

2022/06/09

SNOLAB Director Report

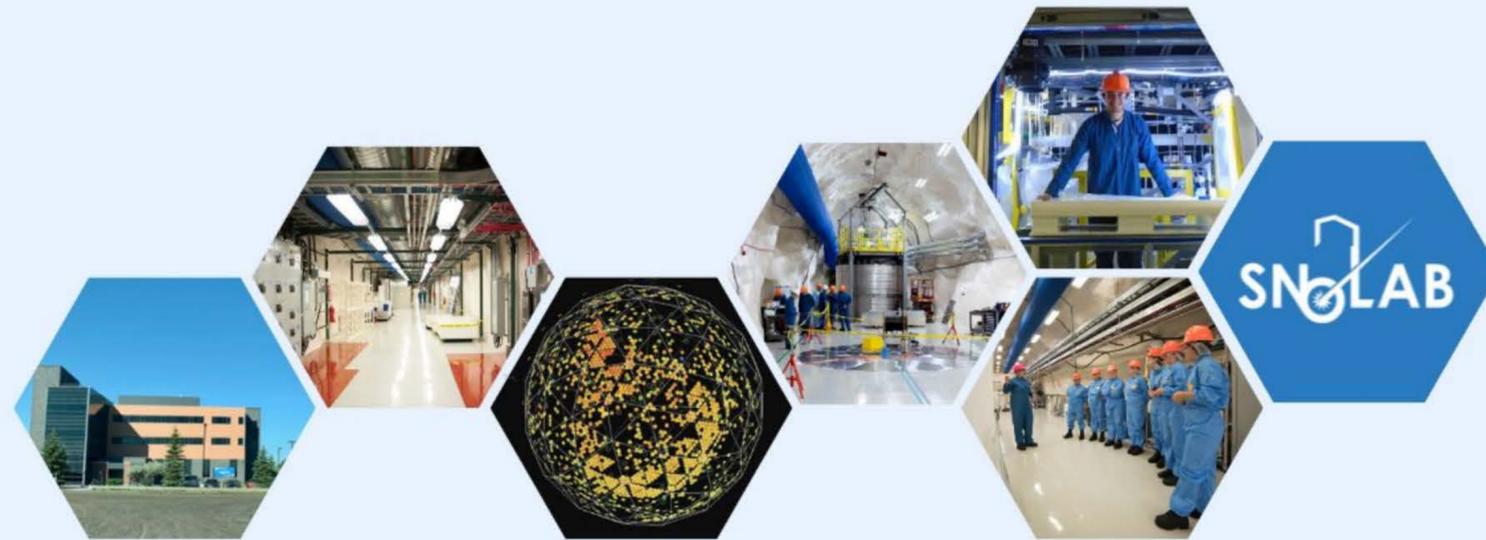
Joint CINP-IPP Session at CAP2022

C.J. Virtue
iED

10

years of SNOLAB science

#SNOLAB10



Partner Universities



Partners



Agenda



- Experimental Programme
- Science Highlights
- tonne-scale $0\nu\beta\beta$ program nEXO and LEGEND-1000
- Funding

