XZLD @ SNOLAB

June 2025 Collaboration Meeting

Hugh Lippincott

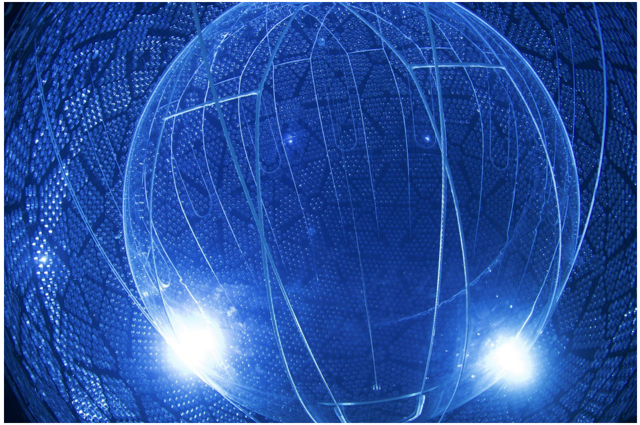
Travel

MSZSYS

Date	Flight	Status	From		To	
Sun, Jun 29, 2025	UA 435	Delayed	SFO	San Francisco, CA, US	EWR	New York/Newark, NJ, US
Sun, Jun 29, 2025	UA 1333	Delayed	SFO	San Francisco, CA, US	DEN	Denver, CO, US
Sun, Jun 29, 2025	UA 435	Delayed	SBA	Santa Barbara, CA, US	SFO	San Francisco, CA, US
Sun, Jun 29, 2025	UA 793	Delayed	SFO	San Francisco, CA, US	ORD	Chicago, IL, US
Sun, Jun 29, 2025	UA 2650	Delayed	SFO	San Francisco, CA, US	EWR	New York/Newark, NJ, US
Sun, Jun 29, 2025	UA 1374	Delayed	SFO	San Francisco, CA, US	DEN	Denver, CO, US
Sun, Jun 29, 2025	UA 970	Not Flown	ORD	Chicago, IL, US	FCO	Rome, IT
Sun, Jun 29, 2025	UA 507	Rebooked	SFO	San Francisco, CA, US	FCO	Rome, IT
Sun, Jun 29, 2025	UA 177	Delayed	DEN	Denver, CO, US	FCO	Rome, IT

SNOLAB

- 5000 m2 of space, 6800 ft (6000 m.w.e.) below Sudbury, Ontario (about 4 hours north of Toronto)
- Active nickel mine, site owned and operated by Vale Mining
- Three large underground caverns
  - SNO/SNO+
  - Cube Hall (DEAP, PICO, NEWS-G)
  - Cryopit
- Class 2000 cleanroom for the entire lab
- ~125 FTE staff, with around 50 UG per shift (up to ~120)
- Single shaft access, followed by 1.8 km drift to reach lab



SNOLAB

- Not shortlisted in original draft of siting report (April 2024) for four main reasons:
  - Space not adequate - at the time, discussed space could not clearly accommodate 12 meter water tank
    - SR-XLZD-INS-UG-0010 and 0020. 574 m^2 and 590 m^2 (1164 m^2) required for water tank and associated infrastructure
  - LN2 supply not adequate - only 300 liters/day
    - SR-XLZD-FAC-UG-0020 - 3000 liters/day with storage of 3000 liters
  - Severe conveyance constraints - cannot convey 4 m x 5.2 m object
  - No current Canadian participation
- Both XLZD and SNOLAB now think this was too pessimistic
- With nEXO status uncertain, motivation to revisit XLZD at SNOLAB
  - Draw from significant development of nEXO at SNOLAB project

