Exploring Concepts for ReStoX at SNOLAB

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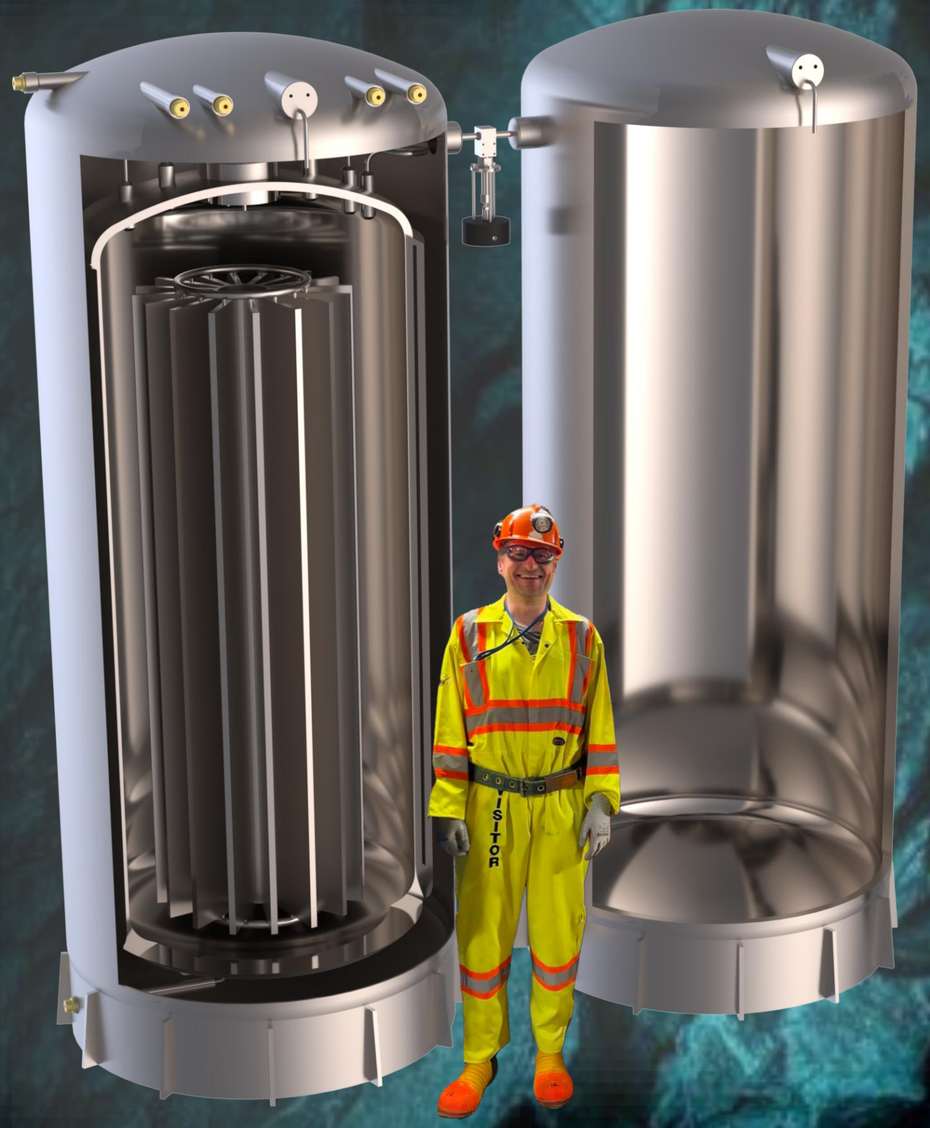
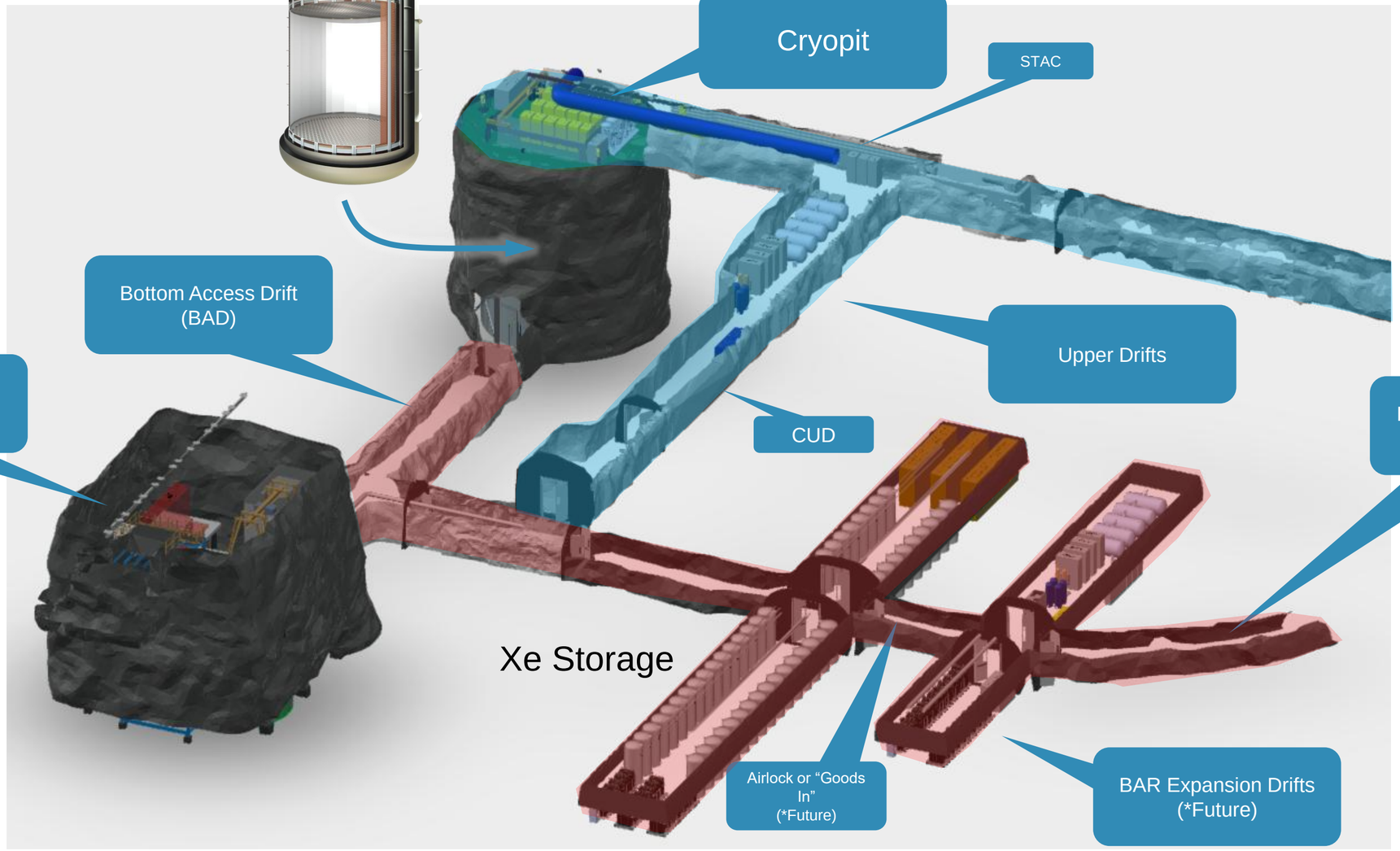
XLZD Collaboration Meeting

