TESTS OF THE REM DETECTOR ON THE BETATRON

Wojtek Hajdas*, Sven Ljungfelt*, Imogen Cordt†

* Astrophysics Division, Paul Scherrer Institute

† Institute for Medical Radiobiology (IMR) of the University of Zürich and Paul Scherrer Institute

Intruduction

The Radiation Environment Monitor (REM) was developed by PSI and CIR[1] for the study of proton and electron spectra in space. The first flight version of the REM detector will be launched in early 1994 on the Space Technology Research Vehicle (STRV) to investigate radiation conditions in the geostationary transfer orbit and the earth's radiation belts. The STRV model of REM consists of two thin, totally depleted Silicon diodes (300 μm thick, 25 and 150 mm^2 area) shielded with hemispherical domes of 3.0 mm Al and 3.0 mm of Al plus 0.75 mm of Ta respectively. The dome thicknesses correspond to ranges of electrons with energies of 1.7 and 3.5 MeV respectively.

Experiment

During on-ground tests, the PSI Proton Irradiation Facility (PIF) was used to establish the detector response function for protons with energies up to 300 MeV[2]. First electron tests were done recently using the electron beam from the BBC betatron of IMR. The betatron works at 50 Hz and provides electrons with energies up to 30 MeV[3]. As a typical spectrum of cosmic electrons decreases exponetially by about 3 orders of magnitute between 1.5 and 5 MeV, only this energy region is of special interest. At these energies, however, the betatron beam is to some degree contaminated with X-rays.

Properties of the betatron beam were determined using two plastic detectors arranged in a ΔE-E telescope and mounted on the betatron beam line about 10 cm from the beam collimator exit. The thin ΔE detector was 10x10x2 mm^3 whereas the stopping detector was a cylinder (25 mm diameter) of 72.5 mm length. Compton edges of four gamma sources (^{60}Co, ^{137}Cs, ^{54}Mn and ^{22}Na) and the end-point energy of the ^{90}Sr beta source were used to calibrate the E detector. (The parameters of the calibration line were found with the least squares minimization method.) It was assumed that the mean energy loss of the 1 to 10 MeV electrons in the ΔE detector is energy independent (within 5%). The ΔE detector was calibrated by fitting the shape of the electron spectrum with the help of the GEANT code from CERN[4].

In order to avoid counting more than one electron per beam burst, the count rate had to be kept below 50 counts per second. In this way the number of pile-ups was reduced to less than 2-4%. The spectra of the electrons and X-rays background were determined using ΔE and E detectors working in coincidence and anticoincidence - see Figures 1a and 1b.

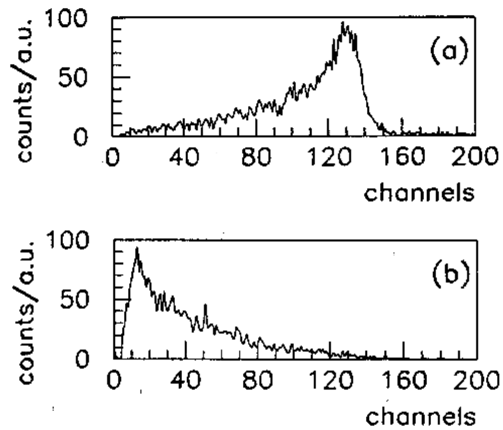

Figure 1: Energy spectra from the E-detector of the ΔE-E telescope. (a)- electrons, (b) - X-rays.

It was found that the relative amount of the low energy tail electrons in the spectrum increased with lower beam energies. Similarly, for lower energies, the contamination of the electron beam with X-rays was higher. Because X-rays were produced by electrons, their energies were always lower than the maximum electron energy. Their spectrum was found to decrease exponentially with the energy.

Experimental procedure for testing the REM detector consisted of two steps. During the first, the beam parameters, e.g. energy, intensity, stability, were optimized (as well as the non-electron background was determined) with the help of the ΔE-E telescope set as already desribed. In the second, the telescope was replaced by one of the REM detectors while the beam was monitored by single ΔE plastic counter mounted as close as possible to the REM, i.e. about 2.0 cm from the beam axis. The measurements were performed at several energies between 1.0 MeV and 10.0 MeV. Both plastic and REM detector spectra were measured using PC Multichannel Analyzers, and stored on the PC disk for further analyses. The spectra measured by the small (25 mm^2 area) REM detector at beam energies of 1.4 and 3.0 MeV are presented on Figures 3a and 3b (full dots).

