HEAVY IONS TEST REPORT

Single Event Effects
40MHz-CFPT9006
SMD Temperature Compensated Crystal Oscillator (PLUTO)
From
Rakon

Ref: TRAD/TI/40MHz-CFPT9006/XXX1/ESA/BR/1207	***Labège, May 15th, 2013***
Tests & radiations afaq ISO 9001 Qualité AFNOR CERTIFICATION N° QUAL/2005/24529c	TRAD, Bat. Gallium 907, Voie l'Occitane 31670 LABEGE Cedex ☎ : (33)5 61 00 95 60 Fax: (33)5 61 00 95 61 E-mail: trad@trad.fr http://www.trad.fr

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Rev.	Change description	Comment
0	First issue	28/11/2013
1	Updated report with new results obtained during the second campaign	

TO: EUROPEAN SPACE AGENCY Mr. Christian POIVEY	**Ref: Project/program:**

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1. Introduction

This report includes the test results of the heavy ions **S**ingle **E**vent **E**ffects (SEEs) test sequence carried out on the **40MHz-CFPT9006,** a SMD Temperature Compensated Crystal Oscillator (PLUTO) from **Rakon.**

This test was performed for the **EUROPEAN SPACE AGENCY** on the **40MHz-CFPT9006** susceptible to show **S**ingle **E**vent **L**atch-ups (SELs), **S**ingle **E**vent **T**ransients (SETs) and **S**ingle **E**vent **F**unctional **I**nterrupt (SEFIs) induced by heavy ions.

This report includes the test results obtained during a second campaign which was performed in order to investigate on the SEFI.

2. Documents

2.1. Applicable documents

Technical Proposal : TRAD/PF/ESA/COO1/CC/071111 rev.0
Irradiation Test Plan : ITP-TI-40MHz-CFPT9006-RAK-ESA-1227 Issue 3 of 14/08/2012 for the first campaign
ITP-TI-40MHz-CFPT9006-RAK-ESA-1227-Issue 4 of 27/03/2013

2.2. Reference documents

RAKON Specification : E2900LF-RAD Issue A of 20-06-2012.

3. Organization of Activities

The relevant company has performed the following tasks during this evaluation:

1	Procurement of Test Samples	Rakon
2	Preparation of test Samples (delidding)	Rakon
3	Preparation of Test Hardware and Test Program	TRAD
4	Samples Check out	TRAD
5	Accelerator Test	TRAD
6	Heavy Ion Test report	TRAD

Table 1 : Organization of activities.

4. Device Description

The CFPT9000 uses Rakon's proprietary ASIC 'Pluto™', a single chip oscillator and analogue compensation circuit, capable of sub 0.3ppm performance over an extended temperature range. Its ability to function down to a supply voltage of 2.4V and low power consumption makes it particulary suitable for mobile applications

5. Parts Informations

PART IDENTIFICATION	
Type :	40MHz – CFPT9006
Manufacturer :	Rakon
Function :	SMD Temperature Compensated Crystal Oscillator (PLUTO)
PARTS PROCUREMENT INFORMATIONS	
Packaging :	Specific with 5 pins
Sample size:	4 irradiated samples during the first campaign and 3 irradiated samples during the second campaign (one part was reused from the first campaign).

6. Sample pictures

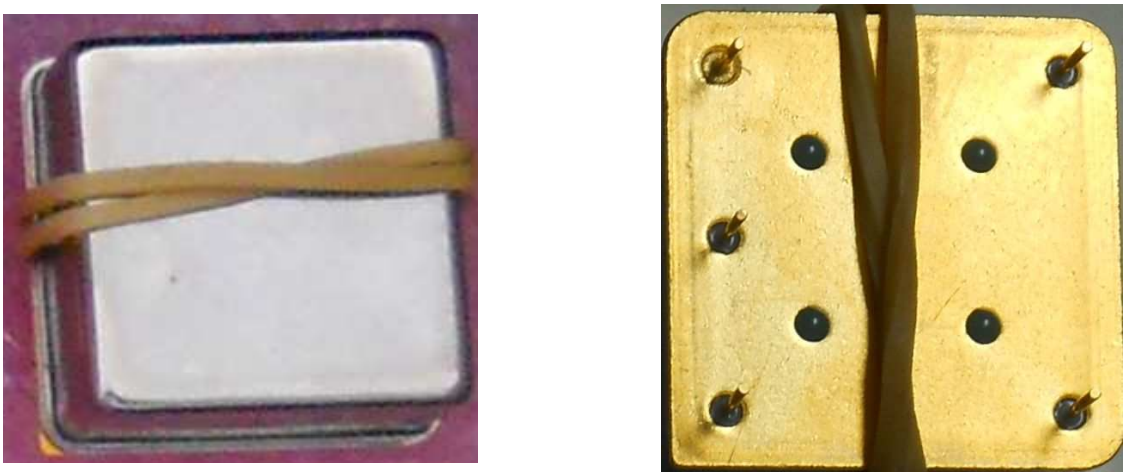


Figure 1 : Sample pictures

7. Test Condition Description

7.1. Procurement of test samples

Six 40MHz-CFPT9006 delidded samples procured by Rakon.

7.2. Preparation of samples

All parts were delidded by Rakon .
No sample damaged during this operation.

7.3. Preparation of test hardware and program

TRAD has developed a specific test program and a specific motherboard to feed power supply to components.
The output of the DUT is visualized using one oscilloscope and curves are saved when an event occures.
The test system is driven by a personal computer through a standard IEEE488 communication interface. All signals are delivered and monitored by this equipment and SEE curves are saved in its memory.
At the end of each test run, data are transferred to the hard disk for storage. An overall description of the test system is given in Figure 4.
Before performing the heavy ion test, the whole system (delidded sample, test board and software) has been assembled and tested by TRAD in V.A.S.C.O (Vacuum System for Californium Operation).

7.4. Samples Check

A functional test sequence has been performed on delidded samples to check that devices have not been degraded by the delidding operation.

7.5. Accelerator facility

The tests were performed at U.C.L (Université Catholique de Louvain) on October 25th and 26th, 2012 and on April 19th, 2013. Respectively, 4 and 3 delidded samples were irradiated.
The following table presents the different ion types available at UCL, and their relevant characteristics.

Ion	DUT energy (MeV)	Range (µm(Si))	LET (MeV/mg/cm²)
$^{124}Xe^{26+}$	420	37	67.7
$^{84}Kr^{17+}$	305	39	40.4
$^{40}Ar^{8+}$	151	40	15.9
$^{20}Ne^{4+}$	78	45	6.4
$^{15}N^{3+}$	60	59	3.3

Table 2 : Cocktail n°1 (M/Q=5) at the UCL

Ion	DUT energy (MeV)	Range (µm(Si))	LET (MeV/mg/cm²)
$^{83}Kr^{25+}$	756	92	32.6
$^{58}Ni^{18+}$	567	100	20.4
$^{40}Ar^{12+}$	372	117	10.2
$^{22}Ne^{7+}$	235	216	3
$^{13}C^{4+}$	131	292	1.1

Table 3 : Cocktail n°2 (M/Q=3.33) at the UCL

8. Dosimetry and Irradiation Facilities

8.1. Beam description used during the first campaign

The characteristics of the ion beams used during the test for the first campaign are described hereunder :

IRRADIATION FACILITIES	
Heavy Ions used :	Cocktail n°1 : $^{124}Xe^{26+}$, $^{84}Kr^{17+}$ Cocktail n°2 : $^{83}Kr^{25+}$, $^{58}Ni^{18+}$, $^{40}Ar^{12+}$, $^{22}Ne^{7+}$ $^{13}C^{4+}$
Vacuum:	1.3 E-4 mbar
Flux range :	Cocktail n°1 : $1,12.10^{2}$ to $1,56.10^{4}$ ions/cm².s Cocktail n°2 : $1,90.10^{2}$ to $1,59.10^{4}$ ions/cm².s
Fluence range :	Cocktail n°1 : $1,19.10^{4}$ to $1,10^{7}$ ions/cm² Cocktail n°2 : $2,64.10^{3}$ to $1,10^{7}$ ions/cm²
Particle angle :	Cocktail n°1 : 0° Cocktail n°2 : 0°, 50° and 57°
Uniformity beam :	Diameter 2,5 cm +/- 30%
Dosimetry:	Scintillation detector, Faraday cups

8.2. Beam description used during the second campaign

The characteristics of the ion beams used during the test for the second campaign are described hereunder :

IRRADIATION FACILITIES	
Heavy Ions used :	Cocktail n°2 : $^{58}Ni^{18+}$, $^{40}Ar^{12}$
Vacuum:	1.3 E-4 mbar
Flux range :	Cocktail n°2 : $4,88.10^{3}$ to $1,78.10^{4}$ ions/cm².s
Fluence range :	Cocktail n°2 : 1.10^{6} to 1.10^{7} ions/cm²
Particle angle :	Cocktail n°2 : 0°
Uniformity beam :	Diameter 2,5 cm +/- 30%
Dosimetry:	Scintillation detector, Faraday cups

9. Test equipment identification

The tests were carried out with evaluation test boards developed by TRAD.

COMPUTER	PO-TE-096
REF. TEST BOARD	TRAD/CT1/I/CFPT9006/5pins/BR/1207 TRAD/TA1/I/CFPT9006/suiveur/BR/1208
EQUIPMENT	ME-56 ; ME-70 ; ME-48 ; SM-15 ; ME-77
TEST PROGRAM	CFPT9006_TI_XXX1_V10.spf

10. Device setup

The test board requires the following apparatus and setups to operate properly.

