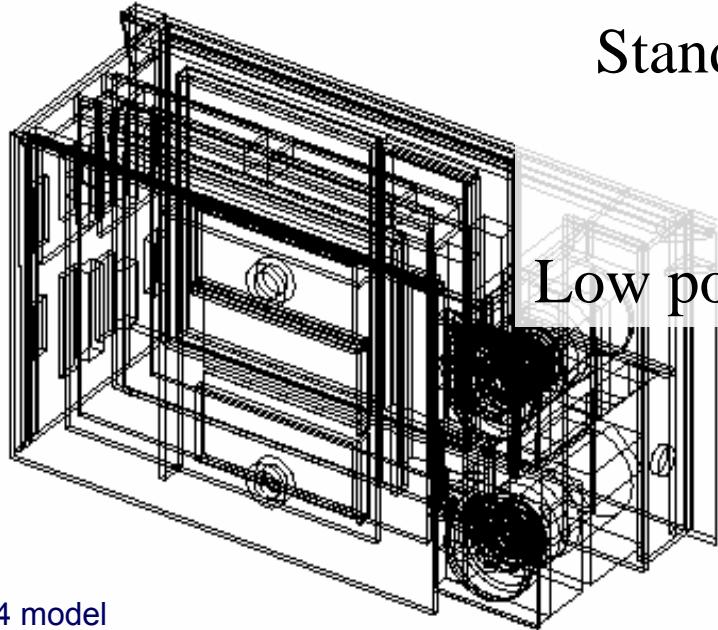


ESA Radiation Monitors

On-going and Planned Activities

Hugh Evans, Eamonn Daly, Ali Mohammadzadeh, Petteri Nieminen
ESA/ESTEC

ESA Standard Radiation Environment Monitor (SREM)

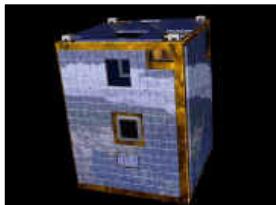


SREM
Geant4 model

Standard interfacing
Low cost
Low mass
Low power requirements



Contraves Space



PROBA-1
2001



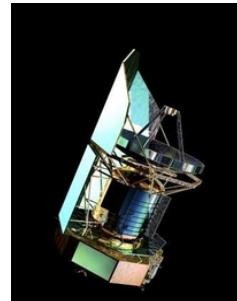
INTEGRAL
2002



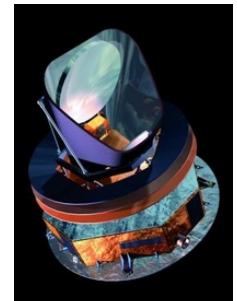
ROSETTA
2004



GIOVE-B
2006



HERSCHEL
2008



PLANCK
2008

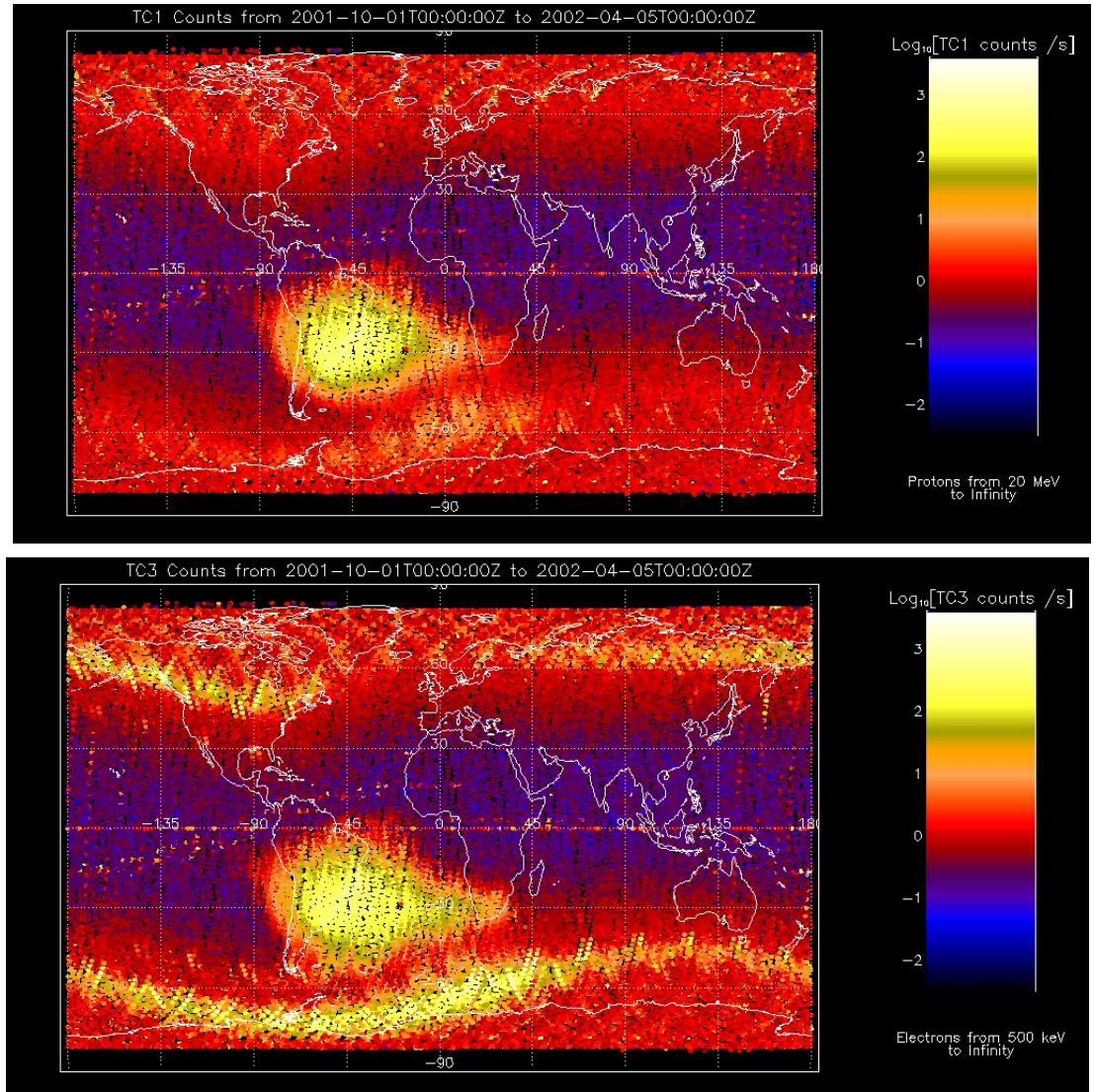
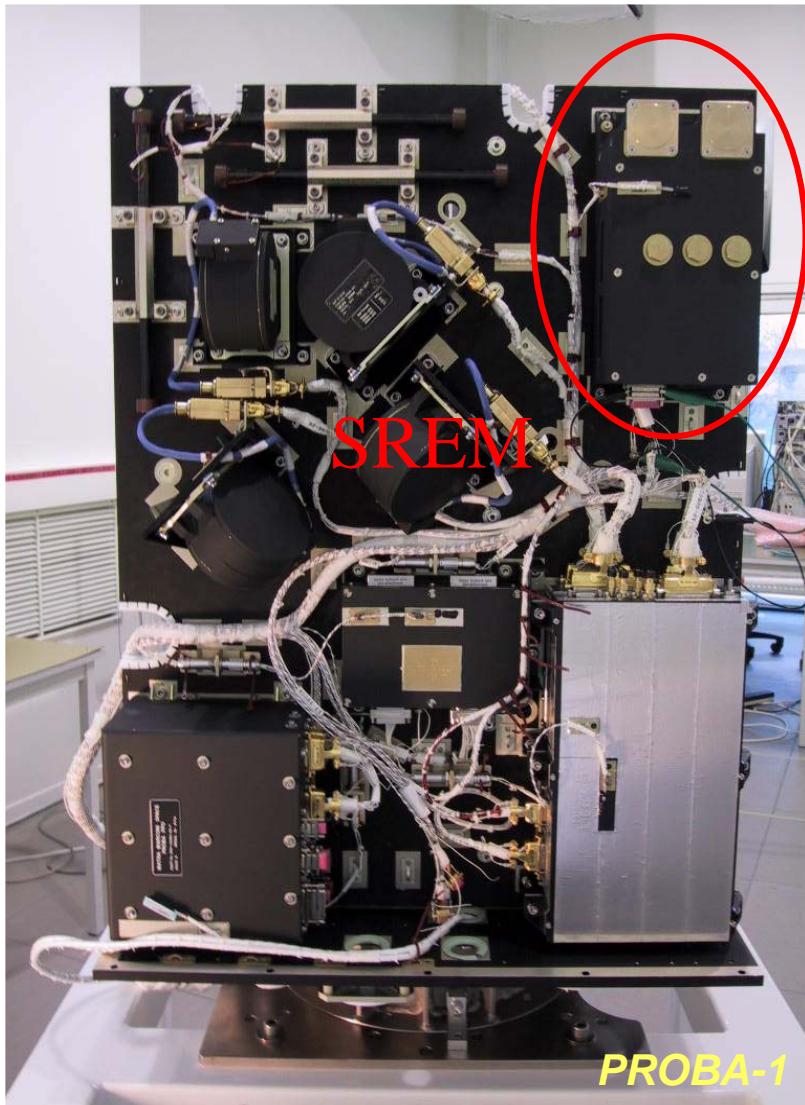


