

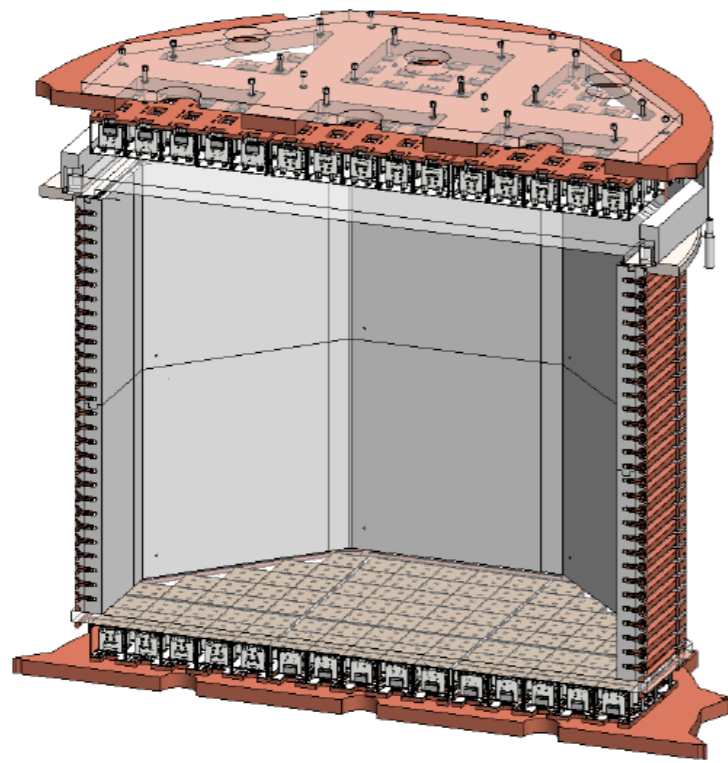
# The DarkSide-Proto detector

Giuliana Fiorillo

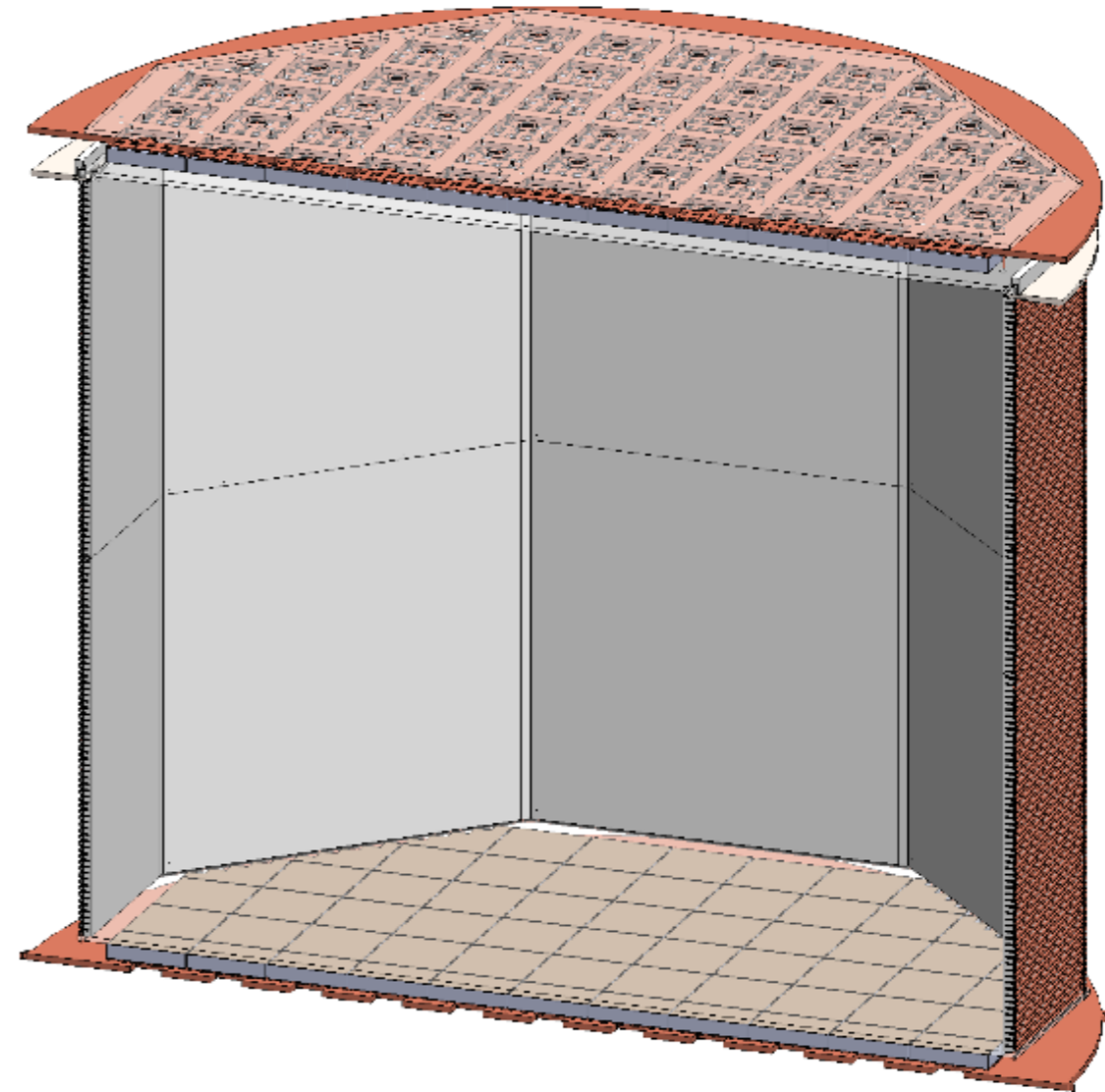
Università degli Studi di Napoli “Federico II” & INFN Napoli

AstroCent Meeting  
Warsaw, January 29, 2019

# Future detectors in the DarkSide program



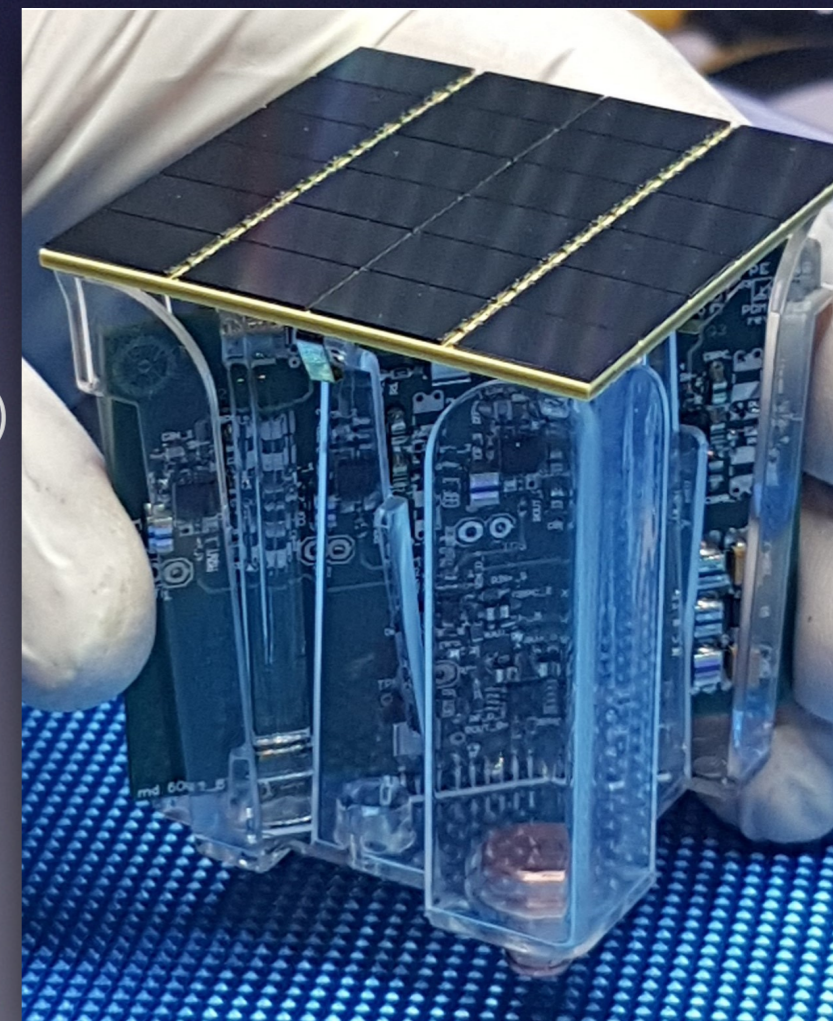
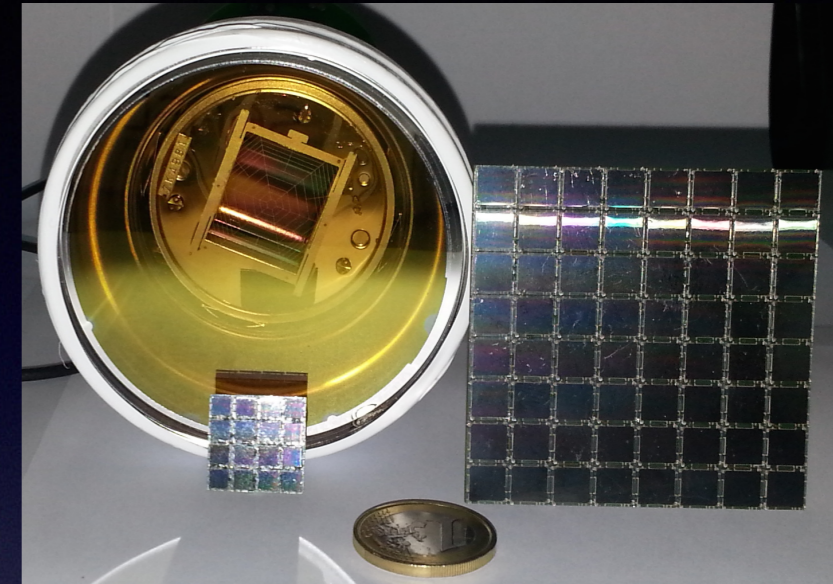
**DarkSide-Prototype**  
1 tonne  
1 m<sup>2</sup> of SiPM coverage  
(2018 - )

