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P2.10: Feasibility of Using 3D CZT Drift Strip Detectors for Small Compton Camera Space Missions

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The electromagnetic emission from astronomical sources in the MeV-energy band (0.1 to 100 MeV) is exceedingly difficult to detect –both due to low flux, and the fact that photons may penetrate significant thicknesses of material without interacting. However, in an astrophysical context, photons in this energy band carry specific and valuable information about gamma-ray lines that originate from radioactive nuclei created in supernova explosions, or ejected from colliding neutron stars. Gamma-rays from matter-antimatter annihilation, and accreting black holes are further examples of sources exciting the interest in this energy band. New state-of-the-art sensor technology is a key factor to improve sensitivity of observations in this energy range.

The detector group at DTU Space started a development program, focusing on improving the spectral performance of CdZnTe (CZT) detectors, a special readout technique, the so-called Drift Strip Method (DSM) was developed. The DSM method leads to a considerable improvement of the achievable energy resolution even for CZT crystals of limited quality, despite suffering inefficient charge collection [1], [2], [3]. Contrary to the common pixelated electrode geometry (where the typical number of readout channels required increase with cubic power with the sensitive detector volume), the 3D CZT drift strip detector minimizes the number of readout channels. Recent prototypes of size 2cm x 2cm x 0.5 cm perform with sub-millimeter position resolution (<0.5mm @662 keV) in 3D and energy resolution (<1% @662 keV) [4], [5], [6]. The latest development is a set of new 3D CZT drift strip detector module of size 4cm x 4cm x 0.5cm (Figure 1).

It has previously been demonstrated that a single 3D CZT drift strip detector crystal can be operated as a Compton Camera [7]. The next step of the development program is to fly several 3D CZT drift strip detectors on a small payload (e.g. CubeSat) operating as a Compton Camera. This is to increase technology readiness level of the detector. We will present the initial design and simulations of a Compton Camera concept utilizing the detector using the simulation software "The Medium-Energy Gamma-ray Astronomy library"(MEGAlib) [8]. We will present in-orbit simulations of effective area, sensitivity, and minimal detectable polarization, utilizing the simulations to optimize design choices and improve sensitivity of the Compton Camera, and to give first light insight on the 3D CZT drift strip detector performance on a small satellite MeV space mission.

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