SPACE LIFE SCIENCES SYMPOSIUM (A1)
Radiation Fields, Effects and Risks in Human Space Missions (4)

Author: Dr. Brad Cox
University of Houston Clear Lake, United States

RELATIVE DAMAGE TO CELL NUCLEI FROM DELTA RAYS PRODUCED BY HIGH ENERGY IONS

Abstract

Track structure of high energy ions can be analyzed to estimate the damage to a mammalian cell. When penetrating matter, these ions produce secondary electrons, or delta rays, that vary in abundance and kinetic energy based on the charge and kinetic energy of the primary ion. In cellular targets, the tracks of these electrons determine the location of ionizations that create oxidizing radicals and DNA strand breaks. Clustering of ionization sites around DNA strands produces lesions that are more difficult to repair during the cell cycle, causing increased biological damage. The damaging ability of radiation is often described by its quality factor (Q) as a function of linear energy transfer (LET). LET is a mean value of a broad range of possible energy deposition events experienced by the primary ion. In the low-dose rate space environment, the cell cycle plays an important role in responding to damage between radiation events. To better understand cellular damage from a single ion, the dosimetry must be studied on a very small scale and account for individual ion traversals. A microdosimetric approach focuses on the particle fluence and energy deposited within small targets, such as cell nuclei, where the spatial distribution of delta-ray events varies greatly for ions of equal LET and Q.

Ions of equal LET have largely varying velocities and produce a significantly different spectrum of secondary particles. Using the FLUKA transport code, the microdosimetry of an ion traversing biologically relevant targets can be simulated. This approach models the dose and particle fluence for individual cell nuclei making up a larger target volume. The damaging ability of an ion can be compared with other ions having equal LET by assessing the number of particle crossings and dose to each cell. This study presents the dose characteristics of various ions having an LET of 100 keV/um. Individual ion traversals are simulated where delta rays scatter outwards from the primary ion track. Using this method, the dose and delta-ray fluence can be measured across many cell-sized targets surrounding the ion track. Preliminary results show that the number of targets affected significantly increases as ion velocity increases, as delta rays are produced with higher kinetic energies. Lower-velocity ions (of equal stopping power) produce higher ionization density inside a single-cell volume, but affect fewer neighboring cells. The aim of this research is to establish relative damaging ability among ions of equal LET for cell-nucleus sized targets.