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Implementation of cylindrical PET scanners with block detector geometry in STIR

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The SAFIR collaboration is developing a PET insert for a pre-clinical MRI system, aiming at excellent temporal resolution, of ~5s time frames. Image reconstruction is performed using the Software for Tomographic Image Reconstruction (STIR). An accurate system matrix is necessary for the precise reconstruction of quantitative PET data and the exact representation of the scanners geometry is a key component of a precise system matrix. STIR models the scanner as a cylinder, i.e. it assumes the scanner is made of individual detector elements arranged uniformly on a cylinder, whereas the crystals in the SAFIR detector are assembled in blocks which are in turn arranged on the sides of a polygon. In this study, we implemented and evaluated the true block type model into the STIR library. We evaluated this new implementation with three sets of Monte Carlo simulations: a rotating plane source for normalization, a uniform cylinder, and a Derenzo phantom. We reconstructed the data using both the existing cylinder and the new block model. Attenuation and normalization corrections were included in the reconstruction algorithm. The random rate was estimated using Monte Carlo simulation and data were corrected prior to their reconstruction. Our results demonstrate a significant improvement for the new block model in terms of resolution and uniformity. The peak to valley ratio for the 2 mm Ø spheres of the Derenzo phantom increased from 1.64 to 2.53. The reconstructed images of the uniform cylinder show better uniformity already prior to normalization. The standard-deviation-to-mean ratio for the uniform cylinder is ~2.5 times smaller for the new block model.

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