Introduction to the space radiation environment and the EPT instrument

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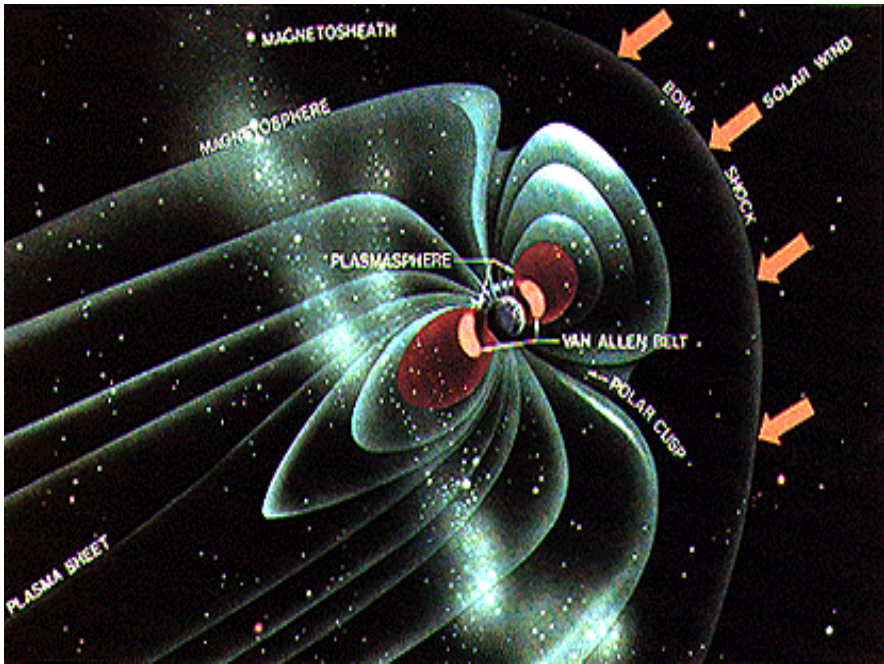
Implications for travel

Radiation belt models

Magnetic storms variations

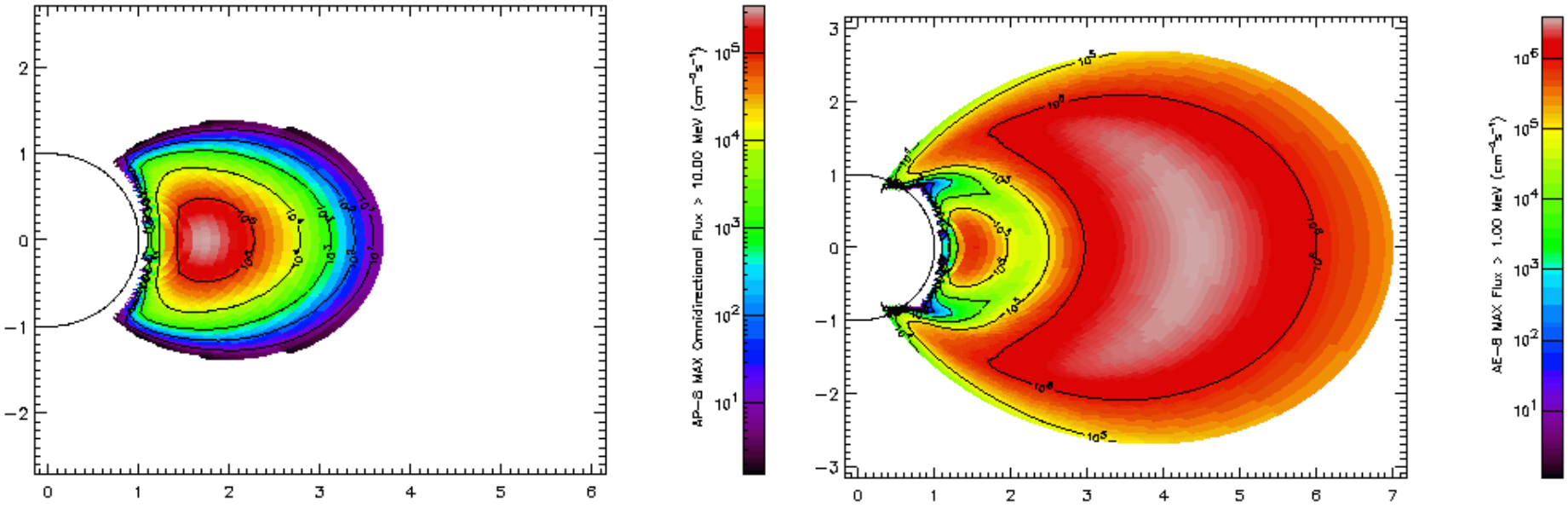
EPT insturment



Van Allen radiation belts

p^+ (100 keV-500 MeV) **e^- (10 keV-10 MeV)**

- **AP8 Max J(E>10 MeV)** **AE8 Max J(E >1 MeV)**



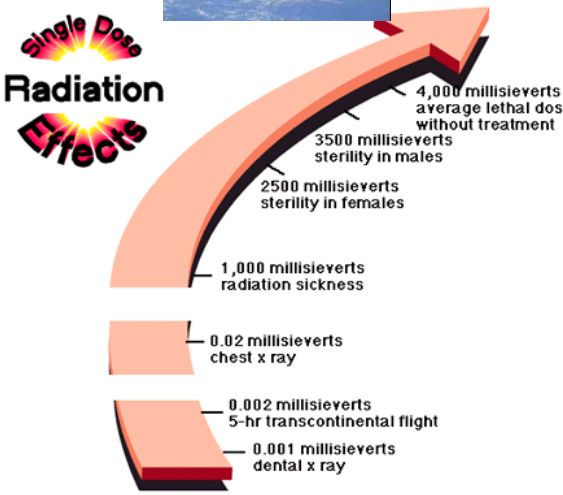
Static empirical models based on average observations from 20 satellites

