AbstractID: 13652 Title: Biologically optimized treatment planning for proton therapy: Monte Carlo calculated Linear Energy Transfer distributions in patients

Purpose: To apply Monte Carlo simulations to simulate the Linear Energy Transfer (LET) distributions in patients undergoing proton therapy. These distributions can be used to identify areas of elevated biological effect. The location of such areas might be influenced in intensity-modulated proton therapy (IMPT) optimization. **Method and Materials:** Proton Monte Carlo calculations are performed using a code considering all relevant primary and secondary particles. Since Monte Carlo studies to investigate the LET distribution in patients have not been undertaken so far, the code is first validated: simulations in a water phantom are compared to published data. The code was subsequently used to track particles through the patient geometry based on CT information for five patients. For each of them three different proton therapy planning and delivery techniques were simulated: passive scattering, 3D modulation IMPT (3D-IMPT) and Distal Edge Tracking IMPT (DET-IMPT). **Results:** Detailed examination of the LET distributions and LET-Volume-Histograms reveals significant differences between the treatment techniques. While passive scattering and 3D-IMPT lead to largely comparable LET distributions, the DET-IMPT plans result in considerably increased LET values in normal tissues and organs at risk. In the brainstem, dose-averaged LET values exceeding 10 keV/μm are observed in areas with significant dose levels (above 70% of prescribed dose). In non-critical normal tissues even values above 15 keV/μm occur, although in areas with low doses. **Conclusion:** This work demonstrates that active scanning offers the possibility to influence the distribution of dose averaged LET (i.e. the biological effect) without significantly altering the distribution of physical dose. Based on this finding, we propose a method to deliberately alter the LET distribution of a treatment plan in such a manner that the LET is maximized within the target and minimized in normal tissues, while leaving the prescribed dose to the target unchanged.