Equipment	Function	Test Conditions
ME-56	Power Supply	+Vs = +3.3V
ME-70	Oscilloscope	SEL Visualizations
ME-48		SET Visualizations
SM-15	Ultra stable, Frequency meter	SEFI Visualizations
ME-77	GUARD SYSTEM	+Vs : Range 3, Is = 8mA

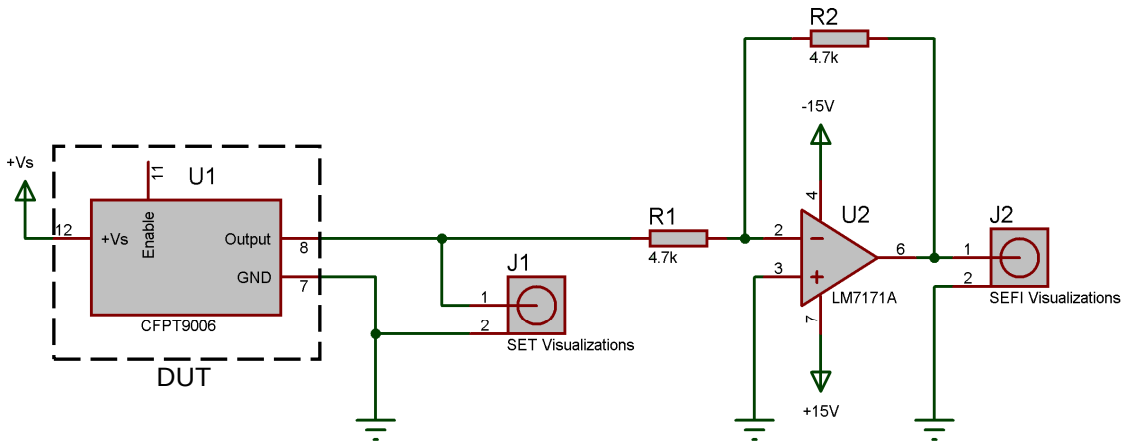


Figure 2 : Test Board description

11. Test Procedure

11.1. Description of the test method

We divided the test in two parts, under respect of reference or applicable documents:

- We performed runs up to a fluence of 1.10^6 #/cm^2 for the SET detection. A latchup monitoring was used during these tests. This configuration allowed to verify the SET and the SEL sensitivity of the device.
  The test terminated when the maximum fluence was reached or when about a hundred events were detected.

- We performed runs up to a fluence of 10^7 #/cm^2 with only SEL monitoring. This configuration allowed to verify the latchup sensitivity of the device.
  The test terminated when the maximum fluence was reached or when about a hundred events were detected.

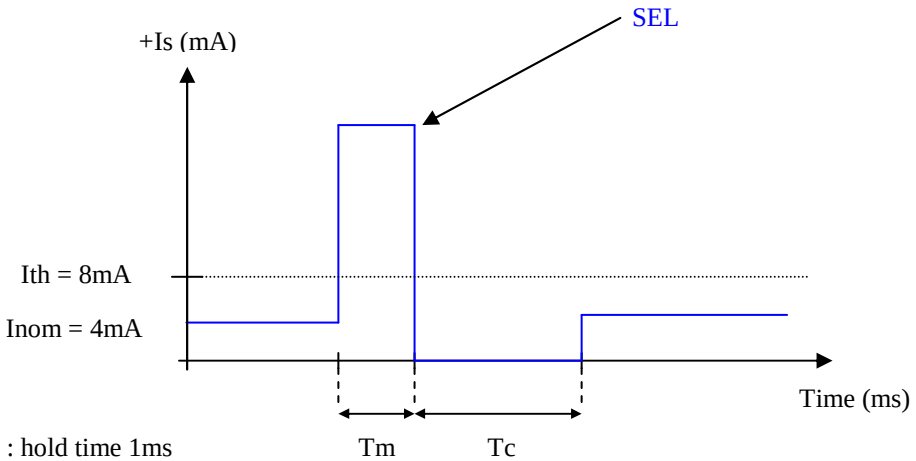
11.2. SEL Test Principle

The power supply is applied to the device under test through the GUARD SYSTEM, a voltage of 3.6V is needed to get 3.3V applied on the part under test. The threshold current of the GUARD SYSTEM was set to 8mA. When an event occurs, the GUARD SYSTEM sends a trigger command to the oscilloscope, to cut off the power supply, after 1ms, for a duration of 7ms. Then, the power supply is turned on with the nominal current consumption expected.

At the end of each run, the test program reads the oscilloscope's "Local Scope Counter" which indicates the total number of detected events and downloads and saves the record current waveforms.

Event description

During the test, the GUARD SYSTEM controls the device's current. If the value exeeds 8mA, the delatcher is triggered and the event is counted as a SEL.



Tm : hold time 1ms
Tc : cut off time 7ms

Figure 3 : Common SEL characteristics.

11.3. SET and SEFI Test Principle

We always used the GUARD SYSTEM on the component's power supply to detect SEL and to prevent the destruction of the device under test.

The SEFI detection was performed with a frequency meter. The output frequency is checked every 100ms and if a frequency shift of 1ppm is noticed or if a loss of frequency occurs, the test bench counts a SEFI and turns on the power supply.
For the second test campaign, in order to obtain additional results, a modification of the test bench was performed to focus the experiment on the SEFI events. Two modes were implemented.
The first mode, called SEFI ON, consists on checking the frequency in permanence and record its variation. If a variation higher than 40 Hz is detected during 300ms then a functional interrupt is counted and the power supply is switched OFF/ON.
The second mode, called SEFI OFF, disables the automatic SEFI disarmament in order to be sure that the event identified previously as a SEFI doesn't recover by itself.
In this test mode the operator can reset the part manually if the part doesn't seem to recover after a few seconds.

At the end of each run, the test program reads the oscilloscope's "Local Scope Counter" which indicates the total number of detected events and downloads and saves the record current waveforms.

11.4. Test Configurations

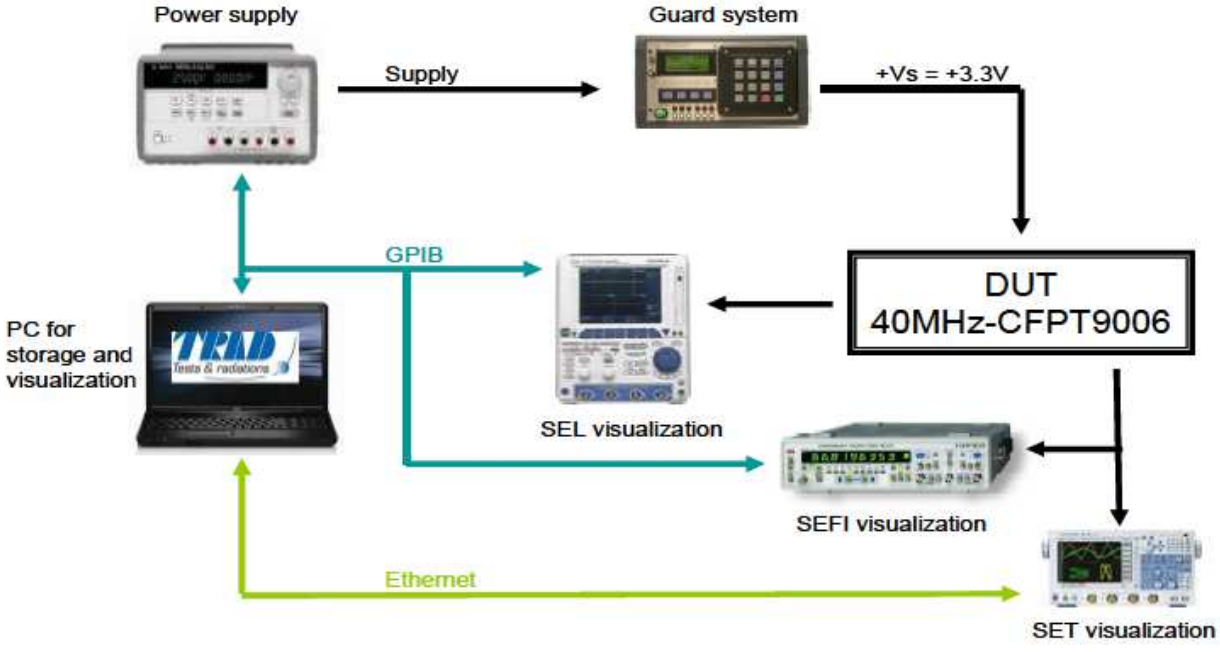


Figure 4: Description of the test system

12. Test Story

Test sequence, test and measurement conditions were nominal for the two campaigns.

13. RESULTS

13.1. SEL test results.

The SEL test has been performed at 85°C.

- SELs were observed during the irradiation up to the Argon Heavy Ion with a particle angle of 57° (LET = 18.73 MeV.cm²/mg and range = 63.7µm).

13.1.1. Cross sections

SEL Cross Section (cm^2)				
LET Eff ($MeV.cm^2.mg^{-1}$)	N° 1	N° 2	N°3	N° 4
67.7	1.47E-05	1.88E-05	2.06E-05	1.54E-05
40.4	7.00E-06	7.20E-06	7.80E-06	6.40E-06
32.6	5.50E-06	7.80E-06	6.30E-06	6.80E-06
20.4	1.60E-06	2.60E-06	8.00E-07	1.30E-06
18.73*		2.00E-07		
15.87**		<1.00E-07		
10.2	<1.00E-07	<1.00E-07	<1.00E-07	<1.00E-07

*The LET was obtained by tilting at 57° with the Argon Heavy Ion.
**The LET was obtained by tilting at 50° with the Argon Heavy Ion.

