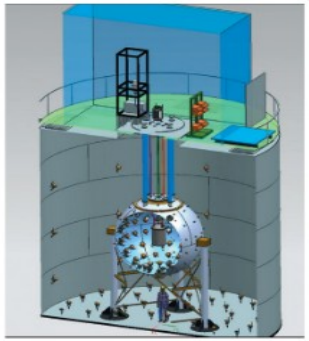
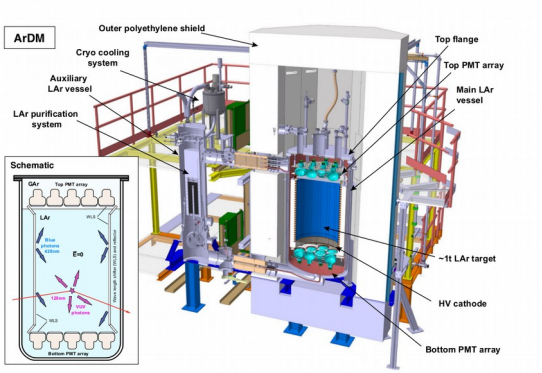
A Global Liquid Argon Dark Matter Search Program

M. Ave (Universidade de São Paulo, Brazil) on behalf of GADMC

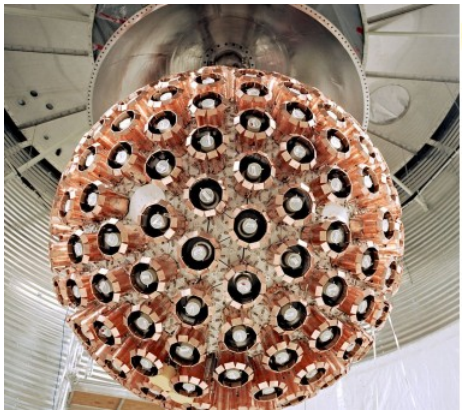
Global Argon Dark Matter Collaboration



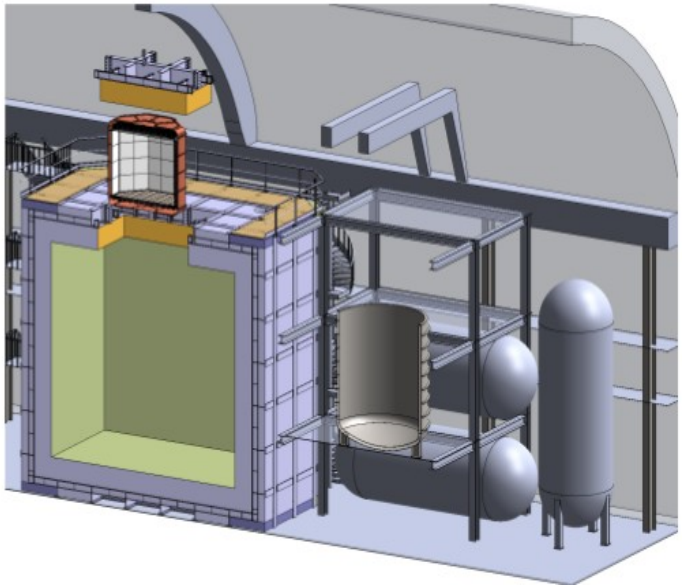
DS-50 (*UAr*, **Dual-Phase**, 50 kg)



ArDM (*AAr,* **Double-Phase**, 1 ton)



DEAP (*AAr,* **Single-Phase**, 3.3 tons)

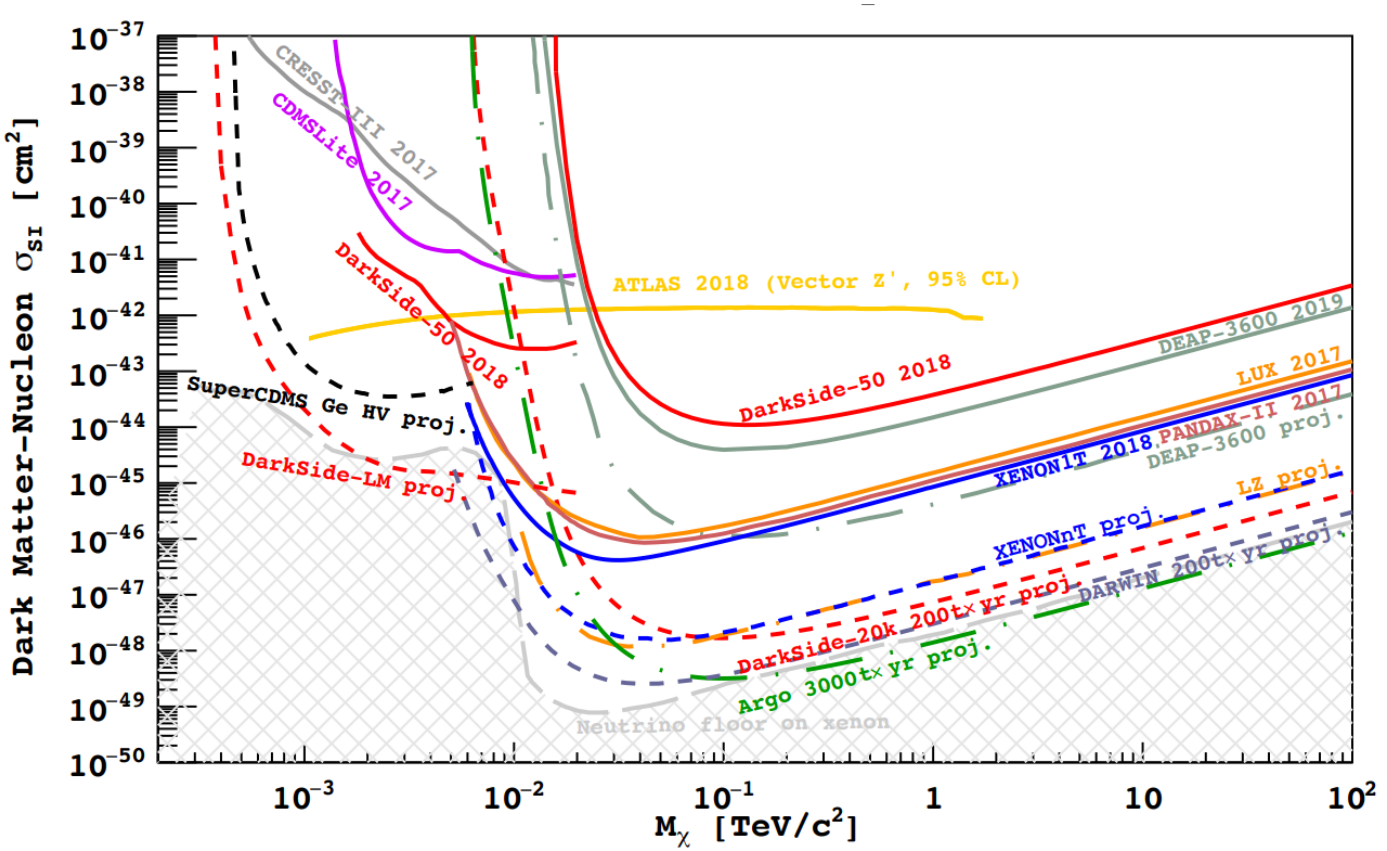


DS-20K (*UAr,* **Dual Phase**,50 tons)

Argo (*UAr,* **Dual Phase,**300 tons)