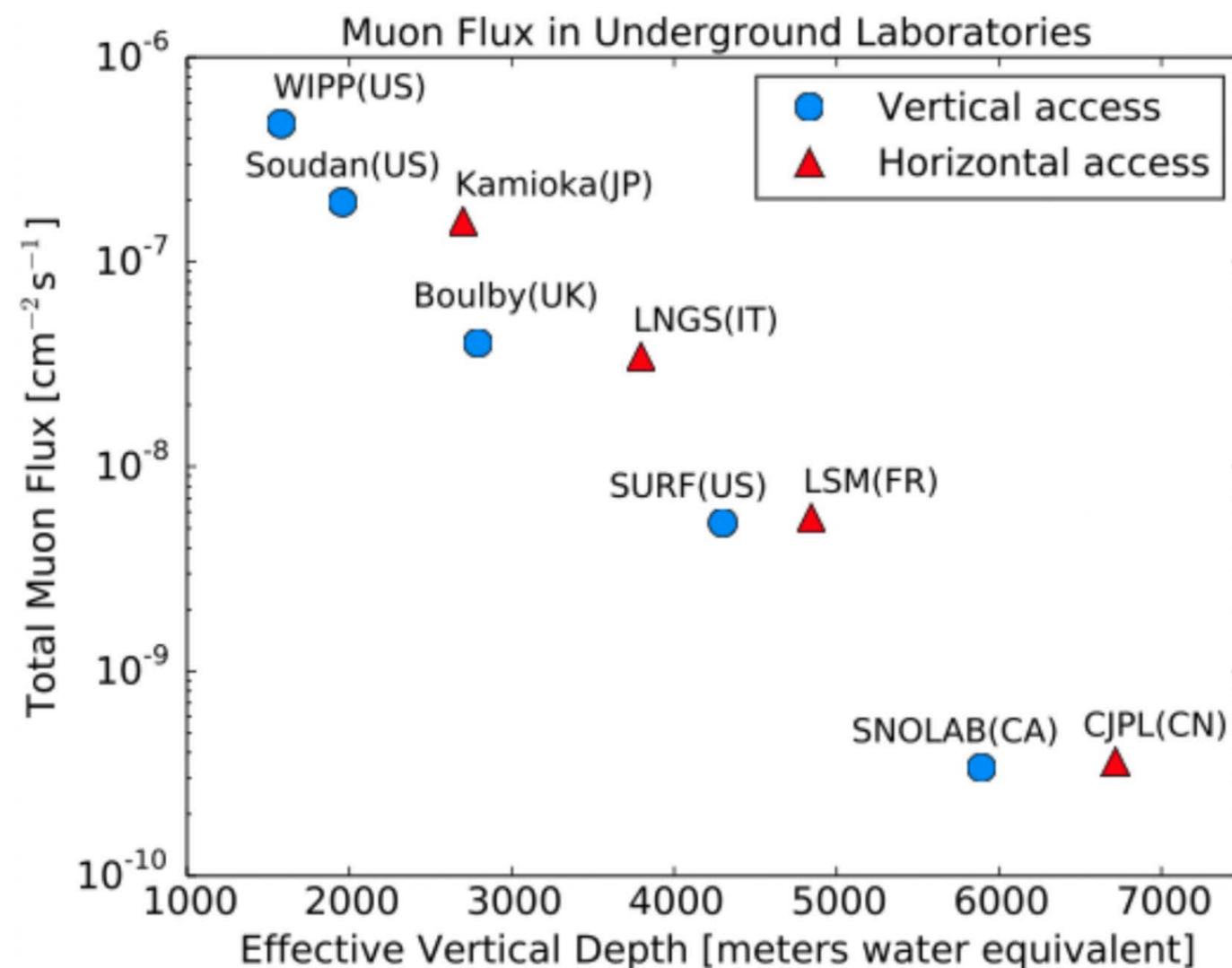


Figure 8 This plot shows the muon flux vs depth for underground laboratories around the world. Note that China hosts the deepest laboratory, but SNOLAB has the lowest muon flux due to having flat land overburden versus a mountain topology. This figure is adapted from Guo *et al.*, Chinese Physics C45, 025001 (2021).



Experimental Programme

Experiment	Research Focus					Status	
	Dark Matter	Neutrino $0\nu\beta\beta$	Neutrino Other	Supernova	Other	Space allocated	Phase
Ar2D2	√				Low-rad argon	LBL	Letter of Intent
ARGUS-I	√	√			Ar storage	4000L	Letter of Intent
COUPP-4	√					Ladder Labs	Completed
CTBT-HPGe					Low background	LBL	In construction
CUTE	√				Test facility	Ladder Labs	Operational
DAMIC	√					J-Drift	Operational
DEAP-1	√					J-Drift	Completed
DEAP-3600	√					Cube Hall	Completed
DEAP-3600-II	√					Cube Hall	In construction
ECUME					Cu electroform	Cube Hall	In design
FLAME					Genomics	Bio/chem lab	Operational
HALO				√		Exp. Stub	Operational
LEGEND-1000		√				Cryopit	In design
LNG-CTF					Cryogenics	Surface Facility	In design
MiniCLEAN	√					Cube Hall	Completed
MODCC					Mining data	Surface Facility	Completed
nEXO		√				Cryopit	In design
NEWS-DM	√					Cube Hall	Discontinued
NEWS-G	√					Cube Hall	Operational
OSCURA	√					J-Drift	Letter of Intent
PICASSO-III	√					Ladder Labs	Completed
PICO-2L	√					J-Drift	Completed
PICO-60	√					Ladder Labs	Completed
PICO-40L	√					Ladder Labs	Operational
PICO-500	√					Cube Hall	In preparation
PUPS					Seismicity	External drift	Completed
SBC	√					Ladder Labs	In preparation
SENSEI	√					J-Drift	Operational
SNO+ (H2O)			√	√		SNO Cavity	Completed
SNO+ (LAB)			√	√		SNO Cavity	Operational
SNO+(Te)		√	√	√		SNO Cavity	In construction
SuperCDMS	√					Ladder Labs	In construction
REPAIR					Genomics	Bio/chem lab	Operational
Xe-Still					Cryogenics	Cryopit	Operational

CERN COURIER | Reporting on international high-energy physics

Physics ▾ Technology ▾ Community ▾ In focus Magazine



NEUTRINOS | FEATURE

The deepest clean lab in the world

30 November 2018

The great depth and cleanliness of SNOLAB allows the study of extremely rare interactions and weak processes.

