Heavy Ion SEE results on GR718A, MT29F16G08, Dual LVDS Transceiver

Presented by Pierre GARCIA

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with the support of Christian POIVEY

Thanks to the input from Pierre WANG, Fredrik STURESSON and Jan WOUTERS

For ESA Contract No 4000105666

Outline

- Dual LVDS Transceiver from Gobham Gaisler
- GR718A SpaceWire router from Gobham Gaisler
- MT29F16G08 16Gbit NAND Flash Memory from Micron

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- **Dual LVDS Transceiver from Gobham Gaisler**

Prototype characterized with laser experiment

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Commercial part characterized with heavy ions

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- GR718A SpaceWire router from Gobham Gaisler

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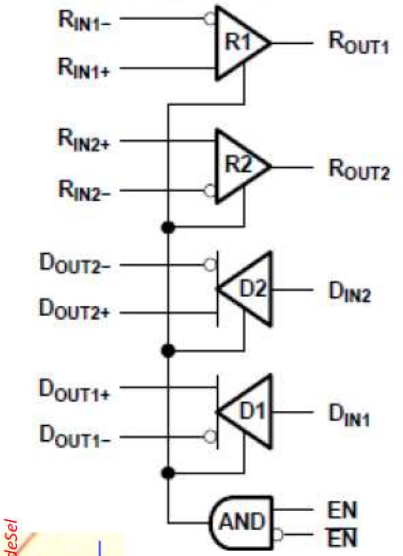
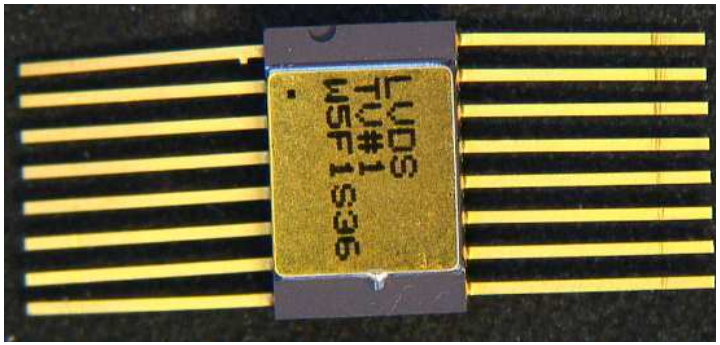
Dual LVDS Transceiver prototype

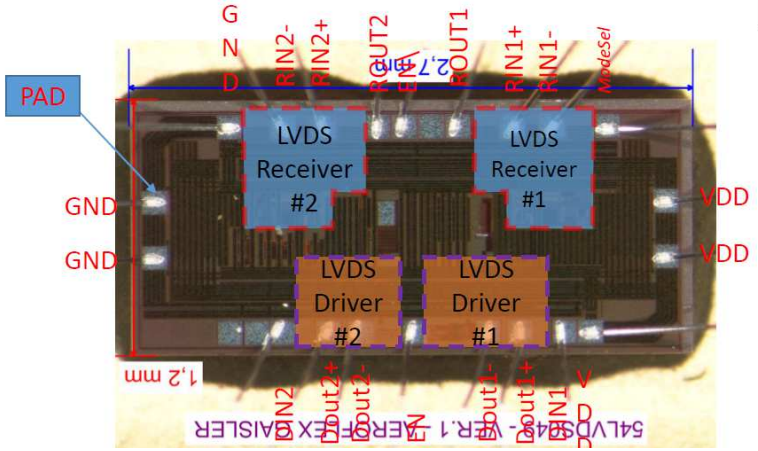
- Dual LVDS Transceiver is a prototype from Gobham Gaisler
- Aim of this project is to identify sensitive node on the design in order to correct and harden it helped with the laser test bench.

Dual LVDS Transceiver prototype

PART IDENTIFICATION	
Manufacturer :	Cobham Gaisler
Function :	Dual LVDS Transceiver
PARTS PROCUREMENT INFORMATIONS	
Packaging :	FP-16
Sample size:	2 tested samples



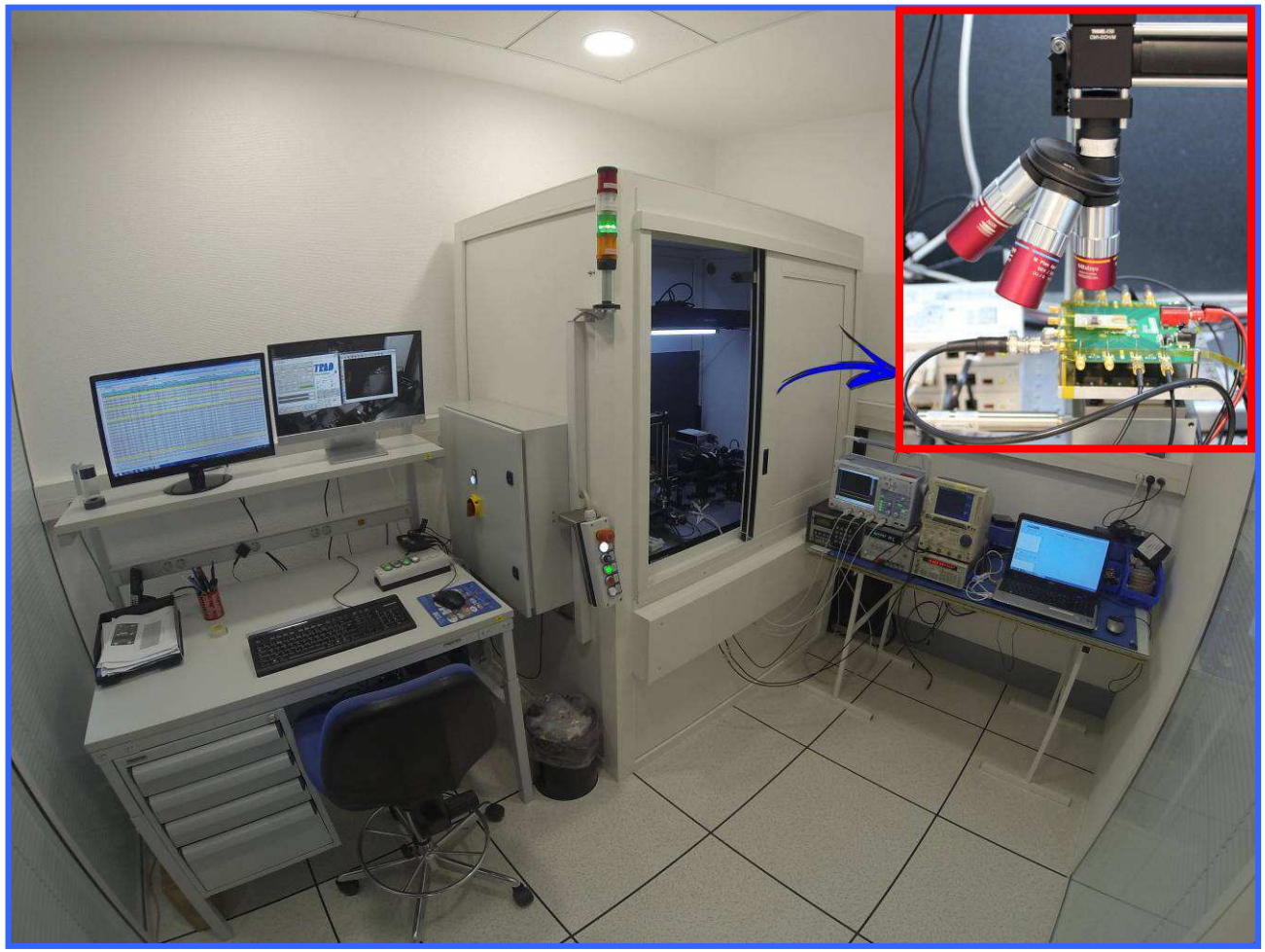




- Dual flow-through differential line driver-receiver pair
- Compliant with TIA/EIA-644-A LVDS standard

Dual LVDS Transceiver prototype

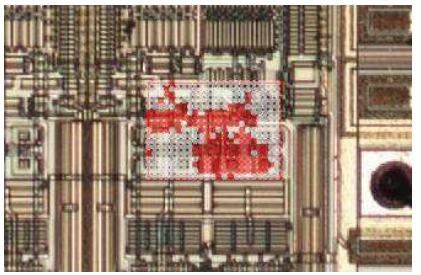
Laser test bench for SEE characterization



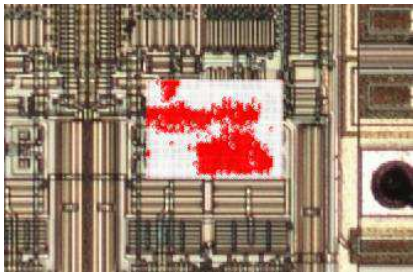
Pulsed Laser Test description

- Laser Nd:YAG with wavelength 1064nm
- Pulse duration : 790ps
- Can be triggered from single shot to 50kHz frequency pulse
- Energy : 0.06 – 135.9 nJ/pulse
- Spot size: 1.8, 2.6 and 8µm
- 3 motorized linear stages (X, Y, Z), resolution 0.3µm
- Tests performed on front or back side scanning of the delidded device

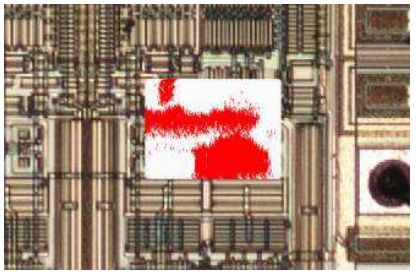
- Efficient tool for the designers
- Help to Improve the hardening process



