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Long-Term Performance of VUV-Sensitive Silicon Photomultipliers in Cryogenic Environments for nEXO

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The nEXO experiment, a next-generation liquid xenon time-projection chamber enriched to 90% ^{136}Xe , will search for neutrinoless double-beta decay with a projected half-life sensitivity of 1.35×10^{28} years over a 10-year lifespan. Achieving this sensitivity requires high efficiency vacuum-ultraviolet (VUV) silicon photomultipliers (SiPMs) to detect xenon scintillation light at 175 nm, motivating a rigorous characterization of their long-term performance under cryogenic conditions. We present a multi-year study of a single Fondazione Bruno Kessler HD3 VUV SiPM in a kilogram-scale liquid xenon cryostat. This setup allows for the long term characterization of the SiPM through IV curves, detection of single photon events, and measurement of xenon scintillation light. This enables the characterization of SiPM properties such as gain, breakdown voltage, correlated avalanches, and photon detection efficiency across three mediums: vacuum, gaseous nitrogen, and liquid xenon. These conditions directly replicate the nEXO detector environment, providing essential validation of SiPM longevity and performance for the experiment's decade-scale lifetime.

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