Zürich, 2026



XLZD at SNOLAB



Upper level
Lower level

Purification and distillation columns

Xenon Recovery and Storage at SNOLAB

- SNOLAB was awarded money to conduct feasibility studies for xenon storage solutions
- We must determine requirements, define recuperation schemes, find commercial partners to inform on standards, design, costs and conduct pre-production analysis
- For a 100-tonne Xe storage at room temperature, five schemes to consider

1) 6× 16.7 tonnes ReStoX in Cube Hall
2) 40× 2.5 tonnes ReStoX in BAR expansion
3) 40× 2.5 tonnes foam-insulated ReStoX in BAR expansion (à la ReStoX 2)
4) Hybrid (15× 2.5 tonnes ReStoX + 15× 4.4 tonnes pressure vessel) in BAR expansion
5) Compressors + cylinder packs

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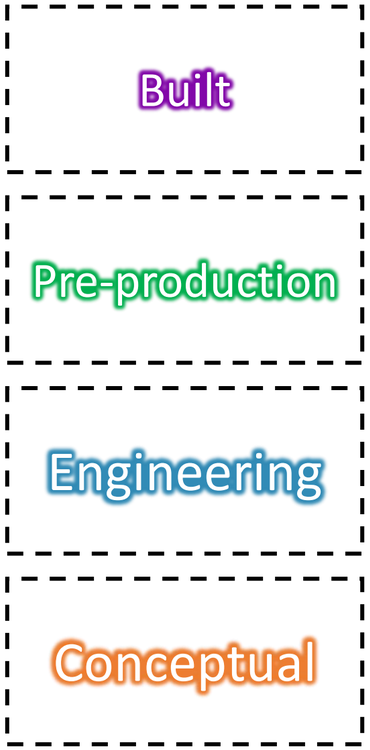
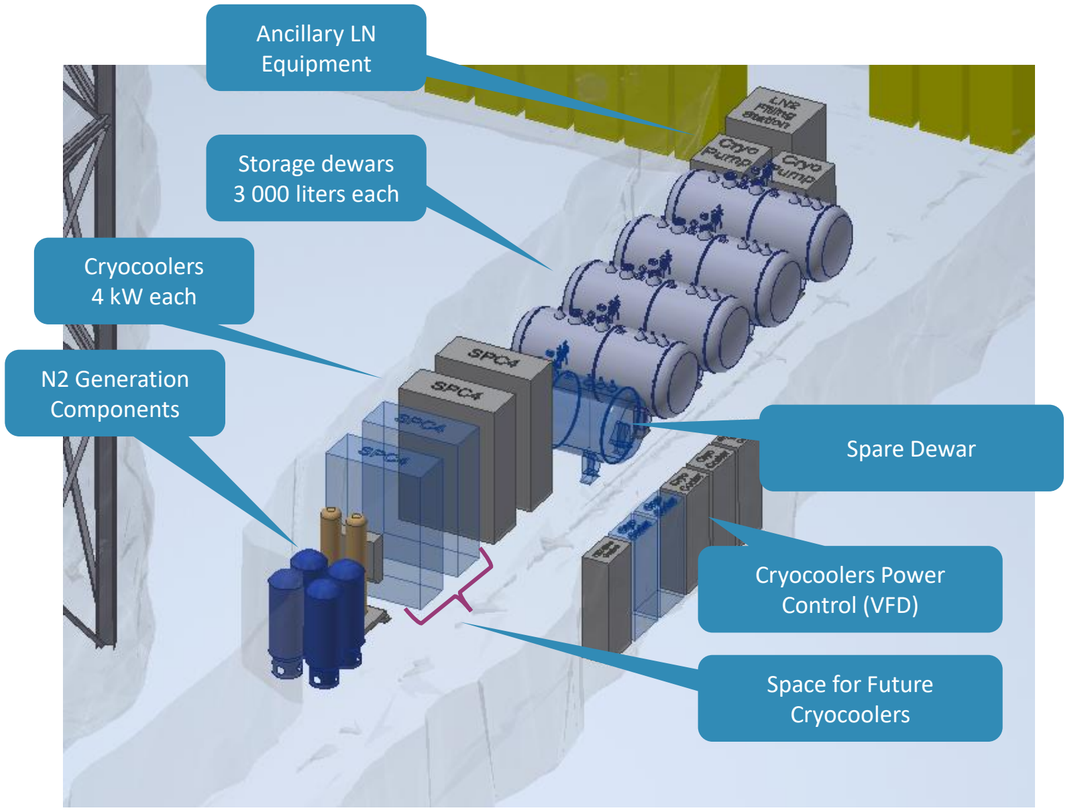


Design maturity throughout this presentation

Engineering

LN_2 production at SNOLAB

- LN_2 Enables:
  - Detector cooling
  - Radon removal
  - Xenon recovery
- N_2 system = Generation + Cooling + Energy Buffer
- Produced in 2 locations (redundancy + distribution)
- Distributed storage acts as thermal battery
- Boil-off GN_2 reused across subsystems
- Cryocoolers reliquefy boil-off in closed-loop (4 kW each)
- Based on commercial + SNOLAB-proven systems
- New LN_2 Production rate: 18 L/h
- Space available for a total of 30 000 L of LN_2

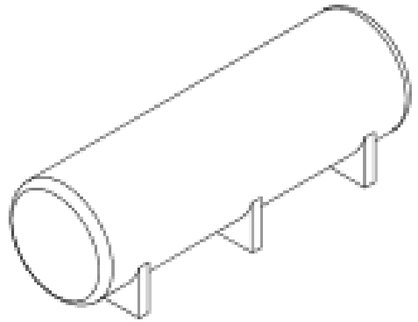


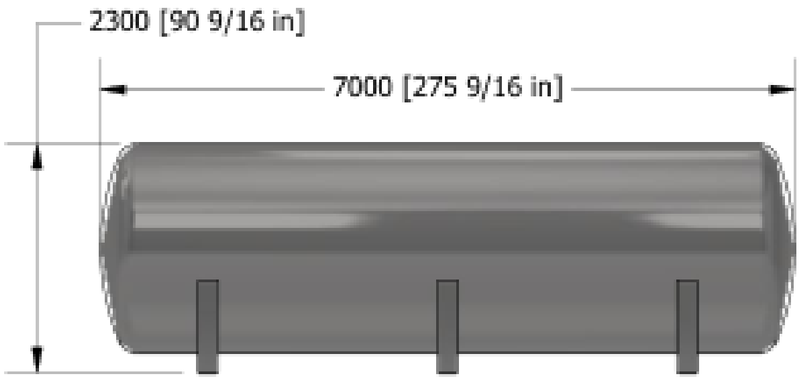
CUD Equipment Layout
(Equipment Allocation Shown)

