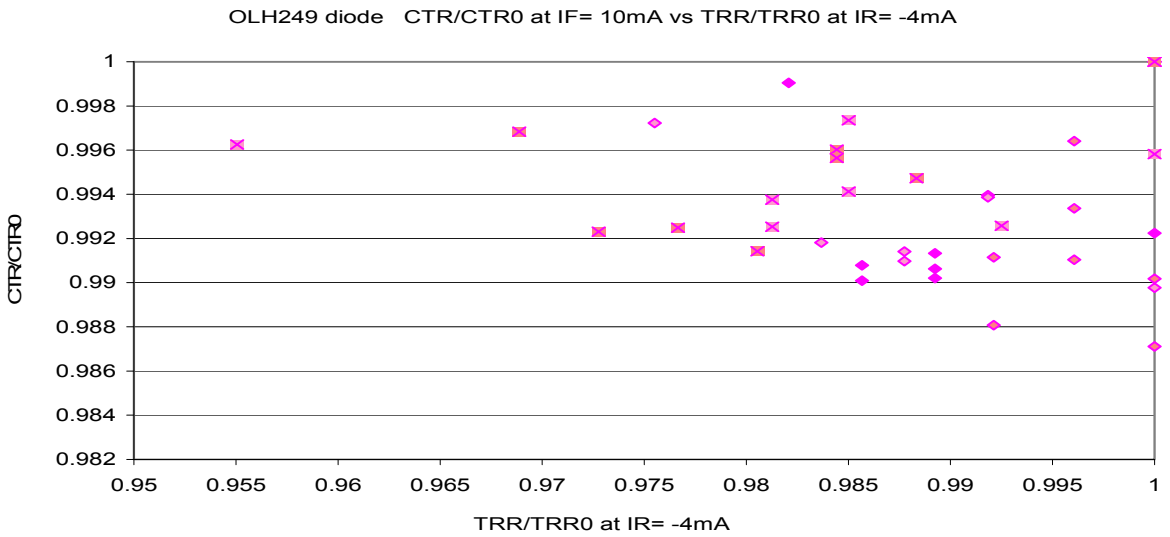
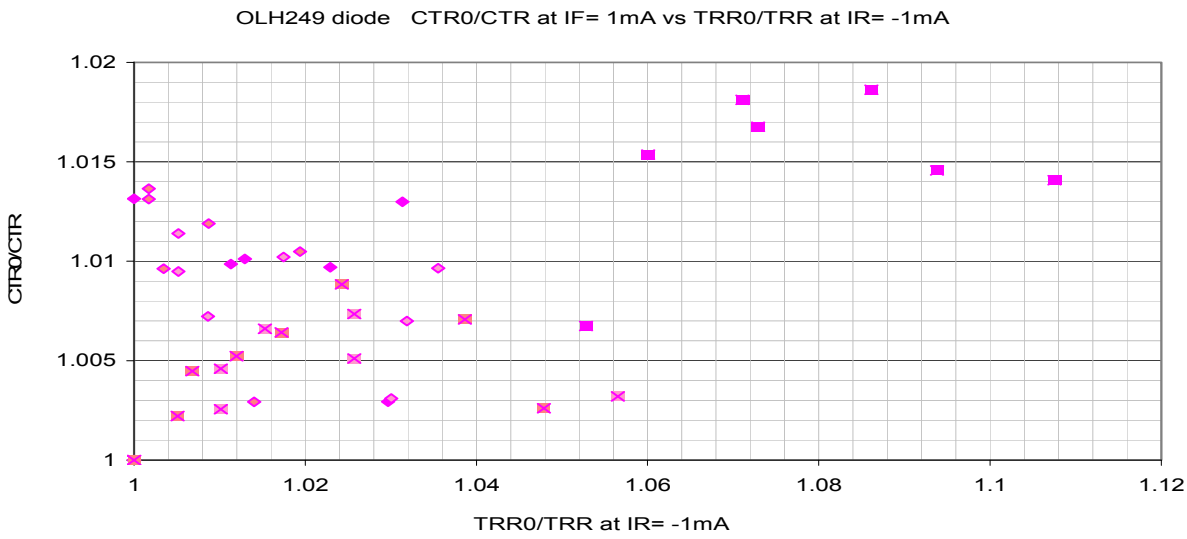
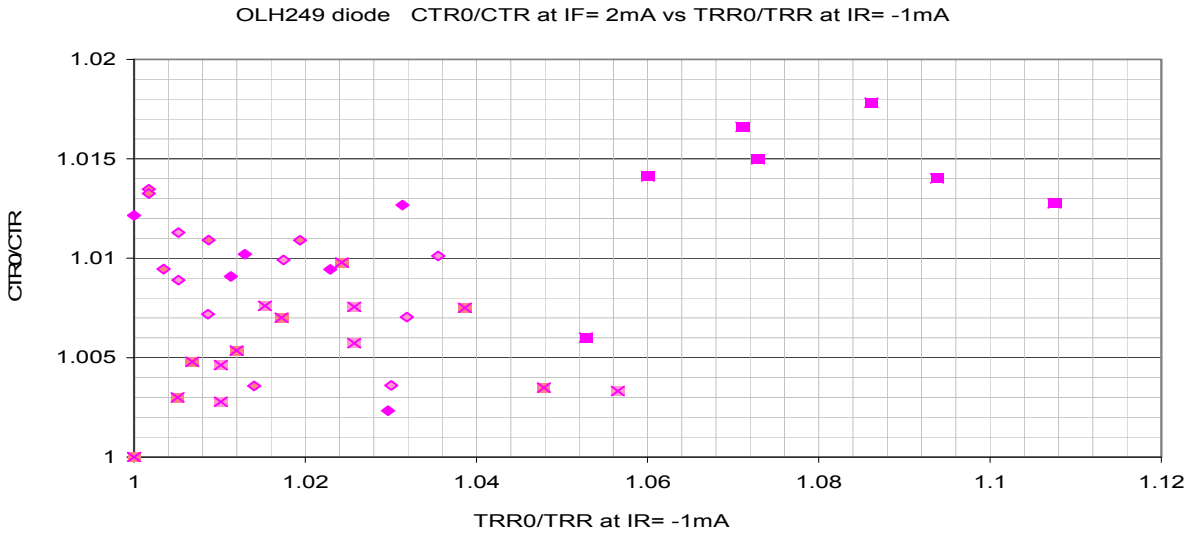
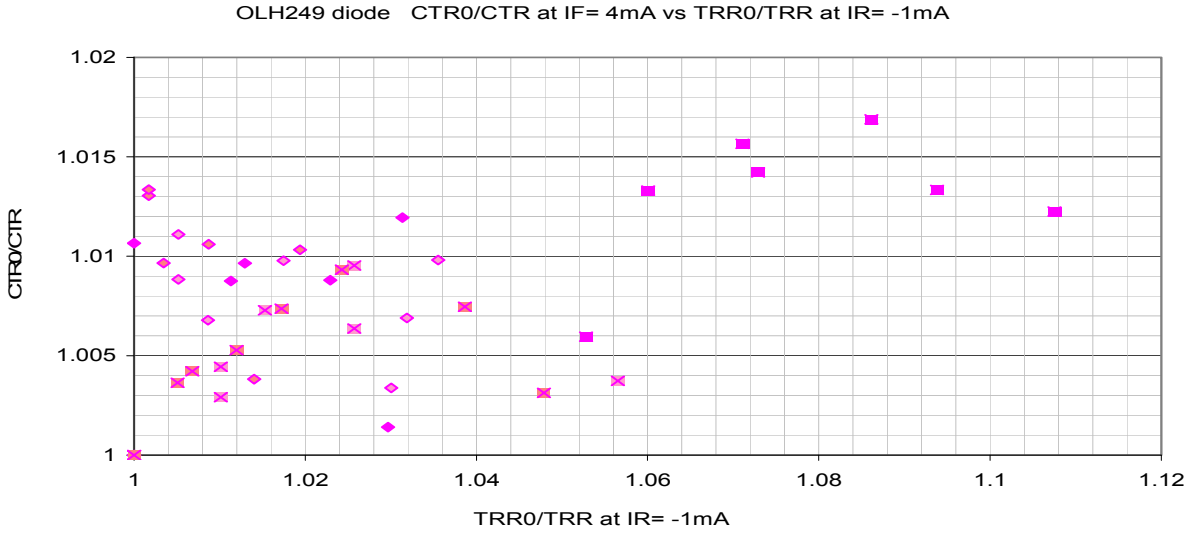

OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1
0.998
0.996
0.994
0.992
0.99
0.988
0.986
0.984
0.982
0.95
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -4mA

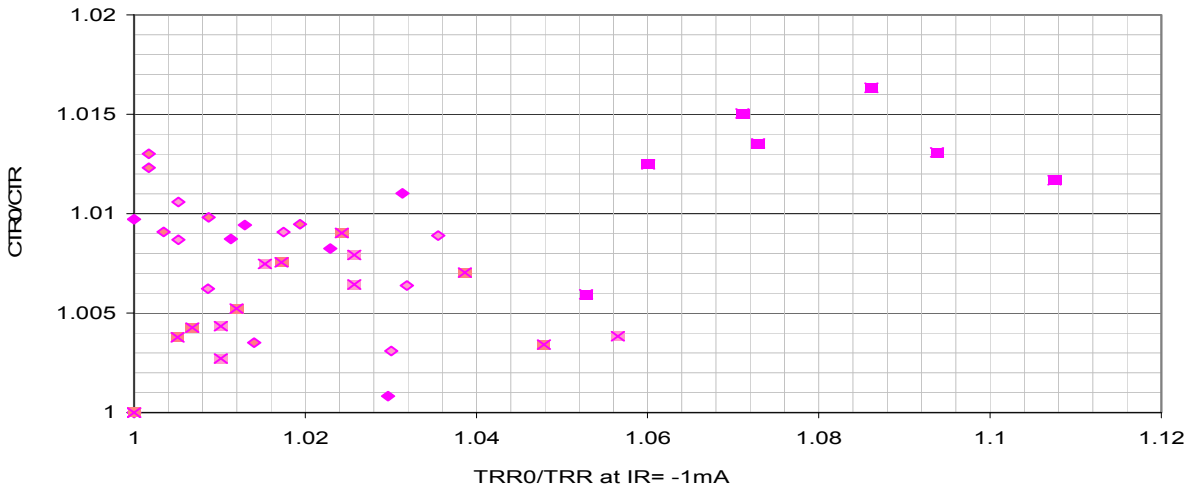
Fig. 13-210: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA







OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA

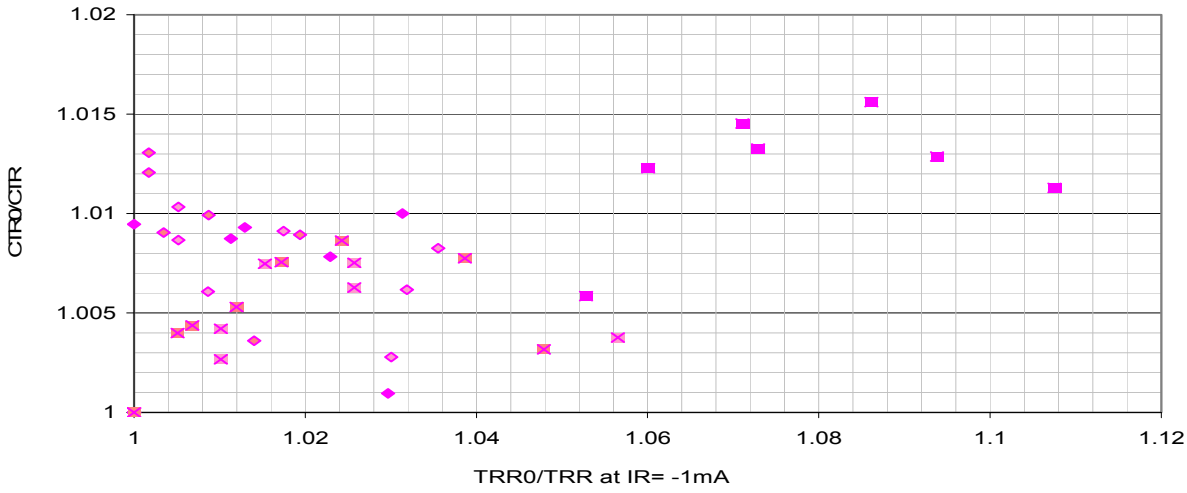
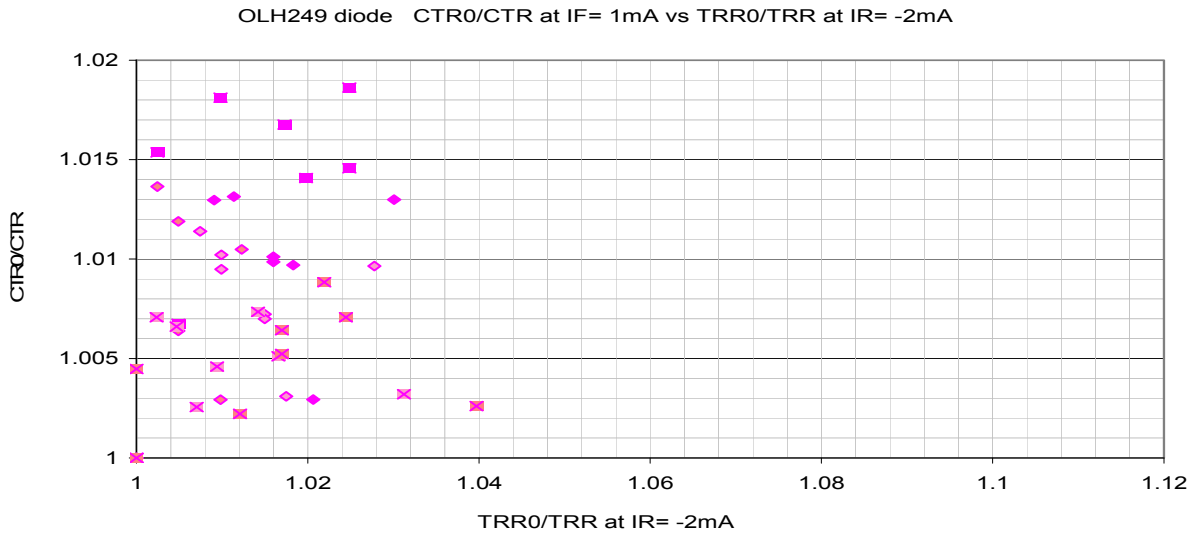
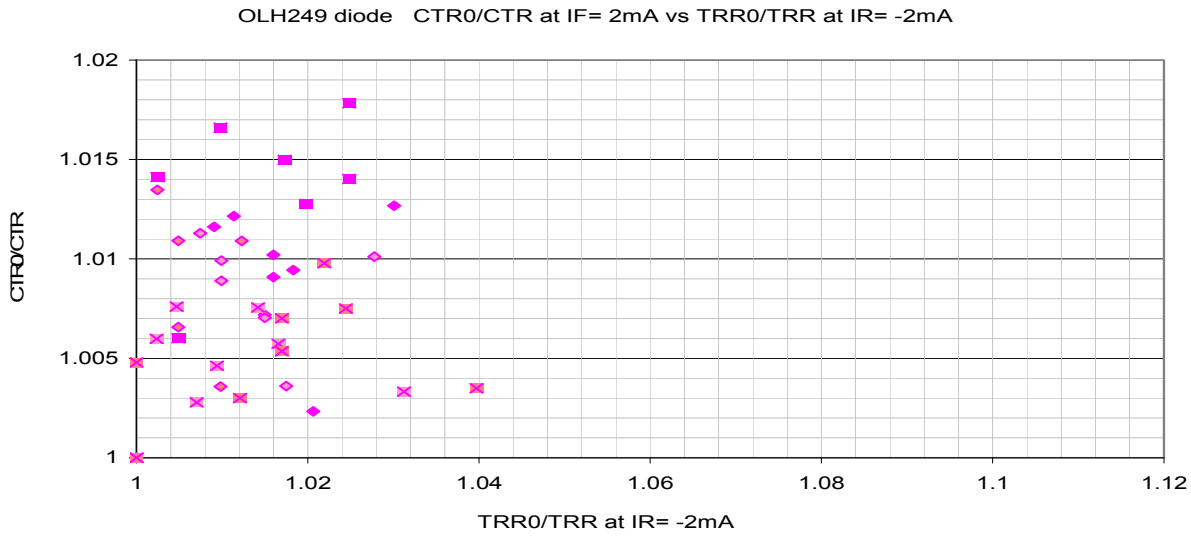
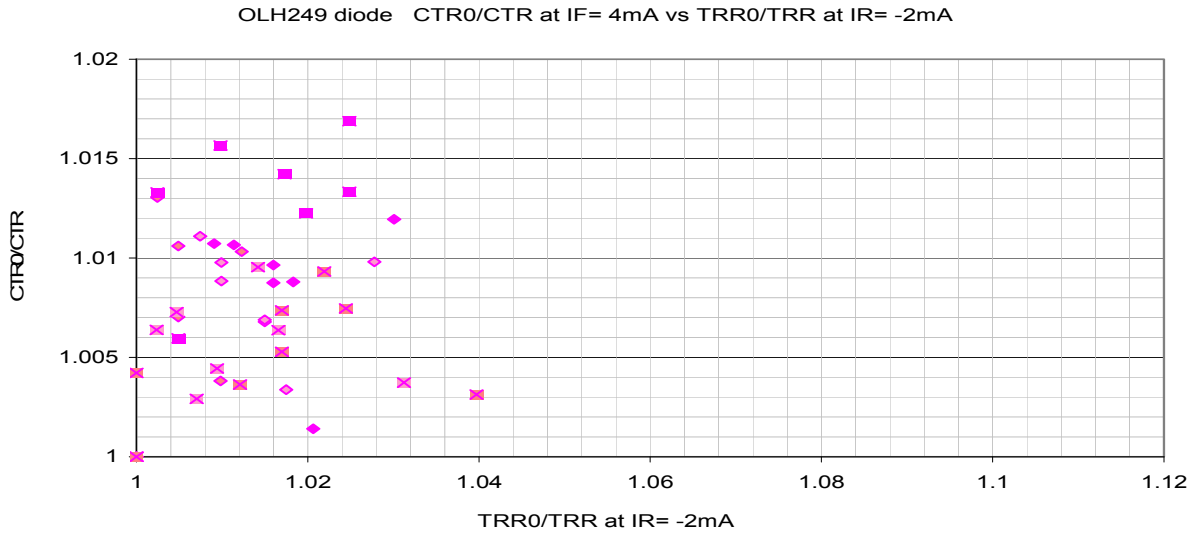


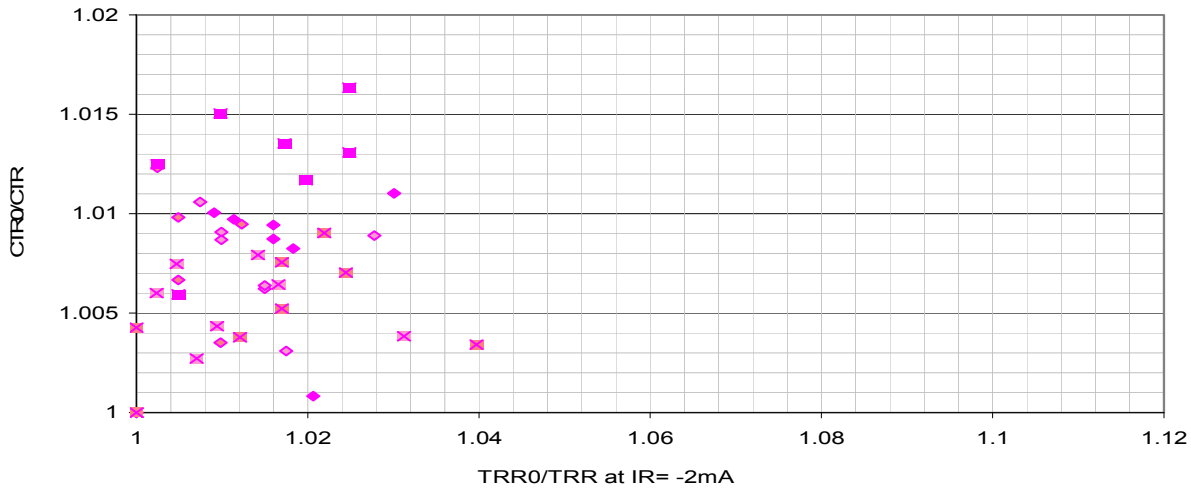
Fig. 13-211: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA







OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

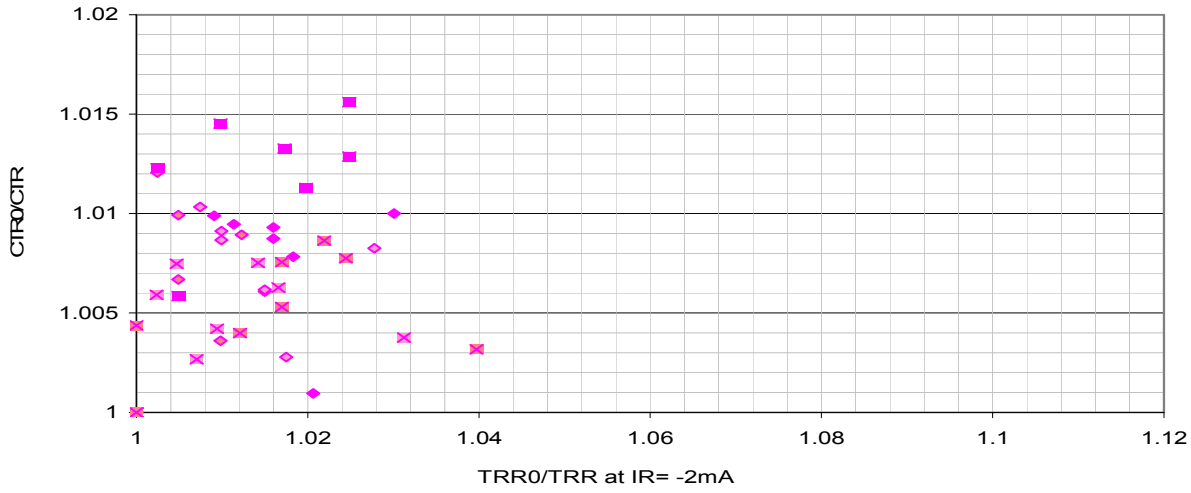
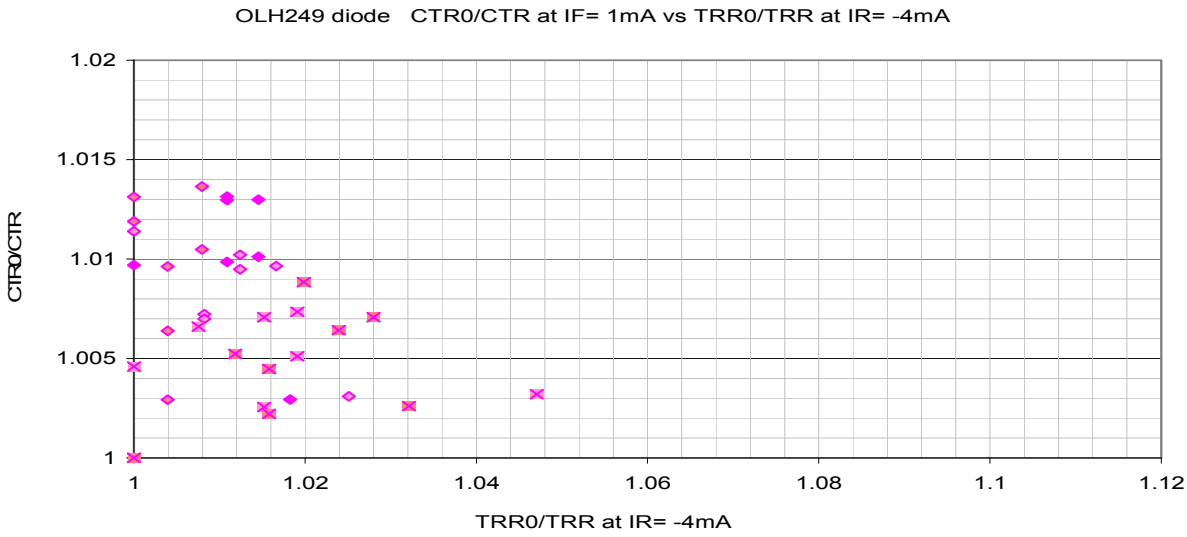
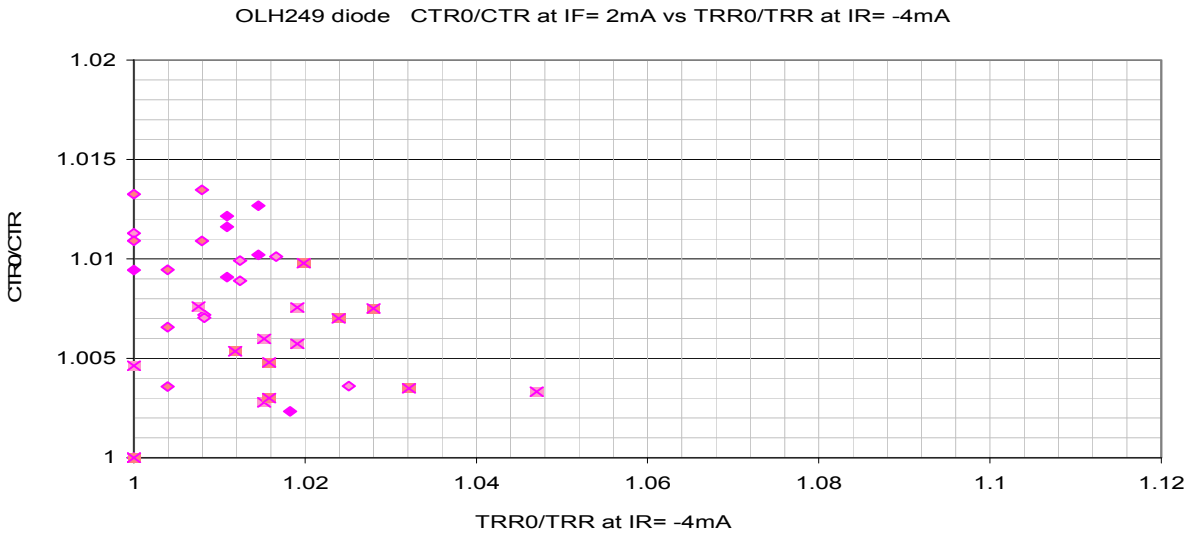
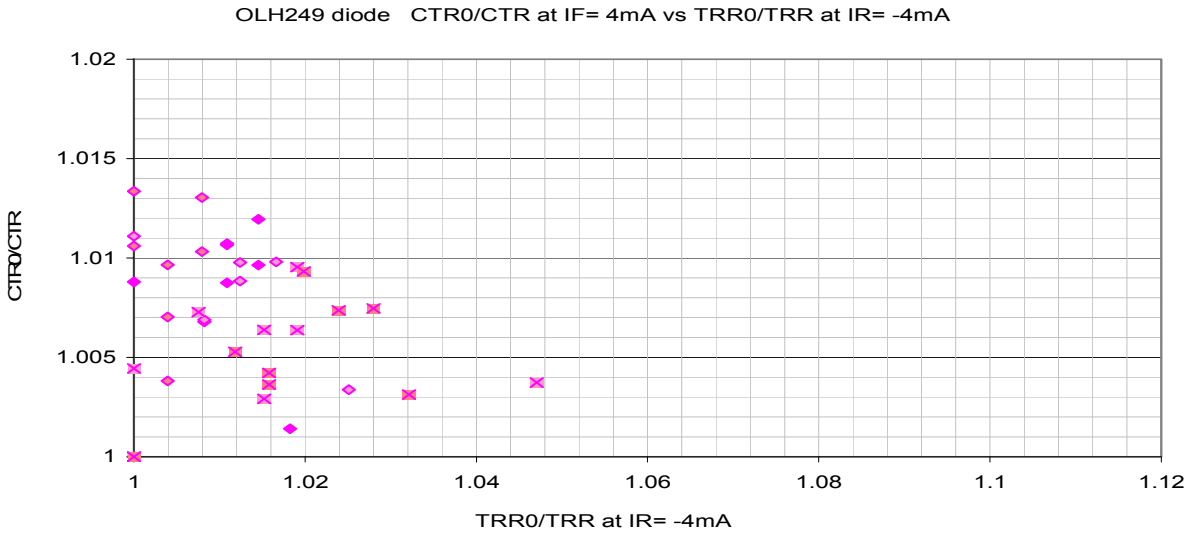


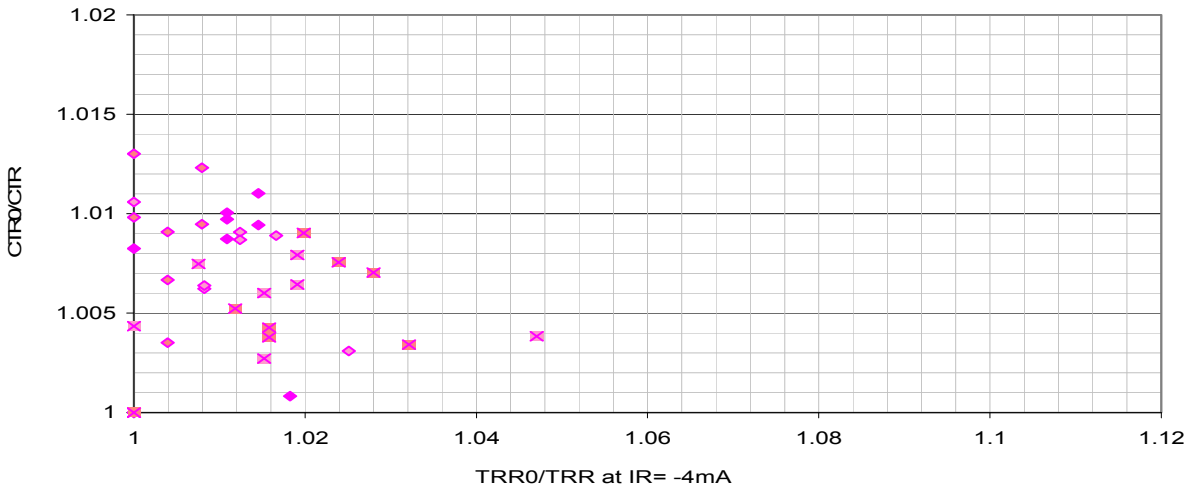
Fig. 13-212: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

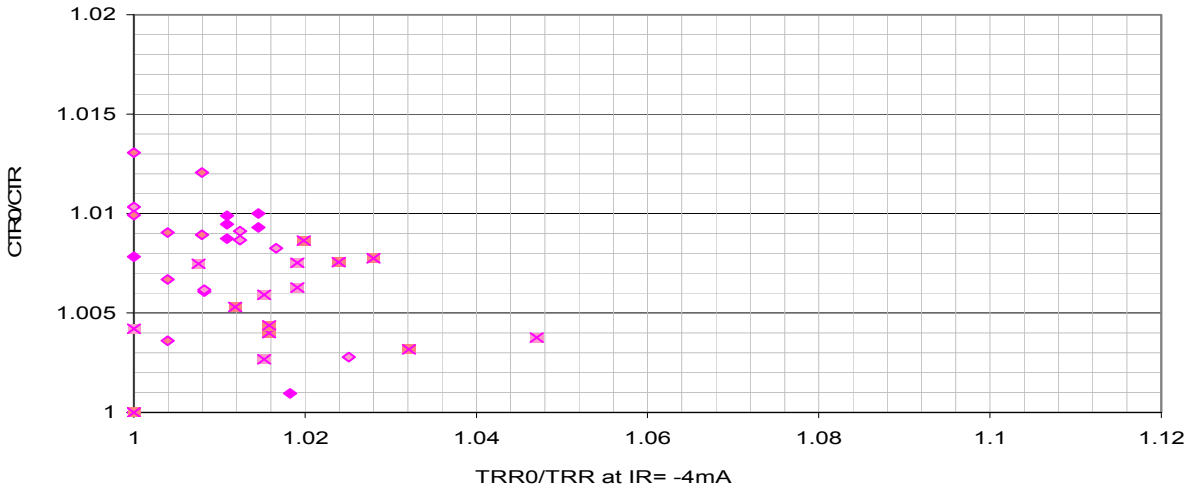
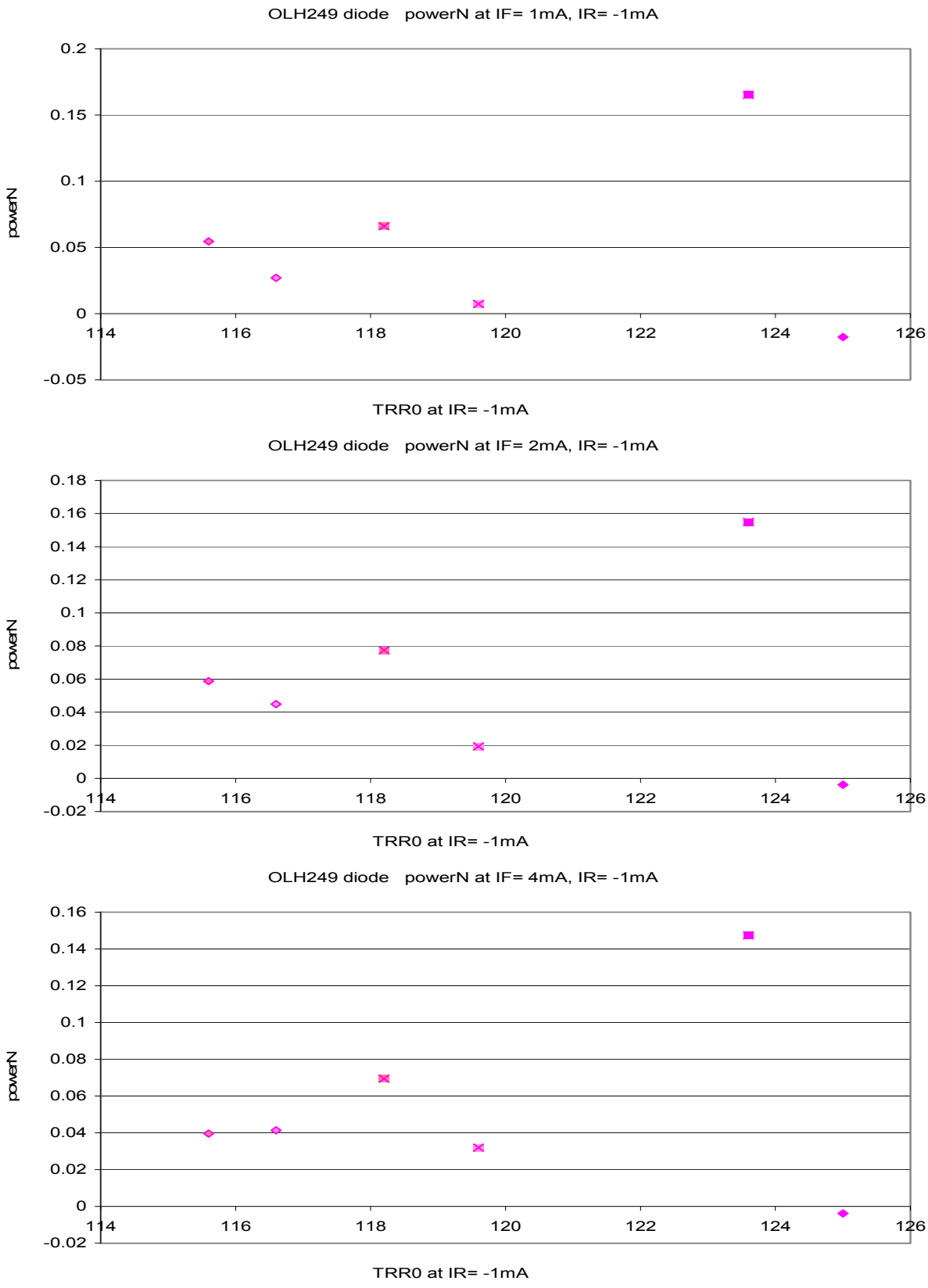
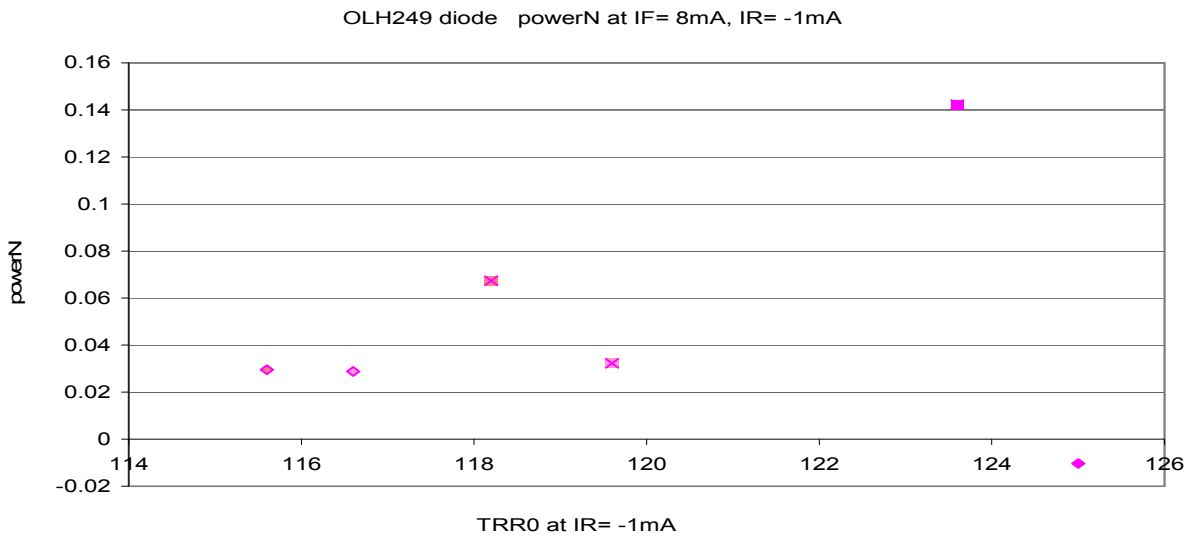


Fig. 13-213: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA




OLH249 diode powerN at IF= 8mA, IR= -1mA
powerN
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
114
116
118
120
122
124
126
TRR0 at IR= -1mA

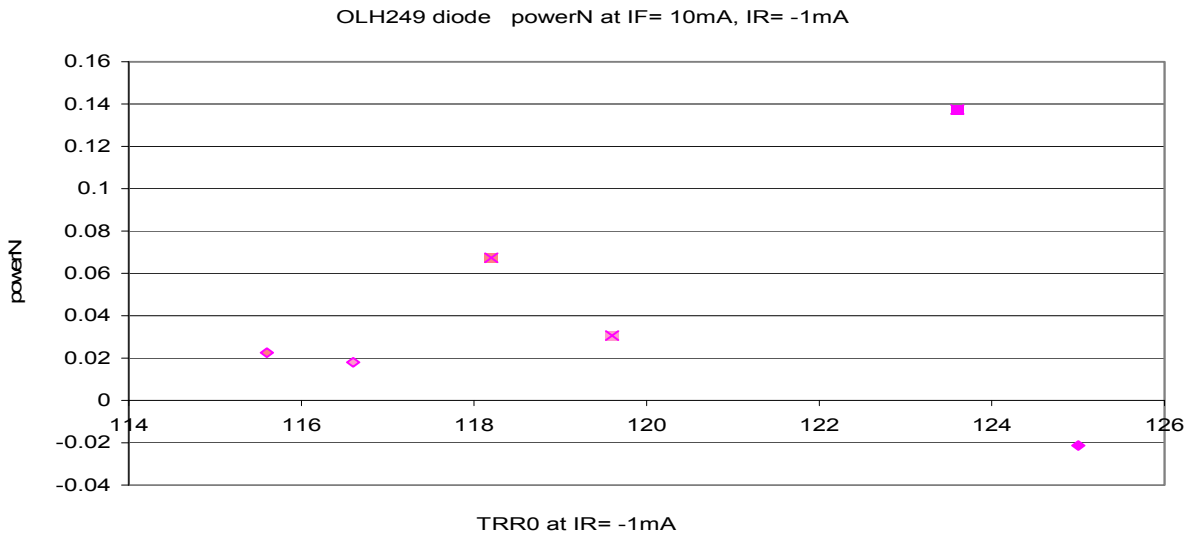
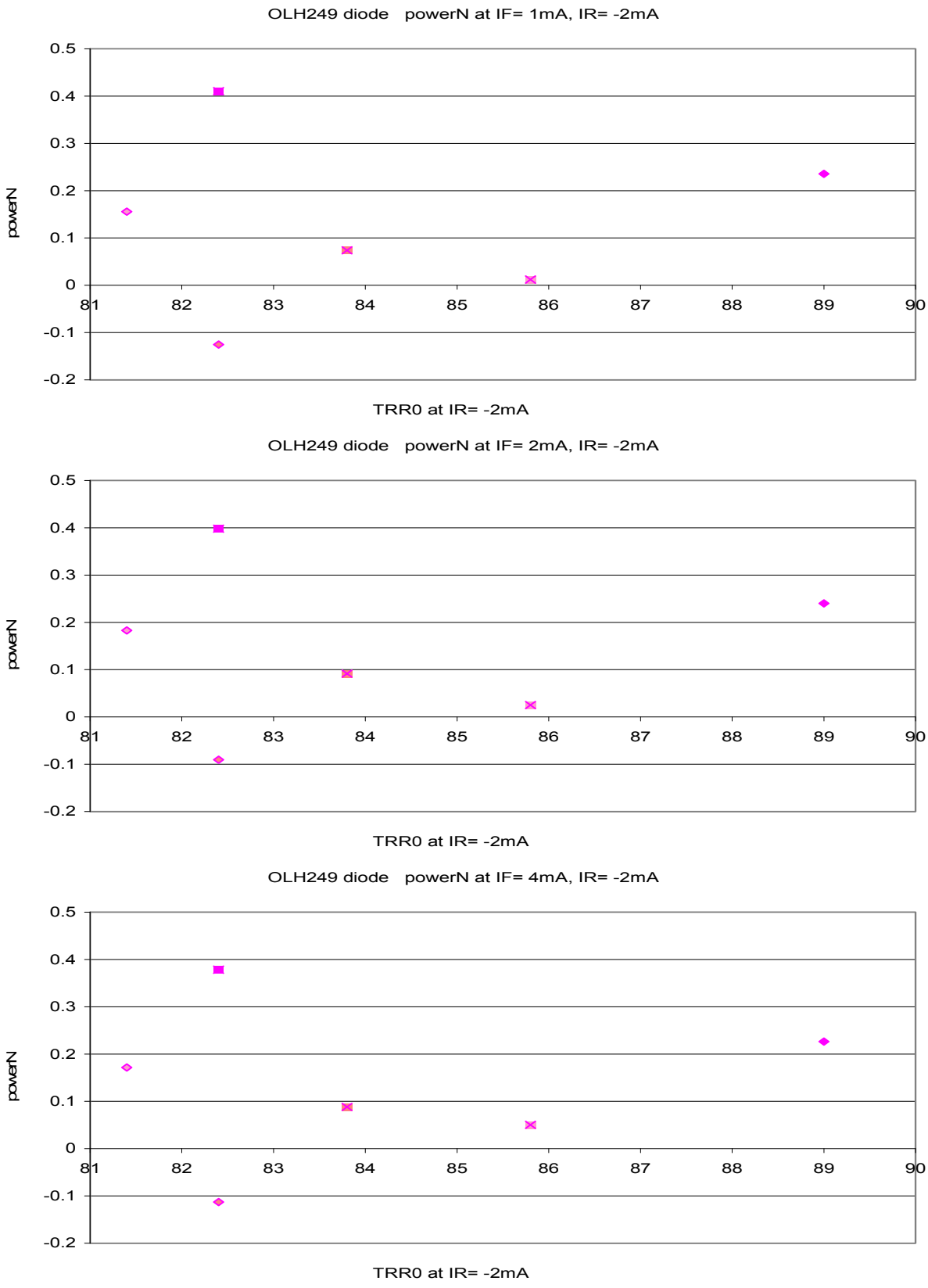
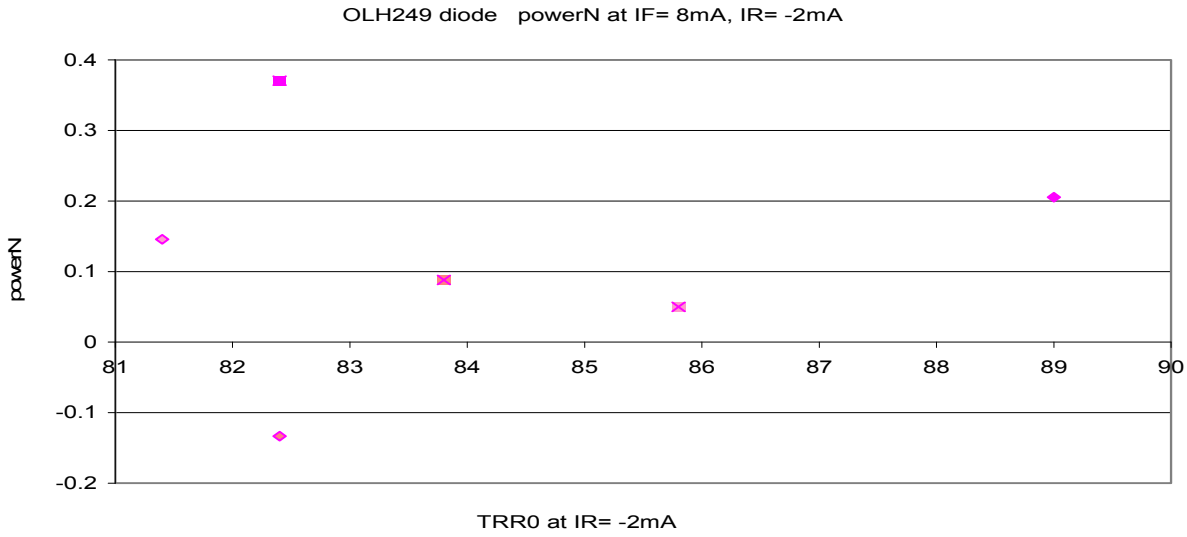

OLH249 diode powerN at IF= 10mA, IR= -1mA
powerN
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
114
116
118
120
122
124
126
TRR0 at IR= -1mA

Fig. 13-214: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA




OLH249 diode powerN at IF= 8mA, IR= -2mA
powerN
0.4
0.3
0.2
0.1
0
-0.1
-0.2
81
82
83
84
85
86
87
88
89
90
TRR0 at IR= -2mA

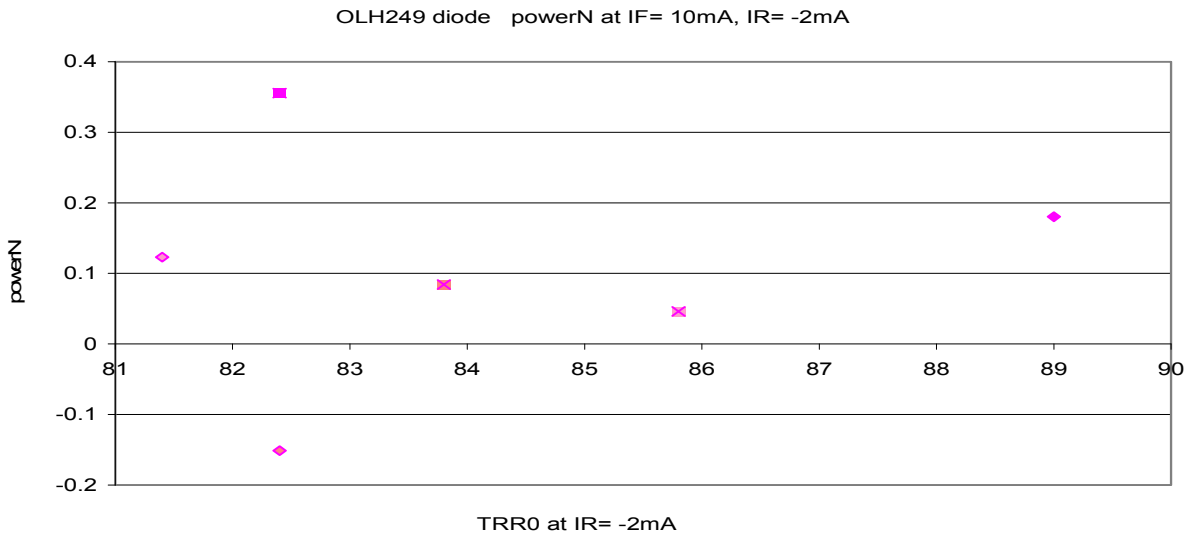
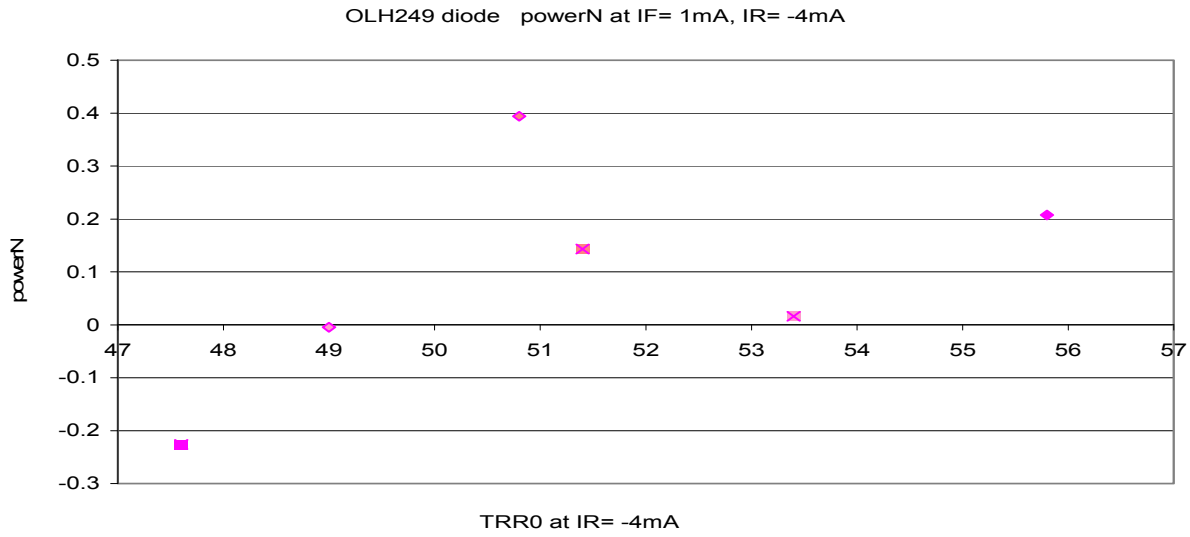
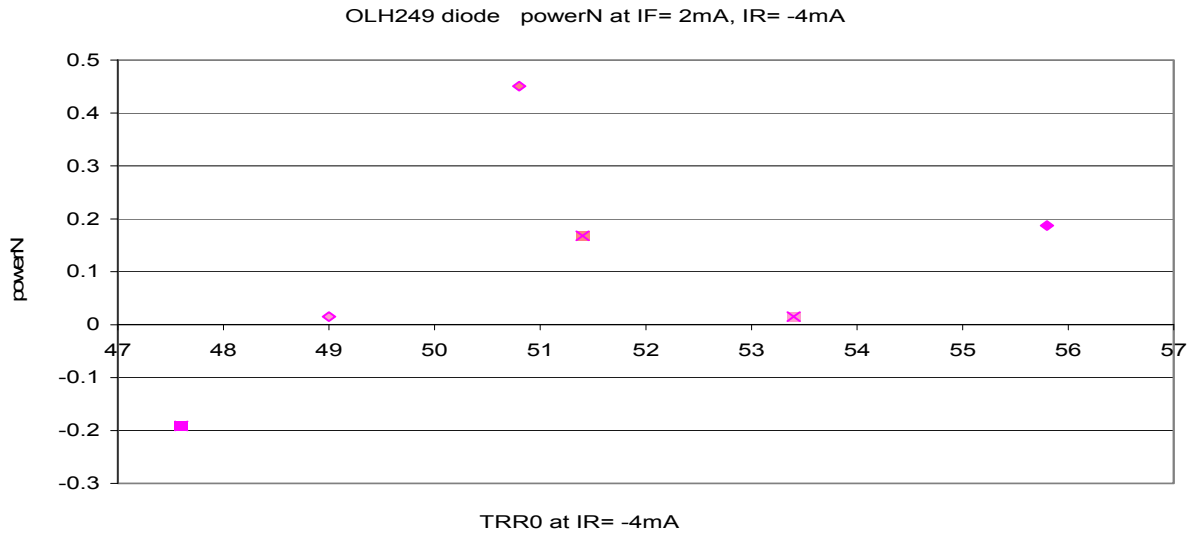
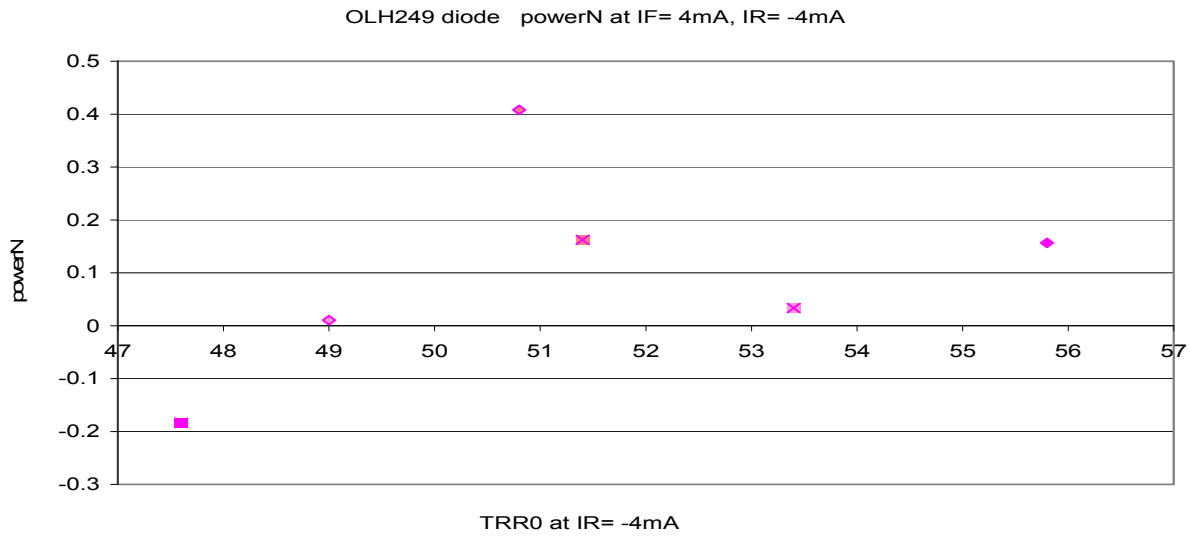
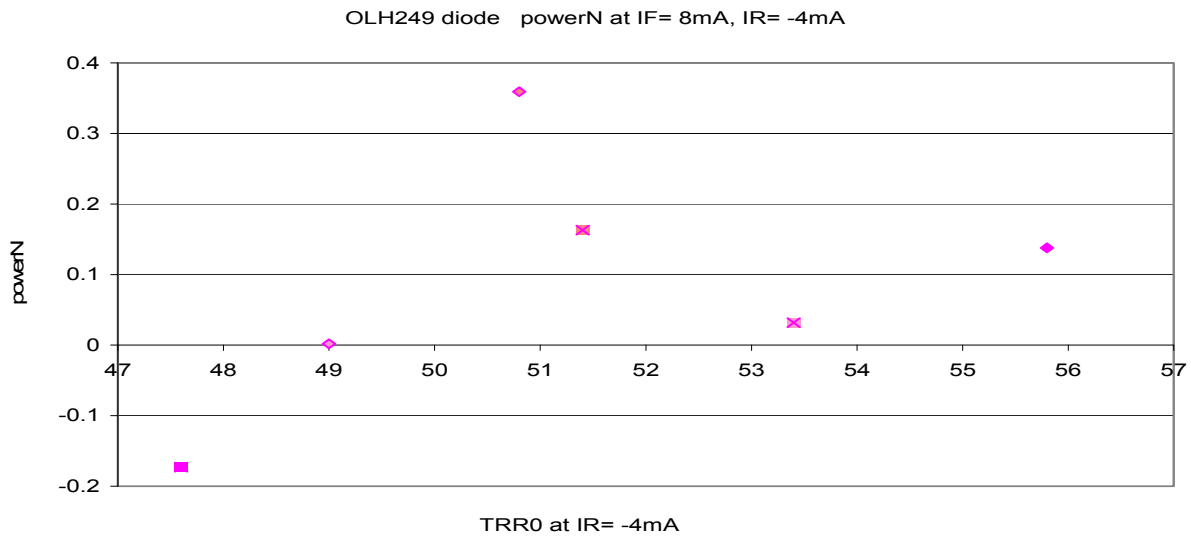

OLH249 diode powerN at IF= 10mA, IR= -2mA
powerN
0.4
0.3
0.2
0.1
0
-0.1
-0.2
81
82
83
84
85
86
87
88
89
90
TRR0 at IR= -2mA

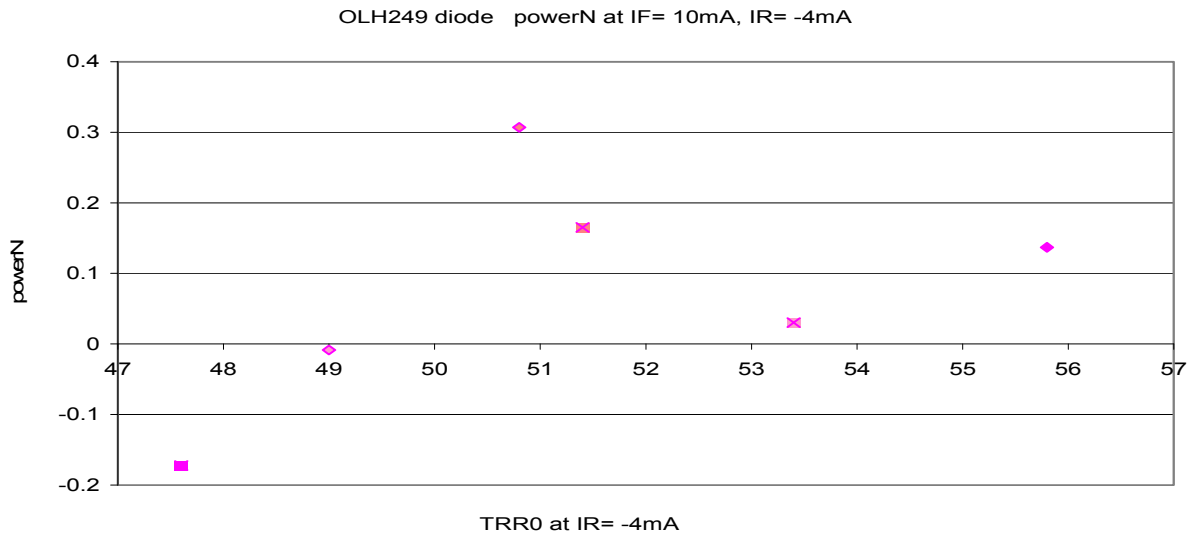
Fig. 13-215: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA





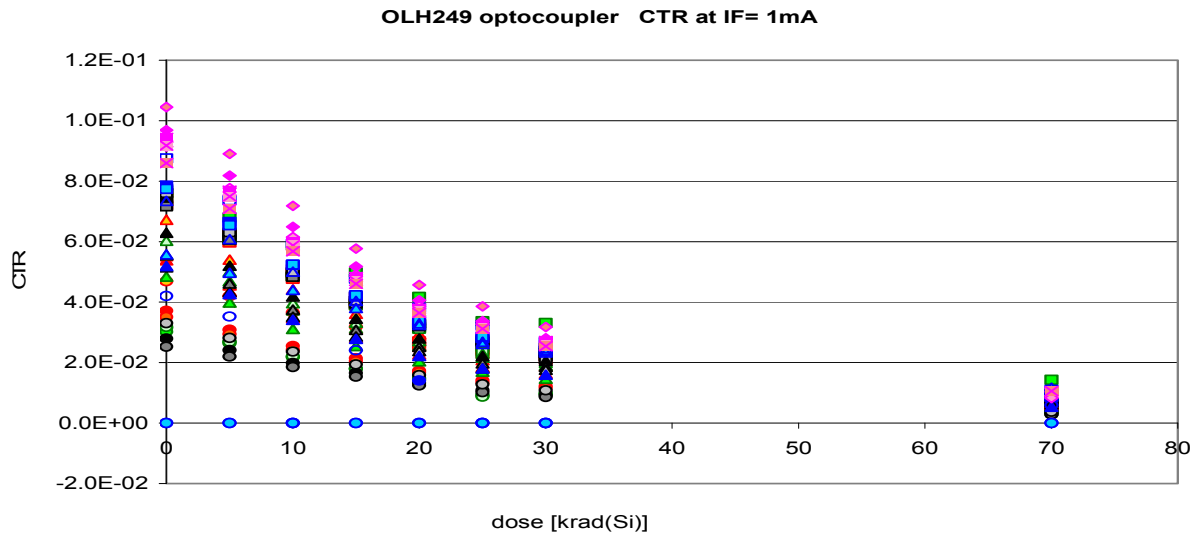


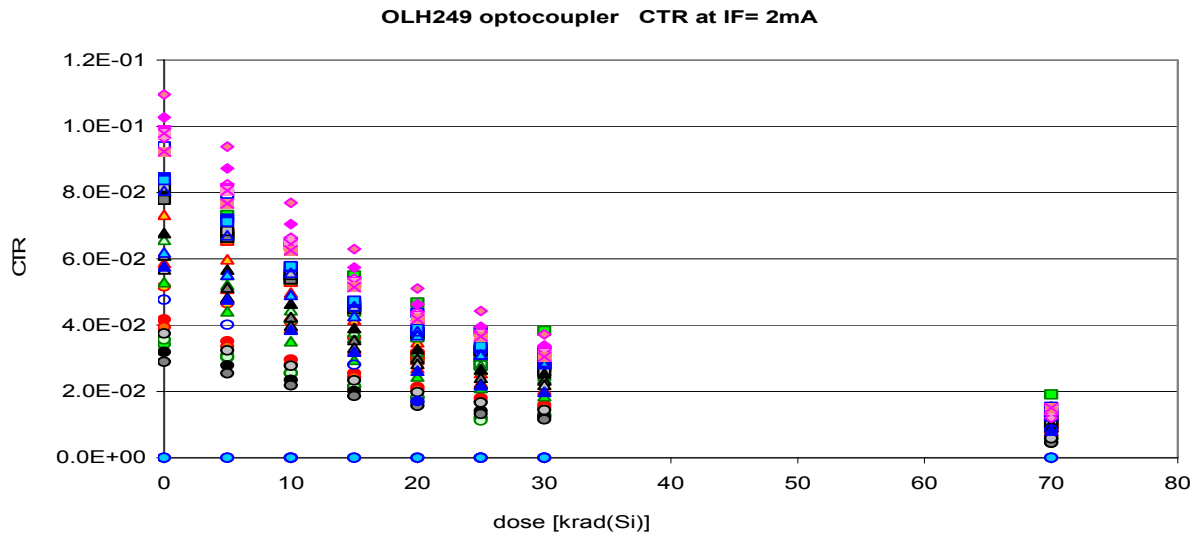

OLH249 diode powerN at IF= 8mA, IR= -4mA
powerN
0.4
0.3
0.2
0.1
0
-0.1
-0.2
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA

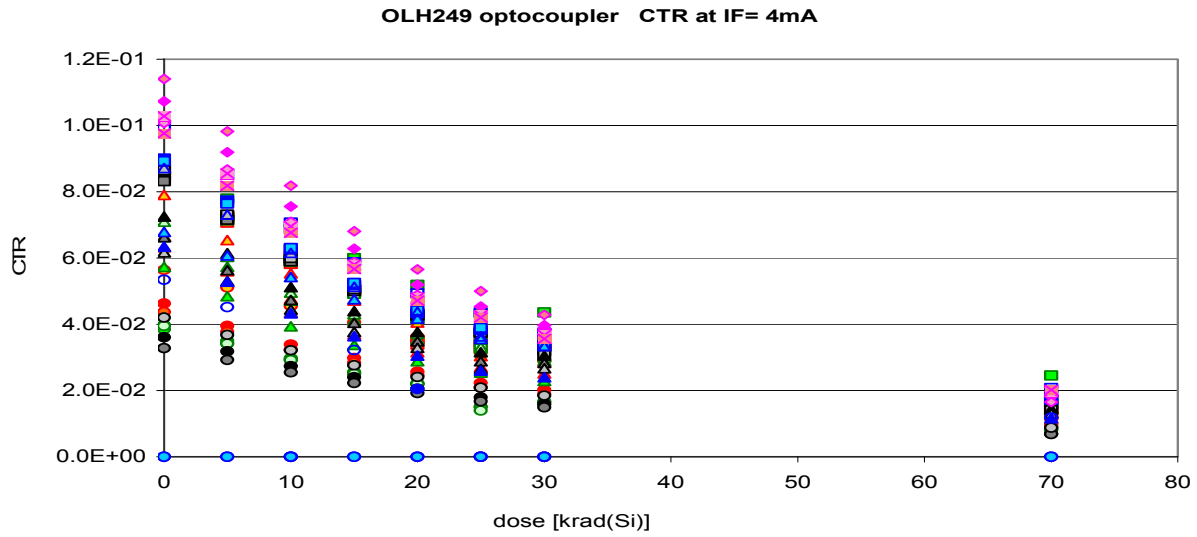

OLH249 diode powerN at IF= 10mA, IR= -4mA
powerN
0.4
0.3
0.2
0.1
0
-0.1
-0.2
47
48
49
50
51
52
53
54
55
56
57
TRR0 at IR= -4mA

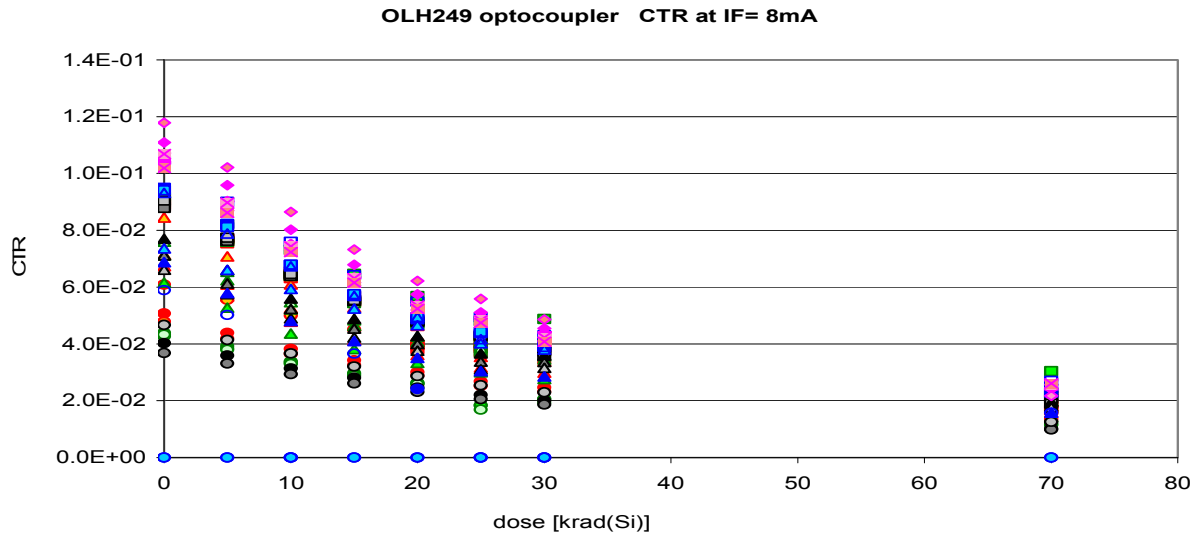
13.4 GAMMA IRRADIATION AFTER NEUTRON AND PROTON IRRADIATION

Fig. 13-216: OLH249 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

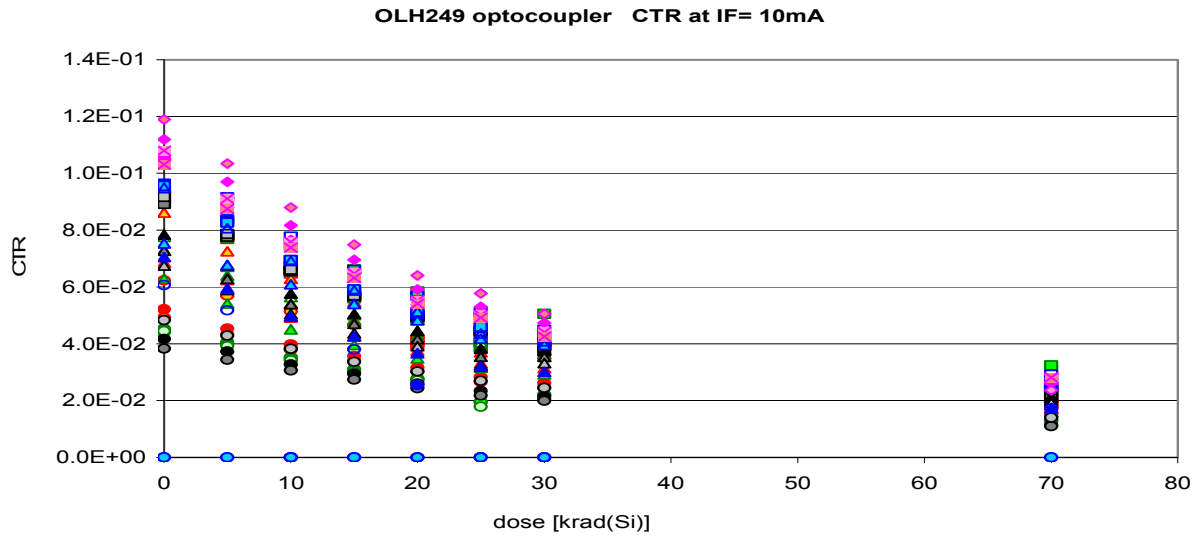
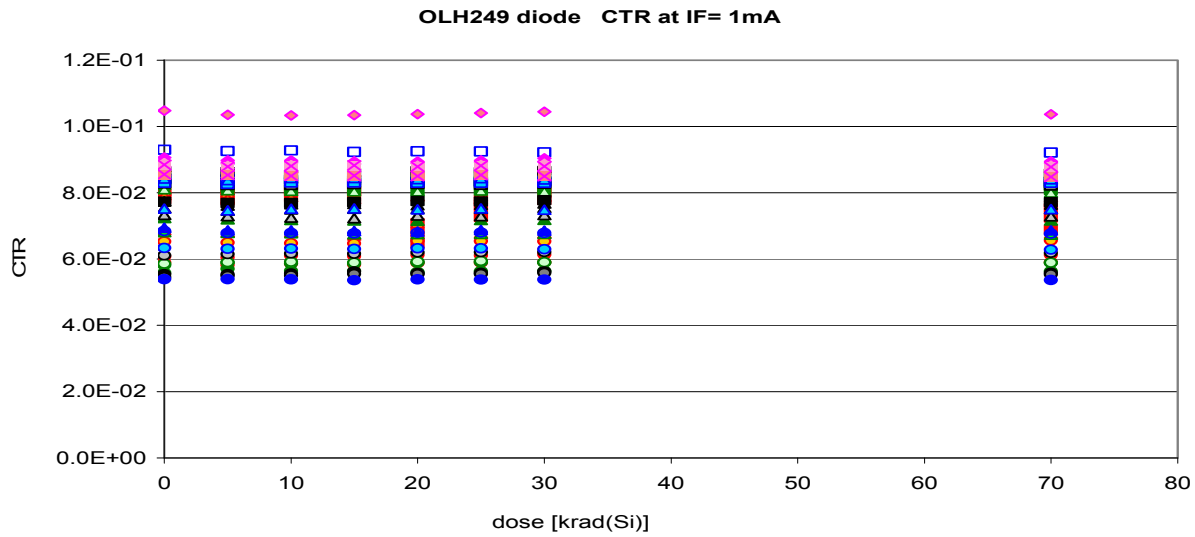
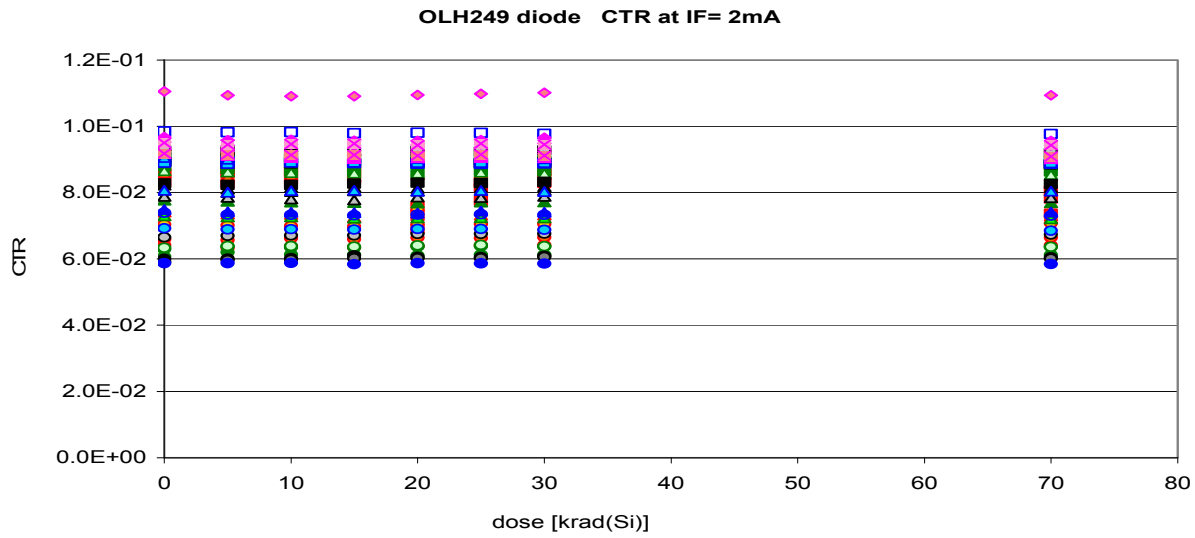
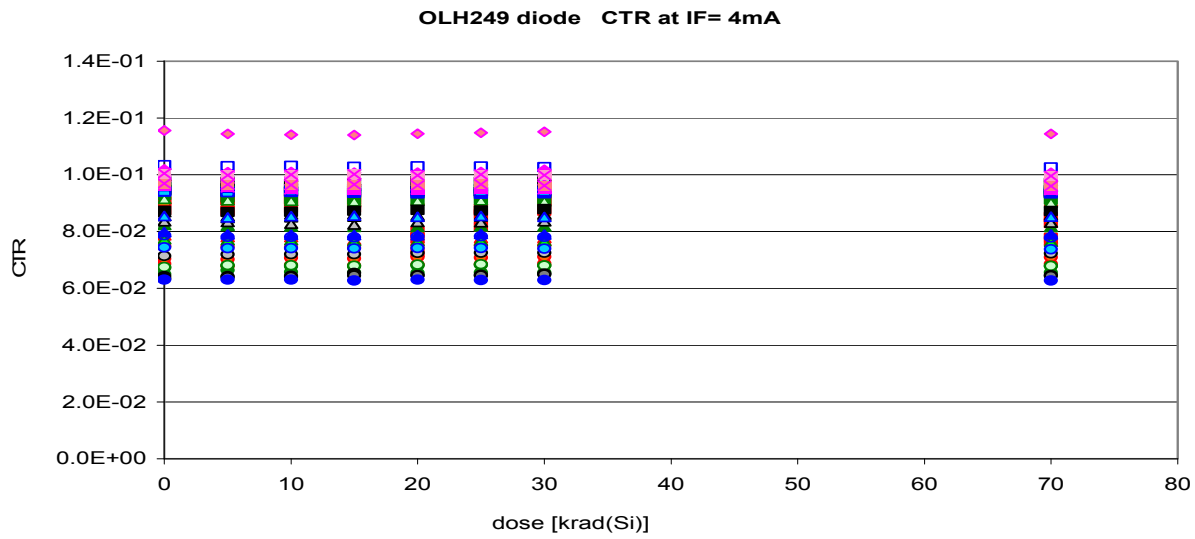
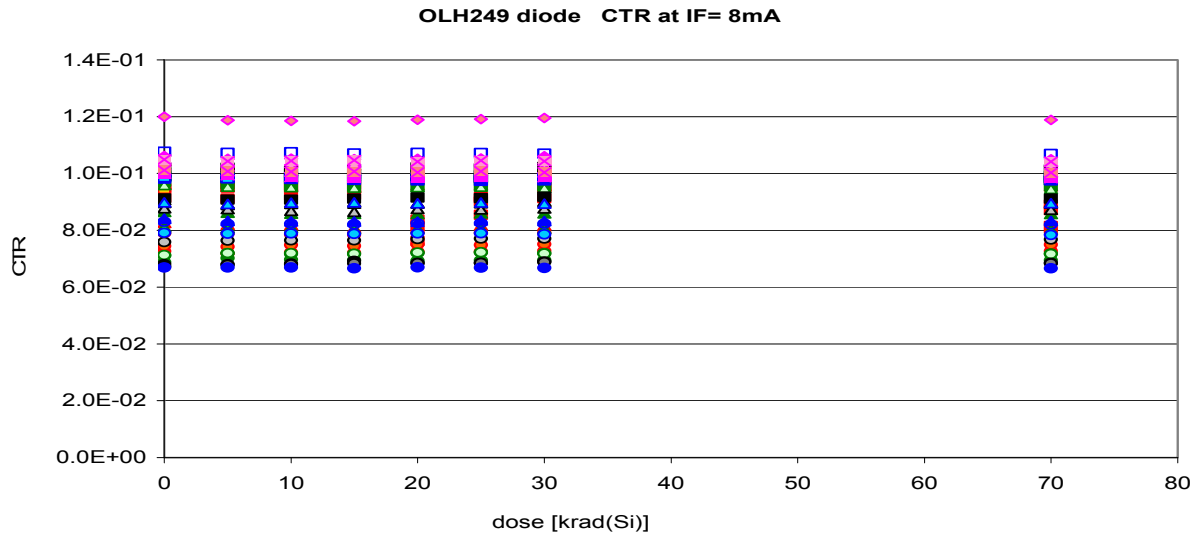

OLH249 optocoupler CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-217: OLH249 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR at IF= 8mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

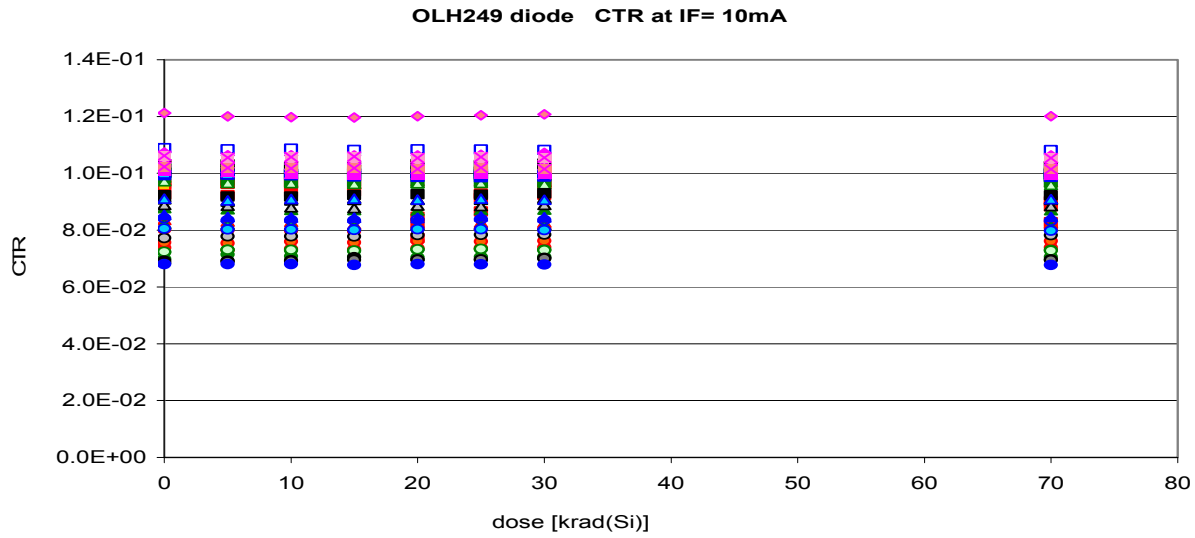
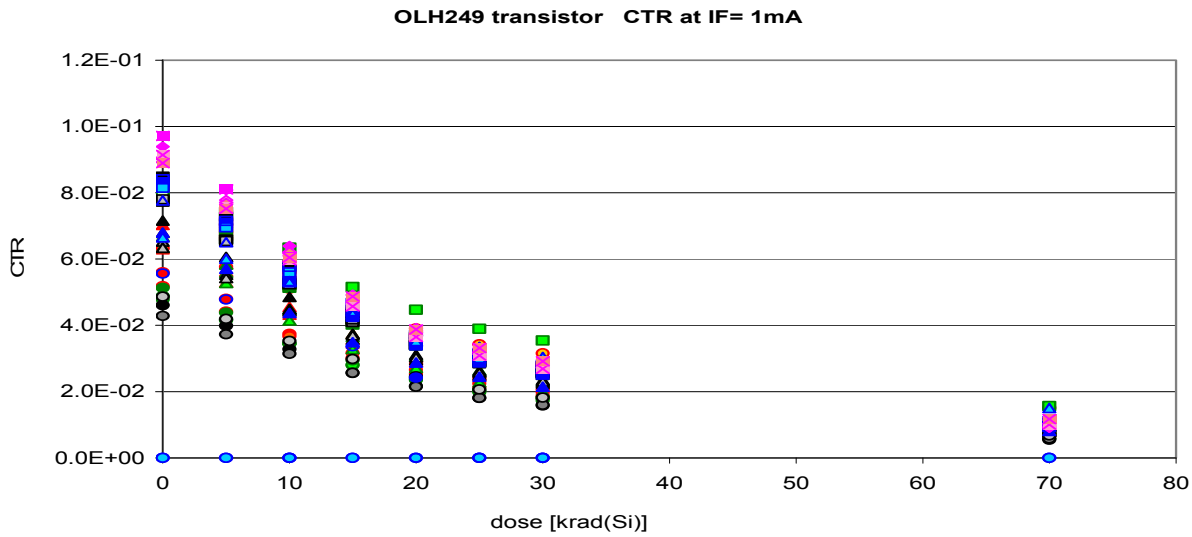
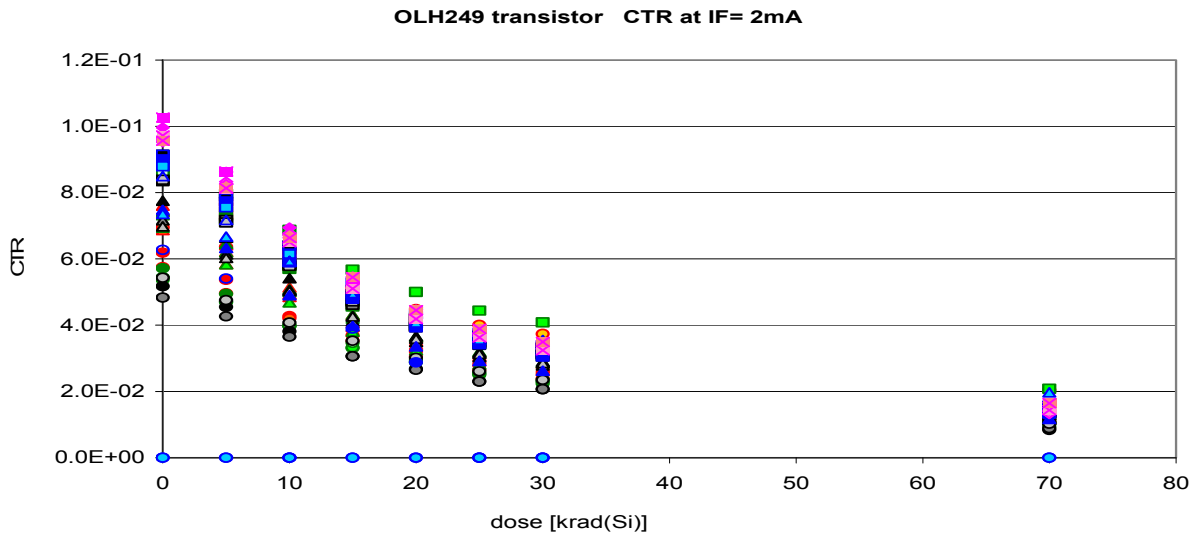
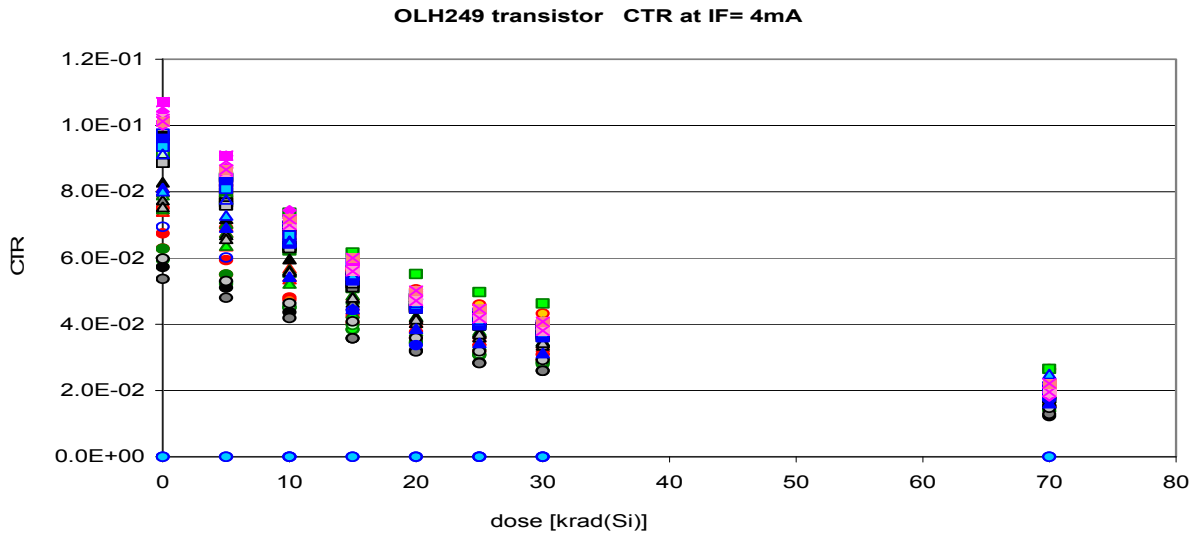
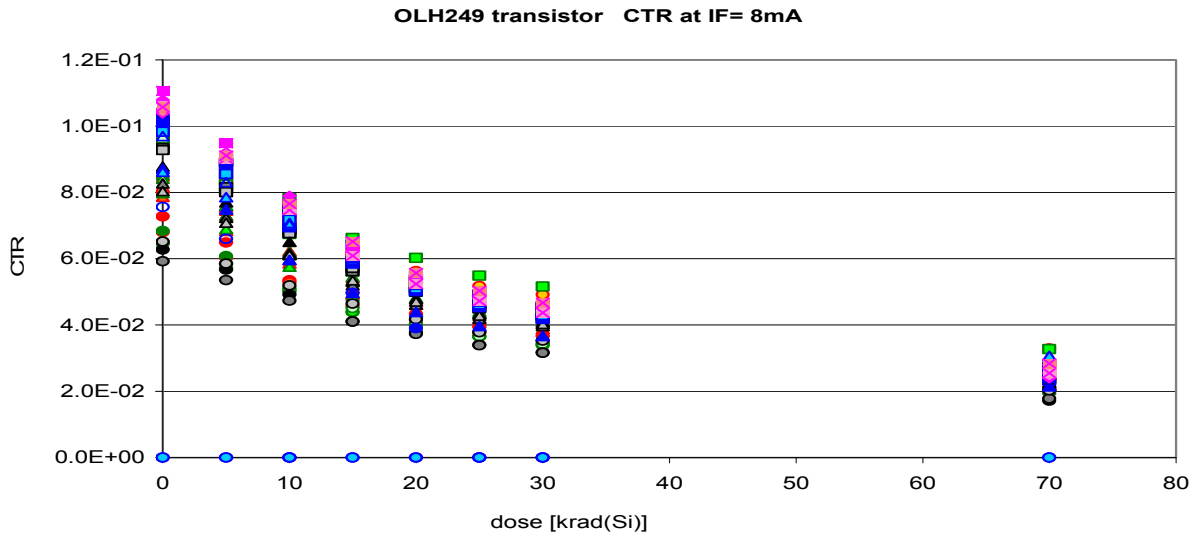

OLH249 diode CTR at IF= 10mA
CTR
1.4E-01
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-218: OLH249 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR at IF= 8mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

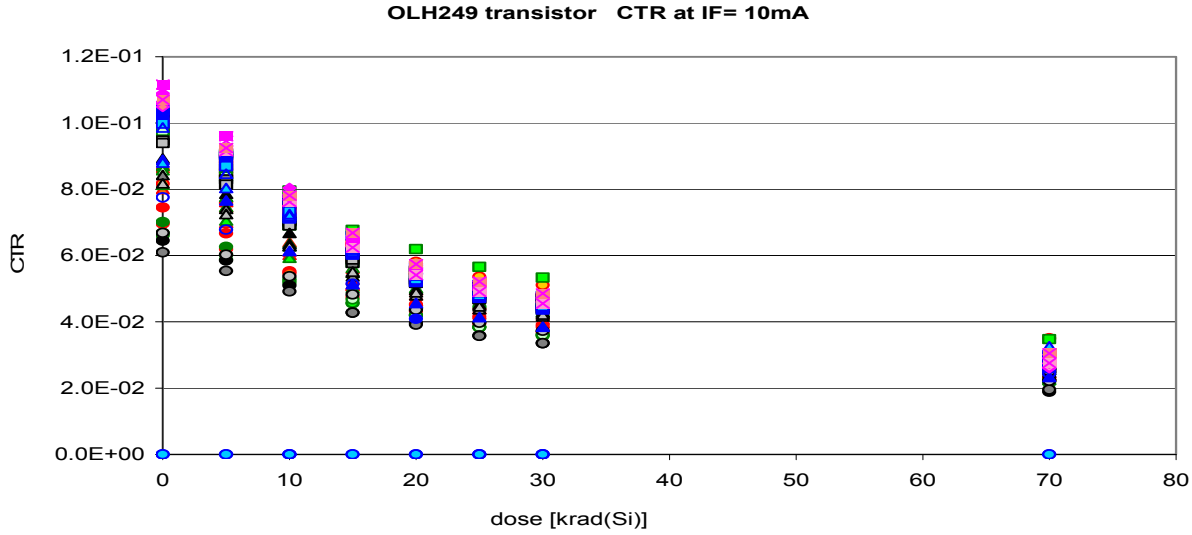
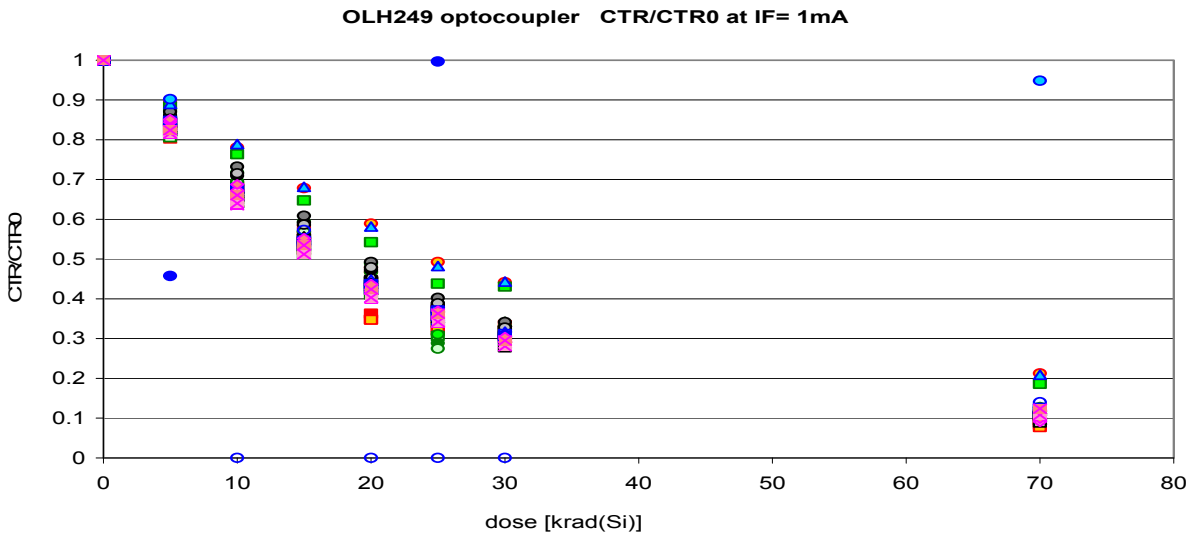
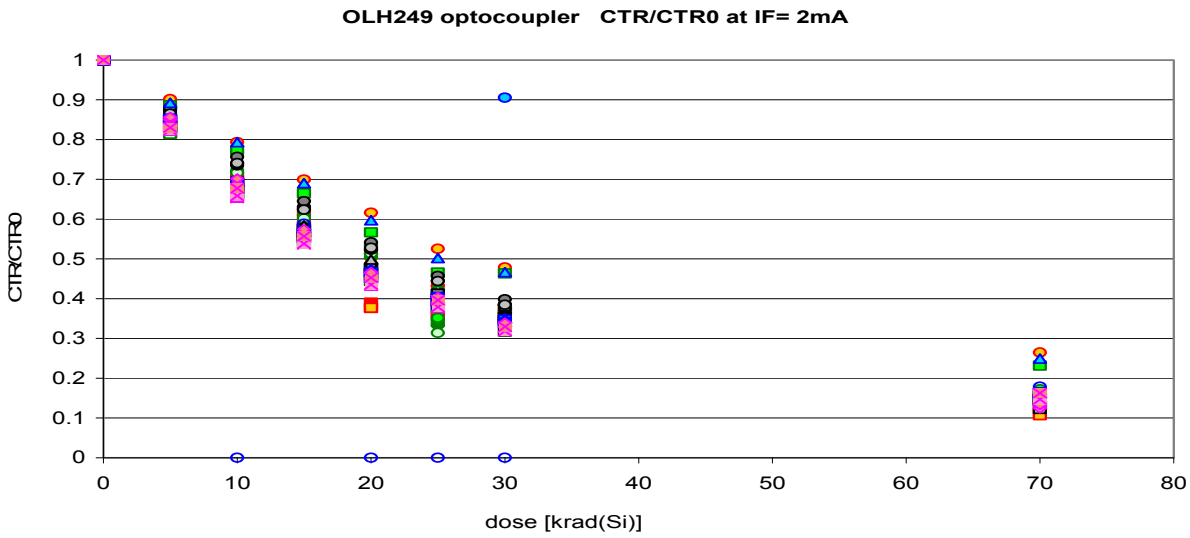
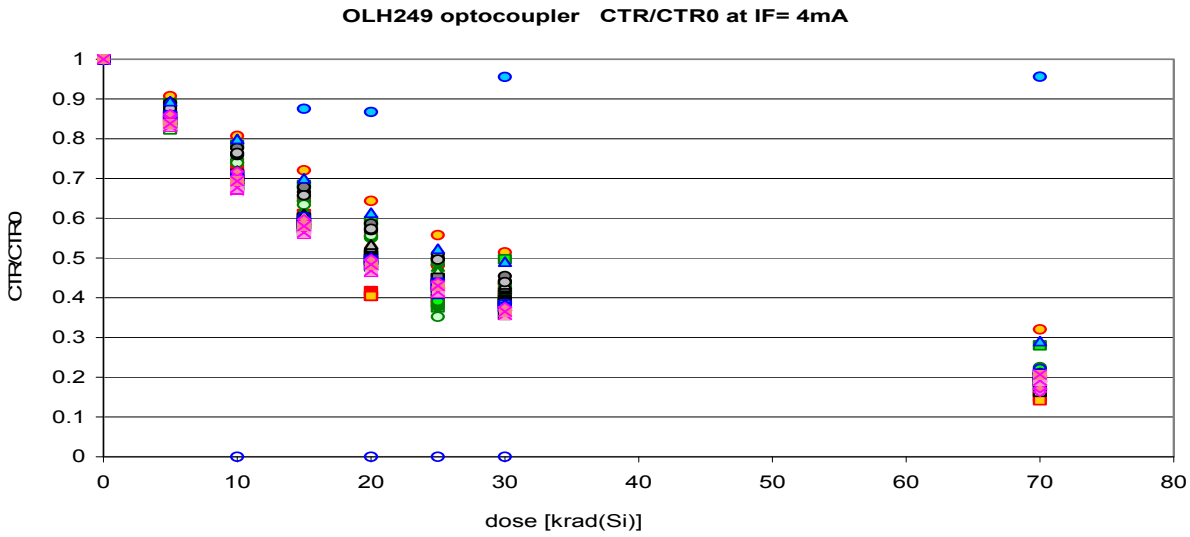
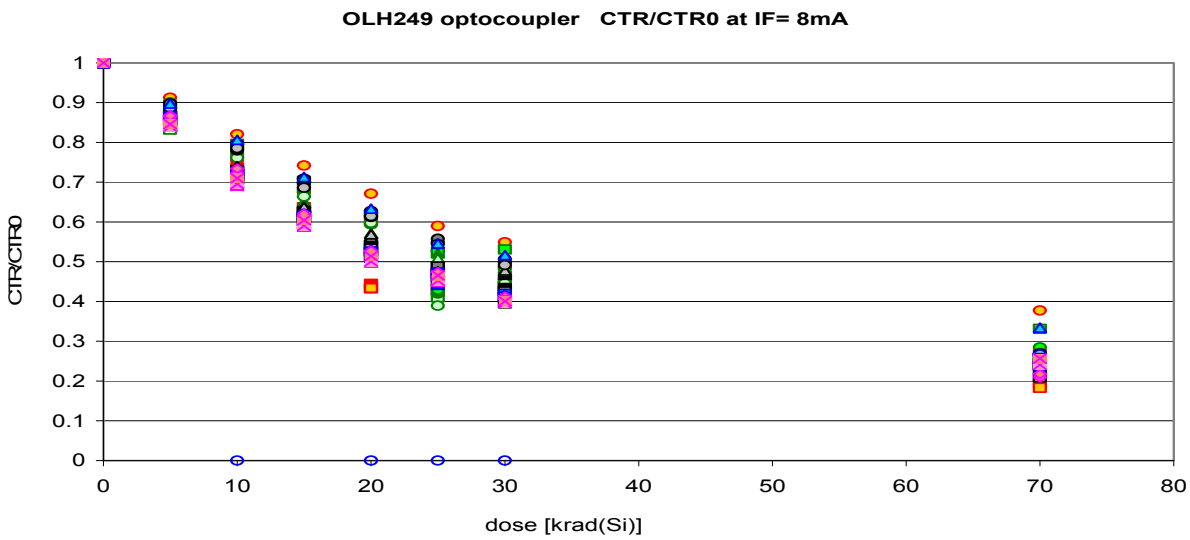

OLH249 transistor CTR at IF= 10mA
CTR
1.2E-01
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-219: OLH249 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

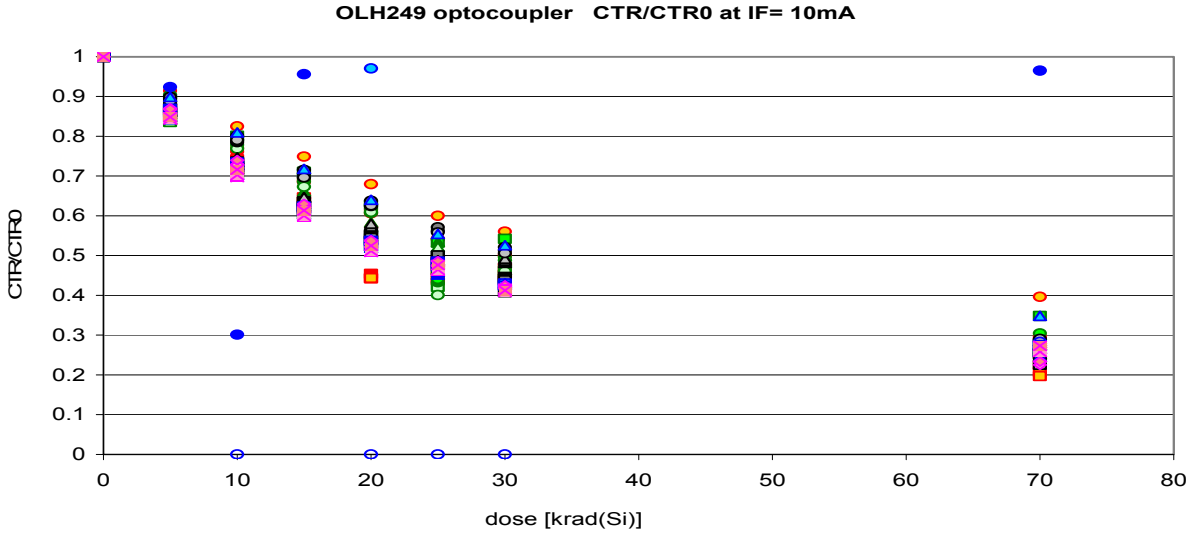
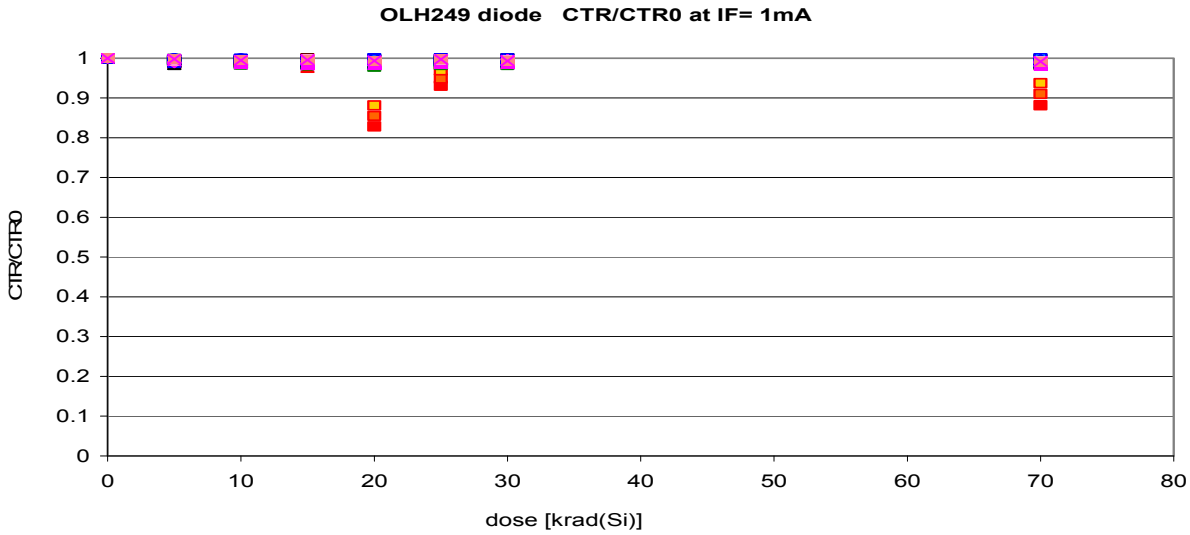
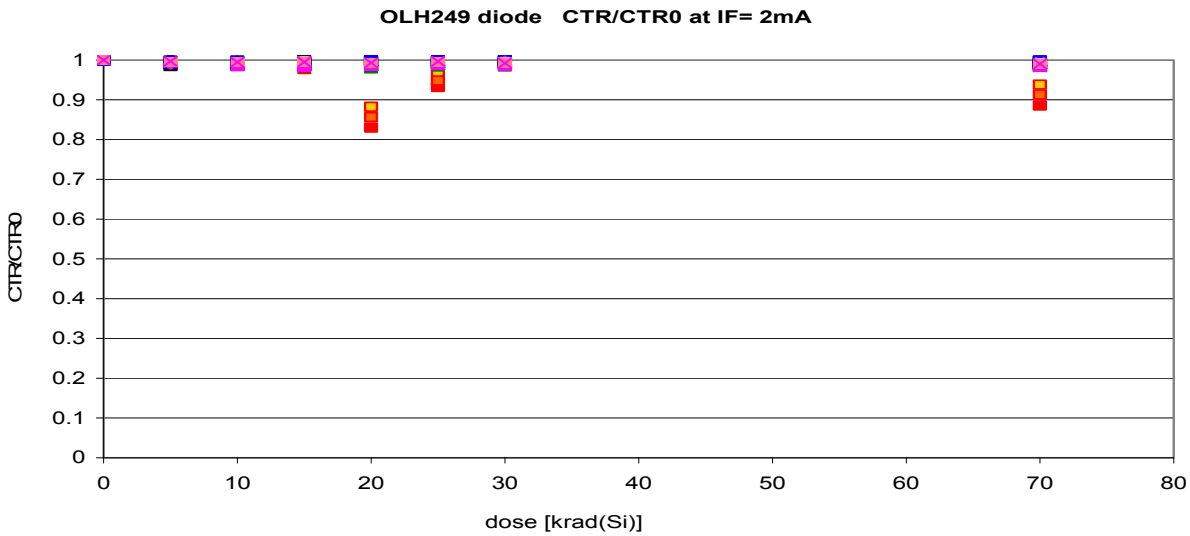
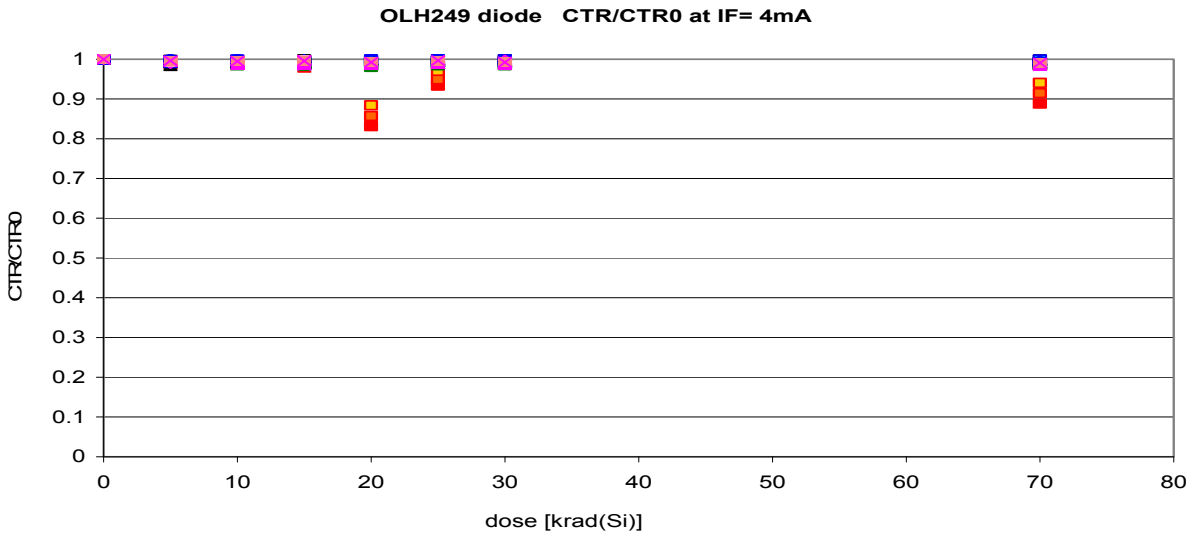
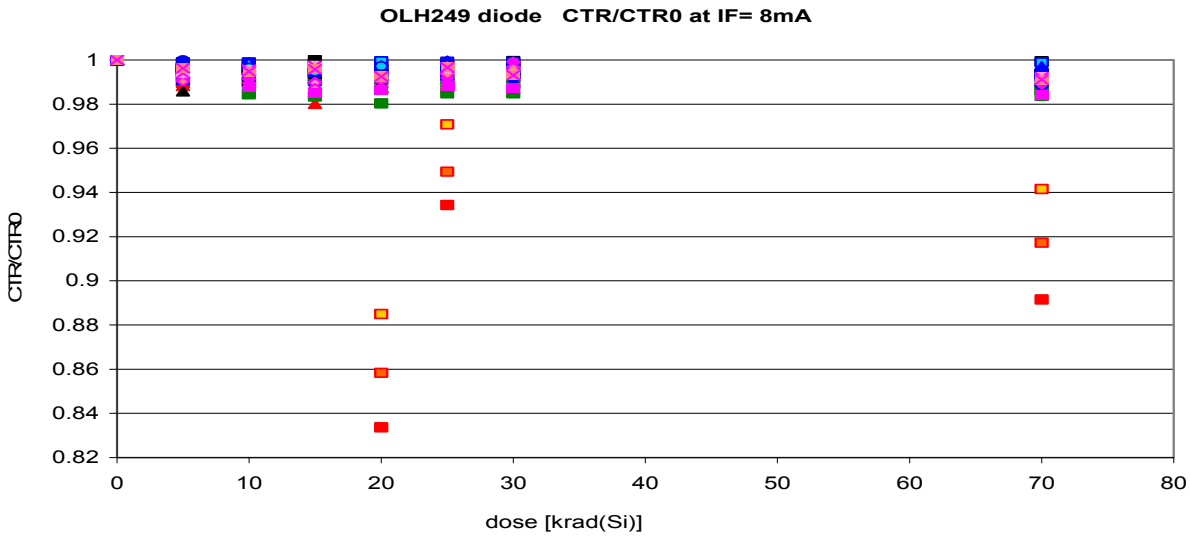

OLH249 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-220: OLH249 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

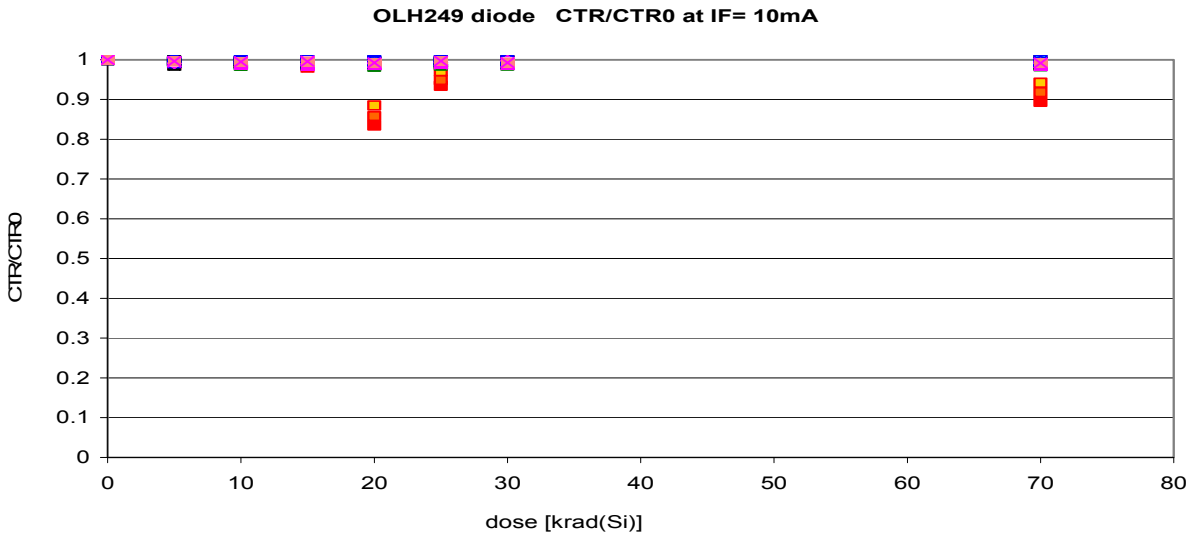
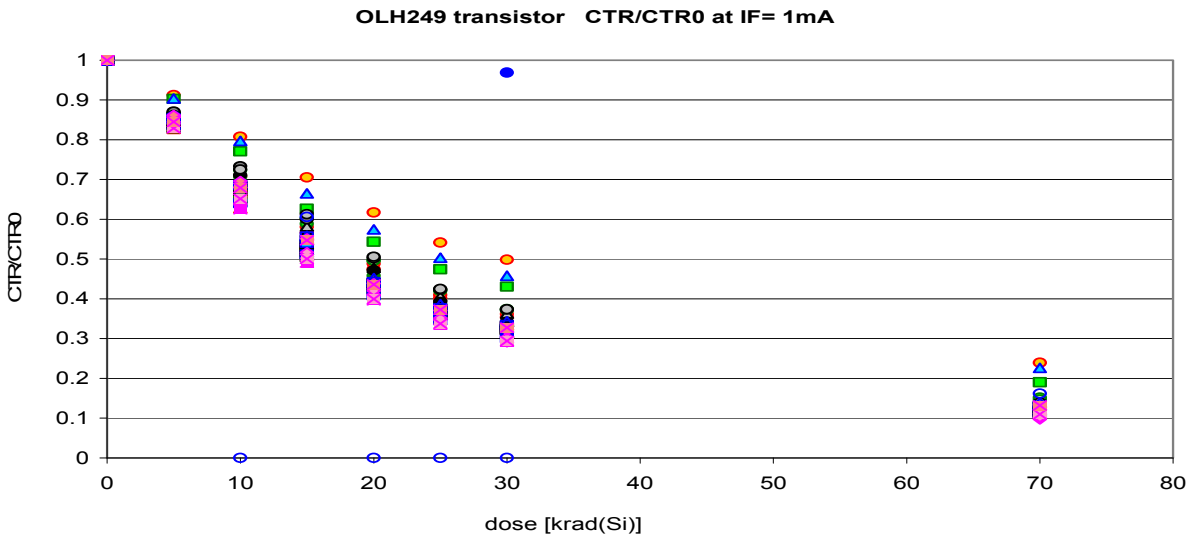
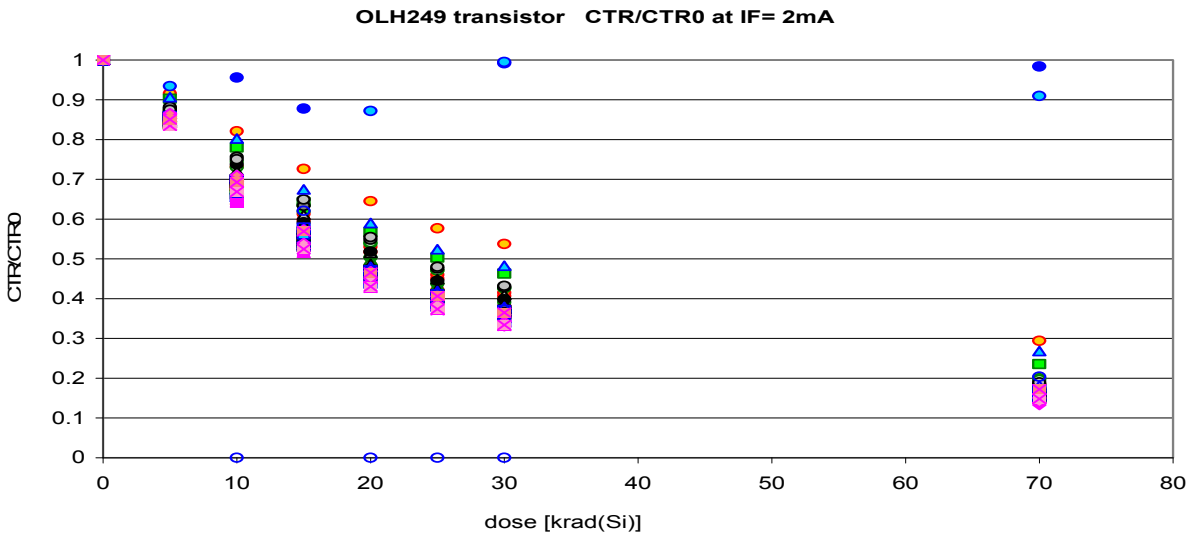
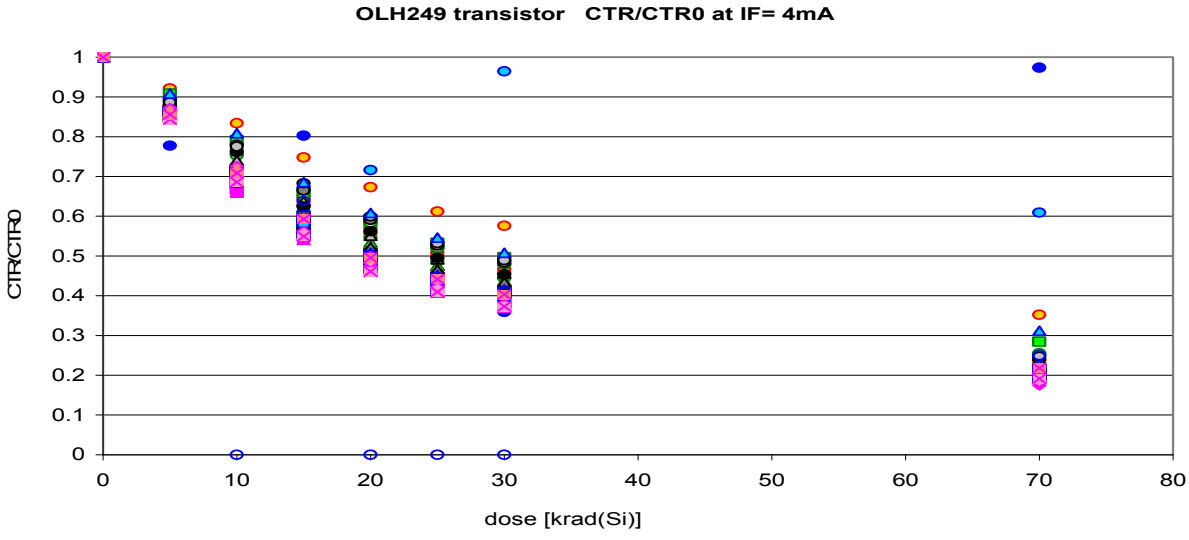
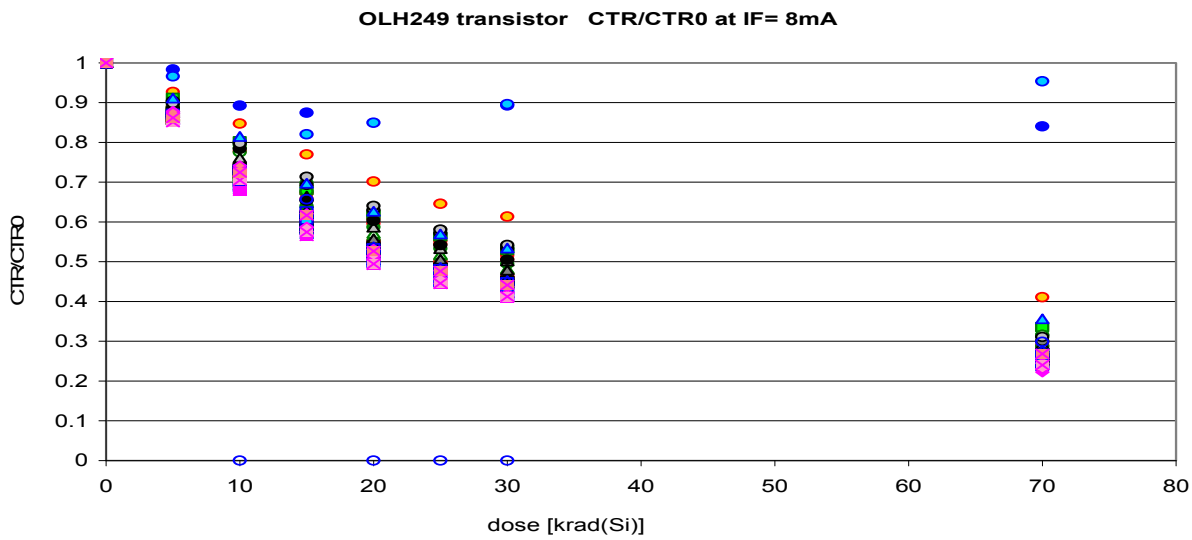

OLH249 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-221: OLH249 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

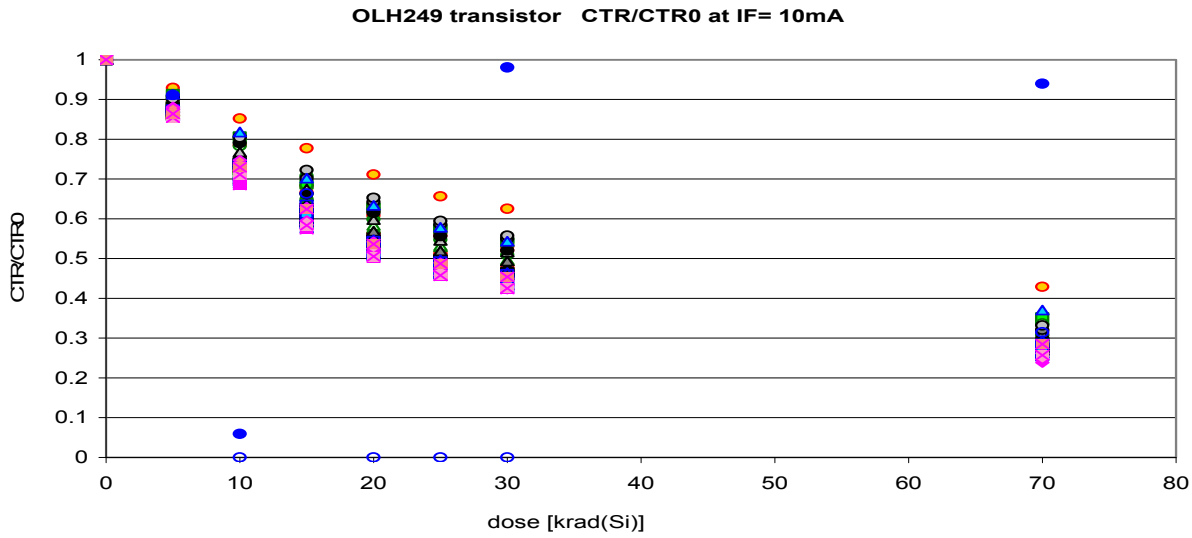
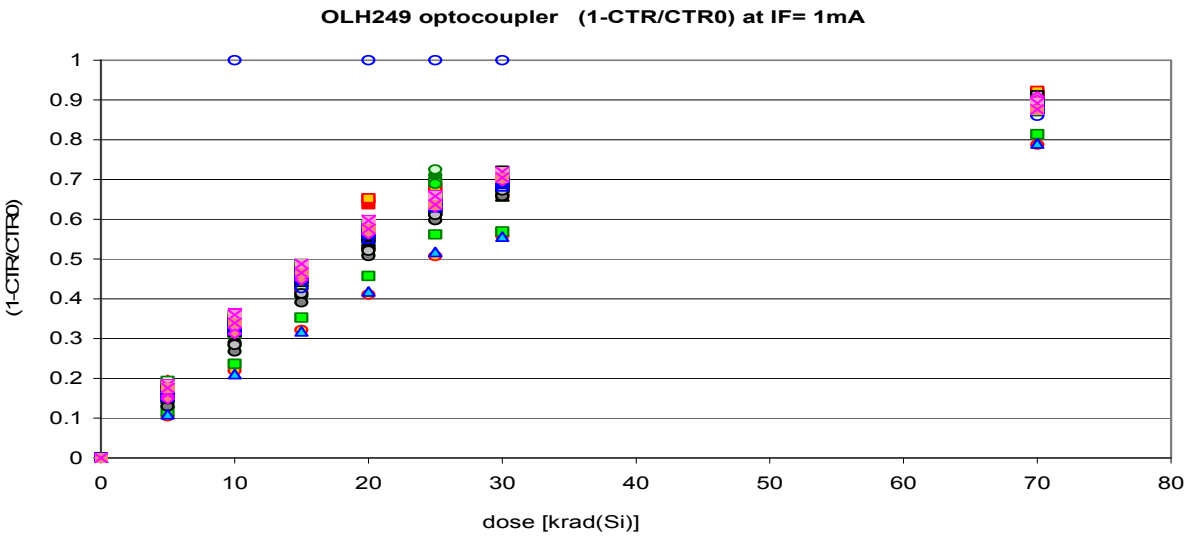
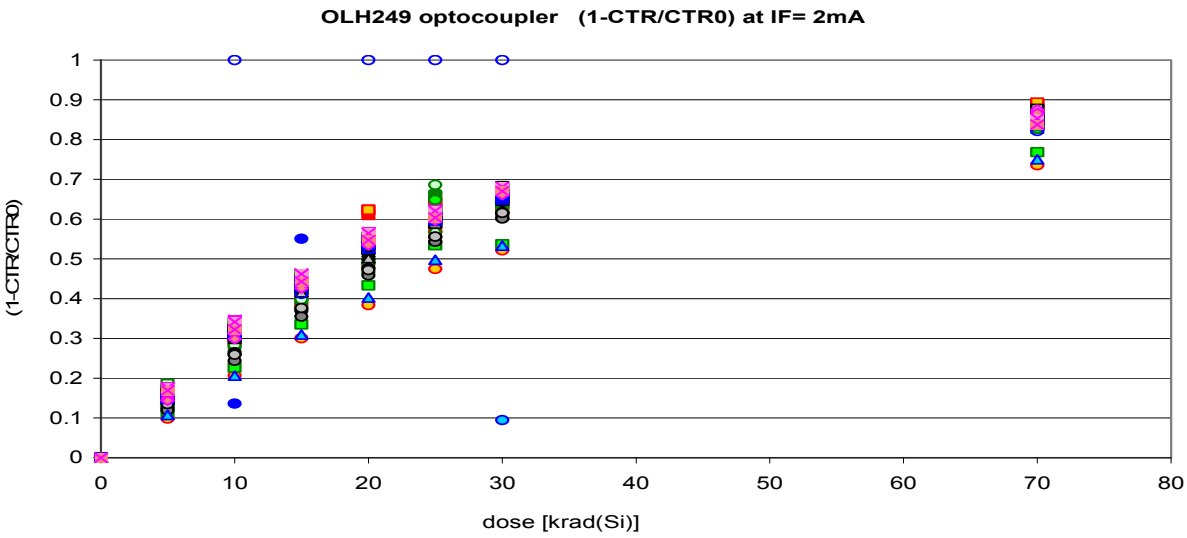
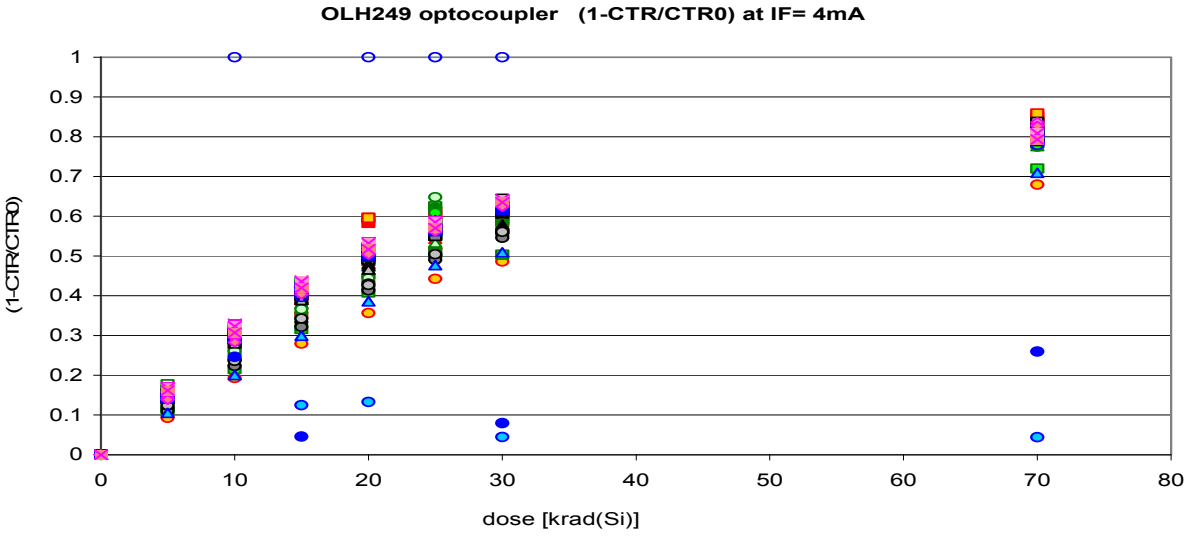
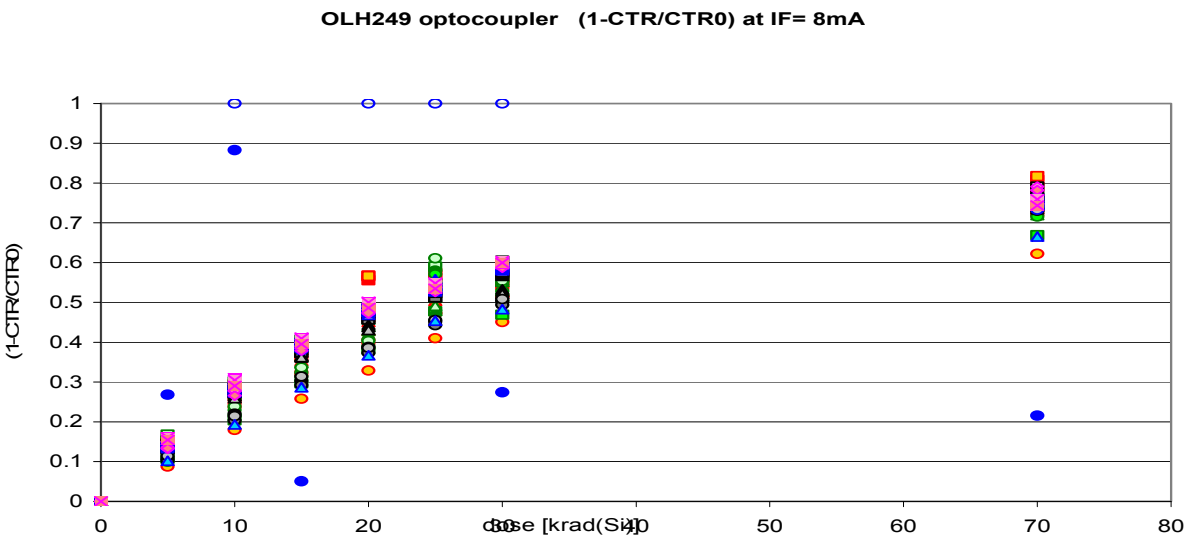

OLH249 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

Fig. 13-222: OLH249 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

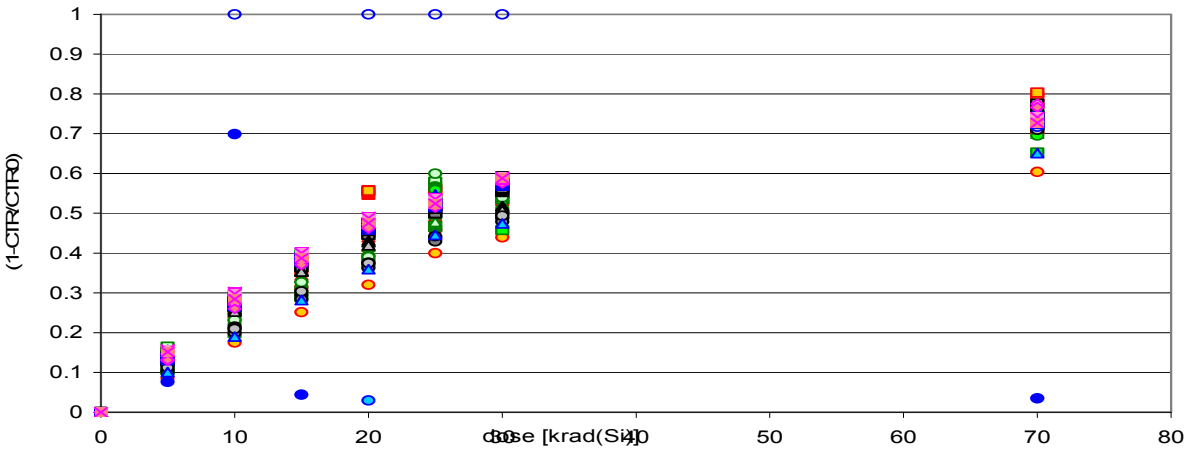
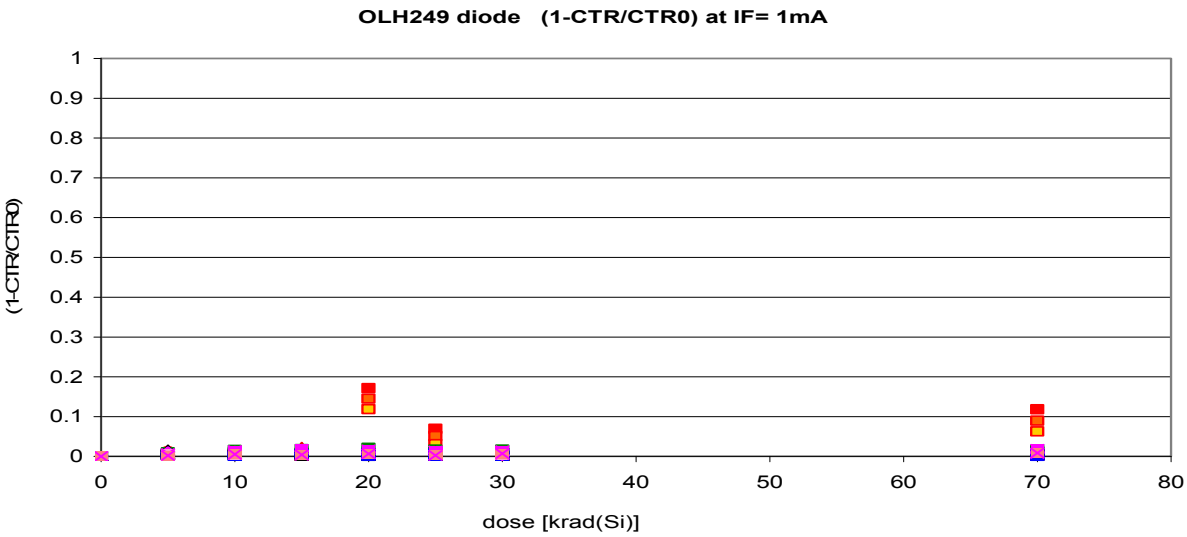
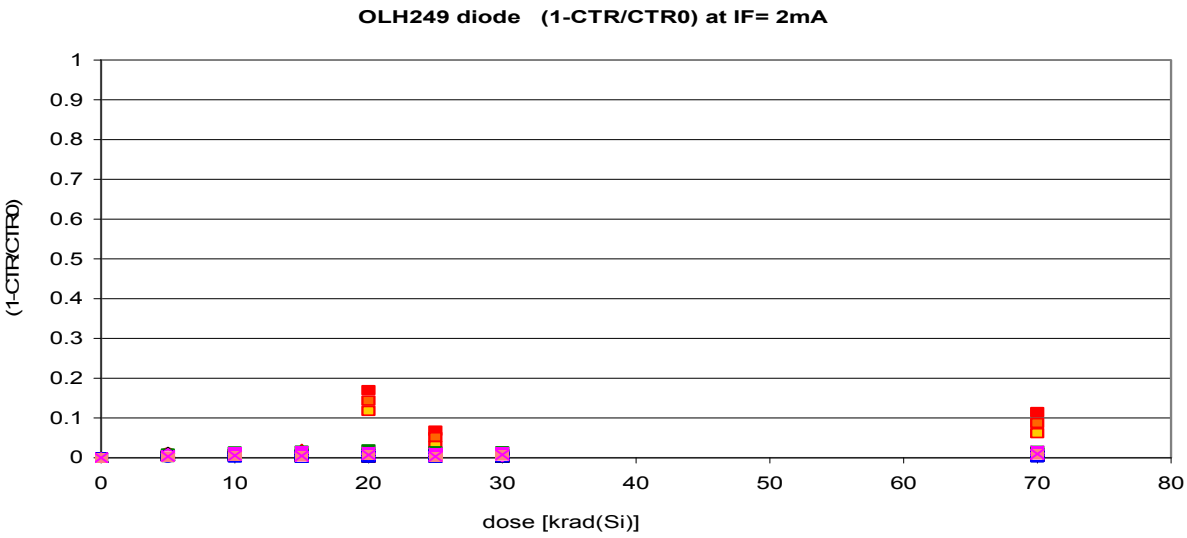
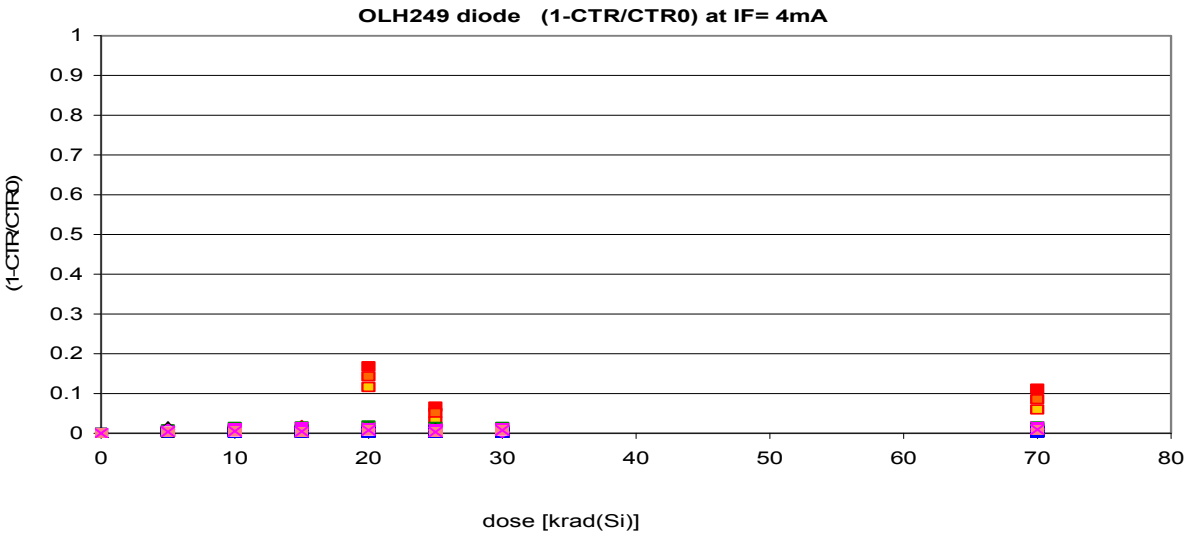
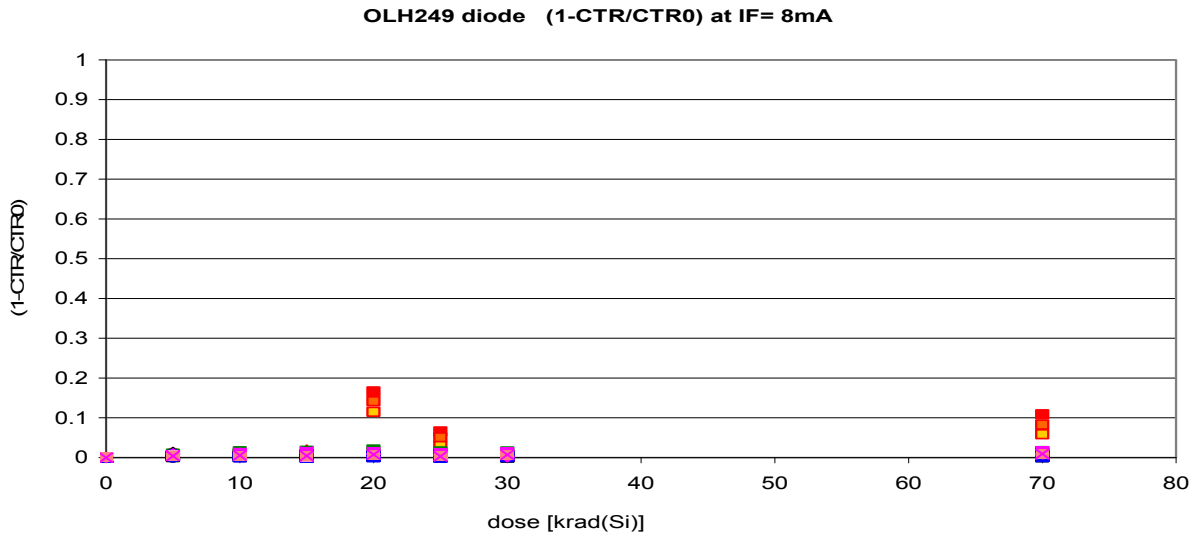

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
dose [krad(Si)]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80

Fig. 13-223: OLH249 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

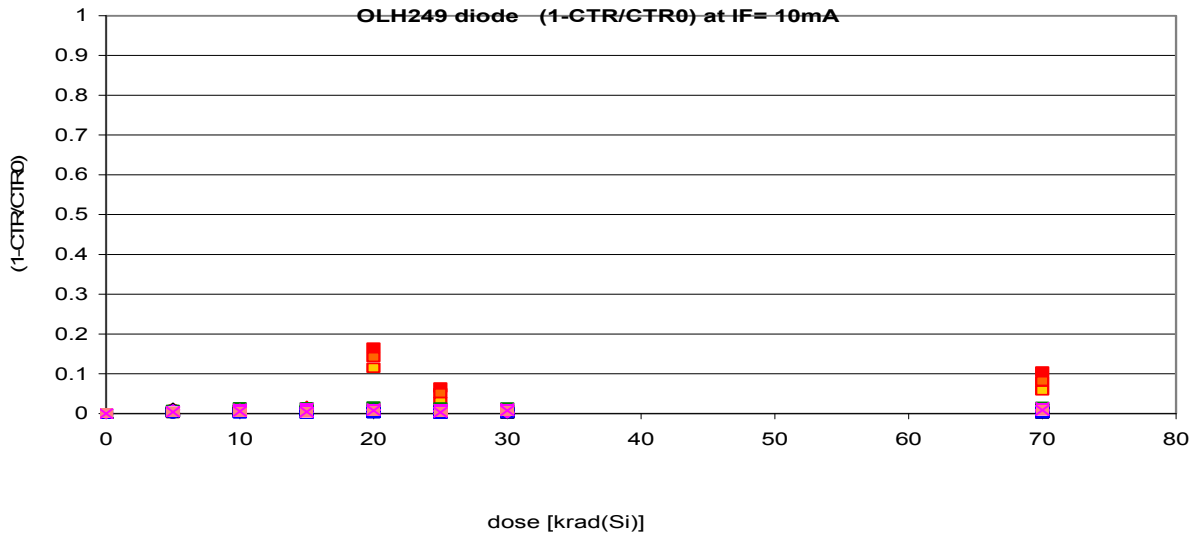
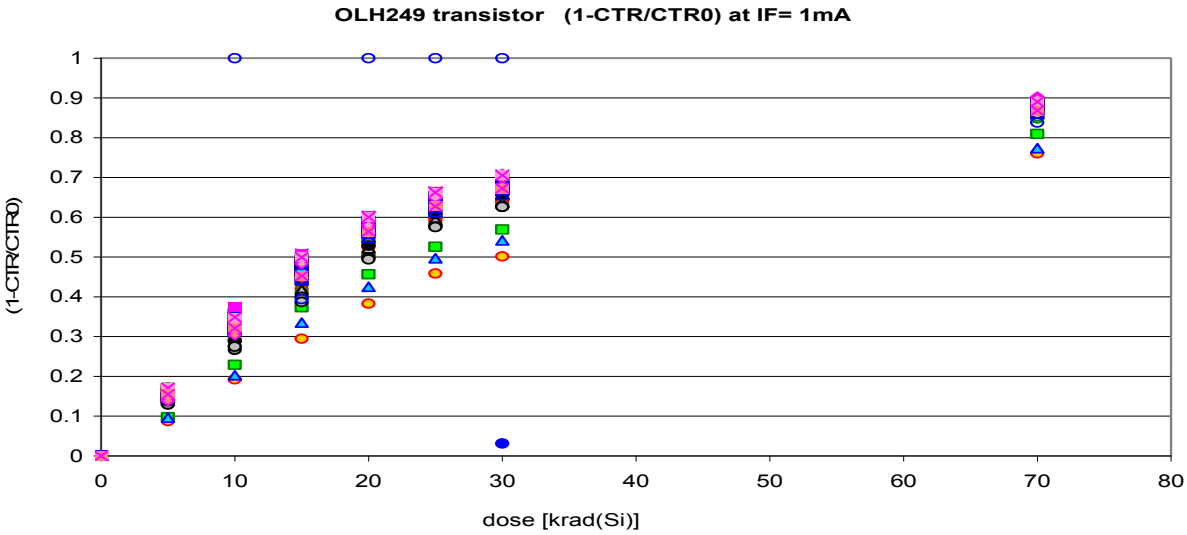
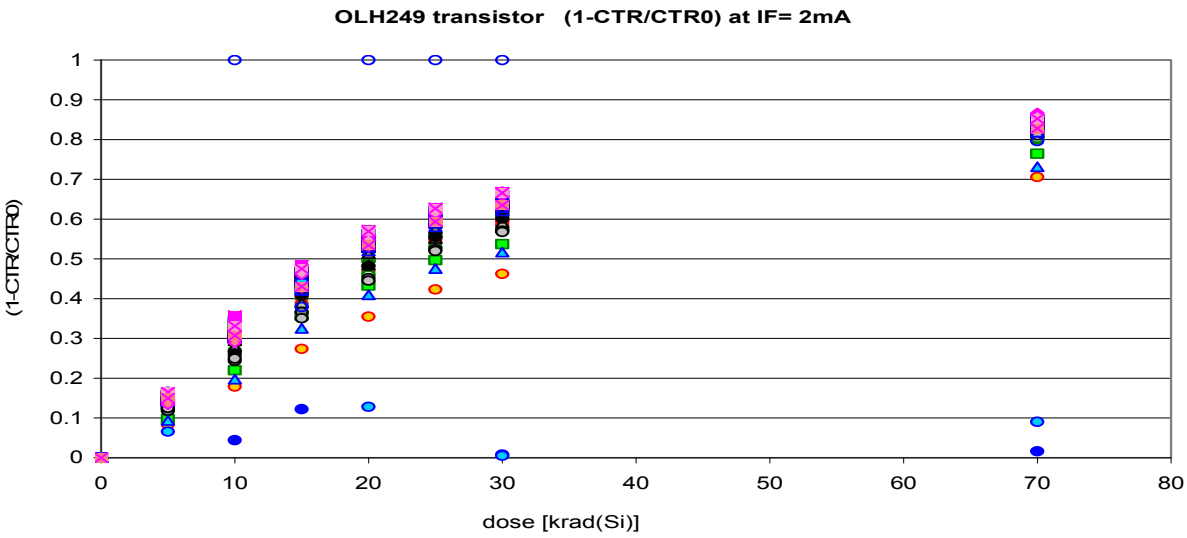
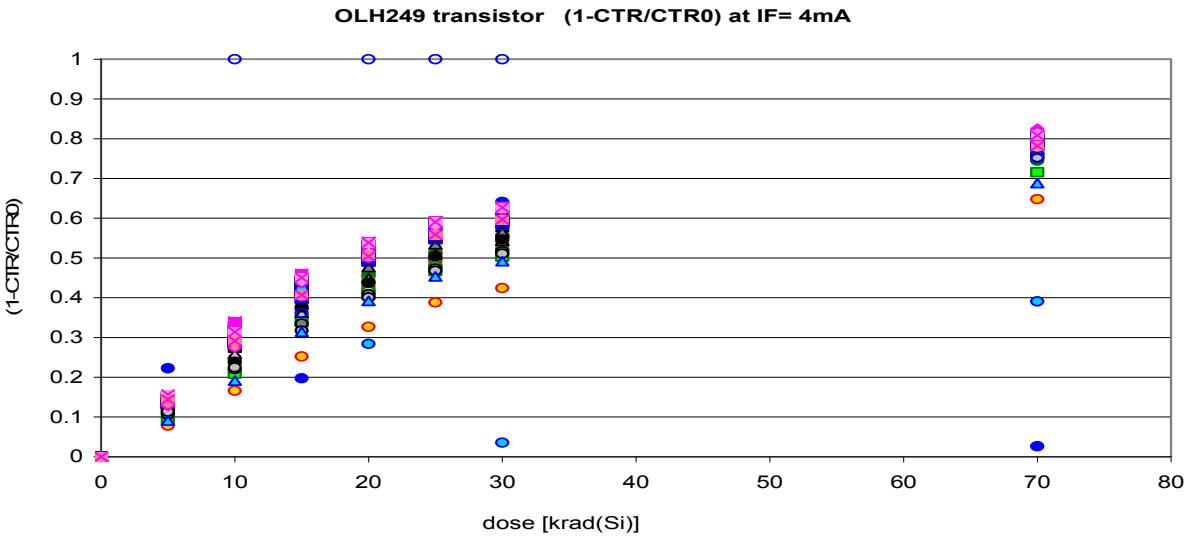
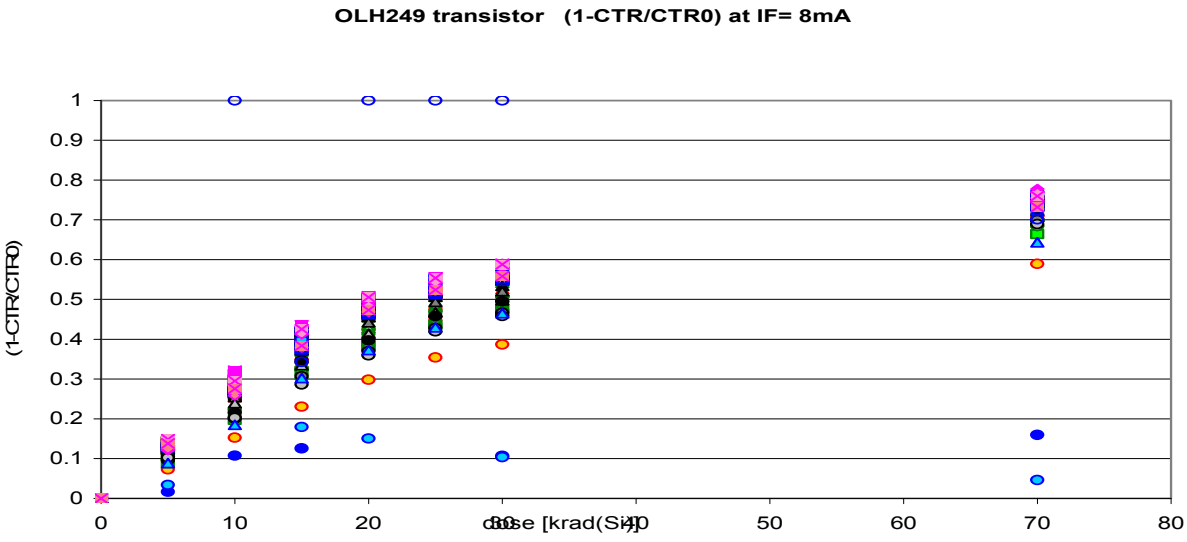

OLH249 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 13-224: OLH249 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








OLH249 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

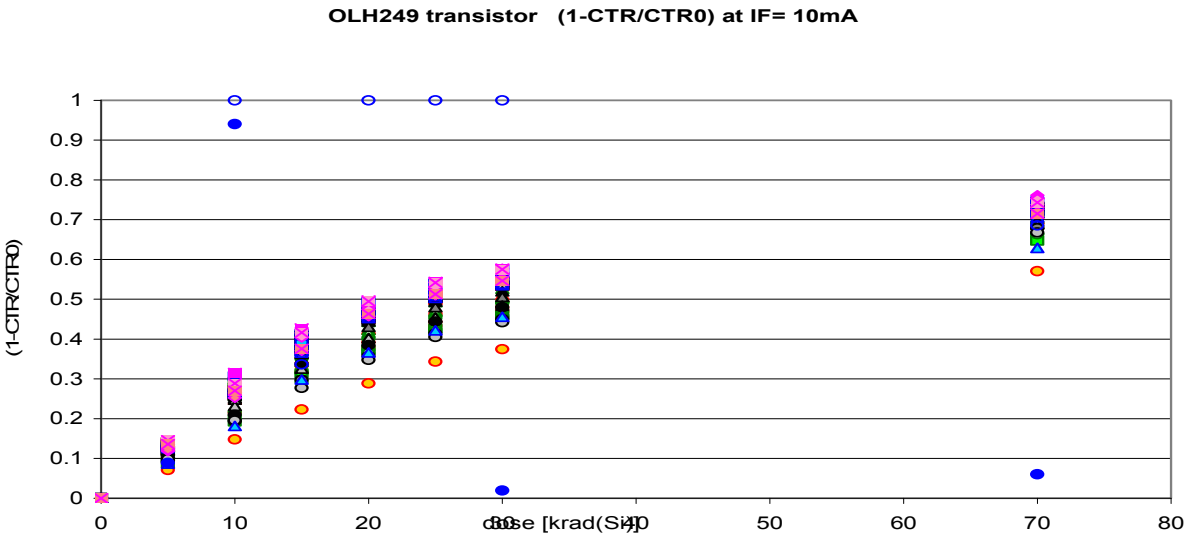
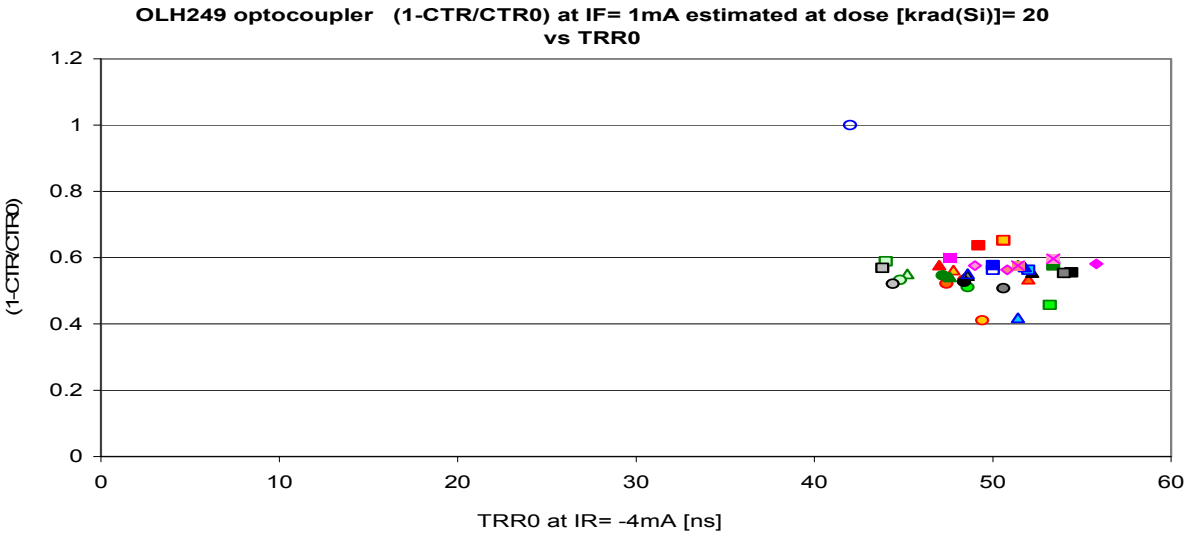
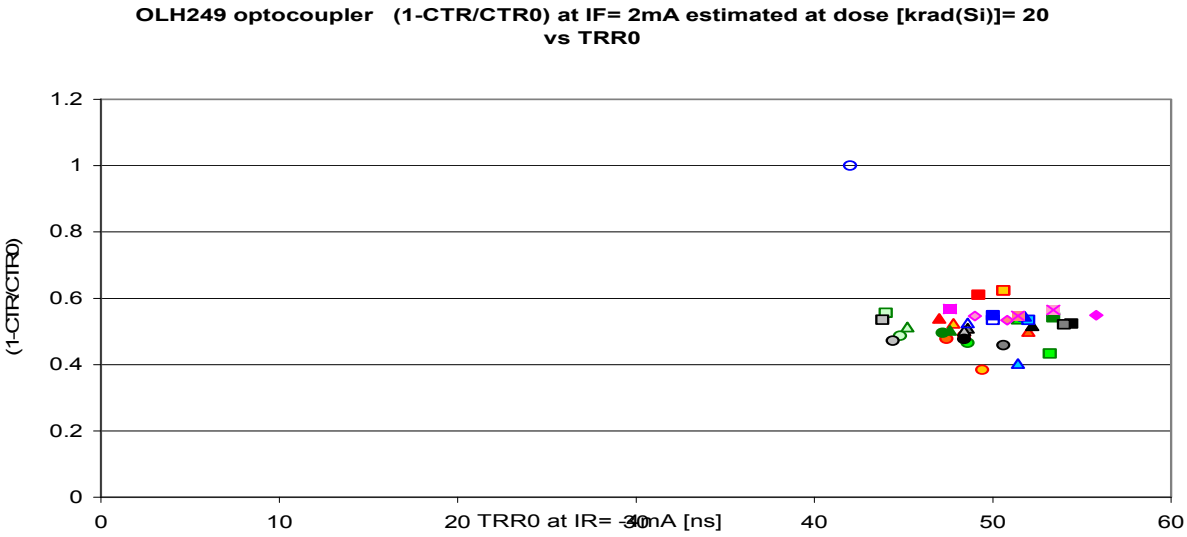
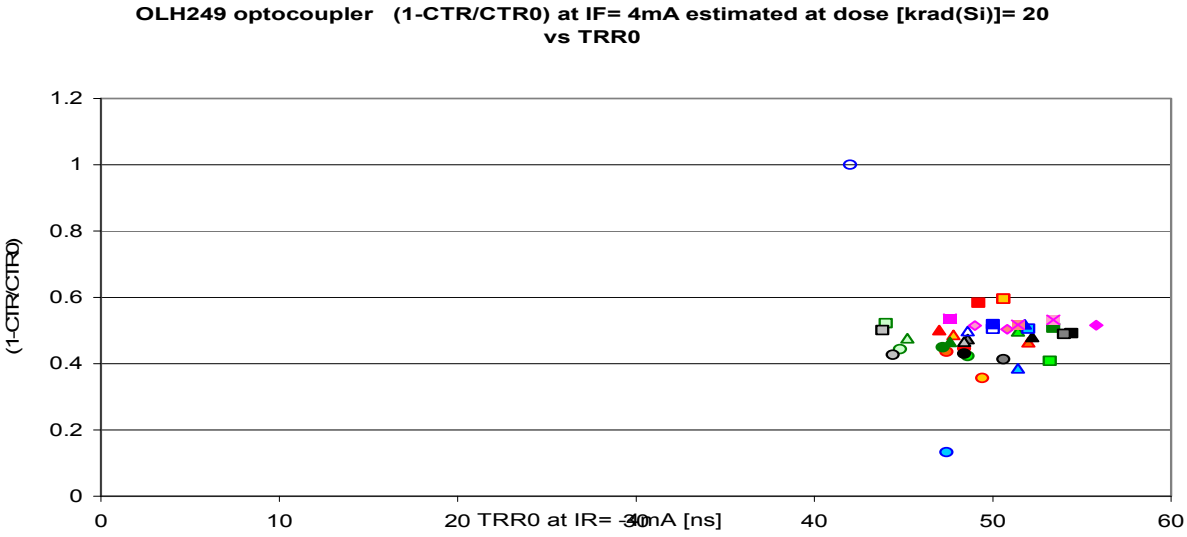

OLH249 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

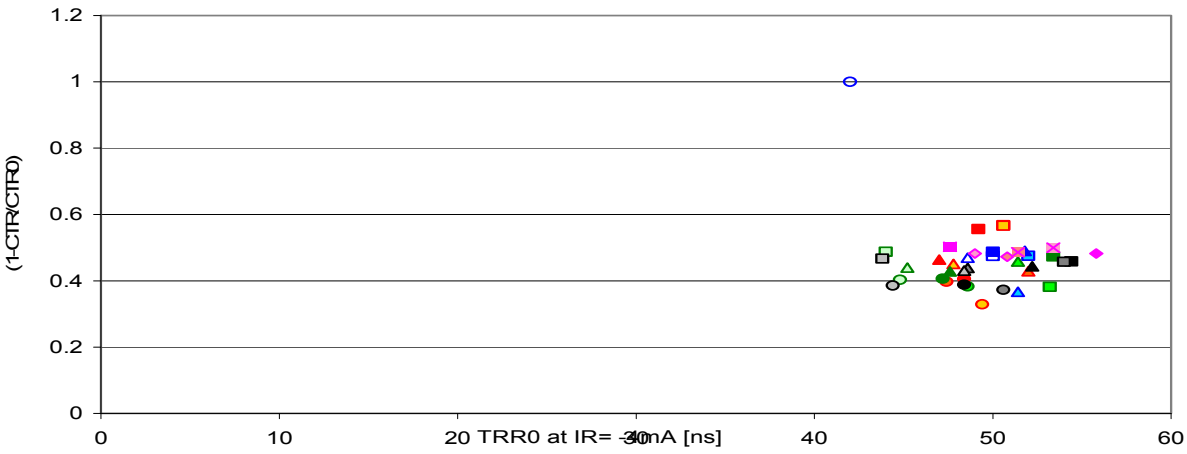
Fig. 13-225: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0



OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0

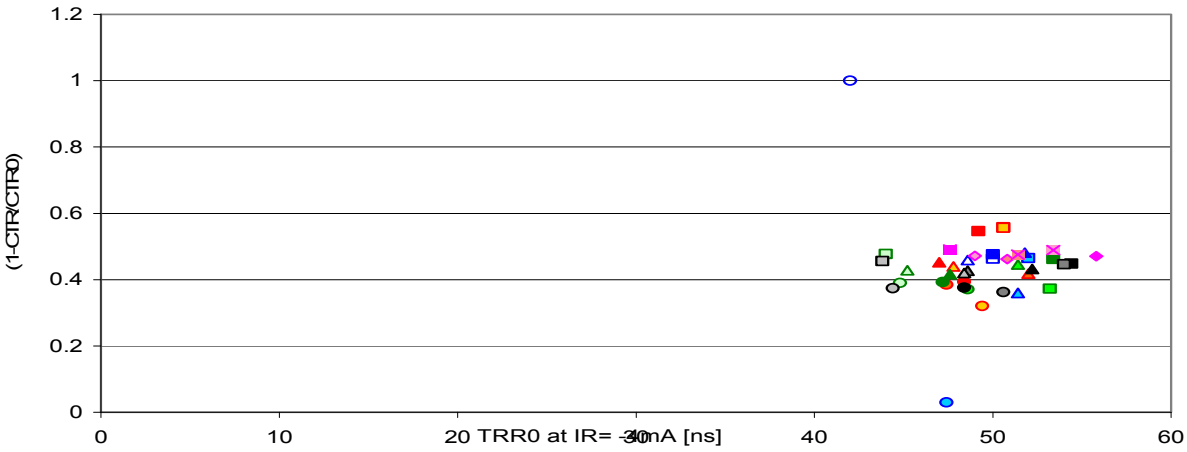
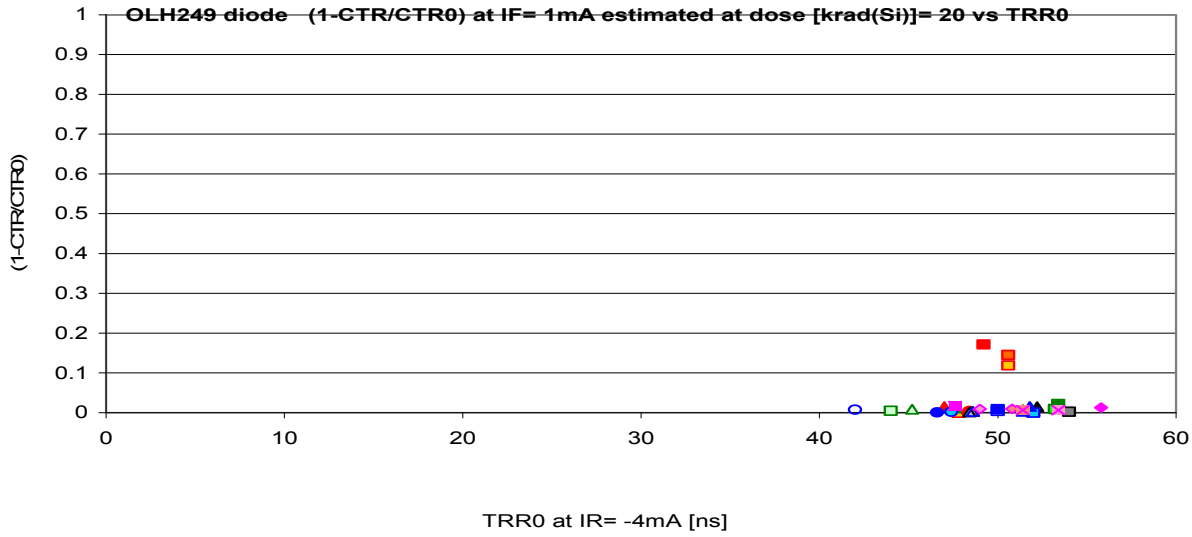
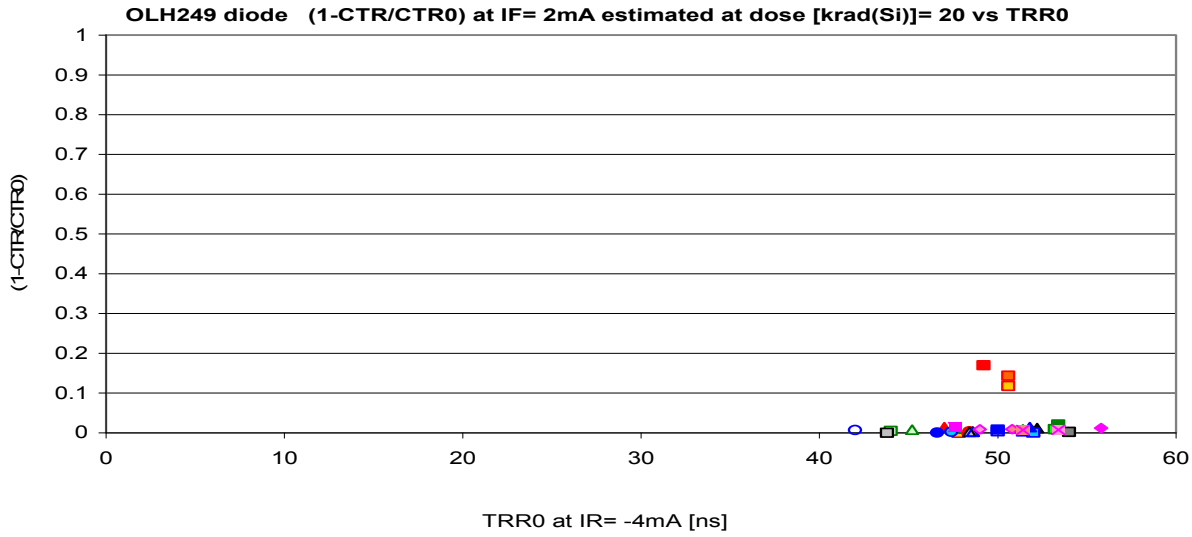
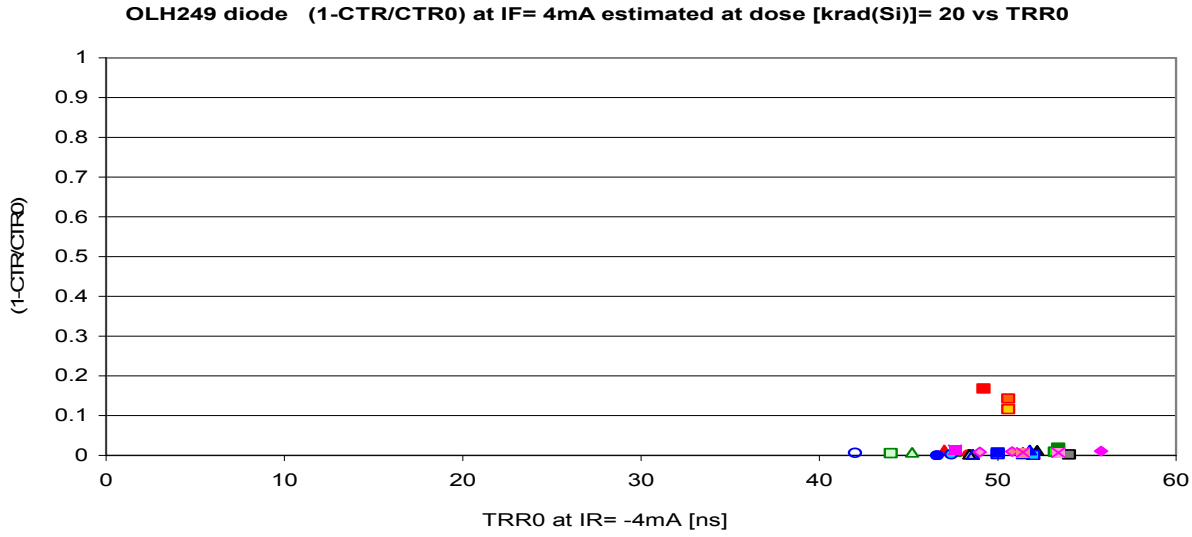
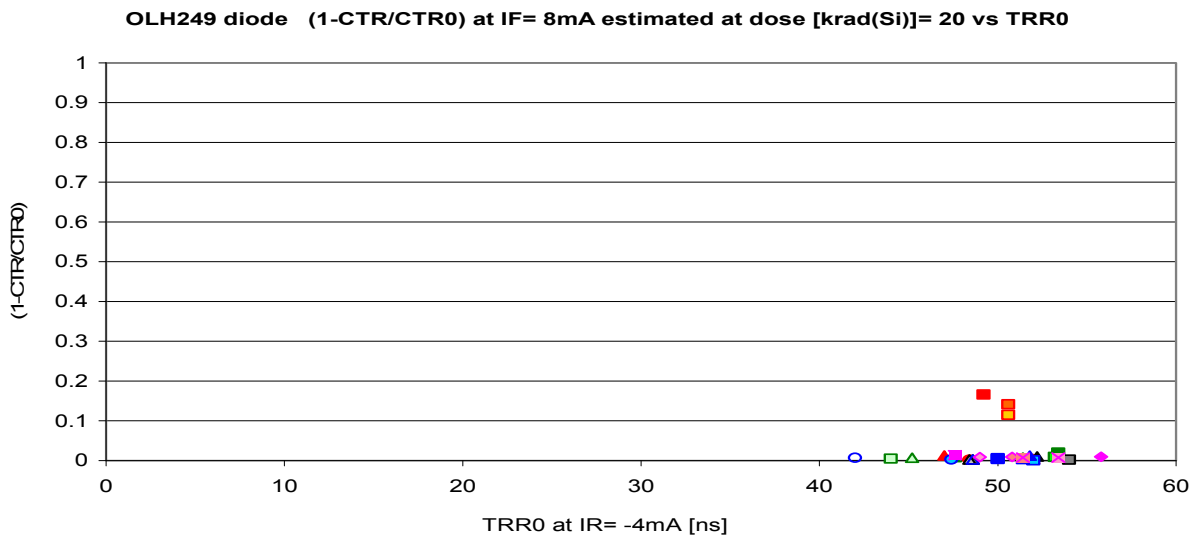


Fig. 13-226: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

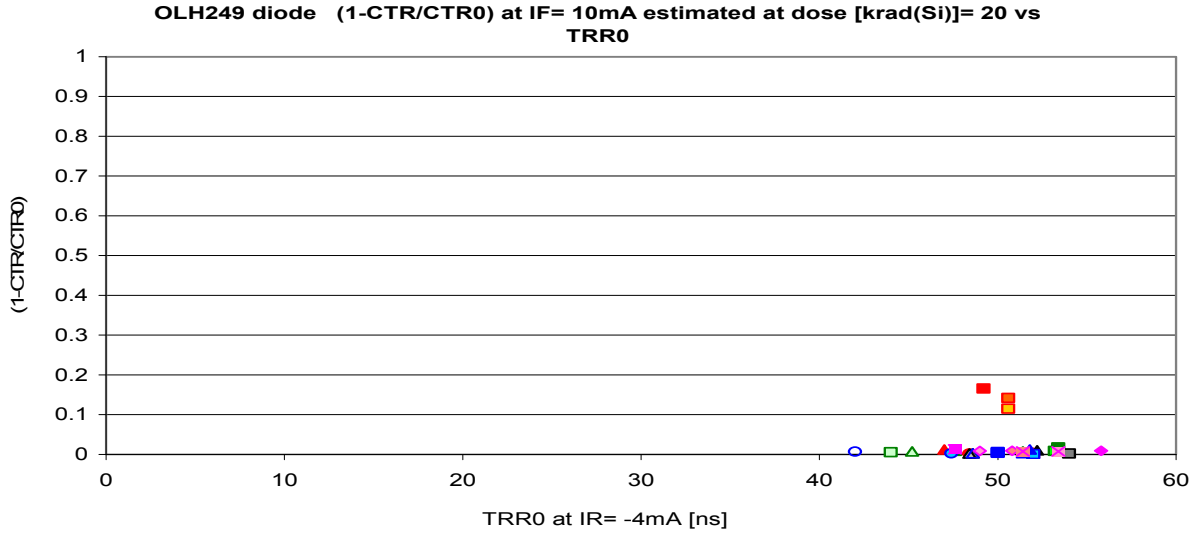
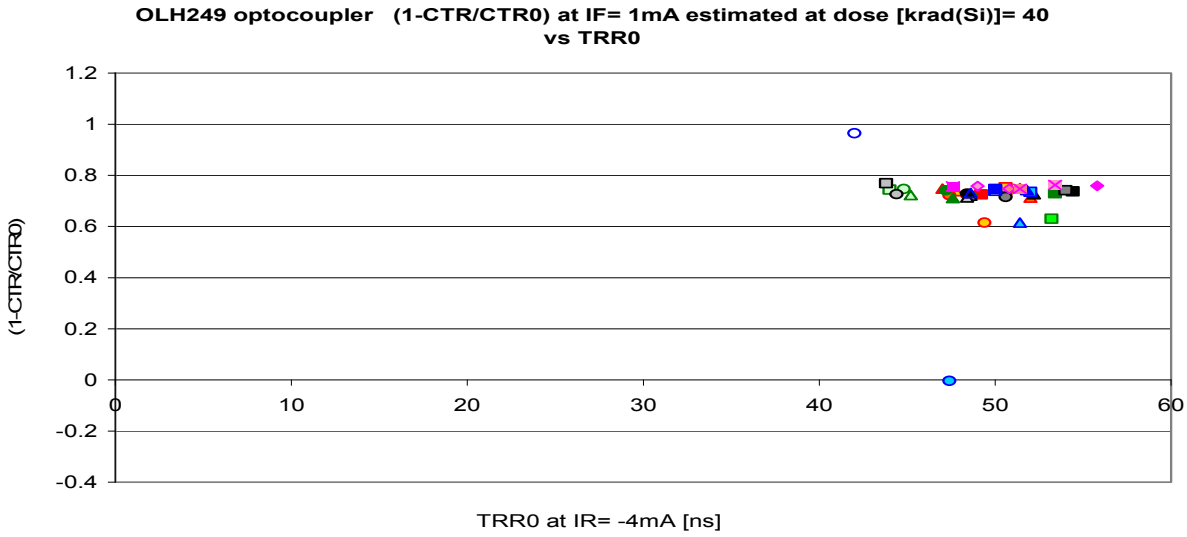
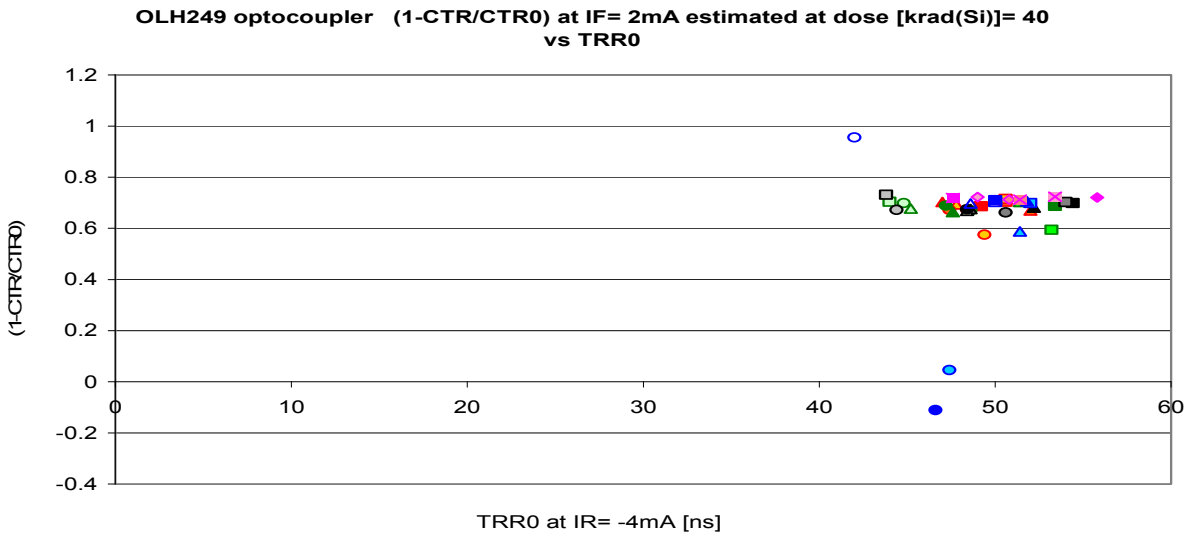
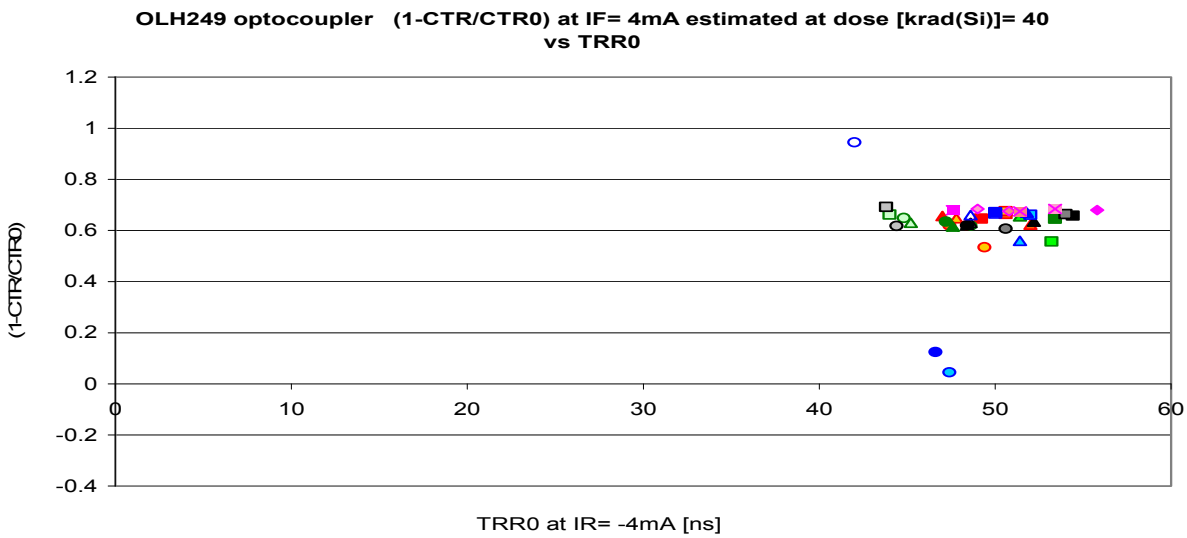
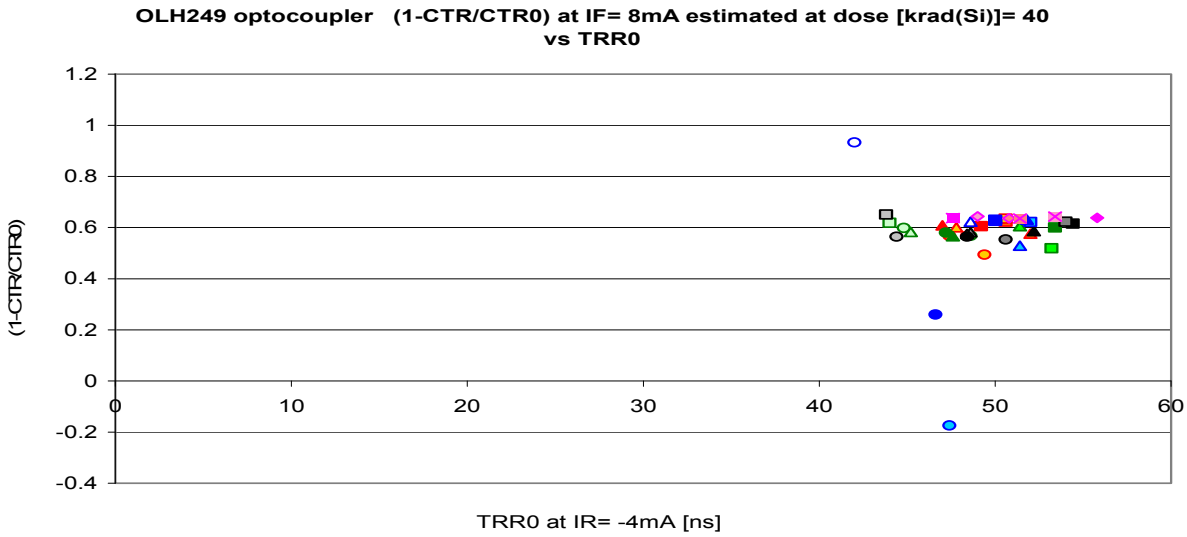

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-227: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40
vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

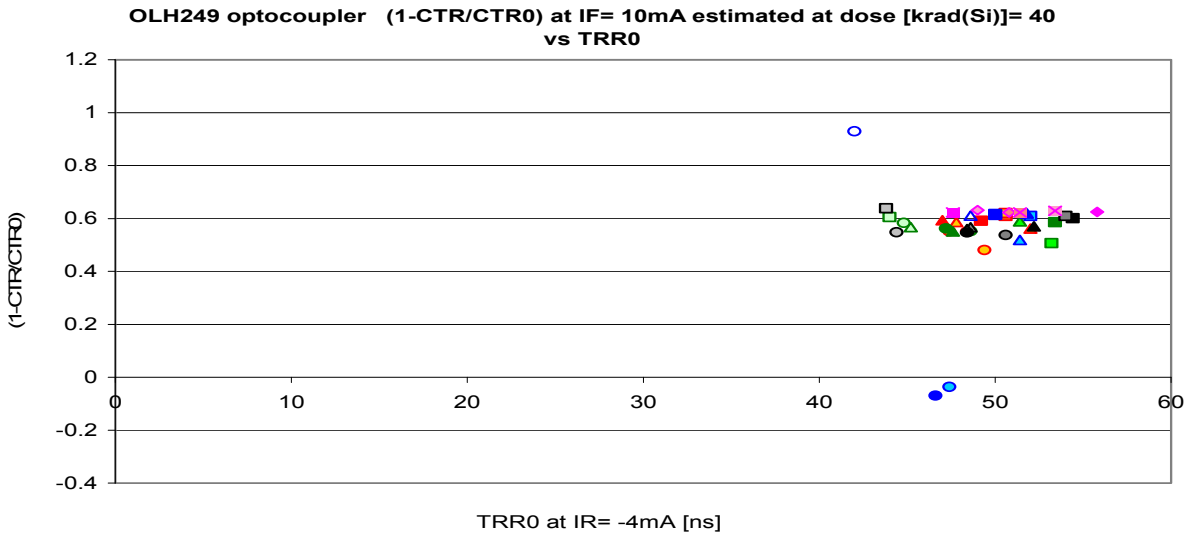
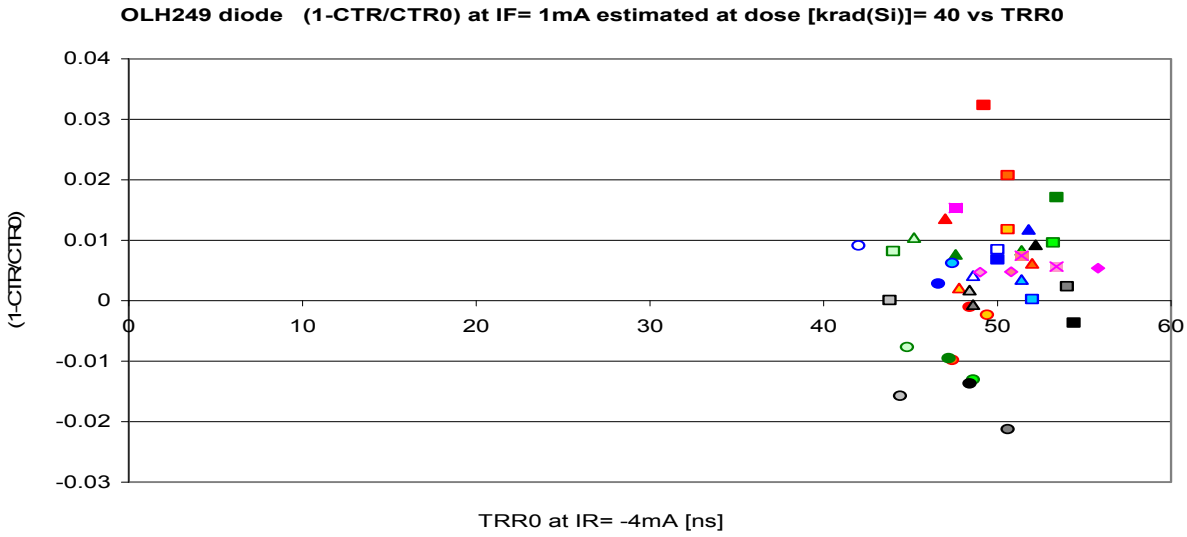
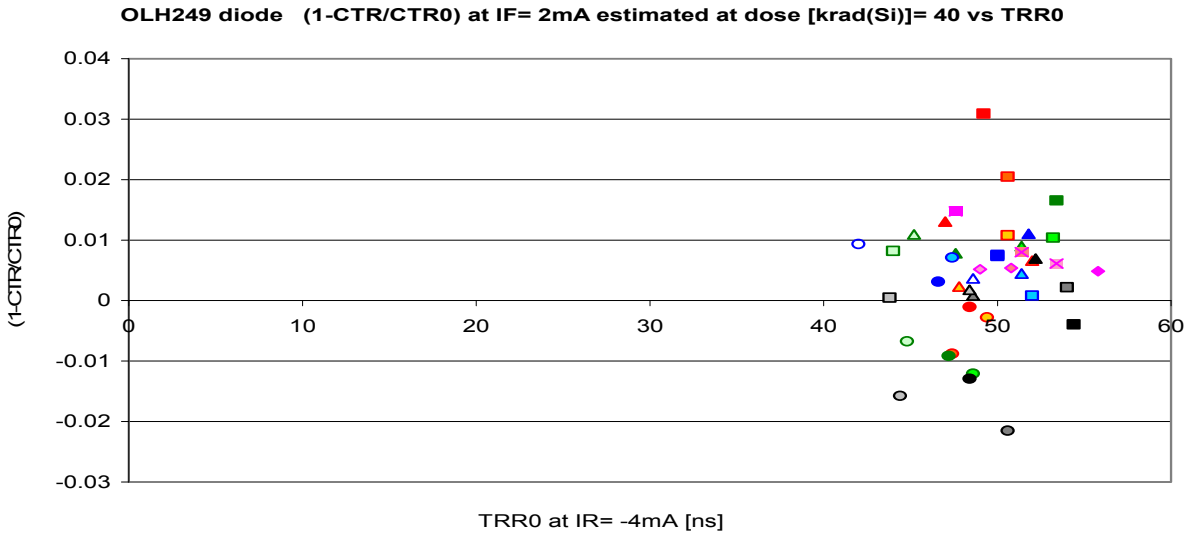
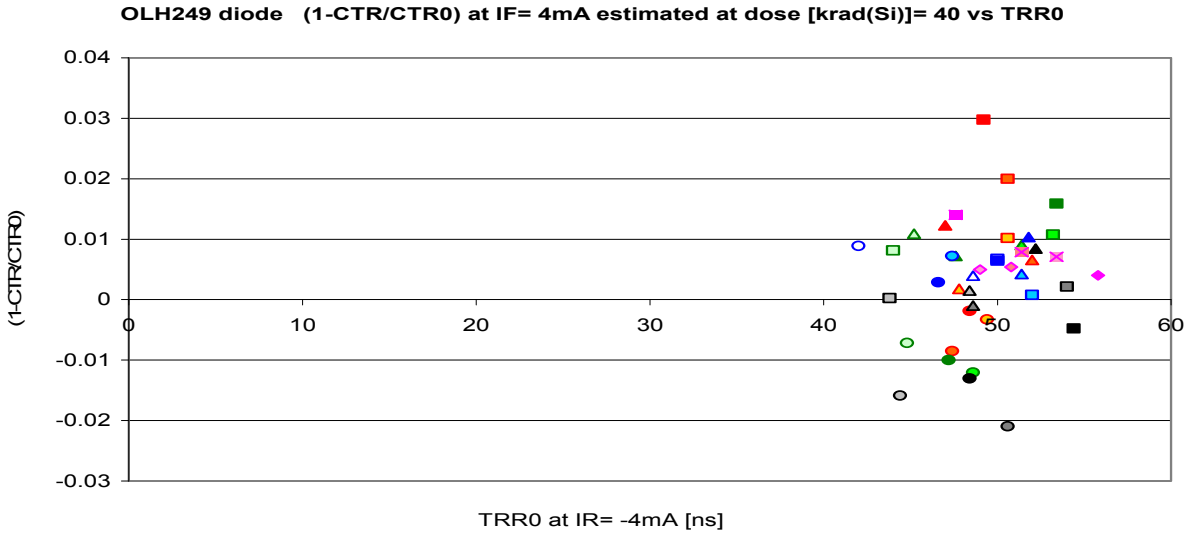
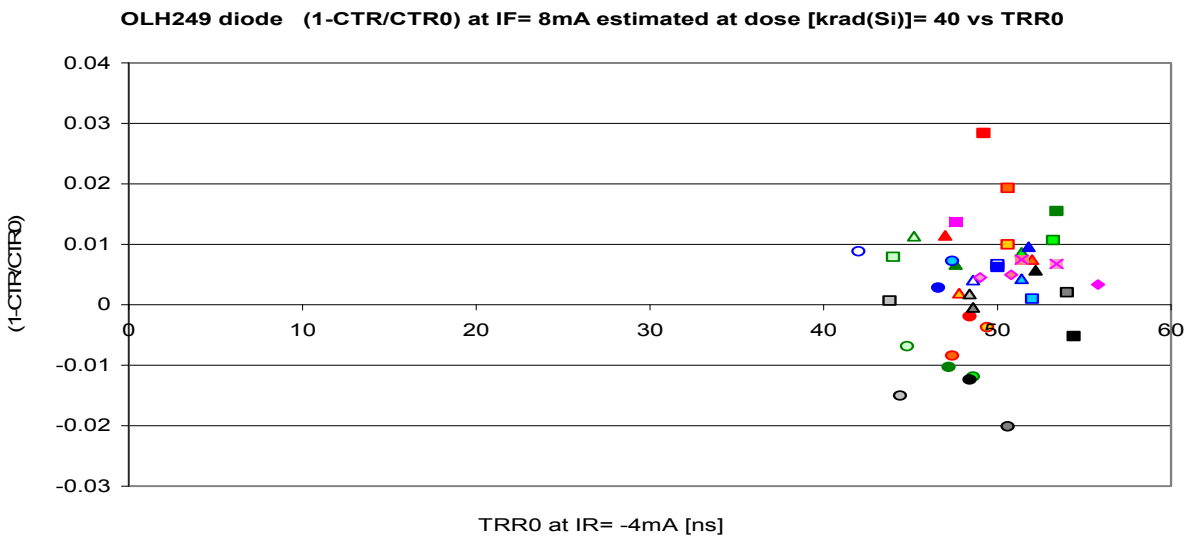

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40
vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-228: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

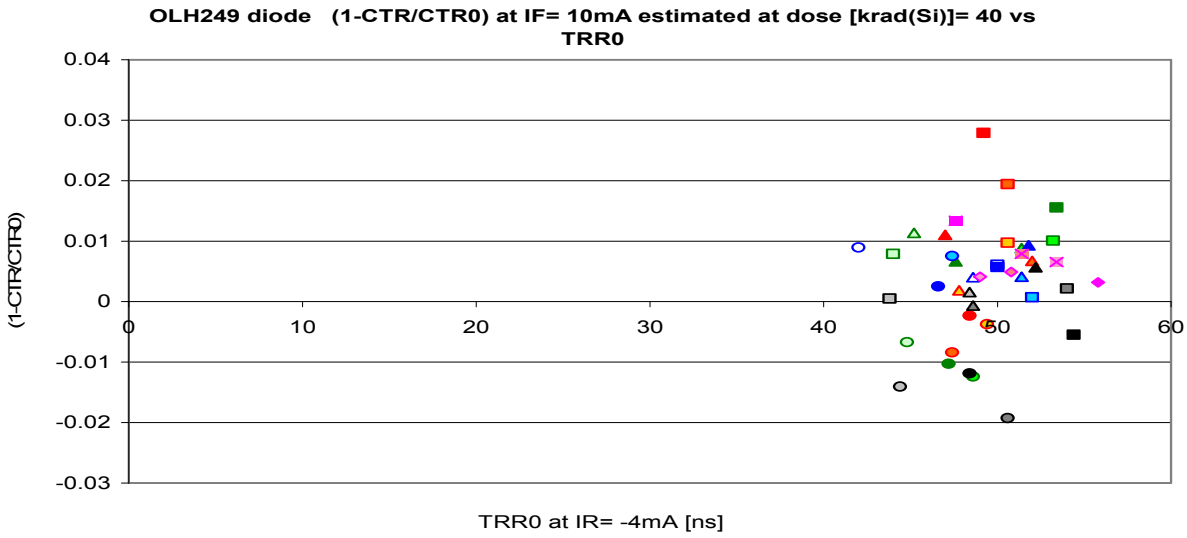
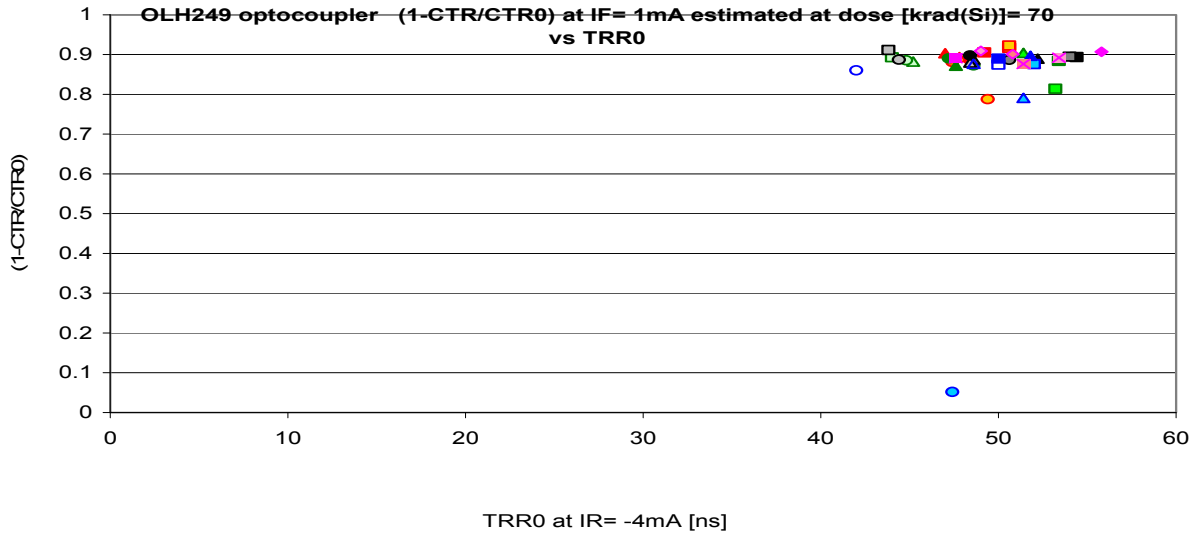
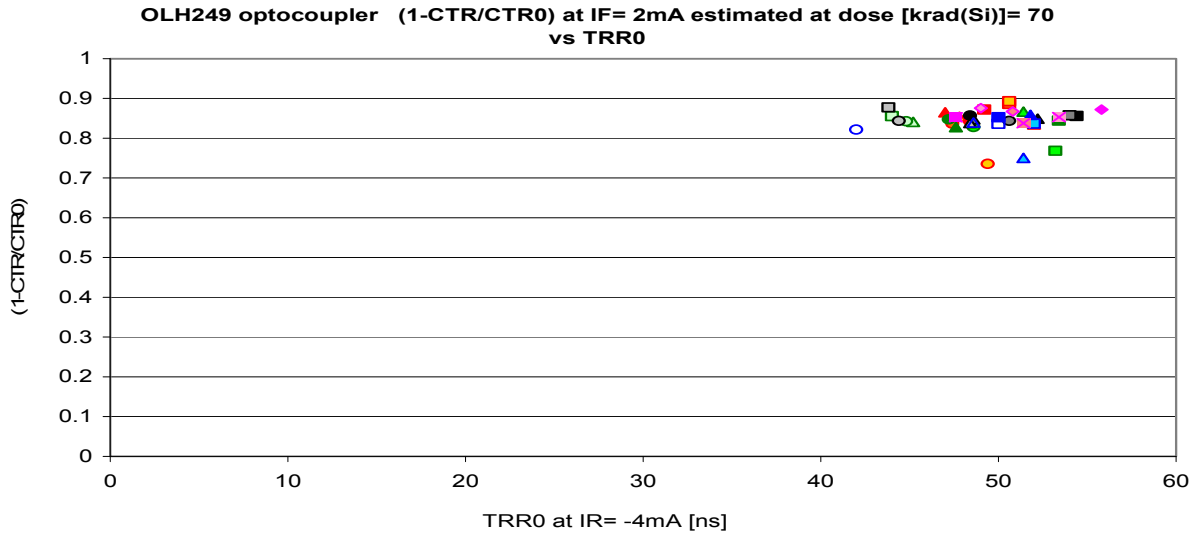
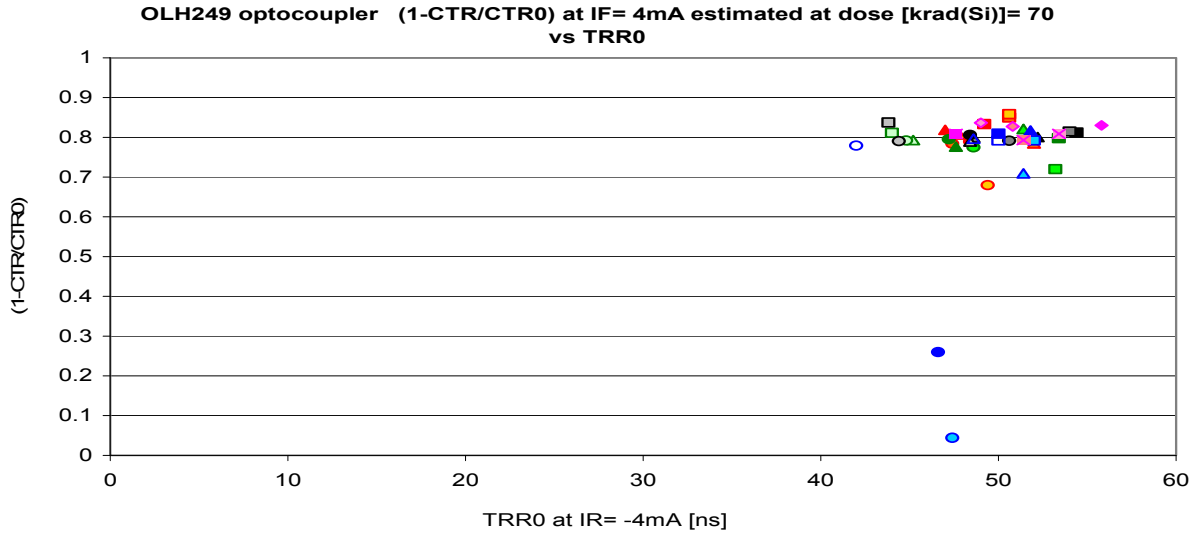
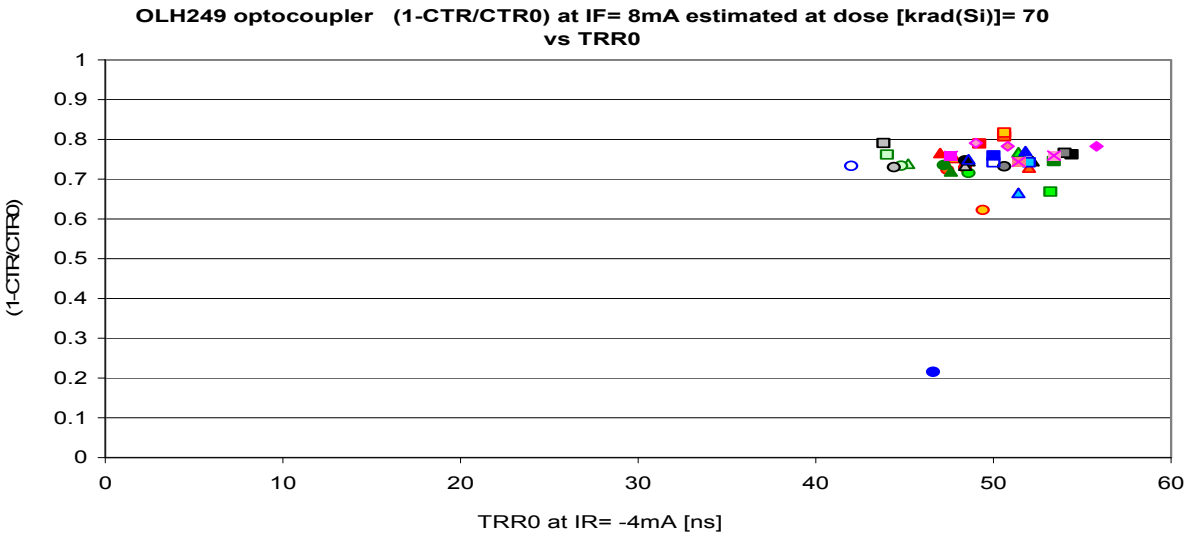

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-229: OLH249 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








OLH249 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70
vs TRR0
(1-CTR/CTR0)
TRR0 at IR= -4mA [ns]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60

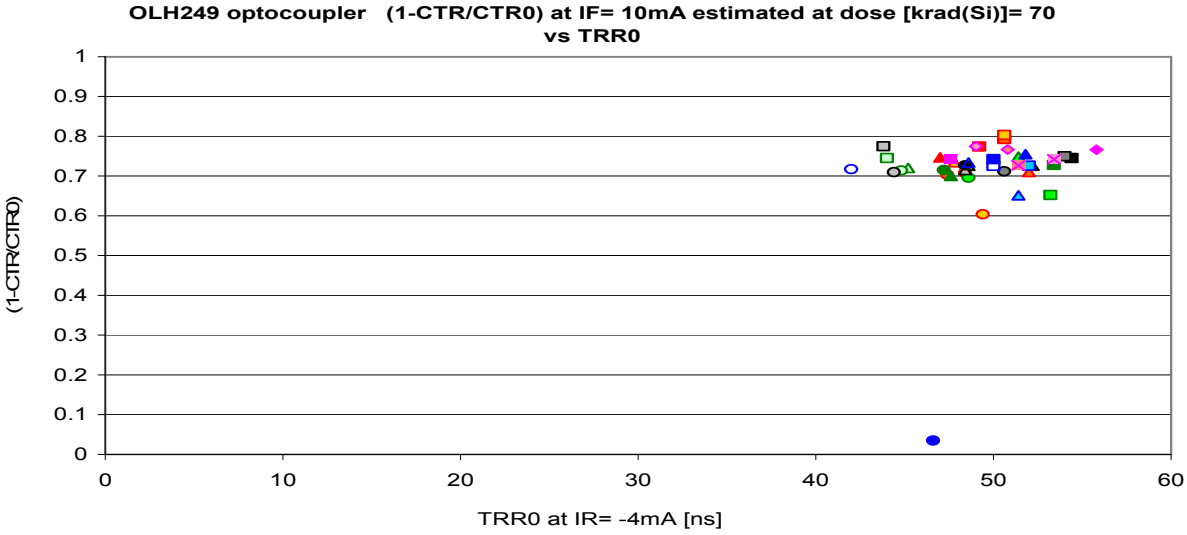
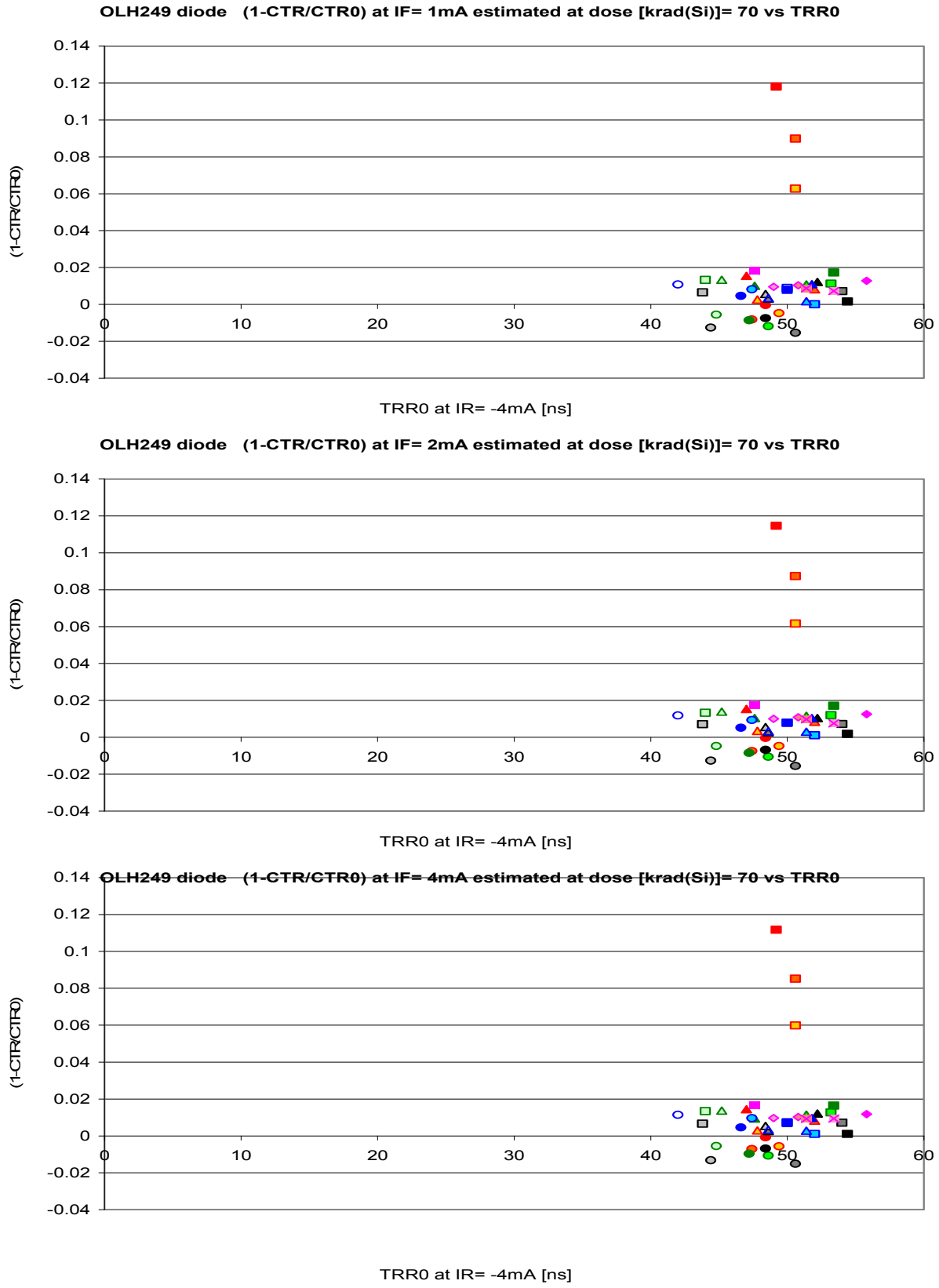
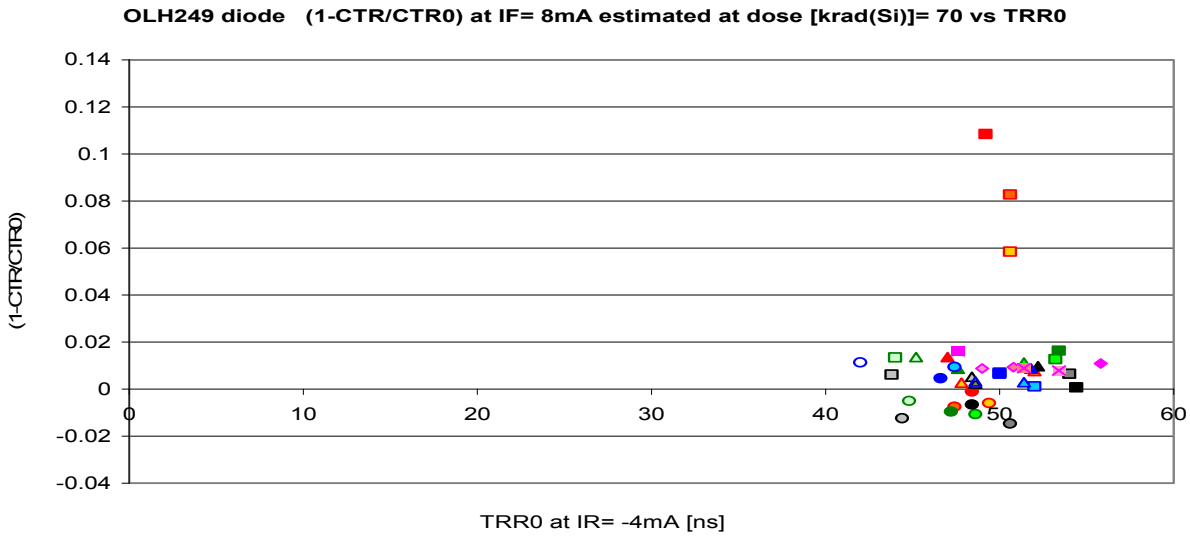

OLH249 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70
vs TRR0
(1-CTR/CTR0)
TRR0 at IR= -4mA [ns]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60

Fig. 13-230: OLH249 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}




OLH249 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

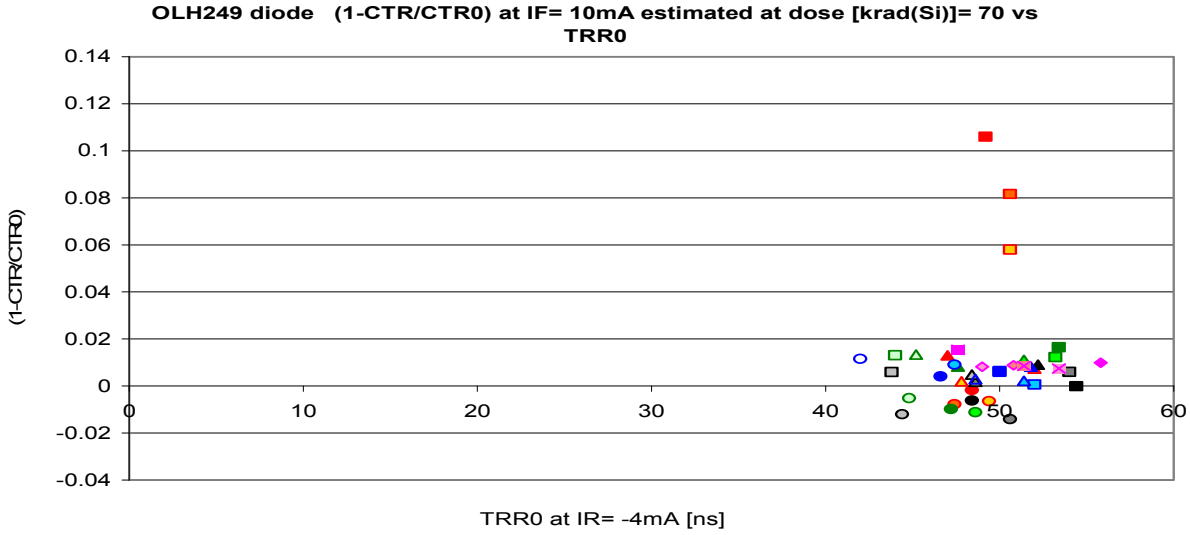

OLH249 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
10
20
30
40
50
60
TRR0 at IR= -4mA [ns]

Fig. 13-231: OLH249 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA

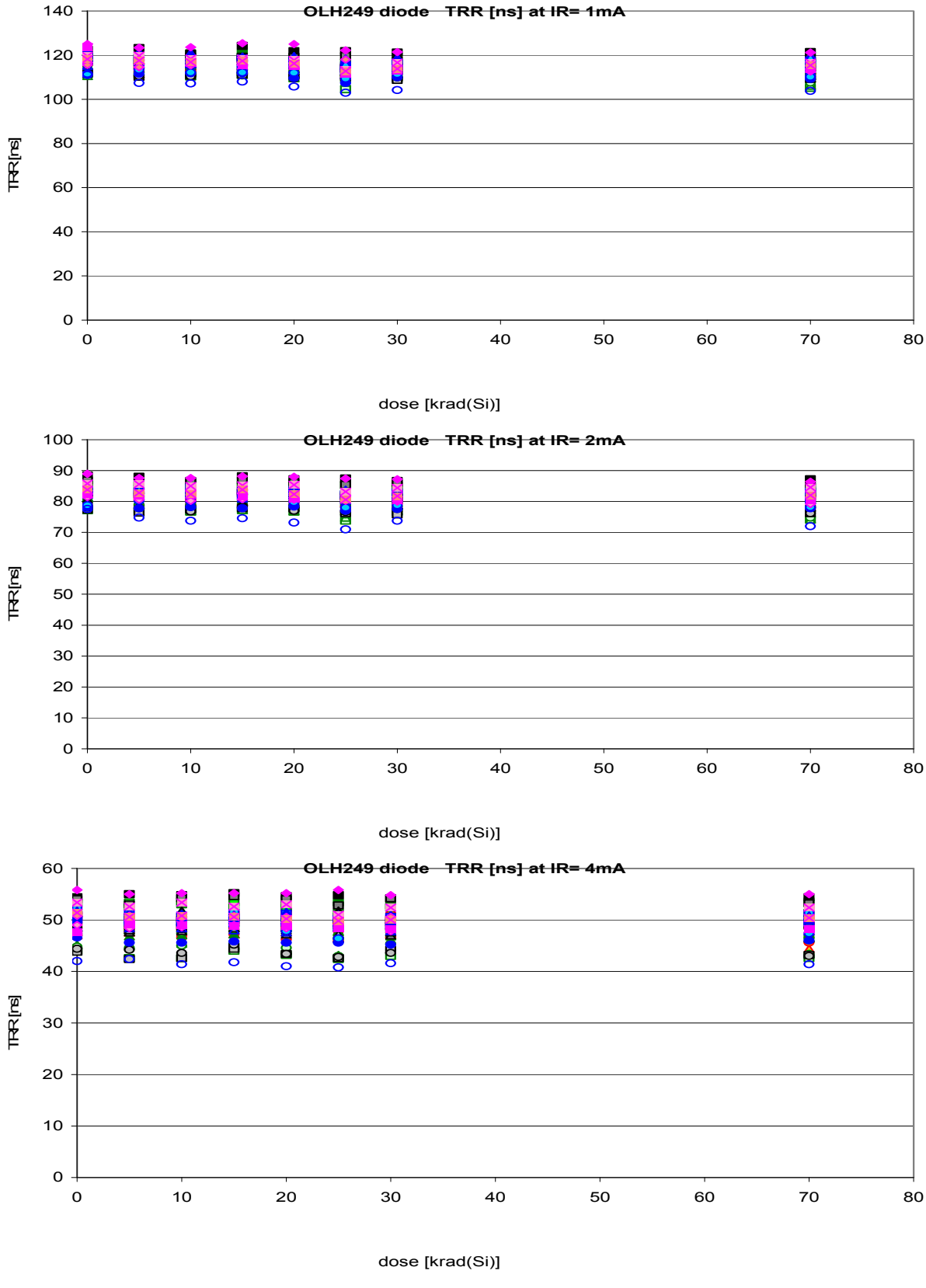
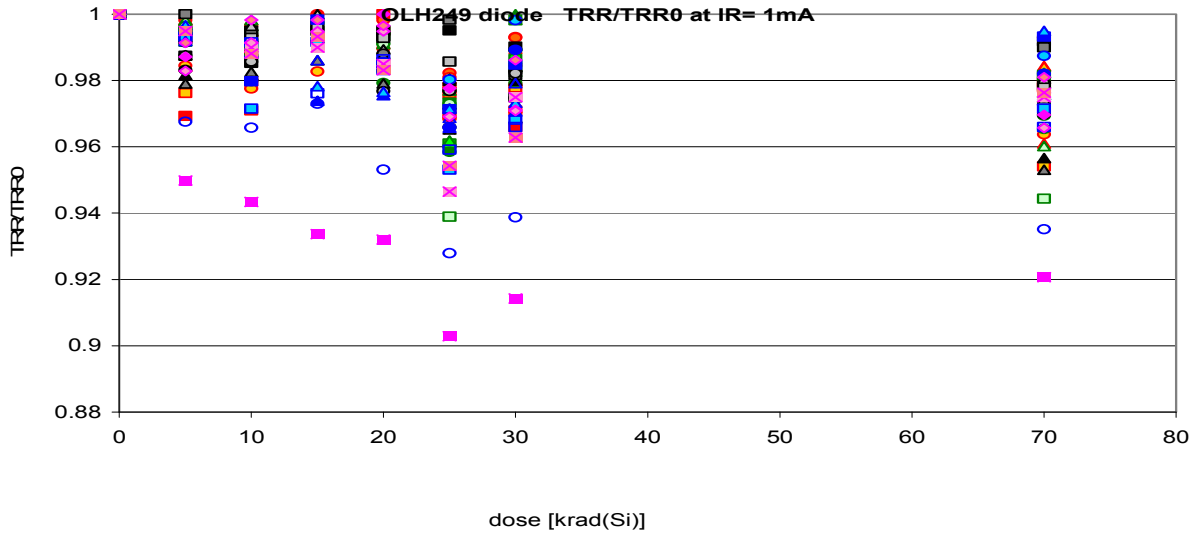
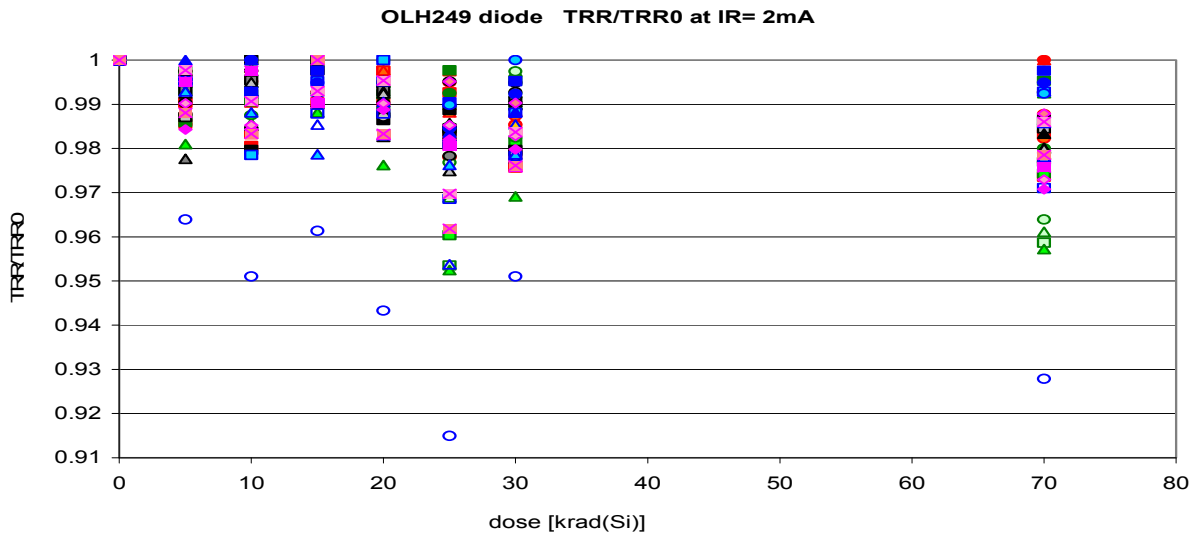


Fig. 13-232: OLH249 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA





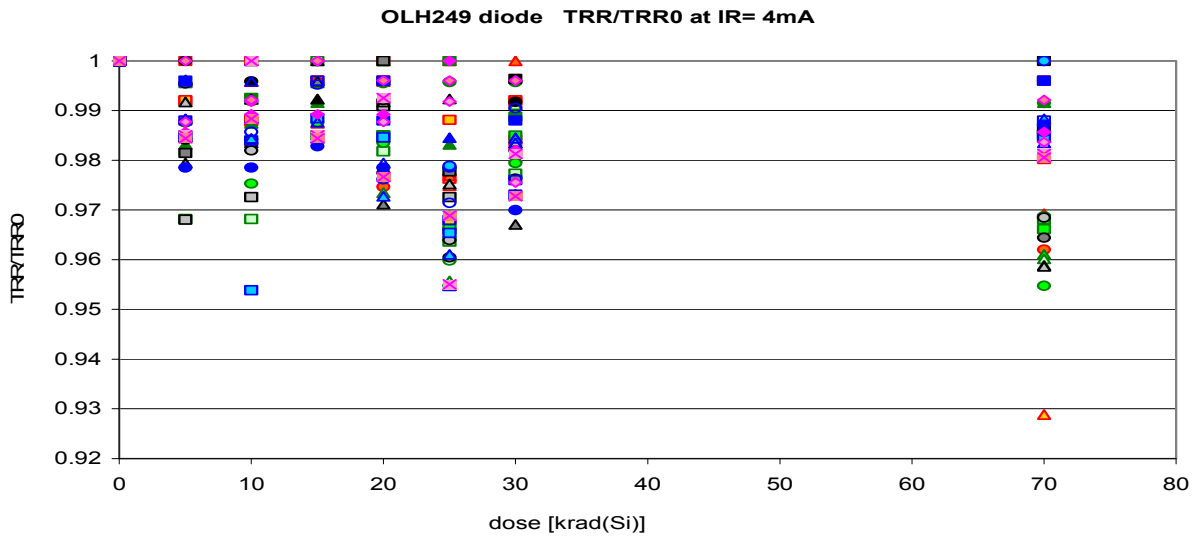


Fig. 13-233: OLH249 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA

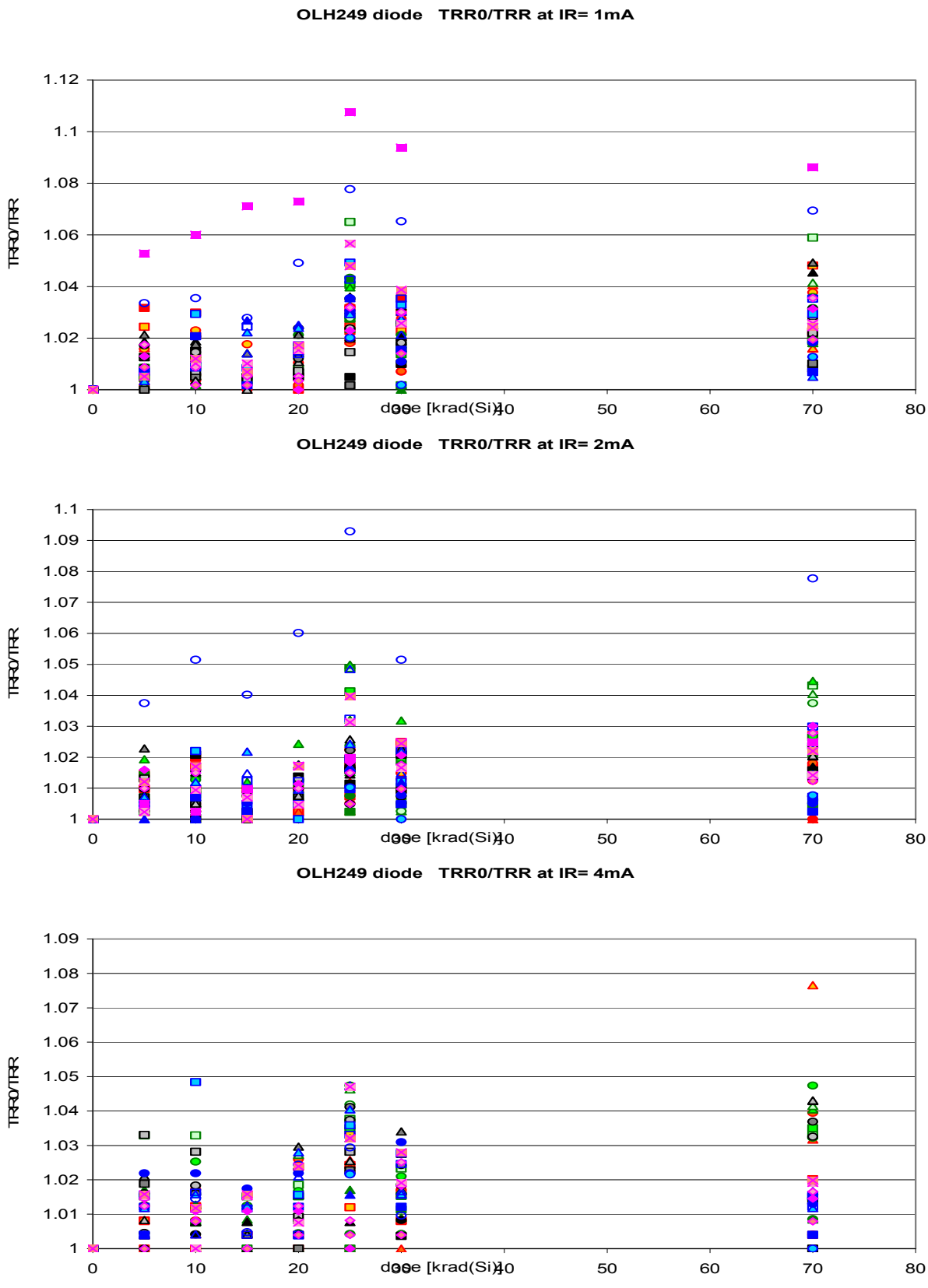


Fig. 13-234: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA

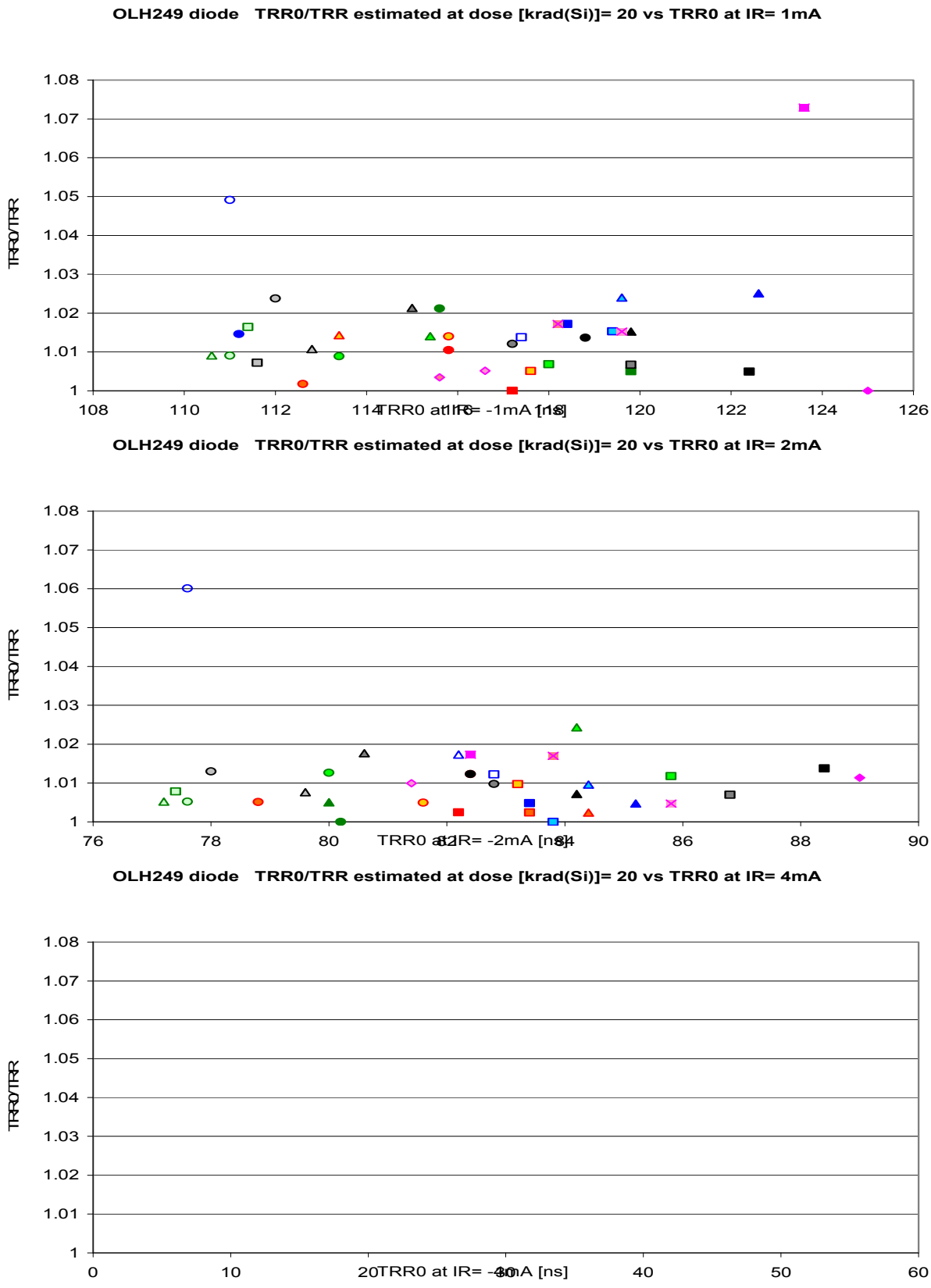
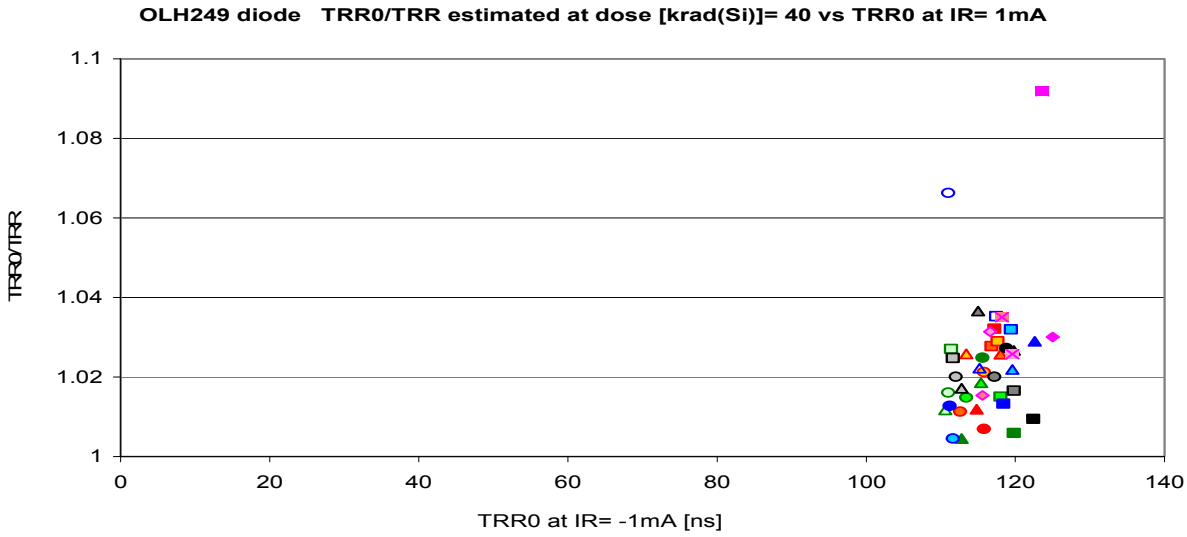
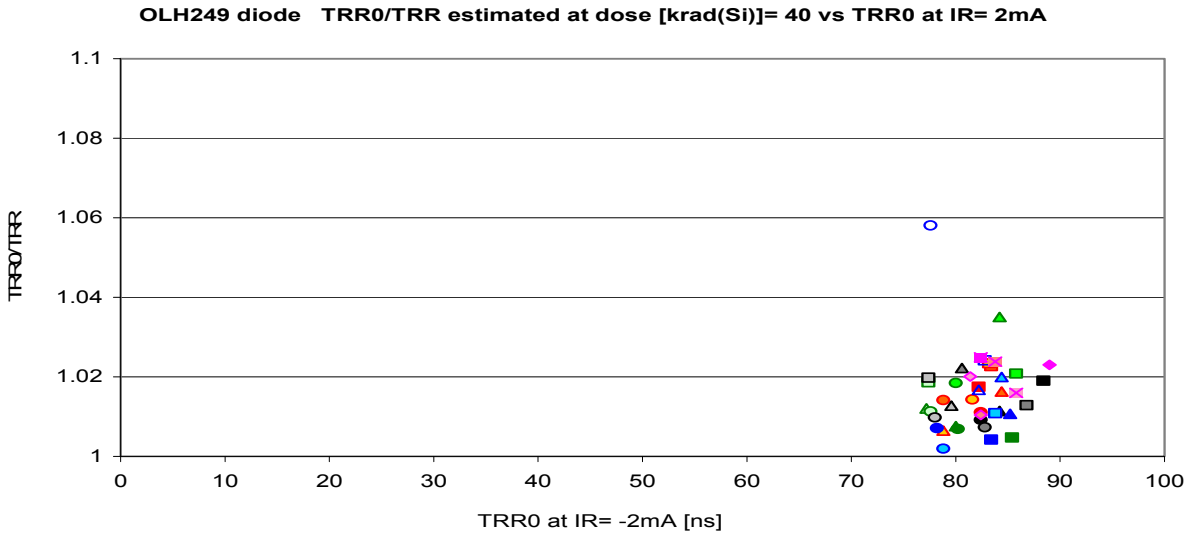


Fig. 13-235: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





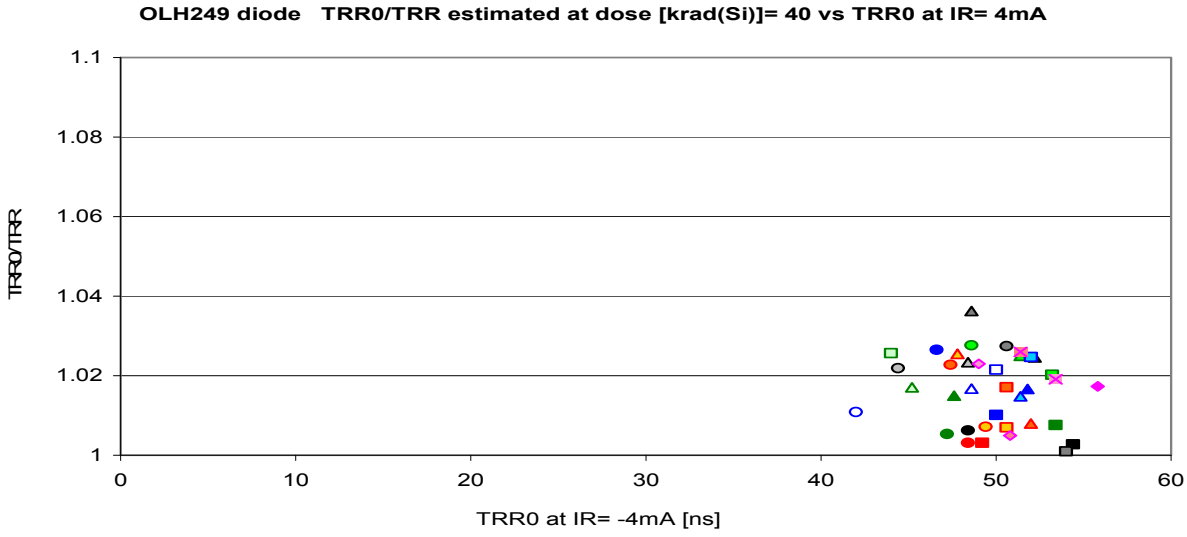
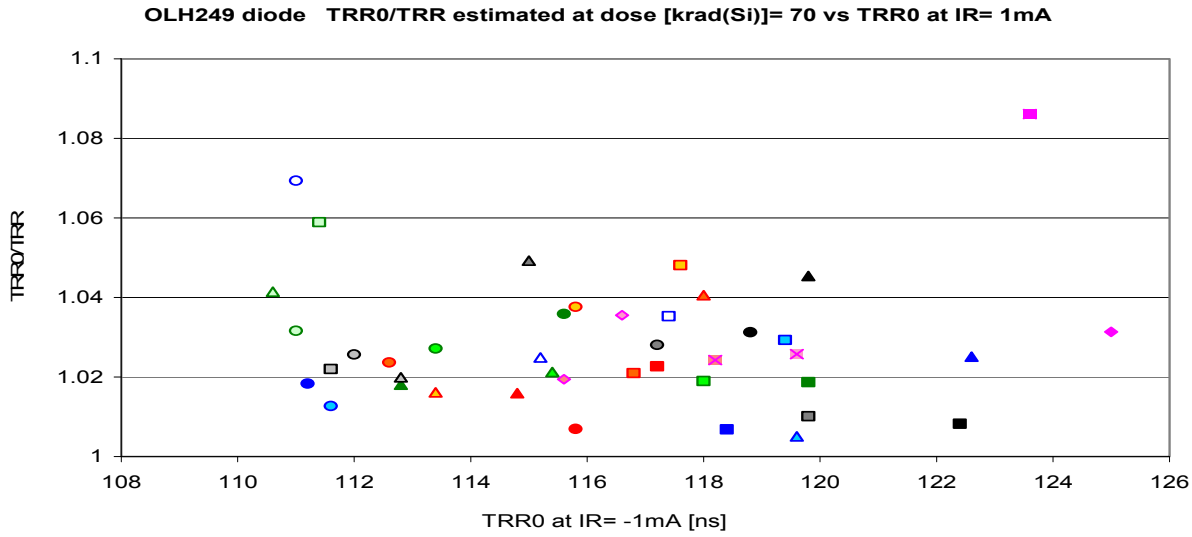
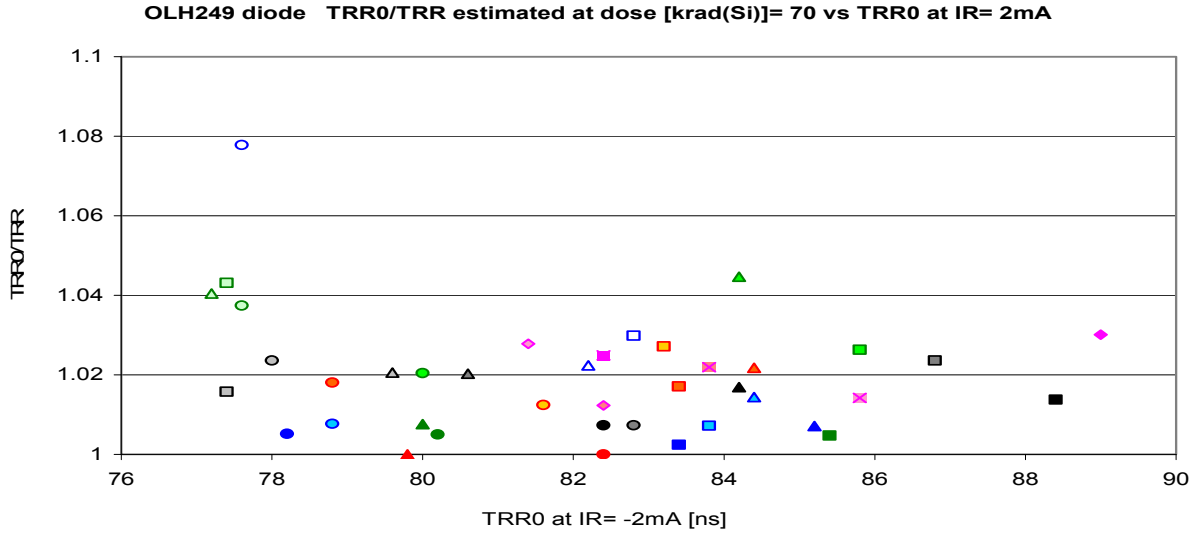


Fig. 13-236: OLH249 diode: τ_{RR0}/τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





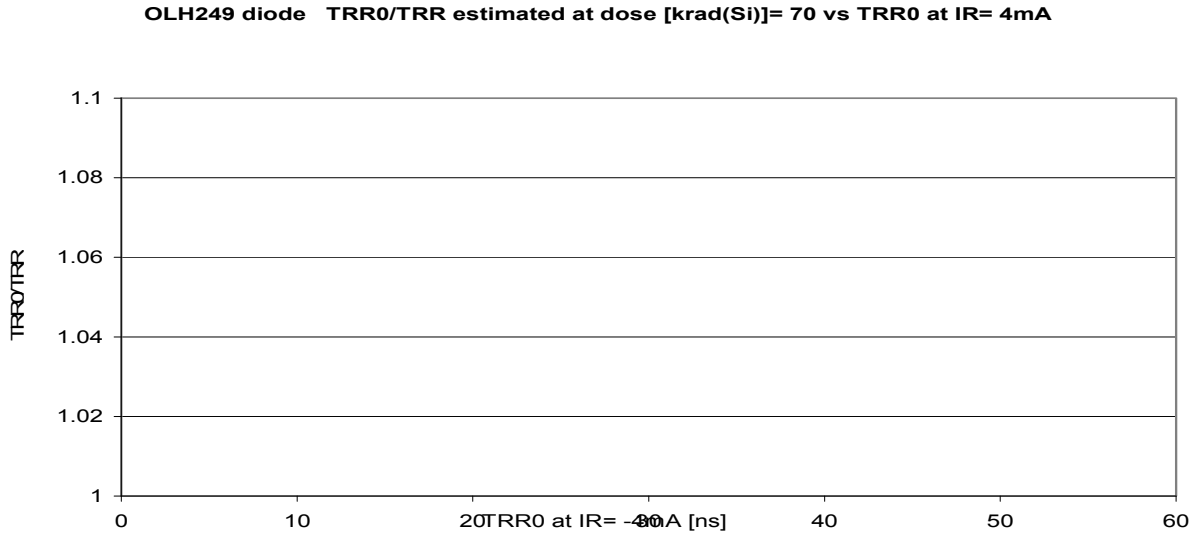
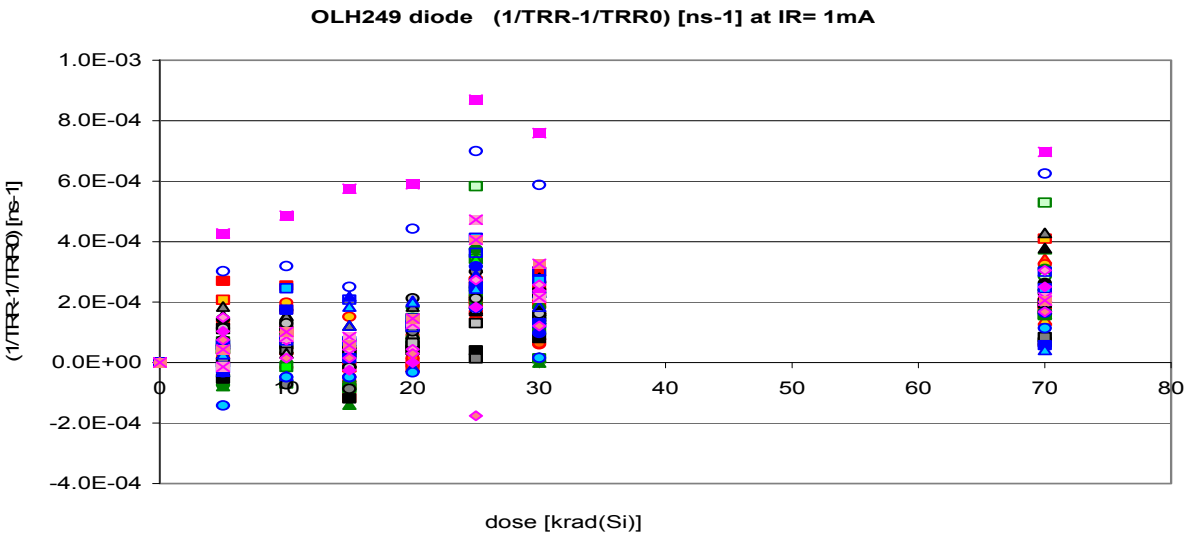
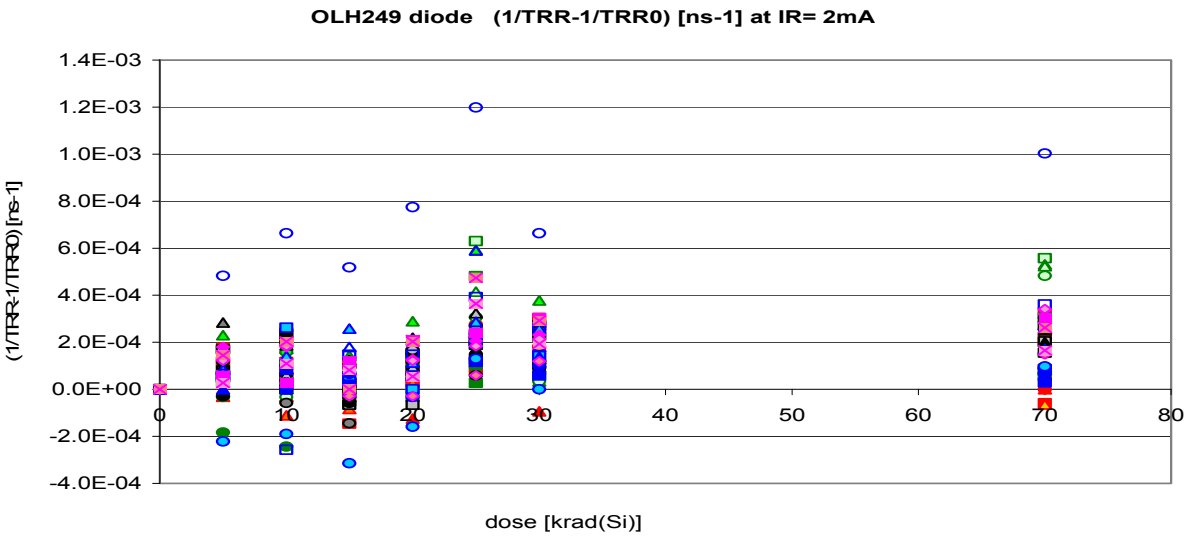


Fig. 13-237: OLH249 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose





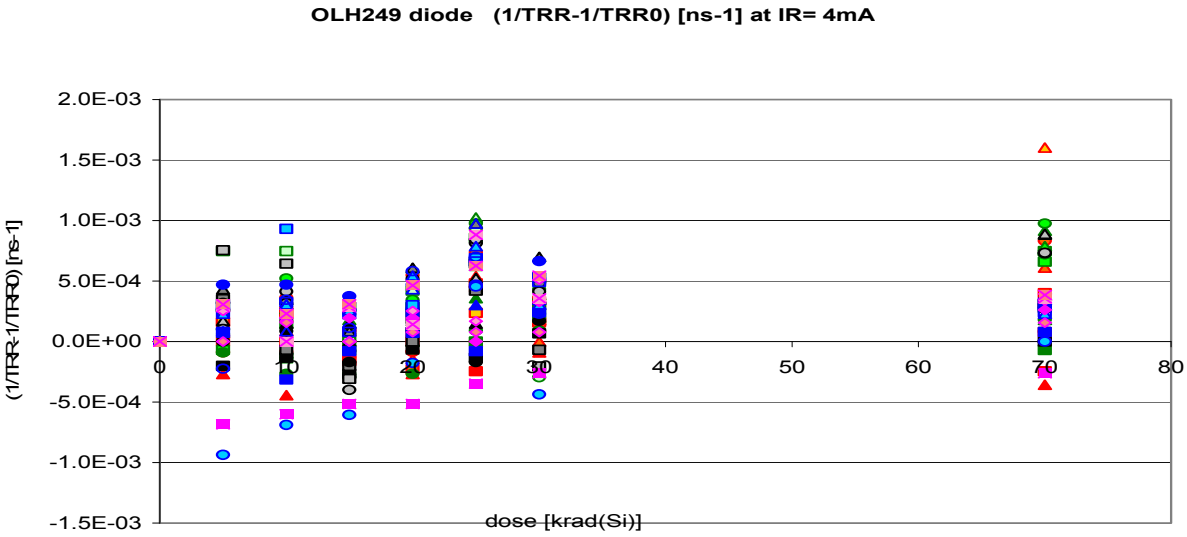


Fig. 13-238: OLH249 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}

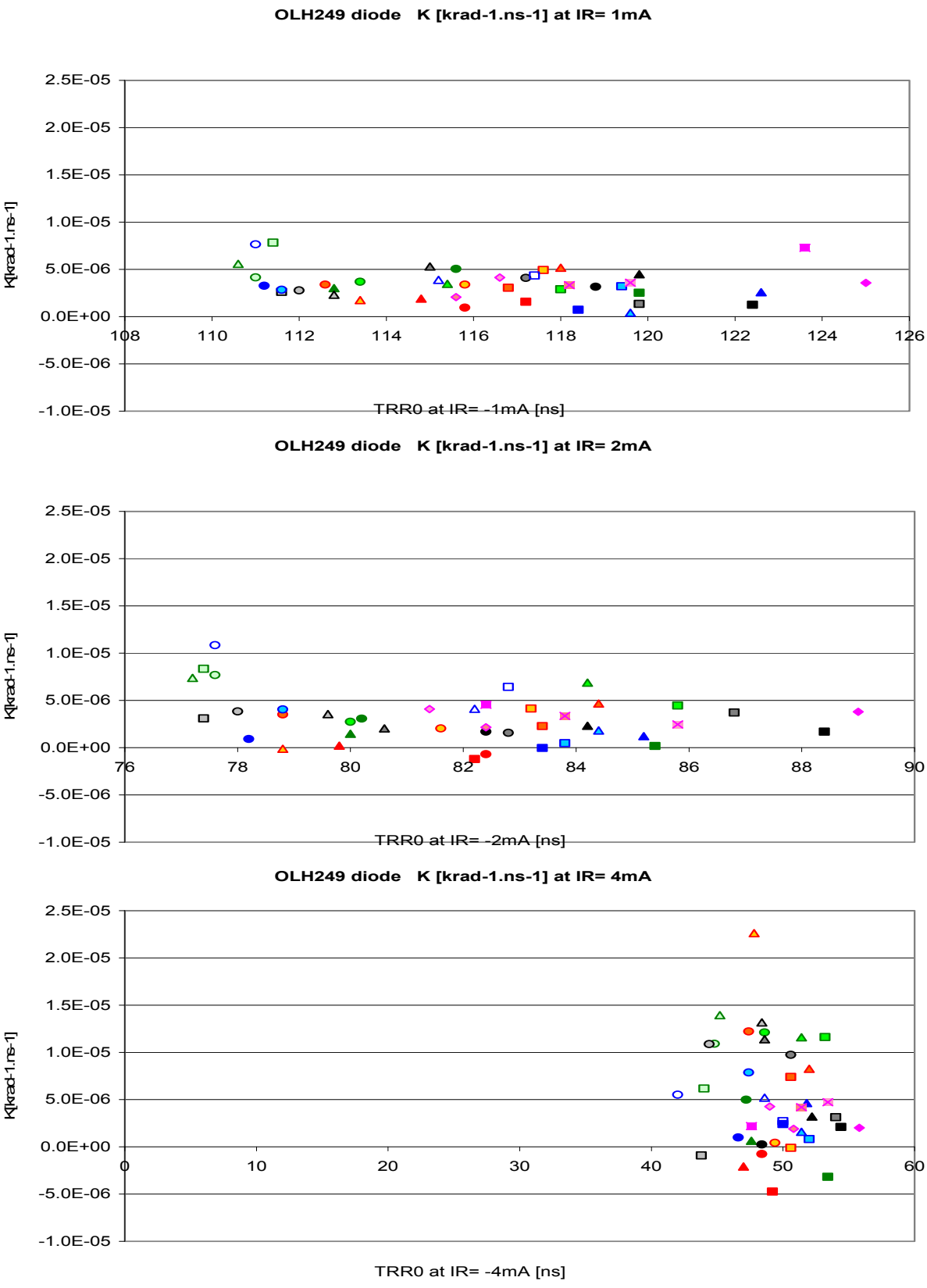
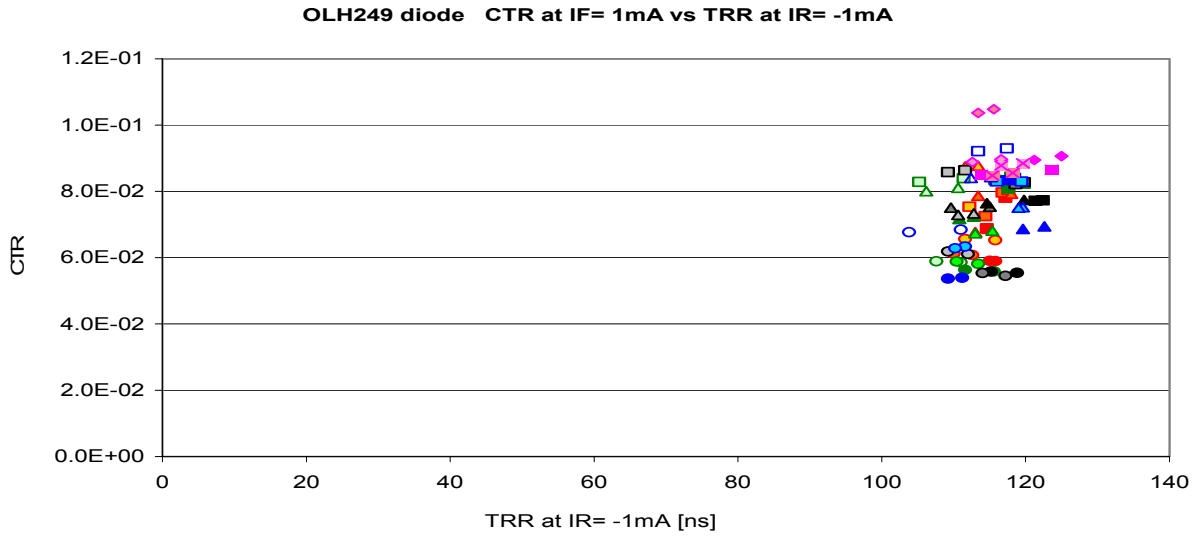
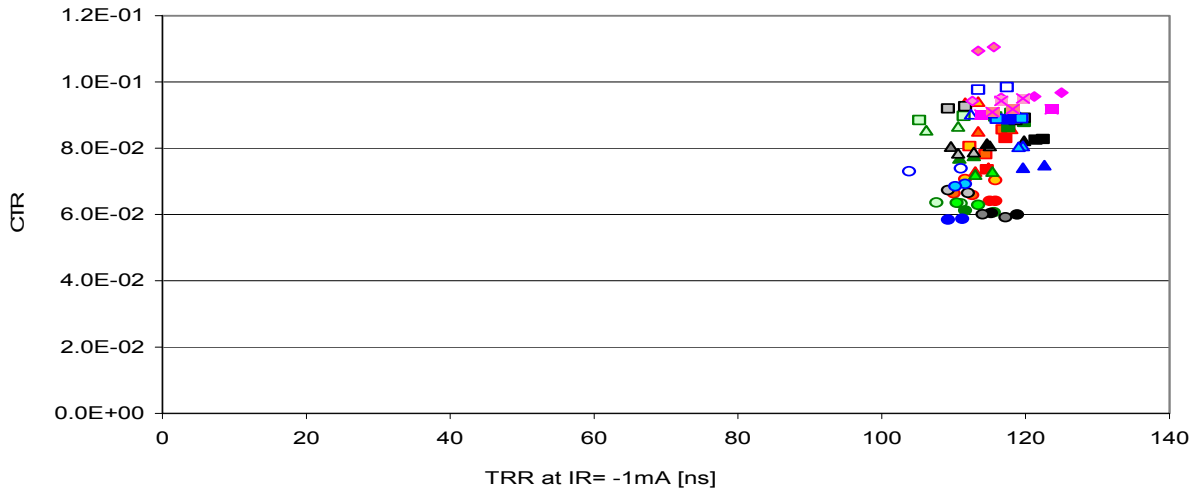
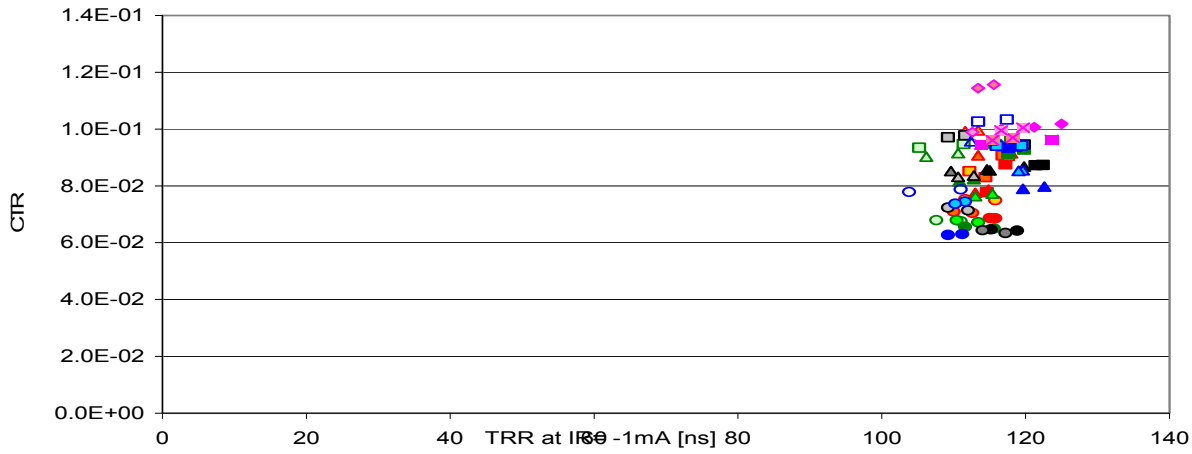


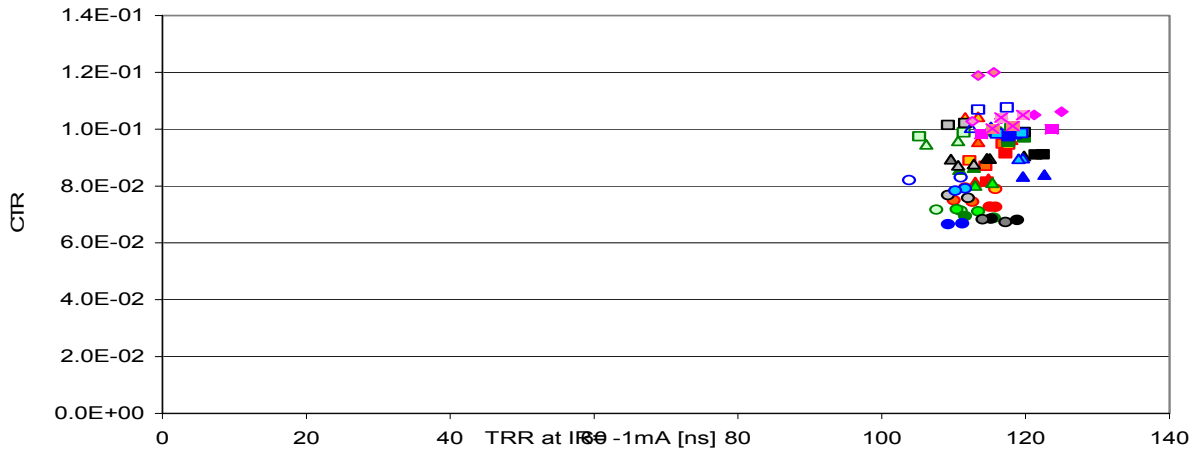
Fig. 13-239: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA







OLH249 diode CTR at IF= 8mA vs TRR at IR= -1mA



OLH249 diode CTR at IF= 10mA vs TRR at IR= -1mA

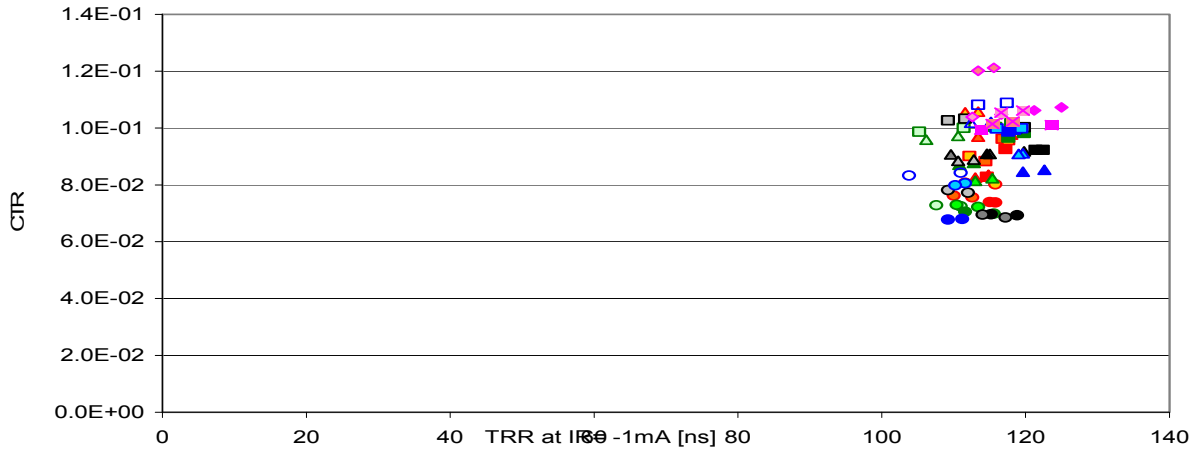
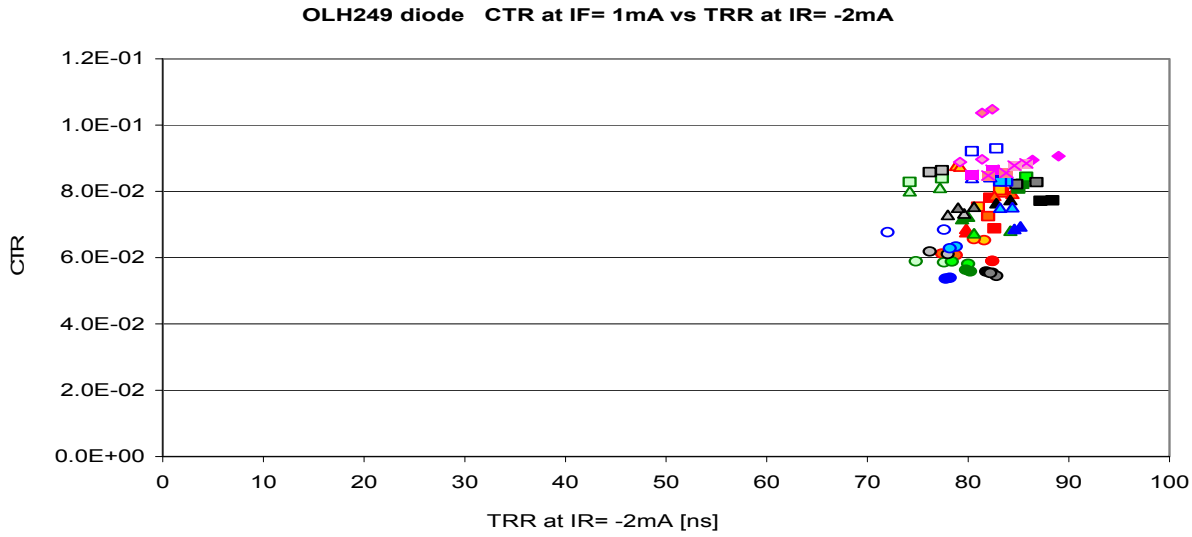
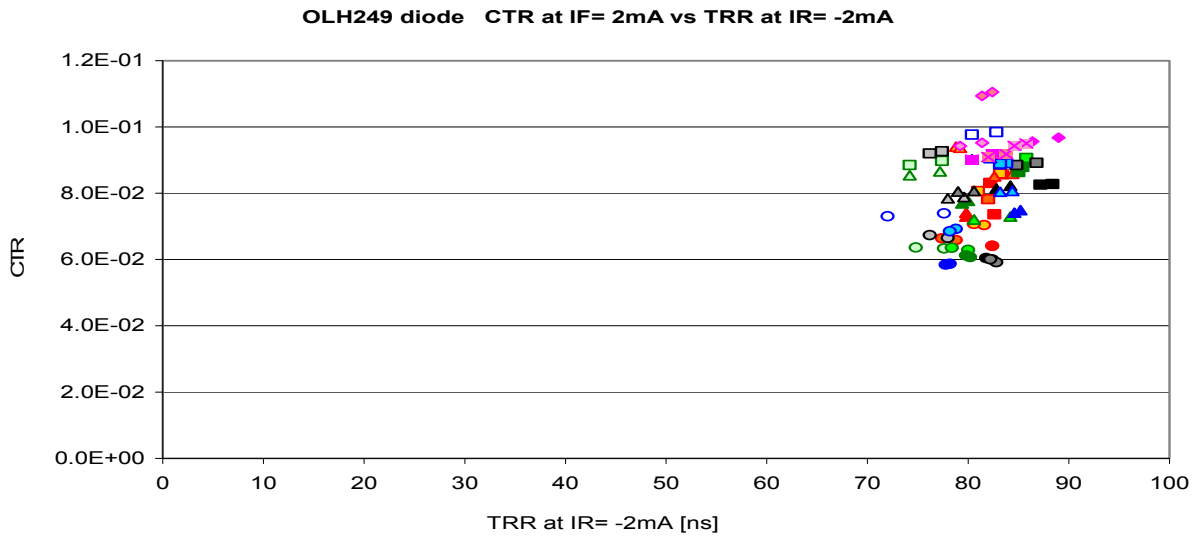
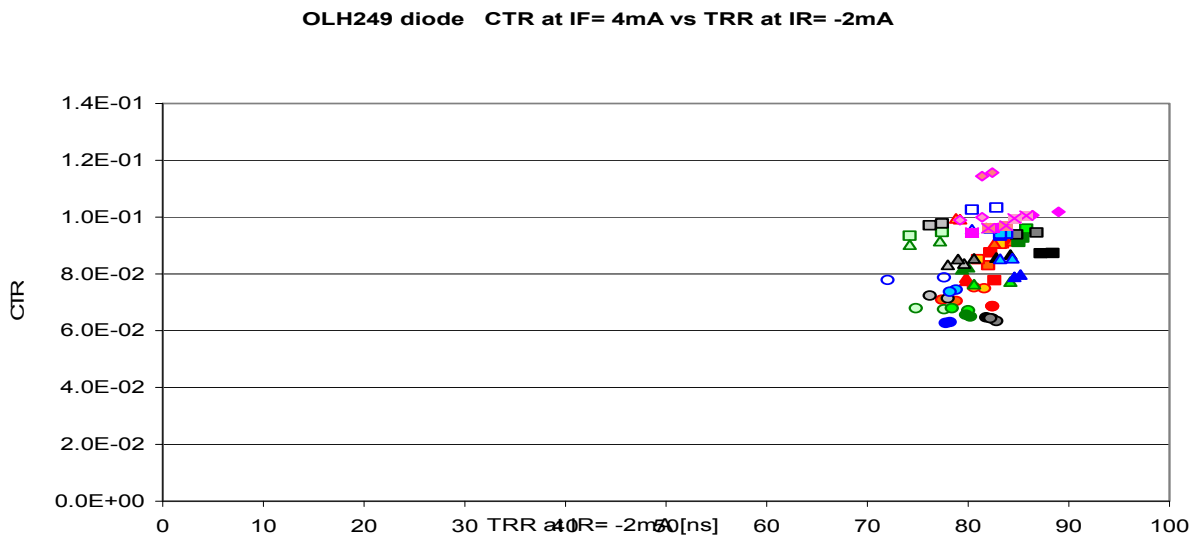


