LUX-ZEPLIN(LZ)
and
Super Cryogenic Dark Matter Search(SCDMS)
Status

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November 21, 2019
HEPAP

Overview

	LZ	SCDMS
Location	SURF	SNOLAB
Countries	5	5
Institutions	37	25
Collaboration Size	~ 250	~ 90
Cost	DOE \$55.5M Overall ~ \$75M	DOE \$18.6M NSF \$12.5M Overall ~ \$34M
Detection Medium	~10 tonnes LXe	25 kg Ge 3.6 kg Si

Project Timelines

Event	LZ	SCDMS
CD-0	Sep 2012(A)	Sep 2012(A)
CD-1	Apr 2015(A)	Dec 2015(A)
CD-2	Aug 2016(A)	May 2018(A)
CD-3	Feb 2017(A)	
CD-4(Early Finish/ Milestone)	Jul 2020/ Mar 2022	Sep 2020/ Sep 2021
Start 1st Science Run	Aug 2020	Jan 2021
Decomm. or Upgrade	2026	2026

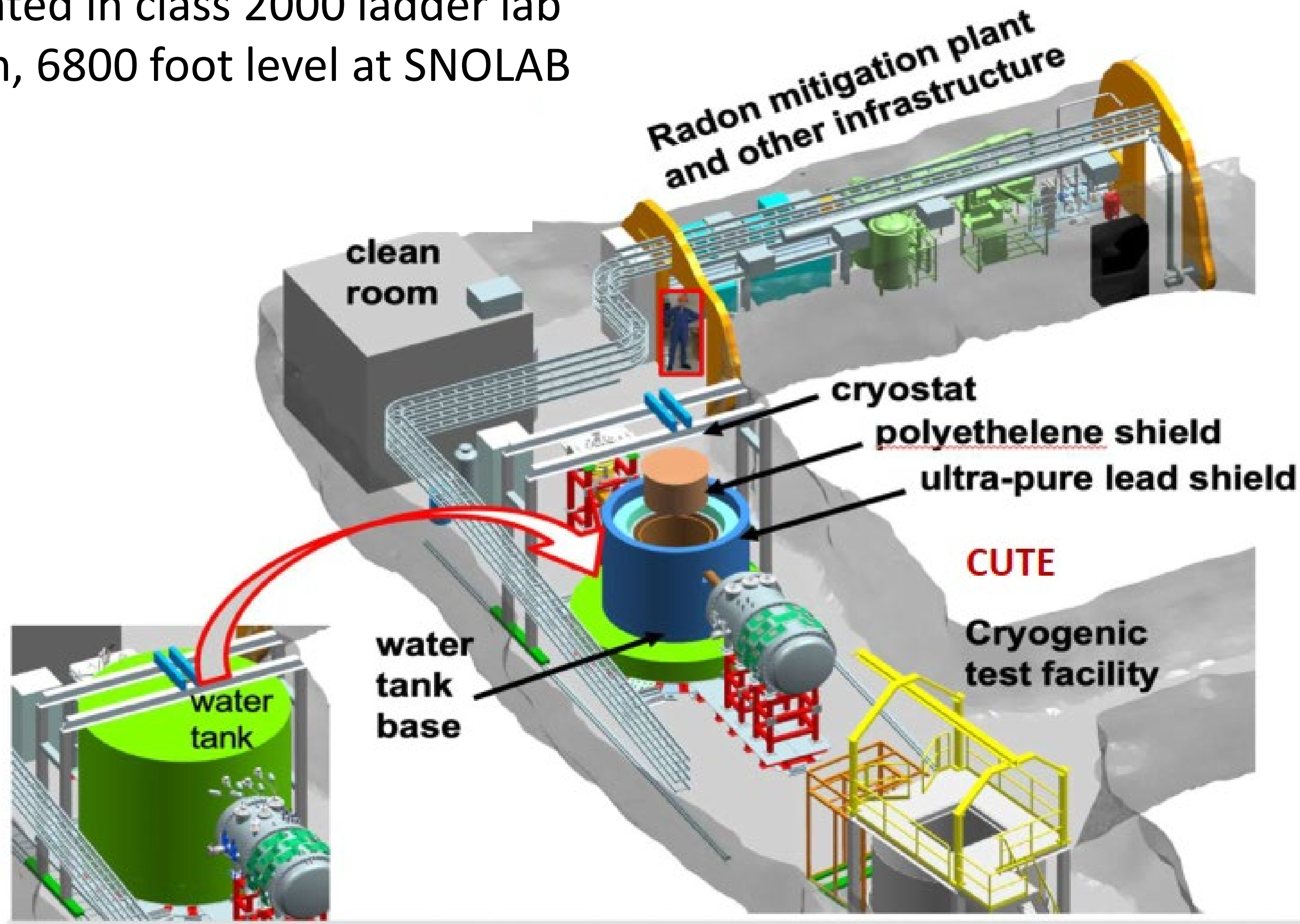
SuperCDMS Collaboration: ~ 90 physicists at 25 institutions worldwide, 3 US national labs, 2 Canadian labs

California Inst. of Tech.
CNRS-LPN*
Durham University
FNAL
NISER
NIST*
Northwestern
PNNL
Queen's University
Santa Clara University
SLAC
South Dakota SM&T
SMU
SNOLAB
Stanford University
Texas A&M University
TRIUMF
U. British Columbia
U. California, Berkeley
U. Colorado Denver
U. Florida
U. Montréal
U. Minnesota
U. South Dakota
U. Toronto

