ND Installation sequence

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Near Site Integration Workshop

16 March 2021

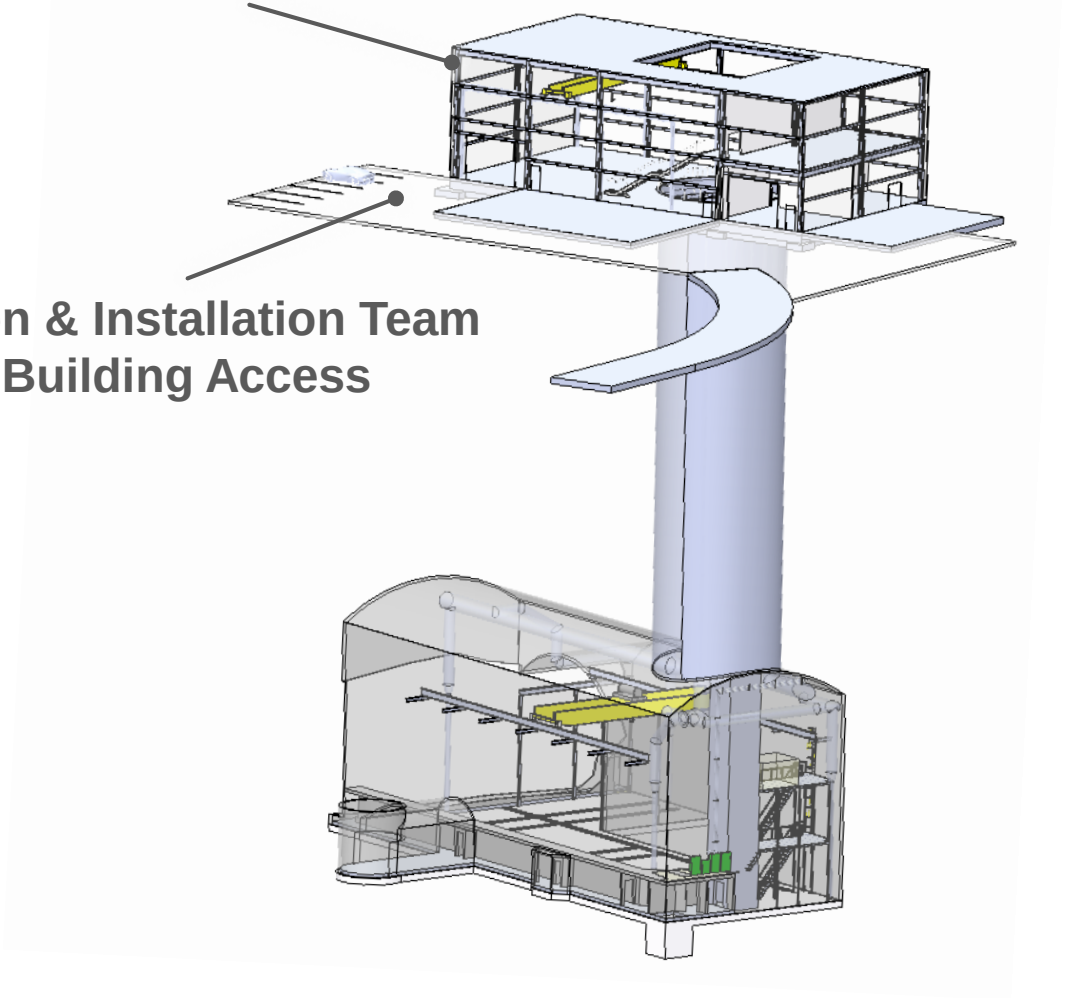
Goals for this talk:

- Updated installation sequence
- Including input from consortia
- Timeline and parallel activities
- Resources and conflicts

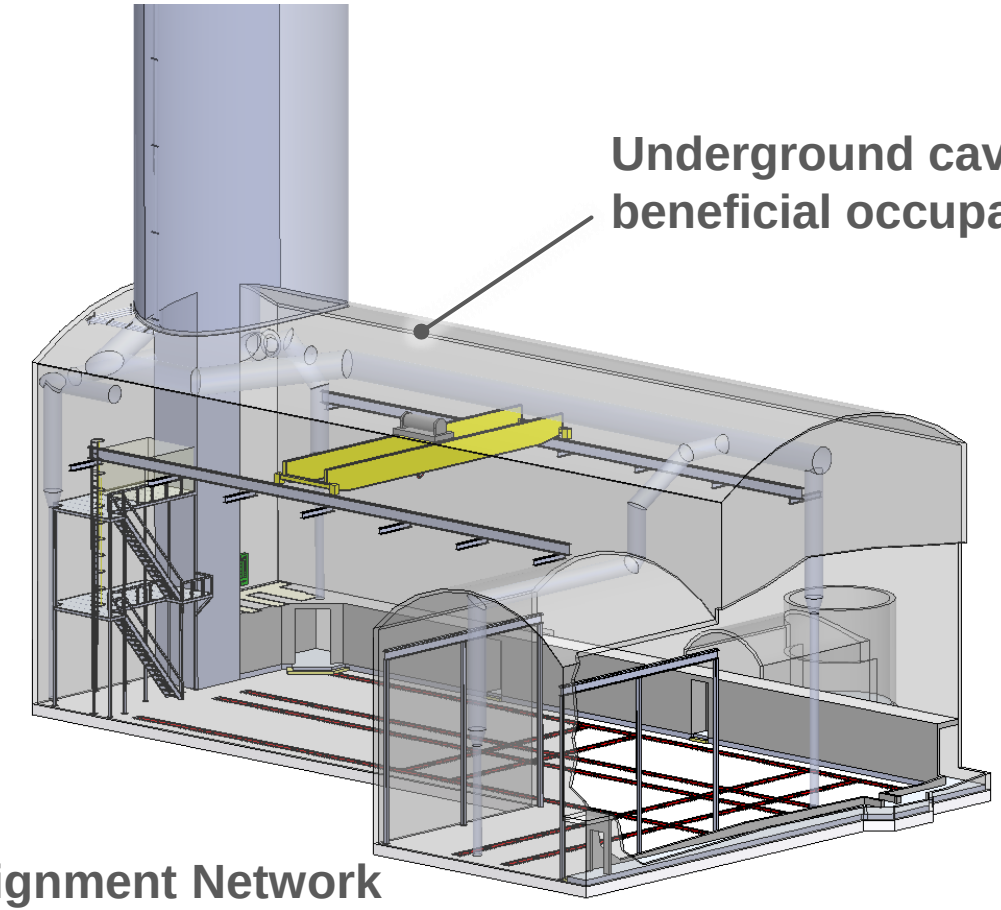
Conventional Facility beneficial occupancy - 2026

Surface building
beneficial occupancy

Integration & Installation Team
Prepares Building Access

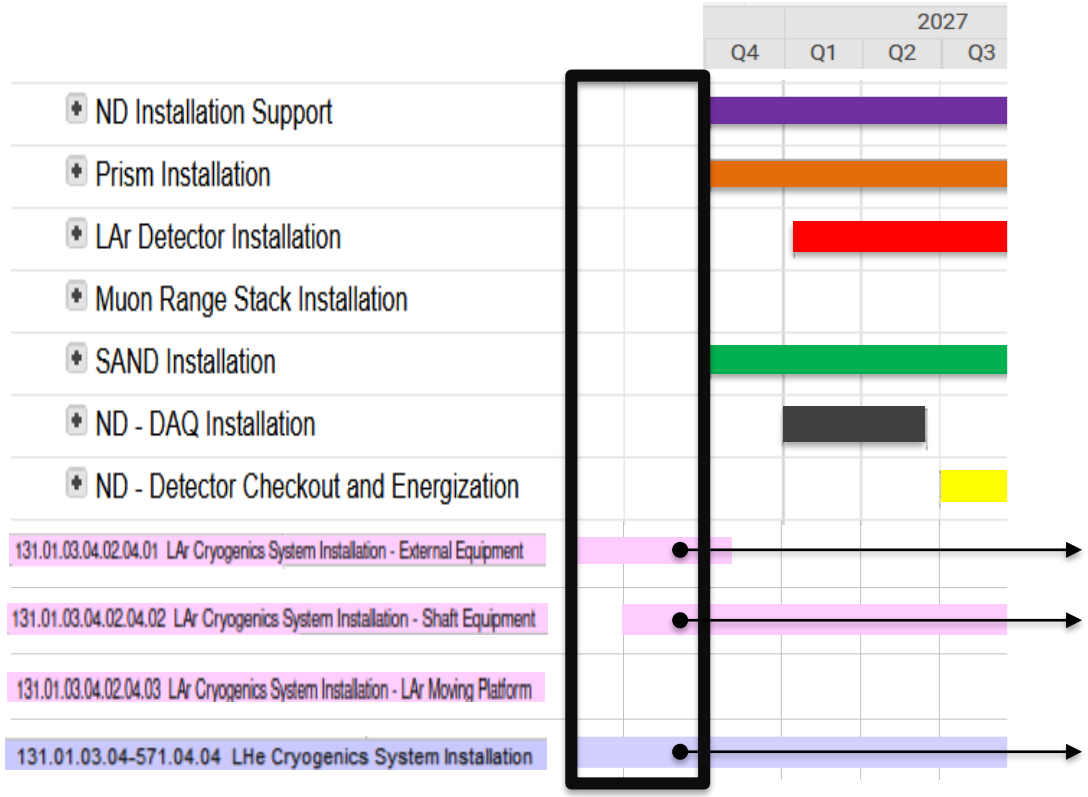


Underground cavern
beneficial occupancy

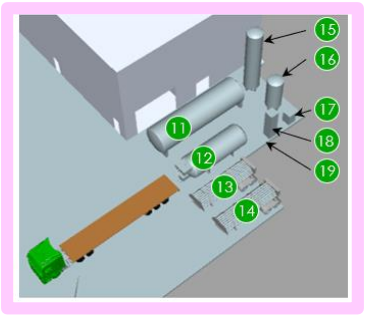


Alignment Network
(May 2026)

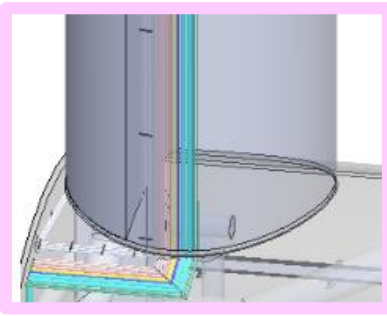
Install Sequence Q2-Q3 2026



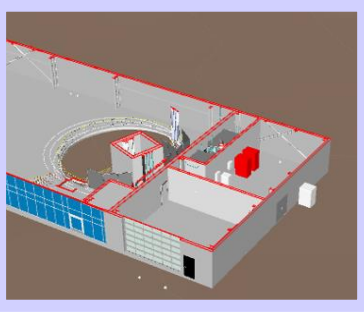
Location	Equipment	I&I Support	Consortia	Others
External	M-Crane	Crane Operator (1) Rigging Crew (2)	Engineer(1) Technician (1)	Rigging Contractor
Shaft	Mast Climber	-	-	Welding crew (2)
Surface	S-Crane	-	-	-