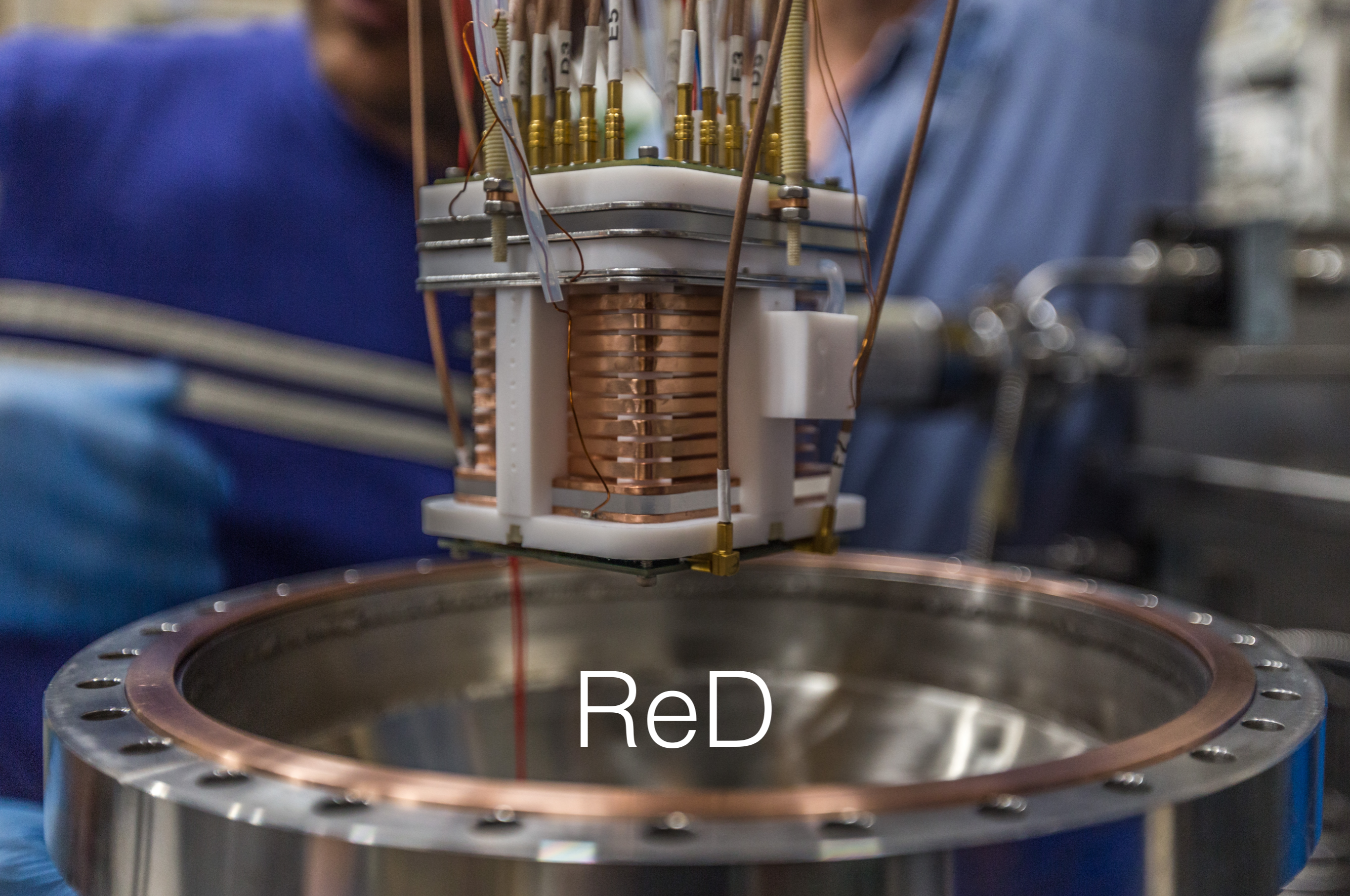


**DarkSide-20k**  
50 tonne  
20 m<sup>2</sup> of SiPM coverage  
(2022 - )

# SiPM to enhance LAr technology: 24 cm<sup>2</sup> single-channel detector

- Advantages w/r to cryogenic PMTs
  - Very compact, much lower radioactivity
  - Light yield increase by 50%
  - Greater stability
  - Ten-fold reduction of costs per unit area
  - SiPMs love to run at LAr temperature!
- A full chain (development-production-packaging-testing) strategy largely funded by Regione Abruzzo
  - Custom SiPM development for cryogenic temperature (FBK)
  - Industrial cooperation for large-scale production (LFoundry)
  - Radiopure packaging of the tiles and of the cryogenic FE readout board (Nuova Officina Assergi - NOA)
  - Massive test and selection of detector modules before installation in DS-20k (INFN-Naples)

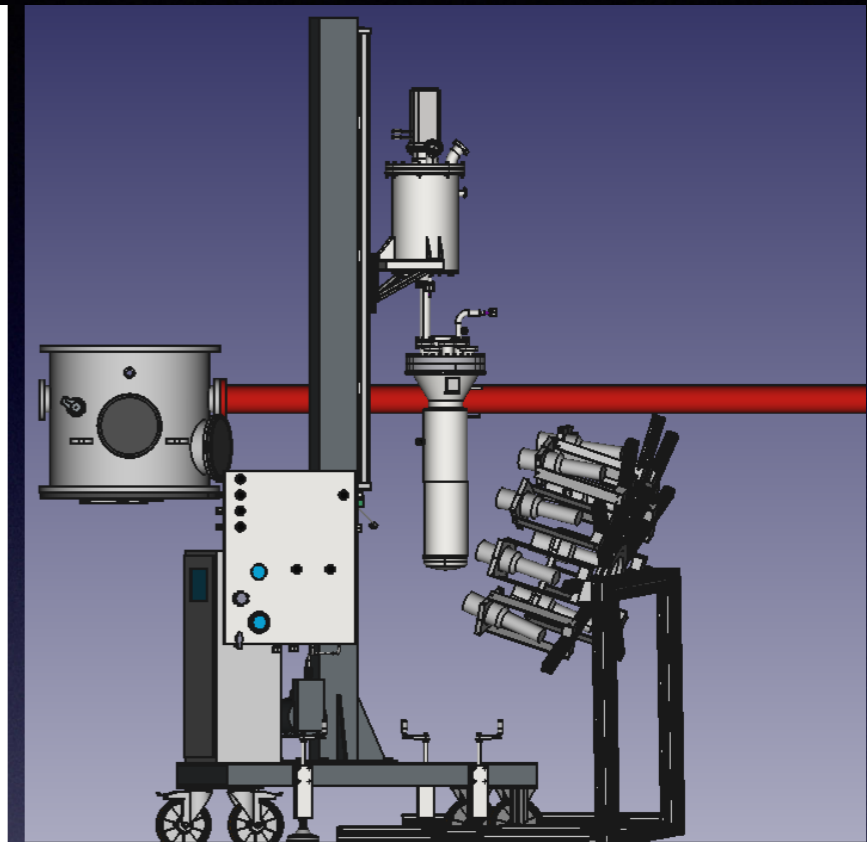
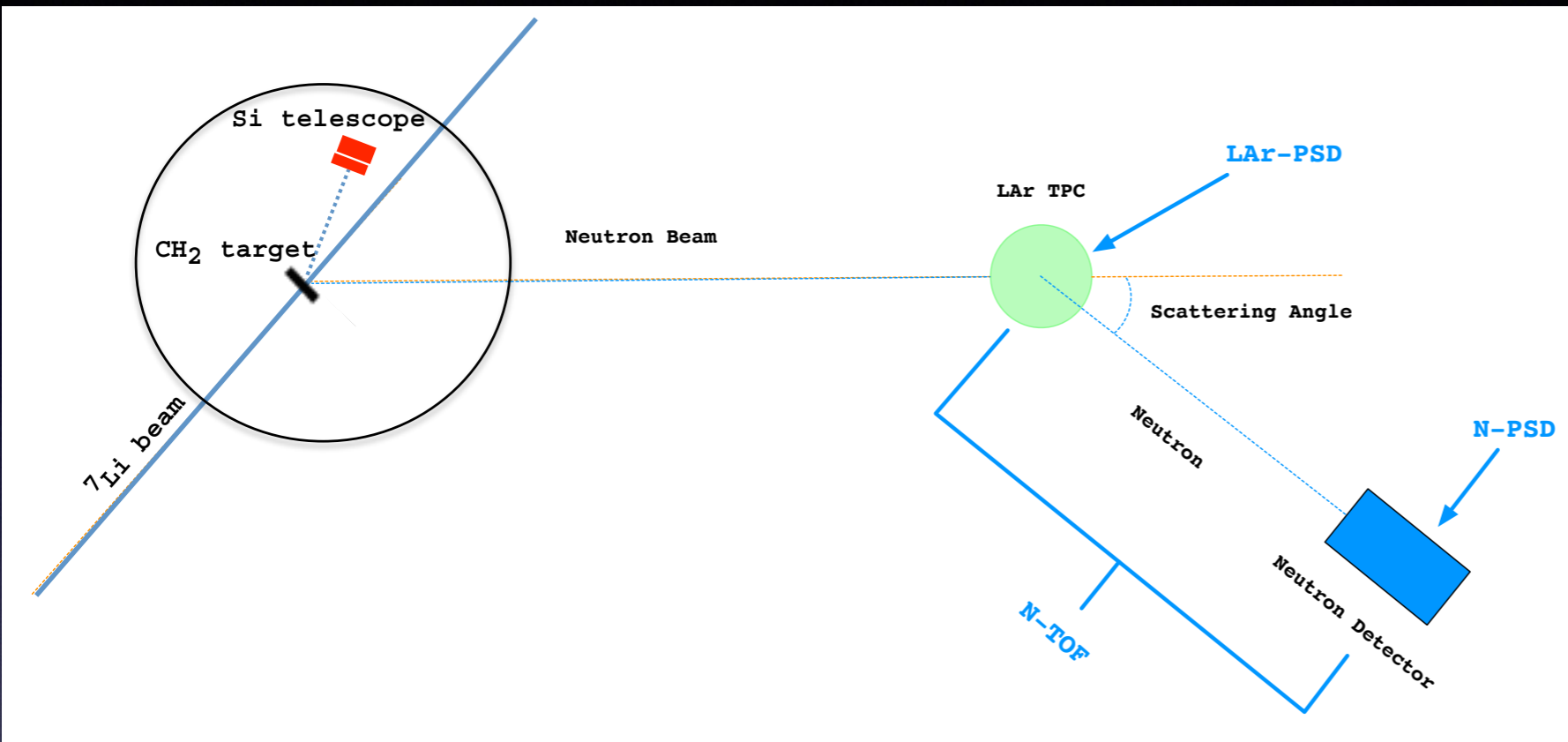




