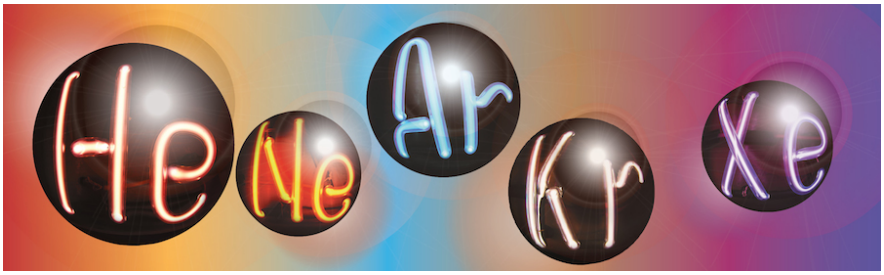

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Development of Cryogenic Silicon Photomultipliers Based on FBK Technology for the DUNE Experiment and Light Detection in Liquid Argon

The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino experiment designed to investigate neutrino oscillations, determine the neutrino mass ordering, and search for possible CP violation in the lepton sector. The experiment comprises a Near Detector and a Far Detector located 1300 km apart. The Far Detector will consist of four liquid argon time projection chambers (LArTPCs), which detect particles through the collection of ionization charge and scintillation light produced in the active medium. The Photon Detection System (PDS) is based on X-ARAPUCA light collectors coupled to silicon photomultipliers (SiPMs).

For this application, FBK has developed the NUV-HD-Cryo SiPM technology, specifically optimized for operation at cryogenic temperatures. These devices exhibit extremely low dark count rates, of the order of a few mHz/mm^2, enabled by a low peak electric field, reduced afterpulsing probability, and a limited temperature dependence of the quenching resistance. Within the framework of the DUNE collaboration, the technology has been further tailored to meet the experiment requirements obtain a device with high gain and limited crosstalk by increasing the number of Deep Trench Isolation (DTI) structures, with the goal of achieving a better signal-to-noise ratio.

For the Vertical Drift detector module, a new SiPM architecture, named FLEXI, has been developed. Compared to the previous design adopted for the first DUNE module, FLEXI introduces several improvements. All SiPMs are operated at the same bias voltage, ensuring uniform gain and photon detection efficiency across the device. Moreover, the reduced total capacitance results in lower electronic noise and faster signal response, producing narrower and cleaner pulses. In addition, the differential signal readout enhances the signal-to-noise ratio by suppressing common-mode noise through the measurement of the voltage difference between two signal lines.

To support the large-scale production of FLEXI devices, FBK has developed a dedicated setup for their characterization and validation. This contribution presents the FLEXI architecture and its main features, together with the experimental setup implemented for quality control and the characterization results obtained during the validation phase.

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