Results

The data are under evaluation. The largest part of the analyses is performed using the particle tracking code GEANT. The electron and X-rays spectra measured with the ΔE-E telescope are used as the program input. For each beam energy the relative normalization of their intensities is found by fitting the spectrum shape of the single ΔE detector - see Figure 2. It allows to determine the electron and X-ray contributions in spectra of the REM detector. In Figures 3a and 3b, the experimental REM data taken at beam energies of 1.4 and 3.0 MeV are compared with the simulated electron and X-ray spectra.

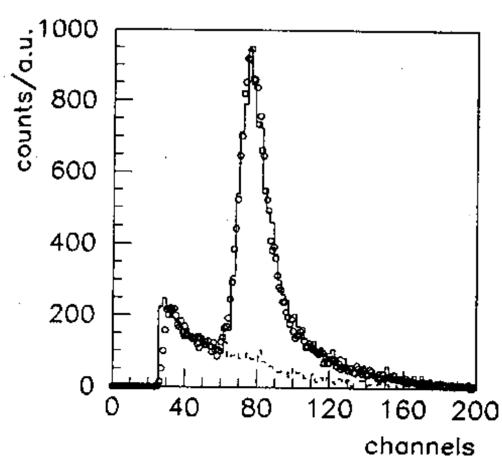

Figure 2: Energy spectrum of the monitor detector. The solid line represents GEANT calculations with electron and X-ray contributions. The dashed line shows the X-ray part of the spectrum.

Further tests with improved experimental apparatus are forseen for the next future. It is planned to install a gamma veto detector and to purify the electron beam with the help of a simple magnet spectrometer.

We want to thank Fred Dürr, Reinhold Henneck and Bob Nickson for their help with the measurements.

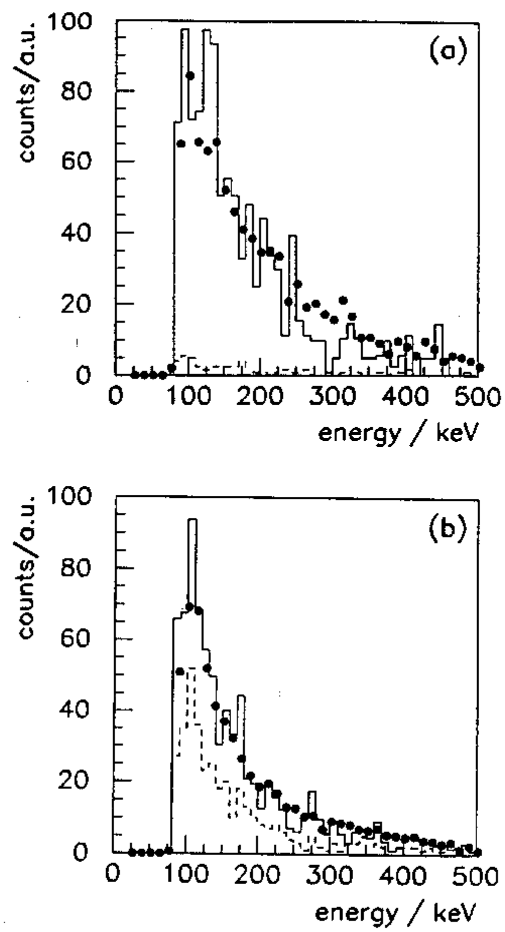

Figure 3: Spectra of the REM detector at 1.4 (a) and 3.0 MeV (b) beam energies. The solid lines show GEANT calculations with electron and X-ray contributions. Electron parts of the spectra aré shown using dashed lines.

References

[1] REM - executive summary, REF. 2057, CIR SA, Neuenburgstr. 7 CH-2076 GALS-BE

[2] S.Ljungfelt et all., PSI Annual Report 1994

[3] The Brown Boveri Review, Sept-Oct 1951, p260

[4] GEANT - Detector Description and Simulation Tool, CERN Program Library Long Writeup Q123