GAIA
2011

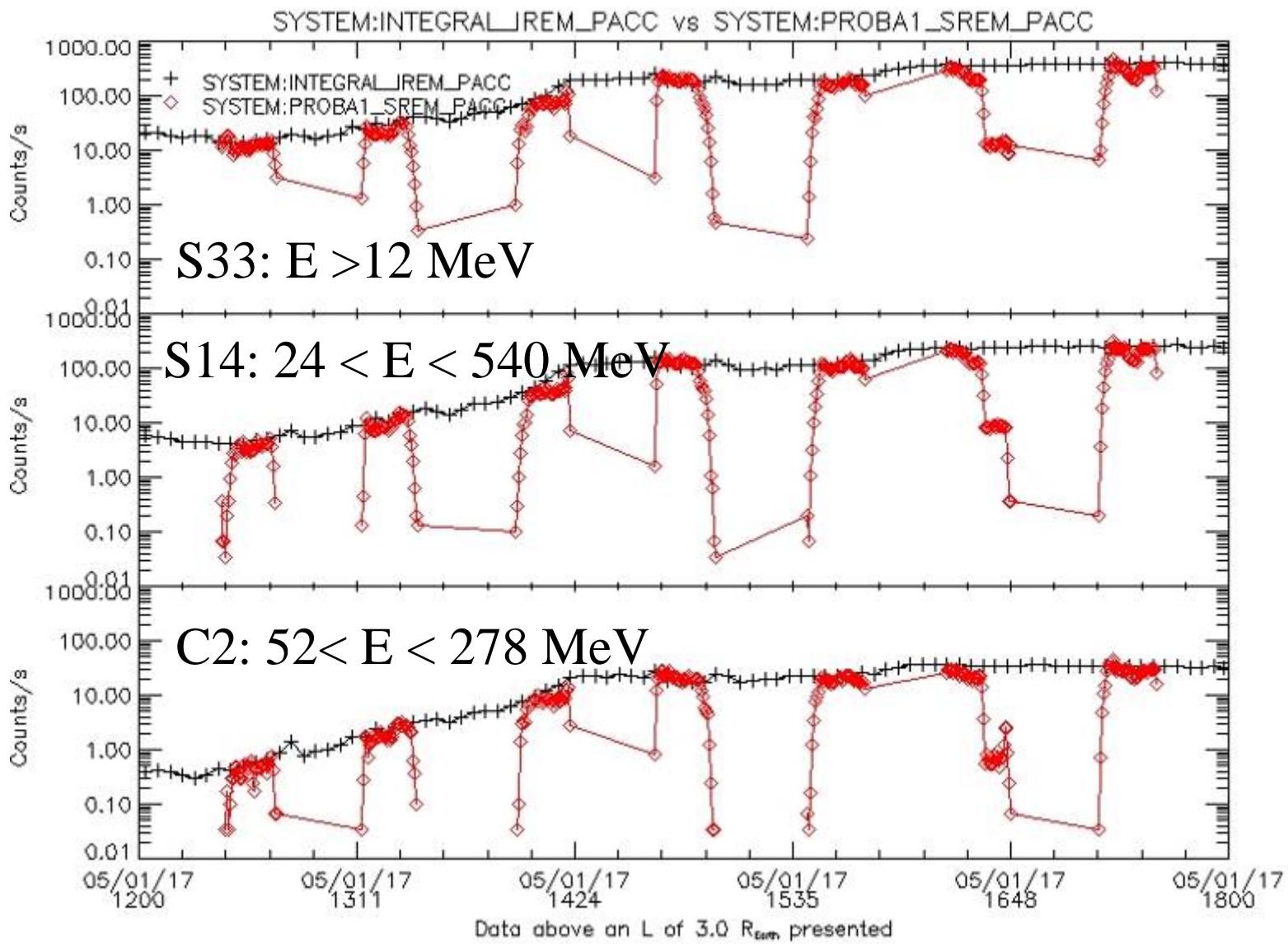
SREM energy binning

	Logic	dE discr. level [MeV]	Particle	E min [MeV]	E max [MeV]
1.	D1/TC1	0.085	Proton Electron	20 2	Inf. Inf.
2.	D1 /S12	0.25	Proton	20	550
3.	D1/S13	0.6	Proton	20	120
4.	D1/S14	2	Proton	20	27
5.	D1/S15	30	Proton	20	34
6.	D2/TC2	0.085	Proton	39	Inf.
7.	D2/S25	9	Ions	150	185
8.	D1*D2/C1	0.6, 2	Proton coincidence	40	50
