

## Modeling Partial Shining in Proton Therapy

**Purpose:** A range modulator wheel (RMW) is an essential component in passively scattered proton therapy. It is observed that proton beam spots shine on multiple steps of RMW in our proton treatment facility. The conventional proton dose calculation algorithm without considering the partial shining effects will overestimate the dose at proximal shoulder of spread-out Bragg peak (SOBP) and underestimate the entrance dose compared with the measurement. The purpose of this work is to develop an algorithm to model this partial shining effect, and to allow a dose calculation to better fit the measured SOBP.

**Methods and Materials:** First, a set of apparent modulator weights were calculated without considering partial shining. Second, protons spilled from the accelerator reaching the modulator wheel is simplified as a circular beam spot of uniform intensity. The spot may span neighboring steps while the center of the spot is on the step A. The apparent weight of step A can be split proportional to the spot areas occupied by the spanned modulator steps. After all the apparent weights are split, the splitting results are reorganized, and summed up for each step to generate the effective modulator weights that encompass partial shining effects. The weight splitting process is affected by the ratio of the beam spot distance off the modulator wheel center to the beam spot radius, modulator gate-off angle, and the set of partially shined steps.

**Results:** The SOBPs of eight options, which are used to label different combinations of proton beam energy and scattering devices, were calculated using our algorithm. Our algorithm correctly fitted the measured SOBP in all depth for all eight options.

**Conclusions:** An efficient algorithm was developed to correctly calculate the dose distribution when a proton beam shines on multiple steps of RMW.