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Characterization of Kr-filled Gas Proportional Scintillation Counters

Gas Proportional Scintillation Counters (GPSCs) are gas-filled detectors in which the charge signal generated by radiation interactions is amplified through secondary scintillation - electroluminescence (EL) - induced by electron impact. In these detectors, primary electrons are drifted into a scintillation region where the electric field is strong enough to produce EL without initiating additional ionization. The resulting scintillation signal is directly proportional to the number of primary electrons and, therefore, to the energy deposited by the incident radiation. Compared to amplification via electron avalanches, EL-based amplification provides superior energy resolution.

Krypton-based GPSCs offer an attractive balance between performance and cost, making them well-suited for applications requiring large detection volumes and operation at high pressure. Krypton, being denser than argon and significantly less expensive than xenon, provides enhanced X-ray absorption efficiency in the 14–34 keV range - spanning the region between the K-edges of krypton and xenon. This makes krypton-filled GPSCs especially promising for X-ray imaging and spectroscopic applications. Krypton-based detectors have been employed in the measurement of double electron capture in ^{78}Kr and in the search for solar hadronic axions emitted in the M1 transition of 83Kr. Additionally, 83Kr has been proposed for use in inelastic dark matter searches.

In this study, we evaluate the performance of two krypton-filled GPSC prototypes: one equipped with a Large Area Avalanche Photodiode (LAAPD) and the other with a Photomultiplier Tube (PMT) as VUV photosensors. We determine the electroluminescence and ionization thresholds for krypton and measure the Fano factor, a key parameter influencing the intrinsic energy resolution of the detectors. Energy spectra from ^{55}Fe, ^{109}Cd, and ^{244}Cm sources are recorded and compared with previous results obtained using argon- and xenon-filled GPSCs.

Workshop topics

Detector systems

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