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Modelling Orthogonal Strip HPGe Detector Systems

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The Monash Centre for Synchrotron Science (MCSS) Instrumentation Group is working on various detector designs for biomedical imaging and synchrotron use. The development of orthogonal planar strip HPGe detectors offers advantages of good energy and x,y,z-axis position resolution of gamma ray interactions. The efficiency in terms of photoelectron absorption type events is quite low however (˜3%), but could be greatly improved by tracking and including Compton interactions through the detector. If successful a system such as a small animal PET detector would have either better image resolution or shorter acquisition time (lower radioisotope dose).

In order to optimise the detector design it is useful to simulate the various stages from interaction, through to detection, and image reconstruction. This will aid decision making on the cost/benefit trade-offs of increasing electronics complexity versus better image resolution. For example, using more strips in the design would improve the (x, y) position resolution but require more high speed data channels. Likewise increasing pre-amplifier bandwidth would improve resolution in depth (z) of near-coincident interactions but increase the noise. Each of these effects on final image quality will be evaluated before starting construction.

Here the modules for each simulation stage are described, the first two of which have been written in IDL. In the first module the detector geometry is defined and the signals appearing on each strip for a set of incident gamma rays are generated using the method-of-images. A graphical interface allows the user to vary the detector's physical and electronics parameters and view the signal results, or batch process an events file into a signal output file.

The second module implements the Pulse Shape Analysis (PSA) algorithms to identify the charge collecting and spectator strip signals. The PSA algorithm is first calibrated by fitting signature waveforms to the current signals of charge collecting strips at a grid of known locations. As well, the ratio of induced signals on the adjacent spectator strips is stored for points across the strip width. This aids the later separation of superimposed interactions along the z-axis and improve the x,y-axis positioning to better than one strip width. The aim is to capture as much detail about partial gamma energy interactions as possible and determine the limits of resolving separate interactions. While initially the PSA algorithms are intended for modelling and off-line analysis, the second aim is for the final algorithms to be robust and fast enough to use in a real-time embedded system.

The resulting interaction positions and energies can then be used for the image reconstruction stage, details of which are presented in companion MCSS papers. Where there are multiple Compton interactions the energy and position of the first, and position of the second interactions are needed. This cycle is repeated for different detector designs and some initial results will be presented.

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