Total Dose Steady-State Irradiation

(3-5) µm 384x288 MCT Focal Plane Array

mounted as

Integrated Detector Cooler Assembly

Total Dose Ionisation Tests

^{60}Co-γ-Irradiation at ESTEC, Noordwijk

12/2005

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Content

1. Scope

This test plan describes the steady state Gamma irradiation testing of the (3-5) µm $Hg_{1-x}Cd_xTe$-Infrared Focal Plane Array (MCT-FPA) consisting of 384x288 pixels. The MCT-FPA is mounted as integrated detector cooler assembly (IDCA) which consists of the following components:

- Hg_{1-x} Cd_x Te (MCT) PV-Detector-Array with integrated read out circuit (Silicon)
- Drive- and read out electronics including A/D converter (Frontend Electronics, FEE)
- Dewar with integrated linear cooler

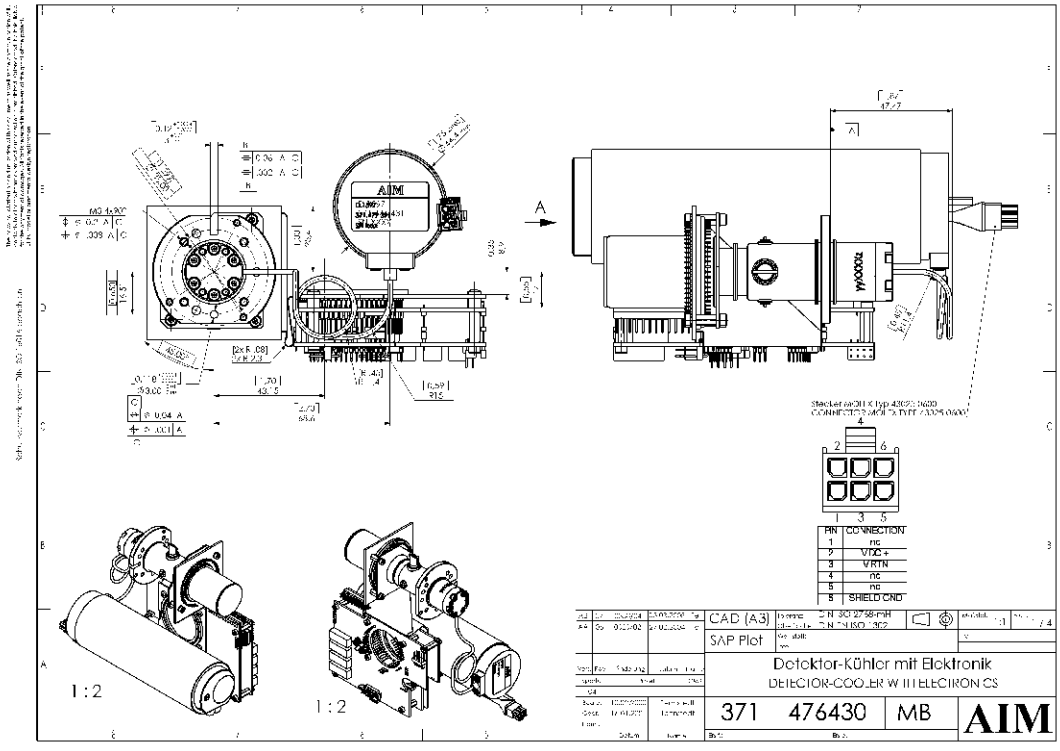
The irradiation tests were carried out within the frame of the DLR funded programme “Generic Short Wavelength Infrared Sensor, GENSIS”. The analysis of the reference detector module after Gamma irradiation shall indicate application specific design set-points for the development of a hyperspectral focal plane array operating in the spectral range 0.9 µm < λ < 2.5 µm in on board of a satellite.

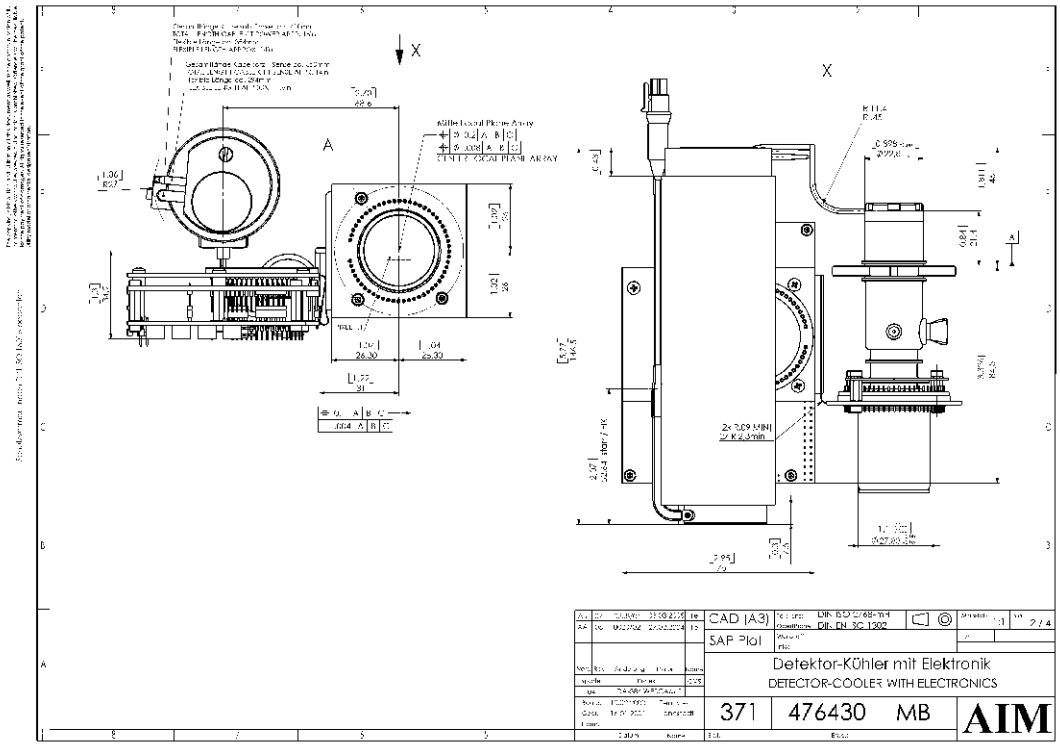
1.1 Reference Documents

Ref. [1] 371.566669.PV — Technical specification linear compressor Type SL 035-40, AIM INFRAROT-MODULE GmbH

Ref. [2] 371.476 430.MB see drawings below — Drawing „Detector-cooler with electronics“ for IDCA384MW, AIM INFRAROT-MODULE GmbH

Ref. [3] 371.T43 120 — Technical specification CAE384, AIM INFRAROT-MODULE GmbH





1.2 Optical interface

1.2.1 Spectral sensitivity

The spectral sensitivity including dewar entrance window extends

from	λ (cut-on):	3.4 µm ±0.05 µm	
to	λ (cut-off):	5.0 µm - 5.25 µm,	(50%-values).

1.2.2 Geometry of the detector array

Number of the detector elements:	384 × 288 (horiz. × vert.)
Element size:	20 µm × 20 µm
Pitch:	24 µm × 24 µm

1.2.3 Cold shield and dewar window

The cold shield is designed for an aperture ratio of F/2.6 .The efficiency of the cold shield is 100%. The mechanical setup is shown in Figure 1.

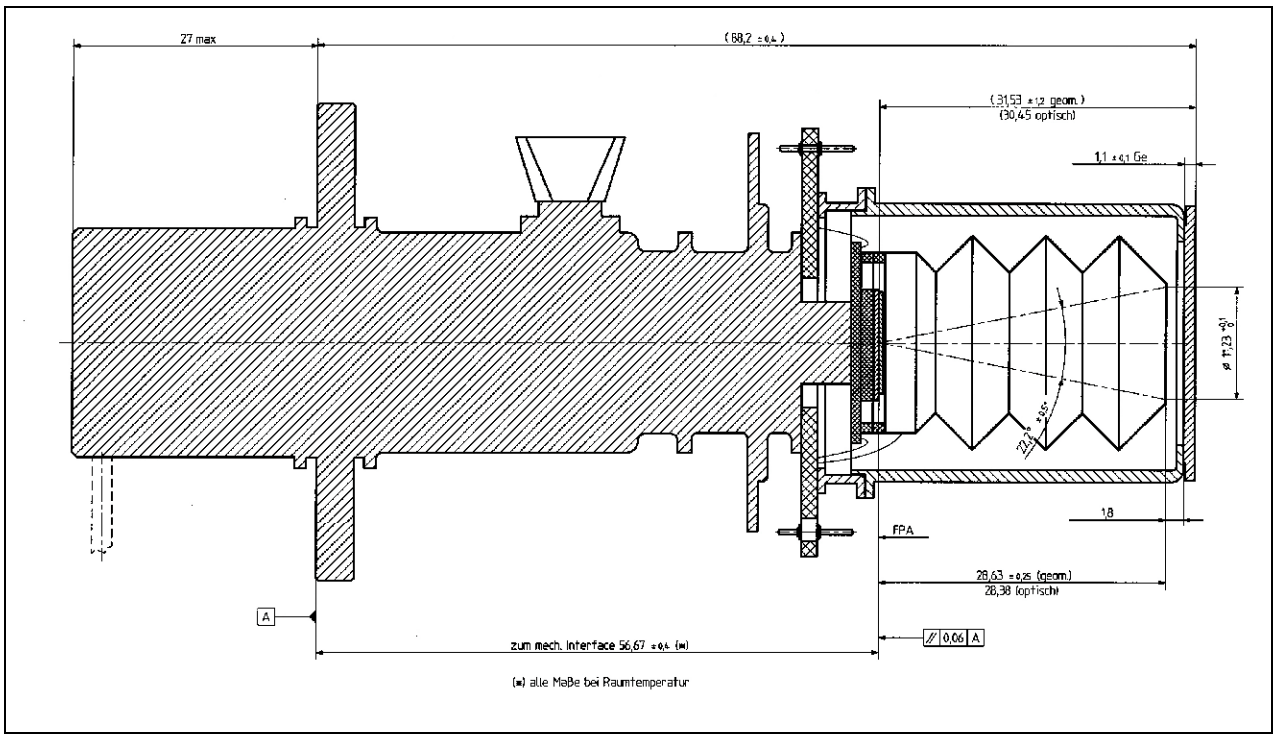


Figure 1: optical interface

Dewar window

Material:	Germanium, coated
Thickness:	1 mm
Distance to the Focal-Plane:	see Figure 1

1.3 Electrical interfaces

The electrical interface of the integrated detector-cooler-assembly is defined in Ref. [1] and Ref. [3].

2 Irradiation Test Plan for IDCA, AIM SN: MW MCT 384x288/2404

The MWIR-MCT-FPA is a reference module to analyse the standard AIM infrared technology according to space requirements, able to identify design options to achieve space demands.

The Total Ionization Dose (TID)-tests were carried out with the Mid Wave Integrated Detector Module.

This module has been subject to stress during the manufactoring process on the left top corner leading to an small extended area of defective pixles. To obtain representative values, we skip the top 18 lines of the array and evaluated only data from a 382 x 270 sub-frame of the full 384 x 288 array.

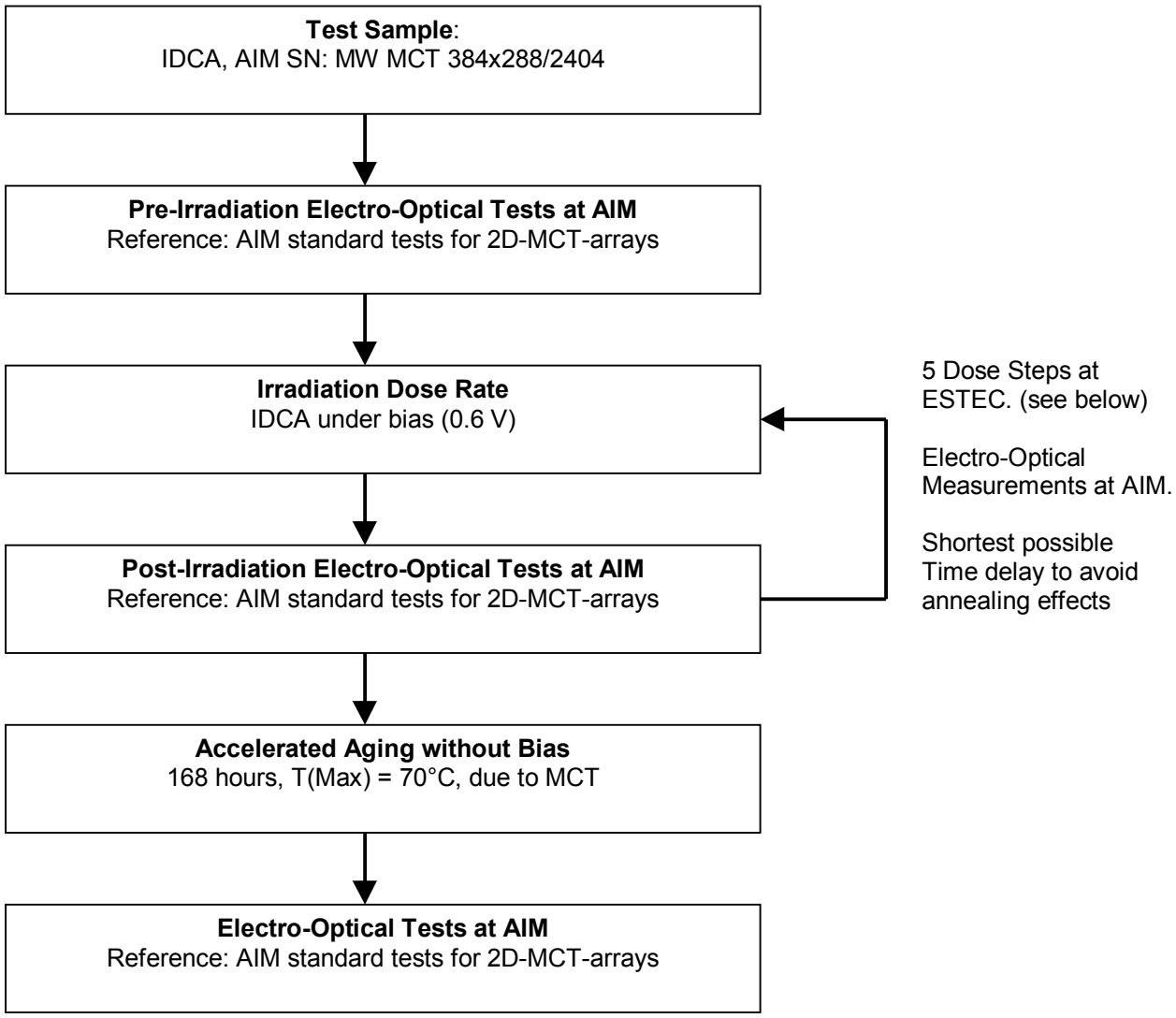
AIM Serial Number	**SN 2404**
With Hybrid	HZD 629
F#	4.6
DETG	0.6 V
Integration Time	13 ms (digital 86)
Frame Rate	15 fps
Number of Frames	35
Physical pixel dimension	384 x 288
A/D converter resolution	14 bit
A/D converter range	2.5 V

The IDCA's electro-optical performance is characterized by a AIM standard test sequence.
During this sequence, the following parameters are measured and reported here:

- Response in [LSB / K] for a 293 K (20°C) black-body temperatur.
- Noise (rms) in [LSB]
- Noise Equivalent Temperature Different (NETD) in [mK]
- DC uniformity. Reported is the average DC level at the 14 bit A/D converter and its standard deviation. Note that lower values correspond to higher IR intensities.
- Defective pixels.
  A pixel is defective (according to AIM's specs.),
  - If its NETD > 51 mK or
  - the DC signal level is below 0.63% of the U_{cos4} value of this pixel. The U_{cos4} value is the average DC value of a 31x31 frame centered at the pixel of interest

Starting basis are the electro-optical evaluation measurements carried out at AIM dated 20.05.2005. The infrared MCT focal plane array has been subject to irradiation in accordance with the following flow chart.

2.1 Flow Chart for Evaluation Testing



The electro-optical tests and observations are collected in this test report. As a result, conclusions and recommendations for a redesign phase are expected for MCT infrared detector components to meet space requirements.

