Data on Radiation Belt and Solar Energetic Particles deduced from Dosimetry in Low Earth Orbits

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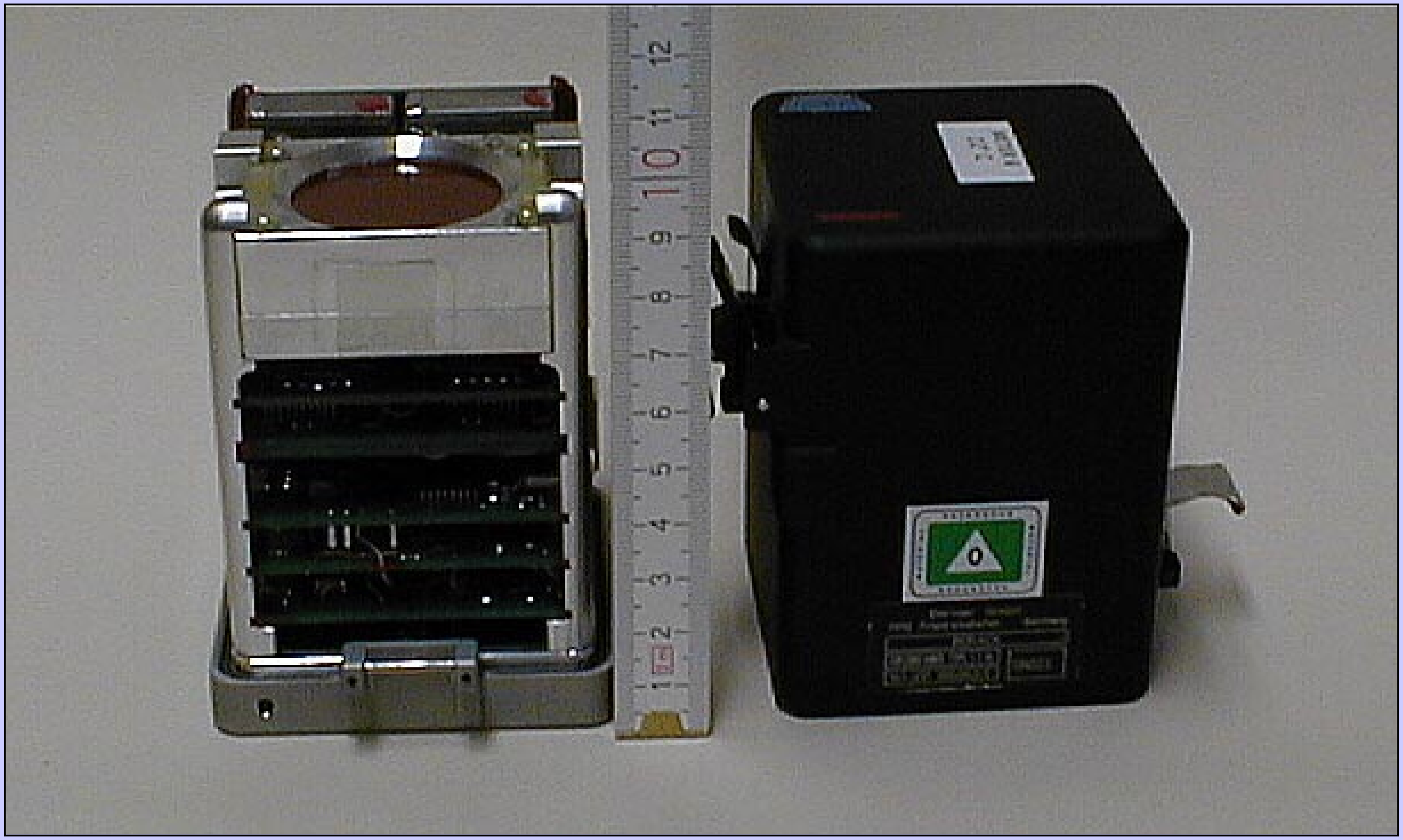
Photo of DOSTEL

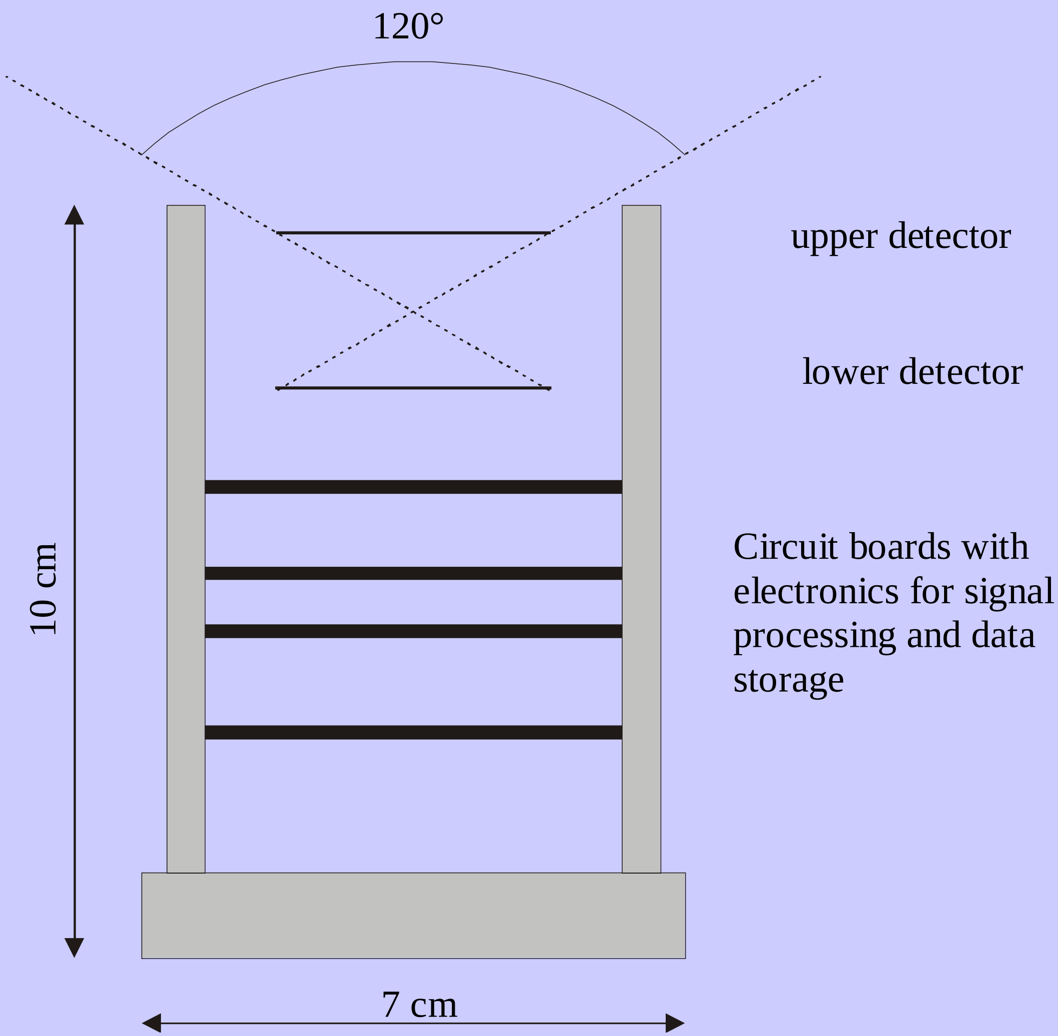


DOSTEL Unit B without cover. During the mission DOSTEL is enclosed with an aluminium cover (on the right). DOSTEL has a size of 7cm x 7cm x 10cm.

