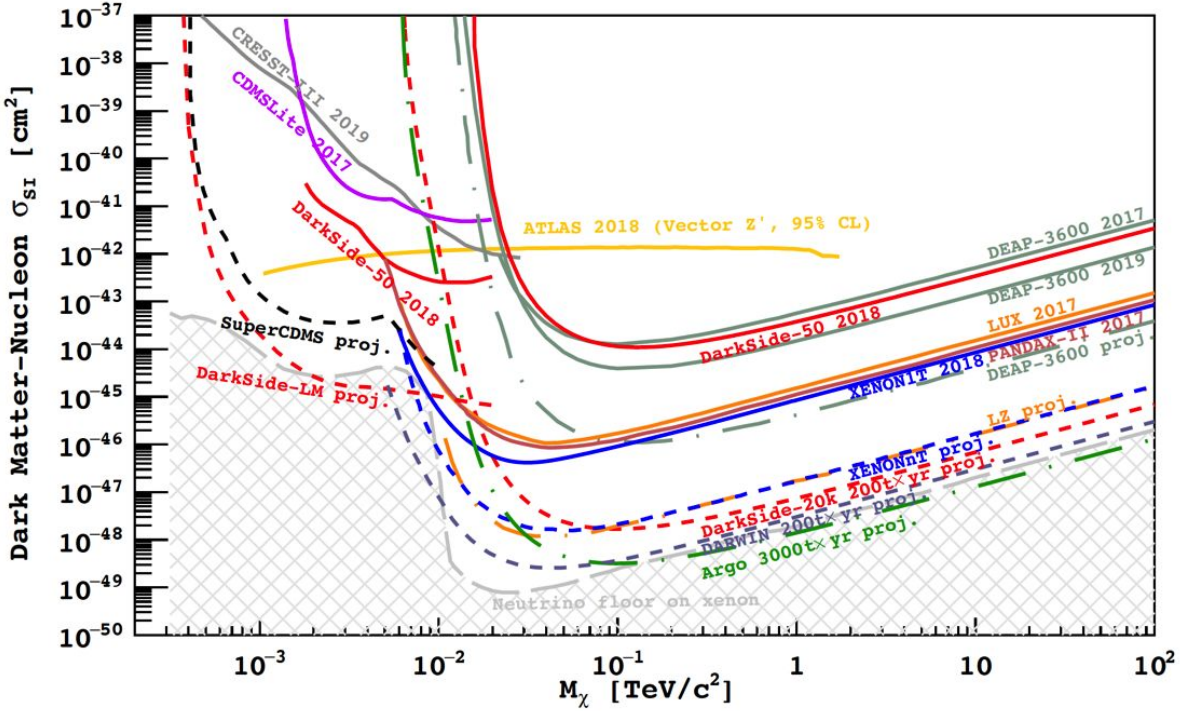
The search for dark matter with liquid argon: DS20-K, ARGO, DEAP 3600 and the Global Argon Dark Matter Collaboration

Aksel Hallin for Canadian Darkside Collaboration

July, 2020

The Physics: Search for Dark Matter

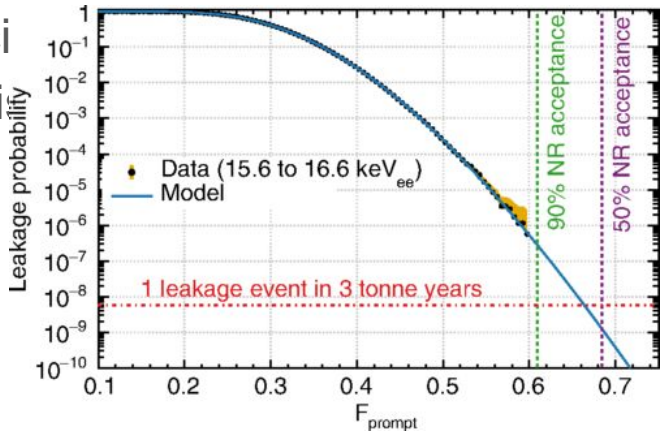


Understanding the detailed nature of dark matter will remain one of the highest physics priorities until it is discovered.