8µm step

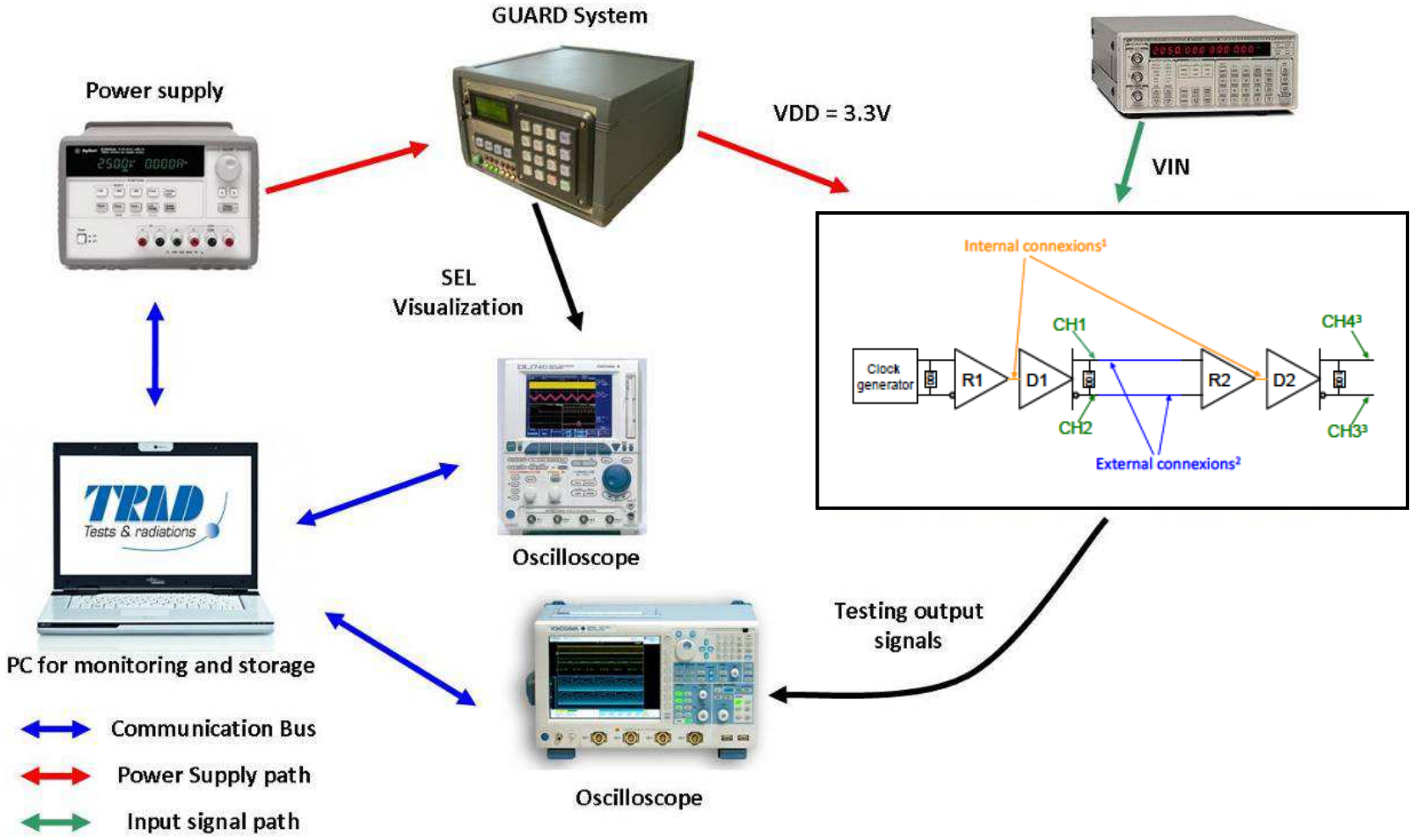


4µm step



2µm step

Test bench description

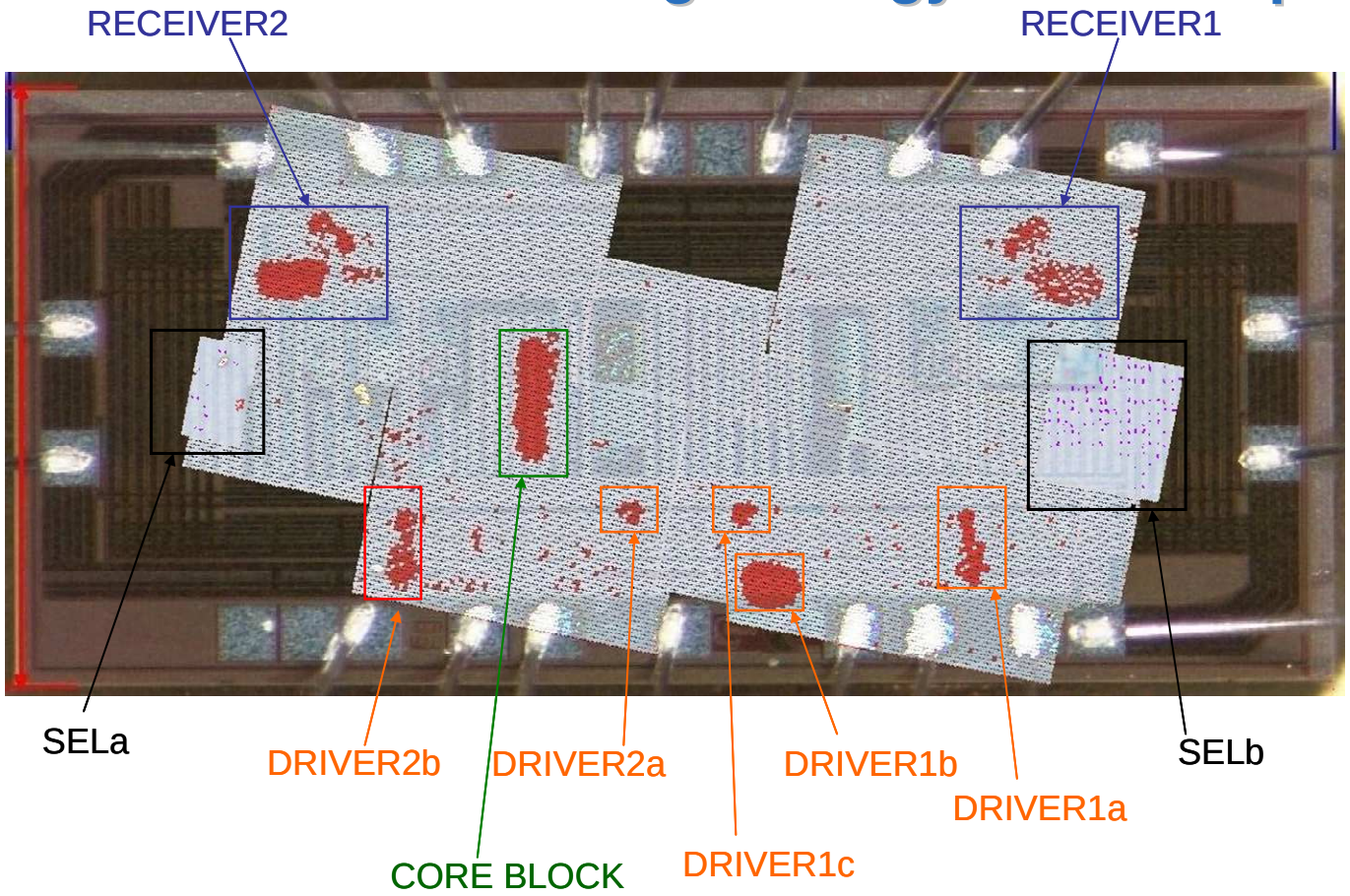


Dual LVDS Transceiver prototype

- The laser study was based on previous heavy ions test performed by Gobham Gaisler
- At the first approach, TRAD choose to irradiated the all die with a beam with high energy

Dual LVDS Transceiver prototype

- **At the first approach, TRAD choose to irradiated the all die with a beam with high energy of 13.8nJ/pulse**



Dual LVDS Transceiver prototype

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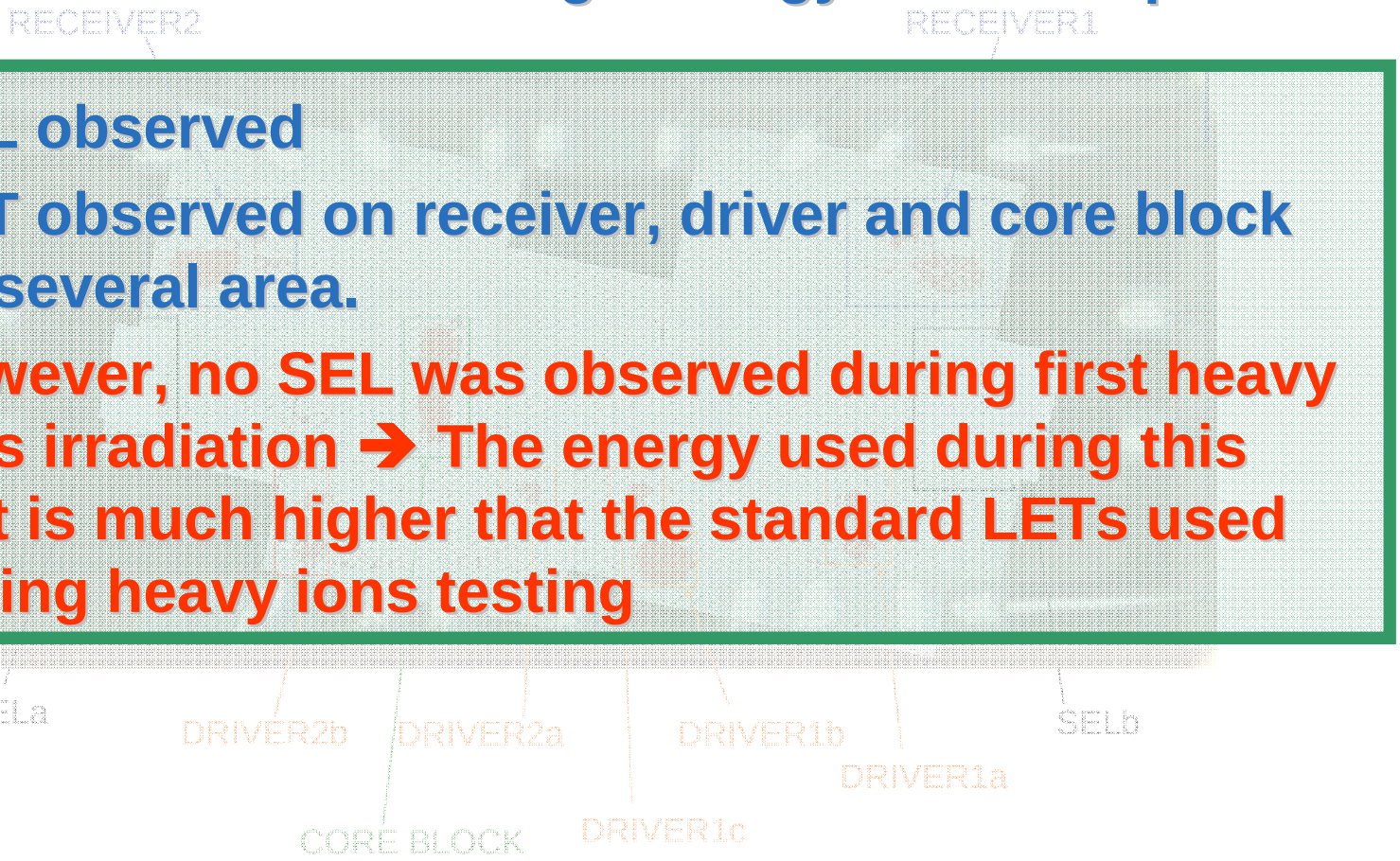
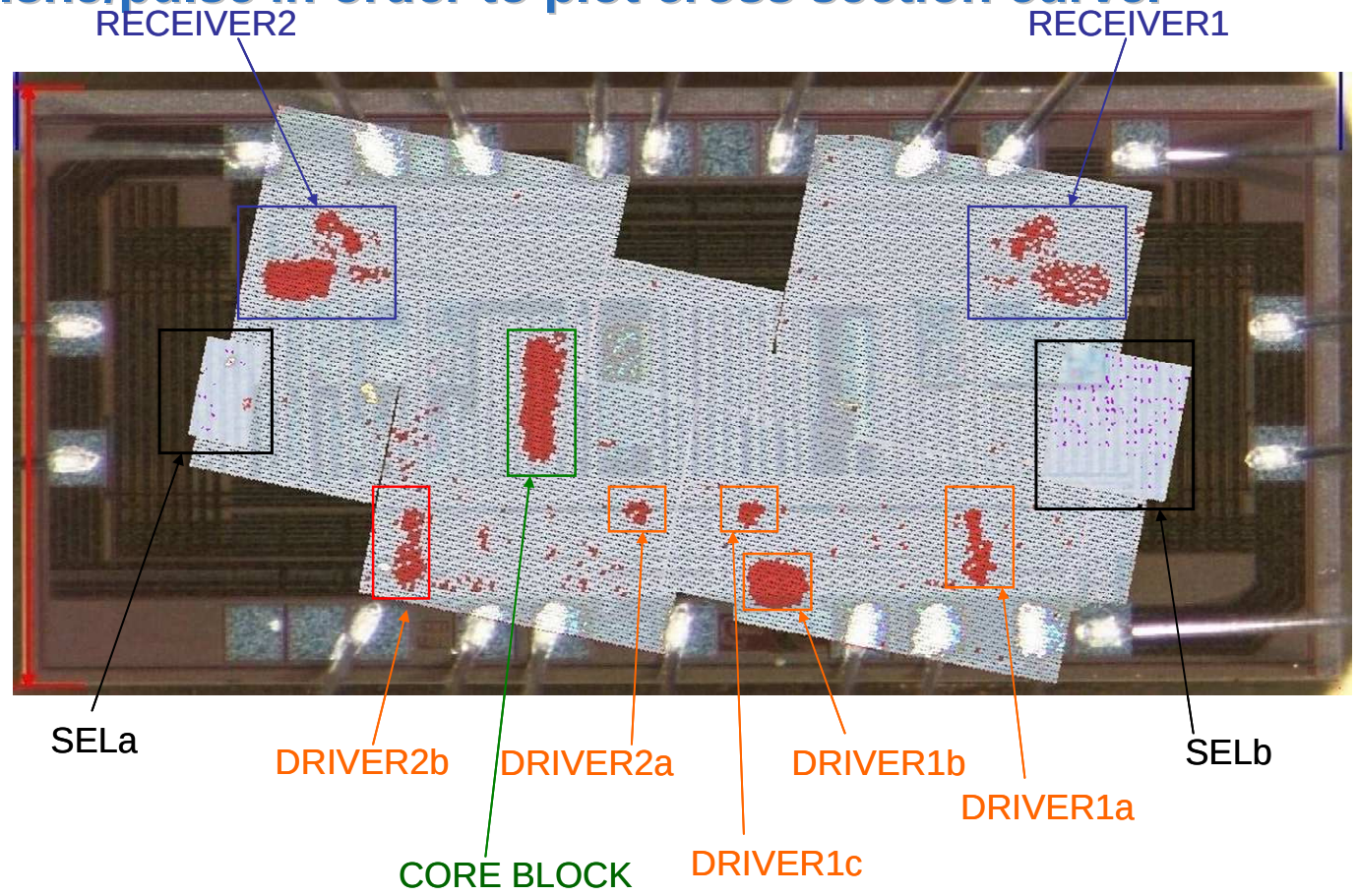


- SEL observed
- SET observed on receiver, driver and core block on several area.

  However, no SEL was observed during first heavy ions irradiation ➔ The energy used during this test is much higher that the standard LETs used during heavy ions testing

Dual LVDS Transceiver prototype

- At the second approach, the test was focused on receiver 2 area with energy comprise between 0.48nJ/pulse and 13.8nJ/pulse in order to plot cross section curve.



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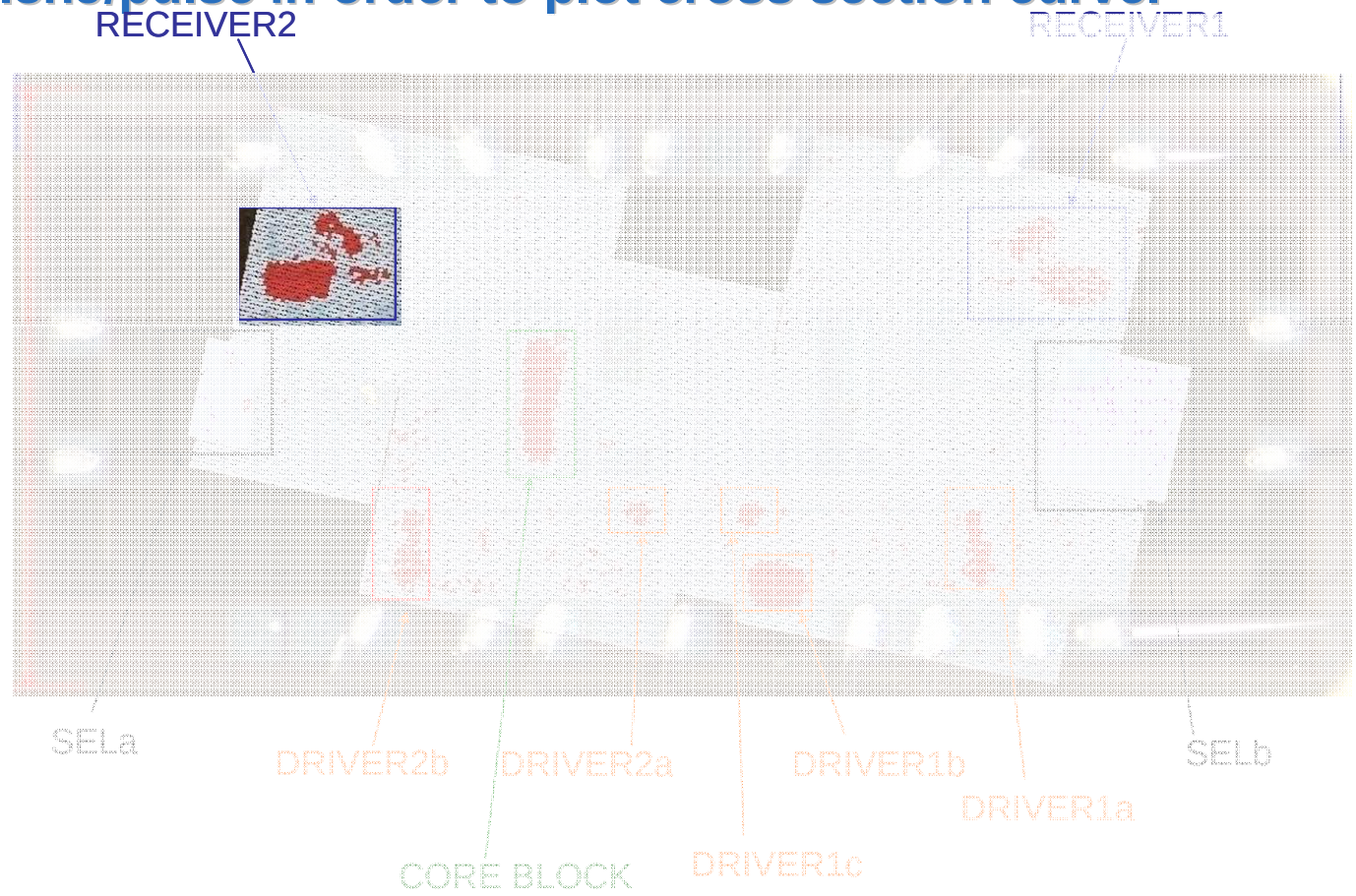