2.2 Irradiation Test: Overview

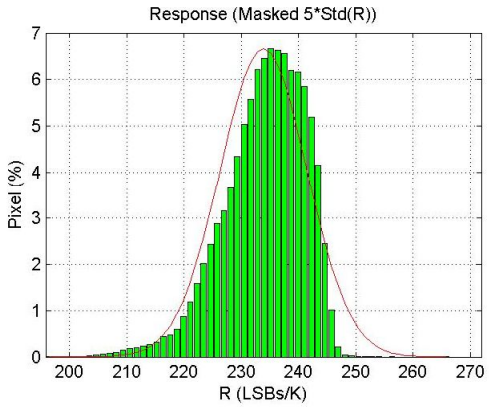
1.	Total Dose Test Plan.	No									
2.	Issue.			Rev.		Date					
3.	SCC Component	No									
4.	Component Designation	Infrared Integrated Detector Cooler Assembly or Space Applications									
5.	Irradiation Spec.	No.		Issue		Rev.					
6.	Specifications										
7.	Acceptance										
8.	Sample Size	Drawing No. 371.476 430, attachment 1									
9..	Project / Programme	Generic Short Wave Infrared Sensor Project (DLR funded under 50EP0501)									
10.	Family	(3-5) µm Hg_{1-x} Cd_x Te Infrared Detector (MCT Detector)									
11.	Group										
12.	Package	Integrated Detector Cooler Assembly, IDCA									
13	Manufacturer, Address	AIM INFRAROT-MODULE GmbH Theresienstraße 2 D-74072 Heilbronn									
14.	Test House	ESA / ESTEC, 2201 AZ Nordwjik, The Netherlands, Dept. TEC-QCA									
15.	Originator	AIM		Name: H.-P. Nothaft		Tel. +49 7131 6212 181					
16	Facility Source	AIM INFRAT-MODULE GmbH									
17.	Irradiation:	Single	No		Multiple		Yes				
18.	Irradiation Measurement Interval	Biased	Yes , 0.6 V								
		Unbiased	No		Supply Voltage		Yes, specified				
		Temp: °C	Room Temp		Duration		acc. Dose Rate				
			T (FPA) ≈ 80 K								
19.	Level of Interest										
20.	Single Irradiation	Dose (krad)				No					
		Dose Rate (rad)				N/A					
		Exposure Time				N/A					
21.	Multiple Irradiation Steps	1	2	3	4	5	6				
	Dose (krad)	1 krad	4 krad	5 krad	10 krad	10 krad	20 krad				
	Total Dose (krad)	1 krad	5 krad	10 krad	20 krad	30 krad	50 krad				
	Exposure Time	71 min	270 min	334 min	675 min	639 min	1211 min				
	Exposure Date 2005	04.10.	10.10	14.10.	24.10.	17.11.	29.11.- 30.11.				
	E/O Measurement Date 2005	05.10.	11.10.	18.10.	07.11.	21.11.	06.12.				
22.	Irradiation Conditions	Biased IDCA				Yes					
		In-Situ Test				Not applicable, tested at AIM					
23.	Anneal Test	Biased IDCA				No					
		Temp 70°C				168 h					
24.	Electro-optical Parameters to be Tested	Before Irradiation (acc. to AIM form sheets)									
	Characteristics		Acc. To AIM Spec. /Method		Remarks						
24.1	Response [LSB/K]	Average									
24.2	Response [LSB/K]	Standard deviation									
24.3	Response	pixels outside 5 σ									
24.4	NETD [mK]	Average									
24.5	NETD [mK]	Standard deviation									
24.6	NETD	pixels outside 5 σ									
24.7	Rms-Noise [LSB]	Average									
24.8	Rms-Noise [LSB]	Standard deviation									
24.9	Noise	pixels outside 5 σ									
24.10	Defective Pixels										
24.11	Defective Center Pixels										
24.12	DC-Uniformity										
24.13											
24.14											
24.15											

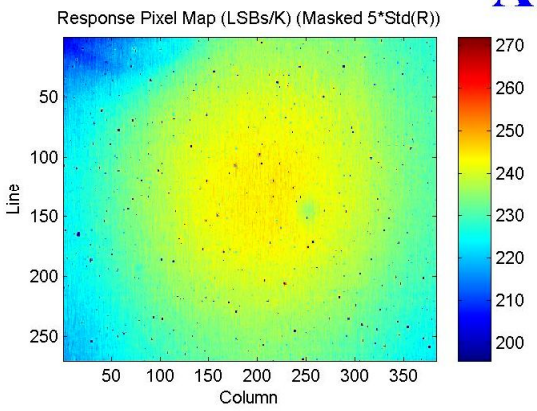
2.3 Irradiation Tests

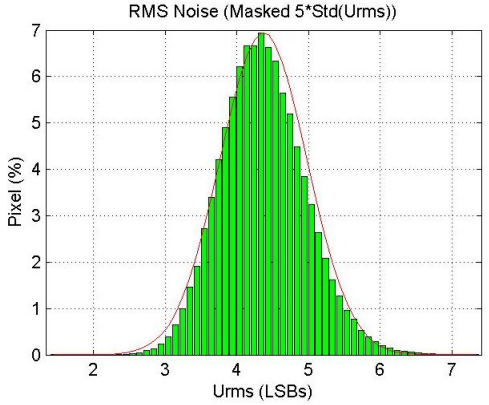
2.3.0 Test Step 0: AIM Acceptance Output Test

	Total Dose Test Plan.	No								
	Issue	No.		Rev.			Date	20.05.2005		
	Irradiation Test Sequence	No. 0, i.e. AIM-Production Output Tests								
	Test Step No. 0	Description: before irradiation								
	Evaluation area (full)	382 x 270 = 103'140 Pixel								
	Evaluation area (center)	114 x 80 = 9'120 Pixel								
	Detector Bias [V]	0.6 ± 0.1 V Note that the absolute value of E/O parameters depend on the detector bias. Unfortunately, the value for this measurement was not determined precisely								
	No. of frames	35								
	Frame rate	15 frames per second								
	Integration time	13 ms								
		average	std. dev.	unit	pixels outside		criterion	remarks		
1.	Response	234	7.6	LSB / K	257	0.25 %	5 σ			
2.	NETD	18.7	2.7	mK	105	0.10 %	[0, 3*27 mK]	according to specs.		
3.	rms-Noise	4.4	0.61	LSB	107	0.10 %	5 σ			
4.	DC-uniformity	8'692	224	LSB						
5.	Spatial uniformity IETD	9.1		mK						
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	115	0.11 %	77	13	6	2	5	-	-
7.	center area	12	0.13 %	6	3	3	-	-	-	-
8.	Remarks Date of measurement: 20.05.2005 Operator: Christian Ellerbrake Before Gamma Irradiation N/A Total Gamma dose: 0 krad									

COMPANY PROPRIETARY AIM







Response / RMS Noise

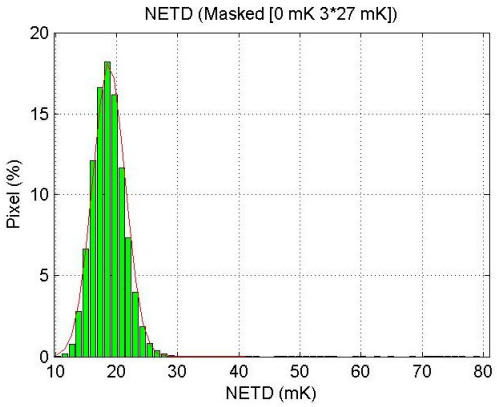
CMT 384x288 MW SN2404-HZD629; 20.05.05-mh hl; Tint=13ms; F/#:4.6

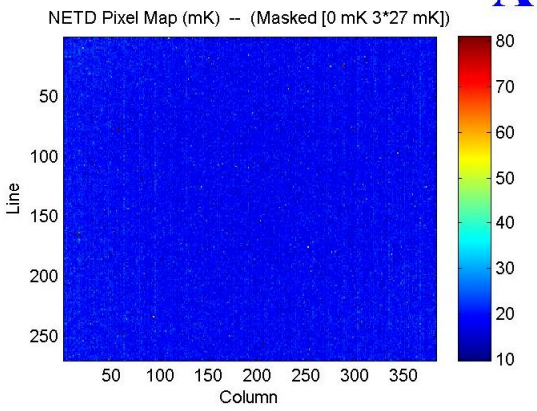
0 krad

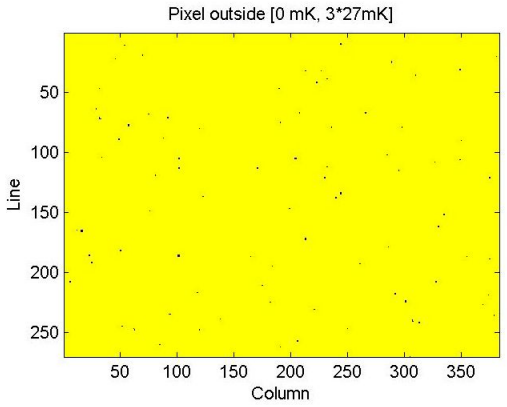
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 233.87 LSBs/K
std(R) = 7.61 LSBs/K
Pixel outside 5*Std(R): 257

Temperatur T3: 293 K
<Urms> = 4.37 LSBs
std(Urms) = 0.61 LSBs
Pixel outside 5*Std(Urms): 107

COMPANY PROPRIETARY AIM







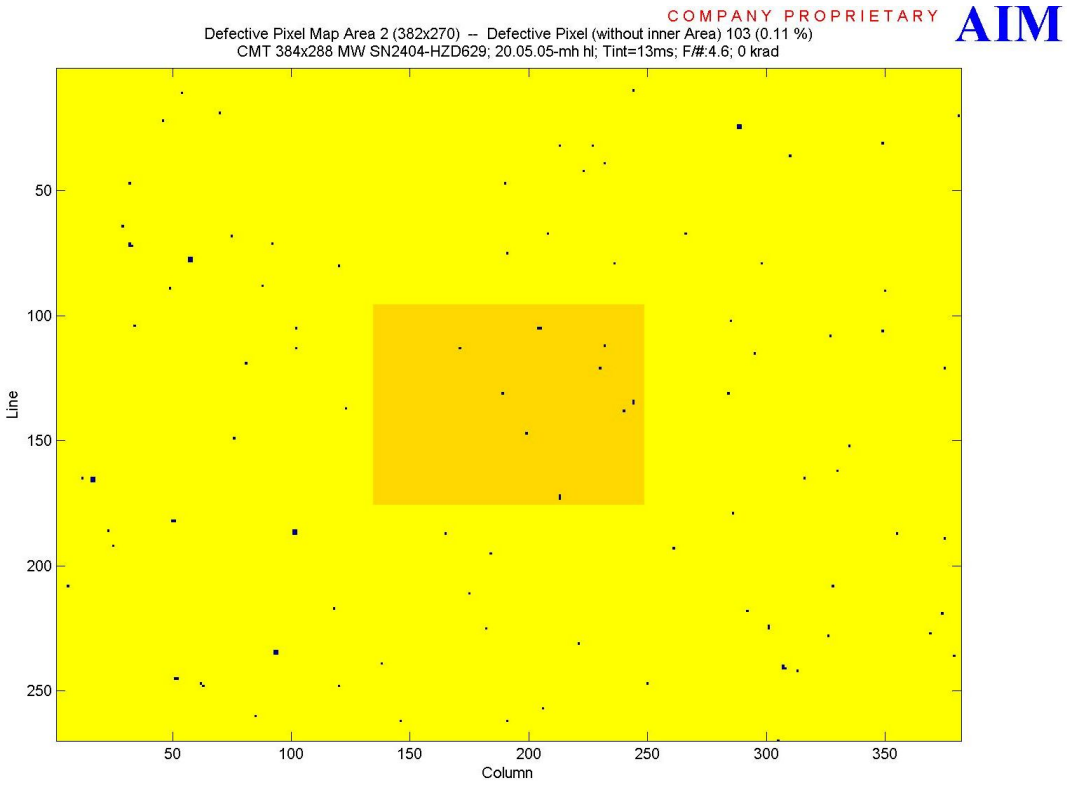
NETD @ T3 = 293 K

CMT 384x288 MW SN2404-HZD629; 20.05.05-mh hl; Tint=13ms; F/#:4.6

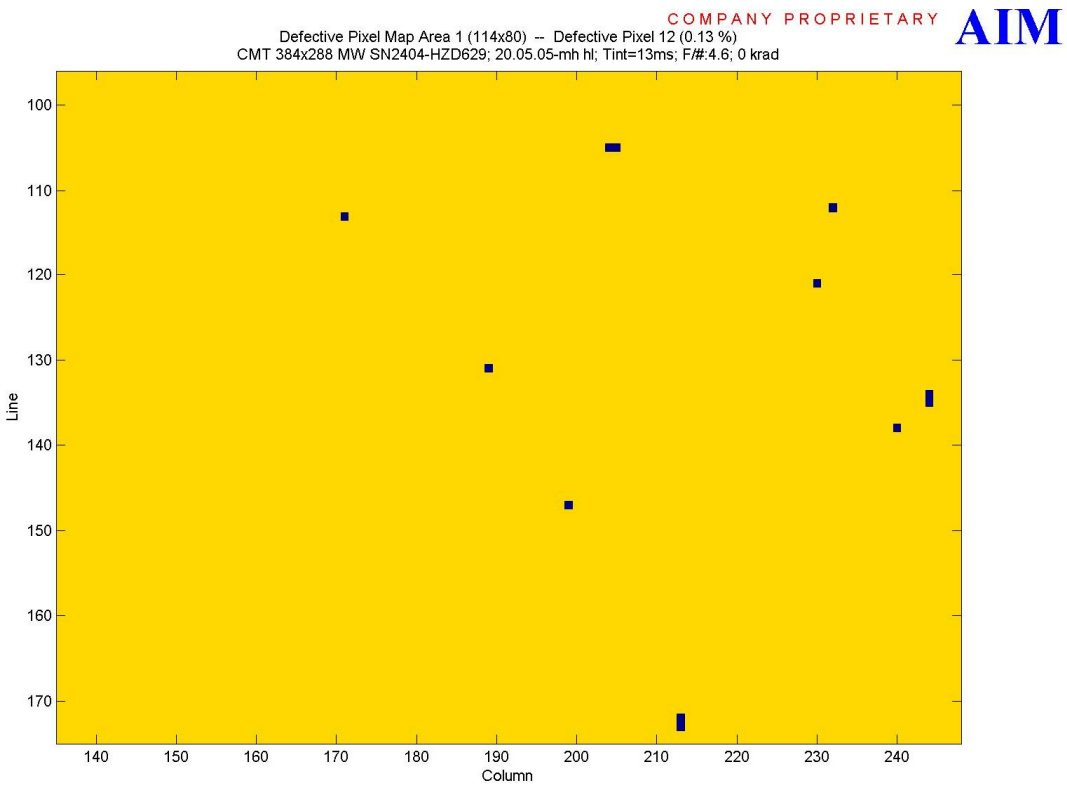
0 krad

<NETD> = 18.72 mK
std(NETD) = 2.67 mK

Pixel outside [0 mK, 3*27 mK] = 105 (0.10%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.1 Test Step 1: TID = 1 krad

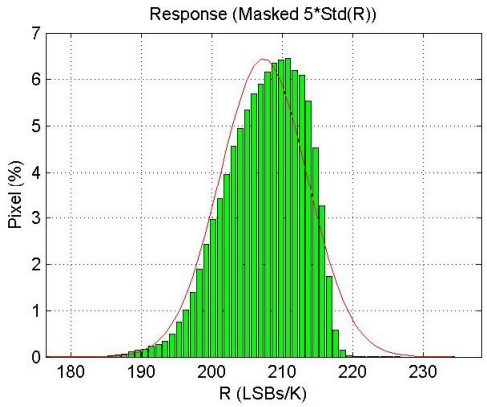
	Total Dose Test Plan.		No						
	Issue		No.		Rev.		Date	05.10.2005	
	Irradiation Test Sequence		No. 1				Date	04.10.2005	
	Test Step No. 1		Description: after 1 krad Irradiation			Total Dose =		1 krad	
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	207	6.2	LSB / K	262	0.25 %	5 σ		
2.	NETD	14.4	2.0	mK	95	0.09 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	3.0	0.41	LSB	192	0.19 %	5 σ		
4.	DC-uniformity	7'681	185	LSB					
5.	Spatial uniformity IETD	5.3		mK					
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	98	0.10 %	62	13	7	2	4	-	-
7.	center area	11	0.12 %	5	3	3	-	-	-	-
8.	Remarks									

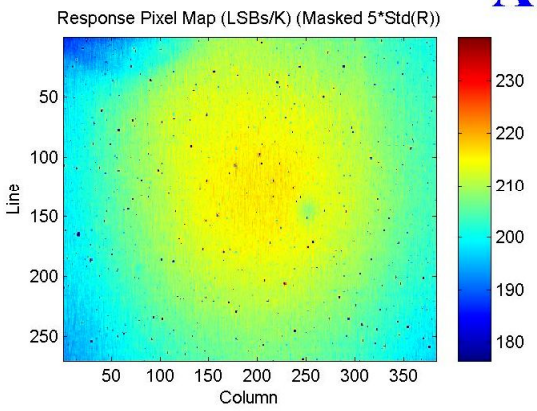
Date of γ-FPA-Irradiation: 04.10.2005

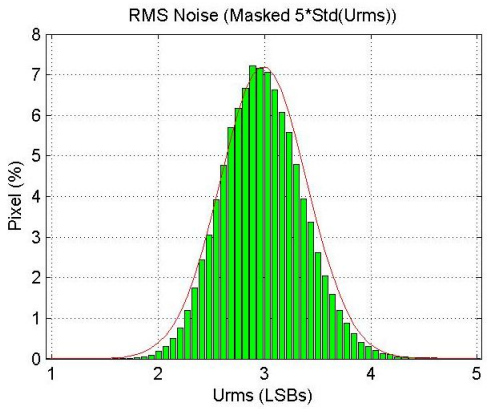
Date of IDCA-measurement: 05.10.2005 Operator: Holger Lutz

