Hot news:
Liquid Argon Synergy

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

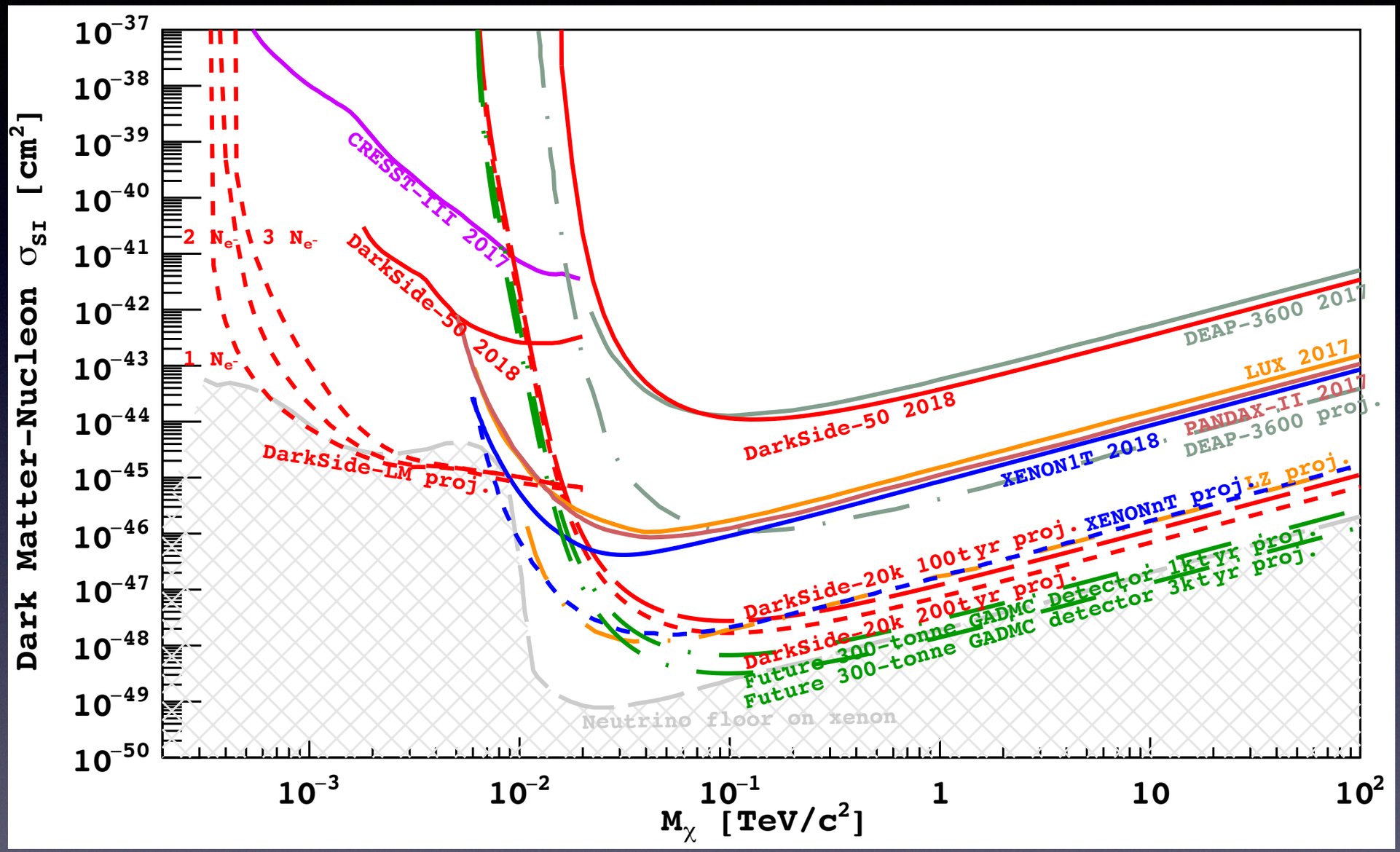
European Neutrino "Town" meeting and ESPP 2019 discussion
CERN 22-24 October 2018

European Astroparticle Physics Strategy 2017-2026

5. Dark Matter

APPEC encourages the continuation of a diverse and vibrant programme (including experiments as well as detector R&D) searching for WIMPs and non-WIMP Dark Matter. With its global partners, APPEC aims to converge around 2019 on a strategy aimed at realising worldwide at least one 'ultimate' Dark Matter detector based on xenon (in the order of 50 tons) and one based on argon (in the order of 300 tons), as advocated respectively by DARWIN and Argo.

