The Technology Demonstration Module On-Board PROBA-II.

by

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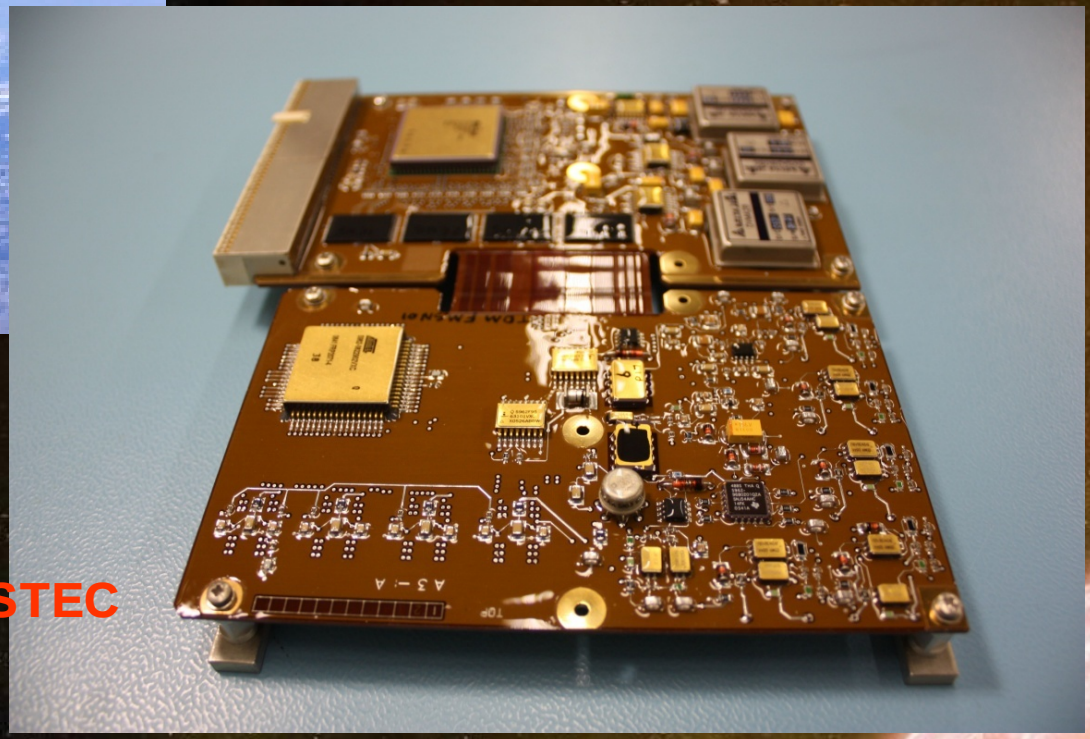


Technology Demonstration Module

- ***The TDM is primarily a Radiation Experiment focussing on Single Event Effects in advanced Semiconductor Components in order to address and study the difference between flight and ground events.***

- ***The TDM was designed and manufactured (by Qinetiq Space & ESA) at a late point in time, taking advantages of an empty slot being available within the Advanced Data and Power Management System (ADPMS).***

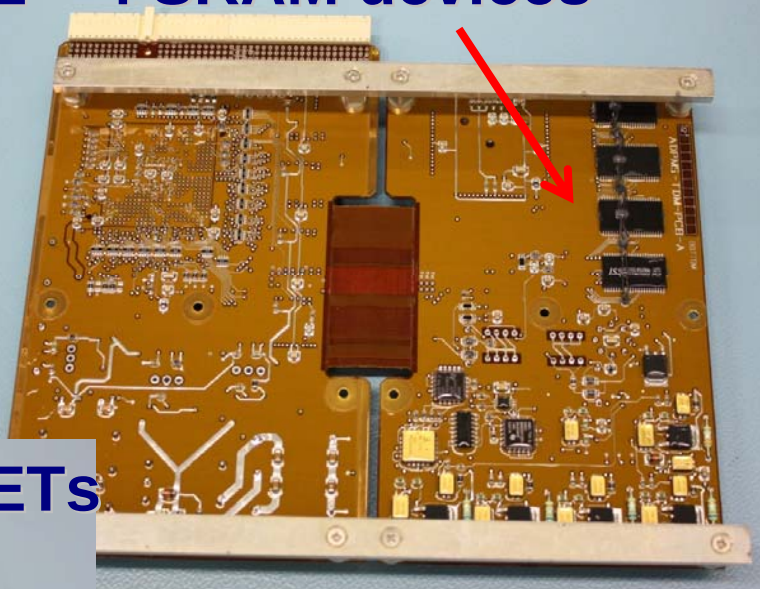
Technology Demonstration Module

- ***The TDM consist of 4 different experiments:***
  - *Assessing Single Event Upsets in SRAM devices using the Hybrid version of the "Reference SEU Monitor" (Atmel 4 x 4Mbit SRAMs).*
  - *Assessing Single Event Latch-ups in 4 different SRAM devices having a very different SEL sensitivities (to both heavy ions and protons)!*
  - *Validating the flight concept of 4 x 8Gbit FLASH Memory devices configured into a SENTINEL-II prototype test platform.*
  - *Monitoring the PROBA-2 Total Ionizing Dose (TID) level via 2 RADFETs in relation to the board temperature*