After Gamma 1 krad

Total Gamma dose 1 krad







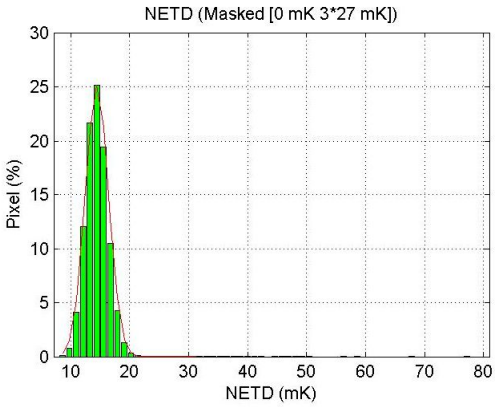
Response / RMS Noise

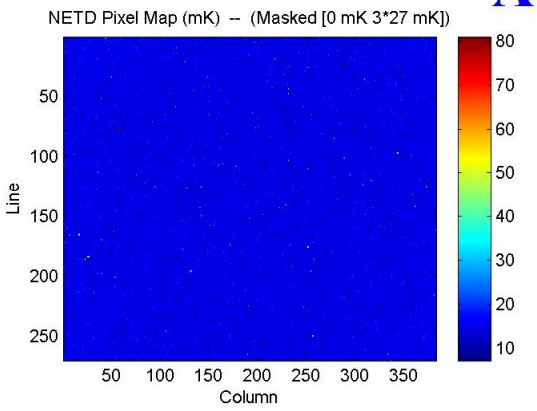
CMT 384x288 MW SN2404-HZD629; 05.10.05-mh hl; Tint=13ms; F/#:4.6

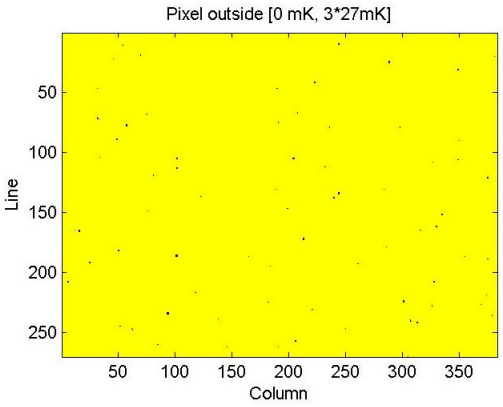
1 krad

Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 207.35 LSBs/K
std(R) = 6.18 LSBs/K
Pixel outside 5*Std(R): 262

Temperatur T3: 293 K
<Urms> = 2.99 LSBs
std(Urms) = 0.41 LSBs
Pixel outside 5*Std(Urms): 192







NETD @ T3 = 293 K

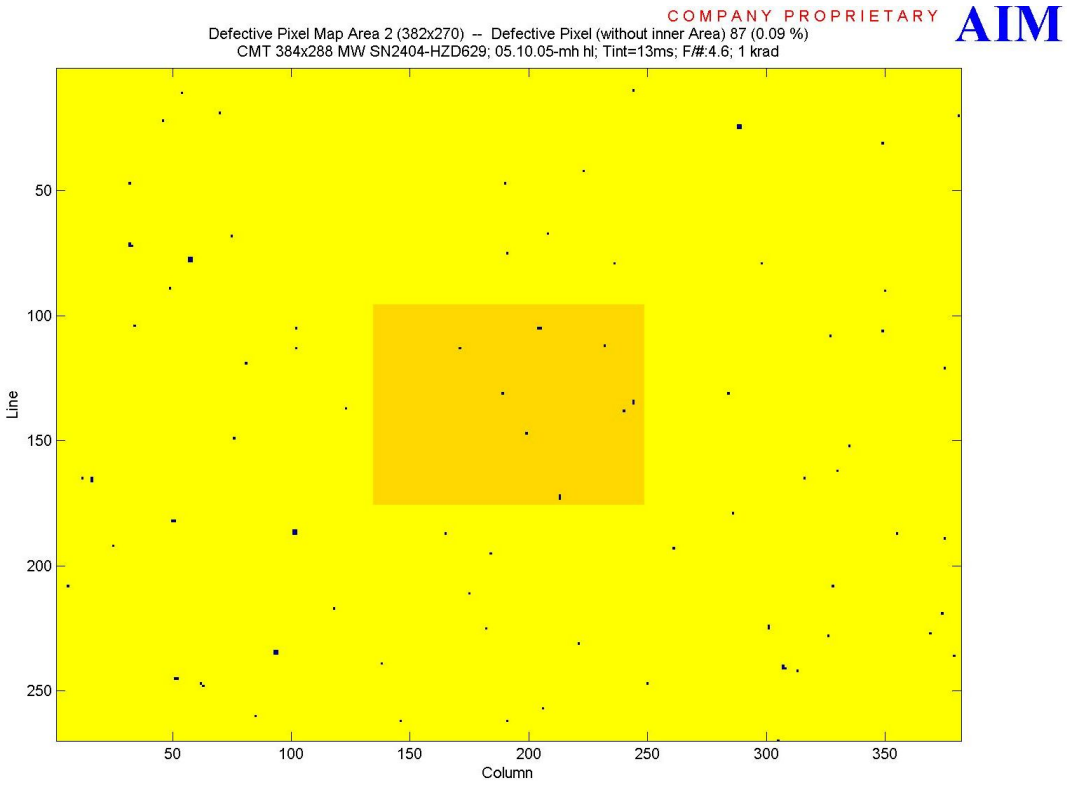
CMT 384x288 MW SN2404-HZD629; 05.10.05-mh hl; Tint=13ms; F/#:4.6

1 krad

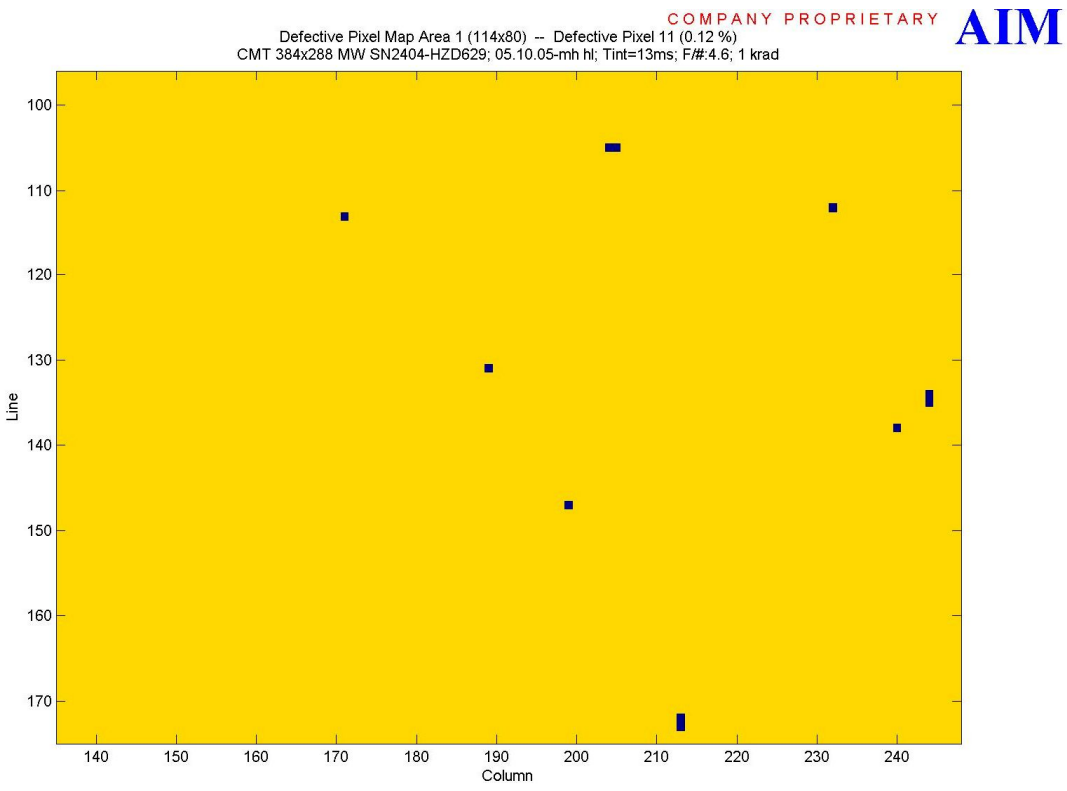
<NETD> = 14.43 mK

std(NETD) = 1.98 mK

Pixel outside [0 mK, 3*27 mK] = 95 (0.09%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.2 Test Step 2: TID = 5 krad

	Total Dose Test Plan.	No							
	Issue	No.		Rev.		Date	11.10.2005		
	Irradiation Test Sequence	No.				Date:	10.10.2005		
	Test Step No. 2	Description: after 4 krad Irradiation			Total Dose =		5 krad		
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	208	6.2	LSB / K	267	0.26 %	5 σ		
2.	NETD	14.1	2.0	mK	109	0.11 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	2.9	0.41	LSB	182	0.18 %	5 σ		
4.	DC-uniformity	7'714	186	LSB					
5.	Spatial uniformity IETD	5.1		mK					
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	111	0.11 %	73	13	6	2	5	-	-
7.	center area	12	0.13 %	6	3	3	-	-	-	-

8. Remarks

Date of γ-FPA-Irradiation: 10.20.2005

Date of measurement: 11.10.2005 Operator: Holger Lutz

After Gamma 4 krad

Total Gamma dose 5 krad

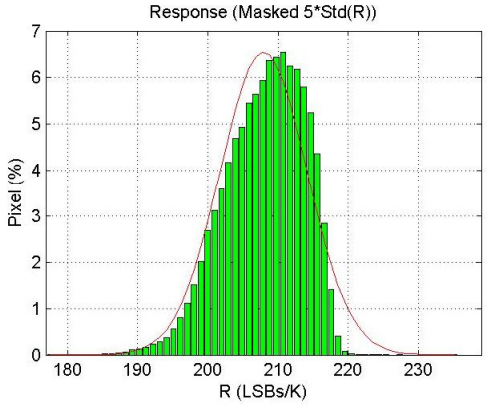
Mr. Bob Nickson, ESTEC

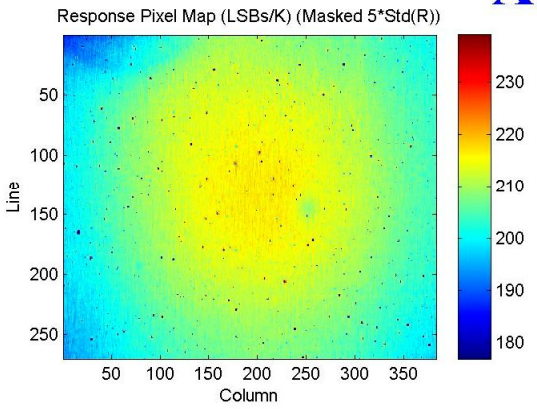
Here is a synopsis of the second MCT radiation run on Monday 10th October :

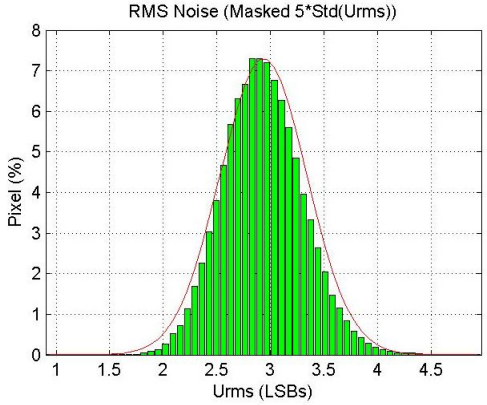
Set up detector module and checked pulse outputs with scope.
09:10 Started radiation at 14.9 rads/min (water)
13:37 Stopped run at 4 krads.

Dismantled and re-packed detector in original packaging. Ready for collection by DHL at around 17:00

COMPANY PROPRIETARY AIM







Response / RMS Noise

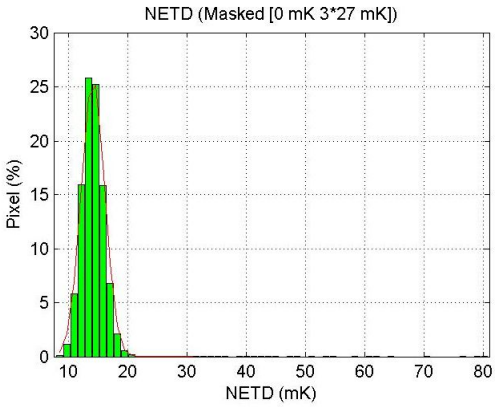
CMT 384x288 MW SN2404-HZD629; 11.10.05-mh hl; Tint=13ms; F/#:4.6

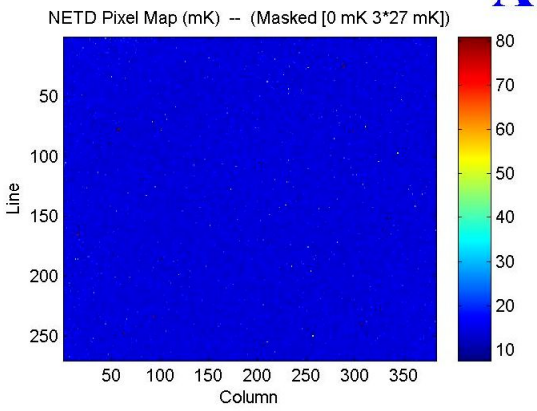
5 krad

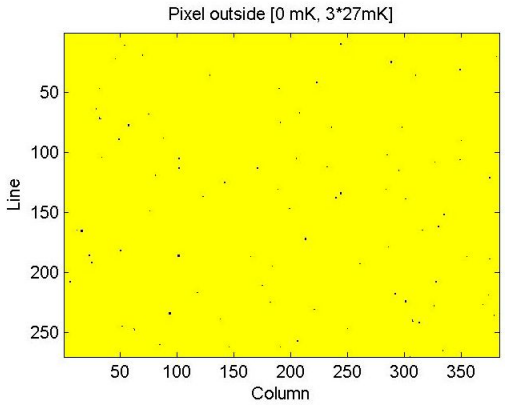
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 207.93 LSBs/K
std(R) = 6.20 LSBs/K
Pixel outside 5*Std(R): 267

Temperatur T3: 293 K
<Urms> = 2.94 LSBs
std(Urms) = 0.41 LSBs
Pixel outside 5*Std(Urms): 182

COMPANY PROPRIETARY AIM







NETD @ T3 = 293 K

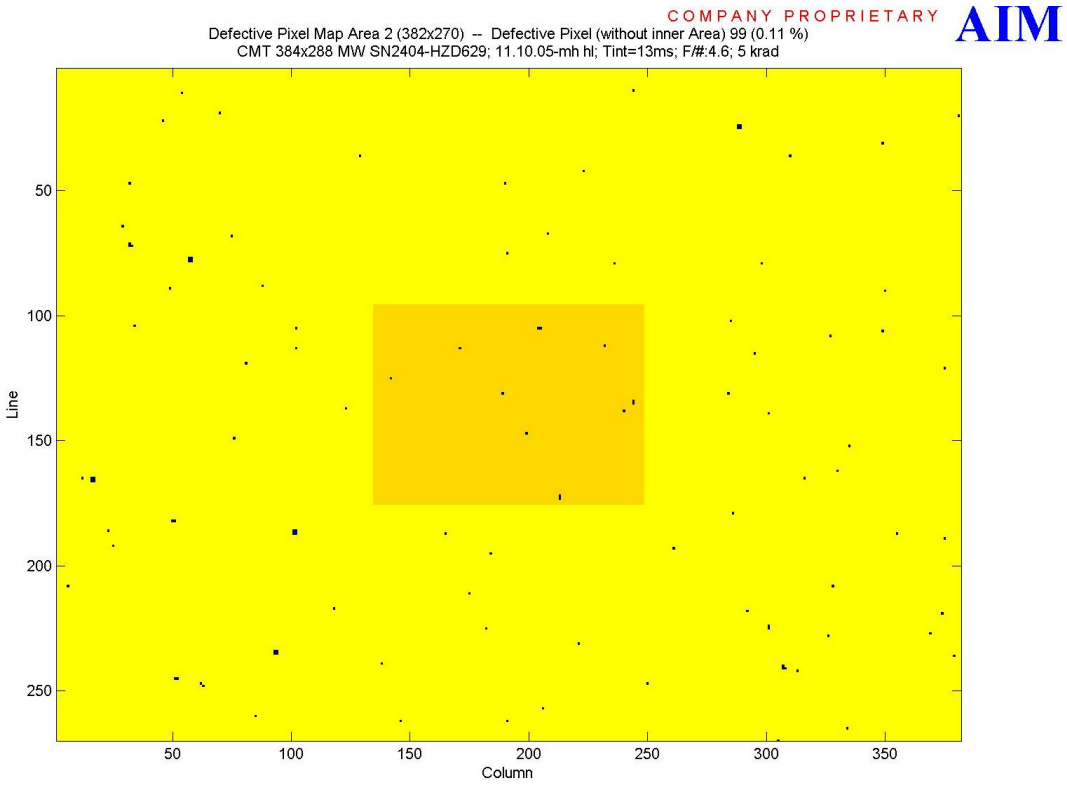
CMT 384x288 MW SN2404-HZD629; 11.10.05-mh hl; Tint=13ms; F/#:4.6

