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Detector R&D of a Cold Liquid Scintillator Veto for the PandaX-20T Experiment

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The PandaX-20T experiment, a next-generation multi-ton liquid xenon TPC at the China Jinping Underground Laboratory, aims to achieve unprecedented sensitivity for direct dark matter detection. As experiments approach the neutrino-floor regime, efficient suppression of neutron and gamma-induced backgrounds becomes increasingly important. An **active Cold Liquid Scintillator (CLS) veto** surrounding the xenon target offers a promising approach for enhancing **background discrimination**, with the additional benefit of **reducing thermal gradients** and potentially enabling a **thinner liquid-xenon cryostat**.

We report R&D results from a **˜1 L CLS prototype operated down to −100°C**, employing **wavelength-shifting optical fibers** coupled to **silicon photomultipliers (SiPMs)** for scintillation readout under cryogenic conditions. The system demonstrates stable operation, with a **˜59% reduction in photoelectron yield at −20 °C relative to room temperature**. **Independent LED calibration measurements confirm reliable SiPM performance at −100 °C, with an observed gain increase of about a factor of two.** Geant4 simulations are employed to model optical photon transport, optimize detector geometry, and evaluate neutron and gamma veto performance. These combined studies provide essential input for the design of a large-scale cryogenic scintillator veto for PandaX-20T and demonstrate its potential to significantly enhance background rejection in rare-event searches. Future work will focus on detailed characterization at −100 ℃ and quantification of **neutron-tagging efficiency**.

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