ReD

**Recoil directionality in Liquid Argon**

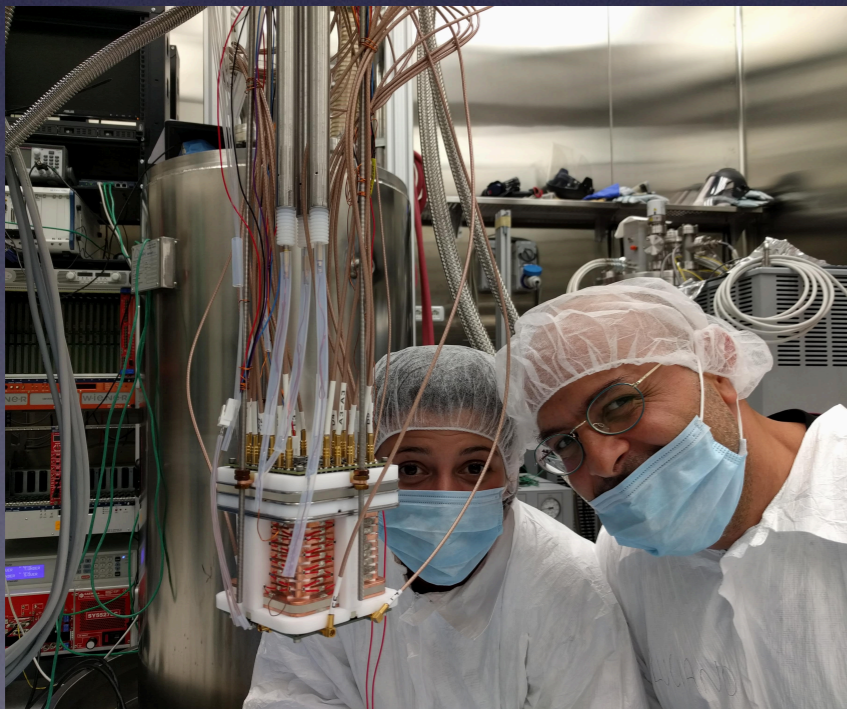
# ReD Experiment @ LNS



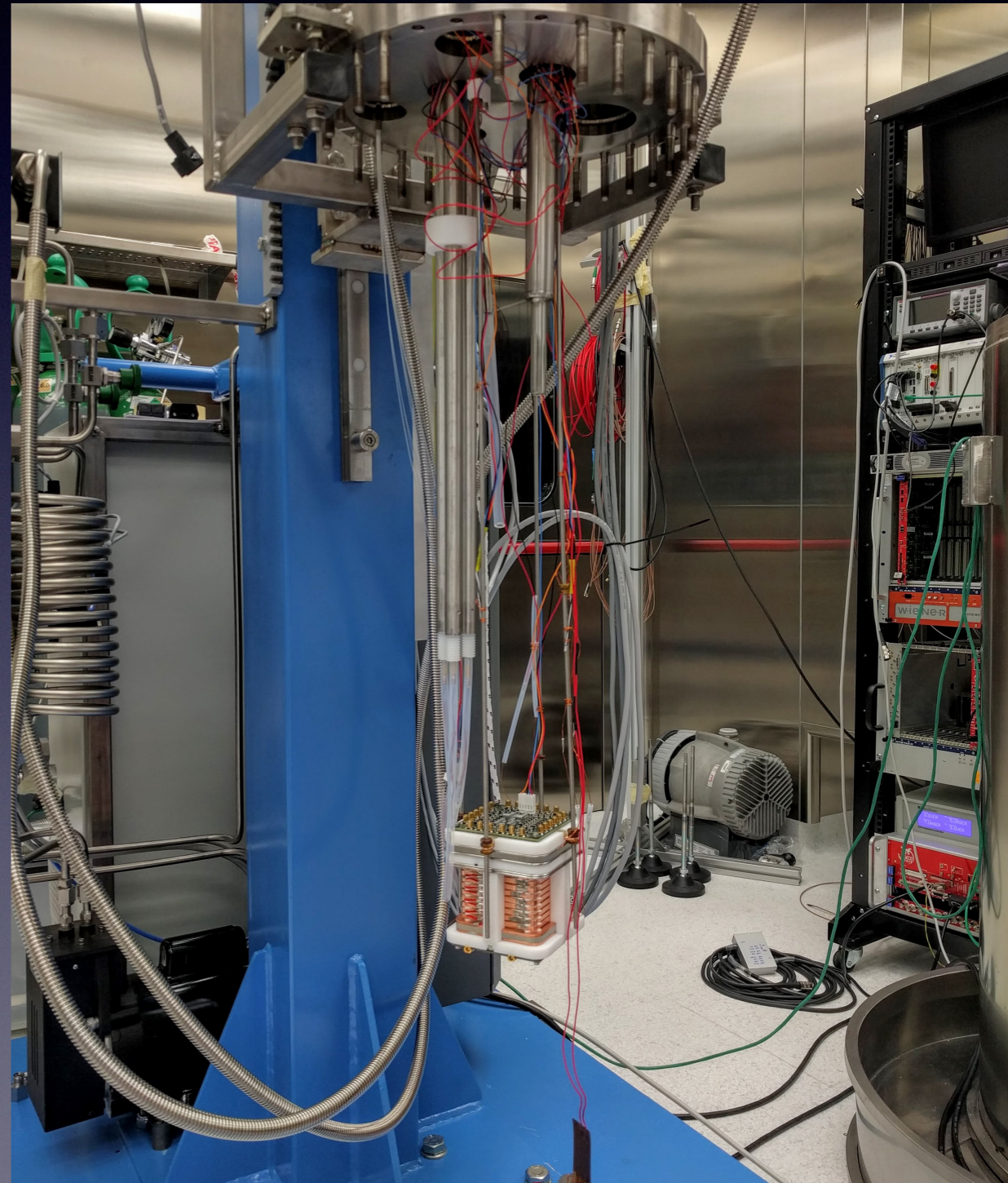
- Irradiate a small LAr TPC with neutrons and produce recoils parallel or orthogonal wrt the E field to test Columnar Recombination models
- Measure scintillation & ionization at variable recoil energy and E field
- **Bonus: measure light and charge yield for low energy nuclear recoils**
- A significant reduction in  $Q_y$  uncertainty and “some” indication of the underlying distribution of the number of ionization electrons at very low recoil would allow significant improvement in the sensitivity at lower masses (1-2  $\text{GeV}/c^2$ )

# ReD TPC

- Designed and built at UCLA
- Optimized for neutron beam tests
- Assembled at Naples CRYOLAB
- In its dedicated LAr cryosystem



B. Bottino and M. Caravati



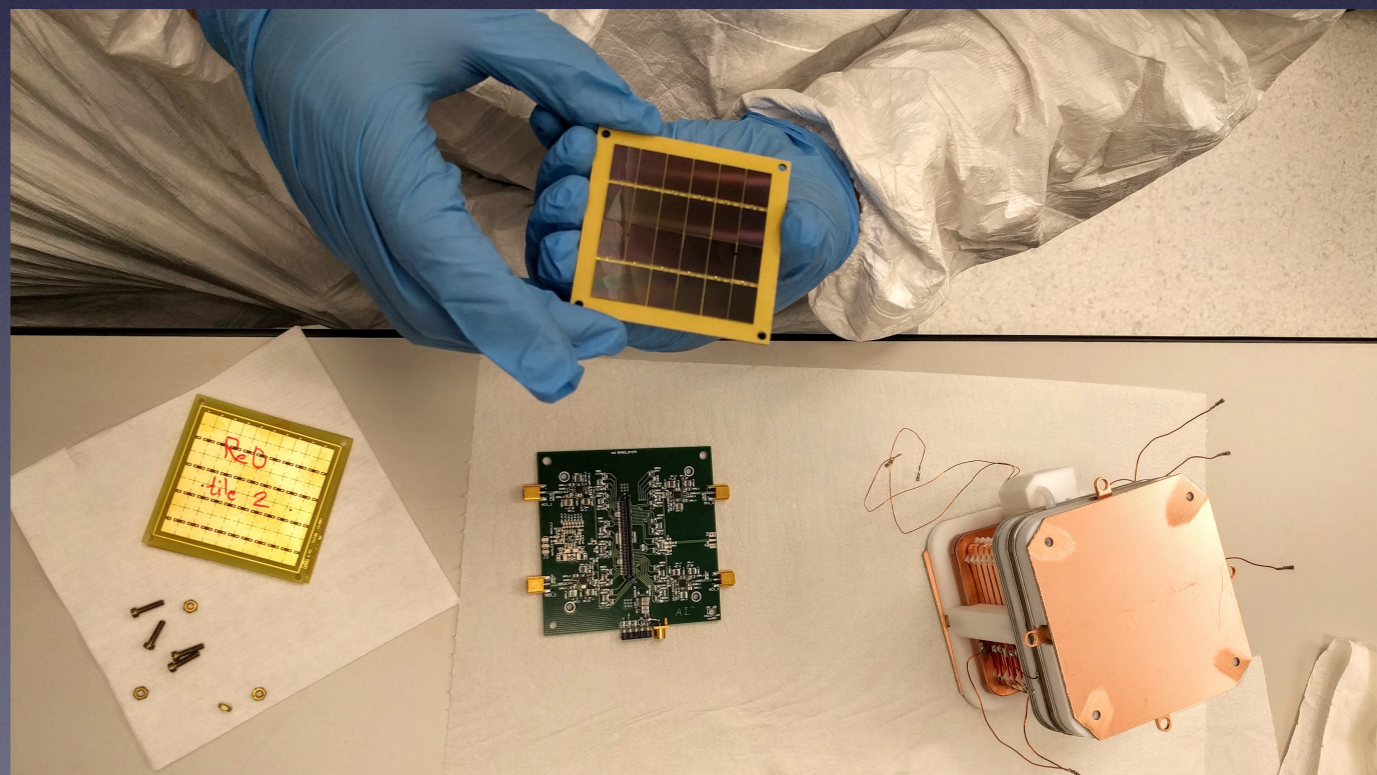
# Photoelectronics

- RED TPC with SiPM based optical readout
- Higher PDE compared to PMTs
- Individual readout of top SiPMs provides sub cm spatial resolution of the X-Y position of the S2 signal, improving recoil measurement
- Low noise at cryogenic temperatures

Two  $5 \times 5 \text{ cm}^2$  tiles  
24 NUV-HD-LF rectangular  
SiPM,  
 $25 \mu\text{m}$  cell, 10 M $\Omega$ m  
quenching resistor,  
Arlon substrate

