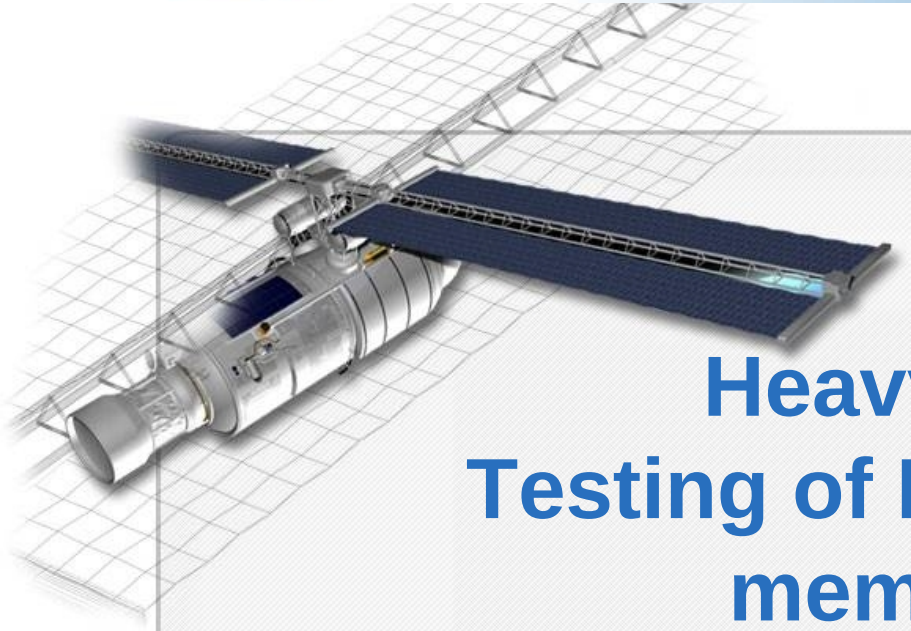


Heavy Ion SEE Testing of M65609E SRAM memory from Atmel

Presented by Pierre GARCIA

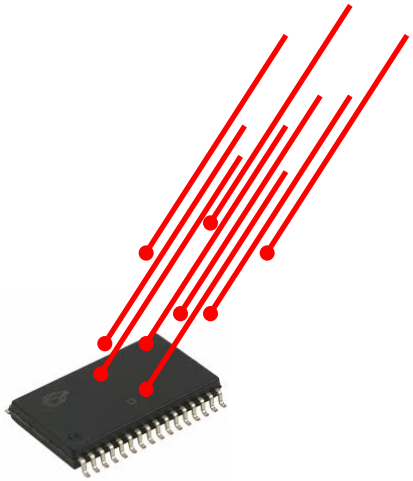
Work performed by Lionel GOUYET , Benjamin VANDEVELDE , Alexandre ROUSSET, Athina VAROTSOU

Outline

- The project
- Parts, beam description, test system
- Results
- Conclusions

Context

MBU or not MBU? That is the question.

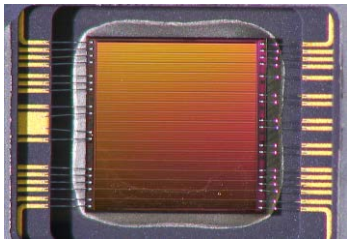


Read Data	Expected Data			
51 01010001	55 01010101	→	SEU (1 error in the read data)	Error correction
71 01110001	55 01010101	→	MBU (more than 1 error in the read data)	More critical

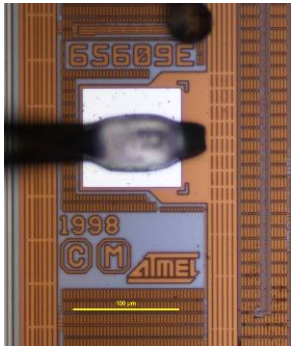
Part tested – M65609E – Atmel

PART IDENTIFICATION	
Type :	M65609E
Manufacturer :	Atmel
Function :	Rad. Hard. 128k x 8, 3.3-Volt SRAM
PARTS PROCUREMENT INFORMATIONS	
Packaging :	FP-32
Sample size:	10 irradiated samples

Part of the tested lot



Delidded part



Die marking

SEE irradiation Facilities

Irradiation facility: U.C.L.

IRRADIATION BEAM CHARACTERISTICS	
Heavy Ions used :	High LET cocktail : Xe High range cocktail : Kr, Ni, Ar, Ne and C
Flux :	465 $cm^{-2}.s^{-1}$ up to 7600 $cm^{-2}.s^{-1}$

