

## **Mixed-field GCR Simulations for Radiobiological Research using Ground Based Accelerators**

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Space radiation is comprised of a large number of particle types and energies, which have differential ionization power from high energy protons to high charge and energy (HZE) particles and secondary neutrons produced by galactic cosmic rays (GCR). Ground based accelerators such as the NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL) are used to simulate space radiation for radiobiology research and dosimetry, electronics parts, and shielding testing using mono-energetic beams for single ion species. As a tool to support research on new risk assessment models, we have developed a stochastic model of heavy ion beams and space radiation effects, the GCR Event-based Risk Model computer code (GERMcode). For radiobiological research on mixed-field space radiation, a new GCR simulator at NSRL is proposed. The NSRL-GCR simulator, which implements the rapid switching mode and the higher energy beam extraction to 1.5 GeV/u, can integrate multiple ions into a single simulation to create GCR Z-spectrum in major energy bins. After considering the GCR environment and energy limitations of NSRL, a GCR reference field is proposed after extensive simulation studies using the GERMcode. The GCR reference field is shown to reproduce the Z and LET spectra of GCR behind shielding within 20% accuracy compared to simulated full GCR environments behind shielding. A major challenge for space radiobiology research is to consider chronic GCR exposure of up to 3-years in relation to simulations with cell and animal models of human risks. We discuss possible approaches to map important biological time scales in experimental models using ground-based simulation with extended exposure of up to a few weeks and fractionation approaches at a GCR simulator.