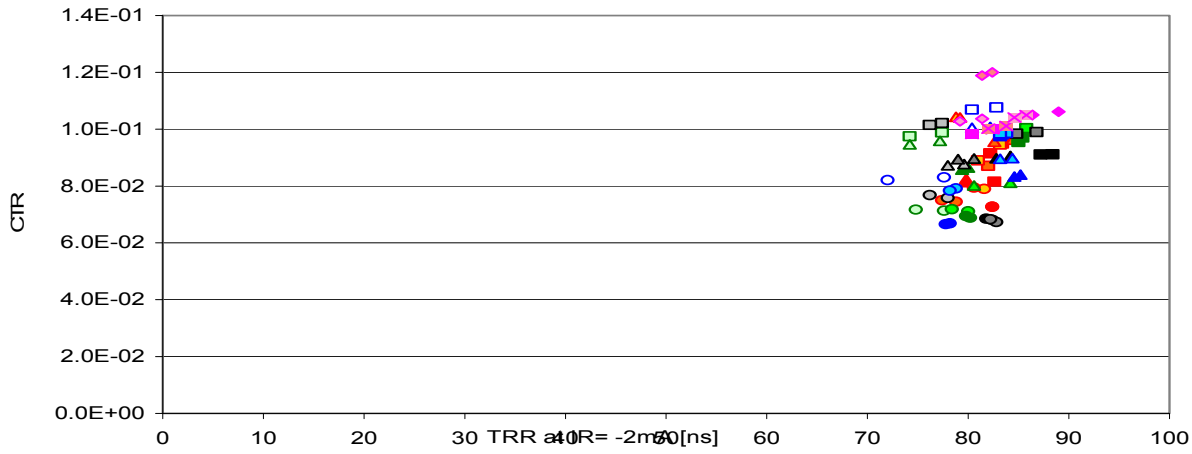
Fig. 13-240: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA







OLH249 diode CTR at IF= 8mA vs TRR at IR= -2mA



OLH249 diode CTR at IF= 10mA vs TRR at IR= -2mA

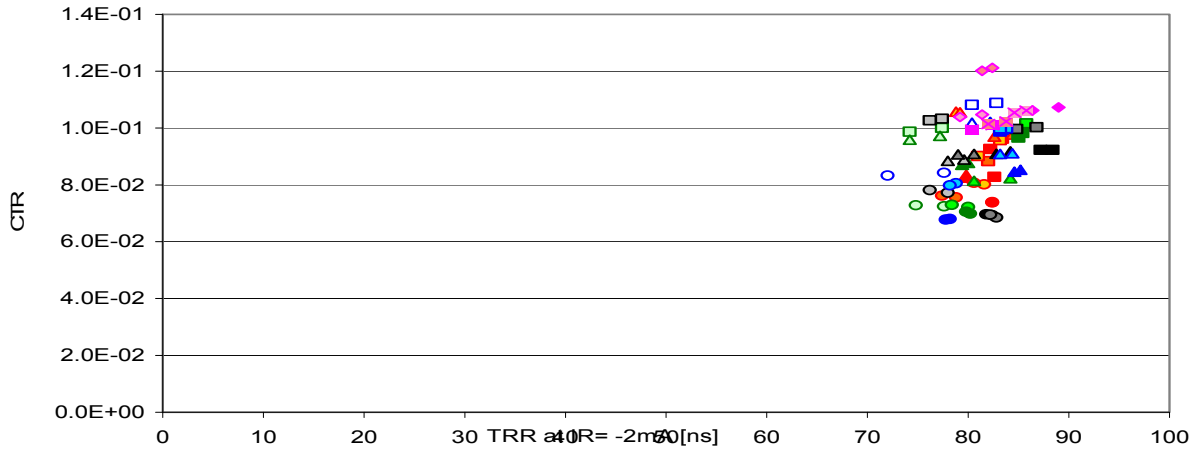
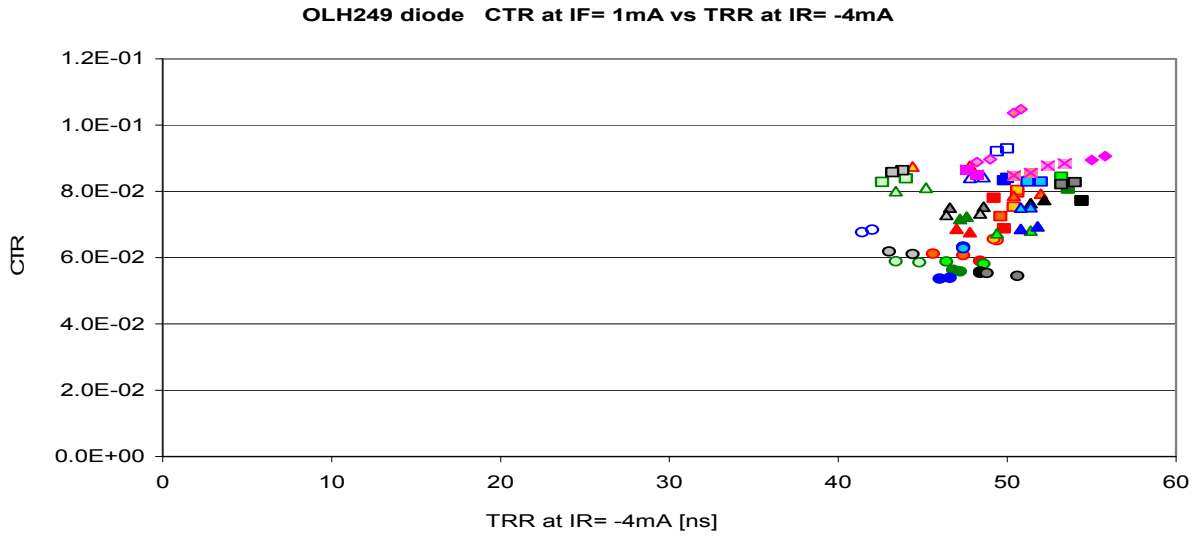
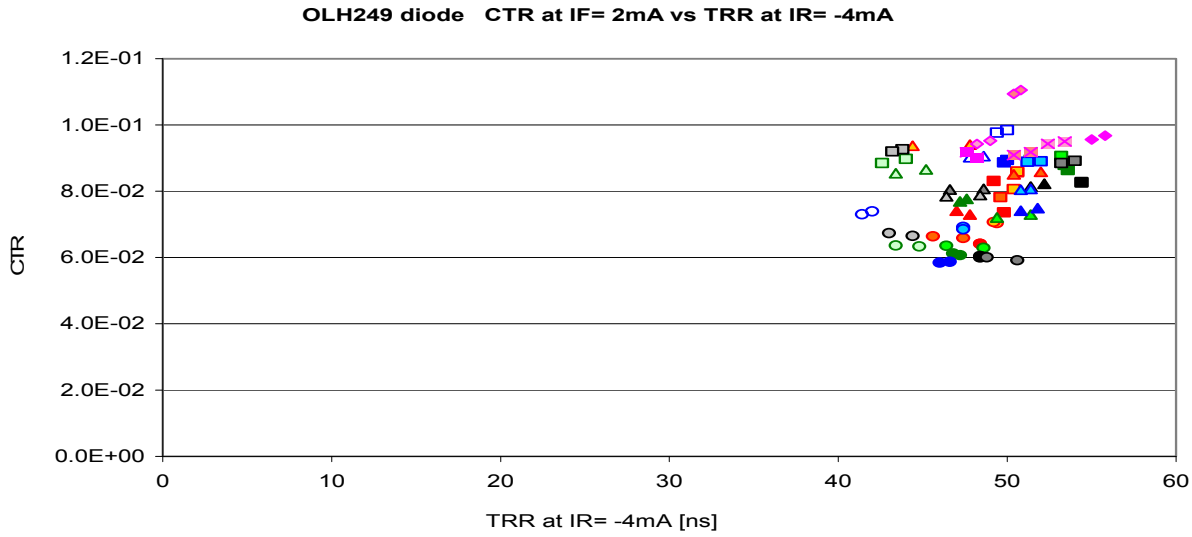
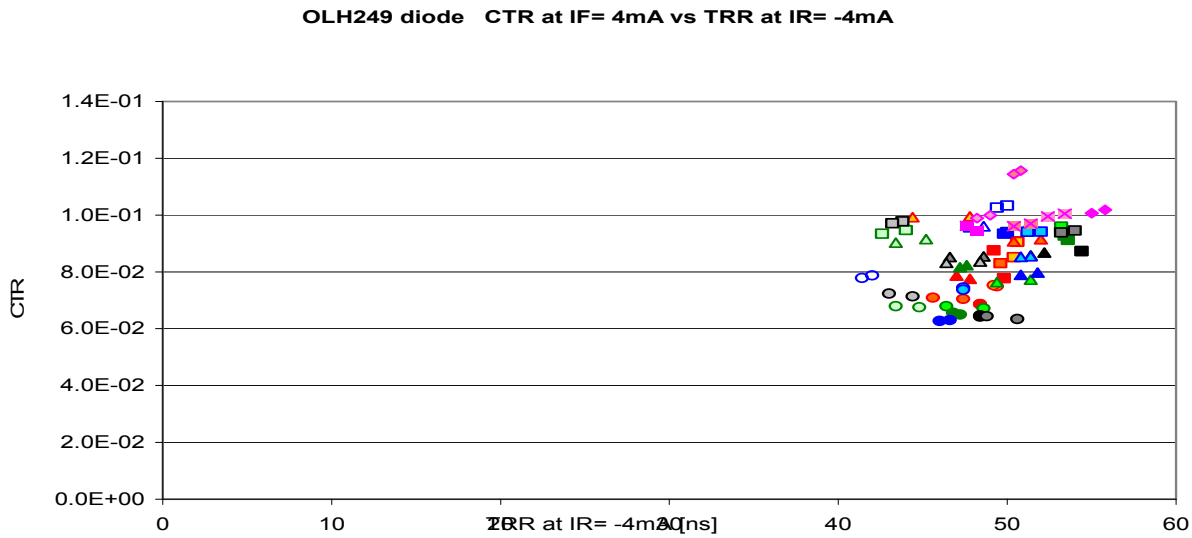


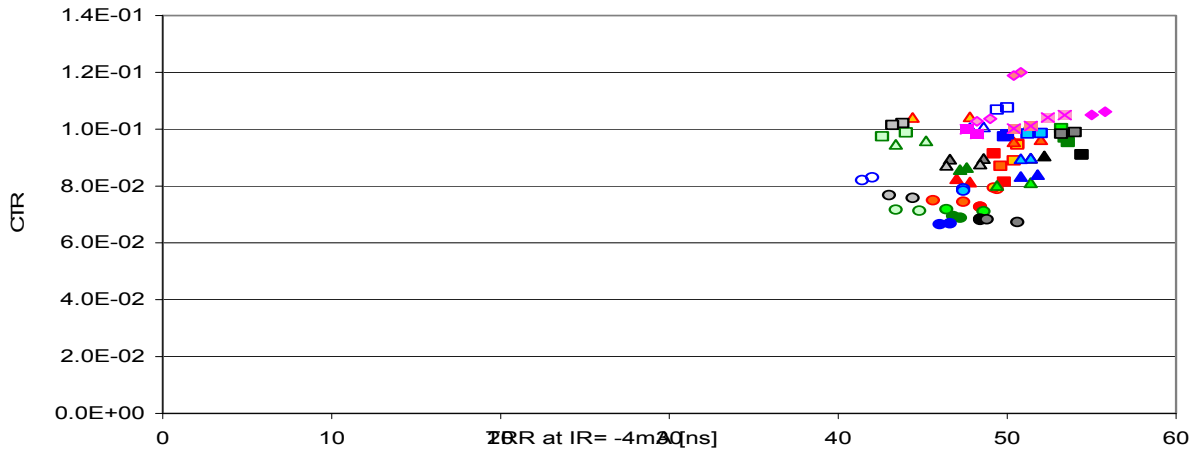
Fig. 13-241: OLH249 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA







OLH249 diode CTR at IF= 8mA vs TRR at IR= -4mA



OLH249 diode CTR at IF= 10mA vs TRR at IR= -4mA

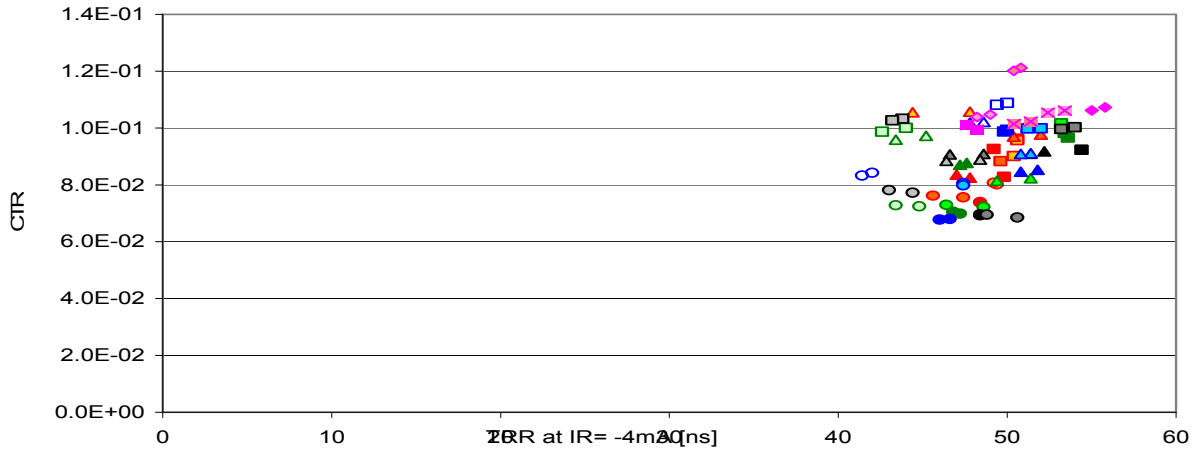
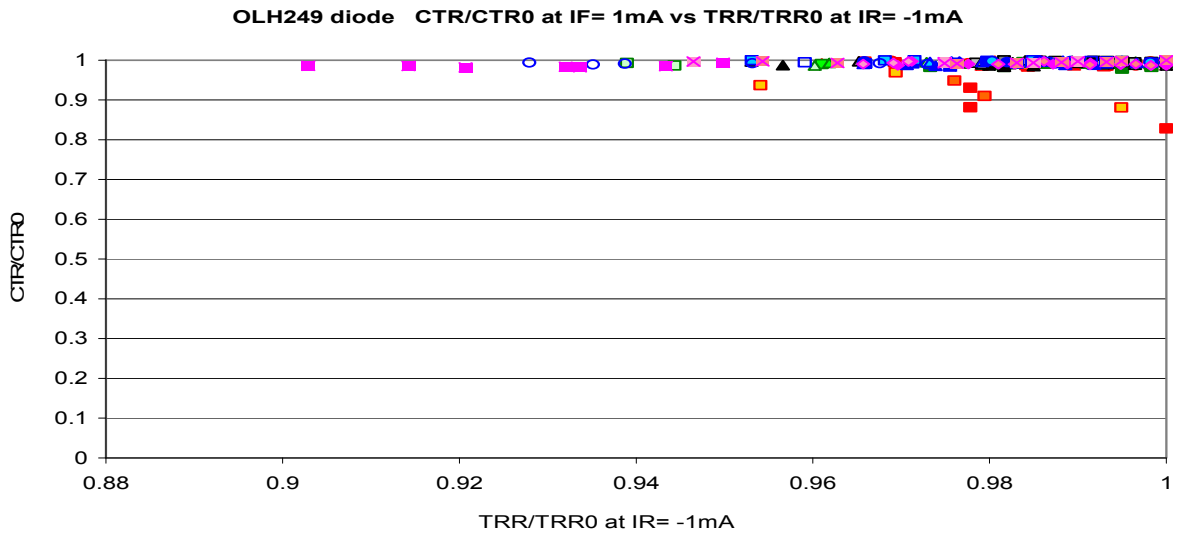
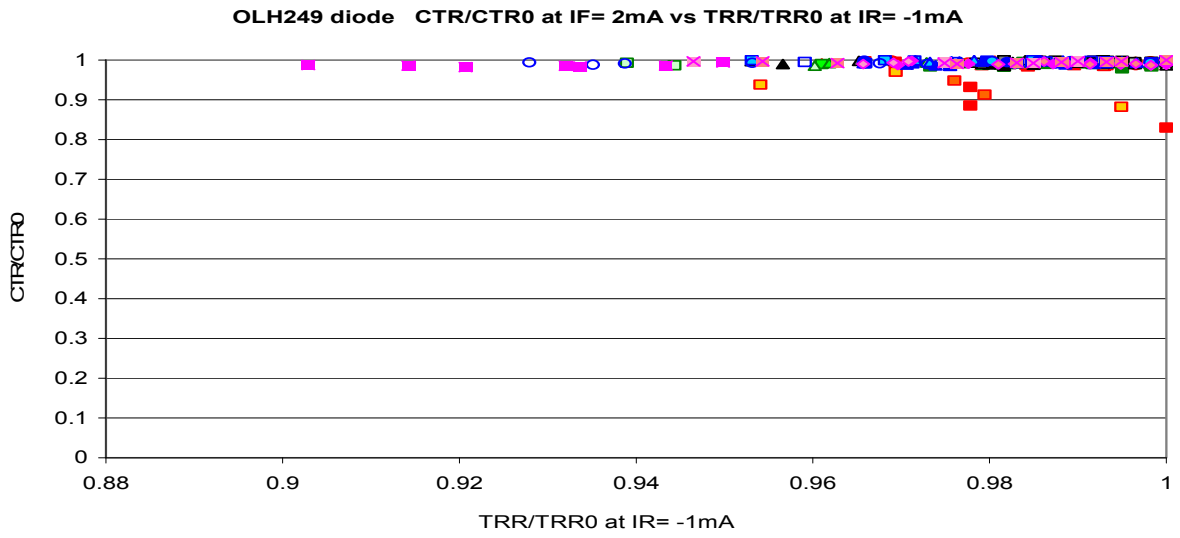
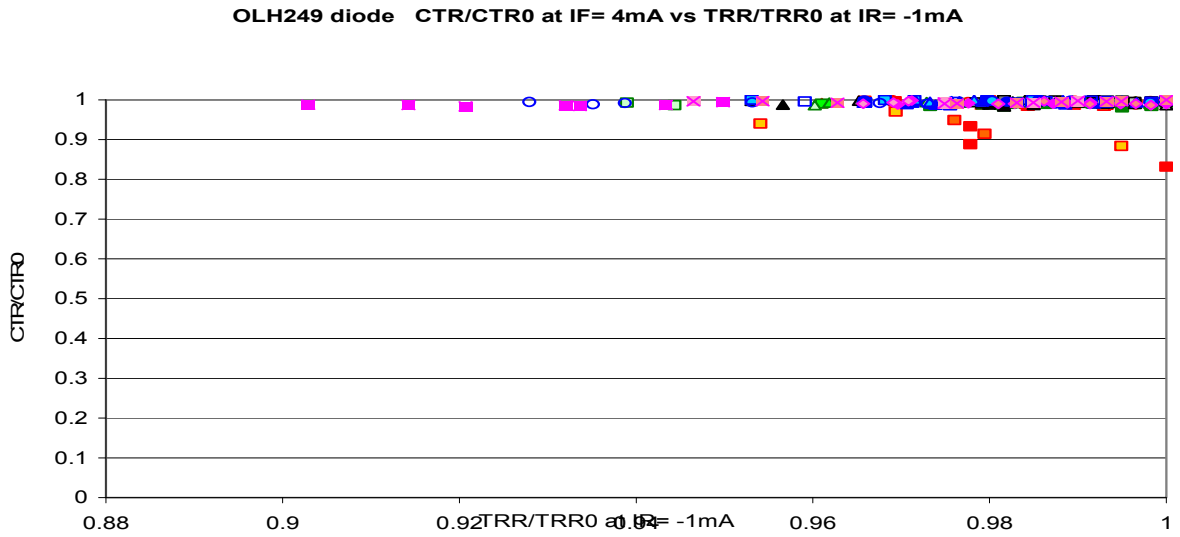


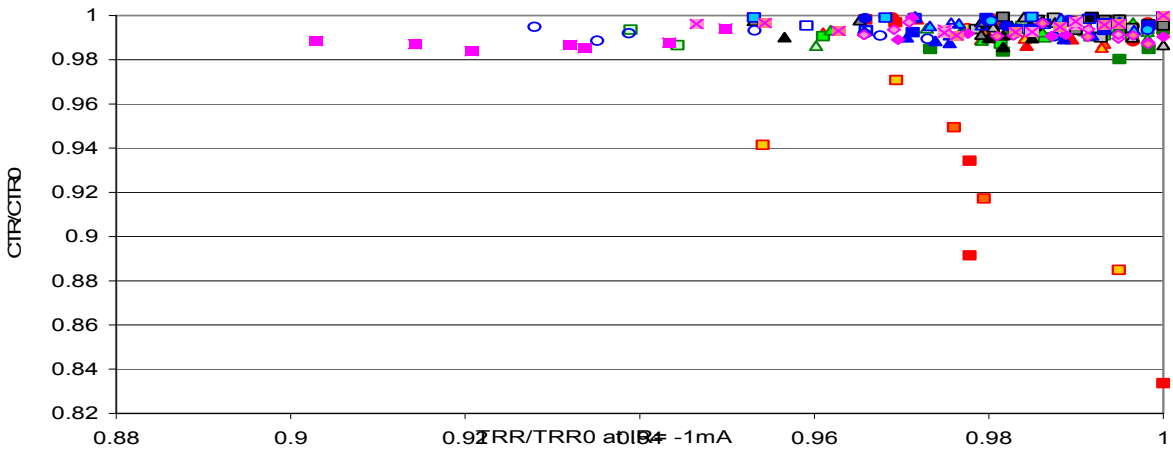
Fig. 13-242: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA



OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA

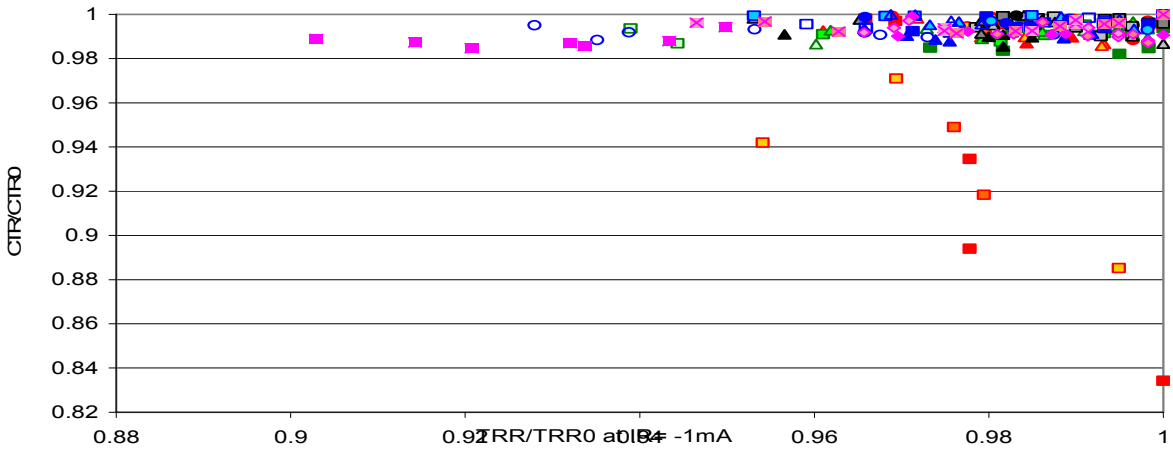
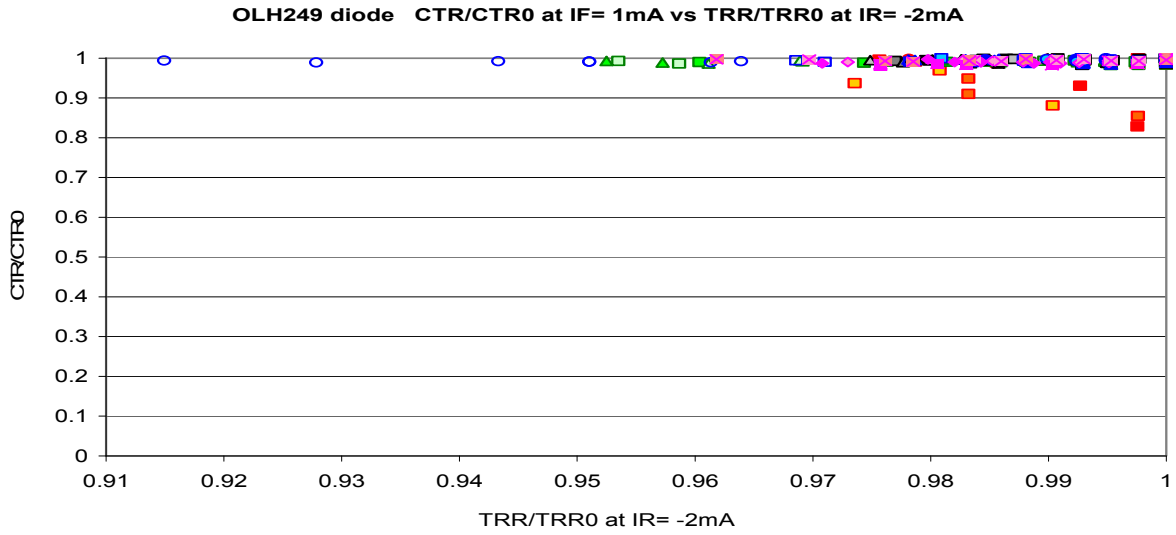
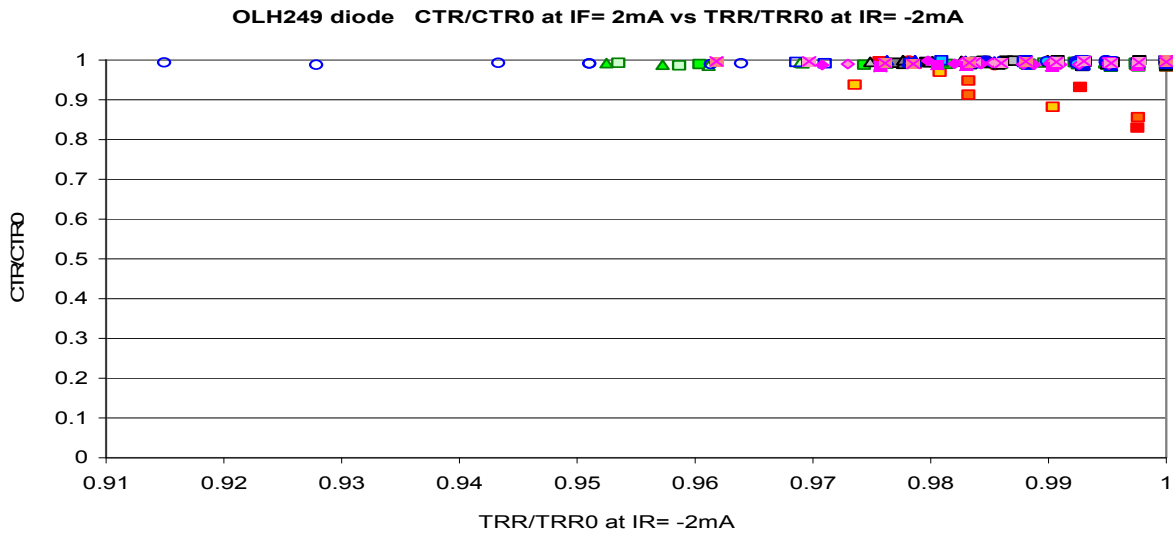
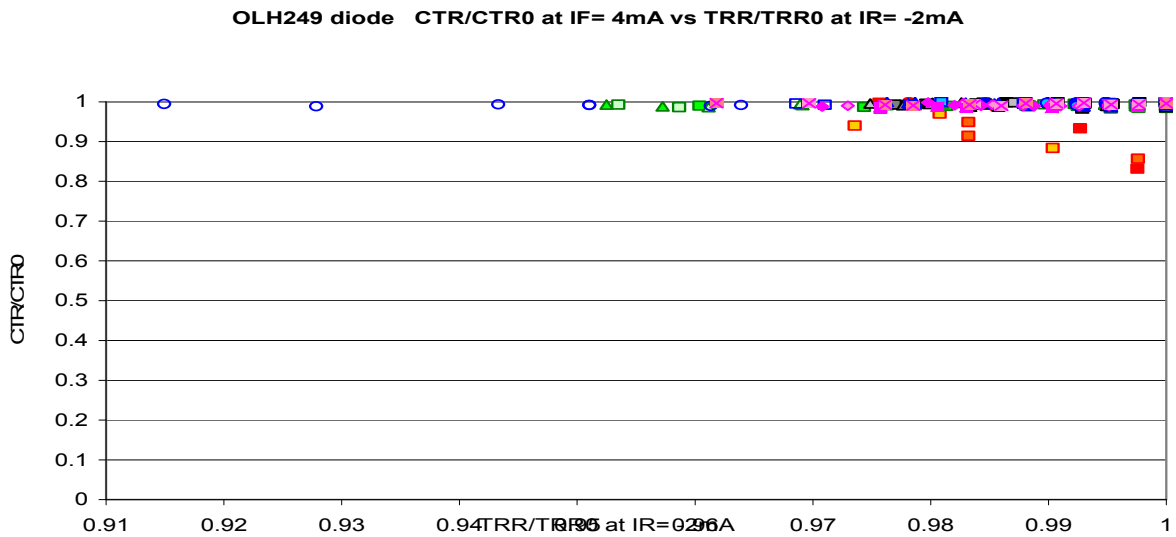


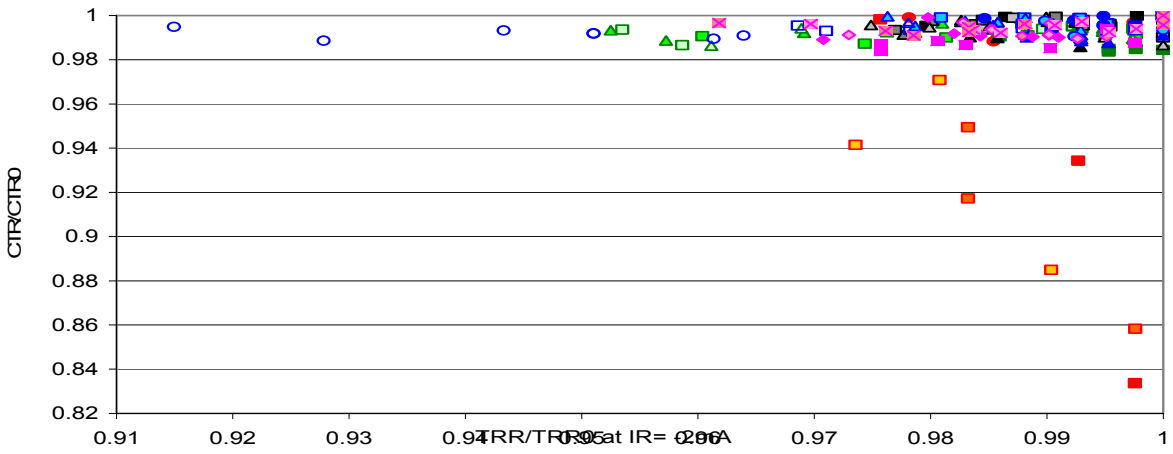
Fig. 13-243: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA







OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA



OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA

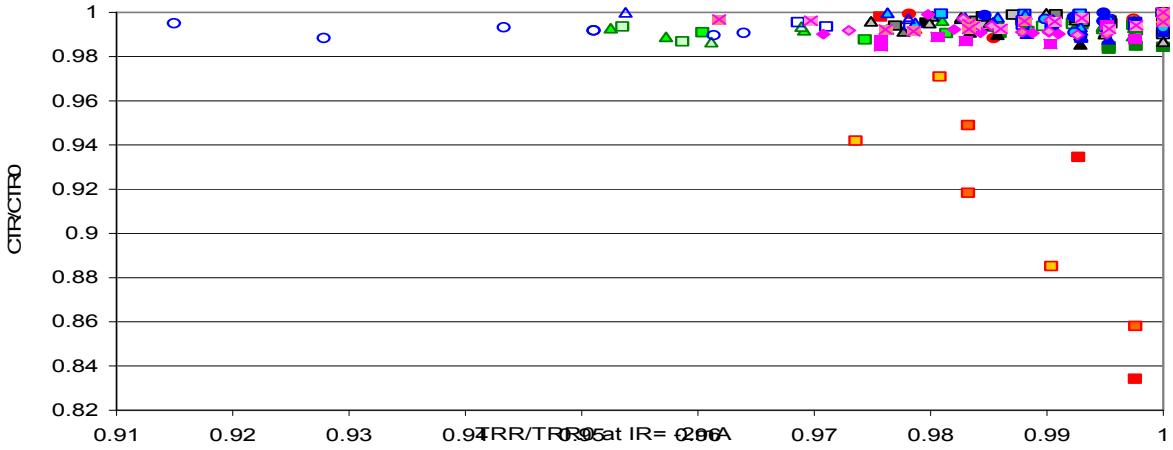
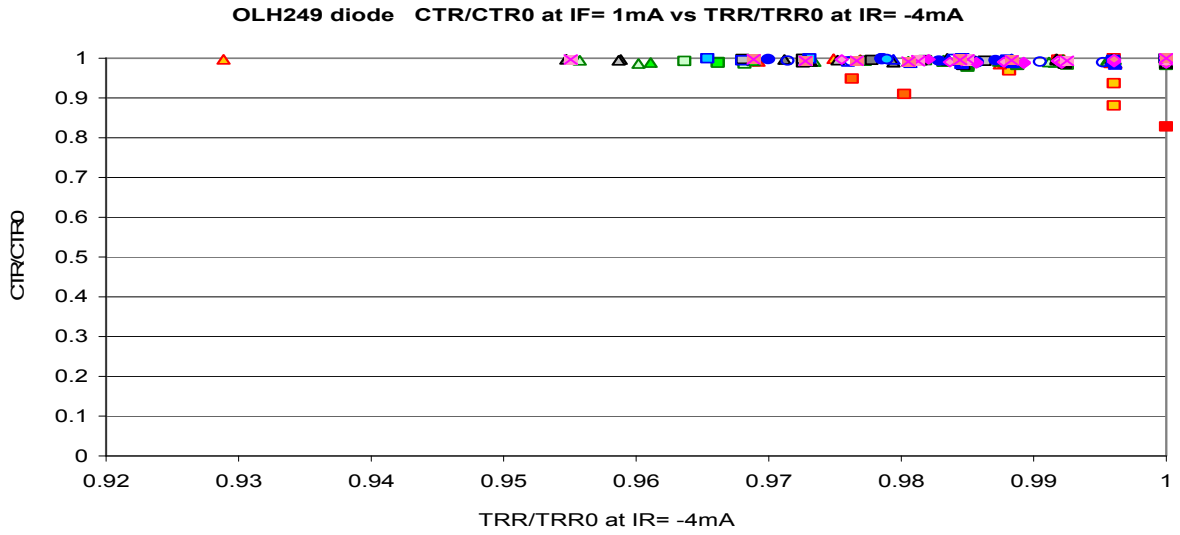
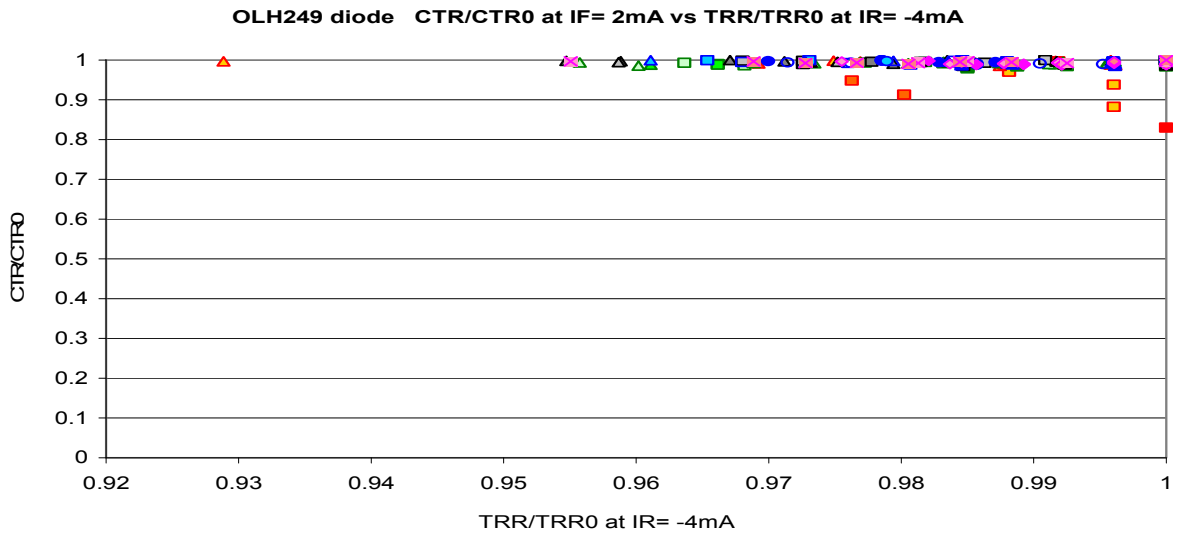
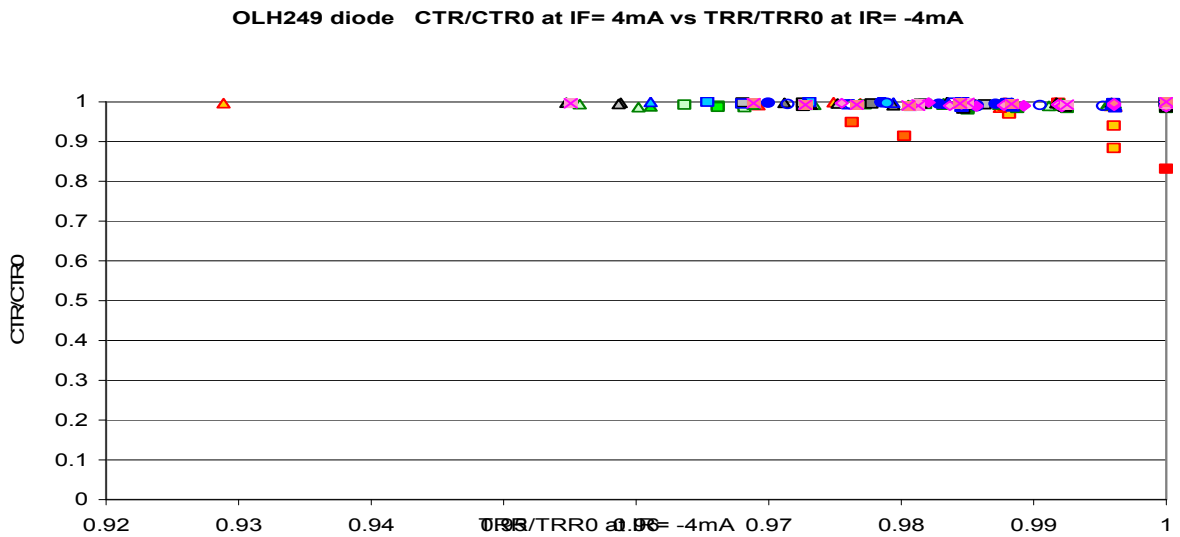


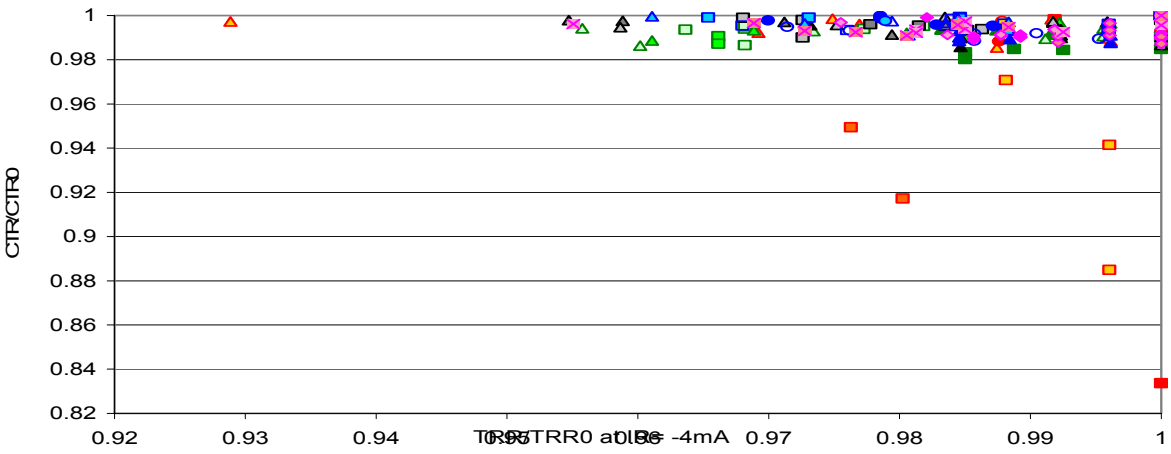
Fig. 13-244: OLH249 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA







OLH249 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA



OLH249 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA

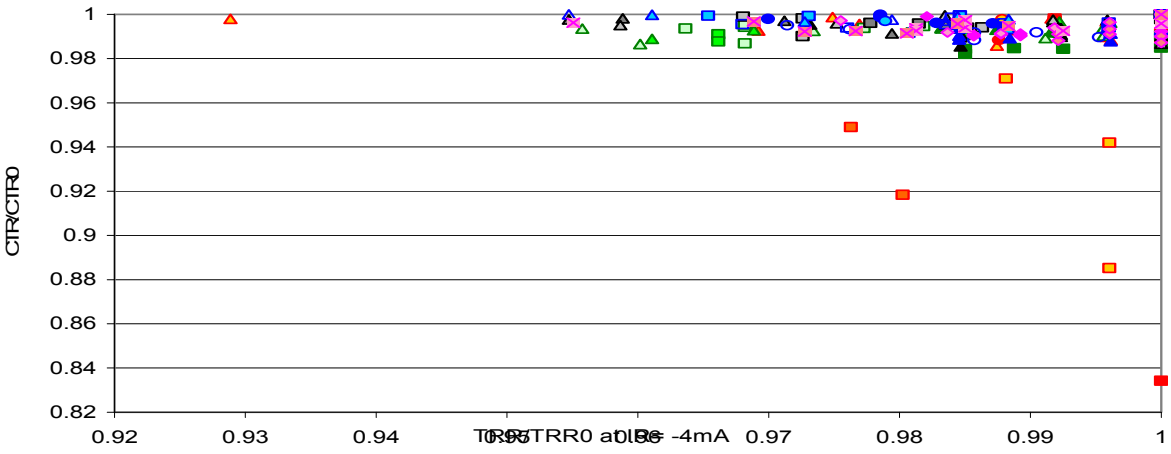
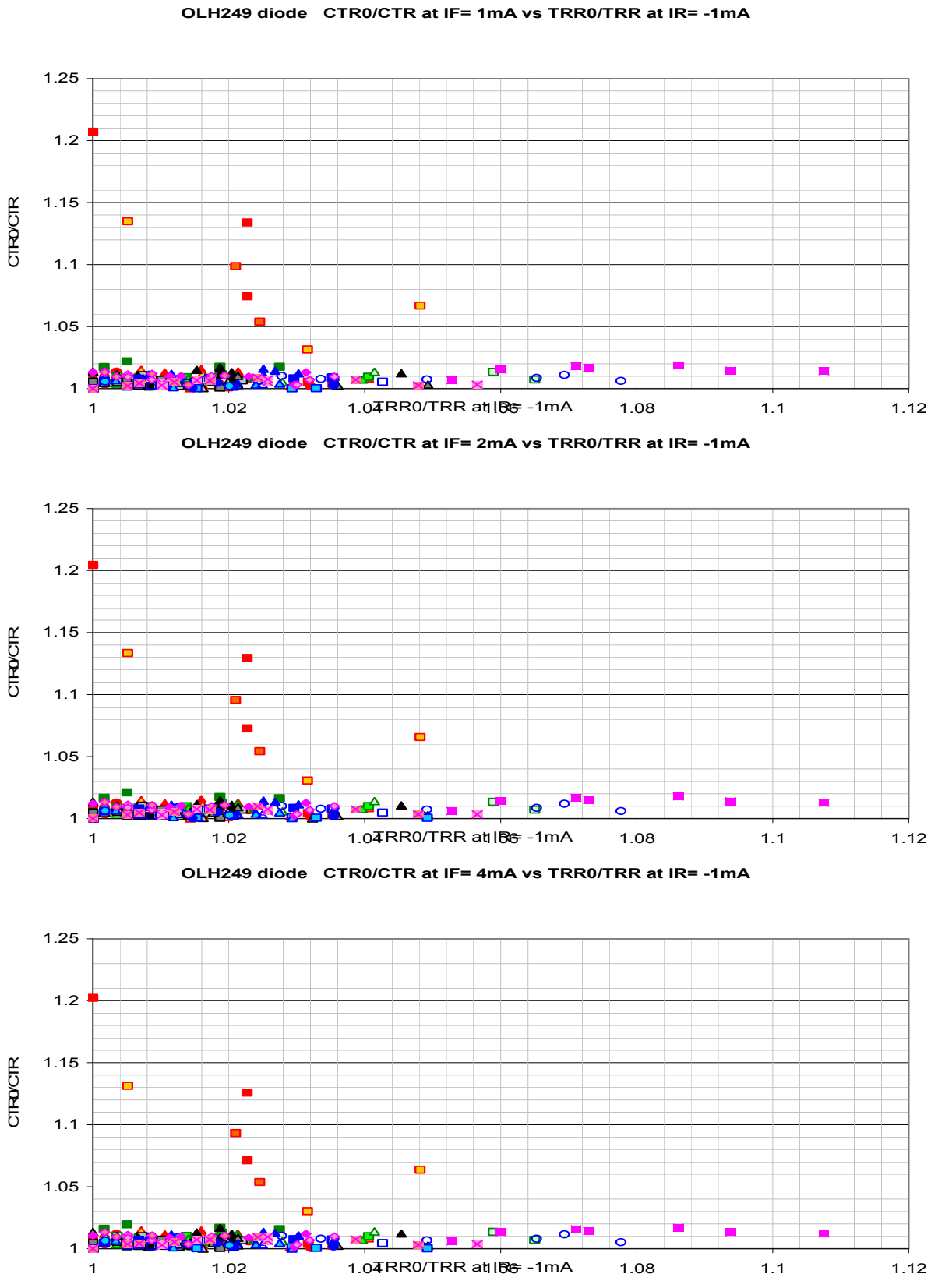
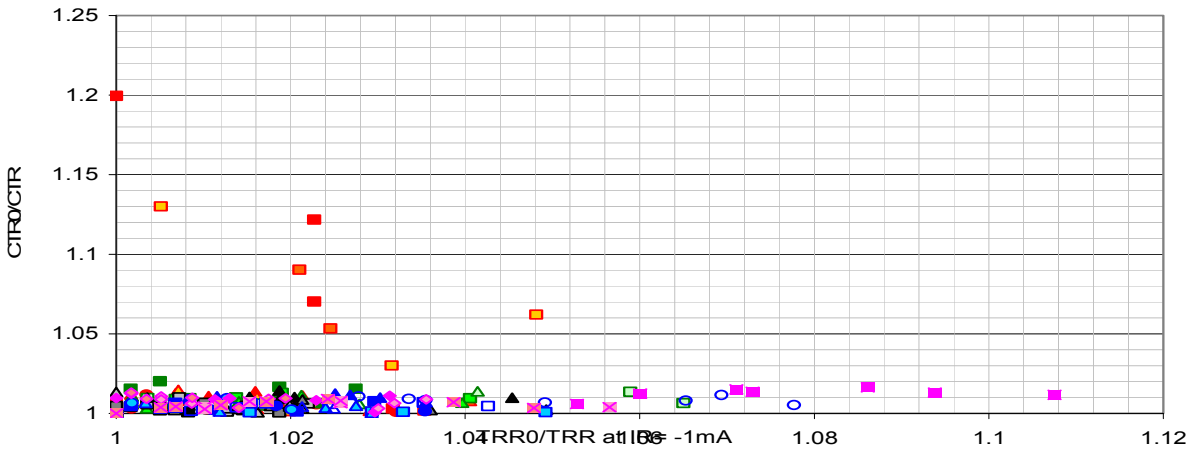


Fig. 13-245: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA



OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA

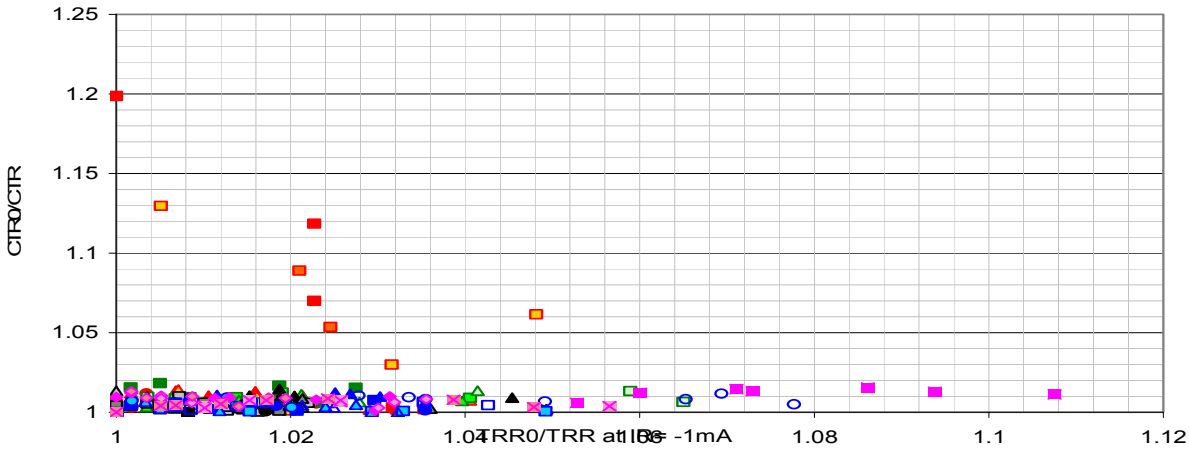
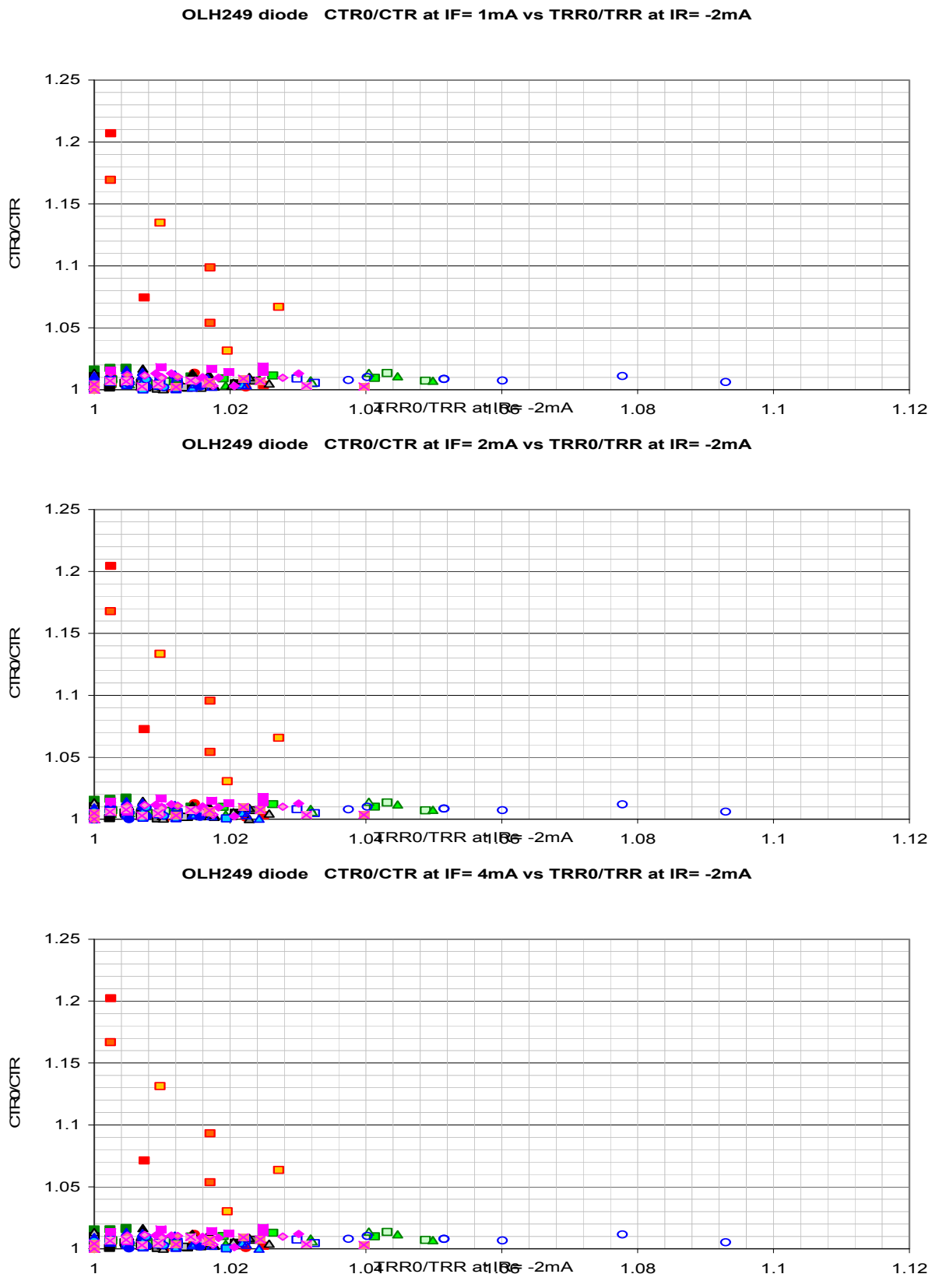
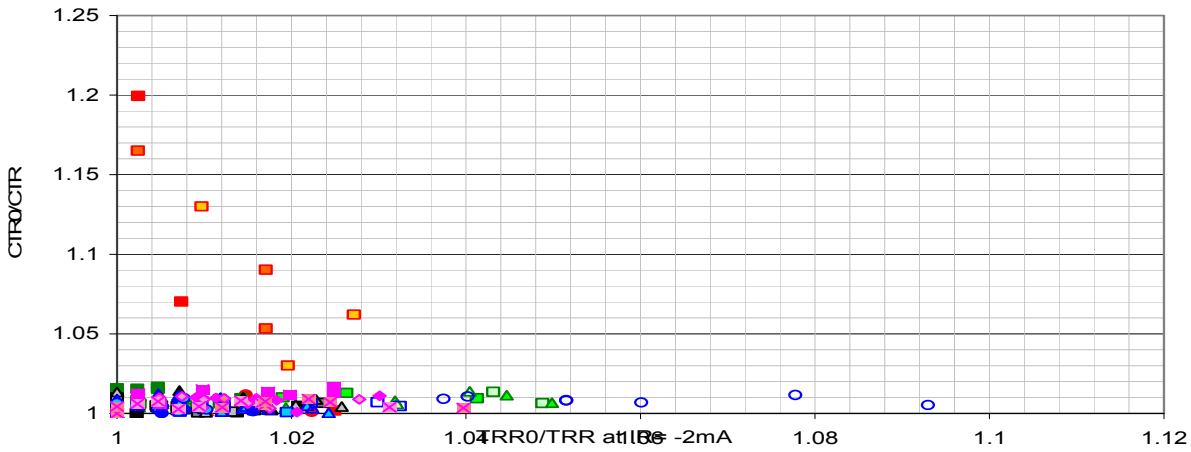


Fig. 13-246: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA



OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

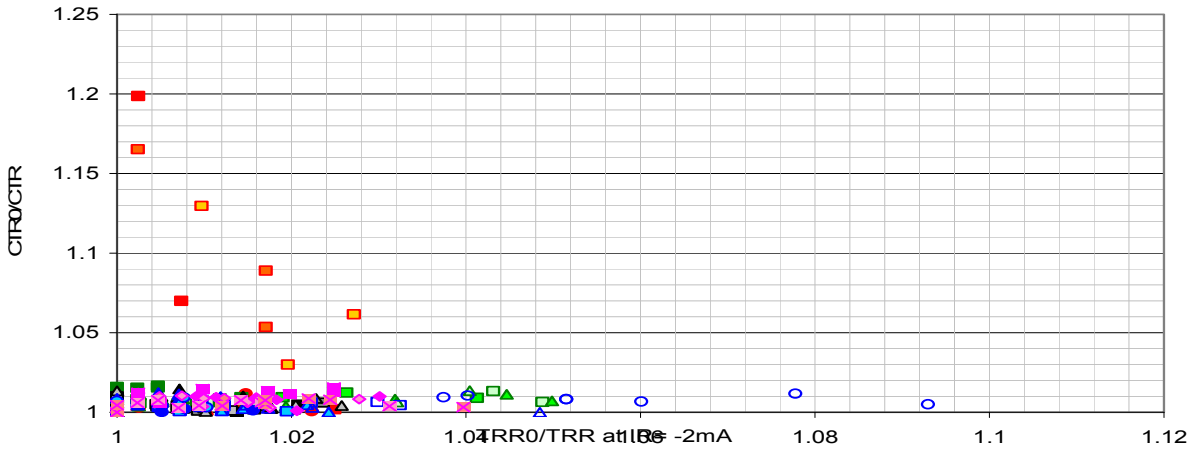
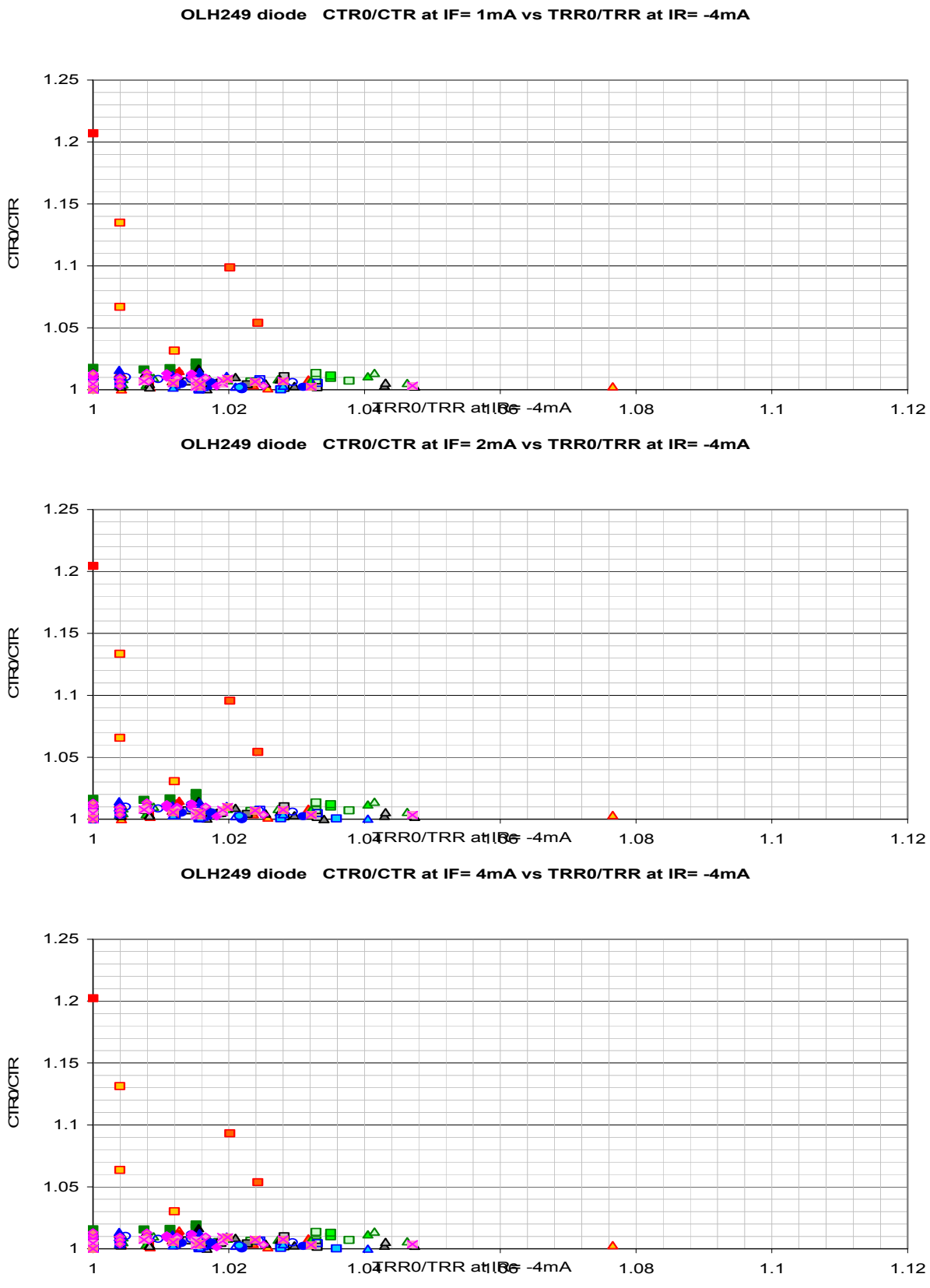
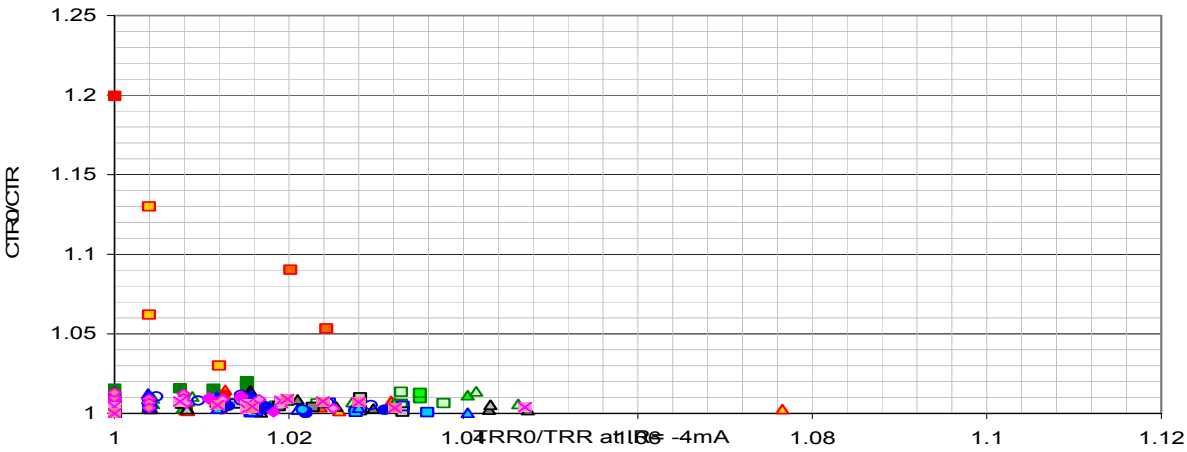


Fig. 13-247: OLH249 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA



OLH249 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



OLH249 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

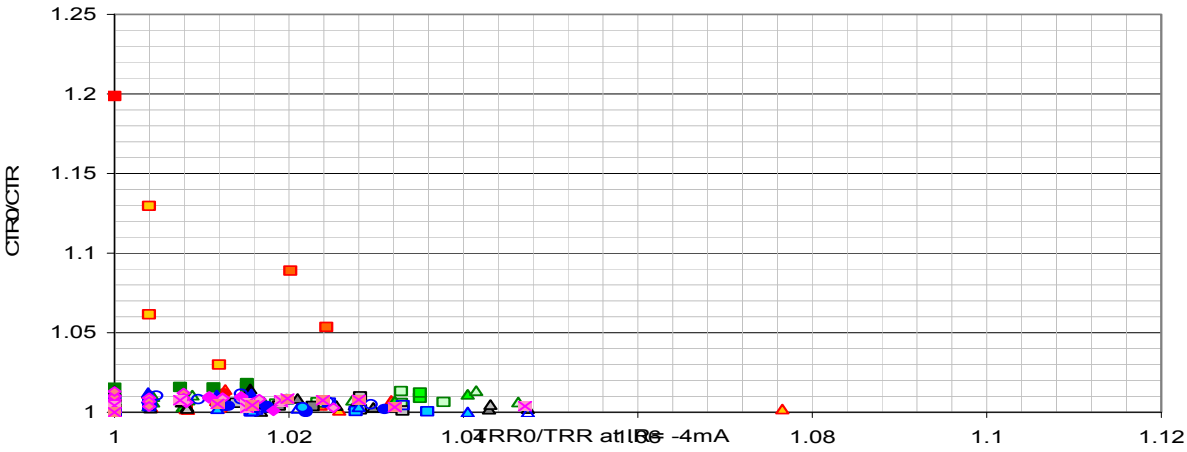
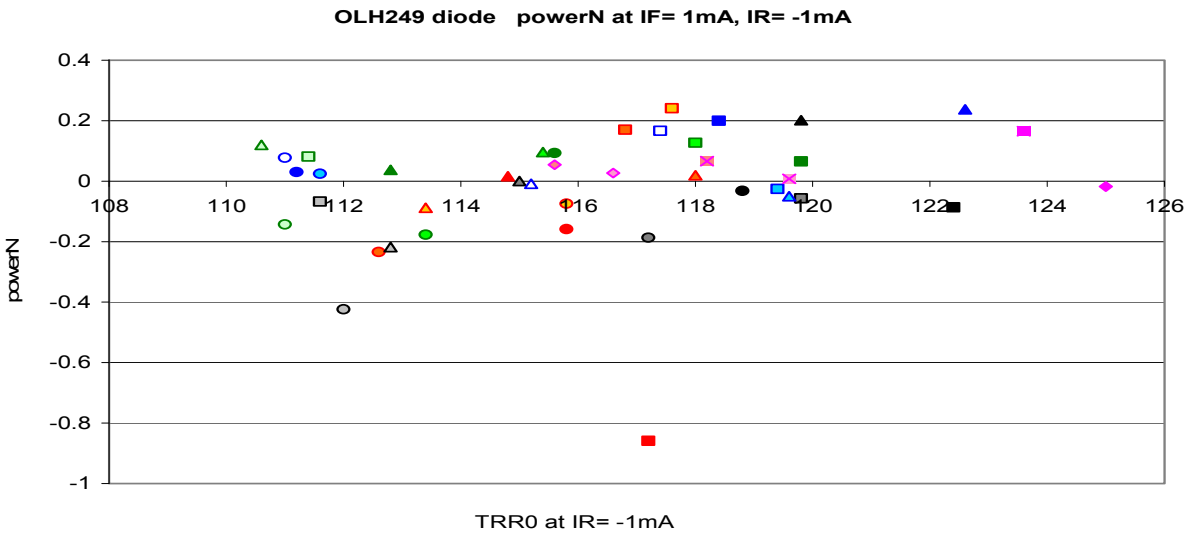
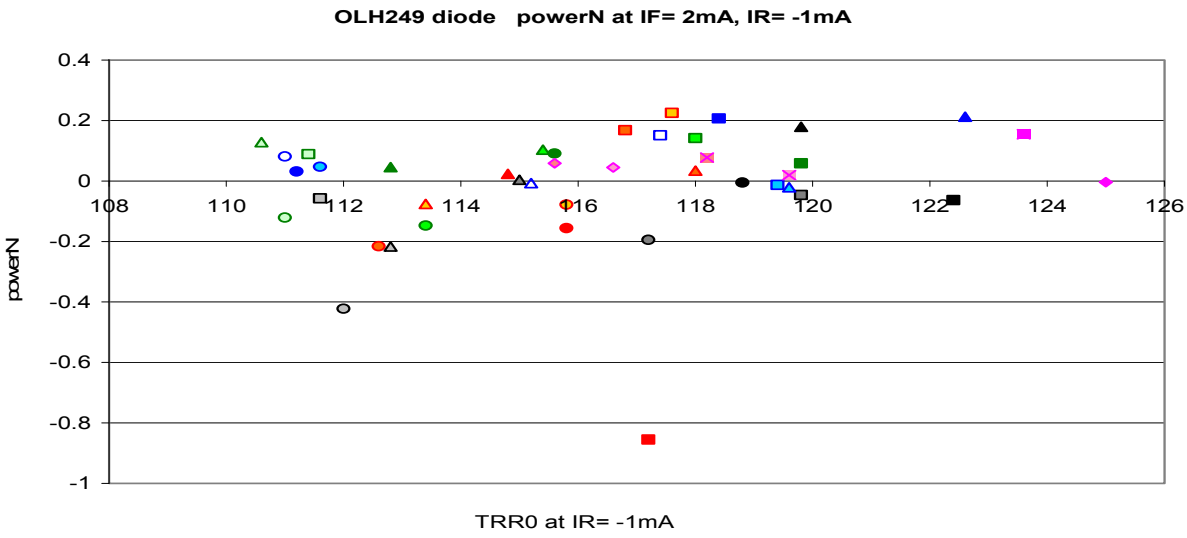
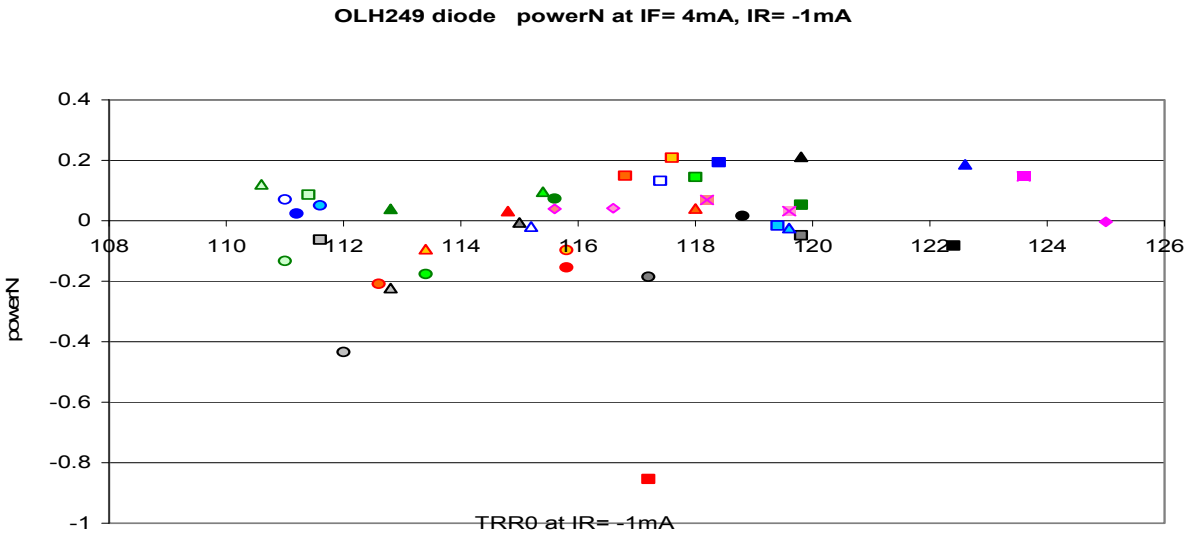


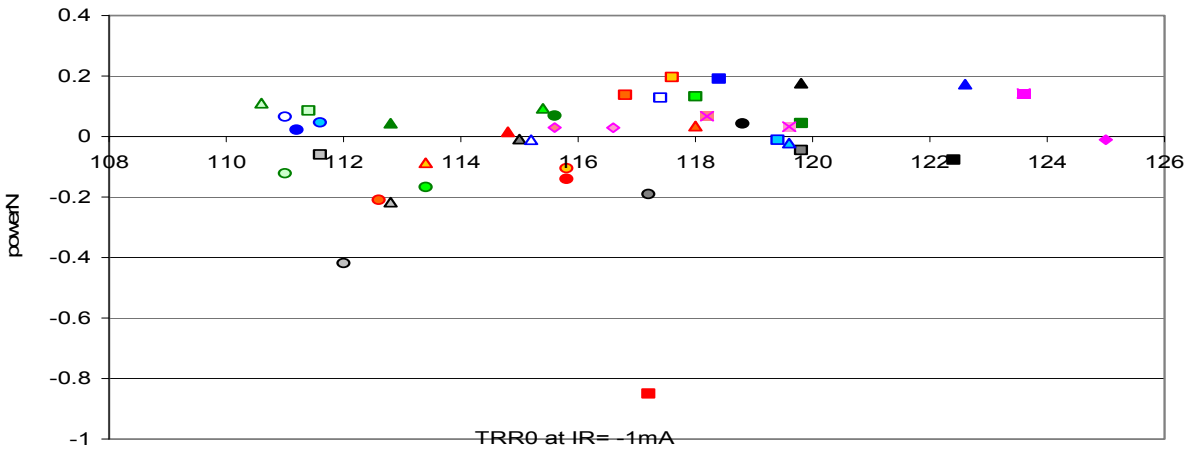
Fig. 13-248: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA







OLH249 diode powerN at IF= 8mA, IR= -1mA



OLH249 diode powerN at IF= 10mA, IR= -1mA

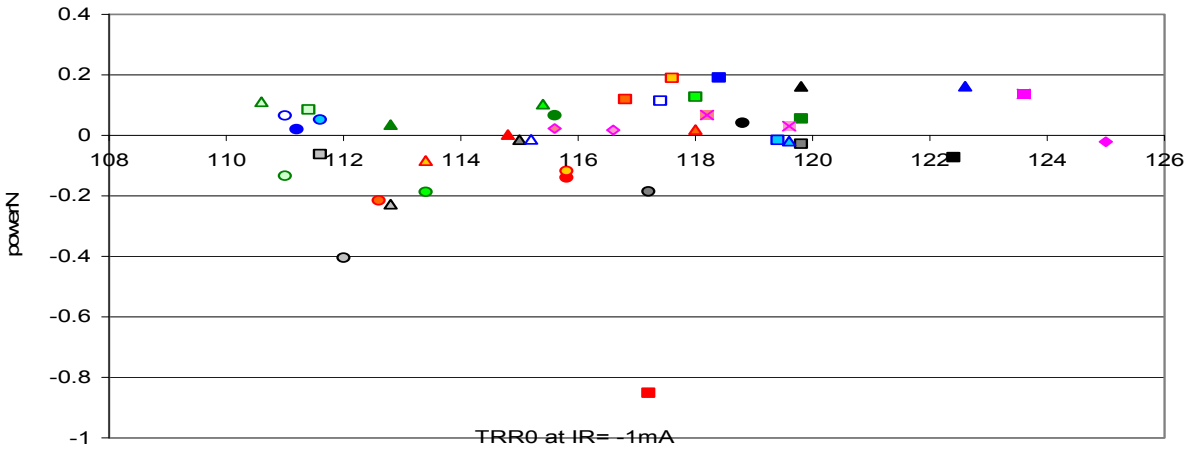
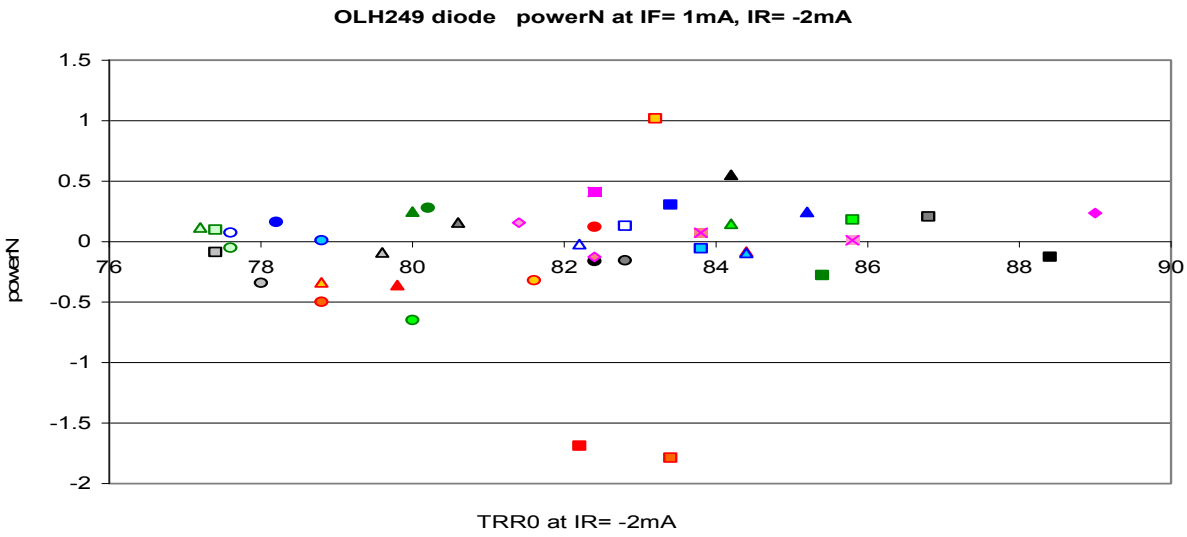
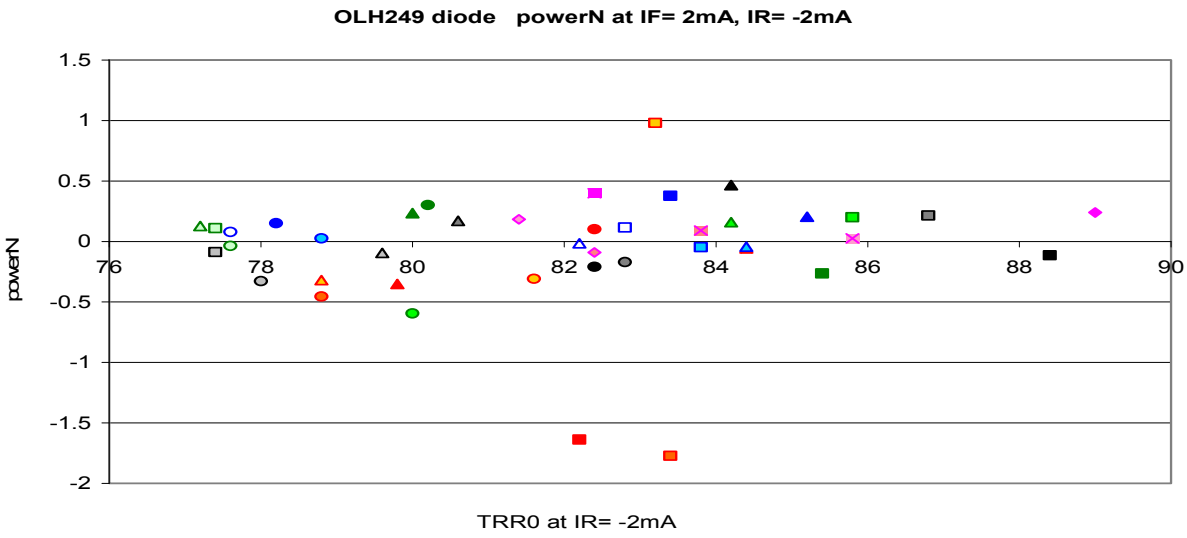
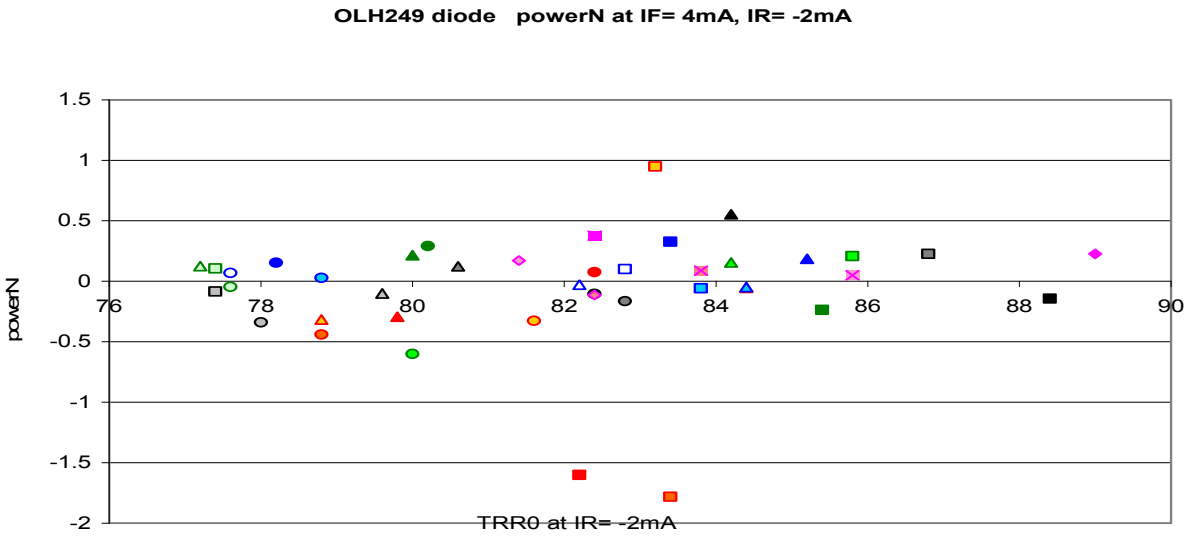


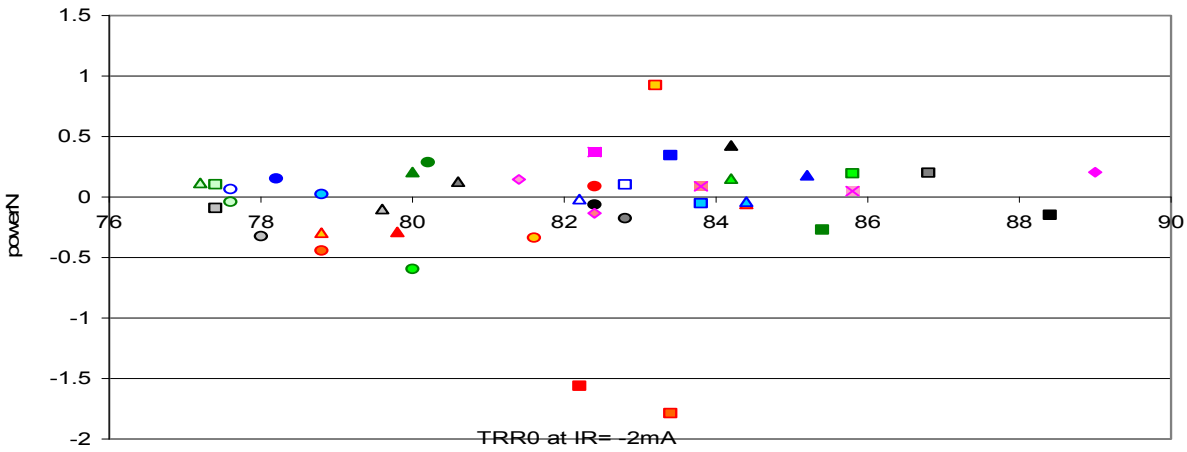
Fig. 13-249: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA







OLH249 diode powerN at IF= 8mA, IR= -2mA



OLH249 diode powerN at IF= 10mA, IR= -2mA

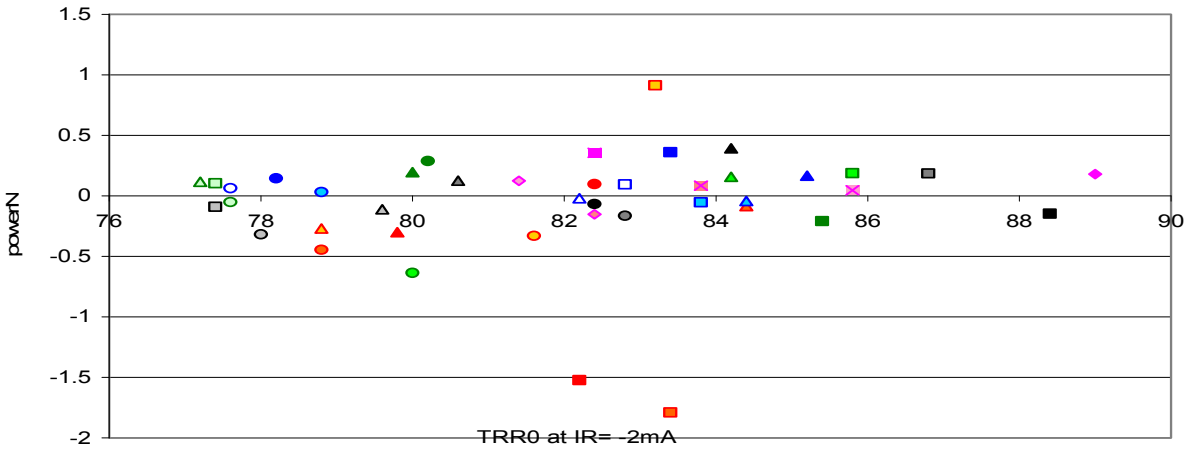
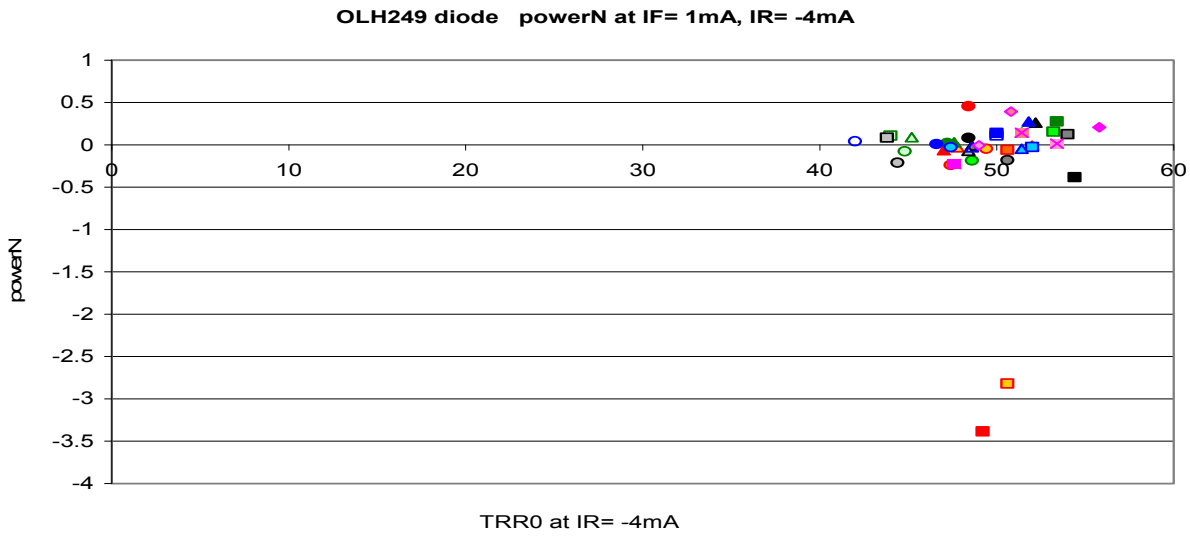
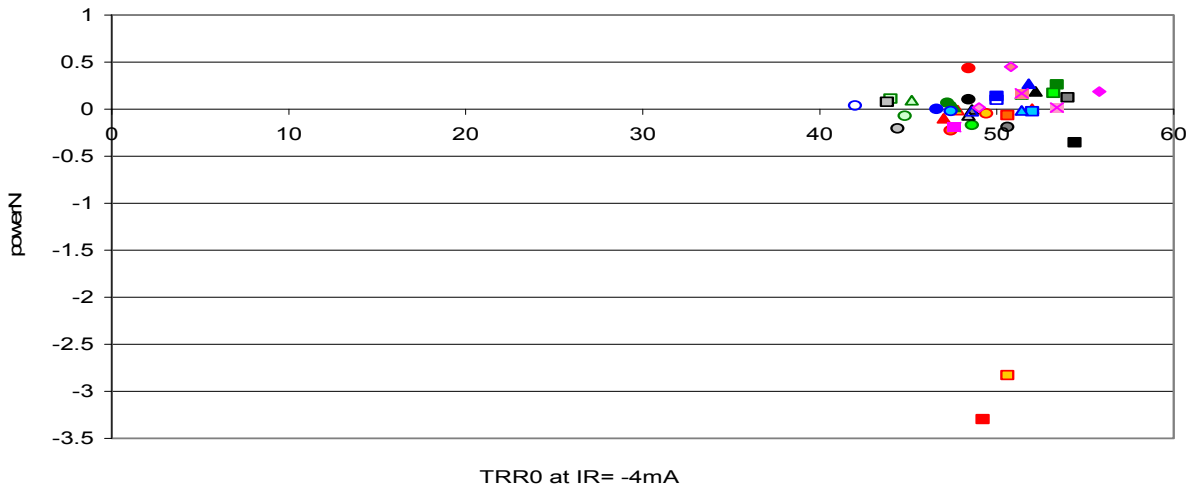
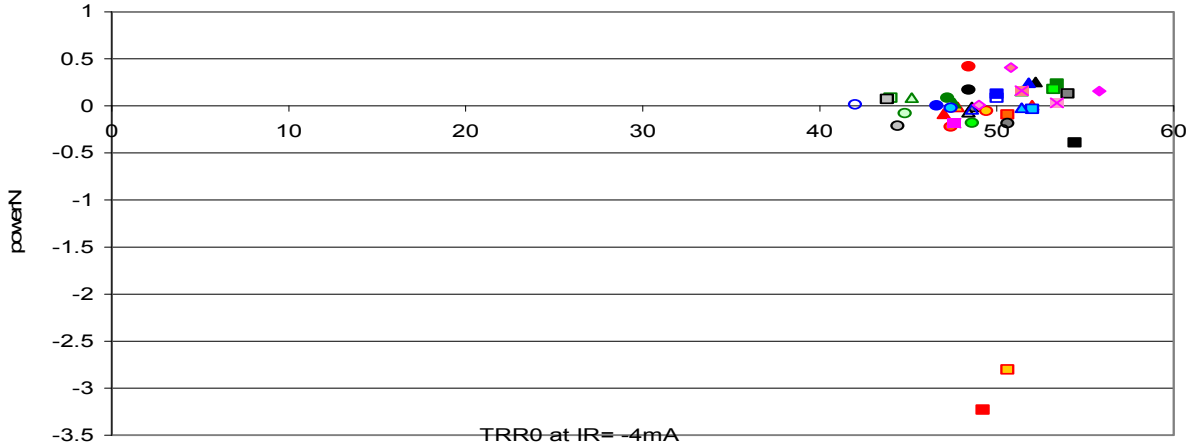
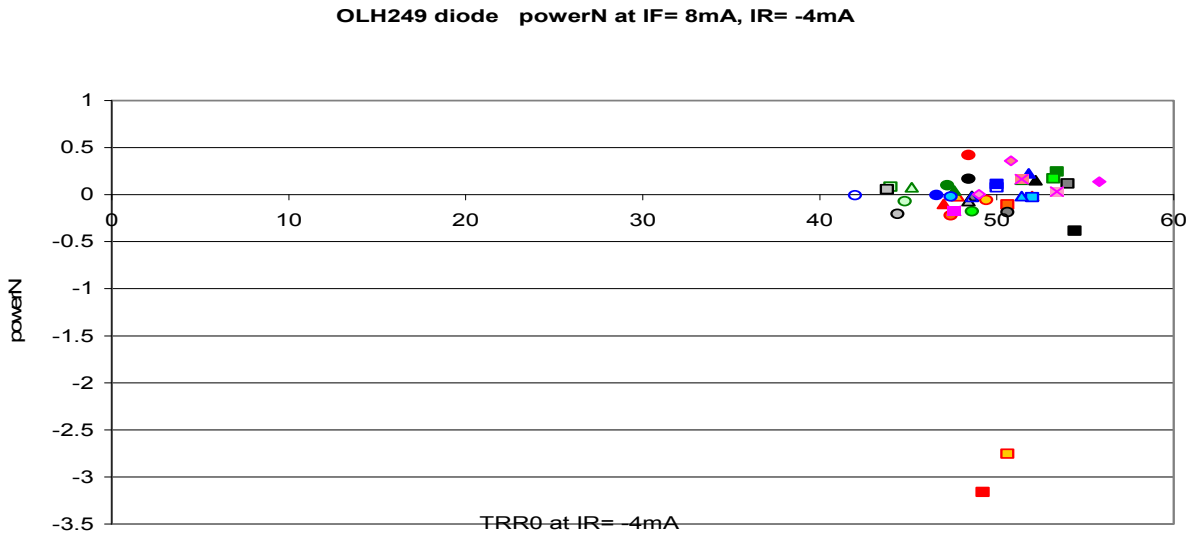


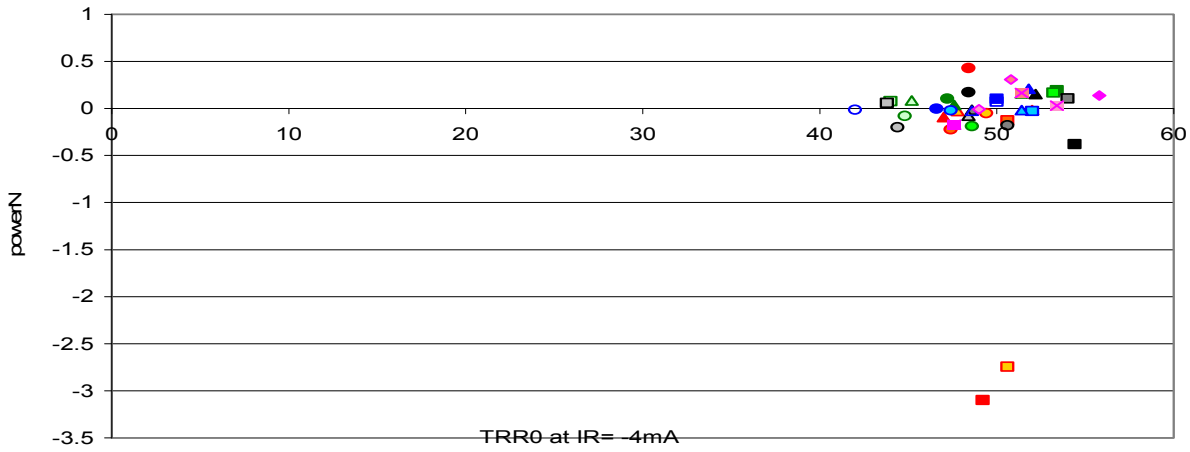
Fig. 13-250: OLH249 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA








OLH249 diode powerN at IF= 8mA, IR= -4mA
powerN
TRR0 at IR= -4mA
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
10
20
30
40
50
60

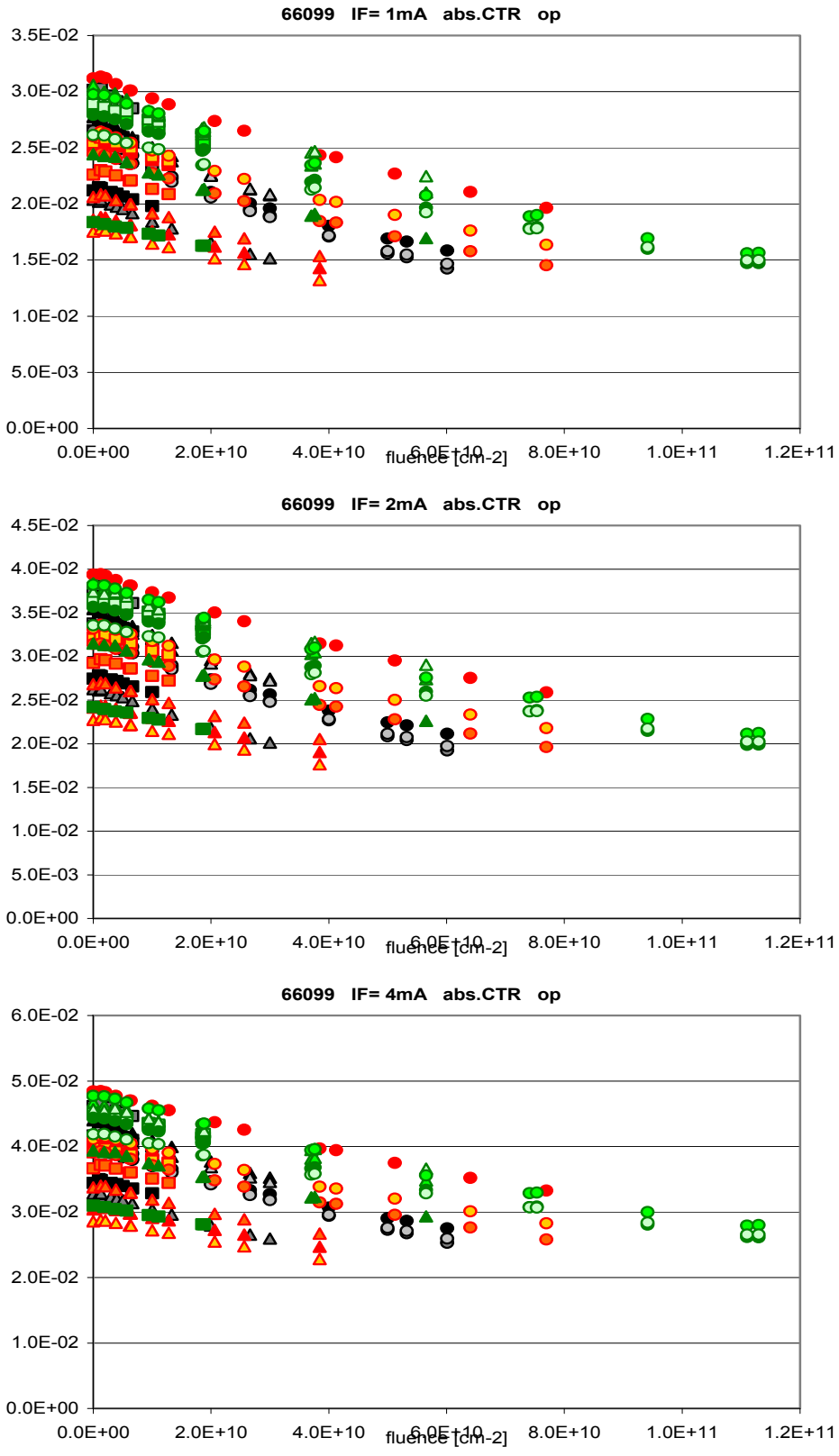

OLH249 diode powerN at IF= 10mA, IR= -4mA
powerN
TRR0 at IR= -4mA
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
10
20
30
40
50
60

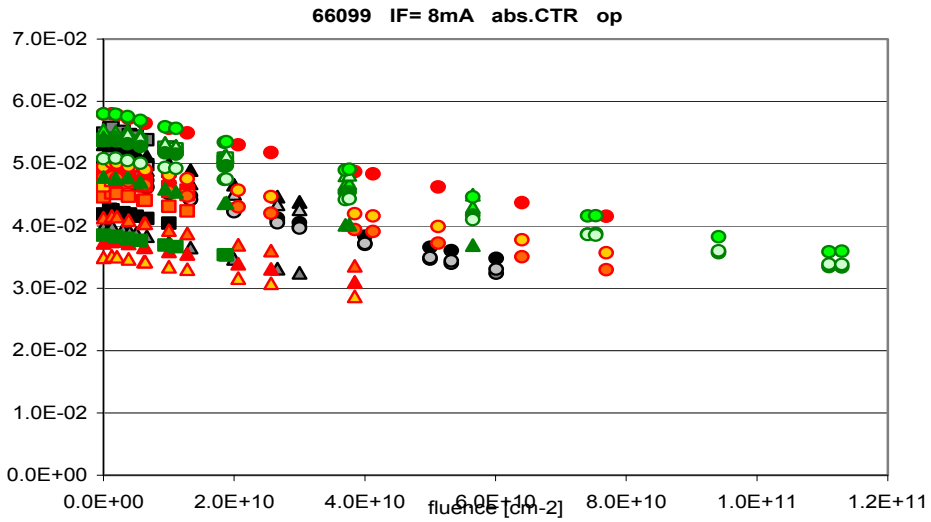
14. APPENDIX 66099

Part type	Emitter	Receiver			Package
	LED	Photodiode	Phototransistor	Output transistor	
66099 / MICROPAC **(DC0636)**	660 nm Double heterojunction AlGaAs	**0.04 inch sq**	N/A	**2N2222**	Window can

14.1 PROTON IRRADIATION

Fig. 14-1: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

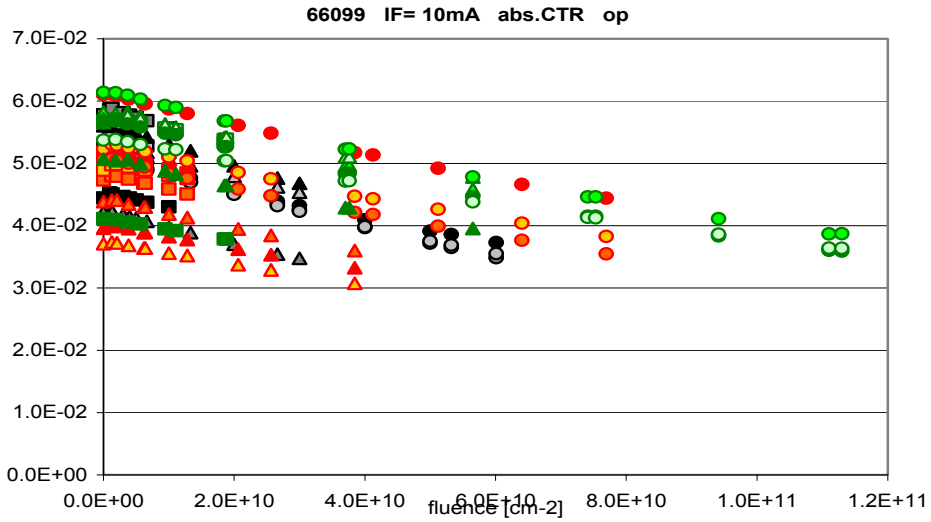
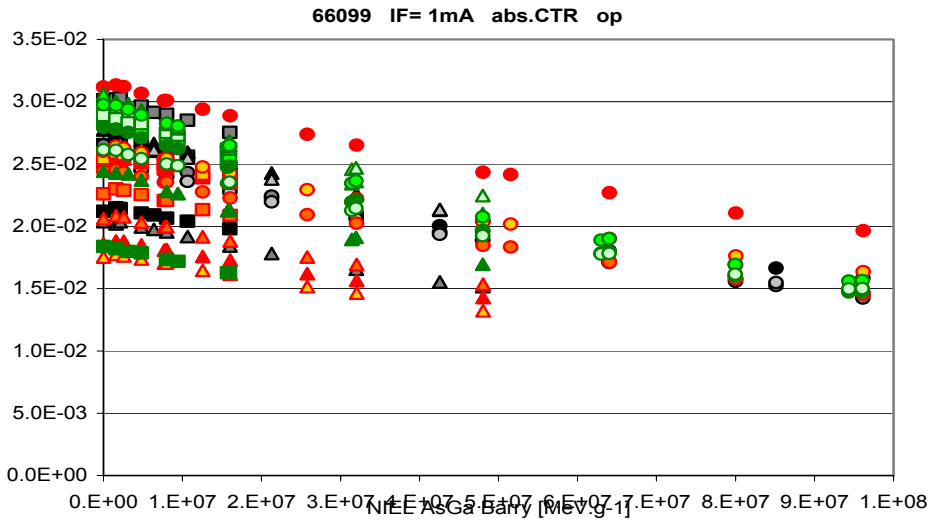
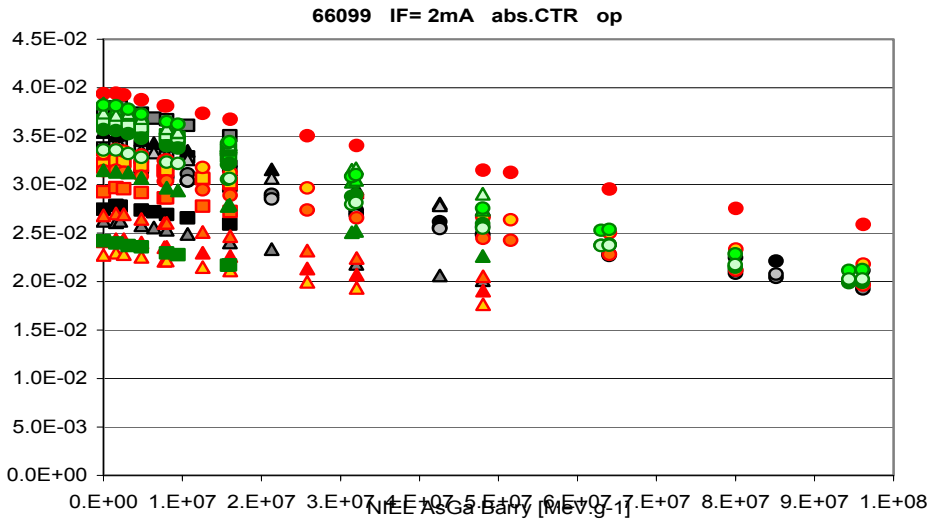
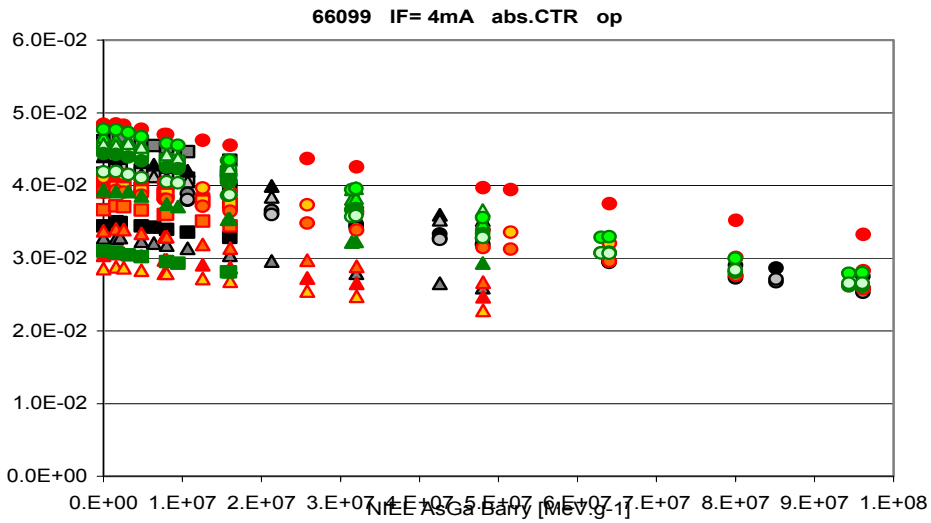
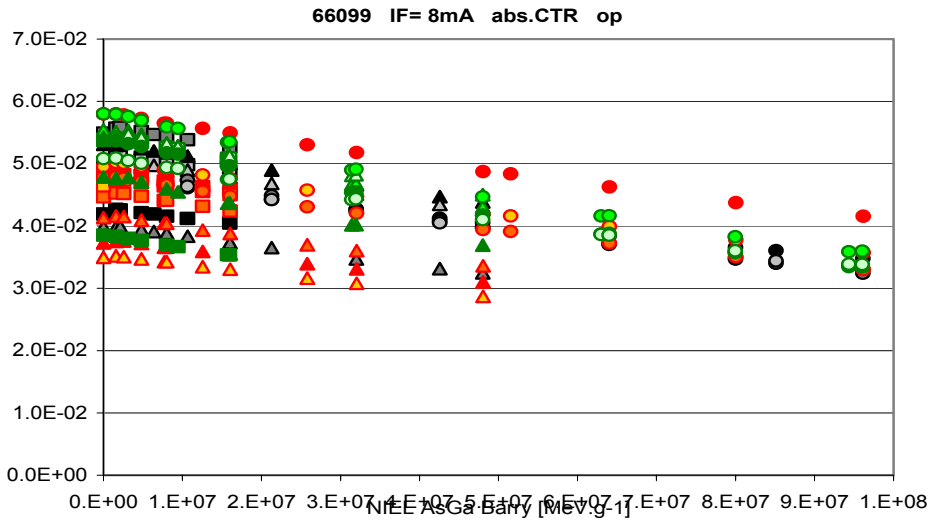

66099 IF= 10mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-2: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)








66099 IF= 8mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

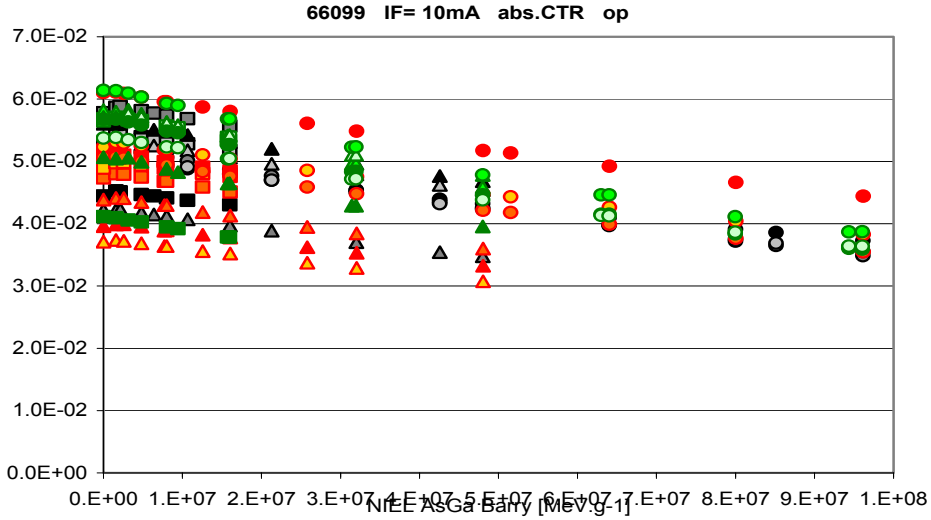
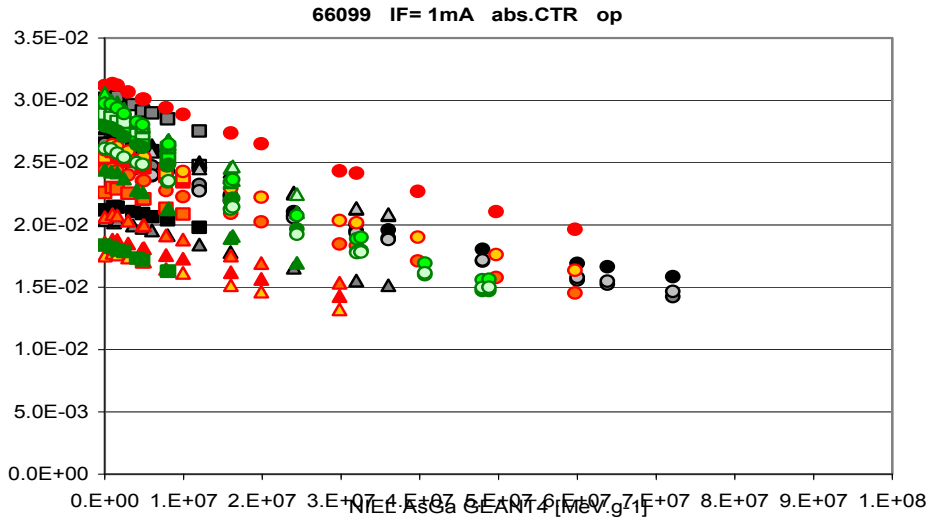
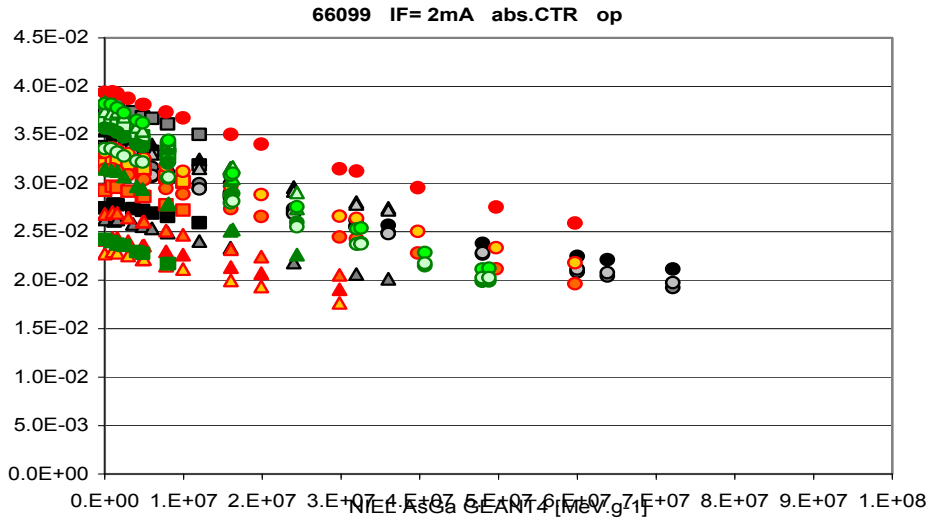
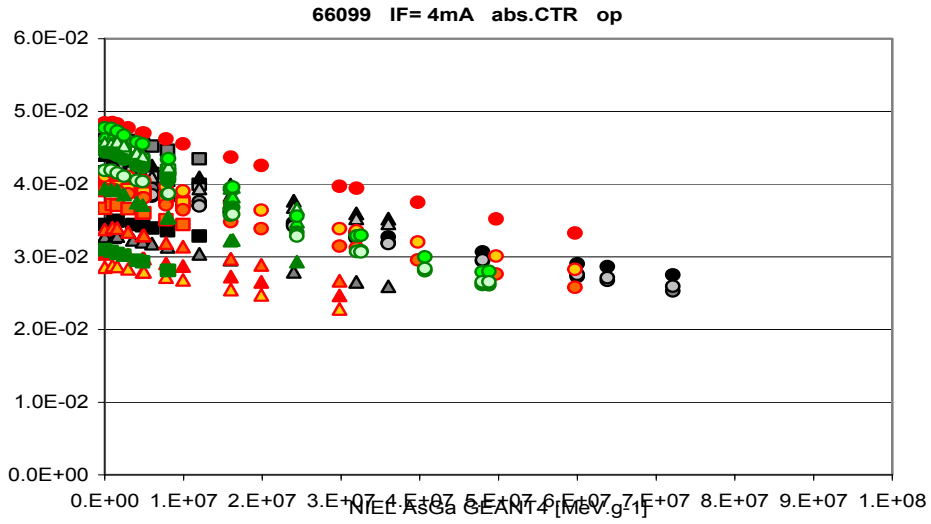
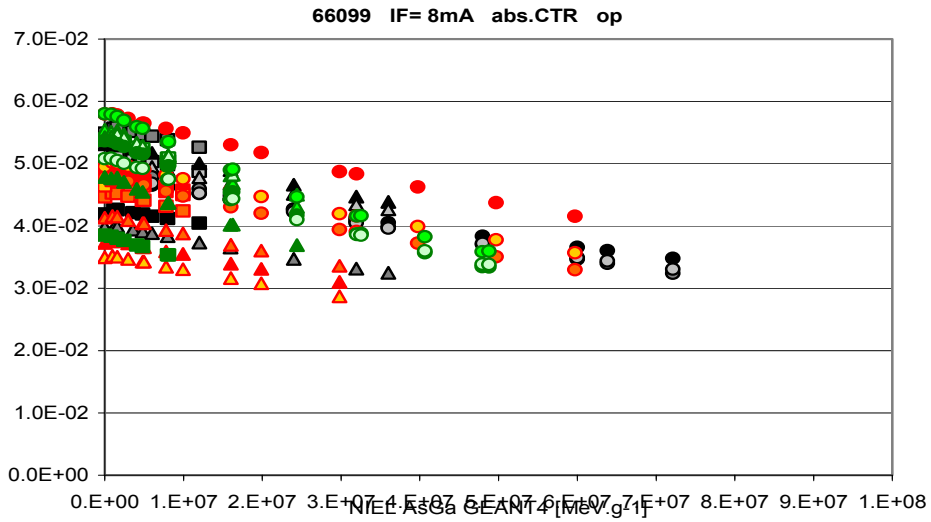

66099 IF= 10mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-3: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)








66099 IF= 8mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

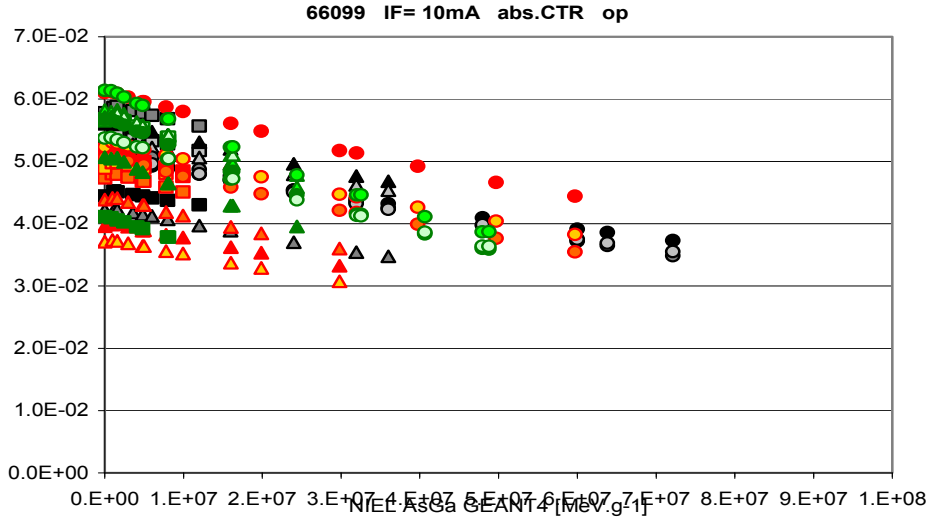
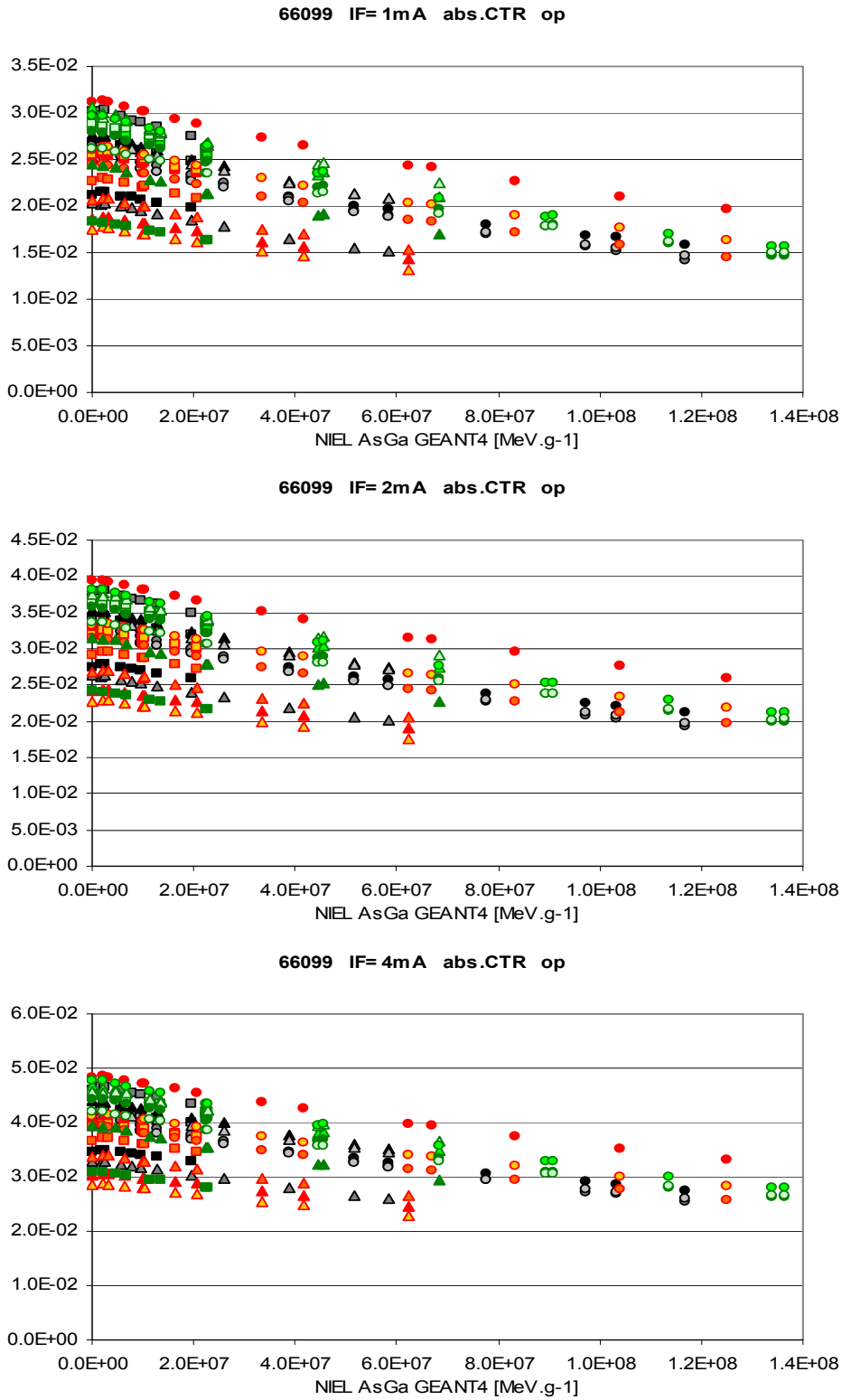
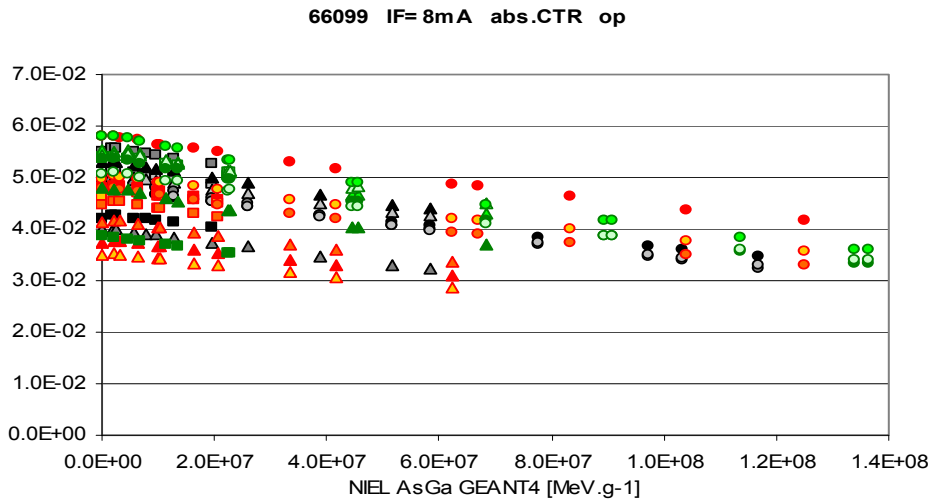

66099 IF= 10mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-4: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)




66099 IF= 8mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

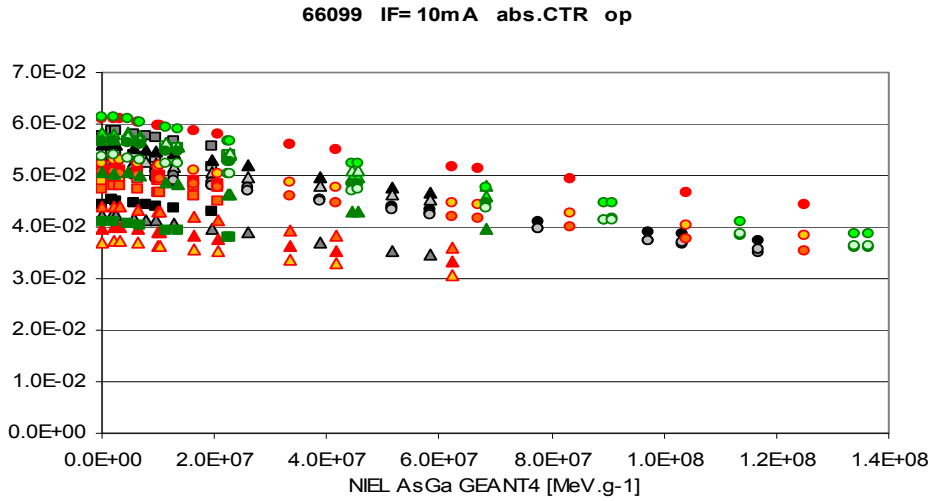
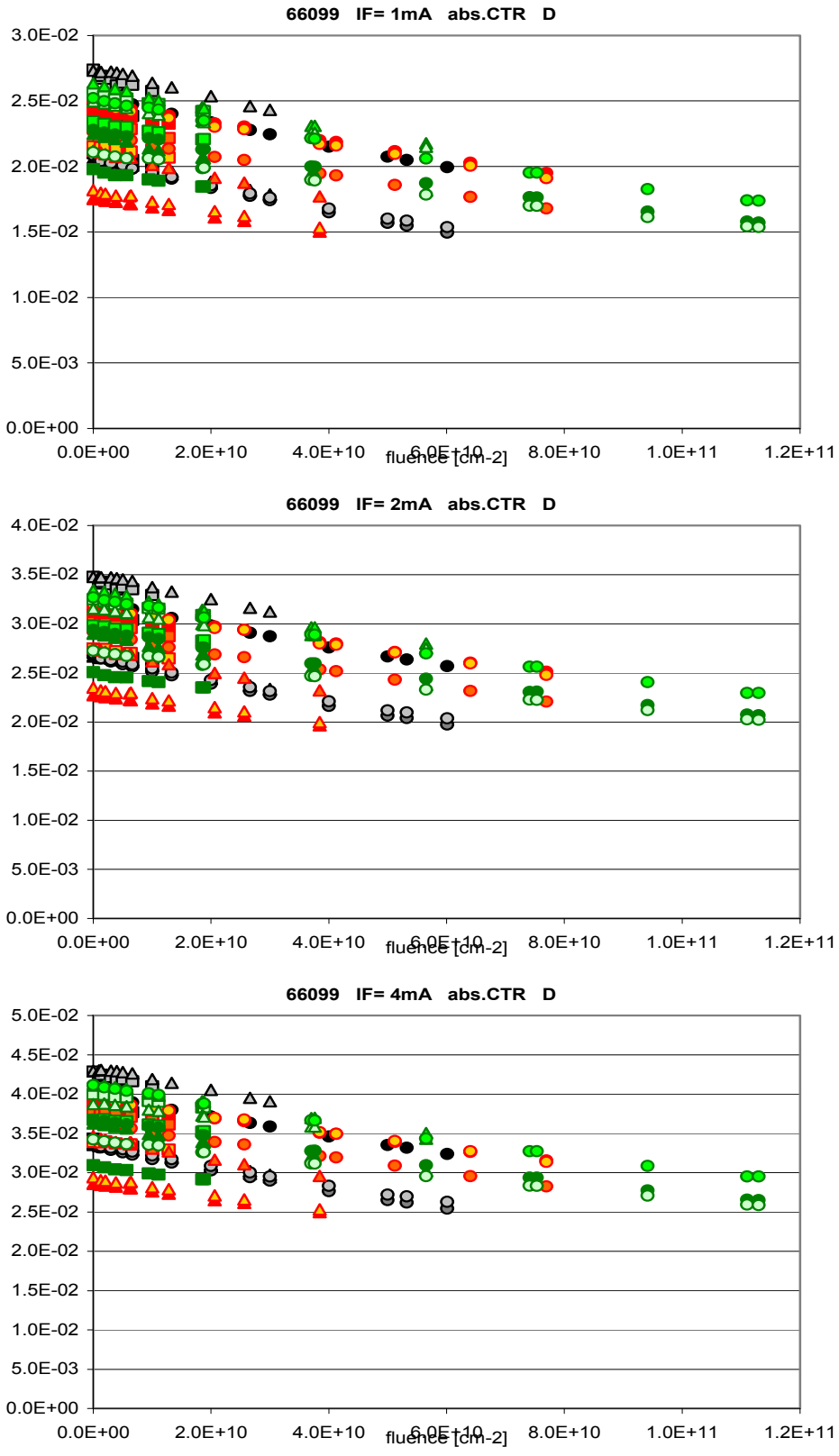
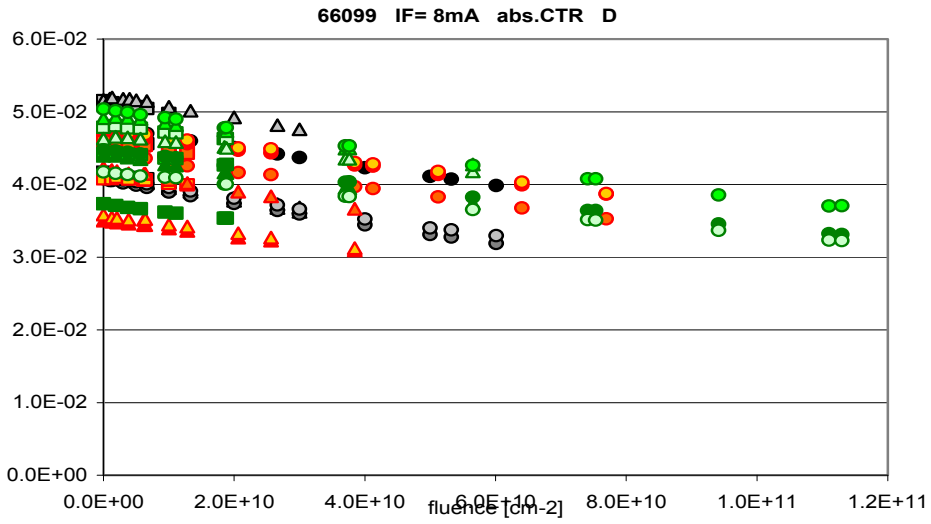

66099 IF= 10mA abs.CTR op
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-5: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

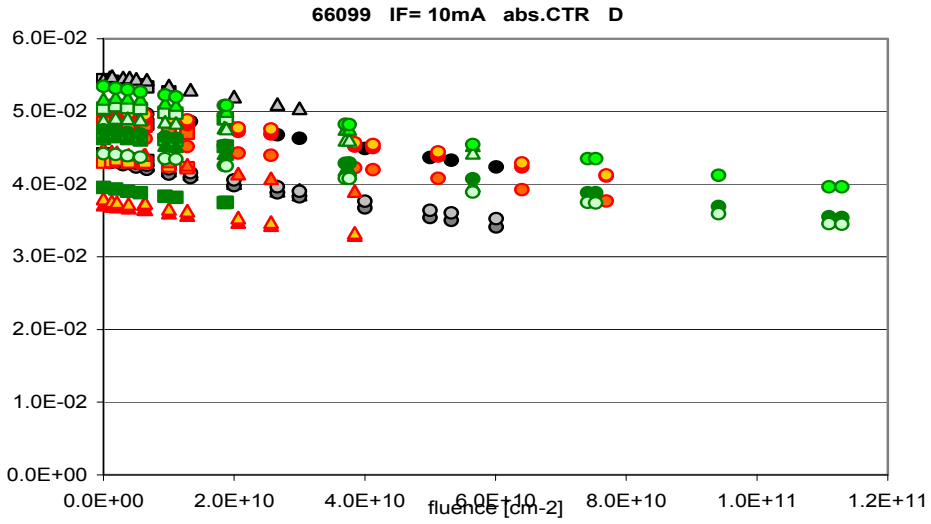
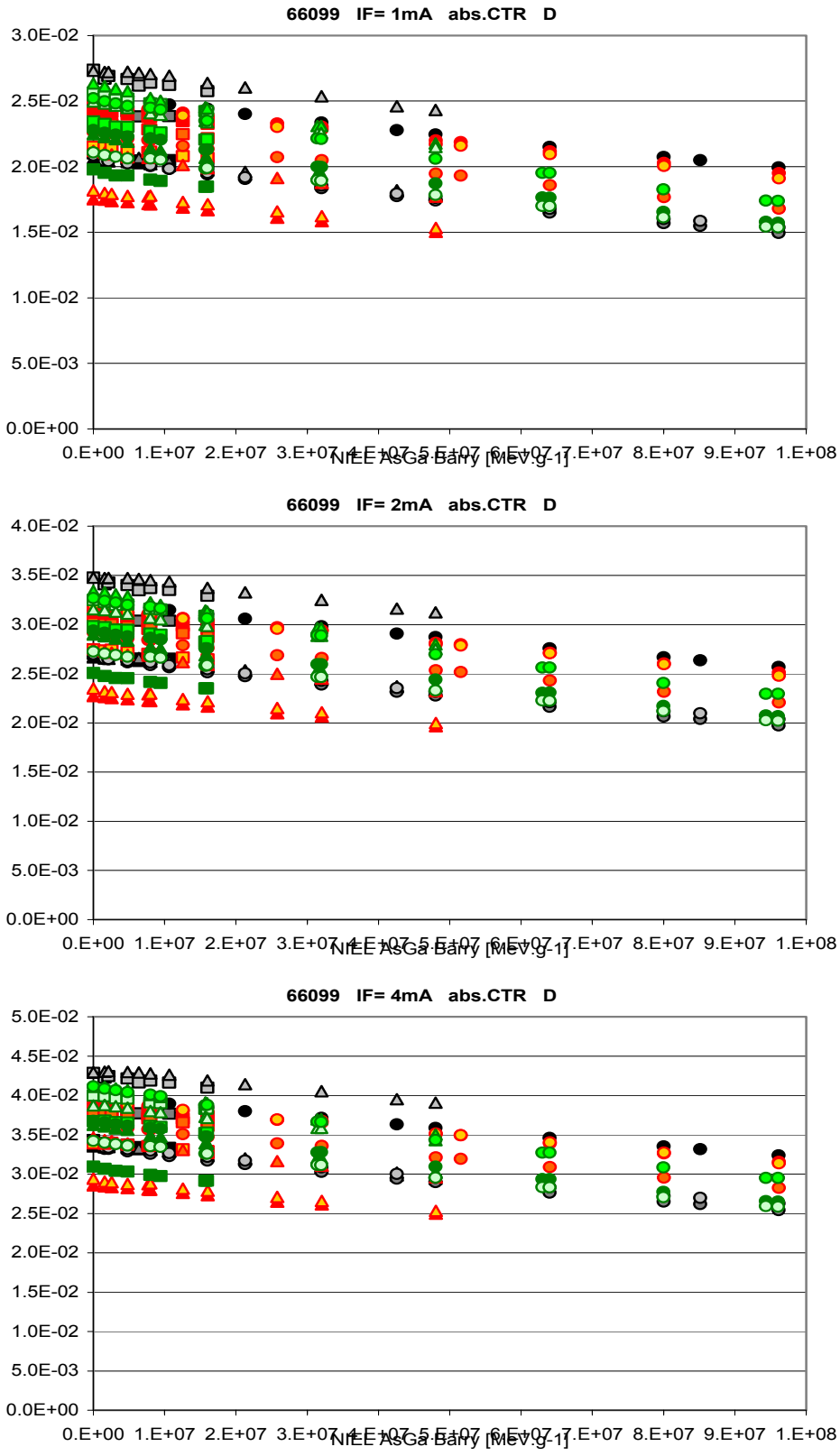
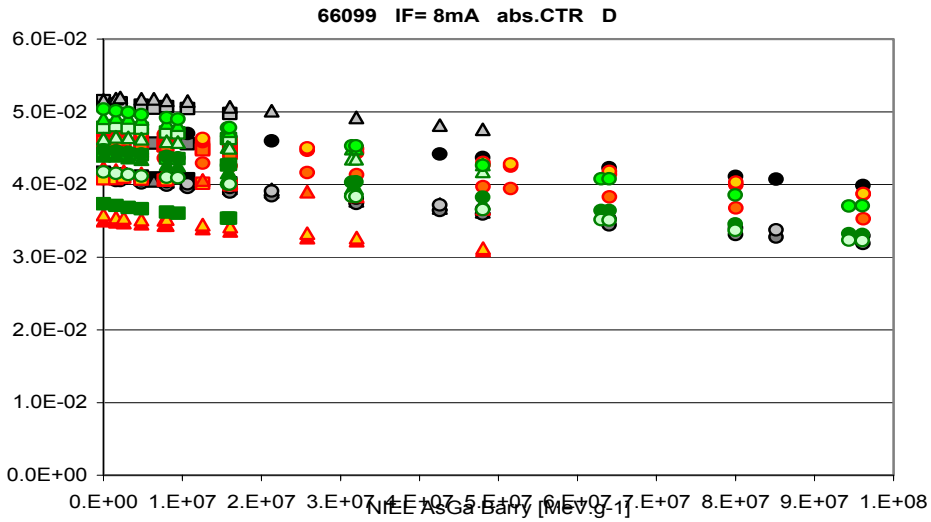

66099 IF= 10mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-6: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)




66099 IF= 8mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

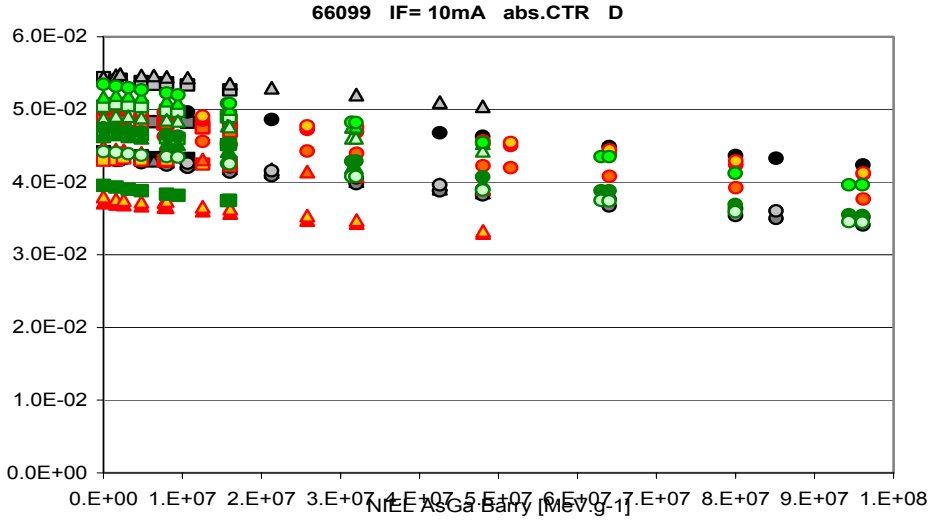
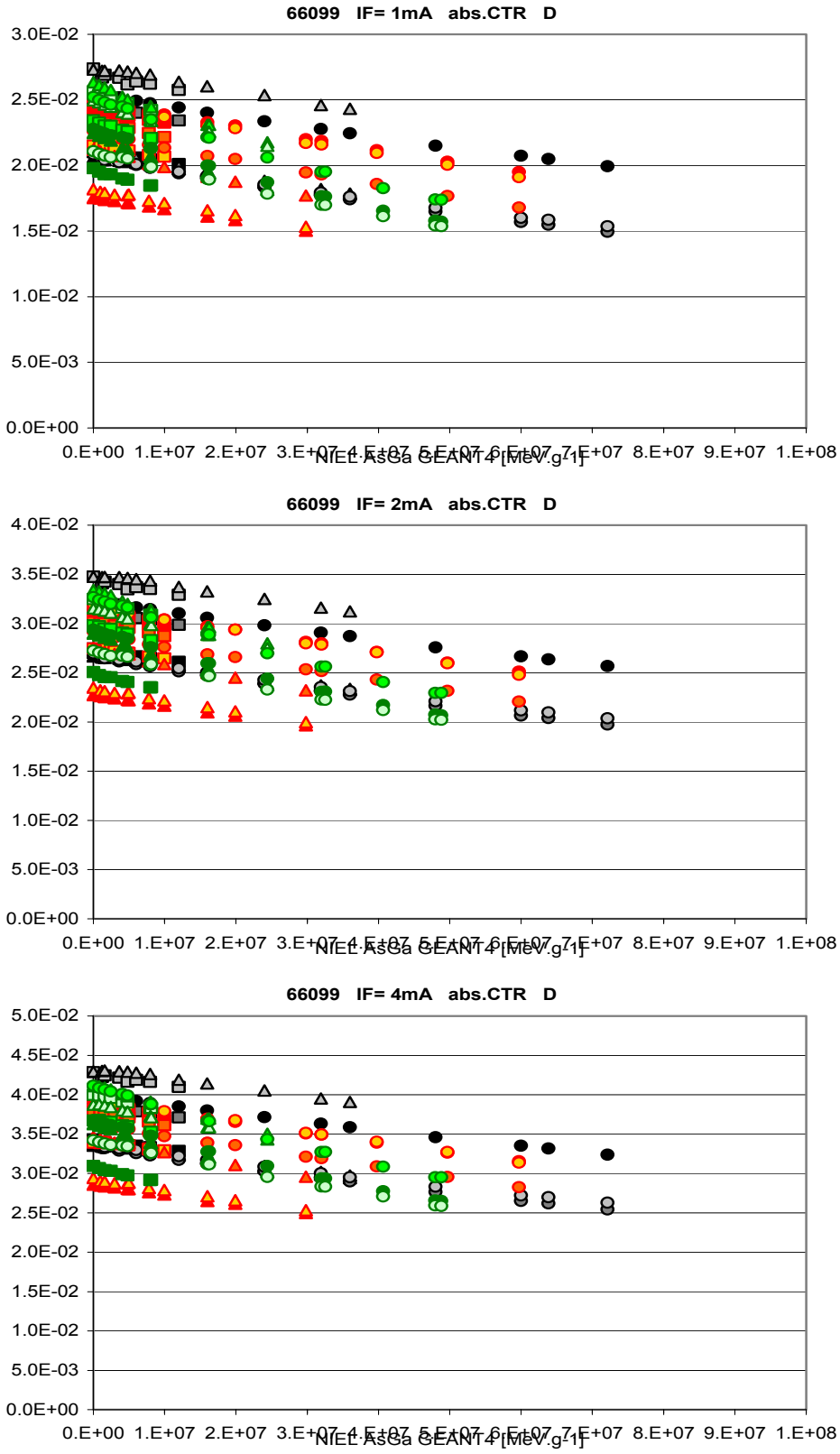
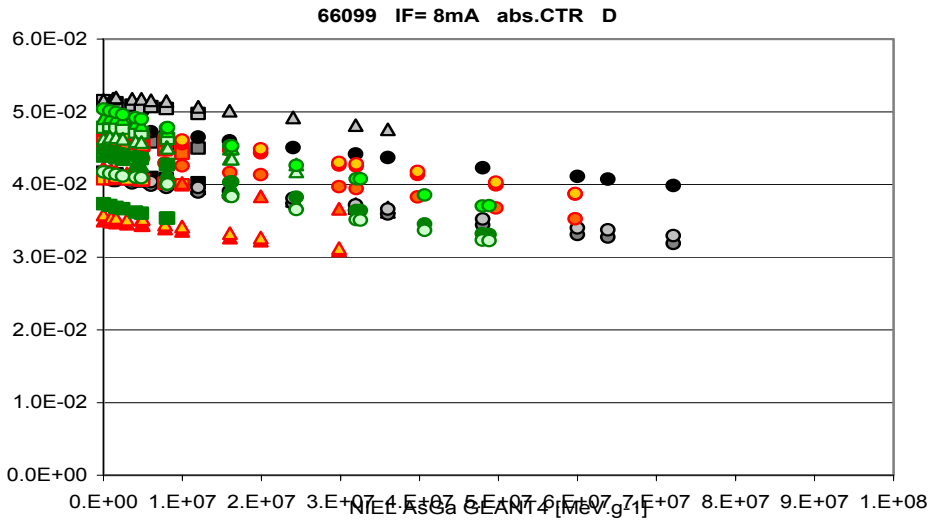

66099 IF= 10mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-7: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)




66099 IF= 8mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

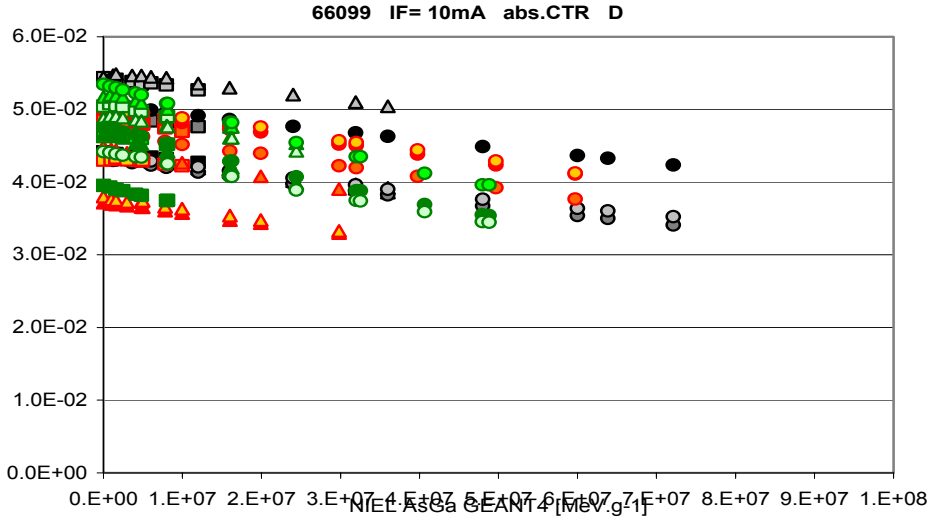
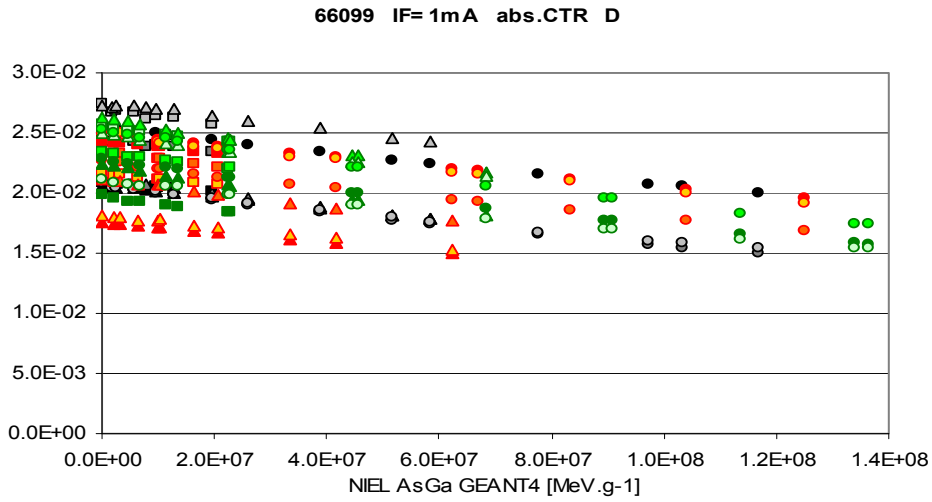
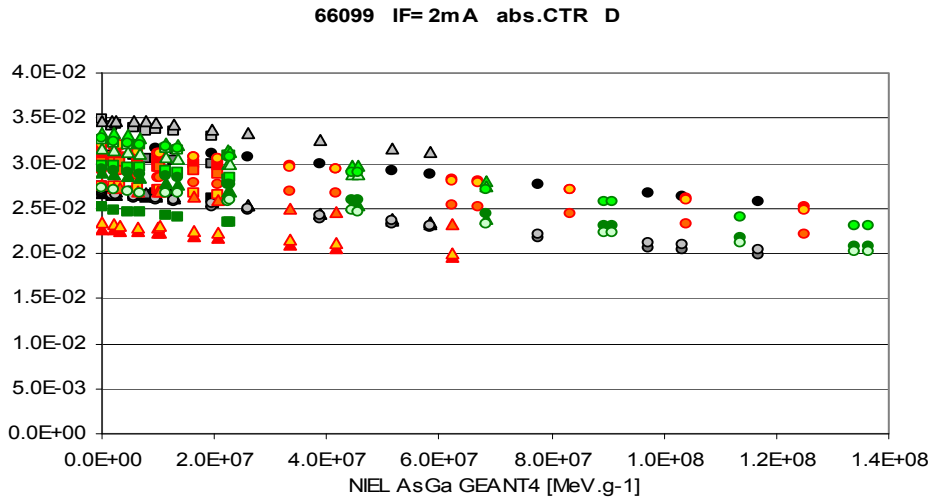
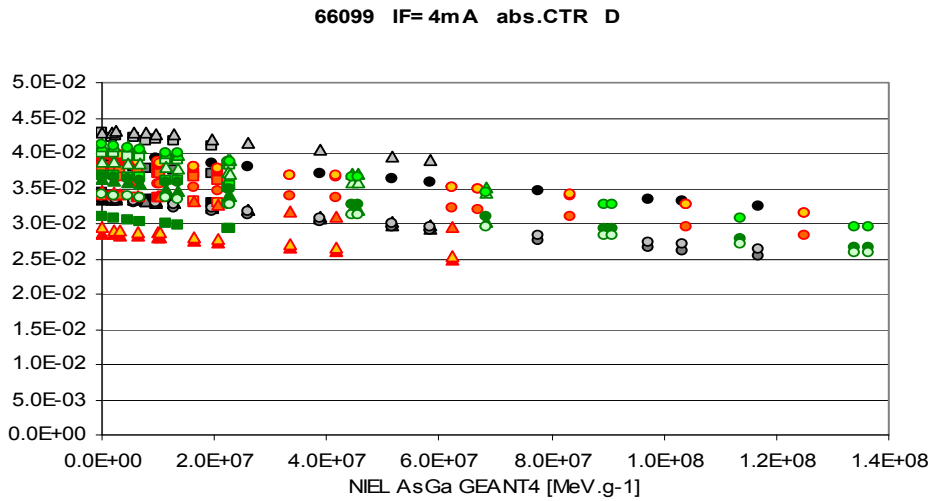

66099 IF= 10mA abs.CTR D
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

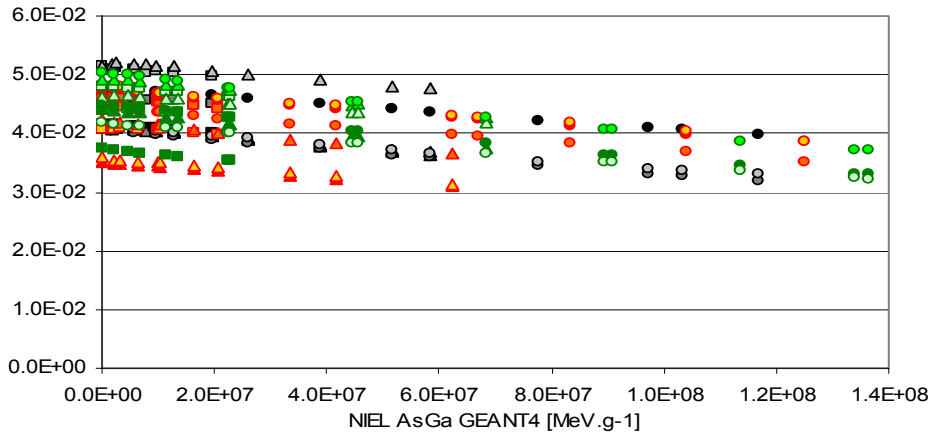
Fig. 14-8: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







66099 IF= 8mA abs.CTR D



66099 IF= 10mA abs.CTR D

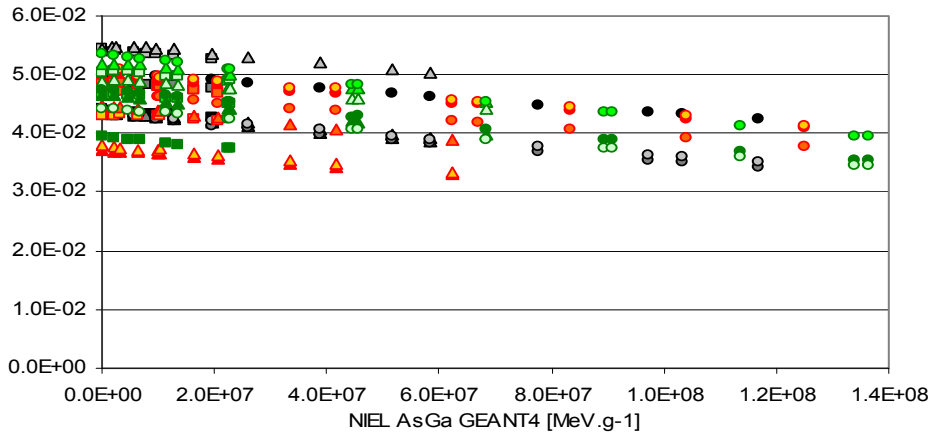
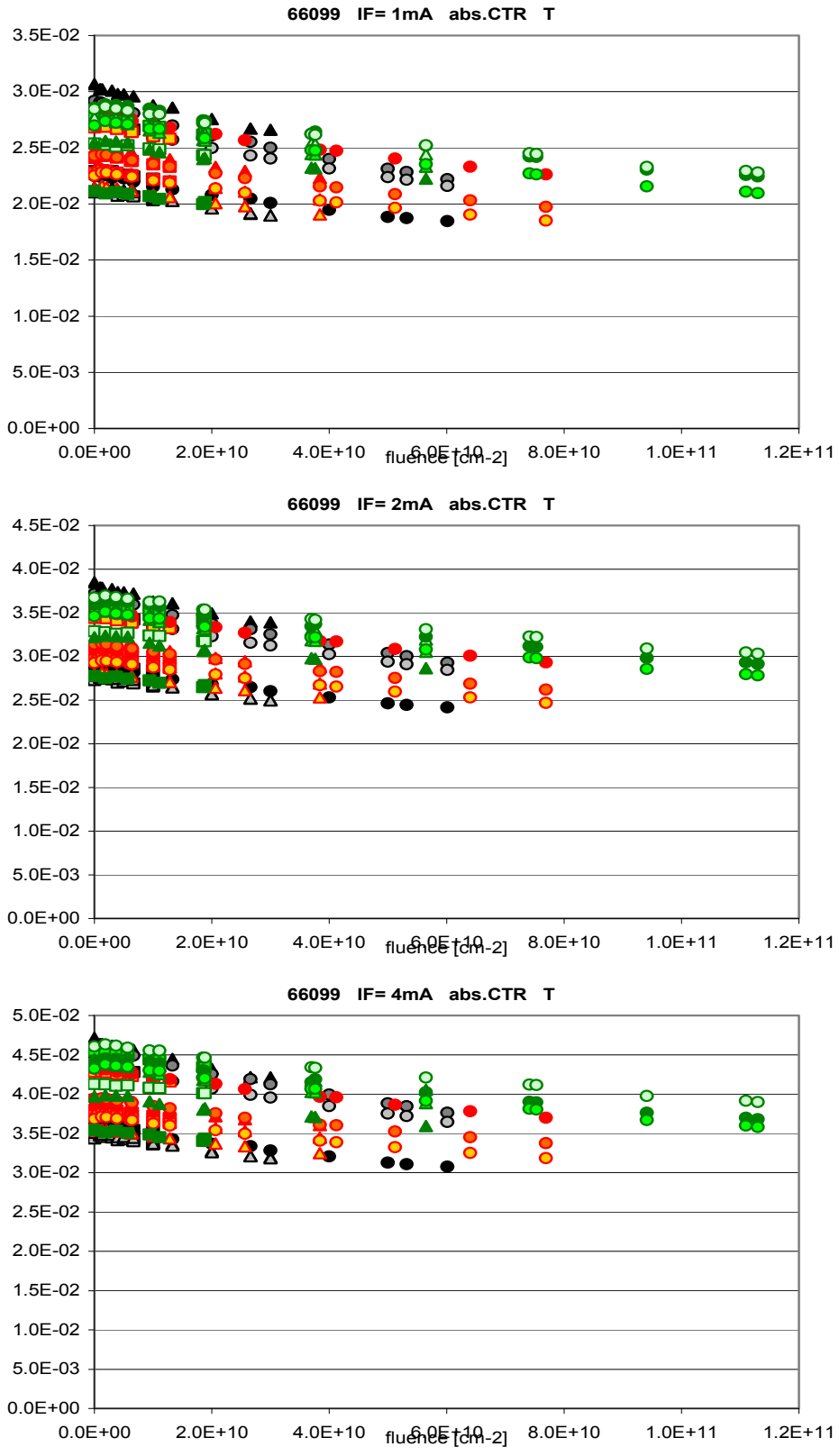
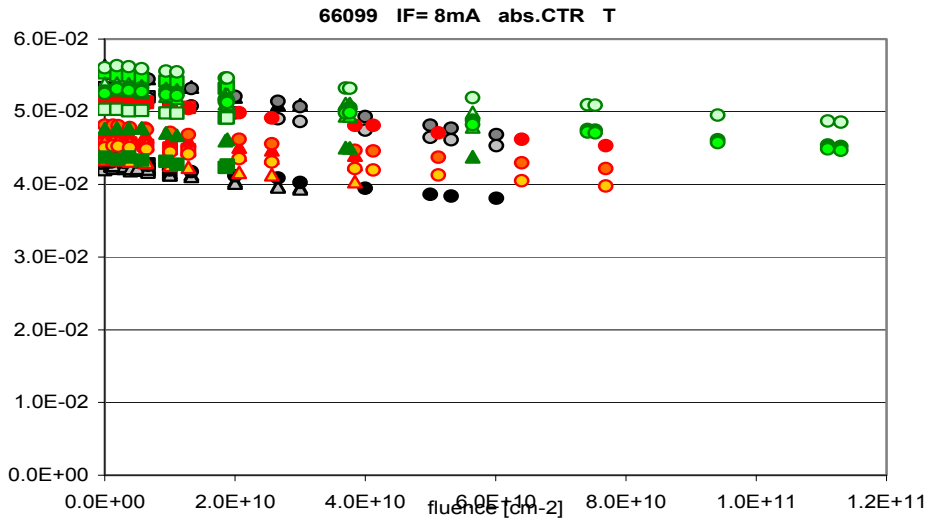


Fig. 14-9: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA abs.CTR T
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

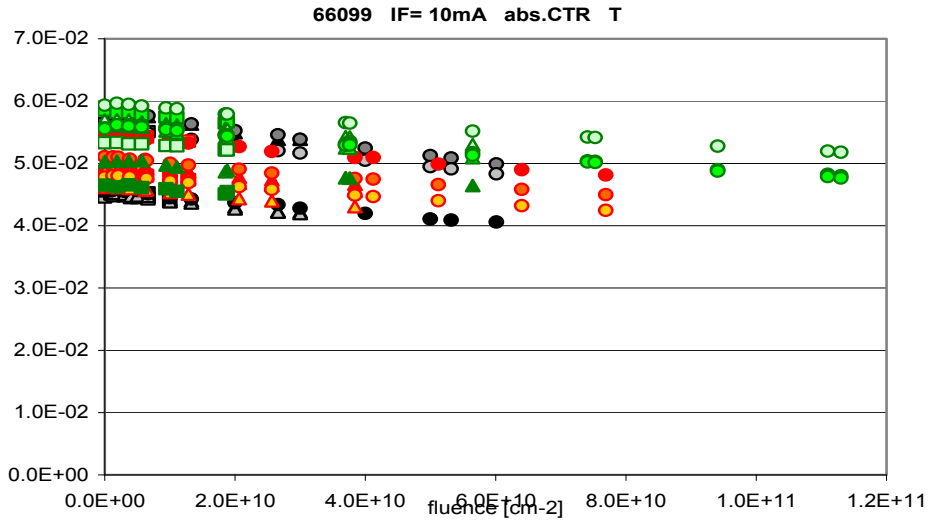
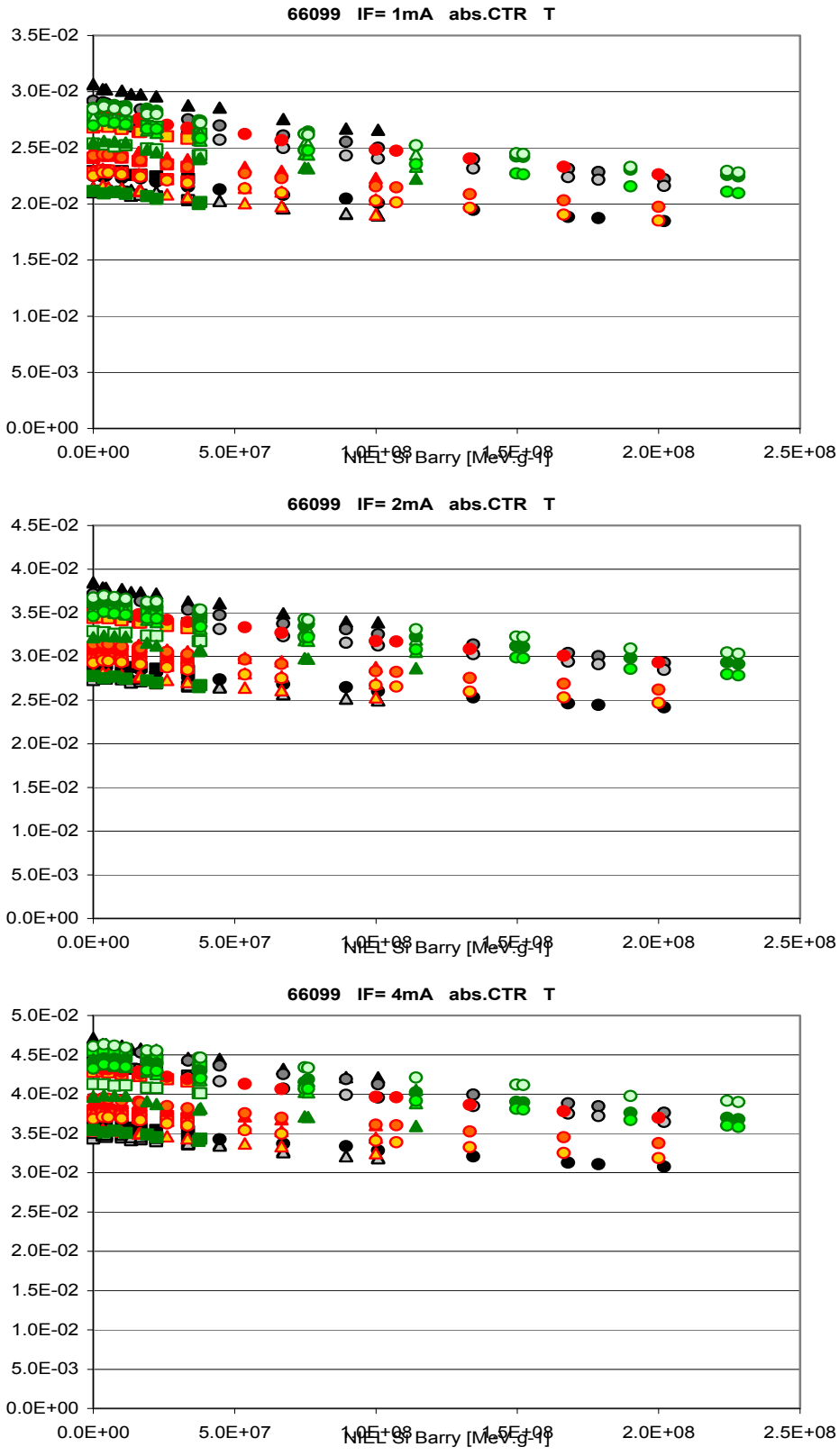
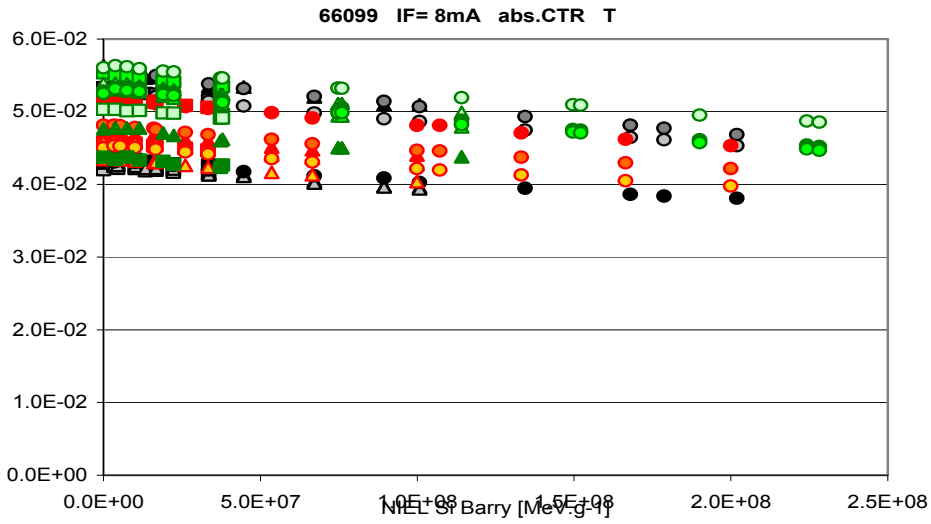

66099 IF= 10mA abs.CTR T
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-10: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)




66099 IF= 8mA abs.CTR T
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

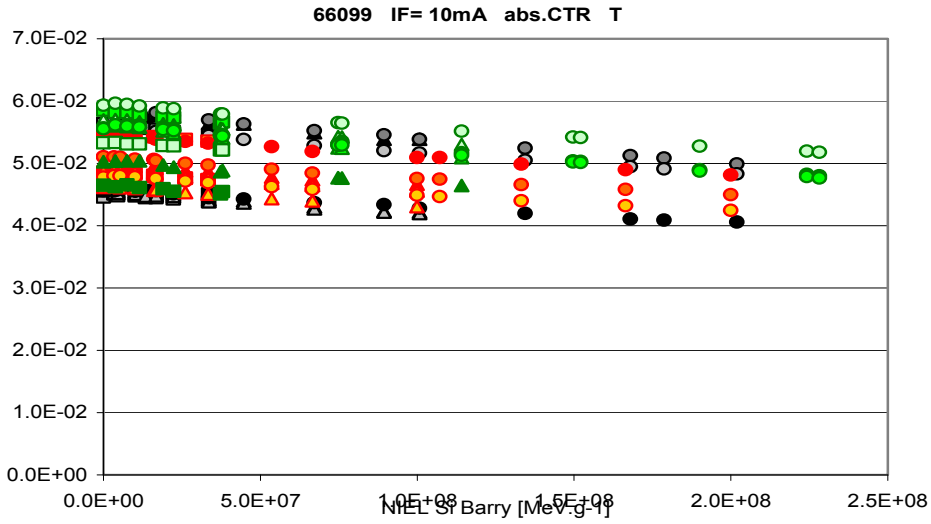
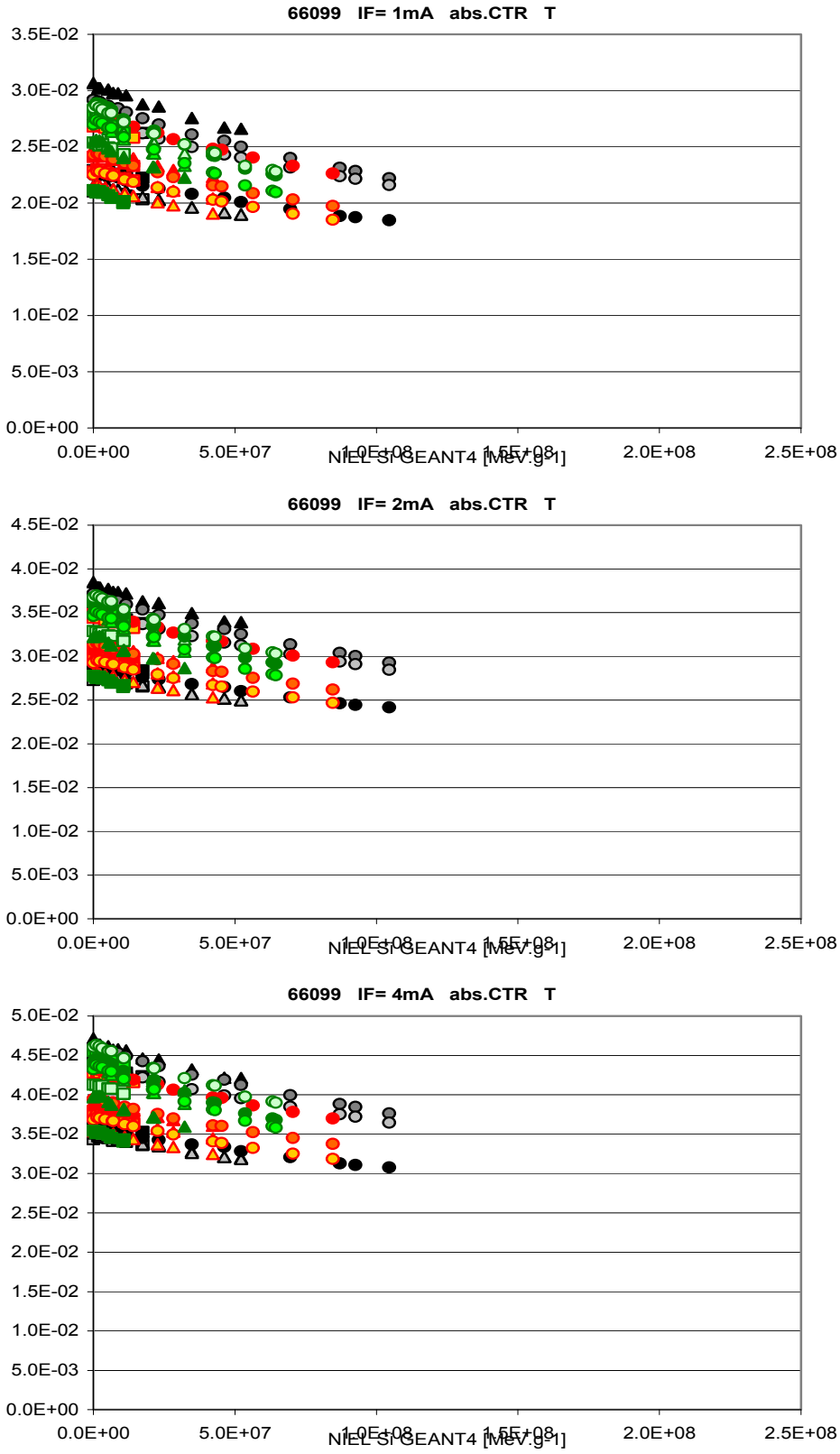
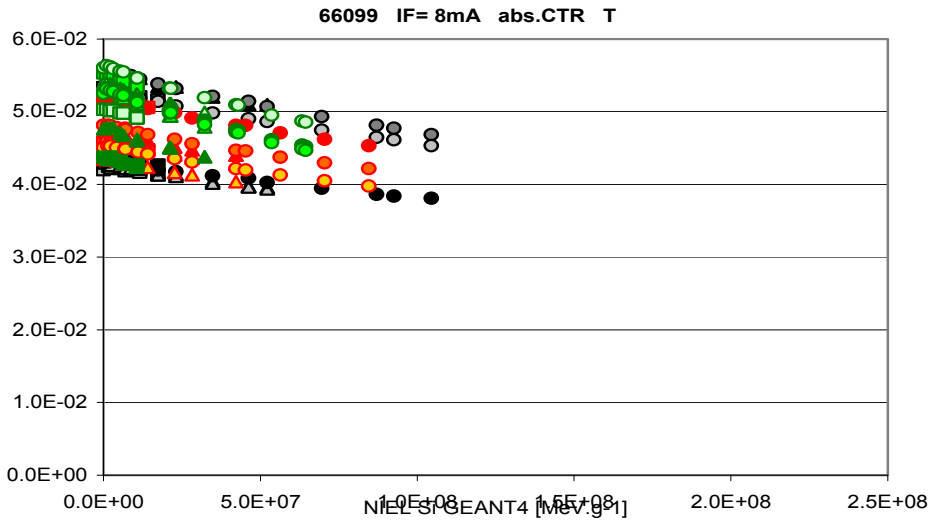

66099 IF= 10mA abs.CTR T
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 14-11: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




66099 IF= 8mA abs.CTR T
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

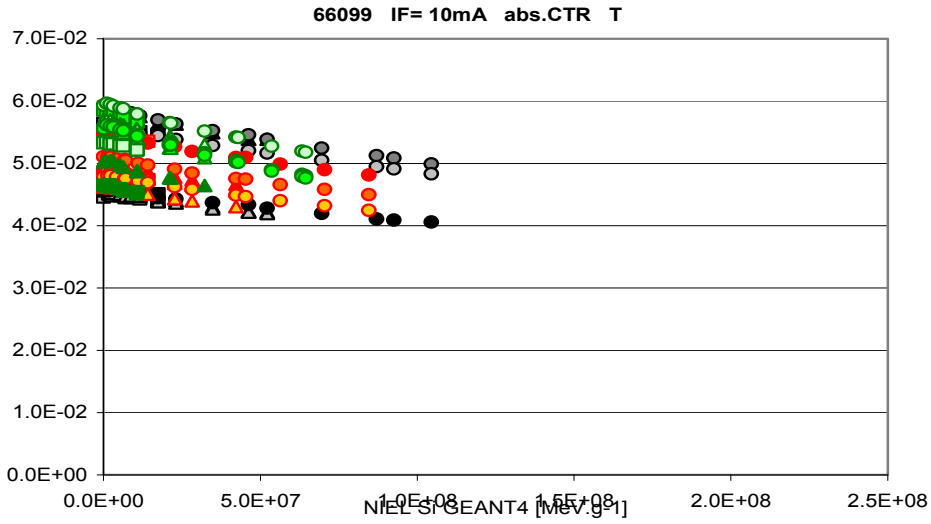
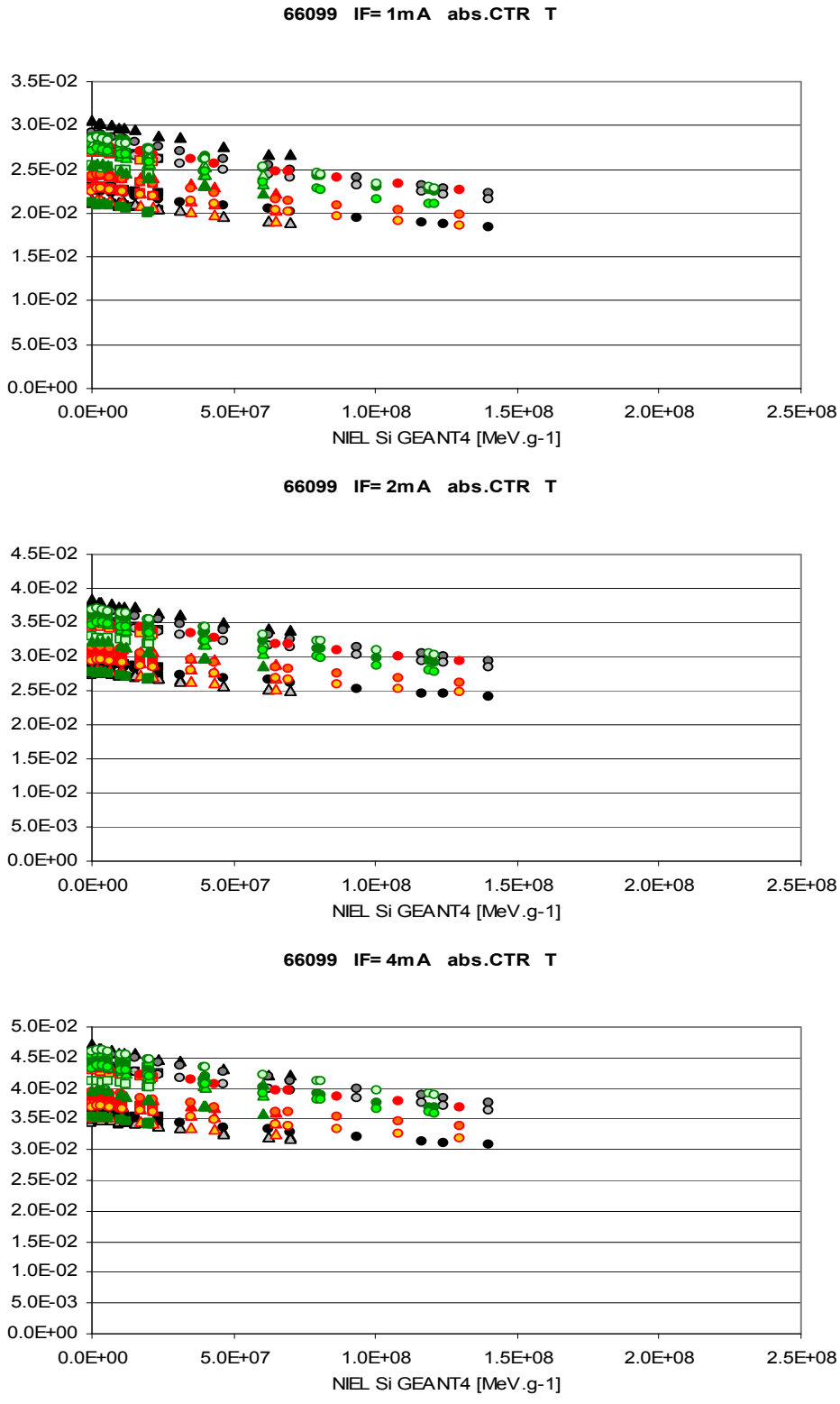
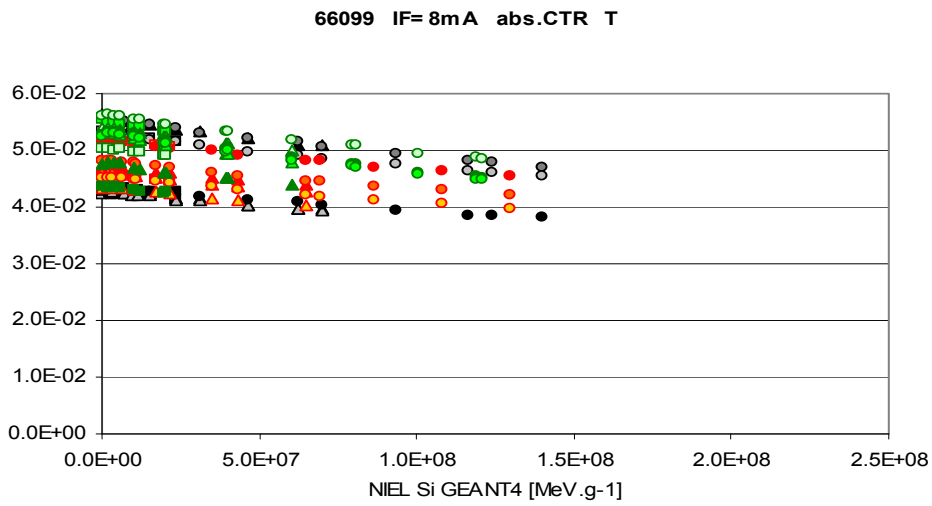

66099 IF= 10mA abs.CTR T
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 14-12: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




66099 IF= 8mA abs.CTR T
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

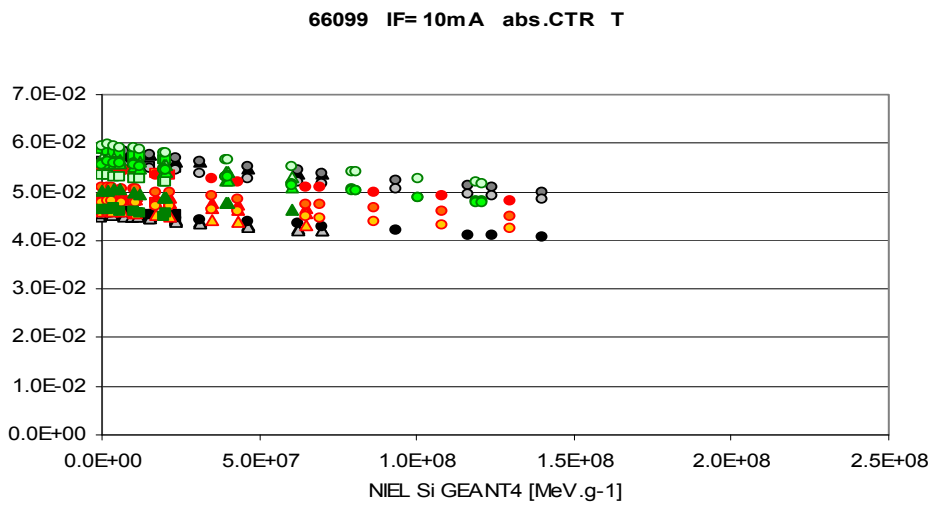
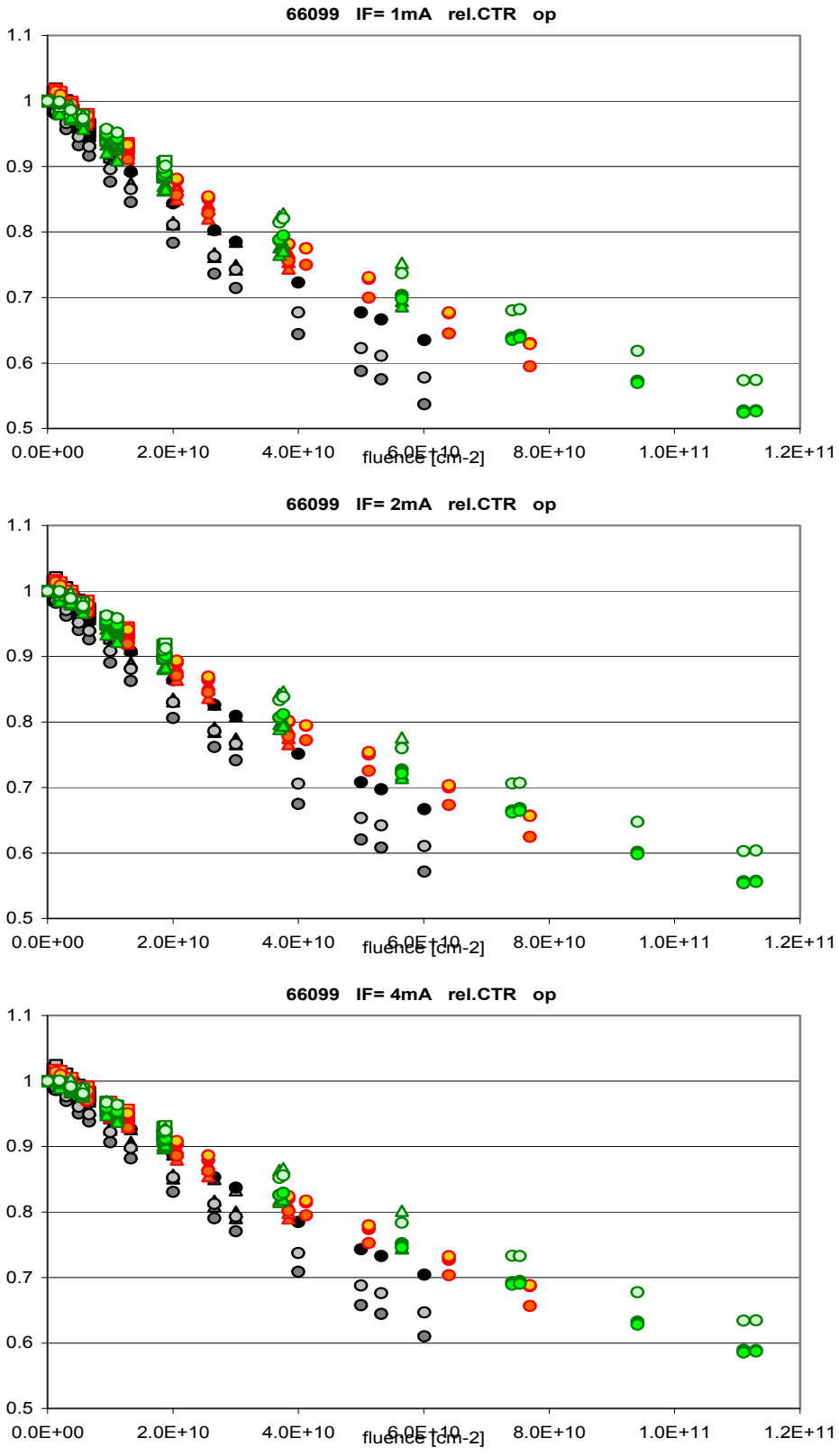
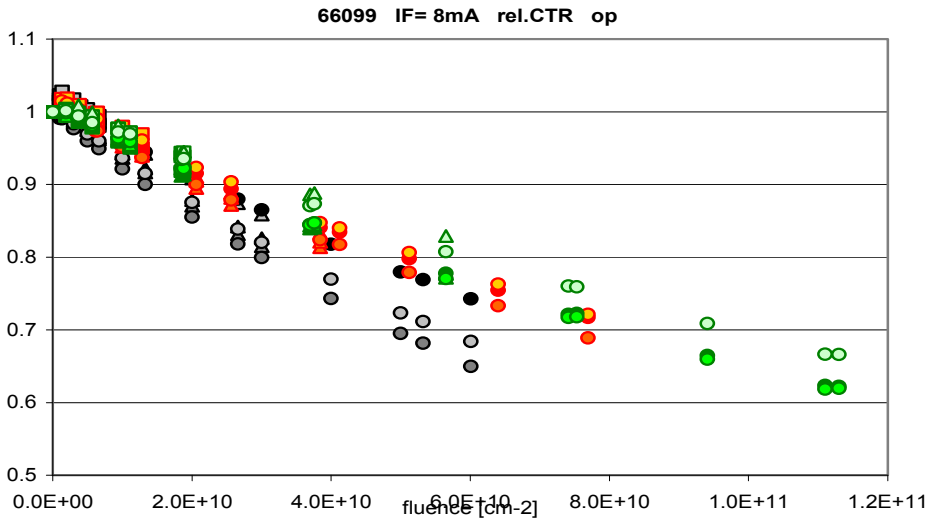

66099 IF= 10mA abs.CTR T
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 14-13: 66099 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

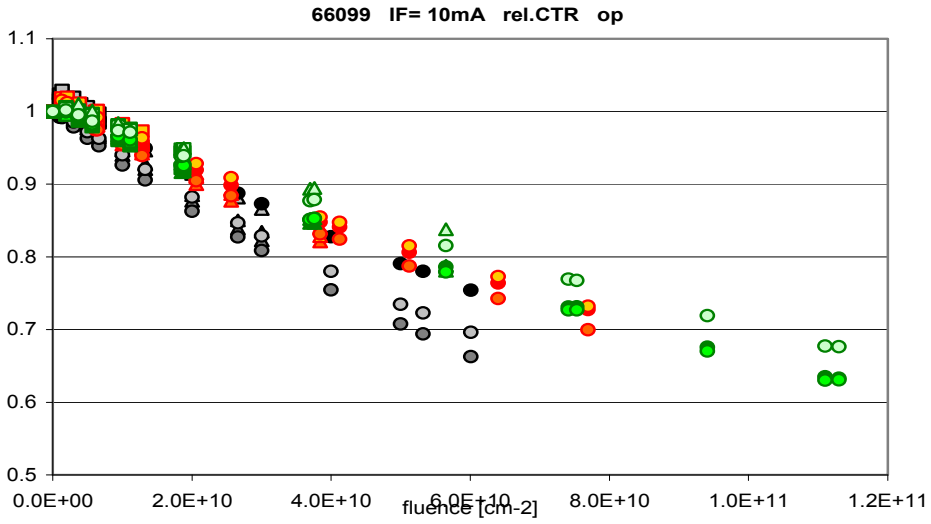
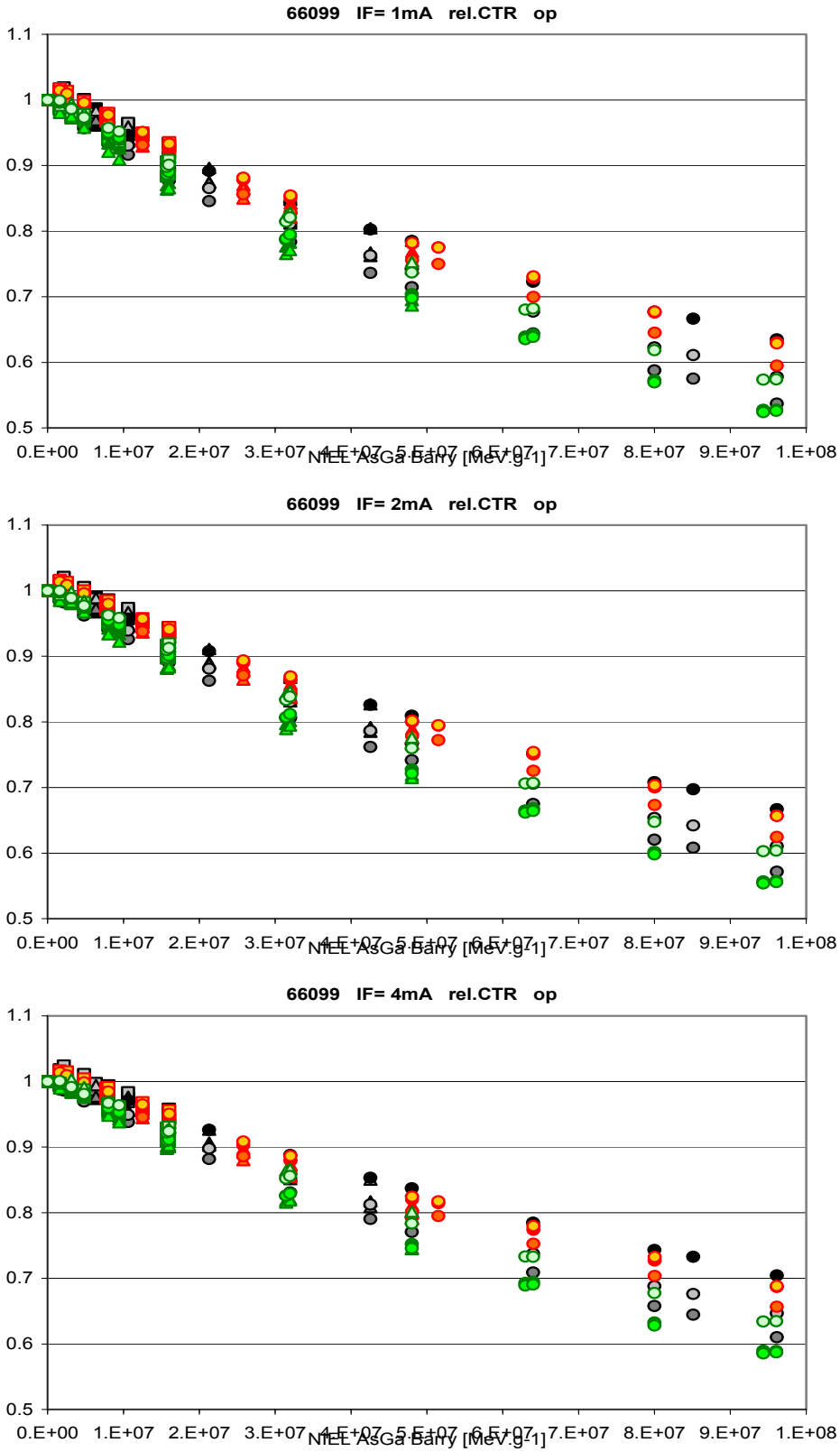
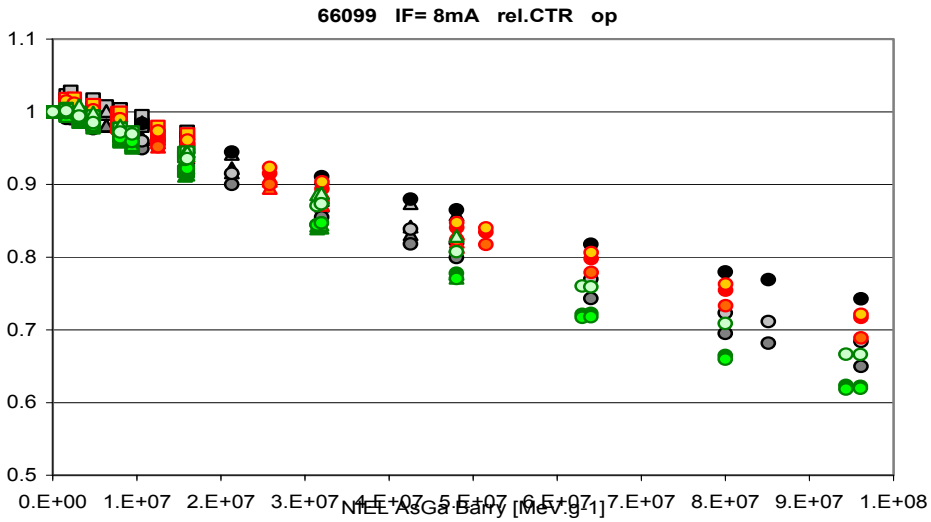

66099 IF= 10mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-14: 66099 optocoupler: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)




66099 IF= 8mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

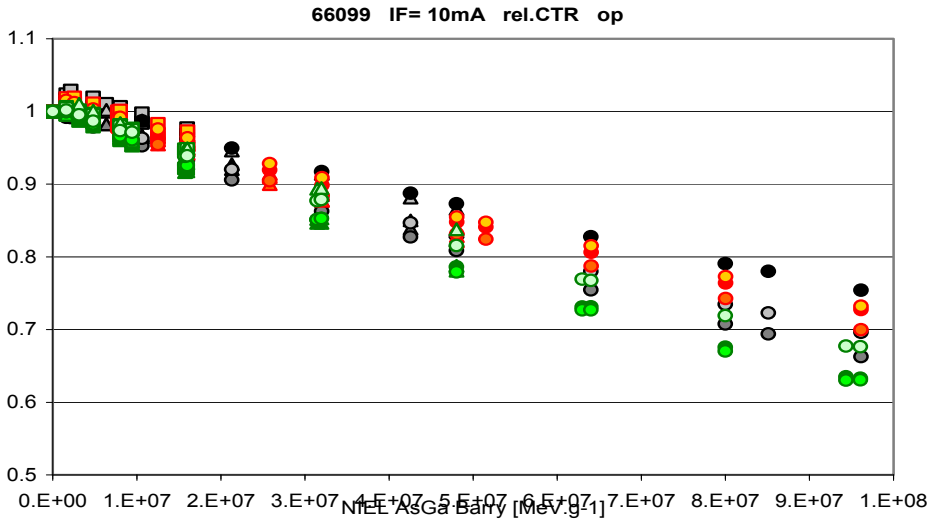
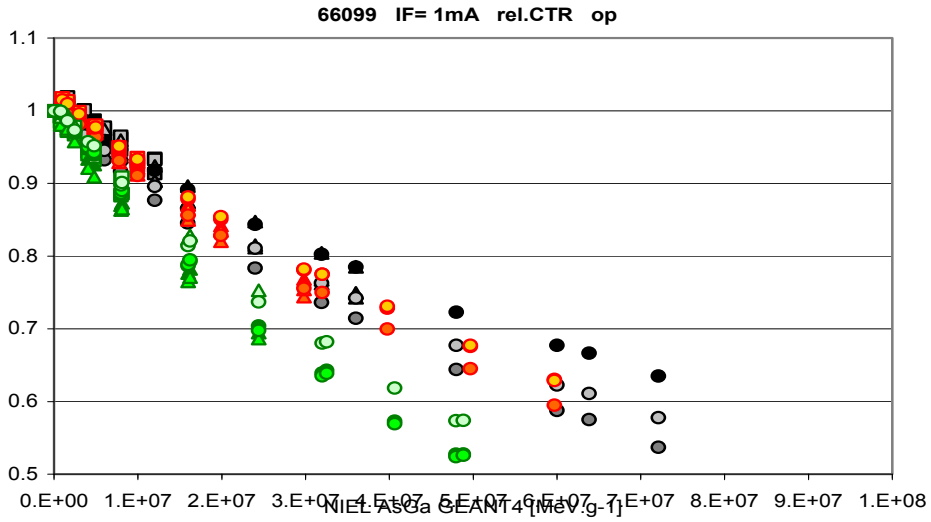
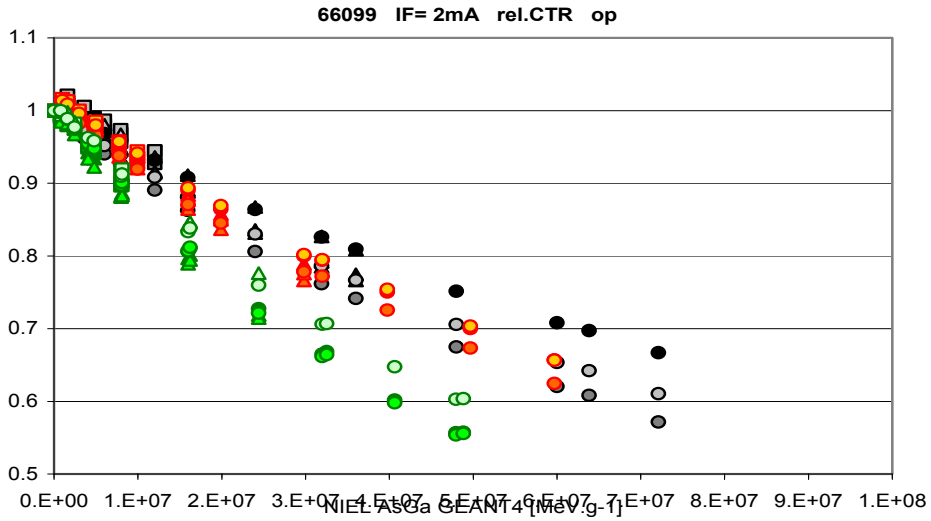
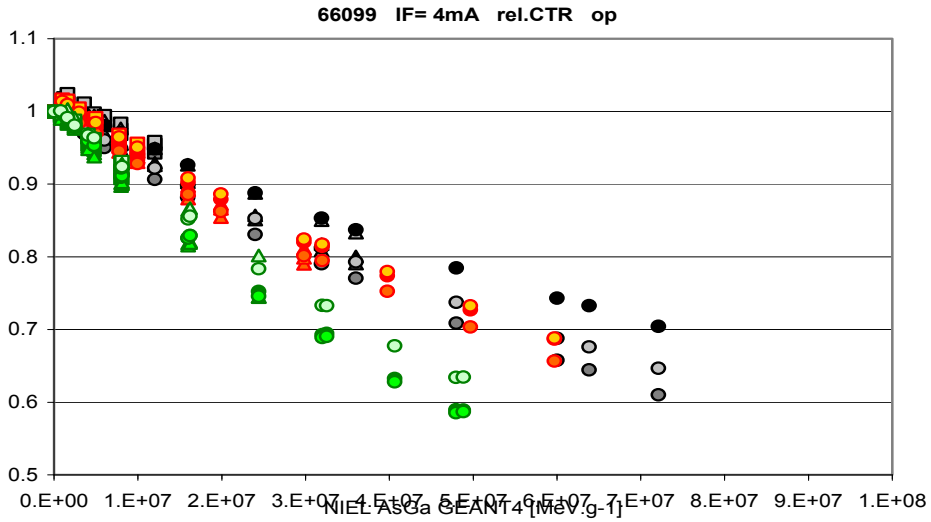
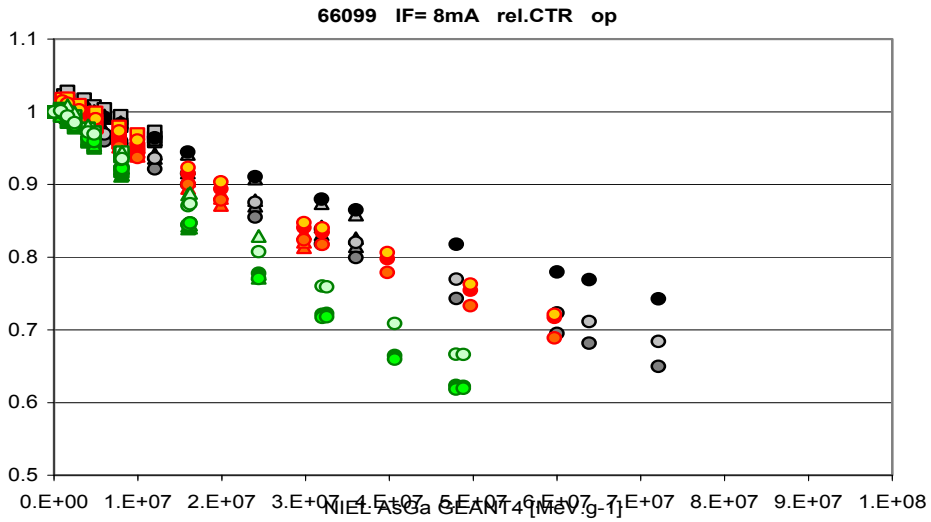

66099 IF= 10mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-15: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)








66099 IF= 8mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

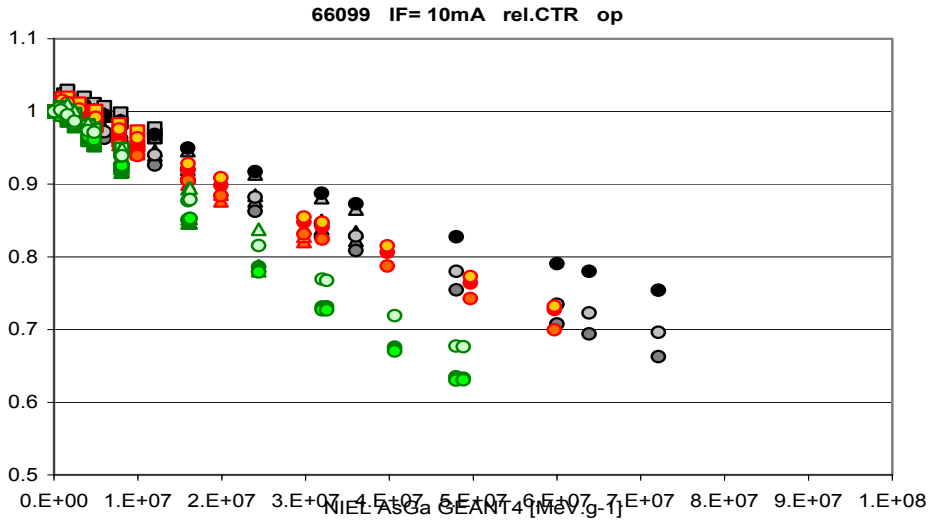
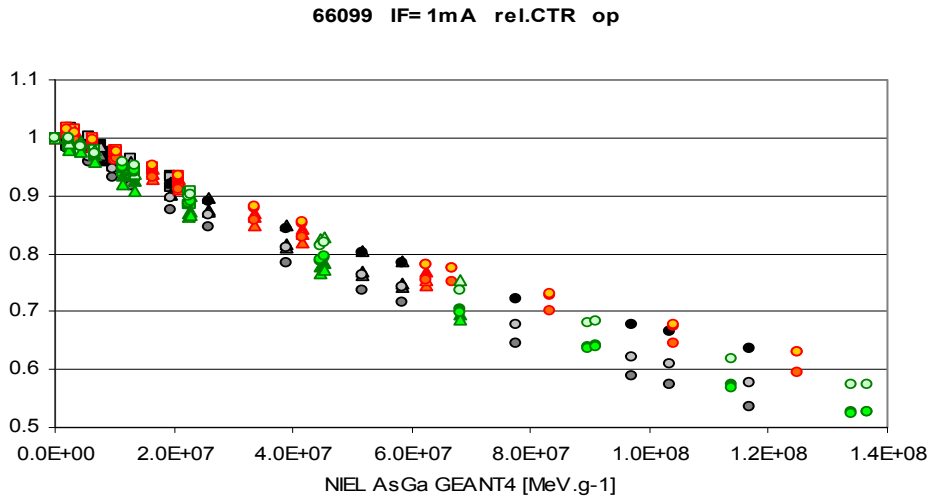
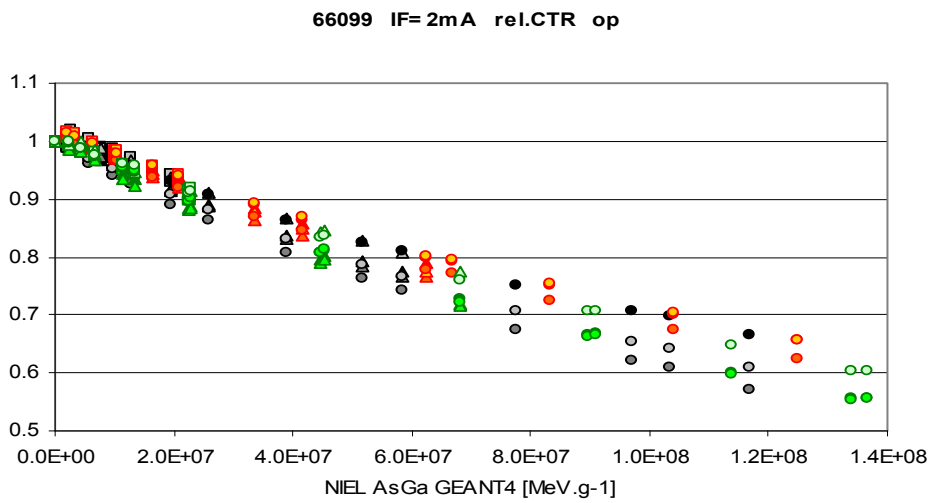
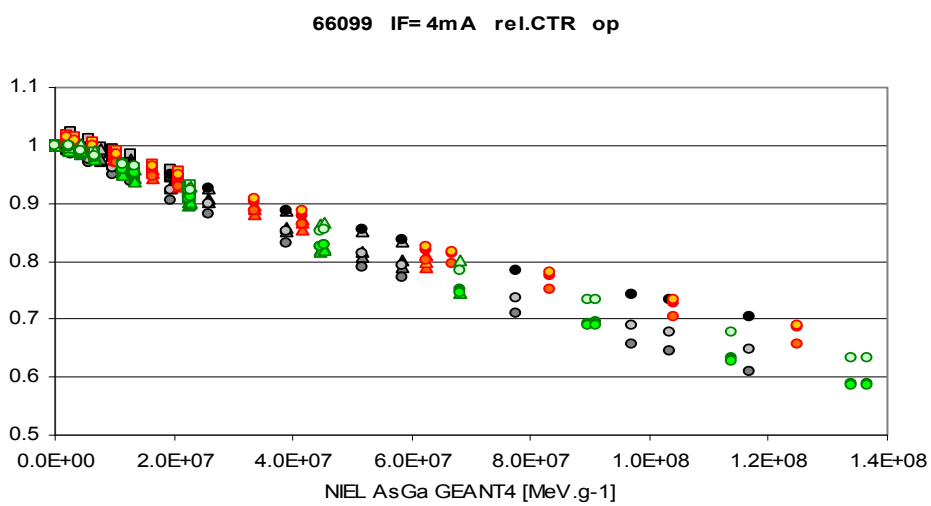
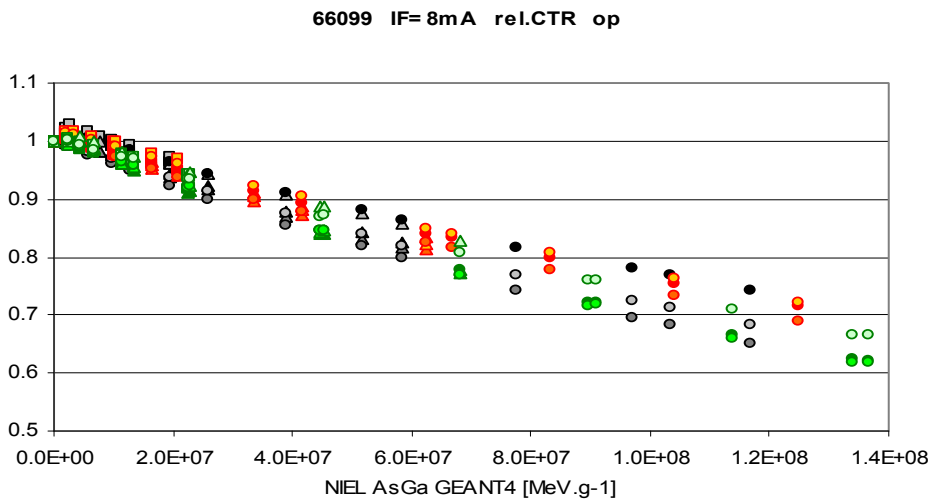

66099 IF= 10mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-16: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)








66099 IF= 8mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

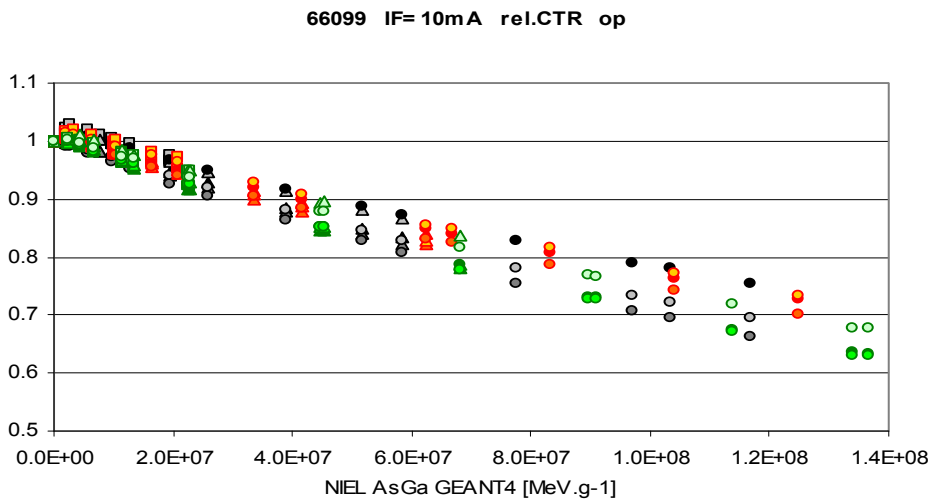
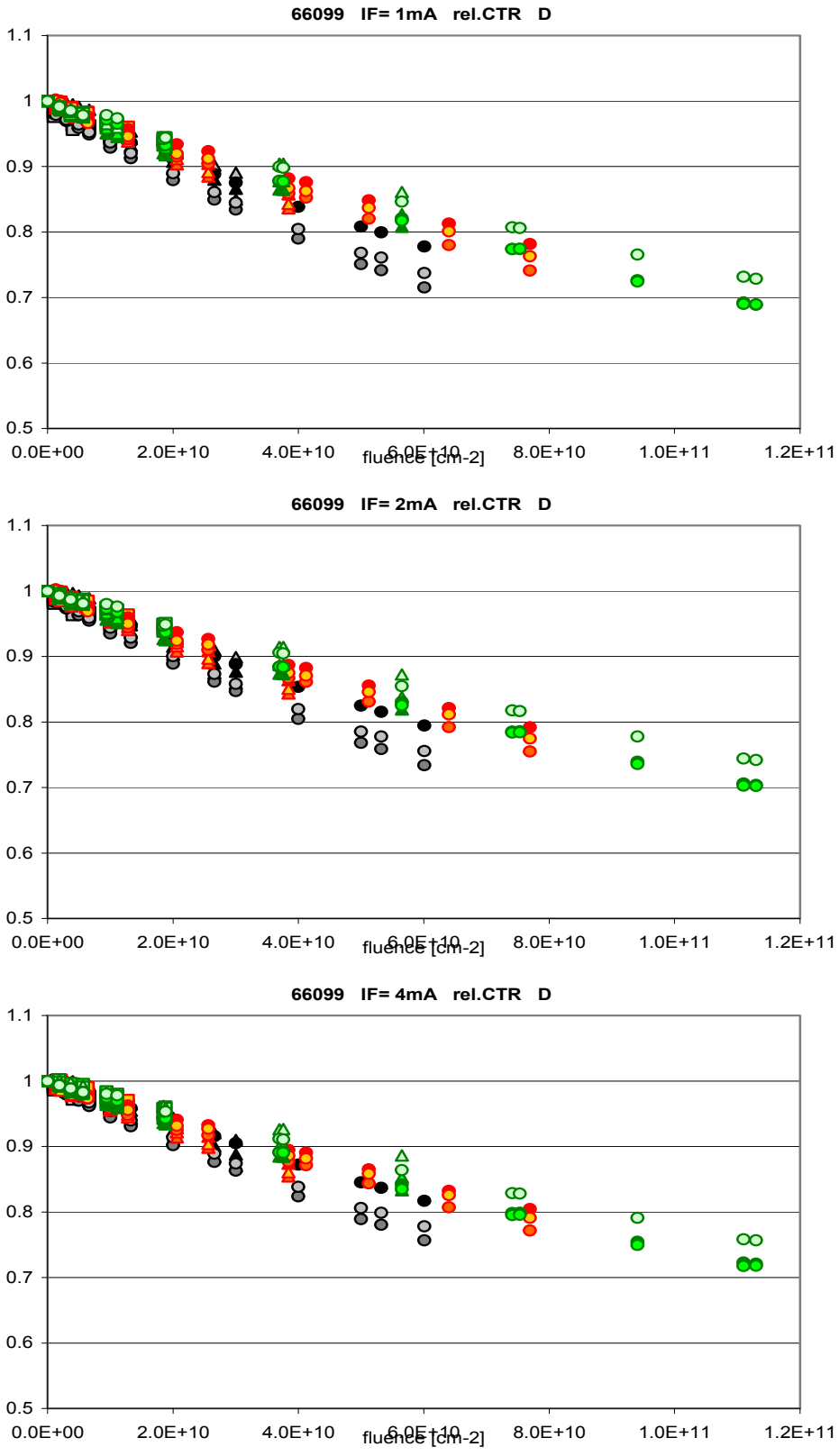
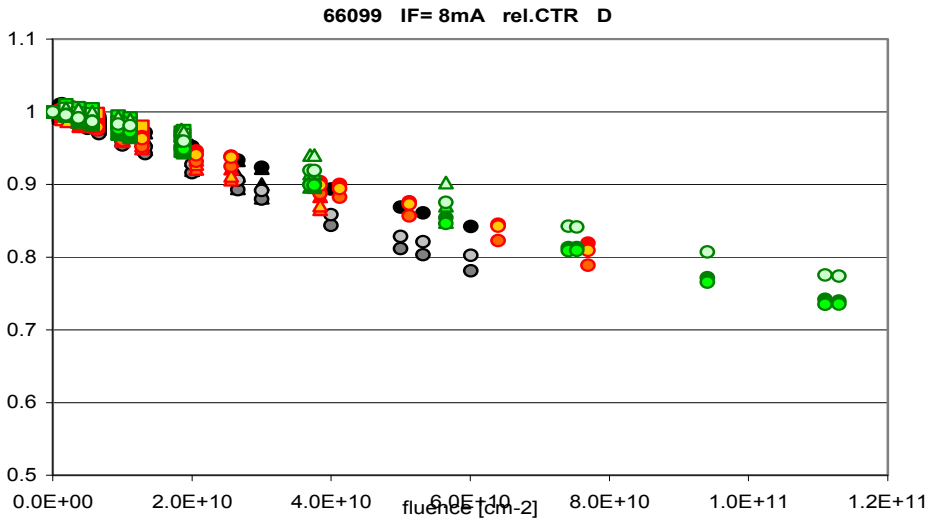

66099 IF= 10mA rel.CTR op
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-17: 66099 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

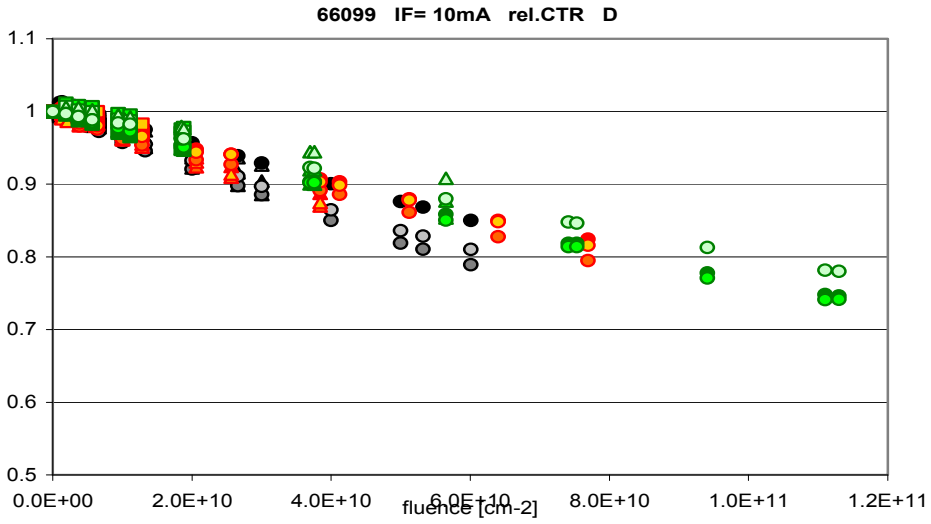
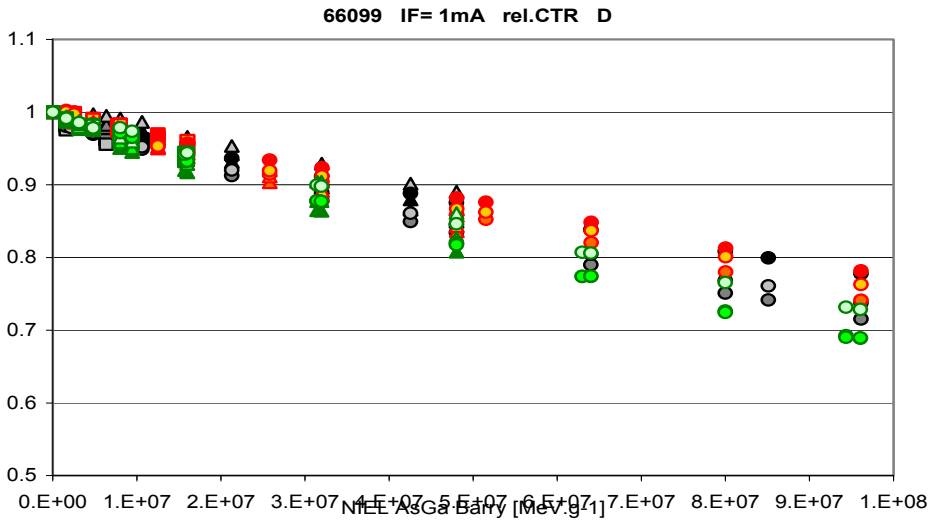
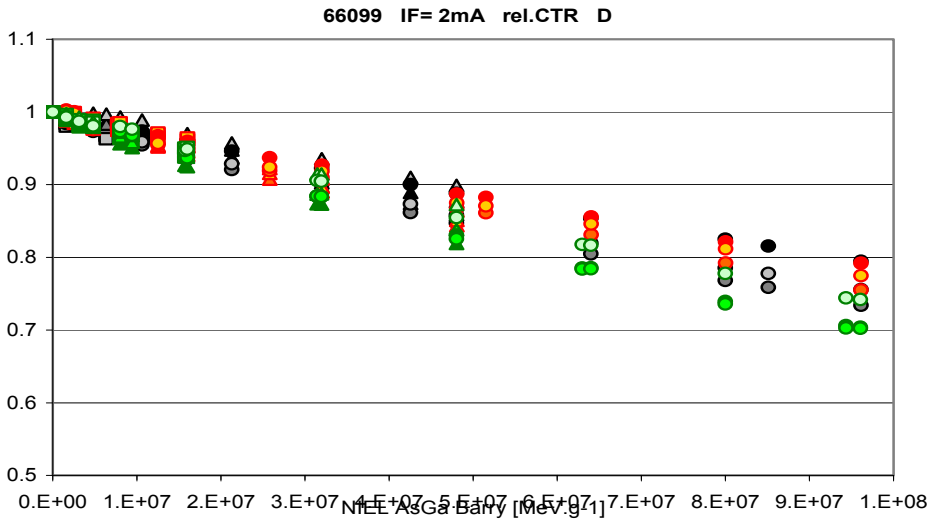
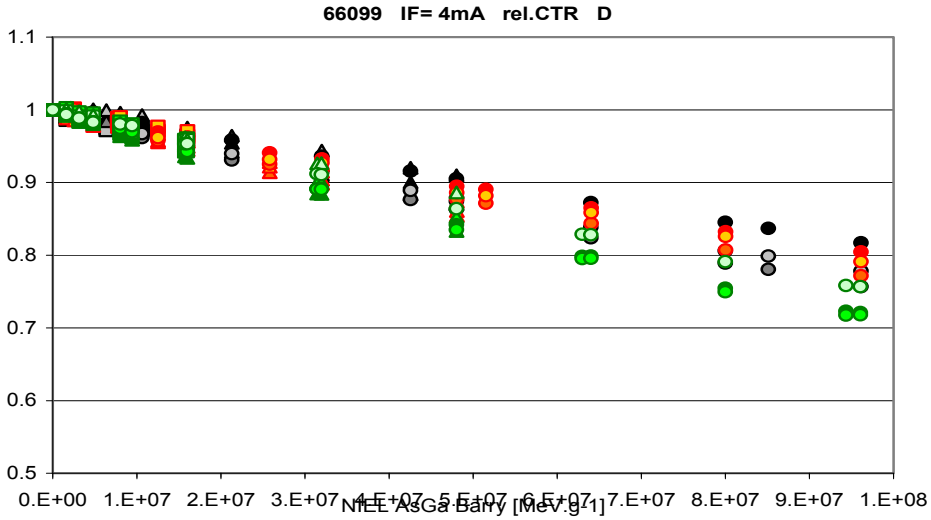
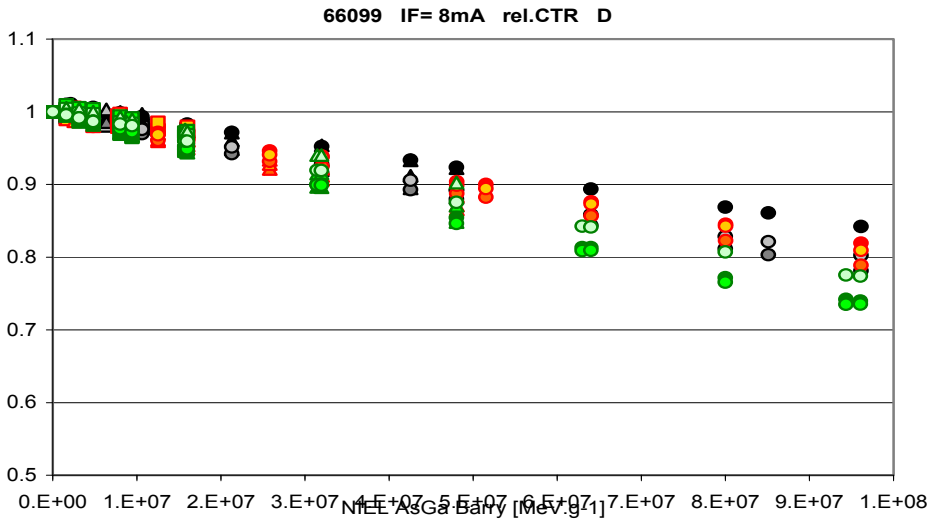

66099 IF= 10mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-18: 66099 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)








66099 IF= 8mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

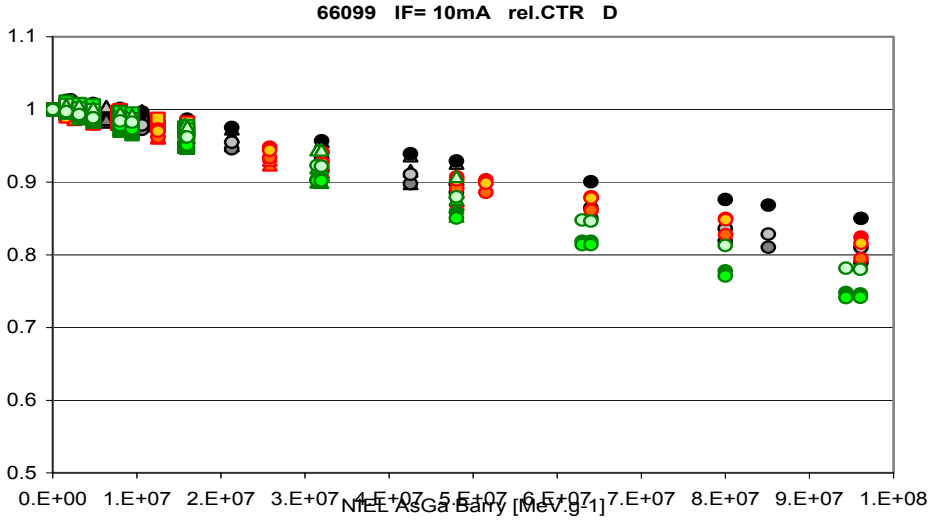
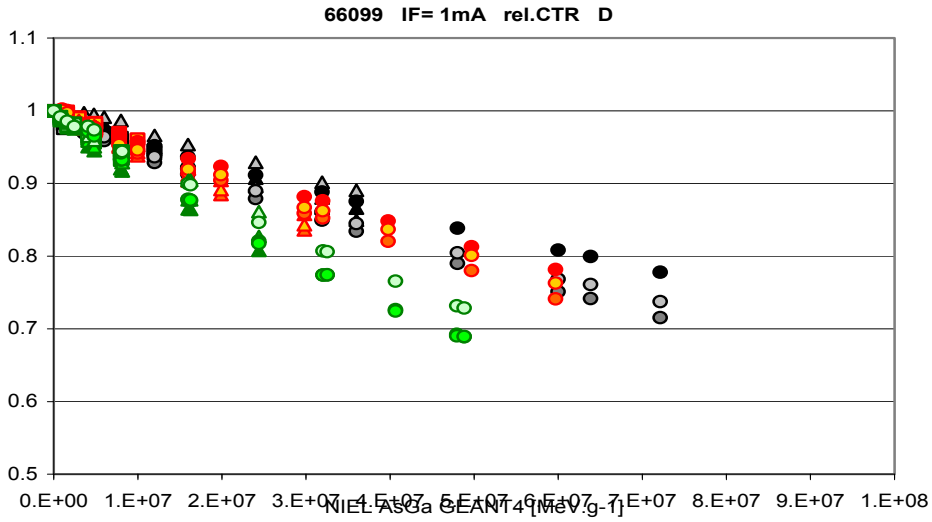
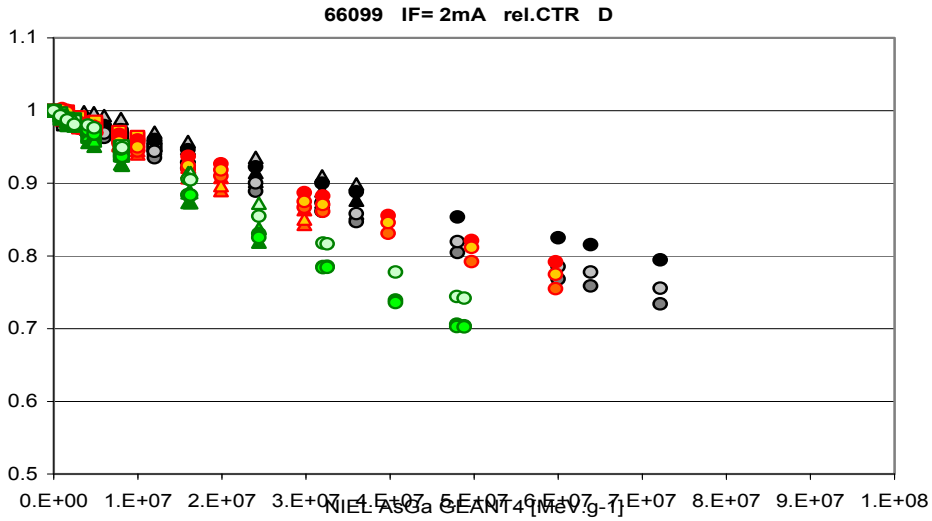
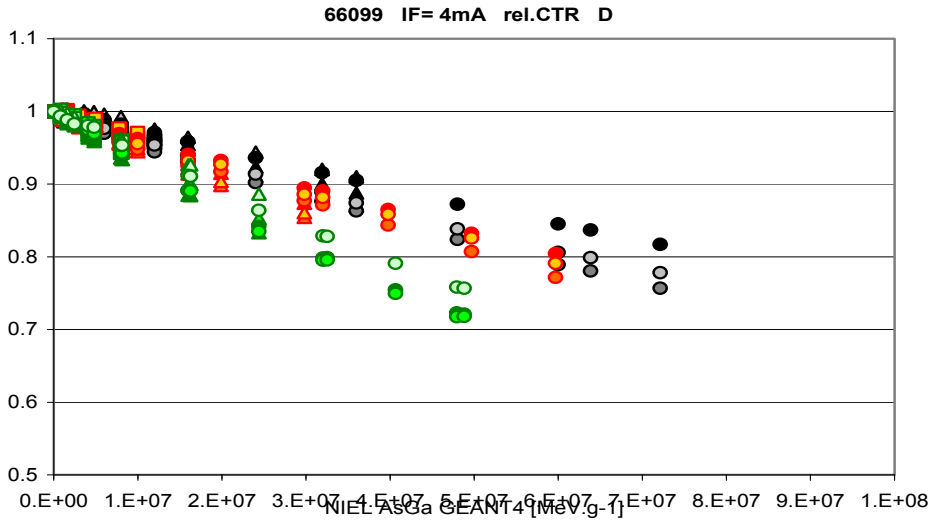
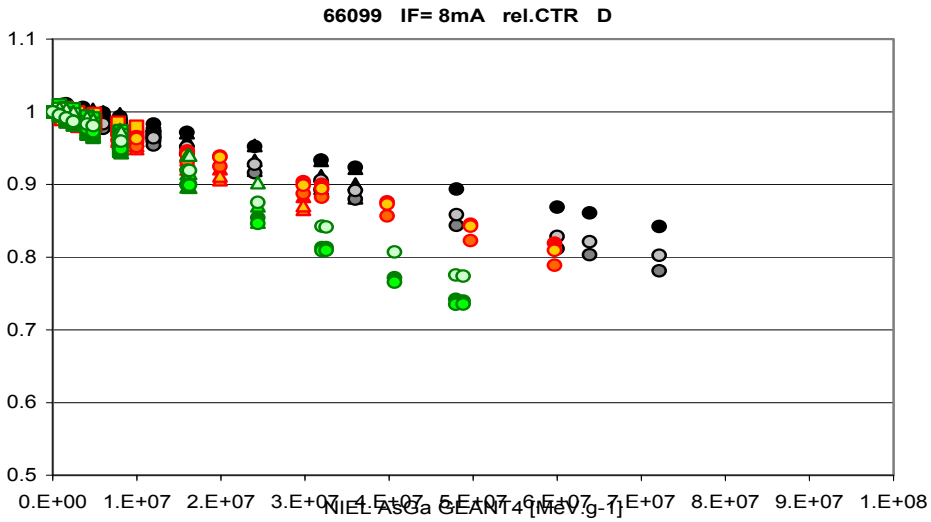

66099 IF= 10mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-19: 66099 diode: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)








66099 IF= 8mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

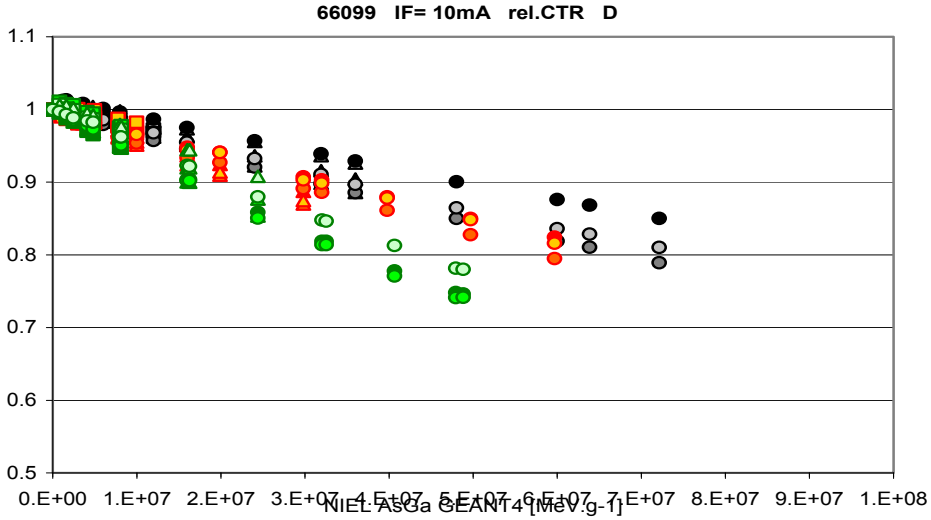
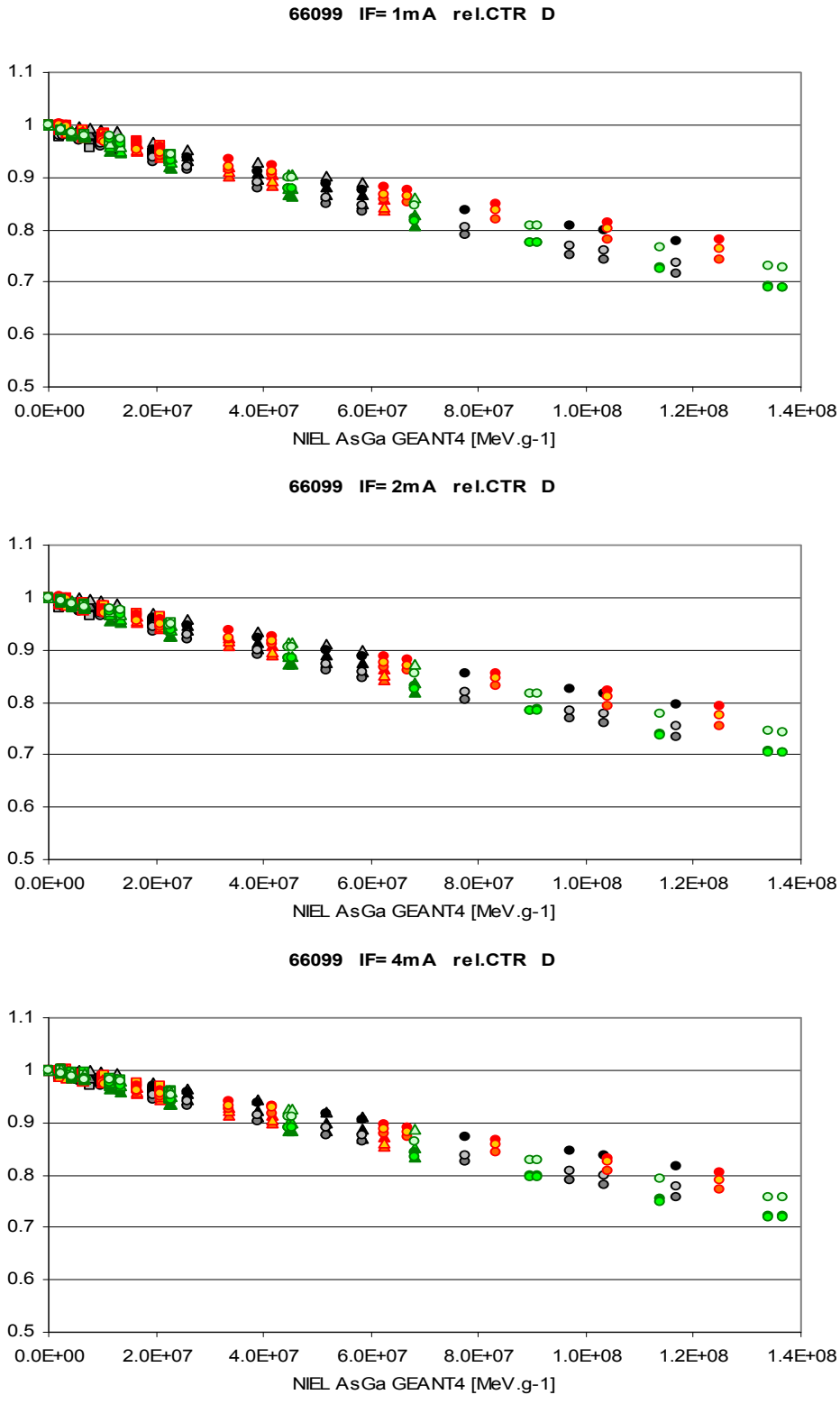
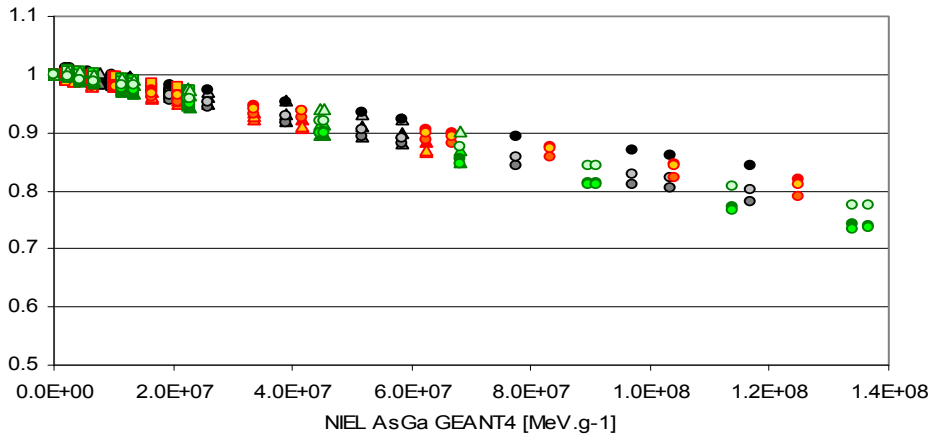

66099 IF= 10mA rel.CTR D
1.1
1
0.9
0.8
0.7
0.6
0.5
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-20: 66099 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)



66099 IF= 8mA rel.CTR D



66099 IF= 10mA rel.CTR D

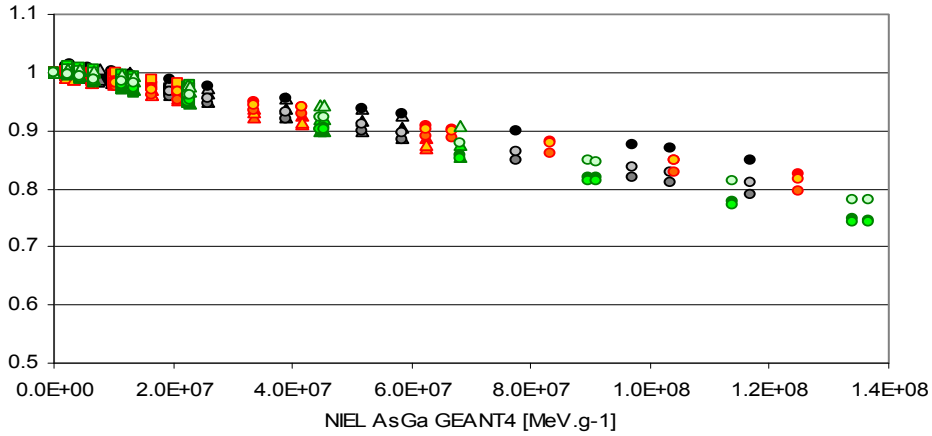
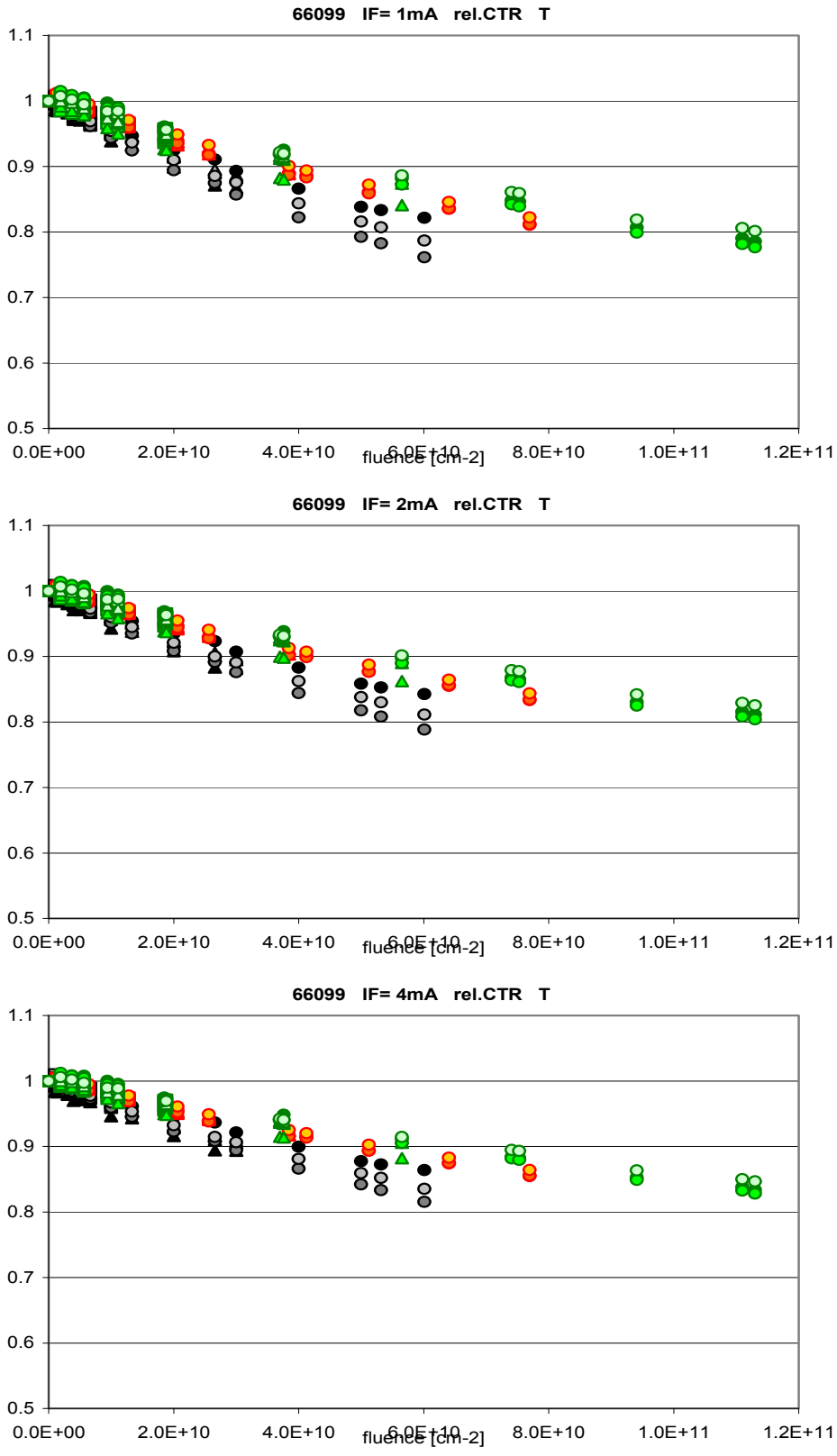
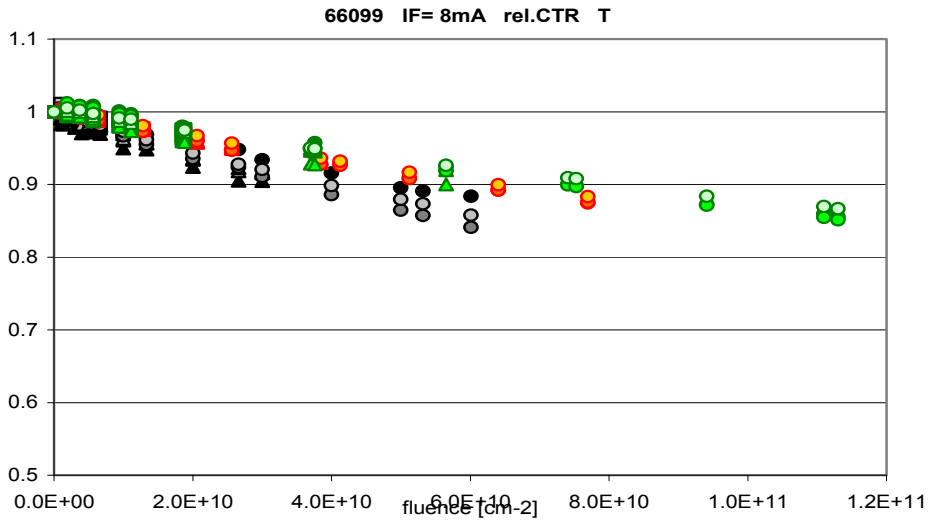


Fig. 14-21: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

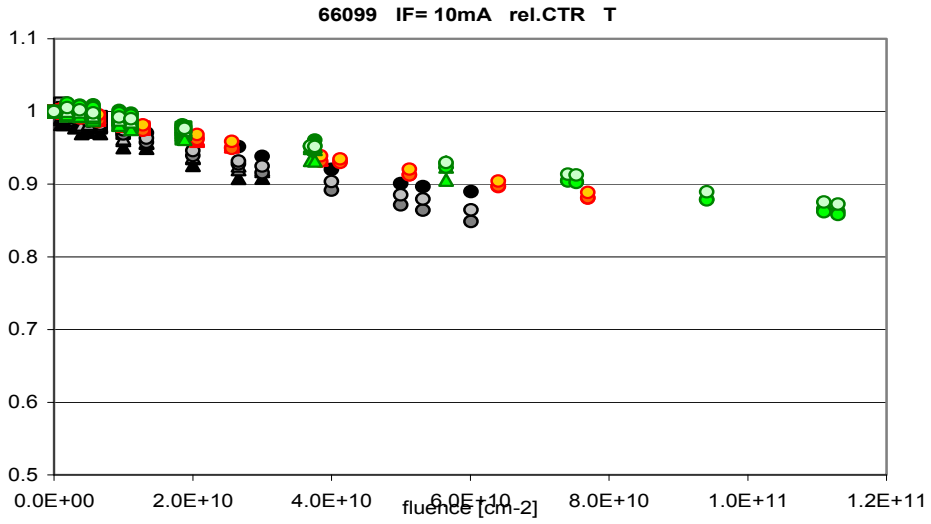
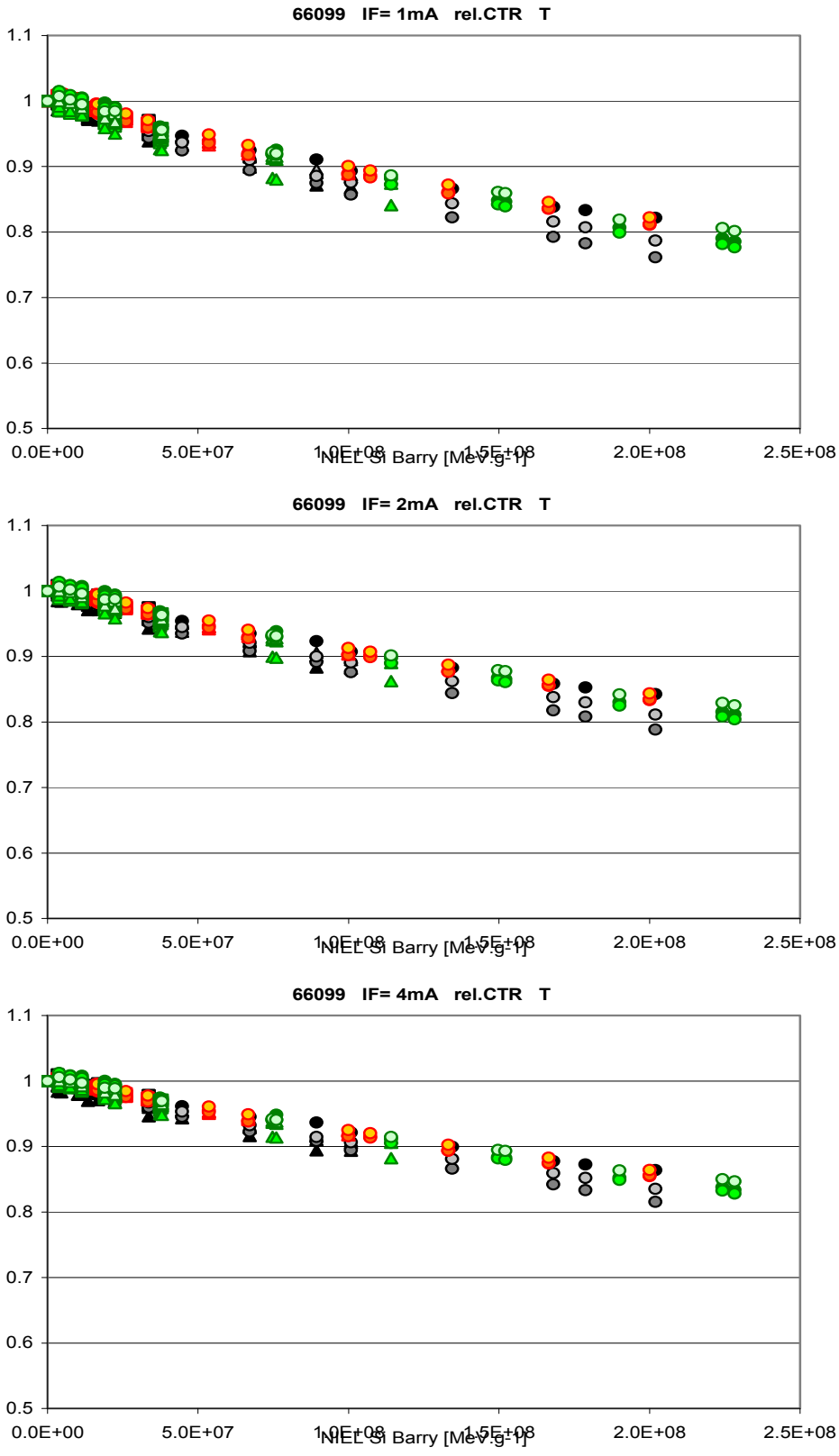
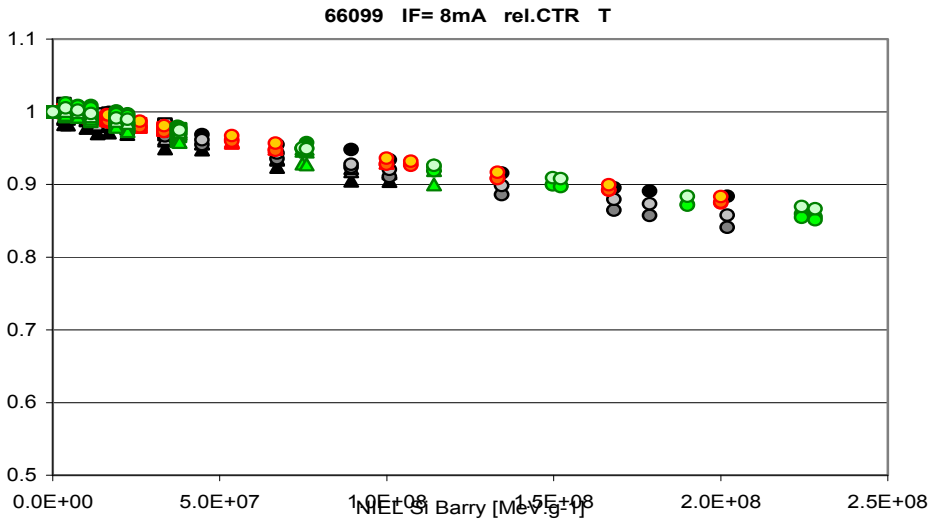

66099 IF= 10mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-22: 66099 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)




66099 IF= 8mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

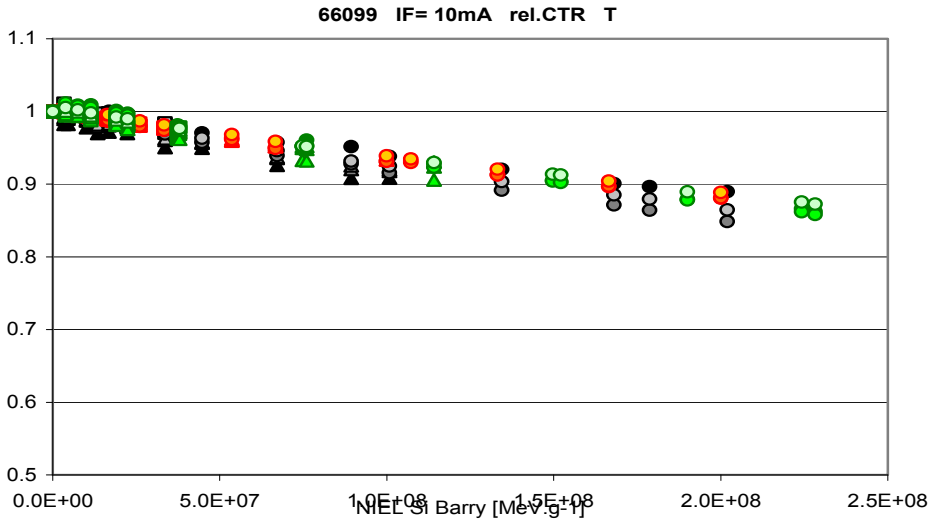
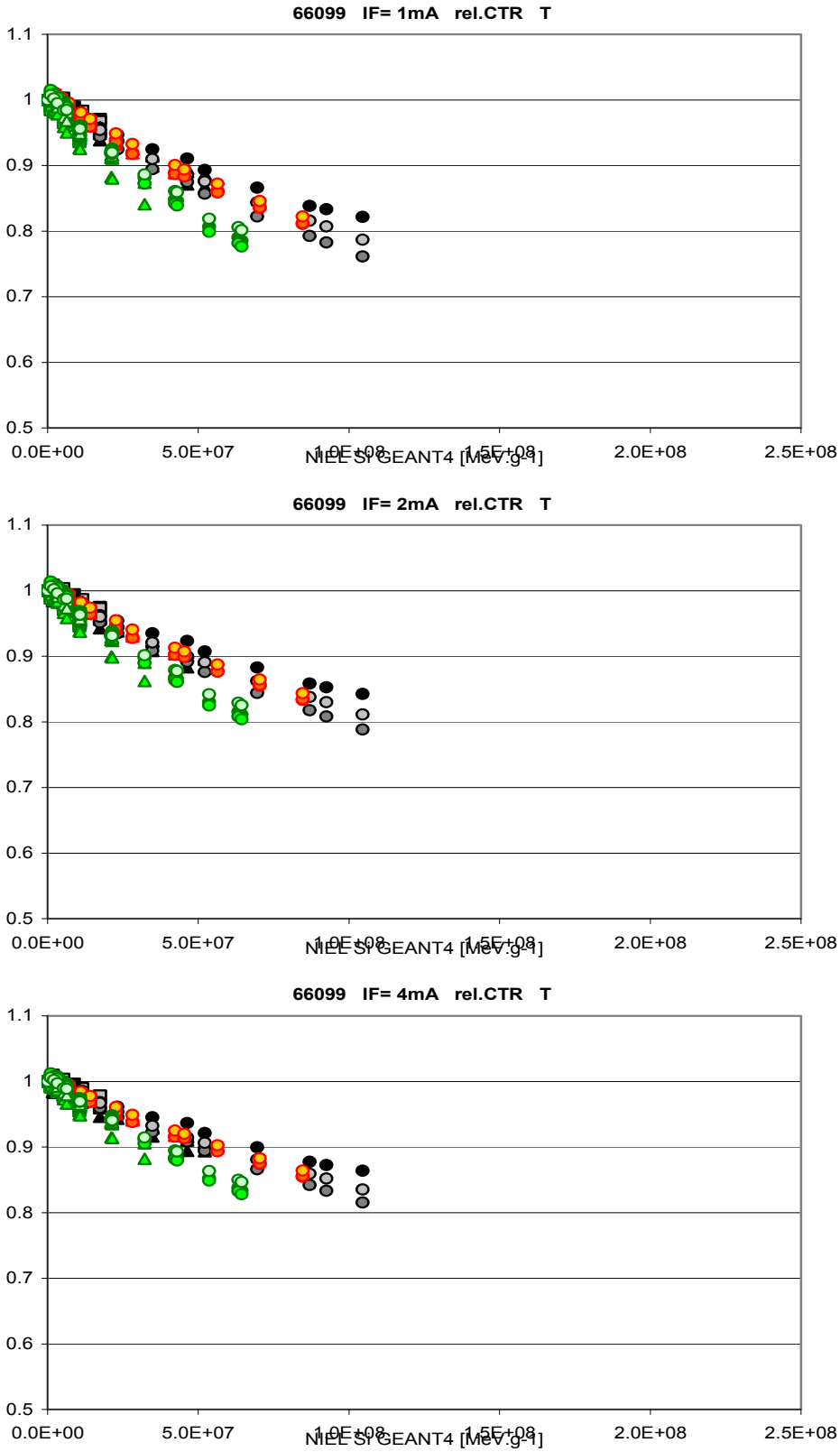
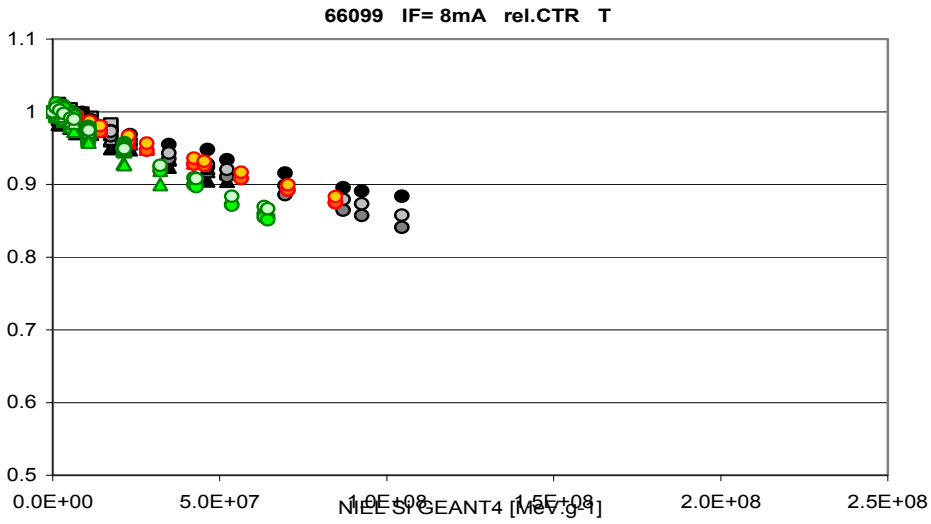

66099 IF= 10mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 14-23: 66099 transistor: CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




66099 IF= 8mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL SI GEANT4 [MeV.g-1]

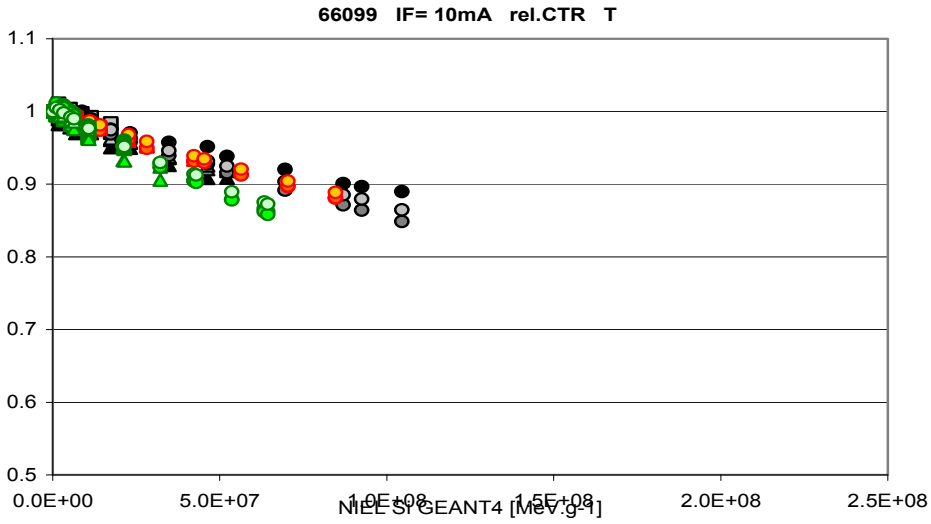
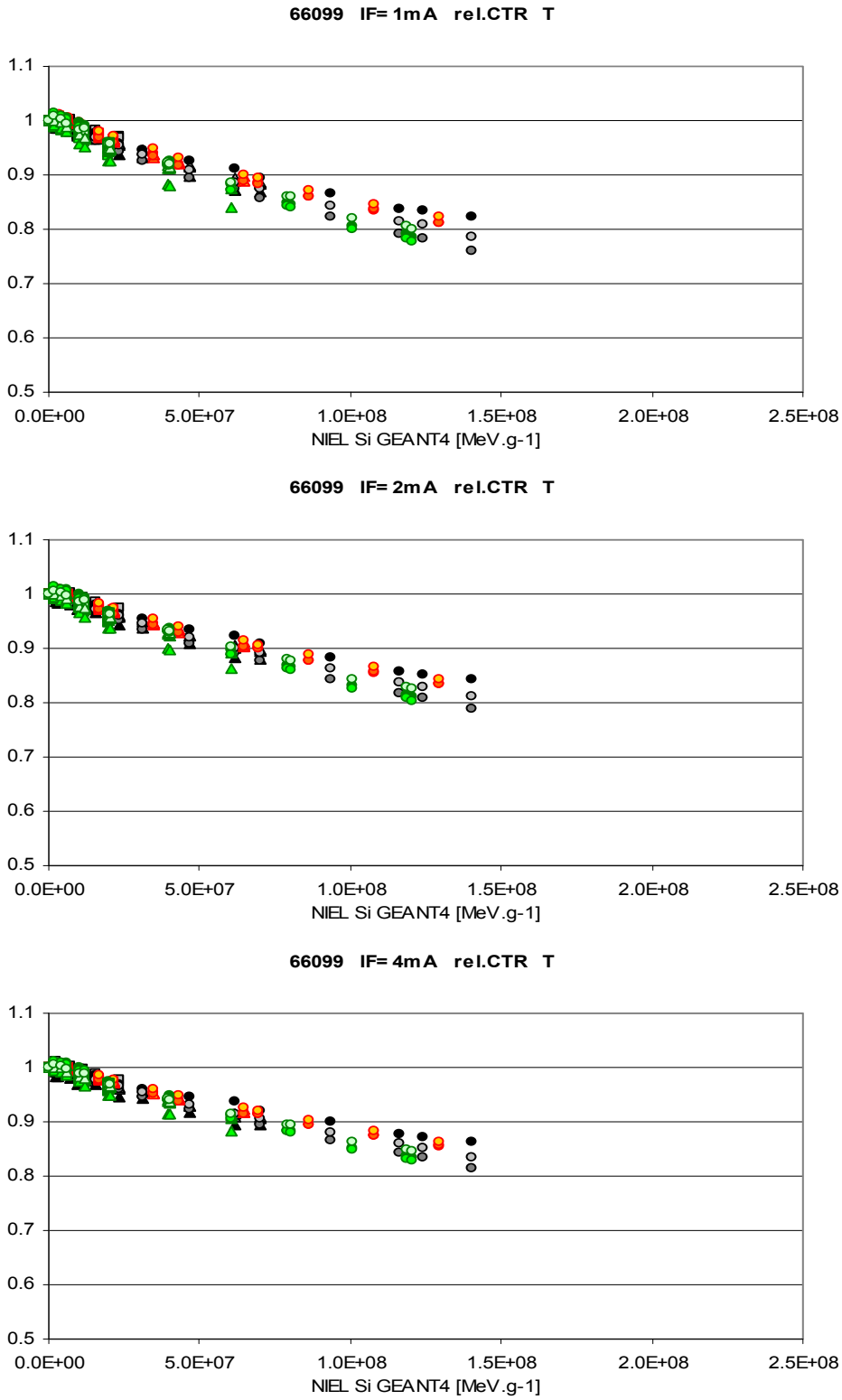
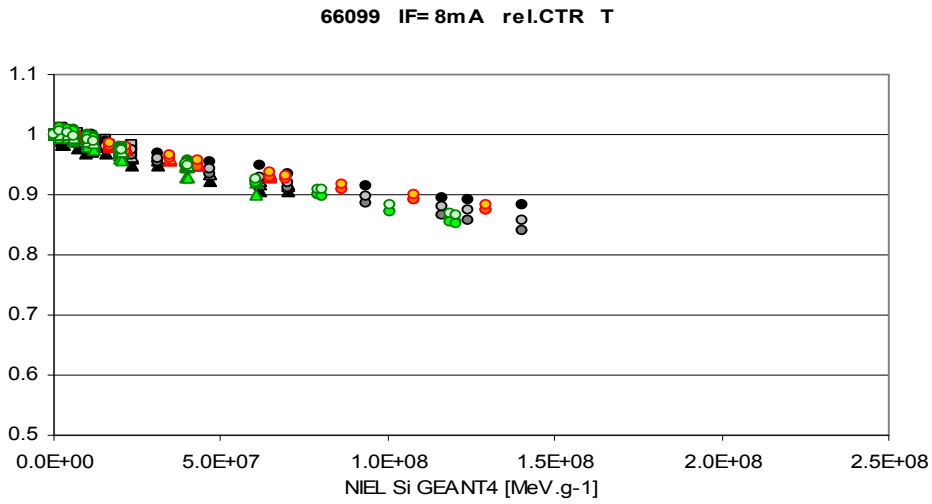

66099 IF= 10mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL SI GEANT4 [MeV.g-1]

Fig. 14-24: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)




