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Investigations of a novel small animal PET scanner with depth of interaction using GATE and a newly developed data rebinning application

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INVESTIGATIONS OF A NOVEL SMALL ANIMAL PET SCANNER WITH DEPTH OF INTERACTION USING GATE AND A NEWLY DEVELOPED DATA REBINNING APPLICATION

by

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requirements for the Doctor of Philosophy Degree
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Thesis supervisors:
Dr Michael Lerch and Prof Anatoly Rosenfeld

CERTIFICATION

I, Lakshal Perera BE, BSc, MSc, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Centre for Medical Radiation Physics, School of Engineering Physics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

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ABSTRACT

Current Positron Emission Tomography (PET) detectors suffer degradation in the spatial resolution at the edges of the field of view. This occurs as a result of the lack of depth of interaction (DOI) information which causes uncertainty in deducing the Lines of Response (LOR) between coincident events. The Centre for Medical Radiation Physics at the University of Wollongong has developed a novel detector module for use in small animal PET which will provide depth of interaction information while retaining the sensitivity of current scanners. This will result in superior imaging together with the ability to locate smaller lesions. This work focuses on preliminary investigations of the suitability of replacing the bulky scintillator crystals and photomultiplier tubes of traditional PET detector modules with compact LYSO scintillator crystals individually coupled to Si photodetectors.

Preliminary simulations focused on optimising the detector module were performed using the GATE Monte Carlo package. Data from the simulations was processed using a newly developed sinogram binning application. This application is flexible and able to adapt to numerous detector geometries based on user input. Depth of interaction information is automatically considered when binning the sinogram. Comparison of data from Monte Carlo studies processed with the sinogram binning application and experiments using a microPET Small Animal PET scanner are presented to illustrate the suitability of the sinogram binning application for future Monte Carlo PET data processing.

The spatial resolution results which are provided indicate this detector module is capable of providing superior performance to monolithic scintillator crystal detector modules. Furthermore, notable advances can be made towards a significant reduction of the radial elongation artefact at the edges of field of view. Other parameters

which are important to the process of quantifying the performance of a small animal PET scanner are also presented including optimisation of energy windows, the crystal size and detector configuration.

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