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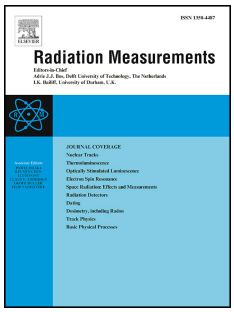

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Electronic Neutron Dosimeter in High-Energy Neutron Fields

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ABSTRACT

In neutron fields including neutron energies above 20 MeV a conventional neutron dosimeter is not suitable for measurements of neutron personal dose equivalent, $H_p(10)$, over the whole energy range. Therefore, for such fields an electronic neutron dosimeter has been developed recently at Helmholtz Zentrum München (HMGU). In general, neutron dose measurements performed with this dosimeter at neutron energies below 2 MeV show an accuracy of about 30% [1]. Here we report the use of this dosimeter at the CERN-EU high-energy Reference Field (CERF) facility in Geneva, Switzerland. At this facility the available neutron fields include neutrons with energies below, but also above 20 MeV.
In the present paper, personal dose equivalent ($H_p(10)$) values obtained with the ELectronic neutron DOsimeter (ELDO) are compared to neutron personal dose equivalent ($H_p(10)$) values obtained with the HMGU extended-range Bonner Sphere Spectrometer, and to reference values from FLUKA Monte Carlo simulations provided by CERF. It is shown that for continuous neutron spectra as those at CERF behind concrete shielding or secondary neutrons from cosmic rays, the dosimeter results are satisfactory for radiation protection purposes. However, in neutron fields including neutrons above about 7 MeV, where the major neutron dose contribution is from neutrons between 10 keV and several MeV (like those at CERF behind iron shielding), the doses provided by ELDO might be too small and care must be taken in interpreting the results.

High-energy neutrons fields are present in the Earth's atmosphere as secondary particles produced by cosmic rays, behind the shielding of particle accelerators, and at ion therapy facilities. For example, at flight altitudes or behind the shielding of particle accelerators about 50 % of neutron ambient dose equivalent ($H^*(10)$) originates from neutrons with energies above 20 MeV.
Because of a lack of commercially available high-energy neutron individual dosimeters, an in-house electronic neutron individual dosimeter was developed at Helmholtz Zentrum München (HMGU), which is sensitive to neutrons from thermal energies up to about 200 MeV.
To test the electronic dosimeter in a well-known high-energy neutron field, a measurement campaign was performed at the CERN EU High Energy Reference Field (CERF), in October 2015. This facility provides a high-energy neutron field similar to that of secondary cosmic ray neutrons (see chapter 2.1). To get spectral information about the neutron fields, measurements with an Extended Range Bonner Sphere Spectrometer (ERBSS) were also performed. The results obtained with both instruments are compared to reference values provided by CERF, based on FLUKA Monte Carlo simulations.

2. Materials and Methods

2.1. CERN-EU High-Energy Reference Field (CERF) – Facility

The CERF facility was established in 1992, as a result of the 1990 recommendations of the International Commission on Radiological Protection [2] to monitor the exposure of aircrew from cosmic radiation. The aim was to provide a neutron field similar to that present at flight altitudes (10-15 km), for test and calibration of radiation detectors and dosimeters developed to study the radiation exposure for commercial flight routes. The radiation field at those altitudes is characterized by various particles (e.g., neutrons, photons, protons, pions, muons, and electrons) with a wide range of energies. The neutron radiation is of particular interest, because it dominates aircrew exposure in terms of $H^*(10)$ and personal dose equivalent

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