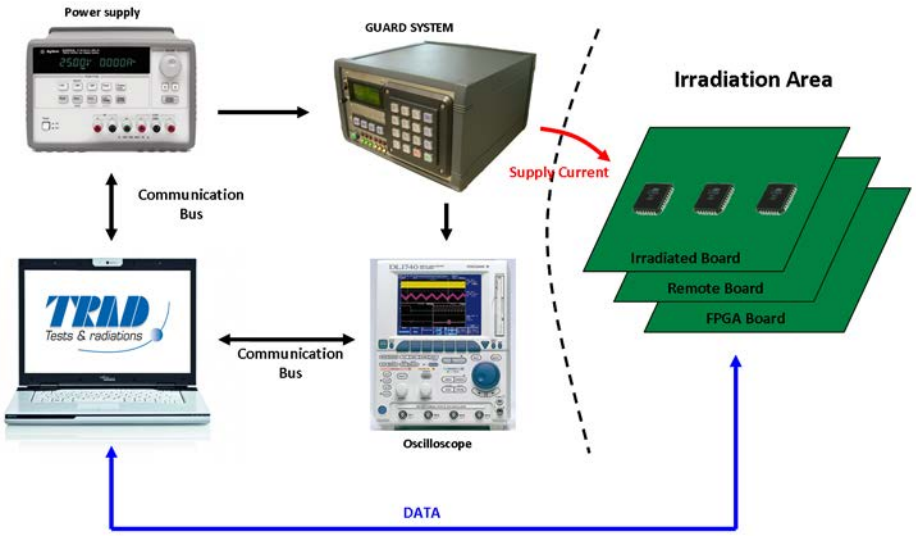
Flux set for High LET ions

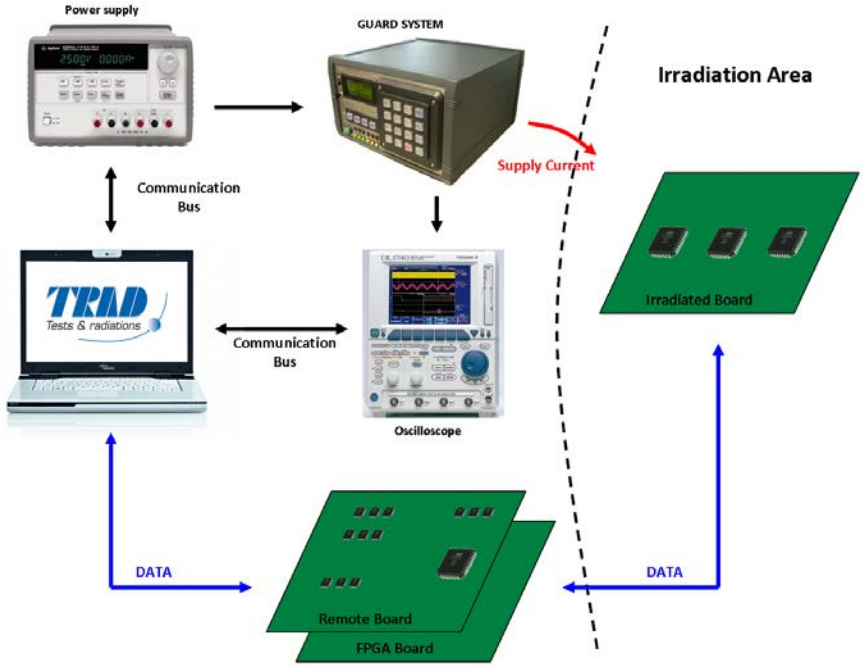
Irradiation facility: P.S.I.

IRRADIATION BEAM CHARACTERISTICS	
Proton Energy :	230 MeV, 200 MeV, 151 MeV, 101 MeV and 75 MeV
Flux :	4,46 10^{6} $cm^{-2}.s^{-1}$ up to 3.14 $10^{7}cm^{-2}.s^{-1}$

Test Bench - Hardware

Same Test bench for proton and Heavy ions irradiation





Heavy ions irradiation: DUT the closest possible control board

Proton irradiation: No active part in the beam field

Test Bench - Detection method

- **Event classification:**
  - Transient (error type 1)
  - Upset (error type 2 or 3)
  - Stuck bit (error type 4)

Difference between SEU and MBU

Results - Post treatment

- **For the test bench:**

Read Data	Expected Data	
51 01010001	55 01010101	→ SEU (1 error in the read data)
71 01110001	55 01010101	→ MBU (more than 1 error in the read data)

- **In reality:**

MBU: One or multiple particles shots in the same data ?