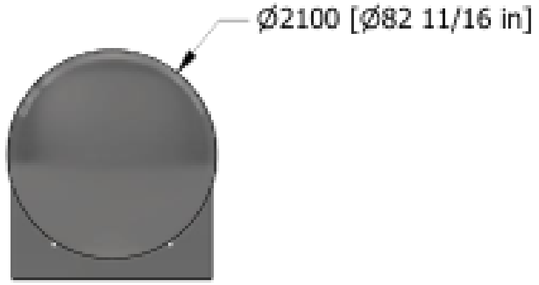
1) 6× 16.7 tonnes ReStoX in Cube Hall

Conceptual

- Array of six cryo-capable ReStoX
- Installed on the ground floor of the Cube Hall
- Capacity of 16.7 tonne of Xe each at room temperature
- No production drawings yet
- Need for cryo-engineering and input from commercial partners
- Underground fabrication needed







16.7T RESTOX
SCALE 1 / 100

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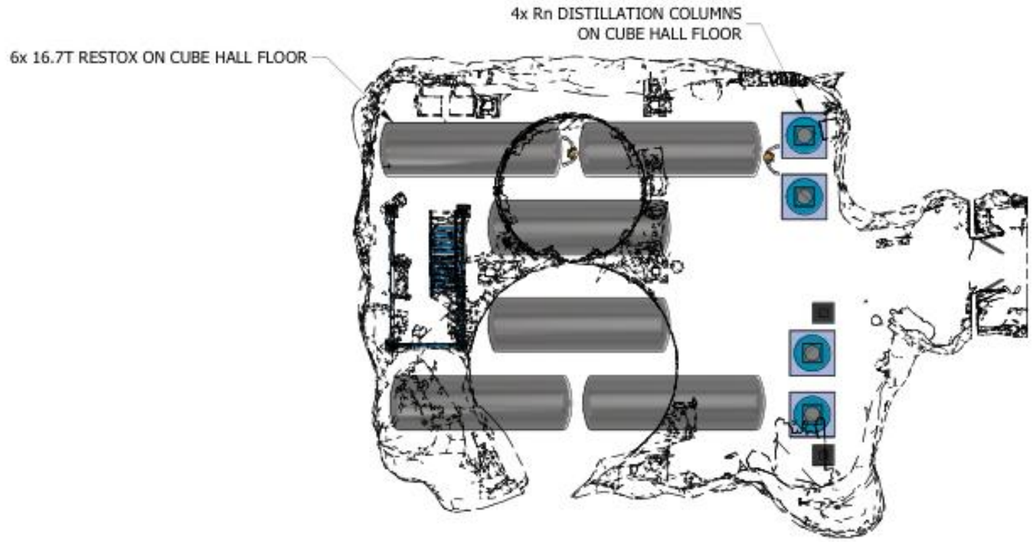
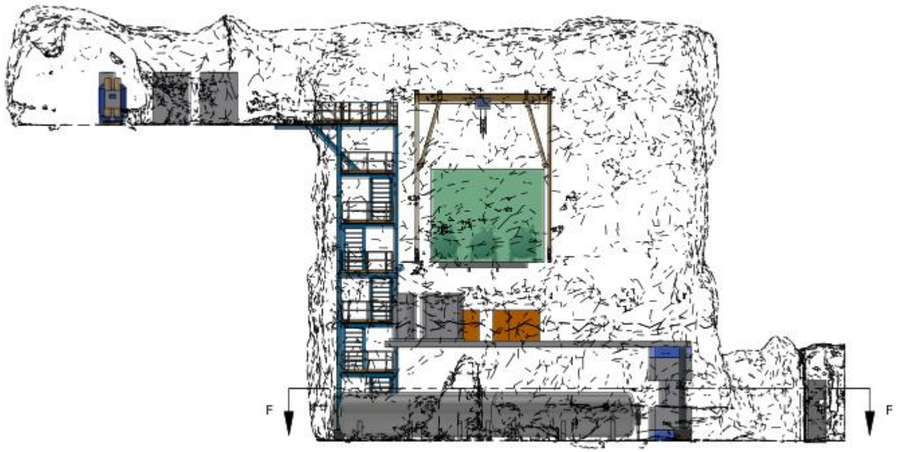
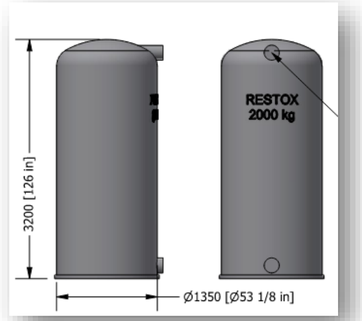




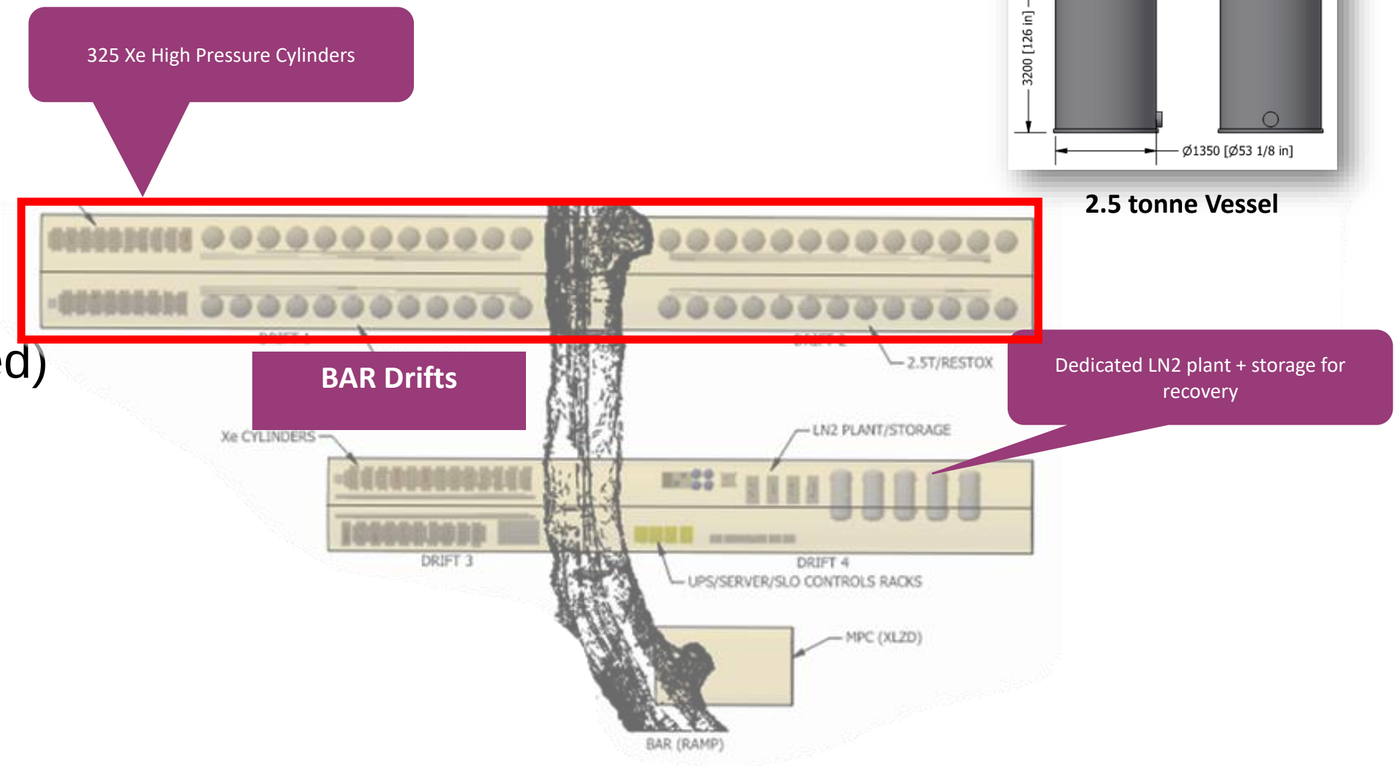
2) 40× 2.5 tonnes ReStoX in BAR expansion

