

Temperature-Dependent Performance of NaI(Tl) Scintillators with Dual-Channel SiPM Readout for Low-Mass Dark Matter Searches

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We investigate the scintillation characteristics of a NaI(Tl) crystal coupled with dual-channel silicon photomultipliers (SiPMs) across a temperature range of 94 to 293 K. While low-temperature properties of NaI(Tl) have been previously studied using photomultiplier tubes (PMTs) [1] or single-channel SiPMs [2, 3], the performance and coincidence advantages of a dual-channel SiPM configuration remain largely unexplored. In this study, a 5.5 mm × 6.0 mm × 15 mm NaI(Tl) crystal was directly coupled to two SiPMs and characterized at 10 K intervals in a liquid nitrogen-cooled cryostat. Our results demonstrate a significant enhancement in light output at reduced temperatures, peaking near 240 K with a light yield of 17.7 ± 1.1 photoelectrons/keV—a 35.2% increase over the room-temperature (293 K) baseline. The dual-channel SiPM approach effectively suppresses random thermal noise via coincidence triggers, which, together with the observed increase in light yield, provides a critical pathway toward lowering the energy threshold for dark matter and coherent elastic neutrino-nucleus scattering (CEvNS) detection.

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2. H.Y. Lee *et al.*, “Scintillation characteristics of a NaI(Tl) crystal at low-temperature with silicon photomultiplier”, *J. Instrum.* **17**, P02027 (2022).
3. E. Martinenghi *et al.*, “First use of large area SiPM matrices coupled with NaI(Tl) scintillating crystal for low energy dark matter search”, *Eur. Phys. J. C* **85**, 1444 (2025).