Shielding geometry effect on SEE prediction using the new OMERE release: JASON-2 mission case study

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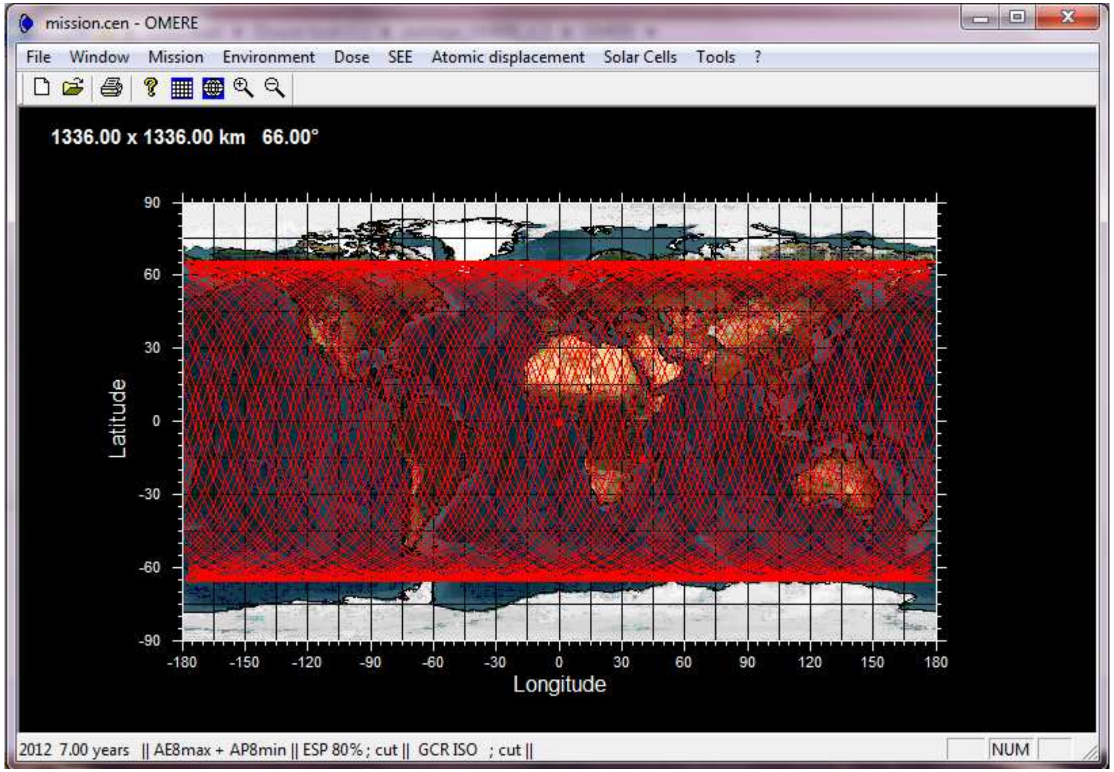
Outline

- **The project**
- **OMERE freeware**
- **JASON-2 radiation model**
- **Electronic Component data**
- **Results for:**
  - LEO mission
  - A hypothetical GEO mission
- **Conclusions**

The project

- Research and Technology study financed by the CNES.
- Goal: study the shielding effect of satellite geometry in the calculation of Single Event Effects for components aboard the JASON-2 satellite (1336 km, 66°).
- Validate new OMERE developments, co-financed by the CNES.