5 krad

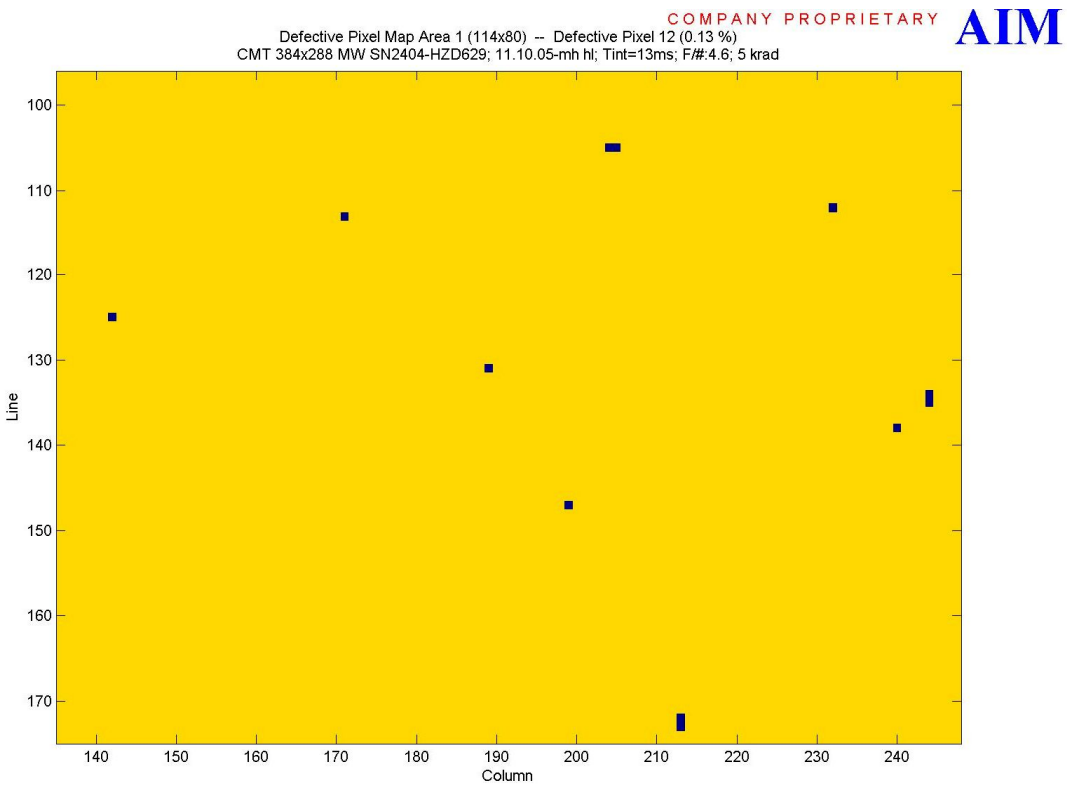
<NETD> = 14.12 mK

std(NETD) = 1.96 mK

Pixel outside [0 mK, 3*27 mK] = 109 (0.11%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.3 Test Step 3: TID = 10 krad

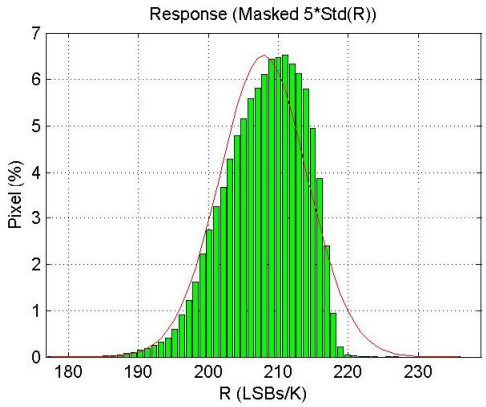
	Total Dose Test Plan.		No						
	Issue		No.		Rev.		Date	14.10.2005	
	Irradiation Test Sequence		No.				Date	18.10.2005	
	Test Step No. 3		Description: after 5 krad Irradiation			Total Dose =		10 krad	
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	208	6.2	LSB / K	265	0.26 %	5 σ		
2.	NETD	14.9	2.1	mK	100	0.10 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	3.1	0.44	LSB	130	0.13 %	5 σ		
4.	DC-uniformity	7'746	184	LSB					
5.	Spatial uniformity IETD	5.0		mK					
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	102	0.10 %	65	13	6	3	4	-	-
7.	center area	12	0.13 %	6	3	3	-	-	-	-
8.	Remarks									

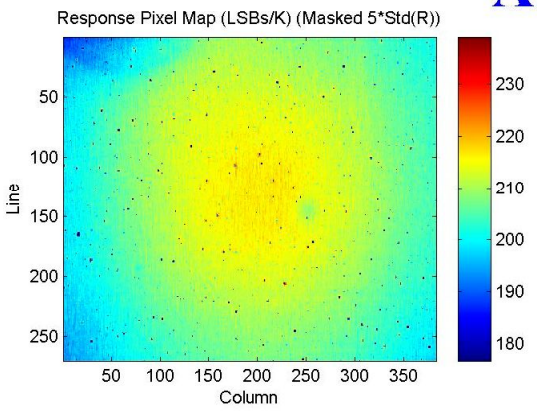
Date of γ-FPA-Irradiation: 14.10.2005

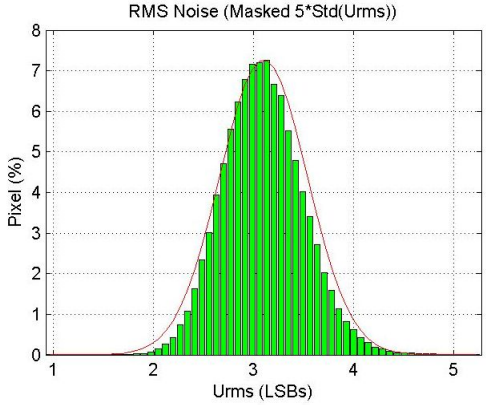
Date of measurement: 18.10.2005 Operator: Holger Lutz

After Gamma Irradiation 5 krad

Total Gamma dose 10 krad







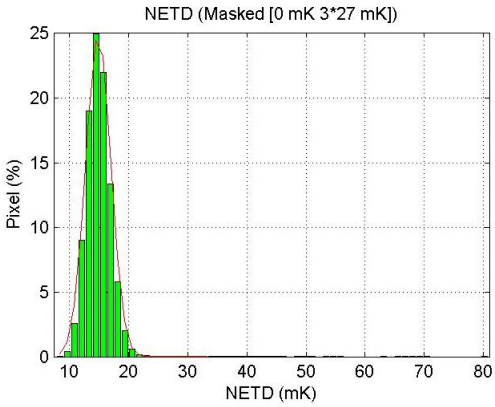
Response / RMS Noise

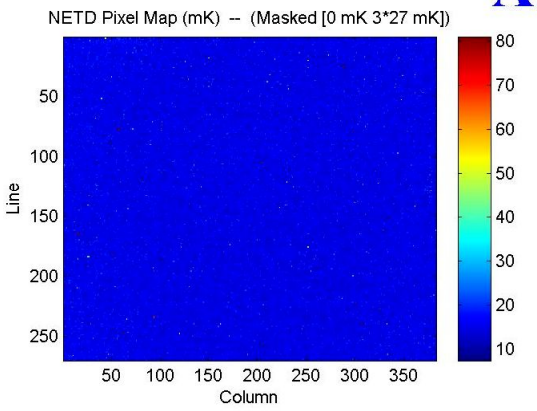
CMT 384x288 MW SN2404-HZD629; 18.10.05-mh hl; Tint=13ms; F/#:4.6

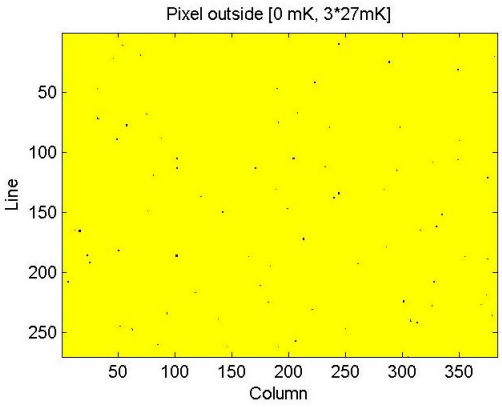
10 krad

Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 207.88 LSBs/K
std(R) = 6.23 LSBs/K
Pixel outside 5*Std(R): 265

Temperatur T3: 293 K
<Urms> = 3.10 LSBs
std(Urms) = 0.44 LSBs
Pixel outside 5*Std(Urms): 130







NETD @ T3 = 293 K

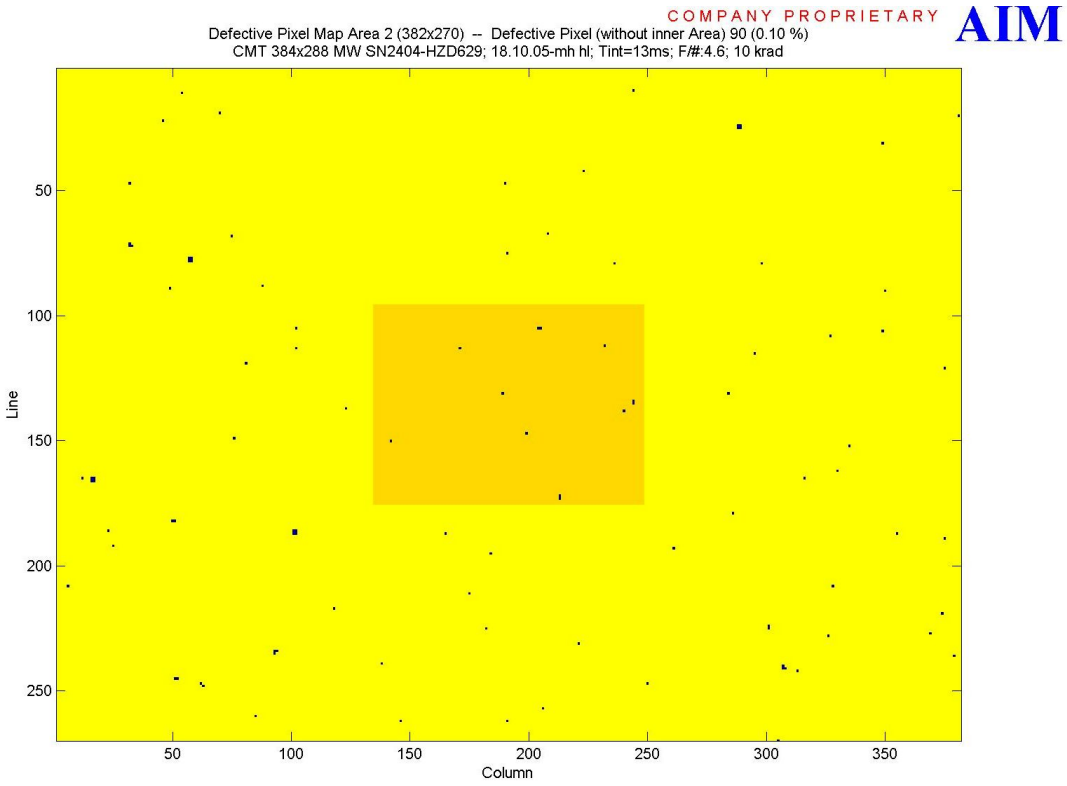
CMT 384x288 MW SN2404-HZD629; 18.10.05-mh hl; Tint=13ms; F/#:4.6

10 krad

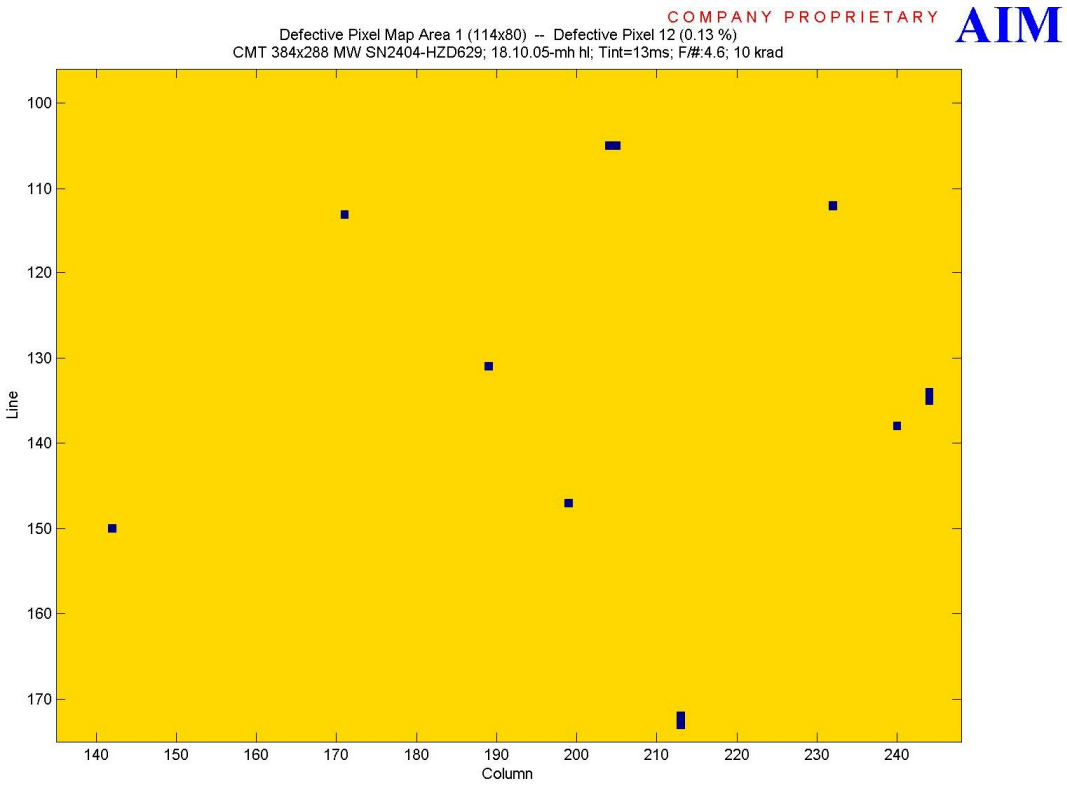
<NETD> = 14.93 mK

std(NETD) = 2.12 mK

Pixel outside [0 mK, 3*27 mK] = 100 (0.10%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.4 Test Step 4: TID = 20 krad

	Total Dose Test Plan.		No						
	Issue		No.		Rev.		Date	14.10.2005	
	Irradiation Test Sequence		No.				Date	24.10.2005	
	Test Step No. 4		Description: after 10 krad Irradiation			Total Dose =		20 krad	
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	208	6.2	LSB / K	267	0.26 %	5 σ		
2.	NETD	19.0	2.3	mK	107	0.10 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	4.0	0.49	LSB	187	0.18 %	5 σ		
4.	DC-uniformity	7'687	188	LSB					
5.	Spatial uniformity IETD	4.9		mK					
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	110	0.11 %	66	14	5	3	5	1	-
7.	center area	18	0.20 %	6	4	2	1	-	1	-
8.	Remarks									

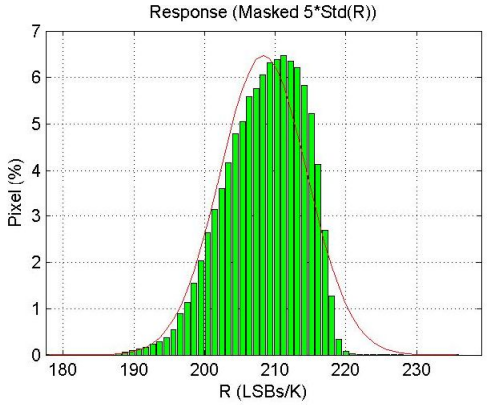
Date of γ-FPA-Irradiation: 24.10.2005

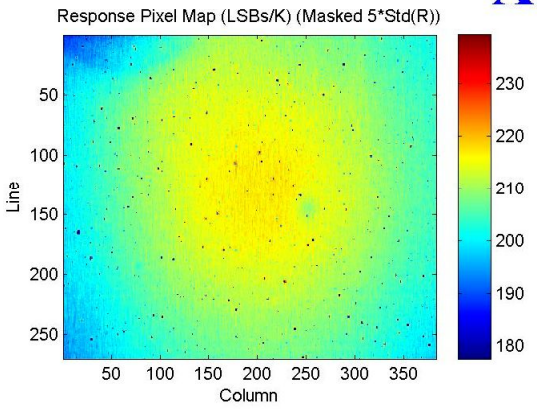
Date of measurement: 07.11.2005 Operator: Holger Lutz

