Aim of the study

Reproduce this phenomenon at ground level

⇨ Understand the origin of this effect

Two SRAM references were tested

- ⇨ Samsung 4 Mb, KM684000ALG-7, CARMEN2/JASON2
- ⇨ Cypress 4Mb, CY62148EV30LL45ZSXI

Two SDRAM references were tested

- ⇨ Hyundai 64 Mb, HY57V651620BTC-10, SST/PICARD
- ⇨ Elpida 512 Mb, EDS5104ABTA-75 CARMEN2/JASON2

SRAM Results

	TID		Neutron		SEE Proton	
	Tamb	80°C	Tamb	80°C	Tamb	80°C
SRAM Samsung KM684000	√	√	#	#	#	#
SRAM Cypress CY62148	#	#	#	#	#	#

- Weakened cells observed under Ionising dose.
  - At ground Level 4400krad(Si) ≠ In flight 100rad(Si)
- Number of weakened cells increased with temperature
- Weakened cells partly recovered at ambient temperature

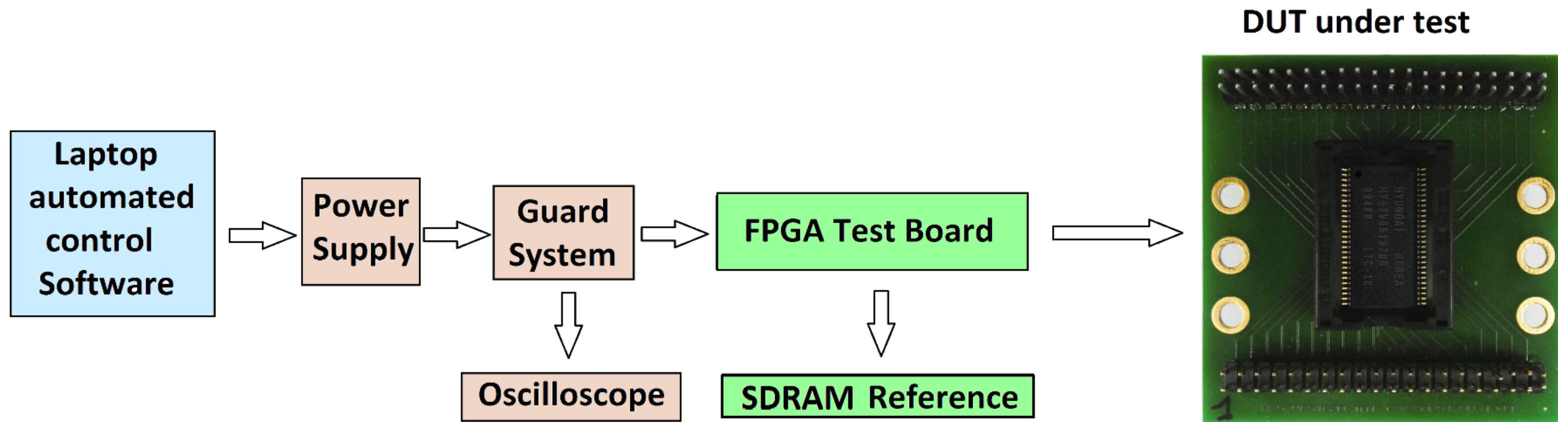
⇒ **the Ionizing microdose is a mechanism able to explain the stuck bits in the SRAM.**

⇒ Oldham [ref]

SDRAM Results

	TID	Neutron	SEE Proton
	Tamb	Tamb	Tamb
SDRAM EDS5104ABTA			√
SDRAM HY57V651620BLTC	#	√	√

