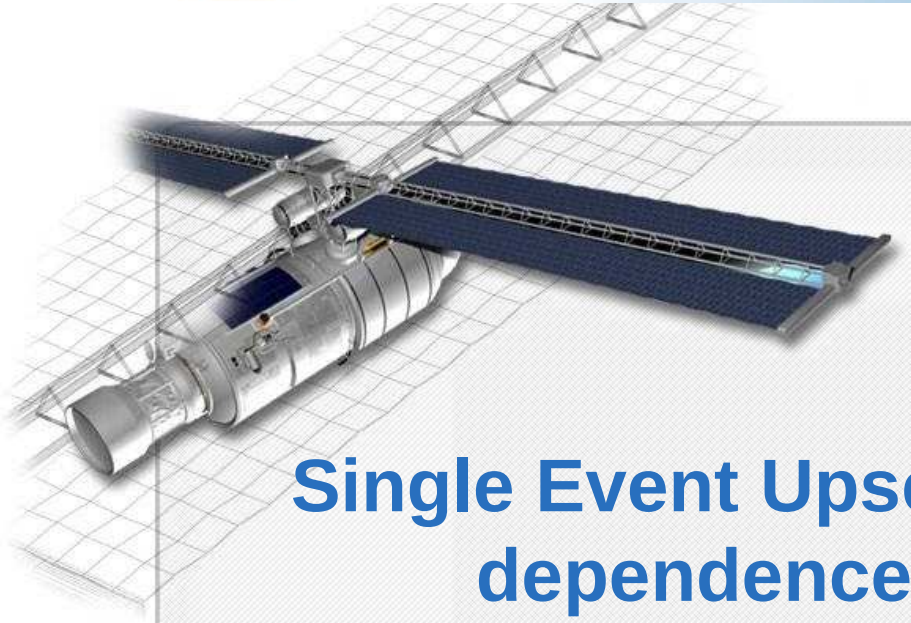


Single Event Upset cross section dose dependence on 90nm SRAM

Anne Samaras

Purpose of the study

During space application, devices are subject to TID and SEE at the same time.

But parts radiation qualification process includes both ionizing dose and SEE tests, performed independently

⇨ Synergistic effects between Dose and SEU / SEL on SRAM memories ?

Devices under test

The devices under test are two 90nm Cypress SRAM memories

	CY62148EV30LL45ZSXI	CY62167EV30LL45ZXA
Manufacturer	Cypress Semiconductor	Cypress Semiconductor
Date code	DC0831	DC1113
Type	4Mb 90nm SRAM	16Mb 90nm SRAM
Word size	8 bit	16 bit
Package	TSOPI-48	TSOPII-32
		

Total Dose test conditions

Four electrical parameters are chosen to follow the device degradation due to total dose

They are identical for both references :

Symbol	Parameter	Unit
Iw	Write mode supply current	mA
Ir	Read mode supply current	mA
Isb	Stand-by supply current	µA
Vdr	Data retention voltage	V

Total Dose test conditions

Preliminary ^{60}Co test

Step	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Total Dose krad(Si)	0	5	10	20	35	45	55	70	85	105	125	150	175	195
Dose rate rad(Si)/h	210													

- **3 irradiated devices + 1 reference sample**
- **Université Catholique de Louvain (UCL) ^{60}Co Gamma Irradiation Facility (GIF)**

⇨ **Devices behavior under total dose.**

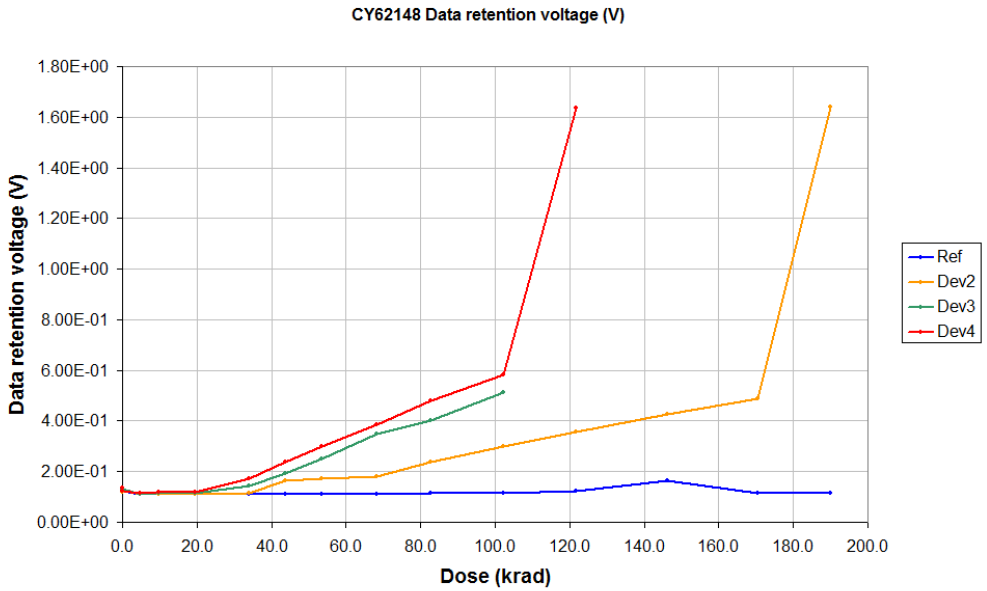
Total Dose test conditions

CY62148EV30LL Preliminary ^{60}Co test

Device N°2: functional at 190 krad(Si)

