

AbstractID: 11447 Title: Density scaled analytical formula for SOBP calculation

Purpose: To investigate a method to derive the proton energy spectrum required for clinical spread out Bragg peaks in heterogeneous patient geometry for divergent proton beams with small source-to-surface distances (SSD) for compact proton therapy gantries.

Method and Materials: Previous work using a simple analytical model based on Boltzmann kinetic equations permitted to derive a SOBP for broad proton beams in homogeneous media at large SSDs. The calculated results agreed well with Fluka Monte Carlo simulations. We revised this formula for broad proton beams with smaller SSDs designed for compact proton treatment gantries under development. This study further improved the analytic model to generate deliverable SOBPs for broad proton beams with small SSDs in heterogeneous patient geometry. Fluka Monte Carlo simulations were performed to validate our analytical calculations.

Results: Using the same spectrum for different density materials leads to a distortion of the SOBP for divergent beams in heterogeneous media. One has to recalculate the spectrum according to the density. We showed that the spectrum expression for the SOBP reconstruction can be given by: $F_0(E_0) = H(E_0 - E_{\min})H(E_{\max} - E_0)E_0^\mu / (E_{\max}^2 - E_0^2)^{0.6}$ where μ is the density dependent factor. Analytic calculations with the revised model and direct Monte Carlo simulations are in good (within 2%) agreement.

Conclusion: We demonstrated the possibility of analytically calculating the proton spectrum to achieve the SOBP for broad divergent proton beams in low-density media. This model is accurate and efficient for proton therapy treatment planning.