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Imaging X-Ray Photons and Electrons with the Spectroscopic 166-Pixel SDD Monolithic TRISTAN Detector

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We present a spectroscopic detection module with position sensitivity based on the largest monolithic array of Silicon Drift Detectors (SDD) ever reported. It consists of 166 pixels of 3 mm diameter with integrated JFET. This module has been developed within the TRISTAN project, aiming at investigating the existence of the sterile neutrino in the keV mass range by beta spectroscopy [1]. The TRISTAN detector will be installed in the KATRIN focal plane to profit of the Tritium generation facility. The investigation of the whole spectrum of electrons (up to 30 keV) leads to very high count rates, spread across 3486 pixels (each one counting at 100 kcps) and grouped into 21 modules, each one featuring a monolithic array of 166 SDDs. SDD proved to be excellent detectors also for electron spectroscopy [2]. The compact size of the module (4 cm) and the need for four-side buttability, poses demanding challenges in terms of signal integrity and module design.
After achieving preliminary results with a smaller detector, already commissioned in the monitor spectrometer of KATRIN (47 pixels [3]), we present here the design and characterization of the final detection module with 166 channels (Fig. 1). Analog processing of events and data acquisition is performed by means of the FPGA-based Athena platform, featuring 4 Kerberos modules [4], each one acquiring 48 channels. The average energy resolution of all pixel simultaneously acquired (Fig. 2) is below 250 eVFWHM (at 5.9 keVm with 6 µs shaping time and 0℃ cooling). Despite satisfying the experiment requirements, detector improvements are ongoing.

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