OMERE freeware

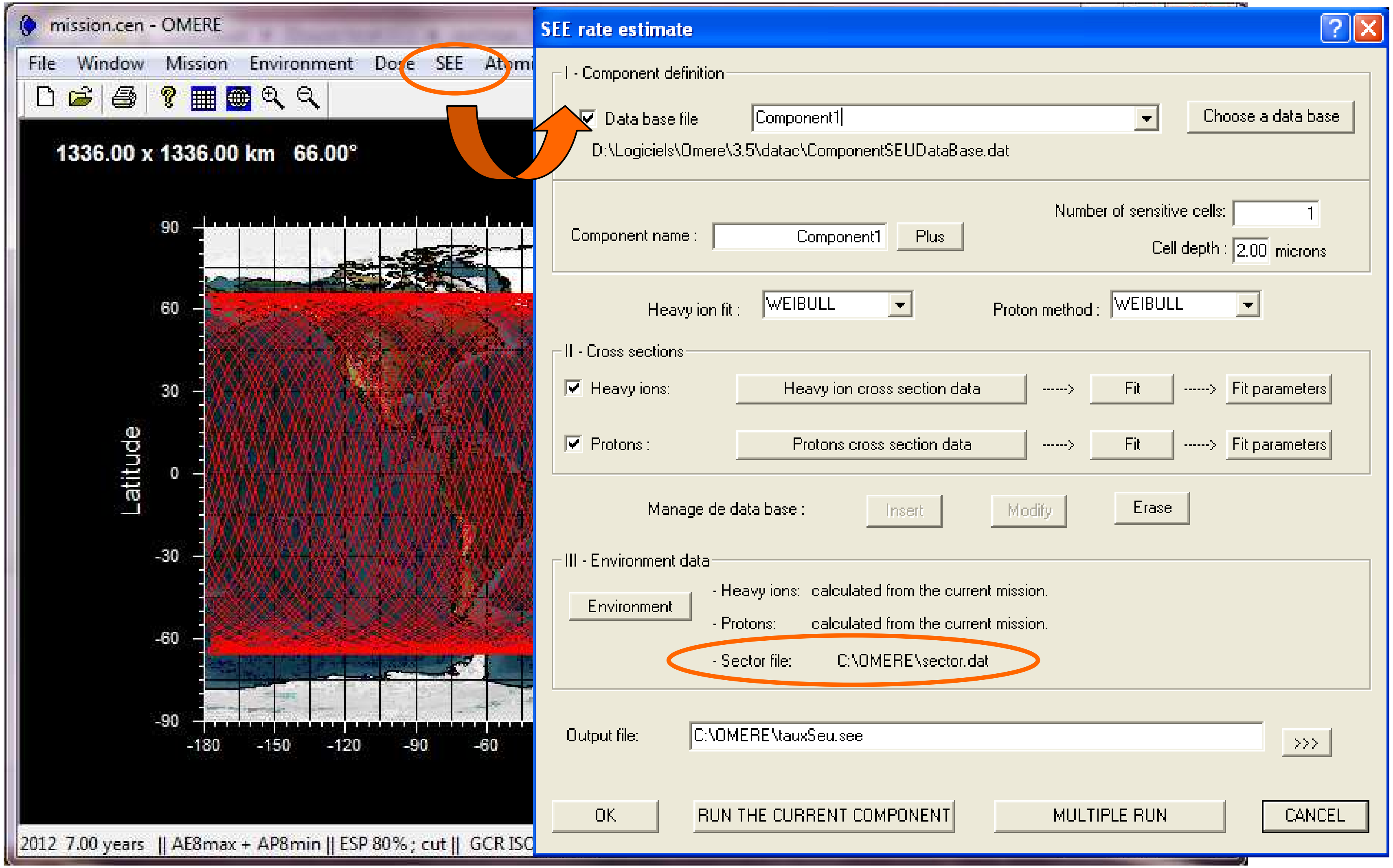


Download OMERE for free at
http://www.trad.fr/OMERE-Software.html

- Developed by the TRAD company with the support of CNES.
- A freeware dedicated to space environment and radiation effects on electronics.
- Strong engineering interest: an industrial, institutional and agency multi-partnership decides on the new modules to be added.