Large spatial and energy coverage

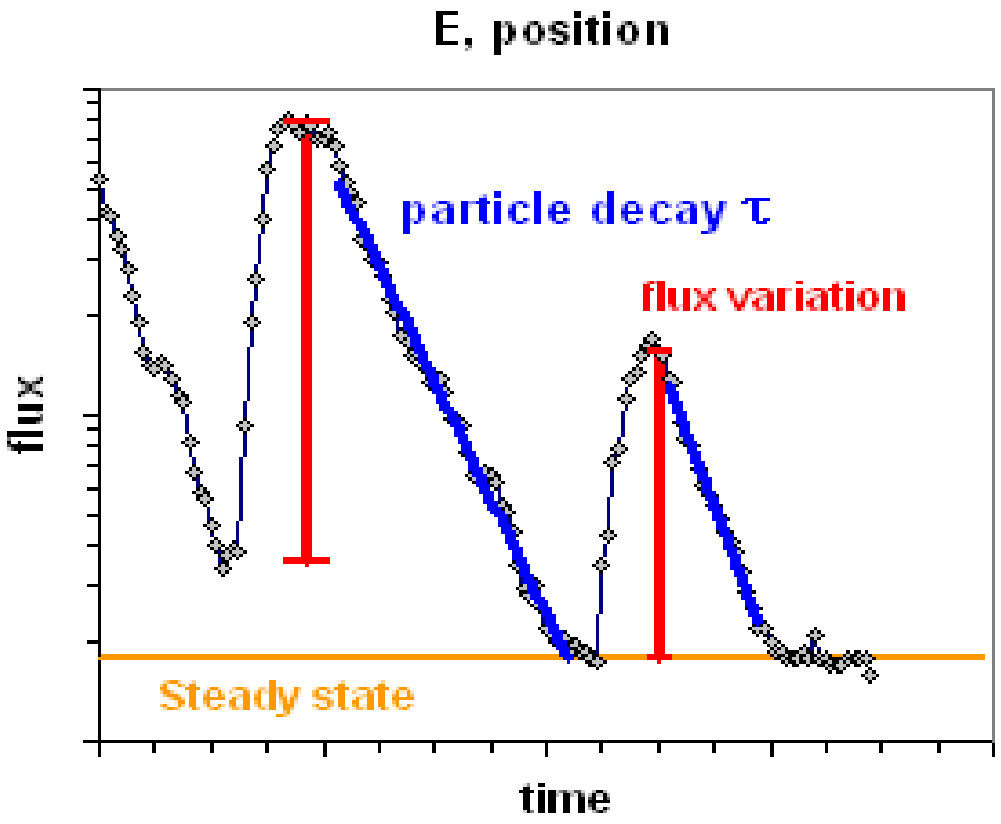
www.spenvis.oma.be

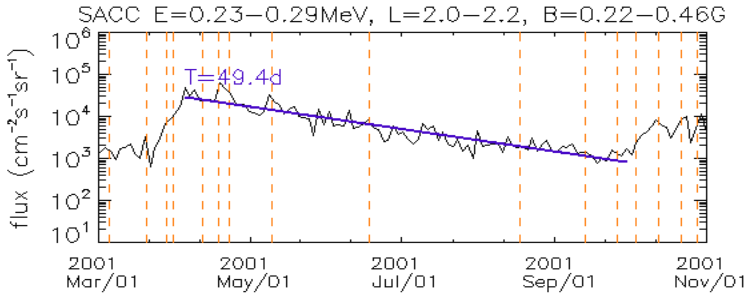
Implications for space travel

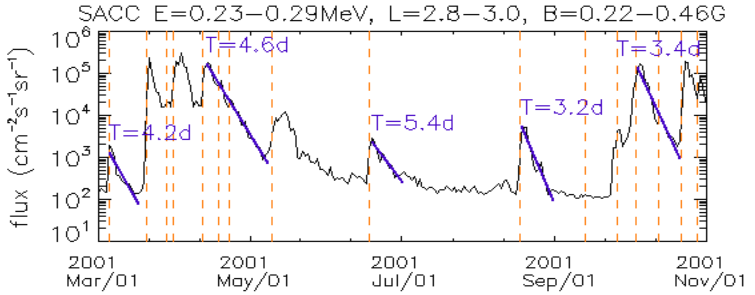
1. MeV electrons: internal charging (satellites failures)
2. 0.1-100 keV electrons: surface charging (electronic problems, integrated circuits, parasite signals, discharges…)
3. MeV ions: Single Event Upset (micro-electronic devices, semiconductor memory, transistors, microprocessors, solar cells, sensors…)
4. Radiation sickness (astronauts limite dose: 1 sievert) shielding

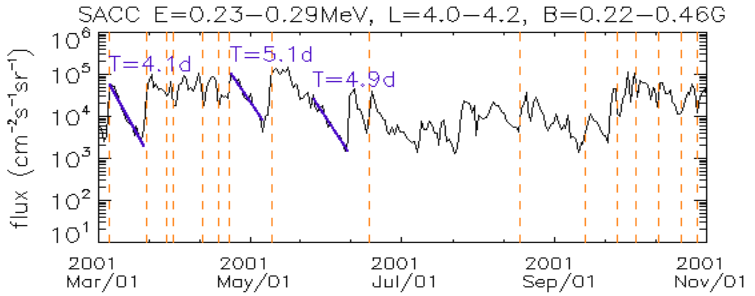


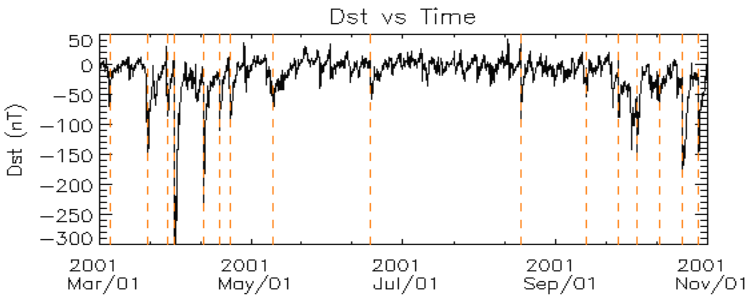
Dynamic model based on SAC-C and Demeter observations





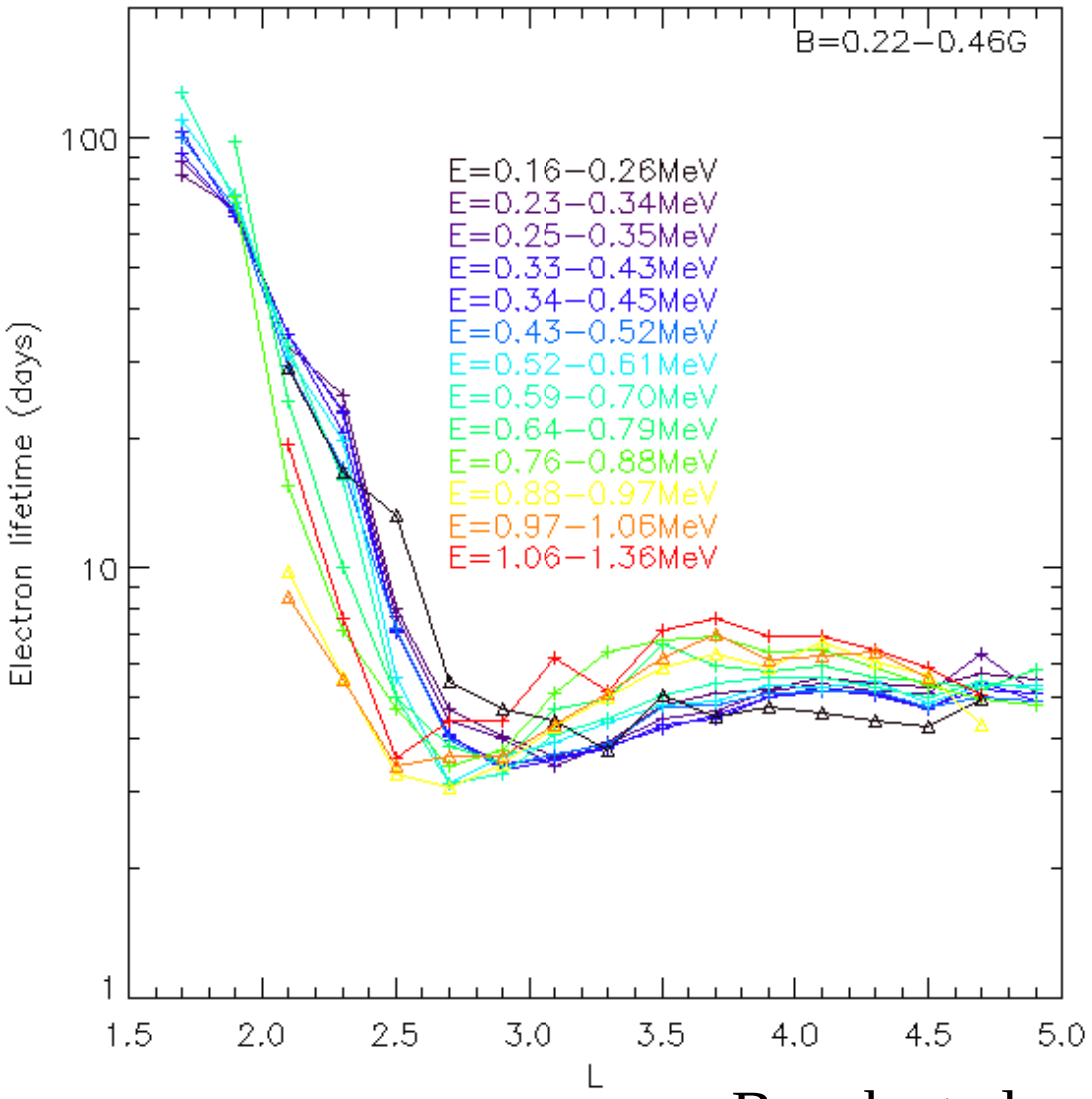






Benck; Mazzino; Cyamukungu; Cabrera and Pierrard, Annales Geoph., 28, 848-859, 2010. www.ann-geophys.net/28/849/2010/