Engineering

- Array of 40 cryo-capable ReStoX
- Space available for up to 50 vessels
- Installed in the BAR expansion drifts (planned)
- Capacity of 2.5 tonne each
- Originally designed for nEXO
- “In principle” production-ready

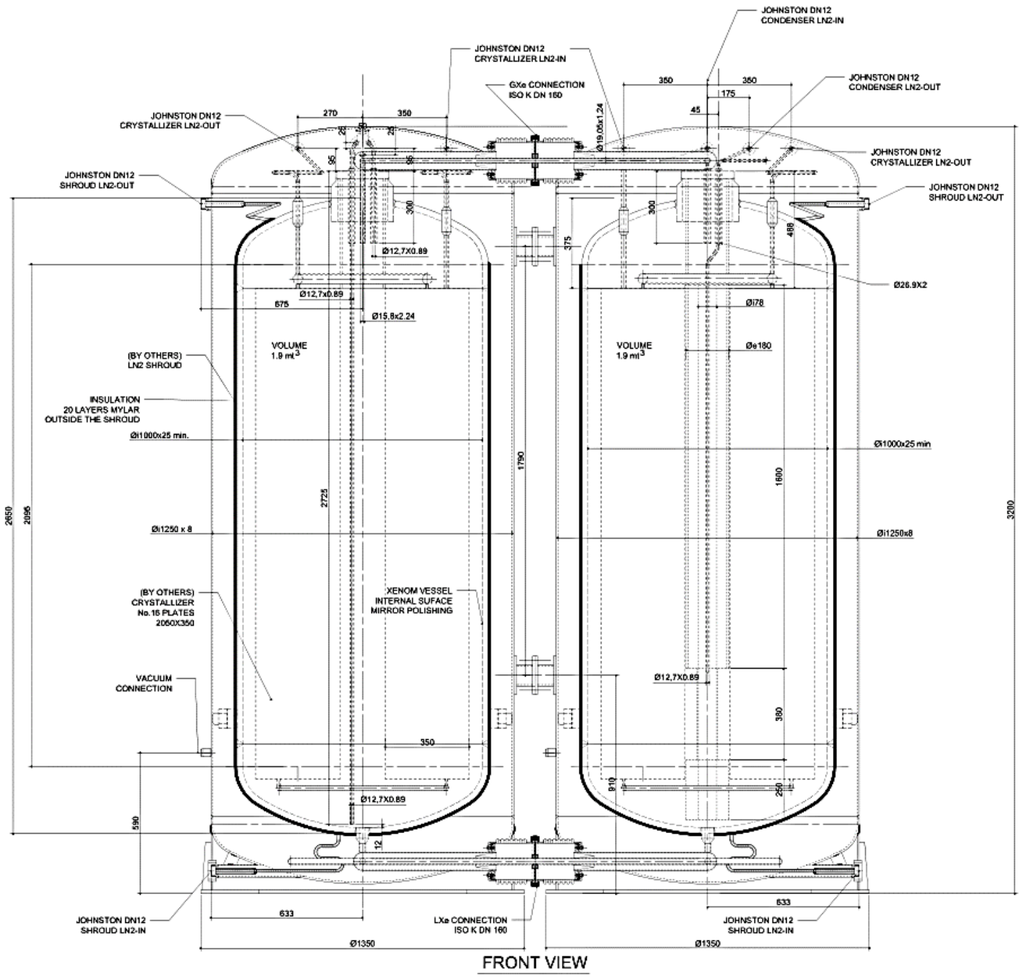


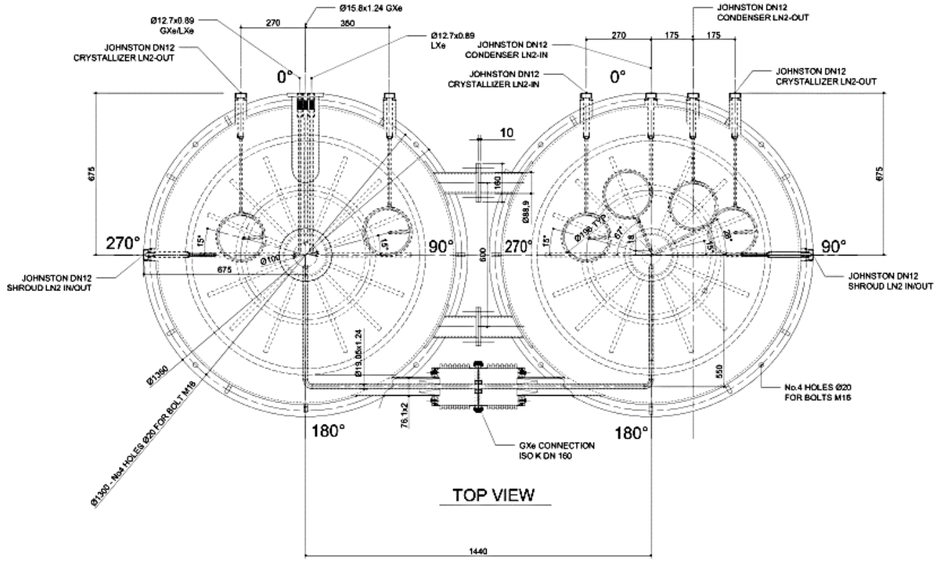
2.5 tonne Vessel



2) 40× 2.5 tonnes ReStoX in BAR expansion

Pre-production





Rev.	DESCRIZIONE DESCRIPTION	FORNITORE Supplyer	DATA DATE
2	REVISIONE GENERALE – GENERAL REVISION		19.08.2022
1	REVISIONATO DOVE INDICATO – REVISED AS NOTED		28.04.2022
0	EMESSO PER INFORMAZIONE–Issued for information		12.04.2022

Costruzioni Generali srl

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20015 Parabiago (MI)
Tel. +39 0331 559630 Fax +39 0331 559638
Web: www.cgsrl.it e-mail: cg@cgsrl.it

COMMESSA Job: 064-22

DATA – Date: 12.04.2022 | SCALA – Scale: –

PROGETTO: Project: NEXO CANADA

DIS. – Drw: MR | CONTR. – Ck: C.G.