66099 IF= 8mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

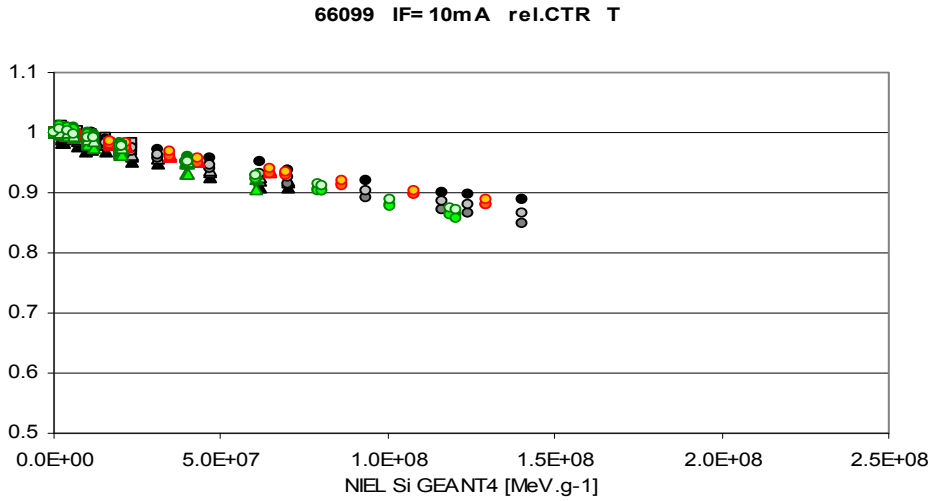
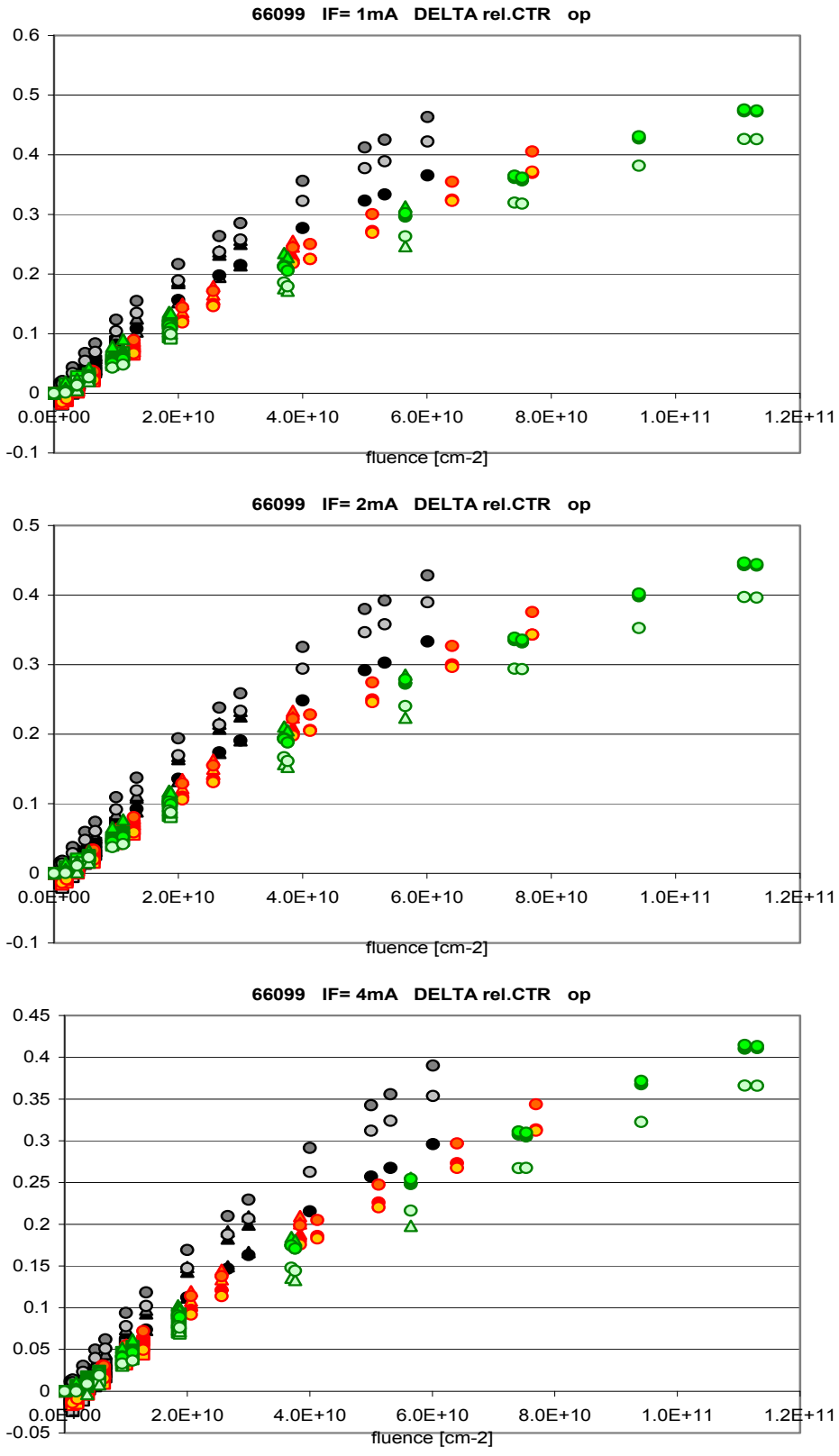
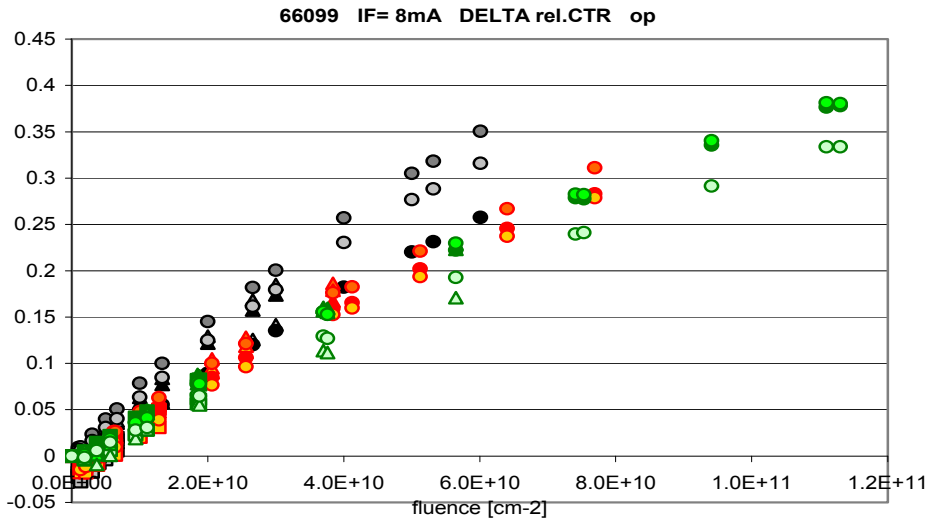

66099 IF= 10mA rel.CTR T
1.1
1
0.9
0.8
0.7
0.6
0.5
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

Fig. 14-25: 66099 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA DELTA rel.CTR op
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

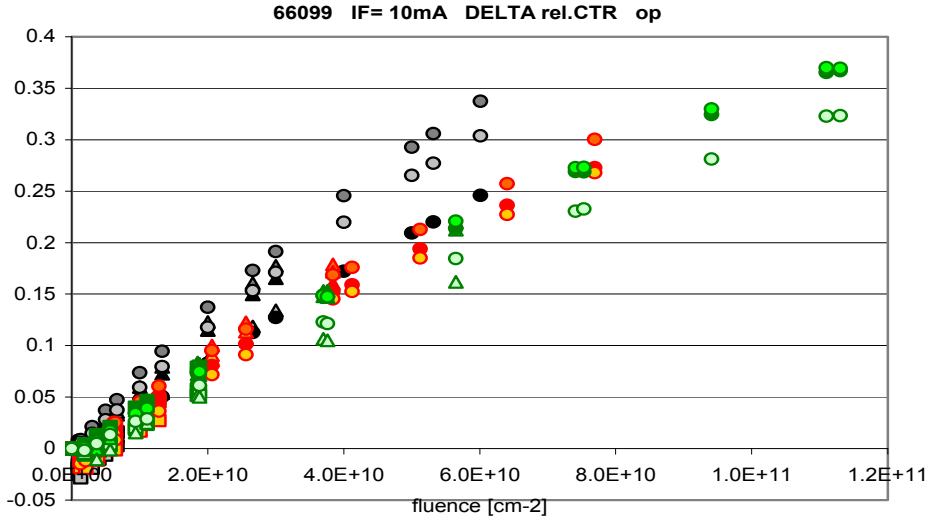
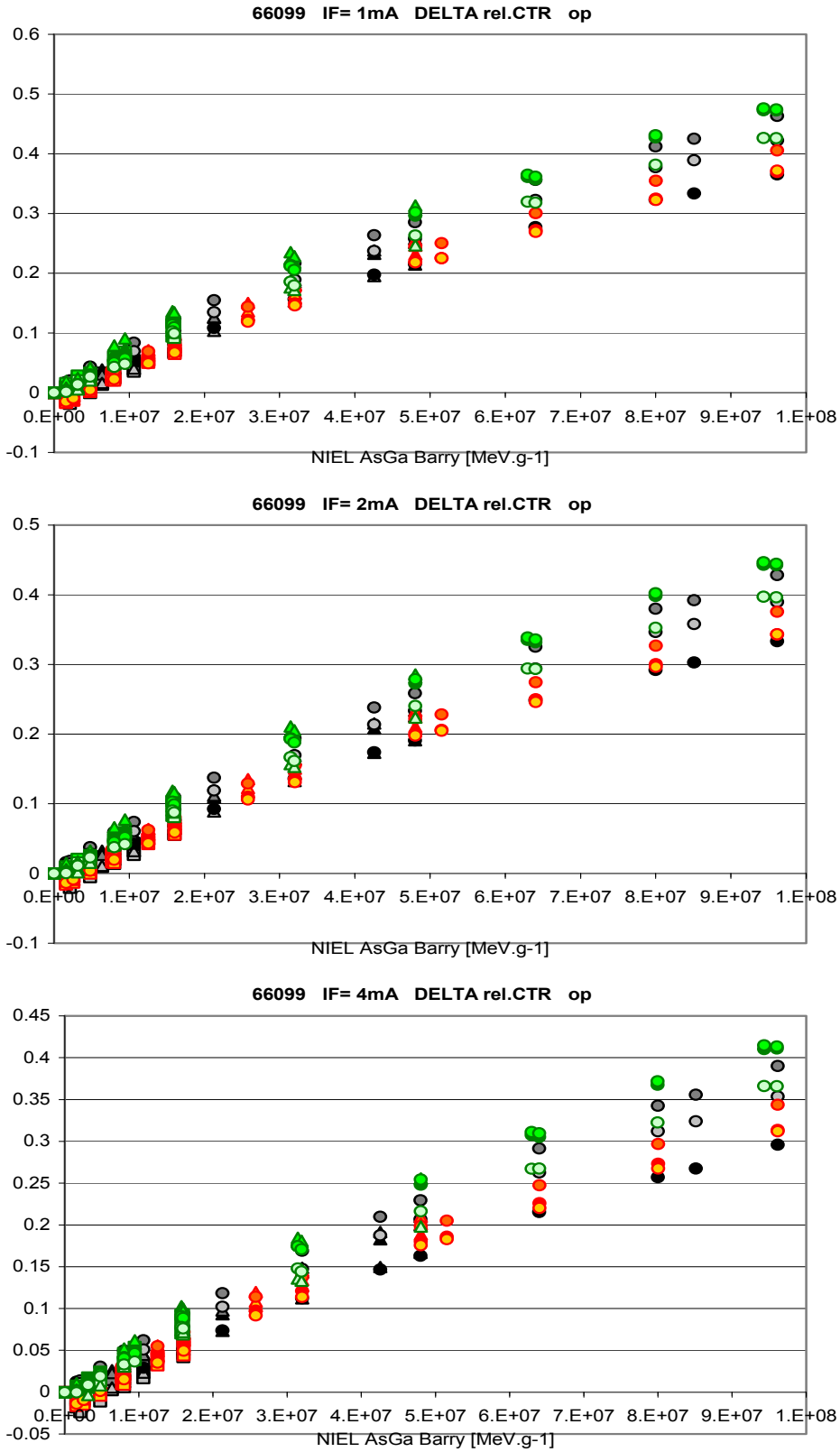
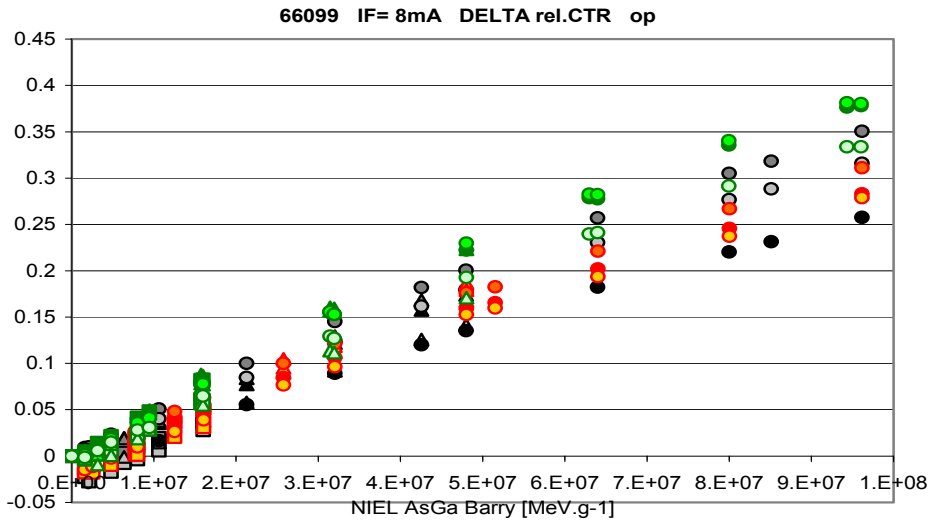

66099 IF= 10mA DELTA rel.CTR op
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-26: 66099 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)




66099 IF= 8mA DELTA rel.CTR op
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00
1.E+07
2.E+07
3.E+07
4.E+07
5.E+07
6.E+07
7.E+07
8.E+07
9.E+07
1.E+08
NIEL AsGa Barry [MeV.g-1]

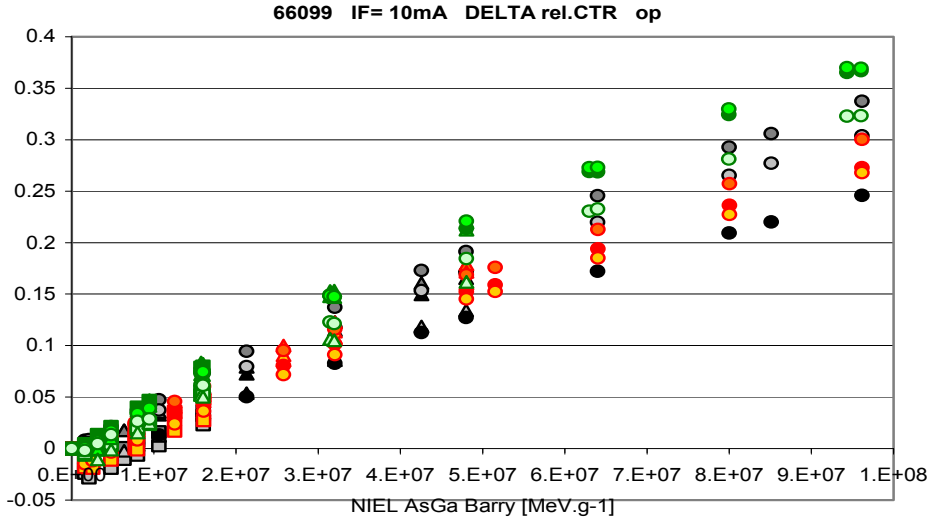
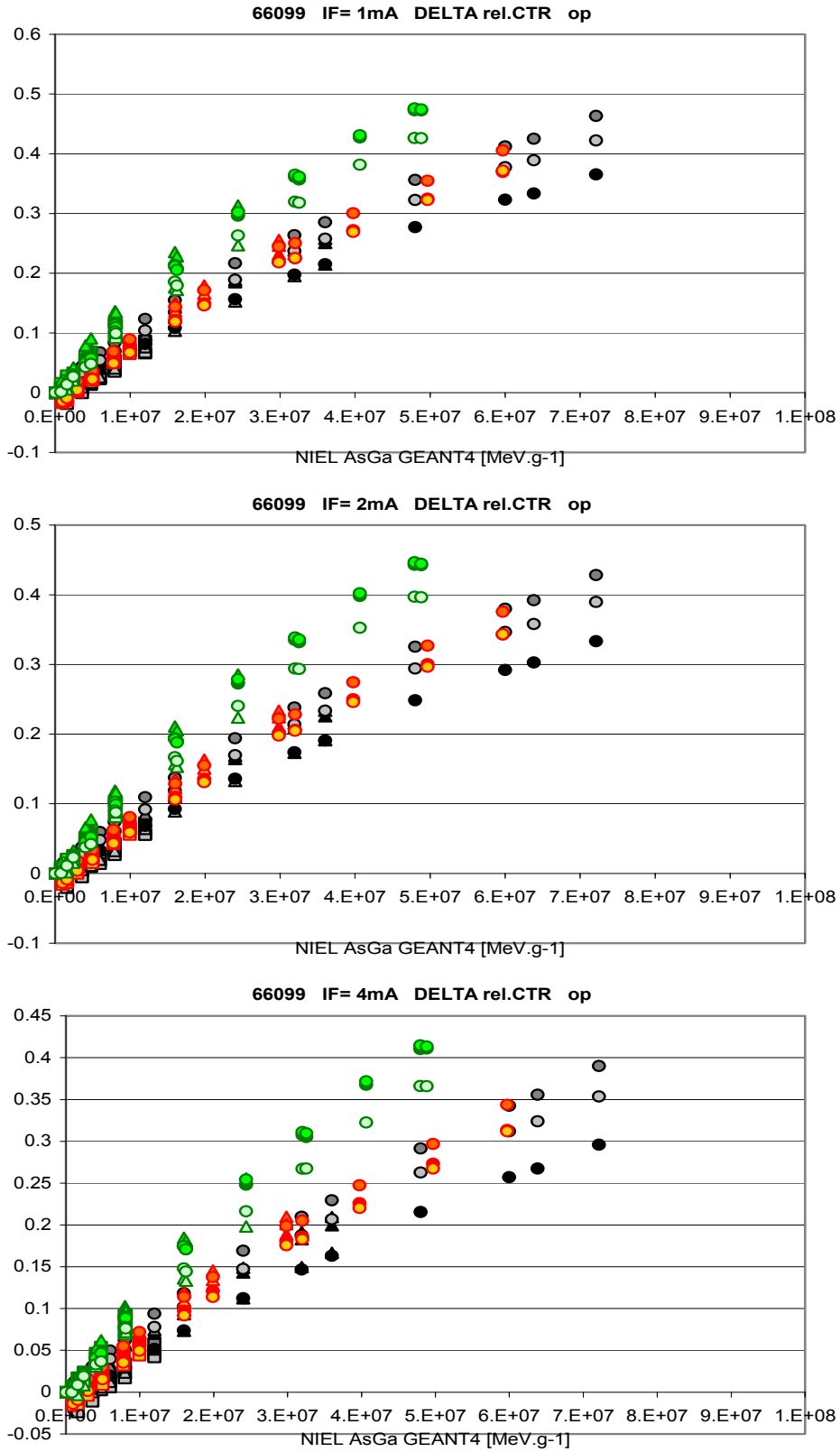
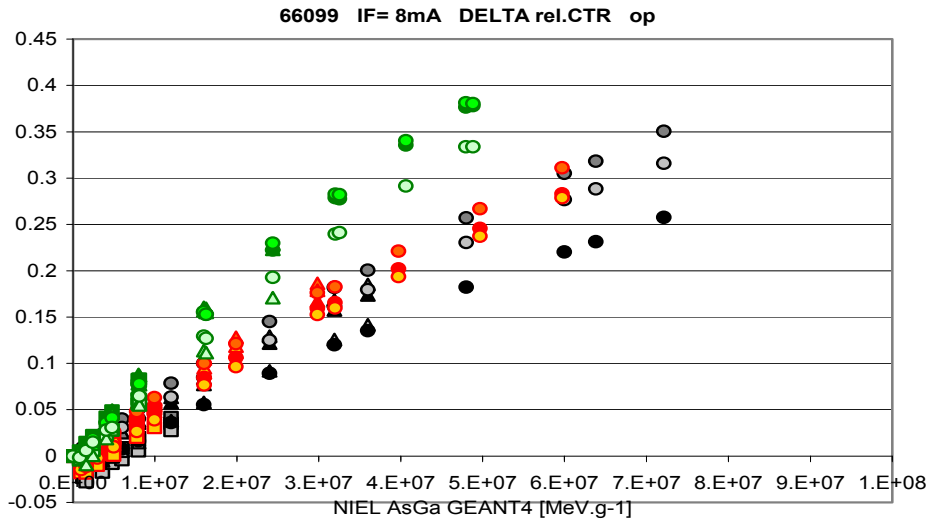

66099 IF= 10mA DELTA rel.CTR op
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00
1.E+07
2.E+07
3.E+07
4.E+07
5.E+07
6.E+07
7.E+07
8.E+07
9.E+07
1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-27: 66099 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)




66099 IF= 8mA DELTA rel.CTR op
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

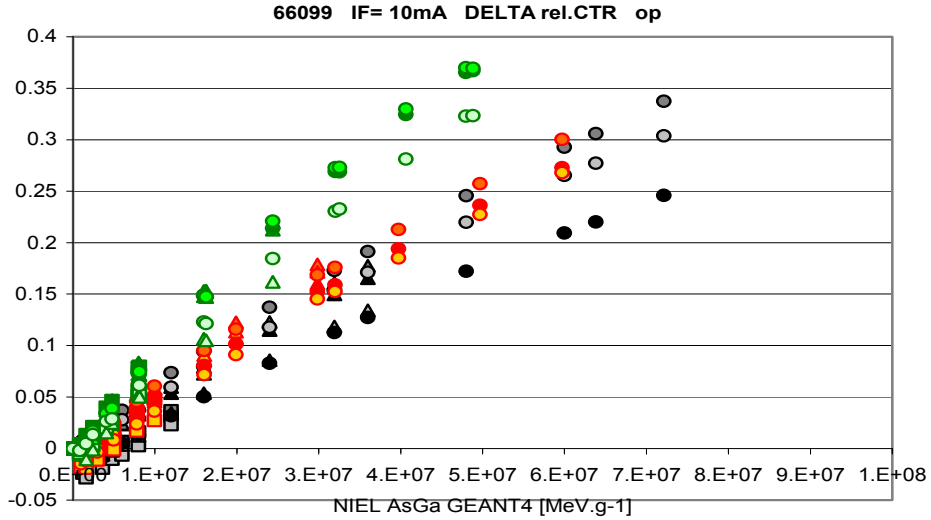
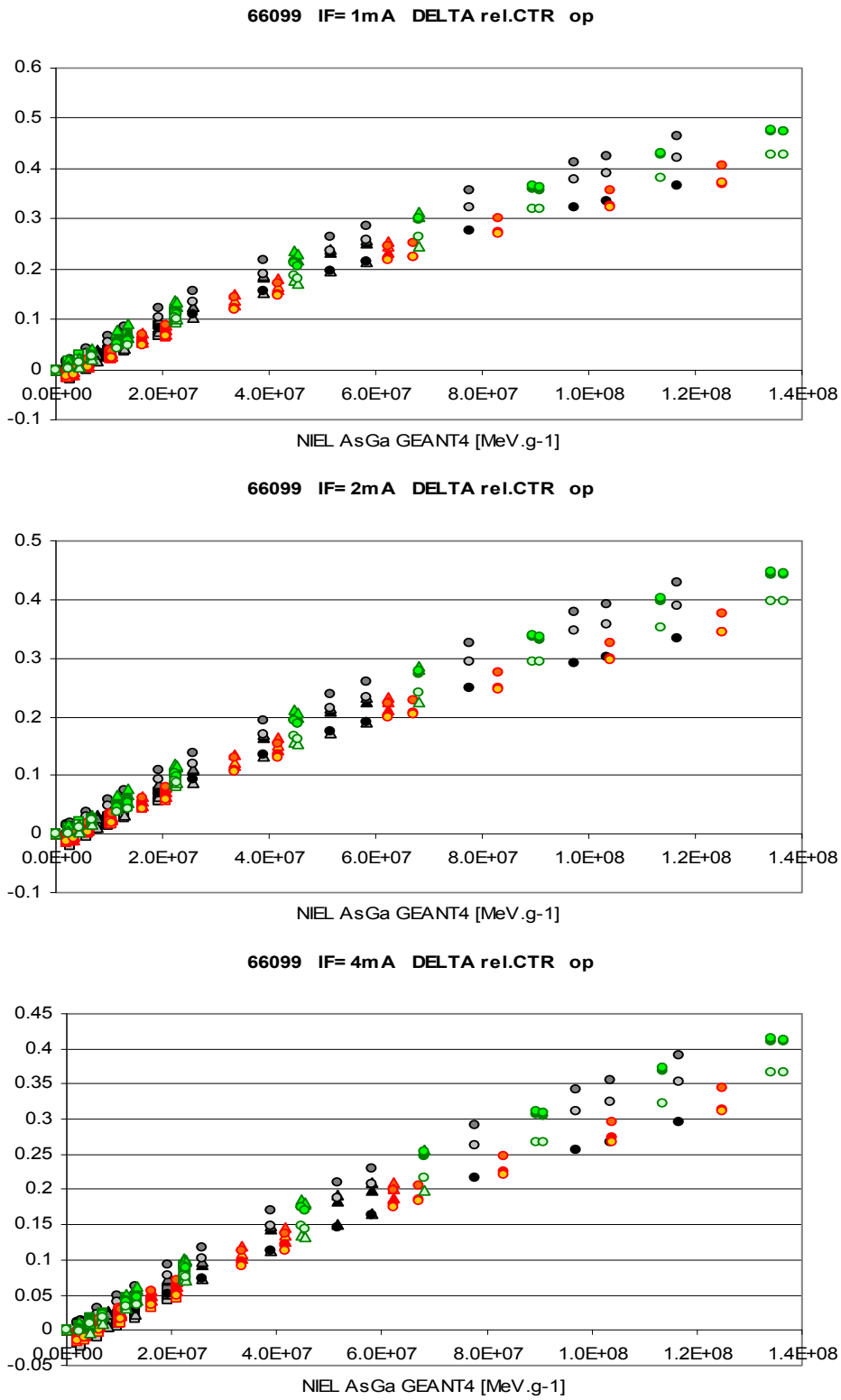
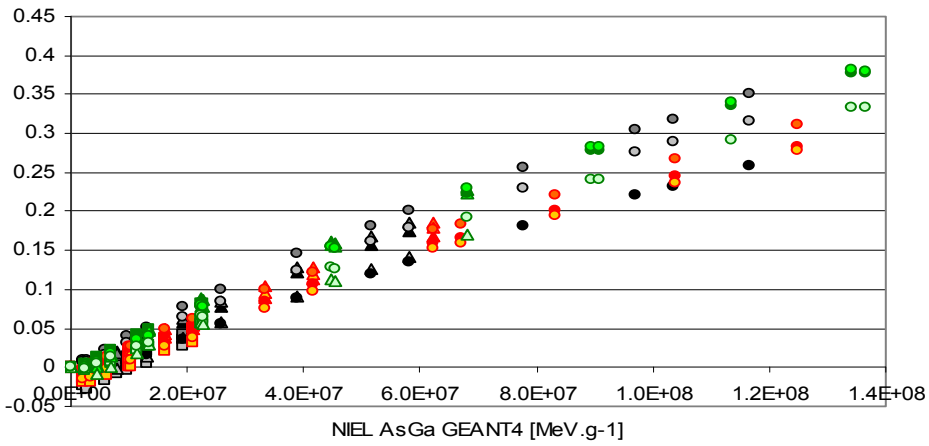

66099 IF= 10mA DELTA rel.CTR op
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

Fig. 14-28: 66099 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)



66099 IF= 8mA DELTA rel.CTR op



66099 IF= 10mA DELTA rel.CTR op

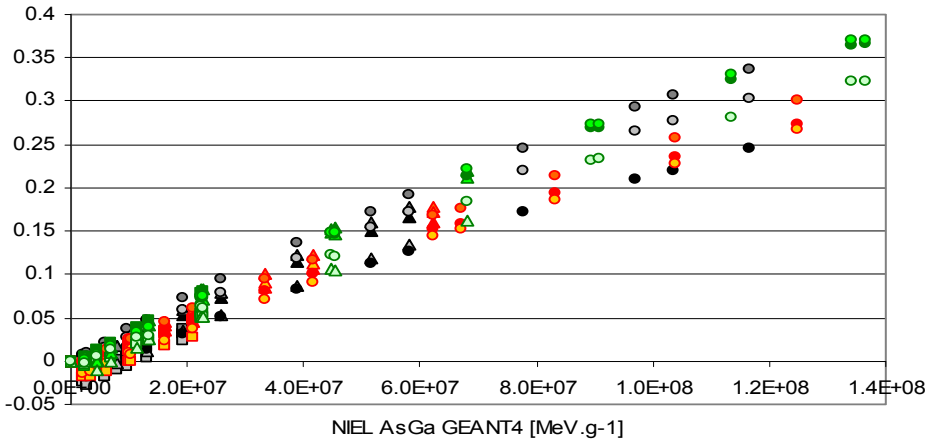
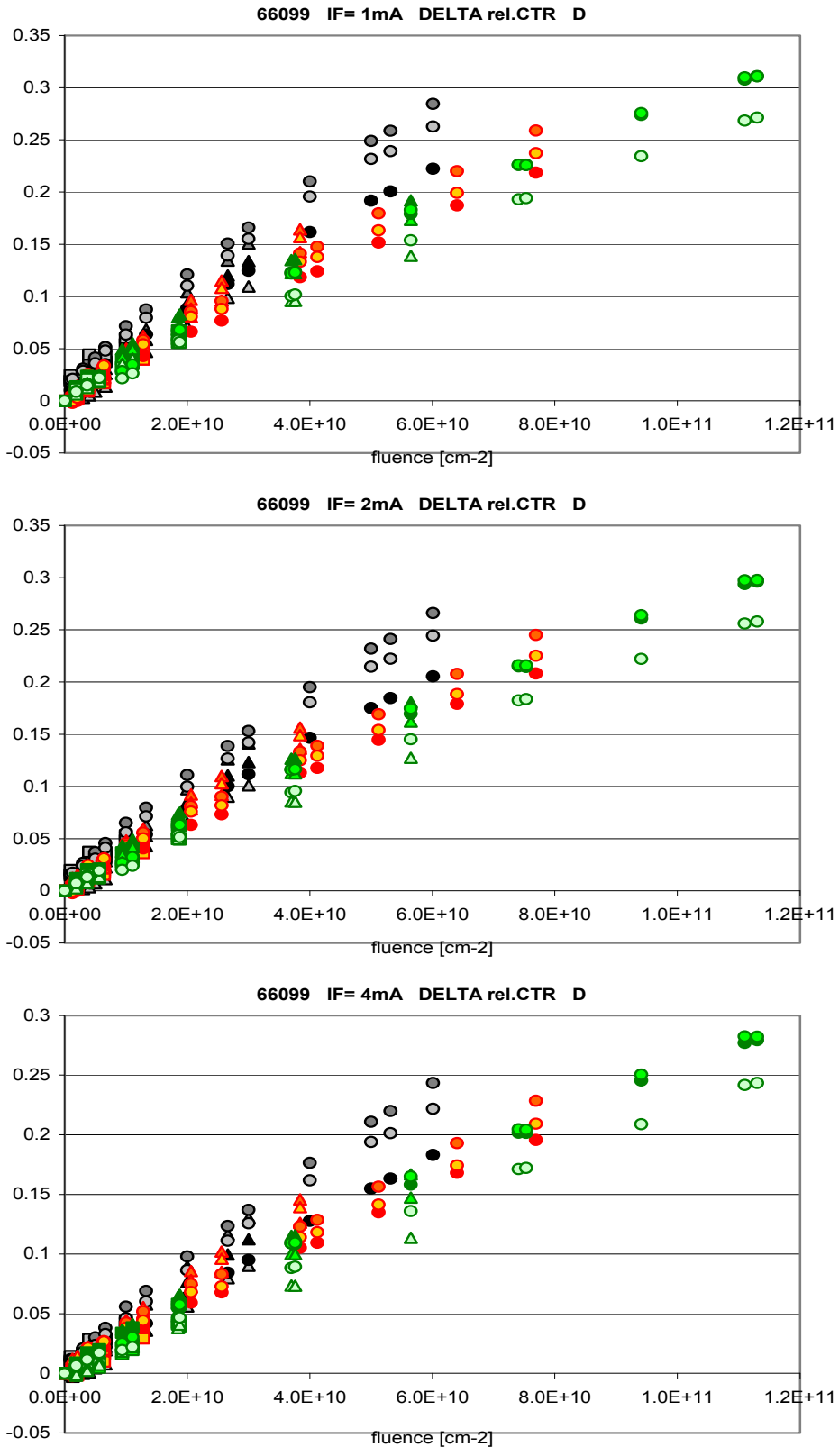
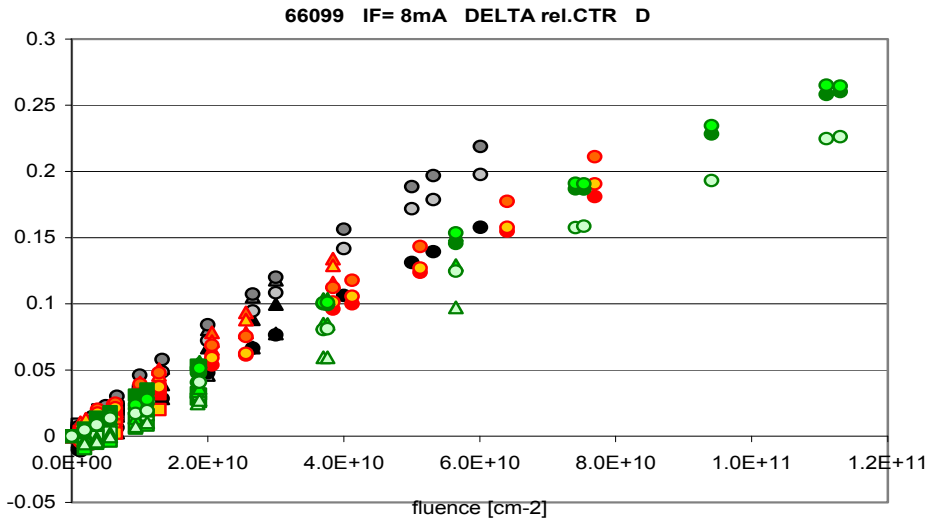


Fig. 14-29: 66099 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

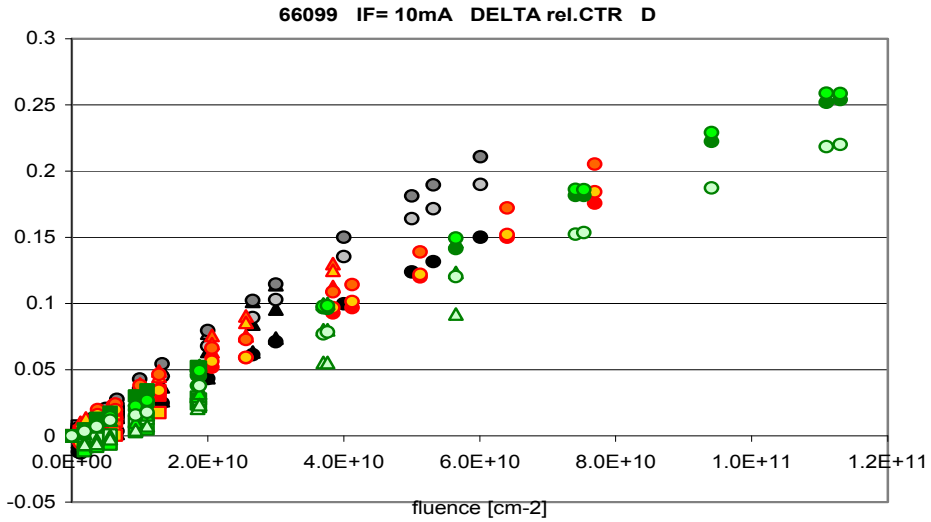
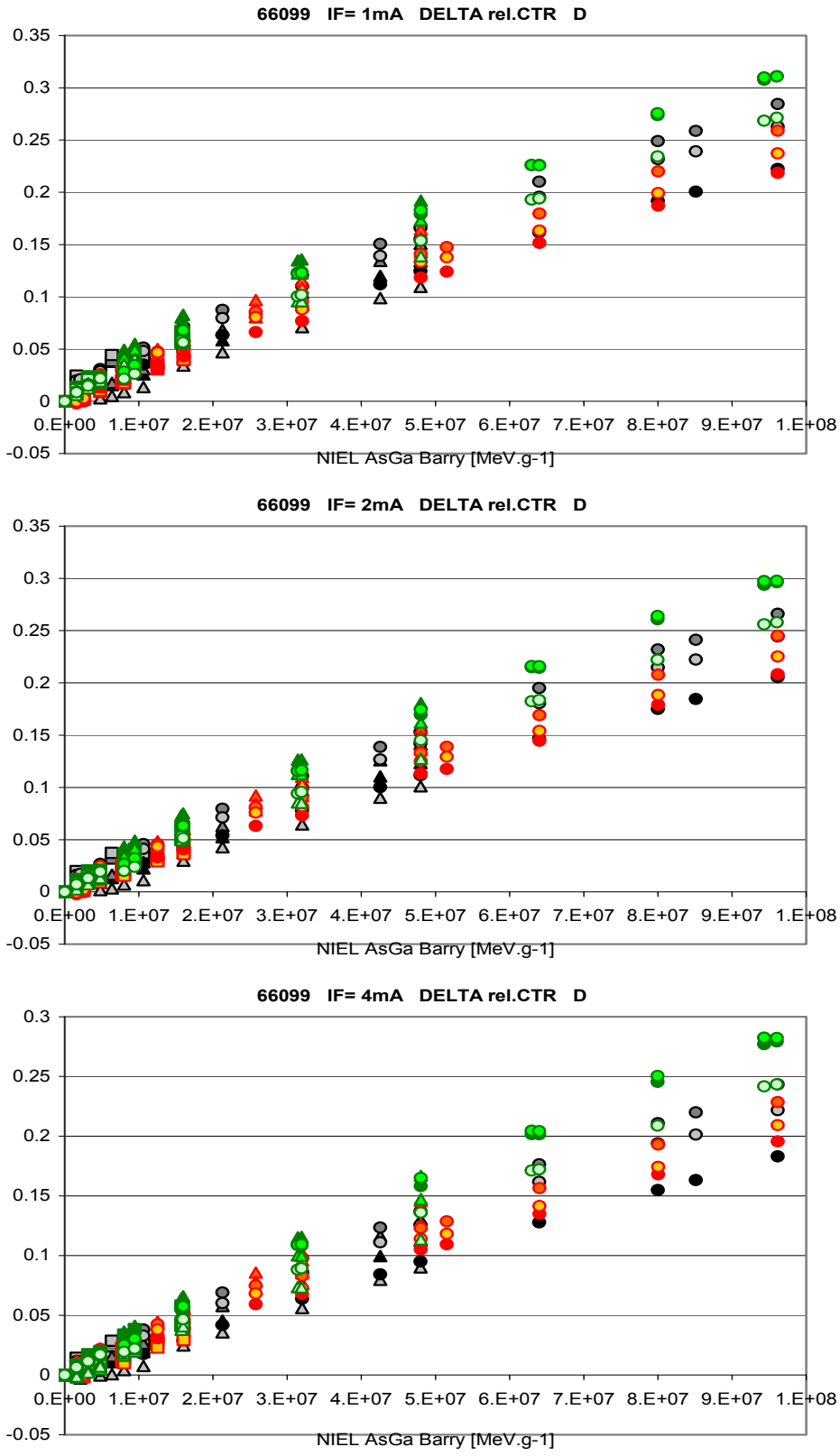
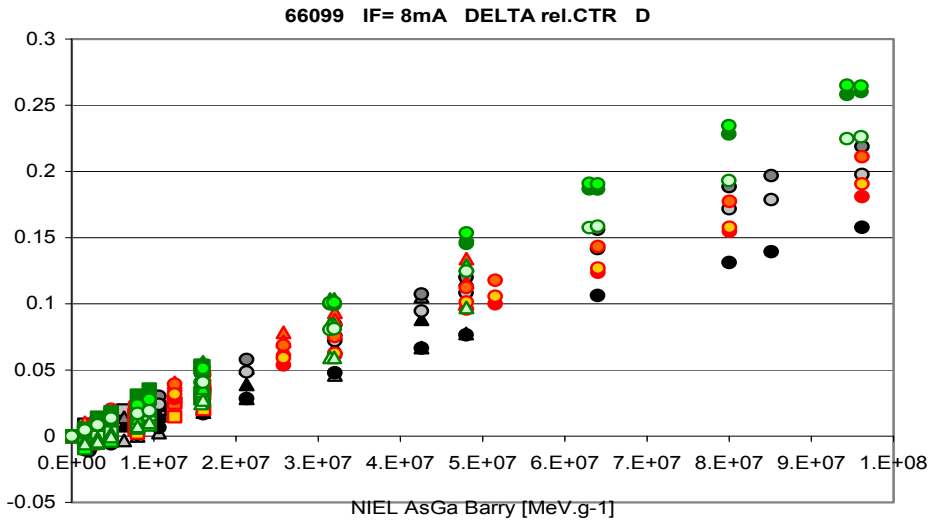

66099 IF= 10mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-30: 66099 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (Barry)




66099 IF= 8mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00
1.E+07
2.E+07
3.E+07
4.E+07
5.E+07
6.E+07
7.E+07
8.E+07
9.E+07
1.E+08
NIEL AsGa Barry [MeV.g-1]

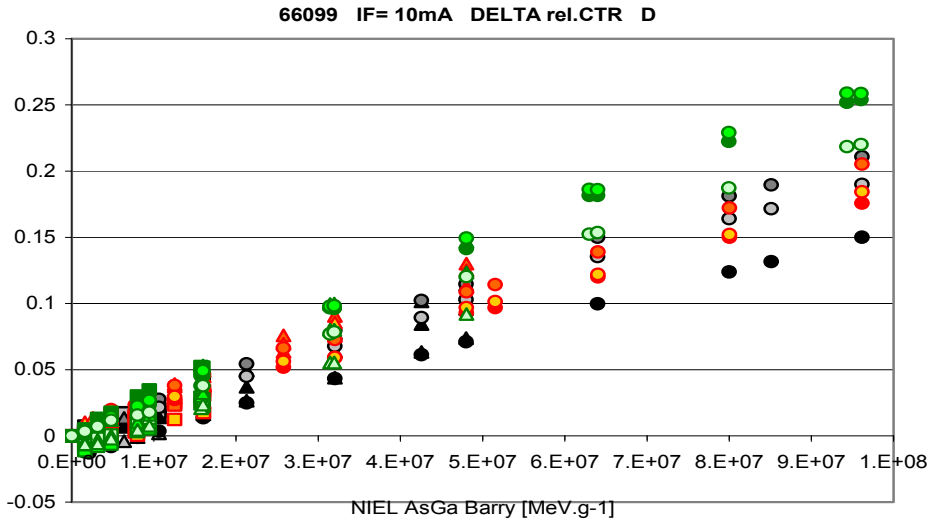
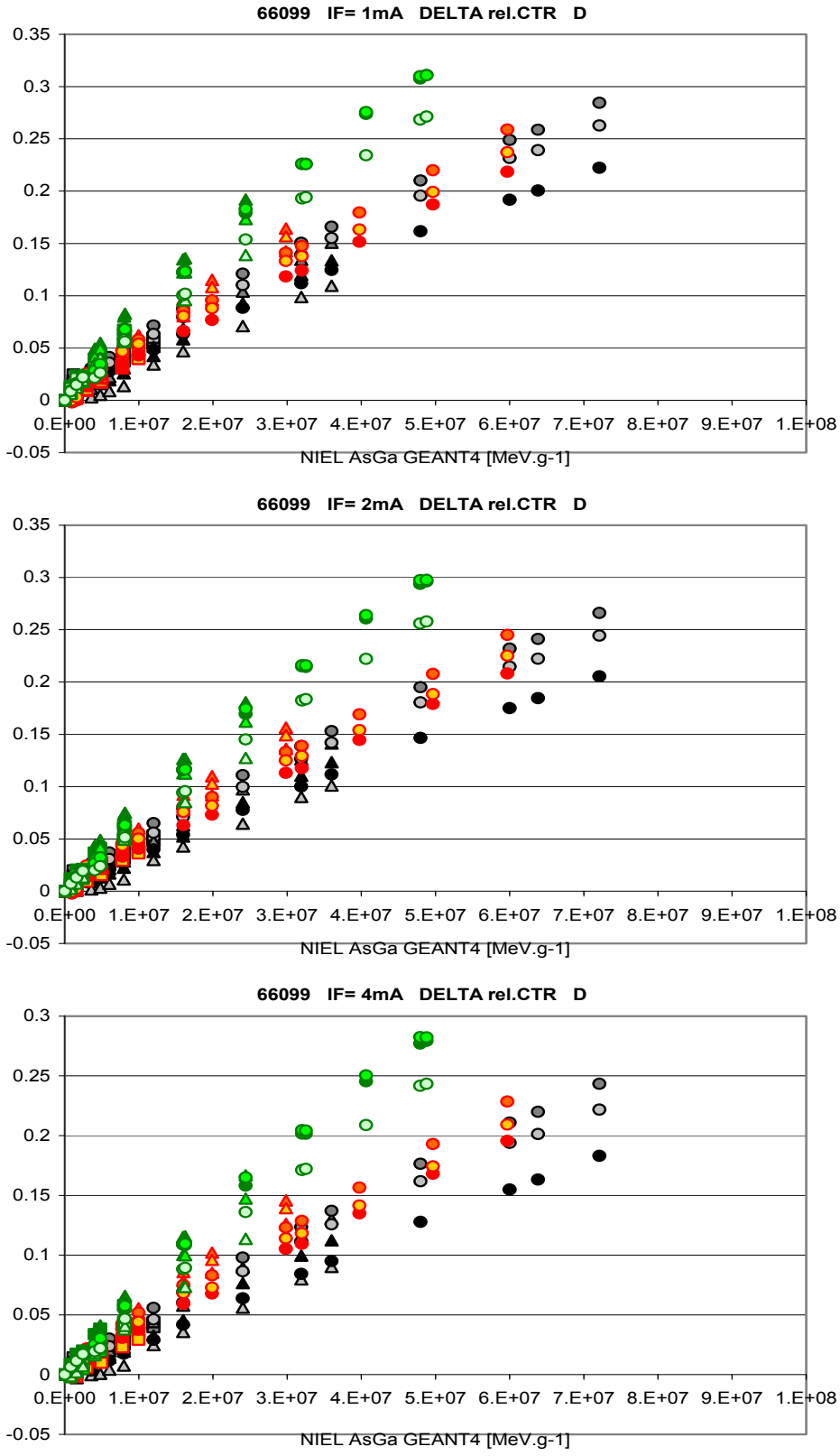
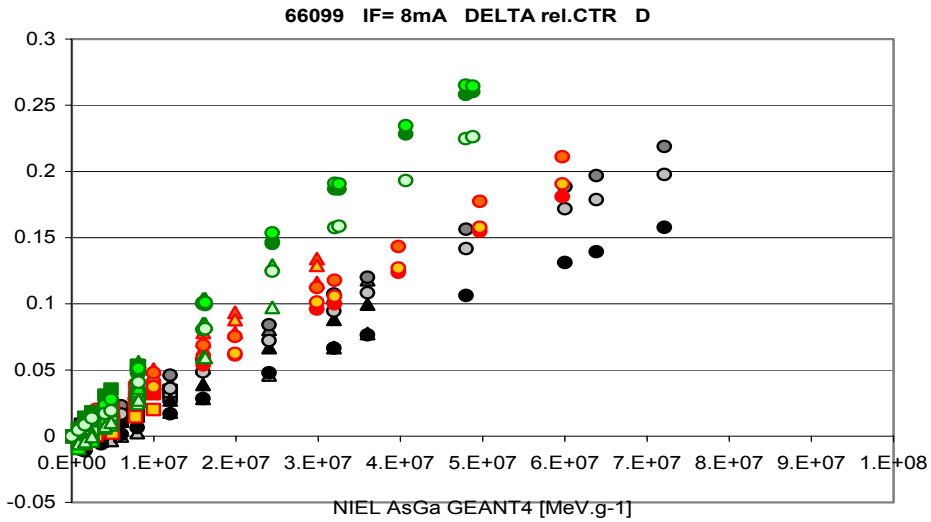

66099 IF= 10mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00
1.E+07
2.E+07
3.E+07
4.E+07
5.E+07
6.E+07
7.E+07
8.E+07
9.E+07
1.E+08
NIEL AsGa Barry [MeV.g-1]

Fig. 14-31: 66099 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 ELASTIC)




66099 IF= 8mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

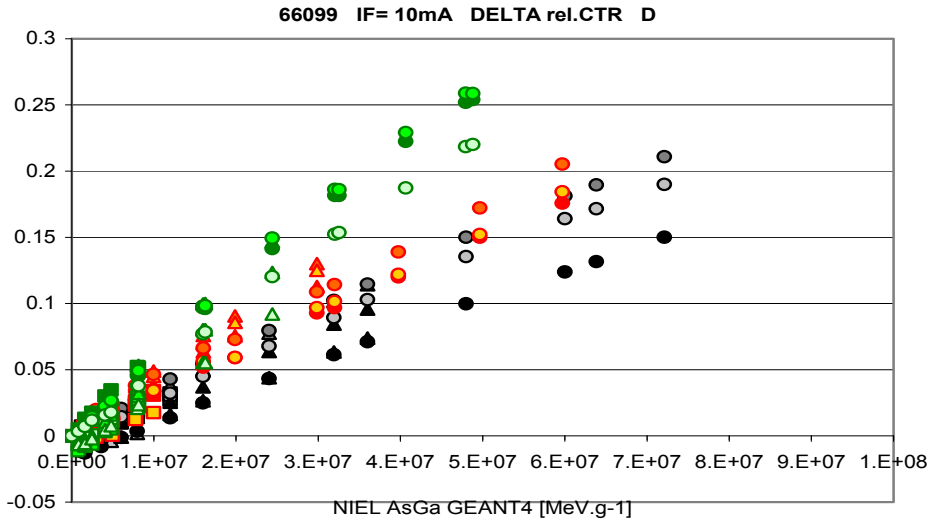
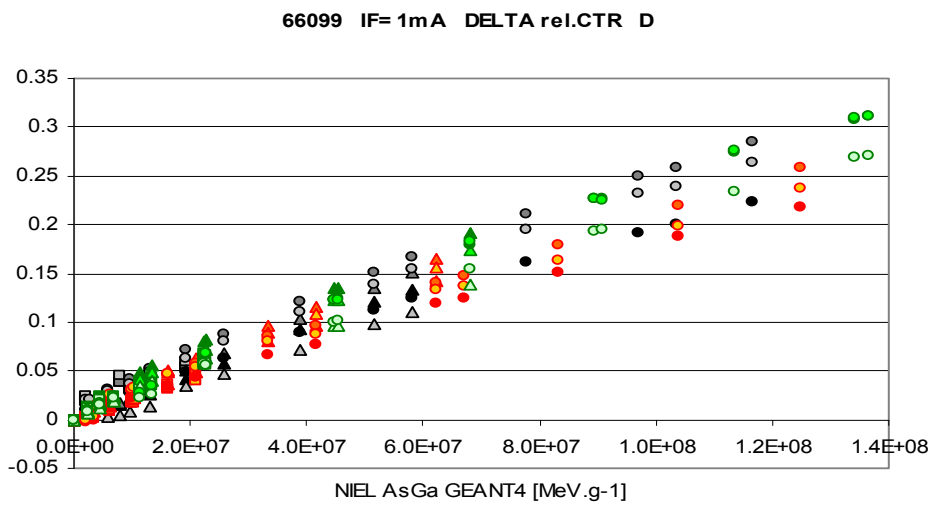
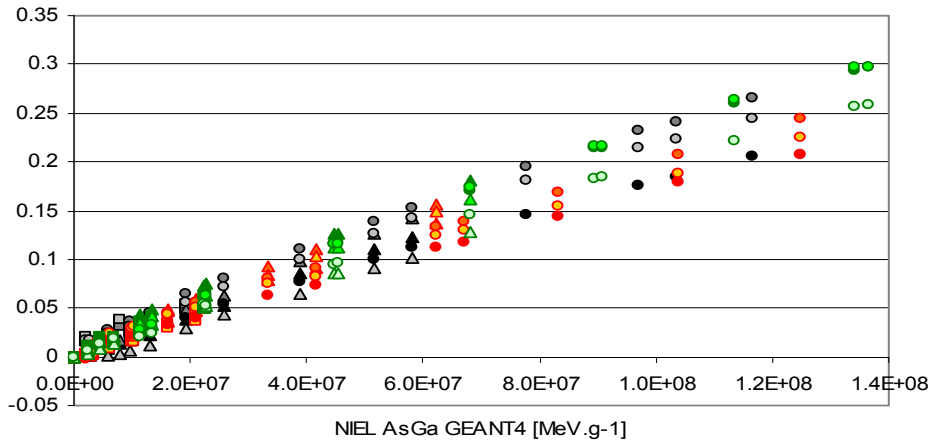
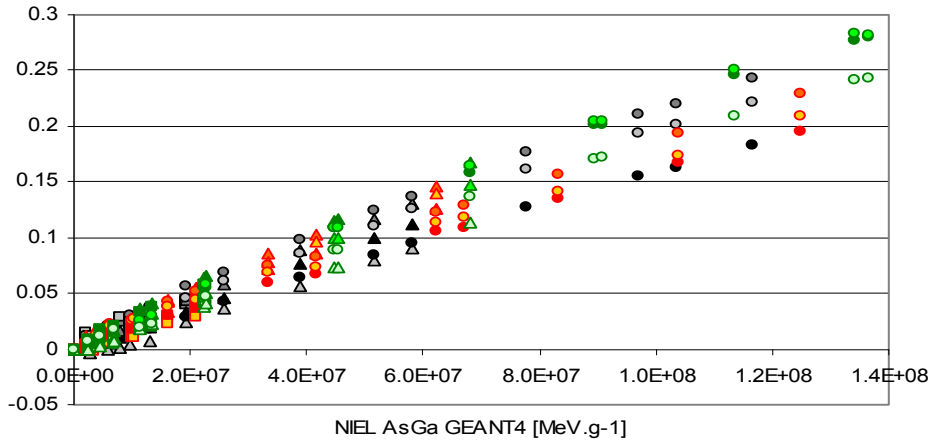

66099 IF= 10mA DELTA rel.CTR D
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.E+00 1.E+07 2.E+07 3.E+07 4.E+07 5.E+07 6.E+07 7.E+07 8.E+07 9.E+07 1.E+08
NIEL AsGa GEANT4 [MeV.g-1]

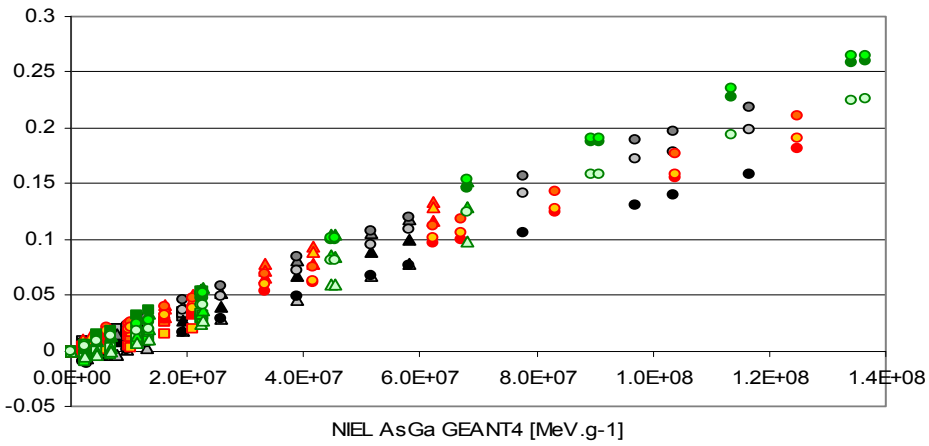
Fig. 14-32: 66099 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in GaAs (GEANT4 TOTAL)







66099 IF= 8mA DELTA rel.CTR D



66099 IF= 10mA DELTA rel.CTR D

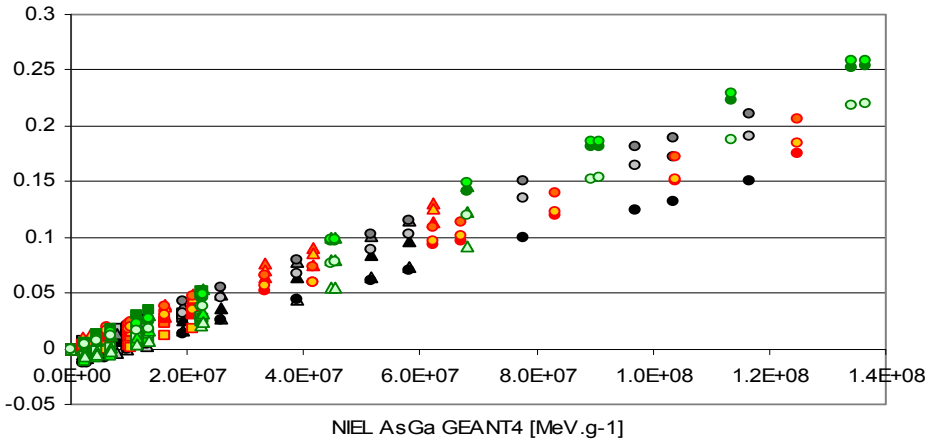
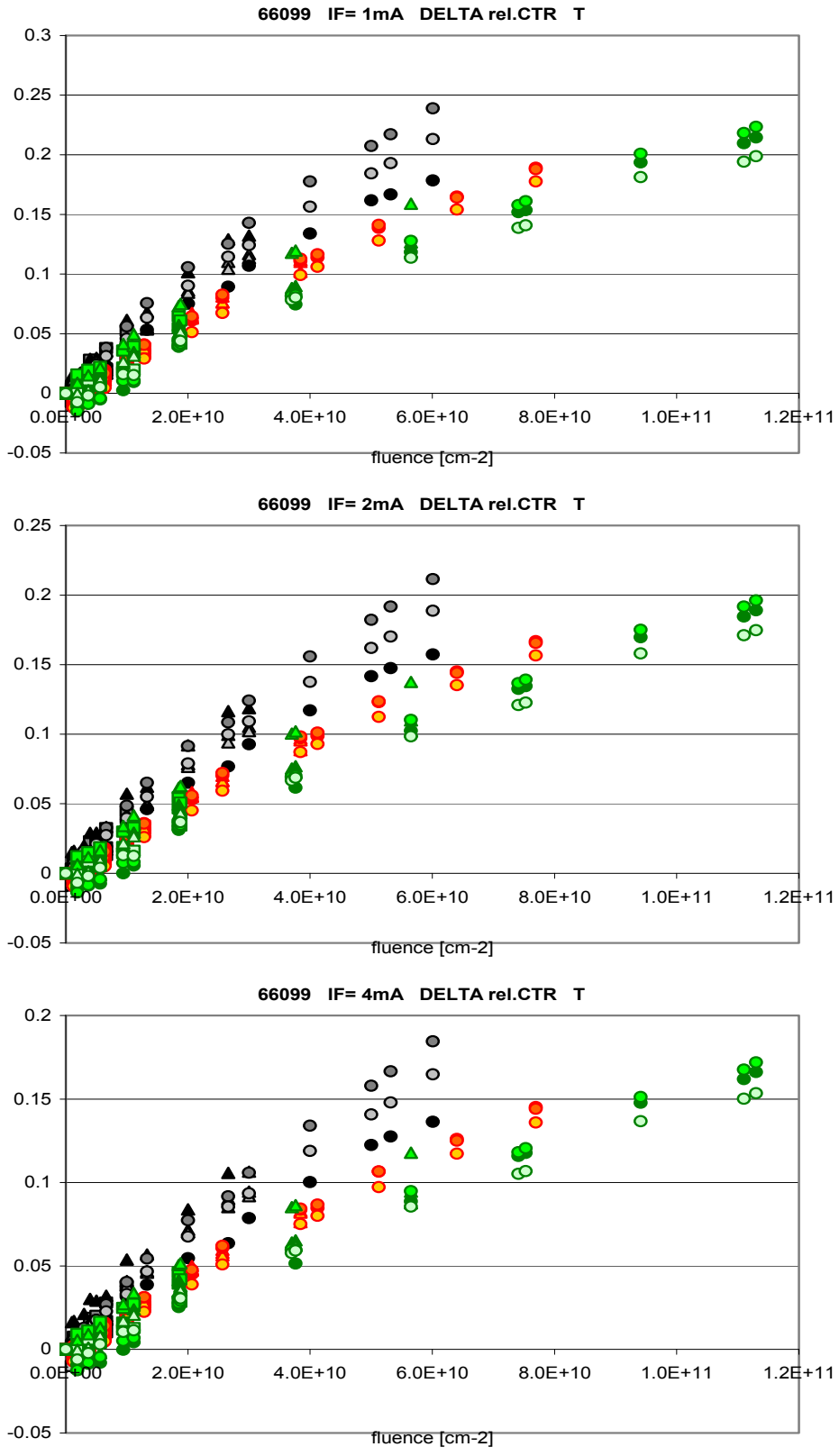
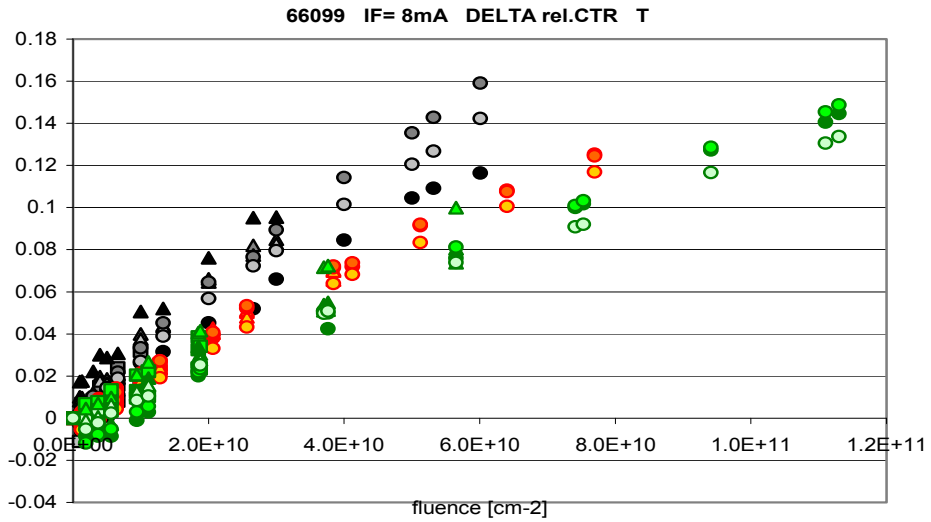


Fig. 14-33: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence




66099 IF= 8mA DELTA rel.CTR T
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

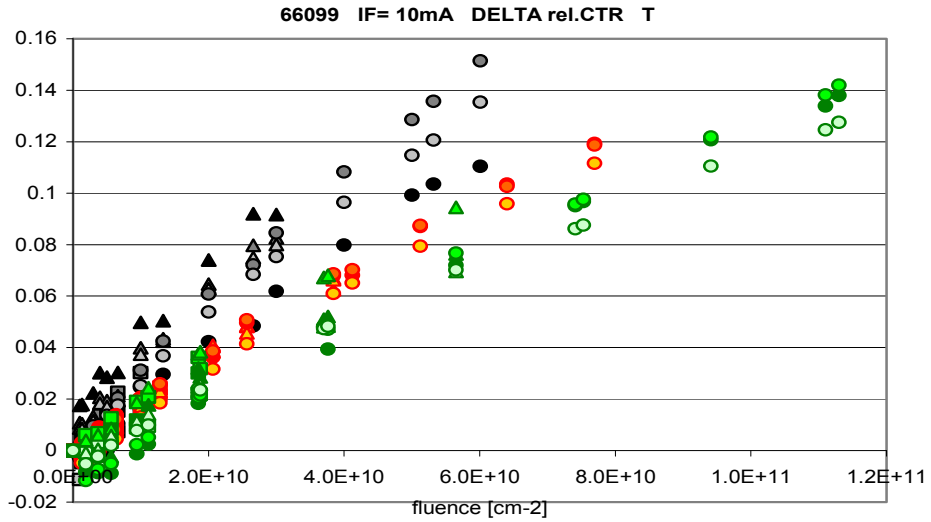
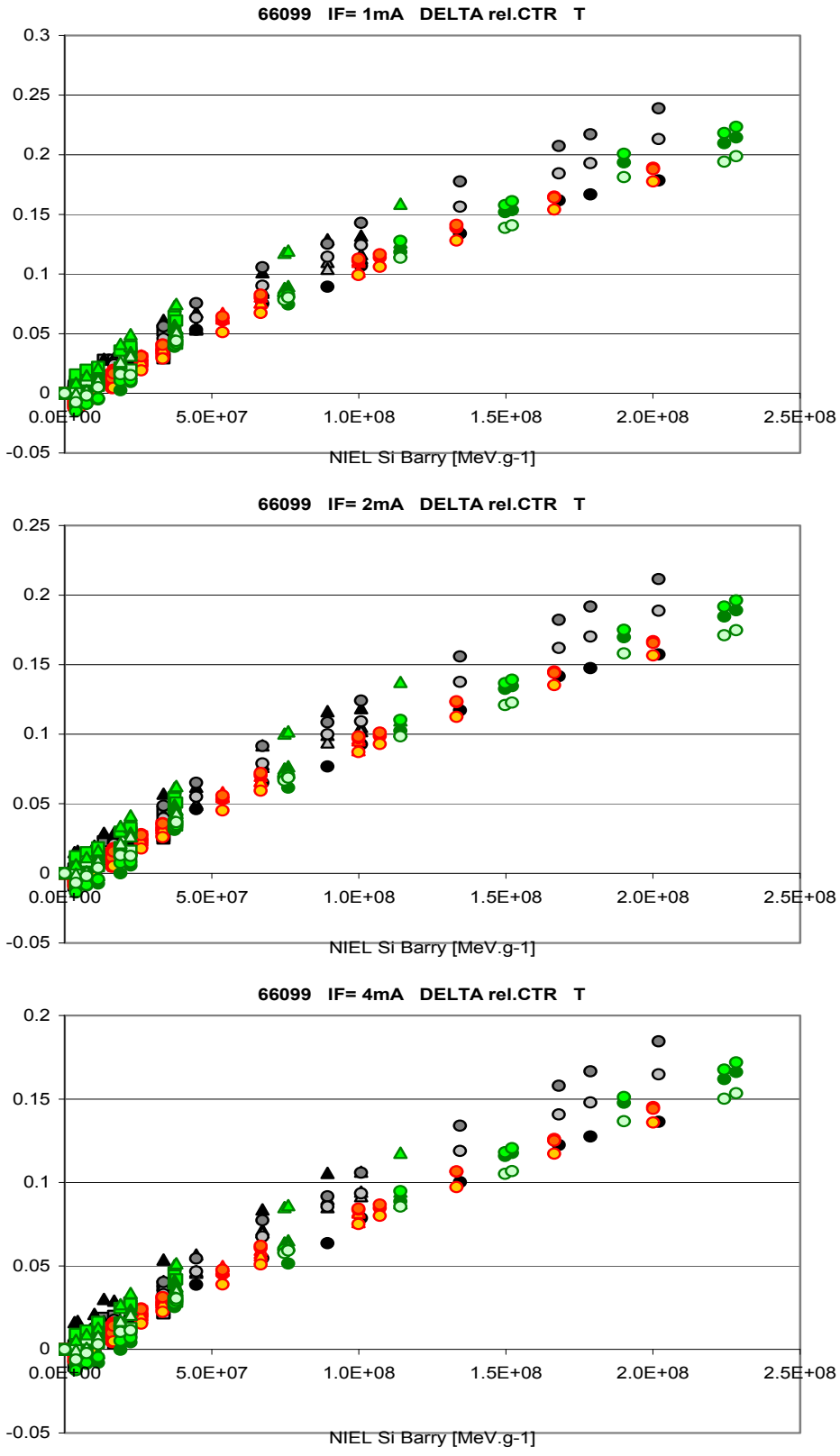
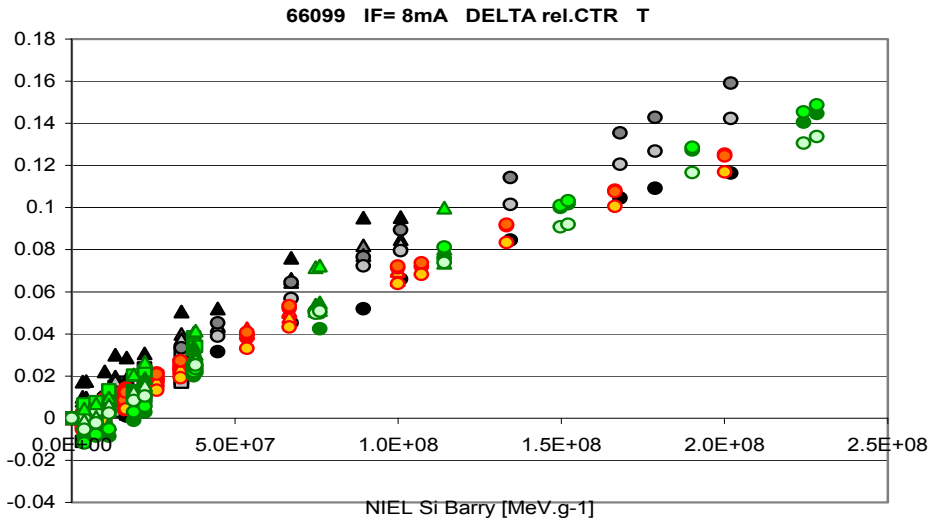

66099 IF= 10mA DELTA rel.CTR T
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
fluence [cm-2]

Fig. 14-34: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (Barry)




66099 IF= 8mA DELTA rel.CTR T
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

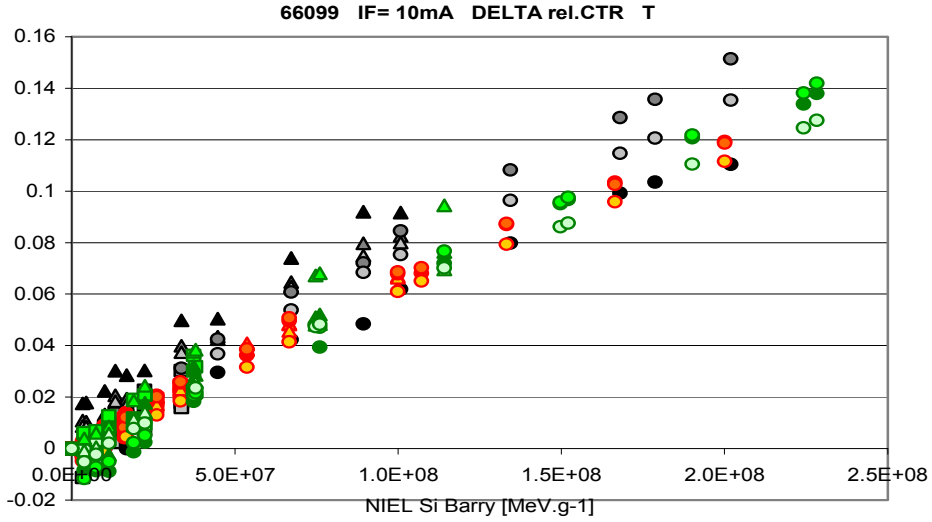
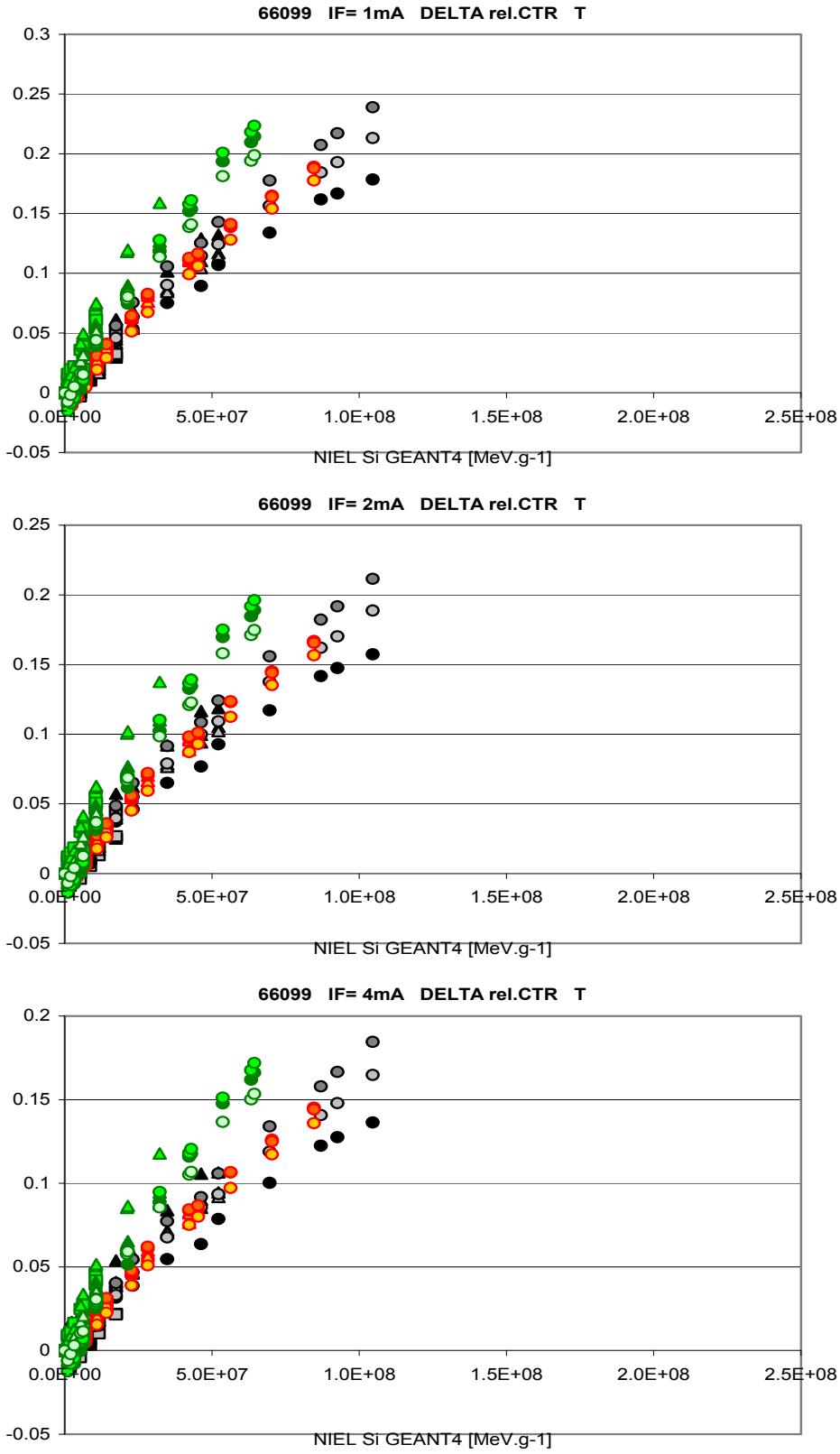
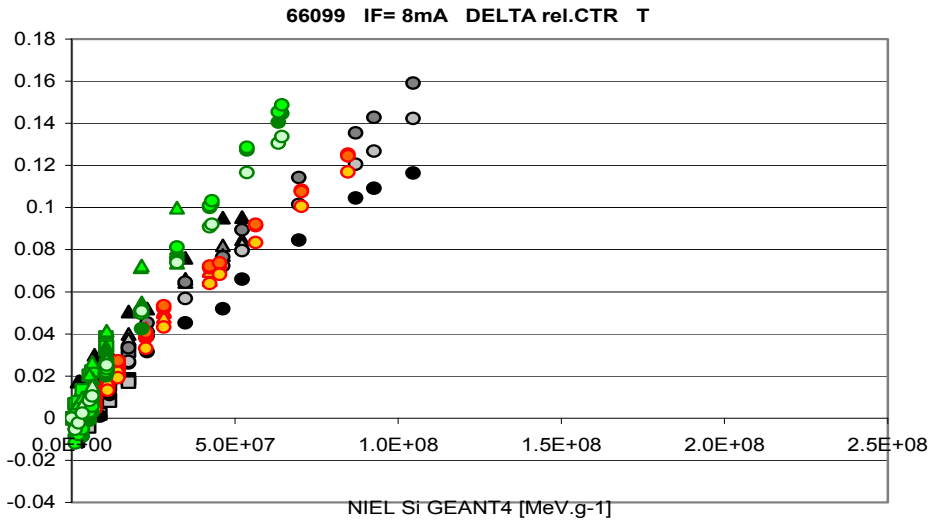

66099 IF= 10mA DELTA rel.CTR T
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si Barry [MeV.g-1]

Fig. 14-35: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 ELASTIC)




66099 IF= 8mA DELTA rel.CTR T
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

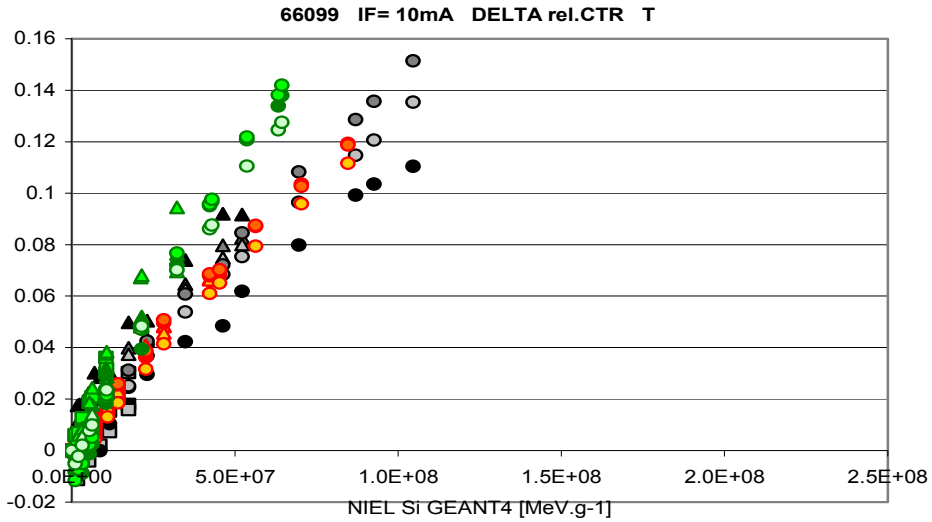
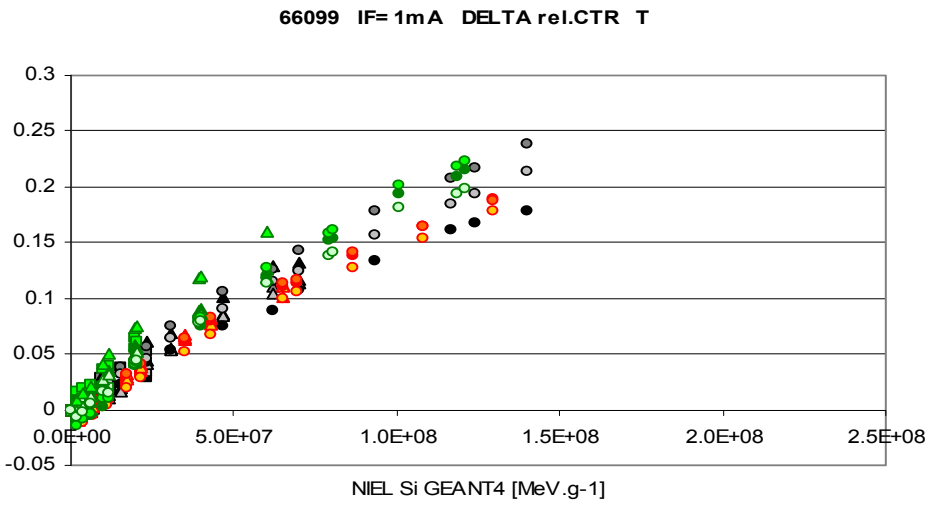
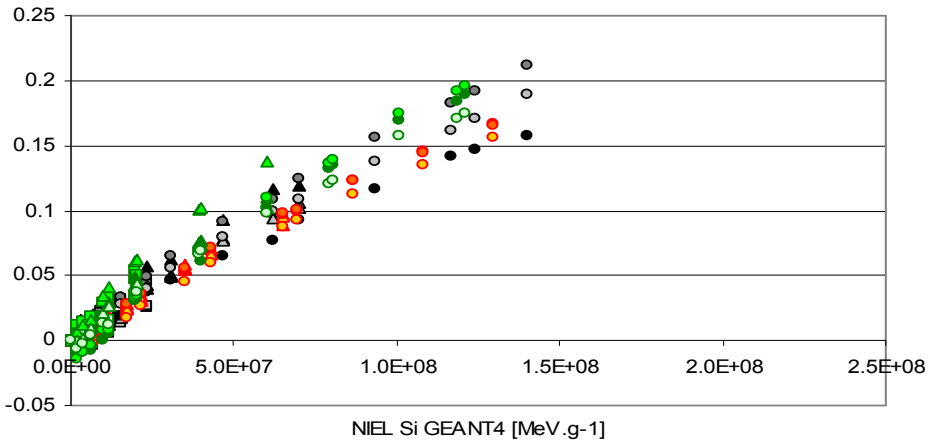
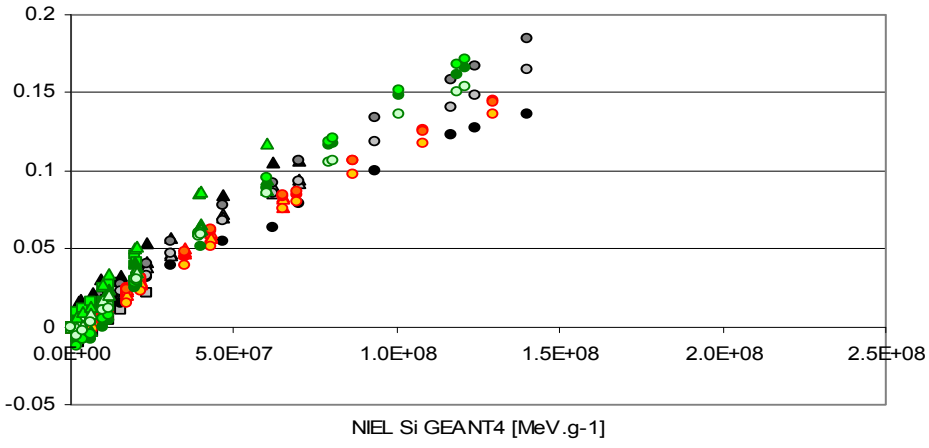

66099 IF= 10mA DELTA rel.CTR T
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
0.0E+00
5.0E+07
1.0E+08
1.5E+08
2.0E+08
2.5E+08
NIEL Si GEANT4 [MeV.g-1]

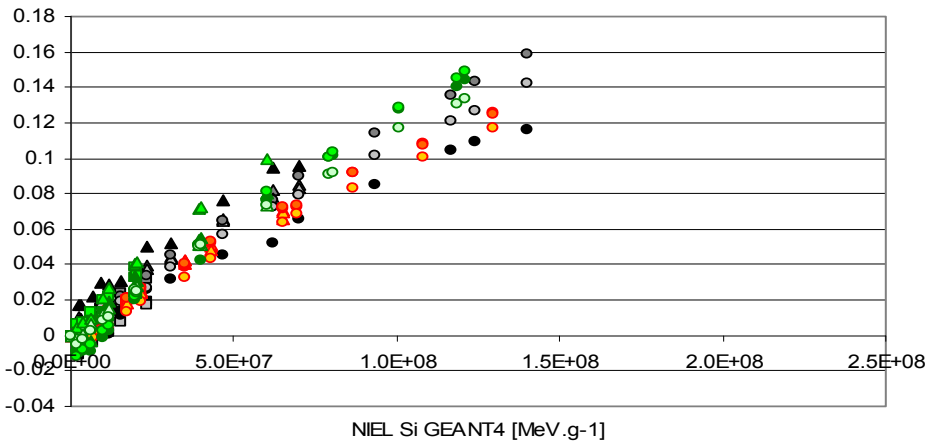
Fig. 14-36: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)







66099 IF= 8mA DELTA rel.CTR T



66099 IF= 10mA DELTA rel.CTR T

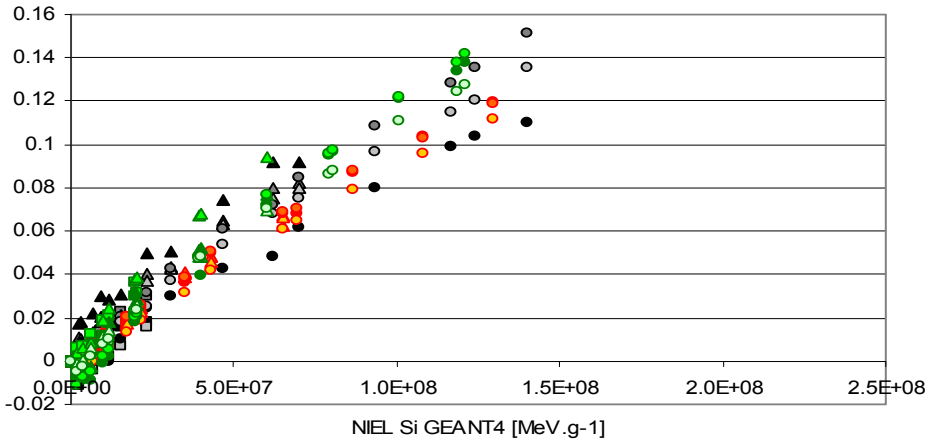
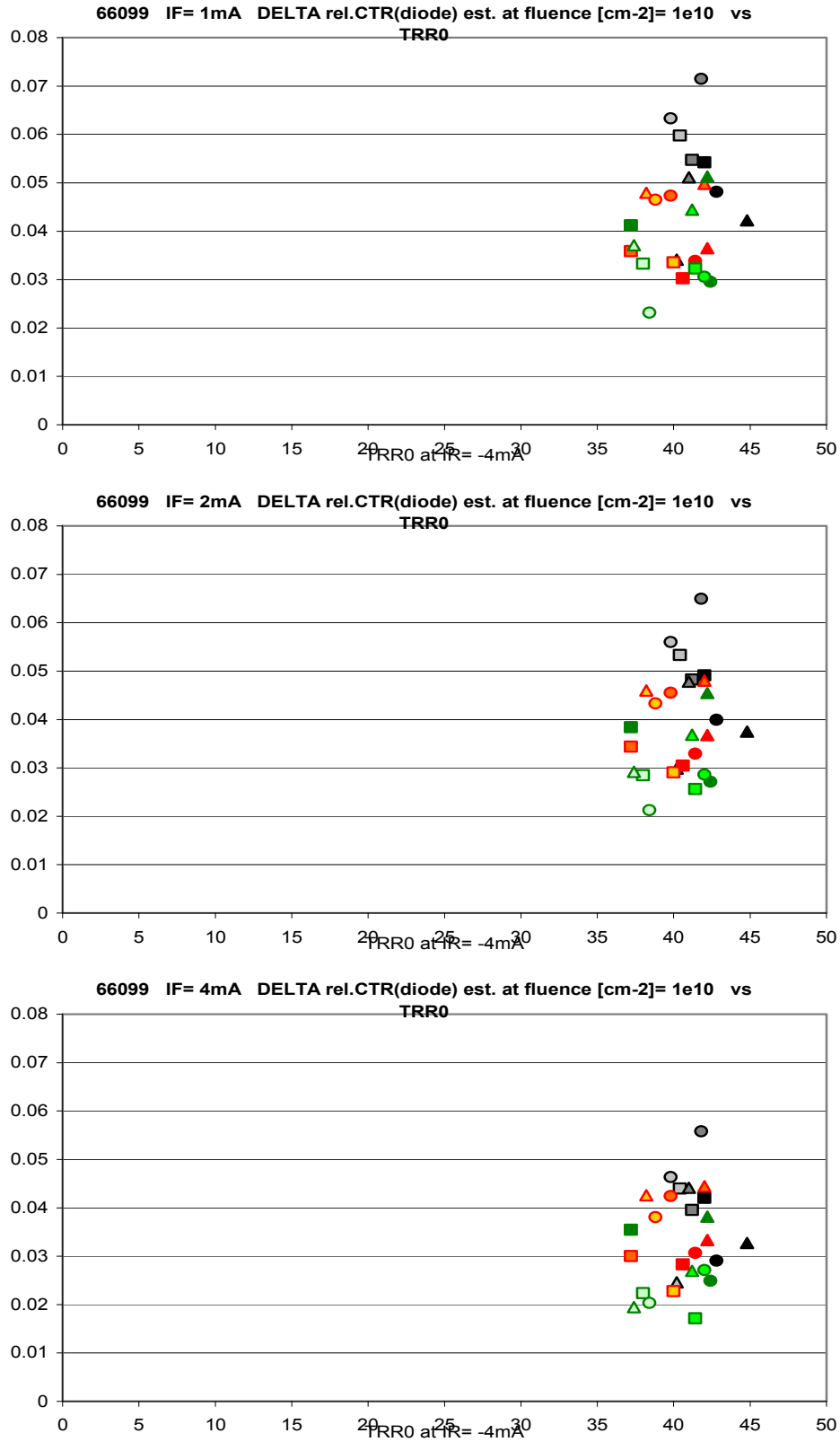
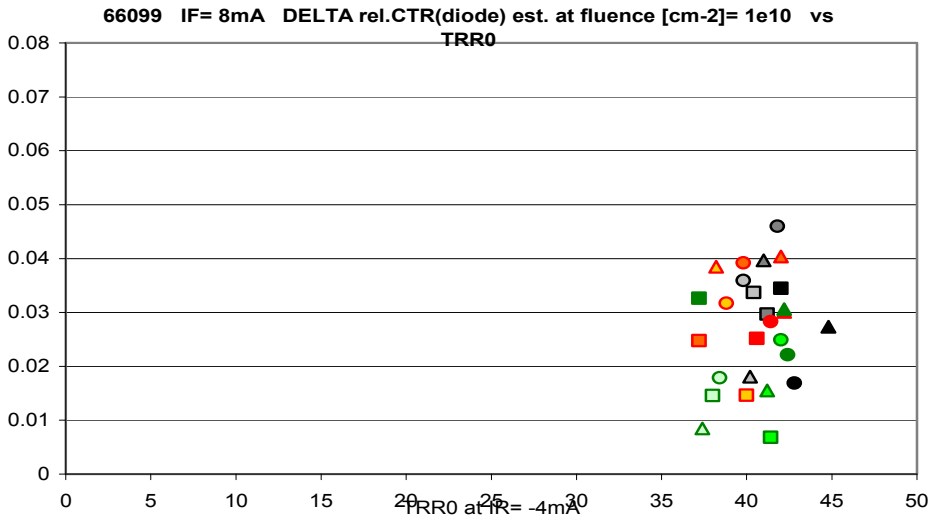


Fig. 14-37: 66099 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 1.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA




66099 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10 vs TRR0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40
45
50
TRR0 at IR= -4mA

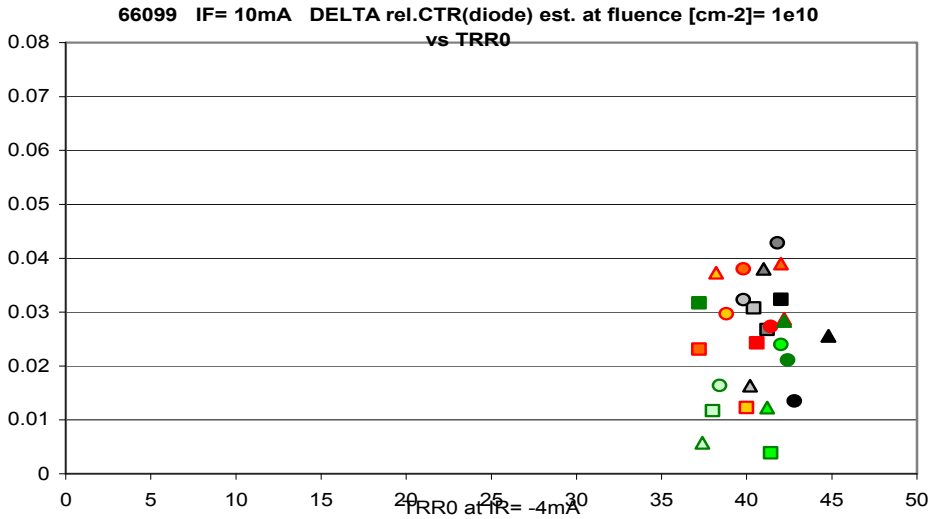
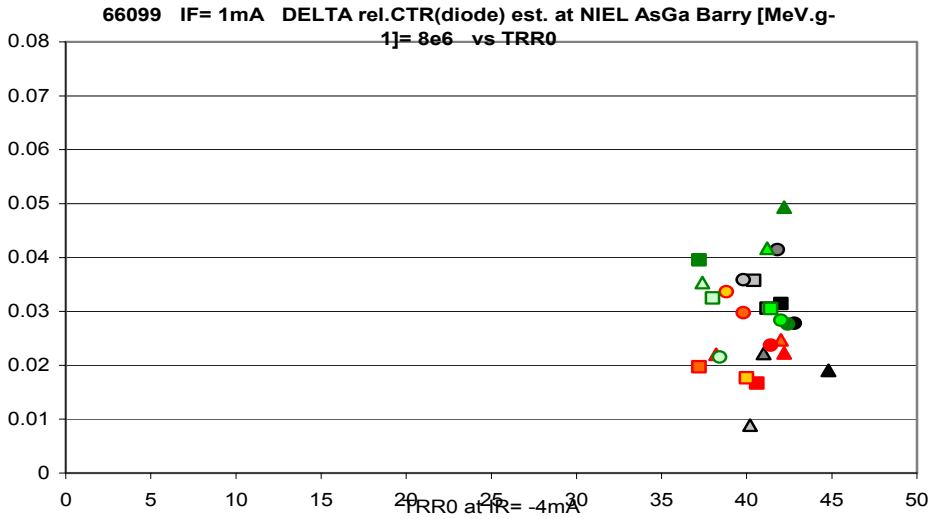
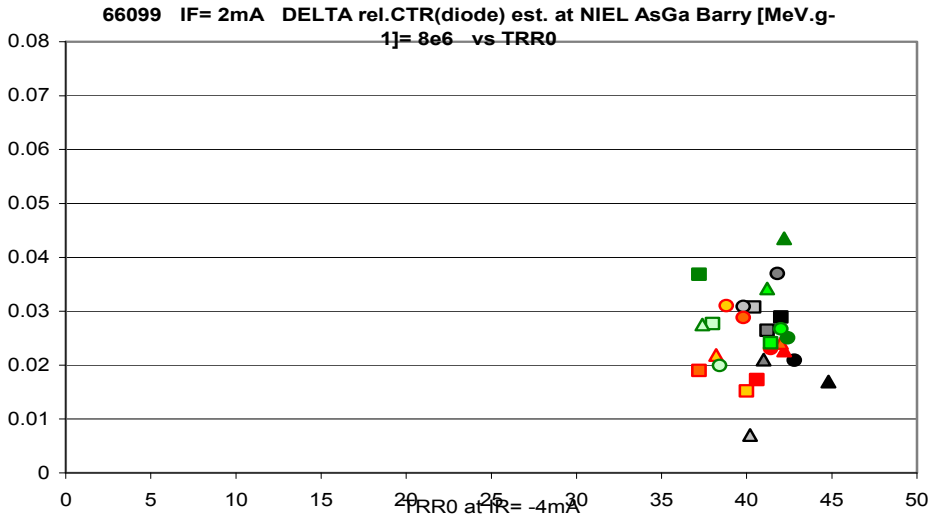
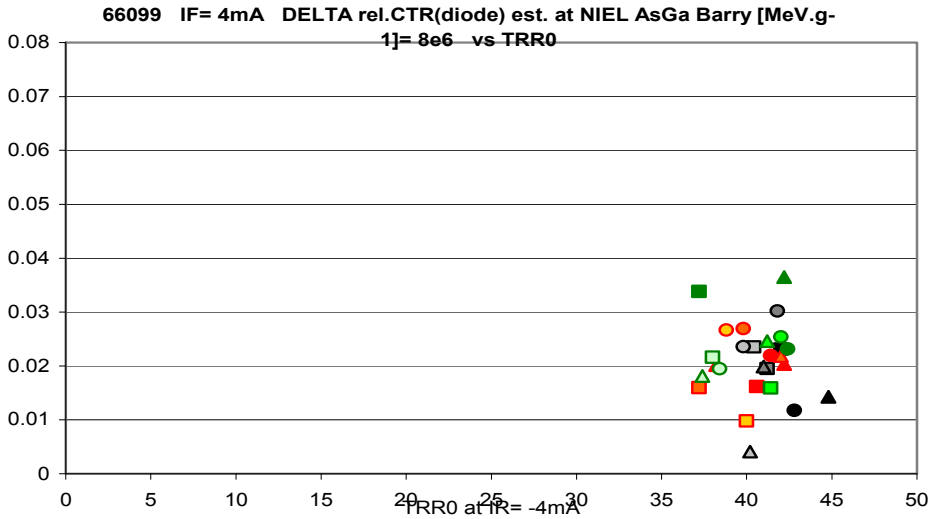
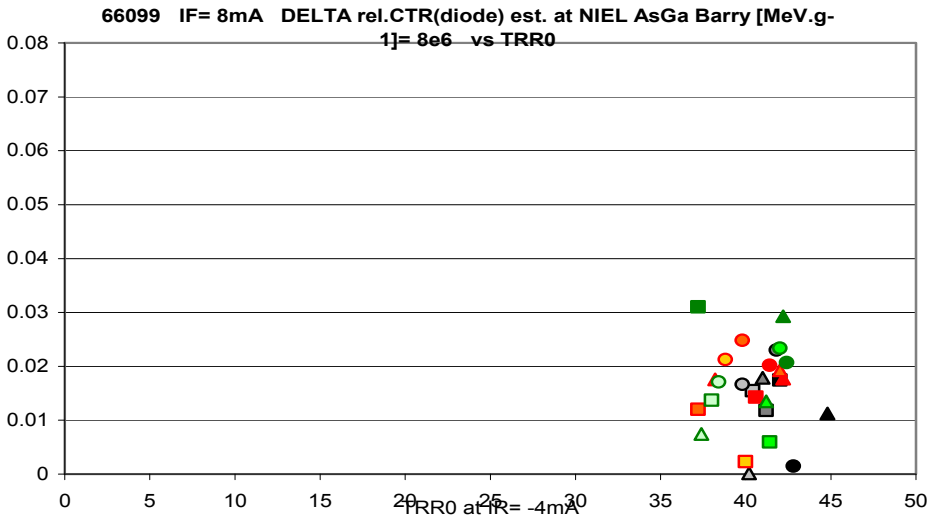

66099 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 1e10 vs TRR0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40
45
50
TRR0 at IR= -4mA

Fig. 14-38: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA








66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 8e6 vs TRR0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 5 10 15 20 25 30 35 40 45 50
TRR0 at IR= -4mA

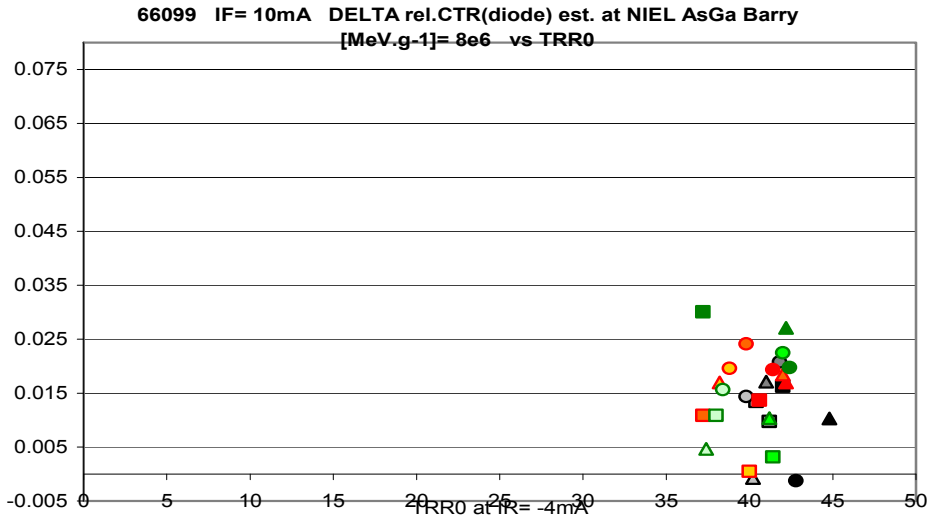
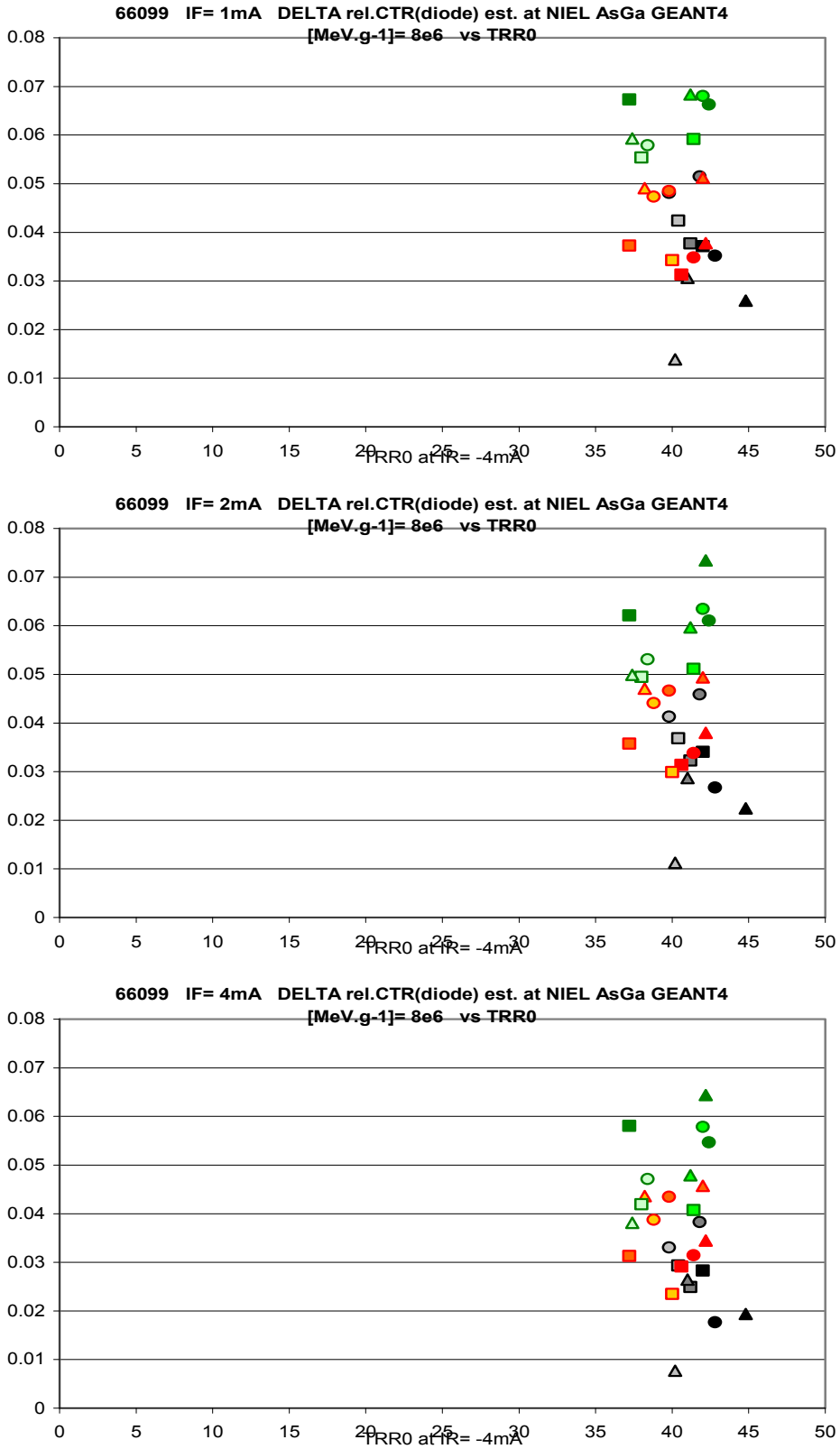
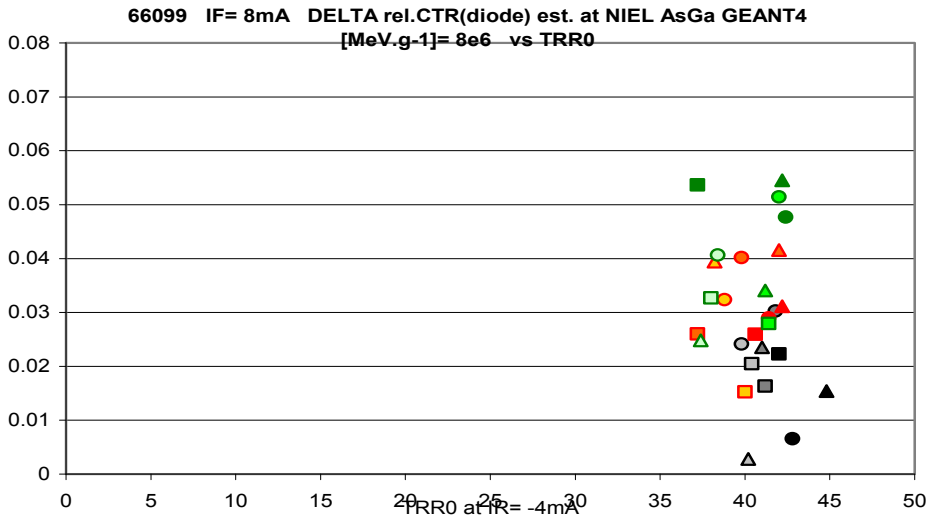

66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 8e6 vs TRR0
0.075
0.065
0.055
0.045
0.035
0.025
0.015
0.005
-0.005
0 5 10 15 20 25 30 35 40 45 50
TRR0 at IR= -4mA

Fig. 14-39: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA




66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40
45
50
TRR0 at IR= -4mA

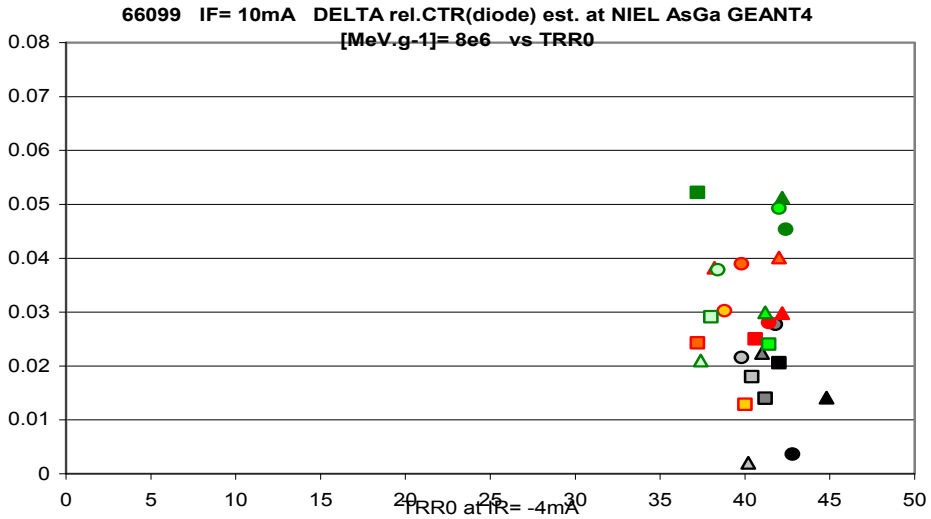
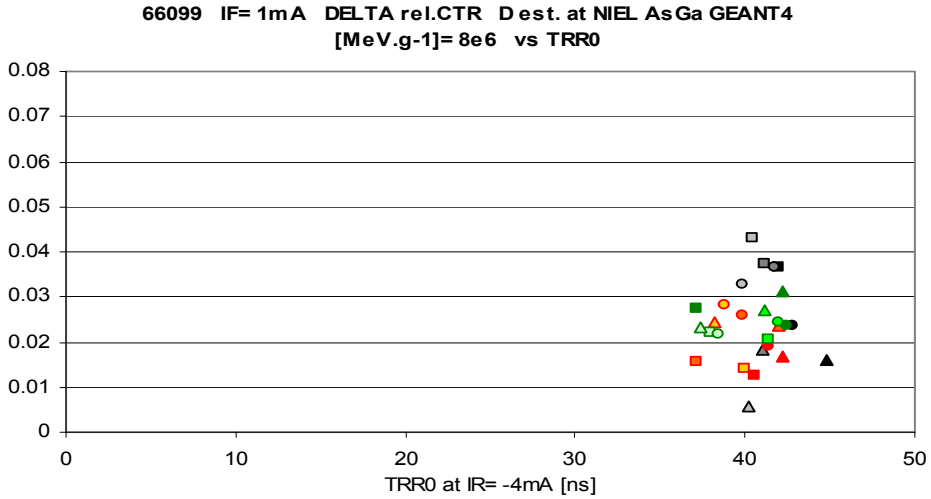
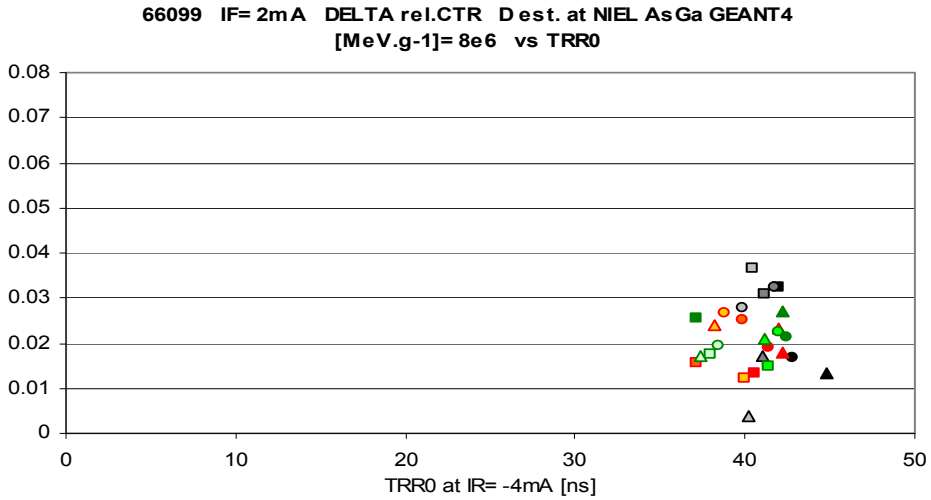
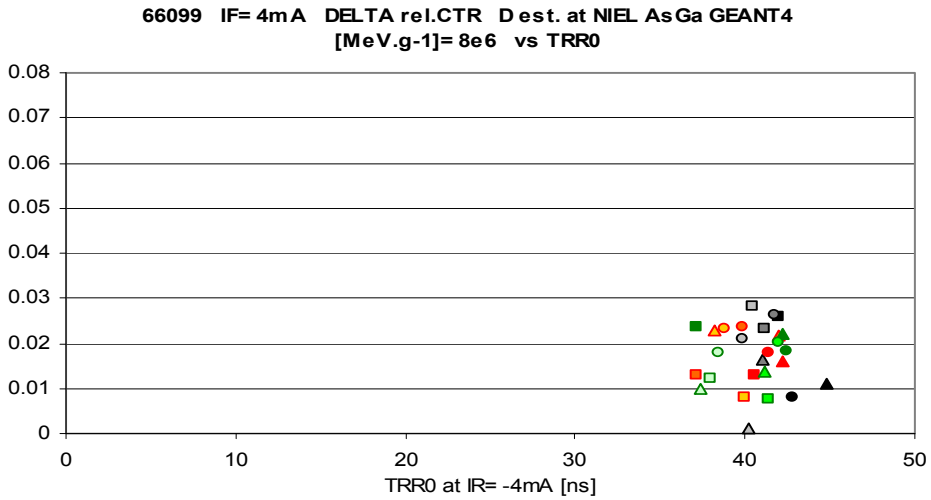
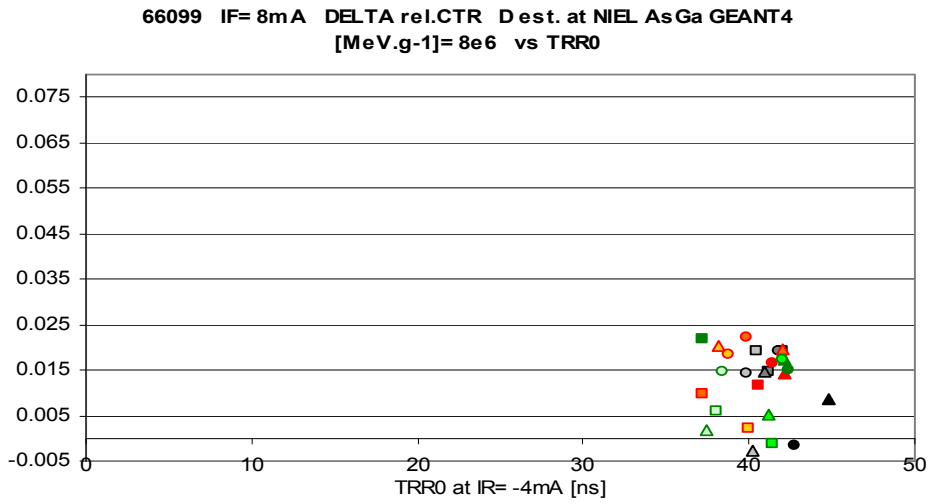

66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40
45
50
TRR0 at IR= -4mA

Fig. 14-40: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








66099 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.075
0.065
0.055
0.045
0.035
0.025
0.015
0.005
-0.005
0
10
20
30
40
50
TRR0 at IR= -4mA [ns]

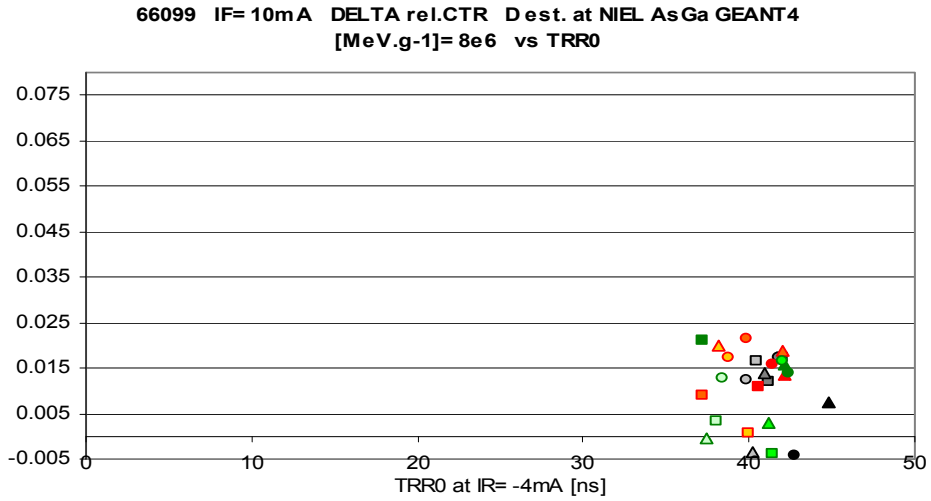
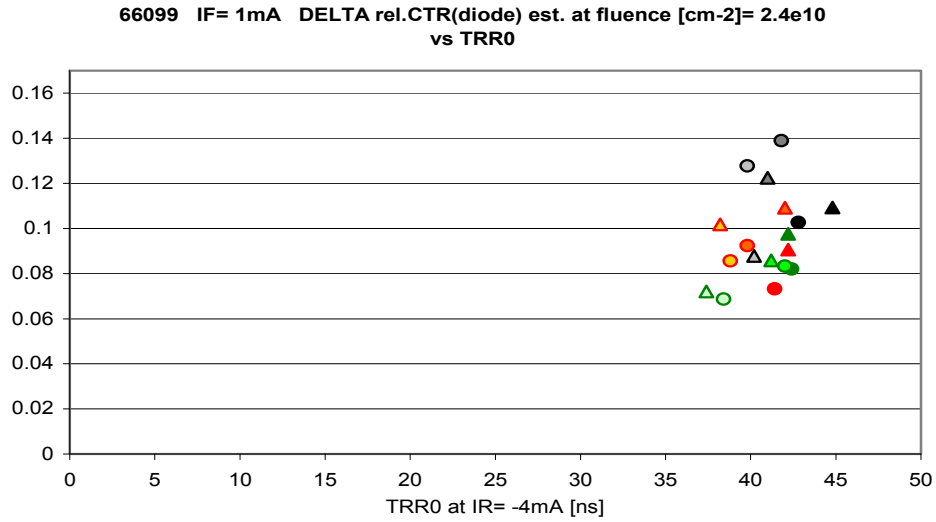
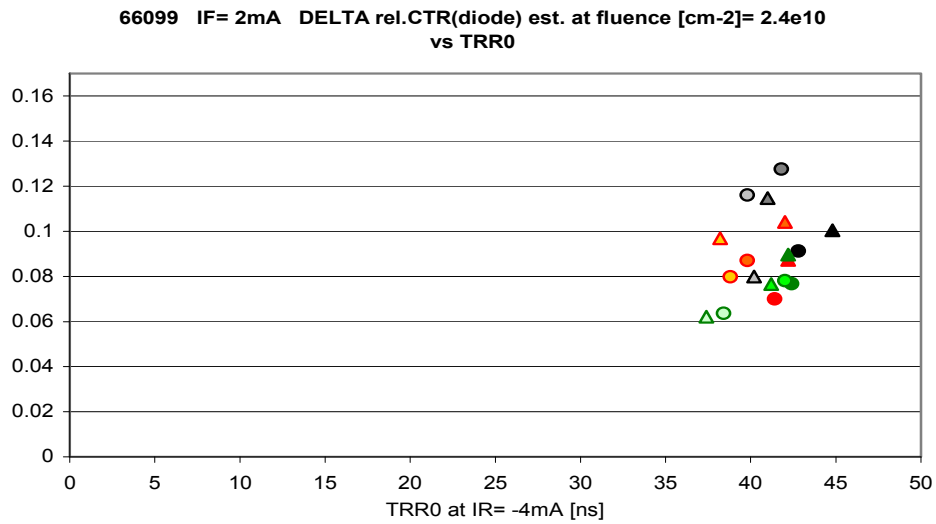
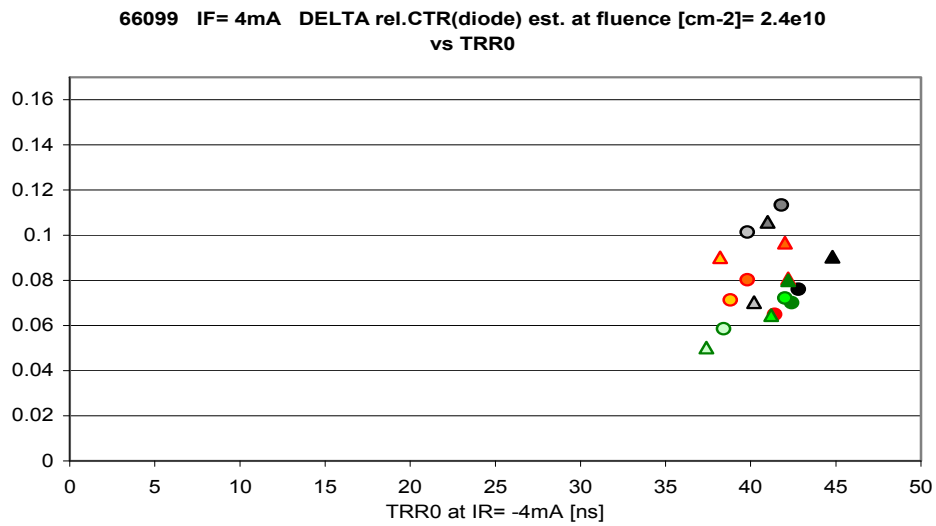

66099 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4
[MeV.g-1]= 8e6 vs TRR0
0.075
0.065
0.055
0.045
0.035
0.025
0.015
0.005
-0.005
0
10
20
30
40
50
TRR0 at IR= -4mA [ns]

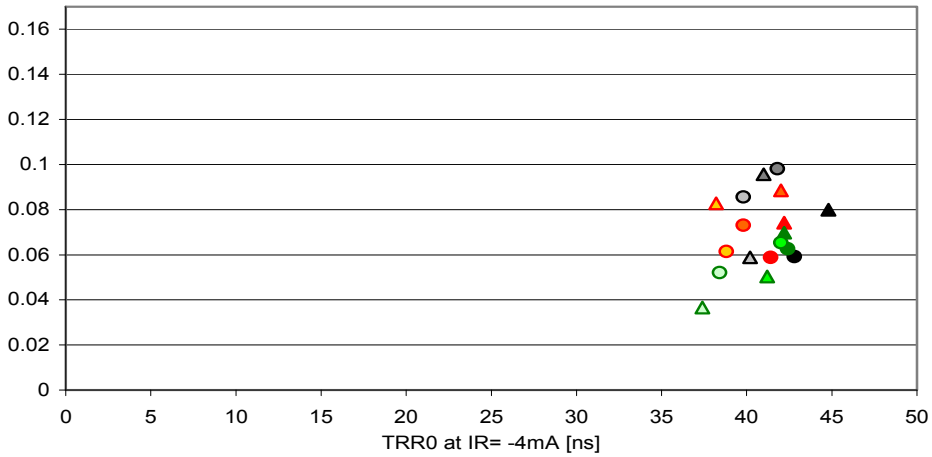
Fig. 14-41: 66099 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 2.4.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA







66099 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0



66099 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 2.4e10 vs TRR0

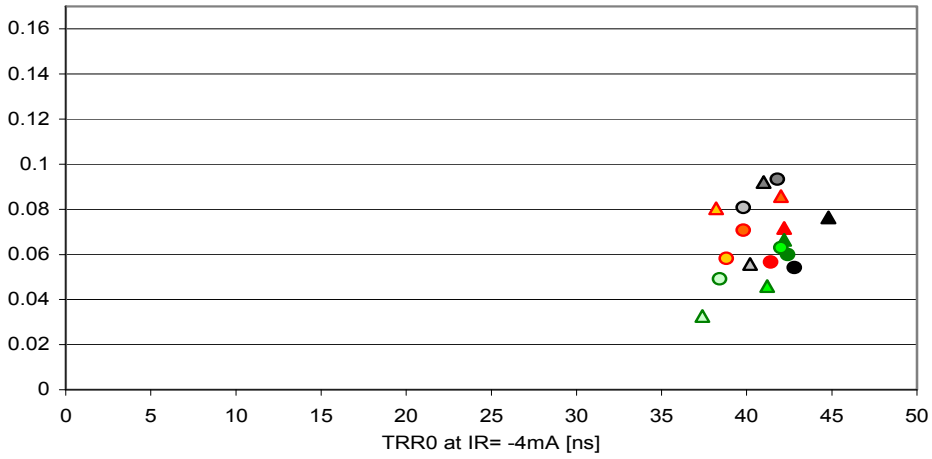
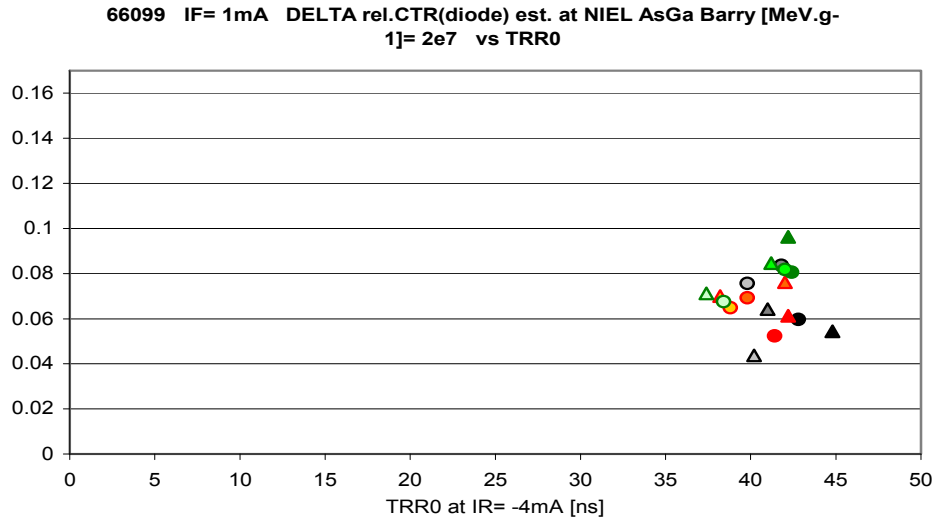
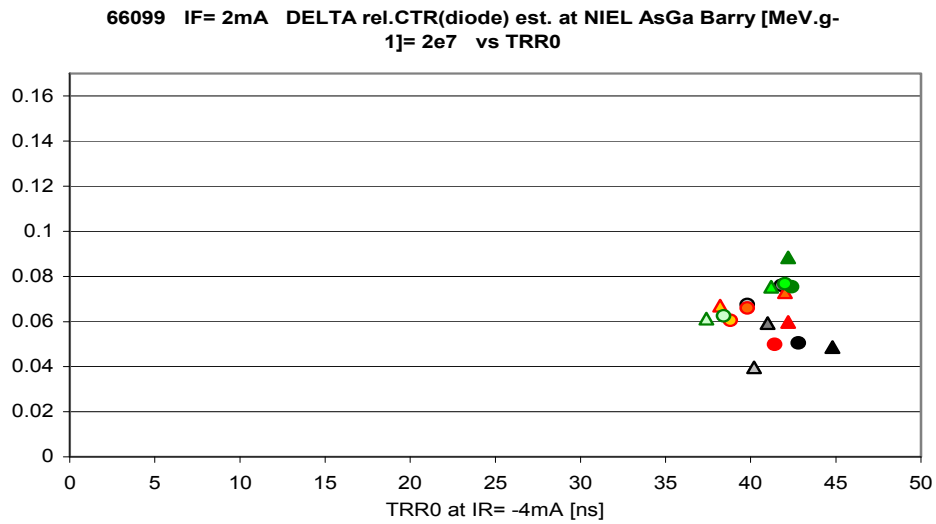
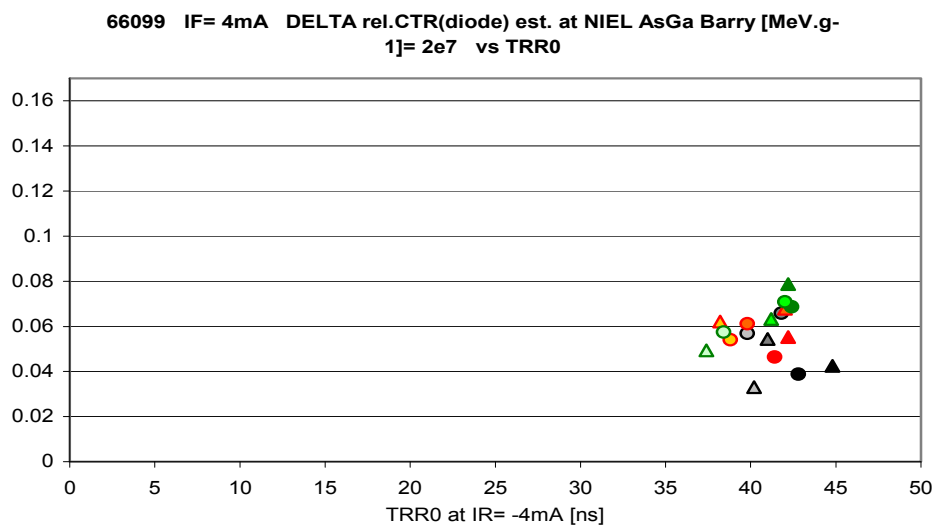


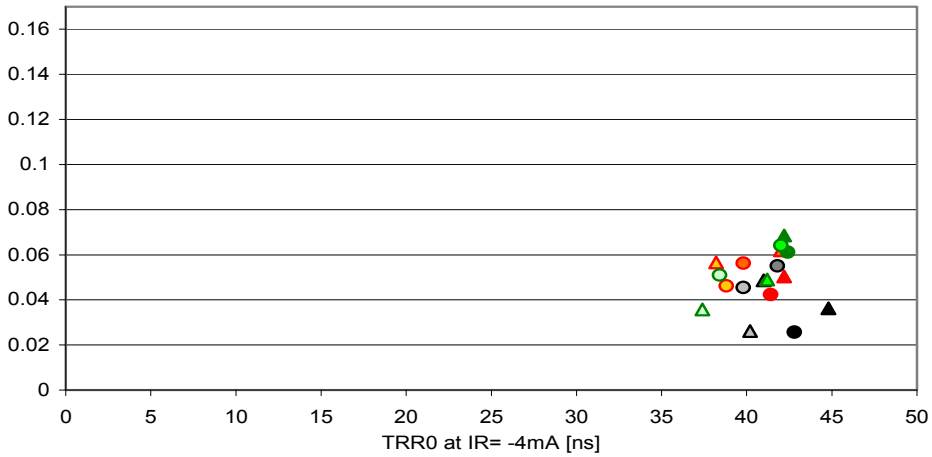
Fig. 14-42: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA







66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 2e7 vs TRR0



66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 2e7 vs TRR0

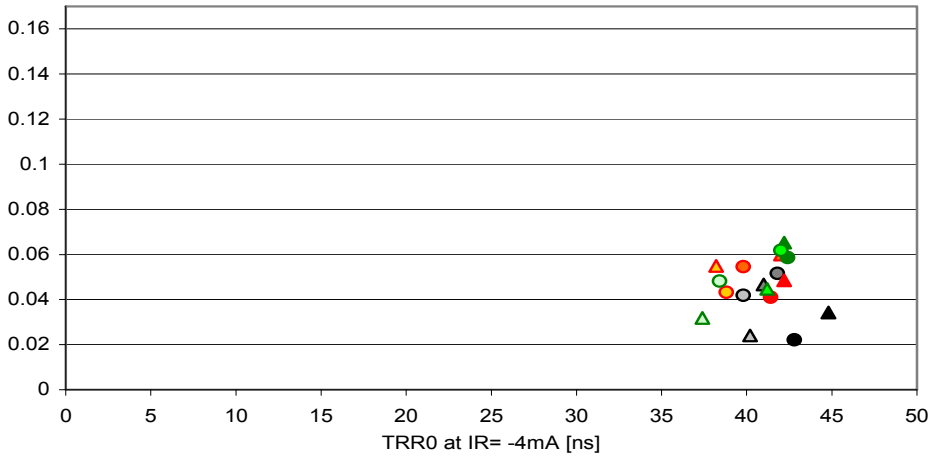
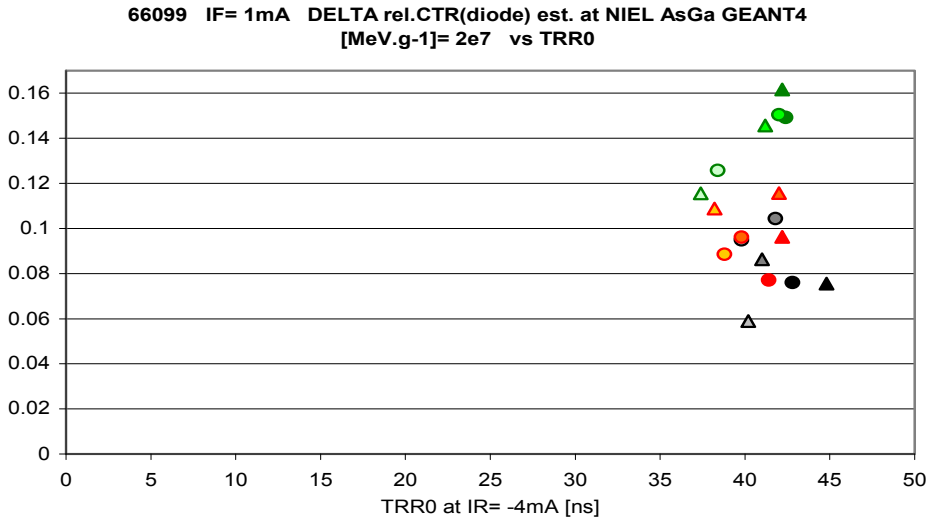
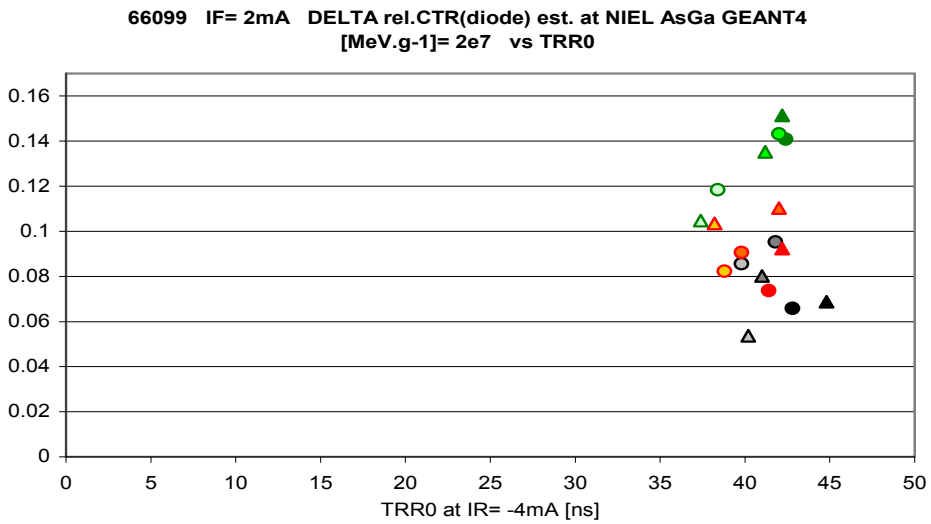
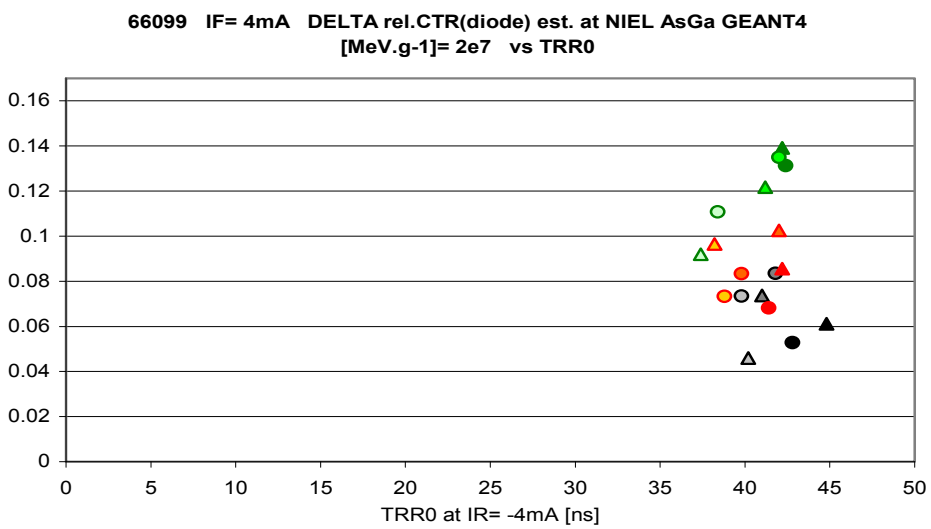
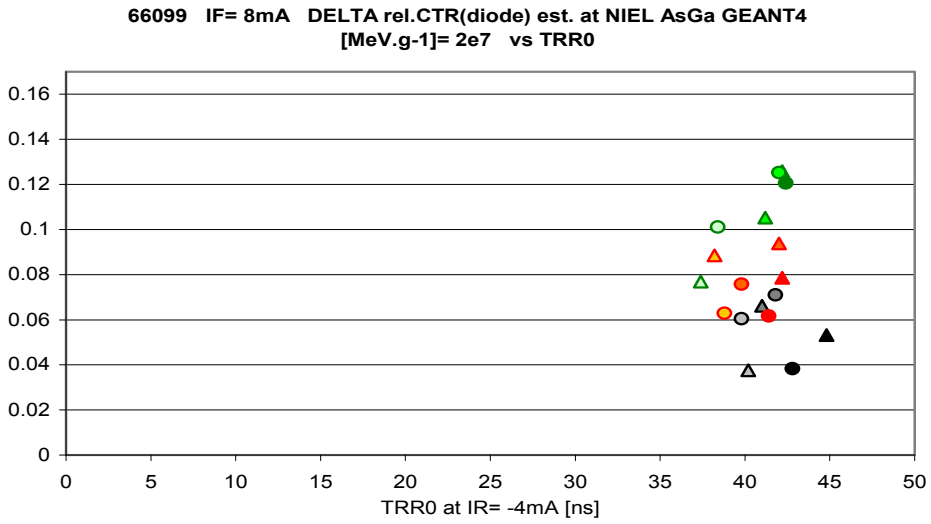


Fig. 14-43: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 5 10 15 20 25 30 35 40 45 50
TRR0 at IR= -4mA [ns]

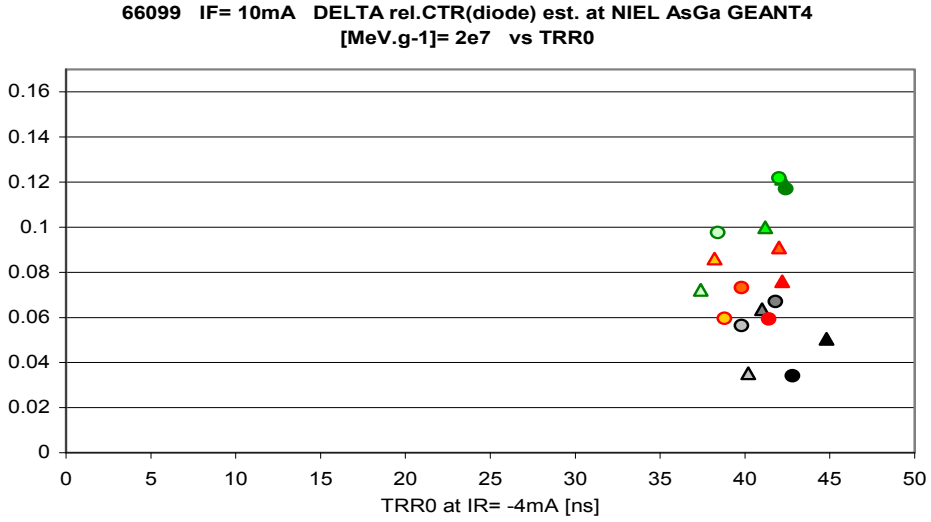
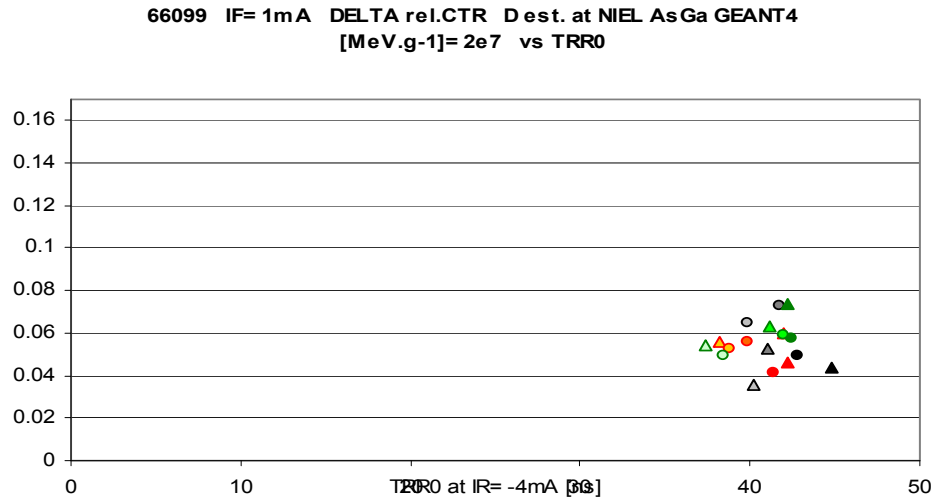
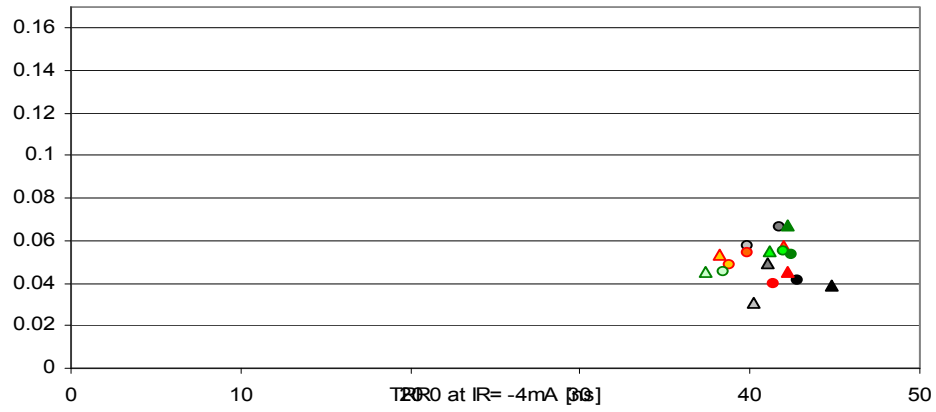
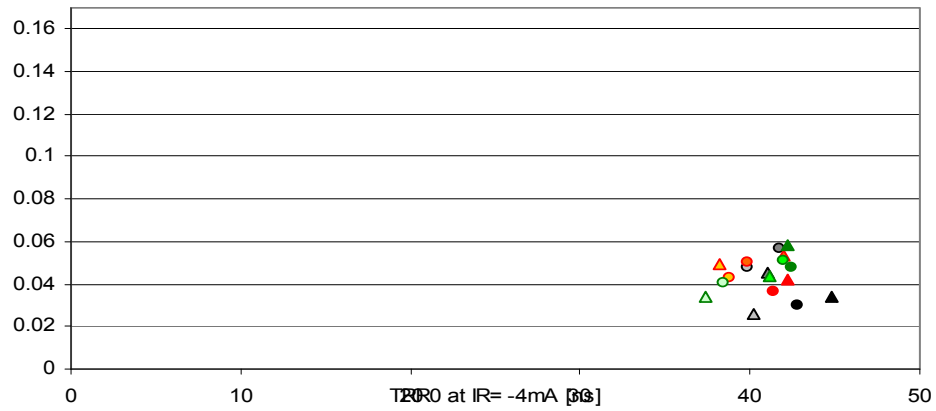

66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4
[MeV.g-1]= 2e7 vs TRR0
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 5 10 15 20 25 30 35 40 45 50
TRR0 at IR= -4mA [ns]

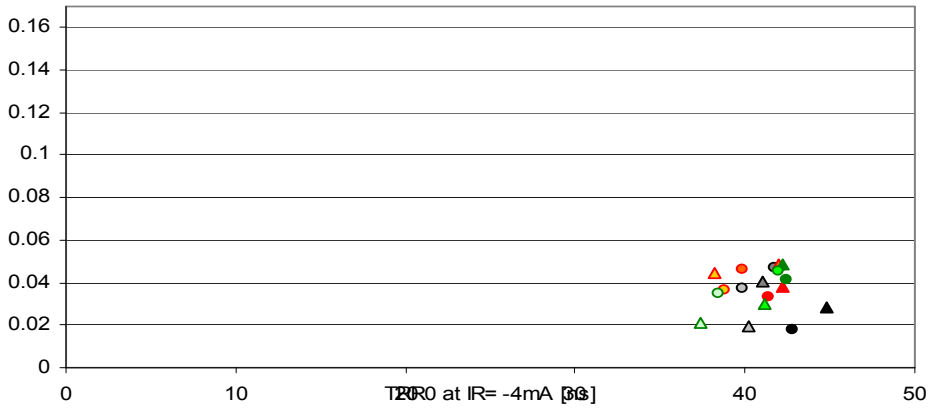
Fig. 14-44: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA







66099 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 2e7 vs TRR0



66099 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 2e7 vs TRR0

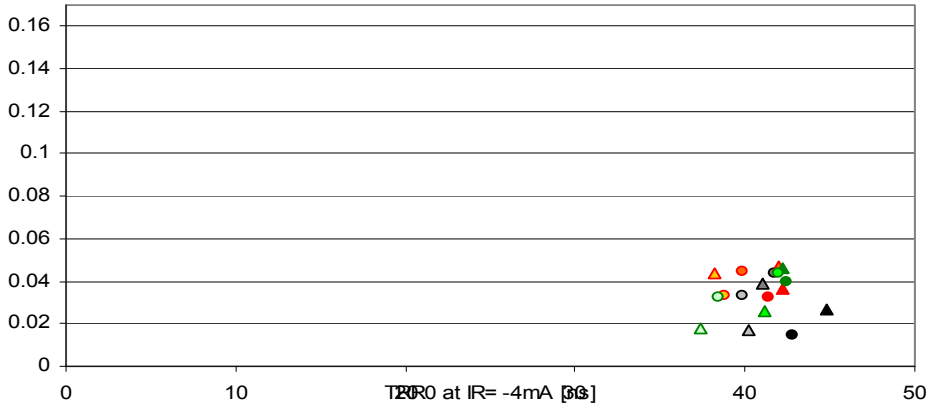
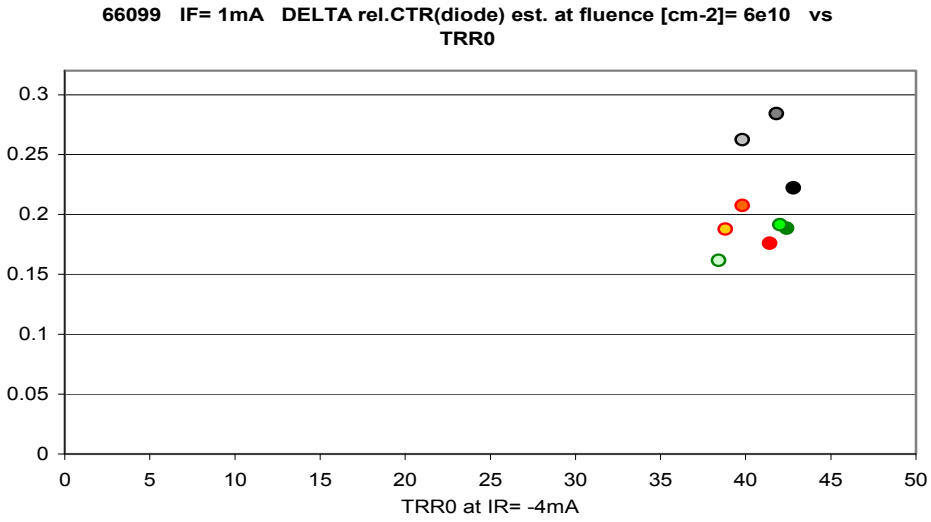
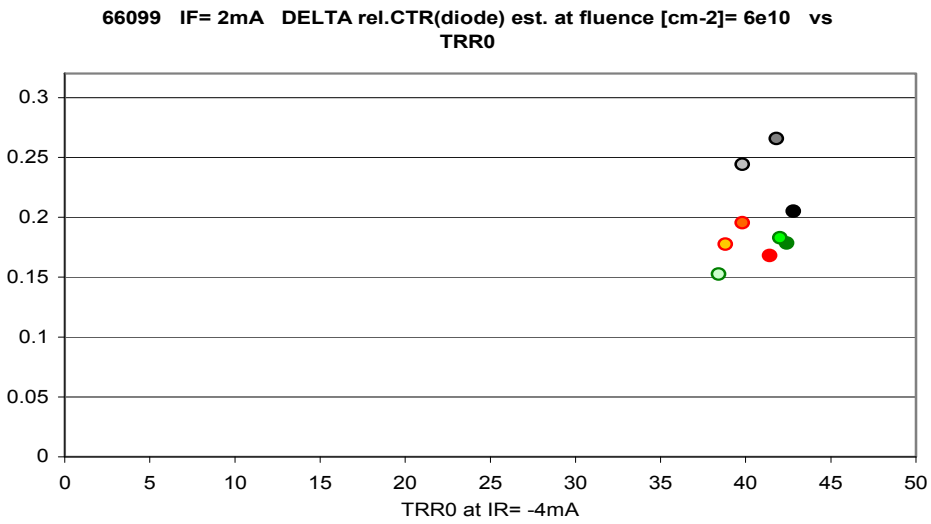
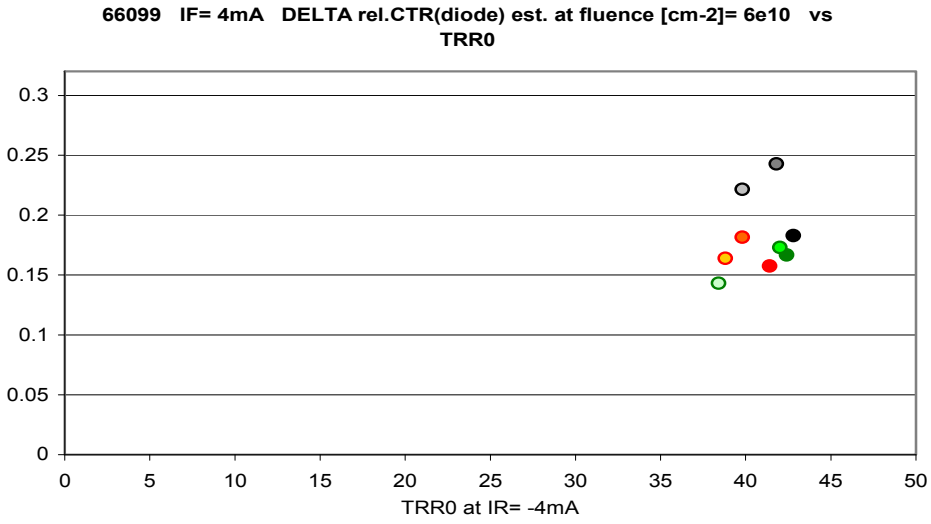


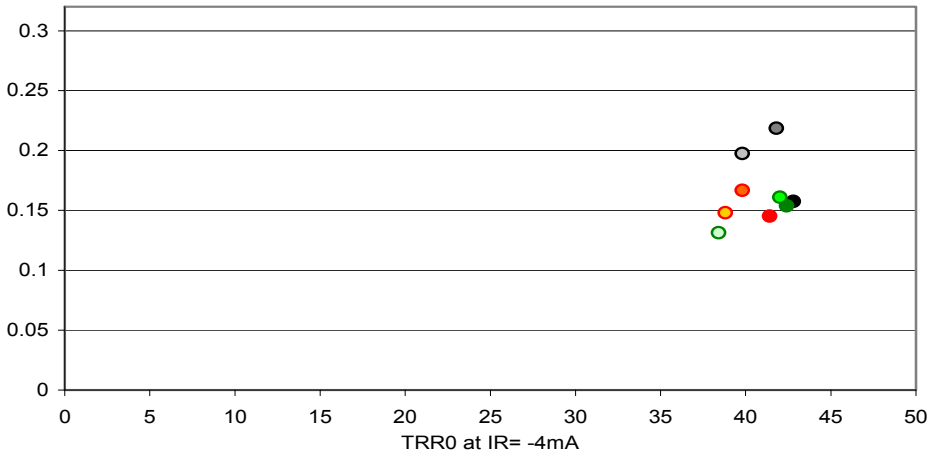
Fig. 14-45: 66099 diode: 1 - CTR/CTR$_0$ estimated at a fluence of 6.10^{10} cm^2 at I$_F$= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I$_R$ = -4mA







66099 IF= 8mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10 vs TRR0



66099 IF= 10mA DELTA rel.CTR(diode) est. at fluence [cm-2]= 6e10 vs TRR0

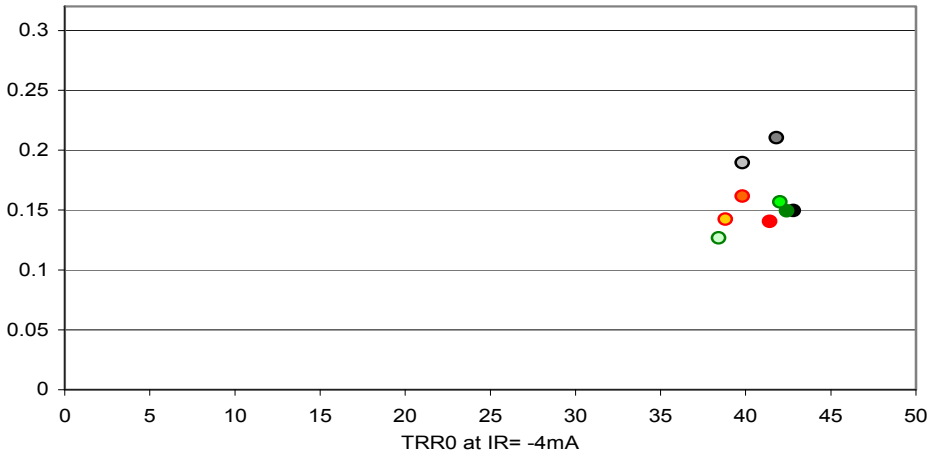
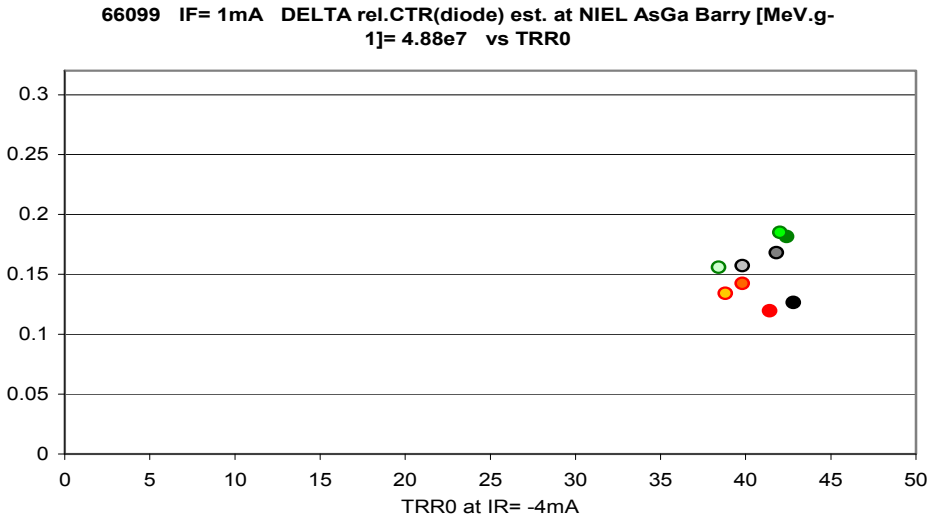
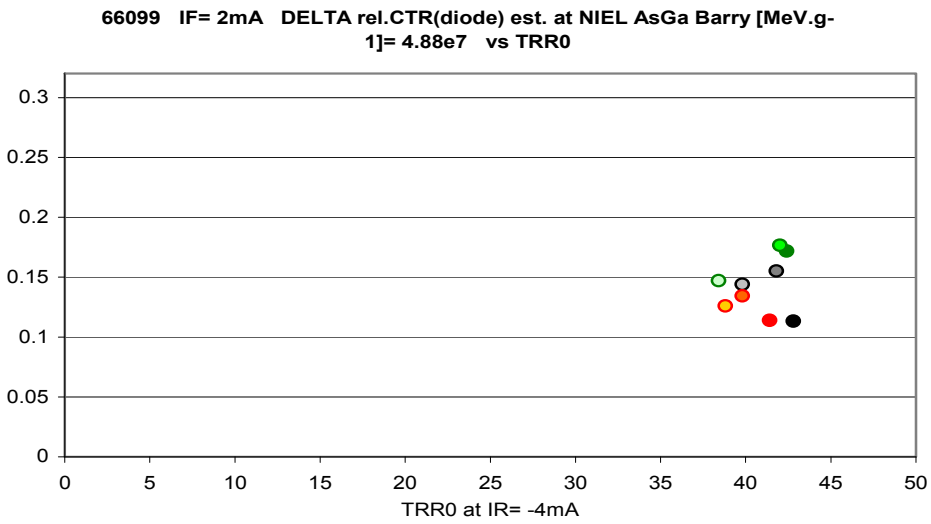
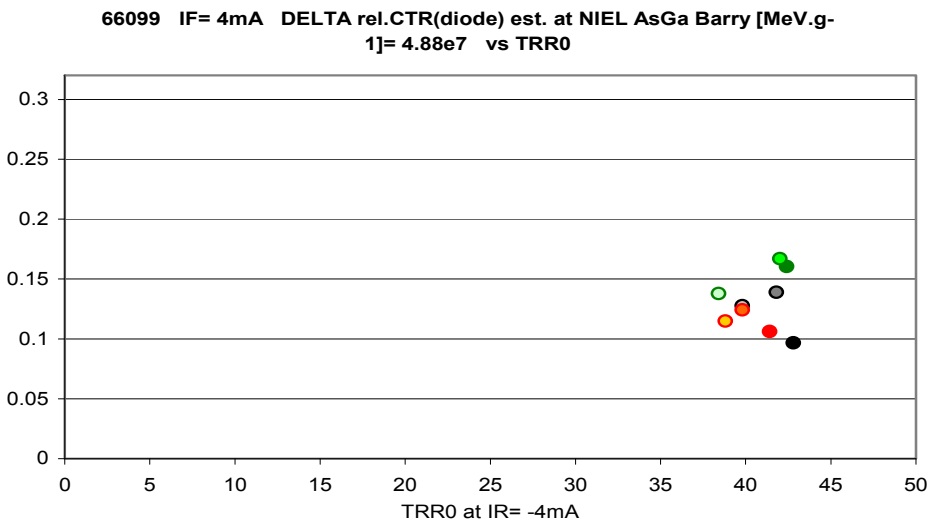


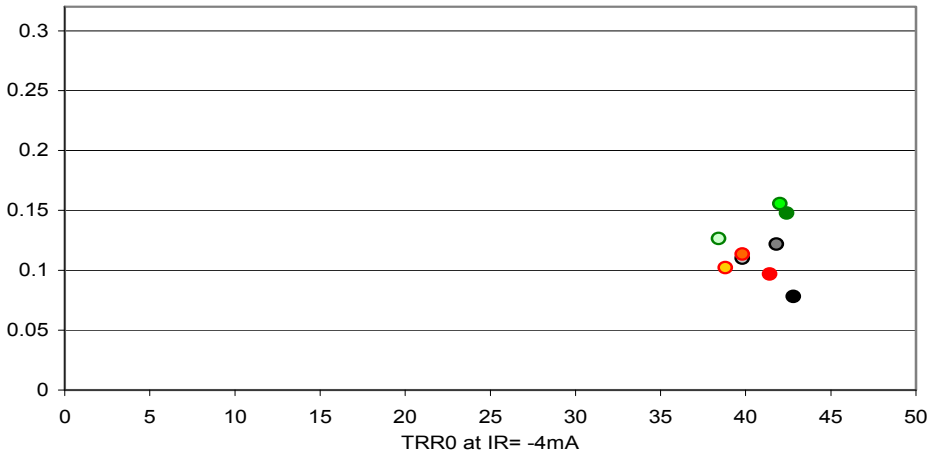
Fig. 14-46: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (Barry) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA







66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 4.88e7 vs TRR0



66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa Barry [MeV.g-1]= 4.88e7 vs TRR0

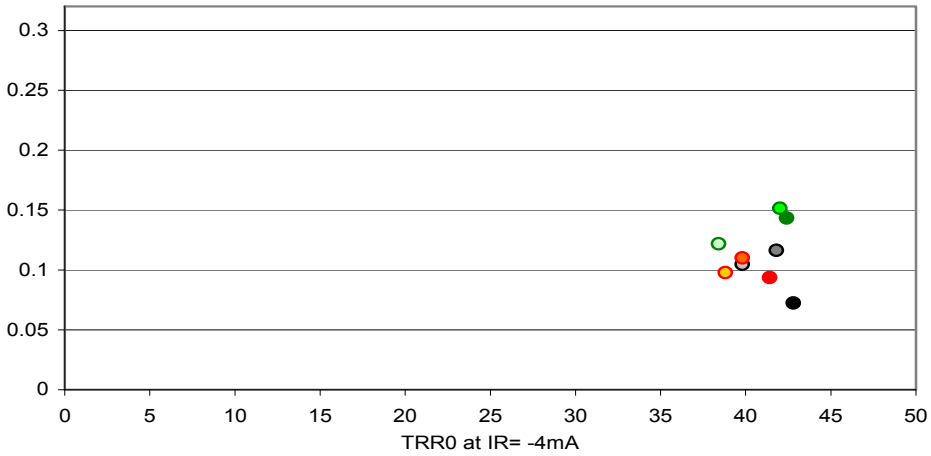
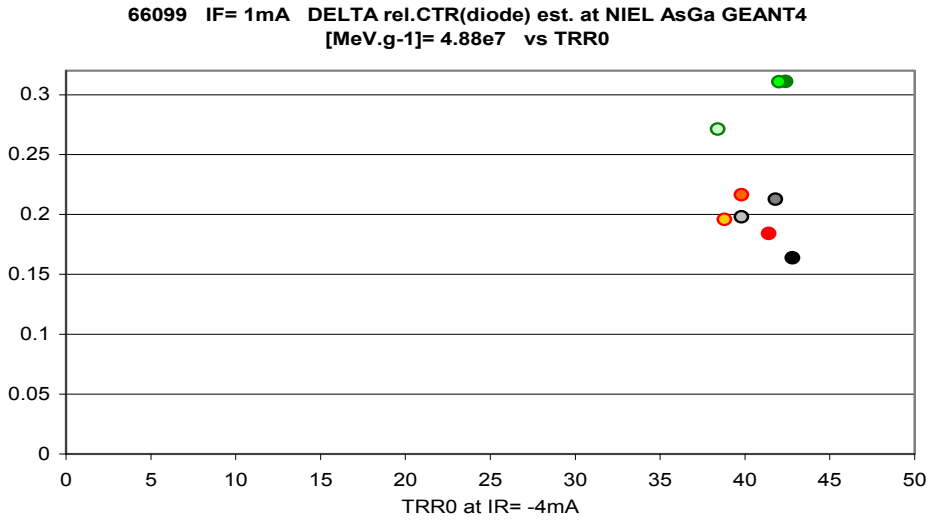
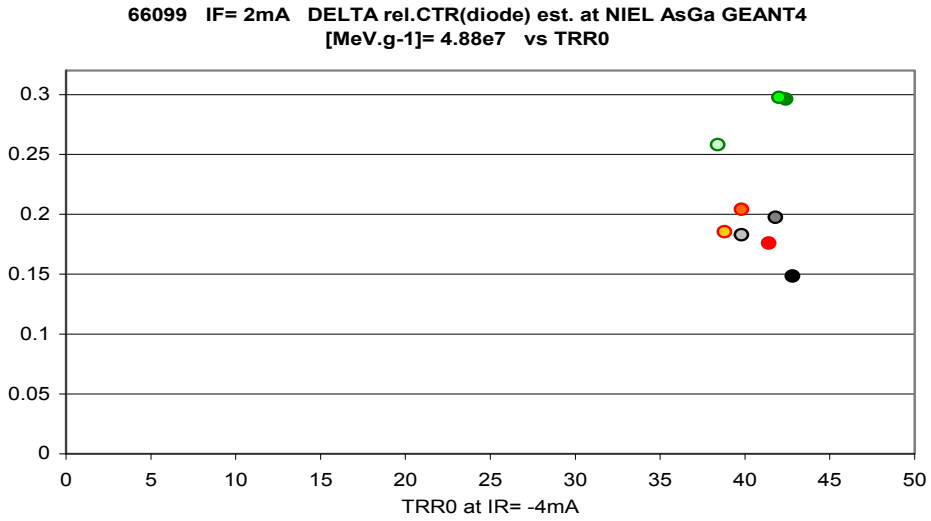
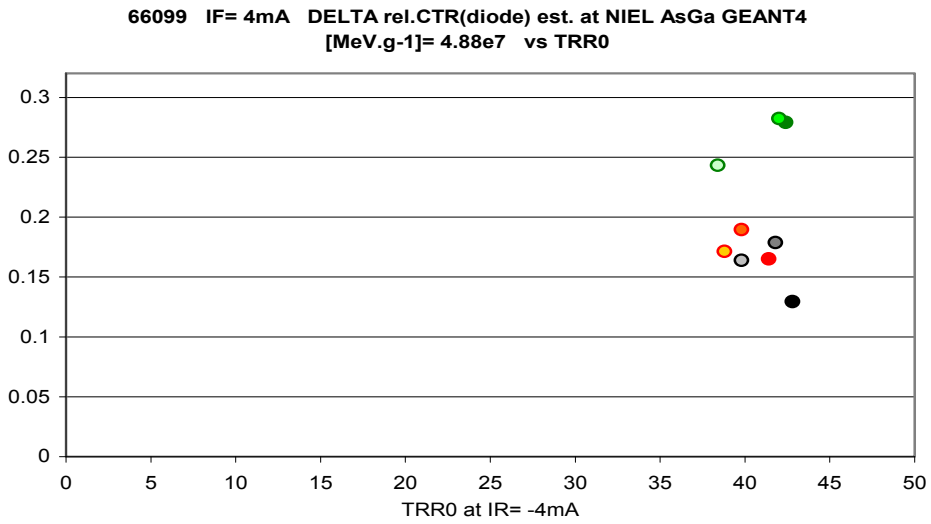


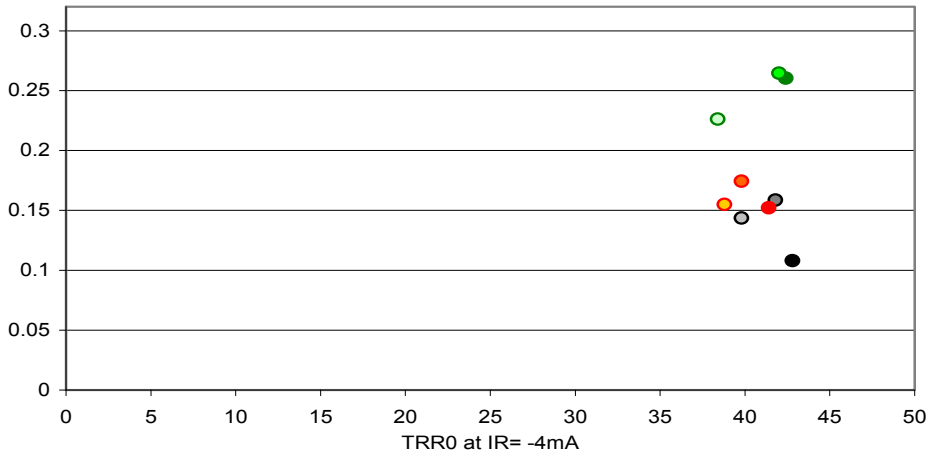
Fig. 14-47: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 ELASTIC) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA







66099 IF= 8mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0



66099 IF= 10mA DELTA rel.CTR(diode) est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0

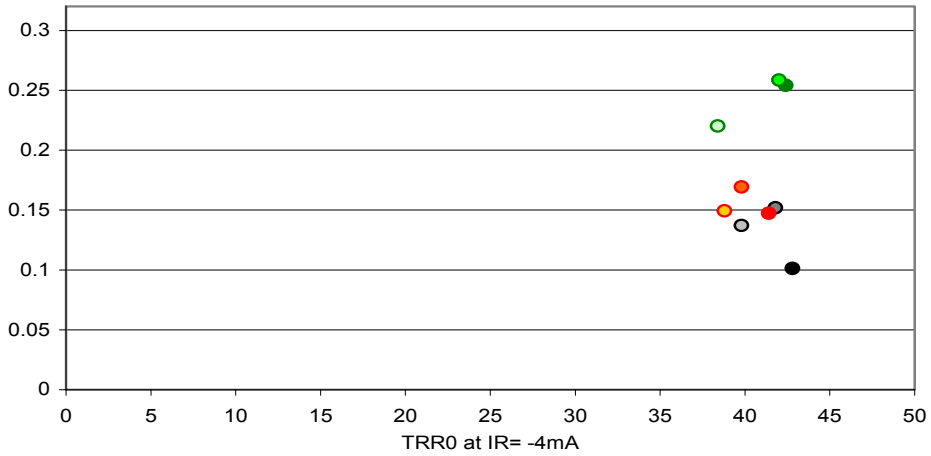
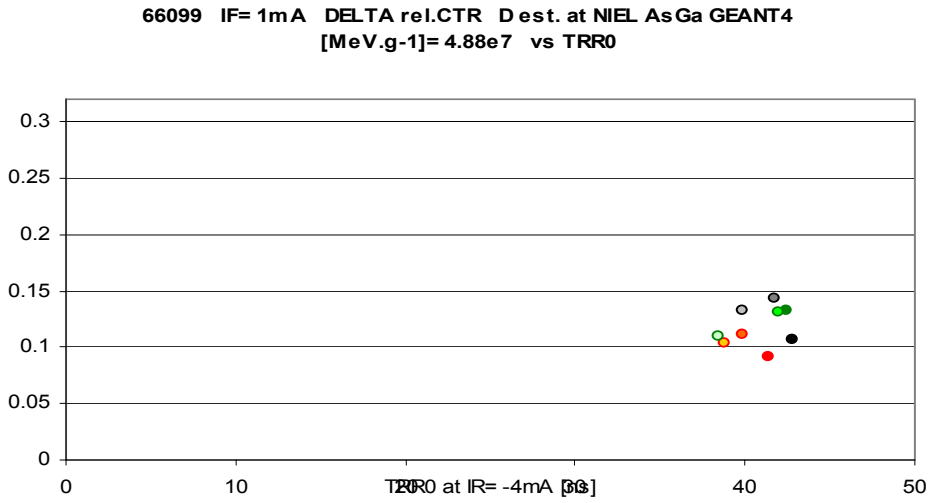
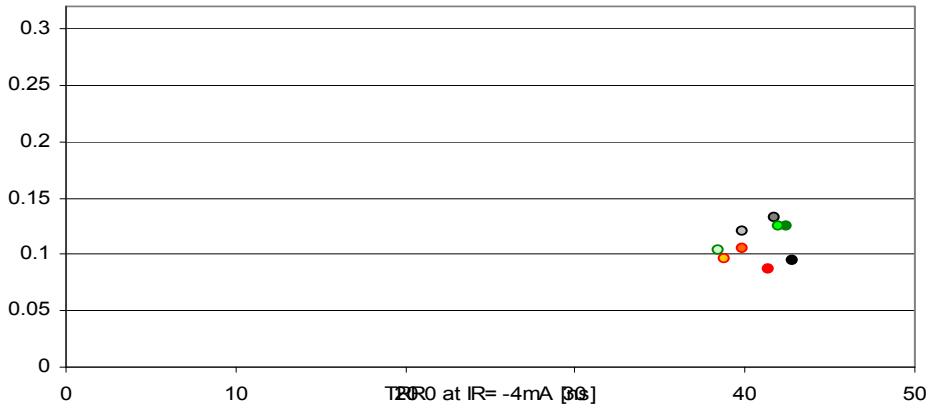
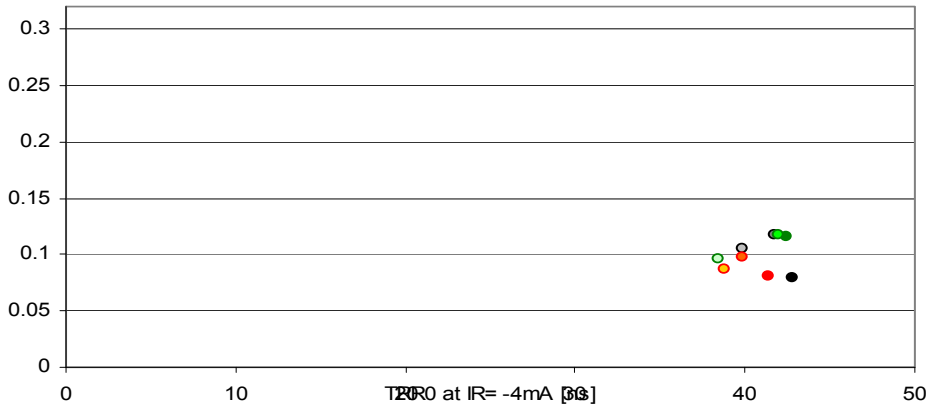


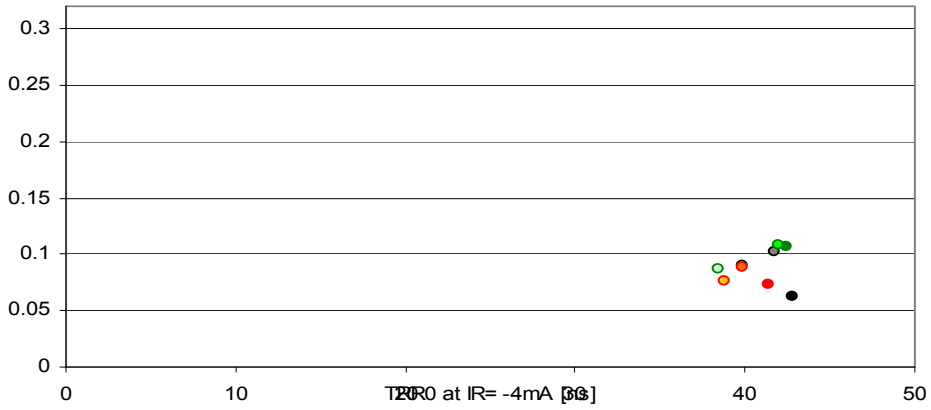
Fig. 14-48: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA







66099 IF= 8mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0



66099 IF= 10mA DELTA rel.CTR D est. at NIEL AsGa GEANT4 [MeV.g-1]= 4.88e7 vs TRR0

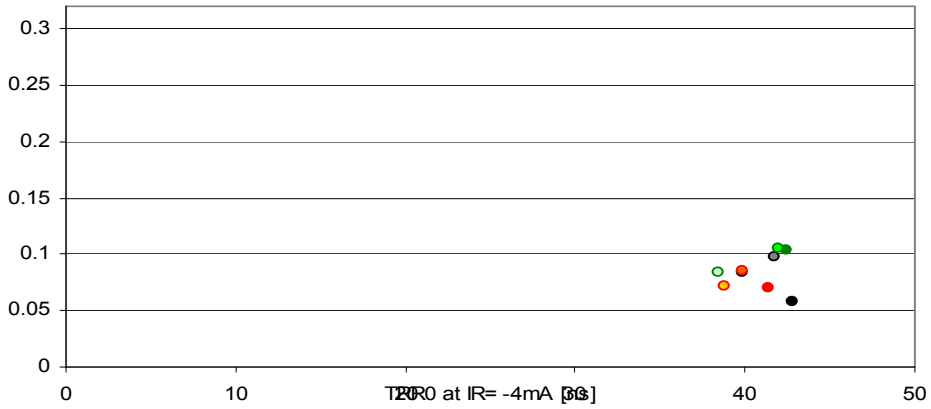


Fig. 14-49: optocoupler irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to diode current I_F

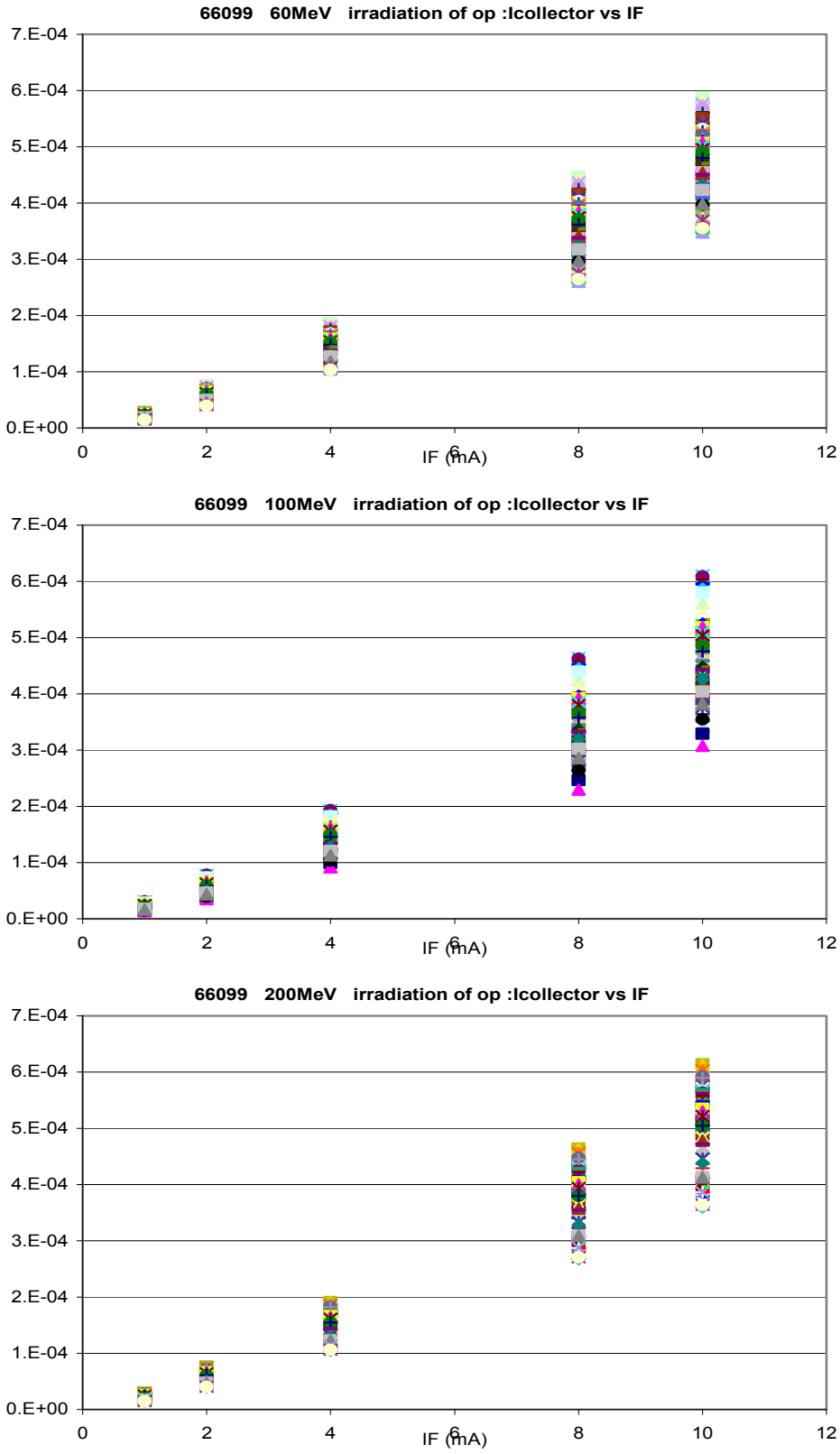


Fig. 14-50: diode irradiated at E=60, 100, 200 MeV: reference transistor collector current I_C for each step with respect to diode current I_F

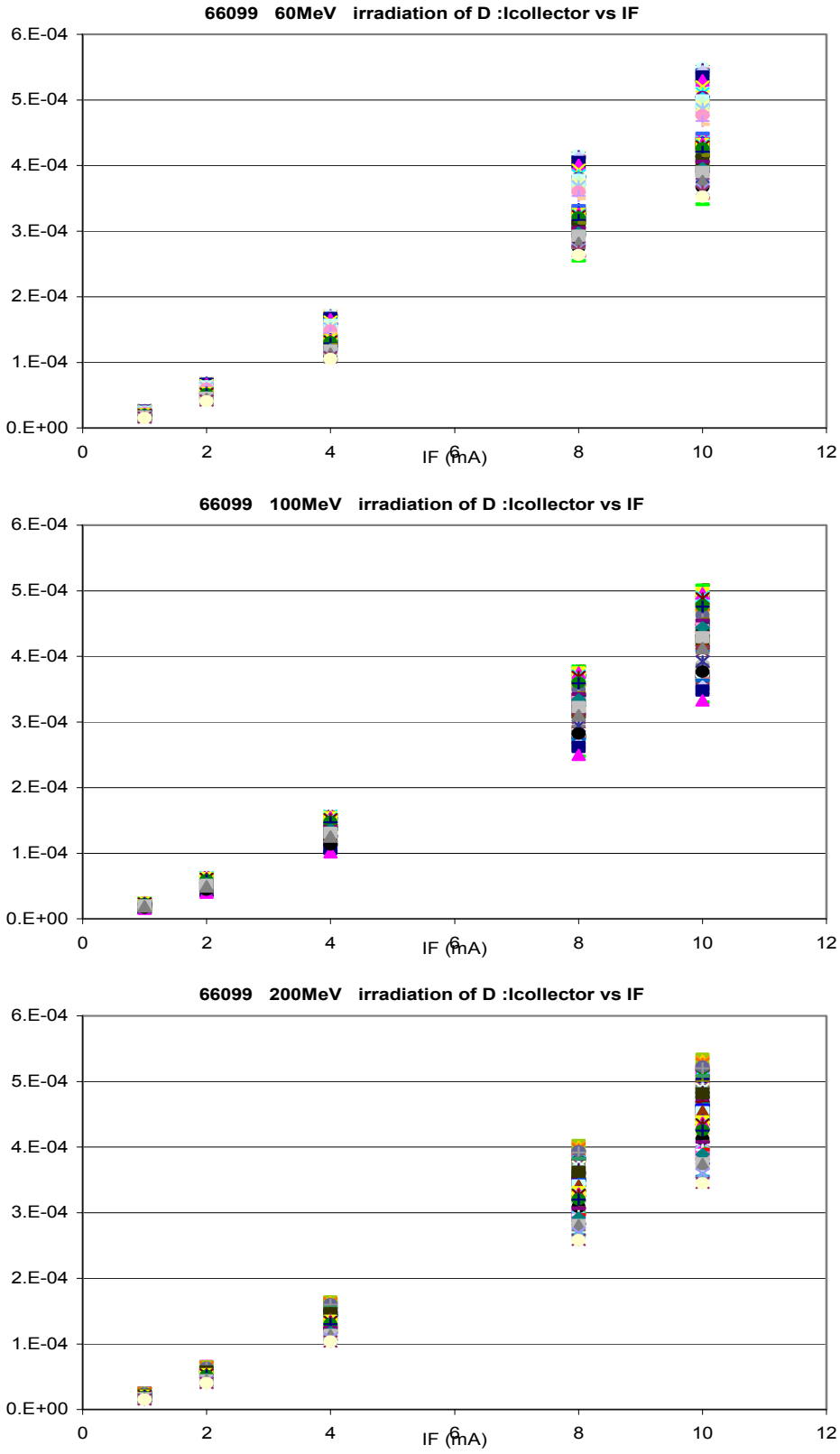


Fig. 14-51: transistor irradiated at E=60, 100, 200 MeV: transistor collector current I_C for each step with respect to reference diode current I_F

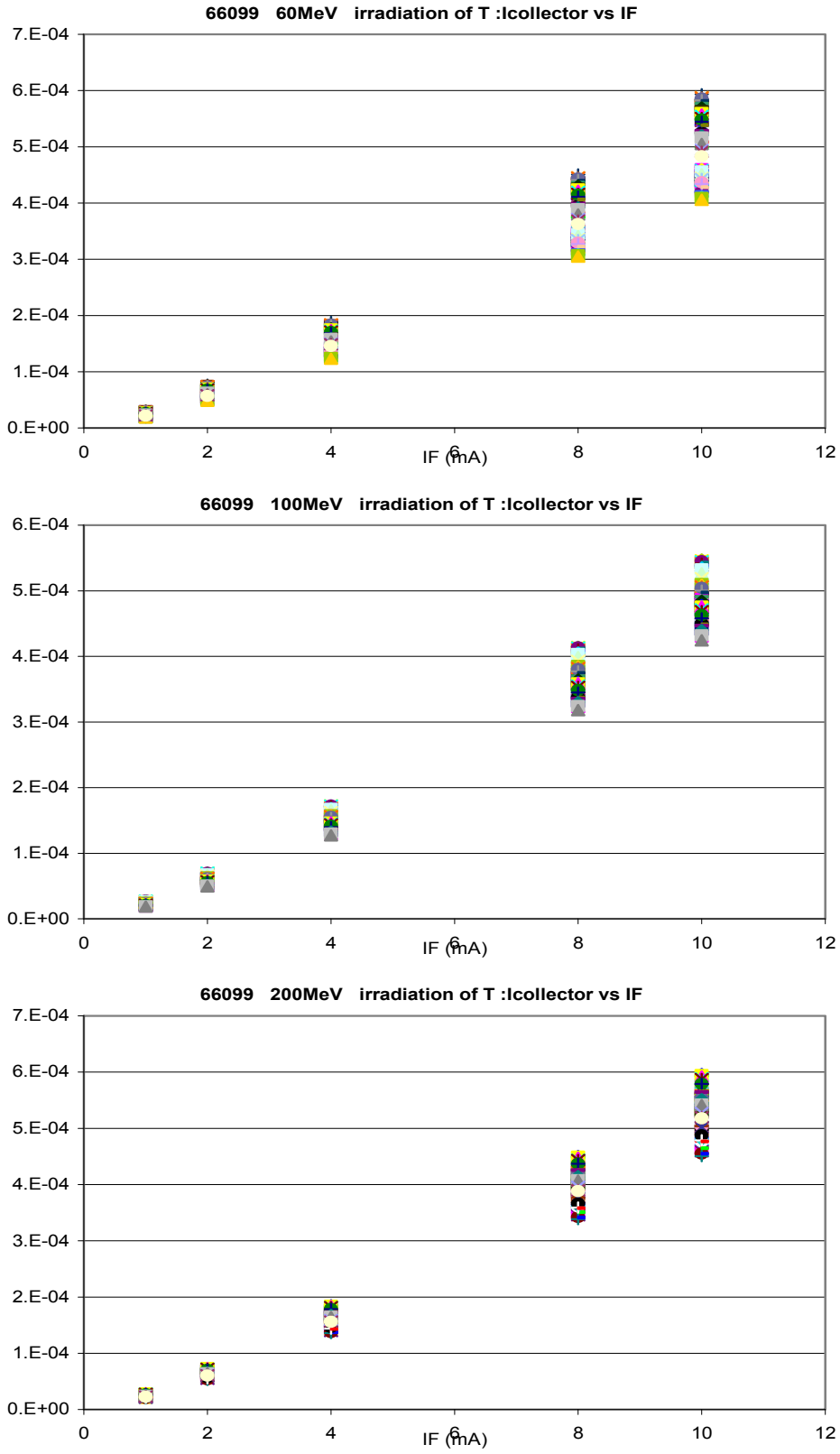


Fig. 14-52: optocoupler irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

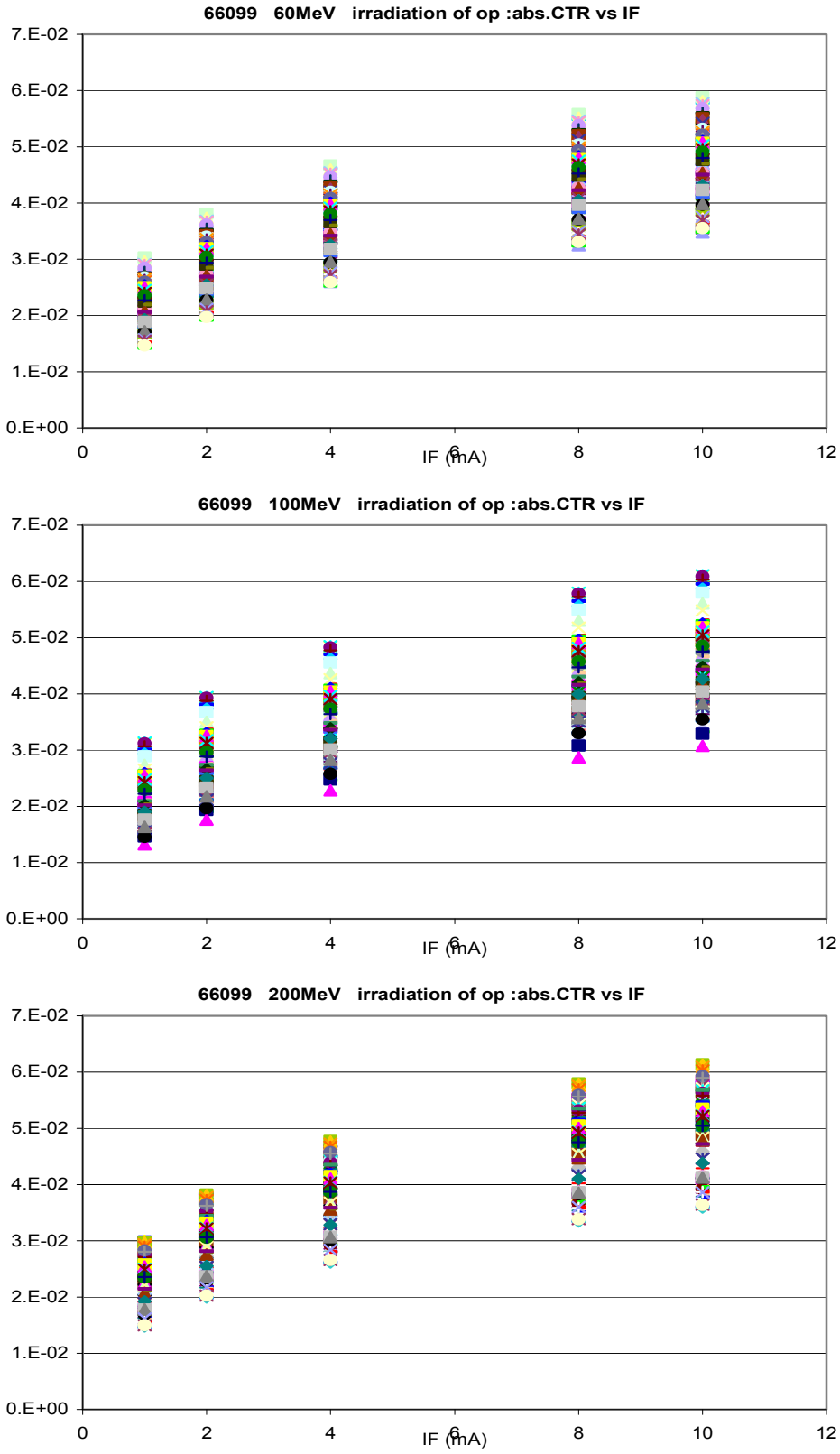


Fig. 14-53: diode irradiated at E=60, 100, 200 MeV: CTR for each step with respect to diode current I_F

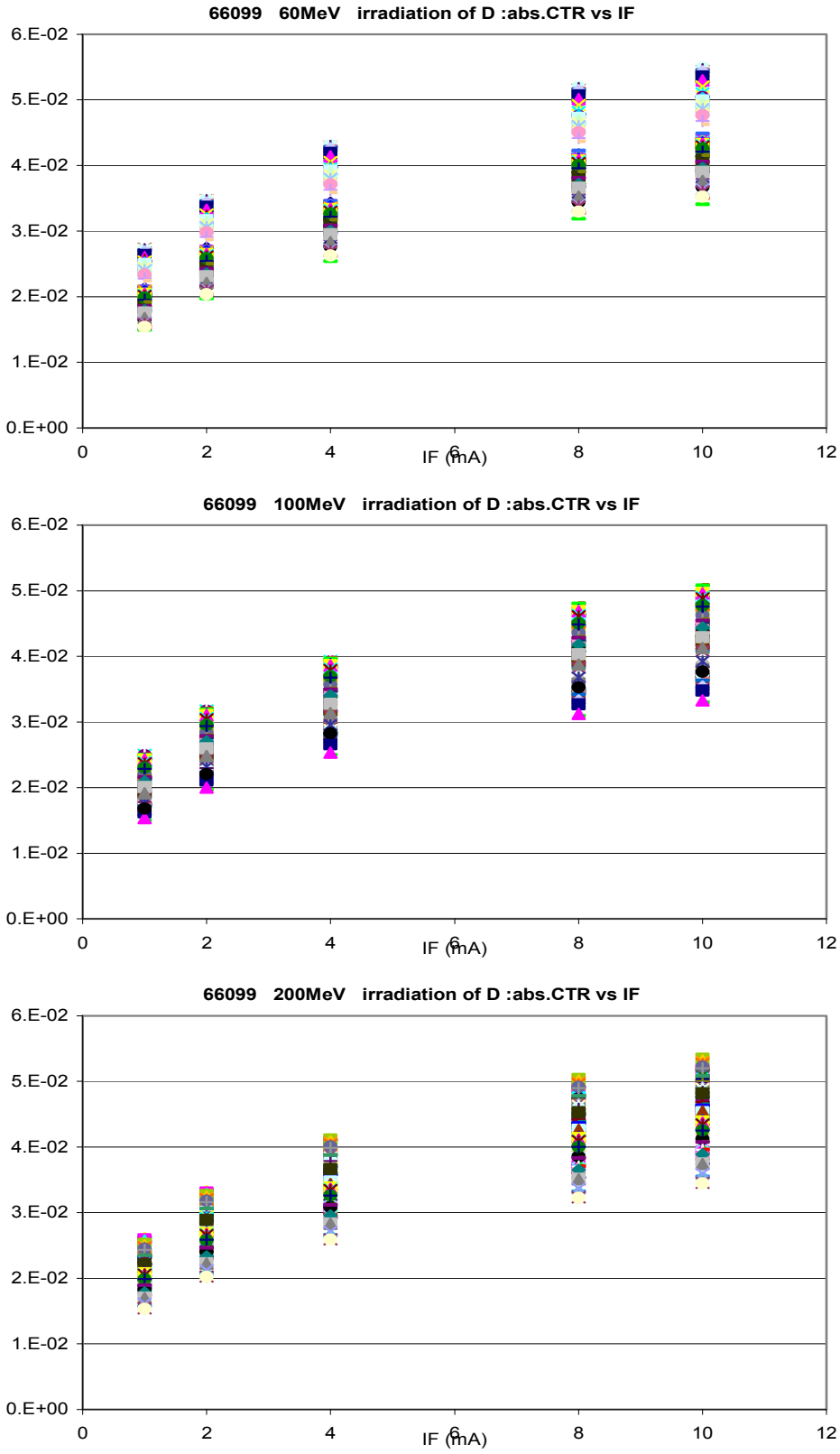


Fig. 14-54: transistor irradiated at E=60, 100, 200 MeV: CTR for each step with respect to reference diode current I_F

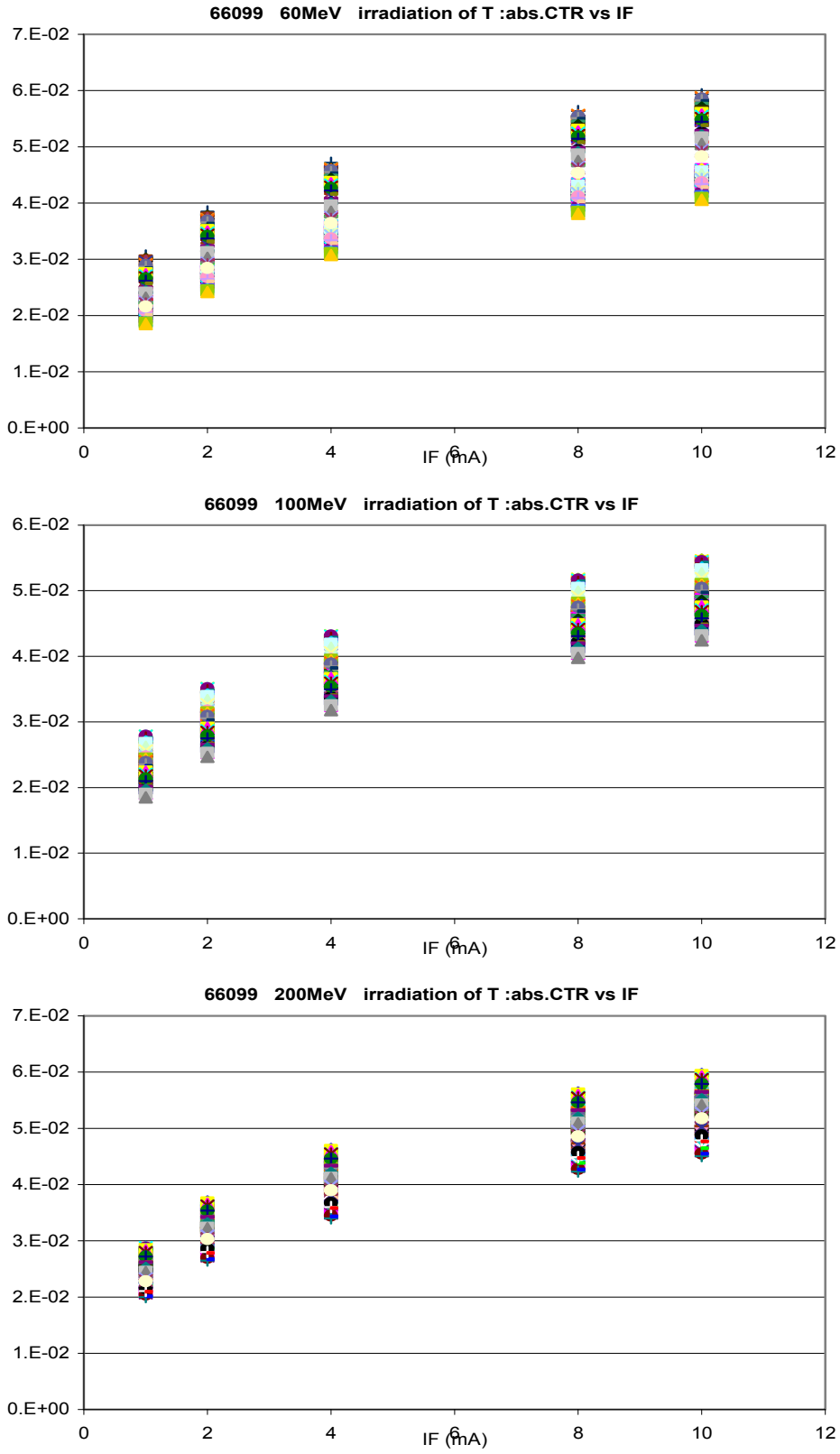


Fig. 14-55: optocoupler irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

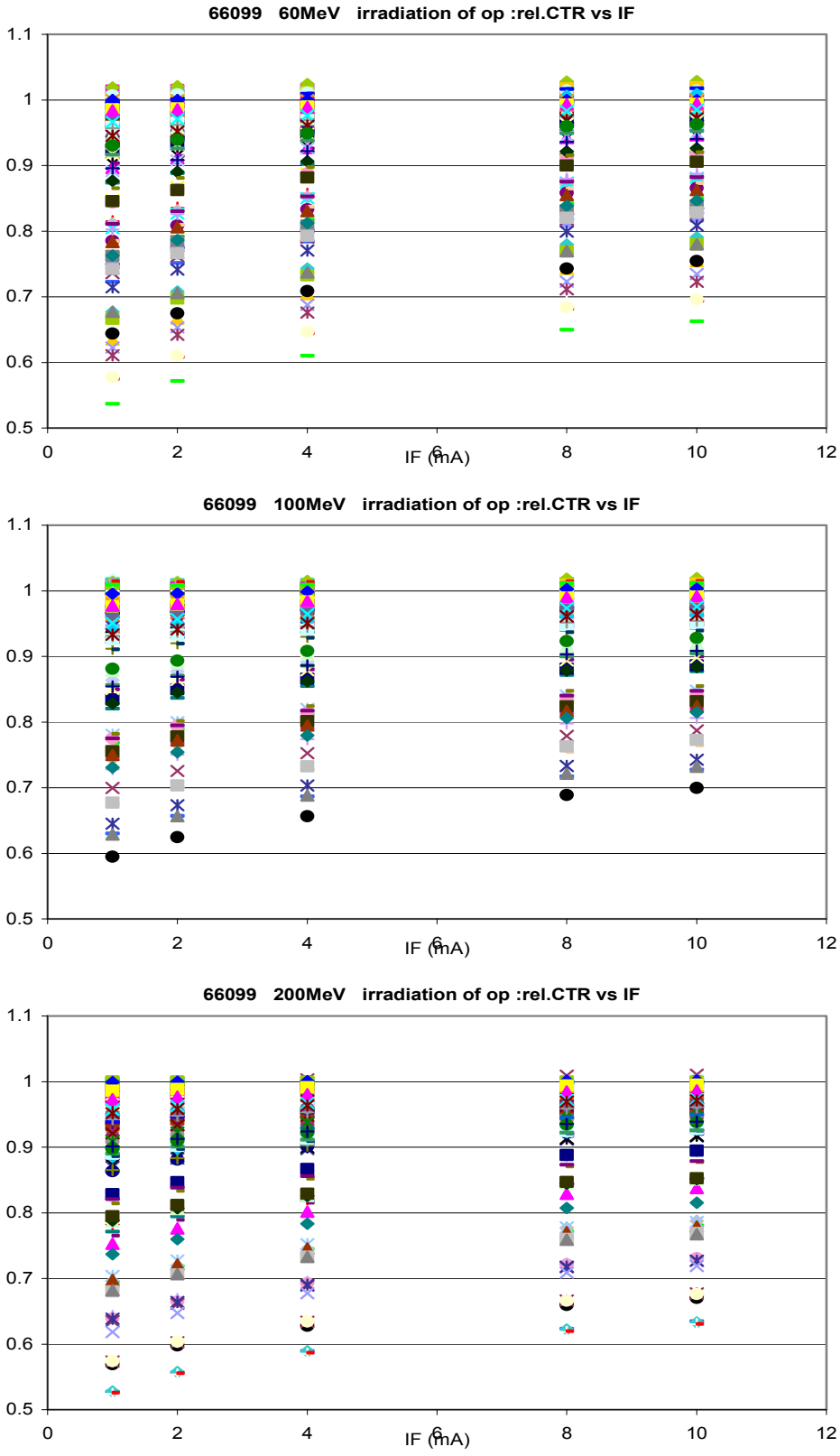


Fig. 14-56: diode irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to diode current I_F

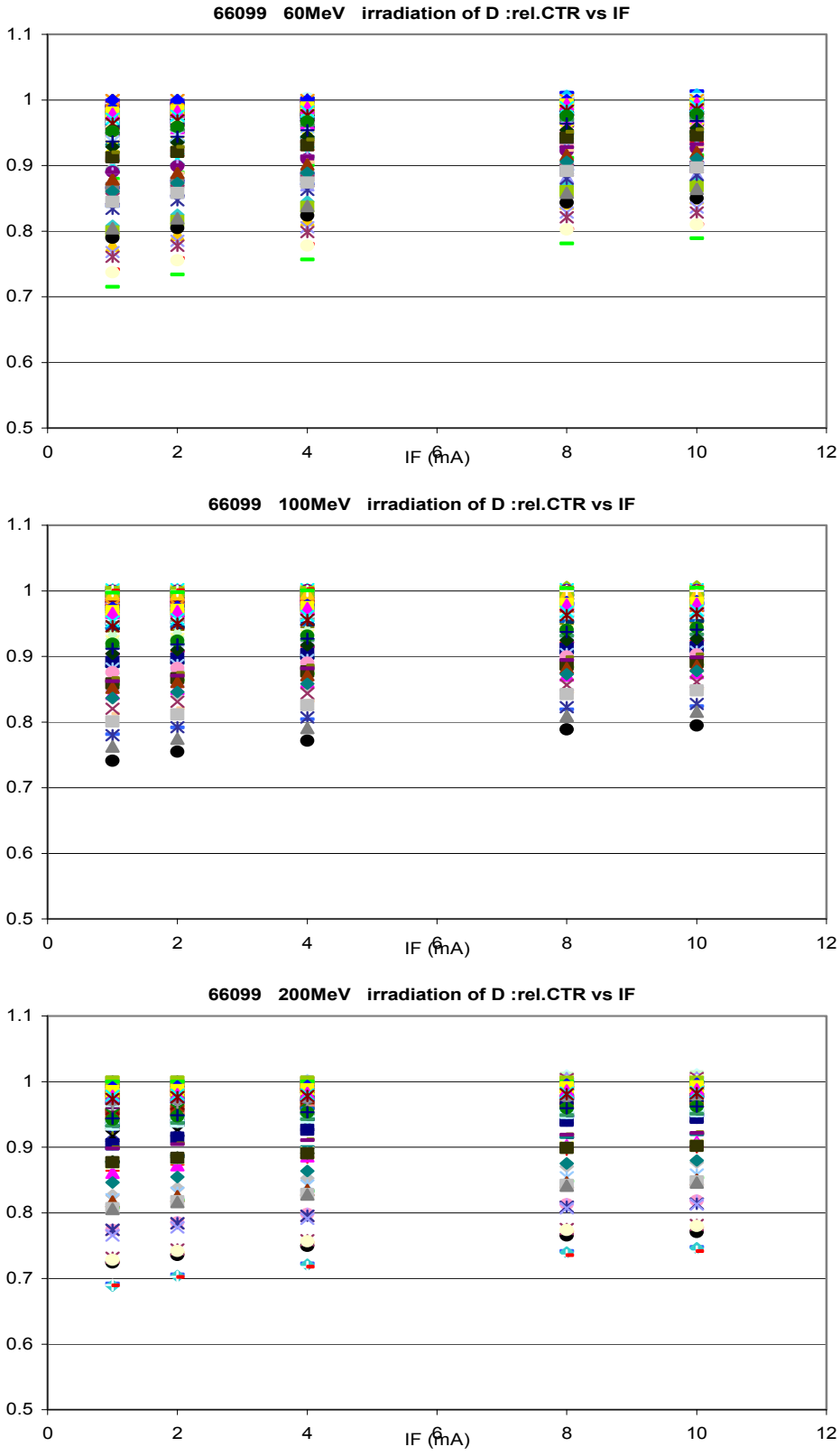


Fig. 14-57: transistor irradiated at E=60, 100, 200 MeV: CTR/CTR$_0$ for each step with respect to reference diode current I_F

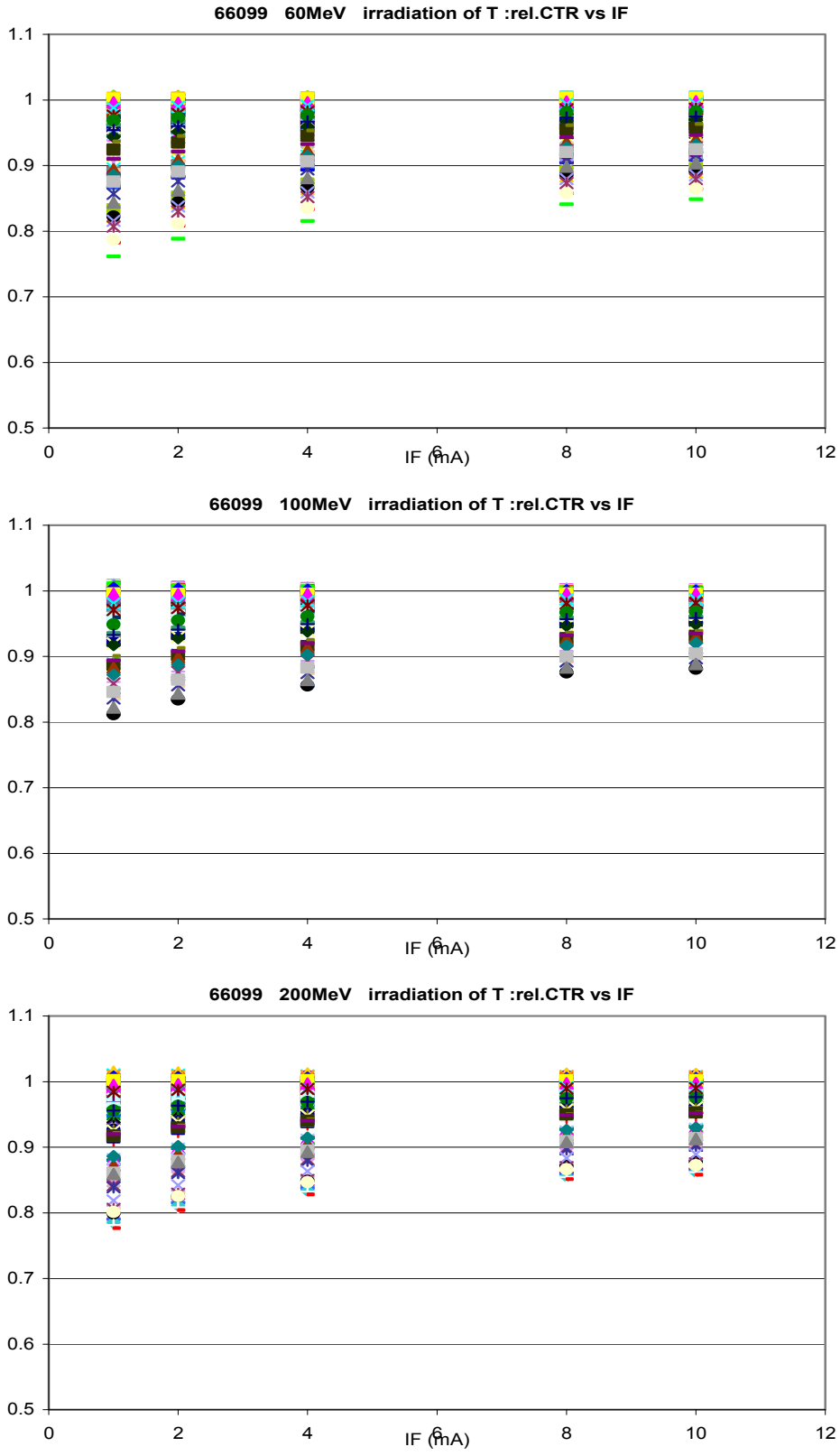


Fig. 14-58: 66099 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA

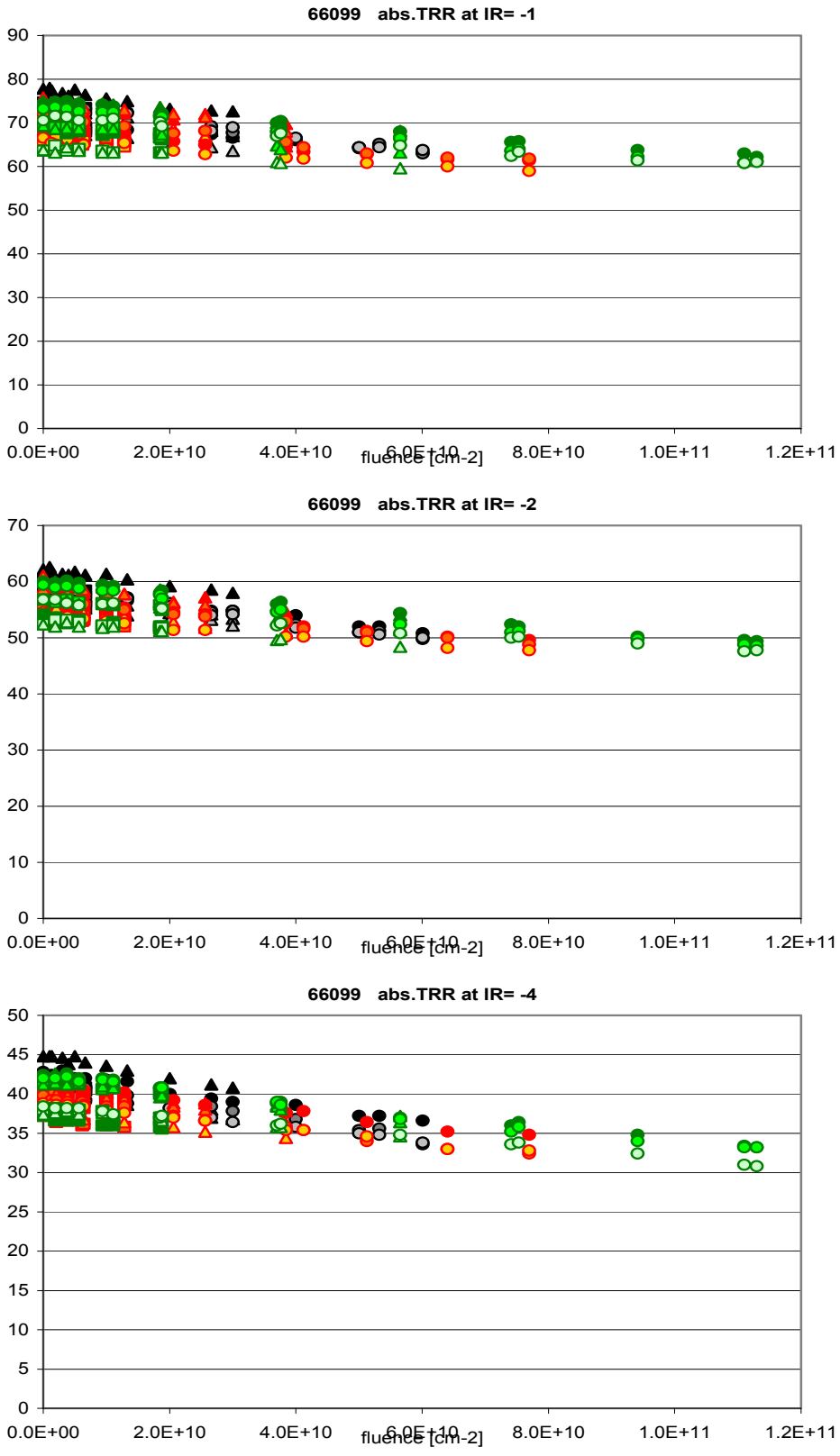


Fig. 14-59: 66099 diode: τ_{RR} [ns] with respect to NIEL (Barry) at I_R = -1, -2, -4 mA

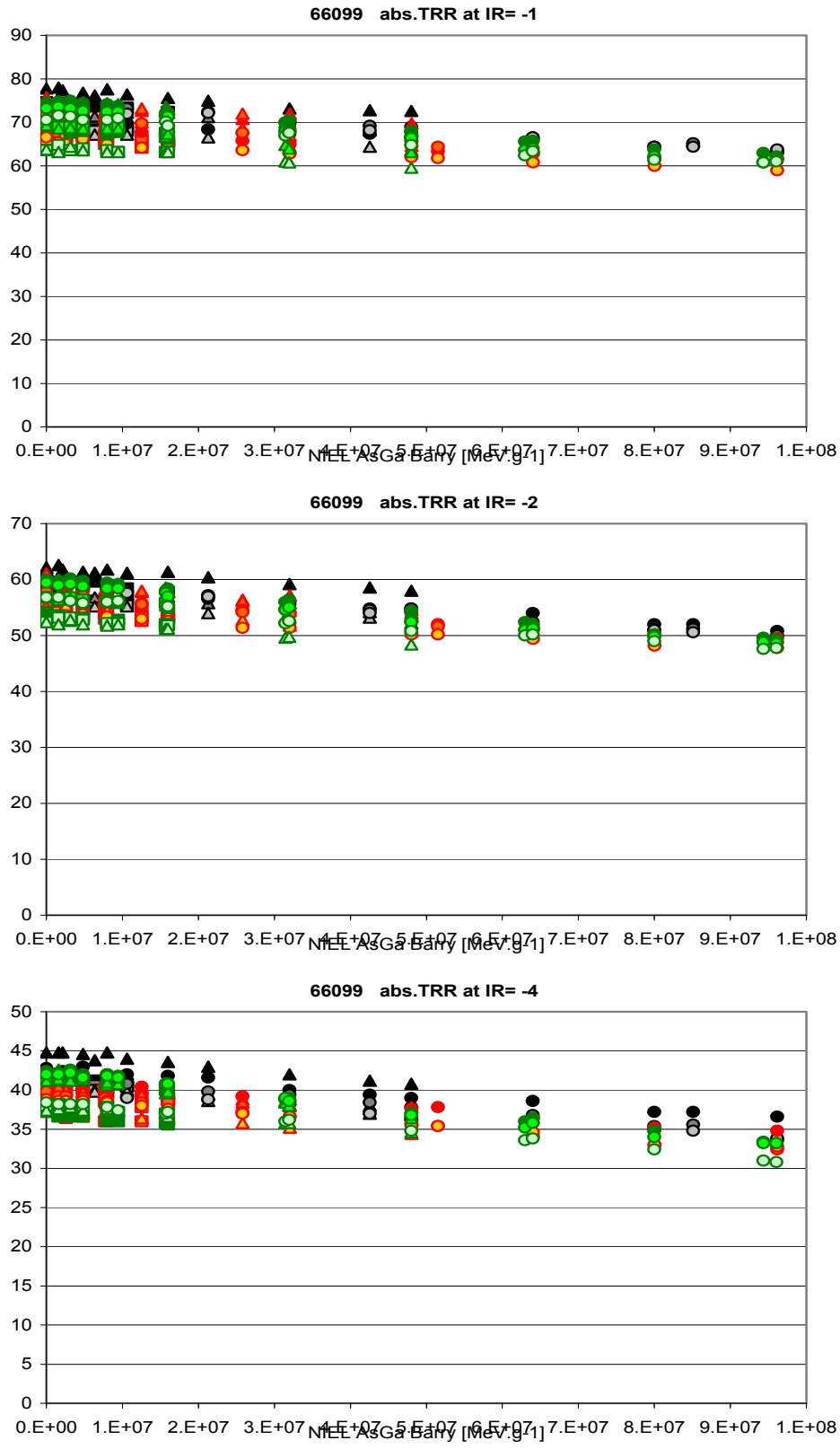


Fig. 14-60: 66099 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA

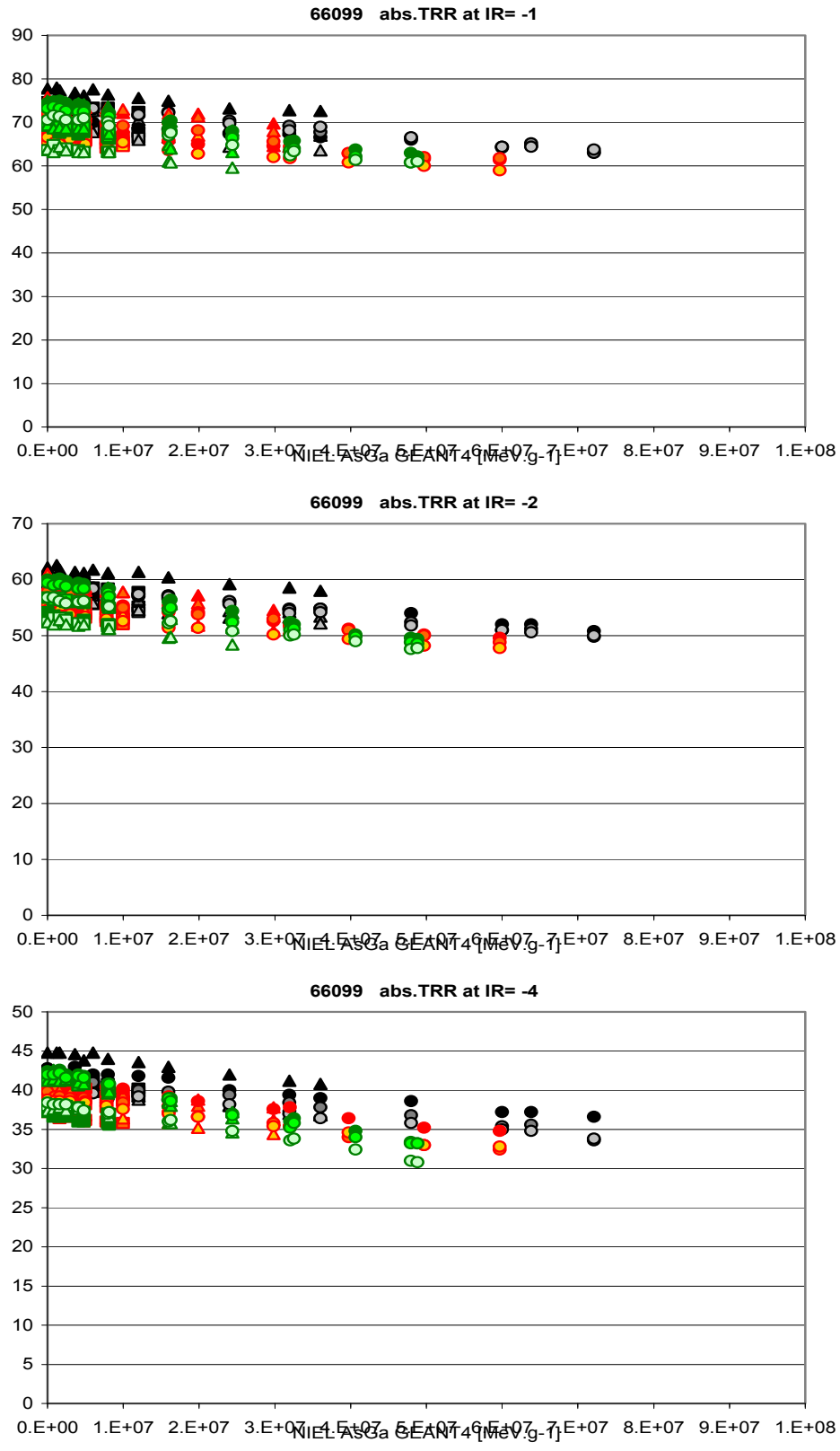


Fig. 14-61: 66099 diode: τ_{RR} [ns] with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA

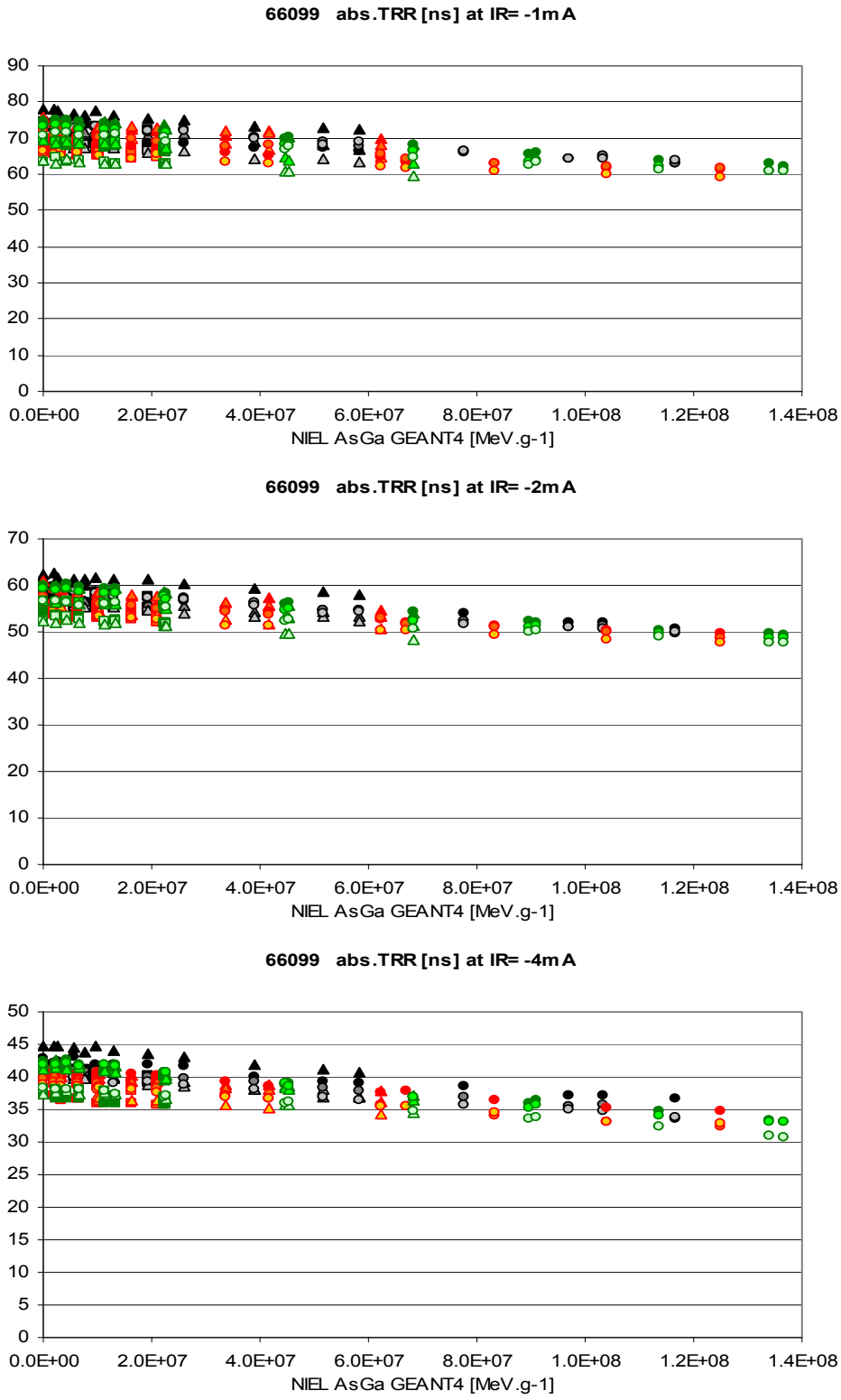
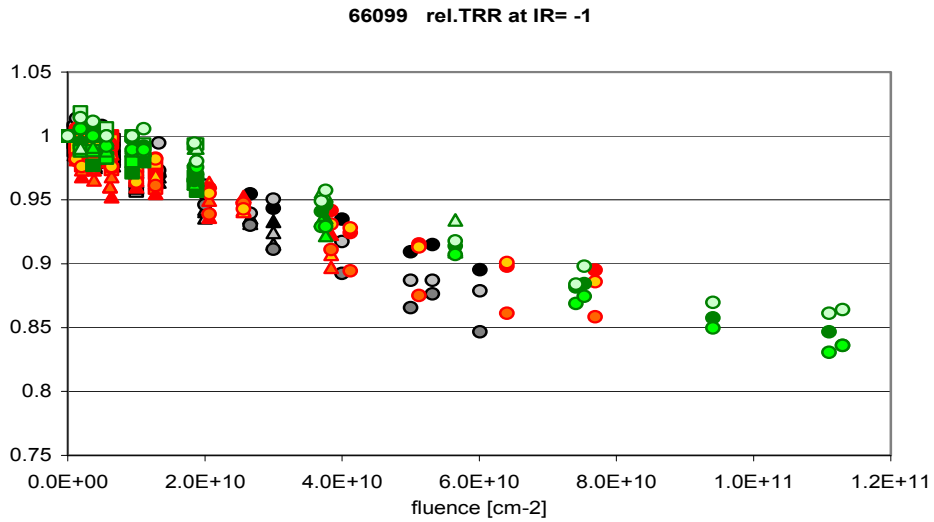
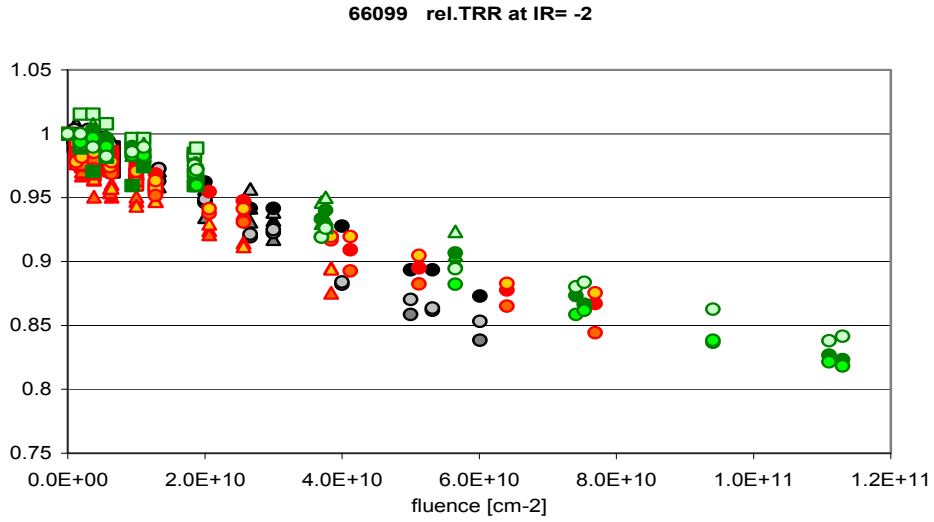


Fig. 14-62: 66099 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA





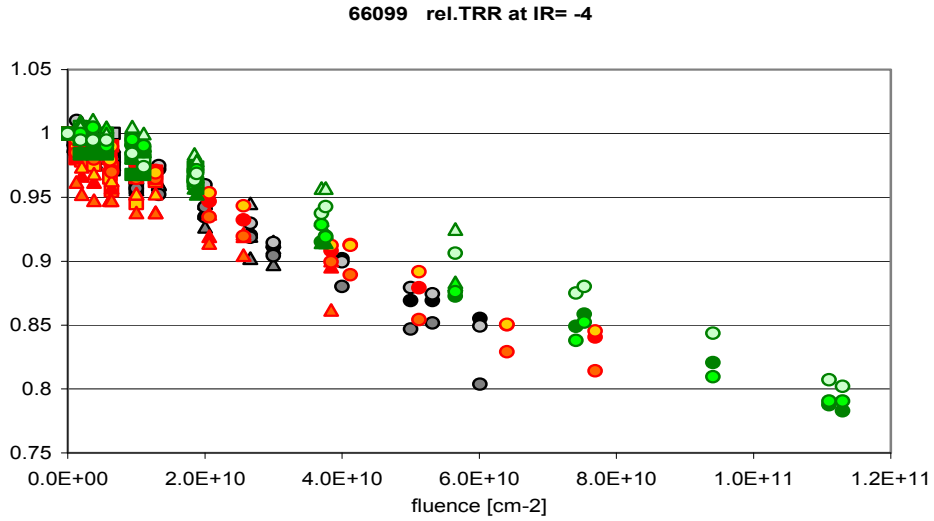
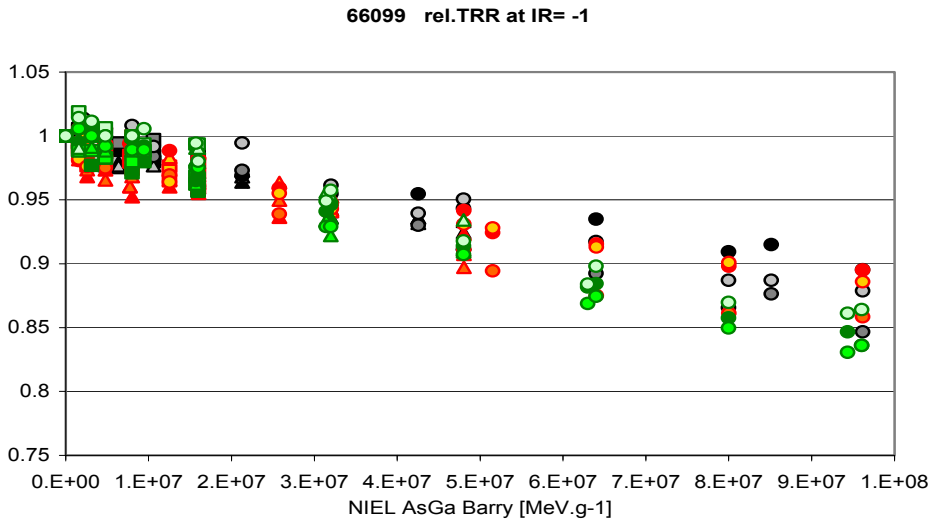
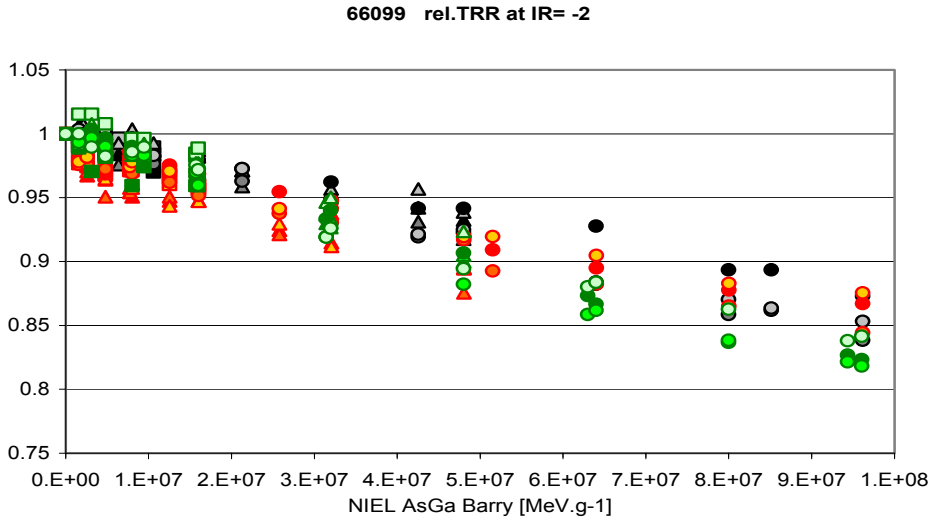


Fig. 14-63: 66099 diode: τ_{RR}/τ_{RR0} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





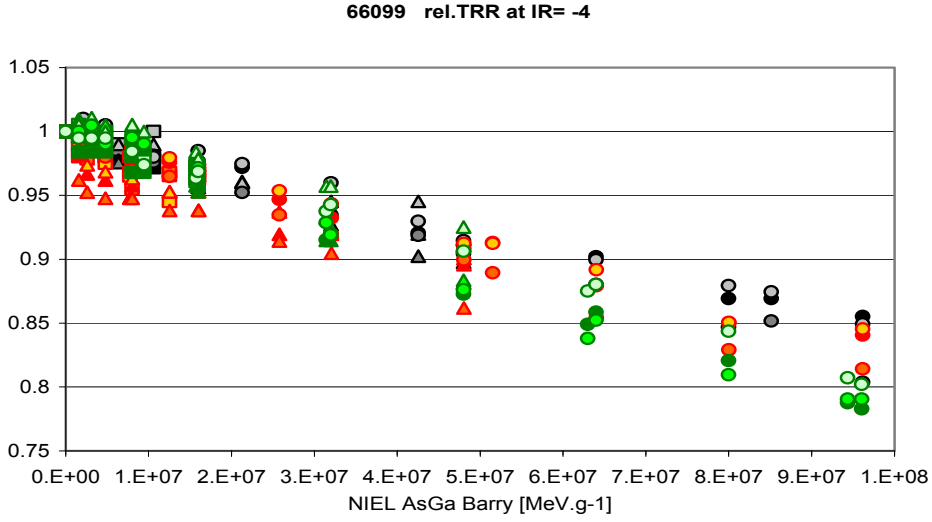
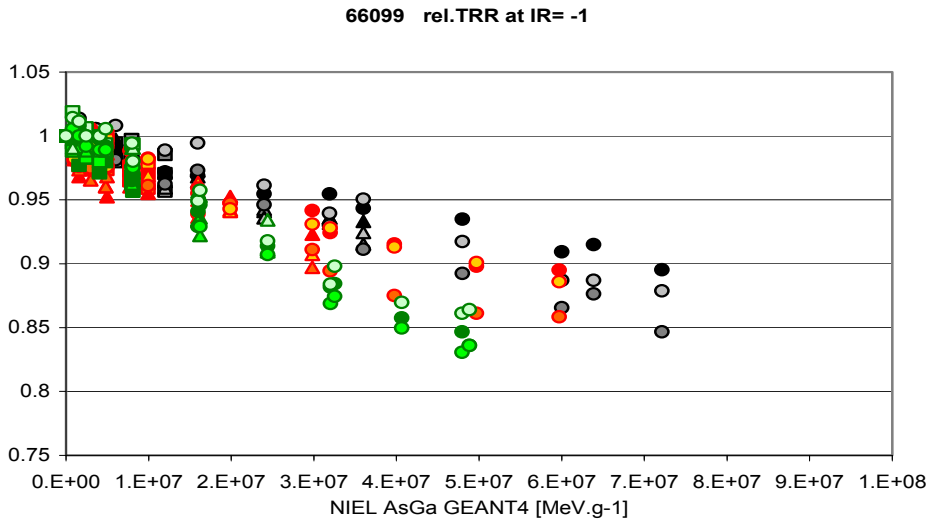
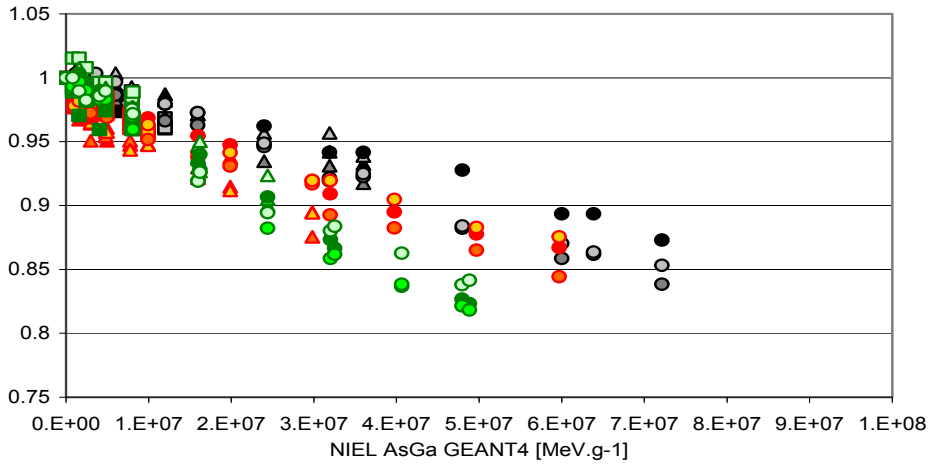


Fig. 14-64: 66099 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





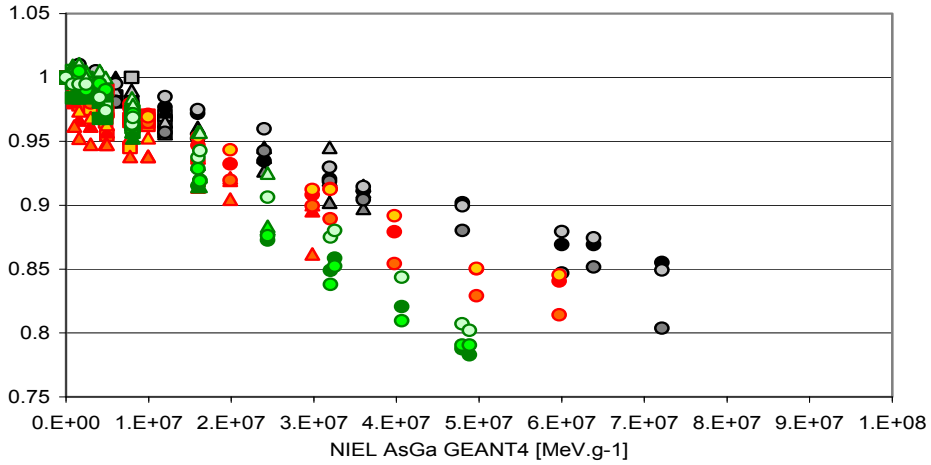
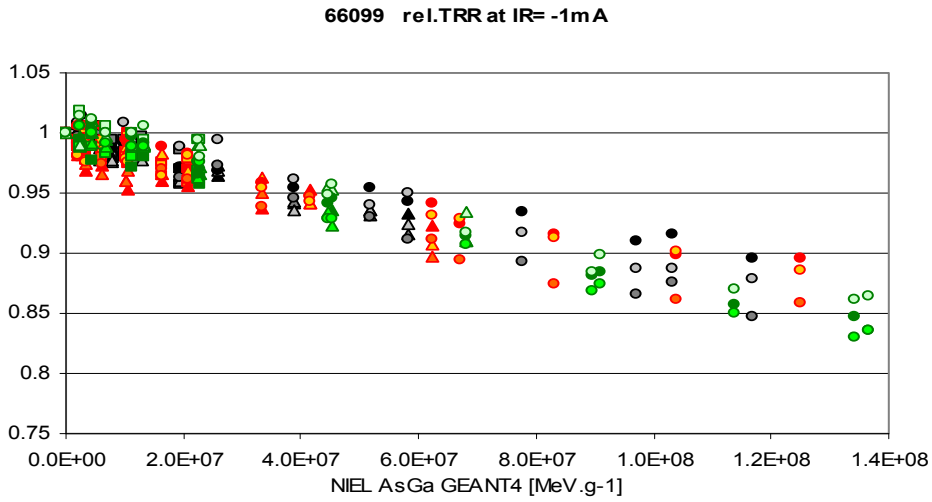
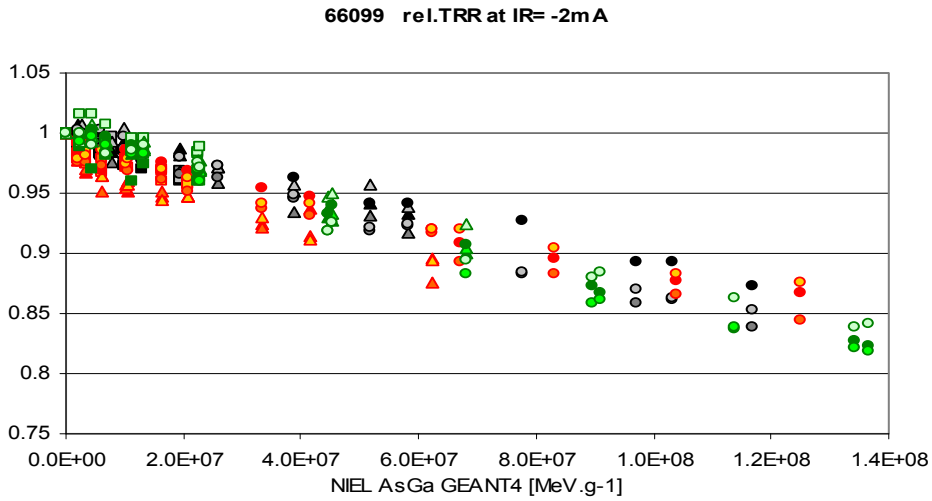


Fig. 14-65: 66099 diode: τ_{RR}/τ_{RR0} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





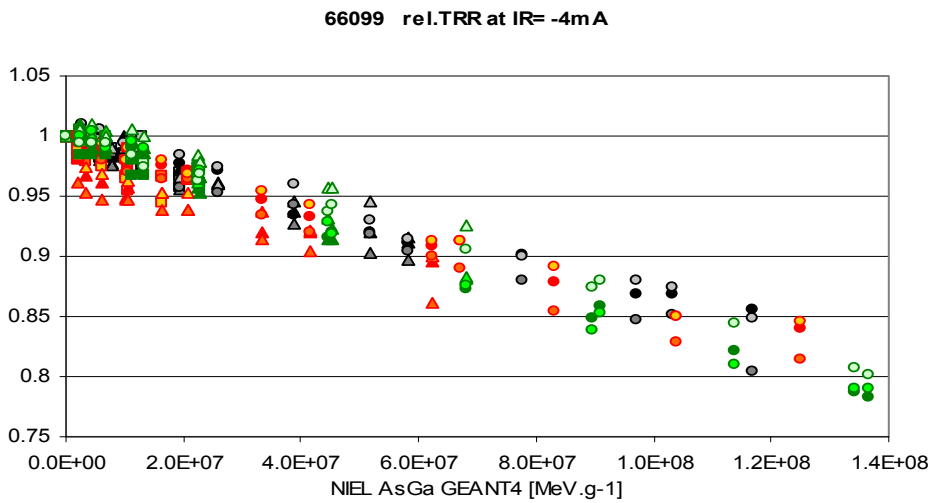
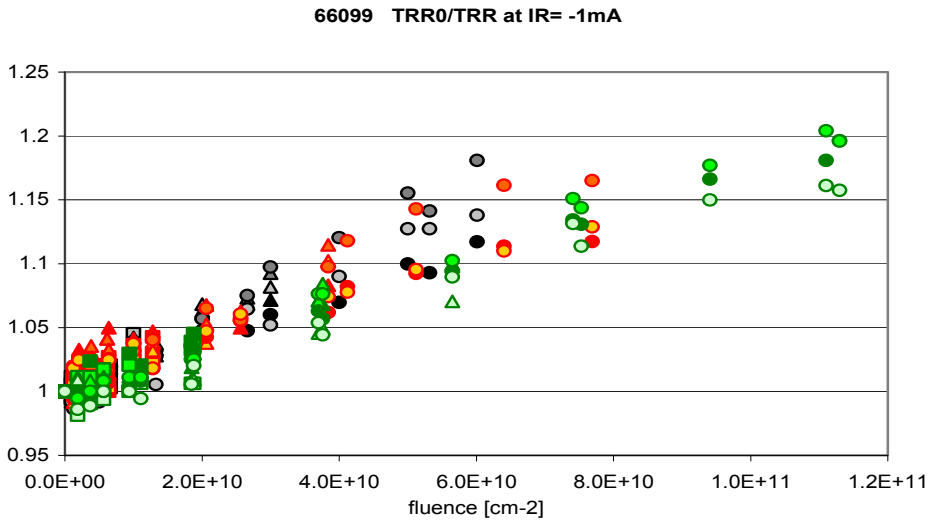
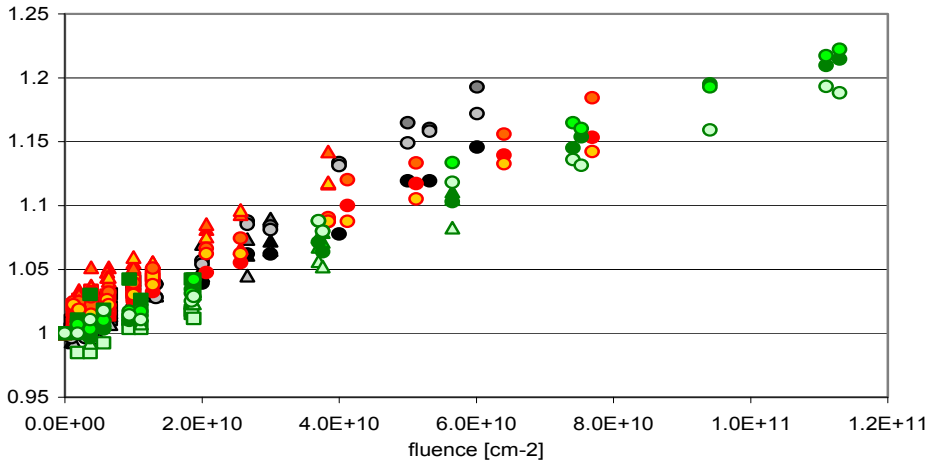


Fig. 14-66: 66099 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





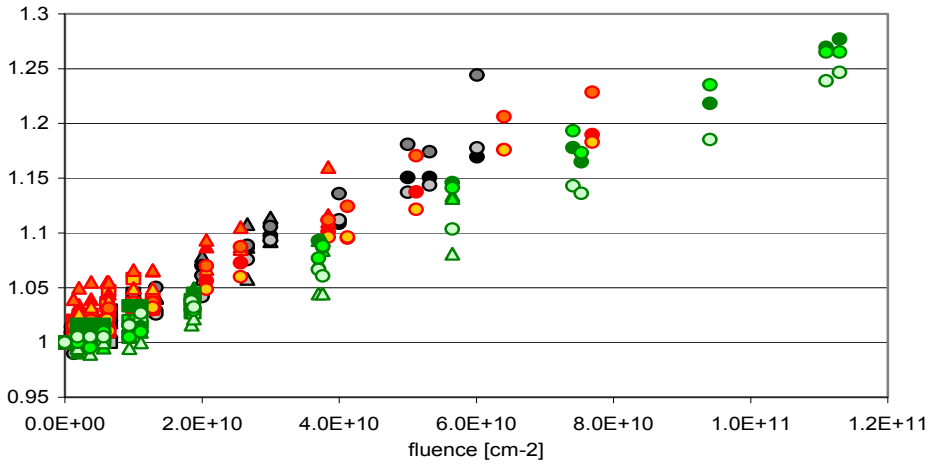
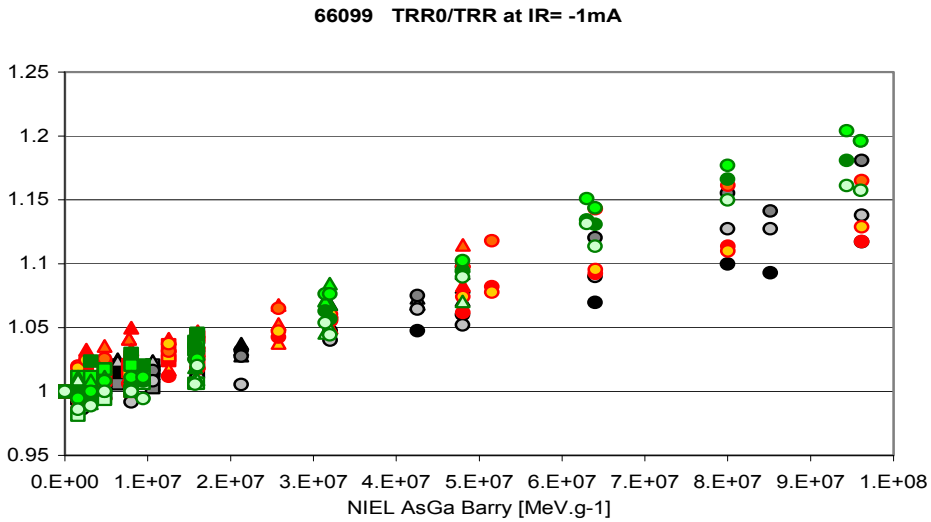
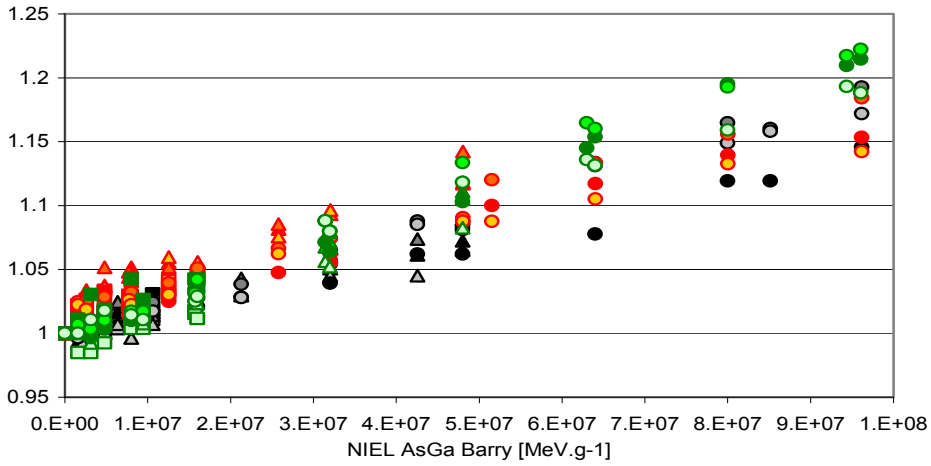


Fig. 14-67: 66099 diode: τ_{RR0}/τ_{RR} with respect to NIEL (Barry) at I_R = -1, -2, -4 mA





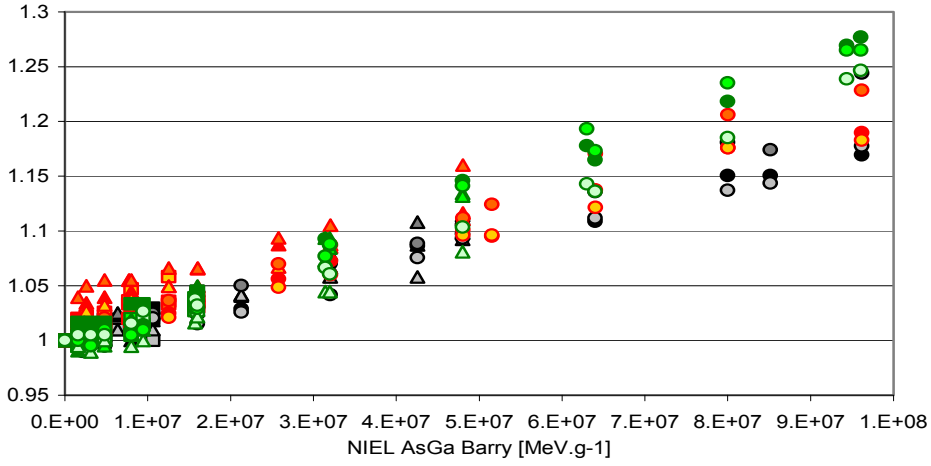
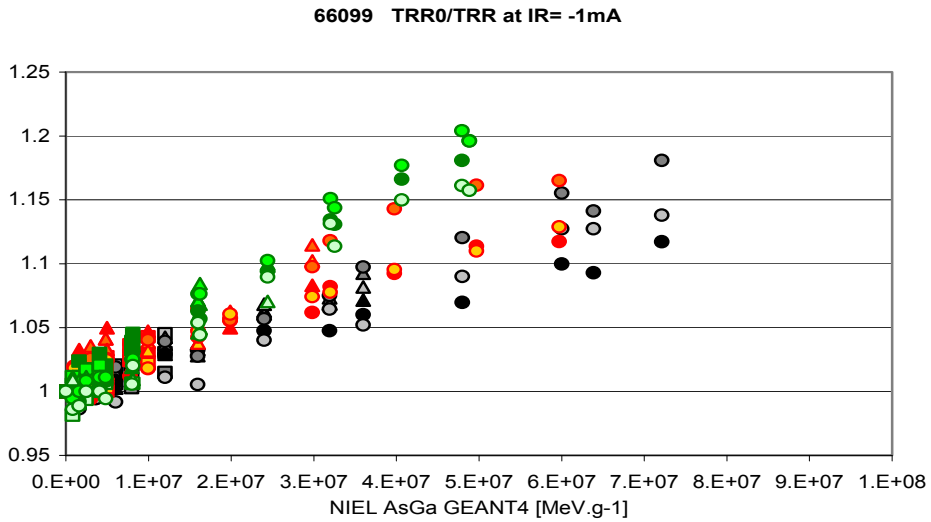
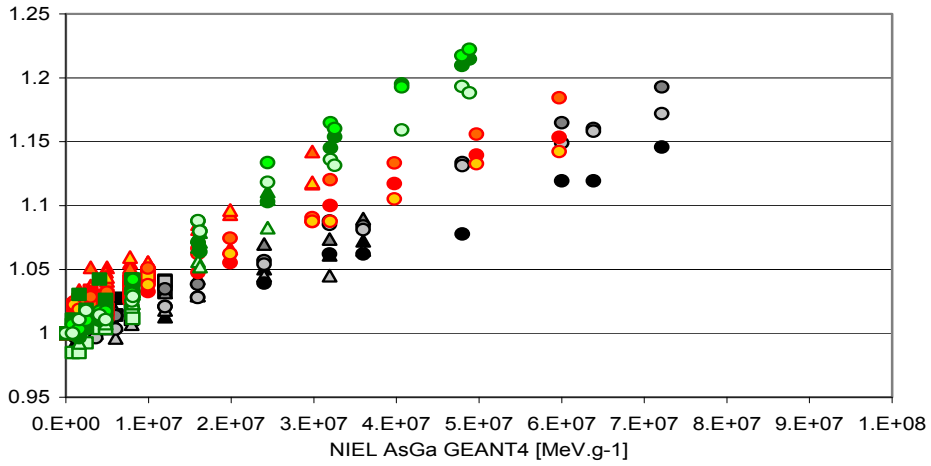


Fig. 14-68: 66099 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 ELASTIC) at I_R = -1, -2, -4 mA





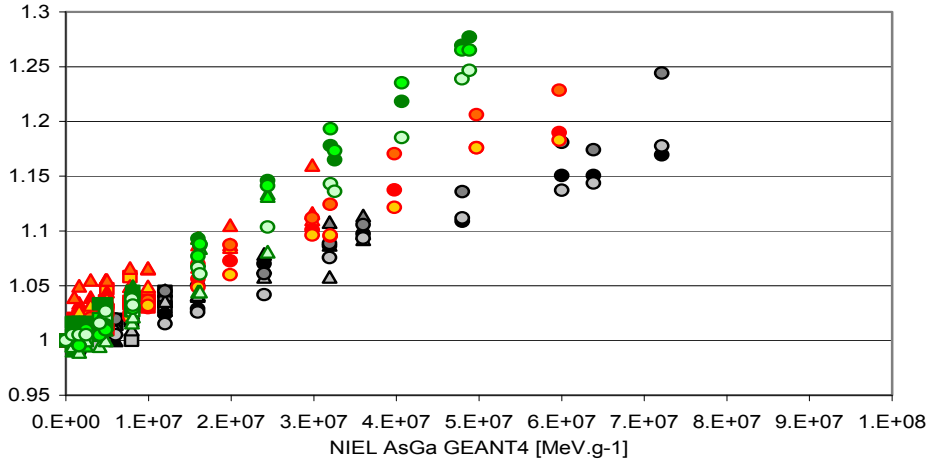
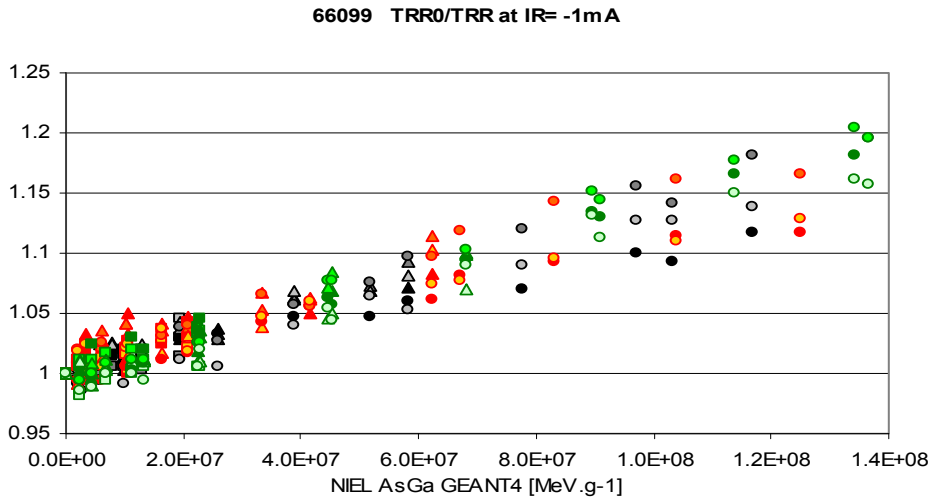
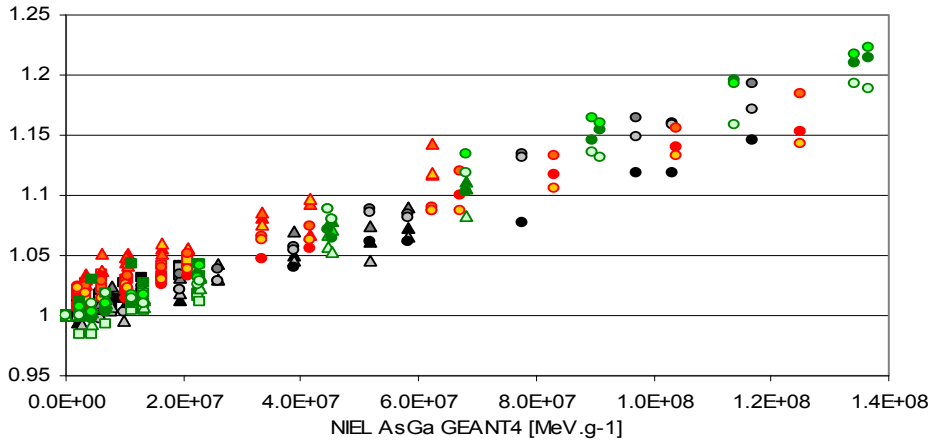


Fig. 14-69: 66099 diode: τ_{RR0}/τ_{RR} with respect to NIEL (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





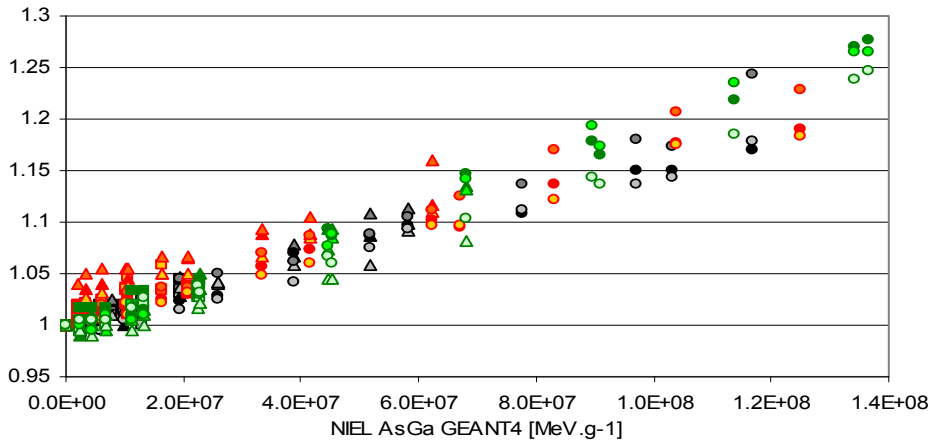


Fig. 14-70: 66099 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 1.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4 mA