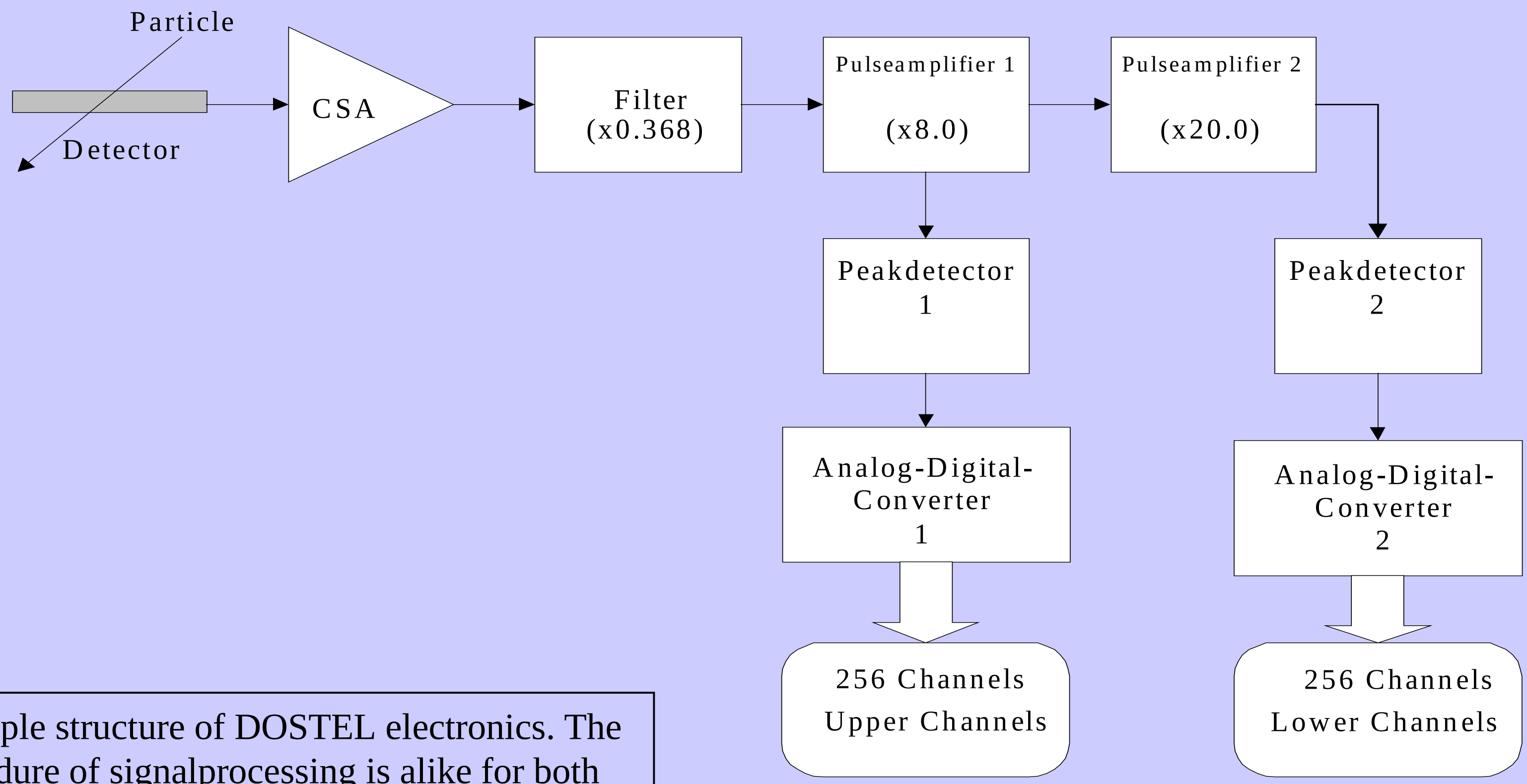
DOSimetry TELescope

- 7 cm x 7 cm x 10 cm, 570g
- two Si detectors (6.93cm^2 x 315µm)
  telescope geometry 120° opening angle
  geometric factor 6.58 cm^{2}sr

Schematic Description of DOSTEL



Block Diagram of the DOSTEL Electronics



Principle structure of DOSTEL electronics. The procedure of signalprocessing is alike for both detectors

Possible Measurements of DOSTEL

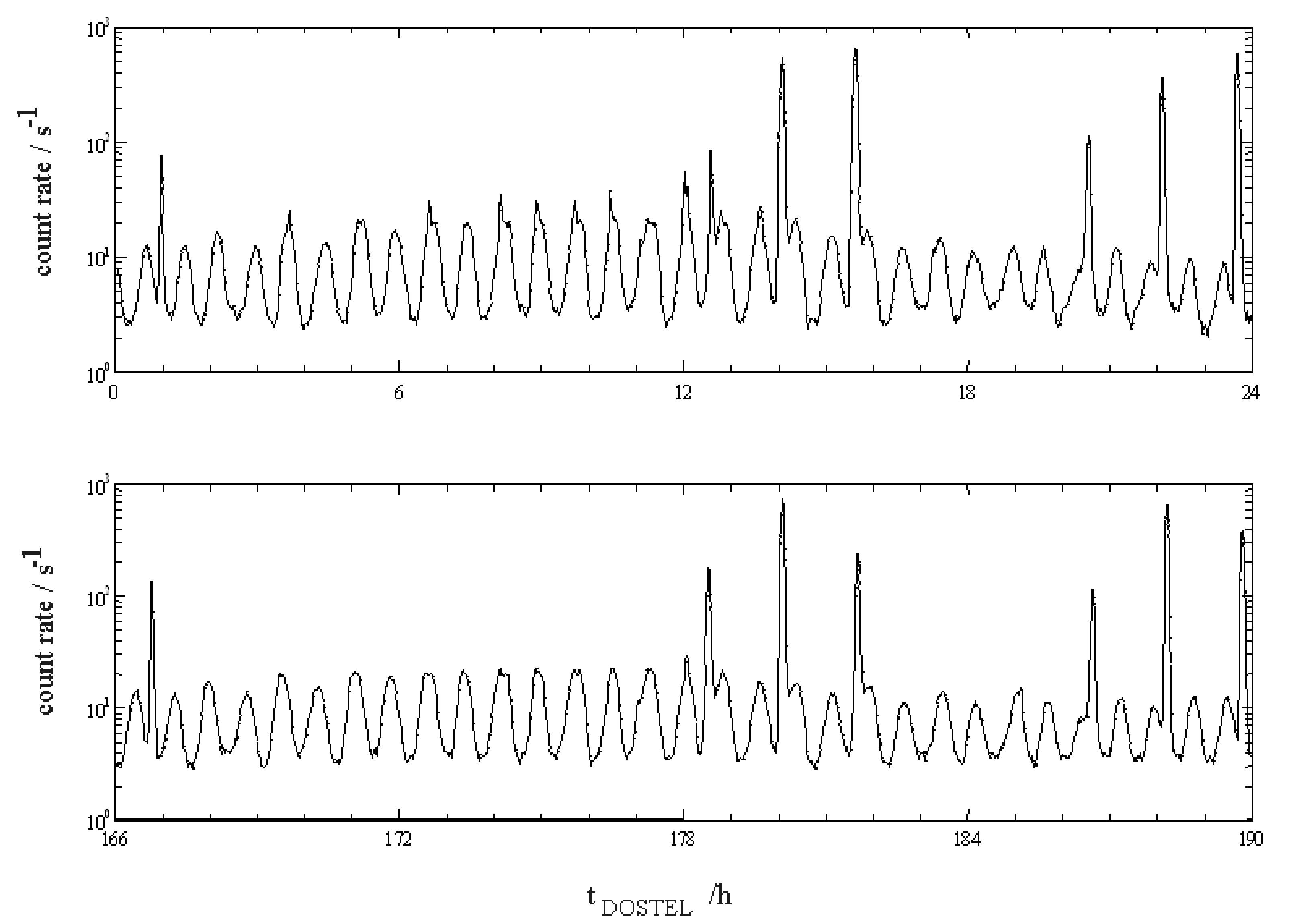
- Mode 1
  - Telescope-Mode (Coincidence submode)
    - DOSTEL measures LET-spectra for each detector
    - DOSTEL measures dose and particle rates in each single detector
  - Single-Detector-Mode (no coincidence submode)
    - DOSTEL measures LET-spectra for each detector
    - DOSTEL is able to measure particle rates in each detector
    - DOSTEL measures dose rates in each detector
- Mode 2 (Single-Event-Mode)
  - DOSTEL measures LET for each event detected by one of the detectors (no coincidence submode)
  - DOSTEL measures LET (in both detectors) for each event detected by both detectors (coincidence submode)