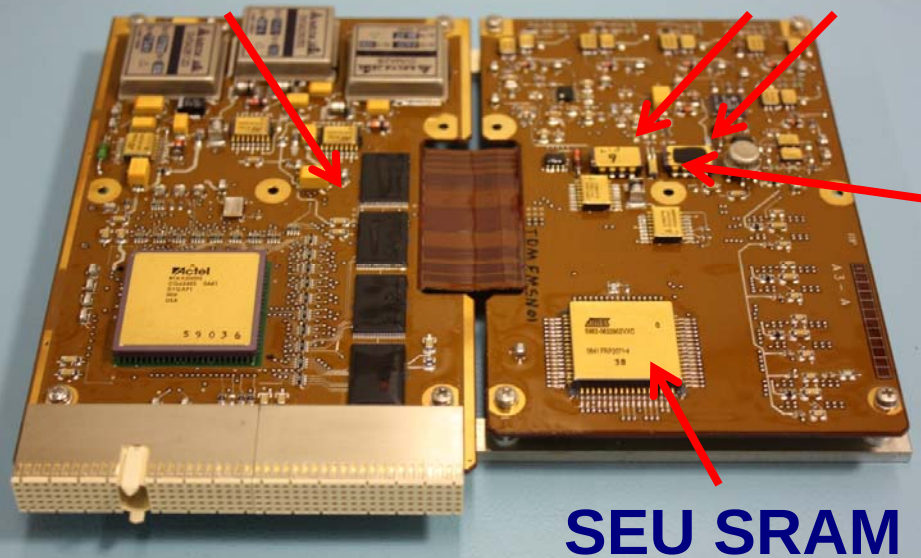
Technology Demonstration Module

Budgets
Mass 300g
Volume 160x100x25mm
Power 4 W (operating)
Temp range –20/+60°C

SEL – 4 SRAM devices



4 NAND-FLASH 2 TID - RADFETs

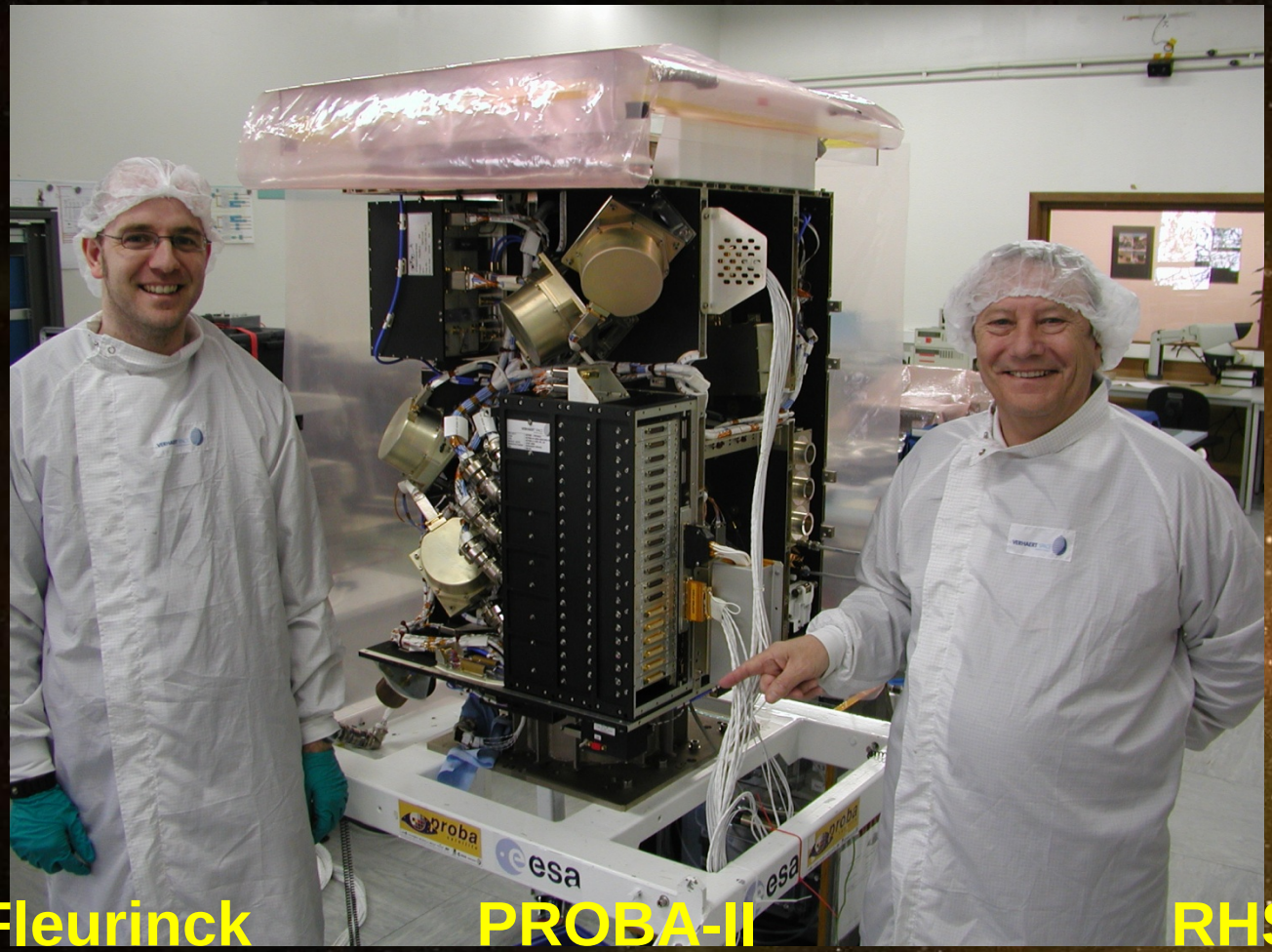


Temperature Sensor

SEU SRAM

Satellite: PROBA-II

- *Project for On-Board Autonomy (PROBA)*
  - *Just room for one more board – the TDM!*