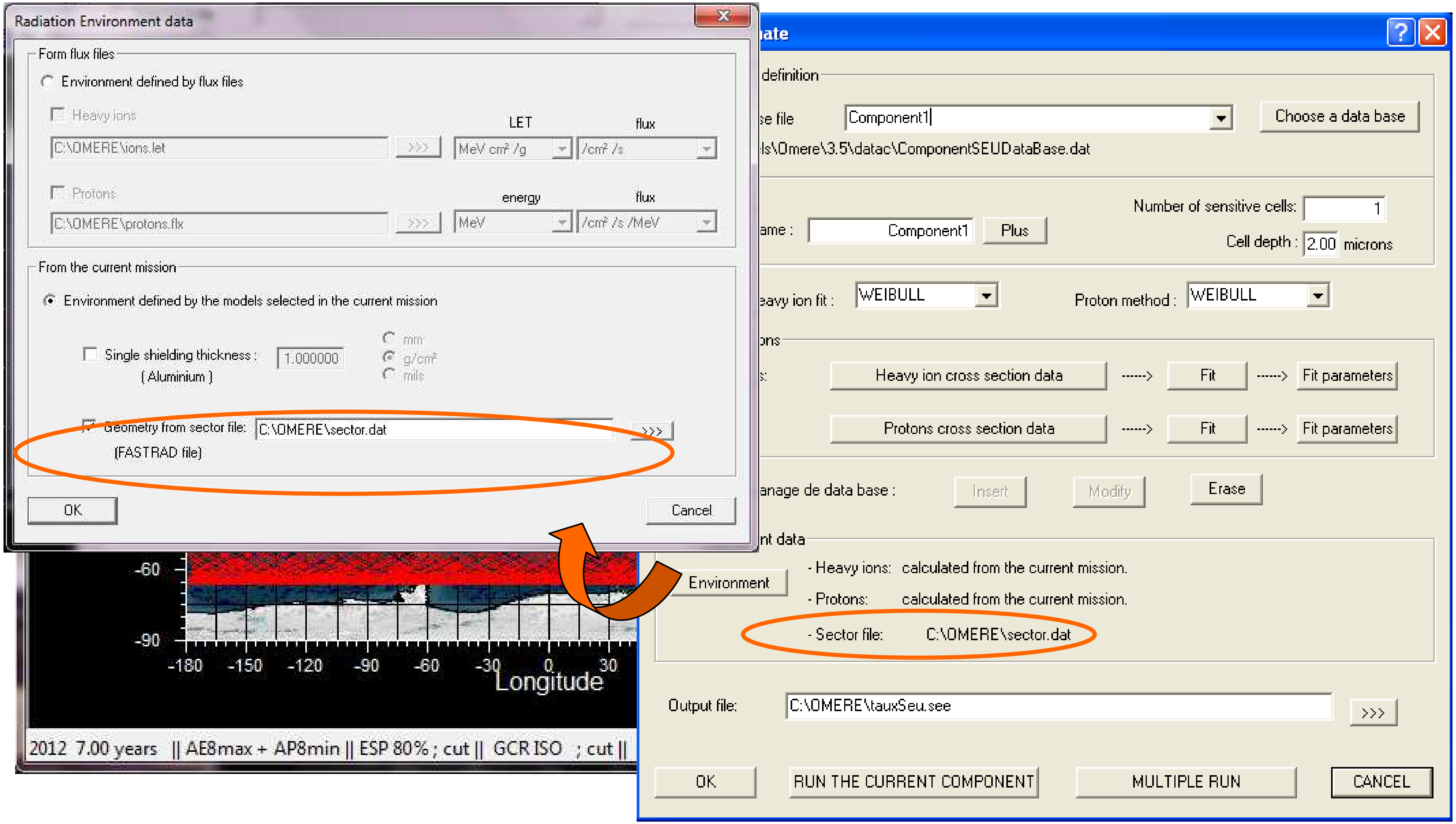
OMERE freeware

New module for SEE prediction behind a sector analysis geometry



OMERE freeware

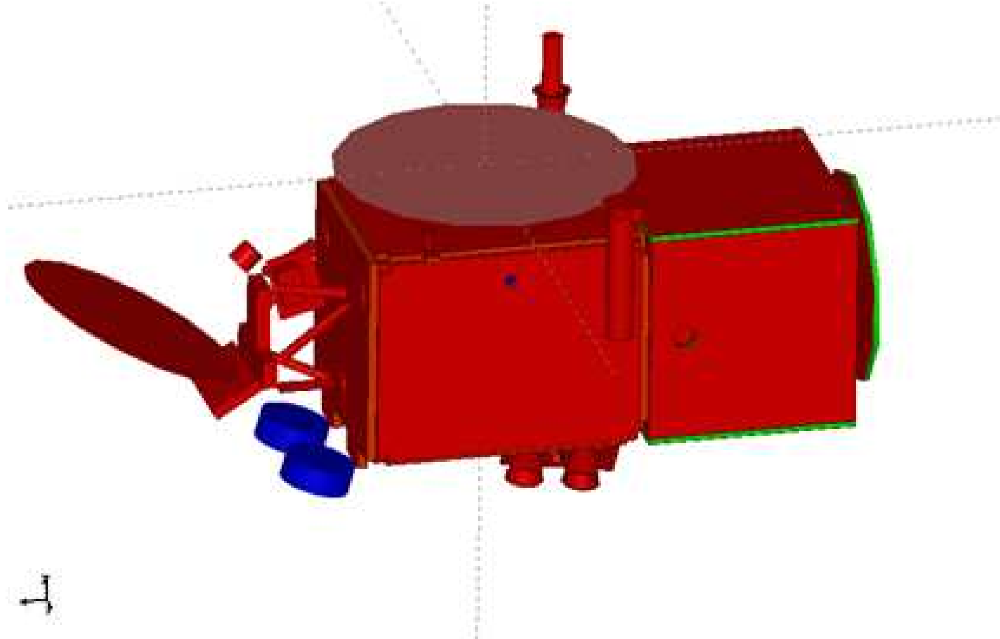
New module for SEE prediction behind a sector analysis geometry



