Mass production of large-area SiPM arrays for the TPC of DarkSide-20k

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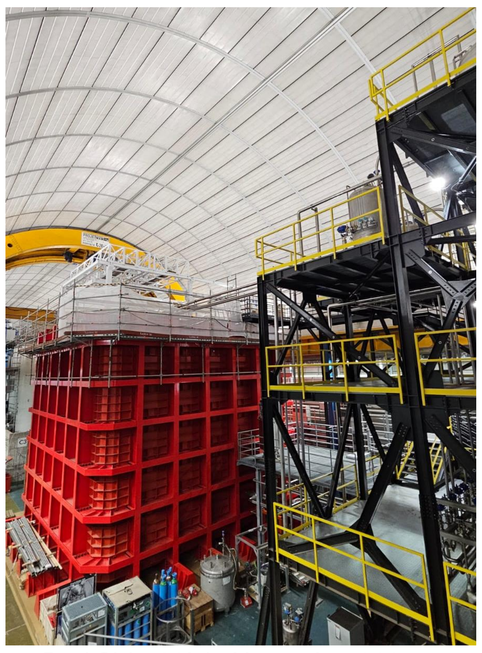
DarkSide-20k



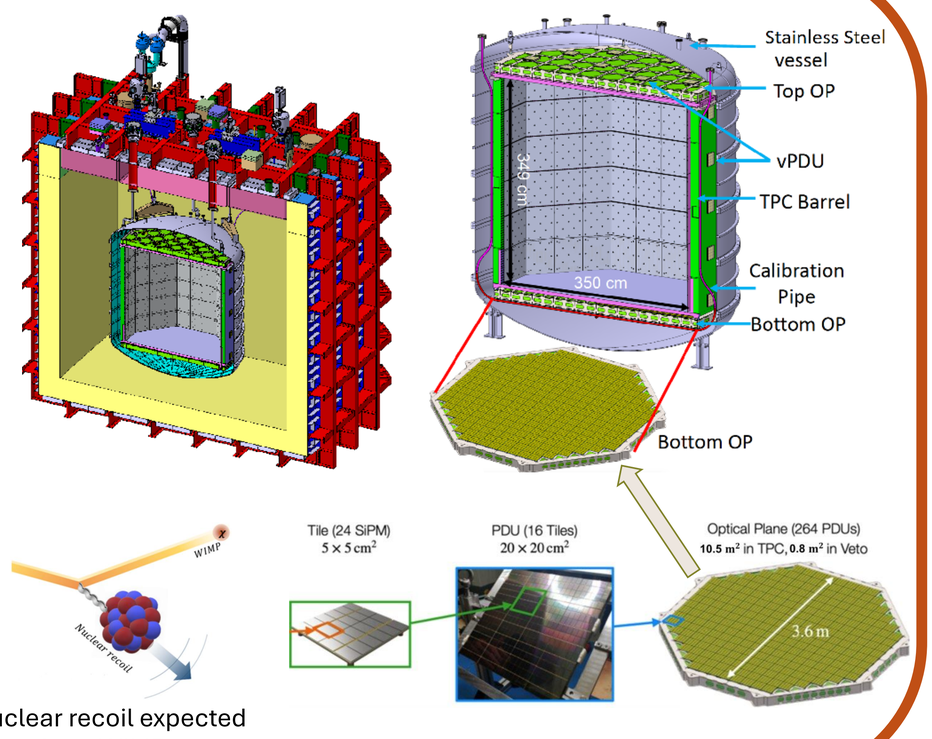
DarkSide-20k in November 2025

DarkSide-20k (DS-20k) is a **direct dark matter search** experiment under construction in Hall C at **Laboratori Nazionali del Gran Sasso** (LNGS), L'Aquila, Italy.

