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Abstract Title: Configuring Monte Carlo-based Dose Calculation as a Precise Third-party Dose Verification Tool for Proton and Carbon Beam with Ripple Filter

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Background / Aims:

The Shanghai Proton and Heavy Ion Center (SPHIC) has developed an in-house treatment planning system (TIMPS®) that utilizes a track-repeating Monte Carlo algorithm for precise dose calculations in ion beam radiotherapy. Serving as an independent third-party dose verification tool, TIMPS recalculates dose distributions for plans generated by the Syngo clinical treatment plan system and compares them with the original Syngo-calculated dose distributions. This process aids in determining the need for beam measurements. A 6 mm ripple filter has been applied in treatments to broaden the Bragg peak of ion beams and reduce the number of energies in treatment plans. The aim of this study was to assess the impact of the 6 mm ripple filter on beam characteristics, including beam spot sizes and energy spectrum, and to refine the phase spaces within TIMPS to guarantee precise dose calculations.

Subjects and Methods:

The phase spaces for TIMPS were generated by adjusting the incident energy spectrum and lateral spot sizes based upon depth dose measurements obtained using PTW Peakfinder (PTW, Freiburg, Germany) and lateral profiles measured at five different distances in air using a multi-wire proportional counter. Energy-dependent factors were determined using doses measured in a flat phantom for both mono-energetic and cube plans. A 24-pinpoint chamber array in a PTW water phantom was used to measure 177 proton and 308 carbon ion patient verification beams that utilized the 6 mm ripple filter. These measurements were compared against the calculated results from both TIMPS and Syngo using a 3D Gamma analysis. A 3D gamma analysis was performed to compare the two dose distributions calculated by TIMPS and Syngo.

Result:

The Gamma analysis comparison between the measurement results from the 24-pinpoint chamber array and the TIMPS calculated results showed that both proton and carbon ion beams had passing rates exceeding 95%. By applying a Gamma comparison between Syngo and TIMPS using a passing rate criteria greater than 95% of points for 2% dose difference, 2 mm distance-to-agreement, and a 10% threshold, 75.8% of verification measurements could be reduced.

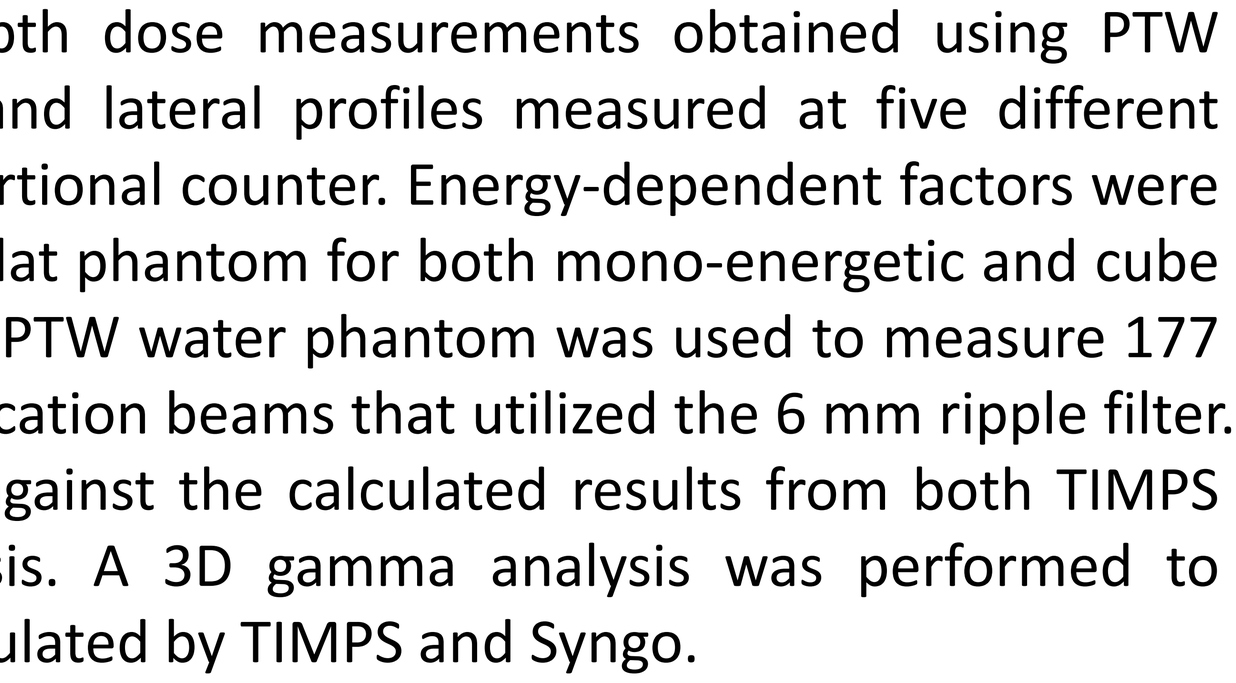

Fig 1. Dose comparison between TIMPS and Syngo

For current clinical practice, physicists can perform comparisons between Syngo and TIMPS calculations instead of water phantom measurements to verify Syngo calculations for the majority of cases. Further efforts are needed to enhance the agreement between measurements and calculations with TIMPS and Syngo in order to reduce the number of verification measurements.

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