Decay times

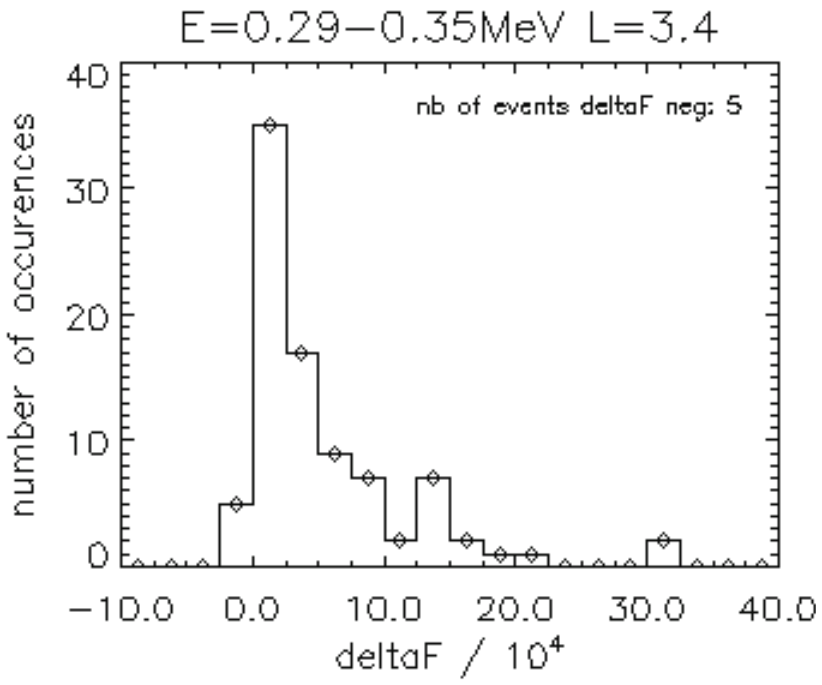


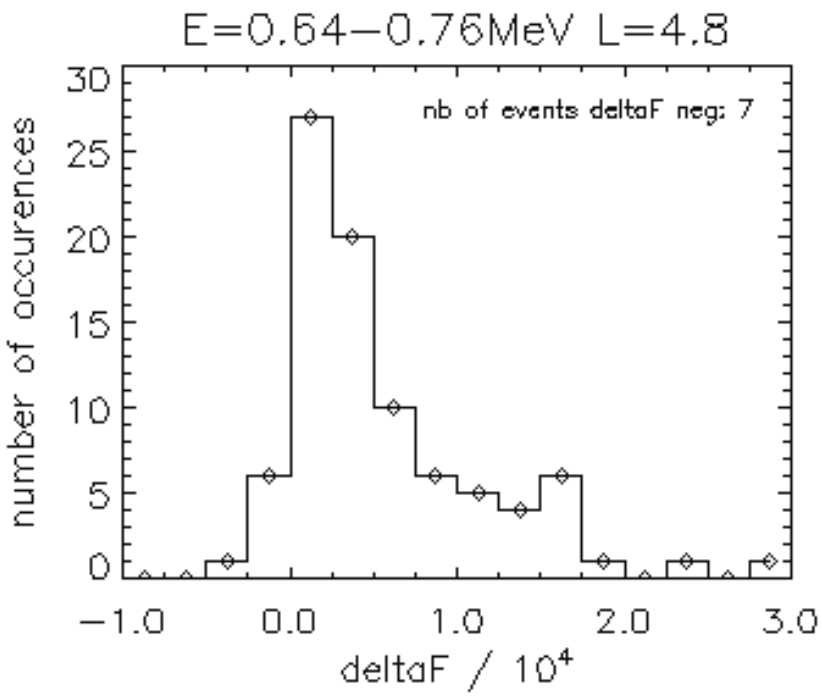
SAC-C/ICARE diff. F:
LEO 700 km
inclin.:98.2°
0.19-4.11 MeV,
18 channels,
Dec 2000- Sep 2006

DEMETER/IDP:
LEO: 710 km
Inclin.: 98°
0.07-2.34 MeV,
27 channels,
Aug 2004-Mar 2006

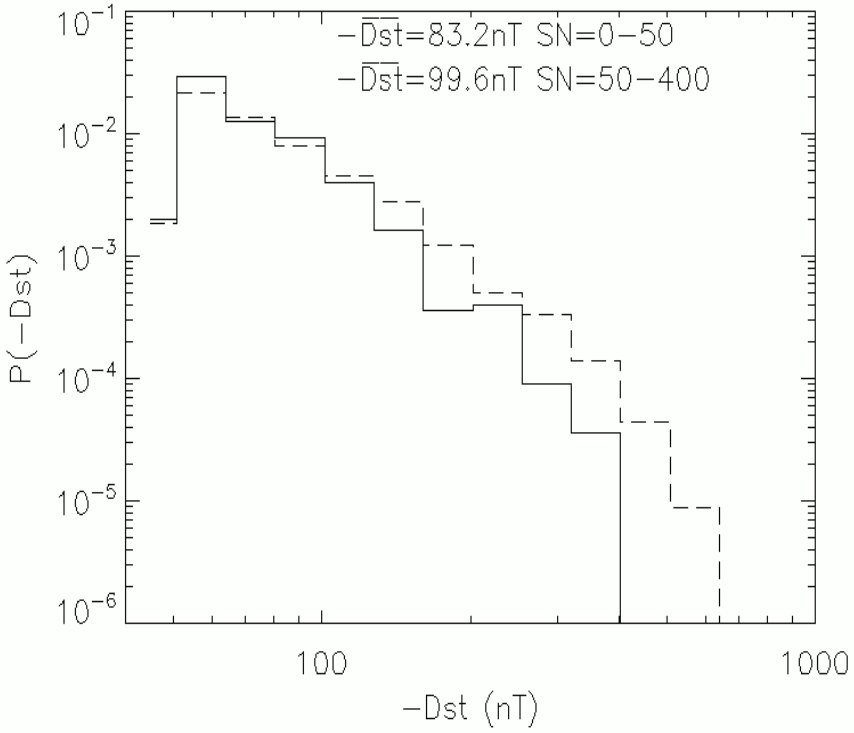
Benck et al., Ann. Geophys. 28, 849, 2010

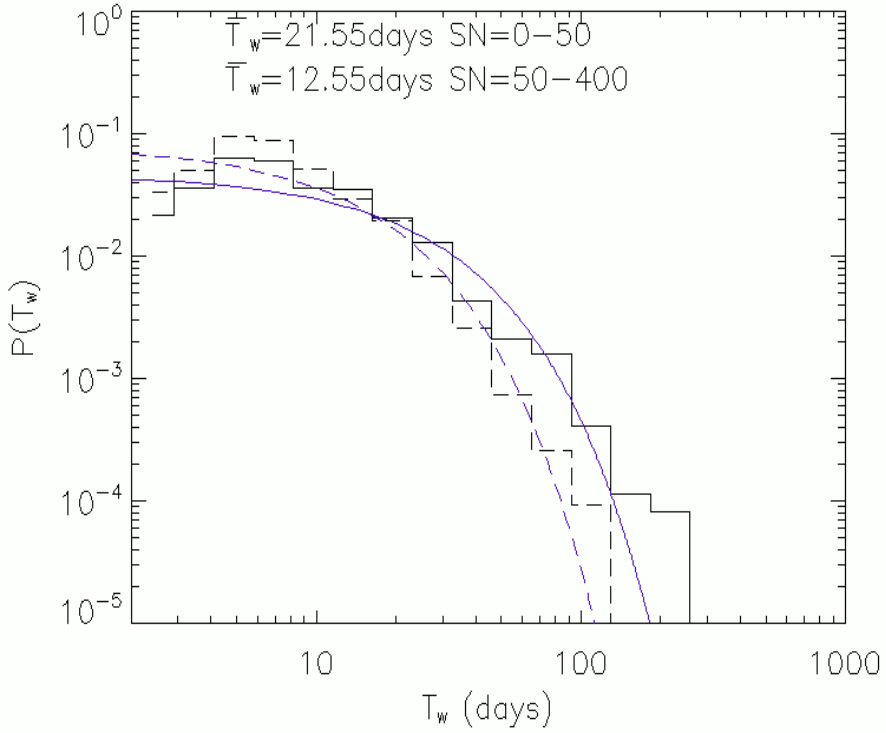
Flux enhancement distribution functions





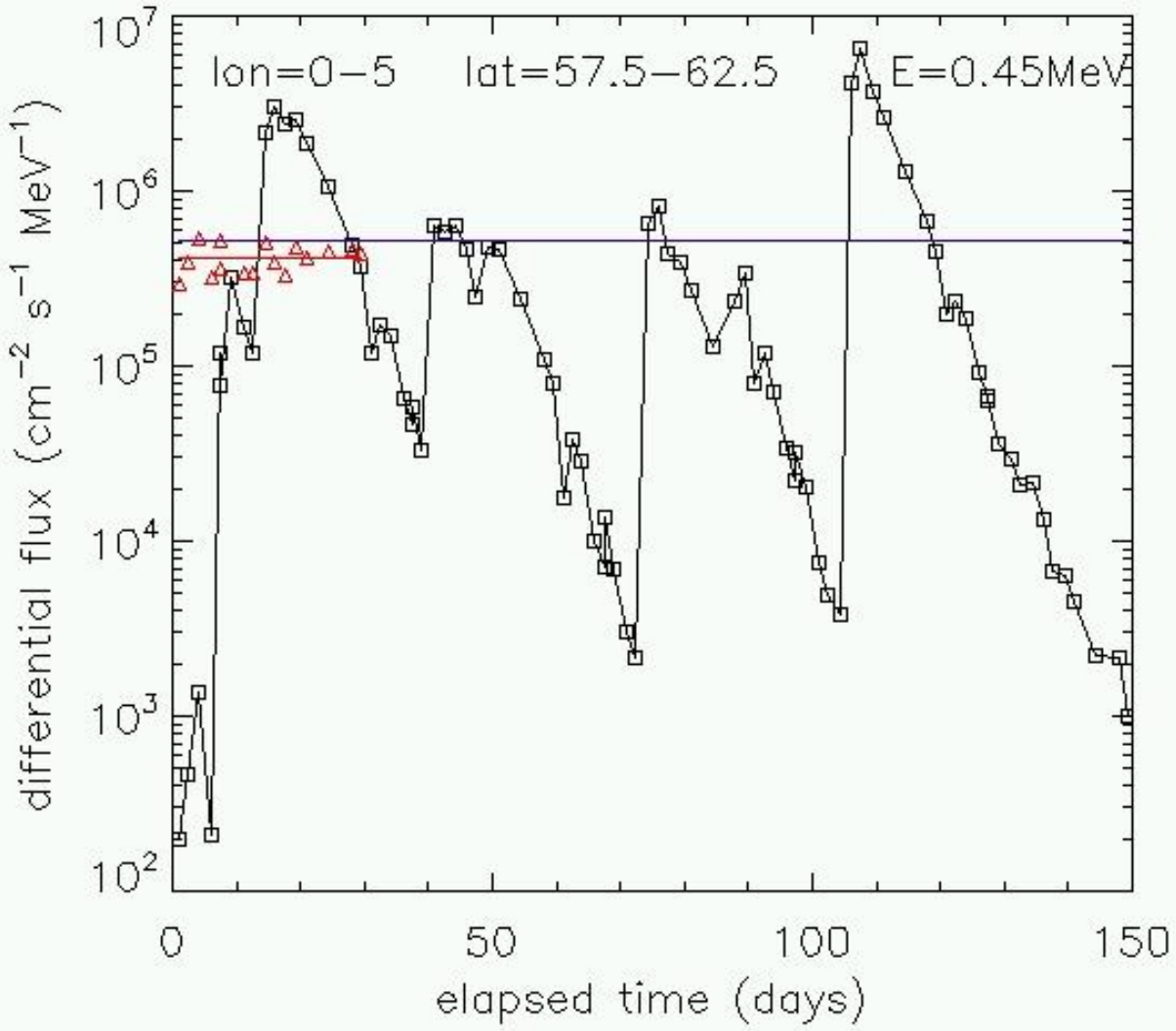
Dst probability (1957-2007)





