AbstractID: 10749 Title: Monte Carlo computation of the effective dose in scanning beam proton therapy

Purpose:
Currently most clinical proton centers use constant, generic relative biological effectiveness (RBE) value of 1.1. However, the RBE for protons depends on the dose per fraction, the tissue type, the biological endpoint and the local energy spectrum characterized by the linear energy transfer (LET). In this work we describe the tools for automatic Monte Carlo (MC) calculation of the LET in clinical scanning beam proton plans and investigate the effects of variable LET on the effective dose.

Method and Materials:
A clinical prostate scanning beam proton treatment plan was used to automatically generate the input for the MC code MCNPX. The input contained a detailed model of the scanning beam nozzle and delivery system with spot positions and intensities extracted from the actual patient treatment plan. The input also contained a voxelized, CT based patient model or a water phantom. A rectangular mesh tally was used to score the energy deposition and the fluence in the patient or in the water phantom. These values were used to compute the absorbed dose, the LET, the RBE as a function of the LET, and the RBE-weighted effective dose in the patient or in the water phantom. We have adopted a simple functional dependence of the RBE on LET from literature.

Results:
Three dimensional distributions of the absorbed dose, the LET, and the effective dose were computed both in the water phantom and in the patient. The results show a steady LET and RBE increase along the beam path with a number of spikes resulting from the end-of-range effects of the individual energy layers.

Conclusion:
Monte Carlo model can be used for computation of the RBE-weighted effective dose distributions in clinical scanning beam proton plans. This model can be used to investigate whether the effects of variable RBE can be clinically significant.