Comparison of Model Calculations of Biological Damage from Exposure to Heavy Ions with Measurements

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The space environment consists of a varying field of radiation particles including high-energy ions, with spacecraft shielding material providing the major protection to astronauts from harmful exposure. Unlike low-LET γ or X rays, the presence of shielding does not always reduce the radiation risks for energetic charged-particle exposure. Dose delivered by the charged particle increases sharply at the Bragg peak. However, the Bragg curve does not necessarily represent the biological damage along the particle path since biological effects are influenced by the track structures of both primary and secondary particles. Therefore, the ''biological Bragg curve'' is dependent on the energy and the type of the primary particle and may vary for different biological end points. Measurements of the induction of micronuclei (MN) have made across the Bragg curve in human fibroblasts exposed to energetic silicon and iron ions *in vitro* at two different energies, 300 MeV/nucleon and 1 GeV/nucleon. Although the data did not reveal an increased yield of MN at the location of the Bragg peak, the increased inhibition of cell progression, which is related to cell death, was found at the Bragg peak location. These results are compared to the calculations of biological damage using a stochastic Monte-Carlo track structure model, Galactic Cosmic Ray Event-based Risk Model (GERM) code (Cucinotta, et al., 2011). The GERM code estimates the basic physical properties along the passage of heavy ions in tissue and shielding materials, by which the experimental set-up can be interpreted. The code can also be used to describe the biophysical events of interest in radiobiology, cancer therapy, and space exploration. The calculation has shown that the severely damaged cells at the Bragg peak are more likely to go through reproductive death, the so called "overkill".

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