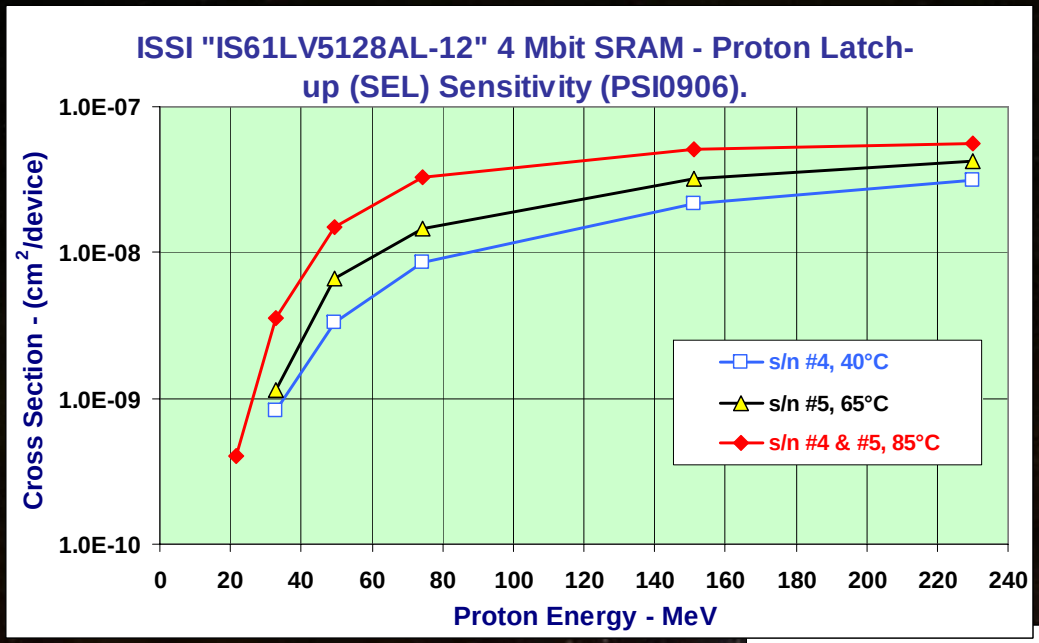


Nico Fleurinck PROBA-II RHS

TDM Ground Testing: I

- ***The SEU Monitor was earlier fully Heavy ion, Proton, Temperature SEE and TID Tested:*** *see RADECS 2005 proceedings*
- ***The FLASH Devices were fully Heavy ion, Proton, Temperature SEE and TID Tested:*** *see RADECS & NSREC 2008 proceedings*
- ***The RADFET's Devices were fully Proton and Co-60 TID Tested:*** *see 9th QCA Day www-pages, January 2009*

TDM Ground Testing: II



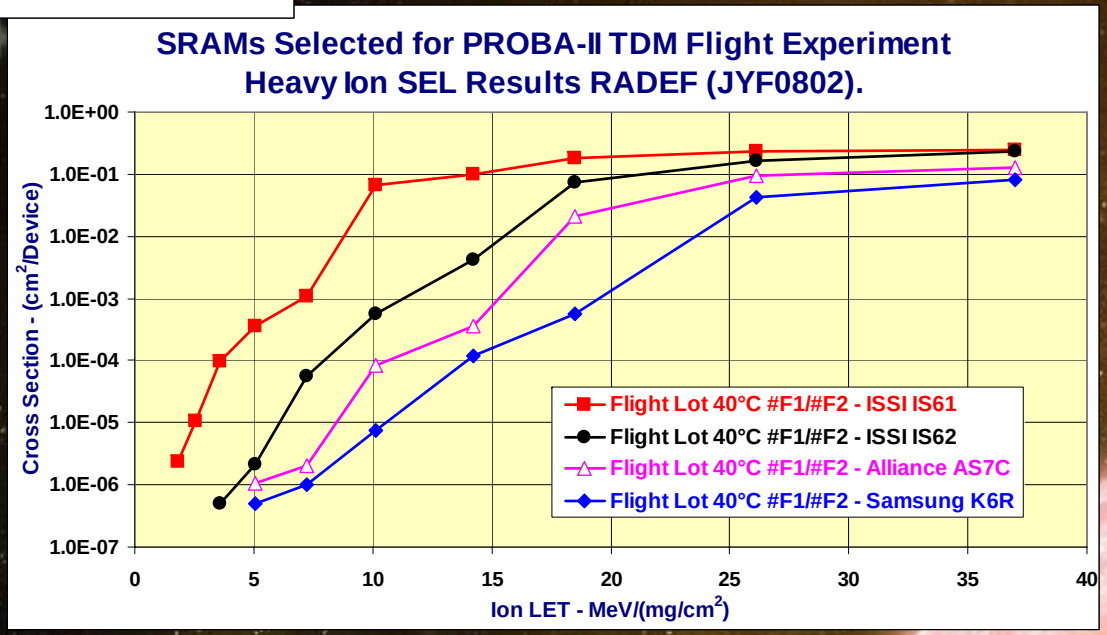
Latch-up Experiment

4 different SRAMs

- *Heavy ion*
- *Proton*
- *Temperature*

Temperature:

- *40 ºC*
- *65 ºC*
- *85 ºC*



TDM Flight Performance: I

- ***PROBA-II was launched on November 2nd 2009, into a 800 km polar orbit (together with SMOS satellite) from the Plesetsk Cosmodrome, Russia.***
- ***The TDM was switched on February 15th 2010 and has been on since.***
- ***Basically all 4 Experiments works correctly***
- ***'REDY' telemetry data directly available***