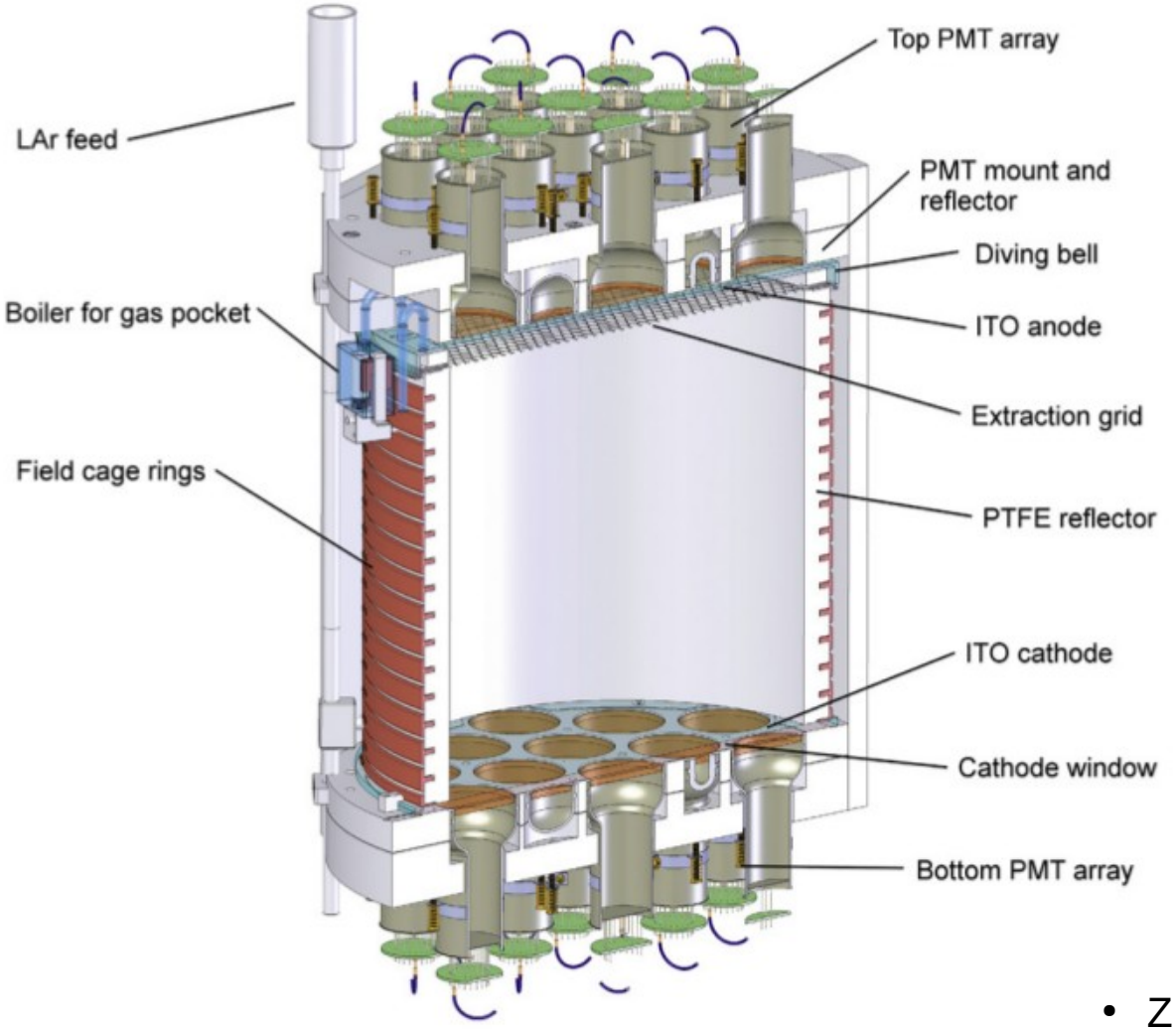
Ultimate Goal

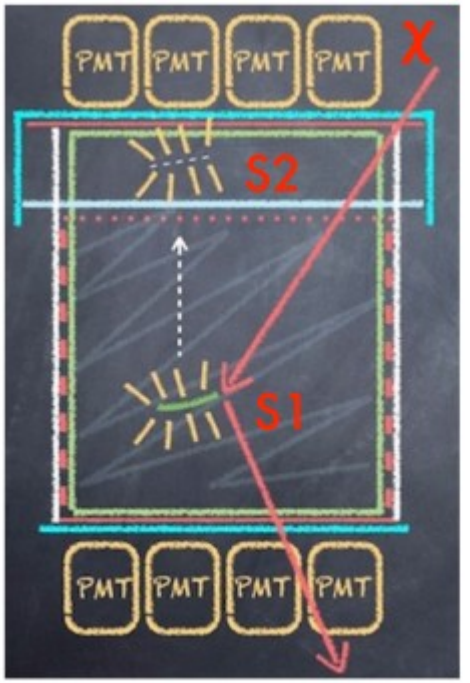
WIMP search down to the neutrino floor with no experimental background



Key technologies

Time Projection Chamber





DS-50 46.4 kg total mass

- Z position: S1/S2 time difference
- XY position: Fraction of light in each PMT in S2 pulse.

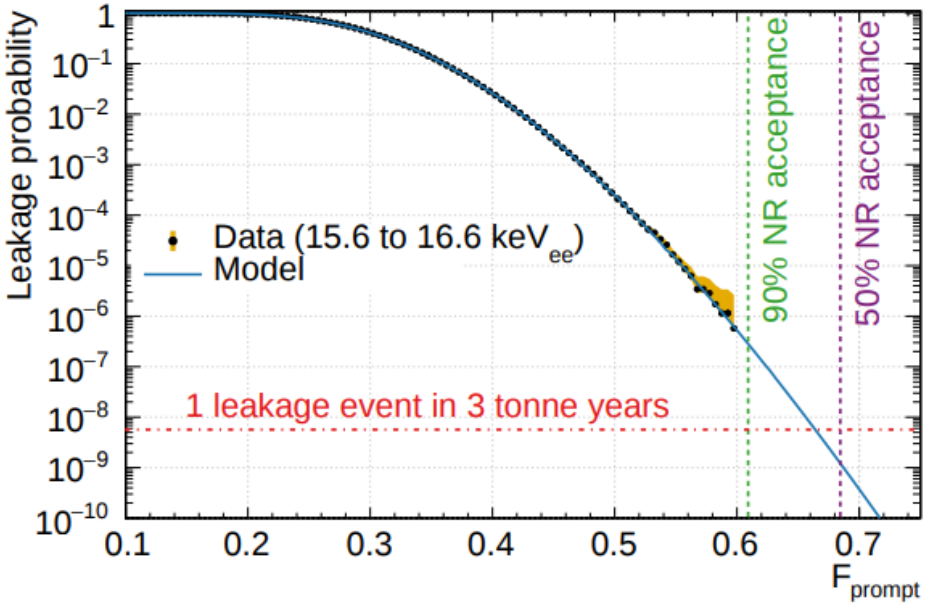
Key technologies

Liquid Argon

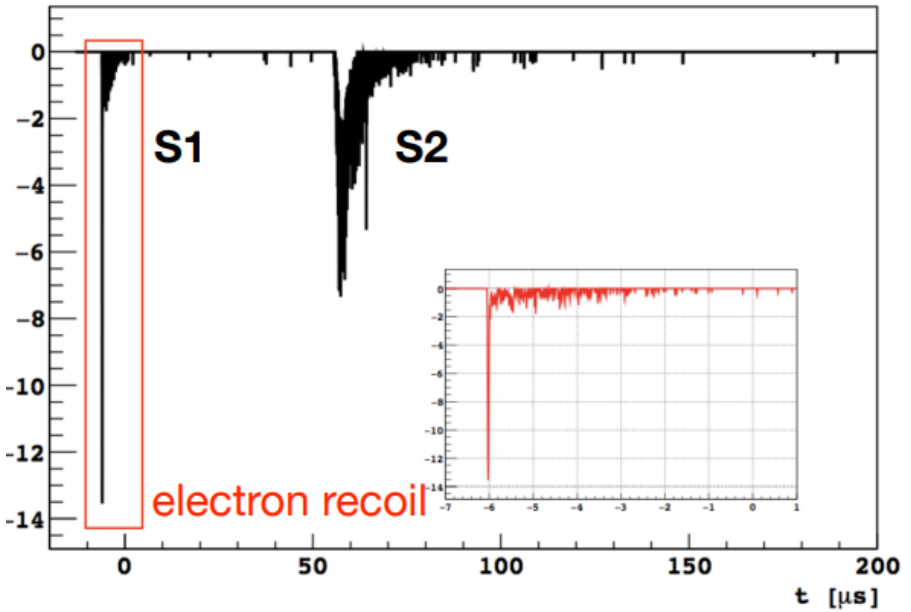
S1 → Scintillation signal
Prompt light Fraction: ER/NR discrimination

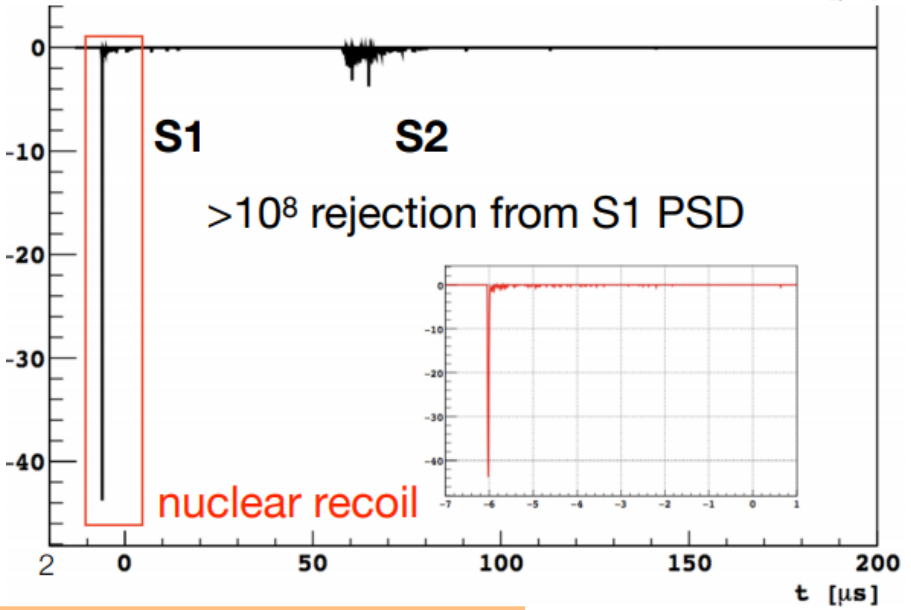
S2 → Ionization signal
S2/S1 : ER/NR discrimination