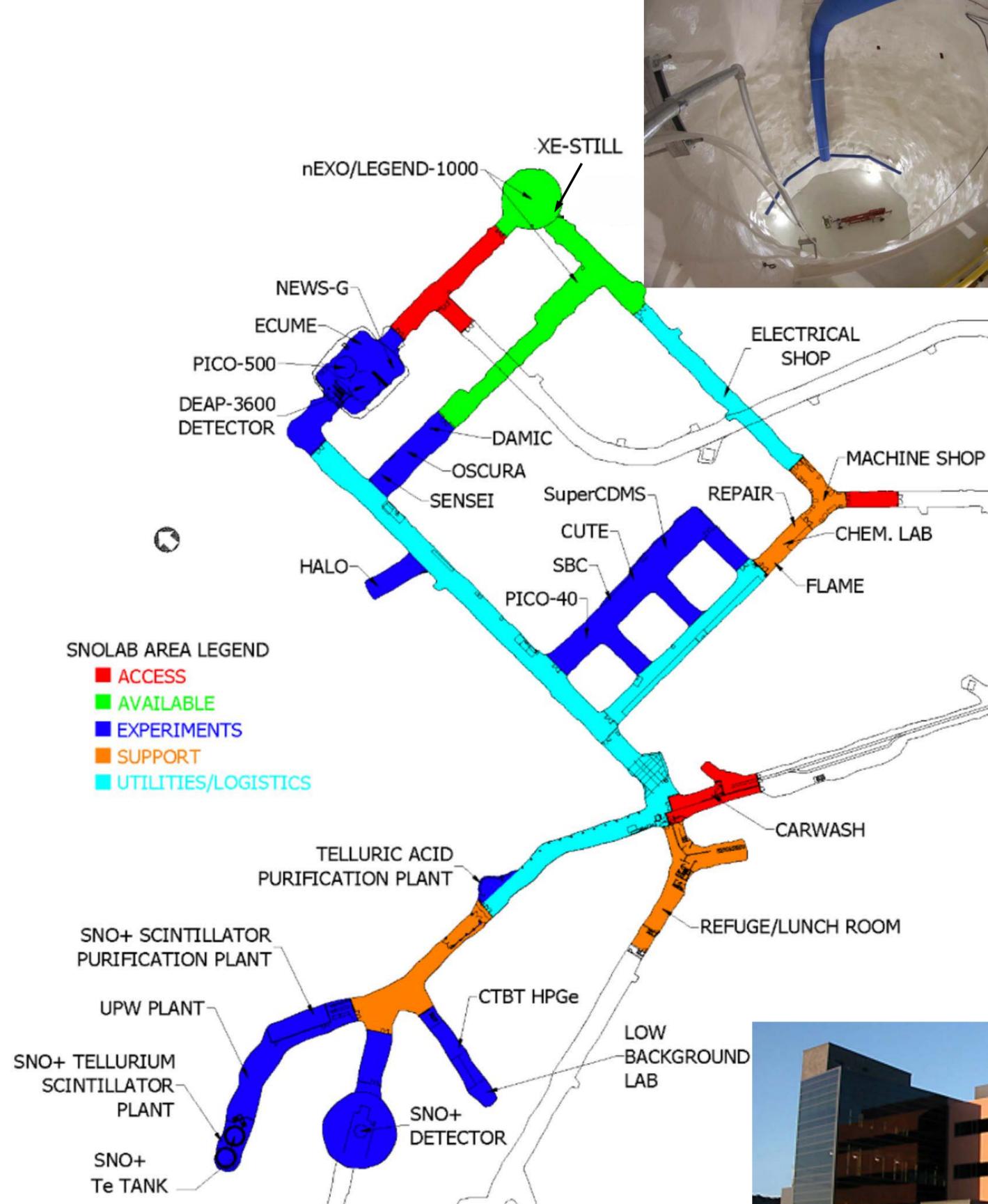


6800' lab layout

(6000 m.w.e. / $0.3 \mu \text{m}^{-2} \text{day}^{-1}$)

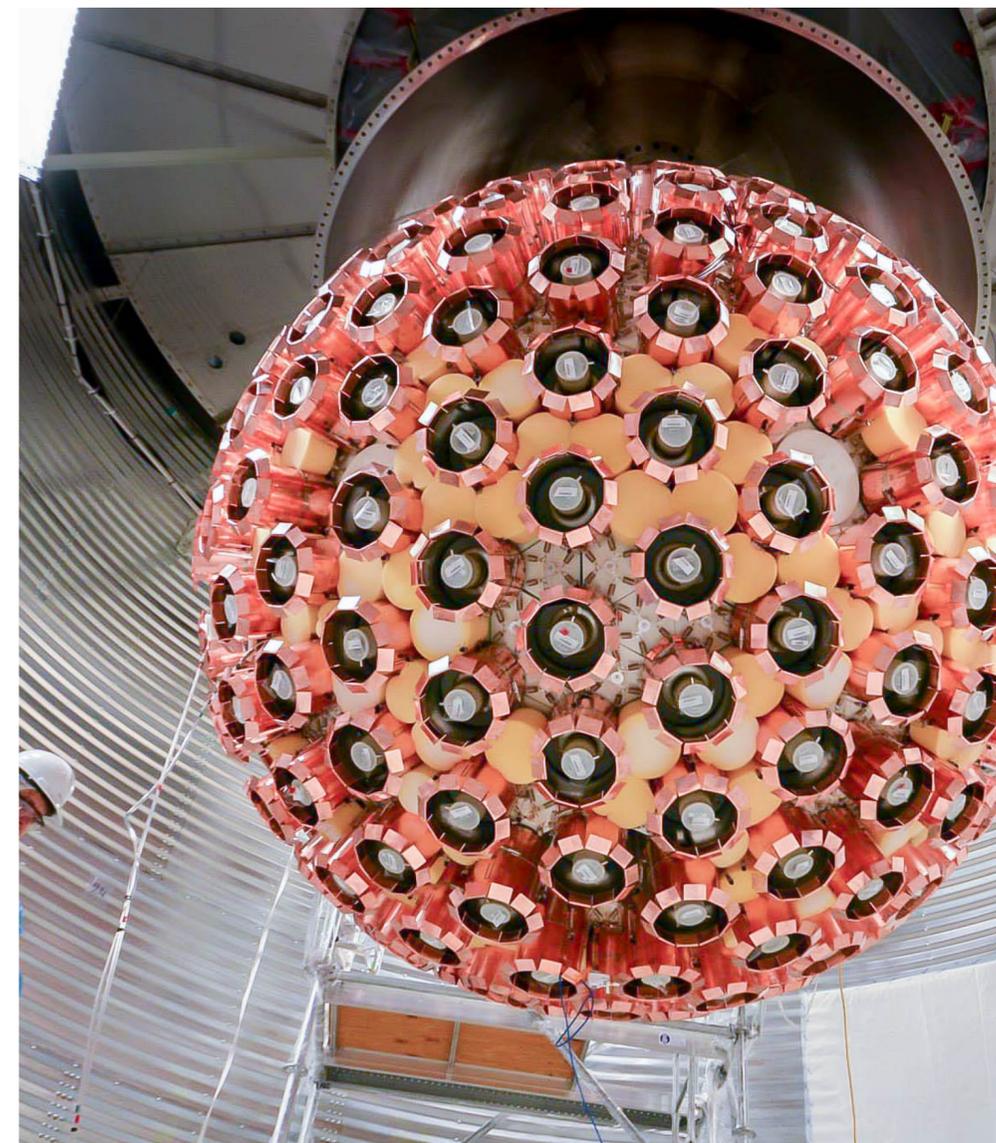
- Cryopit is allocated to the tonne-scale $0\nu\beta\beta$ program
- Otherwise all available space is occupied and actively managed under SNOLAB's project lifecycle program
- A conceptual design for a lab expansion exists...

