| Paul Scherrer Institute | Memo | PROBA 1/SREM first results |
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# PROBA 1/SREM first results

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# 1 Introduction

SREM was launched aboard PROBA 1 on October 22, 2001 into a sun synchronous orbit. Between November 1 and 7, 2001, SREM was switched on and operated a few times. Results of this first test are presented in this report.

The data looks promising!

## 1.1 Timing

SREM was accumulating data during 5 periods, which are listed in table 1. The instrument was operated with varying accumulation time, reaching from one to ten minutes.

**Table 1:** SREM operation periods

| Start | Stop |
|---|---|
| 01-Nov-2001 17:07:03.050 | 01-Nov-2001 20:35:51.600 |
| 02-Nov-2001 14:27:32.000 | 02-Nov-2001 16:56:11.600 |
| 05-Nov-2001 10:23:46.950 | 05-Nov-2001 22:39:55.050 |
| 06-Nov-2001 11:42:33.000 | 06-Nov-2001 15:03:25.650 |
| 06-Nov-2001 21:40:33.000 | 07-Nov-2001 13:46:59.000 |

# 2 Orbit

The orbit parameters of the PROBA 1 orbit are listed in table 2. Figure 1 shows the satellite positions at the median time of each accumulation. In the upper panel the the orbit is projected onto a world map and in the lower panel the satellite positions are shown in the L-B-plane.

**Table 2:** Orbit parameters of the PROBA 1 orbit.

| Parameter | value |
|---|---|
| Height of apogee | 570 km |
| Height of perigee | 640 km |
| Inclination | 98° |
| Period | 97' |