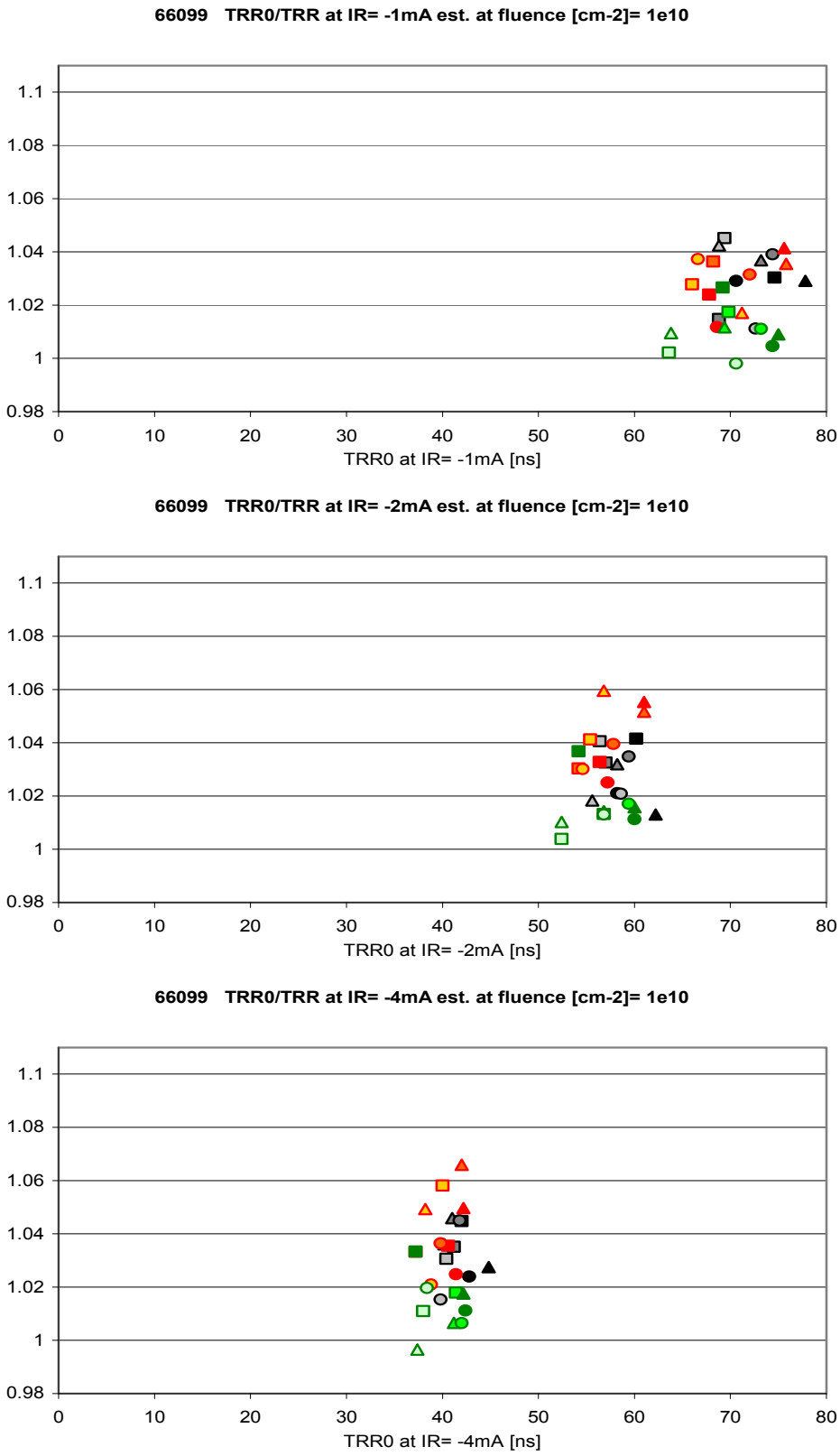


Fig. 14-71: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

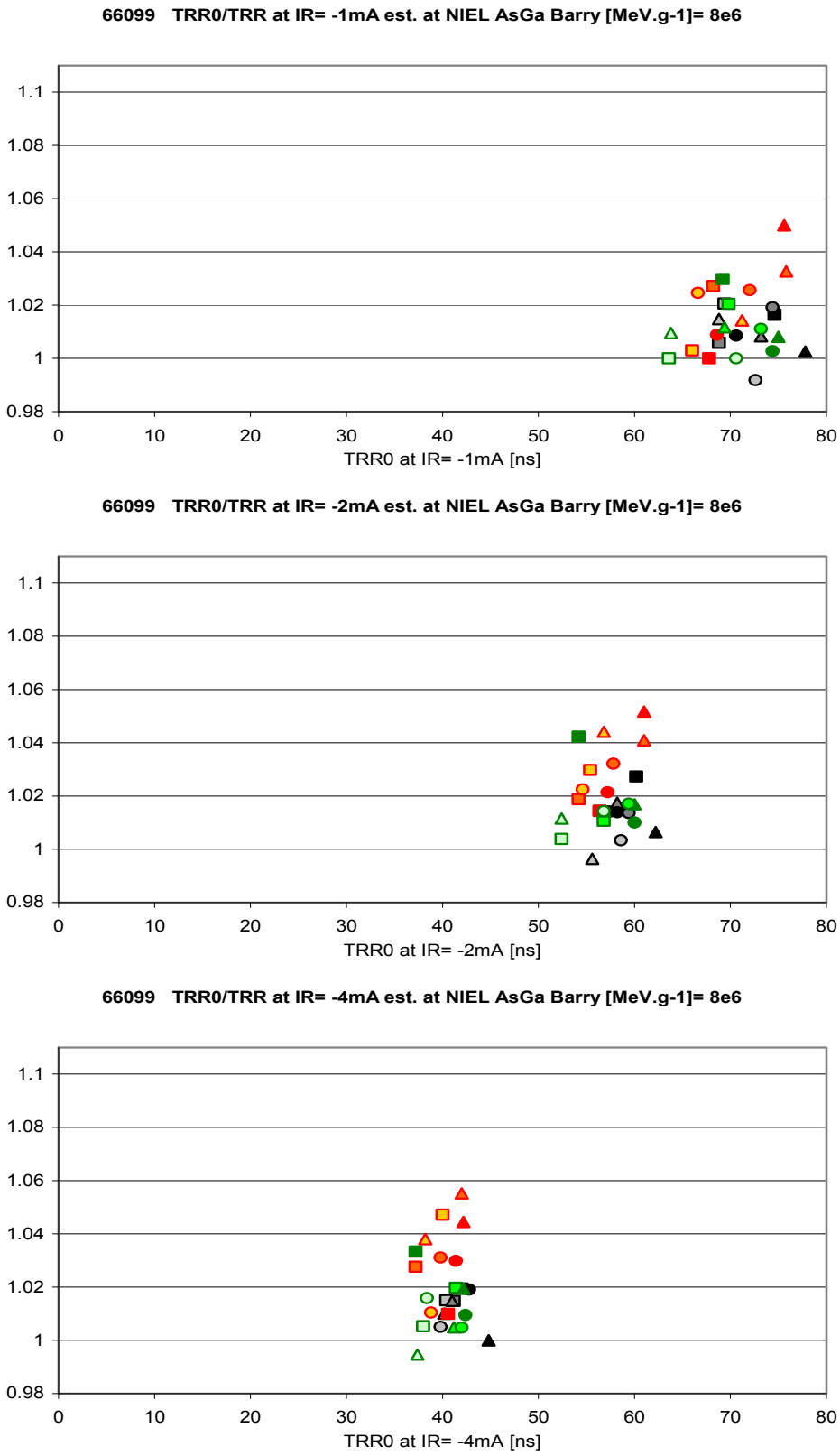


Fig. 14-72: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

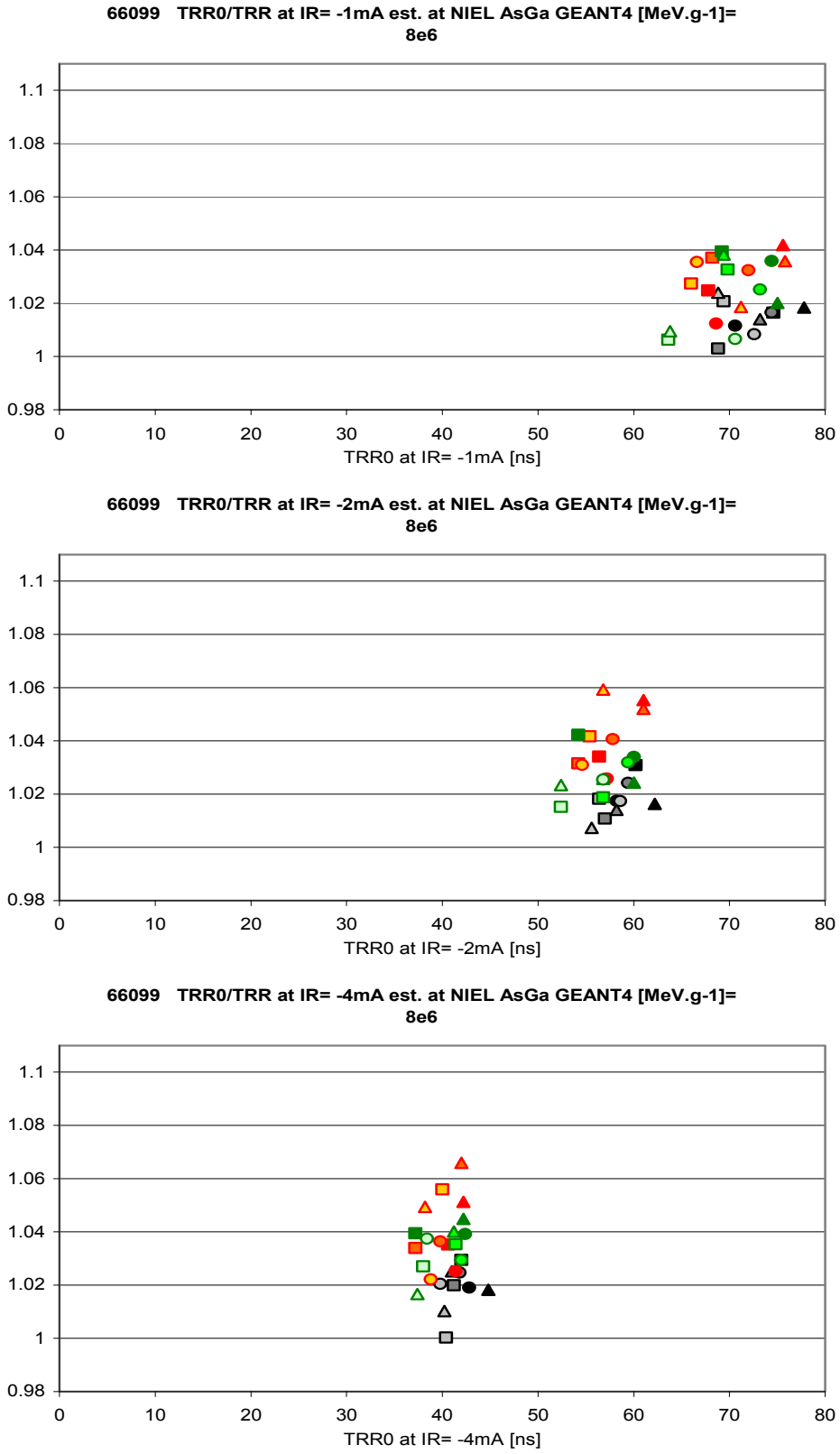


Fig. 14-73: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

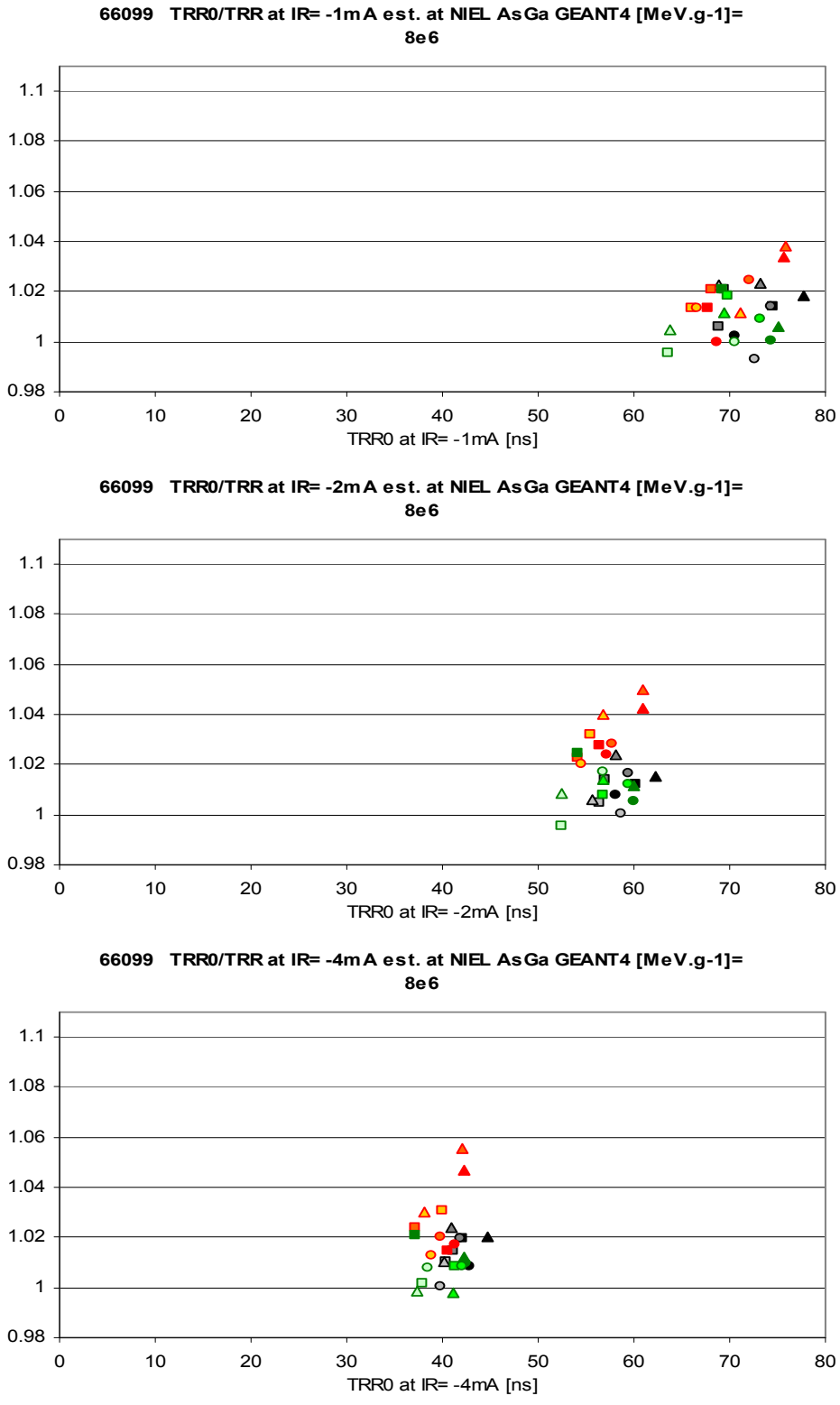


Fig. 14-74: 66099 diode: τ_{RR0}/τ_{RR} estimated at a fluence of $2.4.10^{10}$ cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

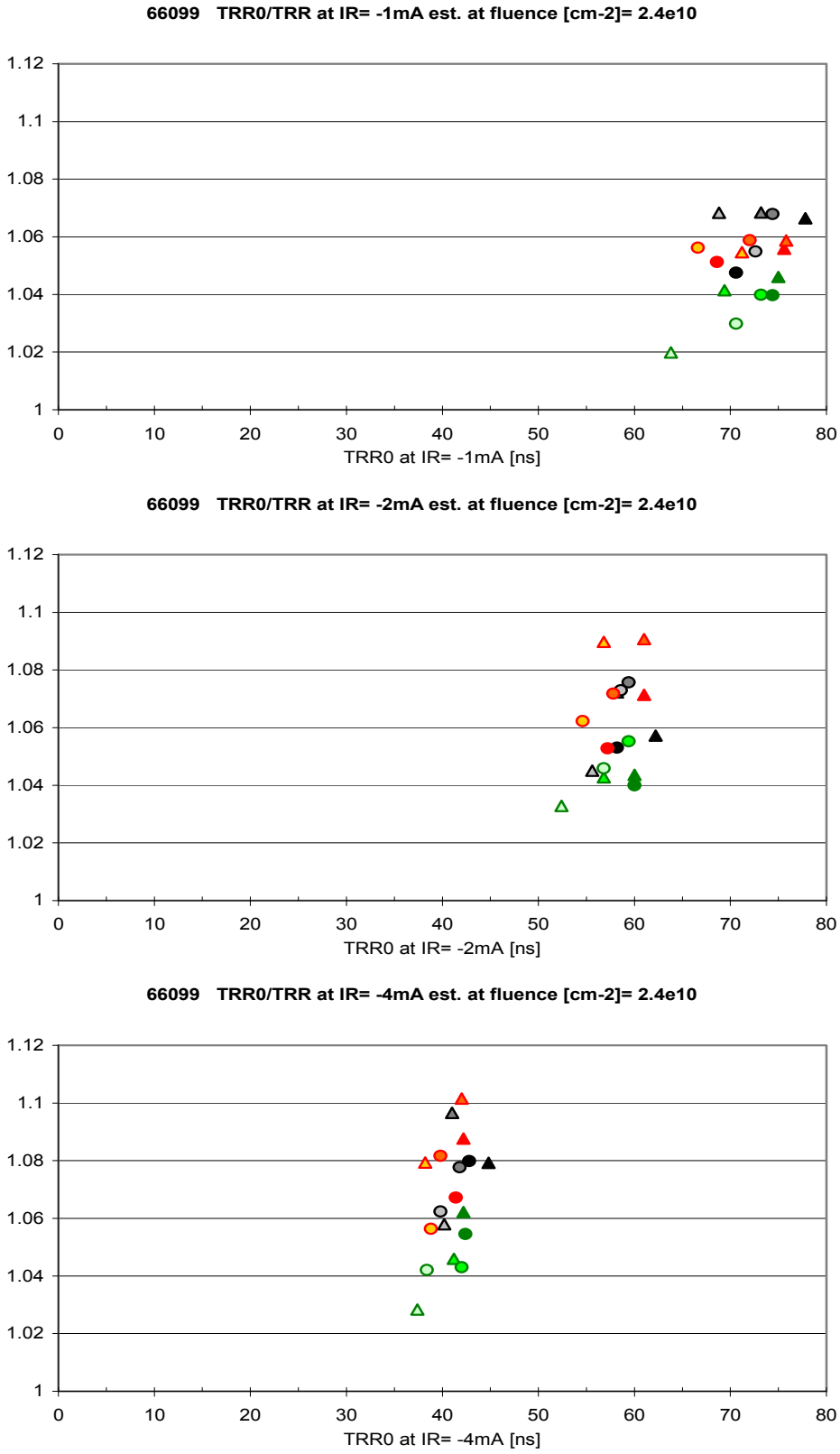
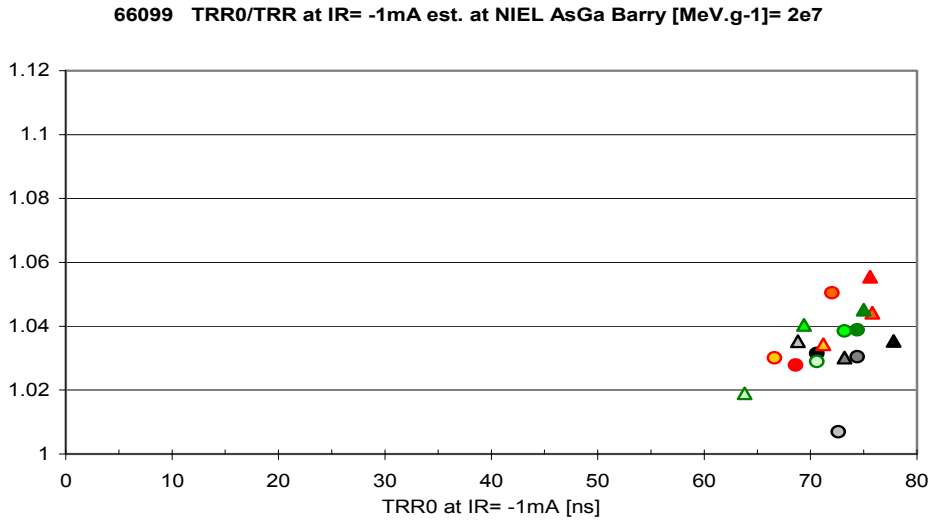
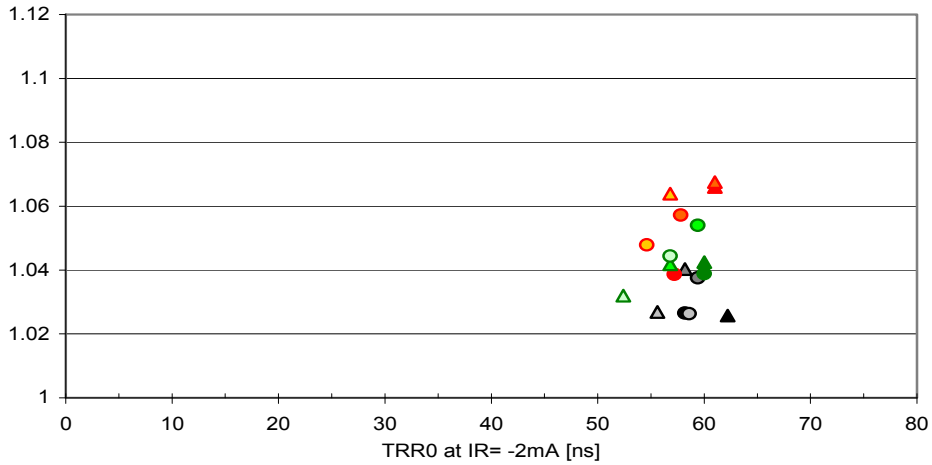


Fig. 14-75: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA





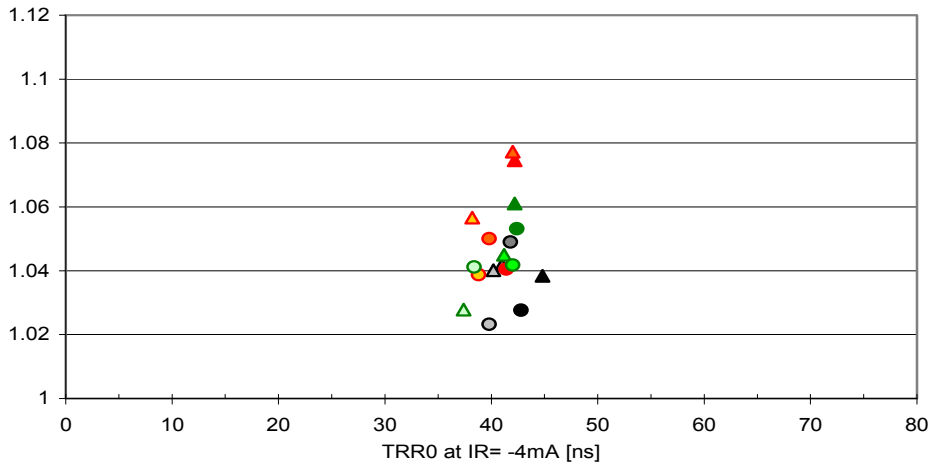


Fig. 14-76: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA

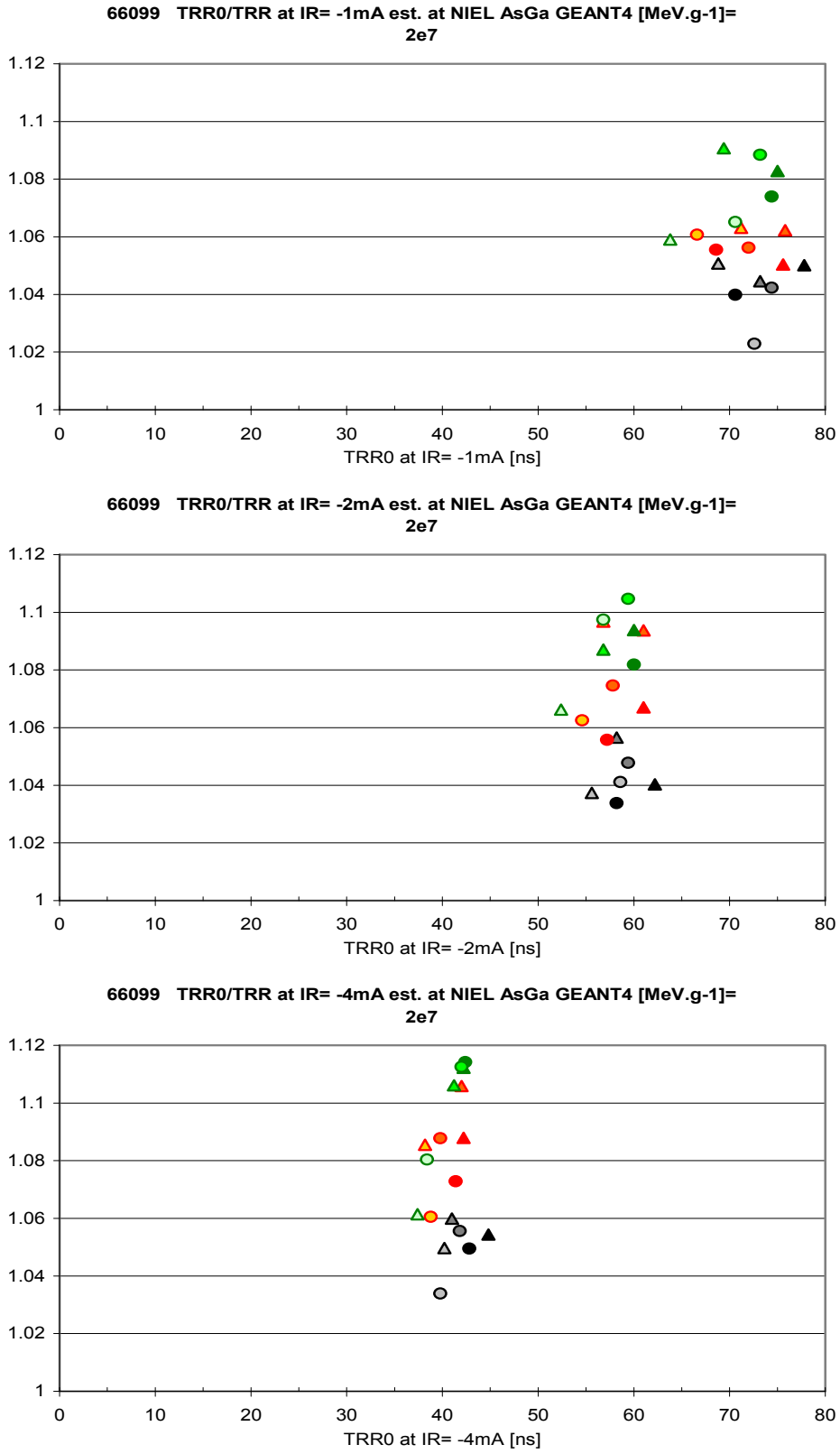
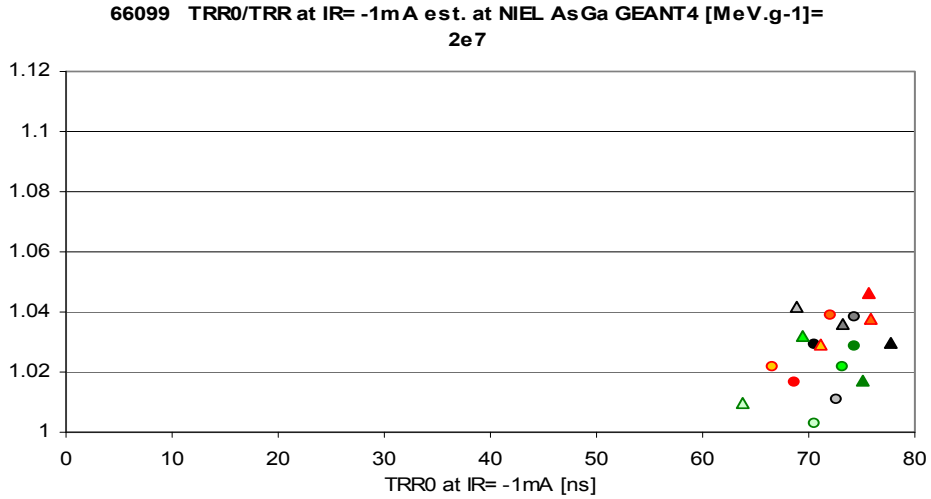
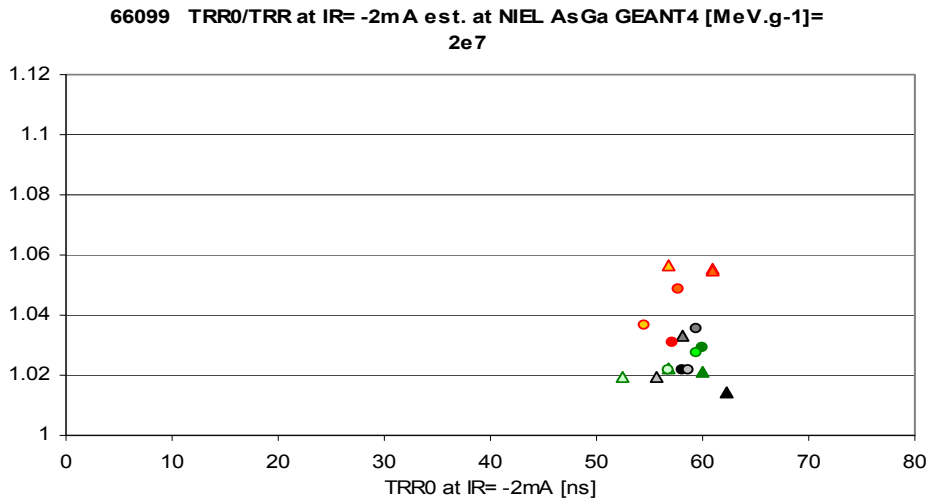


Fig. 14-77: 66099 diode: τ_{RR0}/ τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





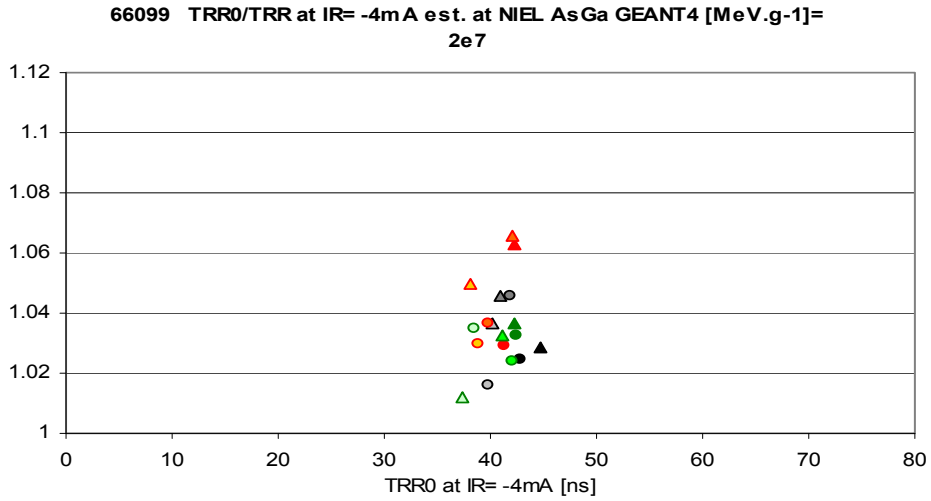


Fig. 14-78: 66099 diode: τ_{RR0}/τ_{RR} estimated at a fluence of 6.10^{10} cm^{-2} with respect to τ_{RR0} at I_R = -1, -2, -4mA

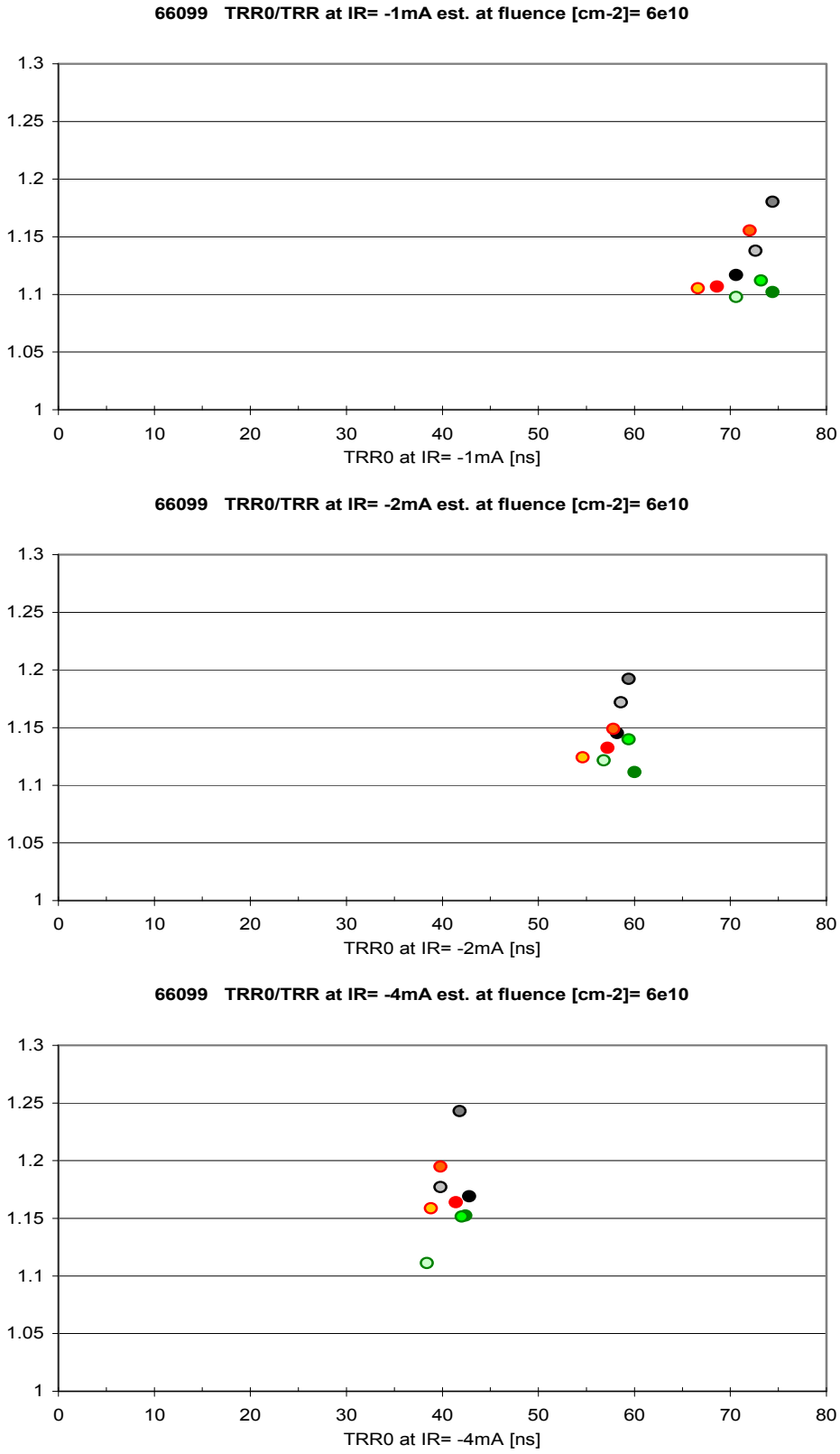
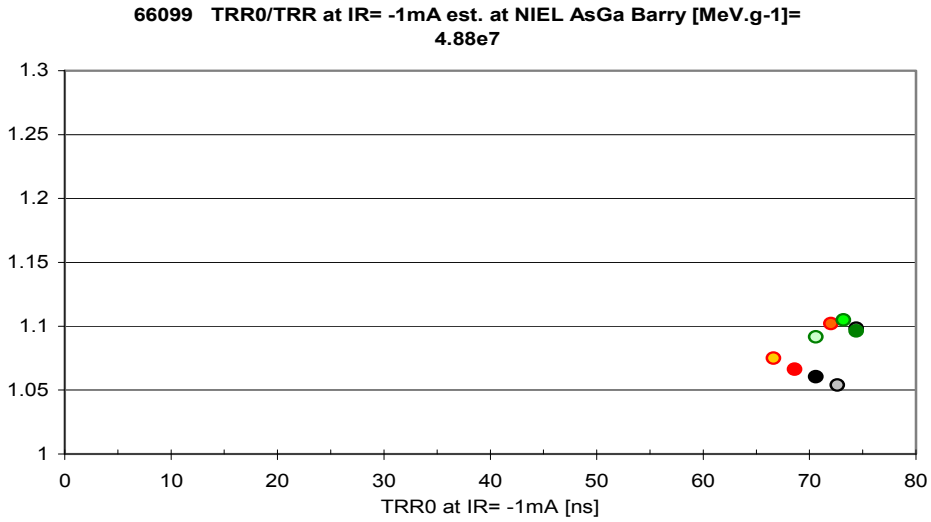
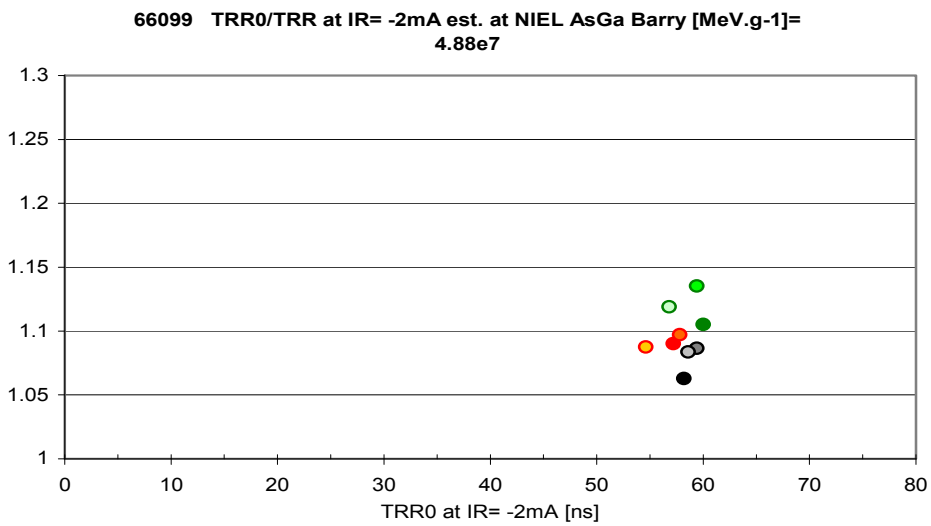


Fig. 14-79: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (Barry) with respect to τ_{RR0} at I_R = -1, -2, -4mA





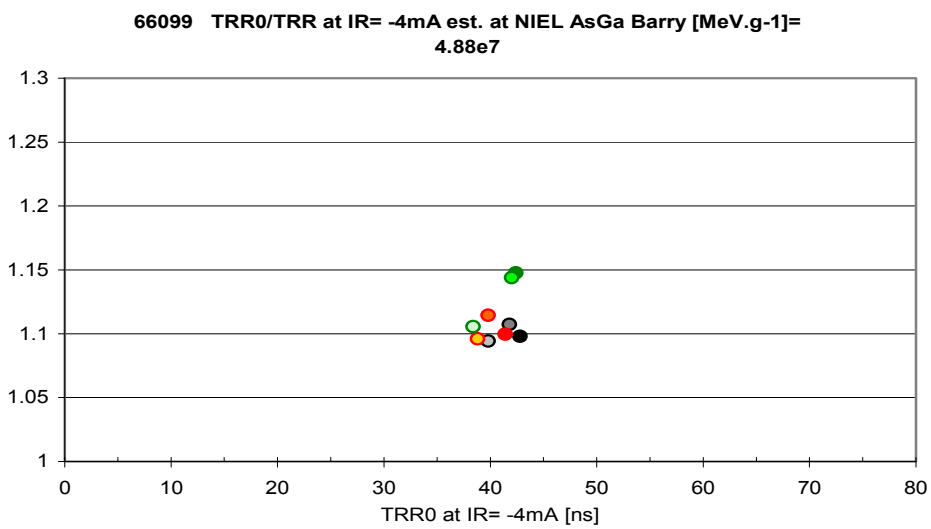


Fig. 14-80: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 ELASTIC) with respect to τ_{RR0} at I_R = -1, -2, -4mA

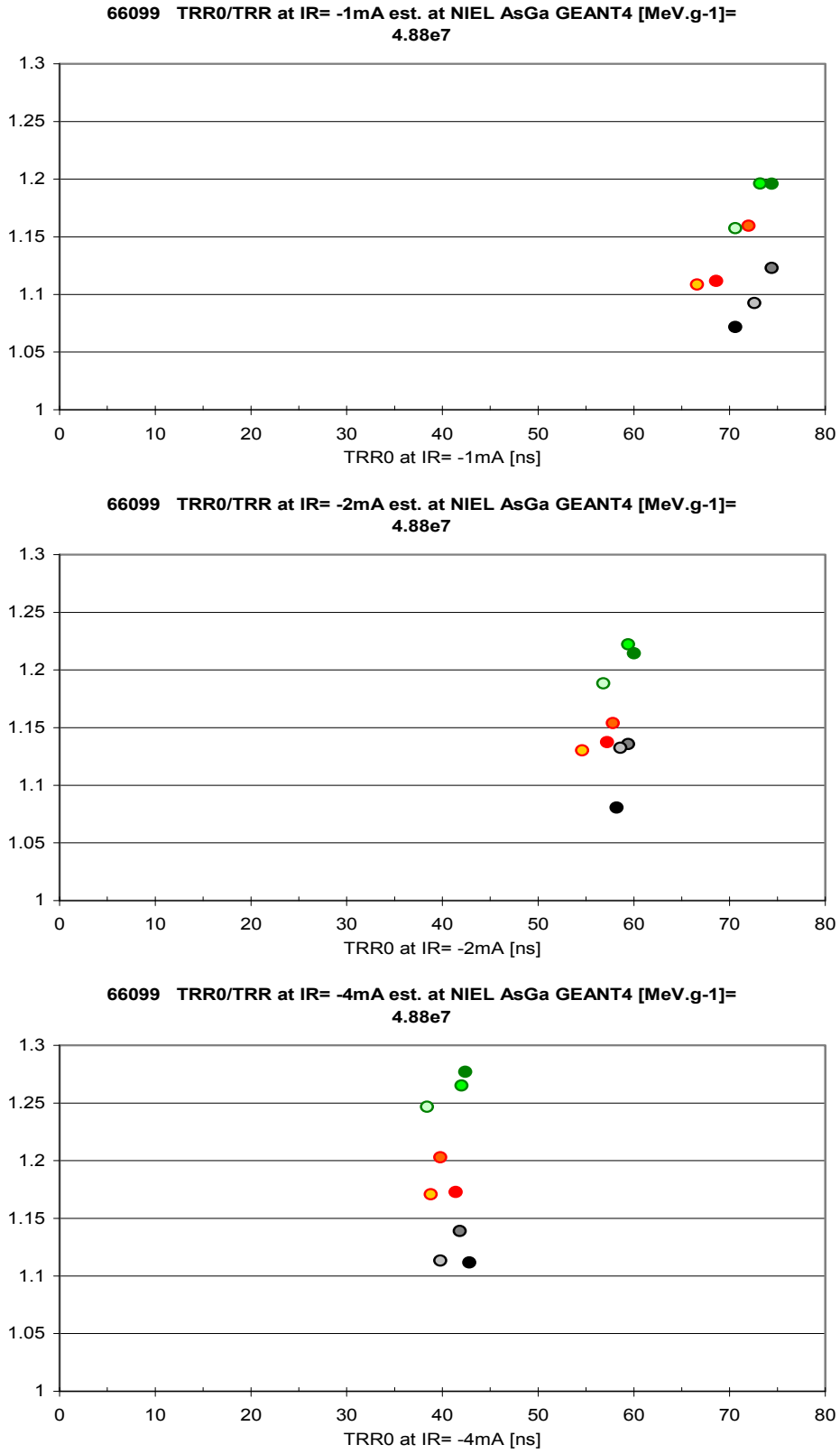
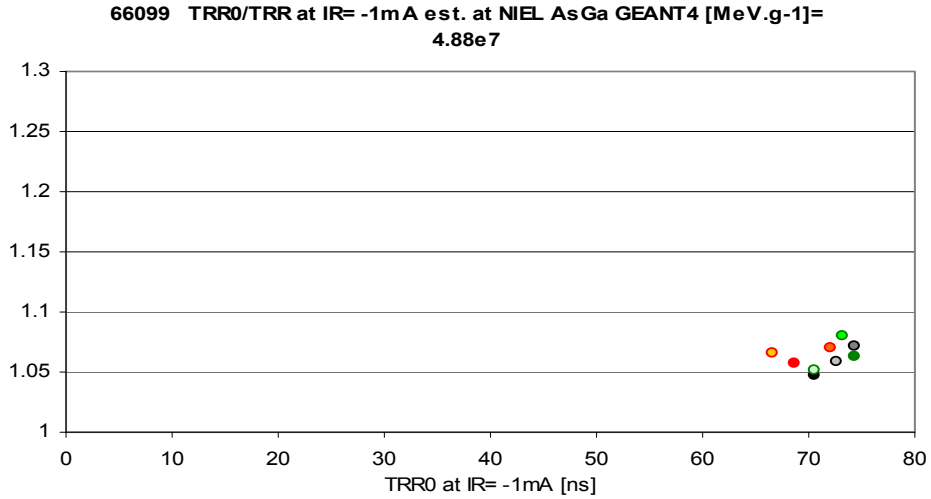
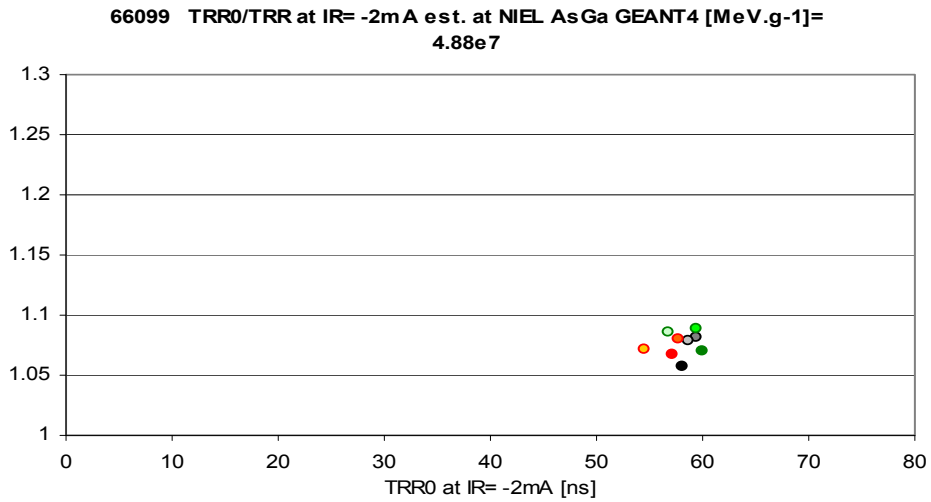


Fig. 14-81: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4mA





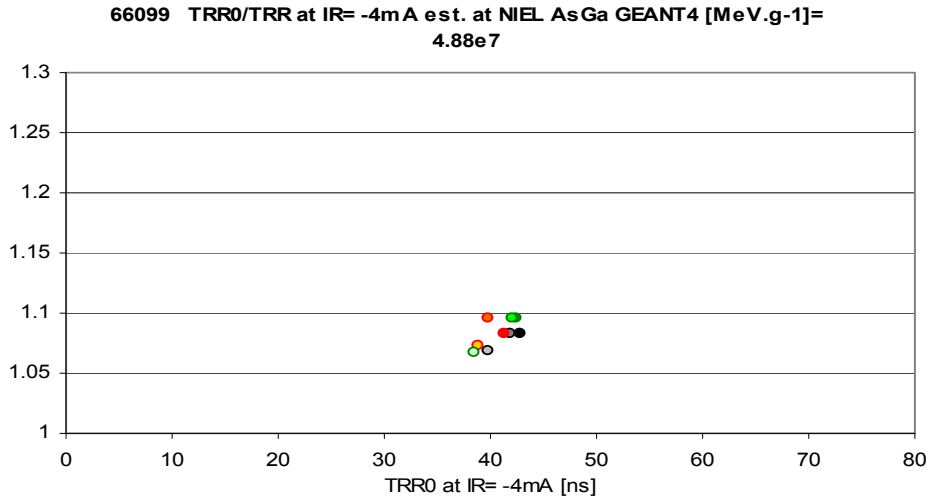


Fig. 14-82: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence

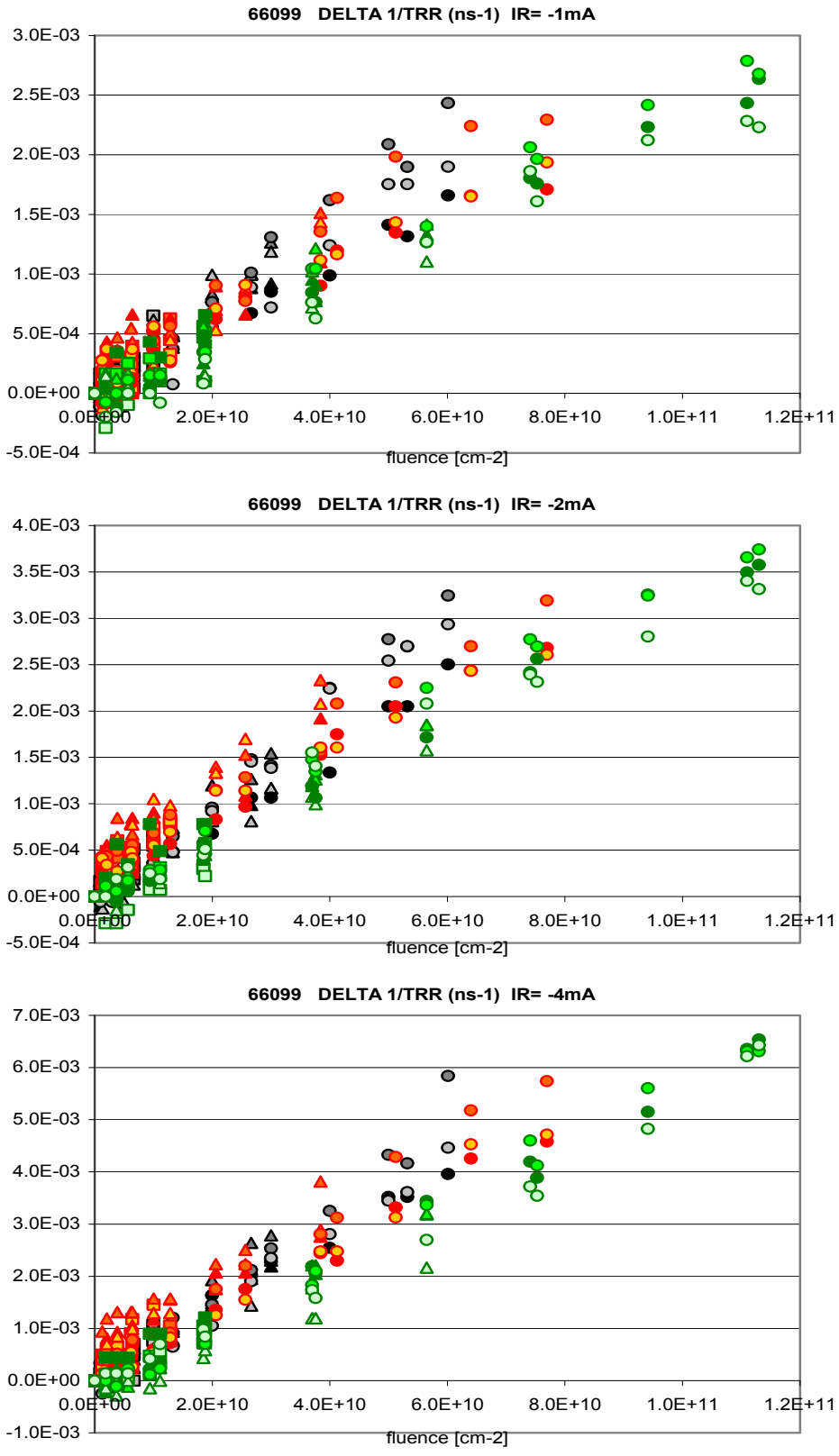


Fig. 14-83: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (Barry)

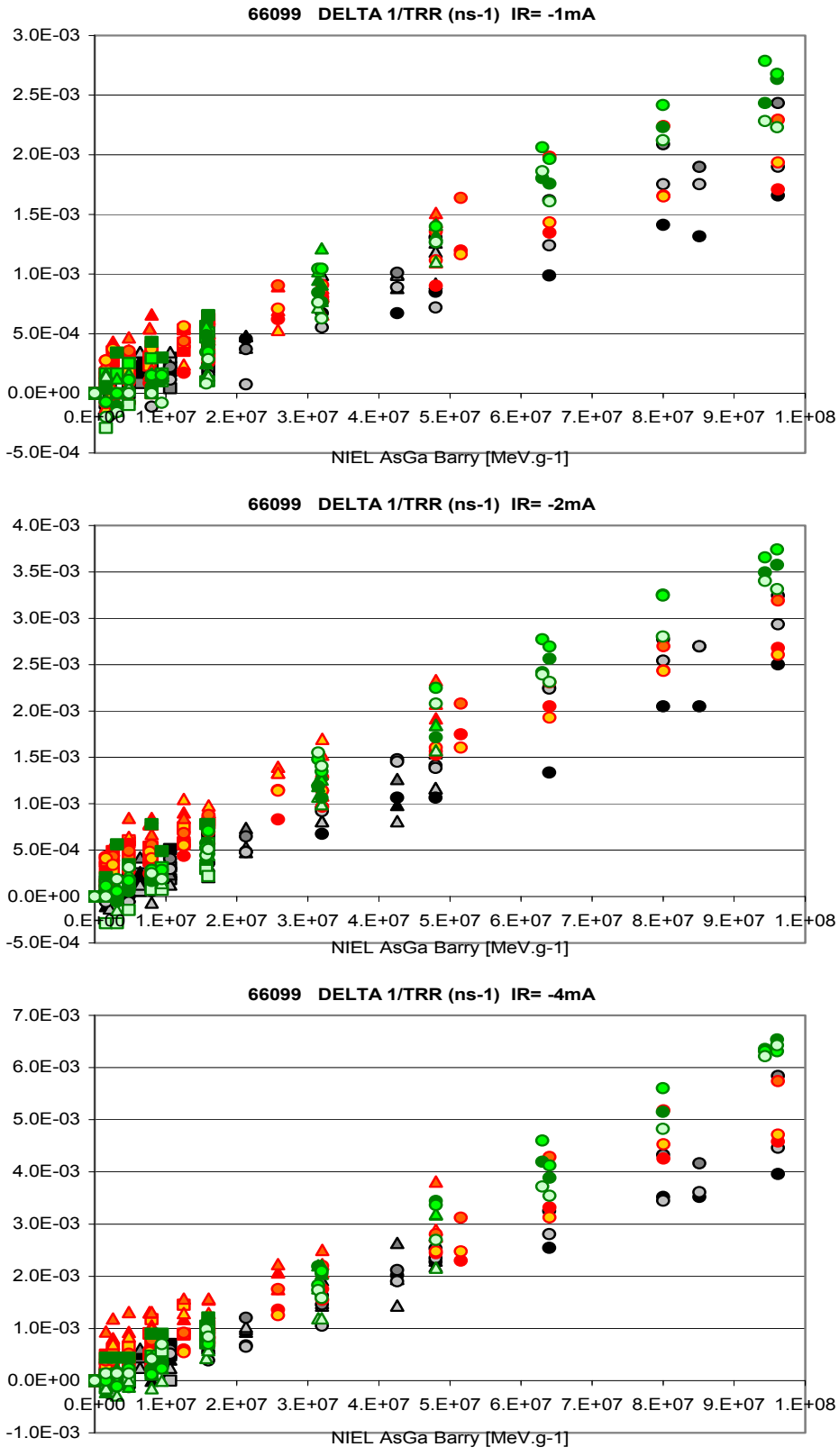


Fig. 14-84: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 ELASTIC)

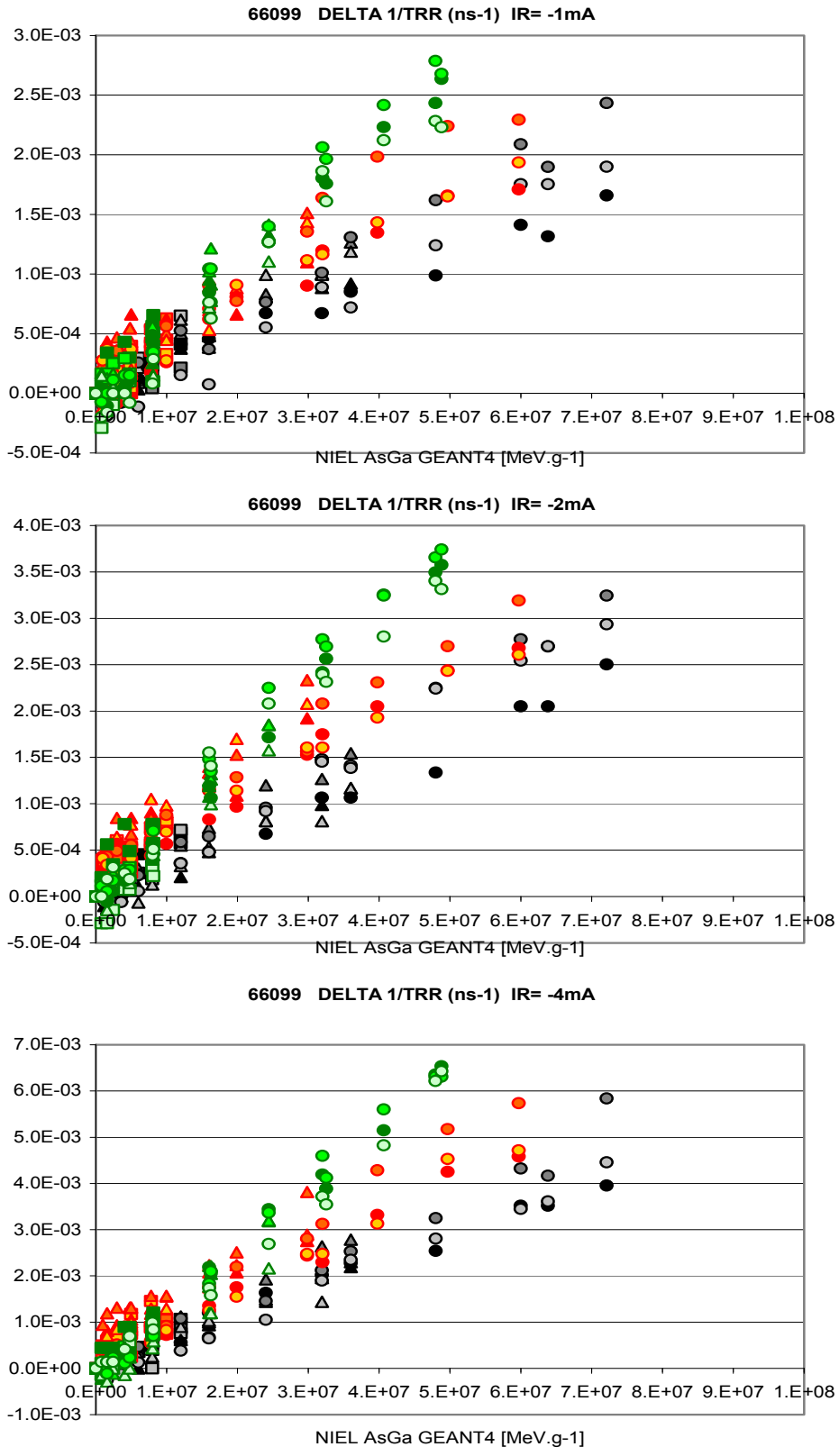
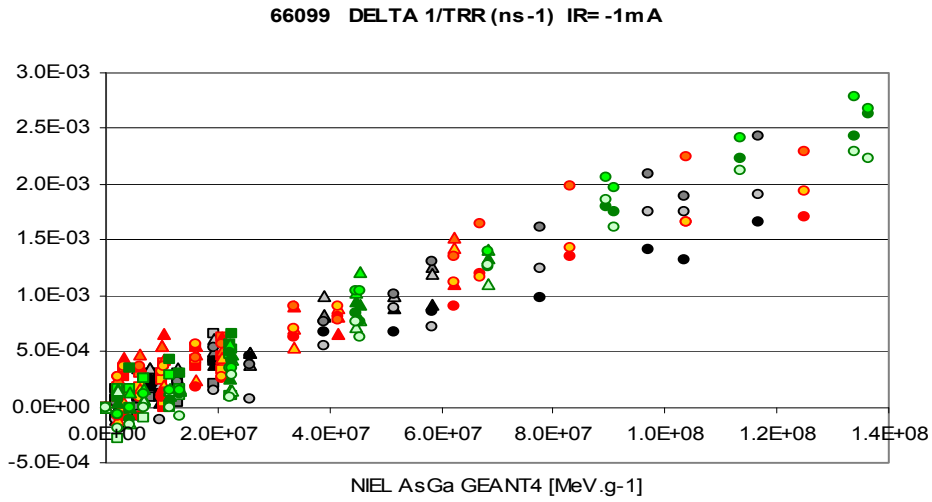
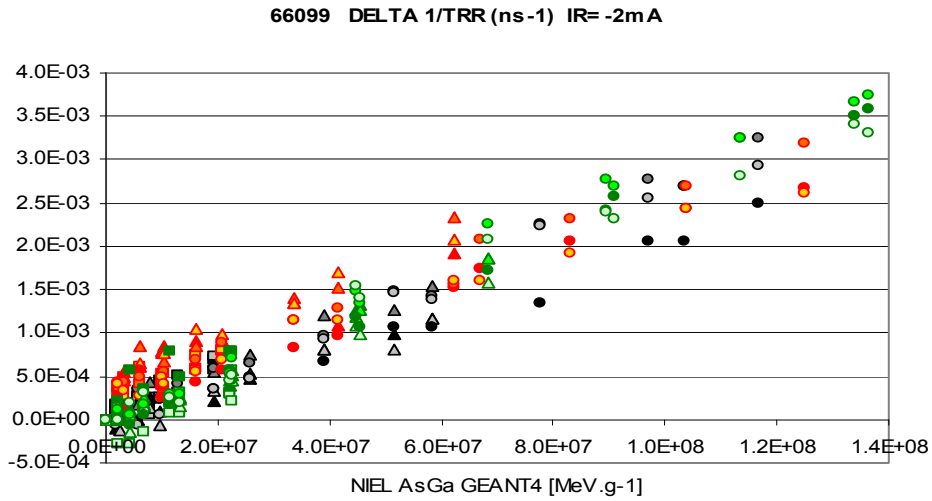


Fig. 14-85: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL (GEANT4 TOTAL)





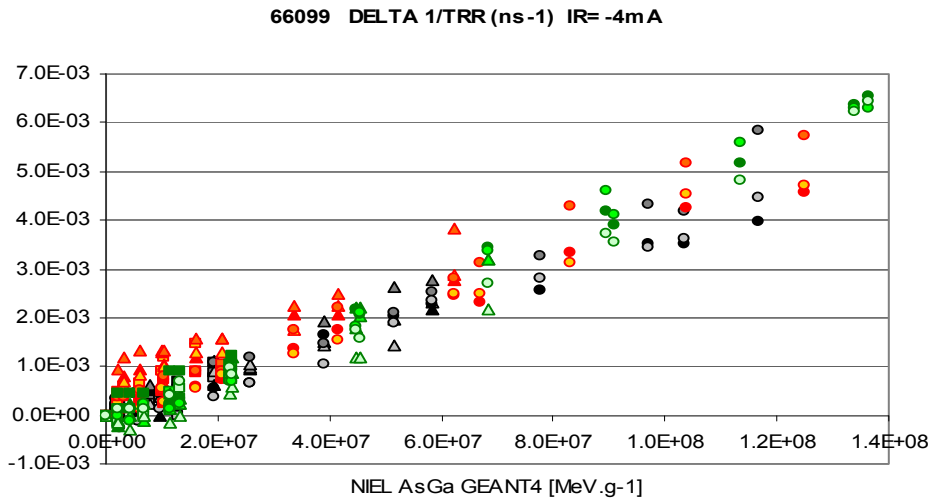


Fig. 14-86: 66099 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{TRR0}

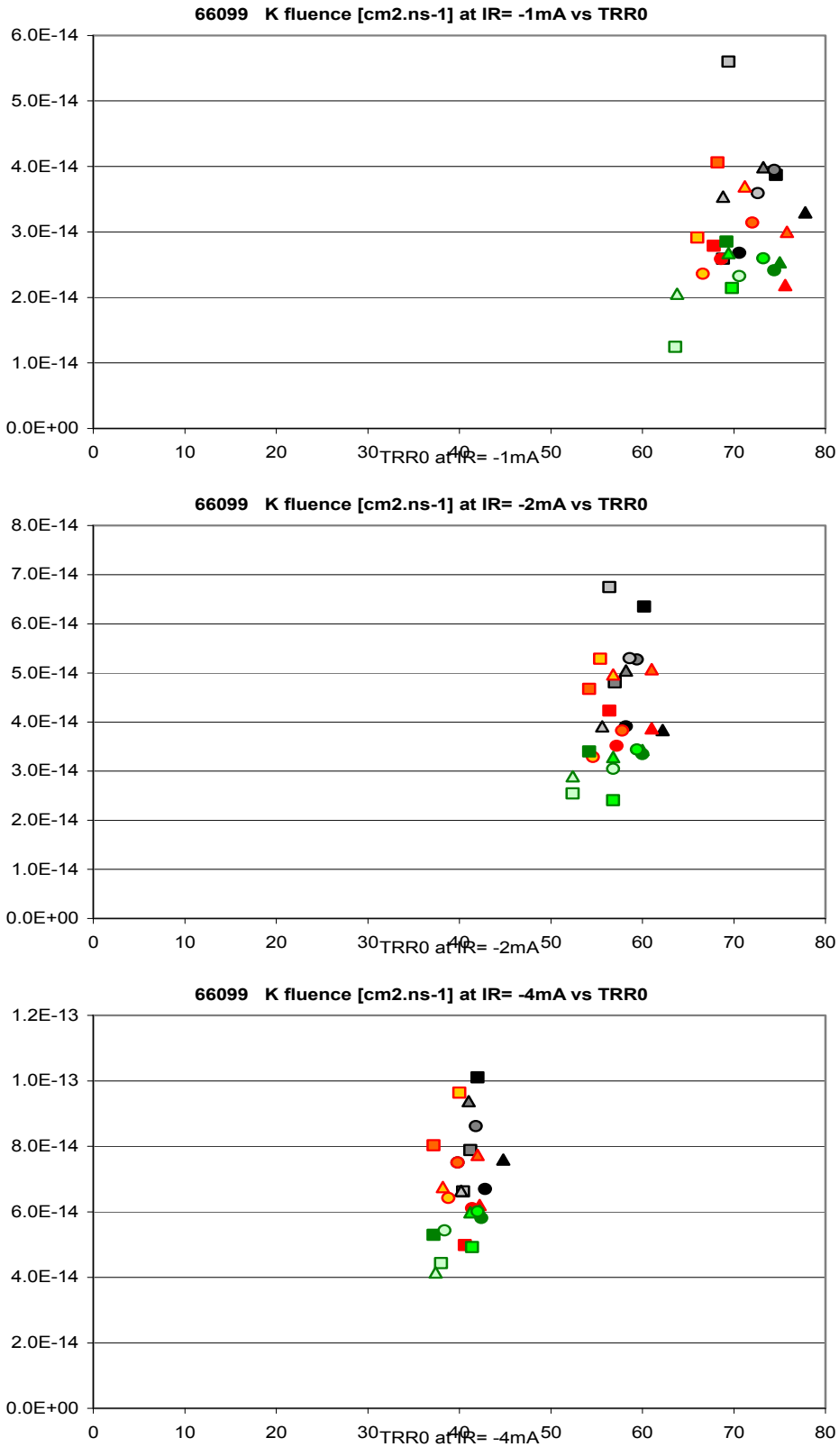


Fig. 14-87: 66099 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to τ_{RR0}

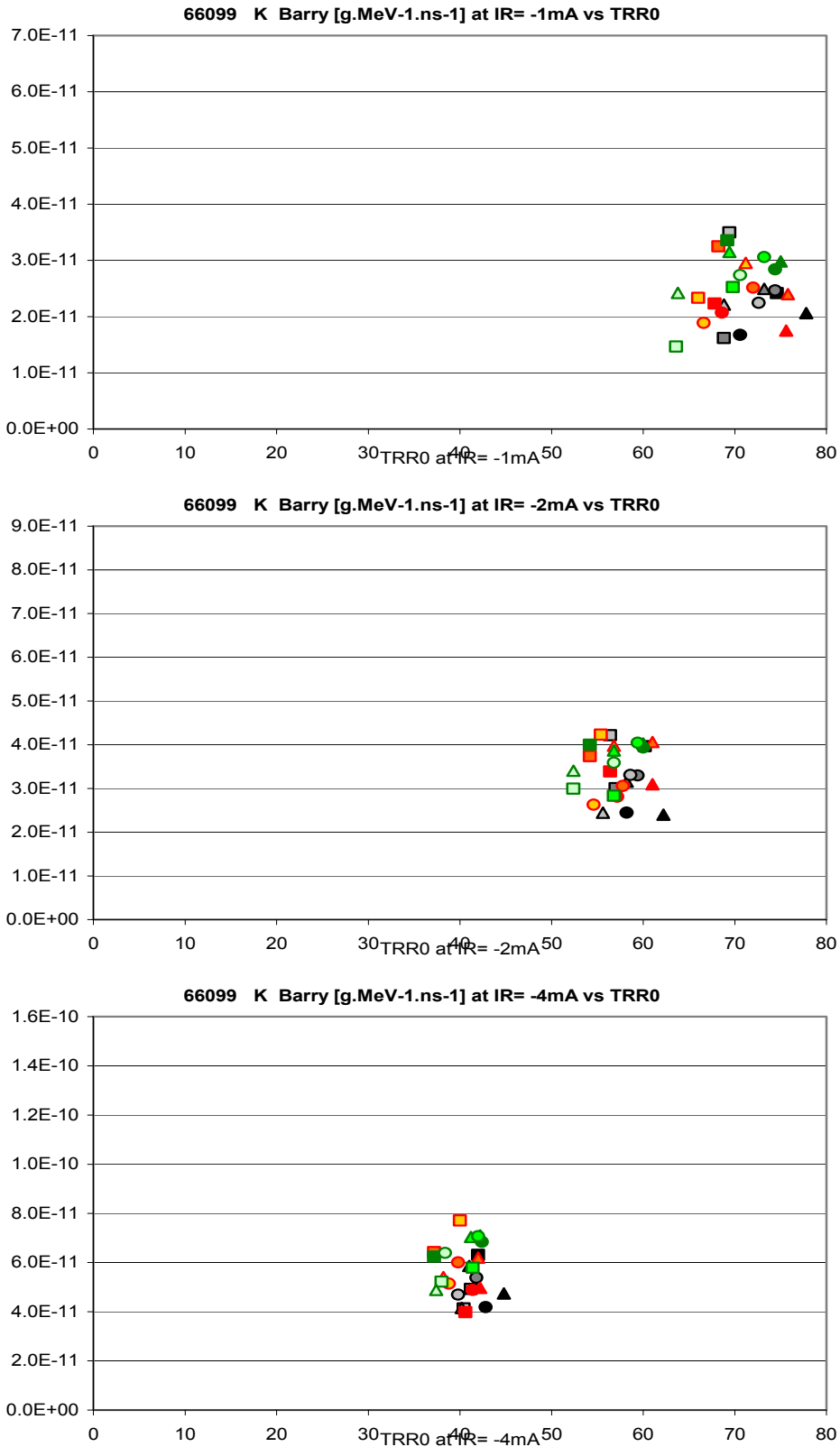


Fig. 14-88: 66099 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to τ_{RR0}

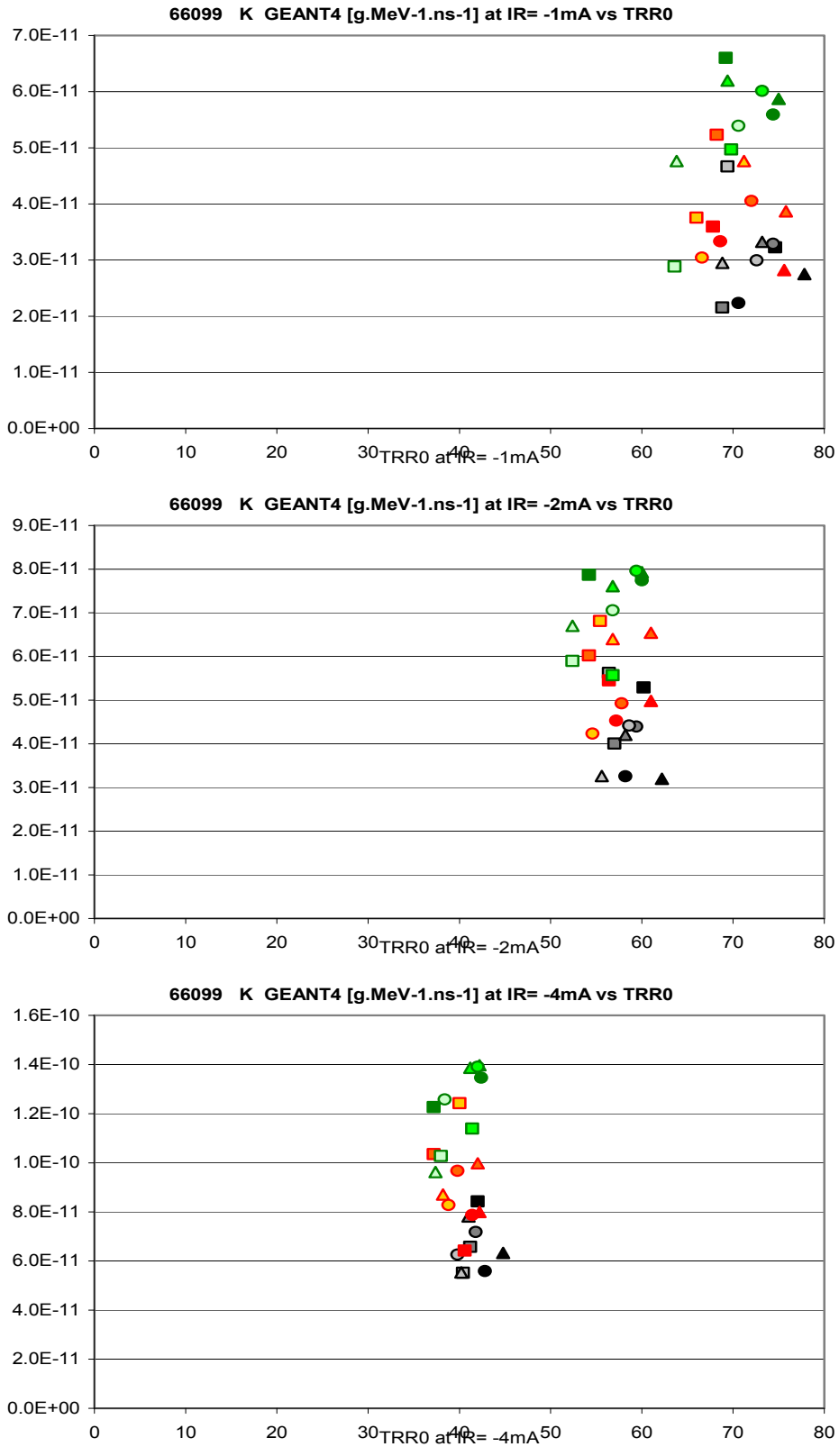
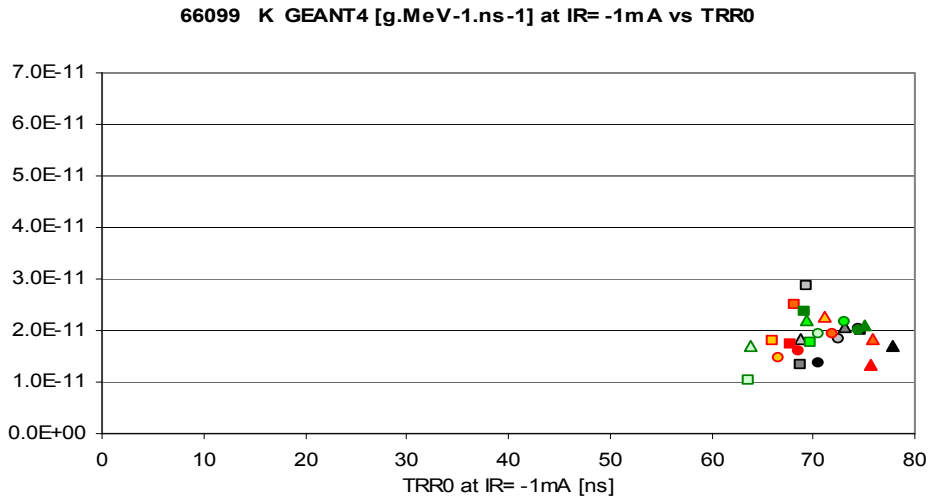
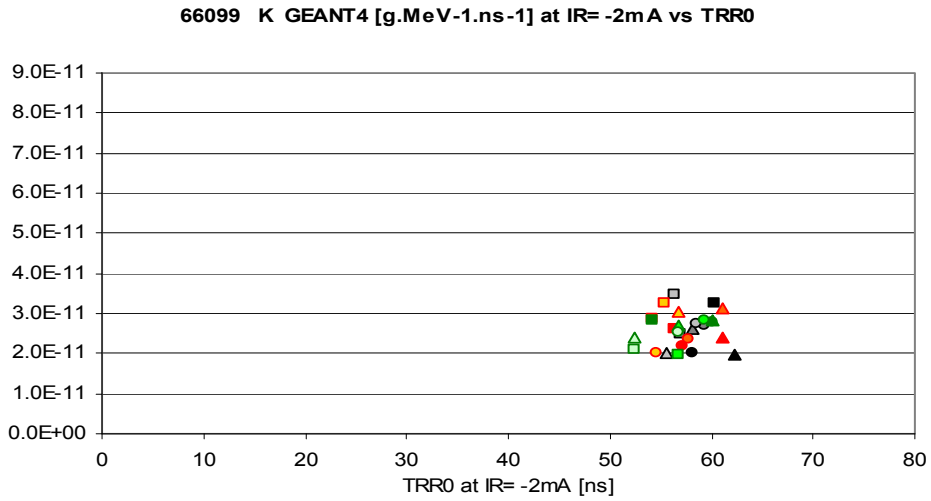


Fig. 14-89: 66099 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to τ_{TRR0}





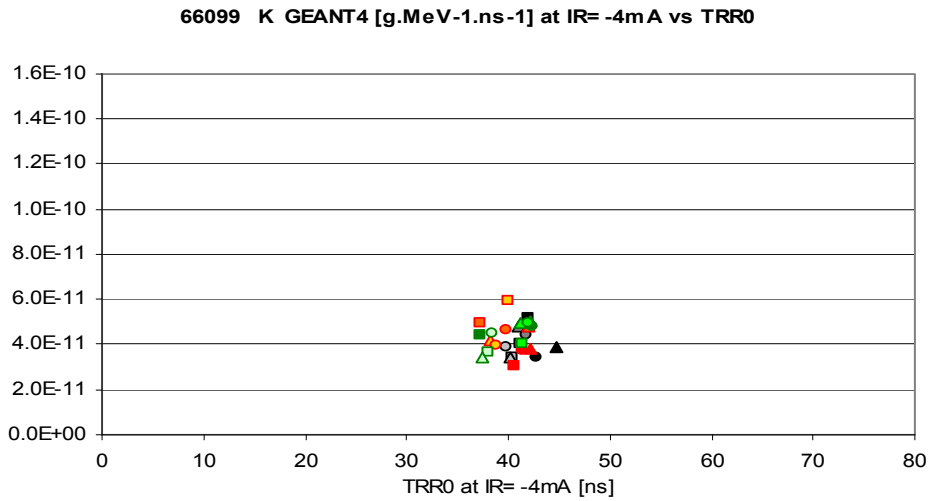
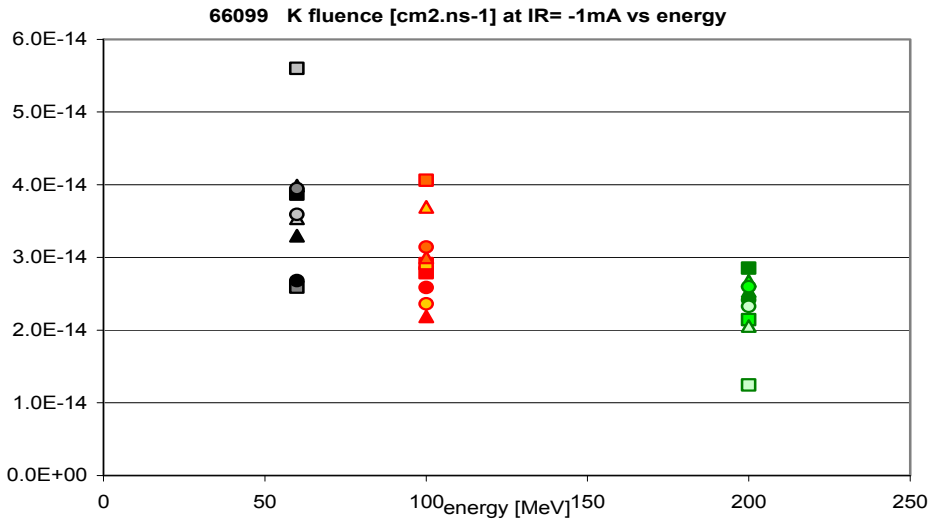
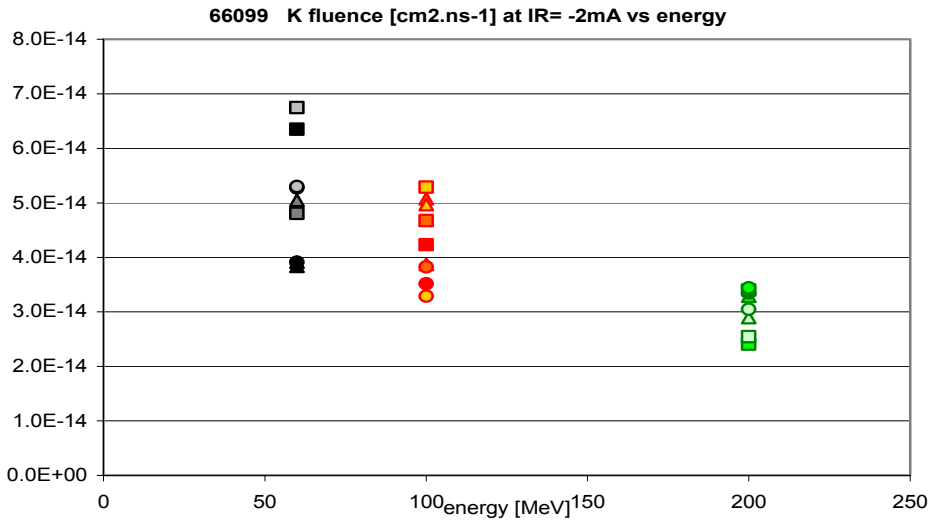


Fig. 14-90: 66099 diode: K_Φ at I_R = -1, -2, -4mA with respect to energy





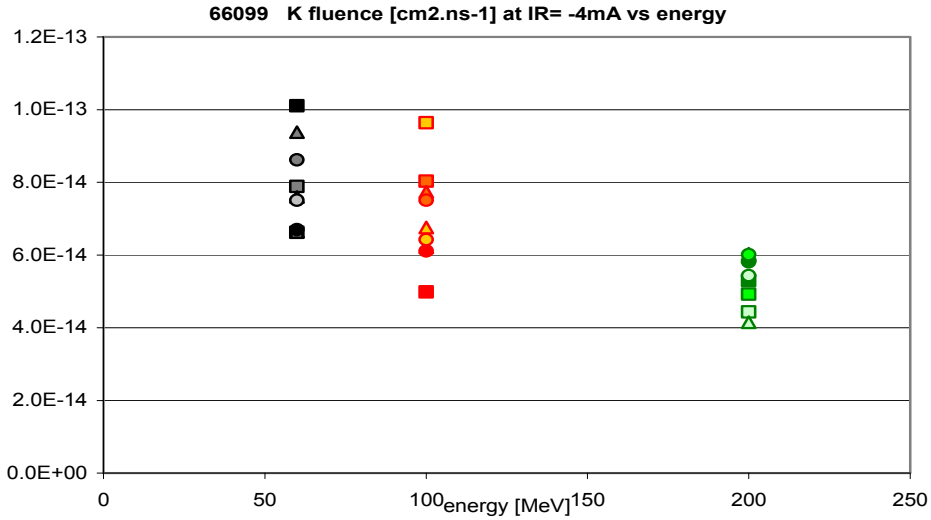


Fig. 14-91: 66099 diode: K_{NIEL_Barry} at I_R = -1, -2, -4mA with respect to energy

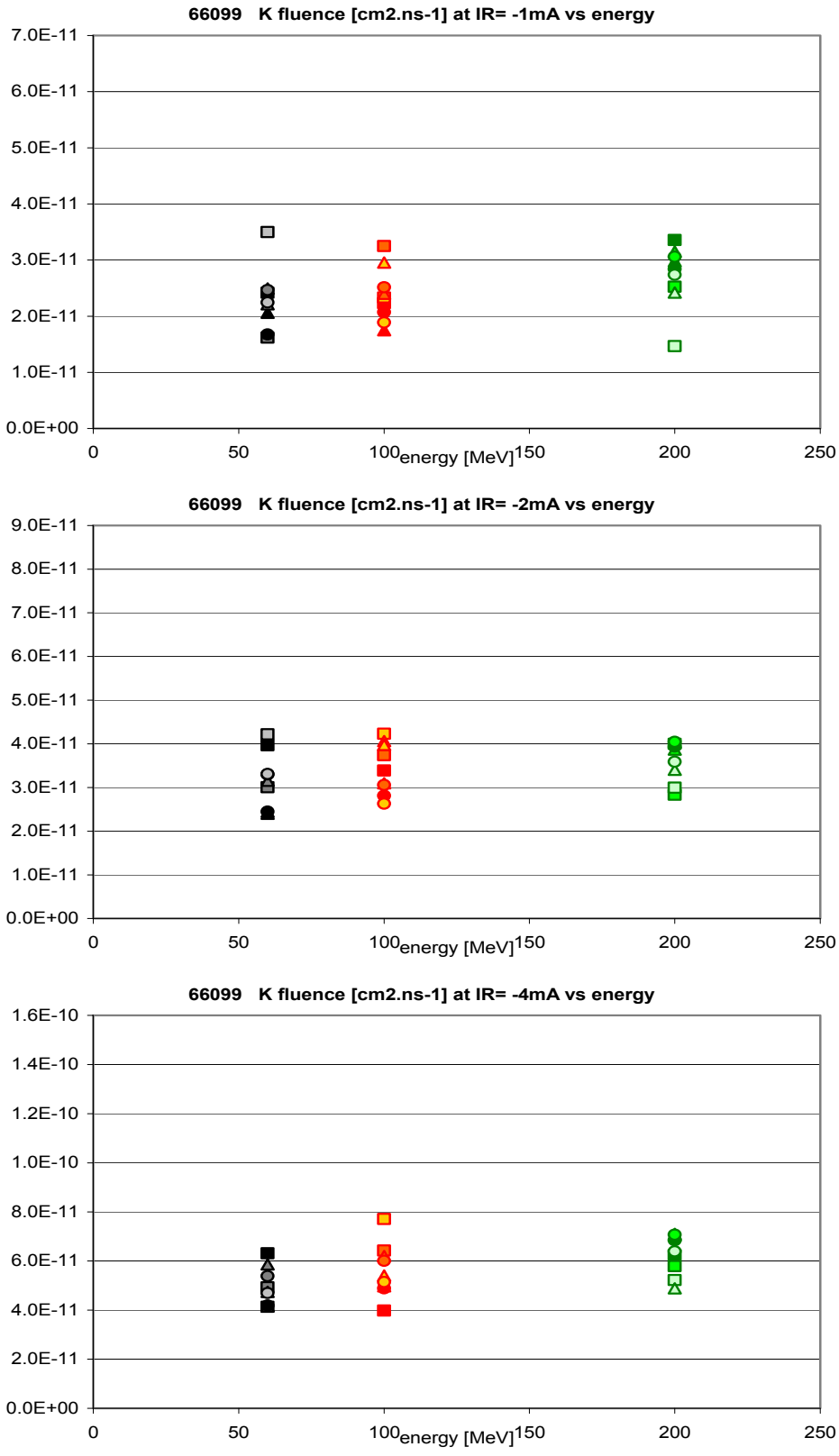


Fig. 14-92: 66099 diode: $K_{NIEL_GEANT4\ ELASTIC}$ at I_R = -1, -2, -4mA with respect to energy

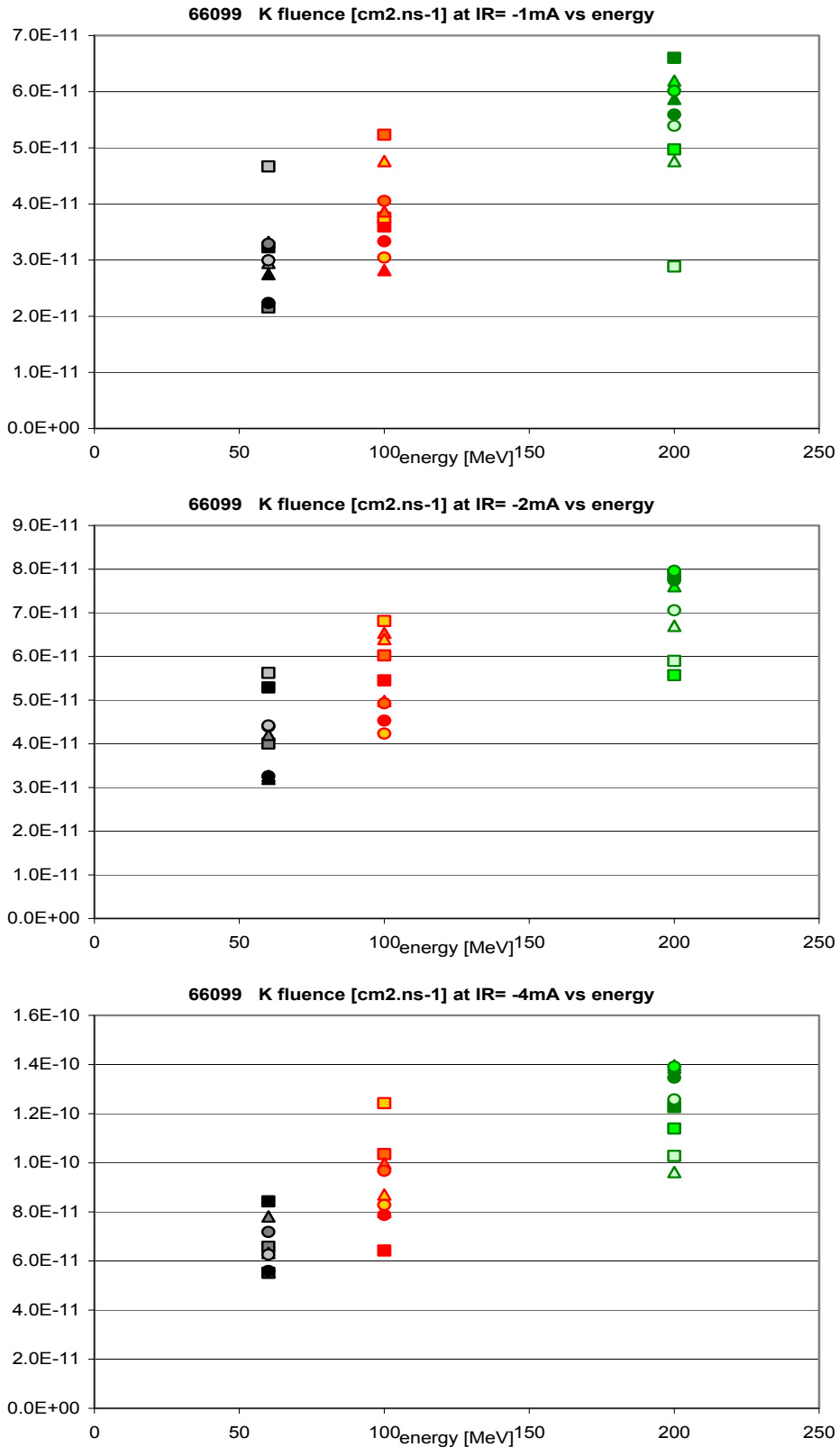
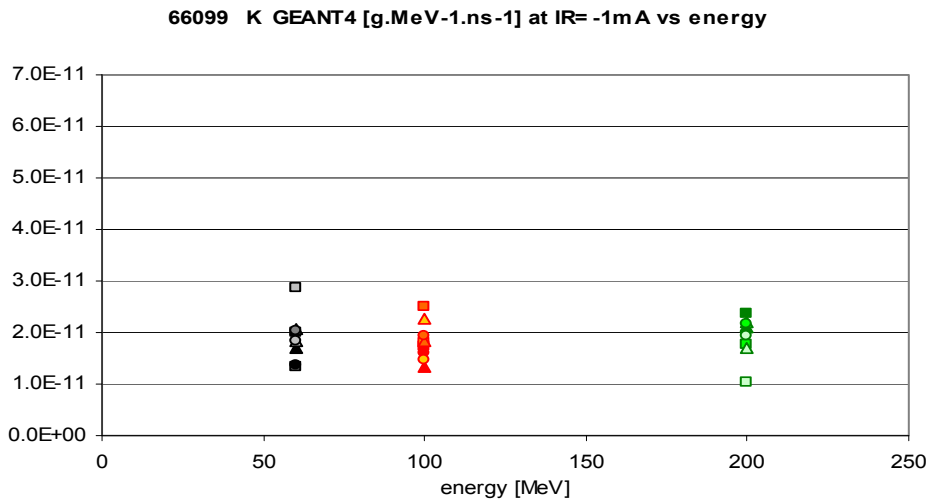
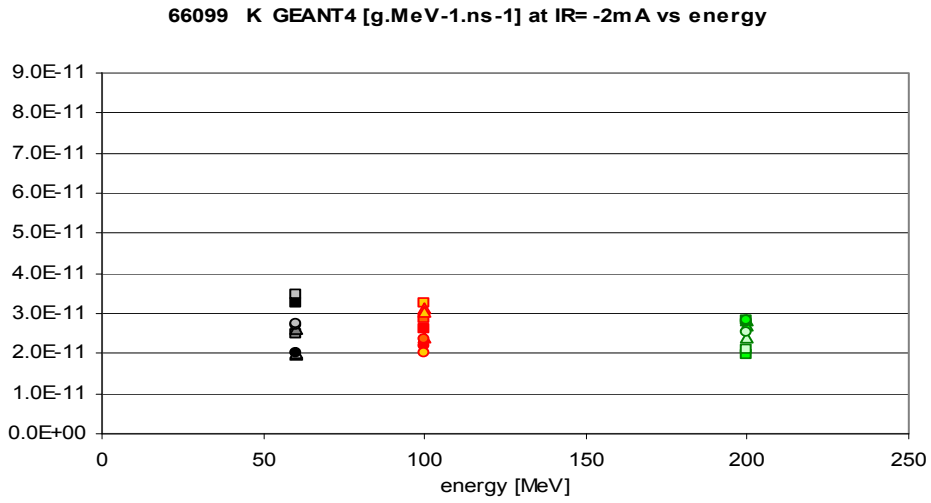


Fig. 14-93: 66099 diode: $K_{NIEL_GEANT4\ TOTAL}$ at I_R = -1, -2, -4mA with respect to energy





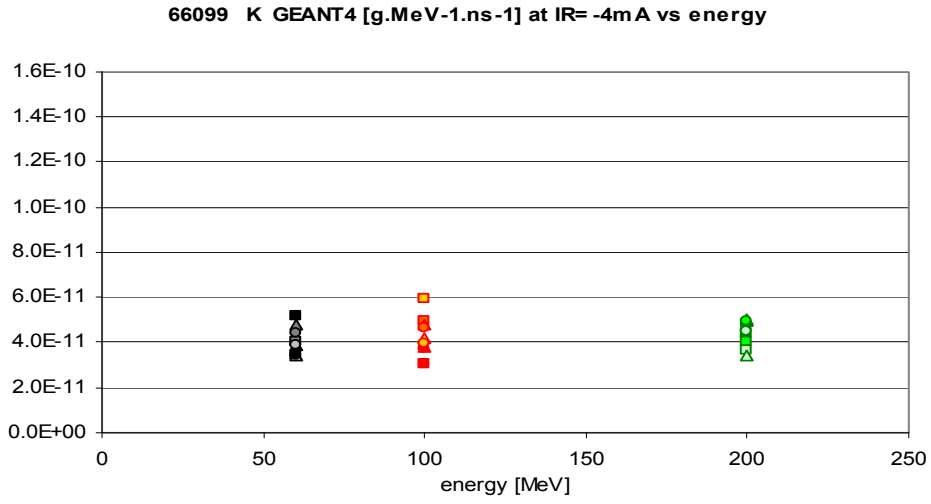
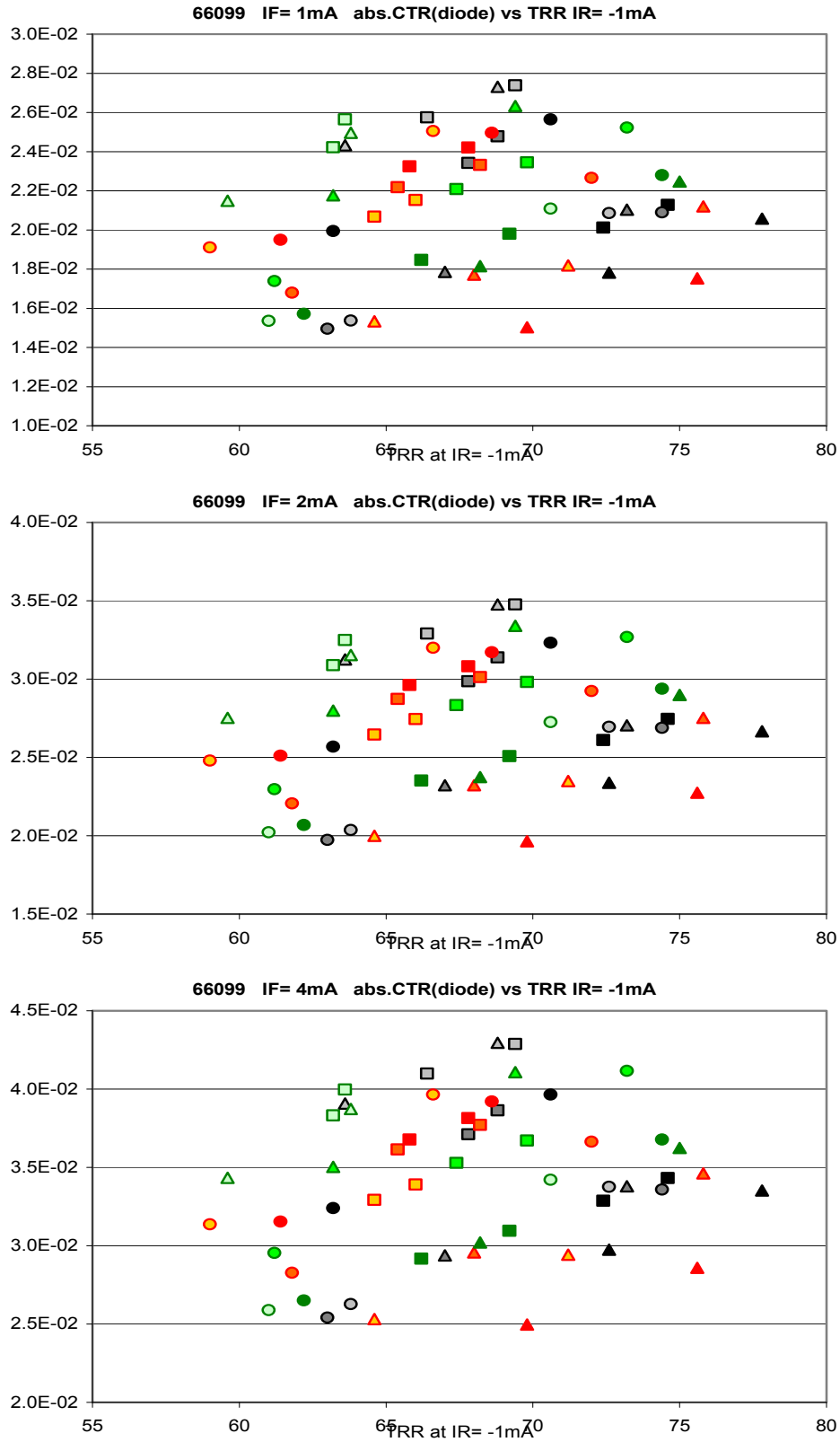
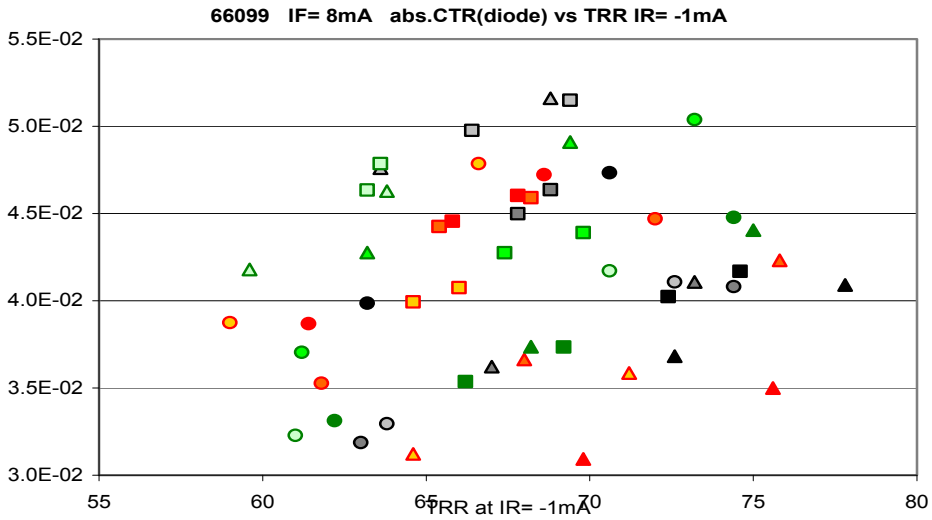


Fig. 14-94: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA




66099 IF= 8mA abs.CTR(diode) vs TRR IR= -1mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
55
60
65
70
75
80
TRR at IR= -1mA

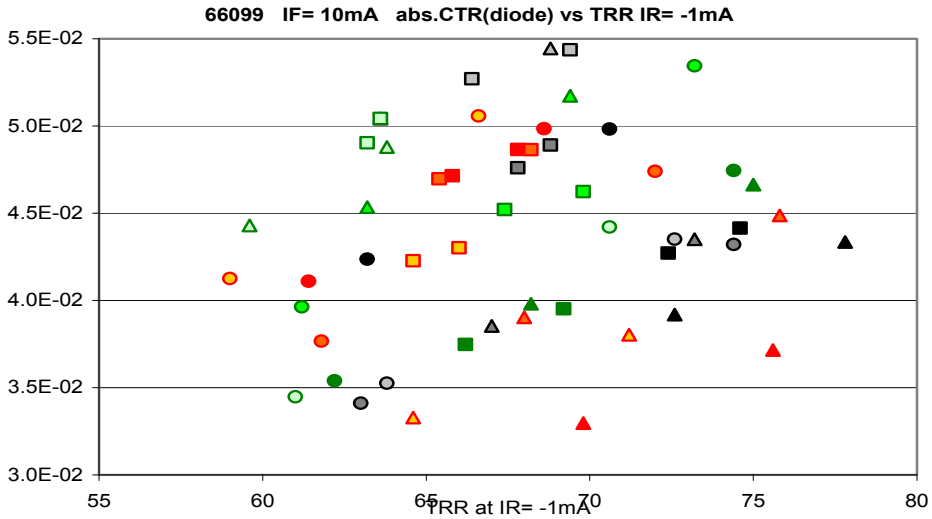
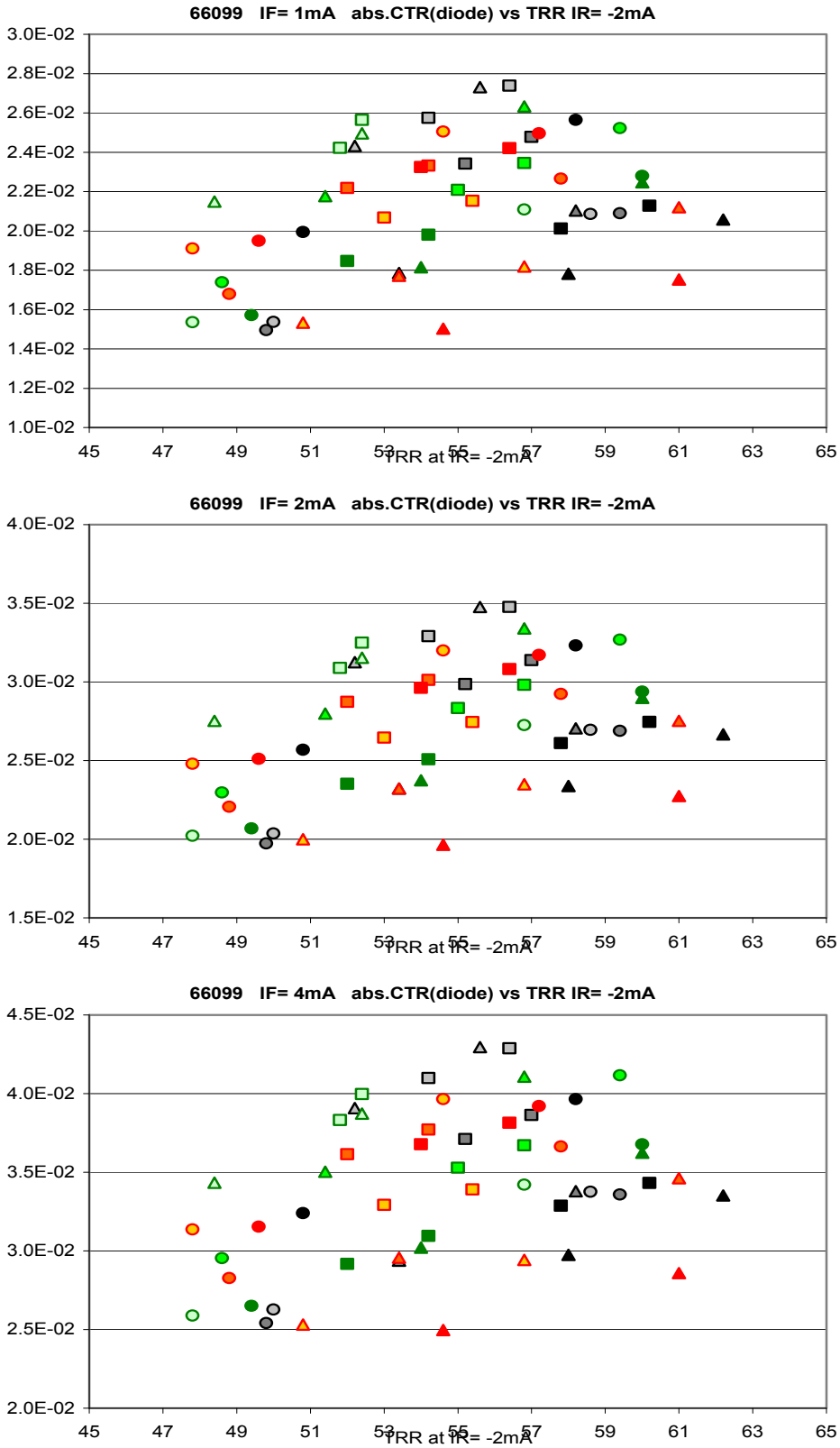
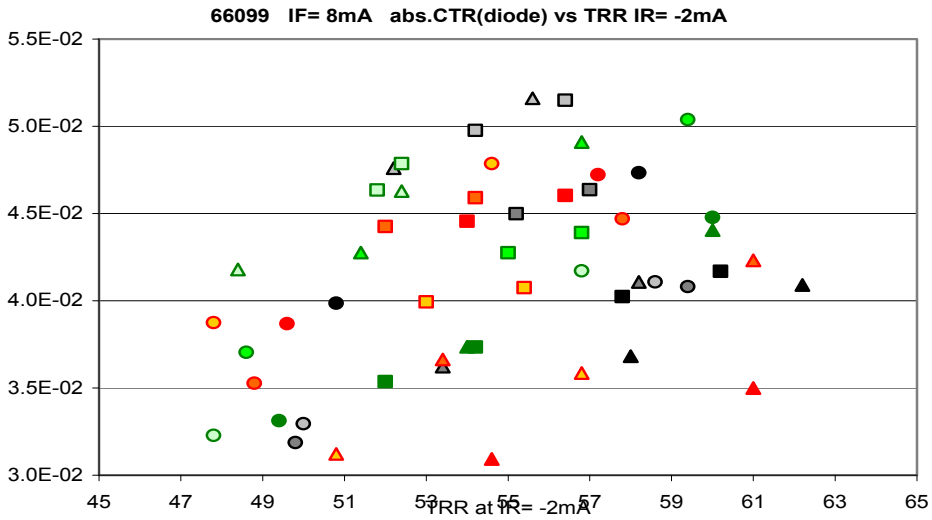

66099 IF= 10mA abs.CTR(diode) vs TRR IR= -1mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
55
60
65
70
75
80
TRR at IR= -1mA

Fig. 14-95: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA




66099 IF= 8mA abs.CTR(diode) vs TRR IR= -2mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
45
47
49
51
53
55
57
59
61
63
65
TRR at IR= -2mA

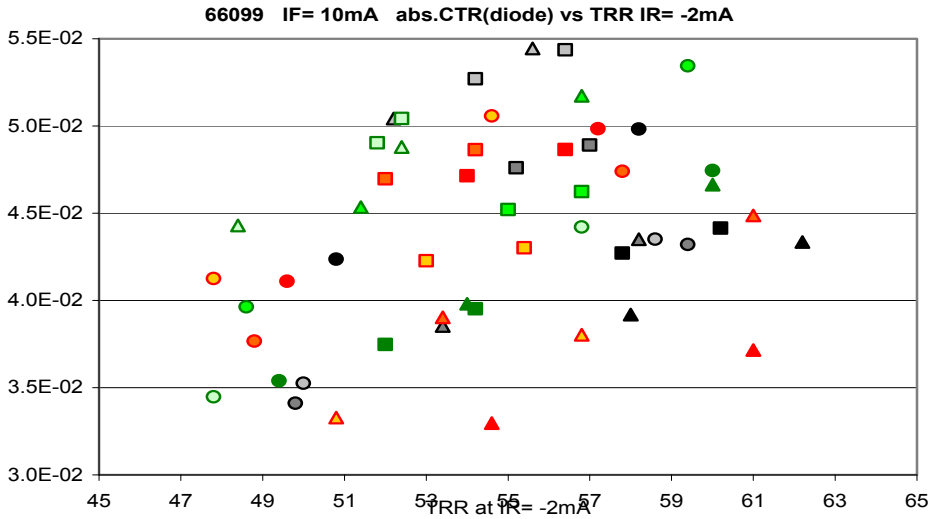
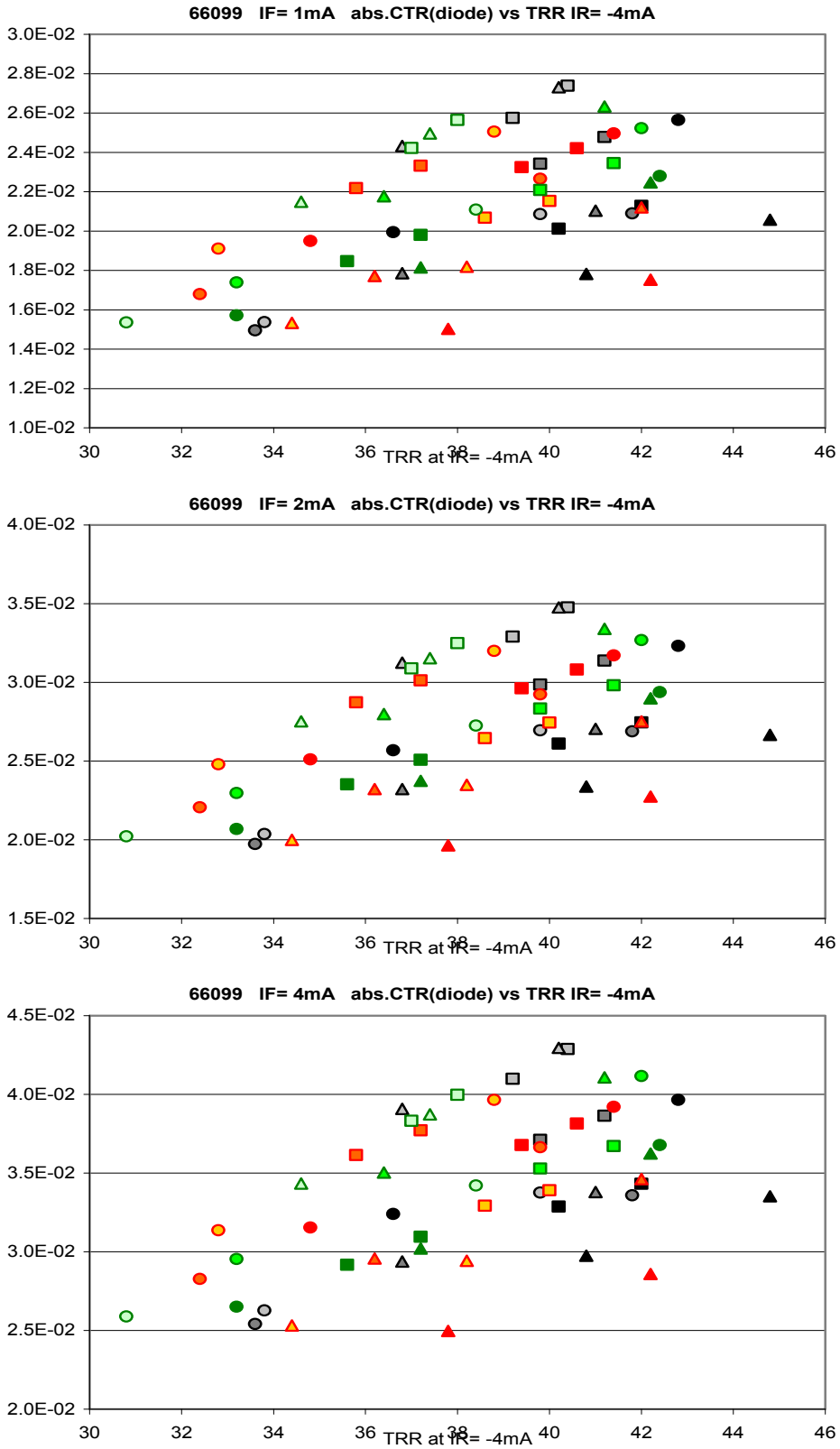
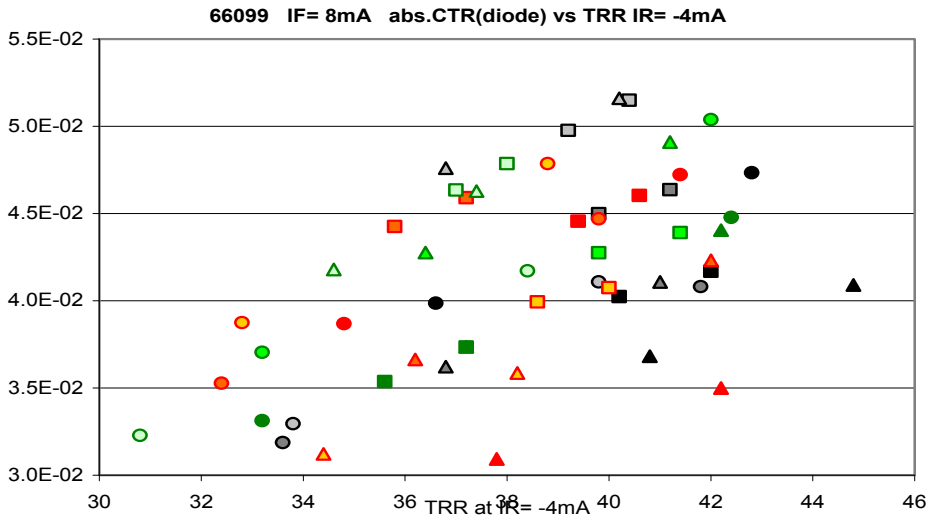

66099 IF= 10mA abs.CTR(diode) vs TRR IR= -2mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
45
47
49
51
53
55
57
59
61
63
65
TRR at IR= -2mA

Fig. 14-96: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φp_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA




66099 IF= 8mA abs.CTR(diode) vs TRR IR= -4mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
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3.0E-02
30
32
34
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38
40
42
44
46
TRR at IR= -4mA

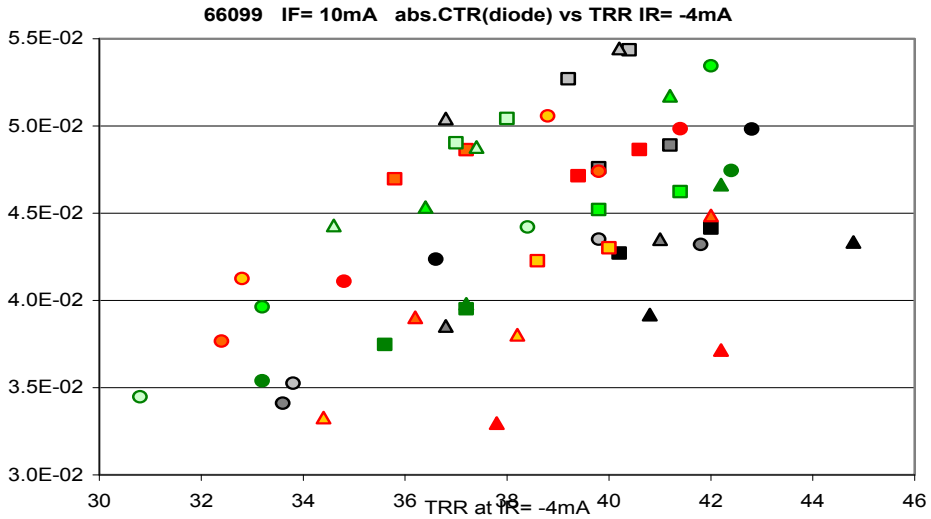
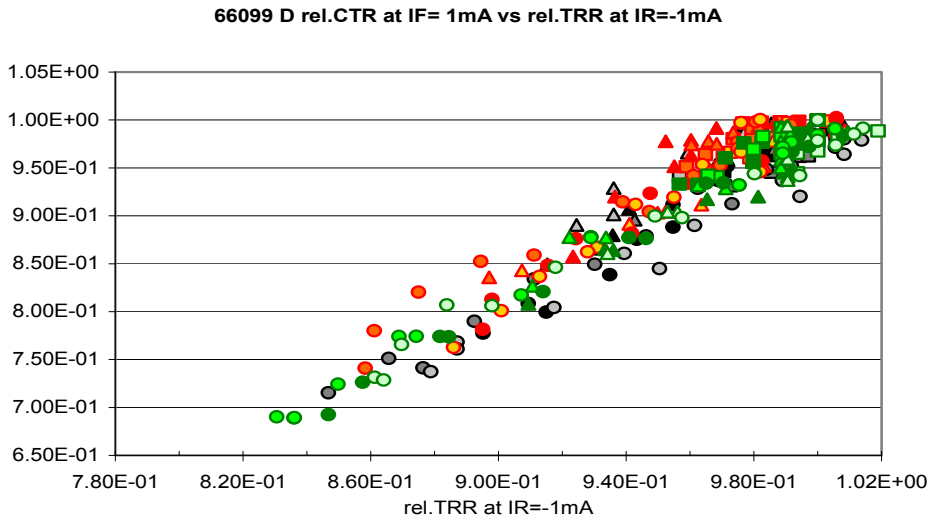
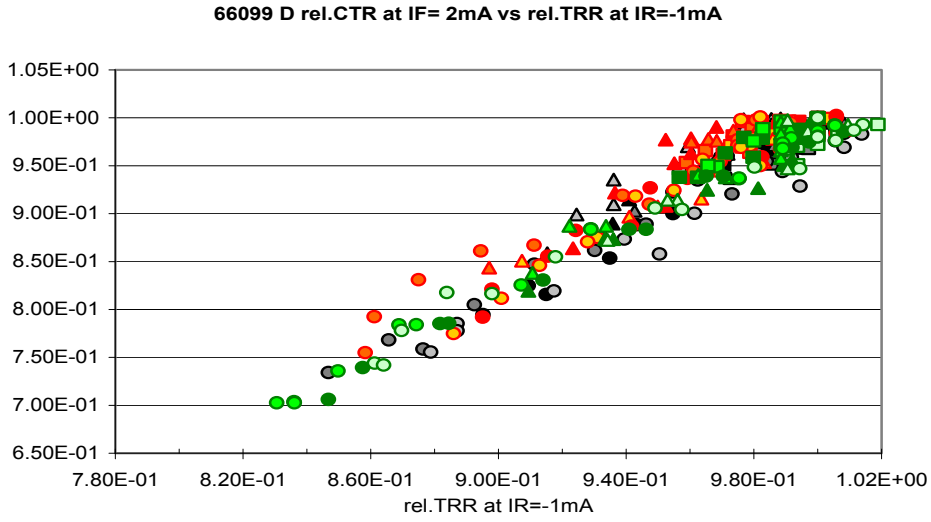
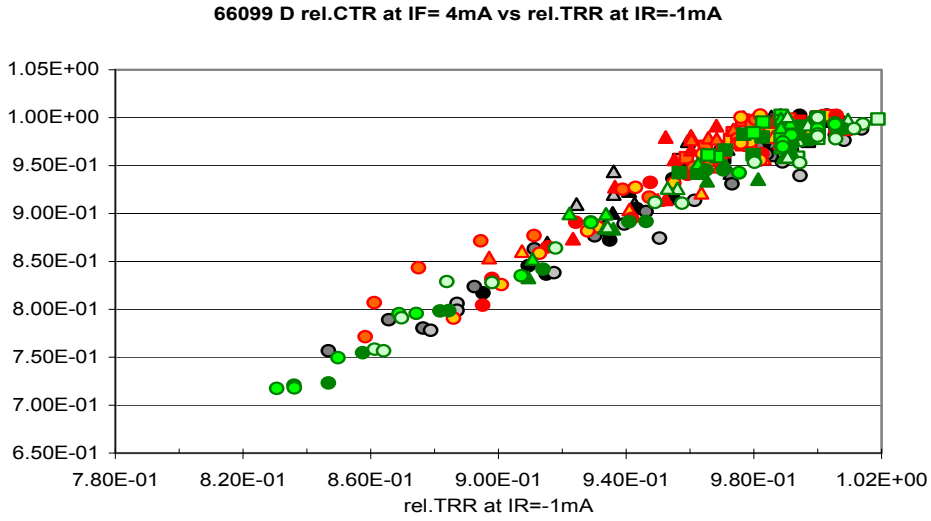

66099 IF= 10mA abs.CTR(diode) vs TRR IR= -4mA
5.5E-02
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
30
32
34
36
38
40
42
44
46
TRR at IR= -4mA

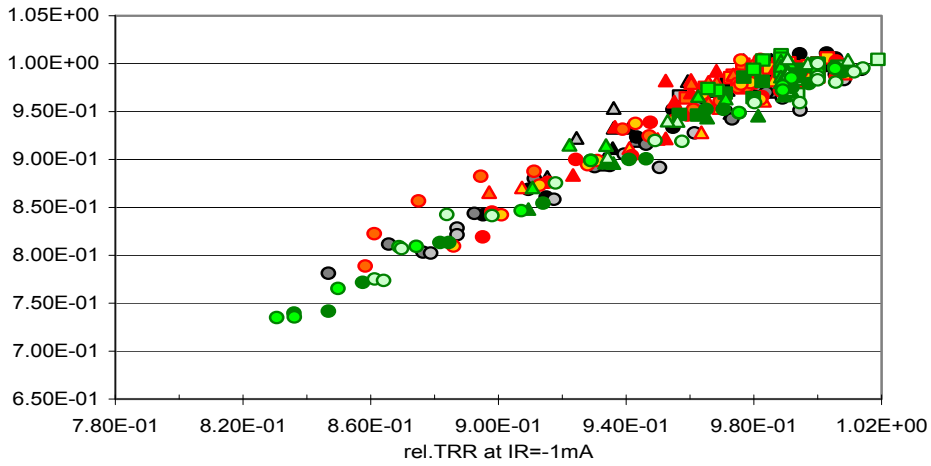
Fig. 14-97: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA







66099 D rel.CTR at IF= 8mA vs rel.TRR at IR=-1mA



66099 D rel.CTR at IF= 10mA vs rel.TRR at IR=-1mA

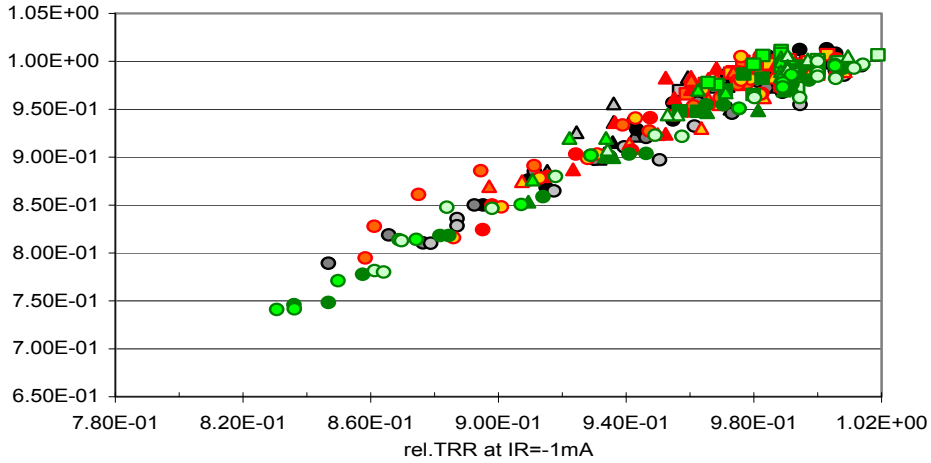
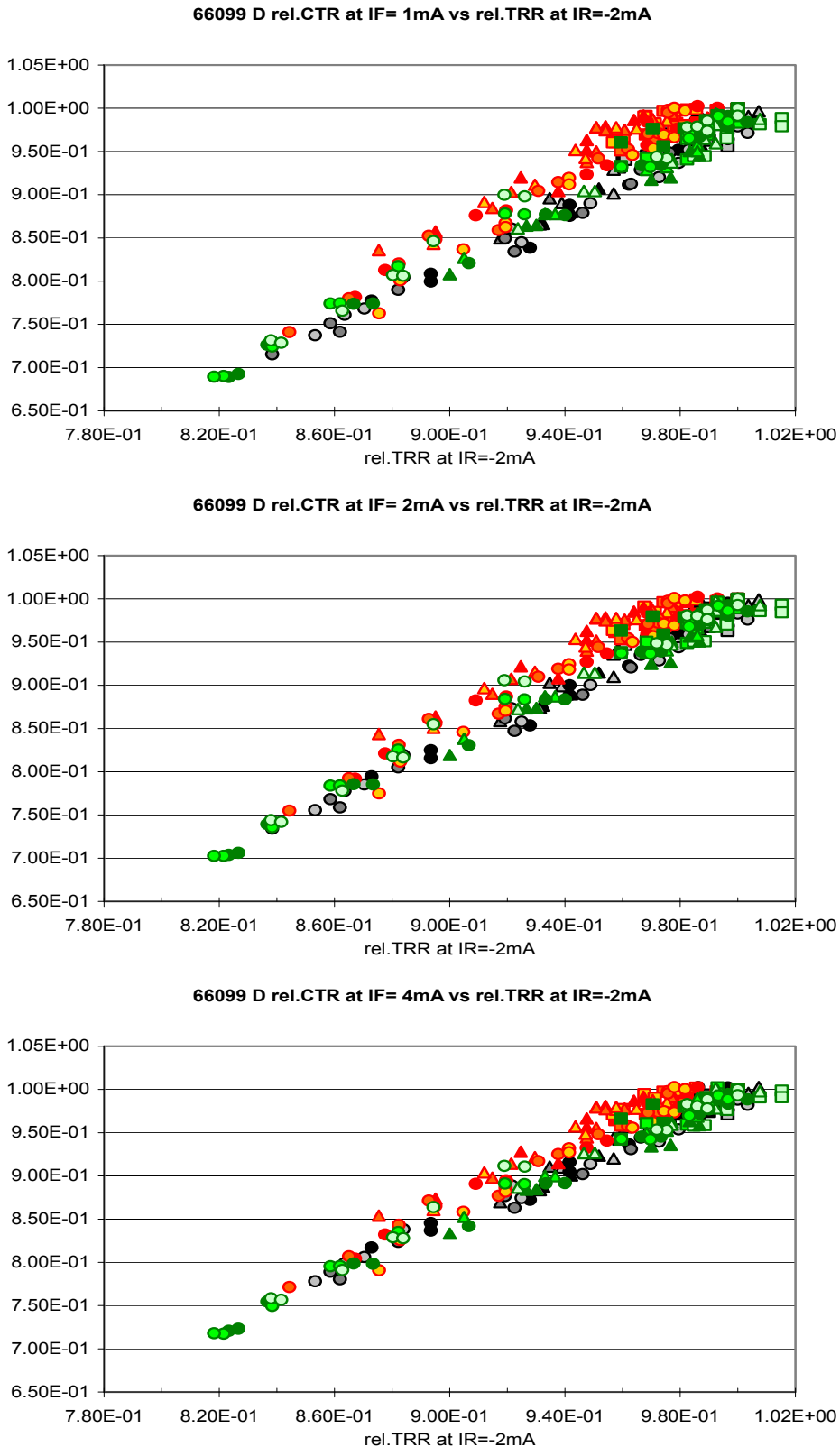
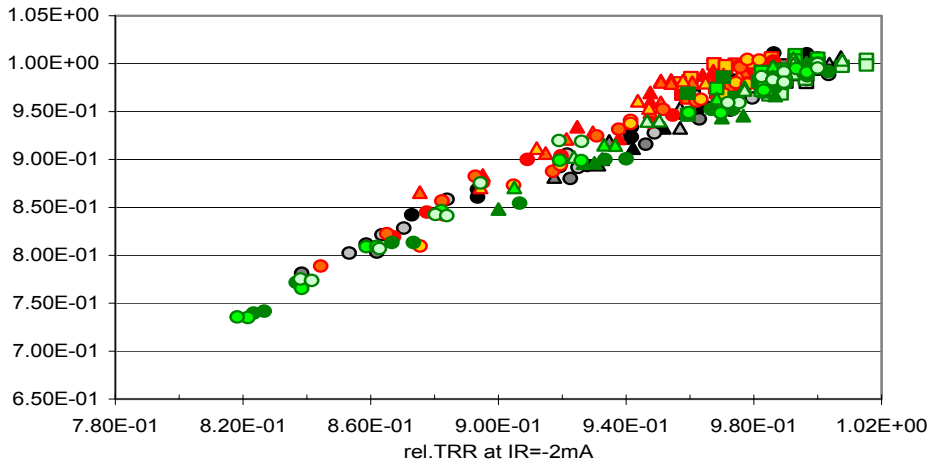


Fig. 14-98: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA



66099 D rel.CTR at IF= 8mA vs rel.TRR at IR=-2mA



66099 D rel.CTR at IF= 10mA vs rel.TRR at IR=-2mA

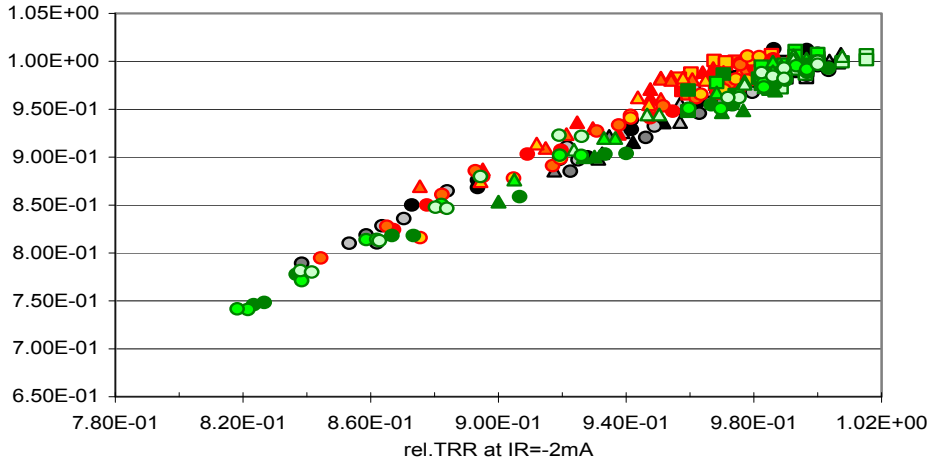
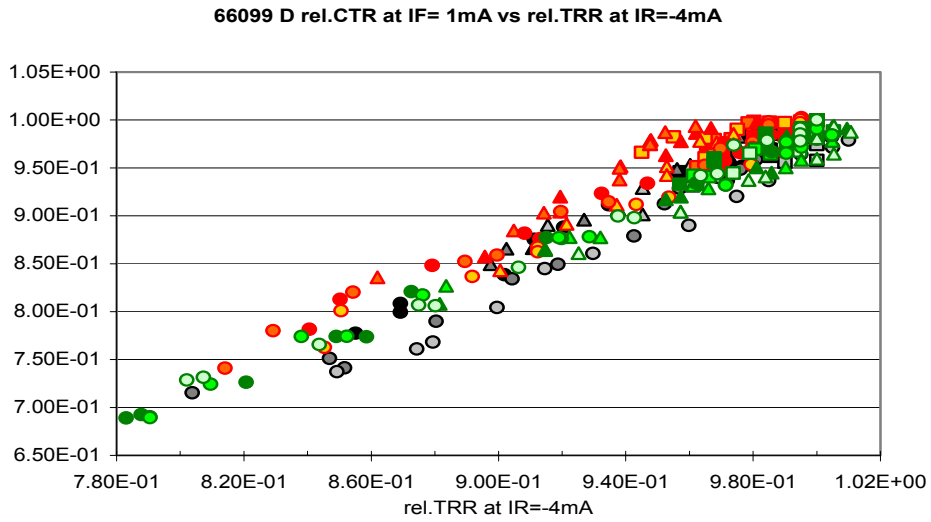
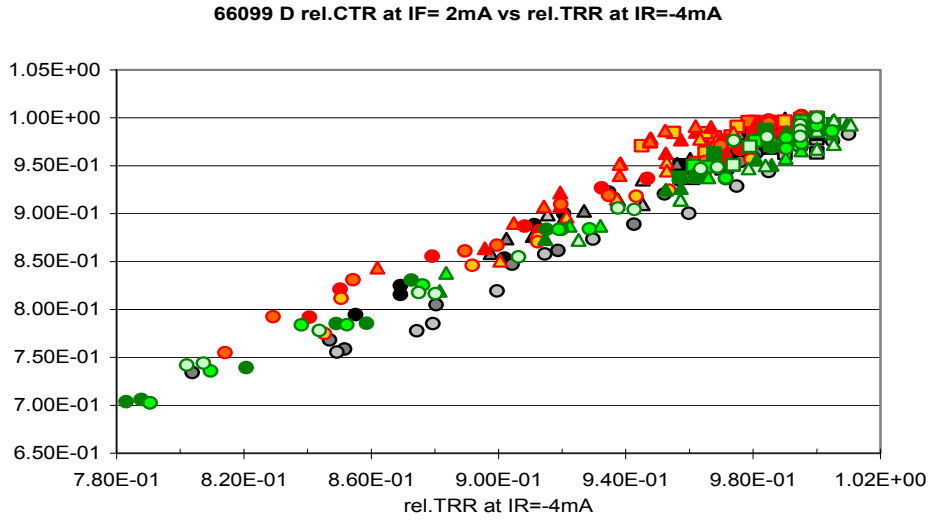
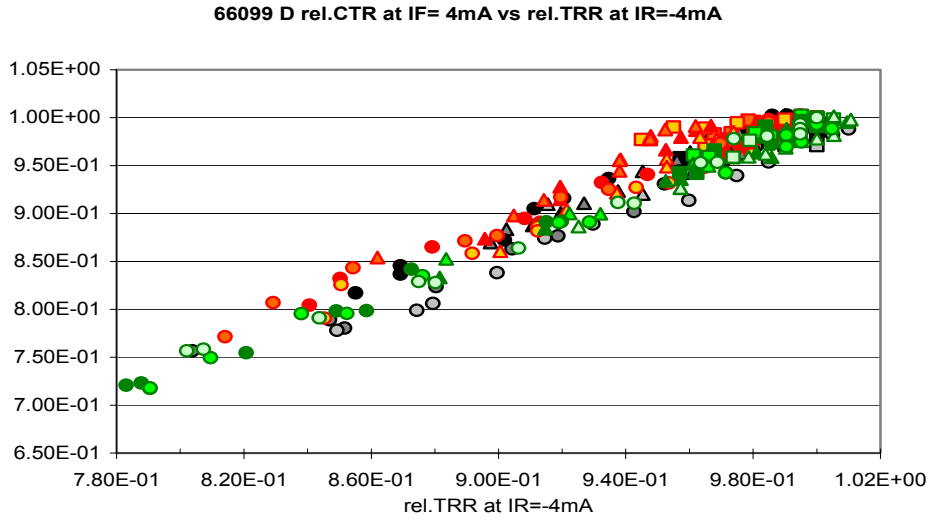


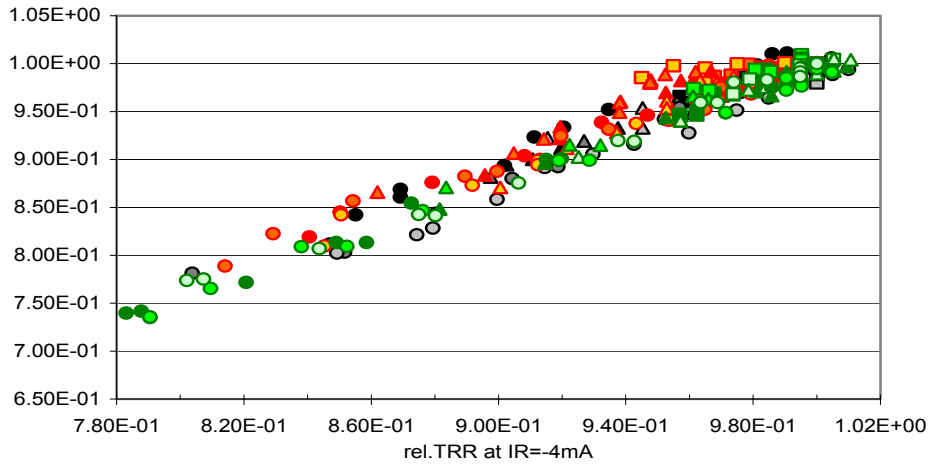
Fig. 14-99: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA







66099 D rel.CTR at IF= 8mA vs rel.TRR at IR=-4mA



66099 D rel.CTR at IF= 10mA vs rel.TRR at IR=-4mA

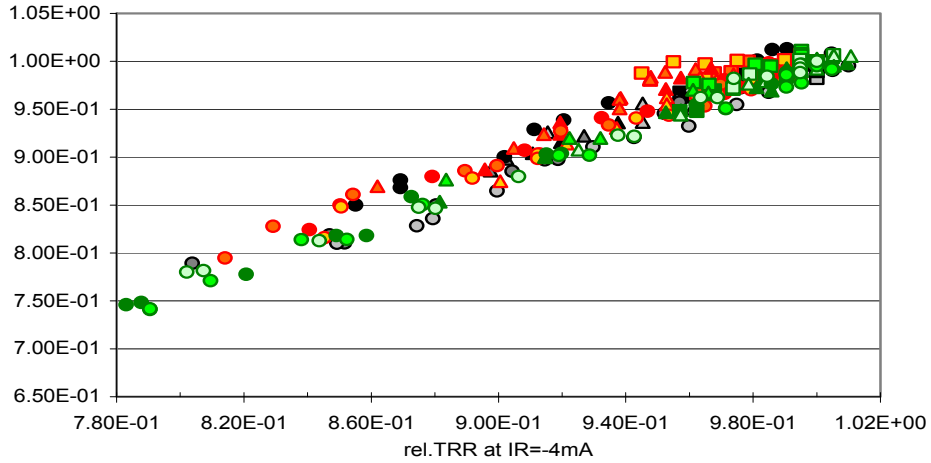
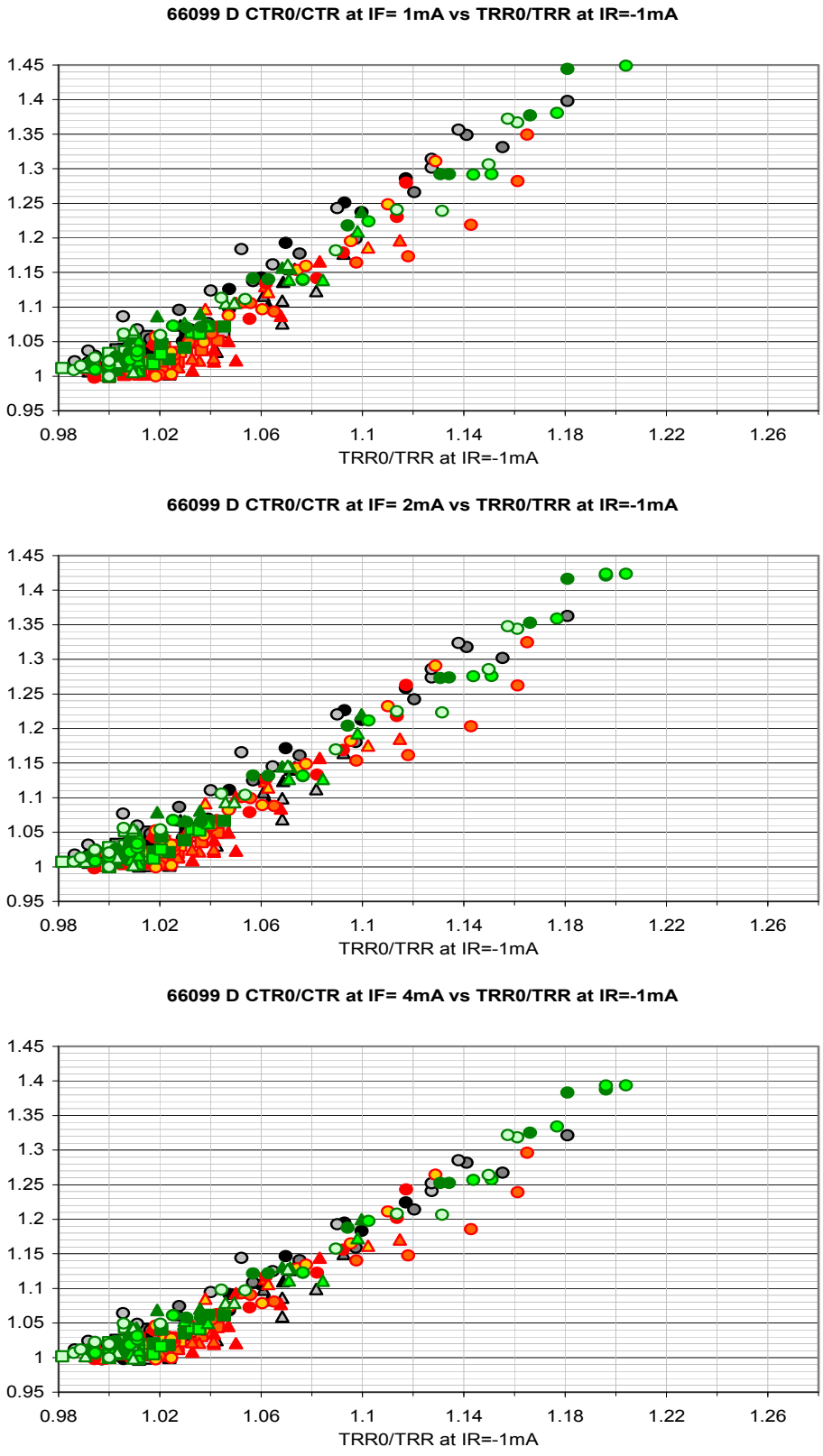
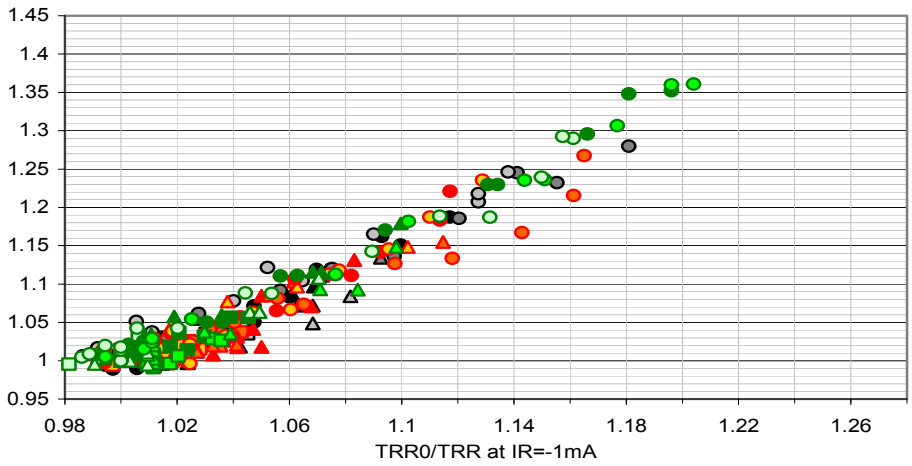


Fig. 14-100: diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA



66099 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-1mA



66099 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-1mA

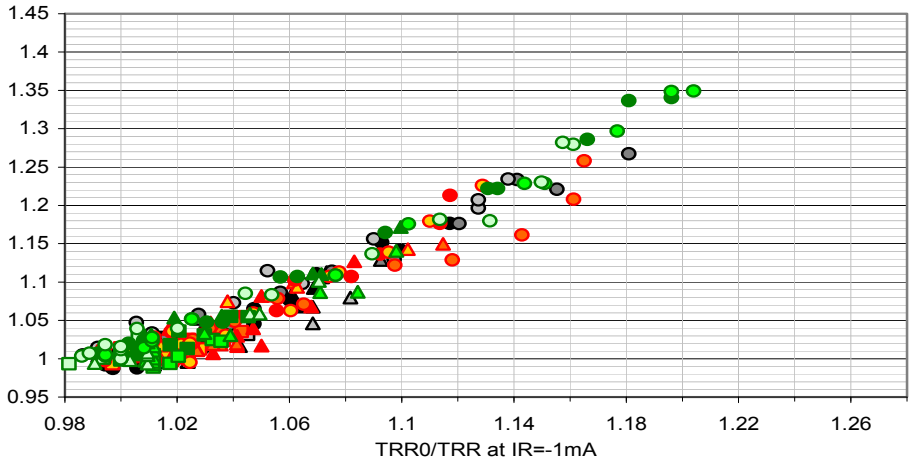
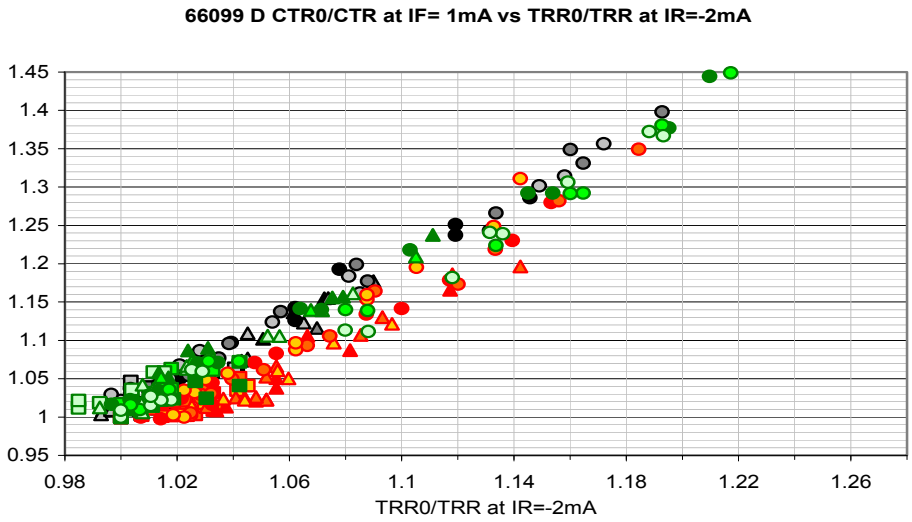
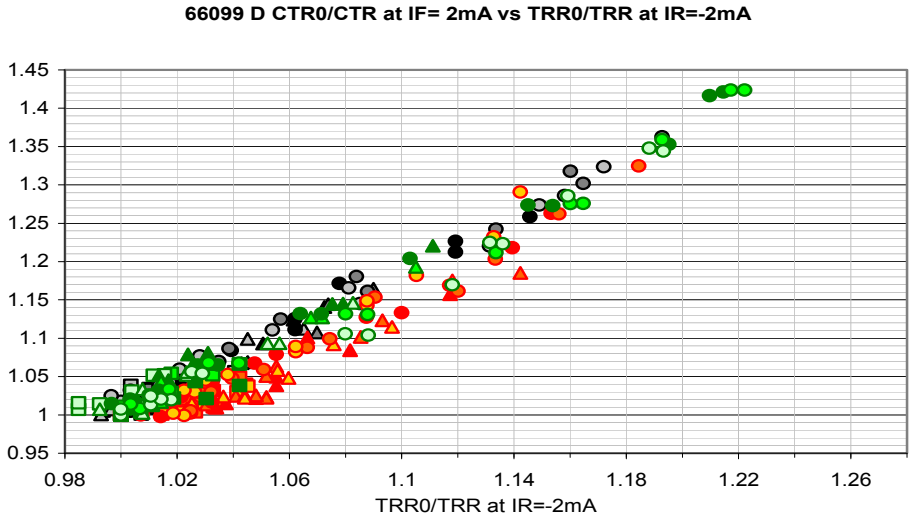
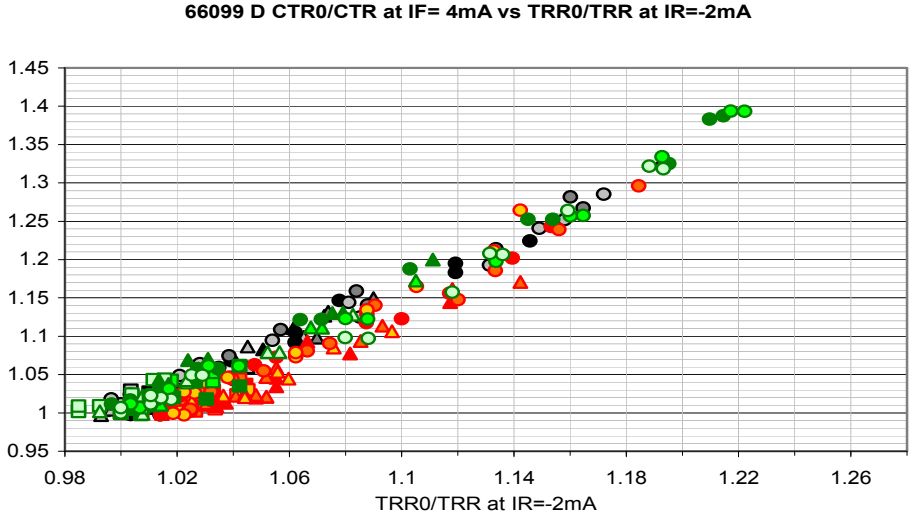


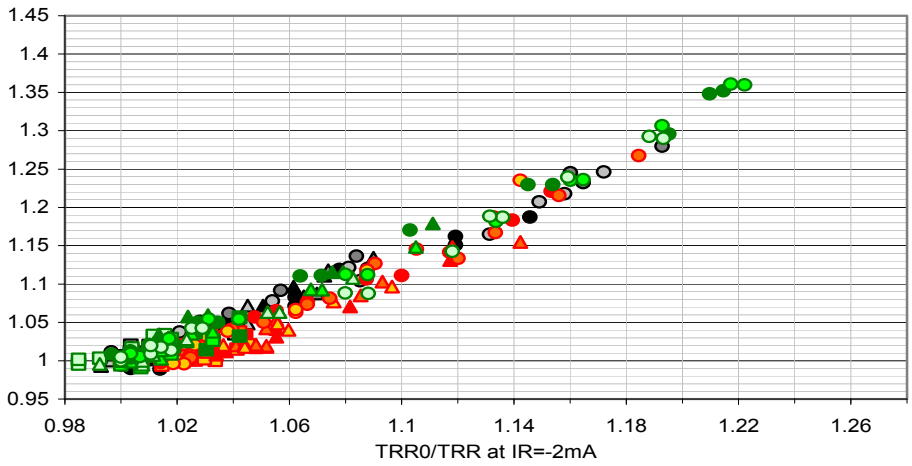
Fig. 14-101: diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA







66099 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-2mA



66099 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-2mA

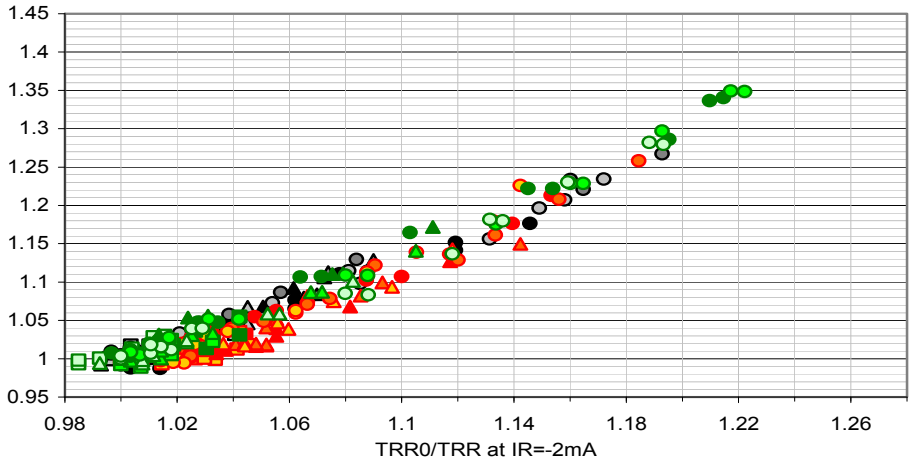
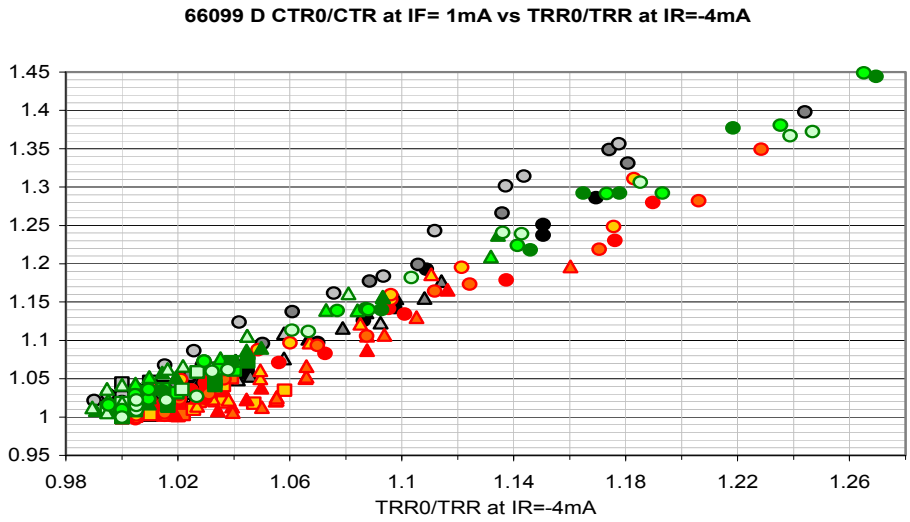
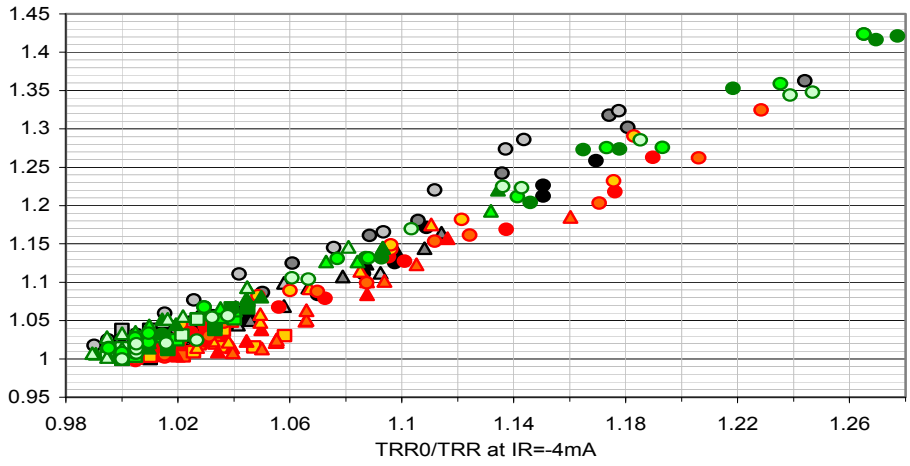
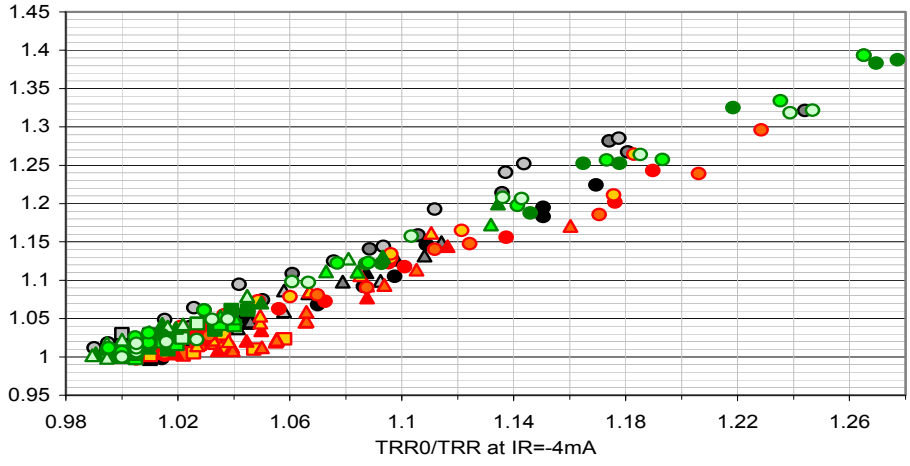


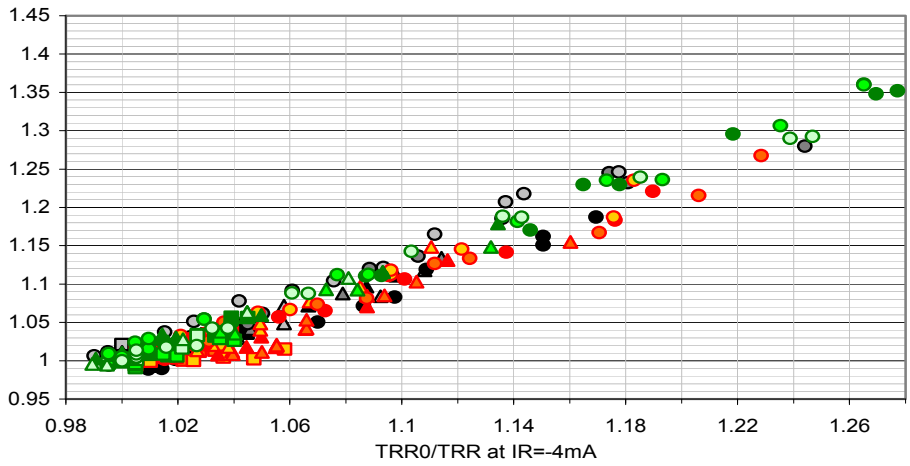
Fig. 14-102: diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







66099 D CTR0/CTR at IF= 8mA vs TRR0/TRR at IR=-4mA



66099 D CTR0/CTR at IF= 10mA vs TRR0/TRR at IR=-4mA

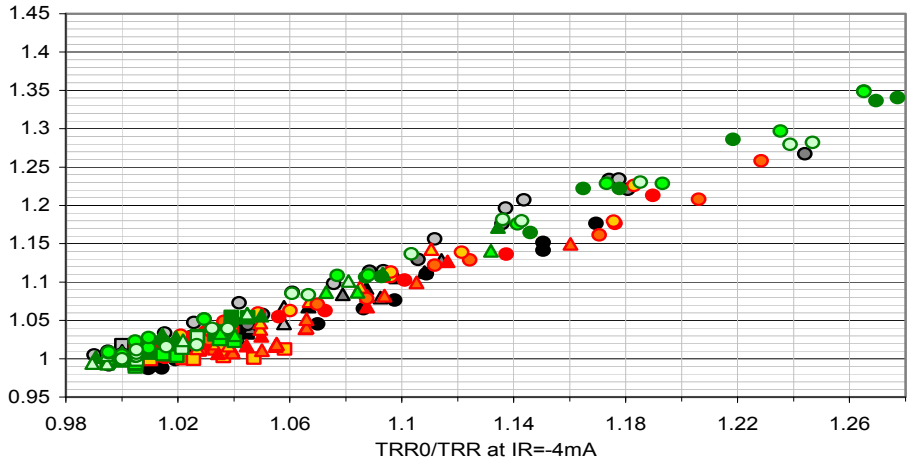
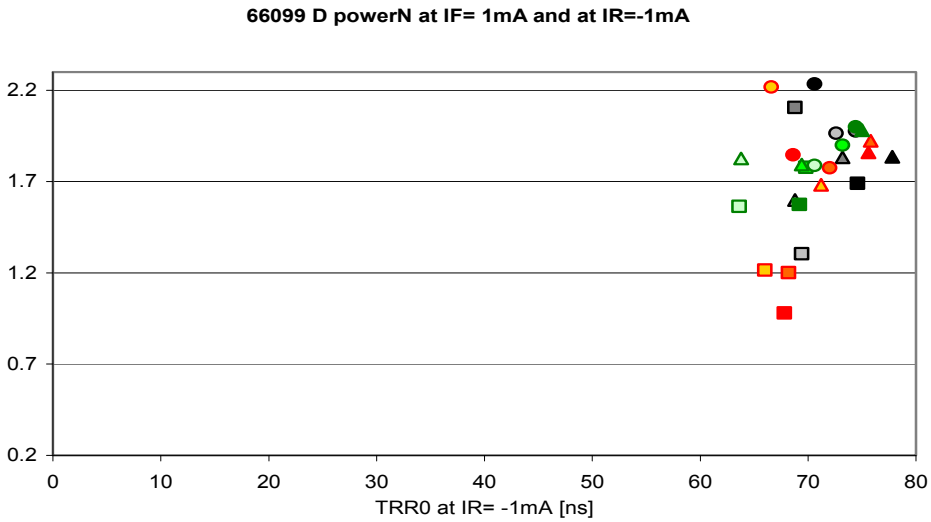
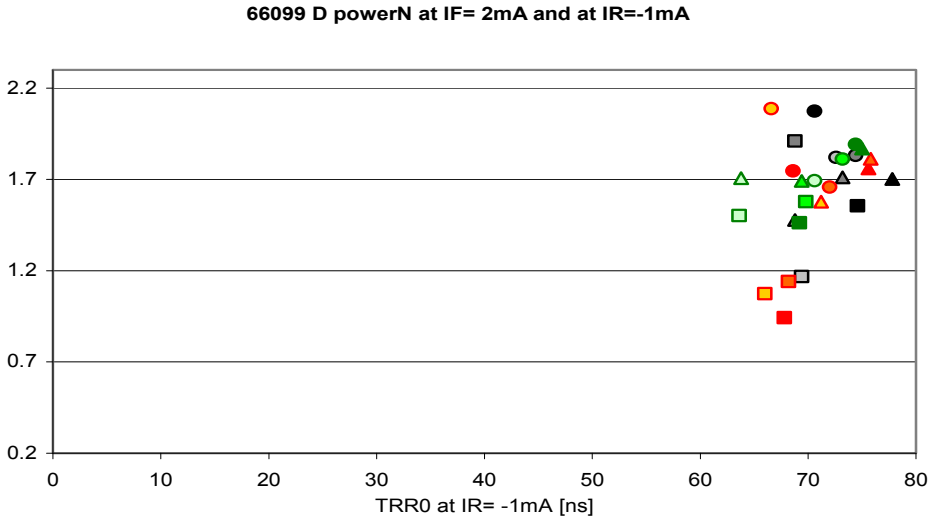
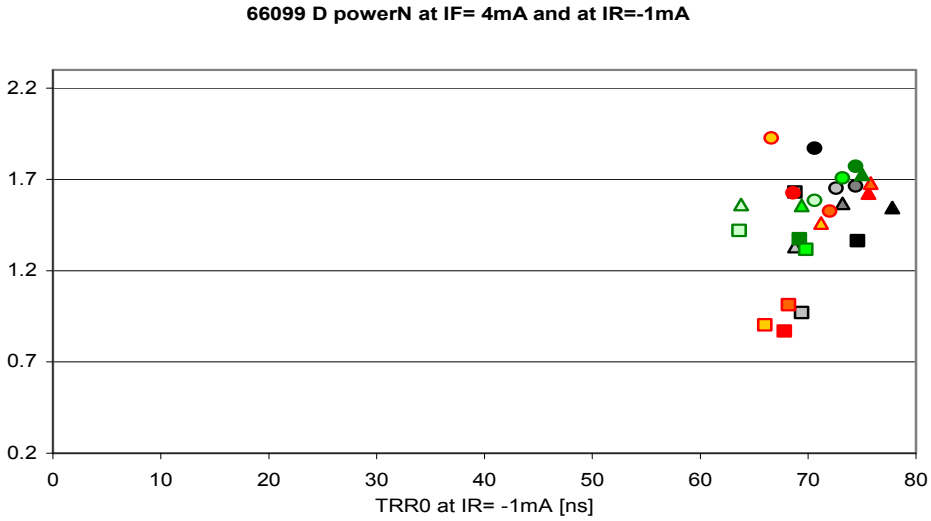


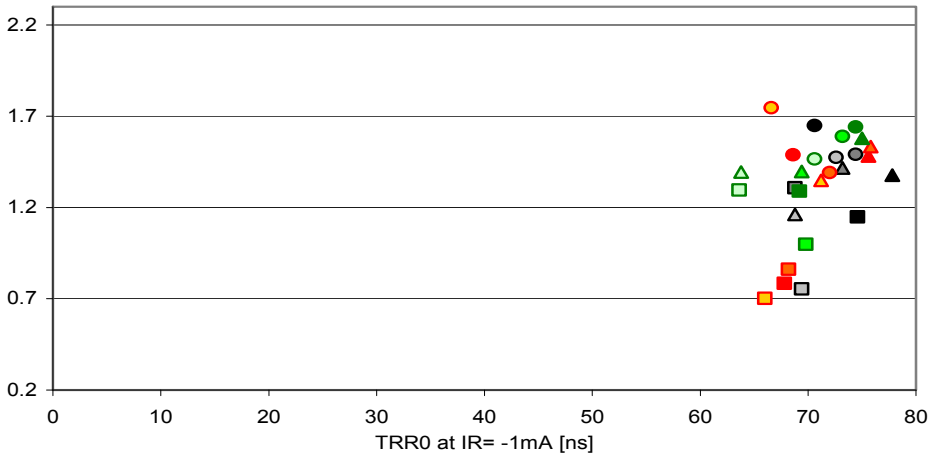
Fig. 14-103: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA







66099 D powerN at IF= 8mA and at IR=-1mA



66099 D powerN at IF= 10mA and at IR=-1mA

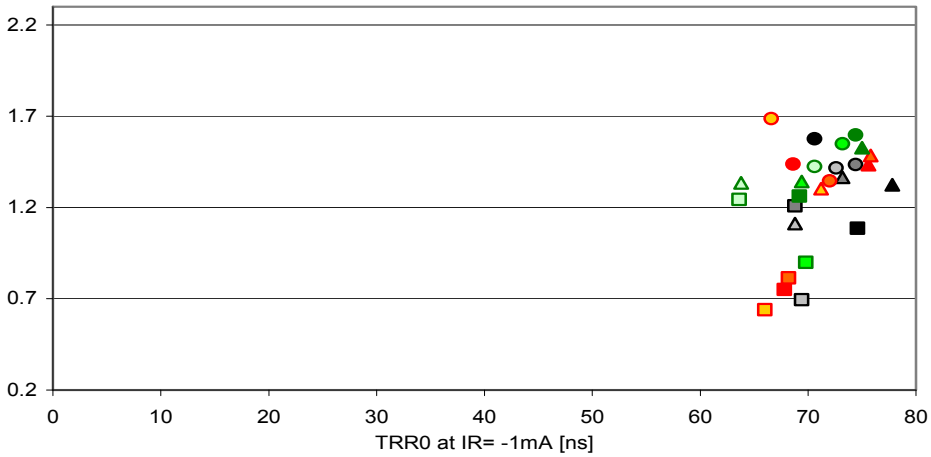
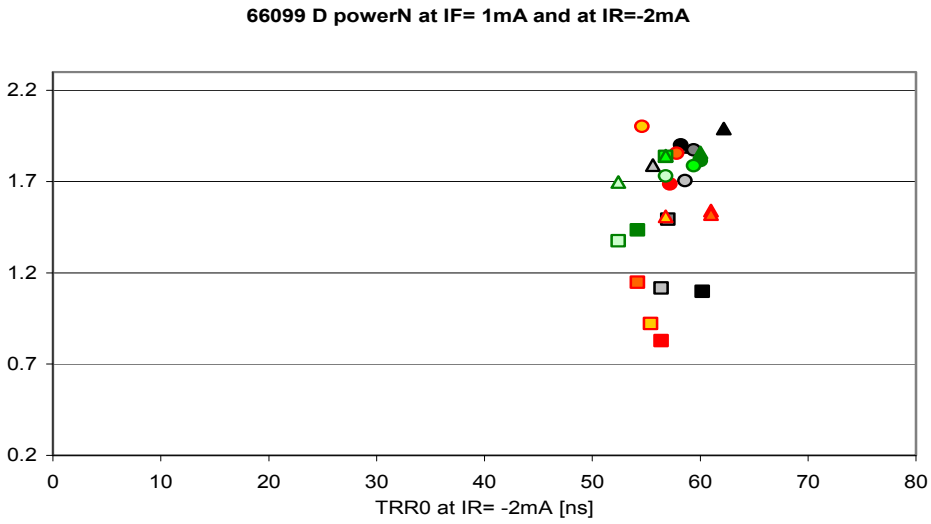
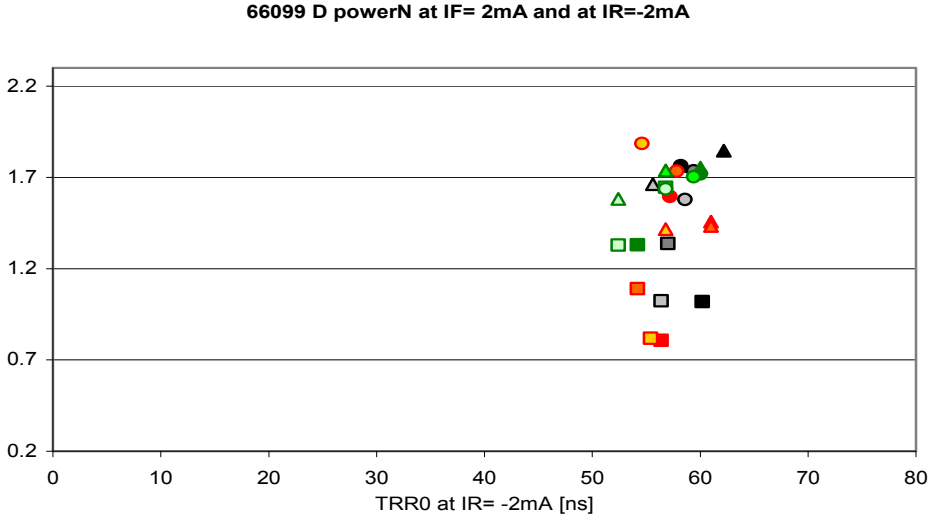
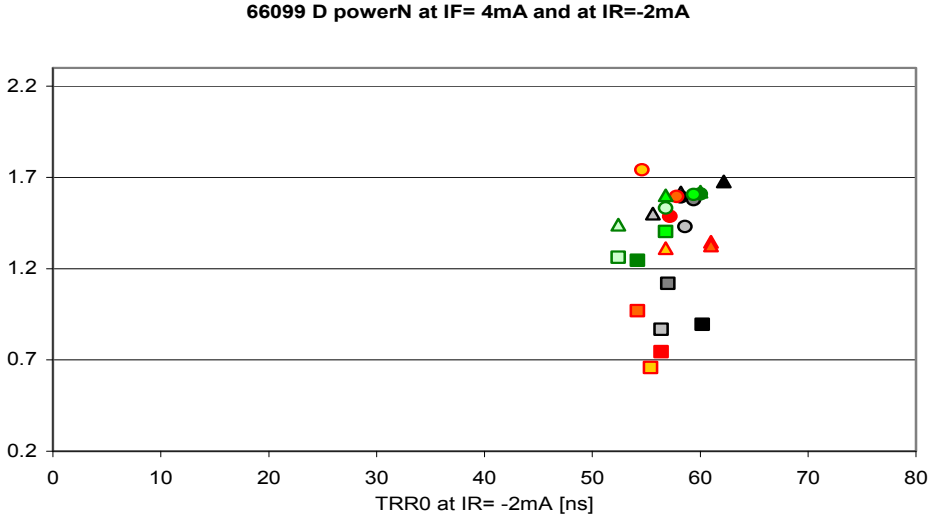


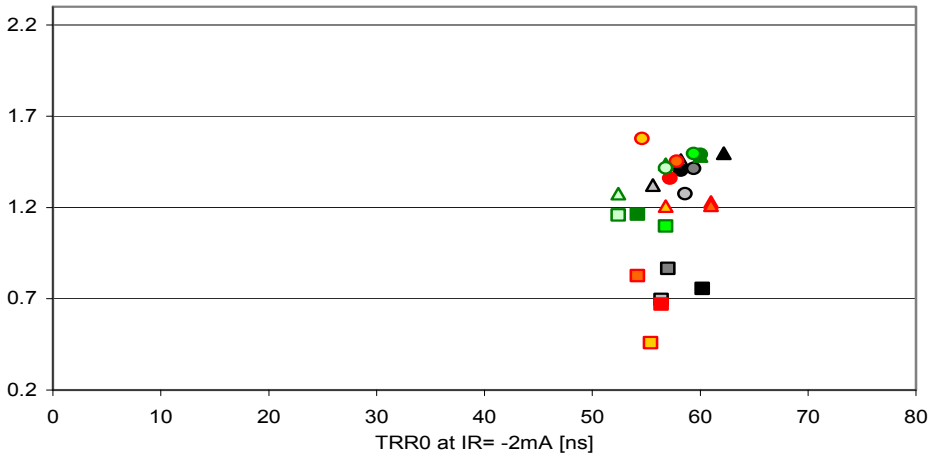
Fig. 14-104: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA







66099 D powerN at IF= 8mA and at IR=-2mA



66099 D powerN at IF= 10mA and at IR=-2mA

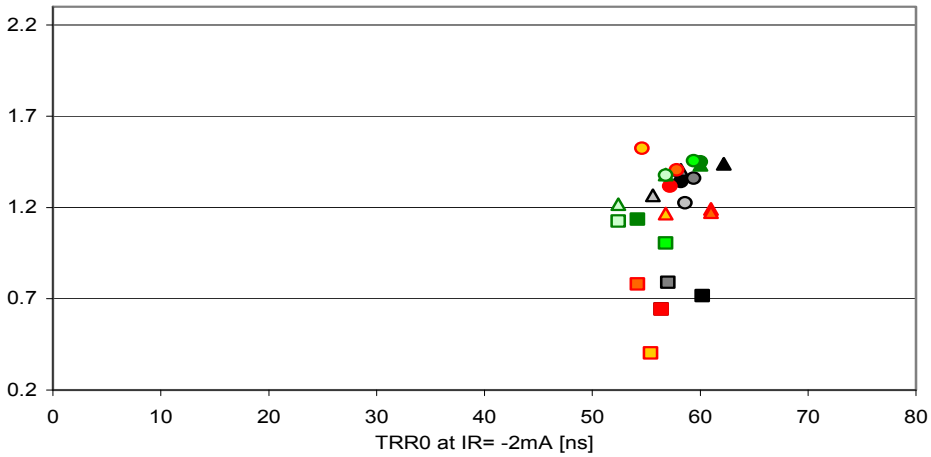
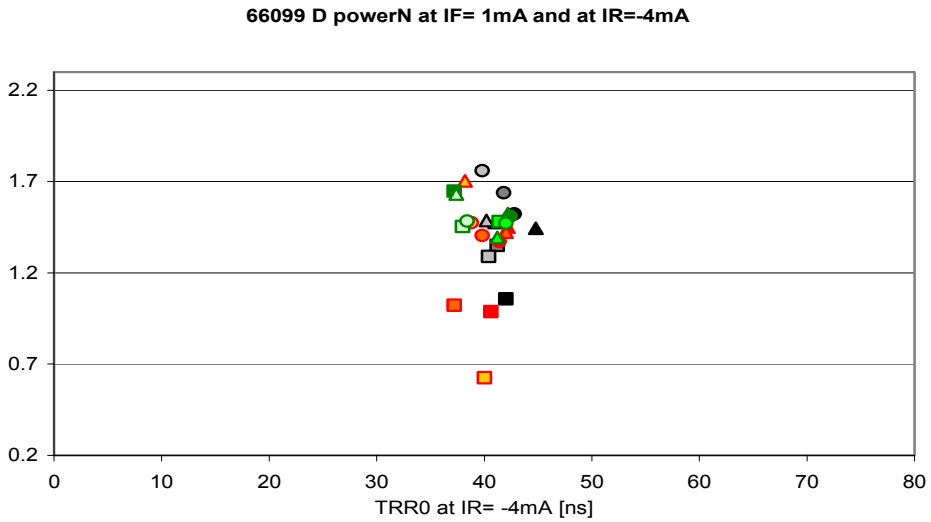
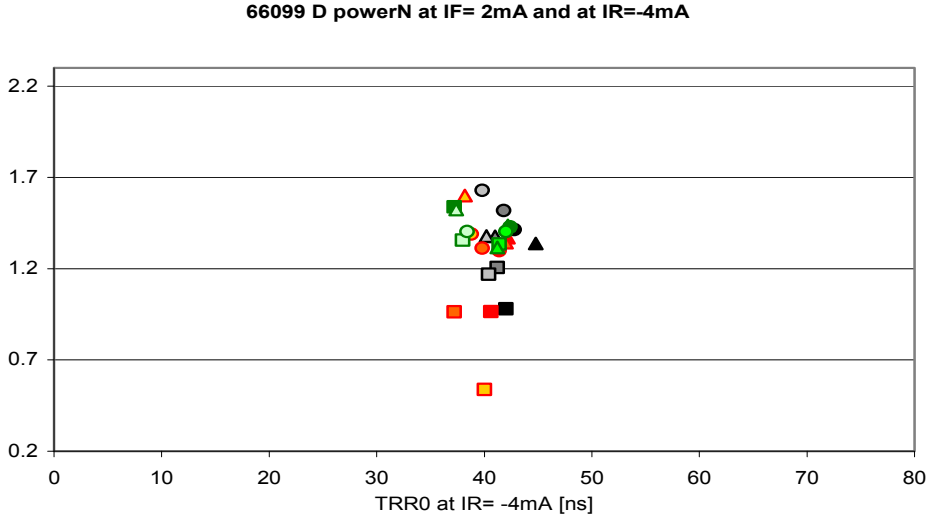
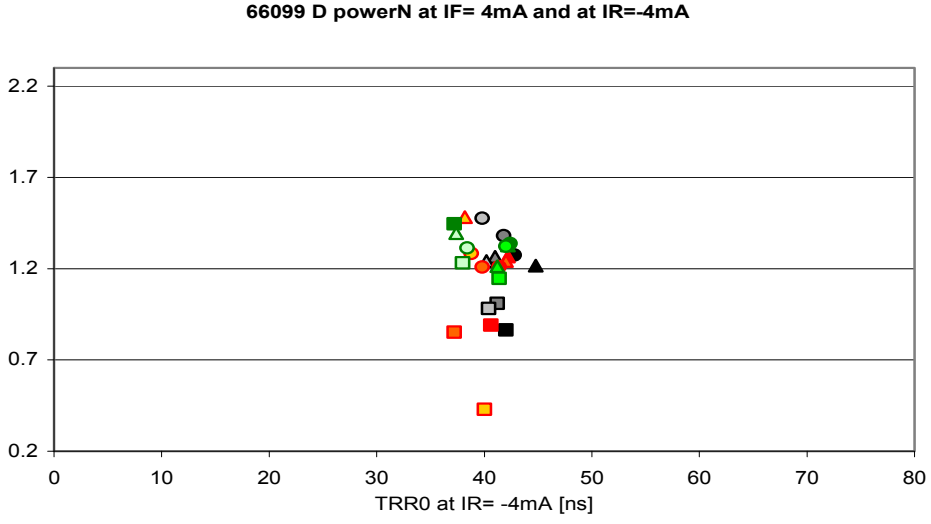


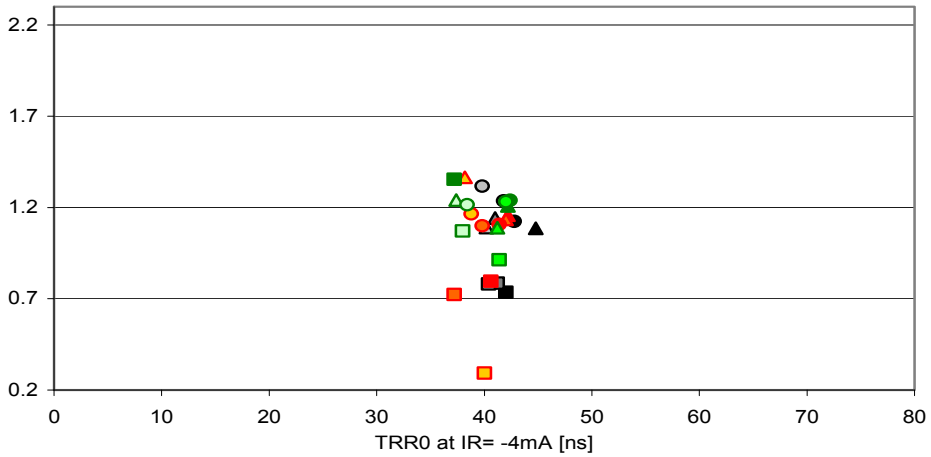
Fig. 14-105: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA







66099 D powerN at IF= 8mA and at IR=-4mA



66099 D powerN at IF= 10mA and at IR=-4mA

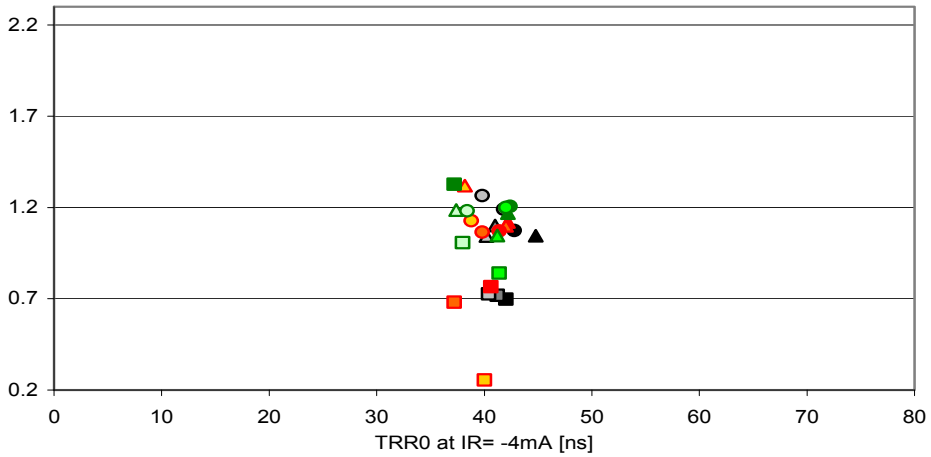
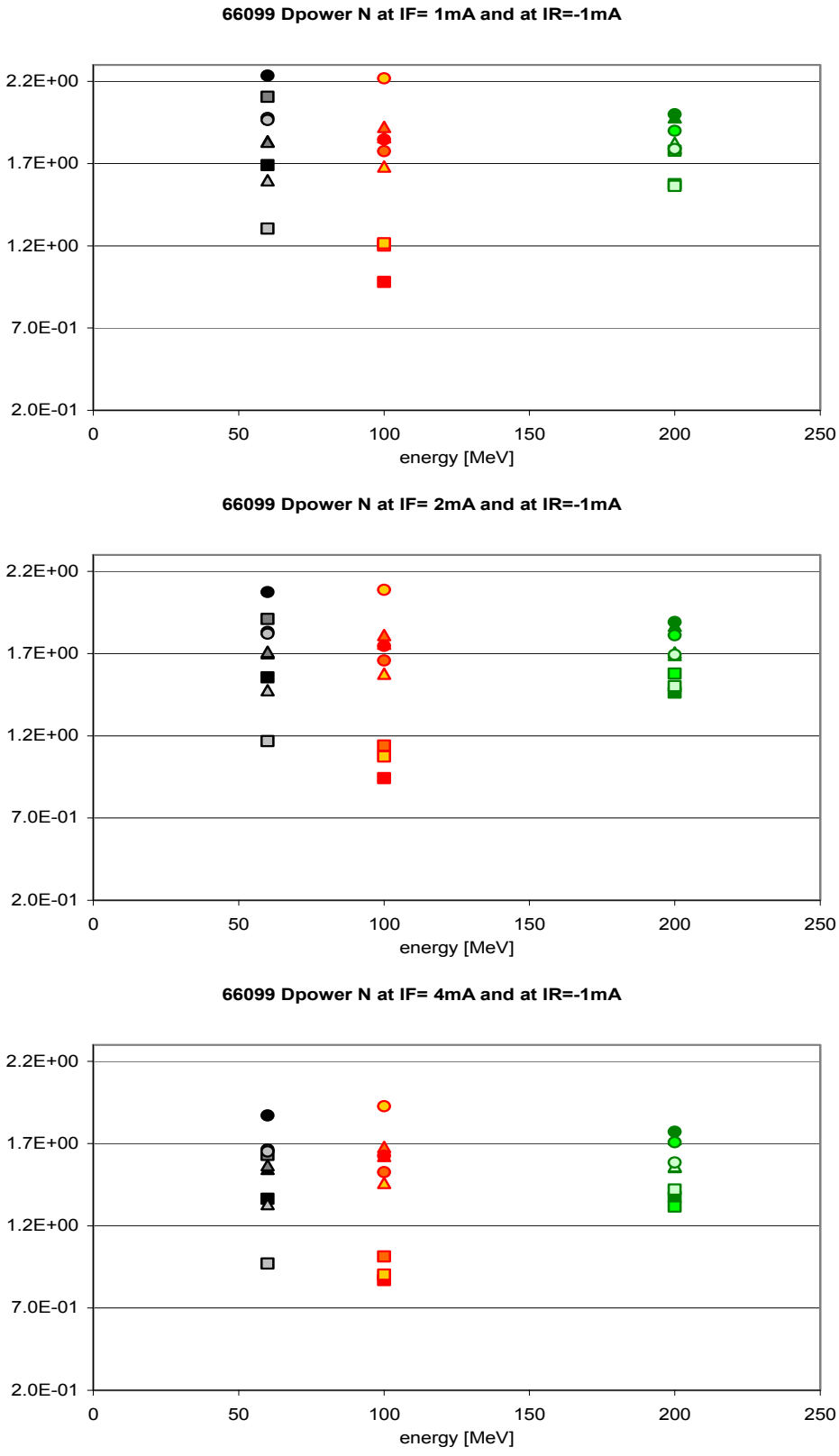
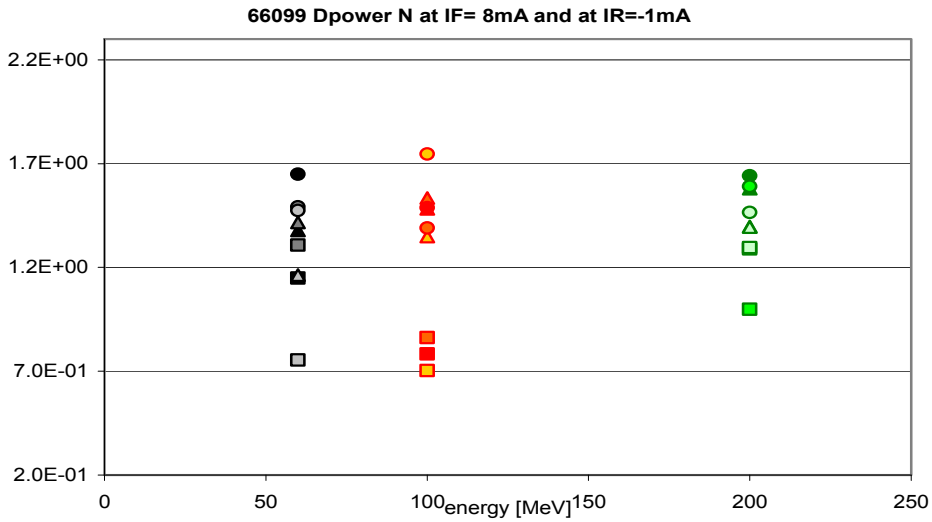


Fig. 14-106: 66099 diode: N at I_R = -1 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy




66099 Dpower N at IF= 8mA and at IR=-1mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

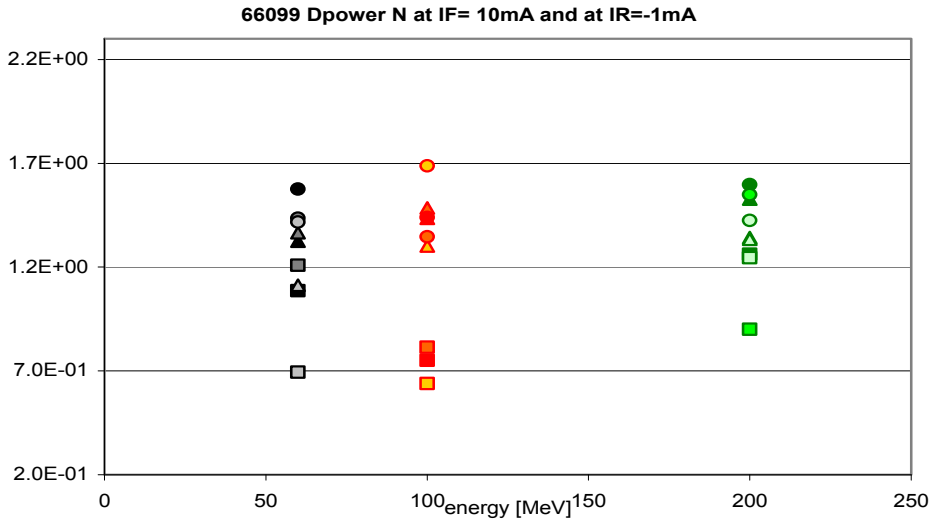
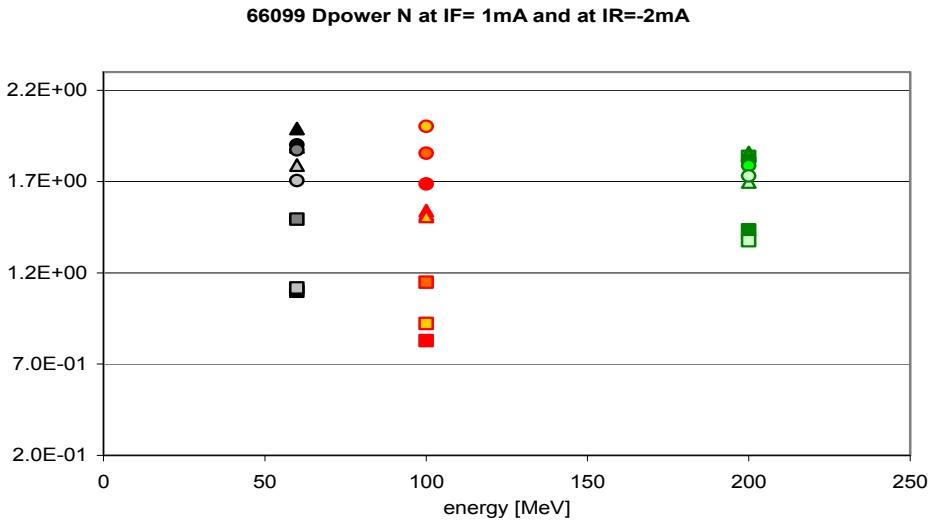
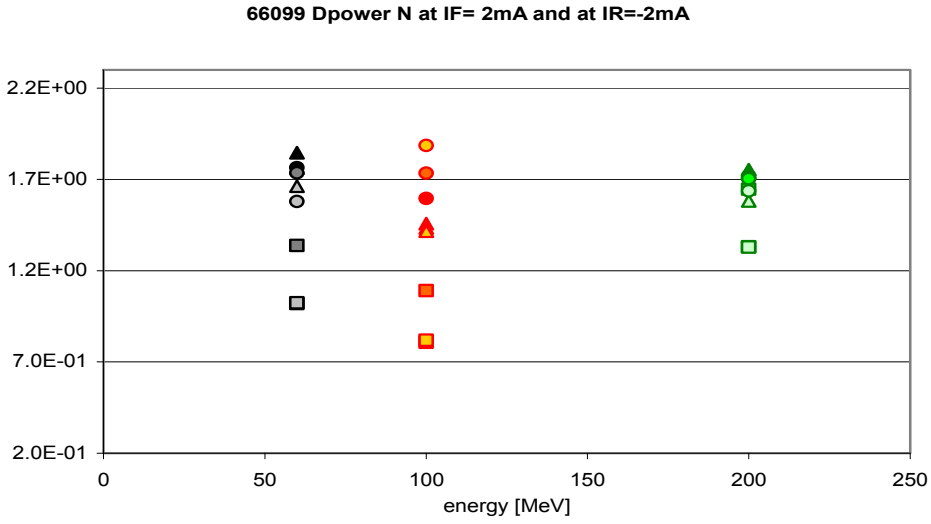
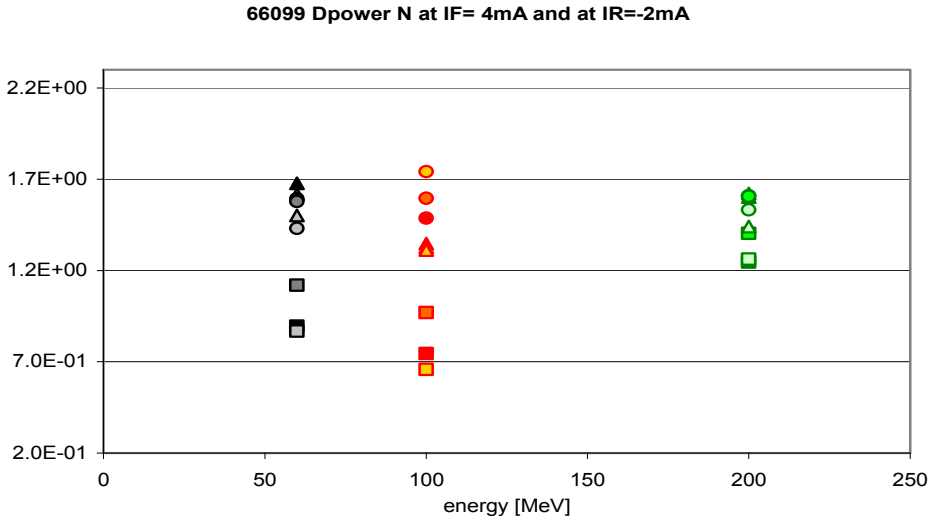
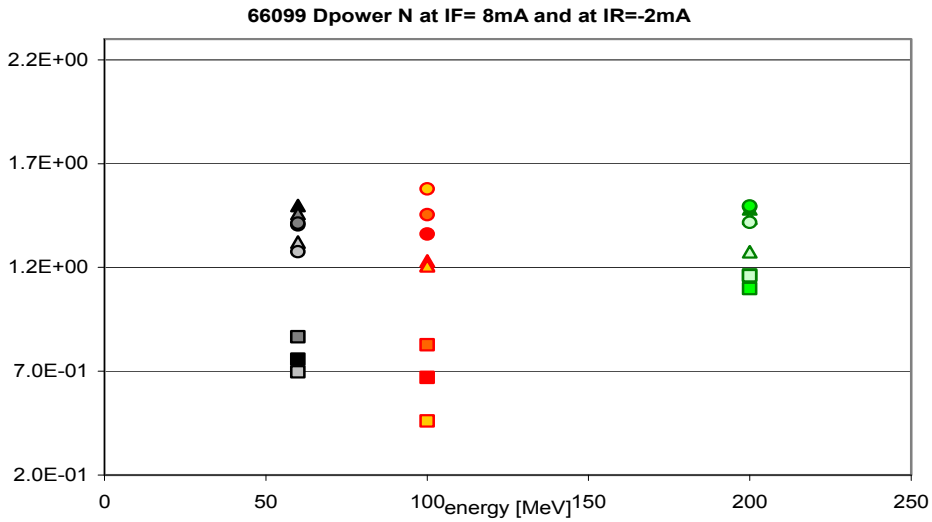

66099 Dpower N at IF= 10mA and at IR=-1mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

Fig. 14-107: 66099 diode: N at I_R = -2 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy








66099 Dpower N at IF= 8mA and at IR=-2mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

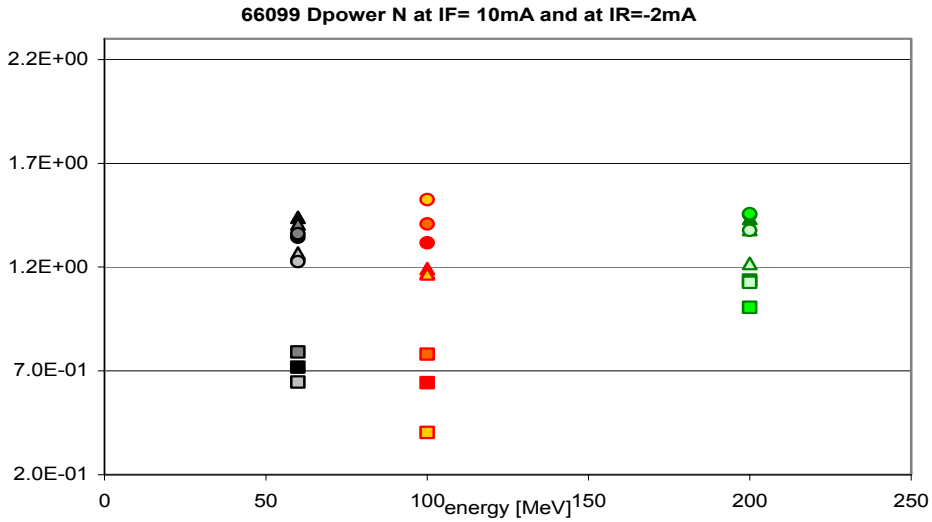
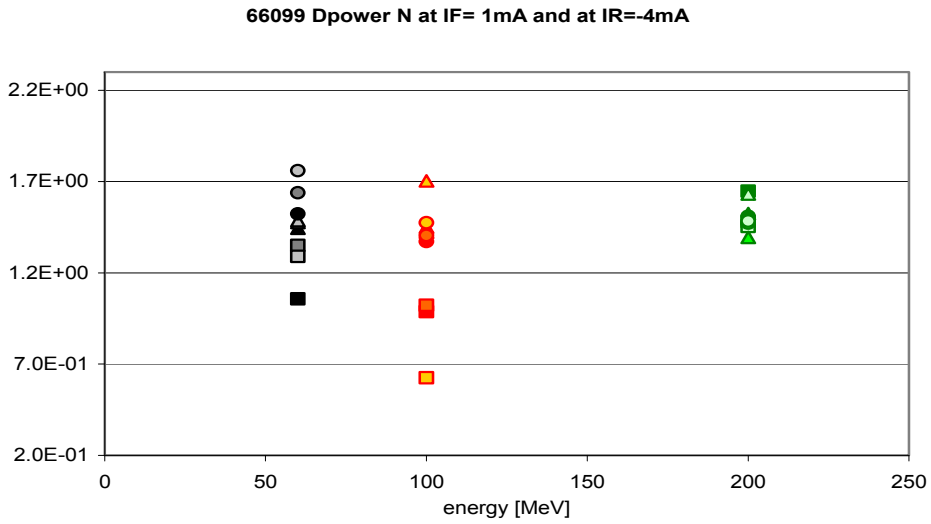
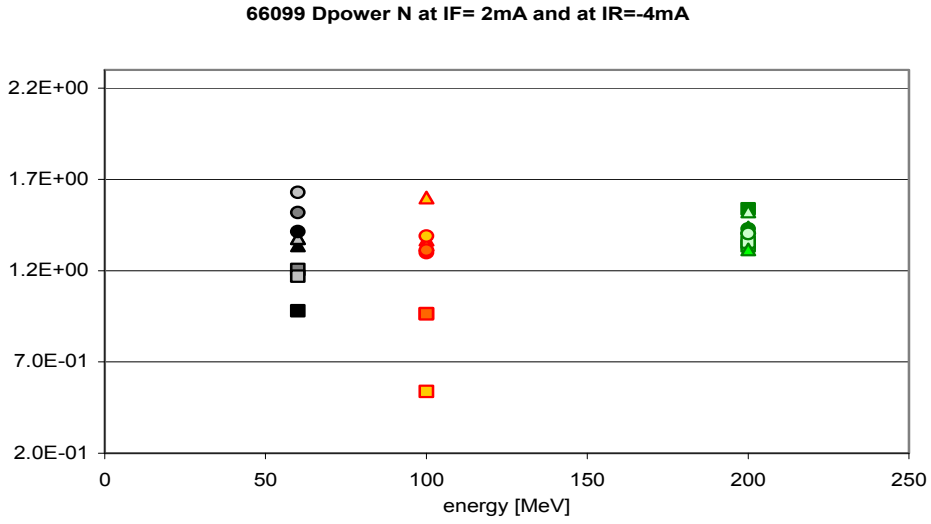
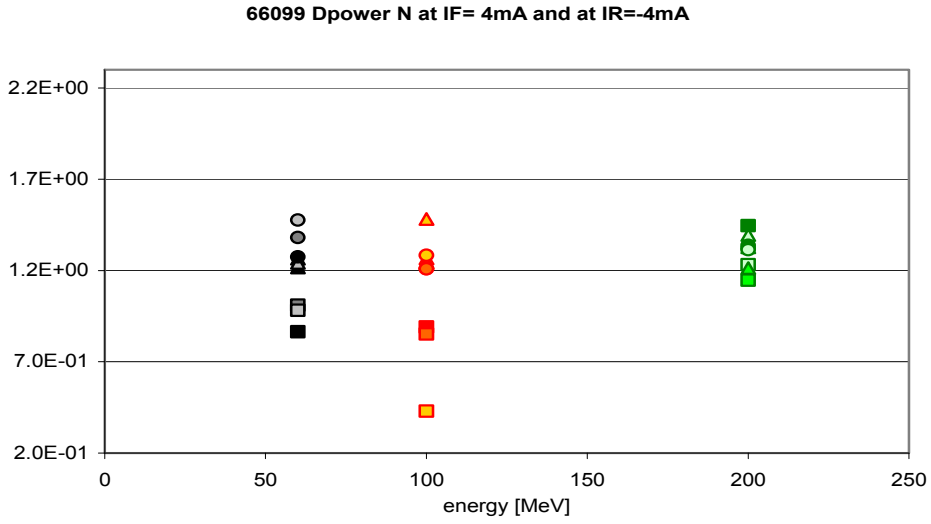
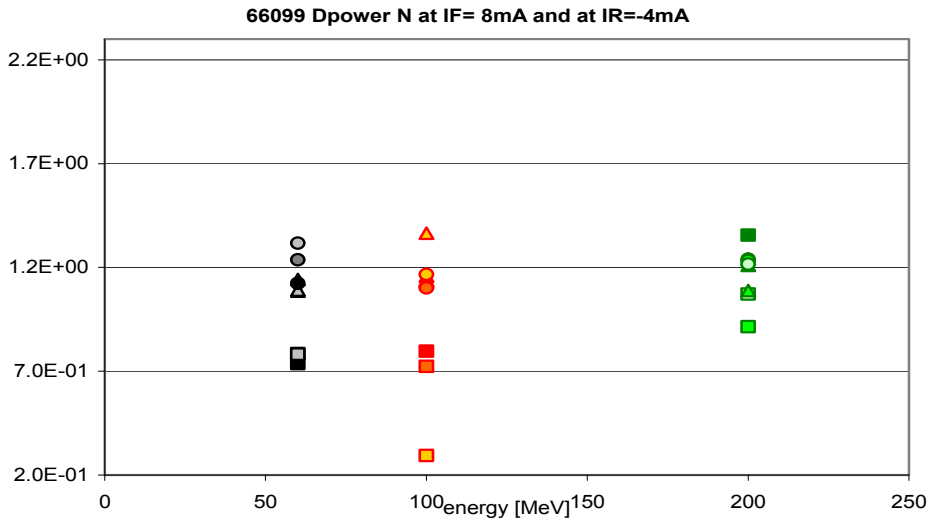

66099 Dpower N at IF= 10mA and at IR=-2mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

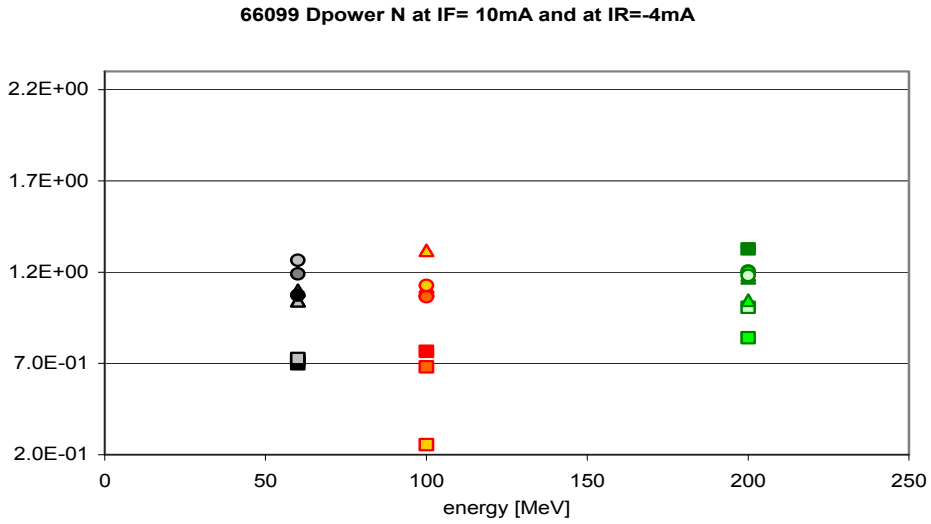
Fig. 14-108: 66099 diode: N at I_R = -4 mA and I_F = 1, 2, 4, 8, 10 mA with respect to energy





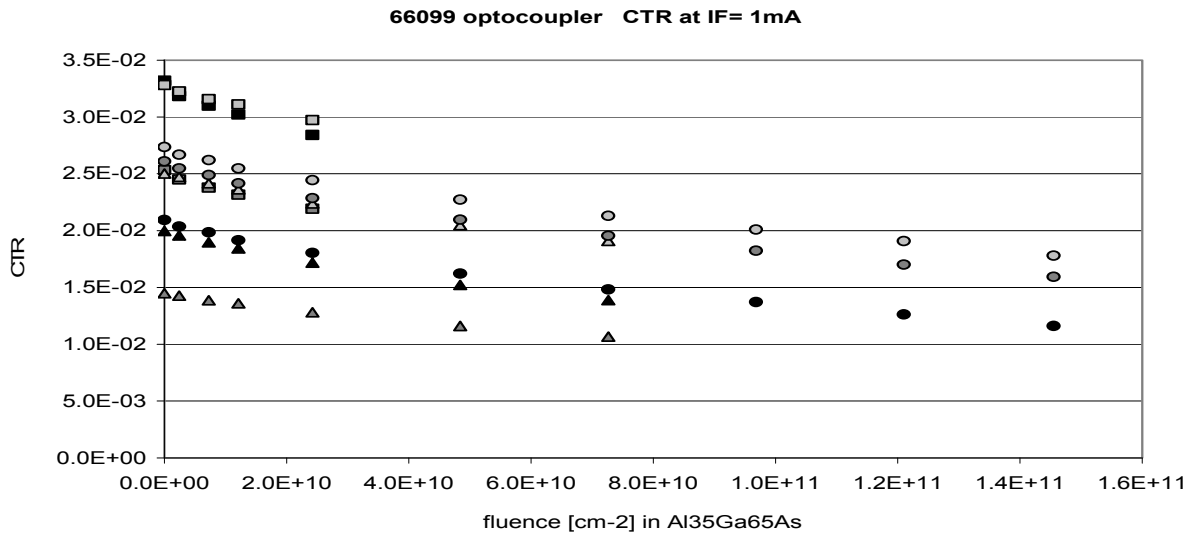


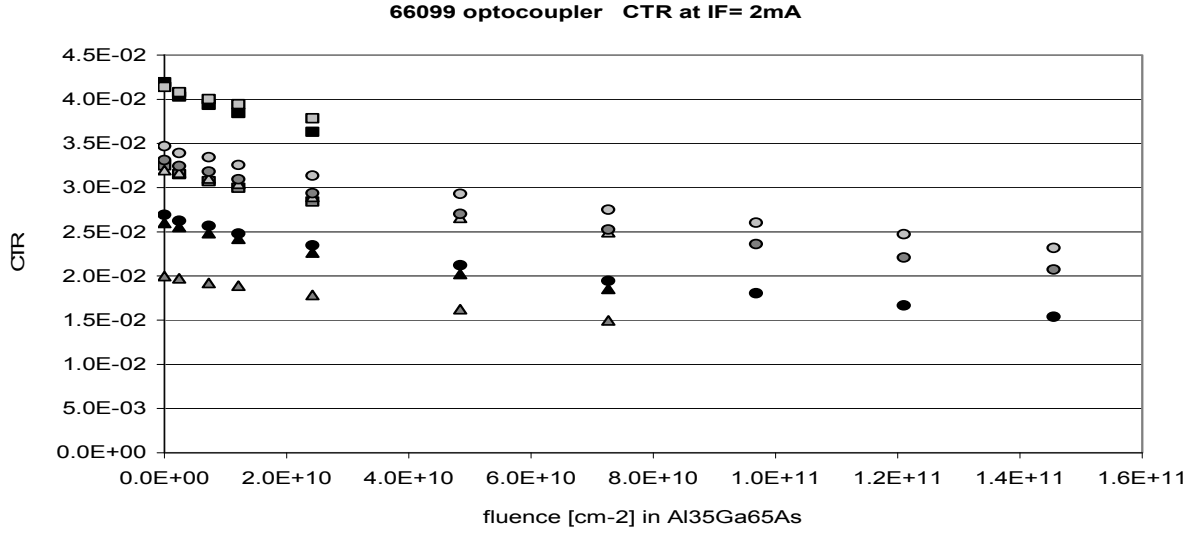

66099 Dpower N at IF= 8mA and at IR=-4mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

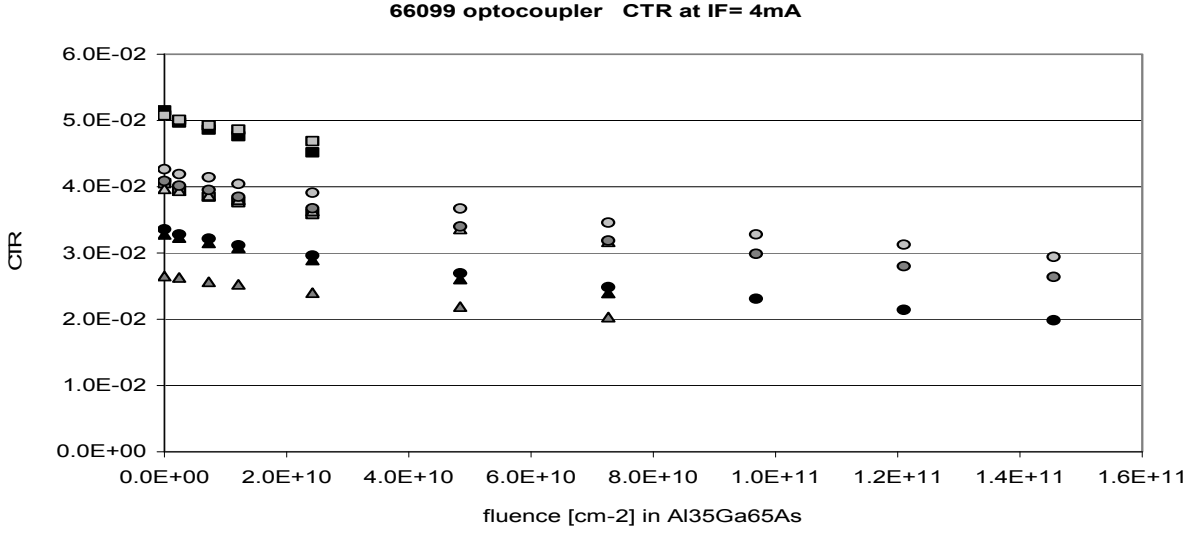

66099 Dpower N at IF= 10mA and at IR=-4mA
2.2E+00
1.7E+00
1.2E+00
7.0E-01
2.0E-01
0
50
100
150
200
250
energy [MeV]

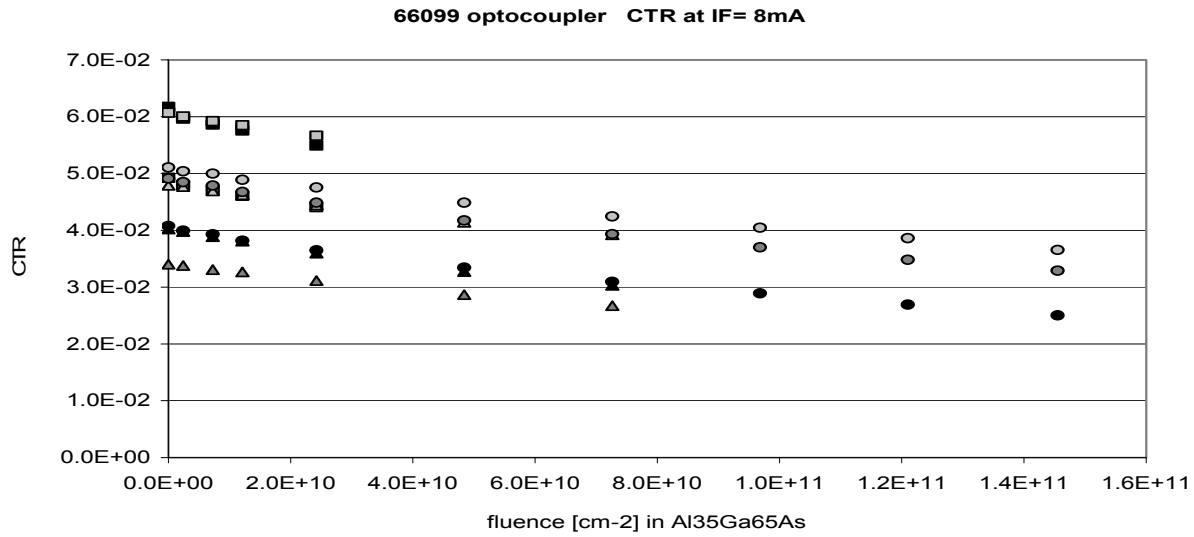
14.2 NEUTRON IRRADIATION

Fig. 14-109: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 optocoupler CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

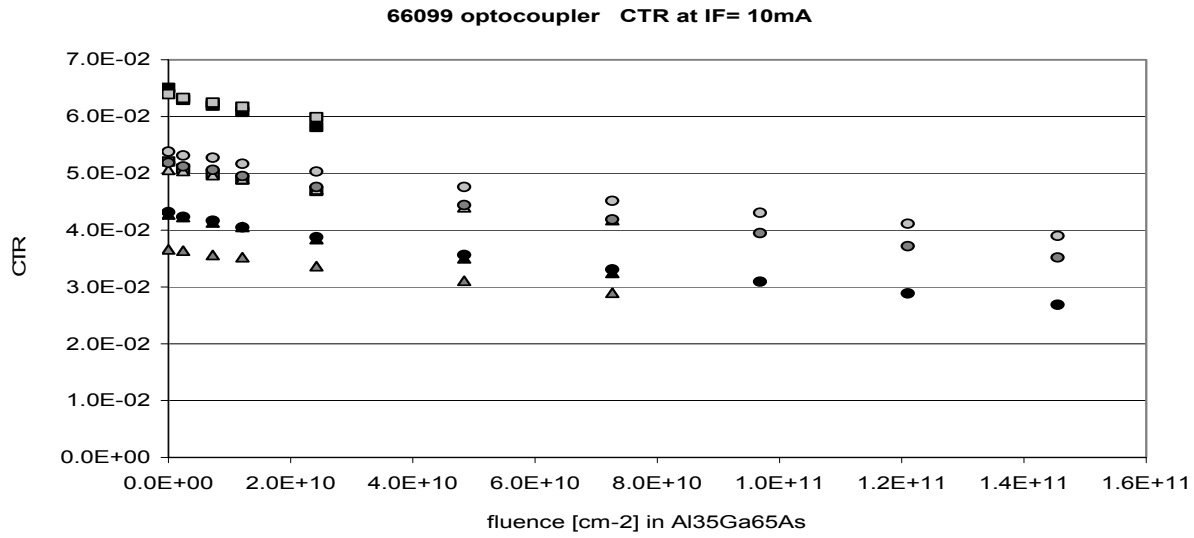
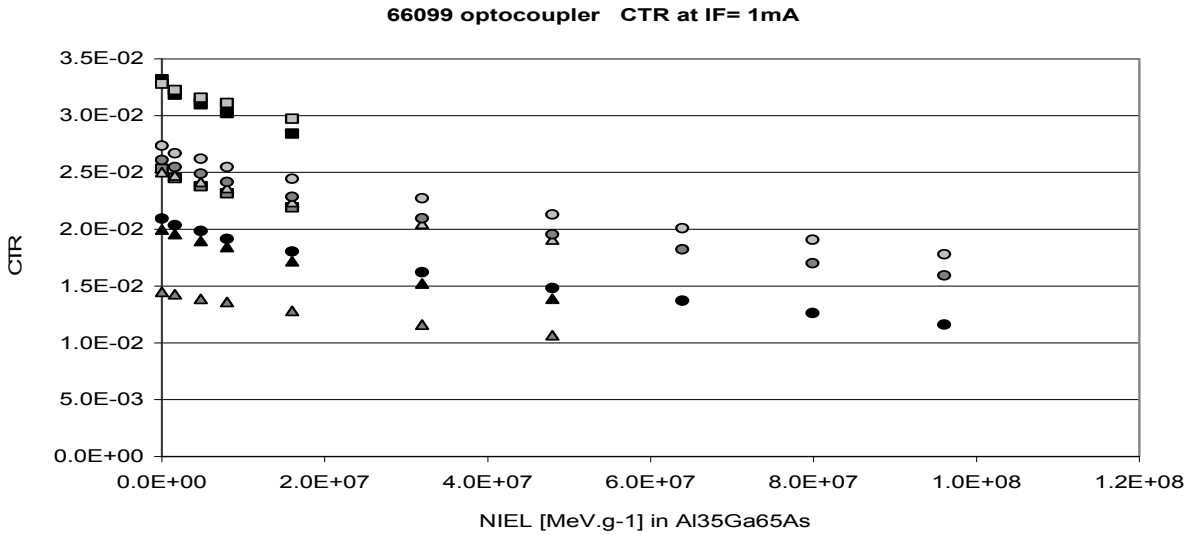
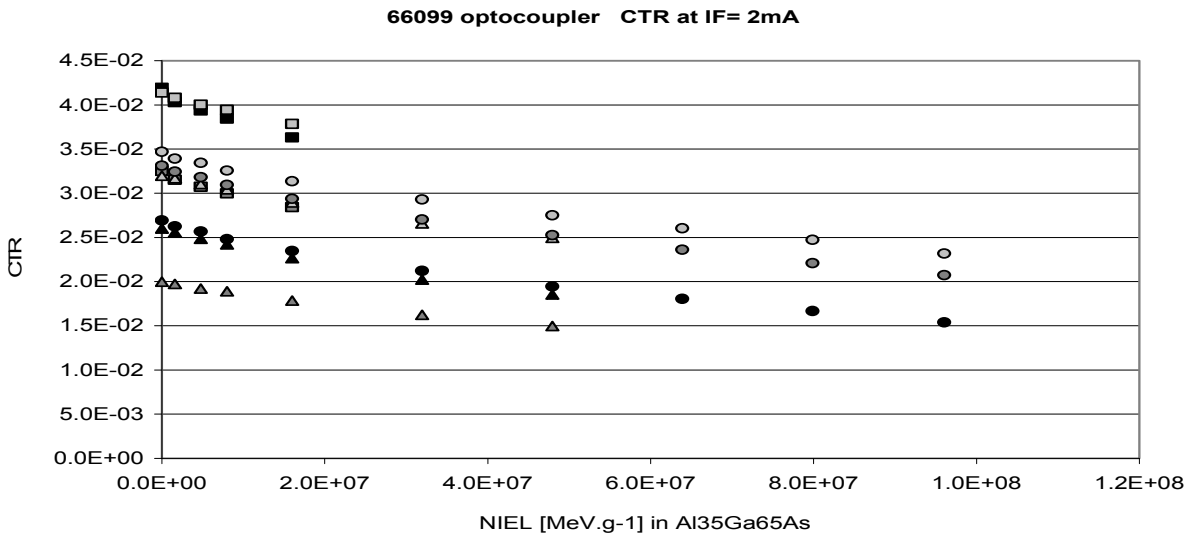
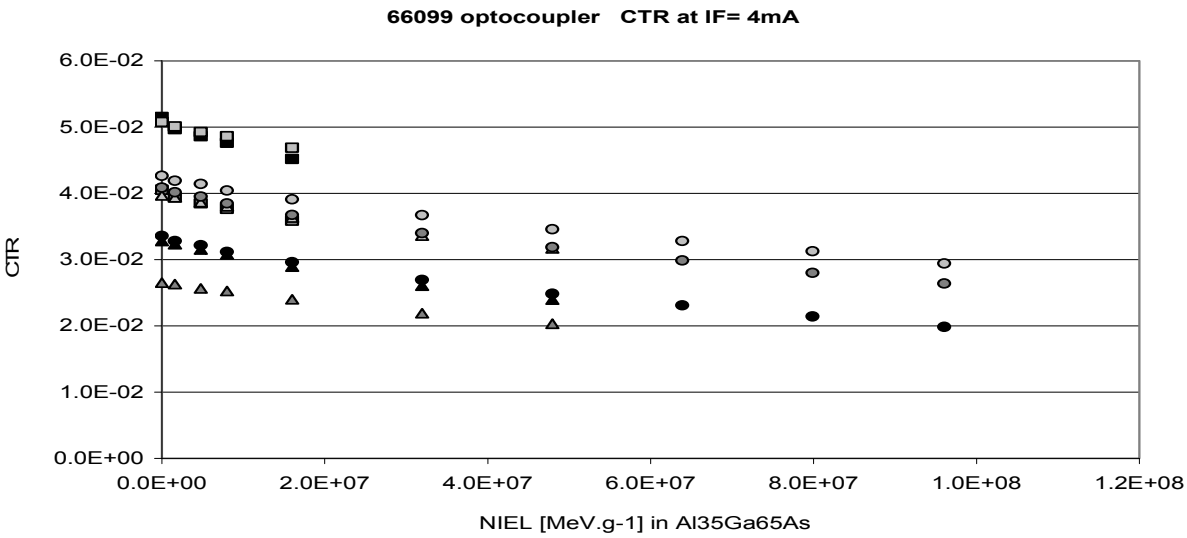
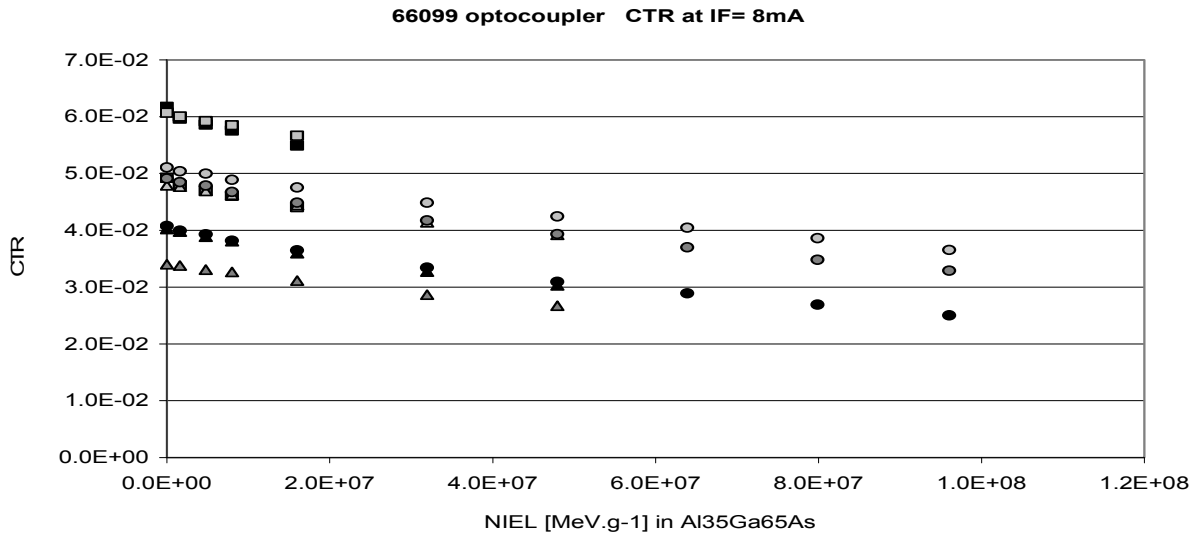

66099 optocoupler CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-110: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 optocoupler CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

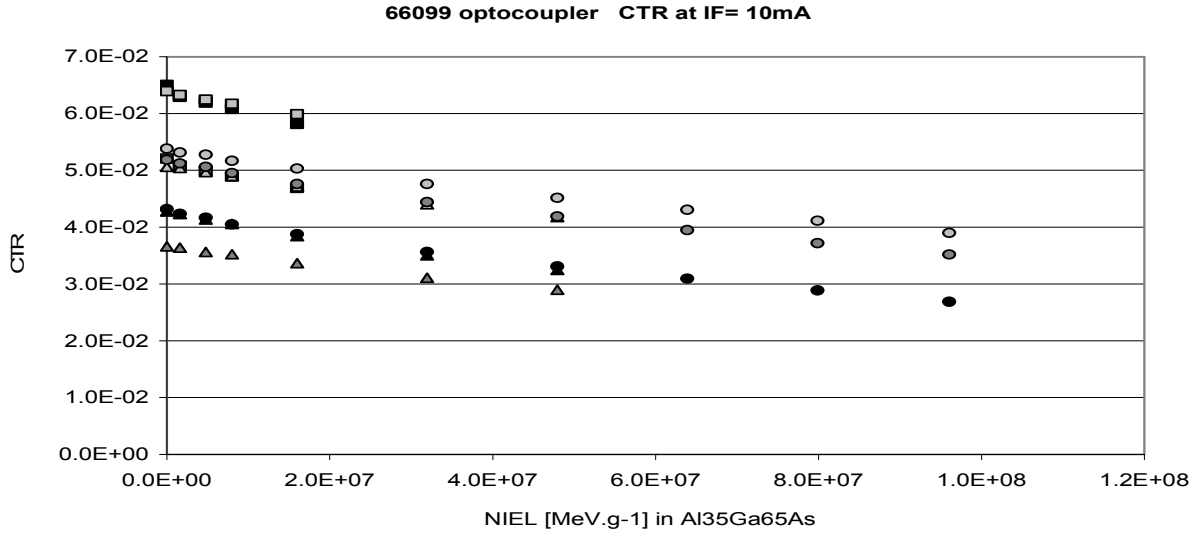
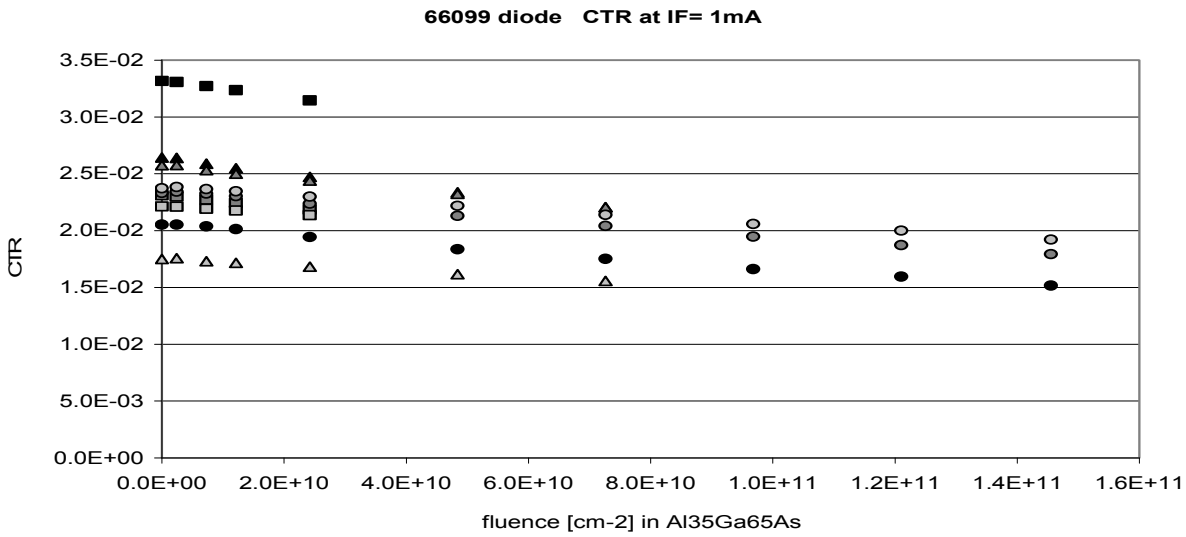
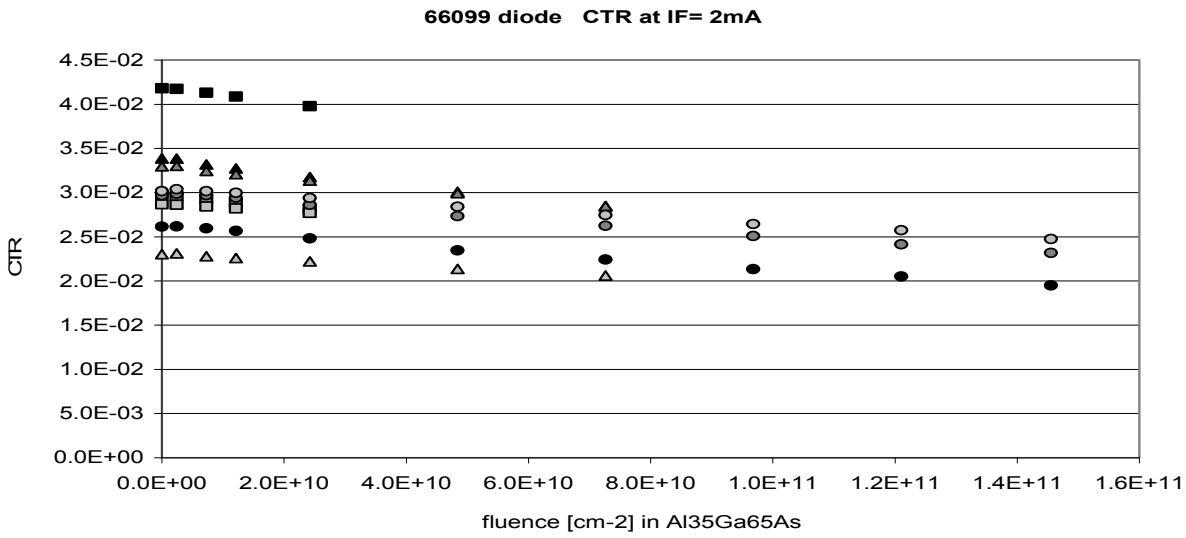
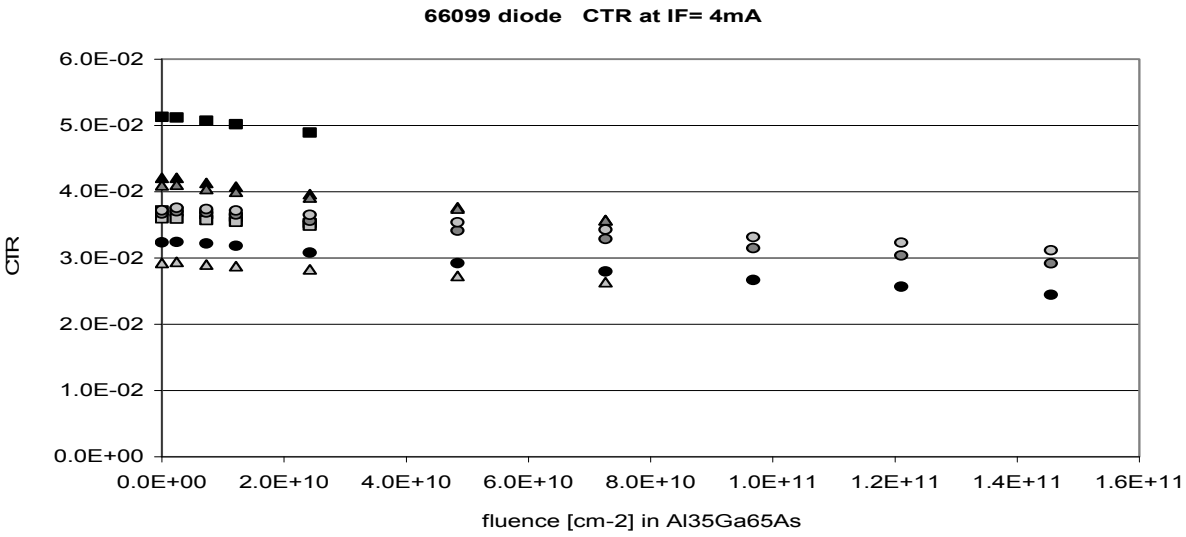
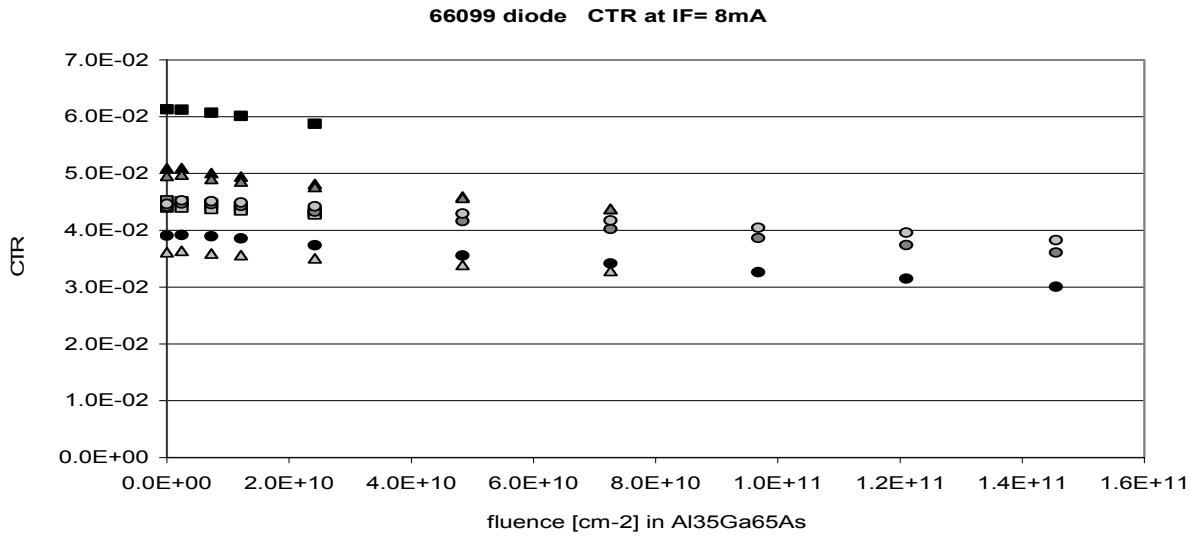

66099 optocoupler CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-111: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 diode CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

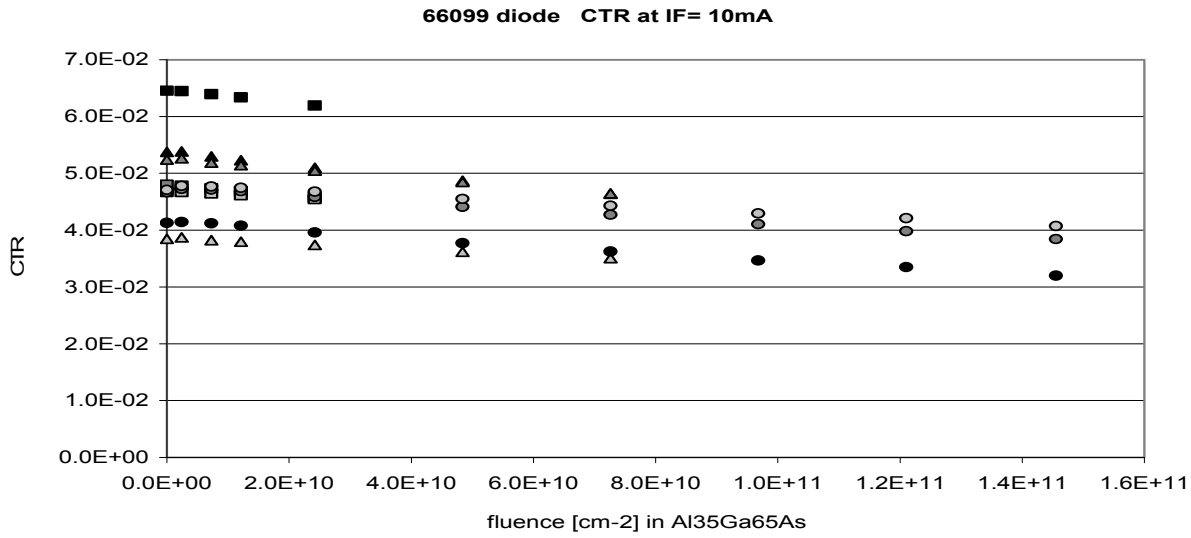
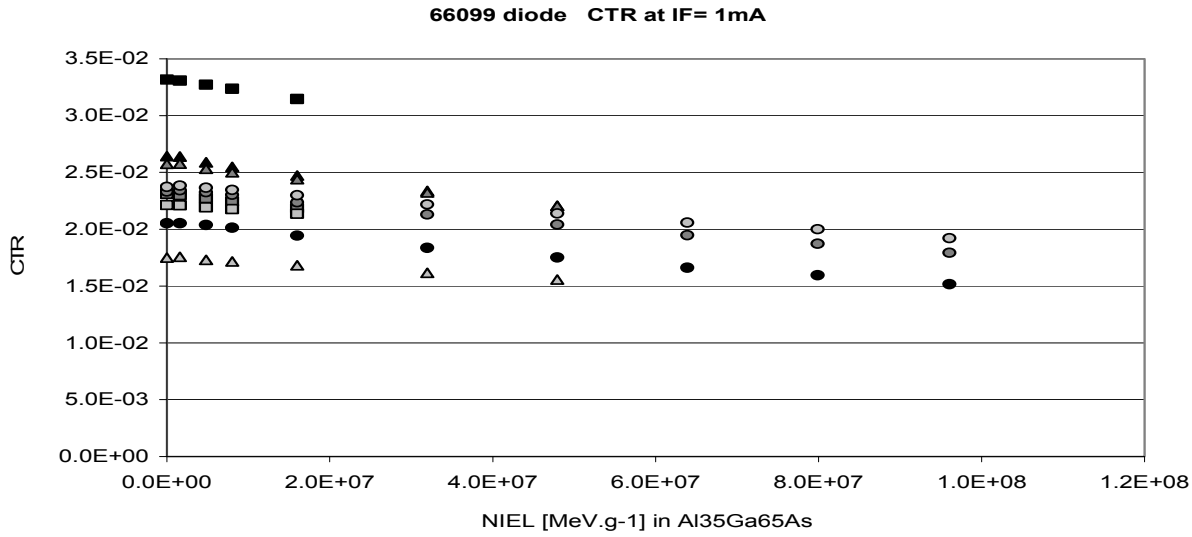
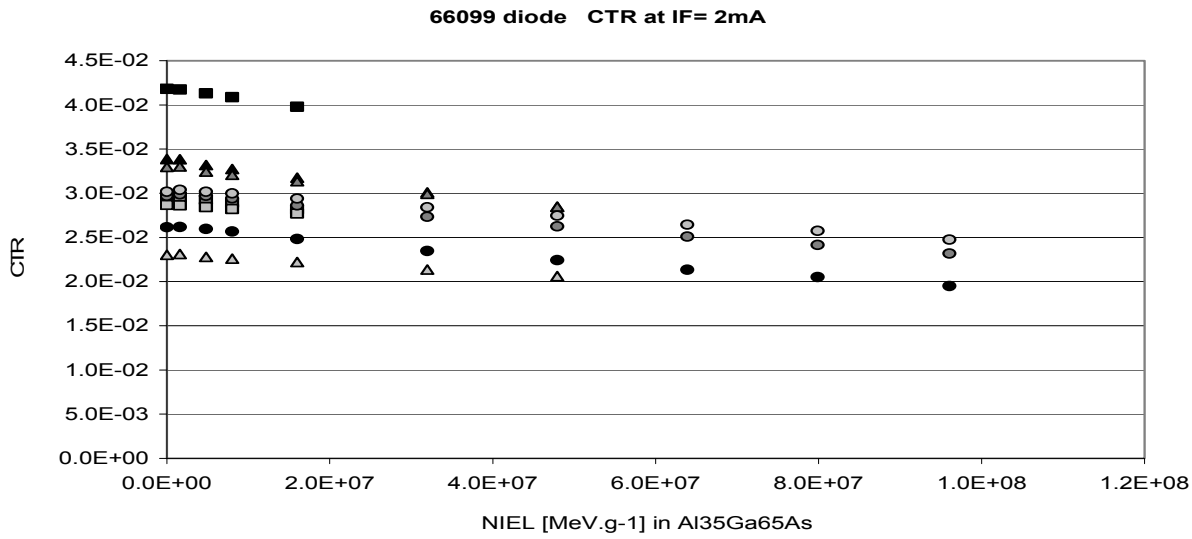
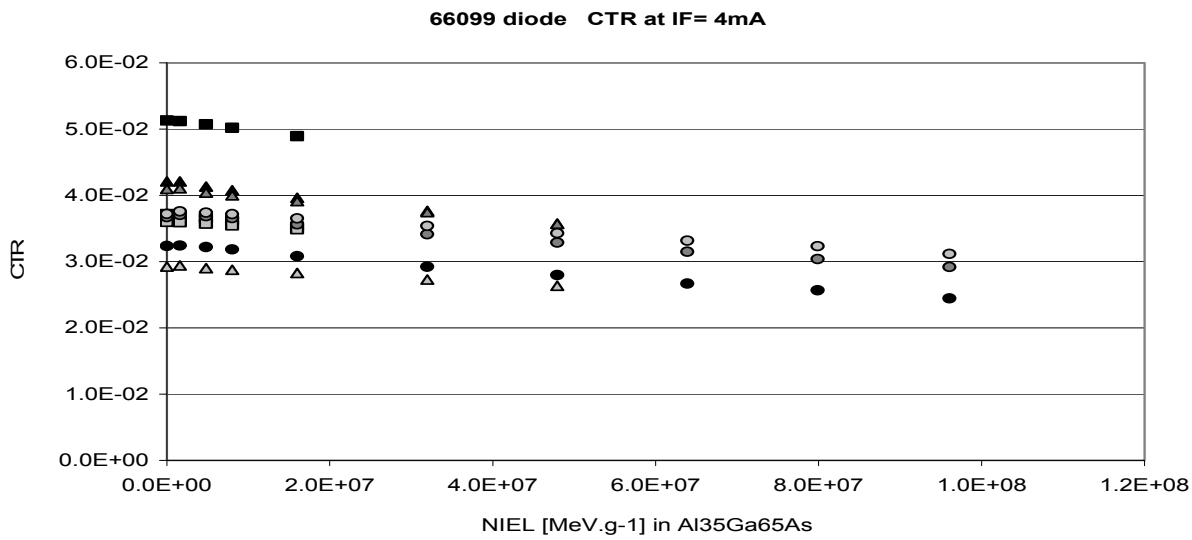
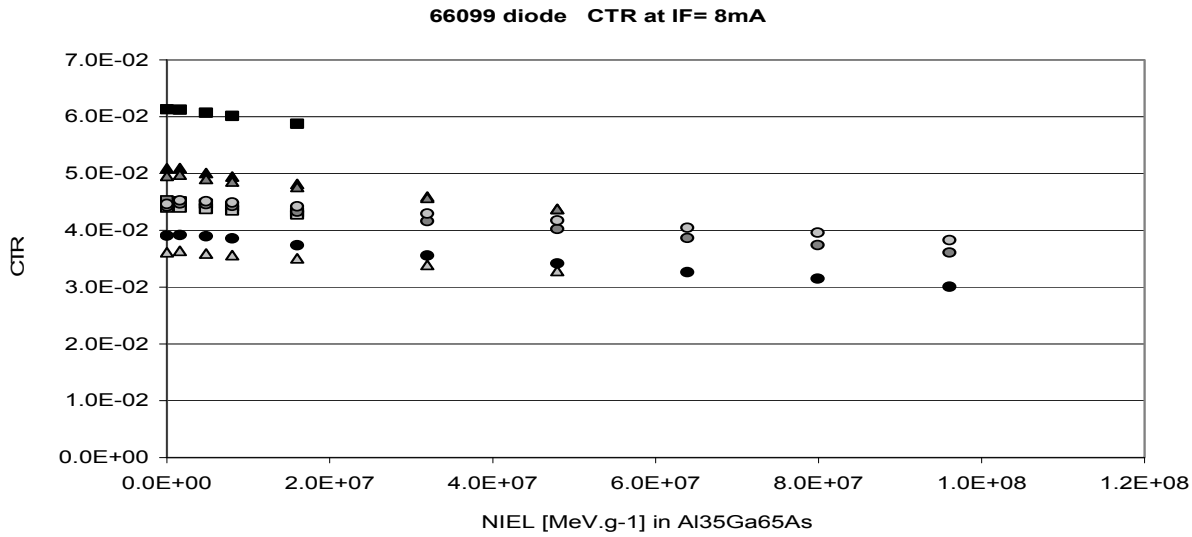

66099 diode CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-112: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 diode CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

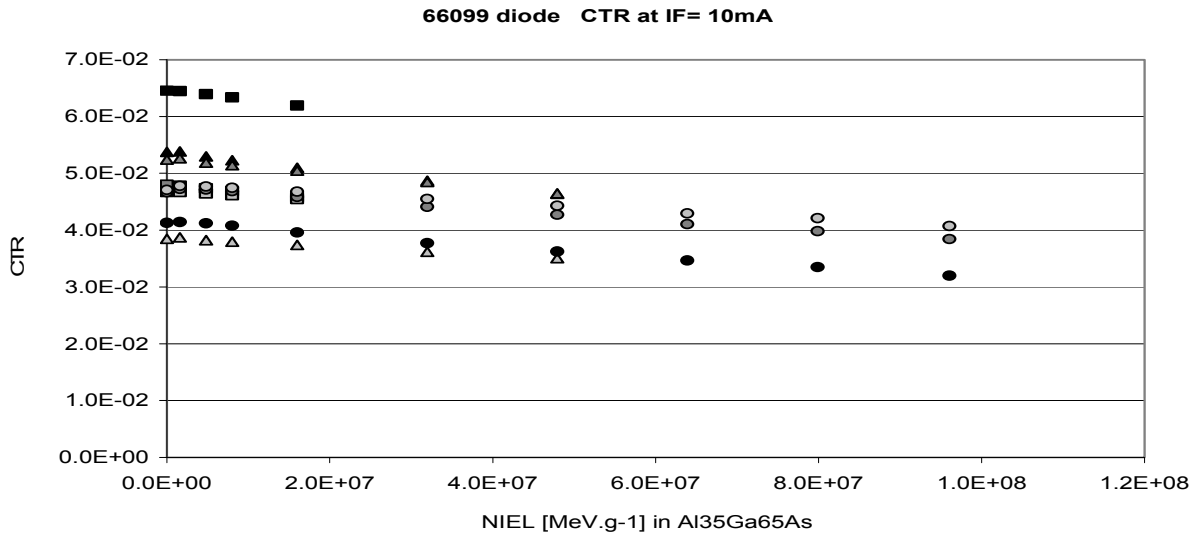
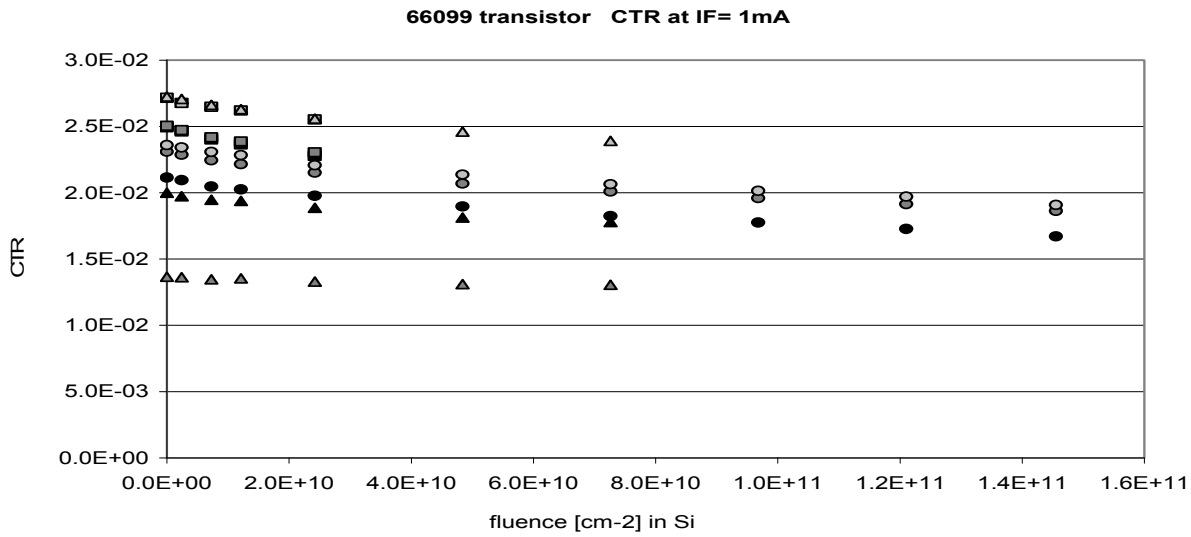
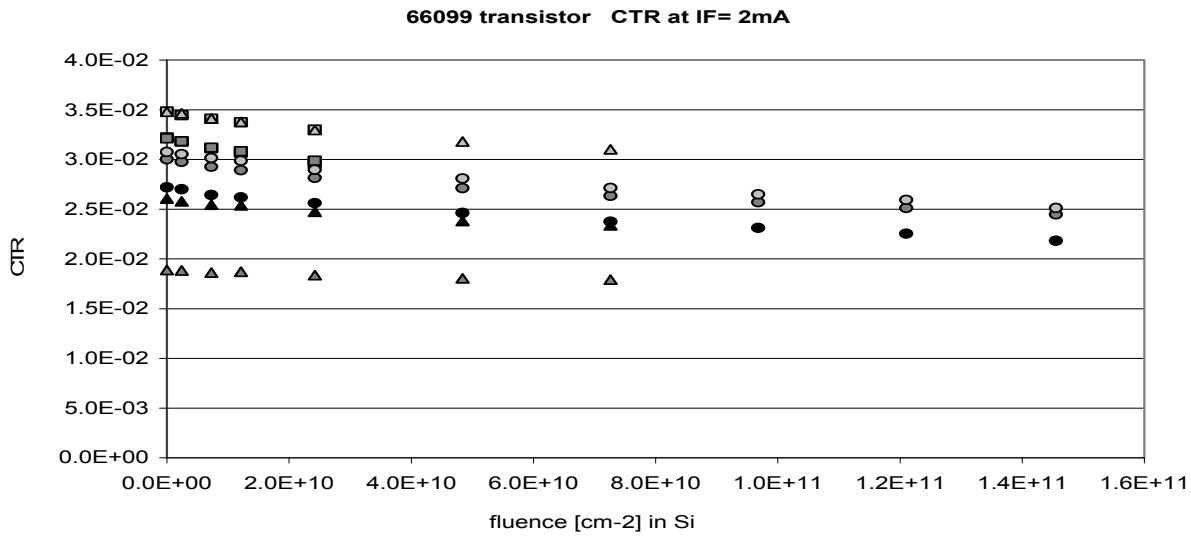
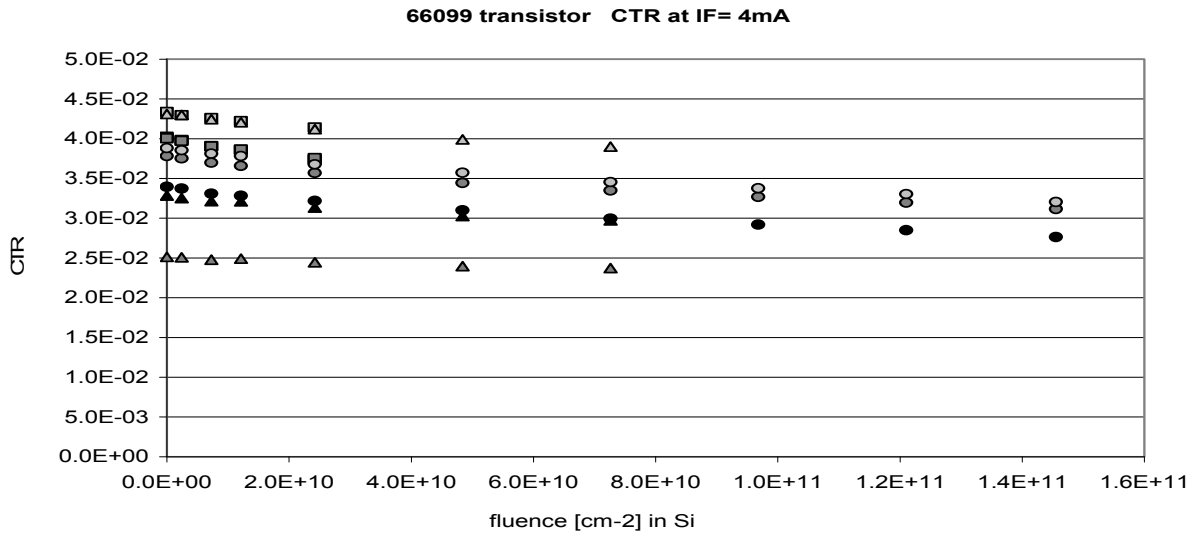
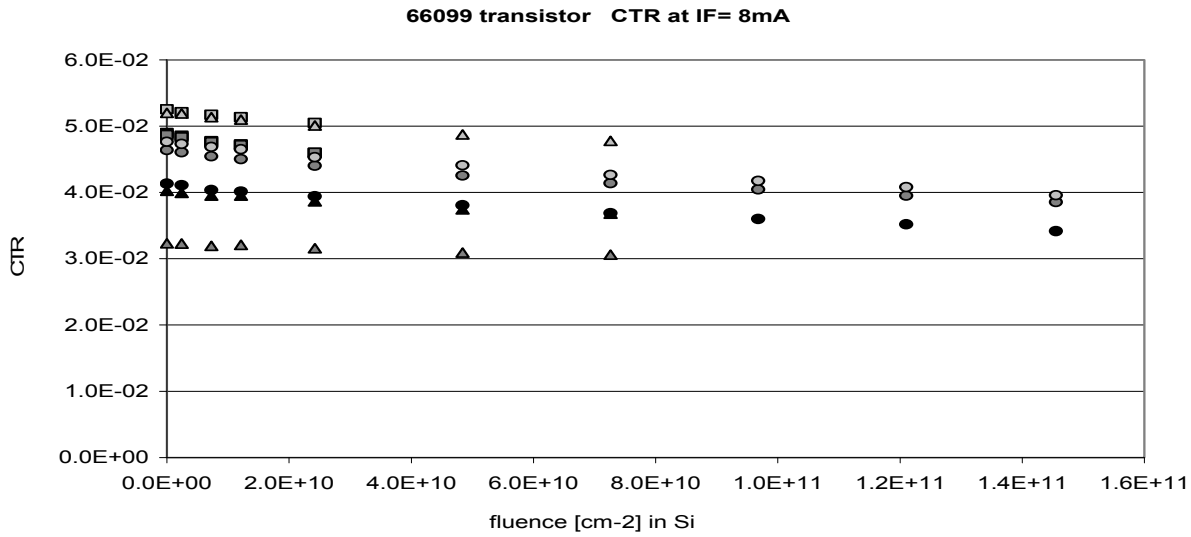

66099 diode CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-113: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 transistor CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

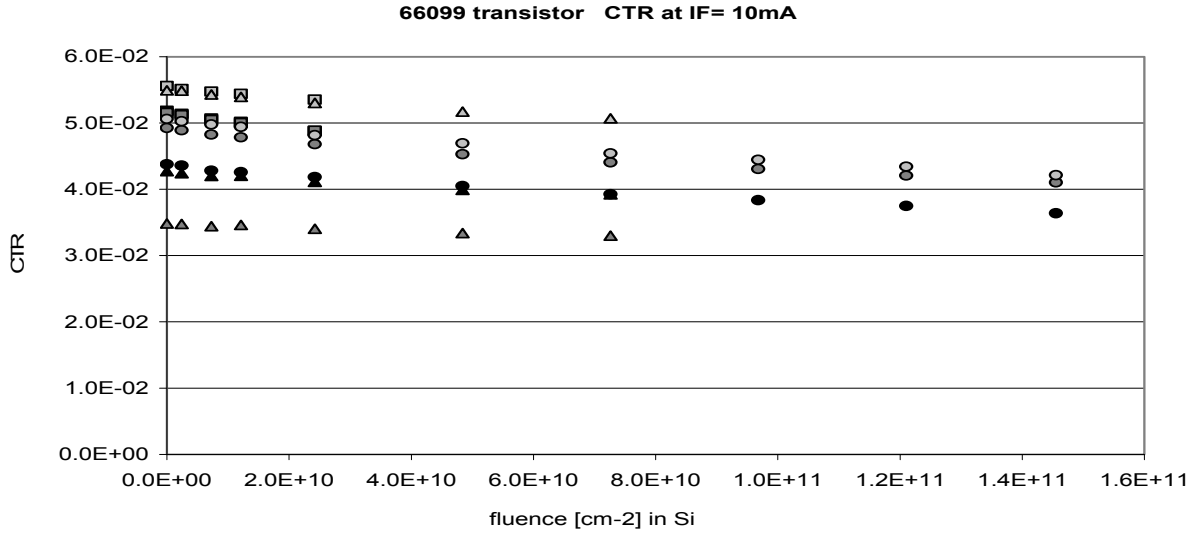
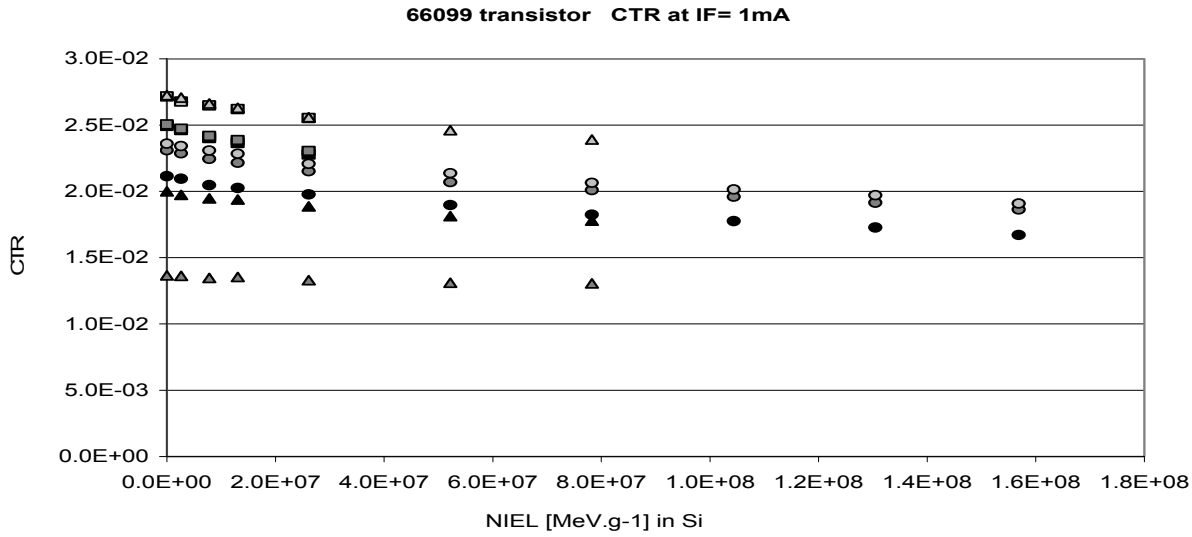
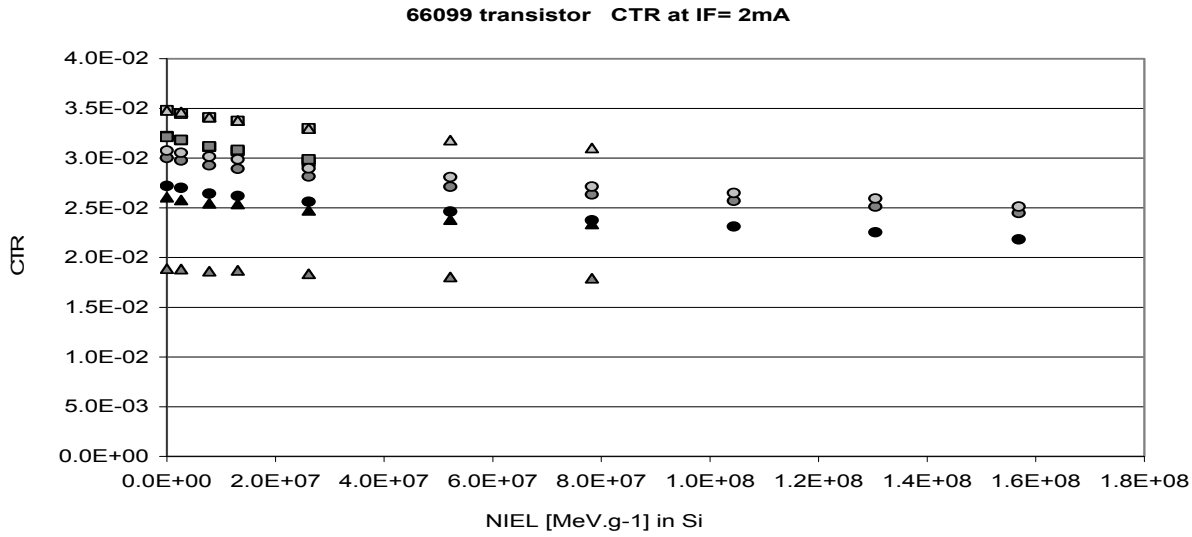
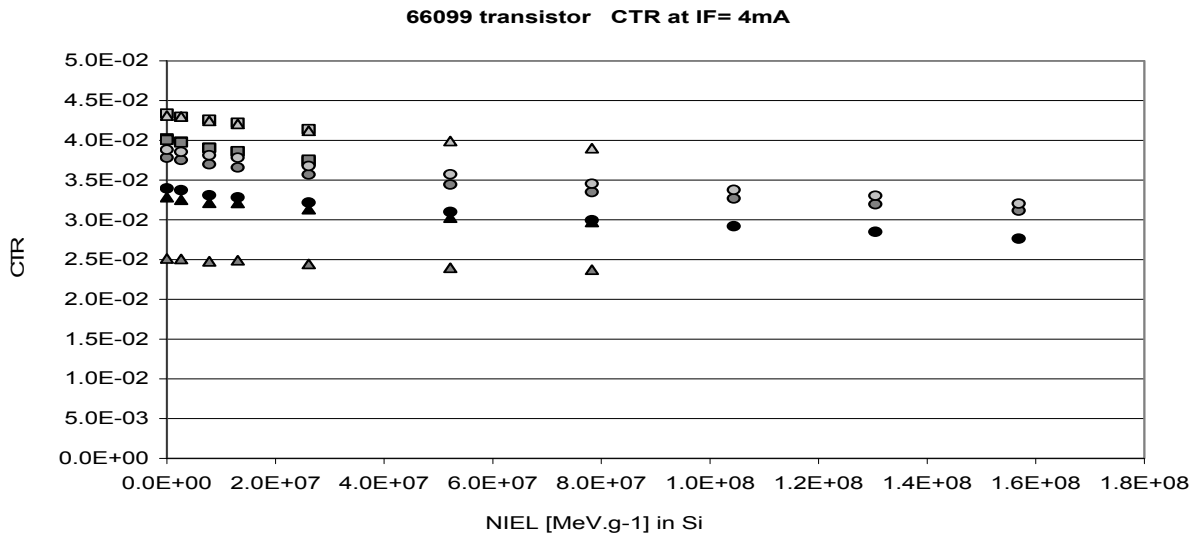
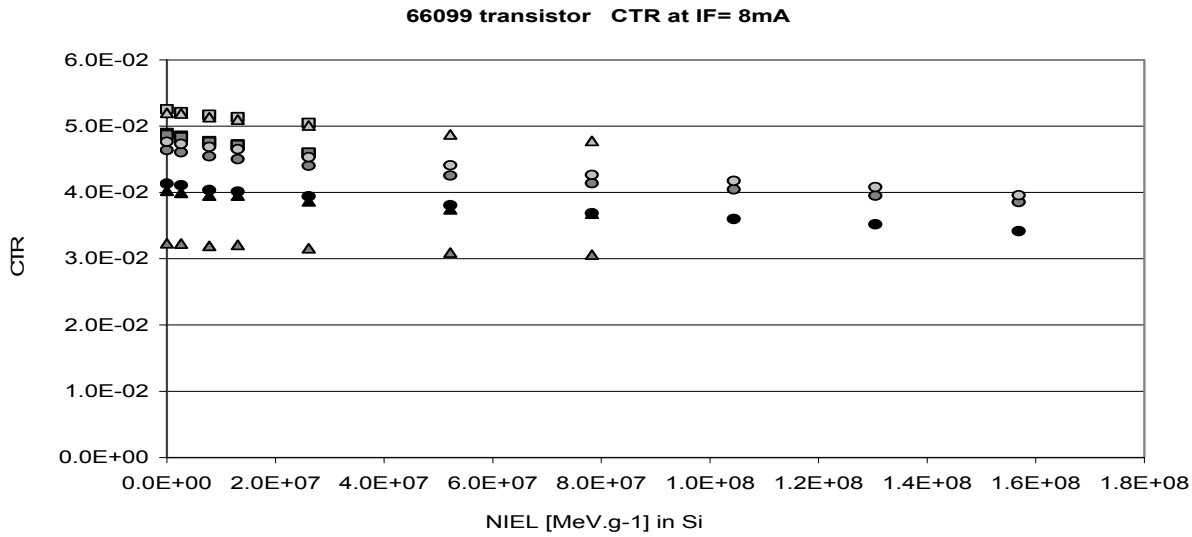

