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Radiation Fields, Effects and Risks in Human Space Missions (4)

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MEASUREMENTS OF NEUTRON RADIATION ON THE INTERNATIONAL SPACE STATION: ISS-34 TO ISS-40

Abstract

Radiation protection associated with human spaceflight is an important issue that becomes more vital as both the length of the mission and the distance from Earth increase. Radiation in deep space is a mixed field due to galactic cosmic rays (GCRs) and solar particle events (SPEs). In low-Earth orbit (LEO), protons and electrons trapped in the Van Allen radiation belts also make a major contribution to the radiation field. Neutrons encountered in LEO, for example on the International Space Station (ISS), are produced predominantly by nuclear interactions of GCRs and trapped protons with various elements in the walls and interior components of the spacecraft, and by neutron albedo from GCRs incident on the Earth's atmosphere. Previous investigations using bubble detectors have shown that neutrons contribute significantly to the total radiation dose received by astronauts.

As part of the ongoing Matroshka-R experiment, bubble detectors have been used to characterize neutron radiation on the ISS, starting with the ISS-13 mission in 2006. Two types of bubble detectors have been used for these experiments, namely space personal neutron dosimeters and the space bubble-detector spectrometer (SBDS). The SBDS is a set of six detectors with different energy thresholds, which is used to determine the neutron energy spectrum. During the ISS-34 to ISS-40 expeditions (2012 – 2014) bubble detectors were used in both the US Orbital Segment (USOS) and the Russian segment

of the ISS. The Radi-N2 experiment, a repeat of the 2009 Radi-N investigation, started during ISS-34 and included repeated measurements in four USOS modules: Columbus, the Japanese Experiment Module, the US Laboratory, and Node 2. Parallel experiments using a second set of detectors in the Russian segment included the first characterization of the neutron spectrum inside the tissue-equivalent Matroshka-R phantom.

The Radi-N2 dose and spectral measurements are not significantly different from the Radi-N results collected in the same ISS locations, despite the large difference in solar activity between 2009 and the present. The experiments with the phantom in the Russian segment suggest that the dose inside the phantom is approximately 70% of the dose at its surface, while the spectrum inside the phantom contains a larger fraction of high-energy neutrons than the spectrum outside the phantom. Characterization using bubble detectors in both the USOS and the Russian segment will continue beyond the ISS-40 expedition. Results of the ongoing measurements, which reinforce the importance of neutrons on the ISS, will be presented and discussed.