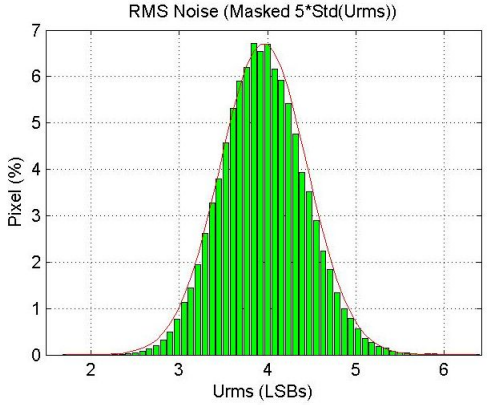
After Gamma Irradiation 10 krad

Total Gamma dose 20 krad

COMPANY PROPRIETARY AIM







Response / RMS Noise

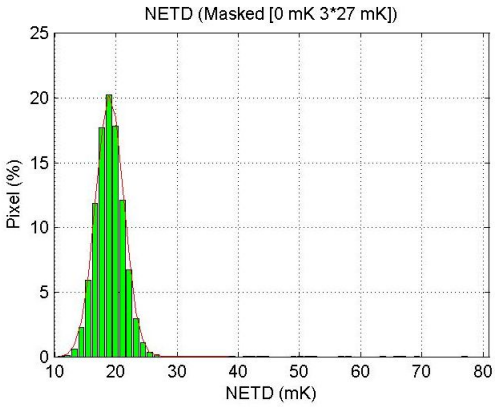
CMT 384x288 MW SN2404-HZD629; 07.11.05-mh hl; Tint=13ms; F/#:4.6

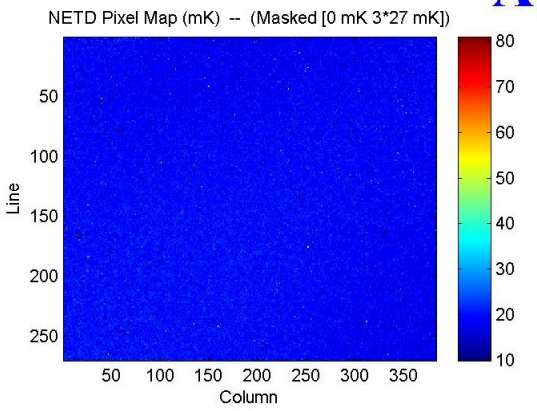
20 krad

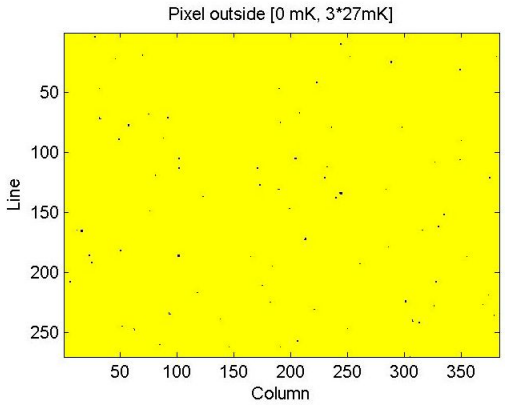
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 208.34 LSBs/K
std(R) = 6.16 LSBs/K
Pixel outside 5*Std(R): 267

Temperatur T3: 293 K
<Urms> = 3.95 LSBs
std(Urms) = 0.49 LSBs
Pixel outside 5*Std(Urms): 187

COMPANY PROPRIETARY AIM







NETD @ T3 = 293 K

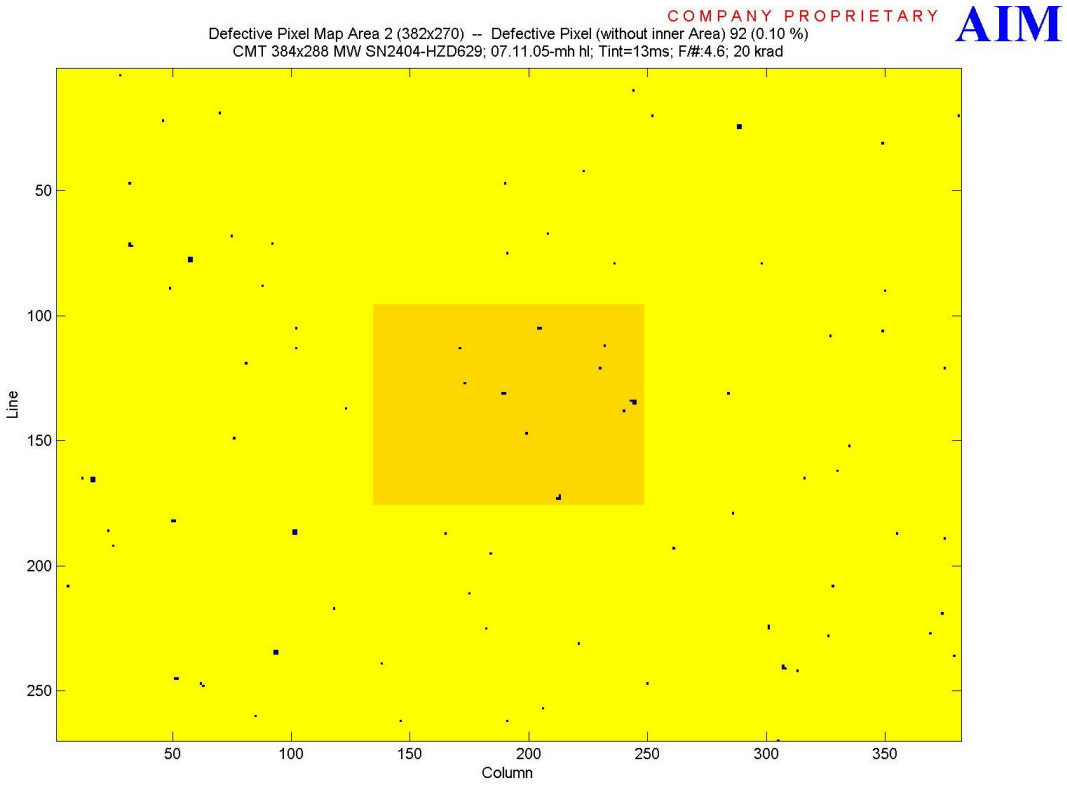
CMT 384x288 MW SN2404-HZD629; 07.11.05-mh hl; Tint=13ms; F/#:4.6

20 krad

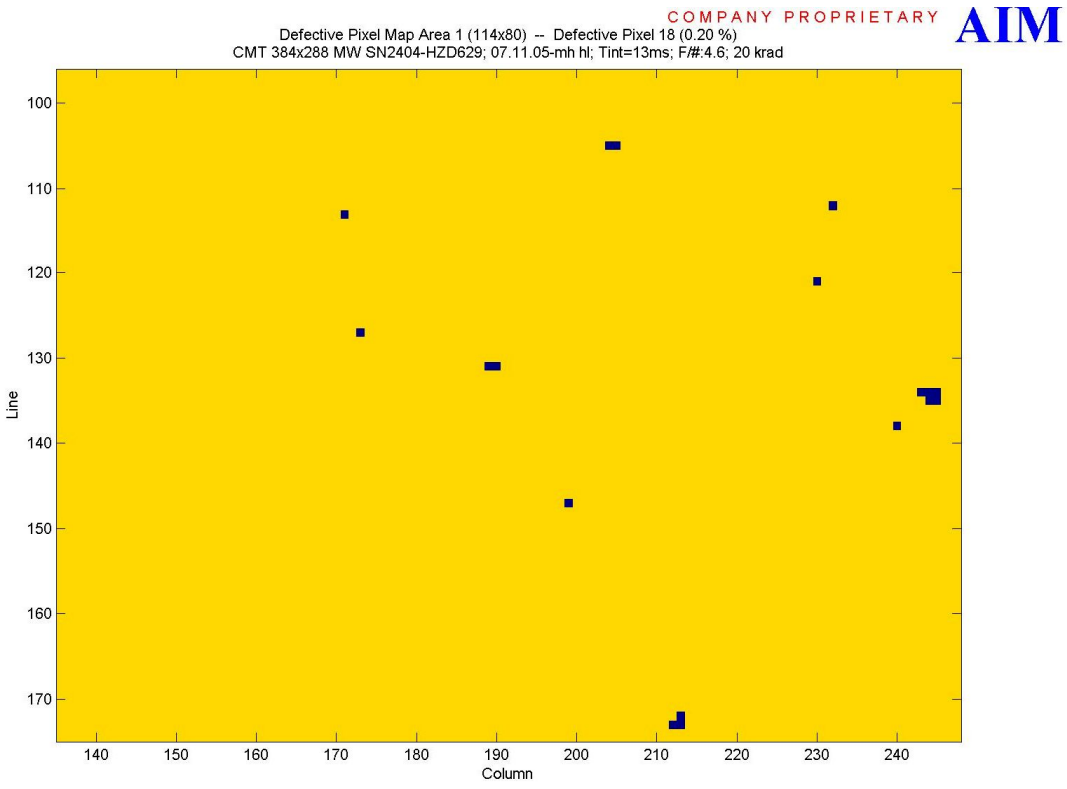
<NETD> = 18.97 mK

std(NETD) = 2.30 mK

Pixel outside [0 mK, 3*27 mK] = 107 (0.10%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.5 Test Step 5: TID = 30 krad

	Total Dose Test Plan.			No					
	Issue			No.		Rev.		Date	
	Irradiation Test Sequence			No.				Date	17.11.2005
	Test Step No. 5			Description: after 10 krad Irradiation				Total Dose = 30 krad	
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	209	6.2	LSB / K	277	0.27 %	5 σ		
2.	NETD	14.3	2.0	mK	120	0.12 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	3.0	0.42	LSB	186	0.18 %	5 σ		
4.	DC-uniformity	7'948	184	LSB					
5.	Spatial uniformity IETD	5.4		mK					
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	123	0.12 %	70	13	4	7	6	-	-
7.	center area	17	0.19 %	4	4	1	1	2	-	-
8.	Remarks									

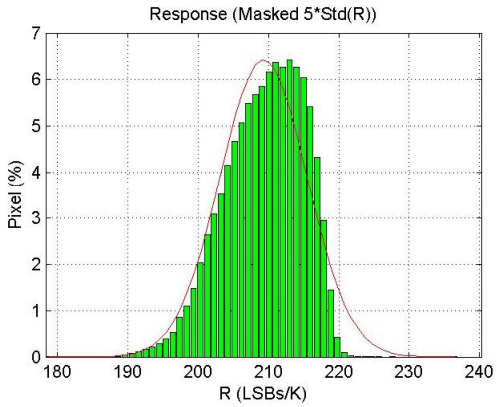
Date of γ-FPA-Irradiation: 17.11.2005

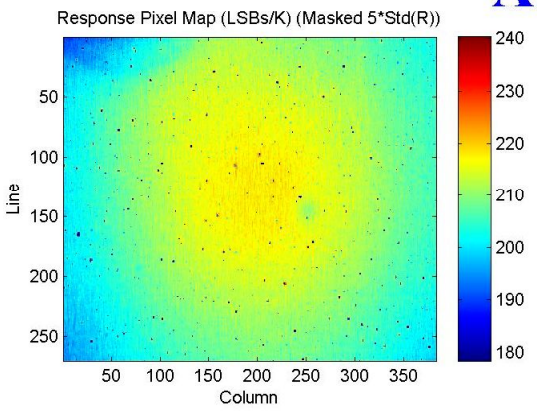
Date of measurement: 21.11.2005 Operator: Holger Lutz

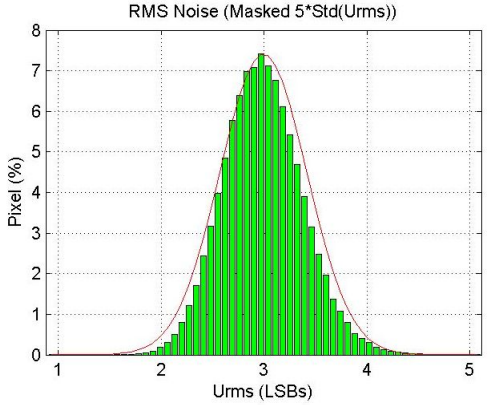
After Gamma Irradiation 10 krad

Total Gamma dose 30 krad

COMPANY PROPRIETARY AIM







Response / RMS Noise

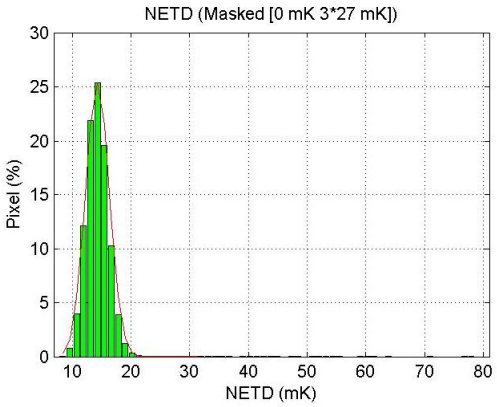
CMT 384x288 MW SN2404-HZD629; 21.11.05-mh hl; Tint=13ms; F/#:4.6

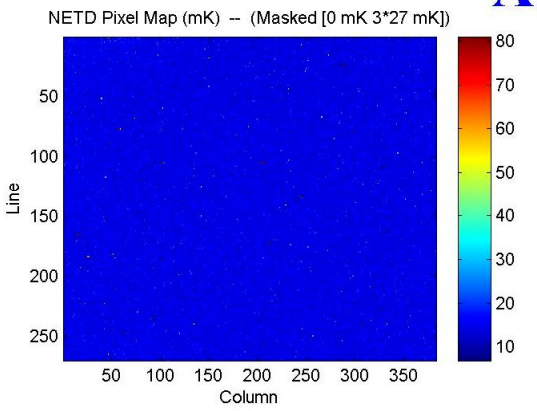
30 krad

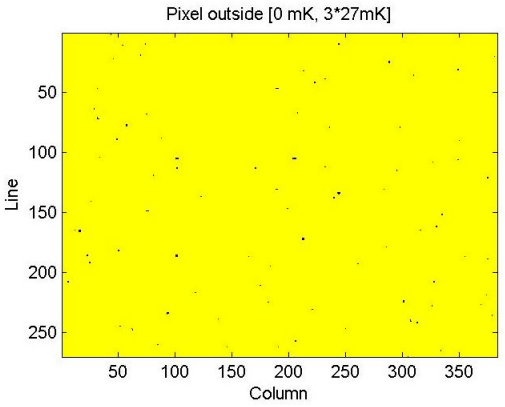
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 209.30 LSBs/K
std(R) = 6.19 LSBs/K
Pixel outside 5*Std(R): 277

Temperatur T3: 293 K
<Urms> = 2.99 LSBs
std(Urms) = 0.42 LSBs
Pixel outside 5*Std(Urms): 186

