AbstractID: 11826 Title: Design of a PET scanner for in situ Dose Verification in Proton Beam Therapy

Introduction -- During proton therapy, positron emitting radio-isotopes are produced along the trace where incident proton beam interacts with human tissue. The isotope activity profile is related to the proton dose distribution. Such isotope activities can be measured and imaged using a PET scanner. Therefore an accurate and sensitive PET image of the isotope activities can be used for verification of proton dose. Our work is to design an efficient PET system for *in situ* proton dose measurement in order to measure the activities of short-lived isotopes.

Method -- A non-rotating partial PET ring configuration is advantageous for such measurements as the decay of short-lived isotopes can be measured almost immediately after the stop of proton irradiation. The PET design is optimized by varying 1)crystal cross-section that is related to spatial resolution; 2) crystal types that affect intrinsic sensitivity and Time of Flight information; 3) angular coverage of the PET ring that is related to system sensitivity and reconstructed image quality. This study uses EGS4 based Monte Carlo simulation software that has been developed at Penn for PET scanner design studies. Geant4 software is used to produce the proton isotope activity. This isotope distribution is parameterized and used as the source distribution in EGS4. It is placed in a cylindrical water phantom initiating from phantom surface inward to mimic the patient treatment configuration. Iterative image reconstruction, together with data corrections for scatter, and attenuation, are incorporated to achieve high-quality images and quantitative data.

Results -- The reconstructed isotope source from PET images agrees well with the source activity for several design configurations. The distal falloff region of the isotope trace can be clearly identified.

Summary -- The design of PET system can be optimized so that the configuration yields an accurate and efficient reconstruction of the isotope activities.