ER → Electron Recoil
NR → Nuclear Recoil



DEAP 3600: astro-ph 1902.04048

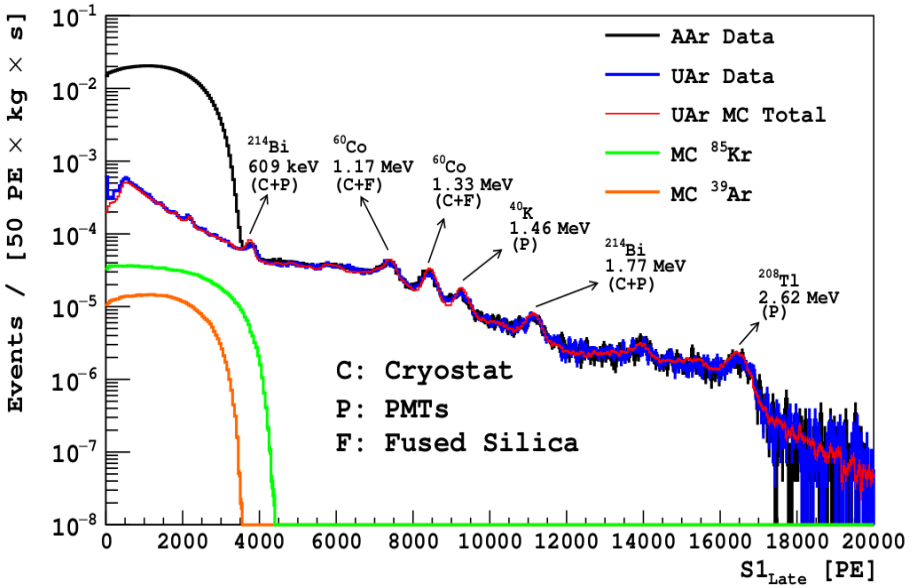




ER background severely suppressed

Key technologies
Underground Argon

AAr: 1 [Bq/kg] of ^{39}Ar
UAr: 0.73 [mBq/kg] of ^{39}Ar

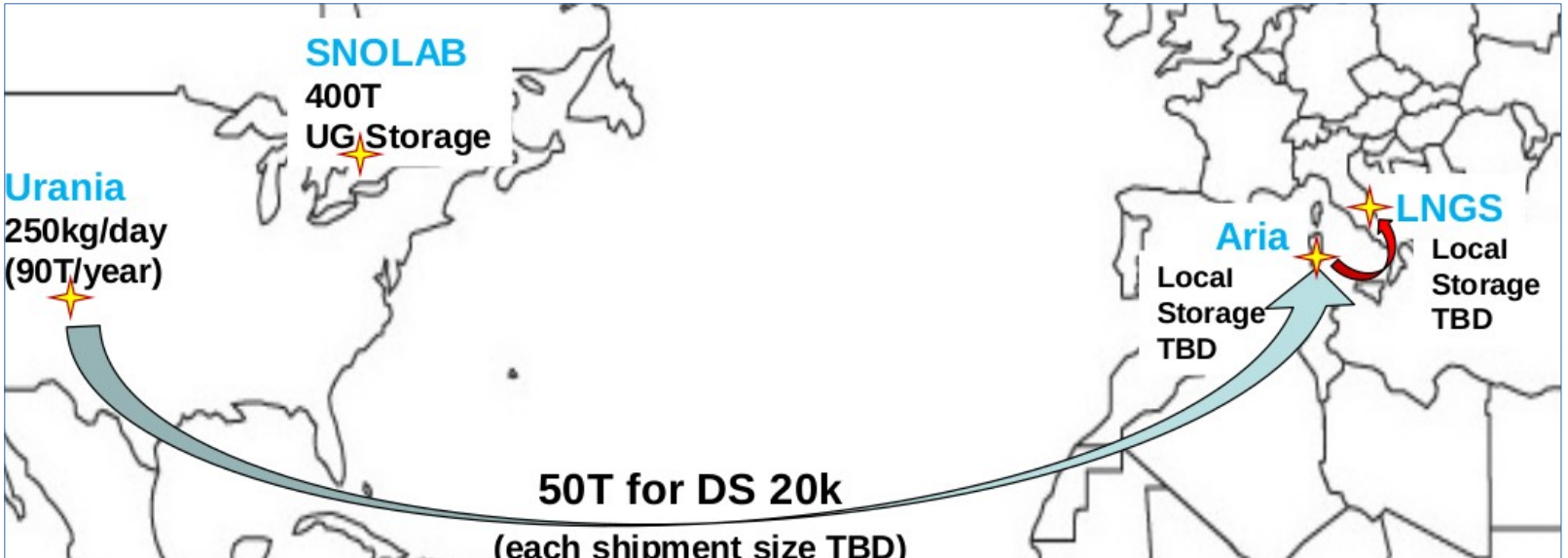


URANIA (Colorado, USA)
Extraction 250 kg/day at Kinder Morgan/Air Product plants.

ARIA (Seruci, Sardinia, Italy)
Distillation Column for final Argon purification (CO, CO_2, H_2O, O_2, CH_4)

Also ^{39}Ar further depletion for ARGO and DS-LowMass

Transportation and Storage scheme: avoid leakage ad UAr activation

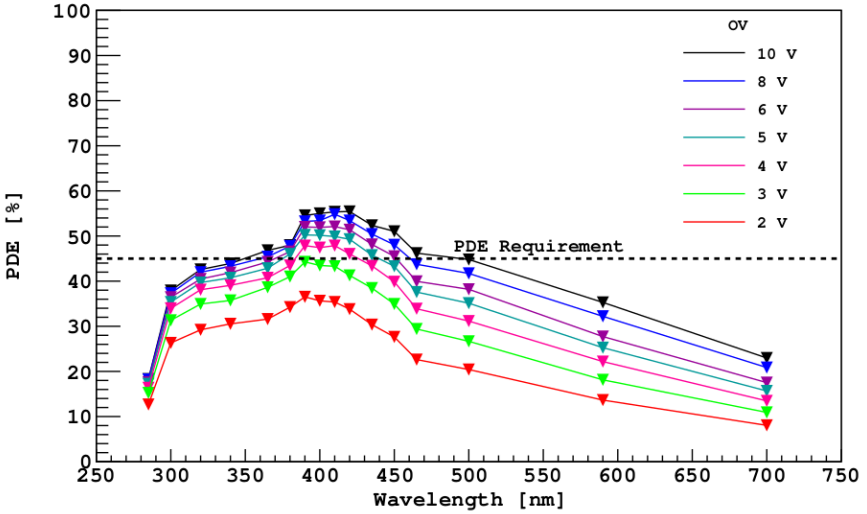


V. Strickland

Key technologies
Photodetectors

Silicon PhotoMultipliers

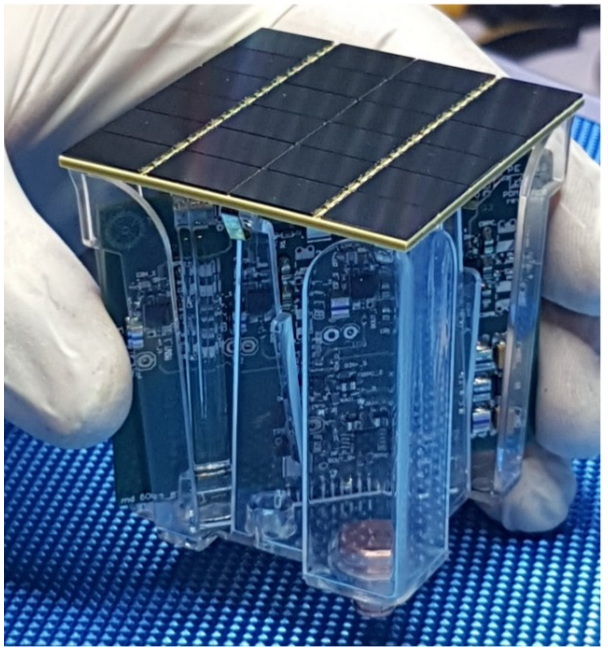
- High Photon Detection Efficiency (>45% at 420 nm).
- Easily integrated into Tiles.
- Low Radioactive Background.

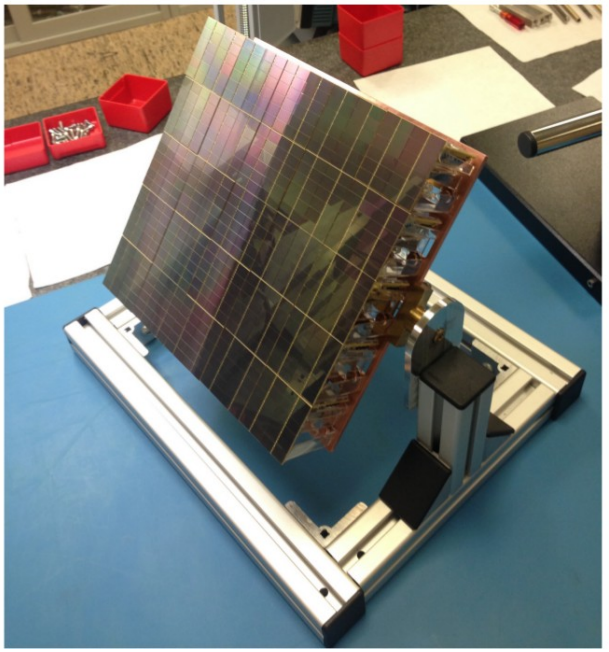


Required performance:

- DCR lower than 0.1 Hz/mm^2 at cryogenic temperatures
- Direct/Delayed Cross talk and Afterpulsing ~30%