External Cryogenics

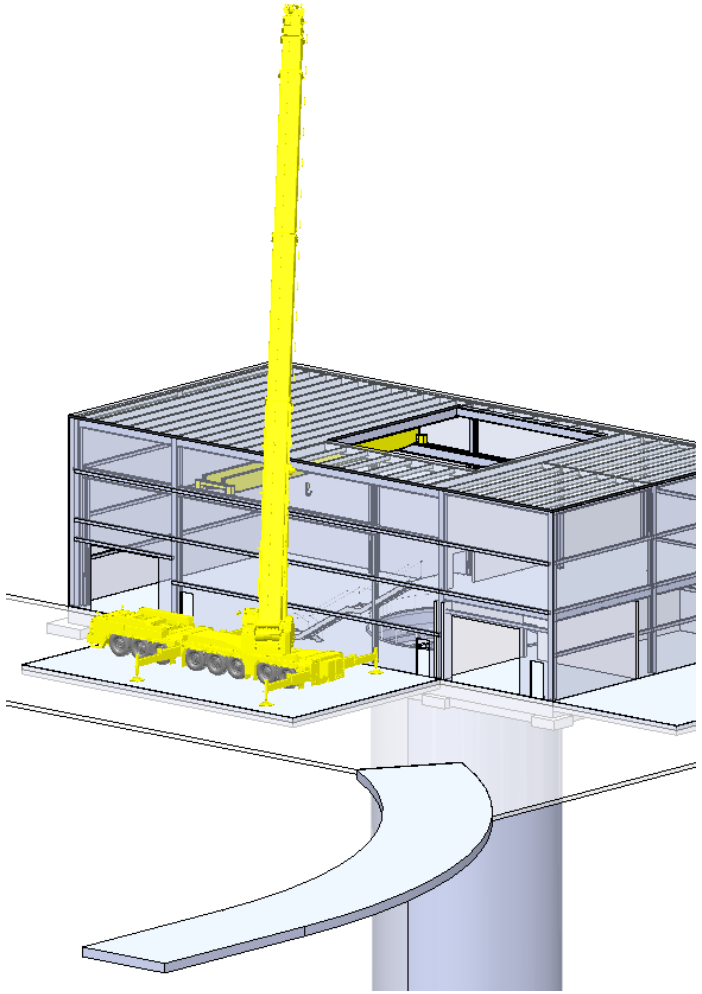


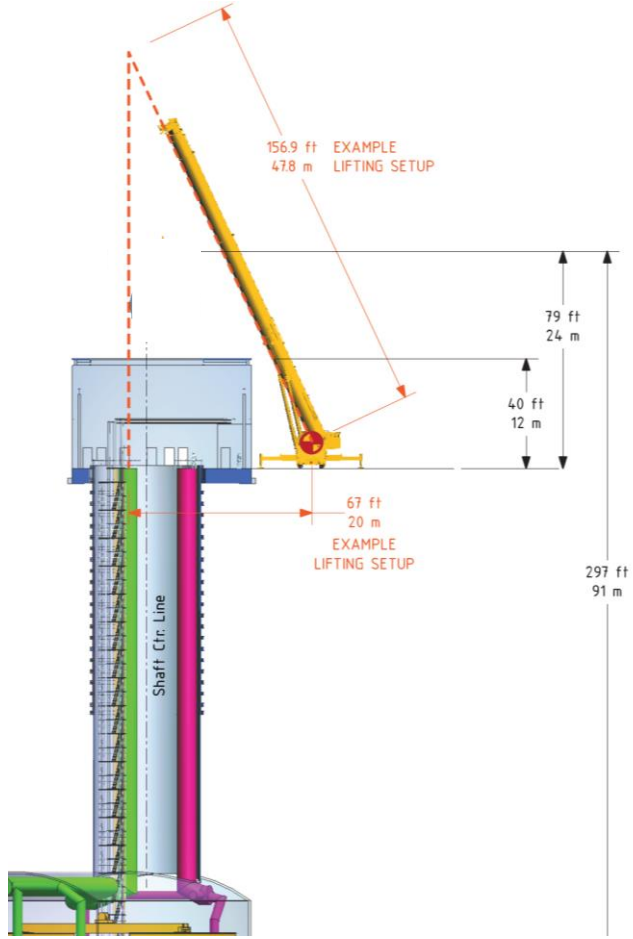
Shaft Cryogenics



Helium Room

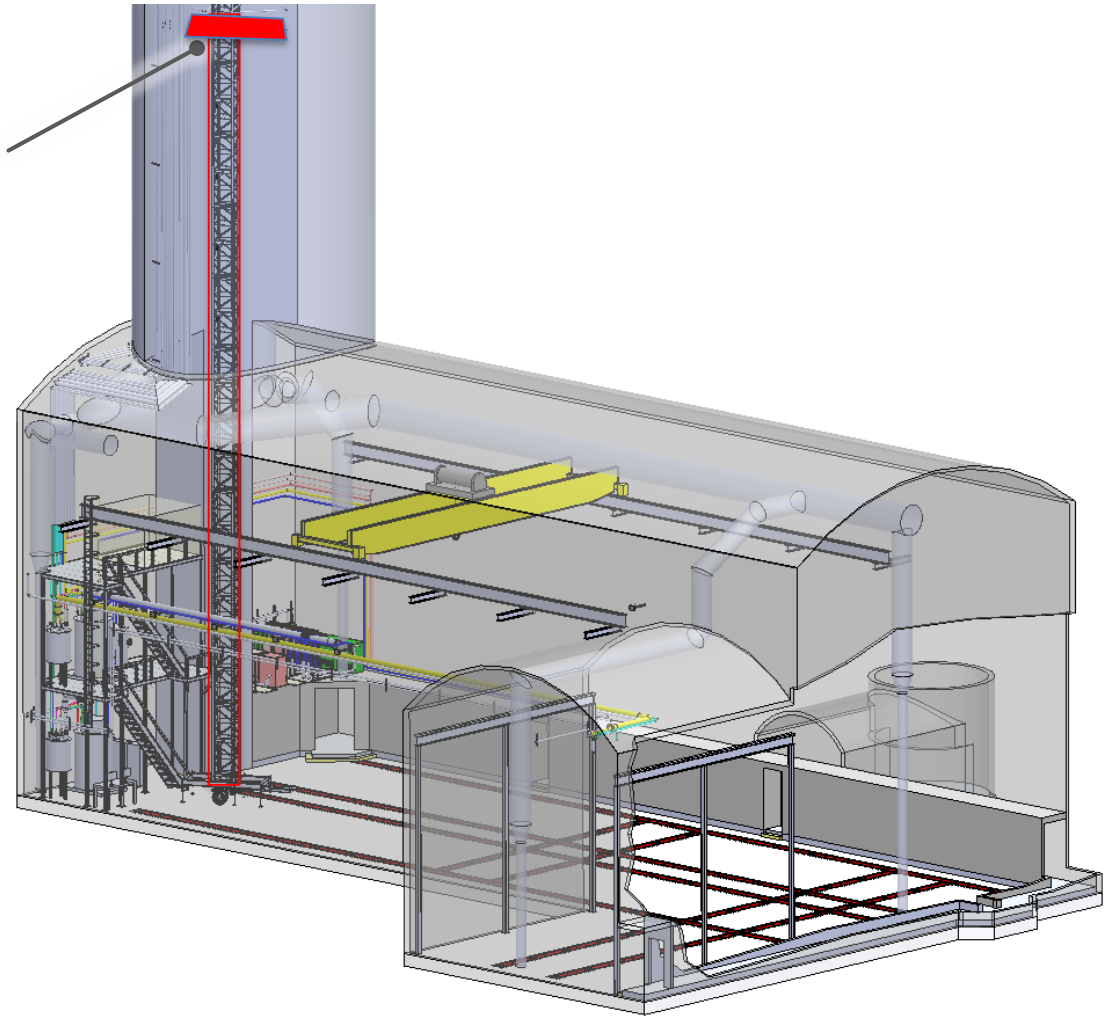
Surface Crane – 180 US TON

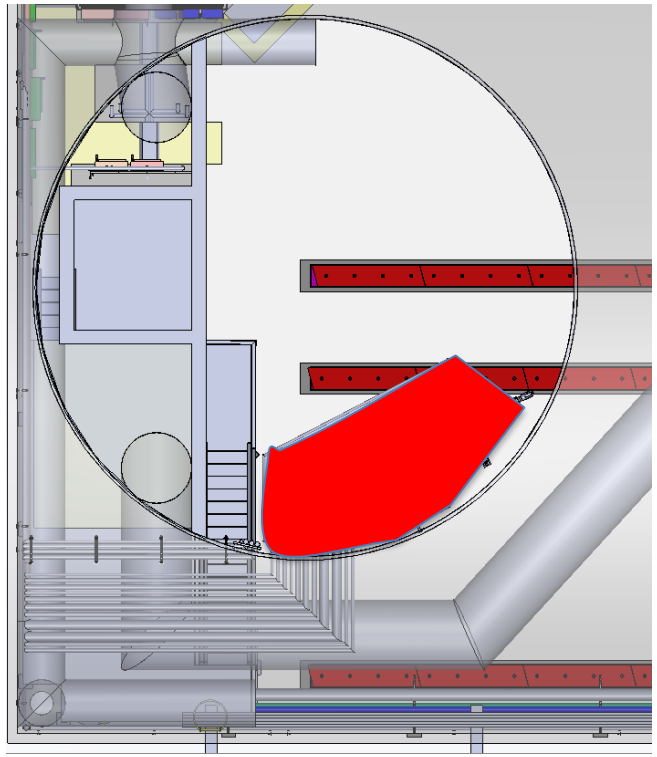




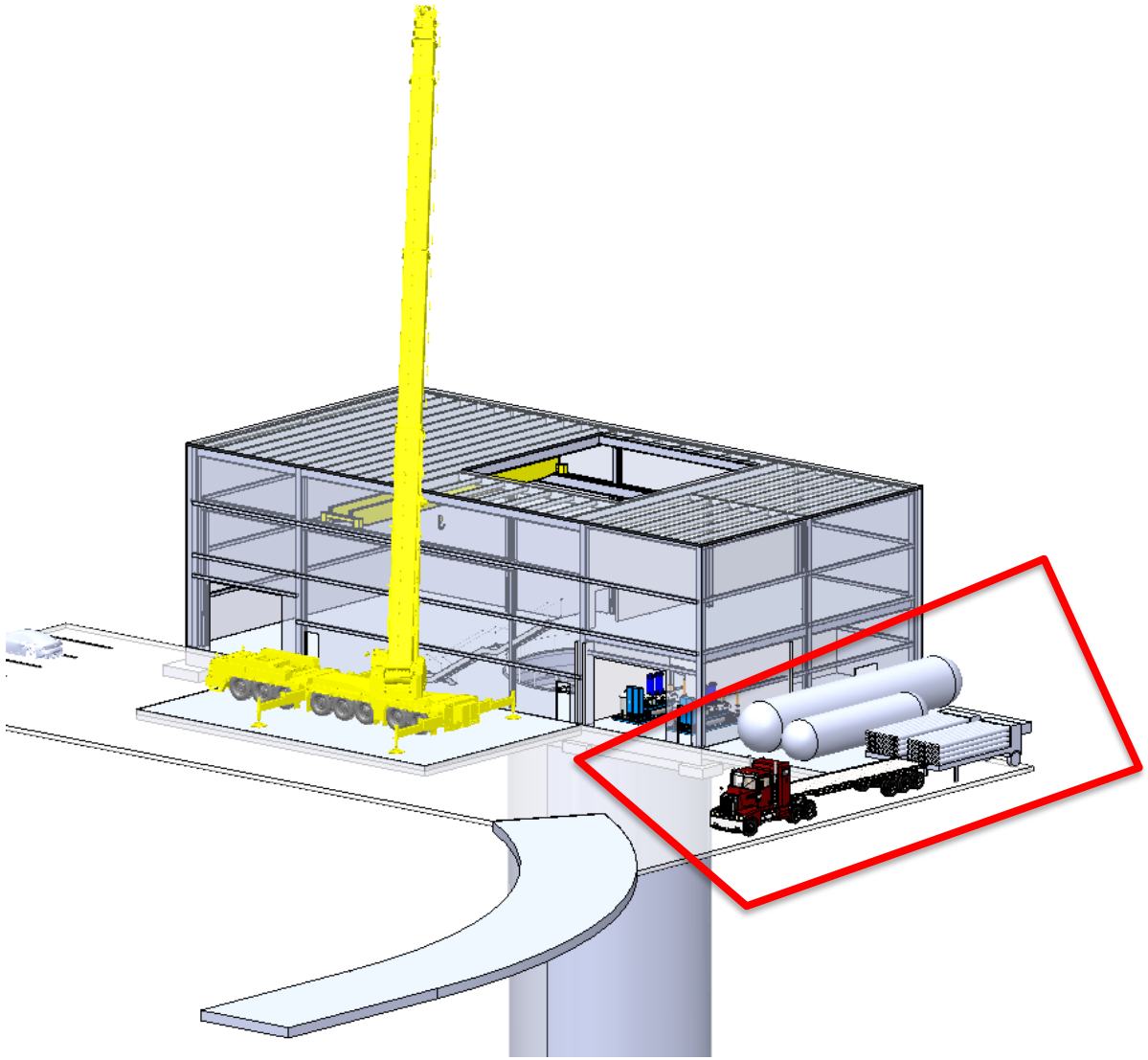
Mast Climber

Mast Climber for installation of cryogenic pipes and shared data cables





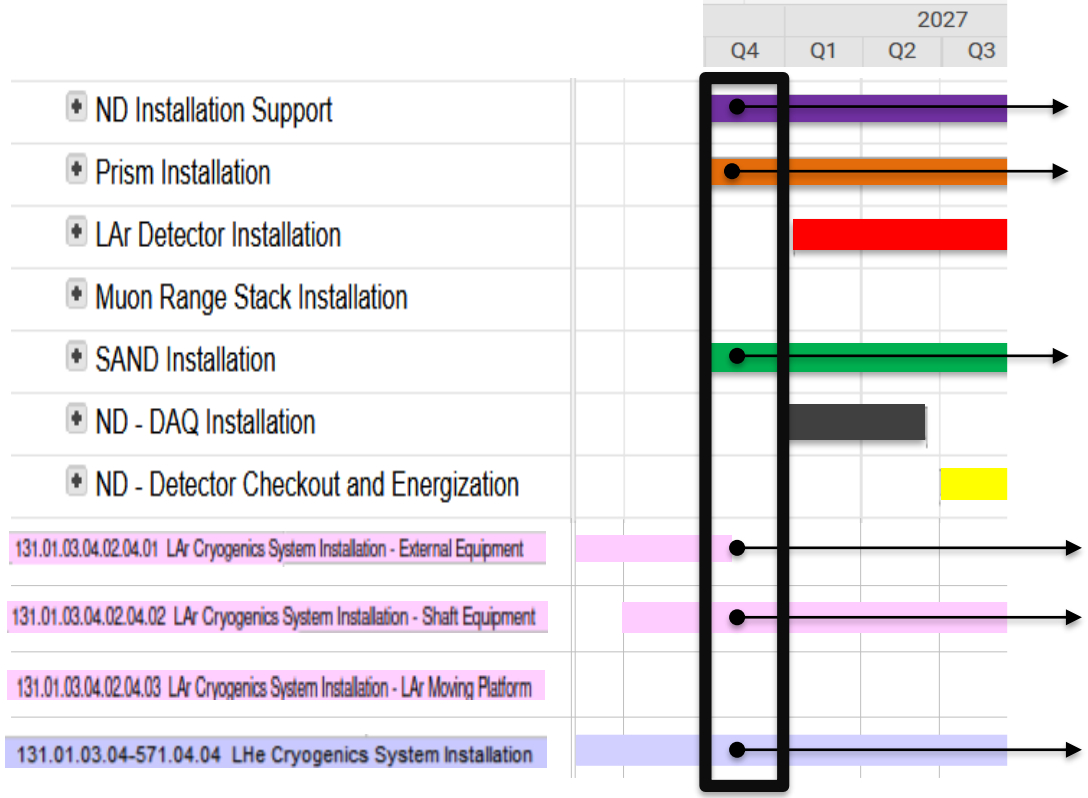
External Cryogenics



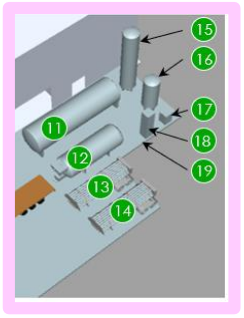
NON-CRITICAL PATH

- Delivery and rigging of vessels for both LAr and LHe systems
- Block road access for 2 weeks
- Piping activities

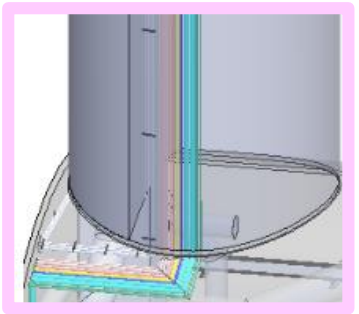
Install Sequence – Q4 2026



Location	Equipment	I&I Support	Consortia	Others
Surf. & Cav.		3 Techs	N/A	
Cavern				
Surf./Shaft/Cav.				
External				
Shaft				
Surface				

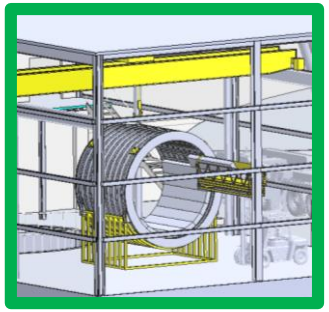


External Cryo.

