1995 / III A

MONITORING OF THE EARTH RADIATION BELTS WITH REM

P. Buhler, L. Desorgher, A. Zehnder (PSI), L. Adams, E. Daly (ESA/ESTEC)

Since now more than a year, two Radiation Environment Monitors from PSI are orbiting the earth. They provide information about the high energetic particles trapped in the earth radiation belts.

Like in a magnetic bottle, charged particles with energies above 200 keV are trapped in the earth magnetic field and form the so-called radiation belts. Two belts are distinguished: the inner and the outer radiation belt. The inner belt consists mainly of protons with energies up to a few hundered MeV and the outer belt, of electrons with energies up to a few MeV. The equatorial distance from the earth center to the inner belt ranges from 1.2 to 1.8 earth radii and of the outer belt, from approximately 3 to 6 earth radii.

These high energetic particles have caught the attention of companies involved in space flight because of their destructive effect on satellite materials and equipment and their danger for spacestation crews. A solid knowledge of the particle fluxes and understanding of the variations is crucial for the planing of adequate protections. One step towards a better understanding is to make continuous measurements of the radiation belt particles.

Since the middle of 1994 two Radiation Environment Monitors, REM [1] form PSI are monitoring the high energetic proton and electron fluxes on two particular orbits. One REM is orbiting the earth aboard the UK satellite STRV-1B on a nearly equatorial elliptical orbit, covering altitudes between 300 km and 36000 km. It thus passes periodically through both radiation belts. The second REM is mounted on the outside of the manned Russian spacestation MIR on a circular orbit at an altitude of 400 km.

The trajectories and fluxes of the radiation belt particles are mainly defined by the configuration of the earth magnetic field. Whereas at low altitudes the magnetic field is rather stable and well described by a dipolar approximation, it is strongly influenced by the solar wind pressure and the Inter Planetary Magnetic Field at larger distances. This is the reason why the outer belt is much more variable than the inner belt.

In Fig. 1 the count rates in the STRV-REM electron detector, encountered at an altitude of 4.5 earth radii are plotted versus time. The vertical dashed lines are equally spaced in time, with a period of 26.5 days and shall help to guide the eye.

Two essential properties of the count rate curve can be noted. First there exists a seasonal variation with higher electron fluxes in fall and spring and low rates during winter and summer. As second property we note that the count rates periodically increase by up to a factor 100. The count rate peakes can be grouped into different series with constant delay of 26.5 days between contiguous maxima. The peiod fits well with the mean solar rotation period. The reason for these periodic enhancements are fast solar wind streams compressing the earth magnetosphere. The solar coronal holes, from where fast wind streams originate, have lifetimes of typically a few solar rotations. Thus the different series of count rate peakes can be understood as reaction of the magnetosphere to fast solar wind streams originating from specific coronal holes.

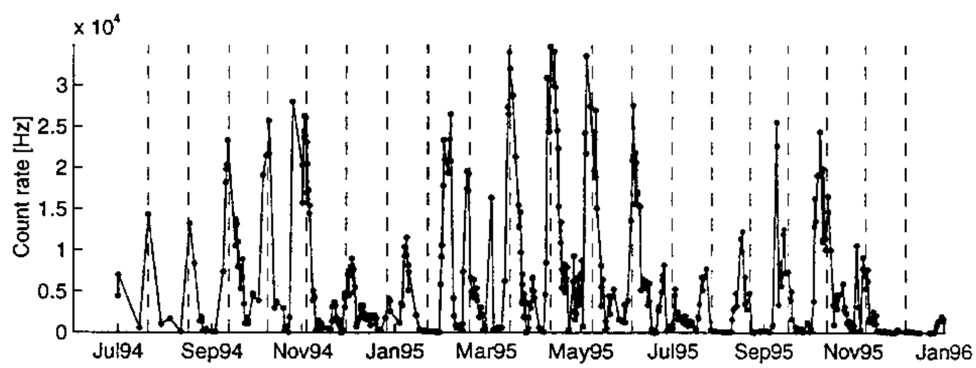

Figure 1: STRV-REM count rates versus time at an altitude of 4.5 earth radii. The vertical lines are equally spaced in time with a period of 26.5 days, the solar rotation period.

The MIR-REM measuremets are dominated by high energetic protons in the South Atlantic Anomaly, SAA. Due to the tilt and shift of the dipole axis of the magnetic field relative to the earth rotation axis, the magnetic field strength at the MIR altitude has a minimum located above the Brazilian east cost. Protons from the inner radiation belt, following the magnetic field lines can penetrate in this region to low altitudes. In Fig.2 contours of constant MIR-REM proton detector count rates (bold lines) are plotted on a geographic map. The ratios of the count rate levels are 25:20:15:10:5:2, starting at the innermost contour. Overplotted are contours of constant B-field strength at an altitude of 400 km (dashed lines). The labels are given in nT.

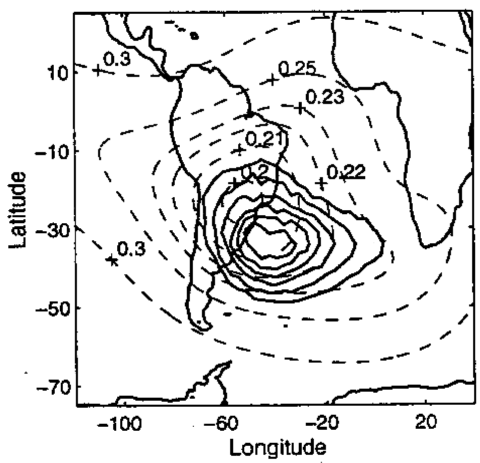

Figure 2: MIR-REM proton detector count rates (bold lines) together with calculated B-field strength at an altitude of 400 km (dashed lines).

References:

[1] P.Buhler et al., Radiation Environment Monitor, Nucl. Instr. and Meth. in Phys. Res. A, in press