PDM:
5x5 cm

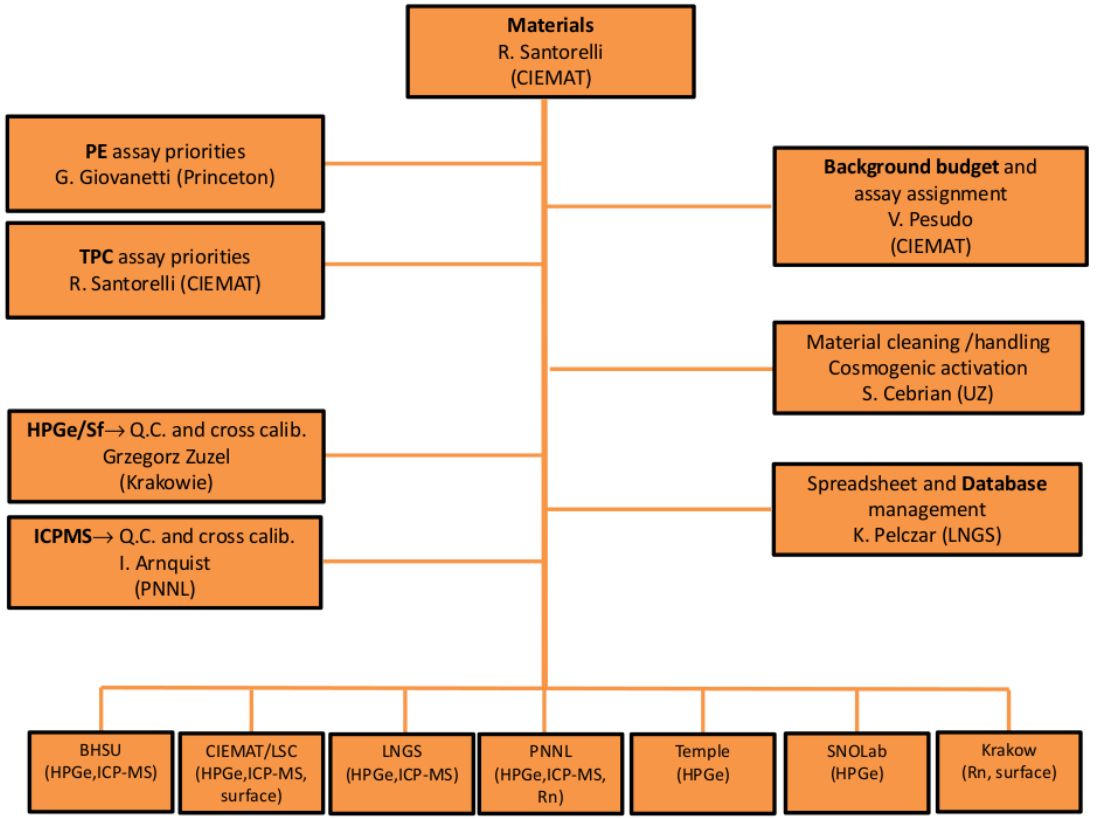




Motherboard:
25x25 cm
25 PDMs

Key technologies

Material purity

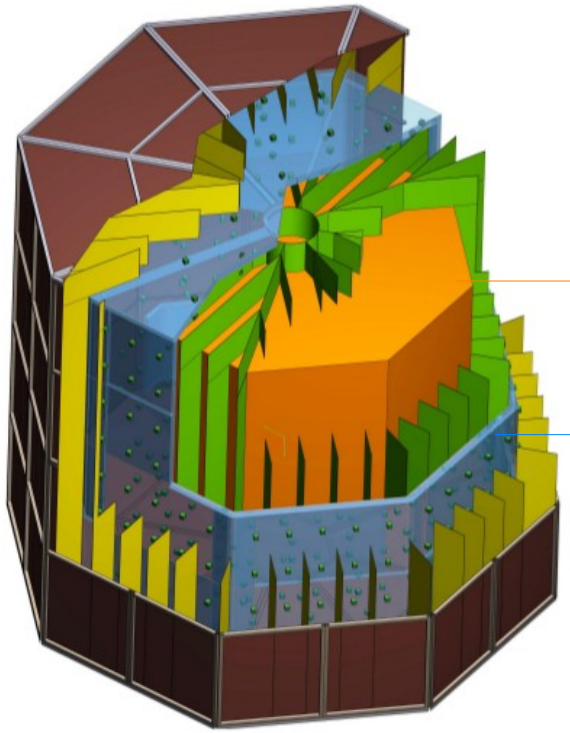


Big effort in radioactive purity assays to assure the goal of 0.1 neutrons in 100 ton~year exposure.

Key technologies

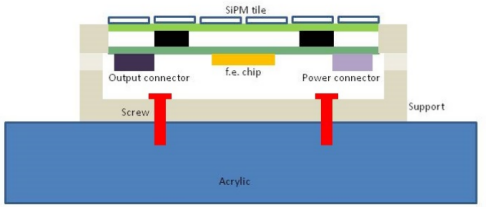
Neutron background abatement

- **Material radio-purity:** Photo-Electronics front end and Acrylic Purity.
- **Fiducialization :**
  50 ton (Active) 20 ton (Fiducial)
- **Outer Neutron Veto**



TPC

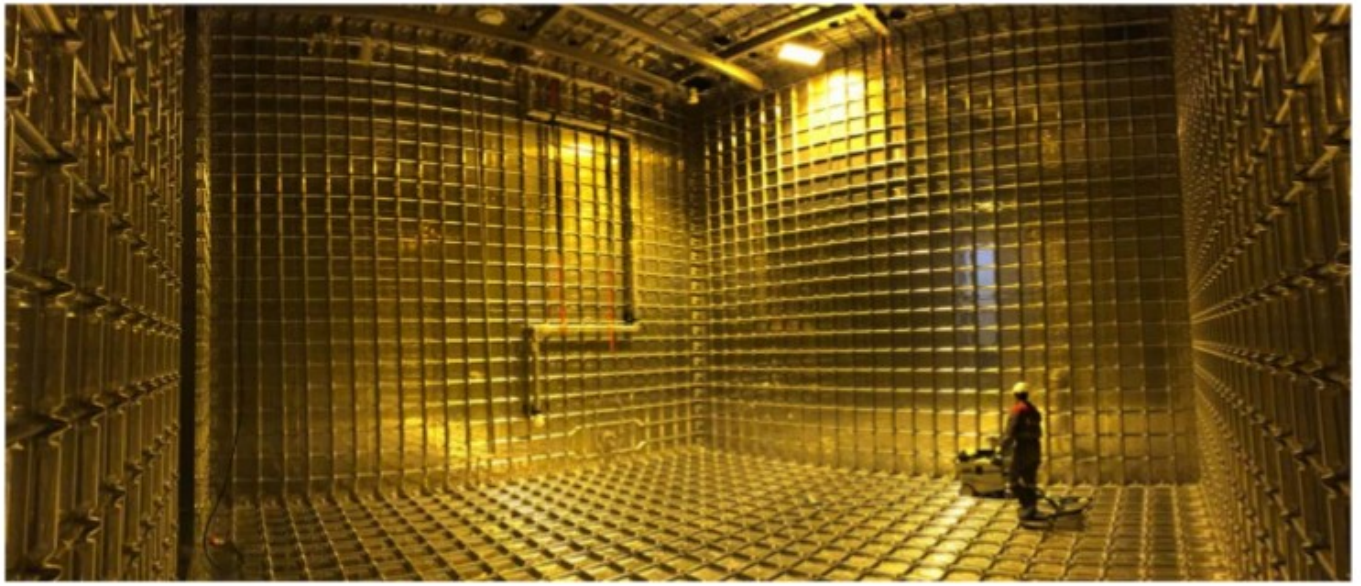
Gd Loaded Acrylic Panels
(with SiPMs)