Device N°3: no longer functional at 122 krad(Si)

Device N°4: no longer functional at 145 krad(Si)



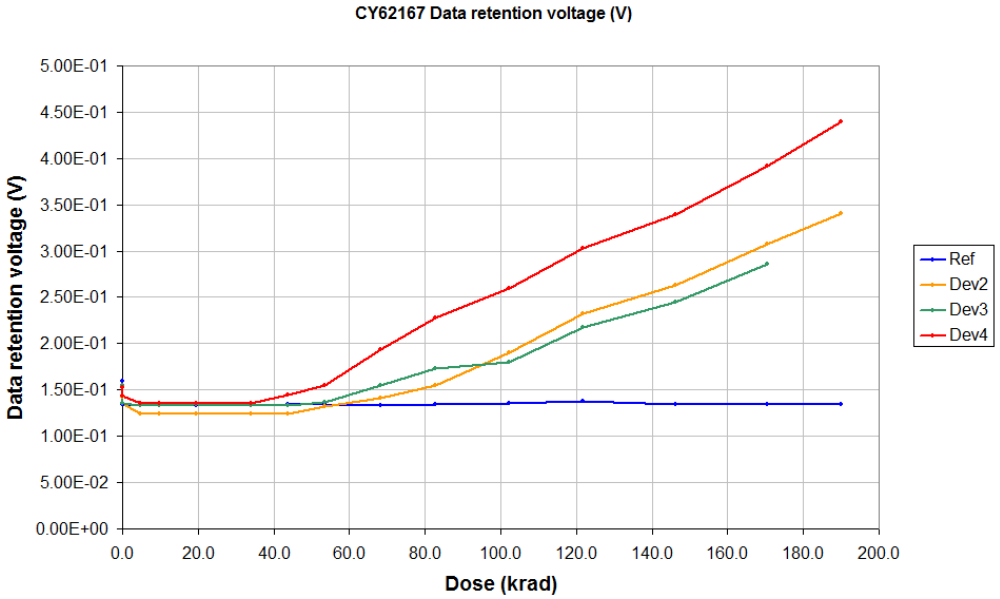
Total Dose test conditions

CY62167EV30LL Preliminary ^{60}Co test

Device N°2: functional at 190 krad(Si)

Device N°3: no longer functional at 170 krad(Si)

Device N°4: functional at 190 krad(Si)



Total Dose test conditions

Preliminary dose characterization

- total dose level and dose steps for each reference

Same ^{60}Co irradiation time for both SRAM.

- Different dose rate

	CY62148		CY62167	
SEE test	Total dose (krad)	Dose rate (rad/h)	Total dose (krad)	Dose rate (rad/h)
1st	0	120	0	150
2nd	55		68	
3rd	101		126	
4th	121		151	
5th	**156**		**194**	

9 irradiated devices + 2 reference samples (a delidded sample + an encapsulated one)

Université Catholique de Louvain (UCL) ^{60}Co Gamma Irradiation Facility (GIF)

Heavy Ion Test conditions

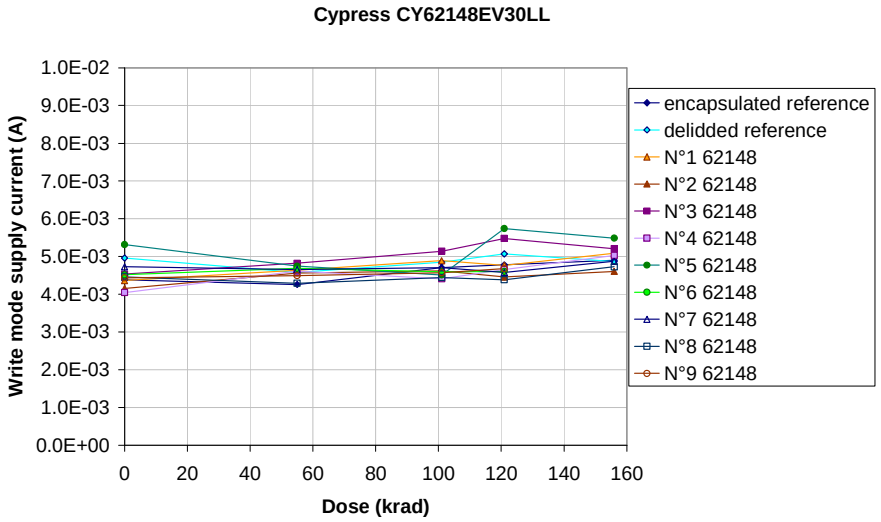
- **SEU & SEL test**
- **During the ^{60}Co total dose irradiation AA pattern is written at all addresses**
- **the SEU test pattern is AA in half of the memory array, and the complementary pattern 55 in the other half**
  - **“Imprint Effect”**