COMPANY PROPRIETARY AIM







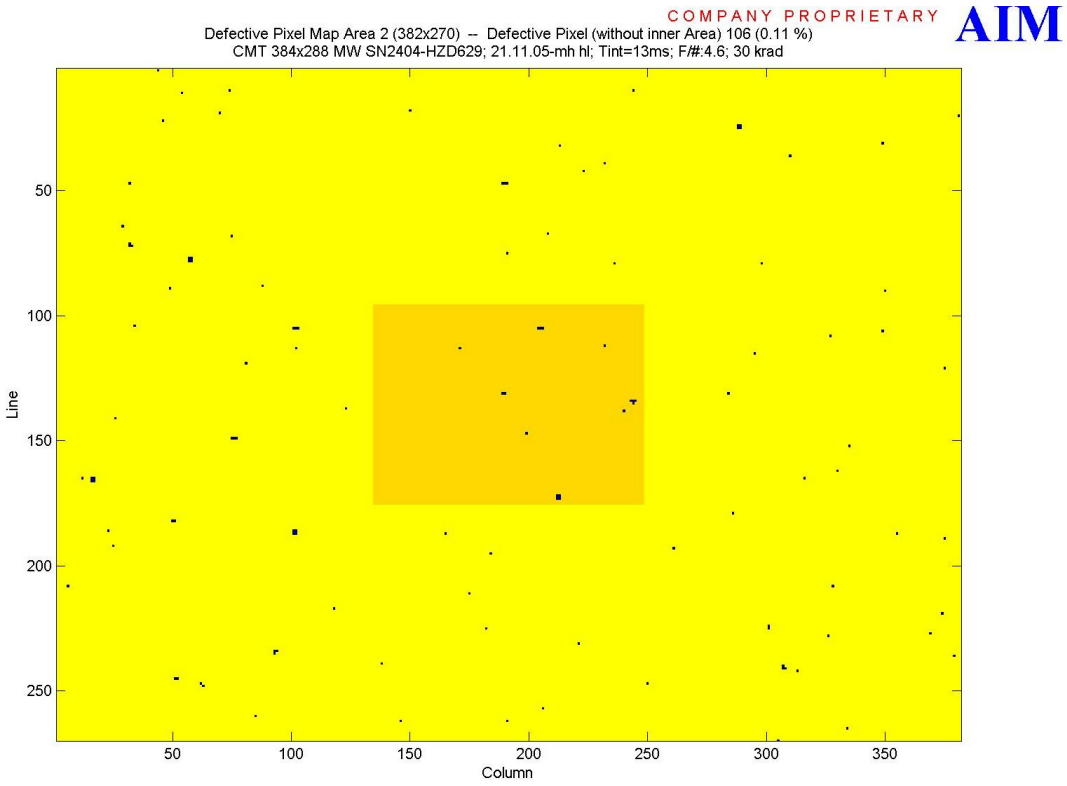
NETD @ T3 = 293 K

CMT 384x288 MW SN2404-HZD629; 21.11.05-mh hl; Tint=13ms; F/#:4.6

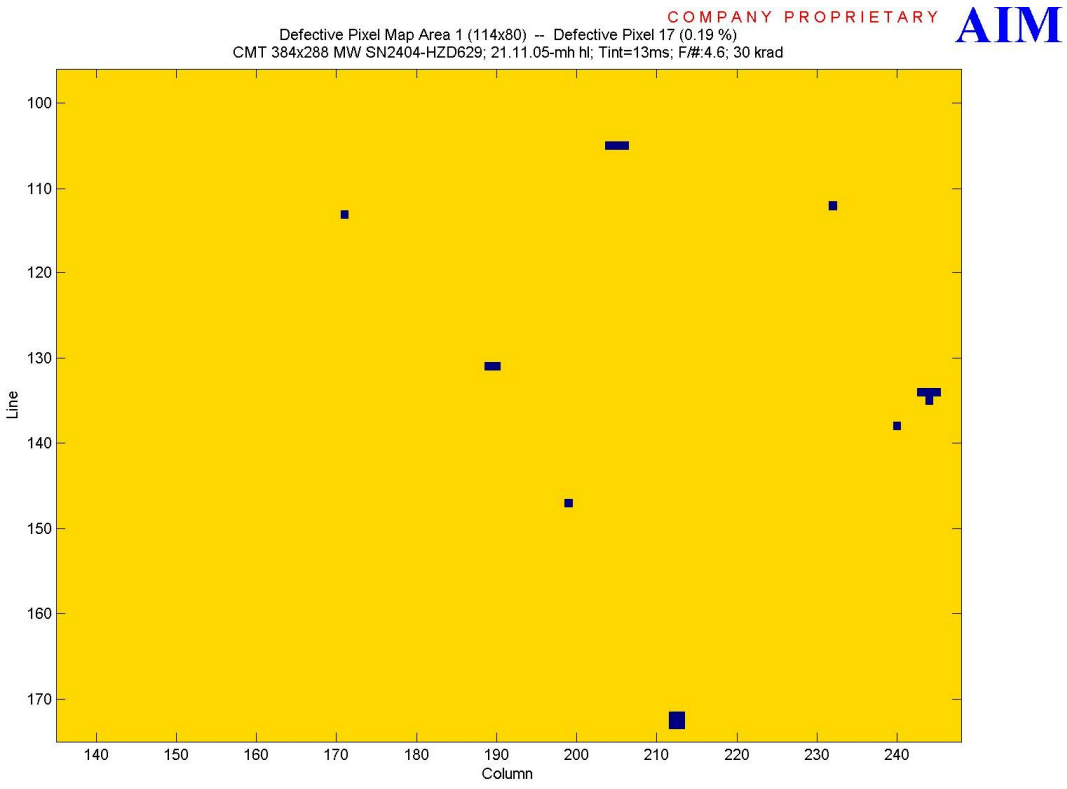
30 krad

<NETD> = 14.31 mK
std(NETD) = 2.03 mK

Pixel outside [0 mK, 3*27 mK] = 120 (0.12%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.6 Test Step 6: TID = 50 krad

	Total Dose Test Plan.			No						
	Issue			No.		Rev.		Date	29./30.11.2005	
	Irradiation Test Sequence			No.				Date		
	Test Step No. 6			Description: after 20 krad Irradiation			Total Dose =		50 krad	
	Evaluation area (full)	382 x 270 = 103'140 Pixel								
	Evaluation area (center)	114 x 80 = 9'120 Pixel								
	Detector Bias [V]	0.60 V								
	No. of frames	35								
	Frame rate	15 fps								
	Integration time	13 ms								
		average	std. dev.	unit	pixels outside		criterion	remarks		
1.	Response	207	6.2	LSB / K	4'187	4.06 %	5 σ			
2.	NETD	18.3	9.5	mK	11'115	10.8 %	[0, 3*27 mK]	according to specs.		
3.	rms-Noise	3.8	2.02	LSB	8'949	8.68 %	5 σ			
4.	DC-uniformity	7'651	527	LSB						
5.	Spatial uniformity IETD	25.6		mK						
	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	11'186	10.9 %	3'981	1'518	683	302	164	259	110
7.	center area	2'687	29.5 %	399	961	147	76	49	87	40
8.	Remarks									

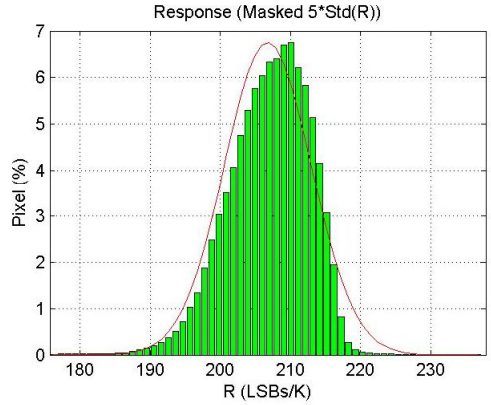
Date of γ-FPA-Irradiation: 29./30.11.2005

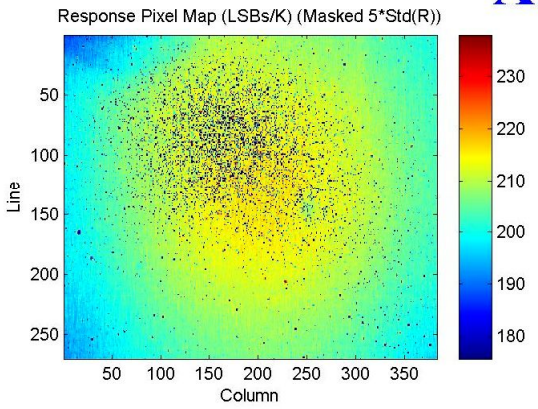
Date of measurement: 06.12.2005 Operator: Holger Lutz

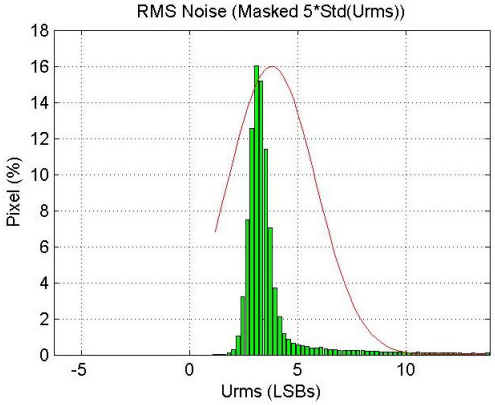
After Gamma Irradiation 20 krad

Total Gamma dose 50 krad

COMPANY PROPRIETARY AIM







Response / RMS Noise

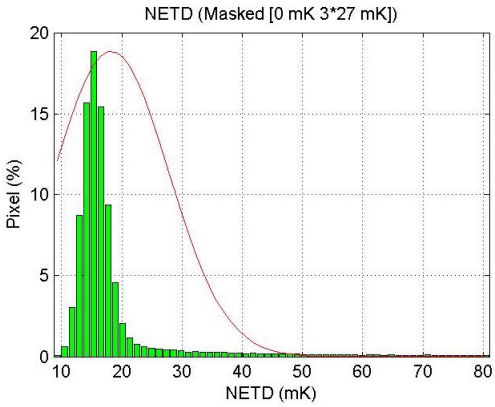
CMT 384x288 MW SN2404-HZD629; 06.12.05-mh hl; Tint=13ms; F/#:4.6

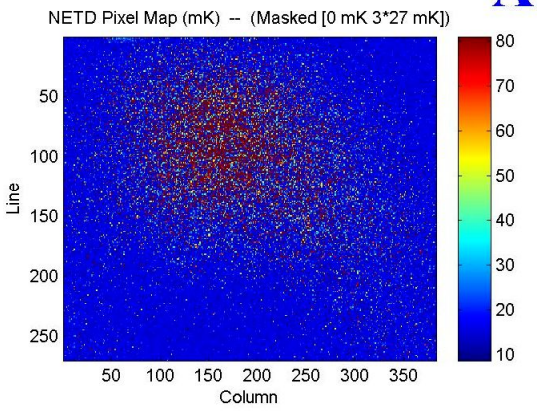
50 krad

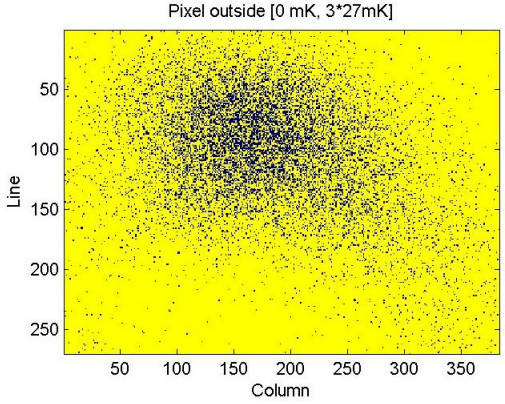
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 206.75 LSBs/K
std(R) = 6.22 LSBs/K
Pixel outside 5*Std(R): 4187

Temperatur T3: 293 K
<Urms> = 3.78 LSBs
std(Urms) = 2.02 LSBs
Pixel outside 5*Std(Urms): 8949

COMPANY PROPRIETARY AIM







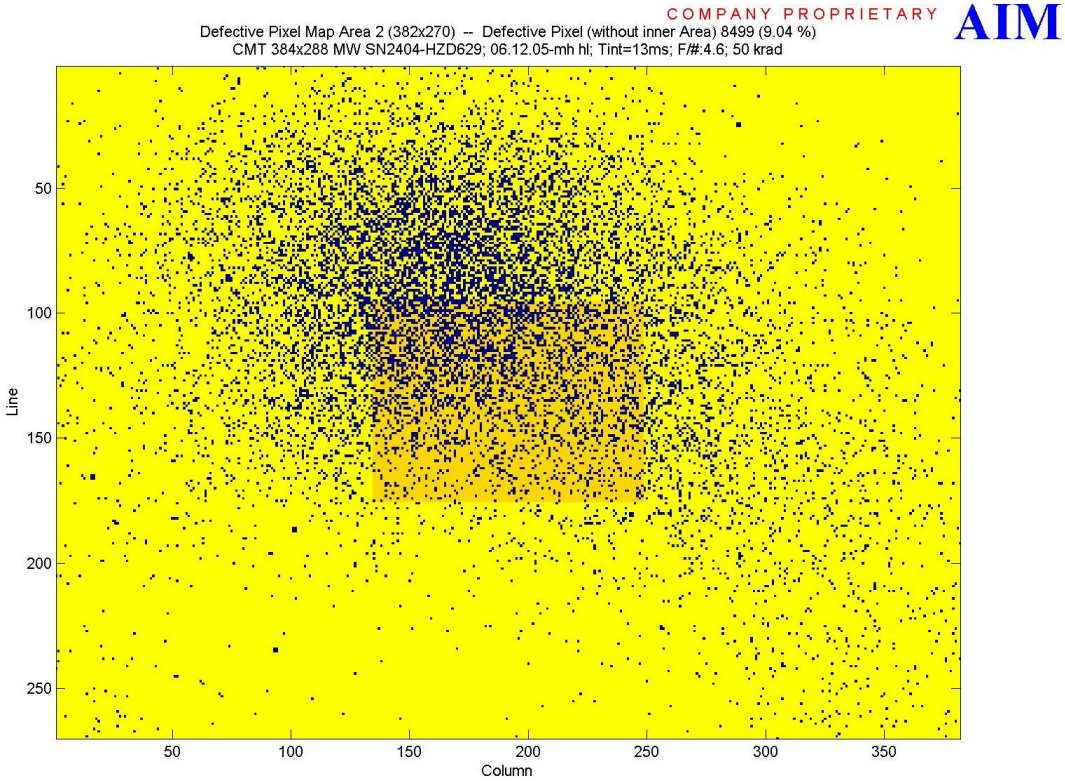
NETD @ T3 = 293 K

CMT 384x288 MW SN2404-HZD629; 06.12.05-mh hl; Tint=13ms; F/#:4.6

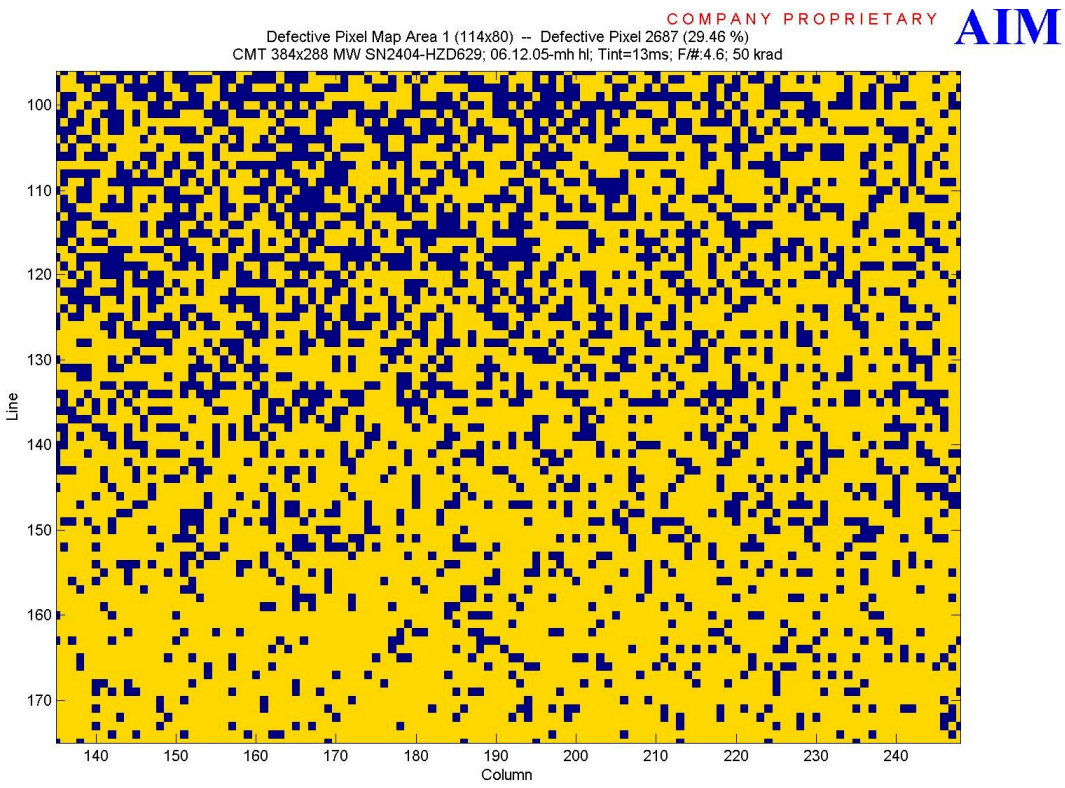
50 krad

<NETD> = 18.25 mK
std(NETD) = 9.52 mK

Pixel outside [0 mK, 3*27 mK] = 11115 (10.75%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.3.7 Test Step 7: annealing at 70°C for 168 hours (1 week)

	Total Dose Test Plan.			No					
	Issue			No.		Rev.		Date	29./30.11.2005
	Irradiation Test Sequence			No.				Date	
	Test Step No. 6			Description: after 20 krad Irradiation			Total Dose =		50 krad
	Evaluation area (full)	382 x 270 = 103'140 Pixel							
	Evaluation area (center)	114 x 80 = 9'120 Pixel							
	Detector Bias [V]	0.60 V							
	No. of frames	35							
	Frame rate	15 fps							
	Integration time	13 ms							
		average	std. dev.	unit	pixels outside		criterion	remarks	
1.	Response	207	7.4	LSB / K	1'915	1.86 %	5 σ		
2.	NETD	16.0	7.5	mK	5'500	5.32 %	[0, 3*27 mK]	according to specs.	
3.	rms-Noise	3.3	1.59	LSB	5'452	5.29%	5 σ		
4.	DC-uniformity	7'807	380	LSB					
5.	Spatial uniformity IETD	26.3		mK					

	Defective pixels	pixels	percntg.	single	clusters	of 2 pxl	of 3 pxl	of 4 pxl	5 - 9 pxl	>9 pxl
6.	full area	5'593	5.4 %	2'807	840	461	173	91	98	17
7.	center area	1'388	15.2 %	603	262	147	58	27	26	4