The Global Argon Dark Matter Collaboration



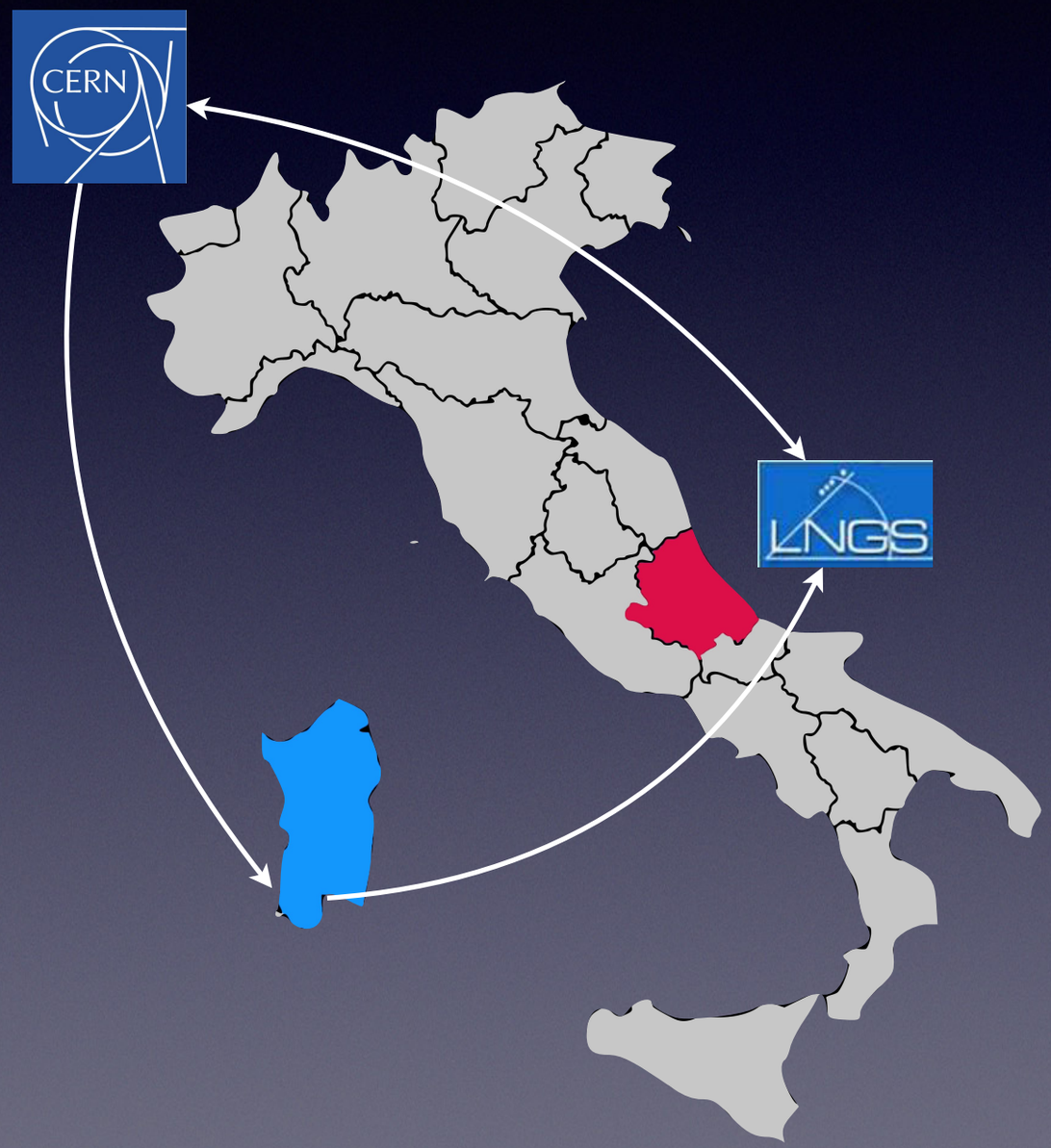
- Currently taking data:
  - ArDM at LSC
  - DarkSide-50 at LNGS
  - DEAP-3600 at SNOLAB
- Under construction at CERN:
  - DarkSide-Proto

- Next step: **DarkSide-20k** at LNGS (2022-)
- Last step: 300 tonnes detector, location t.b.d (2027-)
- A collaboration supported by the three Underground Labs

Liquid Argon Synergies

- Key technologies enabling DarkSide-20k and future liquid argon program

- Low radioactivity argon
  - **ARIA** cryogenic distillation column leak tests and technical review
- Cryogenic Photosensors
  - **NOA** large area SiPM based Photon Detector Modules
- Cryogenics for liquid argon detectors
  - **Proto-DUNE** cryostats