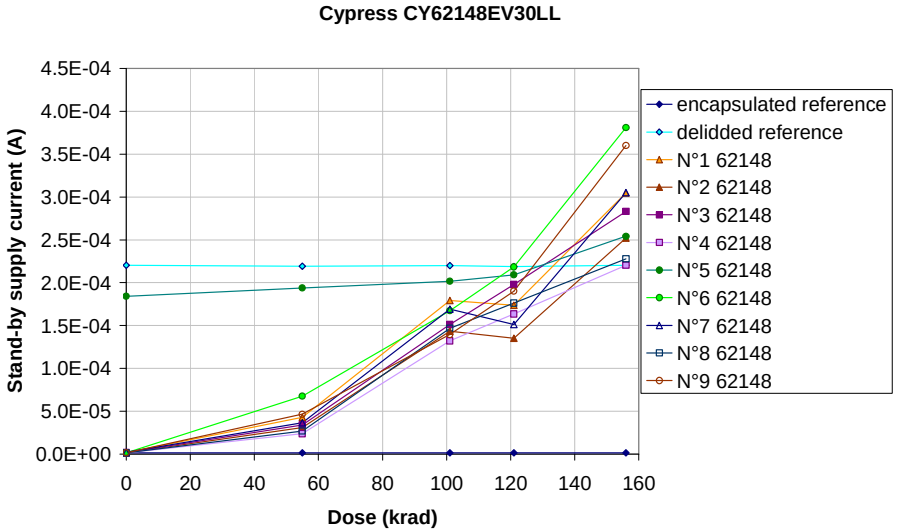
Ion	Energy (MeV)	LET ($MeV.cm^2.mg^{-1}$)	Range (µmSi)
C	131	1.1	292
Ne	235	3.0	216
Ne	78	6.4	45
Ar	372	10.2	117
Kr	756	32.6	92
Xe	420	67.7	37

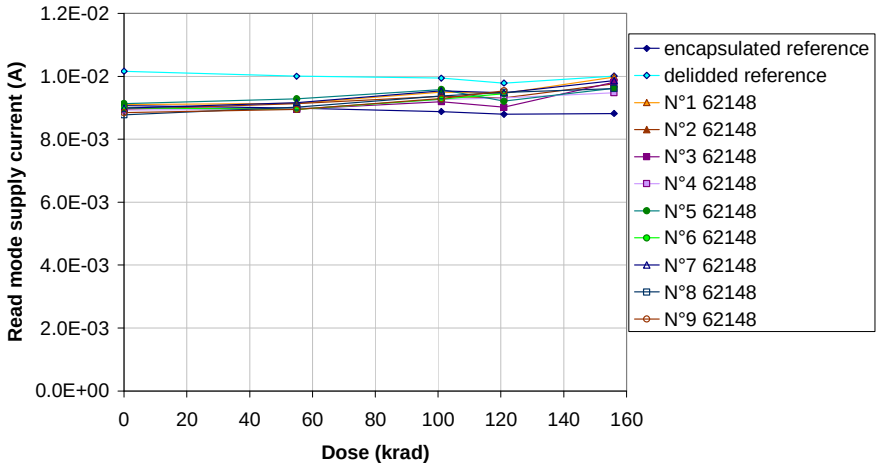
Université Catholique de Louvain (UCL)
Heavy Ion Facility (HIF)