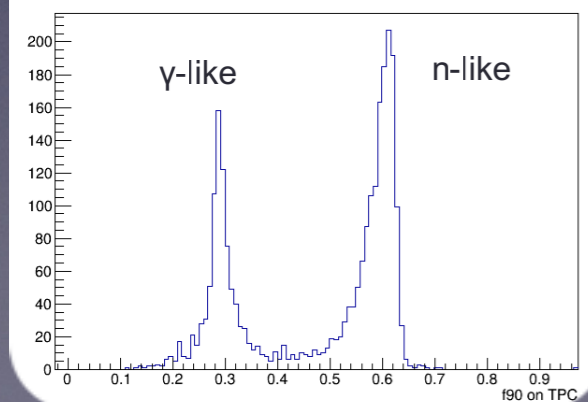
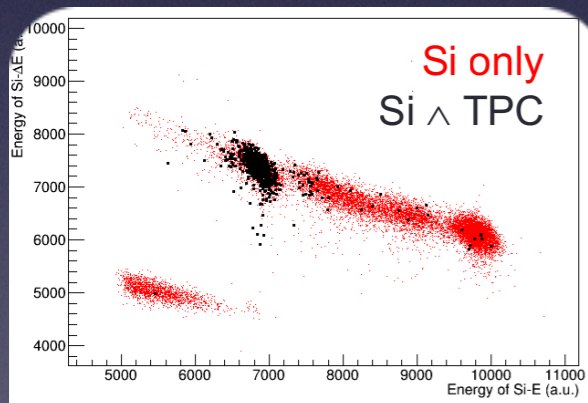
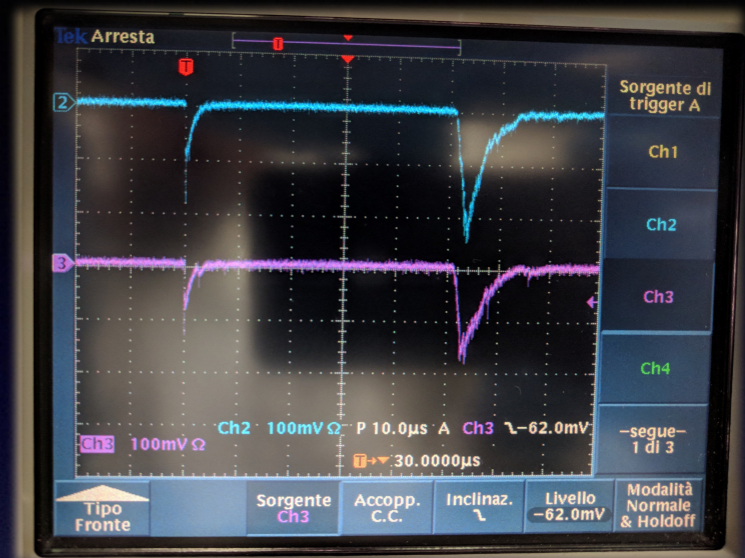
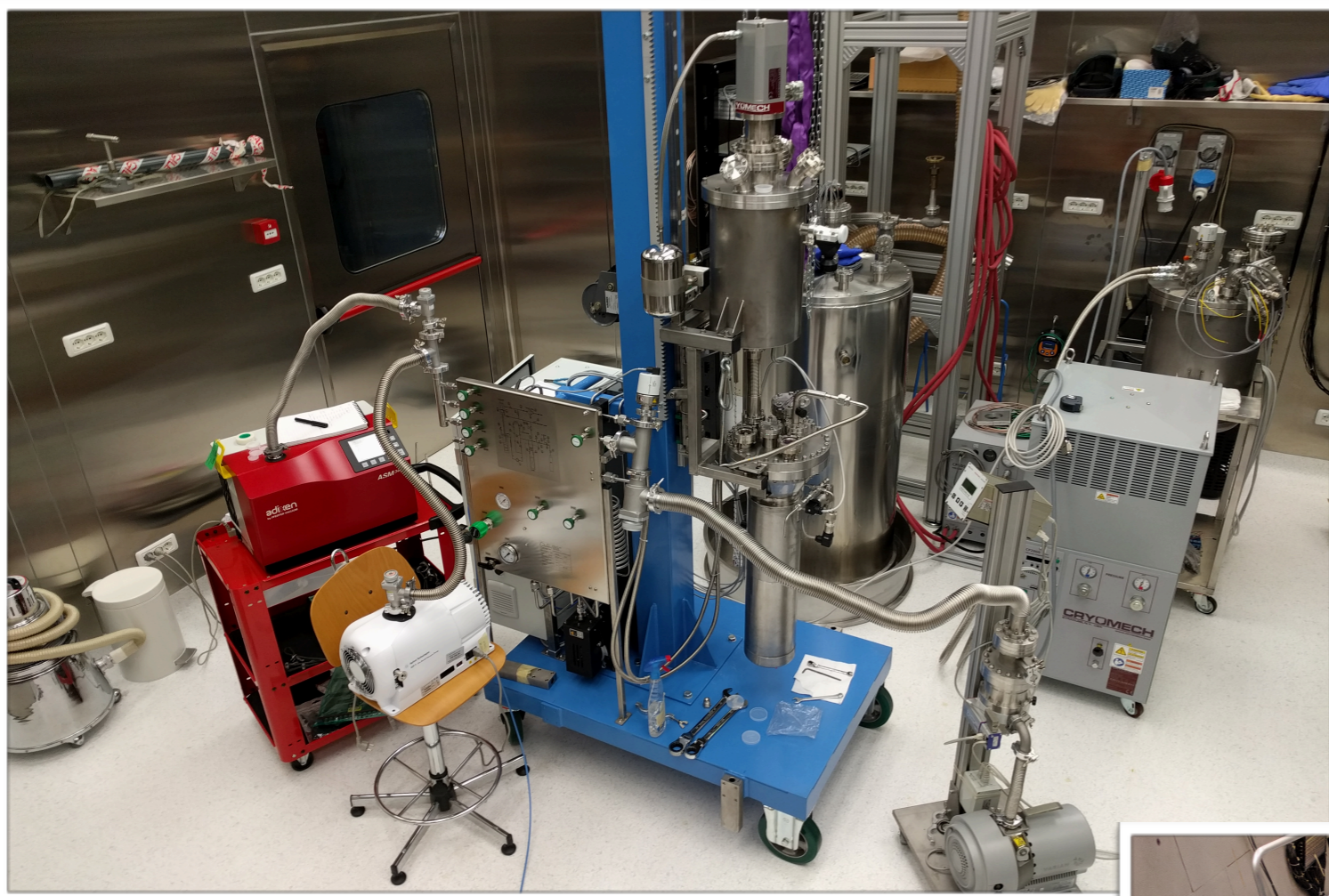