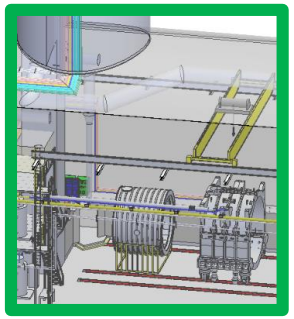


Shaft Cryogenics

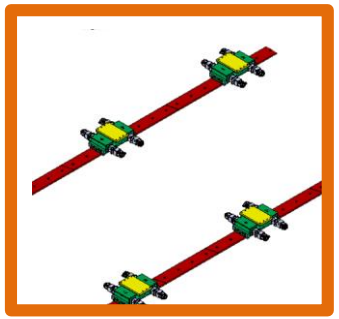
Helium Room



SAND Surface

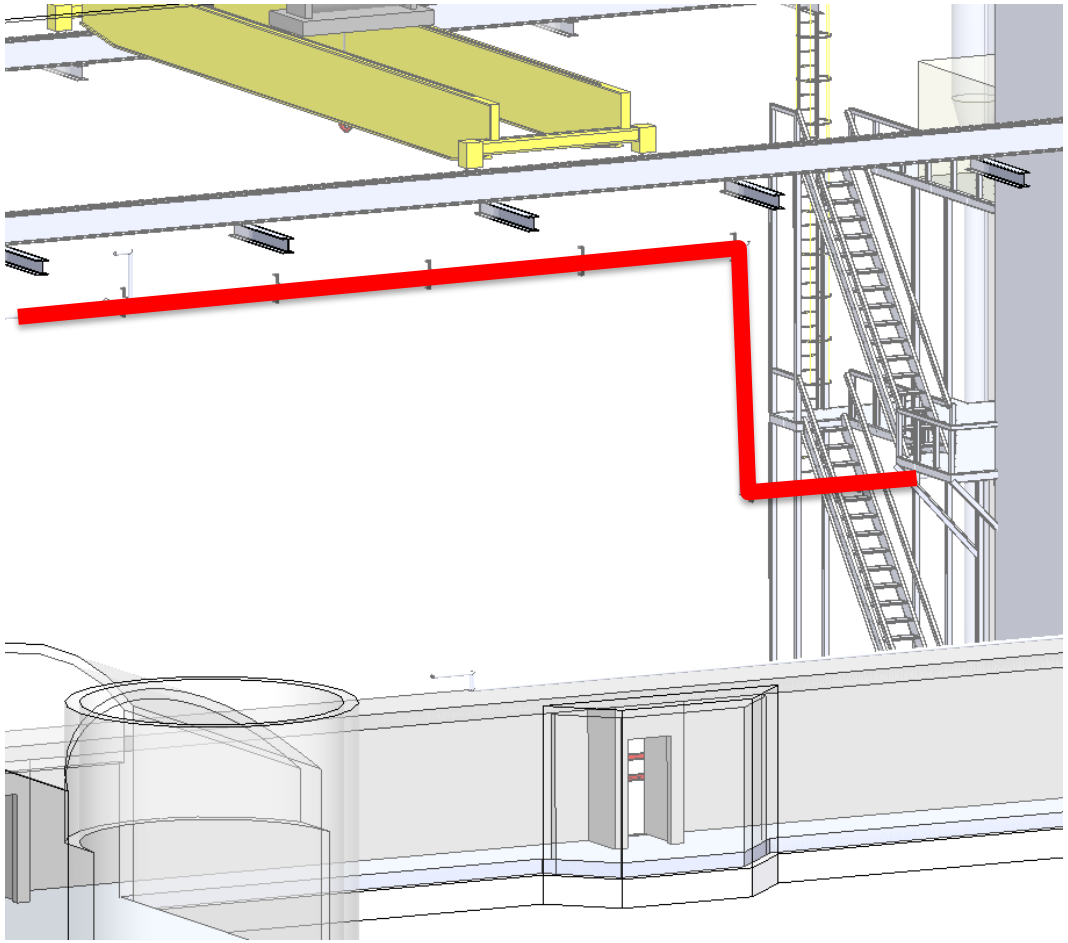


SAND Shaft & Cavern



PRISM

SAND OVERHEAD CRYO PIPING



GENERAL CRITICAL PATH

Duration: 6 weeks with two-person crew

- TMS footprint blocked with access **scaffold**
- Helium Multi TL mass is 600kg with 11m spool

He Multi channel TL (I&I or TMS?)
Uses scaffold by I&I to install SAND detector cable trays and TMS energy chain

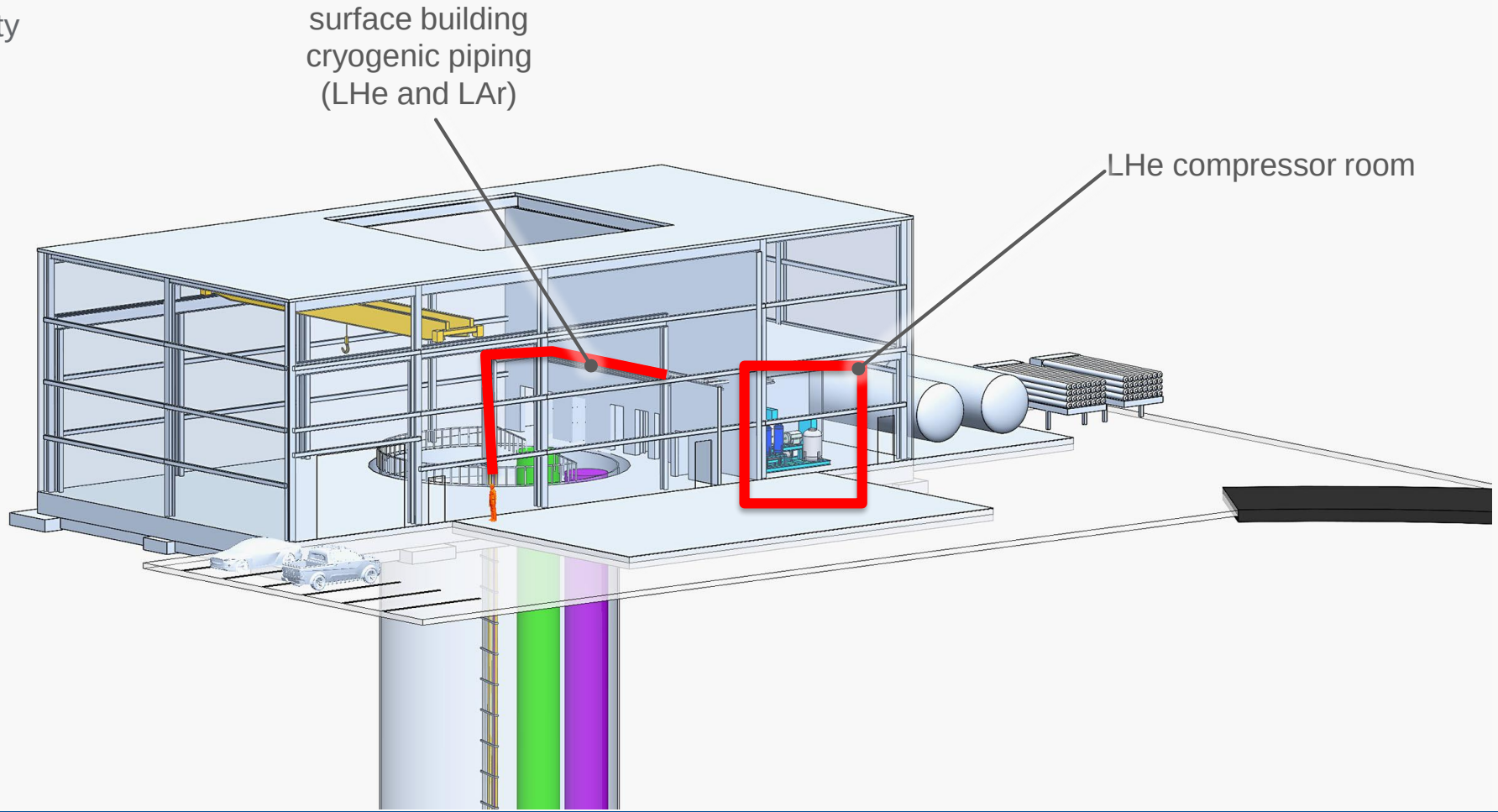
Helium Room, LHe and Lar Piping

Surface work area

- Spools for Helium Room
- Spools for External Cryo
- Spools for Shaft Cryo

NON-CRITICAL PATH

- Install He recycle compressor + ORS + GMP + Ghe purity detector + He Purifier



Shaft Cryogenics

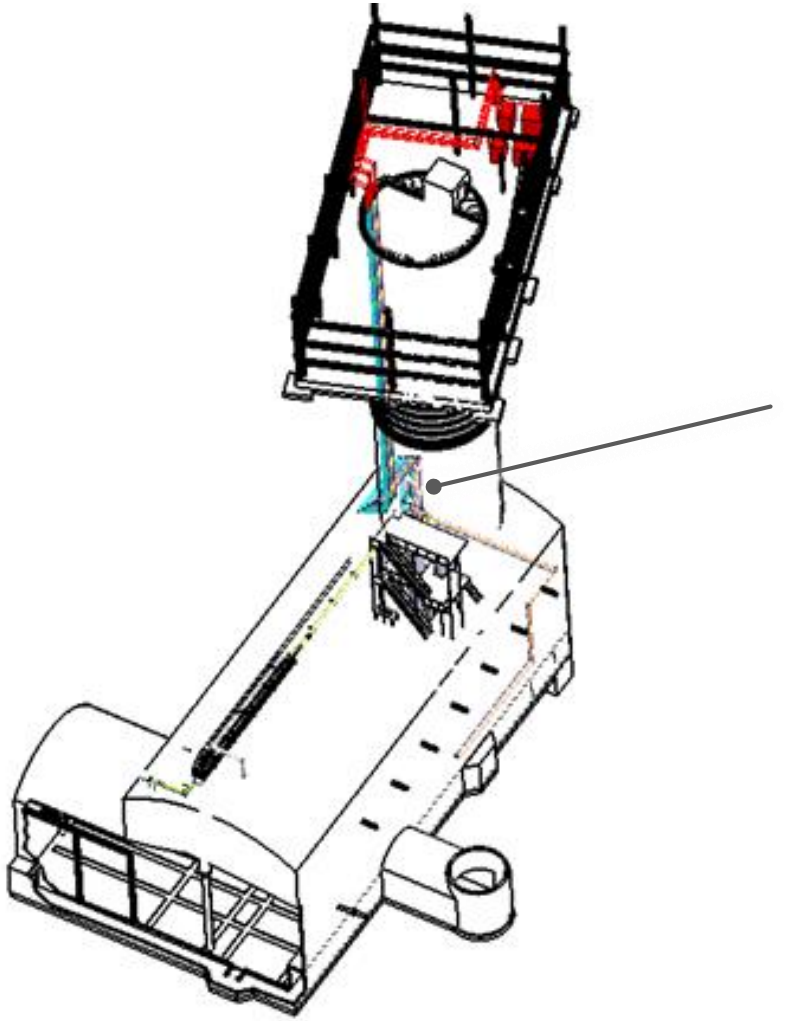
CRITICAL PATH - SHAFT BLOCKED BY CRYO

Piping jobs with mast climber duration

- Helium BOE – 6 weeks two-person crew, 1-shift*
- LAr BOE - 10 weeks two-person crew, 2-shifts
- I&I pull cables in the shaft – unknown duration

Shaft Piping (I&I)

- Mast climber provided by I&I
- Overhang access to install piping in the cavern/shaft interface



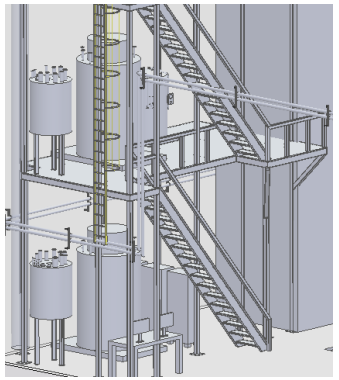
Mezzanine Vessels

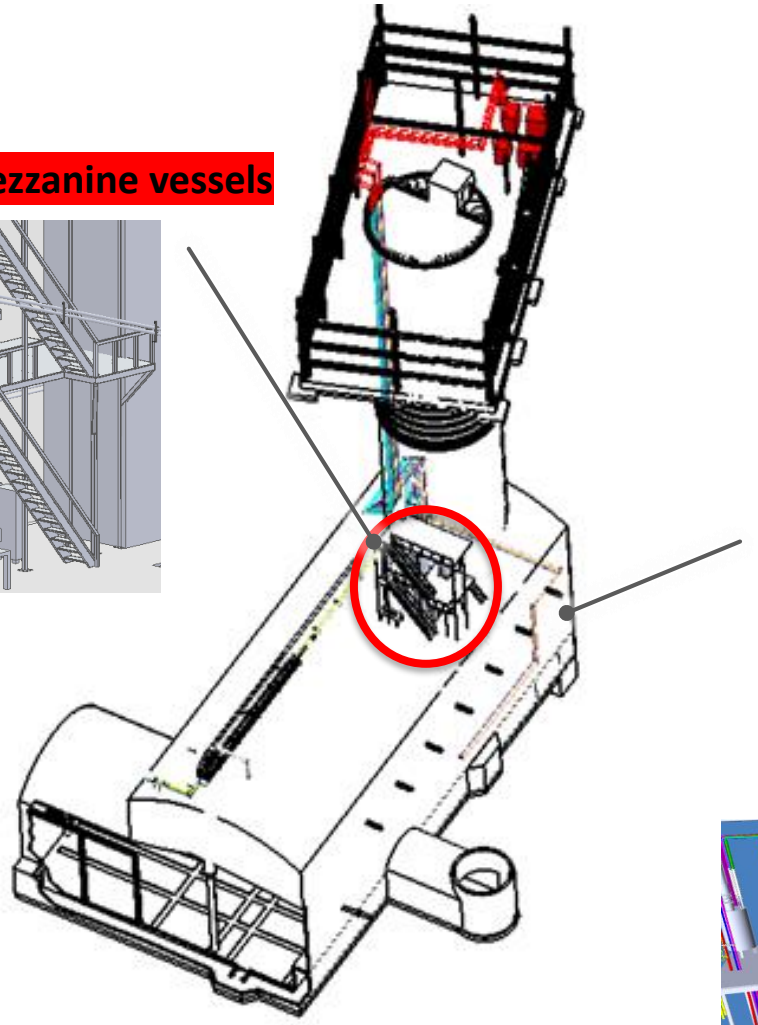
NON-CRITICAL PATH

- Work based on shaft mezzanine.
- Scaffold on South-East cavern side to install transfer lines interfacing with energy chain.

