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Quantifying the limitations of small animal high-purity germanium PET based on Geant4 simulations

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The application of position sensitive semiconductor detectors in medical imaging is a field of global research interest. The Monte-Carlo simulation toolkit GEANT4 [1] was employed to better the understanding of detailed γ-ray interactions within the small animal Positron Emission Tomography (PET) imaging system, SmartPET [2]. The two SmartPET detectors [3] are planar, orthogonally segmented, high-purity germanium strip detectors which are mounted in a rotating gantry and operated in coincidence to perform positron emission tomography. This system has shown promising results in the field of PET [4] and Compton camera imaging [5]. Images for a selection of single and multiple point, line and phantom sources were successfully reconstructed using both a filtered back-projection [6] and an iterative reconstruction algorithm [6]. Techniques developed based on these data will be presented which allow inclusion of multiple interaction events into the image reconstruction, providing a strong argument for semiconductor PET. The simulated data were exploited as an alternative route to a reconstructed image allowing full quantification of the image distortions introduced in each phase of the data reconstruction. Quantifying the contribution of uncertainty in all system components from detector to reconstruction algorithm allows the areas in need of most attention on the SmartPET project and semiconductor PET to be addressed. The results shall be discussed in this contribution.

[1] http://geant4.web.cern.ch/geant4/
[2] A.J. Boston et al., An overview of the SmartPET project: Progress Report, oral contribution, Argonne National Laboratory, Chicago, USA (2006), http://ns.ph.liv.ac.uk/~ajb/public/presentations/smartpet-overview-anl-may-2006.pdf
[3] H.C.Boston et al., Nucl. Instr. and Meth.A (2007), doi:10.1016/j.nima.2007.04.017
[4] R.J. Cooper et al. in preparation for submission (2008)
[5] J.E.Gillam et al. Nucl. Instr. and Meth. A Vol 579 pp 76-79 (2007)
[6] A.R. Mather, PhD Thesis, Evaluation of the Planar Germanium SmartPET system for use in Positron Emission Tomography, University of Liverpool (2007)

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