Probability distribution of the storm magnitude and the waiting time (time interval between two consecutive storms).

Dynamic model simulation



__ model

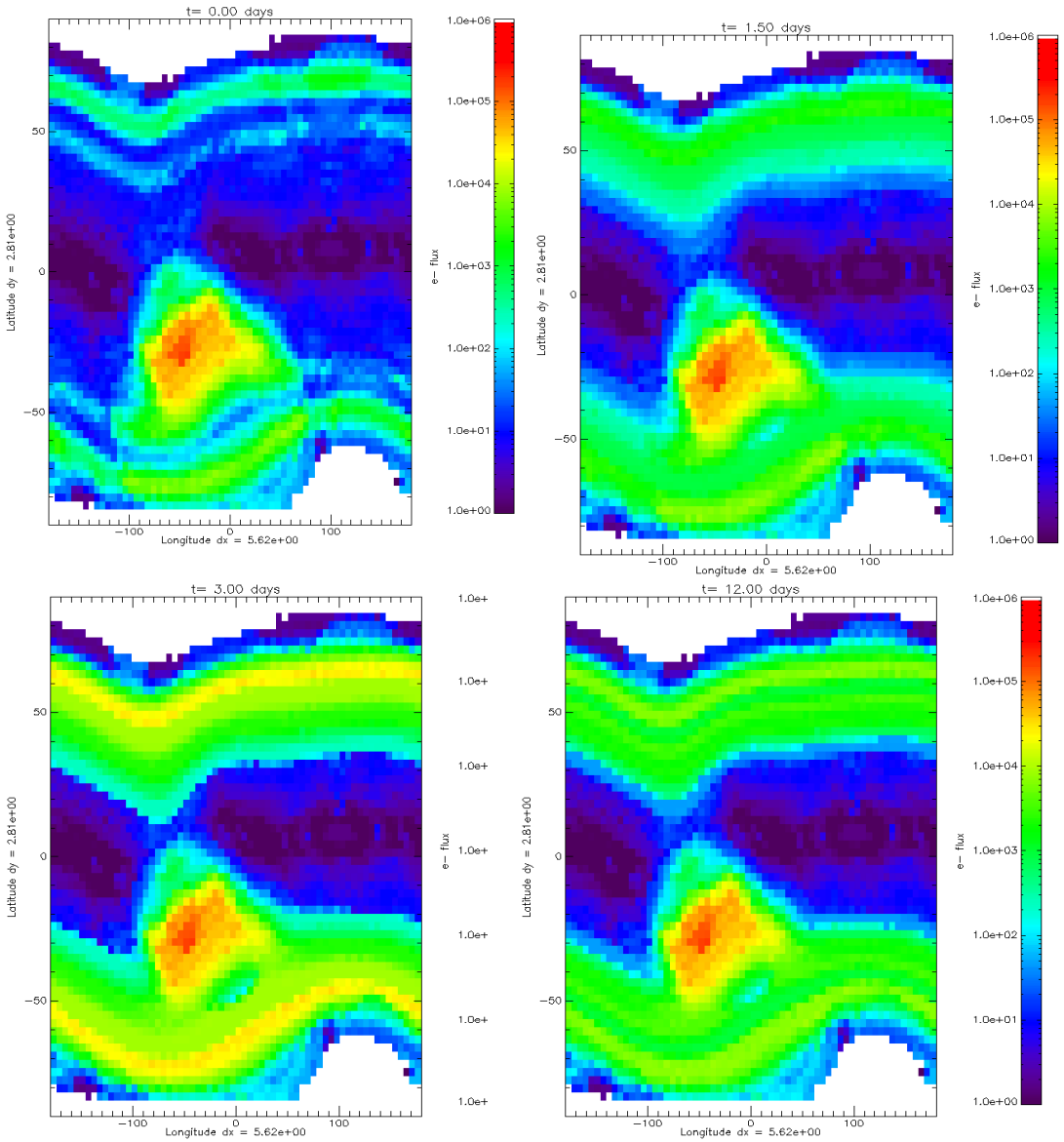
__ average

___ AE8

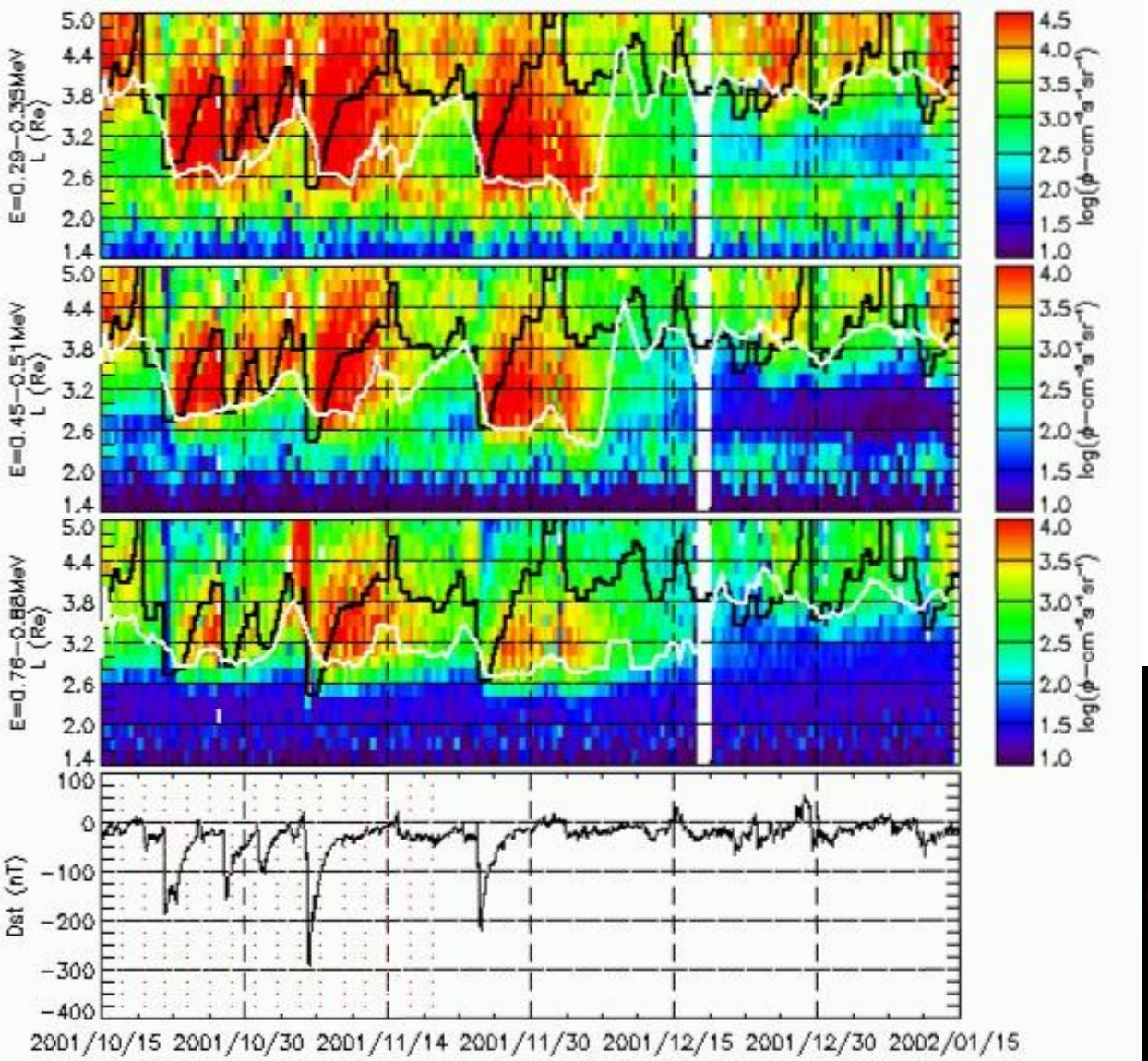
Waiting time: 12.5 days

Dynamic model: SAA

Evolution in time of the flux (in $cm^{-2}/sr^{-1}/s^{-1}$) for E=0.2-0.3 MeV in geographic coordinate system. The left upper graph shows the steady state at the onset of the storm (t=0 days).