JASON-2 radiation model

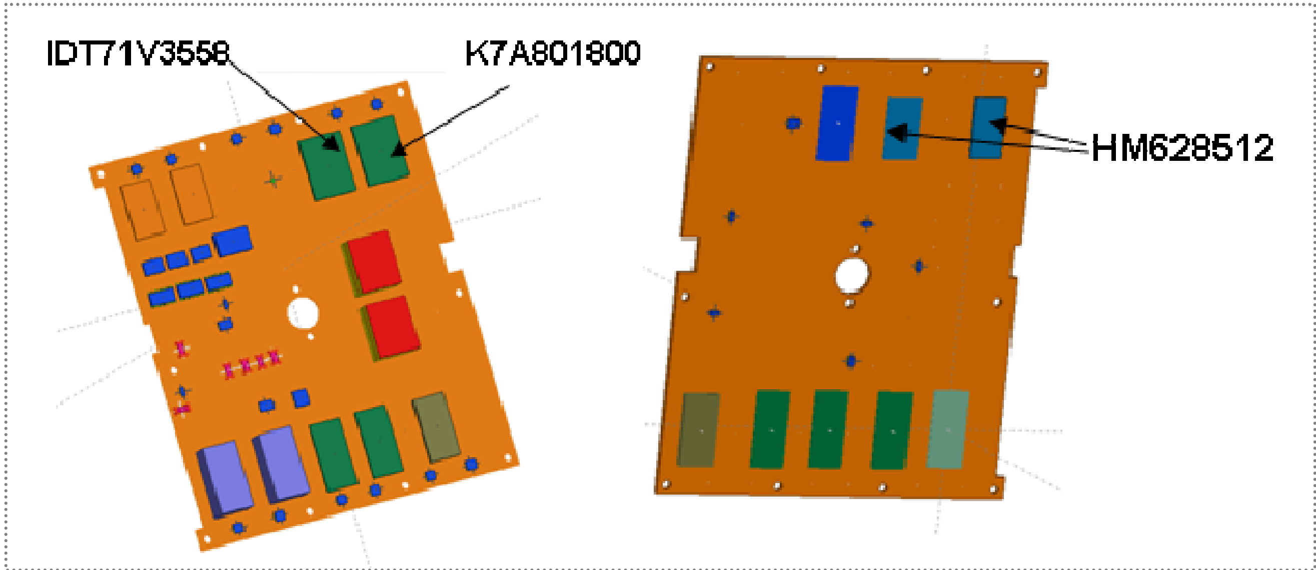
- JASON-2 : a CNES, NASA, EUMETSAT, NOAA collaboration
- Satellite developed by Thales Alenia Space

The complete satellite radiation model in FASTRAD® format was used for this study



