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# Absolute dose calibration for independent Monte Carlo dose calculations of spot scanning proton therapy


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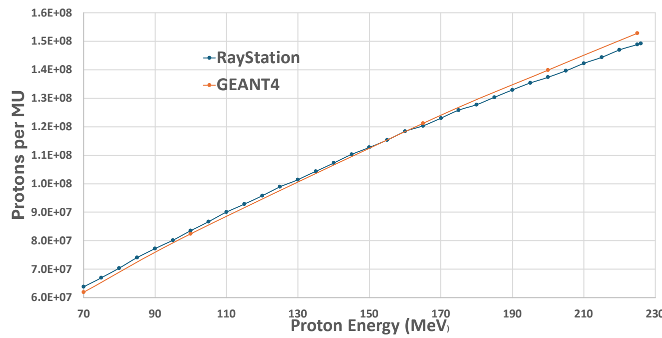
## INTRODUCTION

Independent Monte Carlo (MC) dose calculation of clinical pencil beam scanning (PBS) proton treatment plans requires conversion of beam spot monitor units (MU) into the number of protons transported in MC simulations. This conversion is achieved through absolute dose calibration. This study presents an absolute dose calibration of GEANT4 MC simulations for clinical plans generated by the RayStation treatment planning system (TPS).

## METHOD

GEANT4 simulations were performed under conditions matching ion chamber measurements used for absolute dose commissioning. A sufficiently large rectangular water phantom was modeled with the proton entrance surface at isocenter. A uniform field was created using 1681(41×41) proton spot beams with 2.5mm spacing, forming a 10×10cm$^2$ field. Simulations were conducted for proton energies from 70 to 225MeV in 5MeV increments, resulting in 32 energy settings. A cylindrical detector (1 cm radius, 1 mm thickness), comparable to a PPT05 ion chamber, was modeled and positioned at the corresponding measurement depth (e.g., 3cm for 70MeV and 8cm for 225MeV). Each spot beam simulated 100,000 source protons, yielding a statistical uncertainty of approximately 0.1% within the detector volume. Average detector doses were converted to ions/MU using measured ion chamber data (1 MU per spot) and compared with commissioned RayStation values.

## RESULTS




Absolute calibration curve (Protons per MU v.s. Proton Energy) of RayStation and GEANT4

Differences in ions/MU between GEANT4 and RayStation were observed, with the largest discrepancies at the lowest and highest energies. At 70MeV, GEANT4 was 3.0% lower than RayStation ($6.194\times10^7$ vs $6.386\times10^7$ ions/MU), while at 225MeV it was 2.7% higher ($1.529\times10^8$ vs $1.489\times10^8$ ions/MU). At 150MeV, the two systems showed excellent agreement.

## CONCLUSIONS

Differences in physics models and treatment of air contribute to non-identical absolute dose calibration among MC systems. This study demonstrates agreement within 3% between GEANT4 and RayStation, supporting the feasibility of accurate MC-based dose verification for clinical proton therapy plans.


## CONTACT INFORMATION

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