On STS81 and STS84 DOSTEL measured:

- As single detector:
  - particle rate in each detector (every 90 seconds)
  - dose rate in each detector (every 90 seconds)

- As Telescope:
  - LET-spectra (0.1 - 200 keV / µm Si)
    - for each orbit (90 min or every half-orbit)
    - for each crossing of the earth‘s radiation belts (e. g. in the SAA). Radiation belt crossings are detected by high increase of the countrate

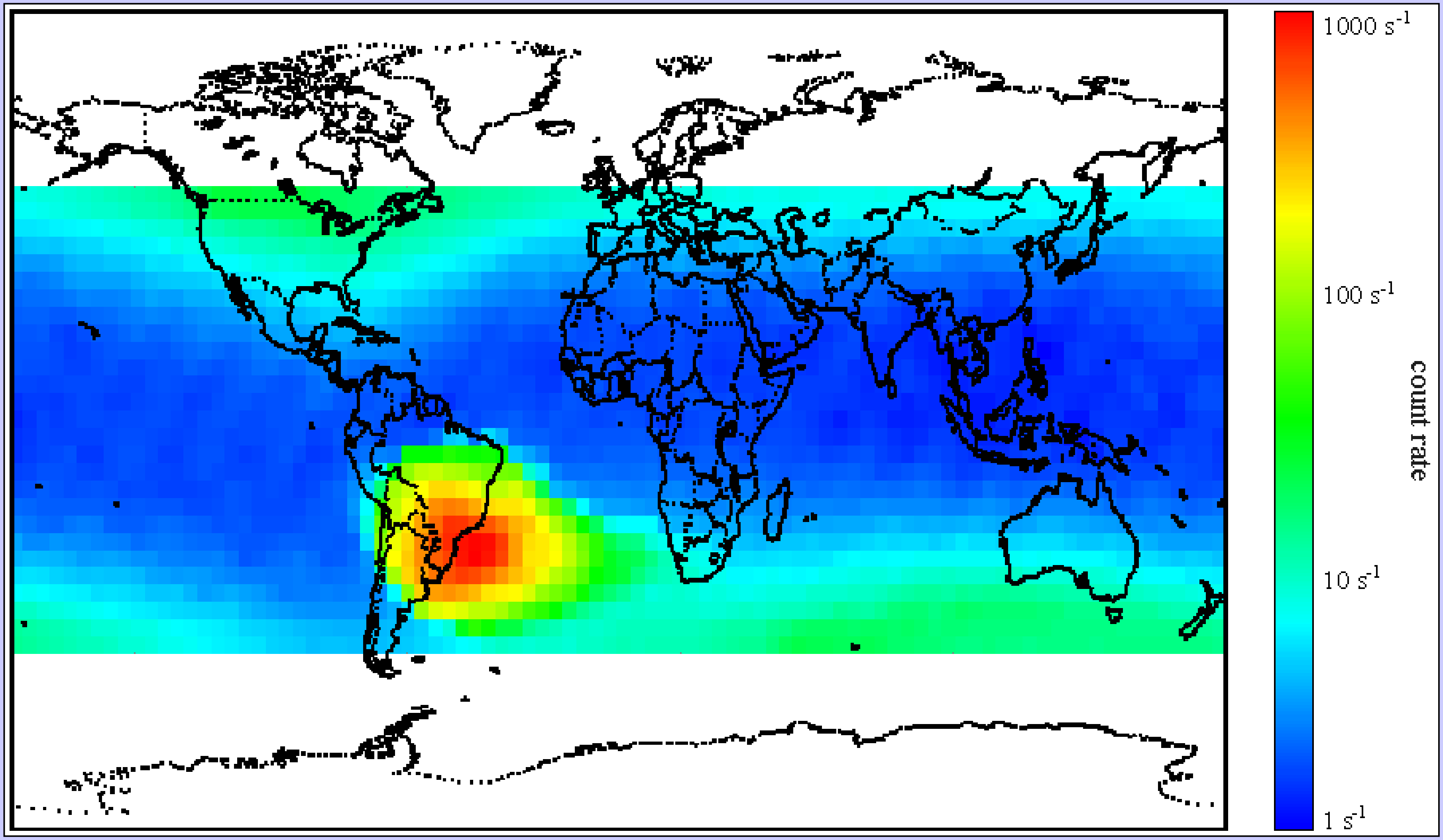
Time Profile of count rate in Low Earth Orbits measured by DOSTEL on STS84



Time Profile of count rate in Low Earth Orbits measured by DOSTEL on STS84

- Geomagnetic modulation
  - minima at geomagnetic equator crossings
  - maxima at high (magnetic) latitude
- inner belt contribution
  - South Atlantic Anomaly
- outer belt contribution
  - at high (magnetic) latitude

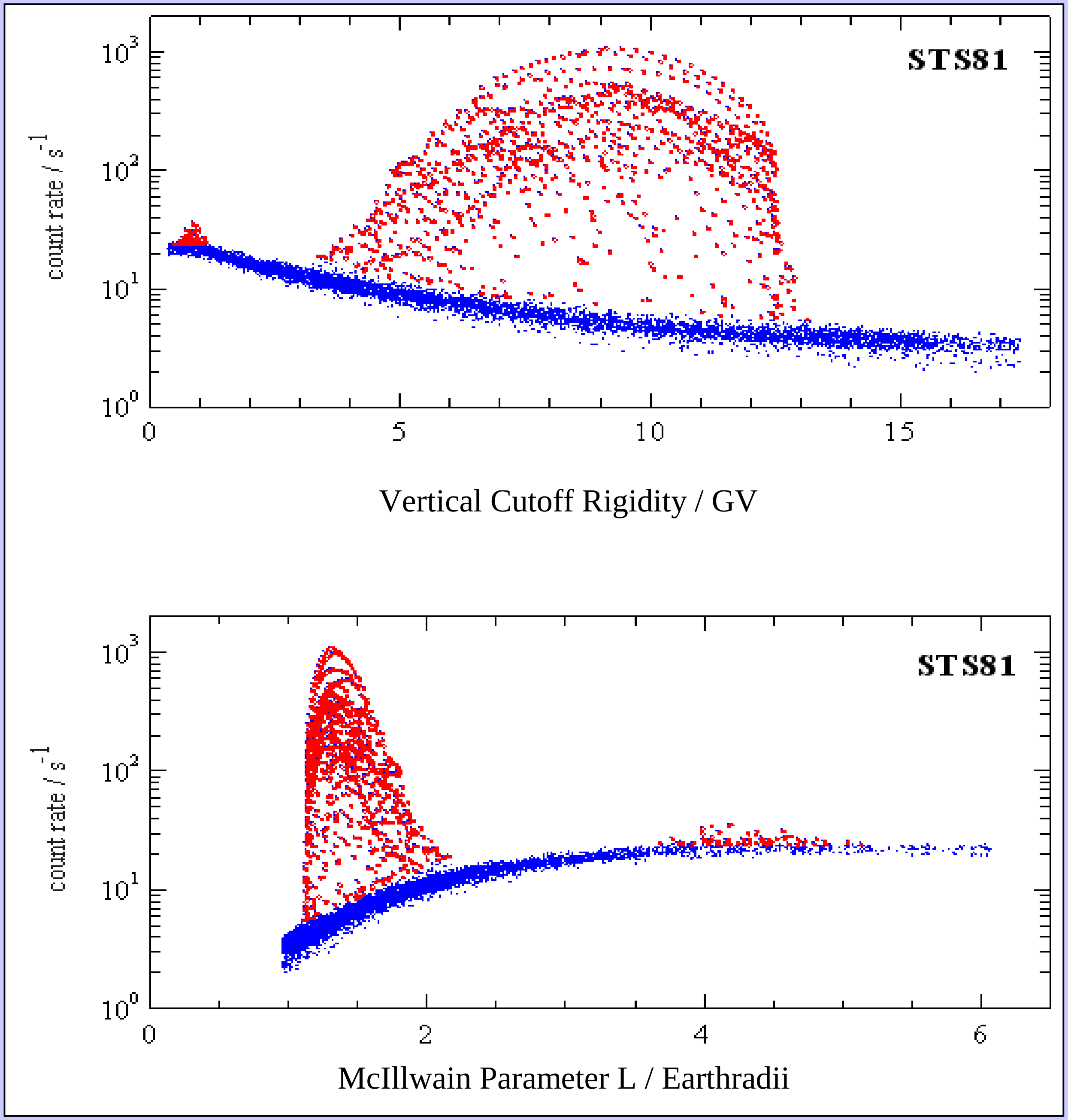
DOSTEL Count Rate Mapping (STS81)