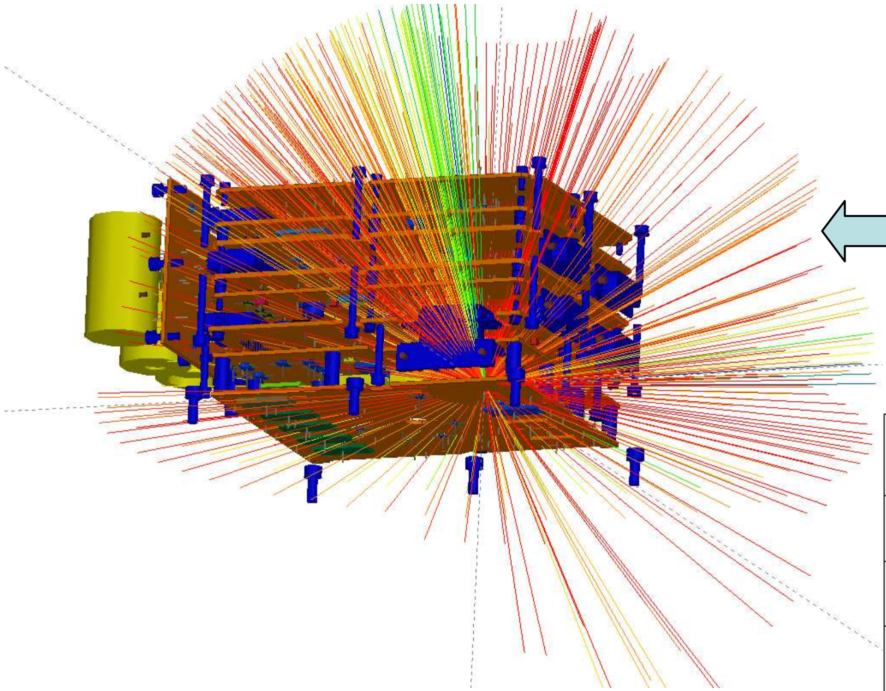
JASON-2 radiation model

Components are placed inside the ICARE-NG/CARMEN-2 equipment aboard JASON-2, a dedicated instrument to study space radiation and its effects on electronics.



JASON-2 radiation model

Ray tracing method: a detector is placed inside the die and shielding thicknesses crossed by 1800 rays drawn around the detector are calculated.



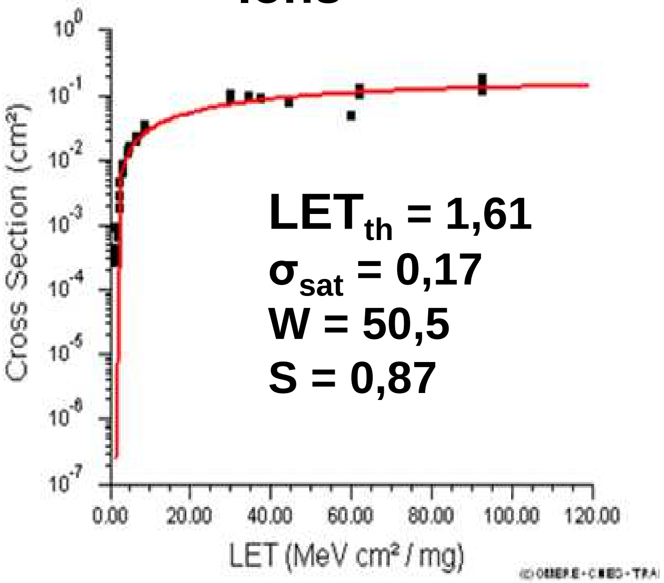
Rays crossing 40 to 170 mm around IDT71V3558

Part	Min thickness crossed (mm)	Max thickness crossed (mm)
IDT71V3558	5.5	257
K7A801800	5.5	170
HM628512 (x 2)	4.2	210 and 330