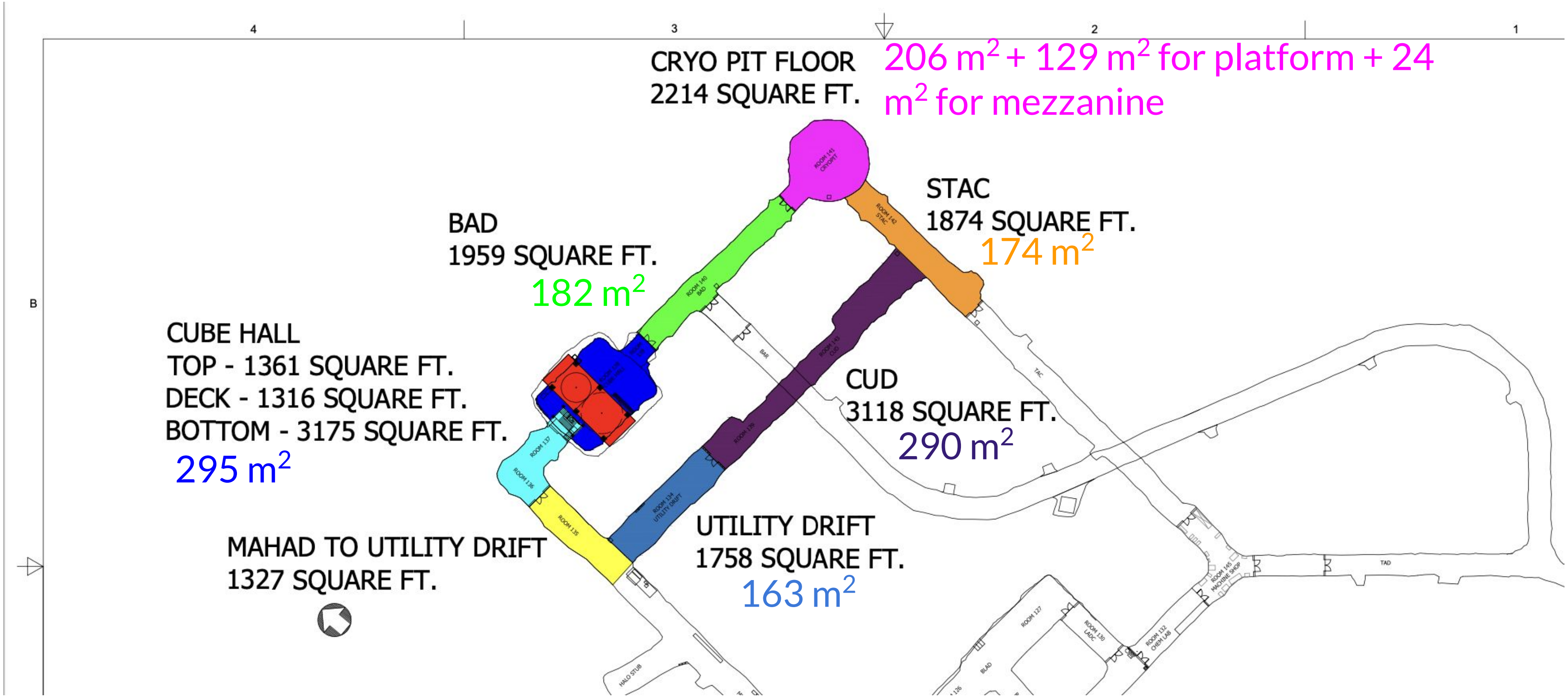
Siting Report

Table 8: Compliance matrix for the candidate sites against the requirements.

Requirement ID	Note	Boulby	Kamioka	LNGS	SNOLAB	SURF
SR-XLZD-SCI-BG-0010	Muon (DM)		128 m^2/d			
SR-XLZD-SCI-BG-0020	Muons ($0\nu\beta\beta$)		128 m^2/d			
SR-XLZD-INS-UG-0010	Space 1	Planned 2030	350 m^2	Minor mods	280 m^2	Planned 2030
SR-XLZD-INS-UG-0020	Space 2	Planned 2030	Hall-D?	With mods	208 m^2	Planned 2030
SR-XLZD-INS-UG-0025	Space 3 (OD)	Planned 2030				Planned 2030
SR-XLZD-INS-UG-0027	LS					Planned 2030
SR-XLZD-INS-UG-0030	Tank	Planned 2030	10 m (D & H)			Planned 2030
SR-XLZD-INS-UG-0035	Crane(19.5)	Planned 2030			~18.5 m	Planned 2030
SR-XLZD-INS-UG-0037	Crane(15)	Planned 2030	Replace 2.6 t			Planned 2030
SR-XLZD-FAC-UG-0010	Radioassay					
SR-XLZD-FAC-UG-0020	LN2 supply	1,500 L/day		TBC	300 L/day	Power/vent
SR-XLZD-FAC-UG-0030	Ventilation	Planned 2028				Planned 2030
SR-XLZD-FAC-UG-0040	Radon	Planned 2028	TBC	Exists, TBD	TBC	Planned 2030
SR-XLZD-FAC-UG-0050	Comms					Planned 2030
SR-XLZD-FAC-UG-0060	Power	Planned 2030	With mods			Planned 2030
SR-XLZD-FAC-UG-0070	Workshop	Planned 2030	Small one	TBC		Planned 2030
SR-XLZD-FAC-UG-0080	Messroom	Planned 2030				Planned 2030
SR-XLZD-FAC-UG-0090	Goods-in	Planned 2030	30 m^2			Planned 2030
SR-XLZD-FAC-UG-0100	Storeroom	Planned 2030	With mods	Minor mods		Planned 2030
SR-XLZD-FAC-UG-0105	Max size	4.0 m D × 0.75 m H	4.0 m D × 2.6 m H	4.0 m D × 5.0 m H	TBC	3.9 m D × 1.5 m H
SR-XLZD-FAC-UG-0110	Manufacture	Planned 2028	N/A	N/A	TBC	Planned 2030
SR-XLZD-FAC-UG-0120	Cleaning	Planned 2028	N/A	N/A	TBC	Planned 2030
SR-XLZD-FAC-UG-0130	Assembly	Planned 2028	N/A	N/A	TBC	Planned 2030
SR-XLZD-FAC-SF-0010	Surface	Planned 2028				Planned 2030

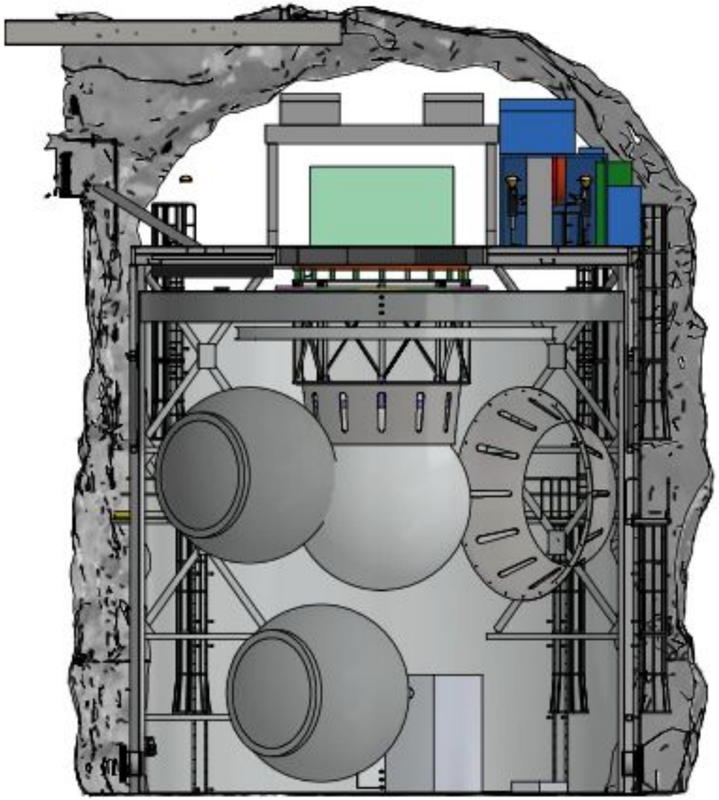
SNOLAB - Space

- SNOLAB - Cryopit, STAC, BAD, CUD, and parts of Cube Hall floor as potentially available



