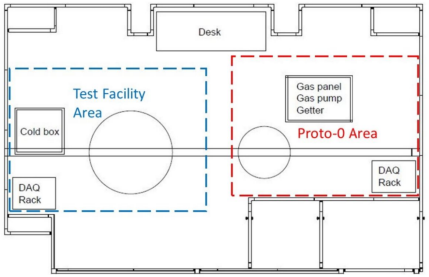
An overview of research activities in Naples' CryoLab

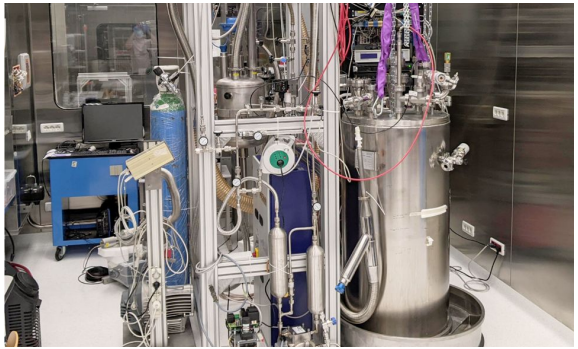
Giuseppe Matteucci
PhD Student at University of Naples Federico II

e-mail: giuseppe.matteucci@na.infn.it

The Naples' DM Laboratory



- 50 m^2 ISO 6 cleanroom
- External tanks (3000L each) for LAr and LN2
- **Two independent cryogenic setups**:
  - **"PTF" setup**: 1000 L cryostat, custom made cold-box with full remote control, exhaust line (to outside evaporator) for quick draining
  - **"Proto-0" setup**: ~300 L cryostat, LN2-based condenser and custom made gas panel for GAr filling and continuous purification via molecular filter
- Although PTF Setup is more suited for LN2 (no recirculation) and Proto-0 for LAr filling (gas condenser, recirculation and filtering)…
- **both setups may be used with LN2 and LAr and are vacuum-compliant**

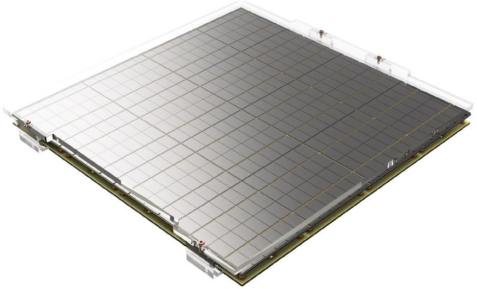


Activities in Naples' DM Laboratory

- Naples Research Group is active in the following two areas:
  - **Characterization and testing of SiPM-based photosensors**
    - Darkside's PDU and vPDU: prototypes and production testing
    - Characterization of X-ARAPUCA systems for DUNE
  - **Prototyping of LAr Time Projection Chambers**
    - ReD (Recoil Directionality) TPC: full characterization
    - Proto-0 (DarkSide-20k prototype) characterization and optimization of design parameters

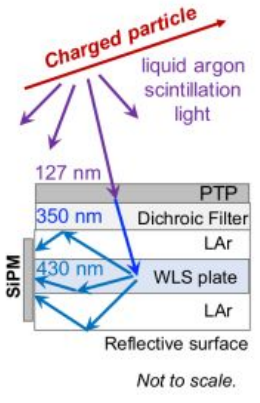
PTF: A Test Facility for DarkSide-20k PDUs

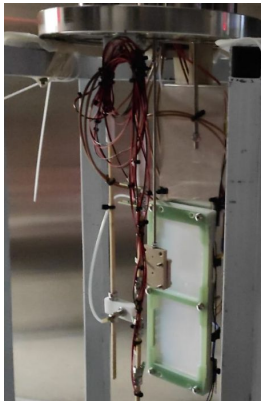
- (v)PDU : (Veto) Photon Detector Unit
  - Large surface SiPM optical readout of 20x20 cm^2 on 4 channels
  - 384 SiPMs organized in 16 independent modules (Tiles)
  - 1 readout channel = sum of 4 Tiles
- Naples' contribution:
  - Measurement of key performances (response, resolution, SNR) in LN2
  - Long-term stability evaluation (~ months) in LN2
  - (*Future*) Production PDU mass testing (~600), full time for ~1 year

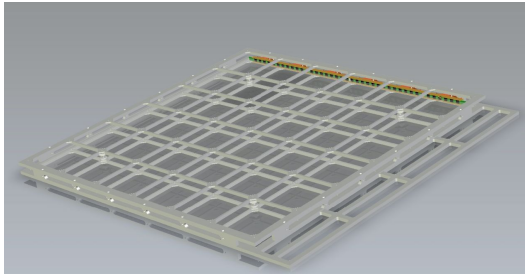


DUNE: characterization of X-ARAPUCA systems

- X-ARAPUCA (XA) [JINST 16 P09027]:
  - Light Trap with two photon downshifting stages for optical readout in DUNE FD
  - Two-window XA (20 × 7.5 cm^2) has 4 radout channels, each with 4 SiPMs in parallel
- XA-MEGACELL:
  - Same concept as two-window XA, different geometry (62x62 cm^2) and SiPM coverage
  - Light detection system for the second DUNE Vertical Drift module
- Naples' contribution:
  - Measured absolute efficiency for two-window XA (in LAr, with a alpha 241Am source) of 2.5 ± 0.3% [ePrint]
  - (*Future*) Measurement of absolute efficiency for X-ARAPUCA MEGACELL in LAr in PTF Setup and 241Am source manipulator

