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Single-event based TOF FBP image reconstruction in J-PET

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We report the results of a modified time-of-flight (TOF) filtered back projection (FBP) image reconstruction method, employed for the Jagiellonian PET (J-PET) scanners of differing geometries. Additional dimension imposed by TOF in projection space significantly reduces the number of coincidences per bin, which affects performance. However, high temporal resolution of J-PET substantiates analytical TOF-based techniques that operate in image space with the most likely position (MLP) of positronium annihilation. It is shown that FBP could be represented as a sum of single-event reconstructions, each performed around MLP within a limited volume by the truncation of radiotracers using TOF and filtering kernels. Such approach resembles kernel density estimation (KDE) applied to MLP with non-symmetrical spherical kernel and, likewise, is highly scalable with the perspective of being employed for real time imaging. For 1-mm spherical source, simulated inside 3-layer 50-cm long J-PET scanner using GATE (Geant4 Application for Tomographic Emission), the estimated transverse spatial resolution was about 4-6 mm, which is better than for KDE and conventional non-TOF FBP from STIR software package. Axial resolution of ~20 mm were similar for all three methods, which is consistent with temporal properties of tube photomultipliers utilised for the readout in J-PET.

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