ARIA column prototype

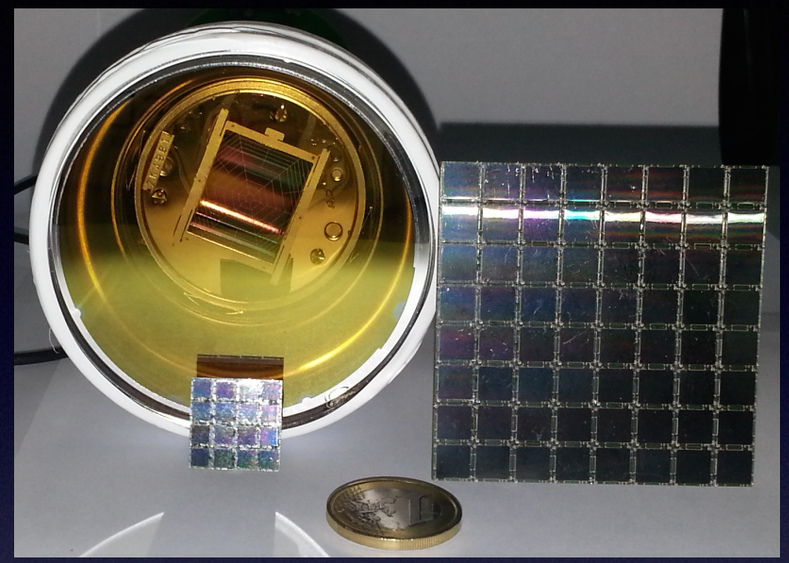
Jan 2018 @ CERN

Aug 2018 @ Nuraxi Figus

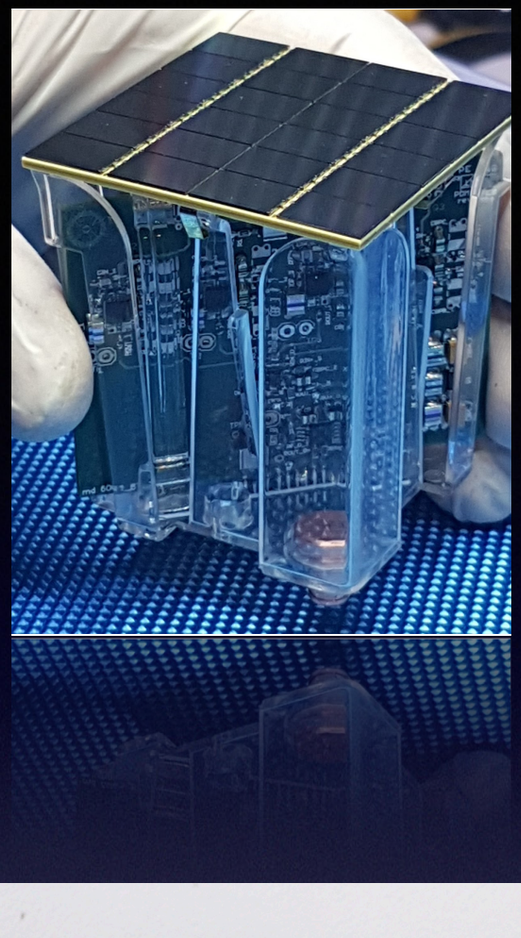
Photon Detector Modules: SiPM + cold electronics to enhance LAr technology

- 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)**
  - 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 @LNGS)