DOSTEL Count Rate Mapping (STS81)

- Count Rate Average Values at geographical positions
- the count rate increases by two orders of magnitude within the area of the SAA
- lowest countrates around cosmic ray equator

Count Rate Dependence on Magnetic Field Parameters



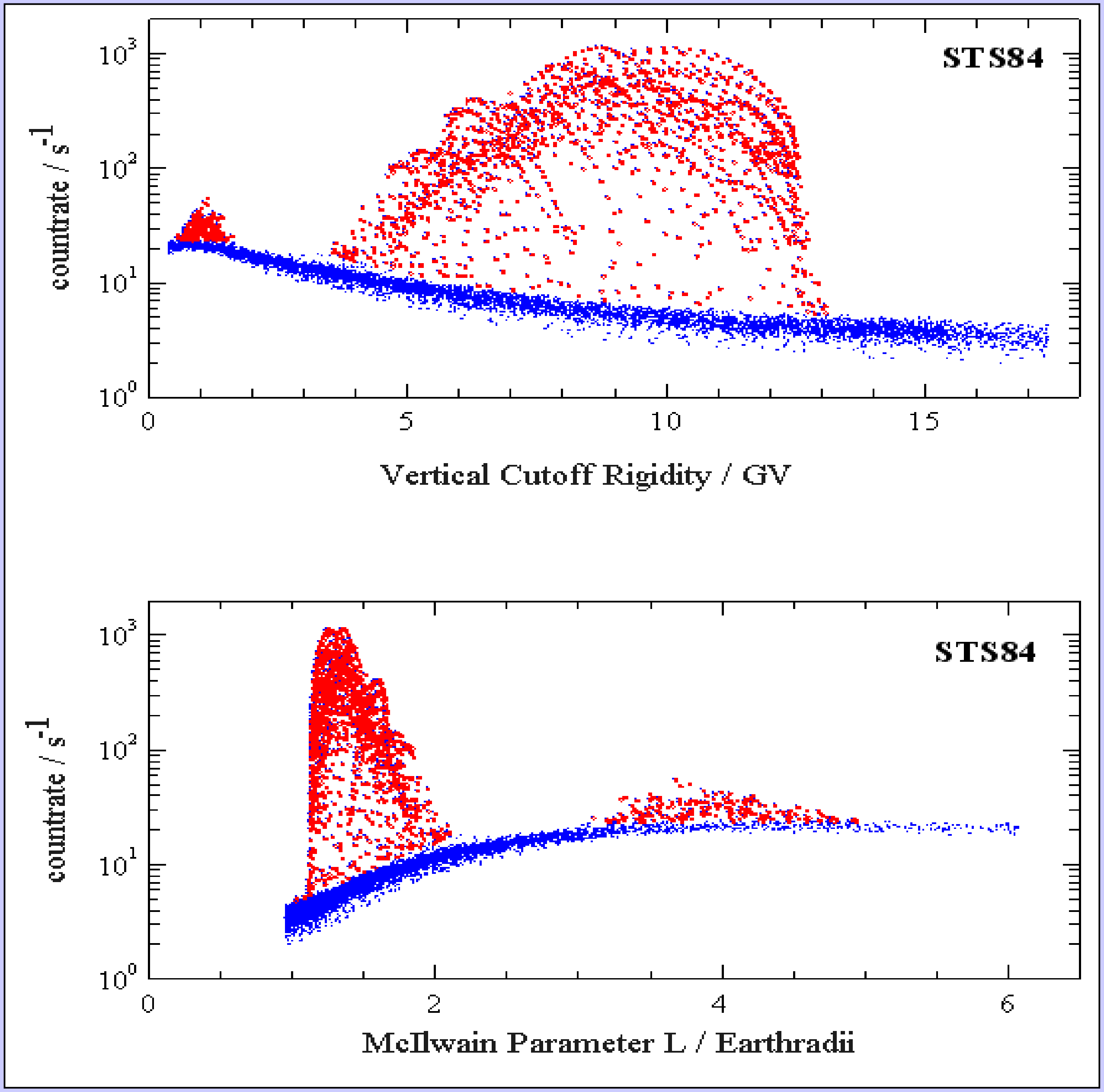
Count Rate Dependence on Magnetic Field Parameters

- A narrow band of GCR and albedo particles streches from L=1 - 6

- particles from the inner belt where detected at L=1.2 - 1.8 with count rates increasing by two orders of magnitude (attitude dependence)

