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The Large Format NIR Detector

Radiation Testing

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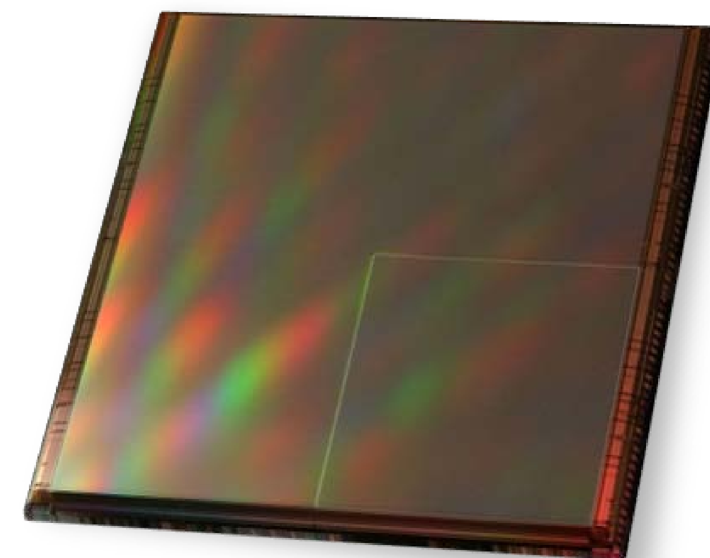
CEOI April 2015

Large Format NIR ROIC

ESA contract 22948 for European alternative to Teledyne Hawaii 2RG arrays

- **0.35 micron CMOS ROIC design for low photon flux and radiation hardness**
- **Development of 1280x1032, 15µm pitch format NIR (0.8 – 2.1 µm)**
- **Source Follower in the Detector (SFD) pixels**
- **Non-destructive reads (NDR) to reduce read noise**
- **100ke- full well**
- **Power consumption 34mW with 4 outputs, 54mW with 32 outputs**



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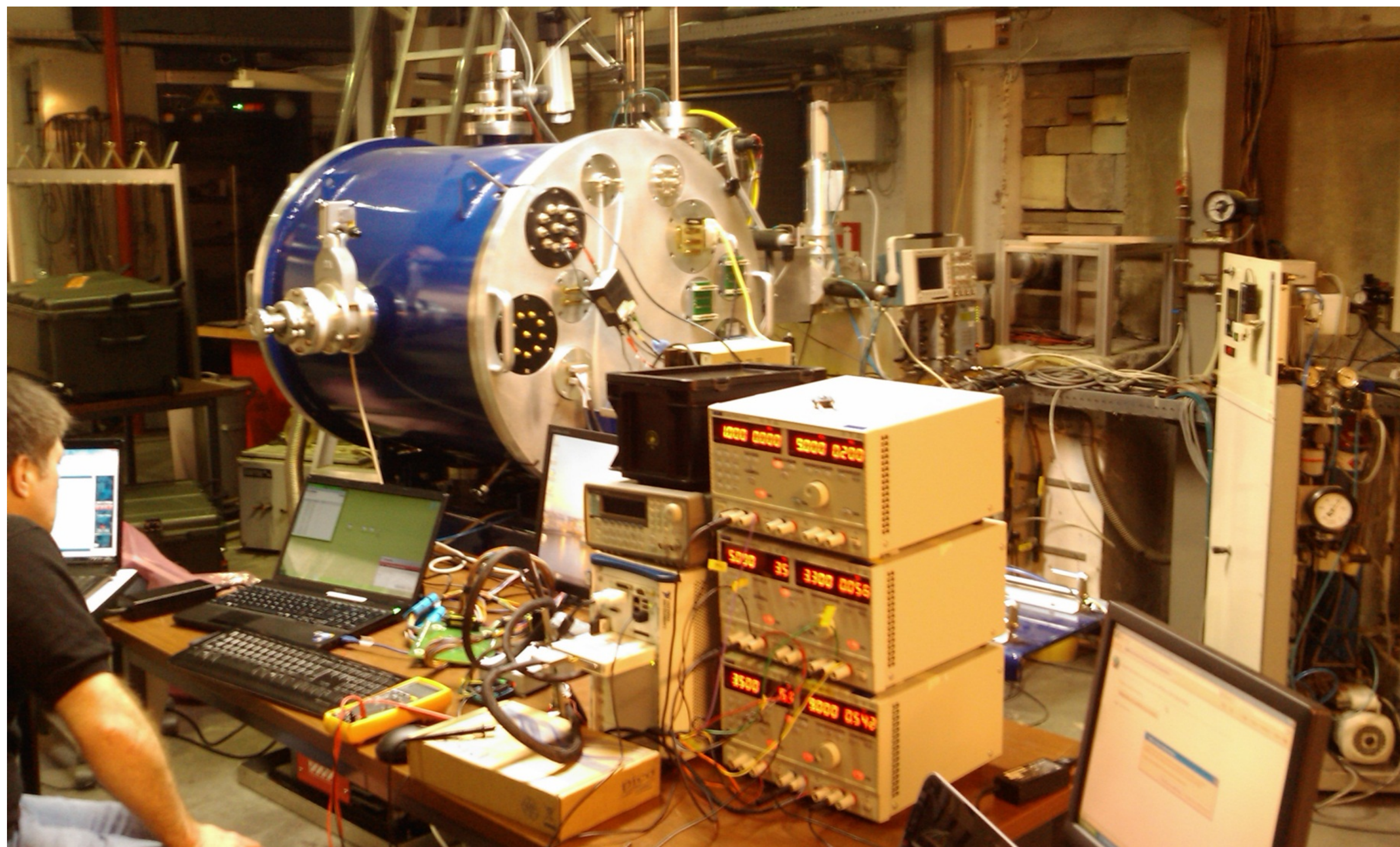
Heavy Ion radiation facility at University of Leuven, Belgium