66099 transistor CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

Fig. 14-114: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








66099 transistor CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

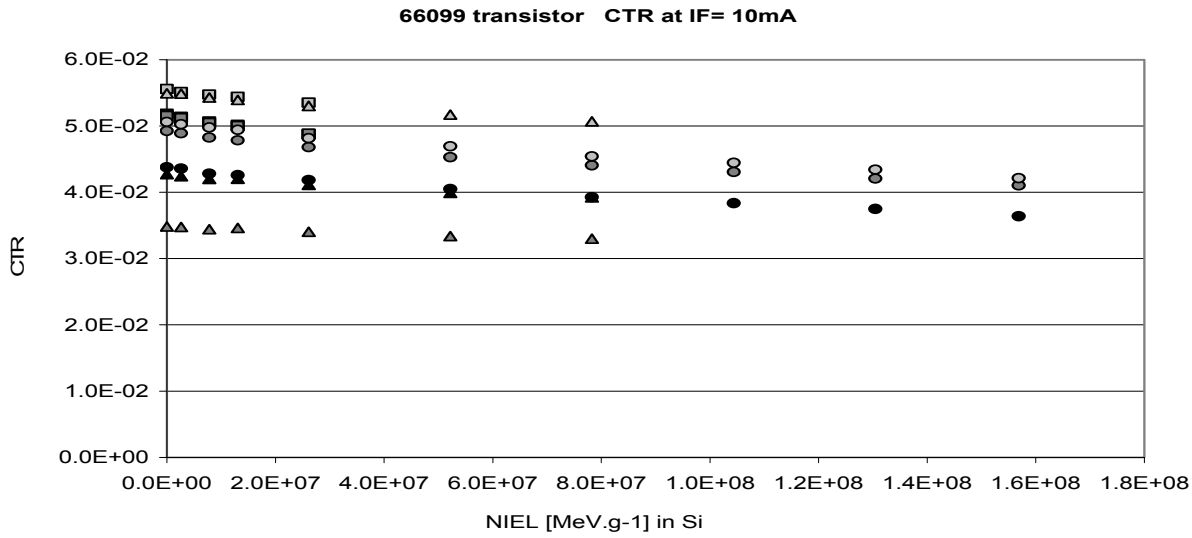
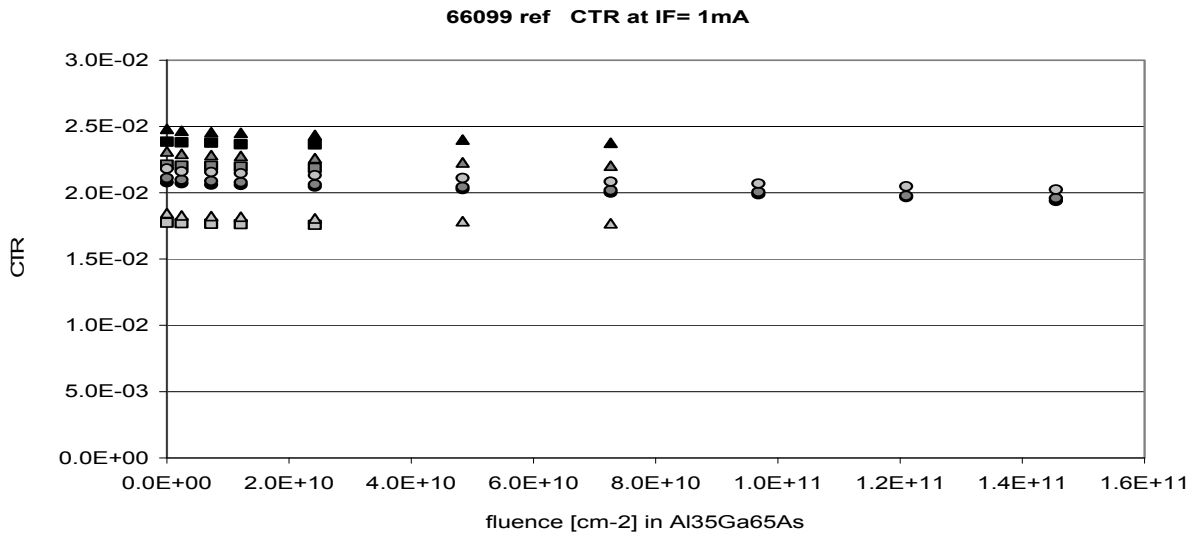
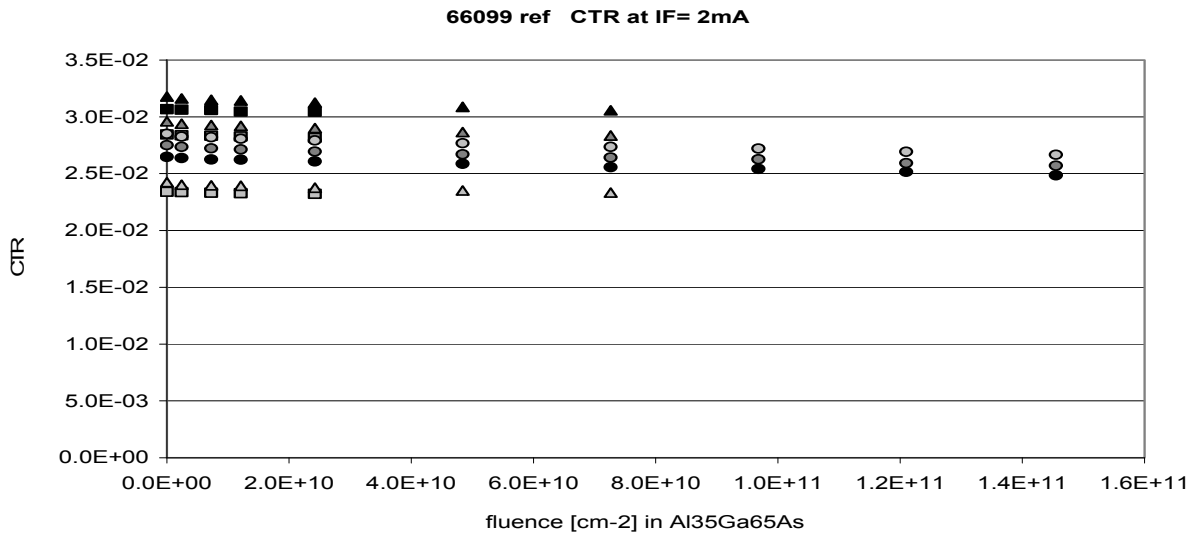
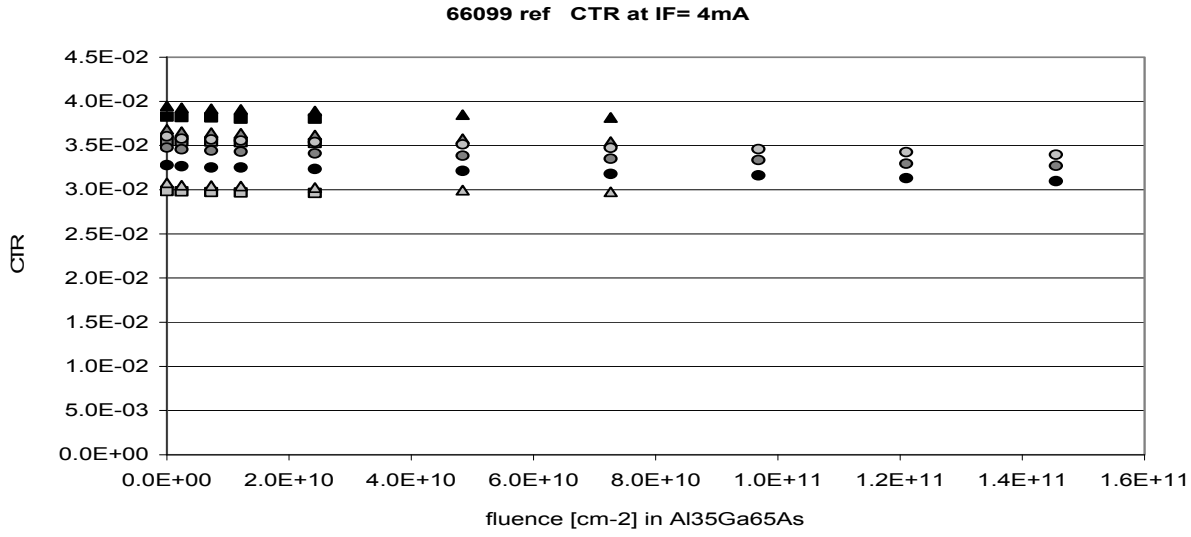
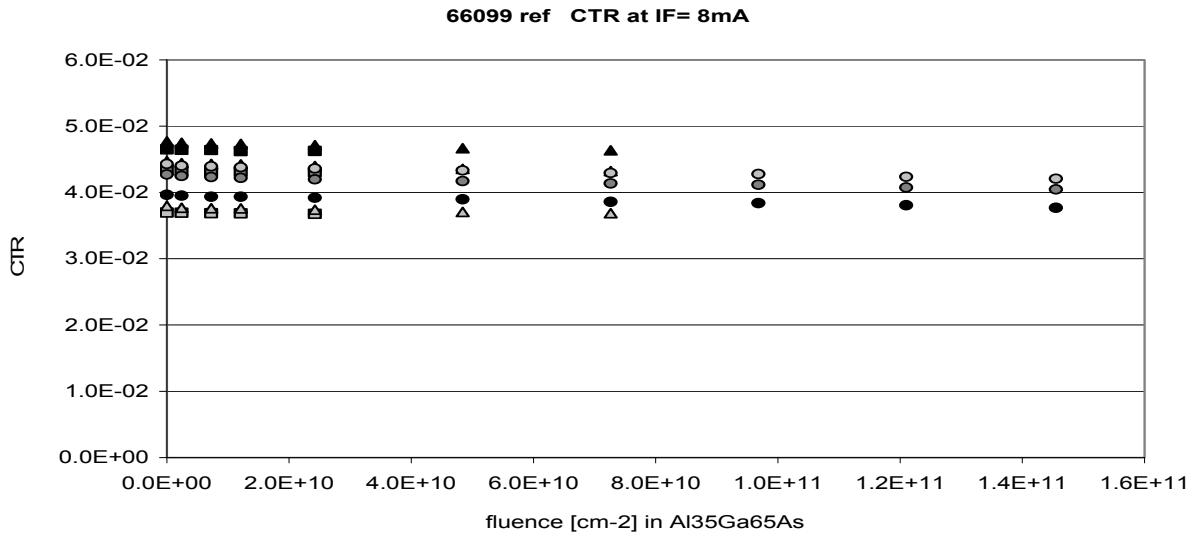

66099 transistor CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00 2.0E+07 4.0E+07 6.0E+07 8.0E+07 1.0E+08 1.2E+08 1.4E+08 1.6E+08 1.8E+08
NIEL [MeV.g-1] in Si

Fig. 14-115: 66099 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 ref CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

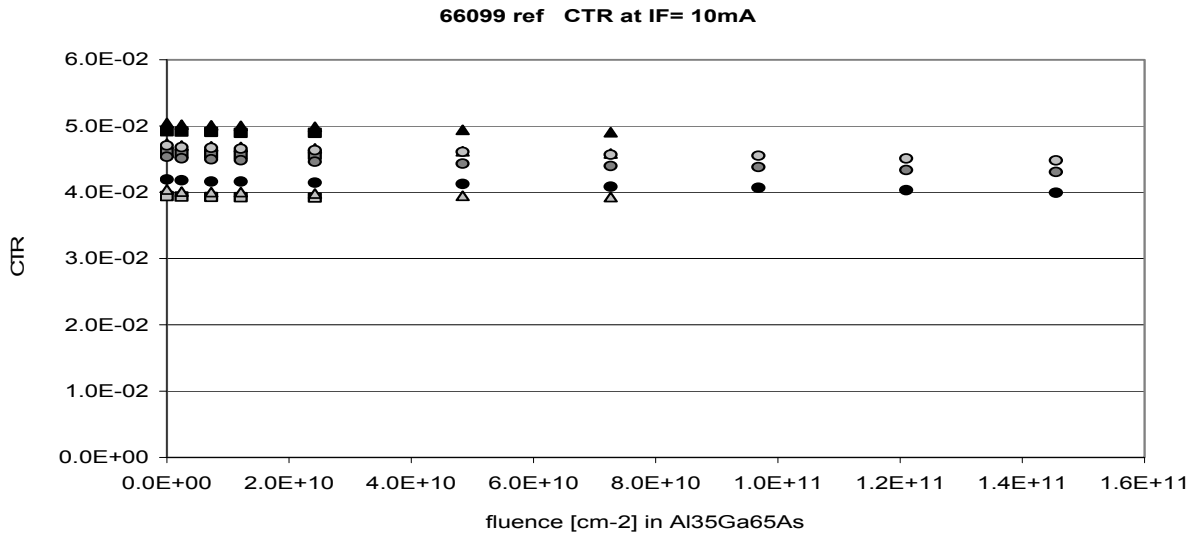
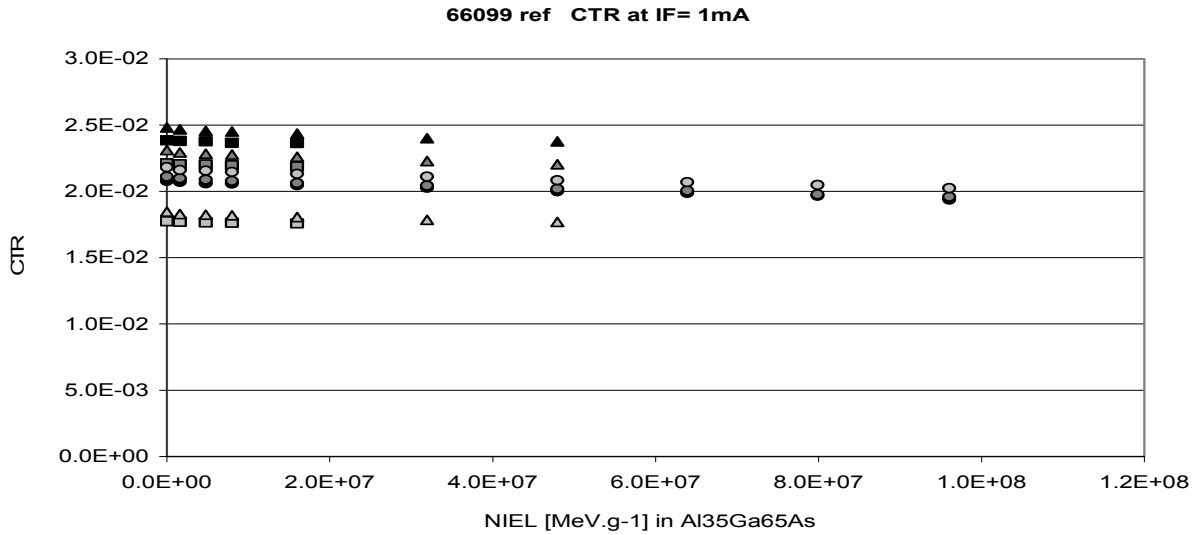
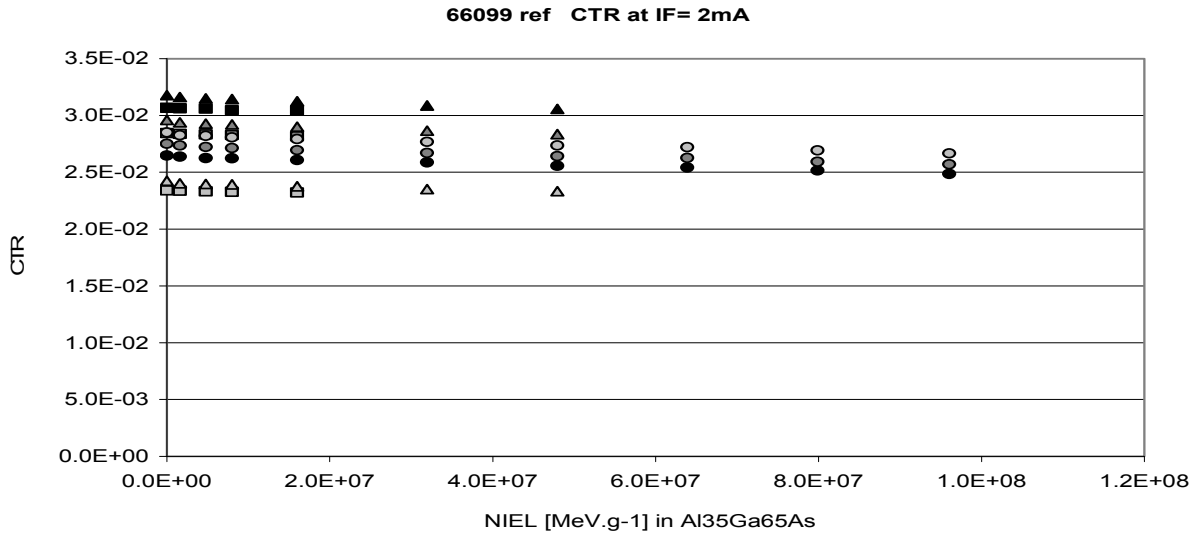
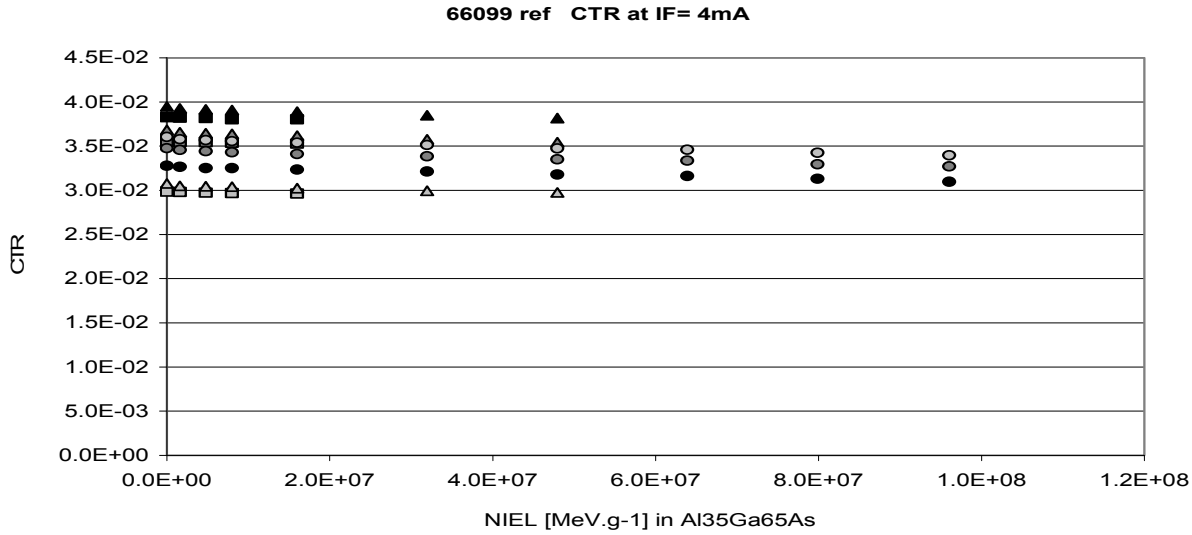
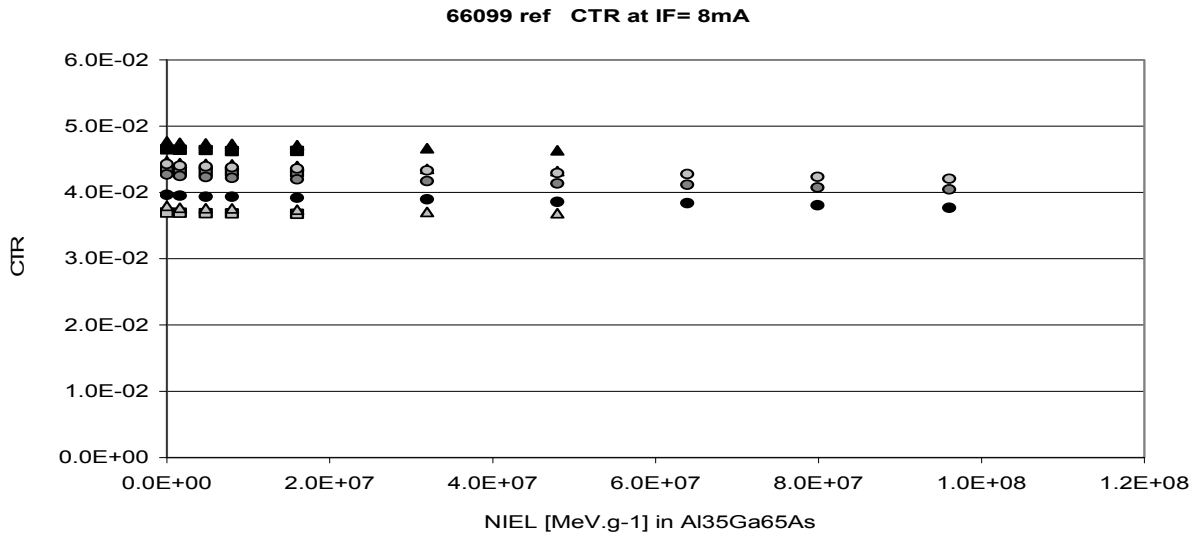

66099 ref CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-116: 66099 reference: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 ref CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

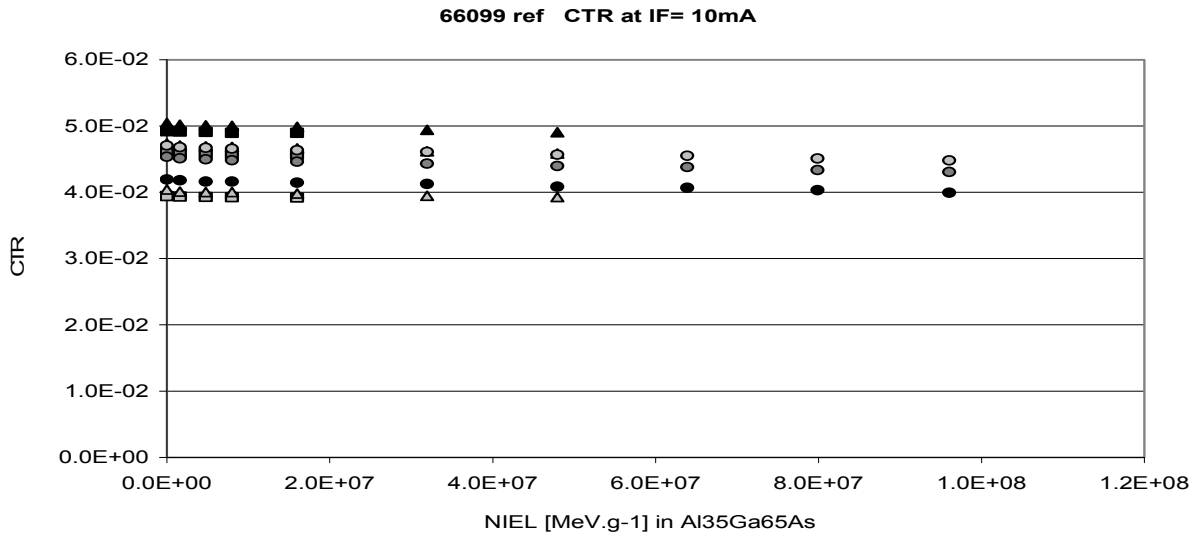
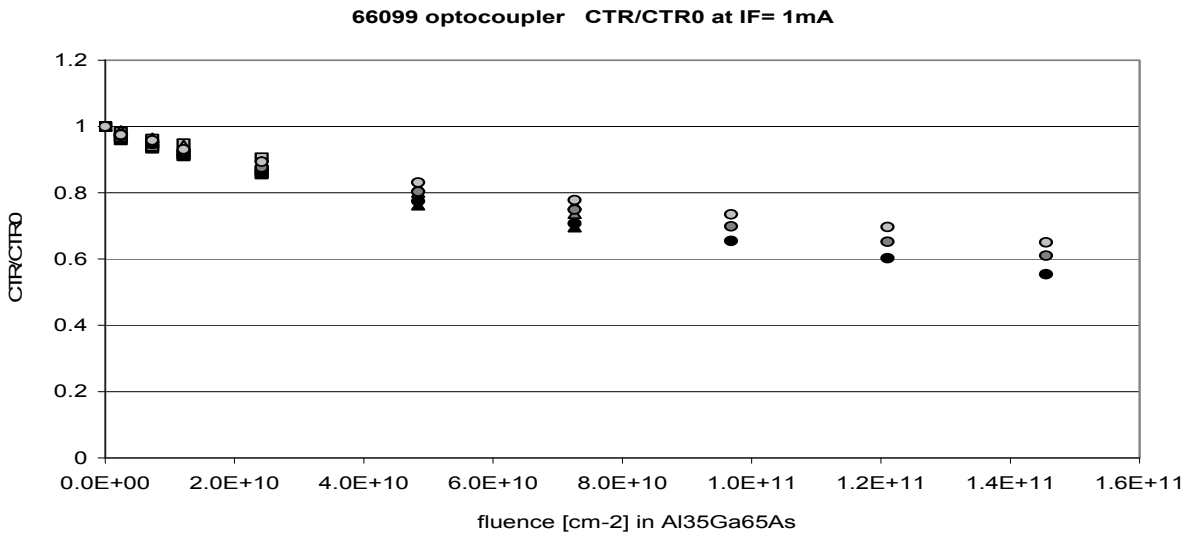
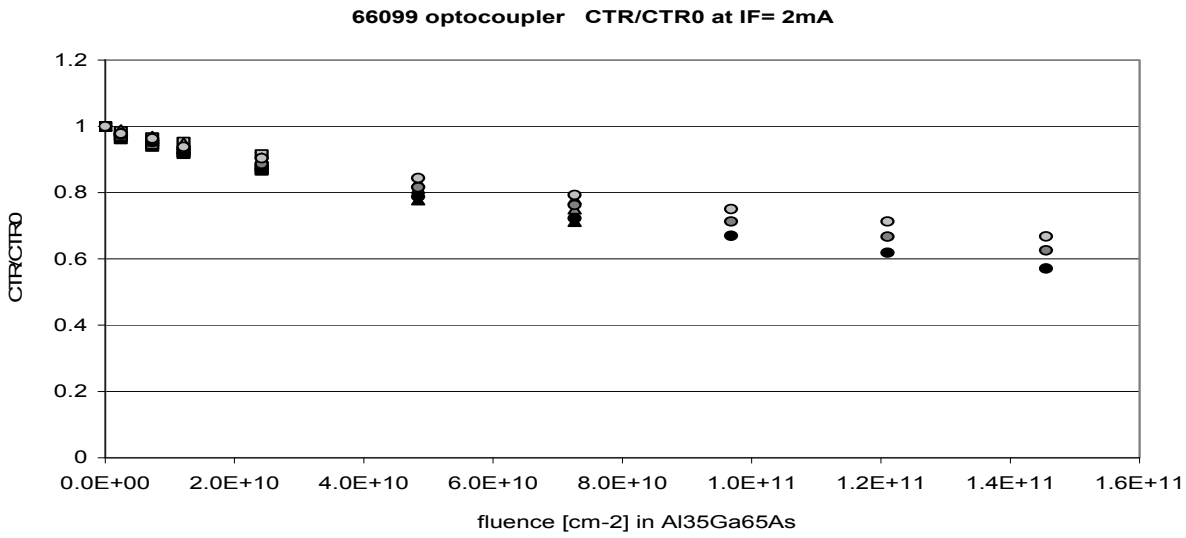
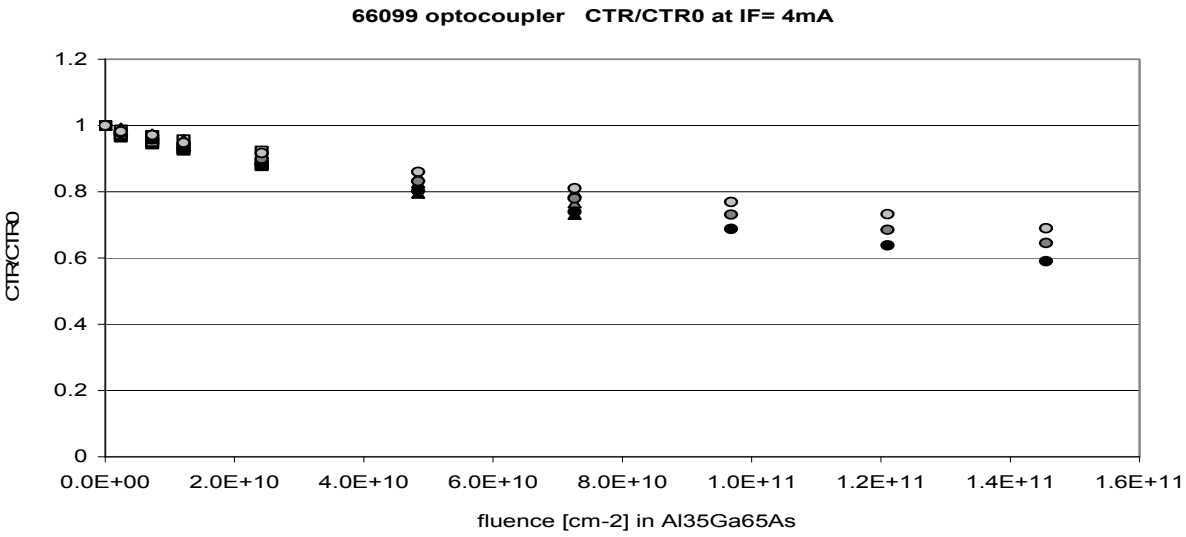
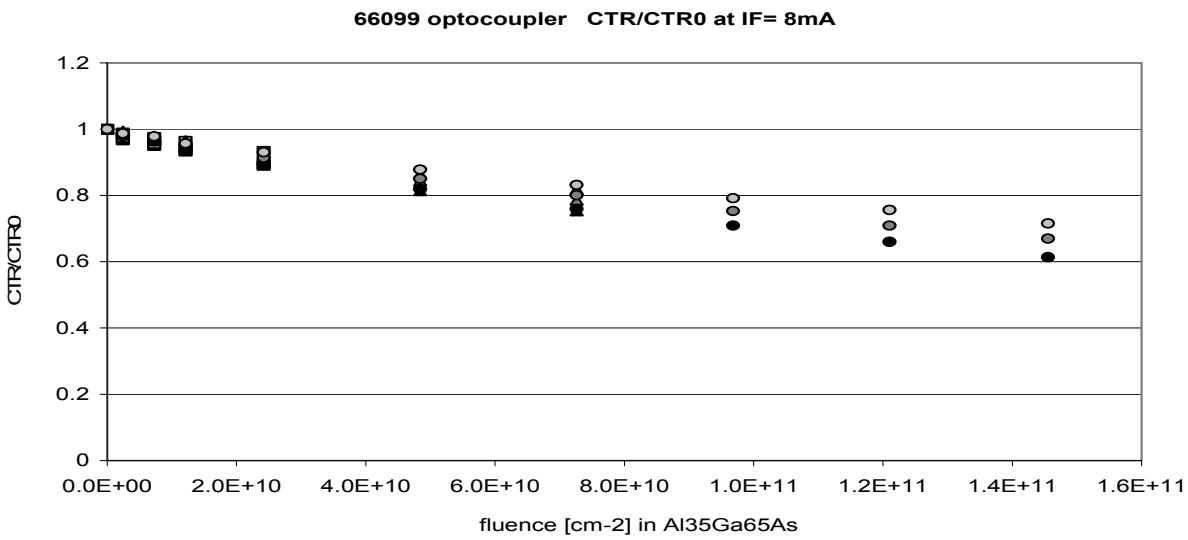

66099 ref CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-117: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

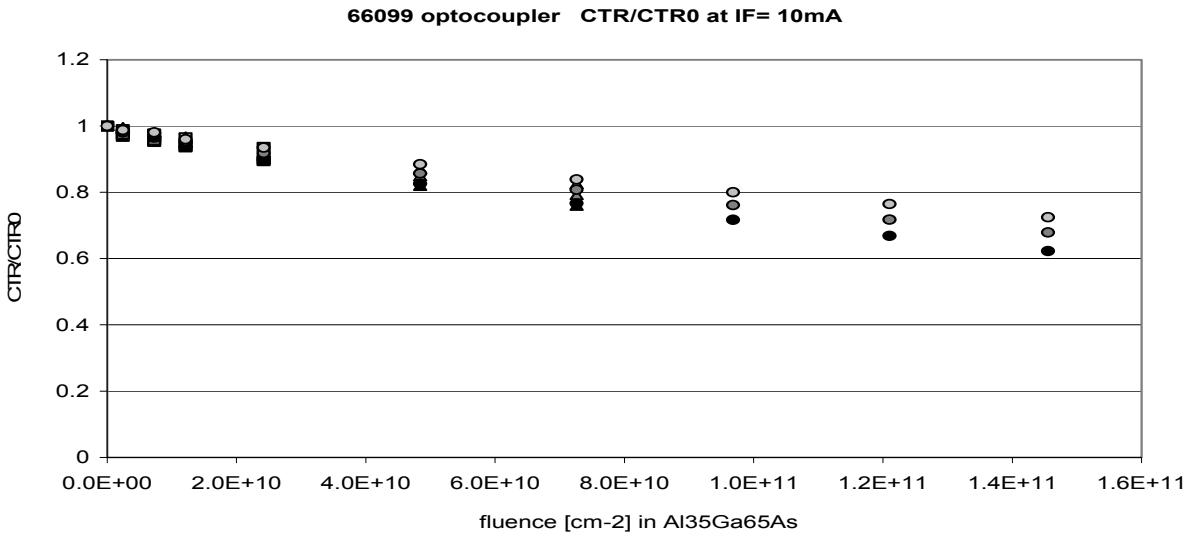
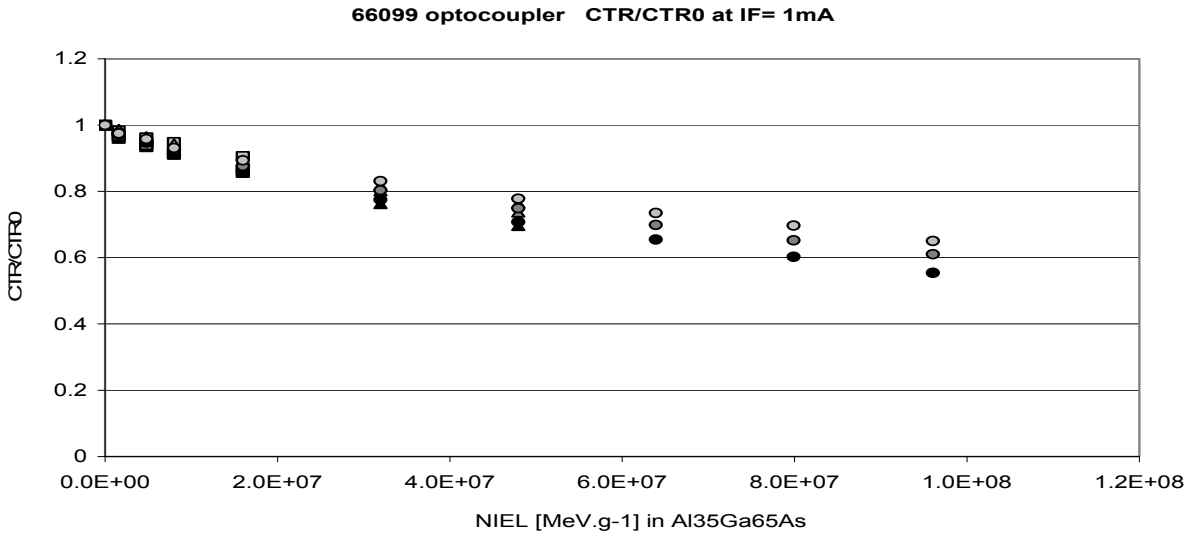
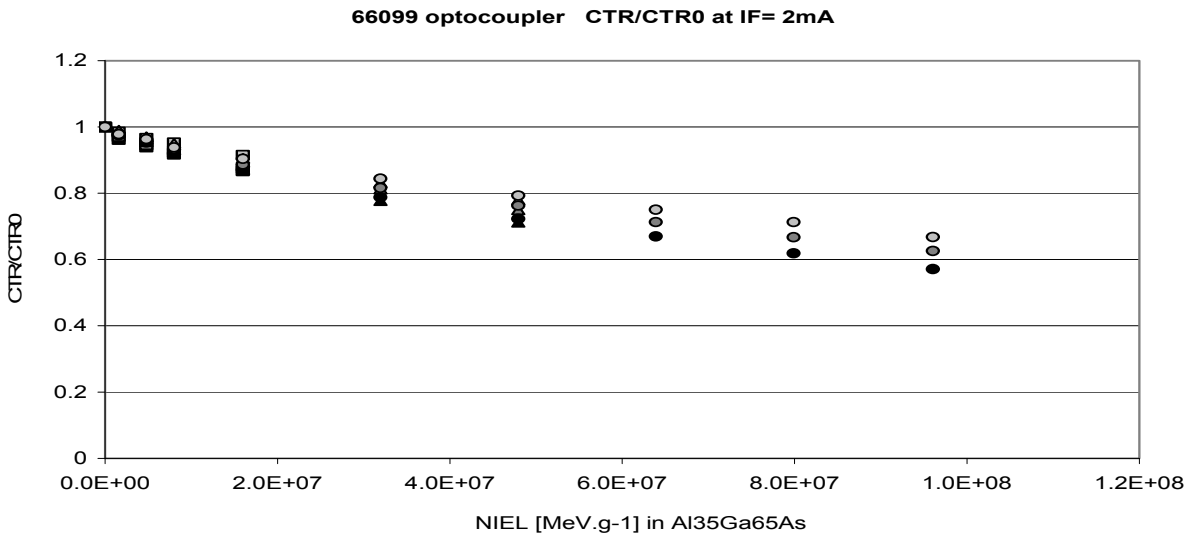
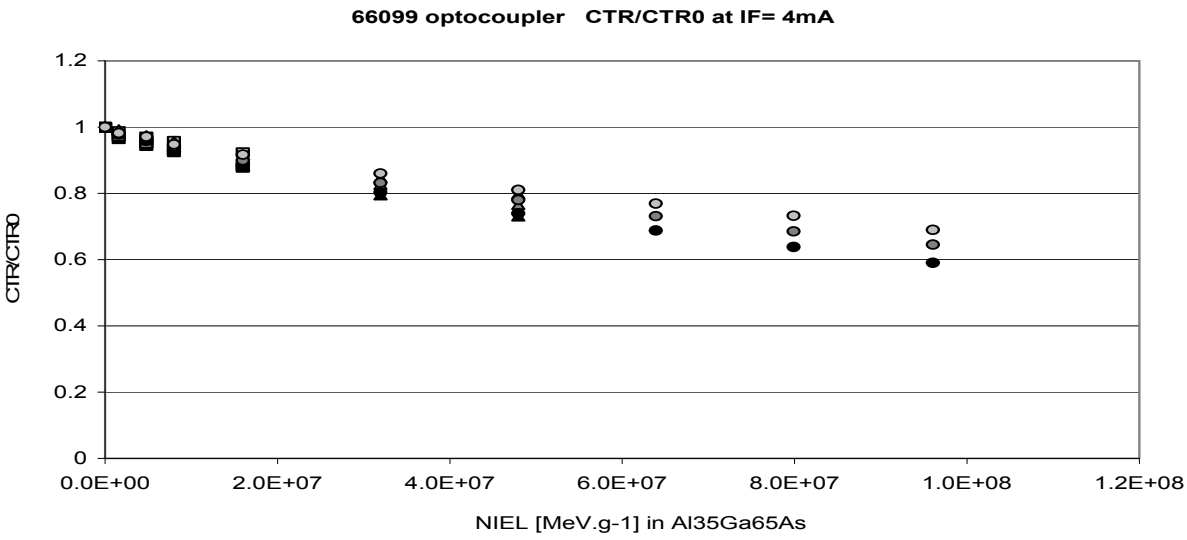
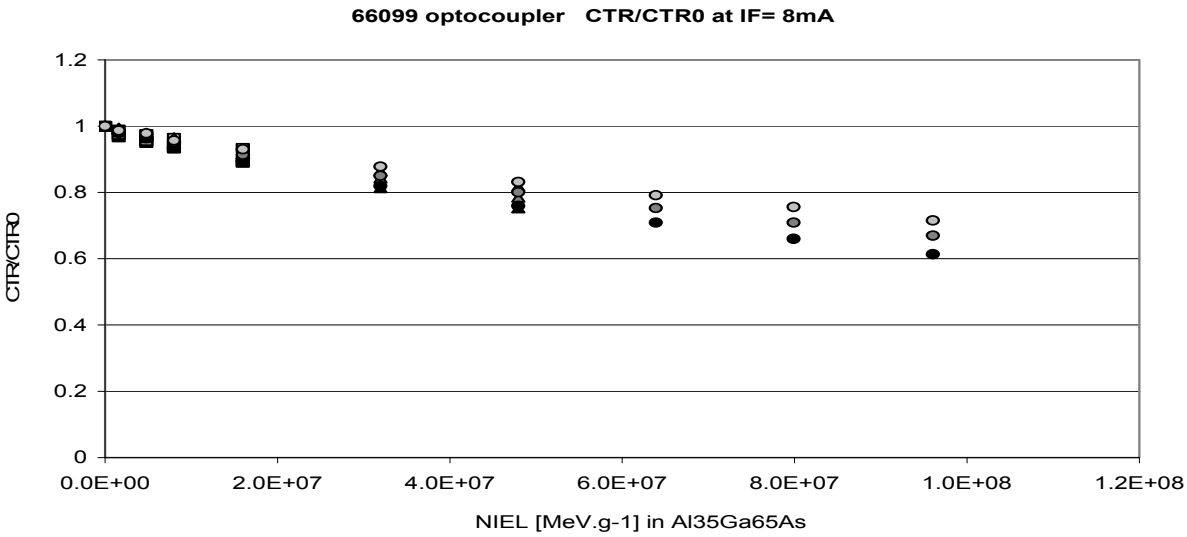

66099 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-118: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

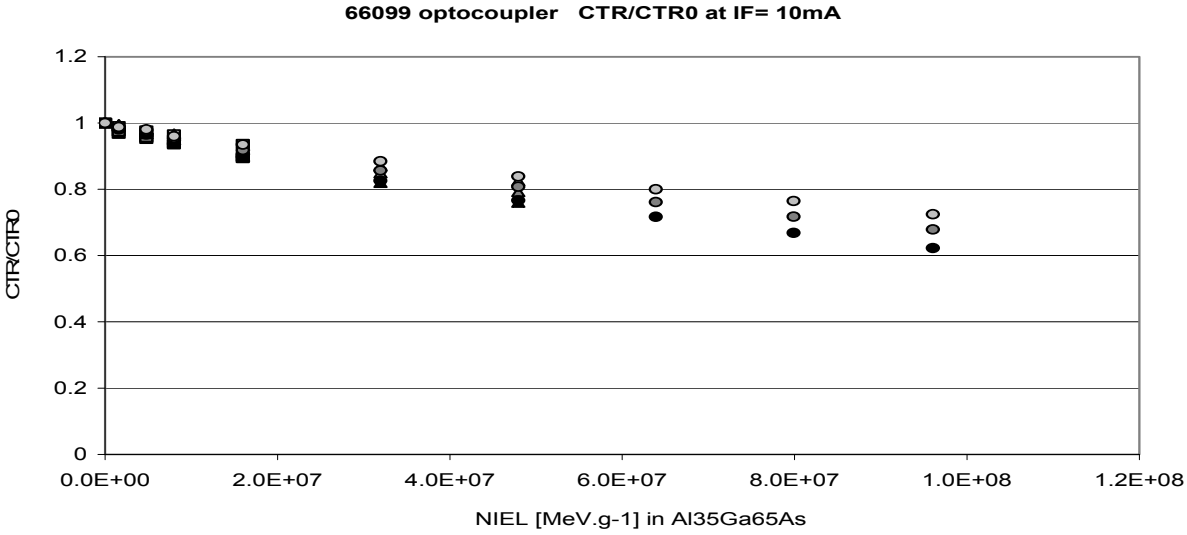
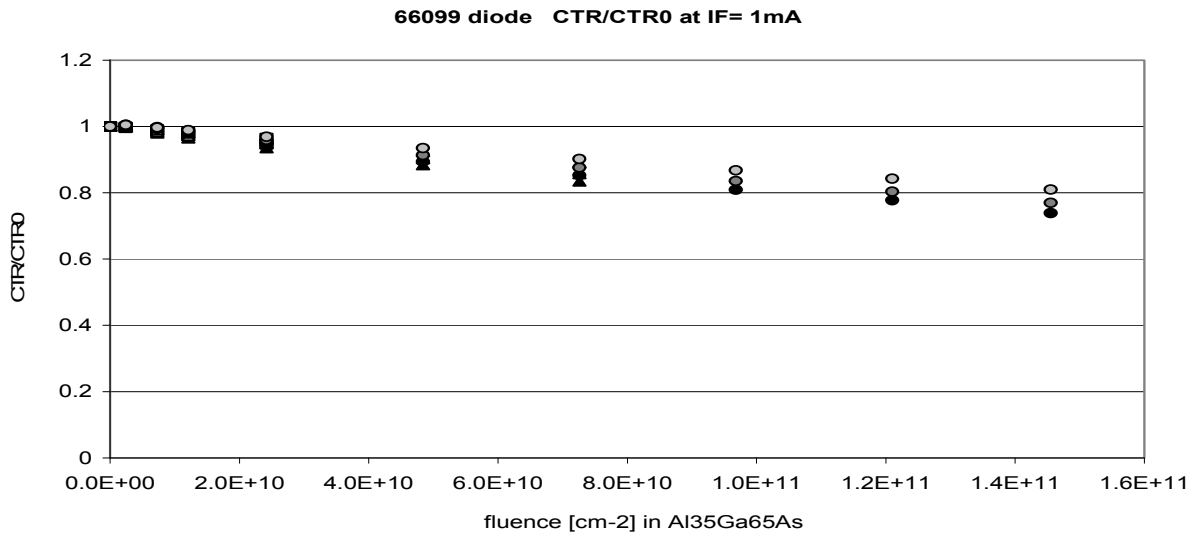
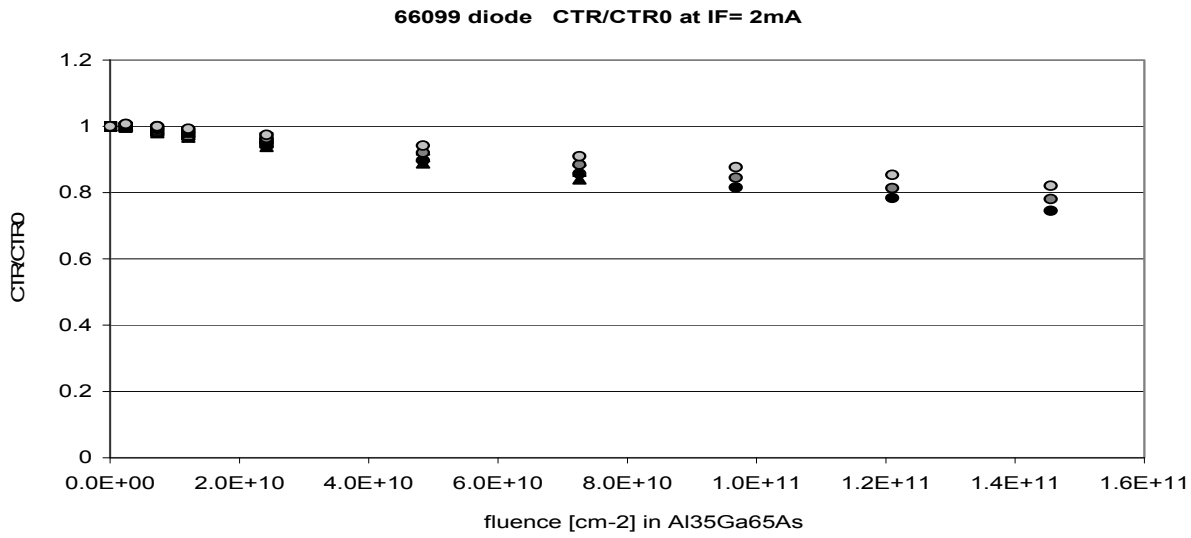
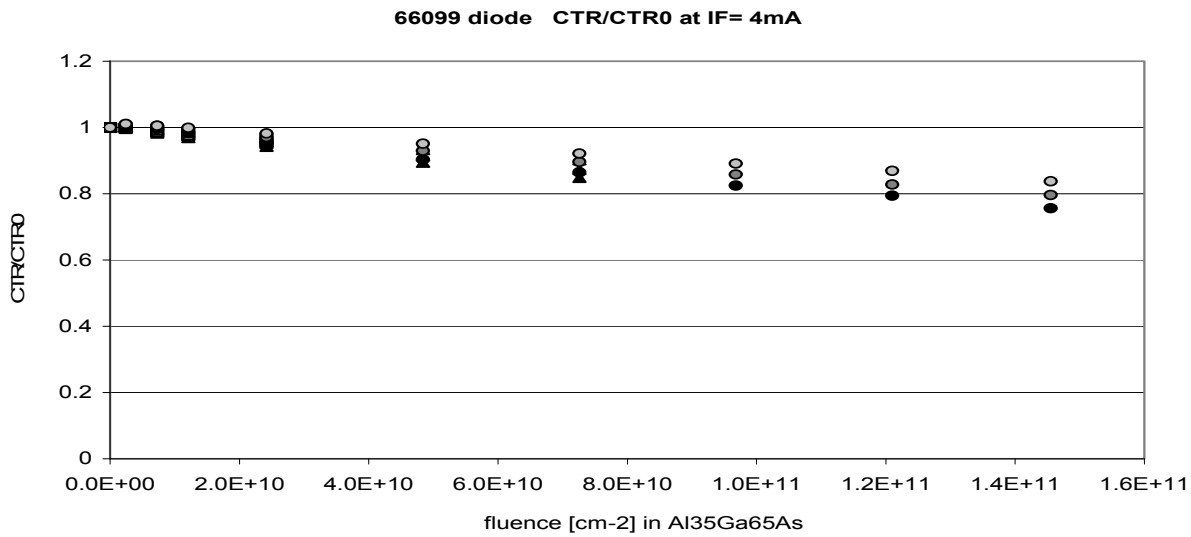
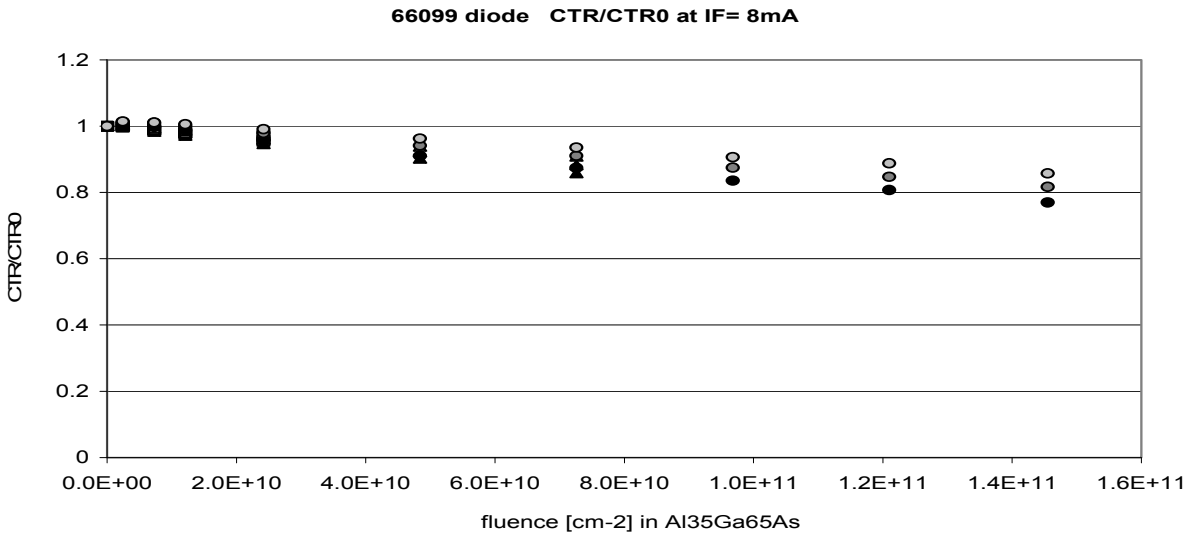

66099 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-119: 66099 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

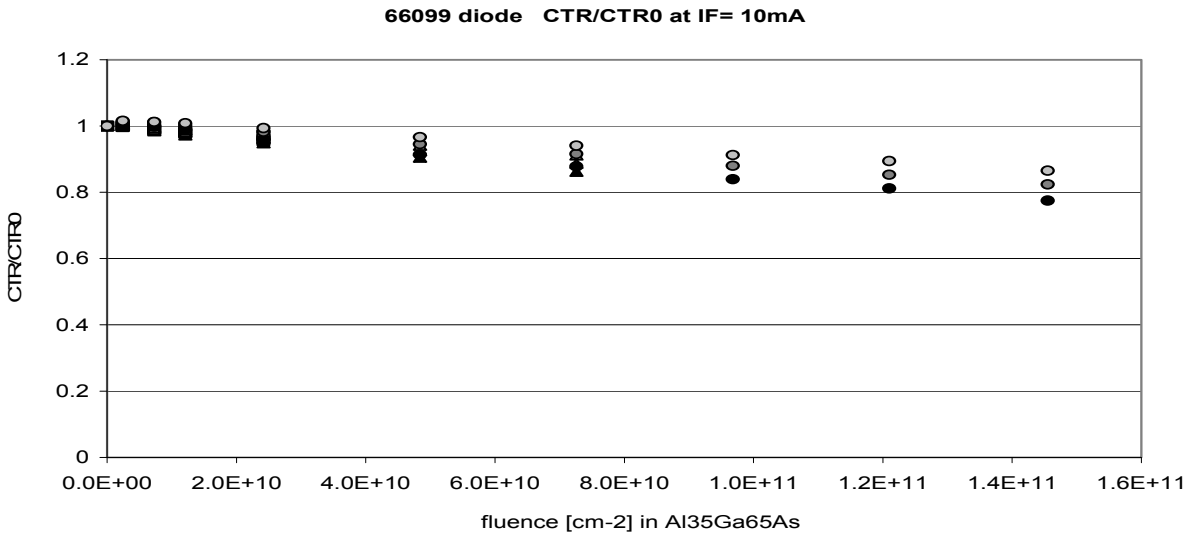
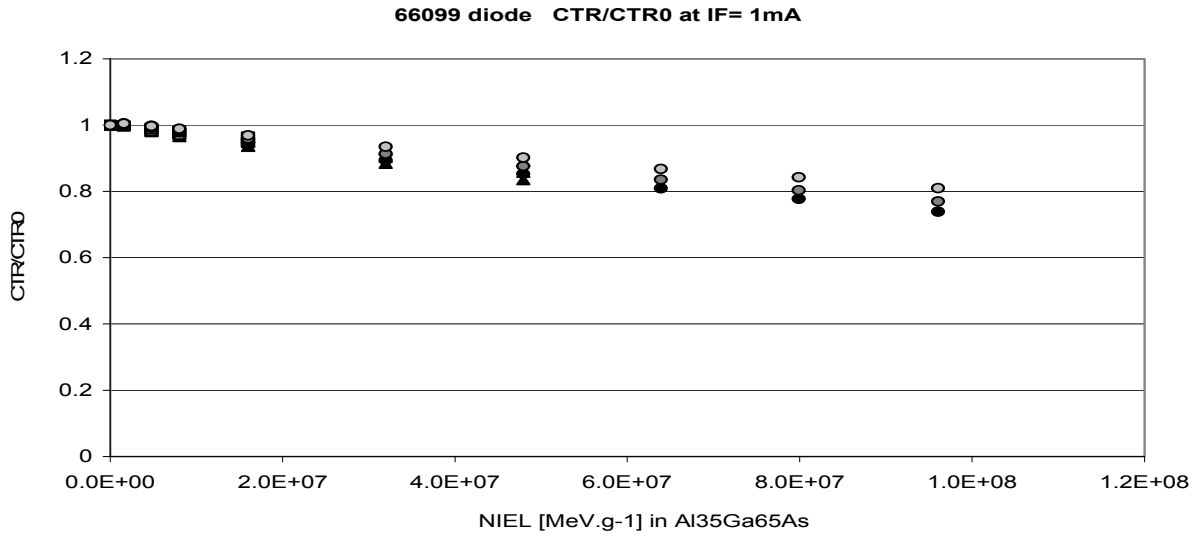
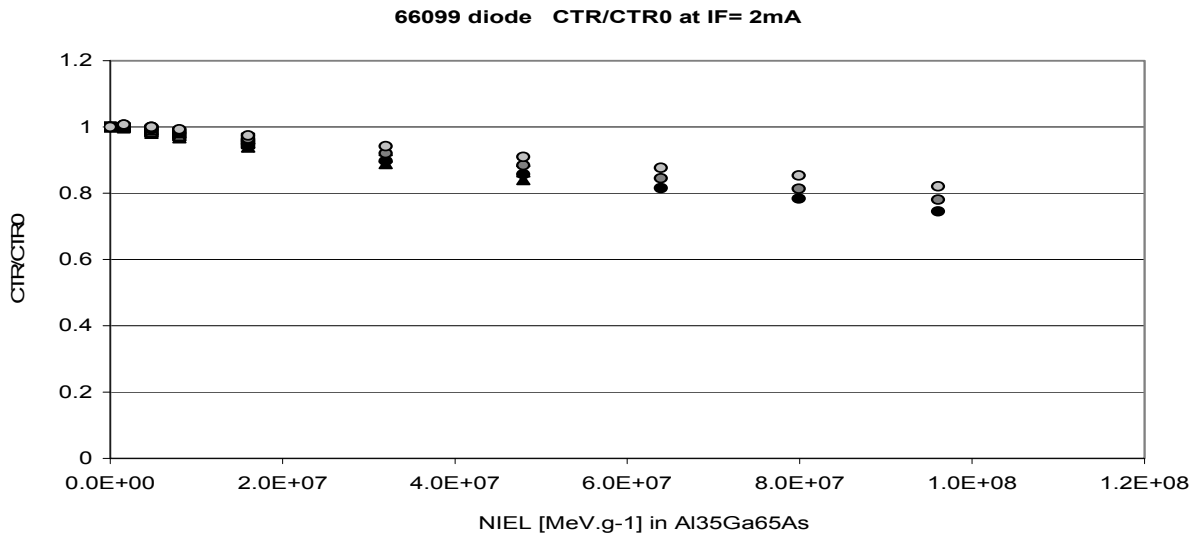
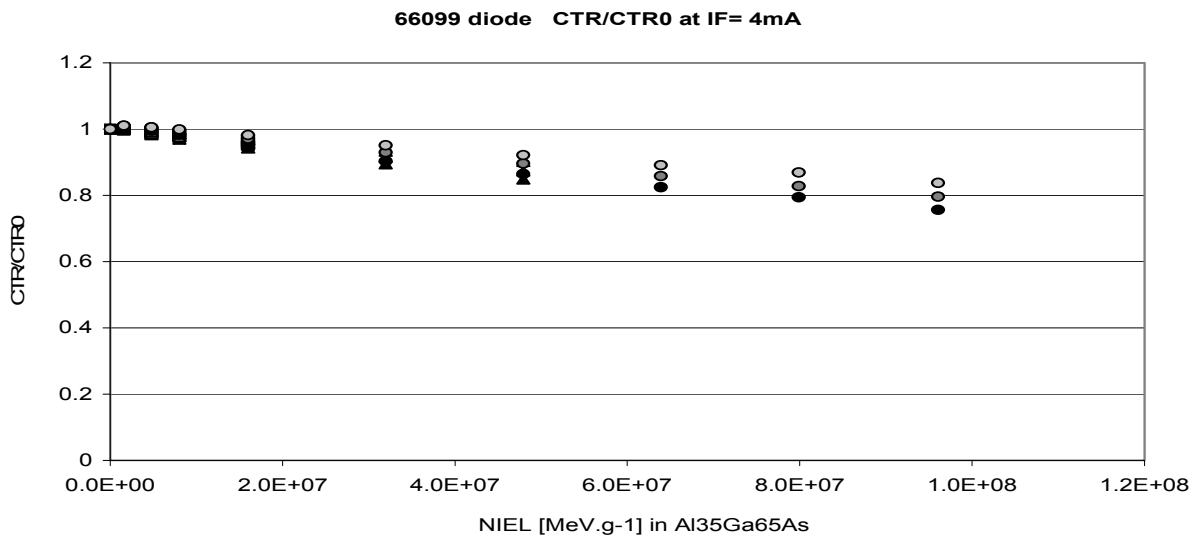
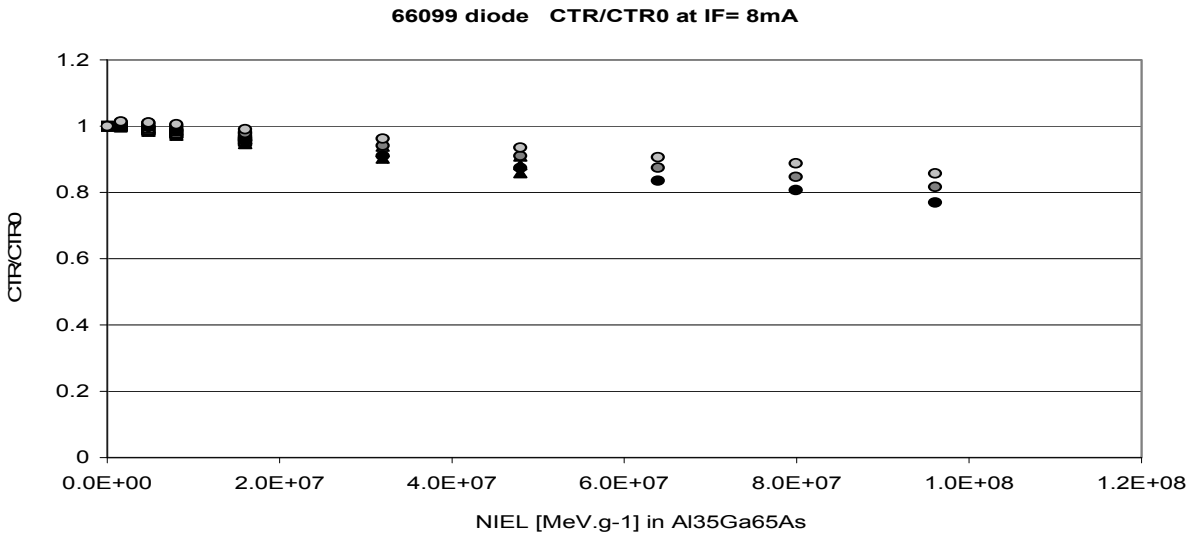

66099 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-120: 66099 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

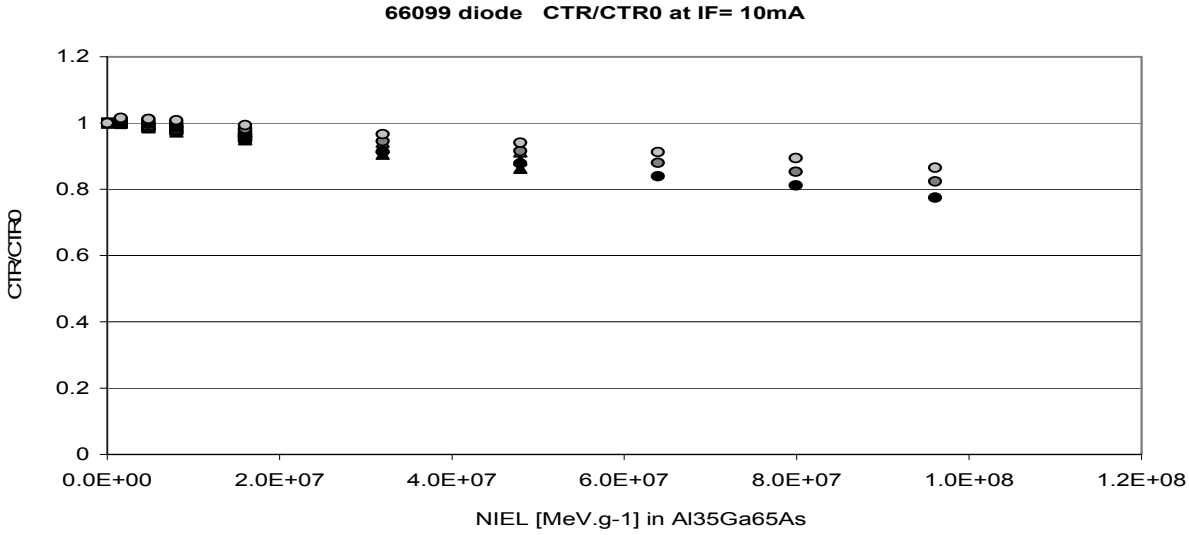
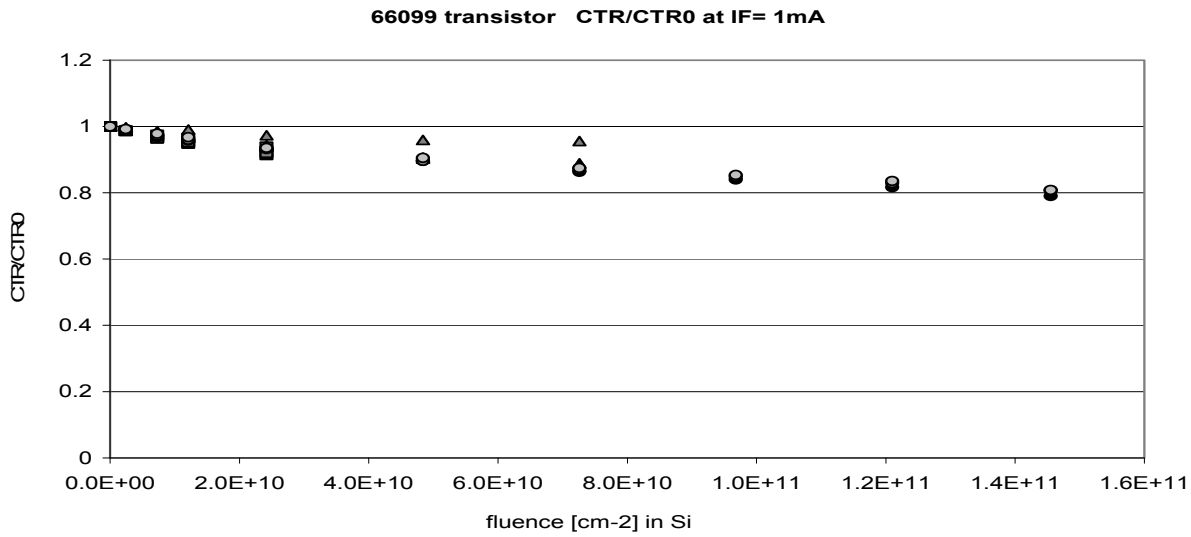
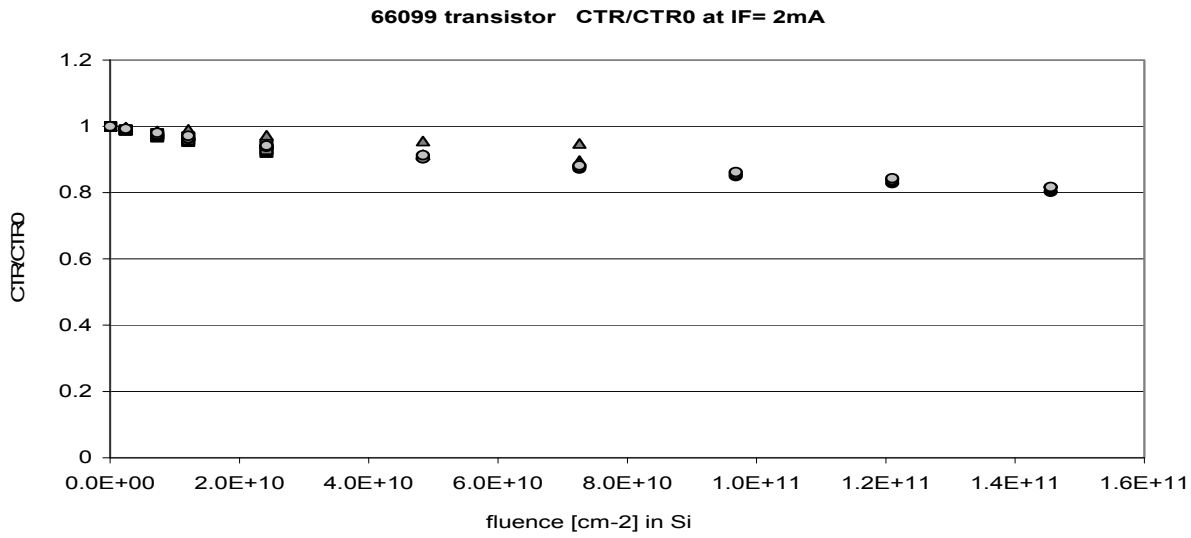
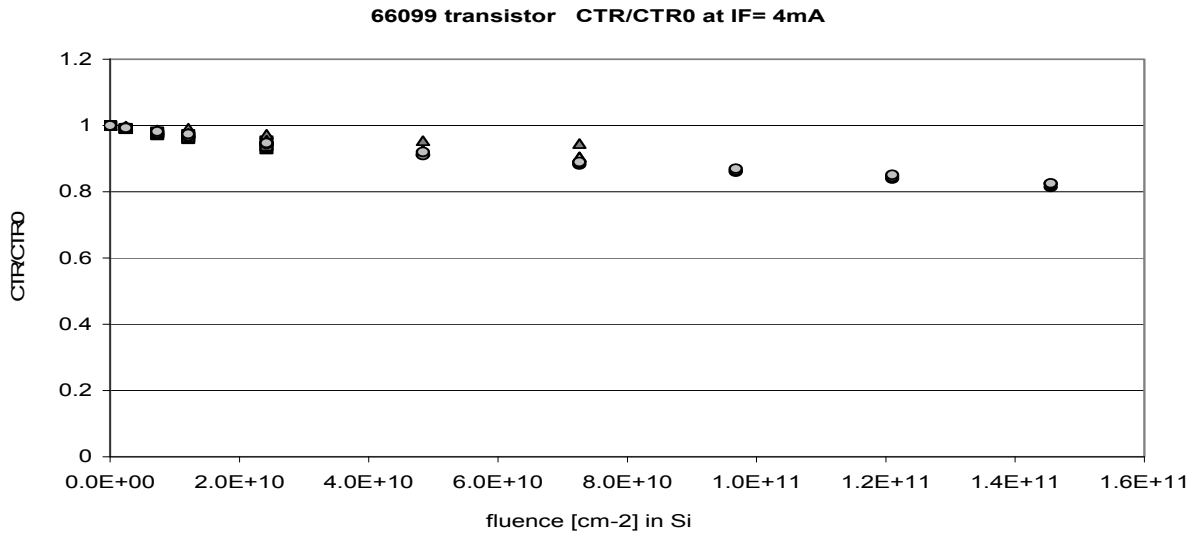
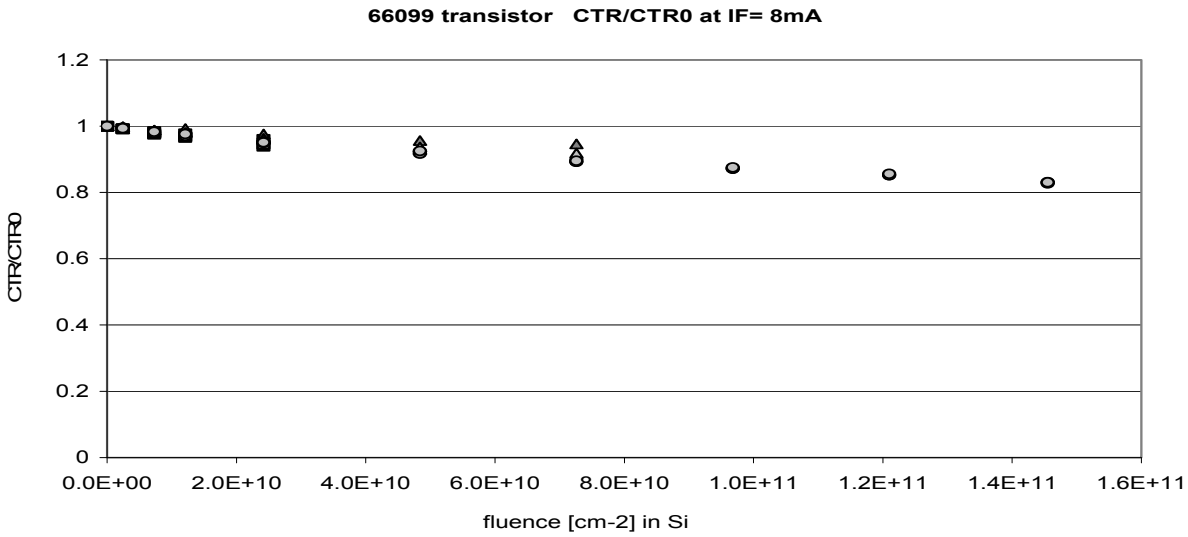

66099 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-121: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

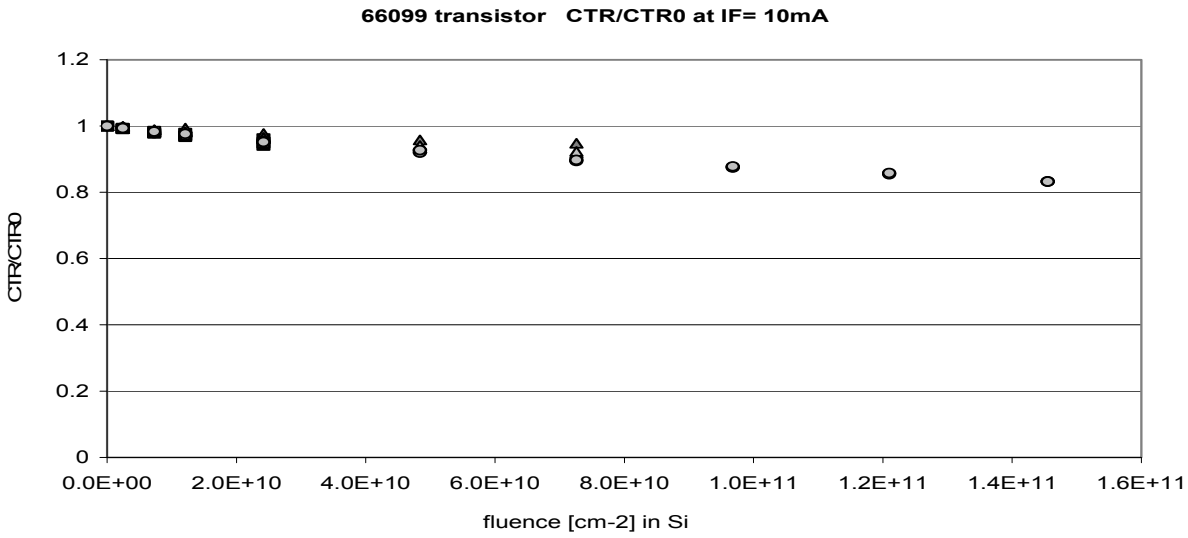
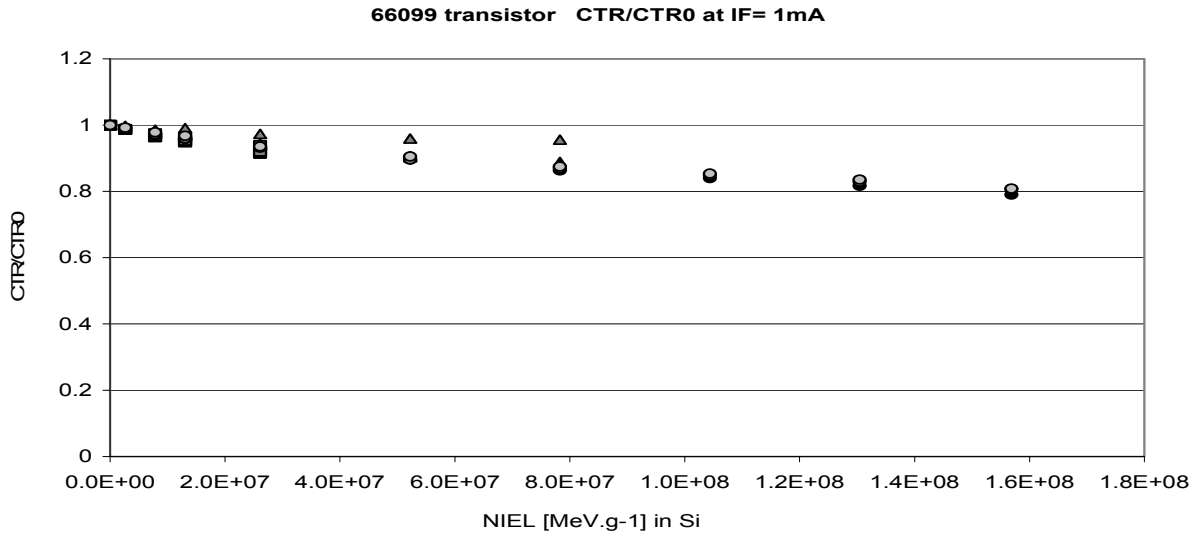
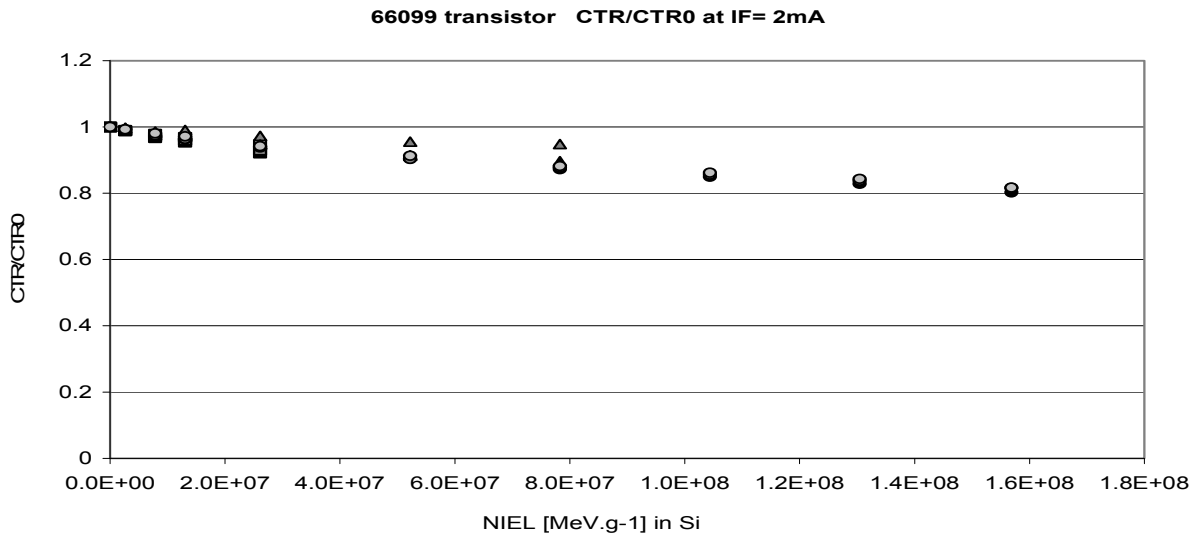
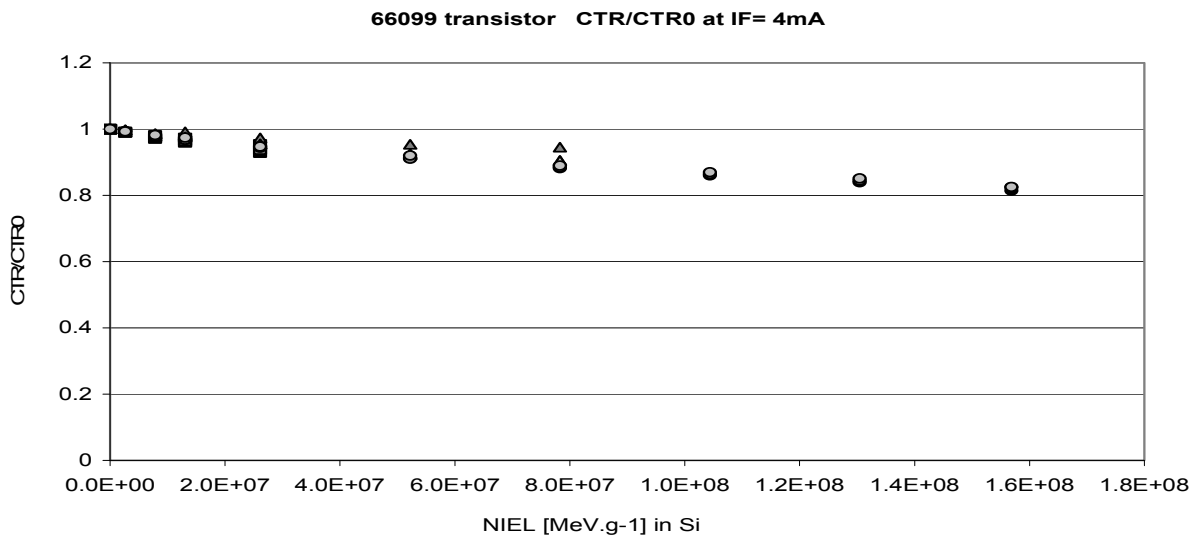
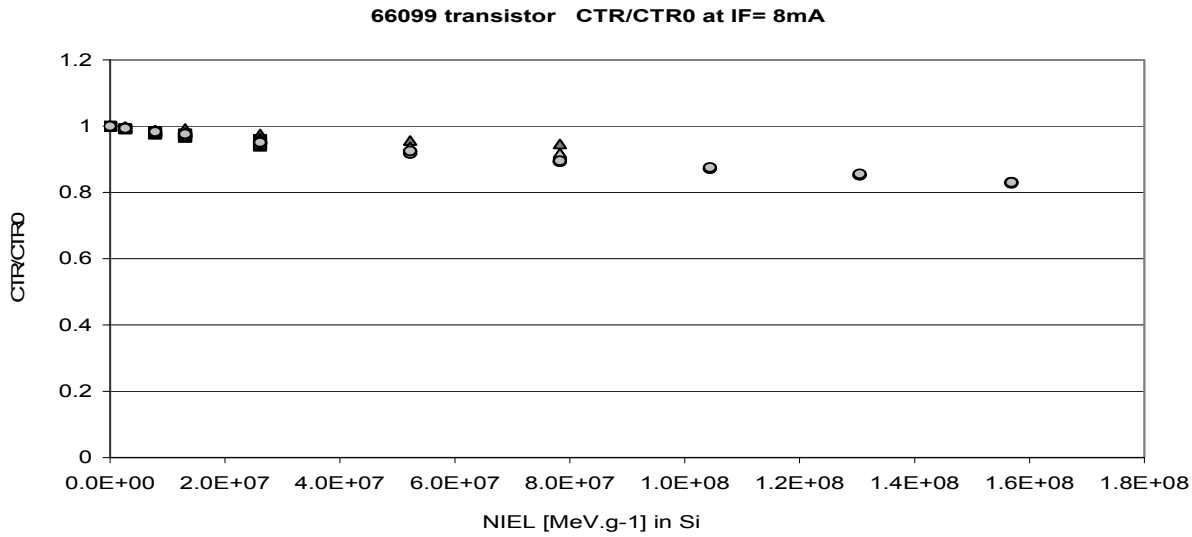

66099 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

Fig. 14-122: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








66099 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

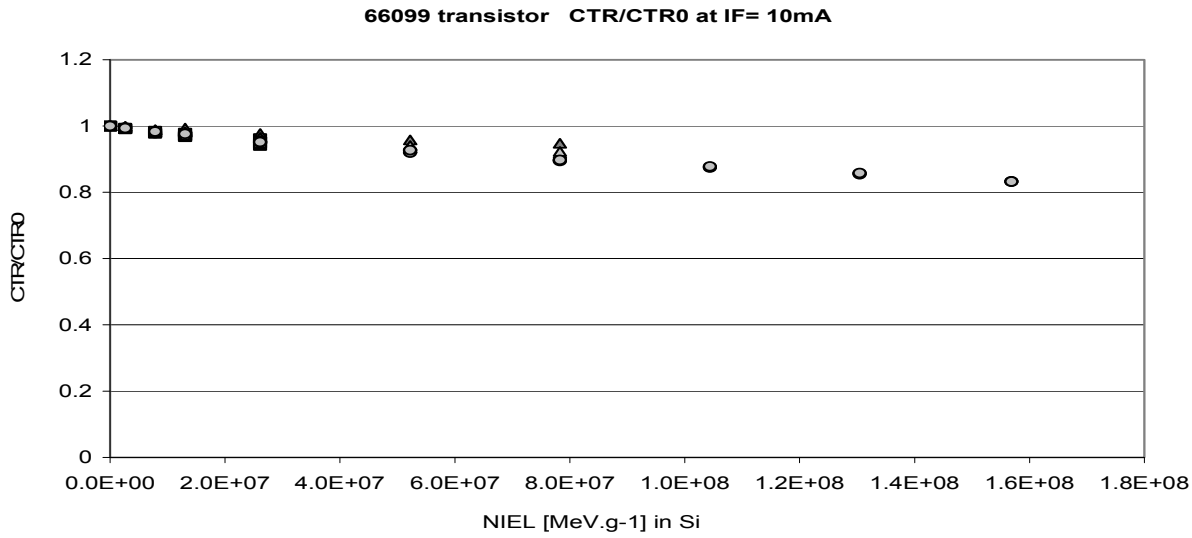
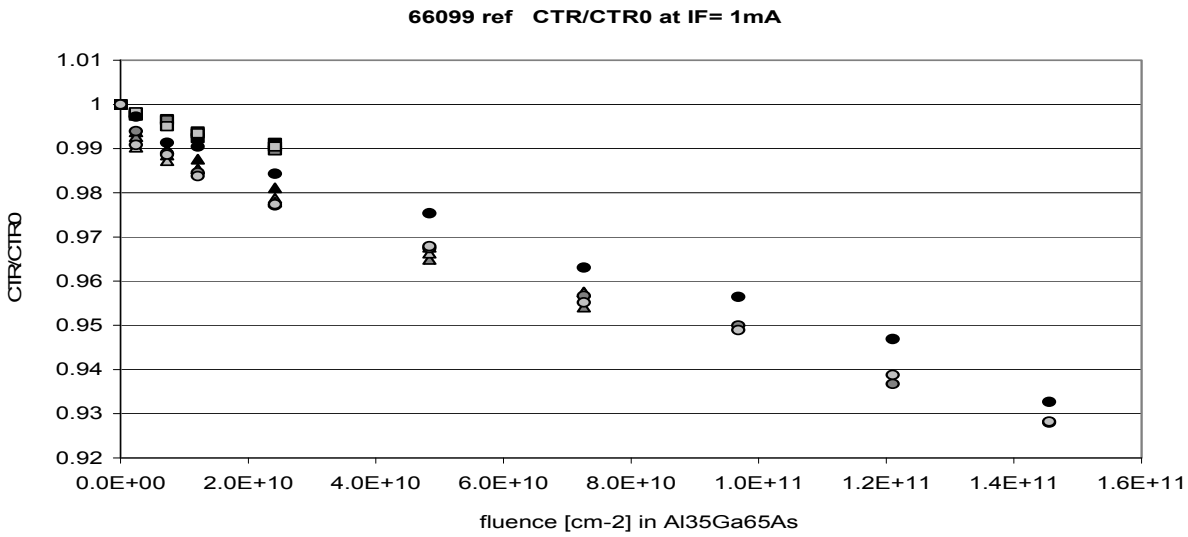
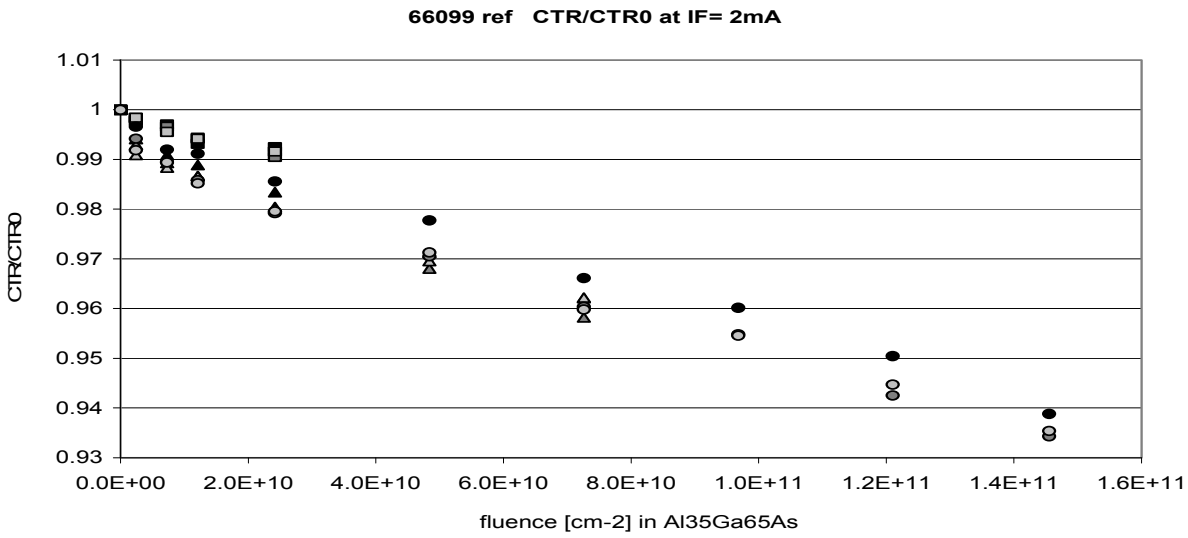
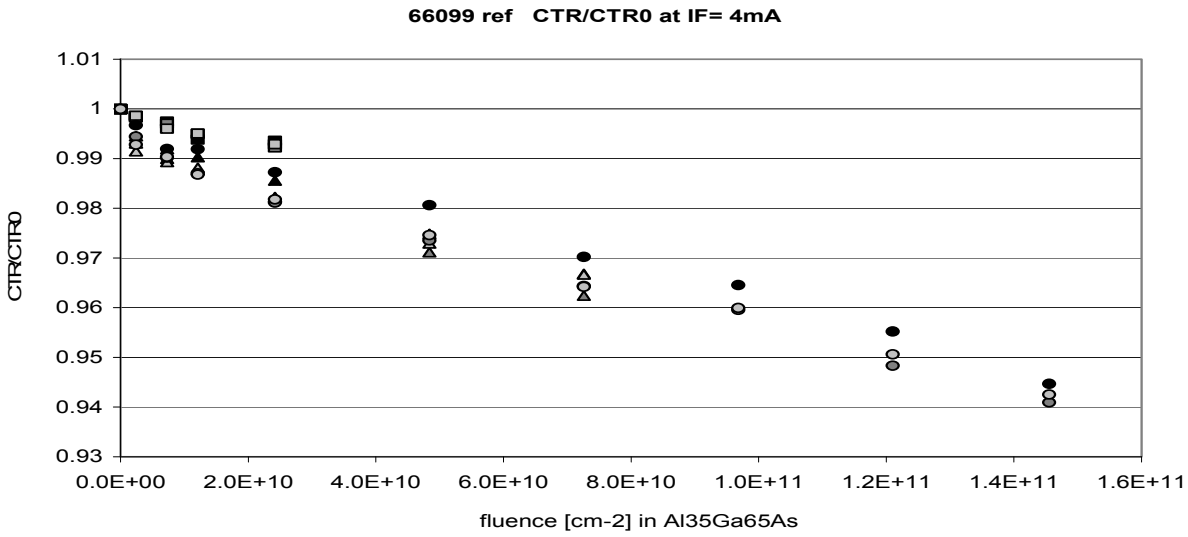
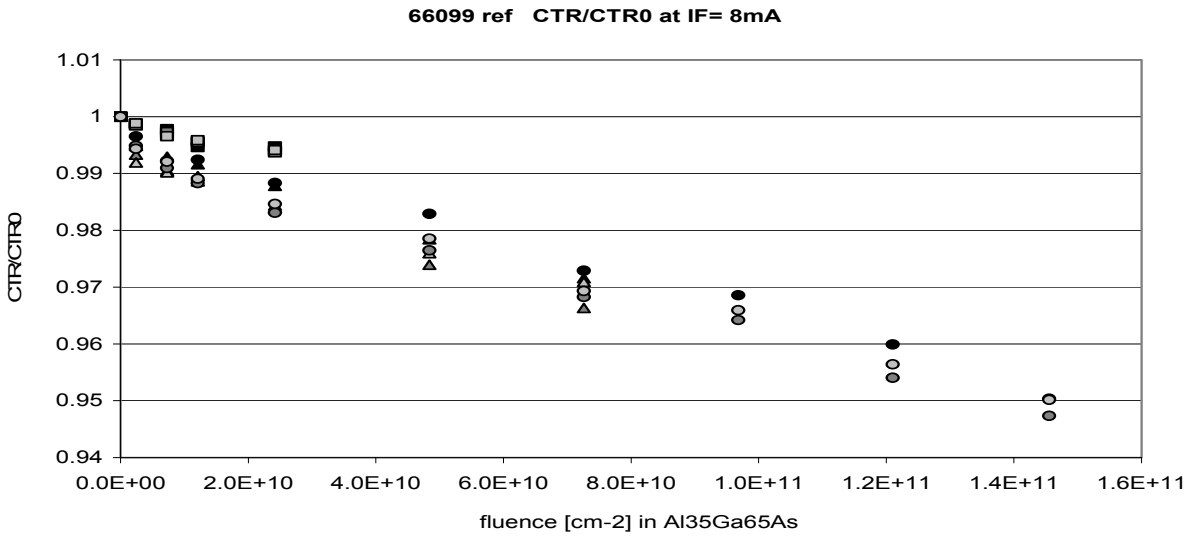

66099 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 14-123: 66099 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

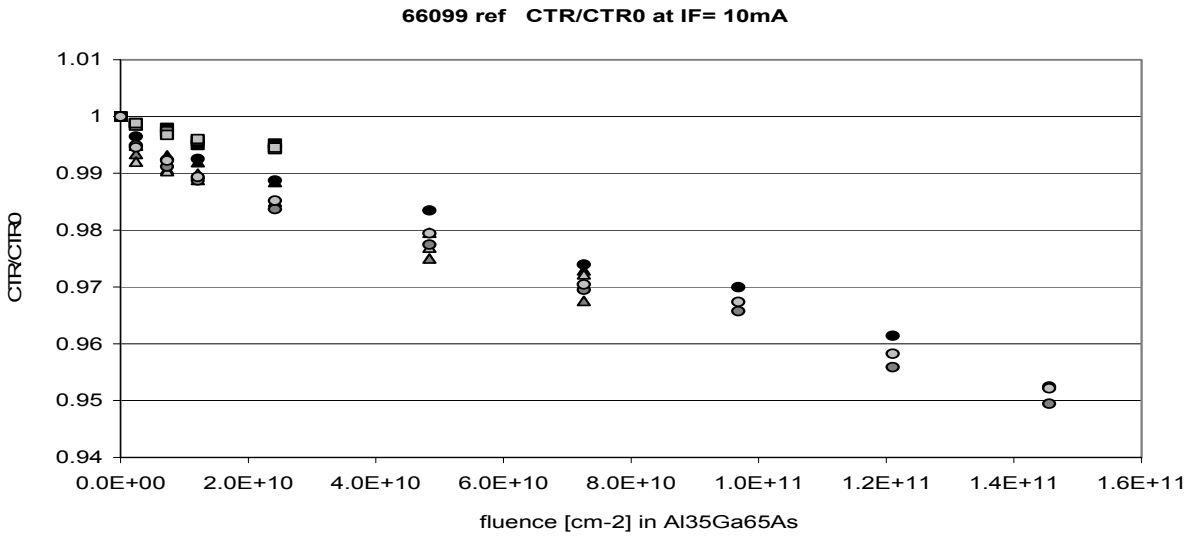
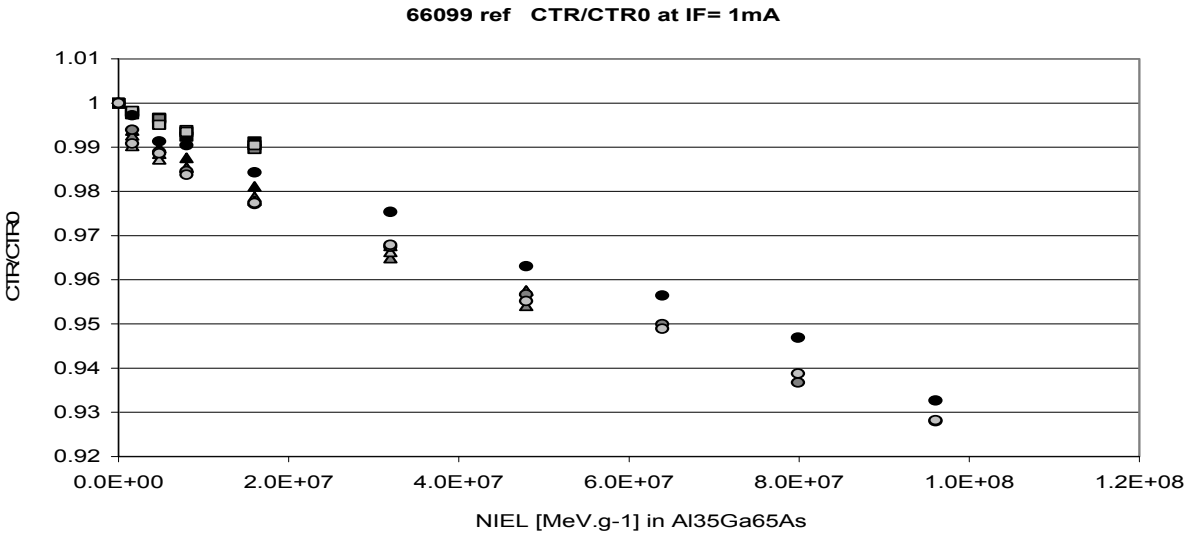
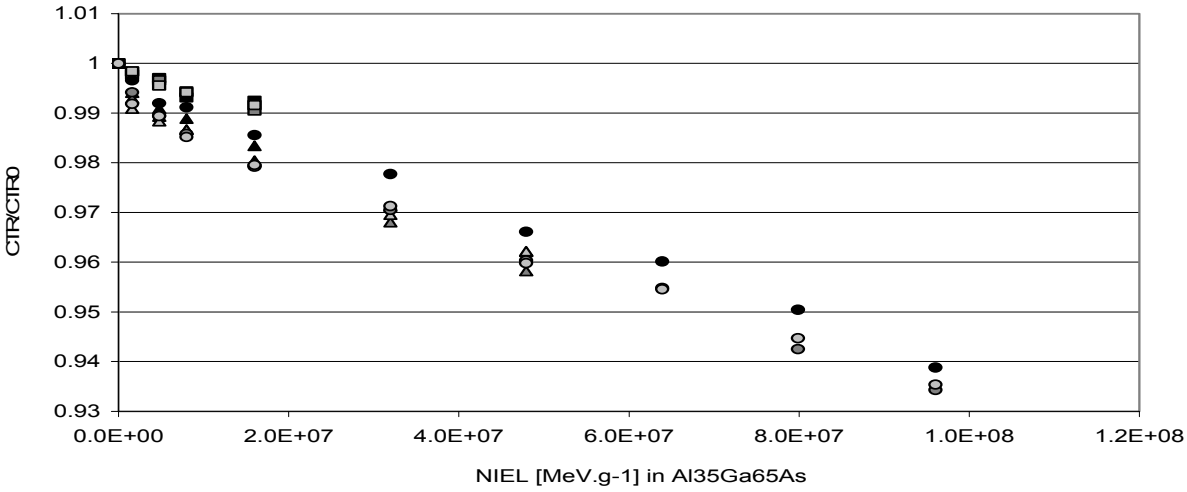
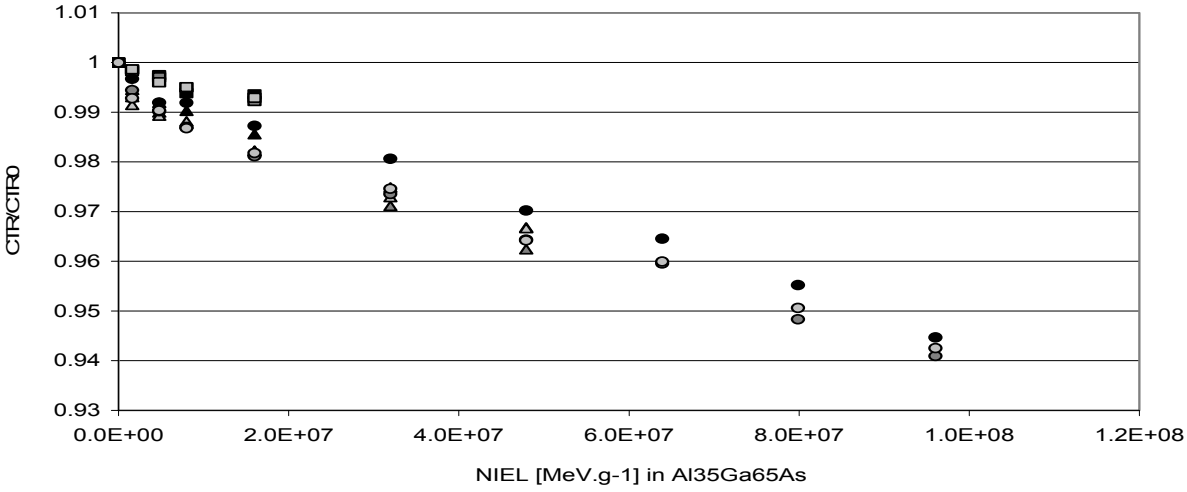
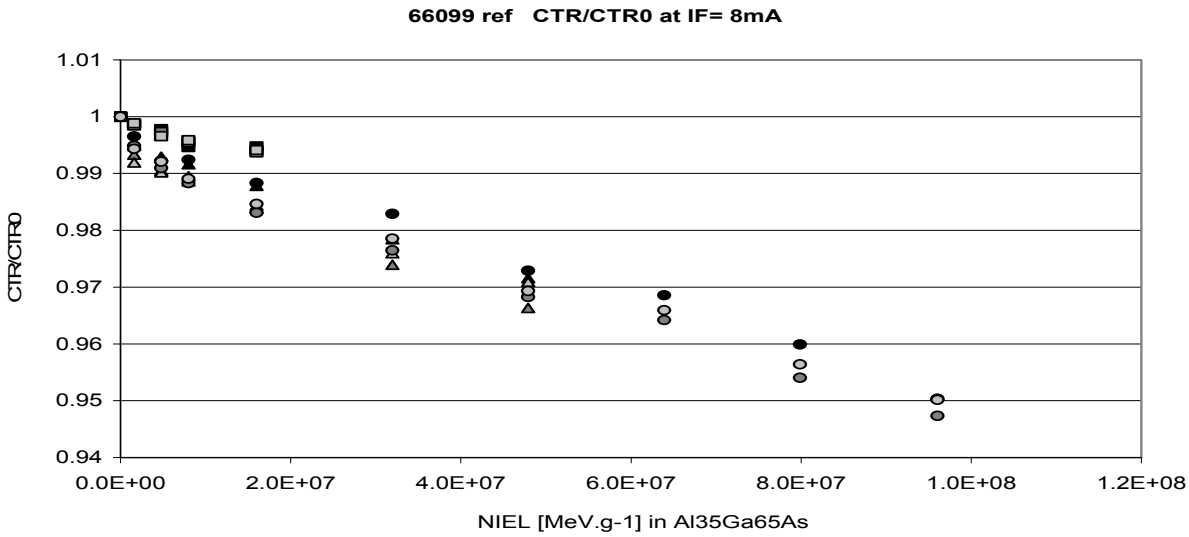

66099 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-124: 66099 reference: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 ref CTR/CTR0 at IF= 8mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

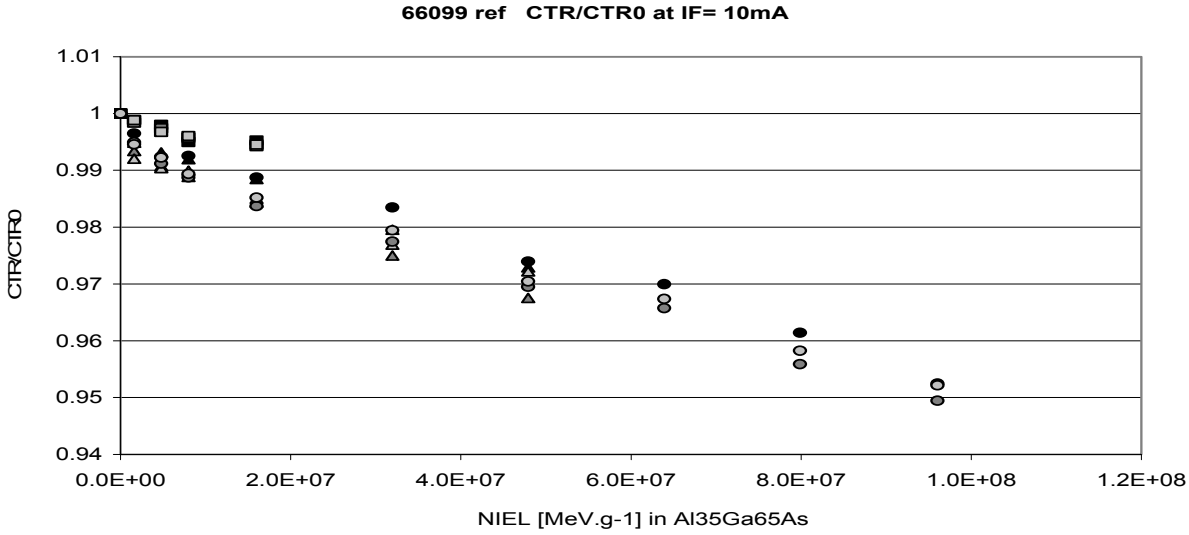
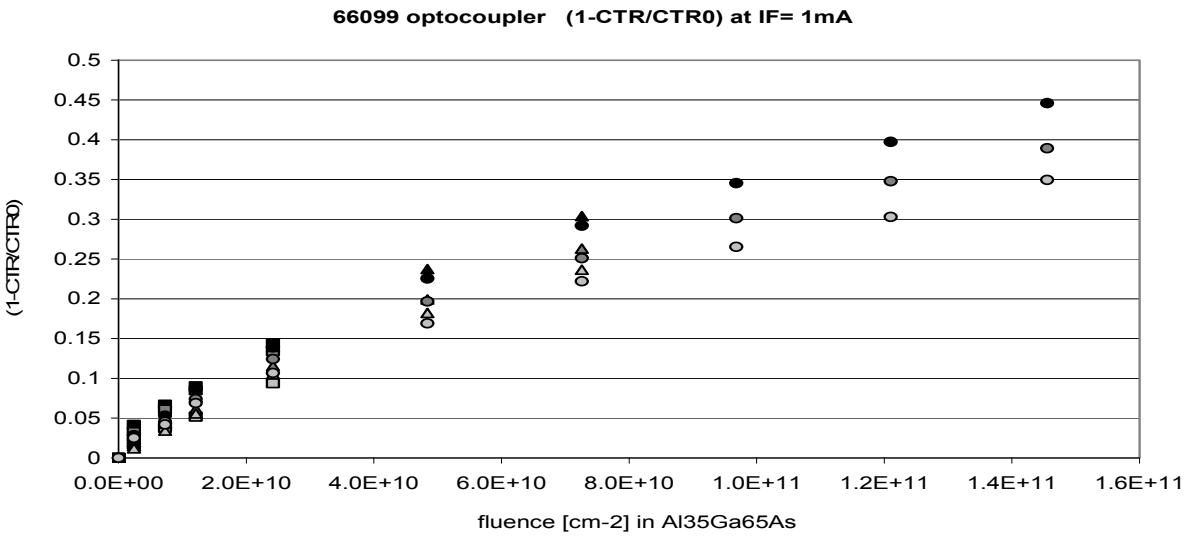
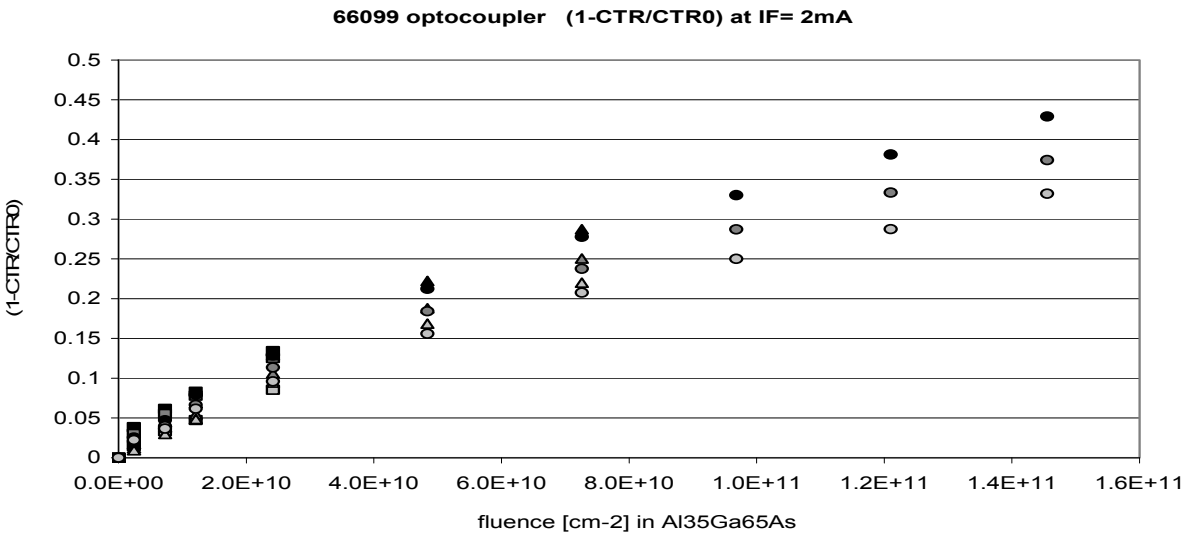
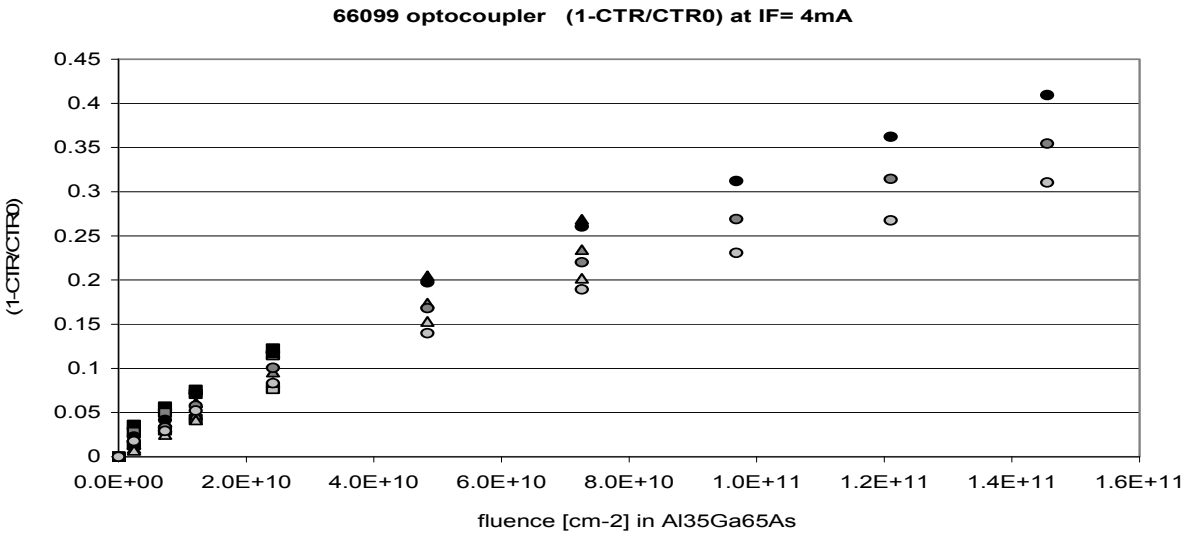
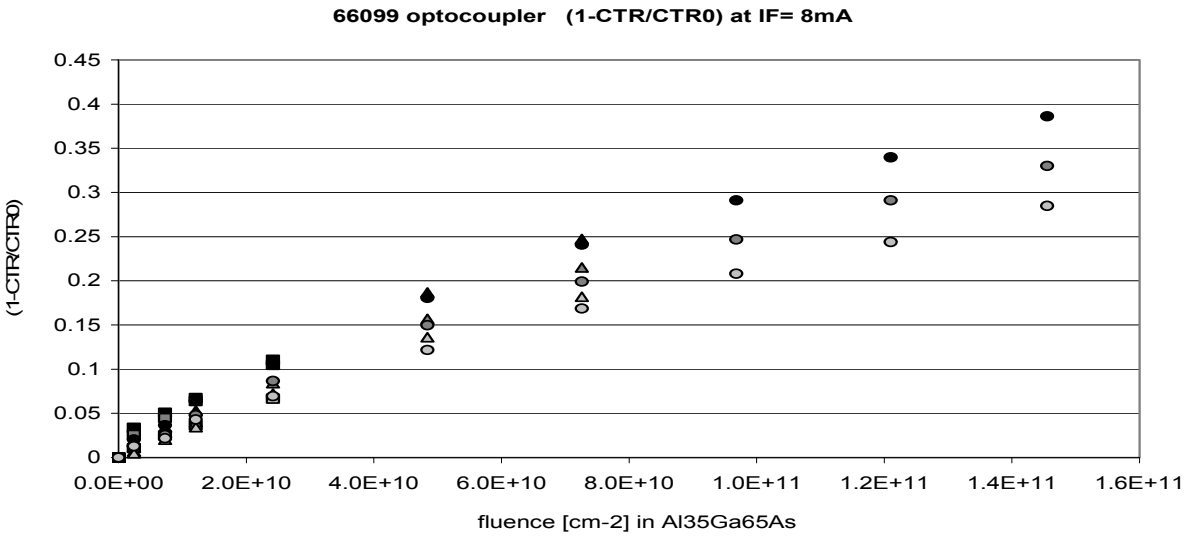

66099 ref CTR/CTR0 at IF= 10mA
CTR/CTR0
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-125: 66099 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to fluence








66099 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

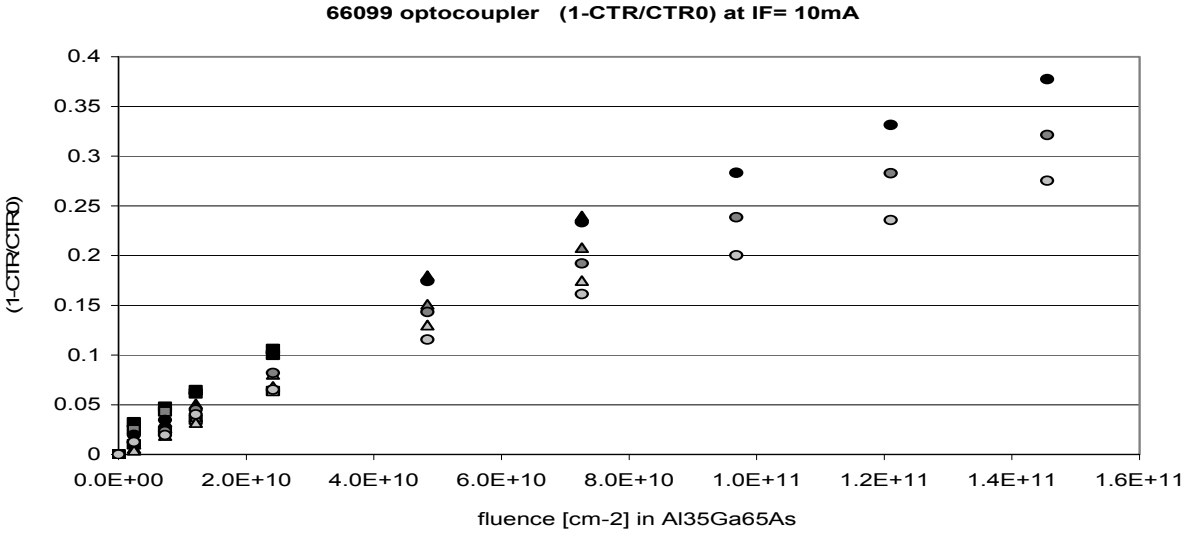
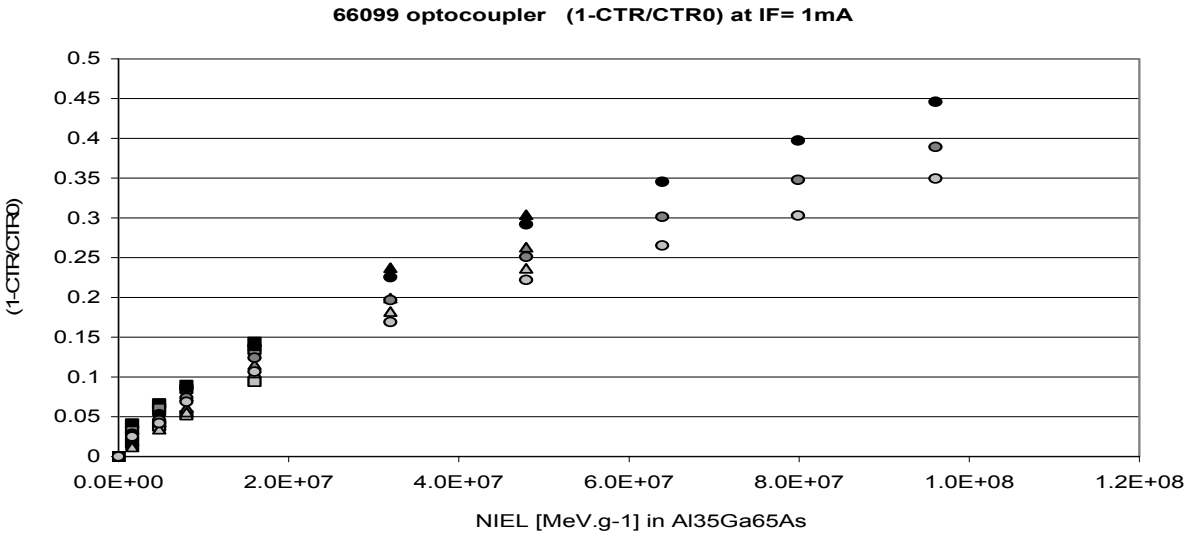
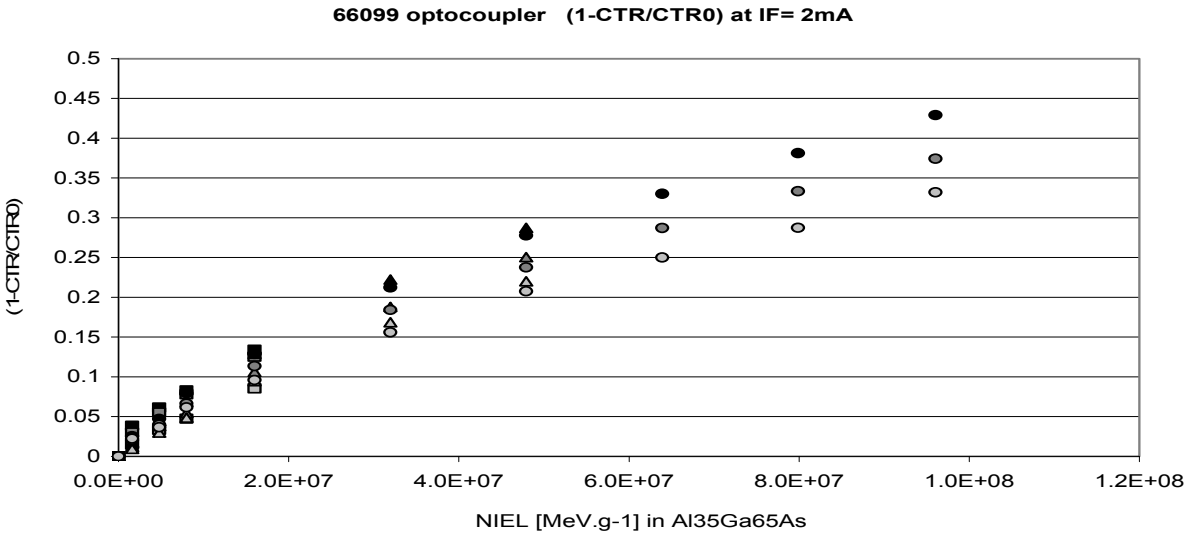
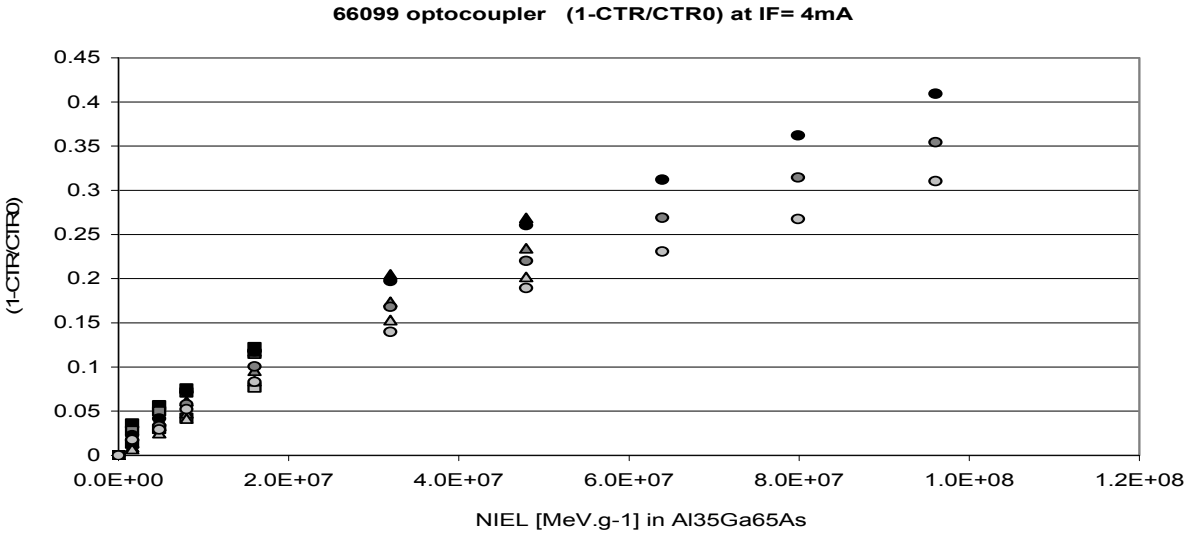
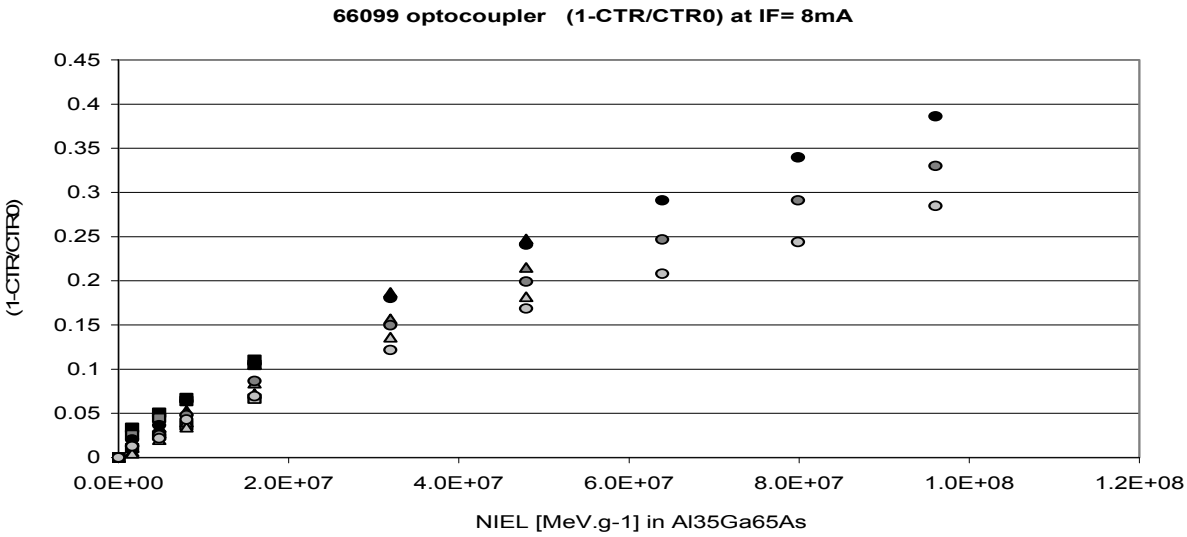

66099 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-126: 66099 optocoupler: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to NIEL in Al$_{0.35}$Ga$_{0.65}$As (GEANT4 TOTAL)








66099 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

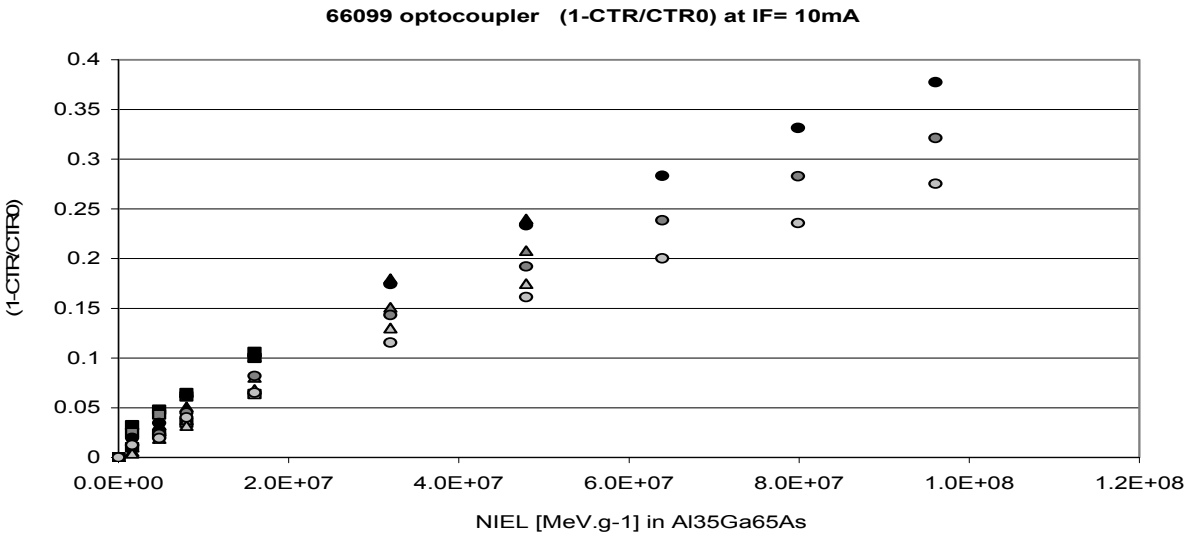
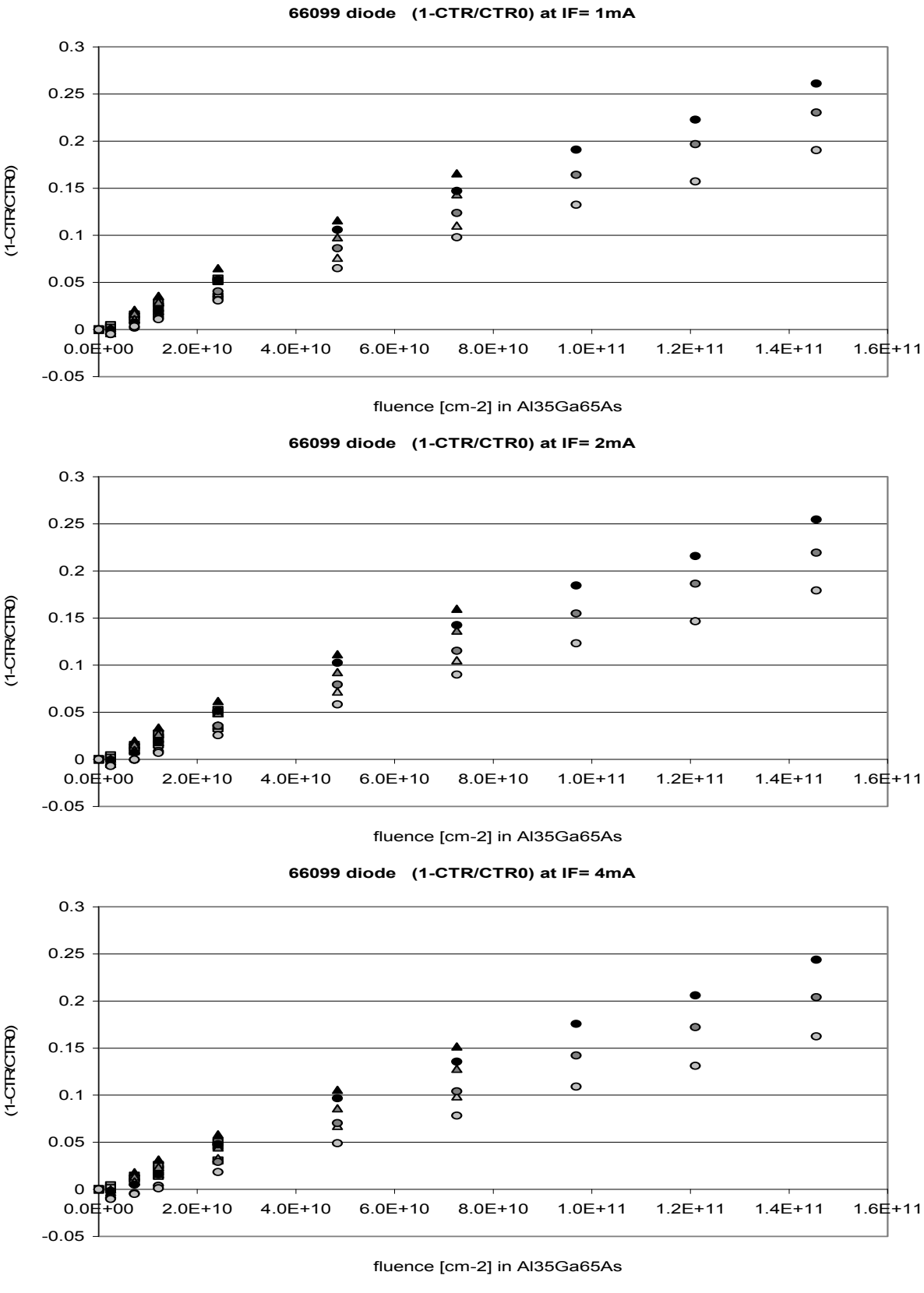
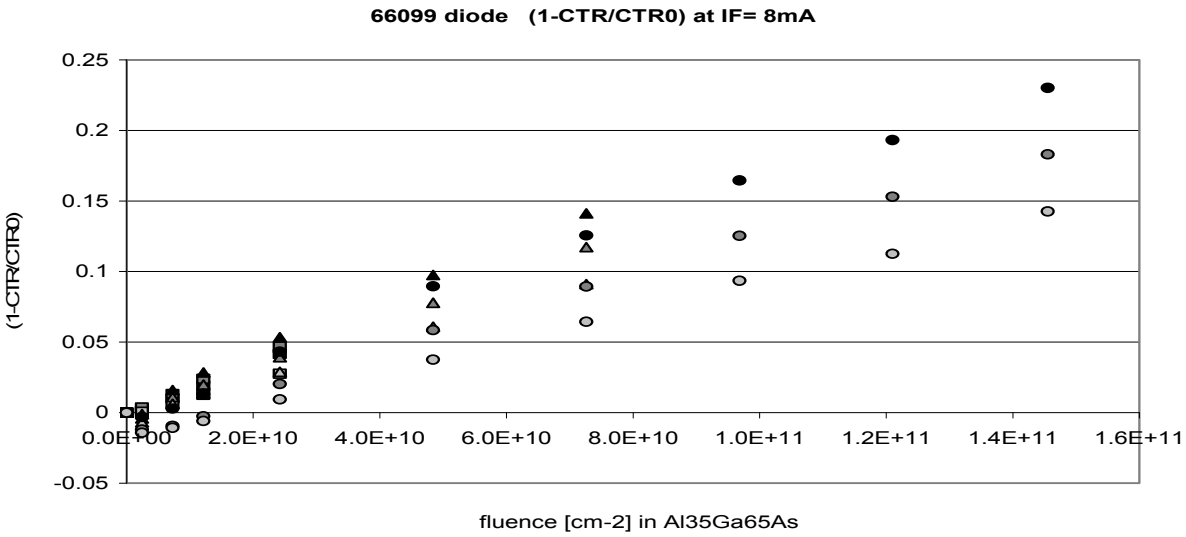

66099 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-127: 66099 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence




66099 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

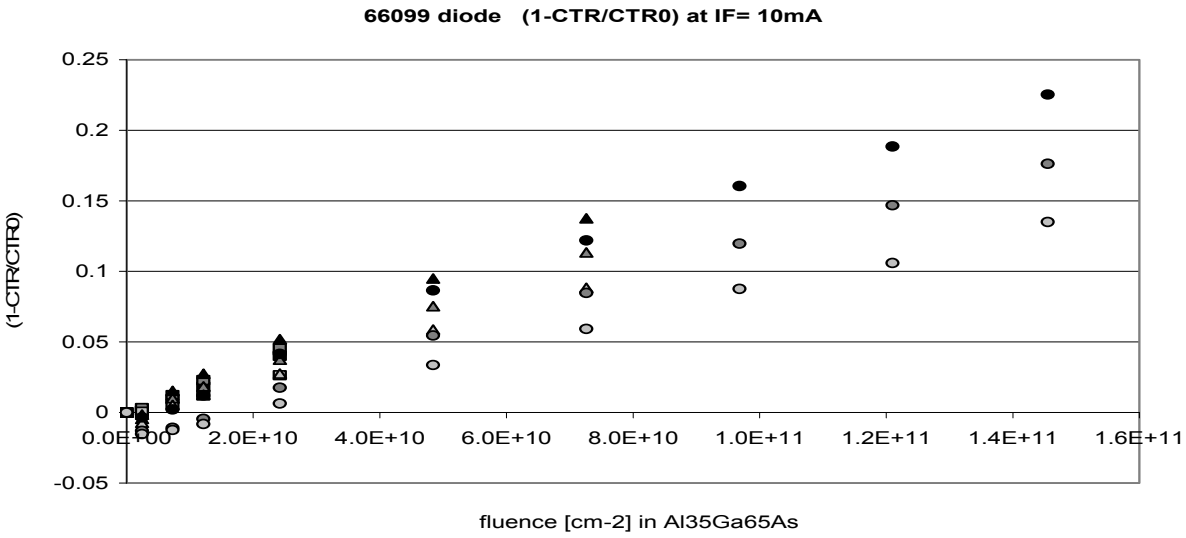
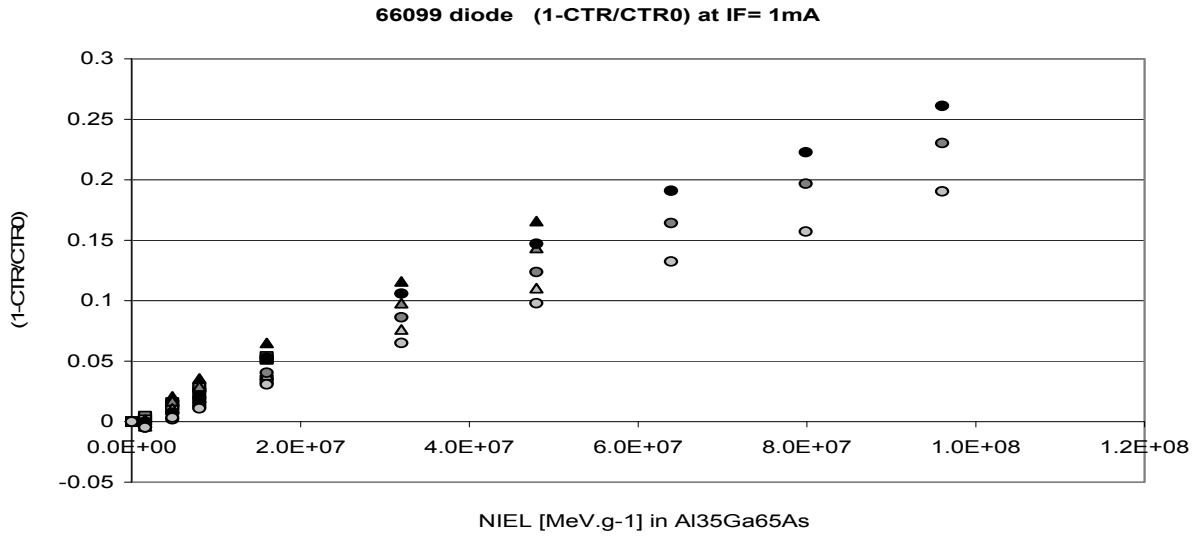
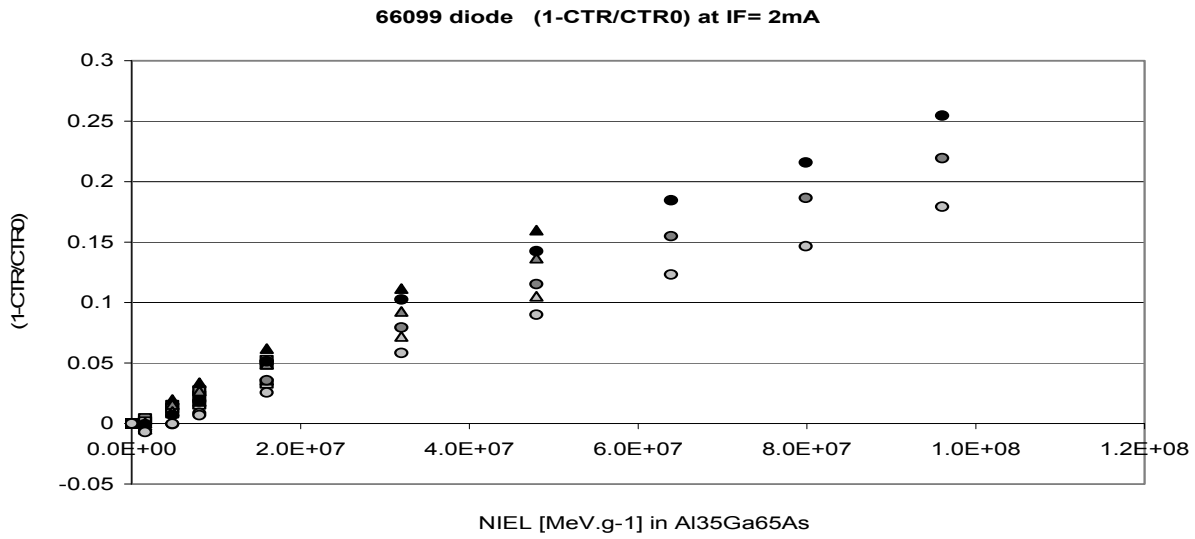
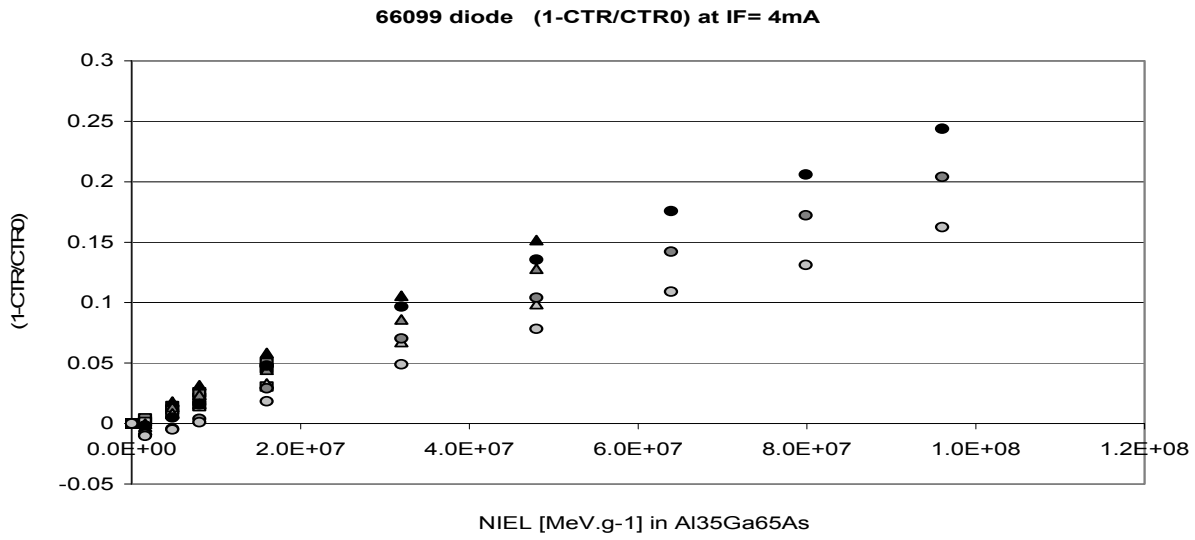
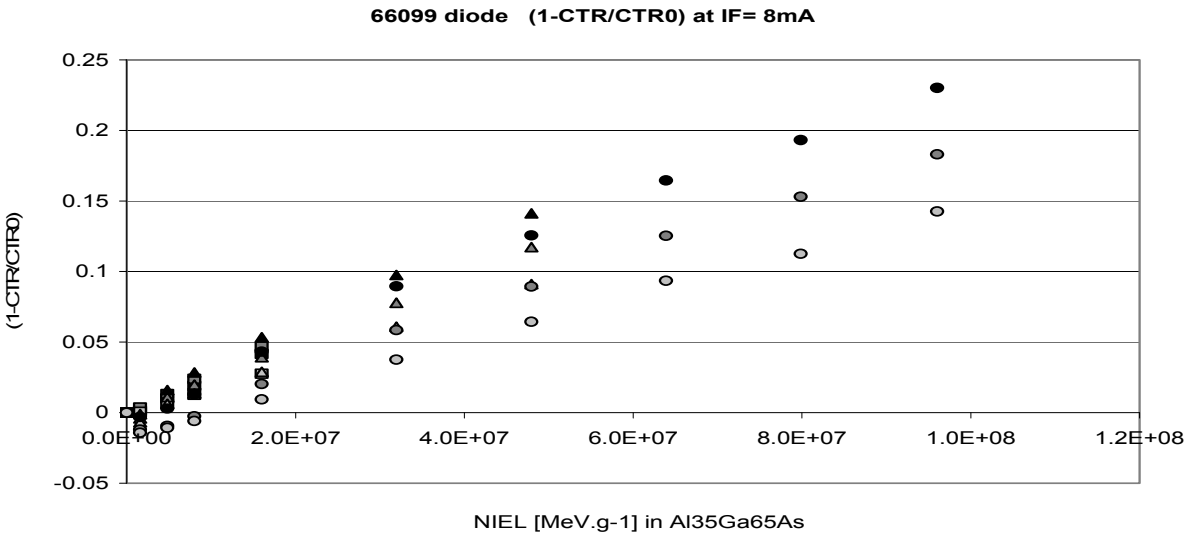

66099 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-128: 66099 diode: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

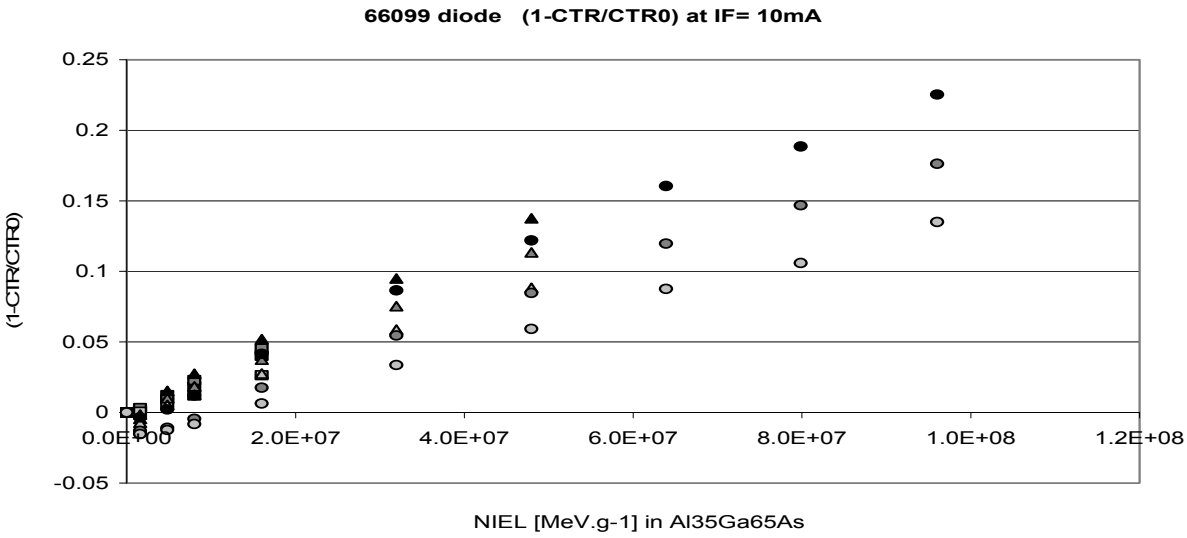
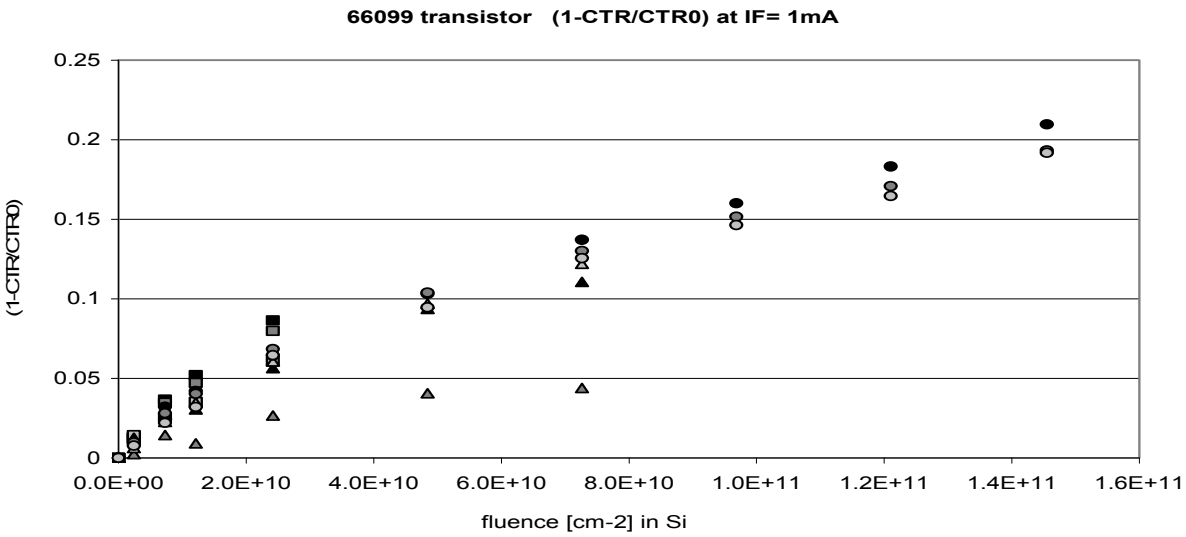
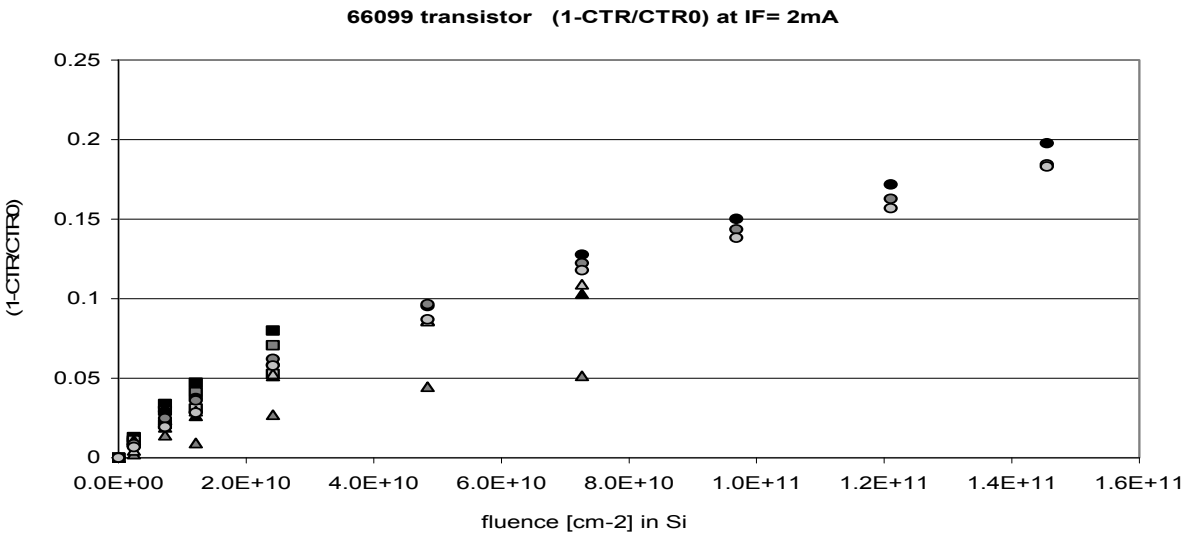
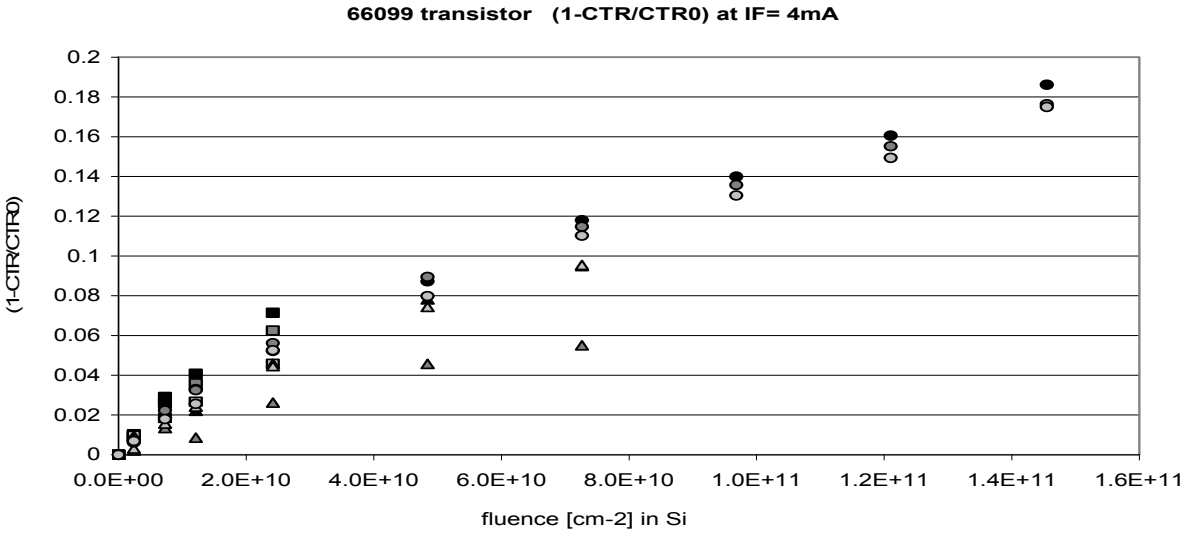
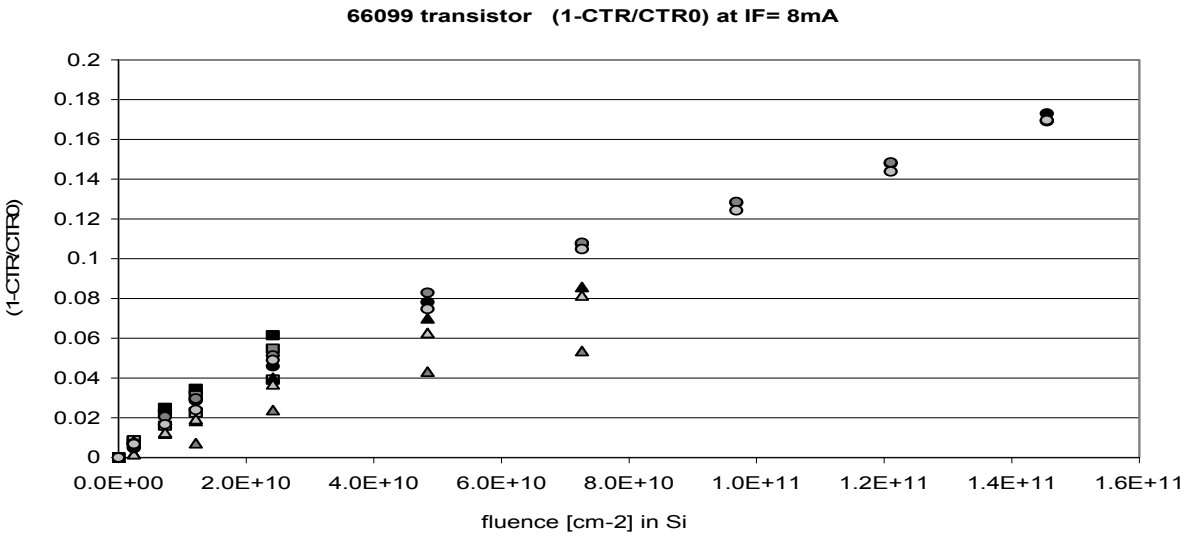

66099 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-129: 66099 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

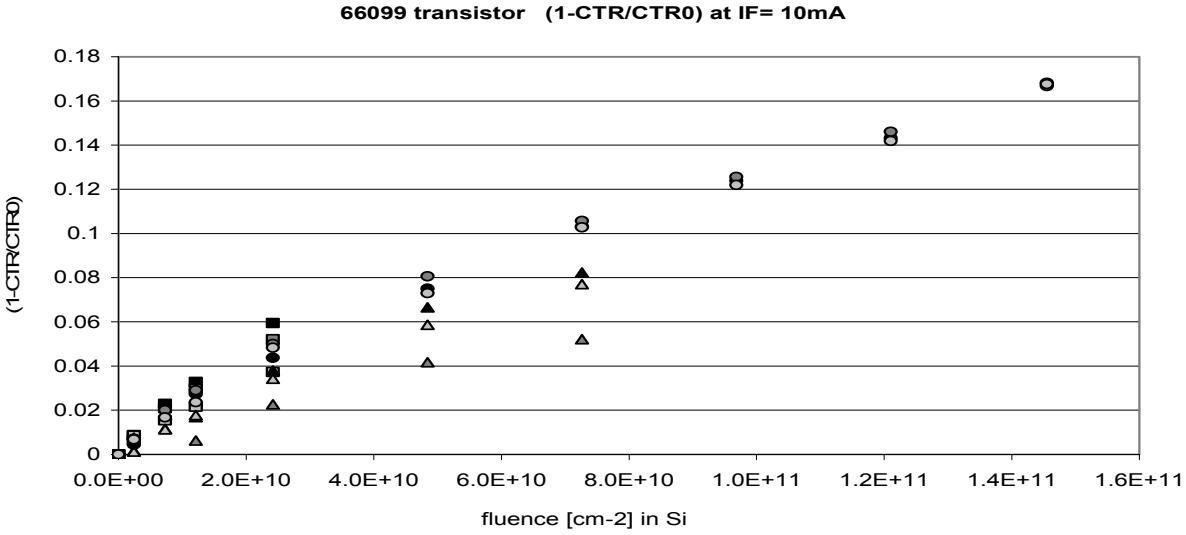
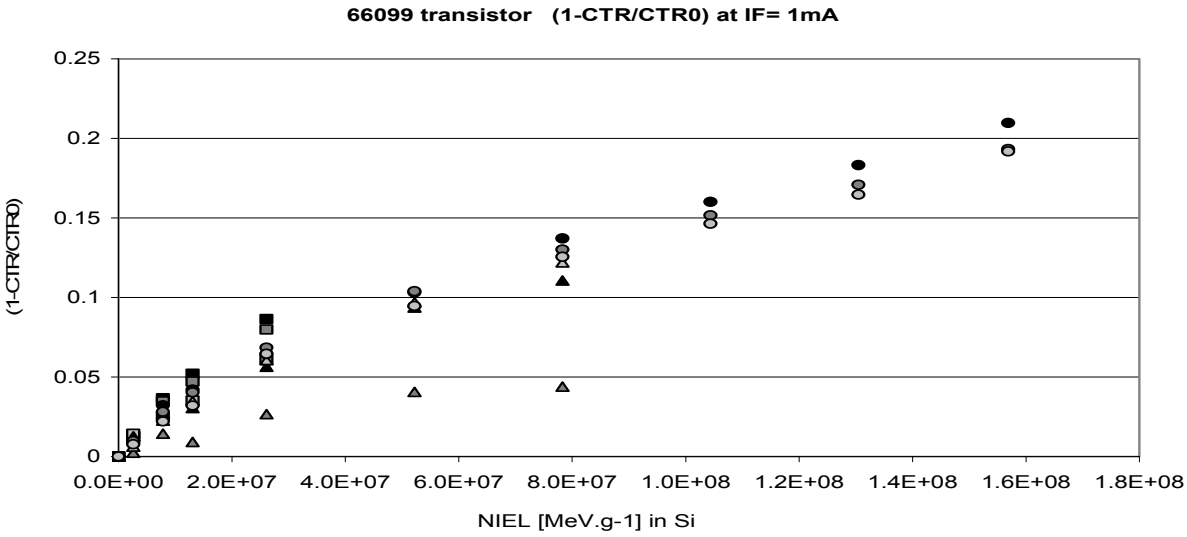
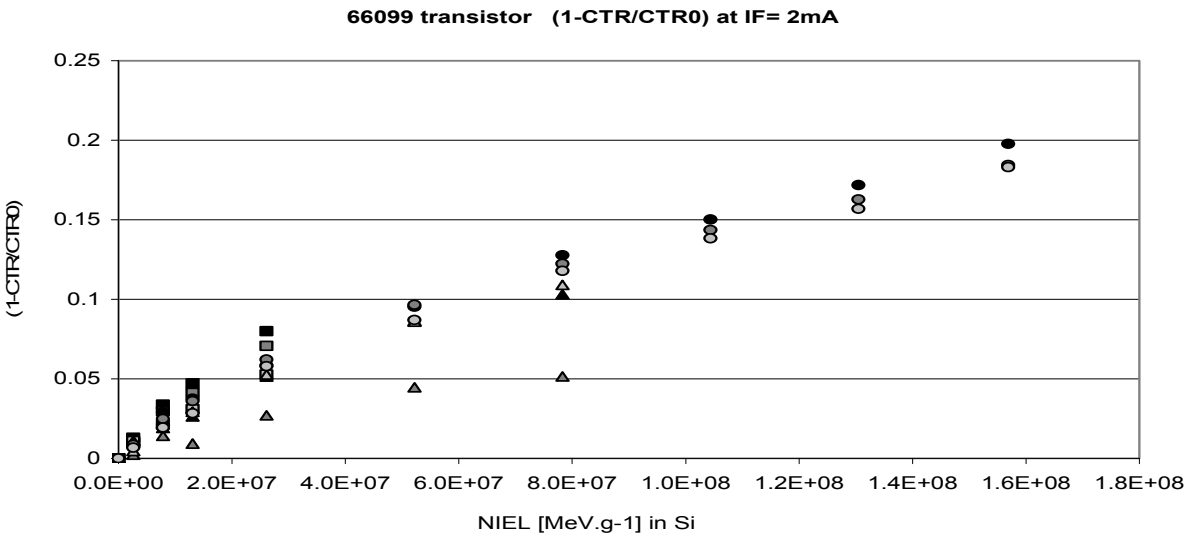
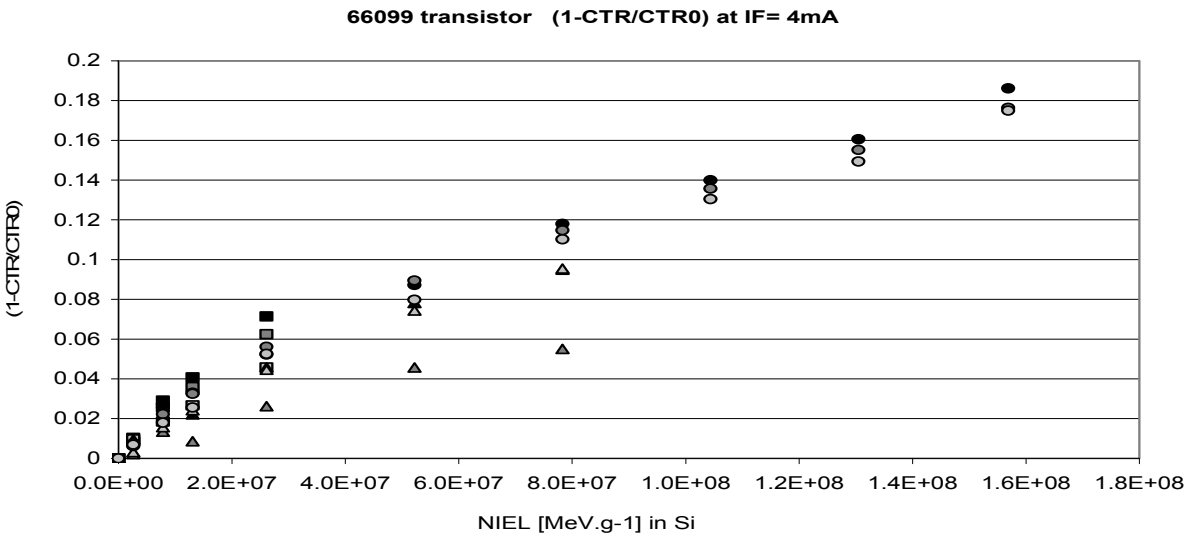
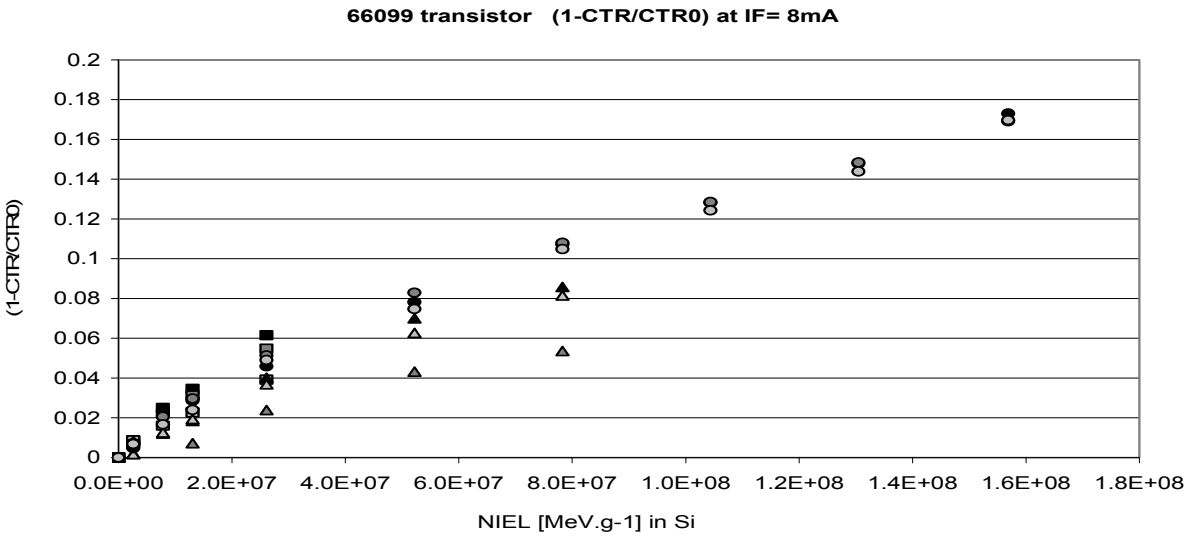

66099 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Si

Fig. 14-130: 66099 transistor: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in Si (GEANT4 TOTAL)








66099 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

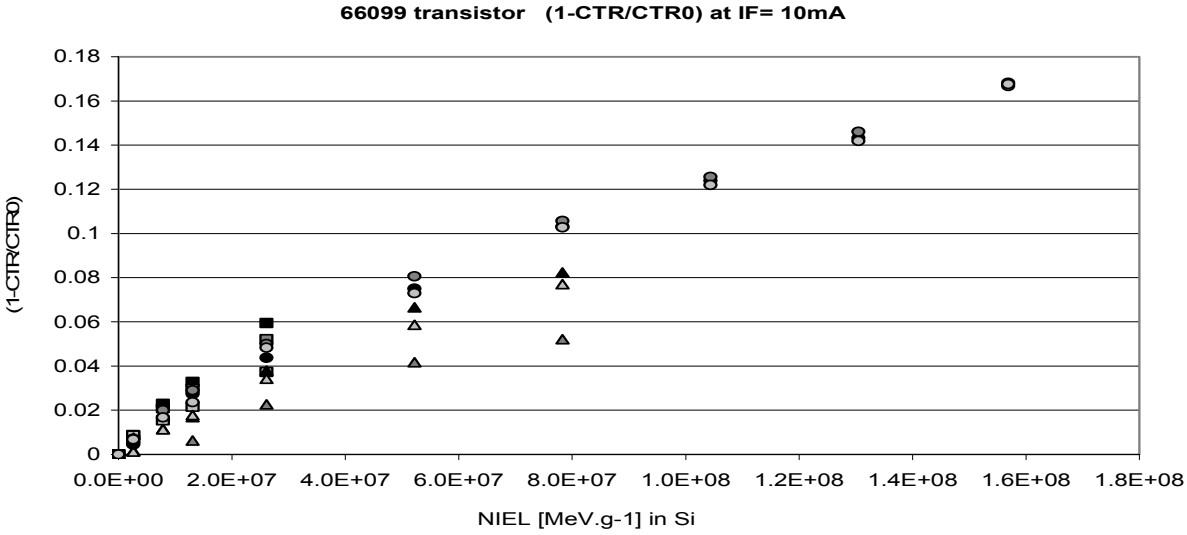
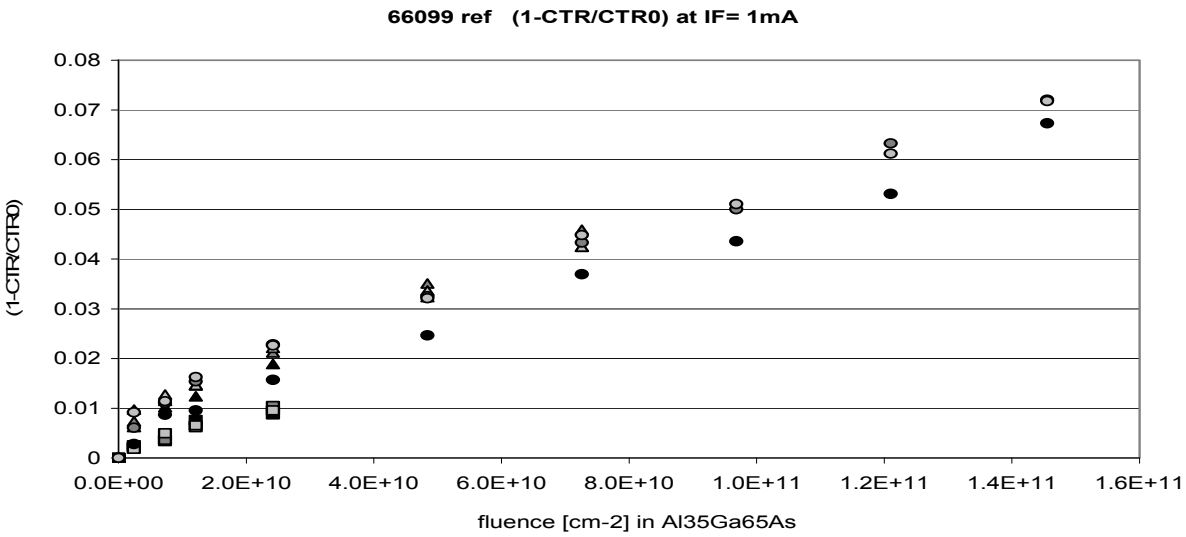
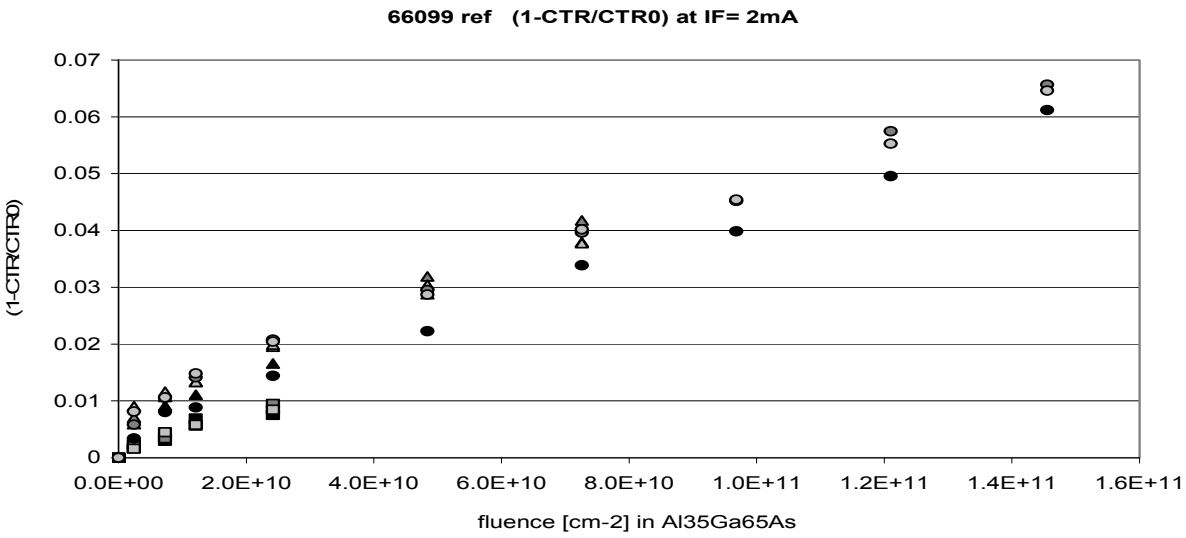
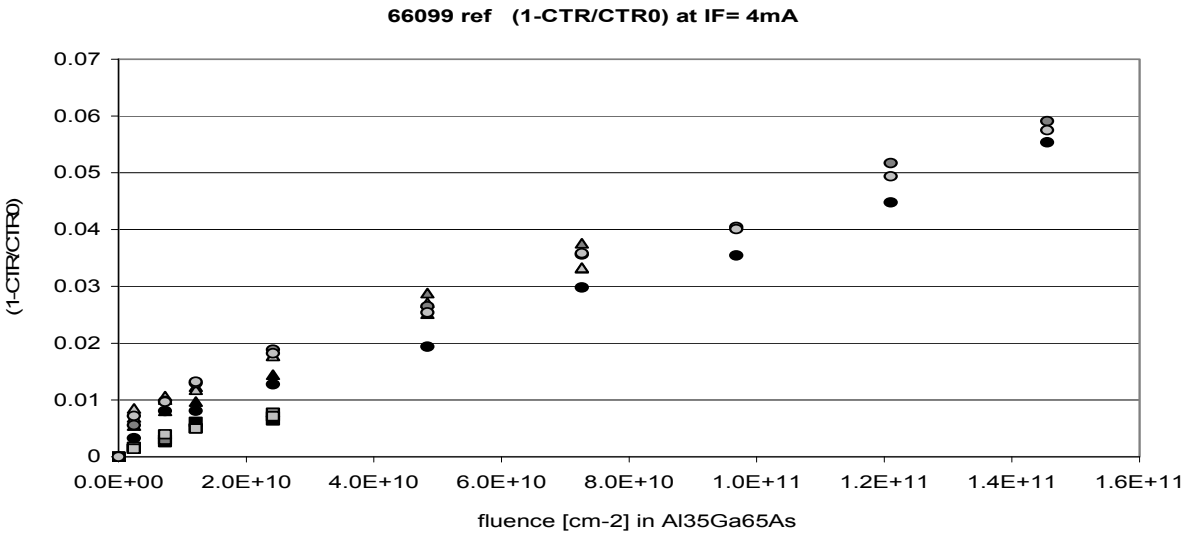
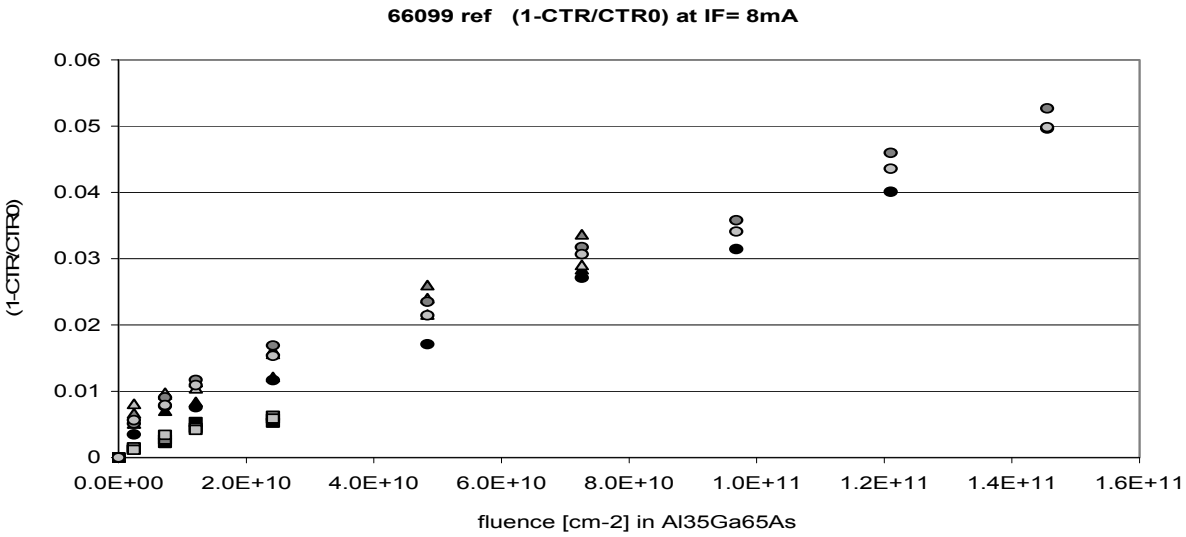

66099 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
1.4E+08
1.6E+08
1.8E+08
NIEL [MeV.g-1] in Si

Fig. 14-131: 66099 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to fluence








66099 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

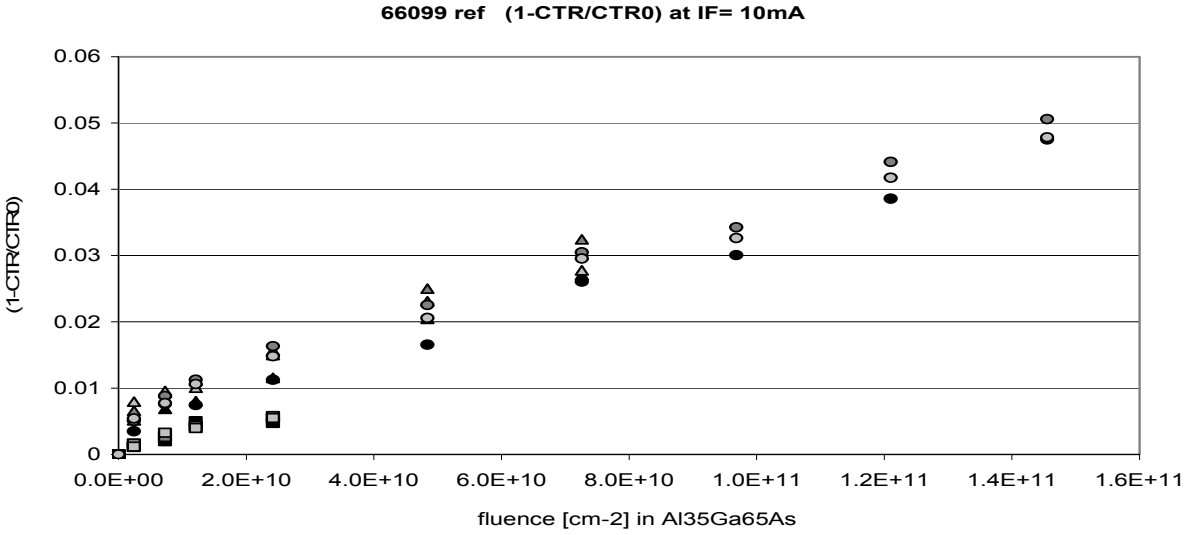
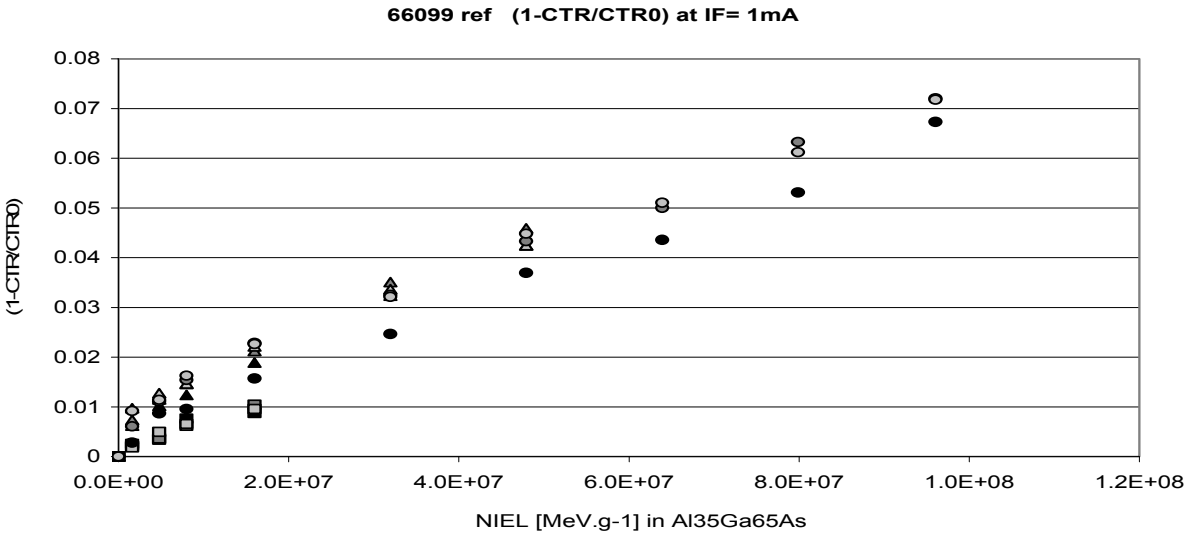
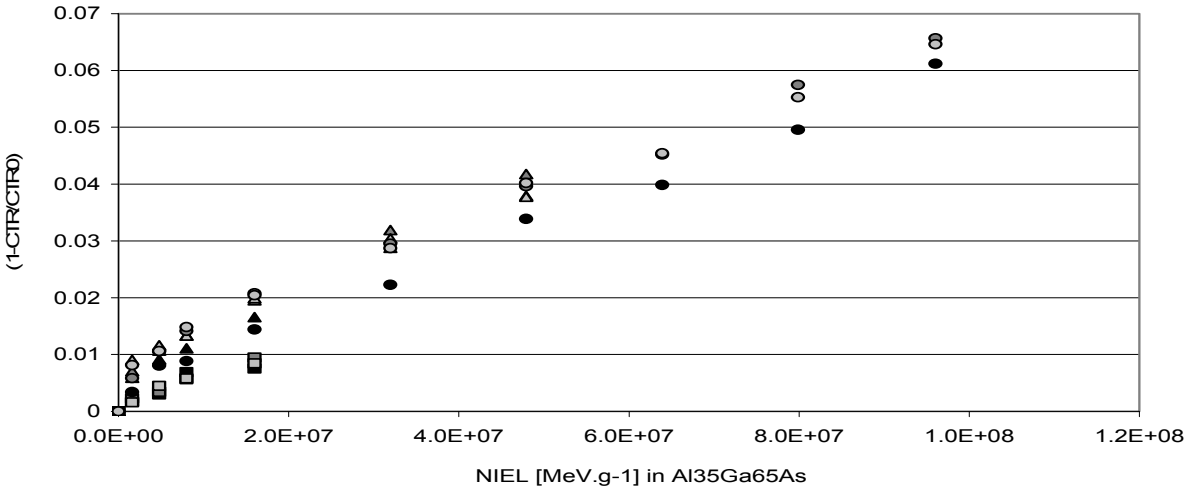
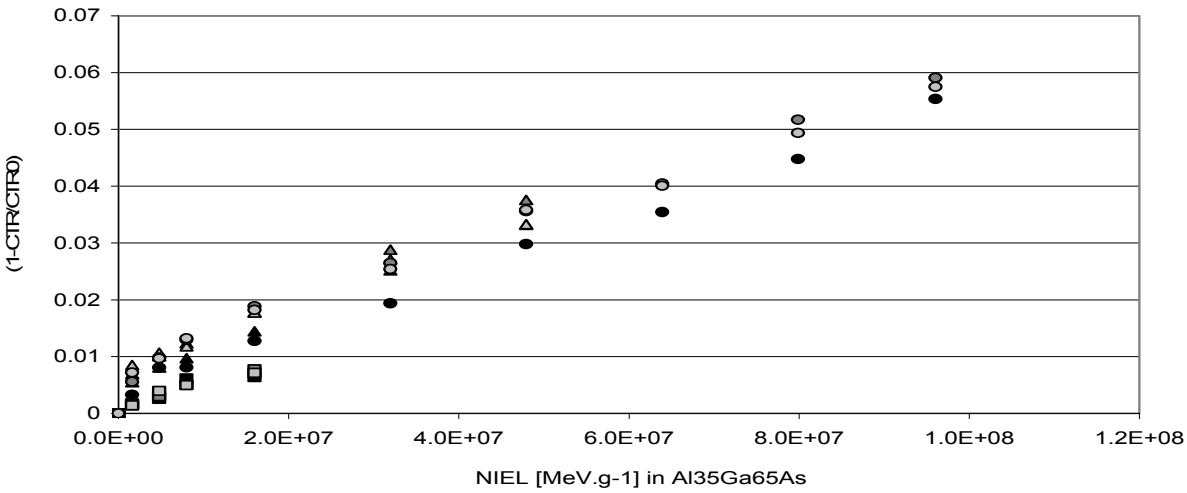
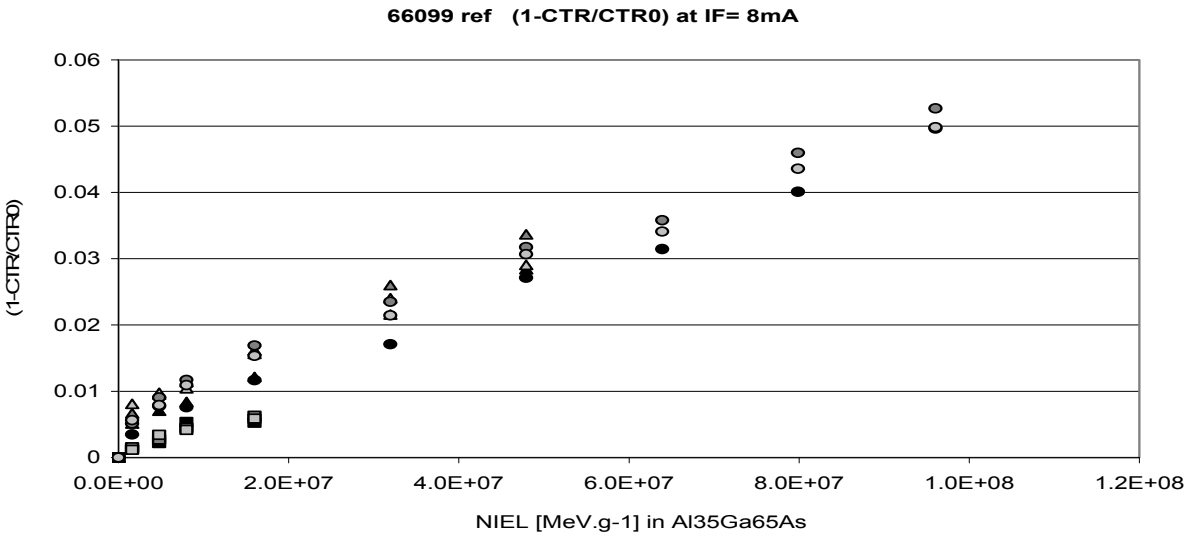

66099 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+10
4.0E+10
6.0E+10
8.0E+10
1.0E+11
1.2E+11
1.4E+11
1.6E+11
fluence [cm-2] in Al35Ga65As

Fig. 14-132: 66099 reference: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)








66099 ref (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

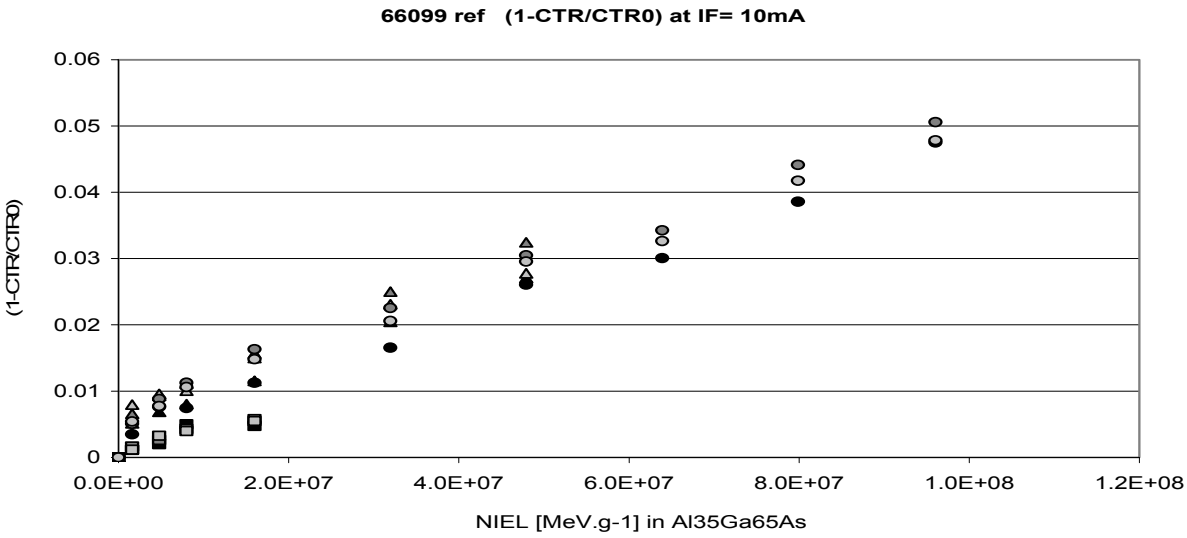
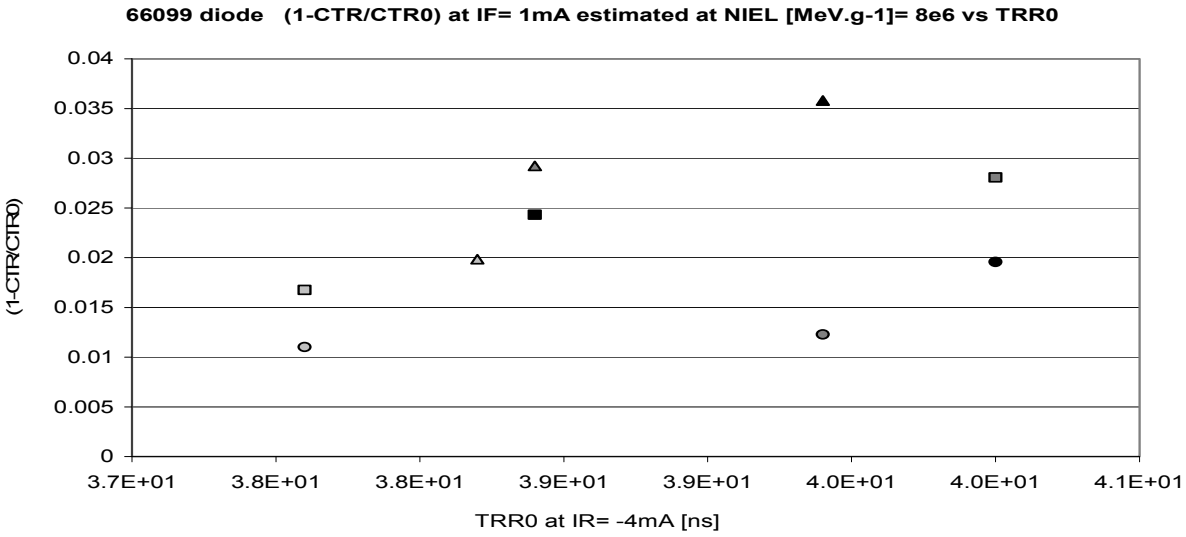
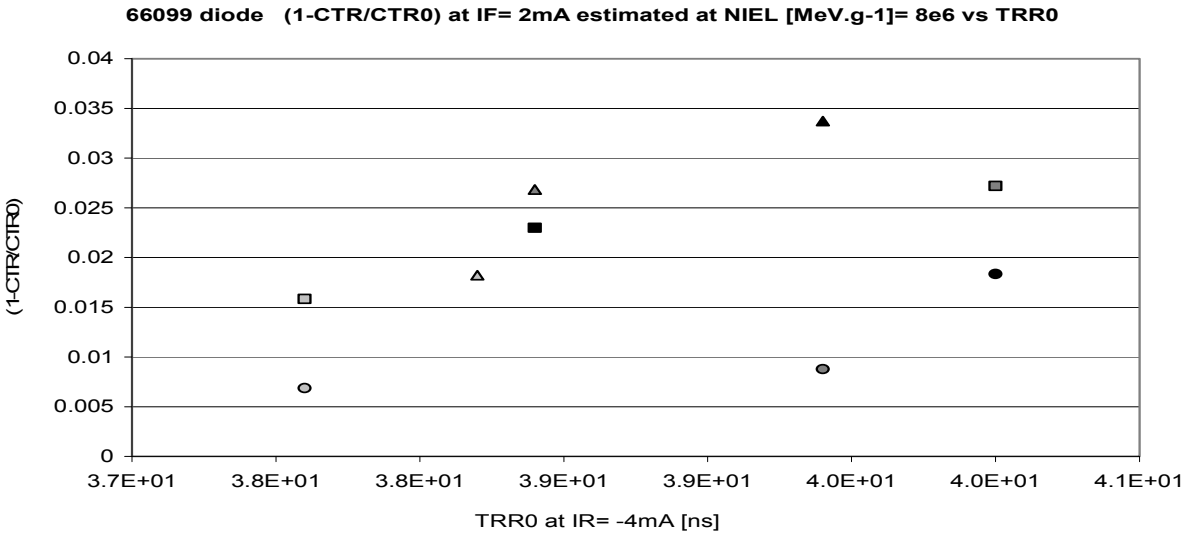
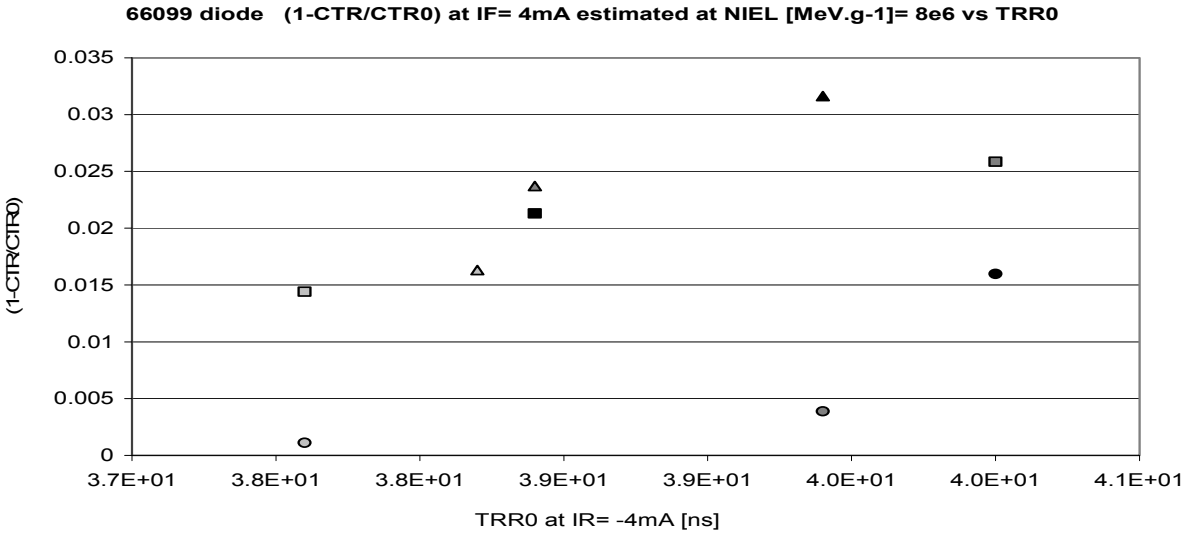
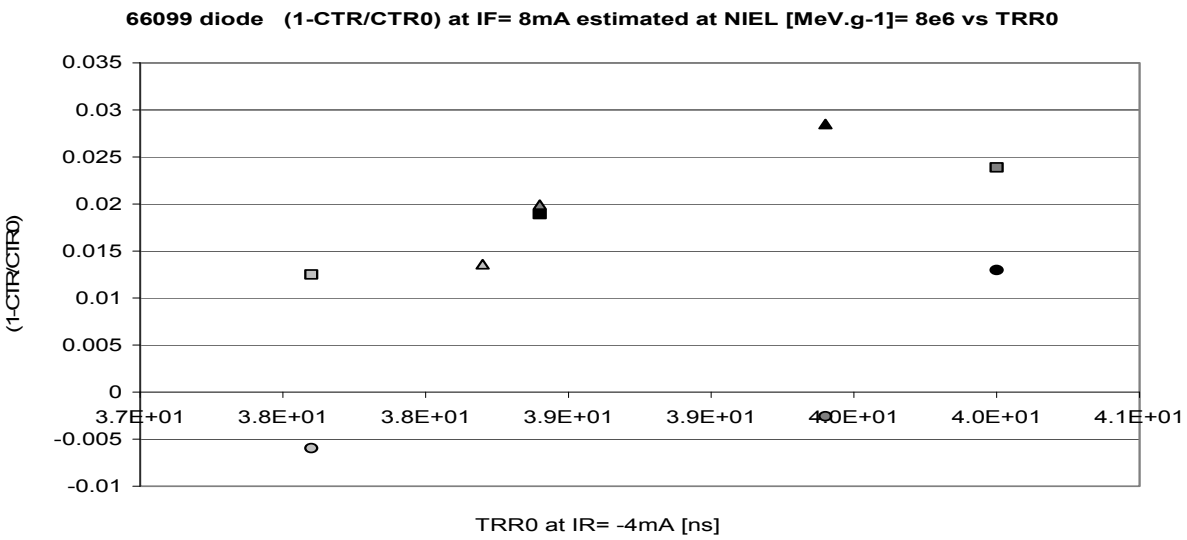

66099 ref (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0E+00
2.0E+07
4.0E+07
6.0E+07
8.0E+07
1.0E+08
1.2E+08
NIEL [MeV.g-1] in Al35Ga65As

Fig. 14-133: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA








66099 diode (1-CTR/CTR0) at IF= 8mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
3.7E+01
3.8E+01
3.8E+01
3.9E+01
3.9E+01
4.0E+01
4.0E+01
4.1E+01
TRR0 at IR= -4mA [ns]

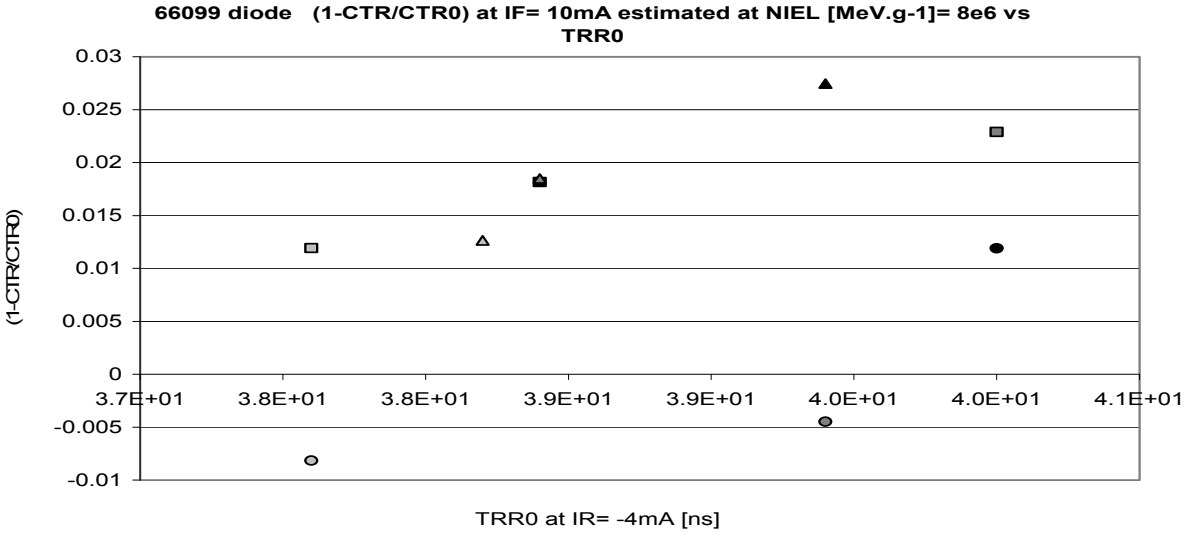

66099 diode (1-CTR/CTR0) at IF= 10mA estimated at NIEL [MeV.g-1]= 8e6 vs TRR0
(1-CTR/CTR0)
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
3.7E+01
3.8E+01
3.8E+01
3.9E+01
3.9E+01
4.0E+01
4.0E+01
4.1E+01
TRR0 at IR= -4mA [ns]

Fig. 14-134: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 14-135: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 4.88.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 14-136: 66099 diode: 1 - CTR/CTR$_0$ estimated at a NIEL of 9.6.10^7 MeV.g^{-1} (GEANT4 TOTAL) at I_F= 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4mA

Fig. 14-137: 66099 optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

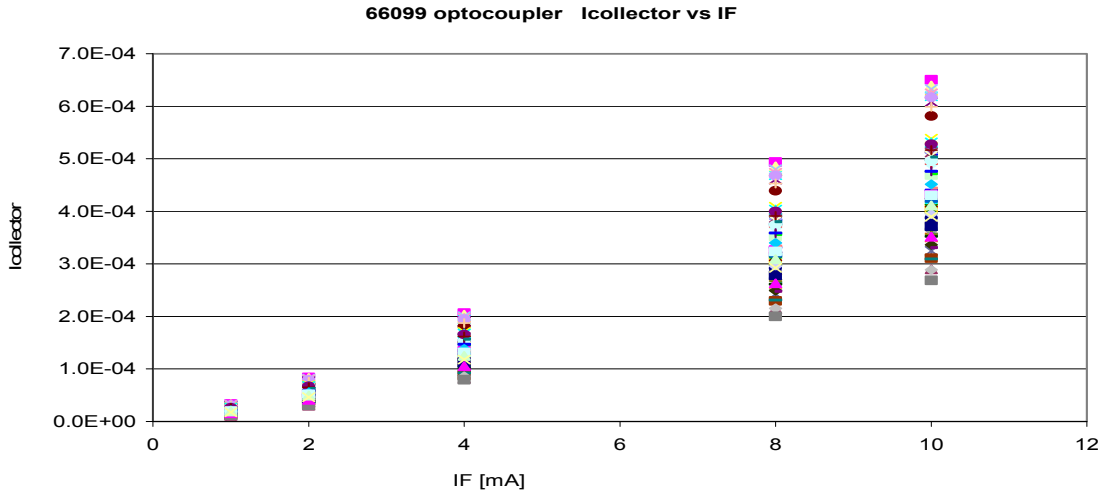


Fig. 14-138: 66099 optocoupler irradiated: CTR for each step with respect to diode current I_F

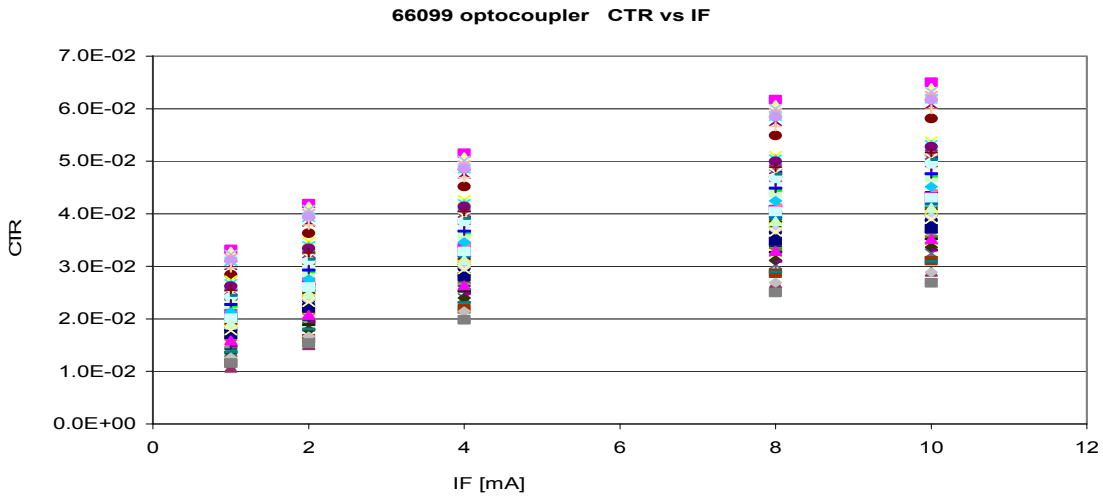


Fig. 14-139: 66099 optocoupler irradiated: CTR/CTR_0 for each step with respect to diode current I_F

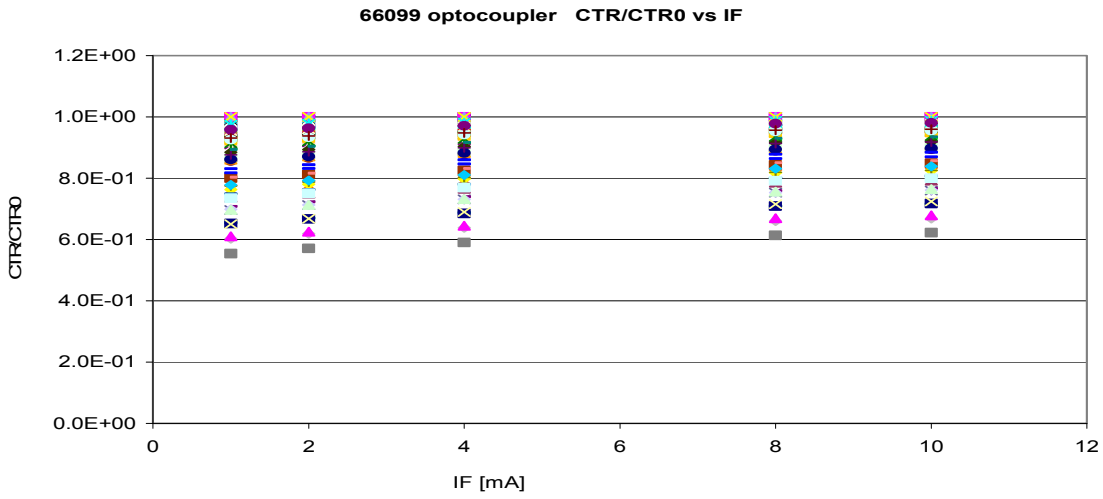


Fig. 14-140: 66099 diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

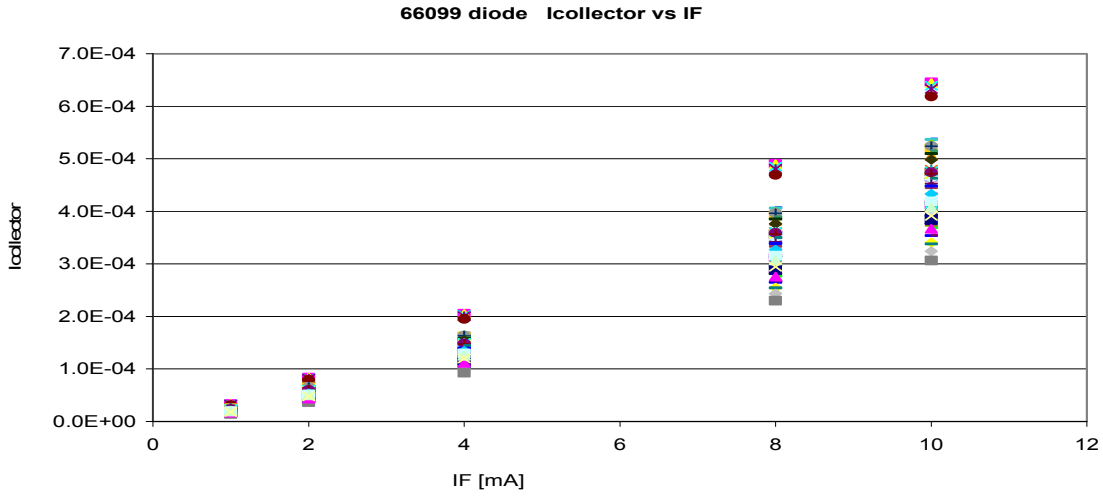


Fig. 14-141: 66099 diode irradiated: CTR for each step with respect to diode current I_F

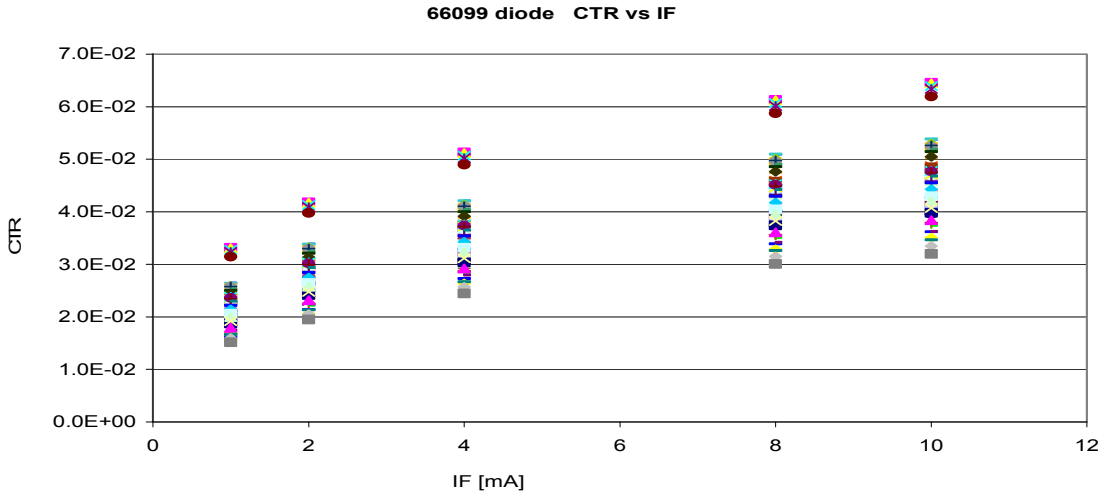


Fig. 14-142: 66099 diode irradiated: CTR/CTR_0 for each step with respect to diode current I_F

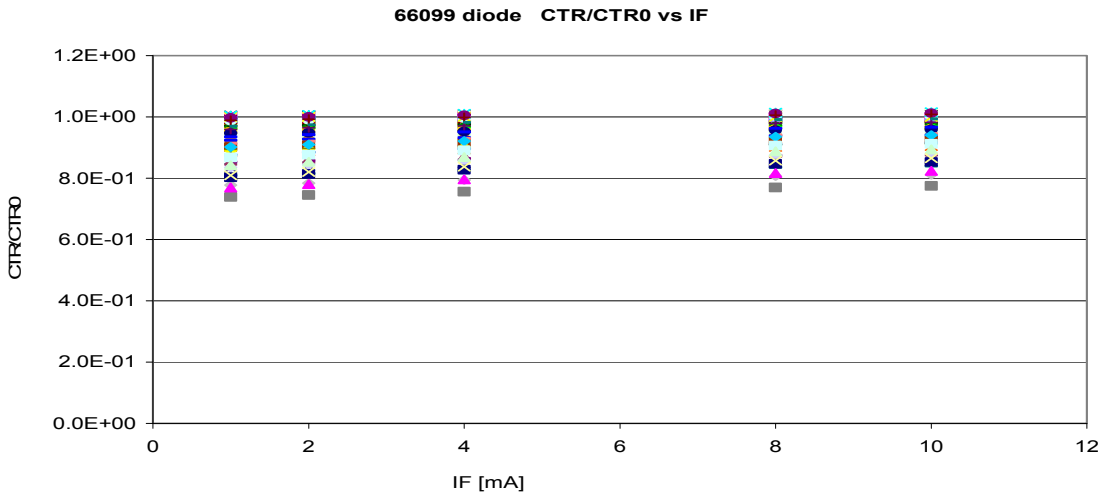


Fig. 14-143: 66099 transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

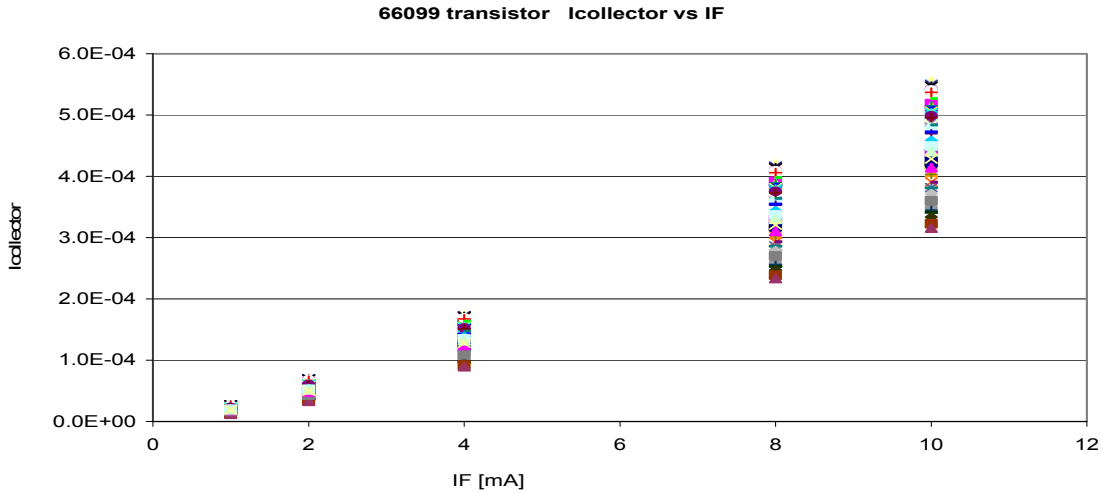


Fig. 14-144: 66099 transistor irradiated: CTR for each step with respect to diode current I_F

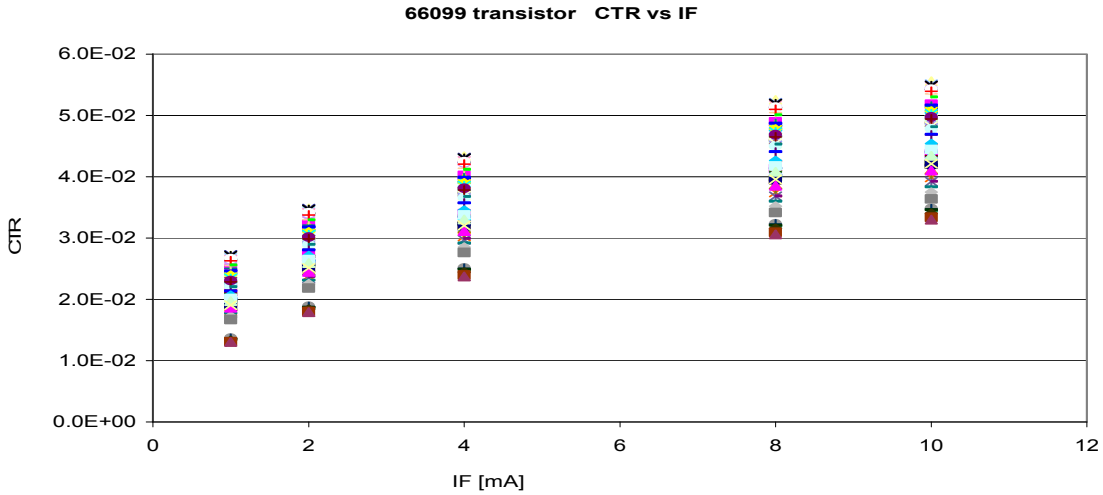


Fig. 14-145: 66099 transistor irradiated: CTR/CTR_0 for each step with respect to diode current I_F

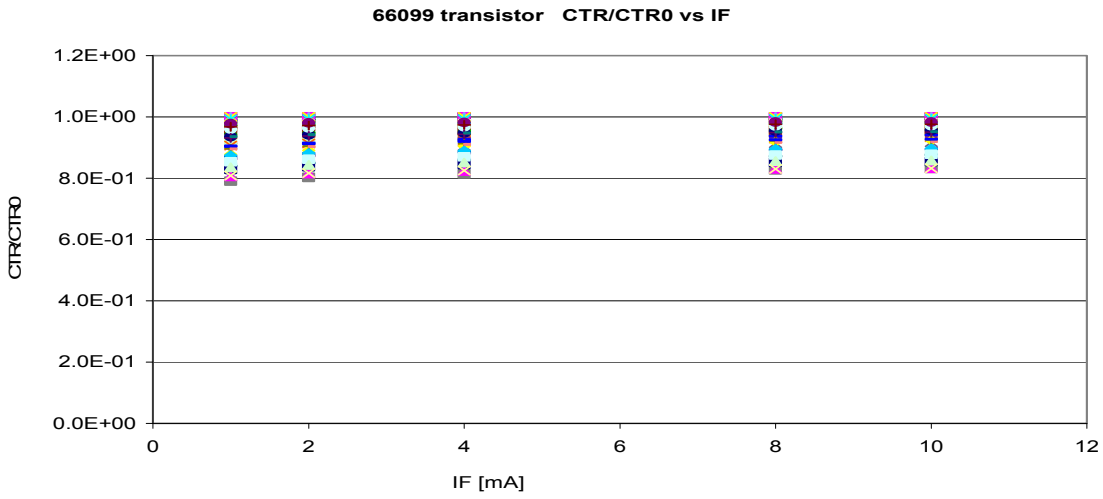


Fig. 14-146: 66099 reference measurement: transistor collector current I_C for each step with respect to diode current I_F

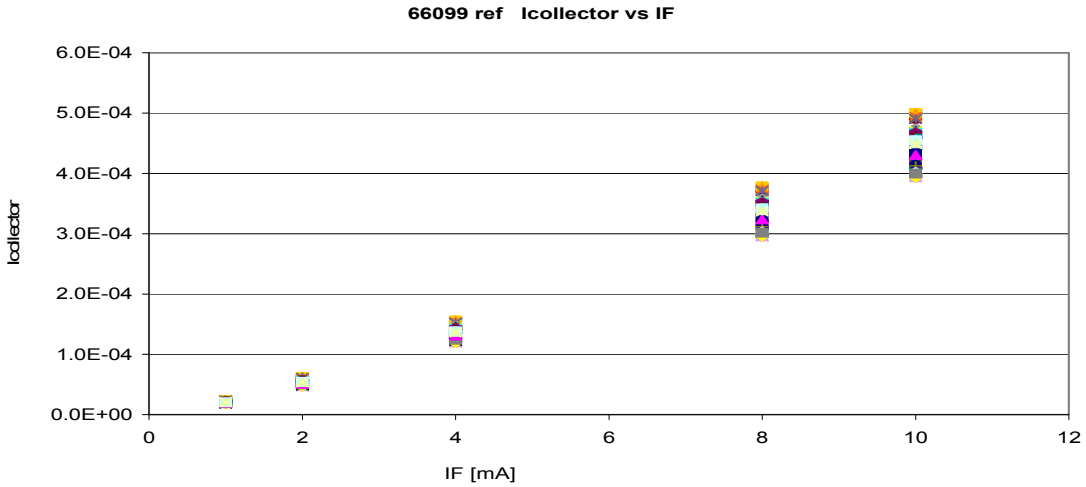


Fig. 14-147: 66099 reference measurement: CTR for each step with respect to diode current I_F

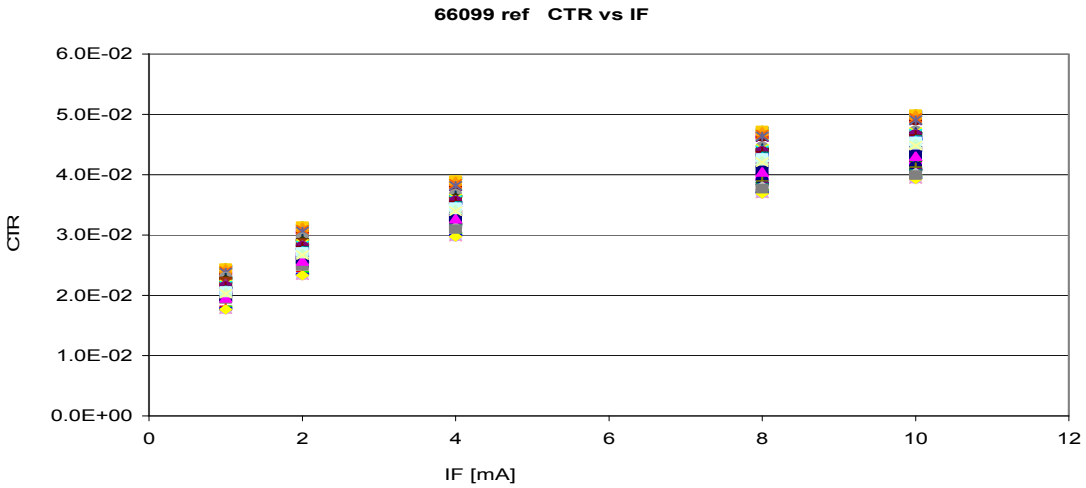


Fig. 14-148: 66099 reference measurement: CTR/CTR_0 for each step with respect to diode current I_F

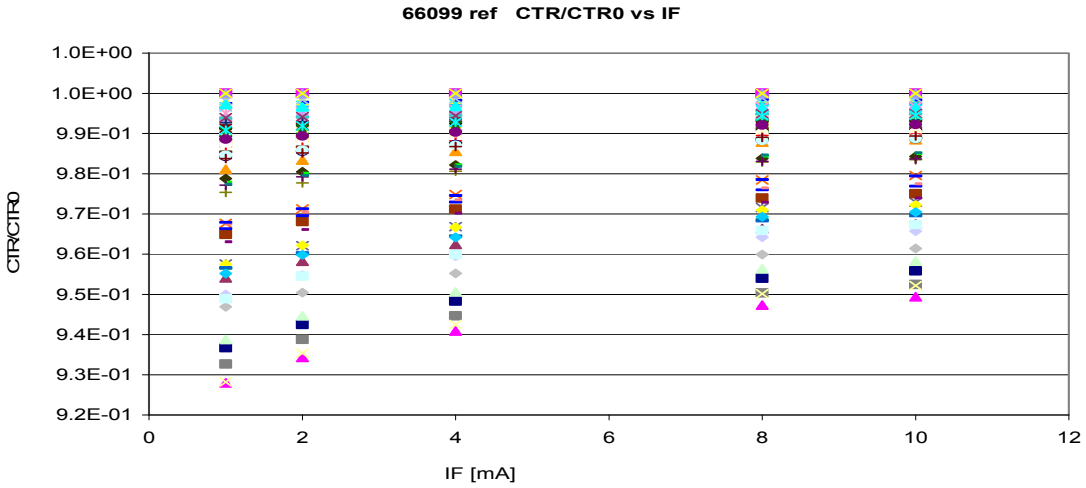
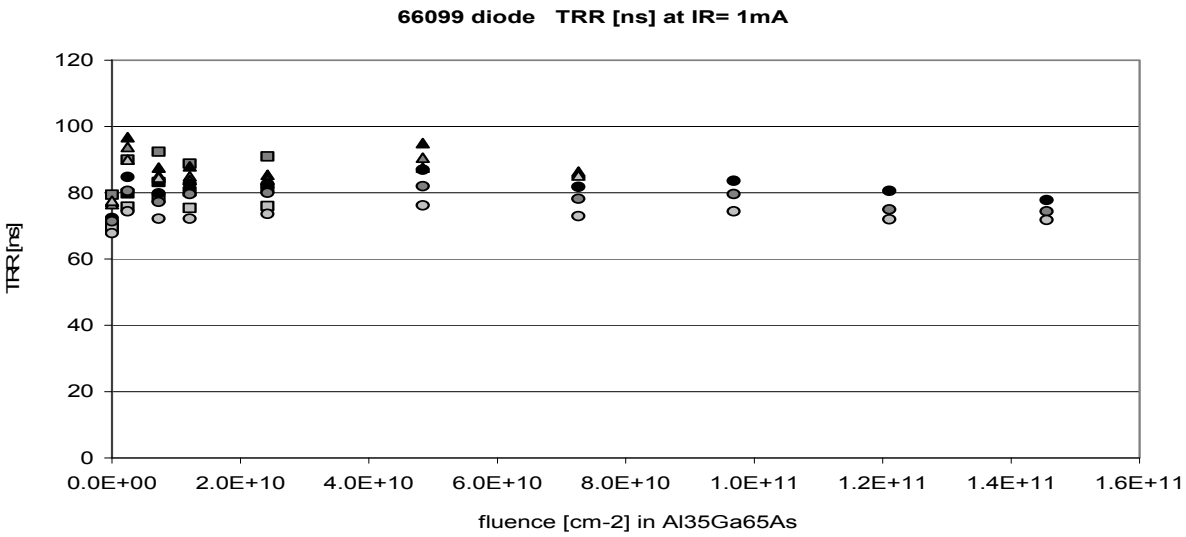
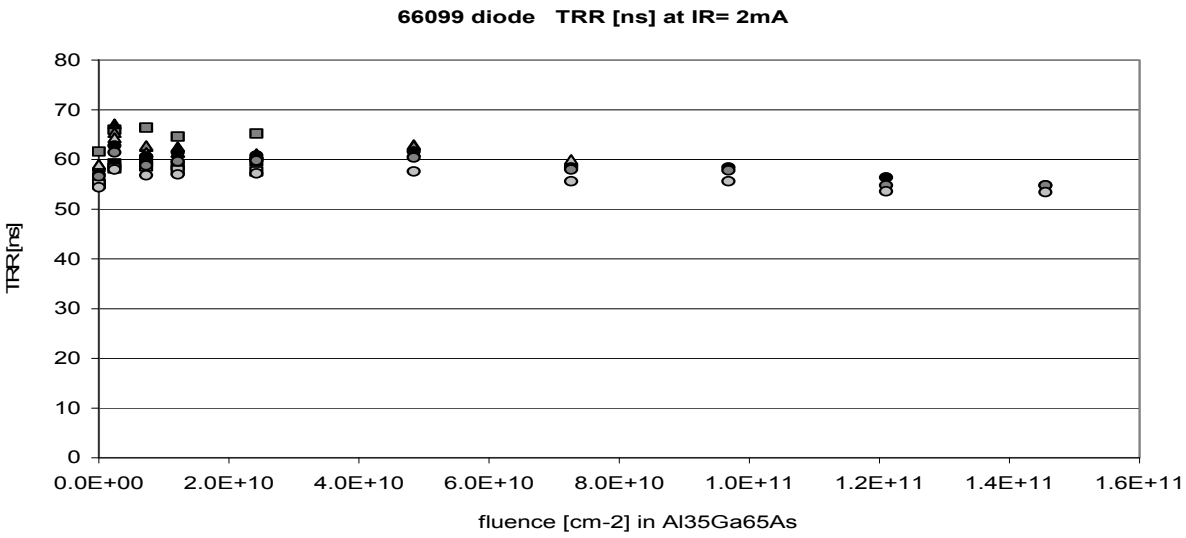


Fig. 14-149: 66099 diode: τ_{RR} [ns] with respect to fluence at I_R = -1, -2, -4 mA





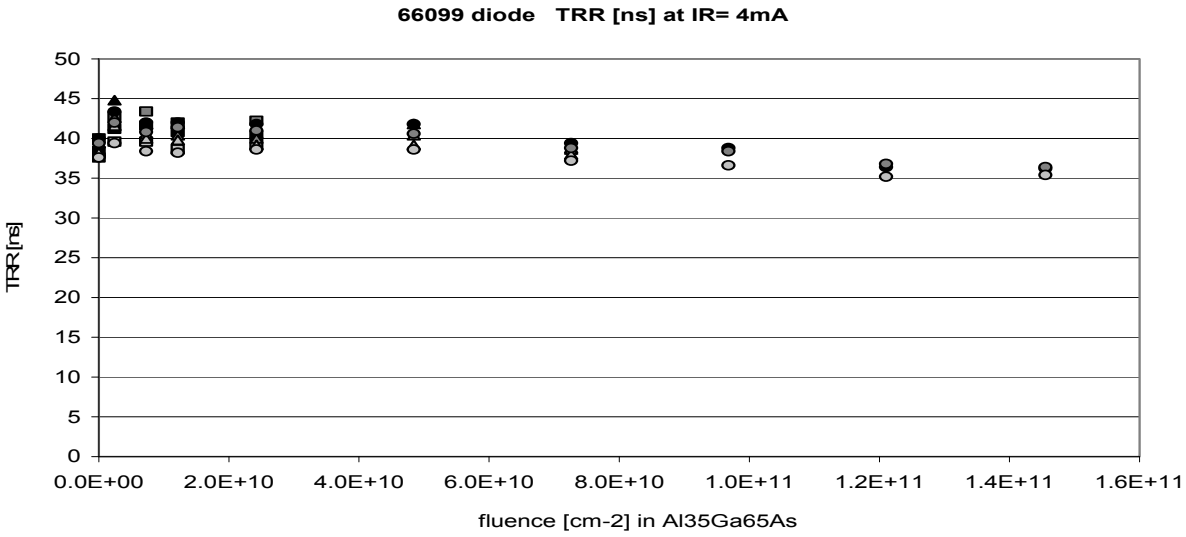
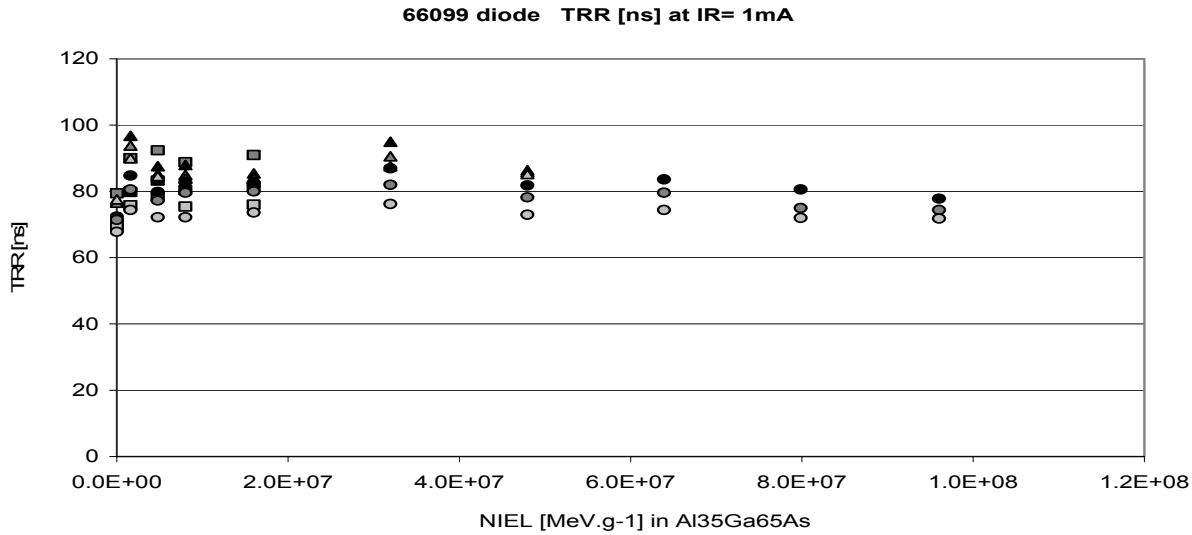
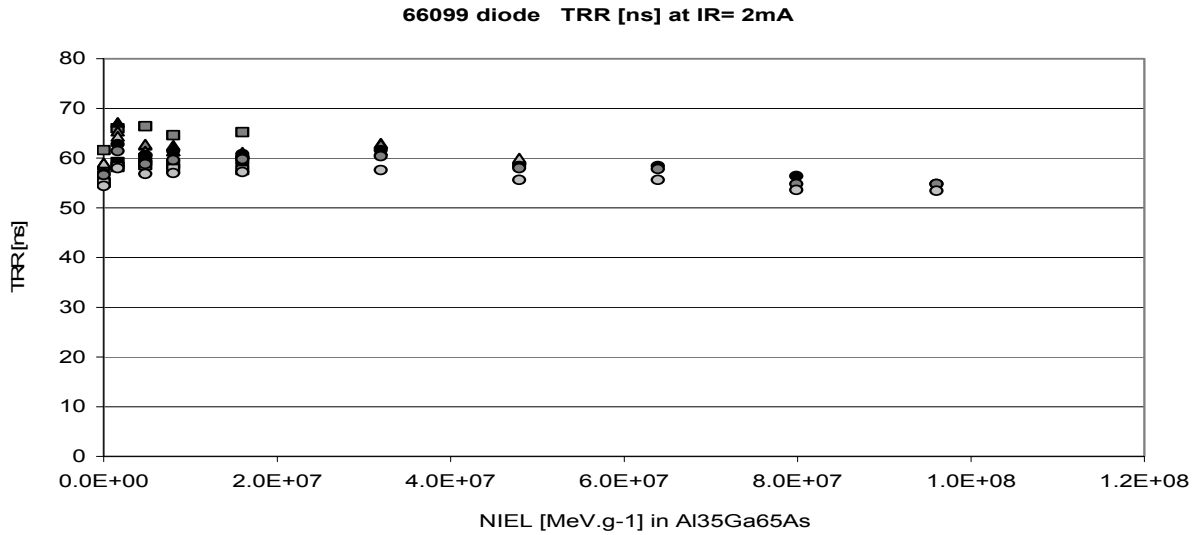


Fig. 14-150: 66099 diode: τ_{RR} [ns] with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





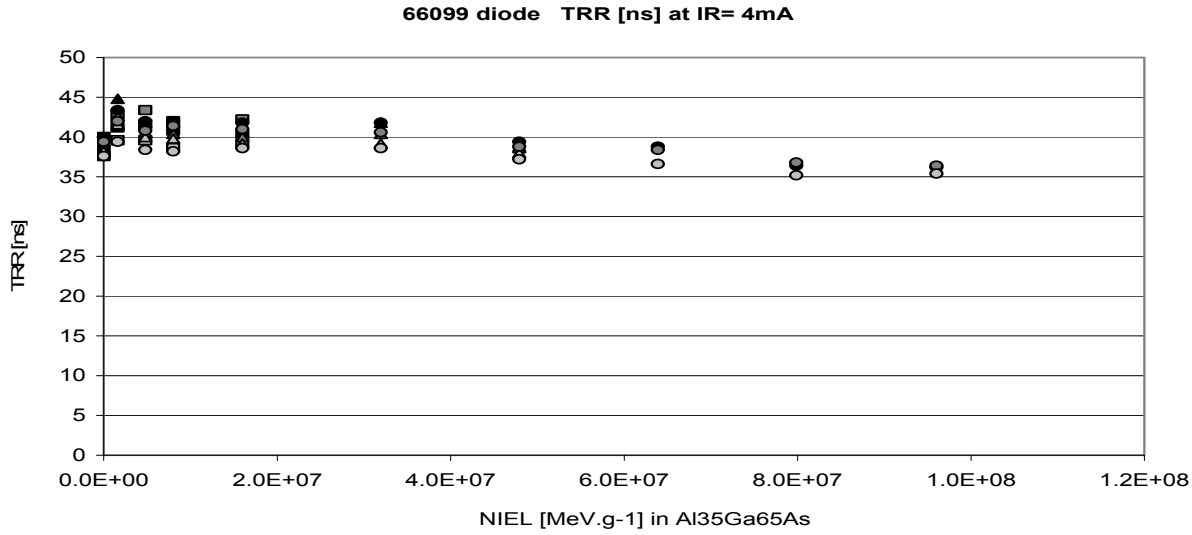
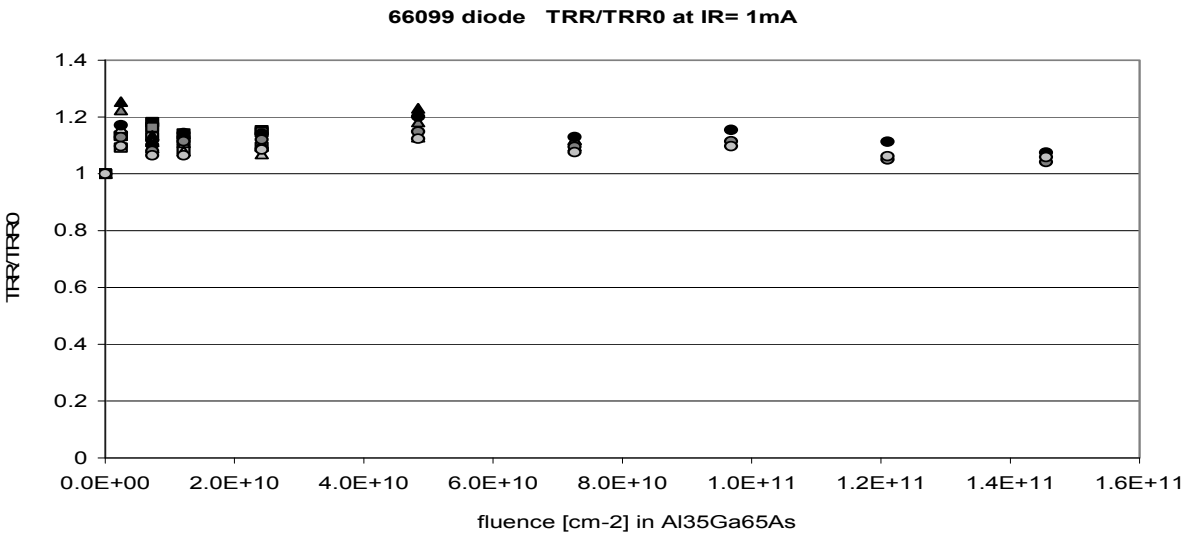
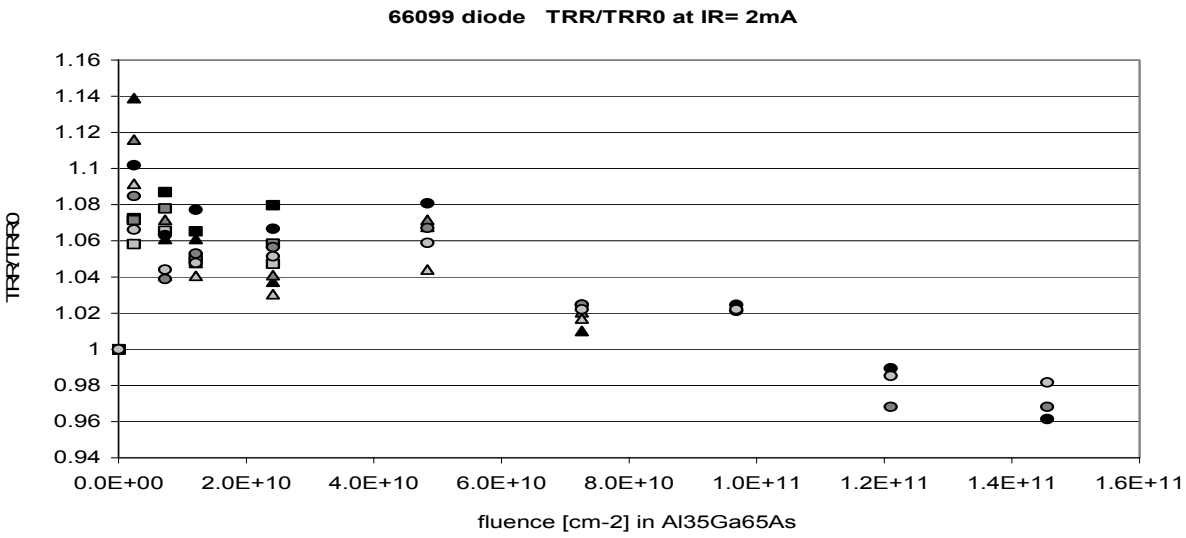


Fig. 14-151: 66099 diode: τ_{RR}/τ_{RR0} with respect to fluence at I_R = -1, -2, -4 mA





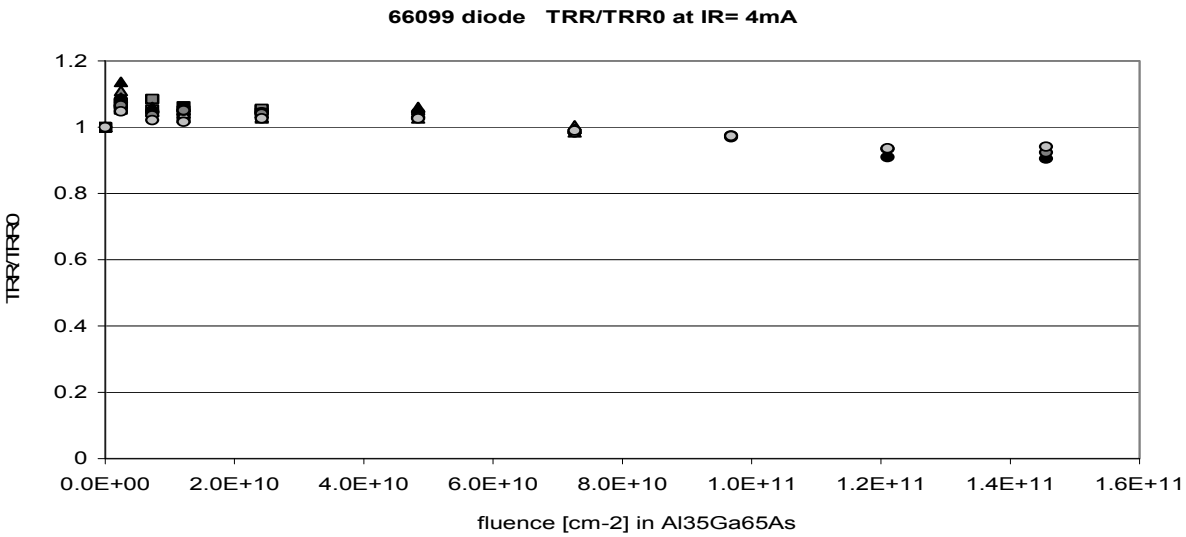
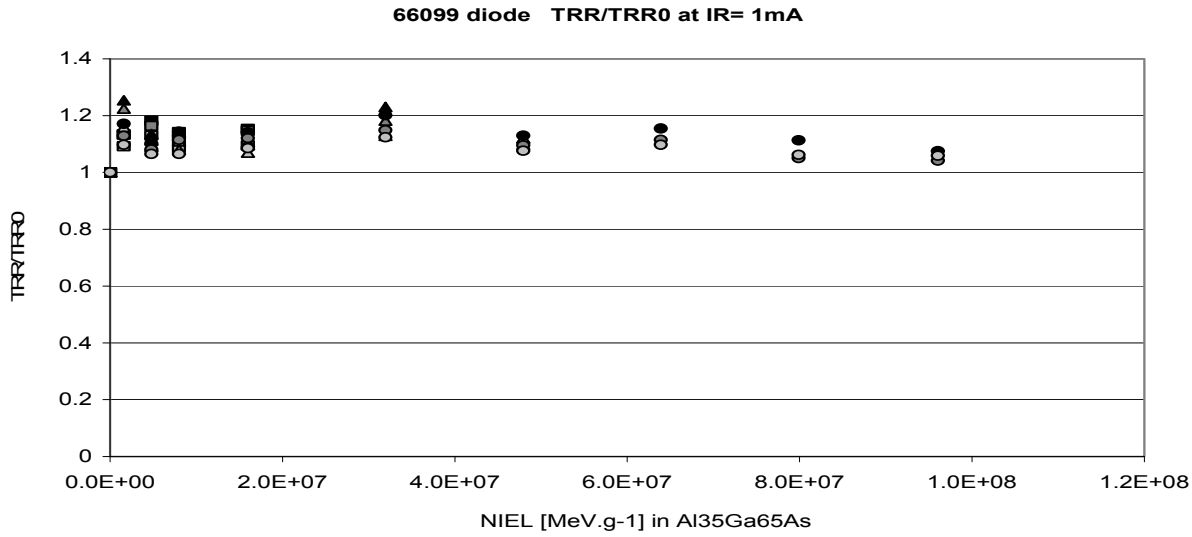
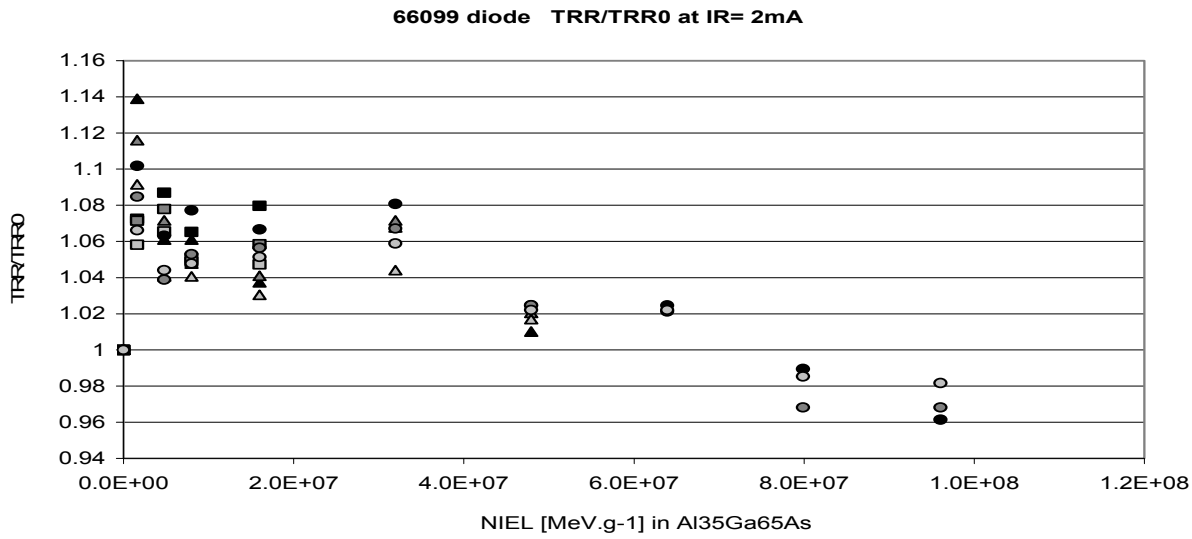


Fig. 14-152: 66099 diode: τ_{RR}/τ_{RR0} with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





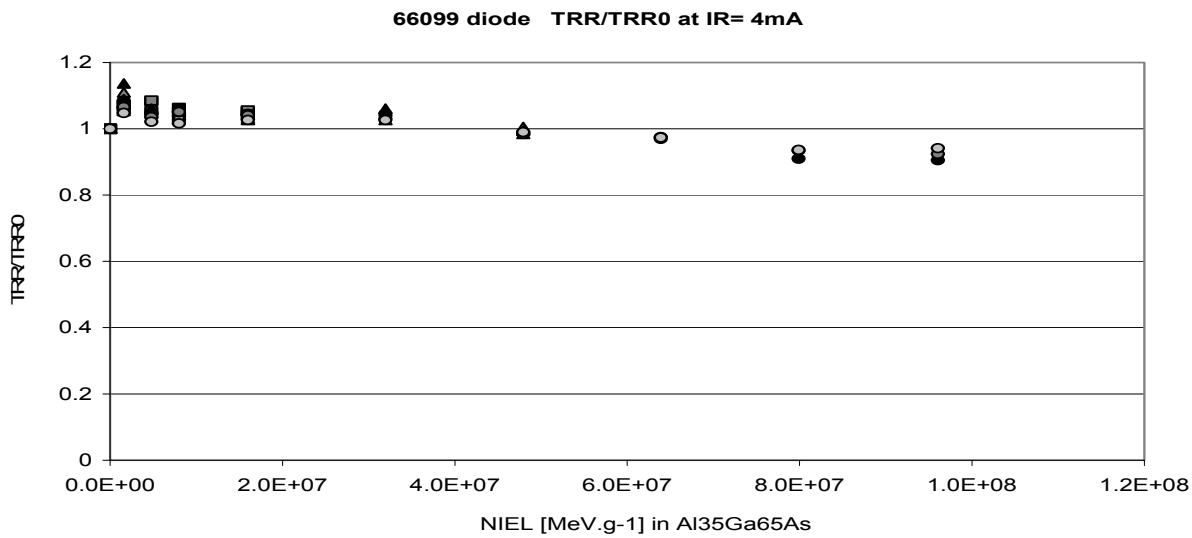
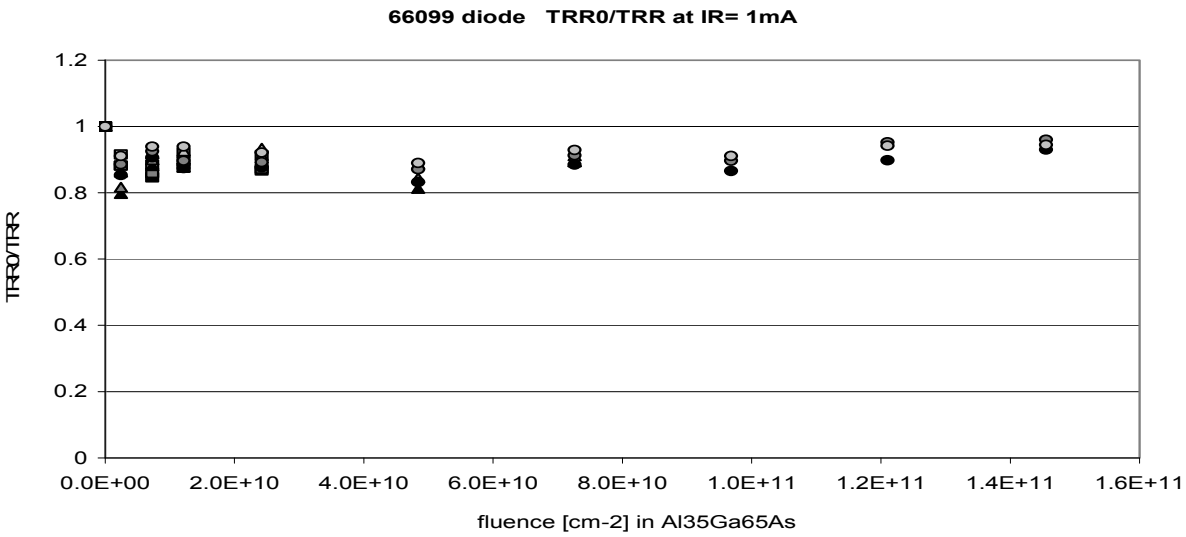
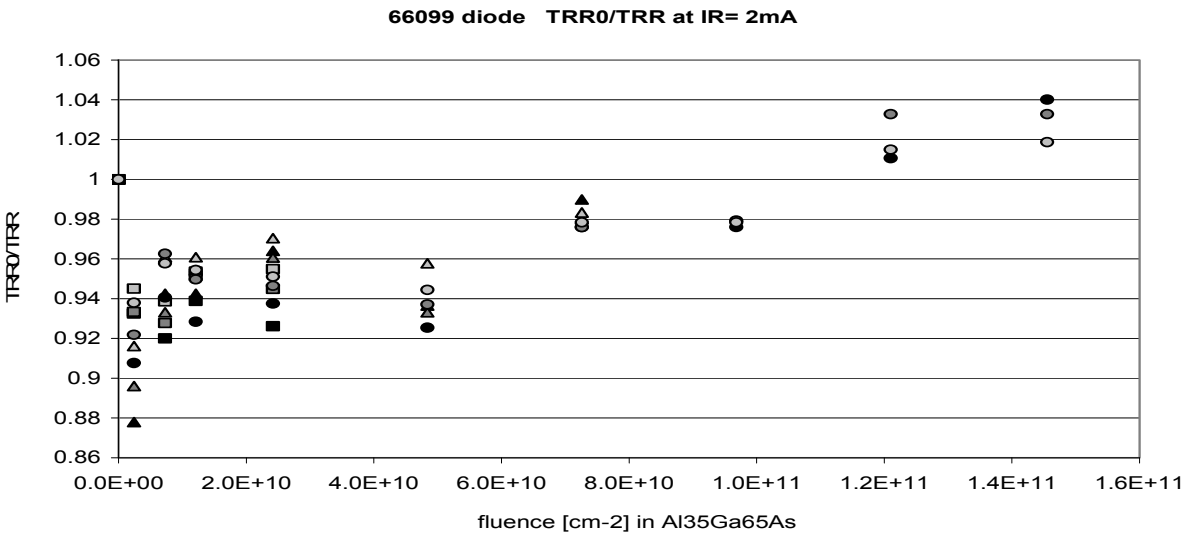


Fig. 14-153: 66099 diode: τ_{RR0}/τ_{RR} with respect to fluence at I_R = -1, -2, -4 mA





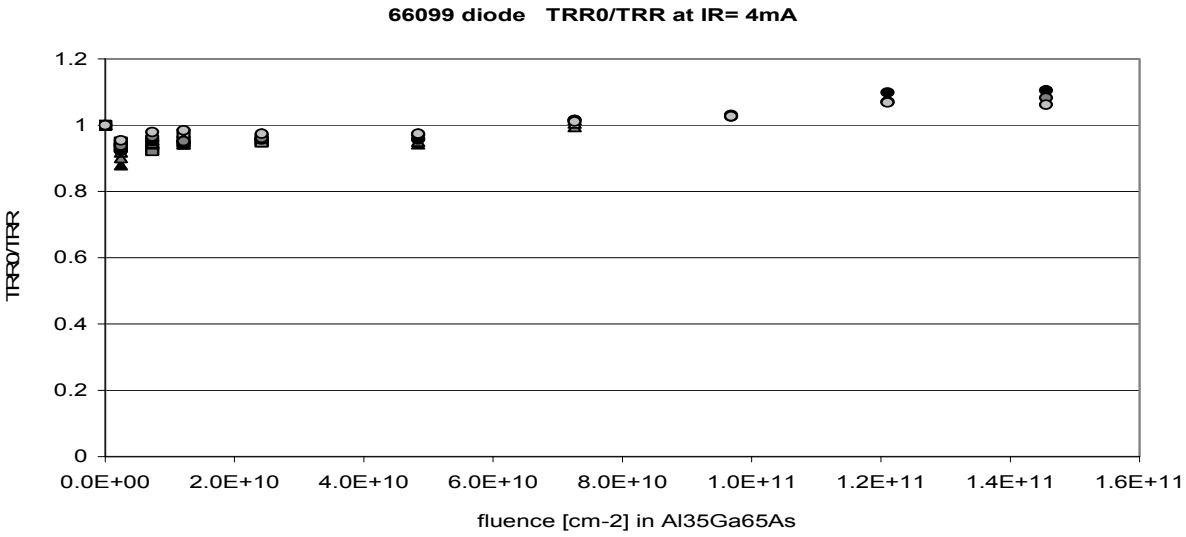
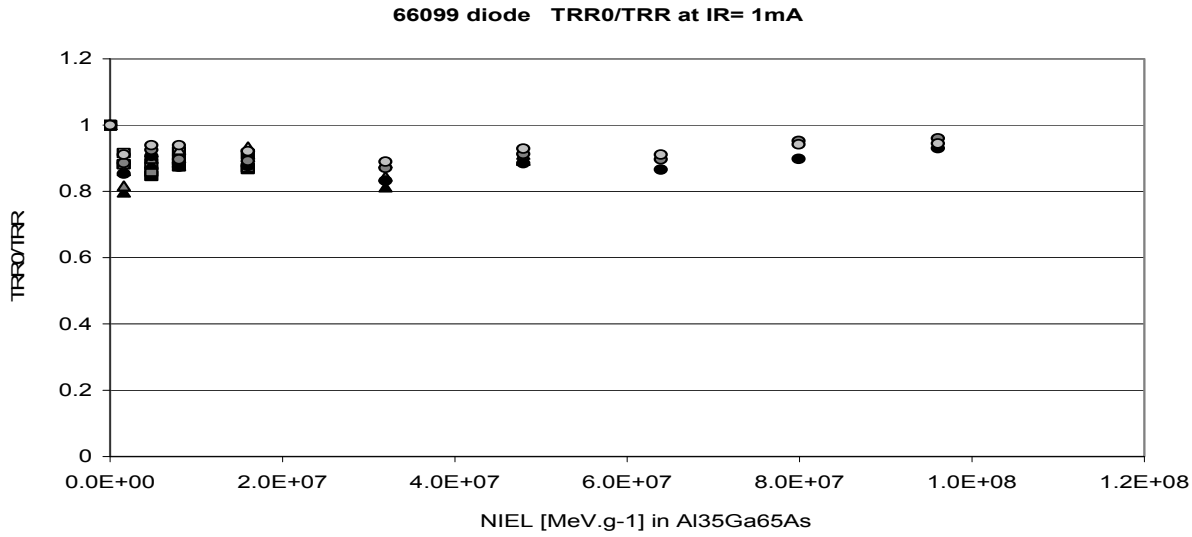
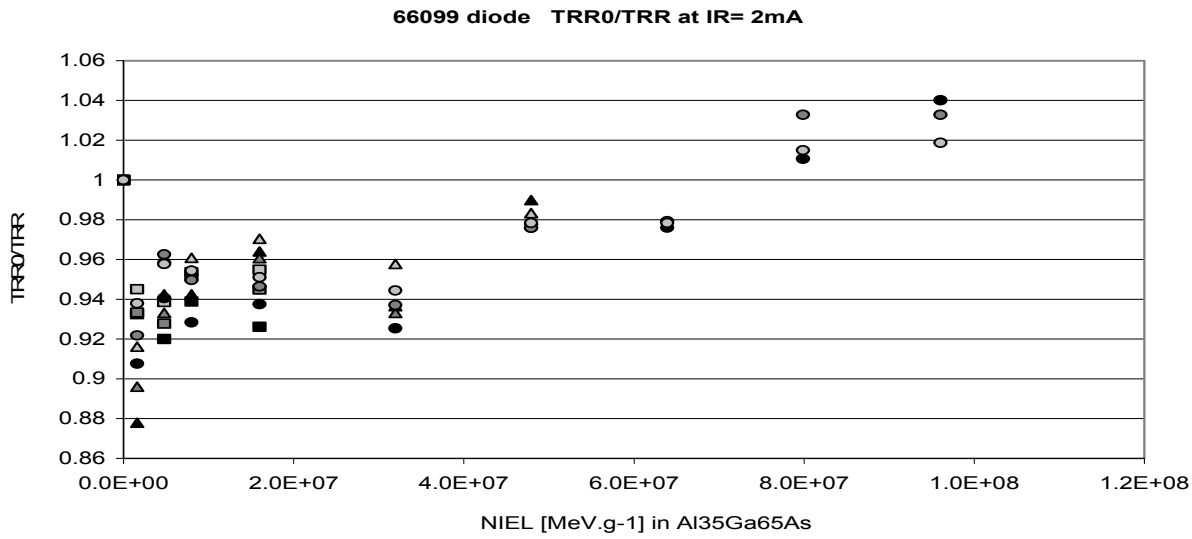


Fig. 14-154: 66099 diode: τ_{RR0}/τ_{RR} with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL) at I_R = -1, -2, -4 mA





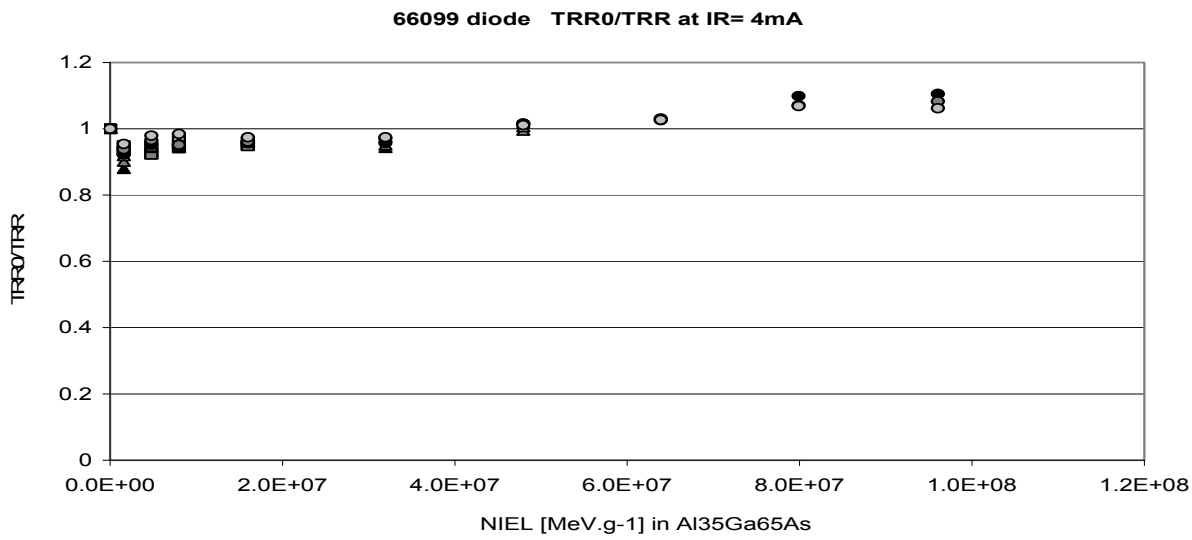
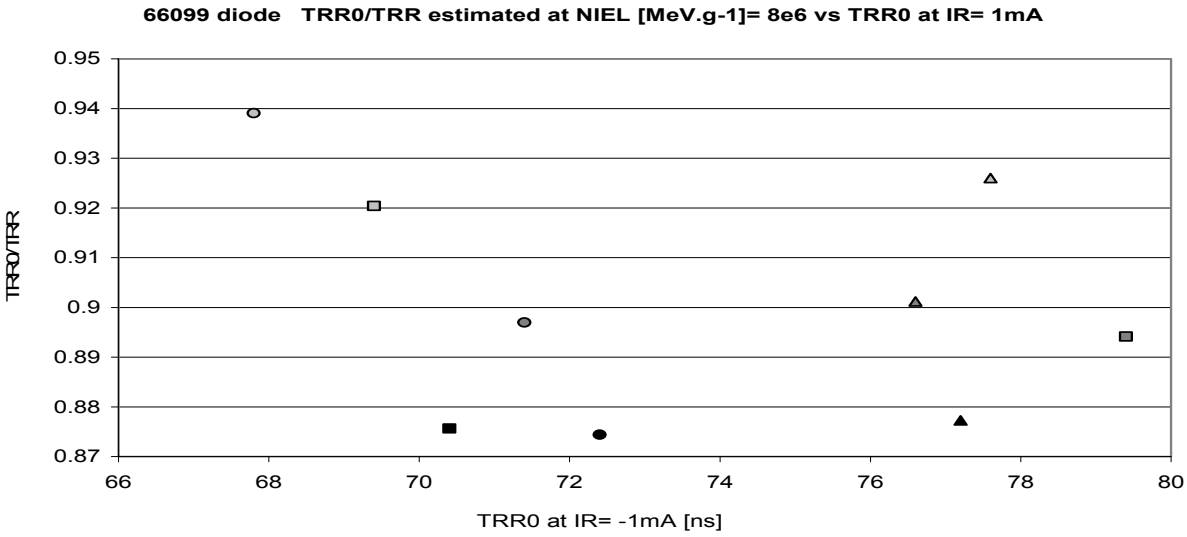
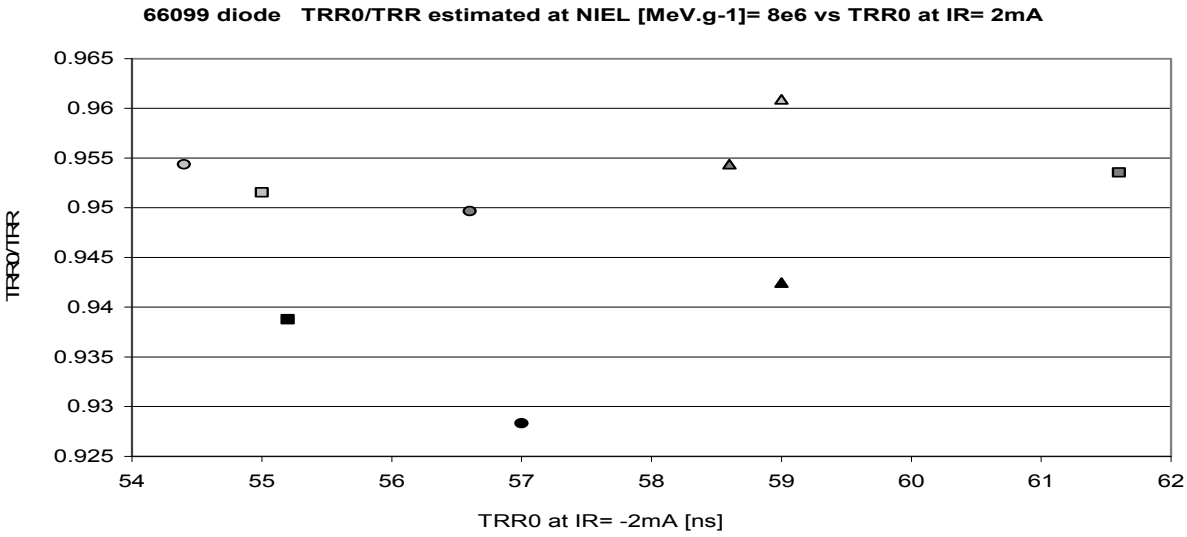


Fig. 14-155: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 8.10^6 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA





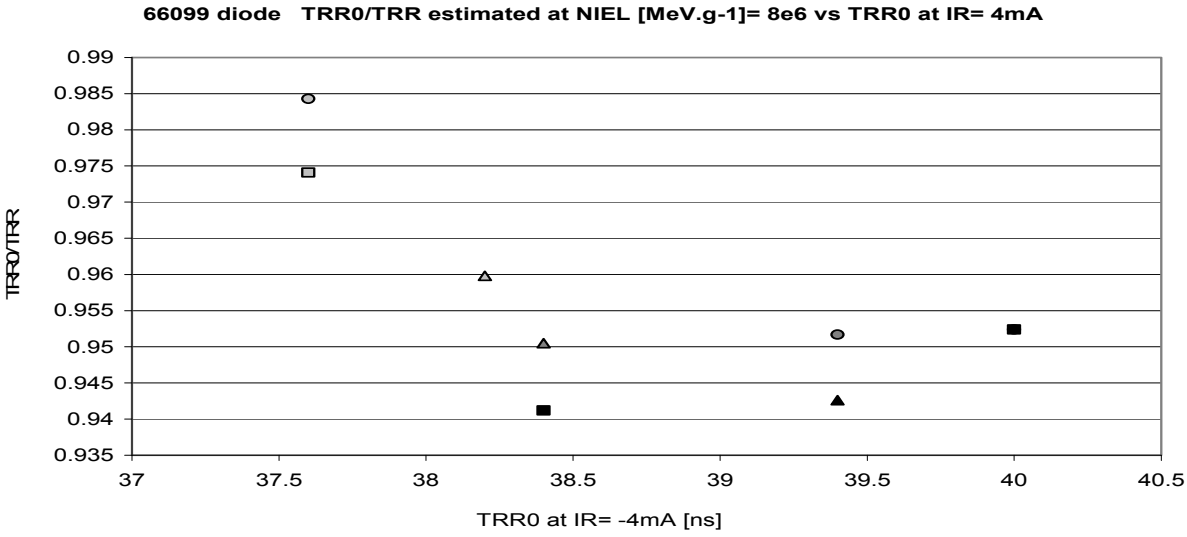


Fig. 14-156: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of 2.10^7 MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

Fig. 14-157: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $4.88.10^{7}$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

Fig. 14-158: 66099 diode: τ_{RR0}/τ_{RR} estimated at a NIEL of $9.6.10^{7}$ MeV.g^{-1} (GEANT4 TOTAL) with respect to τ_{RR0} at I_R = -1, -2, -4 mA

Fig. 14-159: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to fluence

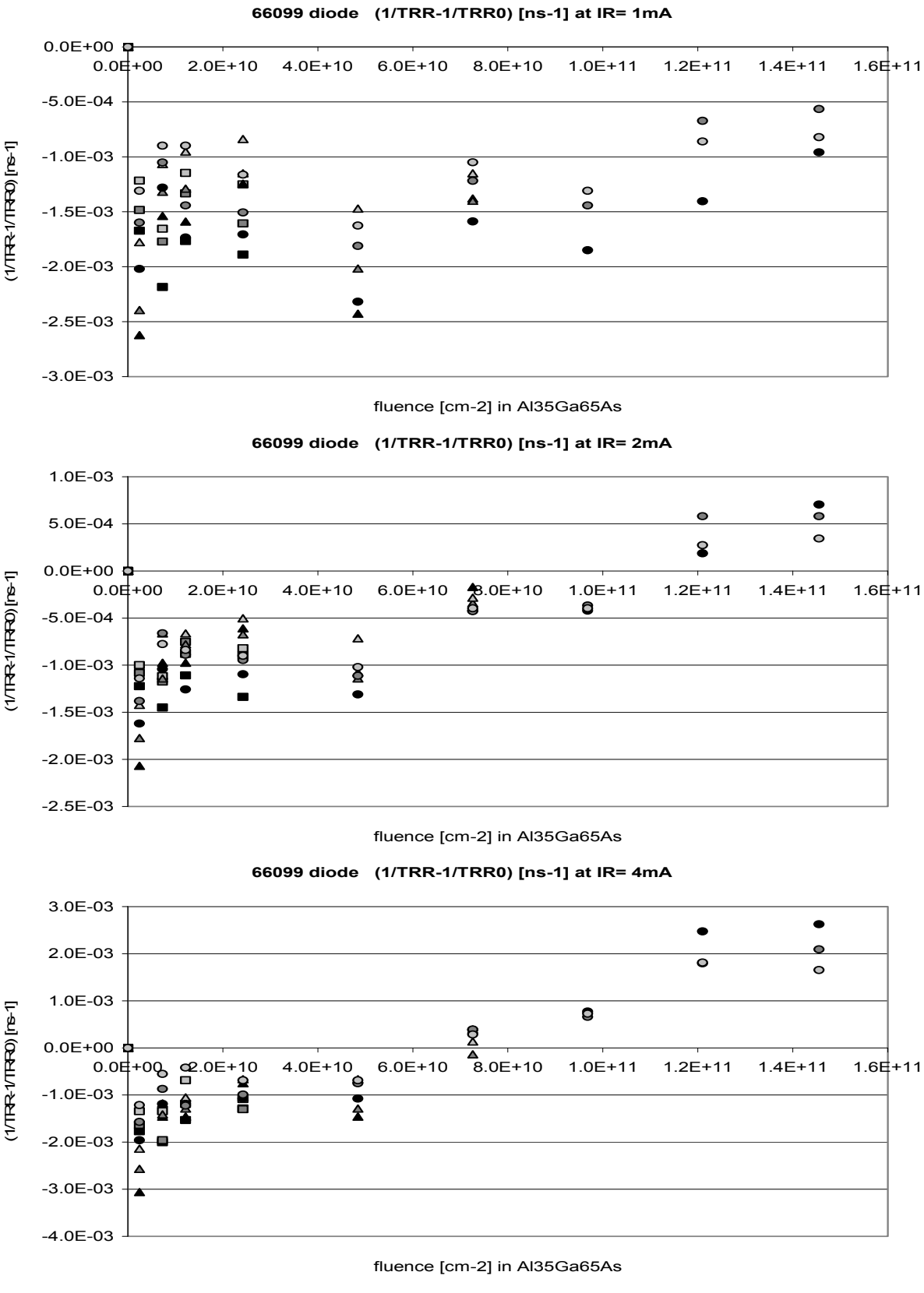


Fig. 14-160: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to NIEL in $Al_{0.35}Ga_{0.65}As$ (GEANT4 TOTAL)

