Optimization of GATE/Geant4 settings for Proton Pencil Beam Scanning simulations towards TPS Quality Assurance.

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Propose:

The Geant4-based GATE Monte Carlo (MC) platform aims at combining the Geant4 capabilities towards medical physics applications with a simple and dedicated interface toolkit. The new GATE release v6.0, planned for February 2010, allows radiation therapy simulations thanks to the addition of a new dedicated module.

This study investigated the different GATE/Geant4 settings for proton-therapy applications in view of Treatment Planning System (TPS) comparisons. We focused on the Pencil Beam Scanning (PBS) delivery, which is the most advanced treatment technique, allowing for Intensity Modulated Proton-Therapy (IMPT) applications.

Materials & Methods:

The most relevant options and parameters (cut, step size, database binning) that influence the dose deposition were investigated, in order to settle a robust, accurate and efficient simulation environment. The second stage of the investigations covered, was the proposition of a reference physics-list. In this perspective, the simulation of depth-dose profiles and transverse profiles at different depth and energies between 100 MeV and 230 MeV has been assessed against reference measurements in water and PMMA. These measurements were performed at the Westdeutschen Protonentherapiezentrum Essen (WPE) in Germany, using the new IBA dedicated Pencil Beam Scanning system, with integral Bragg-peak chambers and radiochromic films. In a third step, transverse profile simulations using GATE/Geant4 were compared to PHITS and MCNPX MC codes.

Results:

Depth-dose simulations reached 0.3 mm range accuracy, with a dose agreement around 1% over a set of 5 different energies. The transverse profiles simulated using the different MC codes showed discrepancies, with up to 15% dose spreading difference between GATE/Geant4 and MCNPX. The preliminary simulations showed the unability of reproducing accurately the measured dose spreading with depth in PMMA.

Conclusion:

A reference physics-list with an optimized parameters-list have been proposed and an excellent agreement against depth-dose profiles measurements was obtained. Secondly, the GATE/Geant4 platform showed competitive results compared to other MC codes like PHITS and MCNPX.

The simulation of transverse profiles using different MC codes showed inconsistencies. This point is crucial for Pencil Beam Scanning delivery simulations and suggests that the GATE/Geant4 multiple scattering algorithm should be revised.