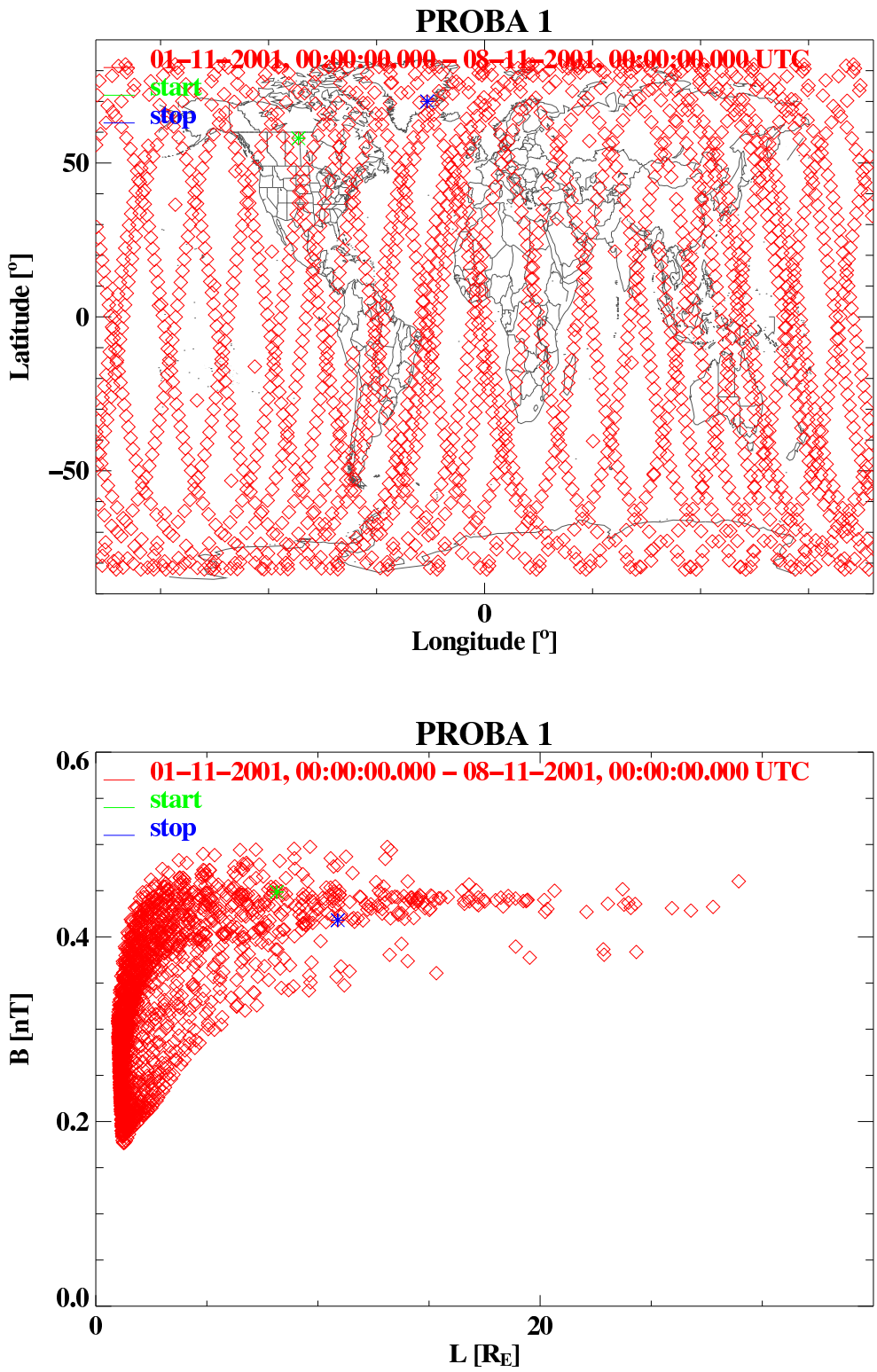


**Figure 1:** Position of PROBA 1 at the median time of each SREM accumulation. The upper panel shows the projection on a world map and the lower panel, the distribution in the L-B-plane.

# 3 HK data

Except of one reading of all the SREM registers on October 29, 2001 at 11:32:20 no housekeeping data was gathered. Regular housekeeping data is needed to judge the health of the system.

The values of some of the registers which were read out on October 29, 2001 at 11:32:20 are listed below.

| | | | |
|---|---|---|---|
| status | 9216 (0010010000000000) | aminterval | 32767 |
| lct | 57235.000 | T1proc | 0 |
| wfc | 0 | T2proc | 0 |
| cfc | 0 | T3proc | 0 |
| dtccr | 200 | T4proc | 0 |
| TC1 | 9.0000000 | T5proc | 0 |
| S12 | 8.0000000 | T6proc | 0 |
| S13 | 3.0000000 | T7proc | 263 |
| S14 | 0.00000000 | T8proc | 263 |
| S15 | 0.00000000 | T9proc | 263 |
| TC2 | 11.000000 | calref1 | 24674 |
| S25 | 0.00000000 | calref2 | 8765 |
| C1 | 0.00000000 | D1proc | 6081 |
| C2 | 0.00000000 | D2proc | 6232 |
| C3 | 0.00000000 | D3proc | 6382 |
| C4 | 0.00000000 | D4proc | 6530 |
| TC3 | 8.0000000 | D5proc | 6678 |
| S32 | 4.0000000 | D6proc | 6825 |
| S33 | 3.0000000 | D7proc | 1633 |
| S34 | 1.0000000 | Agndproc | 5954 |
| PL1 | 0.00000000 | Vcalref1proc | 6298 |
| PL2 | 1.0000000 | Vcalref2proc | 6311 |
| PL3 | 0.00000000 | Vcalref3proc | 6297 |
| pacid | 255 | Vcalref4proc | 6320 |
| pahylev | 0.00000000 | V6proc | 5921 |
| paunlev | 0.00000000 | V5proc | 5117 |
| eacid | 255 | HVproc | 148 |
| eahylev | 0.00000000 | | |
| eaunlev | 0.00000000 | | |

Some comments:

- At least the values of the following registers are as expected:
  - dtccr: the value of 200 corresponds to a deadtime sampling rate of 1 $kHz$
  - V6proc: the value of 5921 corresponds to a tension of 5.921 $V$
  - V5proc: the value of 5117 corresponds to a tension of 5.117 $V$
  - HVproc: the value of 148 is the tension in $V$
- The temperatures T7proc, T8proc, and T9proc of 263 $K$ ($-10\,C^o$) seem to be very low. And it is curious that all sensors measure the same value.
- The value of the status word indicates that the HV is not on, which however is in disagreement with the value of HVproc.

