Abstract ID: 18316 Title: Correcting Spread-Out Bragg Peak Slope Using Time-Resolved Monte Carlo Simulations and Beam Current Modulation

Purpose: To fully characterize the spread-out Bragg peak from the Mevion S250 Proton Therapy System using Monte Carlo simulations, evaluate the slope of the spread-out Bragg peak in the treatment field, and correct this slope by virtually applying beam current modulation.

Methods: MCNPX simulations were performed on the Mevion S250 for each of the 24 beamline configurations, with the modulator wheel rotated in 1 degree increments. Energy deposition was tallied in a water phantom, resulting in 8,640 central axis depth-dose calculations. These data were imported into MATLAB and the slope of the spread-out Bragg peak (SOBP) was evaluated for a constant beam current. An iterative algorithm was developed to determine the optimal beam current modulation (BCM) profile as a function of modulator wheel position for each configuration. These BCM profiles were then applied virtually to the MCNPX SOBP data and slope values were recalculated for the optimized SOBP profiles.

Results: Ideally SOBP slope would measure 0.0 %/cm in the treatment field, corresponding to a uniform dose delivery. Prior to BCM correction, slopes between -1.0 and +2.0 %/cm were observed across all beamline configurations. These were reduced to Â±0.2 %/cm by applying optimized BCM profiles. The algorithm converged quickly, validating its underlying assumption that the optimal SOBP profile can be determined by considering only a single dose values at the depths of maximum individual Bragg peak dose.

Conclusions: Optimized BCM profiles adequately reduce SOBP slope in the treatment field, and may be further studied using time-resolved MCNPX simulations. The algorithm presented efficiently calculates BCM profiles, fully accounting for beamline scatter and partial-shining effects across adjacent steps on the range modulator wheels, and without requiring direct measurements. Future work includes applying this same algorithm to optimize the SOBP distal dose profile.

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