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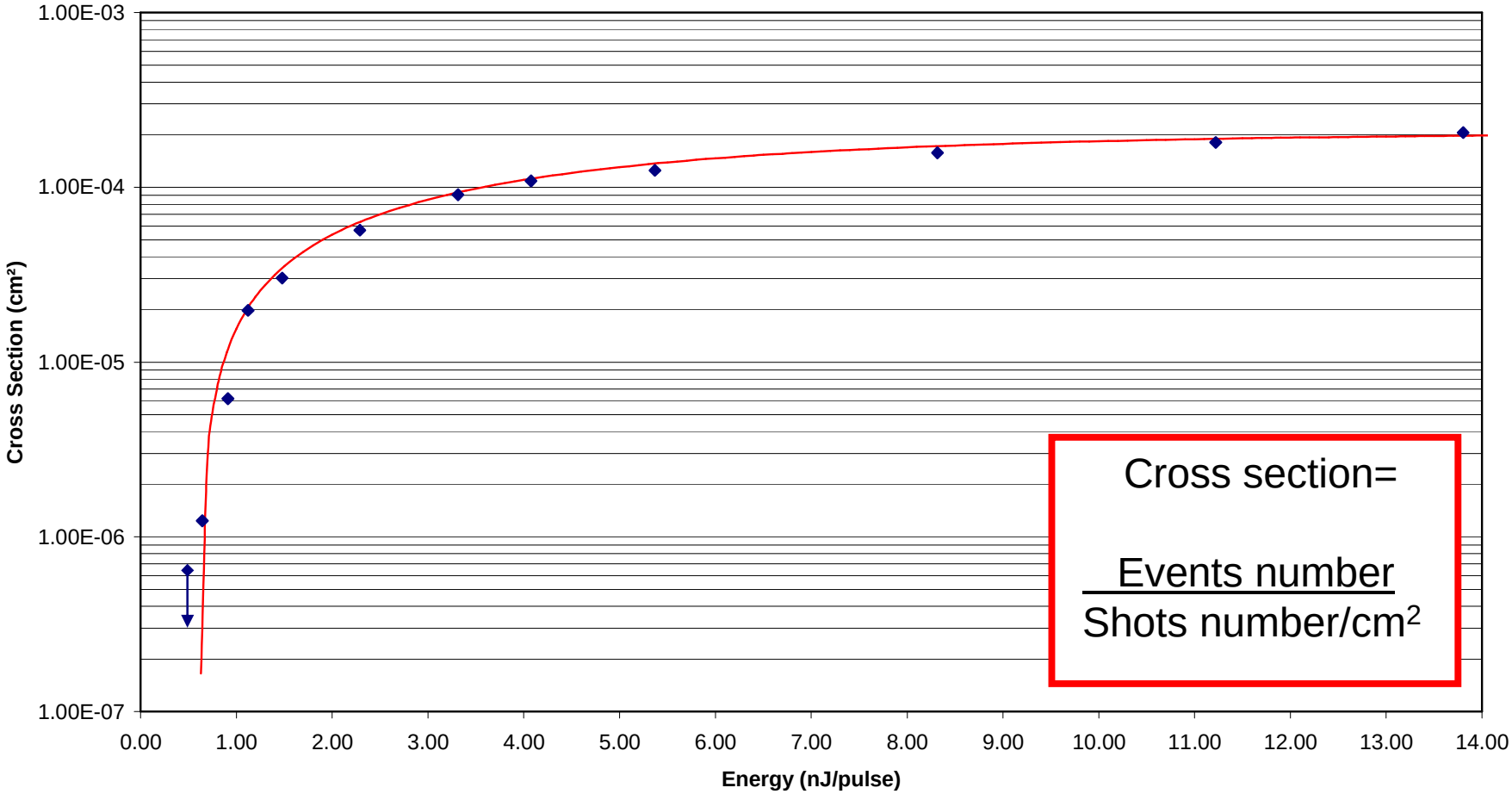

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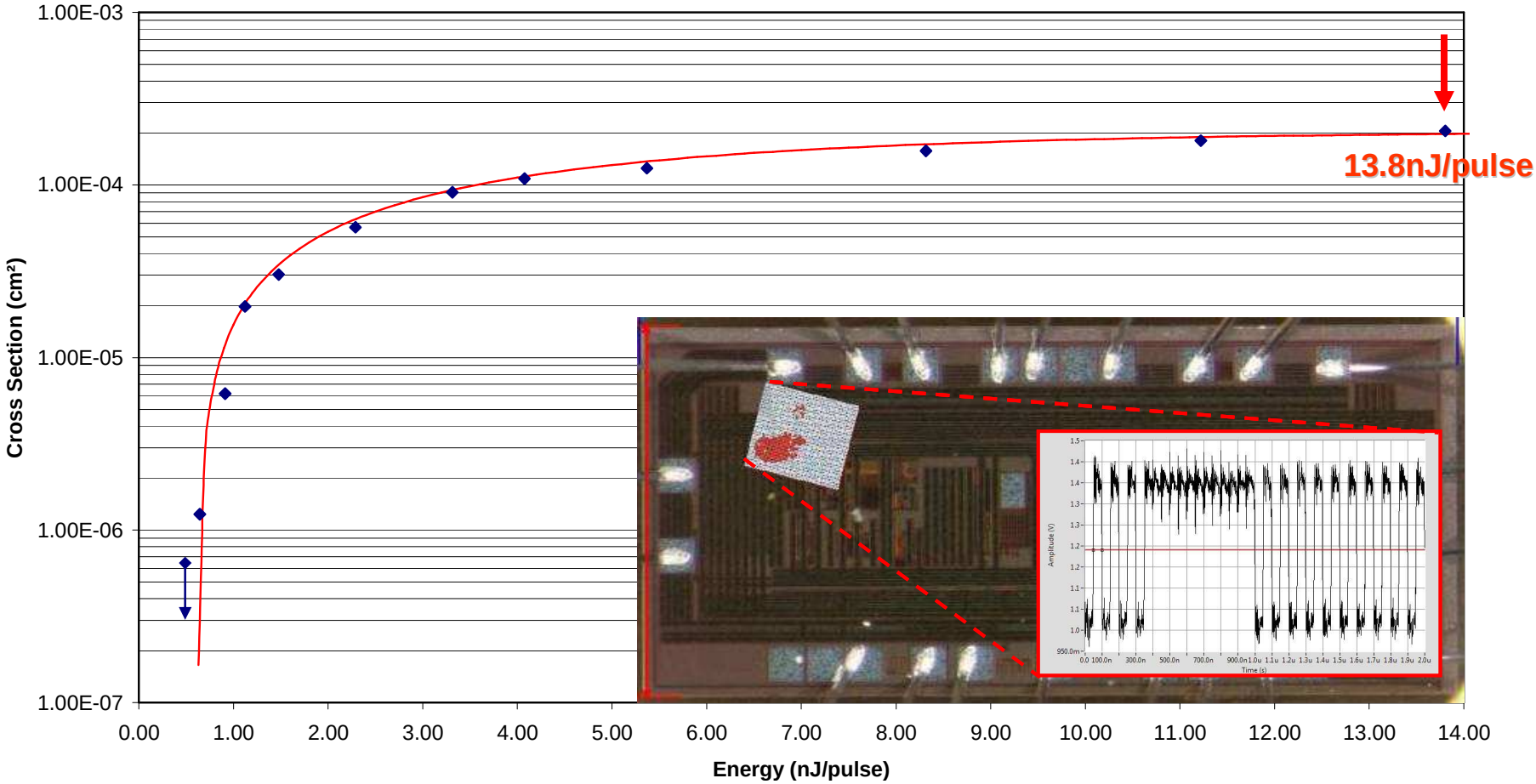

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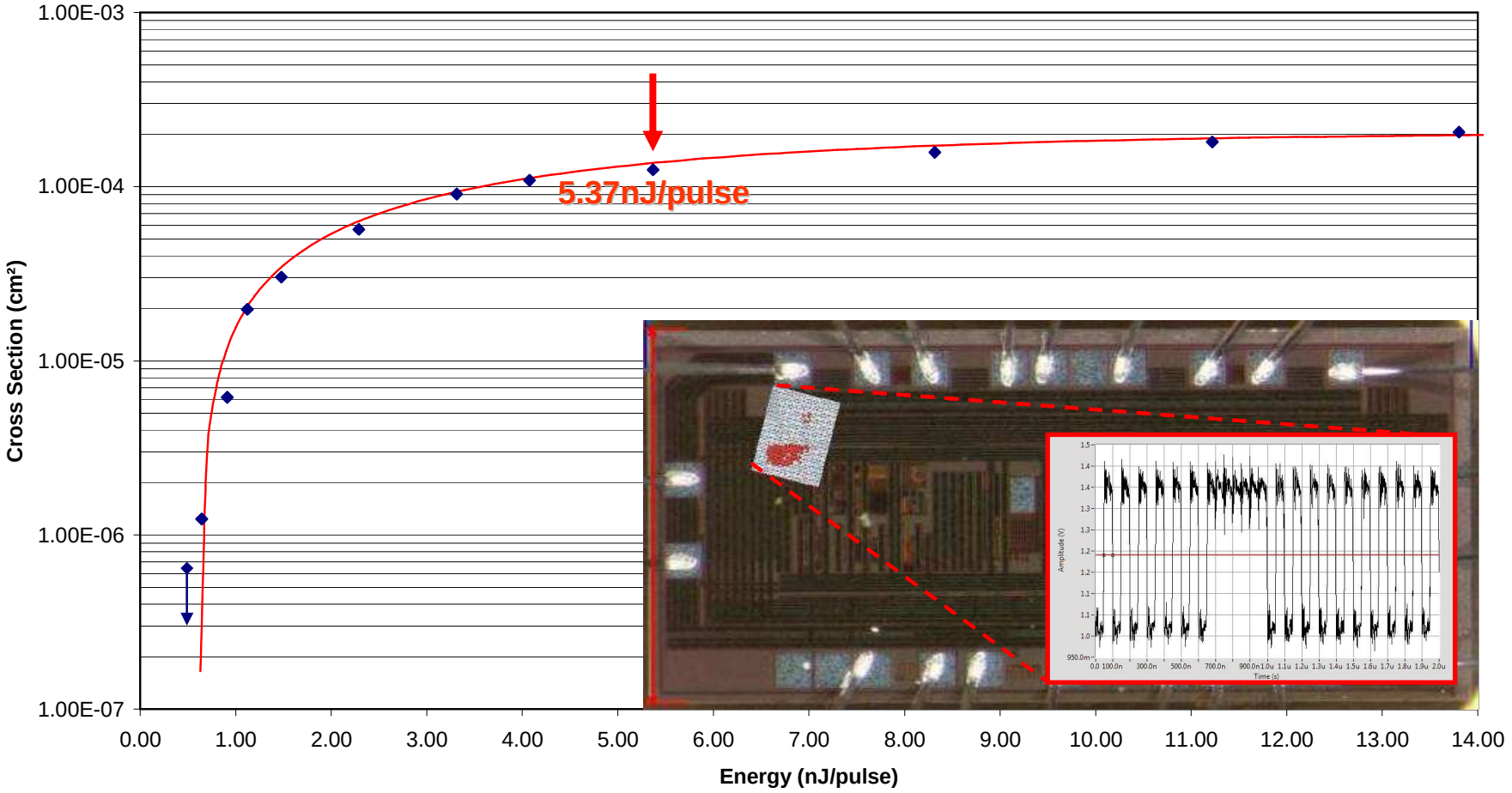