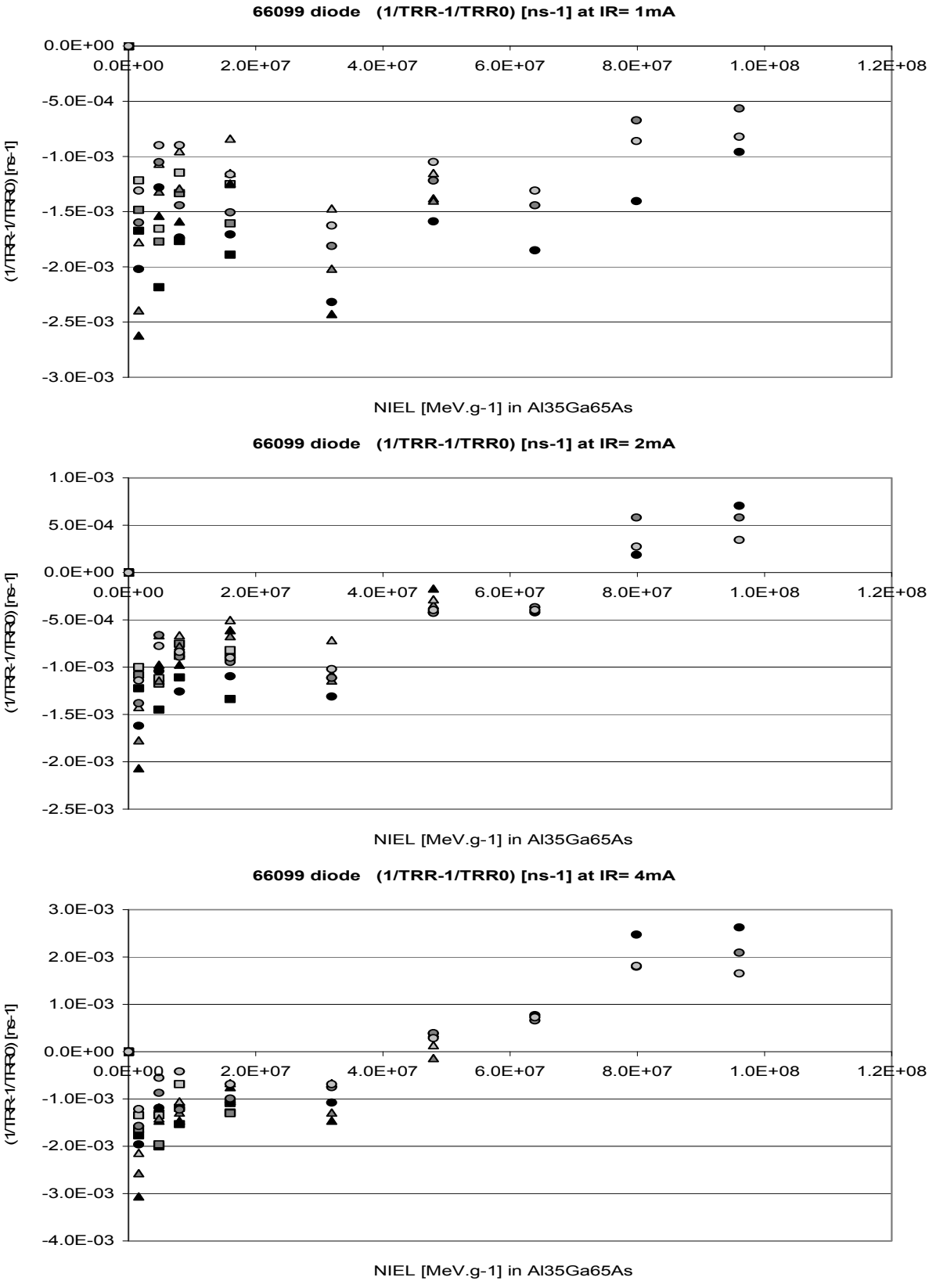


Fig. 14-161: 66099 diode: K_Φ at I_R = -1, -2, -4mA with respect to τ_{RR0}

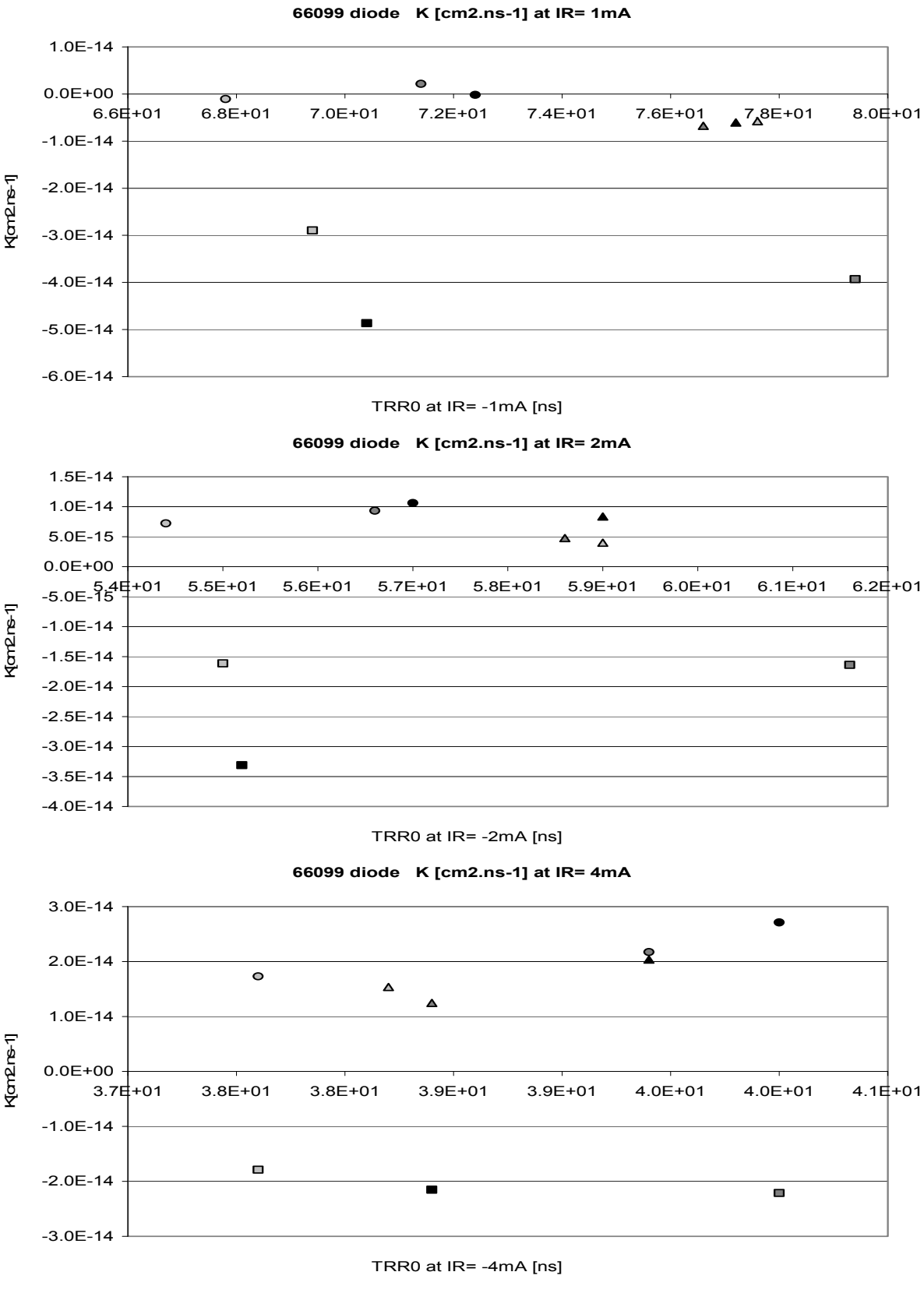


Fig. 14-162: 66099 diode: K_{NIEL} at I_R = -1, -2, -4mA with respect to τ_{RR0}

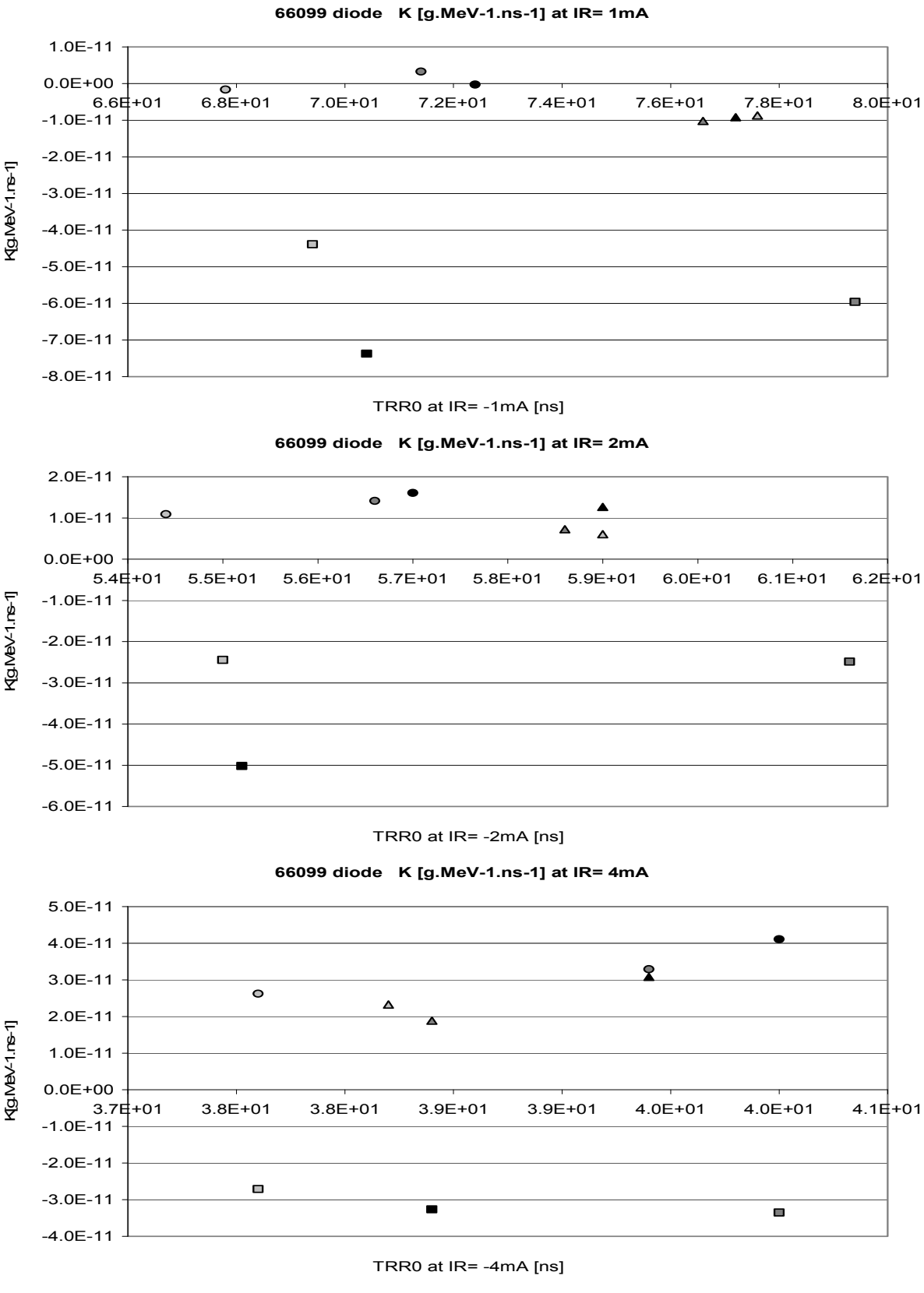
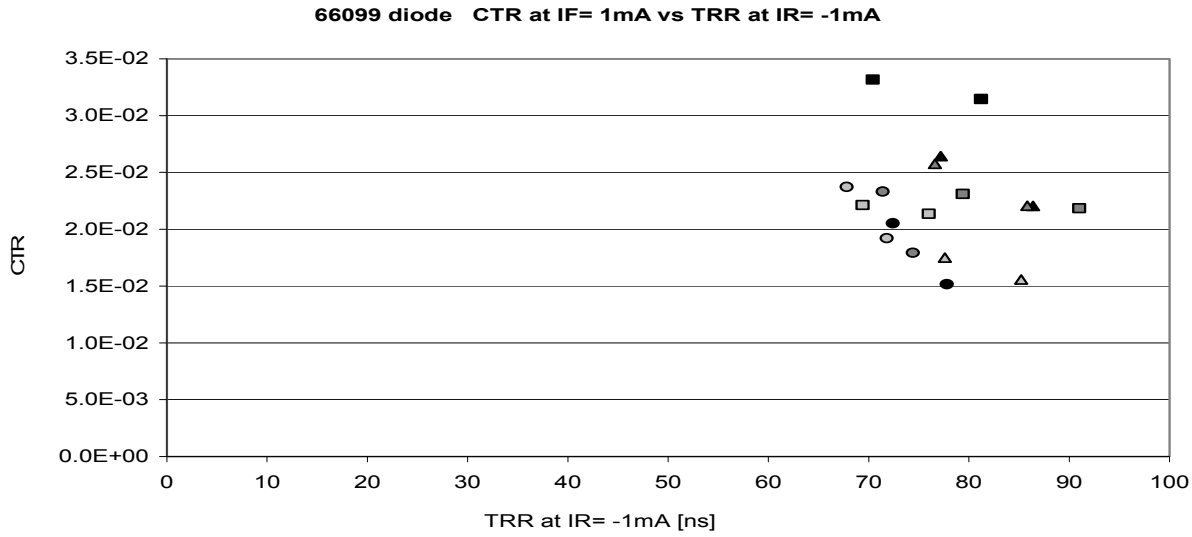
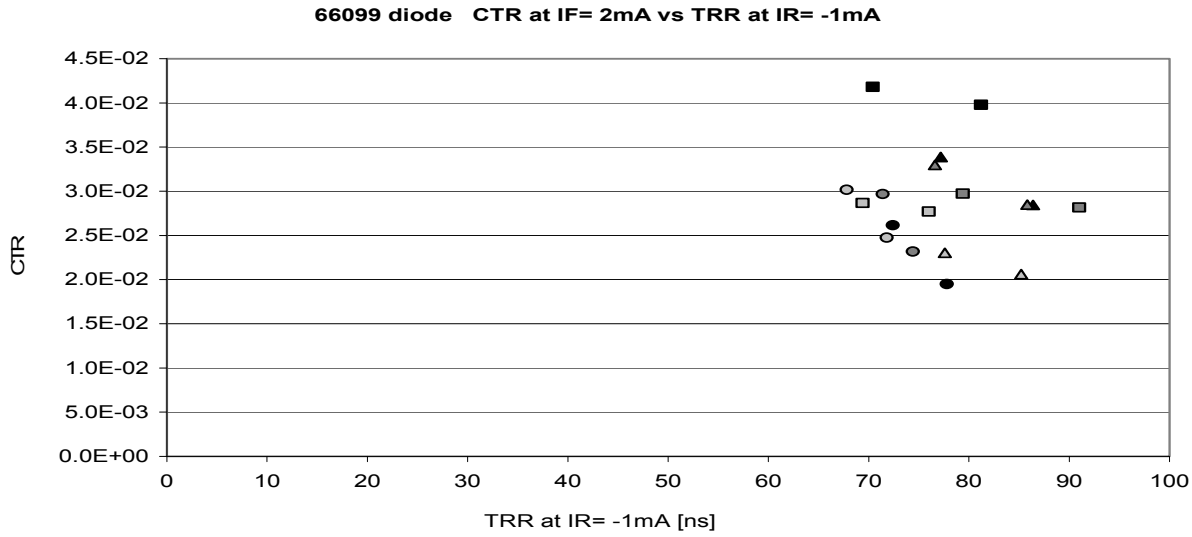
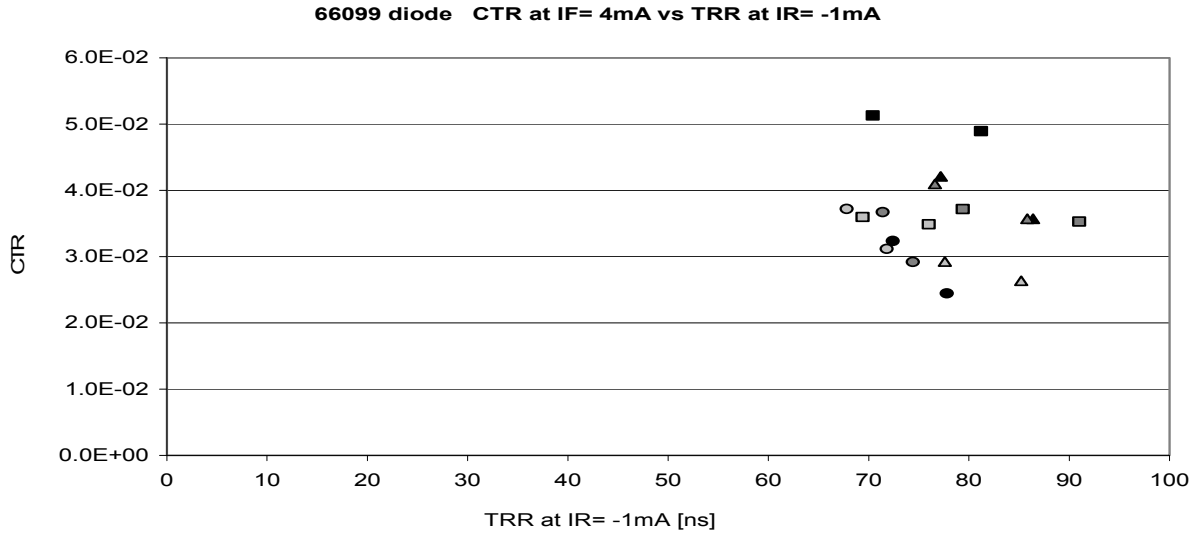
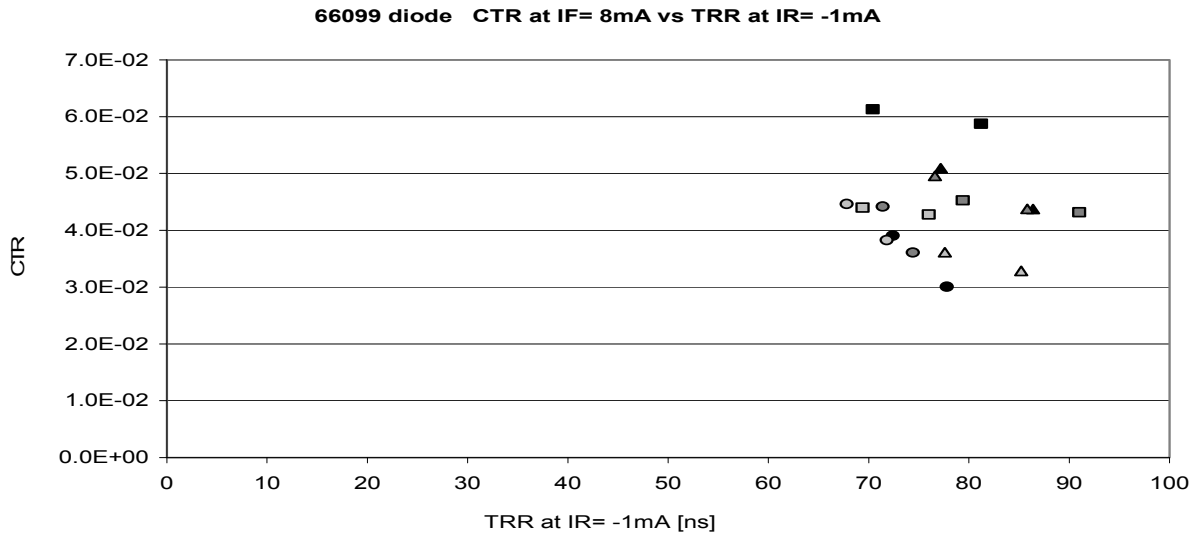


Fig. 14-163: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
90
100
TRR at IR= -1mA [ns]

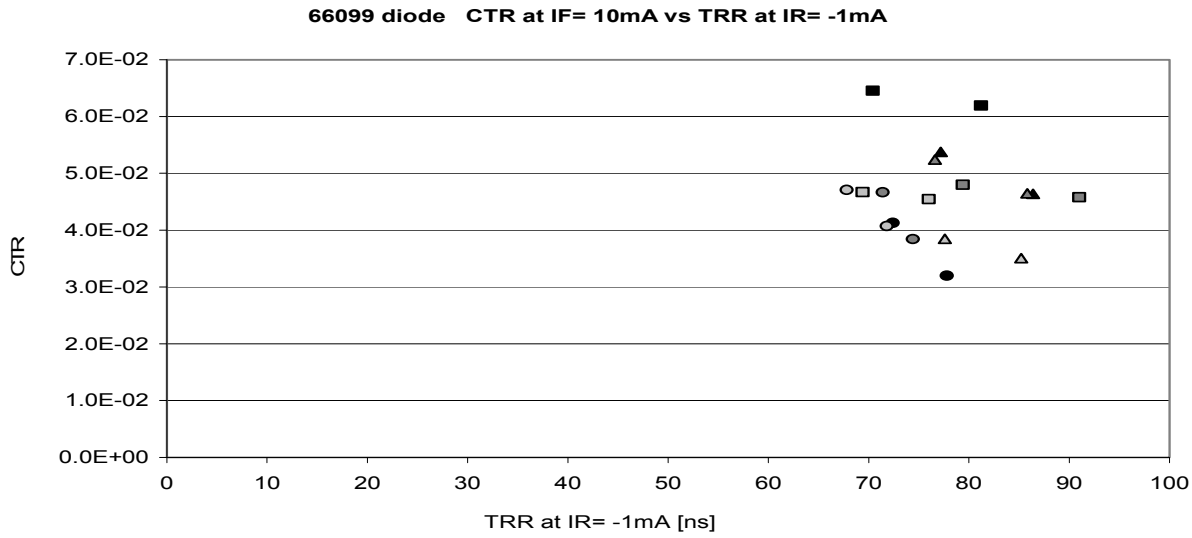
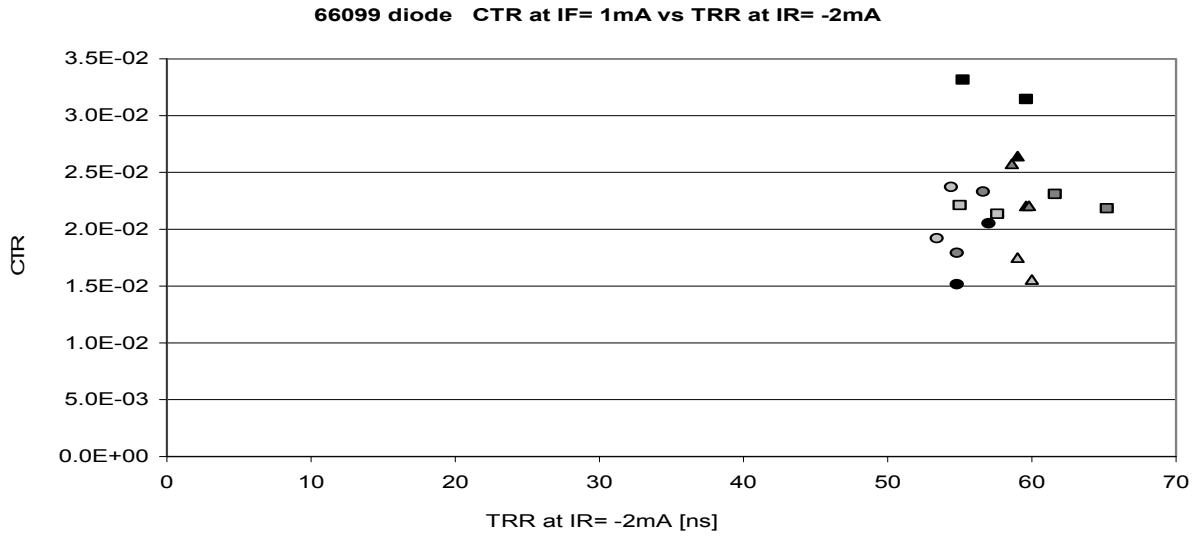
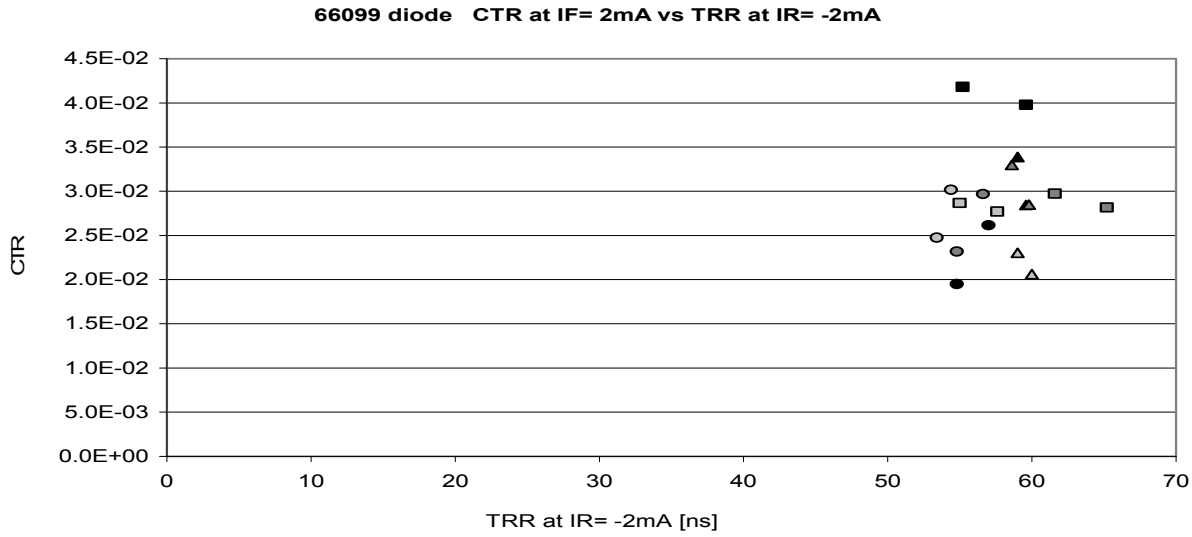
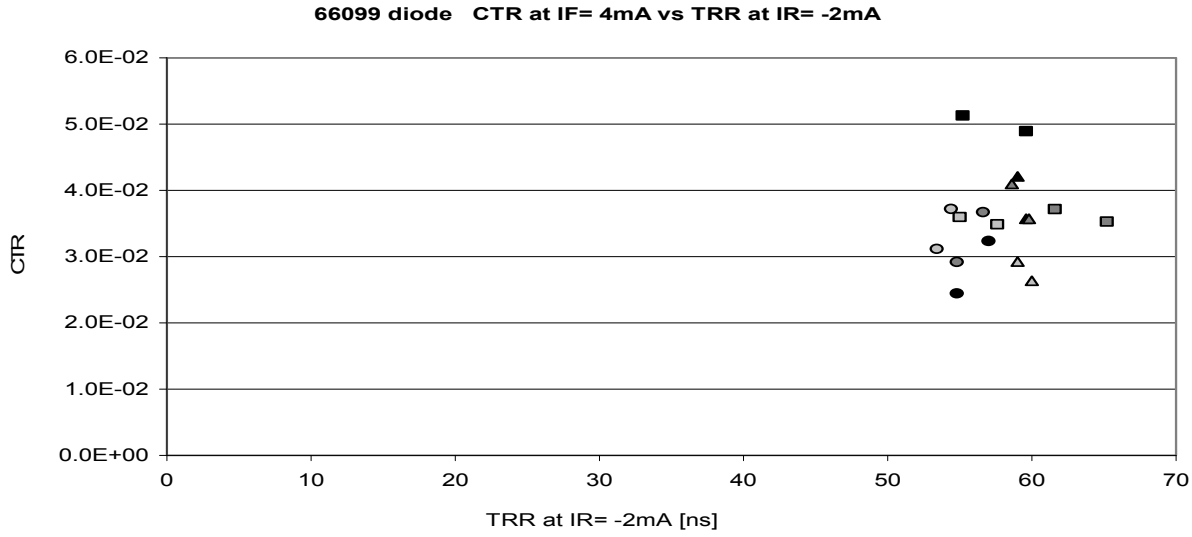
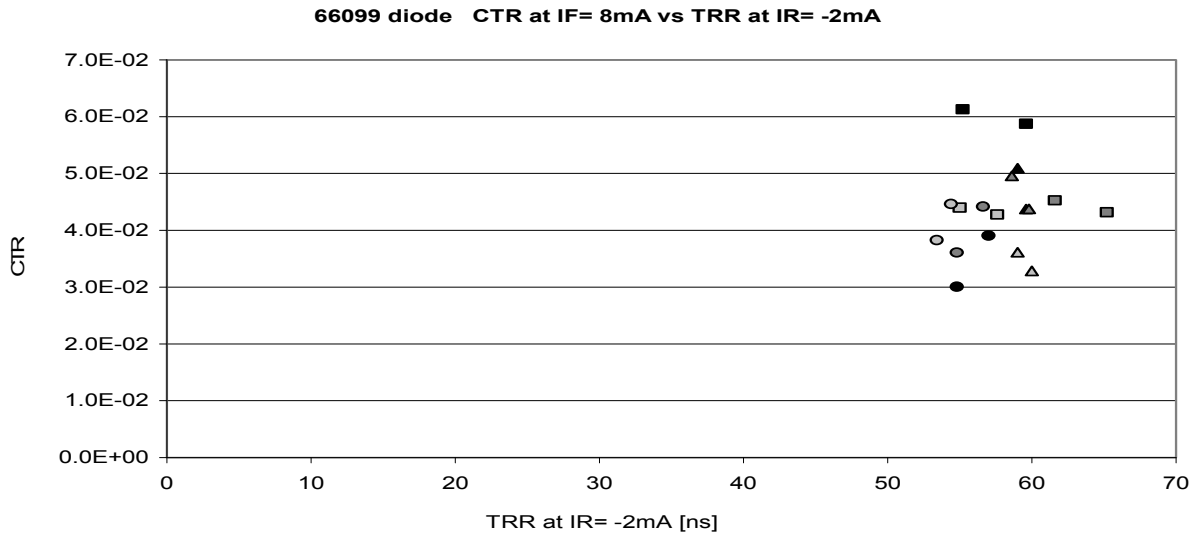

66099 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
90
100
TRR at IR= -1mA [ns]

Fig. 14-164: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φp_2 (lower triangles) Φp_3 (lower circles), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -2mA [ns]

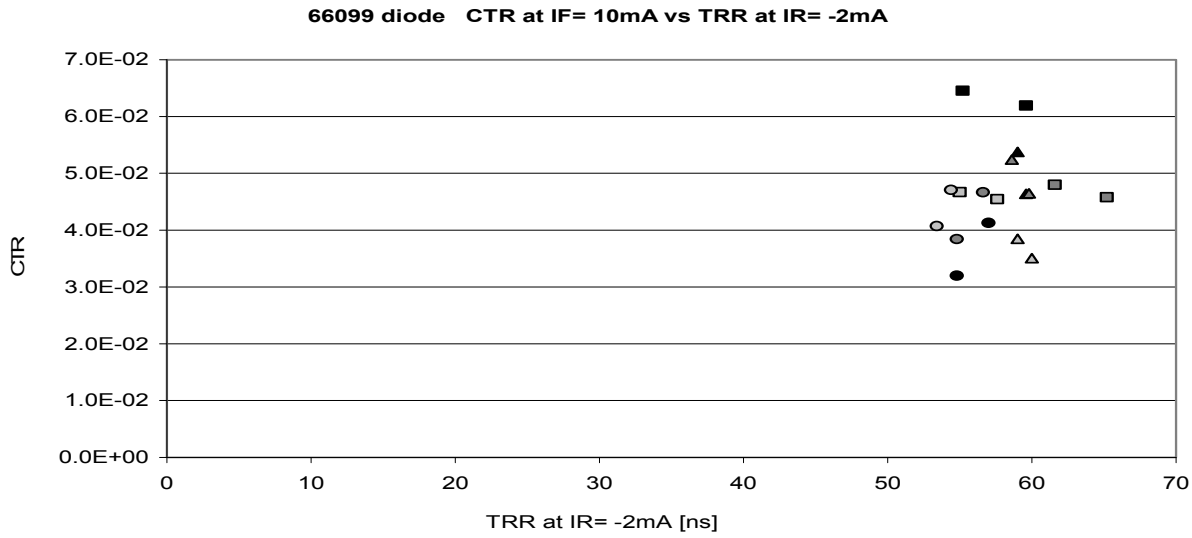
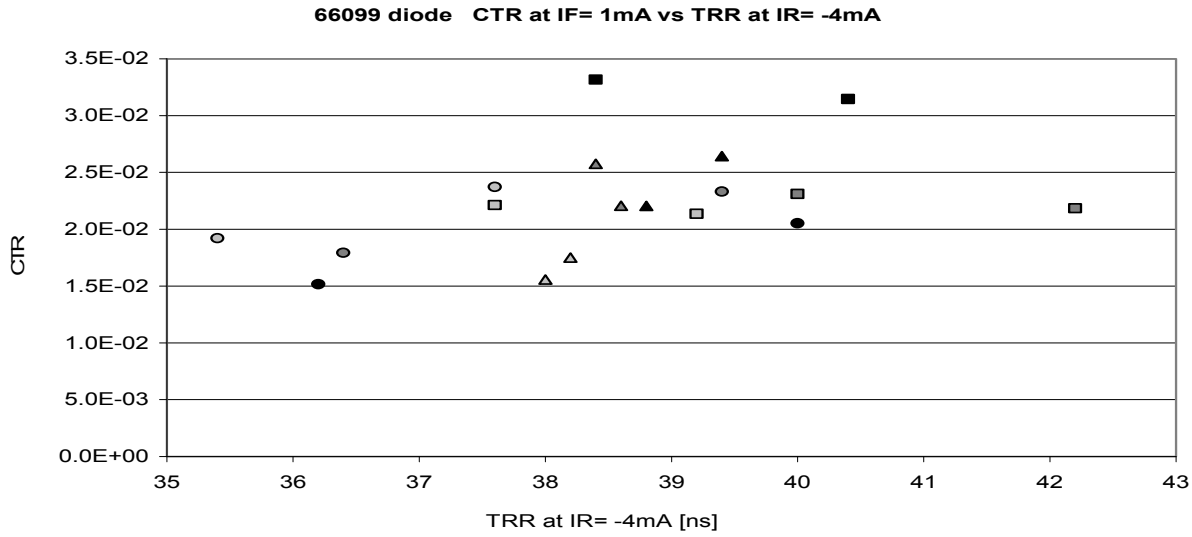
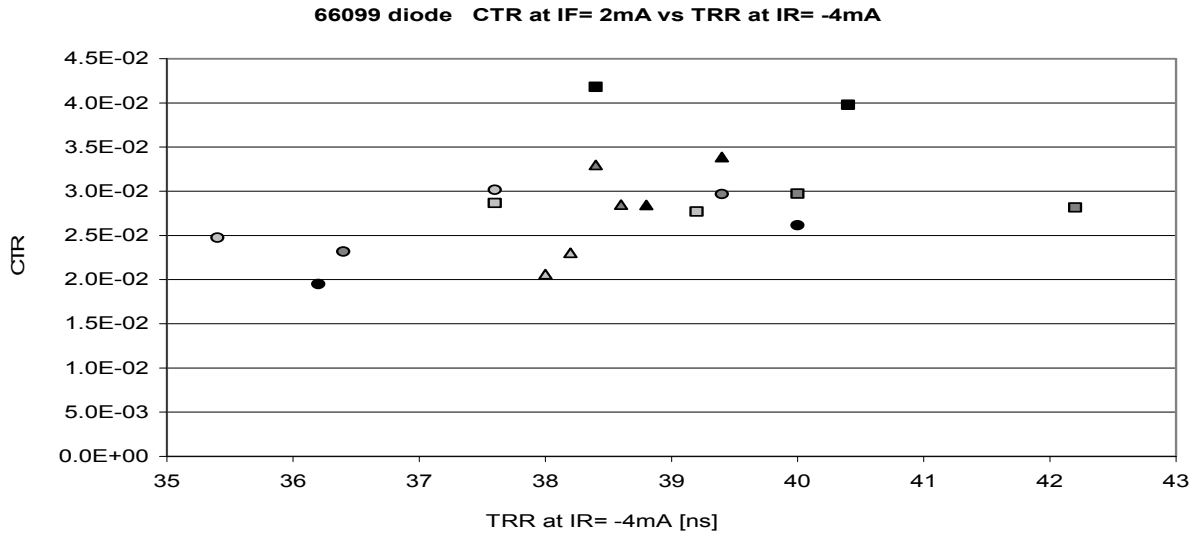
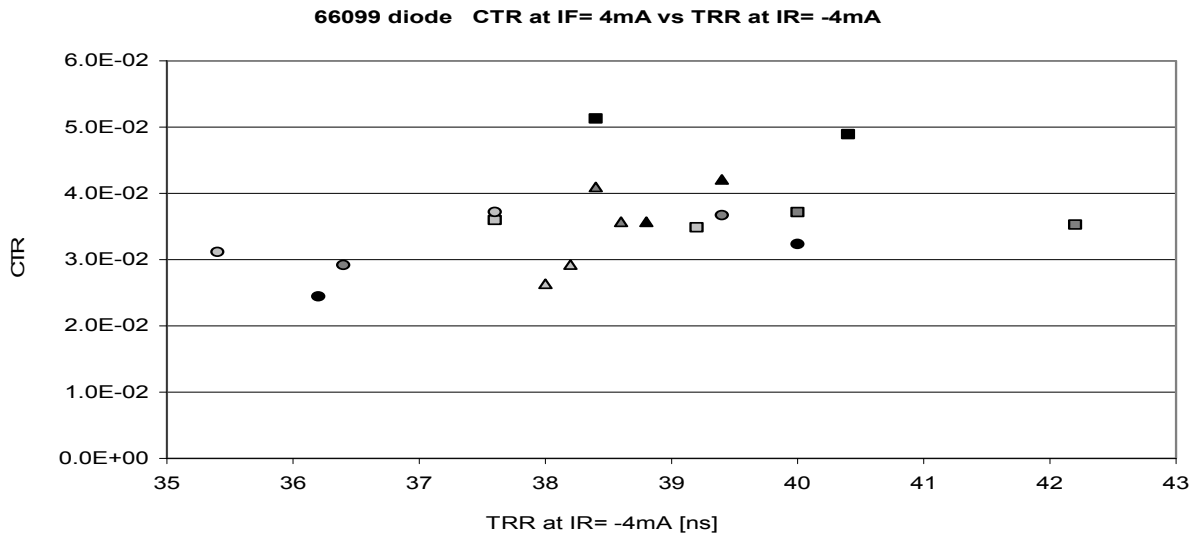
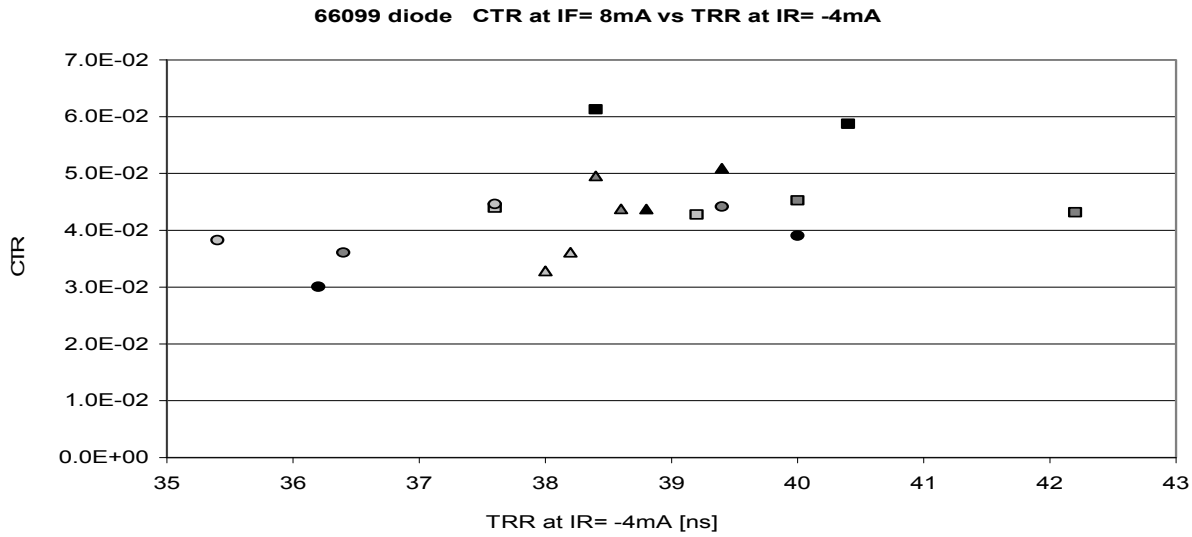

66099 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -2mA [ns]

Fig. 14-165: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points), at Φn_1 (lower squares), Φn_2 (lower triangles) Φn_3 (lower circles), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
35
36
37
38
39
40
41
42
43
TRR at IR= -4mA [ns]

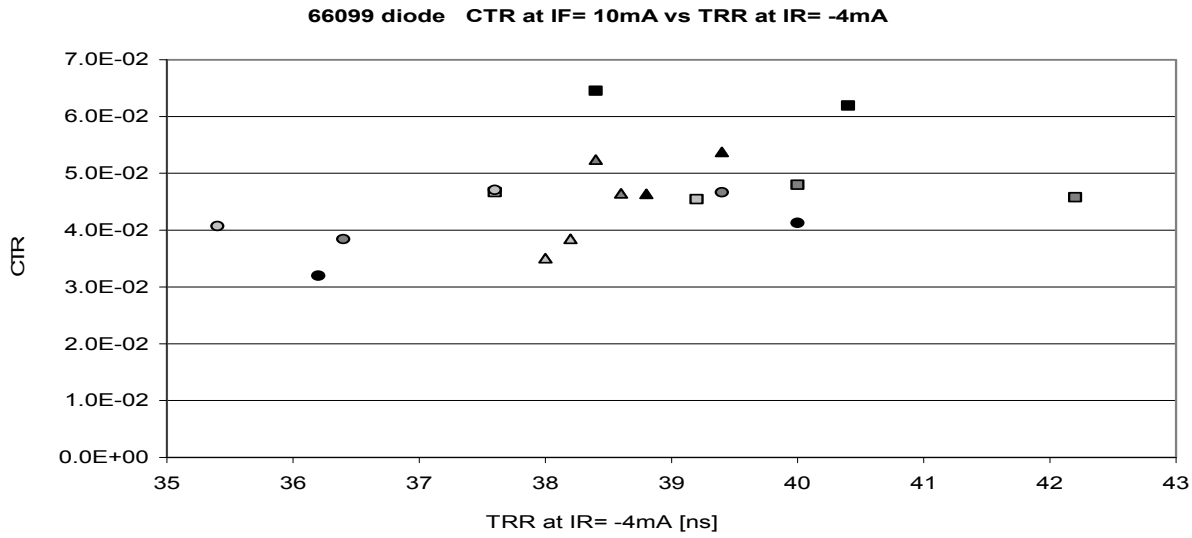
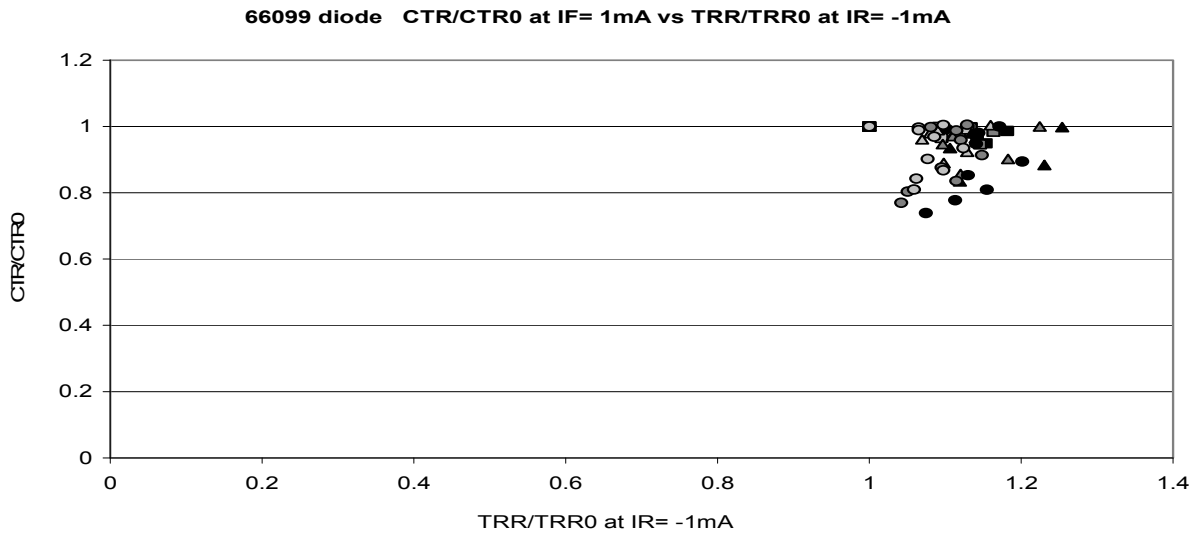
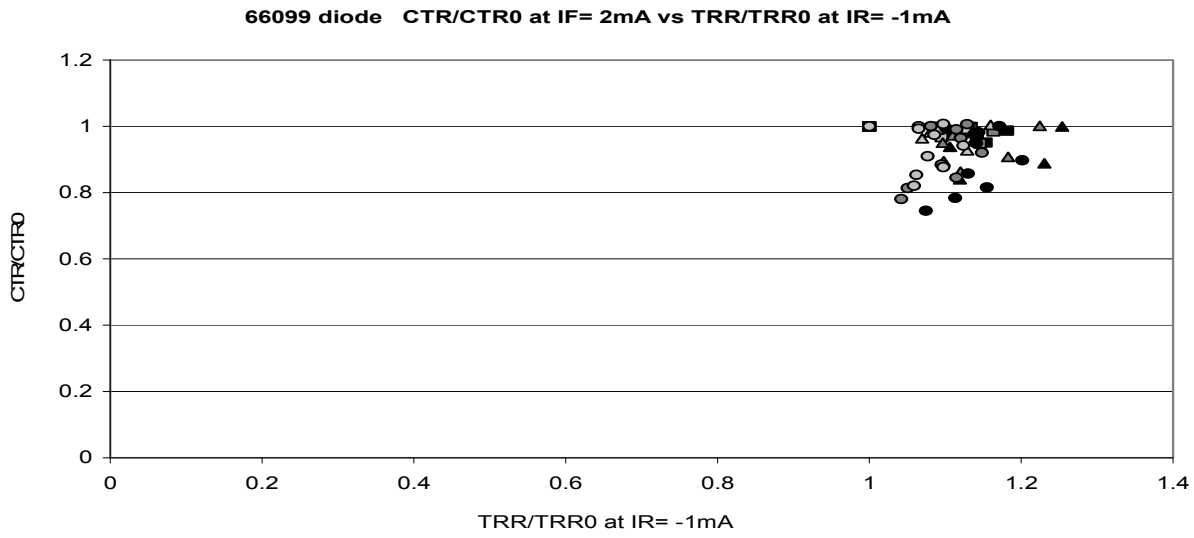
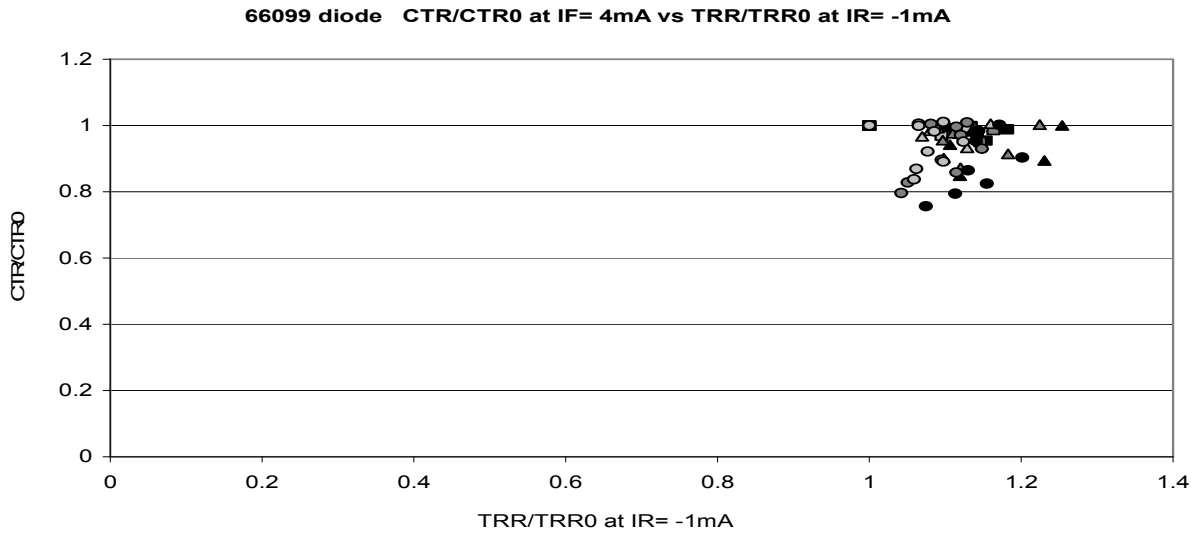
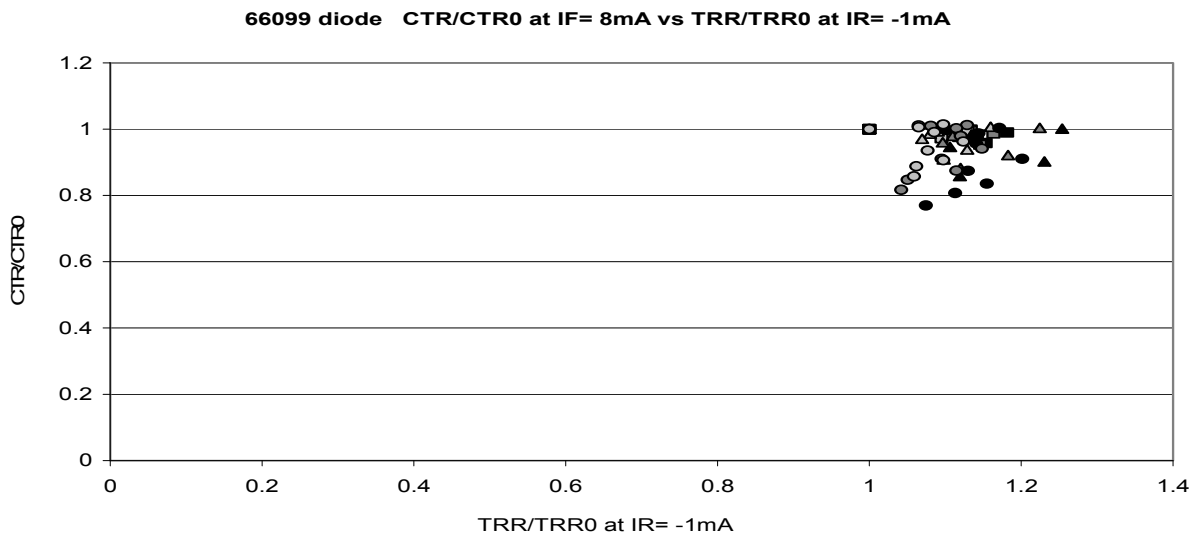

66099 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
35
36
37
38
39
40
41
42
43
TRR at IR= -4mA [ns]

Fig. 14-166: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

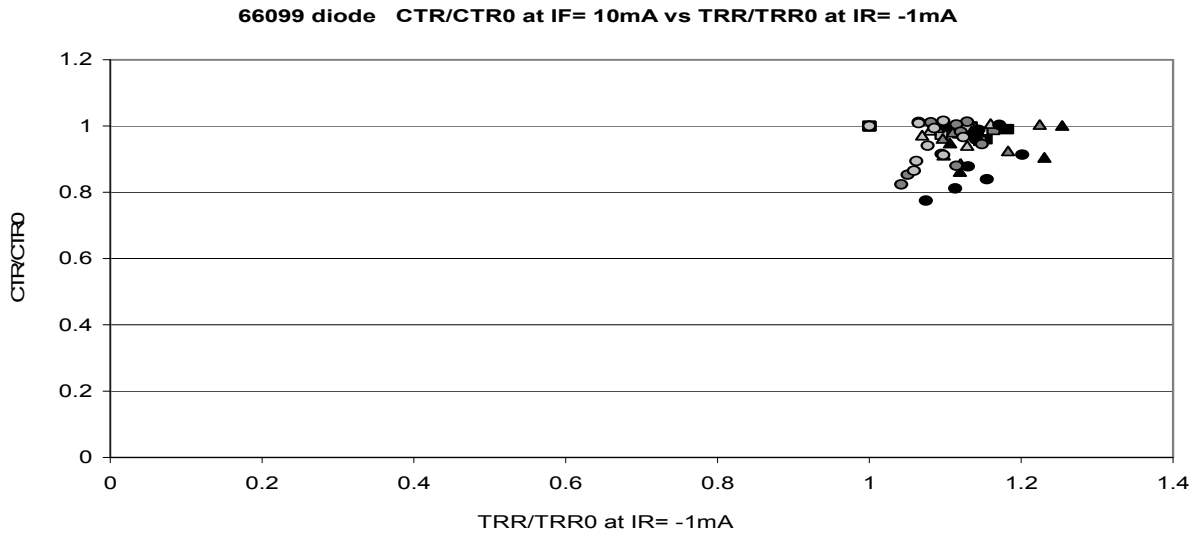
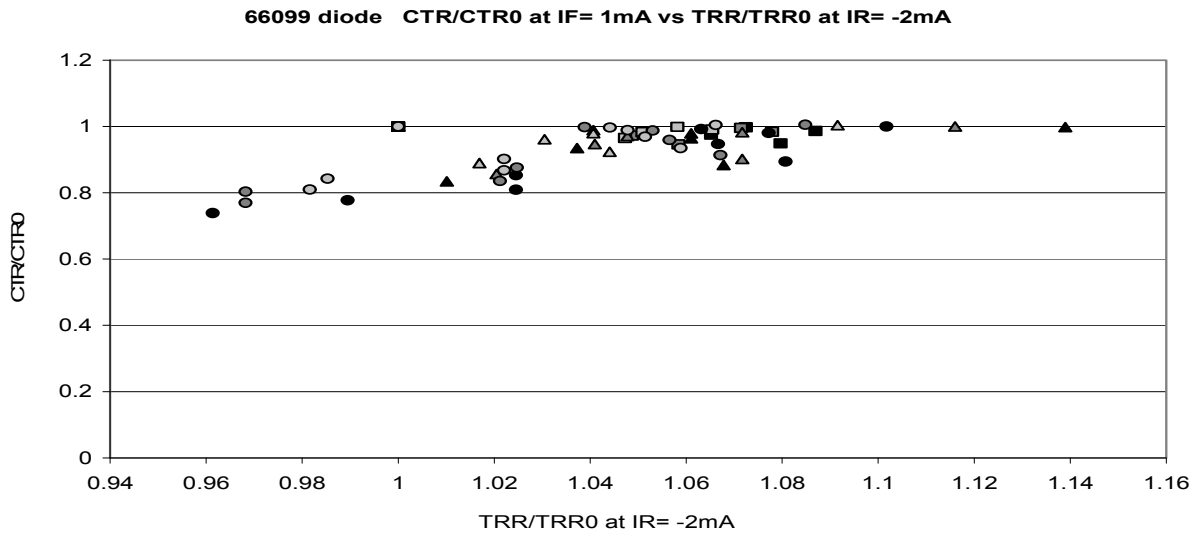
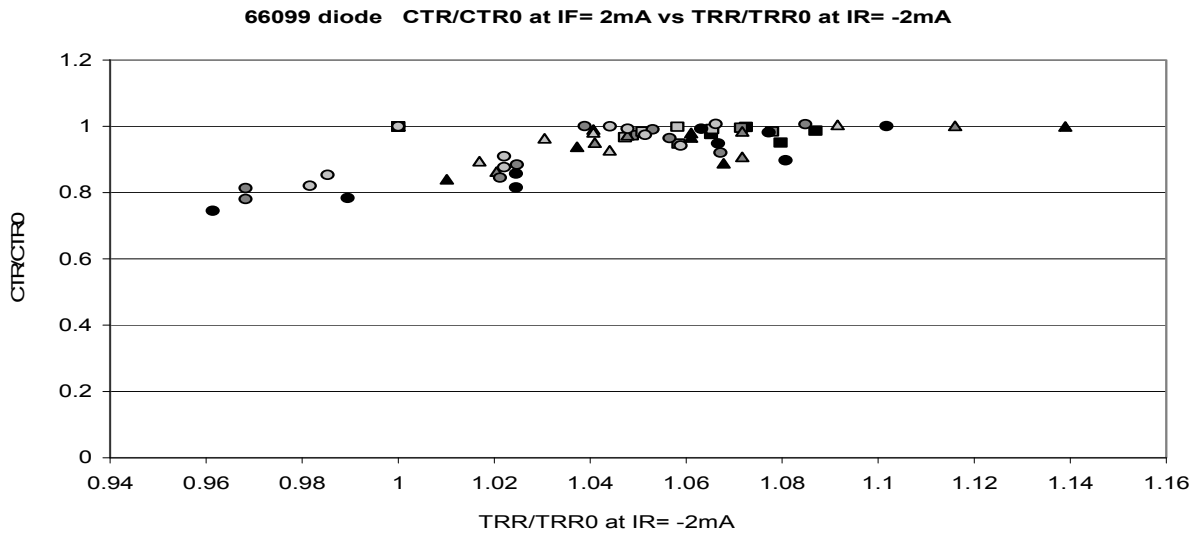
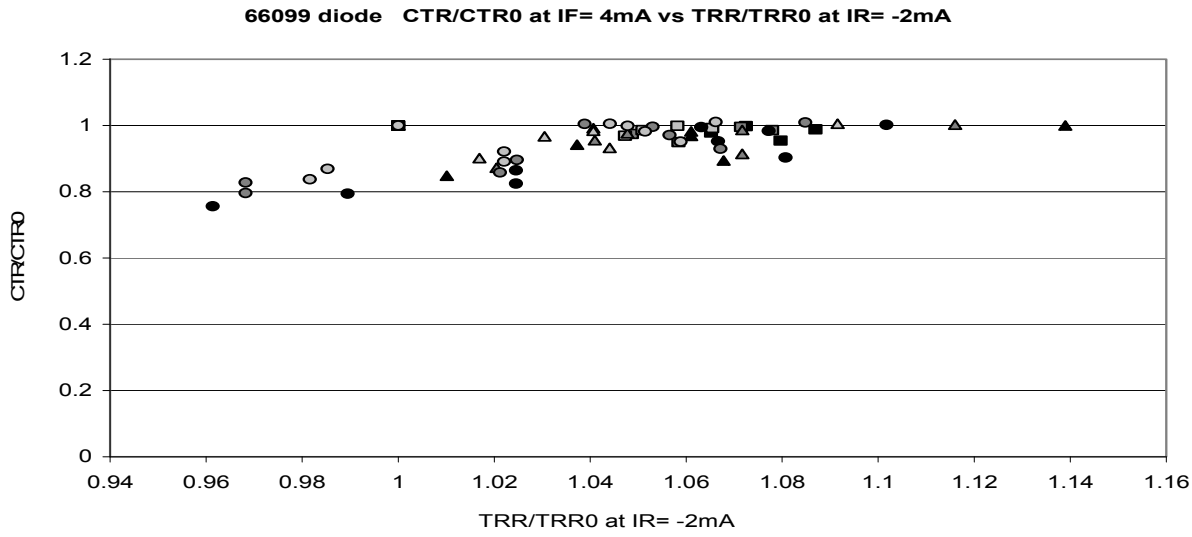
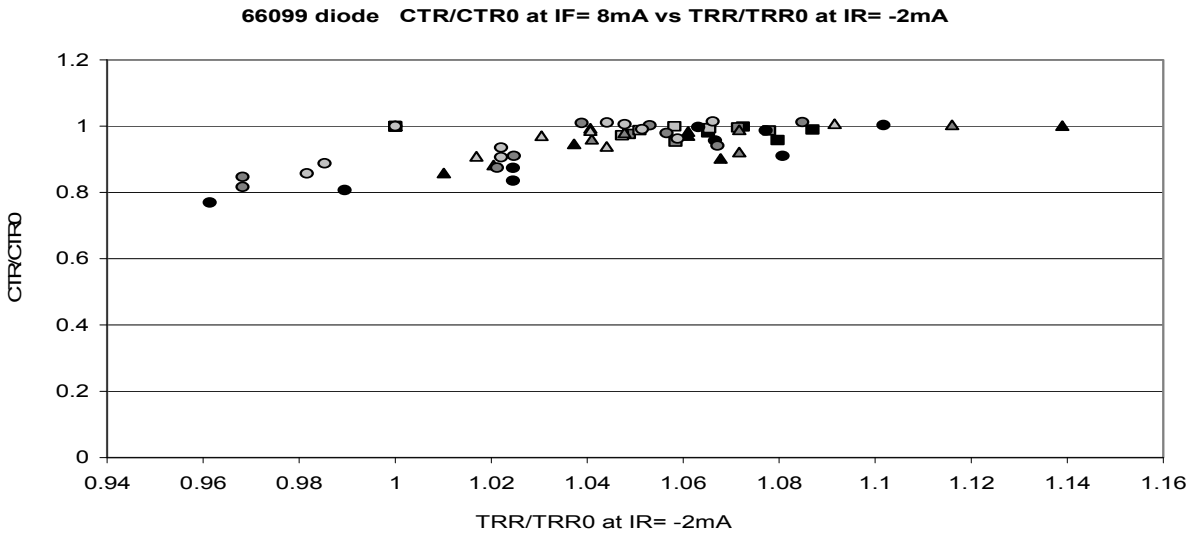

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
TRR/TRR0 at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 14-167: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
TRR/TRR0 at IR= -2mA
0
0.2
0.4
0.6
0.8
1
1.2
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
1.1
1.12
1.14
1.16

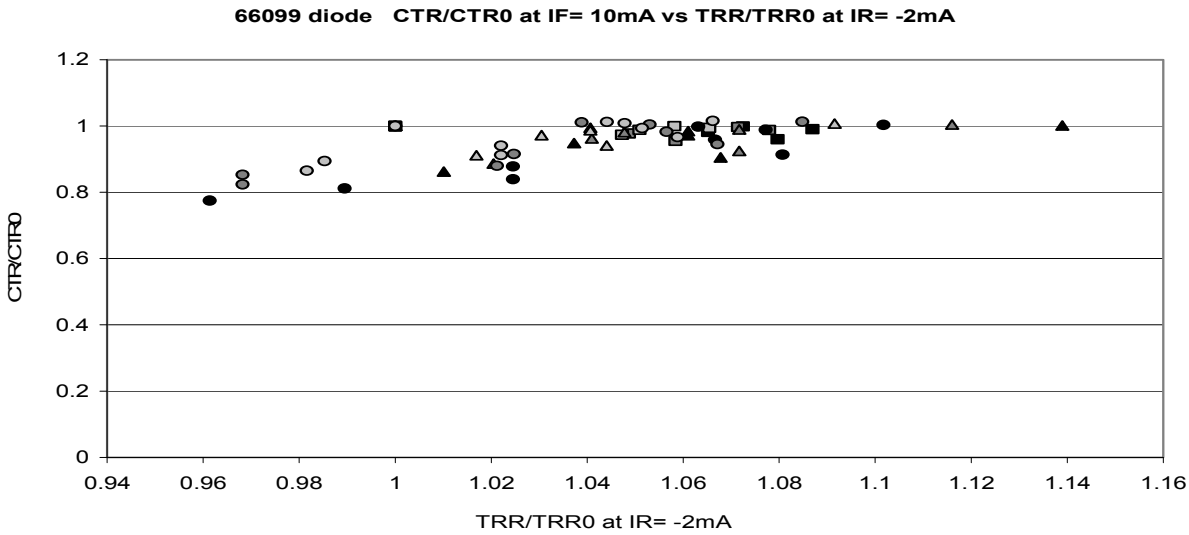
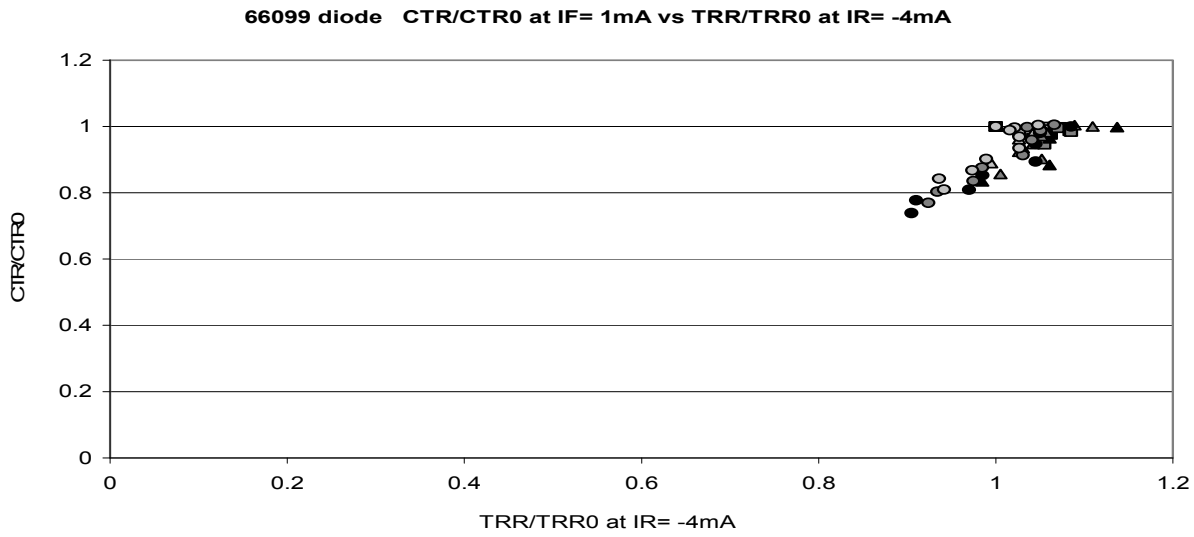
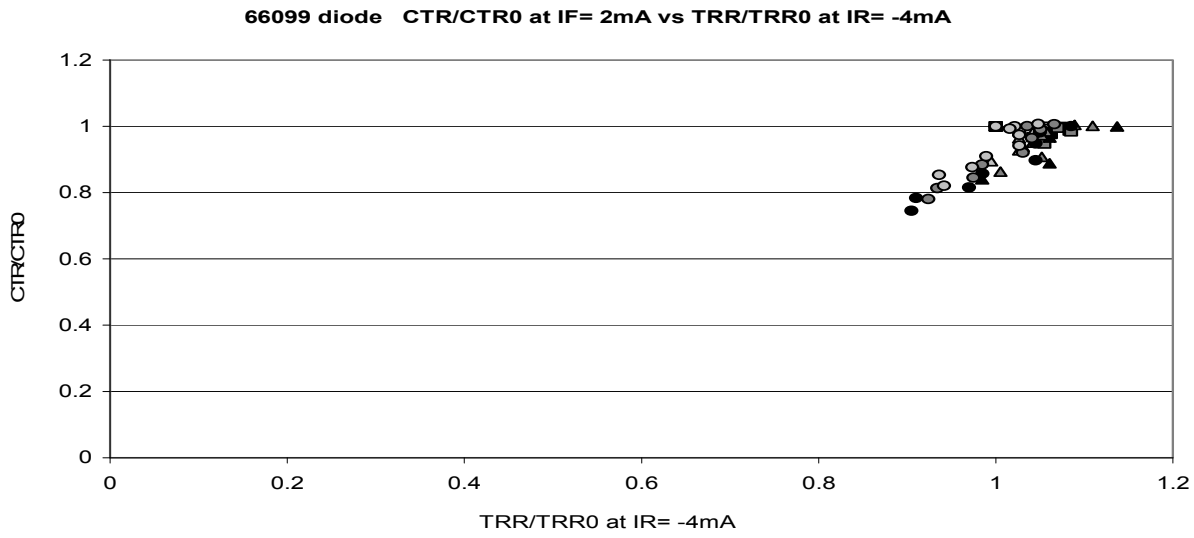
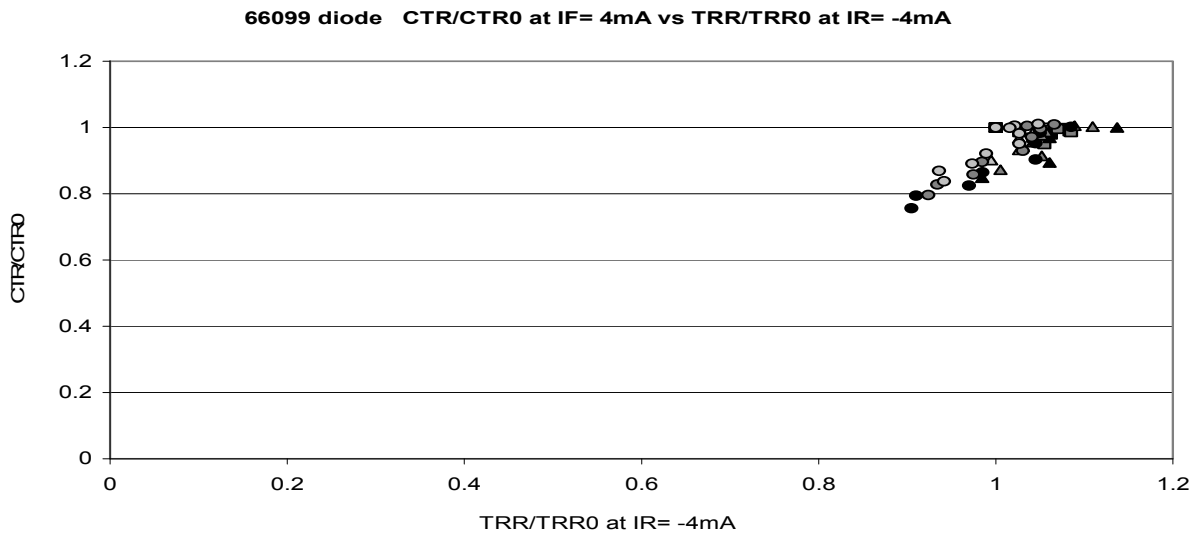
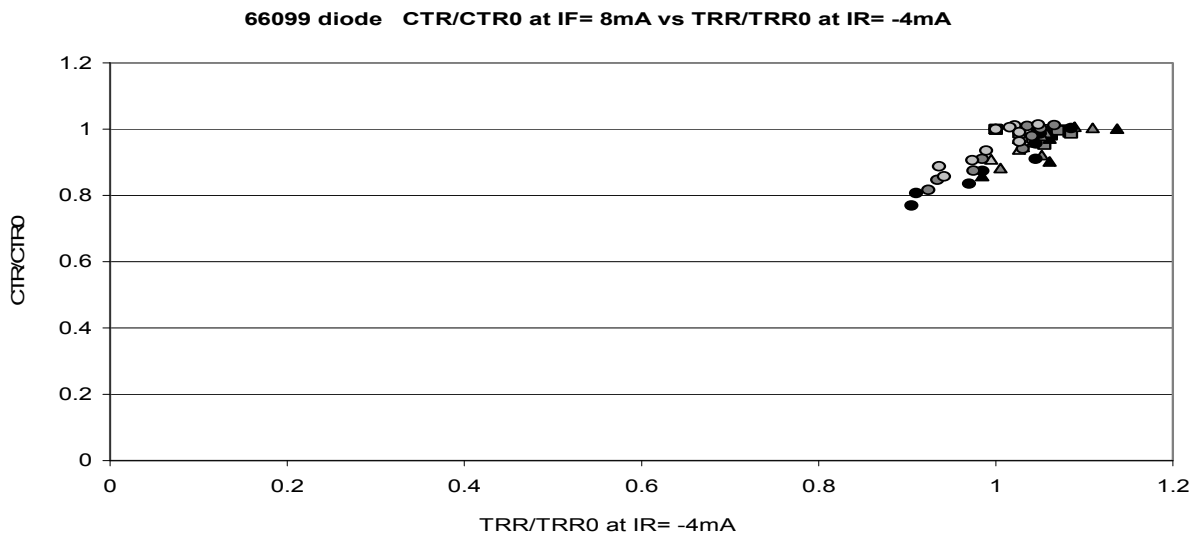

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
TRR/TRR0 at IR= -2mA
0
0.2
0.4
0.6
0.8
1
1.2
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
1.1
1.12
1.14
1.16

Fig. 14-168: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2

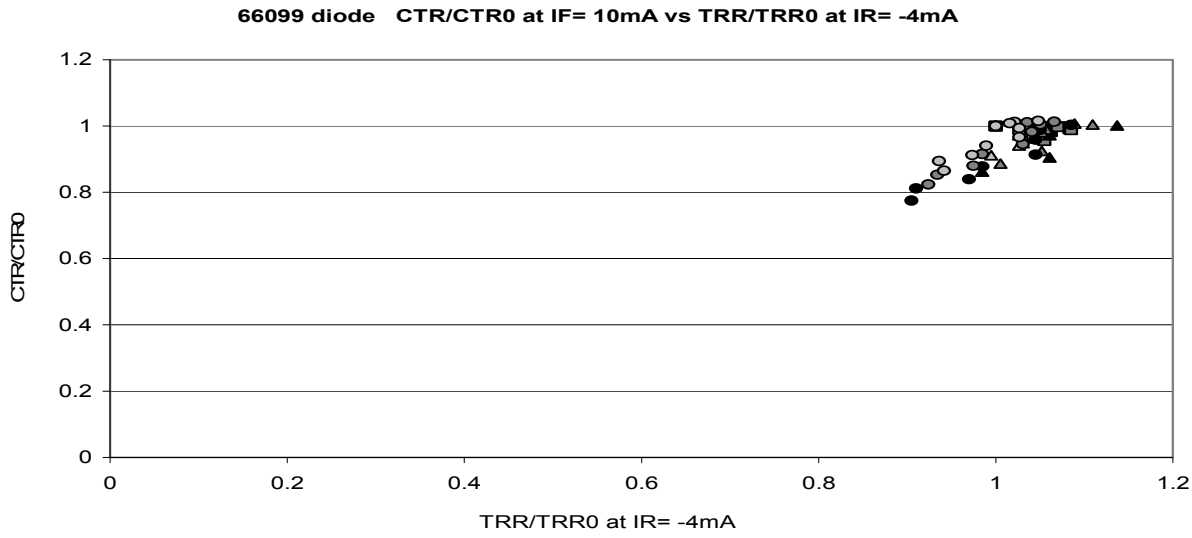
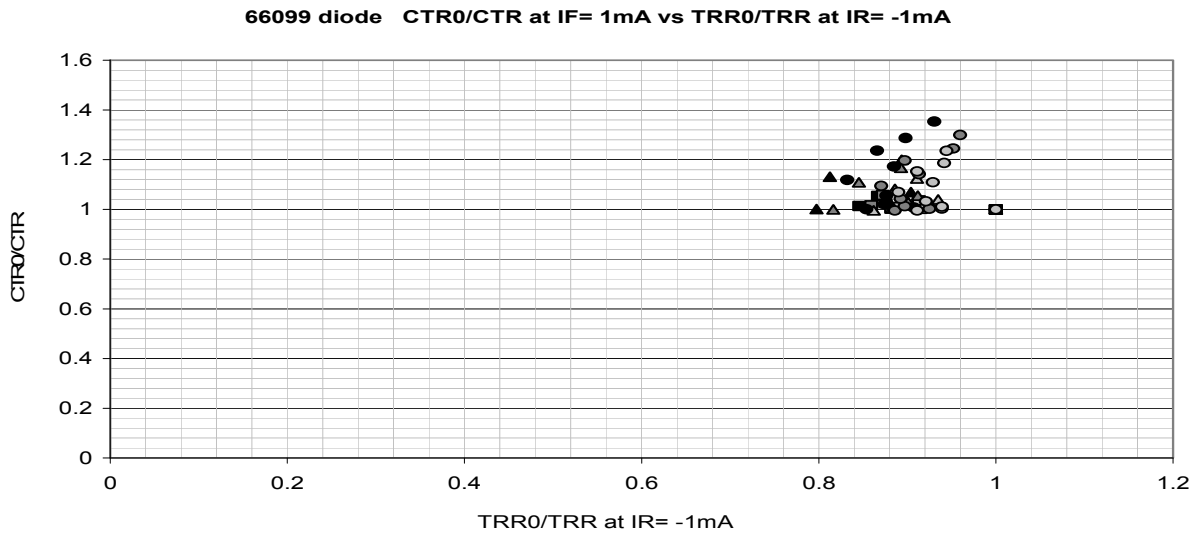
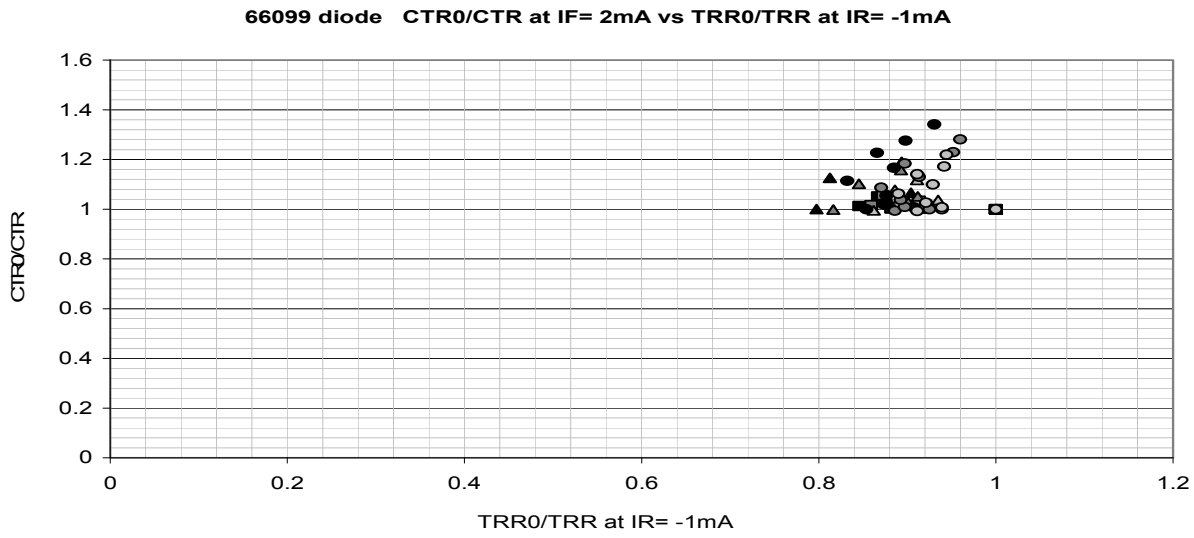
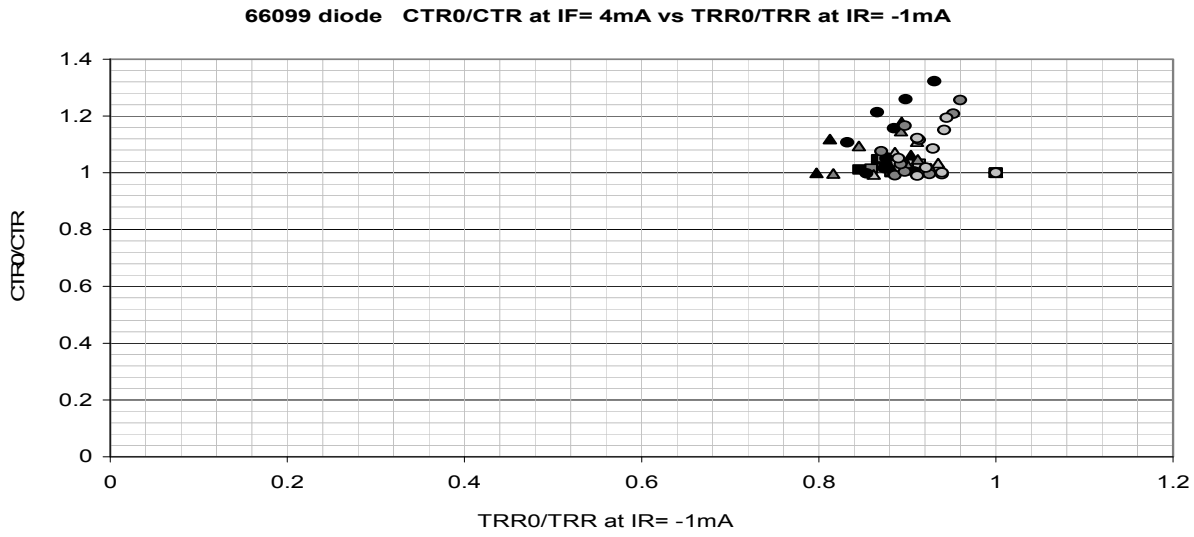
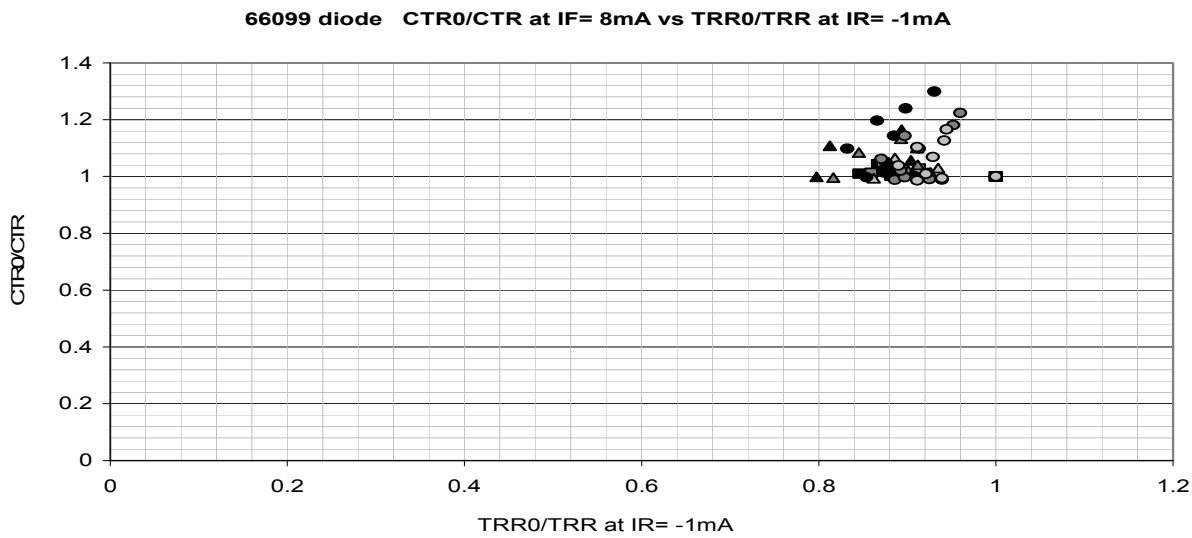

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
TRR/TRR0 at IR= -4mA
0
0.2
0.4
0.6
0.8
1
1.2

Fig. 14-169: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA








66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
TRR0/TRR at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

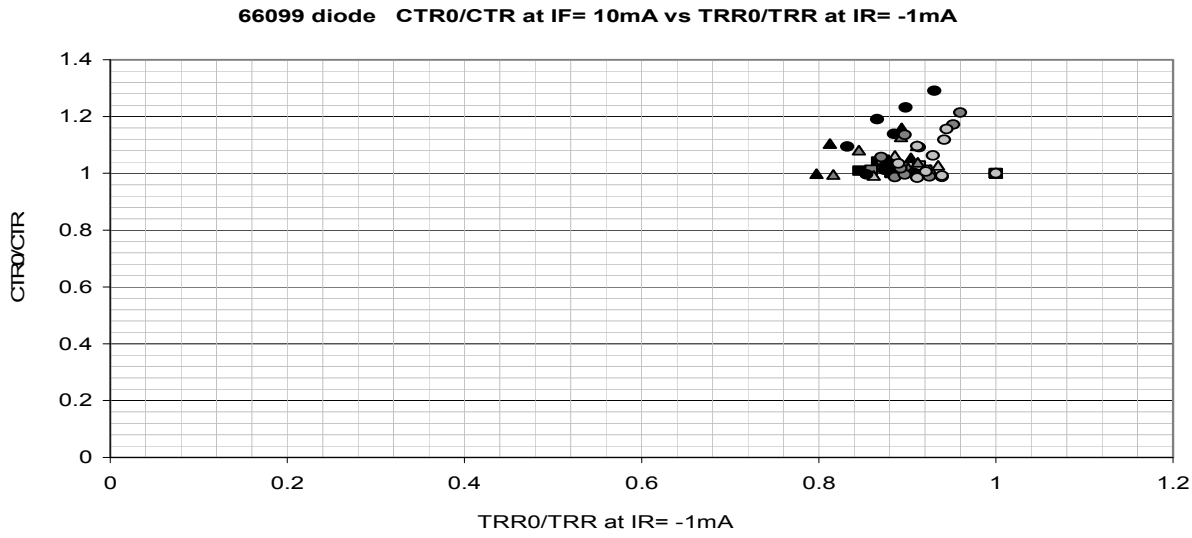
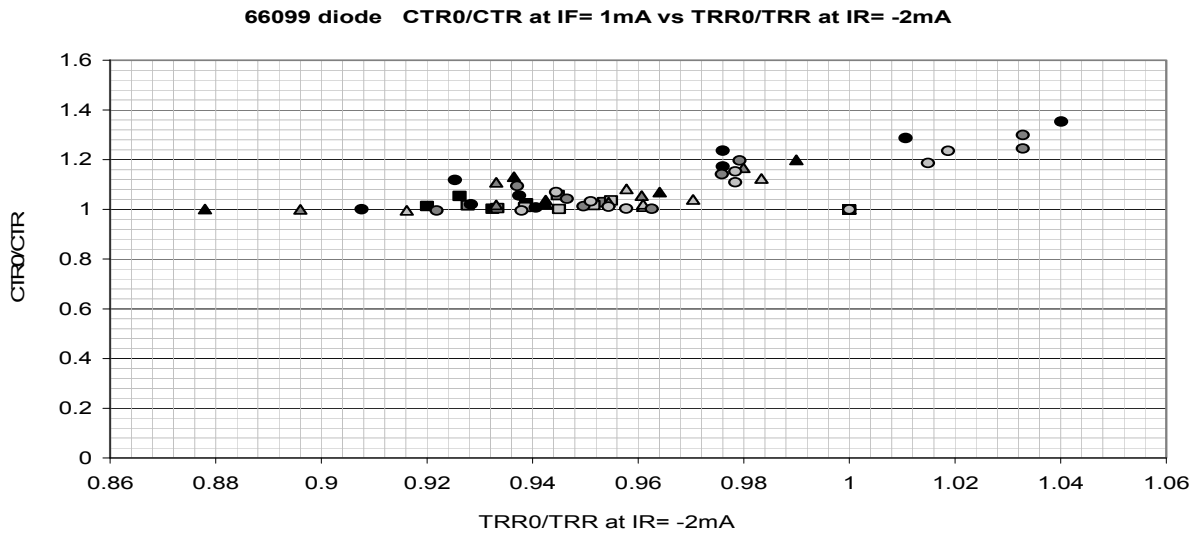
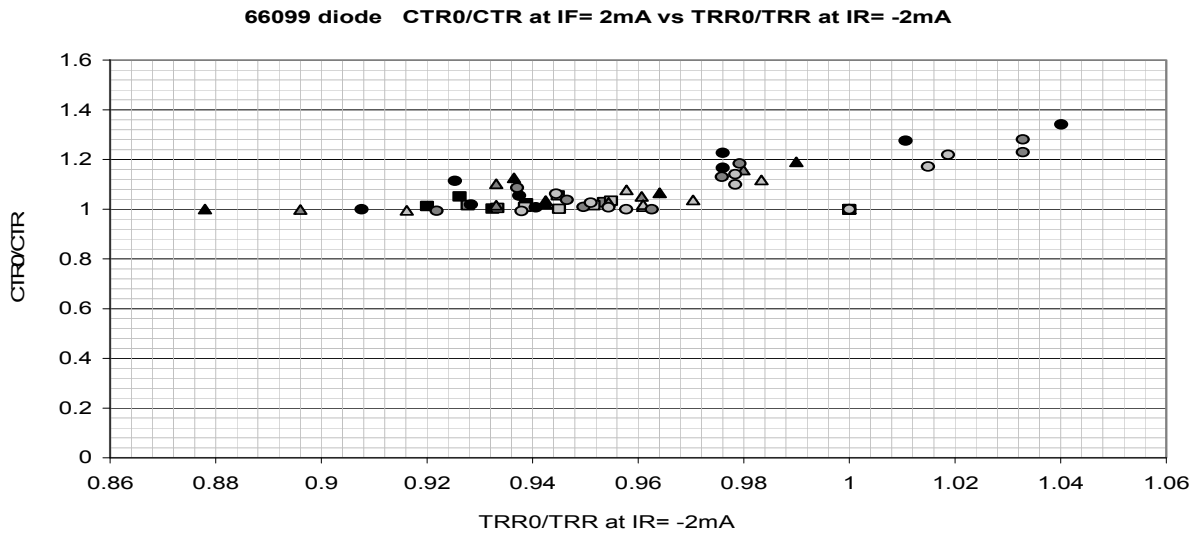
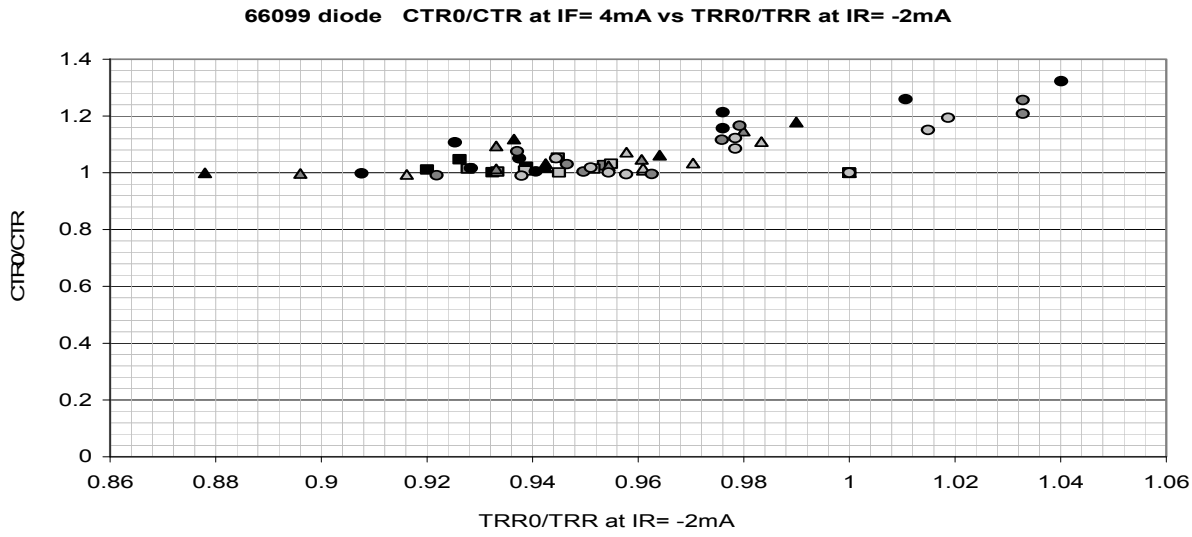
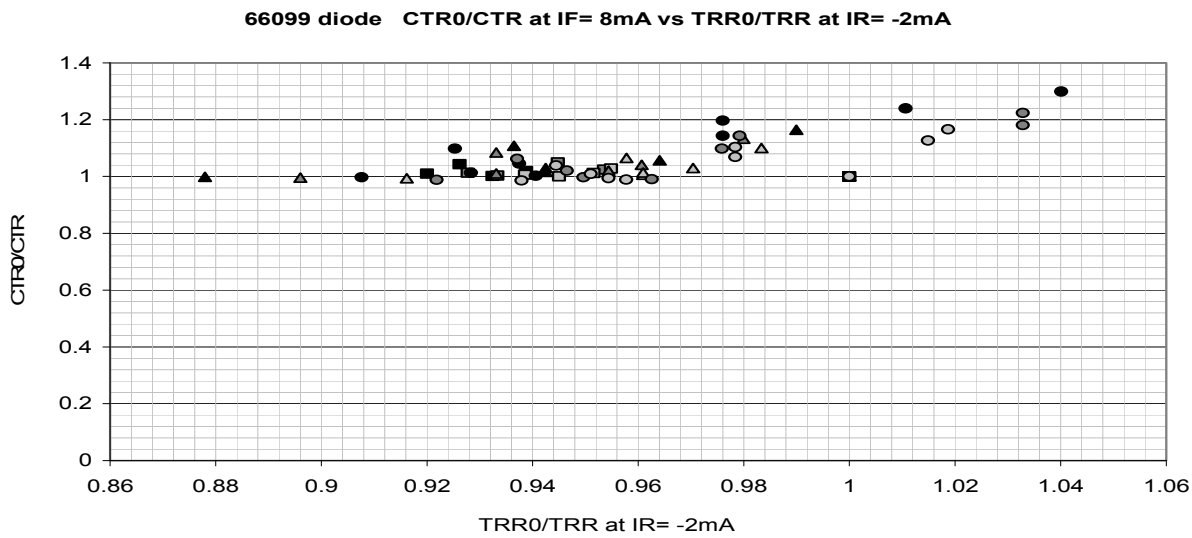

66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
TRR0/TRR at IR= -1mA
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Fig. 14-170: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA








66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR0/TRR at IR= -2mA

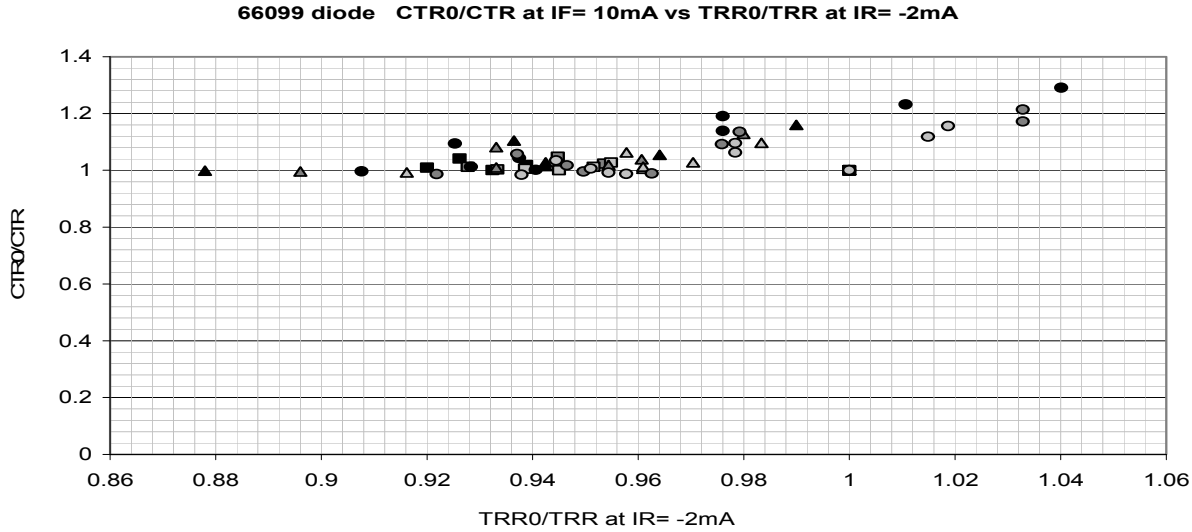
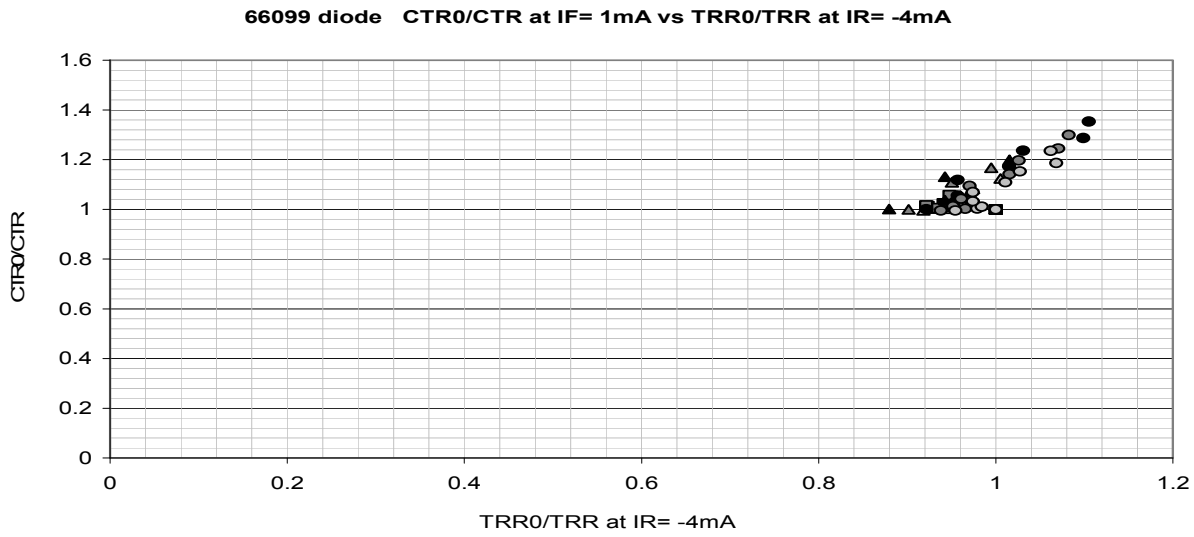
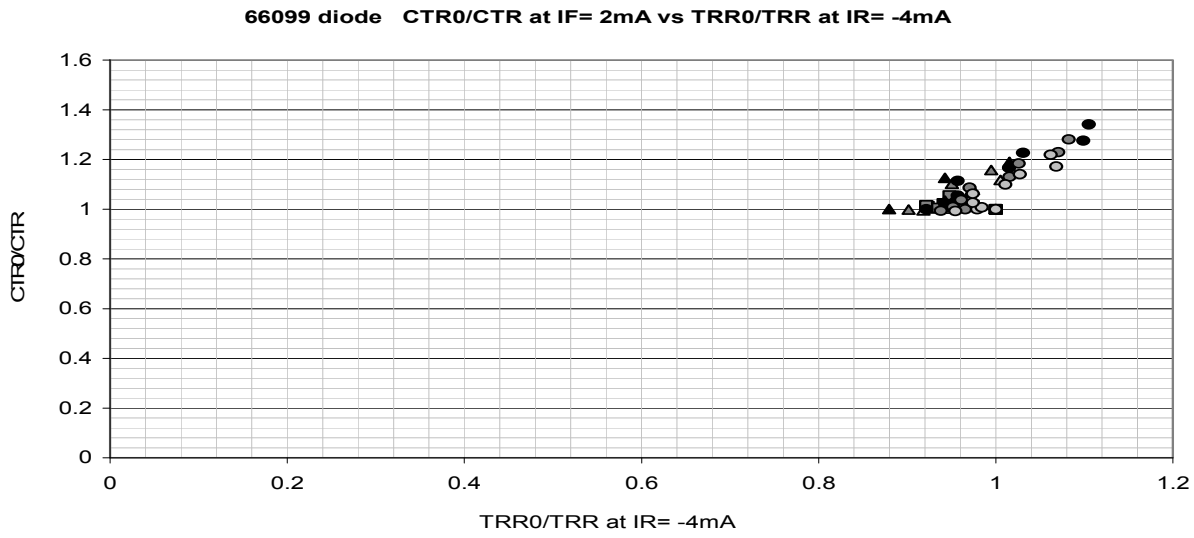
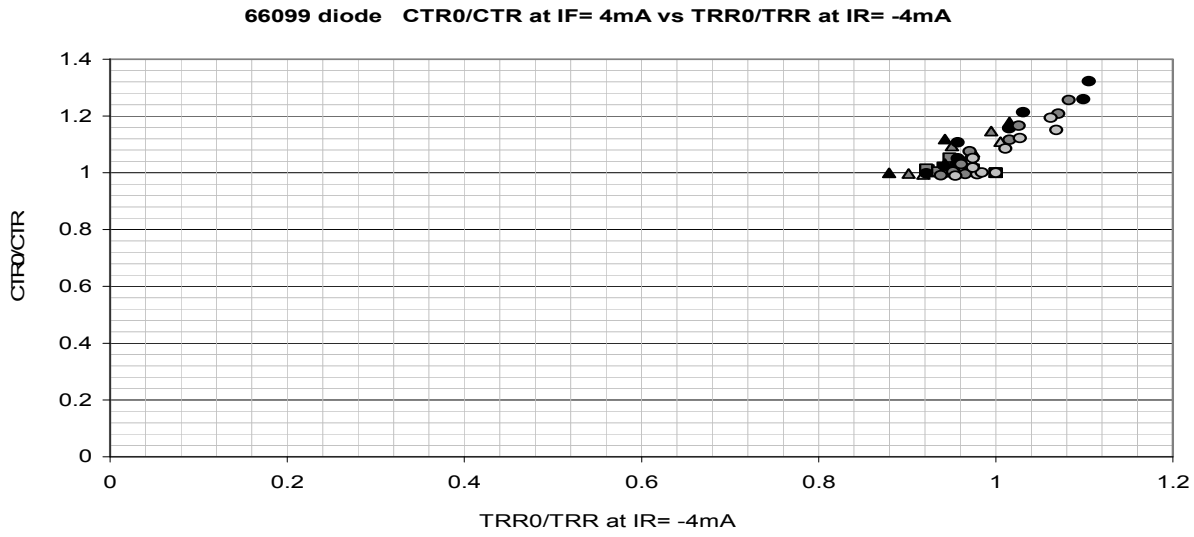

66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR0/TRR at IR= -2mA

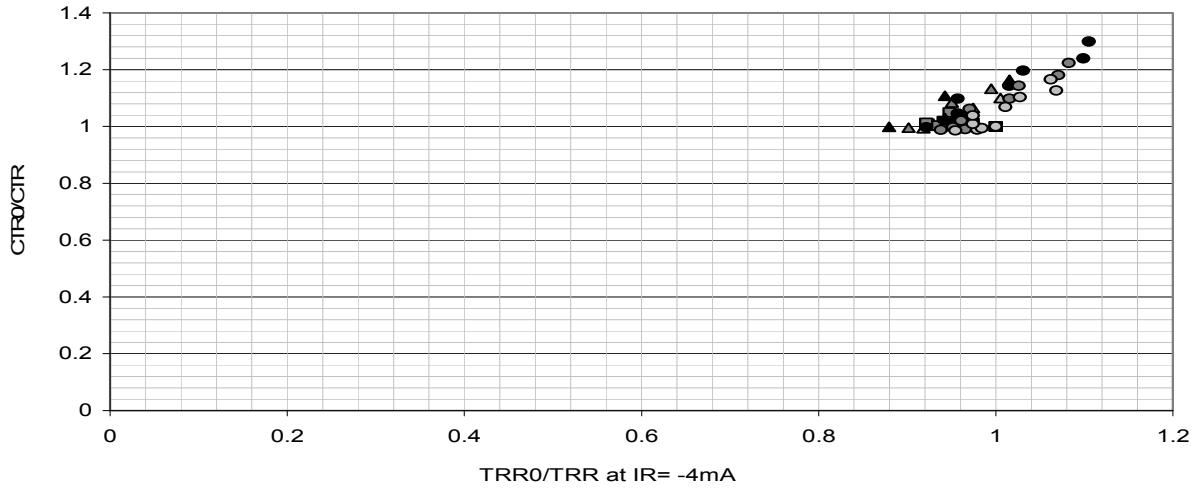
Fig. 14-171: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

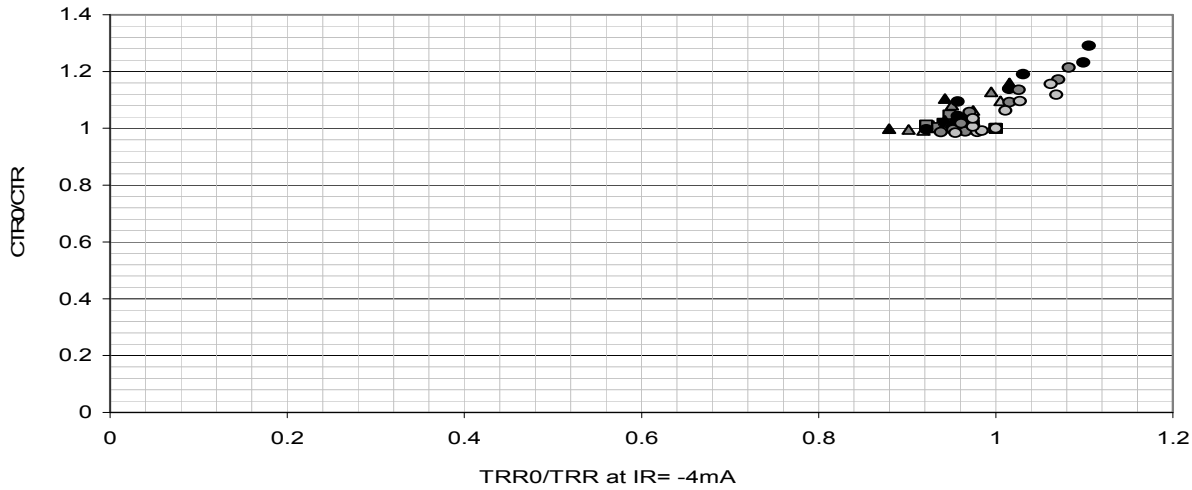
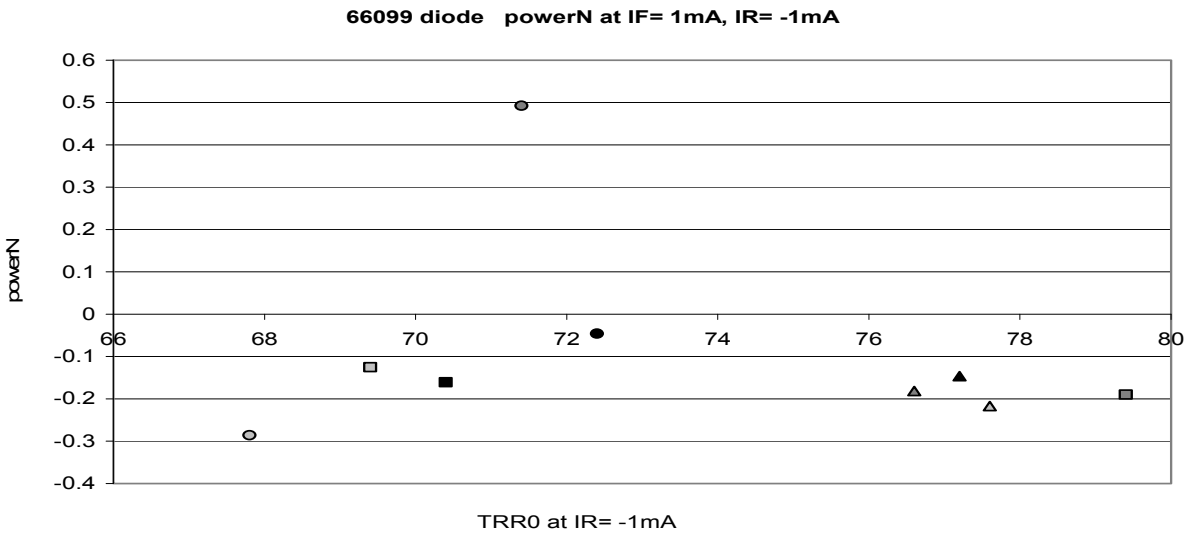
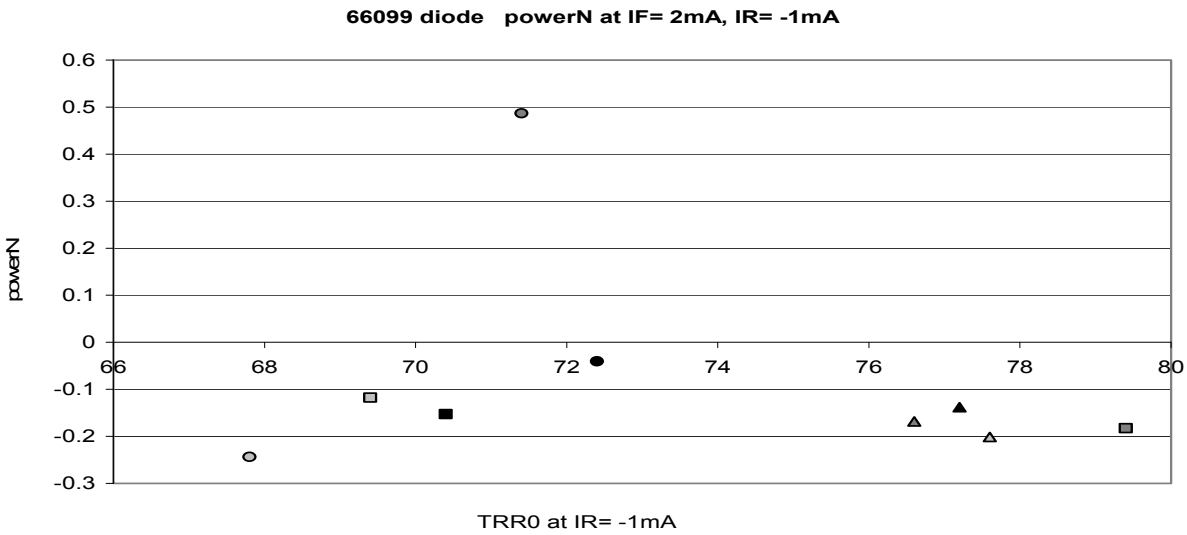
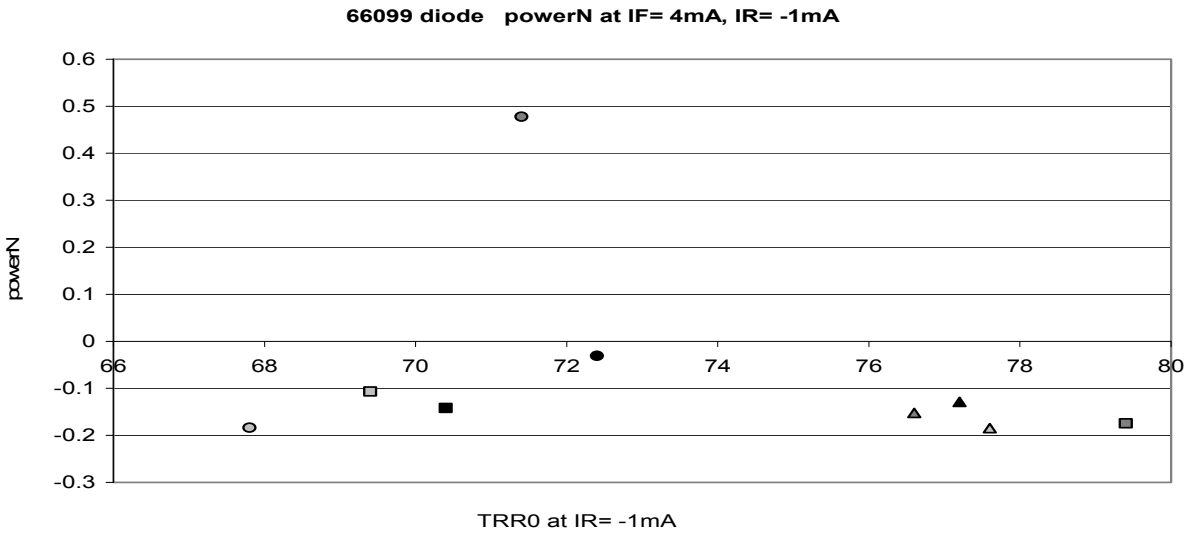
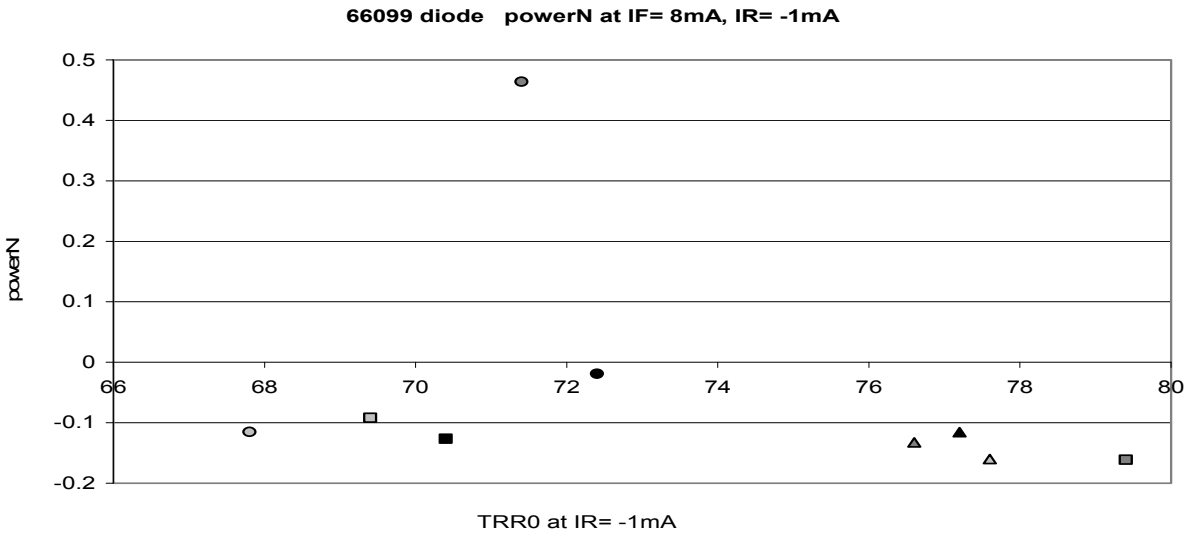


Fig. 14-172: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA








66099 diode powerN at IF= 8mA, IR= -1mA
powerN
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
66
68
70
72
74
76
78
80
TRR0 at IR= -1mA

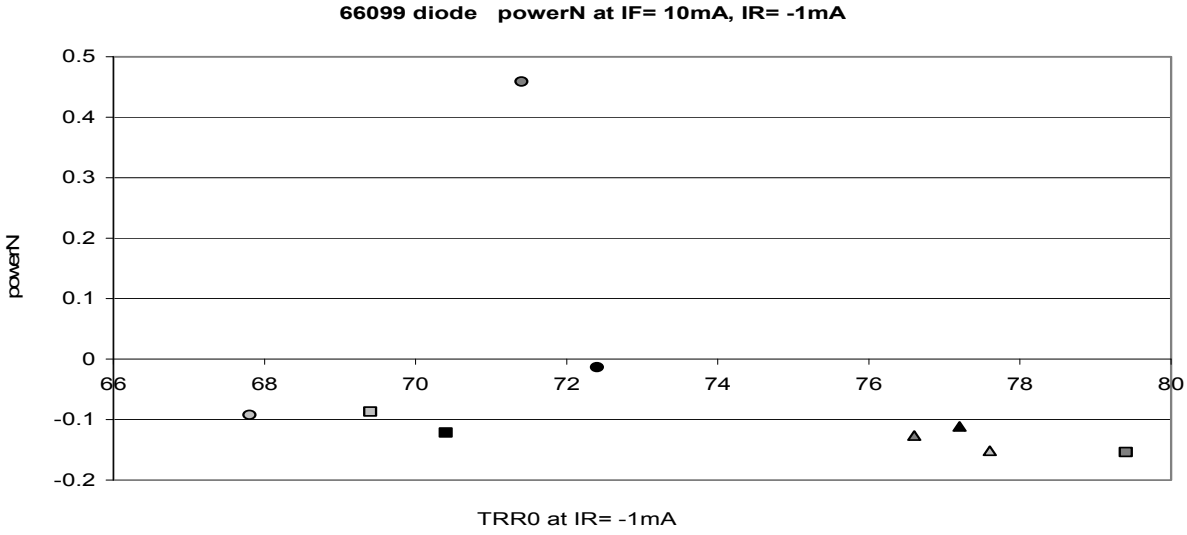
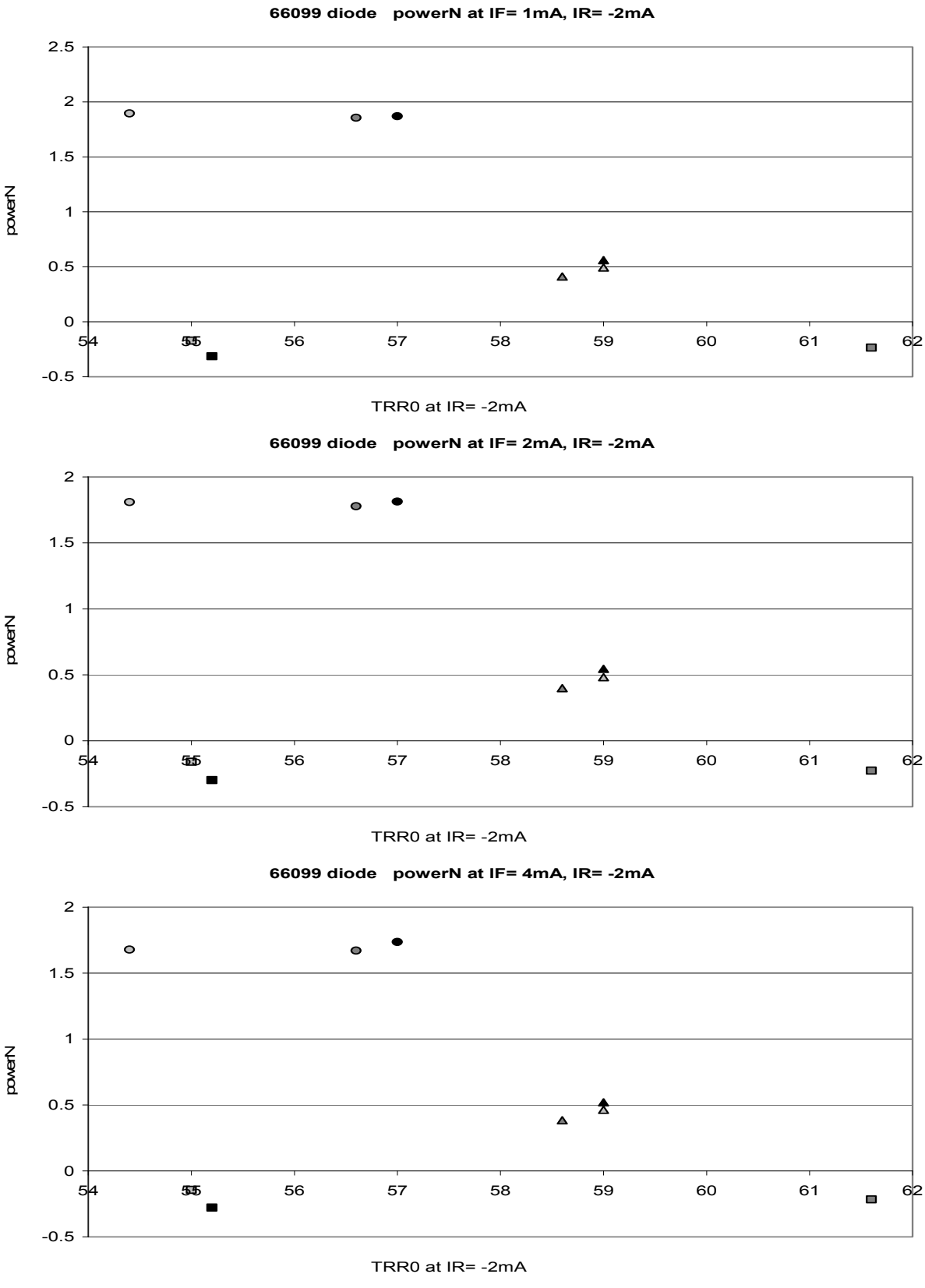
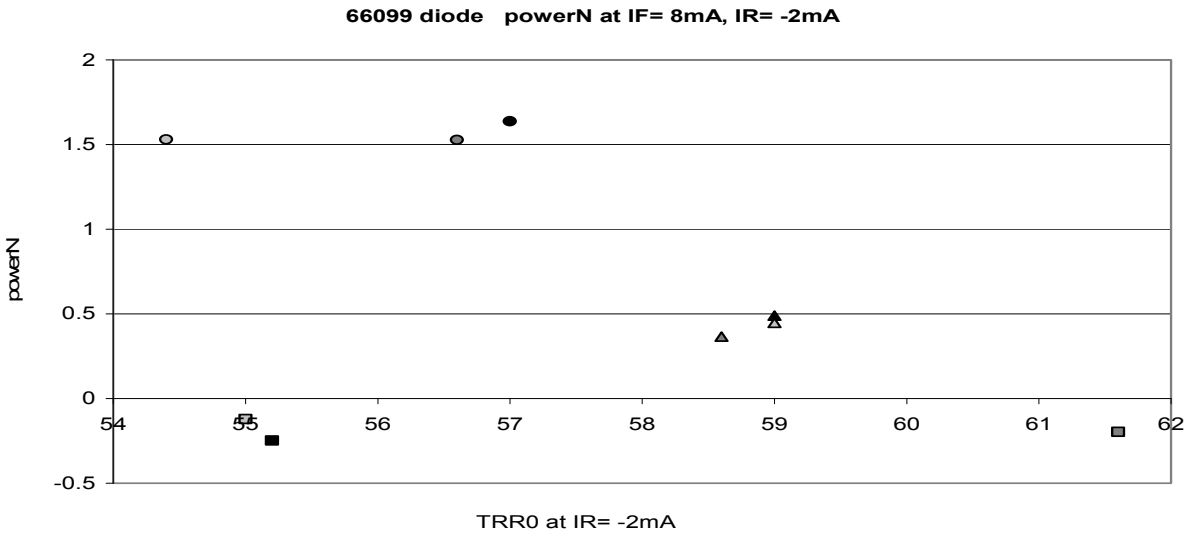

66099 diode powerN at IF= 10mA, IR= -1mA
powerN
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
66
68
70
72
74
76
78
80
TRR0 at IR= -1mA

Fig. 14-173: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA




66099 diode powerN at IF= 8mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
54
55
56
57
58
59
60
61
62
TRR0 at IR= -2mA

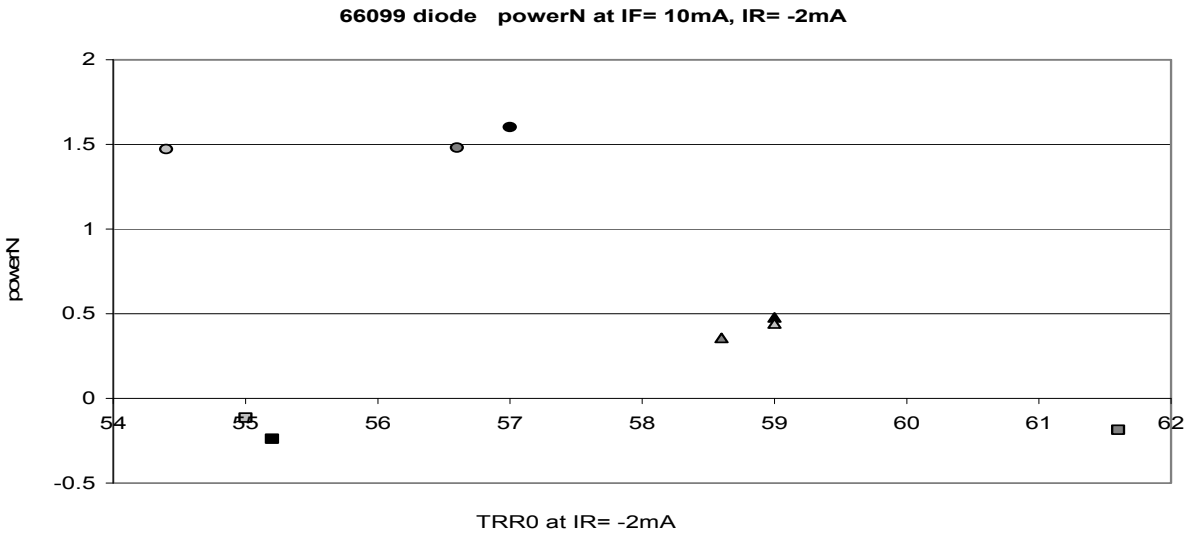
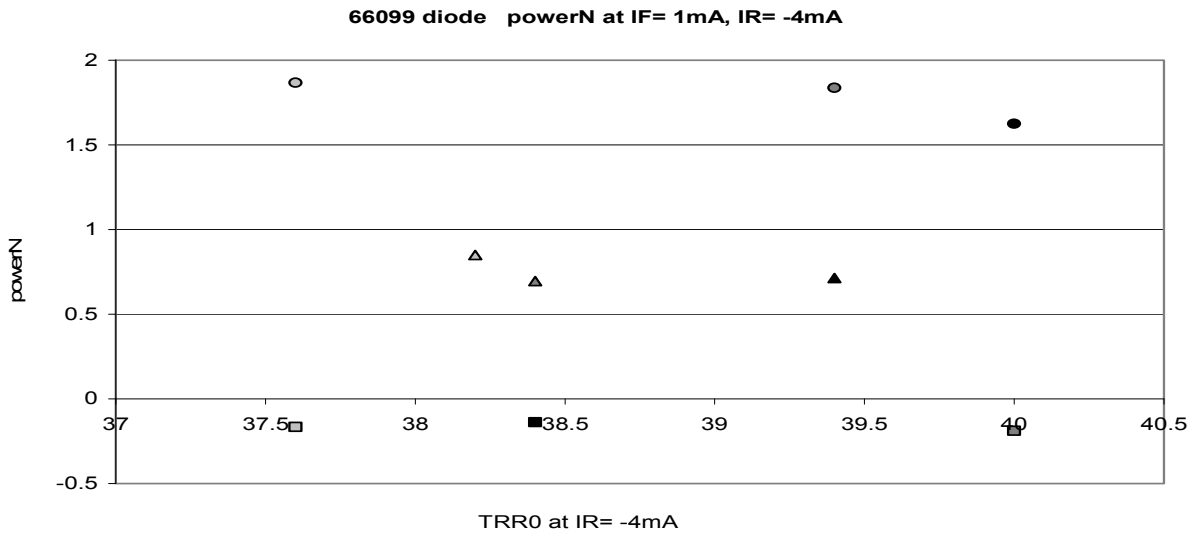
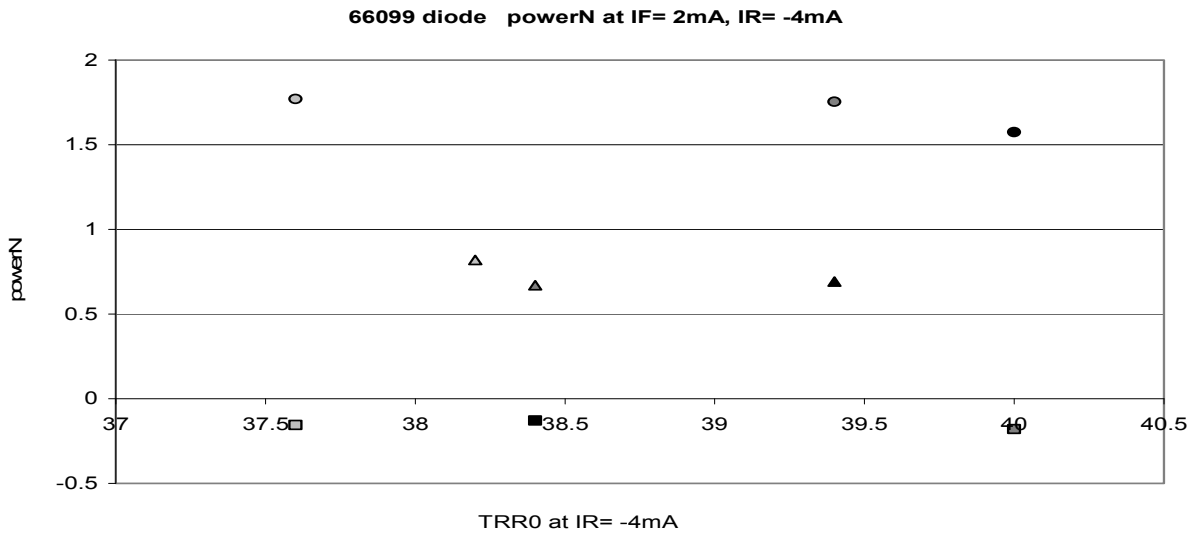
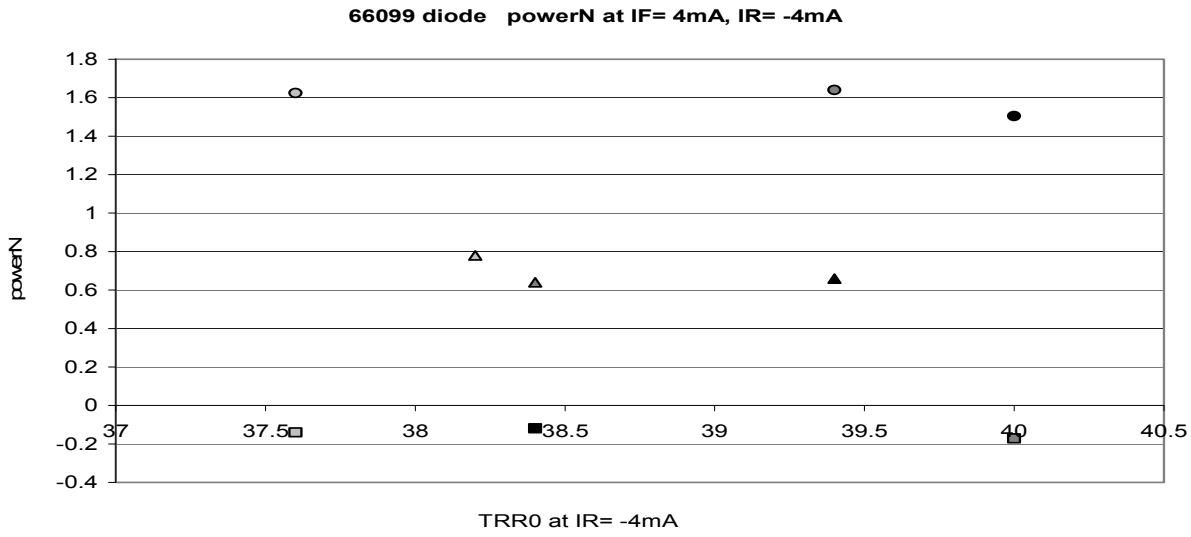
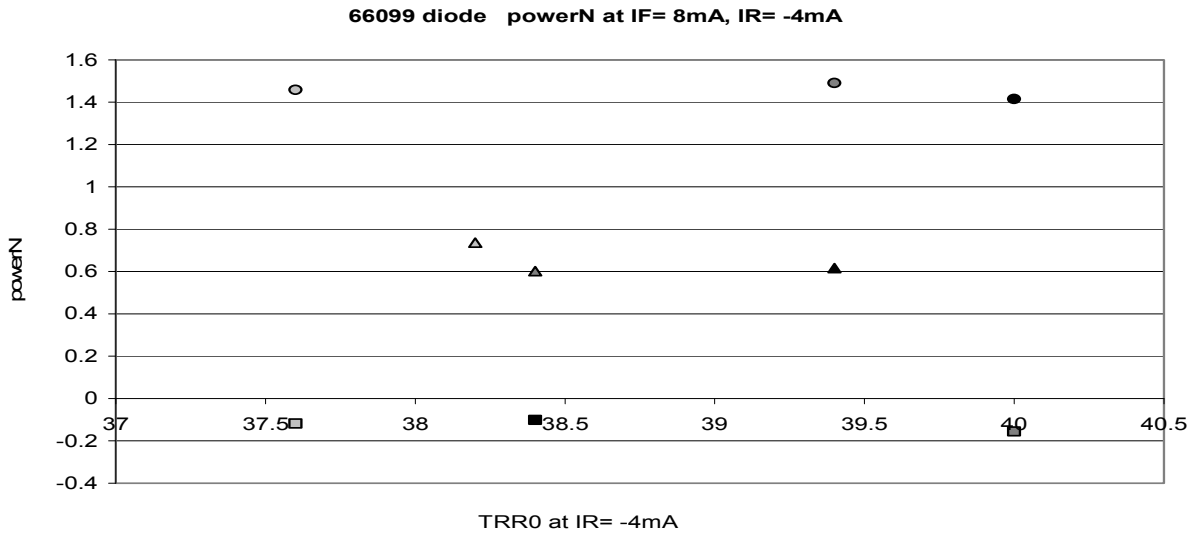

66099 diode powerN at IF= 10mA, IR= -2mA
powerN
2
1.5
1
0.5
0
-0.5
54
55
56
57
58
59
60
61
62
TRR0 at IR= -2mA

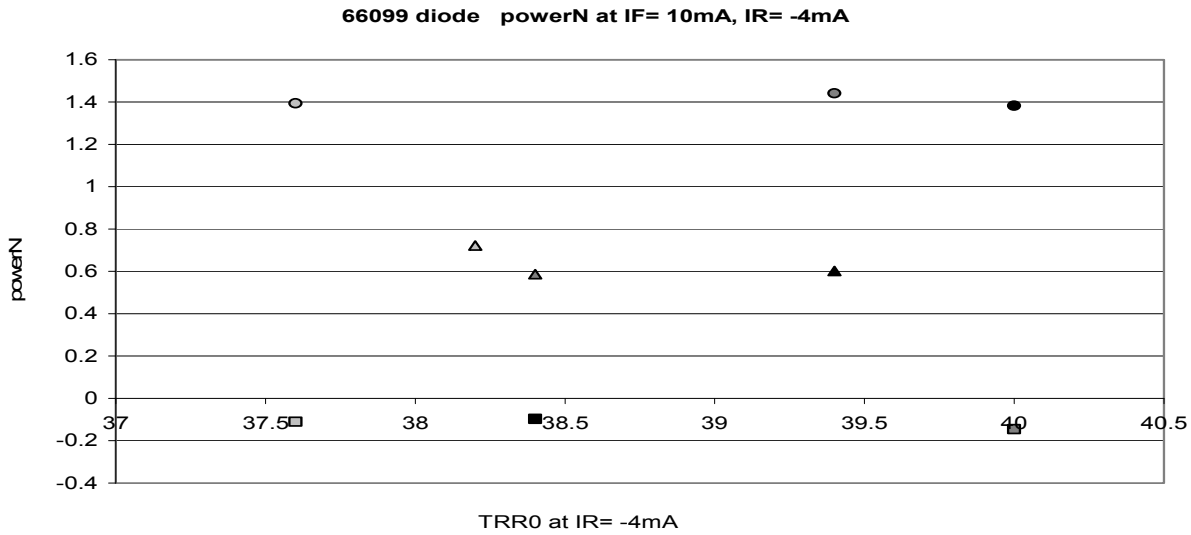
Fig. 14-174: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA





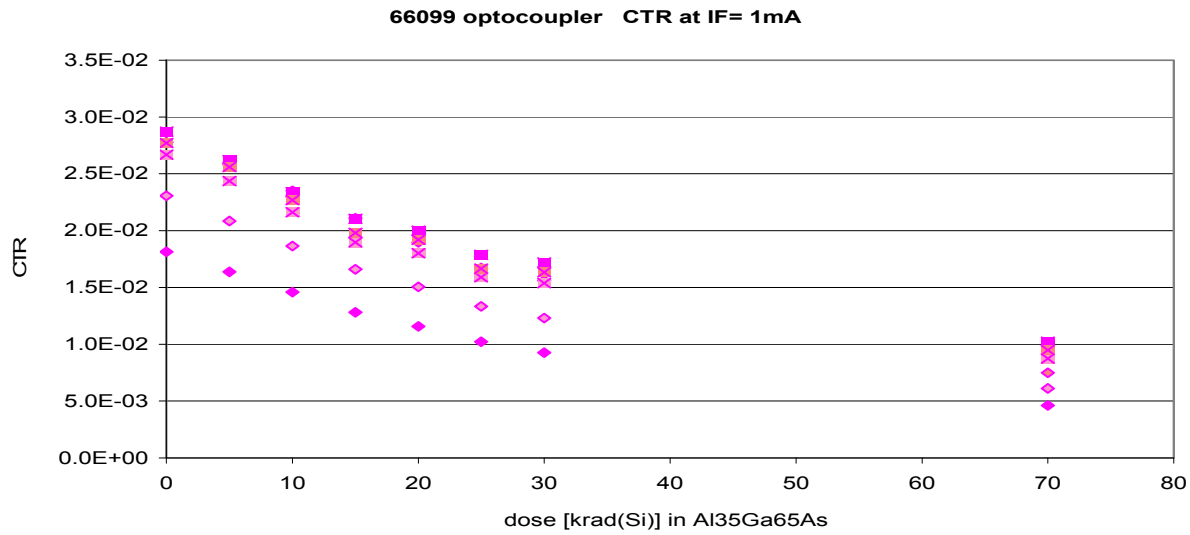


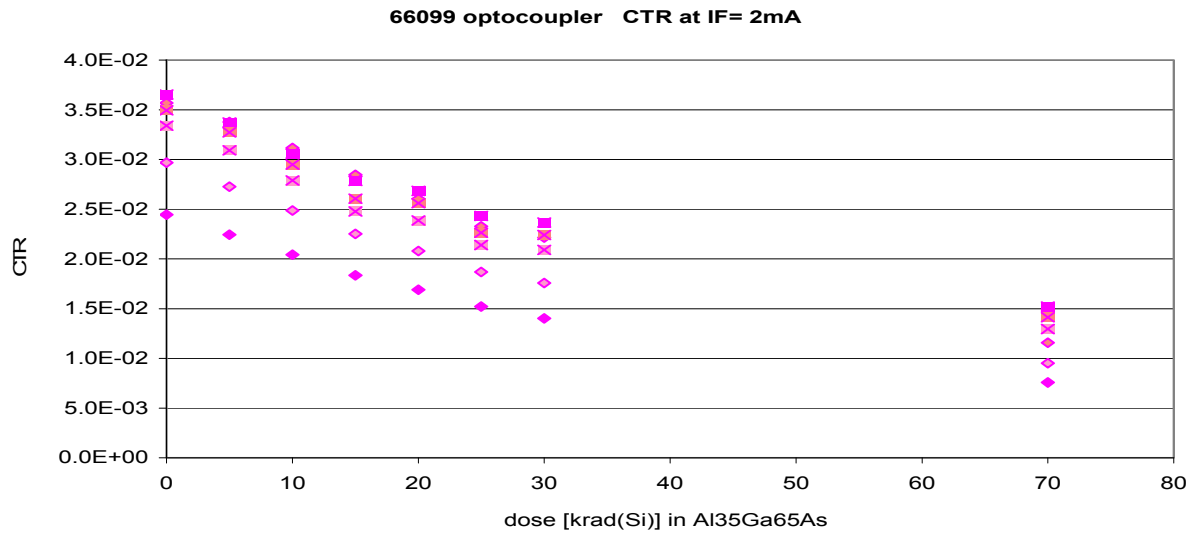

66099 diode powerN at IF= 8mA, IR= -4mA
powerN
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
37
37.5
38
38.5
39
39.5
40
40.5
TRR0 at IR= -4mA

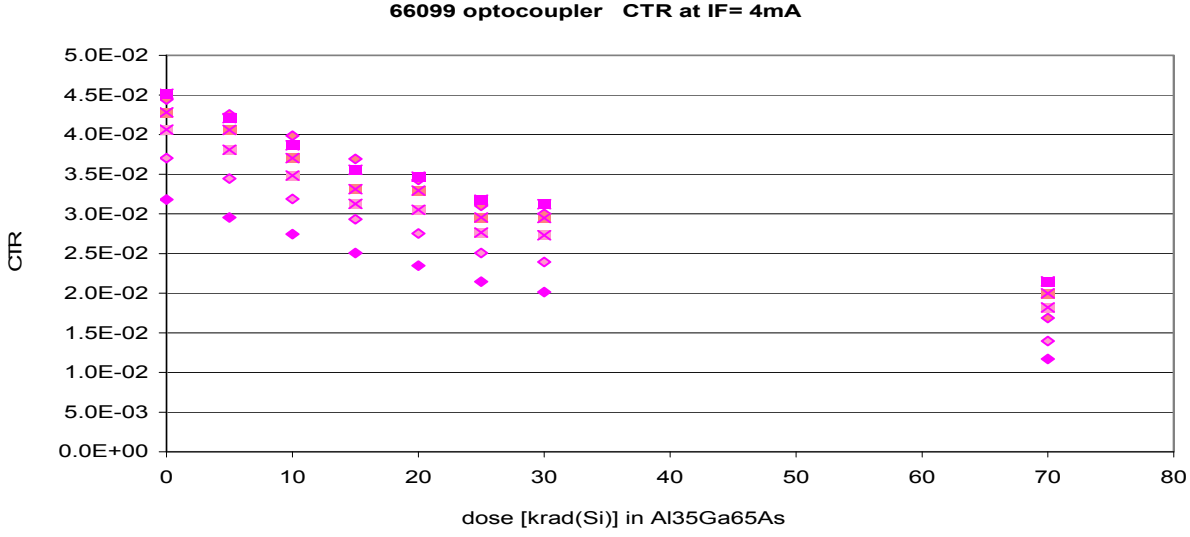

66099 diode powerN at IF= 10mA, IR= -4mA
powerN
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
37
37.5
38
38.5
39
39.5
40
40.5
TRR0 at IR= -4mA

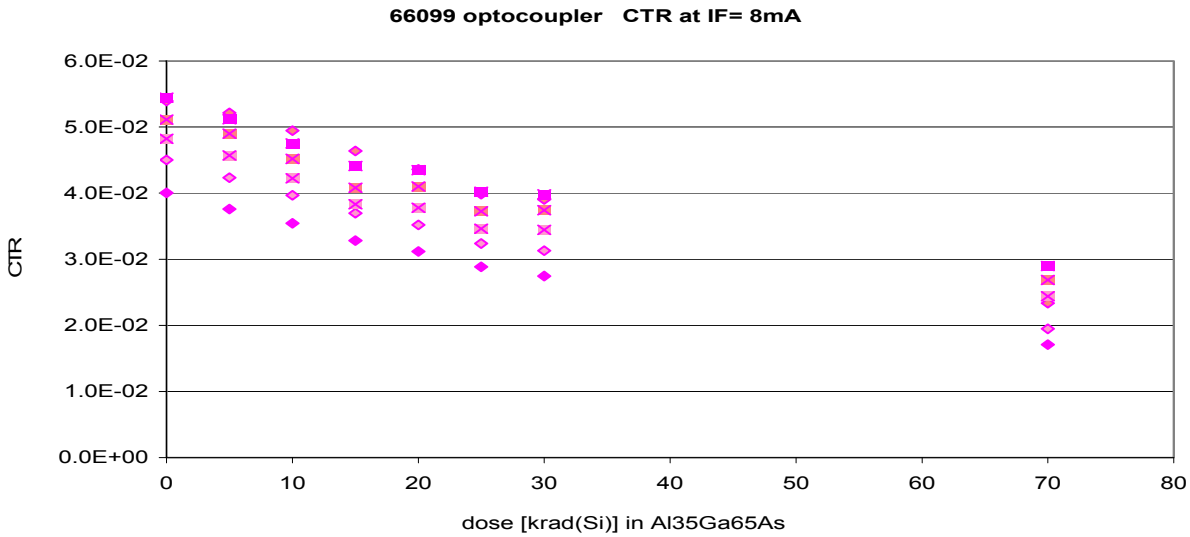
14.3 GAMMA IRRADIATION

Fig. 14-175: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

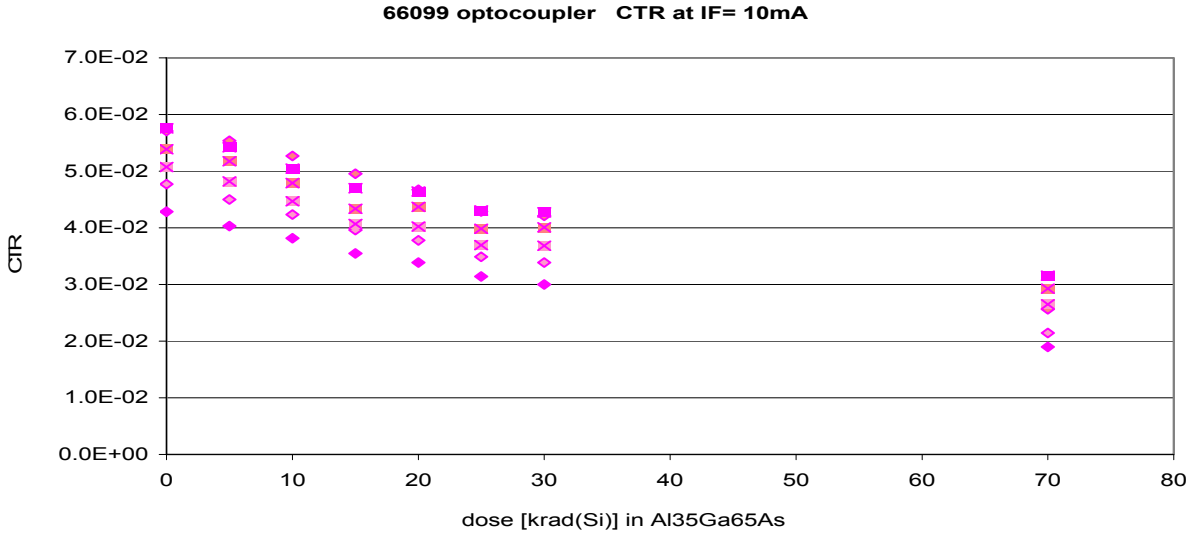
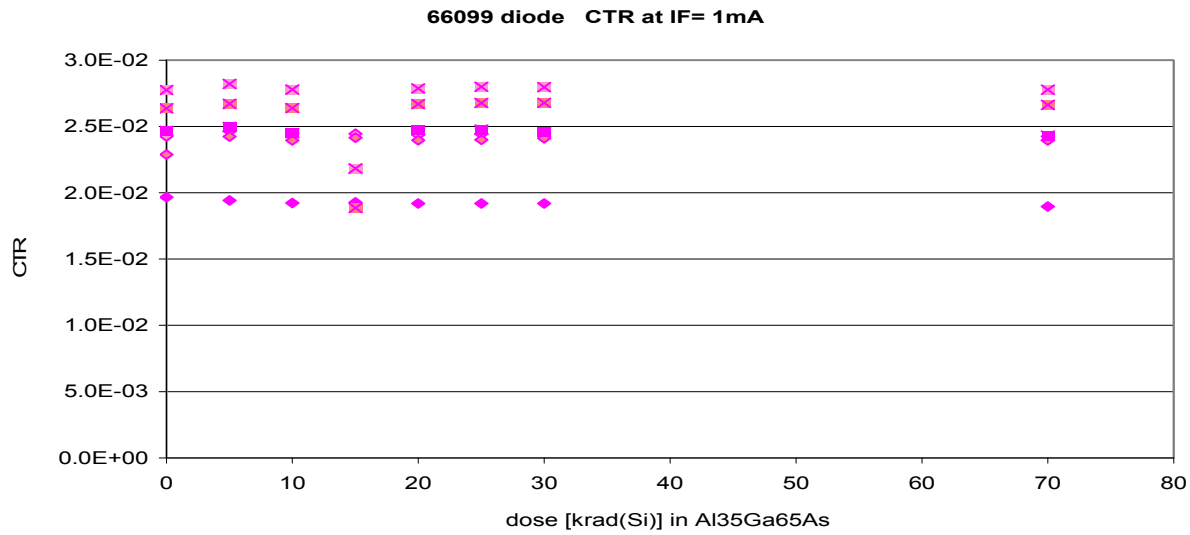
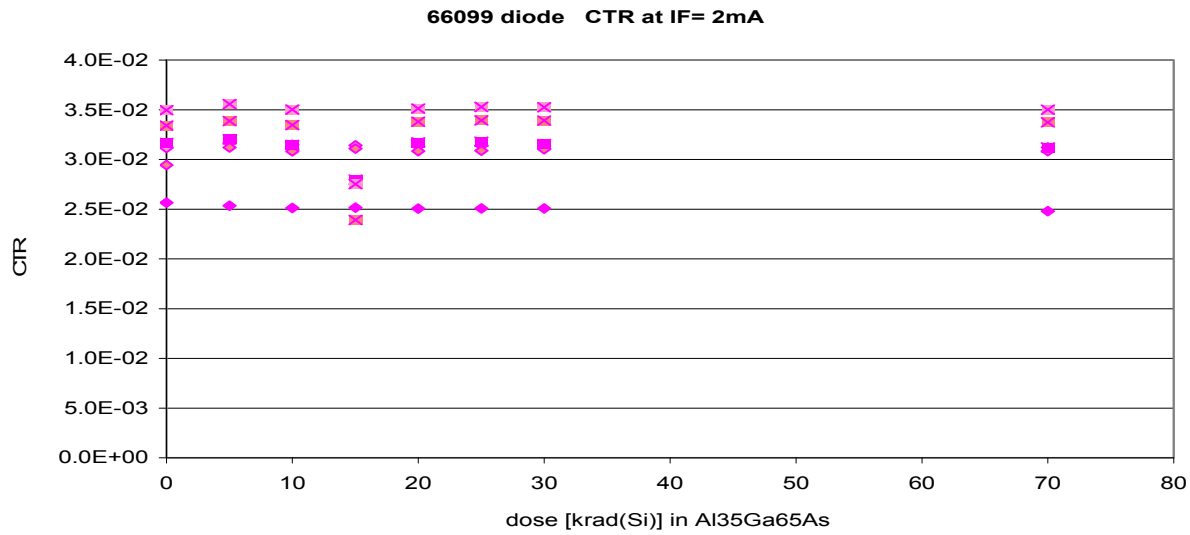
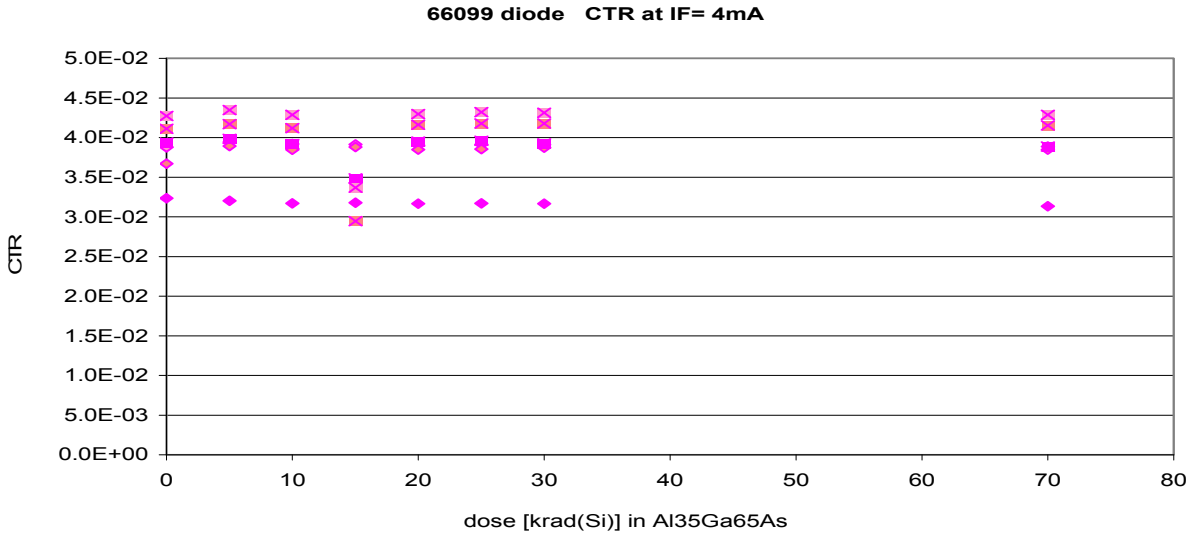
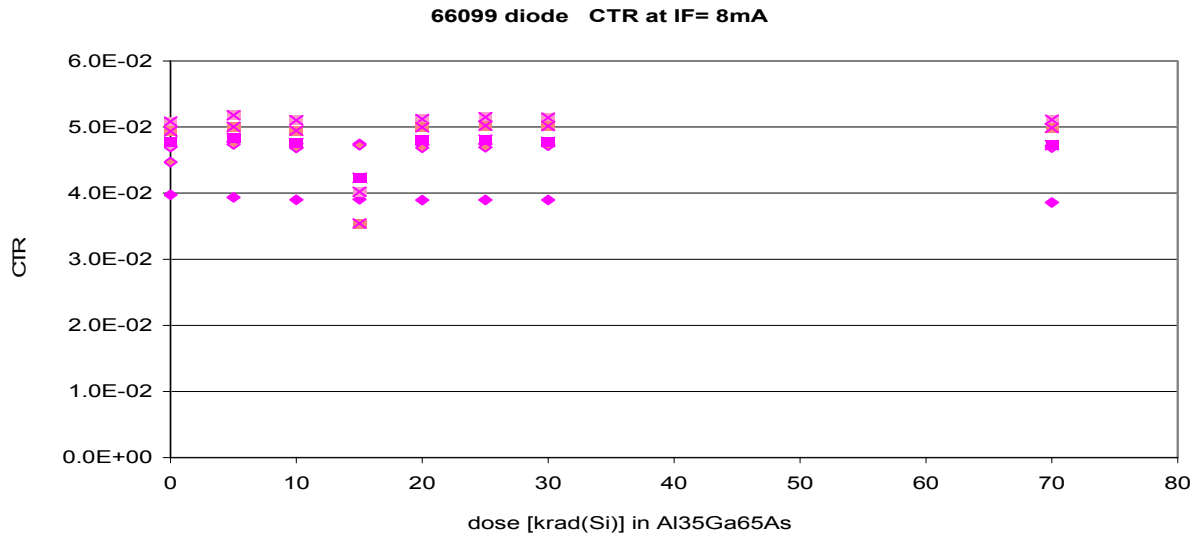

66099 optocoupler CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-176: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 diode CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

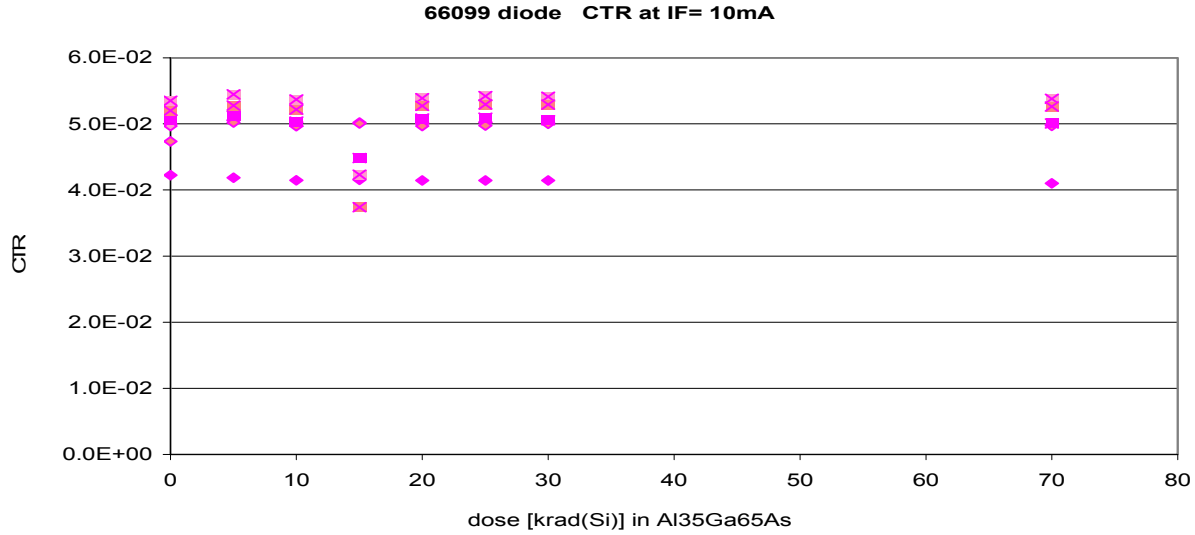
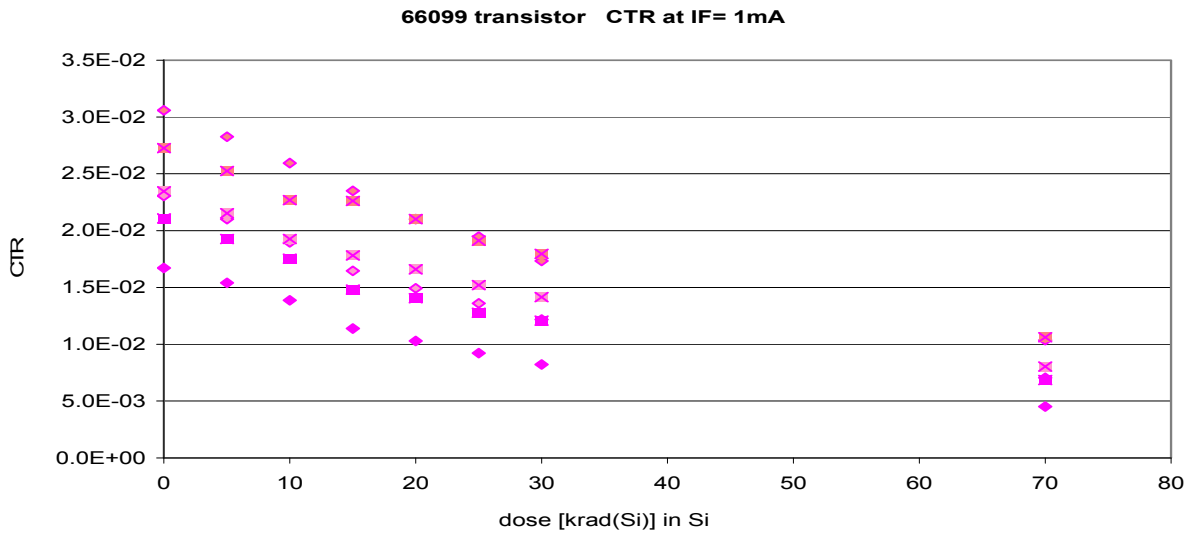
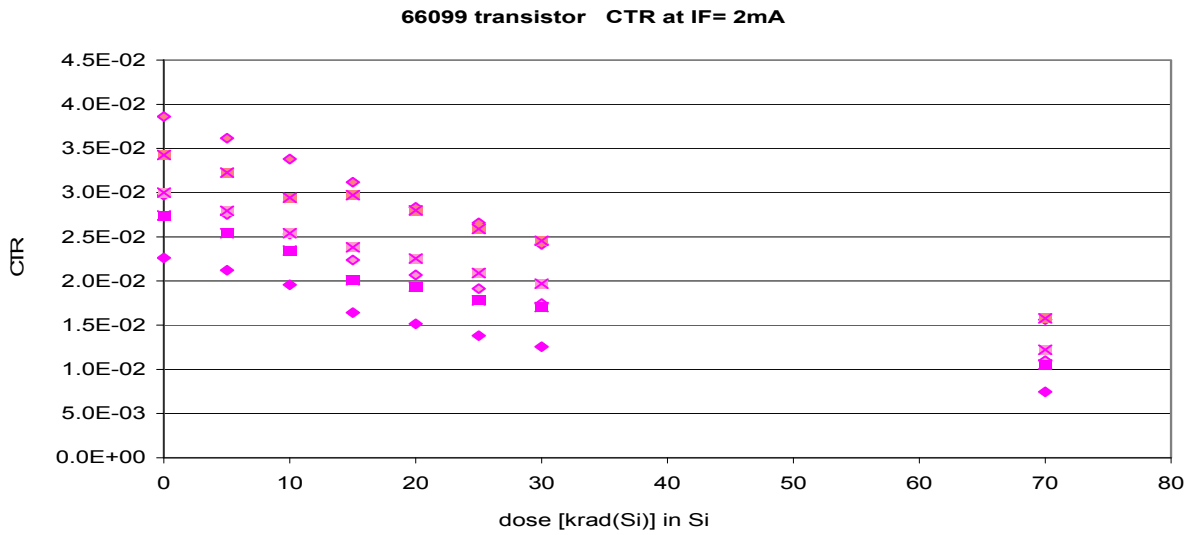
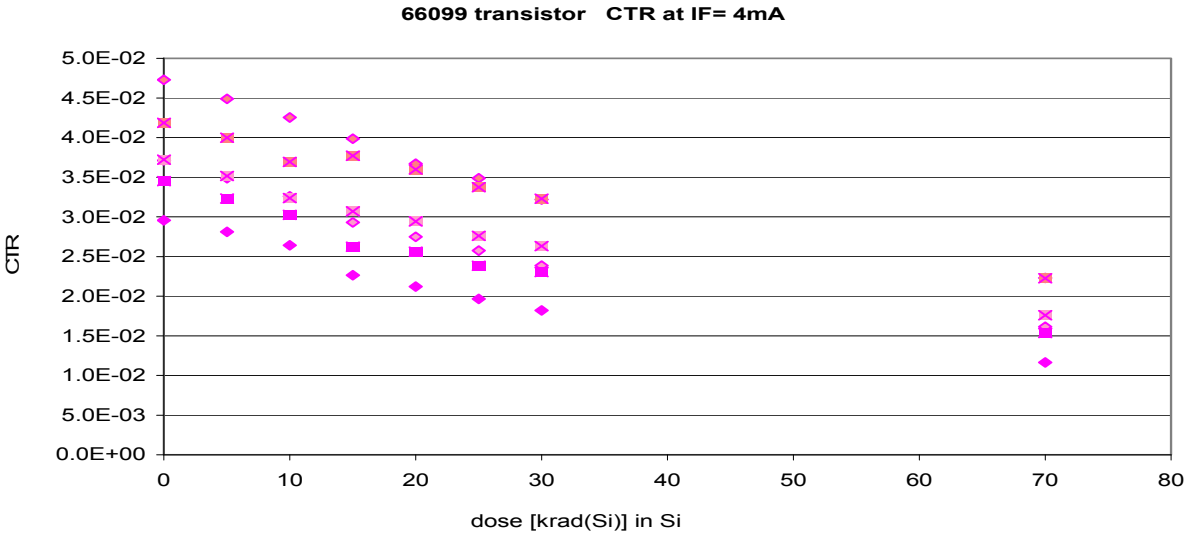
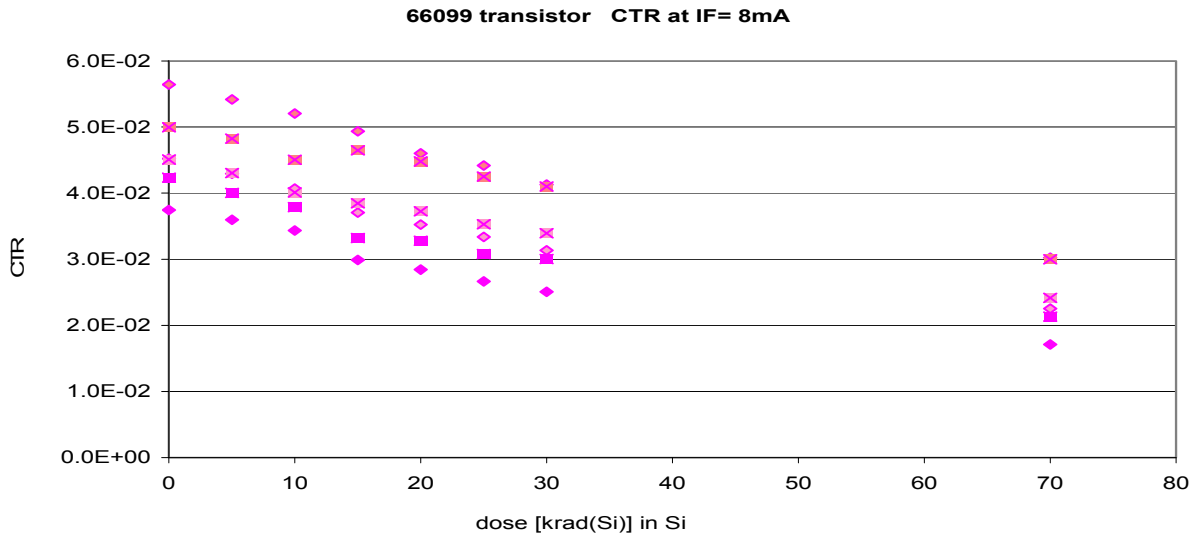

66099 diode CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-177: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 transistor CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

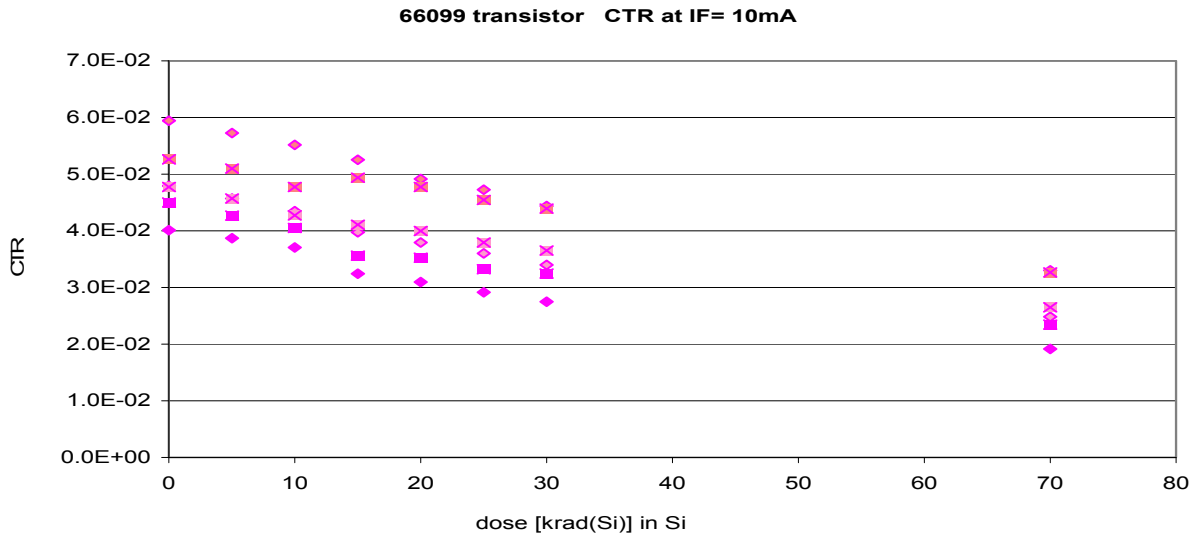
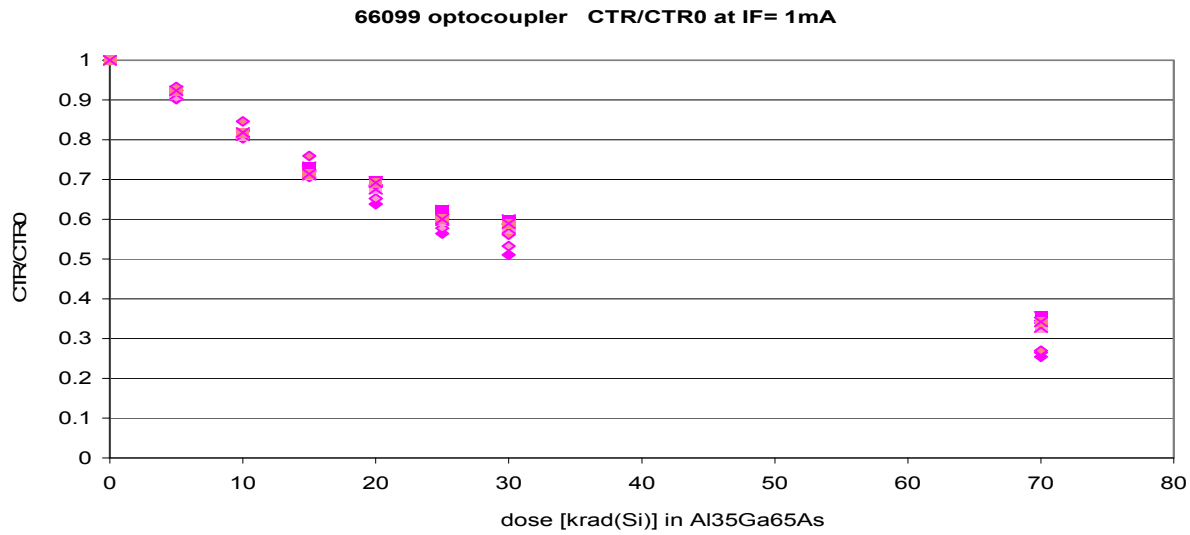
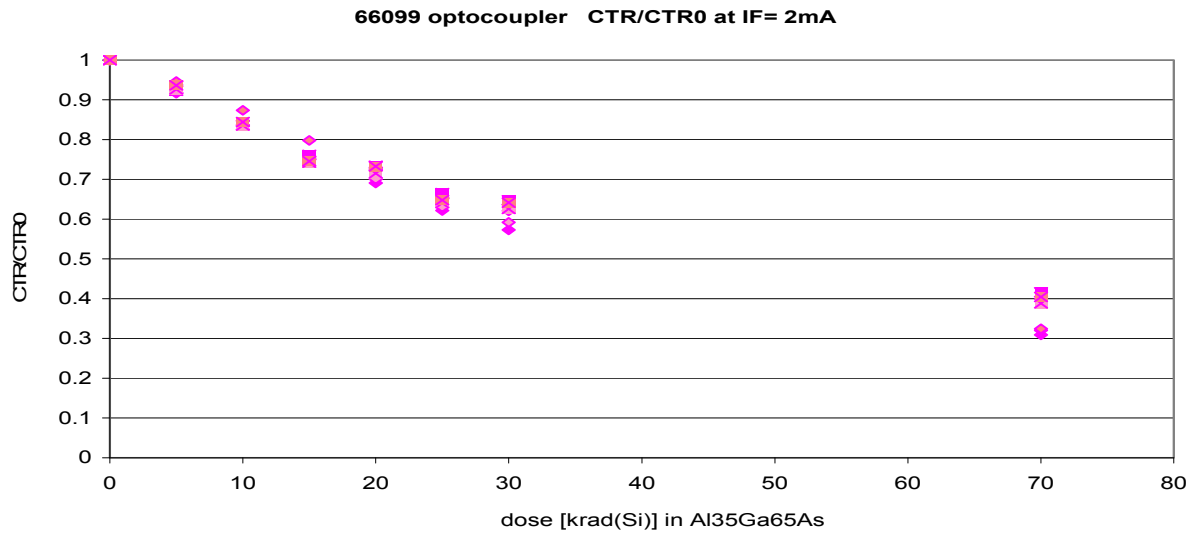
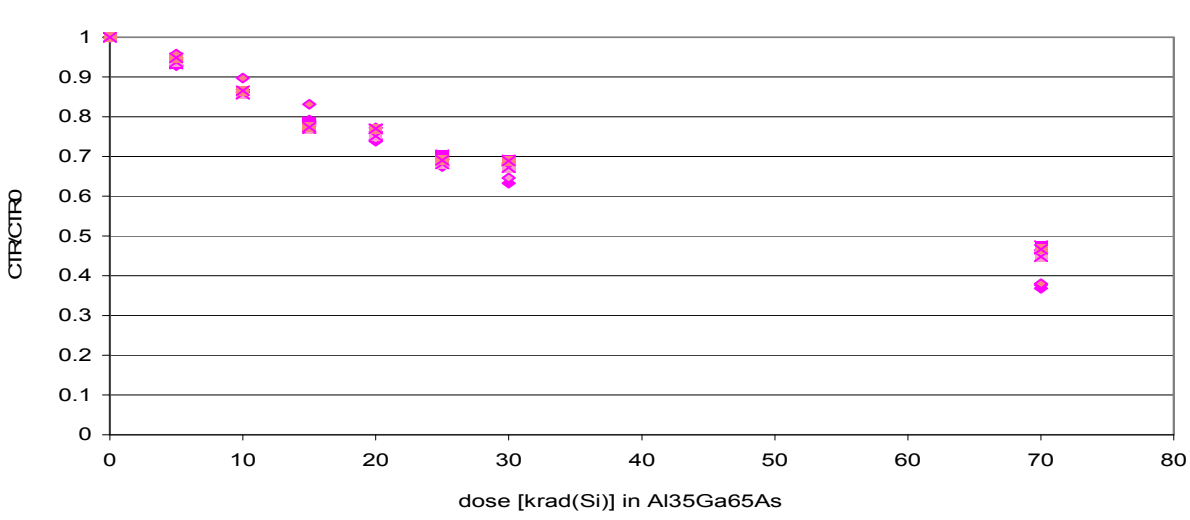
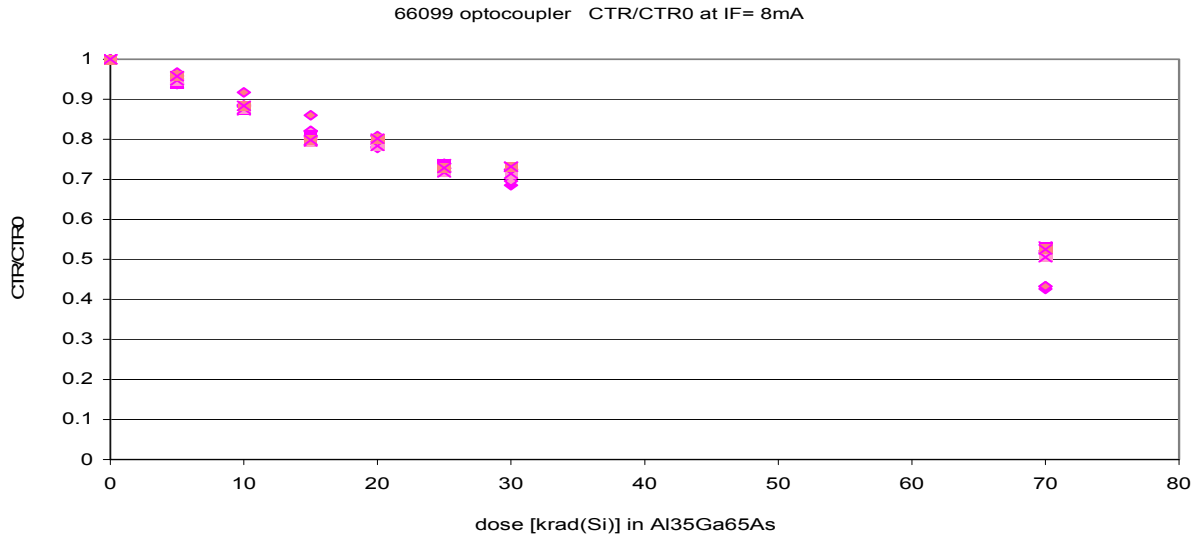

66099 transistor CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 14-178: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

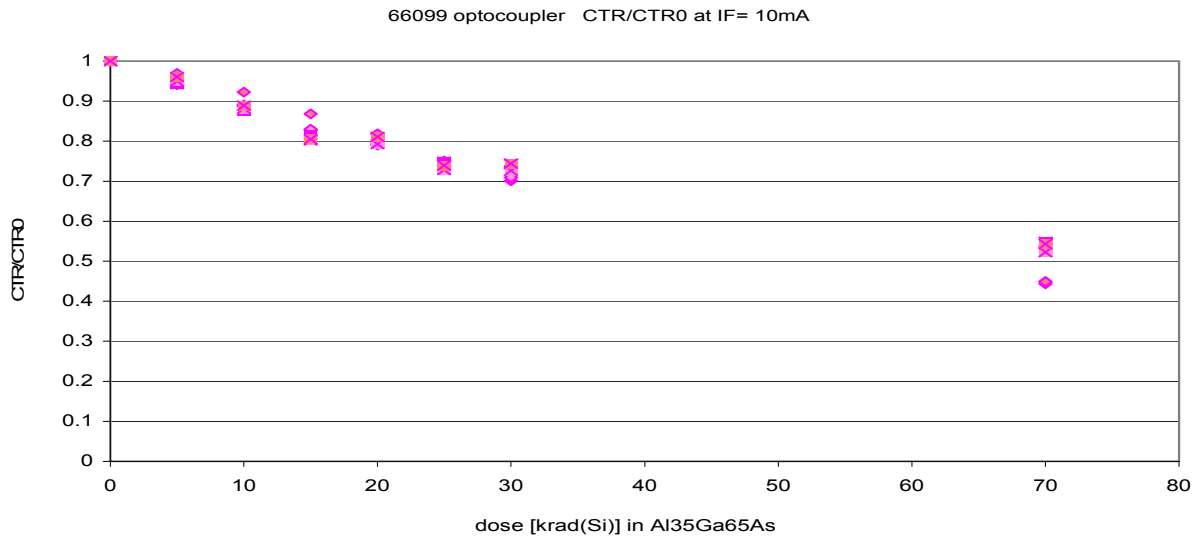
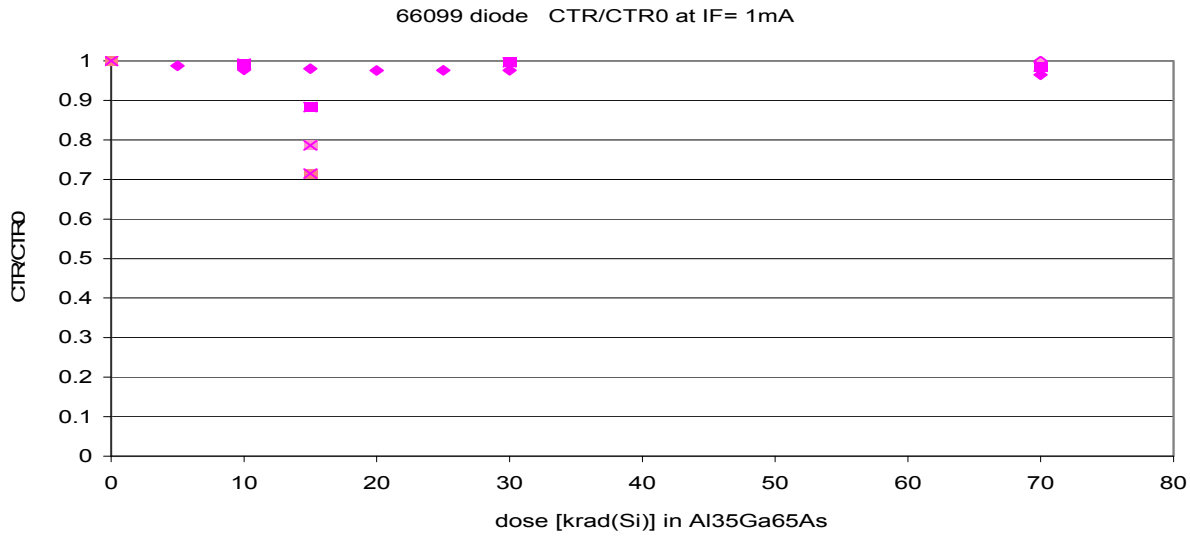
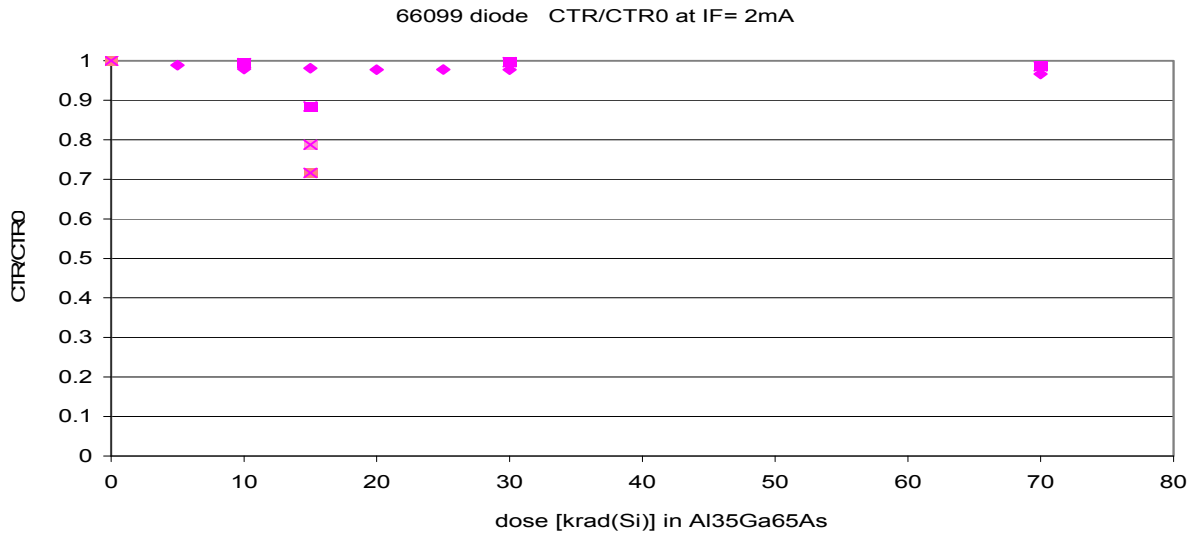
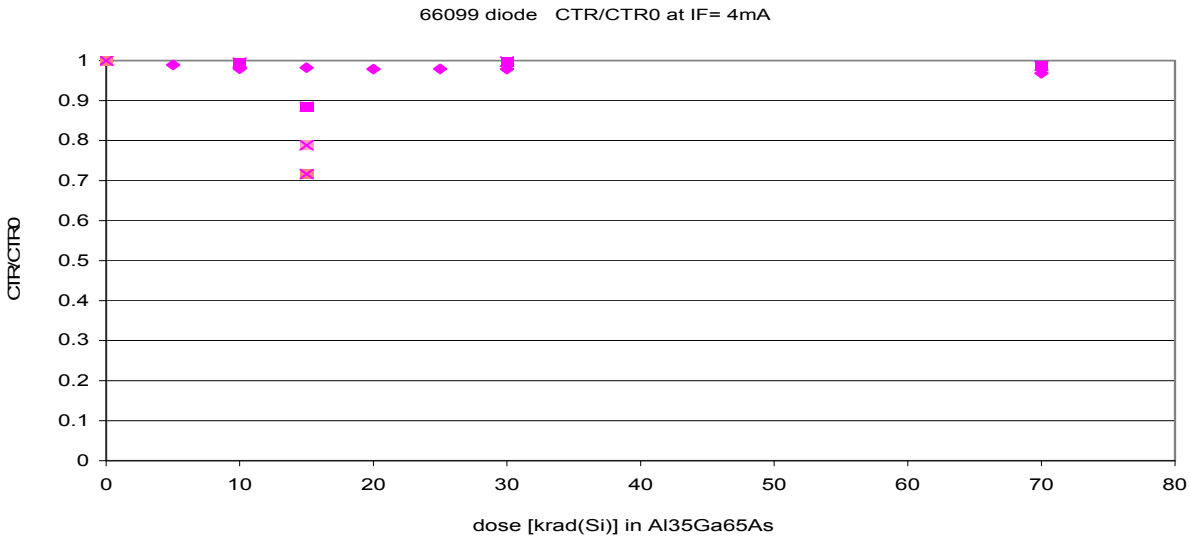
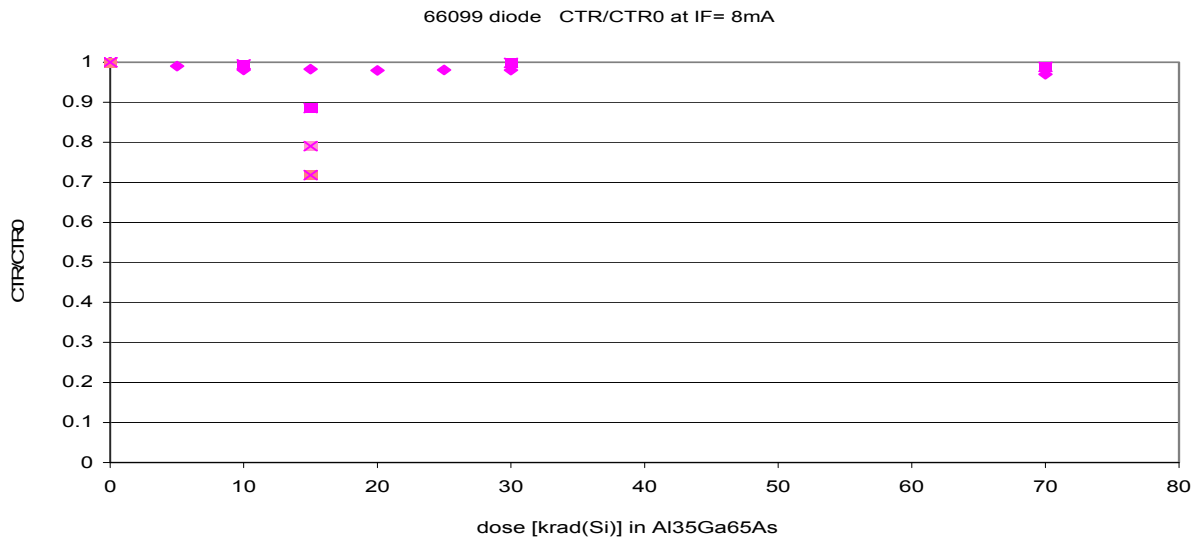

66099 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-179: 66099 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

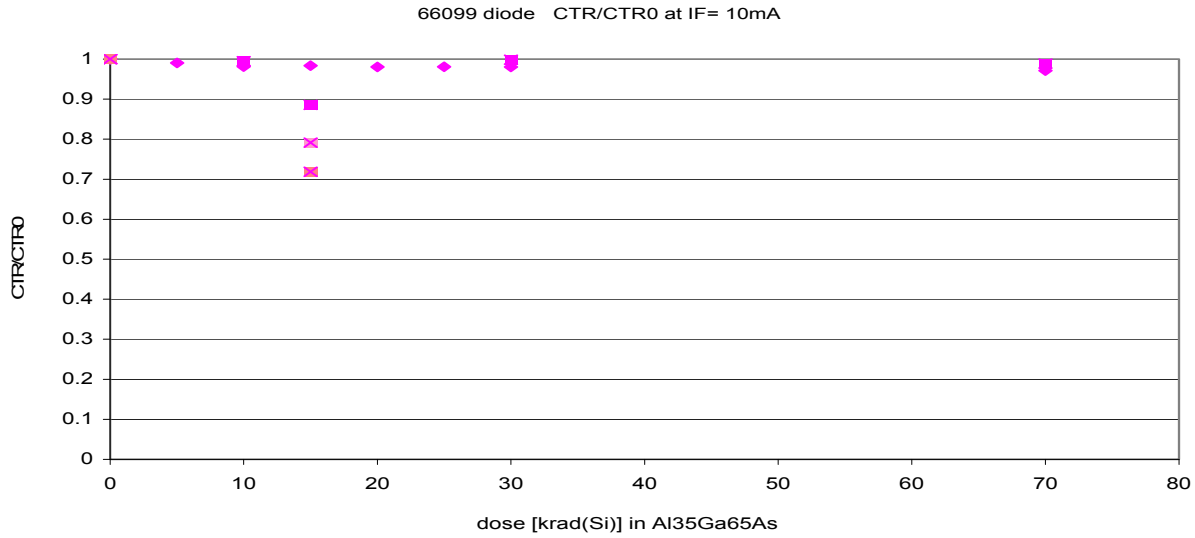
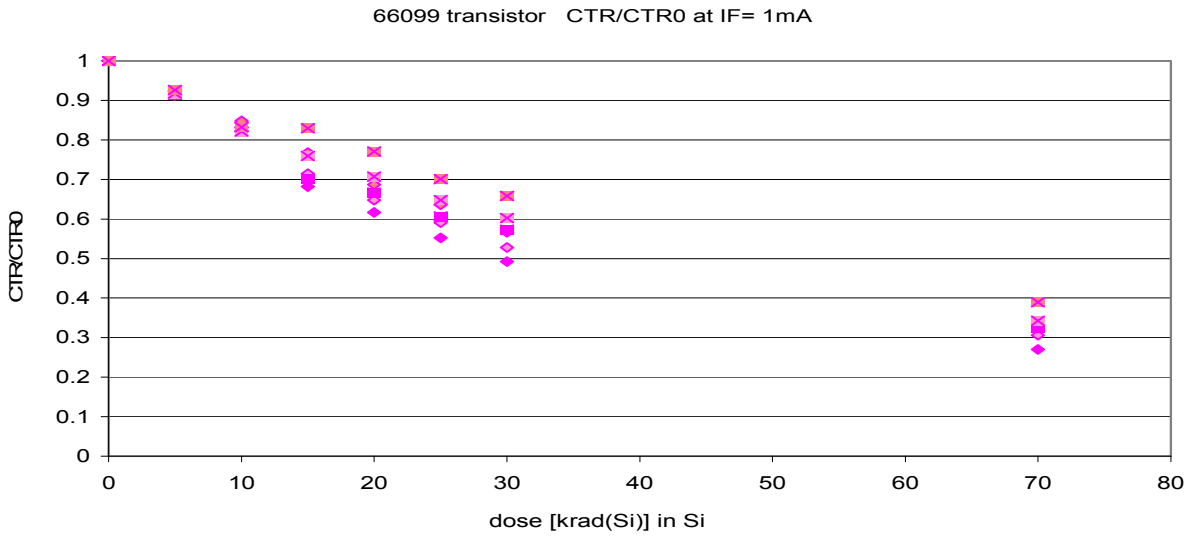
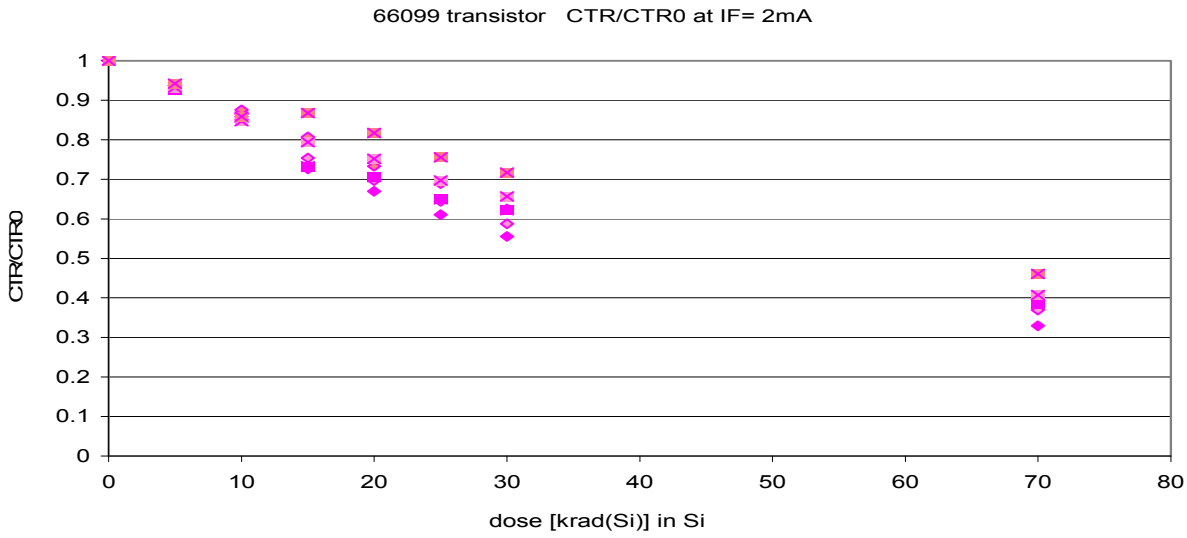
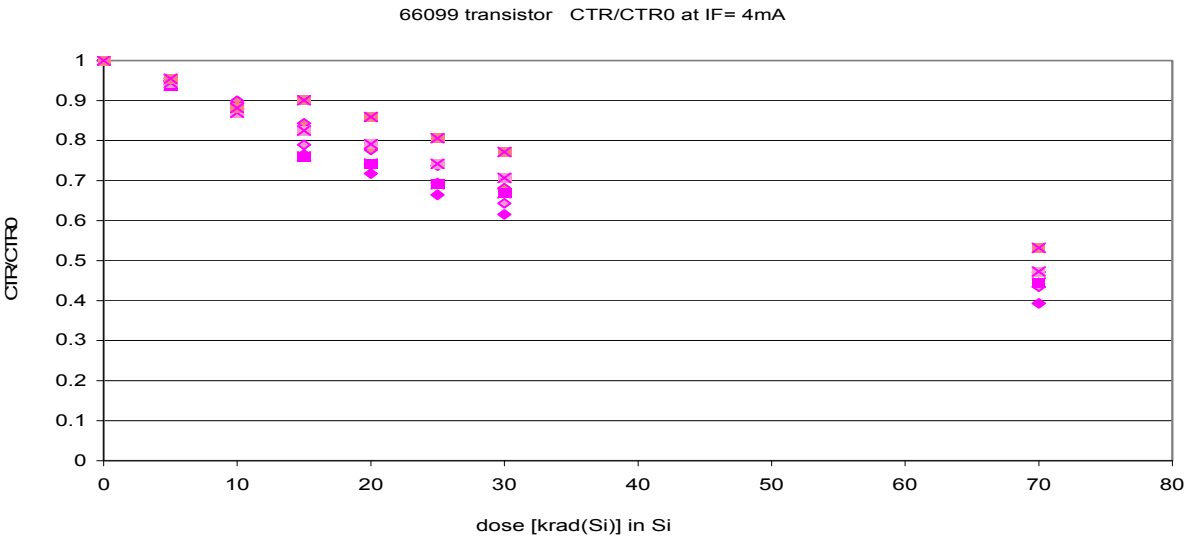
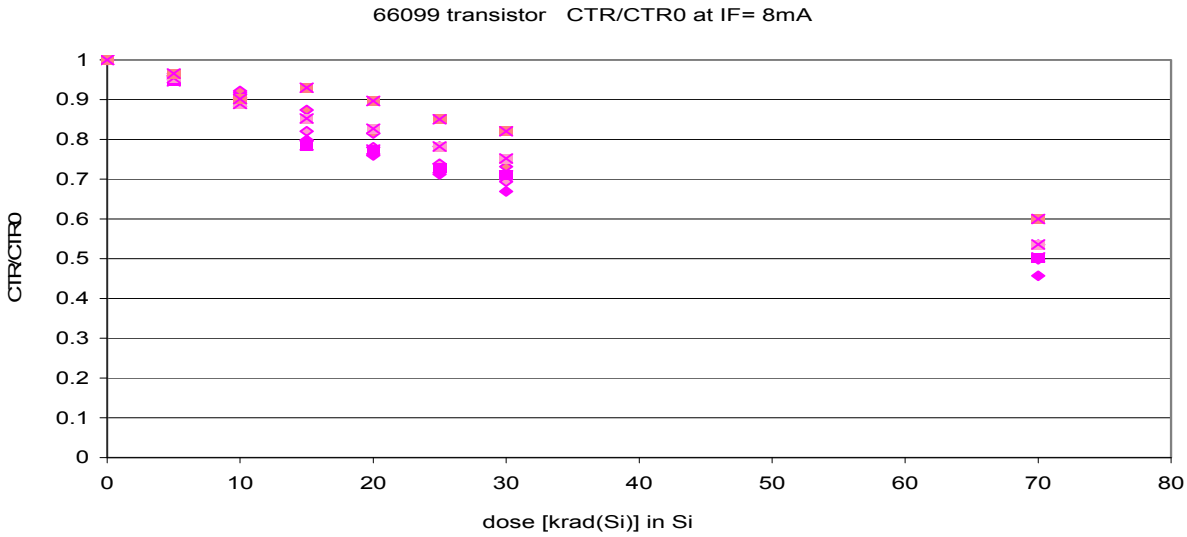

66099 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-180: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

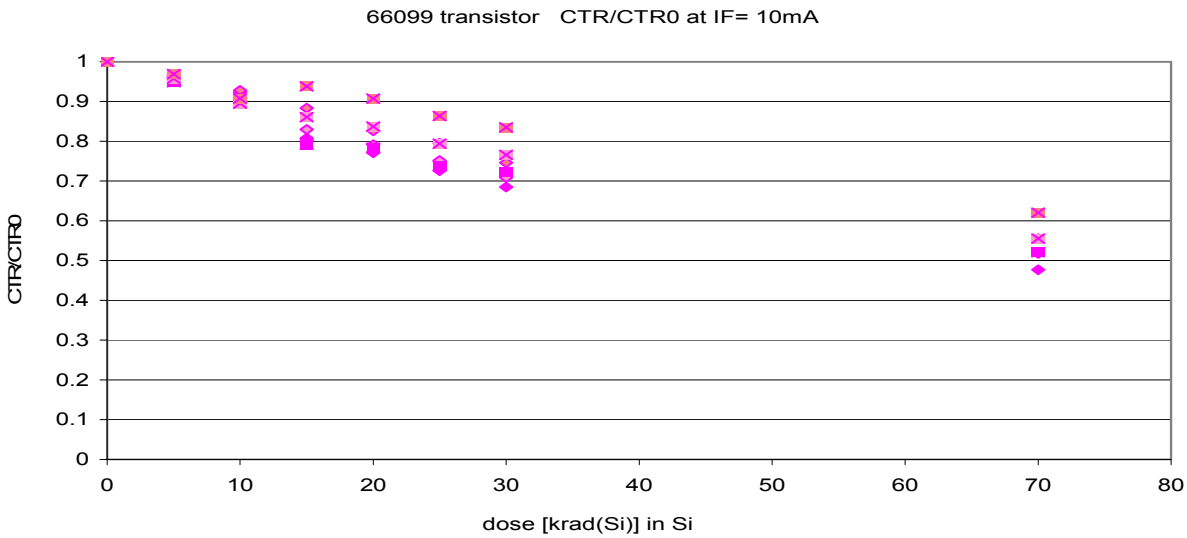
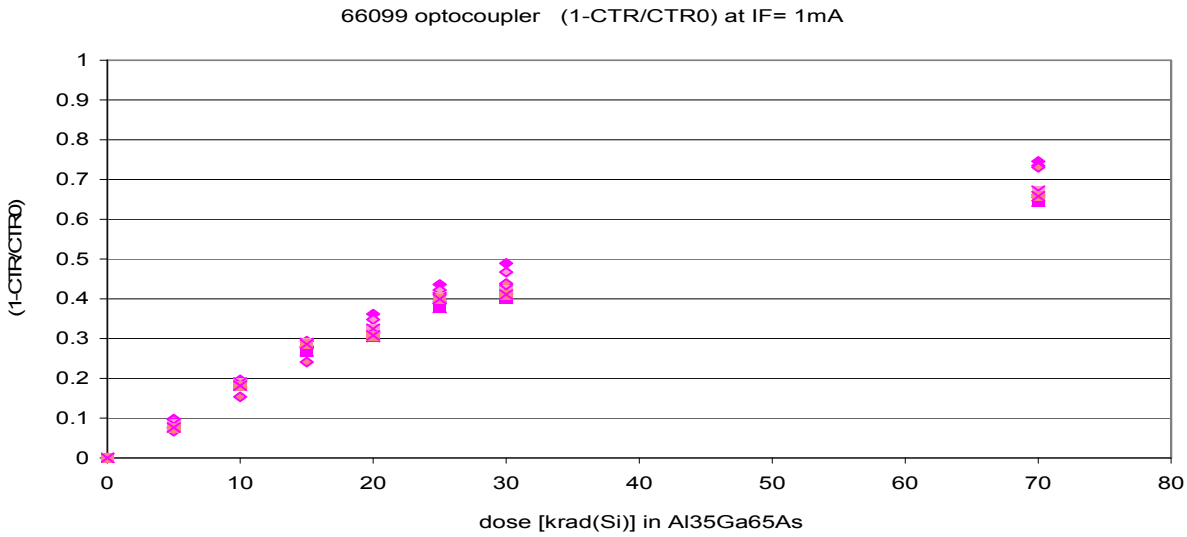
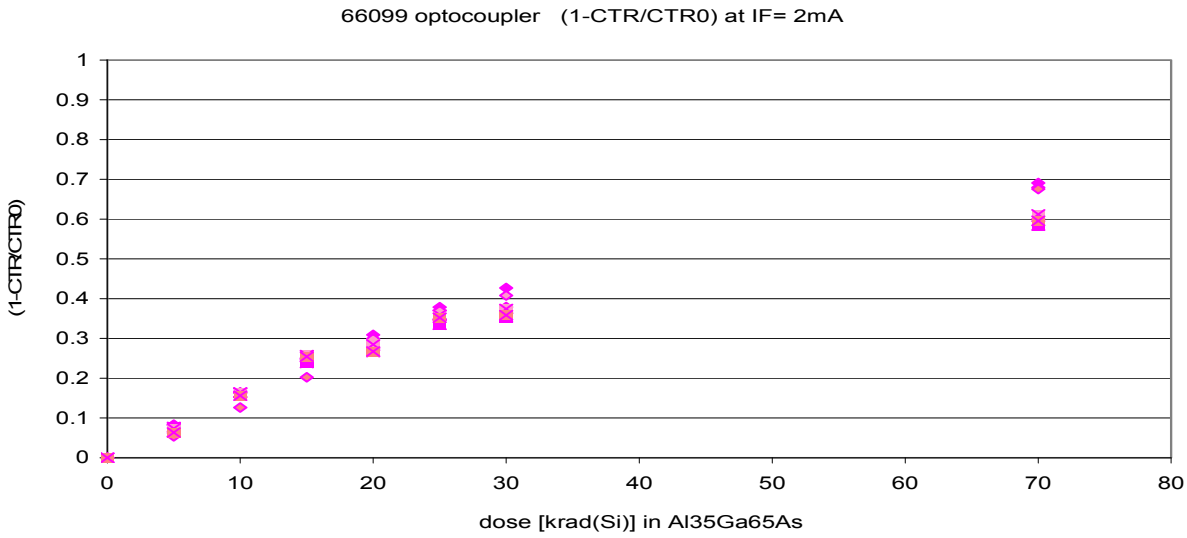
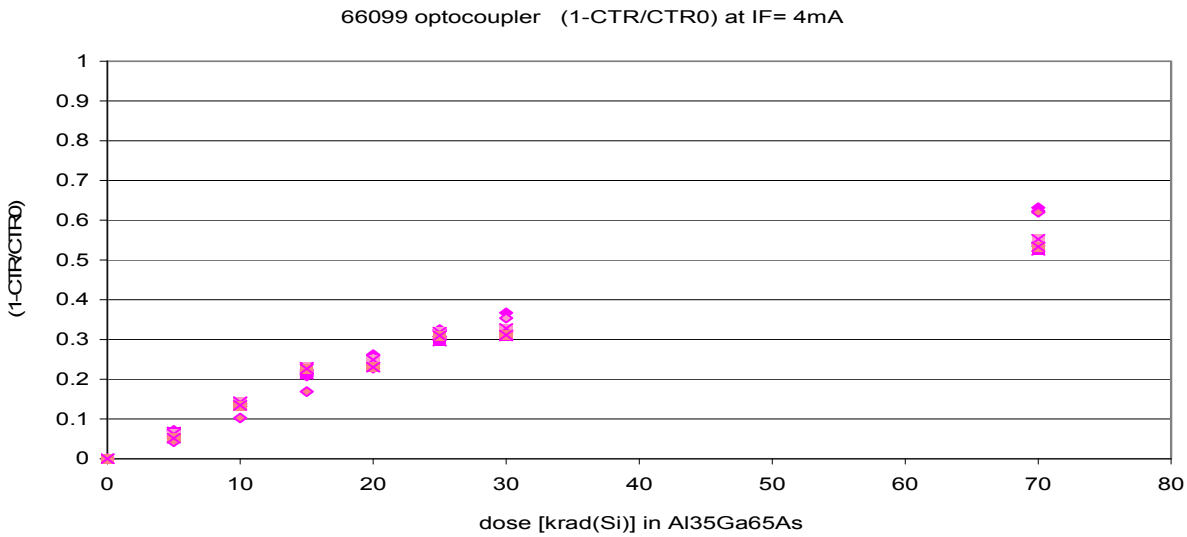
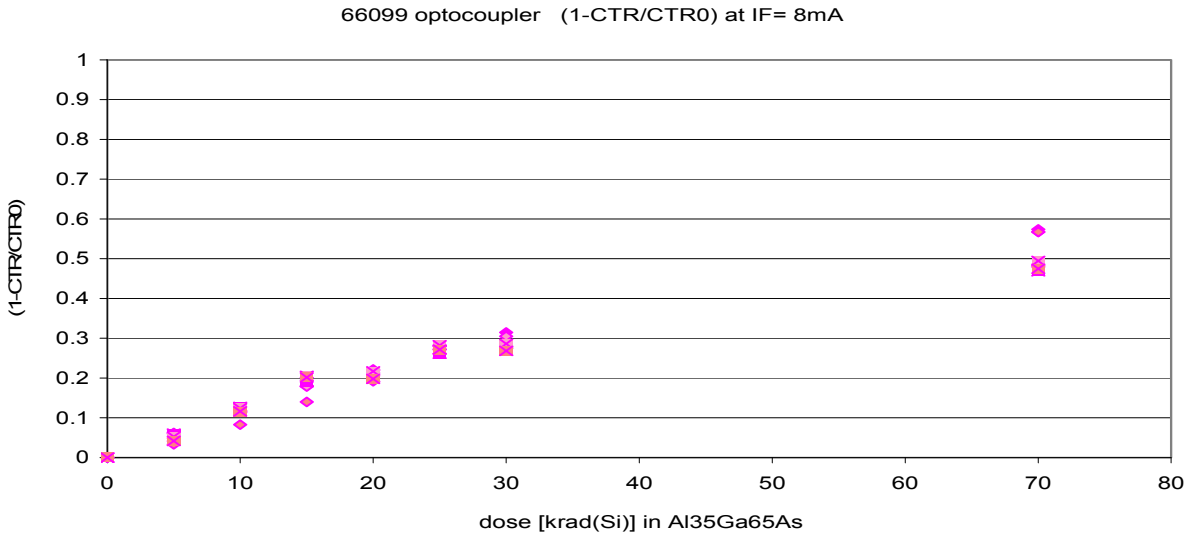

66099 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Si

Fig. 14-181: 66099 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

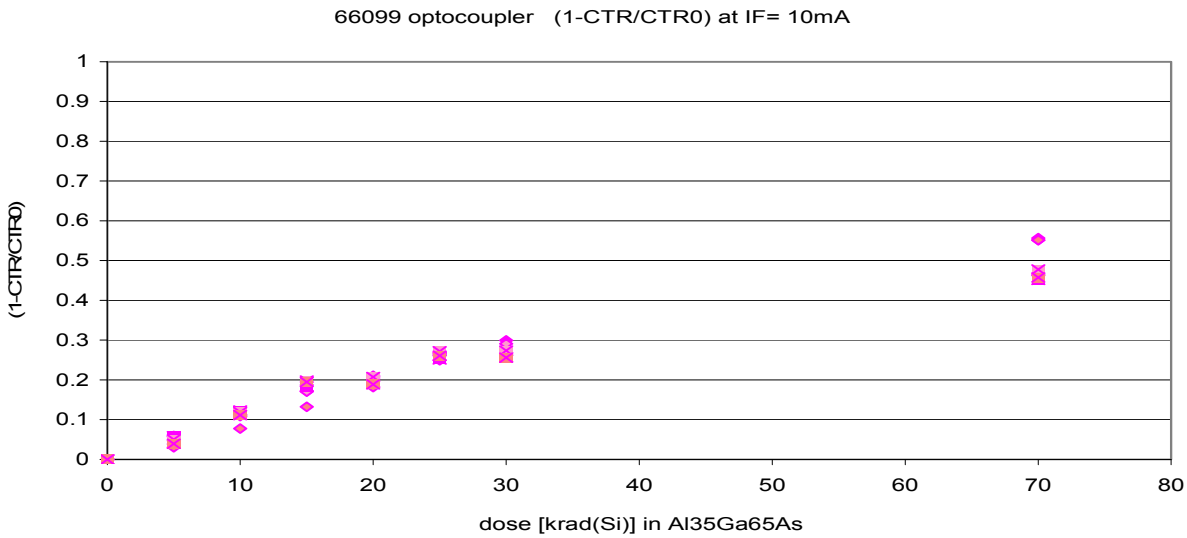
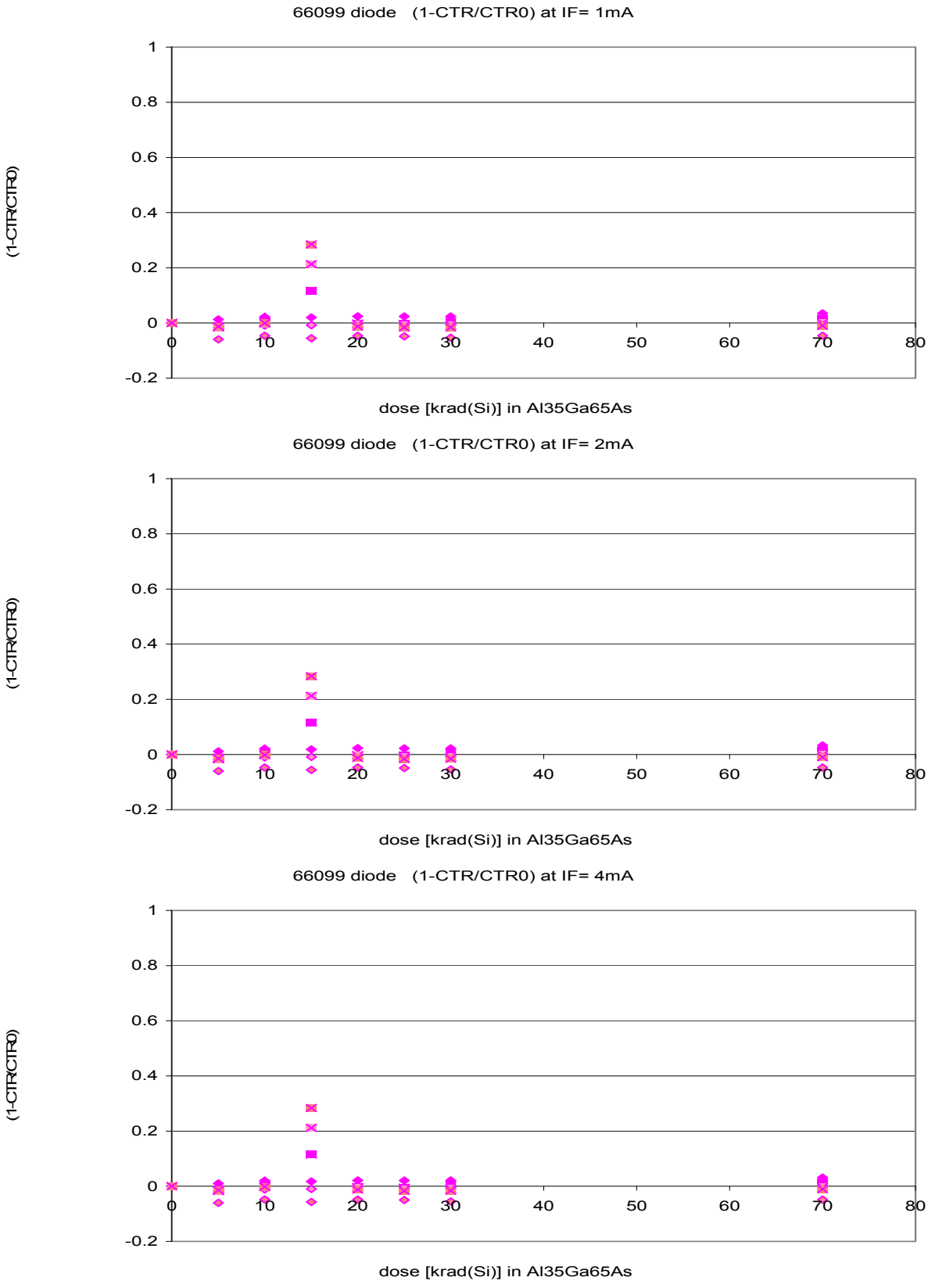
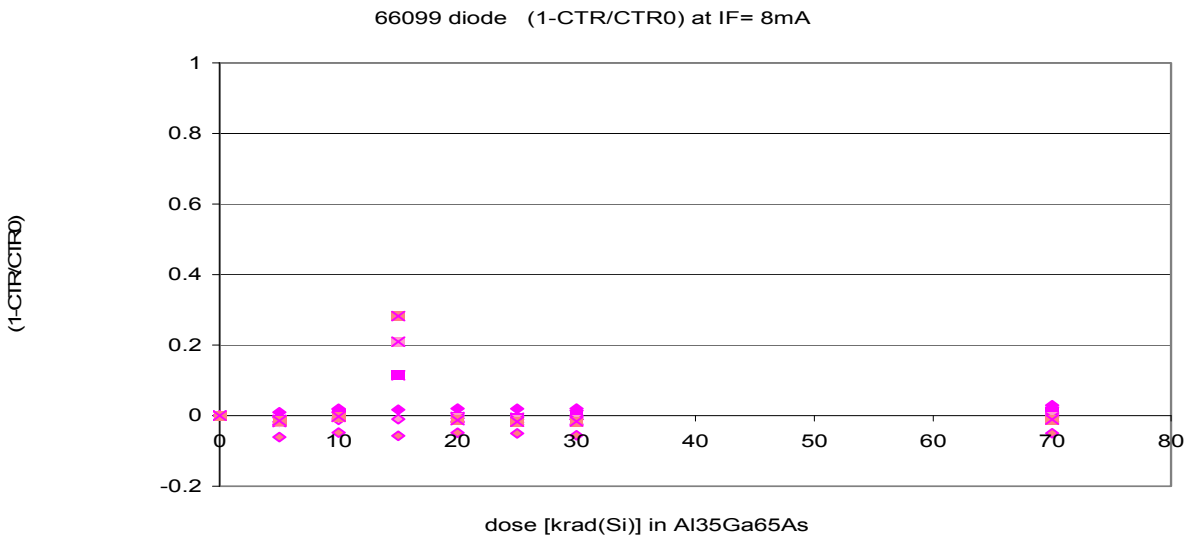

66099 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-182: 66099 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose




66099 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

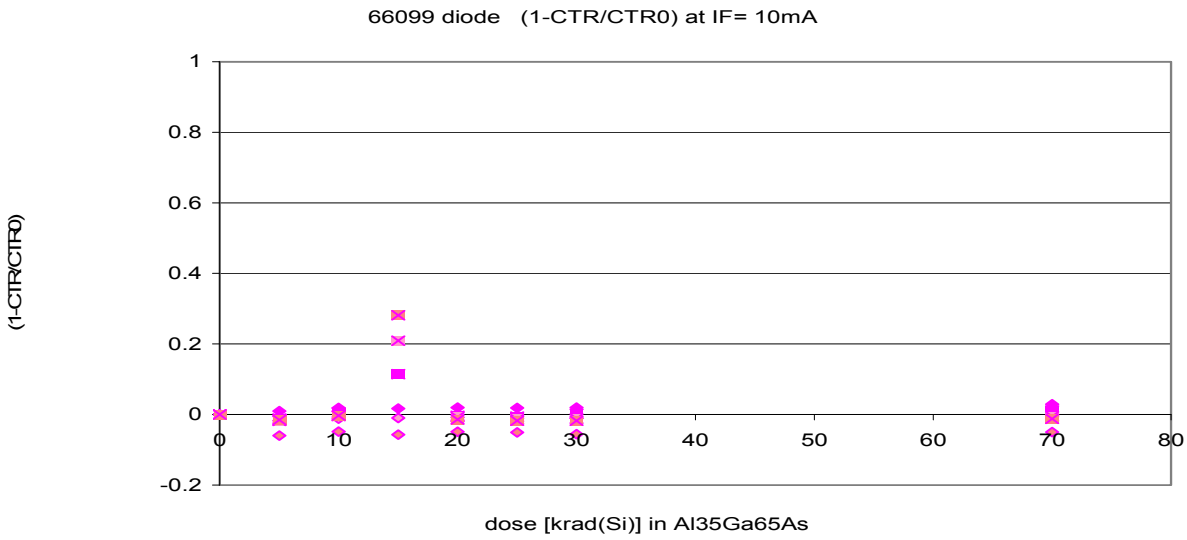
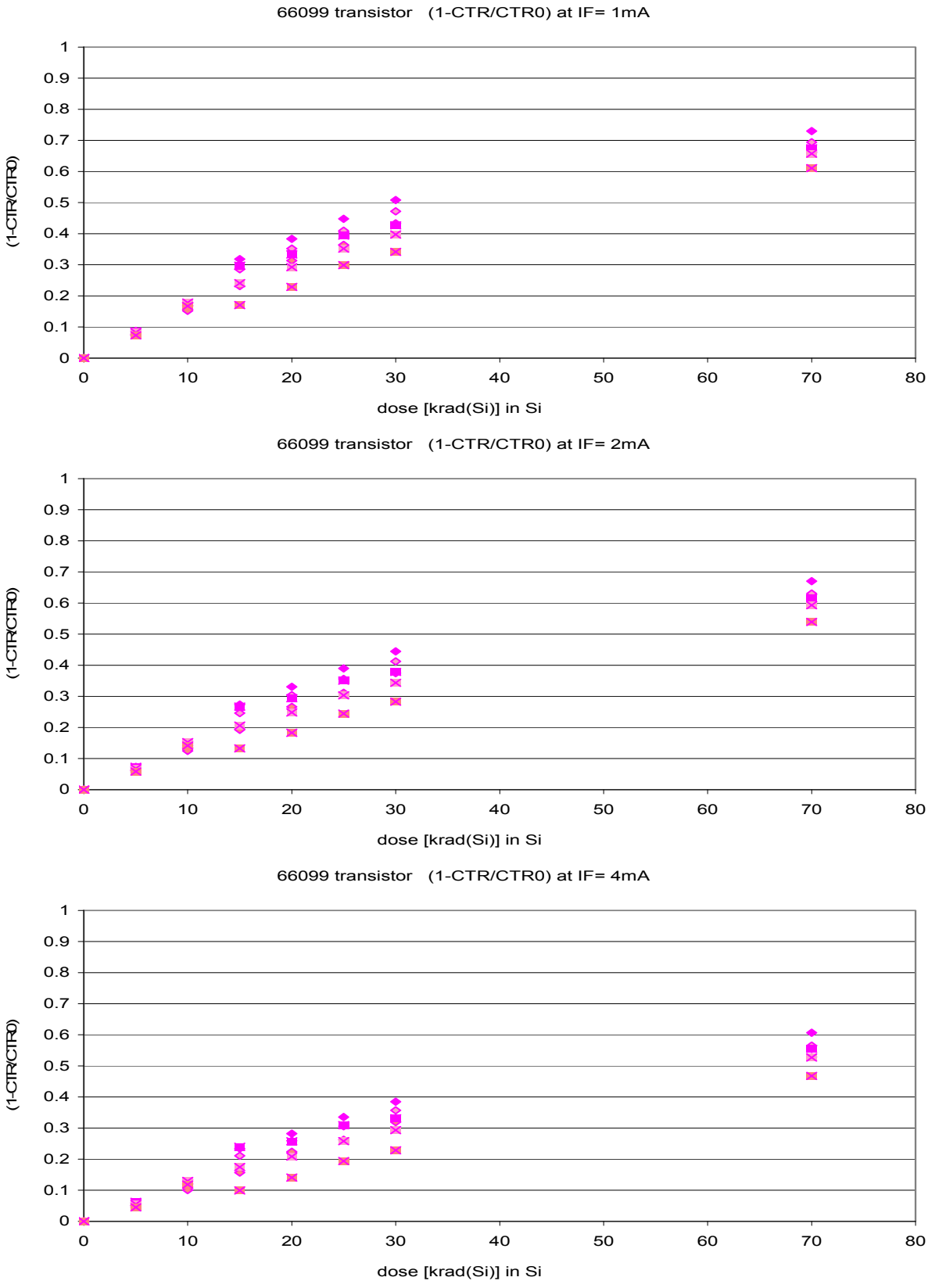
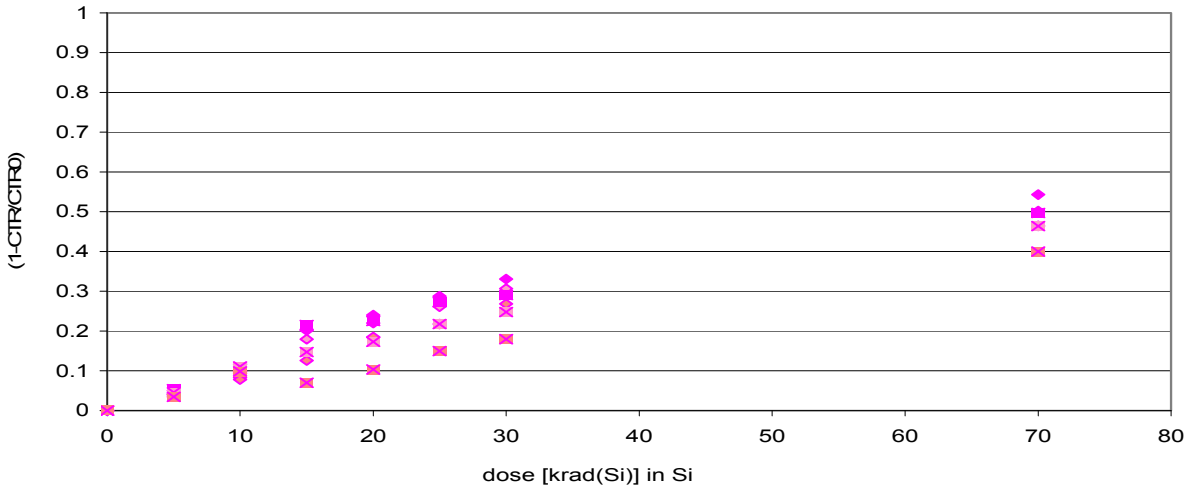

66099 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
40
50
60
70
80
dose [krad(Si)] in Al35Ga65As

Fig. 14-183: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose



66099 transistor (1-CTR/CTR0) at IF= 8mA



66099 transistor (1-CTR/CTR0) at IF= 10mA

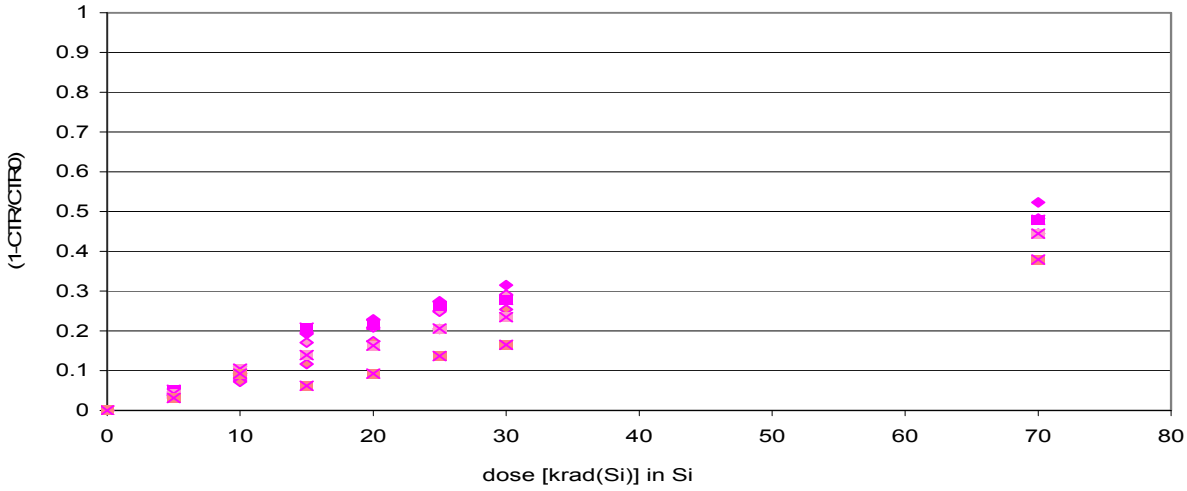
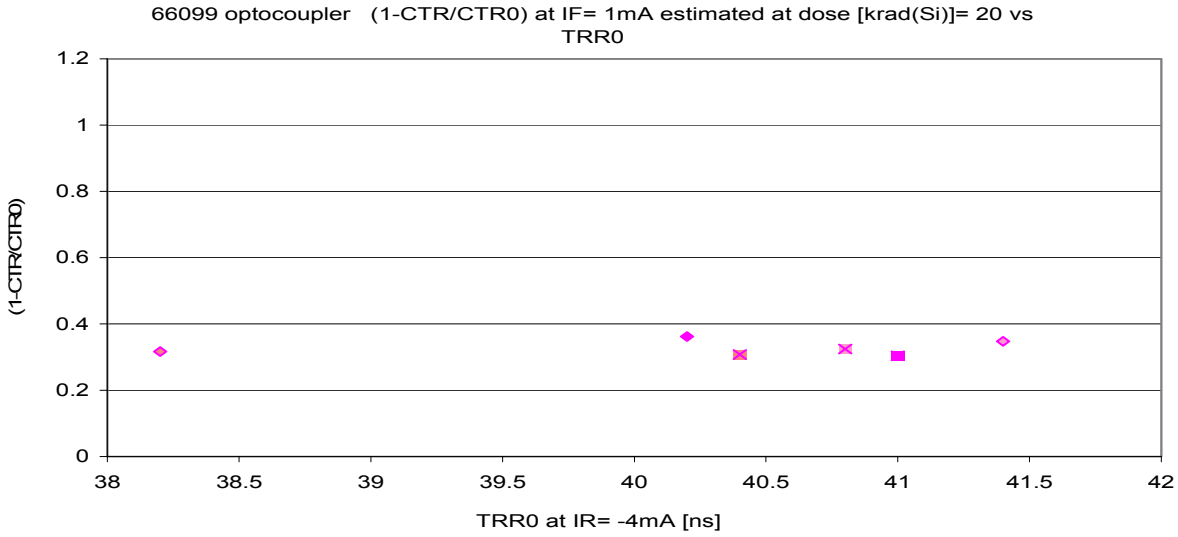
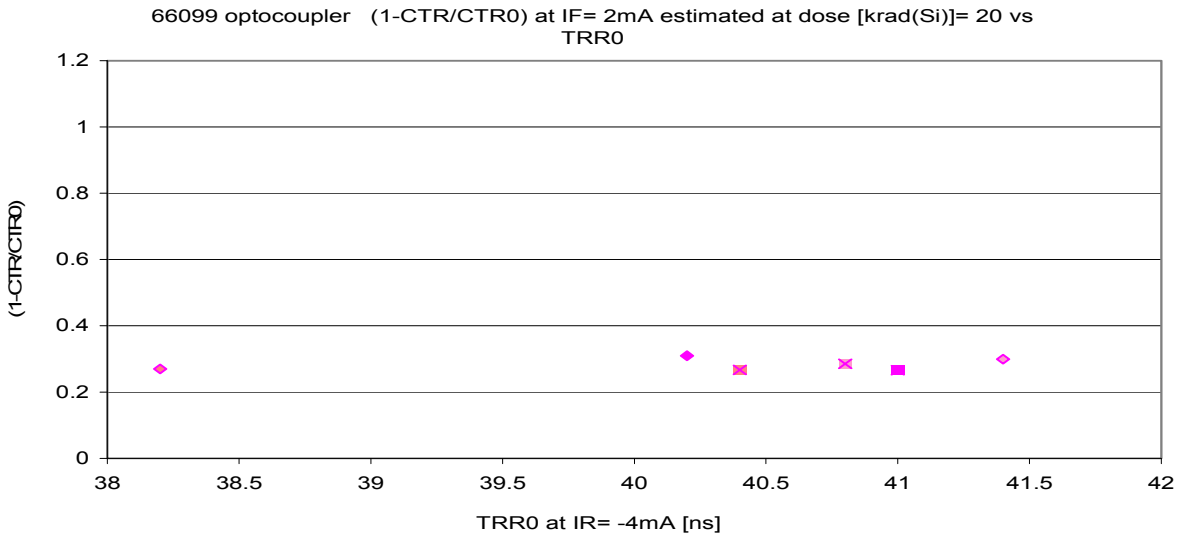
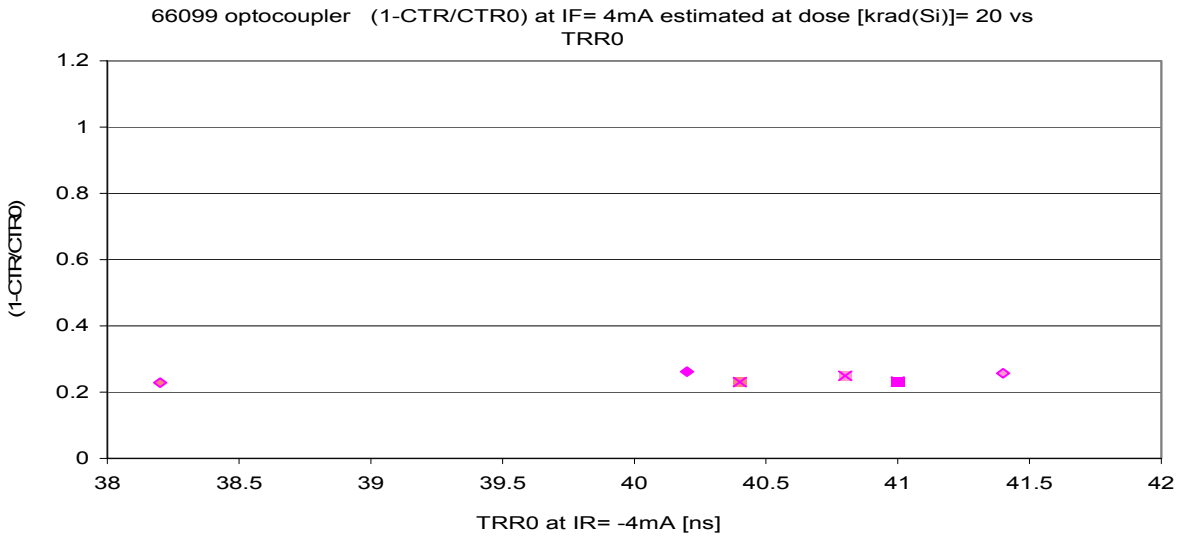
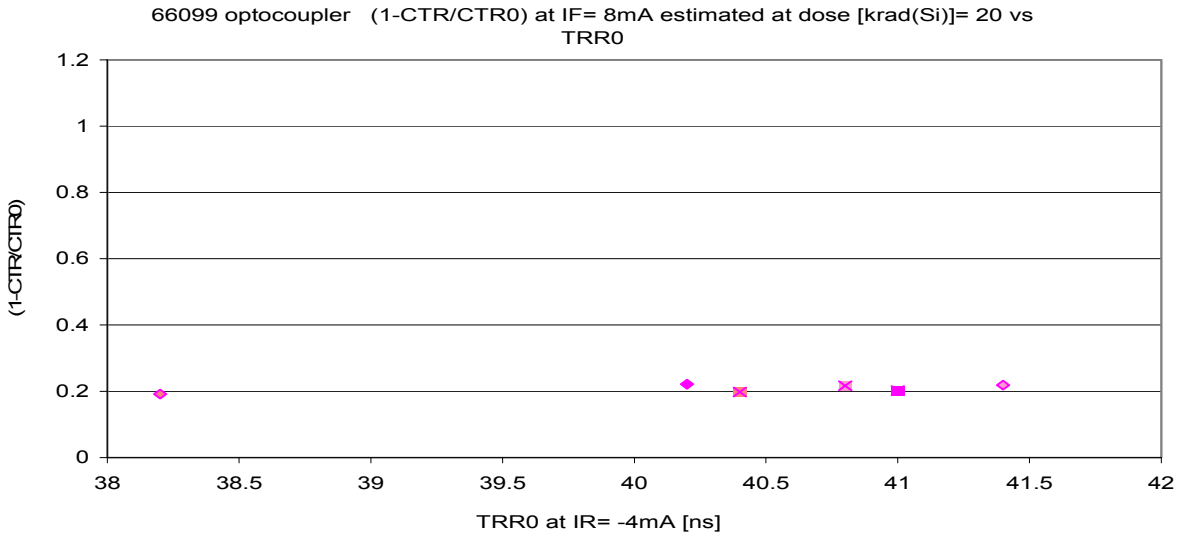


Fig. 14-184: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

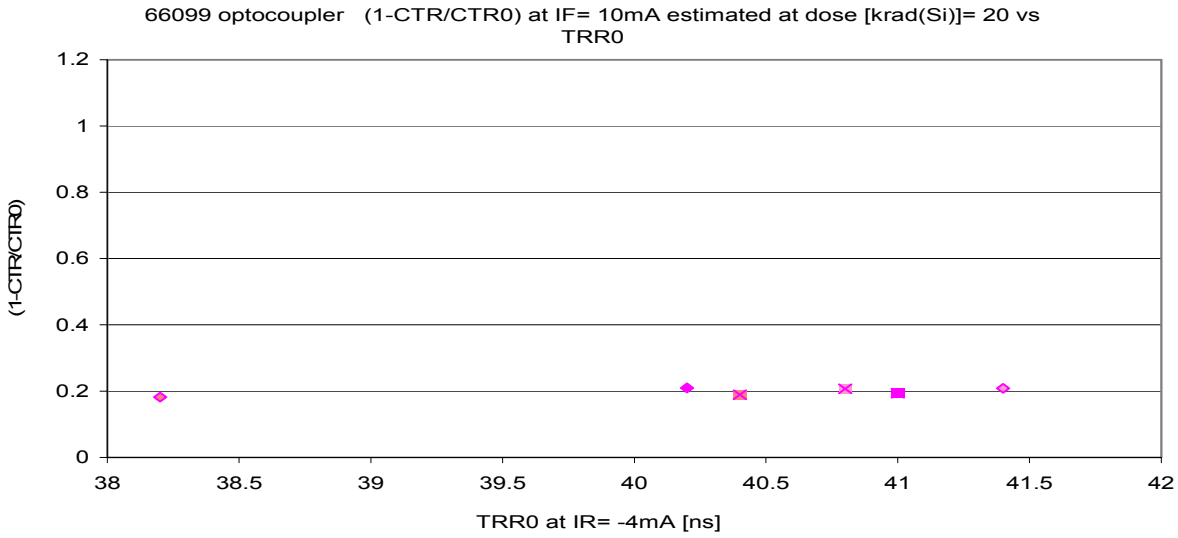
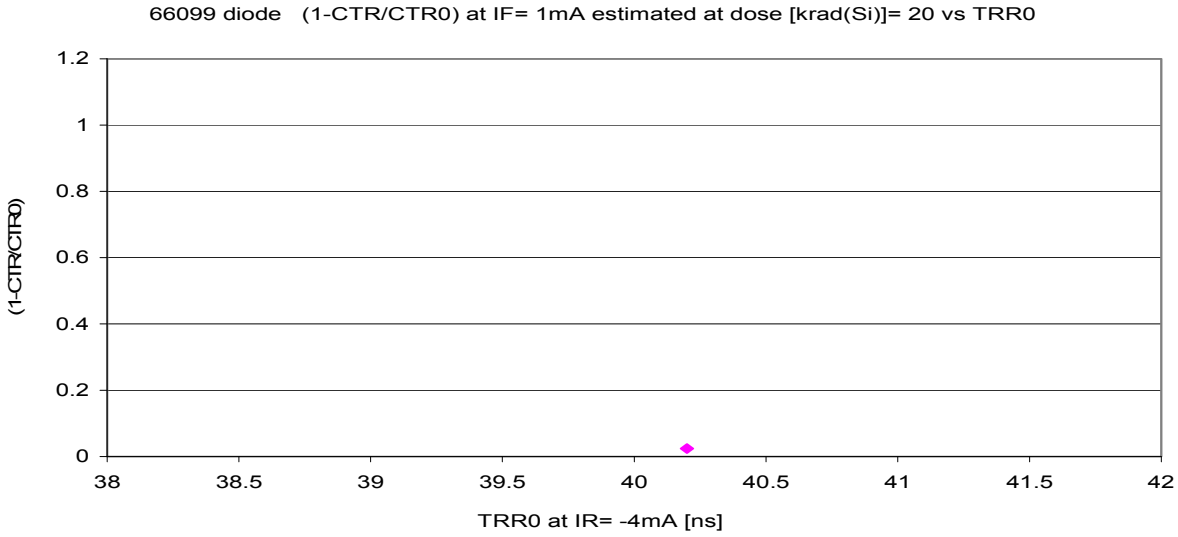
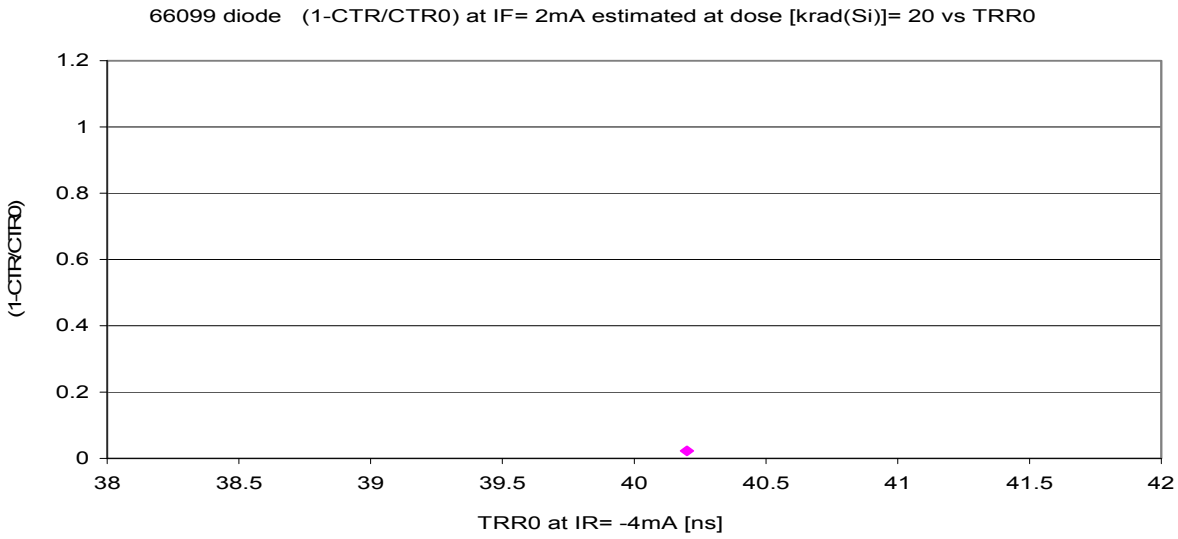
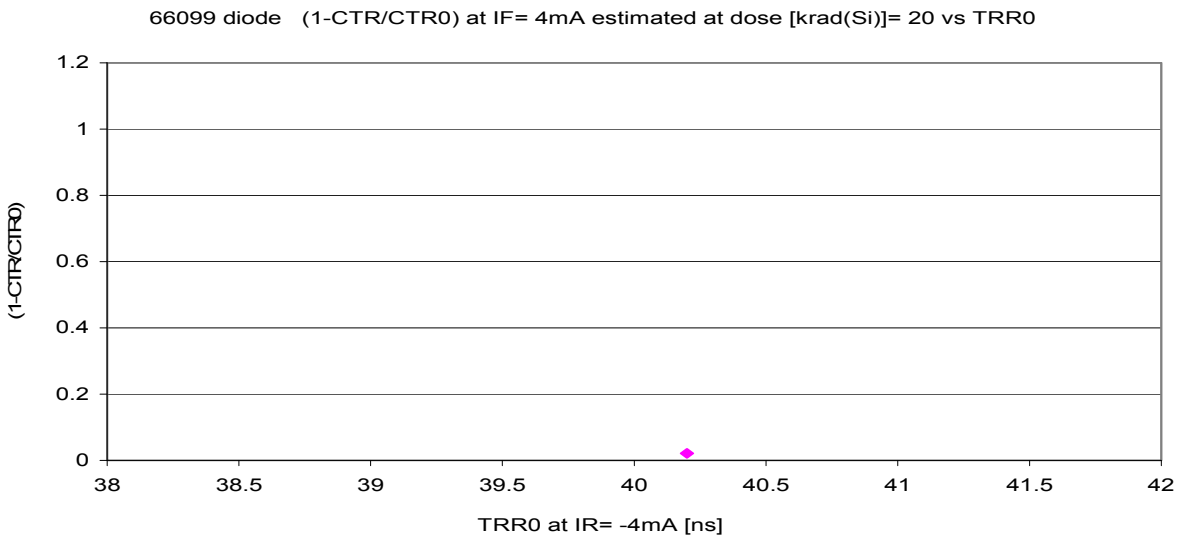
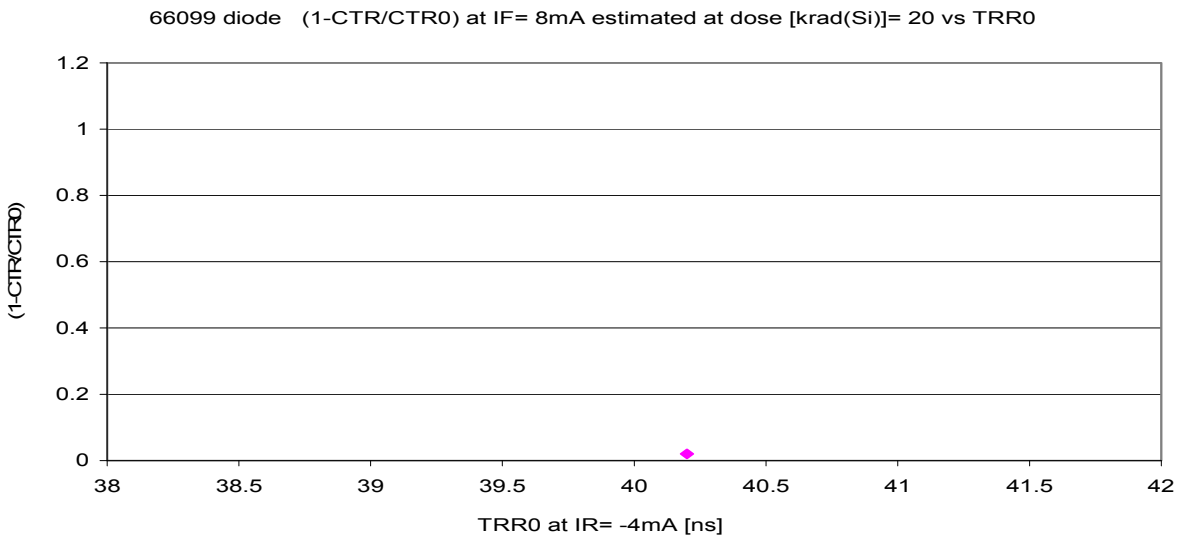

66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-185: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

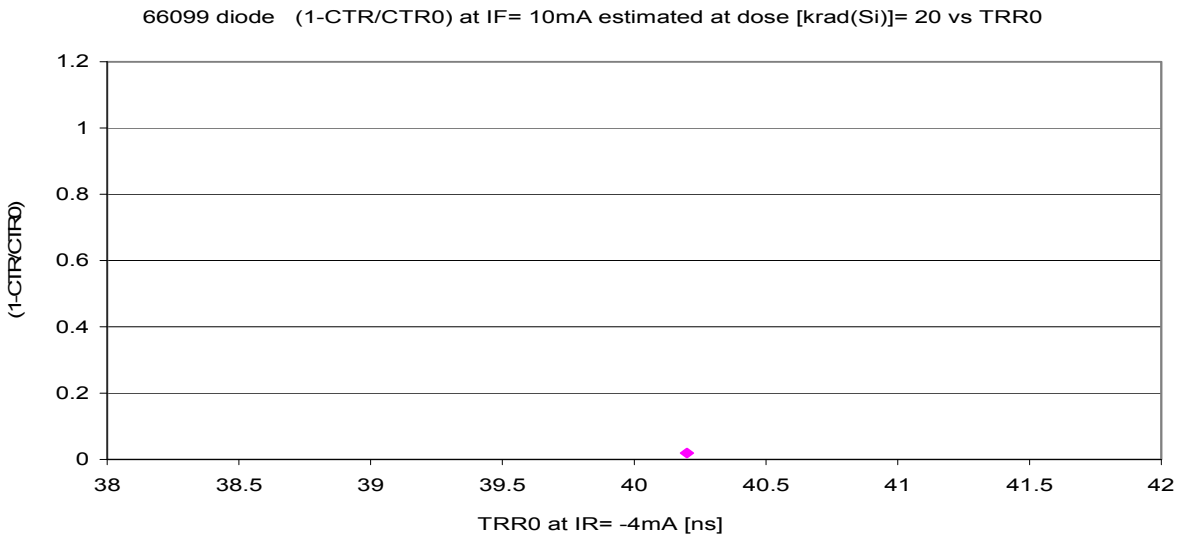
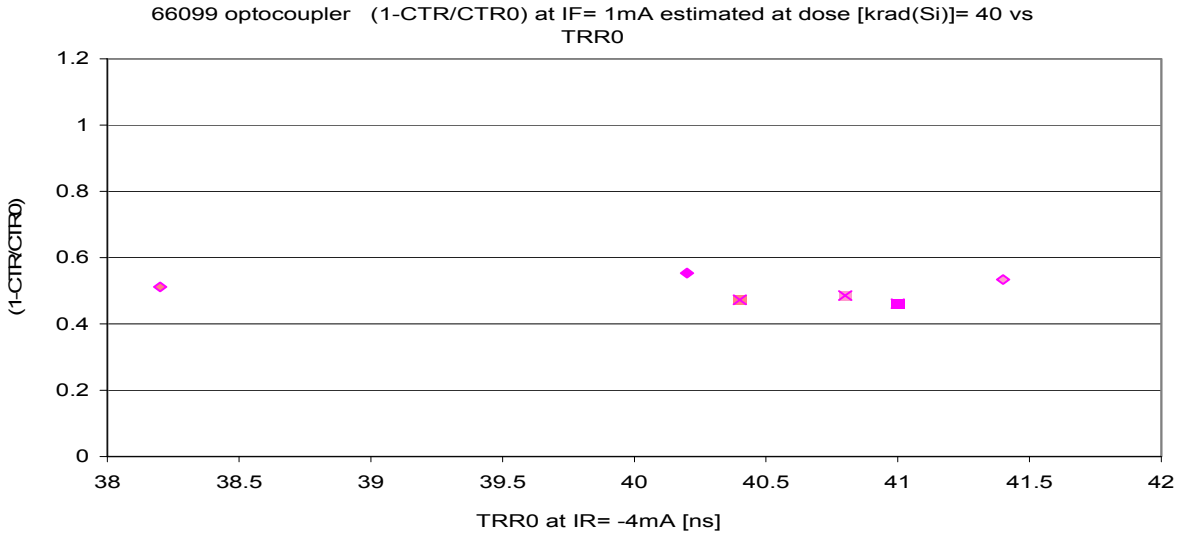
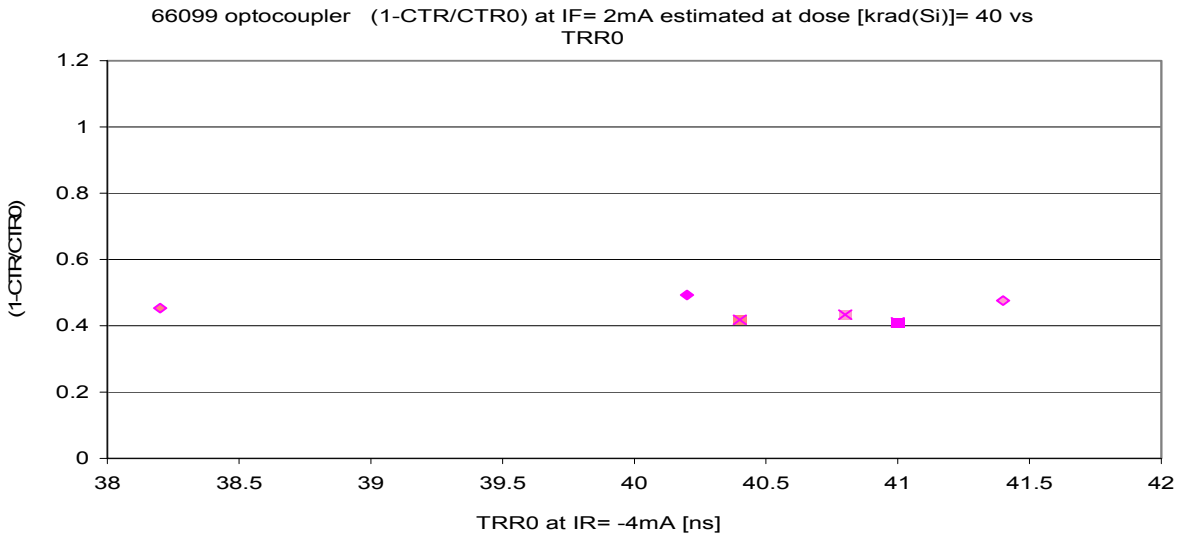
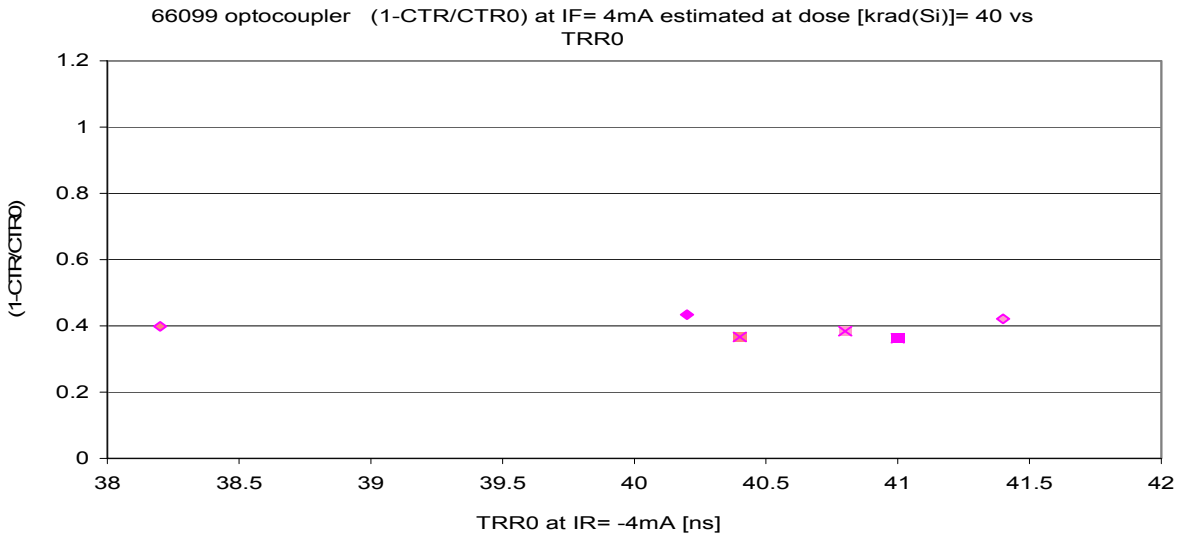
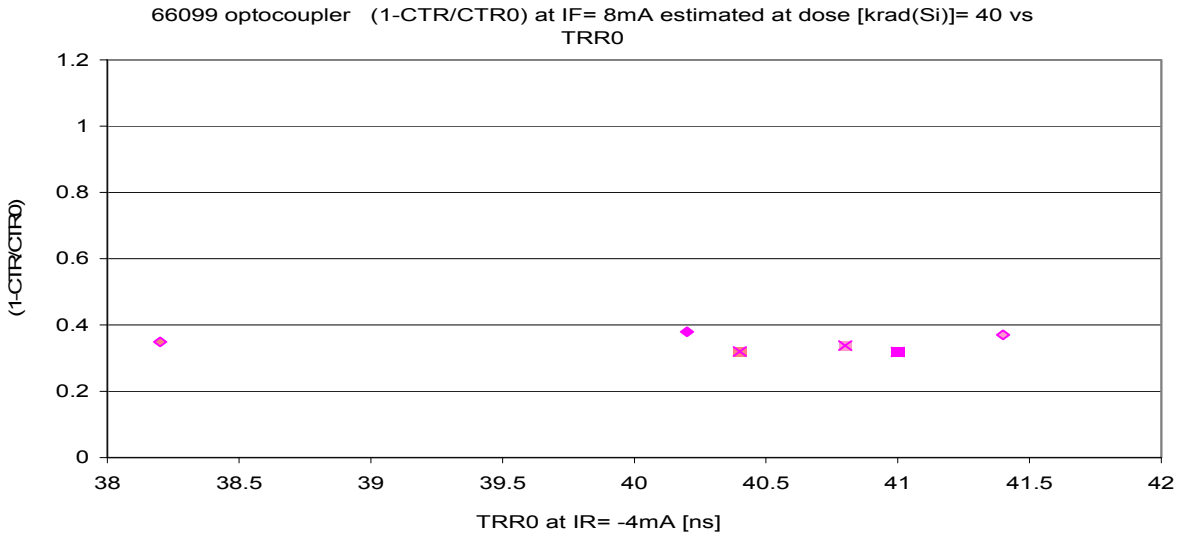

66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-186: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

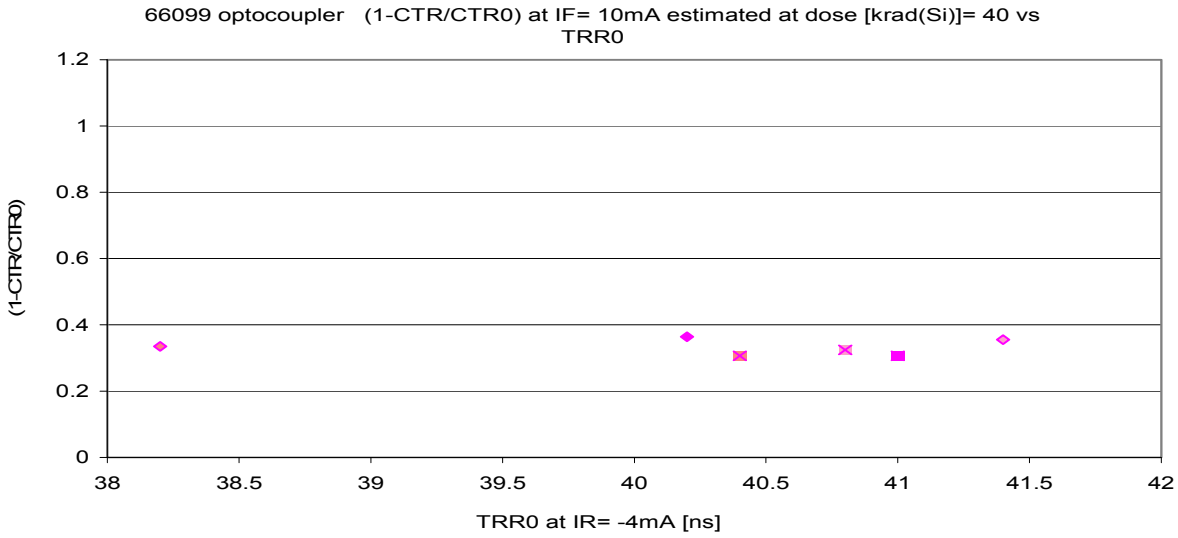
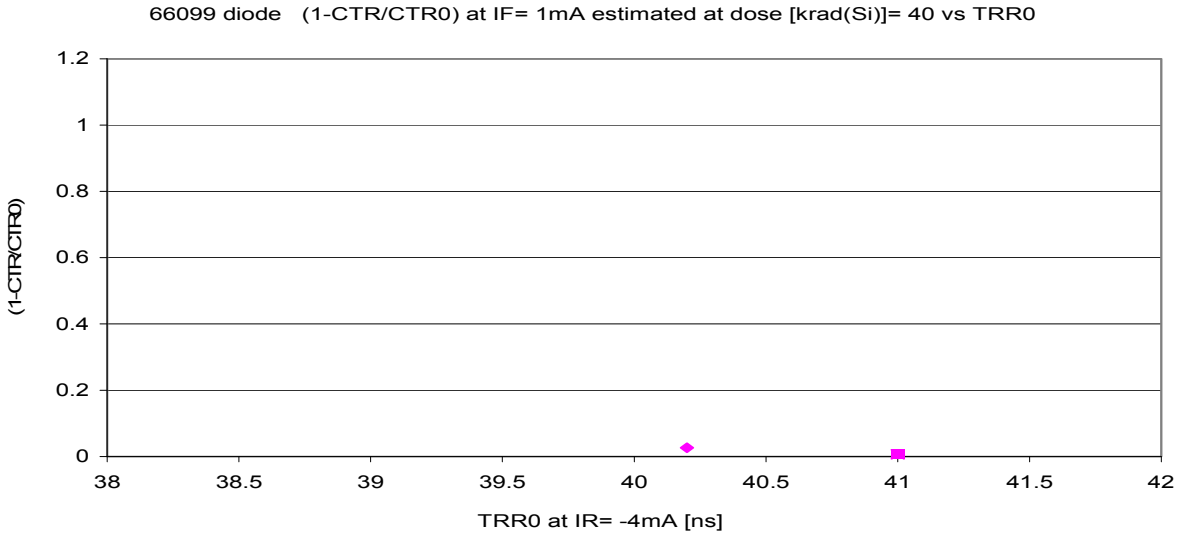
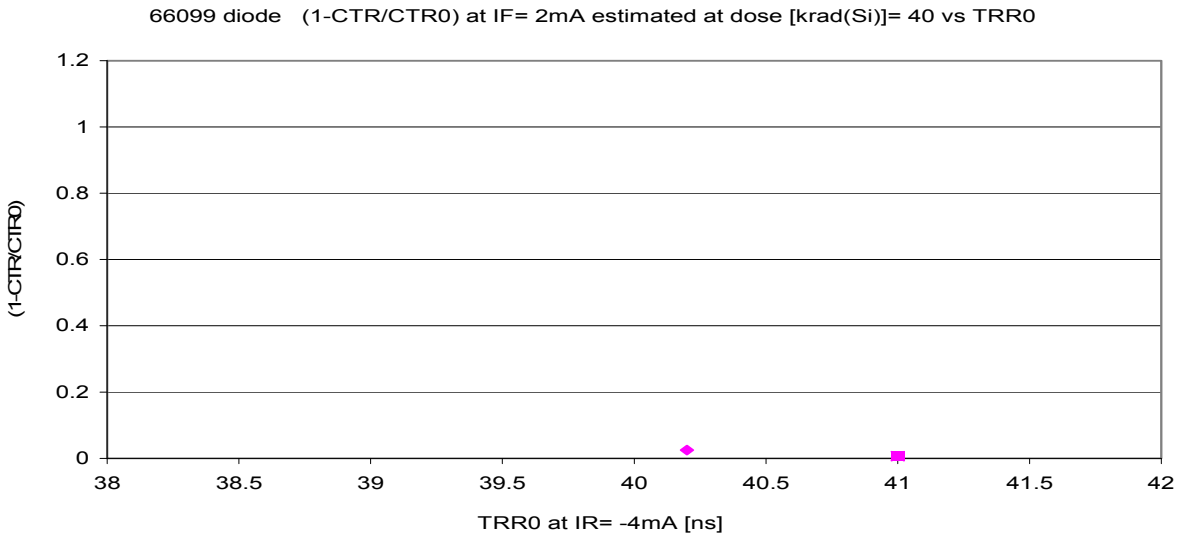
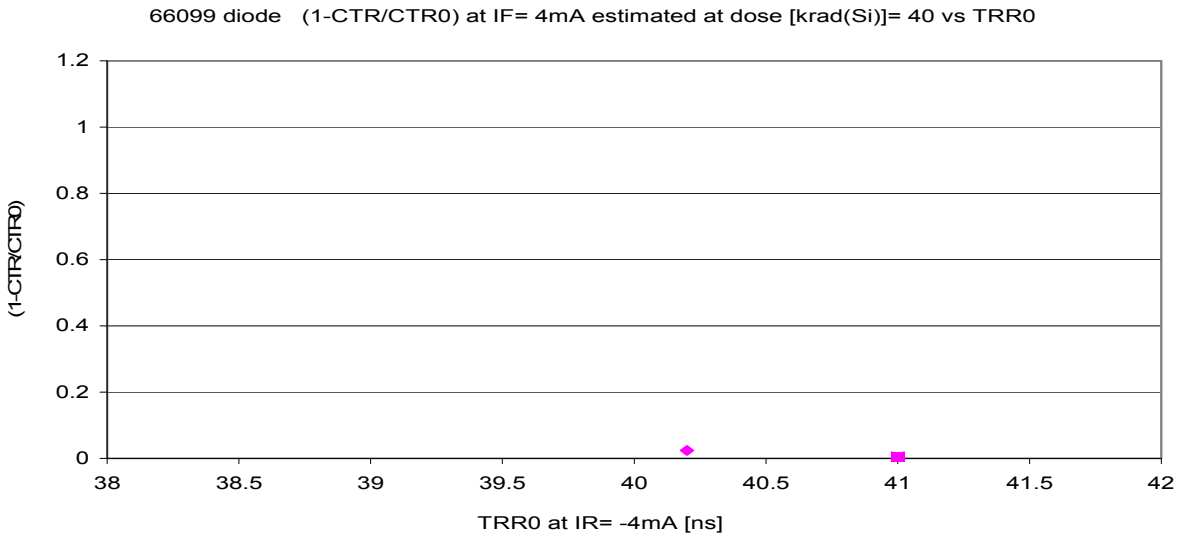
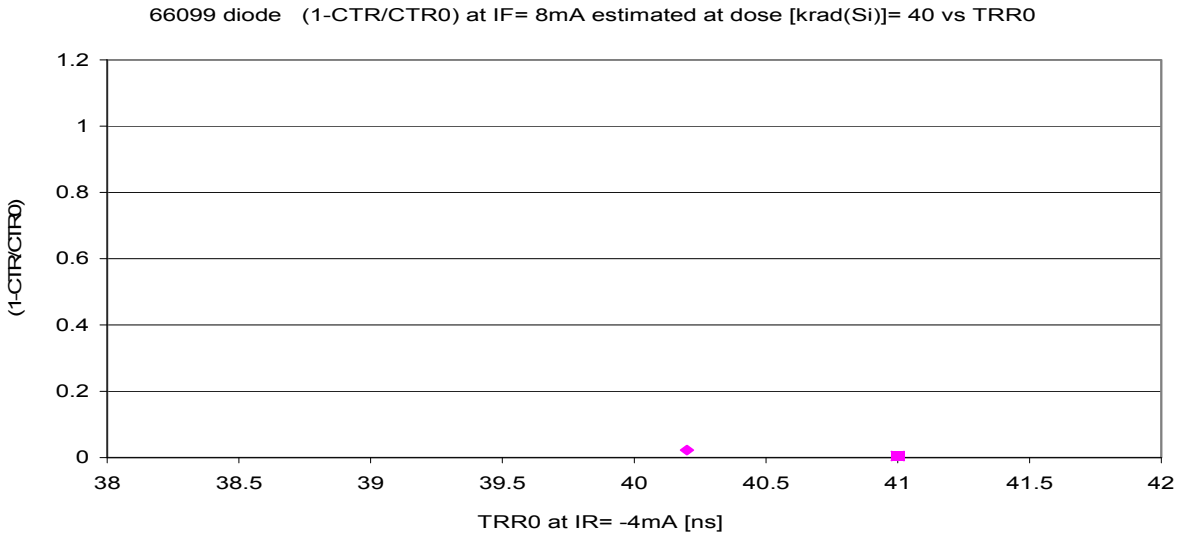

66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-187: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