TITOLO: Title: XENON VESSEL

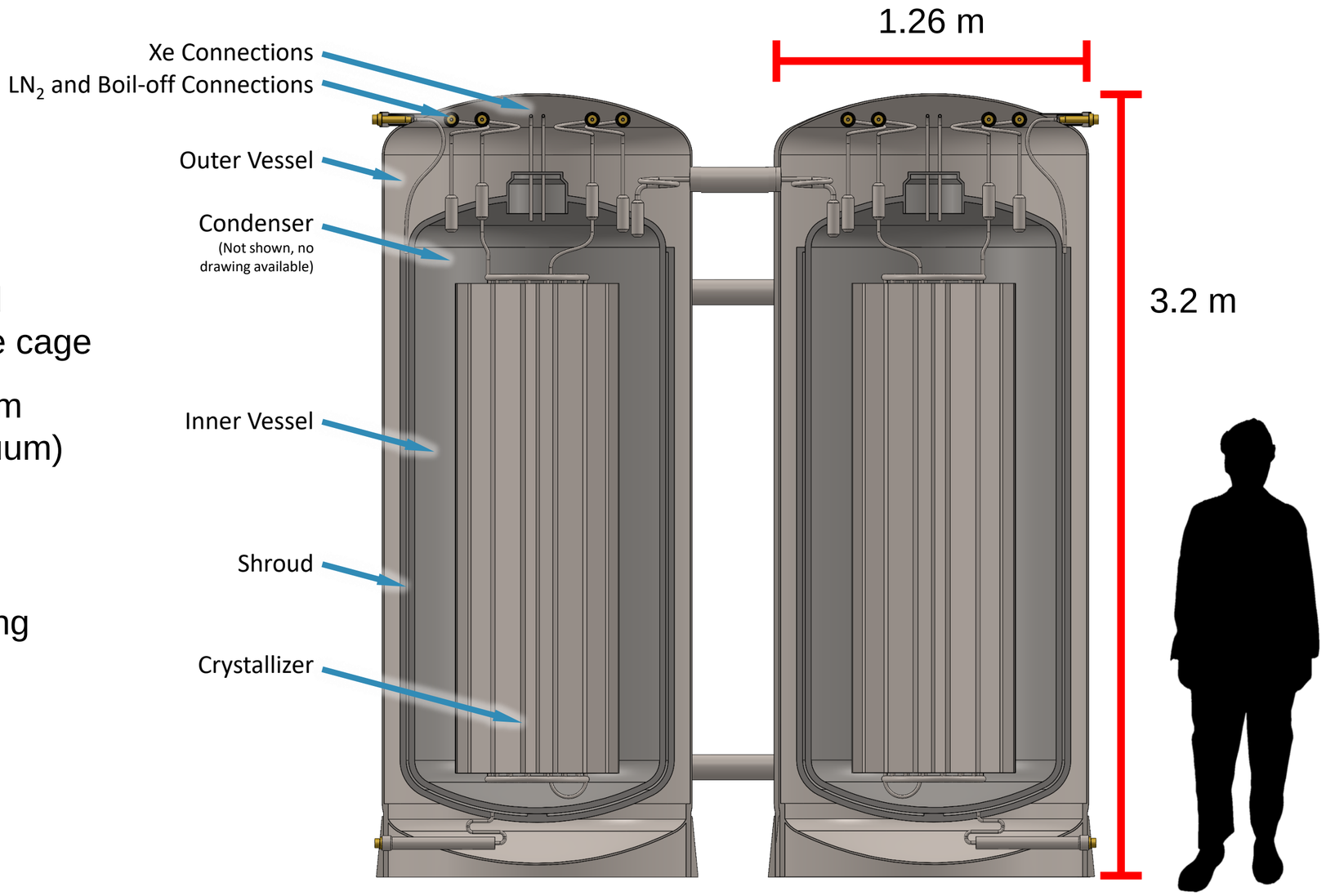
DIS. N° – Dwg. N°: 064-000-001

FOGLIO Sheet 1 DI OF 1 | FORM. Size A2 | REV. 0 1 2 3 4 5 6 7

2) 40× 2.5 tonnes ReStoX in BAR expansion

Conceptual

- 20 pairs of ReStoX
- Design driven by maximum size and weight that can be transported in the cage
- Volume: 1.9 m^3, 2.5 tonne Xe at room temperature each (73 bar + full vacuum)
- Crystalliser: 8 kW cooling power
  - nEXO required two for redundancy
- Shroud: keeps inner vessel cold using 0.1 kW of cooling power (LN_2)
- One vessel with condenser for Xe liquefaction



Built

4) Hybrid Scheme

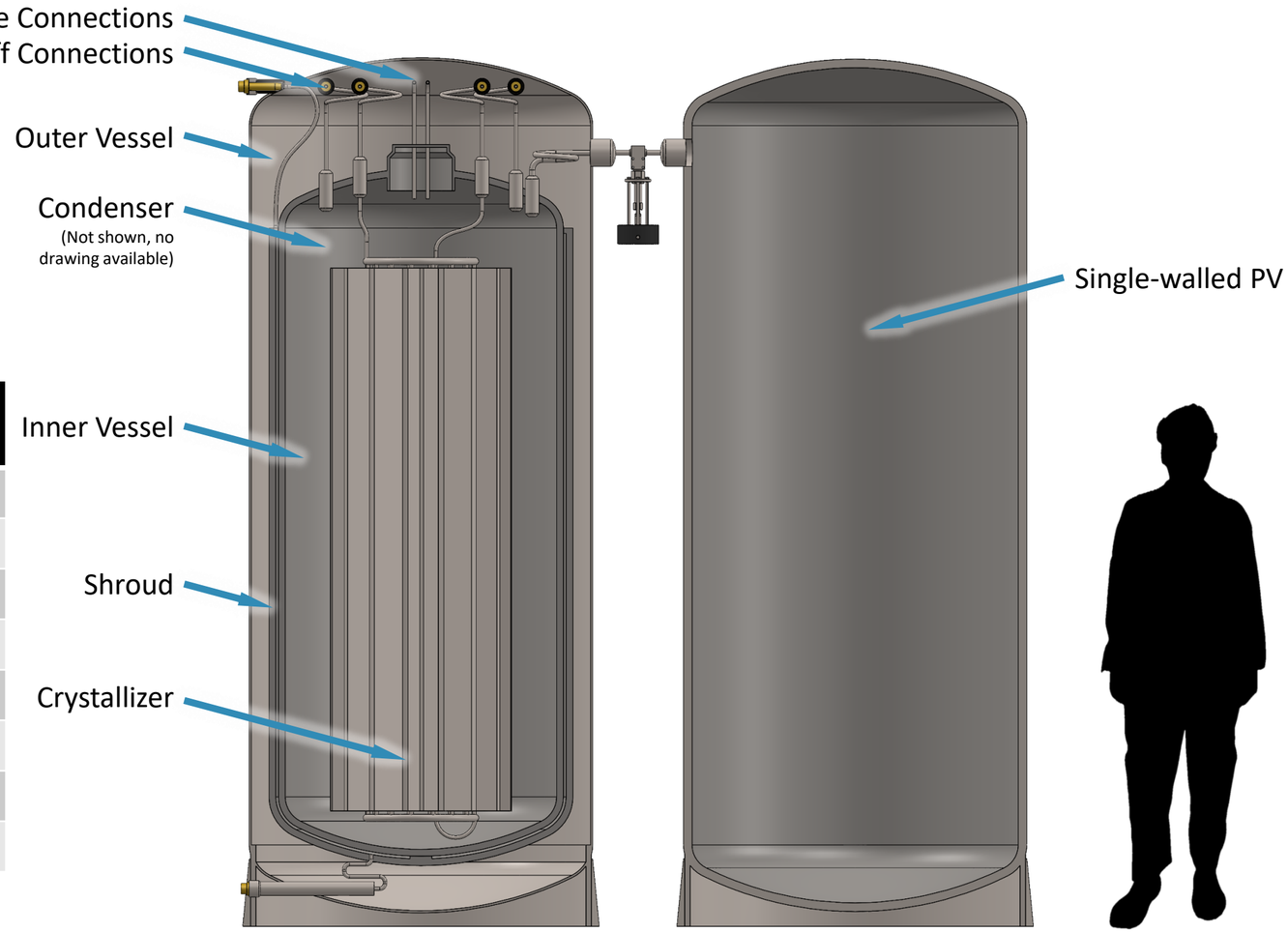
- Inspiration: Gas cylinder recuperation in Xenoscope
- Capacity: ~400 kg
- Cryopump all the xenon in up to 4 cylinders (frozen)
  - Overfills cylinders!
- After recuperation is complete, redistribute all the xenon into a total of 9 cylinders
- Lower cost than all cylinders cryo-capable