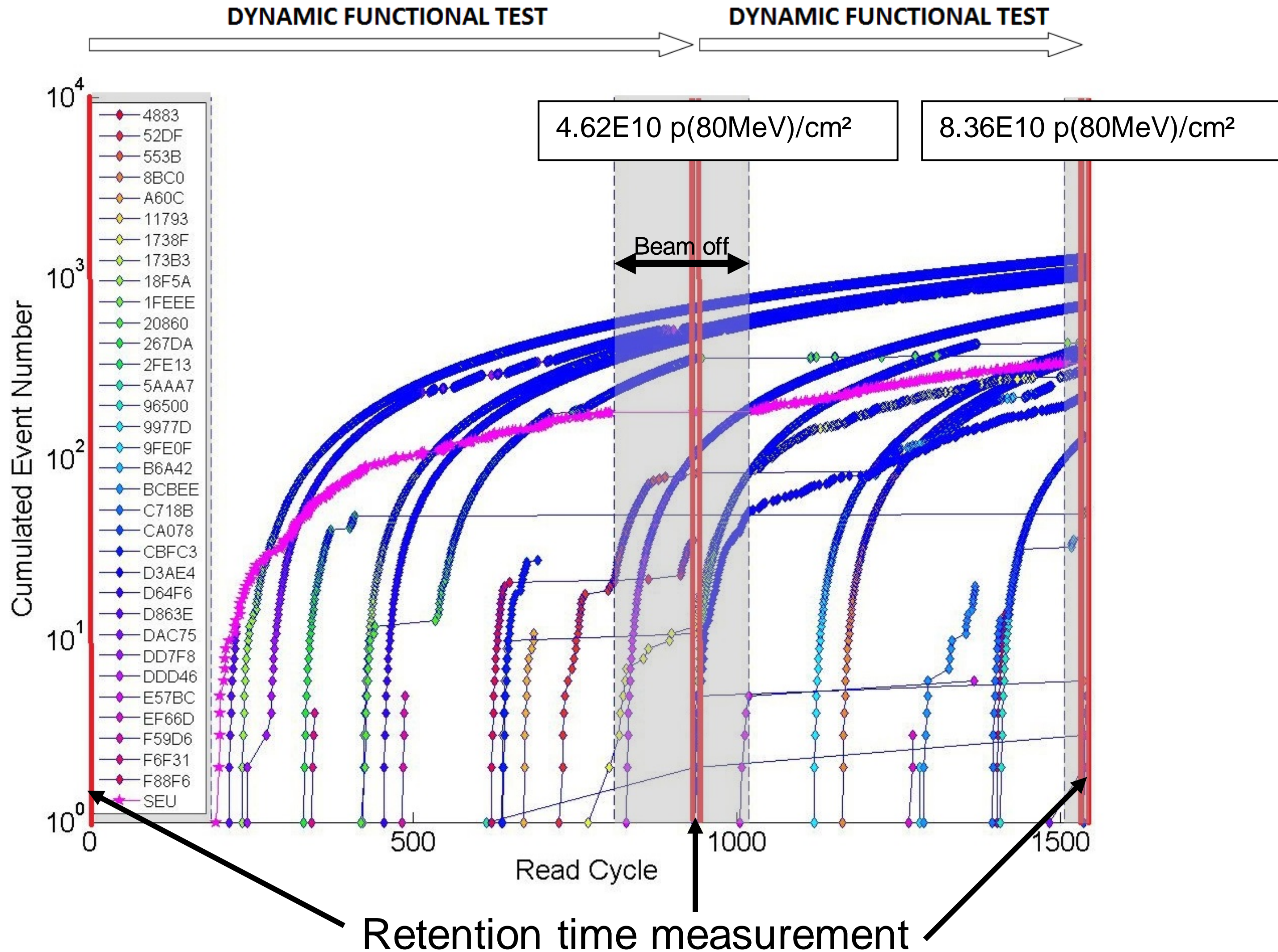
SDRAM - Test Bench description



Functional Test → Refresh = 64ms
1Mb read continually
SEL, SEU, SEFI and Stuck Bit detection