Electronic component data

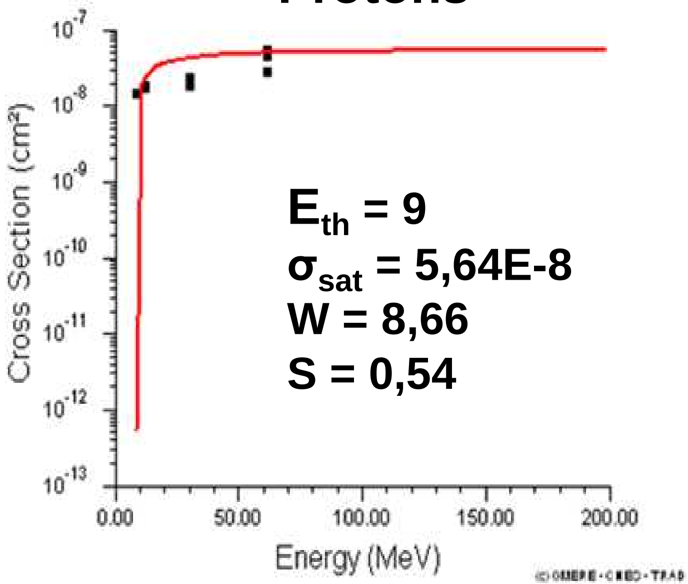
IDT IDT71V3558 SSRAM - SEU

Ions



LET_{th} = 1,61
σ_{sat} = 0,17
W = 50,5
S = 0,87

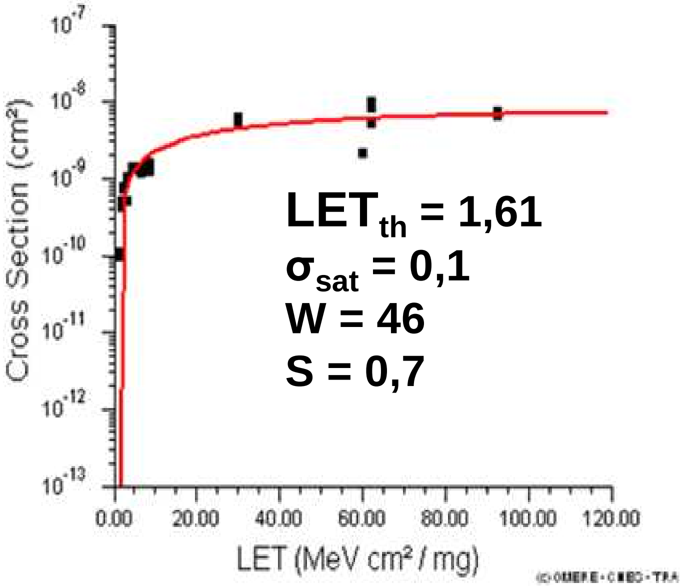
Protons



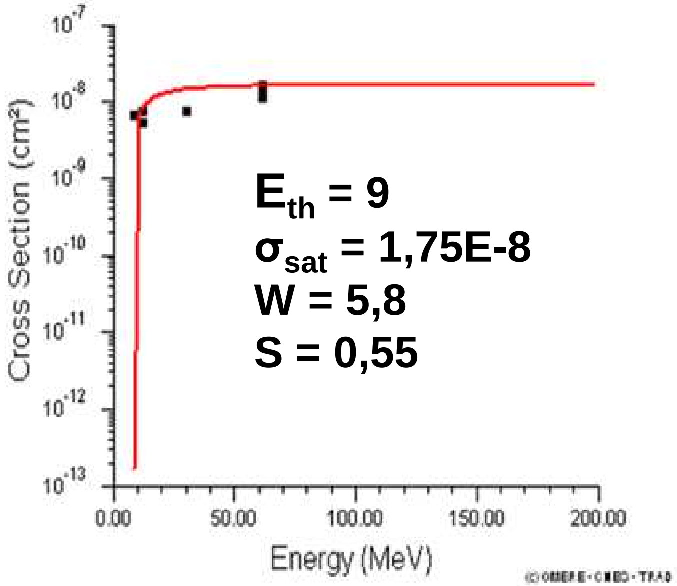
E_{th} = 9
σ_{sat} = 5,64E-8
W = 8,66
S = 0,54