SNOLAB - Space

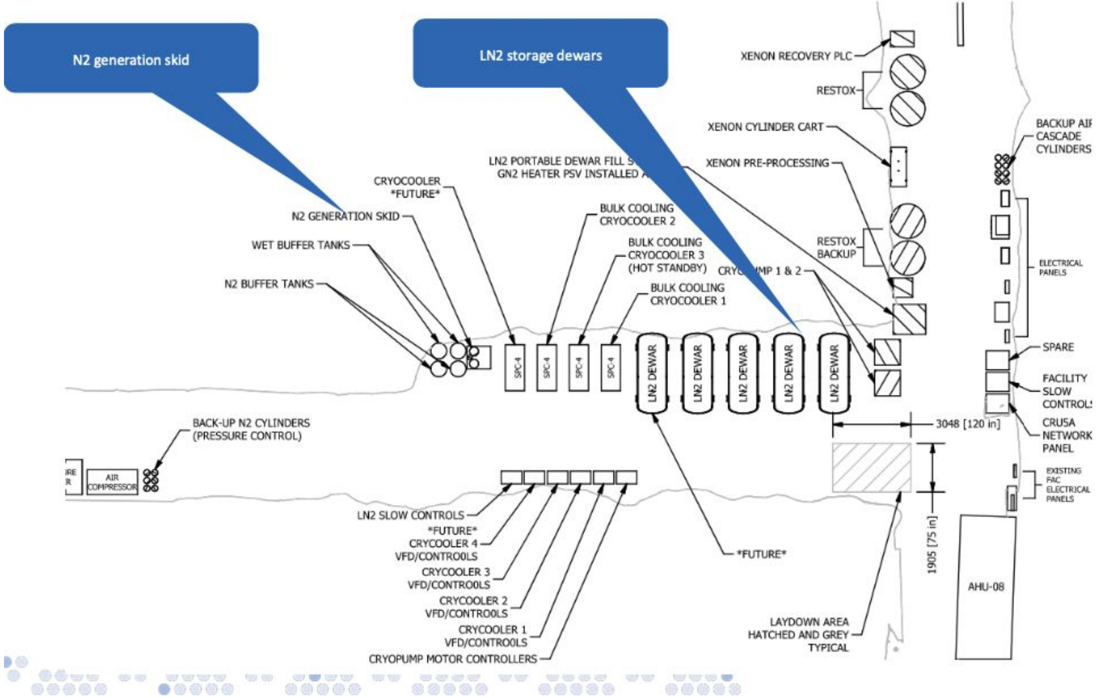
- Cryopit fits 12.3 meter tank (already significant planning for nEXO)
- Platform on top, plus small mezzanine on outside
- Ground floor “BAD” drift plus access “STAC/CUD” drifts on top
- ~1000-1100 square meters



SECTION J-J
SCALE 1:240
SECTION DEPTH 4700 [185 in]

SNOLAB - LN2

- Preliminary designs for 4000 L/day closed loop cooling systems (8-12 kW)
- Plans to store 4-5x3000 L
- dewars in the CUD drift
- Still to determine:
  - What are ReSTOX needs?
  - Kr/Rn distillation columns?
  - Likely to have LN2 generator?
- Footprint likely to be bigger than planned for nEXO