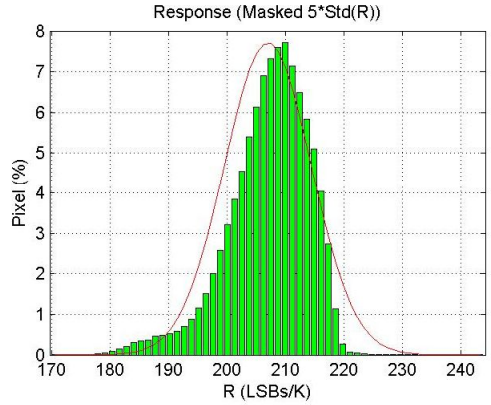
8. Remarks

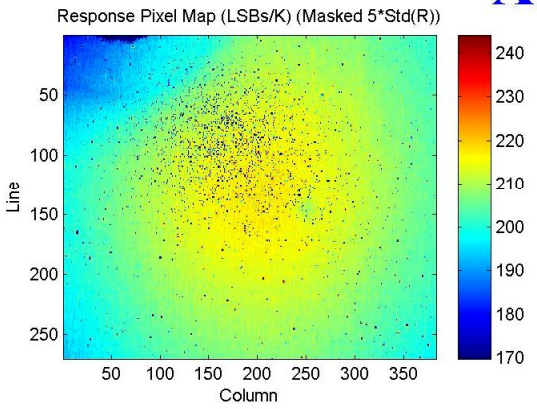
Date of annealing: 29./30.11.2005

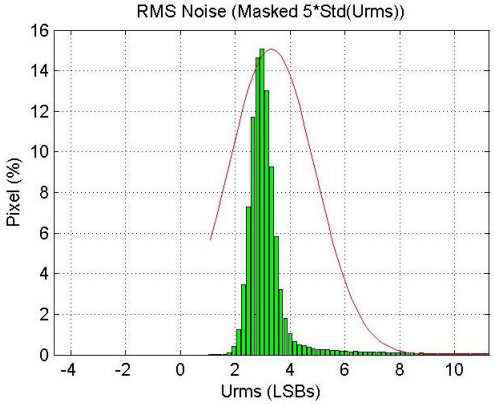
Date of measurement: 21.12.2005 Operator: Holger Lutz

Total Gamma dose 50 krad, annealed for one week at 70°C

COMPANY PROPRIETARY AIM







Response / RMS Noise

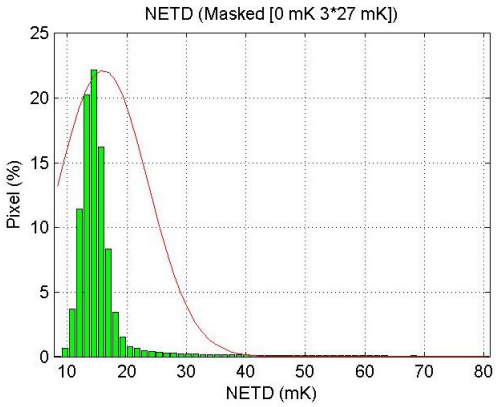
CMT 384x288 MW SN2404-HZD629; 21.12.05-mh hl; Tint=13ms; F/#:4.6

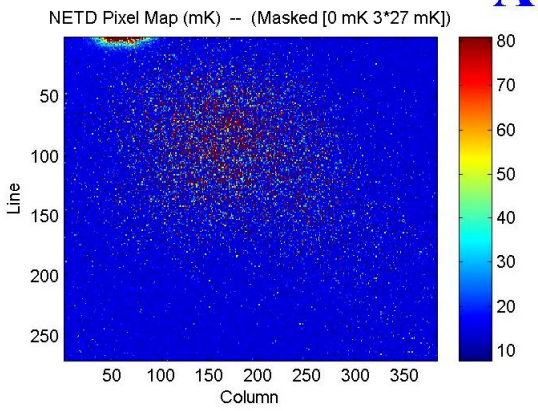
nach ht lagerung

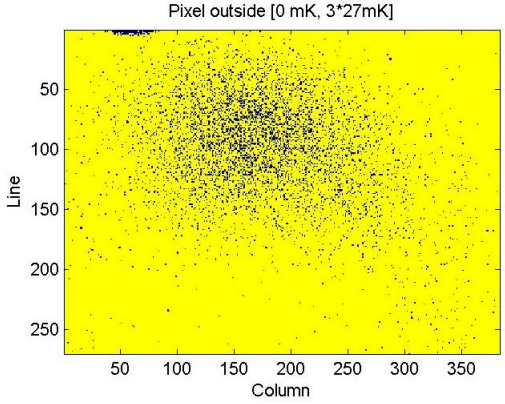
Temperatur T1: 288 K
Temperatur T2: 298 K
<R> = 206.93 LSBs/K
std(R) = 7.44 LSBs/K
Pixel outside 5*Std(R): 1915

Temperatur T3: 293 K
<Urms> = 3.32 LSBs
std(Urms) = 1.59 LSBs
Pixel outside 5*Std(Urms): 5452

COMPANY PROPRIETARY AIM







NETD @ T3 = 293 K

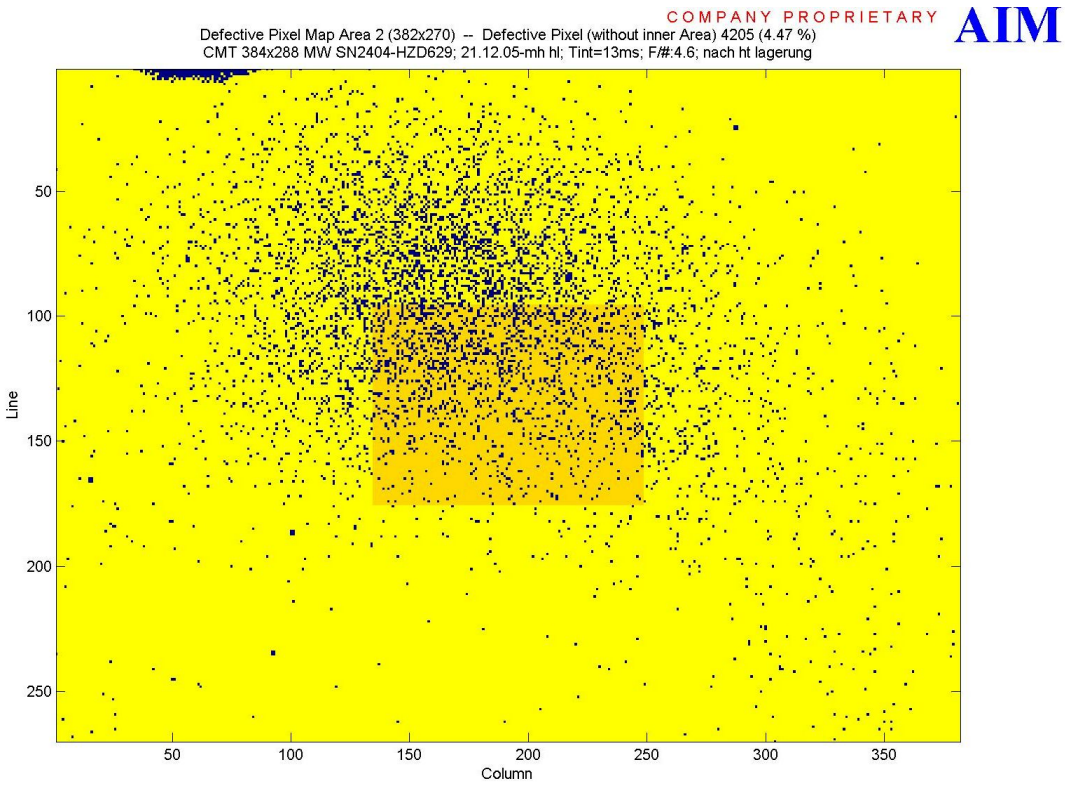
CMT 384x288 MW SN2404-HZD629; 21.12.05-mh hl; Tint=13ms; F/#:4.6

nach ht lagerung

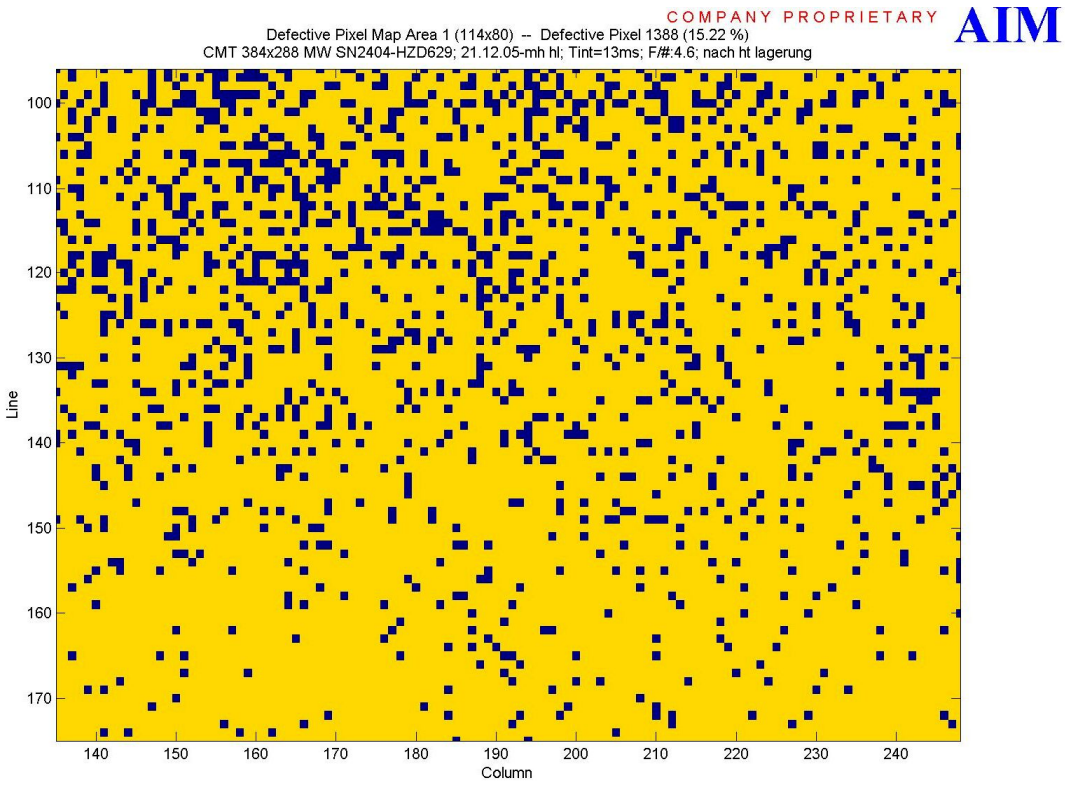
<NETD> = 16.03 mK

std(NETD) = 7.54 mK

Pixel outside [0 mK, 3*27 mK] = 5500 (5.32%)



full FPA area: 382 x 270



center FPA area: 114 x 80

2.4 Irradiation Test Summary

2.4.1 Summary

1.	Total Dose Test Report	No.			
2.	Issue	No.	Rev.	Date	
3.	SCC Component	No.			
4.	Component Designation				
5.	Irradiation Spec.	No.	Issue	Rev.	
6.	Family				
7.	Group				
8.	Package				
9.	Comp. Specifications	Generic	Issue	Rev.	
		Detail	Issue	Rev.	
10.	Test Facility Name	ESA / ESTEC			
11.	Irradiation Test Plan	No.	Issue	Rev.	
12.	Manufacturer, Address	AIM INFRAROT-MODULE GmbH Theresienstraße 2 D-74072 Heilbronn			
13.	Sample Serial No.	AIM S/N 2404			
14.	Manufacturing Data Code				
15.	Irradiation Conditions	Biased (Remote Test) Electro-Optical measurements at AIM after irradiation			
16.	Electrical Measurement Parameters Tested Temp °C				
17.	Facility	ESA / ESTEC - ESCIES			
		Source: ^{60}Co Absorber Material	Energy Thickness	Dose Rate Temp. °C	
18.	Dosimetry/Calibration Method				
19.	Anneal Test	Unbiased		Temp.: 70°C Duration: 168h	
20.	Irradiation Sequence				

20.1	Description	Results or Actual Test Conditions	Begin	End	Exposure Time
20.2	1 krad	1.00 krad	04.10.2005 13:30	14:41	71 min
20.3	4 krad	4.00 krad	10.10.2005 09:09	13:39	270 min
20.4	5 krad	4.92 krad	13.10.2005 16:20	21:54	334 min
20.5	10 krad	9.78 krad	24.10.2005 14:48	02:03	675 min
20.6	10 krad	10.30 krad	15.11.2005 17:03	03:42	639 min
20.7	20 krad	20.25 krad	29.11.2005 09:32	05:43	1211 min
20.8					

23.	Irradiation Test Facility: Responsible	Name: Bob Nickson Tel. +31 - 71 - 565 34 55
24.	Electrical test: Responsible	Name: Dr. Joachim Wendler Tel. +49 - 7131 - 6212 - 480

2.4.2 Summary - Tables

Note, that the detector bias voltage DETG was not precisely measured during the initial characterization before irradiation (Test Step 0, chapter 2.3.0). Therefore the performance 'increases' seemingly after the first irradiation dose. However, this is no real effect but a measurement artefact.
It is more appropriate to interpret the data given below as follows: The E/O performance of active pixels stays about constant for all doses, even for the highest dose of 50 krad. The number of defective pixels stays constant for up to 30 krad, increases significantly by two orders of magnitude (factor of about 100), and decreases again by a factor of 2 after a one week, 70°C, unbiased annealing step.

Table 1: Detector Response and NETD as function of total gamma dose

Parameter	Total Dose [krad]	Response				NETD			
		average [LSB / K]	Std. Dev. [LSB / K]	No. of Pixels outside 5σ		average [mK]	Std. Dev. [mK]	Pixels outside 5σ	
0) before irradiation	0	234	7.6	257	0.25 %	18.7	2.7	105	0.10 %
1) after 1 krad	1	207	6.2	262	0.25 %	14.4	2.0	95	0.09 %
2) after 4 krad	5	208	6.2	267	0.26 %	14.1	2.0	109	0.11 %
3) after 5 krad	10	208	6.2	265	0.26 %	14.9	2.1	100	0.10 %
4) after 10 krad	20	208	6.2	267	0.26 %	19.0	2.3	107	0.10 %
5) after 10 krad	30	209	6.2	277	0.27 %	14.3	2.0	120	0.12 %
6) after 20 krad	50	207	6.2	4'187	4.06 %	18.3	9.5	11'115	10.8 %
7) after 70°C anneal	50 ann.	207	7.4	1'915	1.86 %	16.0	7.5	5'500	5.32 %

Table 2: Detector Noise Equivalent Temperature Difference as function of total gamma dose

Parameter	Total Dose [krad]	rms Noise				DC uniformity		IETD
		average [LSB]	Std. Dev. [LSB]	No. of Pixels outside [0, 3*27 mK]		average [LSB]	Std. Dev. [LSB]	[mK]
0) before irradiation	0	4.4	0.61	107	0.10 %	8'692	224	9.1
1) after 1 krad	1	3.0	0.41	192	0.19 %	7'681	185	5.3
2) after 4 krad	5	2.9	0.41	182	0.18 %	7'714	186	5.1
3) after 5 krad	10	3.1	0.44	130	0.13 %	7'746	184	5.0
4) after 10 krad	20	4.0	0.49	187	0.18 %	7'687	188	4.9
5) after 10 krad	30	3.0	0.42	186	0.18 %	7'948	184	5.4
6) after 20 krad	50	3.8	2.02	8'949	8.68 %	7'651	527	25.6
7) after 70°C anneal	50 ann.	3.3	1.59	5'452	5.29%	7'807	380	26.3

Table 3: Defective Pixel (center area) as function of total gamma dose

Parameter	Total Dose [krad]	total number of defective pixels		single defects	clusters defects	clusters of 2	clusters of 3	clusters of 4	clusters of 5 - 9	clusters of >9
0) before irradiation	0	12	0.13 %	6	3	3	-	-	-	-
1) after 1 krad	1	11	0.12 %	5	3	3	-	-	-	-
2) after 4 krad	5	12	0.13 %	6	3	3	-	-	-	-
3) after 5 krad	10	12	0.13%	6	3	3	-	-	-	-
4) after 10 krad	20	18	0.20 %	6	4	2	1	-	1	-
5) after 10 krad	30	17	0.19 %	4	4	1	1	2	-	-
6) after 20 krad	50	2'687	29.5 %	562	961	147	76	49	87	40
7) after 70°C anneal	50 ann.	1'388	15.2 %	603	262	147	58	27	26	4

Table 4: Defective Pixel (full area) as function of total gamma dose

Parameter	Total Dose [krad]	total number of defective pixels		single defects	clusters defects	clusters of 2	clusters of 3	clusters of 4	clusters of 5 - 9	Clusters of >9
0) before irradiation	0	115	0.11 %	77	13	6	2	5	-	-
1) after 1 krad	1	98	0.10 %	62	13	7	2	45	-	-
2) after 4 krad	5	111	0.11 %	73	13	6	2	5	-	-
3) after 5 krad	10	102	0.10 %	65	13	6	3	4	-	-
4) after 10 krad	20	110	0.11 %	66	14	5	3	5	1	-
5) after 10 krad	30	123	0.12 %	70	13	4	7	6	-	-
6) after 20 krad	50	11‘186	10.9 %	3‘981	1‘518	683	302	164	259	110
7) after 70°C anneal	50 ann.	5‘593	5.4 %	2‘807	840	461	173	91	98	17

2.4.3 Summary - Figures

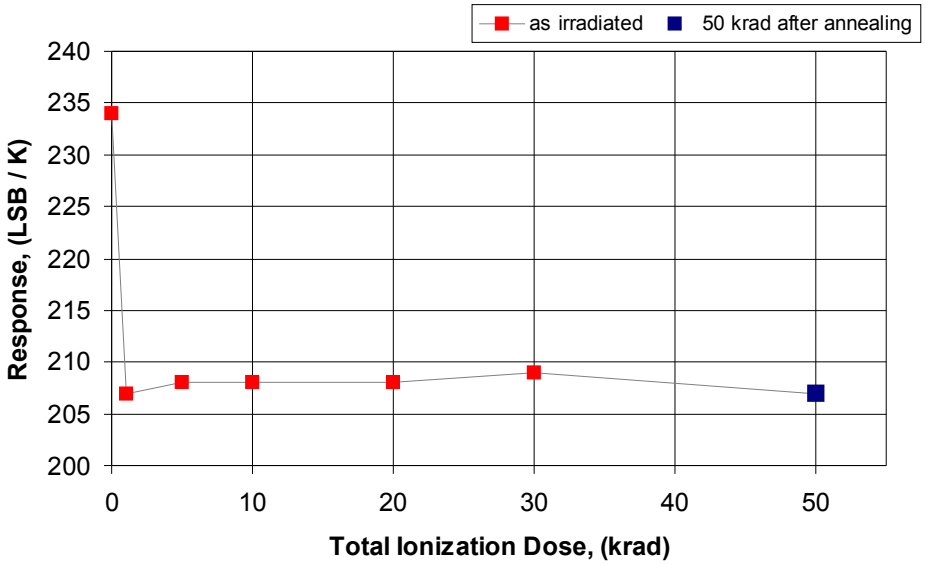


Figure 2: Response vs. total ionization dose.