Scalability:
from Photon Detector Module to Motherboard



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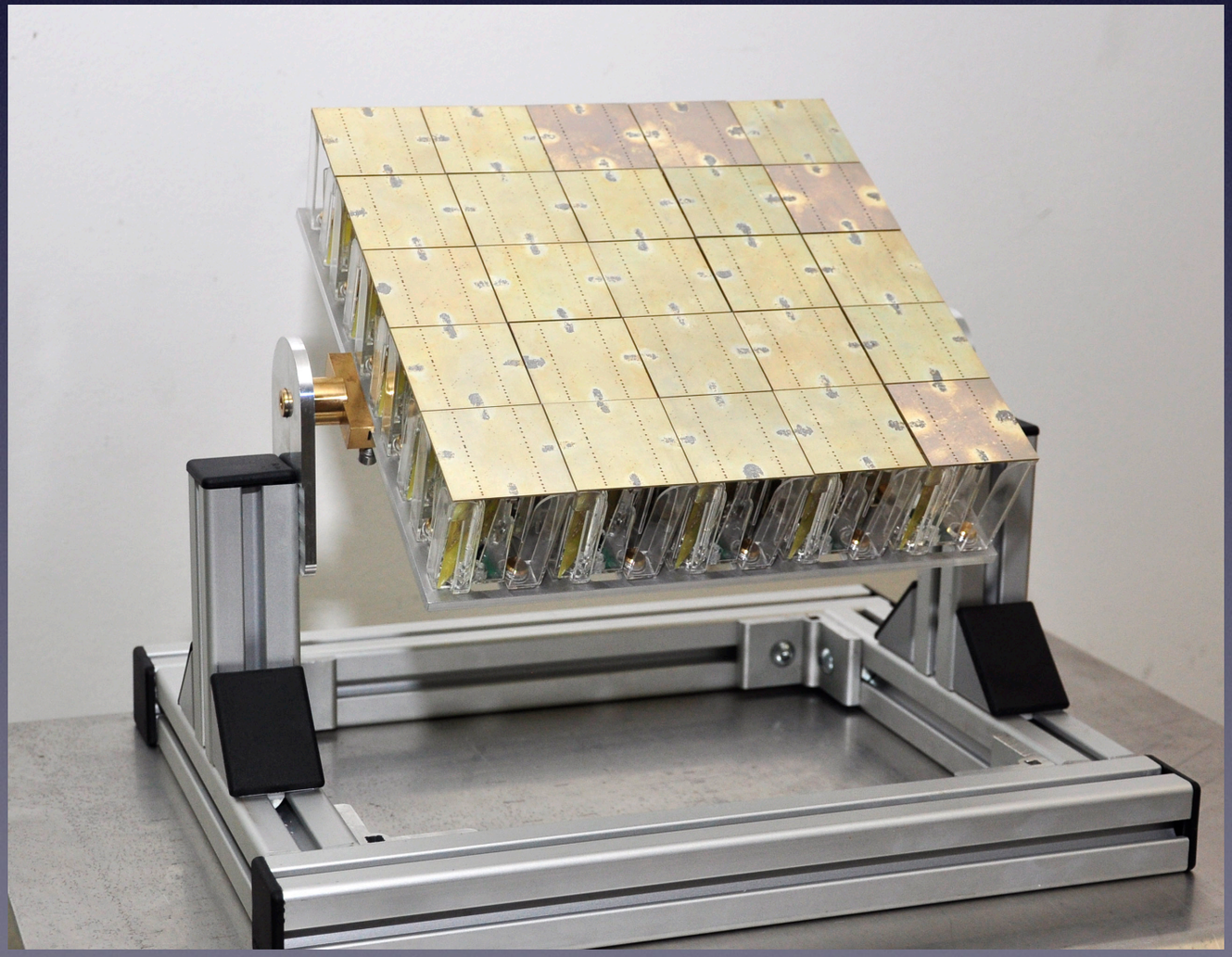
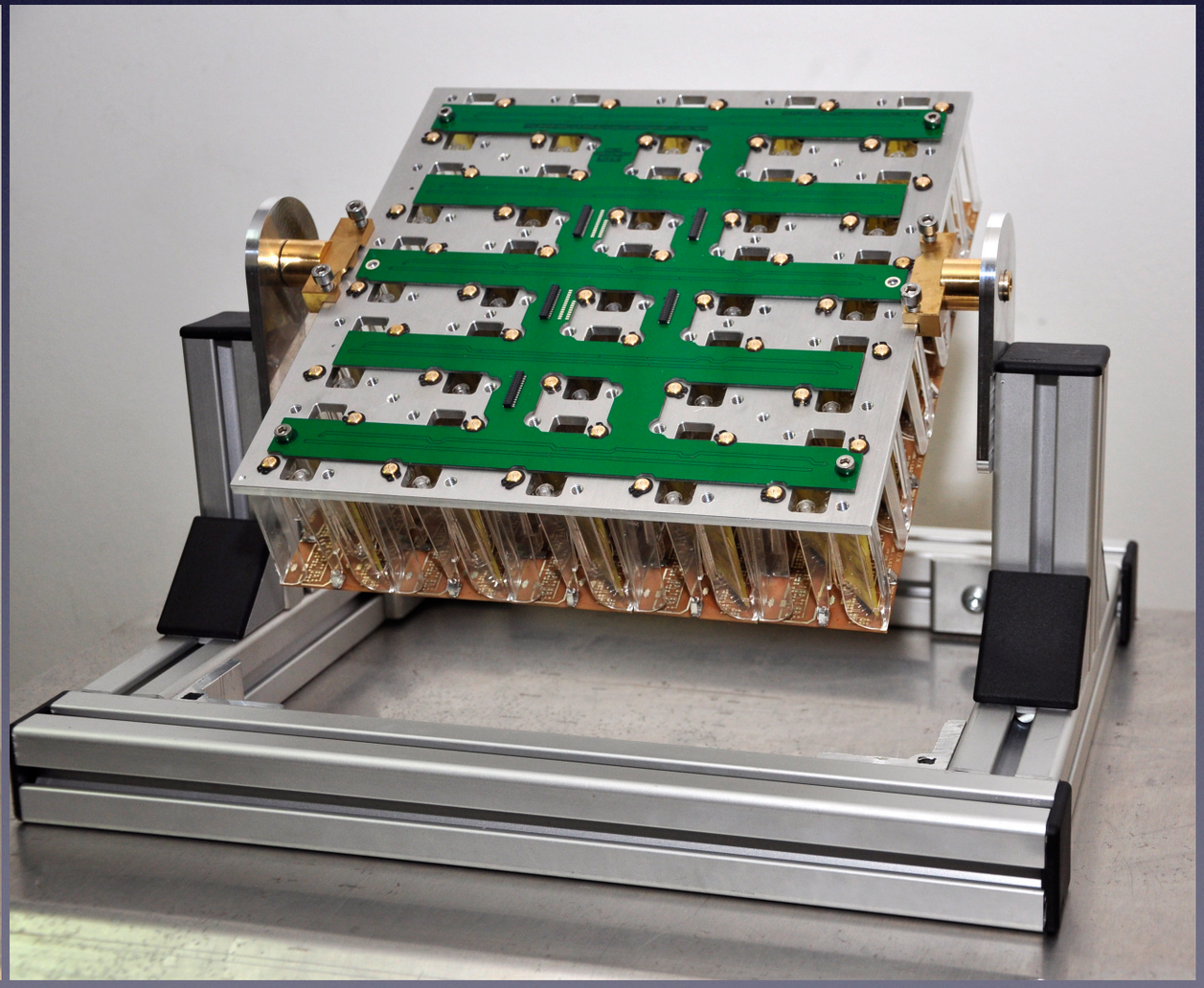