9.	D1*D2/C2	0.6, 1.1-2.0	Proton coincidence	50	70
10.	D1*D2/C3	0.6, 0.6-1.1	Proton coincidence	70	120
11.	D1*D2/C4	0.085-0.6, 0.085-0.6	Proton coincidence	130	Inf.
12.	D3/TC3	0.085	Electron Proton	0.5 10	Inf.
13.	D3/S32	0.25	Electron	0.55	2.3
14.	D3/S33	0.75	Proton	11	90
15.	D3/S34	2	Proton	11	30

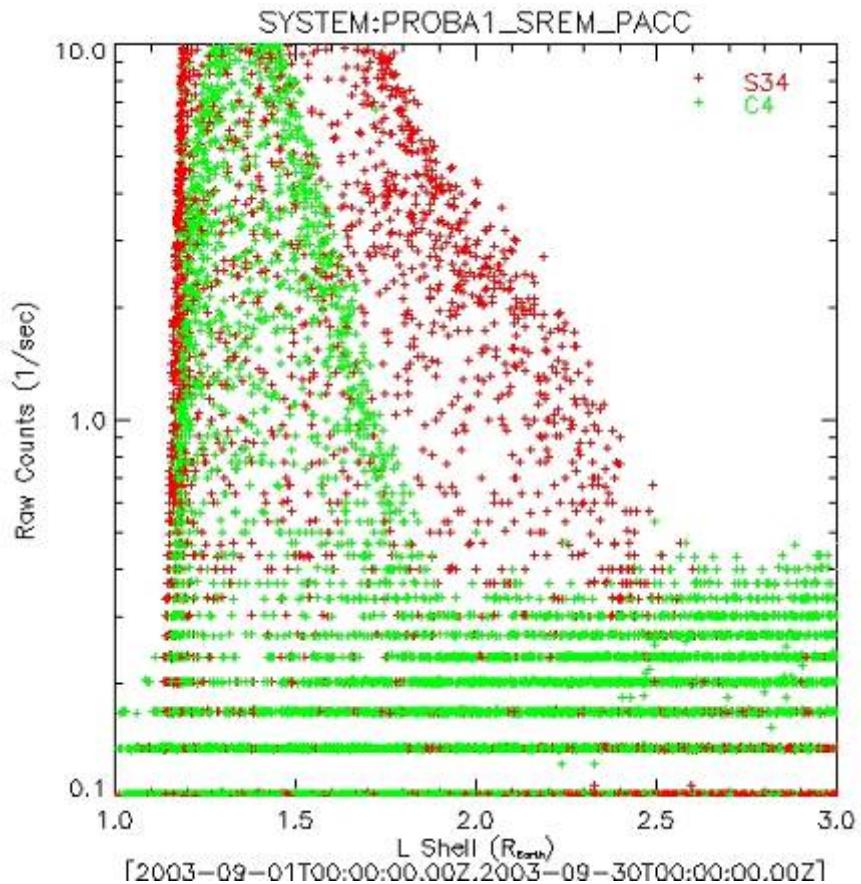
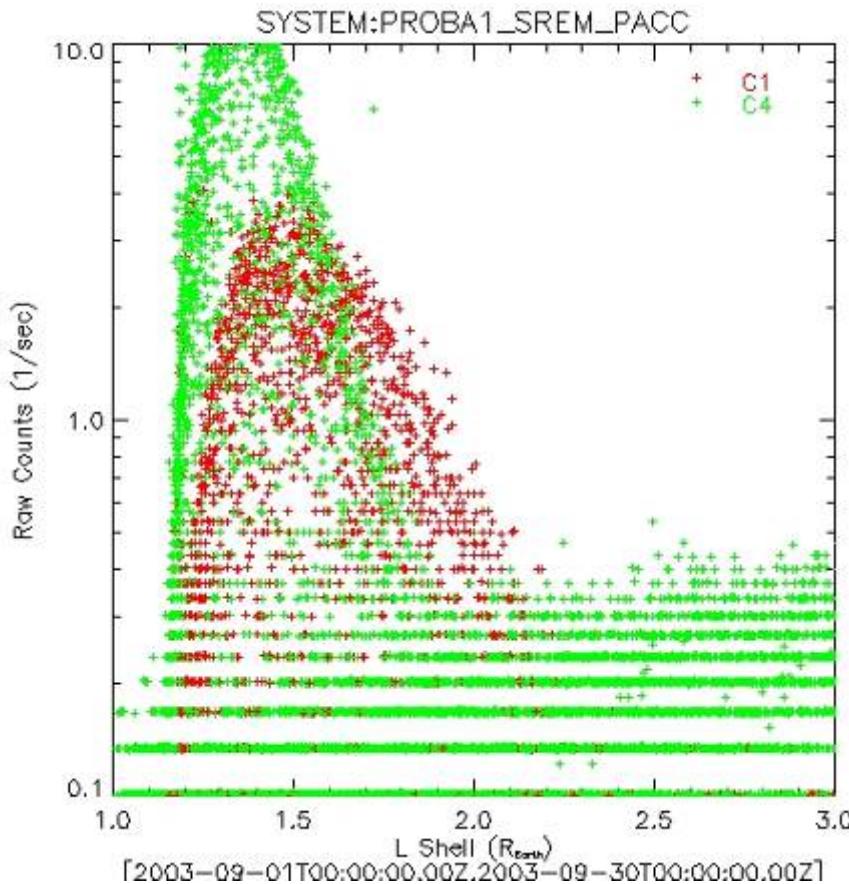
SREM on PROBA-1 (LEO)