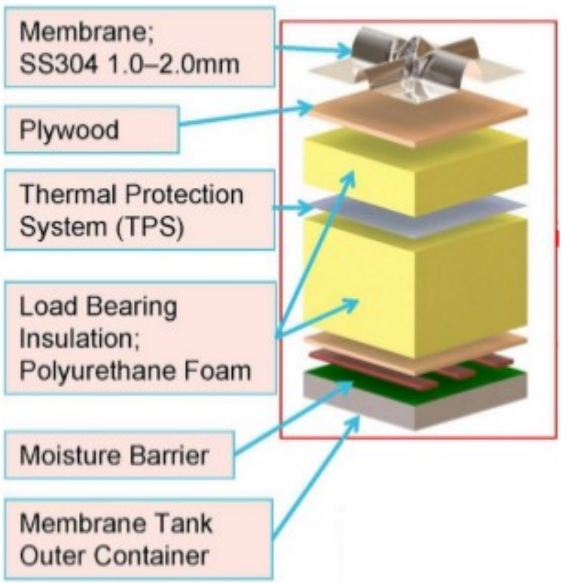


G. Testera

Key technologies

Proto Dunes Cryostat



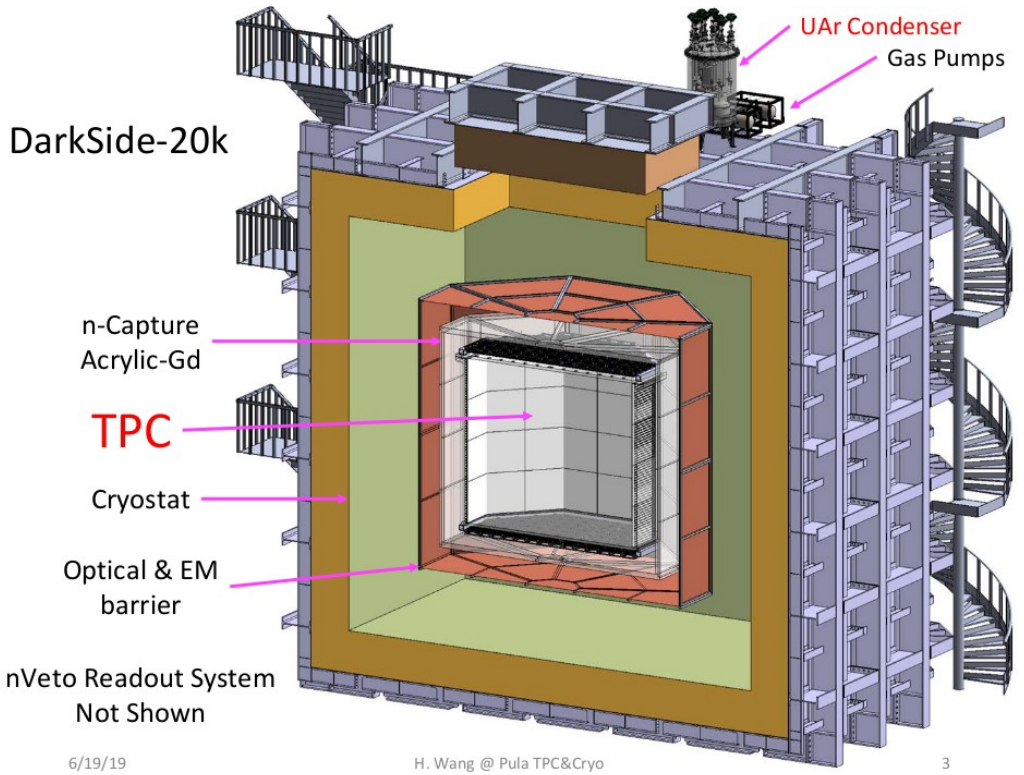


Developed for DUNES. 8x8x8 m (inner dimensions)

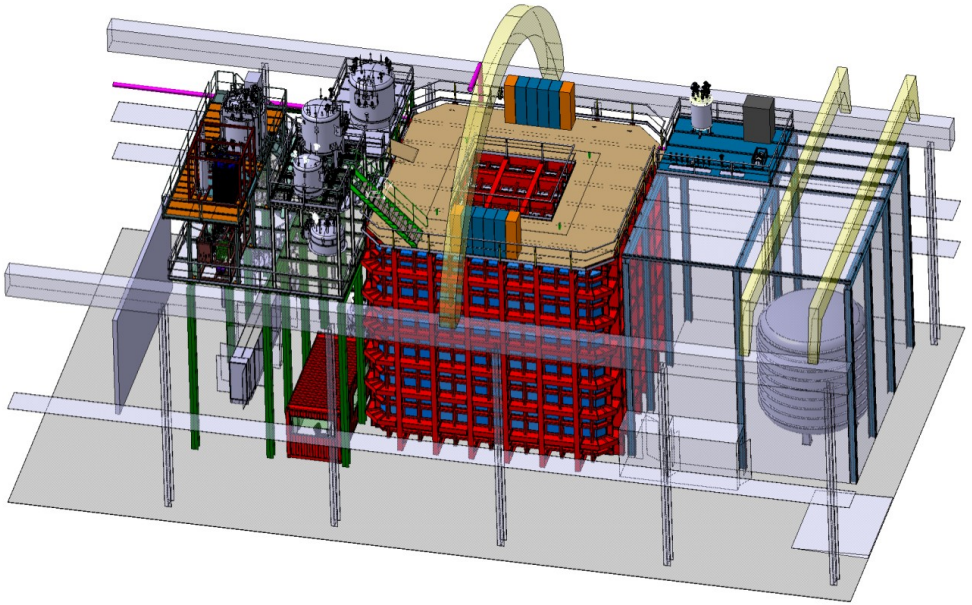
Darkside+CERN Neutrino Platform partnership;

DS-20K (2022-2027)

DS-20k TPC Dimensions	
TPC Drift Length	350 cm
Octagonal Inscribed Circle Diameter	355 cm
Total LAr Mass	51.1 t
Active LAr Mass	49.7 t
Fiducial Cut Distance (vertical)	70 cm
Fiducial Cut Distance (radial)	30 cm
Fiducial LAr Mass	20.2 t
Nominal TPC Fields and Settings	
Drift Field	200 V/cm
Extraction Field	2.8 kV/cm
Luminescence Field	4.2 kV/cm
Cathode Voltage	−73.8 kV
Extraction Grid Voltage	−3.8 kV
Anode Voltage	ground
Gas Pocket Thickness	7 mm
Grid Wire Spacing	3 mm
Grid Optical Transparency	97 %
SiPM PDM	
Number of PDM on TPC Top	4140
Number of PDM on TPC Bottom	4140
PDM Effective Area	$50 \times 50\,\mathrm{mm}^2$



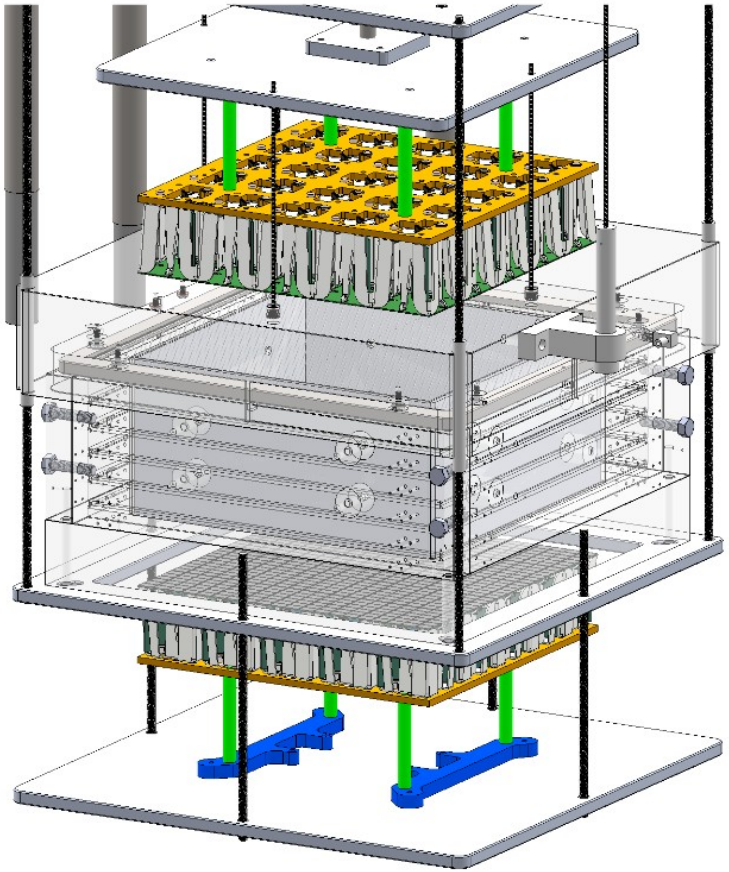
H. Wang



TPC is an acrylic vessel 5 cm thick with field shaping rings coated.

Efficient use of UAr

Prototypes being constructed at CERN



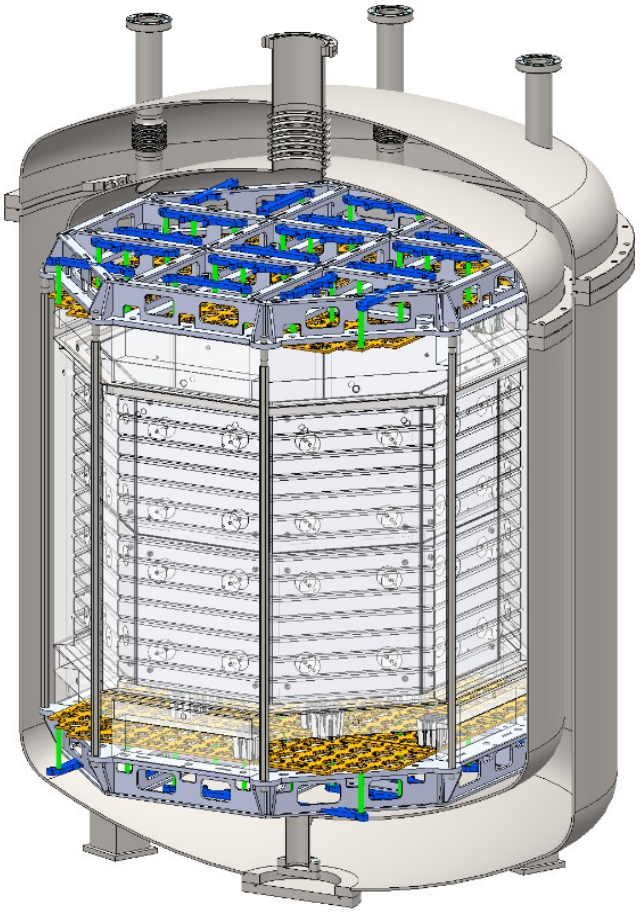
Yi Wang

Proto-Proto

Testing
- The first two Motherboards.
- Acrylic bonding technique.
- Clevios coating.
- ESR reflectors

Optimization of S2 signal (Gas pocket)