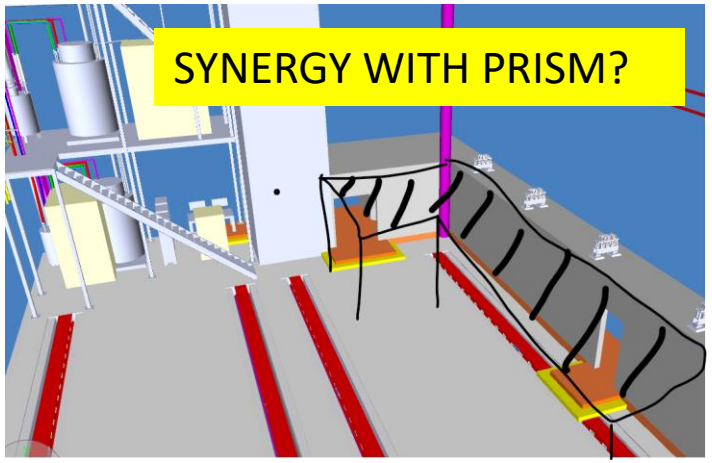
- Install vessels in the mezzanine <u>without crane access</u>. Mass up to 4 Tons.
- Scaffold will be placed above lift door **See A14354 and A14356**

Shaft Mezzanine vessels





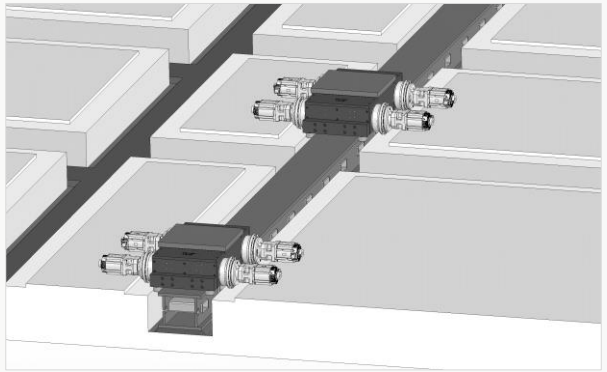
Interconnect to S1/S2 interface

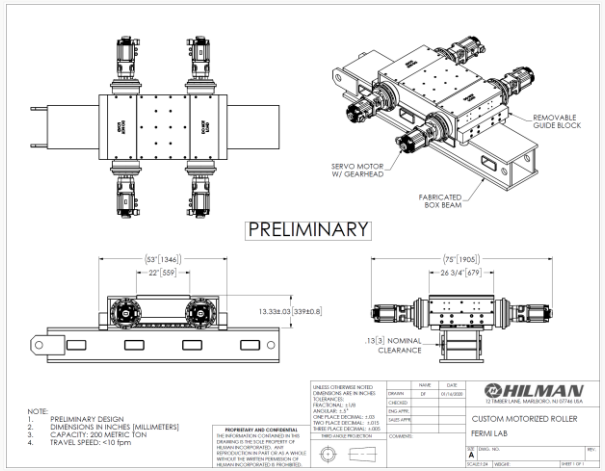


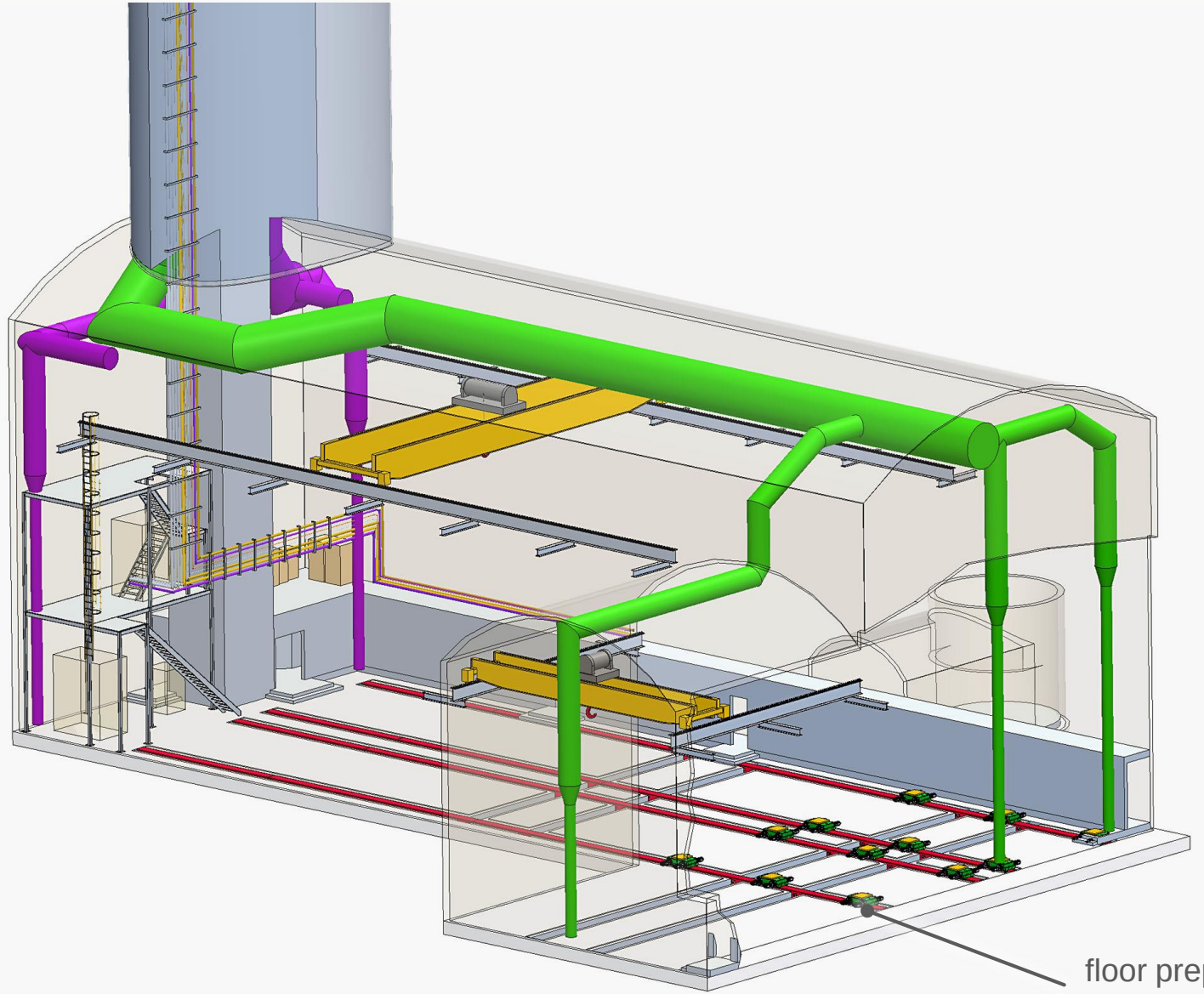
PRISM Scaffold (I&I or PRISM?)

- Scaffold to install prism, piping and cabling in south wall

PRISM



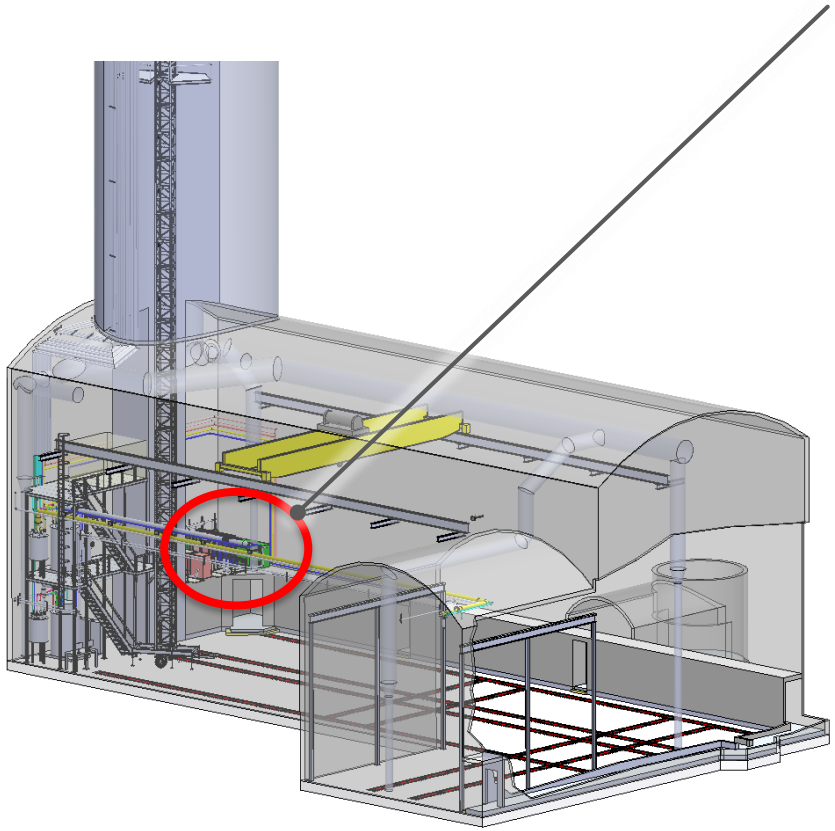


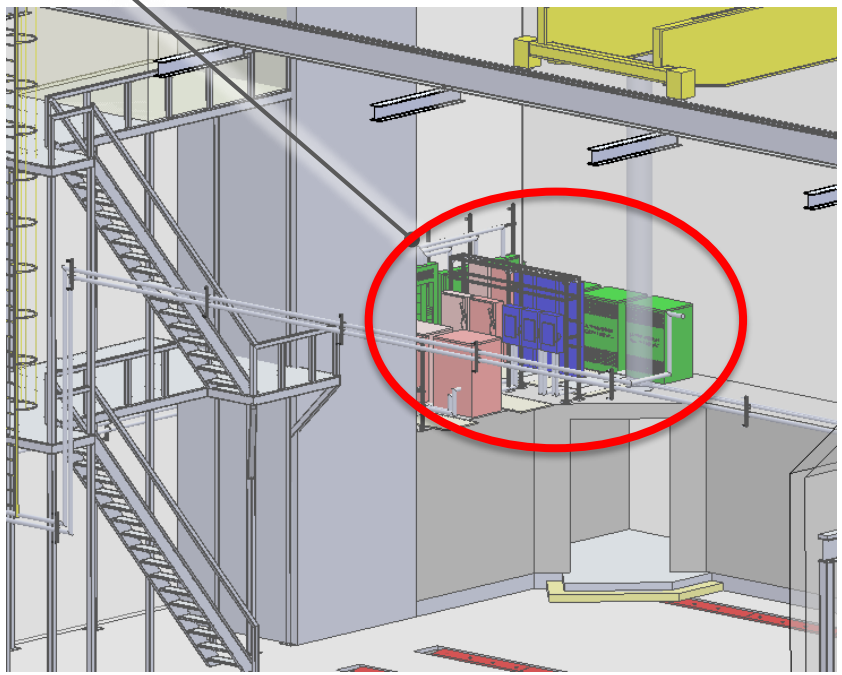


floor preparation and installation of detector rail tracks

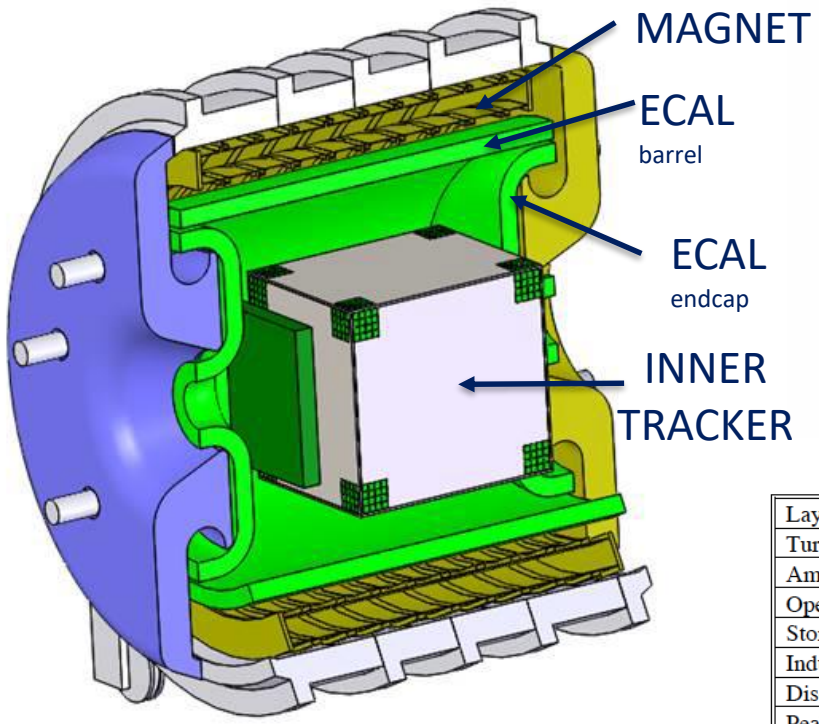
Power Distribution

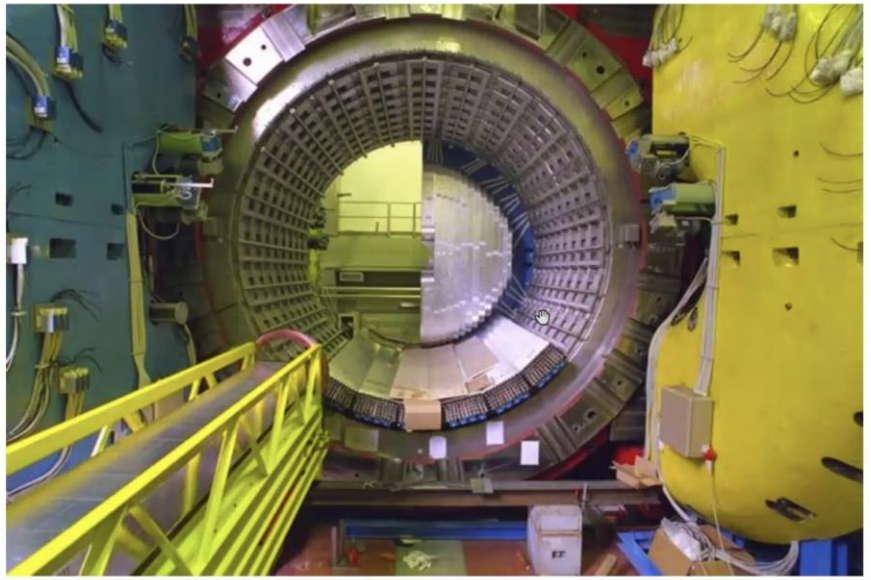
Installation of power distribution





SAND





ECAL

Pb - scintillating fiber sampling calorimeter::
1 mm diameter sci.-fi.
grooved lead foils from molding .5 mm plates