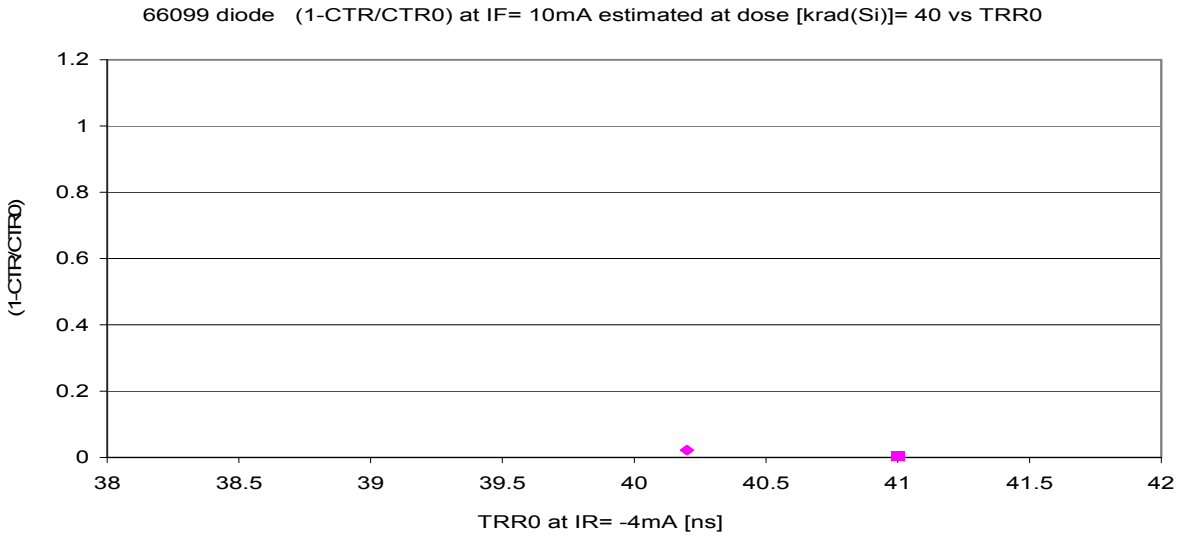
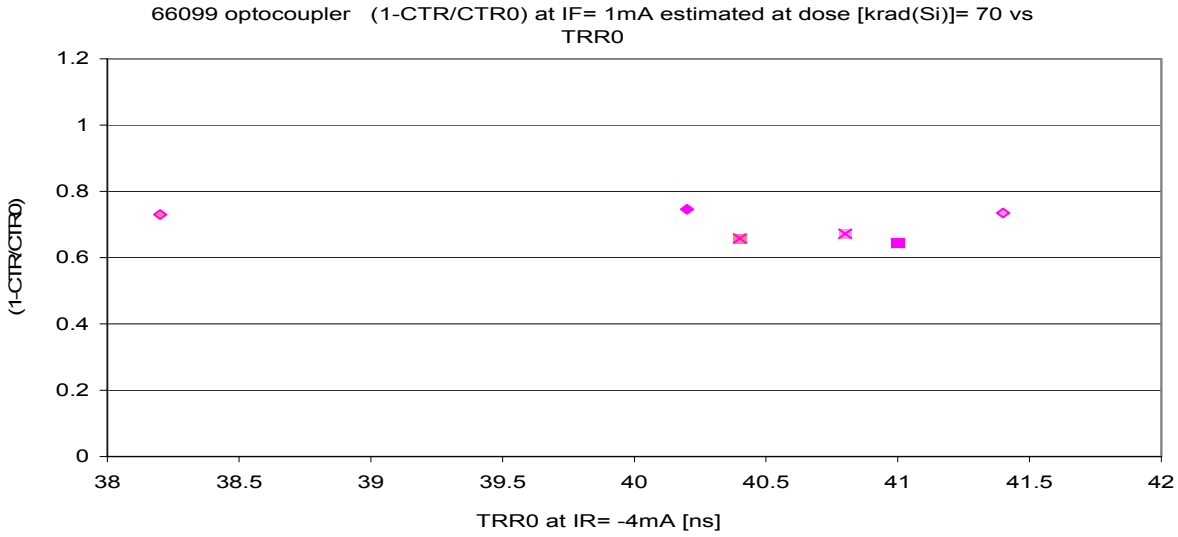
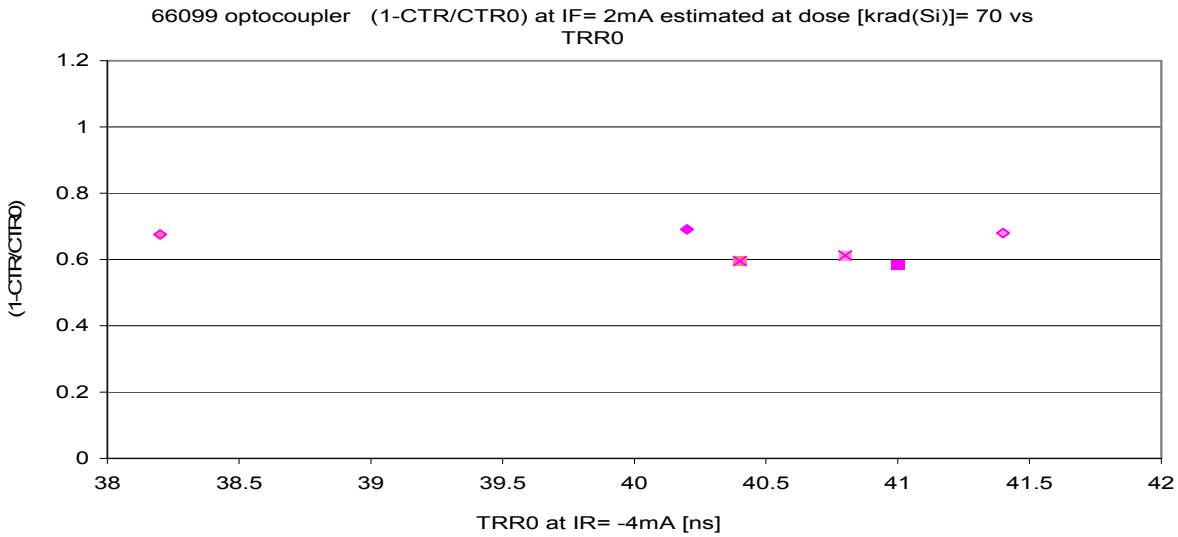
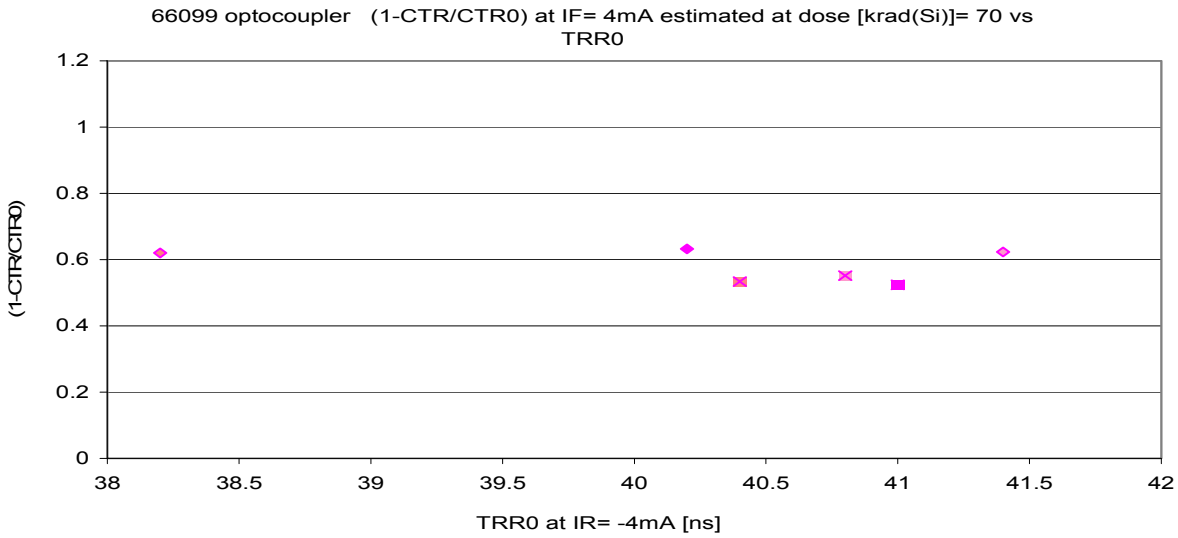
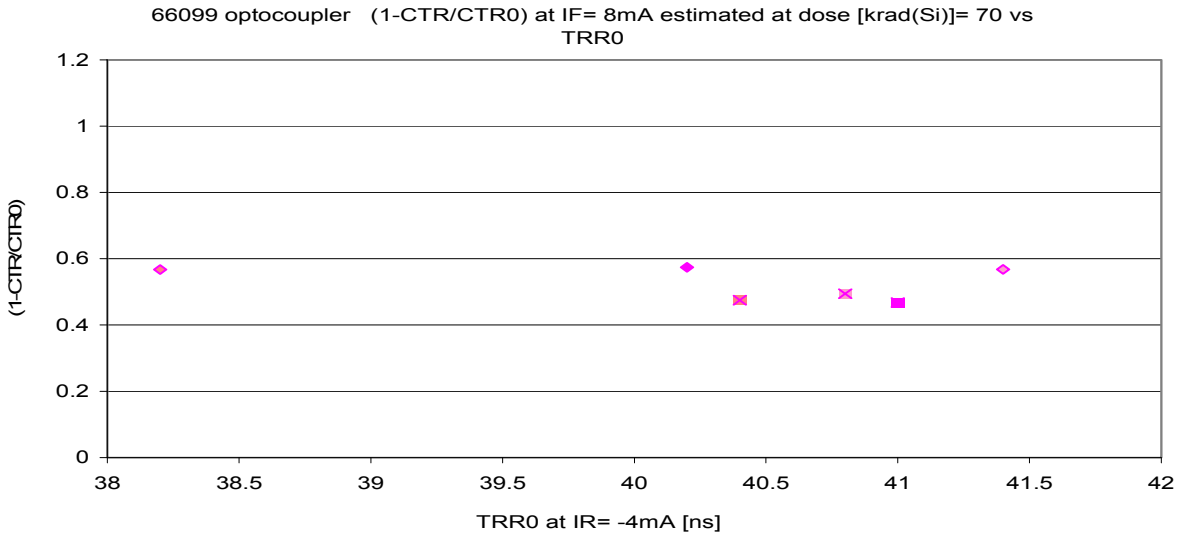

66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-188: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

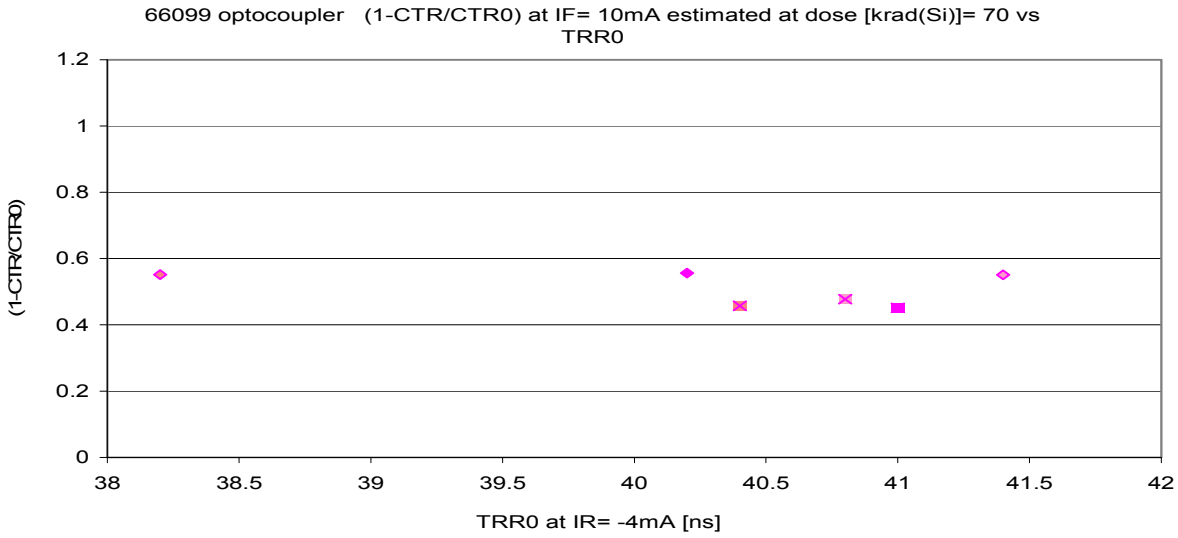
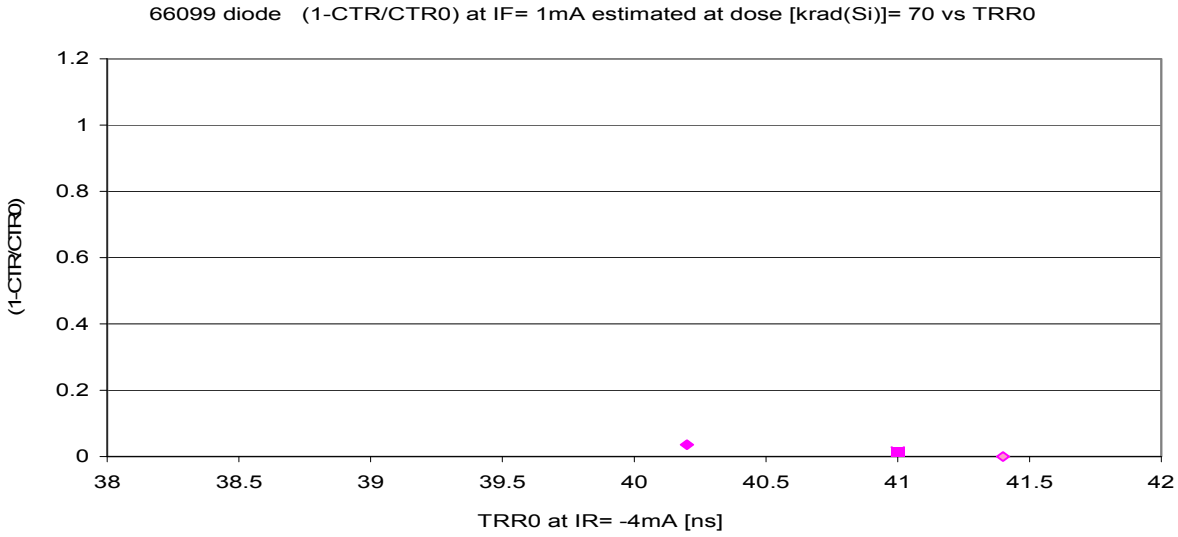
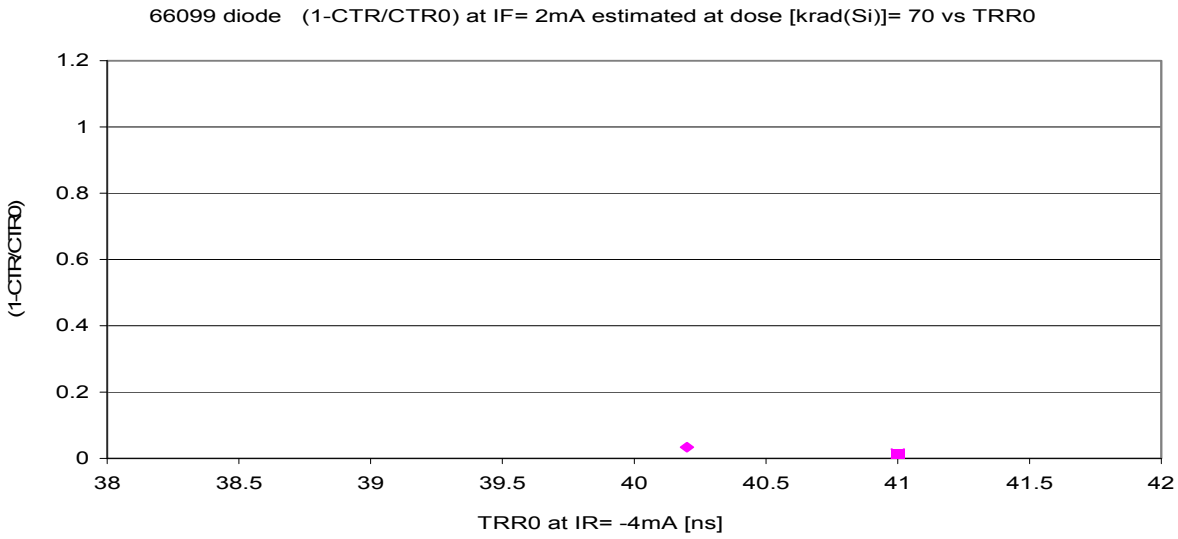
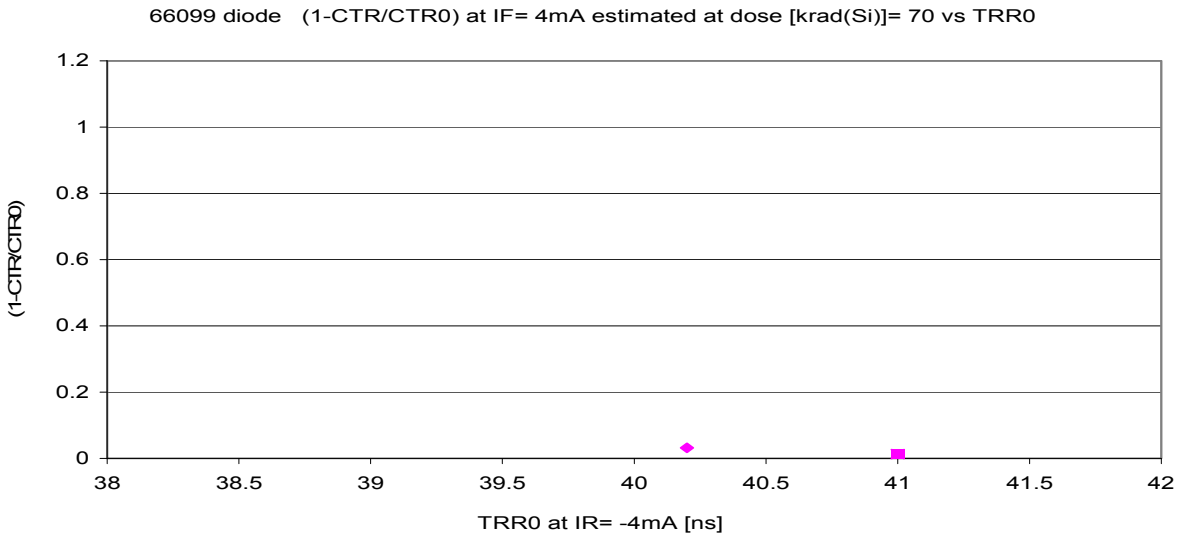
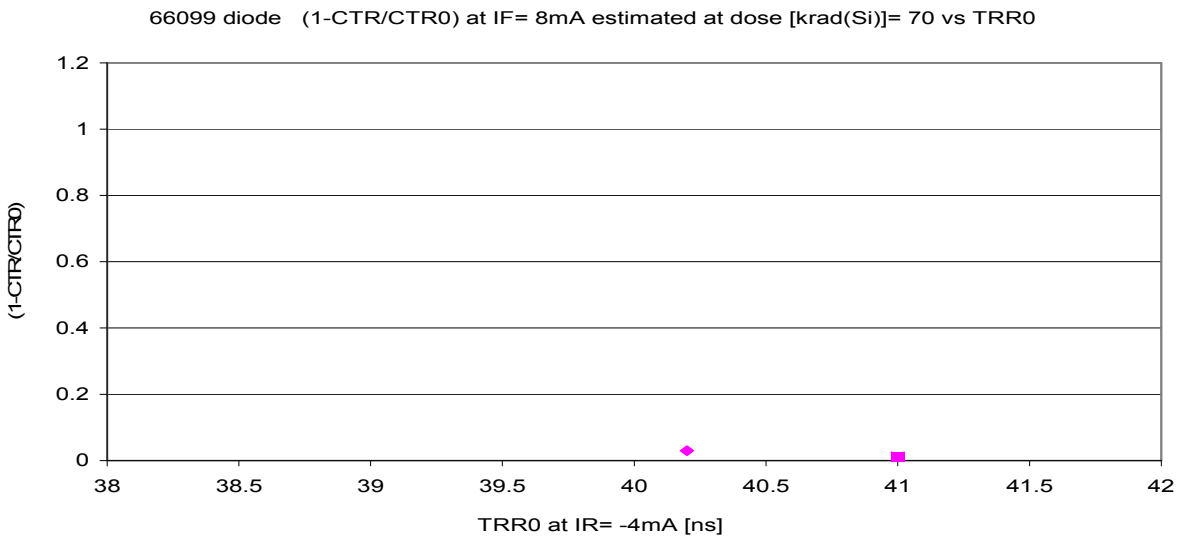

66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-189: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

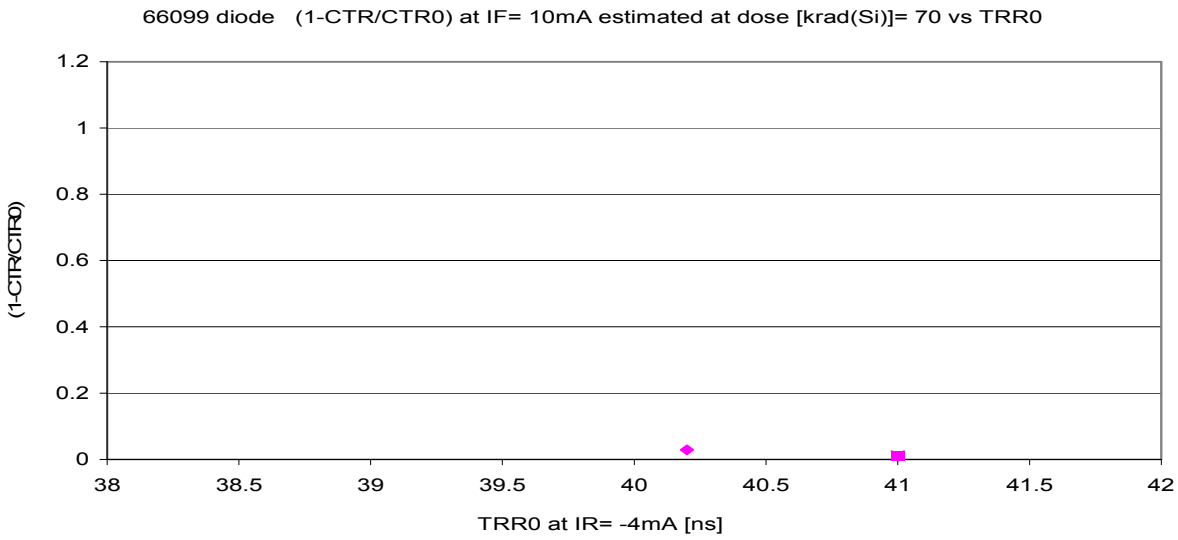

66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
1.2
1
0.8
0.6
0.4
0.2
0
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA [ns]

Fig. 14-190: optocoupler irradiated: transistor collector current I_C for each step with respect to diode current I_F

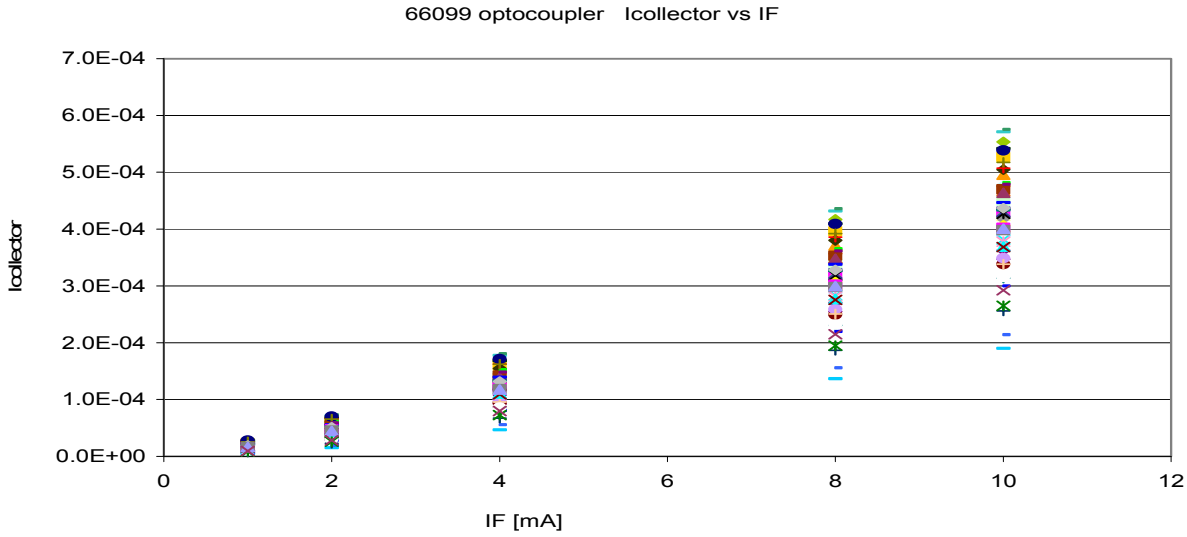


Fig. 14-191: diode irradiated: transistor collector current I_C for each step with respect to diode current I_F

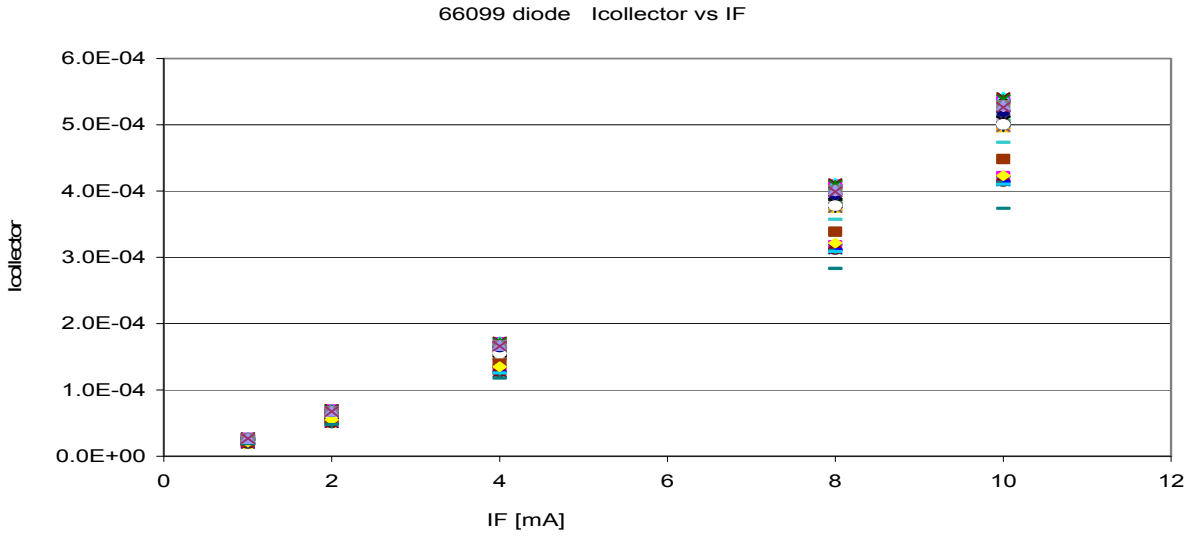


Fig. 14-192: transistor irradiated: transistor collector current I_C for each step with respect to diode current I_F

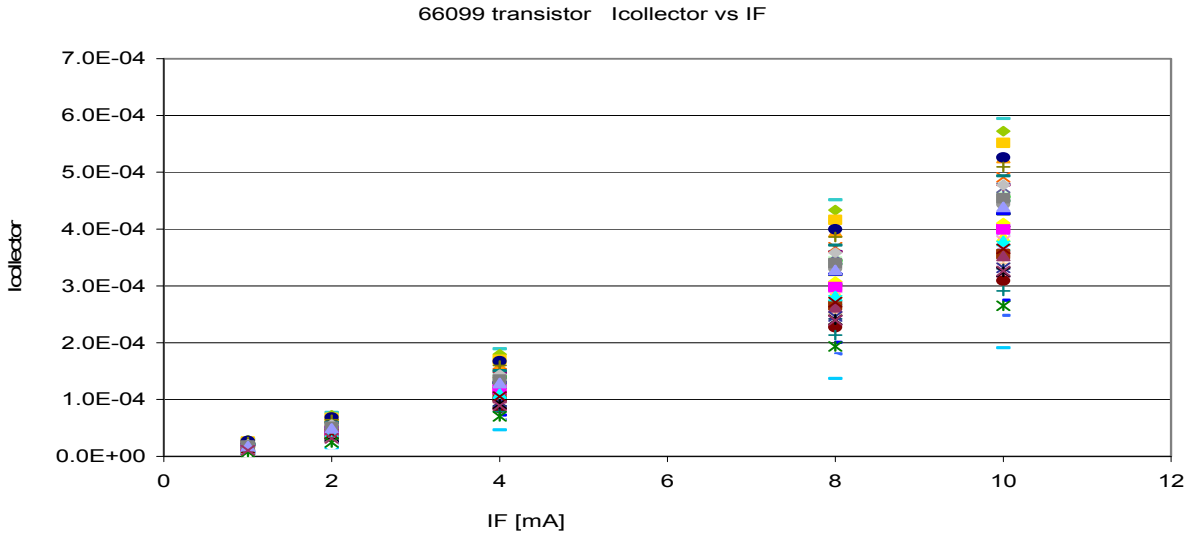


Fig. 14-193: optocoupler irradiated: CTR for each step with respect to diode current I_F

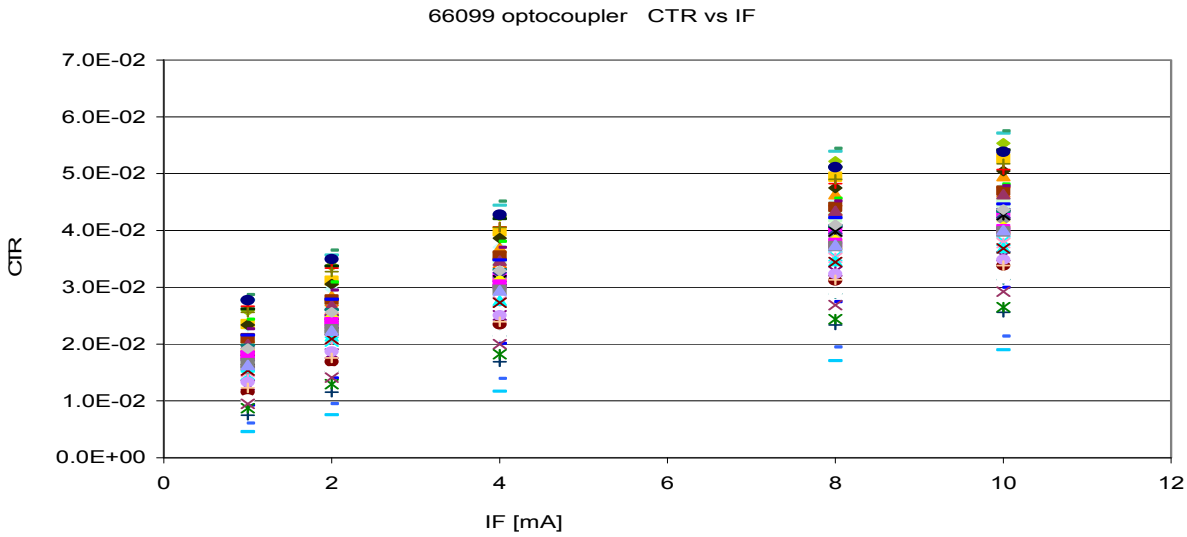


Fig. 14-194: diode irradiated: CTR for each step with respect to diode current I_F

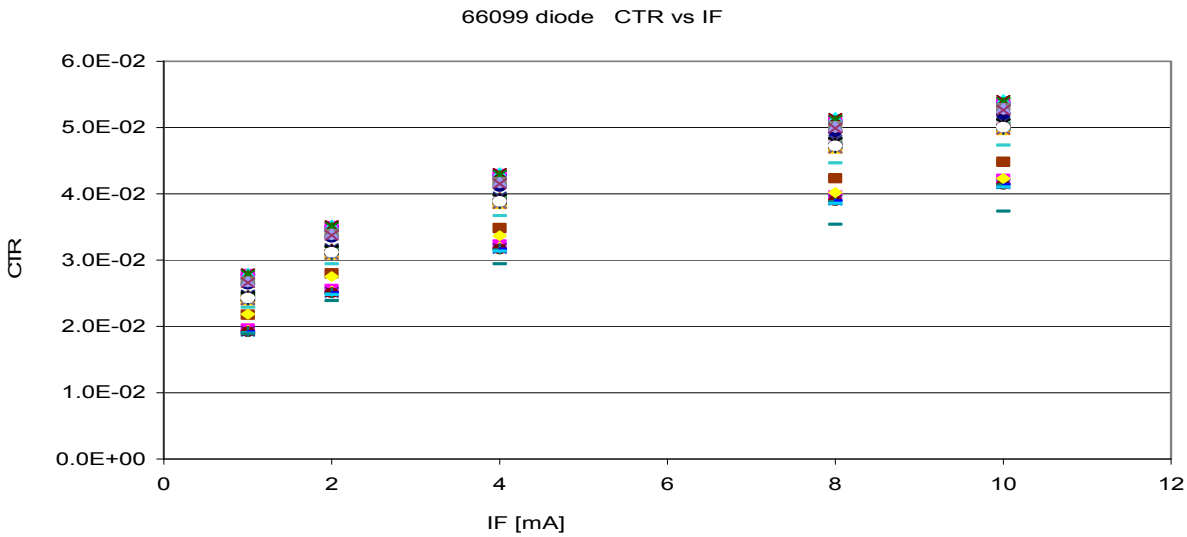


Fig. 14-195: transistor irradiated: CTR for each step with respect to diode current I_F

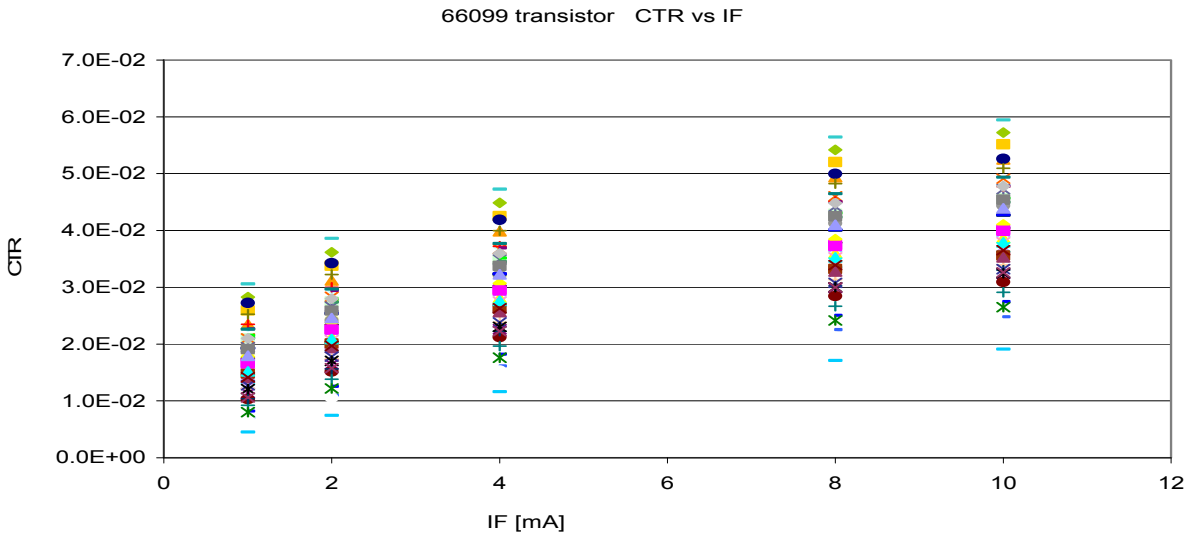


Fig. 14-196: optocoupler irradiated: CTR/CTR_0 for each step with respect to diode current I_F

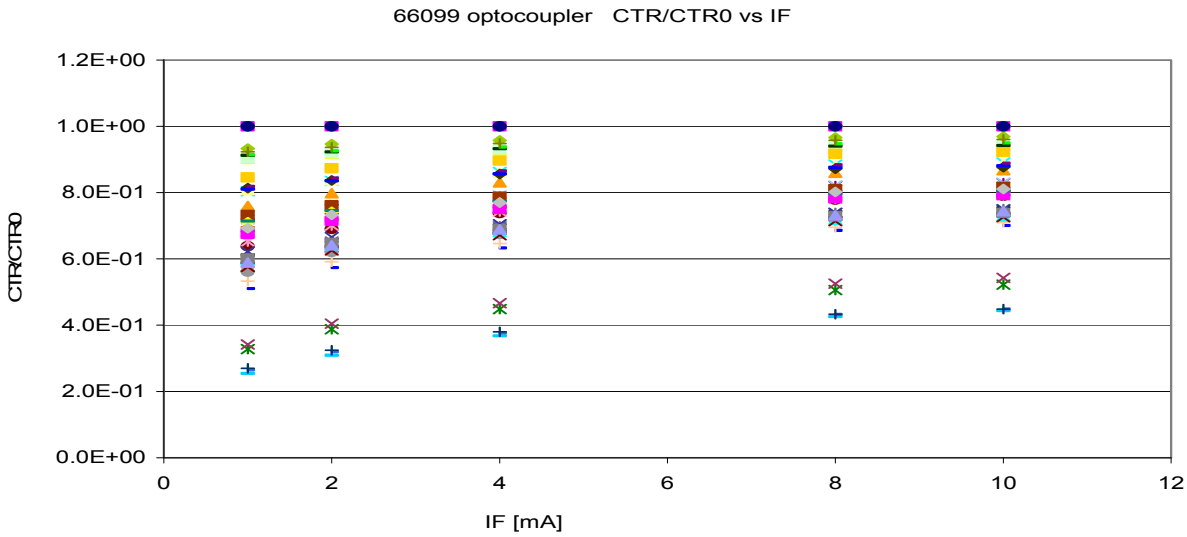


Fig. 14-197: diode irradiated: CTR/CTR_0 for each step with respect to diode current I_F

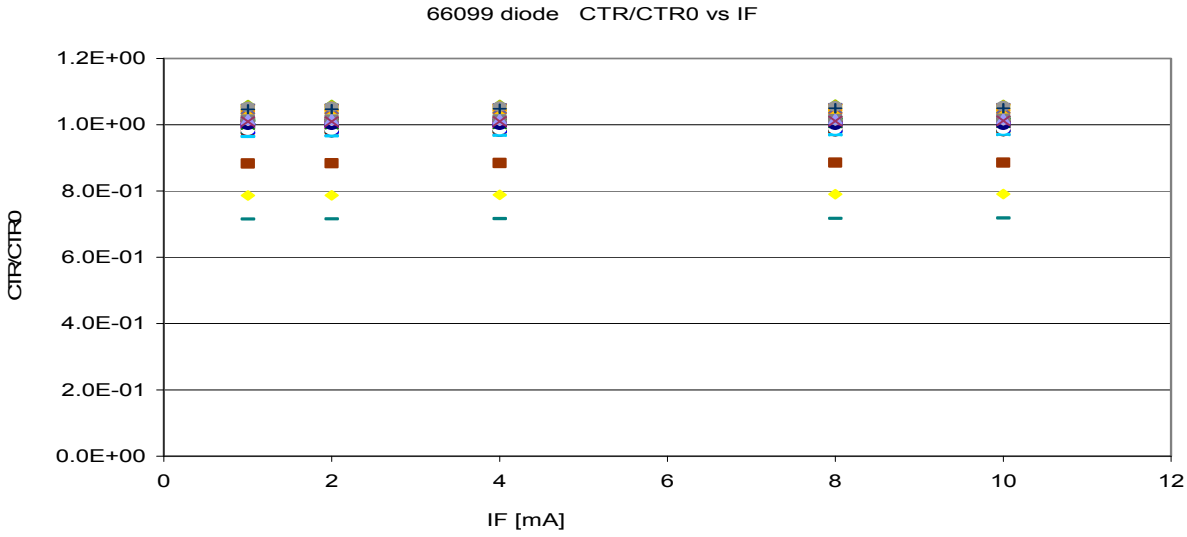


Fig. 14-198: transistor irradiated: CTR/CTR$_0$ for each step with respect to diode current I$_F$

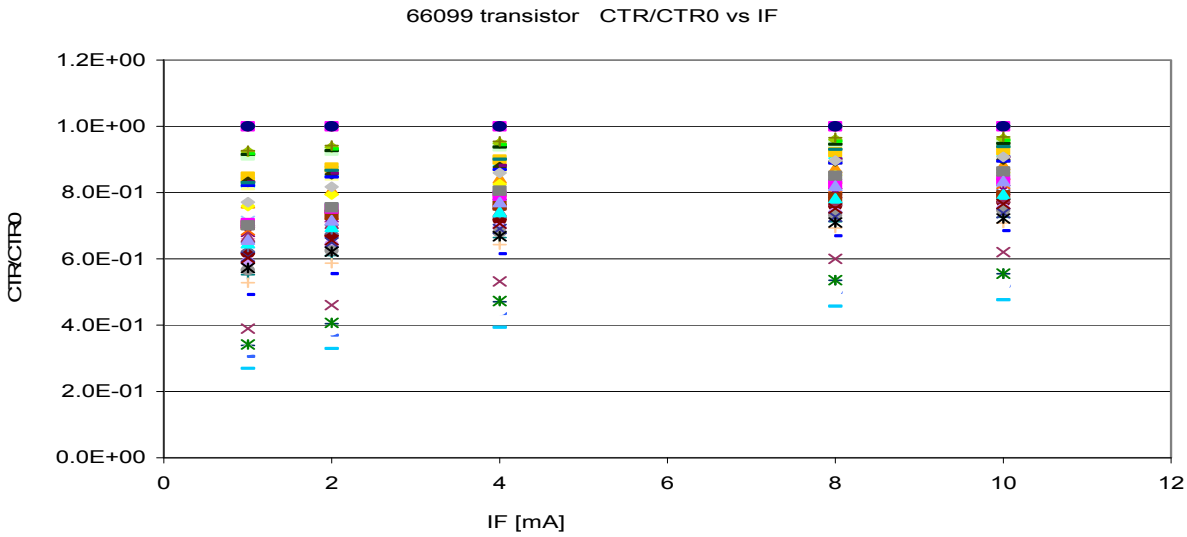
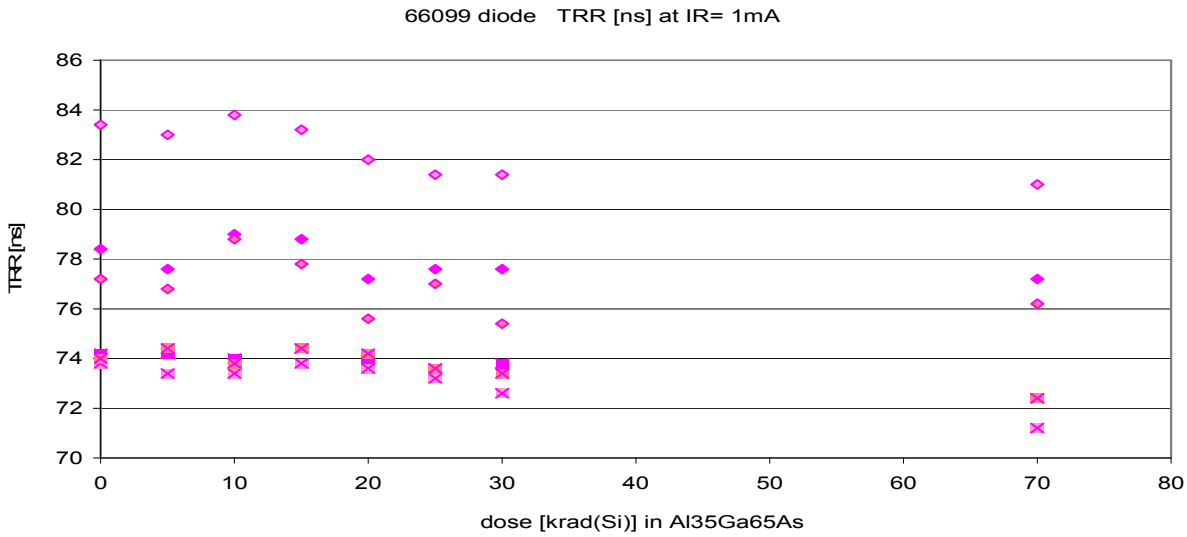
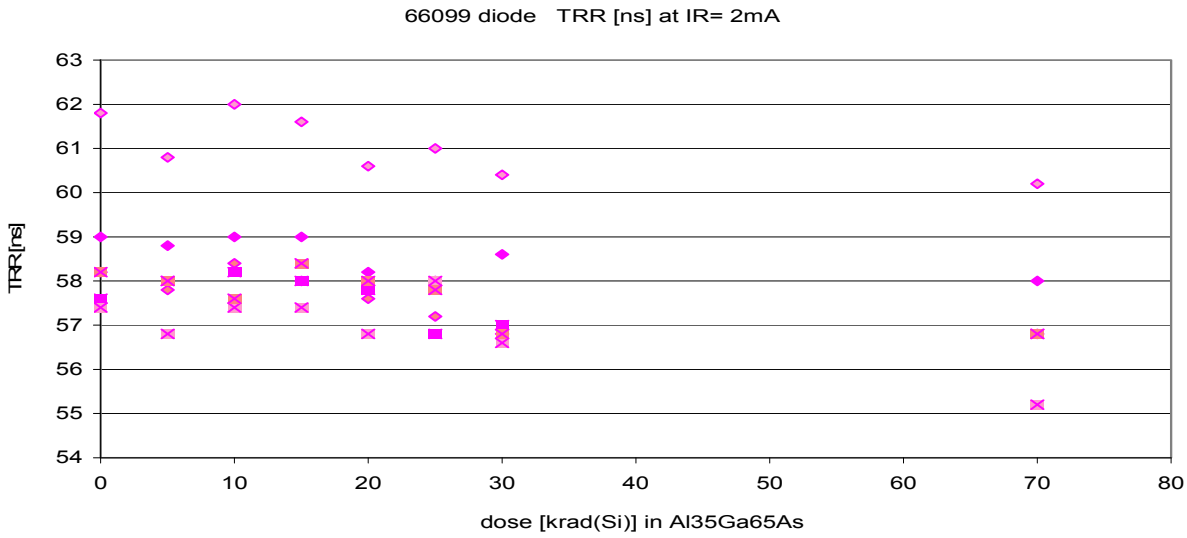


Fig. 14-199: 66099 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





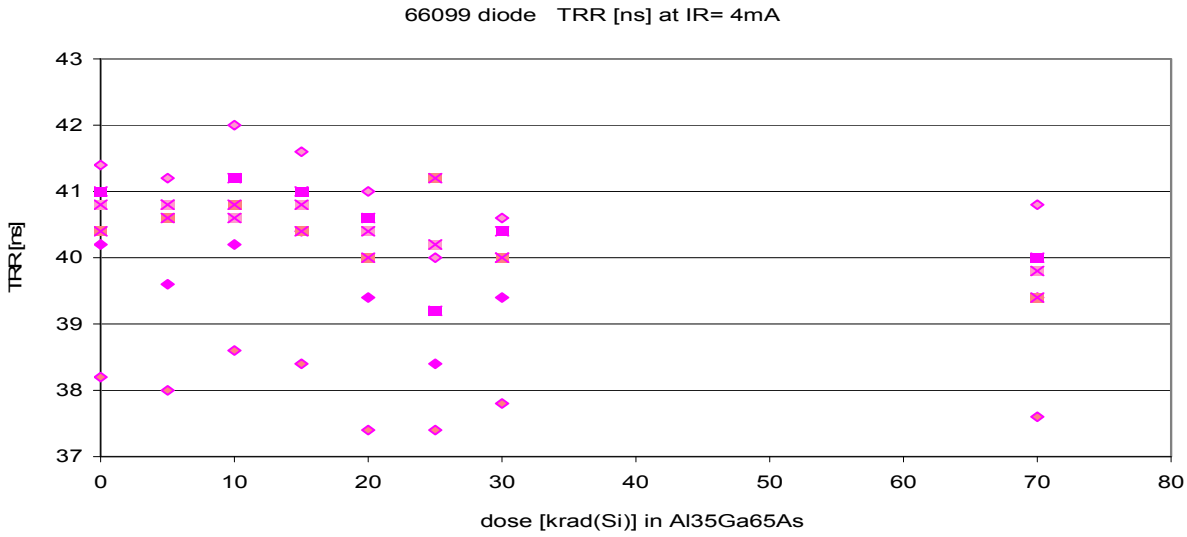
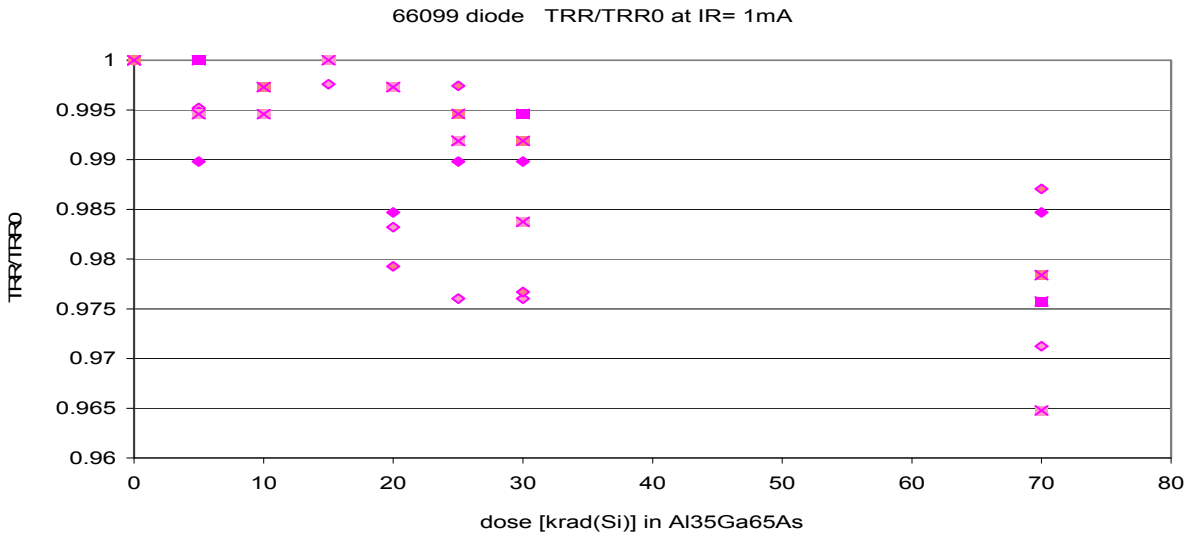
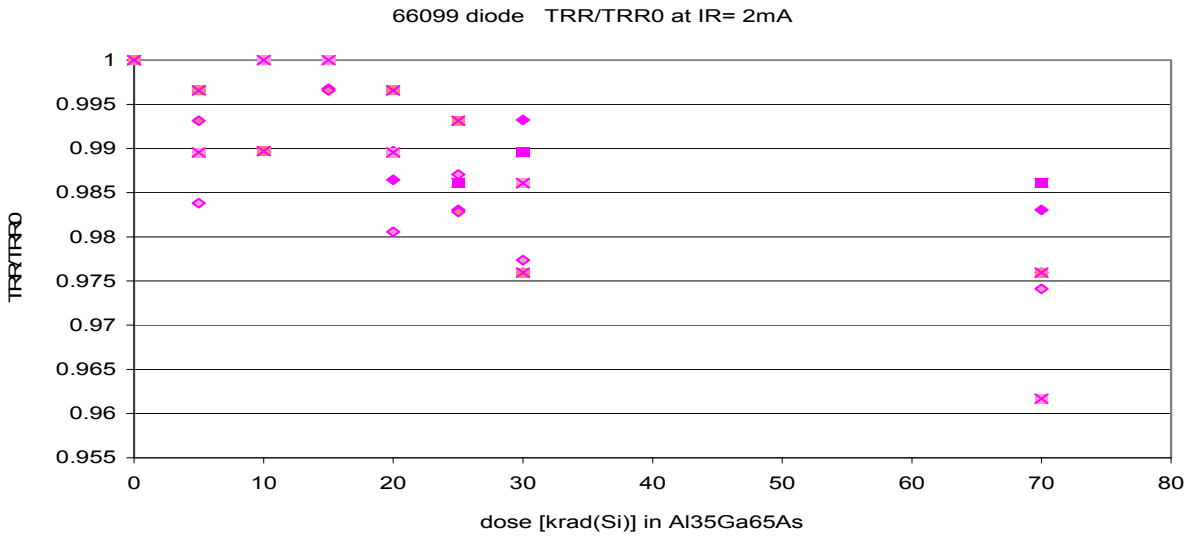


Fig. 14-200: 66099 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA





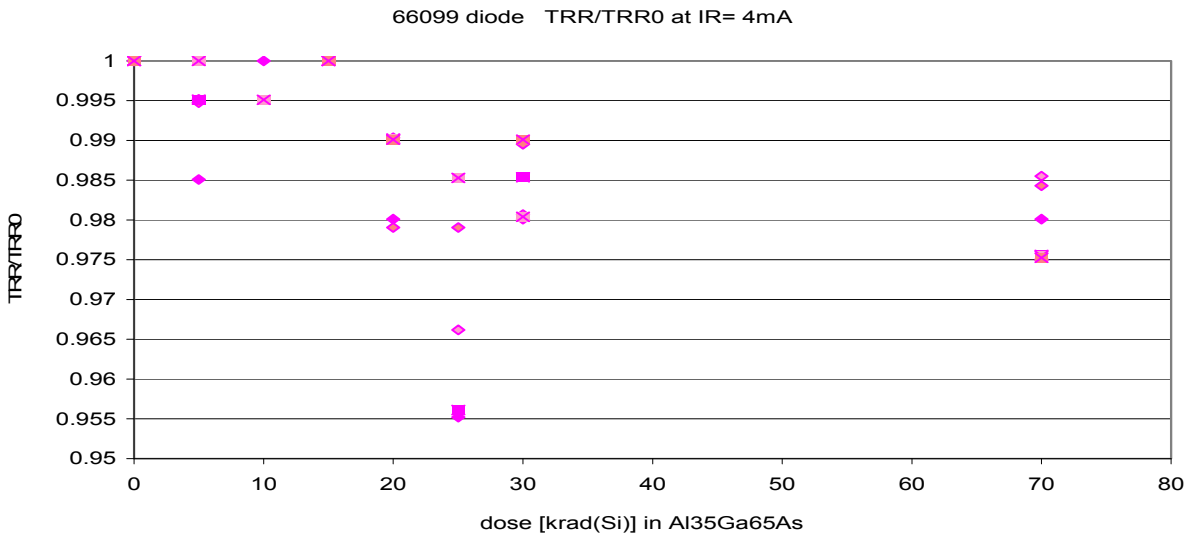
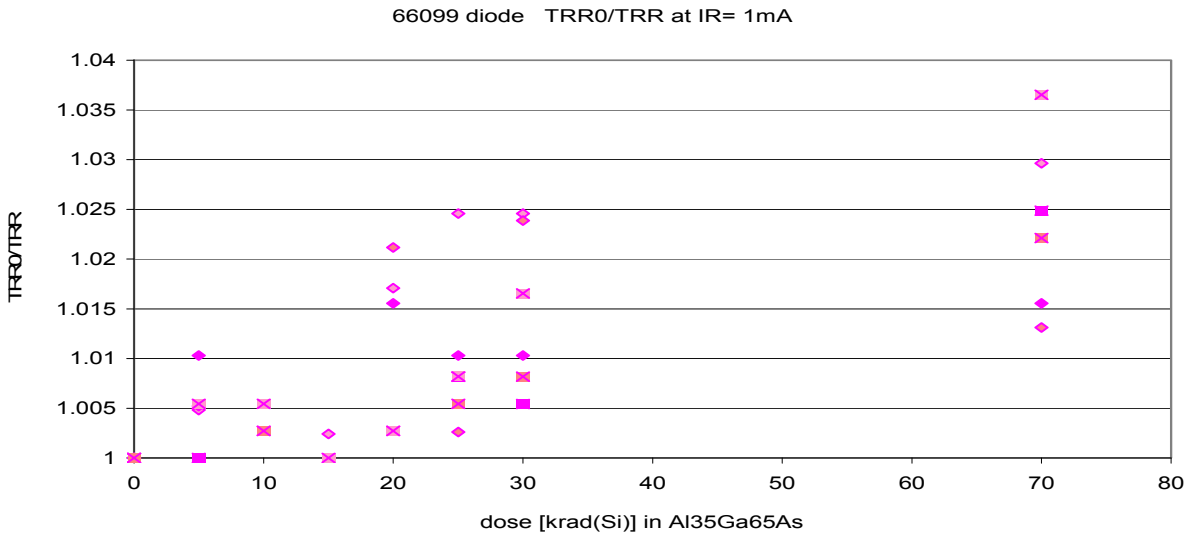
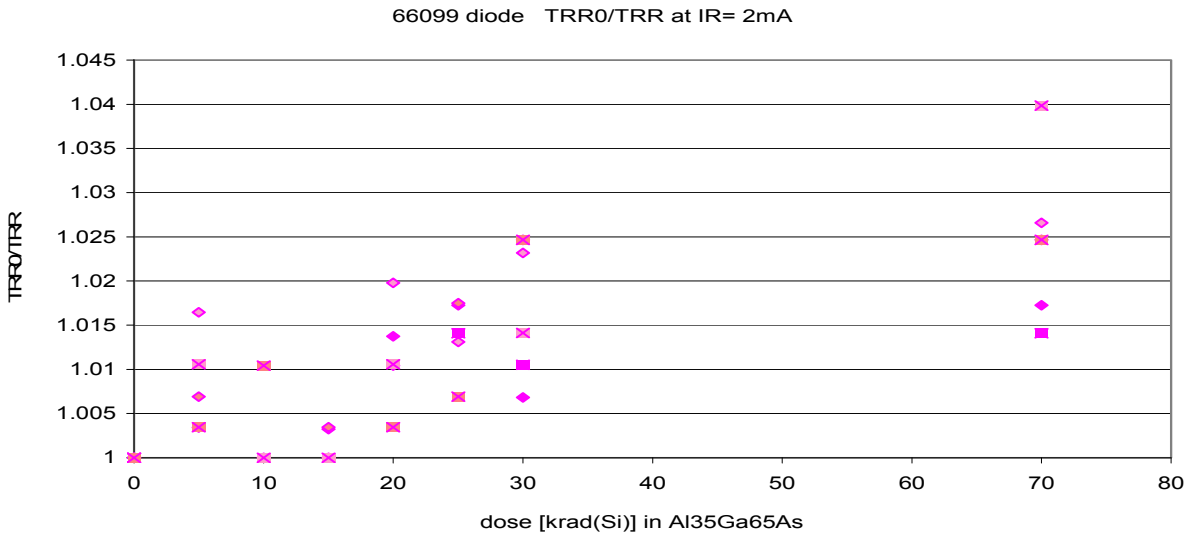


Fig. 14-201: 66099 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





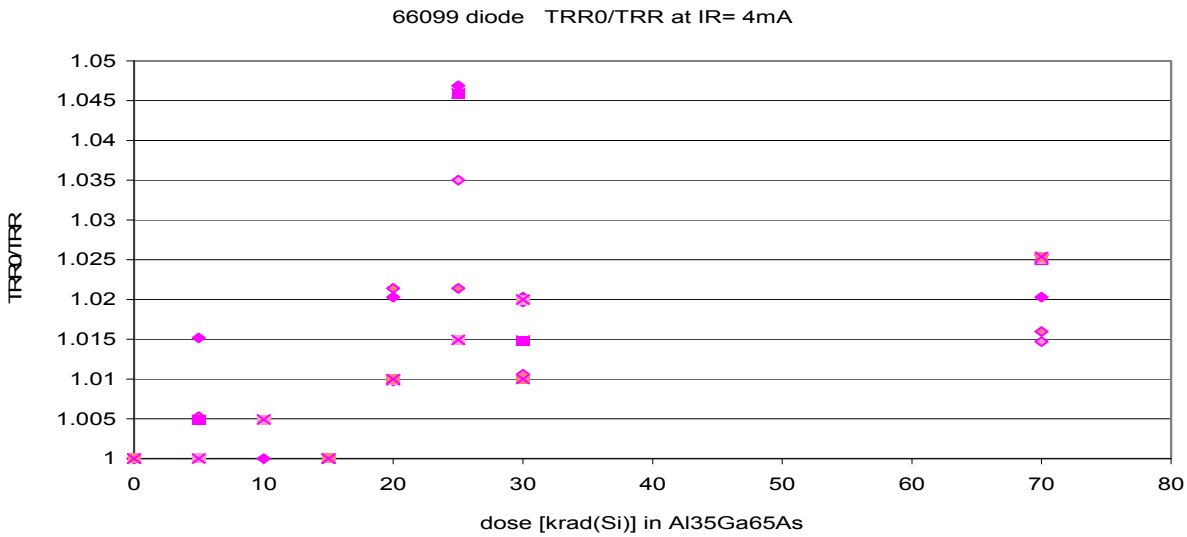
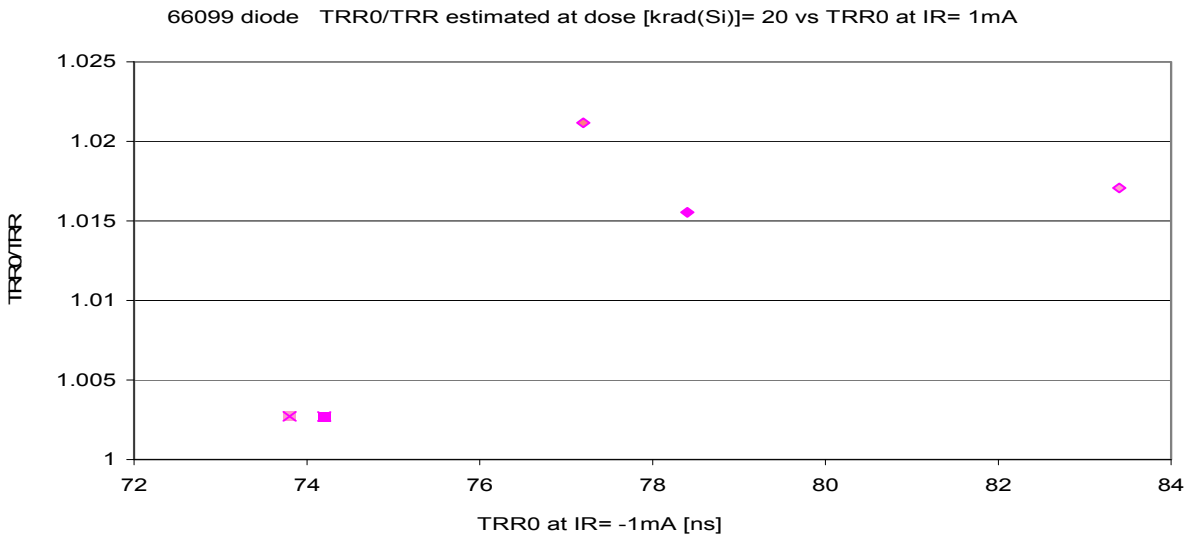
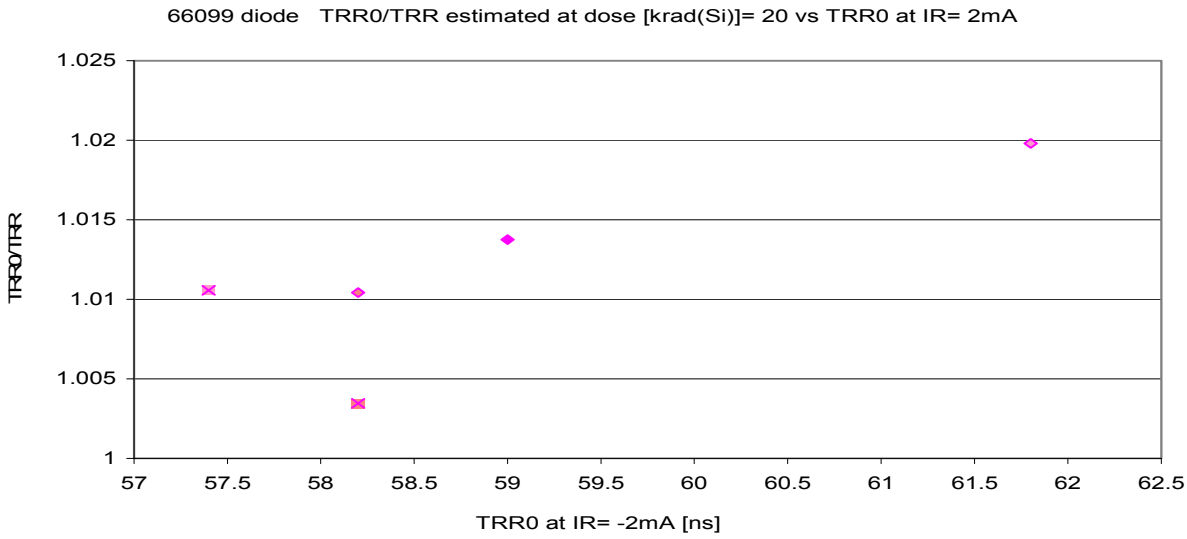


Fig. 14-202: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





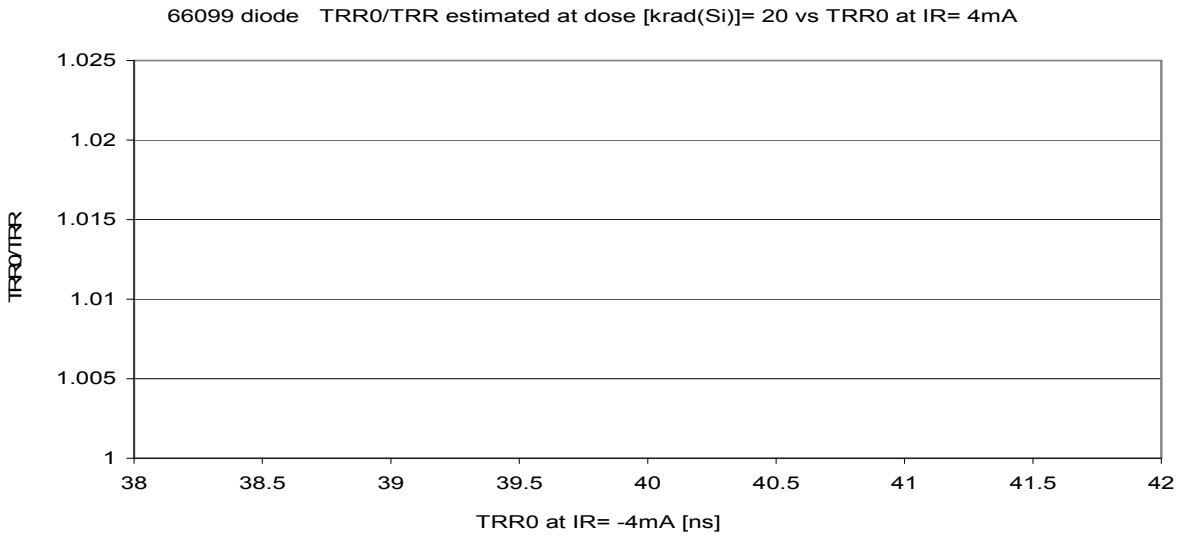
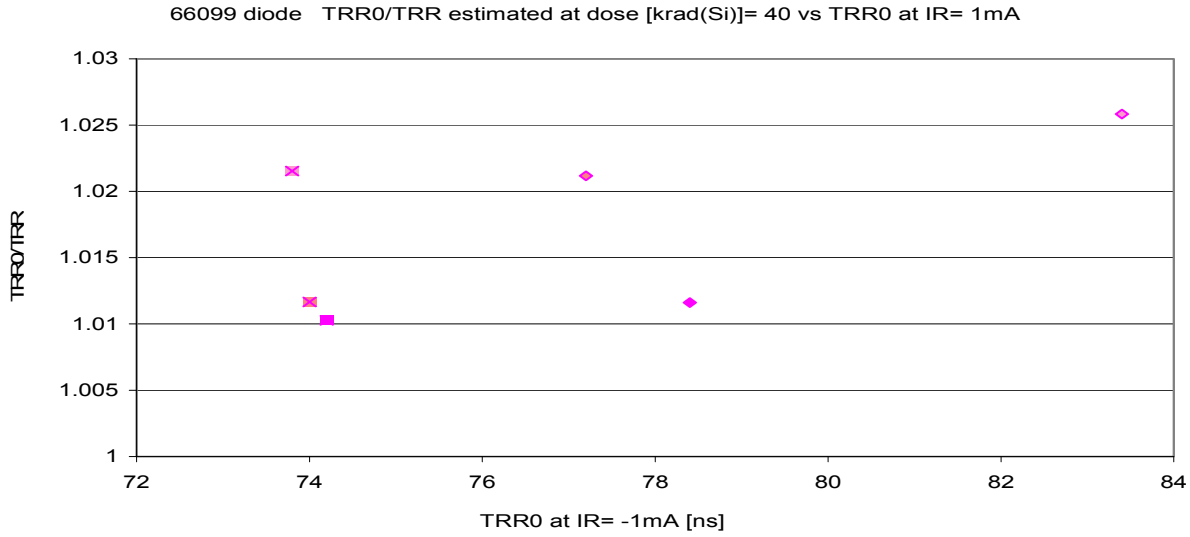
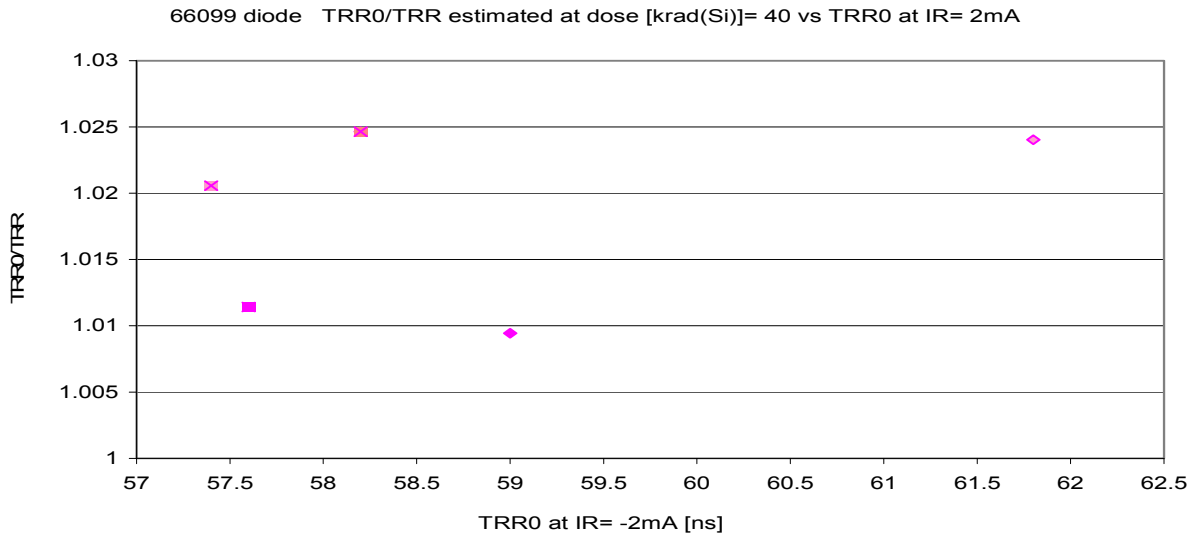


Fig. 14-203: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





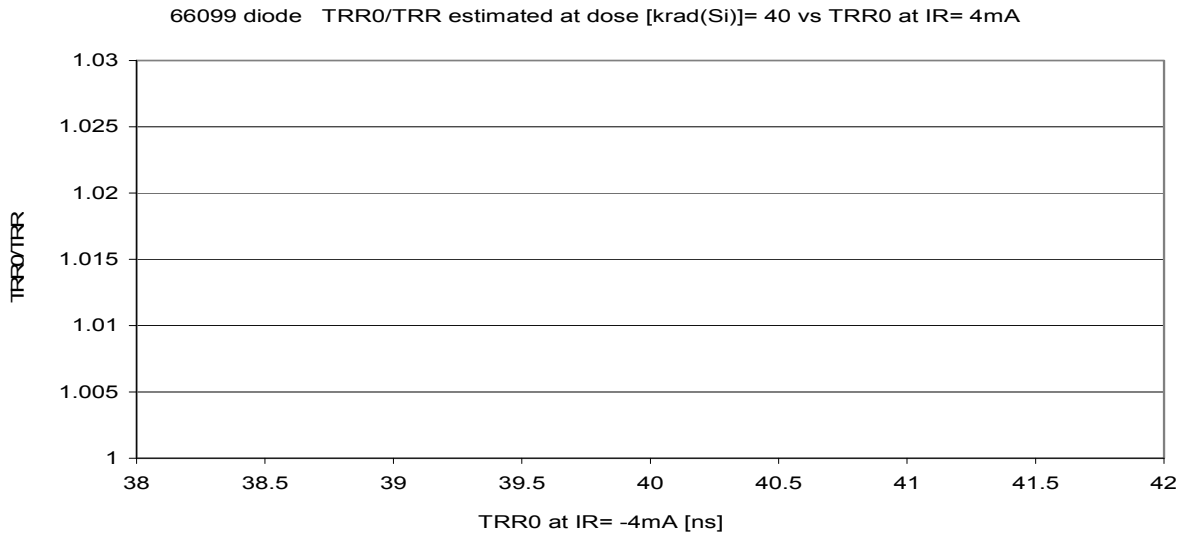
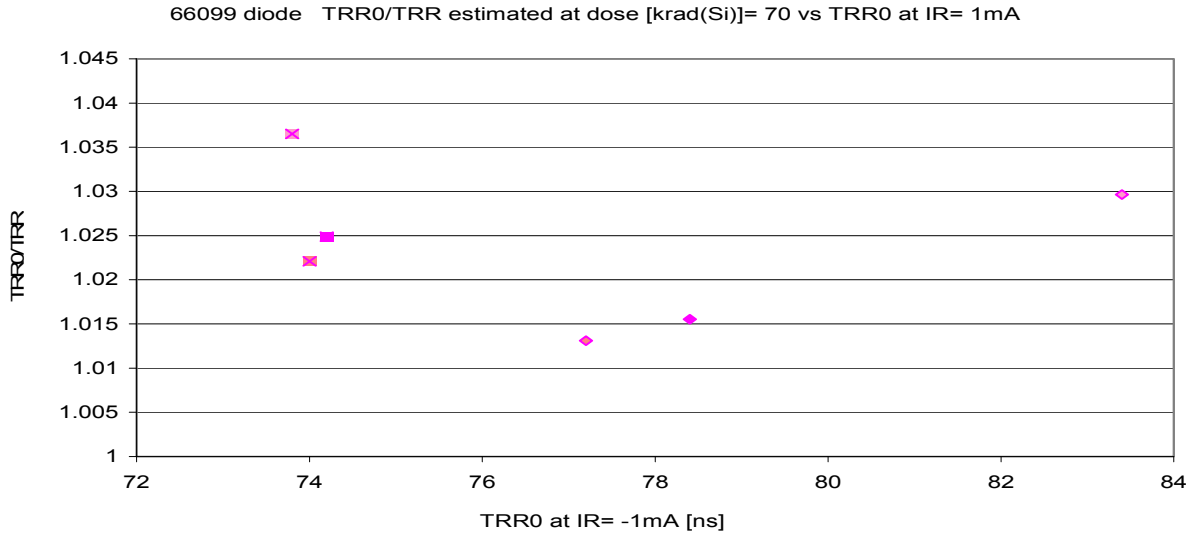
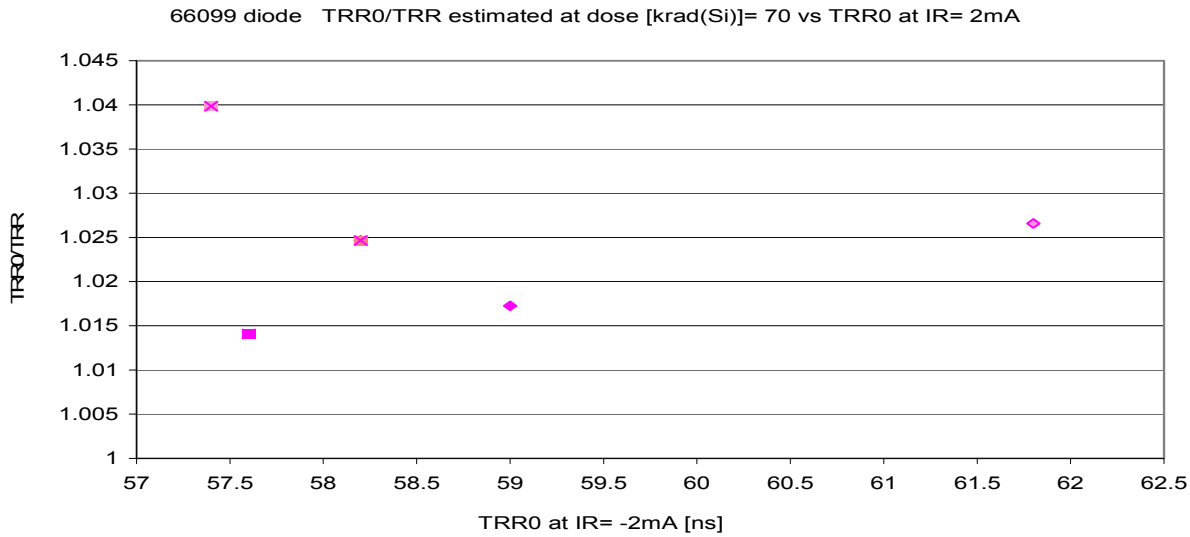


Fig. 14-204: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





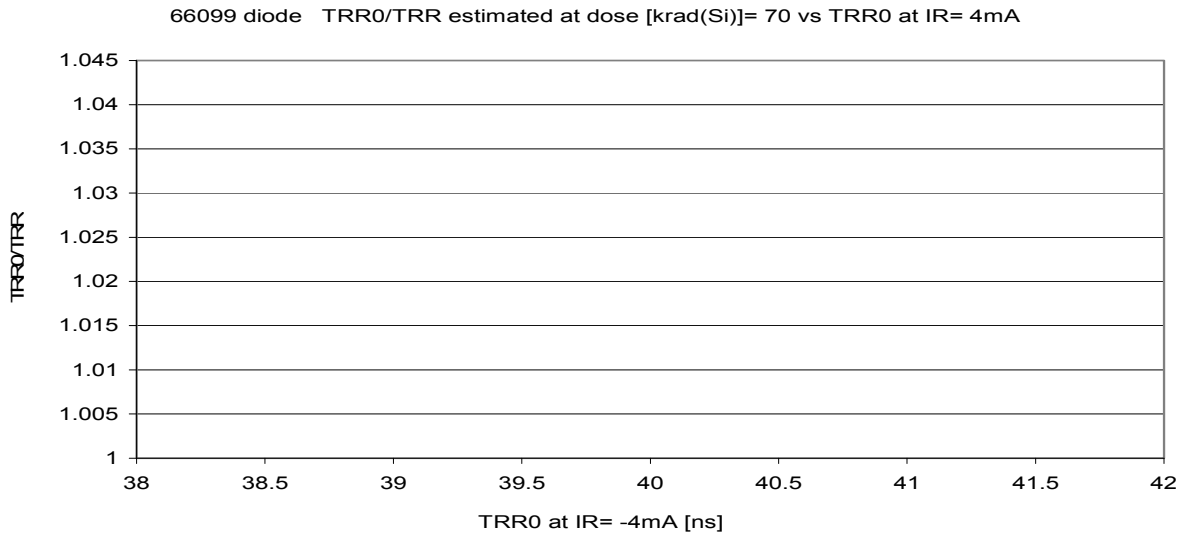


Fig. 14-205: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose

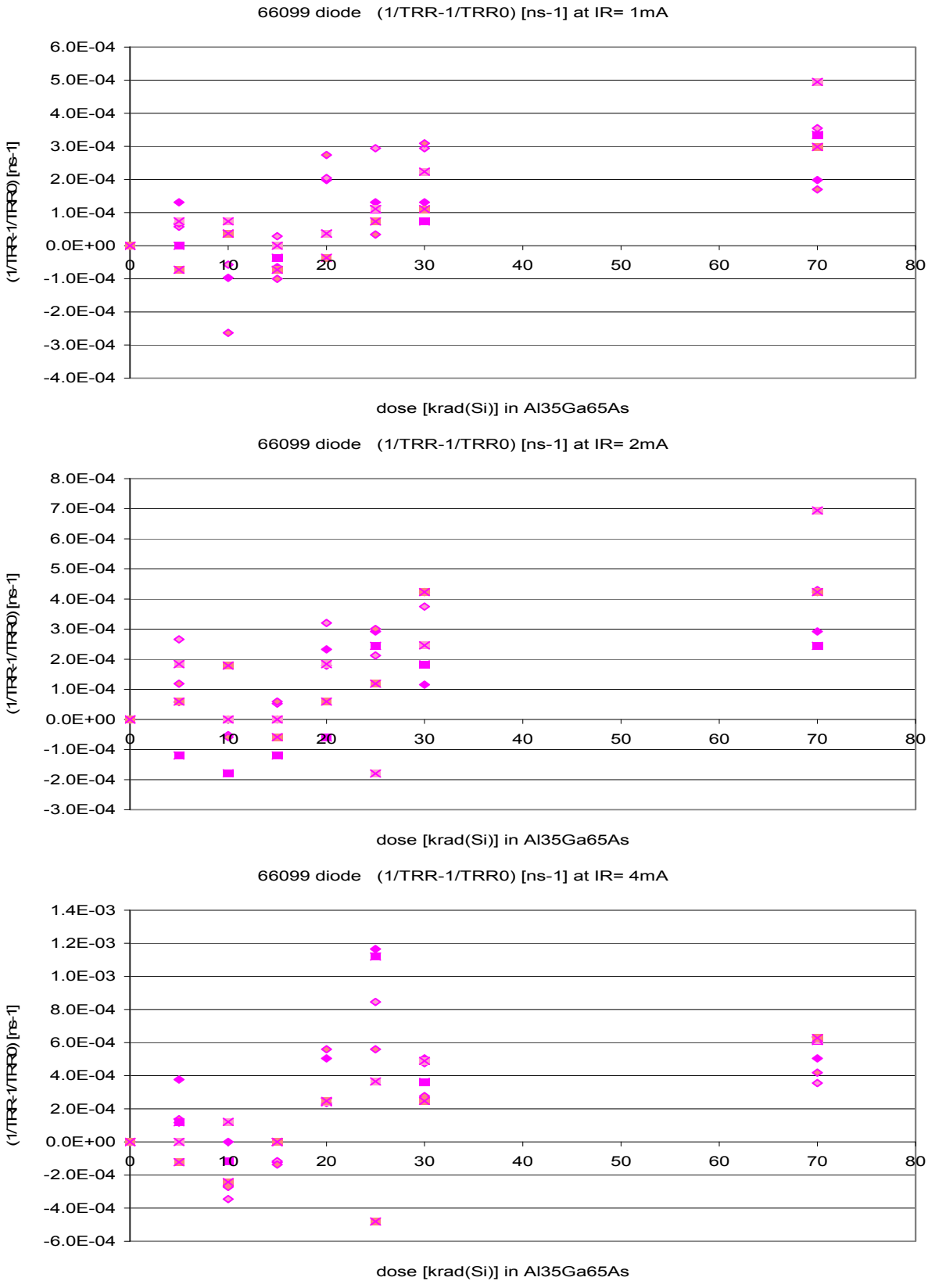
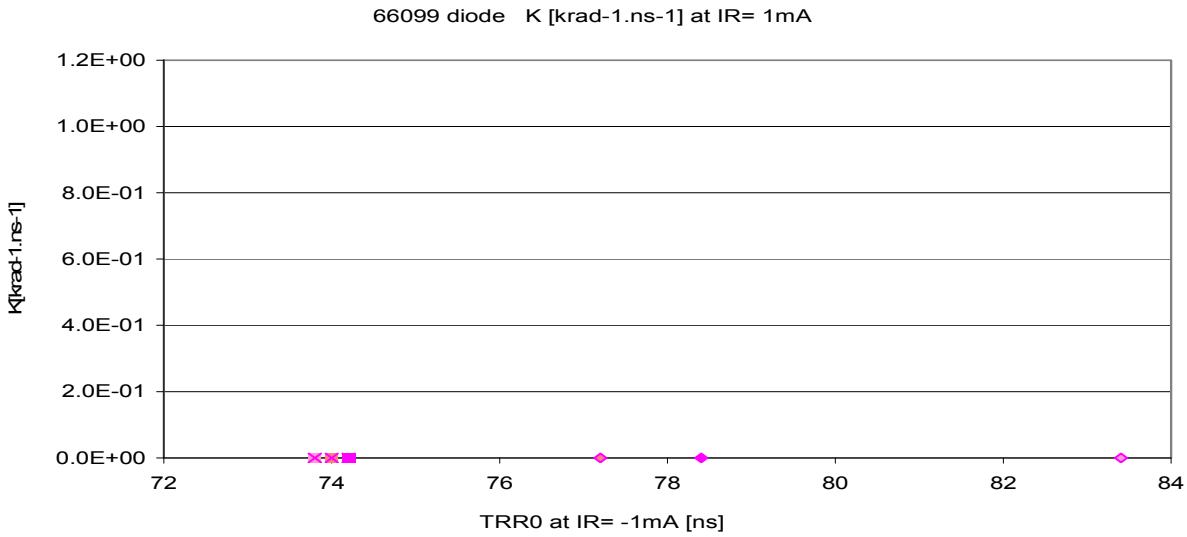
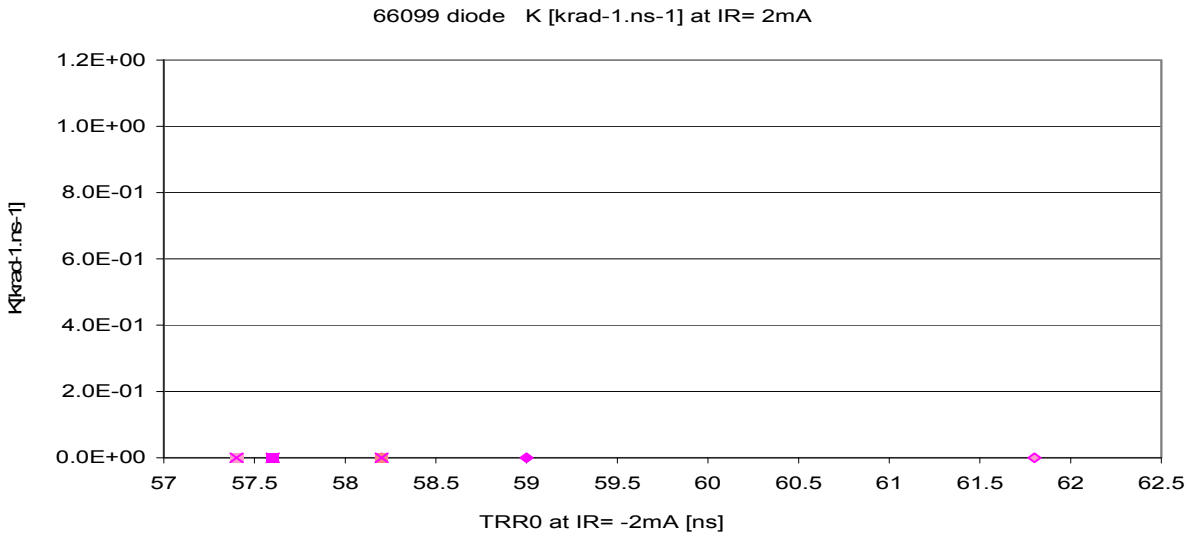


Fig. 14-206: 66099 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}





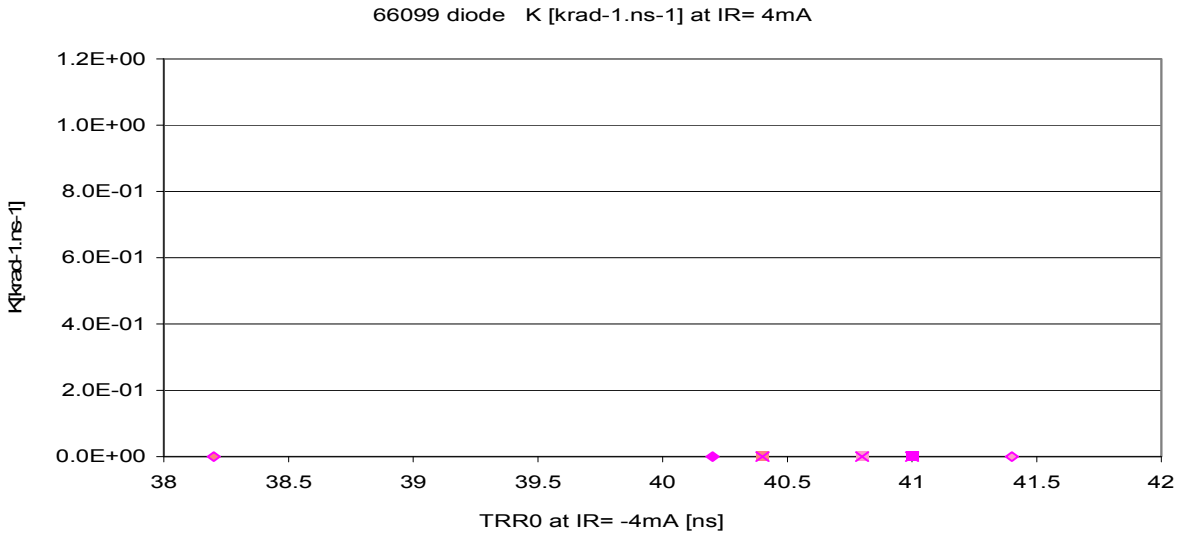
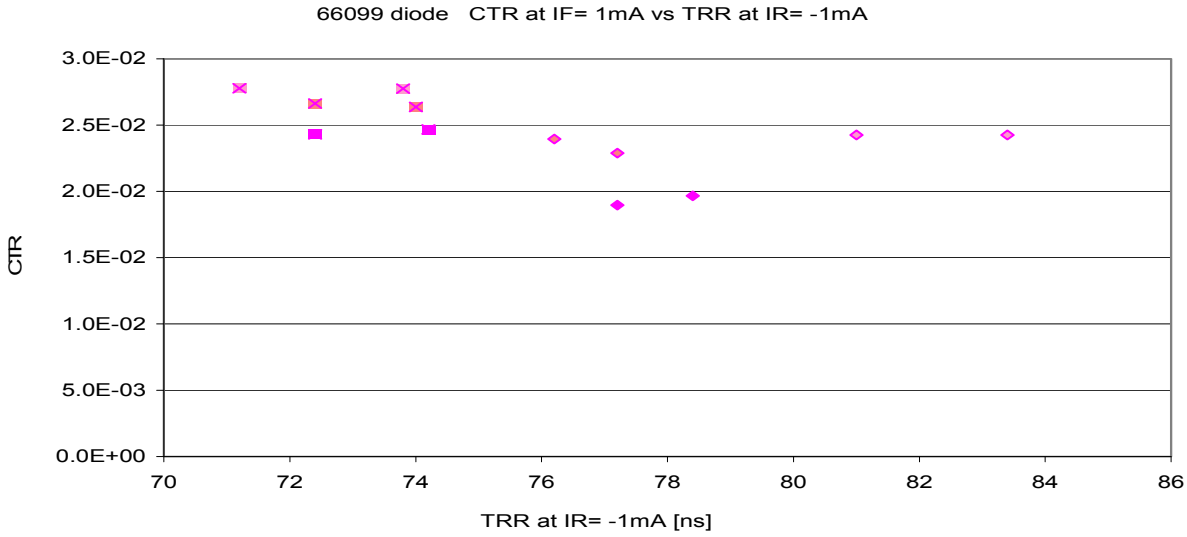
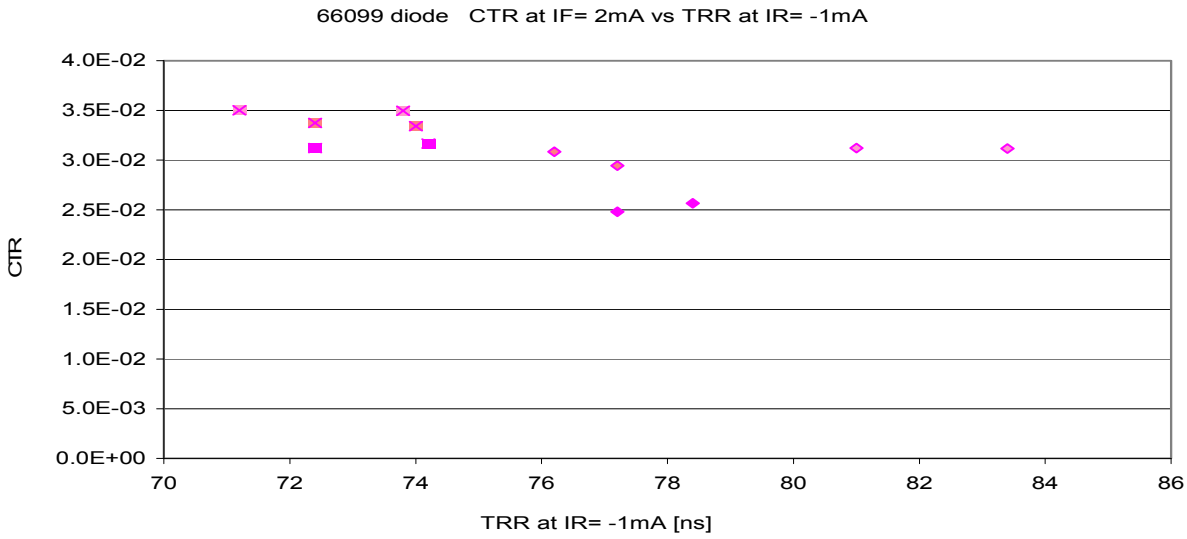
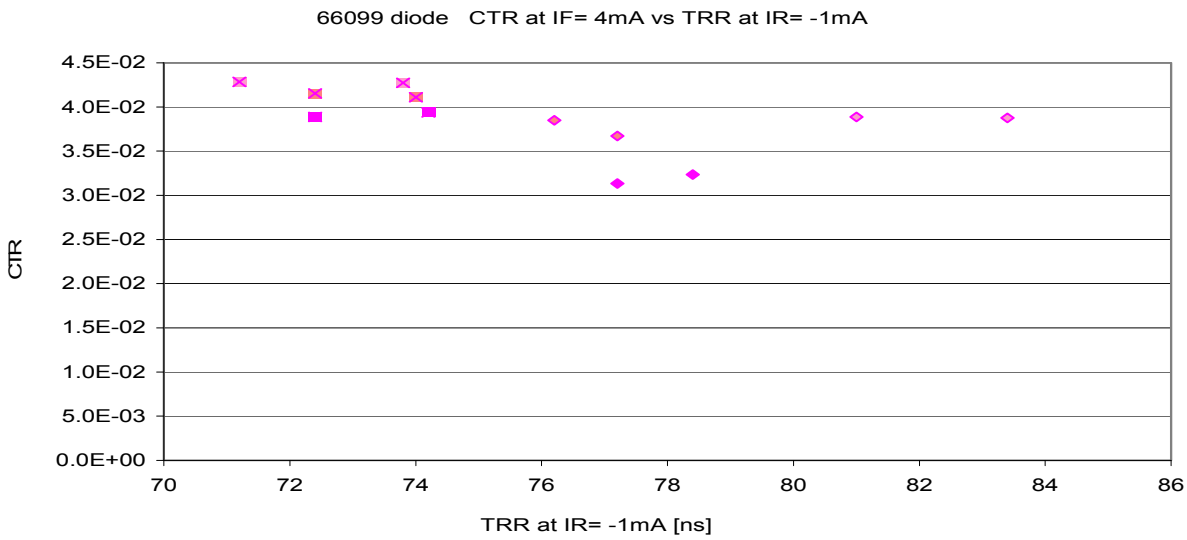
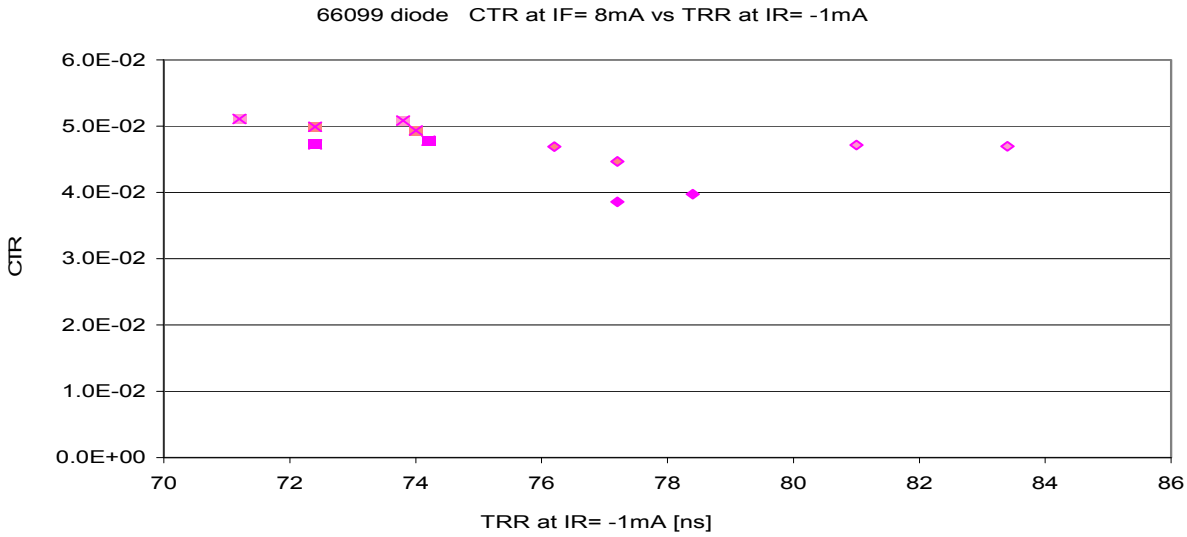


Fig. 14-207: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
70
72
74
76
78
80
82
84
86
TRR at IR= -1mA [ns]

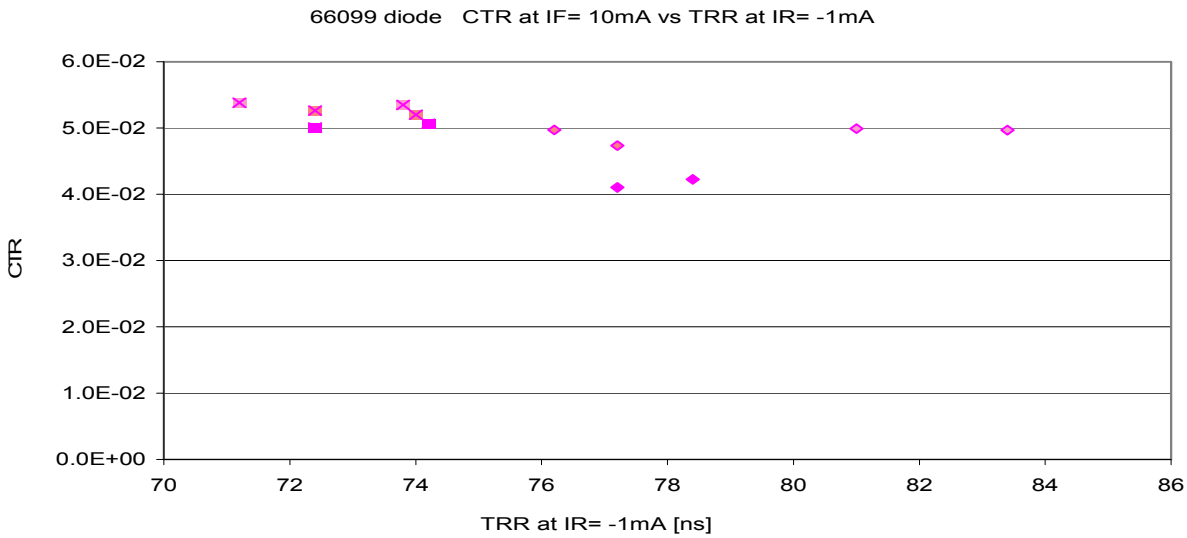
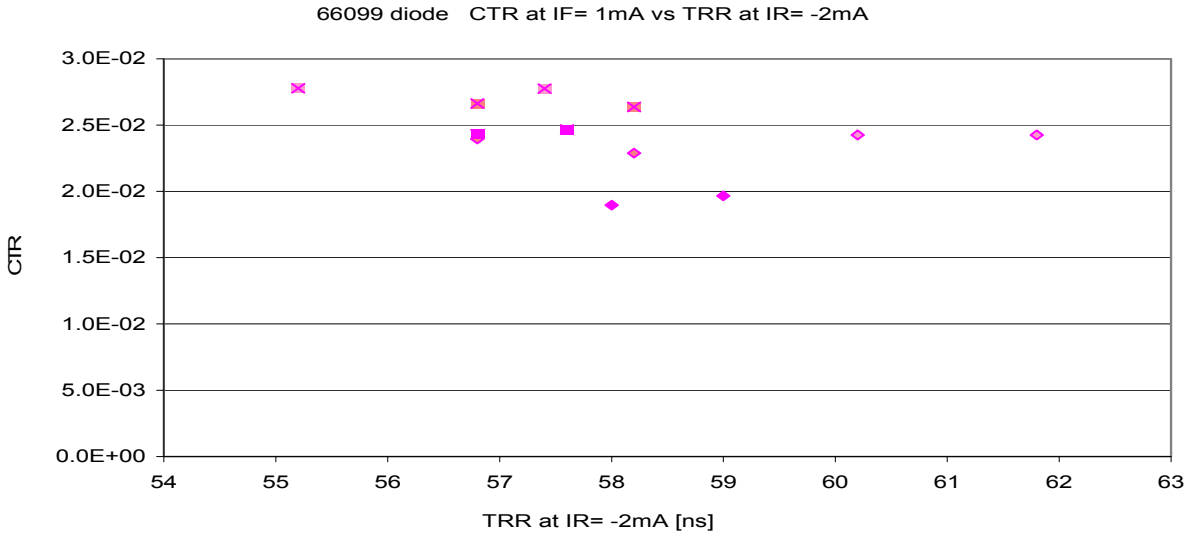
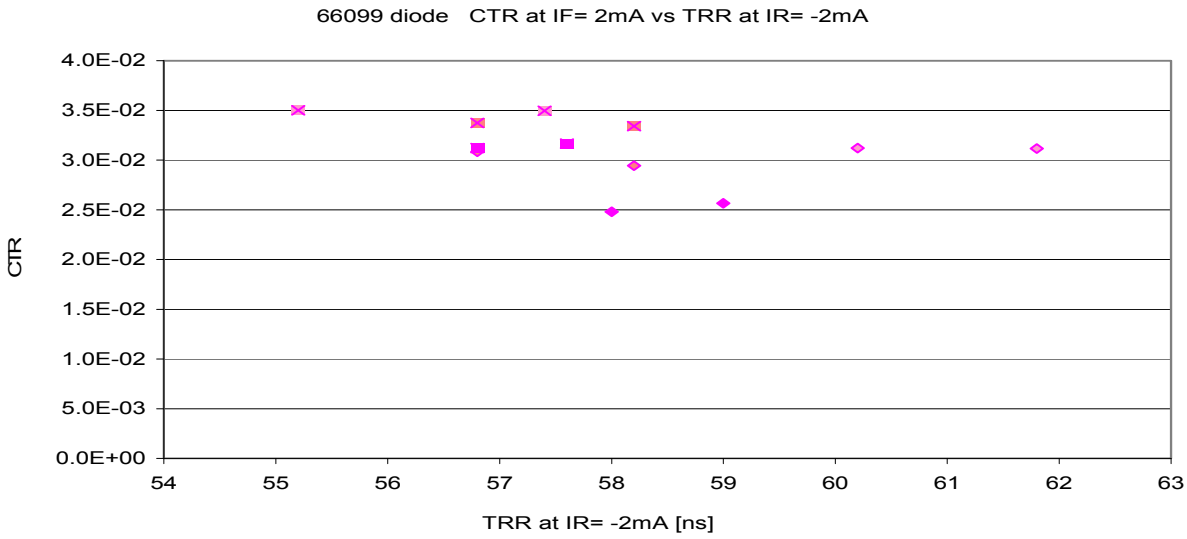
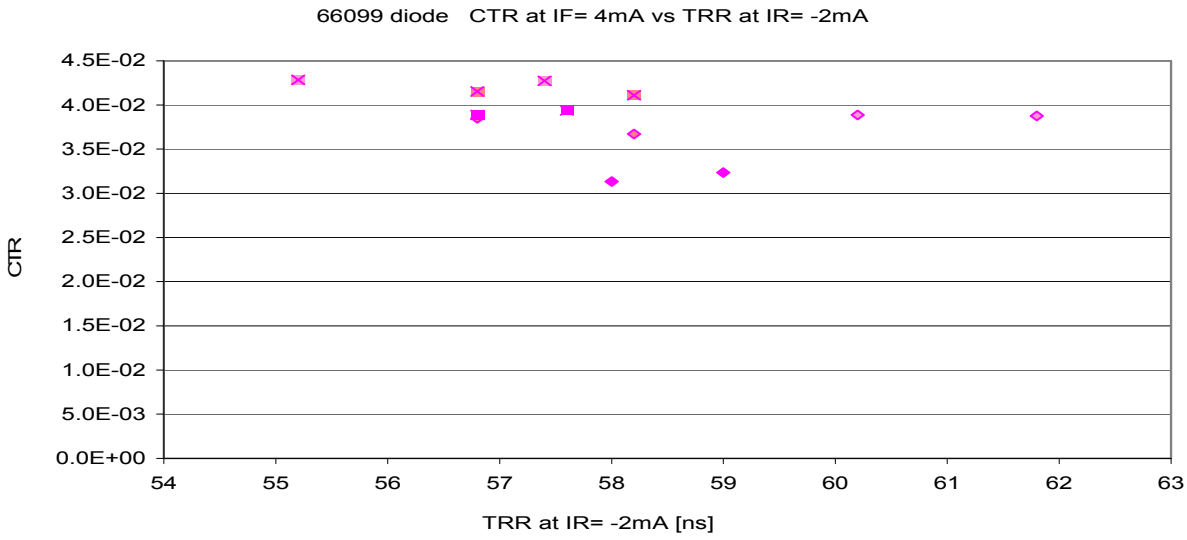
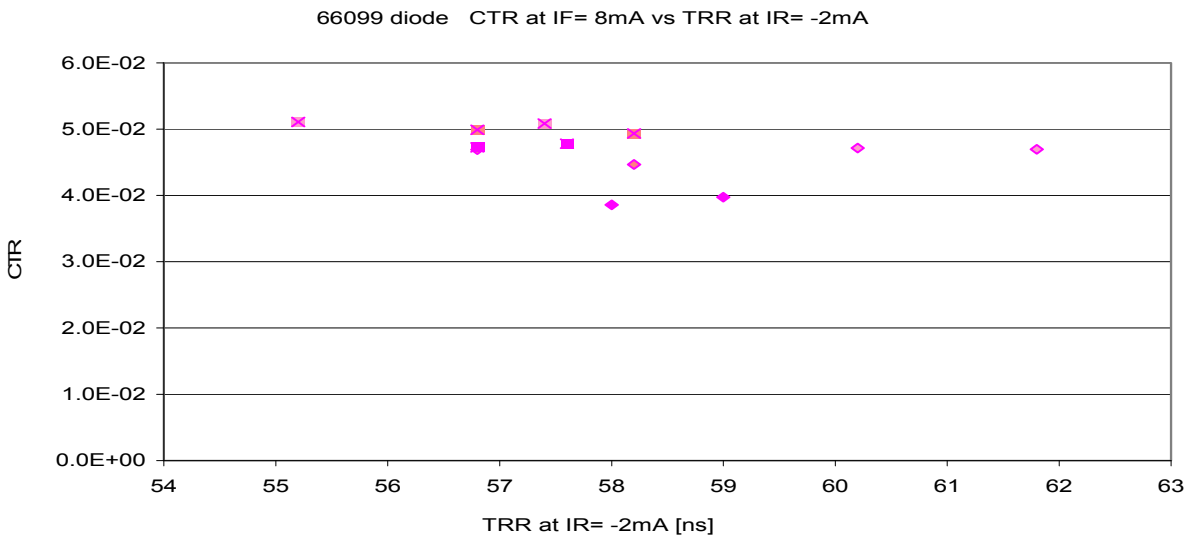

66099 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
70
72
74
76
78
80
82
84
86
TRR at IR= -1mA [ns]

Fig. 14-208: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
54
55
56
57
58
59
60
61
62
63
TRR at IR= -2mA [ns]

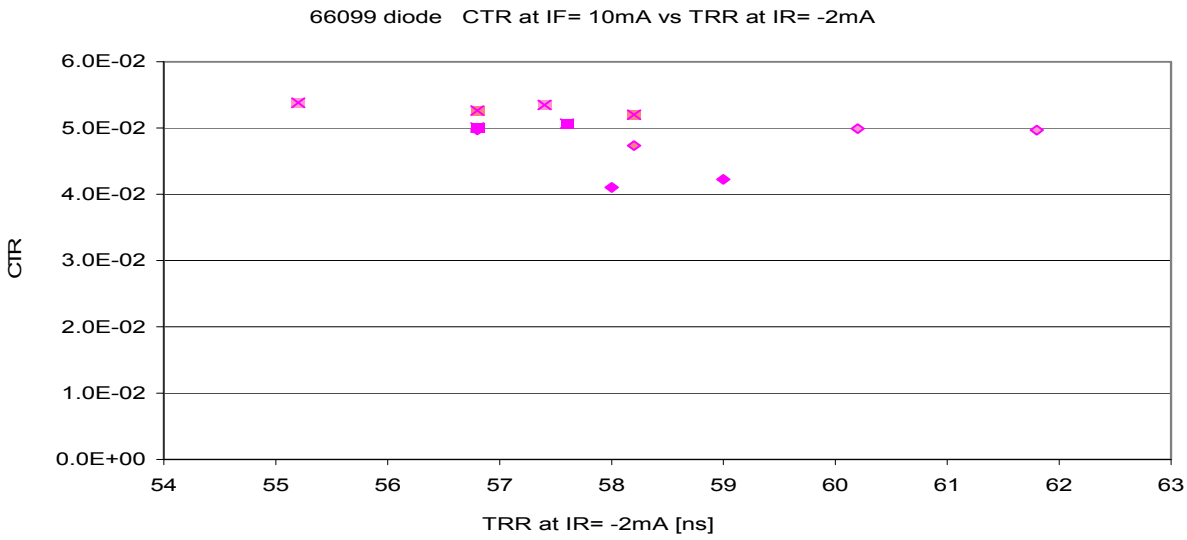
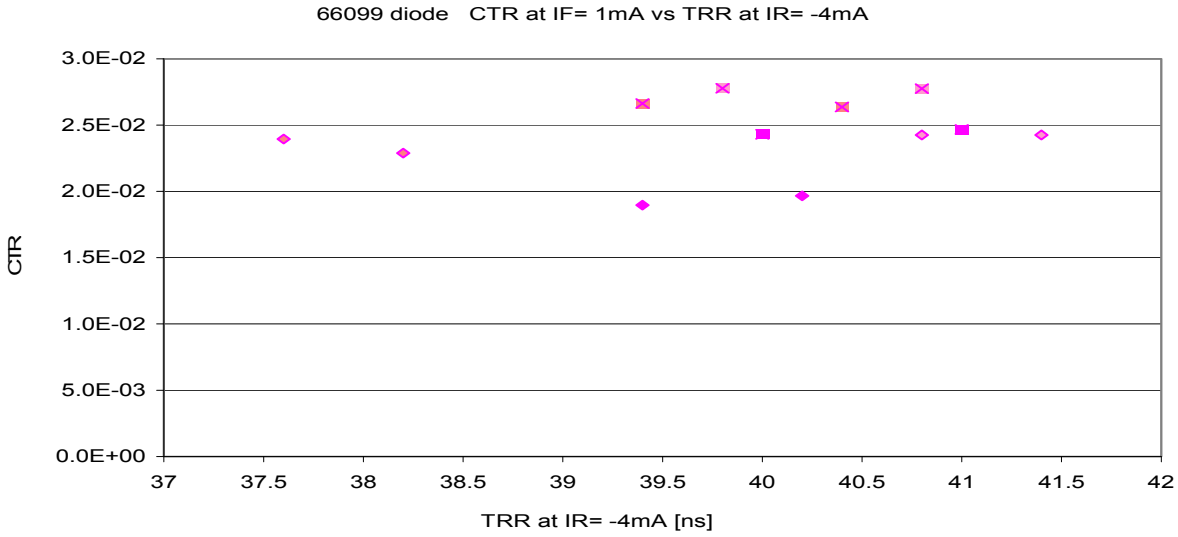
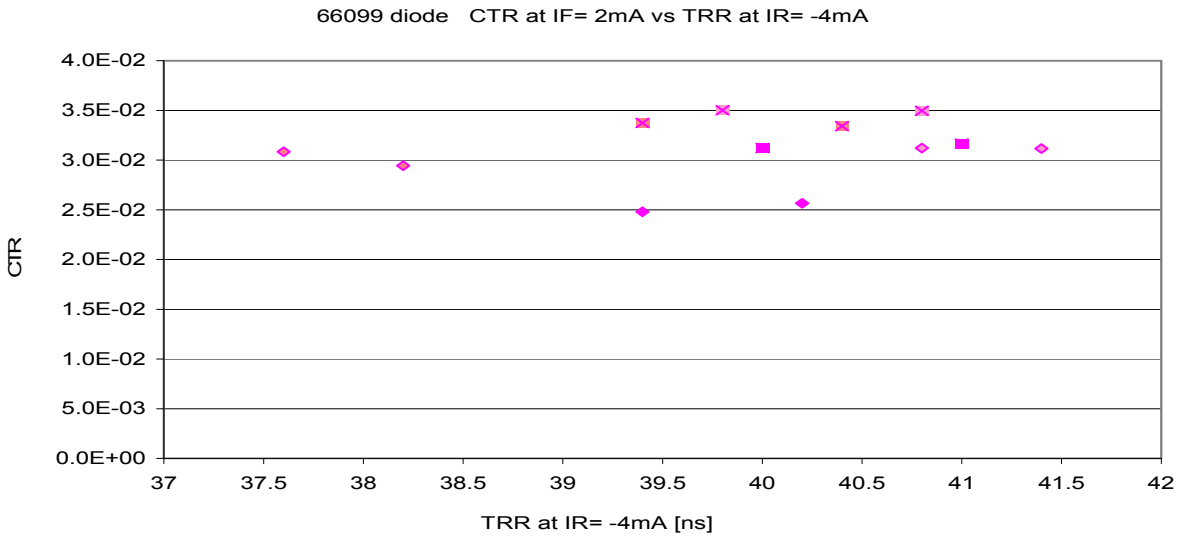
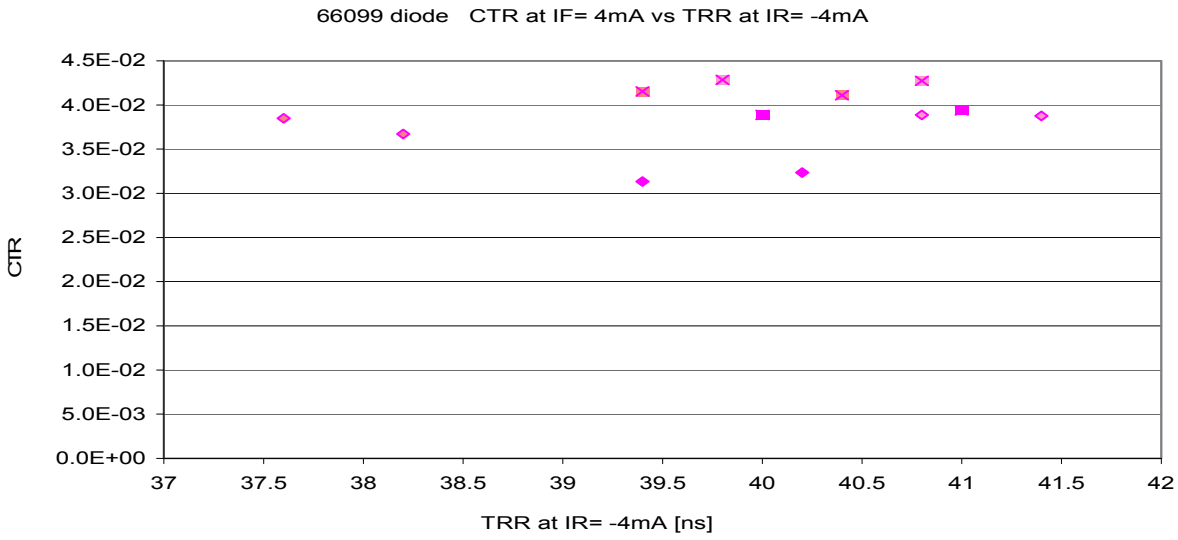
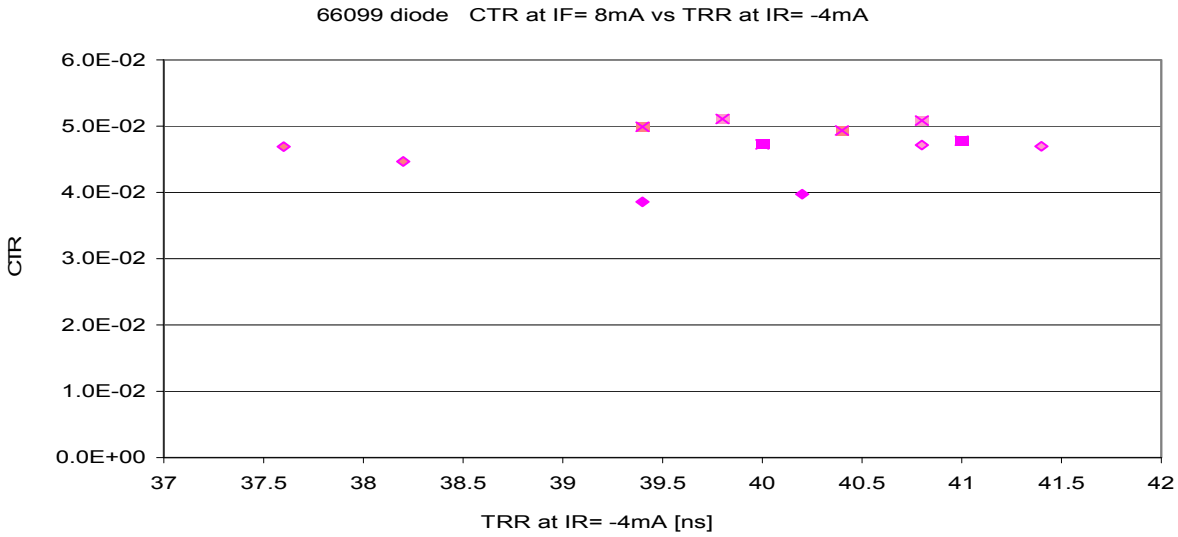

66099 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
54
55
56
57
58
59
60
61
62
63
TRR at IR= -2mA [ns]

Fig. 14-209: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
37
37.5
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR at IR= -4mA [ns]

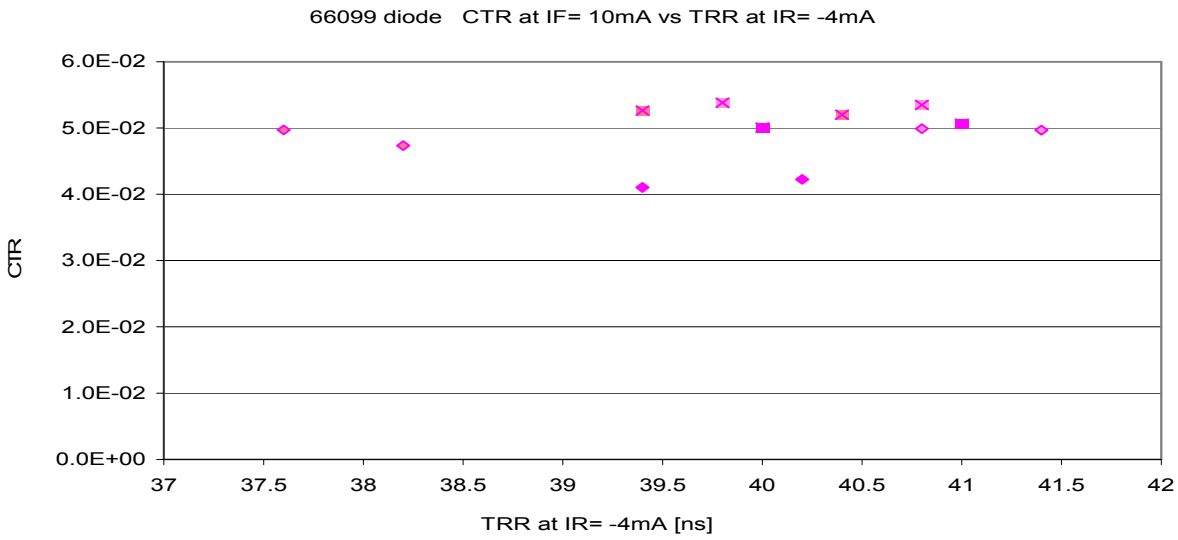
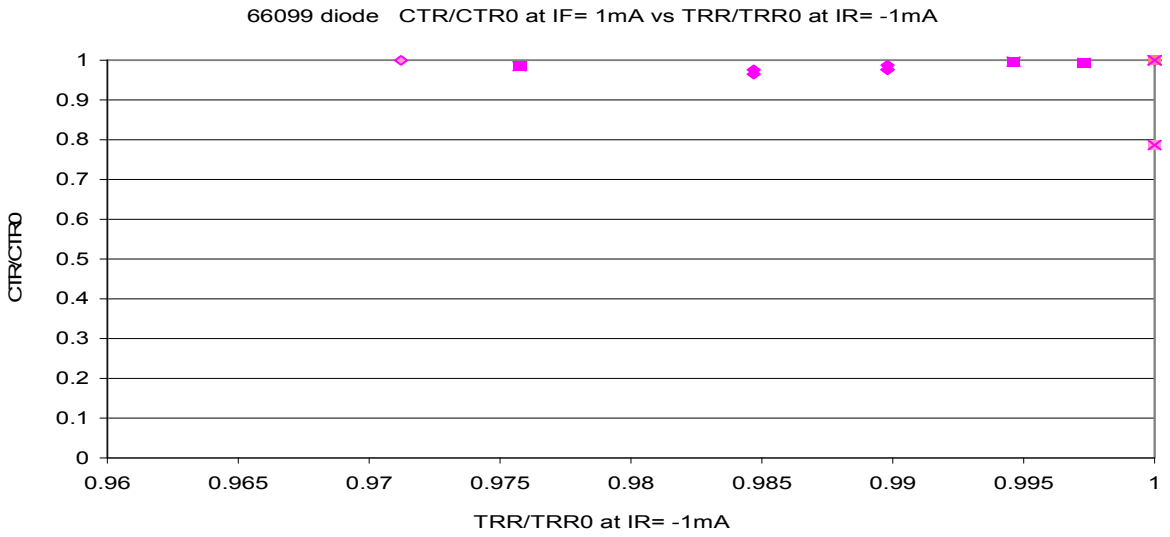
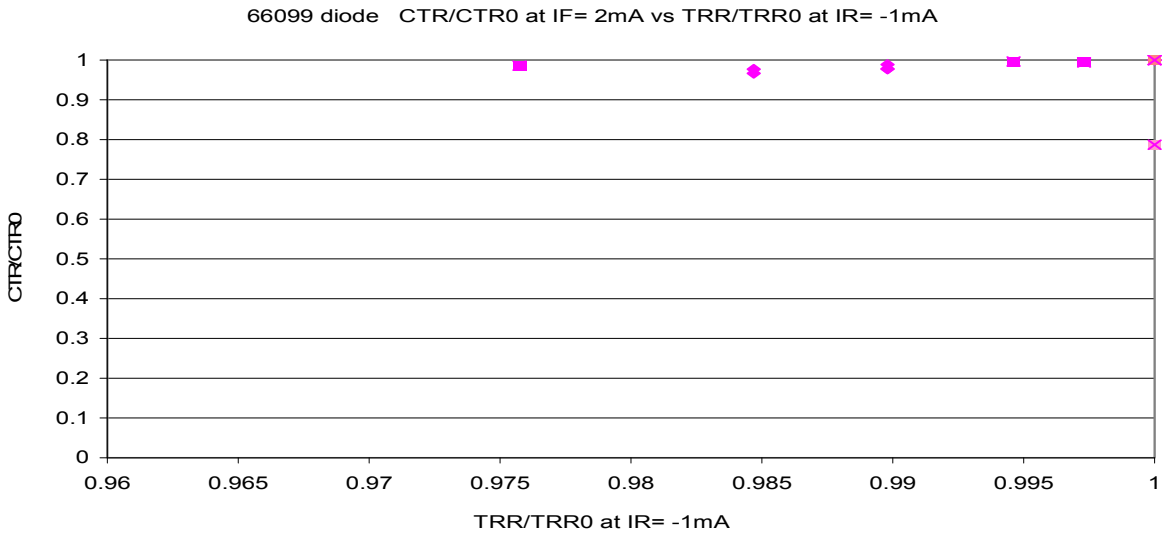
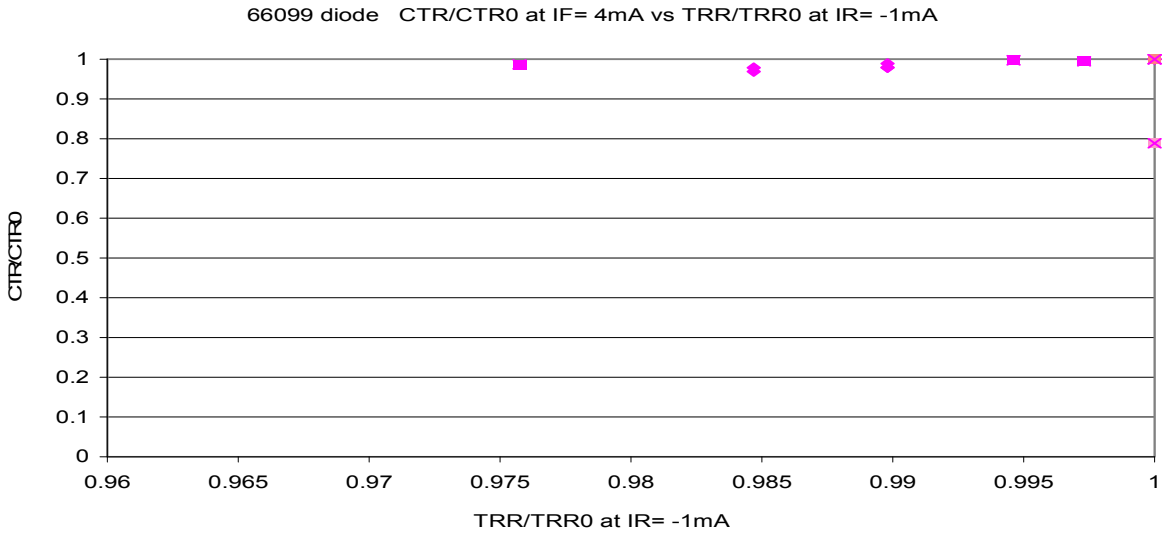
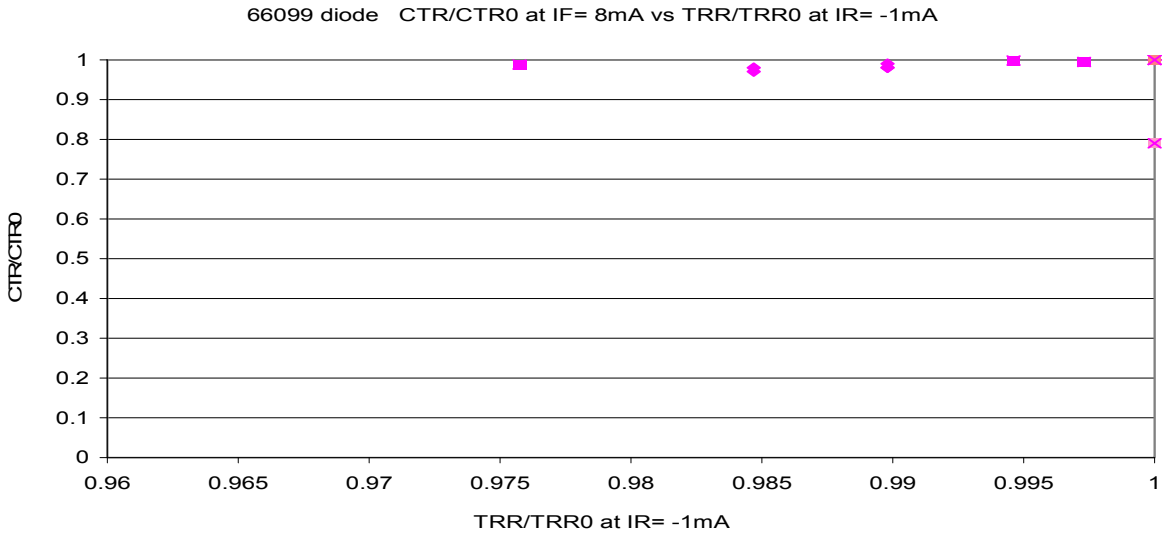

66099 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
37
37.5
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR at IR= -4mA [ns]

Fig. 14-210: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -1mA

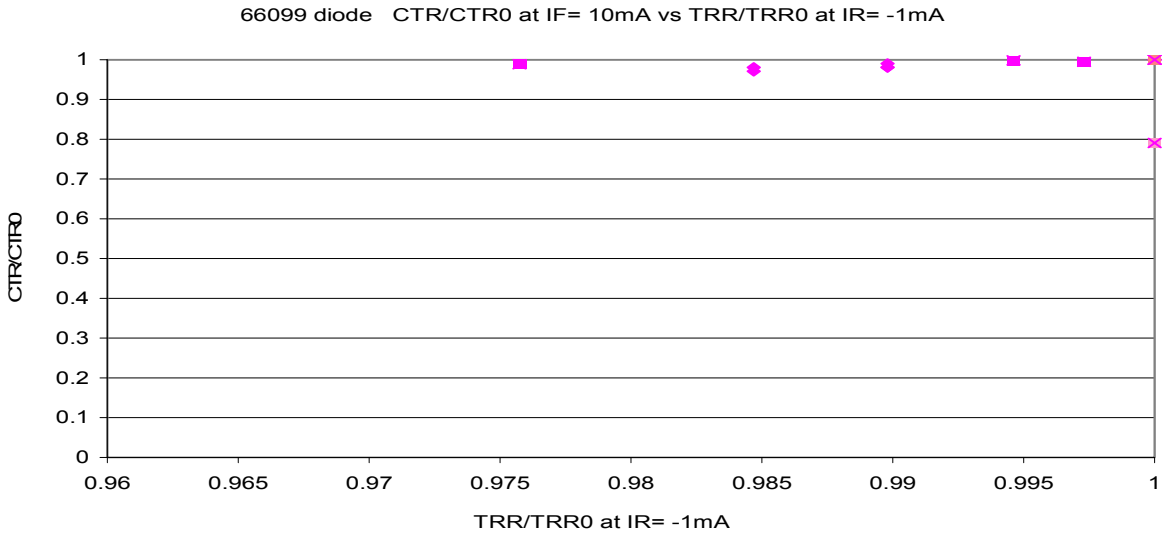
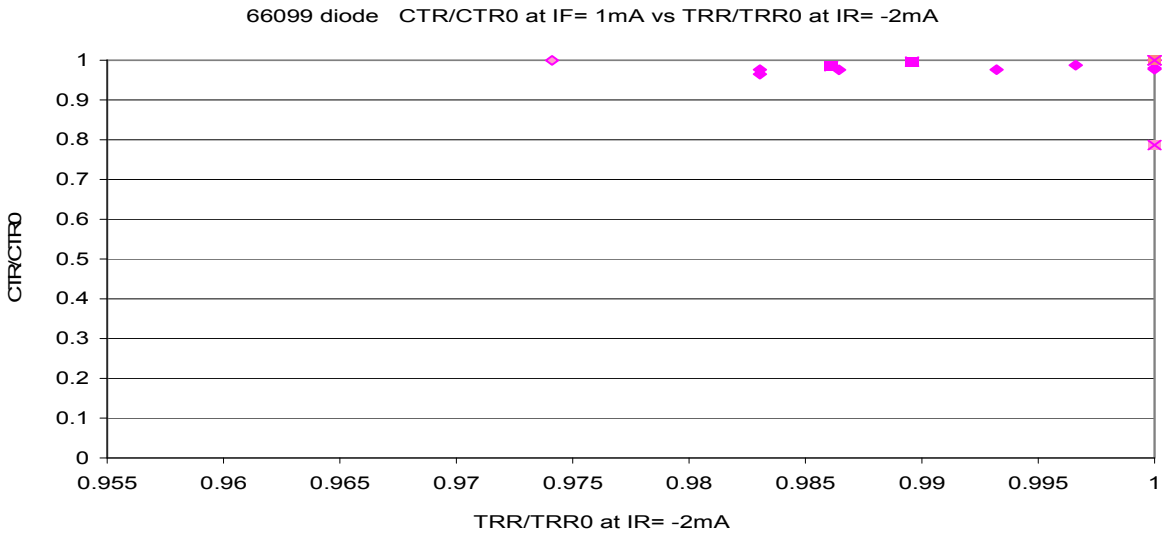
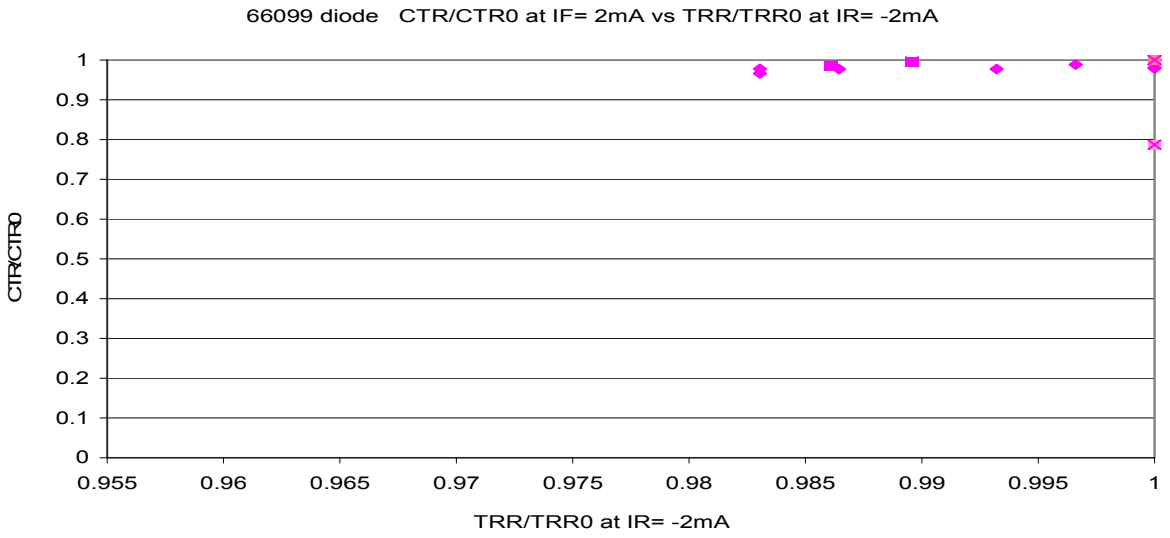
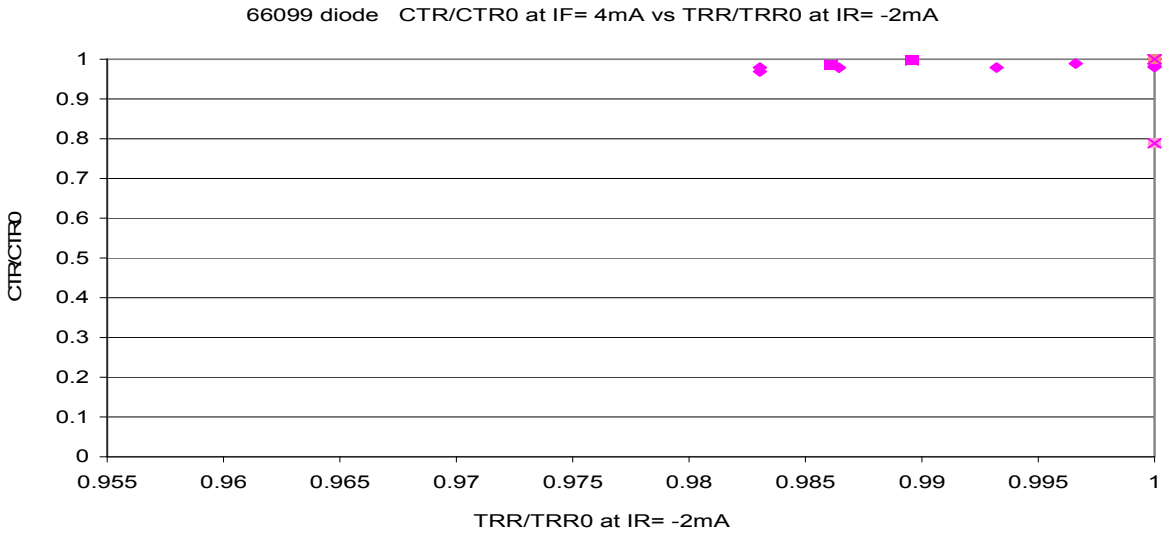
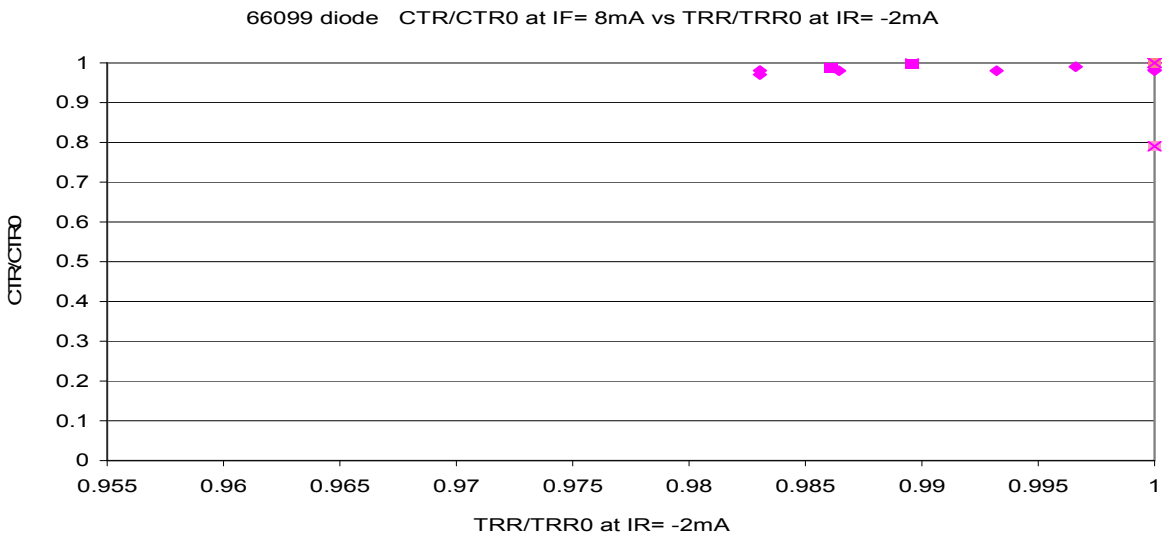

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -1mA

Fig. 14-211: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -2mA

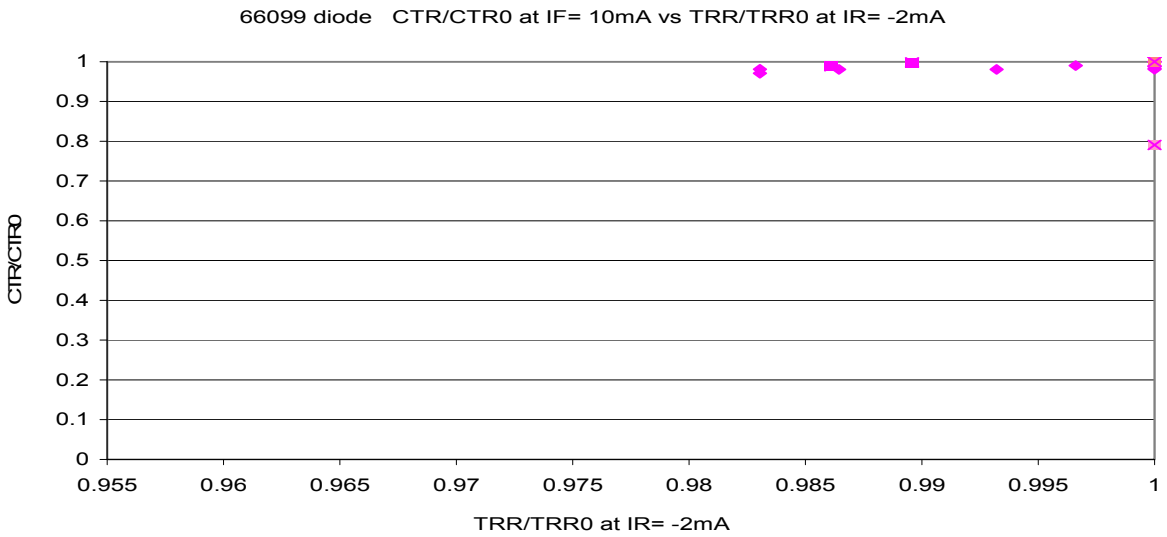
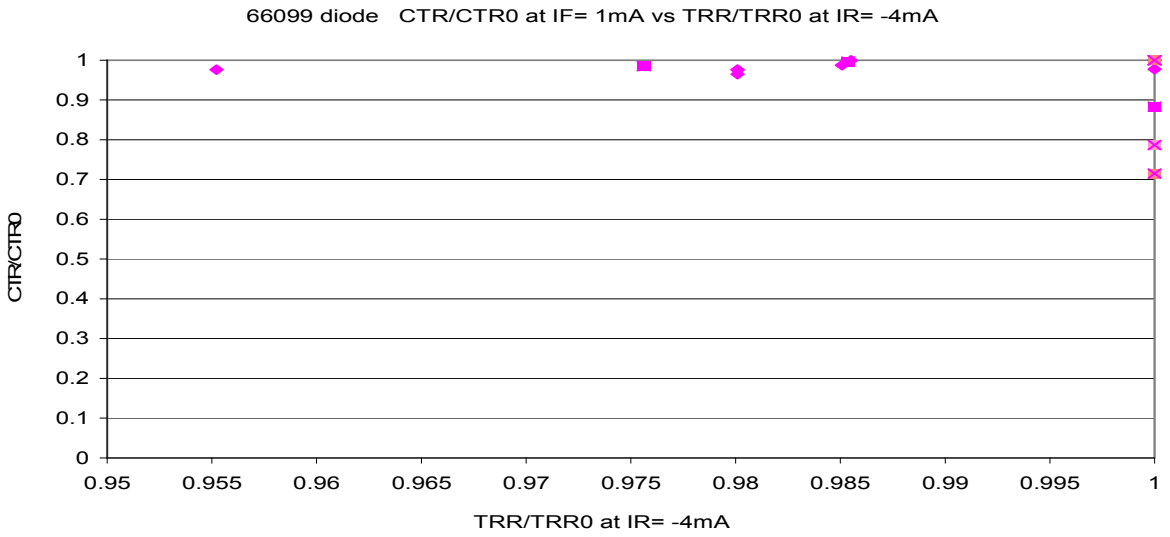
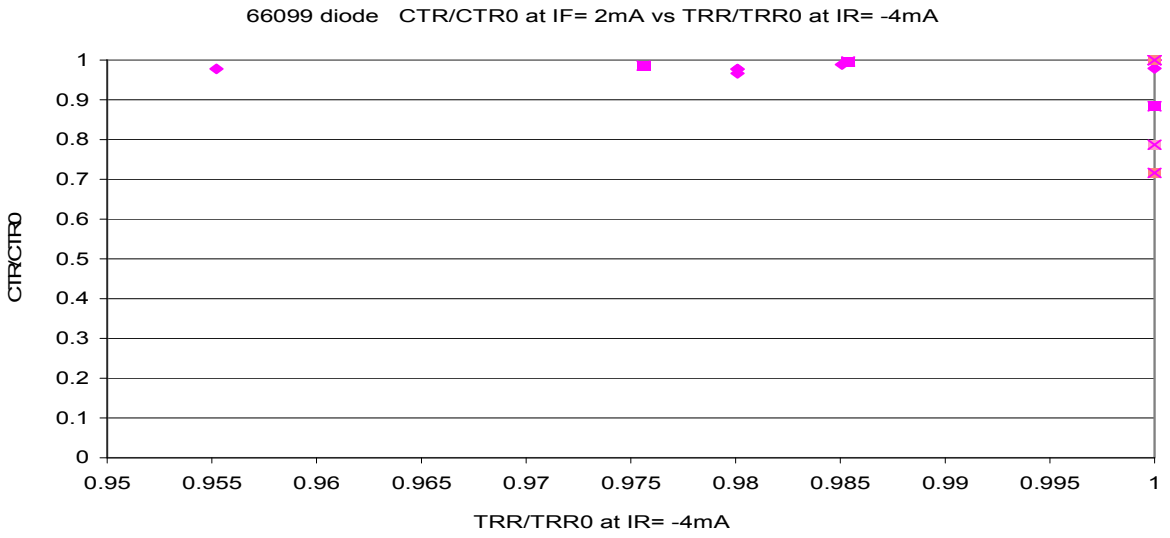
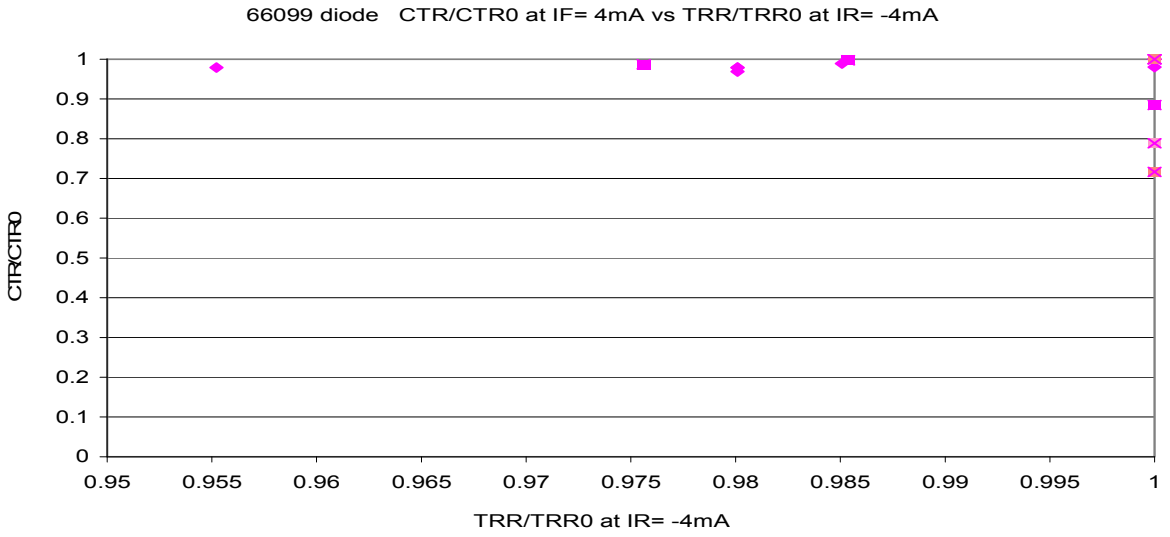
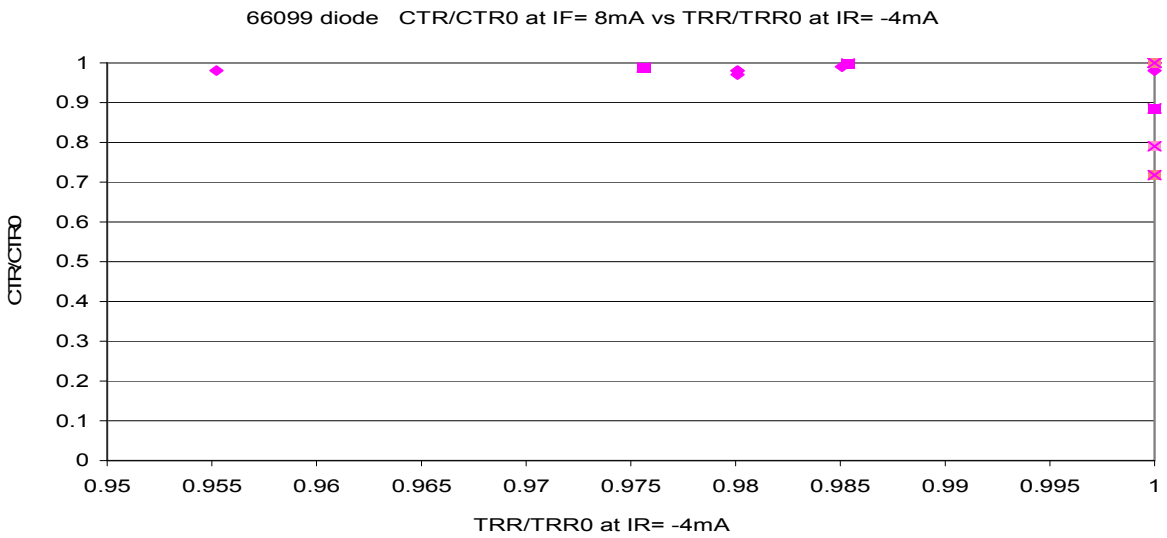

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -2mA

Fig. 14-212: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.95
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -4mA

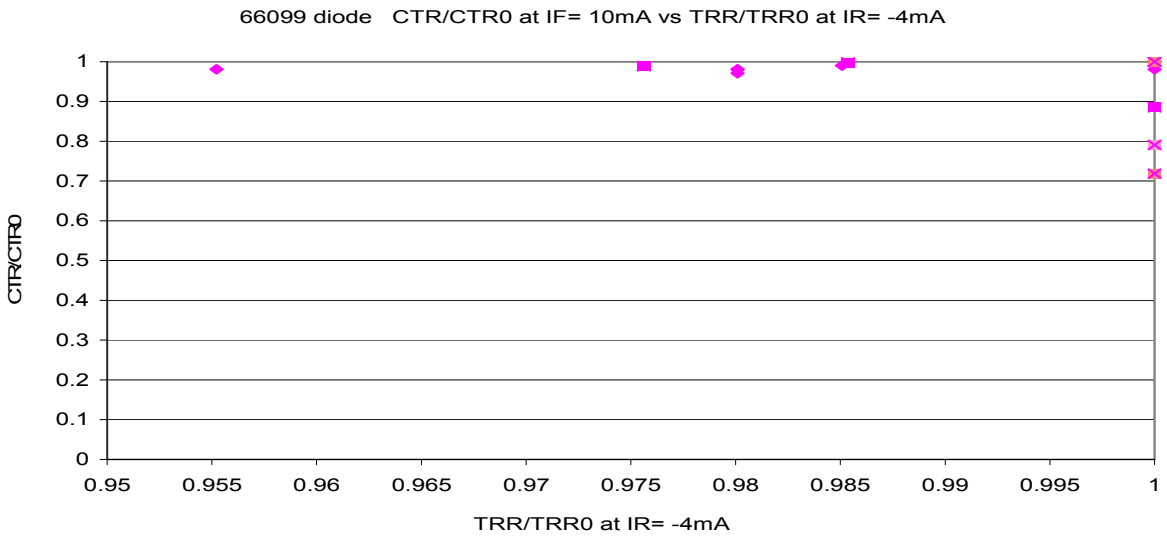
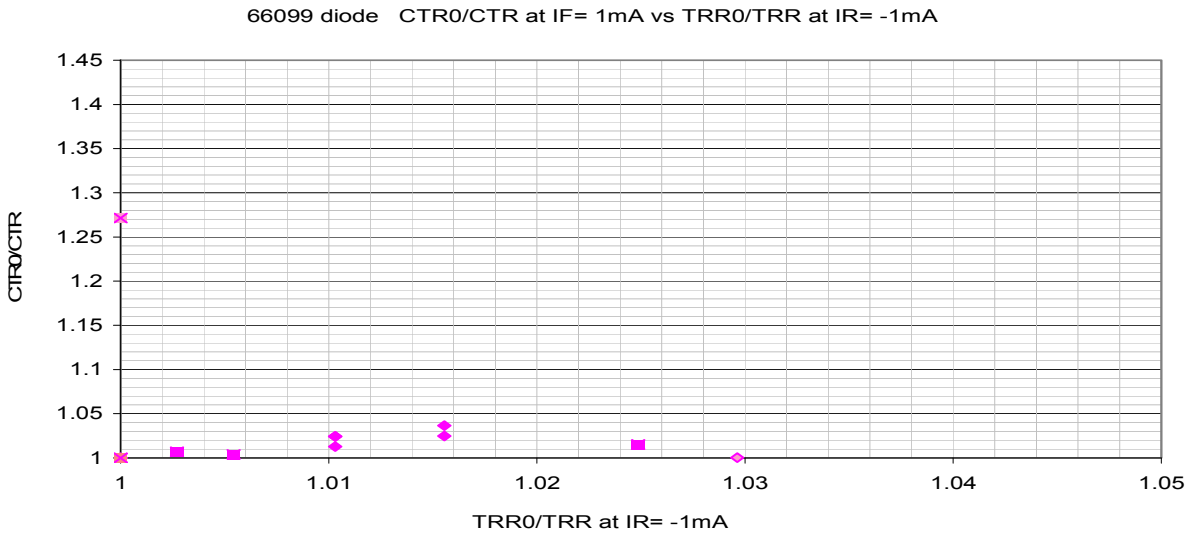
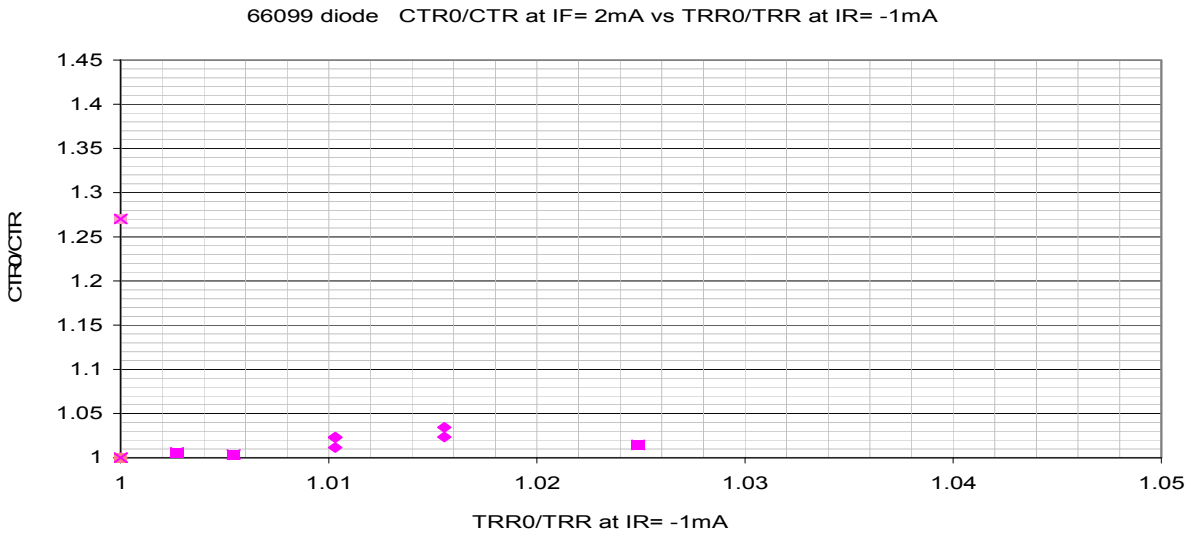
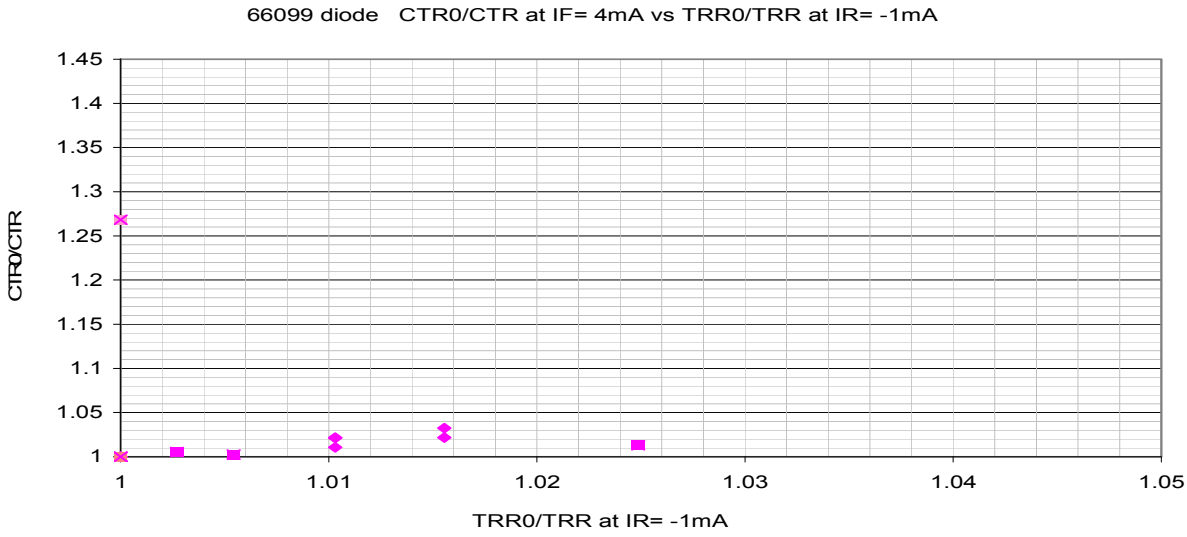

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.95
0.955
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
TRR/TRR0 at IR= -4mA

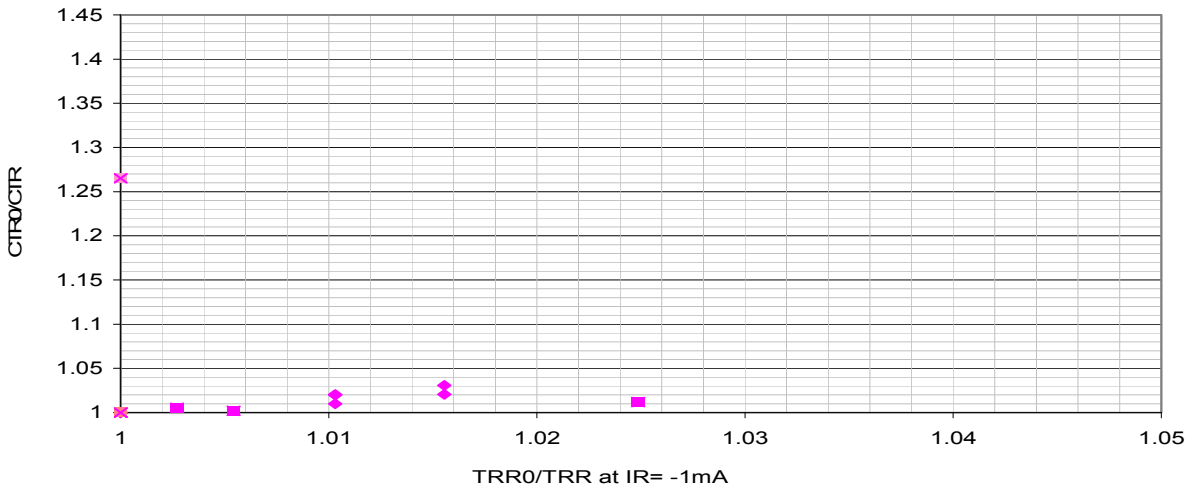
Fig. 14-213: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA







66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA



66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA

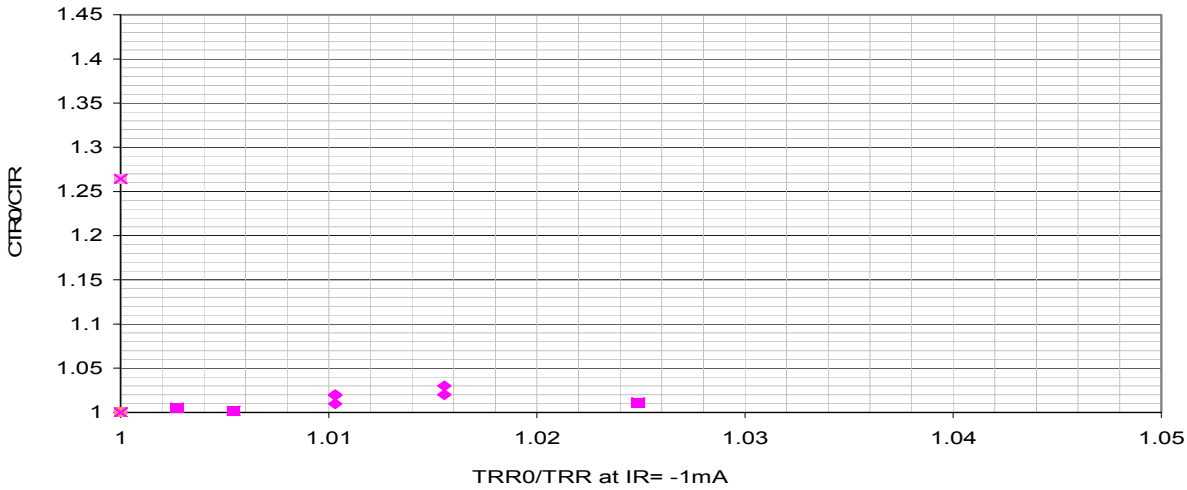
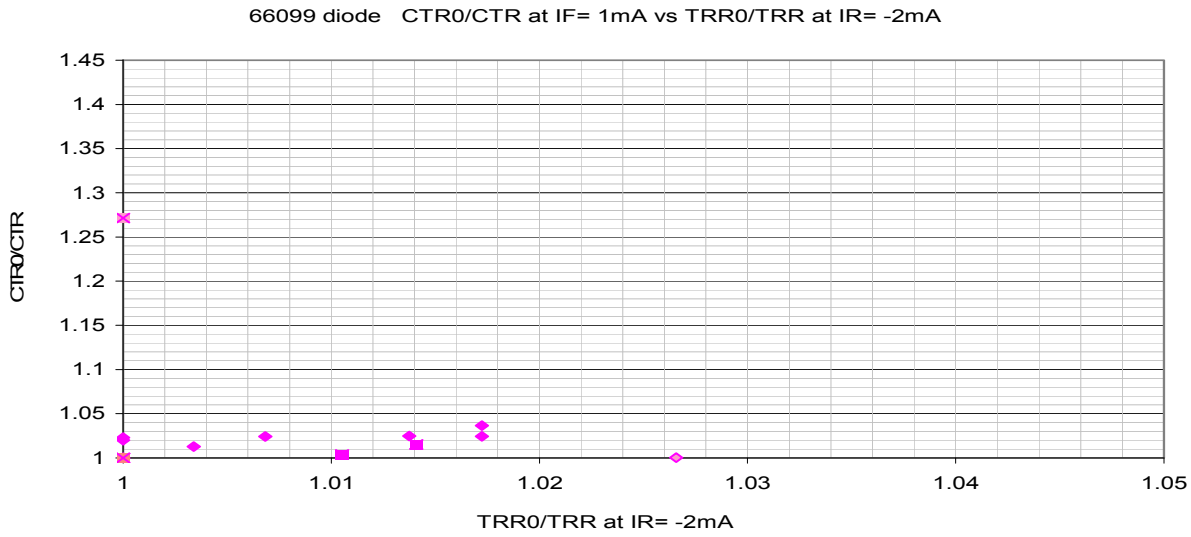
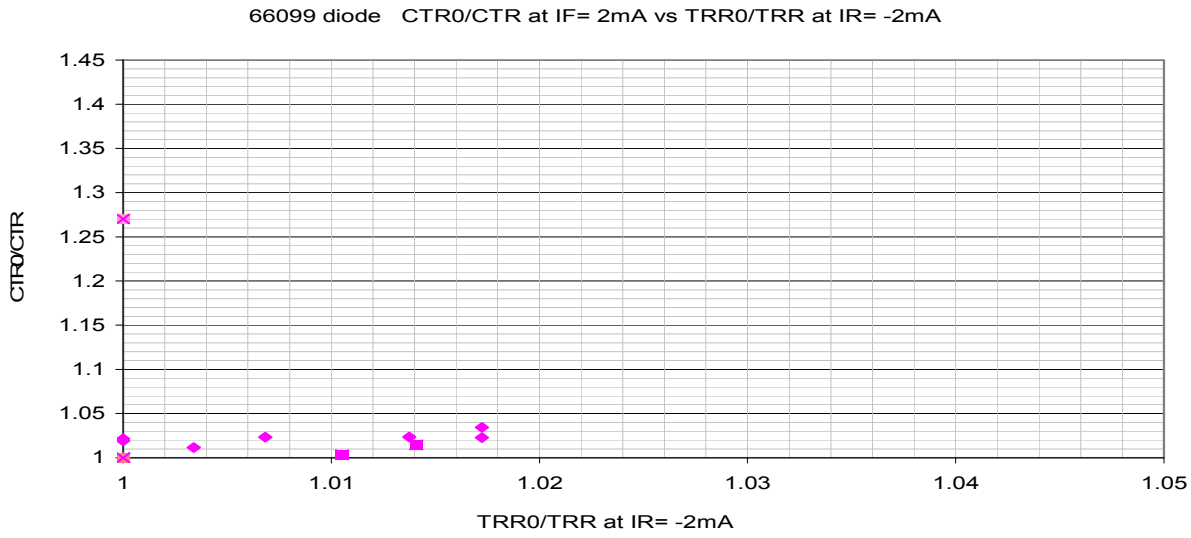
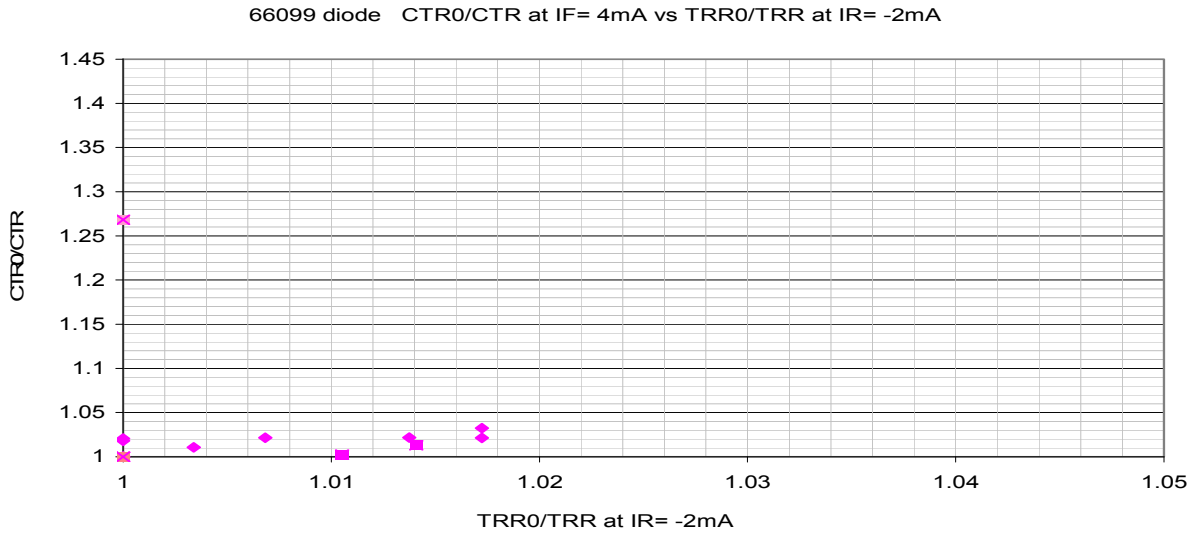


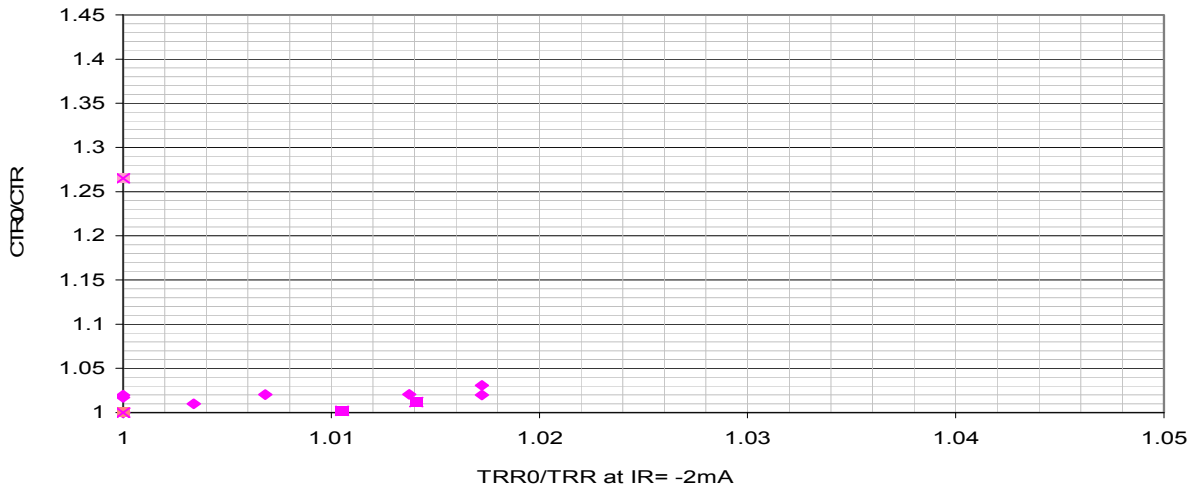
Fig. 14-214: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA







66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA



66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA

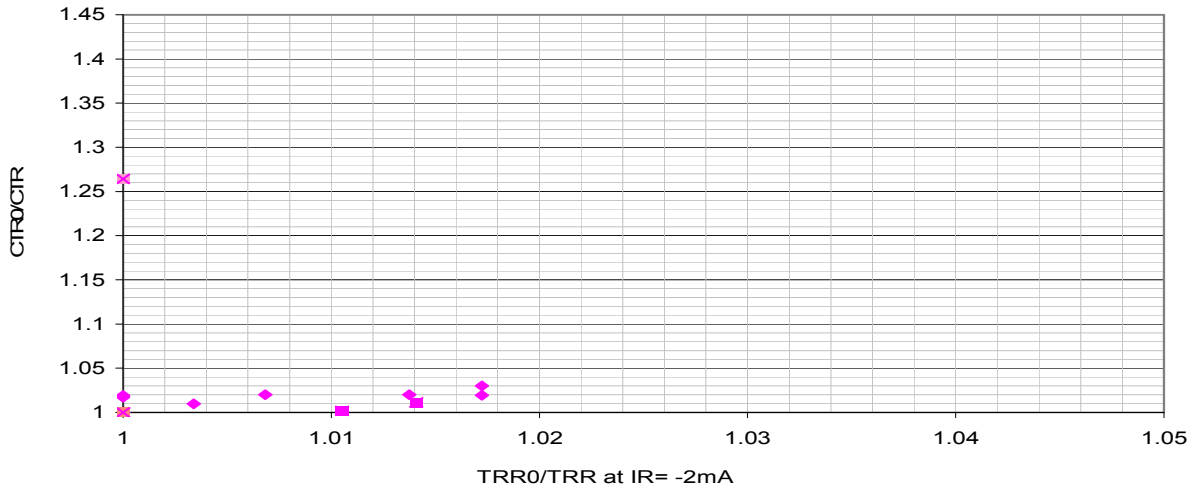
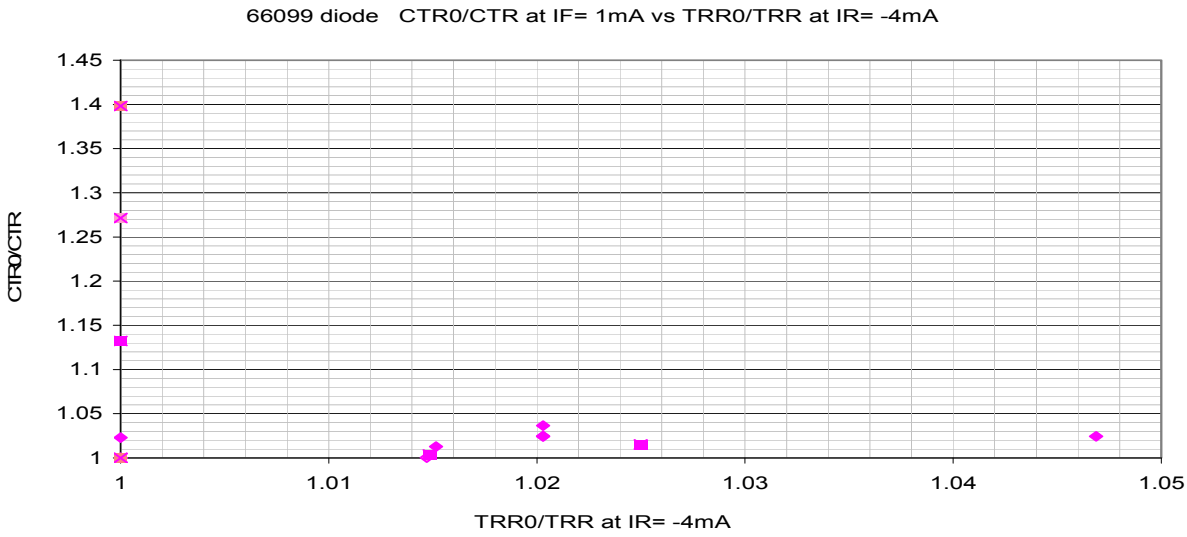
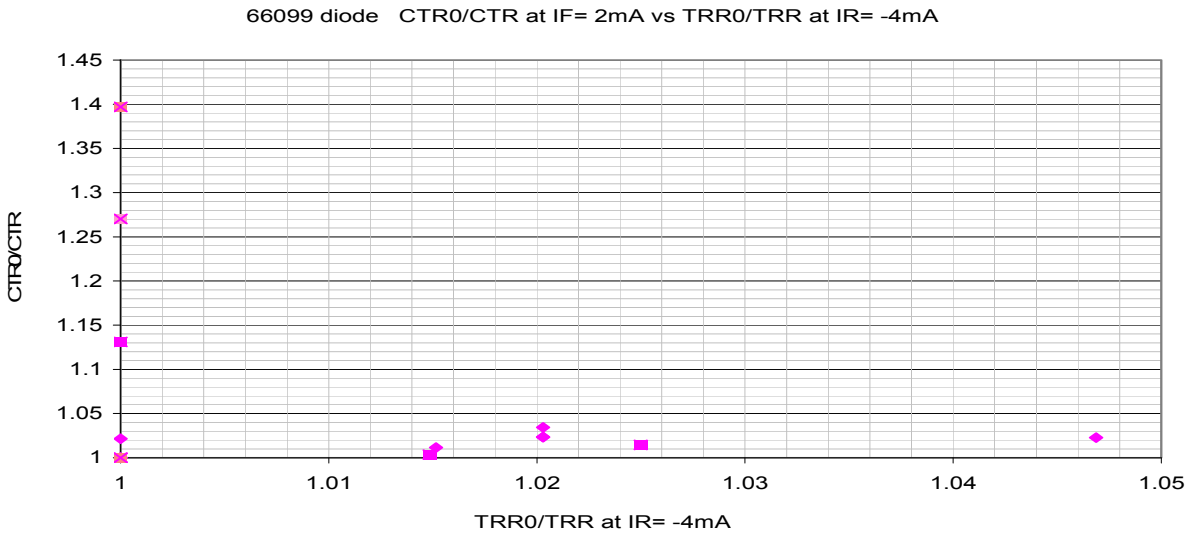
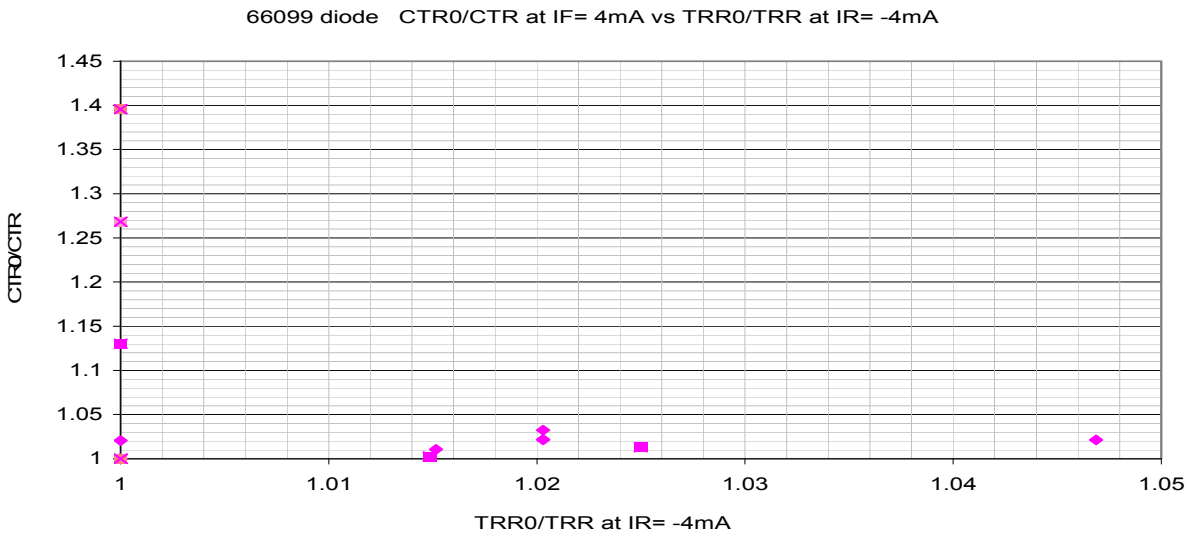


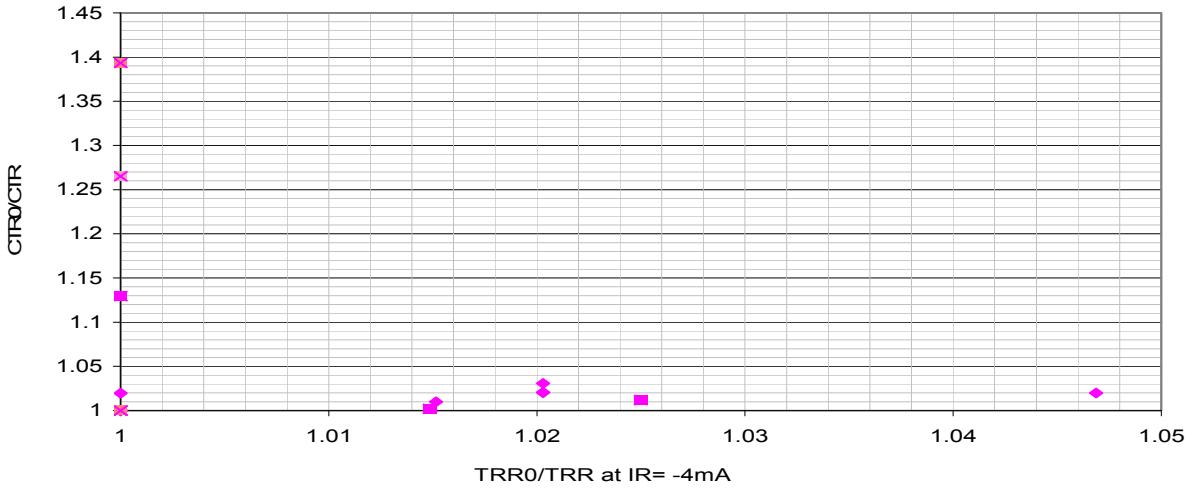
Fig. 14-215: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA







66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA



66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA

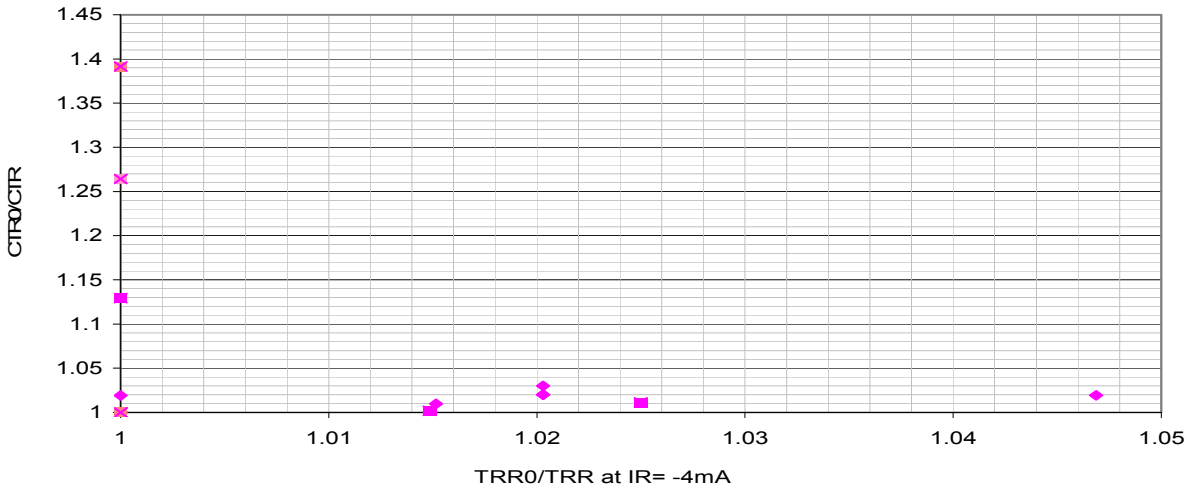
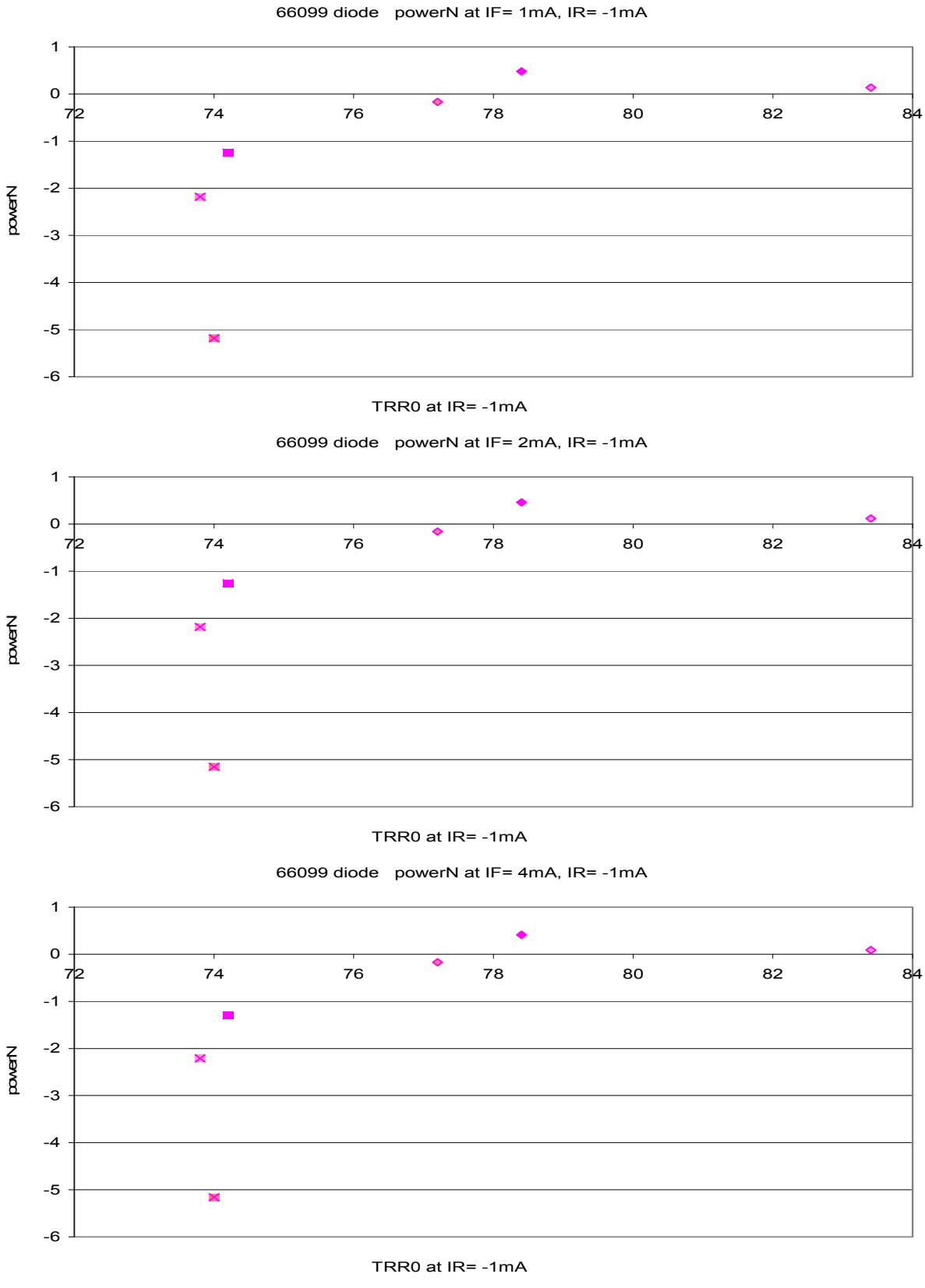
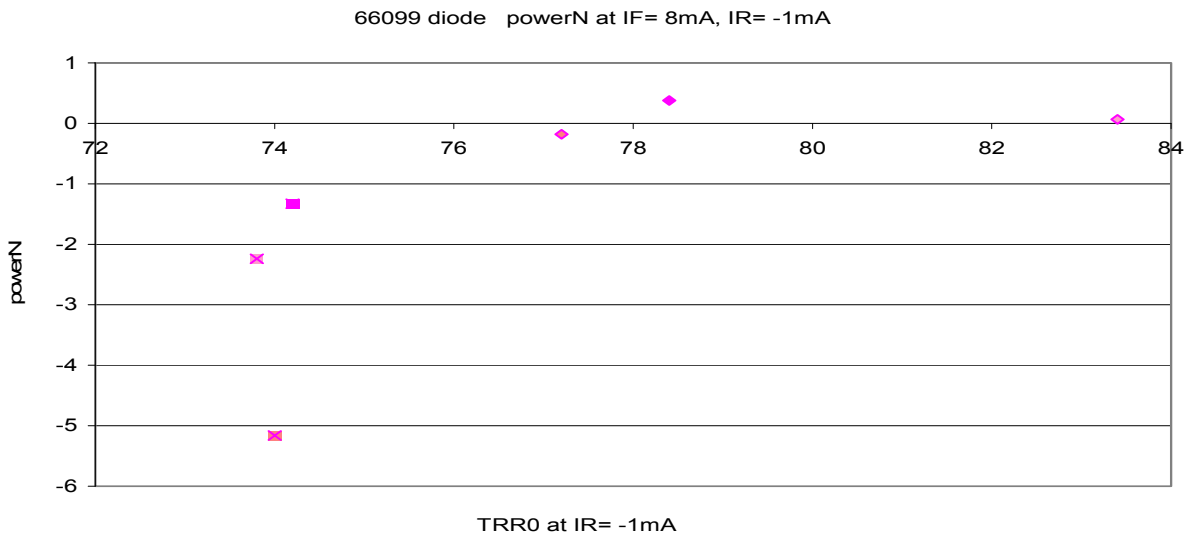


Fig. 14-216: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA




66099 diode powerN at IF= 8mA, IR= -1mA
powerN
1
0
-1
-2
-3
-4
-5
-6
72
74
76
78
80
82
84
TRR0 at IR= -1mA

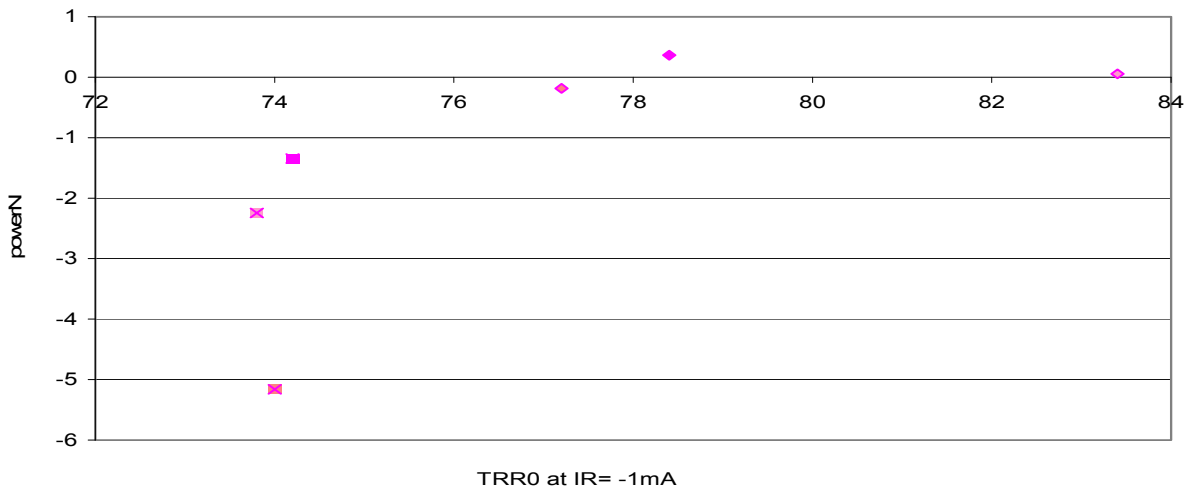
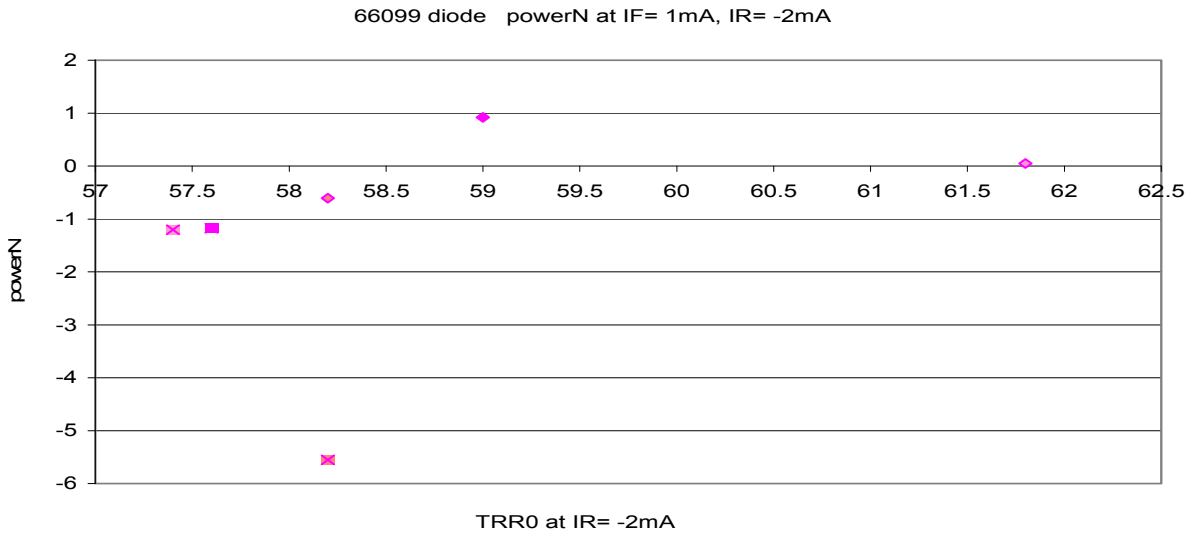
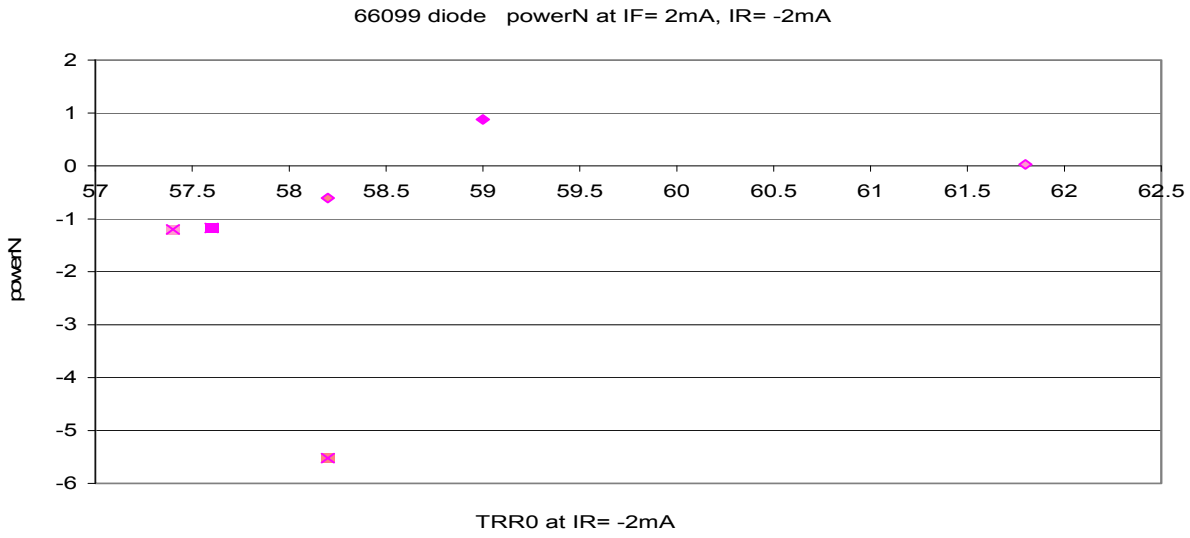
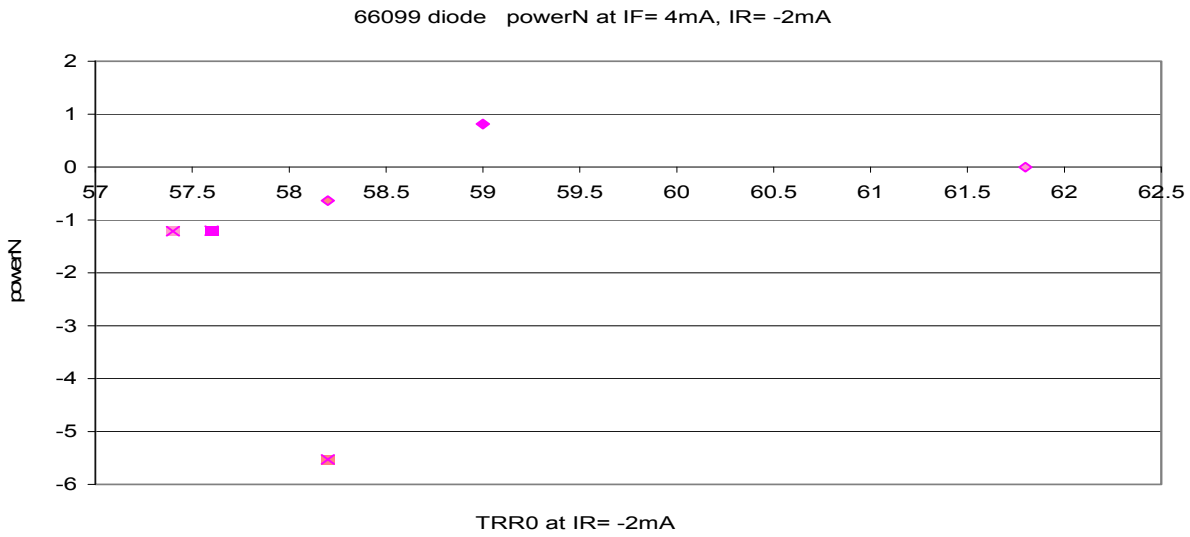
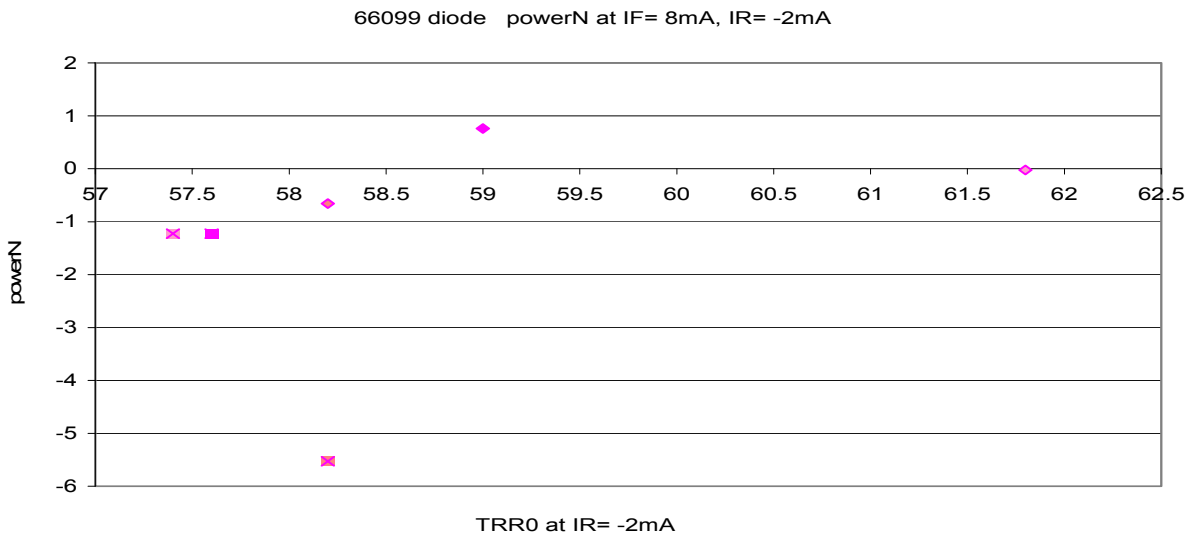

66099 diode powerN at IF= 10mA, IR= -1mA
powerN
1
0
-1
-2
-3
-4
-5
-6
72
74
76
78
80
82
84
TRR0 at IR= -1mA

Fig. 14-217: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA








66099 diode powerN at IF= 8mA, IR= -2mA
powerN
2
1
0
-1
-2
-3
-4
-5
-6
57
57.5
58
58.5
59
59.5
60
60.5
61
61.5
62
62.5
TRR0 at IR= -2mA

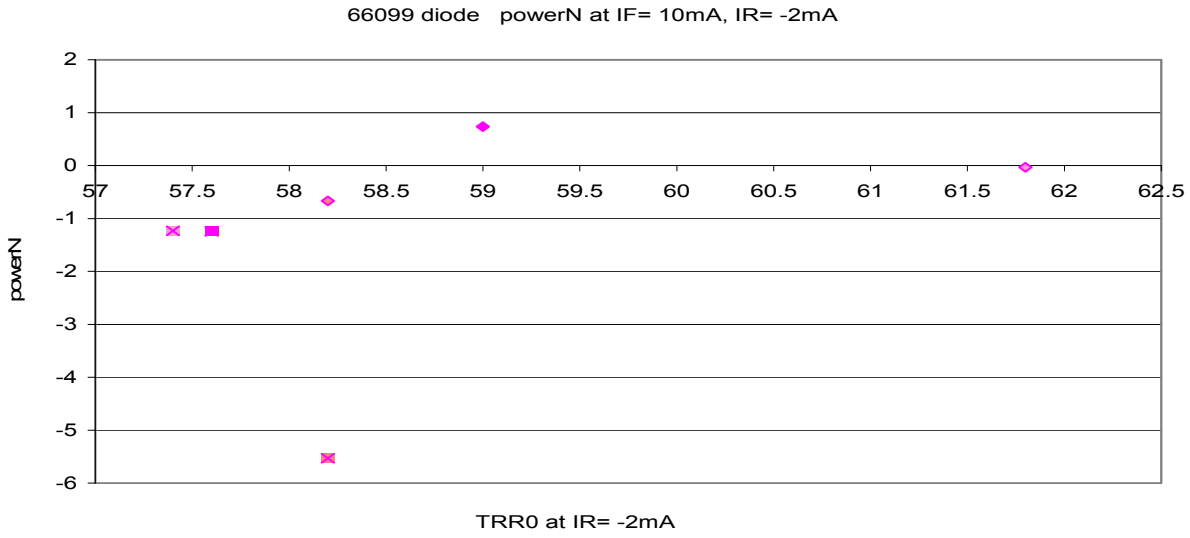
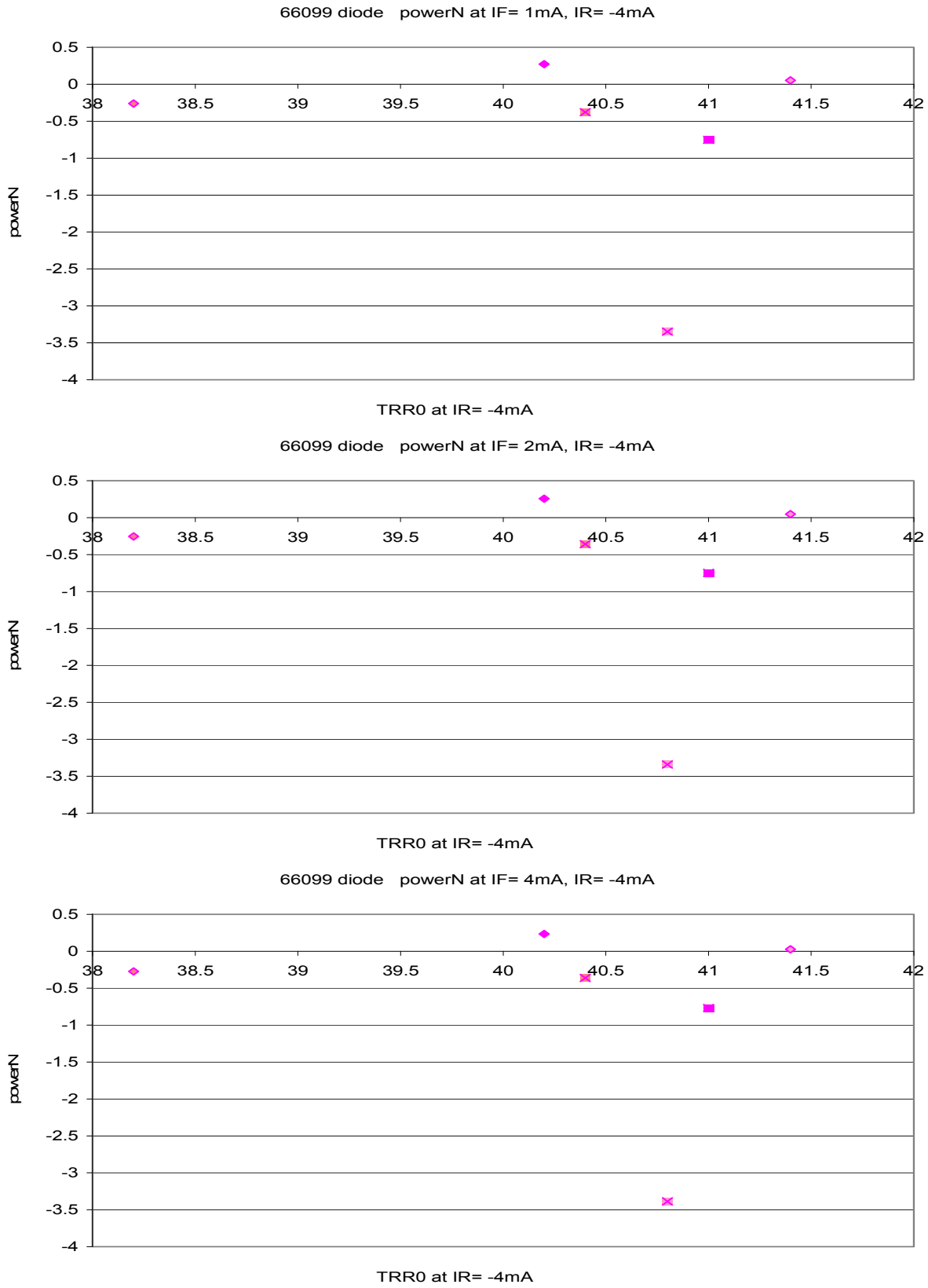
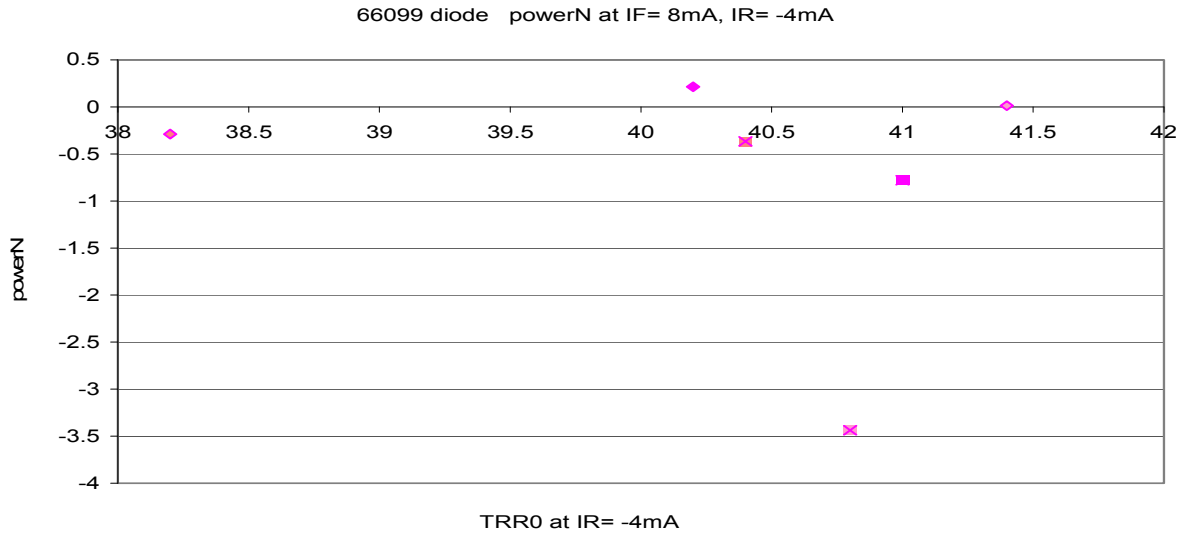
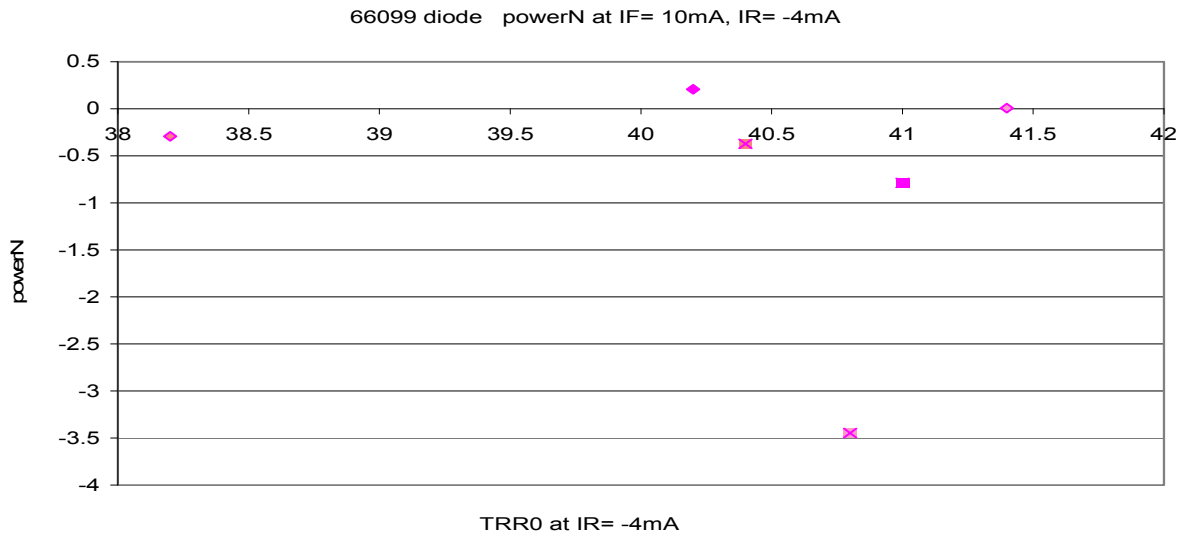

66099 diode powerN at IF= 10mA, IR= -2mA
powerN
2
1
0
-1
-2
-3
-4
-5
-6
57
57.5
58
58.5
59
59.5
60
60.5
61
61.5
62
62.5
TRR0 at IR= -2mA

Fig. 14-218: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA

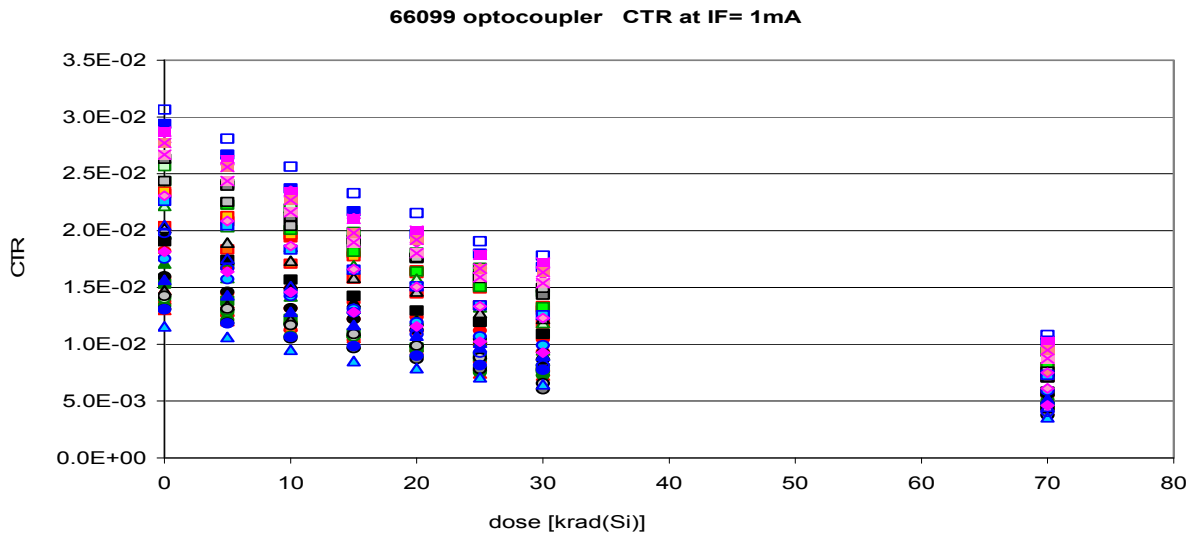


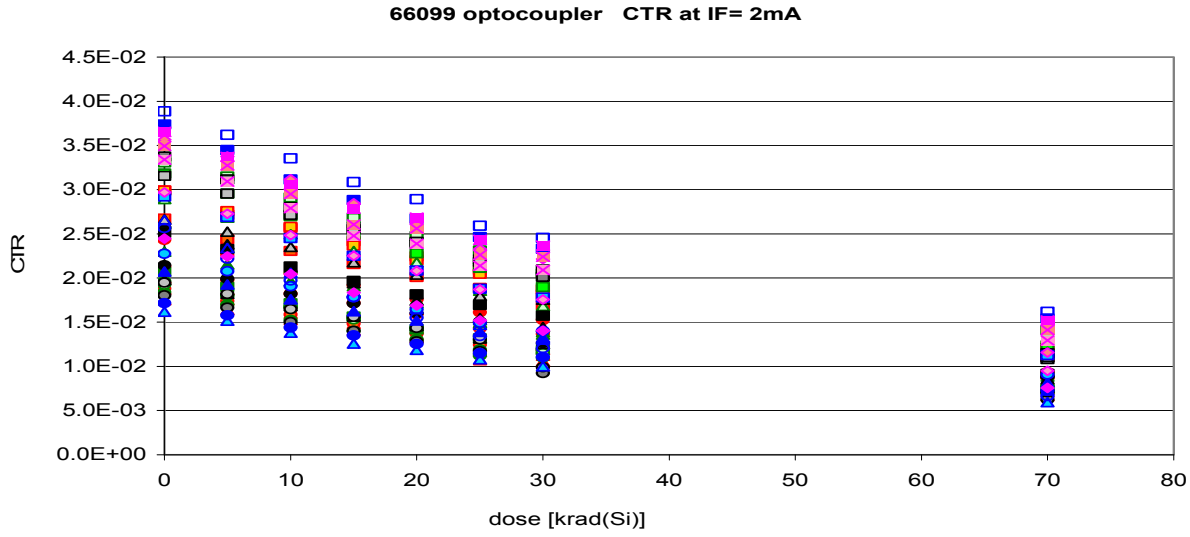

66099 diode powerN at IF= 8mA, IR= -4mA
powerN
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA

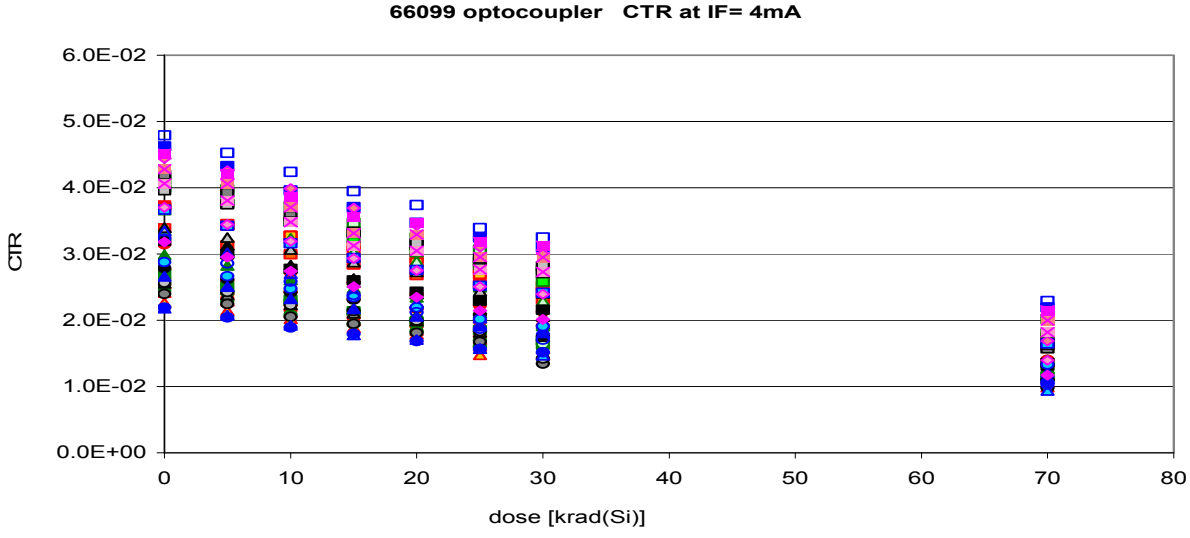

66099 diode powerN at IF= 10mA, IR= -4mA
powerN
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
38
38.5
39
39.5
40
40.5
41
41.5
42
TRR0 at IR= -4mA

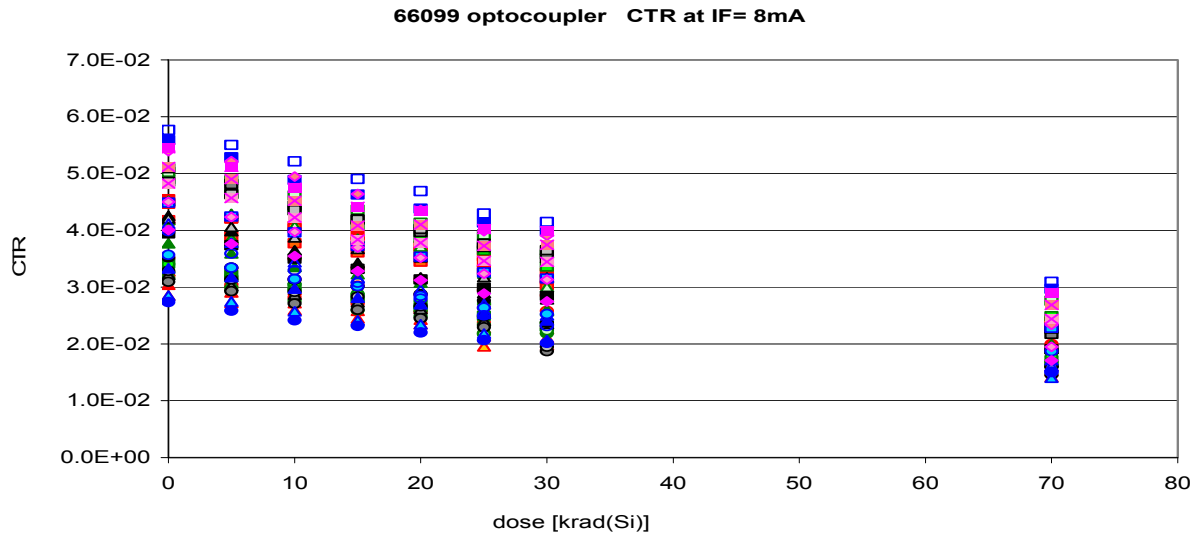
14.4 GAMMA IRRADIATION AFTER NEUTRON AND PROTON IRRADIATION

Fig. 14-219: 66099 optocoupler: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

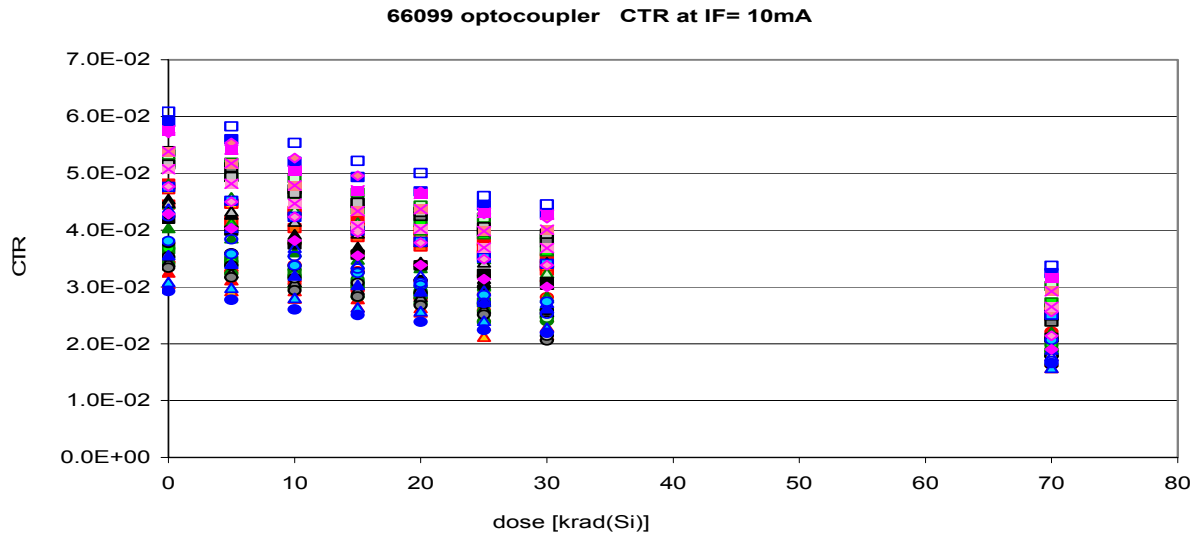
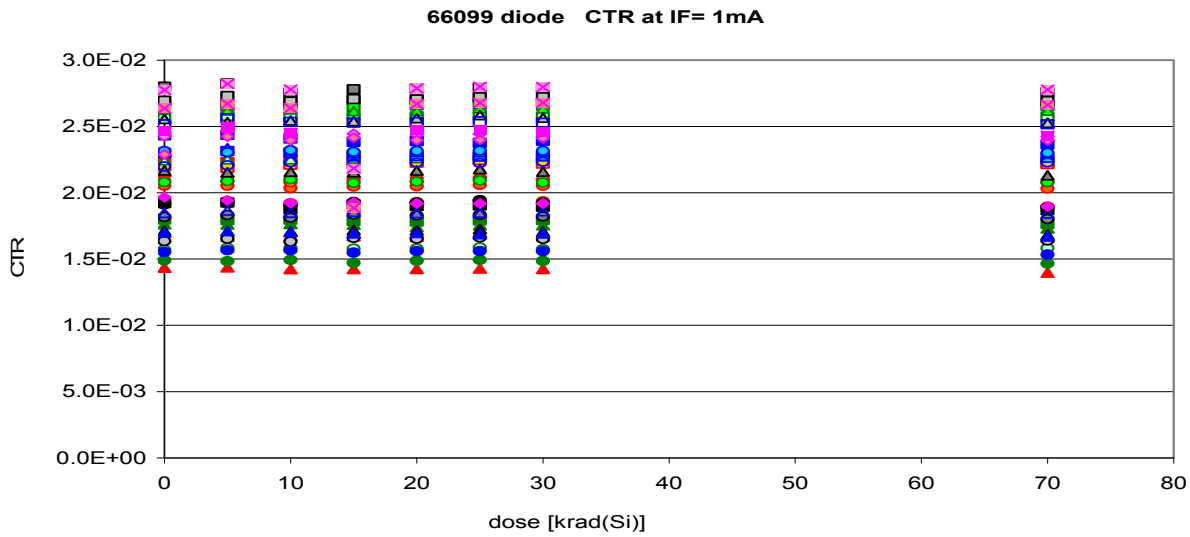
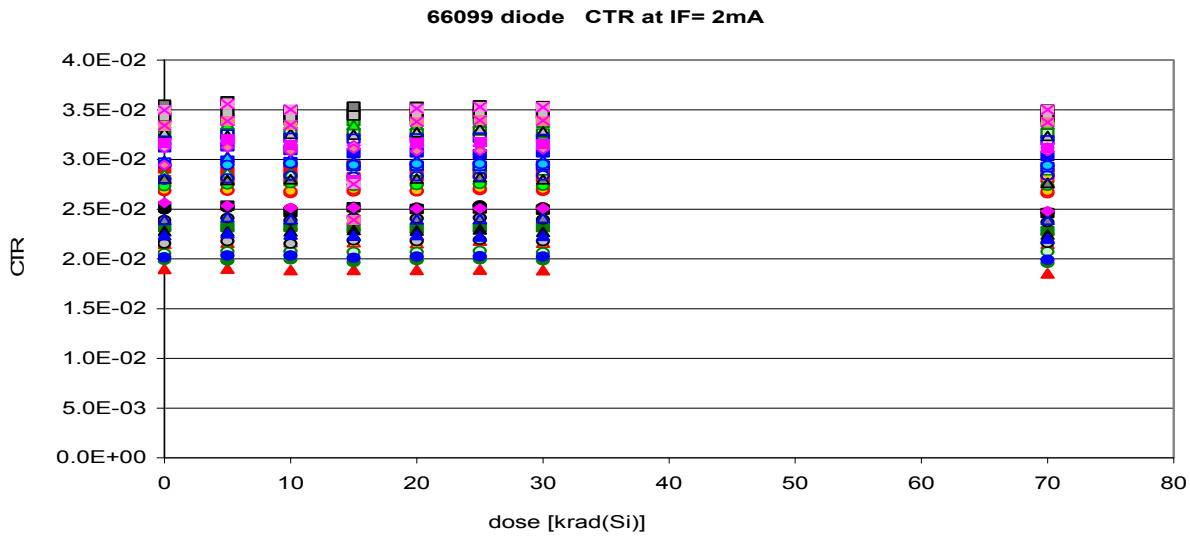
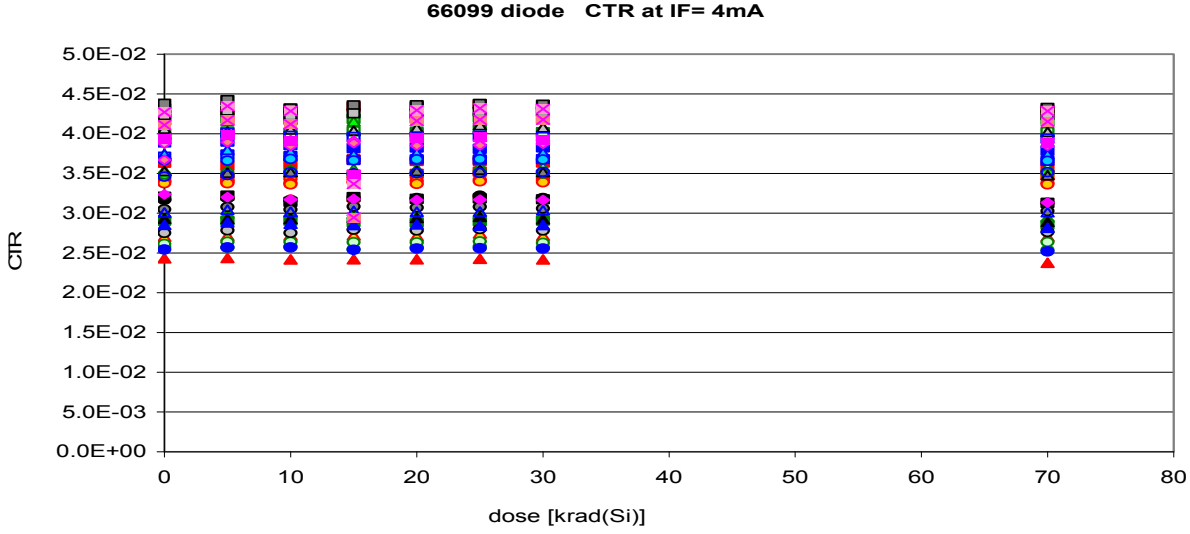
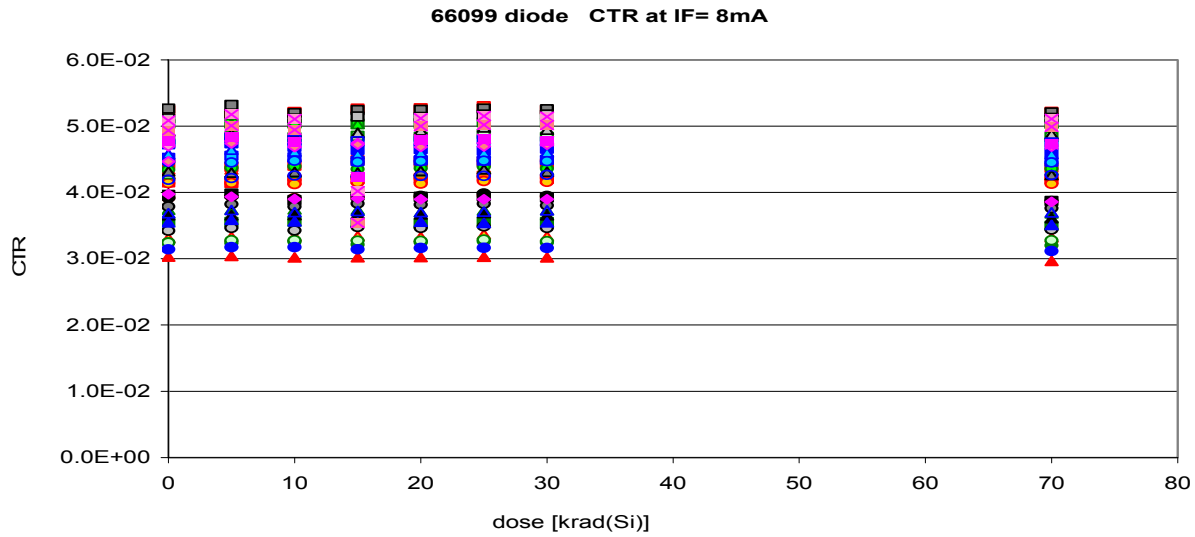

66099 optocoupler CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-220: 66099 diode: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 diode CTR at IF= 8mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

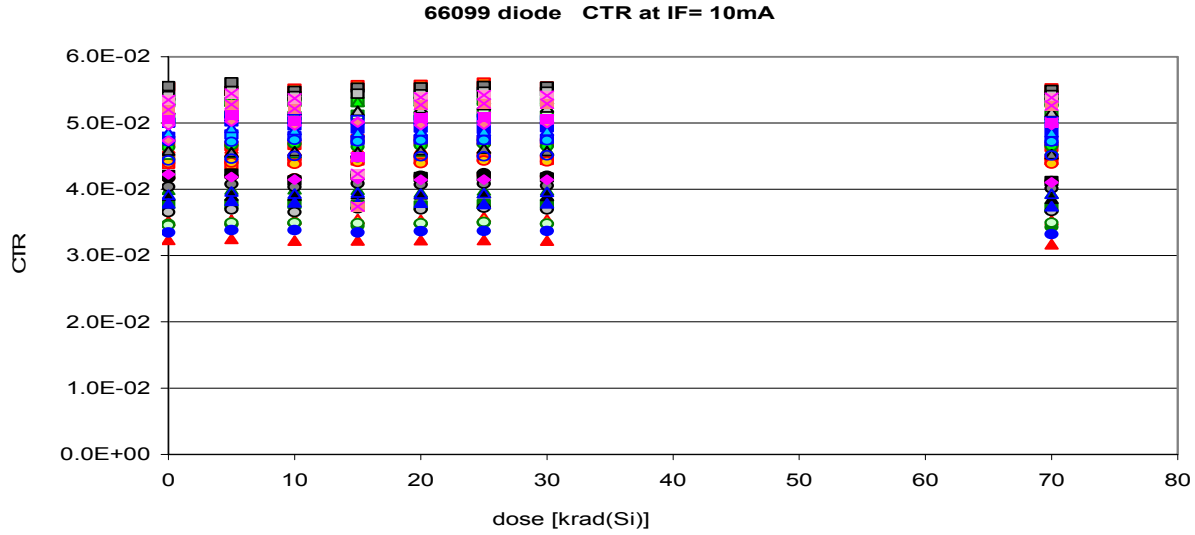
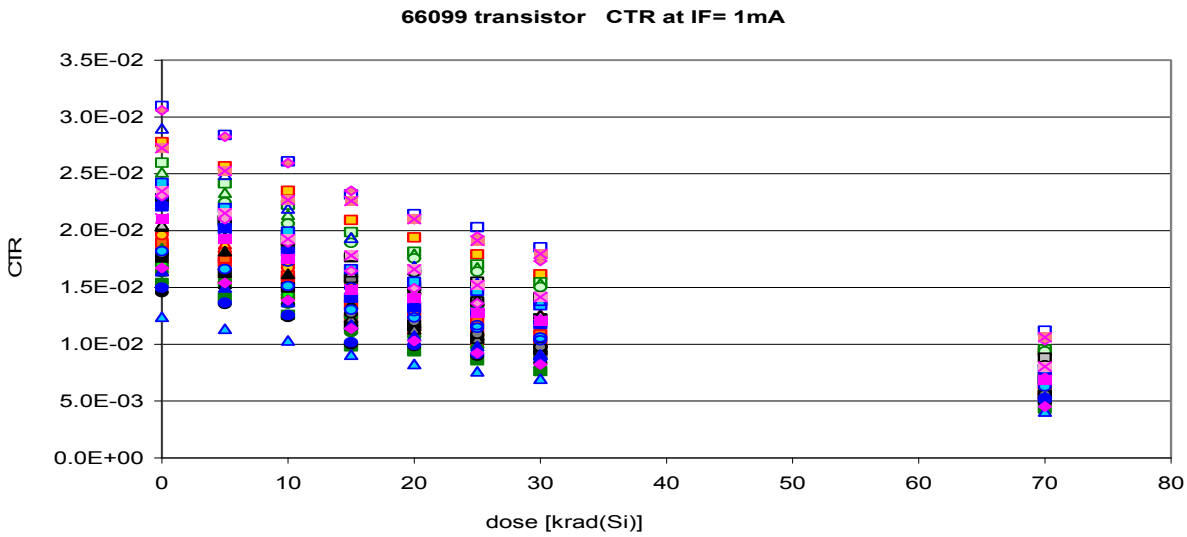
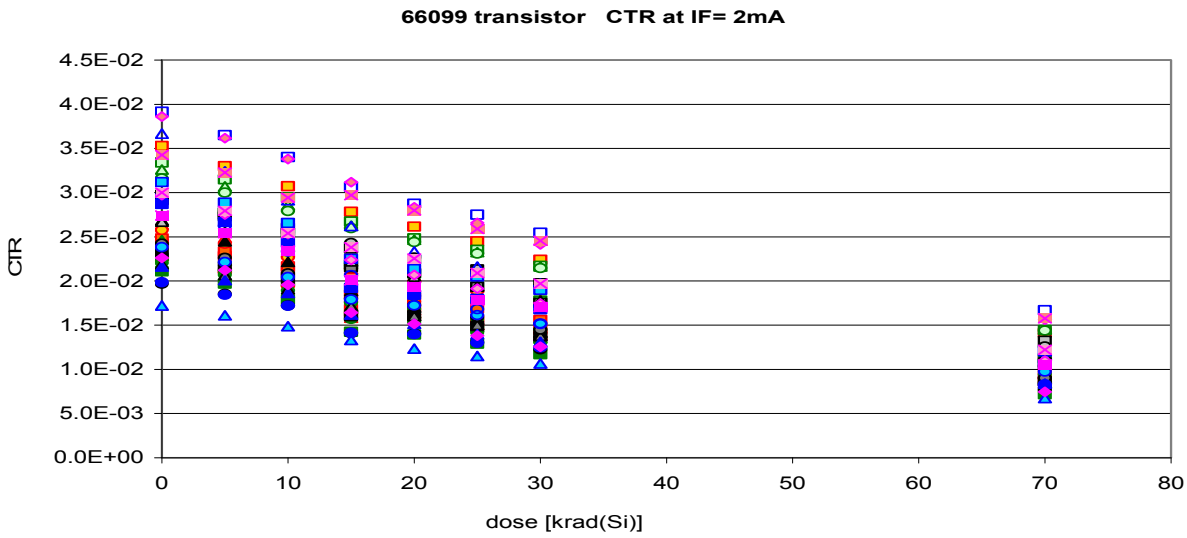
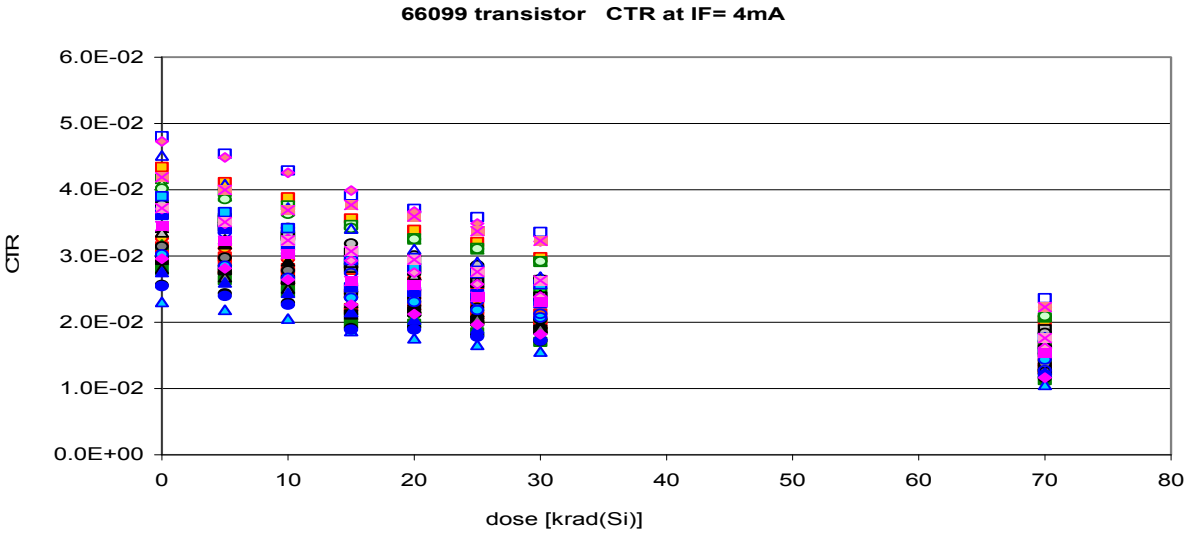
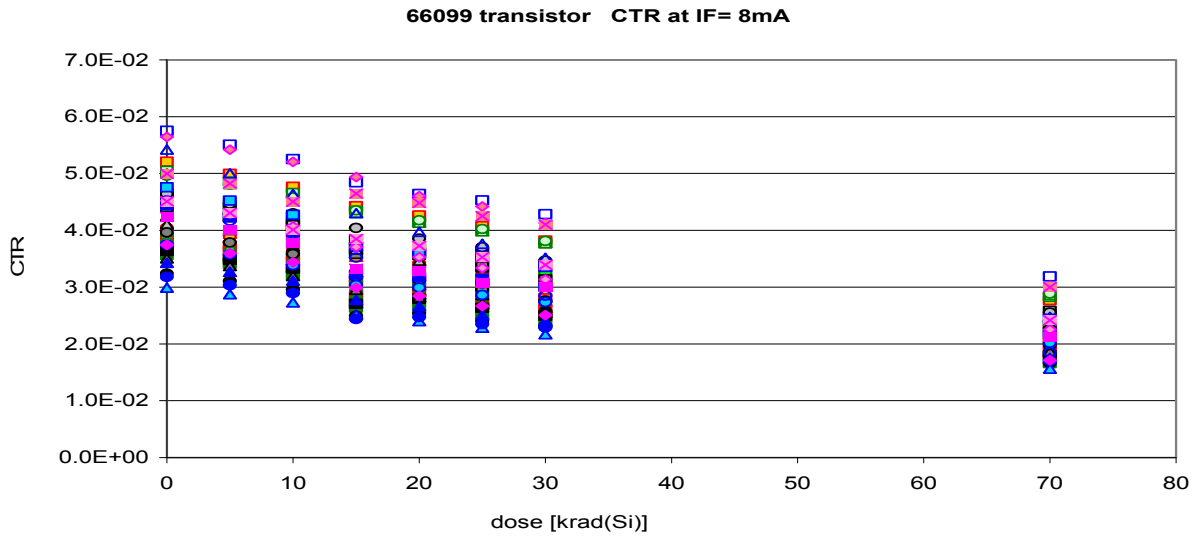

66099 diode CTR at IF= 10mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-221: 66099 transistor: CTR at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 transistor CTR at IF= 8mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

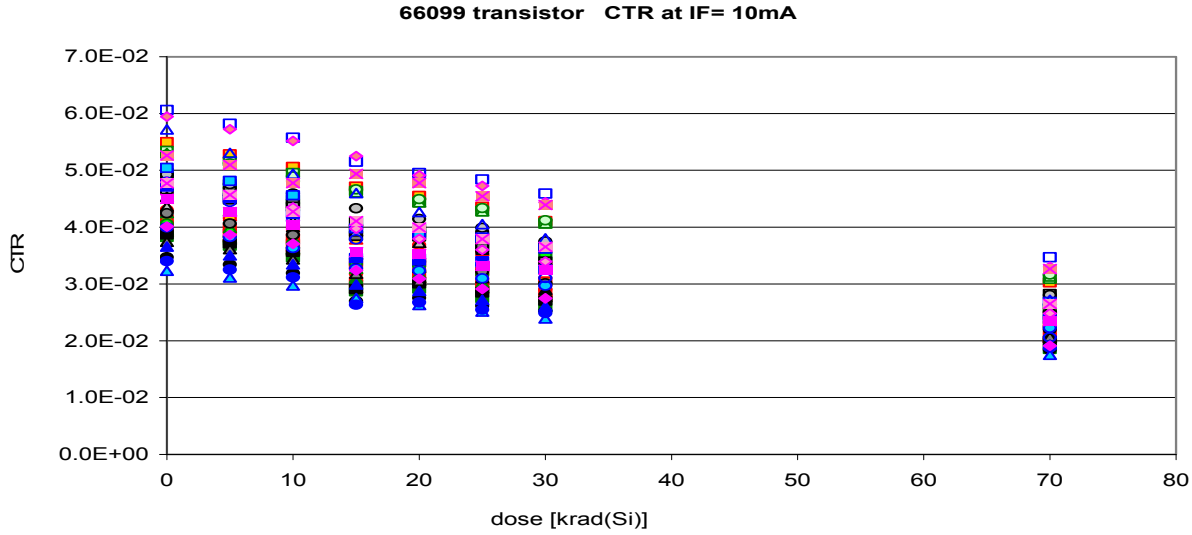
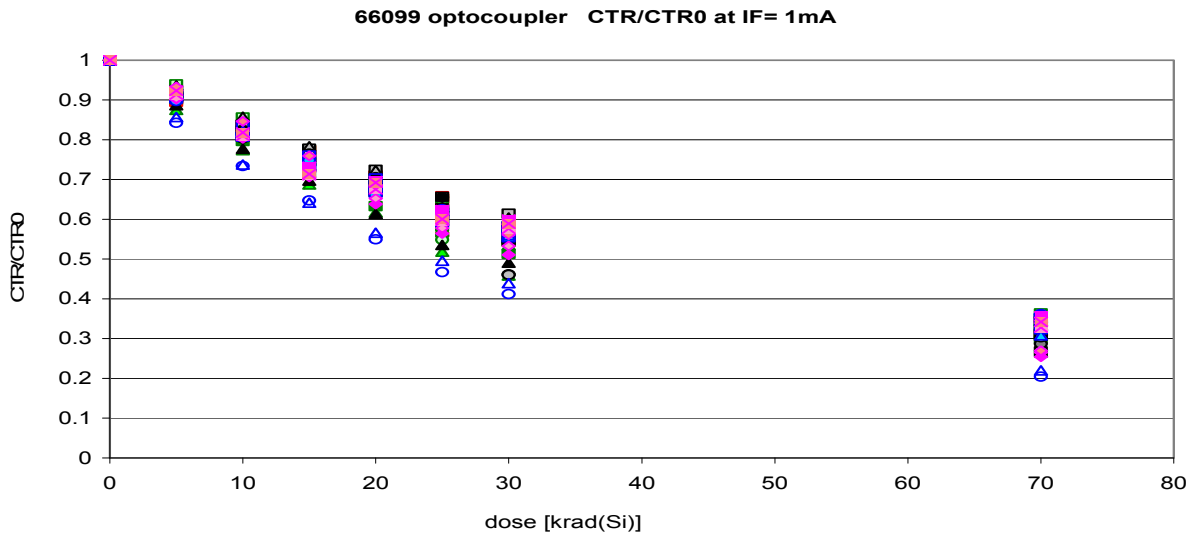
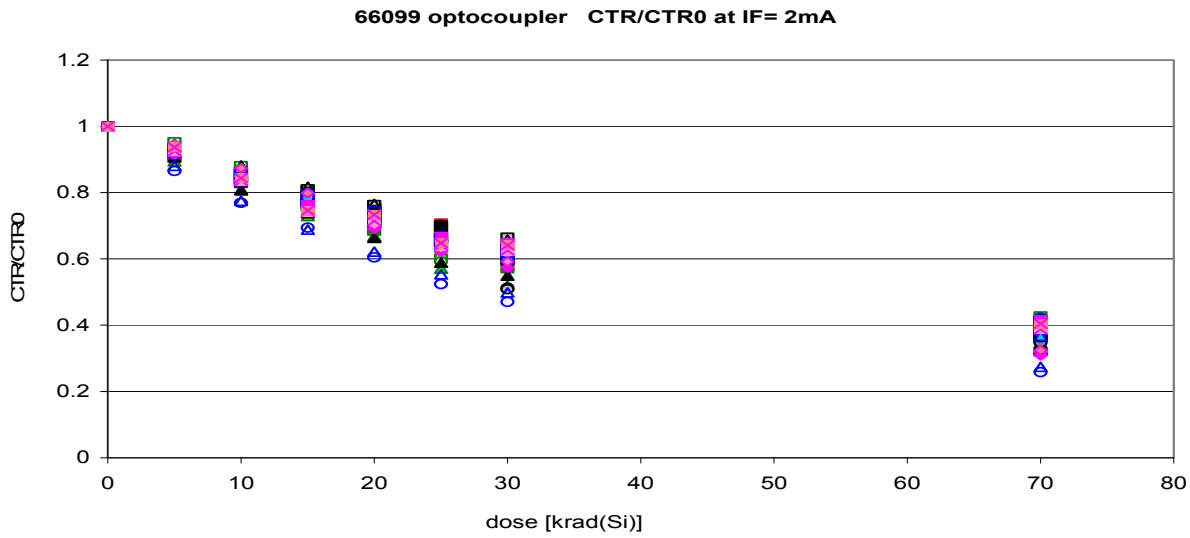
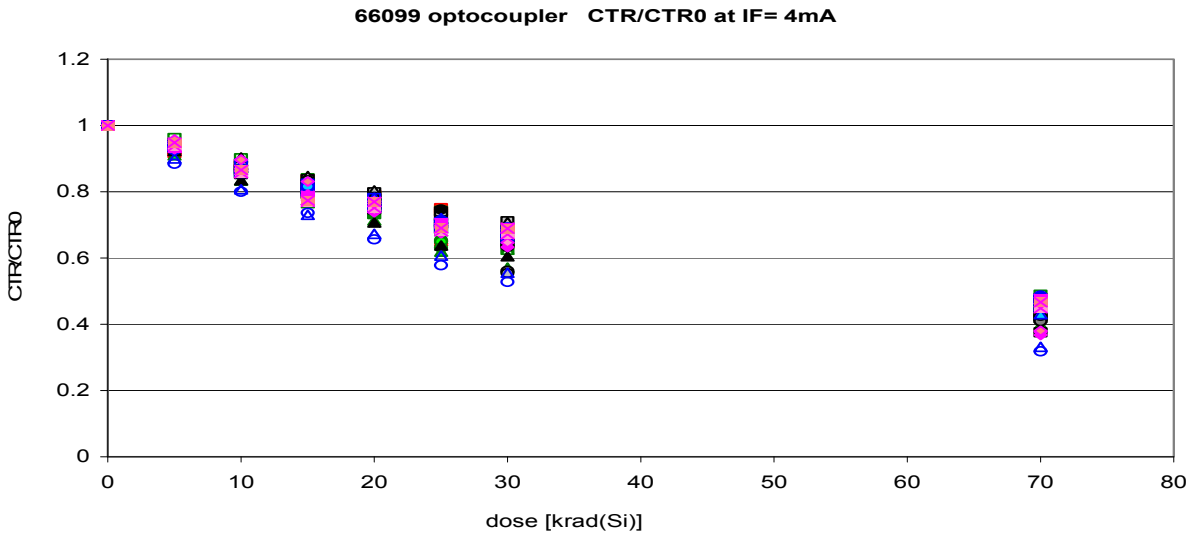
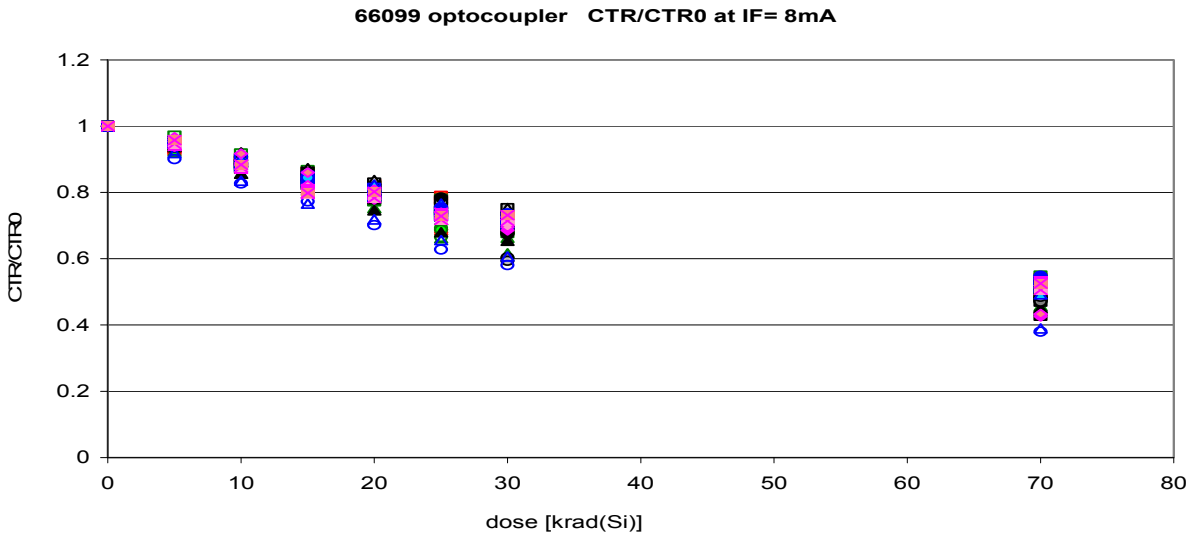

66099 transistor CTR at IF= 10mA
CTR
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-222: 66099 optocoupler: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

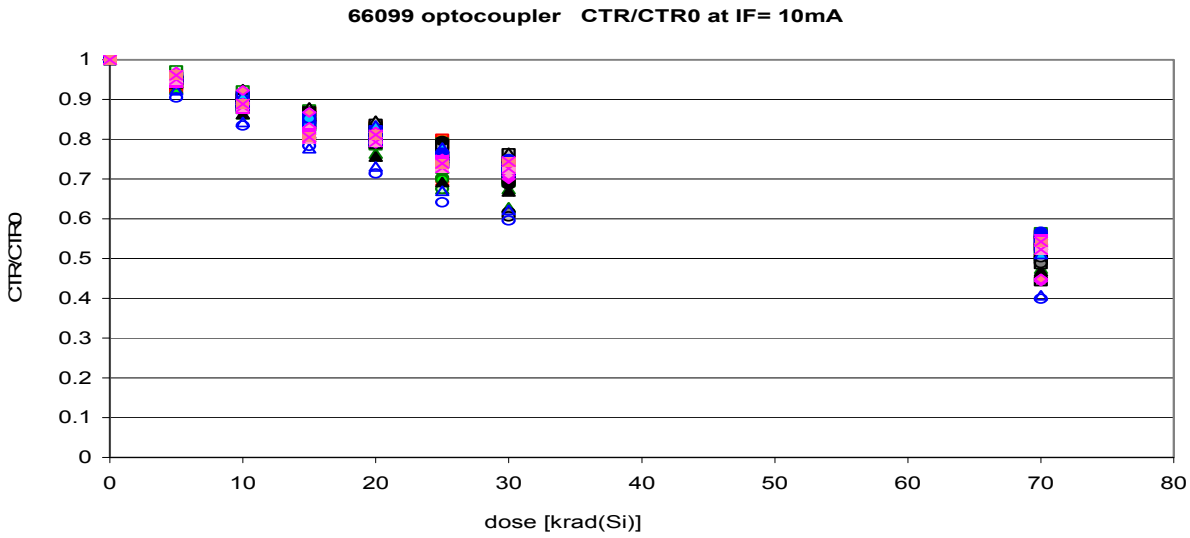
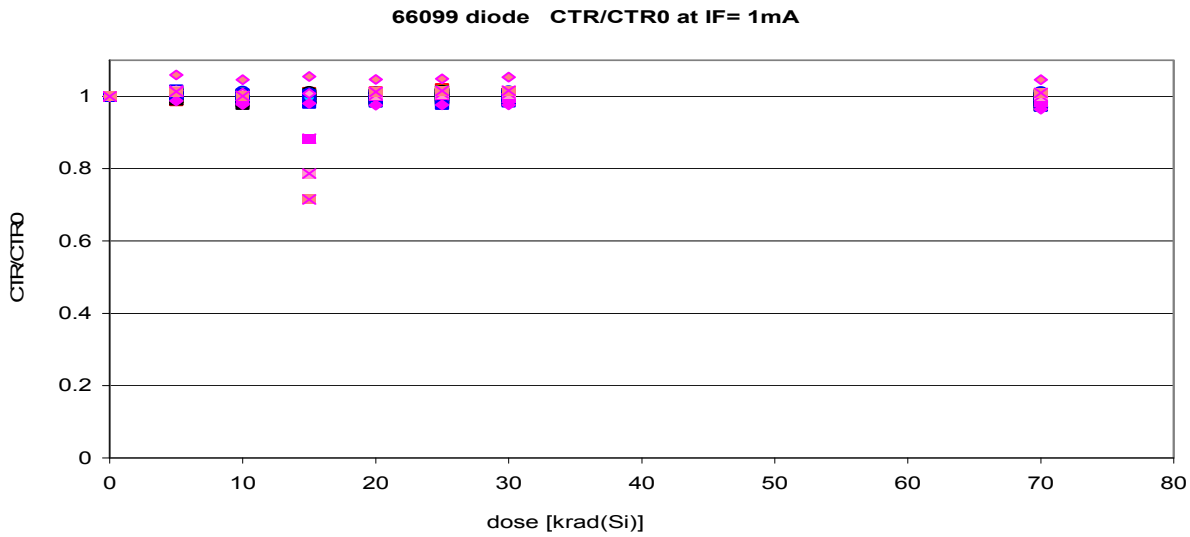
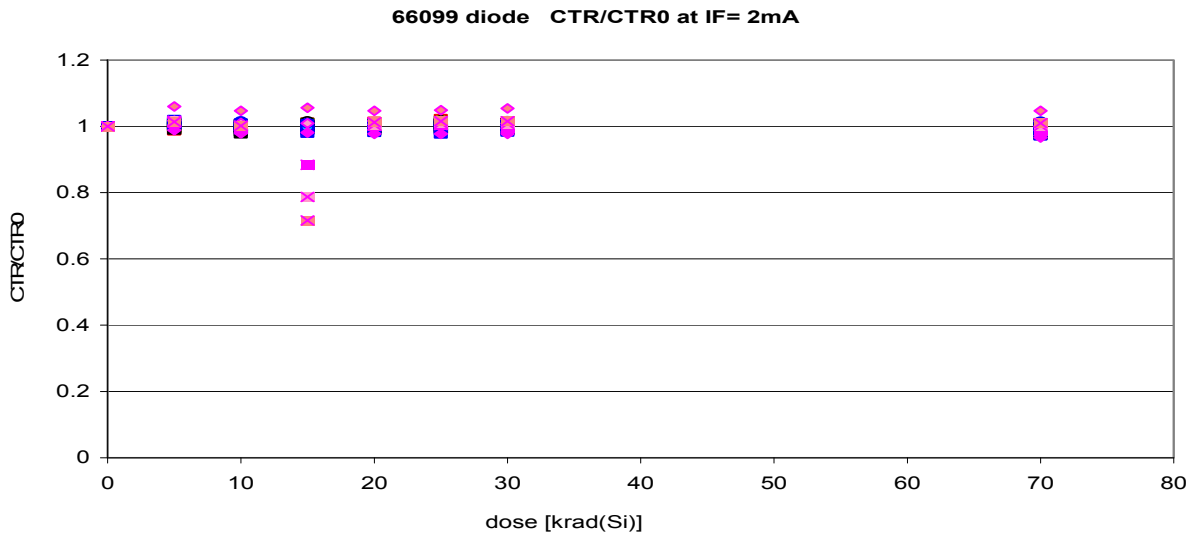
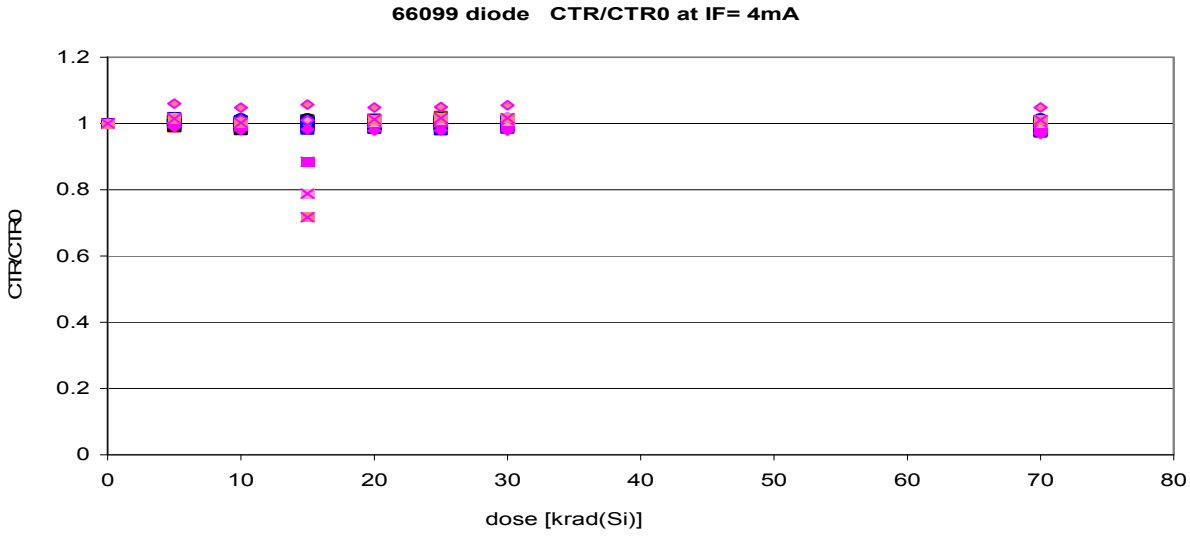
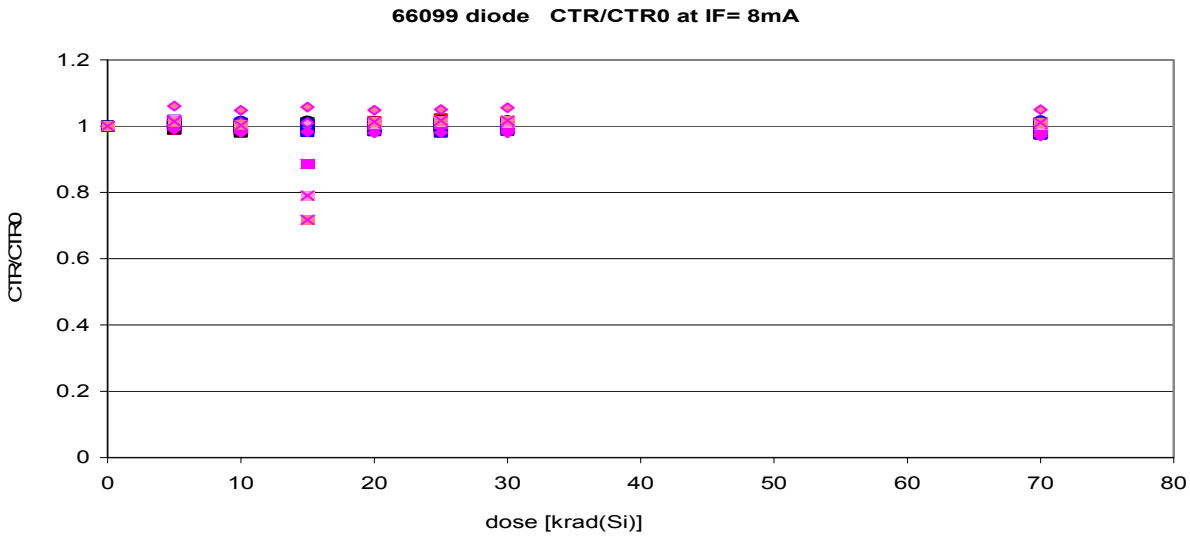

66099 optocoupler CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-223: 66099 diode: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 diode CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

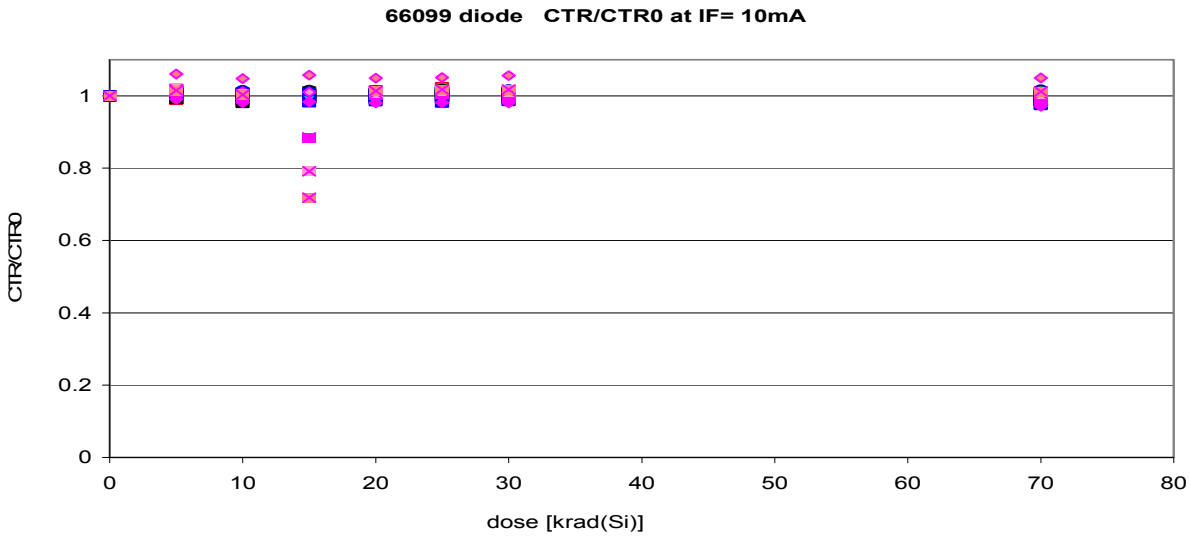
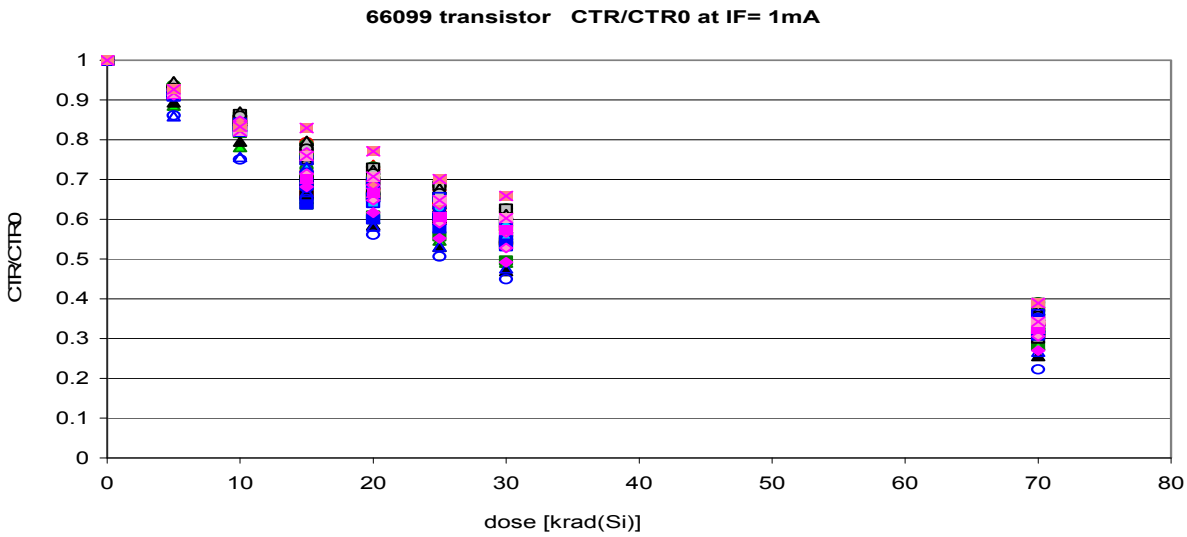
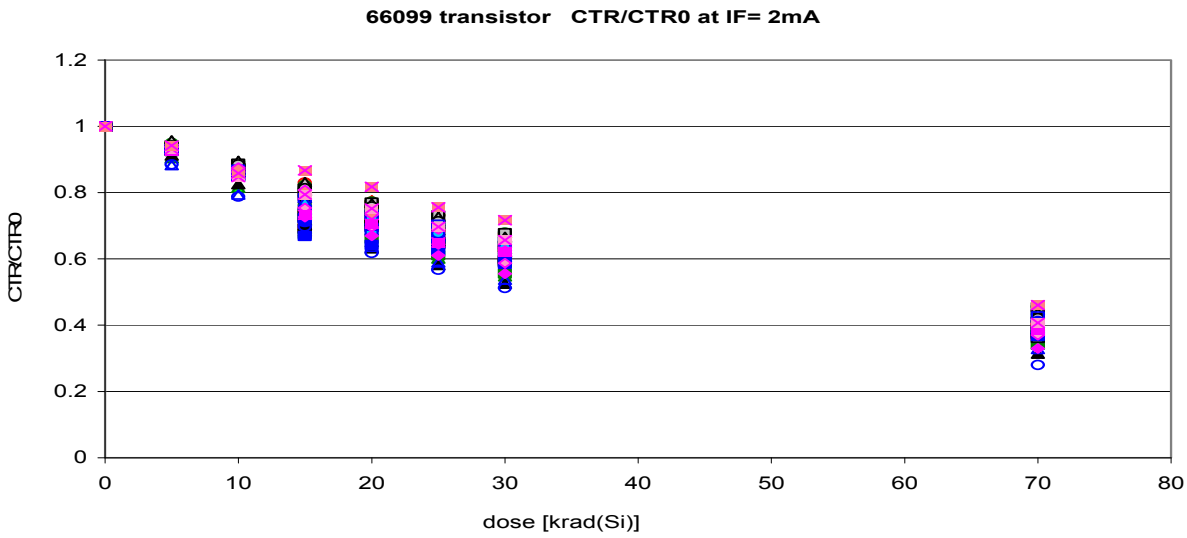
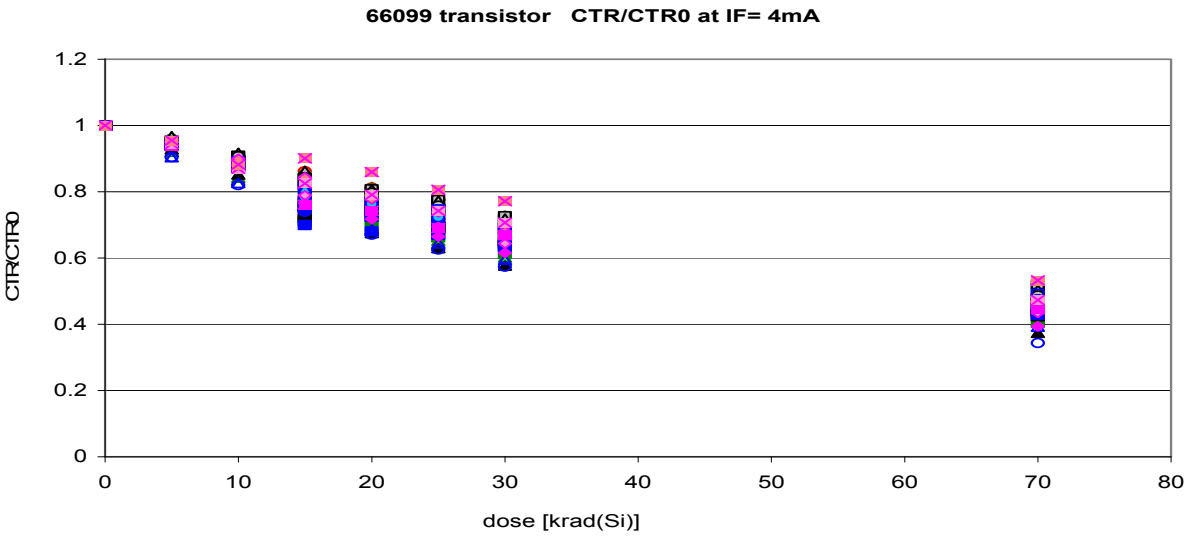
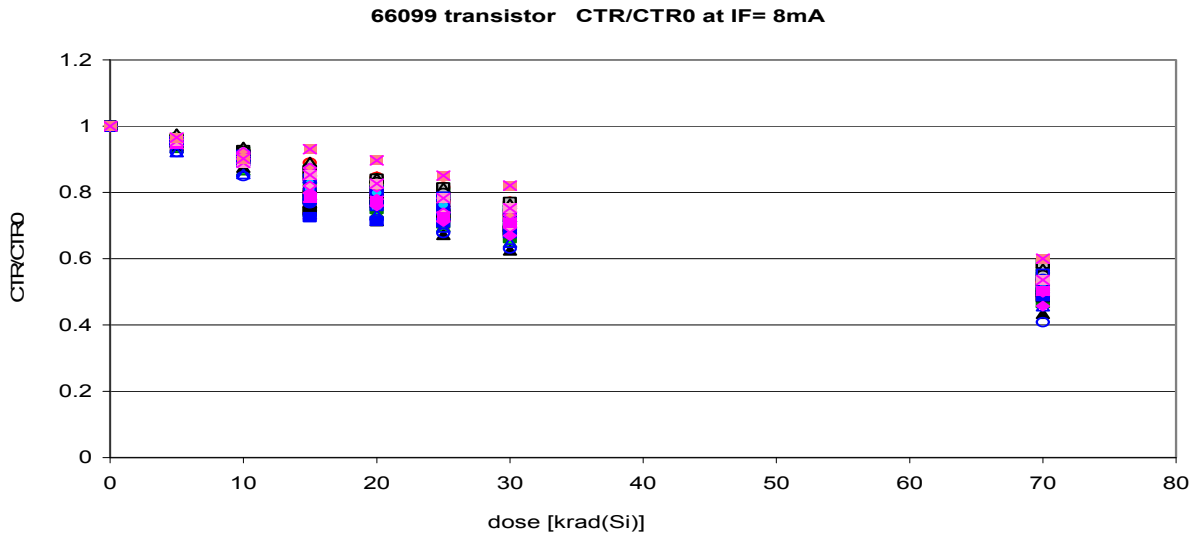

66099 diode CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-224: 66099 transistor: CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 transistor CTR/CTR0 at IF= 8mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