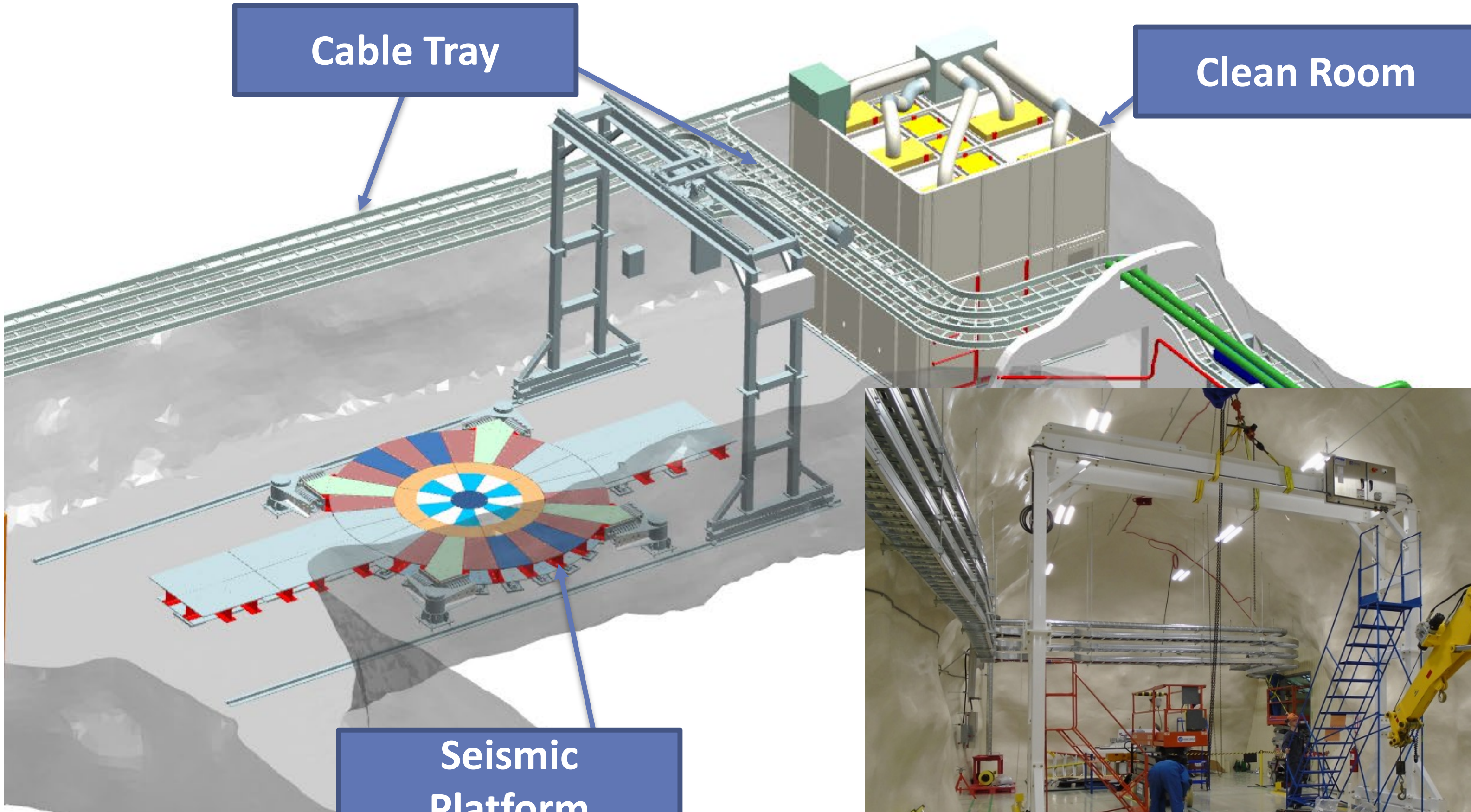
* Associate members

SuperCDMS Detector Overview

To be located in class 2000 ladder lab cleanroom, 6800 foot level at SNOLAB



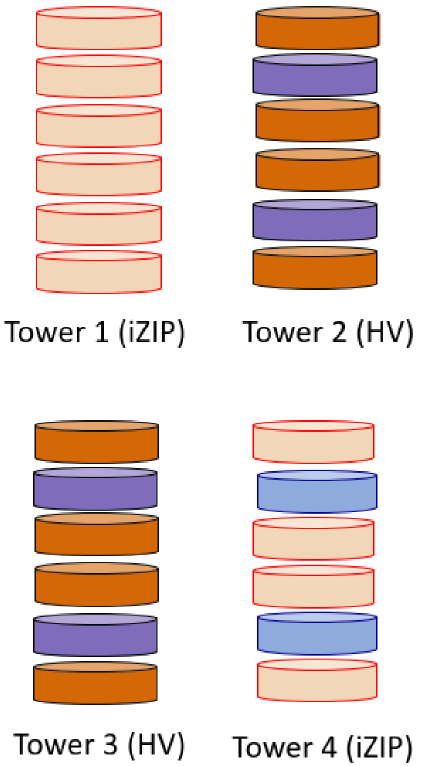
Infrastructure Status at SNOLAB



Initial 4-Tower payload to meet G2 DM science goals

Complementary Targets and Multiple Functionality

	Germanium	Silicon
HV	Lowest threshold for low mass DM Larger exposure, no ^{32}Si bkgd	Lowest threshold for low mass DM Sensitive to lowest DM masses
iZIP	Nuclear Recoil Discrimination Understand Ge Backgrounds Sensitive to ^{8}B ν-scatter	Nuclear Recoil Discrimination Understand Si Backgrounds Sensitive to ^{8}B ν-scatter



For new crystals, (Towers 2,3,4), cosmogenic activation is limited to < 60 days surface exposure [90 ^{3}H atoms/kg/day in Ge]

Stored in N_2 purged containers, Rn exposure tracked for all detectors

Detector Tower Status

- Completed the Transition Edge Sensor(TES) deposition and photolithography for the Tower 2 & 4 endcap detectors
- Completed the solid model for the lids, standoffs, and IR shields and began preparation of fabrication drawings
- Held in-person meeting at vendor to review plans for horizontal and vertical flex cable fabrication → critical path driver for Tower subsystem
- Test wafers for Si HV detectors showed higher T_C than expected
  - Developed multi-pronged R&D plan to reduce T_C for the inner detectors in Towers 2-4
  - Expect main production to start in November

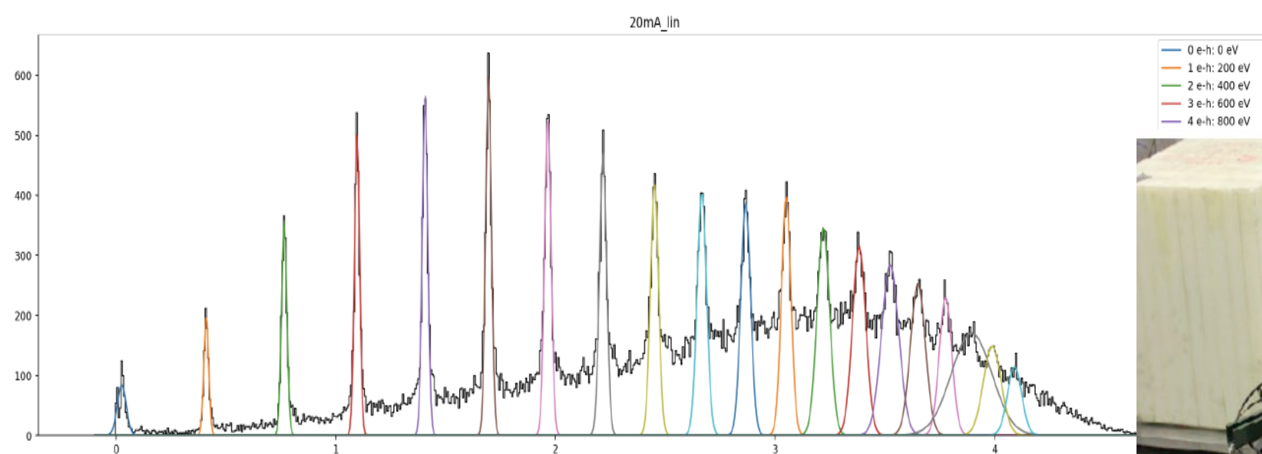
SuperCDMS at SNOLAB: Detector Characterization and Yield Studies Underway

