CARMEN2/MEX – First Set of In-Flight Data

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Summary:

- Introduction to CARMEN project.
- ICARE-NG Instrument
- MEX Experience Module.
- JASON-2 mission radiation environment.
- First In flight data sets
- Conclusion & Perspectives

Introduction to CARMEN mission:

- CARMEN is an extended mission concept that aims to flight similar instruments (ICARE-NG) dedicated to space radiation environment studies is various orbits.

CARMEN1

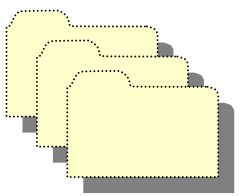
- ICARE-NG + 3 SODAD modules*
- SAC-D argentine satellite
  - To be launched in May 2010.
  - Polar orbit (660km, 98°).
  - 5 years

**dedicated to the study of micro meteroïds*

CARMEN2

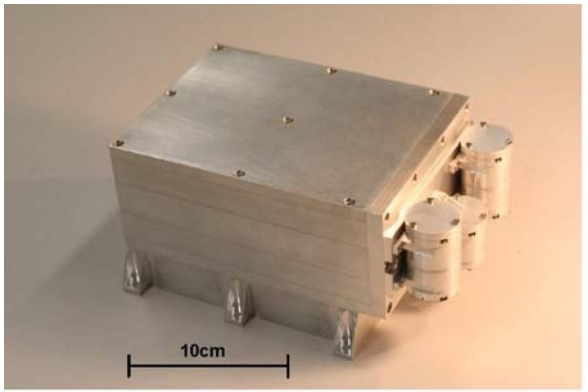
- ICARE-NG instrument
- JASON2 satellite
  - Launched in june 2008.
  - 1340, 66°.
  - 5 years

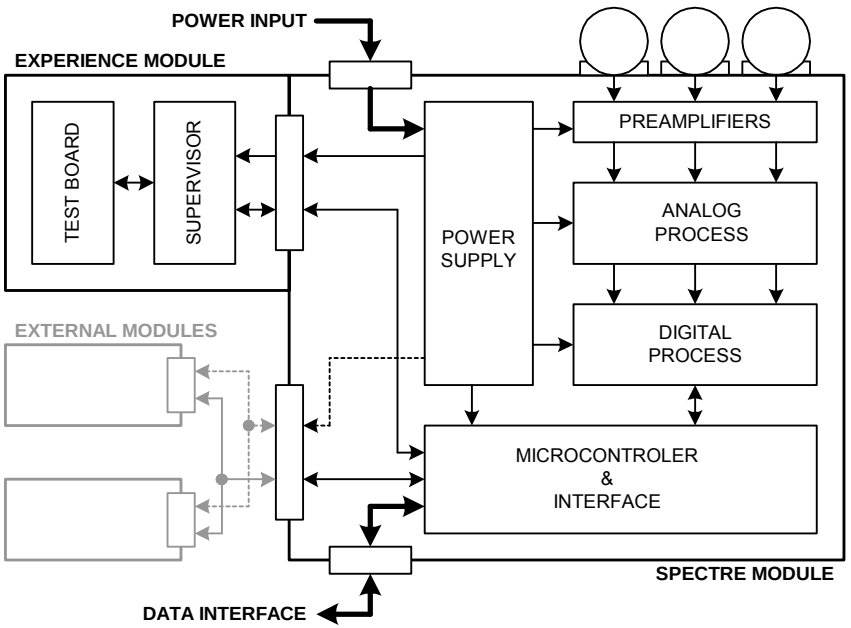
- Other flight opportunities are currently discussed.



ICARE-NG instrument:

- Updated version of ICARE instrument flying on SAC-C argentine satellite.
- Dimensions: 19.7x11.8x9.6cm^3
- Mass: < 2.4kg
- Power consumption: <6W (wo MEX)



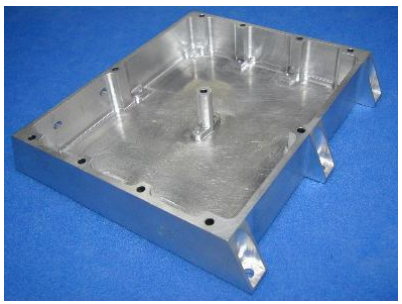


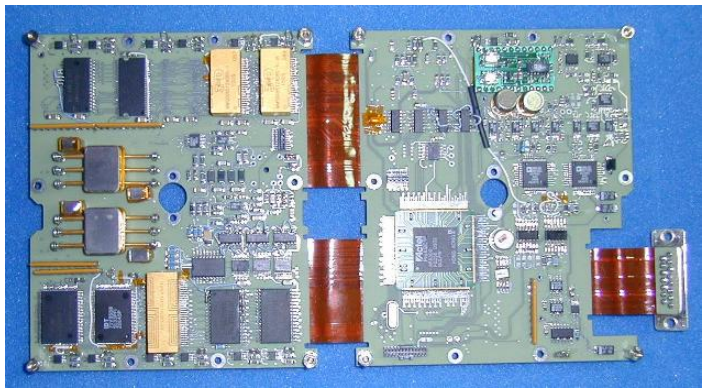
- SPECTRE module dedicated to radiation flux measurements.
- MEX experiment module for the study of space radiation effects on electronic components.
- ICARE-NG can also interface with additional external modules such as SODAD in CARMEN1.

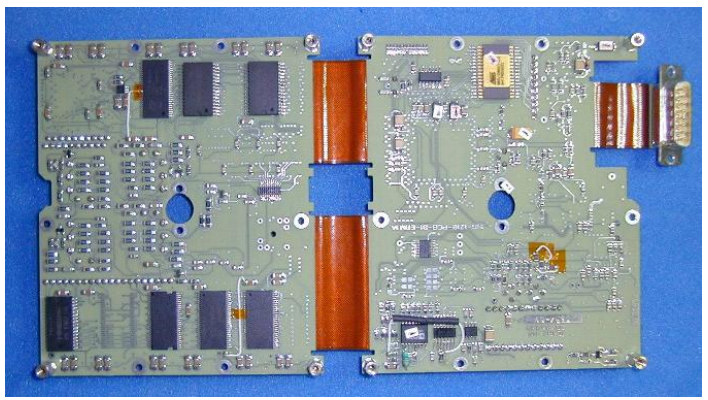
MEX Experiment Module.

