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Enhancing gamma-ray detection and imaging characteristics in HPGe double-sides strip detectors employing signal decomposition algorithms

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Position sensitive semiconductors are important tools for gamma-ray detection and imaging. Compton Imaging is now an established gamma ray imaging modality for energies ranging from about 200 keV to several MeV. The performance is only limited by intrinsic detector properties such as position and energy resolution and the ability to resolve individual interactions. In our effort we focus on the improvement of the position resolution of HPGe double-sided strip detectors (DSSD). Our detectors are 15 mm thick and have 38 strips on each side with a strip pitch of 2 mm resulting in a volume of about 100 cm3 that is read out by 76 individual preamplifiers. We are developing and benchmarking signal processing techniques to improve the position resolution to be significantly better than given by the voxel size. Specifically, we are developing Signal Decomposition (SD) algorithms, which are based on physic models of the charge creation and transport processes and mathematical techniques such as singular value decomposition to infer the energy and three-dimension of individual gamma-ray interactions. Using SD we were able to achieve a spatial resolution of about 0.5 mm resulting in about 800k spatial voxels. The increase in granularity significantly increases the imaging resolution and efficiency, which is the ultimate goal.

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