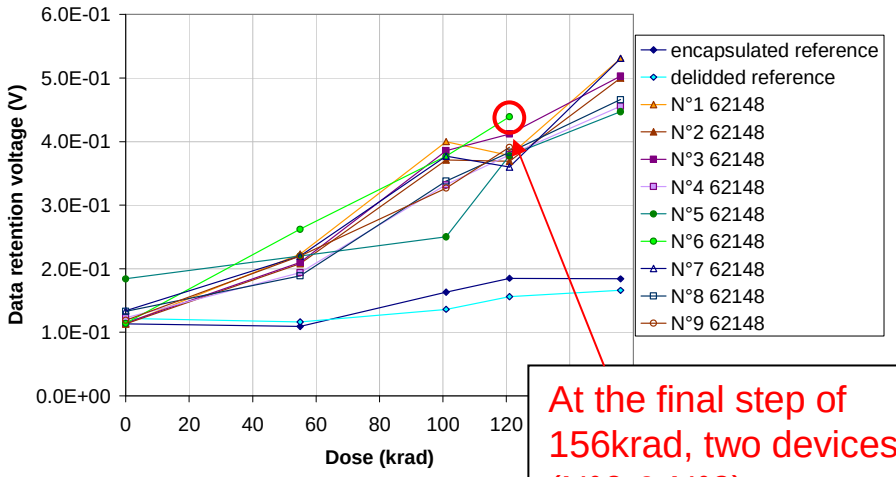
Total Dose Test Results

CY62148EV30LL





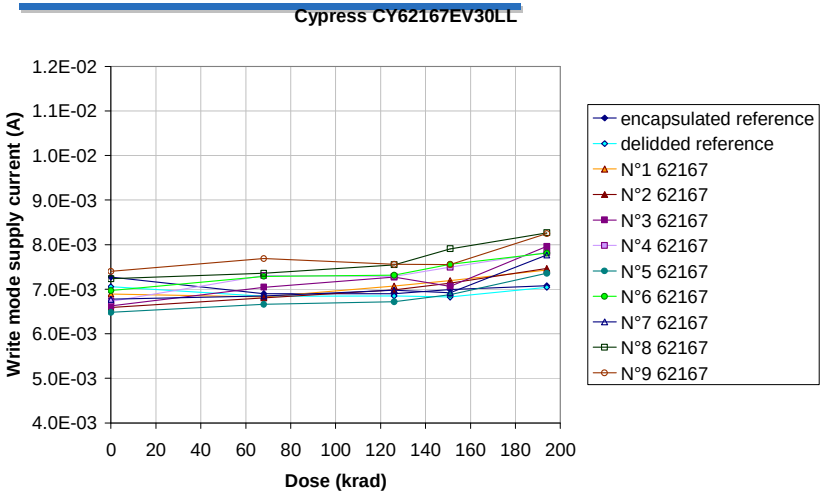


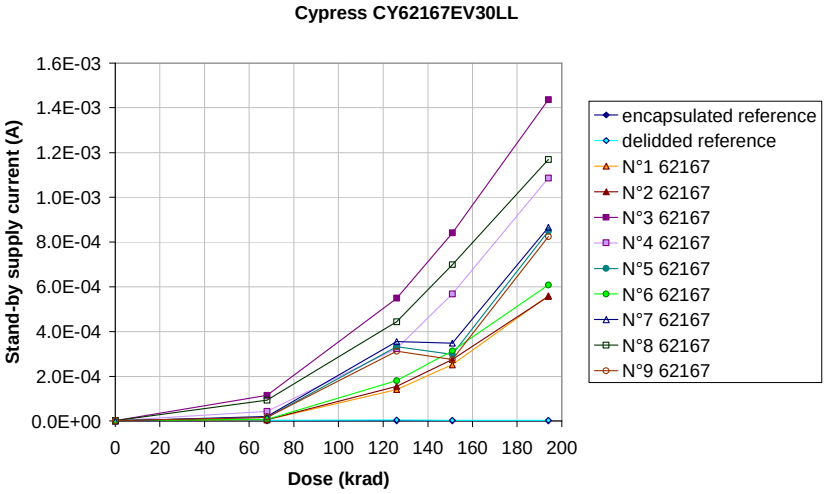


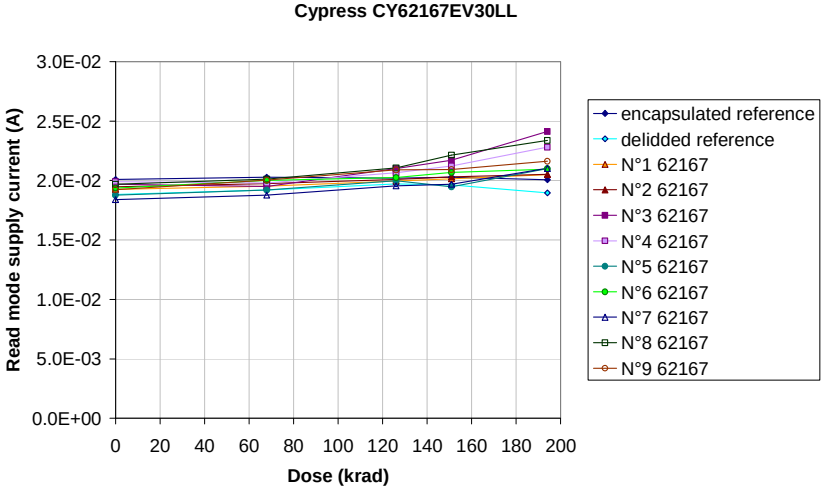
At the final step of 156krad, two devices (N°6 & N°9) are no longer functional