- Addressing various space radiation effects on electronic components:
  - TID (Total Ionizing Dose Effects)
  - DDE (Displacement Damage effects)
  - SEE (Single Event Effects)
- Also includes a dosimetry sub system
- Mass: <500g
- Board only: 211g
- Power supply:

-12V	15mA
+12V	21mA
+3.3V	300mA; 550mA (memories refresh)
5V	45mA



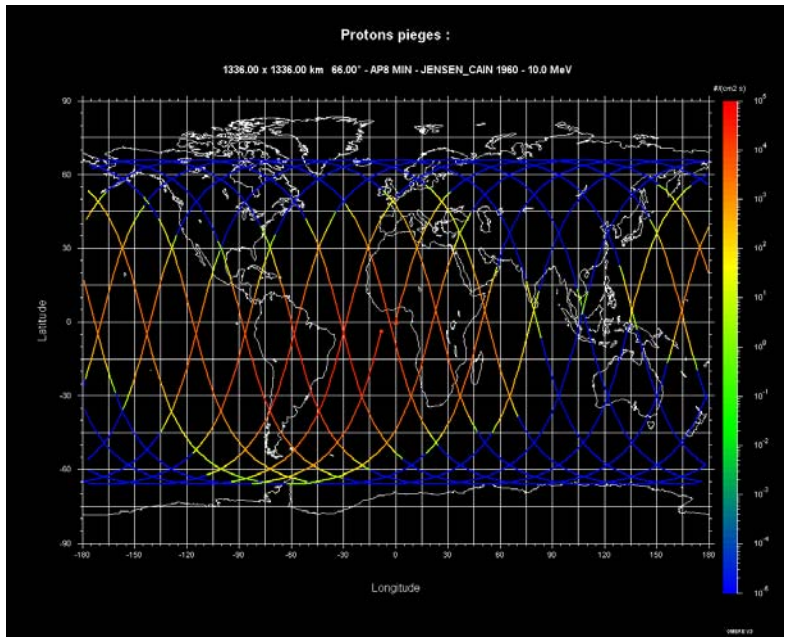




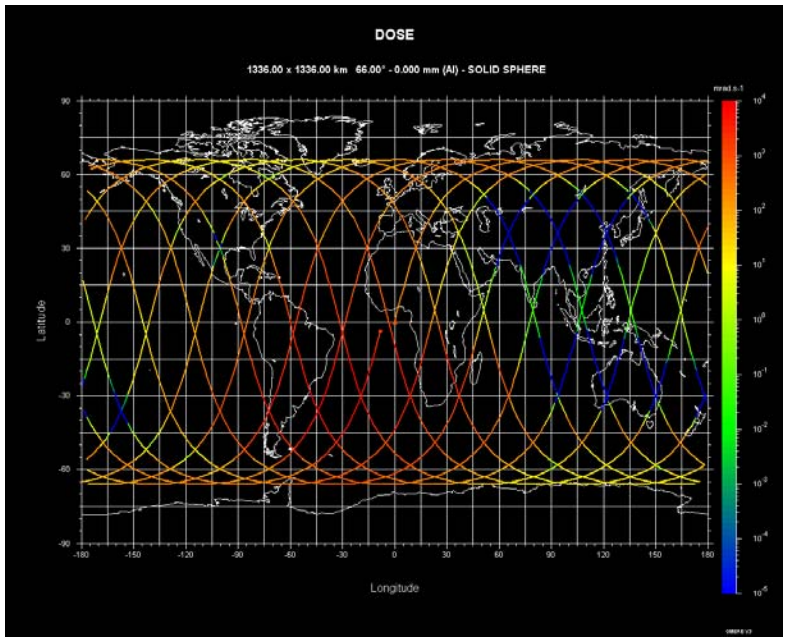
JASON2 Satellite:

- Following TOPEX/POSEÏDON and JASON1, it will collect high accuracy radar altimetry measurements for global ocean circulation and sea surface studies.
- International partnership: EUMETSAT,NASA, NOAA, JAXA and CNES.
- Launched in June 20 2008.
- 1340km, 66° orbit.

Estimated radiation constraints (without shielding).



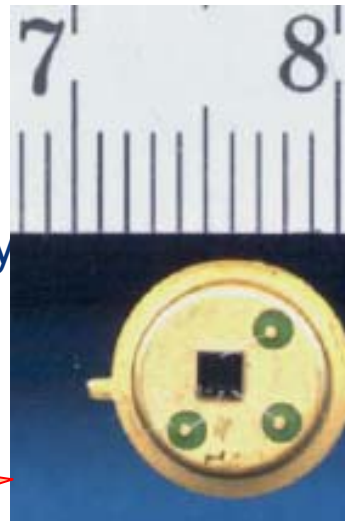
E>10MeV Proton fluxes from 1E-5 to 1E5P/cm²/s



Dose rate from 1E-5 to 1E4 mrad/s

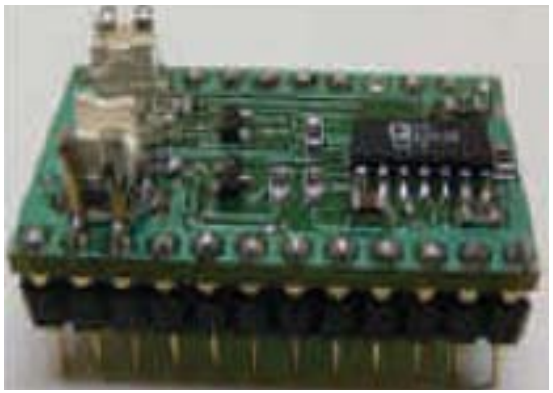
MEX Dose monitoring section.

TSD PMOS dosimeter from LAAS/TRAD.