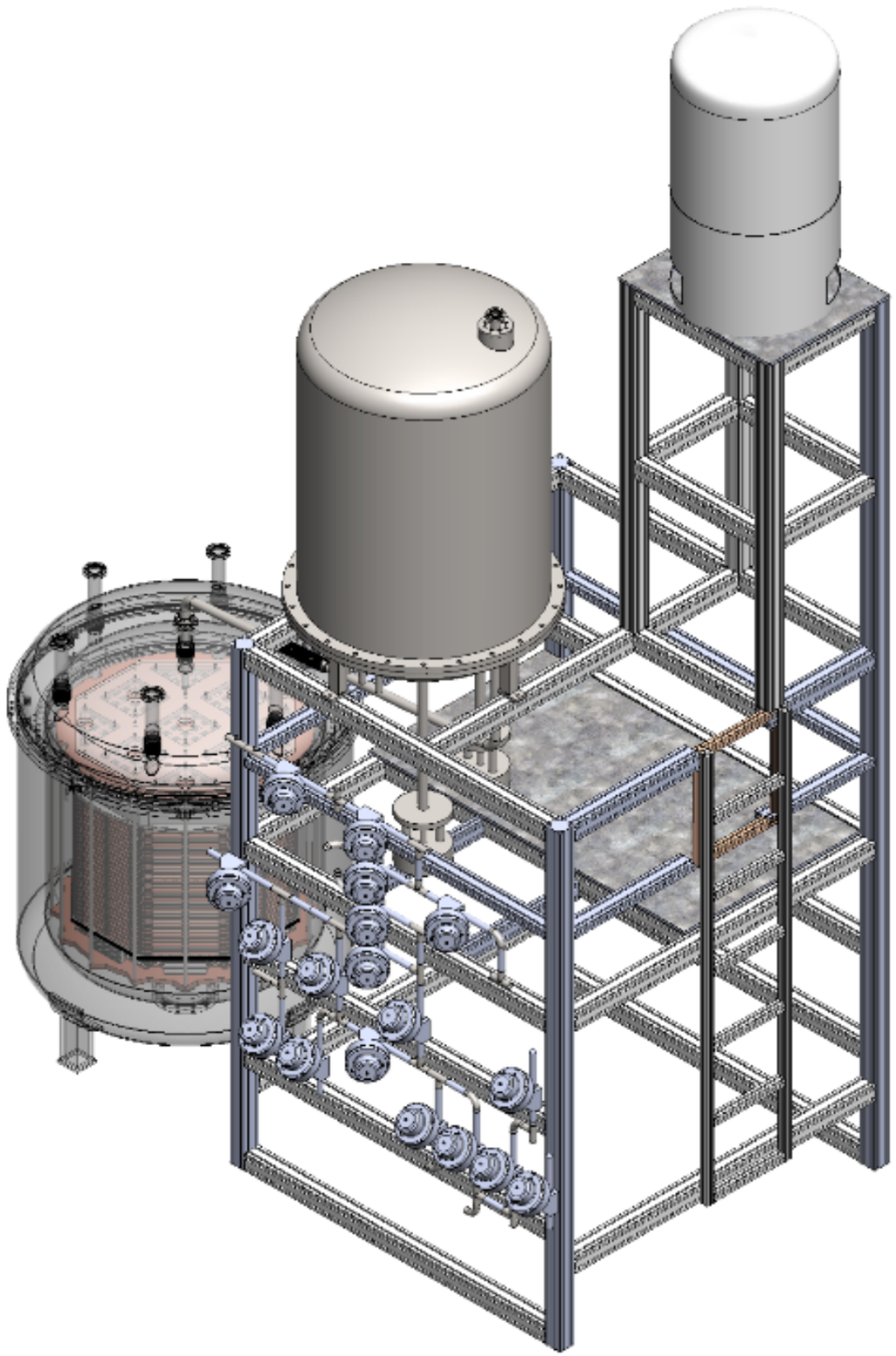


DarkSide-Proto @ CERN

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

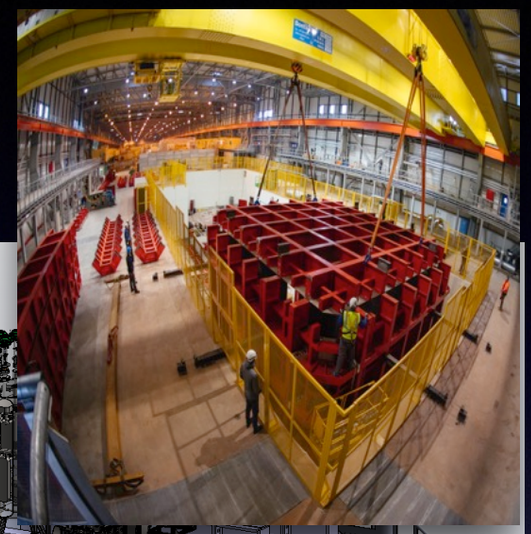
- validation of the design of mechanics and cryogenics of the TPC

- integration tests of the custom SIPM-Photosensors and of the full read-out electronics and data acquisition chain



Scalability: a LAr shield for DarkSide-20k

- AAr in ProtoDune style large cryostat to provide shielding and active VETO
- Benefit from an important technological contribution from CERN Neutrino Platform allowing to eliminate Liquid Scintillator Veto and Water tank
- Significantly simplify the overall system complexity and operation
- Fully scalable design for future larger size detector (300 ton)



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

Exploiting Synergies

NP++: international infrastructure for frontier physics

Scaling up the technologies for NP and DM

- Vacuum & Cryogenics, very large membrane cryostats
- LAr detector technology
- Fully digital R/O optoelectronics

Artificial-Intelligence-powered data acquisition system

- exploit Deep Learning for real-time data processing
- investigate FPGAs as flexible hardware
- synergies with LHC experiments (deep learning for big data real-time processing), also proposed for DUNE, NEXT, …
- synergies with ongoing activities involving CERN (HLS4ML, CERN OpenLab, CERN KT Department)