Geomagnetic Shielding

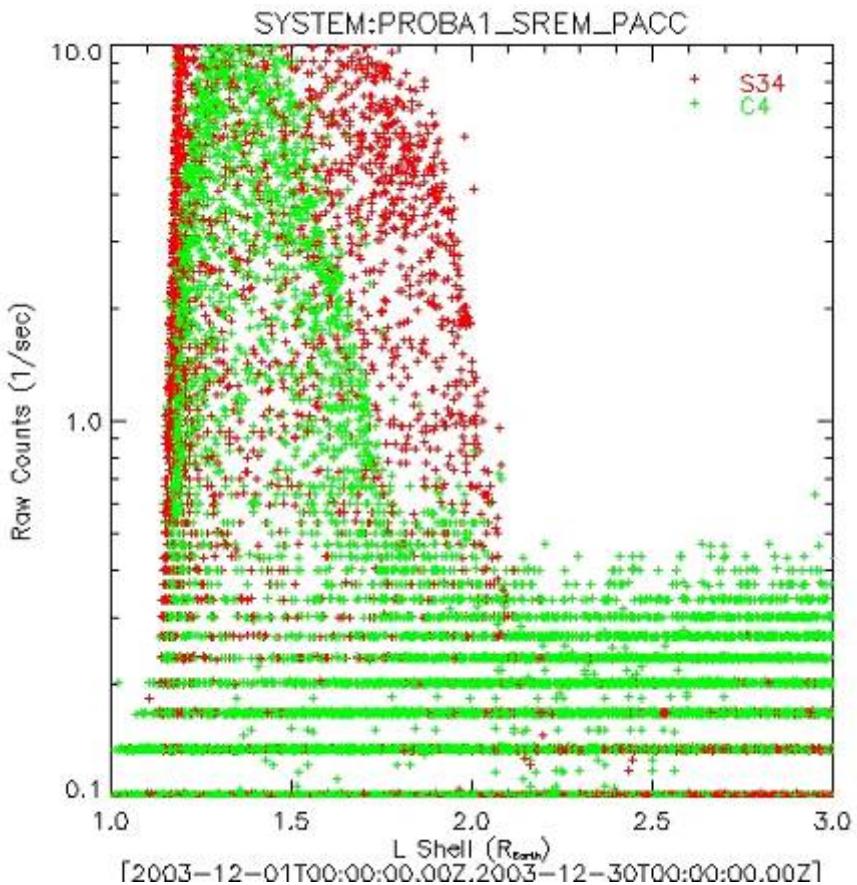
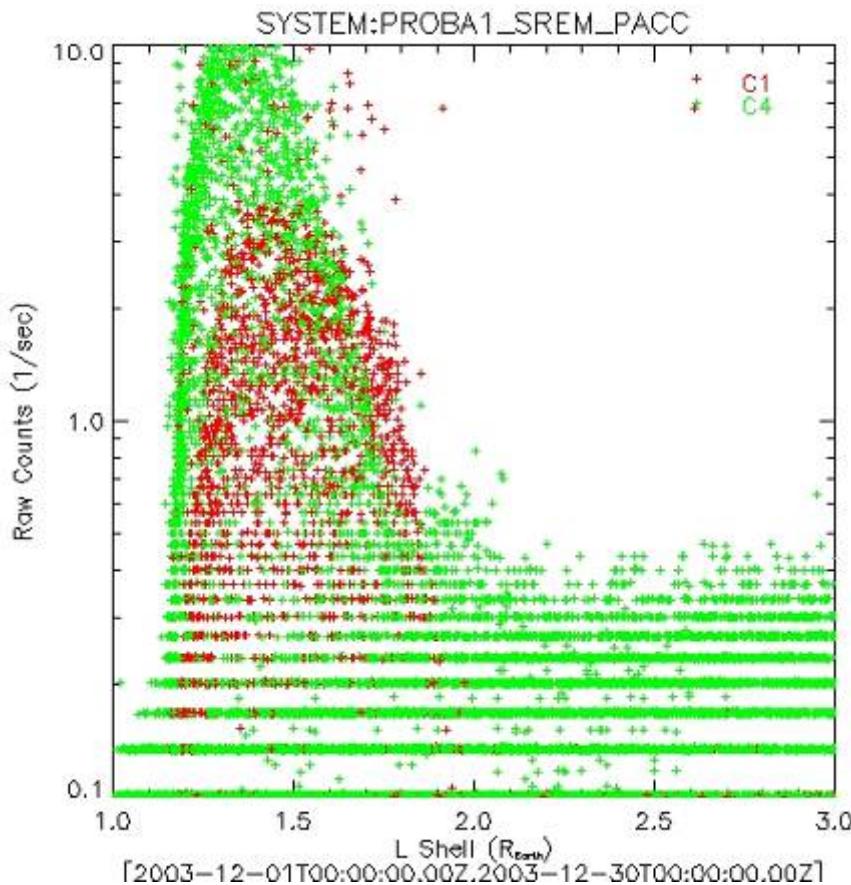


p⁺ Radiation Belt Month Before Storm



C1:	$43 \text{ MeV} < p^+ < 86 \text{ MeV}$
S34:	$p^+ > 12 \text{ MeV}$
	$e^- > 2 \text{ MeV}$