Map of the underground facility showing locations of experiments and various ancillary areas.



Dark Matter Programme

-
- Liquid Argon Dark Matter
 - DEAP-3600 and MiniCLEAN
 - Aimed at $> 20 \text{ GeV}/c^2$ mass range
 - Low mass dark matter
 - SuperCDMS, NEWS-G, DAMIC, SENSEI, SBC, OSCURA
 - Search below $\sim 10 \text{ GeV}/c^2$ mass range
 - Spin-dependent Dark Matter
 - PICO series (60, 40, 500)



DEAP-3600

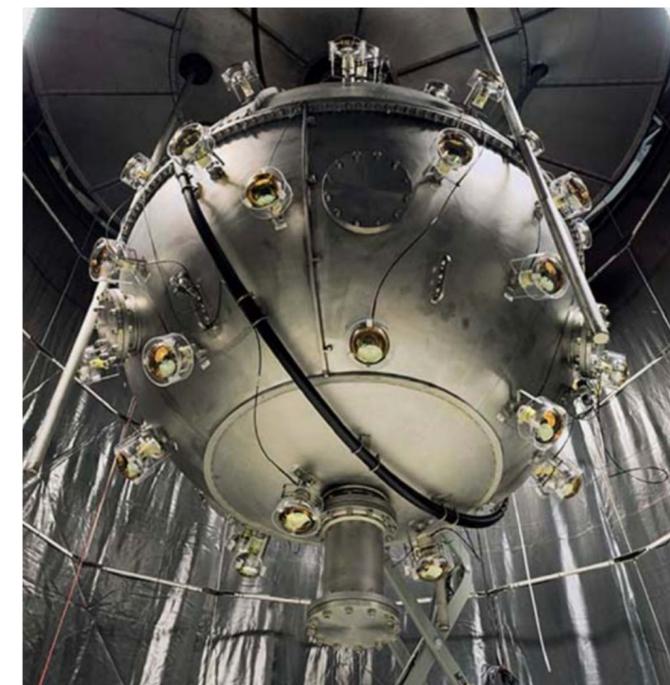
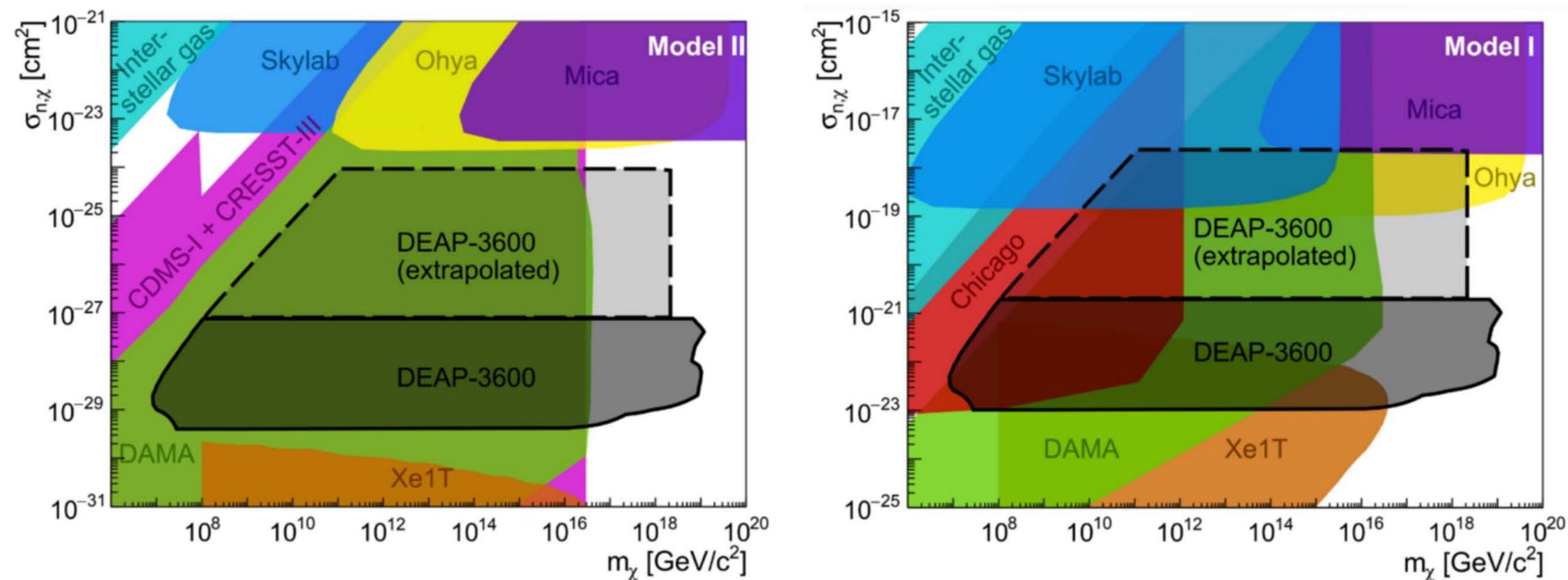