CEOI funding of heavy ion testing of the latest large format ROIC technology for MCT arrays



- Test Facility at the Centre de Ressources du Cyclotron at Louvain-la-Neuve, Belgium
- 10 different heavy ions covering linear energy transfer (LET) from about 1 to 67 MeV cm^2 /mg
- The dose rates can be varied over a wide range, so that a statistically significant number of events can be detected.

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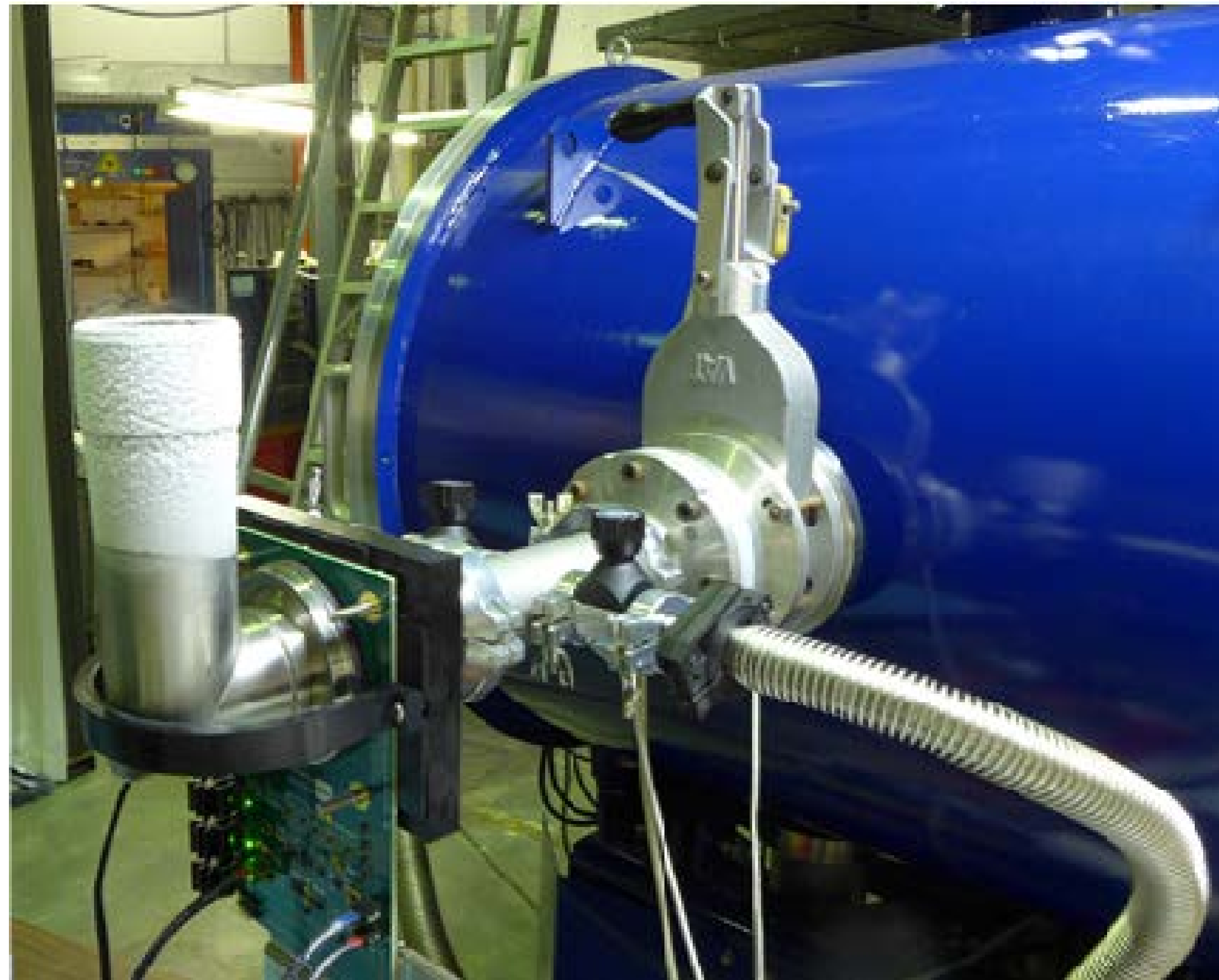
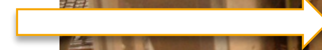
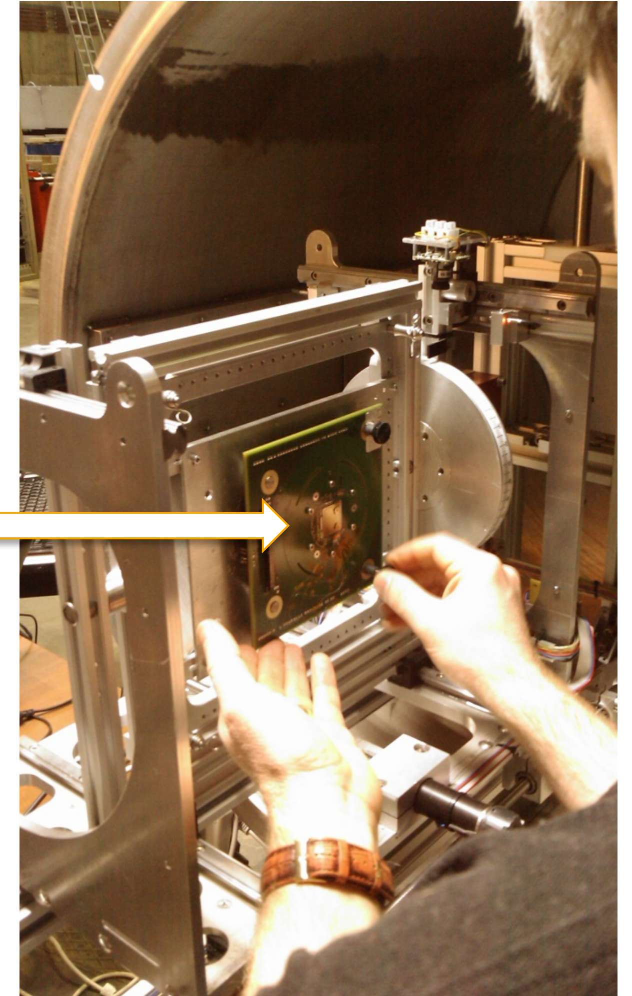
Heavy Ion Test Campaign