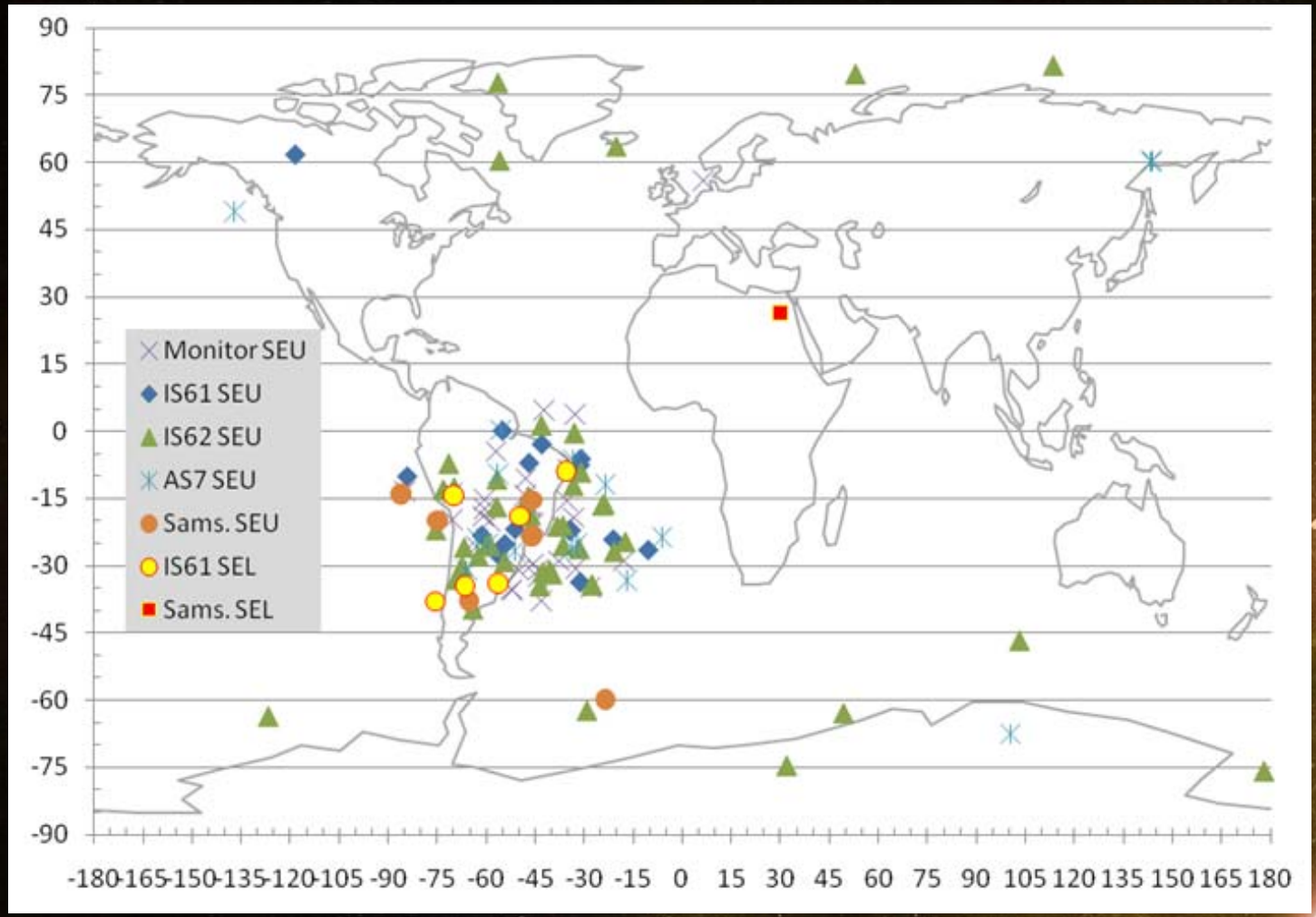
TDM Performance: General

		SEU				SEL				SEU
Period	Hours	AS7	Sams.	IS61	IS62	AS7	Sams.	IS61	IS62	Monit.
Feb/Mar'10	1032	40	28	39	126	0	1	7	1	90
August '10	757	23	23	28	115	0	0	5	0	44
January '11	368	15	7	12	52	0	0	5	0	29
March'11	614	15	15	26	54	0	0	11	0	50

- *Observed SEUs in the SRAMs and the Monitor:*
  - *Feb/Mar'10 = 323 SEUs/1032 hours = 0.31 SEU/hour*
  - *August '10 = 233 SEUs/757 hours = 0.31 SEU/hour*
  - *January '11 = 115 SEUs/368 hours = 0.31 SEU/hour*
  - *March 2011 = 160 SEUs/614 hours = 0.26 SEU/hour*