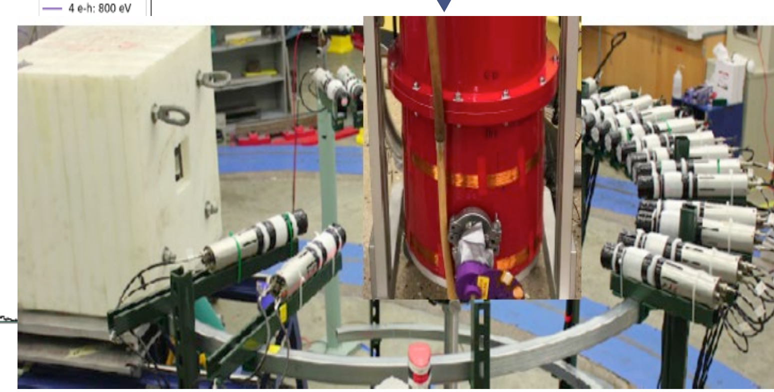
Program to calibrate, characterize, & test detectors well-underway

- Newly-commissioned underground test facilities are up and running
  - NEXUS at MINOS underground Hall at FNAL
  - CUTE facility co-located in SuperCDMS hall at SNOLAB
- First measurement of the intrinsic ionization yield of Si at 50 mK
  - Single e-h detectors with 3 eV resolution in TUNL(=Triangle Universities Nuclear Laboratory) neutron beam
  - Crucial for low mass dark matter reach
  - Si paper published this spring, Ge measurement next year
  - Full-size SuperCDMS detectors at NEXUS using DD generator

