AbstractID: 12797 Title: Fast RBE-Corrected Dose Calculation for Carbon Therapy

Purpose: To design a fast algorithm for RBE-corrected dose calculation for carbon therapy. The interactions of heavy ions with matter produce sharp penumbra and narrow Bragg peak, which result in better dose conformity in comparison with X-rays and electrons. Elevated RBE near the end of the heavy ion track modifies the biologically relevant dose distribution and has to be considered during treatment planning.

Method and Materials: We created a database of 10000 pre-computed (using Geant4 Monte Carlo toolkit) particle histories that are subsequently repeated in the phantom geometry of the MCSIM code. Each history is a stack of energy deposition steps and each step holds information about the particle type, step length, and energy deposited. Since particle type and LET are all part of the database, RBE corrected dose calculation can be implemented, provided the RBE of each particle is known as a function of LET. The analysis of published experimental data resulted in a model for the RBE(LET) for a variety of ion species. This model is used to modify the database accordingly.

Results: We applied our algorithm for the calculation of a RBE-corrected spread-out Bragg peak and compare it with the corresponding physical dose distribution. Three-dimensional dose calculation was carried out using a CT-based patient phantom as well. It takes <4 minutes on a 2.8GHz Intel-Pentium4 processor to achieve 2% accuracy. The code is designed to facilitate the use of arbitrary field sizes and carbon energy spectra, thus allowing for advanced therapy calculations.

Conclusion: Fast RBE-corrected dose calculations are now possible using a track repeating technique for carbon ions. In heterogeneous phantoms the algorithm is more than 100 times faster than both FLUKA2008 and Geant4 and can be used for both fast and clinically accurate dose calculations for carbon therapy with beam scanning and intensity modulation.