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Geant4, a Monte-Carlo simulation tool for nuclear medicine and molecular radiotherapy

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Understanding of how radiation emitted by a particular radiotracer distributed in various organs, deposits energy in different tissues through various mechanisms of radiation interaction with matter, relies on the correct description of the chemical composition of the scattering medium and the involved radiation transport processes. Monte-Carlo (MC) methods allow the simulation of the interaction between particle and matter thus providing a fundamental method to study the physics of nuclear medicine, radiology, and radiation therapy.
The concepts of deposited energy and absorbed dose are of particular interest not only for radiotherapy applications[1] but also for imaging applications[2] involving ionizing radiations.
The accurate assessment of the absorbed dose distribution throughout the organs and tissues of interest is required in radiation therapy (RT) treatment planning whatever the RT approach (e.g., using photons, electrons, protons, carbon beams, radioisotopes) and the different delivery conditions (broad beam, pencil beam, scanning, rotational, brachytherapy, and targeted radionuclide therapy).
In diagnostic imaging applications involving ionizing radiation (e.g., computed tomography, positron emission tomography, or single-photon emission tomography) the assessment of the absorbed doses is important to better analyze the risk-benefit of the procedure.
Hence the need for a MC simulation platform supporting radiation transport modeling for imaging and dosimetry applications. Among the MC simulation tools that have been developed for imaging or dosimetry, the GEANT4[3] toolkit will be presented. It is a powerful tool that allows simulating the interactions between particles and matter, while different geant4 projects provide additional high-level features to facilitate the design of GEANT4-based simulations.

References

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