AbstractID: 6461 Title: Absolute dose reconstruction in proton therapy using PET imaging modality: Feasibility study

Purpose: Radiation treatments using proton beams are accompanied by production of small amounts of positron-emitting isotopes along the beam paths. These short-lived radioisotopes, mainly ^{11}C, ^{13}N and ^{15}O, allow imaging of three dimensional in-vivo activity distribution using positron emission tomography (PET). However, since the correlation between the combined activity distribution and absorbed dose is not linear, one cannot readily ascertain the dose distribution from the measured activity. The purpose of this study is to develop a mathematical model which would allow reconstruction of the absolute dose in a patient based on in-vivo activity distribution.

Method and Materials: Fluka Monte Carlo simulation code was used to generate three dimensional activity kernels for each individual proton energy in the therapeutic range. Subsequently, these kernels can be employed to calculate the unknown energy spectra used in each individual proton beam during patient irradiation. The method is based on a solution of a system of linear inhomogeneous equations using a “random creep” algorithm. The final convolution of the energy spectra with dose kernels will yield the absolute dose.

Results: The developed model has been used to reconstruct the dose distribution for a test case of a tissue phantom irradiated by two parallel-opposed proton beams. Comparison between the known and reconstructed dose distributions shows that the reconstructed dose to the target compares very well (within 2.%) to that initially delivered. This suggests that it should be feasible to use the PET scanning modality to reconstruct in-vivo absolute dose distribution.

Conclusions: Energy delivered by proton beams to the patient in a single fraction generates enough activity that can be used for the inverse problem of dose reconstruction. Our calculations confirmed that by studying a test case of a tissue phantom irradiated by a parallel-opposed beam arrangement. The reconstructed dose is within 2% of the delivered.