IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Radiation Fields, Effects and Risks in Human Space Missions (5)

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RADI-N2 AND MATROSHKA-R: MEASUREMENTS OF NEUTRON RADIATION ON THE INTERNATIONAL SPACE STATION (2009 – 2020)

Abstract

Radiation protection is a high priority for long-duration human spaceflight, including exploration missions to the Moon and Mars. Radiation in deep space is a mixed field due to galactic cosmic rays and solar particle events. In low-Earth orbit (LEO), protons and electrons trapped in the Van Allen belts also contribute to the radiation field. Previous studies in LEO have shown that secondary neutrons contribute significantly to the radiation dose received by crewmembers. A significant neutron contribution is also expected for deep space missions.

The primary goal of Radi-N2 is to characterize the neutron dose equivalent and energy distribution in multiple locations in the US Orbital Segment (USOS) of the International Space Station (ISS) over an extended period of time. The measurements used multiple bubble detectors, which are passive neutron dosimeters based on superheated liquid droplets dispersed in a polymer gel. The preceding Radi-N experiments were conducted in 2009 in Columbus, the Japanese Experiment Module, and the US Laboratory. The Radi-N2 measurements began in 2012 in these three ISS modules, later extending to include Node 1, Node 2, Node 3, and the Cupola. By the conclusion of the measurements in 2020, 75 week-long

sessions had been conducted in the seven USOS locations. The data enable an assessment of the effects of solar activity on the neutron field in the ISS from 2009 to 2020, which corresponds to a full solar cycle. The influence of other quantities, including the ISS altitude and location within the ISS, is also under investigation. For some sessions, one bubble detector was worn by a Canadian astronaut, while a second detector was located in their sleeping quarters. These data provide a comparison of the neutron dose equivalent in the sleeping quarters to that accumulated during daily activities around the ISS.

Radi-N2 is conducted within the framework of the Matroshka-R experiment. As part of the work, experiments were conducted using bubble detectors in the Russian Orbital Segment (ROS), concurrently with the USOS surveys. Measurements in the ROS assessed the neutron field in the Service Module, the Pirs Docking Module, Mini Research Module 1, Mini Research Module 2, and the Functional and Cargo Module. A number of experiments were conducted using a tissue-equivalent phantom and a hydrogenous water shield. These measurements enable an evaluation of the absorption and production of secondary neutrons in the human body and the efficacy of reducing the neutron dose equivalent using water-based shielding.