Experimental validation of a commercial Monte Carlo treatment planning system for proton uniform scanning fields including aperture and range compensator

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INTRODUCTION

A commercial Monte Carlo (MC) treatment planning system (TPS) for proton uniform scanning (US) fields was tested with measurements in water equivalent and Alderson-Rando (AR) head and neck phantoms.

METHODS

- Proton US fields were generated in a research build of the commercial TPS RayStation (v7.120) with different nozzle settings (ranges: 10-25 cm, modulations: 5-10 cm) and a clinically realistic aperture and compensator (Fig. 1).
- Depth-dose curves in water were calculated using the MC dose engine (v4.2) and compared with multi-layer ionization chamber (MLIC) measurements.

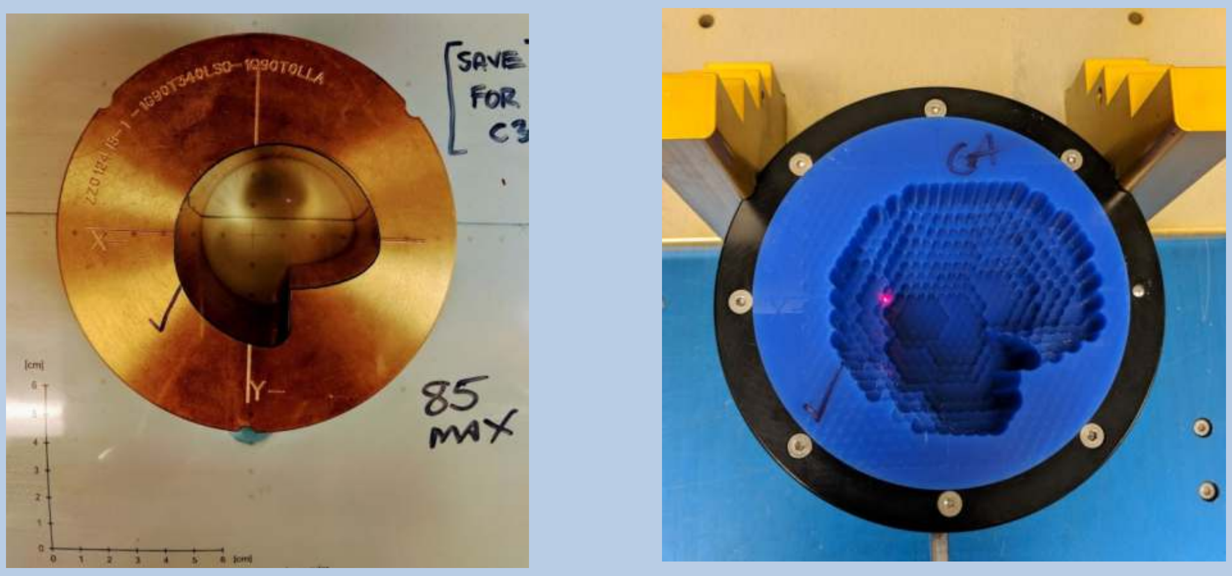

Fig. 1 Fabricated 10-cm aperture and compensator passing the quality assurance criteria (discrepancies < 0.5 mm for aperture cut-out and compensator heights compared to the TPS values).

- An oblique US field using the same aperture and compensator was planned and delivered to an AR phantom (Fig. 2). Four planar doses calculated by MC and pencil beam convolution (PBC) dose engines were compared with the GafChromic™ film measurements using the One-scan dosimetry protocol (Lewis et al., Med Phys. 39: 6339-50, 2012).