CUTE

TUNL Yield measurement

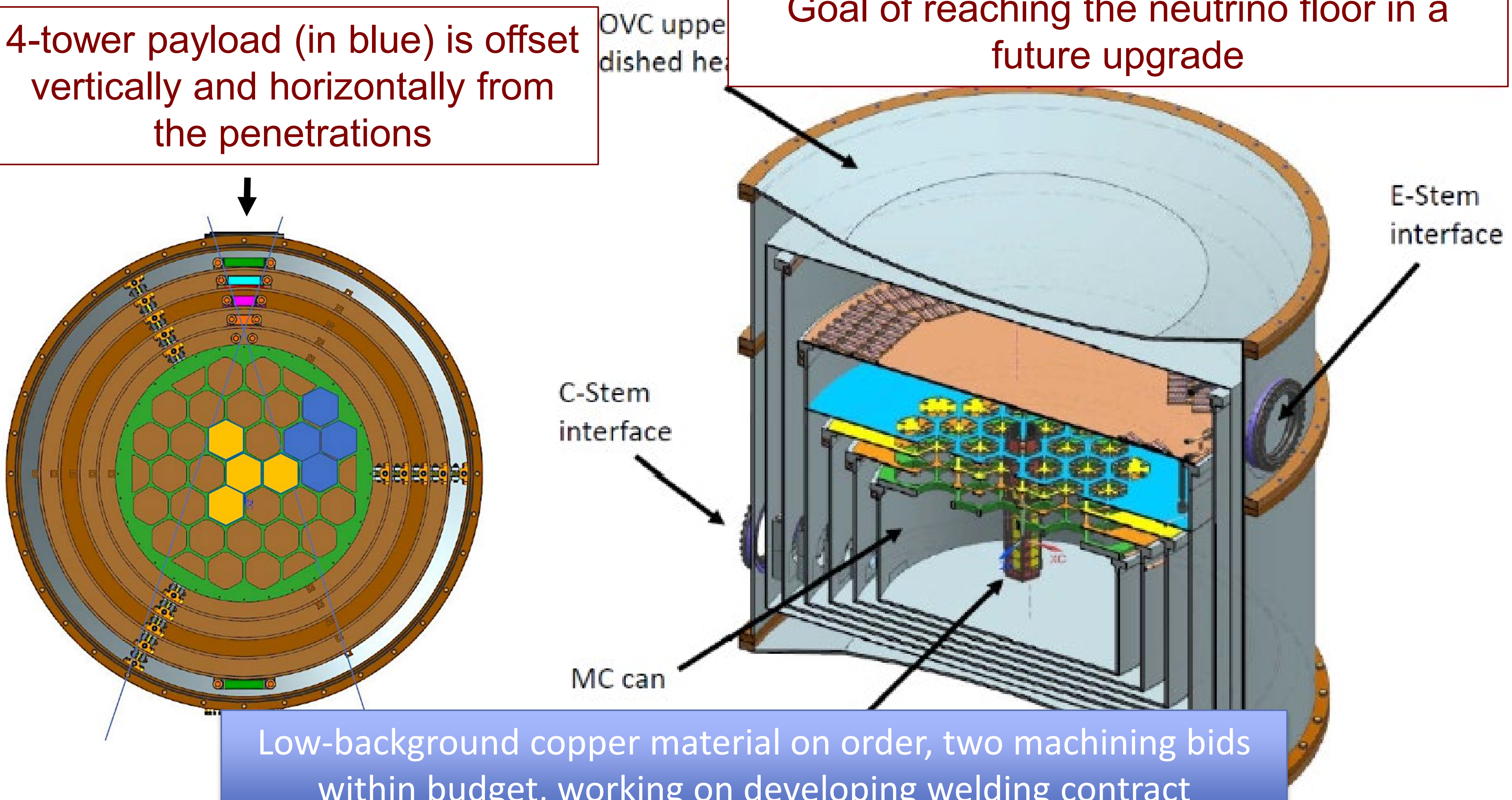




Cryostat Design & Bid Status

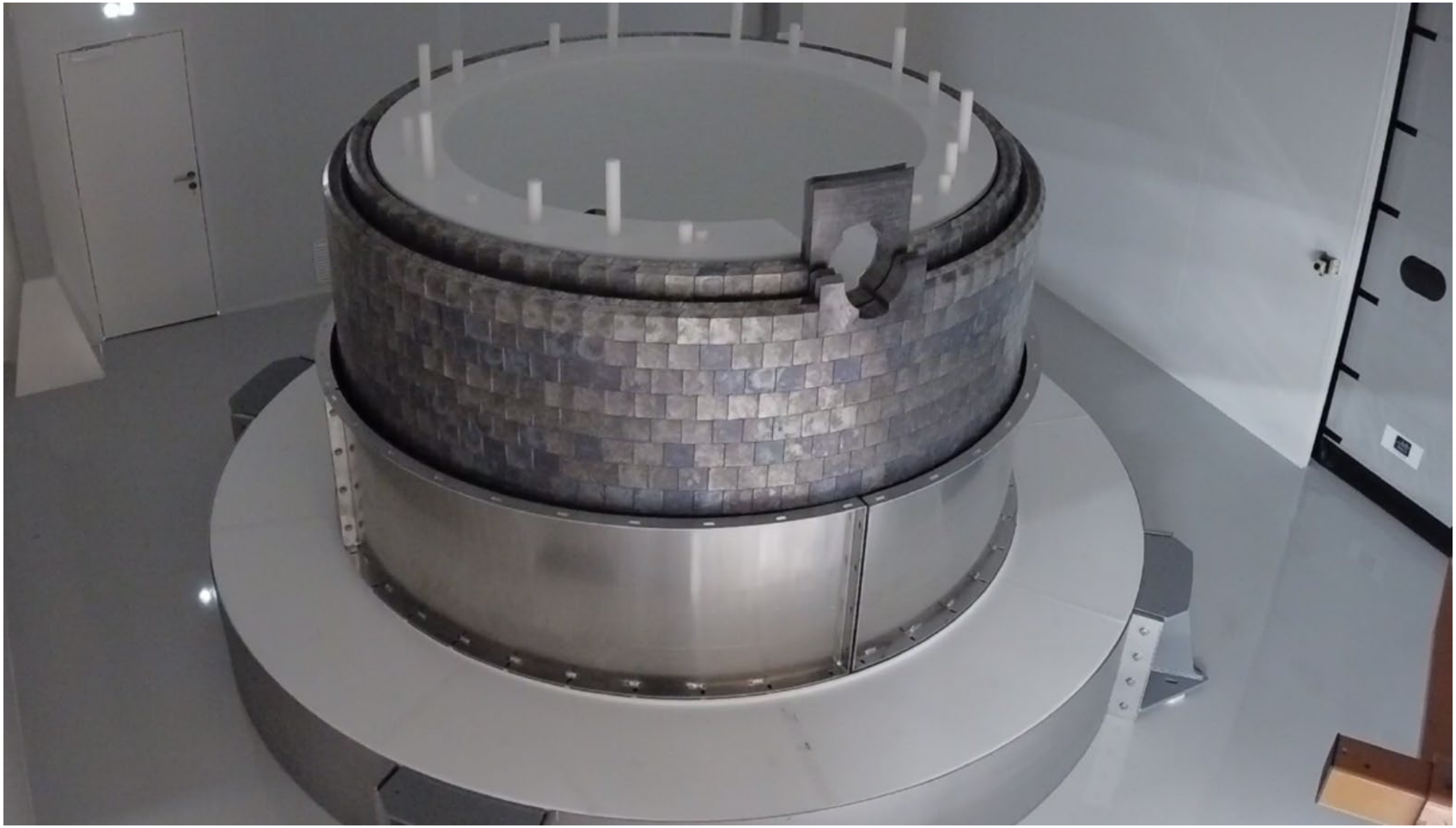
31 Tower capacity to fulfill ultimate Science Goal of reaching the neutrino floor in a future upgrade

4-tower payload (in blue) is offset vertically and horizontally from the penetrations

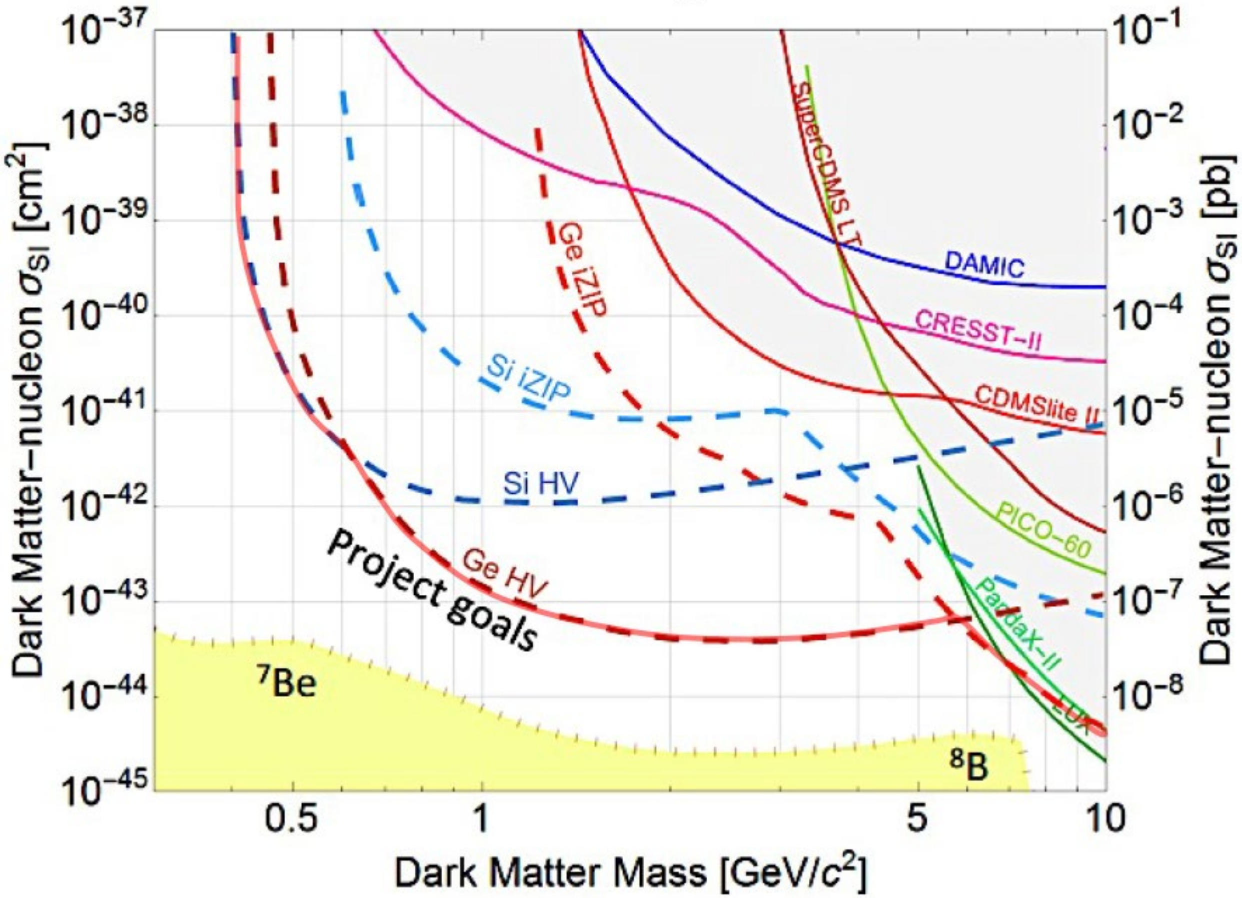


Low-background copper material on order, two machining bids within budget, working on developing welding contract

