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In-beam and post irradiation measurement of proton treatments with the PETITION PET detector

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The PETITION PET detector, has been developed for in-beam use at Gantry 2 at PSI, with an open ring design allowing for measurement of patient activation both during and following proton therapy treatment. Tools for time resolved simulations of patient treatments have been implemented using Gate. Intra-field imaging in the dead time between delivery of each energy layer, approximately 100 ms, can be performed for measurement of short-lived isotopes such as ^{12}N ($t_{1/2} = 11$ ms). Following this inter-field imaging of the produced isotopes, primarily ^{15}O and ^{11}C ($t_{1/2} = 122$ s and 20.3 min respectively), can be performed between delivery of subsequent fields to generate 3D images of the induced activity distribution. We also consider a scenario in which the PET scanner is rotatable, moving the opening of the ring to allow for delivery of each new treatment field. If coincidences are recorded while the scanner rotates, the loss of spatial resolution due to the opening of the scanner may be compensated, allowing for possible detection of anatomical changes in the patient. Imaging for approximately 30 seconds, during the couch and gantry repositioning, provides sufficient counts for reconstruction of the activity. The activity fall off of short lived isotopes produced during delivery of the first treatment field is well correlated to the dose fall off ($R^2=0.947$). Imaging of the field while rotating the scanner leads to a reduction in the mean-absolute-error by 54-70% compared to imaging at a fixed angle for each field. Development of a new PET reconstruction software for the purpose of inter-field imaging allows for fast reconstruction times, and could potentially provide validation of treatments within clinically relevant time frames. In beam measurements with phantoms are currently being performed, and comparison with Gate simulations is ongoing.

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