TDM Performance: General

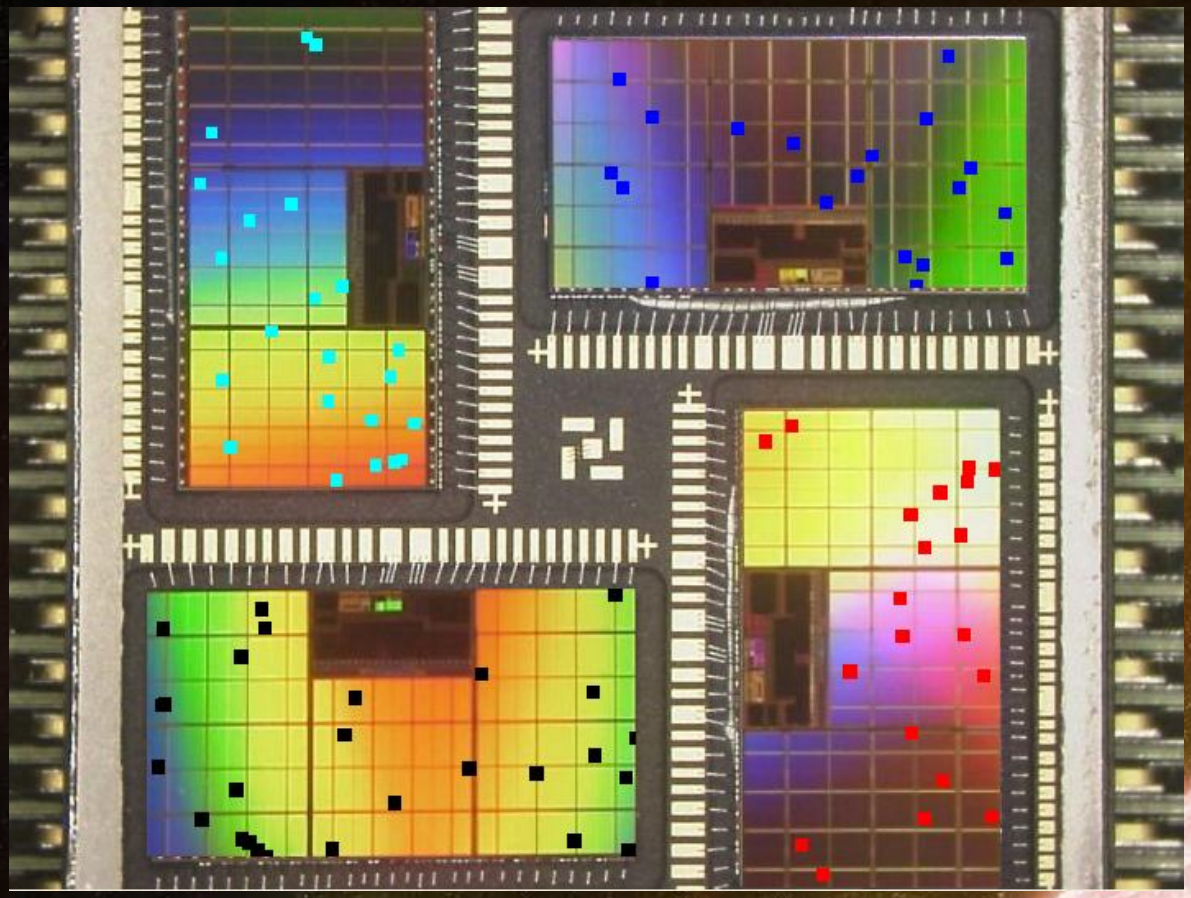
- **Orbital SEU/SEL distribution after 393 hours of analysed flight.**



TDM Performance: SEU Monitor

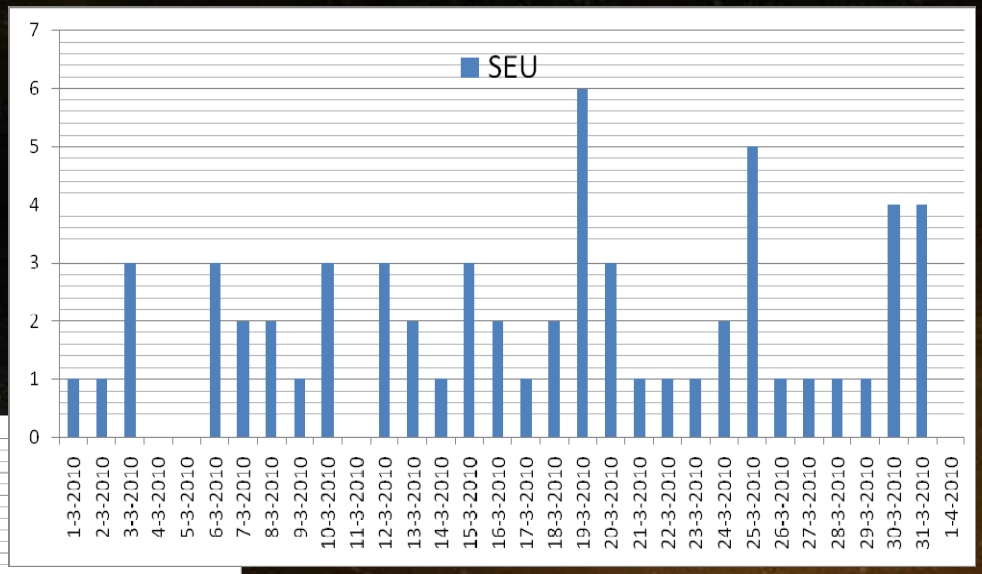
- Analysis after 1032 hours: 90 SEUs (2 x 2 events double)
  - S1 – 23 SEU
  - S2 – 27 SEU
  - S3 – 19 SEU
  - S4 – 21 SEU
  - 51 x 0-»1
  - 39 x 1-»0
- Until now:

  > 700 SEUs

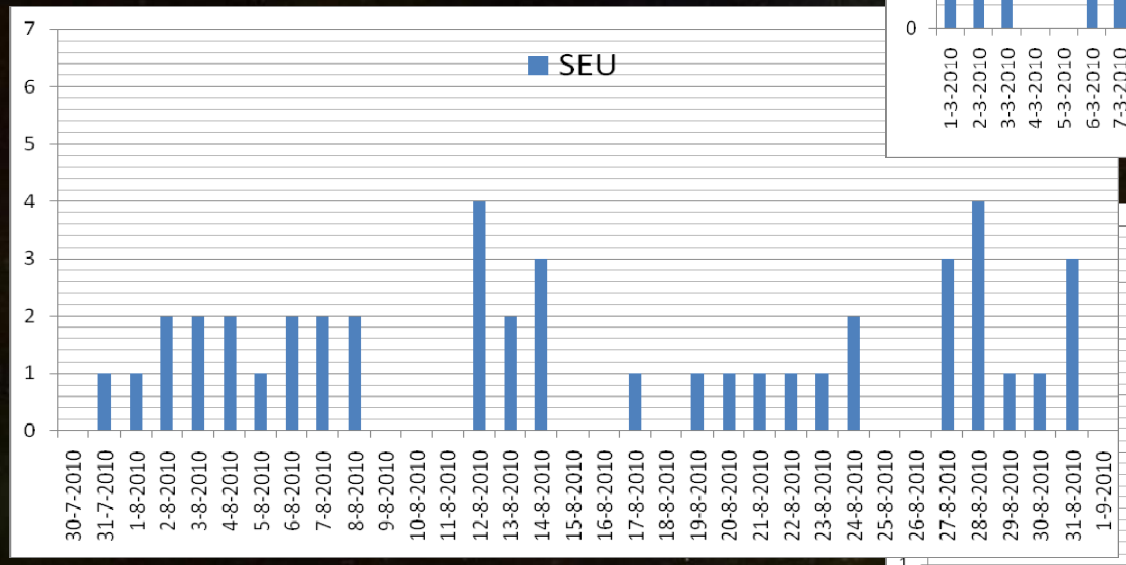


TDM Performance: SEU Monitor

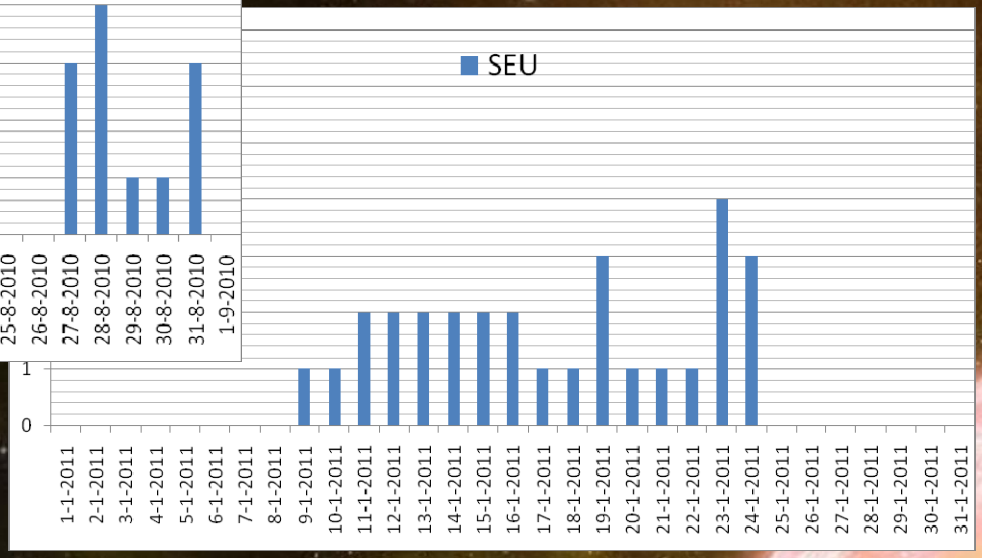
- **Distribution of SEUs over the month of March 2010.**