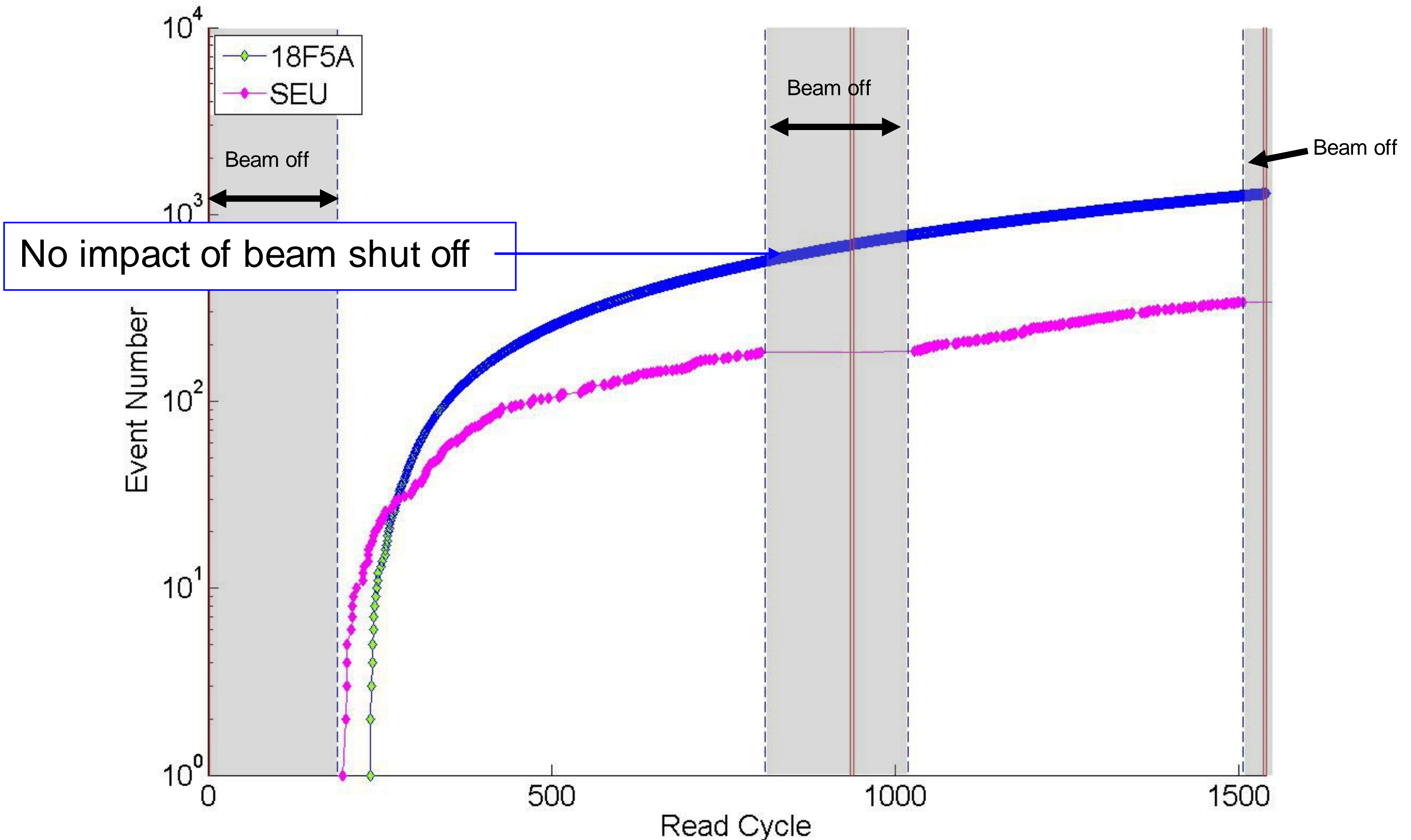
Retention time measurement → Duration measurement for which the stored information is kept