- **Two PMOS monitors from LAAS/TRAD (TSD): measurement of dose.** (build-up of charge in PMOS SiO2 layers)
  - **HS biased:** High sensitivity (~1.3V/Gy)* but saturation after a few Gy
  - **LS unbiased:** Low sensitivity (~0.25V/Gy)* but greater lifetime.

  ** First 100Rad*

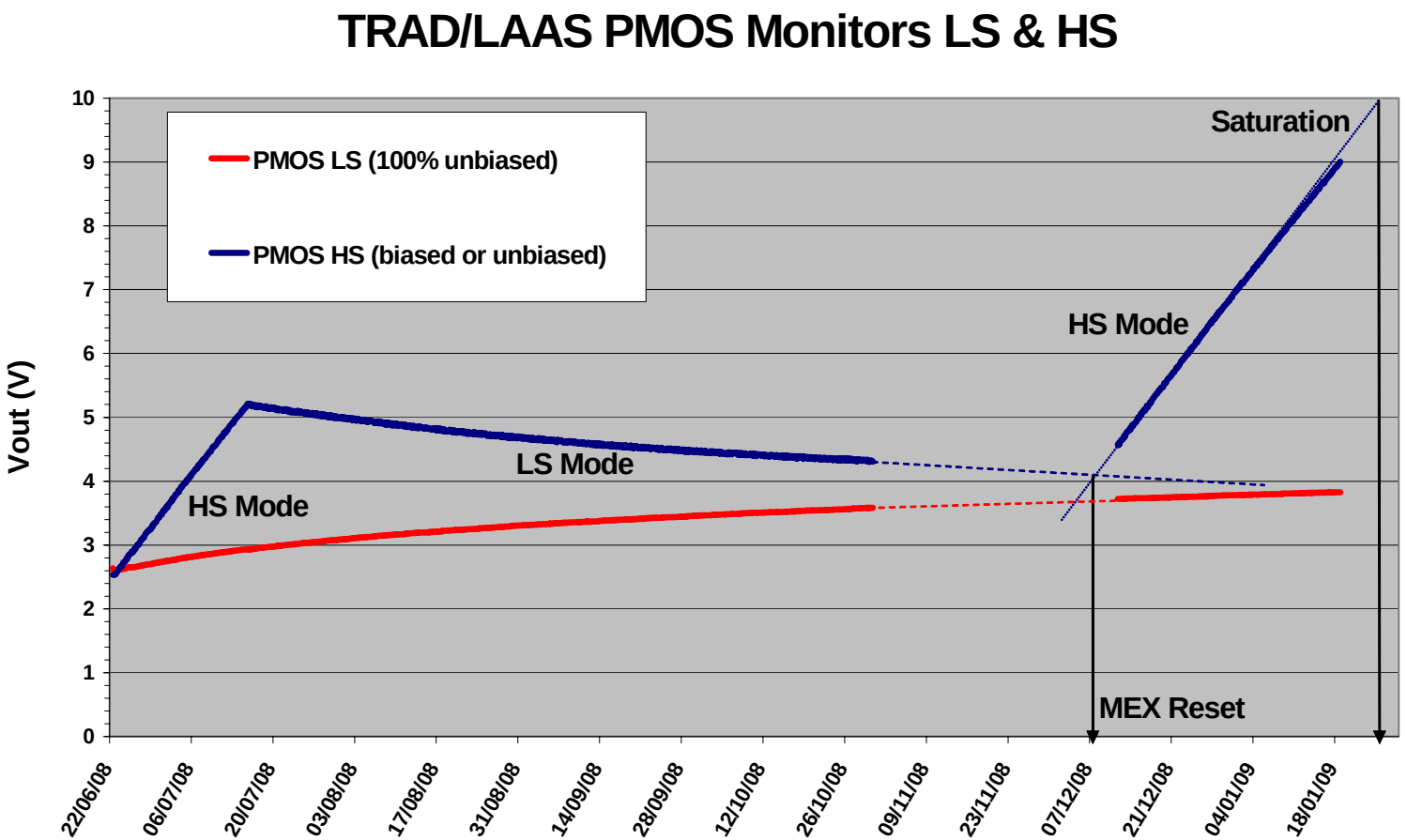


OSL dosimeter from CEM2.

Complementary rules

- **An Optically Stimulated Luminescence (OSL) dosimeter from University of Montpellier/IES**
  Precise (1E-4Gy, 70mV/Gy) but not adapted to very low cumulated dose levels because of the poor Signal/Noise ratio.
  Re-initialized when being read => covers all the mission duration.

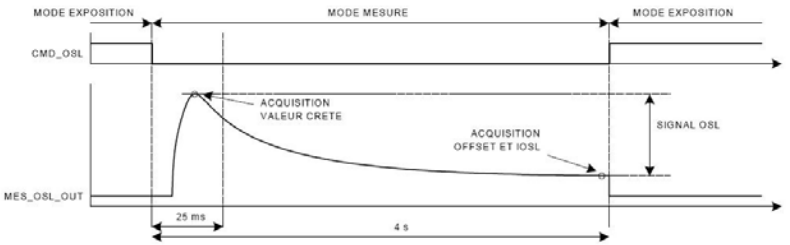
MEX Dose monitoring section: In flight data after 7 months (1/2)



