AbstractID: 8711 Title: Calculation of positron emitters' matrix for absolute dose reconstruction in proton therapy

Purpose: The short-lived radioisotopes, mainly ^{11}C, ^{13}N and ^{15}O produced during proton therapy allow imaging of three dimensional in-vivo activity distribution using positron emission tomography (PET). In our previous study we explored the possibility of reconstructing in-vivo absolute dose distribution using PET imaging information. Developed mathematical model requires the knowledge of the positron emitters' matrix $\Delta\tilde{N}_k(\mathbf{r}, E_i)$, which can either be pre-calculated using Monte Carlo method (time-consuming but easily done) or calculated analytically (time-efficient, but requires some abstract representations). The purpose of this study is to develop an analytical model for the calculation of the positron emitters' kernels which would significantly speed up the dose reconstruction procedure.

Method and Materials: The positron emitters' matrix/kernel is calculated via the energy integration of the given nuclear activation cross section with the proton energy fluence spectrum at position **r**. The proton energy fluence spectrum in turn is found from the solution to the Boltzmann kinetic equation.

Results: As a first step, the calculated proton energy fluence spectra for different initial proton energies have been compared to those obtained from Fluka simulations at different spatial points **r**. An excellent agreement between both approaches is found. In the second step, the nuclear activation cross sections for production of different species have been integrated with the proton energy fluence to obtain the positron emitters' kernel. In the final third step, the positron emitters' kernel is used to calculate the activity distribution and compare it to that simulated using Fluka MC code. An excellent agreement between the results of analytical calculations and computer simulations is also found.

Conclusions: The developed analytical approach offers significant improvement in time efficiency for the problem of dose reconstruction from the measured PET distribution. It constitutes a necessary step forward needed for practical application of this imaging modality in in-vivo proton beam dosimetry.