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Energy deposition in dendritic spines with receptors after irradiation with heavy ions

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Dendritic spines express synaptic receptors on their surface. The synaptic receptors play an important role in generation and propagation of action potential spikes, regulation of learning and memory in the central nervous system. For example, the NMDA receptor is central to the development and function of the nervous system and to neurotoxicity. Initial radiation-induced damage to complex structures of biomolecules is hard to investigate experimentally at the physical and chemical stages during early passage of particle track through the molecular target. Theoretical modeling based on Monte Carlo approach is suitable method for study of initial mechanisms of neuron injury at molecular level. In this work, we simulated 1.5×104 spines and 1.9×106 receptors on the dendritic branches of the CA1 pyramidal cells under irradiation. Computations were performed for different charged particles (from protons to iron ions) within a wide range of linear energy transfers and doses. In the result we obtained the number of energy depositions in spines and receptors and the concentration of free radicals produced by particle tracks. The obtained quantities are of particular importance for understanding the initial molecular damages at the synaptic level leading to further dysfunction of neuron signaling and plasticity under irradiation.

Presenter: Ms LKHAGVAA, bayarchimeg (JINR)

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