SDRAM - Proton Test Results



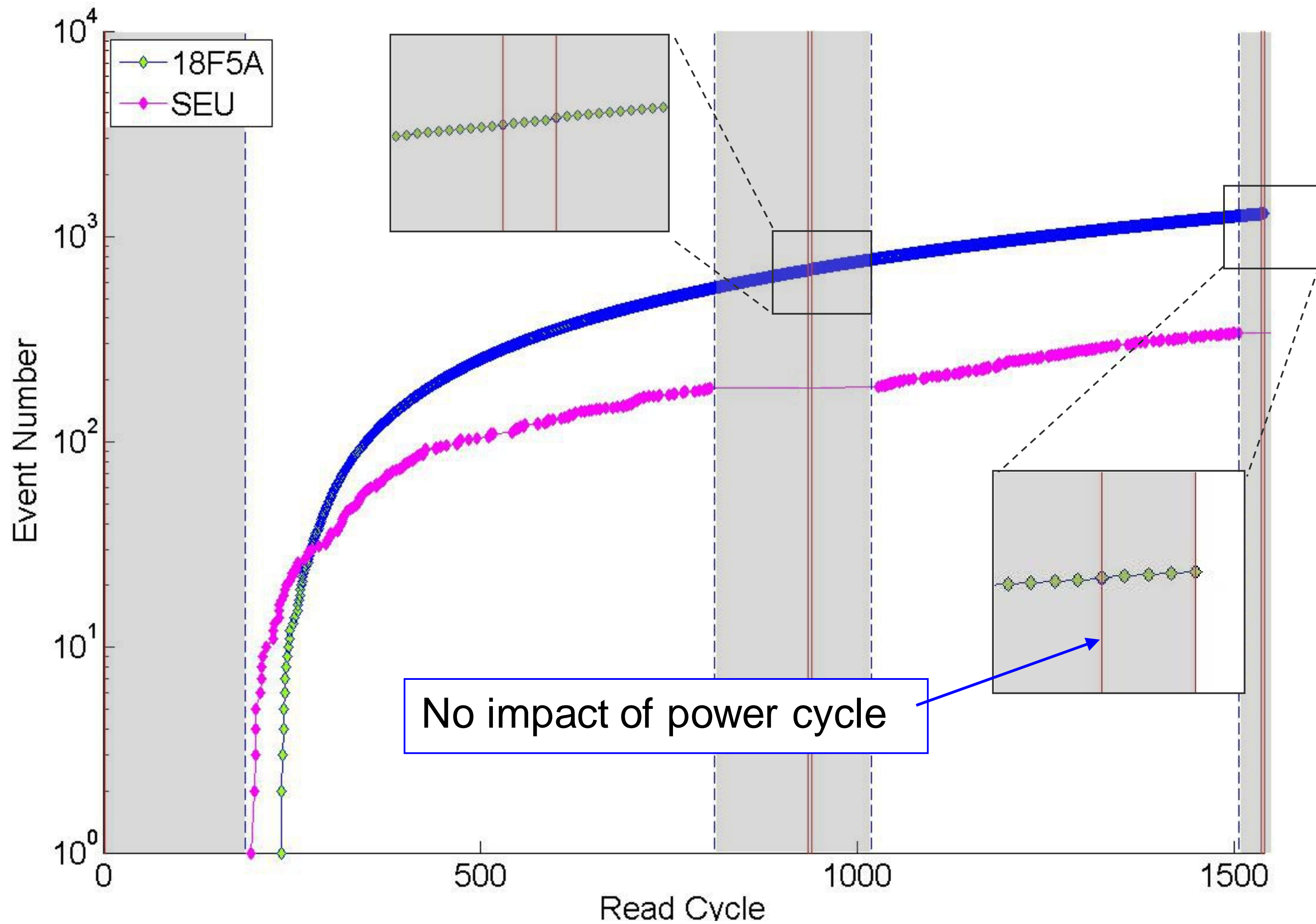
HY57V651620BLTC Cumulated number of soft errors in function of the read cycle and in function of the address for weakened cells during 80MeV proton irradiation using AA55 pattern

SDRAM - Proton Test Results



HY57V651620BLTC Cumulated number of address's weakened cell 18F5A in function of the read cycle and in function of the address for weakened cells during 80MeV proton irradiation using AA55 pattern

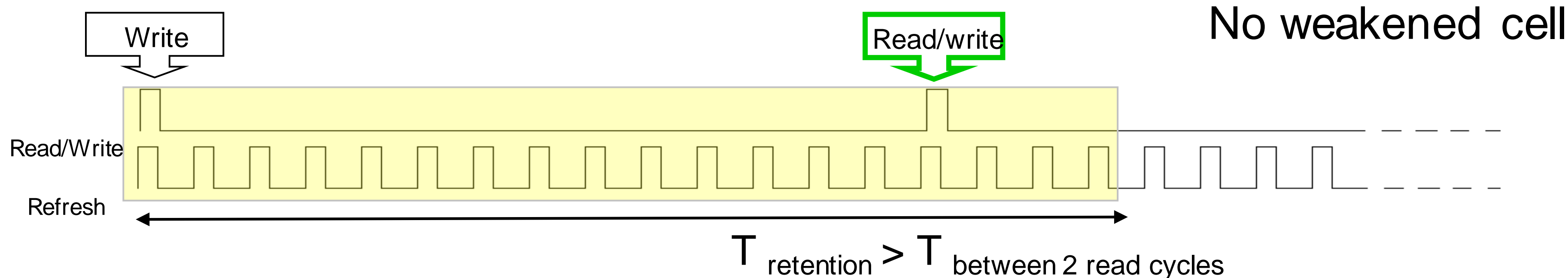
SDRAM - Proton Test Results



HY57V651620BLTC Cumulated number of address's weakened cell 18F5A in function of the read cycle and in function of the address for weakened cells during 80MeV proton irradiation using AA55 pattern