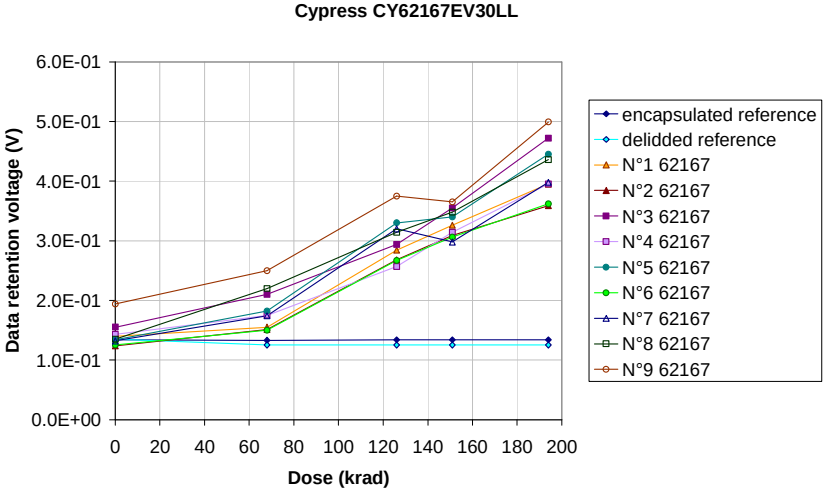
Total Dose Test Results

CY62167EV30LL









All CY62167EV30LL devices remain functional up to the total dose of 190krad

Heavy Ion Test Results

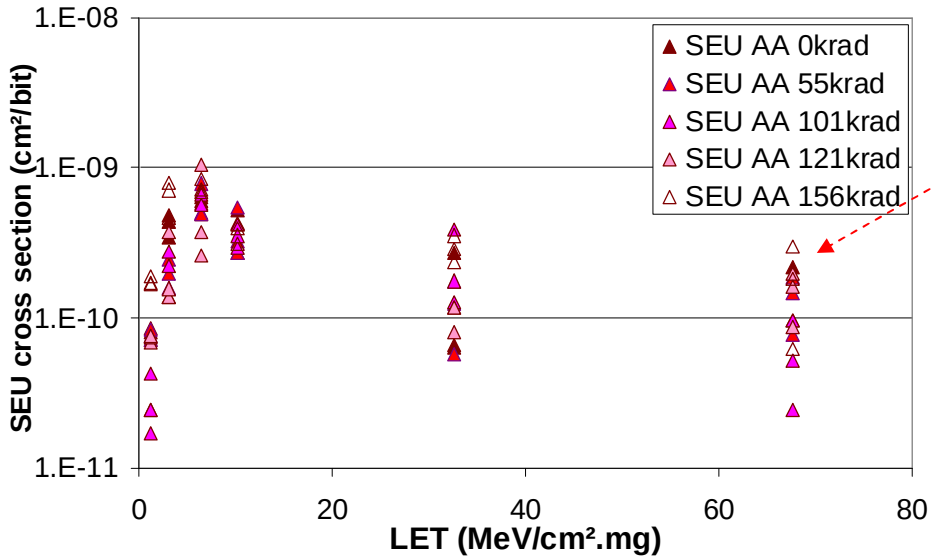
For the two references, errors detected are:

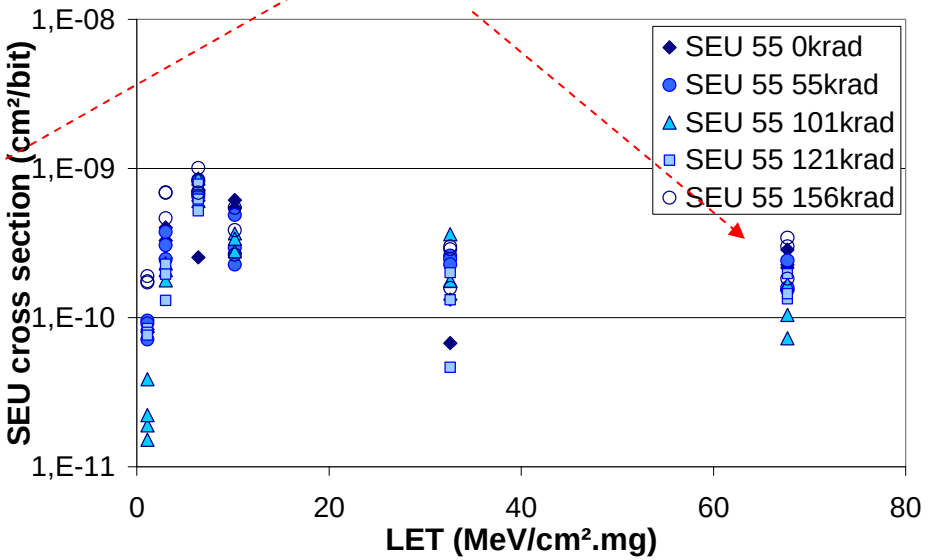
- **No SEL**
- **No stuck bit**
- **SEU**
- **“Burst” errors : large number of errors detected in one read cycle**
  - Data treatments are lead to separate typical SEU and “burst”
  - SEU and Burst cross section

Heavy Ion Test Results

CY62148EV30LL : SEU Test Results

At high LET burst events are much more numerous than at low LET, limiting the SEU detection





