Abstract ID: 15500 Title: Pairs of Sloped Spread-Out Bragg Peaks Improve Normal Tissue Sparing

Purpose: To investigate 3D optimization with parallel-opposed proton beams and show that the solution space can be greatly reduced, resulting in a dramatically shortened optimization time. In passive scattering proton treatments the target is covered with spread-out Bragg peaks (SOBP) produced by modulating the proton spectrum to deliver a constant dose at depth. Larger targets necessitate the use of wider SOBP with wider spectrum, which inevitably leads to dramatic increase of the surface dose to a level comparable to the target dose. Therefore, often two parallel-opposed beams are used to remedy the surface dose increase.

Methods: Using an analytical approach we prove that in a parallel-opposed setup there exist a unique optimum solution that leads to lowest normal tissue dose. The results are further validated in an optimization routine operating on a set of FLUKA-generated Bragg peaks.

Results: In a test case, two opposed optimum SOBP beams create homogeneous target coverage while the dose outside the target is reduced by 22% as compared to the case of two flat SOBPs. We note that the single-beam optimum dose distribution inside the target resembles linear distribution. Therefore, one can seek a sloped spread-out Bragg peak (SSOBP) with weights obtained through optimization regardless of the density fluctuations in the phantom. There is a unique solution when each beam is optimized separately and the optimizer is shown to always converge to the desired weight distribution.

Conclusions: The parallel-opposed technique with two SSOBPs is the ultimate distal edge tracking, for it employs only half of the spectrum necessary to cover the target and results in maximum normal tissue sparing. Its linear modification automatically ensures both homogeneous target coverage and reduced dose to the organs at risk and normal tissue. Full 3D optimization involving this technique will result in faster computation times.