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OPTIMIZATION OF DEEP SPACE HABITATS FOR THE SPACE RADIATION ENVIRONMENT

Abstract

Deep space habitats on Mars or the Moon are exposed to the space radiation environment, due to their lack of a magnetic field to deflect Galactic Cosmic Rays (GCR), Solar Particle Events (SPE), and trapped radiation belts. GCR are composed of high energy protons through heavy-Z ions (HZE) up to 1000 TeV, which are very difficult to block against due to their high energy in a habitat. Traditional habitat designs would not protect astronauts on the surface from radiation, because current passive shielding technology uses only the structure's materials to attenuate incoming radiation. This would require several meters thick of material to shield a habitat, which would be mass and cost-prohibitive. Thus, future missions require another method to protect habitats from GCR, such as suggested by using martian/lunar soil as a shielding material. This study analyzed varying thickness of martian/lunar soil to optimize a deep space habitat for extended martian or lunar mission, using SERA (Space Environment Radiation Analysis). SERA, built on CERN's GEANT4 C++ toolkit for Monte Carlo modeling, is combined with SANDIA national lab's DAKOTA, an optimization software package, to quickly prototype and analyze different shielding configurations. SERA can analyze radiation transport in many different environments from planetary to deep space, because of the flexibility of geometry and source definition. SERA propagates radiation through passive shielding materials to simulate dose and equivalent dose to an International Commission of Radiation Units (ICRU) spheres or human phantom within a spacecraft or habitat. SERA is optimized for high-performance computing (HPC) clusters, using multithreading and Message Passing Interface (MPI). This architecture allows for multiple simulations to run concurrently controlled by DAKOTA for an iterative system to complete optimization and parametric studies of passive shielding design space. DAKOTA iteratively analysis different passive shielding configurations by altering materials, thicknesses, and configurations, using either parametric analysis or genetic algorithms to design a passive shield for a deep space habitat. Presented here is an analysis of varying soil thickness to reduce the dose to a below ground Martian or lunar habitat, using SERA with DAKOTA to optimize shielding.