Being commissioned at CERN this month



Proto 1 ton

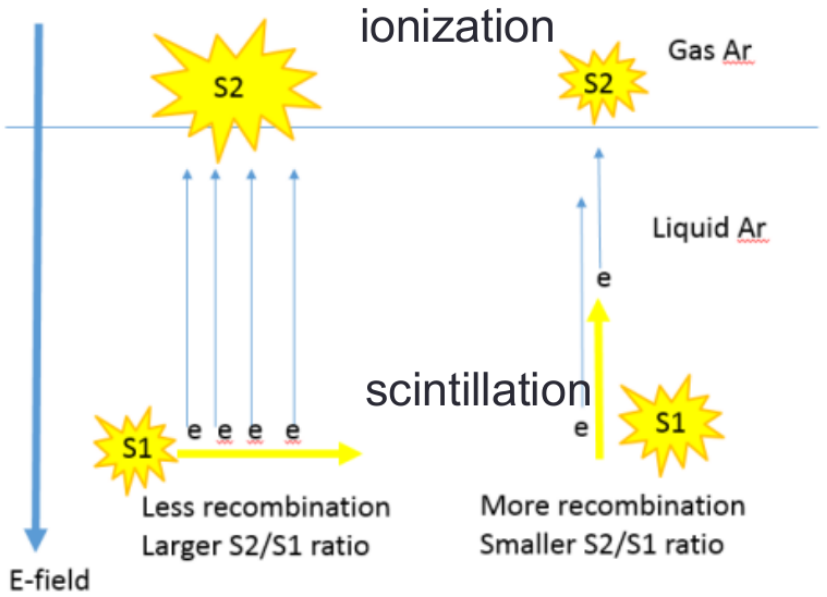
Q2 2020

Scaled down version of TPC

Testing sealed acrylic TPC

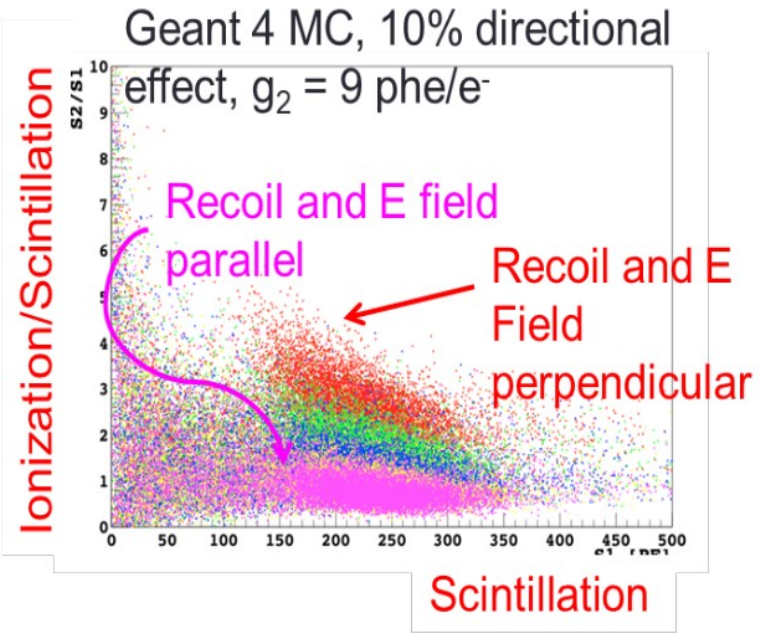
Validation of the final design

The ReD project

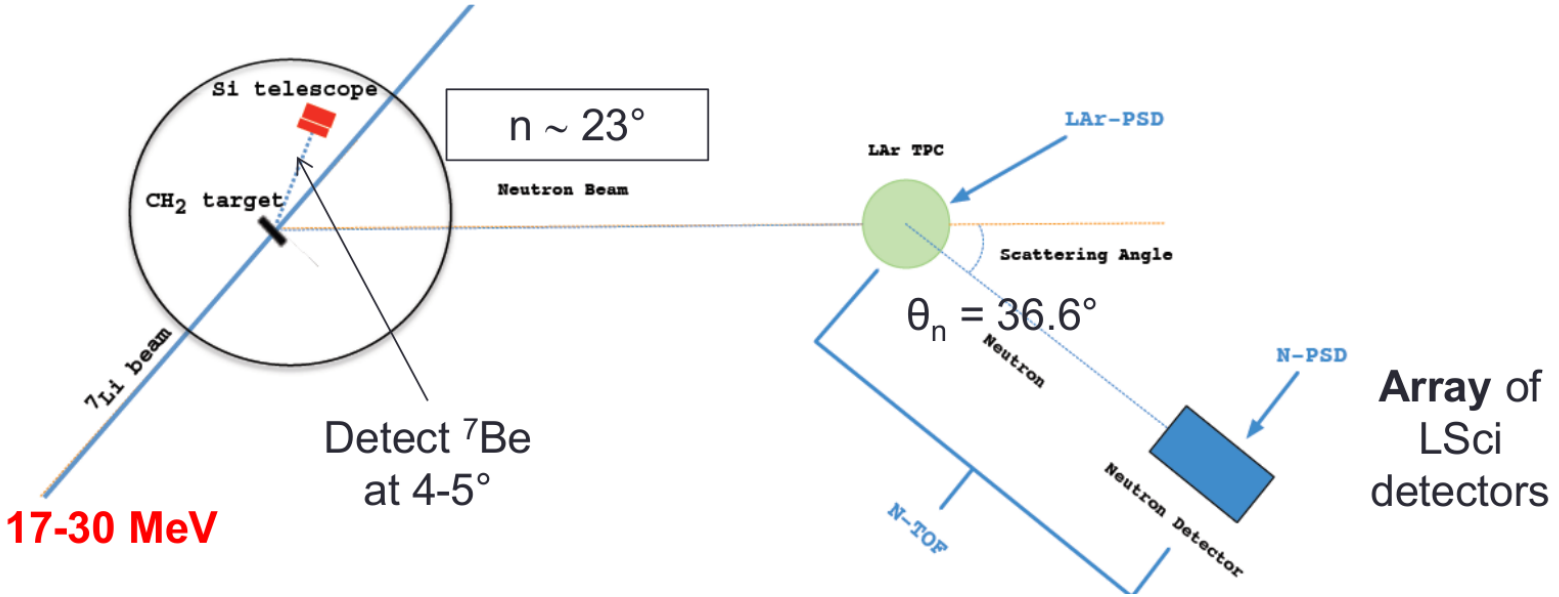


If recombination depends on recoil direction in Argon --> The neutrino floor is not a limitation anymore.