# 4 Counting rates

In order to demonstrate the performance of SREM we focus in the following on the period of time on November 7 from 01:00 to 05:00. This choice is arbitrary and any other period would presumably show similar features. Figure 2 shows from t.t.b the magnetic field strength, L-shell parameter, and the counting rates in the three main counters TC1, TC2, and TC3. The hashed areas in the upper two panels mark periods when PROBA 1 encounters open magnetic field lines (according to the field models used (IGRF95 and Tsyganenko 89 with KP=0)).

From the lower most panel four distinct regimes can be recognized.

1. low L, large B
   The satellite is in the inner belt region at high magnetic latitudes. The counting rates in all channels are very low.

2. low L, low B
   Such regions are encountered twice in the considered period, from 01:45 to 02:00 and from 03:15 to 03:30. The satellite crosses the South Atlantic Anomaly. The counting rates in the three counters TC1, TC2, and TC3 are very similar, indicating protons to dominate the detections (as expected in the SAA).

3. $3 \leq L \leq 7$, low B
   The satellite crosses the outer radiation belt at "relatively" low magnetic latitudes (however it must be recalled that the orbit is highly inclined and that at these L-values the satellite is far off the equator). Examples of such regions are found around 01:40, 03:15, and 04:50. They are traversed in only a few minutes. Here the counting rate of TC3 is much higher than in TC1 or TC2, indicating electrons to dominate the detections. The fact that even in TC1 hardly an enhancement of the counting rates is seen indicates further that these are electrons at energies below 1 $MeV$.

   With an accumulation time of 60 seconds these regions are sampled by only a few data points. In order to enable the resolution of spatial structures in these peaks it would be preferable to reduce the accumulation time to 30 seconds or less.

4. large L, large B (open field regions)
   These periods are characterized by rather high counting rates in TC1, TC2, and TC3. The ratio between the rates of these three counters seems to vary only little (TC3:TC1:TC3 $\approx$ 1:0.5:0.1). Neither protons nor electrons are likely to dominate the detections here!

