



Characterization of DarkSide-20k large-area SiPM Tiles



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On behalf of the DarkSide collaboration

DarkSide-20k



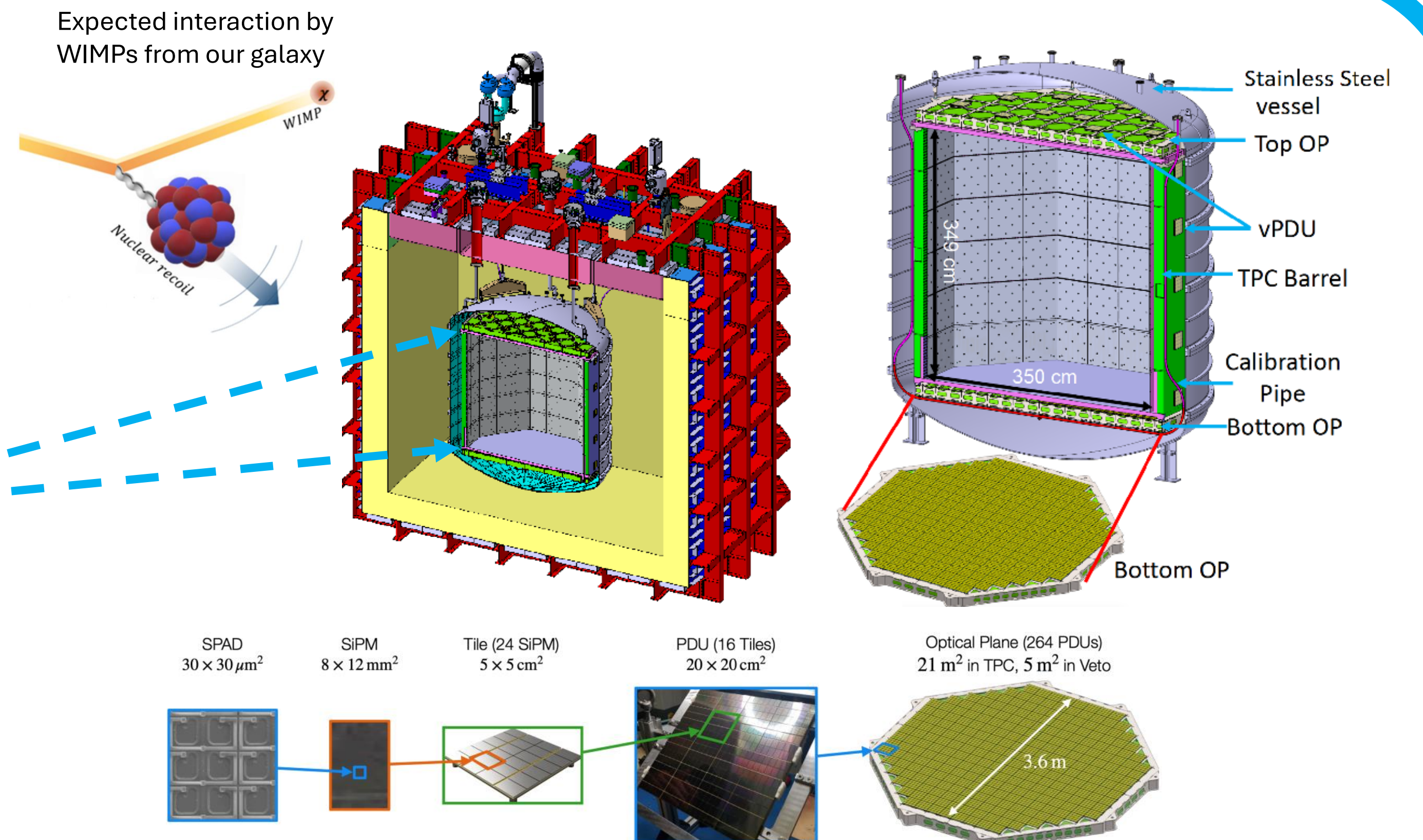
DS-20k in June 2024

The DarkSide-20k (DS-20k) experiment is under construction in Hall C at Laboratori Nazionali del Gran Sasso (LNGS), Italian Institute for Nuclear Physics (INFN).