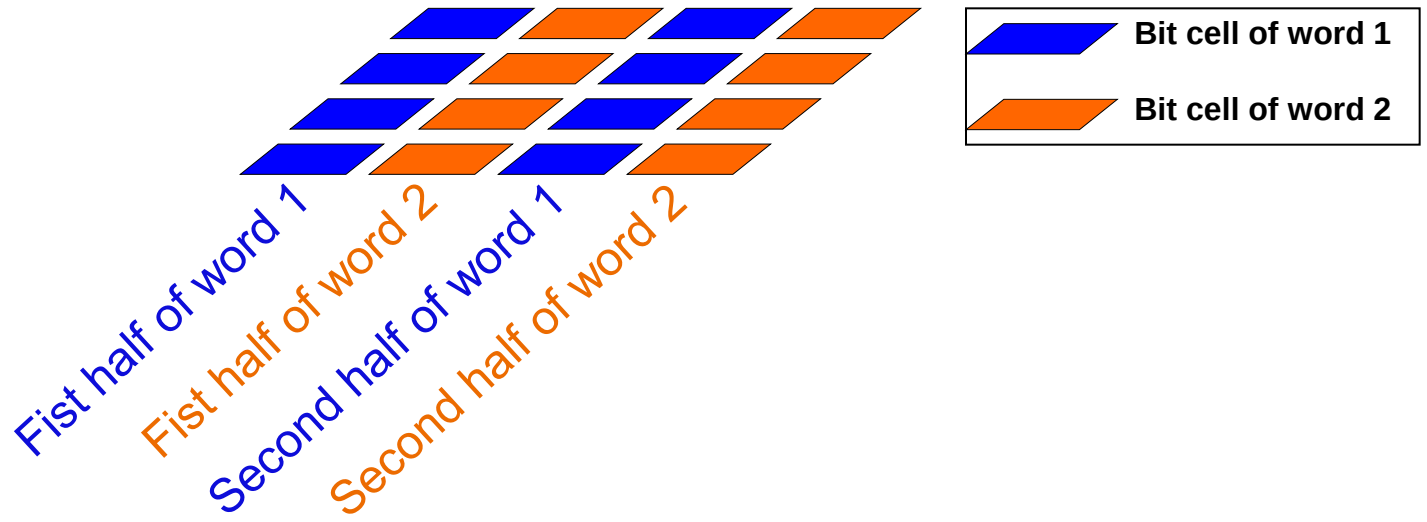
Real MBU

Multiple SEU

- **To estimate real MBU: Flux or mapping**

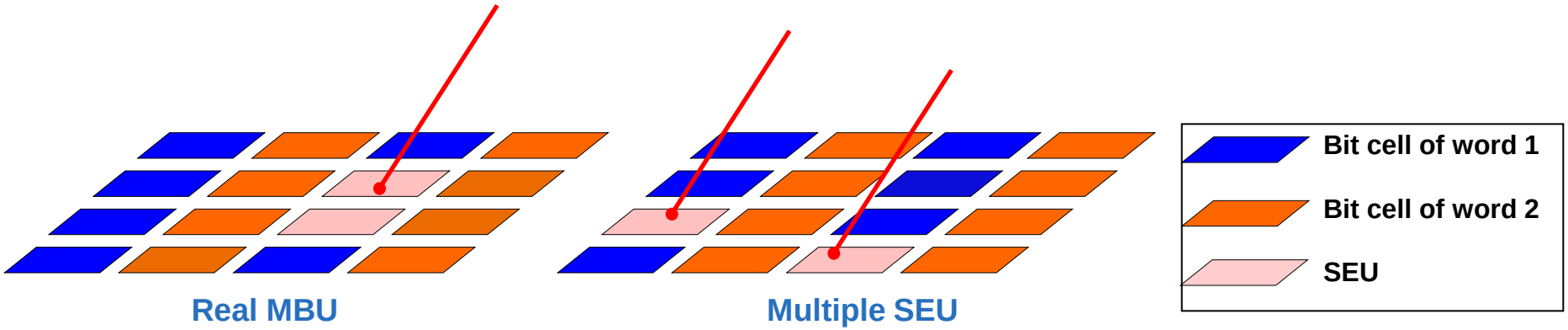
Results - Post treatment

- **Divide a word in several physical area:**
  - Example of a interleaved of 2 bytes on a memory:



Results - Post treatment

- **Divide a word in several physical area:**



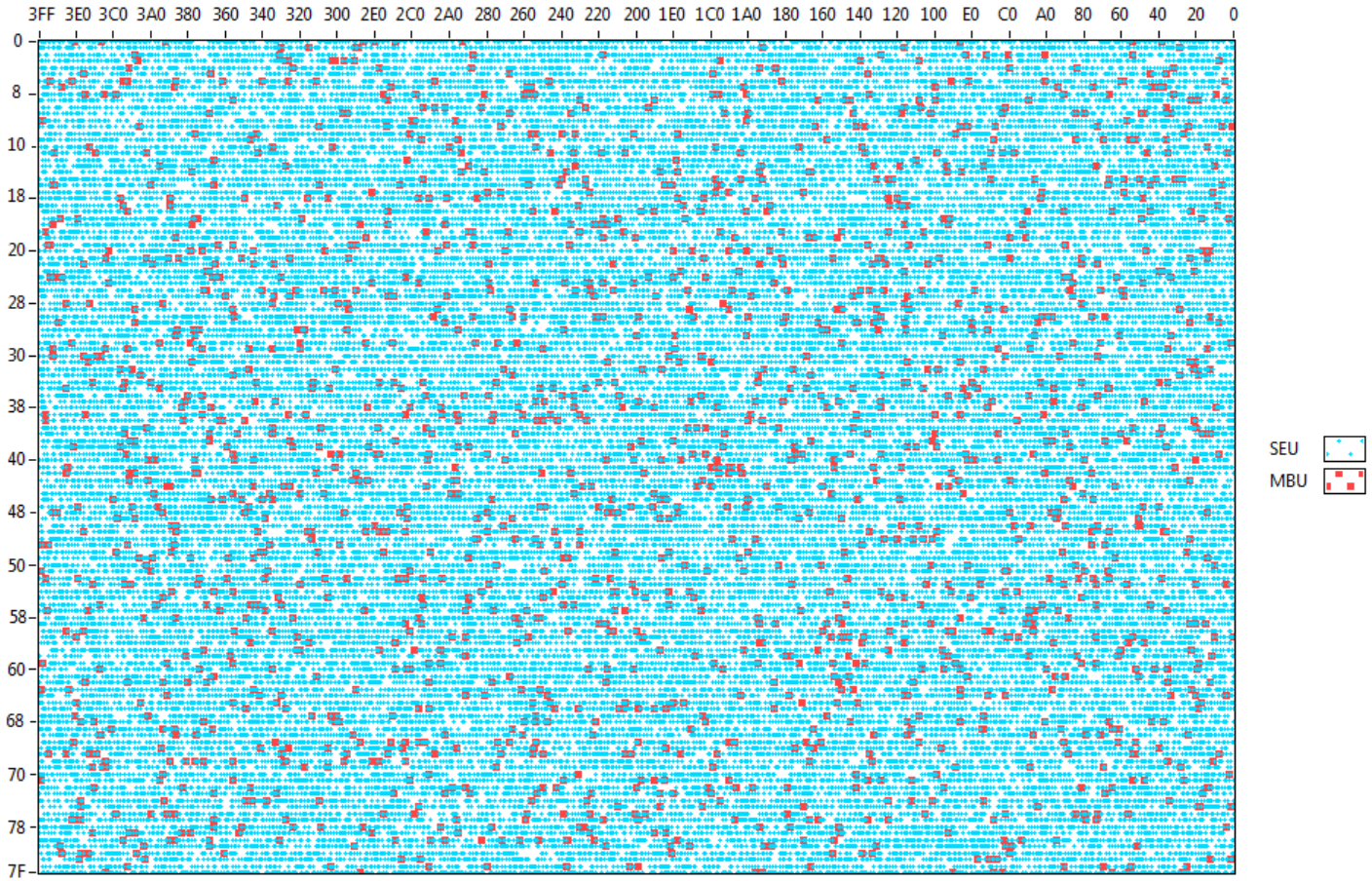
0101 0011
Bits are adjacent

0001 1101
Bits are not adjacent

A Post treatment has been performed on the Heavy ions and Protons results with the physical distribution of memory cells from Atmel