Table 4 : SEL cross section results

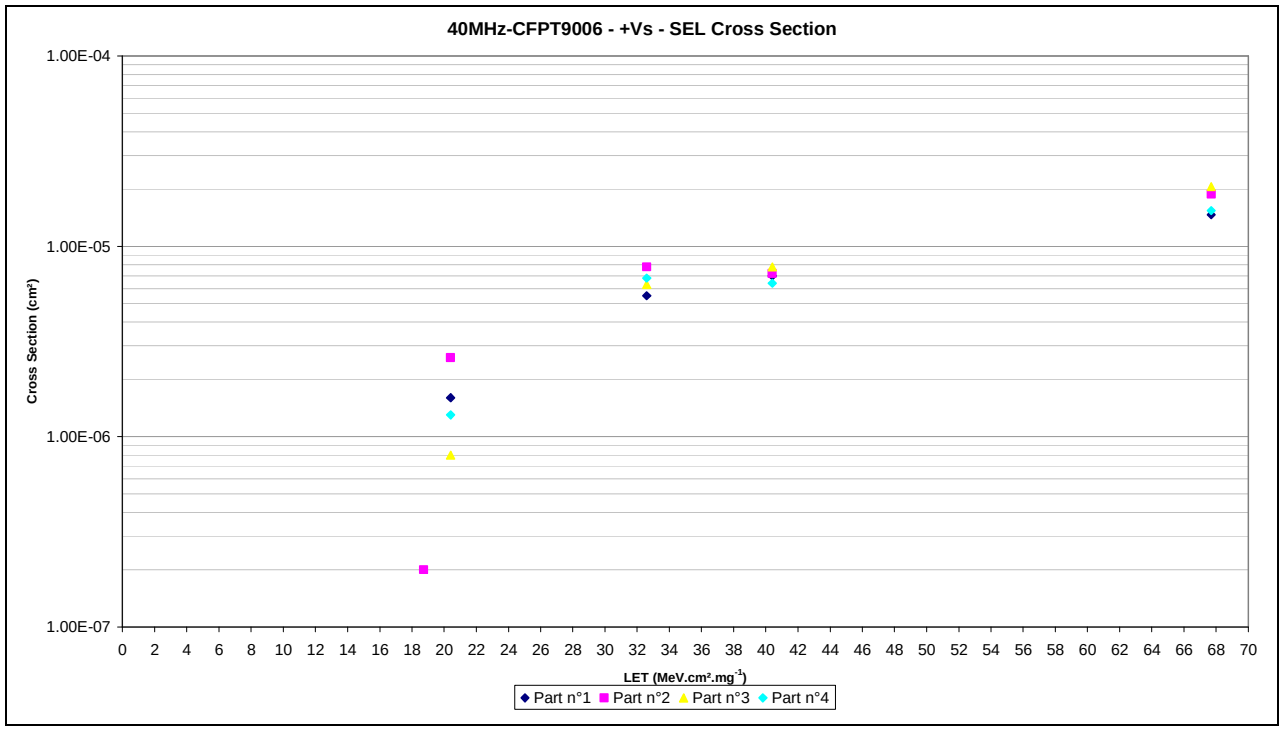


Figure 5: SEL cross section curve for 40MHz-CFPT9006

13.1.2. Worst case observed

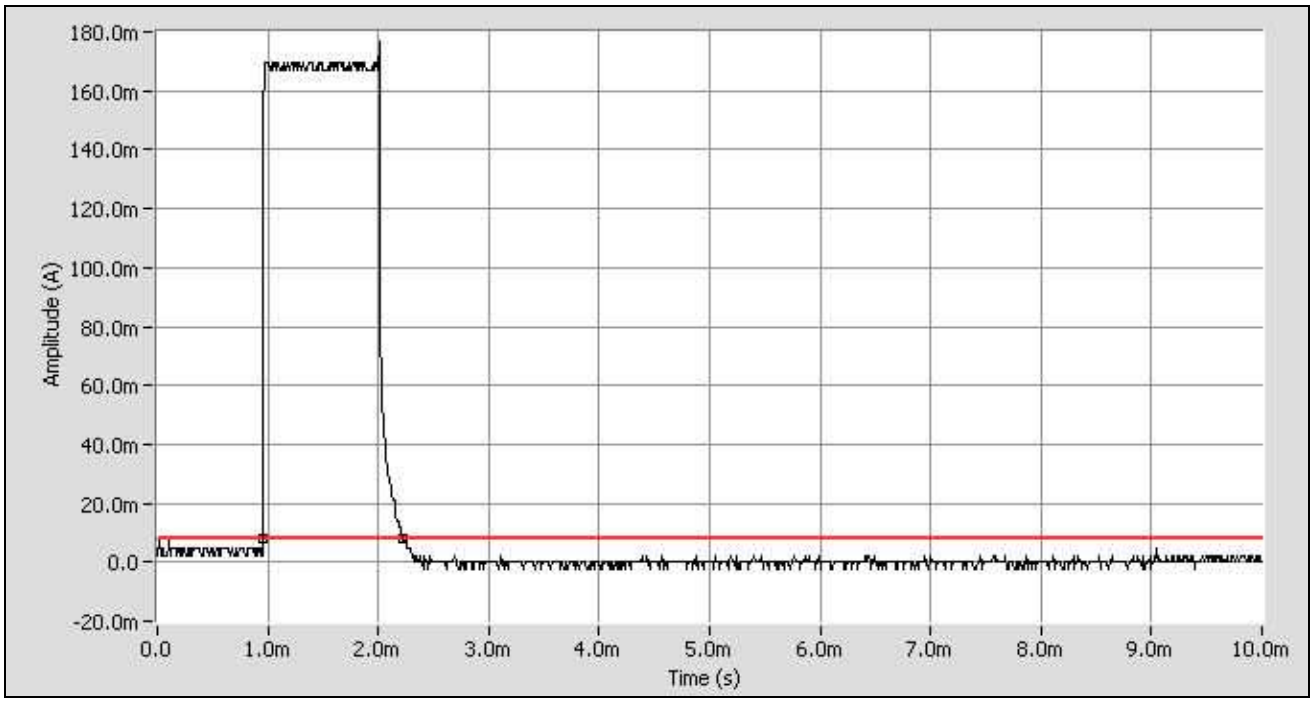


Figure 6: Worst curve SEL, Heavy Ion $^{124}Xe^{26+}$, Part 4, run n°6 event n°62.

13.2. SET results

The SET test has been performed at 25°C.

SETs were observed during the irradiation up to the Neon Heavy Ion (LET = 3 MeV.cm²/mg).

13.2.1. Single Event Transients Observed

SET Cross Section (cm^2)				
LET Eff ($MeV.cm^2.mg^{-1}$)	N° 1	N° 2	N°3	N° 4
67.7	3.64E-04	4.09E-03	1.30E-03	2.08E-03
40.4	2.06E-04	2.53E-03	1.13E-03	7.35E-04
32.6	2.56E-04	2.53E-03	7.27E-04	7.40E-04
20.4	1.68E-04	1.24E-03	4.84E-04	3.27E-04
10.2	4.70E-05	3.02E-04	1.14E-04	9.50E-05
3	5.00E-06	7.00E-06	6.00E-06	4.00E-06
1.1	<1.00E-06	<1.00E-06	<1.00E-06	<1.00E-06