p⁺ Radiation Belt Month After Storm

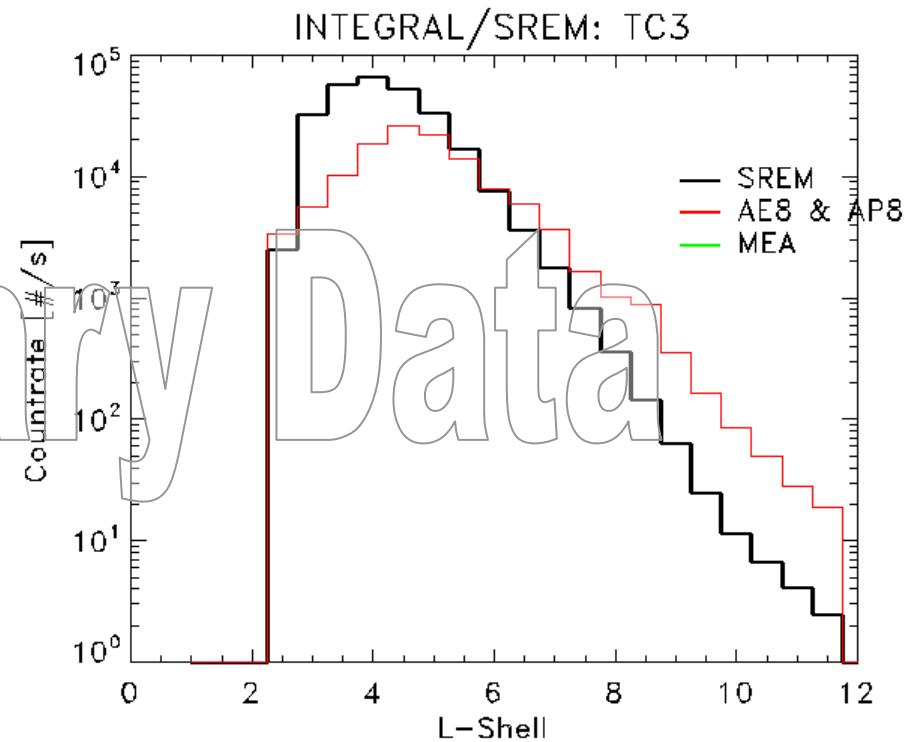
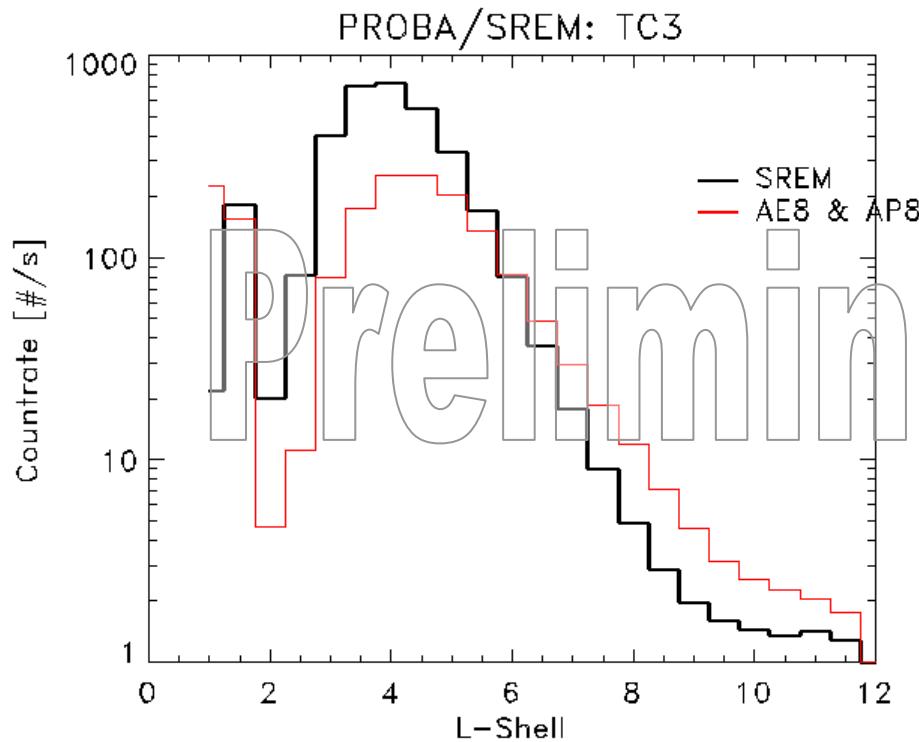
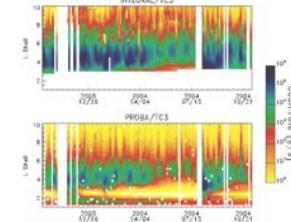


C1:	$43 \text{ MeV} < p^+ < 86 \text{ MeV}$
S34:	$p^+ > 12 \text{ MeV}$
	$e^- > 2 \text{ MeV}$

Comparison to AE8 & AP8

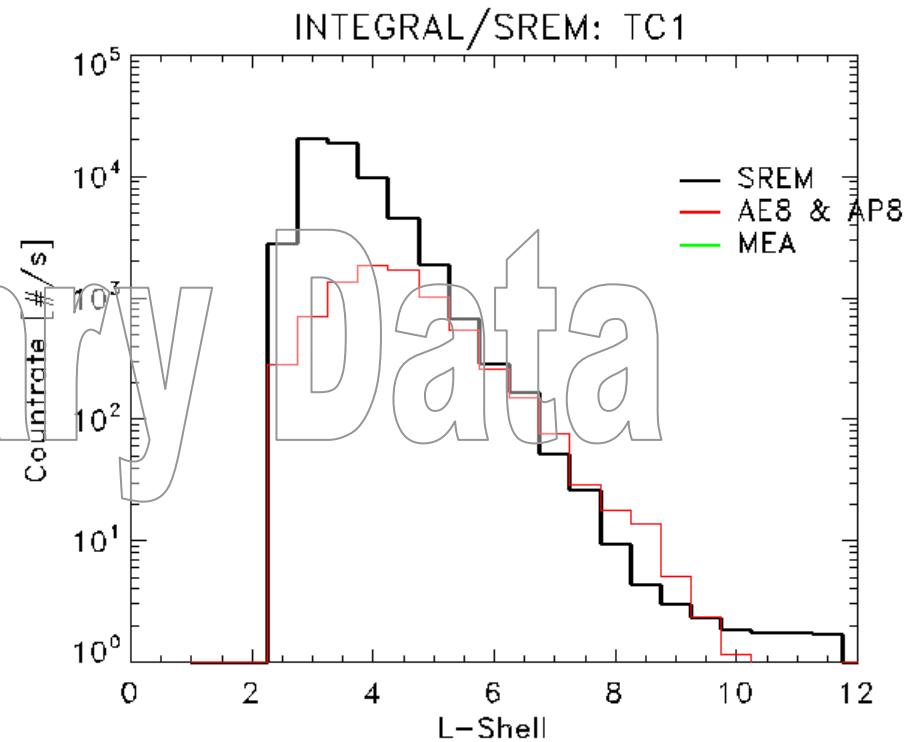
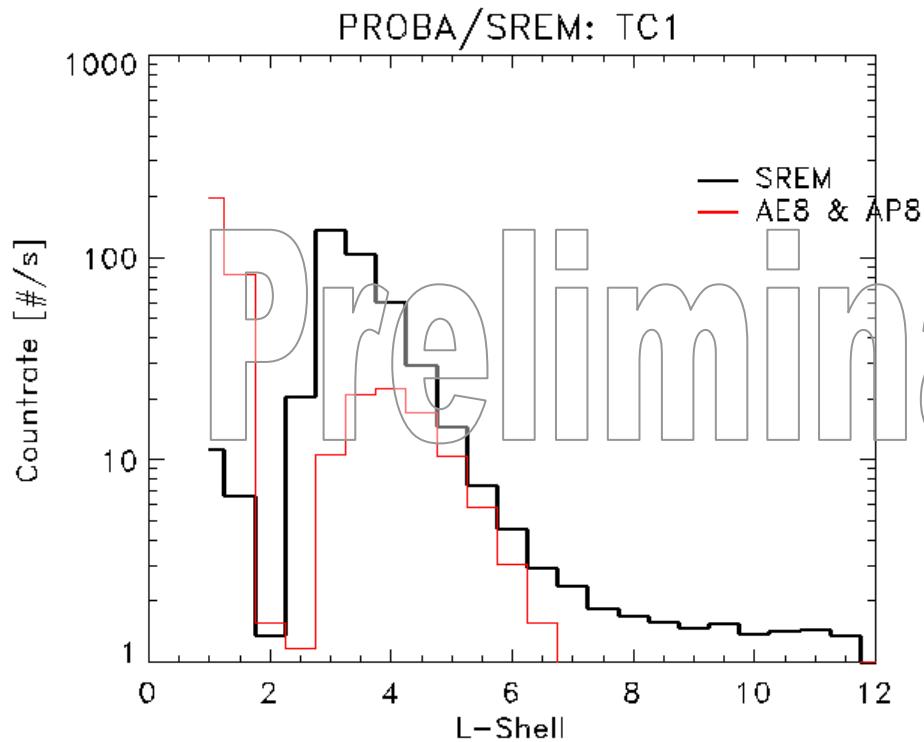
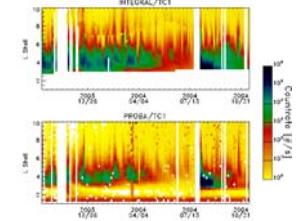
TC3: $e^- > 0.8$ MeV;