DUT





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Heavy Ion Test Campaign

- Designed to detect single event effects in both the digital and analogue circuitry
- A range of different effects from memory bit flip to latch up can be assessed
- For each event type, the data will enable characterisation of the LET threshold (level of immunity), saturation cross section (related to the vulnerability at extremely high LET) and the shape of the reliability curve between these points
- Aim to raise 0.35 micron CMOS building blocks from TRL3 to TRL4/5
- Leads to baseline definition of the heavy ion radiation hardness
- Design input to future ROIC designs

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Large Format NIR array and ROIC Heavy Ion Testing

Heavy Ion Species

	Energy (MeV)	Range (µm Si)	Linear Energy Transfer (LET) (MeV cm²/mg)
M/Q=5 (High LET Cocktail)			
$^{132}Xe^{26+}$	459	43.0	67.7
$^{84}Kr^{17+}$	316	43.0	40.1
$^{40}Ar^{8+}$	150	42.0	15.9
$^{20}Ne^{4+}$	78	45.0	6.2
$^{15}N^{3+}$	62	64.0	3.3
M/Q=3.33 (High Penetration Cocktail)			
$^{84}Kr^{25+}$	756	92.0	31.0
$^{59}Ni^{18+}$	567	98.0	21.3
$^{40}Ar^{12+}$	372	119.0	10.0
$^{22}Ne^{7+}$	233	199.0	3.6
$^{13}C^{4+}$	131	266.0	1.2

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Large Format NIR array and ROIC Heavy Ion Testing

Samples and test conditions

ROICs 50% coated with thin indium to give 2 outputs with grounded and 2 outputs with floating pixels

Room Temperature Indium Coated ROIC

Cooled Indium Coated ROIC

Cooled Thinned CMT Array

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Results Summary

Example - digital SEFI on VDD/VDDPIX/VREF supply during high LET test

Voltage (V)
Current (mA)
Time (s)
Voltage (V)
Current (mA)

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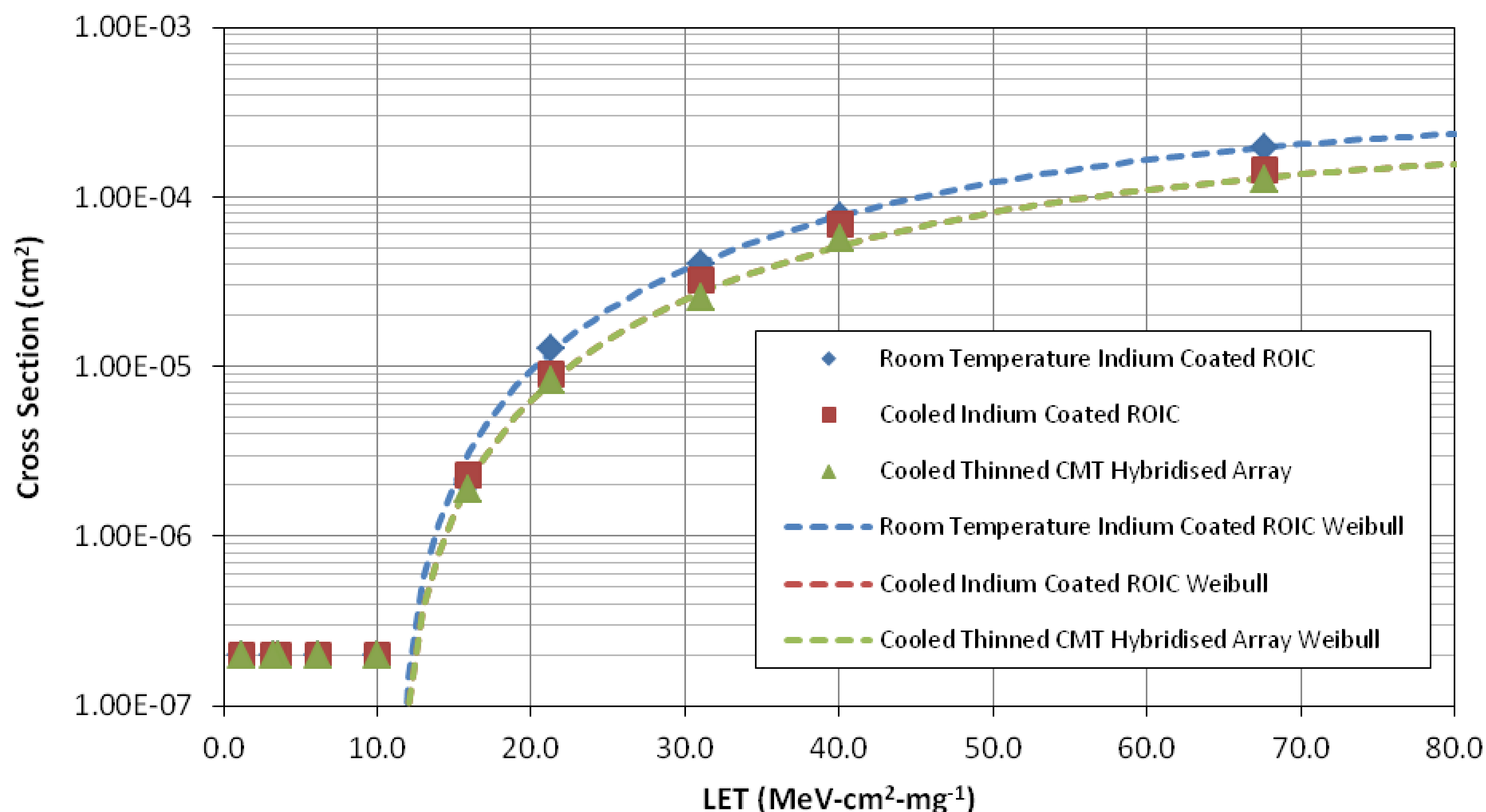
Results Summary

