AbstractID: 11422 Title: Antiproton Radiotherapy: Development of Physically and Biologically Optimized Monte Carlo Treatment Planning Systems for Intensity and Energy Modulated Delivery

Purpose: Antiprotons have become of interest in radiotherapy due to their higher peak to plateau dose ratio relative to protons and carbon ions, and a beneficial increase in RBE towards the Bragg peak as recently verified by experimental investigations of the AD-4 collaboration at CERN. An obstacle limiting further research is the lack of a treatment planning system capable of concurrently optimizing the necessary modulation of intensity and energy, while accounting for the variation in biological effectiveness. Here we develop a Monte Carlo based treatment planning system for this purpose and subsequently quantify its performance. **Materials and Methods:** Dose kernels corresponding to different energy and source configurations were calculated using MCNPX in phantom and voxelized patient CT scans, and then converted to biological equivalent dose using depth dependent RBE weighting factors derived from theory and experiment. Linear equations were formulated for each pixel representing superposition of different kernels weighted by unknown intensities. Algorithms using constrained least square and gradient descent optimization were developed to minimize objective functions measuring the geometric correlation of the planning target volume (PTV) with the calculated distribution, yielding an optimized intensity for beams as function of energy and direction. **Results:** Biologically optimized treatment plans implemented on a voxelized 38 year old human were in good agreement with the input PTVs, reproducing the PTVs with a mean error of less than 2.24%. Proof of principle demonstrations were successful in producing complicated structures, such resemblance of Einstein, in water phantom with a correlation greater than 93%. **Conclusions:** We have developed a Monte Carlo treatment planning system for energy and intensity modulated antiproton therapy capable of incorporating depth-dependency of the RBE, and reproducing complicated PTVs with high accuracy. The work can be readily extended to incorporate more sophisticated objective functions such as NTCP and TCP functionals.