Figure 4 Exclusion regions for very heavy dark matter, in terms of mass m_χ and nucleon scattering cross sections $\sigma_{n,\chi}$ from DEAP-3600, compared to previously published constraints from other experiments. The extrapolated regions exclude regions with cross sections greater than the simulations. P. Adhikari *et al.*, arXiv:2108.09405 [astro-ph.CO] (2021).

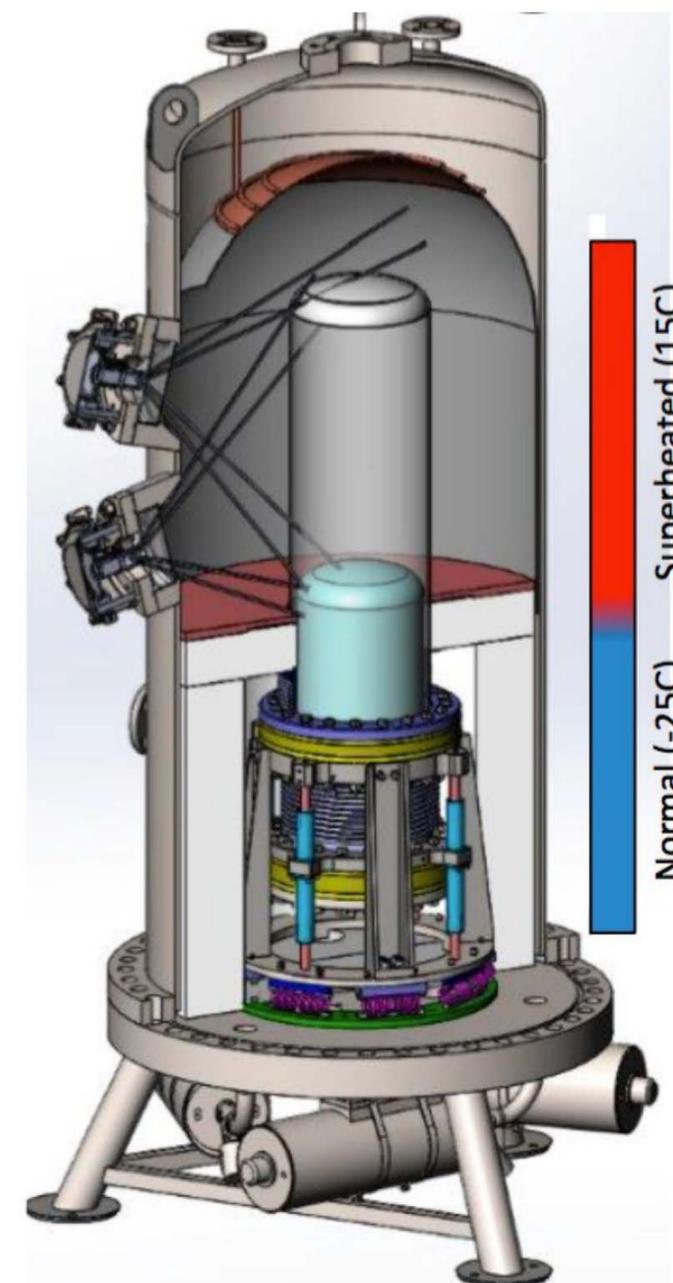
SuperCDMS

- Design is complete and final parts being manufactured
- The SuperCDMS shielding has been test assembled offsite
- SNOLAB infrastructure is largely complete
- The first of four SuperCDMS towers arriving this summer for testing in SNOLAB's Cryogenic Underground Test facility, CUTE
- The SuperCDMS cryostat will be installed and commissioned over the next three years