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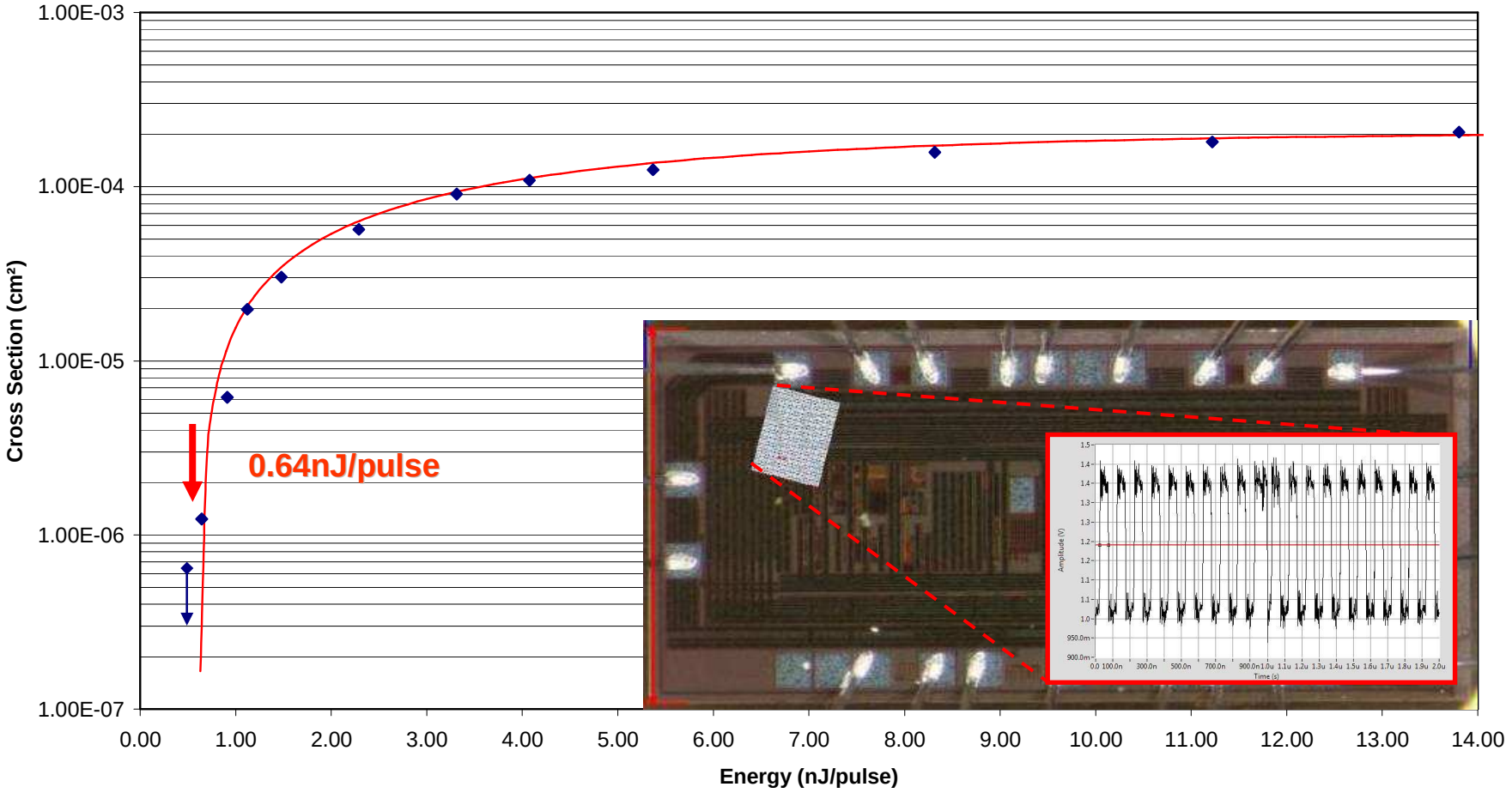

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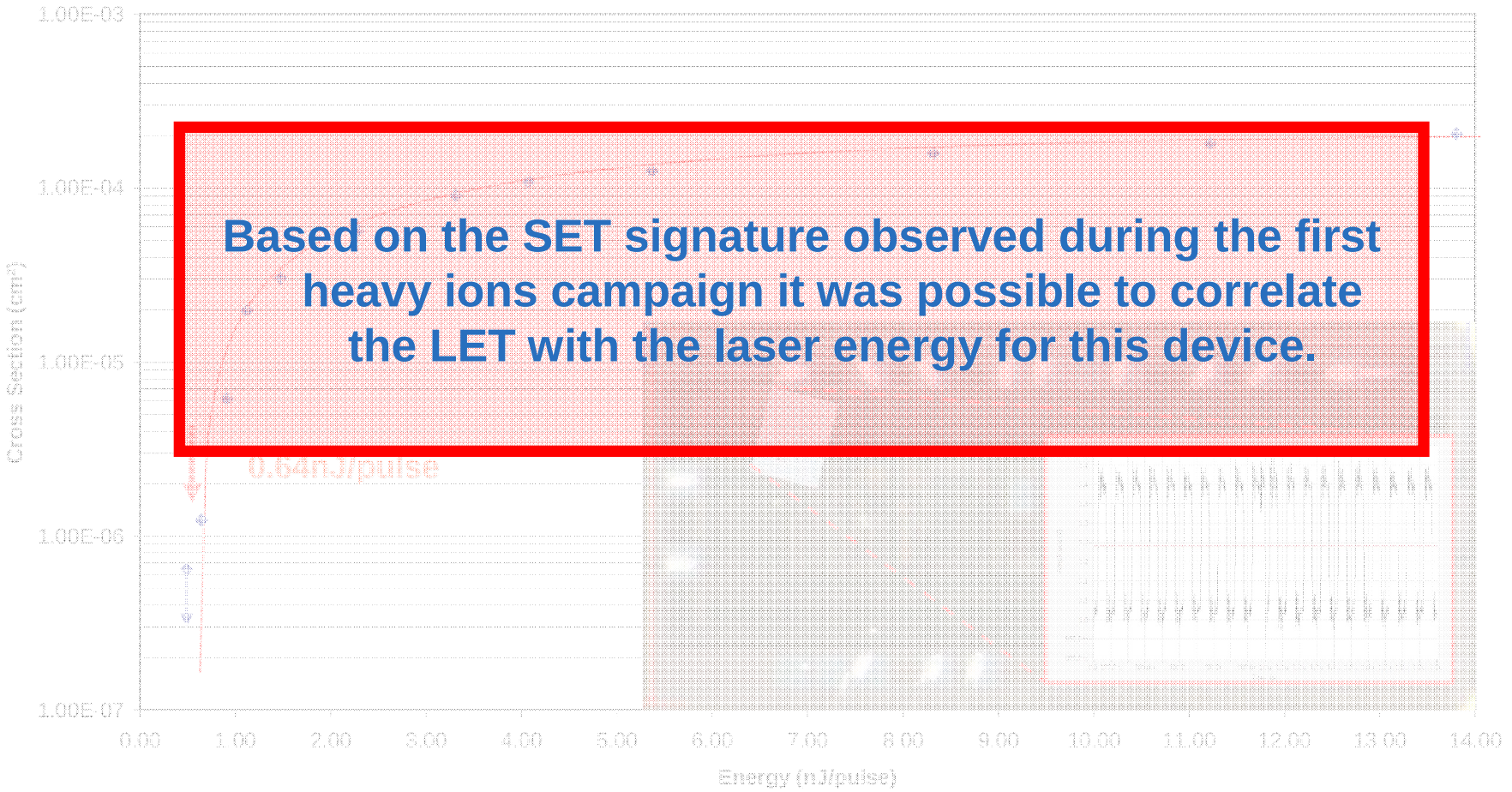
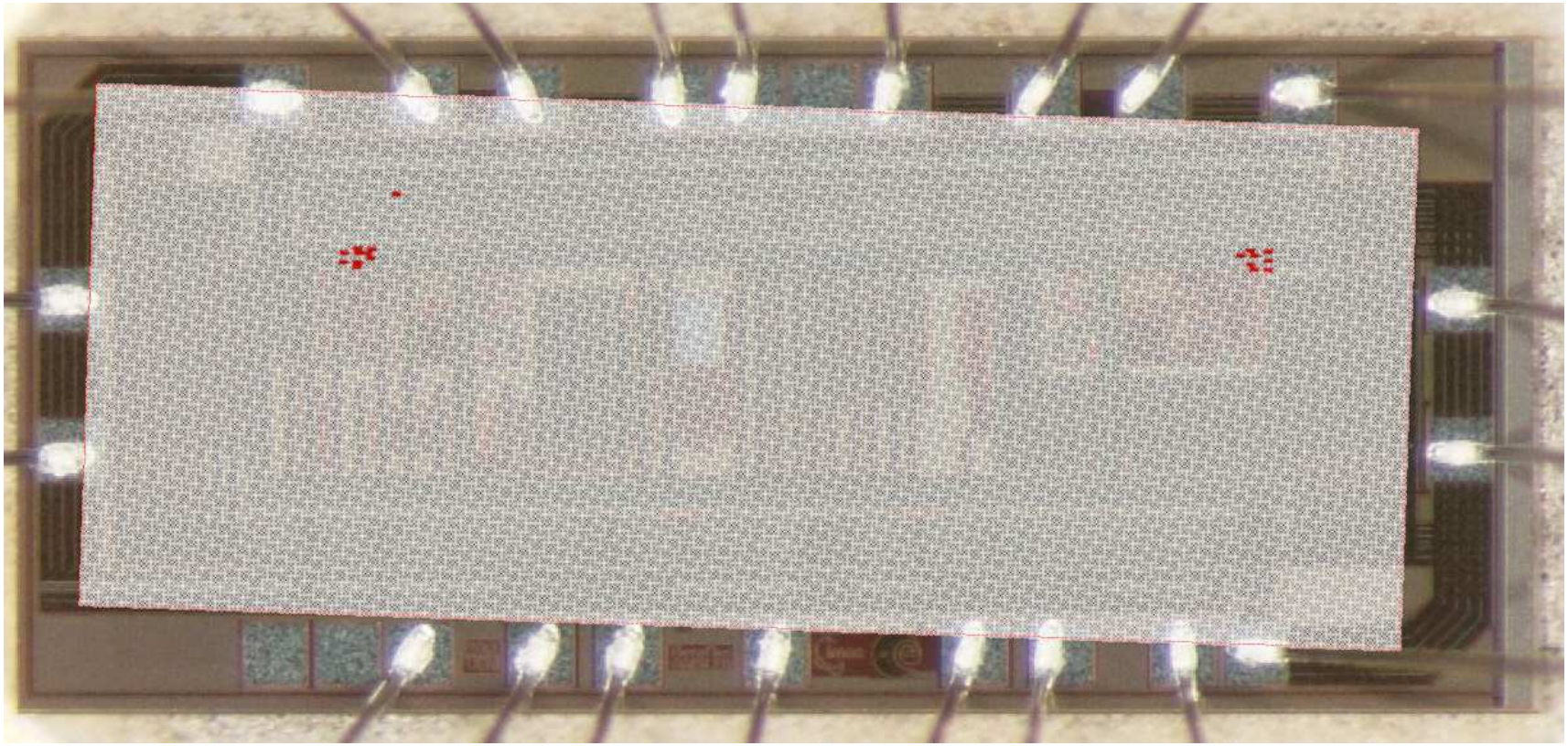


Based on the SET signature observed during the first heavy ions campaign it was possible to correlate the LET with the laser energy for this device.

Dual LVDS Transceiver prototype

- **A new scan of the die was performed with the 1.12nJ/pulse energy**



LASER energy 1.12nJ/pulse

Dual LVDS Transceiver prototype

A new revision of the die was tested with Heavy ions Irradiation (U.C.L)

IRRADIATION BEAM CHARACTERISTICS	
Heavy Ions used :	$^{124}Xe^{26+}$ (62.5 MeV.cm²/mg) $^{124}Xe^{26+}$ tilted @ 60° (125 MeV.cm²/mg) Fluence: 1.10^{7} cm^{-2}
Result @125°C	No latchup observed

➔ No SEL Sensitivity

CONCLUSION

- The objective of this study was to test the Dual LVDS transceiver prototype from Cobham Gaisler with laser in order to improve the design of the die.
- This study helped TRAD to improve its understanding of the laser testing.
- The data collected for this device allowed the location of some SET sensitive structures in the design
- The data collected in this work will allow the developers of the LVDS device to harden its design.

Outline

- Dual LVDS Transceiver from Gobham Gaisler

Prototype characterized with heavy ions

- **GR718A SpaceWire router from Gobham Gaisler**

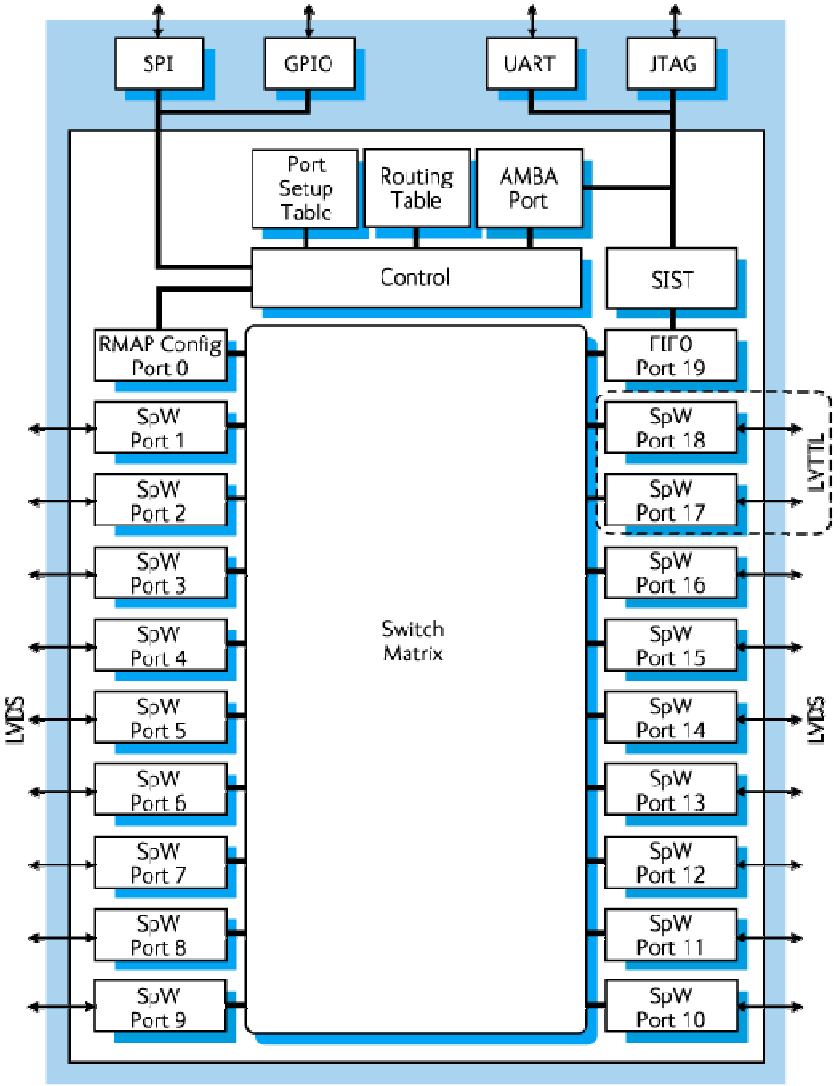
- MT29F16G08 16Gbit NAND Flash Memory from Micron