Exploiting Synergies

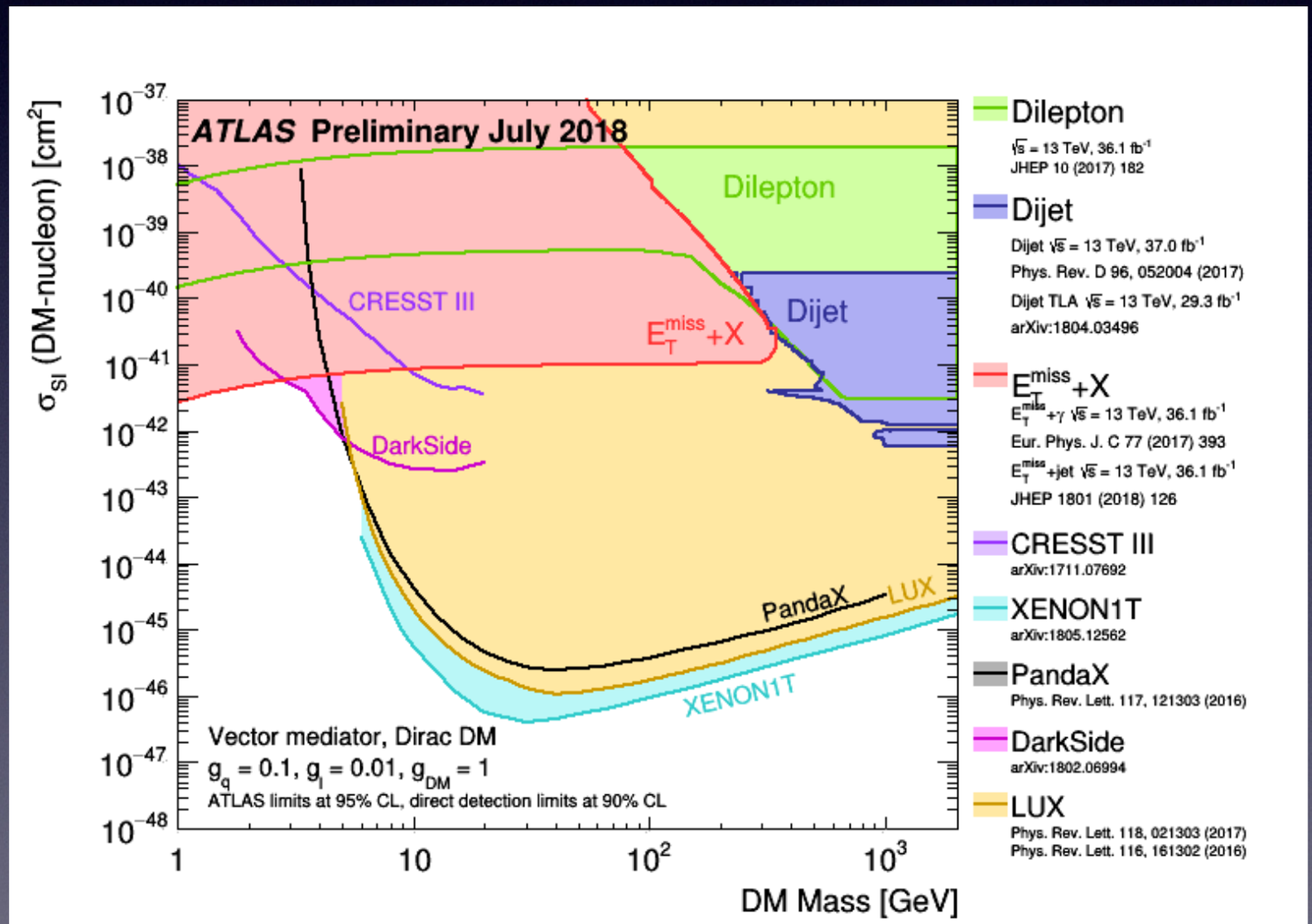
Understanding the nature of Dark Matter

Complementarity

- LHC experiments probe the sub-TeV range for WIMPs. But, if WIMPs are discovered by the LHC, an astrophysical detection will be necessary to connect the produced particles with the cosmic dark matter.
- For WIMP masses at multi-TeV, only direct and indirect detection methods have significant discovery potential.

➡ **Common strategic planning of future research**

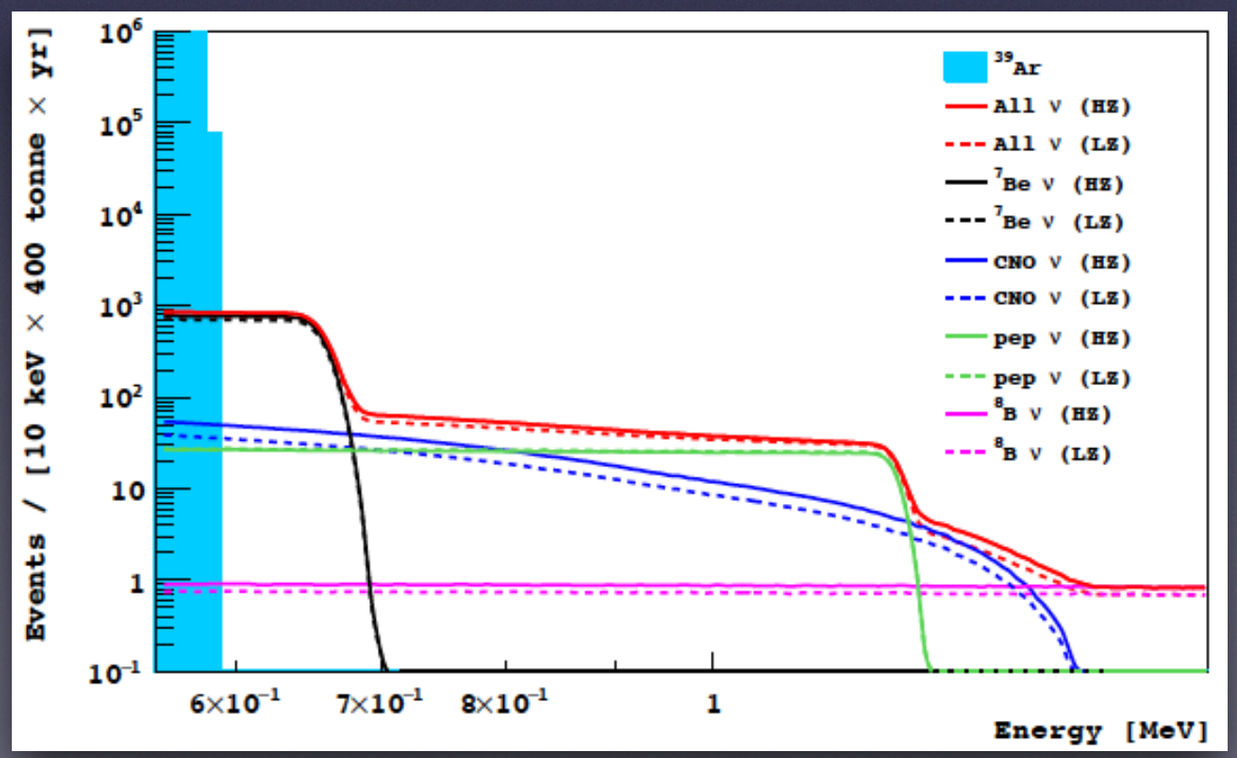
- maximize the combined DM search potential