PICO

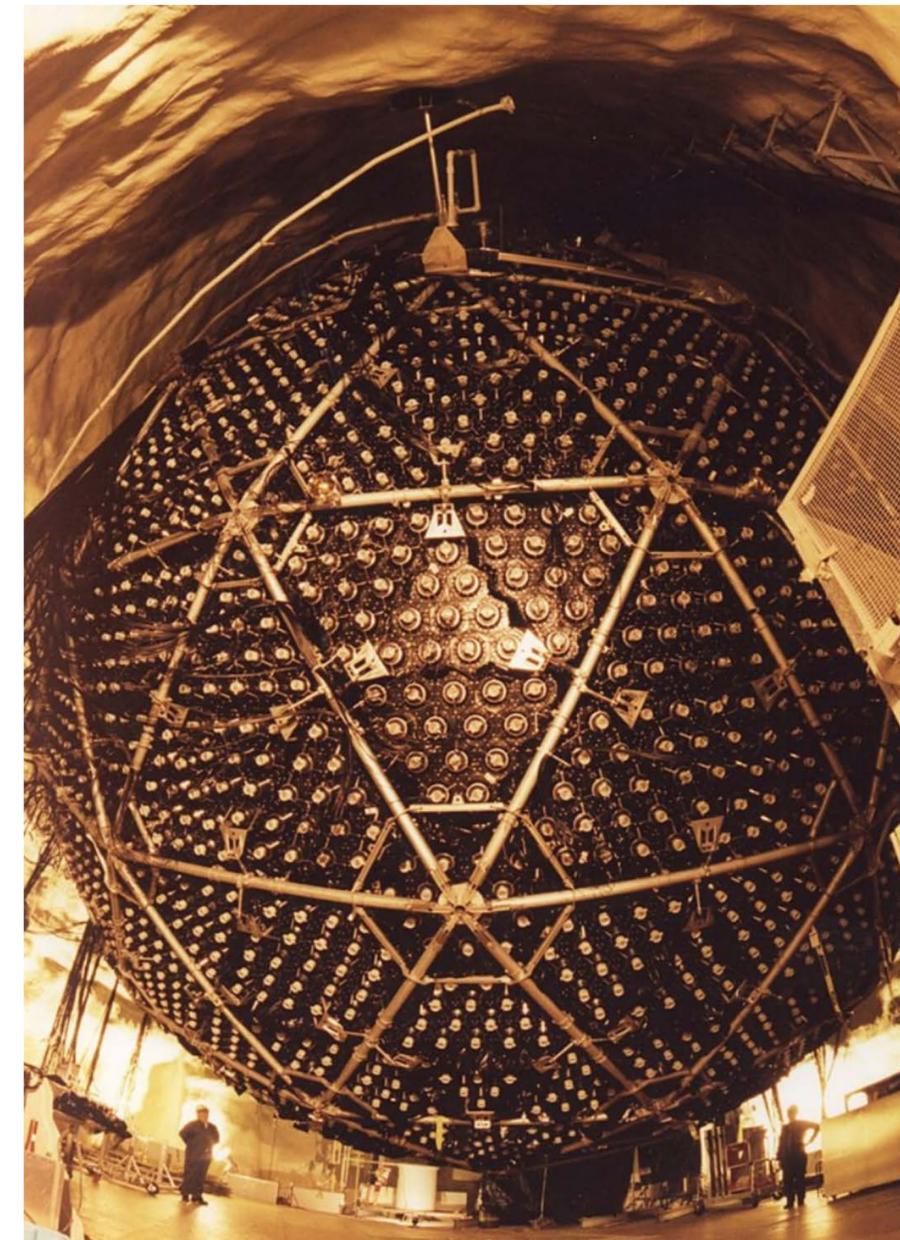
- PICO-60 has published world-leading spin-dependent dark matter limits
- PICO-500 in the Cube Hall is the “right side up” next generation detector
- PICO-40 is an engineering prototype of the right side up design concept
- PICO-40 has completed an engineering run successfully identifying engineering improvements in time for PICO-500
- Plans include another run of PICO-40 with engineering improvements and the installation of PICO-500 in the Cube Hall reusing the MiniCLEAN shielding



PICO-40

Neutrino Programme

-
- $0\nu\beta\beta$ search
 - SNO+ (^{130}Te), nEXO (^{136}Xe), LEGEND-1000 (^{76}Ge)
 - Neutrino detection (solar, terrestrial, reactor)
 - SNO+
 - Supernova neutrino detection
 - SNO+ and HALO



SNO+

- SNO+ has published results from its water-fill phase including a ^8B solar neutrino measurement with impressive backgrounds
- The scintillator fill is complete with 780 tonnes of LAB and 2.2g/L of PPO
- The scintillator-fill phase may result in world-leading reactor-, geo-, and solar neutrino results
- SNO+ is transitioning towards a higher Tellurium-loading project
- SNO+ and SNOLAB are actively engaged in retiring risks associated with operation of the tellurium plants and loaded scintillator chemistry

