Aerospace Seminar

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Operational Space Radiation Environment: Analogs, Pathogenesis, and Translation Into Clinical Outcomes in Humans

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Abstract: Future space missions outside of low-Earth orbit will take on greater risks to establish a long-term human presence on the Moon, a near-Earth object, or the surface of Mars. The study of human health risks of spaceflight typically involves analogs that closely represent the space environment. In contrast, space radiation research is limited to the use of analogs that for many reasons do not accurately represent the space radiation environment or the complexity of human physiology. For example, studies generally use mono-energetic beams and acute, single-ion exposures instead of the complex energy spectra and diverse ionic composition of the space radiation environment. In addition, a projected, cumulative mission dose is often delivered in one-time, or rapid and sequential doses to experimental animals. In most cases, these dose-rates are several orders of magnitude higher than actual space exposures. Further, studies do not challenge multiple organ systems to respond concurrently to the stressors seen in an operational spaceflight scenario.

Here we present a novel modeling approach of the galactic cosmic ray environment by utilizing large-scale multi-core, high-performance computing and Monte Carlo methods to simulate 3D nuclear and subnuclear interactions. We show that the linear energy transfer spectrum of the intravehicular environment of, e.g., spaceflight vehicles can be accurately generated experimentally by perturbing the intrinsic properties of hydrogen-rich crystalline materials in order to instigate specific nuclear spallation and fragmentation processes when placed in an accelerated mono-energetic heavy ion beam. Modifications to the internal geometry and chemical composition of the materials allow for the shaping of the emerging field to specific spectra that closely resemble the intravehicular field. Validation of these results with beam-line measurements, both from the peer-reviewed literature and as performed herein, demonstrate reasonable agreement with model predictions. Our approach can be generalized to other radiation spectra and is therefore of wide applicability for biological exposures as well as general radiation studies, such as the deployment of shielding, electronics, and other materials in a space environment. This provides the first instance of a true ground-based analog for characterizing the effects of space radiation.

Bio: Jeff Chancellor is a scientist and expert consultant on radiation effects for manned spaceflight and the aerospace industry. He is currently in the Computational Physics Group, Dept of Physics & Astronomy at Texas A&M University. He previously was the Radiation Effects Program Manager at the Natl. Space Biomedical Research Institute and held an academic appointment at Baylor College's Center For Space Medicine. Much of his research drive is from his experience as a Senior Research Engineer with the Space Radiation Analysis Group (SRAG) at NASA Johnson Space Center. As part of SRAG, he served as Radiation Lead on the Mission Management team for STS-118, STS-120, STS-122, and STS-125 (Hubble repair mission).