G.3 Calibrations of the Engineering Model of the Standard Radiation Environment Monitor at the PIF

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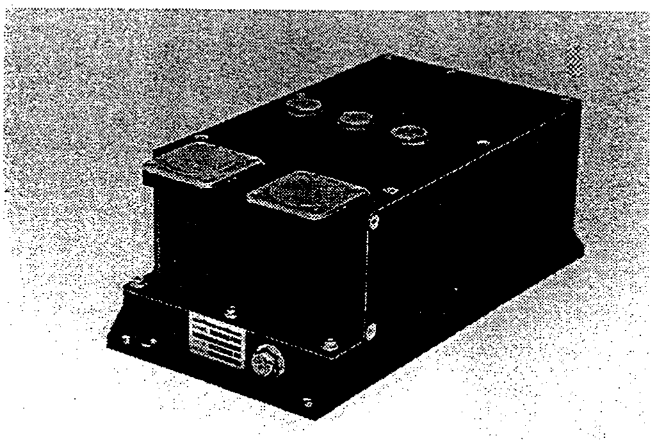
Calibrage du modèle de définition du moniteur d'environnement radiatif standard au PIF

Le modèle de définition du moniteur d'environnement radiatif standard (SREM) a été construit sous contrat ESA par OERLIKON-CONTRAVES SPACE en collaboration avec PSI. Différentes caractéristiques du moniteur ont été testées et les fonctions de réponse aux protons ont été mesurées auprès du PIF, accélérateur de protons. Les résultats sont comparés aux simulations Monte Carlo.

GENERAL

The Standard Radiation Environment Monitor is a second-generation radiation monitor developed by the partnership of ESA, PSI and industry. Compared to the first REM [1], the new design is characterised by smaller weight and dimensions, lower power consumption and a much wider operating temperature range. It has the capability of detecting very high particle fluxes, i.e. up to a few hundred thousand events per cm^2 and sec. While preserving the spectroscopic information, the monitor provides now a certain amount of directional sensitivity. An optional set of external RADFETs enables total dose determination at up to seven distinct locations on the satellite. Two programmable alarm flags for high/low dose rates are implemented, and by using radiation tolerant components the in-orbit operation time will be extended to about 10 years. SREM is designed as a basic dose monitoring equipment for ESA missions with a layout being compatible to most spacecraft standards world-wide [2]. The engineering model of this monitor was manufactured in November 1996. Its view is presented on the photograph below.



SREM Engineering Model.

DETECTION SYSTEM

The SREM consists of 3 Silicon Surface Barrier Detectors embedded in a bi-metallic shielding/ mounting structure of Tantalum (inner) and Aluminium (outer). Two of the detectors are arranged in a telescope set-up to provide better resolutions of type, energy and directionality of the incident radiation. After signal pre-amplification the pulses are scrutinised by a set of 15 fast comparators. Their levels are optimised to get the most accurate information on the spectrum shape (i.e. deposited dose) of the detected particles. The discriminator signals (events) are summed up in counters for immediate on-line processing, as alarm flag setting and dose rate calculation. In the off-line analysis (on ground), the information stored in the counters will be used to extract the particle spectra. An additional set of 3 counters is measuring the dead time of the analogue channels and thus provides the on-line dead time corrections factors. The low energy detection thresholds for protons and electrons are defined by the thicknesses of the Al entrance windows. Thus the window thicknesses can be selected depending on the mission specific requirements. The Engineering Model was designed to detect protons from 8 MeV up to more than 300 MeV and electrons from about 0.3up to 6 MeV. In addition one discriminator/ counter channel is set to identify heavy ionising particles.

CALIBRATIONS

During the PIF [3] calibration runs in November 1996 the following measurements were performed:

- Linearity and minimum sensitivity
- Dead time and pile-up corrections
- Total sensitive area of SREM detectors
- Proton spectra for different energies and angles
- Spectra of ^{60}Co gamma and cosmic rays

All SREM proton and electron bins were located within the linear range. The linearity extends from the low energy threshold of ½ MIP to about 30 MIPs (MIP - Minimum Ionising Particle).

The dead time measured for the ½ MIP signals was below 10% for fluxes above 10^5 p/cm^2/sec. At this particle fluxes the pile-up corrections were found to be on the level of 10-20%. Correcting for the pile-ups becomes very important at these high rates in order to be able to reconstruct reliably the particle spectra.

Totally 35 pairs of energies and angles were set for proton spectra and angular distribution measurements. The energy of the incoming protons was varied in the 38 to 300 MeV range using the PIF energy degrader. The angular position of the SREM was changed to cover the full range of particle incidence angles from 0° to 180°. A flat beam field was set up for uniform irradiation of the two detector housings of the monitor. With fast, plastic detectors arranged in a telescope set-up the proton flux in front of the SREM was measured for normalisation.

MONTE CARLO VERSUS EXPERIMENT

Monte Carlo simulations of the SREM proton response are performed with the GEANT particle transportation code from CERN. An accurate modeling of the experimental data requires a reliable construction of the data bank by taking into account the details of the structures inside the SREM box. An example of angular distributions is shown in the figure below.

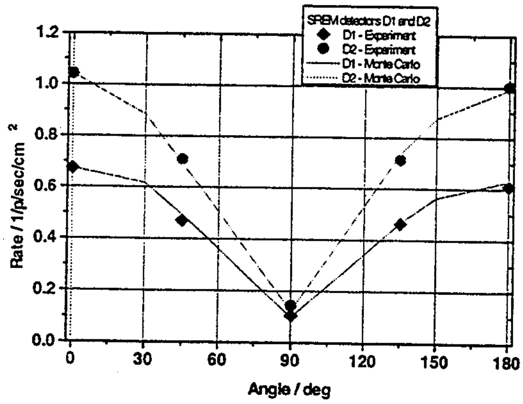


Fig. 2 Proton count rate as a function of angle for two SREM detectors D1 and D2.

FUTURE PROSPECTS

The first SREM flight model is scheduled for operation on the STRV-C mission in 1998. It will succeed the very first REM model still operating on the STRV-B [4] satellite in continuing the survey of the earth radiation environment. Further SREMs are planned by now for the ESA Integral and Propa satellites.

REFERENCES

[1] P. Bühler et al., Nucl. Instr. And Meth. A368, 825 (1995).

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[3] W. Hajdas et al., Nucl. Instr. And Meth B113, 54 (1996).

[4] P. Bühler et al., ESA Symposium Proceedings on 'Environment Modelling for Space-base Applications', p.87, ESTEC, Noordwijk 18-20 Sep 1996.