It aims to **probe** the **cross-section** between **argon nuclei** and **Weakly Interacting Massive Particles** (WIMPs), one of the most promising dark matter candidates, down to $\mathbf{10^{-48}\ cm^2}$ employing a **double-phase** time projection chamber (**TPC**) with a fiducial target of **20 tonnes** of the so-called **underground argon** with a specific activity of **0.066 mBq/kg**.

High-quality **silicon photomultiplier** (SiPM) **arrays**, grouped in two **optical planes** of 10.5 m^2 each, will detect the light emitted in the two phases of the **TPC** by nuclear or electron recoils.

An extensive **material screening** carried out by the DarkSide collaboration allowed to reach an expected radiogenic **background** of **0.1 events** in a **200 ton·year exposure** after analysis. An additional irreducible background of **3.5 coherent neutrinos**, indistinguishable from WIMP-nucleus scattering, is foreseen.

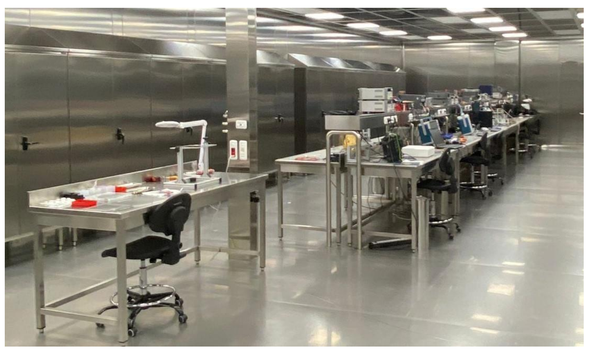


Nuclear recoil expected from WIMPs

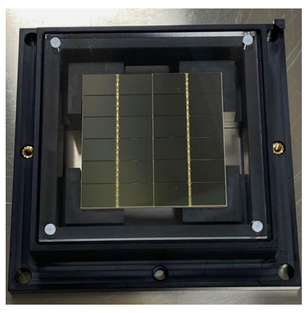
NOA, LNGS

Assembly sector

Test sector



Nuova Officina Assergi (**NOA**) has been built to accomplish the **assembly** of about **10000 SiPM tiles** for the **TPC** of **DS-20k** and their **characterization** at room temperature (warm test) and in liquid nitrogen (cold test).



The tile, composed of 24 SiPMs, is the **elementary photodetection unit** of DS-20k

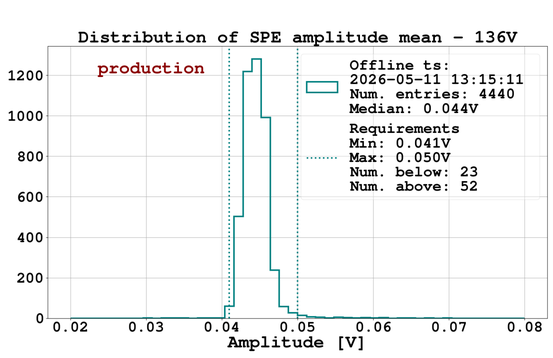
It is designed to have a **photo detection efficiency** greater than **40%** at **liquid argon** temperature (87 K)

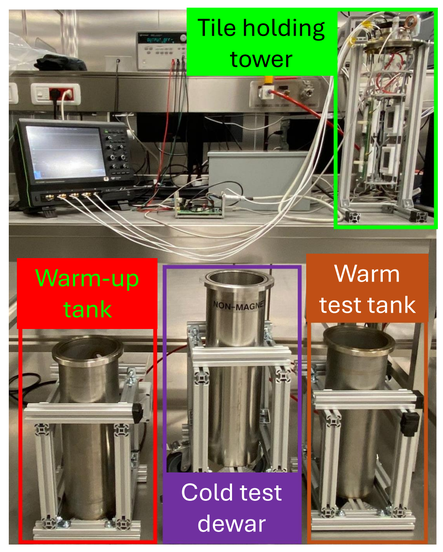
16 tiles are grouped in a **Photo Detection Unit** (PDU). The latter is tested at PTF in cold.