Table 5 : SET cross section results

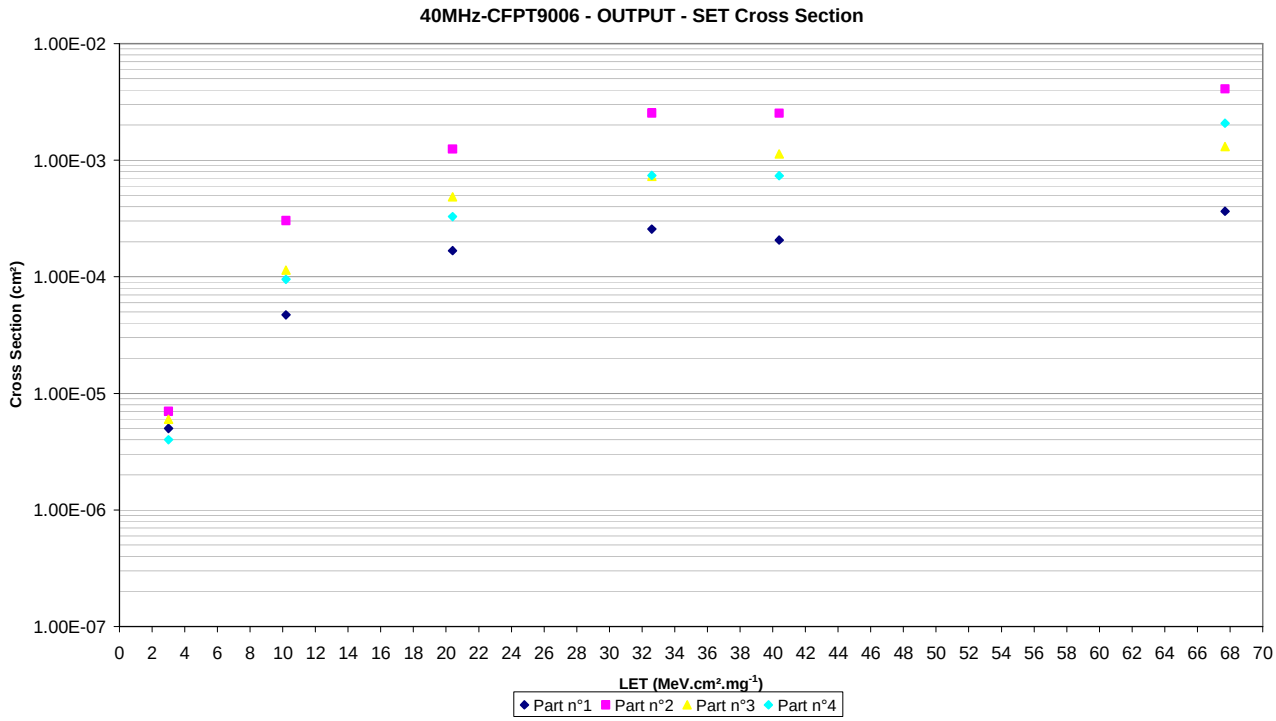


Figure 7: SET cross section curve for 40MHz-CFPT9006

13.2.2. Event observed

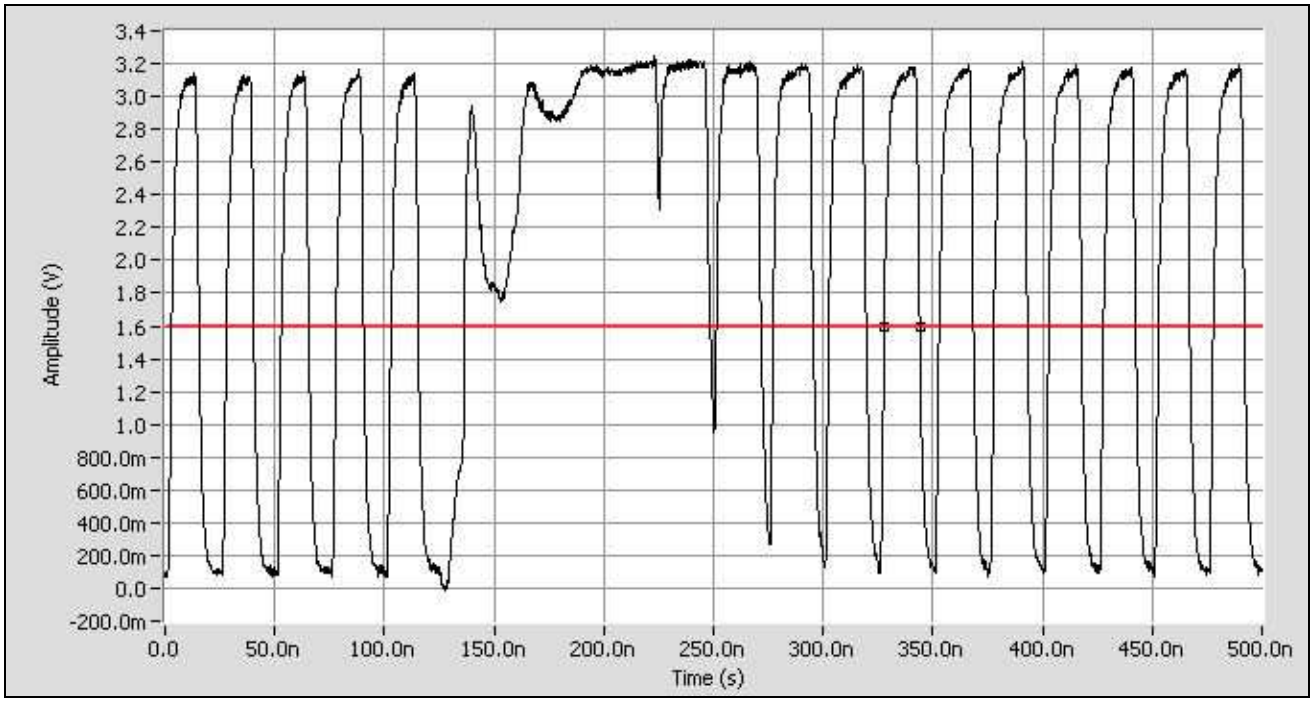


Figure 8: SET curve, Heavy Ion $^{124}Xe^{26+}$, Part 4, Run n°10, Event n°104.

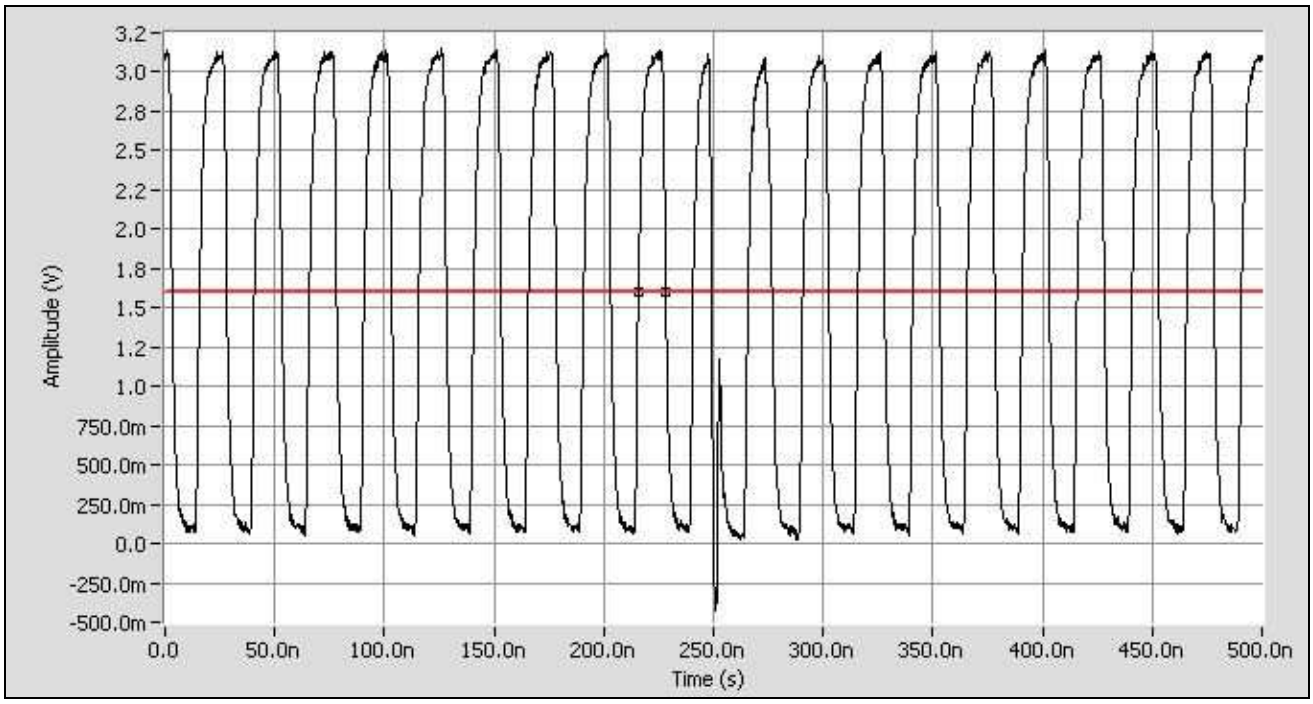


Figure 9: SET curve Heavy Ion $^{124}Xe^{26+}$, Part 4, Run n°10, Event n°73.

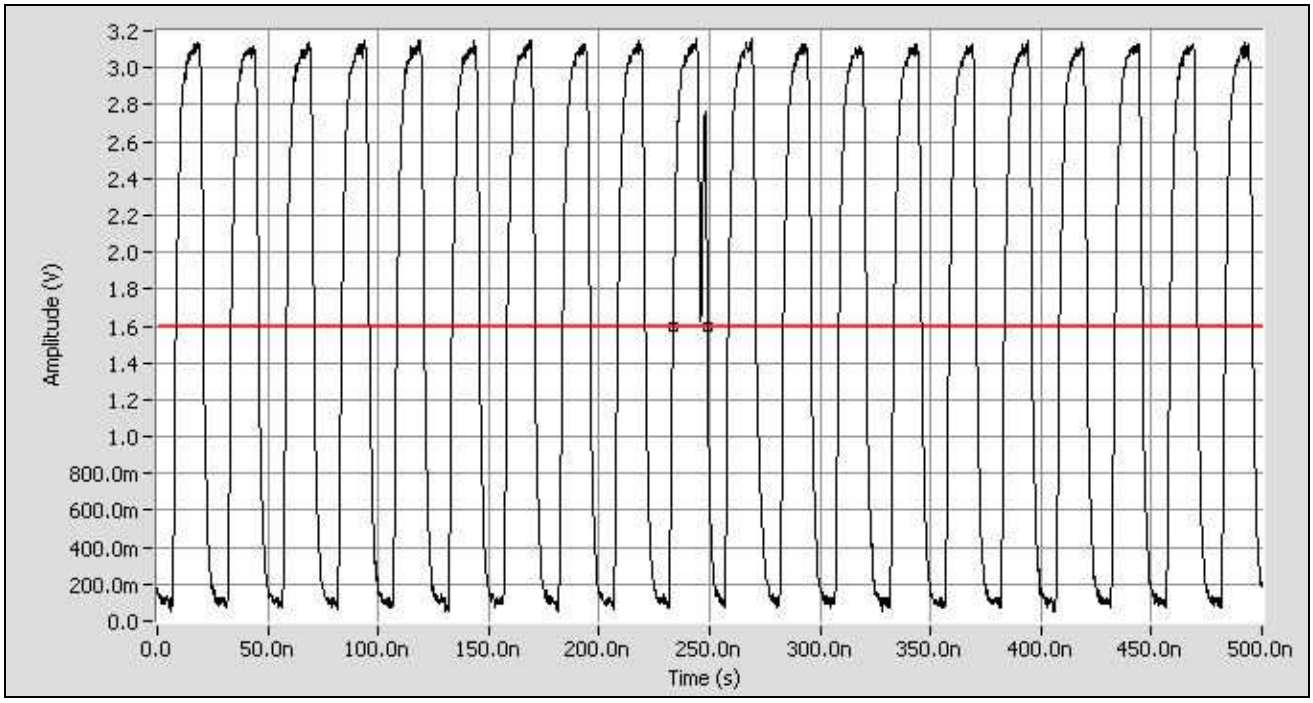


Figure 10: SET curve Heavy Ion $^{124}Xe^{26+}$, Part 4, Run n°10, Event n°29.