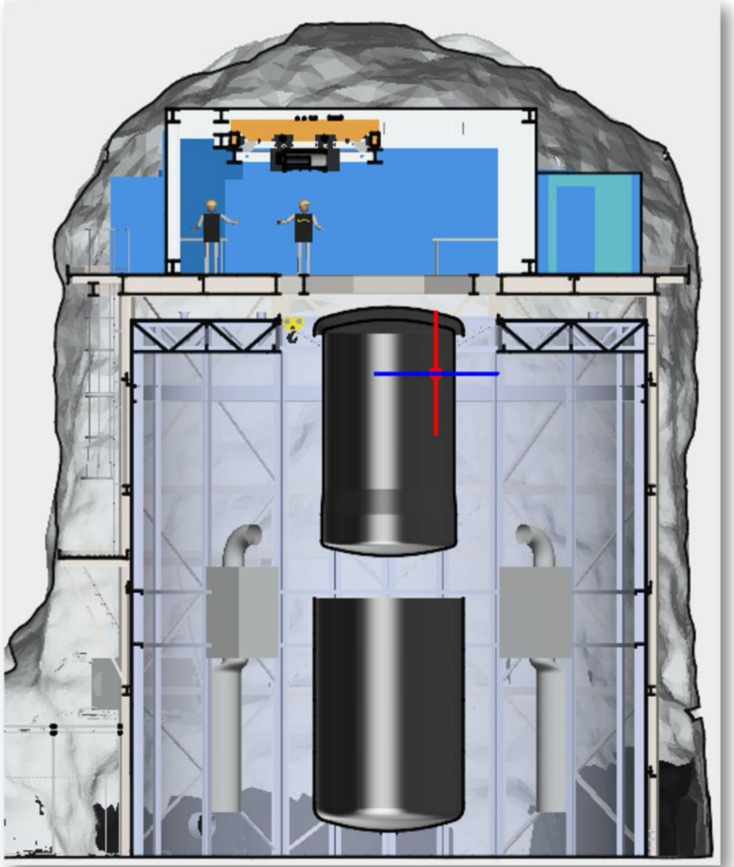
SNOLAB - Conveyance - Big issue

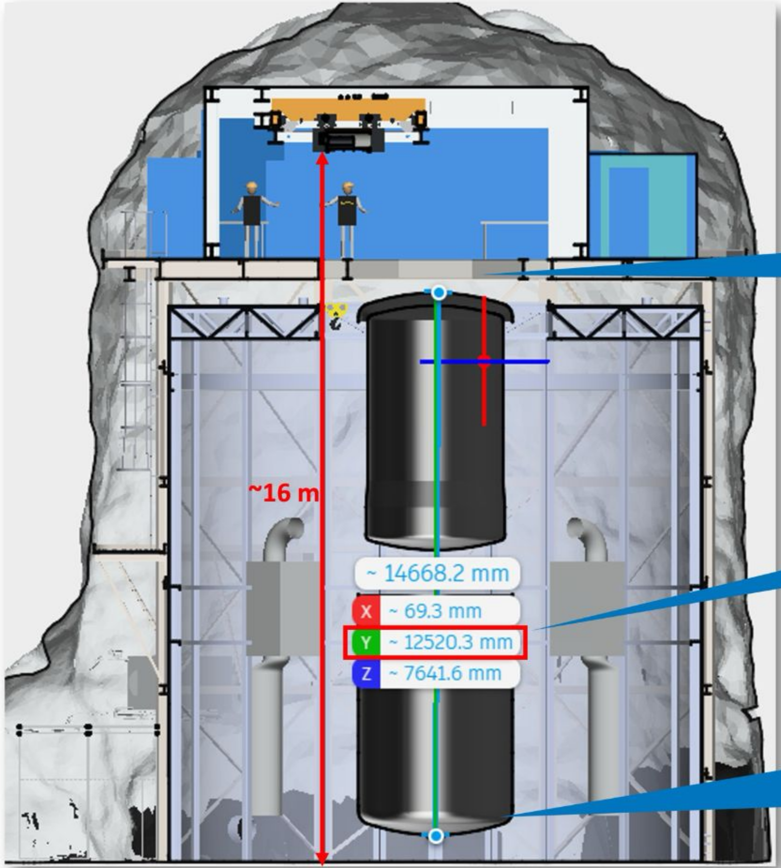
- A 4 meter disc does not make it underground - could maybe get down the shaft but likely not through drift
- A 3 meter disc can work with effort, requires validation through drift
  - 3 meters x 0.35 meters is preliminary estimate
  - Adequate for grid rings?
- Largest objects to date:
  - 1.8 x 2.0 x 2.06 m cube required significant planning and frame to get down the shaft
  - 1.15 x 2.3 x 2.2 is easy in normal boxes
- Consequence: Significant manufacture required underground. Is there space for this?
  - Cryostats, restox, storage tanks, distillation volumes, grid rings.

SNOLAB - Status

- Siting committee put SNOLAB back on shortlist and presented at SNOLAB Future Projects Workshop (May 2025)
- Preliminary work ongoing with SNOLAB engineers on XLZD at SNOLAB based on existing nEXO designs
    - Say hello to David Hawkins and Tristan Hillier, here in person

Vessel Nesting Checks



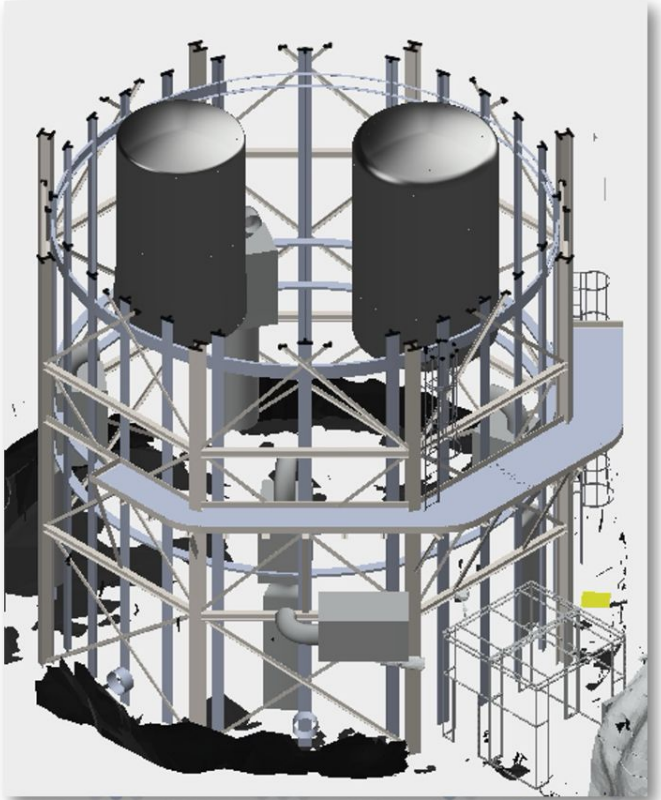


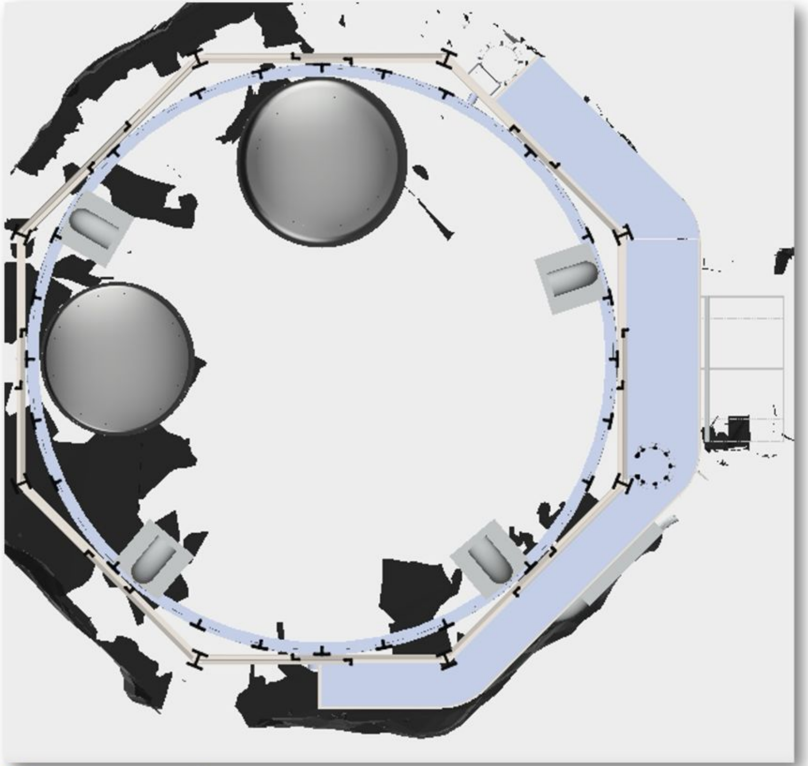
Additional room to lift through lid & platform opening