4) Hybrid (14× 2.5 tonnes ReStoX + 14× 4.4 tonnes pressure vessel)

Very Conceptual

- Two types of vessels, same dimensions, same pressure rating (74 bara at room temperature)
- 15 pairs → 103 320 kg GXe

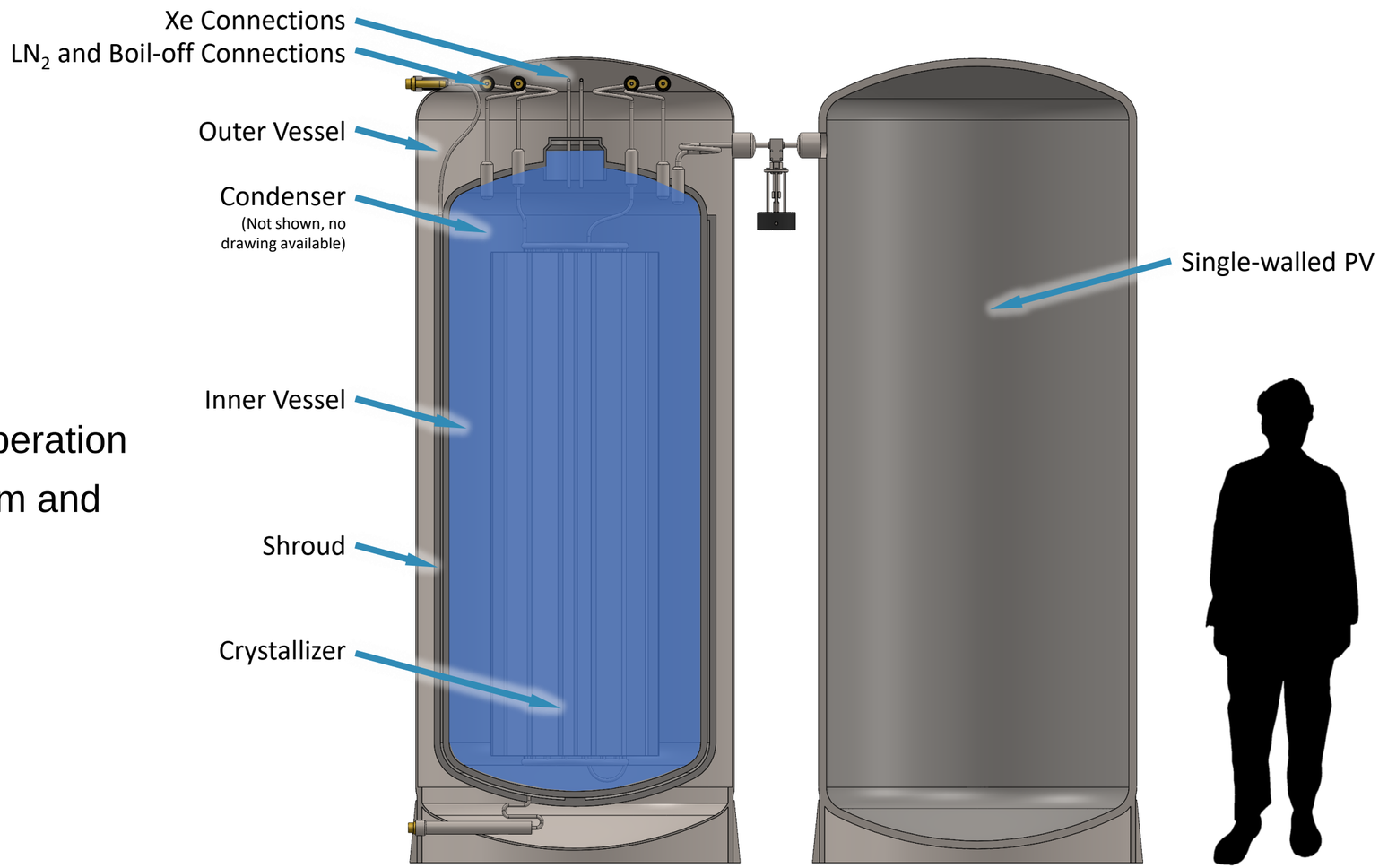
	ReStoX	Pressure Vessel	Total (pair)
Pressure rating at 295 K [bara]	74	74	74
Tare weight (est.) [kg]	4 200	3 500	7 700
GXe capacity [kg]	2 500	4 388	6 888
LXe capacity [kg]	5 590	---	5 590
SXe capacity [kg]	6 916	---	6 916
Cooling Power (Crystallizer) [kW]	8	---	8
Cooling Power (Shroud) [kW]	0.1	---	0.1
Cost	$$$$	$	$$



4) Hybrid (14× 2.5 tonnes ReStoX + 14× 4.4 tonnes pressure vessel)

Very Conceptual

- Recuperation scheme:
  - Receive LXe from TPC in ReStoX
  - Freeze LXe with crystallizer
    - Pressure in ReStoX → 0 bar
    - Pressure difference drives the recuperation
  - When ReStoX full, isolate from the system and switch to another ReStoX