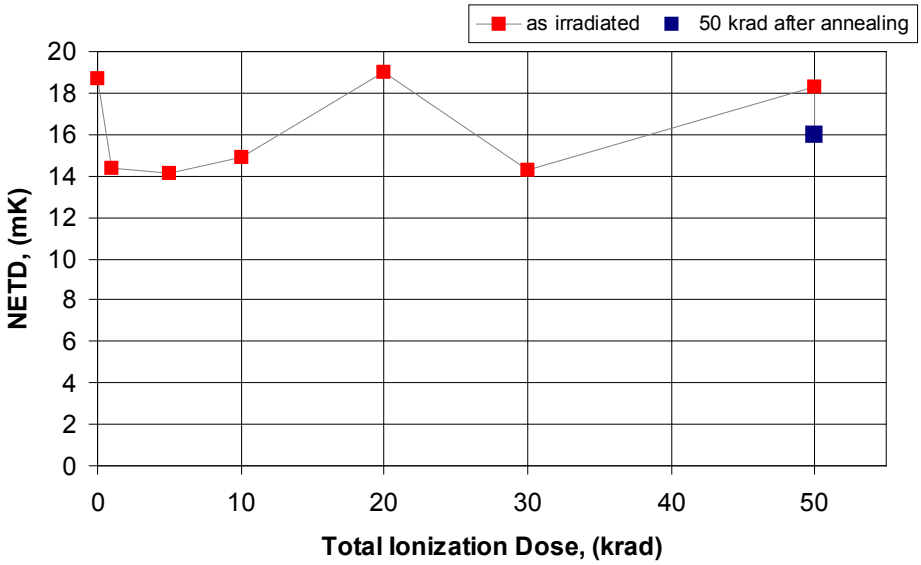


Figure 3: Noise Equivalent Temperature Difference (NETD) vs. total ionization dose.

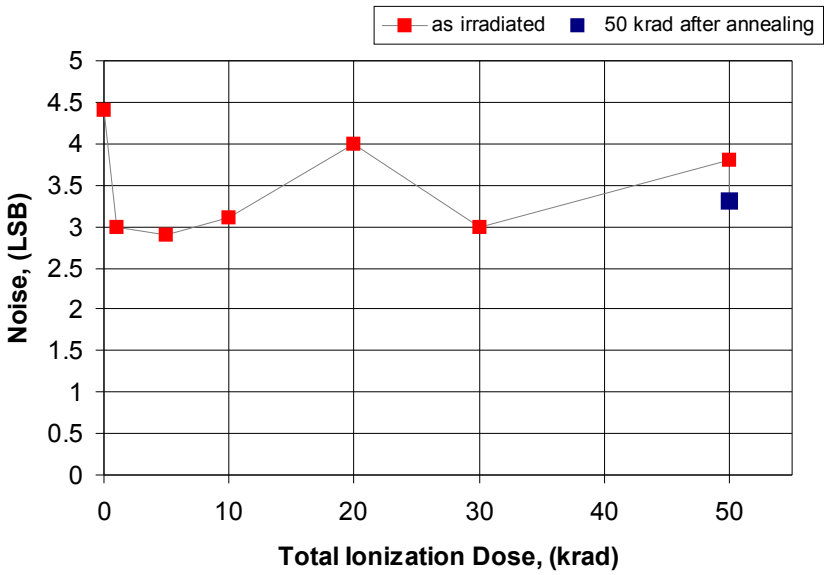


Figure 4: Noise vs. total ionization dose

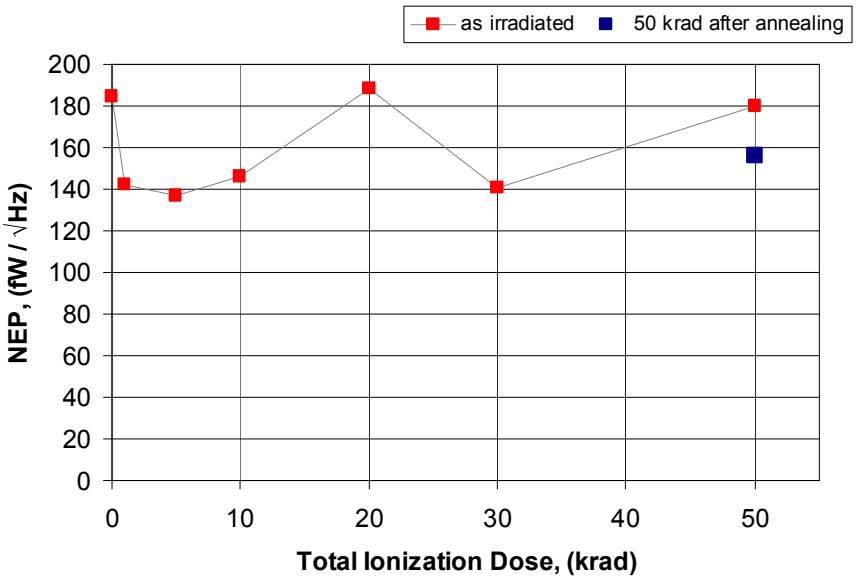


Figure 5: Noise Equivalent Power vs. total ionization dose

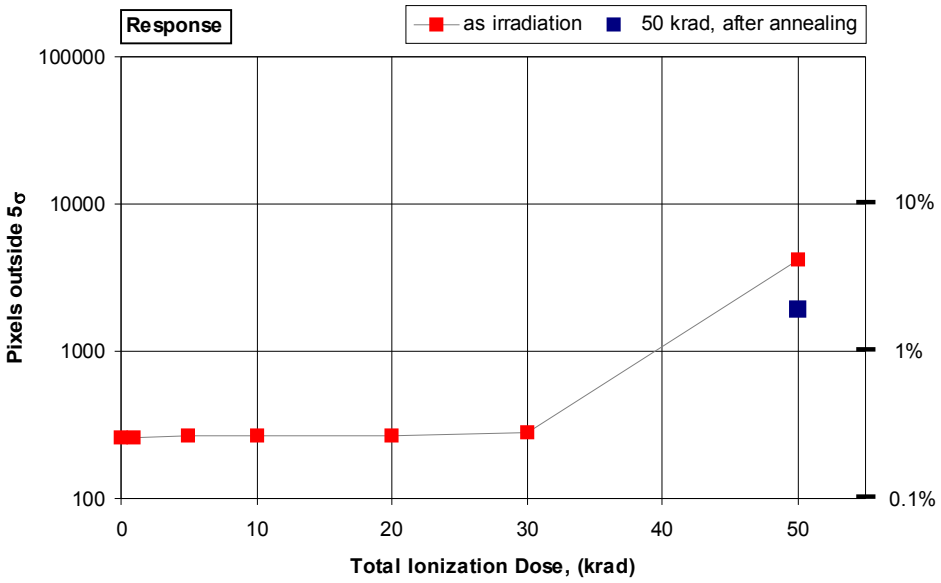


Figure 6: Number of pixels with a response outside 5σ vs. total ionization dose.

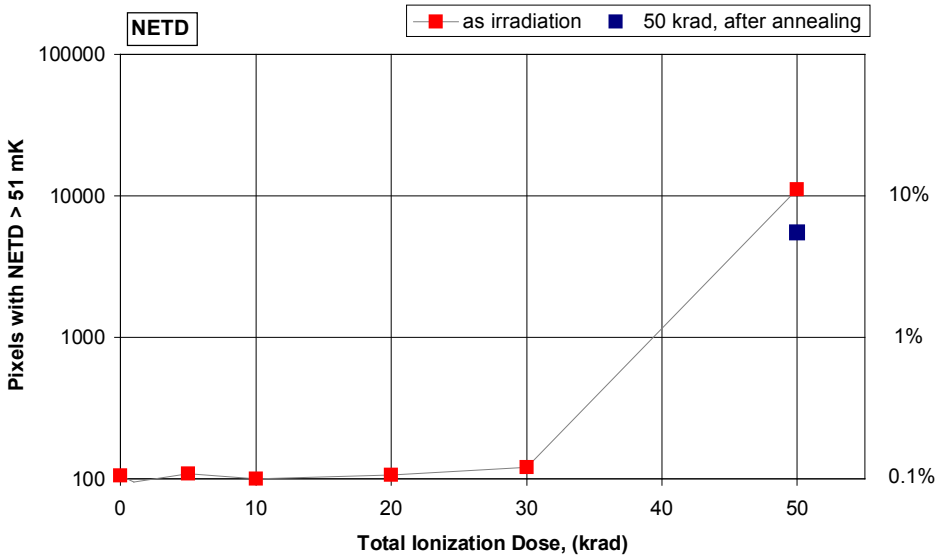


Figure 7: Number of pixels with a NETD > 51 mK.

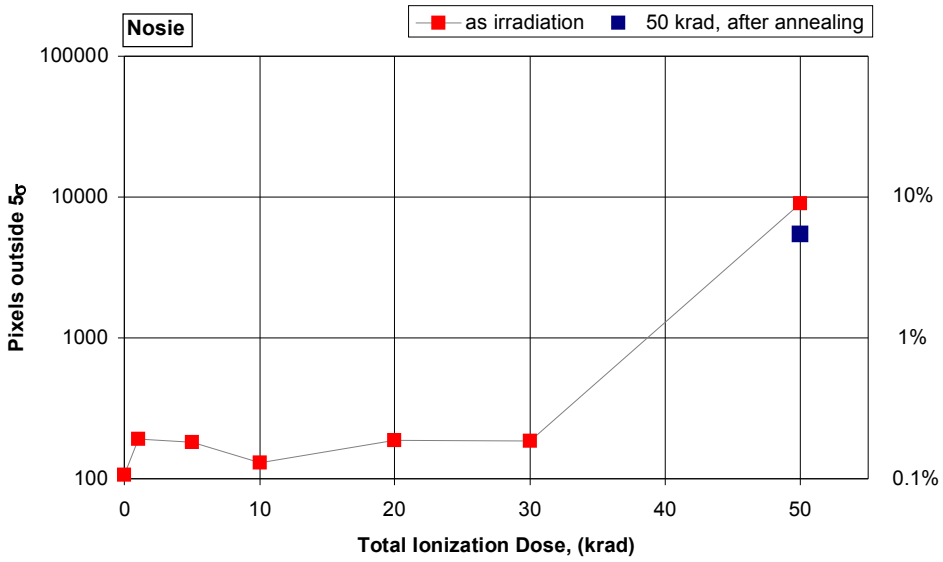


Figure 8: Number of pixels with an rms-noise value outside 5σ vs. total ionization dose.

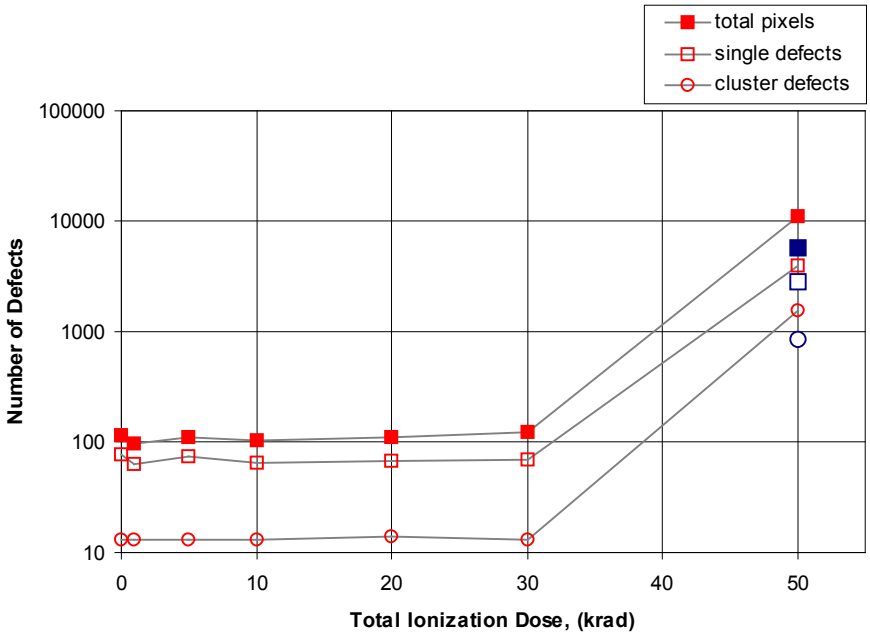


Figure 9: Full frame (382x270): Number of dead pixels, number of single defects and number of cluster defectes vs. total ionization dose.

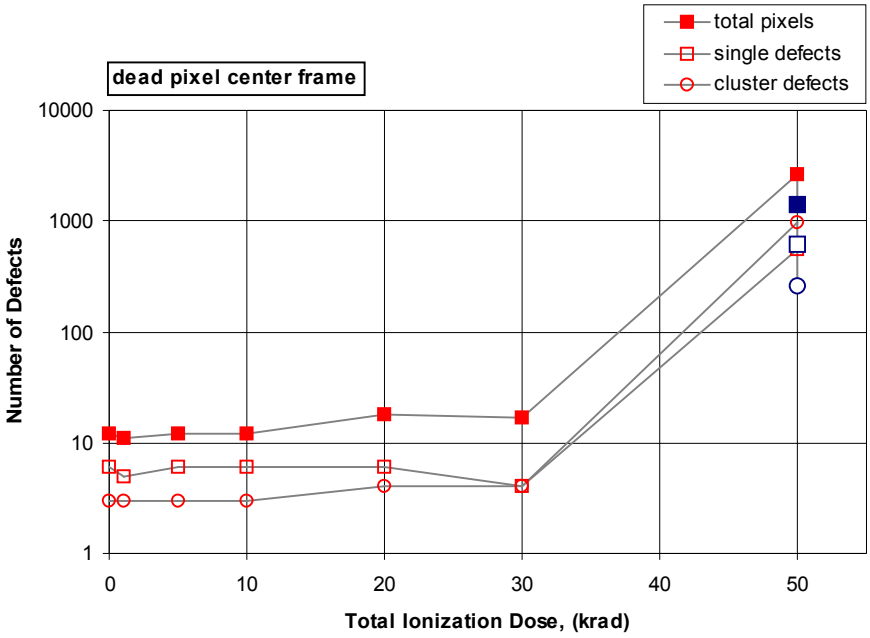


Figure 10: Center frame (114x80): Number of dead pixels, number of single defects and number of cluster defectes vs. total ionization dose.

3. Summary

In summary, the AIM MWIR MCT-FPA technology can withstand γ-radiation doses of up to 30 krad without any significant degradation. We observed 30% dead pixels only after a total dose of 50 krad. Most of the 70% remaining pixels kept the performance (response, noise, etc.) of the non-irradiated FPA. A subsequent unbiased anneal at 70°C for one week (168 hours) recovered half of the dead pixel, leading to a total amount of 15% dead pixel. The detailed damage mechanism is yet unclear and will be the subject of further investigations at AIM.
AIM proposes to perform a similar test series with proton irradiation at the Paul-Scherrer Institute (PSI) in Villigen to complete the irradiation tests during 2006.
In conclusion, the AIM detector technology seems to be well compatible with the radiation environment of space-borne instruments.