Liquid noble gases offer largest sensitivities to WIMP dark matter, have made large improvements to sensitivities over the past decades and it is reasonable to push them to their ultimate limit, the so-called “neutrino floor”.

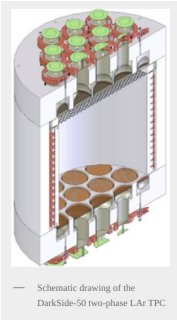
Why argon? Especially compared to xenon?

1. Pulse shape discrimination is much better- means that electromagnetic radiation is not an issue- including solar neutrino elastic scattering. This strong PSD in argon allows a measurement free of detector-related-backgrounds and thus better discovery potential than xenon at the 10-100 ton scale.
2. Different/lower backgrounds/radioactivities
3. Systematically very different: for something as cruci needs more than one experiment in order to establi also be the case for a limit.
4. Inexpensive(?). Underground argon exists.



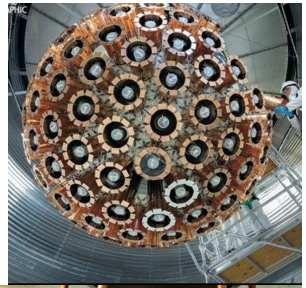
DEAP results (PhysRev D.100.022004)

The plan: to the neutrino floor (and beyond a bit)