SEU error patterns have the same occurrence probability whatever the dose level

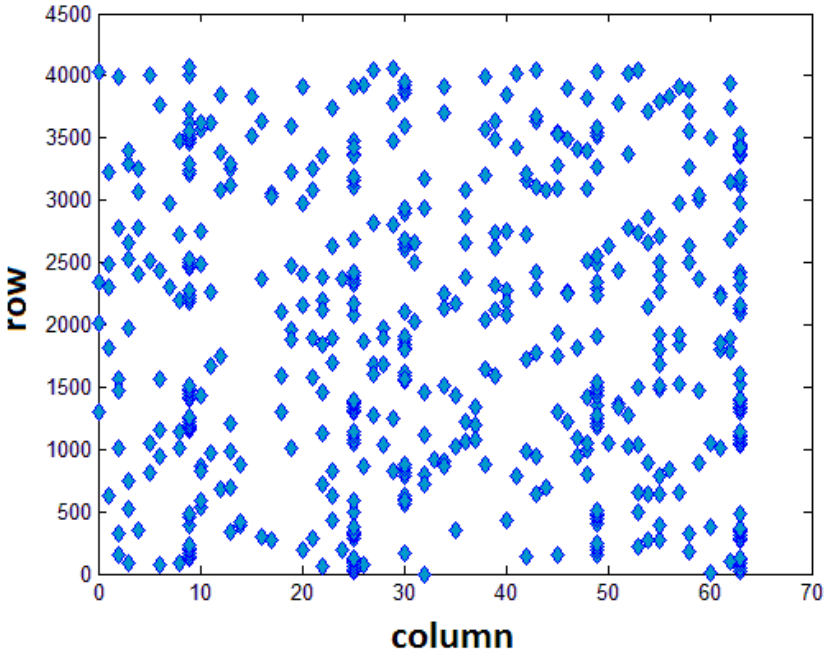
No correlation between cross sections and received dose

Heavy Ion Test Results

CY62148EV30LL : Burst Event Test Results

Several Single Bit Upsets detected :

- **during the same memory read cycle**
- **in the same logical column**



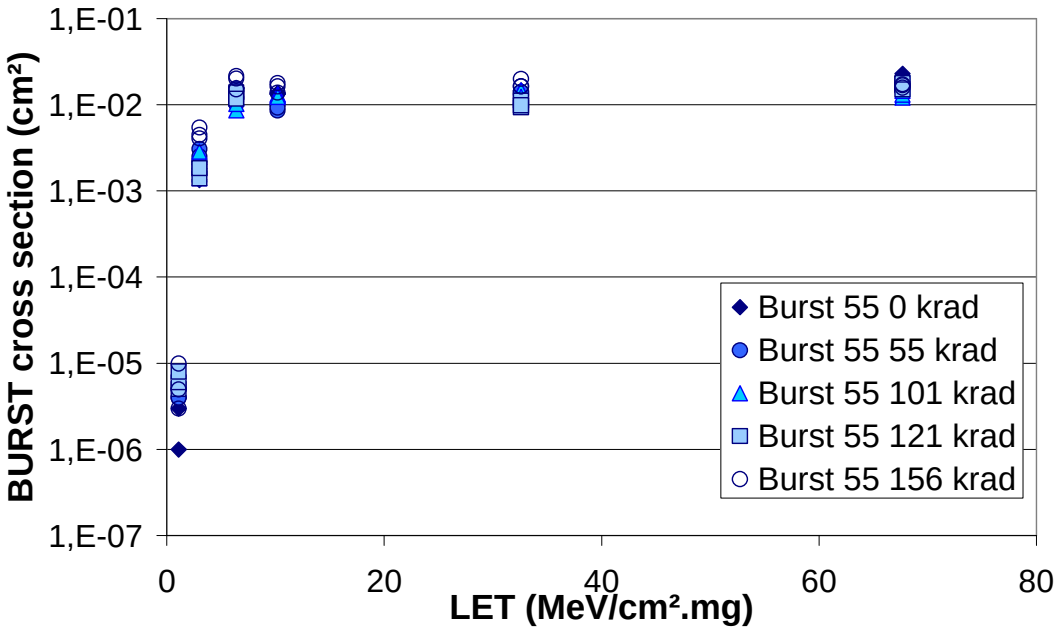
CY62148EV30LL memory plan cartography
at TID=0krad under
C ion LET=1.1MeV.cm^2.mg^{-1}

Heavy Ion Test Results

CY62148EV30LL : Burst Event Test Results

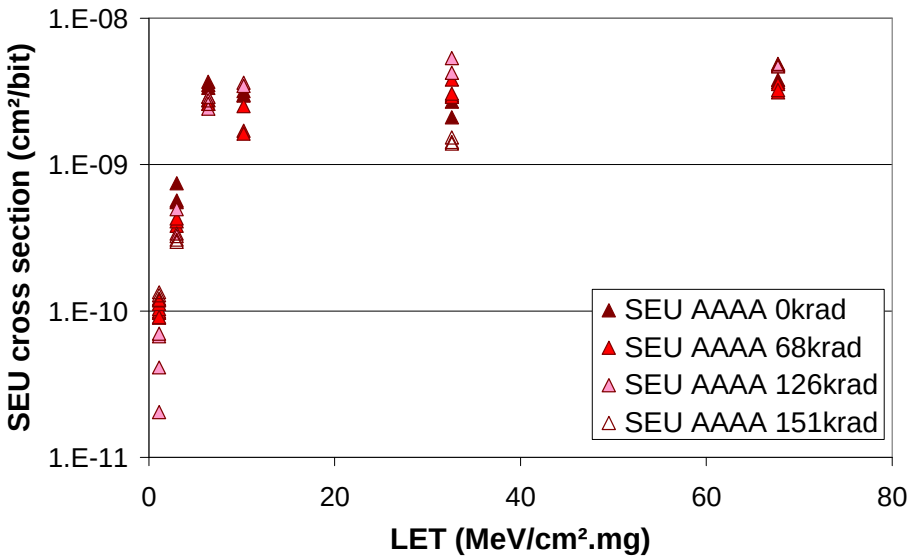
No correlation between received dose and burst sensitivity