12.5 meter minimum

Would require support structure on wheels to shuttle vessel out of the way

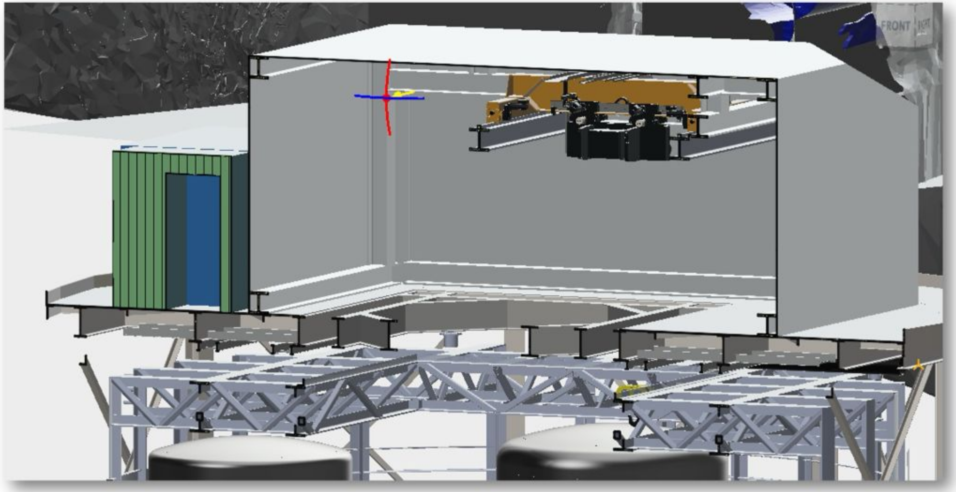
Parking Vessels on Roof



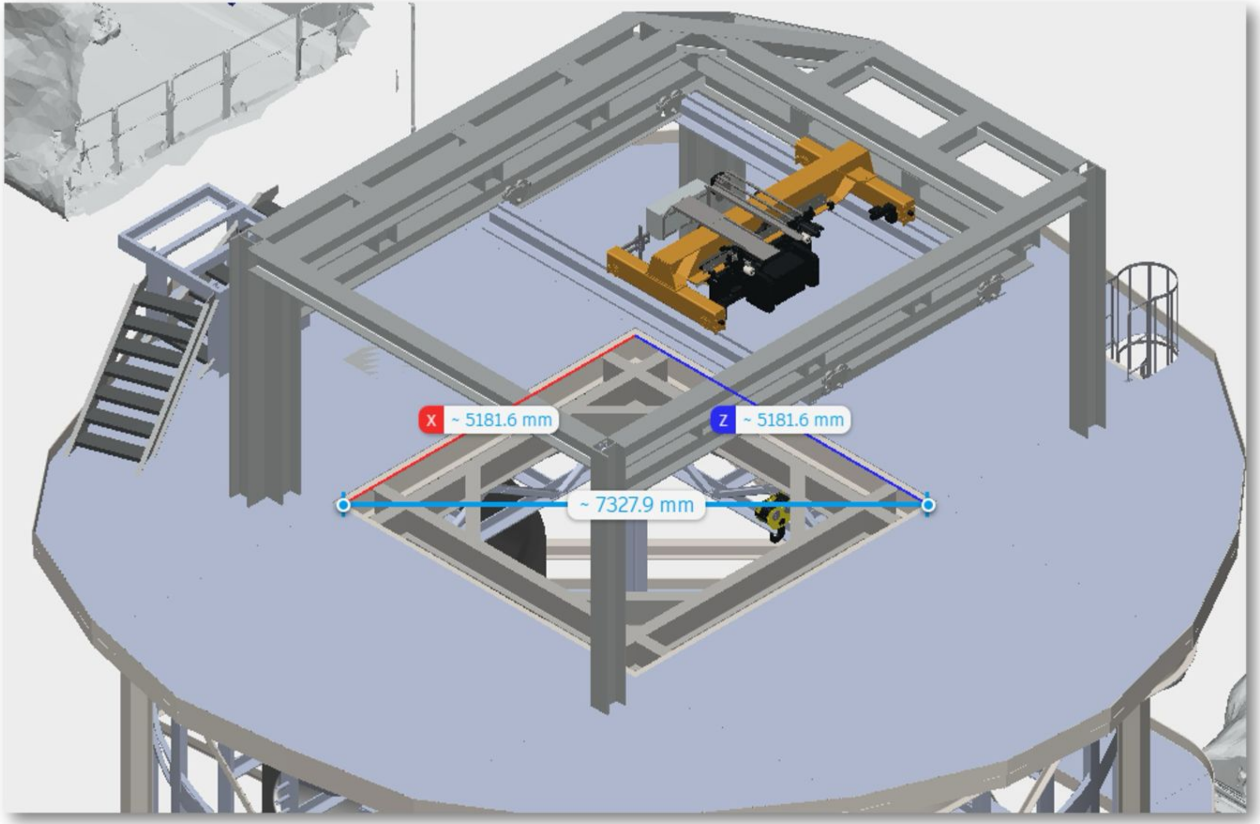


Platform Bridge Crane Concept

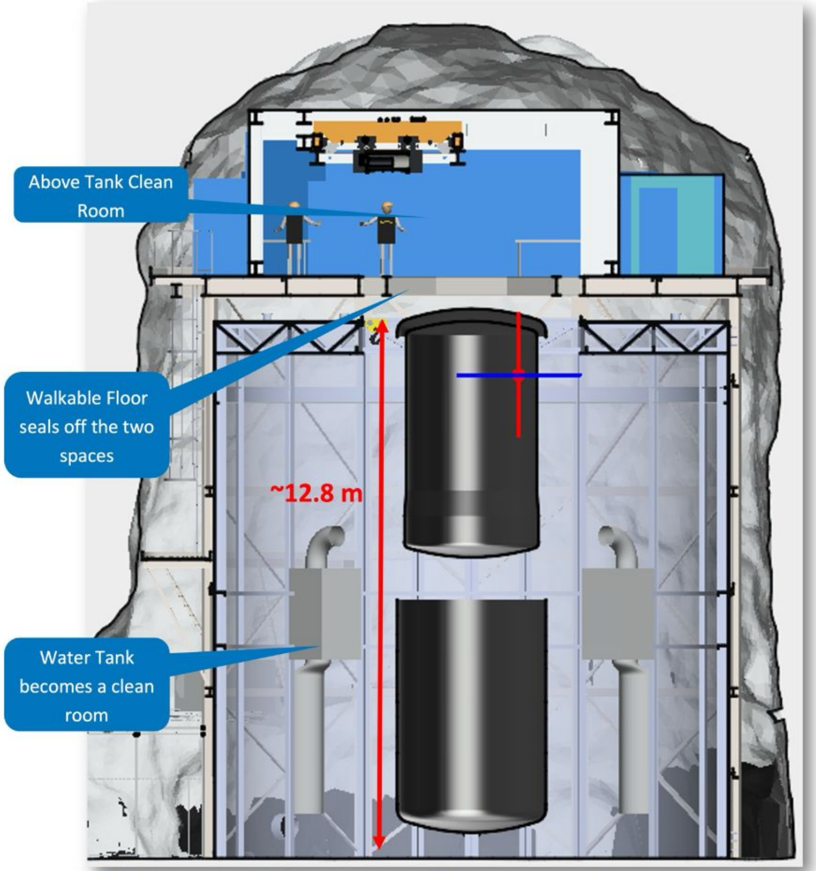
- **Concept** different from previous work on nEXO, build structure to support bridge crane and leverage it to build out aluminum clean room on deck
- Design method to:
  - A: Install easily removable false floor between tank space and this space
  - B: Install HEPA's on roof of this space
  - C: Tie the air space between tank/room to control cleanliness
- Using 3D model from a crane vendor (from nEXO work) assume 20 tonne bridge crane