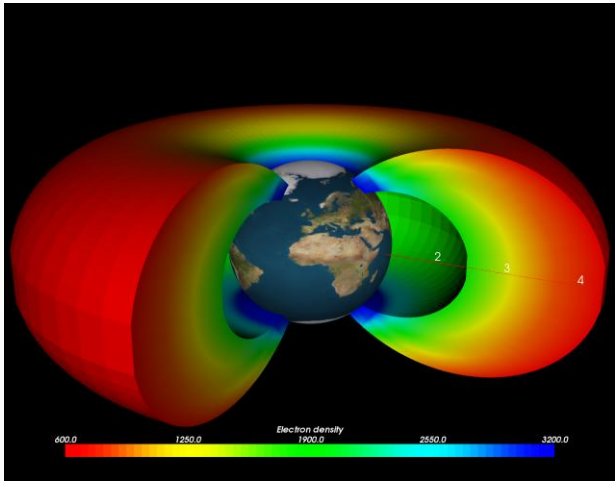


SAC-C fluxes compared to plasmapause

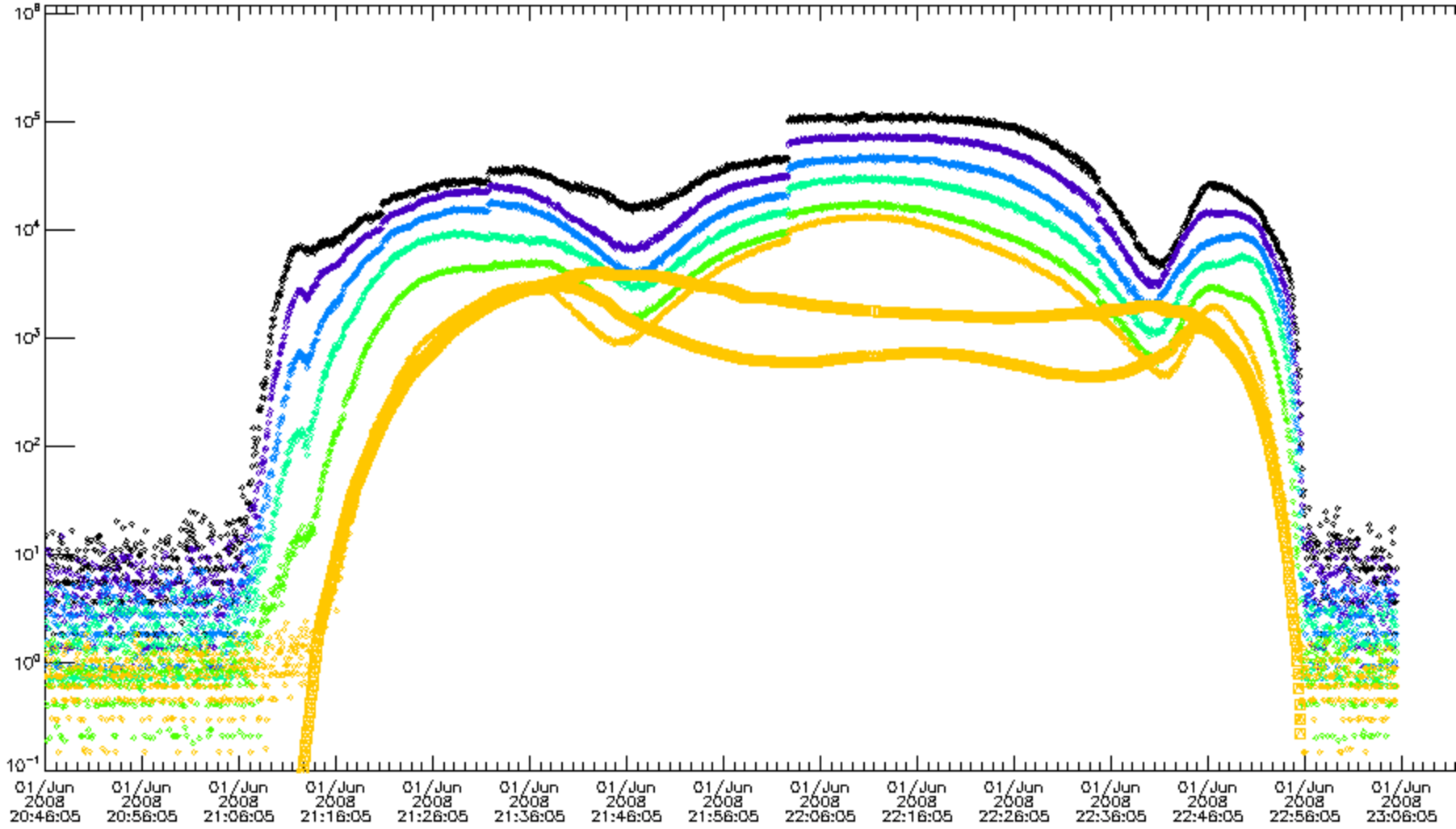


White:
inner edge of the
outer radiation belt

Black:
plasmapause

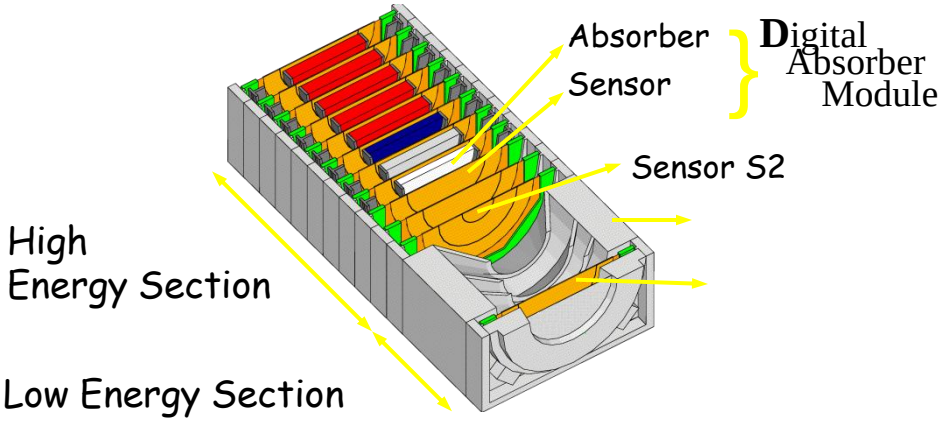


CLUSTER/RAPID 40-406 keV, 6 channels, since 2000 compared to AE8 (1 June 2008)



Energetic Particle Telescope

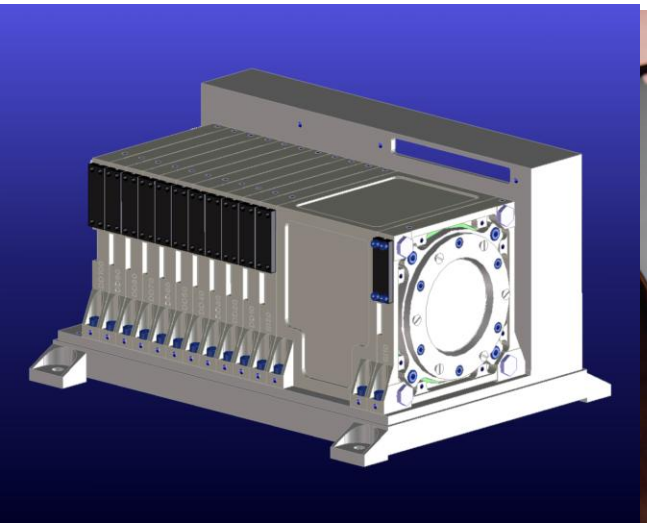
- Spectrometer developed to measure the high-energy particle fluxes (Phase D)
- Qinetiq Space, Center for Space Radiations (UCL), BISA, ASRO