Pb Shield Pre-assembly at Lemer Pax in France: first shipment now at SNOLAB



4-Tower payload meets project science goals; order of magnitude improvement with background subtraction



Ge HV: Limited by backgrounds tritium (cosmogenic) betas

Si HV: Limited by backgrounds ^{32}Si (and tritium) betas

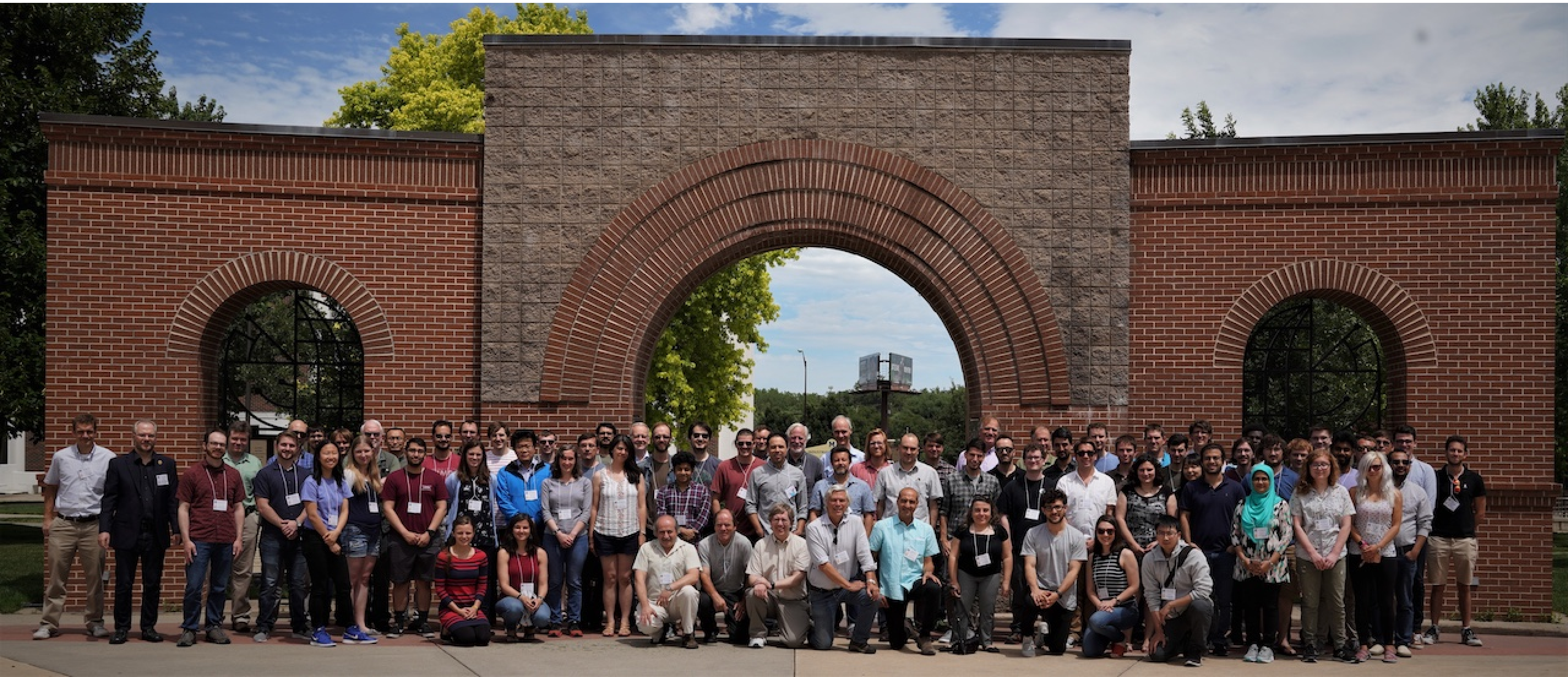
Ge iZIP: Limited by exposure. Excellent ER discrimination

Si iZIP: Limited by exposure Excellent ER discrimination low mass kinematic advantage

LZ Collaboration

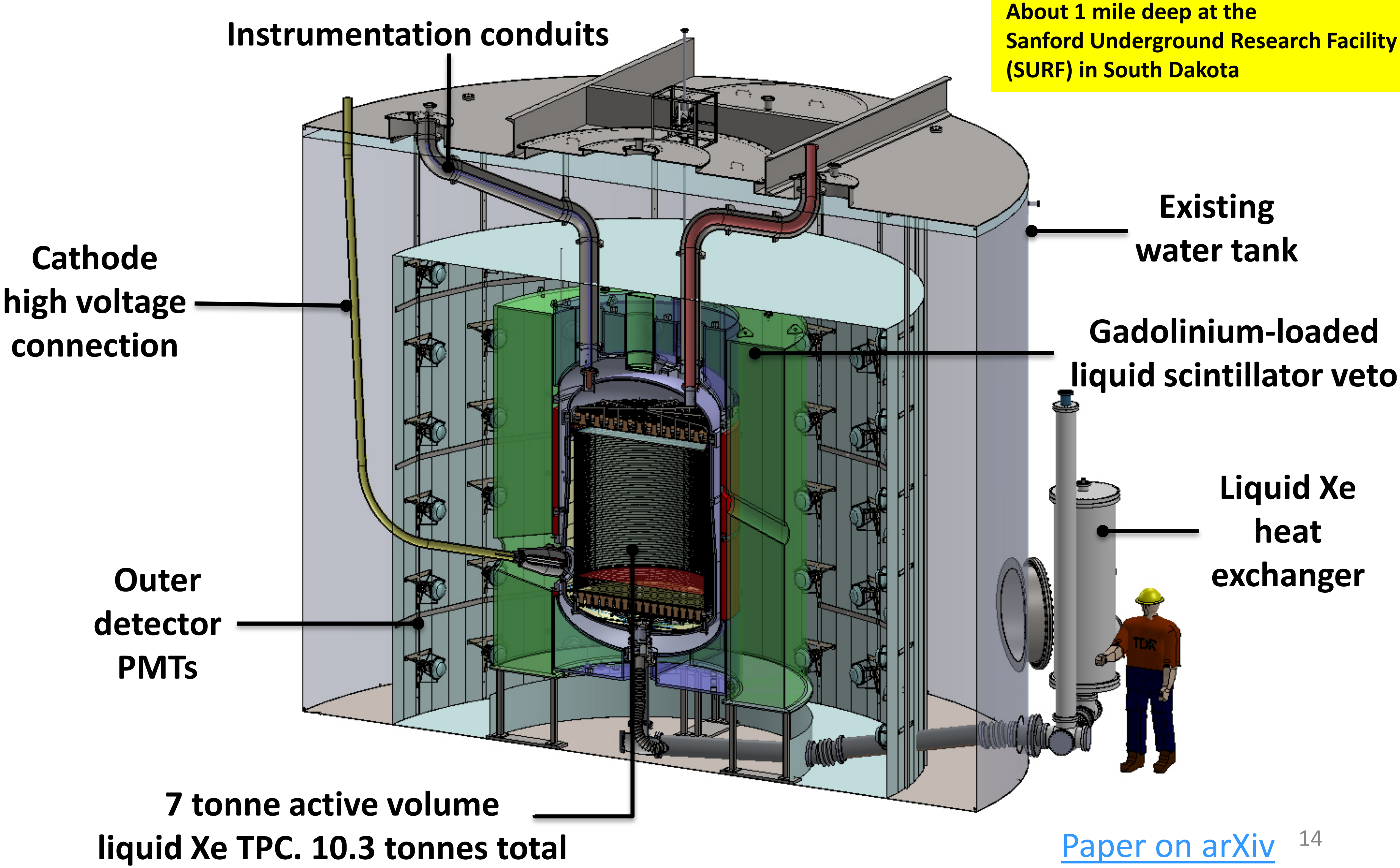
250 scientists & engineers from 37 institutes in the US, UK, Portugal, South Korea & Russia

