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The TRISTAN Detection Module: a 166-Pixel Monolithic SDD Array for Beta Spectroscopy

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The TRISTAN project represents an upgrade under development of the KATRIN (KIT, Germany) focal plane detector (FPD) for the search of the sterile neutrino in the keV energy range. After having assessed and modeled the response of SDDs to electrons and smaller arrays, we present the design and characterization of the detection module featuring a monolithic array of 166 SDD pixels (of 3mm diameter) with integrated JFET readout by integrated preamplifiers (Ettore ASIC). The module is 4-side buttable and mounted on a cold finger (Fig.1). 21 modules will be juxtaposed in the FPD, in high vacuum (10-11mbar) and magnetic fields ($\sim T$) for a total of 3846 pixels, each one operating at 100kcps targeting the best spectroscopic performance for electrons up to 20keV. Given the compact size (4 cm side), high density PCB and interconnection were adopted. Data processing is performed with the custom-developed Ethernet-controlled 192-channel Athena platform, made of four 48-channel Kerberos units, combining integrated analog shapers and peak sampling (SFERA ASIC) with FPGA data acquisition and concentration. Preliminary results were obtained with a planar configuration (Fig.2), showing an average energy resolution across all 166 pixels (Fig.3) better than 250eV at 5.9keV compliant with the experiment specifications, with moderate cooling (0°C) and at a count-rate of 1 kpcs (Fig.4). Noise and cross-talk have been carefully investigated leading to an improved design of detector traces. Commissioning of the first module in the Monitor Spectrometer of KATRIN, in operating conditions similar to the FPD and for characterization with electron sources, is planned for mid 2022.

Collaboration

TRISTAN

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