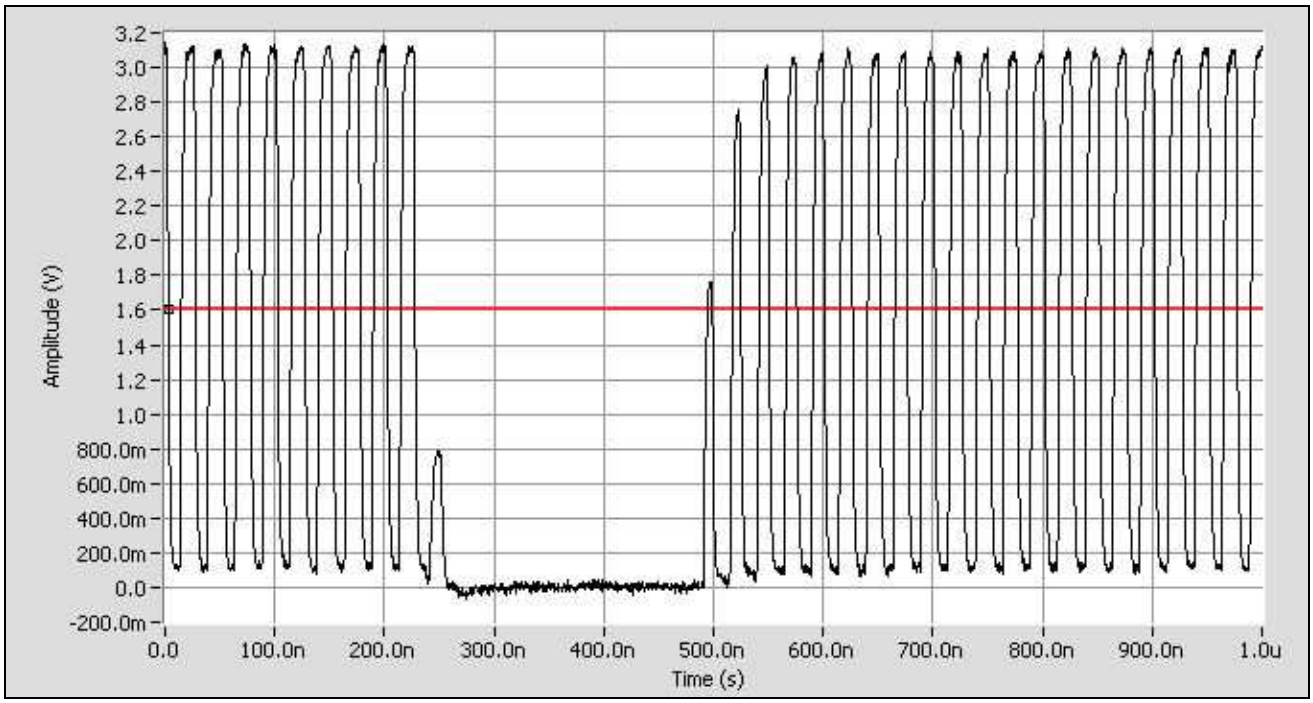


Figure 11: SET curve Heavy Ion $^{84}Kr^{17+}$, Part 4, Run n°17, Event n°59.

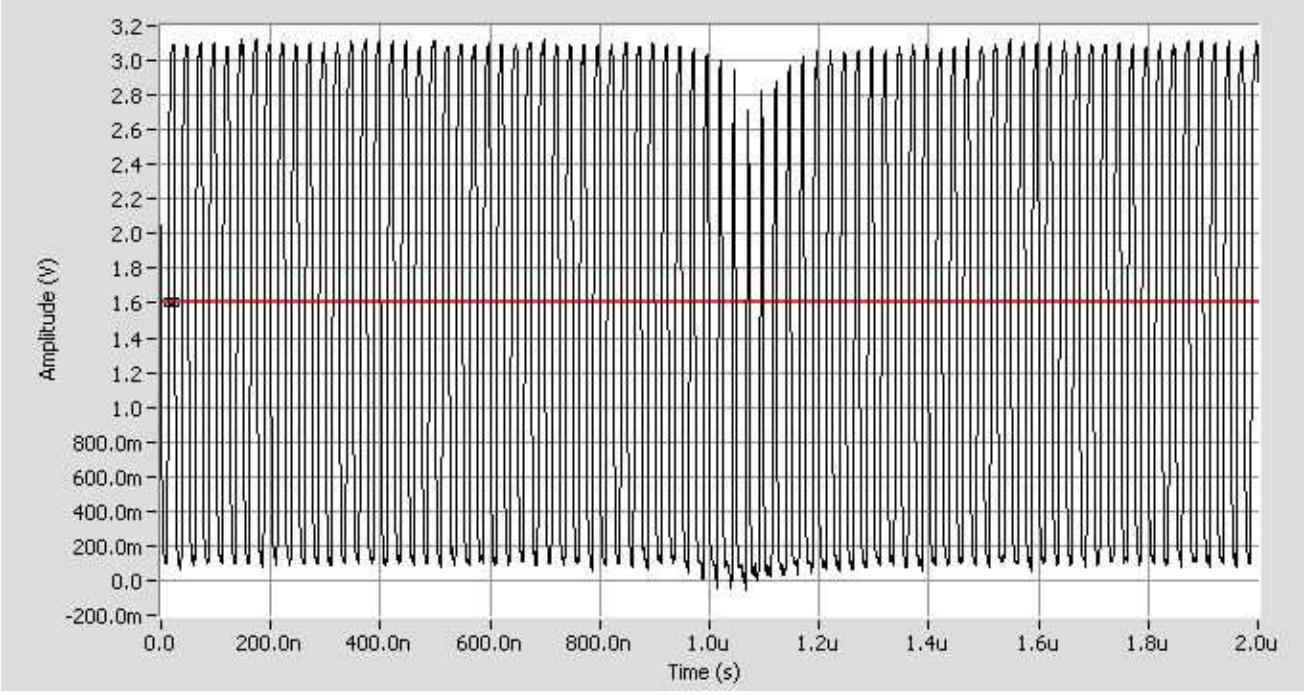


Figure 12: SET curve Heavy Ion $^{84}Kr^{17+}$, Part 1, Run n°23, Event n°67.

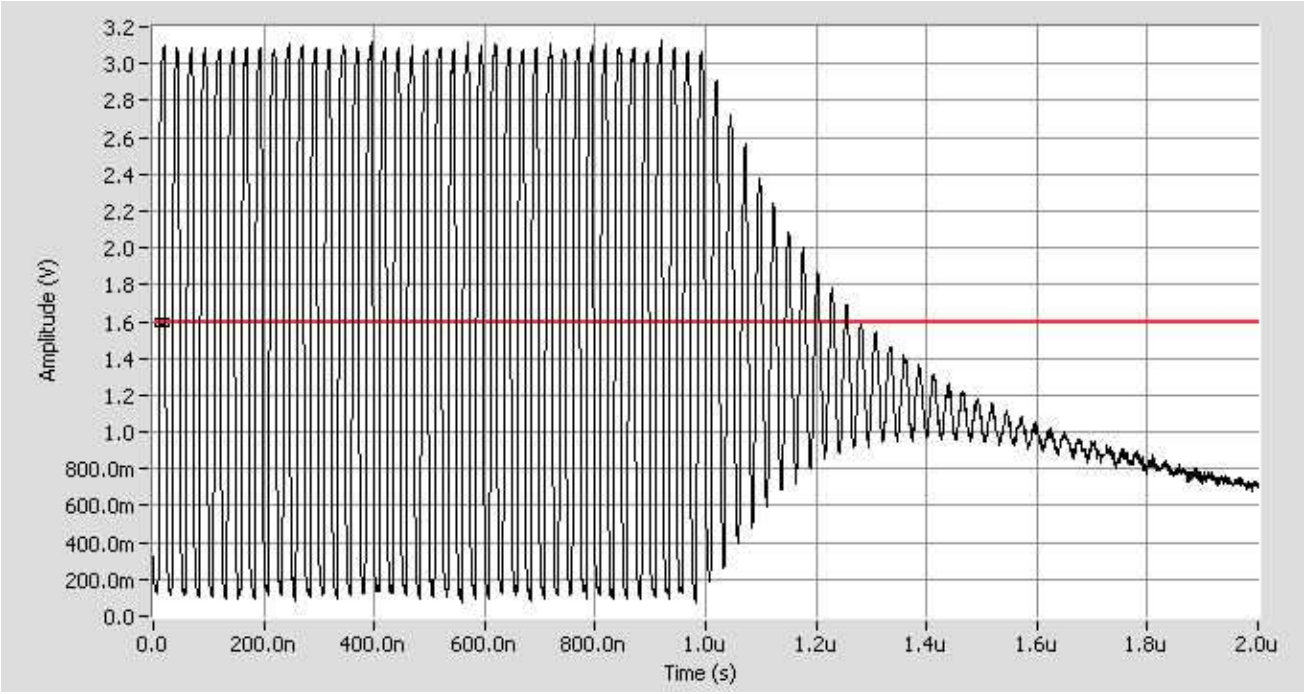


Figure 13: SET curve Heavy Ion $^{83}Kr^{25+}$, Part 1, Run n°38, Event n°60.

13.3. SEFI results

An additional irradiation campaign was performed in order to investigate on SEFI events by increasing the fluence of irradiation up to 1E7 cm^{-2} instead of 1E6 cm^{-2}. Due to the high sensitivity of the parts to SET and the high flux used during the experiment the **SEFI ON** mode was not able to detect SEFI properly. By concequence we focused our attention on the OFF mode, which consists in recording the frequency during the irradiation but without automaticaly switching ON/OFF the voltage supply. Figures 14, 15 and 16 show the frequency (in blue) versus the time during the irradiation of parts 2, 5 and 6 with the Nickel ions up to the fluence of 1E7 cm^{-2}. The dashed red curve indicates SEFI events. The frequency signal shown on Figure 14, presents a lot of variation around the 40MHz (each spike is a SET). Four specific event signatures can be clearly identified. These events correspond to a switch of the frequency during several seconds reseted by a latchup or by a manuel reset. This is SEFI.