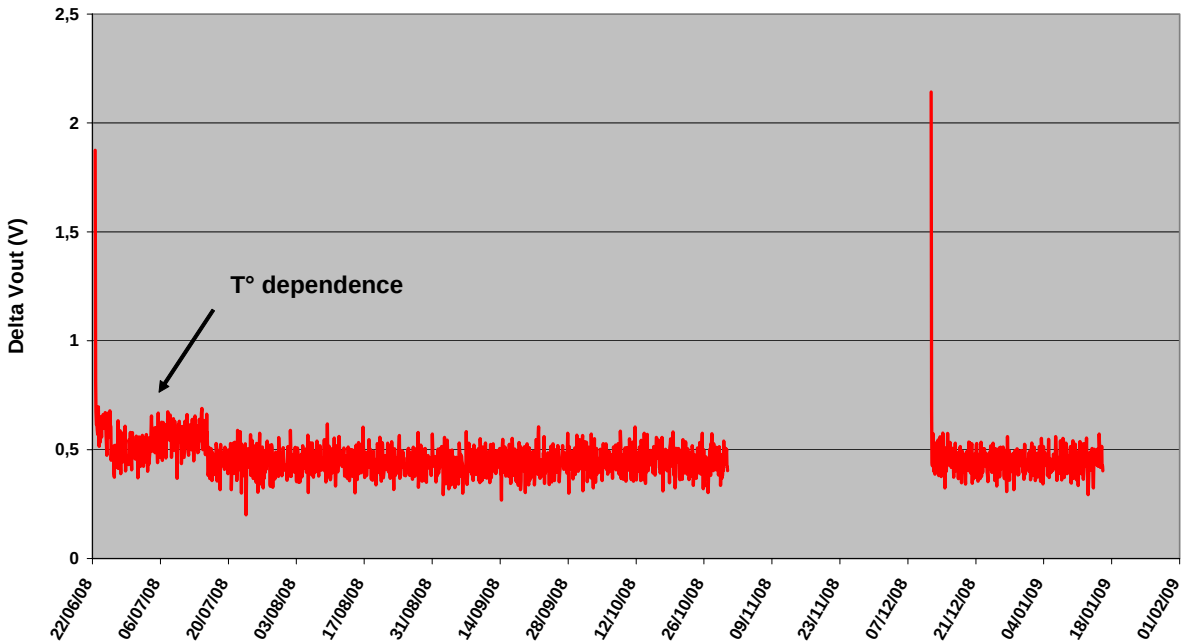
TID rate:
~200 Rad/month

MEX Dose monitoring section: In flight data after 7 months (2/2)

- **OSL monitor**:
  - Up to end 2008: reading period too short (2h)
  - When long (6 weeks): Saturation problem.
  - To be modified week 5 to find the best compromise.

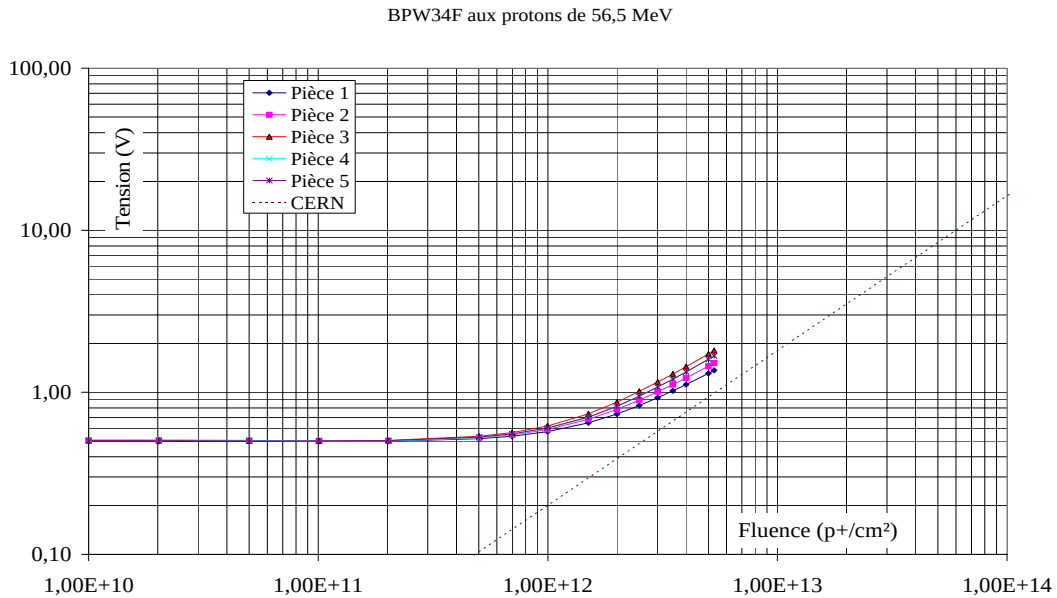


OSL monitor



Total Ionizing Dose and Displacement Damage Effects section (1/3).

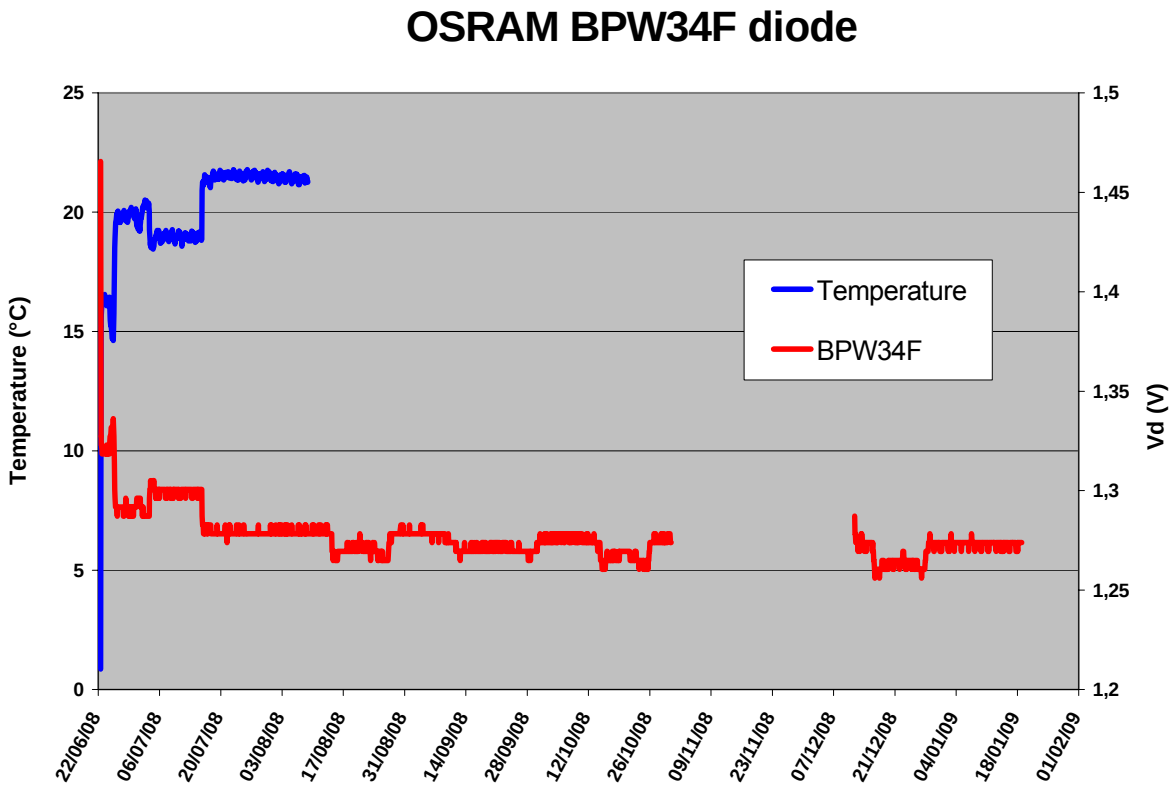
- **OSRAM BPW34F diode**
  - Sensitive to proton dose.
  - Used by CERN as dosimeter.
  - Linear response after a dose threshold => Pre-irradiated samples
  - High T° dependance