Calorimeter thickness = 23 cm
Total scintillator thickness ~ 10 cm

24 barrel modules, 4.3 m total length (4 tons each)
2x32 endcaps modules

Coil parameters

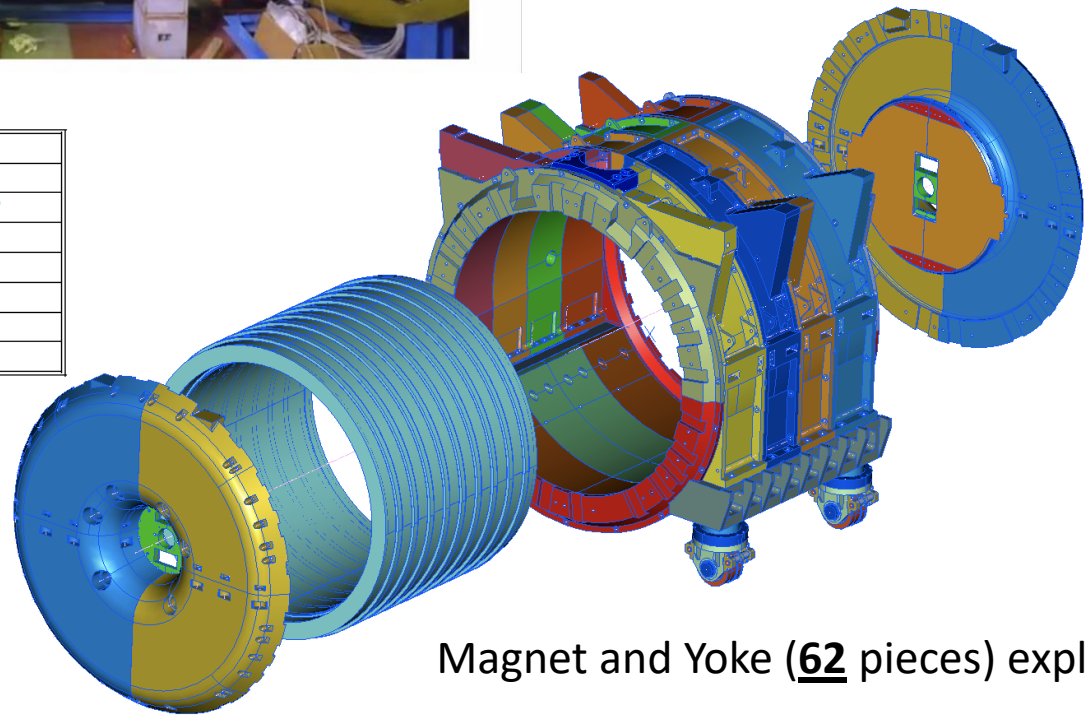
Layers	2
Turns/layer	368
Ampere-turns	2.14 MA-T
Operating current	2902 A
Stored energy	14.3 MJ
Inductance at full field	3.4 H
Discharge voltage	250 V
Peak quench temperature	80 K

Guaranteed heat loads

Source	Heat load
Current leads	0.6 g/s
4 K Radiation and conduction	55 W
70 K Radiation and conduction	530 W

Inner Tracker

Decision in progress

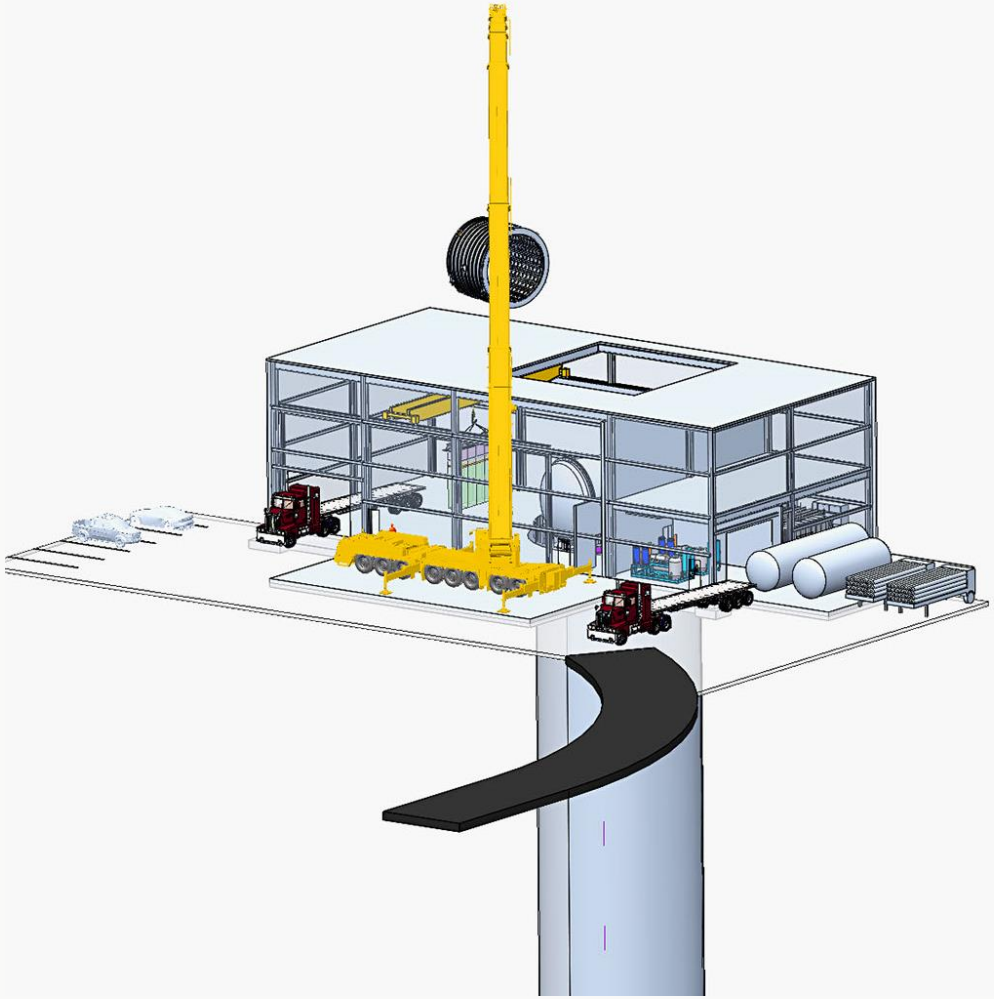


Magnet and Yoke (**62** pieces) exploit

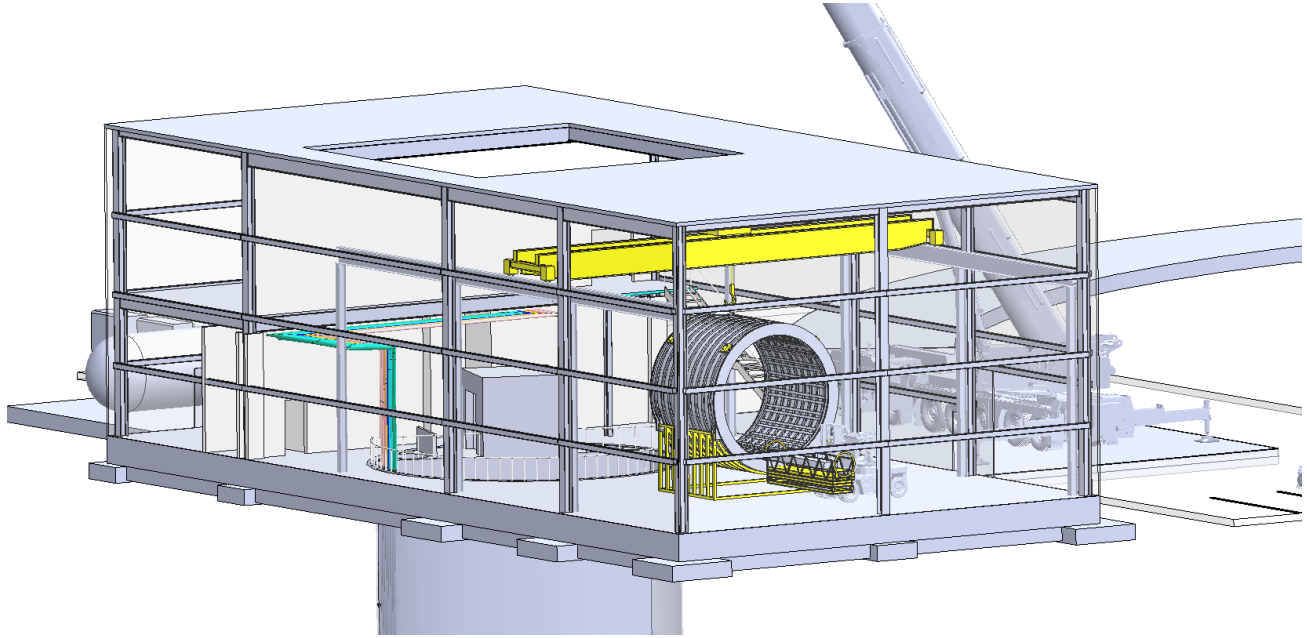
SAND

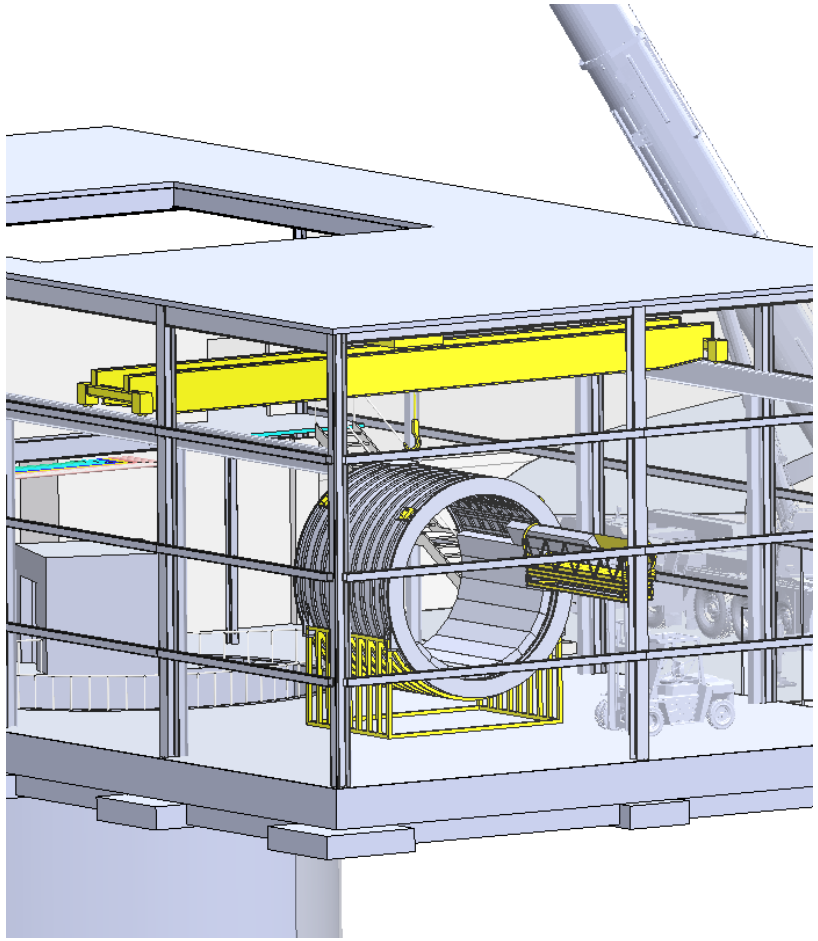
- **Yoke**
  - Total quantity of 62 parts (including small parts) **delivered to storage area** and then lowered in the cavern, as needed, during the assembly
    - Maximum size: L 3590 mm – W 5185 mm – H 1200 mm – Maximum Weight: **30900 kg**
- **Magnet, including cryostat**
  - 1 piece: Ø 5760 mm – L 4386 mm – **Weight: 45000 kg**
  - Delivered with a supporting cradle to the Test area and then to the External Assembly Building
- **ECAL**
  - Total quantity of 24 barrel modules delivered to a storage area and then to the External Assembly Building
    - Size: L 4300 mm – W 590 mm – H 230 mm – **Weight: 4000 kg**
  - Total quantity of 68 end-cap modules delivered to a storage area and then to the cavern
    - Nominal size ~ 1m x 5m x 0,1m, estimated mass = 200kg per unit
- **LAr target**.
  - Cryostat with pre-assembled internal detector delivered to the External Assembly Building.
  - Purification systems installed in the Alcove.
- **Inner tracker** decision making in progress. Components delivered to a storage area and then to the External Assembly Building.