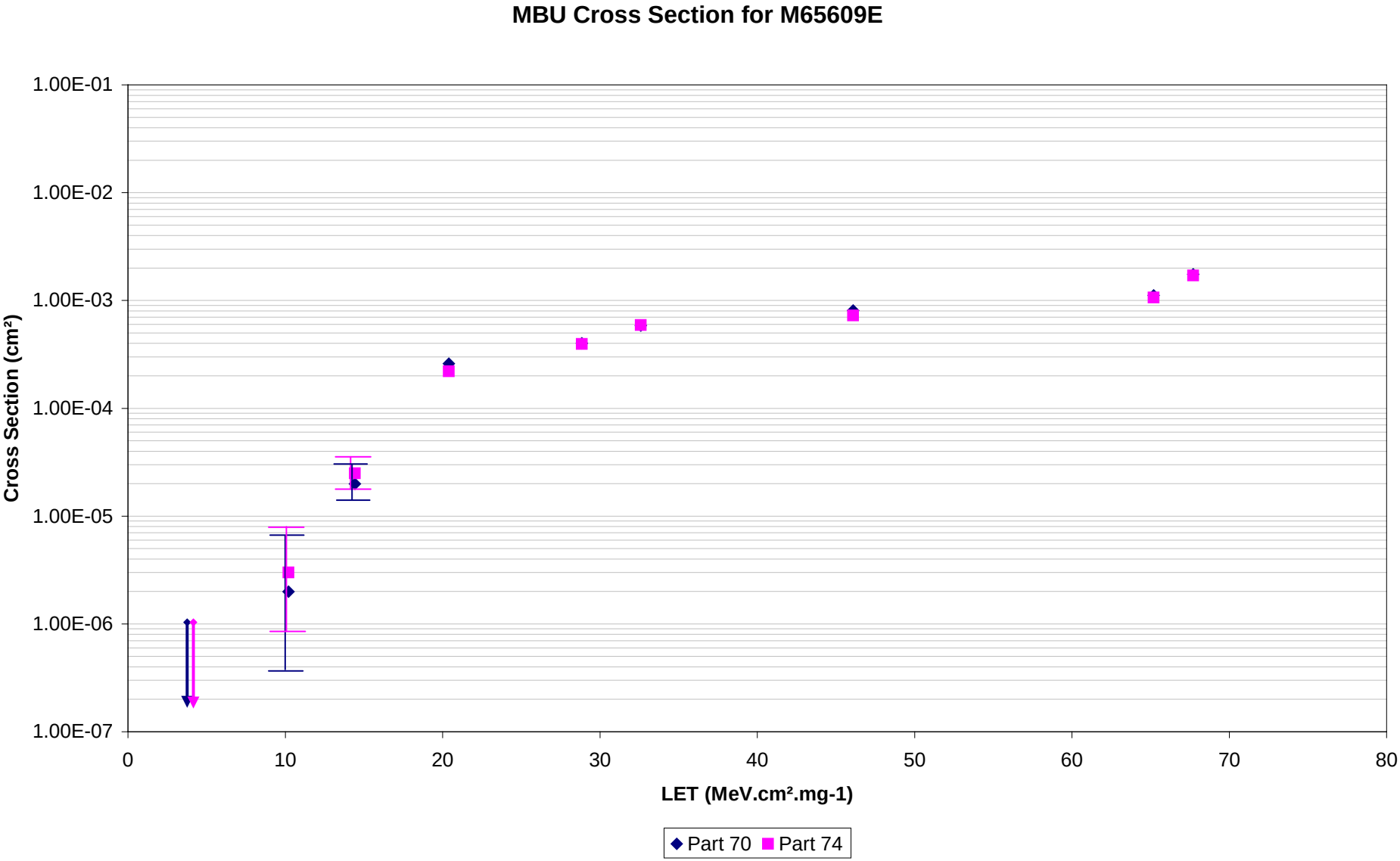
Results - Post treatment

- **Representation of events on the memory plan:**

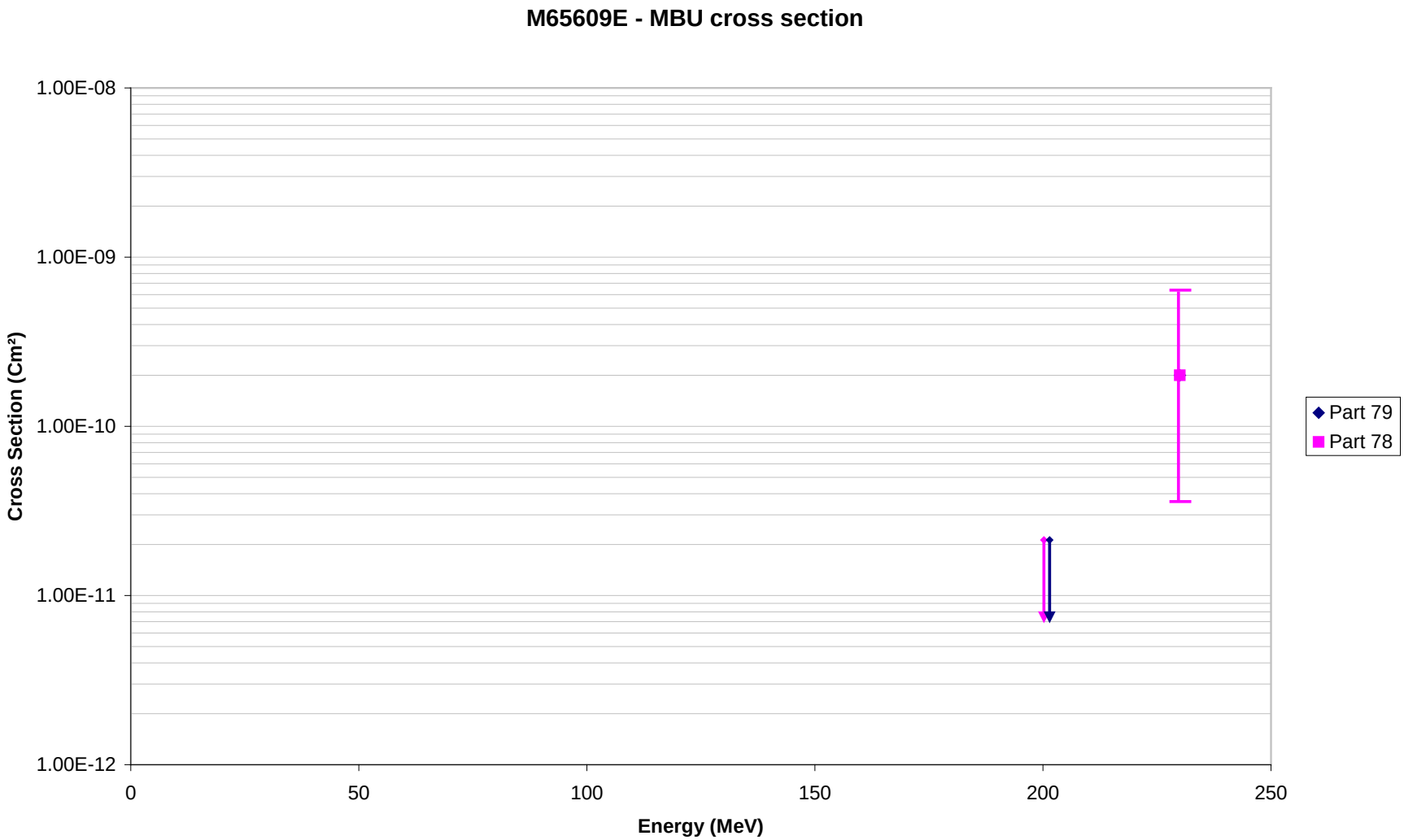


LET 67.7MeV.cm^2.mg^{-1} Heavy ion beam.