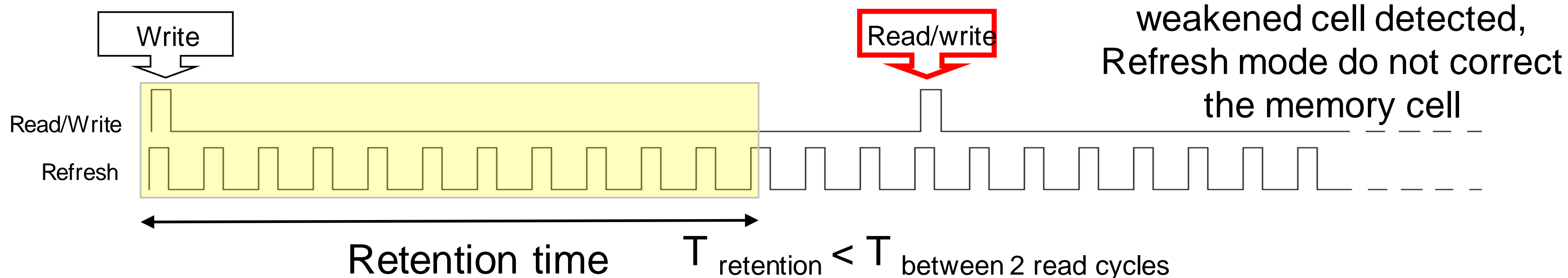
SDRAM – Retention time Results

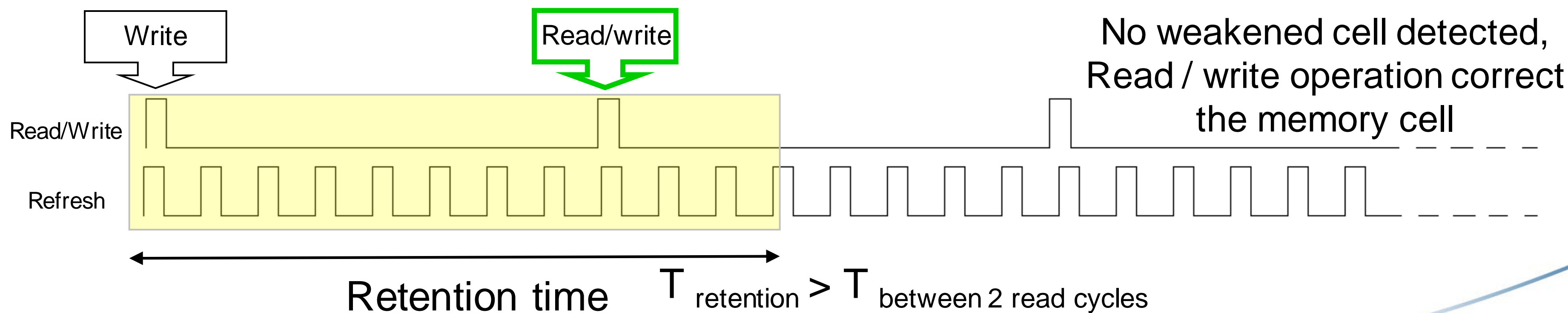
Before irradiation



After irradiation

Retention time





SDRAM - ^{60}Co and Neutron Test Results

^{60}Co :

No errors are detected after :

