Investigation of a Monte Carlo Proton Pencil Beam Scanning Model to Support the Commissioning of Treatment Planning Systems

D Botnariuc[1,2], S Court[3], A Lourenço[2,1], G Royle[1], A Gosling[3], M Hussein[2,1], V Rompokos[3] and C Veiga[1]

[1]*Medical Physics and Biomedical Engineering, University College London, London, UK.*
[2]*Medical Radiation Science, National Physical Laboratory, Teddington, UK.*
[3]*Radiotherapy Physics Services, University College London Hospitals NHS Foundation Trust, London, UK.*

INTRODUCTION

- The clinical commissioning of the treatment planning system (TPS) of a new proton therapy facility includes:
  - Beam commissioning data acquisition: integral depth dose curves in water and spot profile in air
  - Modelling of the beam in the TPS by importing the beam commissioning data
  - **Verification of the TPS dose calculations**
    - Requires a set of comprehensive and **time-consuming experimental measurements** which consist of:
      - Uniform dose fields
      - Non-uniform dose fields of varying complexity

It is fundamental that TPS dose calculation algorithms used clinically are accurate.

Their accuracy must be assessed at each new proton facility prior to the start of patient treatment.

AIM

- Monte Carlo (MC) models of clinical beams:
  - Can be used as an alternative to direct measurements during commissioning of new proton facilities;
  - Can support future decision-making regarding patient treatments.

We demonstrate the potential of MC to complement the time-consuming and resource-intensive measurements that comprise the validation of the TPS of new proton therapy facilities.

METHODS

- A beam model of a pencil beam scanning system (Varian ProBeam) at University College London Hospitals was developed in GATE (v8.2) using commissioning data.
- Point doses of two commercial **TPSs were compared against measurements or GATE** for an extensive set of plans typically assessed during commissioning:

Meas. *vs.* Eclipse PCS RayStation MC *vs.* GATE

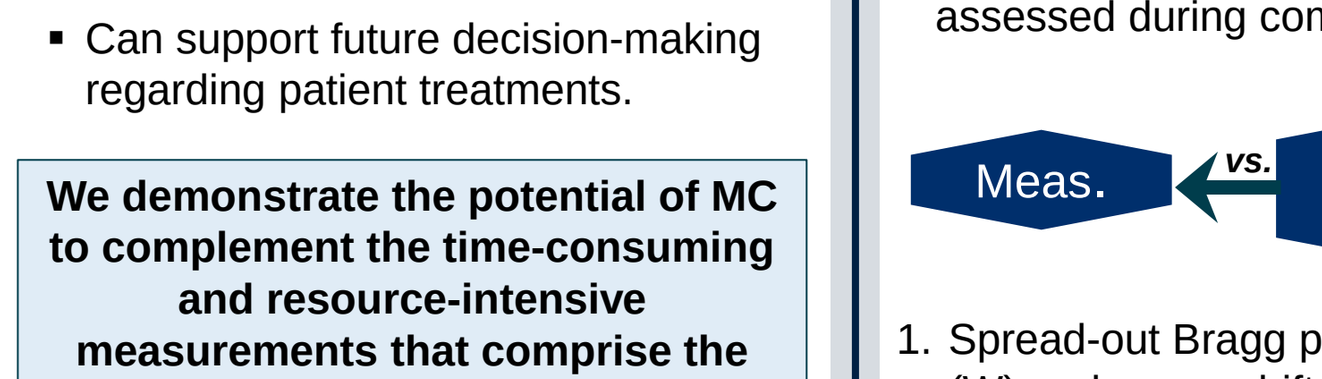
1. Spread-out Bragg peaks (SOBPs) with varying range (R), width (W) and range-shifters (RSs) (n=39 fields)
2. Patient-specific quality assurance (PSQA) plans of different anatomical sites (n=72 fields).

RESULTS

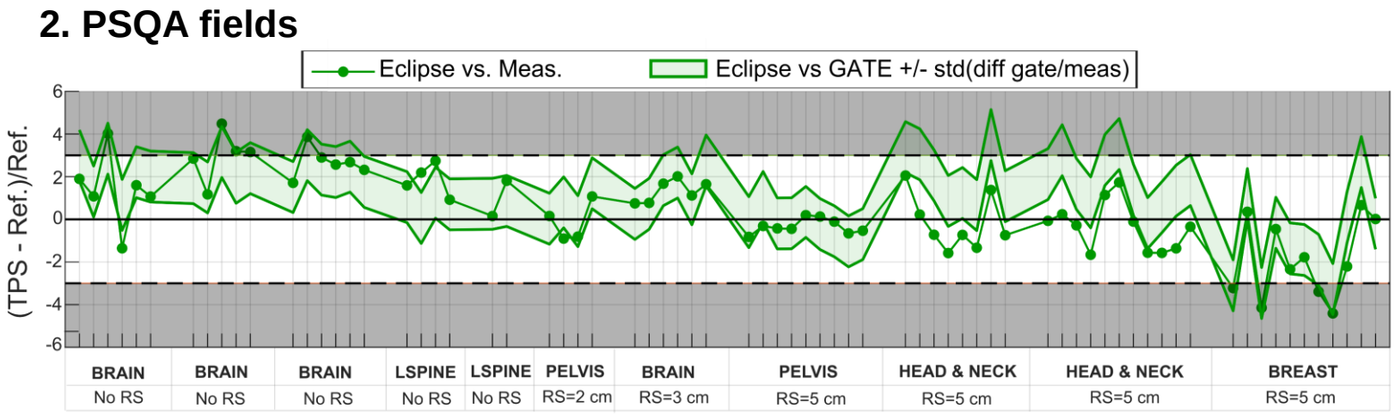
- The standard deviation of the differences between GATE and measurements (±0.5% for SOBP and ±1.2% for PSQA plans) was included as tolerance when comparing TPSs with MC, to account for the GATE uncertainty (shaded region).

The **Pearson's correlation coefficient** for mean differences in dose between the **TPSs and measurements** and the **TPSs and GATE** was above **0.92** (greatly correlated).

1. SOBP fields



2. PSQA fields



***Note:** Similar graphs were obtained for RayStation.*

- **78%** and **60%** of points were within the GATE prediction shaded area for the **SOBP** and **PSQA** plans, respectively, both for Eclipse and RayStation.
- Points falling outside the shaded region corresponded to fields for which GATE presented larger discrepancies in comparison to measurements.

GATE was able to detect the patterns verified in the dataset from comparisons against measurements.

CONCLUSION

- Two commercial TPSs (Eclipse and RayStation) were compared against experiments and GATE, for an extensive set of SOBP and PSQA fields, concluding:

MC system established early on in the commissioning process → Reduced number of time-intensive measurements that must be performed → Enhanced ability of a proton centre to fully explore the performance and limitations of their TPS

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Contact:
daniela.botnariuc.19@ucl.ac.uk