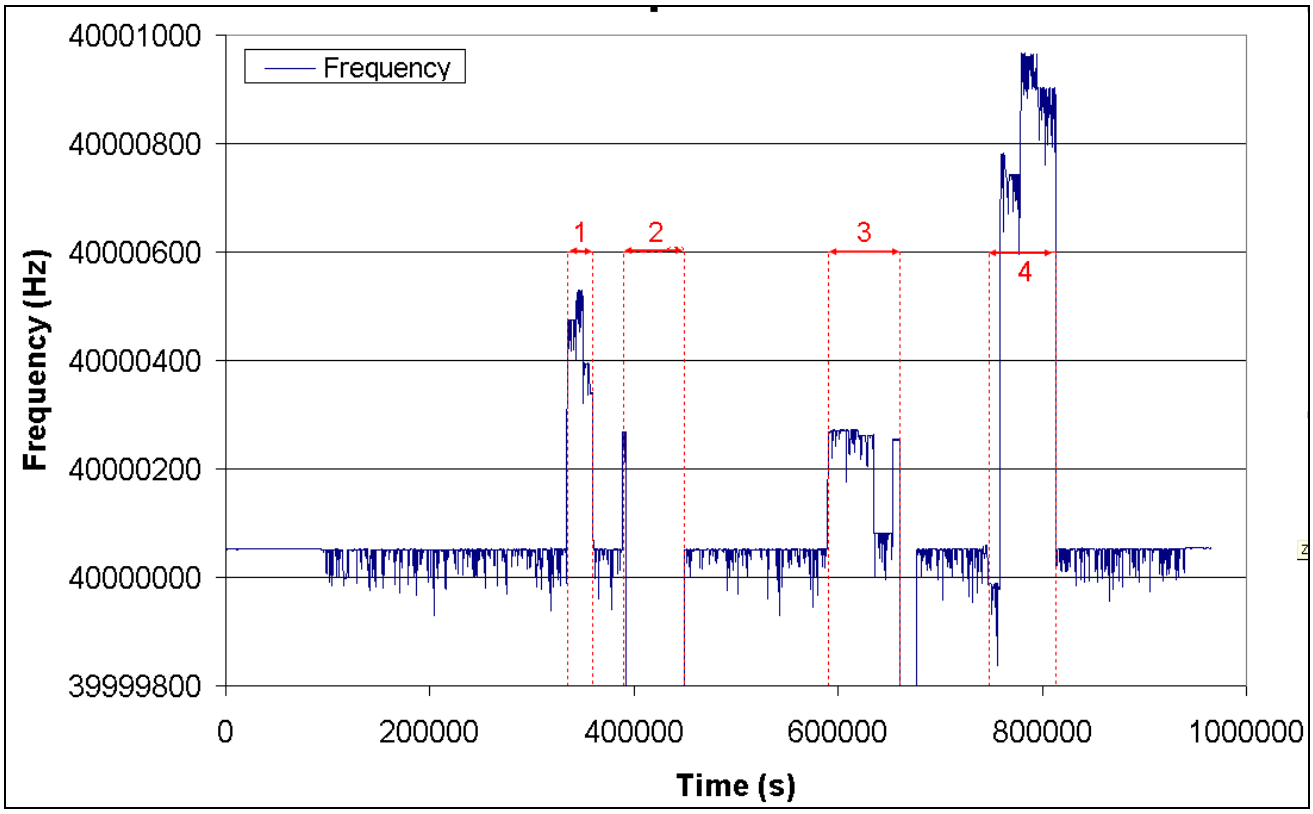


Figure 14: Plot of the output of the 40MHz-CFPT90006 frequency in hertz versus time in seconds on part 2 during run 2 of the second campaign

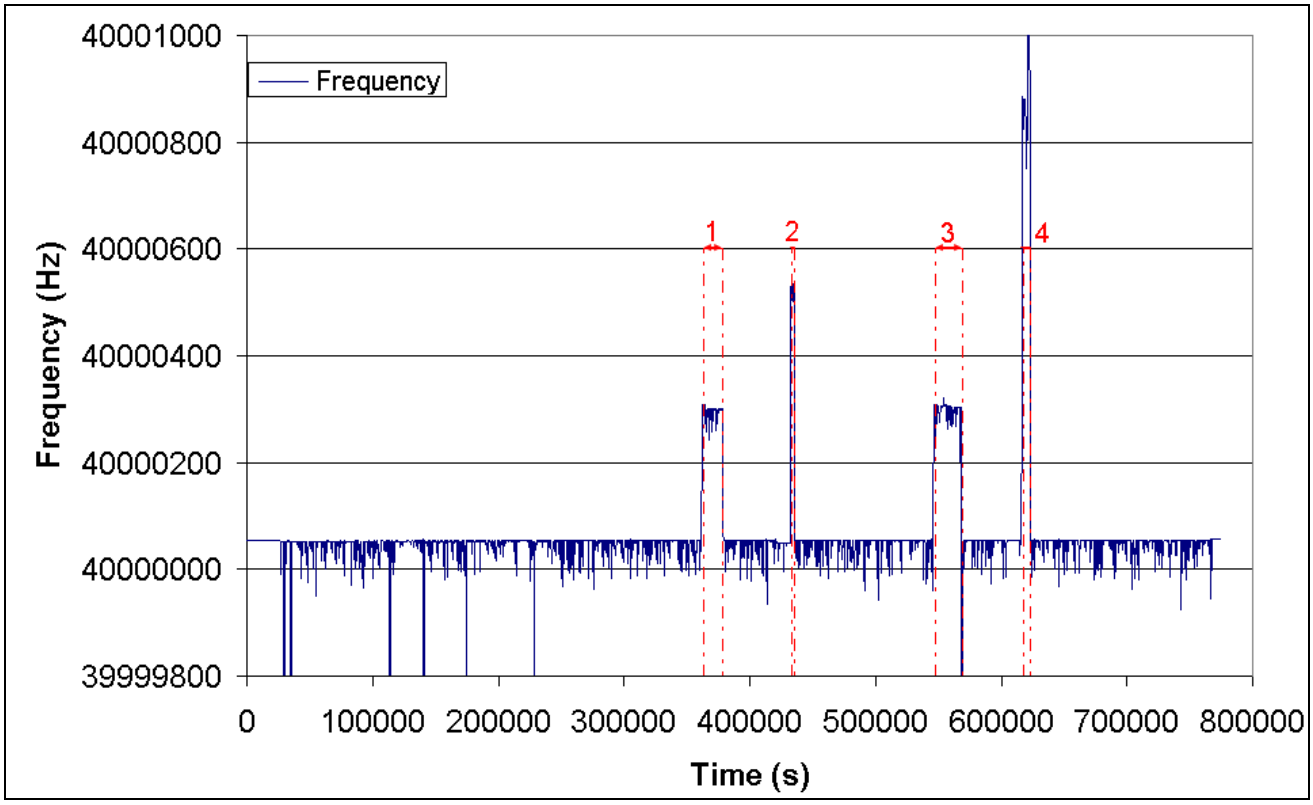


Figure 15: Plot of the output of the 40MHz-CFPT90006 frequency in hertz versus time in seconds on part 5 during run 4 of the second campaign

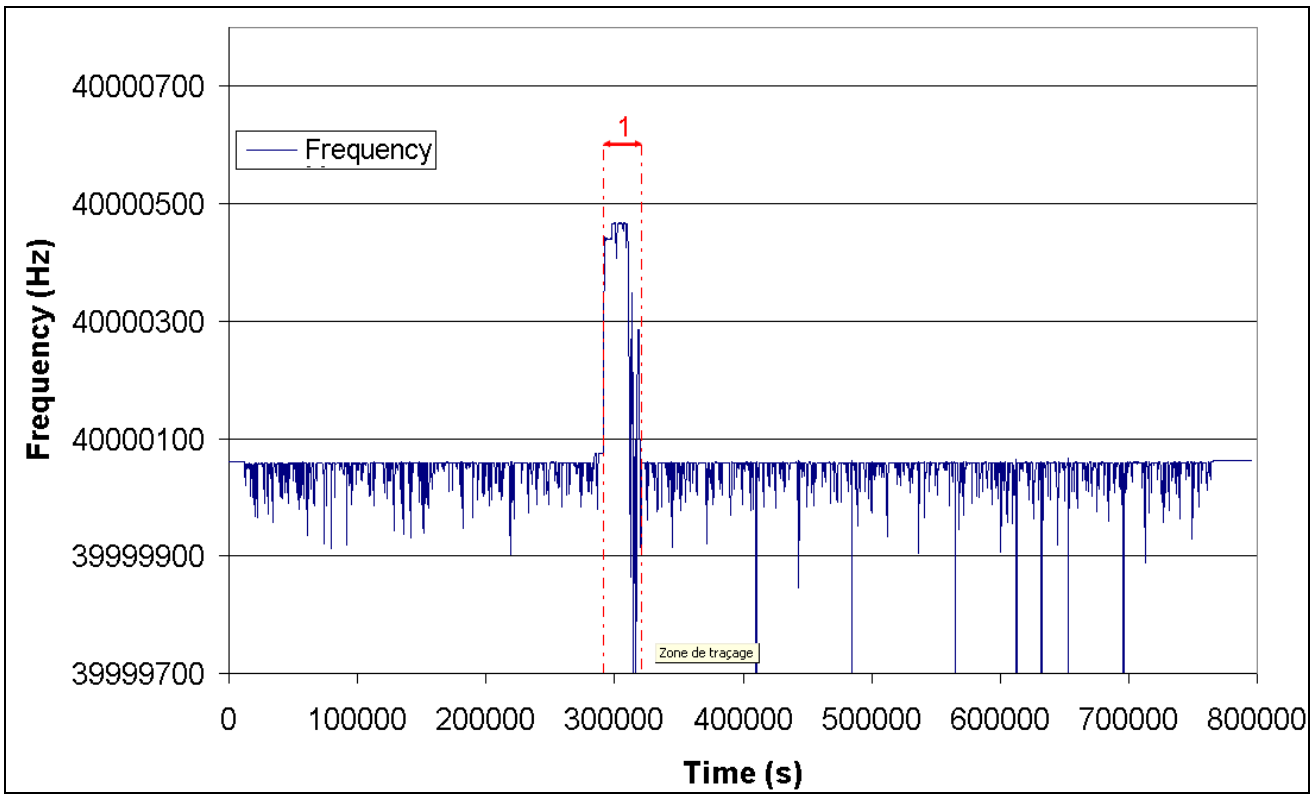


Figure 16: Plot of the output of the 40MHz-CFPT90006 frequency in hertz versus time in seconds on part 6 during run 5 of the second campaign

13.4. Summary of runs.

The runs performed during the two campaigns are shown hereunder. Please note that the runs marqued with * were performed in order to confirm the sensitivity of each part.