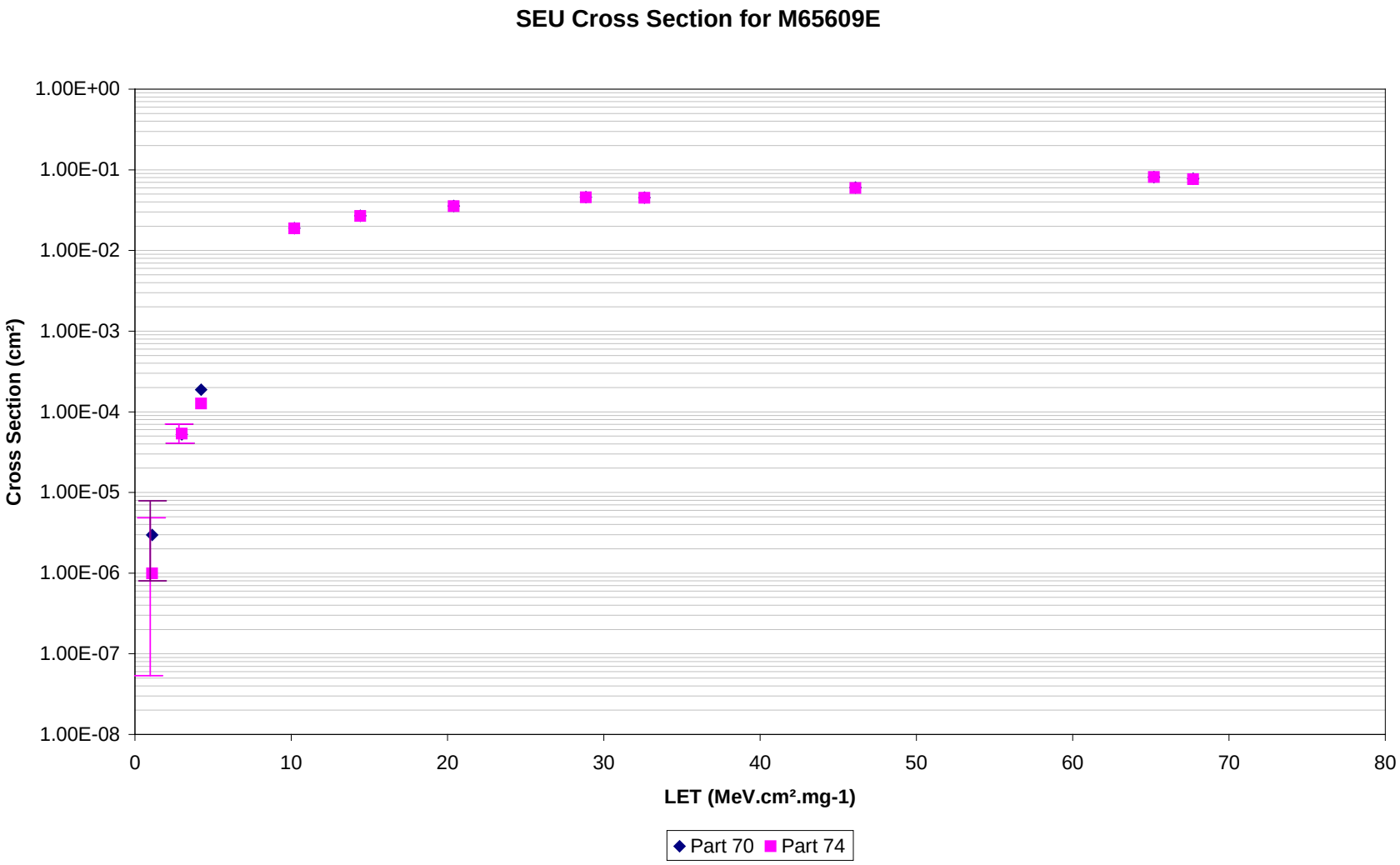
Results - Post treatment



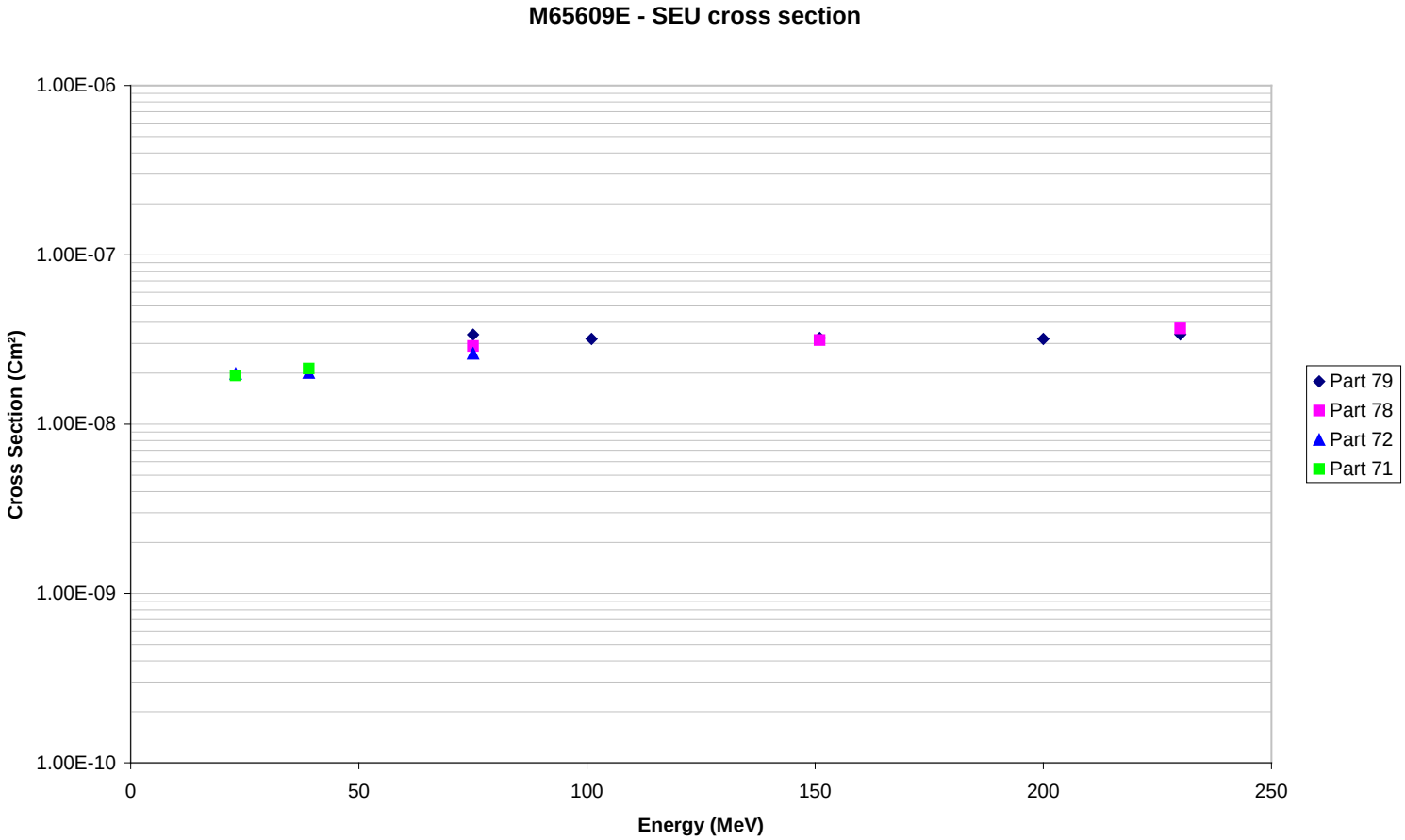
Results - Post treatment



Results - Post treatment



Results - Post treatment



Conclusion

- **Post treatment has been performed**

- **Real MBU observed with Heavy ions and Protons**

Results available in "Single Event Upsets and Multiple Bit Upsets observed on 1Mbit SRAM"
Marc Poizat, Christian Poivey, Alexandre Rousset, Benjamin Vandevelde, Lionel Gouyet, Athina Varotsou