GR718A SpaceWire router prototype

PART IDENTIFICATION	
Type :	GR718A
Manufacturer :	Cobham Gaisler
Function :	SpaceWire Router
PARTS PROCUREMENT INFORMATIONS	
Packaging :	CQFP256
Sample size:	2 tested samples

GR718A SpaceWire router prototype

- 16x SpaceWire ports with on-chip LVDS
- 2x SpaceWire ports with LVTTL for use with off-chip LVDS transceivers
- SpaceWire Plug-and-Play support
- UART and JTAG interfaces to configuration port
- GPIO and SPI interfaces
- Timers on all ports to recover from deadlock



GR718A SpaceWire router prototype

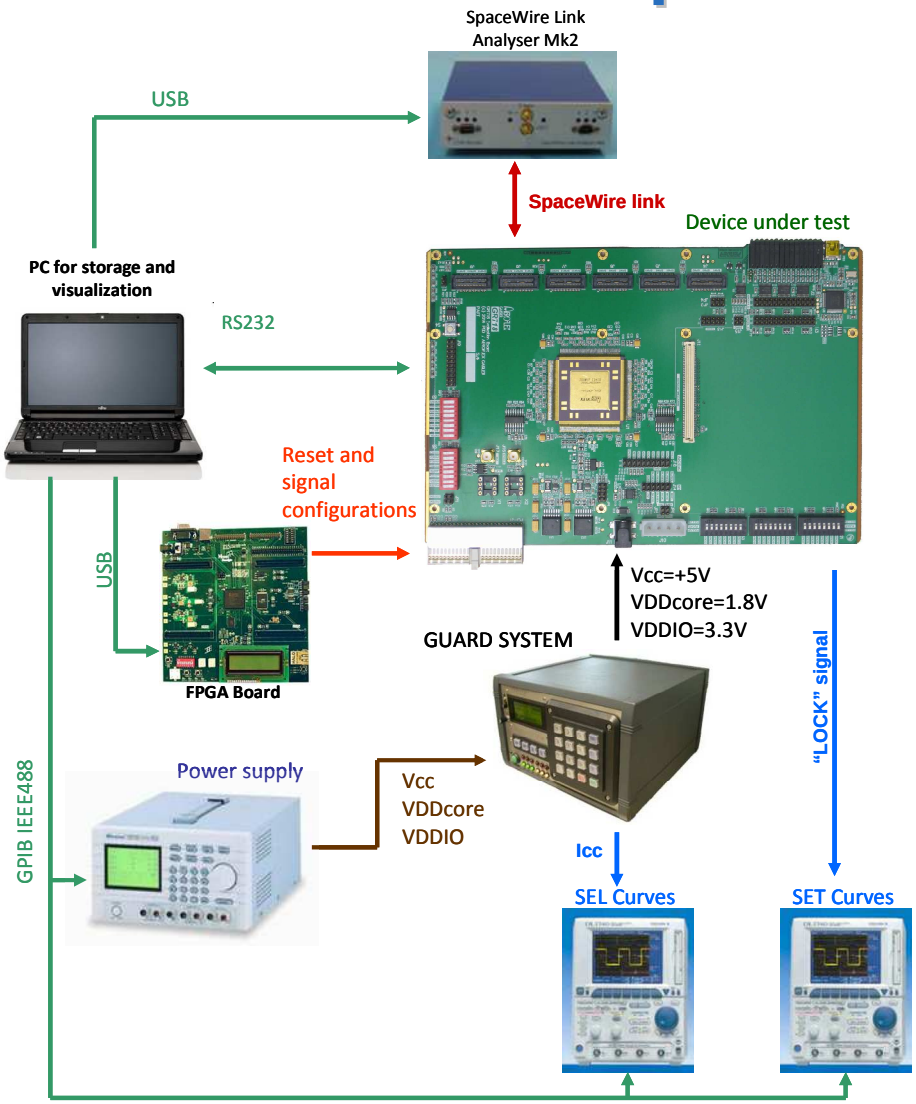
Irradiation performed at UCL

Event Type tested:

- Single Event Latchups (SELs),
- For SET and SEU, 2 modes and 3 configurations for each:

Configurations	Vcore (V)	Vio (V)	Baud rate*	Mode	CLK (MHz)	SPWCLK (MHz)	PLL
1	1.8	3.3	Port No. 18 Derated	Dynamic	50	100	CLKx4
2	1.8	3.3	Full	Dynamic	50	100	CLKx4
3	1.95	3.3	Full	Static	50	100	CLKx2
4	1.65	3.3	Full	Static	50	100	CLKx2
5	1.65	3.3	Full	Static	12.5	100	CLKx2
6	1.8	3.3	Port No. 18 Derated	Dynamic	20	100	CLKx2

Test bench description

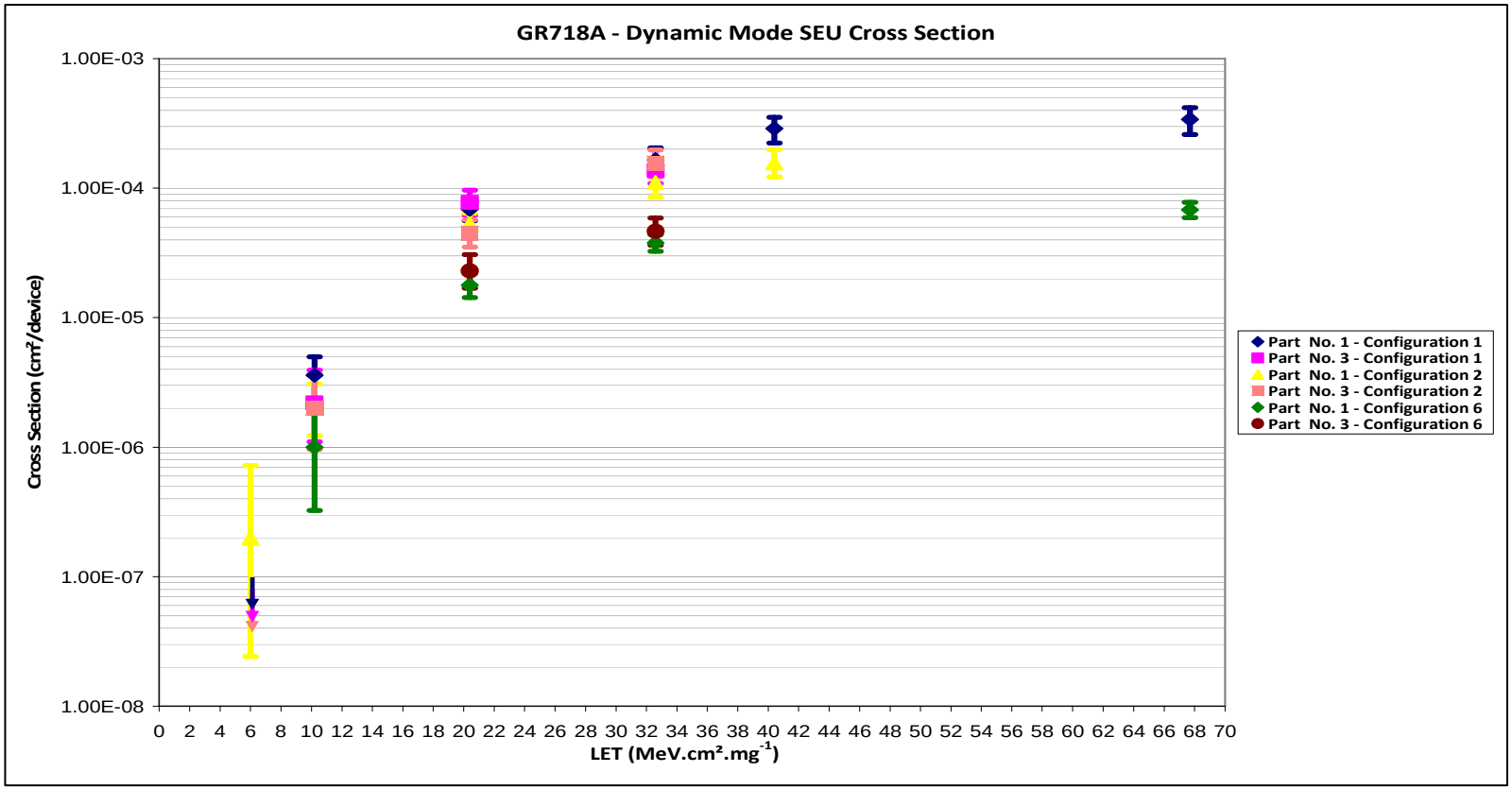


GR718A SpaceWire router prototype

RESULT

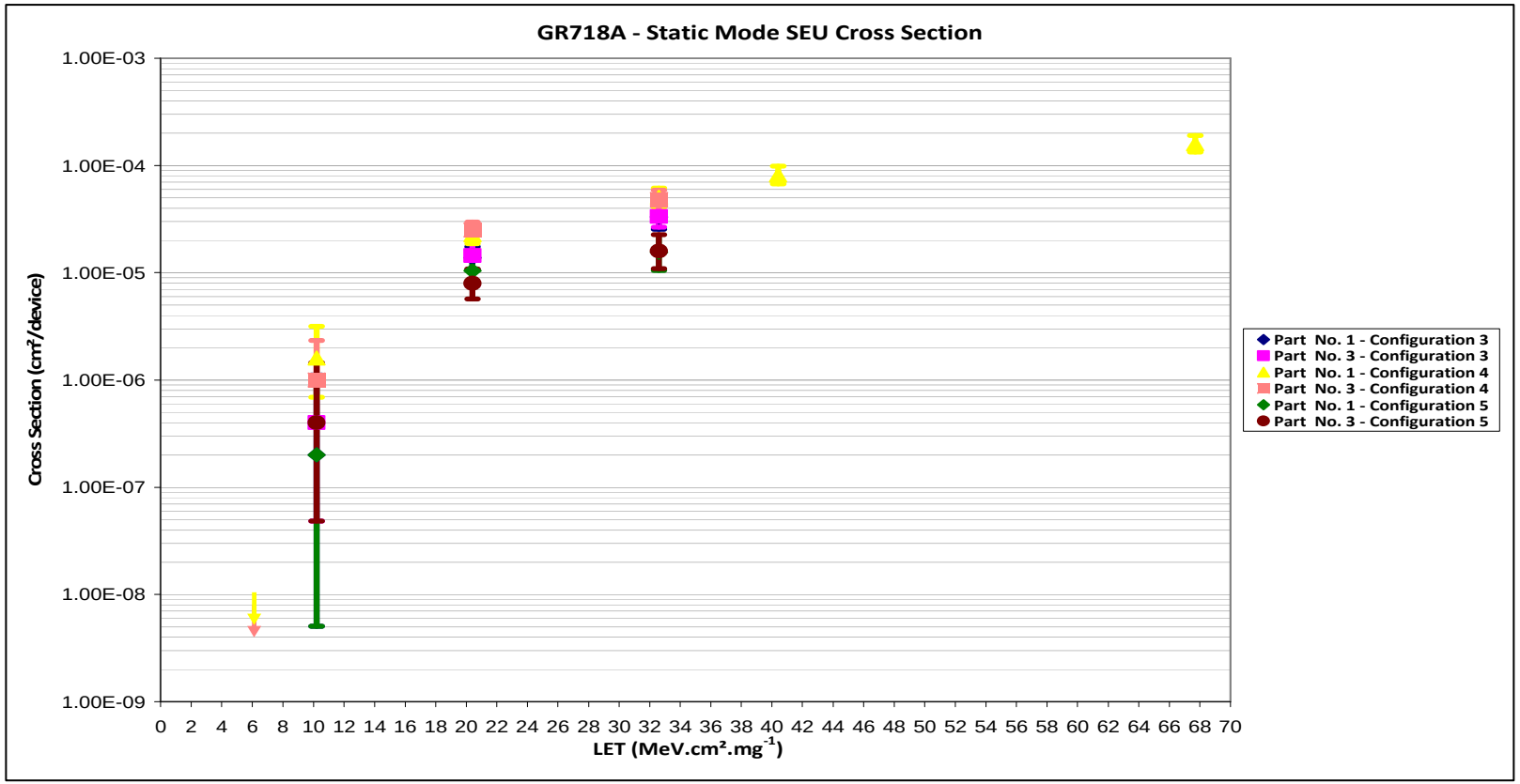
- No Latchup observed @ 125°C
- Some SET observed on operational range (20-50MHz), but it is dependent to low input frequency.
- SEU were observed on static and dynamic mode for all configuration:

GR718A SpaceWire router prototype



- In dynamic mode the DUT showed difference of sensitivity when one port was derated or not (Configurations 1 and 2). The error cross section was slightly higher with port No.18 derated
- In dynamic mode the sensitivity of the DUT increased with higher clock frequency (Configuration 1 and 6).

GR718A SpaceWire router prototype



- In static mode the sensitivity of the DUT increased with lower voltage on VDDCore (Configurations 3 and 4).
- In static mode the sensitivity of the DUT increased with higher clock frequency (Configuration 4 and 5).

Conclusion

- After completion of this study, Cobham Gaisler has made a new revision of the SpaceWire Router,GR718B. The new revision is back compatible with the GR718A tested in this study.
- GR718B is implemented in the same technology. Thus, the results in this study on GR718A related to the technology, e.g. SEL, shall be relevant to the GR718B. However, the GR718B has been designed with new SEU mitigation concepts. Thus it may be expected that the GR718B will be less SEU sensitive compared to the results presented in this study for the GR718A.