- a small contribution of the outer belt is detected at L=3 - 5

Count Rate Dependence on Magnetic Field Parameters



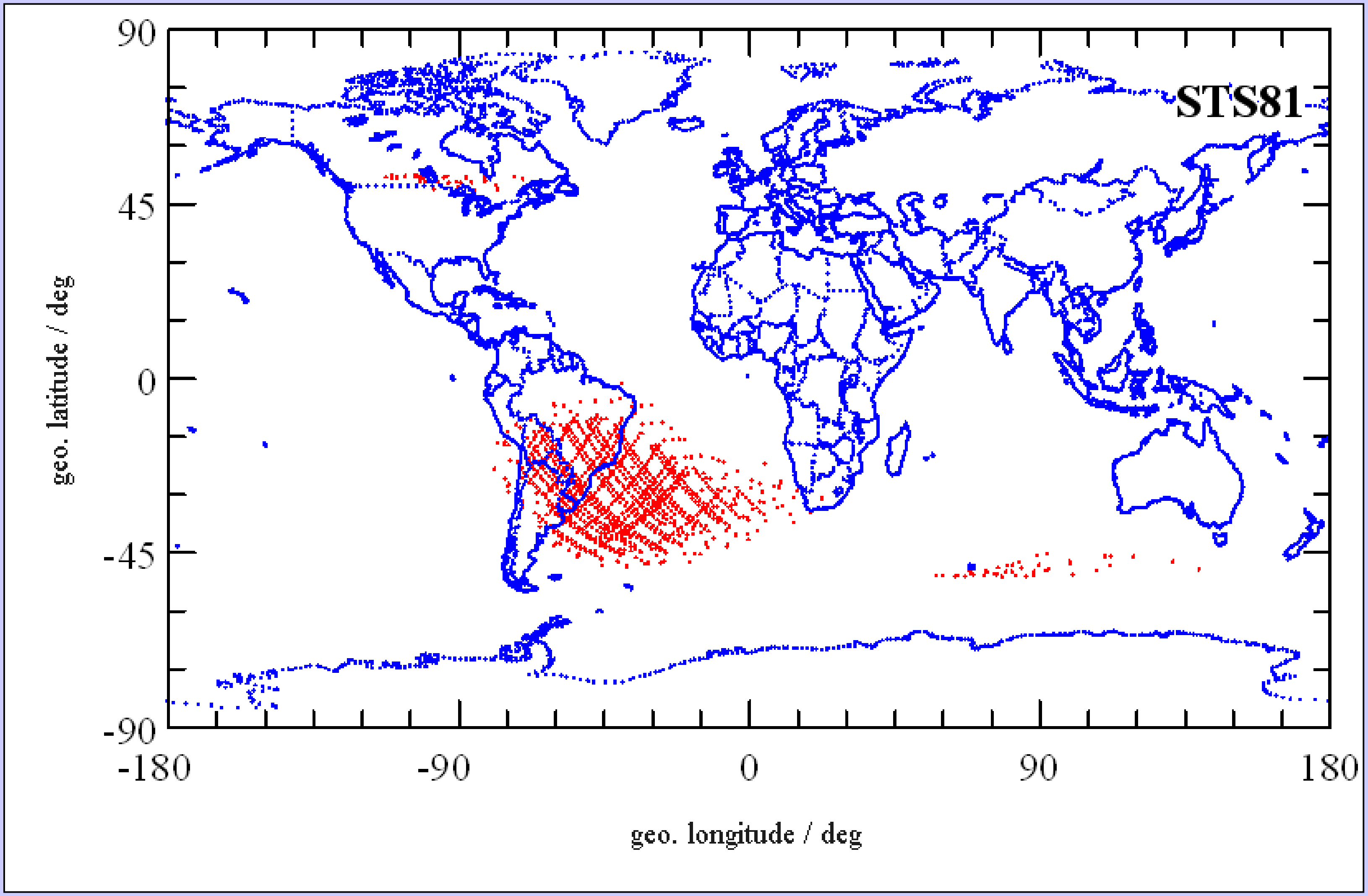
STS81 vs. STS84

- The outer belt contribution to the count rate is higher on STS84
- The location of the highest contribution has shifted from L=4.2-4.5 in STS81 to about L=3.6 in STS84
- The contribution of the outer belt to the measured dose rate inside the spacecraft is negligible

Count Rate Dependence on Magnetic Field Parameters

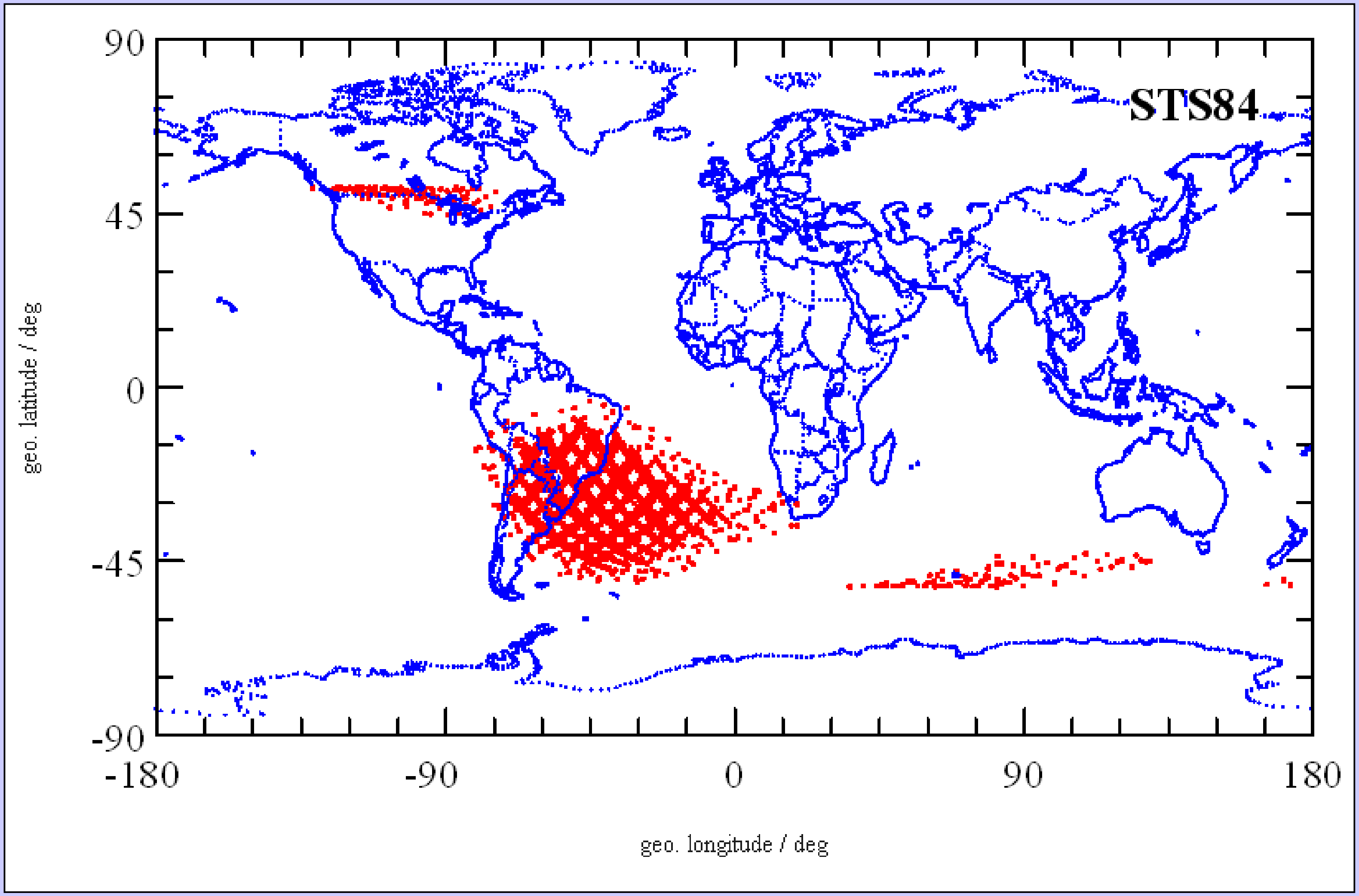
- the count rate dependence on L can be used to seperate inner and outer belt contributions automatically (e. g. to analyse seperate spectra)
- in future missions this automatic seperation can be used to detect increases of count rate or dose rate (e. g. during SEP events)

Mapping of radiation belt crossings on STS81 (ISS alike orbit parameters)



Geographical positions of inner and outer belt contributions to the count rate on STS81.

Mapping of radiation belt crossings on STS84
(ISS alike orbit parameters)

