

REM, FIRST YEAR IN SPACE

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The REM project

After a preparation period of three years, two REM instruments have been installed on two different satellites during the year 1994 and deliver now continuously data from the earth radiation environment.

The REM instrument

The REM detectors consists of two thin (300 μm thick), totally depleted silicon diodes, measuring the differential linear energy transfer (LET) of charged particles [3]. The detector electronics measures the energy deposit and increments one of 16 counters. Data is accumulated over a period of typically 100 seconds and then stored as a 16-bin histogram. The two detectors differ in size (150 mm^2 and 50 mm^2) and shielding. Both detectors are covered with a spherical dome of 3 mm Al and the larger detector with additional 0.75 mm Ta. Whereas the first detector sees protons as well as electrons (called e-detector) the extra tantalum of the second detector reduces the penetration for electrons in the relevant energy range (2 - 10 MeV) by approximately a factor of 200 and makes this detector better at monitoring protons (energy range 35 - 300 MeV) (called p-detector). Due to the variation of the energy loss of protons in silicon in this energy range the incident energy of the protons is measured, whereas the incident energy of the detected electrons is only poorly determined.

Probing the geostationary transfer orbit (GTO) and low earth orbit (LEO)

On June 17, 1994 the Space Technology Research Vehicle (STRV-1B) with a REM aboard was launched into space with an Ariane rocket from ESA. In the middle of September, 1994 a second REM was shipped to the Russian manned MIR station and was subsequently mounted on the outside of the space station by one of the cosmonauts.

The two carriers of REM have completely different orbits. The orbit of the STRV-satellite is highly elliptical with apogee and perigee altitude of 300 km and 36'000 km, respectively and a period of ~10 hours. Its inclination in respect to the earth equator is 7° (GTO). The MIR station surrounds the earth every 90 minutes on a nearly circular orbit (inclination 52°) in an altitude of ~400km (LEO). Both orbits are of special interest for spaceflight. The GTO passes repeatedly through the earth radiation belts (see [4] for an introduction into the physics of geospace) and is an excellent orbit for studying the radiation environment through a range of altitudes. The LEO is the preferred orbit for future manned space stations.

STRV-REM-data: The operation of the REM on the STRV satellite is controlled by commands issued from ground. With an uploaded operation table the start and stop times and the sequence of accumulation times is determined. Once per orbit there is a link session for uploading new commands and/or downloading accumulated data. All data is subsequently made available to PSI where it is archived and a first rough analysis is made to check the proper functioning of the detectors and to ensure the data quality. The total observation time until the end of 1994 amounts to 1450 hours.

The course of the counter rates over one orbit is characterized by the passage through the radiation belts. In figure 1 the accumulated doses are plotted against the time for one orbit. At time 0 the satellite is near apogee, below the inner belt (~6000 km). It then moves away from the earth and reaches after ~19000 seconds the perigee, from where it comes back to reach the apogee again after ~38000 seconds. The steps in the dose-curves during phase 1,2,3, and 4 (see figure 1) mark the passages through the radiation belts. Steps 3 and 5 hardly show up in the p-detector, indicating that the outer belt consists mainly of electrons. Whereas the total amount of deposited energy per orbit varied only weakly in the p-detector (2 - 5 rad) during the first six month of operation it ranged from 3 to 40 rad in the e-detector. The data show a periodic variation with a period of 27 days, the rotation period of the sun, manifesting the influence of the solar activity on the trapped particles in the outer radiation belt.

MIR-REM-data: The MIR-REM is programmed to accumulate data with pre-defined accumulation times of 32 seconds once it has been switched on. The data is stored on board and is periodically downloaded. Since first switch-on at the end of september, 1994 the observations have only been interrupted for a few days. Because the MIR station remains always below the radiation belts the absorbed doses are only typically 0.5 mrad per orbit in the e-detector and even less in the p-detector. Figure 2 shows the detection rates vs. time curves of both detectors over a limited number of orbits. Both curves have a periodic variation with a period of 2700 seconds which is half of the orbit period. The maxima occur when the MIR station passes at maximum latitude where the geomagnetic shielding is weak. The strong peaks in the e-detector curve are electrons from the outer belt brought to low altitude by geomagnetic field lines (polar horns).

References

- [1] E. Daly, ESA Journal 1988, Vol 12, p. 229
- [2] E. Daly, S. Ljungfelt, K. Thomsen, and A. Zehnder, PSI Annual Report III/B, 1991, p. 41
- [3] L.Adams, E.Daly, R. Nickson et al., presented at the ESTEC TDP Workshop, Nordwijk, 21-22 June,1993
- [4] J.K. Hargreaves, The solar-terrestrial environment, Cambridge University Press, 1992

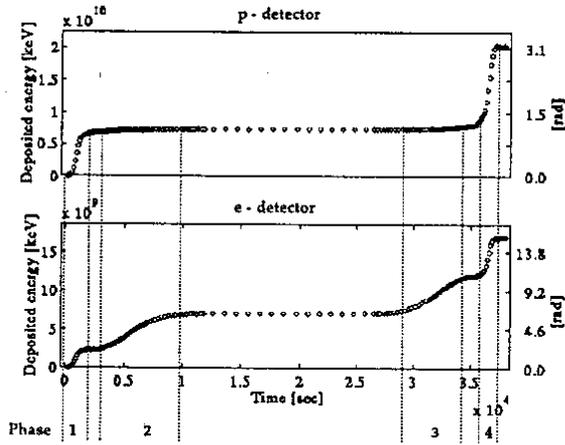


Figure 1: Accumulated doses in the two STRV-REM detectors during one orbit

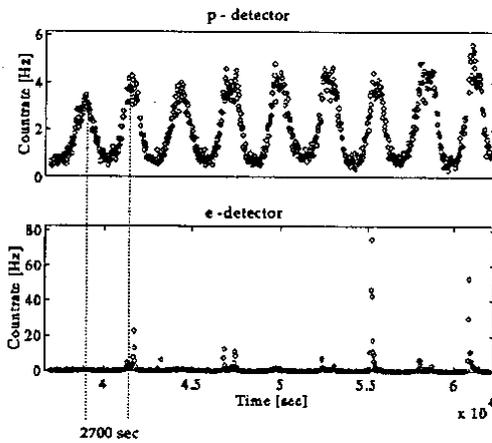


Figure 2: MIR-REM countrates over a limited number of orbits