Outline

- Dual LVDS Transceiver from Gobham Gaisler

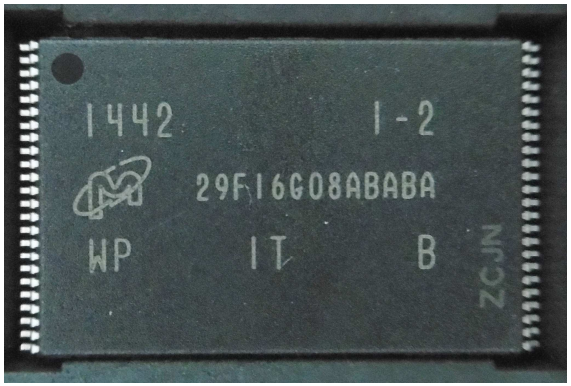
- GR718A SpaceWire router from Gobham Gaisler

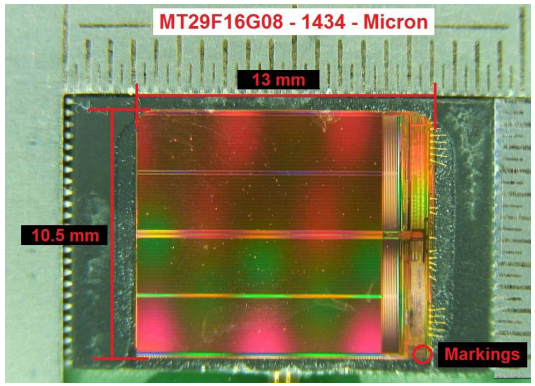
Commercial part characterized with heavy ions

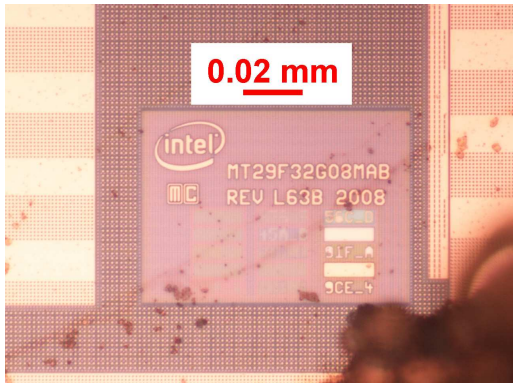
- **MT29F16G08 16Gbit NAND Flash Memory from Micron**

16Gbit NAND Flash Memory

PART IDENTIFICATION	
Type :	MT29F16G08ABABAWP-IT :B
Manufacturer :	Micron
Function :	16Gbit NAND Flash Memory
PARTS PROCUREMENT INFORMATIONS	
Packaging :	48-Pin TSOP Type 1
Sample size:	18 tested samples





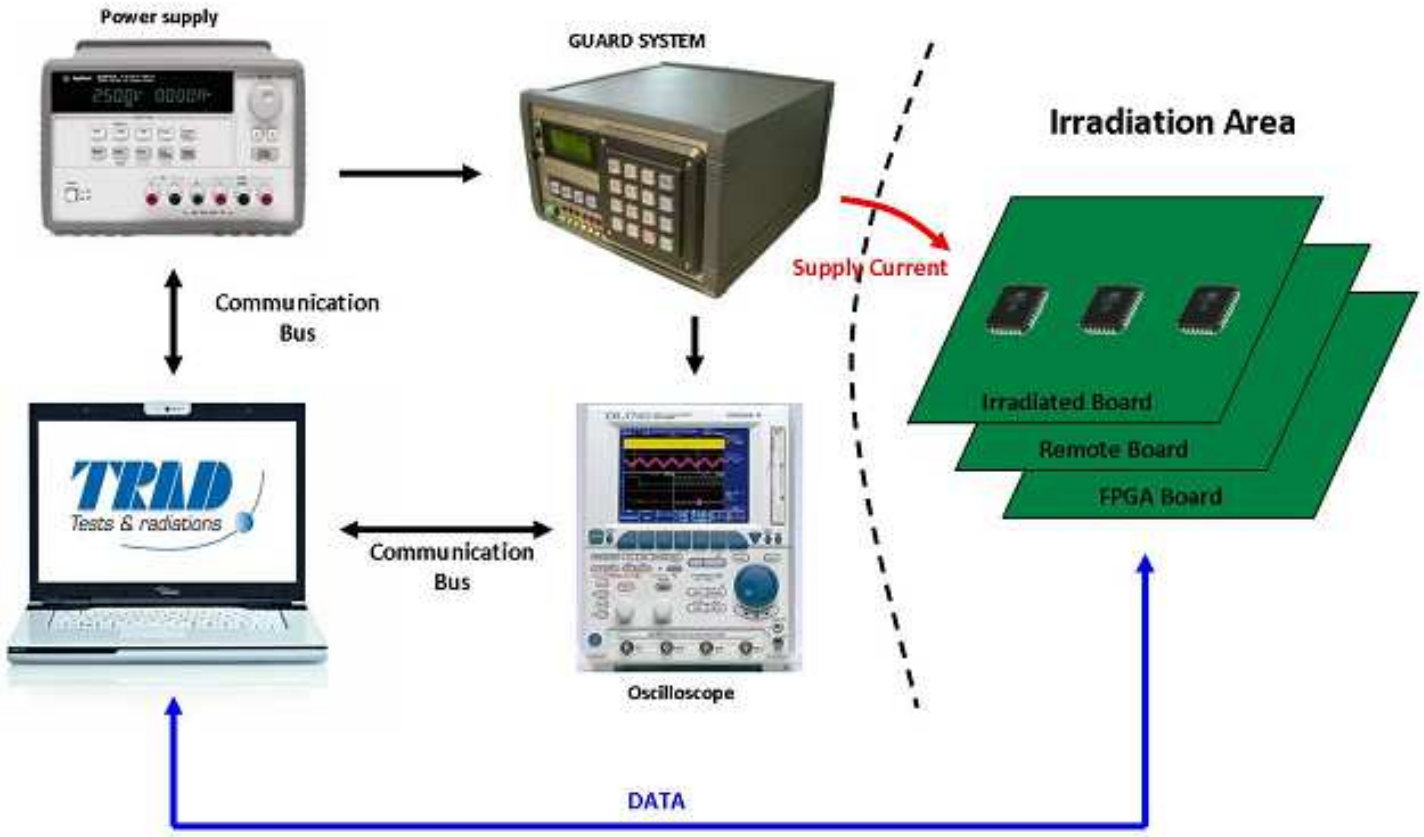


Irradiation performed at UCL

Event Type tested:

- SEL protected and un-protected
- For SEU, MBU, SET, EWE and SEFI :
  - Retention mode
  - Standby mode
  - Read only mode
  - Erase/Write/Read mode

Test bench description

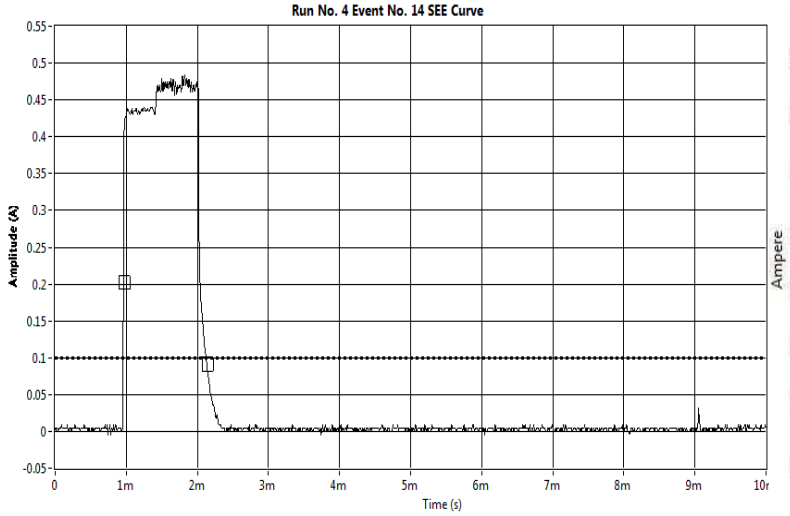


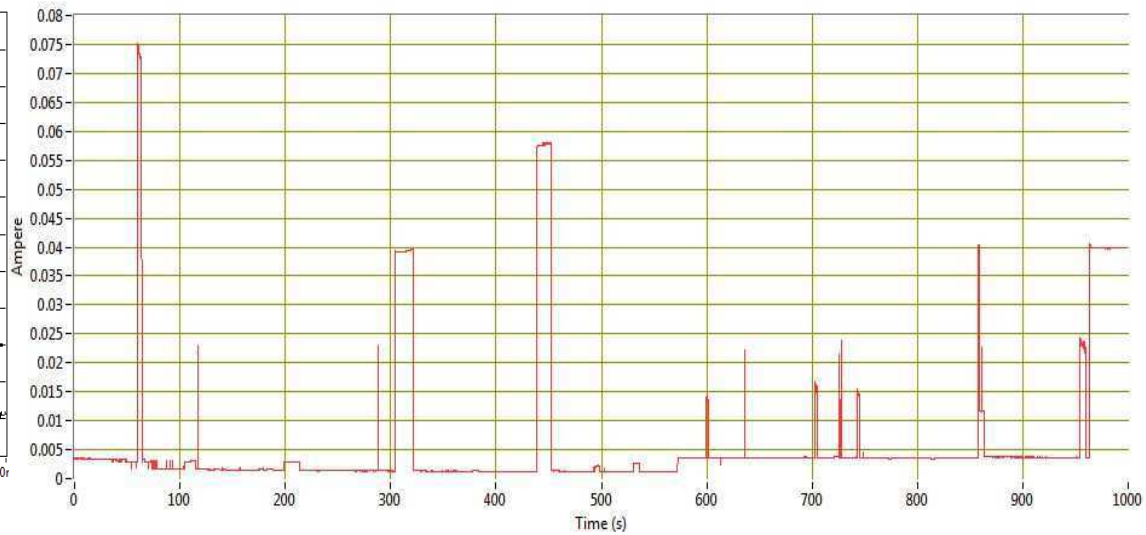
16Gbit NAND Flash Memory

SEL test result

- Irradiation performed at 125°C with a latchup protection set at 100mA in standby mode
- High Current states were observed

MT29F16G08 SEL Cross Section (cm²)			
LET (MeV.cm².mg^{-1})	DUT N°2	DUT N°3	DUT N°11
62.5	1.7E-06	3.20E-06	7.00E-07

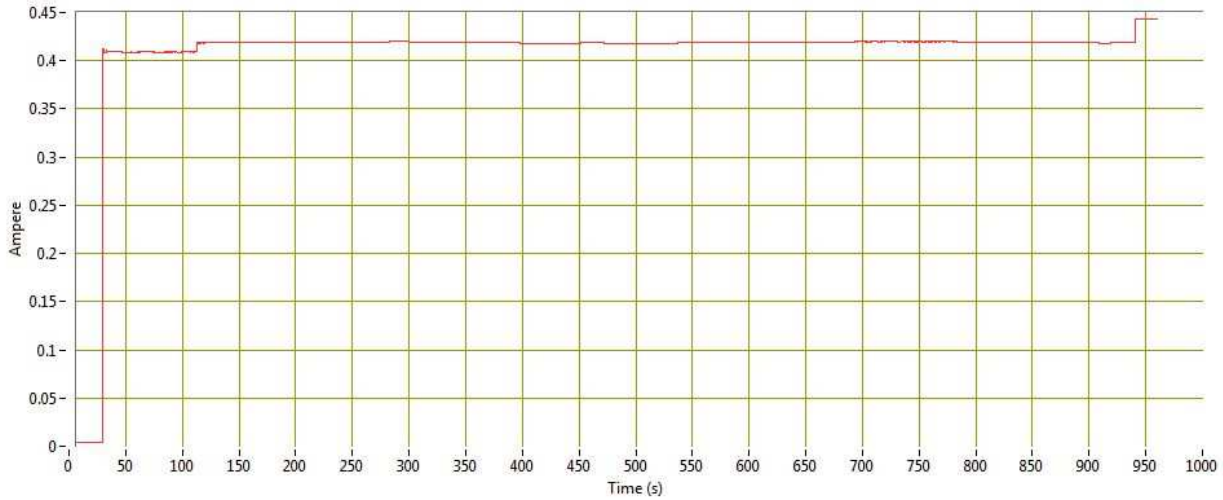




16Gbit NAND Flash Memory

No protected SEL run

- Irradiation performed at 125°C with a without latchup protection in standby mode