$p^+ > 10$ MeV



Data from 27/9/2003 -> 11/11/2004; Smart-1 radiation belt encounter

Comparison to AE8 & AP8

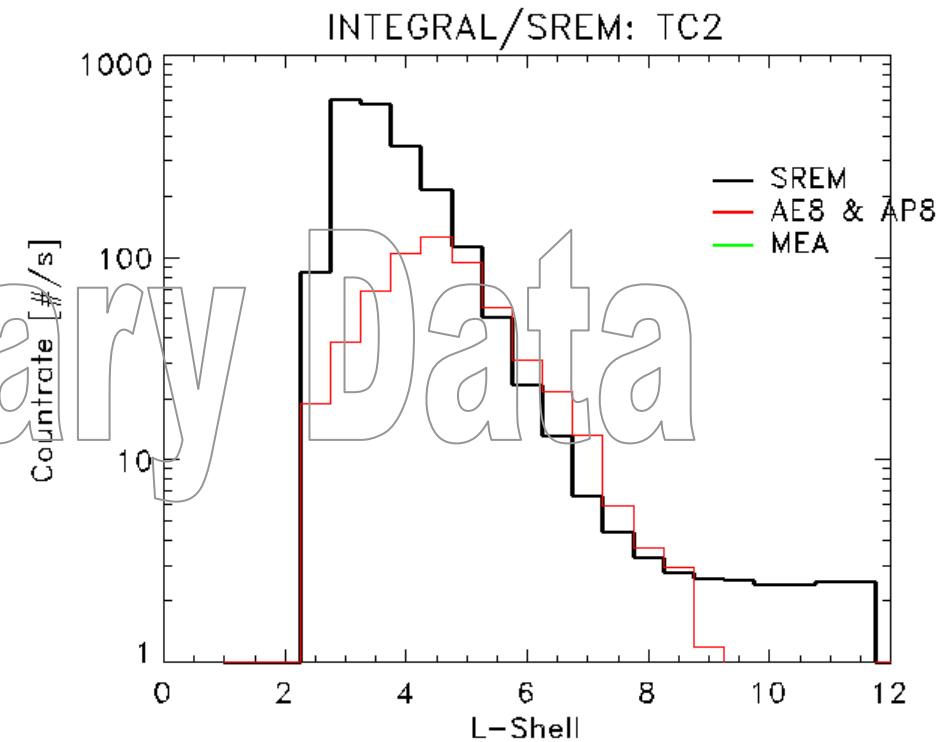
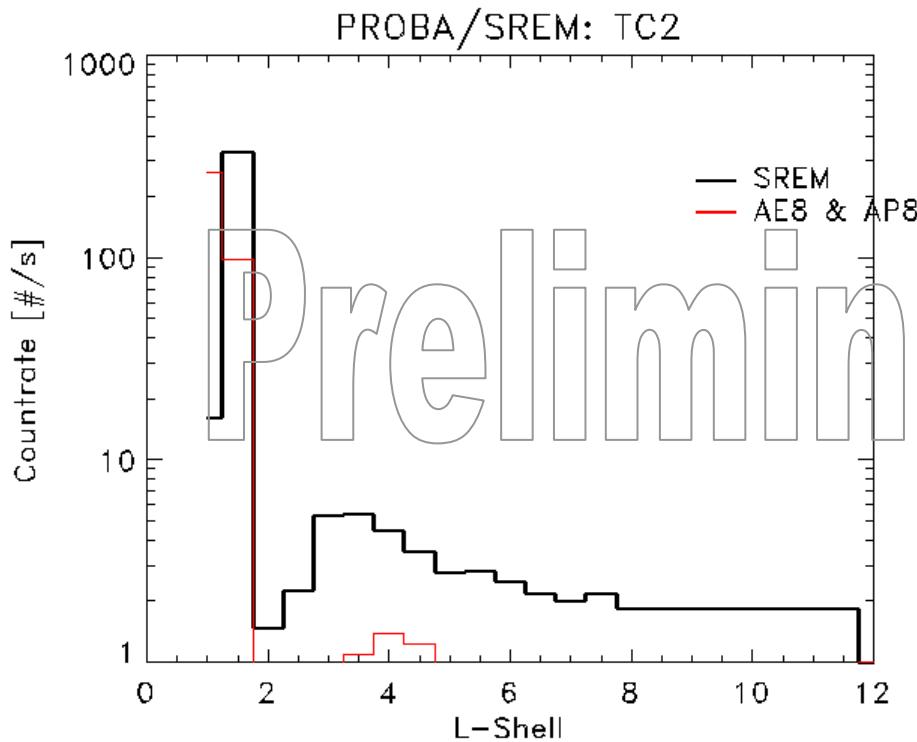
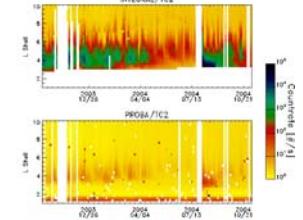
TC1: $e^- > 2$ MeV; $p^+ > 27$ MeV