Black Hills State University ◊ Bristol University ◊ Brookhaven National Laboratory ◊ Brown University ◊ Center for Underground Physics, Korea ◊ Edinburgh University ◊ Fermi National Accelerator Laboratory ◊ Imperial College London ◊ Lawrence Berkeley National Laboratory ◊ Lawrence Livermore National Laboratory ◊ LIP-Coimbra, Portugal ◊ University of Liverpool ◊ MEPHI Moscow, Russia ◊ Northwestern University ◊ Oxford University ◊ Penn State University ◊ Rutherford Appleton Laboratory ◊ Royal Holloway, University of London ◊ SLAC National Accelerator Laboratory ◊ South Dakota School of Mines & Technology ◊ South Dakota Science and Technology Authority ◊ SUNY University at Albany ◊ Texas A&M University ◊ University of Alabama ◊ University of California Berkeley ◊ University of California Davis ◊ University of California Santa Barbara ◊ University College London ◊ University of Maryland ◊ University of Massachusetts ◊ University of Michigan ◊ University of Rochester ◊ University of Sheffield ◊ University of South Dakota ◊ University of Wisconsin



LZ Detector Overview

About 1 mile deep at the
Sanford Underground Research Facility
(SURF) in South Dakota



[Paper on arXiv]

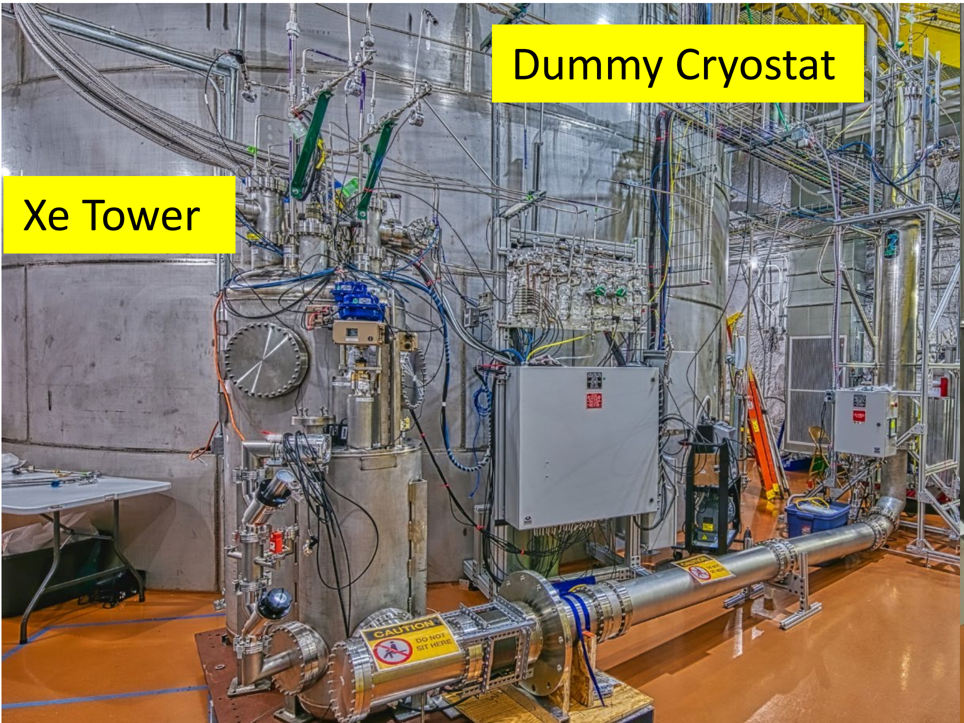
Xe Status

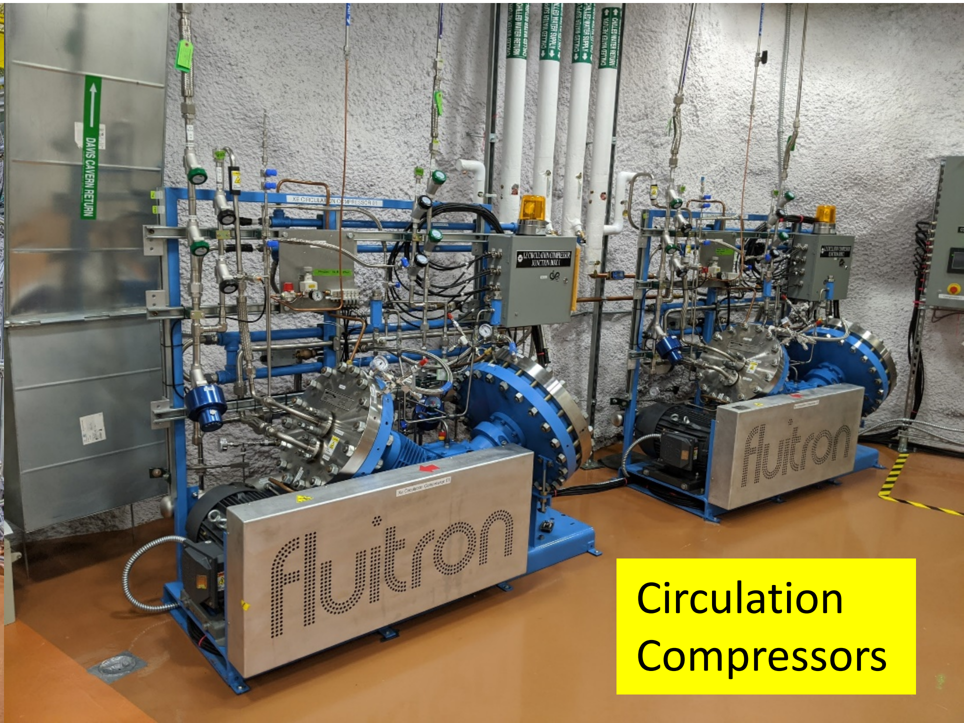
- 10.7 tonnes procured
- 97% of Xe gas in hand
- Last 3% delivered in two weeks.
- Xe gas is at SLAC for removal of trace amounts of Kr, a radioactive contaminant, to achieve ≤ 0.3 parts-per-trillion of Kr.
- Production processing imminent.
- To SURF by April 2020