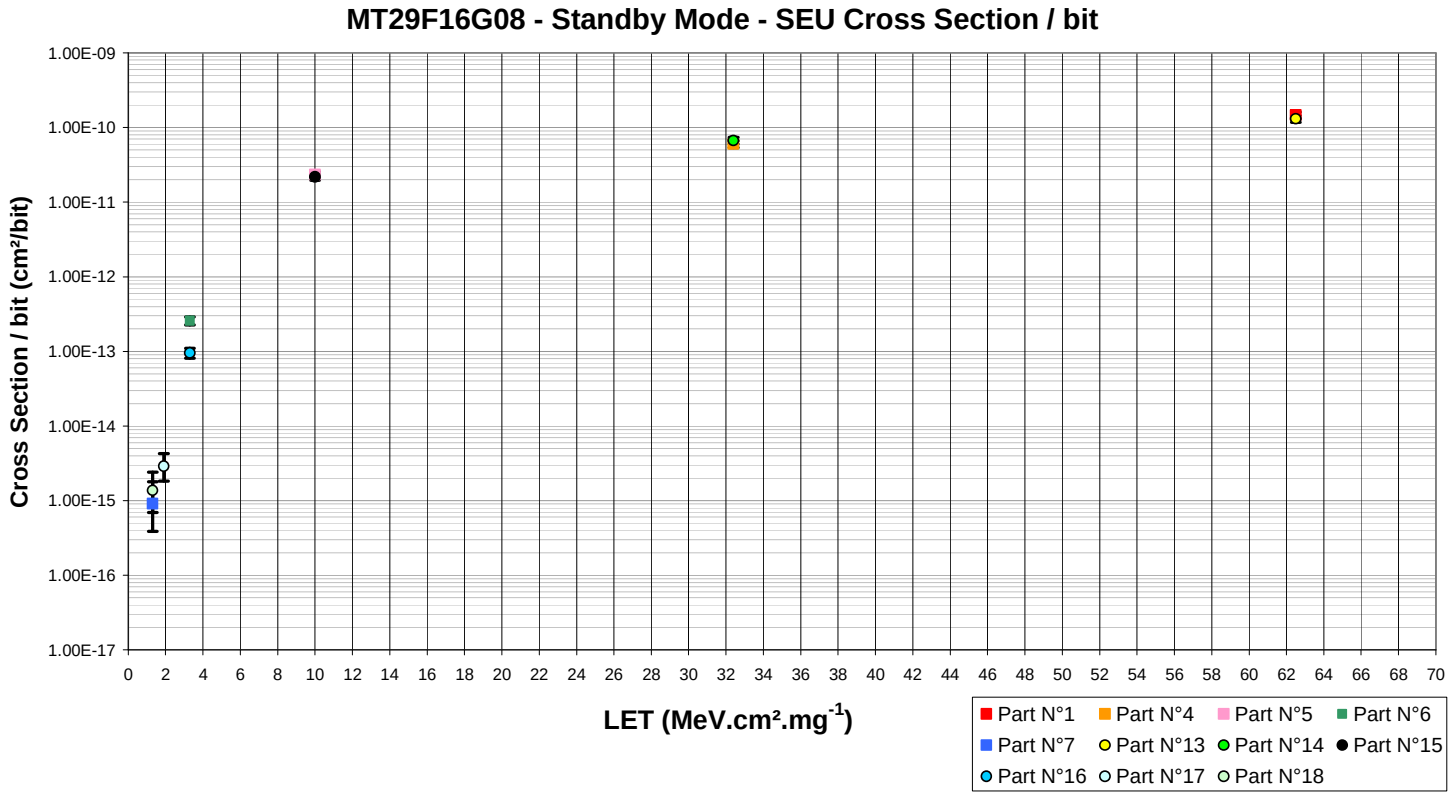


- No fonctional failure was observed even without the lachup protection
- Increase of number of bad block

MT29F16G08 SEL bad blocks number								
Number of bad blocks	DUT N°2		DUT N°3		DUT N°11		DUT N°12	
	Before	After	Before	After	Before	After	Before	After
	3	17	34	56	2	15	1	61

16Gbit NAND Flash Memory

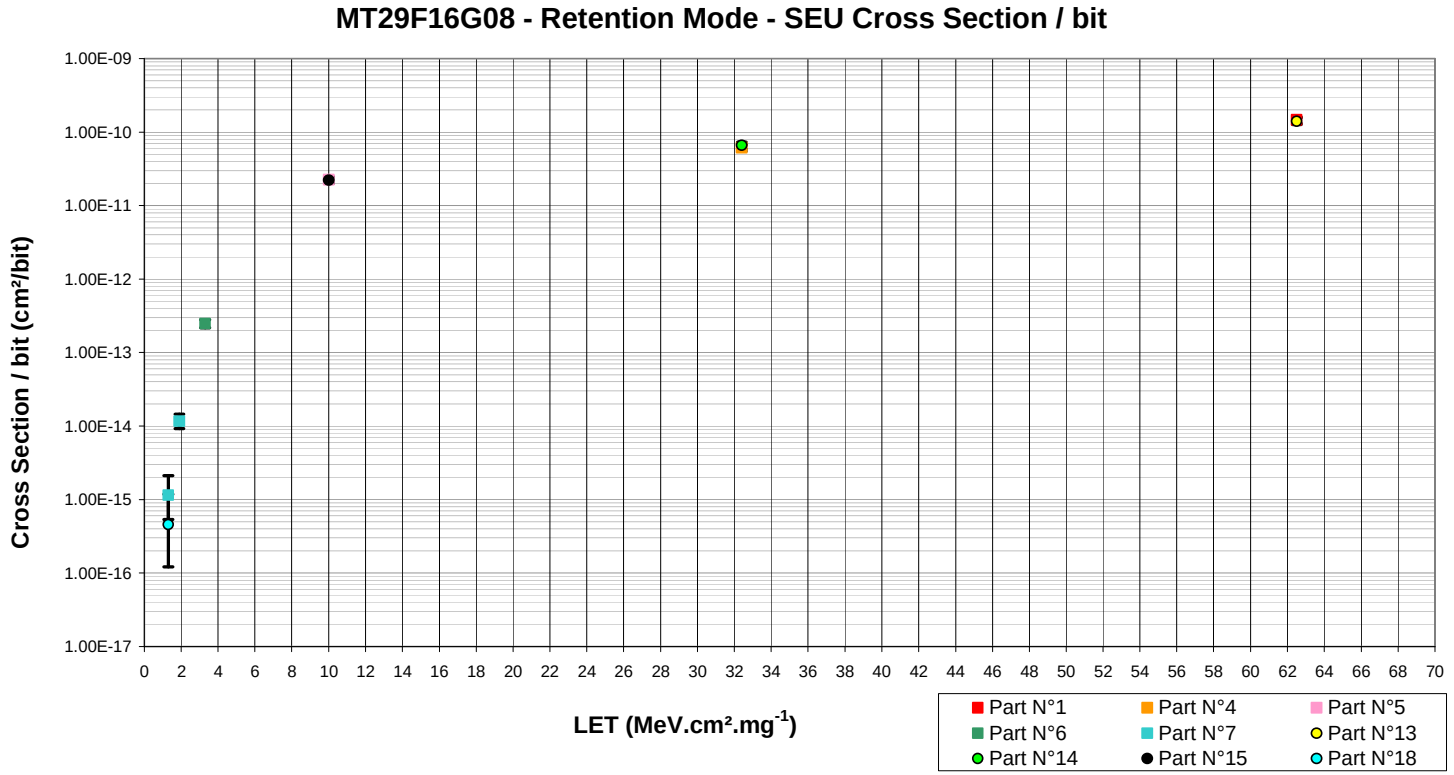
Standby Mode



- **SEUs were observed during irradiation with a minimum LET of 1.3 MeV.cm²/mg (Carbon heavy ion).**

16Gbit NAND Flash Memory

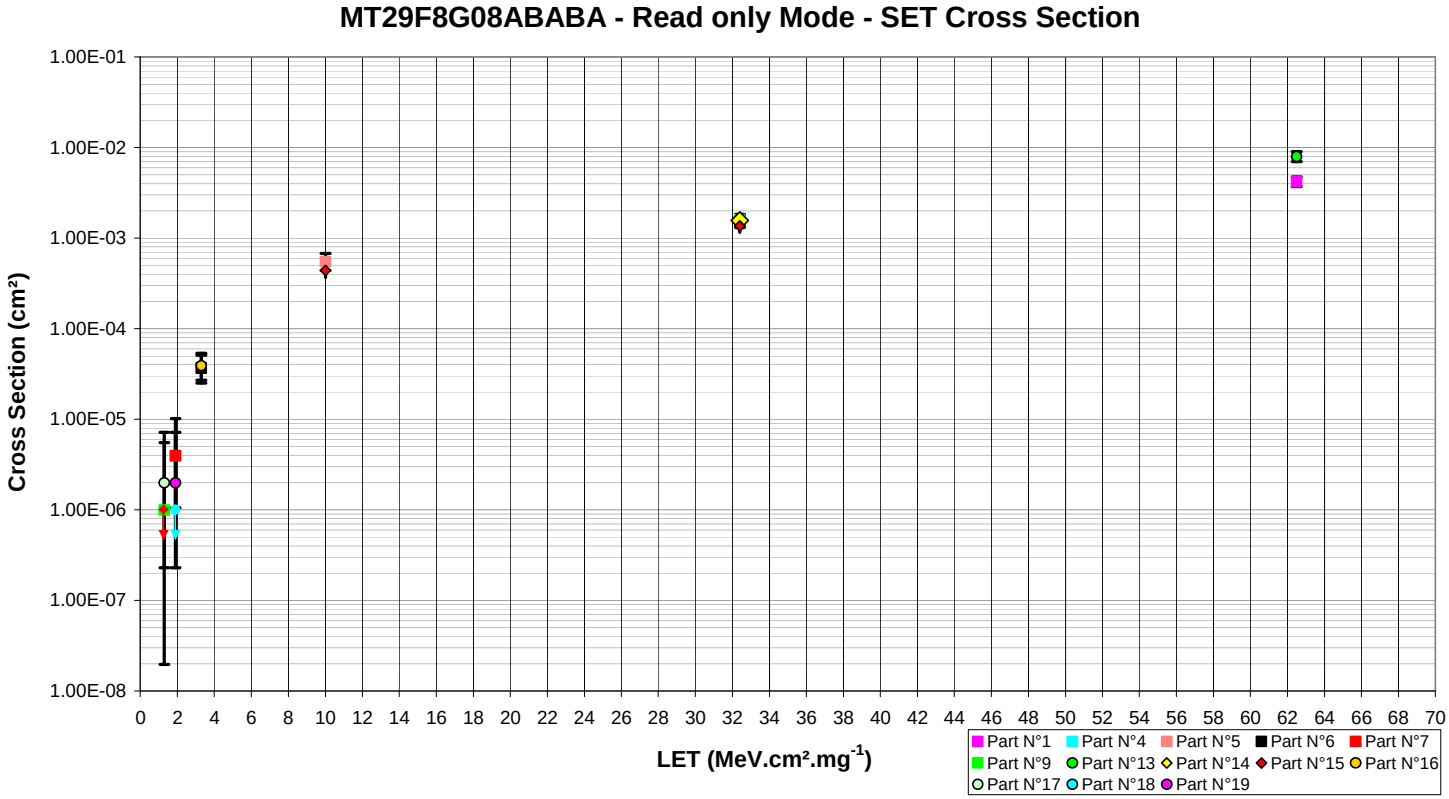
Retention Mode



- **SEUs were observed during irradiation with a minimum LET of 1.3 MeV.cm²/mg (Carbon heavy ion).**

16Gbit NAND Flash Memory

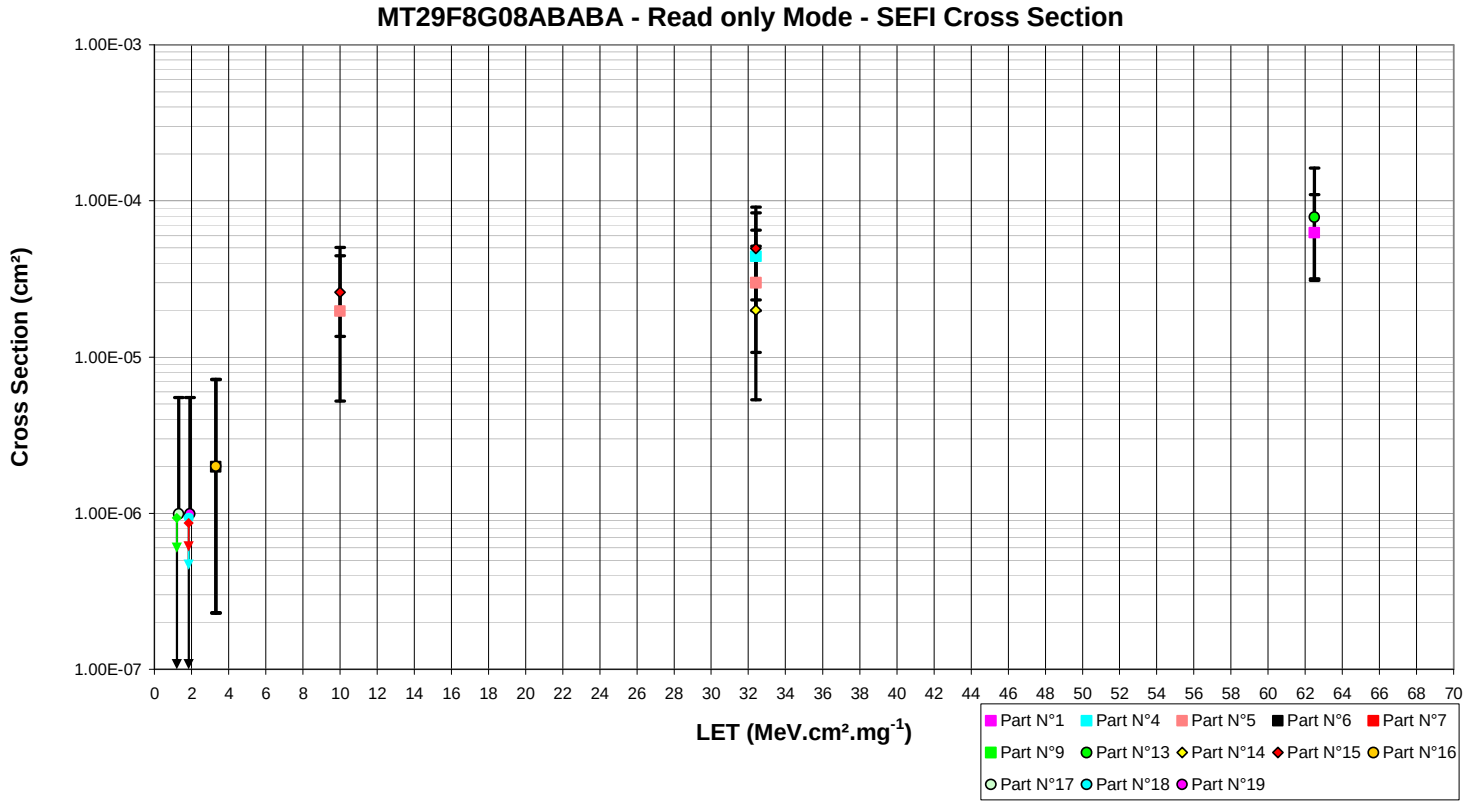
Read Only Mode



- SETs and SEFIs were observed during irradiation with a minimum LET of 1.3 MeV.cm²/mg (Carbon heavy ion).
- No MBU was observed during irradiation with a LET of 62.5 MeV.cm²/mg (Xenon heavy ion).