Tile test at NOA

1. I-V curve (warm and cold)
2. noise power spectrum (warm and cold)
3. single photon spectrum (cold)

More details in **Eur. Phys. J. C (2025) 85:1334**

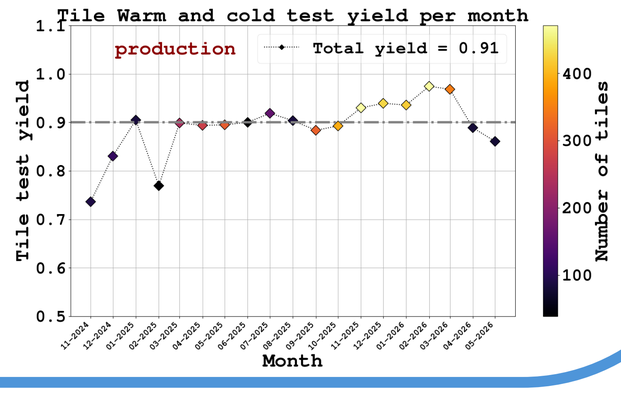




NOA summary:

NOA **throughput** is firmly around **90%** from the first months of the production

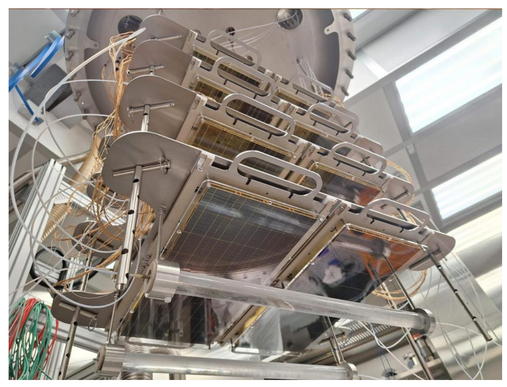
The tile **production** is now at **50%**



PTF, Naples

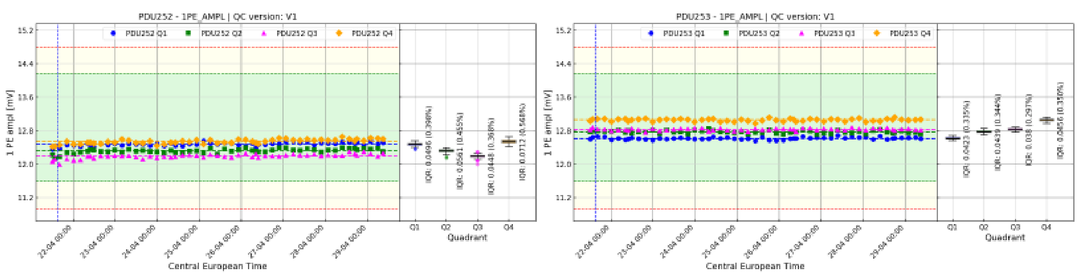
PTF cryostat

16 PDUs loaded in the cryostat



Photosensor Test Facility (**PTF**) is **testing** up to 16 PDUs in **liquid nitrogen** for 9 days. It can accomplish longer tests thanks to an automatic system for dewar refilling. After the warm tests, the PDUs are characterized in liquid nitrogen for an **extended period** to monitor the **stability** of several parameters and their performance at **cryogenic temperatures**.

PDU_252 SPE amplitude **PDU_253**



Cold tests **confirms** the **stability** of the **PDU parameters** in **liquid nitrogen**, in particular:

- Single PhotoElectron (**SPE**) amplitude of about 12 mV
- Signal-to-Noise Ratio (**SNR**) of about 5.5 before signal filtering

Pulse Count Rate (**PCR**) measured to asses the level of uncorrelated noise
→ best indicator of the tile quality up to now

PDU test summary:

- the **average yield** of the **cold PDU test** is **53%**
- test **failures** due to **only 1 tile** per PDU (about **3%** of the **total** tile production)

PDU_252 PCR stability **PDU_253**