Kr Removal Plant at SLAC

Xe and Cryogenic Systems

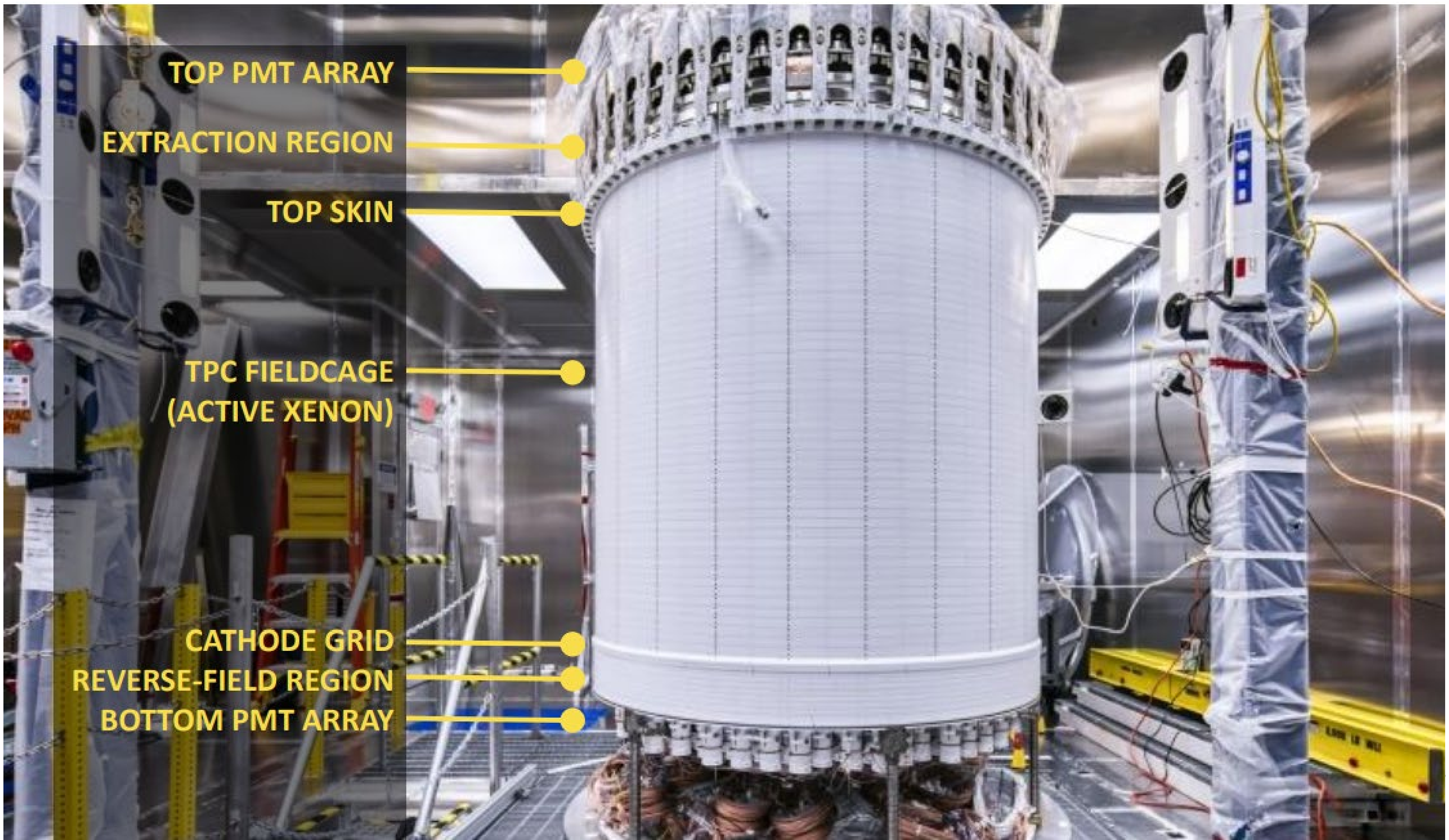
- Underground installation at SURF largely done
- About to begin operation at 100kg Xe scale using “dummy” cryostat and final circulation system to debug system





Inner Detector Status

- Time Projection Chamber fully assembled and checked out in custom low Rn clean room on surface at SURF.



TPC/ICV Underground

- The TPC was installed into the Inner Cryostat Vessel(ICV) and the assembly lowered through the Yates shaft at SURF and transported underground on Oct. 21, 2019
- Next step: put into Outer Cryostat Vessel, already in place in water tank, Dec 2019. Followed by months of hookup & checkout

TPC/ICV & Transporter
Lowered via Yates Shaft

TPC inside ICV
At 4850L SURF

Outer Detector Status

- Acrylic tanks fabricated and delivered to SURF but issues with 2 of 10, now back at vendor for repair by year's end.
- Liquid scintillator production 95% complete at BNL
- All phototubes in hand, production of supports underway