Data from 27/9/2003 -> 11/11/2004; Smart-1 radiation belt encounter

Comparison to AE8 & AP8

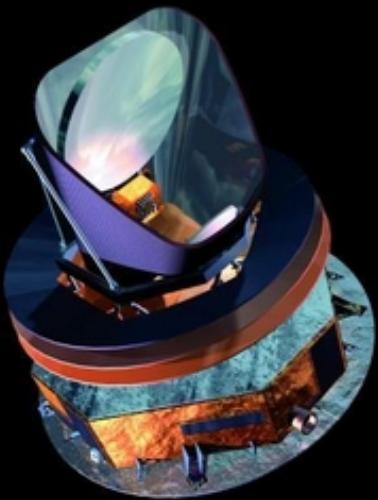
TC2: $e^- > 2.8 \text{ MeV}$;

$p^+ > 49 \text{ MeV}$

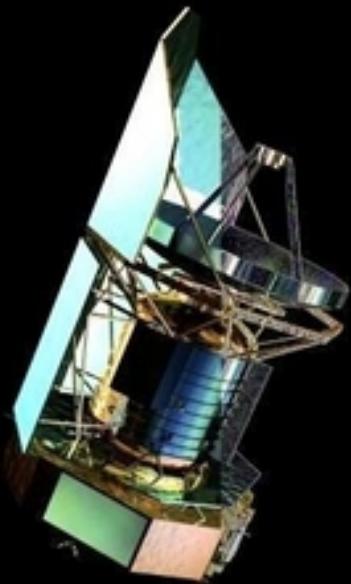


Data from 27/9/2003 -> 11/11/2004; Smart-1 radiation belt encounter

L2 Science Missions



Planck 2008, SREM



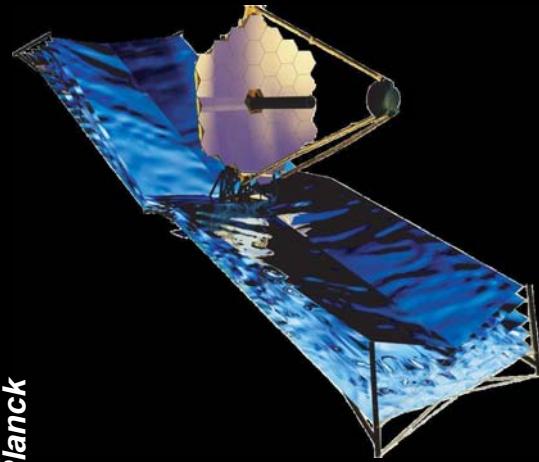
Herschel 2008, SREM



© NASA WMAP



Launch Earth

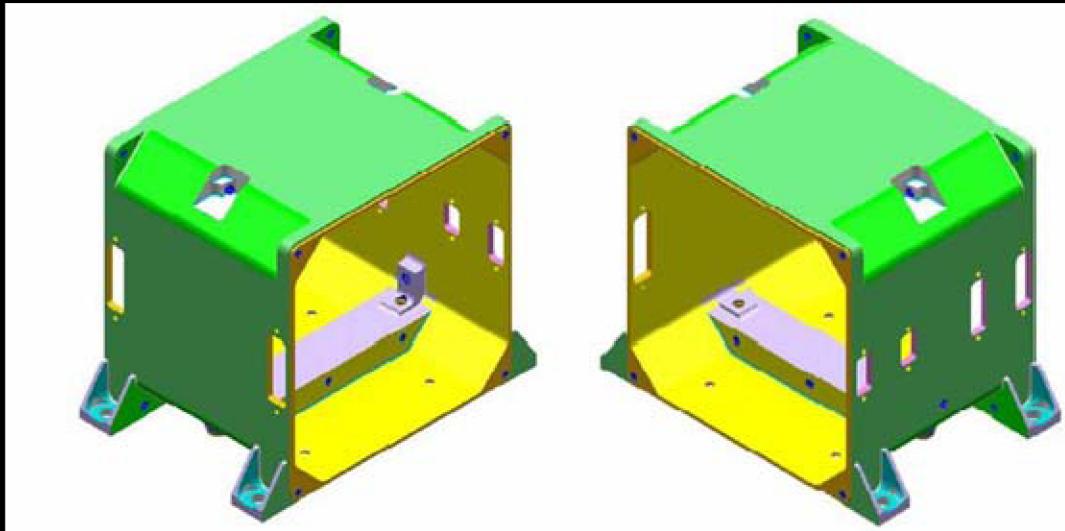


JWST 20??

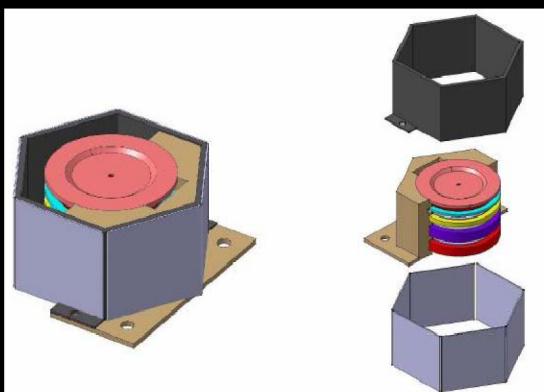


GAIA 2011, SREM ?

General Space Environment Monitor (GSEM)