Samsung K7A801800 SSRAM - SEU

Ions



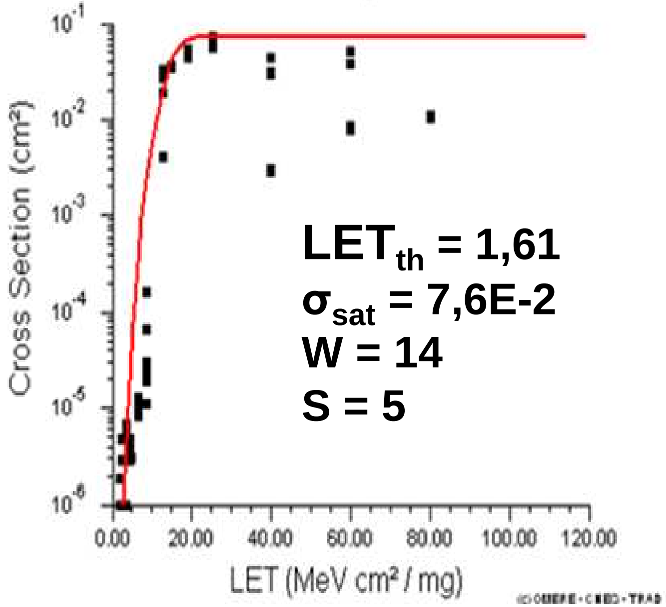
Protons



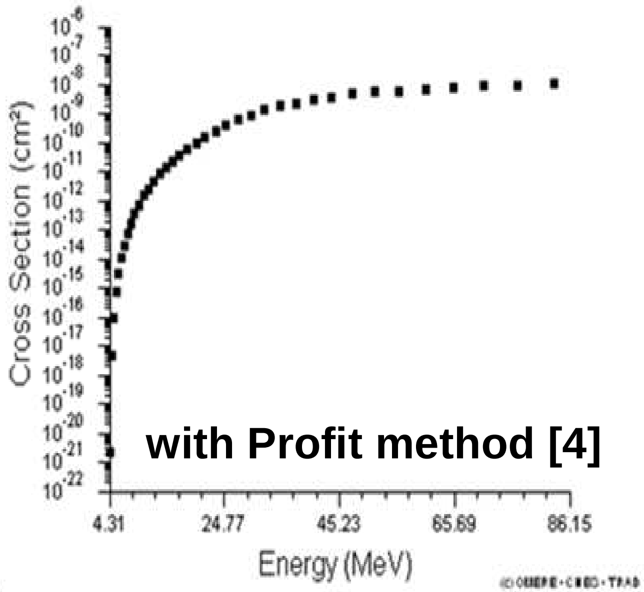
Electronic component data

Hitachi HM628512 SRAM - SEL

Ions



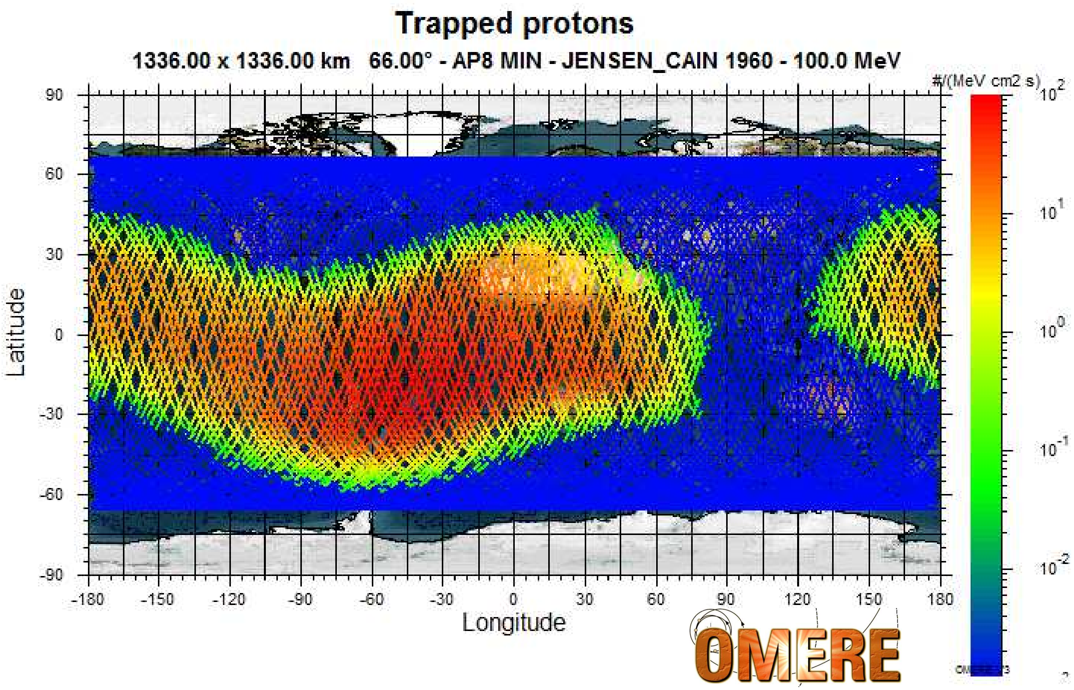
Protons



Results: LEO mission

- Radiation environment defined in OMERE
  - Trapped Protons: AP8 min
  - Solar Protons: ESP
  - Cosmic Rays: GCR ISO solar min

High energy trapped protons are the main environment component.