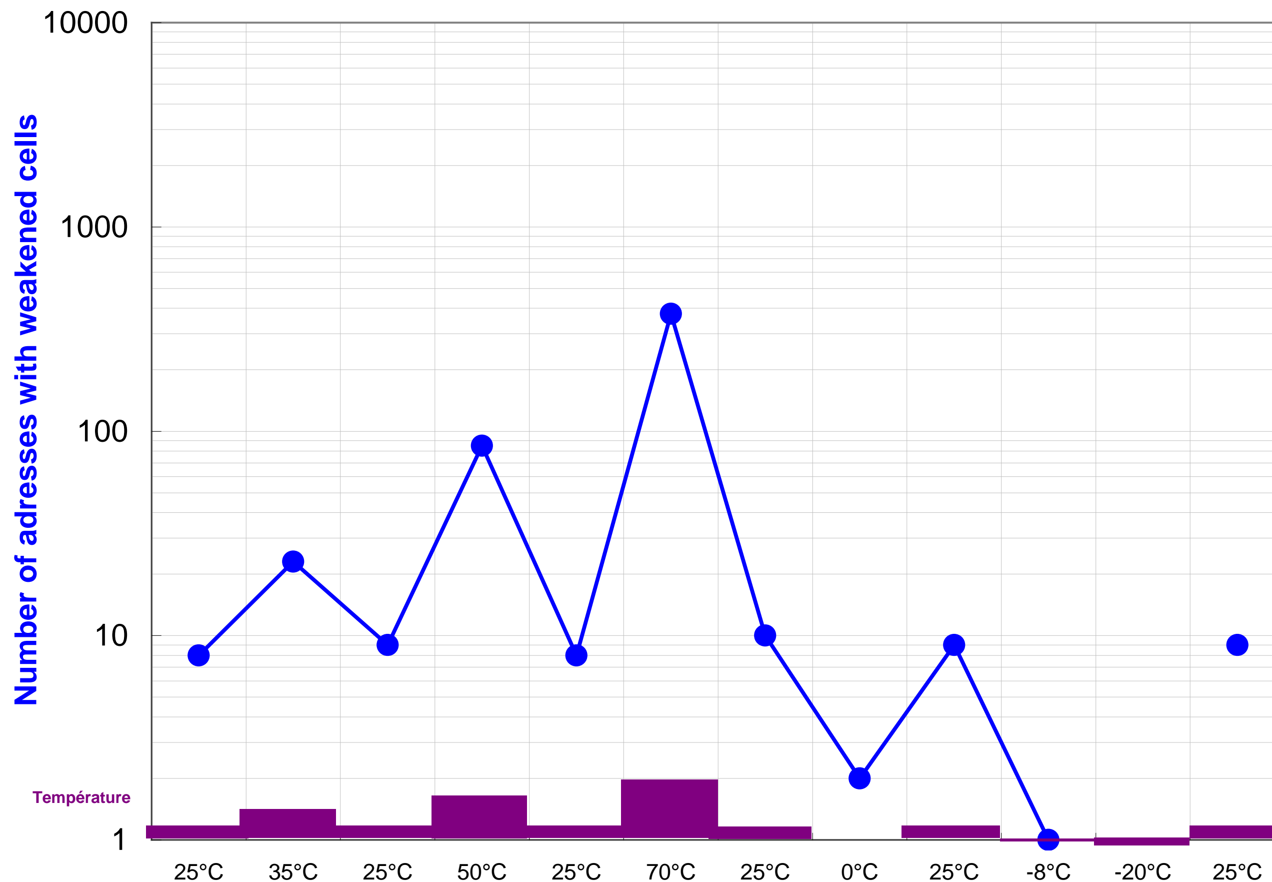
- 300 krad(Si) on unbiased parts
- 50 krad(Si) on biased parts

Neutron :

