Initial results of a mouse brain PET prototype with a staggered 3-layer DOI detector

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The spatial resolution of a small animal positron tomography (PET) scanner deteriorates significantly at the field of view (FOV) periphery because of the parallax error. In a previous study, we developed a staggered 3-layer depth of interaction (DOI) detector with a 1 mm crystal pitch. In this study, we present the initial results of a prototyped small animal PET scanner using the staggered 3-layer DOI detector for submillimeter mouse brain imaging. The prototype small animal PET scanner had a 52 mm inner diameter and 11 mm axial coverage (Fig. 1). The LYSO crystal array had the pixel pitch of 1 mm and total thickness of 15 mm. The PET scanner consisted of 16 DOI detectors each of which had a 3-layer staggered LYSO crystal array. The LYSO crystal array was optically coupled to a 4×4 SiPM (Hamamatsu, S14161-3050HS-04, Japan) array with a pixel pitch of 3.2 mm. The SiPM anode signals were multiplexed using a resistive network and then digitized by the 8-bit DAQ. The coincidence data were generated retrospectively with a coincidence window of 20 ns. The measured spatial resolutions at the center and 15 mm radial offset were 0.67 mm and 1.56 mm for filtered-back-projection (FBP) and 0.50 mm, and 1.16 mm for ordered-subset-expectation-maximization (OSEM), respectively (Fig. 2). The peak absolute sensitivity was 0.76% with an energy window of 400-600 keV (Fig. 2). The 1.35 mm and 0.75 mm rod patterns of the ultra-micro hot phantom were resolved with peak-to-valley ratios of 3.58 and 1.23, respectively (Fig. 3). In conclusion, we developed a high-resolution and high-sensitivity mouse brain dedicated PET scanner with 3-layer DOI detectors. In the JSAP meeting, mouse brain imaging results will be presented.
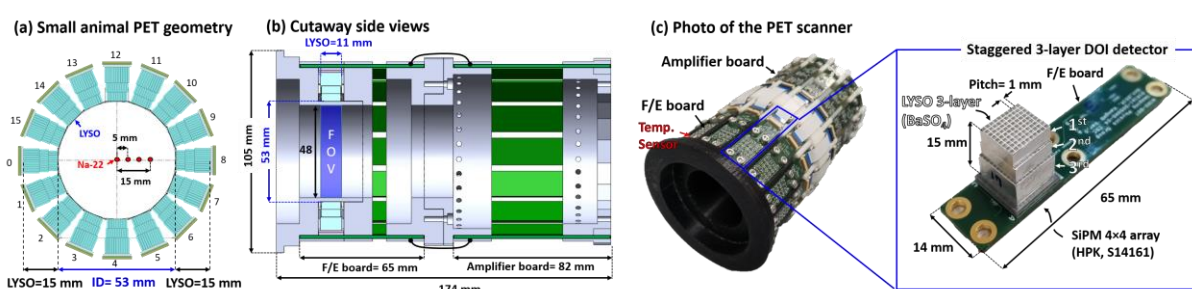

Fig. 1. Prototype mouse brain PET scanner: (a) Front view, (b) cutaway side view, (c) photos of the PET scanner and staggered 3-layer DOI detector.
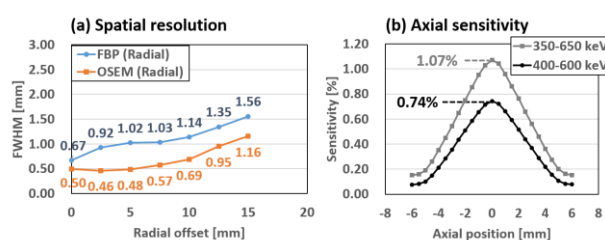

Fig. 2. (a) Spatial resolutions of FBP and OSEM algorithms in radial direction and (b) the axial sensitivity profile.
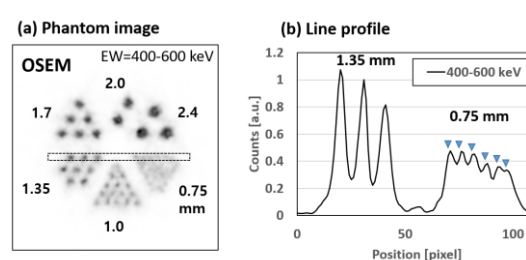
Fig. 3. (a) Ultra-micro hot phantom image (OSEM) and (b) line profile along the rod diameters of 1.35 mm and 0.75 mm.