- **OSL LED is also sensitive do TID and DDD due to protons.**
  - Drift corrected by OSL system
  - Measurement possible.
  - High T° dependance

TID & DDE section (2/3): In flight data after 7 months .

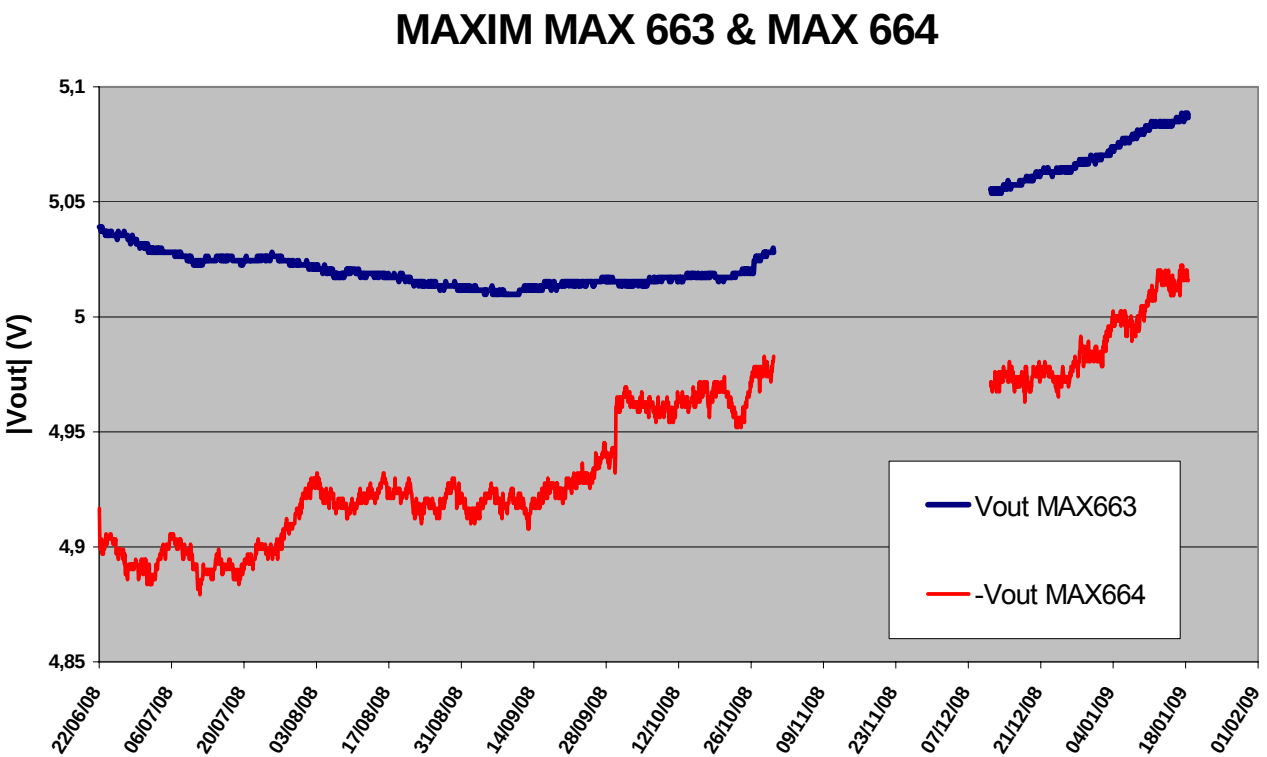
- **OSRAM BPW34F diode :**
- **OSL LED** *(same result)*

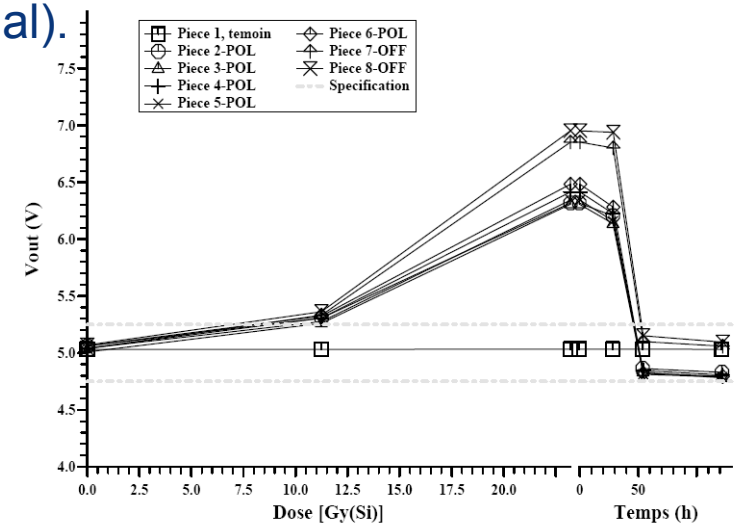


Temperature dependence confirmed
No significant drift up to now.