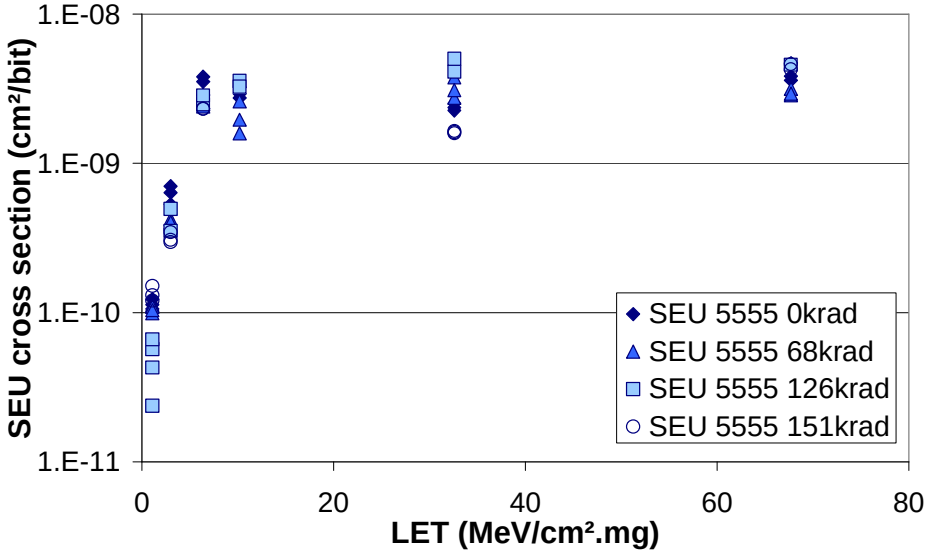
No Impact of pattern



Heavy Ion Test Results

CY62167EV30LL : SEU Test Results





SEU error patterns have the same occurrence probability whatever the dose level

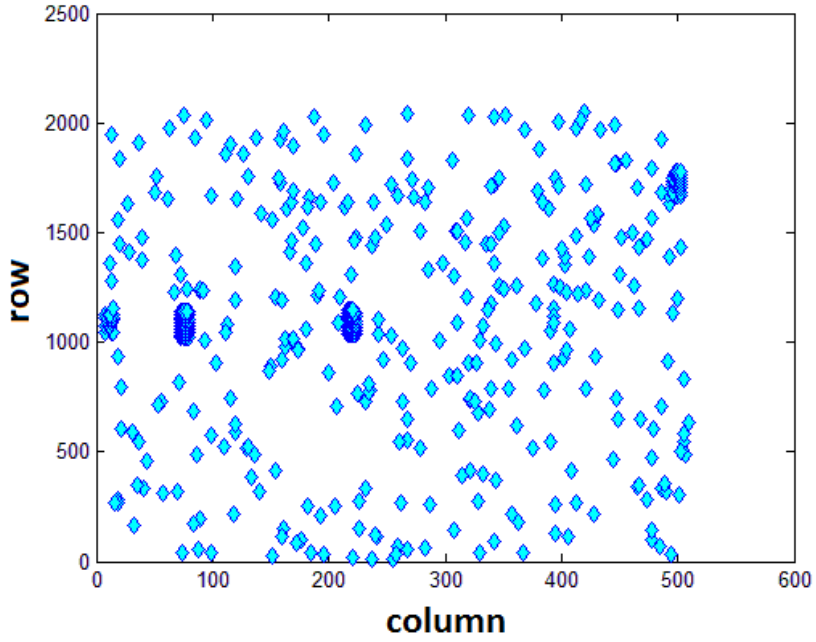
No correlation between cross sections and received dose

Heavy Ion Test Results

CY62167EV30LL : Burst Event Test Results

Several Single Bit Upsets detected :

- **during the same memory read cycle**
- **organized in column with a maximum of 8 bit difference**