40MHz-CFPT9006 SEL-SET-SEFI = 3.3V														LATCHUP		TRANSIENT		FUNCTIONAL INTERRUPT		
Run	Pos	Part	T°	Ion	Energy (MeV)	Tilt (°)	Eff. LET (MeV.cm²/mg)	Eff. Range (µm Si)	Flux (φ) ($cm^{-2}.s^{-1}$)	Time (s)	Run Fluence (Φ) (cm^{-2})	Run Dose (krad)	Cumulated Dose (krad)	+Vs	Cross Section	OUT	Cross Section	OUT	Cross Section	Comment
High LET M/Q=5																				
~~1~~	~~1~~	~~1~~	~~85~~	~~124Xe 26+~~	~~420~~	~~0~~	~~67.70~~	~~37.0~~	~~1.84E+03~~	~~95~~	~~1.75E+05~~	~~0.189~~	~~0.189~~	~~3~~	~~1.72E-05~~	~~-~~	~~-~~	~~-~~	~~-~~	
2	1	1	85	124Xe 26+	420	0	67.70	37.0	1.26E+04	548	6.89E+06	7.464	7.653	101	1.47E-05	-	-	-	-	
~~3~~	~~2~~	~~2~~	~~85~~	~~124Xe 26+~~	~~420~~	~~0~~	~~67.70~~	~~37.0~~	~~1.43E+04~~	~~23~~	~~3.30E+05~~	~~0.357~~	~~0.357~~	~~4~~	~~1.21E-05~~	~~-~~	~~-~~	~~-~~	~~-~~	
4	2	2	85	124Xe 26+	420	0	67.70	37.0	1.54E+04	356	5.47E+06	5.923	6.281	103	1.88E-05	-	-	-	-	
5	3	3	85	124Xe 26+	420	0	67.70	37.0	1.55E+04	322	5.00E+06	5.421	5.421	103	2.06E-05	-	-	-	-	
6	4	4	85	124Xe 26+	420	0	67.70	37.0	1.55E+04	440	6.81E+06	7.371	7.371	105	1.54E-05	-	-	-	-	
7	1	1	25	124Xe 26+	420	0	67.70	37.0	9.28E+02	311	2.89E+05	0.313	7.966	3	1.04E-05	105	3.64E-04	0	<3.46E-06	
8	2	2	25	124Xe 26+	420	0	67.70	37.0	5.97E+02	53	3.16E+04	0.034	6.315	0	<3.16E-05	130	4.11E-03	0	<3.16E-05	
9	2	2	25	124Xe 26+	420	0	67.70	37.0	1.12E+02	218	2.45E+04	0.027	6.342	0	<4.09E-05	100	4.09E-03	0	<4.09E-05	
10	3	3	25	124Xe 26+	420	0	67.70	37.0	2.21E+02	403	8.89E+04	0.096	5.518	1	1.12E-05	116	1.30E-03	0	<1.12E-05	
~~11~~	~~4~~	~~4~~	~~25~~	~~124Xe 26+~~	~~420~~	~~0~~	~~67.70~~	~~37.0~~	~~5.27E+02~~	~~82~~	~~4.32E+04~~	~~0.047~~	~~7.418~~	~~1~~	~~2.32E-05~~	~~89~~	~~2.06E-03~~	~~0~~	~~<2.32E-05~~	
12	4	4	25	124Xe 26+	420	0	67.70	37.0	1.12E+02	431	4.82E+04	0.052	7.470	0	<2.08E-05	100	2.08E-03	0	<2.08E-05	
13	4	4	85	84 Kr 17+	305	0	40.40	39.0	1.56E+04	643	1.00E+07	6.464	13.934	64	6.40E-06	-	-	-	-	
14	3	3	85	84 Kr 17+	305	0	40.40	39.0	1.48E+04	674	1.00E+07	6.464	11.982	78	7.80E-06	-	-	-	-	
15	2	2	85	84 Kr 17+	305	0	40.40	39.0	1.55E+04	647	1.00E+07	6.464	12.806	72	7.20E-06	-	-	-	-	
16	1	1	85	84 Kr 17+	305	0	40.40	39.0	1.50E+04	667	1.00E+07	6.464	14.430	70	7.00E-06	-	-	-	-	
17	4	4	25	84 Kr 17+	305	0	40.40	39.0	4.18E+02	335	1.40E+05	0.091	14.025	0	<7.14E-06	103	7.35E-04	0	<7.14E-06	
18	4	4	25	84 Kr 17+	305	0	40.40	39.0	1.52E+03	138	2.09E+05	0.135	14.160	2	9.55E-06	168	8.02E-04	0	<4.78E-06	Research a specific event
19	4	4	25	84 Kr 17+	305	0	40.40	39.0	9.84E+02	150	1.48E+05	0.095	14.255	0	<6.78E-06	136	9.22E-04	0	<6.78E-06	
20	3	3	25	84 Kr 17+	305	0	40.40	39.0	5.03E+02	197	9.90E+04	0.064	12.046	0	<1.01E-05	112	1.13E-03	0	<1.01E-05	
21	2	2	25	84 Kr 17+	305	0	40.40	39.0	5.28E+02	80	4.22E+04	0.027	12.833	0	<2.37E-05	110	2.60E-03	0	<2.37E-05	
22	2	2	25	84 Kr 17+	305	0	40.40	39.0	1.95E+02	215	4.19E+04	0.027	12.860	0	<2.38E-05	106	2.53E-03	0	<2.38E-05	
23	1	1	25	84 Kr 17+	305	0	40.40	39.0	1.57E+03	300	4.71E+05	0.305	14.735	2	4.24E-06	97	2.06E-04	0	<2.12E-06	
~~24*~~	~~1~~	~~4~~	~~25~~	~~84 Kr 17+~~	~~305~~	~~0~~	~~40.40~~	~~39.0~~	~~4.10E+02~~	~~29~~	~~1.19E+04~~	~~0.008~~	~~14.263~~	~~0~~	~~<8.42E-05~~	~~52~~	~~4.38E-03~~	~~0~~	~~<8.42E-05~~	
25*	1	4	25	84 Kr 17+	305	0	40.40	39.0	2.06E+02	125	2.58E+04	0.017	14.280	1	3.88E-05	109	4.23E-03	0	<3.88E-05	
26*	2	3	25	84 Kr 17+	305	0	40.40	39.0	2.91E+02	333	9.70E+04	0.063	12.108	0	<1.03E-05	103	1.06E-03	0	<1.03E-05	
27*	3	2	25	84 Kr 17+	305	0	40.40	39.0	1.97E+02	197	3.87E+04	0.025	12.885	0	<2.58E-05	110	2.84E-03	0	<2.58E-05	
28*	4	1	25	84 Kr 17+	305	0	40.40	39.0	9.13E+02	409	3.74E+05	0.241	14.976	1	2.68E-06	100	2.68E-04	0	<2.68E-06	
29*	1	4	25	84 Kr 17+	305	0	40.40	39.0	5.82E+02	290	1.69E+05	0.109	14.389	1	5.92E-06	101	5.98E-04	0	<5.92E-06	
30*	1	4	25	124Xe 26+	420	0	67.70	37.0	5.98E+02	180	1.08E+05	0.117	14.506	4	3.72E-05	96	8.92E-04	0	<9.29E-06	
31*	4	1	25	124Xe 26+	420	0	67.70	37.0	1.20E+03	235	2.83E+05	0.306	15.282	2	7.08E-06	98	3.47E-04	0	<3.54E-06	
32*	2	3	25	124Xe 26+	420	0	67.70	37.0	4.32E+02	202	8.72E+04	0.094	12.203	2	2.29E-05	100	1.15E-03	0	<1.15E-05	
33*	3	2	25	124Xe 26+	420	0	67.70	37.0	3.20E+02	107	3.42E+04	0.037	12.922	1	2.92E-05	115	3.36E-03	0	<2.92E-05	

