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Monte Carlo simulation studies of radiation induced damage at cellular and sub-cellular level

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In present days, it is of a great interest to further understand the impact of various radiation types on living beings, at cellular and sub-cellular (DNA) level, for the purpose of radiation protection and radiation therapy. Hadronic particles such as protons, carbon ions, and lately helium ions, have various advantages in regards to previous, conventional cancer therapies using photon beams. The number of hadron therapy facilities in the world is rising rapidly, with more than 250,000 patients having received treatment with proton and carbon ion beams. To study the radiobiological effects of ionizing radiation on cells, Monte Carlo simulations that can reproduce and evaluate radiation damage are mandatory. Several track structure Monte Carlo codes exist, however a few of them are openly available to users. The Geant4-DNA software package is publicly available to the user community. The newly released example application molecularDNA, part of Geant4-DNA and publicly available since December 2022, will be presented. This application enables simulations of realistic cancer cell geometries combined with modelling of physical, physico-chemical and chemical stages of cell irradiation, including also radiolythic processes, to give prediction of direct and indirect DNA damage. In the context of future hadron therapy, the benefits of using helium ions will be discussed, as well as other treatment options.

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