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Original Article

Simulations of Radioactive Decays: an Application of Low-Energy Electromagnetic Packages for the Nuclear Medicine

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Abstract

Key words: Medical radionuclides, *Geant4*, stochastic energy depositions, DNA damage

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Problems of the radiobiology and the nuclear medicine require clarifying the specifics of radionuclides interactions with unhealthy cells. In this work we aimed to simulate emitting particles tracks of radionuclides and their radioactive decays at DNA level inside the cell nucleus. Accordingly, using the Monte Carlo-based track structure simulation technique, we estimated the radial distribution of deposited energy and kinetic energy spectra of electrons produced by primary particles resulting from radioactive decays of different radionuclides within cell nucleus. To address the possibility of DNA damage, we performed the cluster analysis of track structures of emitted particles inside the volumes corresponding to the size of the native double-stranded DNA. For this purpose, *G4-RadioactiveDecay* and low-energy electromagnetic packages form *Geant4* Monte-Carlo toolkit were combined together. Besides, a comparative analysis was performed for various low-energy electromagnetic packages as *G4-DNA* and *G4-Livermore*.

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Introduction

Radiation interaction with tissues and track structure of particles in various kinds of substances are found with wide applications in radiotherapy of brain tumors, radiation protection, nuclear physics and space radiobiology. Motivated primarily by the interest to use the radionuclide emissions in the treatment (or to kill) of tumors (thyroid carcinoma, metastatic tumors) and directly killing the sparing cells. Nowadays Monte Carlo simulations has turned out to be useful and common applicable in utilizing and developing for medical physics and nuclear medicine systems (Amato *et al.*, 2013; Campos, 2008; Buscombe, 2007). In particular, these estimations can be important in two-step targeting which becomes a promising approach in cancer treatment enabling to deliver the toxic substance to the nucleus of the cell (Fondell, 2011). In this regard, simulation of the energy deposition from radionuclides transmitted inside the cell nucleus is required for the correct estimation of DNA damage resulting from nuclide decay.