- Volume shown fits in rock geometry
- Need additional effort on engineering to confirm beam sizes, platform loading etc.



Platform Bridge Crane



Clean Room Sectioning - RRA



CFM calculations are based on human occupancy needs for the spaces assuming 10 person per clean space

1. Above the water tank becomes a clean room, which would require the below CFM of radon reduced air
   - Bridge Crane Clean Room: ~260cfm
   - Aux(Side) Clean Room: ~156cfm

Walkable floor to seal the two spaces

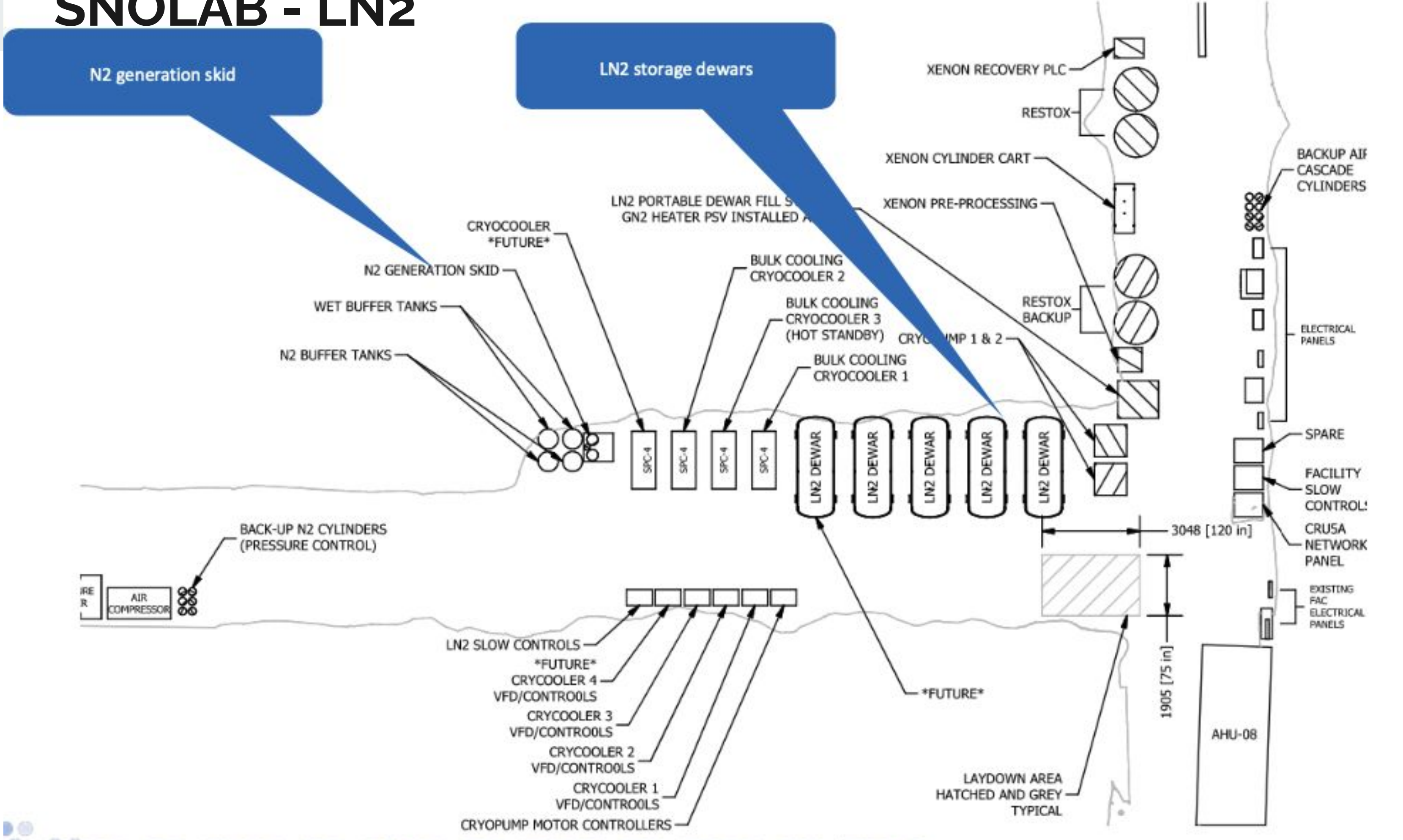
2. Full water tank becomes a clean room that would require about 430cfm, which all could be radon reduced air

