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Improving Position Resolution in Pixelated CZT Detectors through Collimated Gamma-Ray Scanning for use in Molecular Breast Imaging Applications

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Current breast cancer screening techniques suffer from reduced diagnostic performance for patients with mammographically dense breasts. An alternative screening method that overcomes this is Molecular Breast Imaging (MBI), which uses the 140.5 keV gamma-emitting tracer technetium-99m in conjunction with a gamma-camera to image breast tissue.

A gamma-camera is being developed for this application that makes use of a room-temperature pixelated CZT detector in conjunction with a collimator mask. The detecting crystal was taken from a Kromek D-Matrix gamma-ray imager and is 22 x 22 x 5 mm, with a planar cathode and 11 x 11 pixelated anode. This a provided an intrinsic position resolution of 2 x 2 x 5 mm. Pulse Shape Analysis (PSA) techniques can be applied to the signals to improve the position resolution further. The D-Matrix unit provided only timing and energy information via ASIC coupling, so a readout system was designed and constructed that enabled the digitisation and analysis of the raw signals.

Characterisation of the crystal's signal response was performed using high-precision collimated gamma-ray scanning. A cobalt-57 source and a tungsten collimator were used to produce a tightly collimated beam of 122.1 keV gamma rays, analogous to those from technetium-99m, to map the signal response as a function of interaction position. A database of signals from constrained positions was thus formed and used to characterise the charge collection and transient signal response of the crystal. Signal-parameterisation based PSA methods were developed using this database and implemented in order to achieve sub-voxel position resolution both laterally and in depth. The developed algorithms are intended for implementation in the digital ASICs of future detecting systems.

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