1998/I   44

REM MEASUREMENTS VERSUS STANDARD MODELS

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Radiation analysis in spaceflight are based on models from the late 60's and early 70's. Comparison of recent measurements of REM from PSI with these models reveals deficiencies.

RADIATION ENVIRONMENT MODELS: WHAT FOR?

The charged particle environment in space is a serious concern for space missions. The hazardous effects on satellites reach from charging/discharging with associated system anomalies to penetration of high energetic particles into sensitive parts, which can cause performance degradation, transient or even permanent failures of electronic devices. The ionizing particles are also harmful to human beings, which in the era of regular manned space flights must be of special concern. In order to take appropriate measures to protect the crew members and sensitive equipment aboard a space vehicle a so-called radiation analysis is performed in the planing phase of a space mission. It provides an estimate of the radiation environment to be encountered during the missions lifetime. Such estimates are based on radiation environment models. The high energetic particle environment in the inner magnetosphere is dominated by electrons and protons trapped in the earth magnetic field, forming the earth's radiation belts. The most commonly used models to predict these particles are AE8 for electrons [1] and AP8 for protons [2]. These models have been compiled in the late 60's and early 70's from a restricted set of observational data. There are models for solar minimum and solar maximum conditions but otherwise the models are static and are supposed to represent the average trapped particle environment. In order to test AE8/AP8 for their validity we compared them with measurements from the two Radiation Environment Monitors, REM from PSI [3] aboard the UK satellite STRV-1b in a nearly equatorial Geostationary Transfer Orbit and the Russian space station Mir in a Low Earth Orbit. STRV-REM was operational between July 1994 and September 1998 and Mir-REM between November 1994 and November 1996.

MODELS VERSUS OBSERVATIONS

Whereas the experimental data set provides a large number of energy deposit histograms at different points along the orbits, the radiation models provide electron and proton energy spectra at a given point in space. In order to compare models and observations we used the model spectra to compute expected energy deposit histograms and using the calibrated average energy deposit per detector channel the total energy deposit in each histogram was calculated. Then either the observed and modeled histograms or the corresponding total doses could be directly compared.

In order to reduce the amount of information, the observational data was binned into L-bins (L: L-shell parameter) and for each bin the observations were averaged over the entire mission lifetime. The figure shows summary plots of the total doses as function of L for the STRV-1b orbit. The asterisks are model values and the diamonds are the experimental values. The left panel shows results for the p-detector with a shielding of > 2.1 g/cm^2 and the right panel, for the e-detector with a shielding of > 0.8 g/cm^2, respectively. Whereas there is a rather good agreement between model and observations in the inner radiation belt ($\pm$ 30%) the models underrate the observations in the outer belt.. The discrepancy is due to the variability of the electron population trapped in the outer belt. The ratio between maximum and minimum dose rate observed between August 1994 and August 1998 in a given L-bin was up to a factor 1000, showing that static models are not adequate to describe the radiation belts and more sophisticated models are needed.
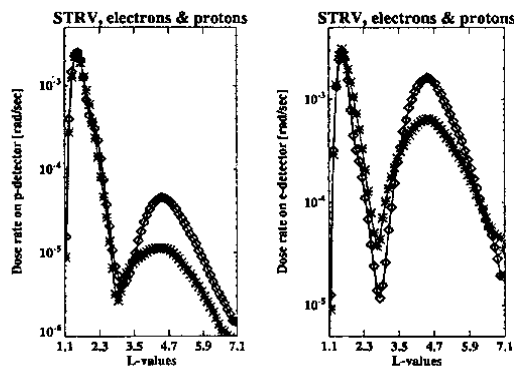

Fig. 1: Comparison of STRV-REM average dose rate, experimental (diamonds) and model (asterisks) values. Left panel shows data for p-detector (>2.1 g/cm^2 shielding) and the right panel for the e-detector(> 0.8 g/cm^2 shielding). Differences are most important in the outer radiation belt which is highly dynamic.

REFERENCES

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