First development of a total-body small animal PET with a 4-layer DOI detector

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Recently, there has been increasing interest in total-body positron emission tomography (PET) scanners which can provide ultra-high sensitive PET imaging as well as a subsecond temporal resolution. However, when it comes to small animal PET, the long axial field-of-view (FOV) causes a parallax error not only in the radial direction but also in the axial direction. In a previous simulation study, we demonstrated that a total-body small animal PET scanner with a 4-layer depth-of-interaction (DOI) detector can reduce the parallax error substantially. In this study, we present the first imaging results with the prototyped total-body small animal (TBS) PET. The developed TBS PET had an inner diameter of 155 mm and an axial length of 325.6 mm which can cover a rat whole-body (Fig. 1). The TBS PET consisted of 6 rings each of which has 10 DOI detectors At this point, only five of 6 rings were used since the detector calibration of the 6th ring had not been finished yet. Each DOI PET detector consisted of 4-layered 16×16 Zr-doped gadolinium oxyorthosilicate (GSOZ) crystals (2.8×2.8×7.5 mm^3) and an 8×8 array multi-anode PMT. A total crystal thickness was 30 mm. The PMT anode signals were multiplexed using a resistive network, and then digitized by the 8-bit DAQ system. The peak sensitivity of 16.7% was obtained at the center of the FOV. The 2.2 mm rod of the Derenzo-like phantom could be resolved even with the 30 mm radial offset (Fig. 2). The parallax error along the radial (Fig. 2) and axial directions (Fig. 3) were reduced by using the 4-layer DOI detector. In the near future, we will perform a real-time dynamic animal imaging study with the prototype PET scanner.

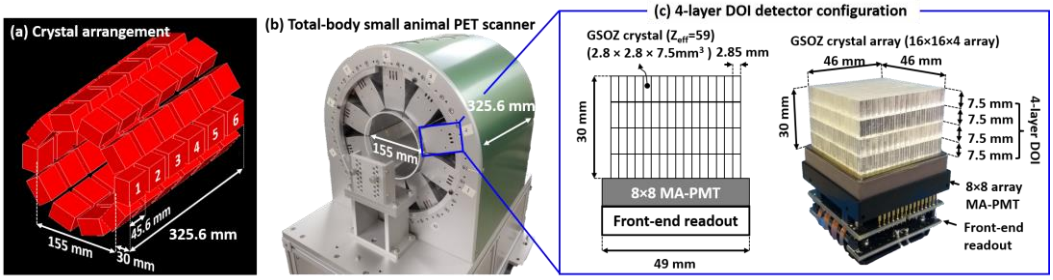

Fig. 1. Total-body small animal PET scanner: (a) GSO crystal arrangement, (b) photo of the TBS PET scanner, and (c) 4-layer DOI detector developed by our group.

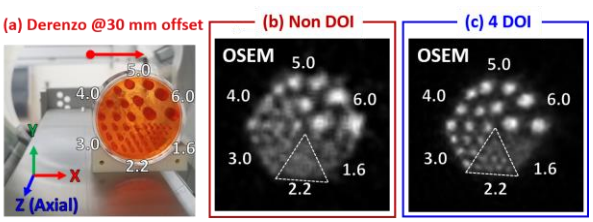

Fig. 2. Radial blurring measurement: (a) Derenzo-like phantom with a 30 mm radial offset, comparison of the PET images between (b) non DOI and (c) 4 DOI at the 30 mm radial offset position.

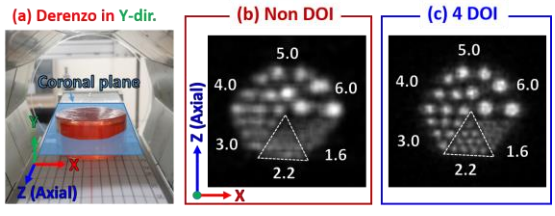

Fig. 3. Axial blurring measurement: (a) Derenzo-like phantom aligned in Y-direction, comparison of the coronal images of the Derenzo-like phantom obtained (a) without DOI information (non DOI) and (b) with DOI information (4 DOI).