24ch FEB from INFN-NA

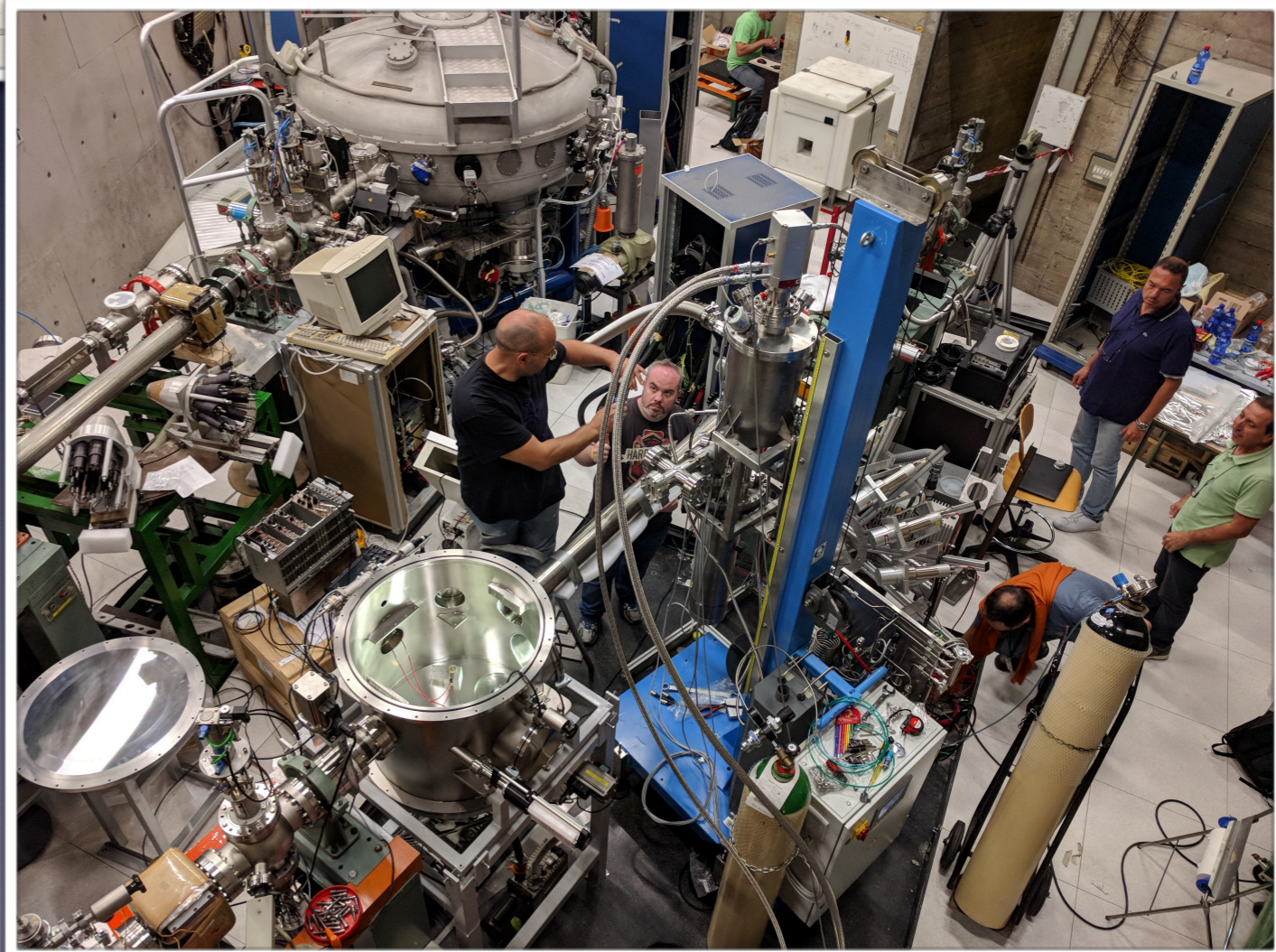


2 tiles with new SiPMs from PU

# ReD @ NAPLES

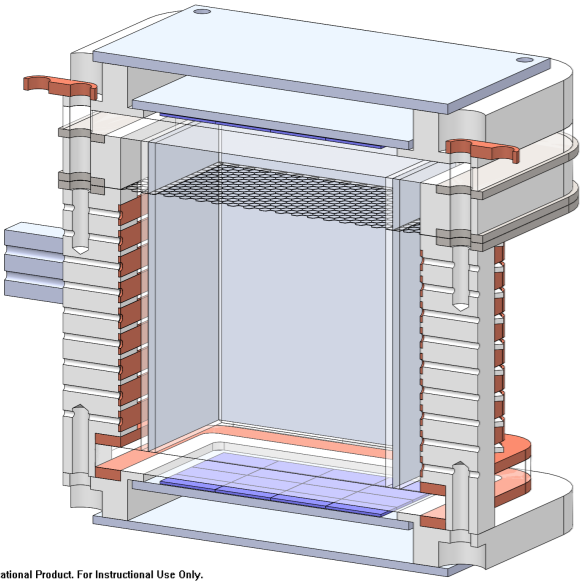


# ReD @ LNS

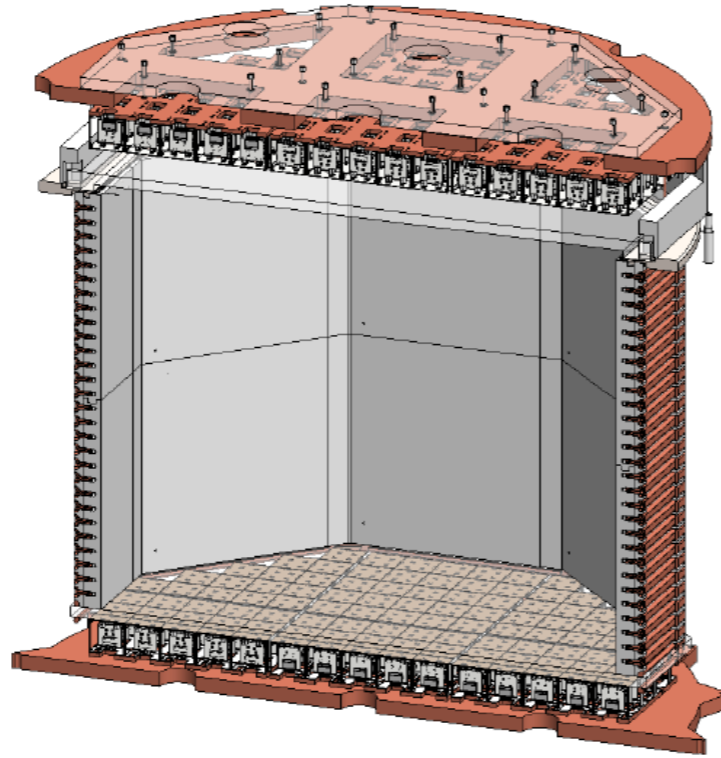




# Evolution

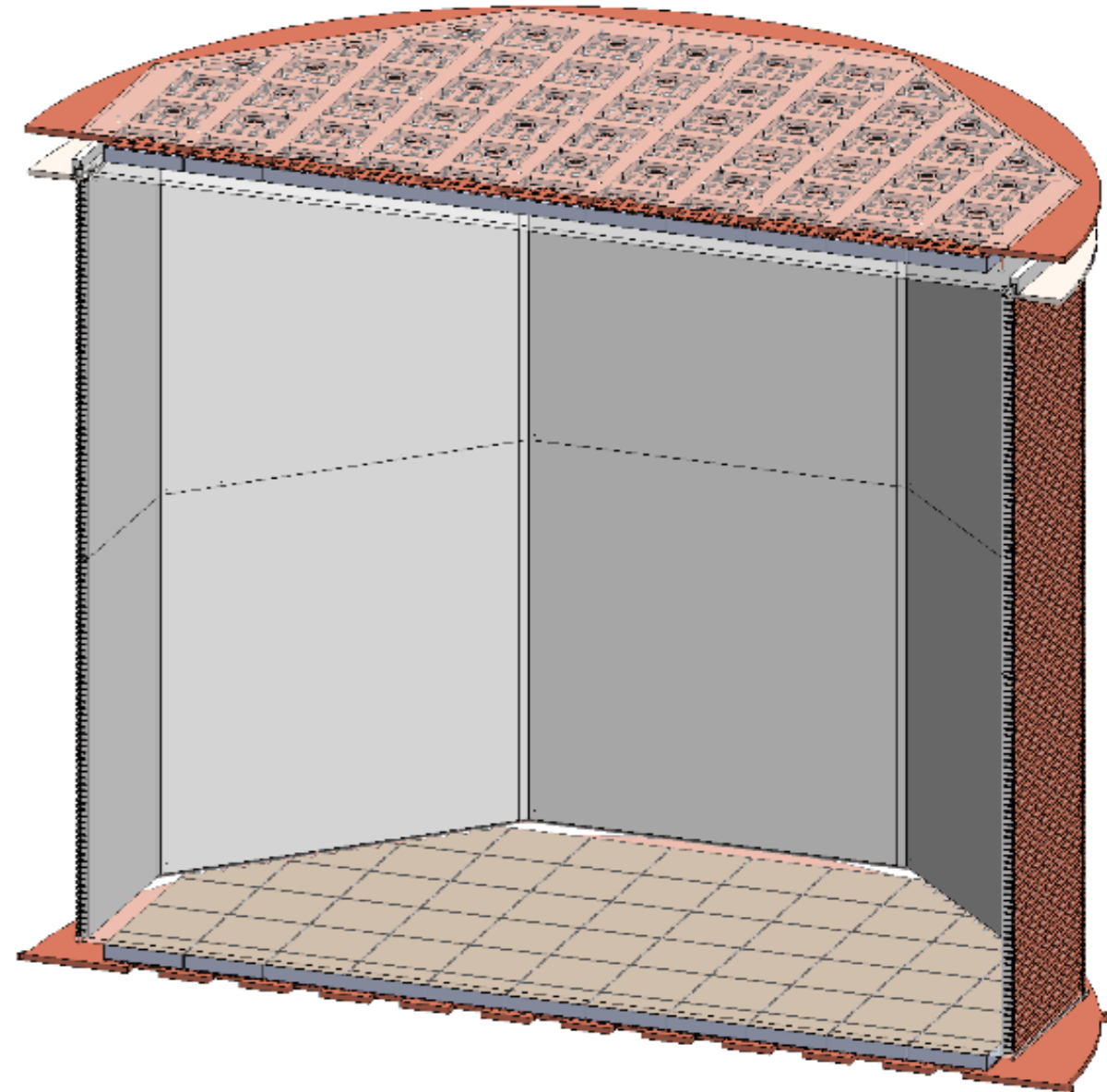


ReD TPC

