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Optimization of Dual Layer Phoswich Detector for Small Animal PET using Monte Carlo Simulation

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As a basic measurement tool in the areas of animal models of human disease, gene expression and therapy, and drug discovery and development, small animal PET imaging is being used increasingly. An ideal small animal PET should have high sensitivity and high and uniform resolution across the field of view to achieve high image quality. However, the combination of long narrow pixellated crystal array and small ring diameter of small animal PET leads to the degradation of spatial resolution for the source located at off center. This degradation of resolution can be improved by determining the depth of interaction (DOI) in the crystal and by taking into account the information in sorting the coincident events.

Among a number of DOI identification schemes, dual layer phsowich detector has been widely investigated by many research groups due to its practicability and effectiveness on extracting DOI information. However, the effects of each crystal length composing dual layer phoswich detector on DOI measurements and image qualities were not fully characterized. In order to minimize the DOI effect, the length of each layer of phoswich detector should be optimized.

The aim of this study was to perform simulations using a simulation tool, GATE to design the optimum lengths of crystals composing a dual layer phoswich detector. The simulated small PET system employed LSO front layer LuYAP back layer phoswich detector modules and the module consisted of 8×8 arrays of dual layer crystals with 2 mm×2 mm sensitive area coupled to a Hamamatsu R7600 00 M64 PSPMT. Sensitivities and variation of radial resolutions were simulated by varying the length of LSO front layer from 0 to 10 mm while the total length (LSO + LuYAP) was fixed to 20 mm for 10 cm diameter ring scanner. The radial resolution uniformity was markedly improved by using DOI information. There existed the optimal lengths of crystal layers to minimize the variation of radial resolutions. In 10 cm ring scanner configuration, the radial resolution was kept below 3.4 mm over 8 cm FOV while the sensitivity was higher than 7.4% for LSO 5 mm : LuYAP 15 mm phoswich detector. In this study, the optimal length of dual layer phoswich detector was derived to achieve high and uniform radial resolution.