

Background

The effects of the complex radiation field in space (consisting of neutrons, electrons and high-energy heavy charged particles) on biological samples are of high interest in the fields of radiobiology and exobiology. Radiation doses absorbed by biological samples must be quantified to allow the determination of the relationship between observed biological effects and the radiation dose. Together with the microgravity condition, the cosmic radiation greatly contributes to the different behaviour of biological samples in space compared to earth conditions. Special techniques and correction methods combining luminescence detectors and track etched detectors are required due to the presence of particles with a wide range of LET (Linear Energy Transfer) values. These doses can be different from those to astronauts, due to a different position in the spacecraft, different compositions of the samples, and different shielding. Previous dosimetric studies have always concentrated on doses to astronauts, while dosimetry for the biological samples has seldom been studied.

Objectives

The objective of this project is to develop a standard dosimetric method (as a combination of different techniques) to measure accurately the absorbed doses and equivalent doses in biological samples. A procedure for these measurements and the associated calculations will be developed and a standard measurement kit will be made for different biological and microbiological samples, for different packaging materials and for different positions in a spacecraft. A special case will be the dosimetry of samples located in external modules, like the EXPOSE hardware. Research on the responses of different detectors is needed to allow the correction for the specific radiation field in space. Therefore ground based experiments are necessary as well as space irradiations.

Different types of dosimeters are used:

- thermoluminescent (TL) detectors of different composition (LiF:Mg,Ti, LiF:Mg,Cu,P, CaF₂:Mn, Al₂O₃:C);
- two different types of optically stimulated (OSL) detectors (Al₂O₃:C in amorphous and crystalline state);
- two track etch detectors (American Technical Plastics CR-39, Page and Tastrak CR-39).

In short, the DOBIES experiments will study the responses of different detector types in real and simulated space radiation fields. This will lead to a unique recommendation and description on dosimetric systems for radiobiological experiments in space.

Principal results

Different ground reference experiments have been performed with accelerators to simulate the radiation spectral shape found in space. Ground based tests will include characterising response of TLD's, OSLD's and track etch detectors to high LET radiation using heavy ion beams.

In the reporting period irradiations have been done in:

- the CERF field (CERN, Switzerland) at the end of 2006. Here we are able to simulate with accelerators the neutron spectrum encountered in space at the orbital altitude of the ISS;
- the JRC-IRMM in Geel, Belgium in November 2006: mono-energetic neutron beams were used to characterize our detectors. This experiment was repeated and extended with higher neutron doses and other neutron energies with new irradiations in November 2007;
- irradiations have been done at Dubna, Russia in September 2007: proton beams were used to characterize our detectors, at the entrance and in Bragg peak region;
- irradiations have also been done at the iThemba laboratory (South Africa) where high energy neutrons (100 MeV and 200 MeV) have been used to irradiate the DOBIES detectors.

During this first period, DOBIES participated to two space flights. Detectors were exposed in space alongside with the BASE-A experiment in September 2006. The dosimeter results were analyzed and compared to previous flights. The differences between the responses of the different detectors are not yet quantitatively explained. A paper on the BASE-A results was prepared. The DOBIES project participates on the BRADOS space intercomparison: our dosimeters were sent to the ISS in April 2007, together with the dosimeters from other international groups for the period of half a year.



Thermoluminescent detectors of SCK•CEN integrated in the experimental trays of the EXPOSE-EUTEF module



The EXPOSE-EUTEF module ready to be integrated in the Atlantis Space Shuttle

Future work

The results from the last series of ground based experiments need to be analyzed and implemented in the procedures for the space measurements.

A whole series of space exposures are planned. Dosimeters were prepared for the EXPOSE-EUTEF experiment, which will take place outside the ISS for the period of 1.5 year, starting at the beginning of 2008. Other confirmed experiments in 2008 are YING-B, BASE-B, CFSA-3 and Mobilisatsia-3 where the DOBIES dosimeters will measure the radiation exposure. Together with the DOSIS project the radiation mapping with passive detectors of the new Columbus module is foreseen in the following years.

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Main reference

F. Vanhavere, J.L. Genicot, D. O'Sullivan, D. Zhou, F. Spurny, I. Jadrníčková, G. O Sawakuchi, and E. G. Yukihiro, "Dosimetry of Biological Experiments in Space (DOBIES) with Luminescence (OSL and TL) and Track Etch Detectors", Radiation Protection Dosimetry, to be published (2008).