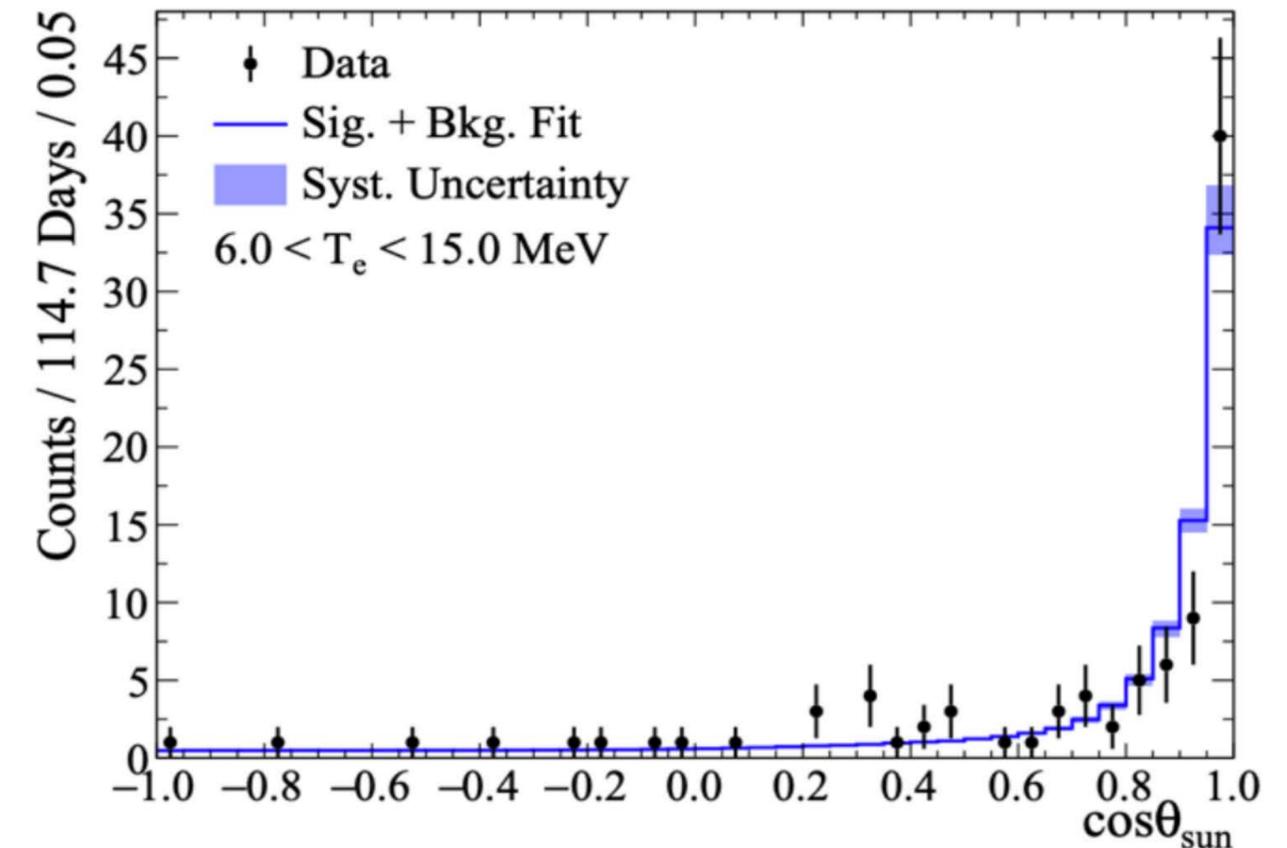
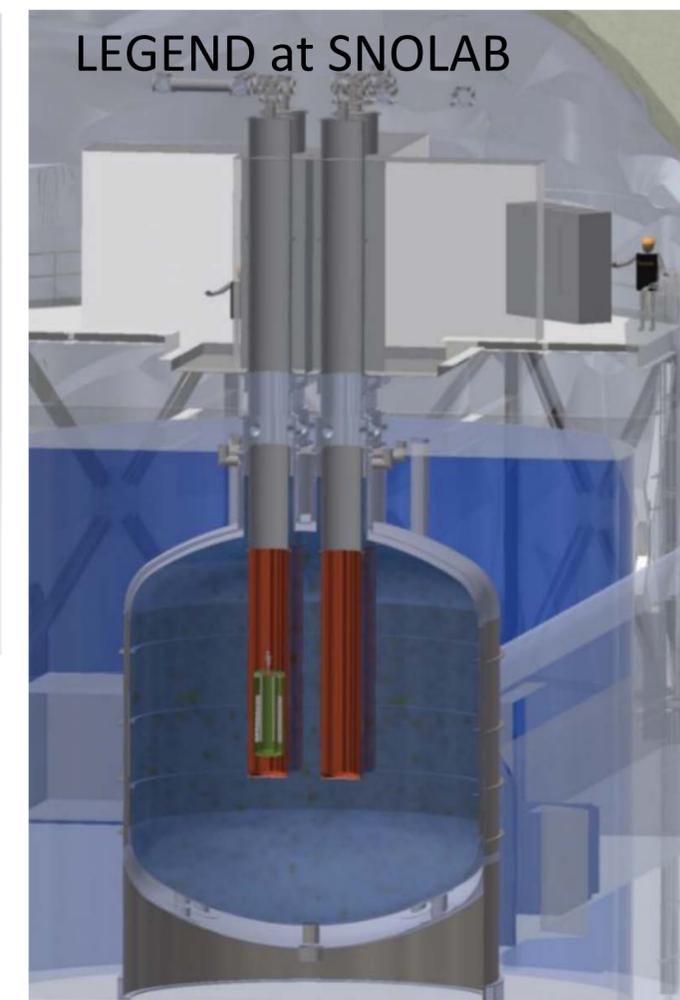
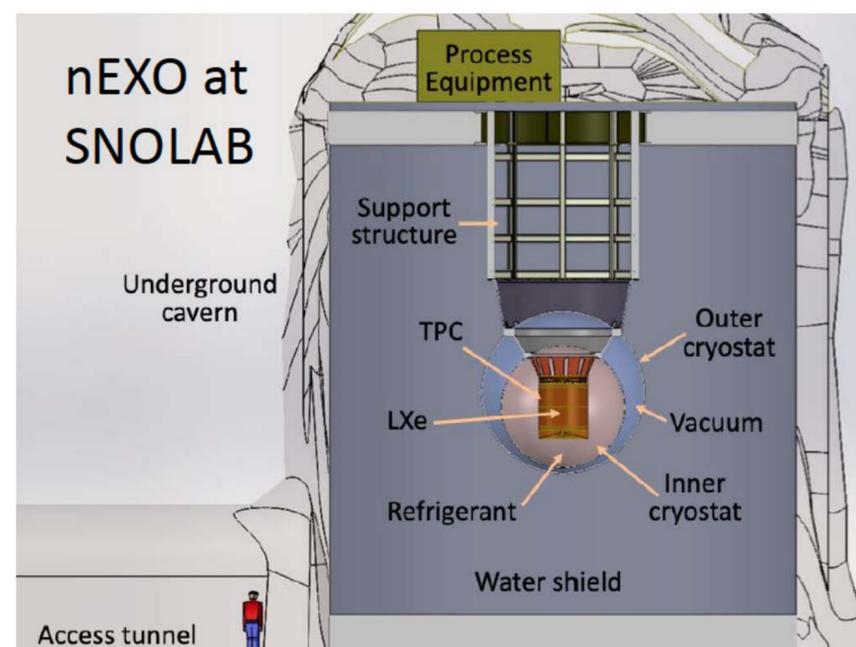