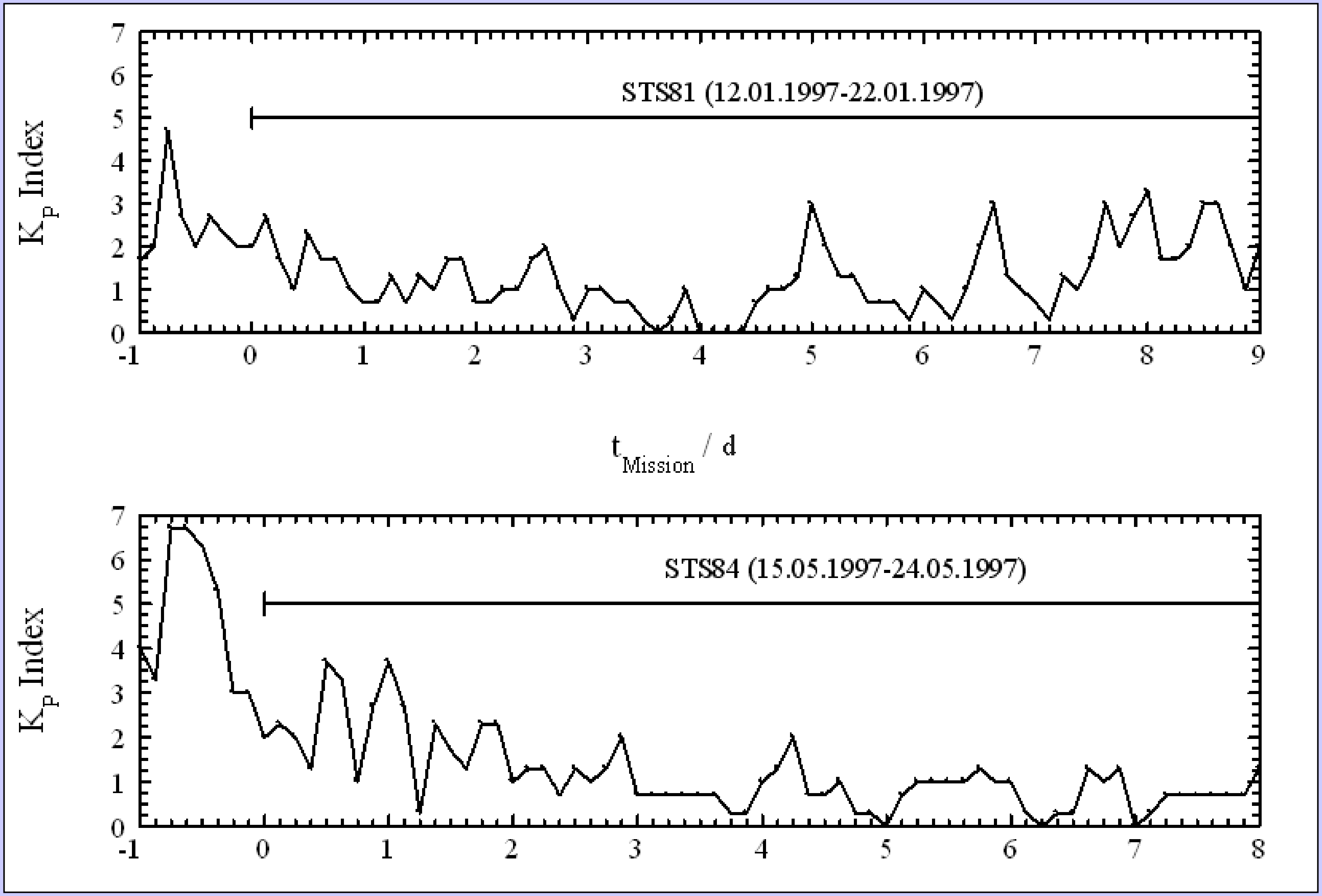


Geographical positions of inner and outer belt contributions to the count rate on STS84.

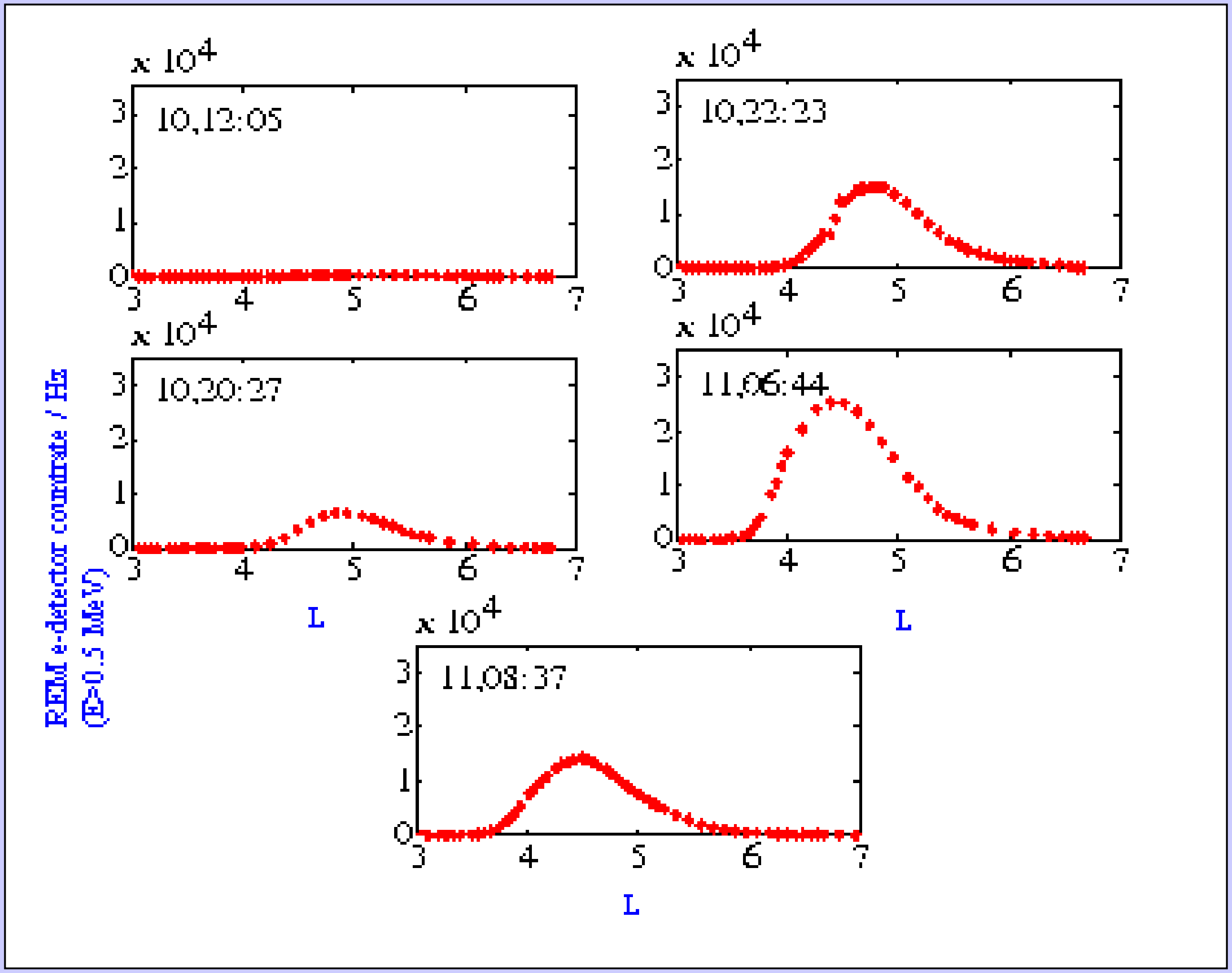
Discussion

- Outer belt contributions were only detected at the beginning of the missions
- highest K_P-values occured just prior to the missions

