Benchmarking dose-averaged LET calculation of a commercial treatment planning system and GATE/Geant4 for carbon ion beams

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Background: Carbon ion beams are known for their high linear energy transfer (LET). Interest towards LET-based optimization [1] and evaluation of treatment plans [2] has risen in the last decade. The aim of this in-silico study was to benchmark the following two LET-related functionalities of a commercial treatment planning system against Monte Carlo simulations: 1) dose-averaged LET (LET_d); 2) dose filtration based on a LET threshold.
Material and Methods: A simple setup, consisting of a cube (4 cm side length) shaped target in a virtual water phantom was simulated in a non-clinical version of RS 9A (RaySearch Laboratories, Sweden) and GATE v9.1/Geant4 10.06. Three different carbon ion plans were generated, in which the target was centered at 5, 12 and 24 cm depth. The LET_d of all charges ($Z \leq 6$) and the filtered doses, i.e. the dose above and below a LET threshold ($LET_{threshold}$=100 keV/µm) were compared between the two calculation systems.
Preliminary results: Along the central axis, the mean absolute (and relative) LET_d difference was less than 1 keV/µm (3.5%) in the plateau and target and less than 2 keV/µm (8.5%) in the tail (Fig 1). For the filtered dose (high-LET- and low-LET-dose), the mean relative dose difference along the central axis was less than 1.3%. The study showed a good agreement between the two platforms.

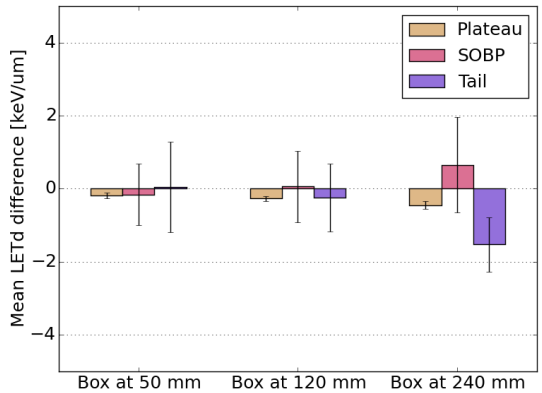

Figure 1: Mean LET_d difference over three regions for three SOBP depth positions.

[1] N. Bassler *et al.*, Acta Oncol., 53 (2013) 25-32.
[2] S. Molinelli *et al.*, Radiother. Oncol., 163 (2021) 209-214.