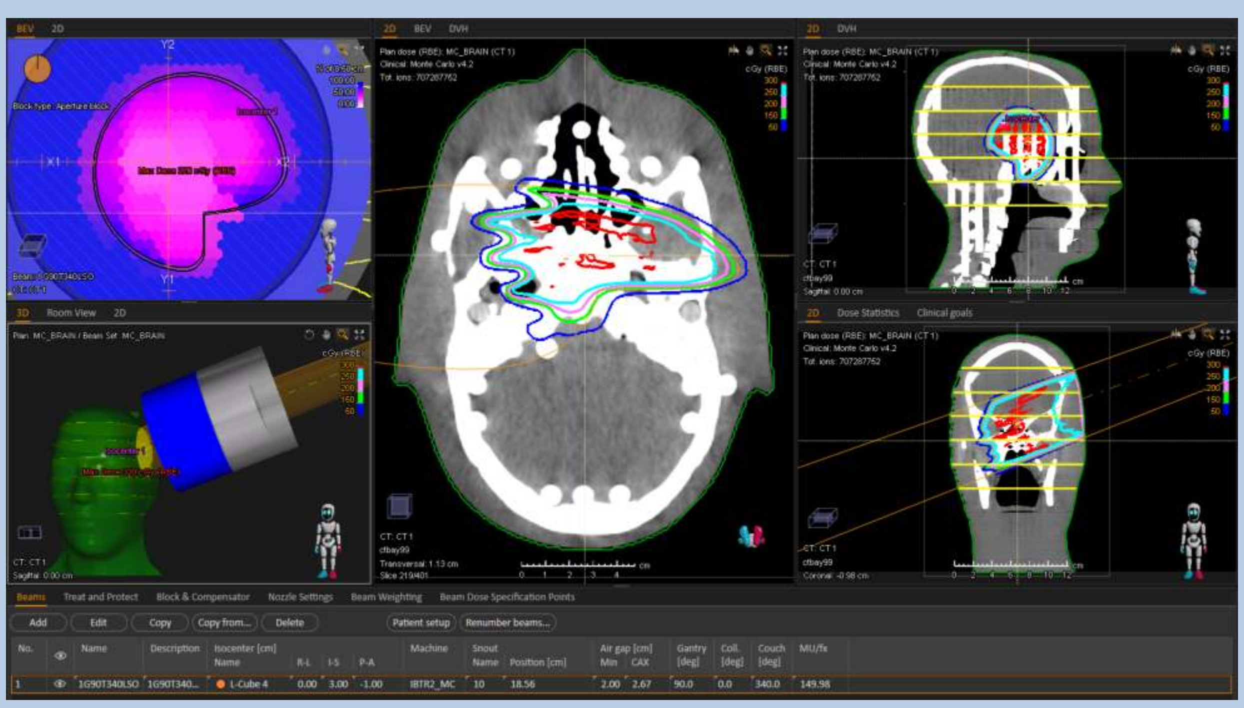

Fig. 2 The US treatment plan and the MC dose distribution on AR phantom.

CONCLUSIONS

The new MC dose engine has been validated by both chamber and film measurements and improves dosimetric accuracy significantly in the heterogeneities.

RESULTS and DISCUSSIONS

- The depth-dose curves in water calculated by the MC dose engine agreed with MLIC measurements within 1.5% dosimetrically and 1 mm in range (Fig. 3).