K_P-Index for STS81 and STS84

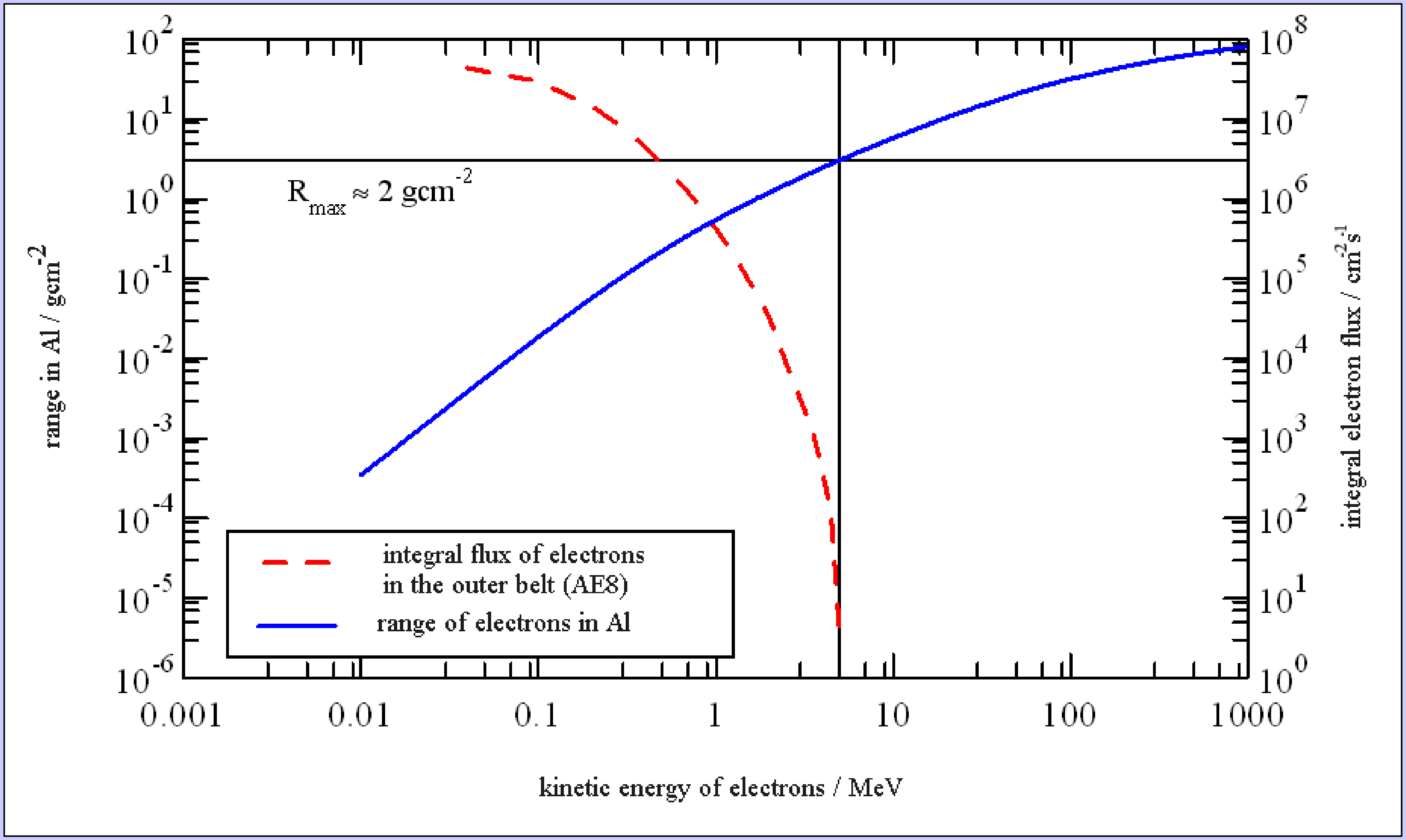


Shift of the outer belt after a solar Event (Buehler et al., 1996)



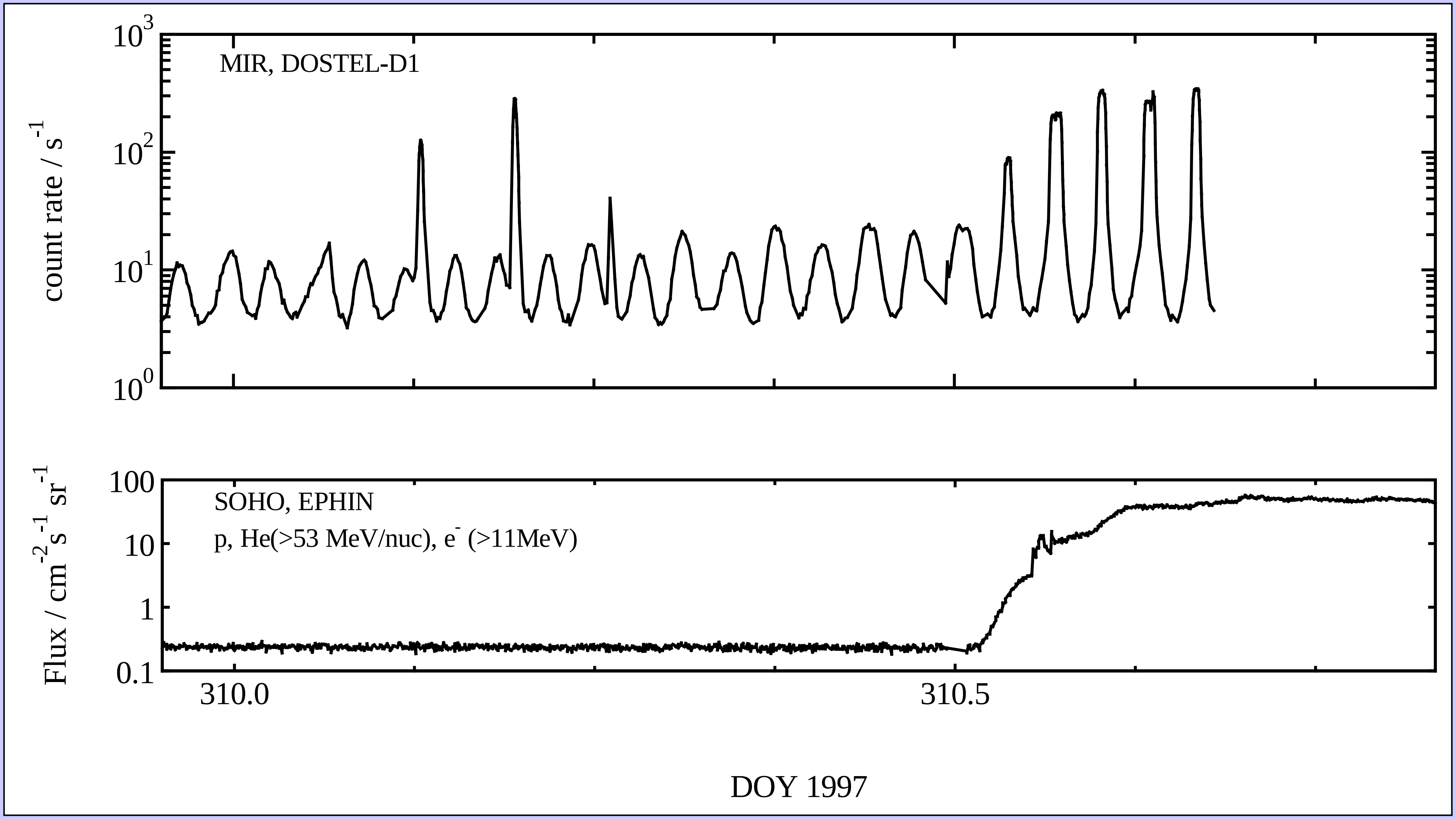
Buehler, P., S. Ljungfelt, A. Mchedlishvili, N. Sclumpf, A. Zehnder, L. Adams, E. Daly, R. Nickson, 1996, "Radiation Environment Monitor Nucl. Instr. and Methods" in Phys. Res. A 368 825-831