XLZD@SNOLAB - Next Steps

- Canadian nEXO groups exploring nEXO2.0, led by Canada with minimal US contribution (seeking international partners)
    - Two rounds of infrastructure funding had been approved contingent on US DOE - still held back.
    - Two initial concepts based on existing nEXO planning - 1 tonne enriched, or 5 tonne natural…
    - Aim for construction start of Outer Detector (Water tank, Canadian scope in nEXO) in 1-2 years
- Currently, no Canadian groups in XZLD…

- Propose/Requested to submit “Expression of Interest” to trigger creation of “XZLD SNOLAB Concept Design” project.
    - No commitment from either side yet, but enables us to enter their lifecycle process and have formal engineering assigned from SNOLAB
- Due before next SNOLAB Experiment Advisory Committee meeting July 30-31

SNOLAB - LN2



N2 generation skid
LN2 storage dewars
XENON RECOVERY PLC
RESTOX
XENON CYLINDER CART
BACKUP AIR CASCADE CYLINDERS
XENON PRE-PROCESSING
LN2 PORTABLE DEWAR FILL S
GN2 HEATER PSV INSTALLED A
CRYOCOOLER *FUTURE*
N2 GENERATION SKID
BULK COOLING CRYOCOOLER 2
WET BUFFER TANKS
BULK COOLING CRYOCOOLER 3 (HOT STANDBY)
RESTOX BACKUP
ELECTRICAL PANELS
N2 BUFFER TANKS
BULK COOLING CRYOCOOLER 1
SPC-4
SPC-4
SPC-4
SPC-4
LN2 DEWAR
LN2 DEWAR
LN2 DEWAR
LN2 DEWAR
LN2 DEWAR
SPARE
FACILITY SLOW CONTROLS
3048 [120 in]
CRUSA NETWORK PANEL
BACK-UP N2 CYLINDERS (PRESSURE CONTROL)
AIR COMPRESSOR
EXISTING FAC ELECTRICAL PANELS
LN2 SLOW CONTROLS
FUTURE CRYOCOOLER 4 VFD/CONTROOLS
CRYOCOOLER 3 VFD/CONTROOLS
CRYOCOOLER 2 VFD/CONTROOLS
CRYOCOOLER 1 VFD/CONTROOLS
CRYOPUMP MOTOR CONTROLLERS
FUTURE
1905 [75 in]
AHU-08
LAYDOWN AREA HATCHED AND GREY TYPICAL

SNOLAB - Other considerations

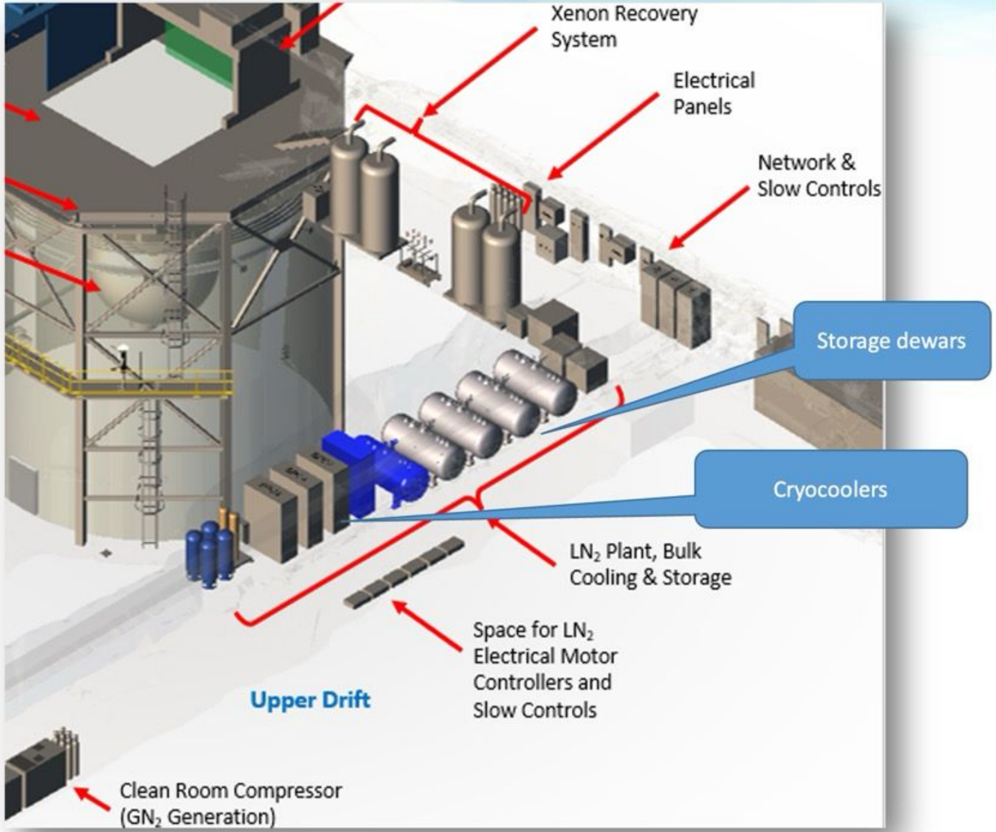
- Most likely scenario would be construction inside the water tank
  - Plan that nEXO was going to follow
    - 4.5 meter outer spherical vessel to be shipped in square pieces and welded UG (dimensions still being worked out)
    - 3.5 meter inner spherical vessel, same
    - 1.3x1.3 meter TPC
  - Water tank converted into clean room, with polar crane
- For XLZD, very hard to build in different location and bring it into the cryopit - not enough space to get through doors with 4 meter objects
- Decision point is cutting or not cutting, not how many pieces. Welding processes are the same either way
- Lose the water tank as anything until you have a certified cryostat. Can't do TPC or outer detector.
- Need 3 footprints for the cryostat - Lid, IV, OV. How much space you need for people? Significant hook height to lift IV into OV - 12 m to 18 m variation if do from bottom or top.
- How many full diameters do you need was surprisingly large? (Maybe presentation from Boulby engineers would be warranted) Or give the cryostat model to see if we can repeat it in SNOLAB.