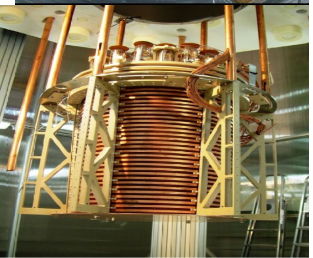


Schematic drawing of the DarkSide-50 two-phase LAr TPC

DS-50, 2 phase,
Underground argon
LNGS

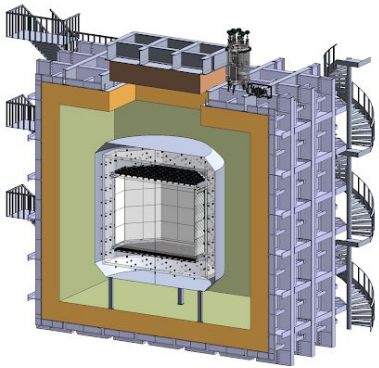


DEAP, 3600 kg
Single phase
Atmospheric Argon
Backgrounds
Acrylic cryostat
SNOLAB



WARP
100 l, 2 phase
AAr
LNGS

Global Argon Dark Matter Collaboration
447 people, 67 institutions, 13 countries

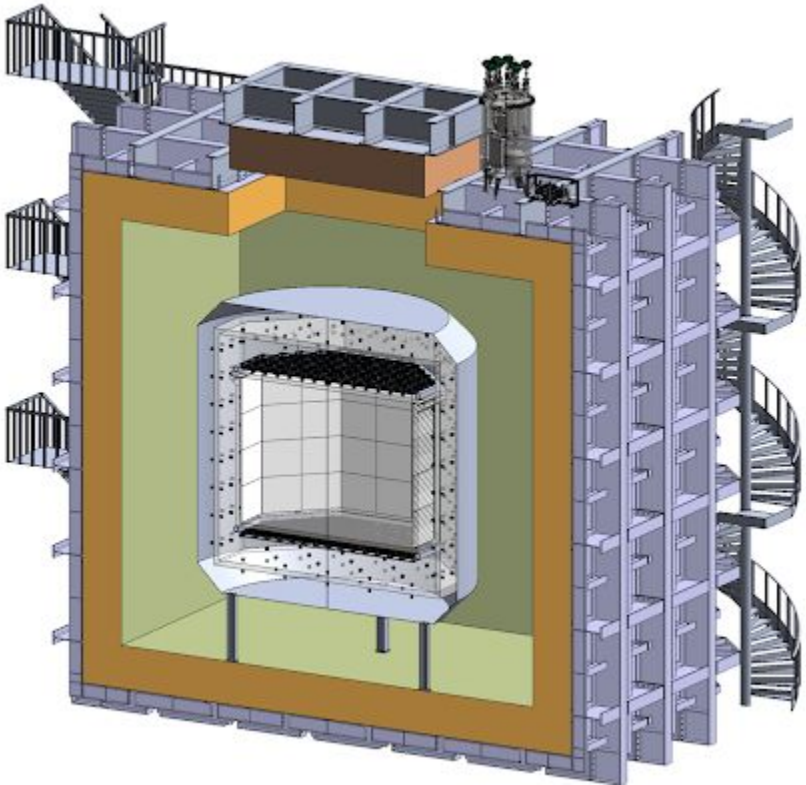


50T UAr (^{39}Ar rate<DEAP)
2 phase
LNGS(Italy)
2023/24

ARGO

~400 T UAr
Single/dual TBD
SNOLAB
Being developed

DS-20k



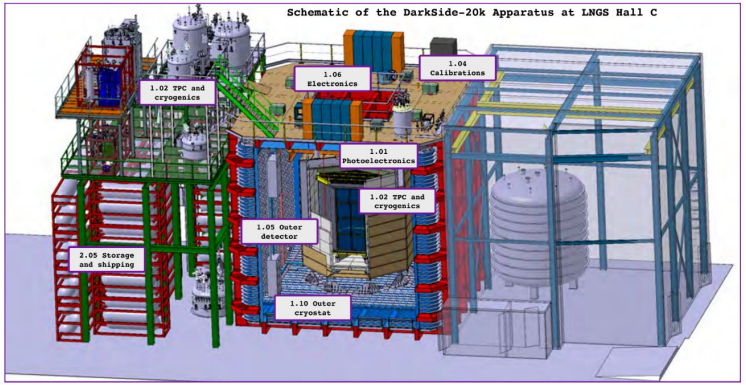


FIG. 3. CAD rendering of the DS-20k experiment in Hall C of LNGS.

1. SiPM's for photodetection (outside acrylic) for both S1(scintillation) and S2(electro-flourescence)
2. All acrylic TPC with LAr (fieldcage, anode and cathode coated with Clevios conductive polymer+TPB wavelength shifter. Reflective panels cover walls.
3. Protodune cryostat with AAr
4. LAr scintillation veto detector for neutrons

Canadian Contributions

- Cryogenic acrylic TPC
- Clevios and TPB coatings of acrylic
- Underground argon, operations, transportation and underground storage
- DAQ
- Electronics
- Material assay and qualification
- SiPM developments

The Team

Name	Institution	FTE
Mark Boulay	Carleton	1.0
Bruce Cleveland	SNOLAB/Laurentian	0.2
Philippe Di Stefano	Queen's	0.6
Pierre Gorel	SNOLAB/Laurentian	0.45
Aksel Hallin	Alberta	0.66
Chris Jillings	SNOLAB/Laurentian	0.75
Szymon Manecki	SNOLAB/Laurentian/Queen's	0.35
Art McDonald	Queen's	0.7
Marie-Cécile Piro	Alberta	0.2
Fabrice Retière	TRIUMF	0.25
David Sinclair	Carleton	0.3
Peter Skensved	Queen's	0.65
Simon Viel	Carleton	0.7

Table 1: Canadian grant eligible members on the project, their institution, and their FTEs

FTE's represe
time on liquid
Argon DM:
DEAP+DS+AR

Funding

CFI: 22.6 M (18 cash) CFI IF proposal in current round. Roughly equally between acrylic/TPC, underground argon/coatings, electronics/SiPM development

NSERC: 180k this year, will be requesting more as we ramp up on construction.

Will also be an R&D for ARGO submission this year.

Significant past investments, as detailed in Mark Boulay's talk.

Summary

There is an active liquid argon direct dark matter detection program, with significant Canadian involvement. DS-20k is the next logical step.