GSEM basic module

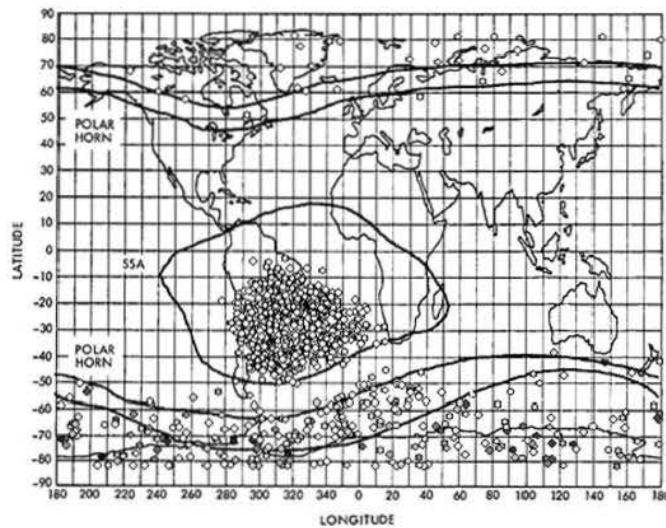


**GSEM
HEP sensor**

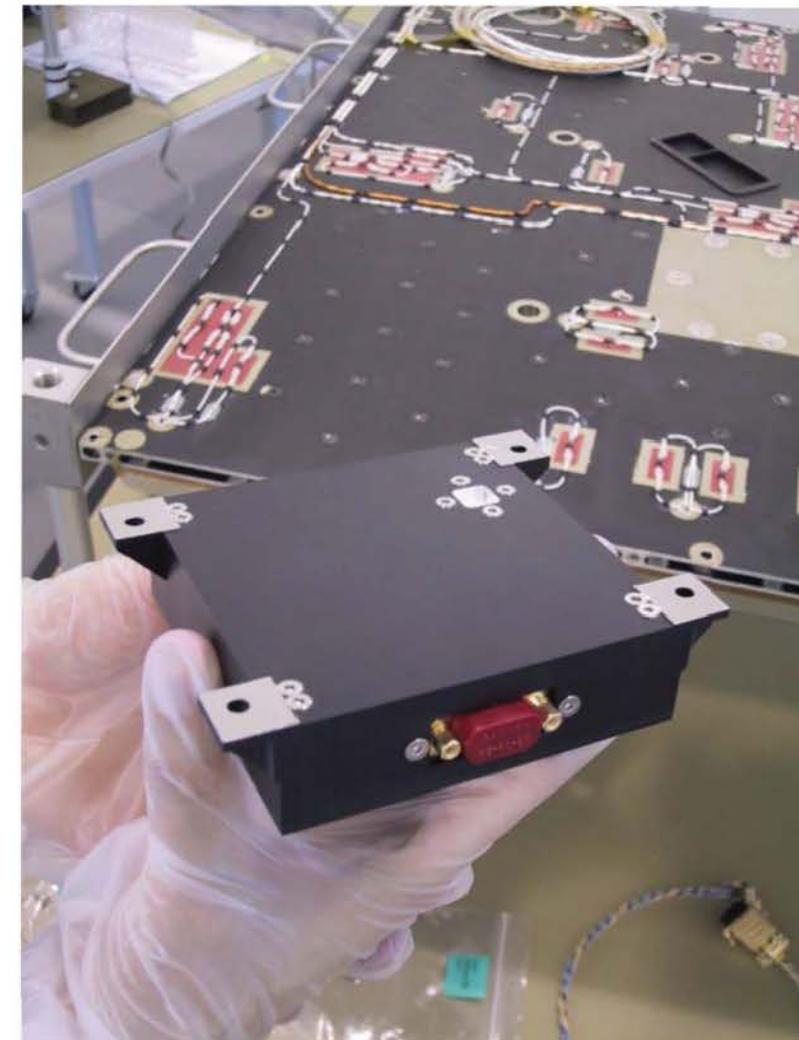
- **Under Development**
- Modular concept intended for radiation, charging, plasma, debris, vibration,...
- Miniaturised compared to SREM
(control unit base configuration
 $\sim 10 \text{ cm}^3$, $\leq 1\text{kg}$, power $\leq 2\text{W}$)
- HEP sensor: Electrons 130 keV – 7 MeV, protons 3 – 300 MeV, heavy ions 15-70 MeV.cm²/mg
- Potential flight opportunities on AMS-2 (ISS), AlphaSat mission (GEO)

Miniature Radiation Monitor (MRM)

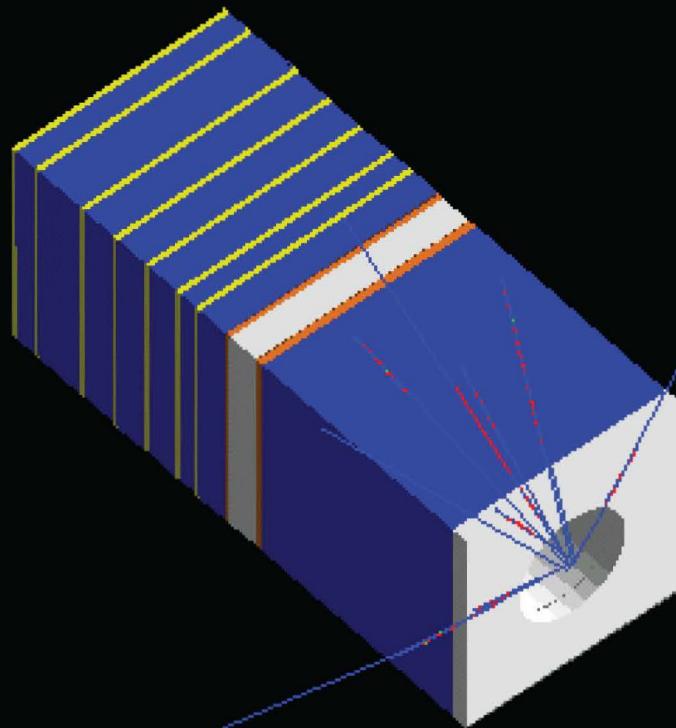
- Prototype flight on PROBA-1 (LEO)
 - Based on a cubical scintillating crystal (CsI)
 - Detects protons and electrons up to 50 MeV deposited energy; pulse shape discrimination
 - Volume 10 x 10 x 3 cm³, mass 327 g
 - Two further flight units being manufactured
- Designed and built by SENSYS (NL)



**MRM > 0.5 MeV
proton data**



Energetic Particle Telescope (EPT)



EPT GEANT4 geometry

- Belgian activity (CSR)
- High-fidelity instrument
- 12 detector elements in digital operation mode
- Electrons 0.2 – 10 MeV, protons 4-300 MeV, α -particles 16-1000 MeV + heavier ions
- High energy, angular and particle species resolutions
- Mass \sim 6 kg
- Flight opportunity on the NRL Environmental Explorer
- Launch \sim 2008



Center for Space Radiations

EPT ENERGETIC
PARTICLE
TELESCOPE

Other Activities

- XMM/RM
- Giove-A (Merlin & CEDEX); Galileo
- Lisa Pathfinder RM
- BepiColombo RM (ESA/SCI)
- CNES (SAC/C; SAC/D; Jason 2;)
- Investigations of crew dosimetry
(Columbus & Aurora programmes)
- ISS Science investigations
(SILEYE, ALTEA, AMS,...)
- Simulation codes (Geant4, Desire, SPENVIS, GRAS, Mulassis...)
- Irradiation facilities (IBER)