- **Thank you for your attention**

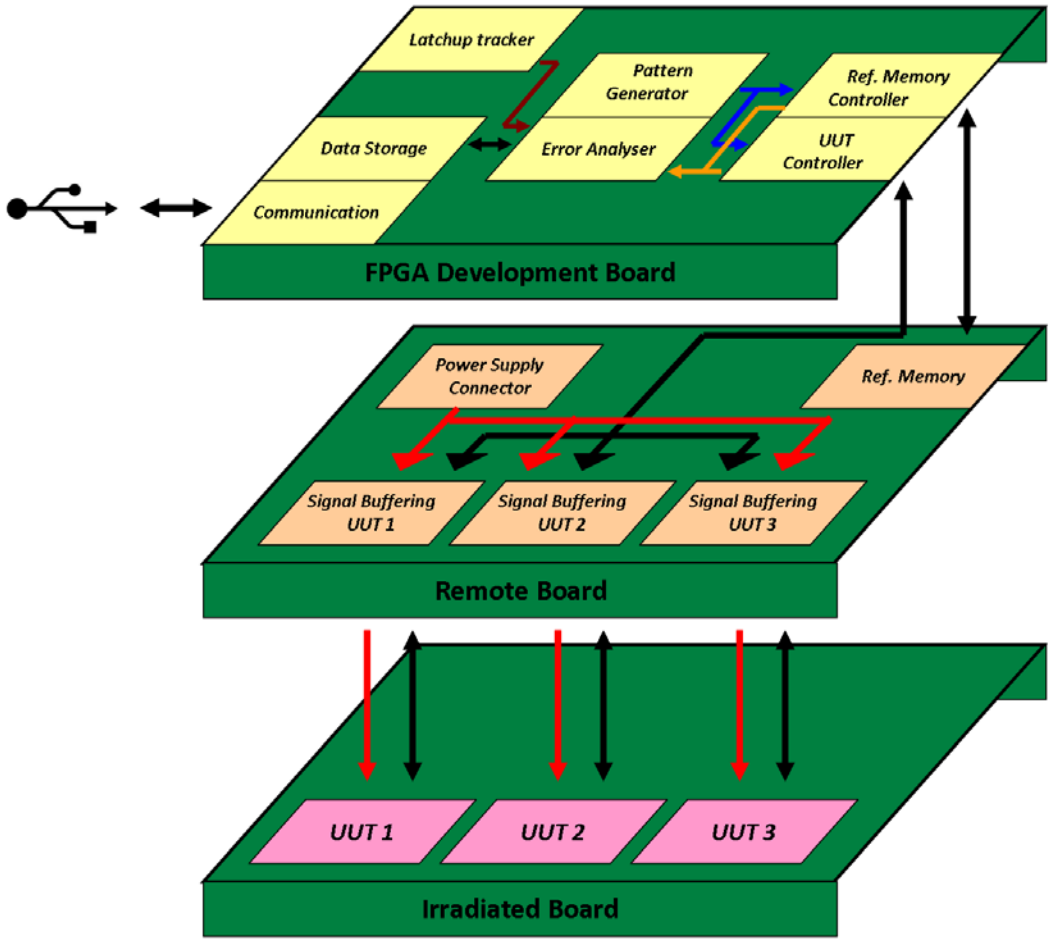
- **Any question ?**

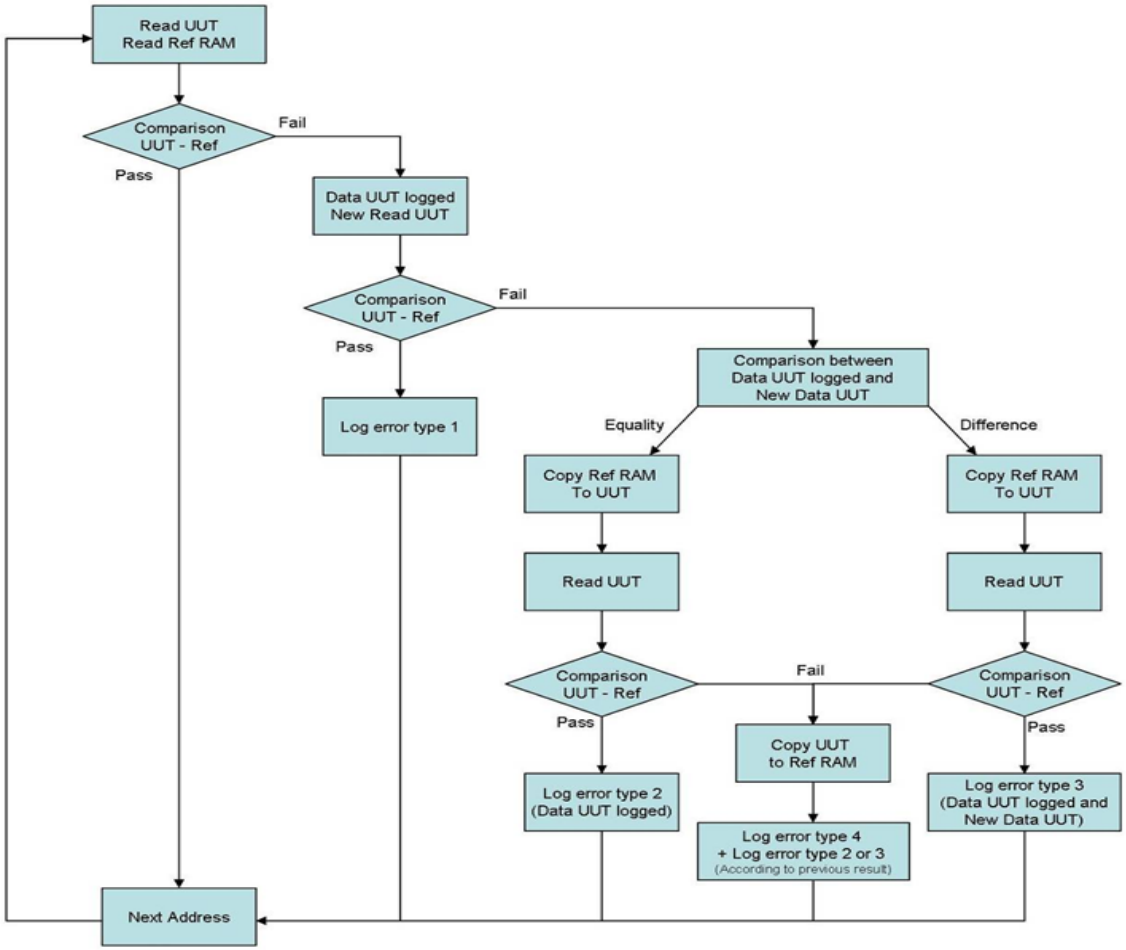
Test Bench - Hardware

Hardware designed around an FPGA witch communicate with a Labview software

Signals buffered and multiplexed depending the tested Unit Under Test (UUT)

DUT can be remote with cables or plugged as close as possible




Read UUT
Read Ref RAM
Comparison
UUT - Ref
Fail
Pass
Data UUT logged
New Read UUT
Comparison
UUT - Ref
Fail
Pass
Log error type 1
Comparison between
Data UUT logged and
New Data UUT
Equality
Difference
Copy Ref RAM
To UUT
Copy Ref RAM
To UUT
Read UUT
Read UUT
Comparison
UUT - Ref
Fail
Comparison
UUT - Ref
Pass
Pass
Copy UUT
to Ref RAM
Log error type 2
(Data UUT logged)
Log error type 3
(Data UUT logged and
New Data UUT)
Log error type 4
+ Log error type 2 or 3
(According to previous result)
Next Address