TID & DDE section (3/3): In flight data after 7 months .

- **MAXIM MAX663 and MAX664 regulators sensitive to TID.**
  - Tested with Co60 => TID level < 1kRad (Functional).
  - Critical parameter: Vout.





Only slight drift after 7 months (dose rate effect?)

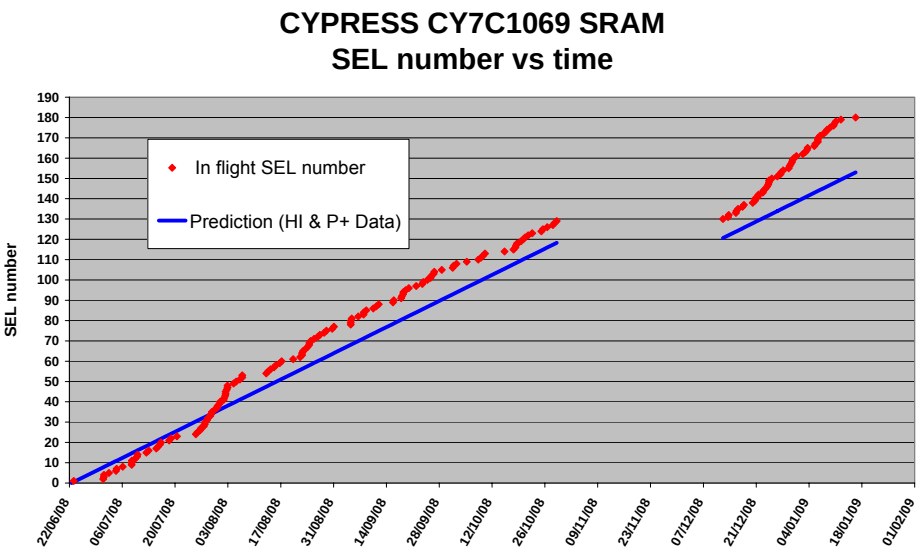
SEE section (1/5): tested devices & phenomena.

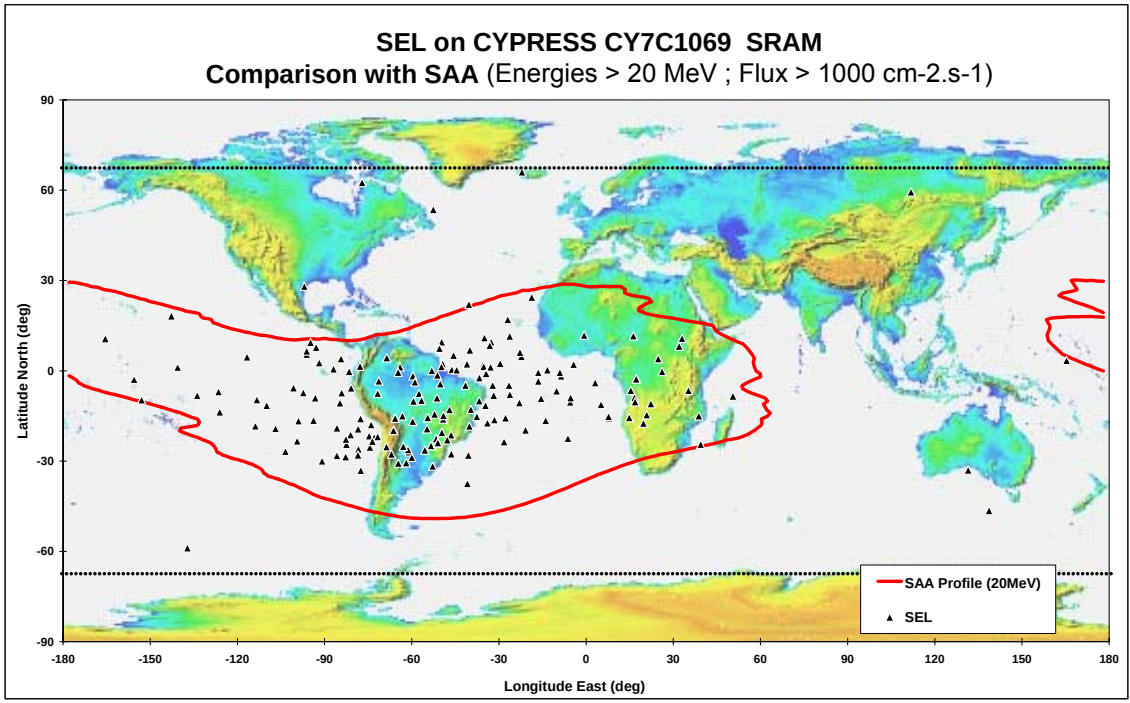
DUT	Function	Number of DUT per MEX	Tested SEE
HITACHI HM628512C	SRAM 512k*8	2	**SEU+SEL**
SAMSUNG KM6840000A	SRAM 512k*8	2	**SEU**+*SEL*
3D+ MMSR32001608S-C	SRAM 2M*16	1	**SEU**+*SEL*
SAMSUNG K7A81800M6	SSRAM 512k*16	1	**SEU**+*SEL*
IDT IDT71V3558S133PSI	SSRAM 512k*16	1	**SEU**+*SEL*
INFINEON HYB39S512800AT	SDRAM 64M*8	2	**SEU**+*SEL*
MICRON MTL48LC64M8A2	SDRAM 64M*8	2	**SEU**+*SEL*
3D+ MMSD08512408S-Y	SDRAM 512M*8	2	**SEU**+*SEL*
SAMSUNG K4S560432C	SDRAM 64M*4	2	**SEU**+*SEL*
SAMSUNG KM44V16004B	DDRAM 16M*4	2	**SEU**+*SEL*
CYPRESS CY7C1069	SRAM	1	**SEL**
INTERNATIONAL RECTIFIER IRF360	400V, N channel power MOSFET	4	**SEB**
TEXAS INSTRUMENTS LM124	Op amp	1	**SET**
NATIONAL SEMICONDUCTORS LM139	Voltage comparator	1	**SET**
ANALOG DEVICES OP470	Op amp	1	**SET+SEDR**

Only circled SEE data have been processed yet. SEU detection is working properly but gives a lot of data to be processed in the following months.