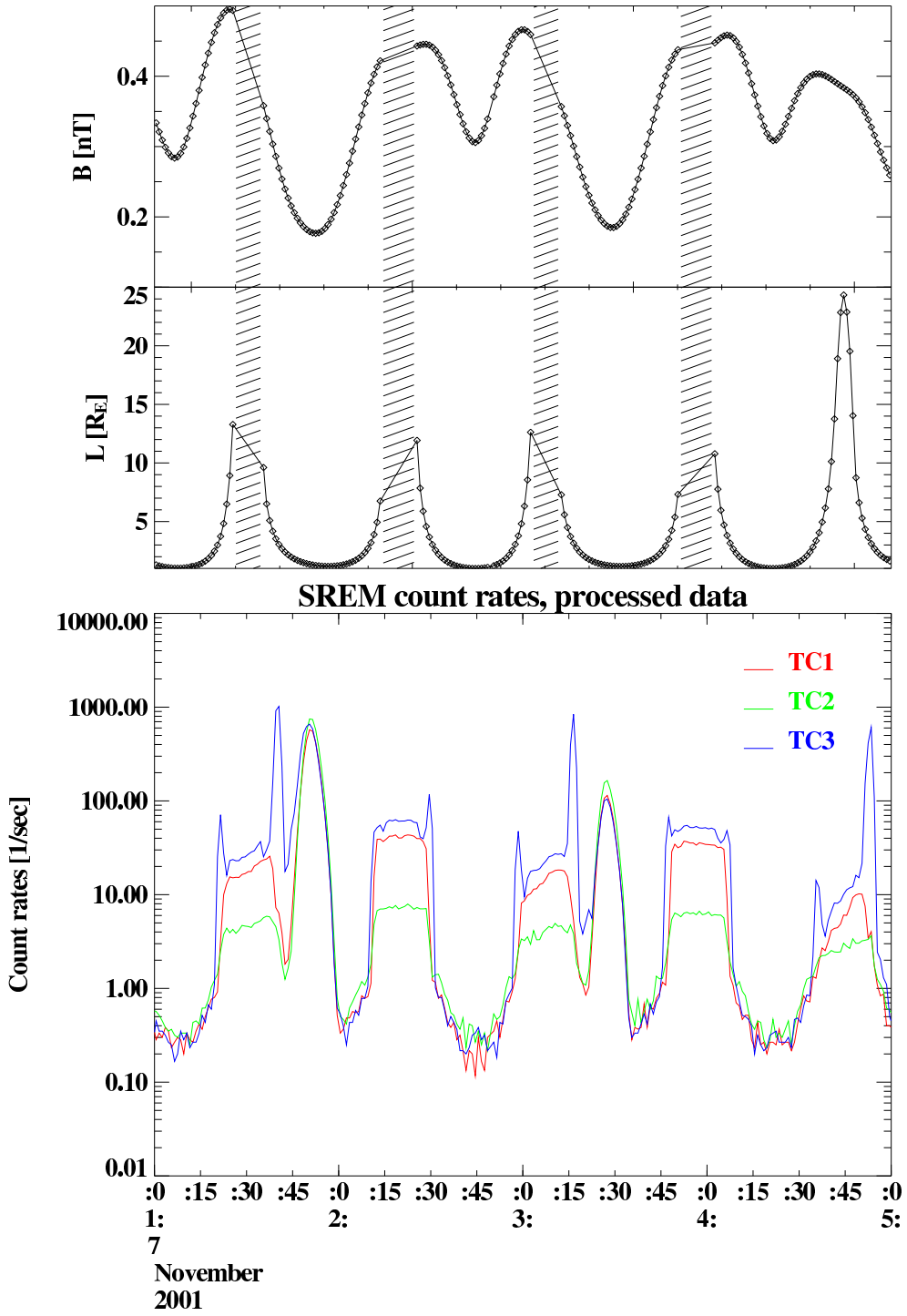


**Figure 2:** SREM counting rates of the three counters TC1, TC2, and TC3. The hashed areas in the upper panel mark periods when PROBA 1 was in regions with open magnetic field lines.

# 5 Comparison with EA8/AP8

In figures 3 and 4 the measured counting rates in TC2 and TC3 are compared with model rates which have been computed by folding the AE8/AP8-max model particle spectra with the SREM response function.

Both figures show the period from November 7, 2001 from 01:00 to 02:00.

There is a remarkable agreement between measurements and model values in the inner proton belt region (01:40 - 02:00) for both counters.

The passage through the outer electron belt does not show up in TC2 (in agreement with the model). In TC3 however, the passage leads to enhanced rates, which is seen in both, measurements and model calculations. However, the positions of the peaks are not in full agreement. Since the outer belt is highly dynamic these differences should not surprise.

Outside the radiation belts the AE8/AP8 particle fluxes are 0.