Results: LEO mission

Component	Effect	Rate prediction (/device/day)		Rate measured in-orbit (/device/day)
		Fixed shielding 1 g/cm^2	Sector file	
IDT IDT71V3558	SEU	3,6	2,1	2,5
Samsung K7A801800	SEU	1,2	0,75	0,4
Hitachi HM628512	SEL	0,71	0,46	0,41

Rates calculated with a fixed spherical shielding of 1 g/cm2 around the part are higher than the ones calculated with the sector file.

Prediction rates calculated with the sector file are in better agreement with the in-orbit measured rate.

Results: a hypothetical GEO mission

Radiation environment defined in OMERE

	Out-of-flare	In-flare
Trapped protons	AP8 min	AP8 min
Average Solar protons	ESP	--------
Solar flare ions and protons	---------	CREME96 worst day
Cosmic Rays	GCR ISO solar min	GCR ISO solar min

Results: a hypothetical GEO mission

Part	Out-of-flare (/device/day)			
	1 g/cm²		Sector file	
	ions	p+	ions	p+
IDT IDT71V3558	0,27	0,27	1,97E-2	7,52E-2
	Total: 0,54		**Total:** 0,0949	
Samsung K7A801800	0,15	8,43E-2	7,08E-2	2,39E-2
	Total: 0,23		**Total:** 0,0947	
Hitachi HM628512	0,21	2,3E-2	0,12	1E-2
	Total: 0,23		**Total:** 0,13	

For out-of-flare conditions: rates calculated with a fixed spherical shielding of 1 g/cm2 around the part are *2 to 6 times higher* than the ones calculated with the sector file.

Results: a hypothetical GEO mission

Part	Out-of-flare (/device/day)				In-flare (/device/day)			
	1 g/cm²		Sector file		1 g/cm²		Sector file	
	ions	p+	ions	p+	ions	p+	ions	p+
IDT IDT71V3558	0,27	0,27	1,97E-2	7,52E-2	57,3	100	2,64	21,6
	Total: 0,54		**Total:** 0,0949		**Total:** 157,3		**Total:** 24,24	
Samsung K7A801800	0,15	8,43E-2	7,08E-2	2,39E-2	36,3	34,3	1,69	7,36
	Total: 0,23		**Total:** 0,0947		**Total:** 70,6		**Total:** 9,05	
Hitachi HM628512	0,21	2,3E-2	0,12	1E-2	89,6	8,15	8,21	3,1
	Total: 0,23		**Total:** 0,13		**Total:** 97,75		**Total:** 11,31	

For out-of-flare conditions: rates calculated with a fixed spherical shielding of 1 g/cm2 around the part are *2 to 6 times higher* than the ones calculated with the sector file.

For in-flare conditions: rates calculated with a fixed spherical shielding of 1 g/cm2 around the part are *7 to 9 times higher* than the ones calculated with the sector file.

Conclusions

- The shielding of the satellite structure and on-board equipment can have a great impact on predicted SEE rates.
- Predictions using a fixed shielding thickness of 1 g/cm2 overestimate SEE rates since the shielding thickness crossed by proton and ion trajectories is higher.
- The effect is more important for solar ion event induced SEE.
- High energy (>100 MeV) proton fluxes observed at the JASON-2 low earth orbit are little affected by the shielding.
- Errors due to bad Weibull fit definition can be of the same order or greater than the ones presented here [Sukhaseum et al., 2011].

Perspectives

- Similar calculations will be performed, on a different orbit and radiation environment, for polar orbit SAC-D mission (launched in June 2011) that accommodates CARMEN-1, a similar equipment as the one placed aboard JASON-2.

- CARMEN equipment at GEO?

Publication

Poster at RADECS 2011:

Shielding Geometry Effect on SEE Prediction Using the New OMERE Release: JASON-2 Mission Case Study, by A. Varotsou, N. Chatry, P-F. Peyrard, F. Bezerra, A. Samaras, E. Lorfèvre and R. Ecoffet