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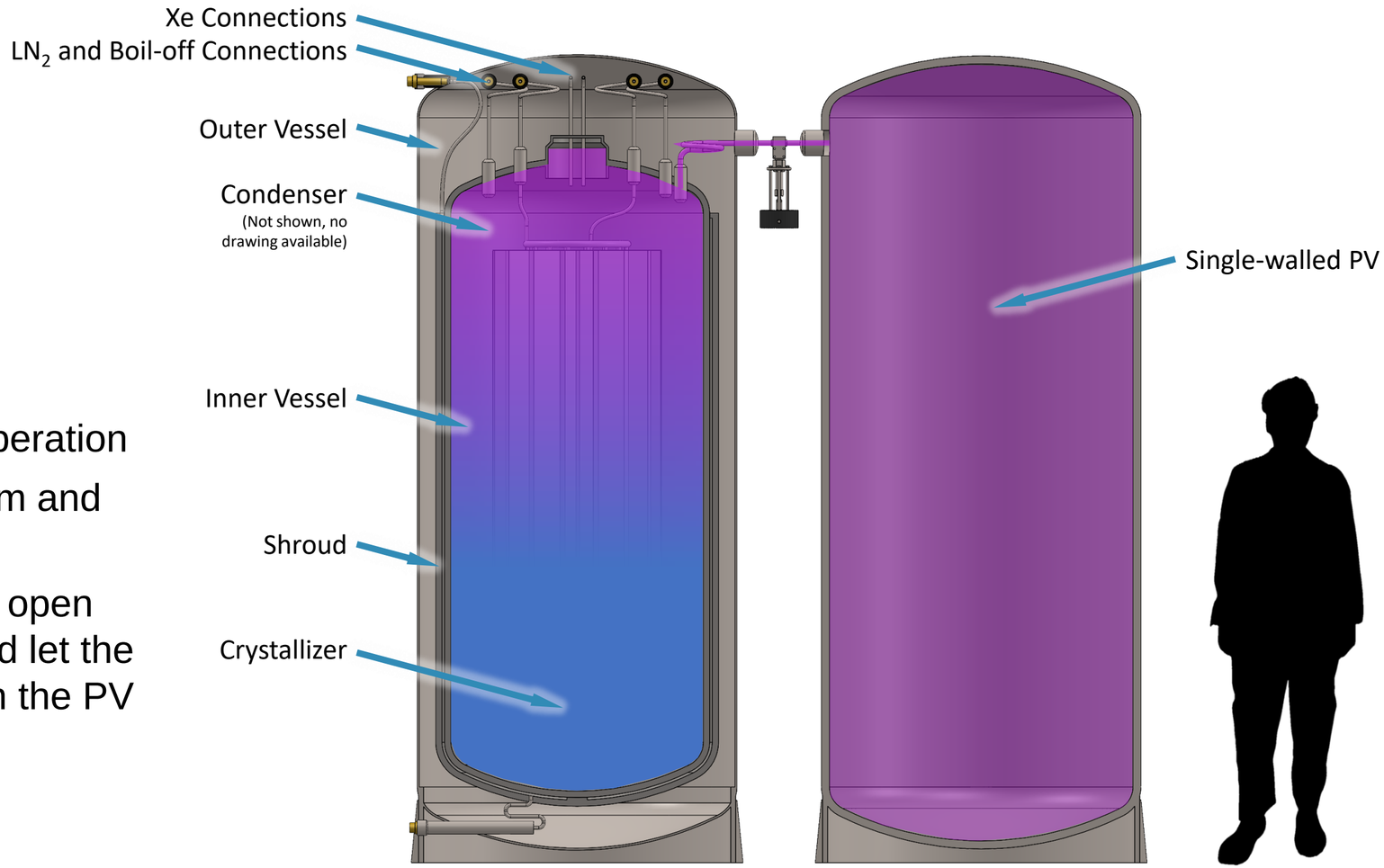
  - After isolation from the recuperation line, open the connection to the pressure vessel and let the SXe warm up and distribute gas between the PV and ReStoX



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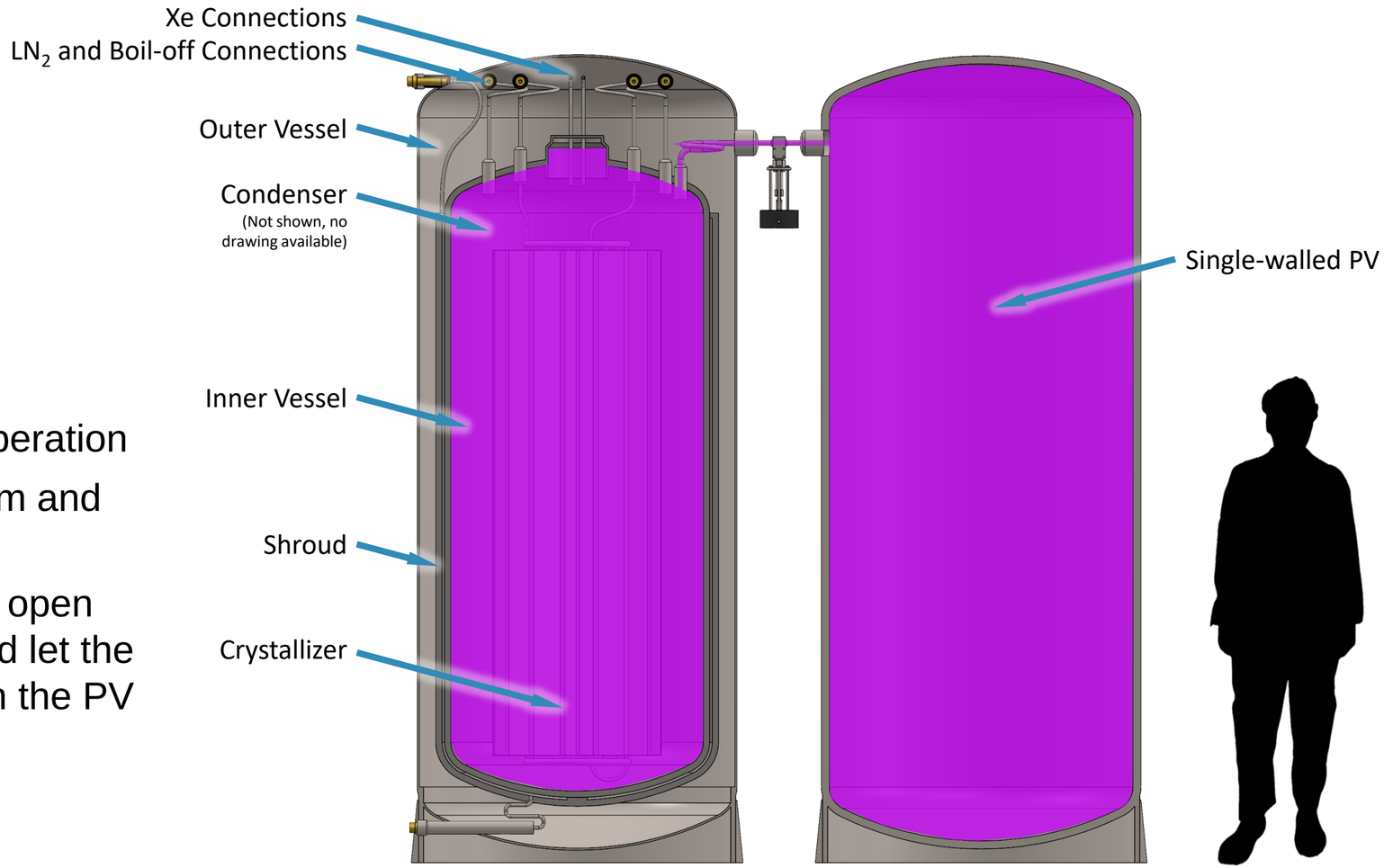
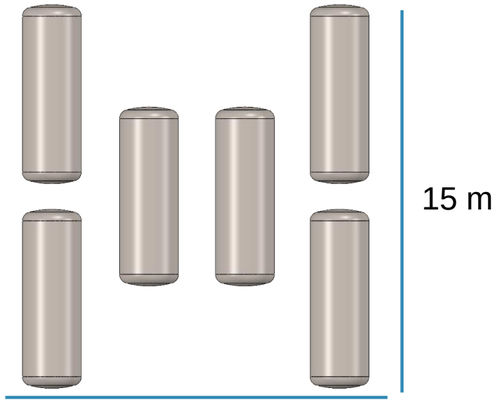


