Purpose: Positron emission tomography (PET) using open dual ring geometry was investigated as an on-board system for functional imaging and PET marker tracking, specifically with tomotherapy. The open dual ring PET would allow measurement of both inter and intra-fractional variation, improving the delineation of tumor volume at any stage in the radiation treatment delivery process. We compare results from data obtained with ray tracing to data from Monte Carlo simulations. This study demonstrates that depth of information (DOI) along the z axis of the crystal is required to reduce artifact from DOI blurring due to long axial PET geometry.

Methods: PET design was accomplished via Monte Carlo simulations with GATE, the Geant4 Application for Emission Tomography. Images were reconstructed using Software for Image Reconstruction (STIR) with a fully 3D OSEM. Investigation of whether the image blurring is the result of DOI was carried out by scaling axially the PET design to one half and one forth the original proposed open PET. Image reconstruction with varying the ring difference or level of obliqueness of the accepted lines of response (LORs) for reconstruction also indicates the role of the DOI blurring.

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Results: Monte Carlo simulations of the open PET geometry indicate that the prominent physical factor that degrades image quality is the DOI. When comparing the Monte Carlo simulation for a phantom with four hot sources and cold background in air (reducing the effect of attenuation, randoms, and scatter) to that of the ray tracing simulations, we can visualize the degradation in the image quality. The reason is that GATE simulates the depth information but does not correct for DOI blurring, but STIR generated data assumes all LORs interact at the crystal surface.

Conclusions: Onboard open PET with Tomotherapy must include DOI detectors to correct for the observed blurring.