Errors detected several weeks after irradiation

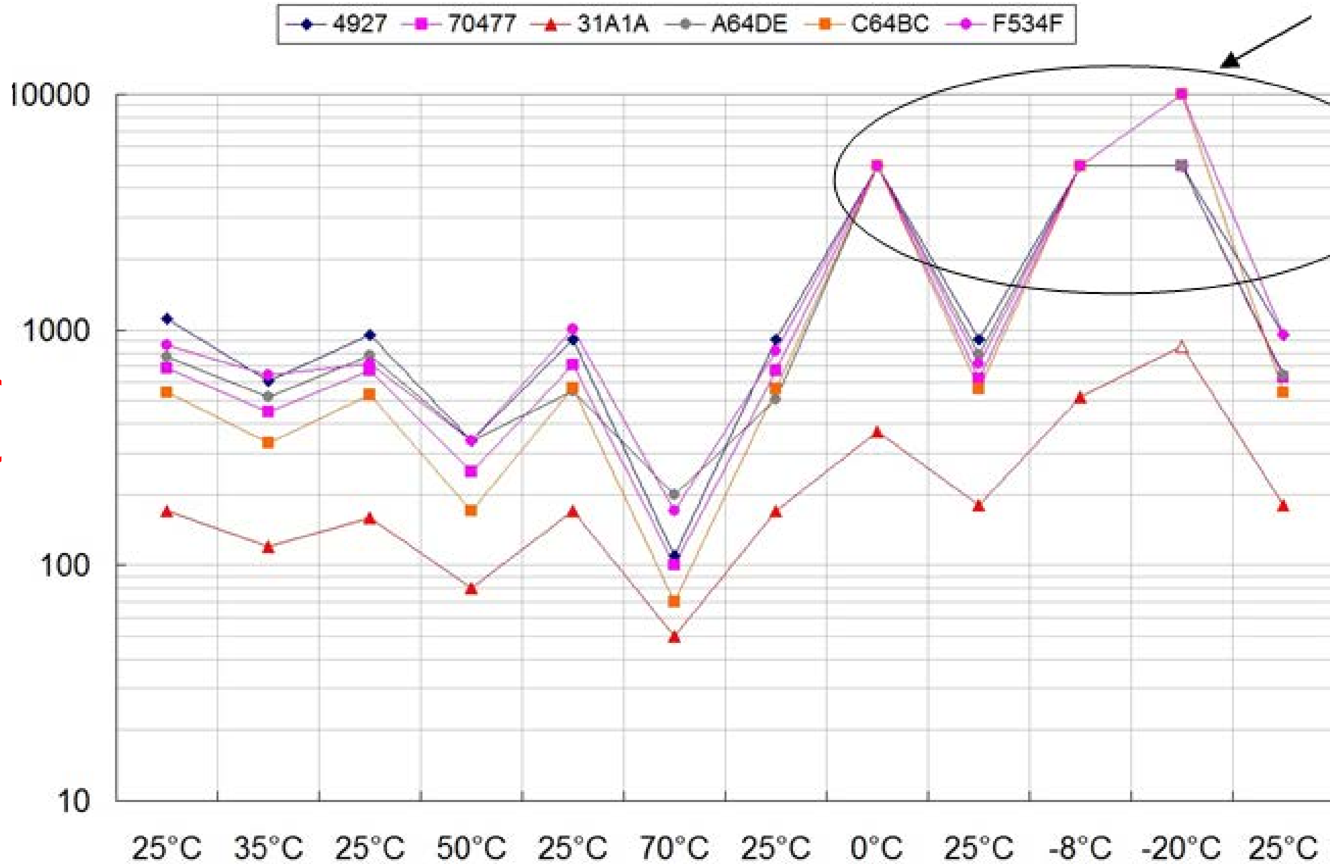
⇨ In flight observations and test results indicate weakened cells seem to be induced by displacement damage effect in the memory array