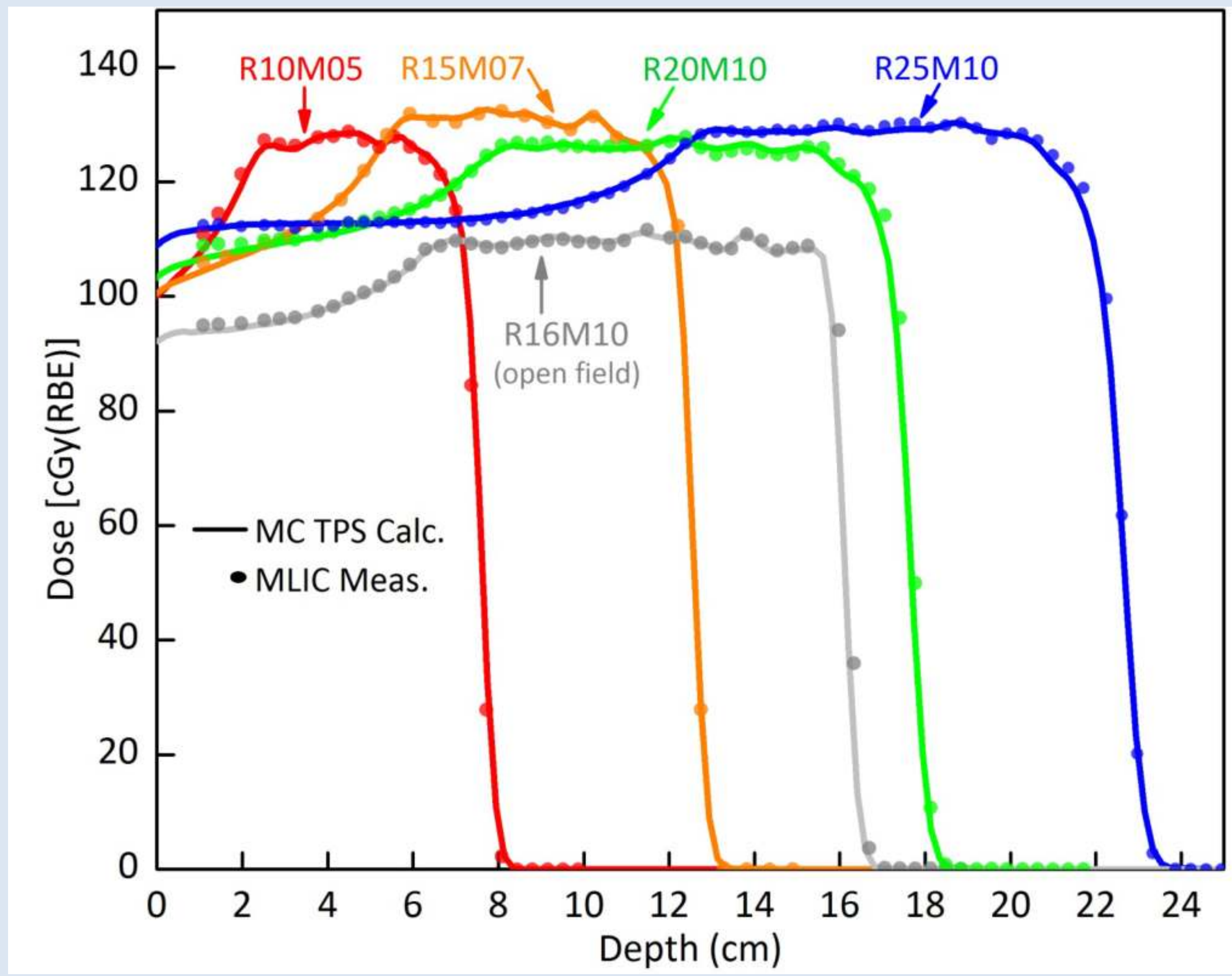

Fig. 3 Comparisons of the MC TPS calculated depth-dose curves and MLIC measurements. The TPS calculated doses were normalized to the measured doses at the centers of corresponding SOBPs.

- The planar doses calculated by the MC dose engine in the heterogeneous AR phantom demonstrated significantly better agreement at the bony structures around the field entrance and distal-dose fall offs, and air cavities around the spread-out Bragg peak (SOBP) (Fig. 4).
- The average Gamma passing rates (absolute DD: 3%, DTA: 3mm) were 97.1% (range: 95.1-98.4%) and 91.6% (range: 88.1-94.1%) for the MC and PBC (pencil beam convolution) planar dose calculations compared with the film measurements respectively.