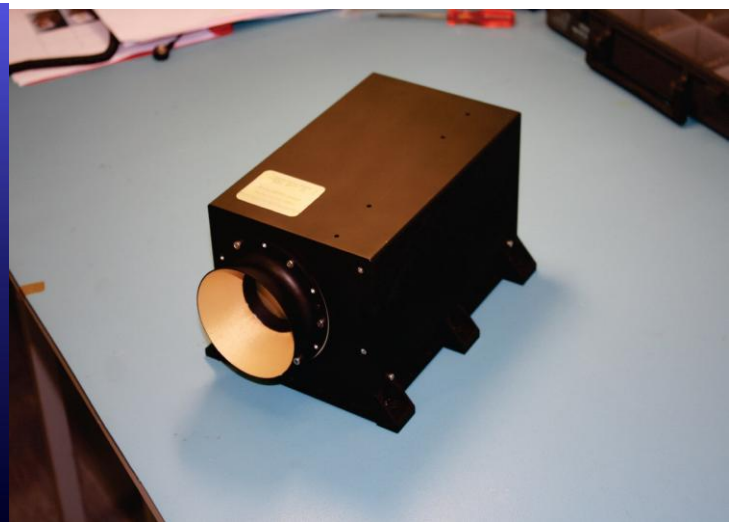


e^-: 500 keV-10 MeV
p^+: 7 MeV-300 MeV
alpha: 27 MeV- 1 GeV

Discrimination

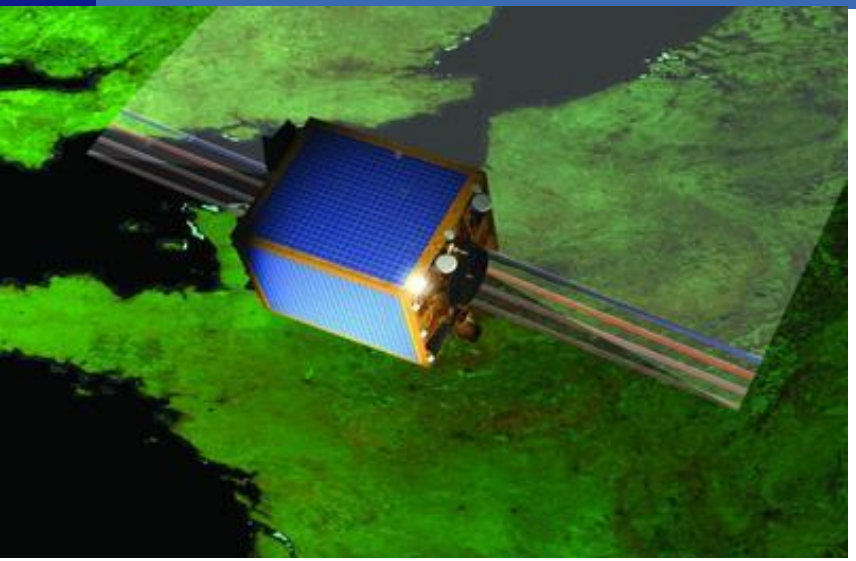
- EPT_short_assy.avi





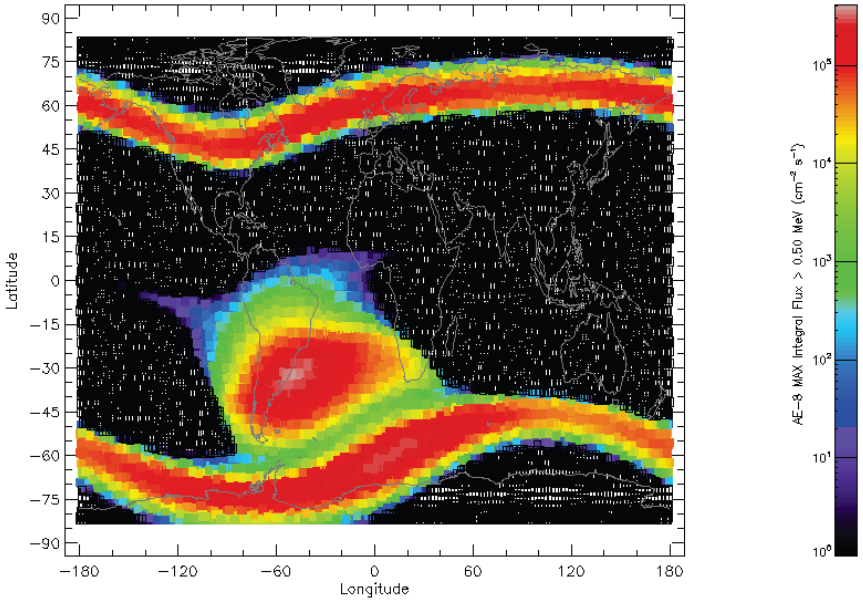
10 DAMs
Dim: 130 x 160 x 210 mm^3
Mass: 4,6 kg

Launch on Proba-V in early 2013



LEO orbit
800 km
98° inclin.
10:30 AM local time at the descending node

Phases A-B of 3DEES:
Improved EPT with angular detection



E>0.5 MeV electrons

Conclusions

- Space radiations are dangerous for space missions

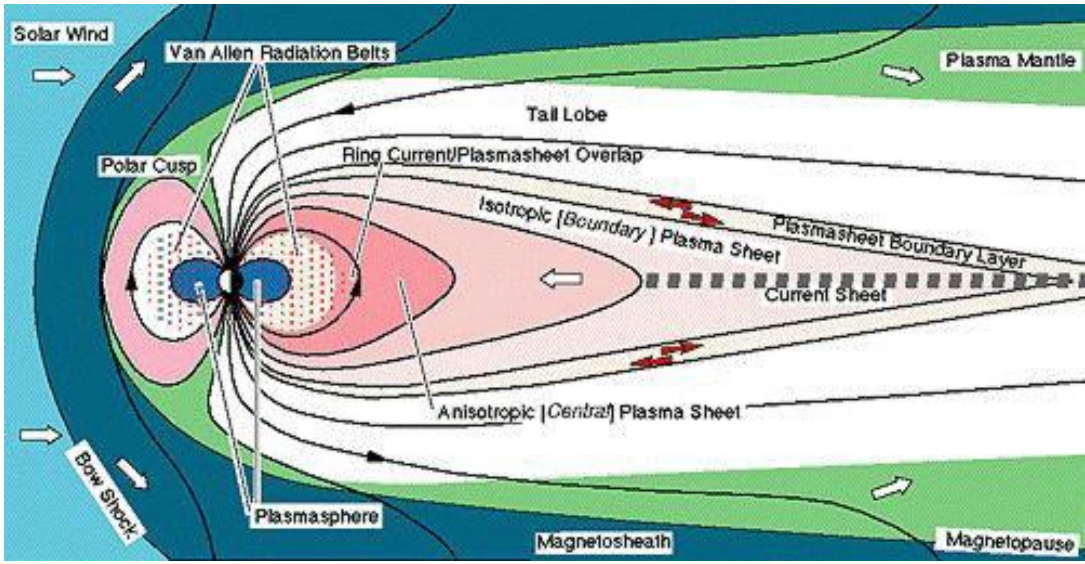
- The outer electron belt is a highly dynamic region

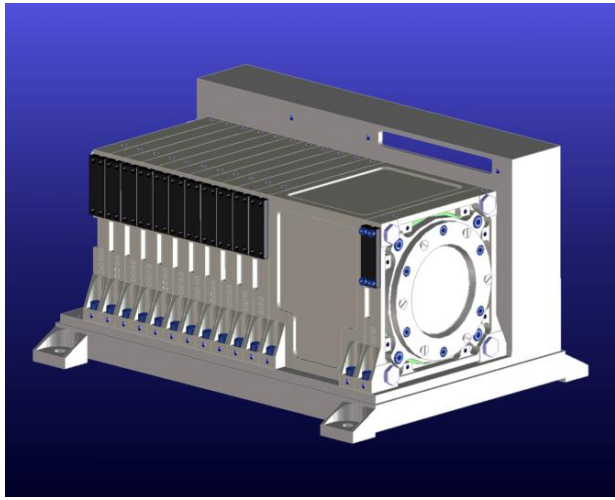
- Dynamic model developed on the basis of observations (SAC-C, Demeter and CLUSTER)

- Storm (Dst): - Flux increase
  - Decay time
  - Probability

- Perspectives:

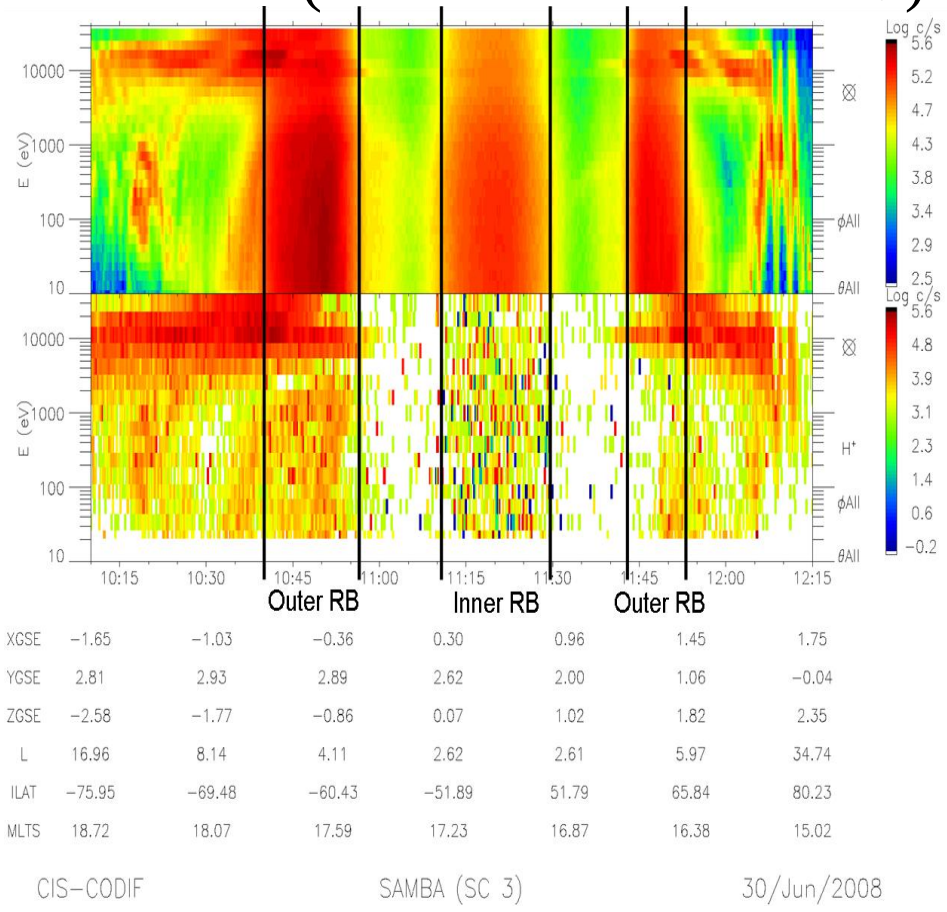
Launch of EPT on Proba-V in 2013

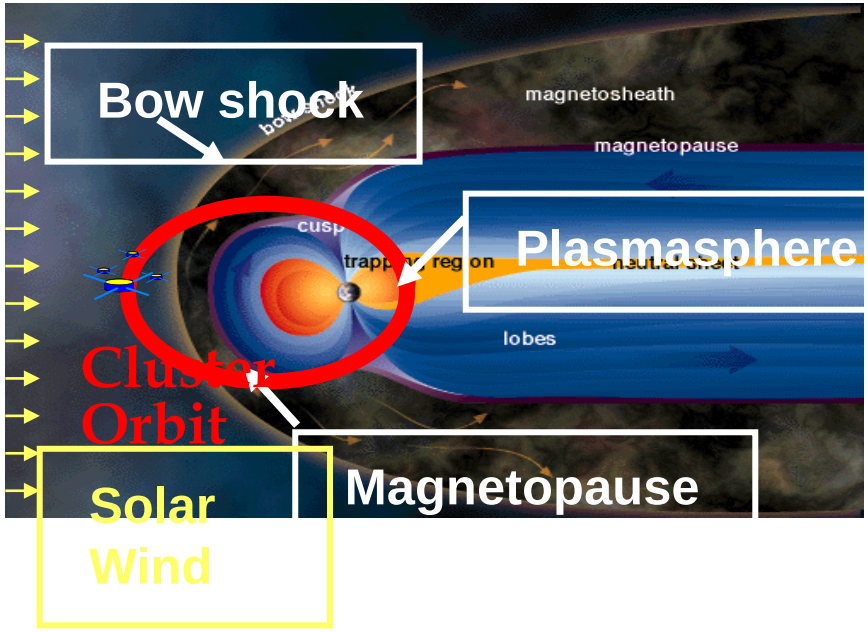


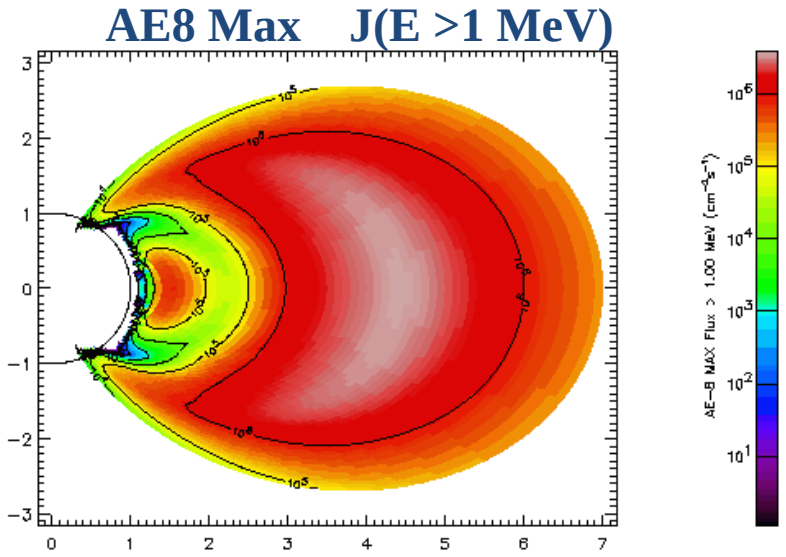


Cluster observations

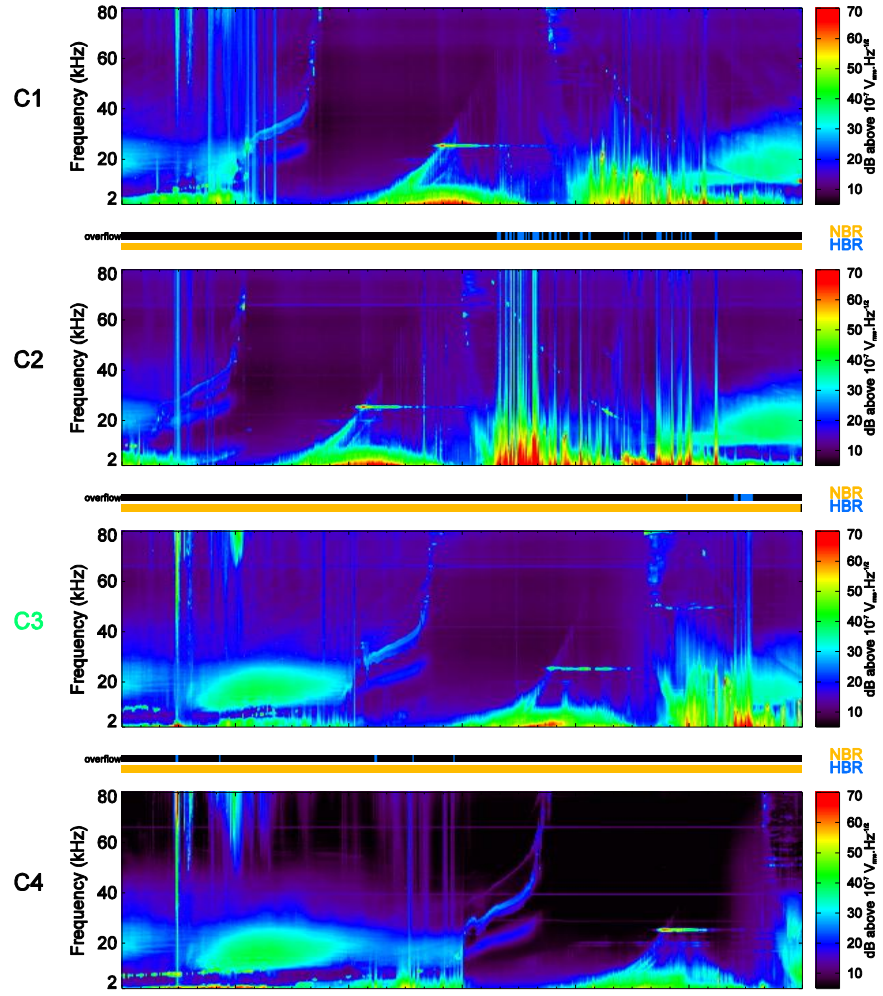
- WHISPER (electrons 1 eV)
- CIS (electrons > 2 MeV)
- RAPID (electrons 244-406 keV)