SEE section (2/5): SEL on CYPRESS CY7C1069 SRAM Ground vs in flight data

- Tested very sensitive under heavy ions and protons
- Predictions (OMERE V3.1, AP8, M=1)
  - Heavy Ions Rate = 0.39 SEL /device/day
  - Trapped Protons Rate=
    - 0.53 SEL /device/day (exp. Data)
    - 6.26 SEL /device/day (PROFIT)

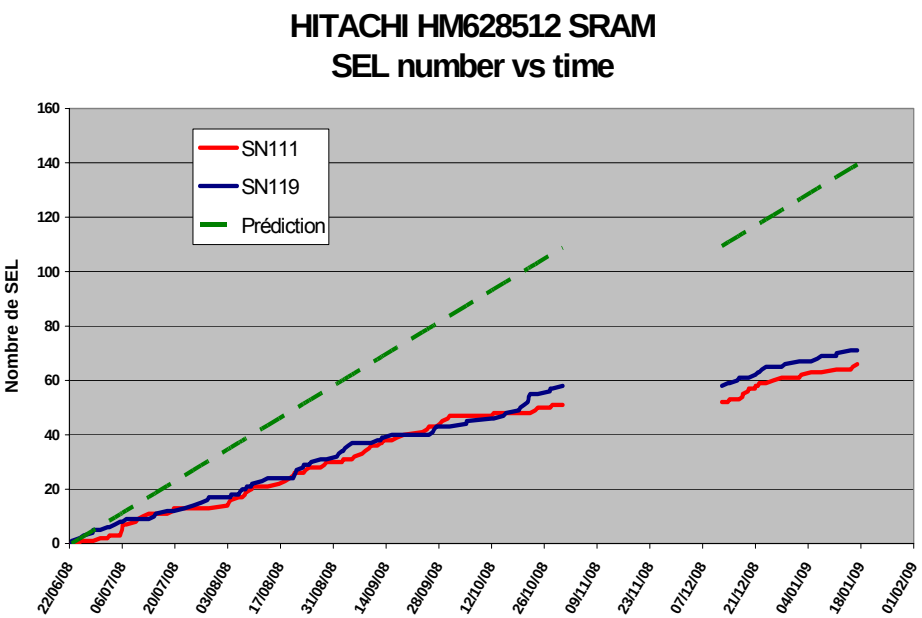


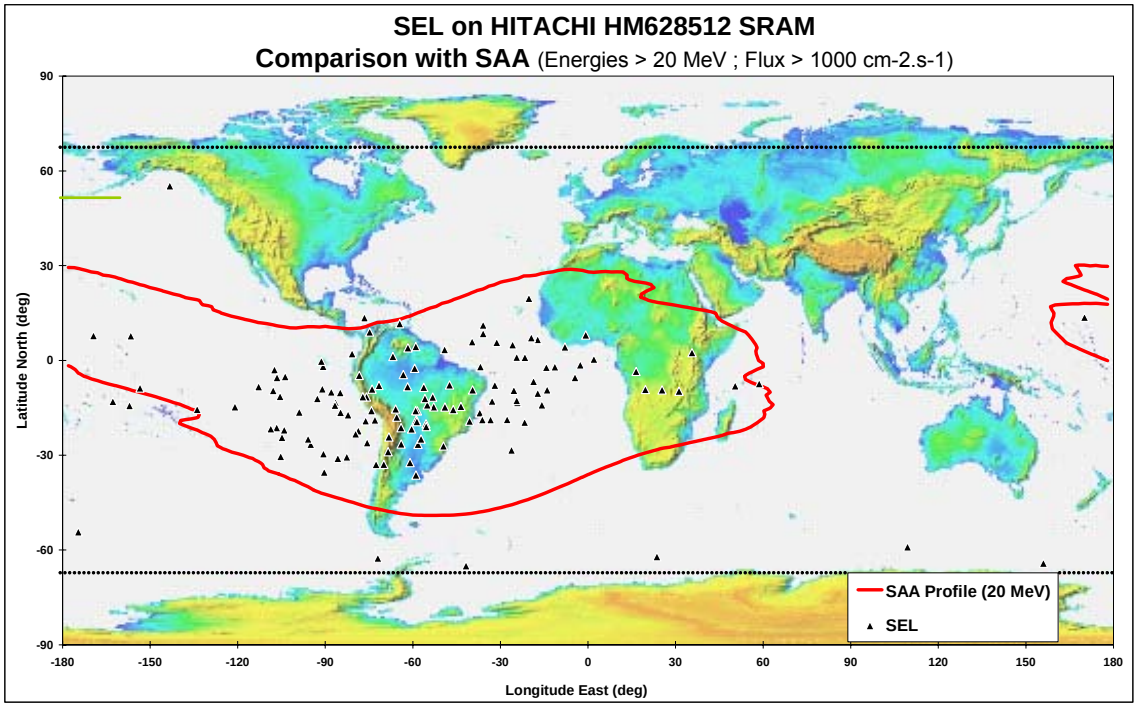


96% of SEL are in the SAA.
Prediction (exp. data) : underestimation (15%)
Prediction (PROFIT): Very conservative (x 6)

SEE section (3/5): SEL on HITACHI HM628512 SRAM Ground vs in flight data

- Tested very sensitive under heavy ions and protons
- Predictions (OMERE V3.1, AP8, M=1)
  - Heavy Ions Rate = 4.87E-2 SEL /device/day
  - Trapped Protons Rate=
    - 0.786 SEL /device/day (PROFIT)
    - P+ experimental data incomplete.