Footprint

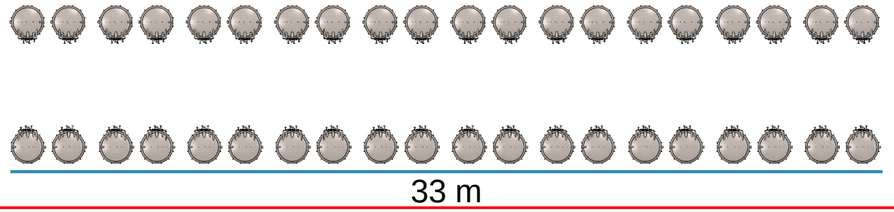
Conceptual

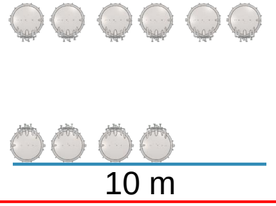
Solution 1:
Qty: 6×
Capacity: 16.7 tonnes



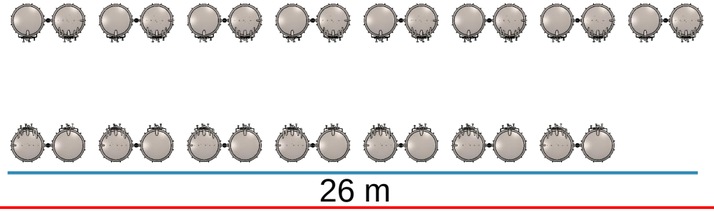
Space available for extra

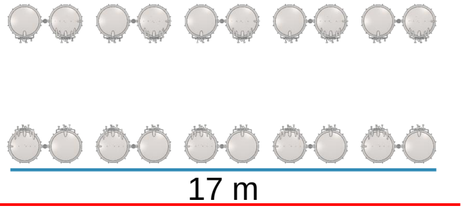
Solutions 2 and 3:
Qty: 40× (50×)
2.5 tonnes





Solution 4:
18× (25×) pairs
2.5 + 4.4 tonnes





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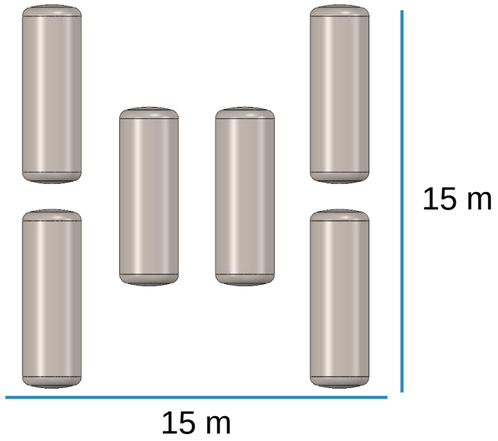

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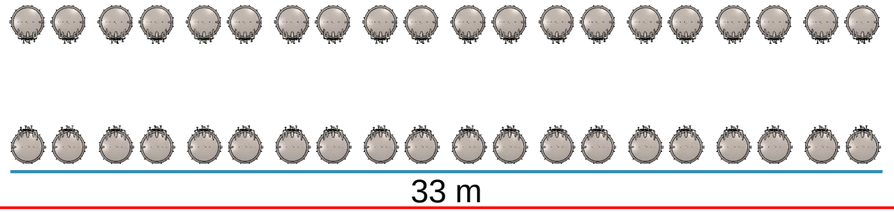

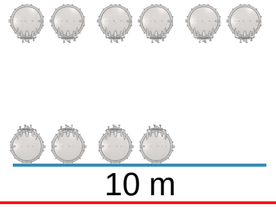

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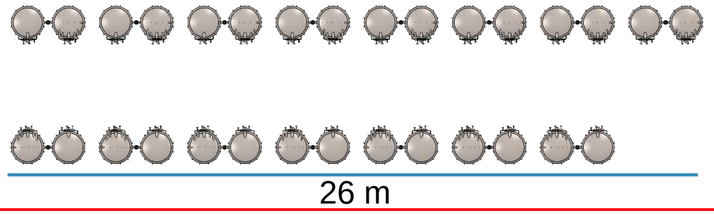
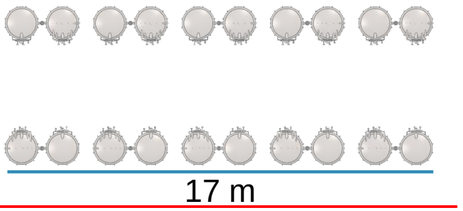
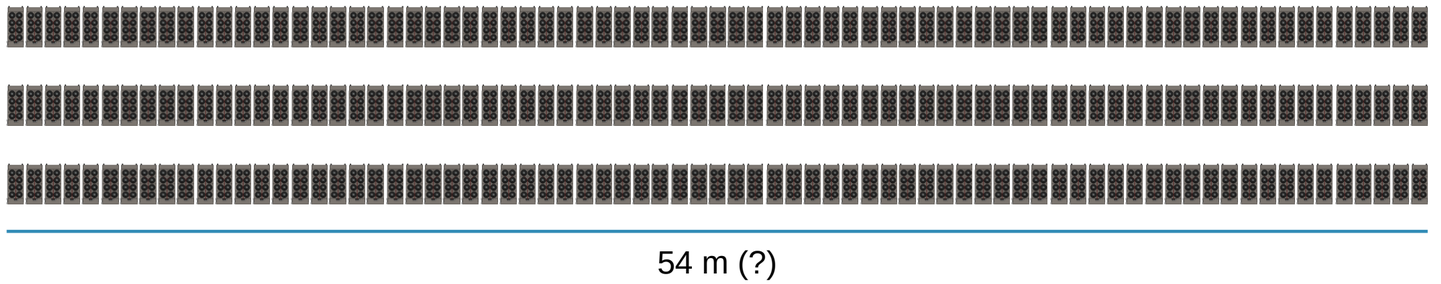




Solution 5:
1 820 cylinders



Xenon Recovery and Storage at SNOLAB

- SNOLAB was awarded money to conduct feasibility studies for xenon storage solutions
- We must determine requirements, define recuperation schemes, find commercial partners to inform on standards, design, costs and conduct pre-production analysis
- Is the SNOLAB solution compatible with ReStoX at Boulby?
- If you think you want to/can help this effort, please join us!
  - 1.03-1.04 meetings (L2: Christian Weinheimer, Lutz Althüser, Frédéric Girard)
  - Recovery task force (TF chair: Carter Hall)
  - Or contact me, David or Chris

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Carter Hall: crhall@umd.edu


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