16Gbit NAND Flash Memory

Read Only Mode

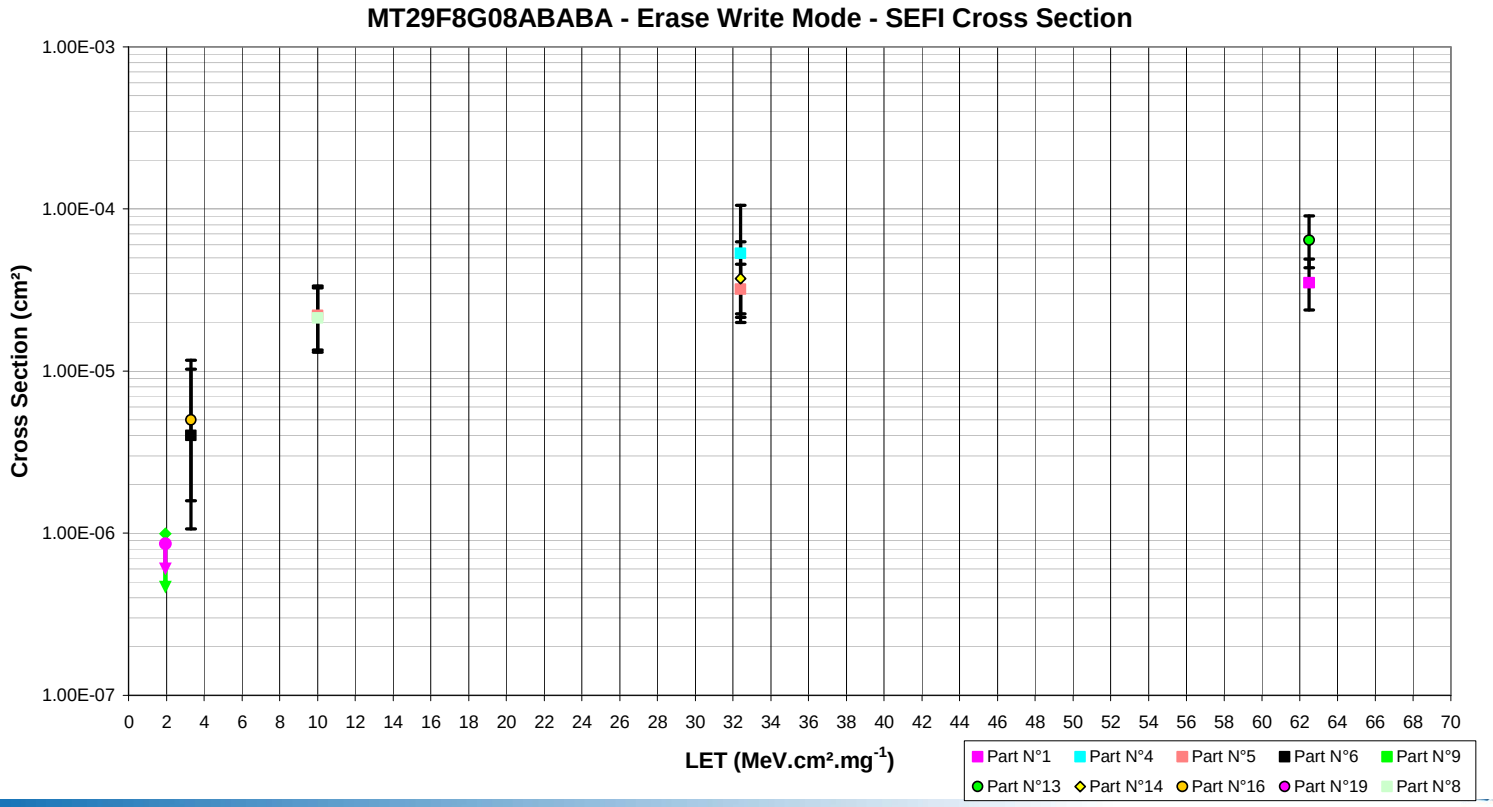


- SEUs, SETs and SEFIs were observed during irradiation with a minimum LET of 1.3 MeV.cm²/mg (Carbon heavy ion).
- No MBU was observed during irradiation with a LET of 62.5 MeV.cm²/mg (Xenon heavy ion).

16Gbit NAND Flash Memory

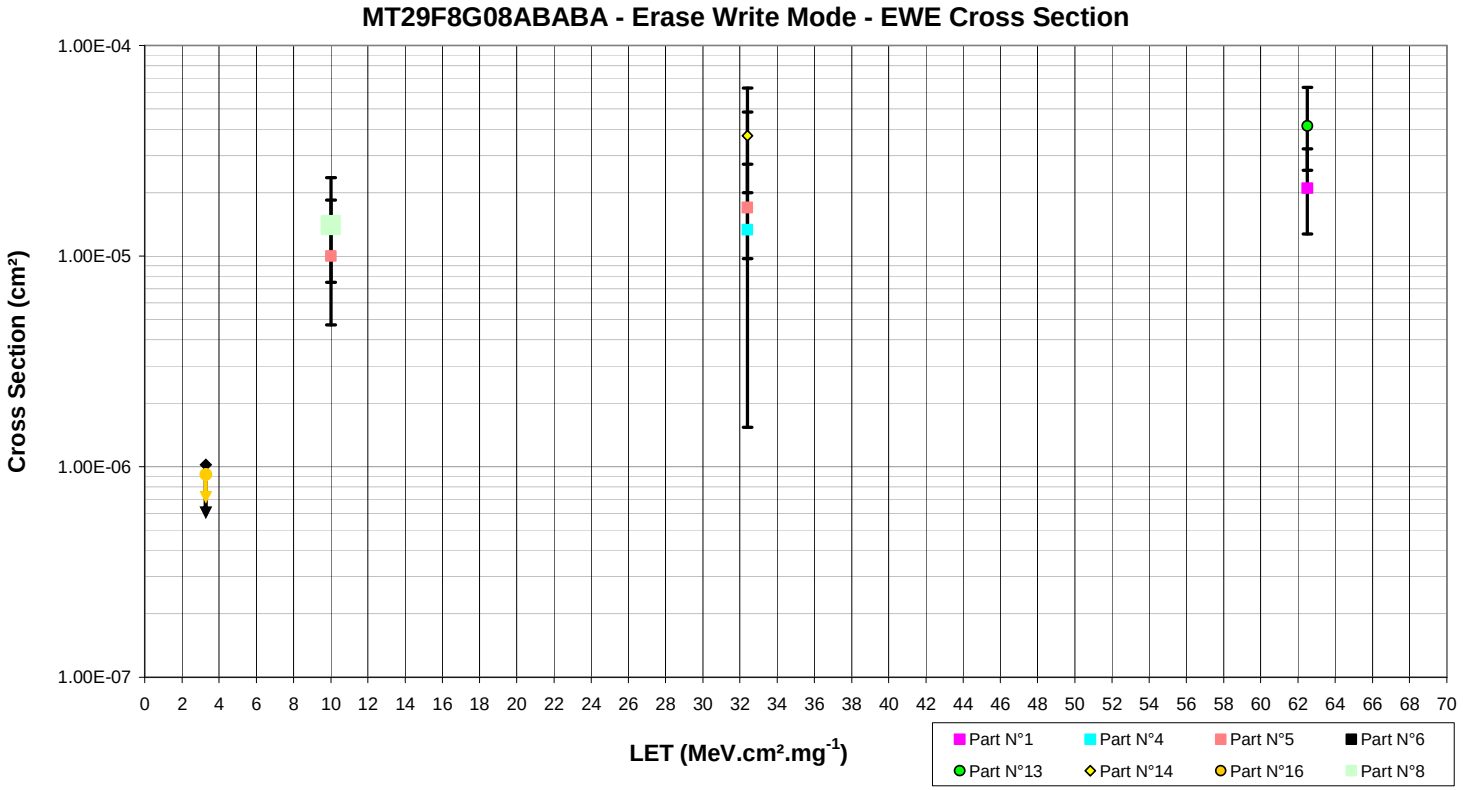
Erase Write Mode

- Time out loop was observed, it was counted as a SEFI
- Atypical number of EWE and SET observed during irradiation and still present after the end of irradiation. This event has been counted as a SEFI too
- Large burst of SETs were observed with more than 200 SET, this event has been counted as a SEFI



16Gbit NAND Flash Memory

Erase Write Mode

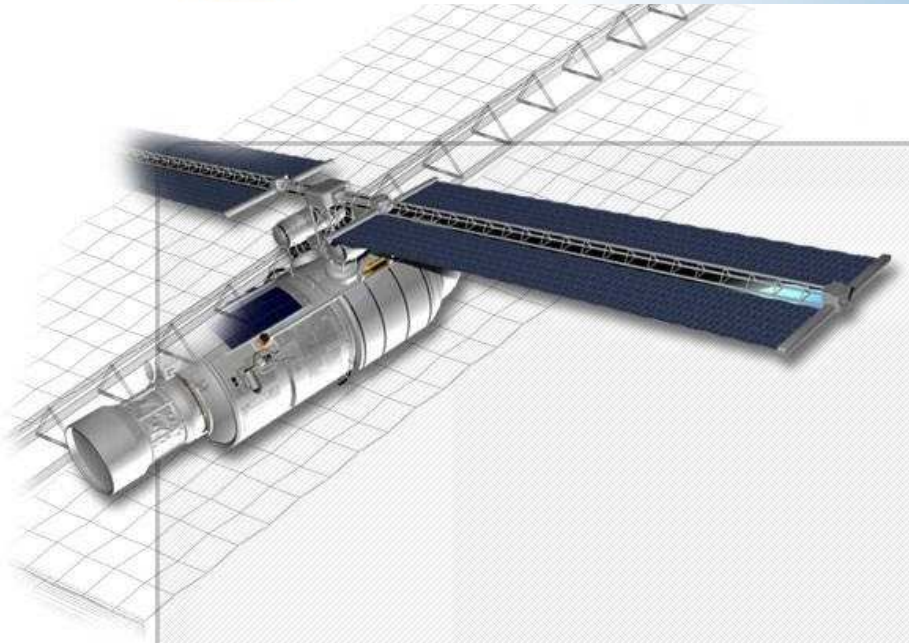


- EWEs were observed during irradiation with a minimum LET of 10 MeV.cm²/mg (Argon heavy ion).
- SETs were observed during irradiation with a minimum LET of 1.3 MeV.cm²/mg (Carbon heavy ion).
- SEFIs were observed during irradiation with a minimum LET of 3.3 MeV.cm²/mg (Neon heavy ion).

16Gbit NAND Flash Memory

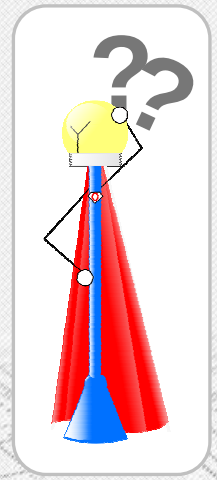
CONCLUSION

	SEL	SET	SEU	MBU	SEFI	EWE
Retention	-	-	C (1.3)	NO	-	-
Standby	Xe (67.7)	-	C (1.3)	NO	-	-
Read Only	-	C (1.3)	C (1.3)	NO	C (1.3)	-
Erase/Write/read	-	C (1.3)	-	-	Ne (3.3)	Ar (10)

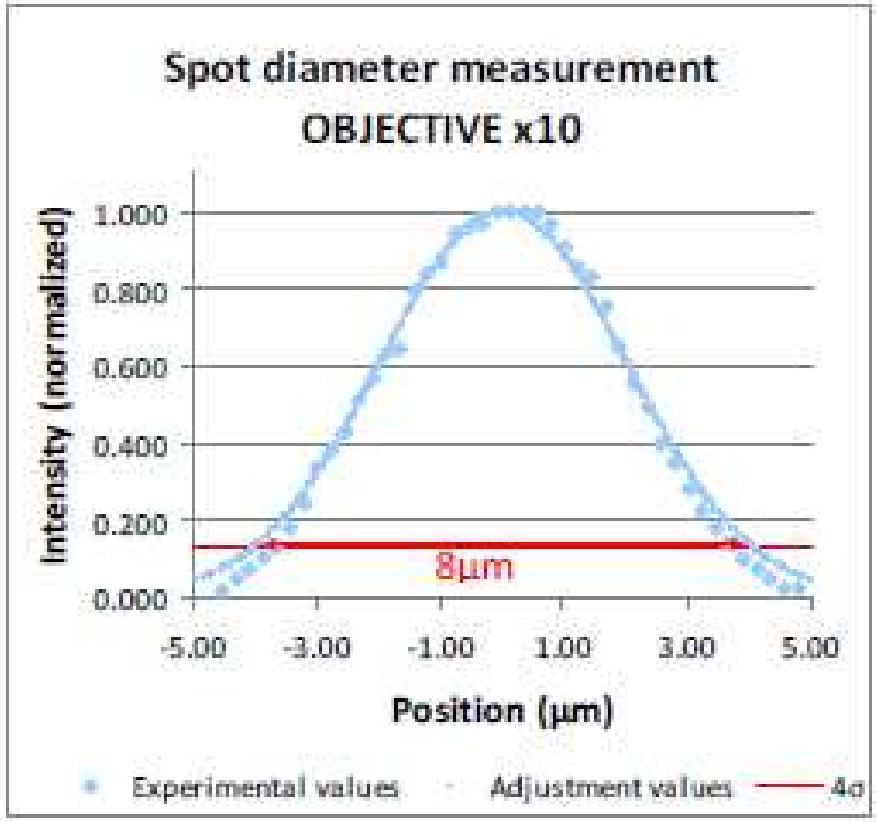


TRAD

Thank you for your attention, any question ?



TRAD Gamma irradiation facility GAMRAY is accredited in compliance with ISO/IEC 17025 standard under n°1-6110 for gamma irradiation, dose deposit.


Spot diameter measurement
OBJECTIVE x10
Intensity (normalized)
1.000
0.800
0.600
0.400
0.200
0.000
8µm
-5.00
-3.00
-1.00
1.00
3.00
5.00
Position (µm)
Experimental values
Adjustment values
4σ