- **August 2010**

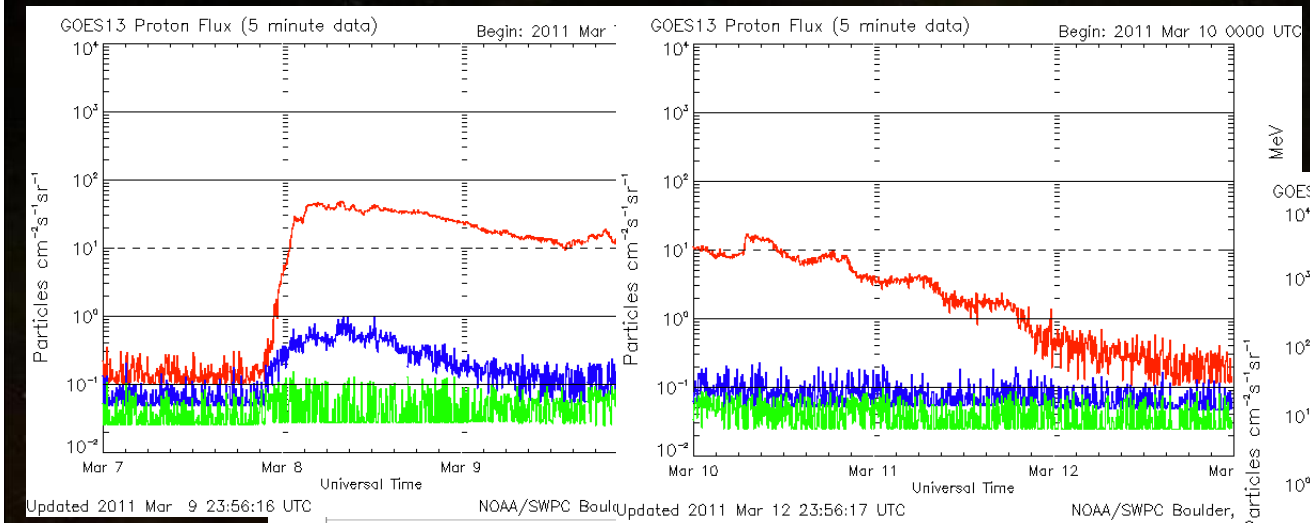


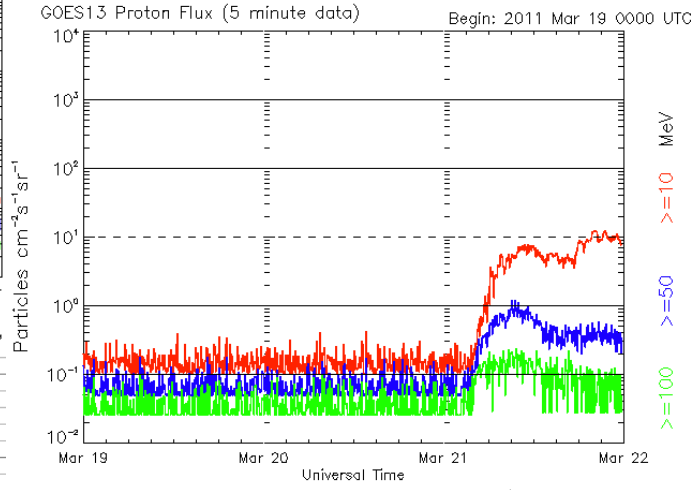
- **January 2011**

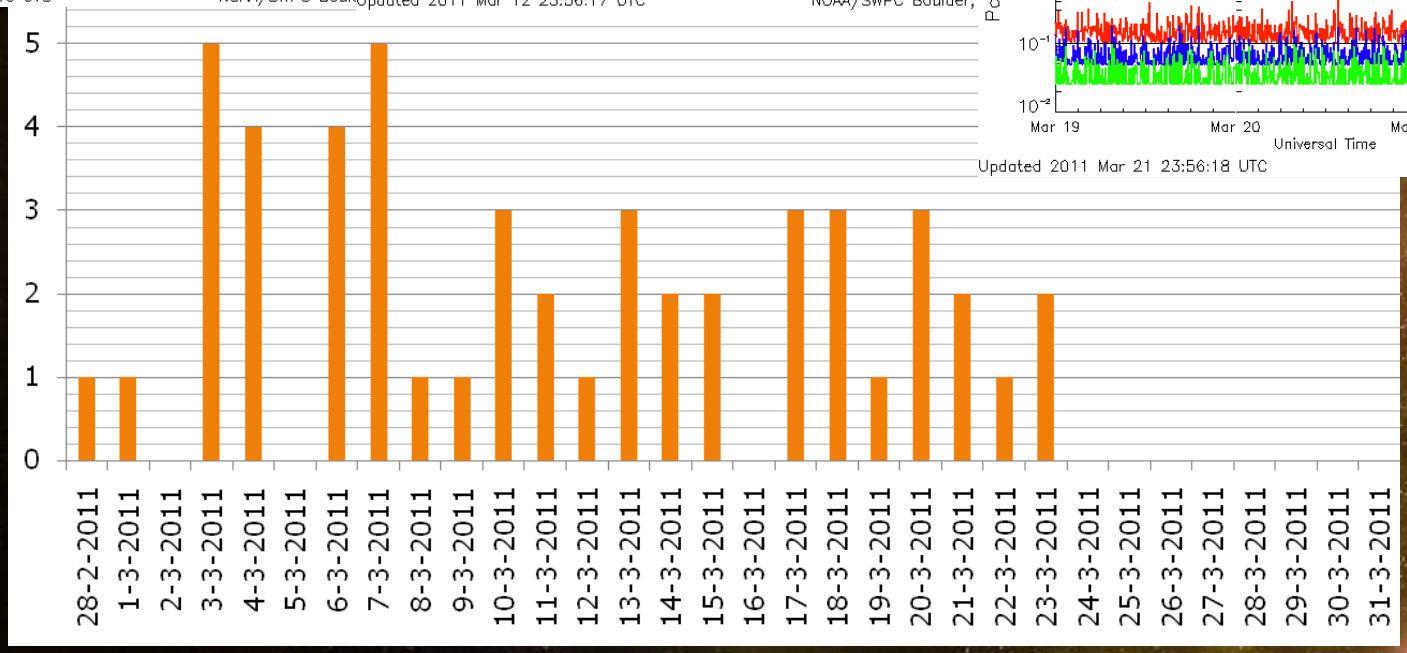


TDM Performance: SEU Monitor

- **Distribution of SEUs over the month of March'11**



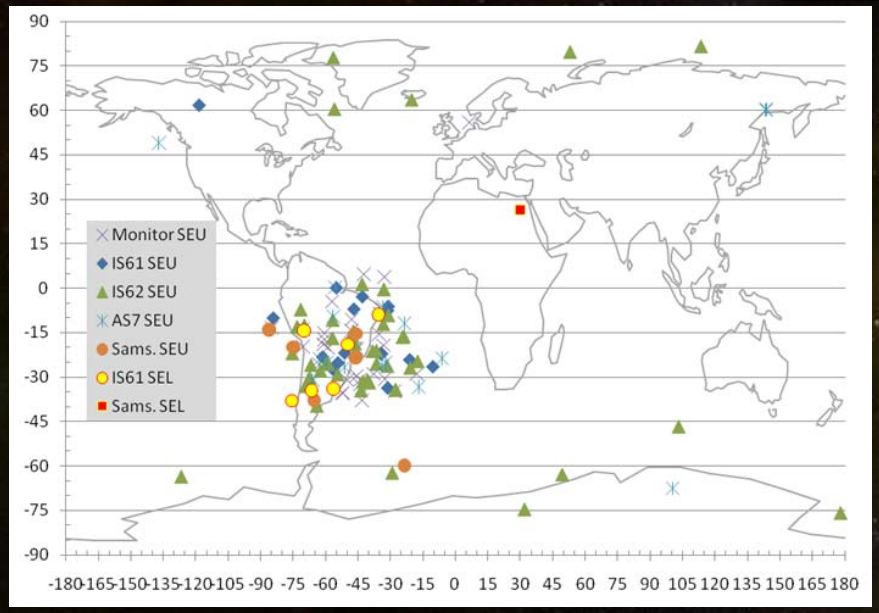




TDM Performance: SEL Monitor

- **SEL Events: Total 86**
- **SEU Events: Total >10.000**

		SEL			
Period	Hours	AS7	Sams.	IS61	IS62
Feb/Mar'10	1032	0	1	7	1
August '10	757	0	0	5	0
January '11	368	0	0	5	0
March'11	614	0	0	11	0
TOTAL	13 M	0	2	83	1