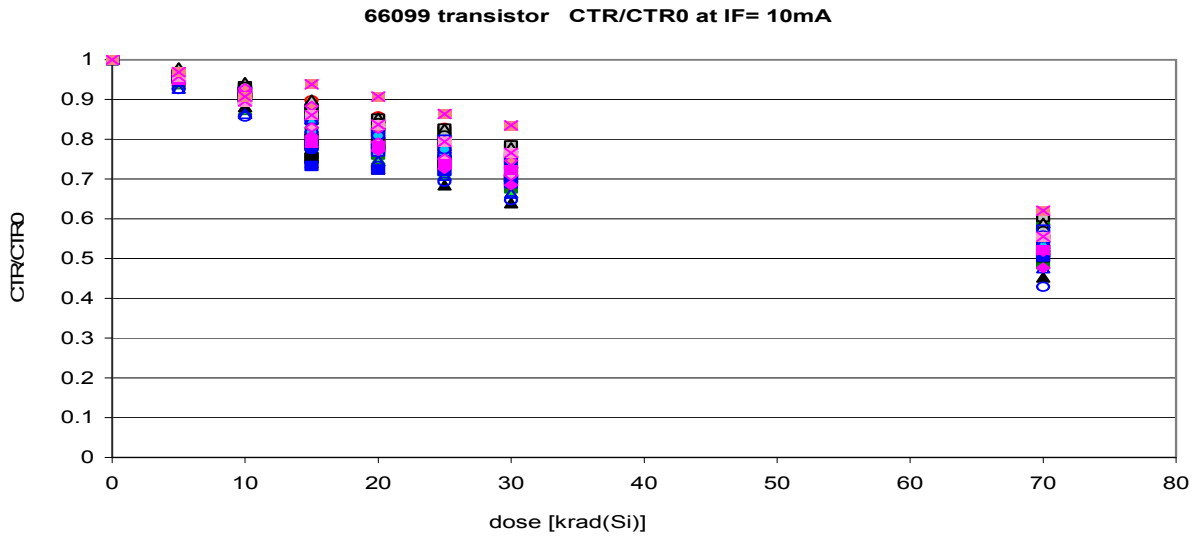
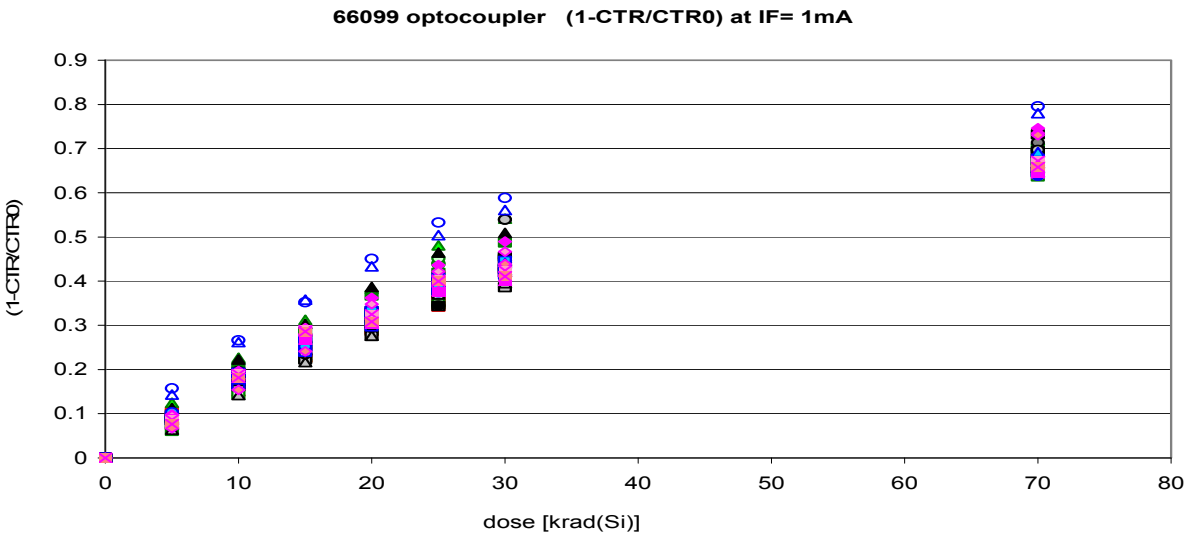
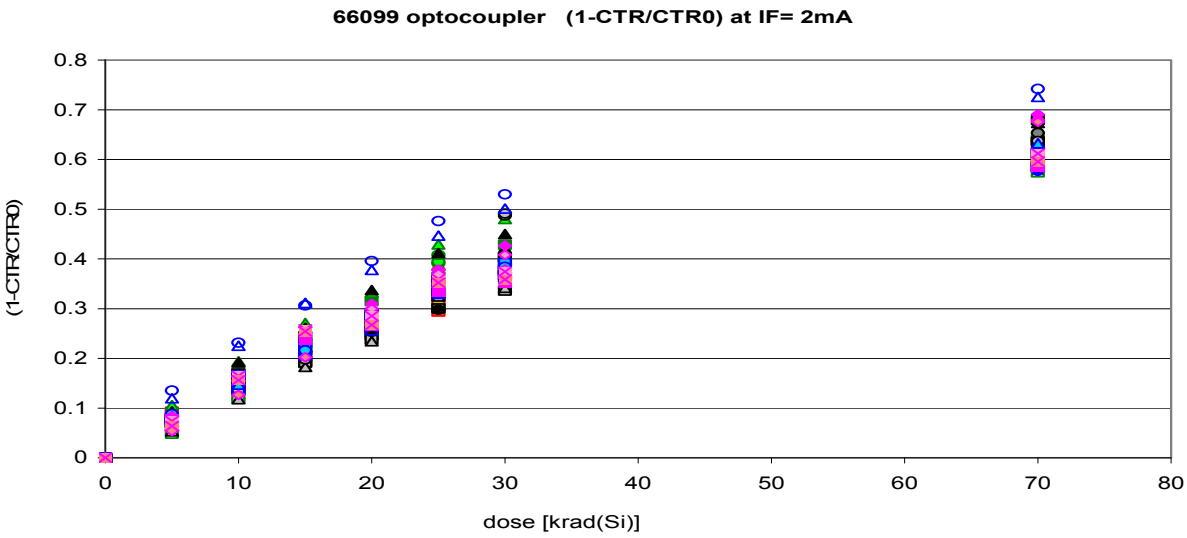
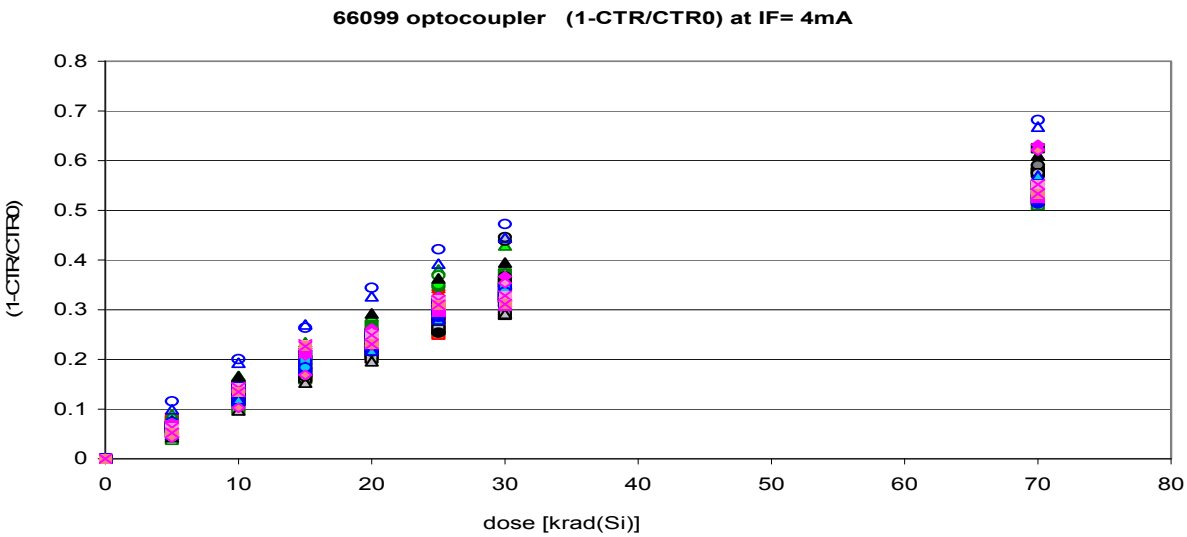
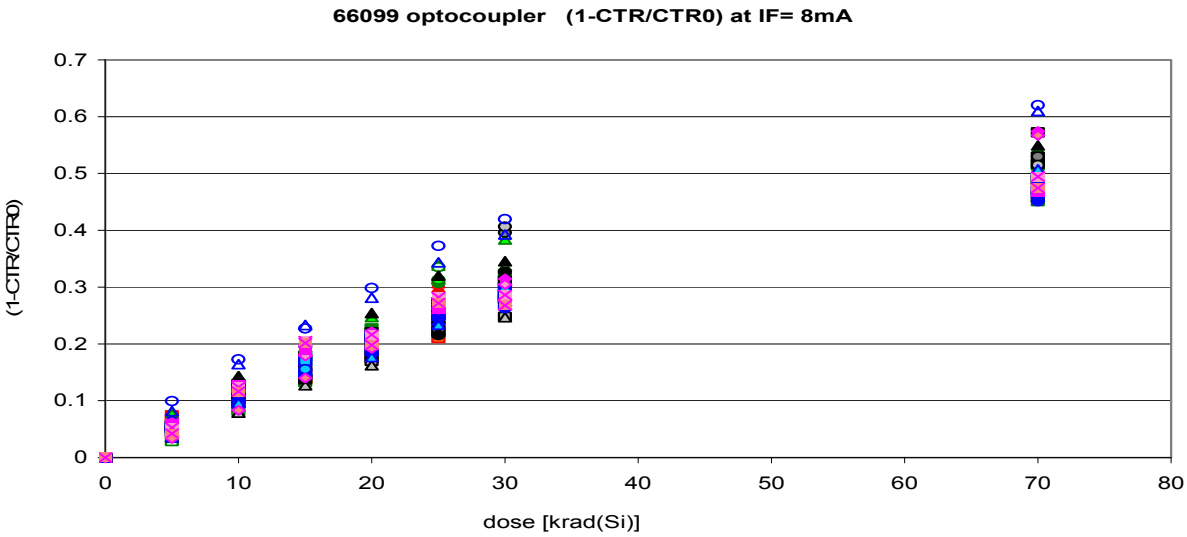

66099 transistor CTR/CTR0 at IF= 10mA
CTR/CTR0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-225: 66099 optocoupler: 1 - CTR/CTR$_0$ at I_F= 1, 2, 4, 8, 10 mA with respect to dose








66099 optocoupler (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

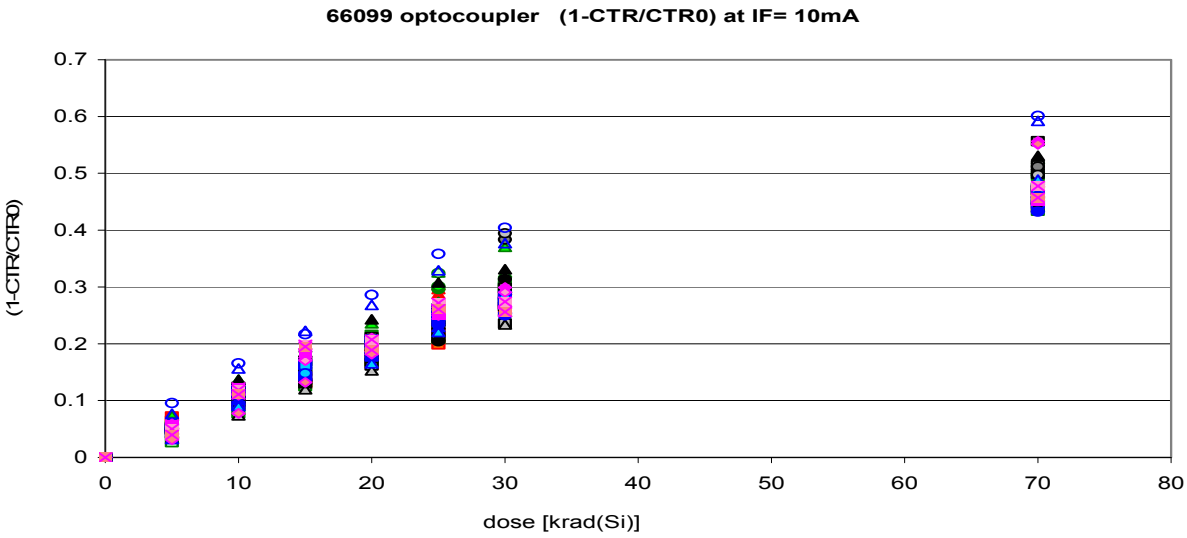
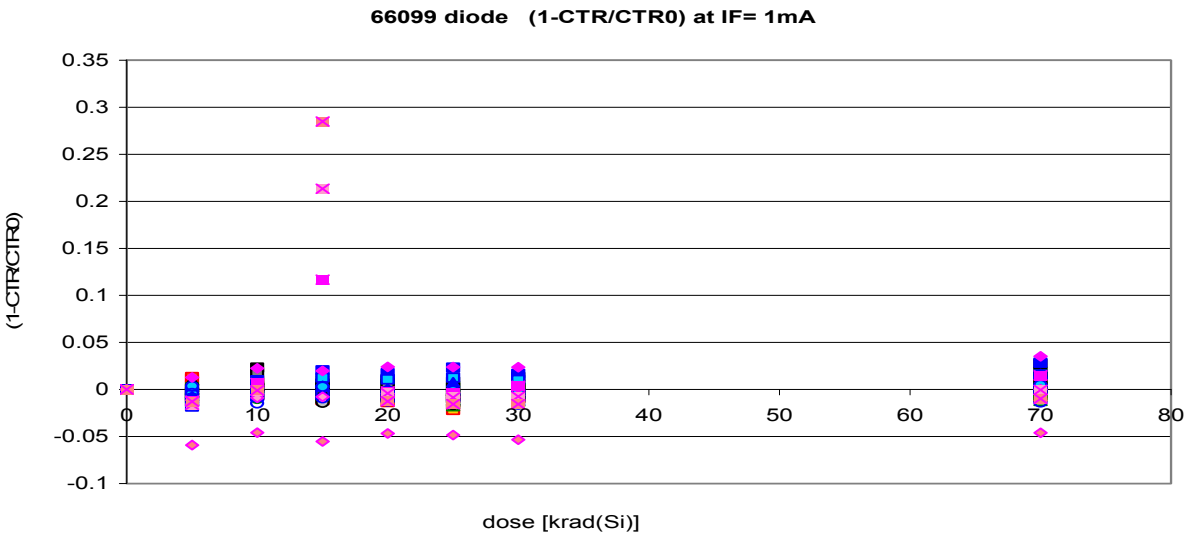
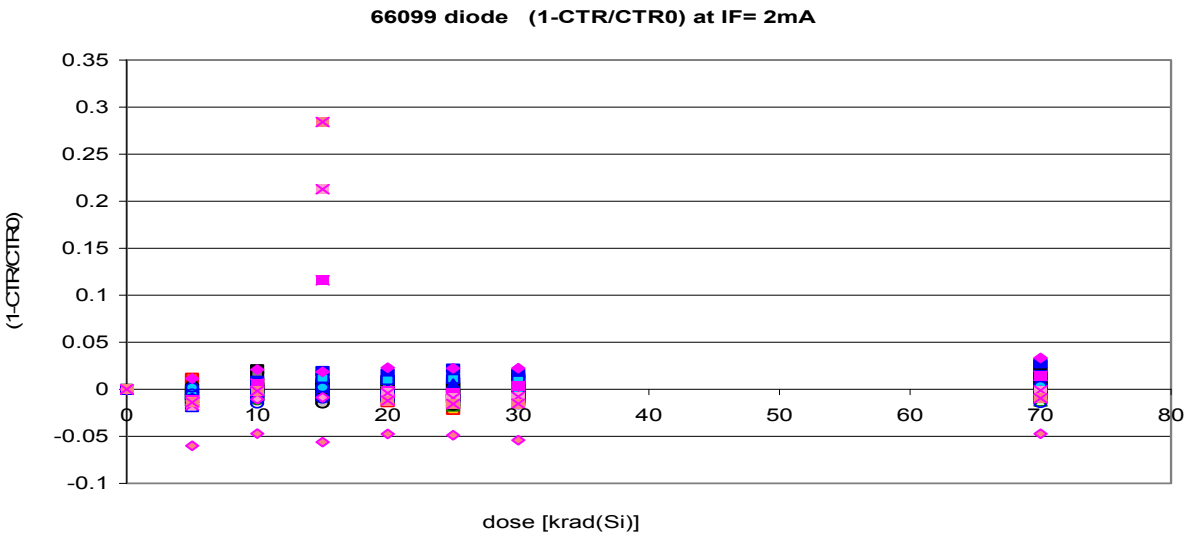
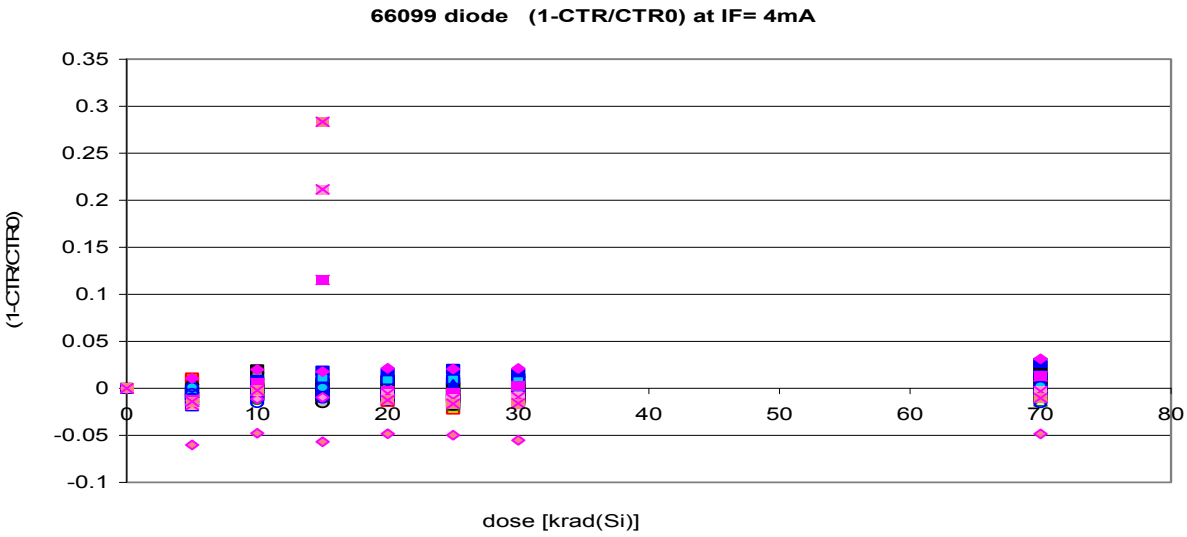
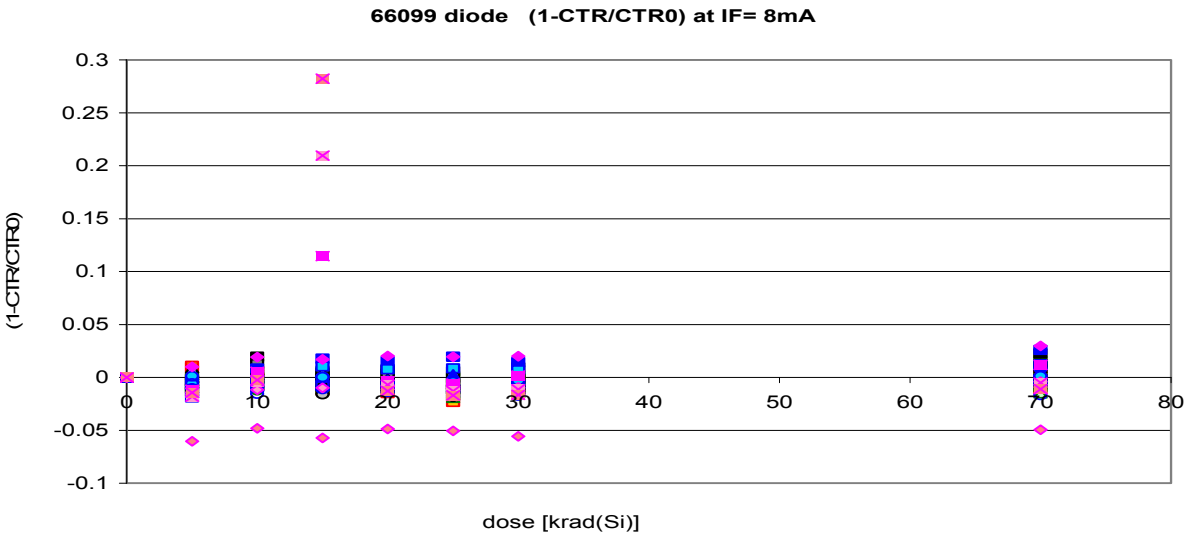

66099 optocoupler (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-226: 66099 diode: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








66099 diode (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

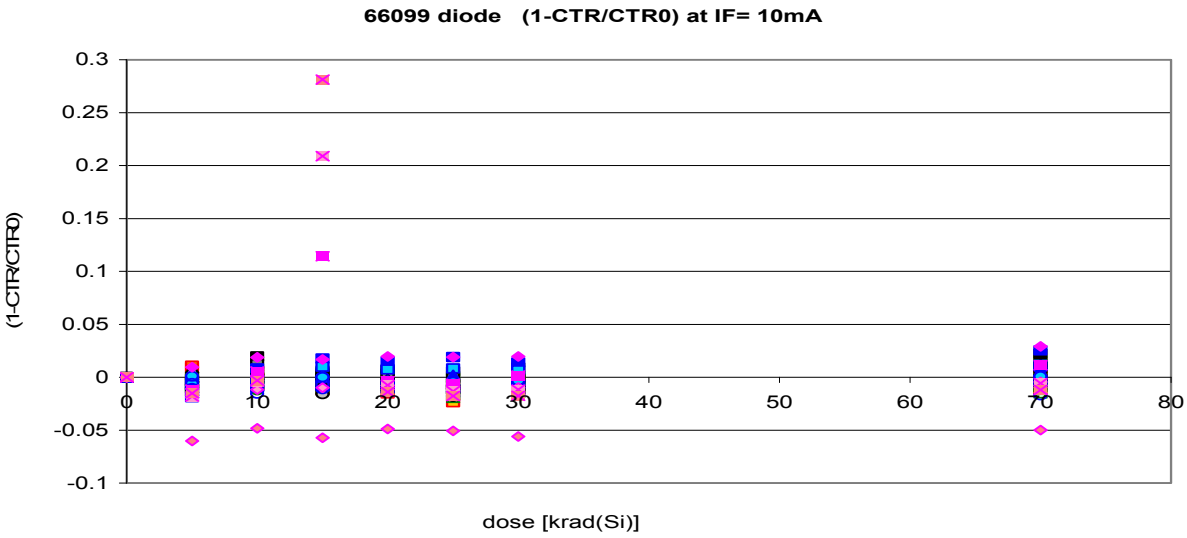
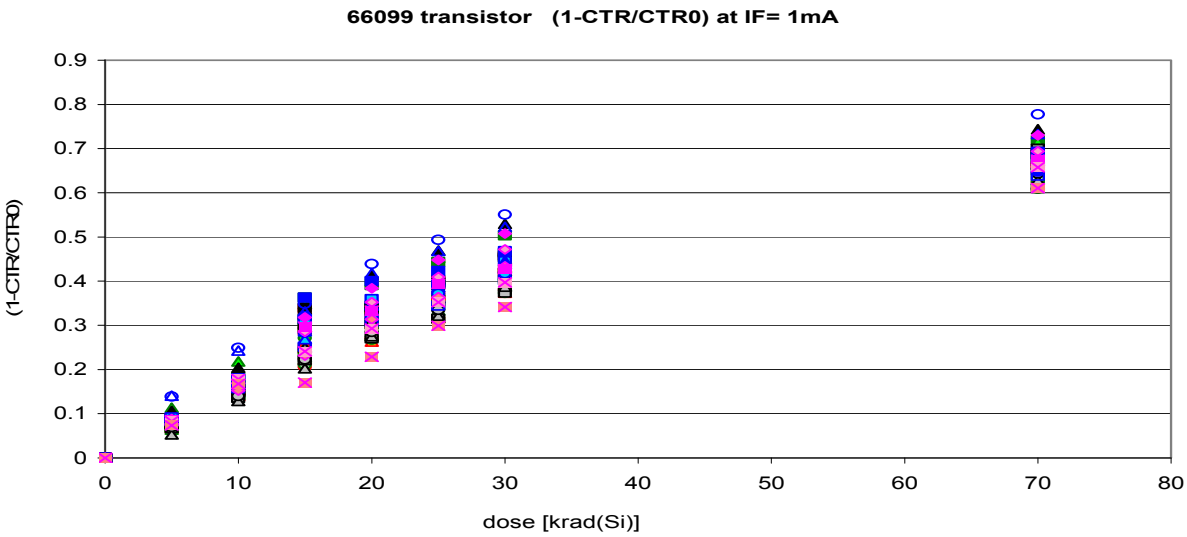
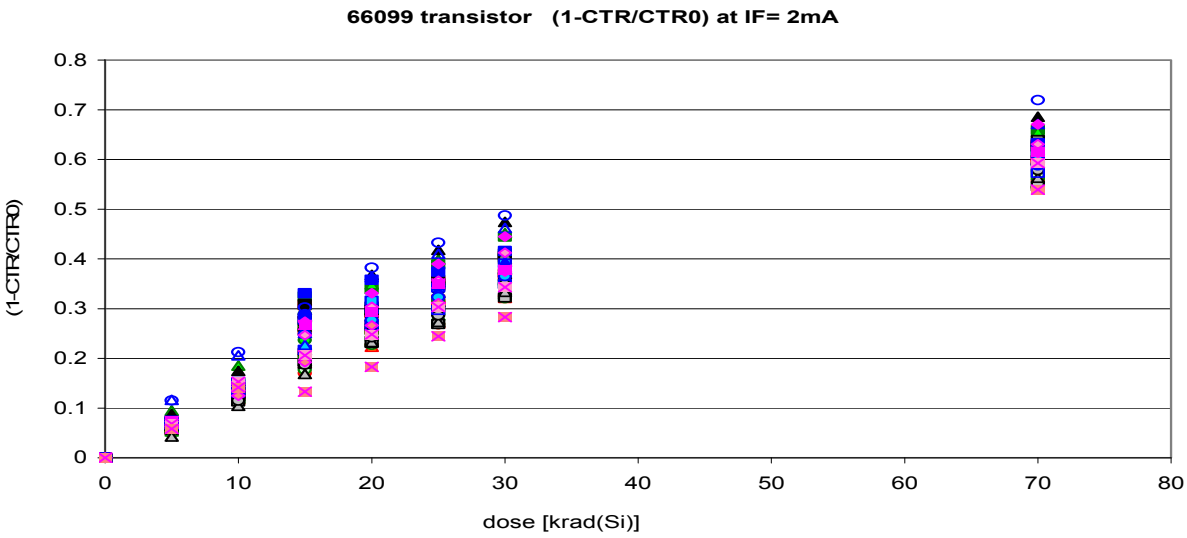
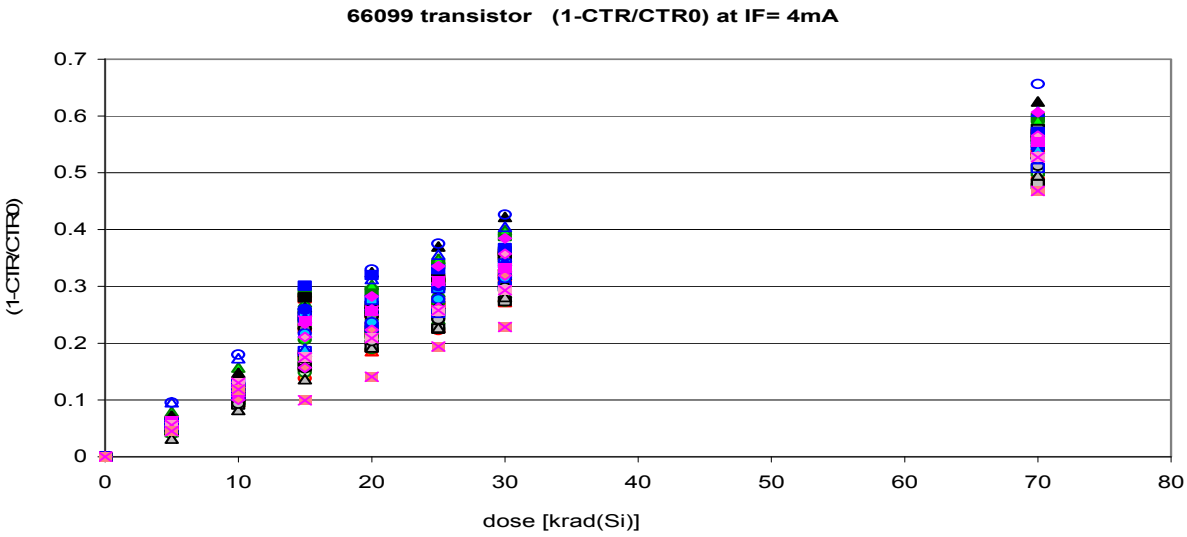
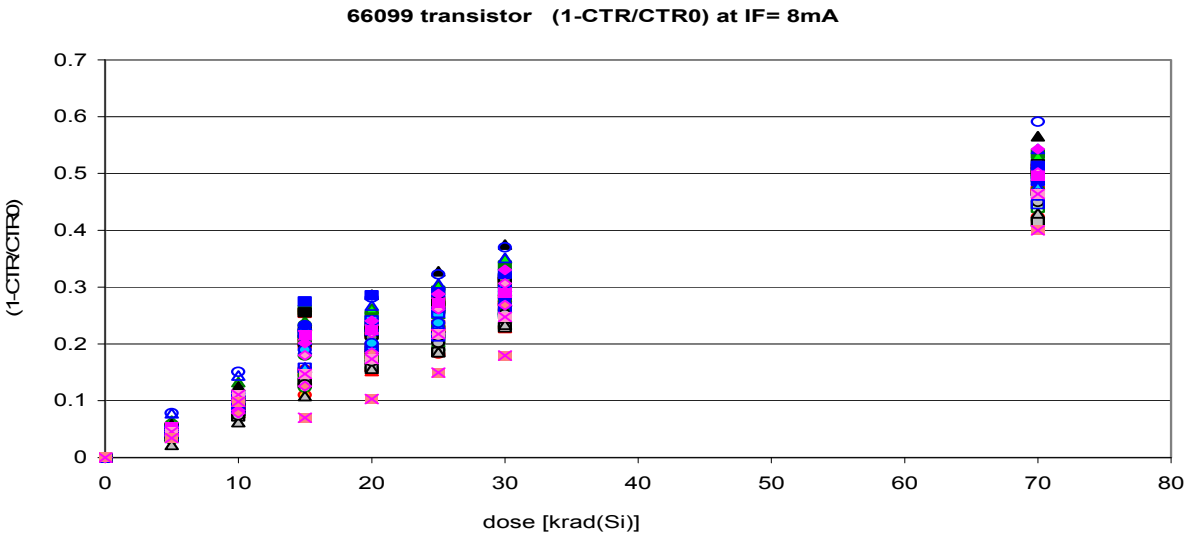

66099 diode (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-227: 66099 transistor: 1 - CTR/CTR$_0$ at I$_F$= 1, 2, 4, 8, 10 mA with respect to dose








66099 transistor (1-CTR/CTR0) at IF= 8mA
(1-CTR/CTR0)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

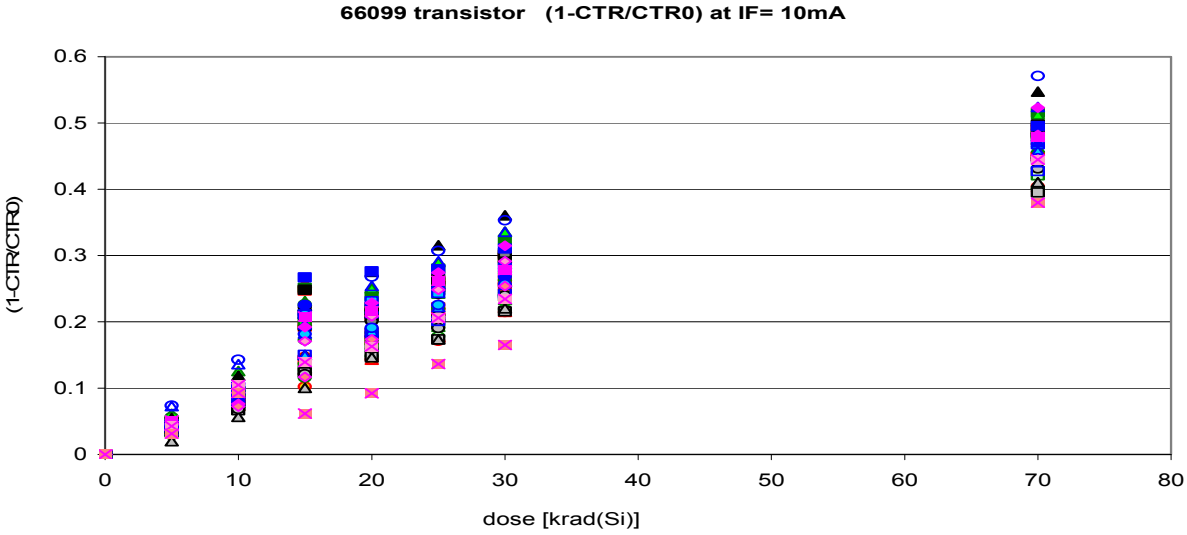
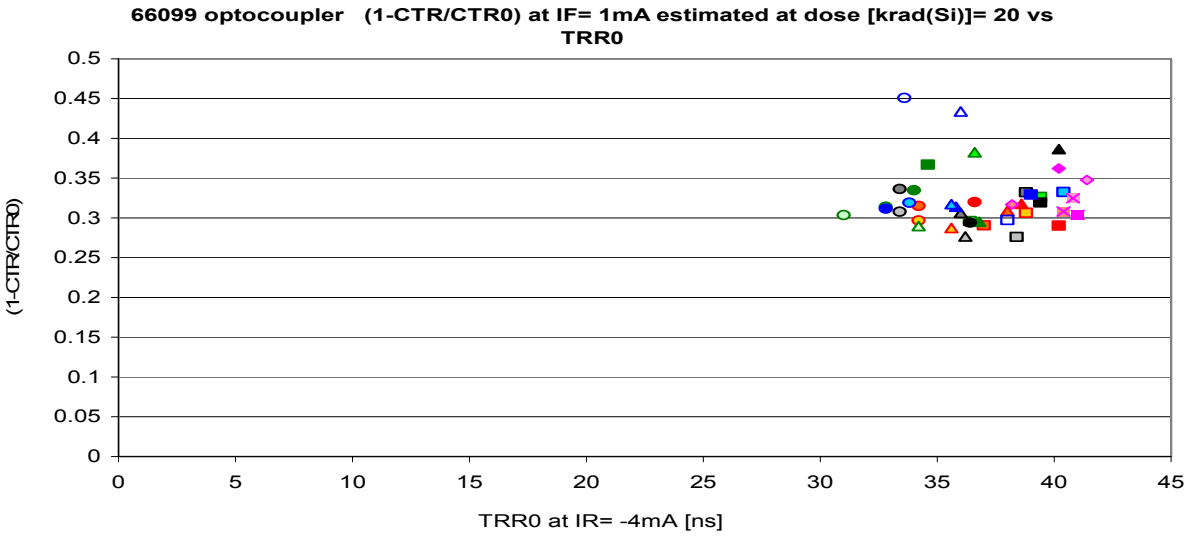
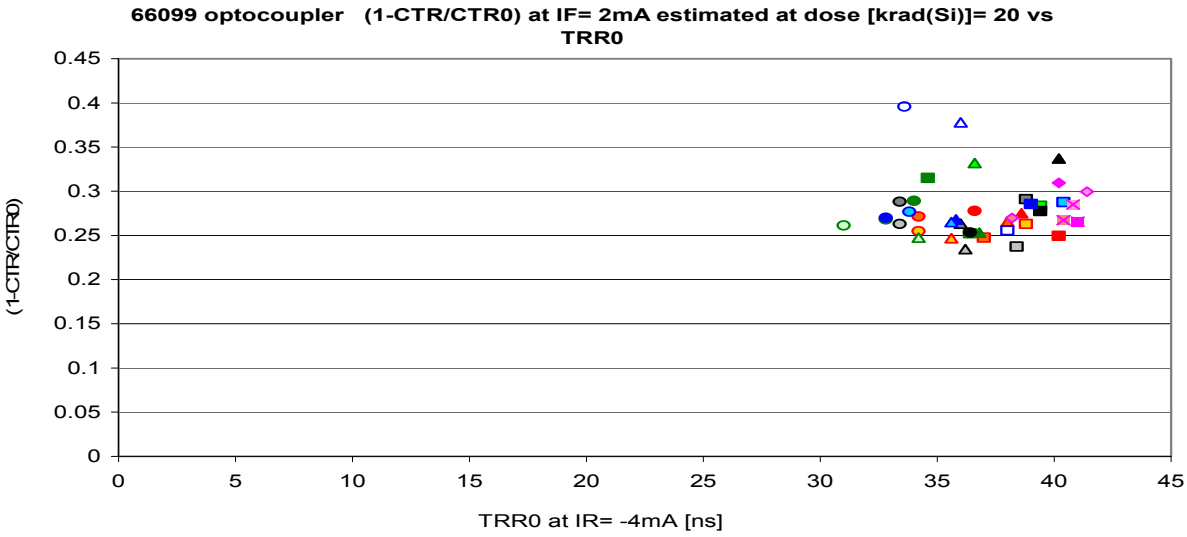
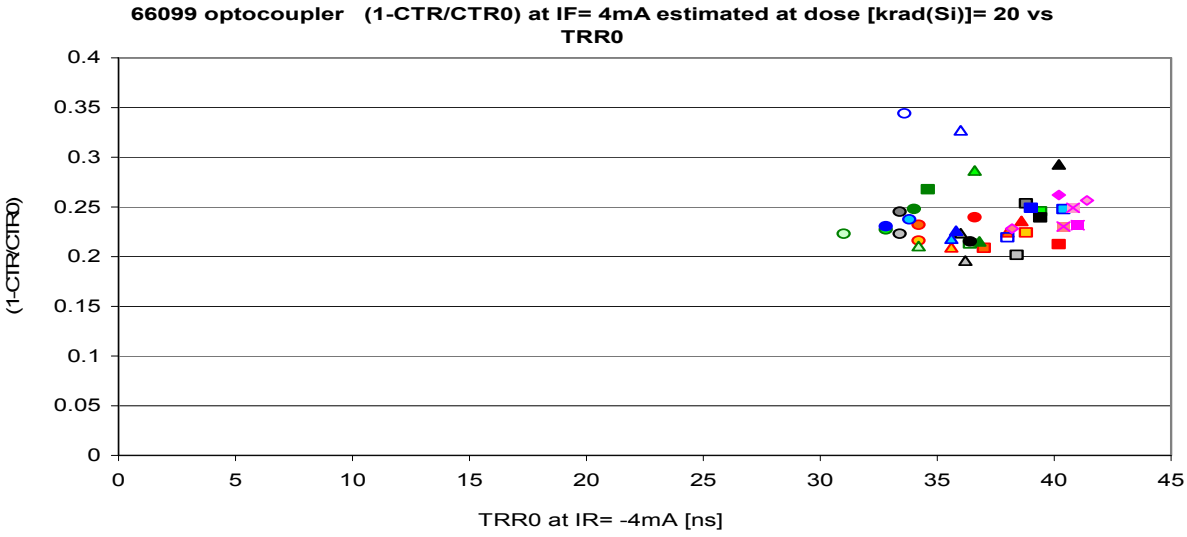
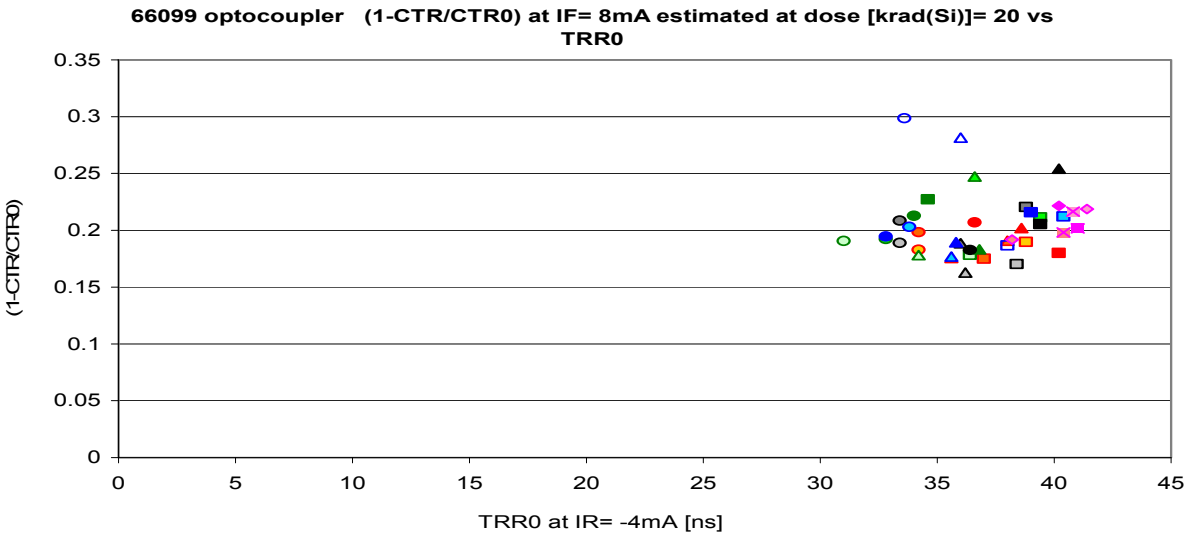

66099 transistor (1-CTR/CTR0) at IF= 10mA
(1-CTR/CTR0)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
dose [krad(Si)]

Fig. 14-228: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA [ns]

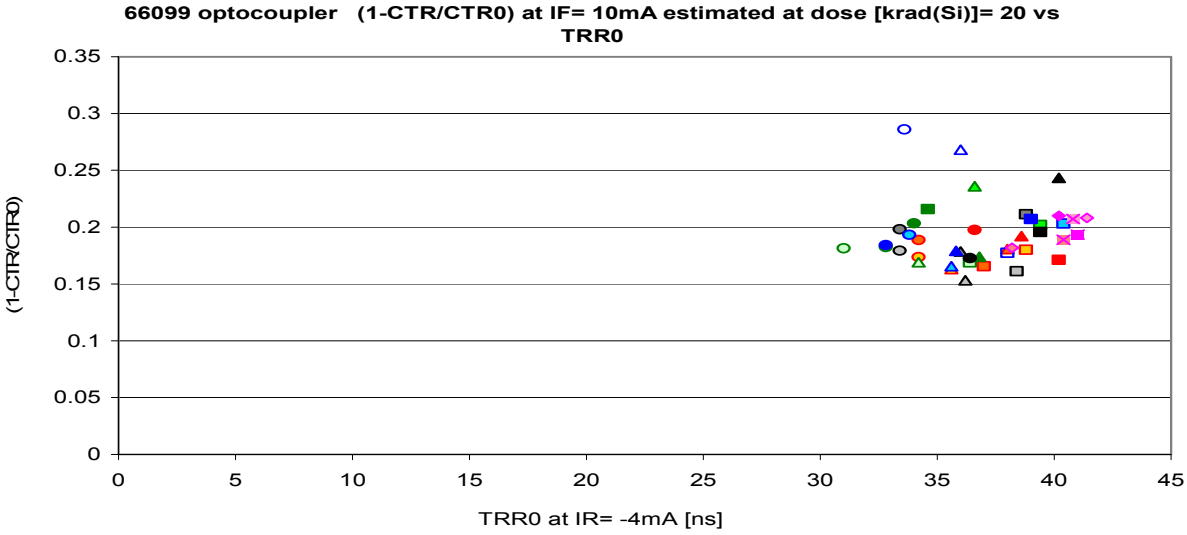
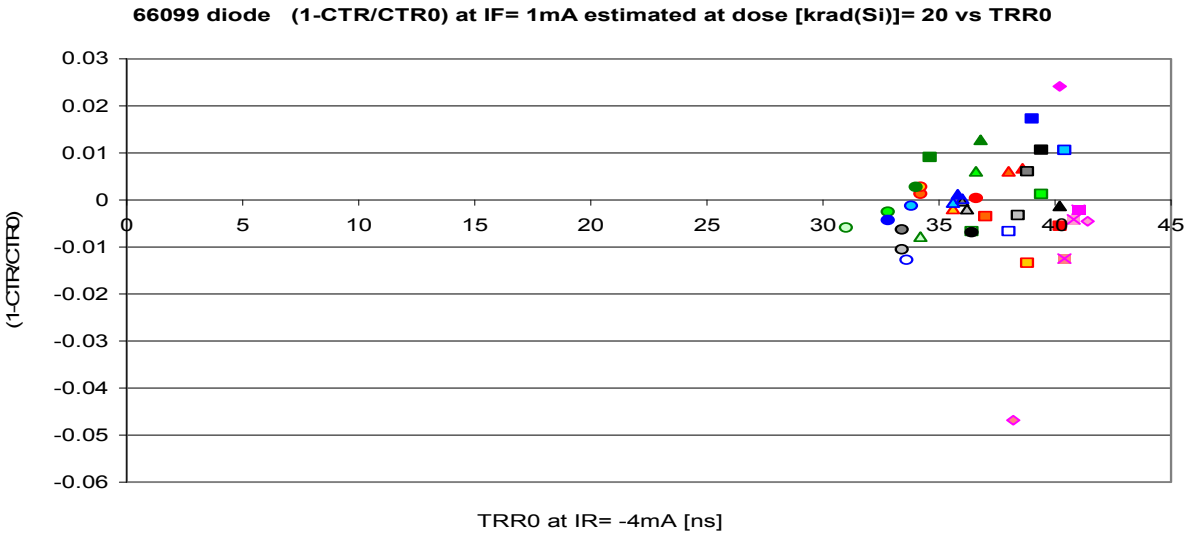
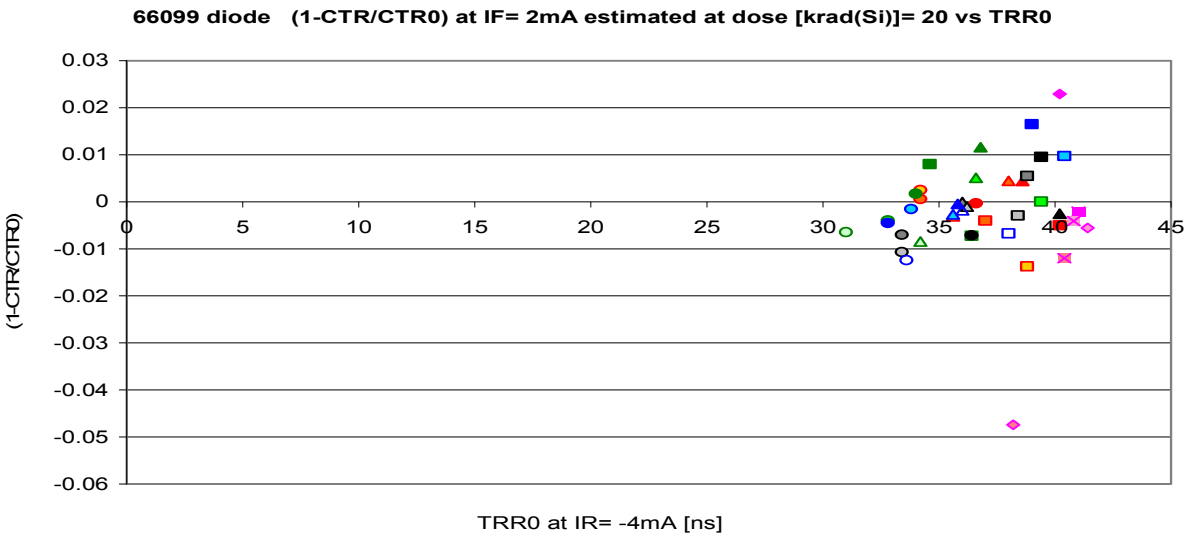
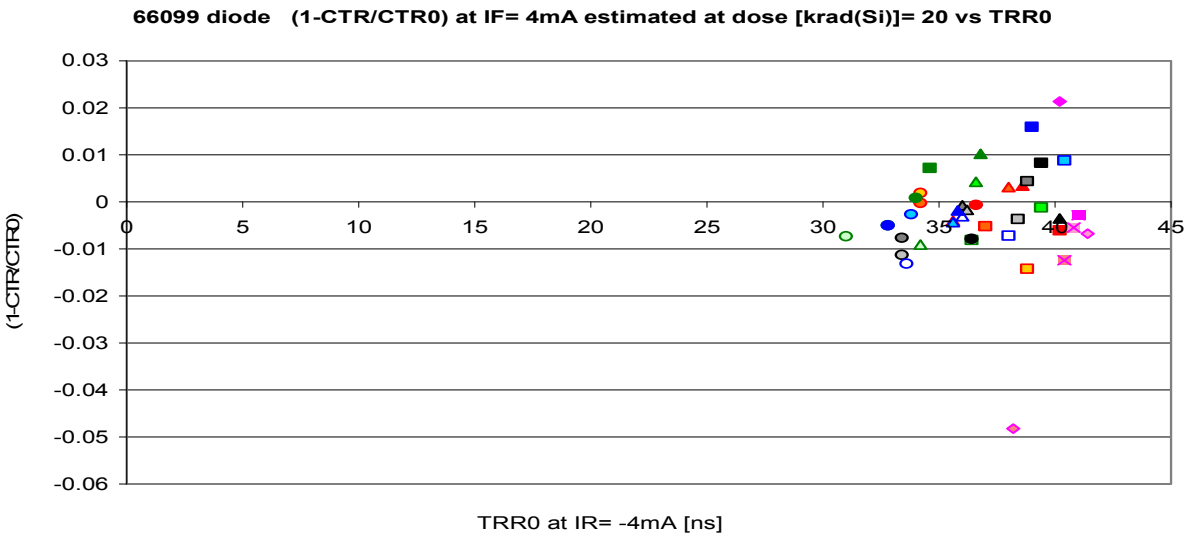
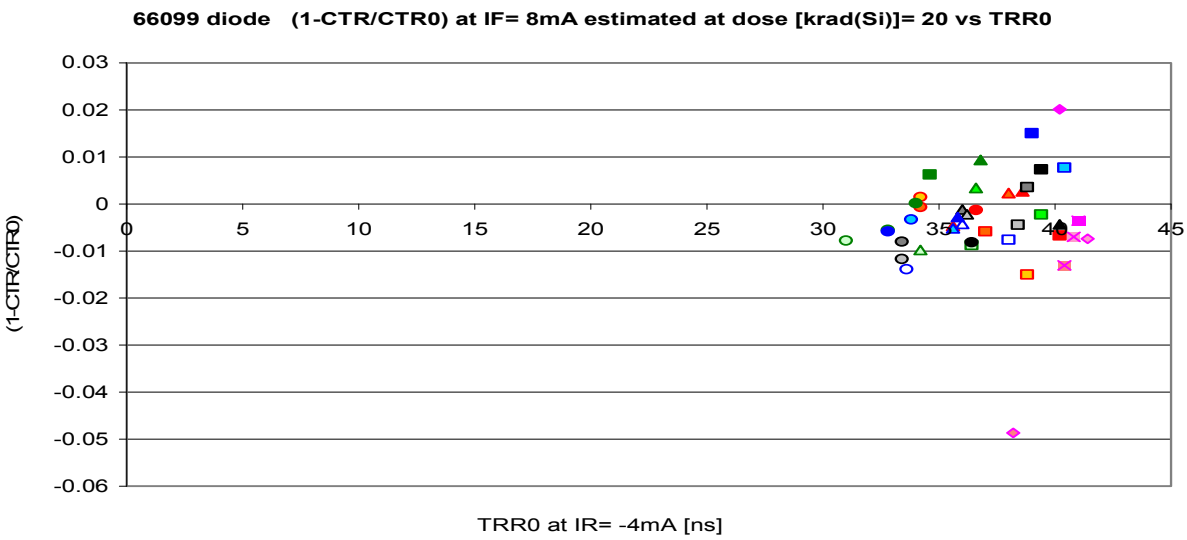

66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
(1-CTR/CTR0)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA [ns]

Fig. 14-229: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 20krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 20 vs TRR0
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
0
5
10
15
20
25
30
35
40
45
(1-CTR/CTR0)
TRR0 at IR= -4mA [ns]

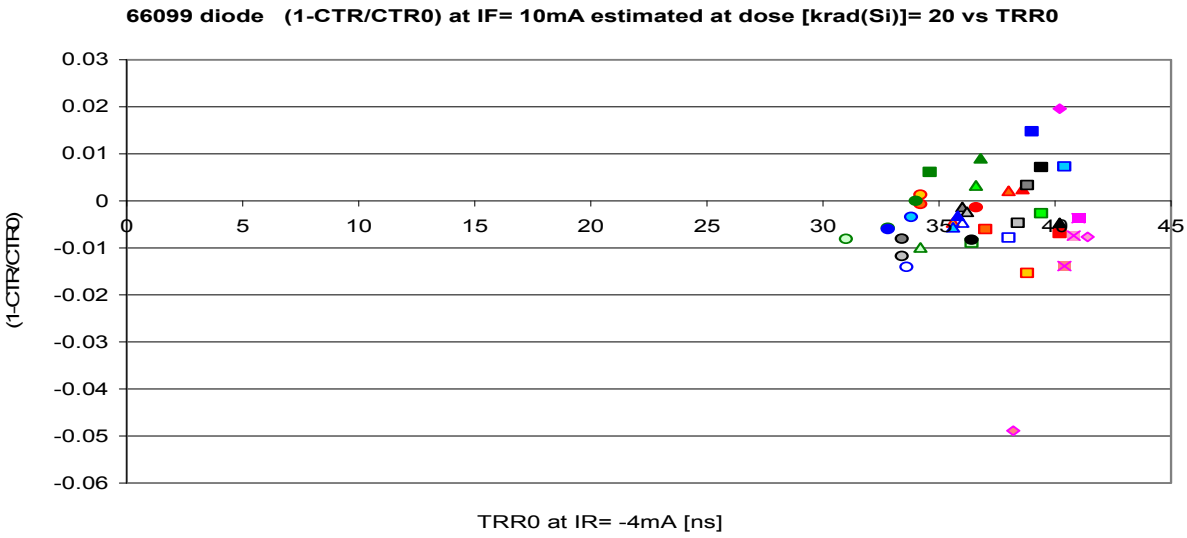
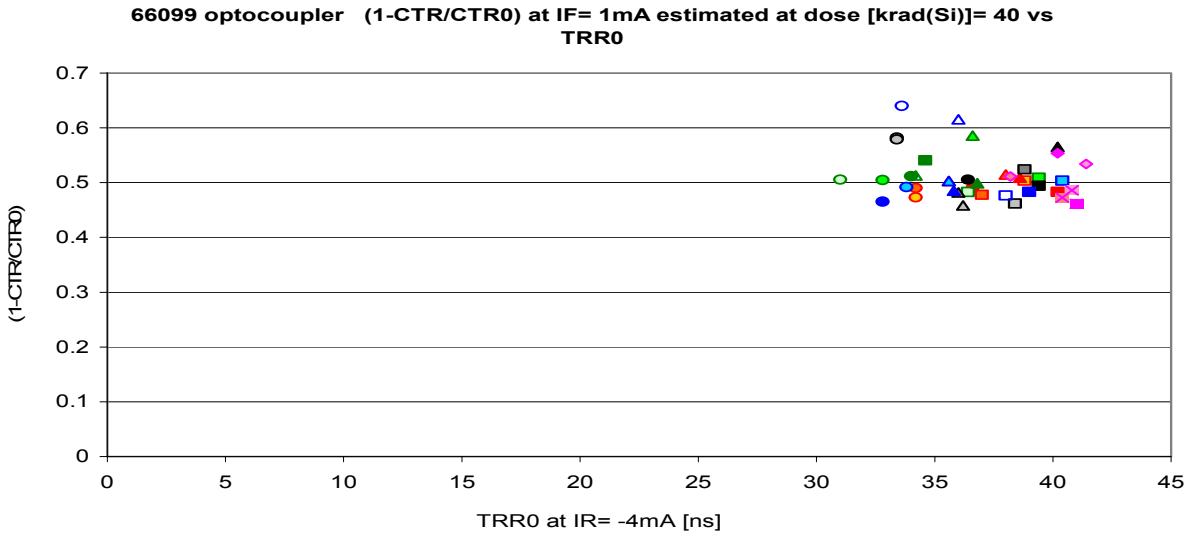
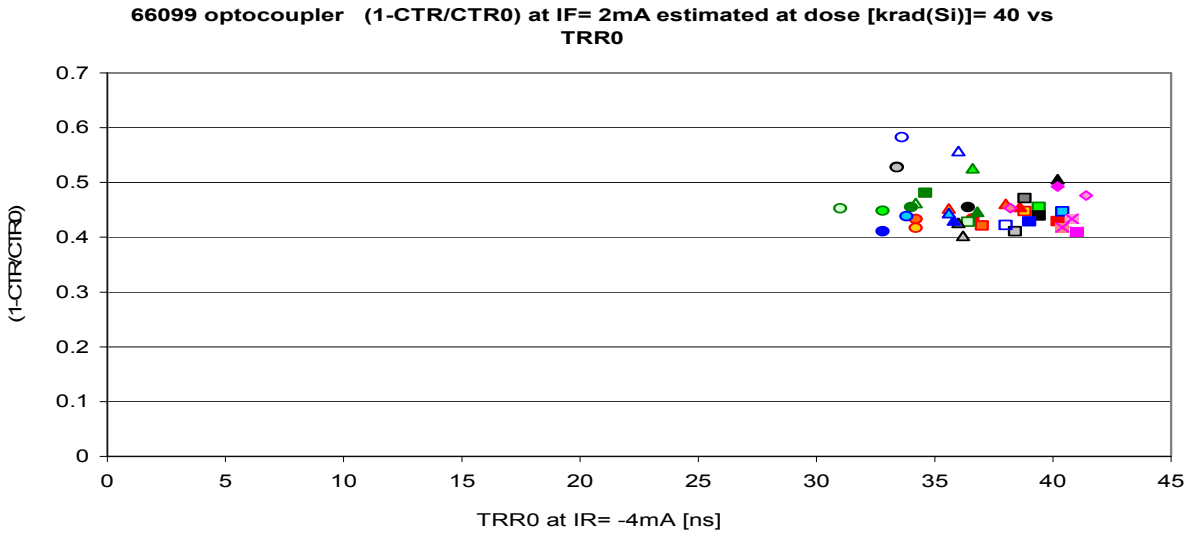
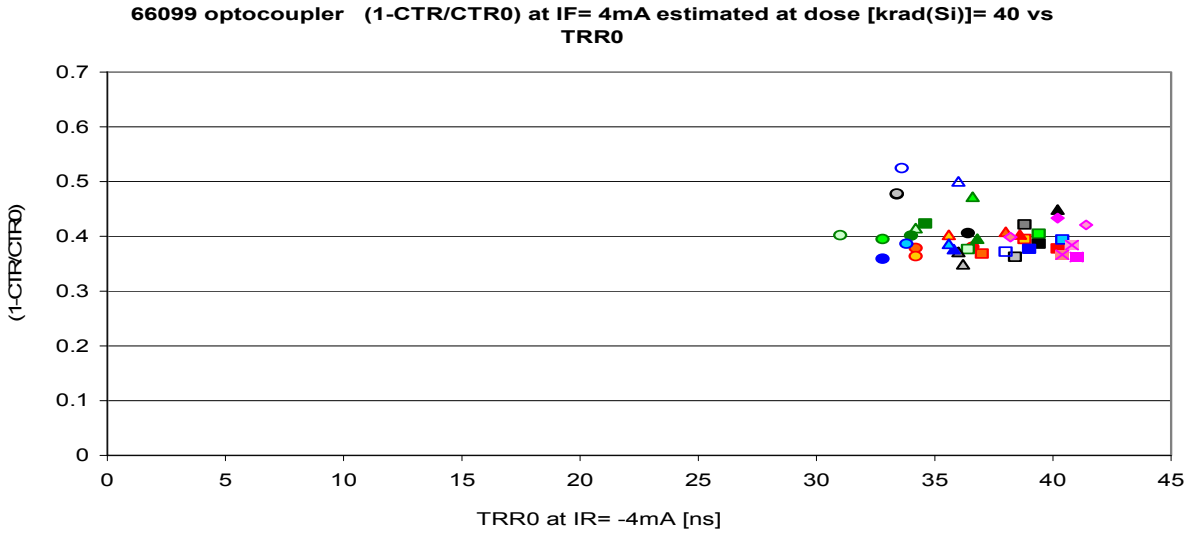

66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 20 vs TRR0
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
0
5
10
15
20
25
30
35
40
45
(1-CTR/CTR0)
TRR0 at IR= -4mA [ns]

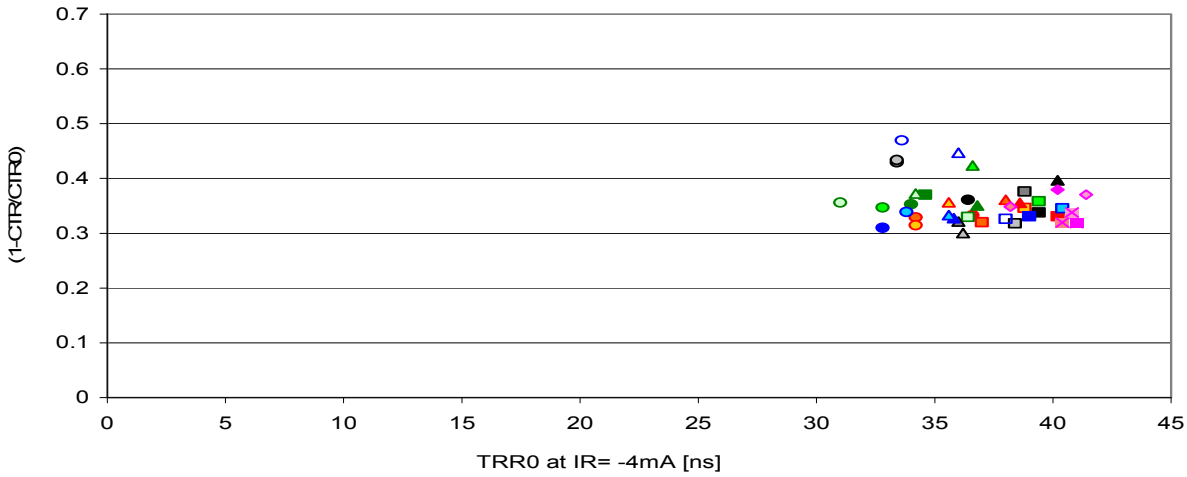
Fig. 14-230: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0



66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0

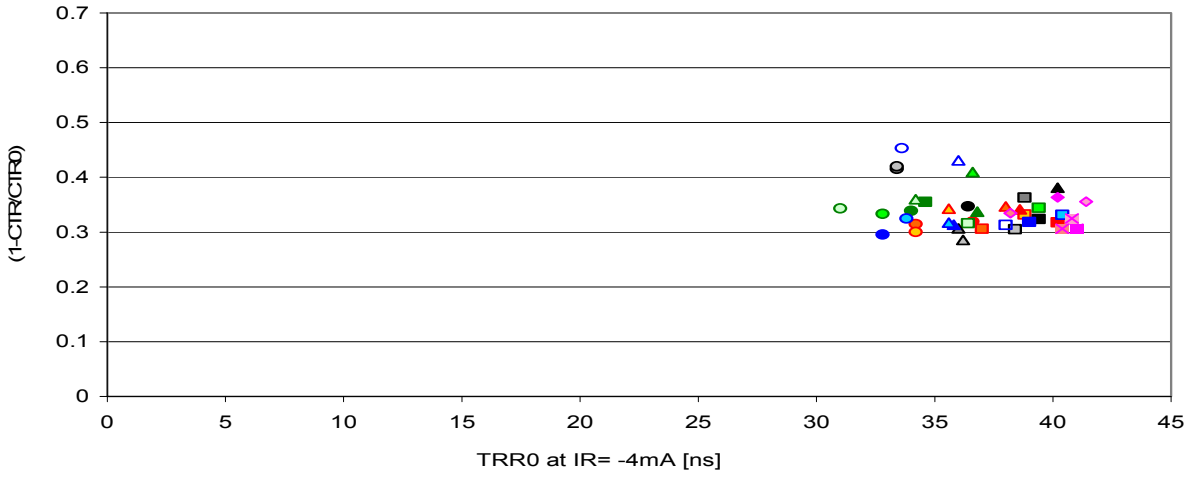
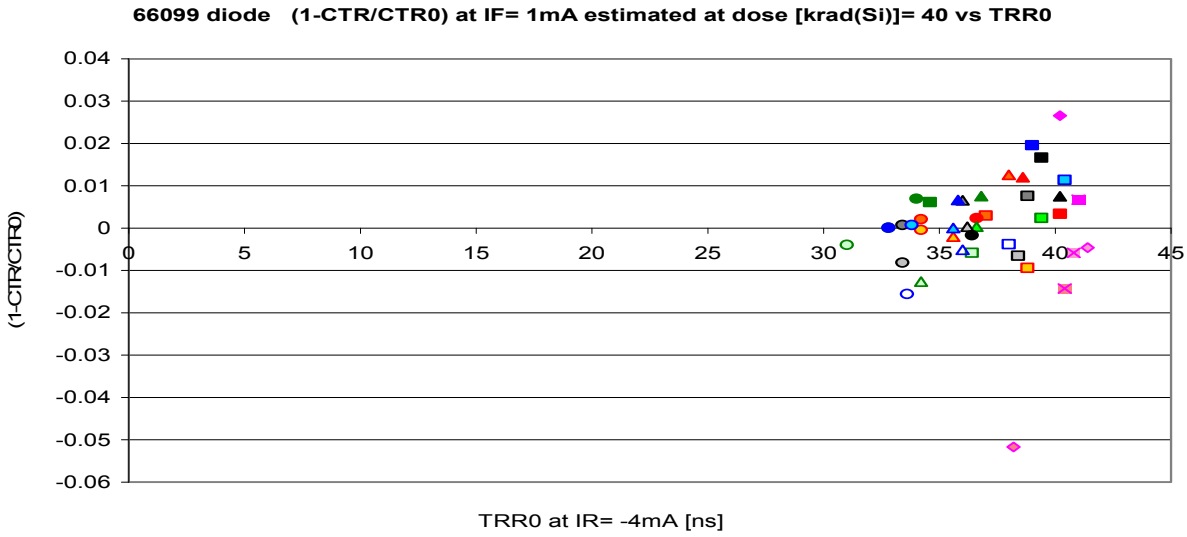
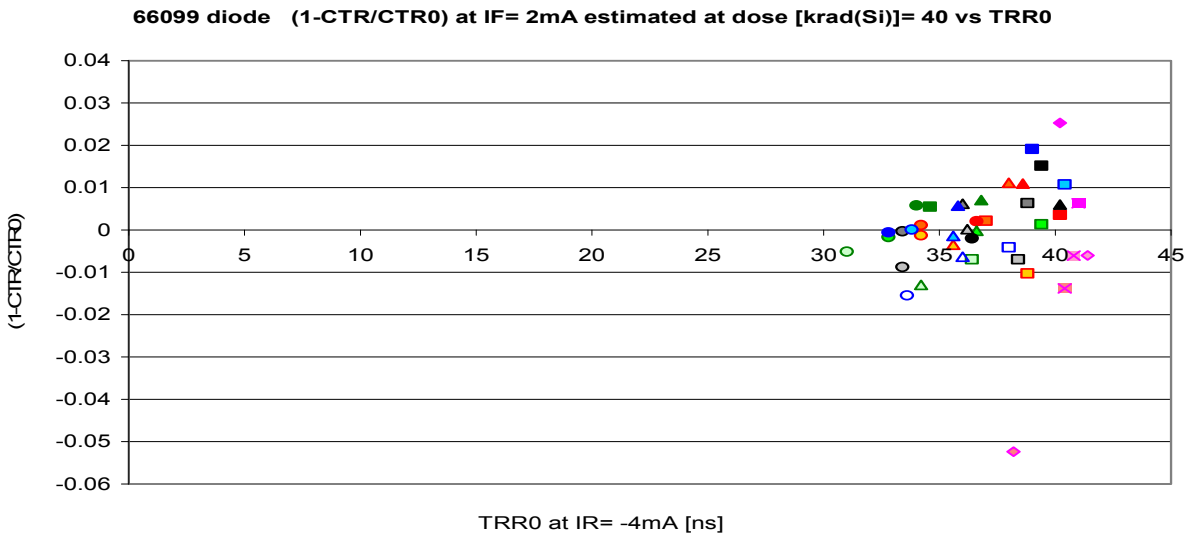
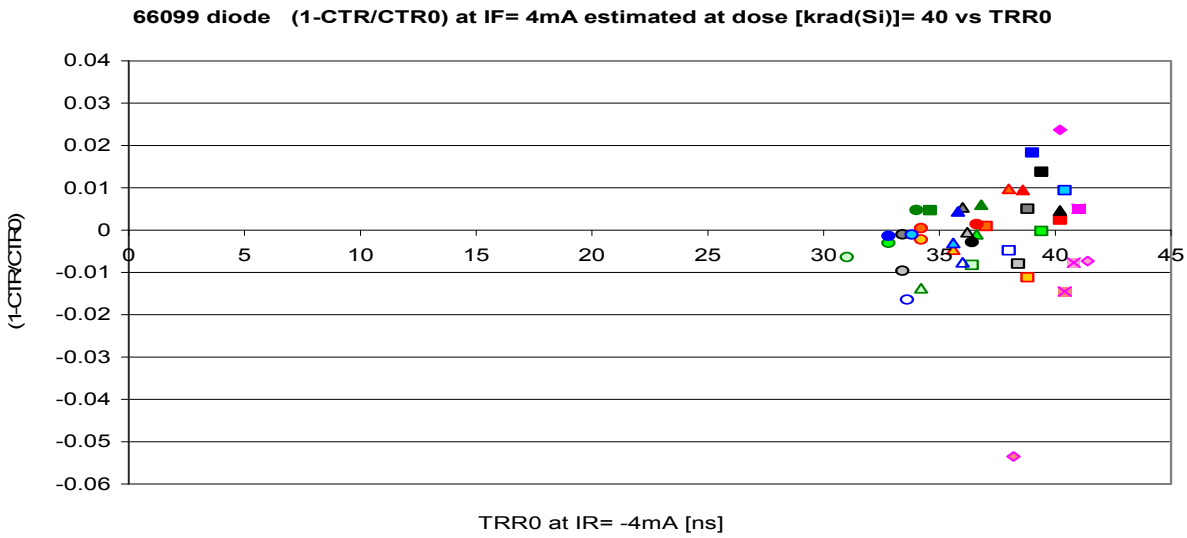


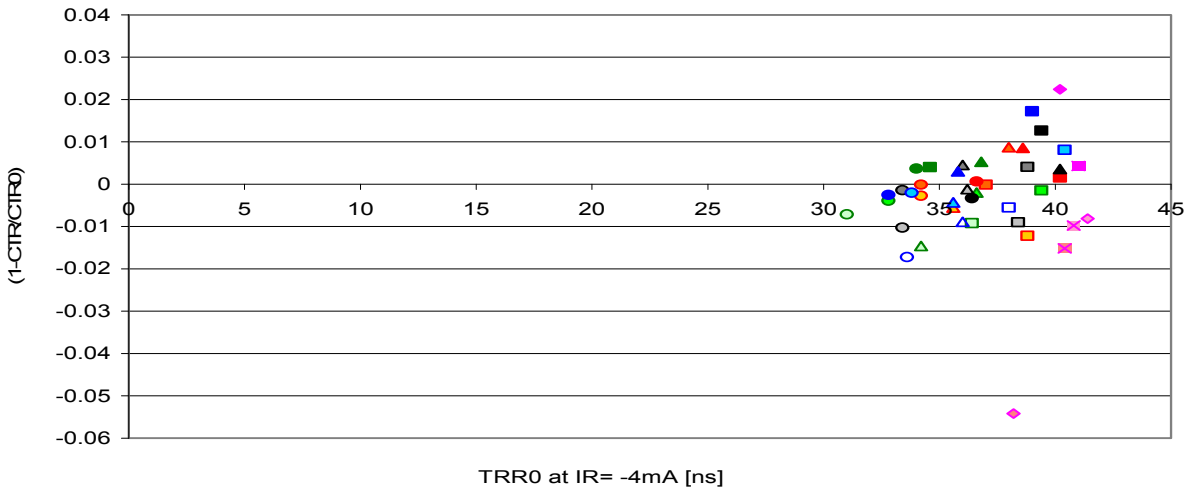
Fig. 14-231: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 40krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 40 vs TRR0



66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 40 vs TRR0

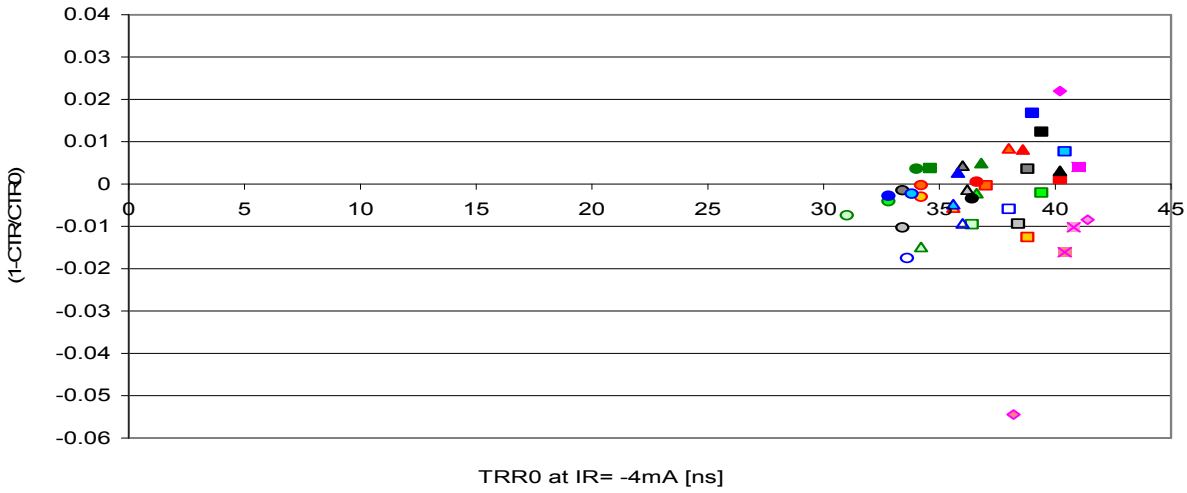
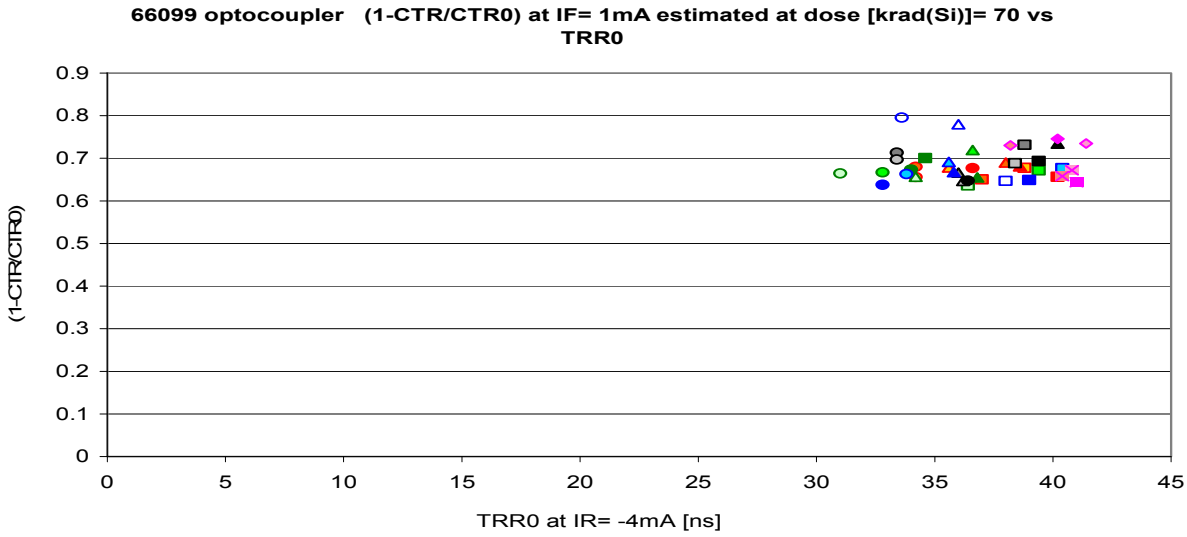
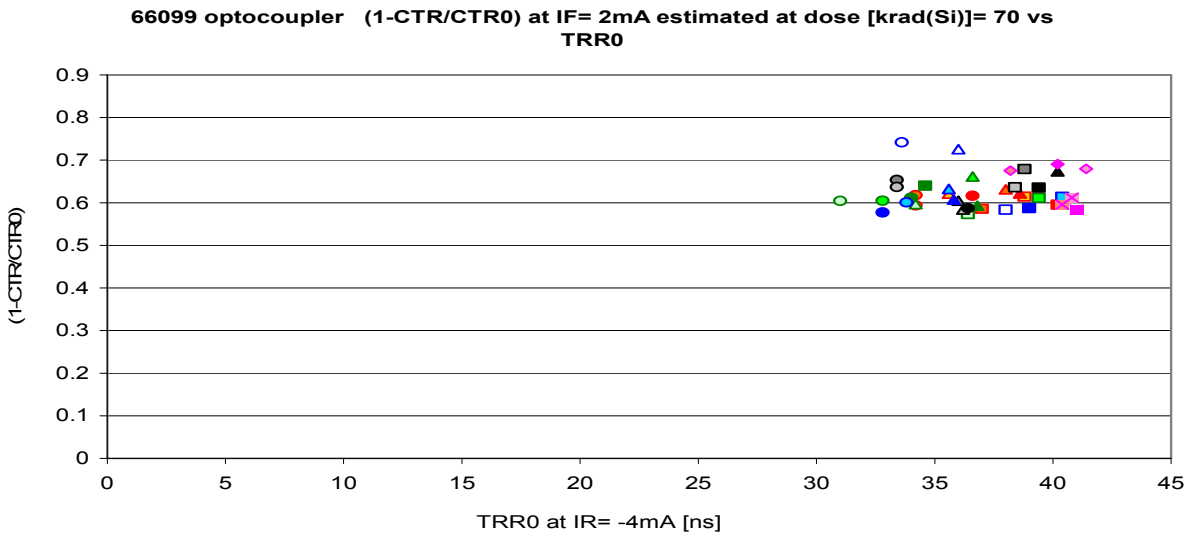
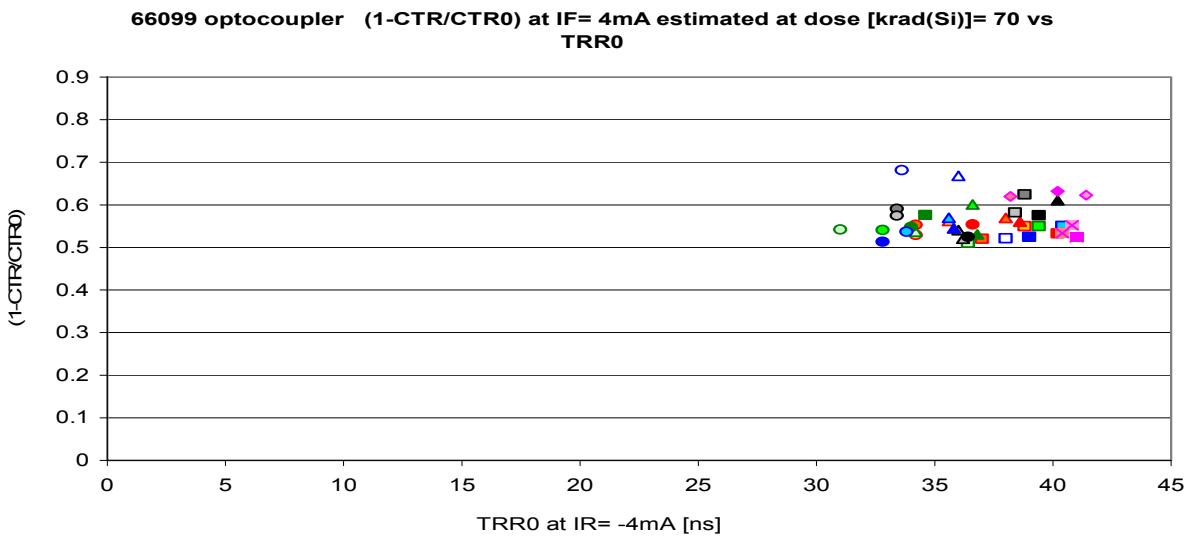
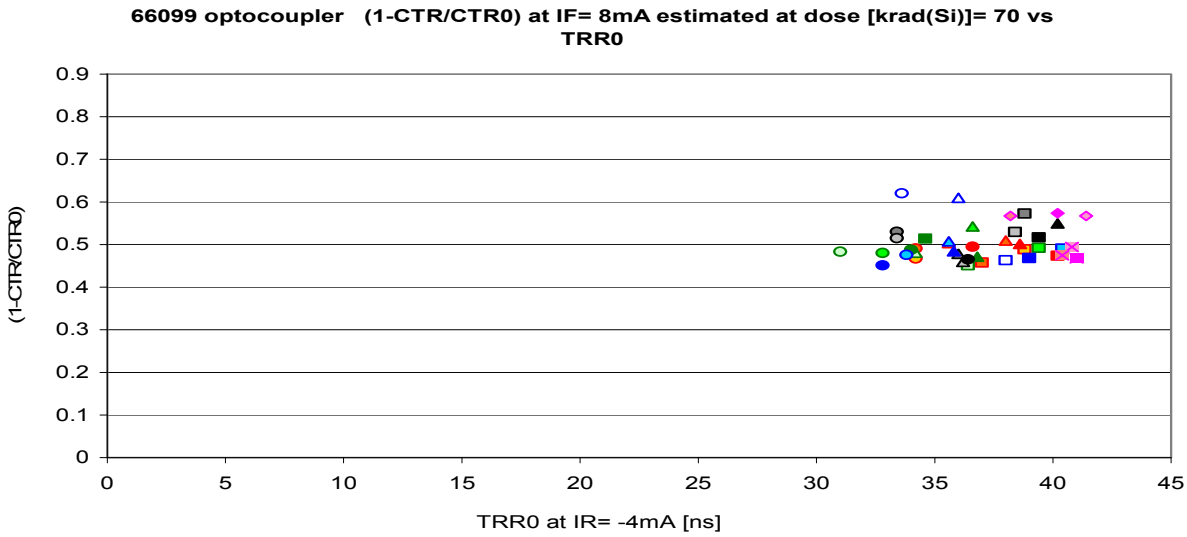


Fig. 14-232: 66099 optocoupler: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}








66099 optocoupler (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA [ns]

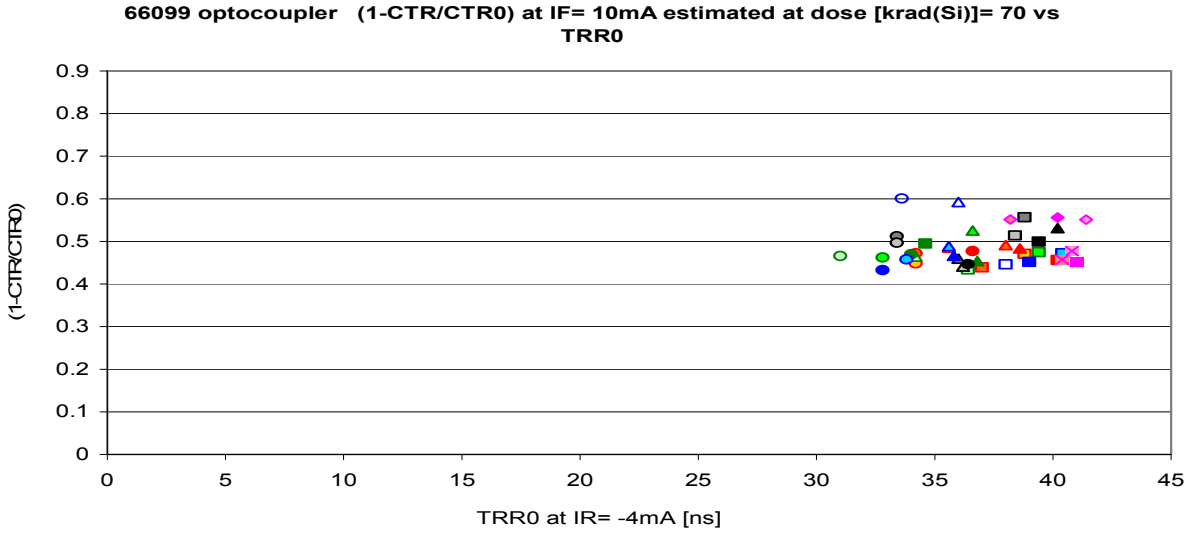
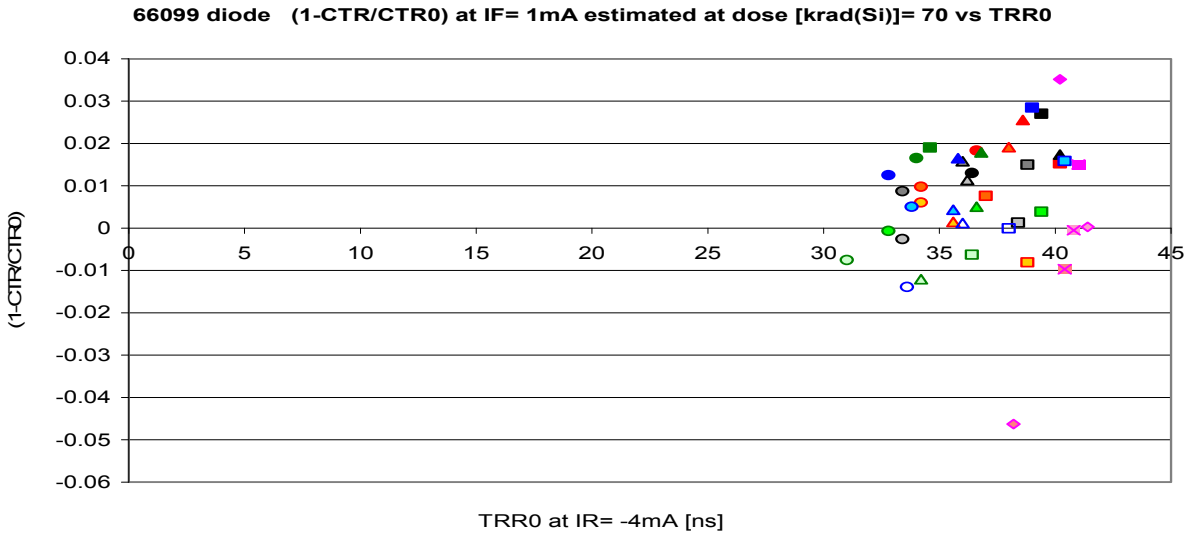
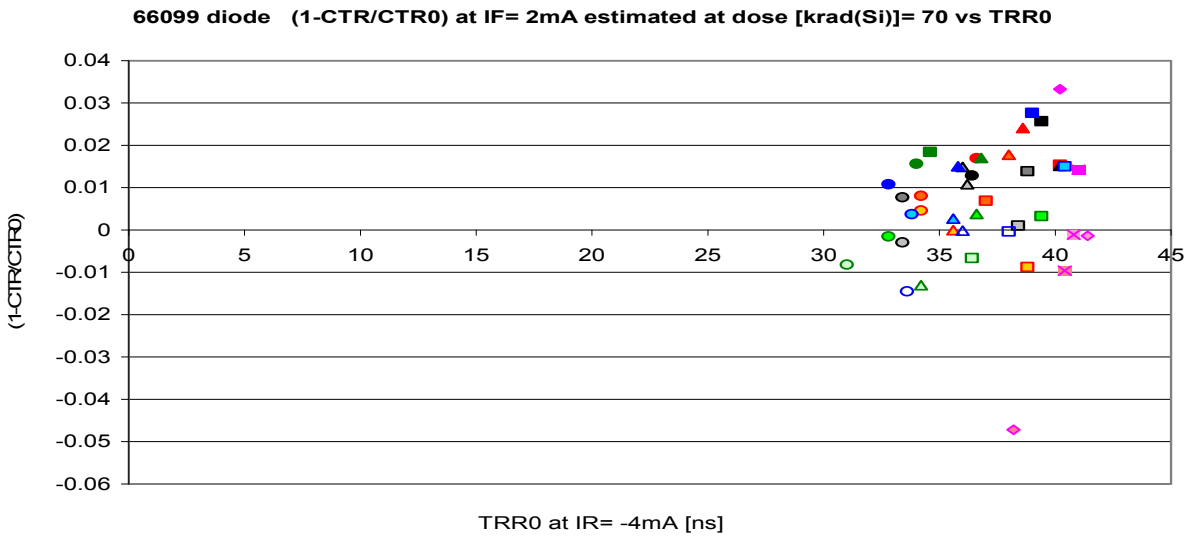
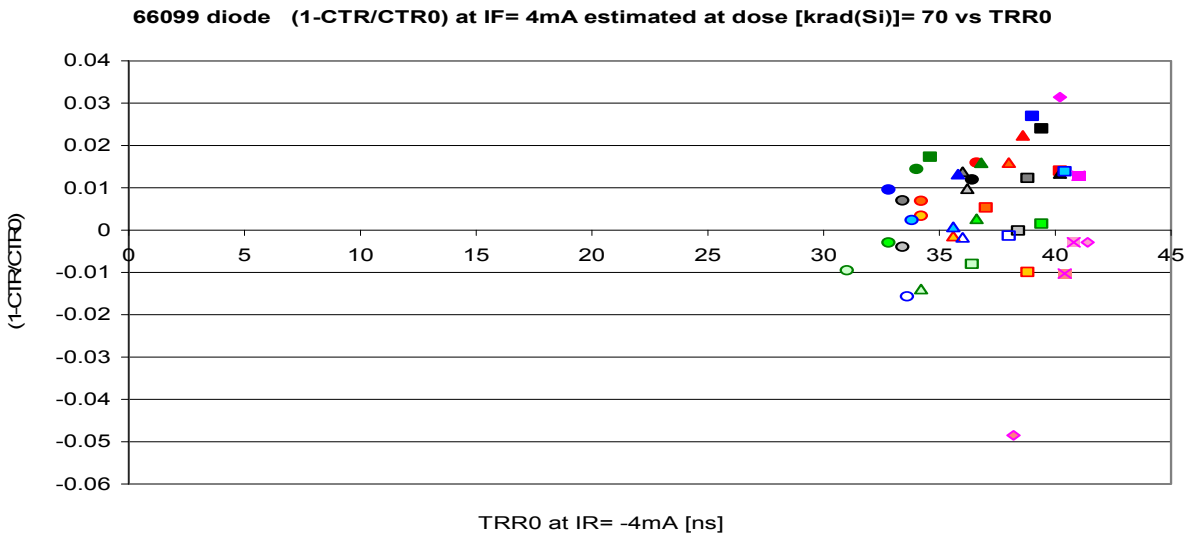

66099 optocoupler (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0
(1-CTR/CTR0)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA [ns]

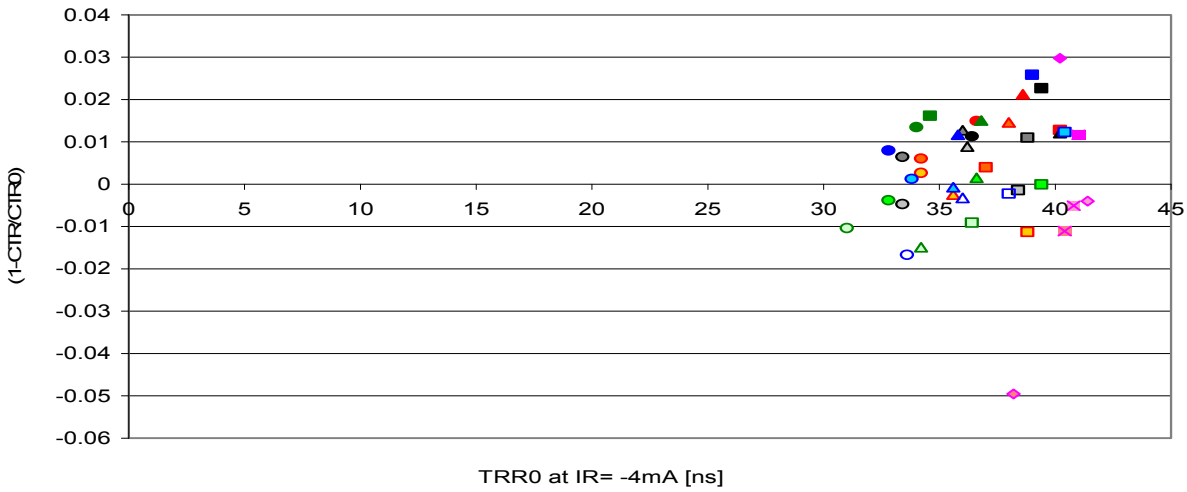
Fig. 14-233: 66099 diode: 1 - CTR/CTR$_0$ estimated at a dose of 70krad at I_F= 1, 2, 4, 8, 10 mA with respect to T_{RR0}







66099 diode (1-CTR/CTR0) at IF= 8mA estimated at dose [krad(Si)]= 70 vs TRR0



66099 diode (1-CTR/CTR0) at IF= 10mA estimated at dose [krad(Si)]= 70 vs TRR0

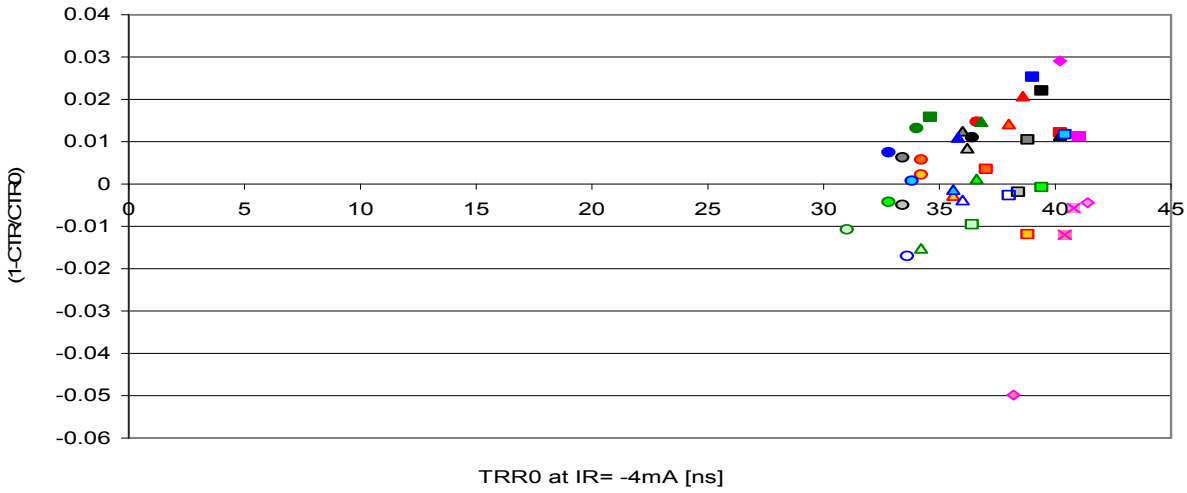
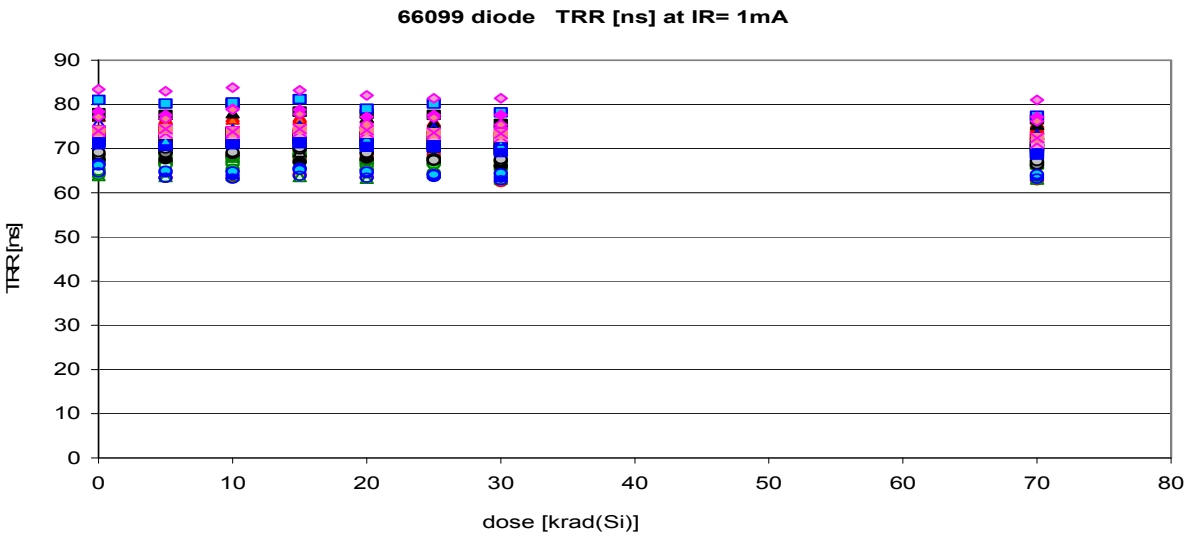
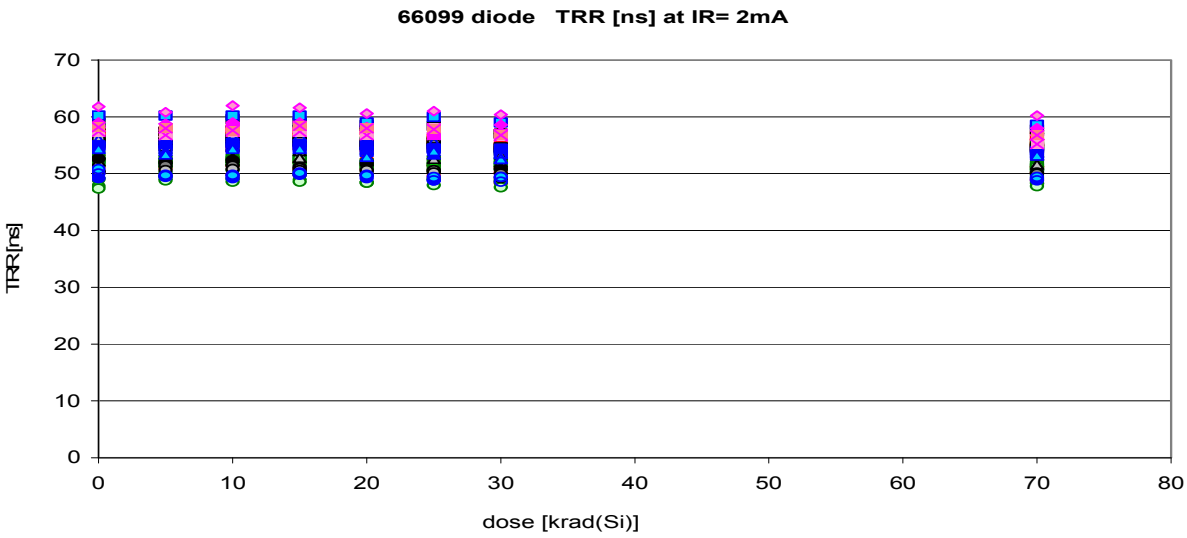


Fig. 14-234: 66099 diode: τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





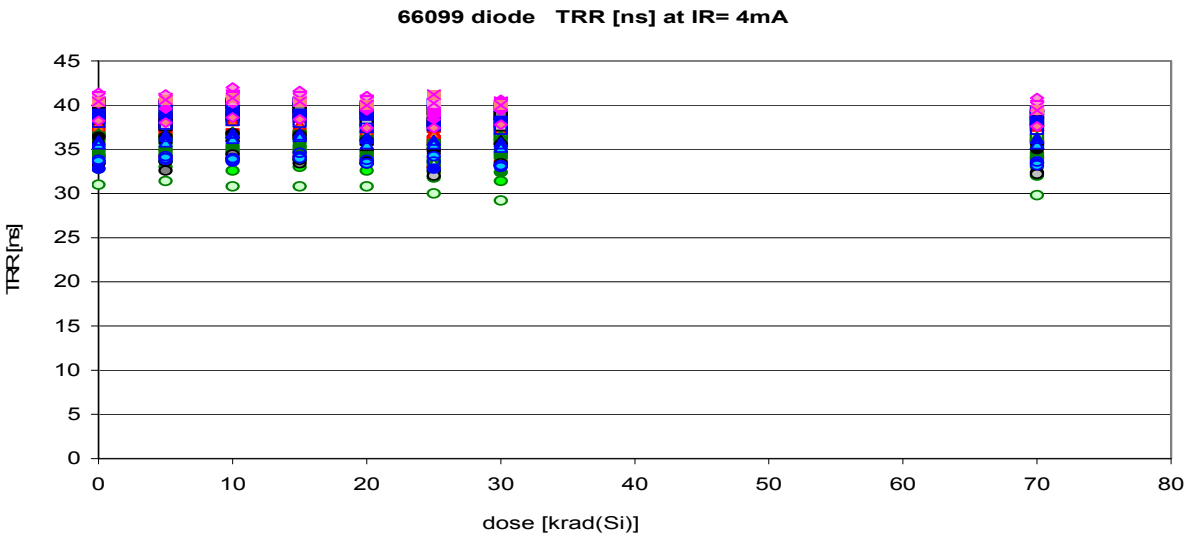
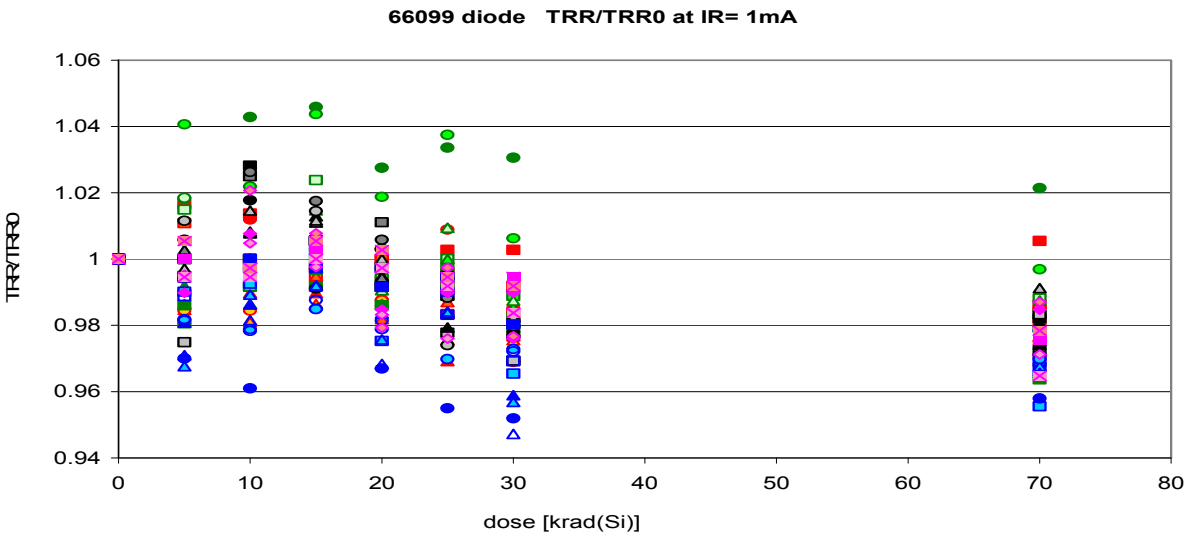
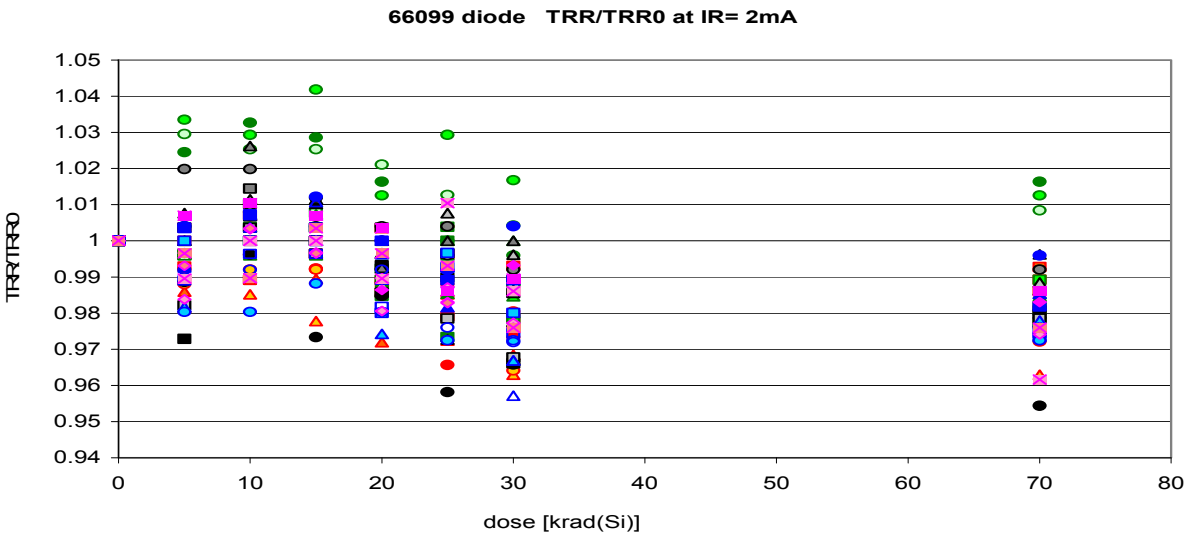


Fig. 14-235: 66099 diode: τ_{RR}/τ_{RR0} [ns] with respect to dose at I_R = -1, -2, -4 mA





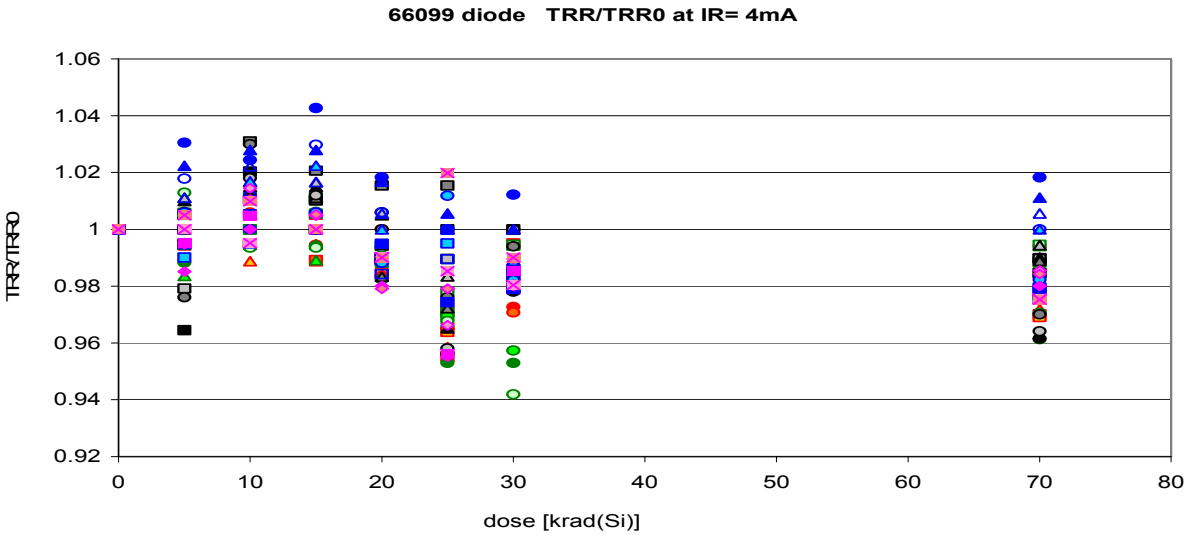
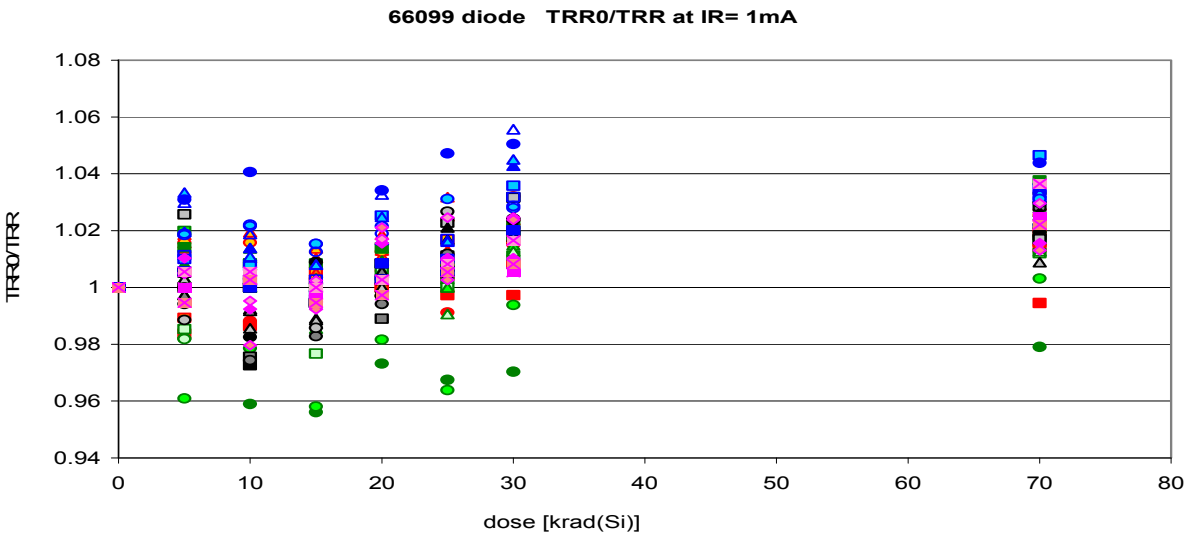
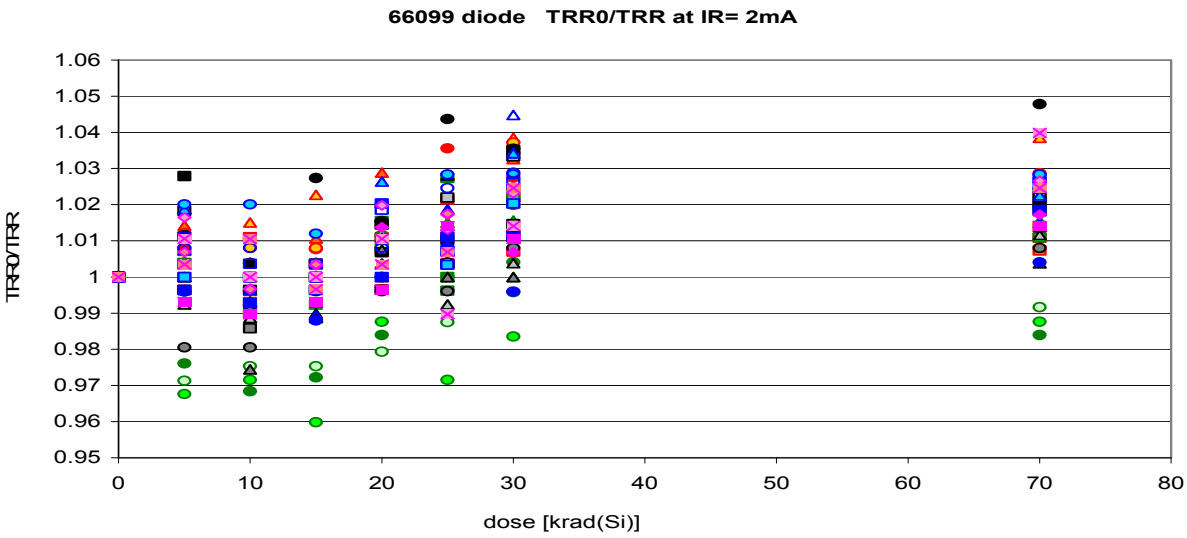


Fig. 14-236: 66099 diode: τ_{RR0}/τ_{RR} [ns] with respect to dose at I_R = -1, -2, -4 mA





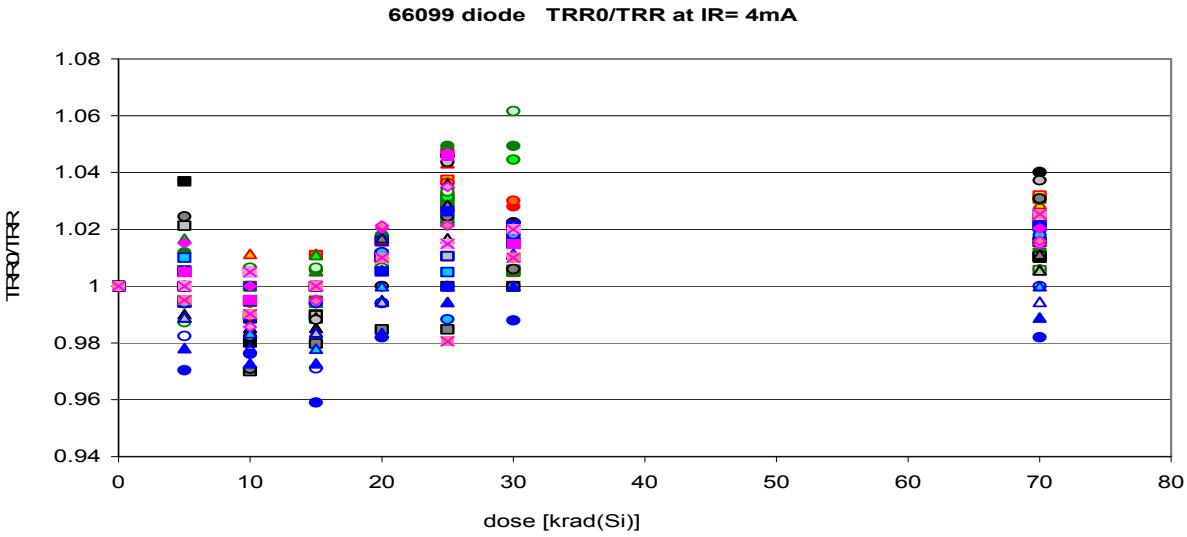
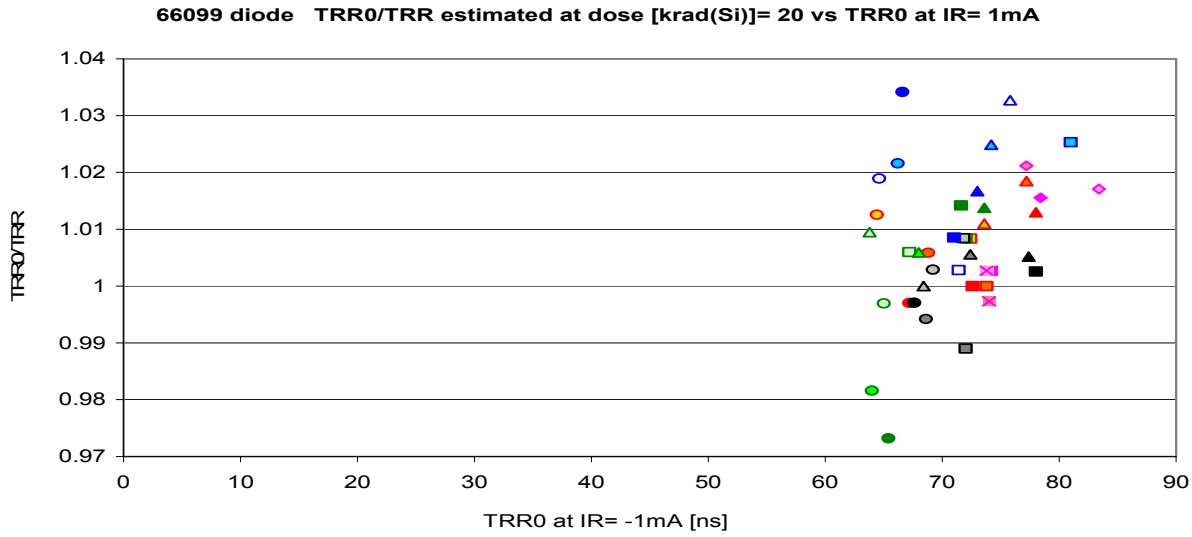
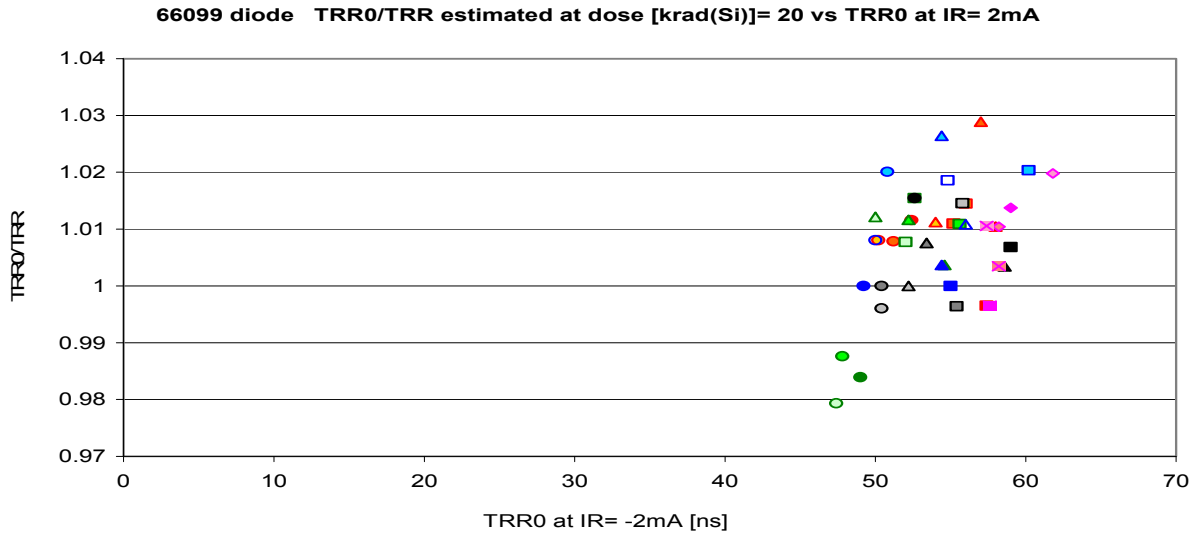


Fig. 14-237: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 20krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





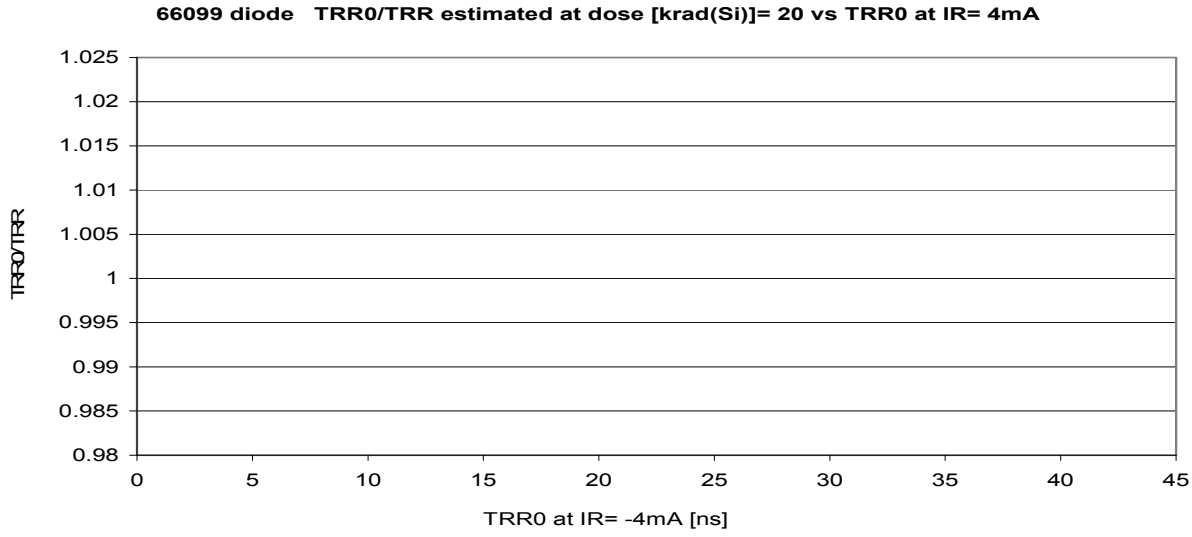
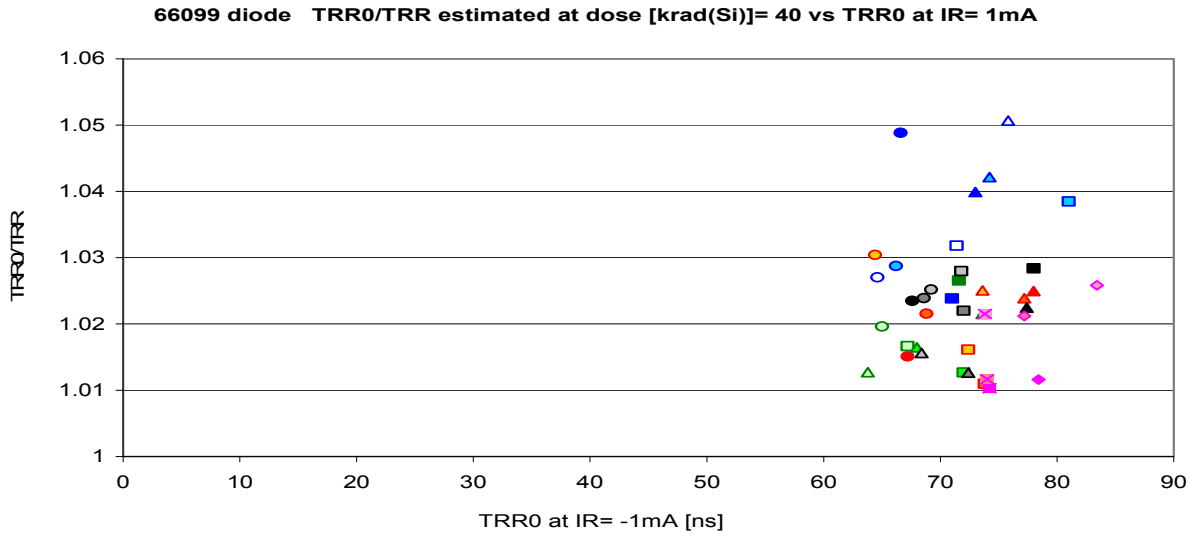
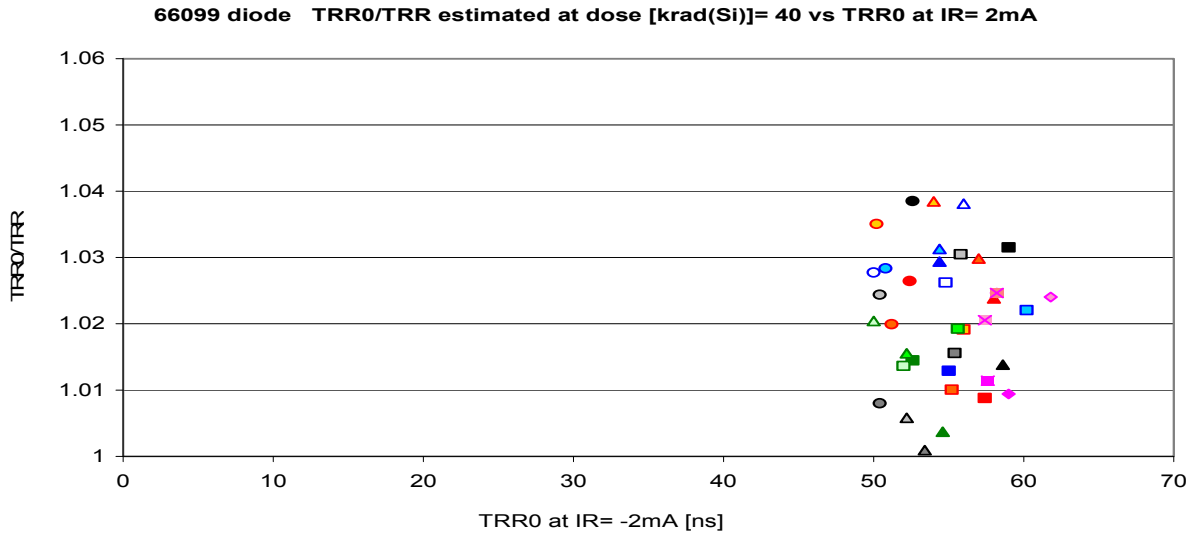


Fig. 14-238: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 40krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





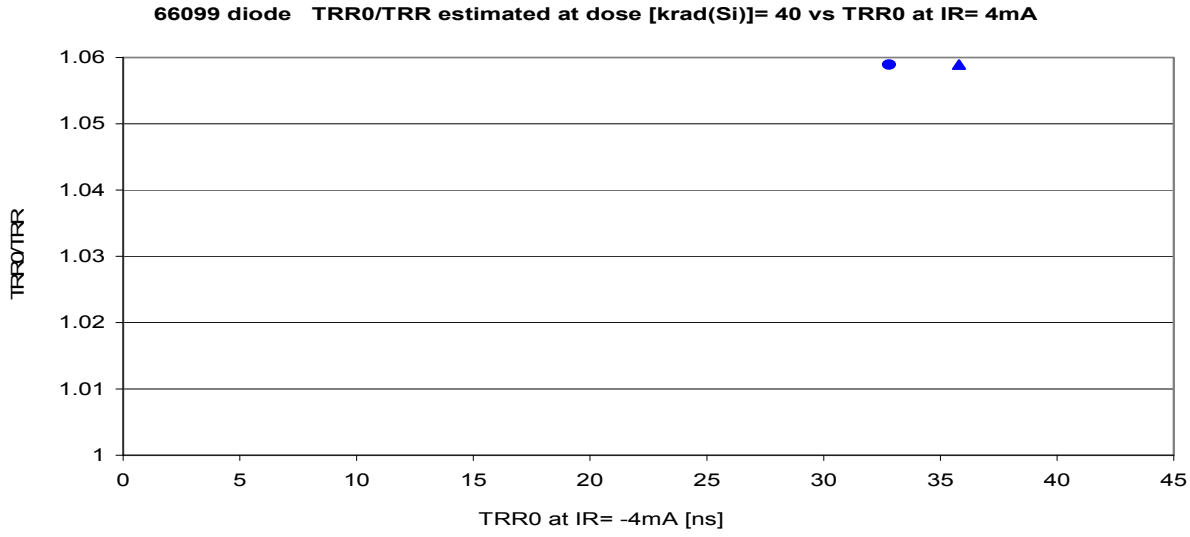
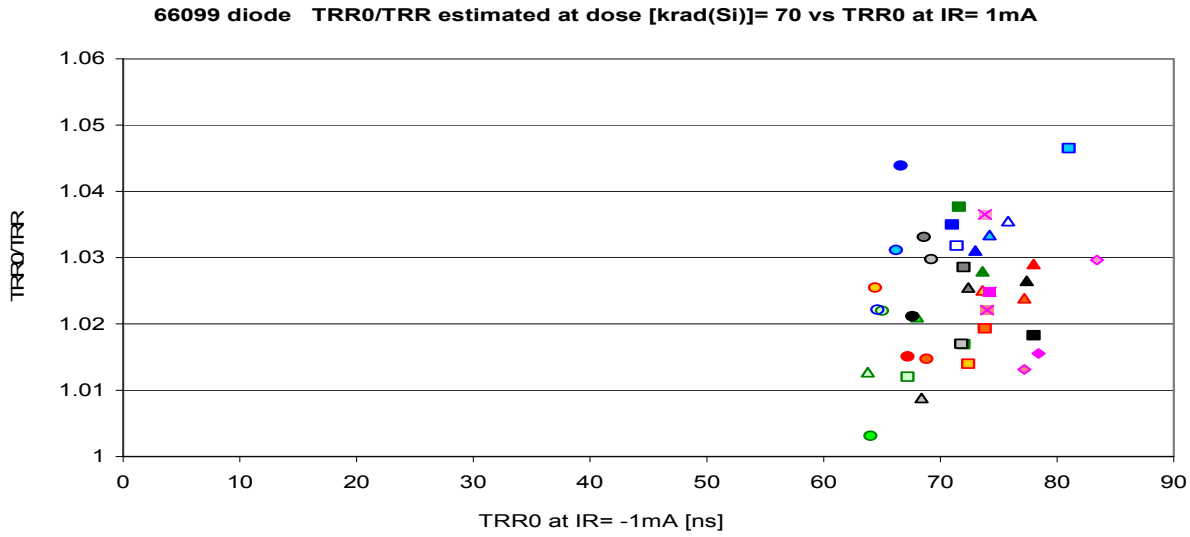
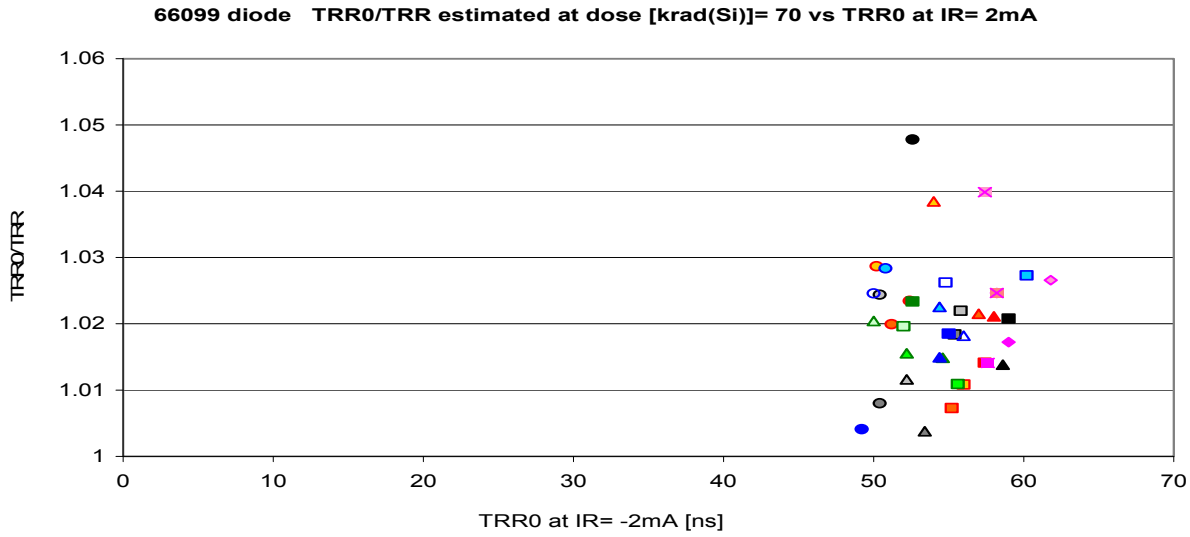


Fig. 14-239: 66099 diode: τ_{RR0}/τ_{RR} estimated at a dose of 70krad with respect to τ_{RR0} at I_R = -1, -2, -4mA





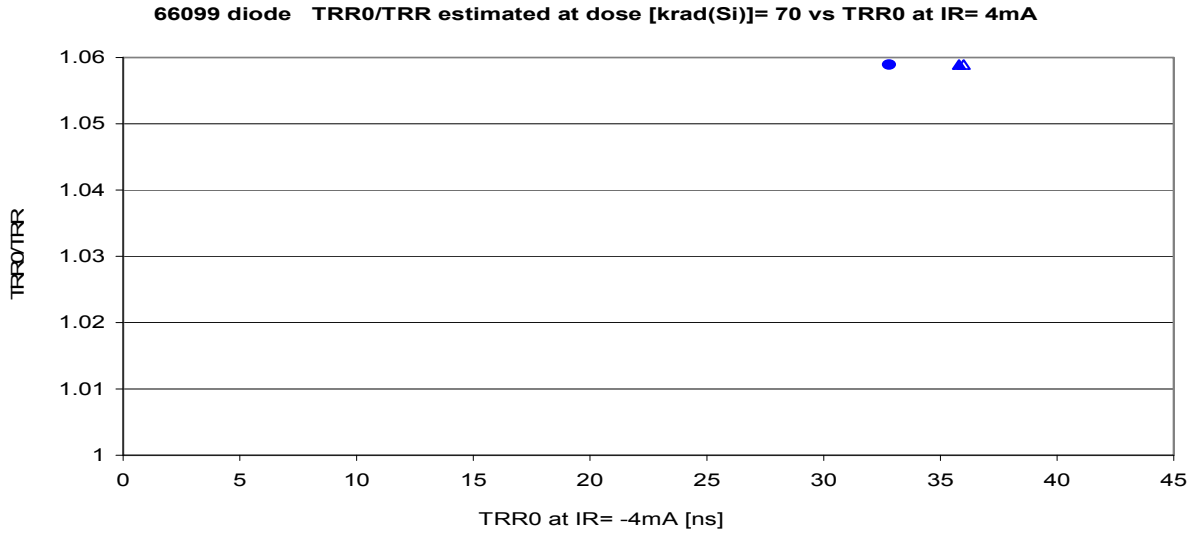


Fig. 14-240: 66099 diode: Δ $1/\tau_{RR}$ at I_R = -1, -2, -4 mA with respect to dose

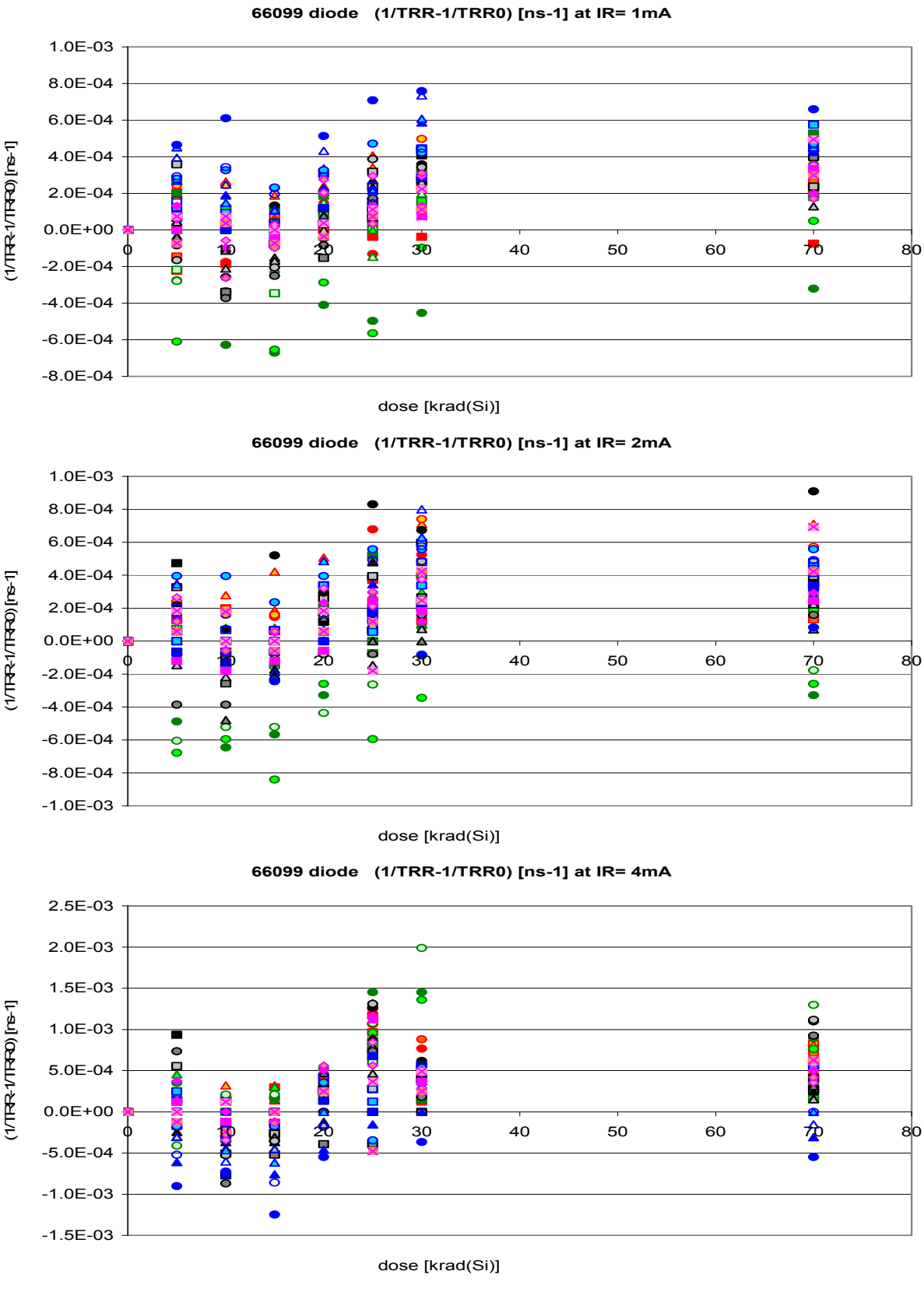
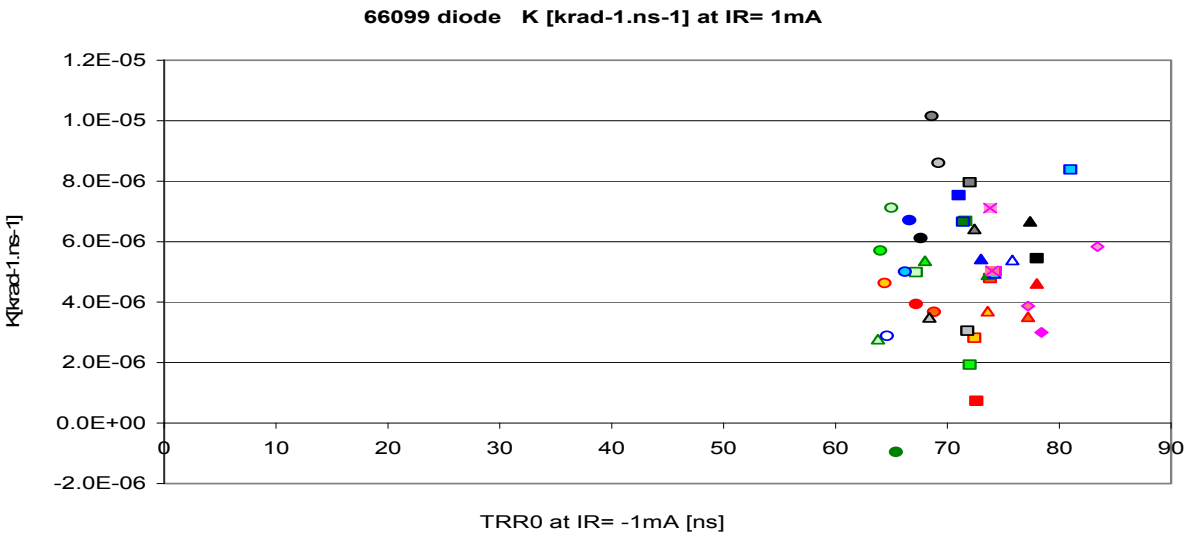
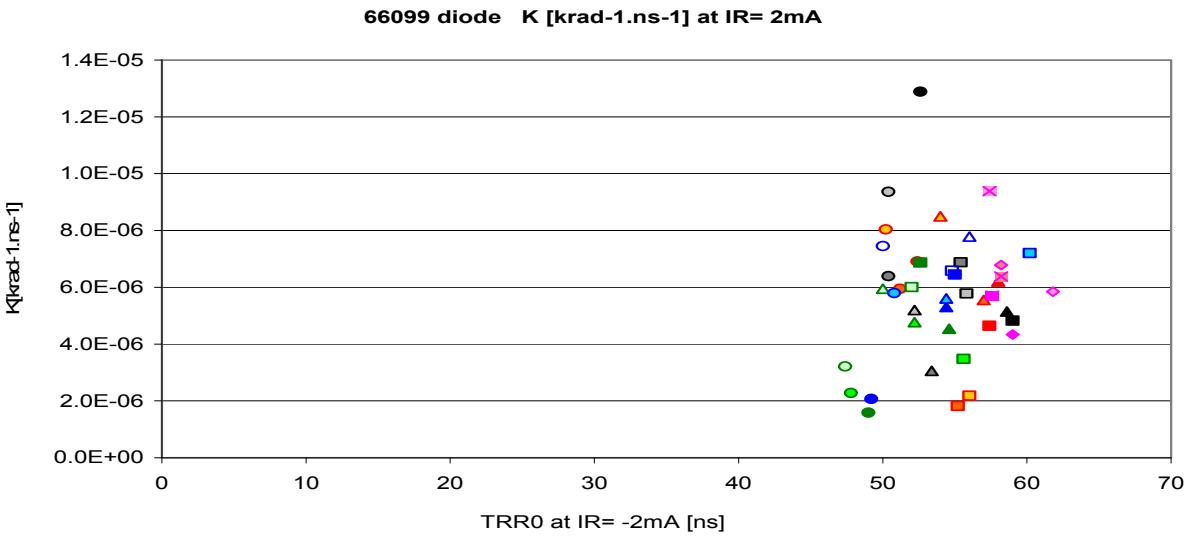


Fig. 14-241: 66099 diode: K_{TID} at I_R = -1, -2, -4mA with respect to τ_{RR0}





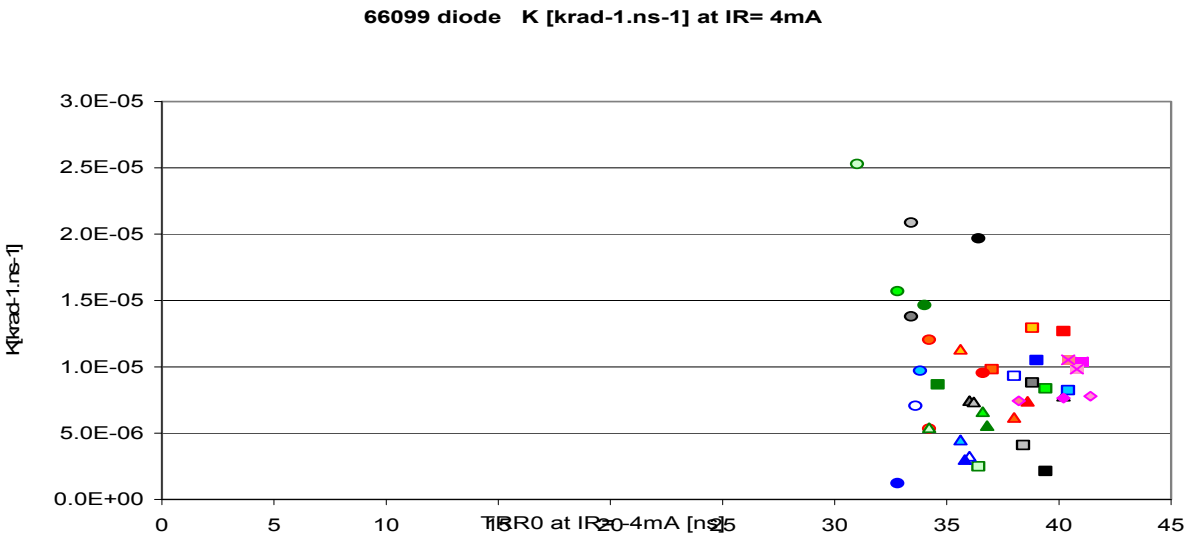
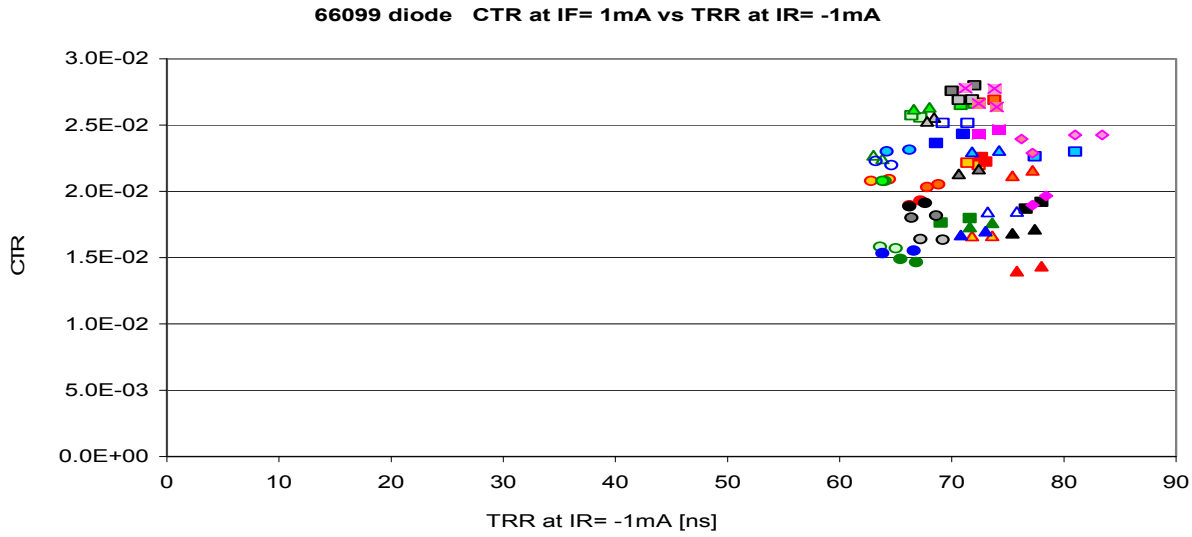
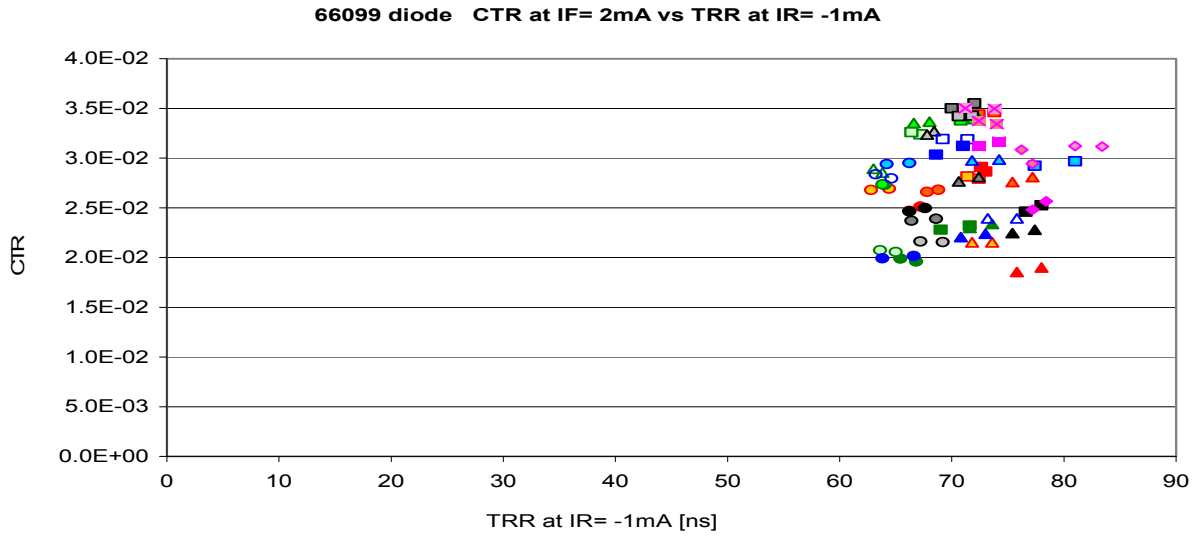
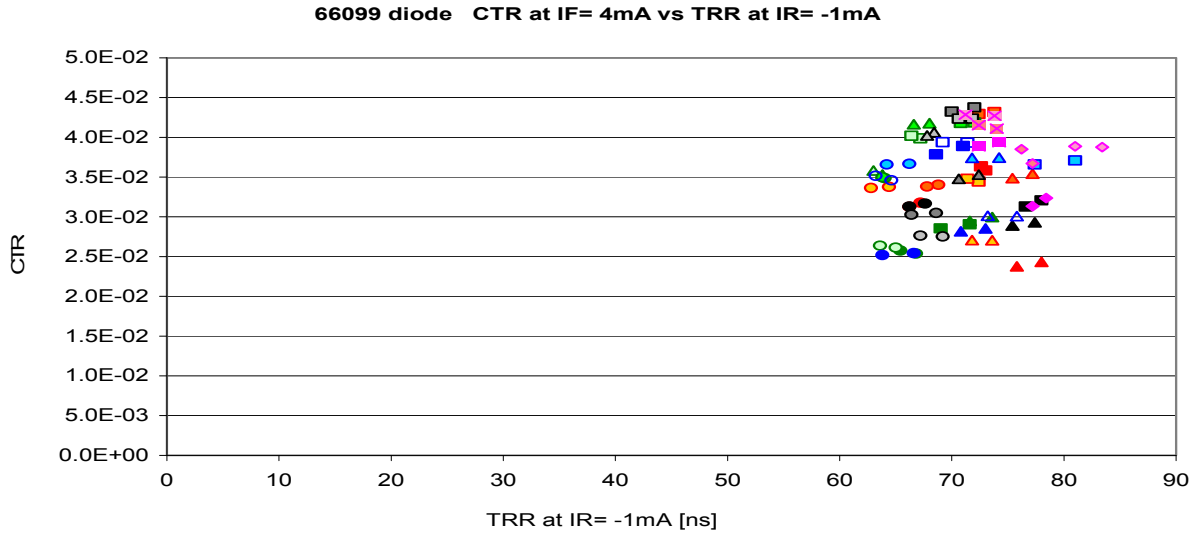
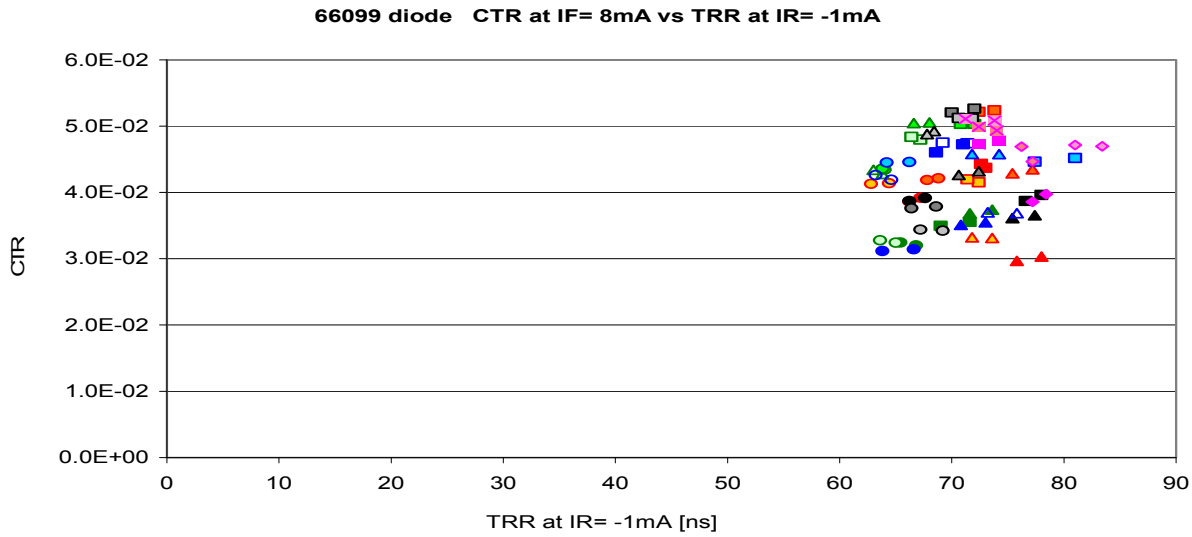


Fig. 14-242: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -1 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -1mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
90
TRR at IR= -1mA [ns]

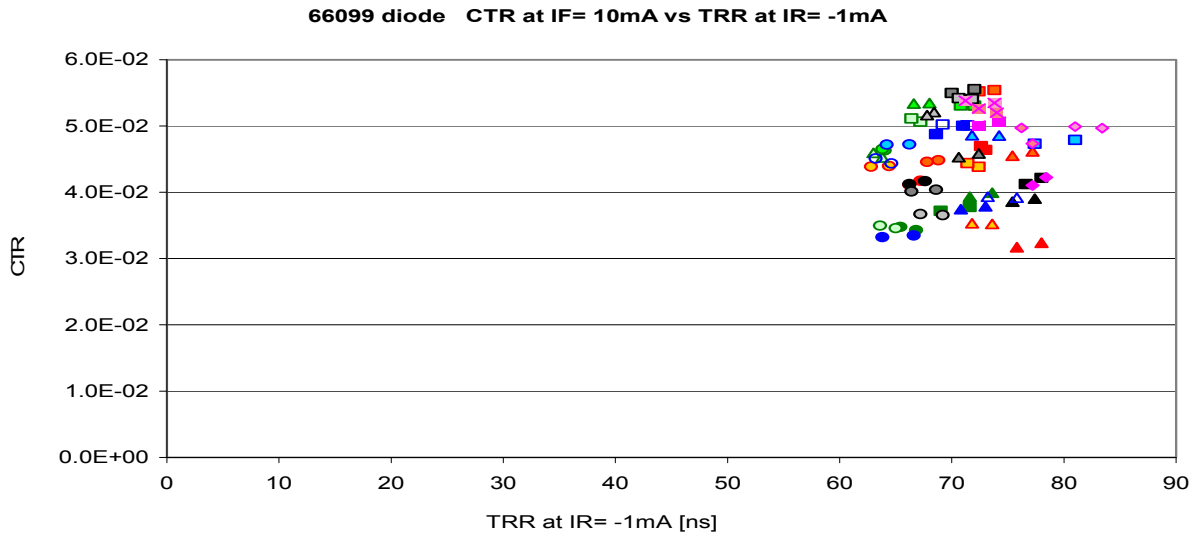
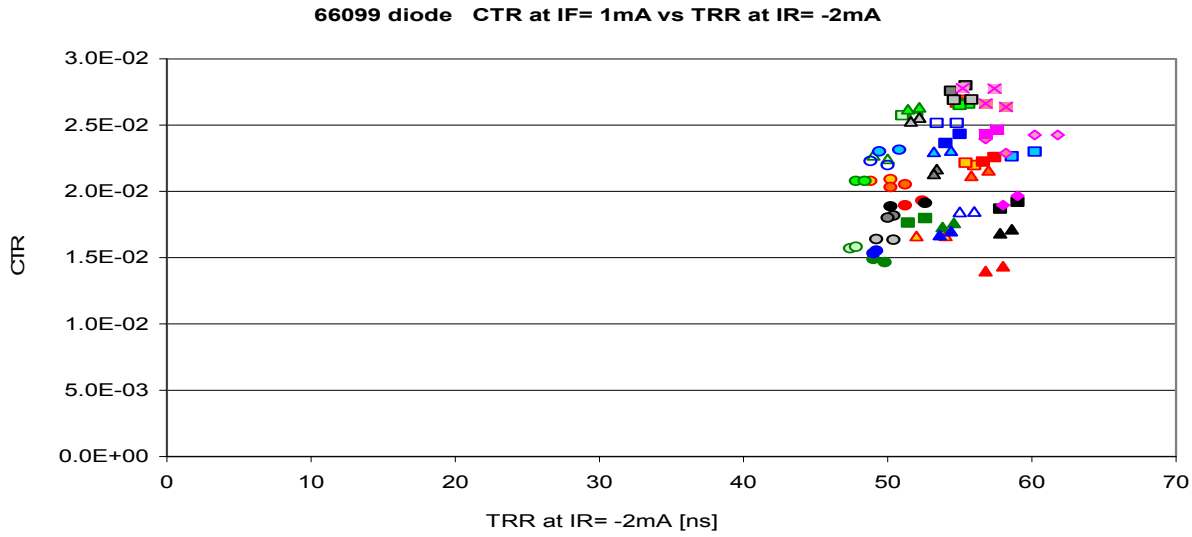
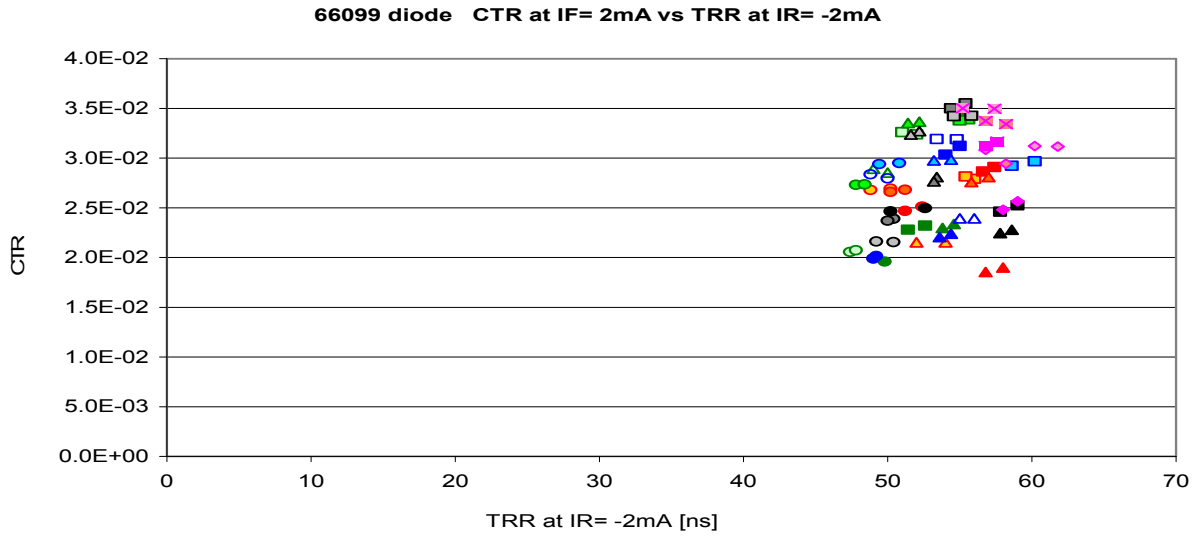
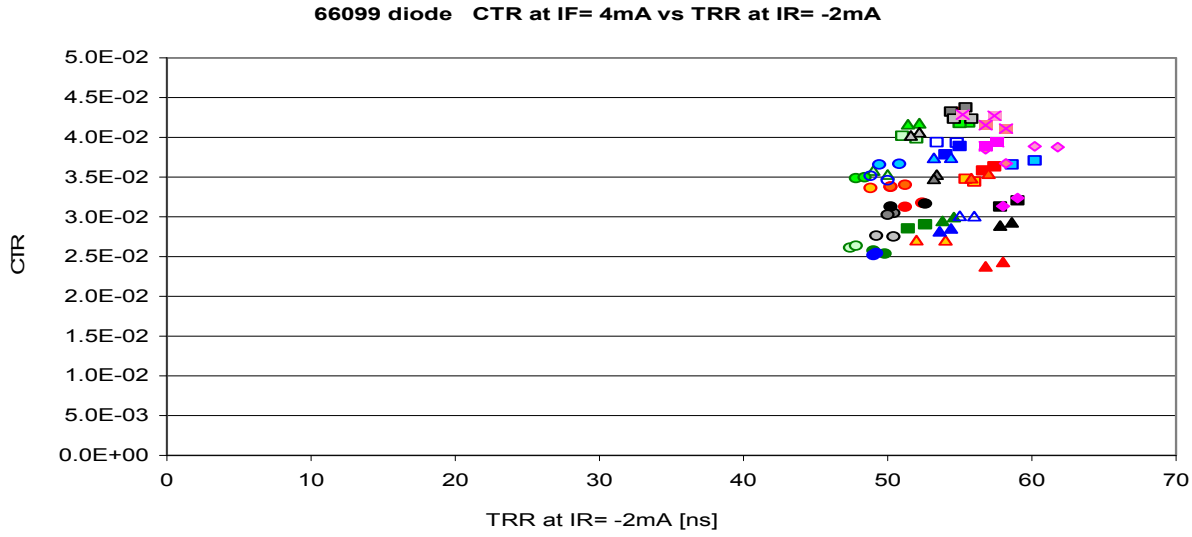
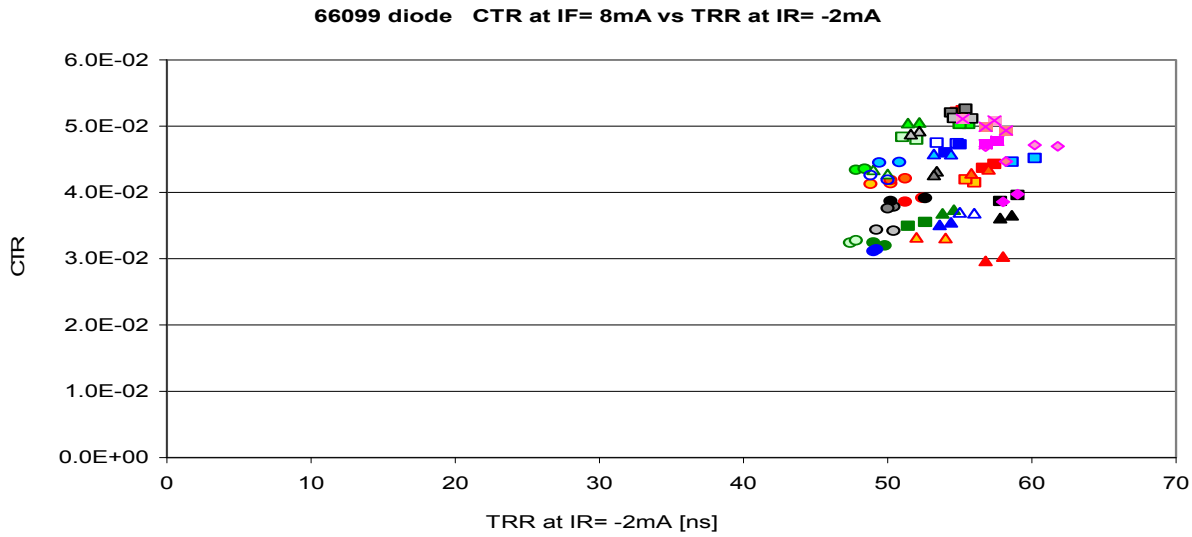

66099 diode CTR at IF= 10mA vs TRR at IR= -1mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
80
90
TRR at IR= -1mA [ns]

Fig. 14-243: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -2 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -2mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -2mA [ns]

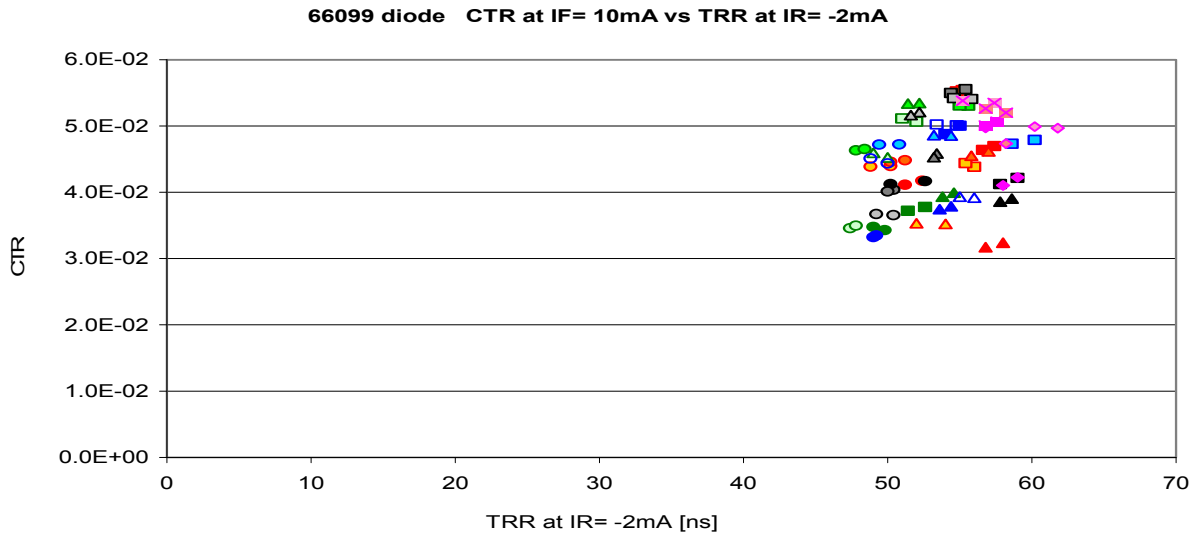
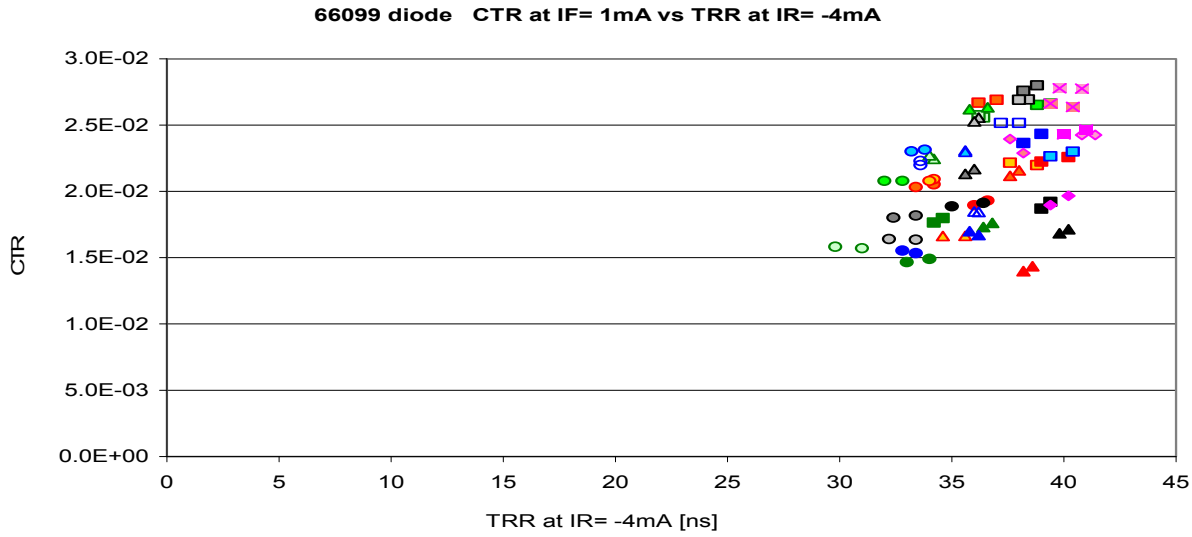
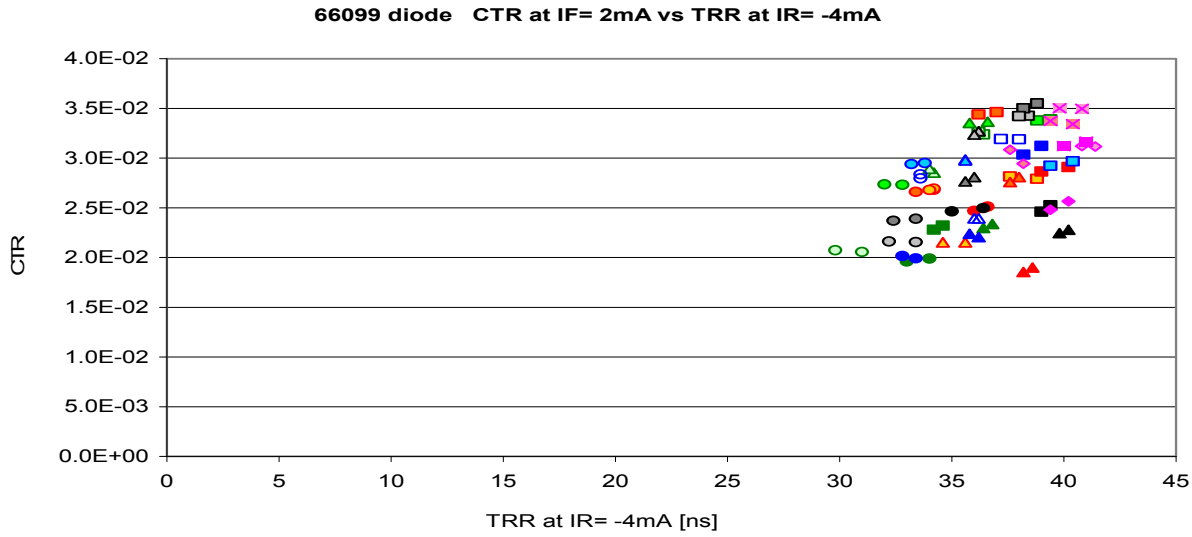
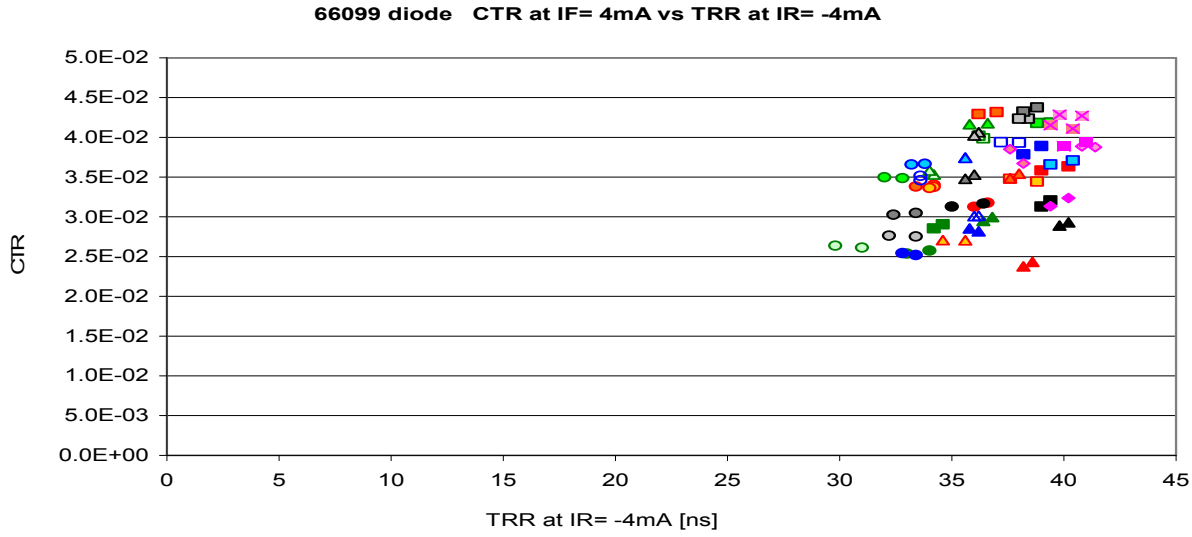
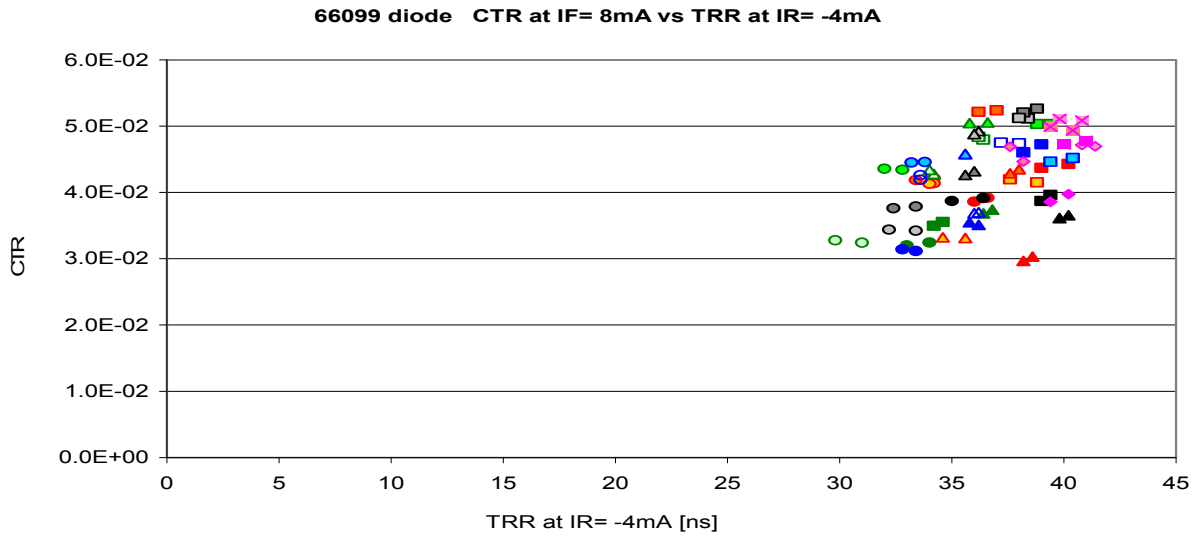

66099 diode CTR at IF= 10mA vs TRR at IR= -2mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
10
20
30
40
50
60
70
TRR at IR= -2mA [ns]

Fig. 14-244: 66099 diode: CTR with respect to τ_{RR} prior irradiation (higher points on the right), and after (lower points on the left), at I_R = -4 mA, and I_F = 1, 2, 4, 8, 10 mA








66099 diode CTR at IF= 8mA vs TRR at IR= -4mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
5
10
15
20
25
30
35
40
45
TRR at IR= -4mA [ns]

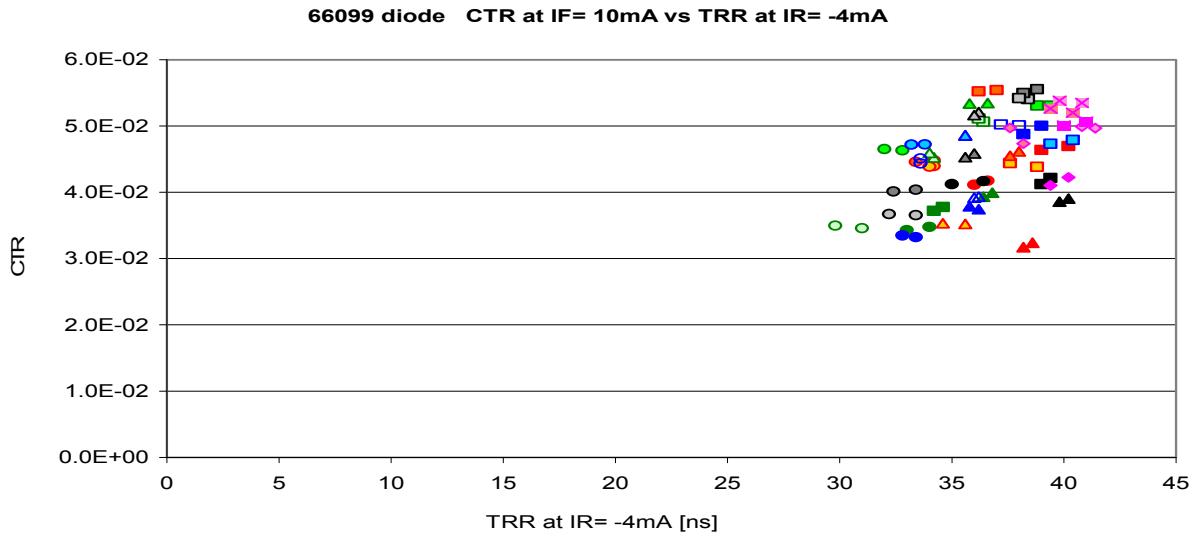
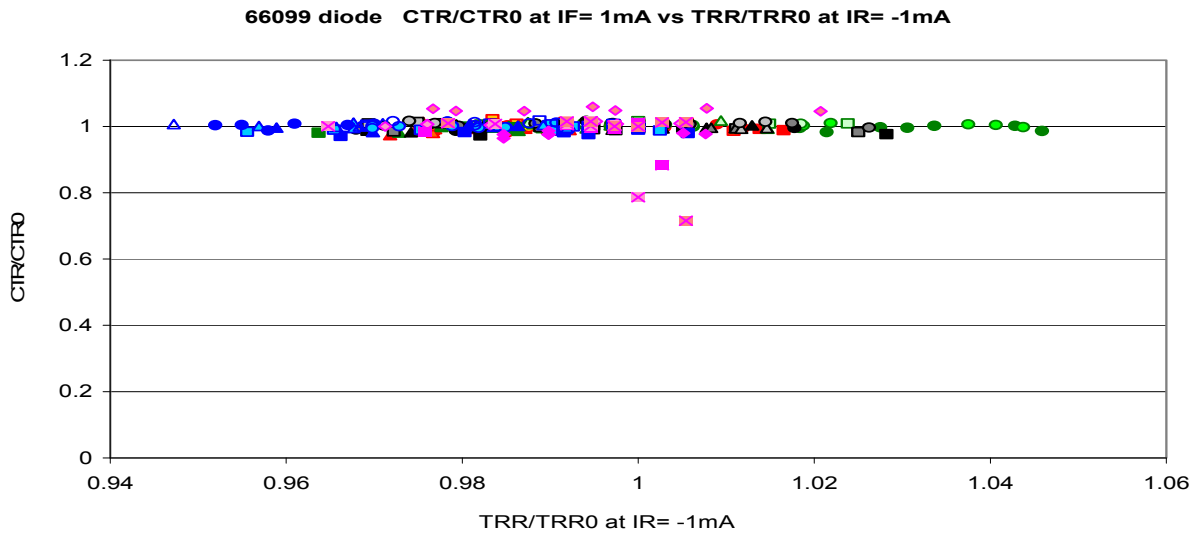
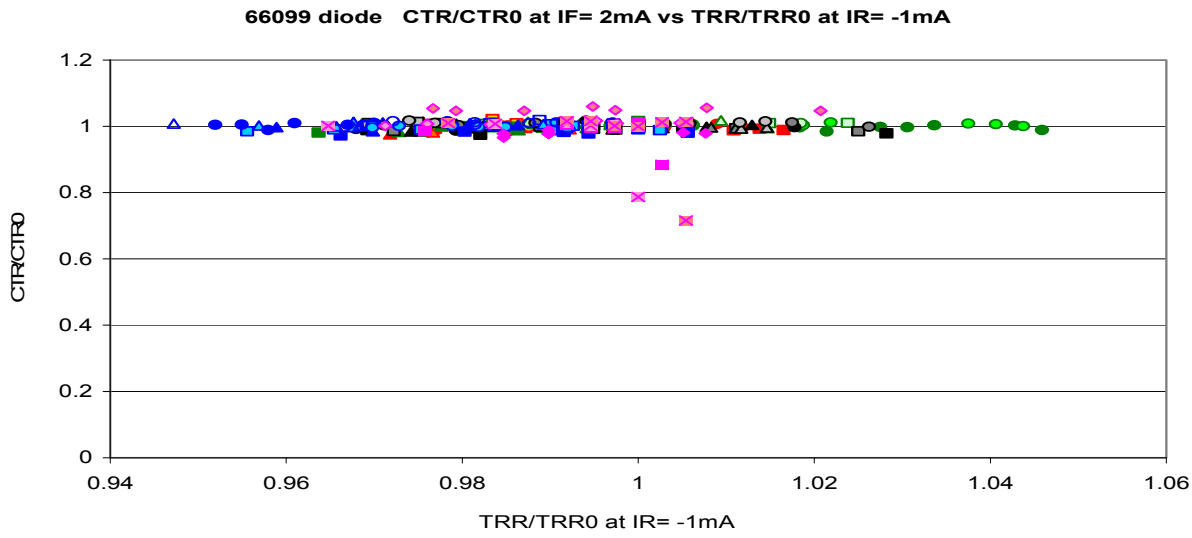
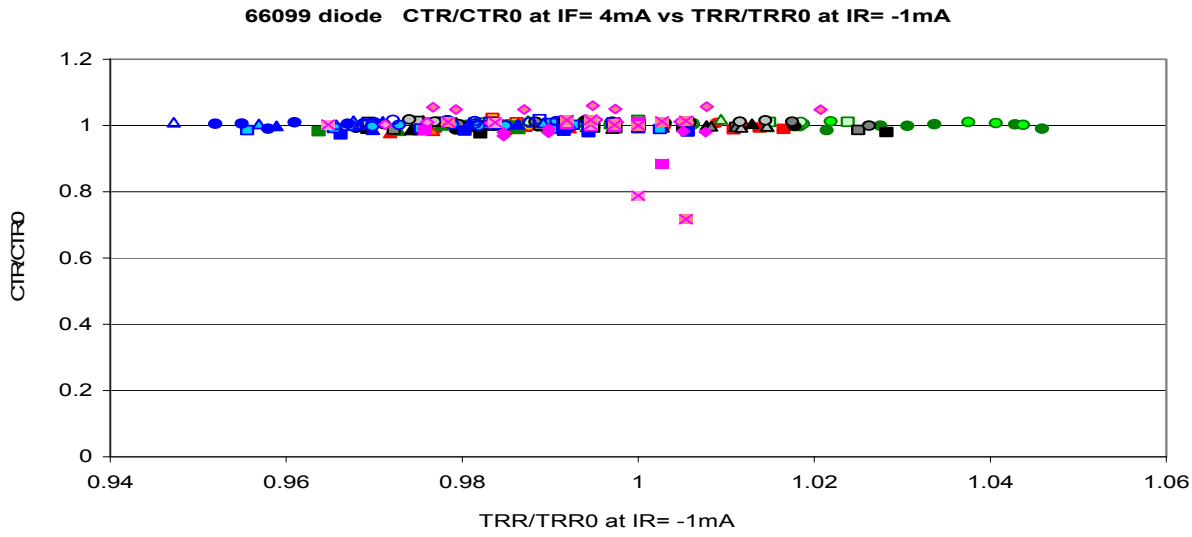
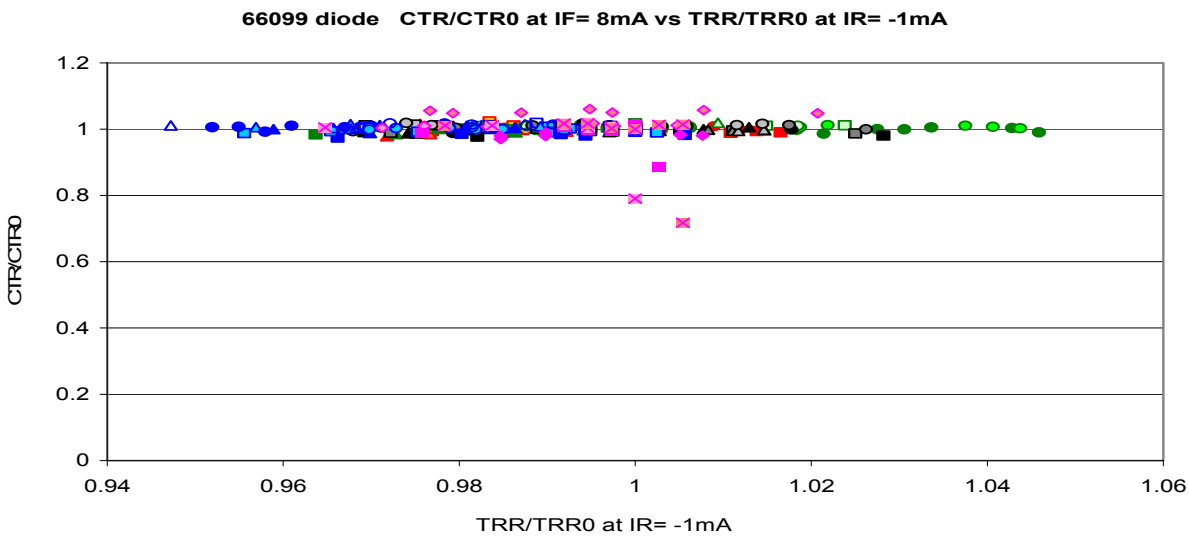

66099 diode CTR at IF= 10mA vs TRR at IR= -4mA
CTR
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
5
10
15
20
25
30
35
40
45
TRR at IR= -4mA [ns]

Fig. 14-245: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -1 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR/TRR0 at IR= -1mA

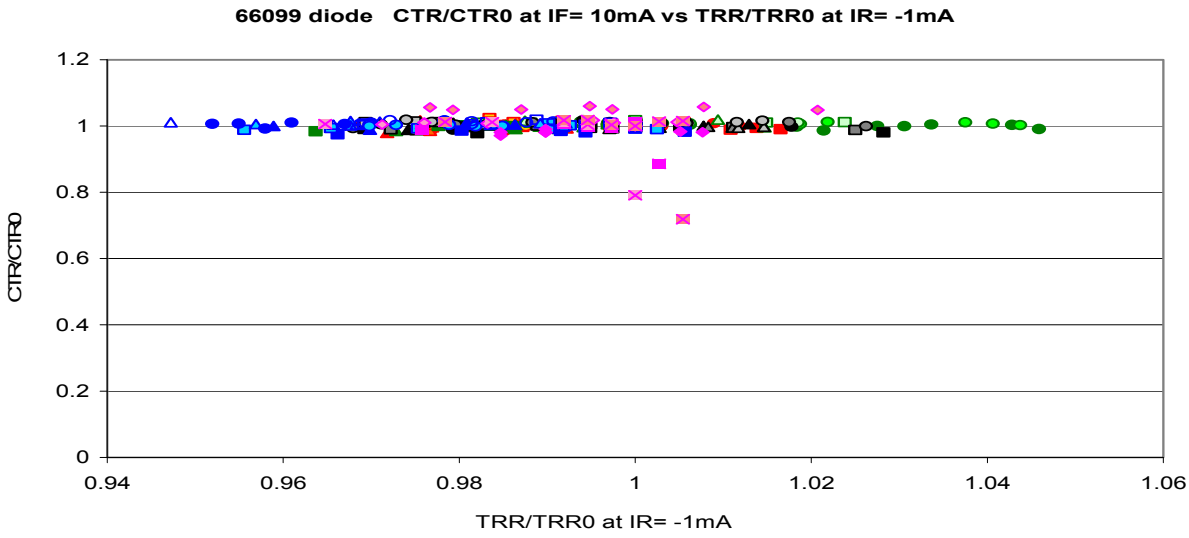
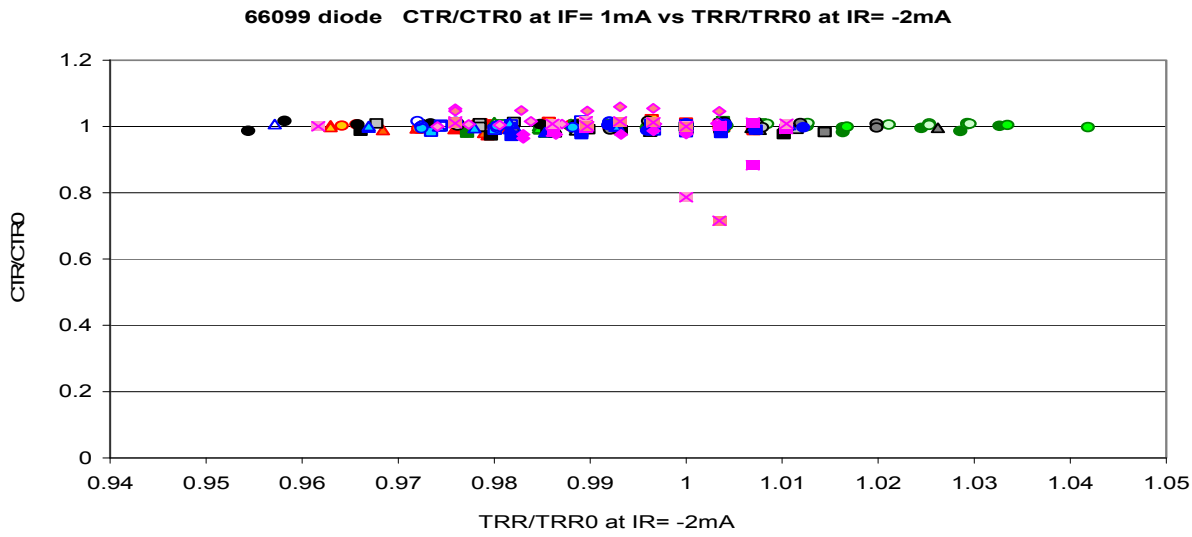
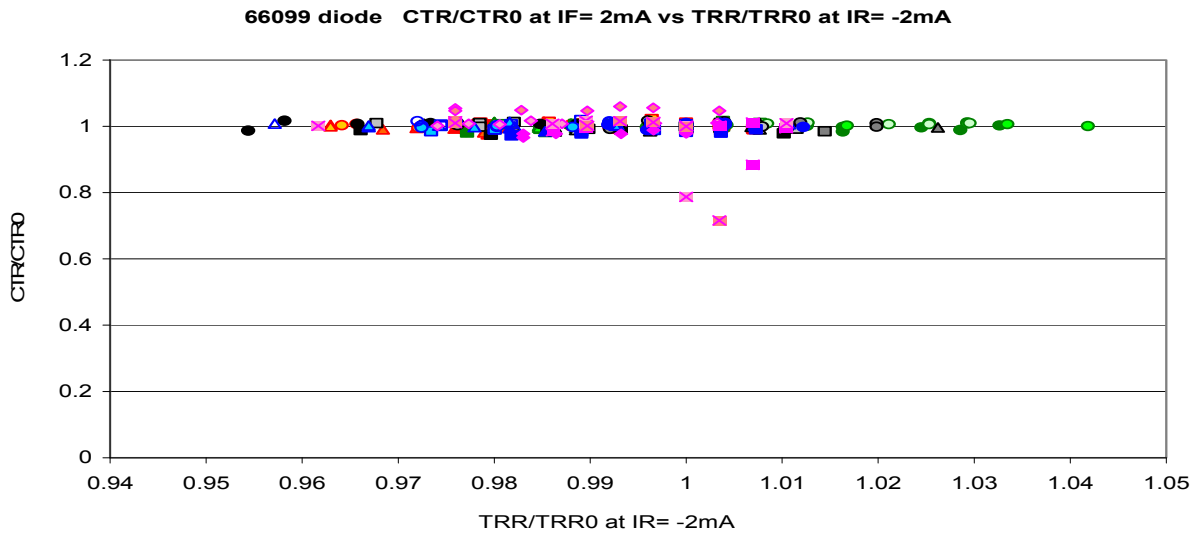
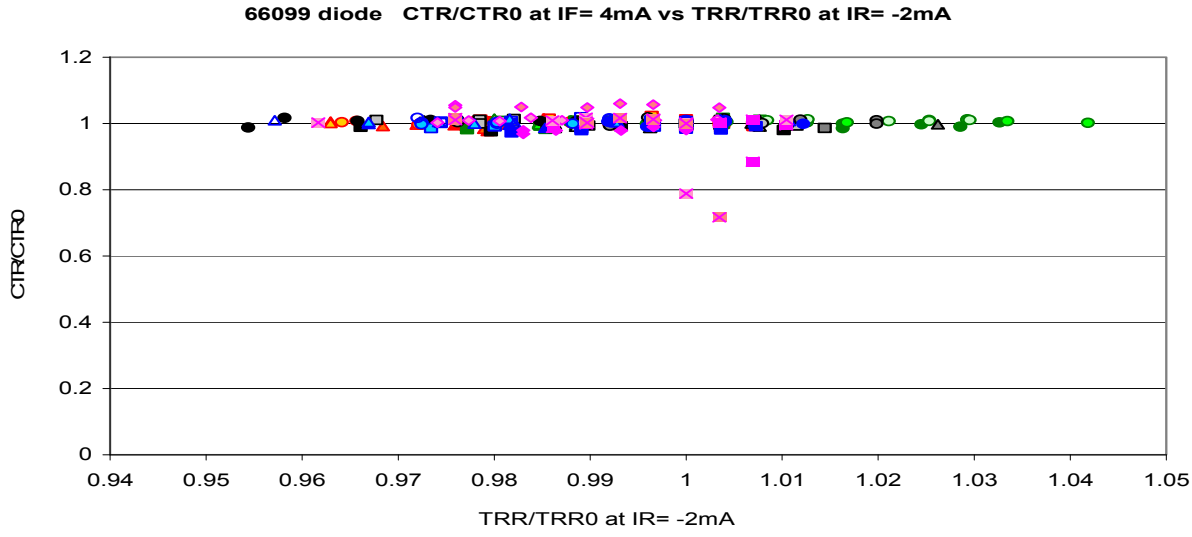
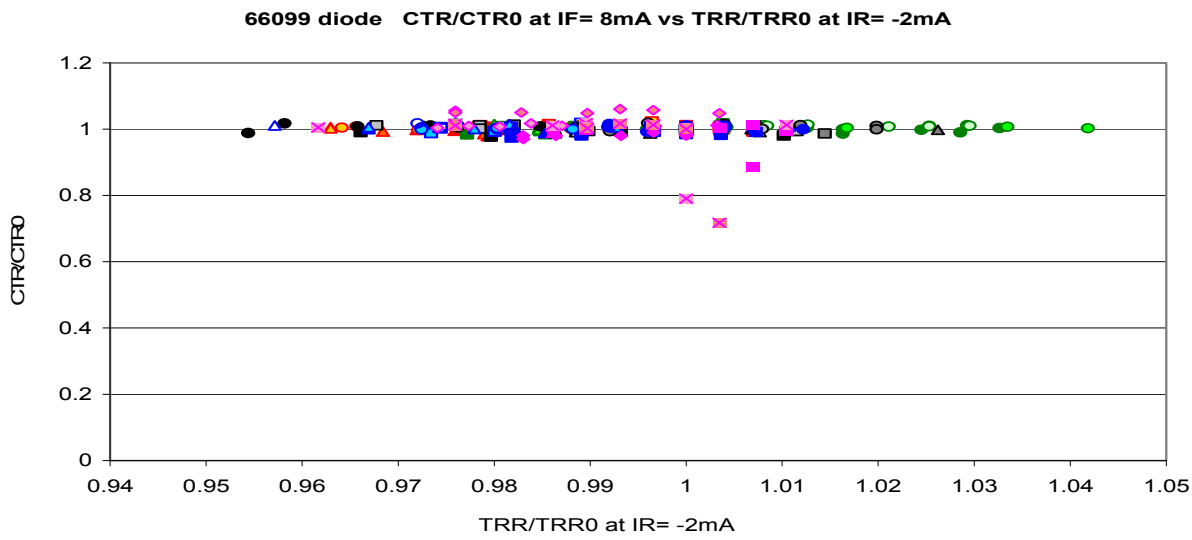

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -1mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR/TRR0 at IR= -1mA

Fig. 14-246: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -2 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.95
0.96
0.97
0.98
0.99
1
1.01
1.02
1.03
1.04
1.05
TRR/TRR0 at IR= -2mA

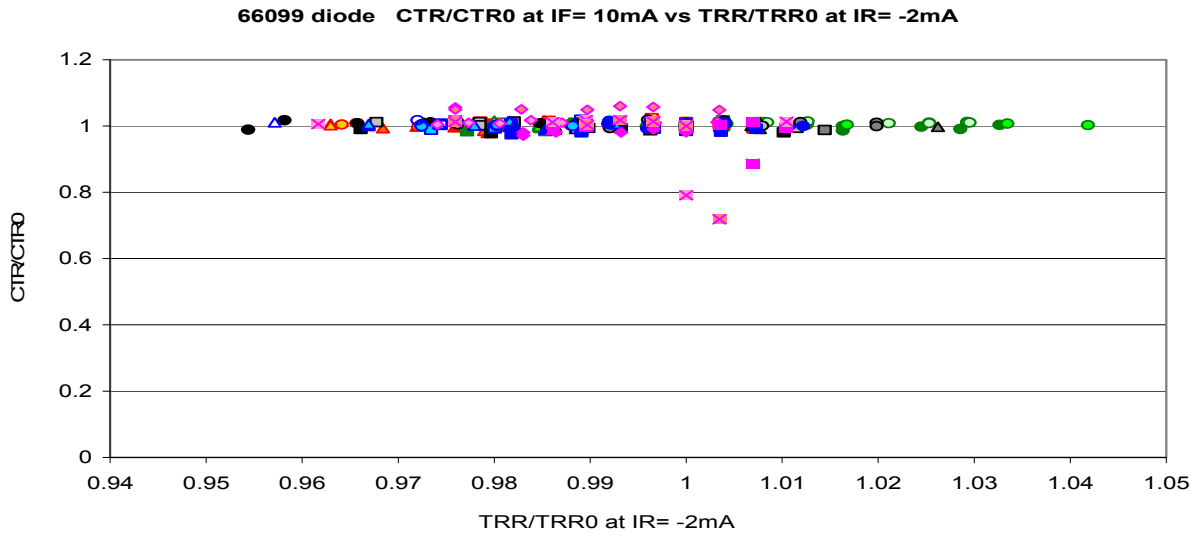
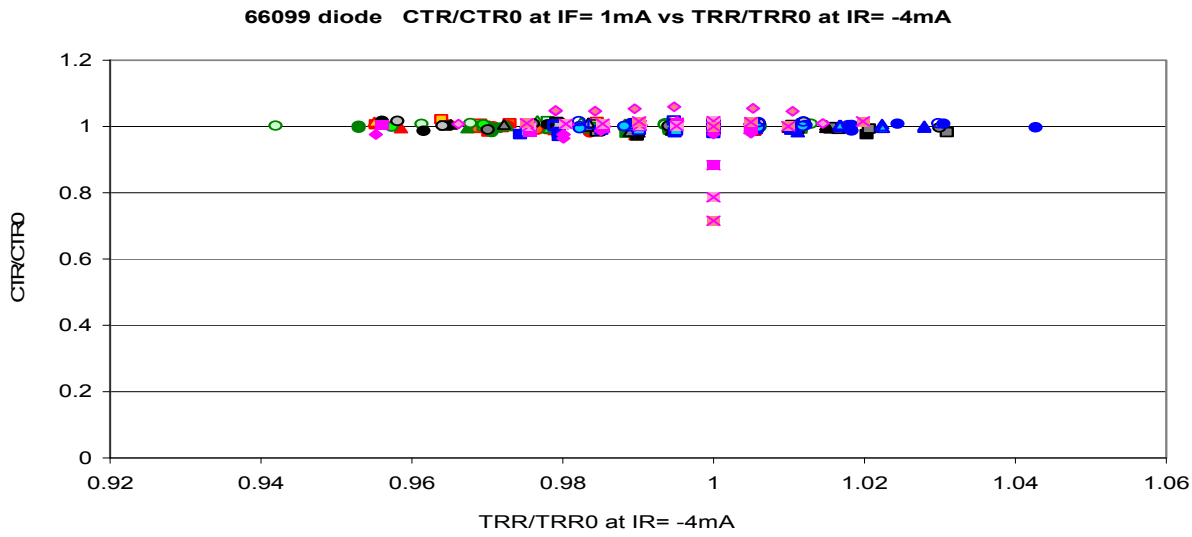
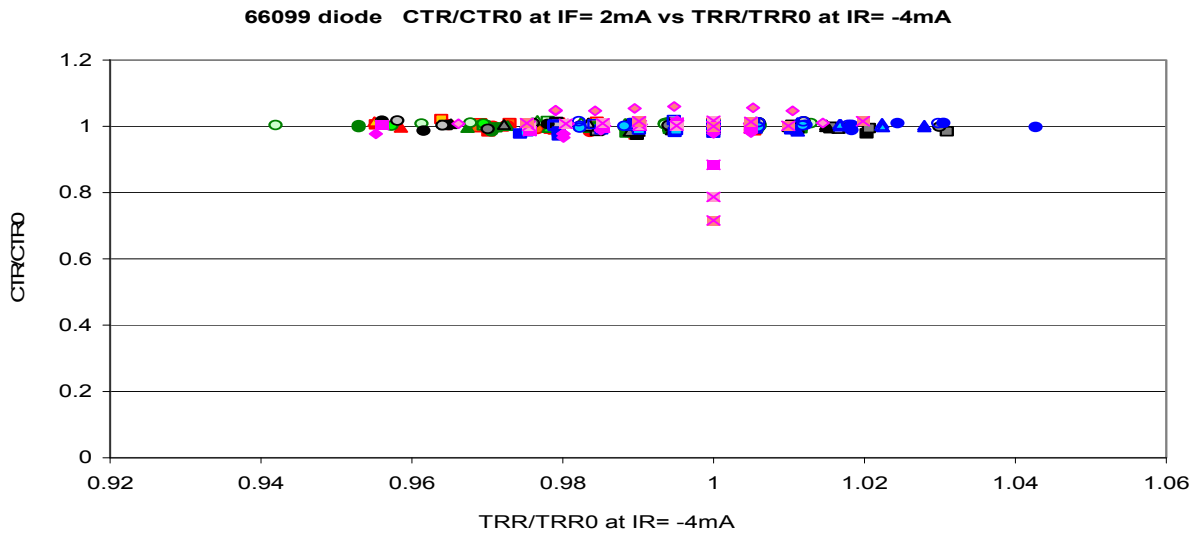
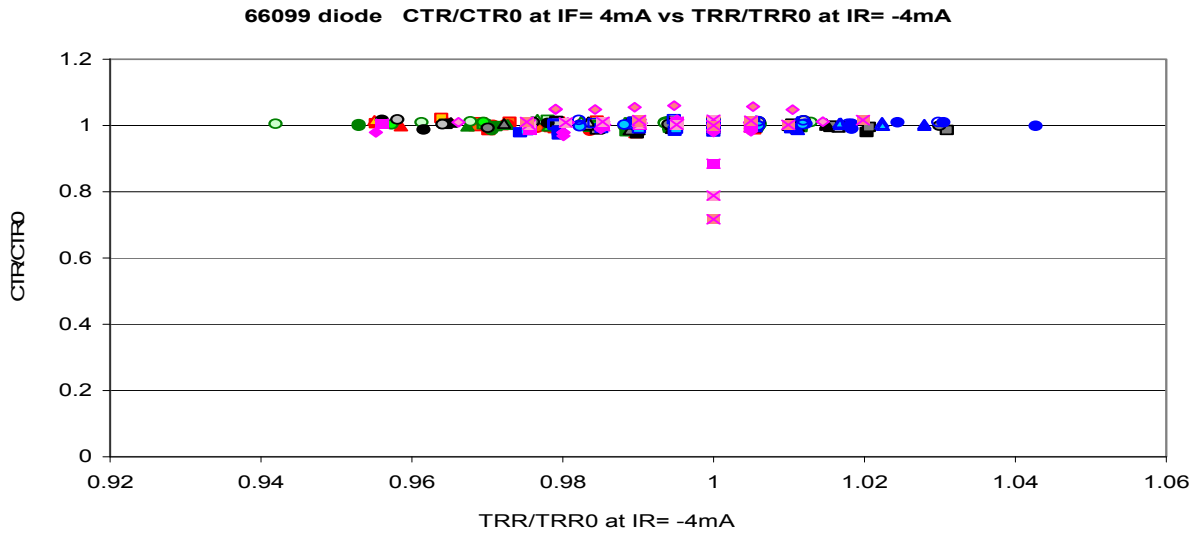
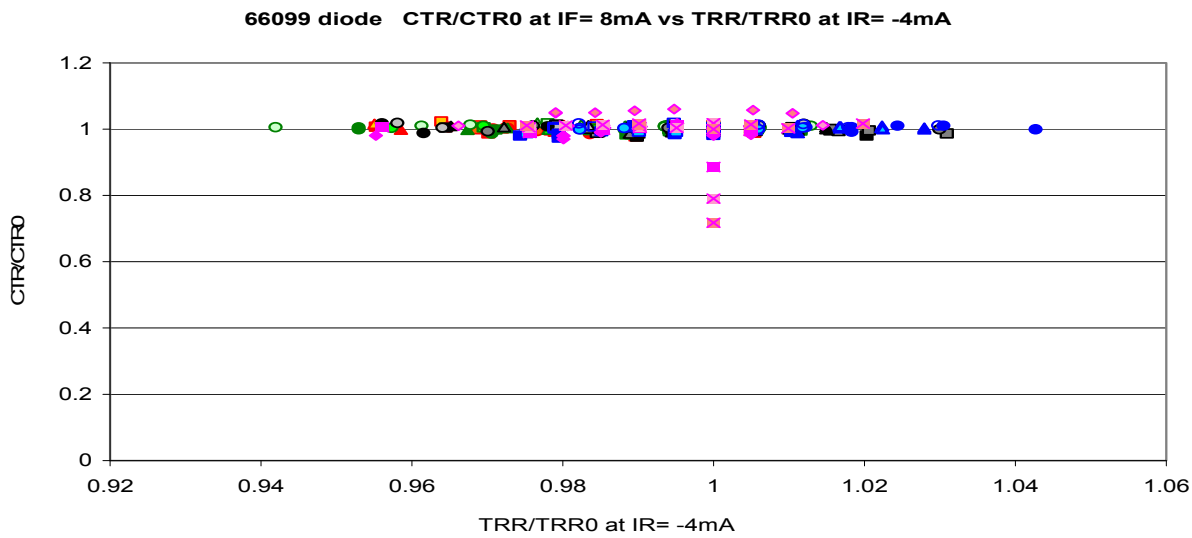

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -2mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.95
0.96
0.97
0.98
0.99
1
1.01
1.02
1.03
1.04
1.05
TRR/TRR0 at IR= -2mA

Fig. 14-247: 66099 diode: CTR/CTR$_0$ at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR}/ τ_{RR0} at I_R = -4 mA








66099 diode CTR/CTR0 at IF= 8mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR/TRR0 at IR= -4mA

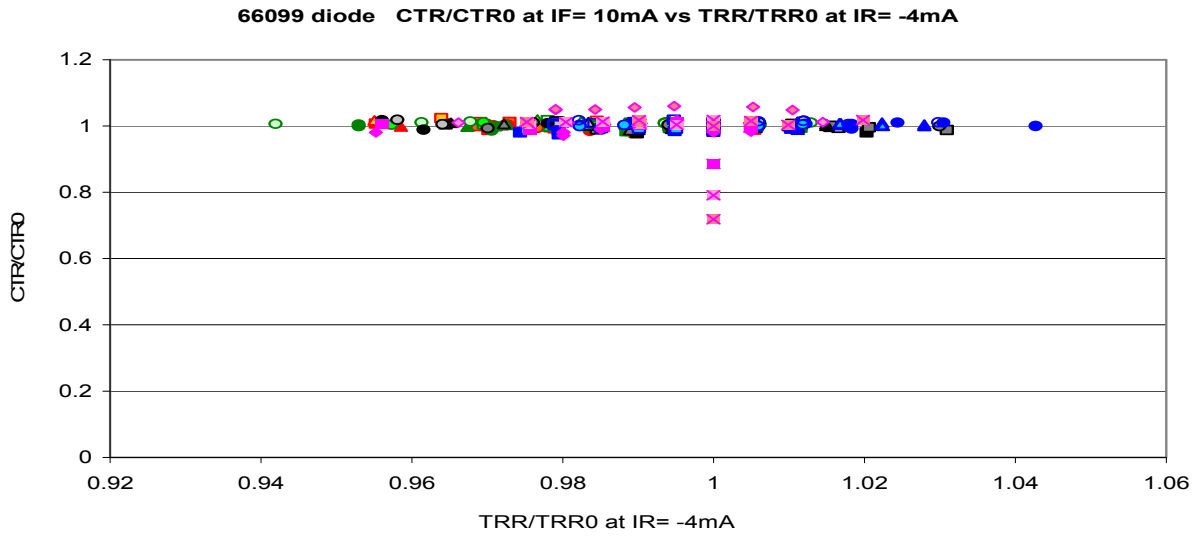
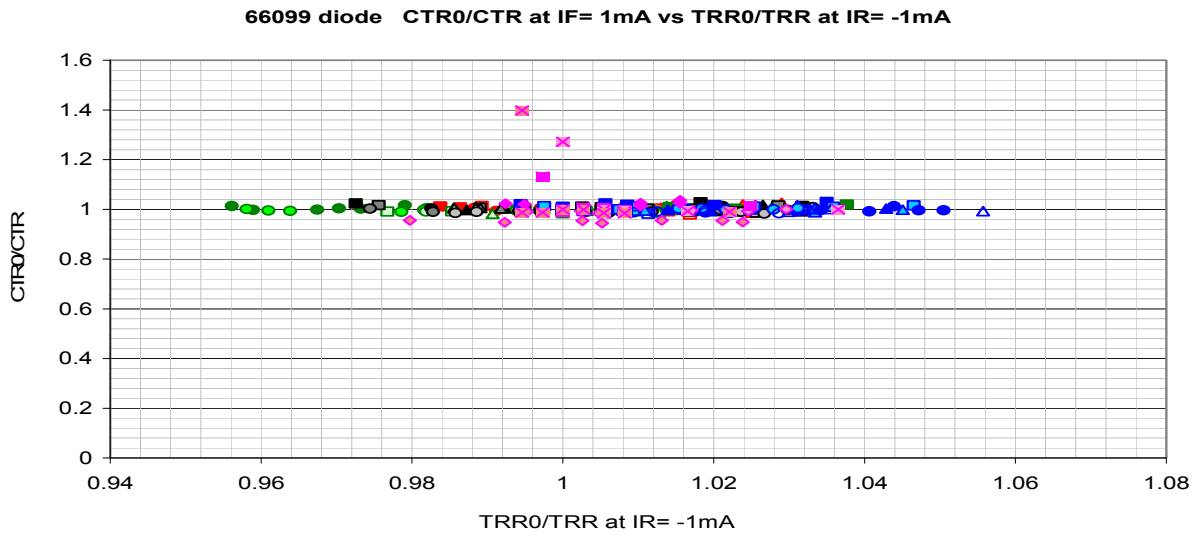
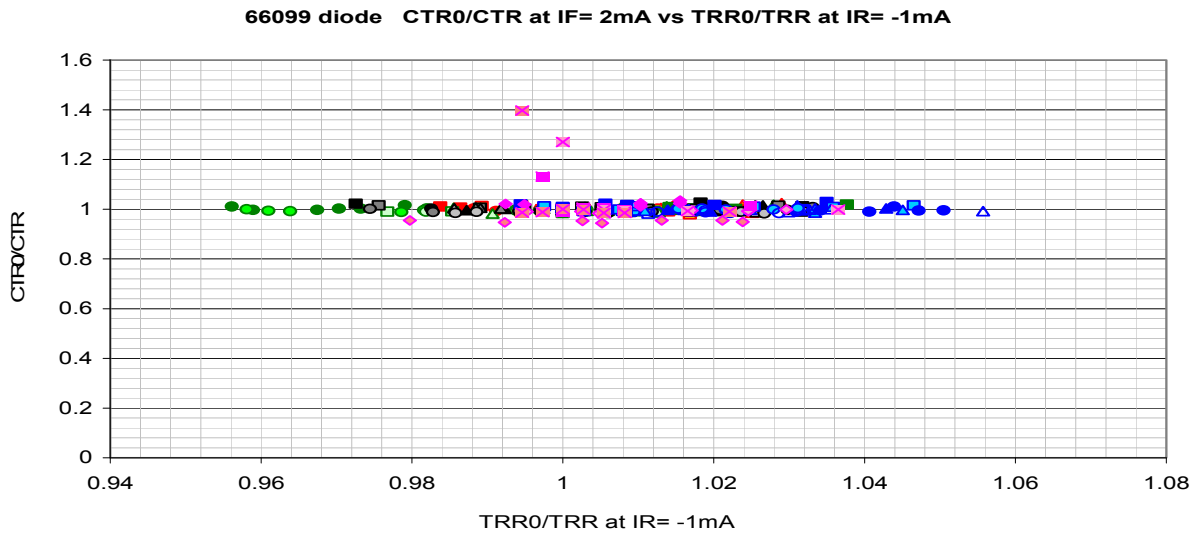
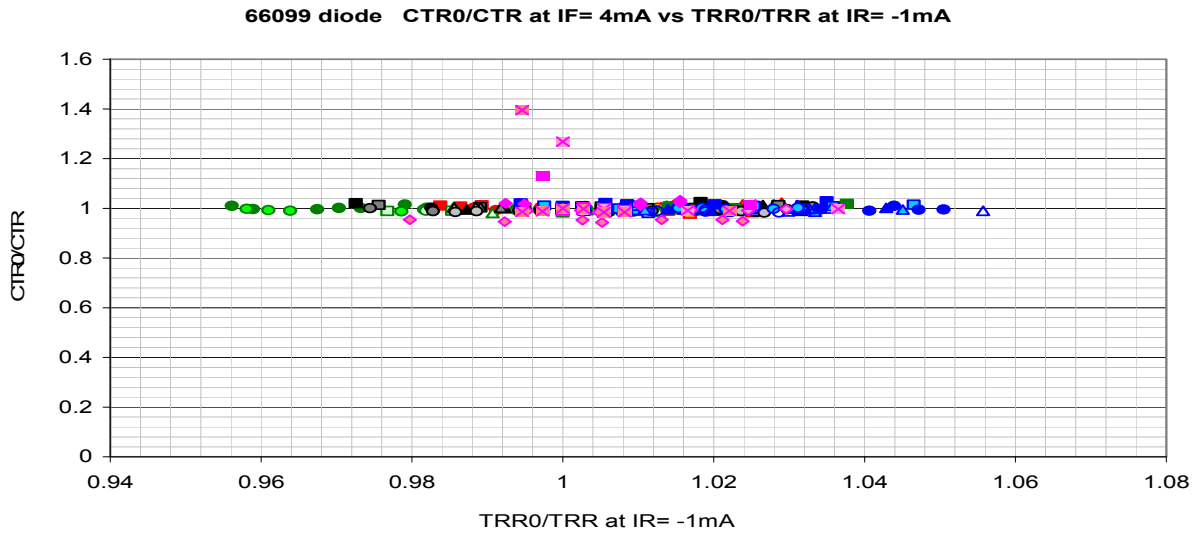
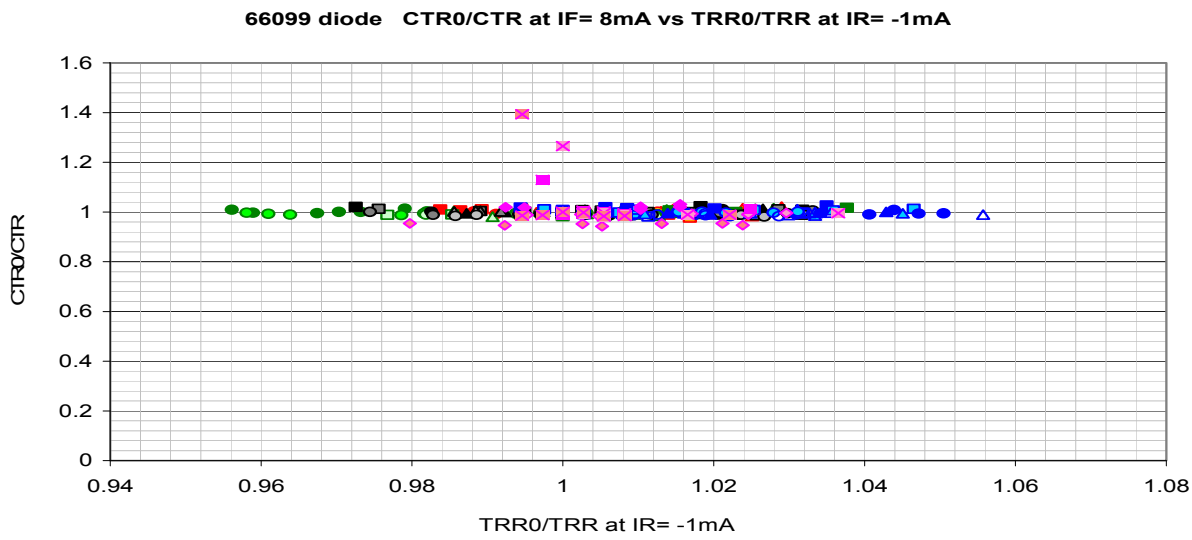

66099 diode CTR/CTR0 at IF= 10mA vs TRR/TRR0 at IR= -4mA
CTR/CTR0
1.2
1
0.8
0.6
0.4
0.2
0
0.92
0.94
0.96
0.98
1
1.02
1.04
1.06
TRR/TRR0 at IR= -4mA

Fig. 14-248: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -1 mA








66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
TRR0/TRR at IR= -1mA

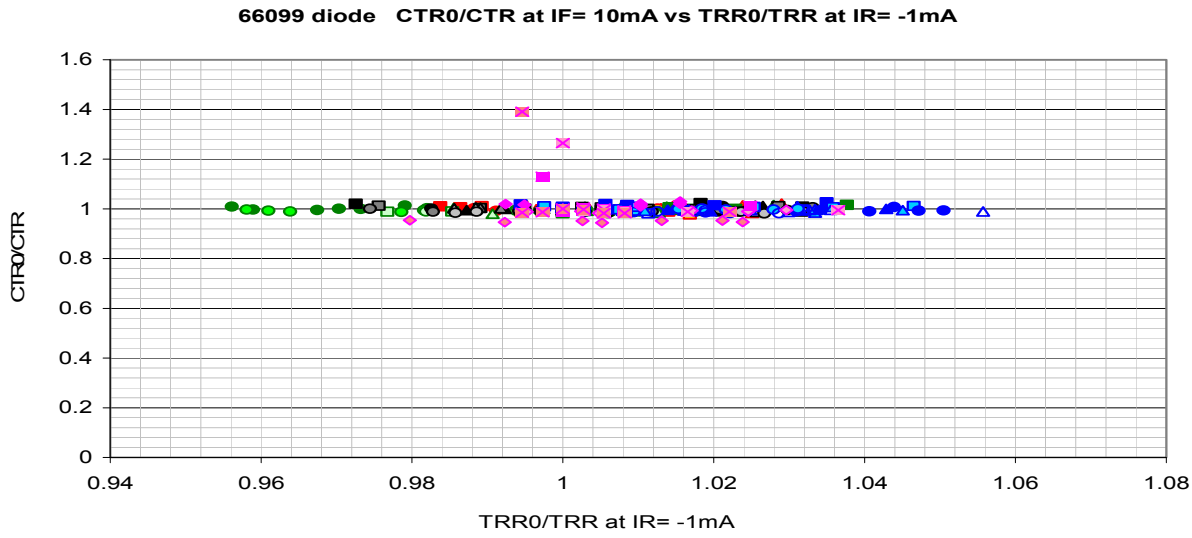
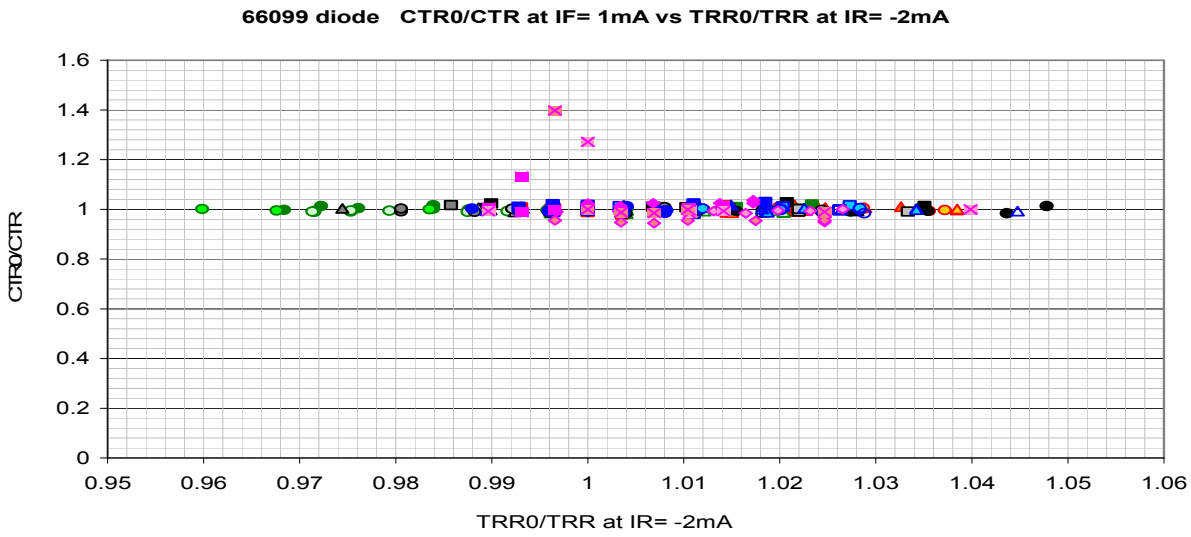
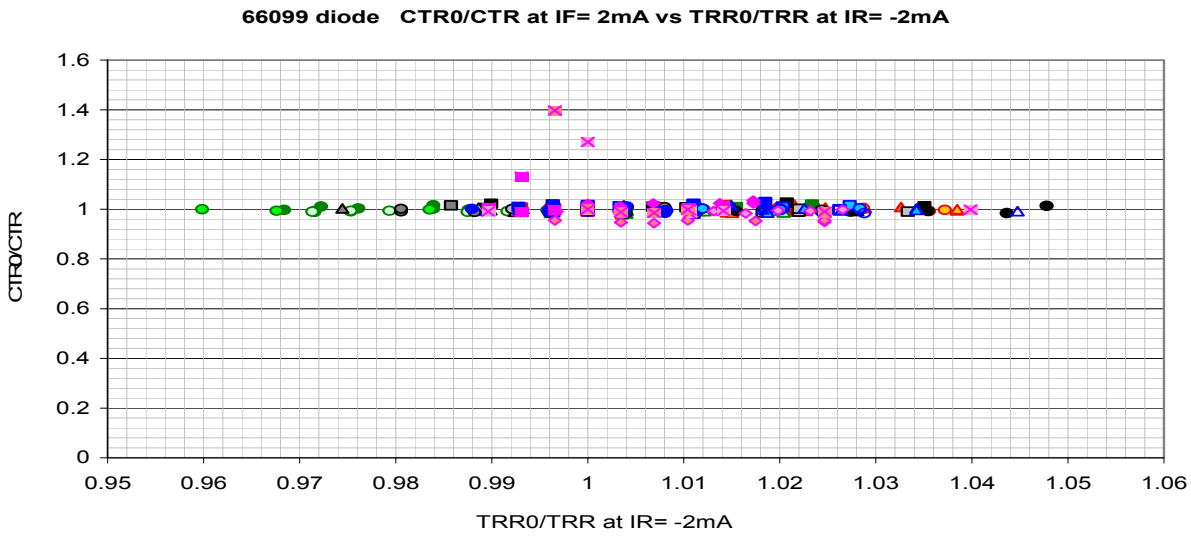
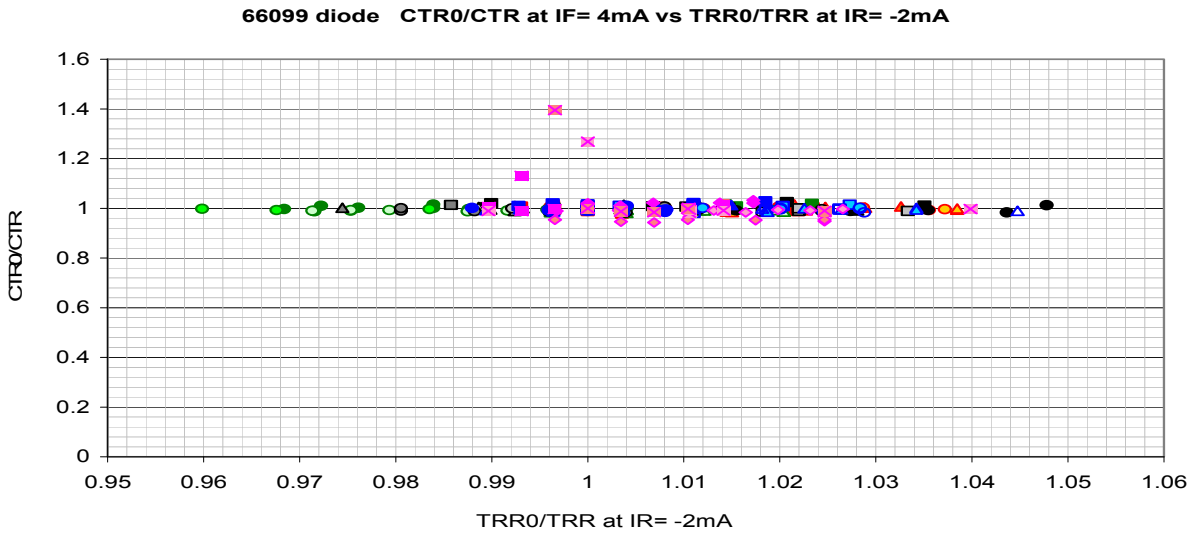
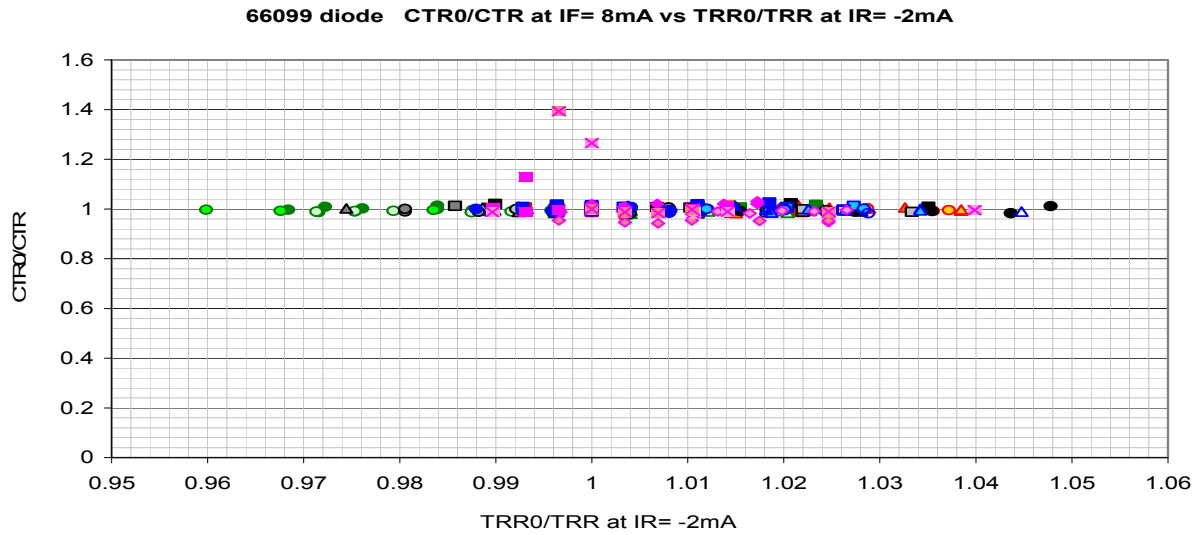

66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -1mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
TRR0/TRR at IR= -1mA

Fig. 14-249: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -2 mA








66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.95
0.96
0.97
0.98
0.99
1
1.01
1.02
1.03
1.04
1.05
1.06
TRR0/TRR at IR= -2mA

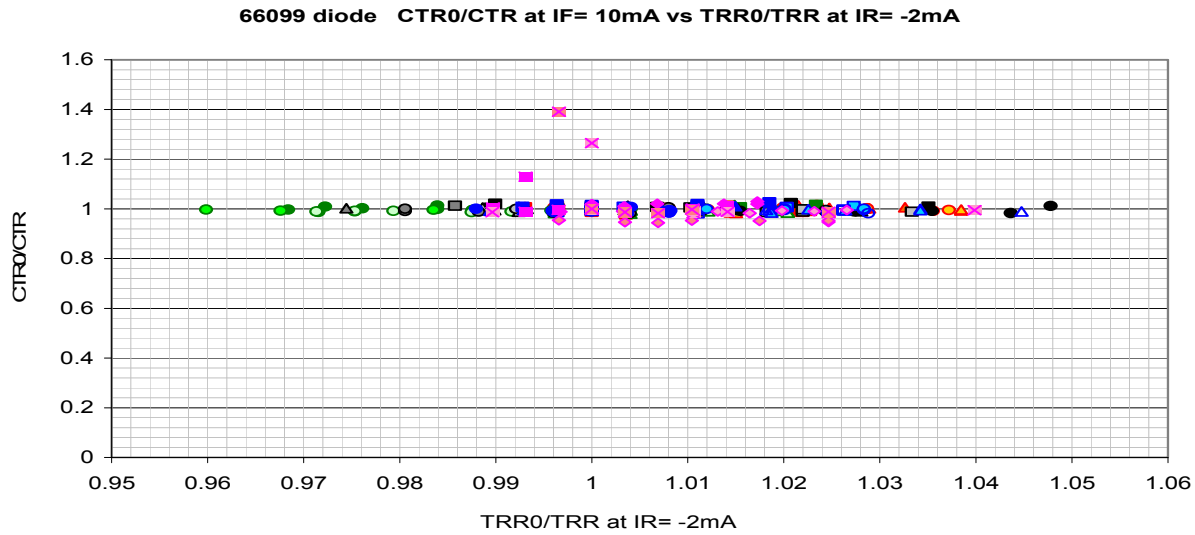
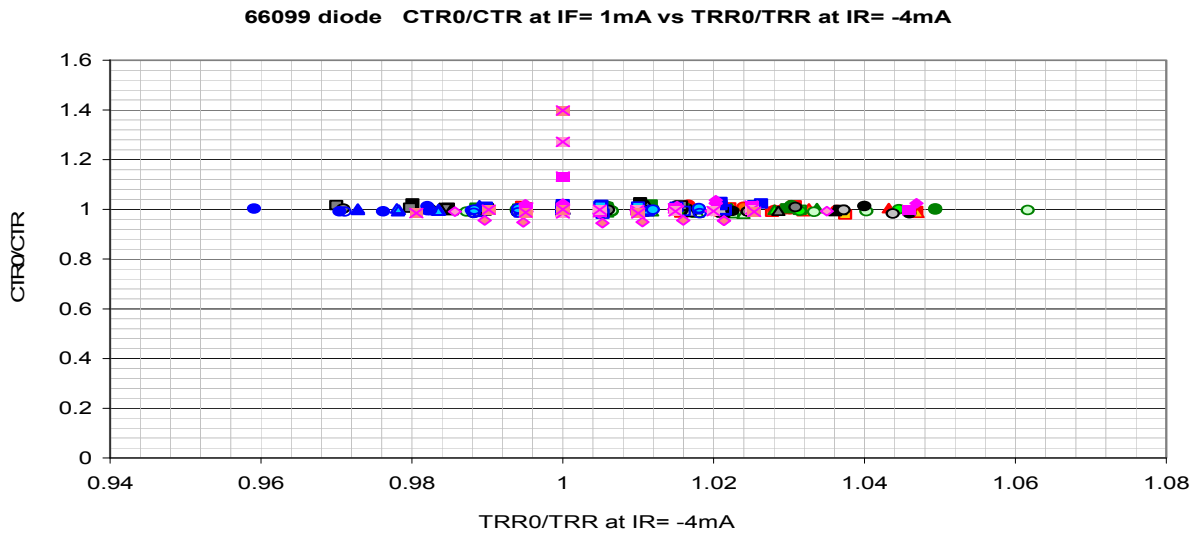
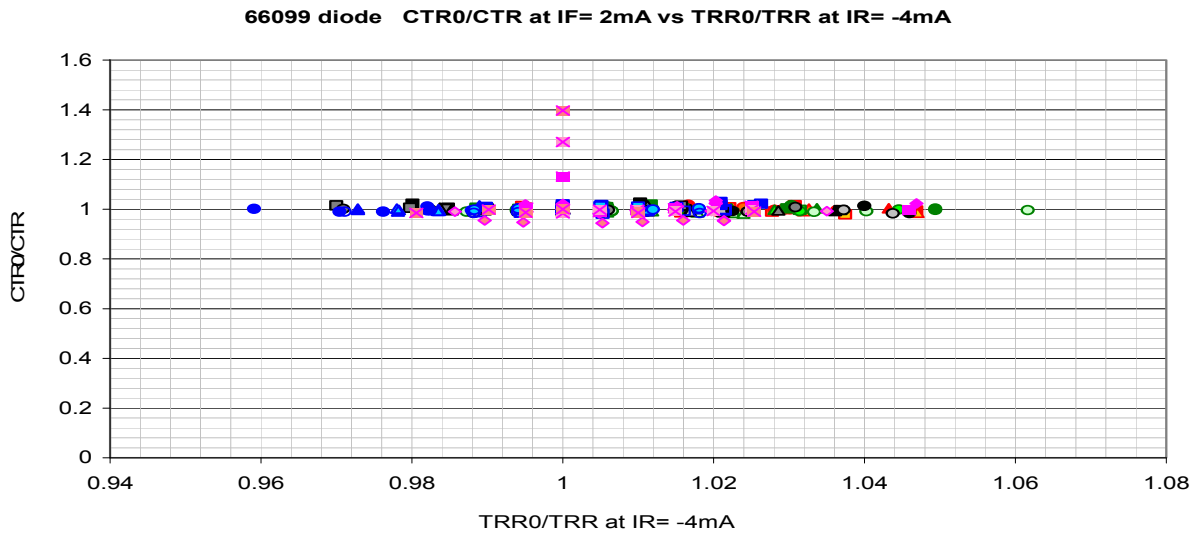
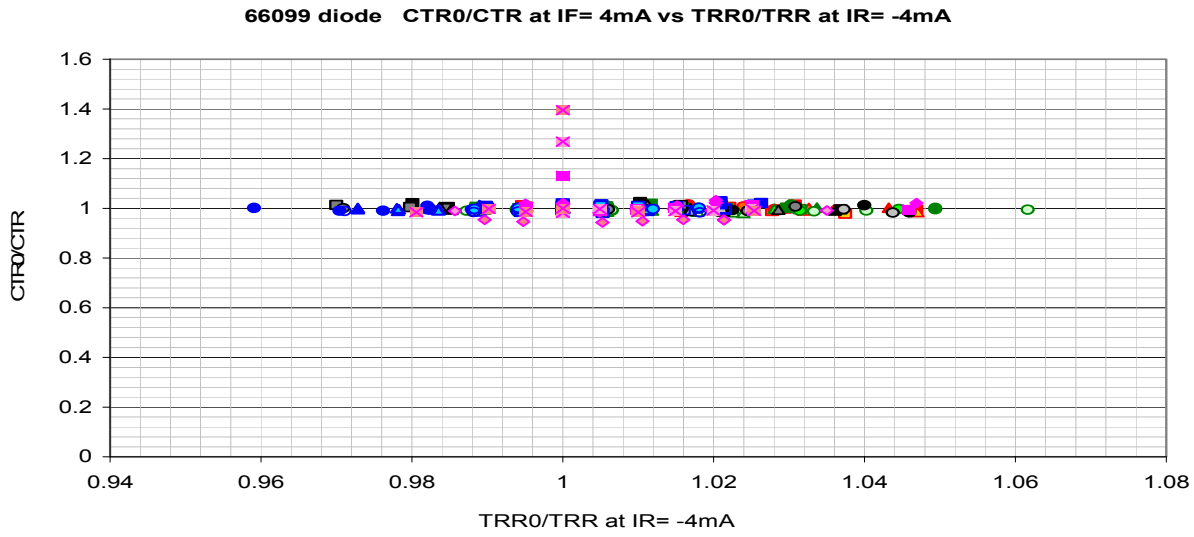
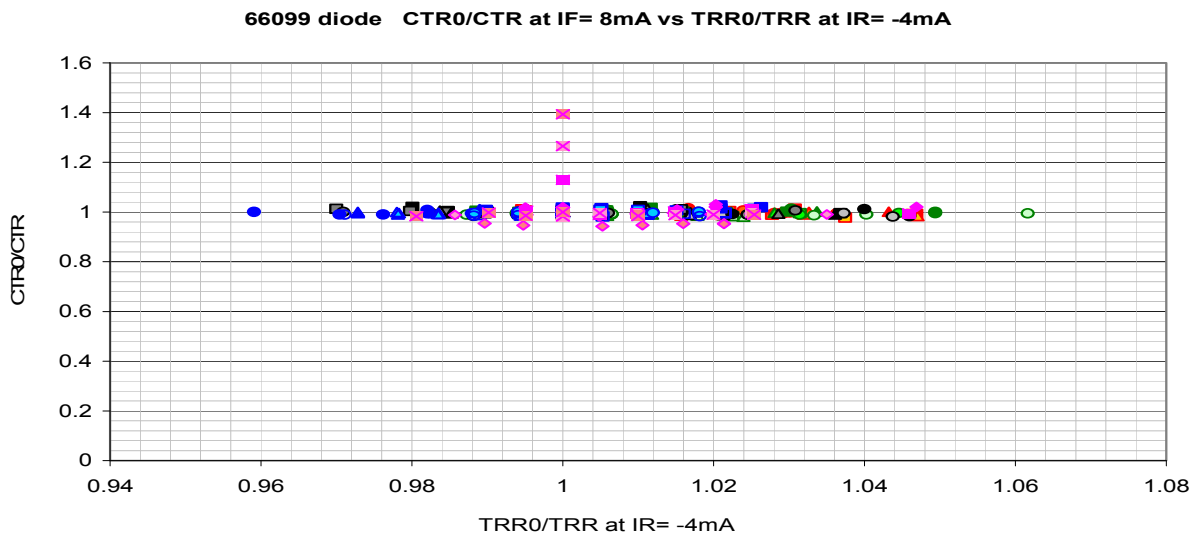

66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -2mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.95
0.96
0.97
0.98
0.99
1
1.01
1.02
1.03
1.04
1.05
1.06
TRR0/TRR at IR= -2mA

Fig. 14-250: 66099 diode: CTR_0/CTR at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0}/τ_{RR} at I_R = -4 mA








66099 diode CTR0/CTR at IF= 8mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
TRR0/TRR at IR= -4mA

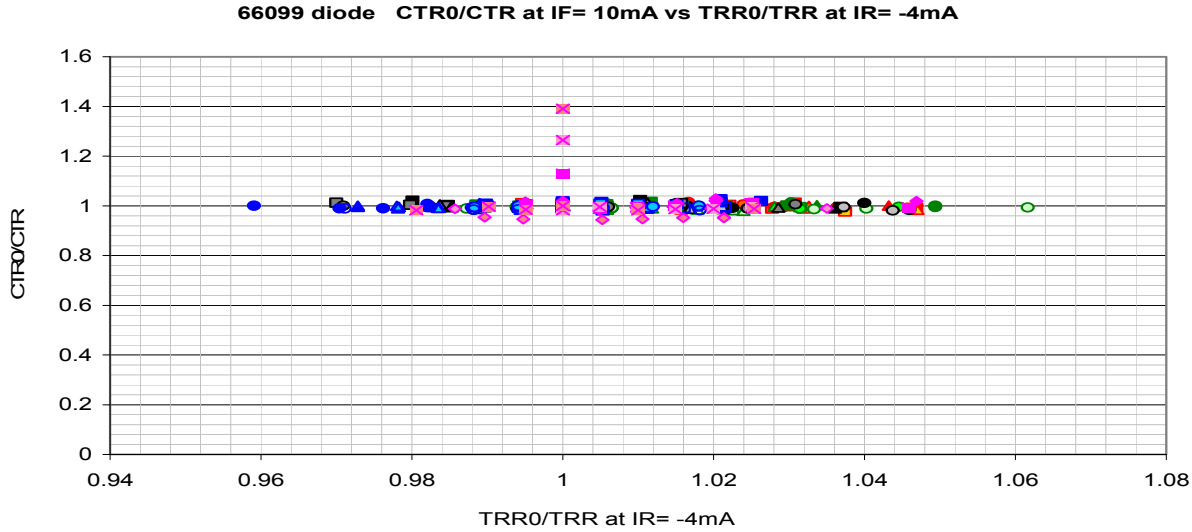
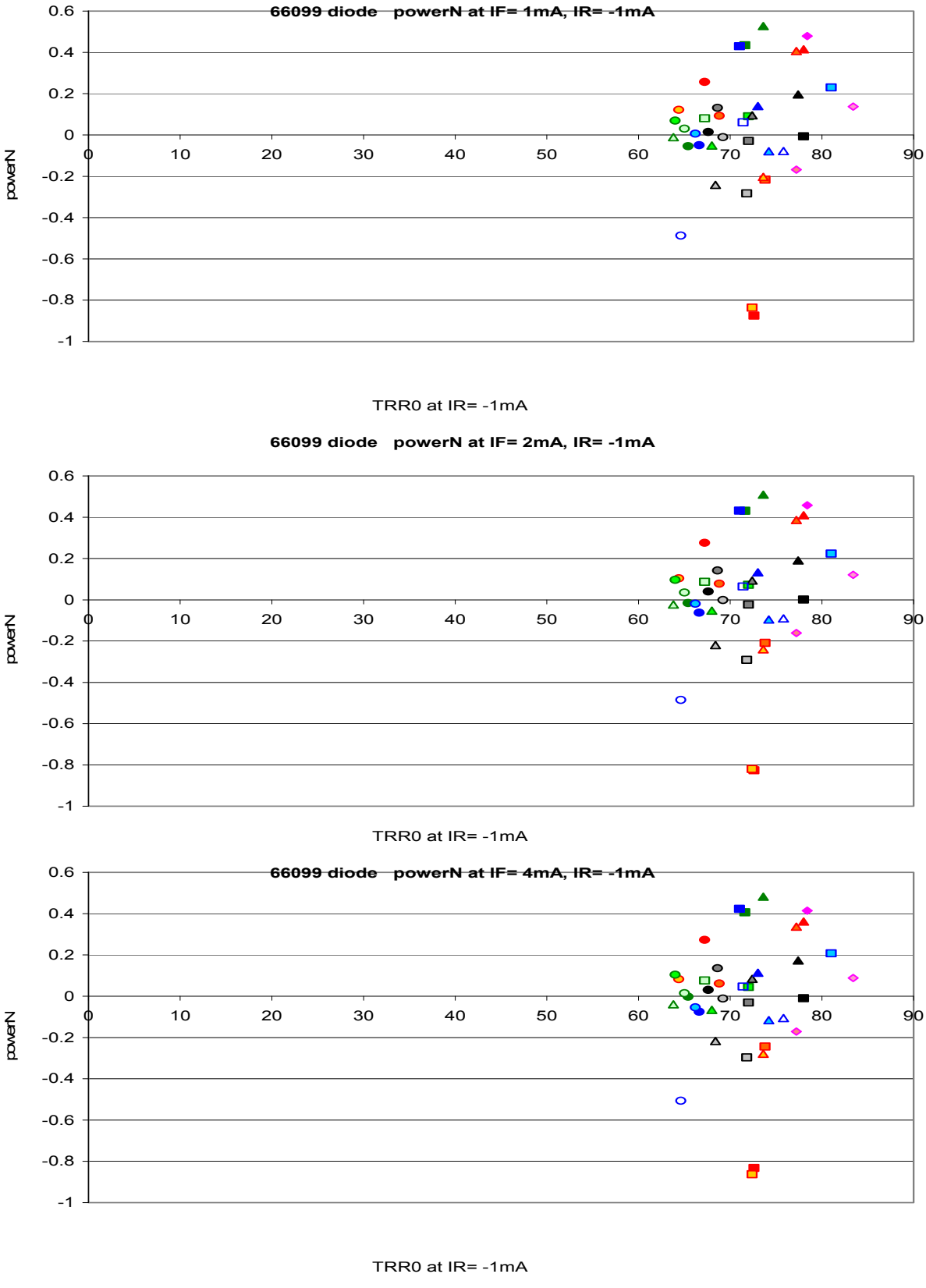
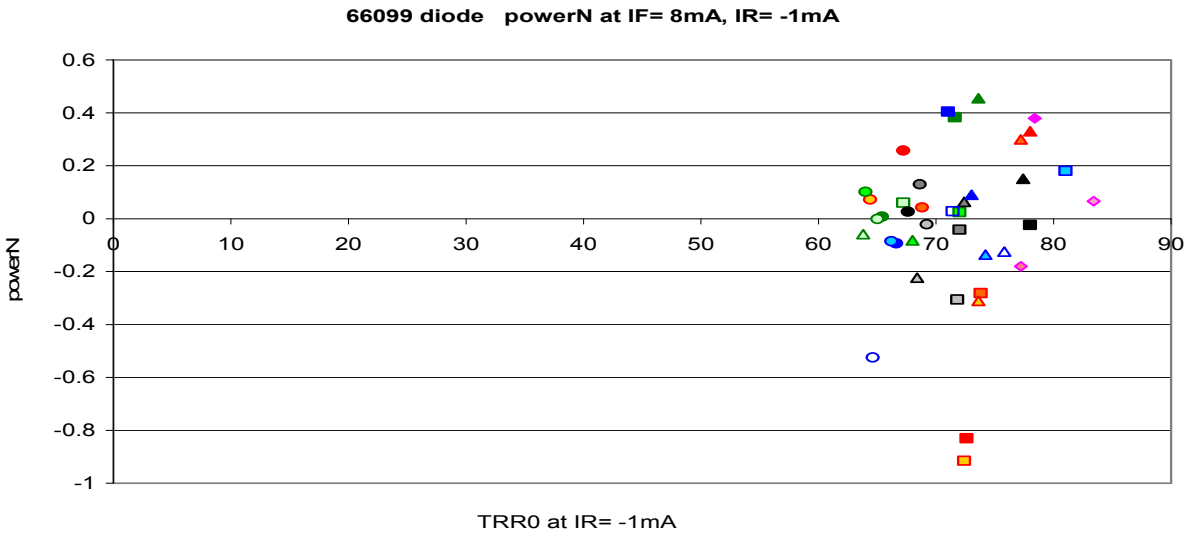

66099 diode CTR0/CTR at IF= 10mA vs TRR0/TRR at IR= -4mA
CTR0/CTR
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.94
0.96
0.98
1
1.02
1.04
1.06
1.08
TRR0/TRR at IR= -4mA

Fig. 14-251: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -1 mA




66099 diode powerN at IF= 8mA, IR= -1mA
powerN
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
10
20
30
40
50
60
70
80
90
TRR0 at IR= -1mA

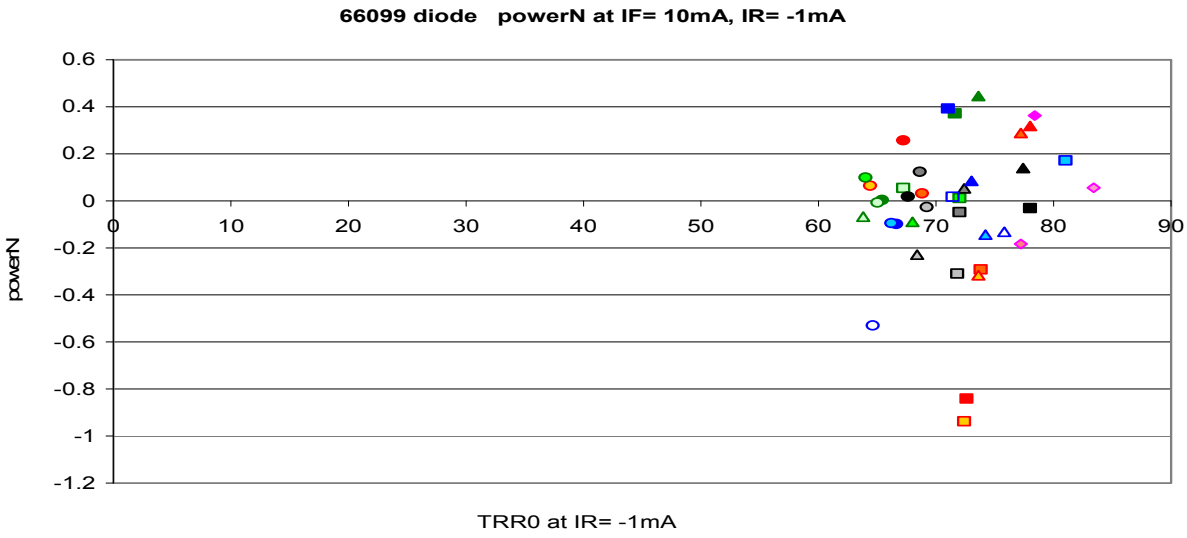
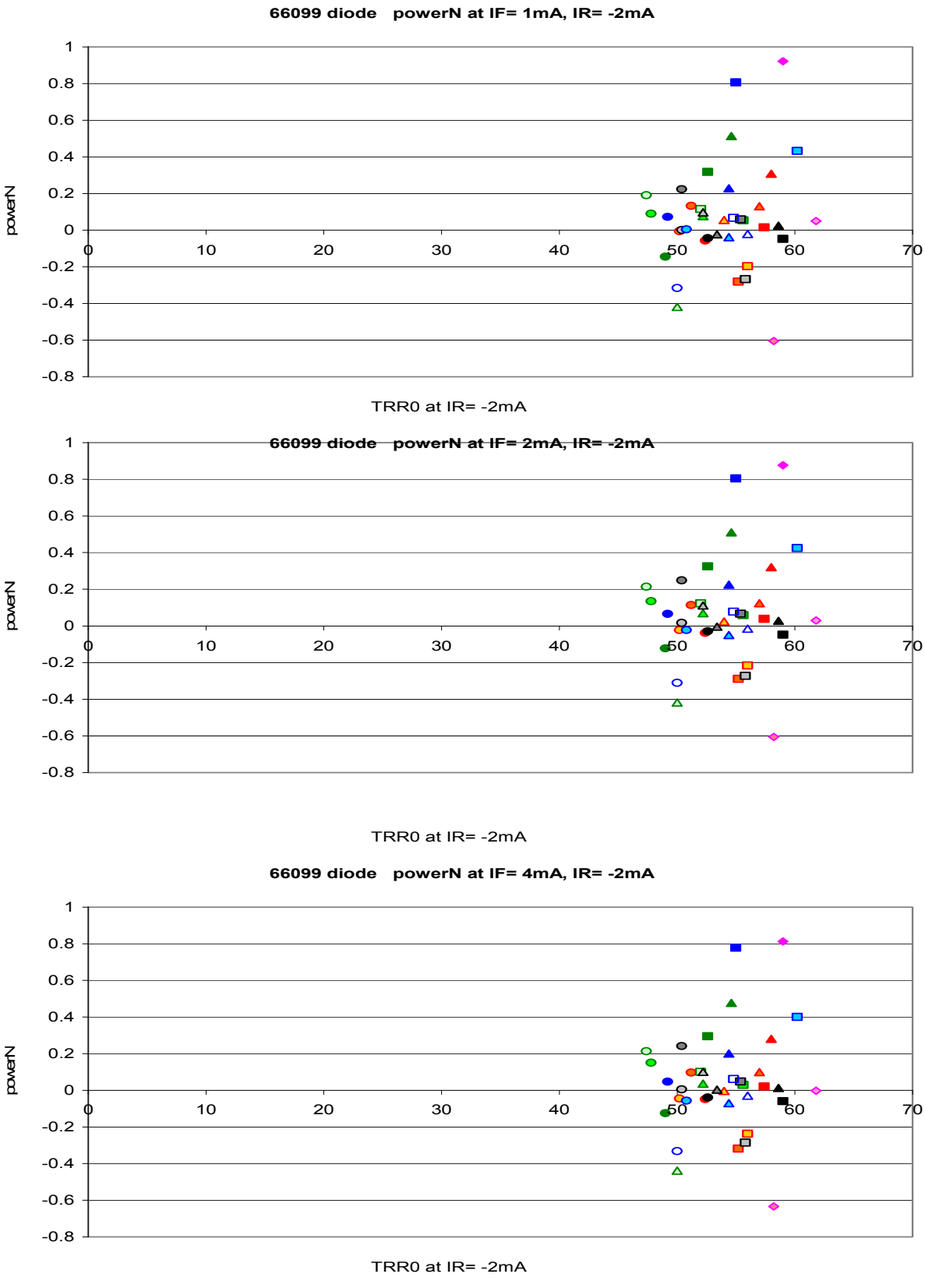
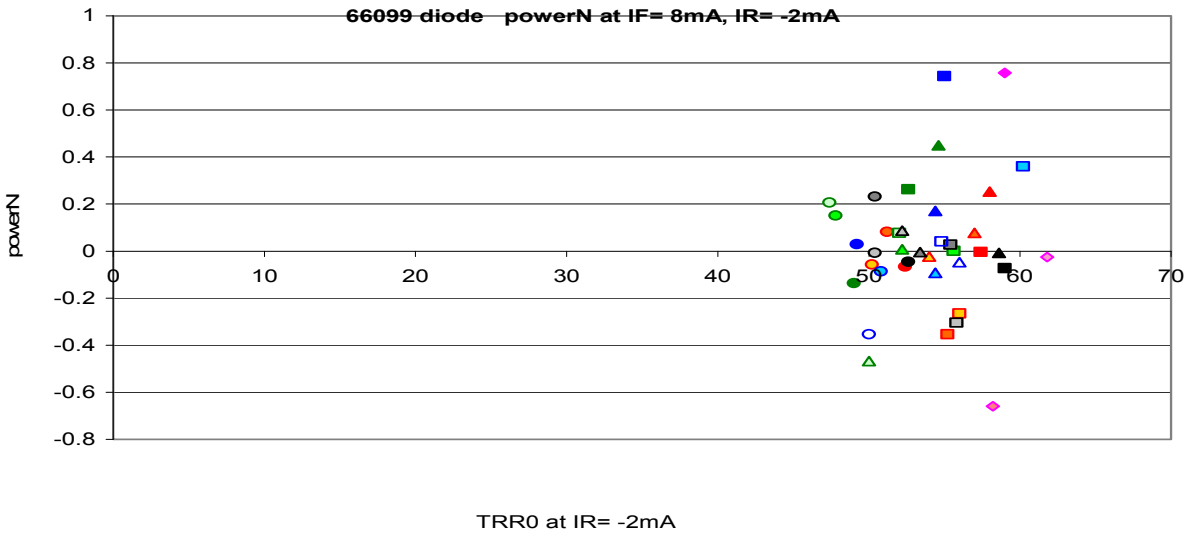

66099 diode powerN at IF= 10mA, IR= -1mA
powerN
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
0
10
20
30
40
50
60
70
80
90
TRR0 at IR= -1mA

Fig. 14-252: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -2 mA




66099 diode powerN at IF= 8mA, IR= -2mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
10
20
30
40
50
60
70
TRR0 at IR= -2mA

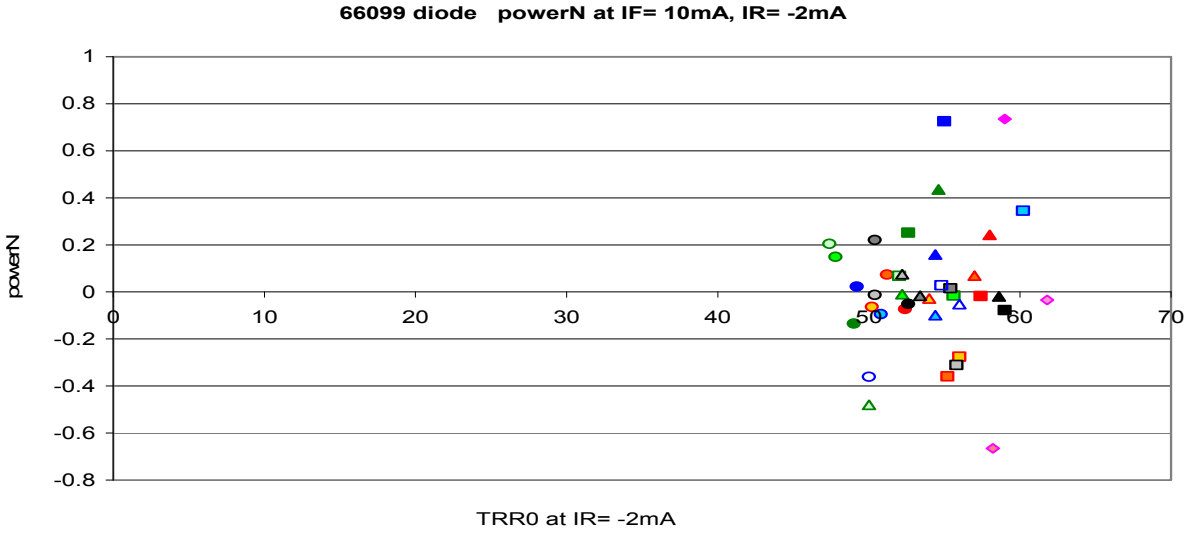
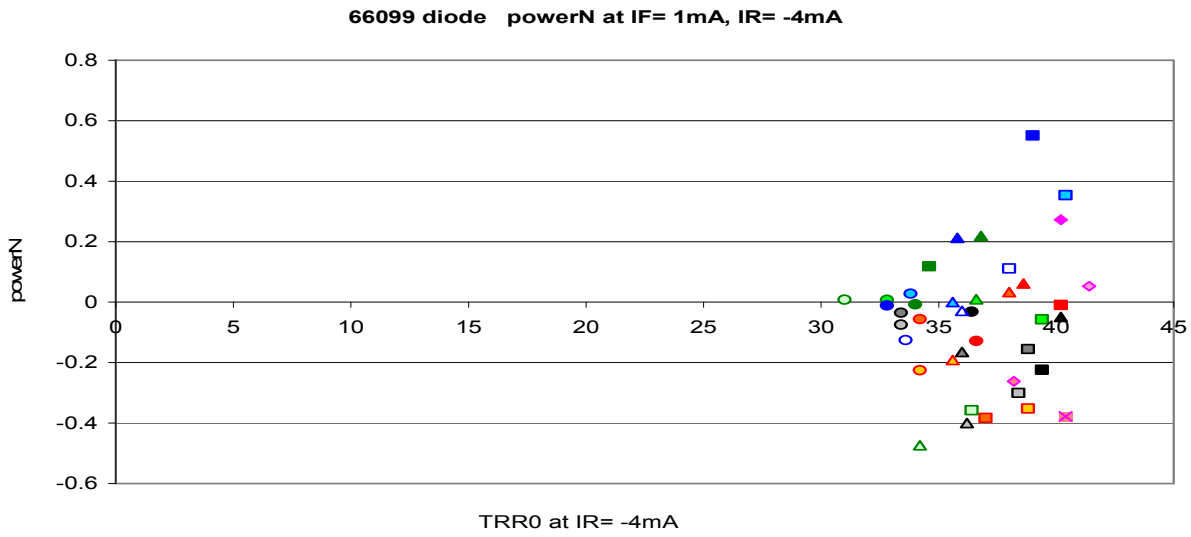
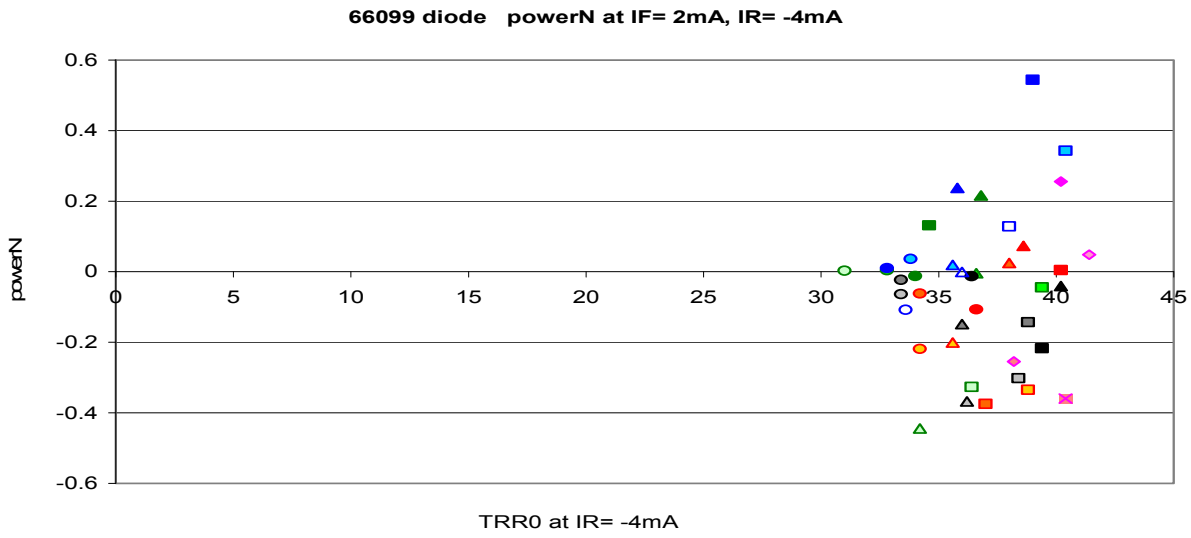
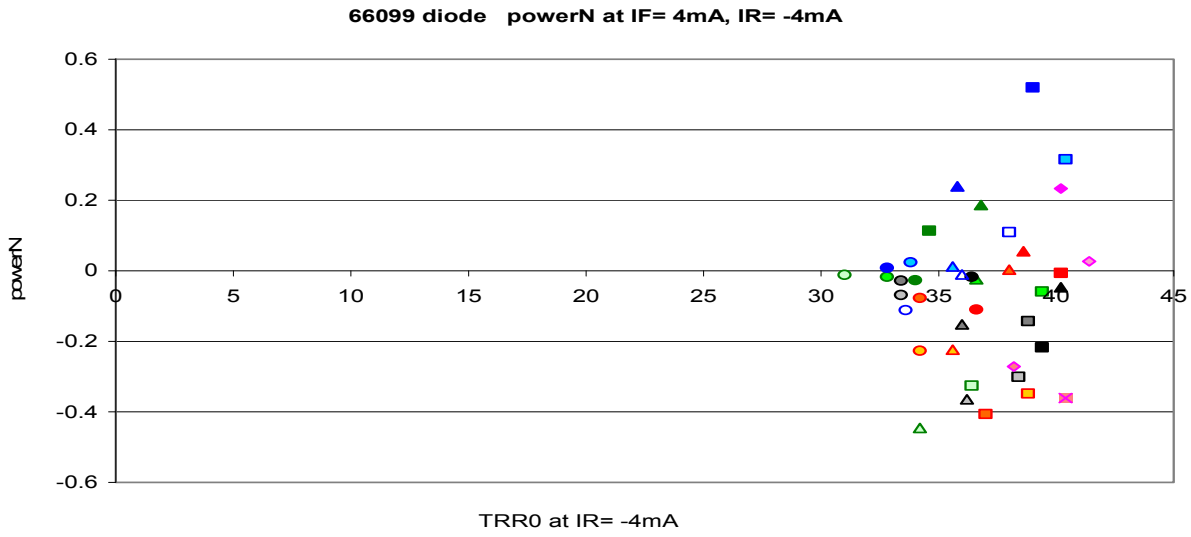
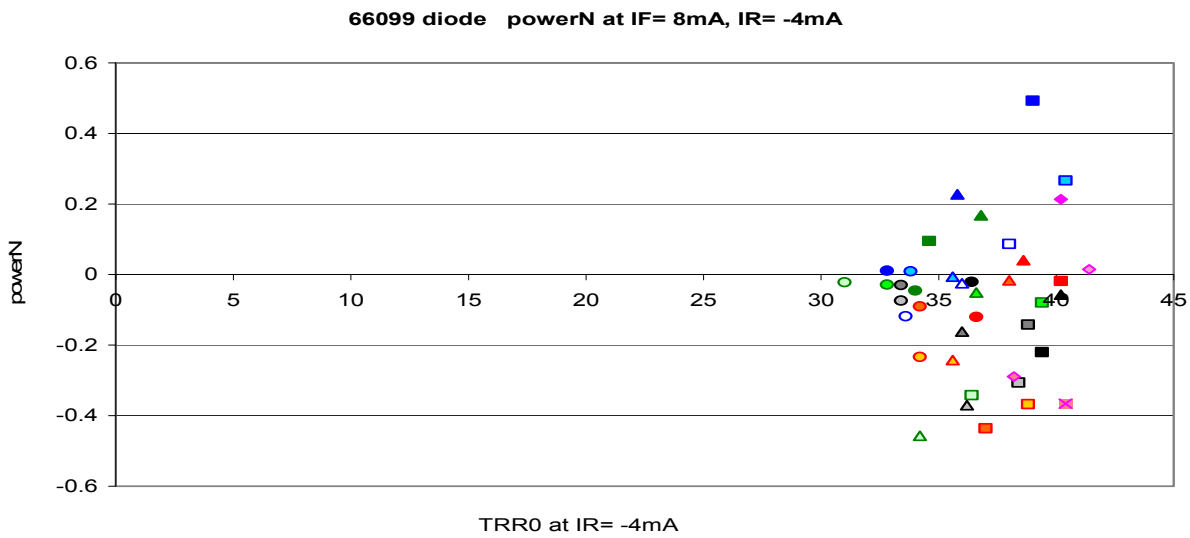

66099 diode powerN at IF= 10mA, IR= -2mA
powerN
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
10
20
30
40
50
60
70
TRR0 at IR= -2mA

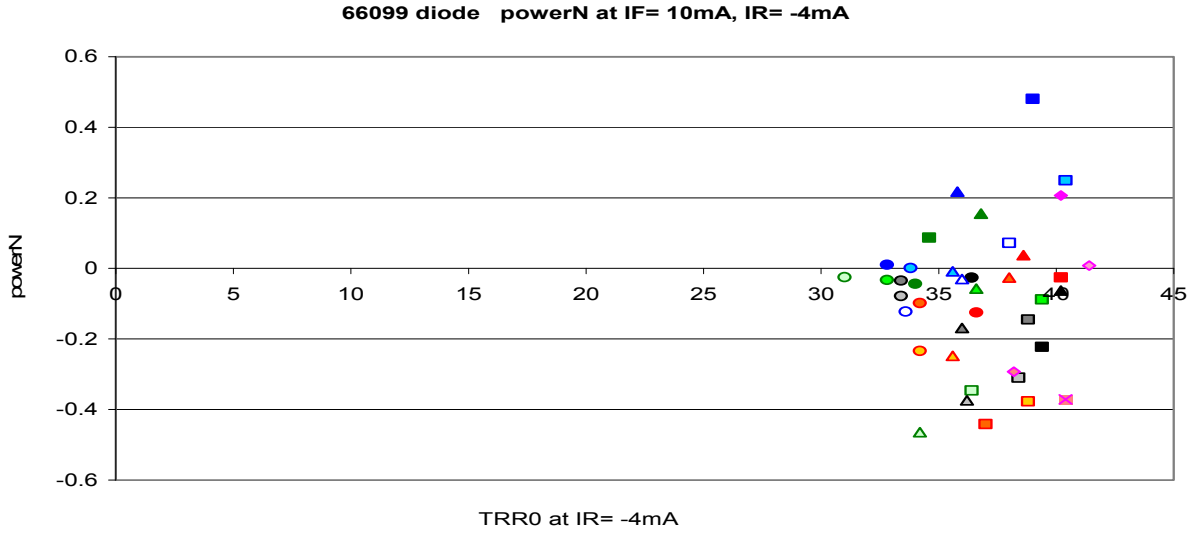
Fig. 14-253: 66099 diode: N at I_F = 1, 2, 4, 8, 10 mA with respect to τ_{RR0} at I_R = -4 mA








66099 diode powerN at IF= 8mA, IR= -4mA
powerN
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA


66099 diode powerN at IF= 10mA, IR= -4mA
powerN
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
5
10
15
20
25
30
35
40
45
TRR0 at IR= -4mA