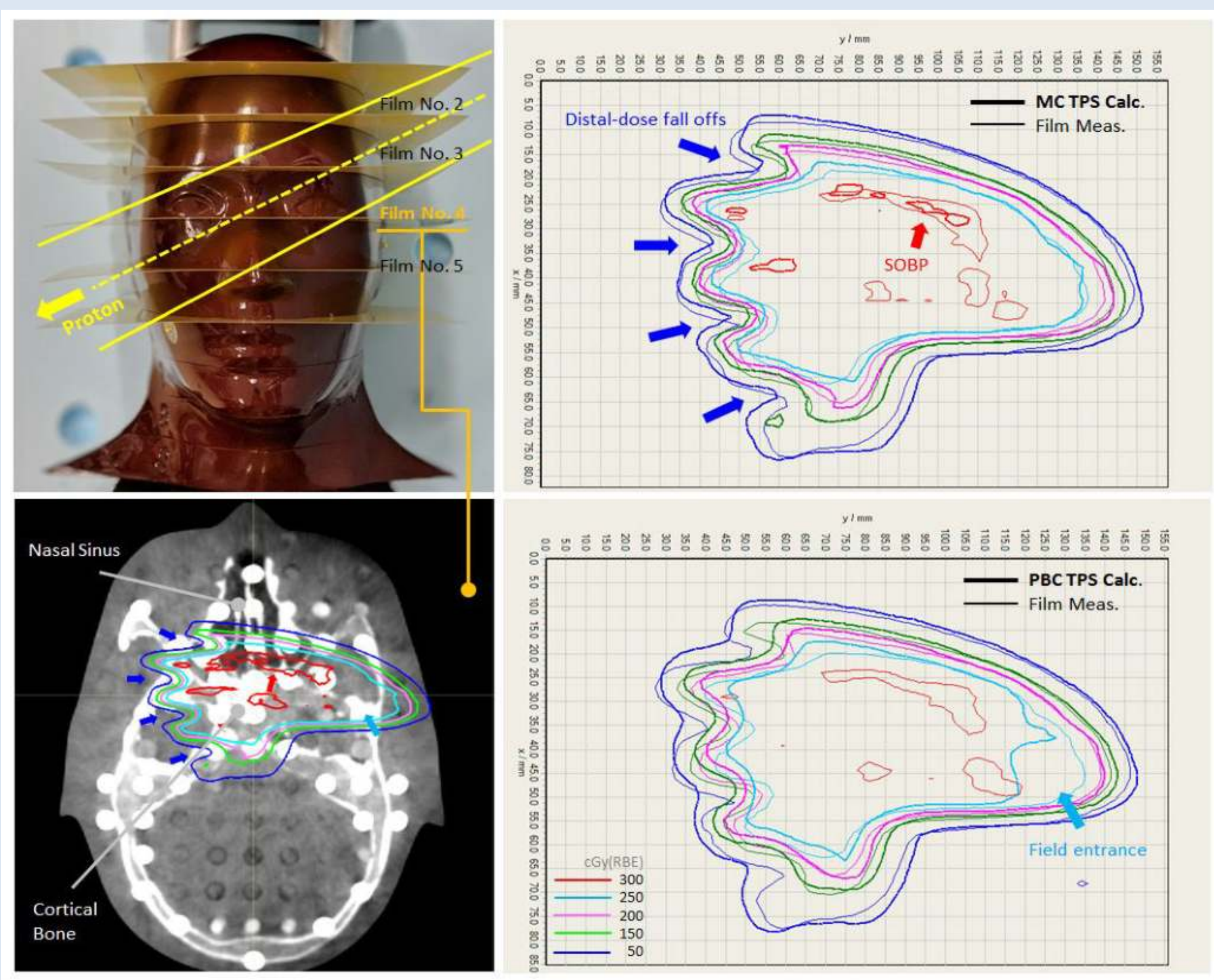

Fig. 4 Comparisons of the absolute planar doses of TPS doses (MC and PBC engines) and film measurements.

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