SAND Cryostat

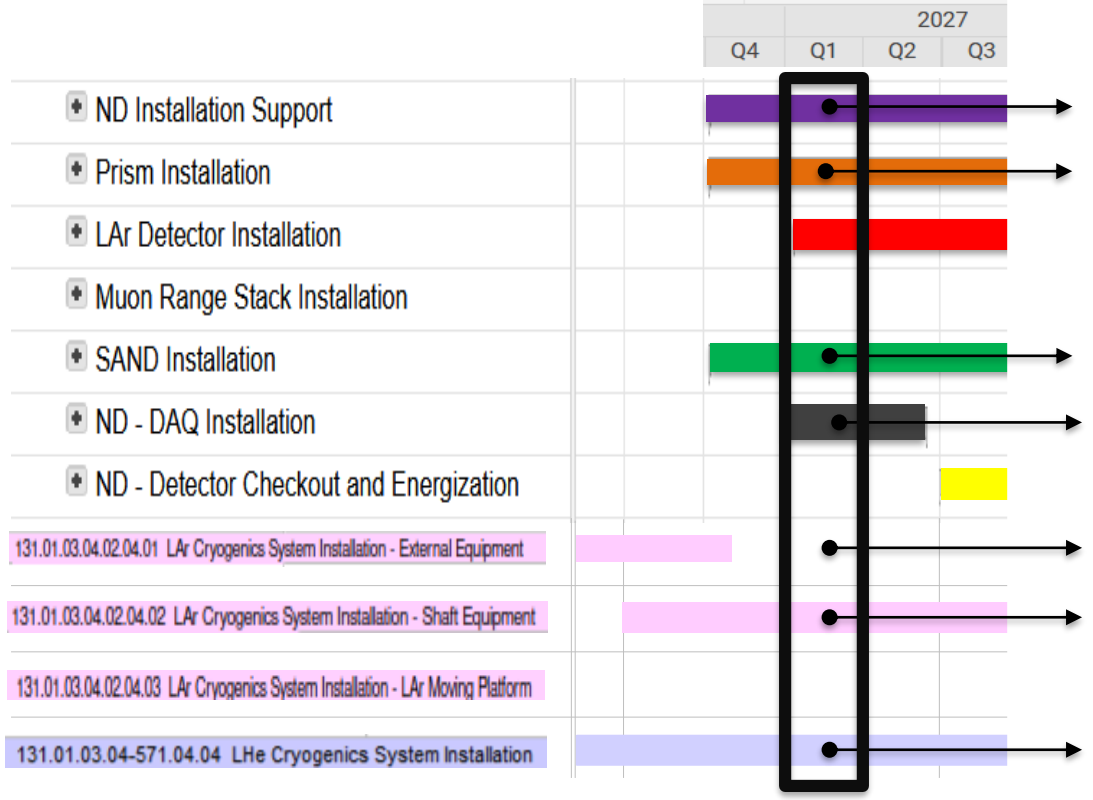


SAND assembly in Surface Building

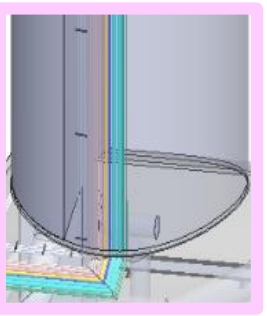




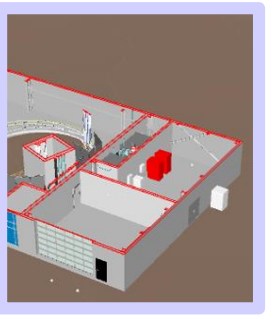
Install Sequence – Q1 2027



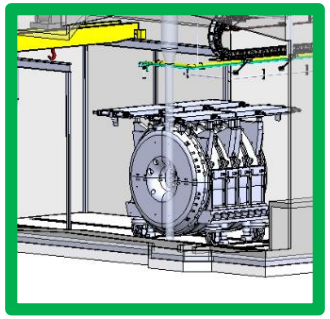
Location	Equipment	I&I Support	Consortia	Others
Cavern				
Surface				
Cav./Alcove				
Surface				
Shaft				
Surface				



