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Development of a low-threshold cryogenic scintillation detector of neutrino

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A scintillation detector concept utilizing high light yield crystals with silicon photomultiplier readout is under development at the Institute for Nuclear Research of the Russian Academy of Sciences (INR RAS). The detector is aimed at registration of neutrino-induced recoil electrons with sub-keV energy thresholds (<1 keV). The detector architecture employs a modular, easily scalable design comprising 64-channel layers of scintillation modules. Each module integrates four compact crystals coupled to SiPM matrixes for photodetection. This system is optimized for low-energy neutrino detection, with applications in studying reactor neutrinos. The proposed scintillator crystals exhibit a high light yield of up to 120 photoelectrons per keV, enabling resolution of energy depositions as low as 100 eV. A detection threshold of 6 p.e. is achievable assuming a SiPM photon detection efficiency (PDE) of 50. Thermal management is critical for noise suppression: operation at cryogenic temperatures reduces SiPM dark count rates (DCR) to levels compatible with sub-keV threshold requirements. Systematic characterization of DCR temperature/voltage dependencies and scintillator performance has been conducted for several types of SiPMs and crystals. Preliminary evaluations of various crystal samples from multiple manufacturers confirm sufficient light yield, validating the detector's feasibility. The modular design permits scalable deployment, positioning this technology as a promising tool for advancing low-energy neutrino physics experiments.

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