Acrylic tanks
In water tank

Acrylic tank
At vendor

Electronics and Controls Systems

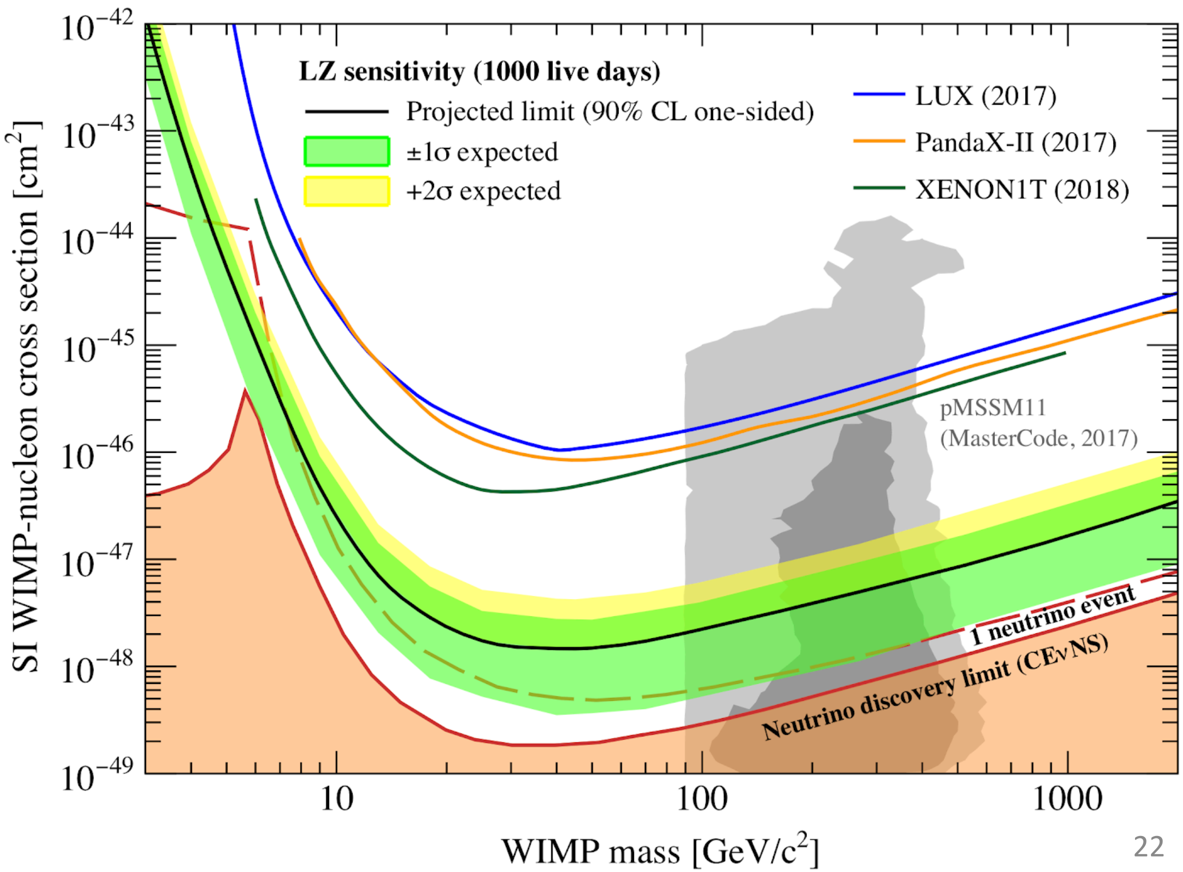
- All significant production is complete
- Underground installation long underway and on track to meet needs as equipment comes online

Computing and Software

- Operational challenge complete, data transfer from SURF to US data center (NERSC at LBNL) successful.
- Mock Data Challenges(MDCs) used to validate software and computing model
- In last stages of MDC3, simulate first few months of data taking, including calibration, and analysis
- Utilizing NERSC resources and UK data centre (roughly equal to NERSC resources)
- Next steps: more operational challenges, code development, leading to computing & software readiness review by April 2020

Expected WIMP Sensitivity

- Plot below based on 1000 live days, ~ 5 years
- Better than XENON1T (2018) in few months of running
- Goal to publish from 1st run in early 2021



Paper

Summary

- LZ and SCDMS Projects preparing for completion in the 2nd half of CY2020
- Plan to begin science operations by end CY2020 – early CY2021
- First science results by CY2021
- Planning for data taking of ~ 5 years

Axion Dark-Matter eXperiment Generation 2 (ADMX-G2)

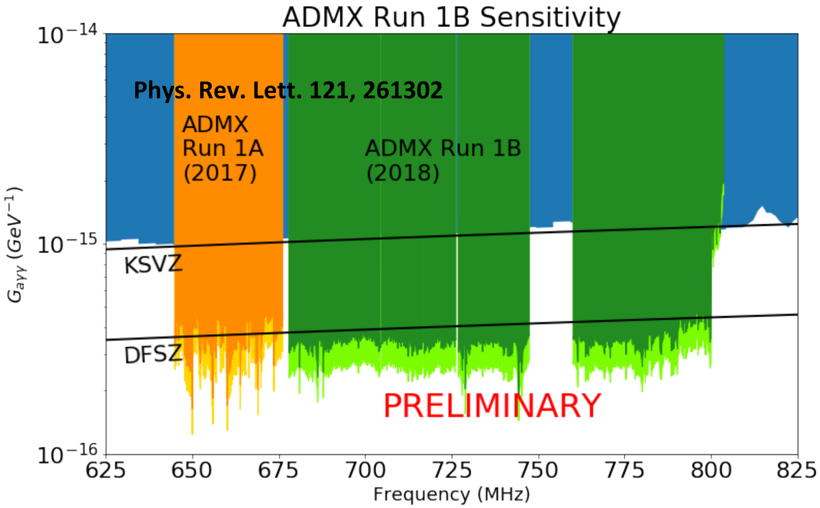
ADMX-G2 is located at University of Washington, managed by Fermilab

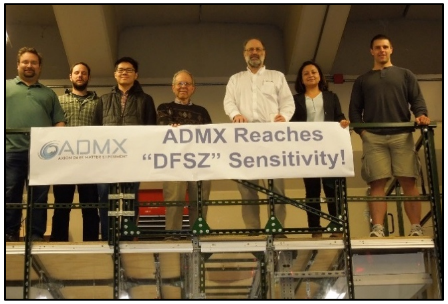
- Primarily DOE supported with contributions from the UK, Germany and Australia; R&D support from the Heising-Simons Foundation
- **Uses a strong magnetic field and resonant cavity to convert dark matter axions into detectable microwave photons**

Operating: Series of runs (1a-2b) with detector modifications cover range 0.5 to 2 GHz (~ 2 to 8 micro-eV mass) – started Aug. 2016; planned to complete ~ 202

- **Run 1A** (2017) & **Run 1B** (2018) - both **reached "invisible" axion (DFSZ model) sensitivity!**
- Run 1C running; Run 2 Cavities under development.

ADMX-Extended being planned (a Dark Matter New Initiative) → 2 - 4 GHz





Pierre Sikivie, inventor of the axion haloscope and recipient of the 2020 Sakurai prize, helping assemble the ADMX experiment.