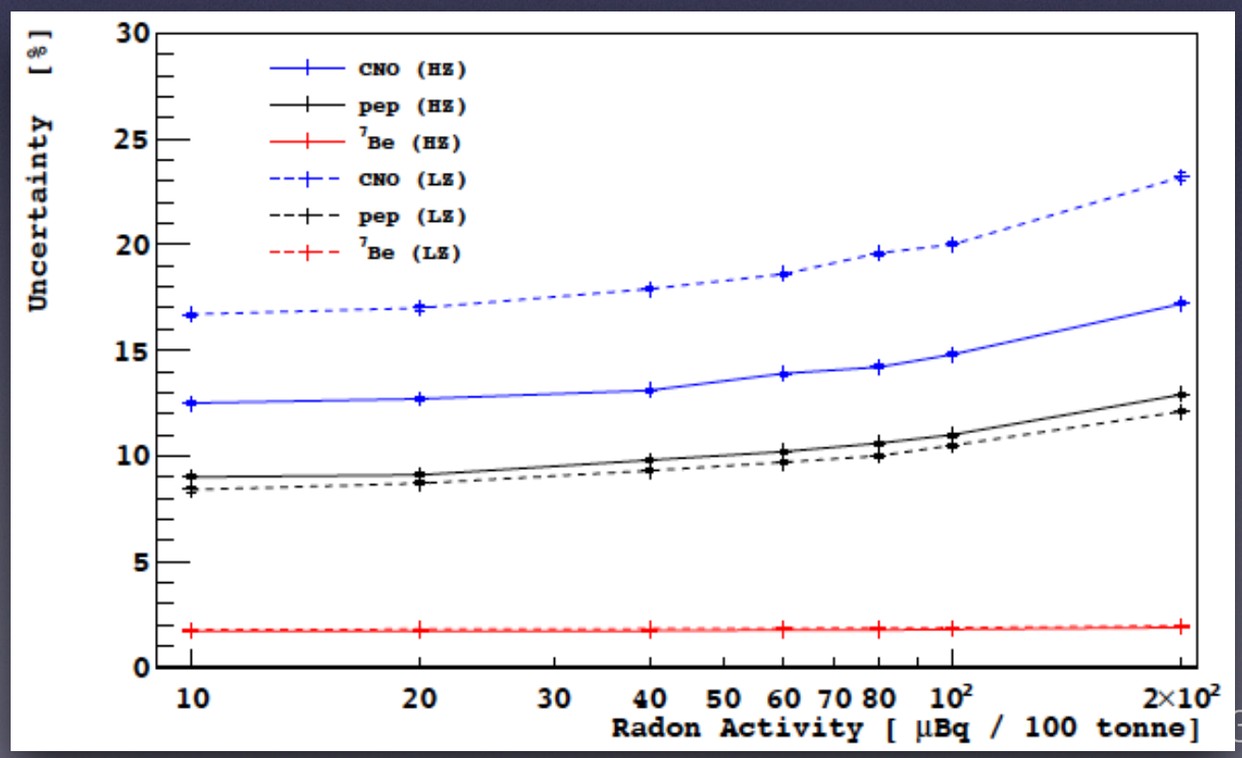


Exploiting Synergies

Not only DM: neutrinos from the Sun

- GADMC 300-tonnes detector could enable a precision measurement of CNO, ^{7}Be and pep neutrinos
  - more than 10,000 CNO neutrino-electron scattering events in 1,000 tonne yr
  - larger LY, larger purity wrt LSci detectors
- strong reduction of ^{222}Rn contamination required





Conclusion

From a wide community to a wider one

Overlapping areas of research

- See for instance US Particle Physics Project Prioritization Panel (P5):
  - Cosmic, Energy and Intensity Frontiers, on equal grounds within the larger field of particle physics

Diversification strategy

- An example: CERN/Fermilab joint LAr programme for neutrino physics
  - Technology + physics reach