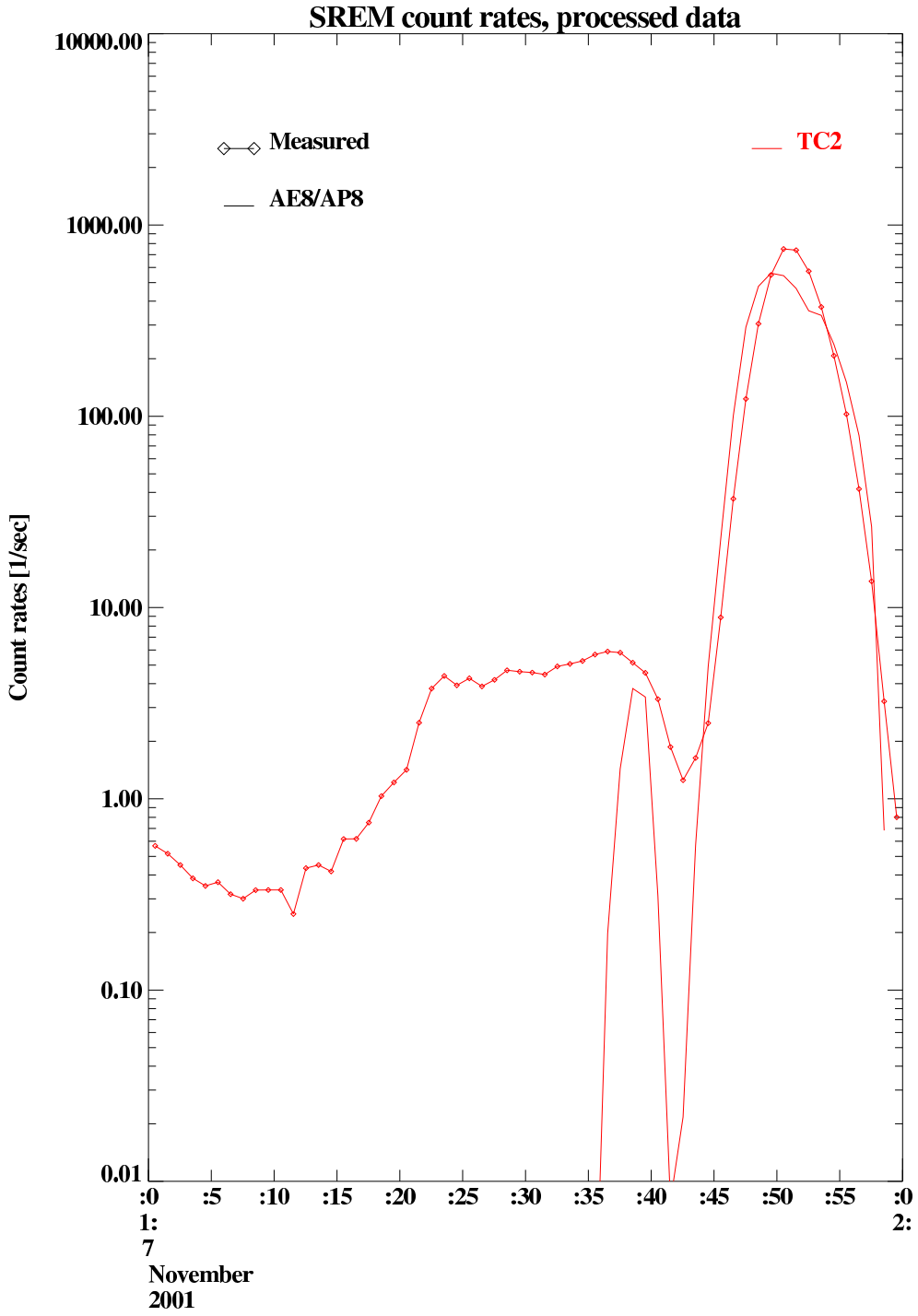


**Figure 3:** Comparison of the registered counting rate in counter TC2 (line with dots) and the counting rate computed with AE8/AP8-max model particle spectra (line without dots).

