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Miniature Neutron Spectrometer for Space

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Radiation doses received by astronauts outside of the geomagnetic field are a main risk factor for human space exploration. The radiation sources of concern are Galactic Cosmic Rays and Solar Particle Events. The charged particles interact with spaceship materials and even with the astronaut body and produce neutrons. Inside the geomagnetic field Galactic Cosmic Rays interacting with atoms in the upper part of the atmosphere produce neutrons. The relative biological effectiveness of neutrons is high and the weighting factors for the calculation of dose equivalent are between 5 and 21 in the energy region between 100 keV and 100 MeV [1]. We develop a miniature personal active detector (the MIDAS active dosimeter) capable to give information on particle fluence spectra and composition and thus provide information for determining dose equivalent. The detector contains a plastic scintillator (Ej299-33 for the 1st version and EJ276 for the 2nd version). The scintillator has dimensions 7mm x 7mm x 7mm and it is connected to a SensL 60035 Silicon Photomultiplier. The scintillator is covered by a Titanium box and the five faces of this box are covered by two layers of High Voltage CMOS active pixel sensors. The Titanium box prevents recoil protons with energies up to 18 MeV to escape and hit the surrounding pixel sensors. The signal from the Silicon Photomultiplier is integrated in an analogue fashion and its total and tail parts are digitized by an ultra low power ADC in order to distinguish between neutrons and gammas. The device behaviour has been studied with the aid of GEANT4 based simulations. Calibrations with gamma sources and measurements with a 252Cf source and in quasi-monoenergetic neutron beams have been performed. The 252Cf spectrum has been reconstructed using the experimental data, thus verifying the correct operation of the neutron monitor subsystem. It has become clear that as the neutron energy increases and subsequently the number of photons created by higher energy recoil protons increases, the saturation effect of the Silicon Photomultiplier affects the shape of the response functions. This effect has to be taken into account for the correct reconstruction of the neutron energy. Furthermore we study ways to extend the range of neutron energy reconstruction to the low limit of 100 KeV.

REFERENCES

[1] ICRP Publication 123, Ann. ICRP 42(4), 2013

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