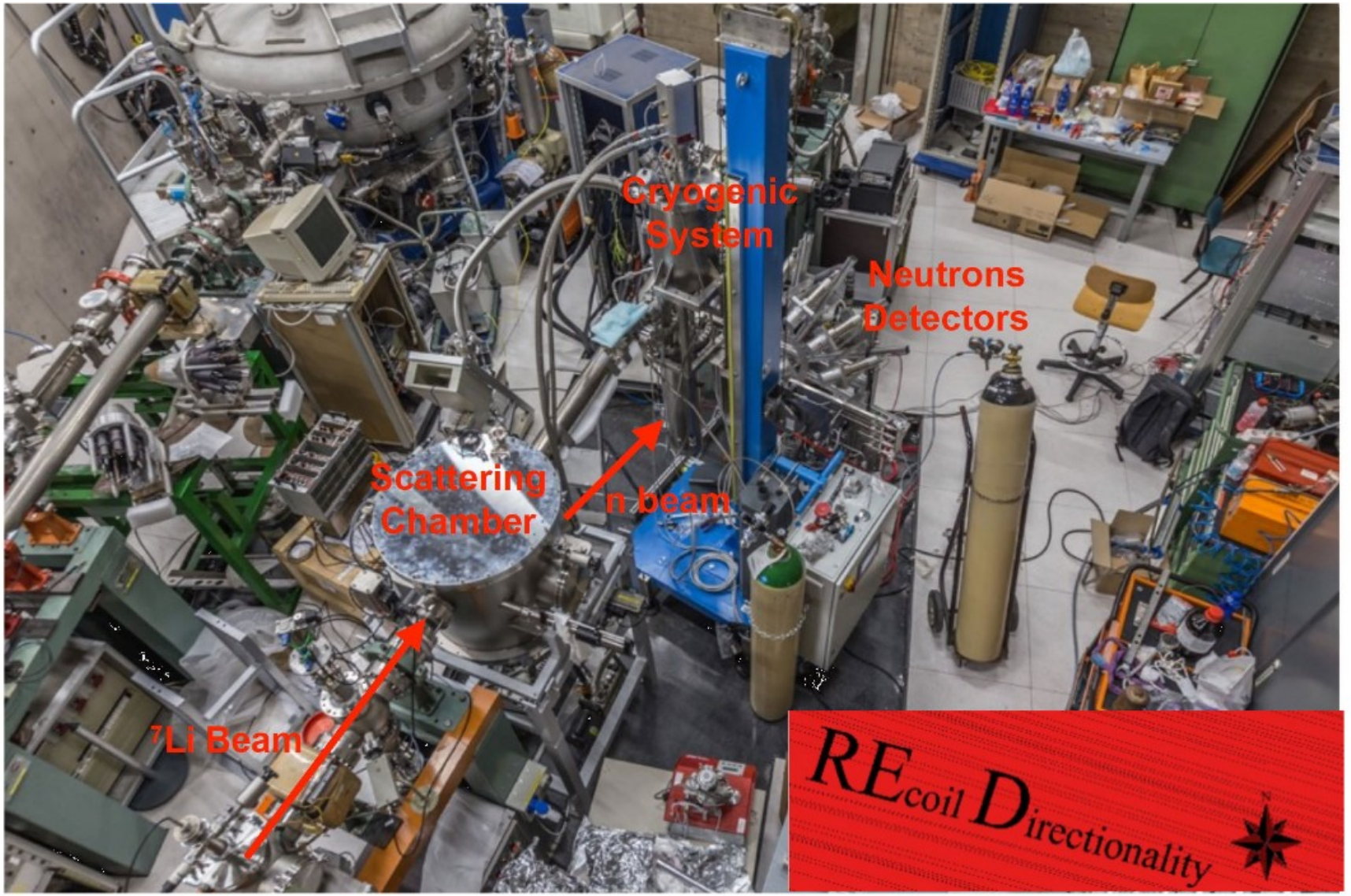
L. Pandola



P. Agnes



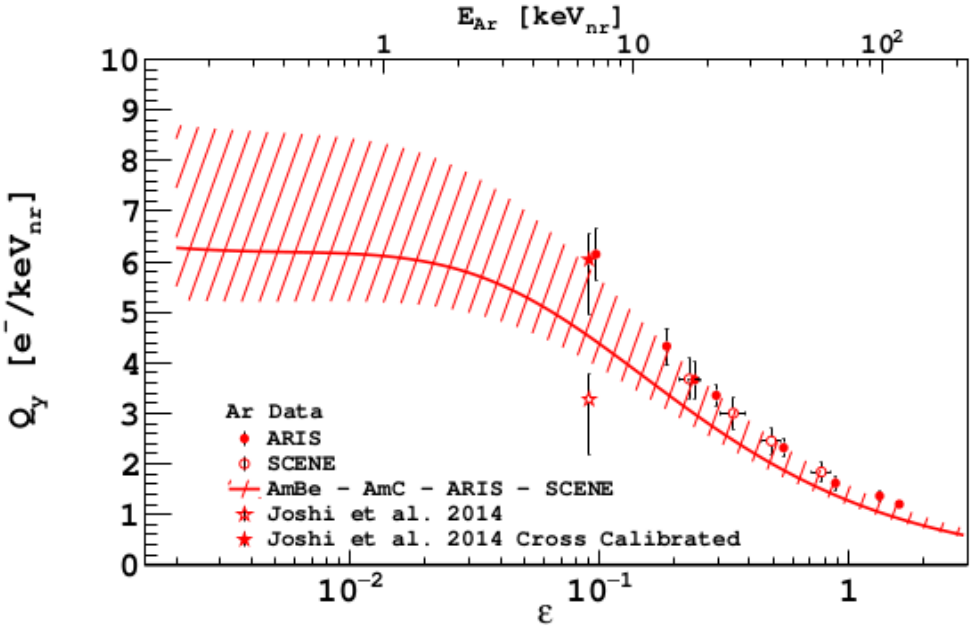
- ^{7}Li(p,n)^{7}Be tagging ^{7}Be with Silicon detector
- Neutron scatters elastically off ^{40}Ar at TPC
- Tagged by Liquid Scintillator detector with PSD capabilities
  - Array of LSci so recoils parallel/perpendicular to the electric field are tagged



On going experiment at LNS (Catania,Italy)

First results expected in 2020.

Low Mass sensitivity



Ionization yield in Argon

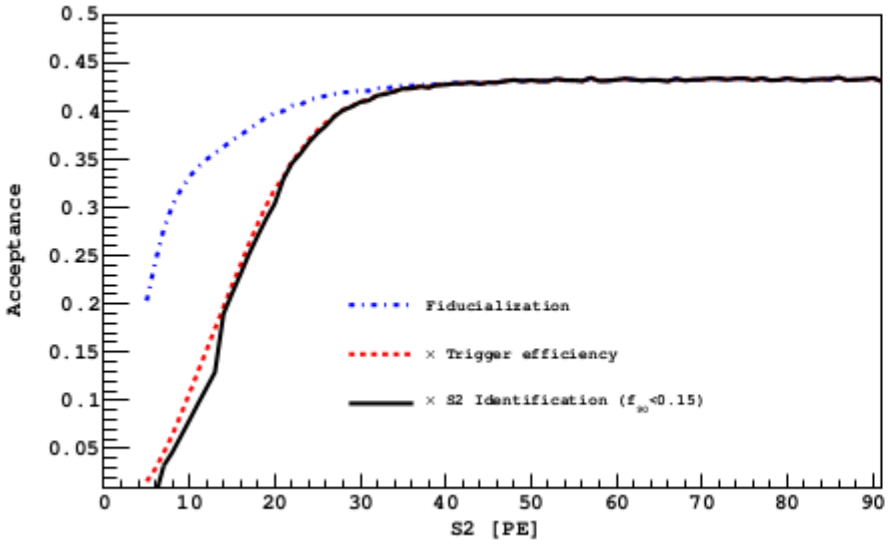
- Argon is sensitive to 2-10 GeV WIMPs if nuclear recoil detection threshold is <=1 keV^{ne}
- No ER/NR discrimination (detection based on spectral shape)
- Sensitivity depends on overall background level.

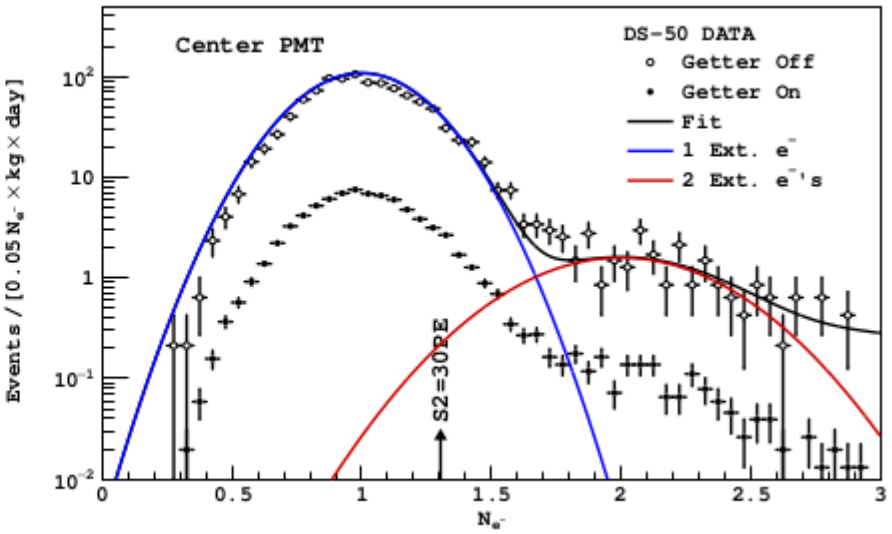
Scintillation signal threshold too high. Ionization signal needs to be used.

For Argon, 1 keV^{ne} → 5-9 electrons

The ionization signal in DS-50

1 electron → 23 PE (at the center of the TPC)



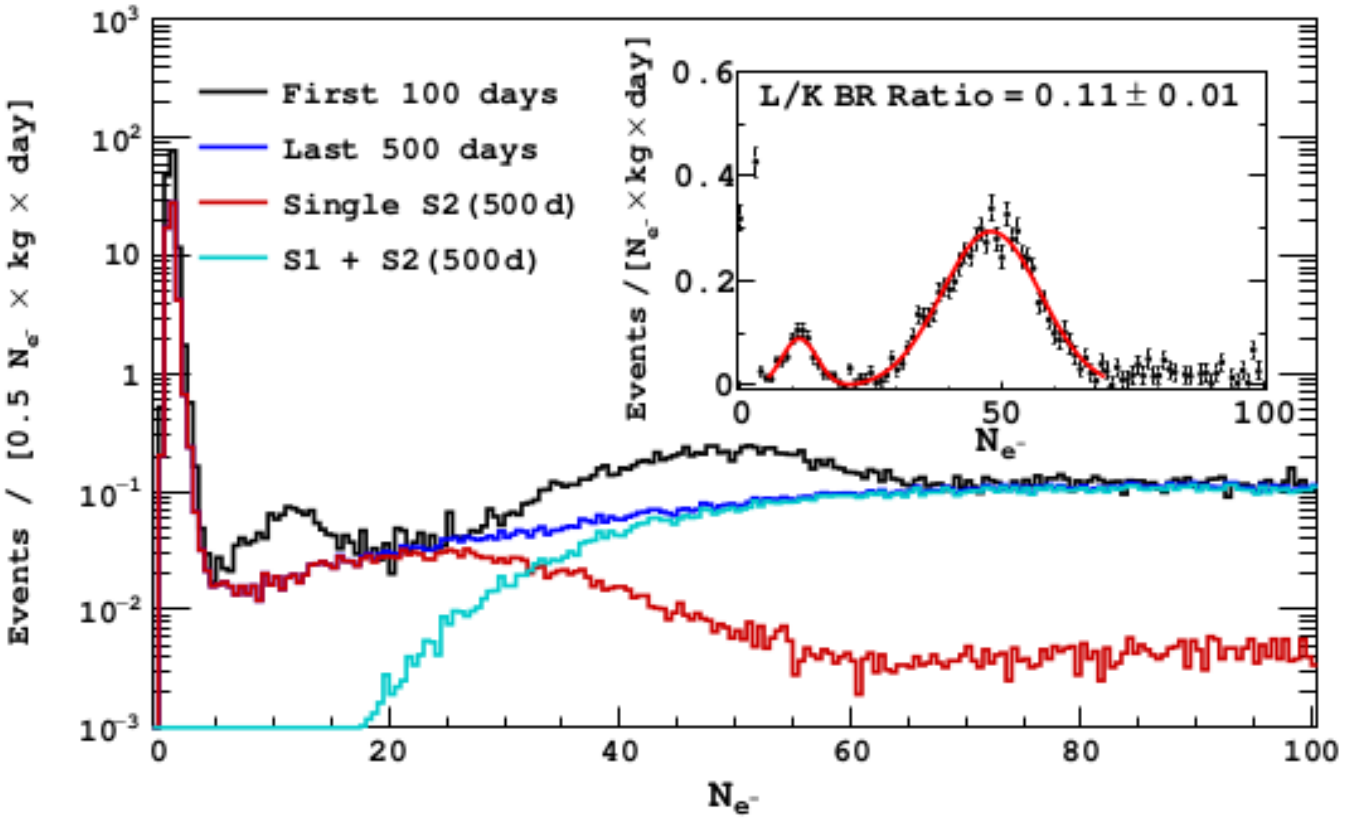


DS-50 is fully efficient for N_e >2

Only events in TPC core are used (less background,a better single electron resolution)