Example – digital SEFI cross section



This type of event is characterised by short transients in the current draw seen by the power supply to chip functions VDD, VDDPIX and VREF.

The sudden current draw on the supply exceeds the capability of the SMU to maintain supply voltage but sufficient supply voltage is maintained to prevent power down of the digital circuits

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Results Summary

Example – digital SEU cross section

These results represent the monitoring of the DUT digital control and therefore the ability for the device to output a valid frame

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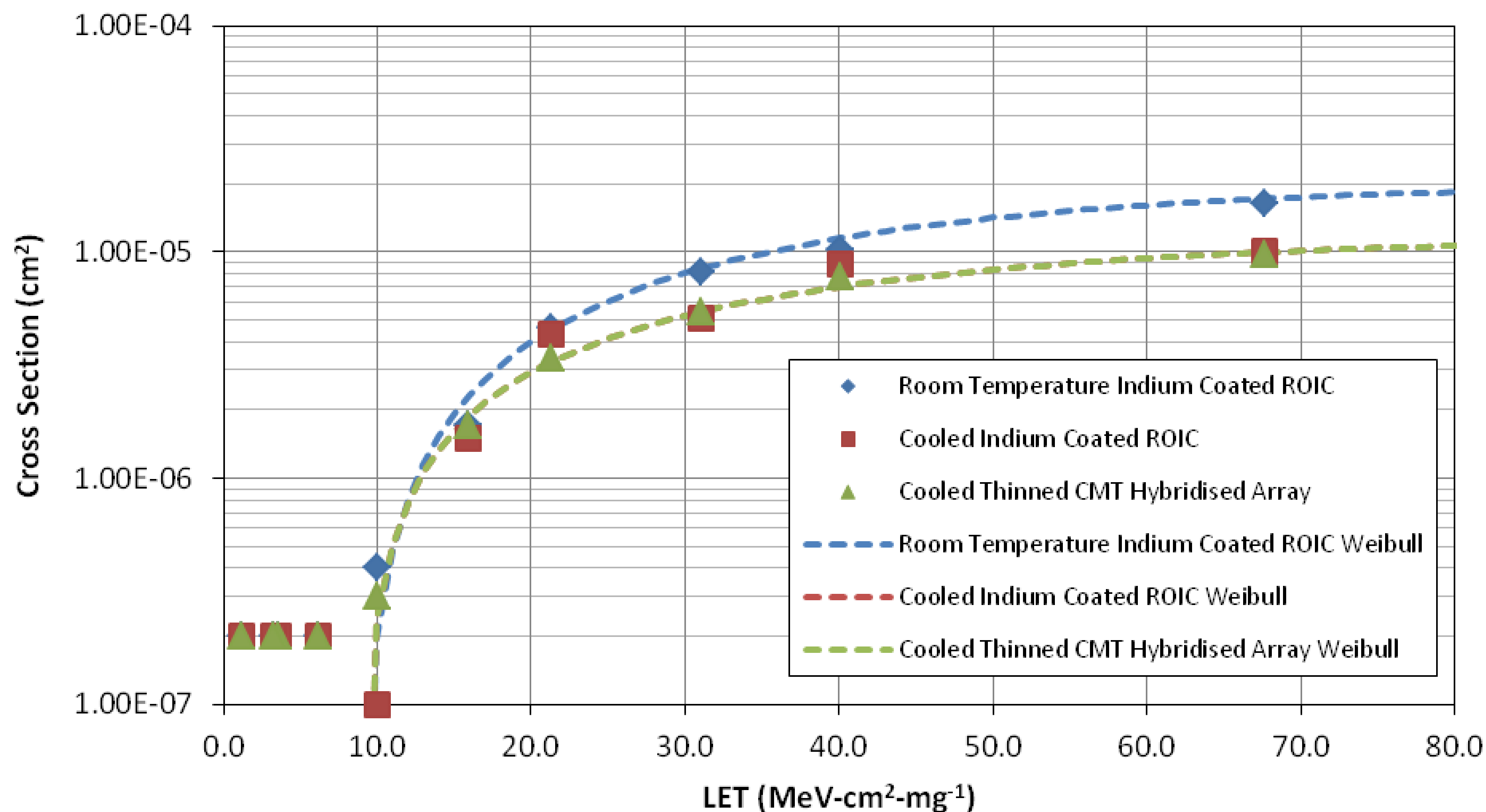
Results Summary

Example – frame SEFI cross section



The test software monitors the frame and line synchronisation outputs and the total number of pixels read out. From this the software determines if the frame is valid or not and records the result.

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Large Format NIR array and ROIC Heavy Ion Testing

Results Summary

		Digital SEU	Frame SEFI	Digital SEFI	Analogue SEFI	Analogue SET	Analogue SEU
Room Temperature ROIC with 50% metal Coat	LET_{th}	11	9	11	8	7	9
	Sat	6.00E-05	2.00E-05	3.00E-04	7.00E-05	1.50E-05	4.00E-05
Cooled ROIC with 50% metal Coat	LET_{th}	11	9	11	8	7	9