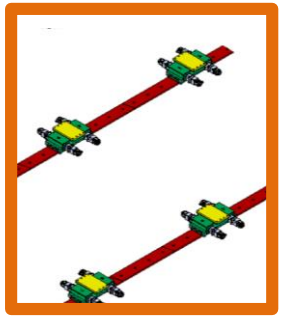
Shaft Cryogenics



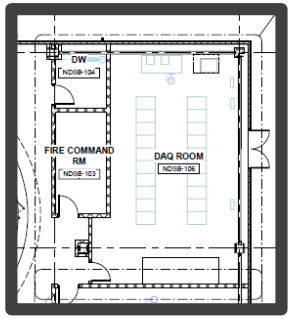
Helium Room



SAND move to Alcove



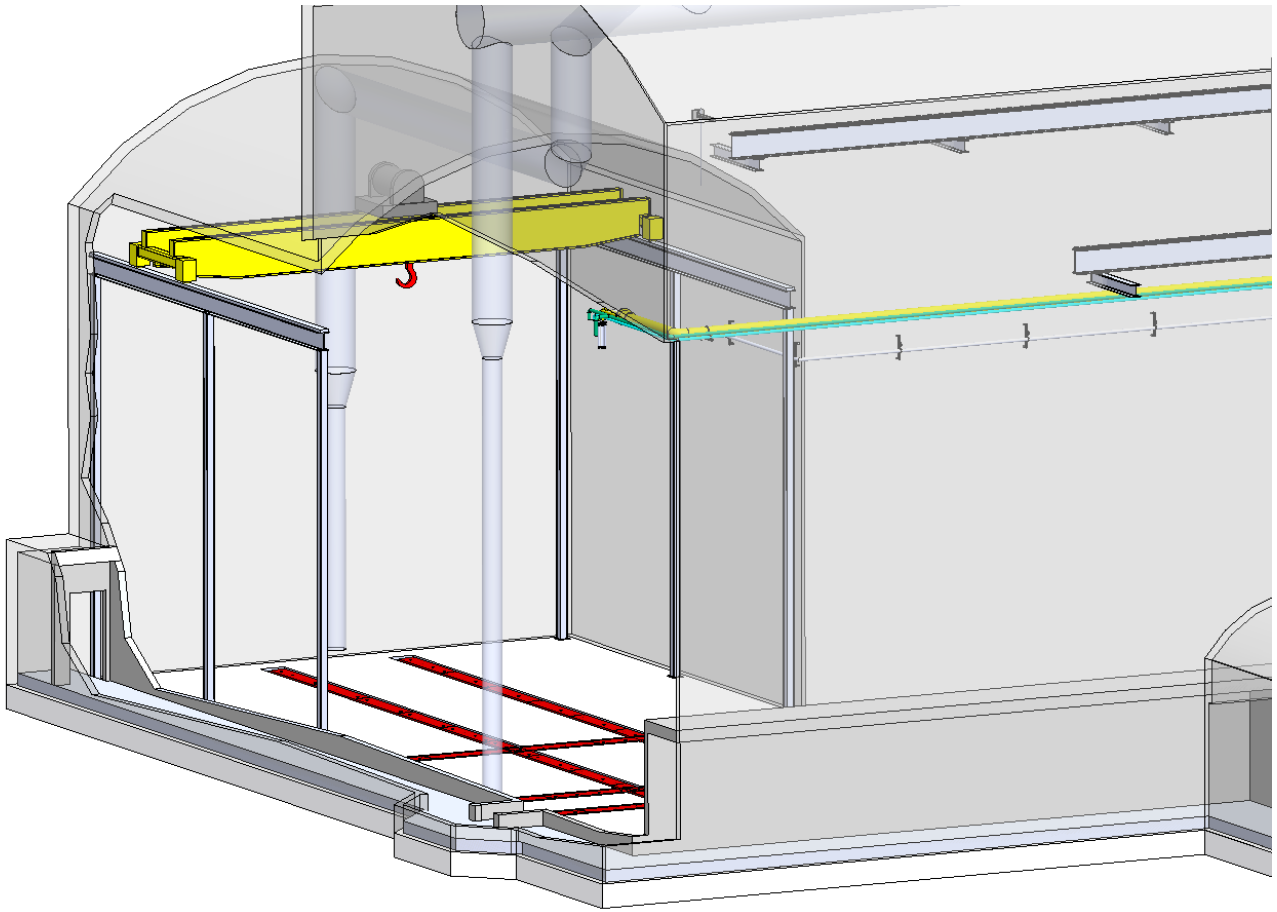
PRISM



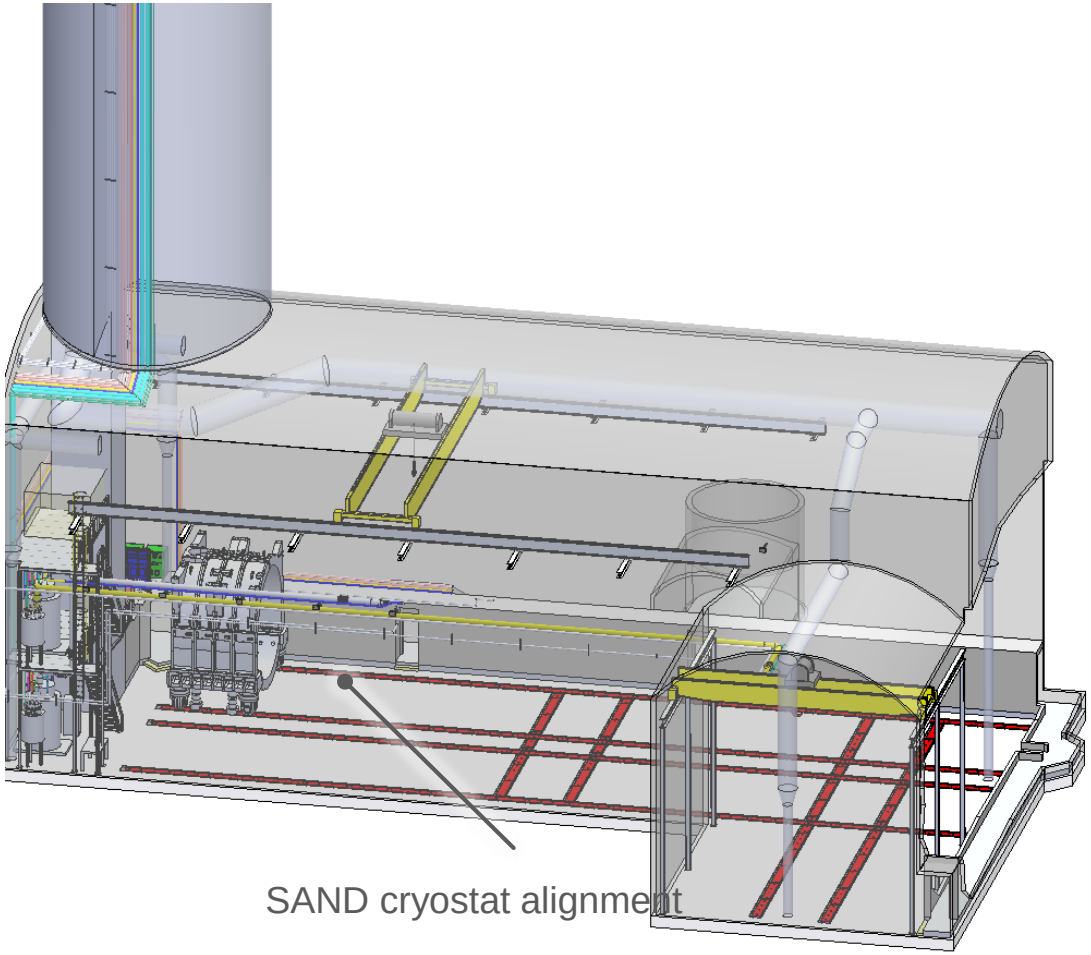
DAQ

LAr - Surface

Alcove Craane



SAND Alignment

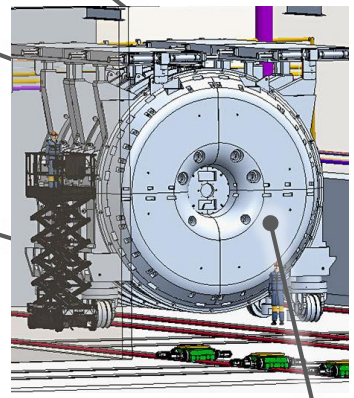


SAND Assembly

SAND top-support platform assembly

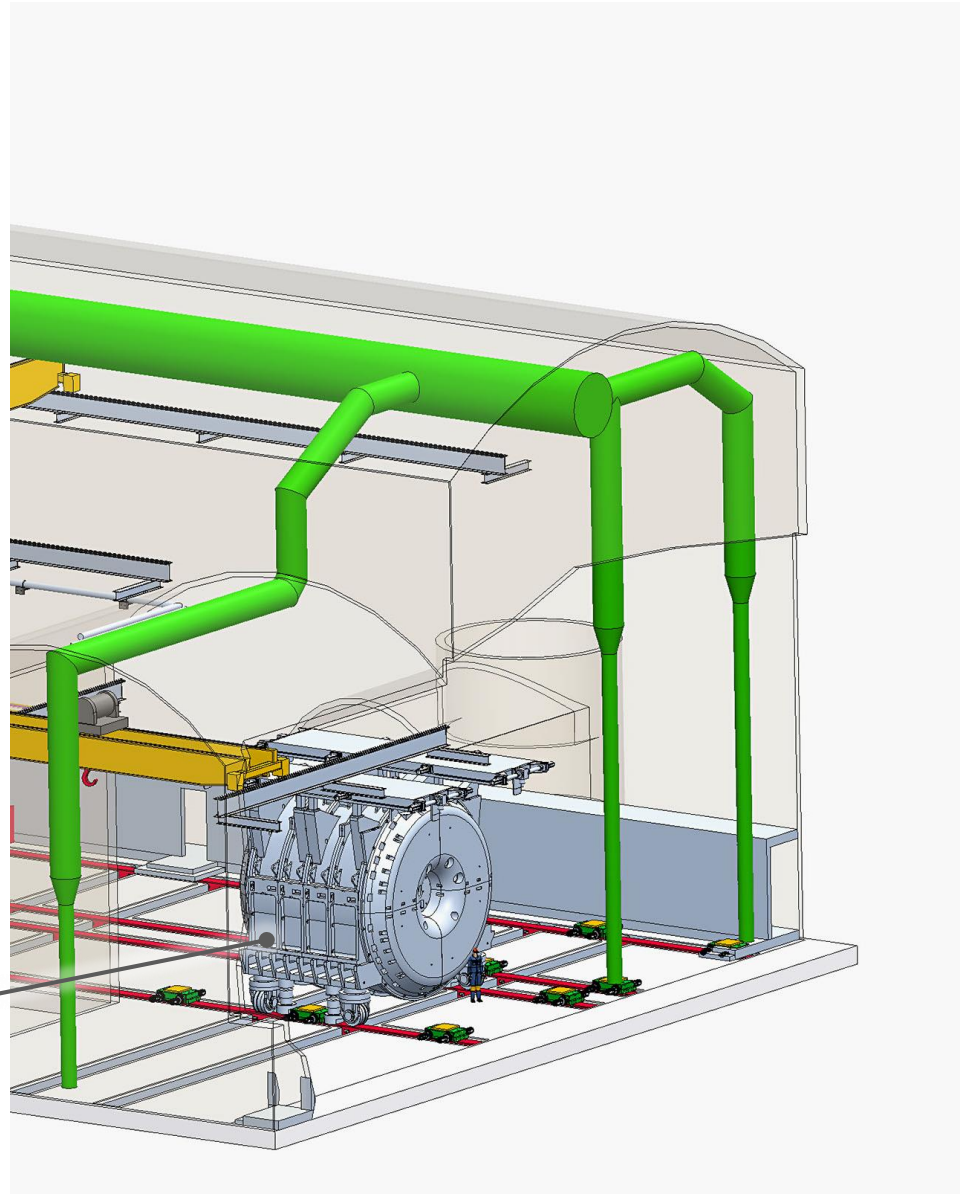
SAND yoke assembly

additional lift platform rentals



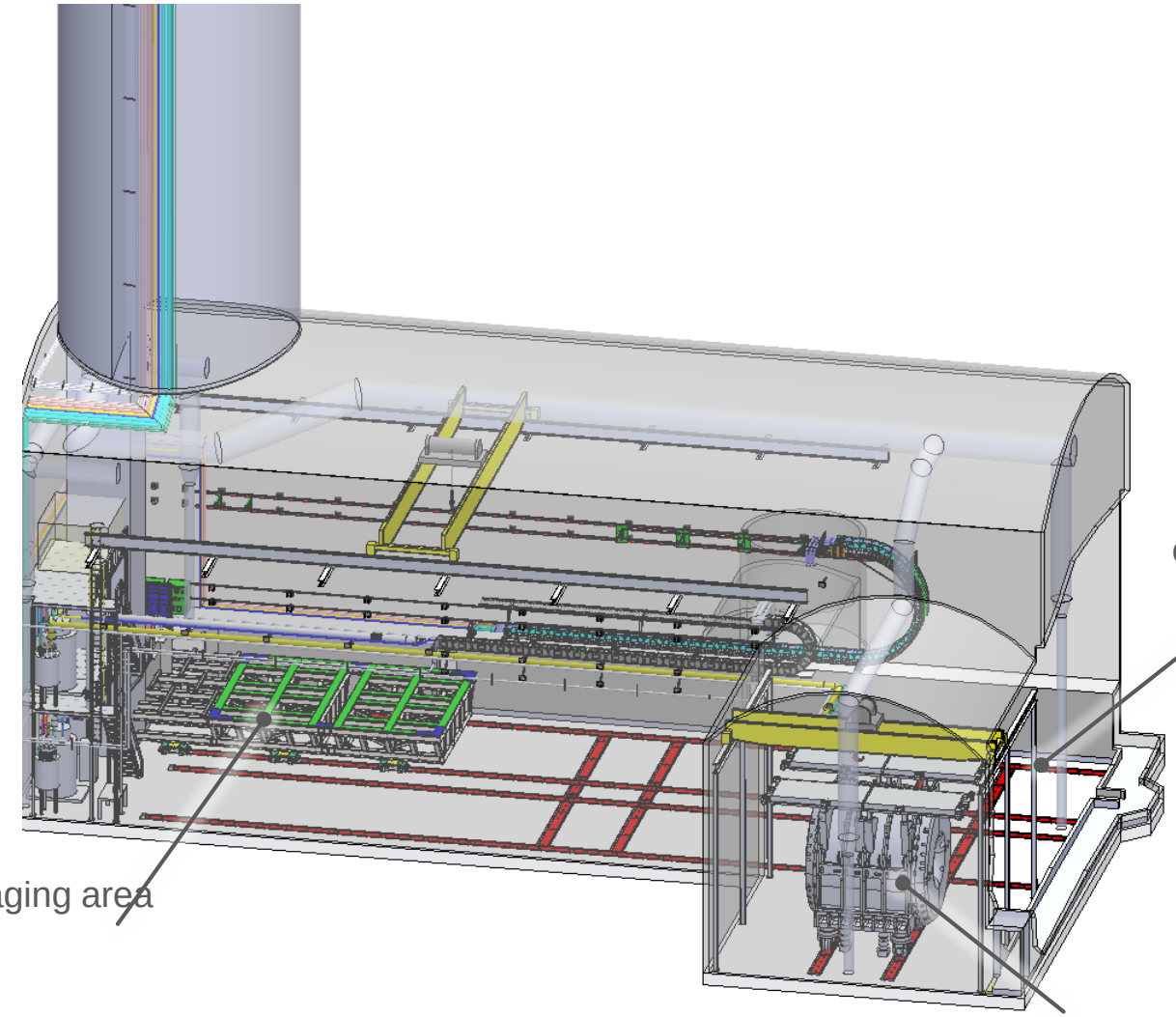
SAND initial end plate assembly

SAND moved in front of alcove: continue with calorimeter and TPC installation (incl. local tooling)

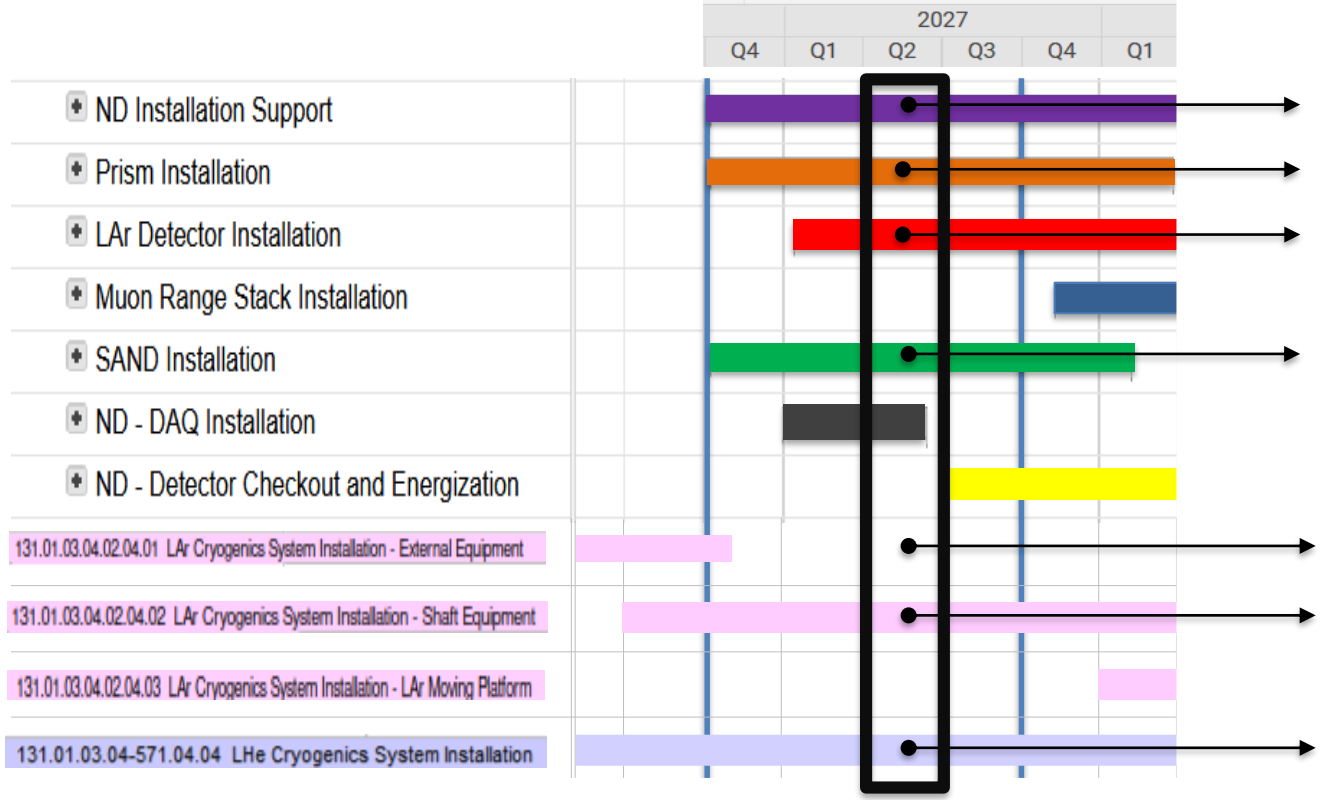


Cryostat

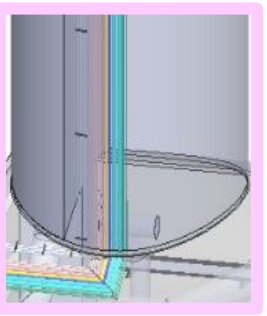
typical size comparison
(ProtoDUNE)



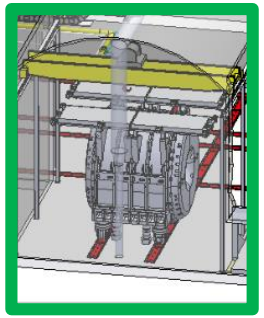
Install Sequence – Q2 2027

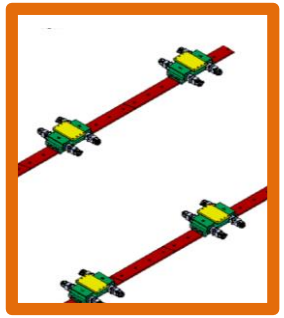


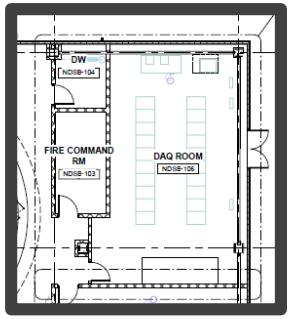
Location	Equipment	I&I Personnel	Consortia Personnel	Others
Cavern				
Surf./Shaft/Cav.				
Alcove				
Shaft				
Surface				


