

## Benchmarking GATE/Geant4 and RayStation MC for pencil beam scanning light ion beams in combination with a passive beam collimation for small fields

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**Background:** Small fields and shallow beam ranges are required for inter-ocular tumor treatments. As pencil beam scanning does not result in sharp lateral dose fall-offs for such small field sizes, a passive beam collimation extension was developed, including a brass collimator located 73 cm downstream of the range shifter. The purpose of this study was to benchmark GATE/ Geant4 and the commercial treatment planning software (TPS), RayStation 11B (RS), RaySearch Laboratories, Sweden.

**Material and Methods:** All beam line elements were modeled in GATE v9/Geant4 10.6 using a dedicated proton and carbon ion beam model. In RS only the brass collimator and range shifter were modeled and evaluated for proton beams since there is no MC algorithm for carbon ions. Three energy thresholds on multiple Coulomb scattering (MCS) were tested in this research version of RS 11B. Depth and lateral dose profiles were measured with several detectors in water. Aperture sizes of 5, 8, 10, 15 and 34 mm were evaluated for proton and 15 mm aperture for carbon ion beams.

**Preliminary results:** Compared to measurements, deviations of GATE along the depth profiles were negligible. Lateral dose profiles were well reproduced for protons, but slightly overestimated for carbon ion beams. Dose profiles (protons) in RS were in excellent agreement apart from beam ranges less than 10 mm. There, the default MCS transport threshold needed to be lowered to result in a good agreement with Geant4 and measurements (See Fig. 1).

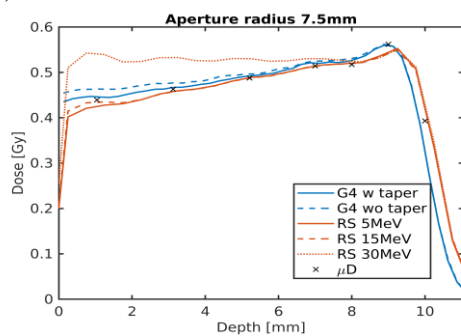


Fig. 1: Calculated dose along the central axis using two geometrical models in Geant4 (blue) and varying MCS thresholds in RayStation MC (red). Measurements with the MicroDiamond, PTW detector are displayed with crosses.