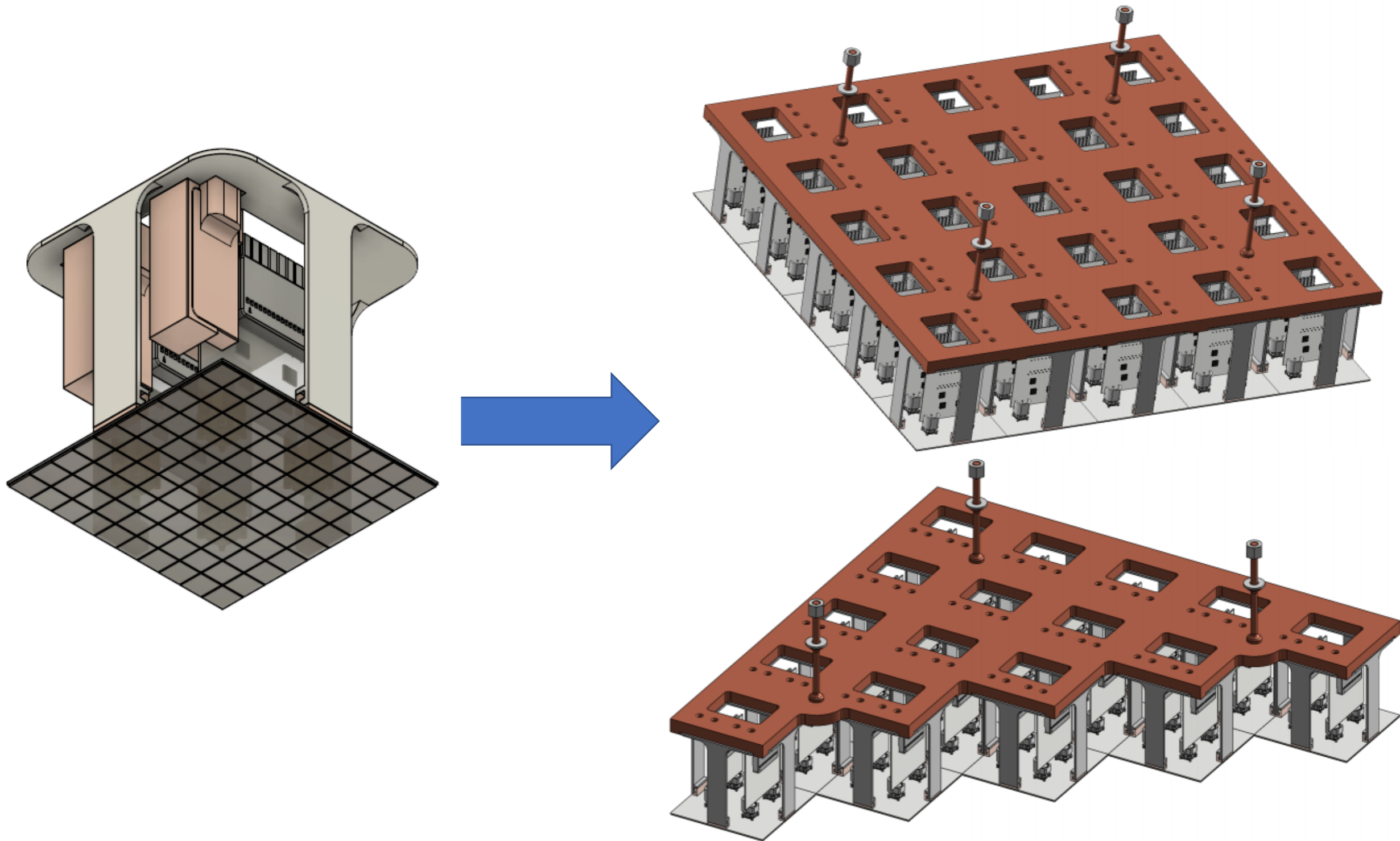


1-ton prototype

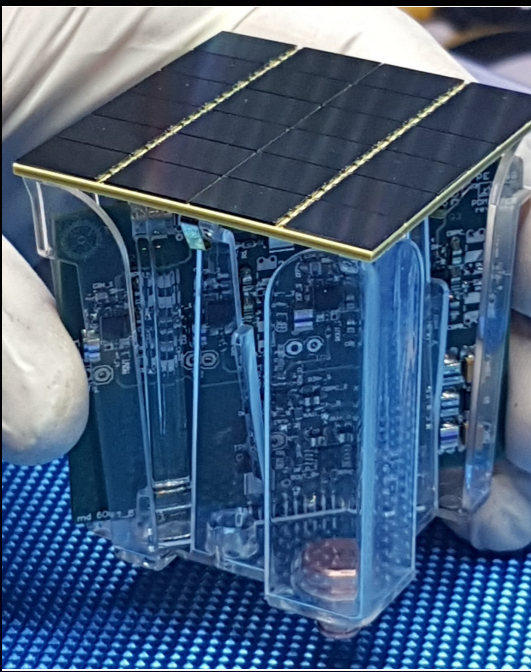
DS-20k



# A scalable design: Motherboards



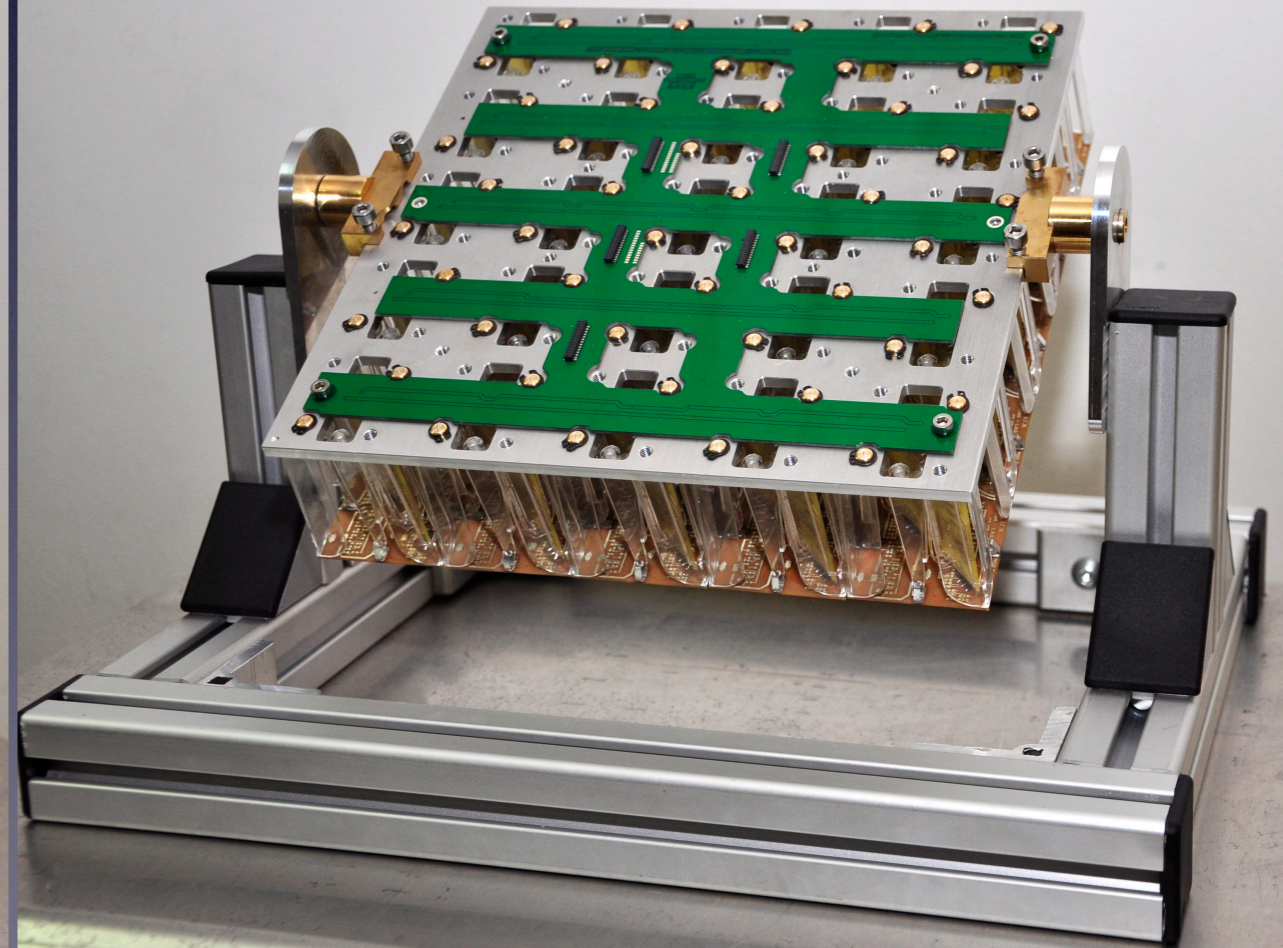
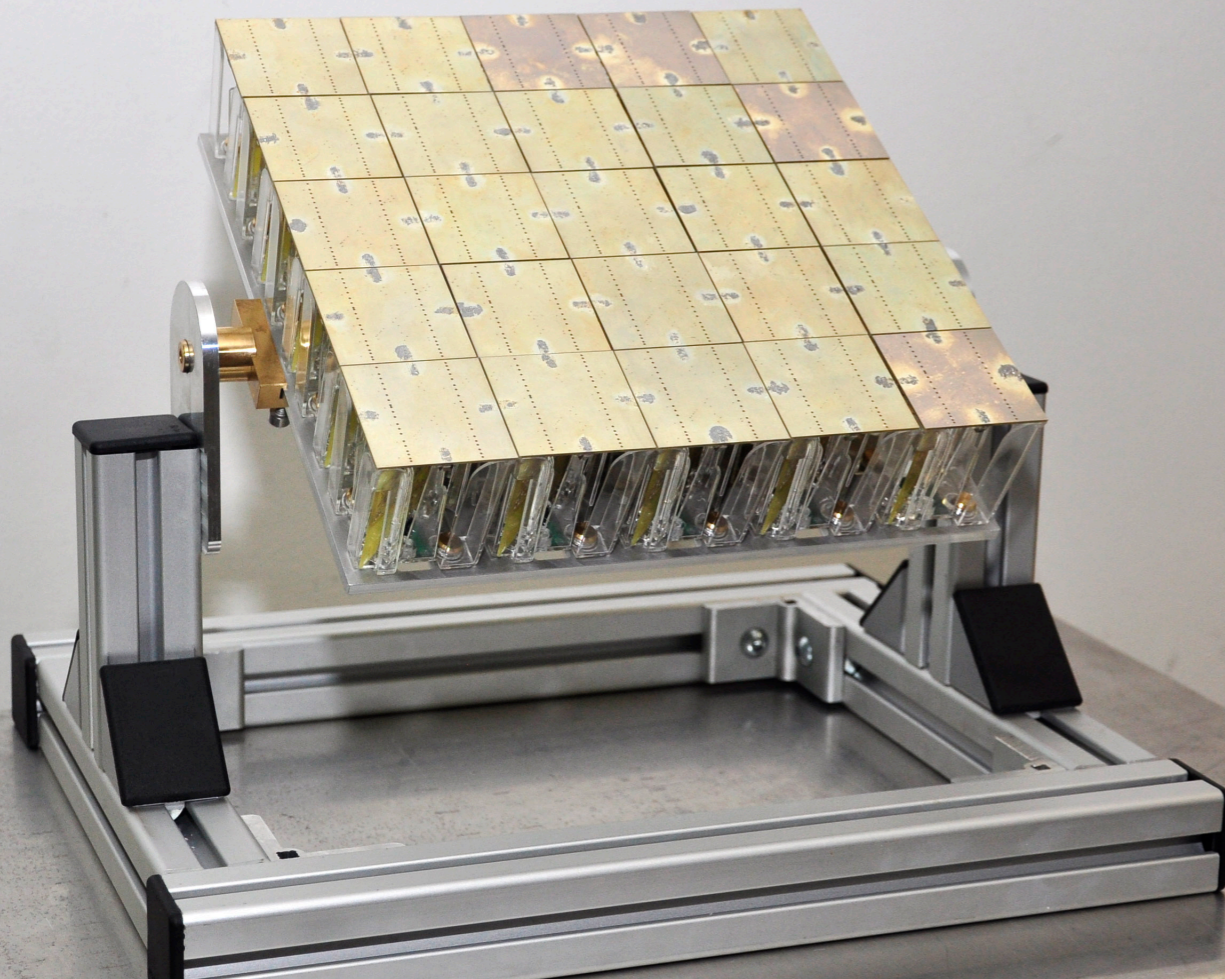
# From Photon Detector Module to Motherboard



