Overview of the Graphical User Interface for the GERM code (GCR Event-based Risk Model)

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Abstract

The descriptions of biophysical events from heavy ions are of interest in radiobiology, cancer therapy, and space exploration. The biophysical description of the passage of heavy ions in tissue and shielding materials is best described by a stochastic approach that includes both ion track structure and nuclear interactions. A new computer code called the GCR Event-based Risk Model (GERM) code was developed for the description of biophysical events from heavy ions at the NASA Space Radiation Laboratory (NSRL) [1]. The GERM code calculates basic physical and biophysical quantities of high-energy protons and heavy ions that have been studied at NSRL for the purpose of simulating space radiobiological effects. For mono-energetic beams, the model evaluates the inelastic energy transfer (QET), range (R), and distribution in tissue equivalent material for a given charge (Q), mass number (A) and kinetic energy (E) of an ion. In addition, a set of biophysical properties are evaluated such as the Poisson distribution of ion or delta-ray hits for a specified cellular area, cell survival curves, and mutation and tumor probabilities [2]. The GERM code also evaluates the biophysical distribution of ion or delta-ray hits for a specified cellular area, cell survival curves, and mutation and tumor probabilities [2].

GERM Model

The GERM code calculates the radiation transport of the beam line for either a fixed number of user-specified depths or at multiple positions along the Bragg curve of the particle. The contributions from primary ion and nuclear secondaries are evaluated [3]. The GERM model accounts for the major nuclear interaction processes of importance for describing heavy ion beams, including nuclear fragmentation, elastic scattering, and inelastic cascade processes by using the quantum multiple scattering model of heavy ions [4]. The GERM code was shown to be in agreement with available experimental data for nuclear interaction cross sections [5], and has been used by the GERM code for application to thick target experiments. The GERM code provides for the interpretation of their experiments [6], including the ability to model the beam line, the shielding of samples and sample holders, and the estimates of biophysical and biological outputs of the designed experiments. We present an overview of the GERM/GUI, as well as providing training applications.

User Input Control Parameters

- Beam transport for fixed depths
- Beam transport for Bragg curve depth

Biophysical models

- No radiobiology model
- Cell survival
- Chrom. aberration
- Cancer therapy

Radiobiology model

- No radiobiology model
- Cell survival
- Chrom. aberration
- Cancer therapy

Biophysical properties output:

- Probability of hits per cell
- Dose, arbitrary
- Energy, MeV/u

Physical properties output:

- Probability of hits per cell
- Dose, Gy 0.0 - 5.0 Gy
- Energy, MeV/u

Biophysical events

- Multiplicity and Charge
- Depth dose table
- Mass number 1 – 58
- Charge number 1 – 28

Biophysical models

- BEAM Transport for fixed depth
- BEAM Transport for Bragg curve depth

Results of 28Si (600 MeV/u) on Water

Progress

- Development of a stochastic simulation tool using track structure and nuclear interactions provides the description and the integration of physical and biophysical events from mono-energetic ions.
- Development of a stochastic Monte-Carlo based model of radiation transport in spacecraft shielding and tissue is made with the quantum multiple scattering model of heavy ion fragmentation (QMSFRG) and the energy loss processes.
- The scientists participating in NSRL experiments obtain the data needed for the interpretation of their experiments.
- Ability to model the beam line, the shielding of samples and sample holders; Estimation of basic physical and biophysical outputs of the designed experiments.

Gaps in Progress and Knowledge

- Detector composition and response functions
- Angular acceptance of detectors
- Description of time-dependent biophysical events produced from GCR within the tissue volumes
- Estimate of GCR event rates to biological signaling induction and relaxation times
- Uncertainty reduction for GCR transport and risk models

Color Categories of the Research

- More mechanistic than descriptive discovery
- More uncertain than risk mitigation
- More using than reduction risk mitigation
- More Green than risk mitigation

References