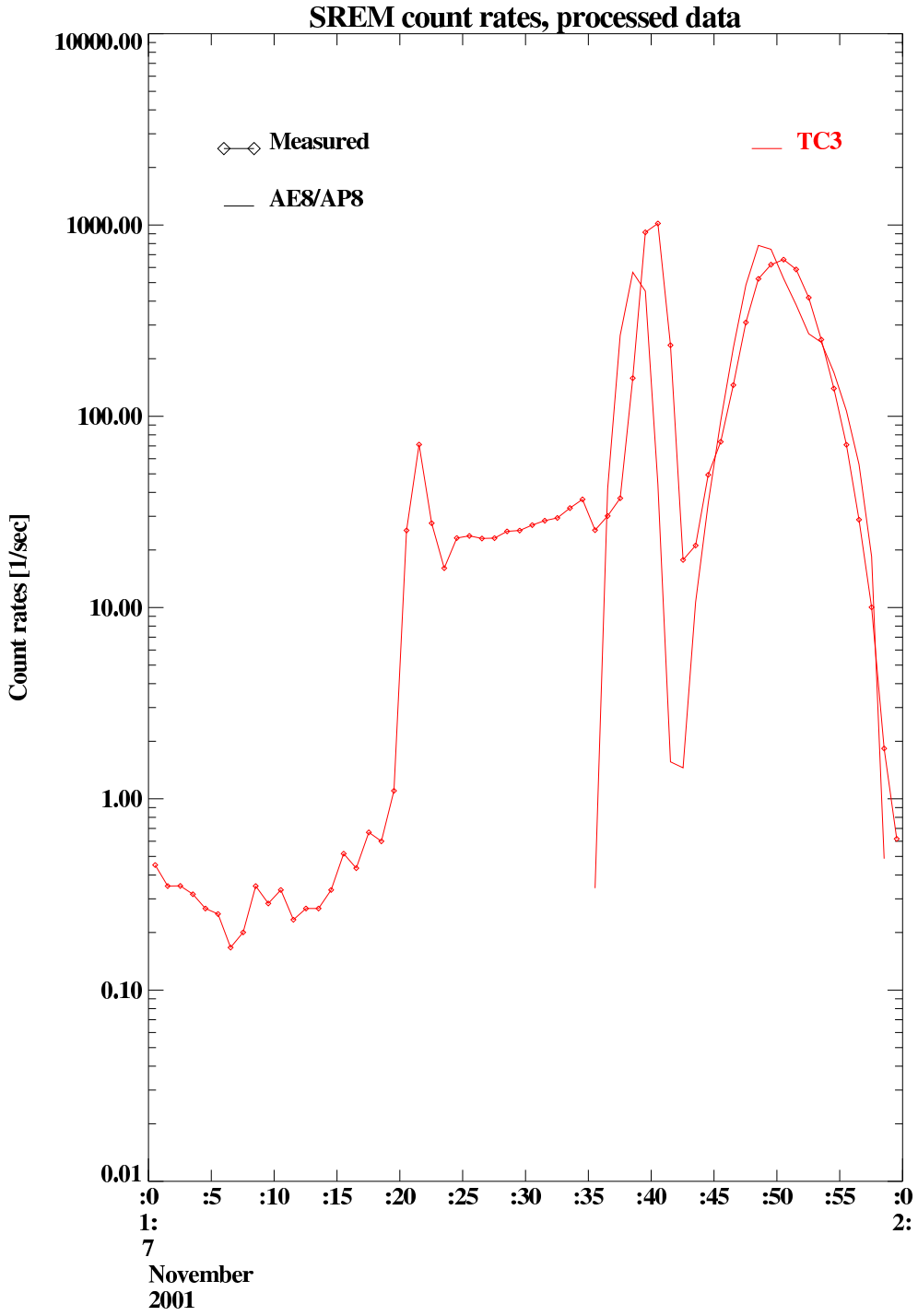


**Figure 4:** Comparison of the registered counting rate in counter TC3 (line with dots) and the counting rate computed with AE8/AP8-max model particle spectra (line without dots).

# 6 Particle spectra

In order to demonstrate the SREM spectral resolving capabilities we selected two measurements from which the particle spectra were deduced.

## 6.1 Proton spectra

The first data point (November 7, 2001, 01:49:32) is located in the inner belt (see figures 3 or 4) where the high energy radiation environment is dominated by protons.

The proton spectrum was approximated by a powerlaw and a step-function. The results are shown in figure 5, where the SREM proton spectrum is compared with the corresponding AP8-max spectrum. Again we find a good agreement for the protons between model and measurements.

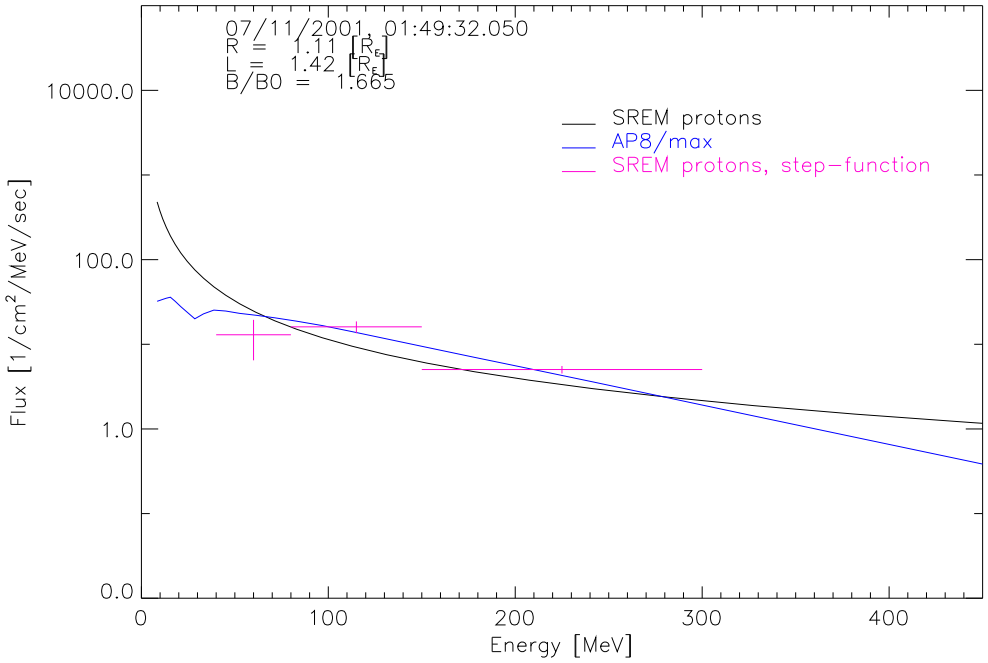


**Figure 5:** Comparison of an SREM proton spectrum with the corresponding NASA AP8-max model spectrum. Time and location of the data point is indicated in the upper left corner.