Figure 7 The direction of events in the water-filled SNO+ detector in the energy range 6-15 MeV. The angular distribution shows that most of these events point away from the Sun and are from ^8B fusion in the Sun. This figure is taken from M. Anderson *et al.*, Phys. Rev. D99, 012012 (2019).

Tonne-scale $0\nu\beta\beta$ (nEXO and LEGEND – 1000)

- Both nEXO and LEGEND-1000 aim to reach sensitivities for $0\nu\beta\beta$ decay times beyond 10^{28} years
- DOE $0\nu\beta\beta$ portfolio review held in July 2021
- Followed by international summit in September 2021
- International consensus that both experiments should be constructed
- Both experiments have SNOLAB as their preferred location (cyropit)
- SNOLAB is currently working closely with both collaborations through a coordinated DOE CD-1 and SNOLAB GW-1 process with SNOLAB research scientists and level 2 managers a part of both of these DOE projects



Additionally...

- SNOLAB has recently commissioned its surface diesel generator for high-availability underground power, important for cryogenic detectors
 - 3 MW backup diesel generator to power entire UG lab
 - Successfully powered the lab through a week-long outage between Christmas and New Years during Vale sub-station work



2023-2029 MSI competition context

- CFI MSI total envelope for 2017-2023 was \$660 M
- This funded 16 projects including SNOLAB \$76.4 M (11.6% of envelope)
- For 2023-2029 competition the envelope remains unchanged at \$660M, but
 - New projects were invited to submit LOIs
 - 18 LOIs were selected to submit full proposals
 - So 34 projects seeking funding
 - SNOLAB ask was for \$128.8 M (19.5% of envelope)
 - All projects were asked to address 15 % and 30% reduction scenarios

2023-2029 MSI competition timeline

-
- NOI submitted September 20th, 2021
 - \$117 M CFI MSI
 - \$41.5 M ORF
 - \$81.7 M Vale in-kind
 - Total project \$240.2 M
 - Full application submitted November 4th, 2021
 - \$128.8 M CFI MSI
 - \$32.4 M ORF
 - \$81.7 M Vale in-kind
 - Total project \$242.9 M
 - Expert Committee Meetings
 - Feb. 22nd – Scientific Excellence & International Competitiveness (10 + 50)
 - Feb. 24th - Need for the CFI funding, Operations and User Access, and Excellence in Management (10 + 50)
 - Feb 25th – Excellence in Governance (30)
 - Funding decisions – May; Announcements – June 22

Breakdown	FTE Evolution								
	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29
Directorate	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Corporate Services Division	22.1	23.4	25.7	29.0	31.5	32.0	32.0	32.0	32.0
Projects Division	22.5	28.5	33.5	36.0	36.5	37.0	37.0	37.0	37.0
Research Division	35.2	36.7	40.0	42.0	46.0	48.0	48.0	48.0	48.0
Operations Division	46.0	49.0	49.3	52.3	54.8	55.3	55.8	55.8	55.8
Totals	135.7	147.5	158.5	169.3	178.8	182.3	182.8	182.8	182.8
CFI "Administration"	27.1	28.4	31.7	35.0	37.5	38.0	38.0	38.0	38.0
CFI "Scientific and Technical"	108.6	119.1	126.8	134.3	141.3	144.3	144.8	144.8	144.8
Totals	135.7	147.5	158.5	169.3	178.8	182.3	182.8	182.8	182.8

Table 5 Staff FTE evolution broken down by organizational chart divisions and by CFI categories for the last three years of the current MSI award and the six years of this application. Included in the Administration category is the full Corporate Services Division plus the Executive Assistant and Administrative Assistants from the Directorate.

Project Description	Total Project Estimate (\$K)
Redundant Electrical Switchgear	\$1,500
UG Lab Flooring Refurbishment	\$1,000
UG Changerooms/Lunchroom/Workspace Refurbishment	\$1,000
Old Carwash Removal / AHU5 Replacement	\$750
UG AHU4 Replacement	\$250
UG Storage Systems	\$750
UG Machine Shop Upgrade	\$1,000
nEXO/LEGEND-1000 dedicated LN2 plant *	\$5,000
Surface Warehouse Refurbishment	\$500
Surface Building Roof Replacement	\$500
Surface Machine Shop Upgrade	\$1,500
Surface Exterior Improvements	\$300
Total	\$14,050

Table 6 Key facility refurbishment project costs, totalled across all years of the proposal. Note: AHU4 and AHU5 refer to Air Handler Units. * the LN2 plant is split across 2026/27 and 2027/28

A black and white photograph showing a complex scientific experiment setup. The scene is filled with a dense network of pipes, cables, and structural beams. In the center, a person wearing a white lab coat and a cap stands on a metal platform or scaffolding, looking towards the camera. The overall appearance is that of a large-scale, intricate piece of scientific equipment, possibly a neutrino detector like SNOLAB.

Questions?