Its scientific aim is to probe WIMP-nucleus cross section down to 10^{-48} cm² by employing 20 tonnes of radiopure argon as target in the fiducial volume of its Time Projection Chamber (TPC).

The light produced by scattering particles in the TPC will be measured by two optical planes located near to top and bottom of the TPC. An active veto surrounds the TPC to improve background rejection.

Differently from previous tonne-scale dark matter experiments, DS-20k will feature arrays of silicon photomultipliers (SiPM) to detect the TPC light, covering a total surface of 21 m².



Large-area Tiles

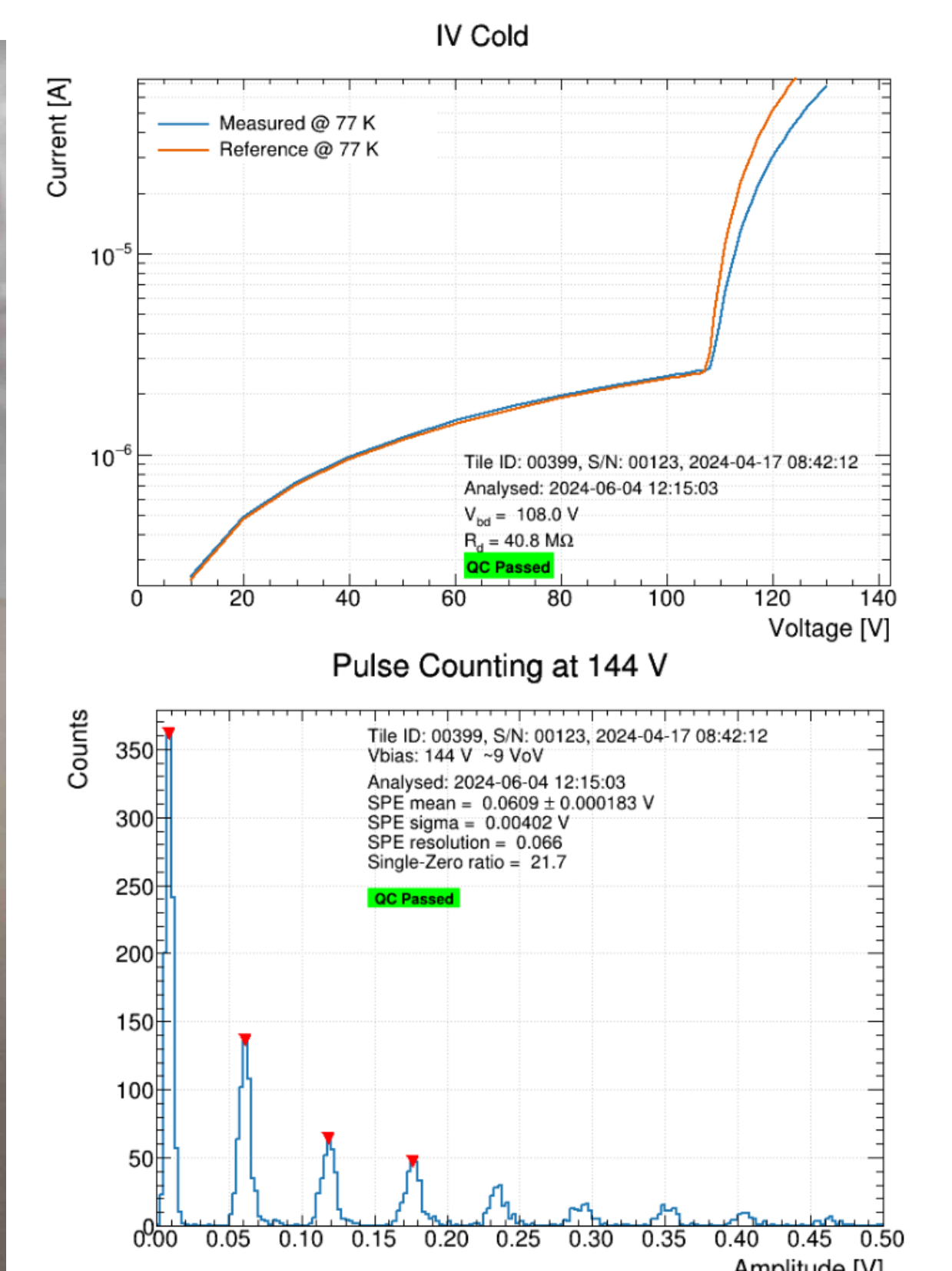
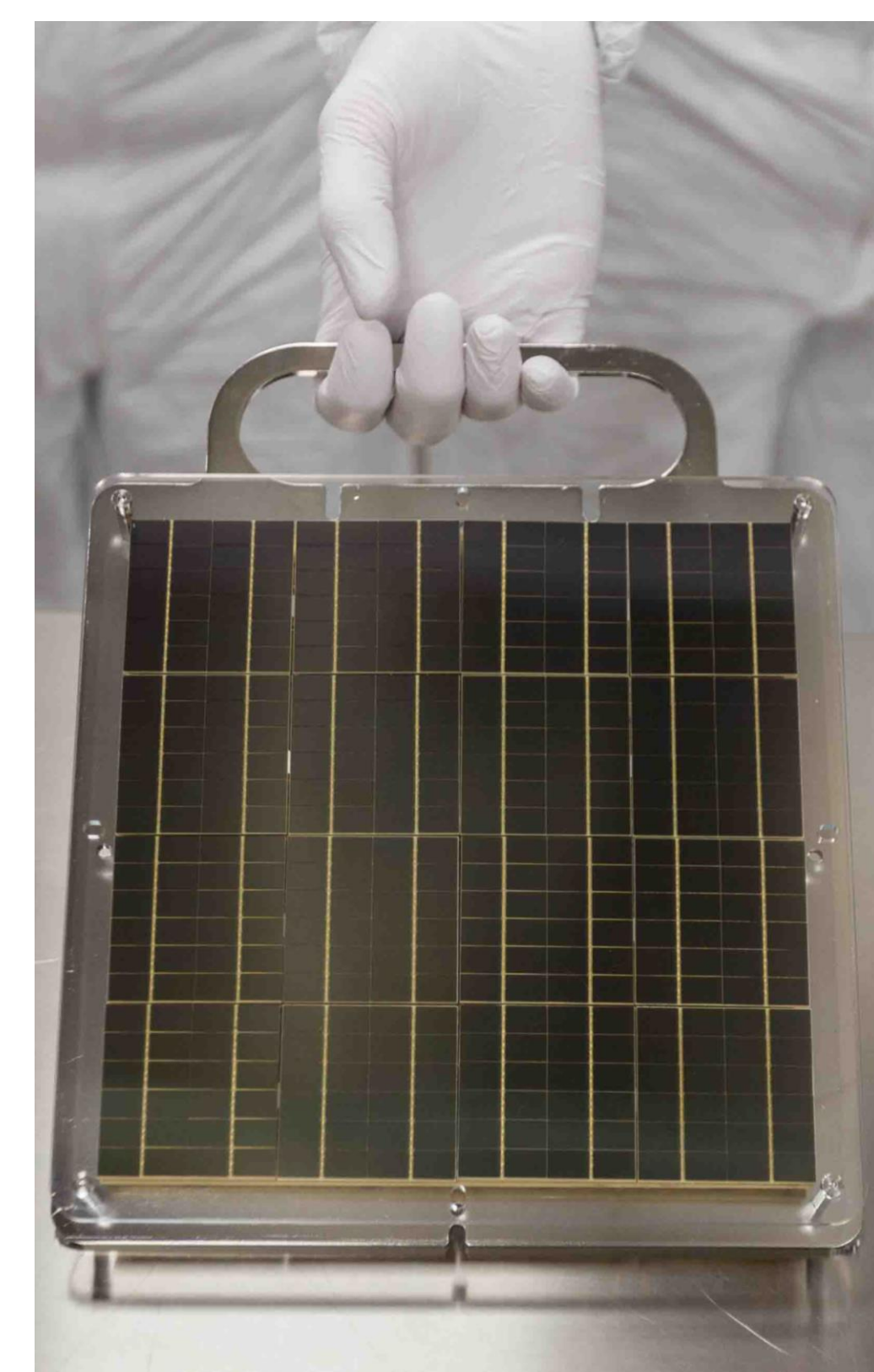
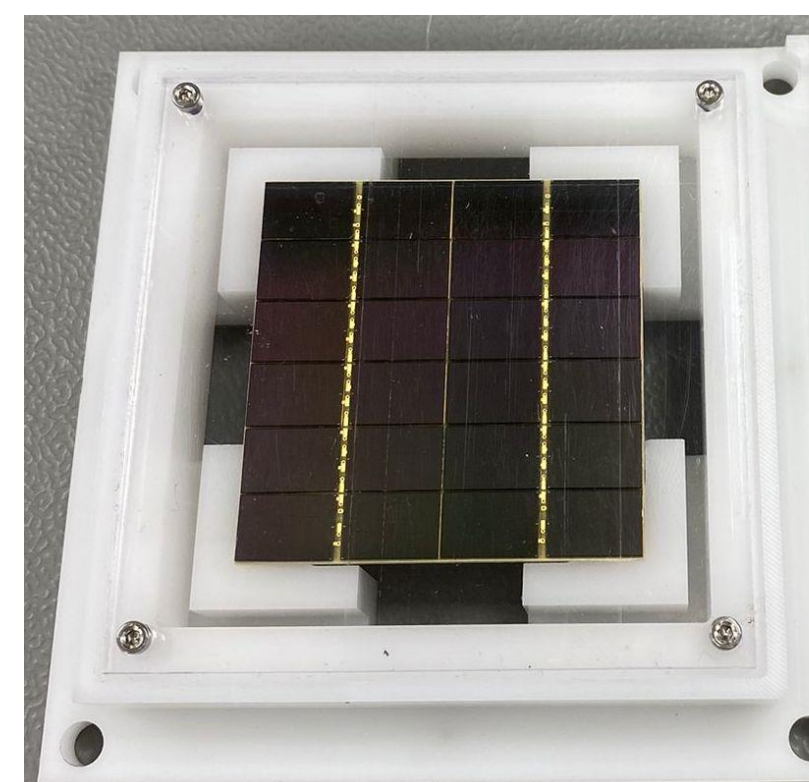
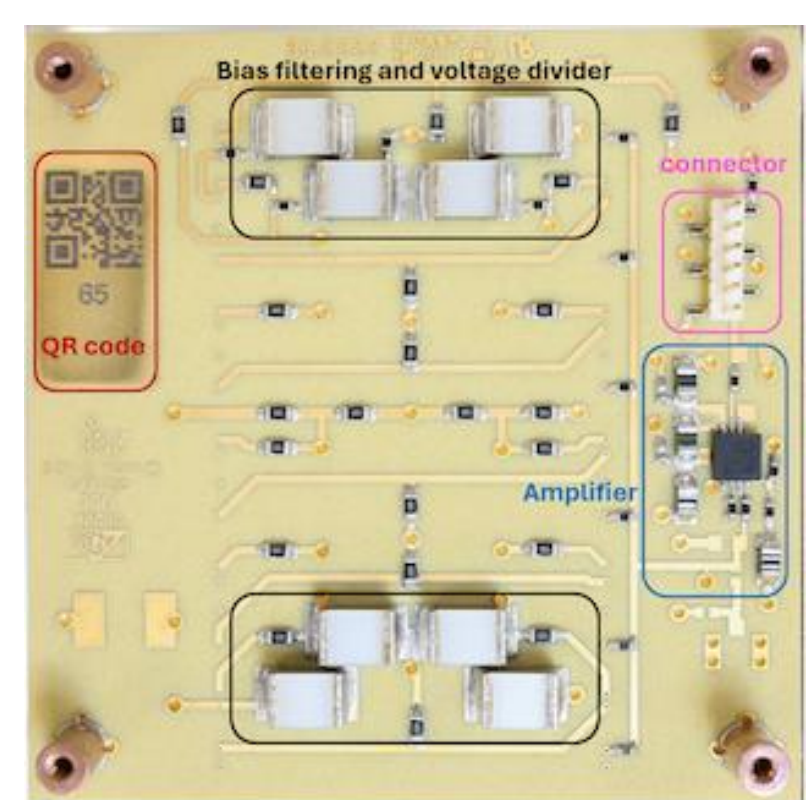
One of the most challenging DS-20k objectives is to cover meter-sized areas with cm-sized SiPMs, resulting in an unprecedented silicon, electronics and packaging development. Sixteen 5x5 cm² SiPM arrays are mounted on a common board to compose a cryogenic low-noise Photo Detection Unit (PDU) that will be the tessellation unit of DS-20k's optical planes.