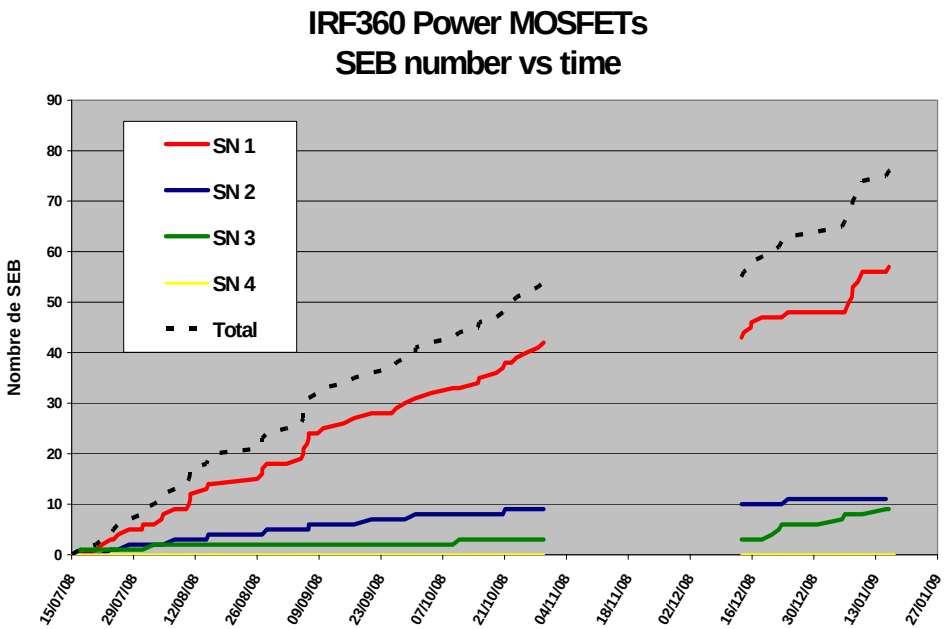


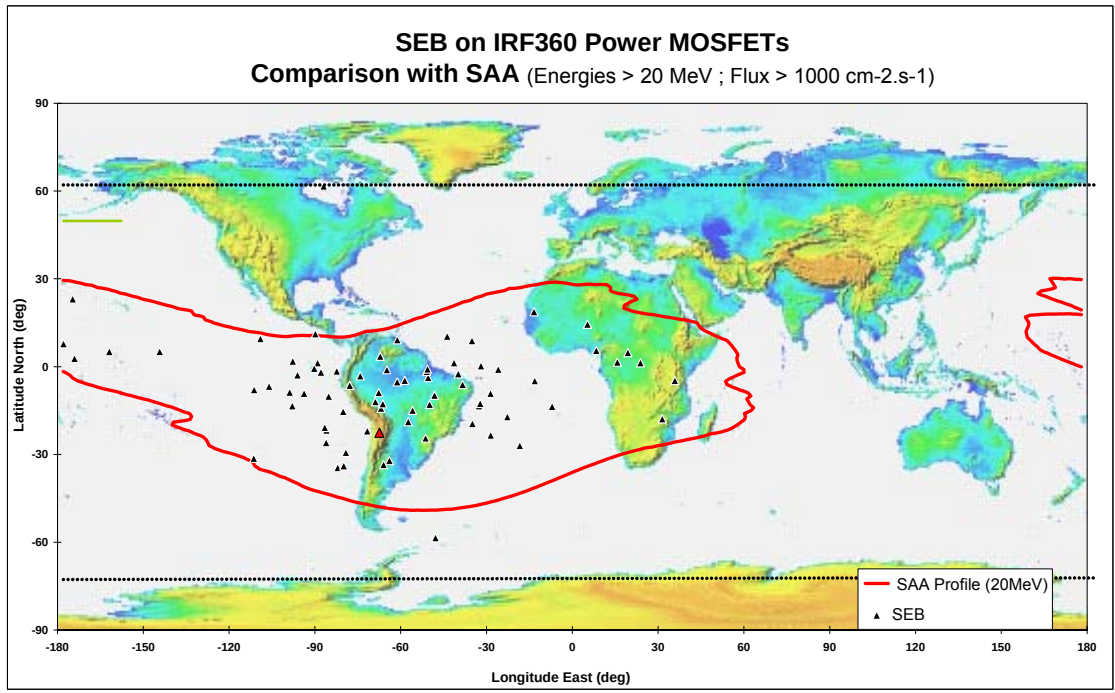


95% of SEL are in the SAA.
Prediction using PROFIT is conservative (x2)

SEE section (4/5): SEB on IRF360 Power MOSFETs

- Tested very sensitive when tested under heavy ions and protons:
  - Severe biasing conditions (Vds=80%Vdsmax & Vgs=0V)
  - SEB destructive when not protected.





97.5% of SEB are in the SAA.
Dispersion under investigation
TAS Prediction method to be applied.

SEE section (5/5): Other SEEs

- **SET:** After heavy ion testing, we should have observed a lot of SET due to protons (LETth<5MeV/(mg/cm²)). After 7 months, no SET has been detected on either LM124, LM139 or OP470. Proton tests are planned in S1/2009.

- **SEDR:** When tested under heavy ions, ADI OP470 shows destructive phenomena leading –Vcc<Vout<0V (see ASTRIUM results). In flight, after 7 months, no event has been detected in the same biasing condition.

- **SEL**: No SEL has been detected on other devices than CYPRESS and HITACHI SRAMs.

Conclusion & perspectives

- CARMEN2/MEX is in flight for 7 months
- A lot of data collected
- Very interesting ones on destructive SEE due to protons (SEL & SEB)
- No observation of predicted SET and SEDR on linear devices up to now
- Only slight drifts due to cumulative phenomena up to now.
- TSD PMOS dosimeters are operational: measured dose close to the prediction.
- OSL dosimeter is still in test phase.
- A lot of SEU data collected to be analysed in Q1/2009.
- These data will be completed by future acquisitions on both CARMEN1 & 2

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