HIGH FIDELITY MEASUREMENT OF DEEP SPACE GATEWAY INTRA-VEHICULAR NEUTRON ENVIRONMENT.

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Introduction: The Deep Space Gateway provides unique opportunities for new science measurements that also can support human exploration operations in the cislunar environment. The NASA Human Research Project has identified radiation exposure as one of the main risks for human space exploration requiring appropriate mitigations for habitation or planetary missions [1]. The contribution of neutron radiation to astronaut radiation exposure is of particular interest.

Background: NASA manages radiation exposure of astronauts by maintaining health risk metrics below established safety limits. The methods and mitigations applied differ for different radiation fields.

Neutron radiation inside spacecraft is created as secondary radiation through interaction of primary Galactic Cosmic Ray (GCR) and Solar Particle Event (SPE) particles with the spacecraft structure and payload material. Neutrons, due to their high potential for biological damage, are found to contribute up to 30-40% to astronaut dose equivalent in first dedicated continuous neutron flux measurements on the ISS [2]. However, predicted neutron fields underestimate measured flux spectra on the ISS by 30-50% [2], underlining that modeling of neutron production in spacecraft relies on assumptions on neutron production processes and shielding distributions with very limited experimental data for model development and verification.

Measuring the neutron flux energy spectrum inside the Deep Space Gateway with high resolution and a large energy range acceptance represents a novel and unique opportunity to both contribute to model improvement of neutron radiation simulations and characterize the Deep Space Gateway shielding distributions with high fidelity. Enhanced capabilities to simulate and measure the neutron radiation field will improve mission planning and astronaut health assessments for the Deep Space Gateway and all future human exploration mission.

Proposed Science Experiment: Free space GCR simulations indicate that 80% of the total neutron effective dose inside a model spacecraft is contributed from neutron energies between about 100 keV and 500 MeV [3]. Therefore, a neutron measurement experiment is proposed to measure the neutron energy flux distribution inside the Deep Space Gateway from energies of 100 keV to 500 MeV, with sufficiently fine energy resolution to capture flux spectrum shape and field variations at different locations inside the Deep Space Gateway.

An expected side-benefit of the data collected by the neutron experiment is the potential for operational use during crew occupations, complementing crew radiation monitoring for health assessments and improving radiation exposure management processes.

Expected Resources of Proposed Experiment: The neutron experiment can be designed as a standalone system (utilizing power and communication provided by the vehicle) to measure at various locations inside the Deep Space Gateway for obtaining a multi-point characterization of the neutron fields, and indirectly, of the shielding distribution of the vehicle and payloads. Relocations would require limited amounts of astronaut time. The experiment would telemeter measured data back to Earth on a regular basis for science analysis.

System/Technology Candidates: Due to the technological and physical challenges of measuring neutron radiation over wide ranges of neutron energy while satisfying size and mass constraints, novel technologies will need to be investigated, or combinations of known technologies will need to be employed. The AES Program develops and supports several compact neutron detection technologies that may provide resource-efficient stepping stones on the path to a wide-energy range system due to previous integration and existing analysis work.

Summary: With the Deep Space Gateway, new science measurements become possible that offer unique opportunities to significantly improve our understanding of astronaut radiation exposure in spacecraft. Advancing our scientific knowledge about neutron radiation generation in spacecraft will drive improvements in human space exploration operations and astronaut radiation protection.

References:

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[3] L.H. Heilbronn et al (2015), *Life Sci. Space Res. 7*, 90-99