CLUSTER WHISPER for the plasmapause

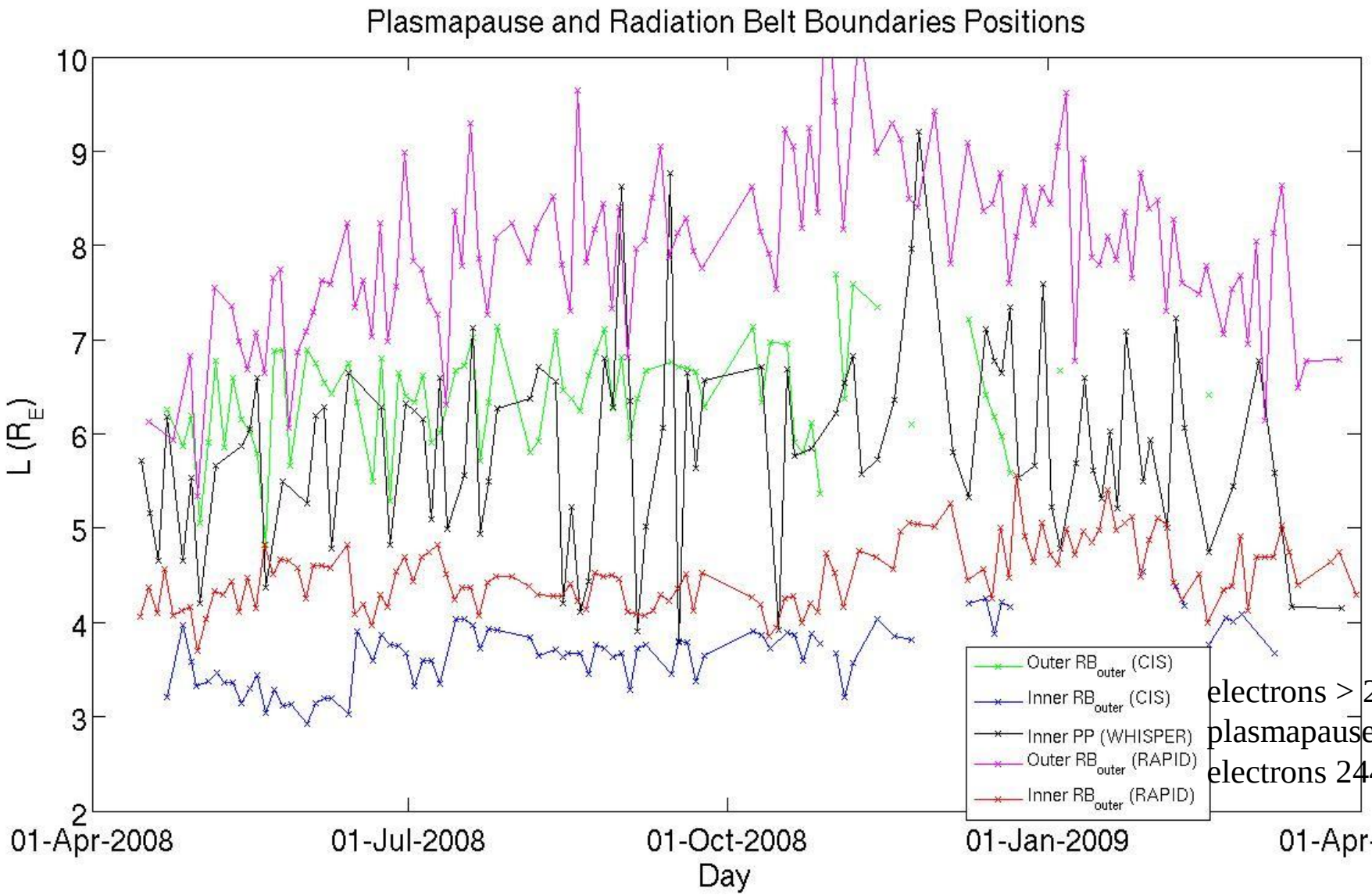


UT	19:00:00	19:50:00	20:40:00	21:30:00	22:20:00	23:10:00	00:00:00
X_gse(Re)	-2.00	-0.78	0.48	1.67	2.26	1.12	-0.90
Y_gse(Re)	4.36	4.07	3.56	2.65	0.97	-1.31	-2.95
Z_gse(Re)	-5.99	-4.90	-3.56	-1.84	0.36	2.13	2.64
LT_sm(h)	17.64	16.81	16.01	15.07	13.67	8.78	4.16
L	58.22	28.47	12.58	4.91	2.59	16.09	9.45

WHISPER time-frequency electric field spectrograms for a plasmasphere crossing:

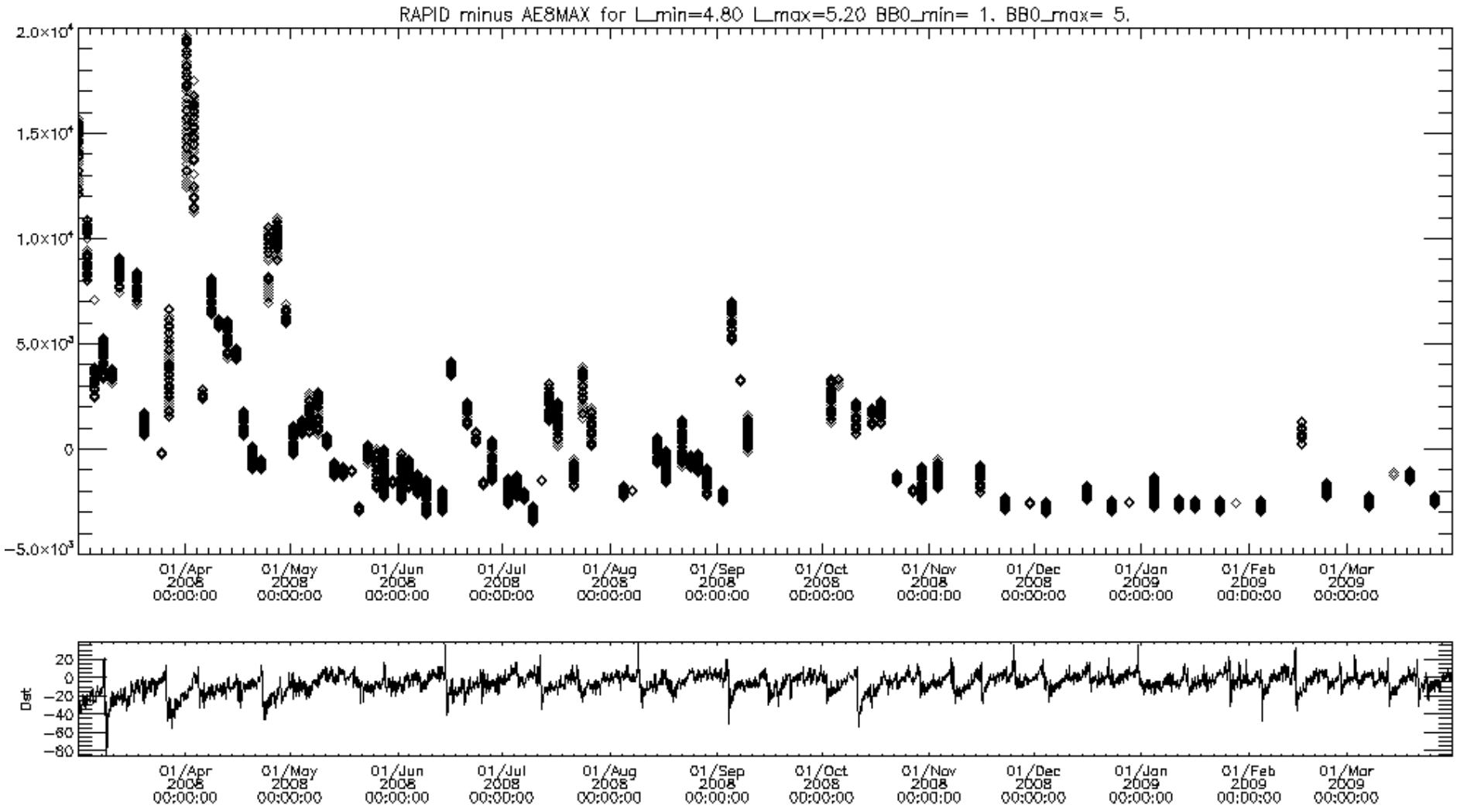
28 August 2008, 19-24 UT, 15 MLT, Kp=3^{-}, separation=10000 km

Plasmapause/ radiation belt boundaries CLUSTER



electrons > 2 MeV
plasmapause
electrons 244-406

RAPID flux variation at L=5 Dst



Plasmapause/Radiation boundaries

Relationship between outer radiation belt (RB) and plasmapause (PP):

SAMPEX for RB + IMAGE for PP

Displacement of outer RB closely associated with reduction of Earth's plasmasphere **(Baker et al., Nature 432, 2004)**

Close correlation between the inner extent of the outer RB (2-6 MeV) and the 3.5-day-averaged PP location **(Goldstein et al., GRL 32, 2005)**

- Using SAMPEX for RB and CRRES and model for PP, innermost PP position is the innermost limit of the outer RB penetration **(Li et al., GRL 33, 2006)**