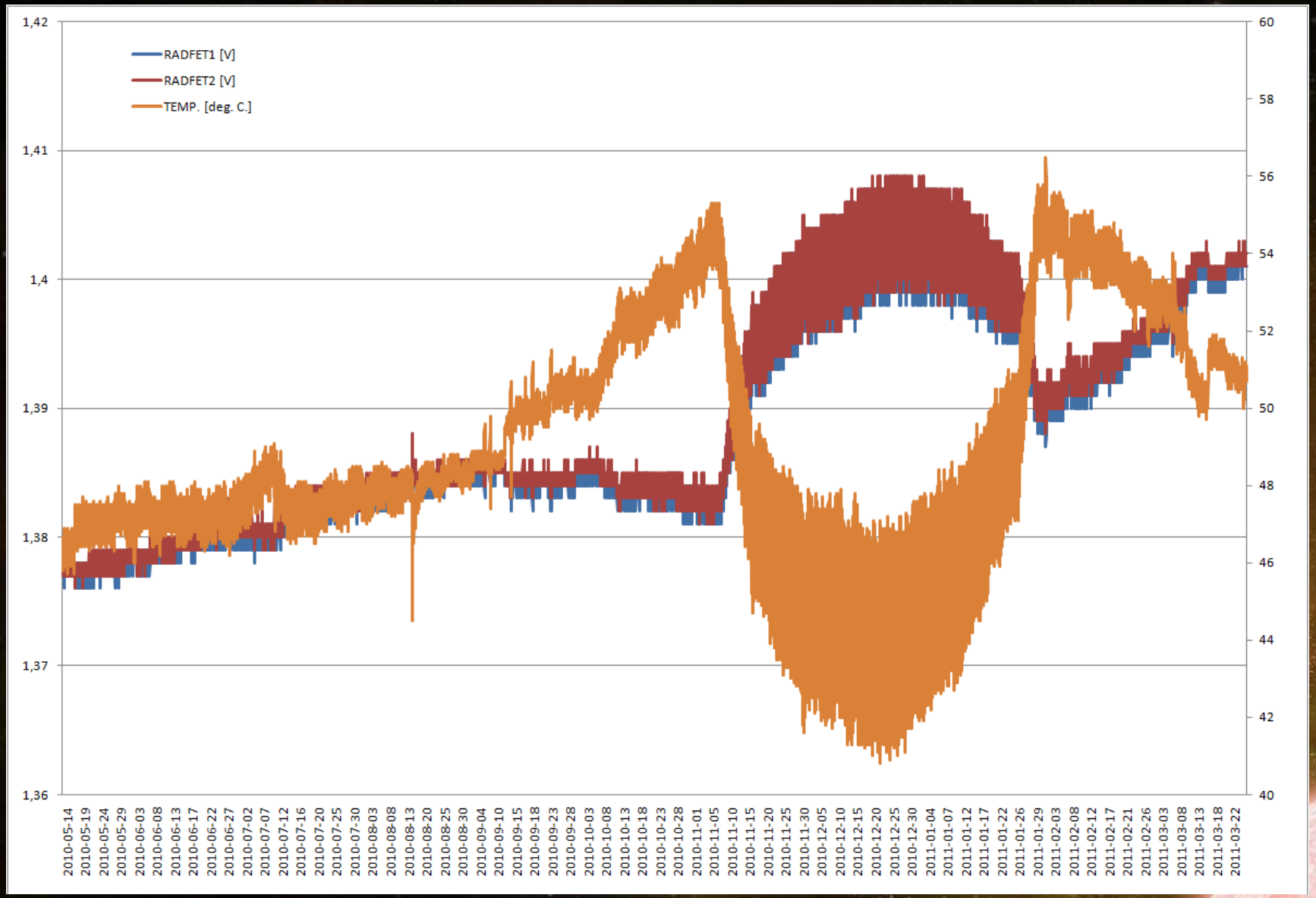
TDM Performance: FLASH Memories

- **Preliminary Analysis:**
  - Event 107 SEU 0-»1 (12-02-2010) Reed Solomon
  - Event 113 SEU 0-»1 (12-02-2010) Reed Solomon
  - Event 310 SEU 0-»1 (15-05-2010) Reed Solomon
  - Event 043 SEU 0-»1 (04-07-2010) Reed Solomon
  - Event 043 SEU 0-»1 (18-08-2010) Reed Solomon
  - Event 049 SEU 0-»1 (18-08-2010) Reed Solomon
  - Event 037 SEU 0-»1 (10-09-2010) Reed Solomon
  - Event 043 SEU 0-»1 (10-09-2010) Reed Solomon
  - Event 065 SEU 0-»1 (11-12-2010) Reed Solomon
  - Event 136 SEU 0-»1 (30-01-2011) Reed Solomon

- **Probably all caused by 'weak blocks' or 'cross page disturbances' and not really by Radiation!**

TDM Performance: TID RADFETs

- **RAD-1 & RAD-2 vs Temperature: Initial 1.36 V.**



TDM Conclusion:

- ***The TDM Experiment works very well and the data received are fairly easy to analyse.***
- ***Unfortunately the FLASH data are not included in the present available database (should be updated).***
- ***Analysis s/w tools to be completed and validated!***

TDM = 265 grams ==>