×25

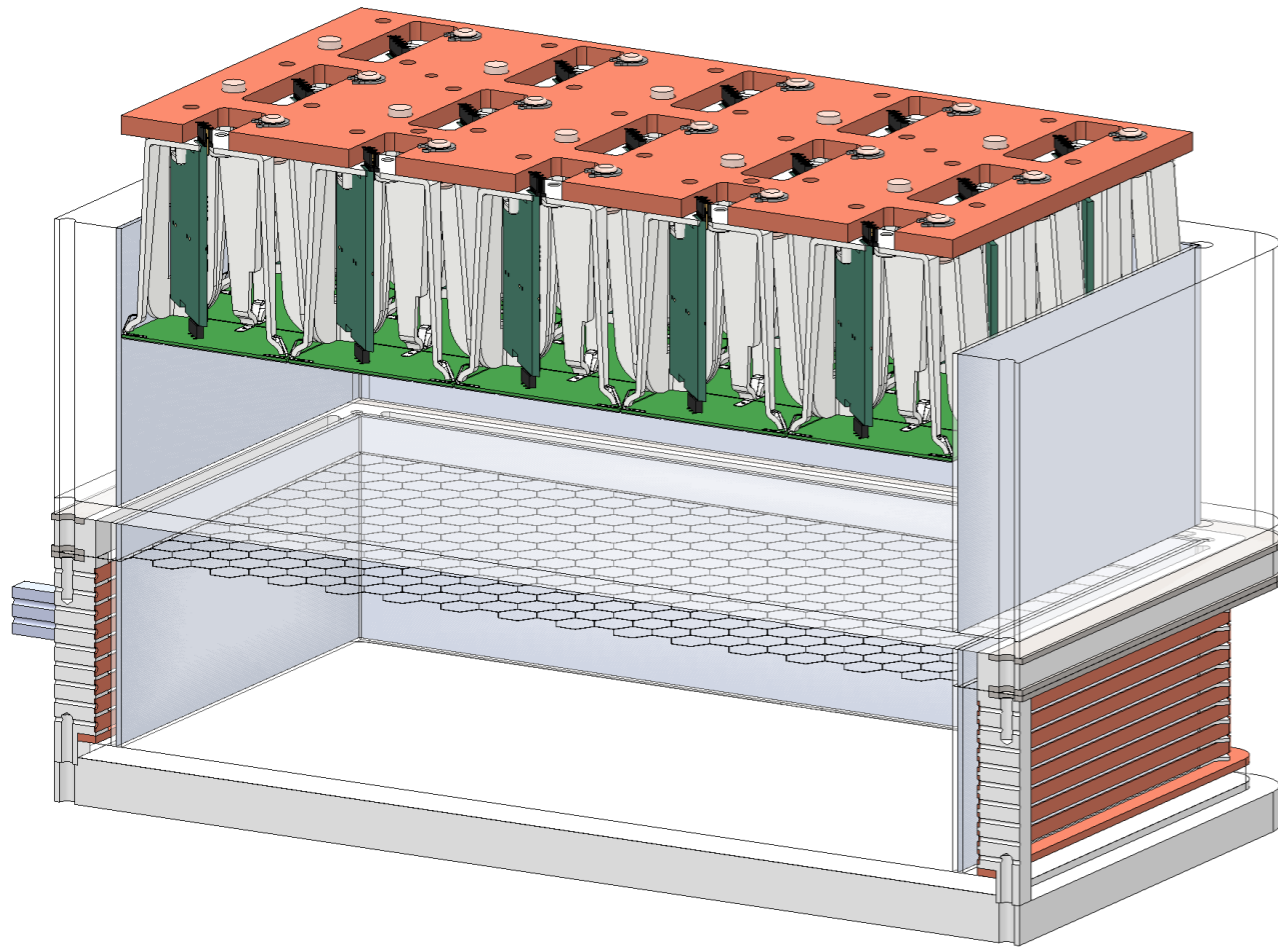


mock-up from INFN-BO/INFN-PI



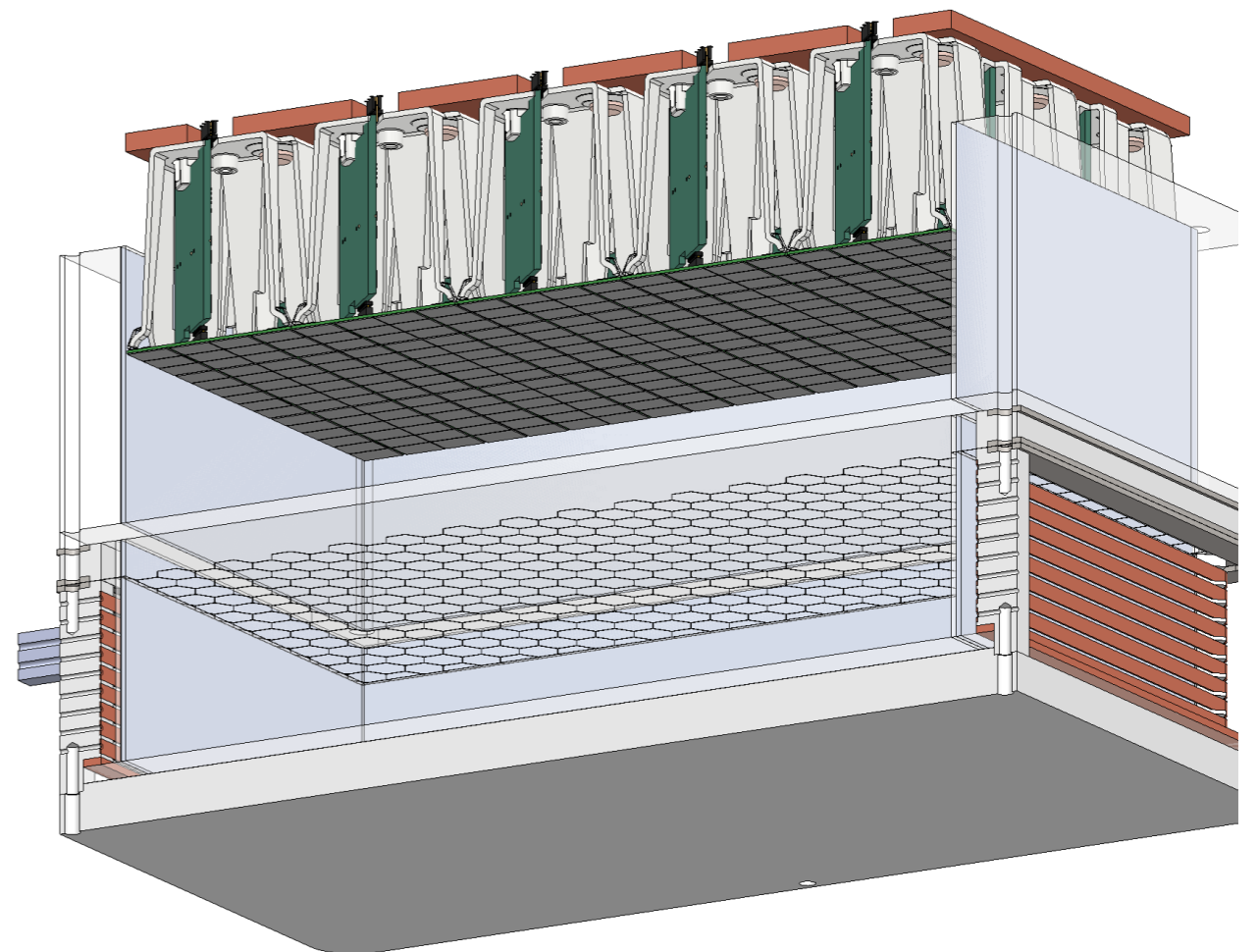
# Motherboard is the basic modular unit: Single MB TPC (so-called Proto-Proto)

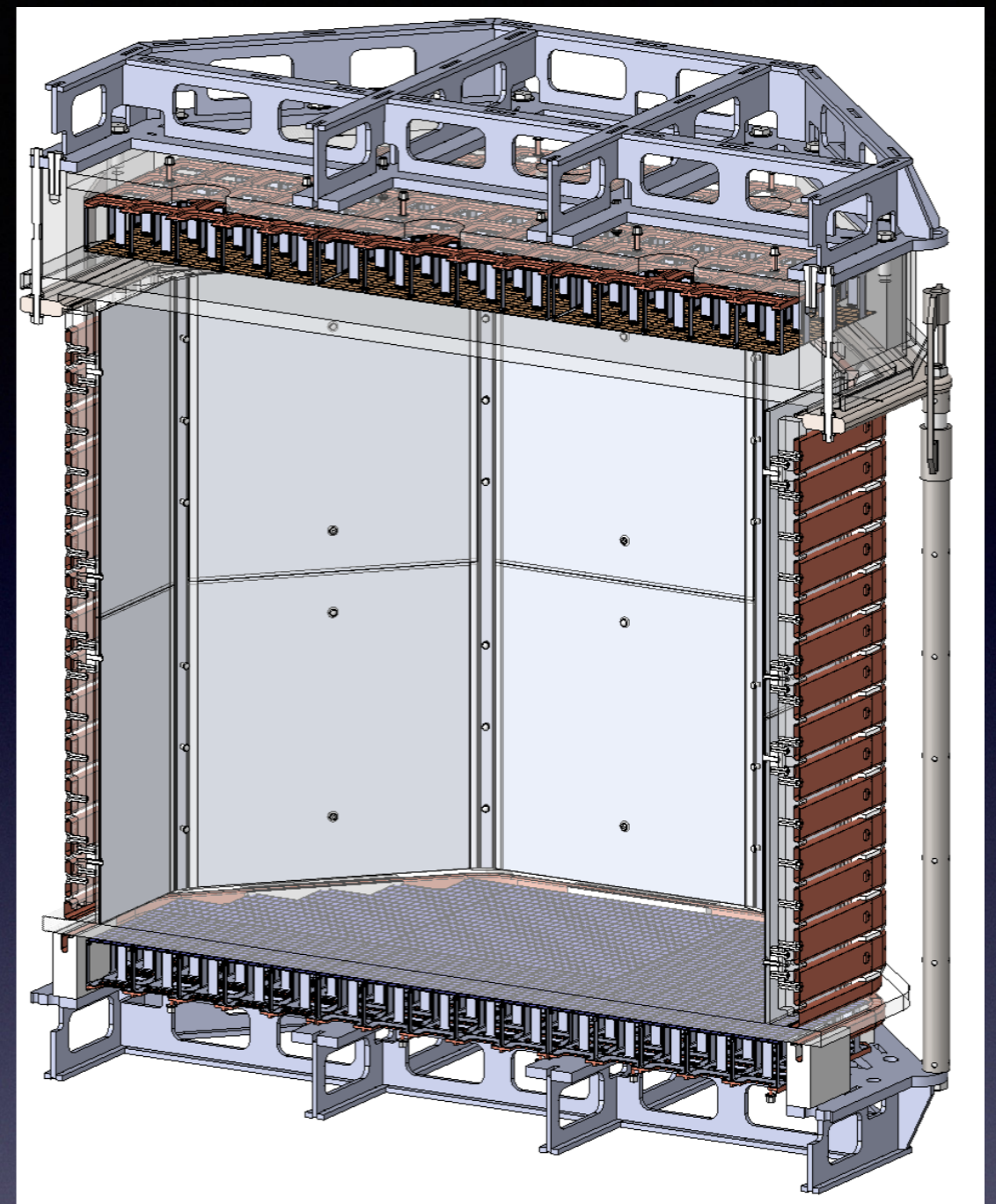
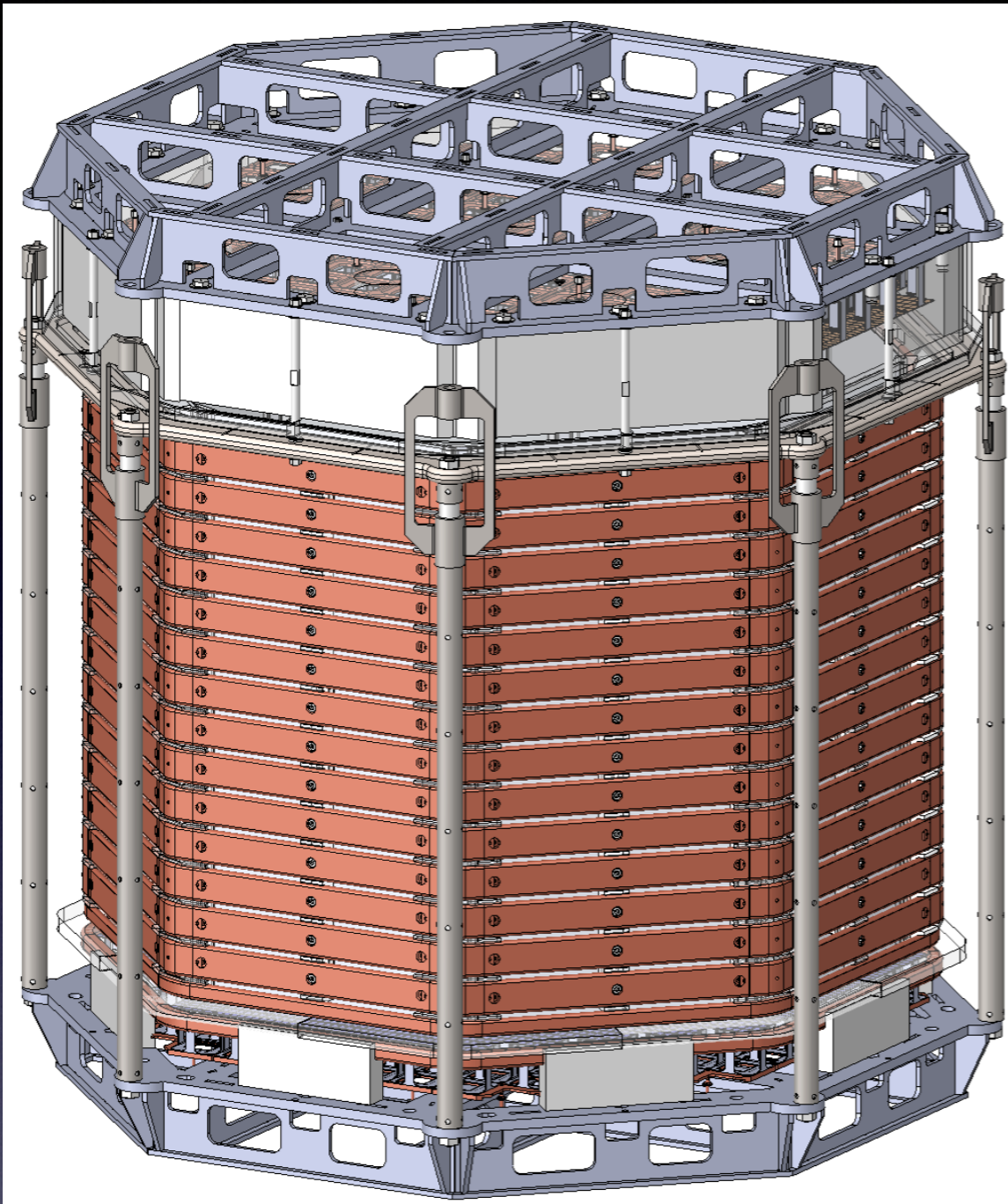
**June design**



