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Cryogenic silicon-based modular photosensors for DarkSide-20k

Silicon photomultipliers are a compelling alternative to PMTs in cryogenic ultra-low background applications, such as in dark matter direct search experiments: with respect to the popular photomultiplier tubes, SiPMs can exhibit better photon detection efficiency, are insensitive to magnetic fields, more compact, and low-voltage powered, cheaper and easier to produce with low radioactive contamination. Working on the next generation of dark matter direct search experiments, the Global Argon Dark Matter Collaboration has committed to this technology, starting from their next programmed experiment: DarkSide-20k. The development of a cryogenic SiPM-based photodetector has been a challenging task due to the strict radiopurity requirements and cryogenic conditions imposed by the expected signature for dark matter signals. The R&D culminated with the design of the Photon Detector Unit (PDU), a modular photon detector of 20x20 cm^2 with 4 readout channels, based on a SiPM technology developed by Fondazione Bruno Kessler and cryogenic front-end electronics; PDUs will be mass-produced in the following year in Nuova Officina Assergi, a 420 m^2 ISO-6 cleanroom located at LNGS. More than 500 PDUs will be used to construct the two ˜10.5 m^2 optical planes for the TPC of DarkSide-20k and as photosensors for the veto systems (˜5 m^2 total SiPM surface). All of the TPC PDUs will be tested at LN2 temperature in the Dark Matter Cryogenic Laboratory of Naples, using a dedicated system equipped with a 1000 L cryostat. The first prototypes of the PDU have already been tested in Naples and satisfy the constraints that the collaboration had defined to reach the desired level of sensitivity.

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