## 6.2 Electron spectra

The second data point (November 7, 2001, 04:53:32) is located at $L = 3.1\ R_E$ (see figure 2) where the high energy radiation environment is dominated by electrons.

The electron spectrum was approximated by a exponential and a step-function. The results are shown in figure 6, where the SREM electron spectrum is compared with the corresponding AE8-max spectrum.

The SREM electron spectrum is very soft. This is in agreement with the fact that these electrons do hardly produce detections in TC1 (see also section 4). If our estimate of the lower energy threshold of TC1 is correct (deduced from calibrations and simulations) then the electron spectrum at this points must indeed be very soft. This behaviour is to be verified with more data.

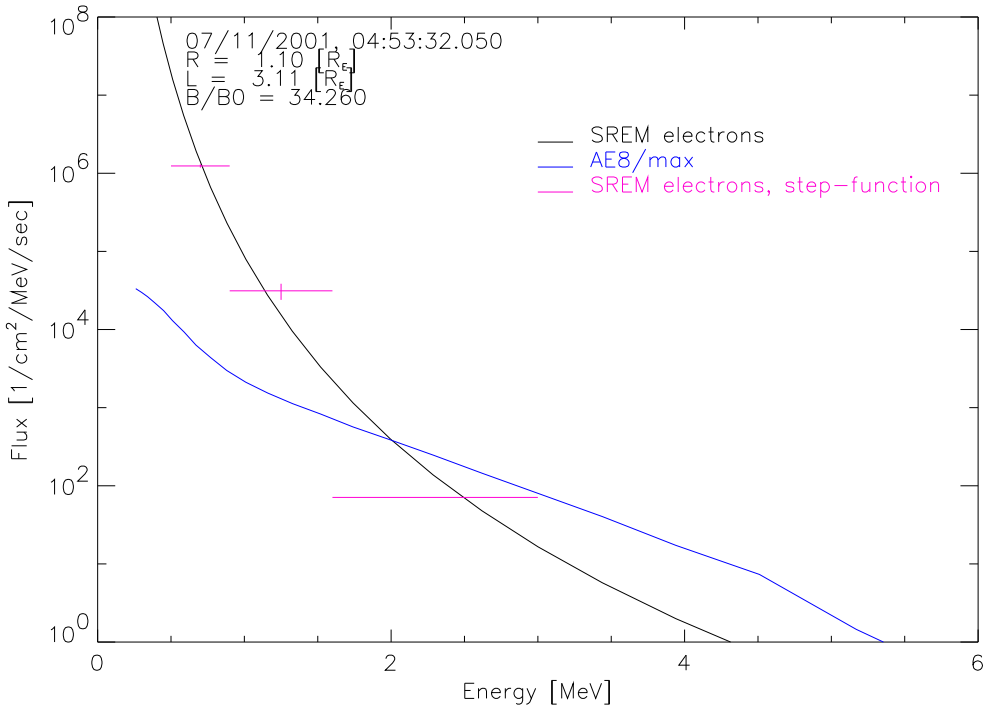


**Figure 6:** Comparison of an SREM electron spectrum with the corresponding NASA AE8-max model spectrum. Time and location of the data point is indicated in the upper left corner.

# 7 Conclusions

After a first quick analysis of this first set of data from SREM aboard PROBA 1 we note:

- The data seems to be free of parasitic noise.
- The relative counting rate variations as function of orbit position are in agreement with the expectations (see section 4).
- In order to monitor the health of the instrument regular housekeeping data would be desirable (see section 3)
- An accumulation time of 60 seconds (as planned for the regular operation) is long compared to the time the satellite needs to pass through the outer electron belt (a few minutes). In order to resolve spatial features in this region an accumulation time of 30 seconds or less is more adequate (see figures 2 and 4).
- The counting rates in the "open field" regions (see section 4) are high. The reason for these high rates is not clear and needs further investigations and monitoring.