SDRAM – Temperature results



- **The number of stuck bits is increasing with temperature**

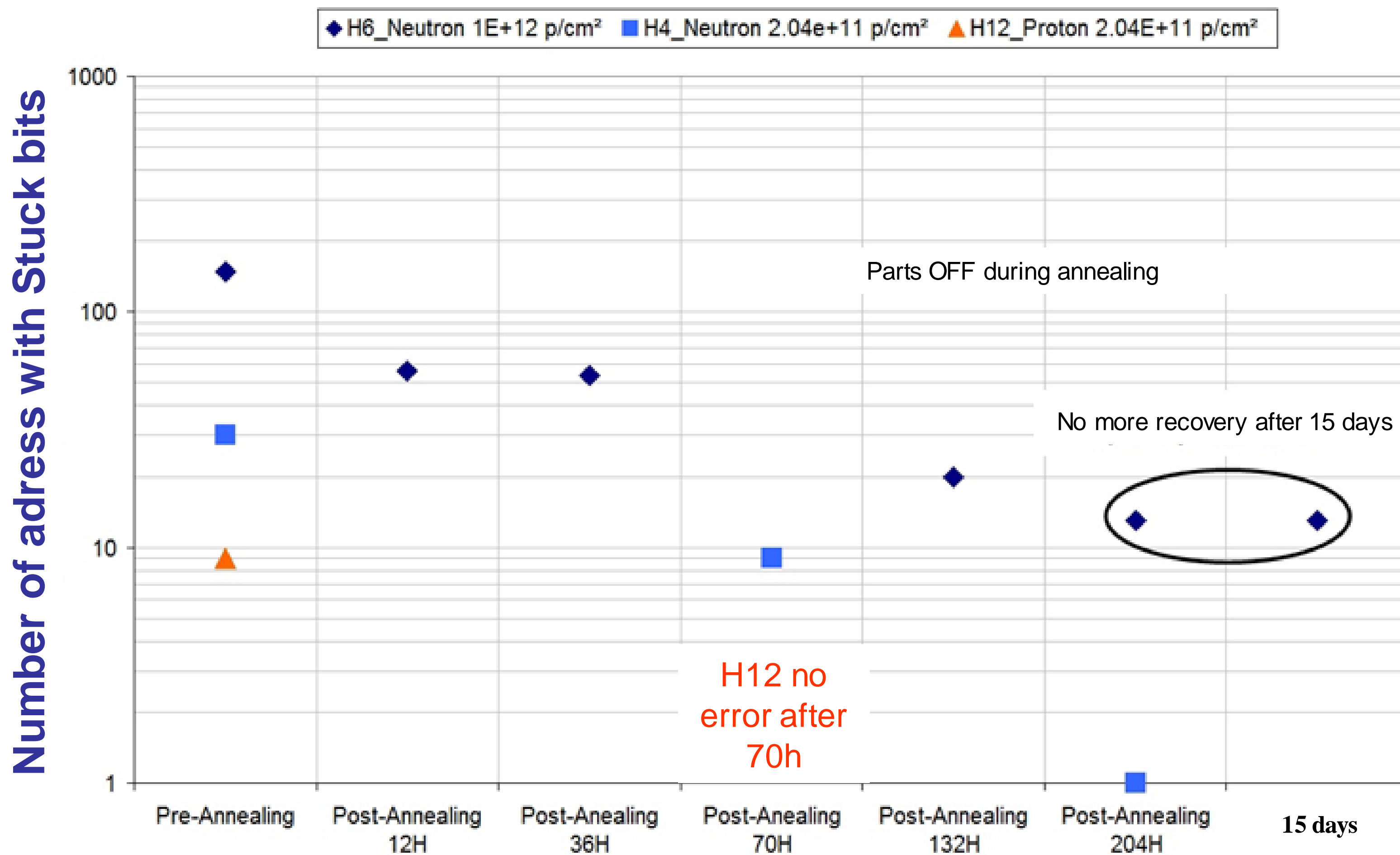
SDRAM – Temperature Results



Retension time (ms) for 6 adresses

No error in the memory

SDRAM - Annealing at ambient Temperature



- **The number of stuck bits is decreasing with time at ambient temperature**

cnes

TRAD Tests & radiations

Displacement damage Effect

- Hypothesis : the degradation is due to a displacement damage single-event.
  - A Rodriguez et Al. [Ref]
  - Shindou [Ref] et Chugg [Ref]
- A single Proton or Neutron is creating one or more closely-spaced clusters of damage.
- large increase in leakage current and intermittent behavior of leakage current as well as annealing at room temperature.

Conclusion

- Equivalent sensitivity to weakened cell effect on flight / on ground
  - SRAM
    - Weakened cell induced by ionizing microdose phenomena
  - SDRAM
    - Weakened cell induced by displacement damage single effect
    - Refresh mode no more functional after irradiation
    - The number of Stuck bits strongly depends on Temperature

- On going study on DDR3

CONCLUSION

Very good results and work still in progress (ISB).

- TRAD is currently working on DDR3/SDRAMs
- In his PhD presented last week, Axel RODRIGUEZ (RADIAC) has explored the hypothesis of a cluster of damage localized at the depletion region of the SDRAM cell.

Perspectives

2017-2020: CNES & TRAD are co funding a PhD hosted by UM/RADIAC on this topic to explore other hypothesis.

Tests & radiations

References

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Thank you for your attention

QUESTIONS