Energy spectrum of outer belt electrons



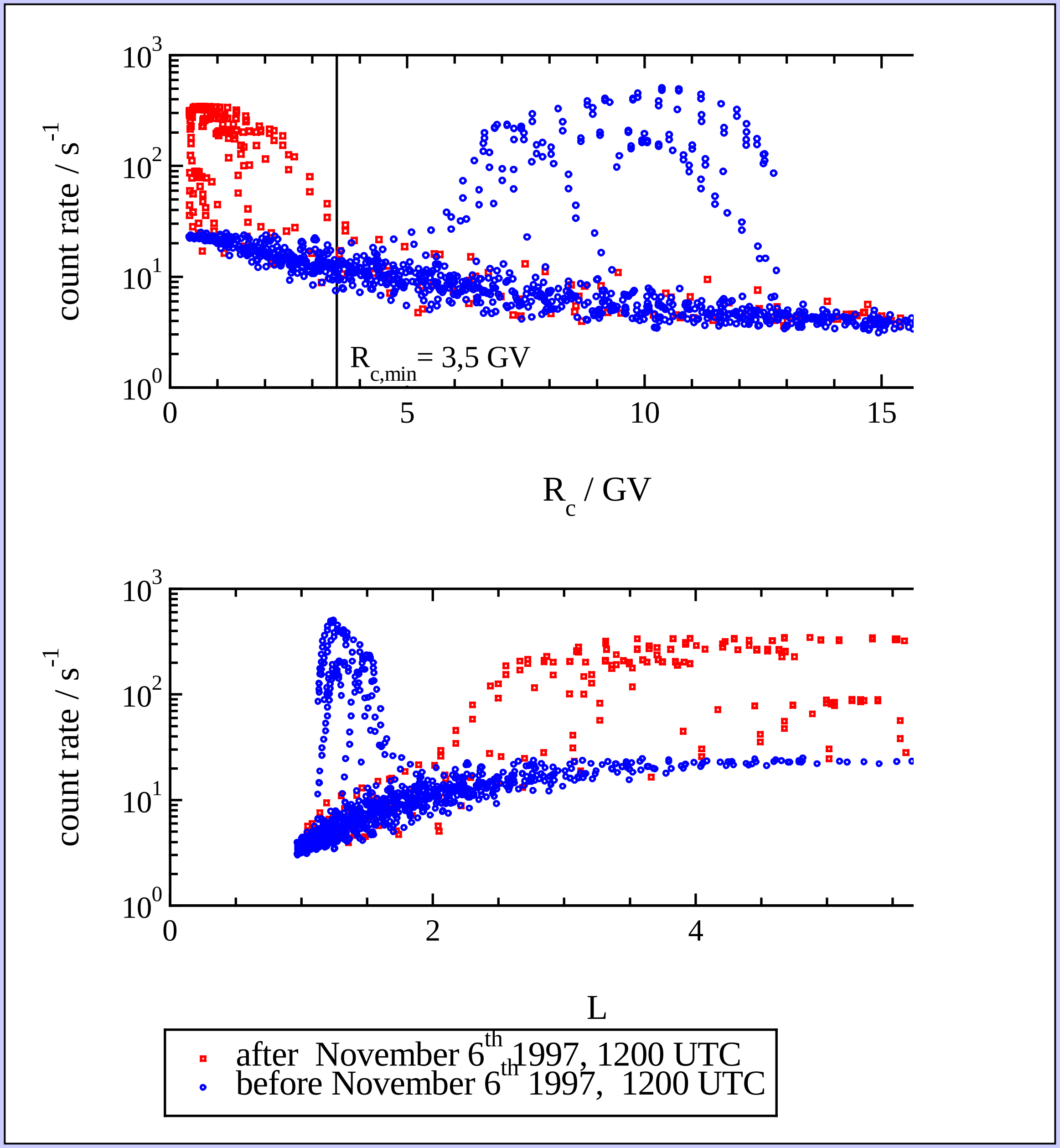
AE8 Electron flux was calculated with an inclination of 51.6° and an altitude of 390 km. Electron ranges from Berger and Seltzer, 1963.

ADCP, MIR Nov 6, 1997



DOSTEL count rates on Nov 6, 1997

- The first three major peaks are due to ascending crossings of the SAA
- minima indicate crossings of the cosmic ray equator
- the first phase of the solar event is well detected inside the MIR station



count rate / s-1
10^3
10^2
10^1
10^0
0
5
10
15
R c,min = 3,5 GV
R c / GV
count rate / s-1
10^3
10^2
10^1
10^0
0
2
4
L
after November 6th 1997, 1200 UTC
before November 6th 1997, 1200 UTC

SEP Dependence on Earth Magnetic Field in LEO

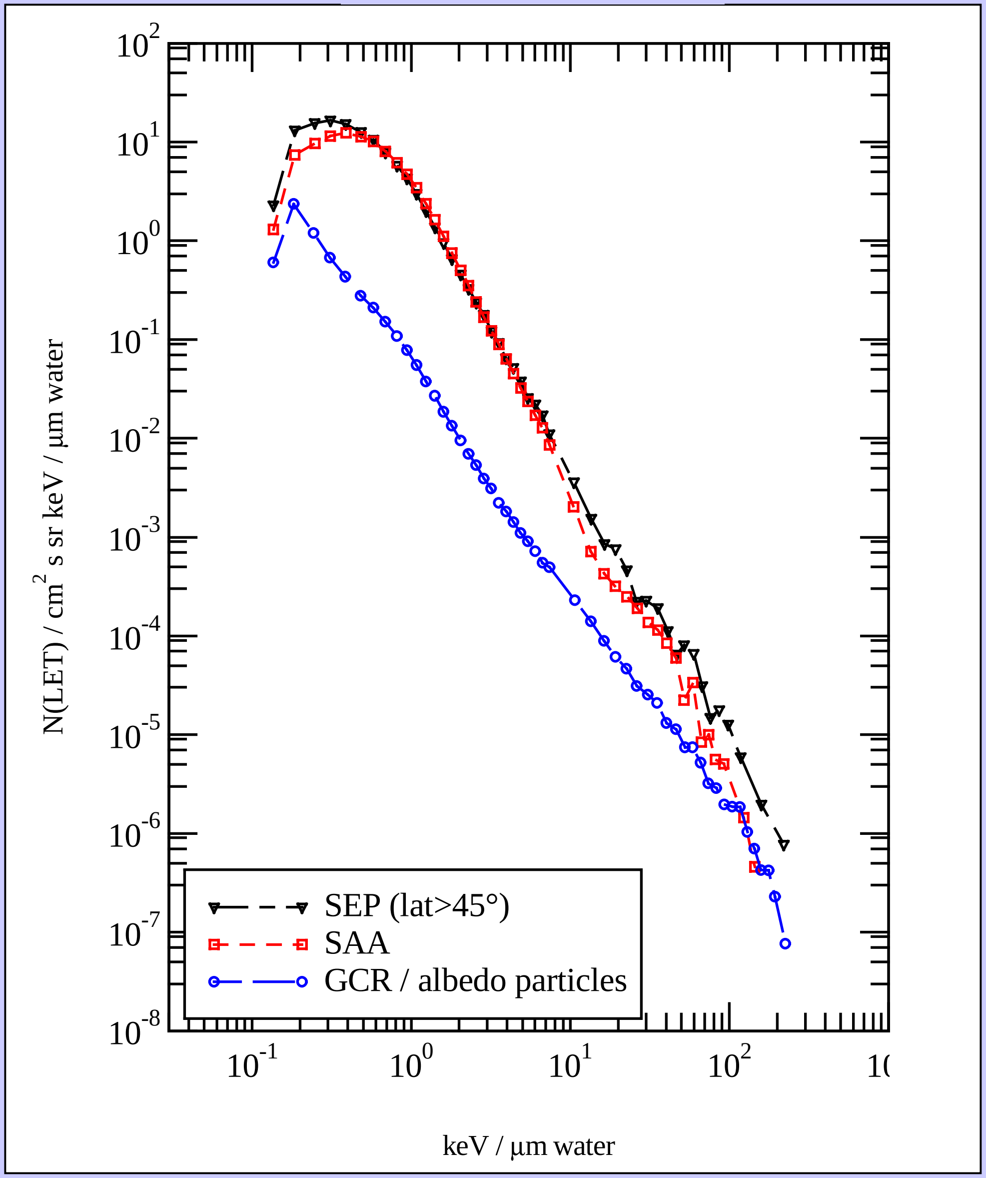
- SEP are only detected at RC < 3.5 GV
  - the maximum energy of the SEP is about 2.7 GeV by

$$R = \frac{A}{Z} \cdot E_0 \cdot \sqrt{\gamma^2 - 1} \qquad \text{with } \gamma = \frac{E+E_0}{E_0}$$

and E_0 = rest energy of a proton

- In the future it is maybe possible to calculate the energy spectrum of the solar protons by using this processing

LET spectra of different components of the radiation field inside the MIR station during the Nov 6, 1997 event



LET spectra of the radiation field inside the MIR station

- SAA and GCR/albedo spectra averaged during five quiet days
- SEP data for orbit segments above 45° lat on both hemisperes.
- GCR/albedo peak belongs to high energy particles with Z=1
- SAA and SEP contributions show a different slope compared to GCR
- SEP event causes a harder energy spektrum