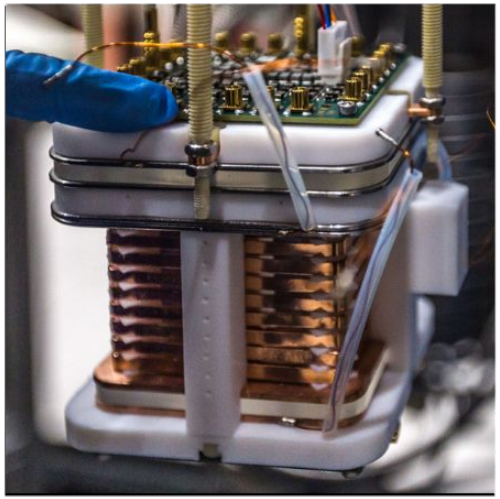






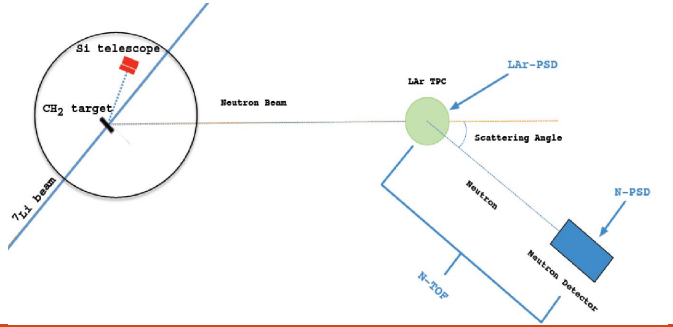
ReD: Recoil Directionality

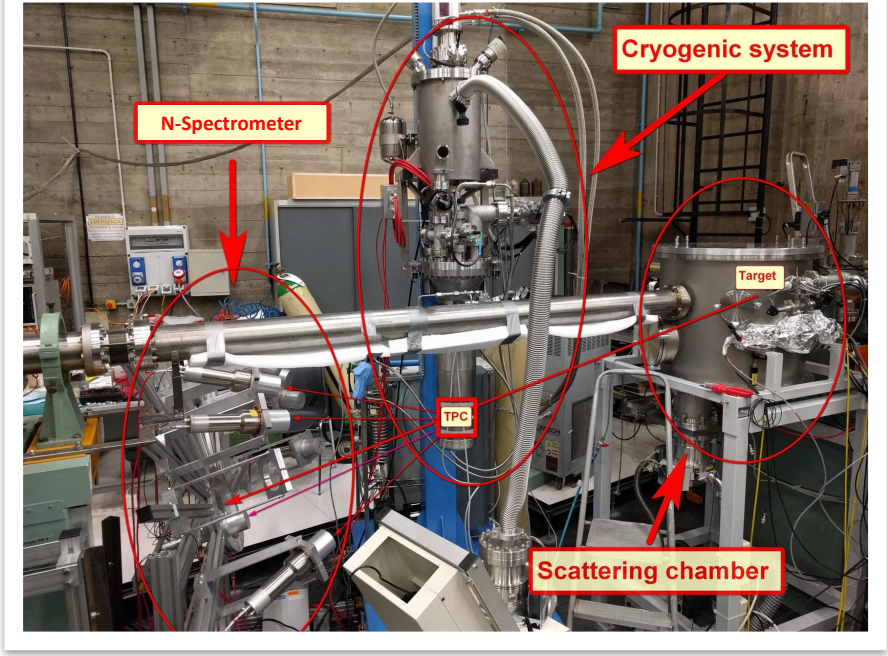
- Objectives:
  - Measurement of directional sensitivity in LAr TPCs for neutrino-WIMP discrimination in future LAr DM experiments
  - Characterization of NR with recoil energies ~ 1 keV
  - Prototyping of DS-20k TPC with cryogenic SiPMs optical readout
- Construction and TPC characterization in Naples, data taking in LNS (ongoing)
- TPC: active volume 5x5x5 cm^3 of LAr, 2 SiPM tiles for optical readout, 7 mm gas pocket



ReD: Setup

- Simulating WIMP-like interaction with mono-energetic neutron beam
- Scattered neutron tagged by a fixed array of LiSci-PMT
  - 1 Tube at ~ 0° scattering angle for tagging Ar recoils with E_R ~ 1 keV
- Recoil energy dependent only on beam energy





ReD: TPC Calibration Campaign

- Naples' contribution [Eur.Phys.J.C 81 (2021) 11, 1014] :
  - Characterization of all key parameters of ReD TPC
    - Gain: g1 = (0.195±0.018) PE/ph , g2 = (20.7±1.6) PE/e-
    - $\sigma/\mu(S2/S1)_{NR}$ ~ 12%
  - Long-term (6 months) stability study:
    - 241 Am (γ) peak stable within 2% over the full period

Proto-0: A DS-20k prototype equipped with PDUs

- Proto-0:
  - LAr TPC with 7 kg LAr active mass
  - Equipped with 2 (v)PDU as photosensors
  - Objectives: study S2 at DS-20k pressure, optimize gas pocket thickness, provide DS-20k-like signals for online and offline analysis
- Naples' contribution:
  - Upgrading first design and commissioning
  - Preliminary run with old PDU prototype carried out in Dec 2022
  - (*Future*) Running of the prototype scheduled in Spring/Summer 2023

Thank you!