IMPLEMENTATION OF HIPPOCAMPAL NEURON MODELS FOR MICRODOSIMETRY AND ELECTROPHYSIOLOGY SIMULATIONS

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Theoretical study of radiation damage to nervous system induced by space-born charged particles is very new and challenging topic in modern radiobiological research. To find a way to overcome computational difficulties in this field, we developed simplified neuron models with properties equivalent to realistic neuron morphology for microdosimetry and electrophysiology simulations. Three-dimensional structure and parameters of simplified and complex models with realistic morphology were adapted based on the experimental data. Both types of models were implemented and tested in the Geant4/Geant4-DNA Monte Carlo radiation transport code and the NEURON software. The computational approach allows to build the uniform random distribution of spines along the dendritic branches in developed geometry model of hippocampal neurons. The microdosimetry calculations were made for beams of protons, carbon and iron ions with same dose corresponding to real fluxes of galactic cosmic rays. The distribution of microscopic energy deposition events and production of oxidative radical species were obtained to be similar in both simplified and realistic models of CA3/CA1 pyramidal neurons and DG granule cells of rat hippocampus following irradiation. Moreover, similar dynamics of action potential and transmembrane currents were obtained in different layers of both neuron models. More detailed calculation of microdosimetry quantities in different layers of hippocampus represented as simplified models is performed. As the result, the increase of computational efficiency for detailed microdosimetry and electrophysiology simulations using simplified neuron models could open new prospects for understanding the pathologies of irradiated brain neurons.