SNOLAB - Status

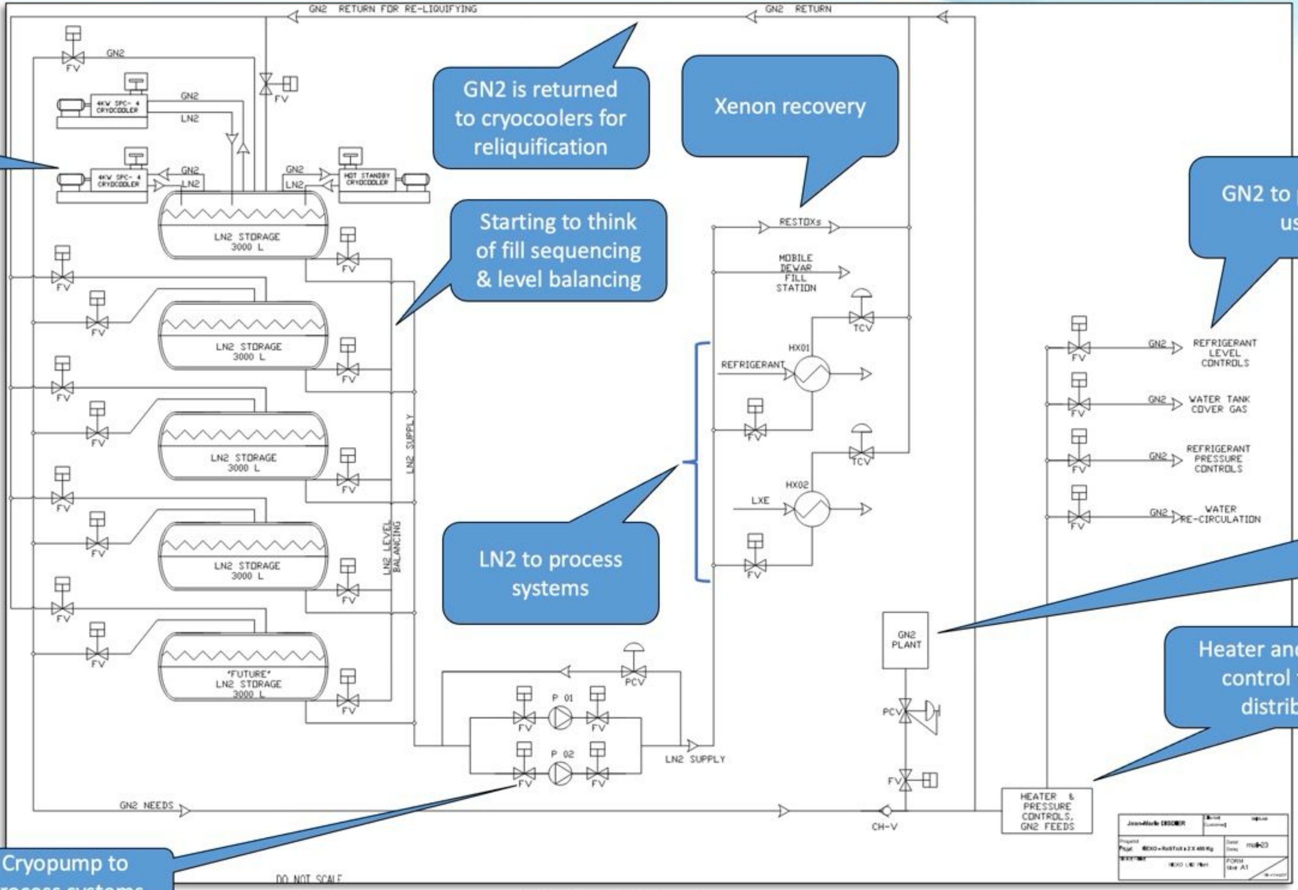
- Radon reduction plans - quantified for us - what is the volume for radon reduction?
  - Baseline for us - full water tank? Or subsection of water tank?
  - Plating underground
  - Req listed as >300 m^3/hr at 0.01 Bq/m^3. (Larger capacity planned at Boulby - look at again (12 x12 m cylinder is 1300 m^3/hr - but would be recirculating air - how much fresh air for workers and maintain positive pressure)
- Purify liquid scintillator - requires additional space for plant somewhere (bigger for WbLS)

LN2 Generation System

- LN2 Plant
  - Generation N2
  - 12,000L Bulk Storage
  - 8kW of cooling (12 kW in active-active arrangement)
  - Re-liquifying GN2 in a closed loop system
- Supplies LN2 to cool Refrigerant & LXE
- Supplies bulk LN2 for
  - LXE normal & emergency recovery
- GN2 for OD, TPCS, CRE and PRE subsystems
- Leverage lessons learned from SNOLAB's low background lab deployment which is currently in operation
- These are standard commercial systems with market research well underway



LN2 Plant P&ID



Bulk cooling (cryocoolers)

Bulk storage of LN2

GN2 is returned to cryocoolers for reliquification

Starting to think of fill sequencing & level balancing

Xenon recovery

LN2 to process systems

GN2 to point of use

Generate nitrogen from lab air, Similar to current SNOLAB Generation

Heater and pressure control for GN2 distribution

Cryopump to process systems

LN2 Plant Piping Iso Sketch