AbstractID: 2753 Title: Analytical calculation of spread-out-Bragg-peak distributions for laser-accelerated proton beams

Purpose: To present a fast and robust analytical method for spread-out-Bragg-peak dose distribution calculation for energy and intensity modulated radiation therapy using laser-accelerated protons.

Method and Materials: A simple analytical calculation of the proton energy spectrum needed to produce a spread-out-Bragg-peak (SOBP) is obtained through the solution to the Boltzmänn kinetic equation. Since the SOBP is realized through the superposition of discrete rather than continuous arrangement of Bragg peaks, the weighting function $W_i(E_i,\Delta,\delta)$ needed to obtain SOBP depth-dose distribution using laser-accelerated protons is calculated through the integration of the continuous distribution function over the finite energy sampling size δ and subsequent expansion of the resulting function into the series of Gaussian distributions of finite width Δ. There exists a correlation between the energy width Δ on one hand and the sampling size δ on the other. A variety of different δ/Δ ratios were considered and an optimal value for this parameter is found.

Results: The obtained expression for the weights depends only on the characteristic energy E_i of the given proton beam, the width of its energy spread Δ and the energy sampling size δ As an example, we show that for the sampling size δ=5 MeV, a superposition of proton beams with the maximum energy spread Δ=3.5 MeV is needed. Proton beams with larger energy spreads will generate the resulting weight distribution, which will significantly deviate from that obtained by the integration of the energy spectrum (derived from the solution to the Boltzmänn kinetic equation) over the sampling interval δ.

Conclusions: This work is a part of inverse treatment planning system for patient dose calculation using laser-accelerated protons. It presents a fast SOBP dose calculation method for each individual beamlet. It also provides a basis for a physical way of energy modulation implementation in laser-proton accelerator.