Active Dosimetry of Charged Particles (ADCP)

Experiment ID: 681

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NASA 6 Operational Accomplishment Report

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I. Introduction

With the advent of manned space flight, radiation risk assessment entered new dimensions. It encountered the energetic heavy particle component of the space radiation field, a radiation quality being absent on earth and hence without established risk estimates. The lack of adequate radiobiological data for risk assessments enforced experiments on radiobiological effects of single heavy ions, ground based and in space.

Measurements of the spectra of charged particles and their linear energy transfer yield basic physical parameters for the assessment of the radiation risk to men in space on the base of the specific radiobiological efficiency of particles of different charge number and energy deposition.

Previous experience with the measurement of the physical parameters of heavy ions in space was obtained with integrating passive solid state nuclear track detectors, mainly. With the use of time resolving active detectors, these measurements can be correlated to orbital parameters and thus to radiation components of different origin.

A. Hypothesis

A set of two planar silicon detectors and a telescopic arrangement of three charge coupled devices (CCDs) measure time resolved linear energy spectra and angular distributions of heavy ions inside the Mir module. The instrument detects the increase of doses during the passage through the South Atlantic Anomaly (SAA) and temporal fluctuations of the doses due to the geomagnetic weather. The data can be correlated to the mass shielding of the station and used for testing of model calculations.

B. Objectives

Based on two passivated implanted silicon detectors (PIPS) of 300 microns thickness and 6 cm^2 sensitive area each (stacked on top of each other), the time profile of dose and particle rate is measured with an integration time of 100 sec and 20 sec outside and inside the south-atlantic anomaly (SAA) region respectively. Separate linear energy transfer (LET)-spectra in the range from 0.1 to 200 keV/µm water are available for each crossing of the radiation belts in the SAA and for each orbit. The system is capable to manage fluxes of 10^3 particles/cm^2 s with full LET-analysis, which is sufficient for measurements inside the SAA.

The time resolved angular distribution of charged particles will be obtained from particle effects in Charge Coupled Devices (CCDs). Three of them in telescopic arrangement measure the coordinates of the impinging point of a particle with a local resolution of 15 µm. The analysis of coinciding signals results in the determination of the direction of a single particle or the angular distribution of all particles detected, respectively. The sensitivity of the CCDs is 2 keV/µm, thus protons up to 60 MeV, He-ions up to 400 MeV and heavier particles at any energy have been detected.

Together with shielding data at the site of the detector sets, calculated from three dimensional mass models of the Mir station tranport code models will be tested for the radiation

environment inside and outside the SAA. The final results of the experiment are expected to contribute to predictable quantities of the radiation load from the particle radiation field depending on orbital parameters and the mass shielding environment.

C. Previous Mission Experience

The PIPS device has measured LET spectra inside Biorack on US-Space-Shuttle missions STS76, TS81 and STS84. The CCD telescope was used in the EUROMIR'95 programm.

II. Research Operations

ADCP was installed and activated in the Krystall module on panel 205 on Oct.9.1997 Except during a few Power OFF periods the experiment monitored radiation events until its termination on Jan.21.1998. All scientfic data obtained were transfered to magnetic tapes and data samples were transmitted to ground for control purpose. Experiment parameters were changed several times on PI request.

A. List of Pre-, In-, and Postflight Anomalies

Preflight Anomalies

None to report

Inflight Anomalies

Out of nominal operations, most probably caused by actions with the tape recorder, did make manual activities of the crew necessary. Two tapes were damaged.

Postflight Anomalies

None to report

B. Completeness/Quality of Data

The hardware and the data tapes were completely sent back to the PI’s lab. State-ments on the completeness and quality of data can not be given before a detailed analysis is performed.

III. Discussion

A. Status of Data Analysis

12 magnetic tapes with scientific data have been investigated for readability and content. The data of 10 tapes are readable with usual software. The number of files on these tapes seem to meet the quantity we expect from the inflight experiment monitoring. The access to the data of the two remaining tapes is postponed to a later date.

Files with data of the PIPS have been extracted from the tapes for automatic analysis, an overview on particle fluxes and LET spectra is expected to be available by end of April.

The evaluation of CCD data files requires specialist assistance on a computer based analysis. Single samples of data have shown particle events. First quantitative results are expected by June 1998.

Calculations on the mass shielding will be started as soon as the exact information on the position of the sensor head inside the station is made available. A test of transport models will be started after the availability of the final results from the PIPSs and CCDs.

B. Preliminary Research Findings

First results from the data samples of PIPS, downlinked during the mission, clearly show the dependence of the flux of particles on the orbital latitude and longitude and the increase of particle fluxes due to the passage through the SAA.

C. Conclusion

All components of the experiment have been returned to the PI‘s lab in good conditions. A fast hardware check out did not result in ‚out off nominal‘ operation.

Preliminary results from inflight transmitted data look very promising. The scientific data available cover a broard time period of the mission. The potential loss of data due to damaged tapes or ‚out off nominal‘ operation is not expected to be of major concern for the scientific output.

Final results of particle yields and LET spectra shall be available by the six month progress report angular distributions and model test results by the end of one year.

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