	Sat	5.00E-05	1.20E-05	2.00E-04	7.00E-05	9.00E-06	4.00E-05
Cooled MCT Hybridised ROIC	LET_{th}	11	9	11	8	7	9
	Sat	5.00E-05	1.20E-05	2.00E-04	5.00E-05	9.00E-06	1.00E-05

LET_{th} : Threshold value (MeV cm^2/mg)   Sat : Saturated cross-section (cm^2)

Definition of Events

SEL	Single event latch-up; defined as the DUT drawing excess current.
Digital SEU	Bit flip in digital memory
Frame SEFI	Incorrect array read out. Can be due to incorrect number of pixels or incorrect sync op signals output by ROIC resulting in the read out array being incorrectly formed into a 2D image.
Digital SEFI	Anomalous current draw via the ROIC digital supplies
Analogue SEFI	Anomalous current draw via the ROIC analogue supply
Analogue SET	Glitch in analogue output
Analogue SEU	Sampled glitch in the pixel resulting in a read out pixel having the wrong voltage.

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Large Format NIR array and ROIC Heavy Ion Testing

Results Summary

- No latch-up (SEL) observed demonstrating good immunity and reduced risk of permanent damage
- Recovery of Frame SEFI occurs after reset
- Other events can be managed

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Large Format NIR array and ROIC Heavy Ion Testing

Results Summary

BCY70 Temperature sensor

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