- GOALS:
  - electroluminescence field uniformity
  - gas pocket thickness uniformity
  - S2 signal resolution
  - xy position reconstruction

- A TPC to test the basic modular unit
  - 25 top + 25 bottom r/o channels
  - reduced drift length to avoid pile-up





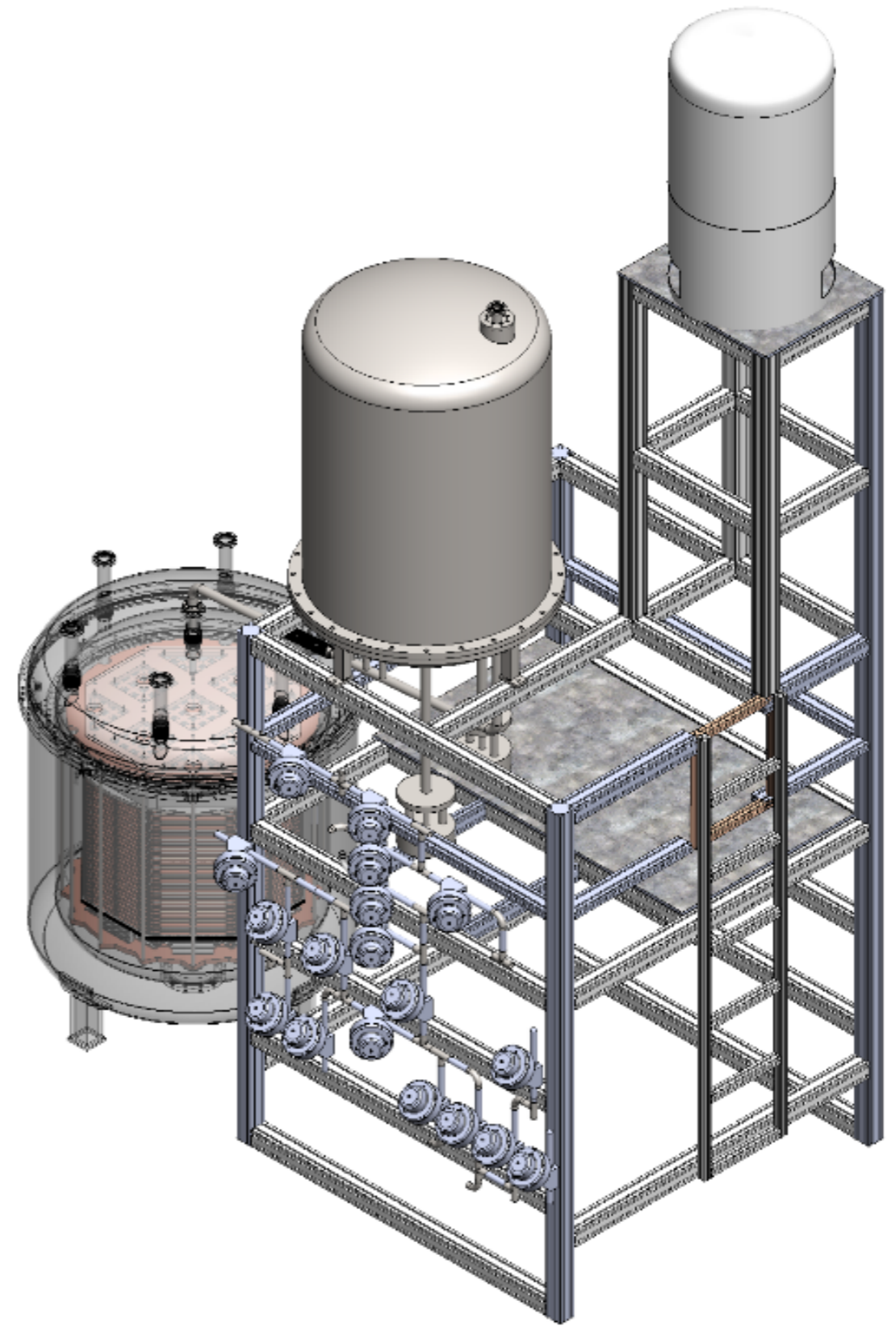
370 PDM (19 MB)

1ton prototype TPC

# DarkSide-Proto @ CERN

1-ton TPC prototype of DS-20k detector will allow:

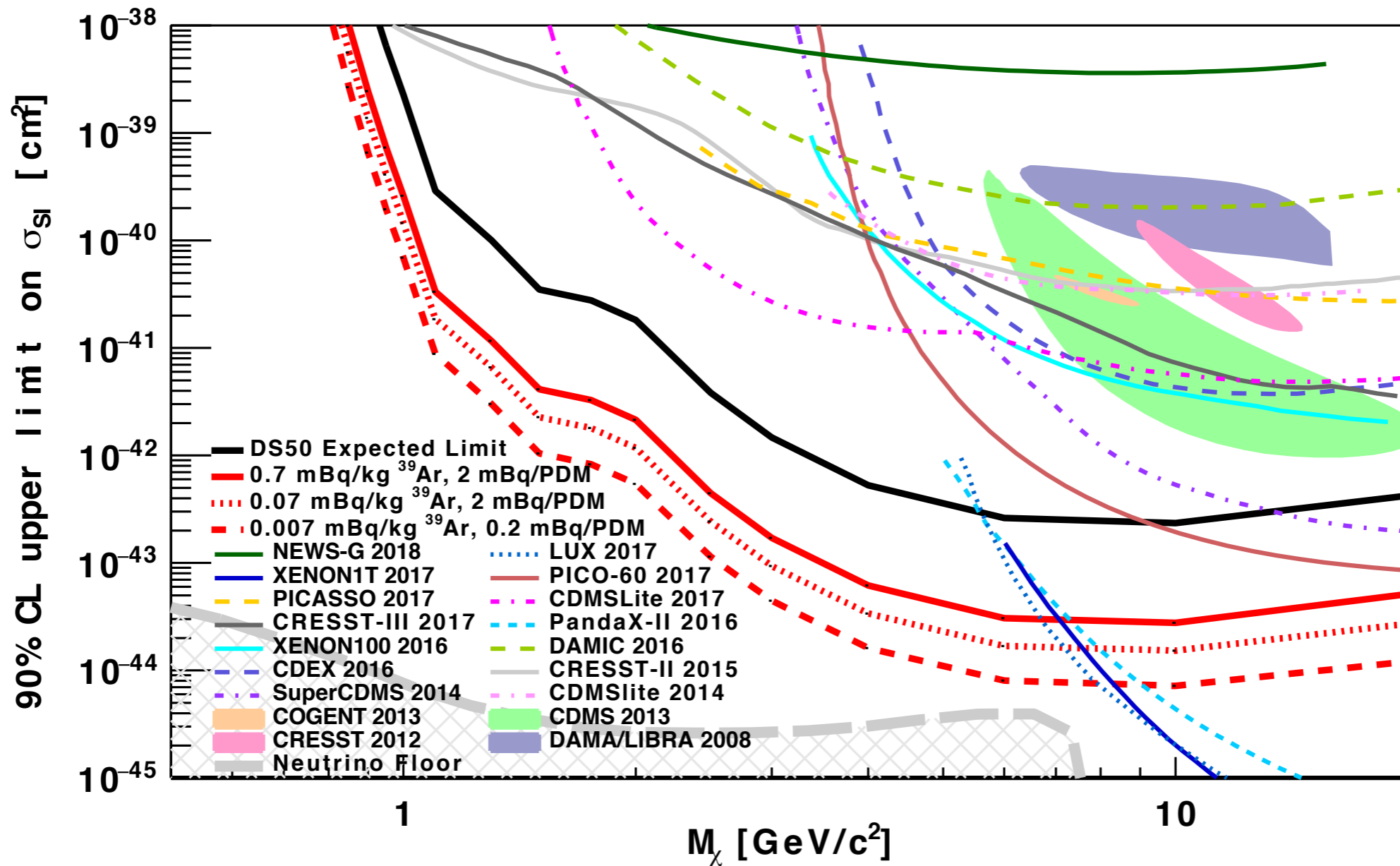
- validation of the design of mechanics and cryogenics of the TPC
- integration tests of the custom SiPM-Photosensors and of the full read-out electronics and data acquisition chain



# Phases of the Proto Project

- ✓ Proto 0:
  - Standalone test of cryogenic system concept; identification and preparation of full readout and DAQ of 50 pre-production PDMs
- ➡ Proto I: **“Proto-Proto”**
  - Design, construction and operation at CERN of R&D TPC equipped with 50 pre-production PDMs (2 Motherboards);
  - assembly, commissioning, and operation of full read-out and DAQ for 50 PDMs;
- ▶ Proto II:
  - Assembly and commissioning of full system, including 400 first production PDMs;
  - full electronics chain and DAQ final components.
- ➡ **Radiopure Proto to be deployed at LNGS to develop Low Mass DM searches**

# Future Darkside Low-Mass Searches



1 year data taking with DS-Proto



# DarkSide future program



## DarkSide-20k

a 20-tonnes fiducial argon detector

100 tonne×year background-free search for dark matter

## GADMC detector

a 300-tonnes depleted argon detector

1,000 tonne×year background-free search for dark matter