Custom SiPMs were developed by Fondazione Bruno Kessler (FBK) and produced by LFoundry.

Main features at 77 K (liquid nitrogen temperature):

- Photo Detection Efficiency (PDE) > 40% at $\lambda \sim 420$ nm
- Dark Count Rate (DCR) at 7 VoV $\sim 10^{-2}$ Hz/mm²
- Breakdown voltage: 27.2 ± 0.1 V

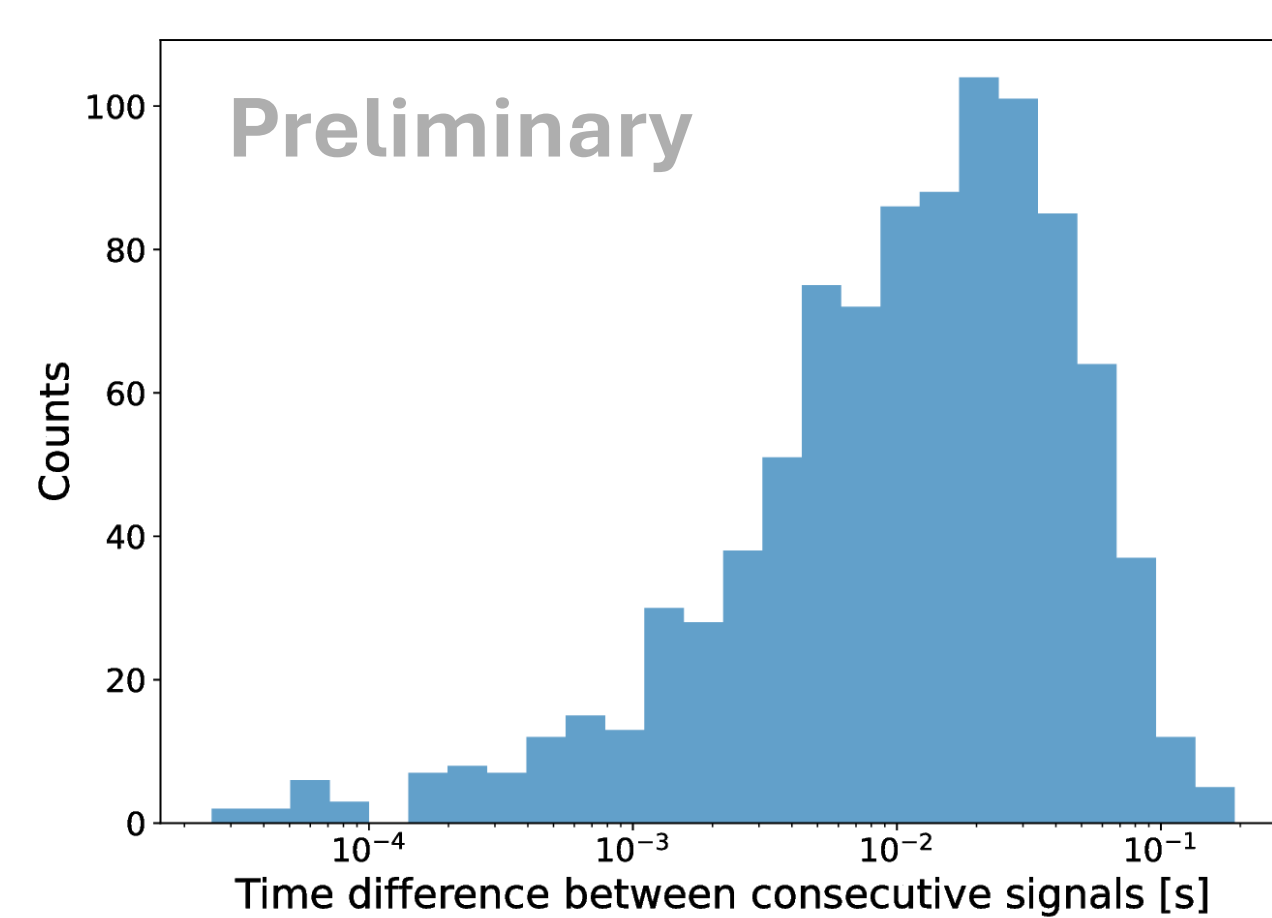
TPC SiPM Tiles are assembled and tested in Nuova Officina Assergi (NOA) at LNGS, a 400 m² ISO 6 clean room equipped for mass production, tracking and testing of silicon-based detectors. The production of about 10000 Tiles is foreseen for DS-20k in 2025. Detectors will be electronically and optically tested at room temperature and in liquid nitrogen.



