Heavy Ion Track Structure Simulations in Liquid Water and Bone

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INTRODUCTION

Monte Carlo (MC) track structure simulations of charged particles provide valuable information on the action of radiation on matter with biological and medical outcomes. These MC codes require reliable interaction cross sections for all charged particles with the material under consideration. In current MC codes liquid water serves as surrogate of soft tissue and is studied well. However, it is often the only material available in track structure codes. Interaction cross sections for other materials are obtained from the water cross sections using density scaling, which is approximate. Calcium is of special interest since it is the most abundant and the heaviest component of bone and needed in studies of radiation effects in the bone/bone-marrow environment.

SUMMARY OF THE PROJECT SO FAR

The main objective of the project was to provide information on local patterns of energy depositions by HZE particles in an appropriate geometrical model including micro- and macro size considerations by means of Monte Carlo (MC) track structure simulations. The focus was on the energy deposition of HZE radiation in trabecular bone. To this extend, we have developed a simple, non-bone-site-specific, non-patient-specific, and computationally-efficient geometrical model of trabecular bone using the geometry package of the general-purpose MC transport code PENELOPE. Internal dimensions are obtained from path-length distributions as measured in different human bones. We have developed a *scaled mouse model*, which is based on our human bone model and scaling factors. We have implemented the transport of HZE particles with energies up to 1 GeV/u into the track structure code PARTRAC and combined it with our geometrical model in a simple, but not too efficient way. We simulated microdosimetric concepts of energy depositions like the spongiosa deposition factor (SDF) using external pencil beams. We find evidence that strongly suggests that scaling or extrapolating from mouse model findings to human risks should be possible, at least for sufficiently fast HZE particles. However, at energies below 50 MeV/u we find substantial differences in SDF values between human and murine models.

CURRENT WORK: INTERACTION CROSS SECTIONS OF CALCIUM AND SIMULATIONS

We have calculated the total and energy differential interaction cross sections for electrons, protons, and alpha particles with calcium within the framework of the fully relativistic plane-wave Born approximation. The cross sections are based on our model of the dielectric response function of metallic calcium. We have determine the optical oscillator strength of metallic calcium and modeled the generalized oscillator strength using Gaussian functions and a parameter free model for the momentum dependence. We are currently evaluating the calculated cross sections and implementing them into the PARTRAC code.

REFERENCES:

I.G. Jorjishvili, *Optical and dielectric properties of metallic calcium, modeled generalized oscillator strength function of calcium, interaction cross sections of electrons, protons, and alpha particles with calcium*. Dissertation. Successfully defended March 30 2012. To be submitted in final form. East Carolina University, July 2012.

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