Table 6 : 40MHz-CFP90006 test results with the Cocktail n°1, M/Q=5

40MHz-CFPT9006 SEL-SET-SEFI = 3.3V														LATCHUP		TRANSIENT		FUNCTIONAL INTERRUPT		
Run	Pos	Part	T°	Ion	Energy (MeV)	Tilt (°)	Eff. LET (MeV.cm²/mg)	Eff. Range (µm Si)	Flux (φ) ($cm^{-2}.s^{-1}$)	Time (s)	Run Fluence (Φ) (cm^{-2})	Run Dose (krad)	Cumulated Dose (krad)	+Vs	Cross Section	OUT	Cross Section	OUT	Cross Section	Comment
High Range M/Q=3.3																				
34	1	1	85	83 Kr 25+	756	0	32.60	92.0	1.50E+04	666	1.00E+07	5.216	20.498	55	5.50E-06	-	-	-	-	
35	2	2	85	83 Kr 25+	756	0	32.60	92.0	1.58E+04	631	1.00E+07	5.216	18.138	78	7.80E-06	-	-	-	-	
36	3	3	85	83 Kr 25+	756	0	32.60	92.0	1.45E+04	688	1.00E+07	5.216	17.419	63	6.30E-06	-	-	-	-	
37	4	4	85	83 Kr 25+	756	0	32.60	92.0	1.59E+04	630	1.00E+07	5.216	19.722	68	6.80E-06	-	-	-	-	
38	1	1	25	83 Kr 25+	756	0	32.60	92.0	1.30E+03	304	3.95E+05	0.206	20.704	4	1.01E-05	101	2.56E-04	0	<2.53E-06	
39	2	2	25	83 Kr 25+	756	0	32.60	92.0	1.90E+02	221	4.19E+04	0.022	18.160	1	2.39E-05	106	2.53E-03	0	<2.39E-05	
40	3	3	25	83 Kr 25+	756	0	32.60	92.0	4.62E+02	301	1.39E+05	0.072	17.491	2	1.44E-05	101	7.27E-04	0	<7.20E-06	
41	4	4	25	83 Kr 25+	756	0	32.60	92.0	5.28E+02	5	2.64E+03	0.001	19.723	0	<3.79E-04	21	7.95E-03	0	<3.79E-04	
42	4	4	25	83 Kr 25+	756	0	32.60	92.0	7.37E+02	198	1.46E+05	0.076	19.799	0	<6.85E-06	108	7.40E-04	0	<6.85E-06	
43	1	1	85	58 Ni 18+	567	0	20.40	100.0	1.41E+04	710	1.00E+07	3.264	23.968	16	1.60E-06	-	-	-	-	
44	2	2	85	58 Ni 18+	567	0	20.40	100.0	1.53E+04	655	1.00E+07	3.264	21.424	26	2.60E-06	-	-	-	-	
45	3	3	85	58 Ni 18+	567	0	20.40	100.0	1.55E+04	647	1.00E+07	3.264	20.755	8	8.00E-07	-	-	-	-	
46	4	4	85	58 Ni 18+	567	0	20.40	100.0	1.52E+04	659	1.00E+07	3.264	23.063	13	1.30E-06	-	-	-	-	
47	1	1	25	58 Ni 18+	567	0	20.40	100.0	2.40E+03	301	7.22E+05	0.236	24.204	2	2.77E-06	121	1.68E-04	1	1.39E-06	
48	2	2	25	58 Ni 18+	567	0	20.40	100.0	4.61E+02	183	8.44E+04	0.028	21.451	0	<1.19E-05	105	1.24E-03	0	<1.19E-05	
49	3	3	25	58 Ni 18+	567	0	20.40	100.0	5.57E+02	378	2.11E+05	0.069	20.824	0	<4.75E-06	102	4.84E-04	0	<4.75E-06	
50	4	4	25	58 Ni 18+	567	0	20.40	100.0	5.85E+02	60	3.51E+04	0.011	23.075	0	<2.85E-05	6	1.71E-04	0	<2.85E-05	Stopped by beam operator
51	4	4	25	58 Ni 18+	567	0	20.40	100.0	1.37E+03	228	3.12E+05	0.102	23.176	1	3.20E-06	102	3.27E-04	0	<3.20E-06	
52	4	4	85	40 Ar 12+	372	0	10.20	117.0	1.54E+04	651	1.00E+07	1.632	24.808	0	<1.00E-07	-	-	-	-	
53	3	3	85	40 Ar 12+	372	0	10.20	117.0	1.56E+04	643	1.00E+07	1.632	22.456	0	<1.00E-07	-	-	-	-	
54	2	2	85	40 Ar 12+	372	0	10.20	117.0	1.53E+04	653	1.00E+07	1.632	23.083	0	<1.00E-07	-	-	-	-	
55	1	1	85	40 Ar 12+	372	0	10.20	117.0	1.55E+04	646	1.00E+07	1.632	25.836	0	<1.00E-07	-	-	-	-	
56	4	4	25	40 Ar 12+	372	0	10.20	117.0	3.64E+03	275	1.00E+06	0.163	24.972	0	<1.00E-06	95	9.50E-05	0	<1.00E-06	
57	3	3	25	40 Ar 12+	372	0	10.20	117.0	3.65E+03	274	1.00E+06	0.163	22.619	0	<1.00E-06	114	1.14E-04	1	1.00E-06	
58	2	2	25	40 Ar 12+	372	0	10.20	117.0	2.96E+03	151	4.47E+05	0.073	23.156	0	<2.24E-06	135	3.02E-04	0	<2.24E-06	
59	1	1	25	40 Ar 12+	372	0	10.20	117.0	6.85E+03	146	1.00E+06	0.163	25.999	0	<1.00E-06	47	4.70E-05	0	<1.00E-06	
60	1	1	25	22 Ne 7+	235	0	3.00	216.0	7.75E+03	129	1.00E+06	0.048	26.047	0	<1.00E-06	5	5.00E-06	0	<1.00E-06	
61	2	2	25	22 Ne 7+	235	0	3.00	216.0	1.08E+04	93	1.00E+06	0.048	23.204	0	<1.00E-06	7	7.00E-06	0	<1.00E-06	
62	3	3	25	22 Ne 7+	235	0	3.00	216.0	1.49E+04	67	1.00E+06	0.048	22.667	0	<1.00E-06	6	6.00E-06	0	<1.00E-06	
63	4	4	25	22 Ne 7+	235	0	3.00	216.0	1.54E+04	65	1.00E+06	0.048	25.020	0	<1.00E-06	4	4.00E-06	0	<1.00E-06	
64	4	4	25	13 C 4+	131	0	1.10	292.0	1.49E+04	67	1.00E+06	0.018	25.037	0	<1.00E-06	0	<1.00E-06	0	<1.00E-06	
65	3	3	25	13 C 4+	131	0	1.10	292.0	1.54E+04	65	1.00E+06	0.018	22.685	0	<1.00E-06	0	<1.00E-06	0	<1.00E-06	
66	2	2	25	13 C 4+	131	0	1.10	292.0	1.56E+04	64	1.00E+06	0.018	23.222	0	<1.00E-06	0	<1.00E-06	0	<1.00E-06	
67	1	1	25	13 C 4+	131	0	1.10	292.0	1.49E+04	67	1.00E+06	0.018	26.064	0	<1.00E-06	0	<1.00E-06	0	<1.00E-06	
68	4	4	85	40 Ar 12+	372	50	15.87	75.2	1.02E+04	981	1.00E+07	2.539	27.576	0	<1.00E-07	-	-	-	-	
69	4	4	85	40 Ar 12+	372	57	18.73	63.7	9.94E+03	1006	1.00E+07	2.996	30.573	2	2.00E-07	-	-	-	-	

Table 7 : 40MHz-CFP90006 test results with the Cocktail n°2, M/Q=3.3

Run cancelled, the run dose is taken into account for the cumulative dose calculation

40MHz-CFPT9006 SEL-SET-SEFI = 3.3V																LATCHUP		TRANSIENT		FUNCTIONAL INTERRUPT	
Run	Pos	Part	T°	Ion	Energy (MeV)	Range (µm)	LET (MeV.cm²/mg)	Tilt (°)	Eff. LET (MeV.cm²/mg)	Eff. Range (µm Si)	Flux (φ) ($cm^{-2}.s^{-1}$)	Time (s)	Run Fluence (Φ) (cm^{-2})	Run Dose (krad)	Cumulated Dose (krad)	+Vs	Cross Section	OUT	Cross Section	OUT	Cross Section
High Range M/Q=3.3																					
1	**2**	**25**	**ON**	**58 Ni 18+**	567	100	20.4	**0**	20.40	100.0	1.16E+04	**861**	**1.00E+07**	3.264	3.264	**11**	2.70E-06	**18274**	1.83E-03	**N.A.**	1.60E-06
2	**2**	**25**	**OFF**	**58 Ni 18+**	567	100	20.4	**0**	20.40	100.0	1.18E+04	**846**	**1.00E+07**	3.264	6.528	**6**	6.00E-07	**18344**	1.83E-03	**4**	1.74E-05
3	**5**	**25**	**ON**	**58 Ni 18+**	567	100	20.4	**0**	20.40	100.0	1.26E+04	**792**	**1.00E+07**	3.264	3.264	**7**	3.40E-06	**7772**	7.77E-04	**N.A.**	2.70E-06
4	**5**	**25**	**OFF**	**58 Ni 18+**	567	100	20.4	**0**	20.40	100.0	1.35E+04	**740**	**1.00E+07**	3.264	6.528	**8**	8.00E-07	**5248**	5.25E-04	**4**	6.50E-06
5	**6**	**25**	**OFF**	**58 Ni 18+**	567	100	20.4	**0**	20.40	100.0	1.33E+04	**751**	**1.00E+07**	3.264	3.264	**11**	1.10E-06	**3381**	3.38E-04	**1**	6.10E-06
6	**6**	**25**	**OFF**	**40 Ar 12+**	372	117	10.2	**0**	10.20	117.0	5.03E+03	**199**	**1.00E+06**	0.163	3.427	**0**	<1.00E-06	**70**	7.00E-05	**0**	<1.00E-06
7	**5**	**25**	**OFF**	**40 Ar 12+**	372	117	10.2	**0**	10.20	117.0	5.46E+03	**183**	**1.00E+06**	0.163	0.163	**0**	<1.00E-06	**146**	1.46E-04	**0**	<1.00E-06
8	**2**	**25**	**OFF**	**40 Ar 12+**	372	117	10.2	**0**	10.20	117.0	4.88E+03	**205**	**1.00E+06**	0.163	0.163	**0**	<1.00E-06	**366**	3.66E-04	**0**	<1.00E-06
9	**2**	**25**	**OFF**	**40 Ar 12+**	372	117	10.2	**0**	10.20	117.0	5.08E+03	**590**	**3.00E+06**	0.490	0.653	**0**	<3.33E-07	**1189**	3.96E-04	**0**	<3.33E-07
10	**2**	**25**	**OFF**	**40 Ar 12+**	372	117	10.2	**0**	10.20	117.0	1.78E+04	**563**	**1.00E+07**	1.632	2.285	**0**	<1.00E-07	**3752**	3.75E-04	**0**	3.00E-07

Table 8 : 40MHz-CFP90006 test results with the Cocktail n°2, M/Q=3.3 during the second campaign