Dark count rate

NOA plans to perform a sampling measurement of DCR to take under control this crucial quantity.

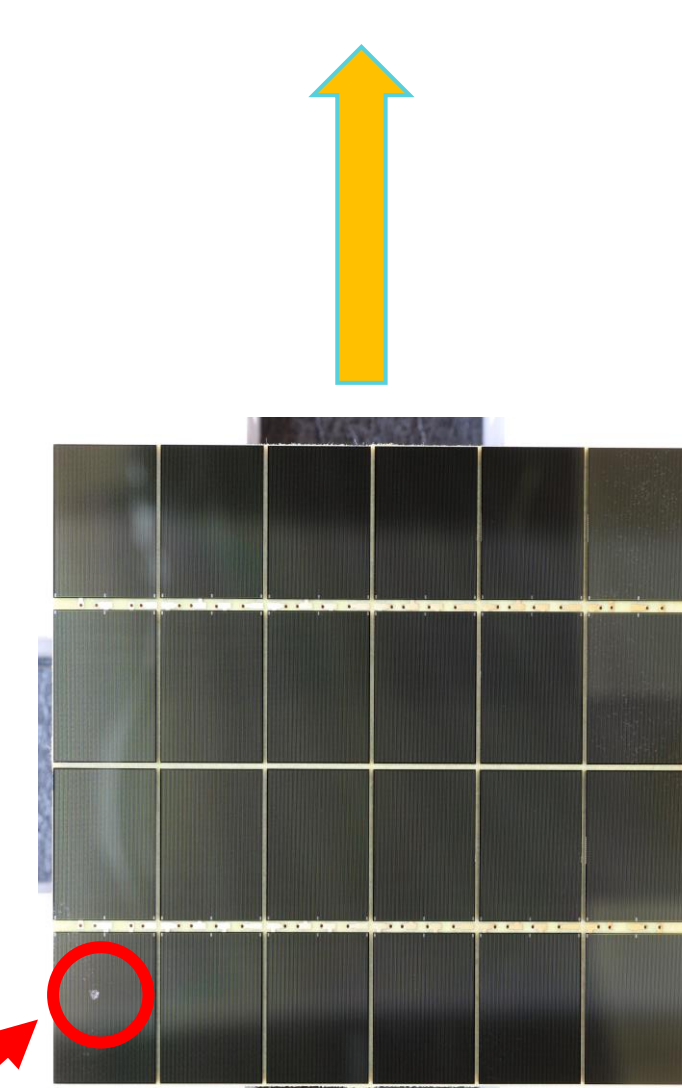
Preliminary DCR measurements are carried out by mounting our Tiles inside a dedicated black box and immersing it in liquid nitrogen. The dark count rate is evaluated from the statistical distribution of delay times between consecutive signals following the method described in A. Butcher et al, NIMA 875, pp. 87-91 (2017)



Our preliminary measurements show DCRs of the order of 10^{-2} Hz/mm², while higher values are correlated to Tiles misbehaviors or defects on the SiPM surface.

Up to now, the DCR test showed to be the most sensitive to Tile's quality, rejecting actually defective Tiles that passed our previous electronics and optical tests (see the example on the right).

Very bad DCR.
No anomaly detected with standard Tile test



Solder paste on a SiPM