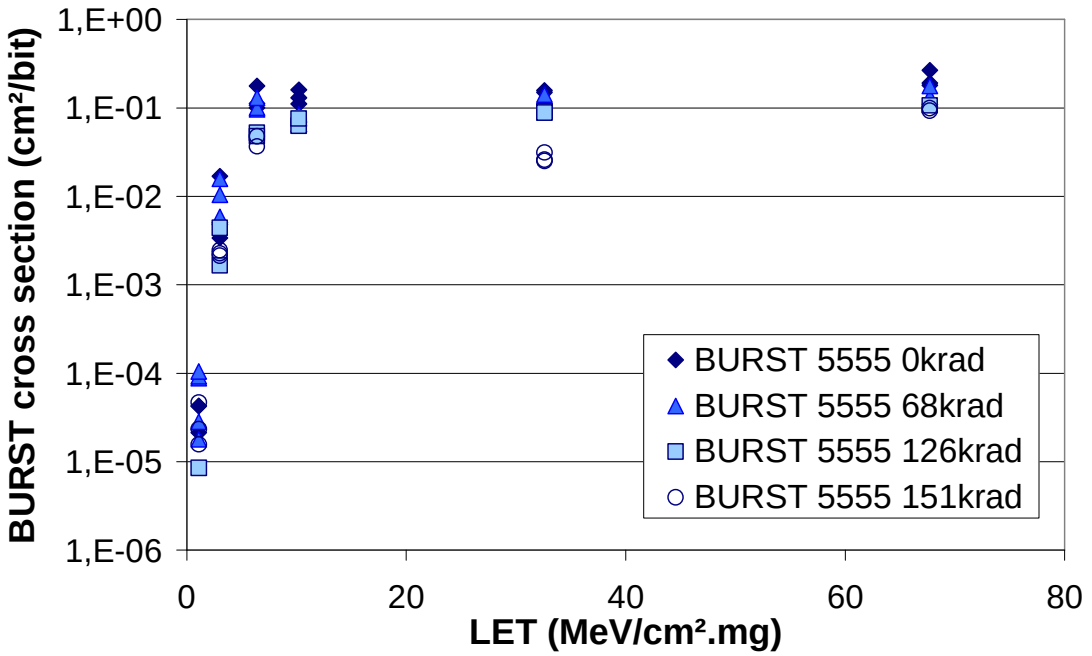
CY62167EV30LL memory plan cartography
at TID=0krad under
C ion LET=1.1MeV.cm^2.mg^{-1}

Heavy Ion Test Results

CY62167EV30LL : Burst Event Test Results

No correlation between received dose and burst sensitivity

No Impact of pattern



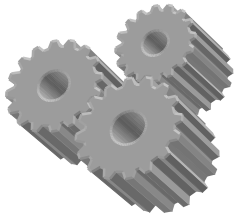
Californium Tests

The aim of these complementary experiments is to go deeper in the study of burst events, and their large occurrence in the two SRAM references tested

The ^{252}Cf source emissions of heavy ions:

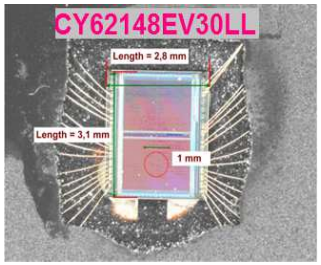
- **LET = 45 MeV.cm².mg^{-1}**
- **Range = 15 µm.**

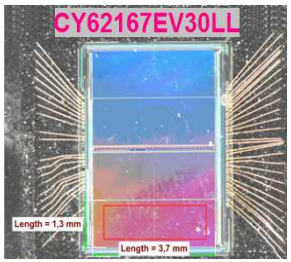
Californium Tests



Dynamic mode – used during heavy ion test – all addresses are checked continuously and written again whenever an error is detected

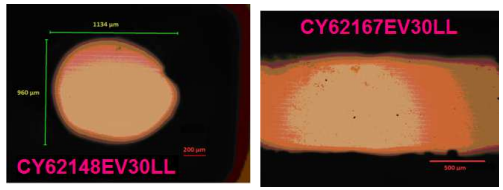
Static mode : writing the memory before irradiation, and reading it once after irradiation





On the complete memory area

On only a part on the memory array, performed with a mask leaving only a piece of memory array visible



Californium Tests

- **Single bit upsets and burst events are detected under ^{252}Cf in any configuration – in static or dynamic mode, with or without mask:**
  - In static mode, the peripheral circuitry is not solicited during the irradiation.
  - burst events are detected even during masked device irradiation

Bursts are due to events occurring in the memory array

Conclusion

- **No SEL and stuck bit are observed whatever the deposited dose**
- **Burst events and SEU are observed under heavy ions**
- **No correlation between SEE cross section and total dose level**
- **Complementary ^{252}Cf characterizations show that burst events are ignited in the memory array**

Perspectives

- **BURST event study:**
  - Specific to CYPRESS memory ?
  - BURST observed on other memories ?

- **SEE and TID Synergetic effect**
  - Less sensitive memories, qualified memories
  - Other SEE ?

- **Data Workshop RADECS 2012 :**

Single event upset cross section dose dependence on 90nm SRAM

N. Sukhaseum, A. Samaras, D. Le Du, B. Vandevelde, N. Chatry, and F. Bezerra

Single Event Upset cross section dose dependence on 90nm SRAM

QUESTIONS