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Characterization of Silicon Photomultiplier Photon Detection Efficiency at Liquid Nitrogen Temperature

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Silicon photomultipliers (SiPMs) are being used by many rare-event search experiments to read out scintillation light from liquid noble detectors due to their single-photon resolution. Knowledge of the photon detection efficiency (PDE) of these SiPMs is a critical input for modeling these detectors' light responses and optimizing their sensitivities for new physics; however, the PDEs of SiPMs are not well characterized at the cryogenic temperatures at which many experiments operate them. Measurements of the PDE at cryogenic temperatures are difficult, as they require an apparatus that is capable of changing a SiPM's temperature while holding all other optical properties constant. In this talk, we detail the design of a cost-effective test stand that has measured the PDEs of off-the-shelf, visible-light-sensitive Hamamatsu S13360-3050C and KETEK PM3325-WB-D0 SiPMs at liquid nitrogen temperature. We find that the PDEs for green-light wavelengths decrease from their room temperature values by roughly 20% for both devices across all measured overvoltages. Numerous systematic studies were performed to ensure that all optical properties of the test stand were temperature-independent and that the decrease in PDE originated solely from the cryogenic cooling of the SiPM.

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