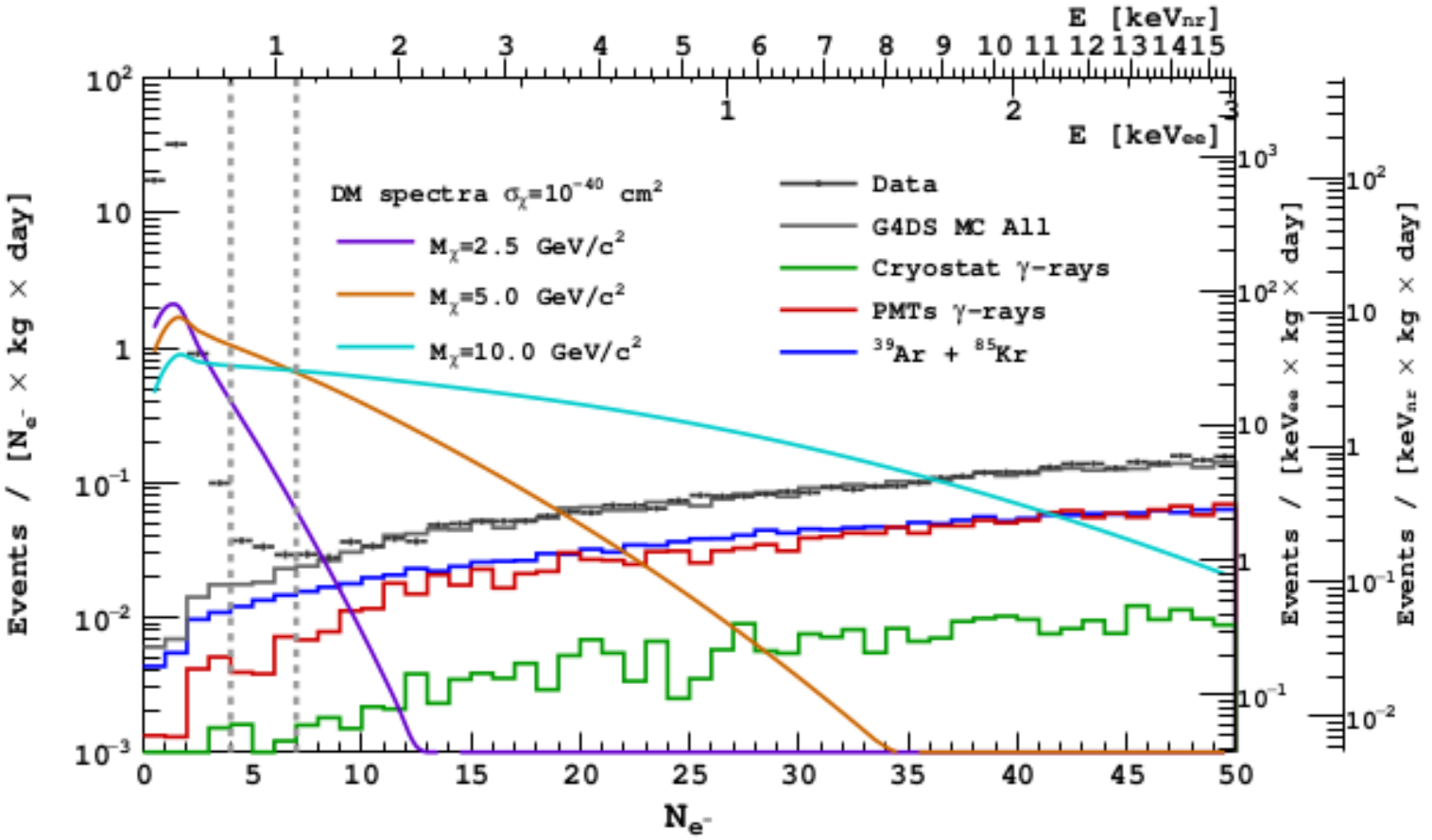
For N_e <3 background is mostly due to impurities.

The N_e spectrum in DS-50

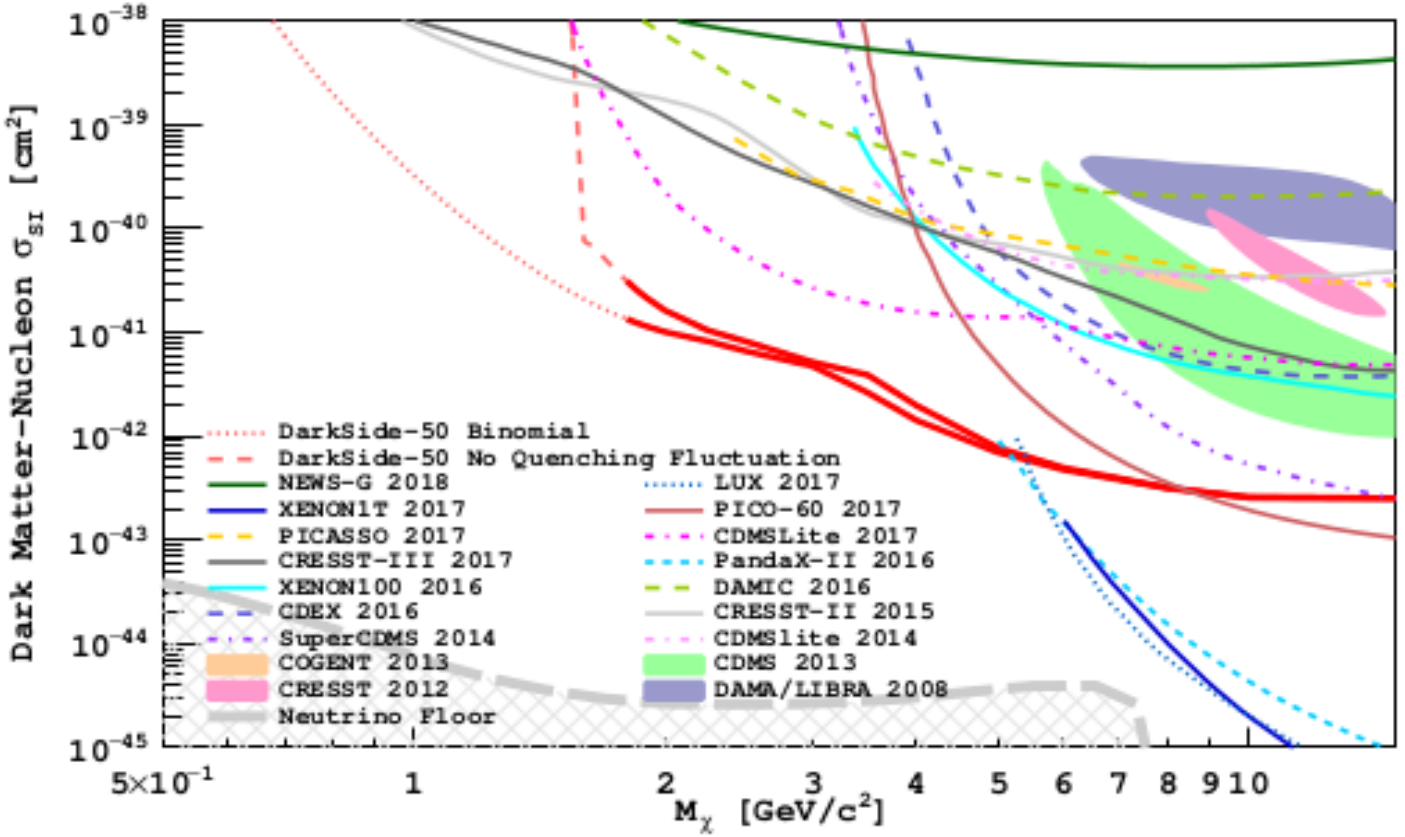


The first 100 days of the UAr run have ^{37}Ar, very useful to calibrate the ER ionization yield at energies as low as 270 eV.

The expected N_e spectrum for WIMPs



The corresponding cross section limits



DS-50 has excellent sensitivity in the 2-10 GeV mass range.

Not possible without **Underground Argon** (1400 lower ^{39}Ar content than Atmospheric)

Very good prospects for DS-20K.

Conclusions

GADMC pursues a sensible search of WIMPs down to the neutrino floor with no experimental background.