Shaft Cryogenics

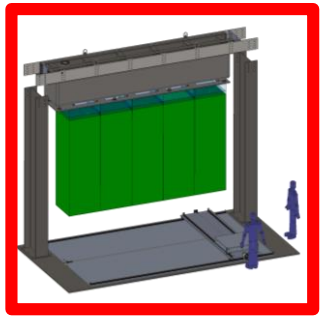

Helium Room

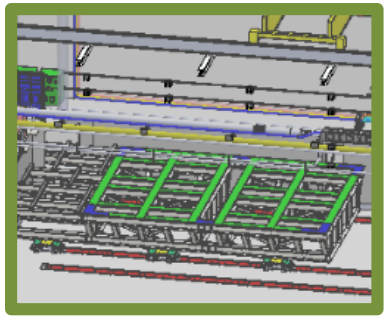

SAND in Alcove


PRISM

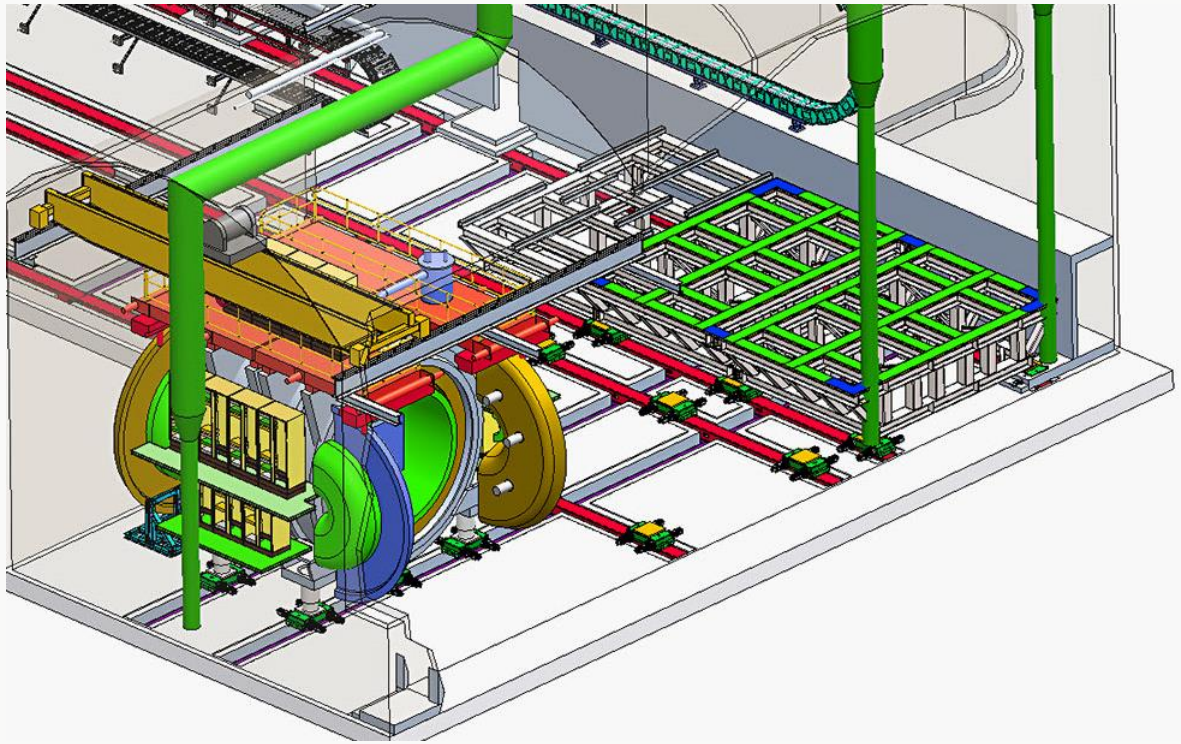


DAQ

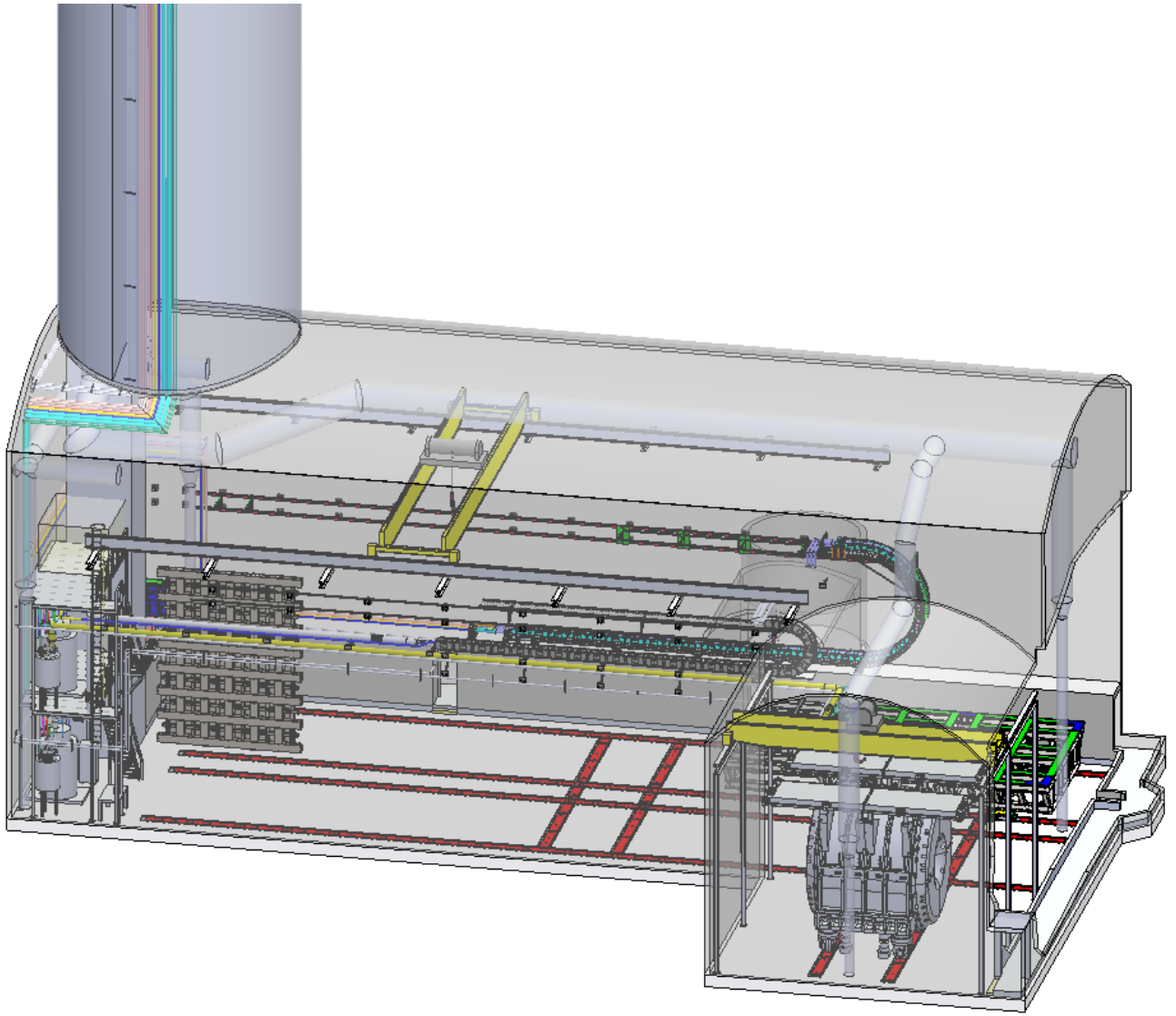

LAr - Surface


Cryostat

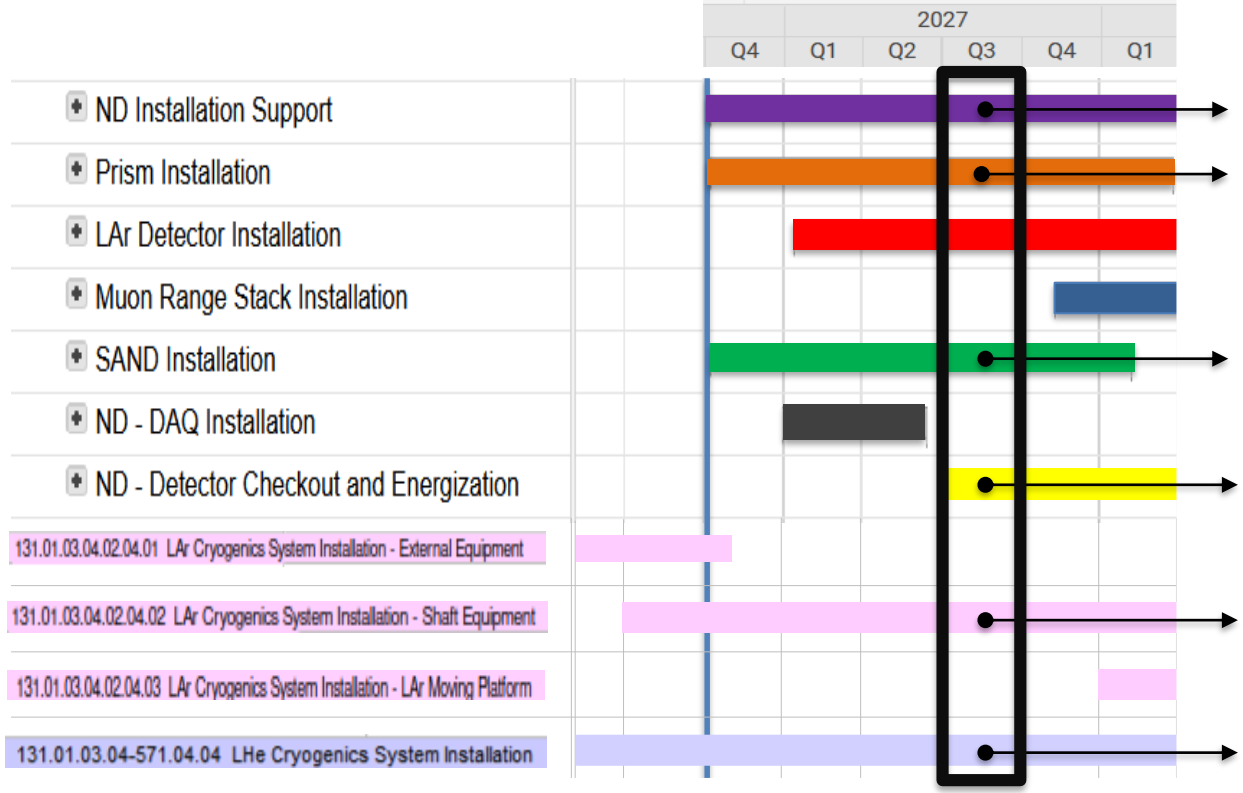
Cryostat in Assembly Location



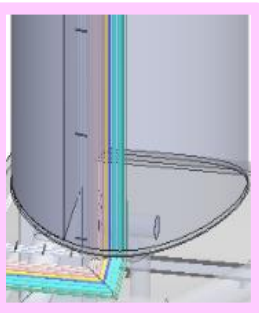
Warm Structure Assembly (April – July 2027)



Install Sequence – Q3 2027

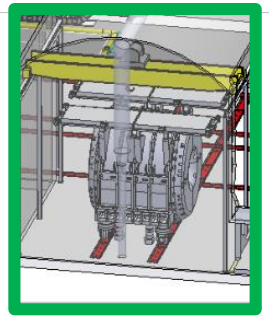


Location	Equipment	I&I Support	Consortia	Others
Cavern				
Alcove				
Mezzanine				
Shaft				
Surface				

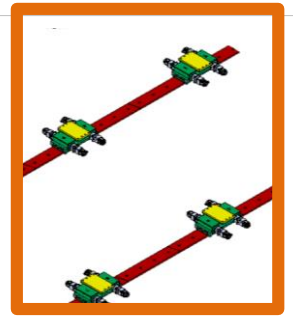


Shaft Cryogenics

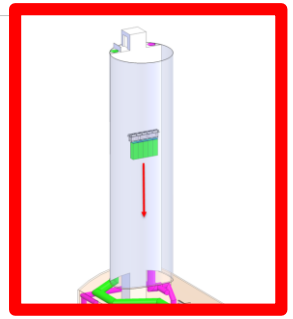
Helium Room



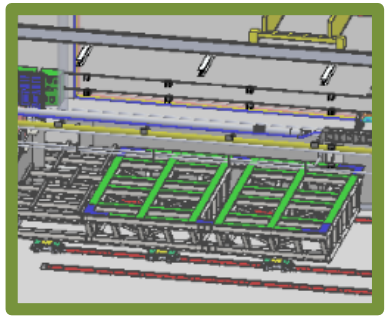
SAND in Alcove



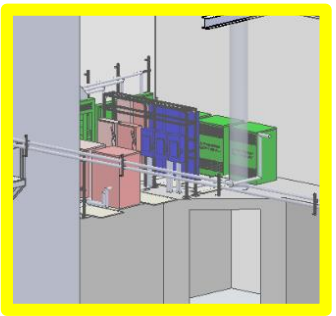
PRISM



LAr - Shaft

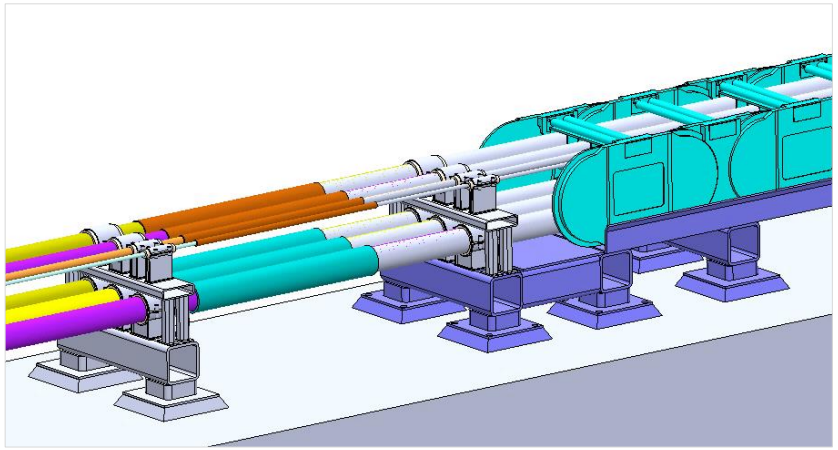


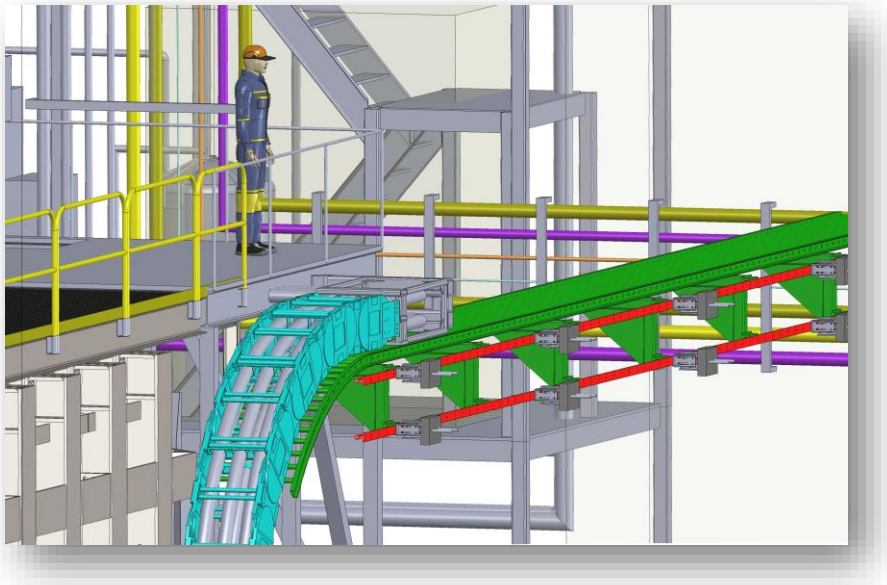
Cryostat

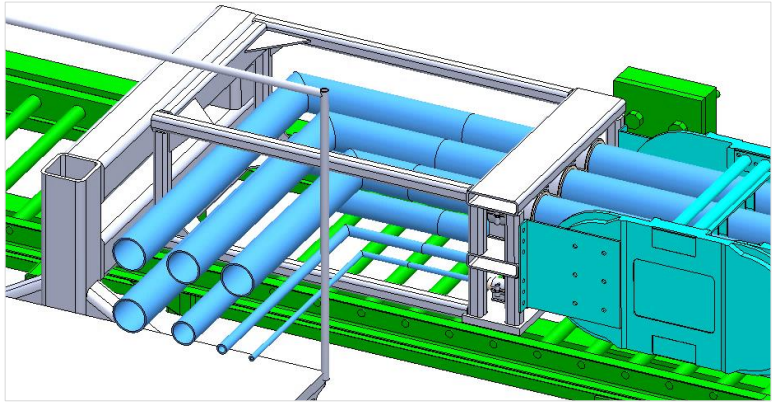


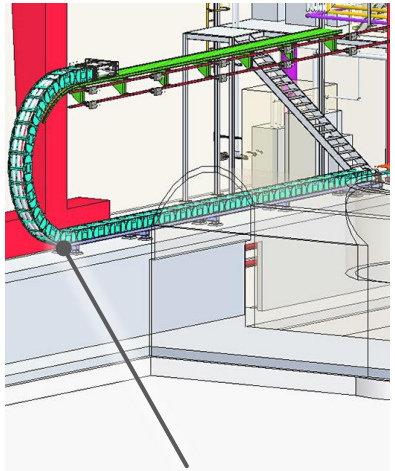
Energization

Energy Chains



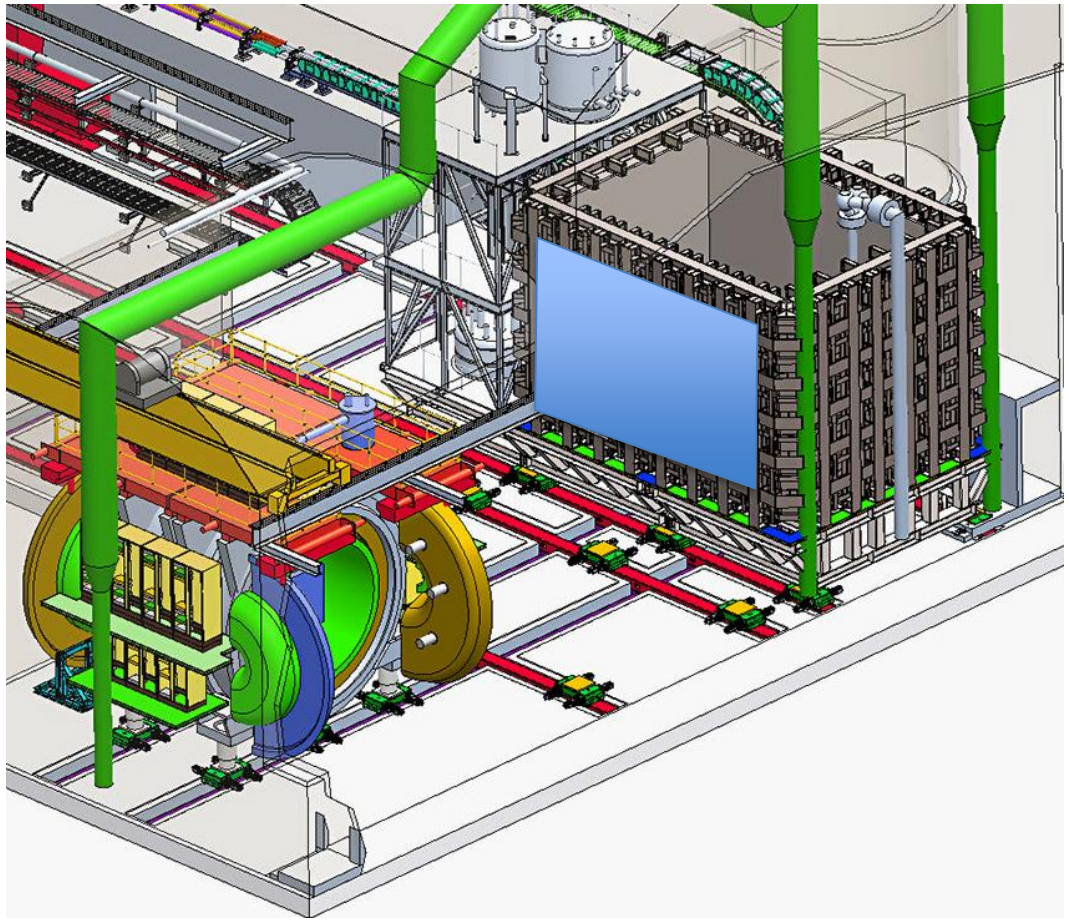






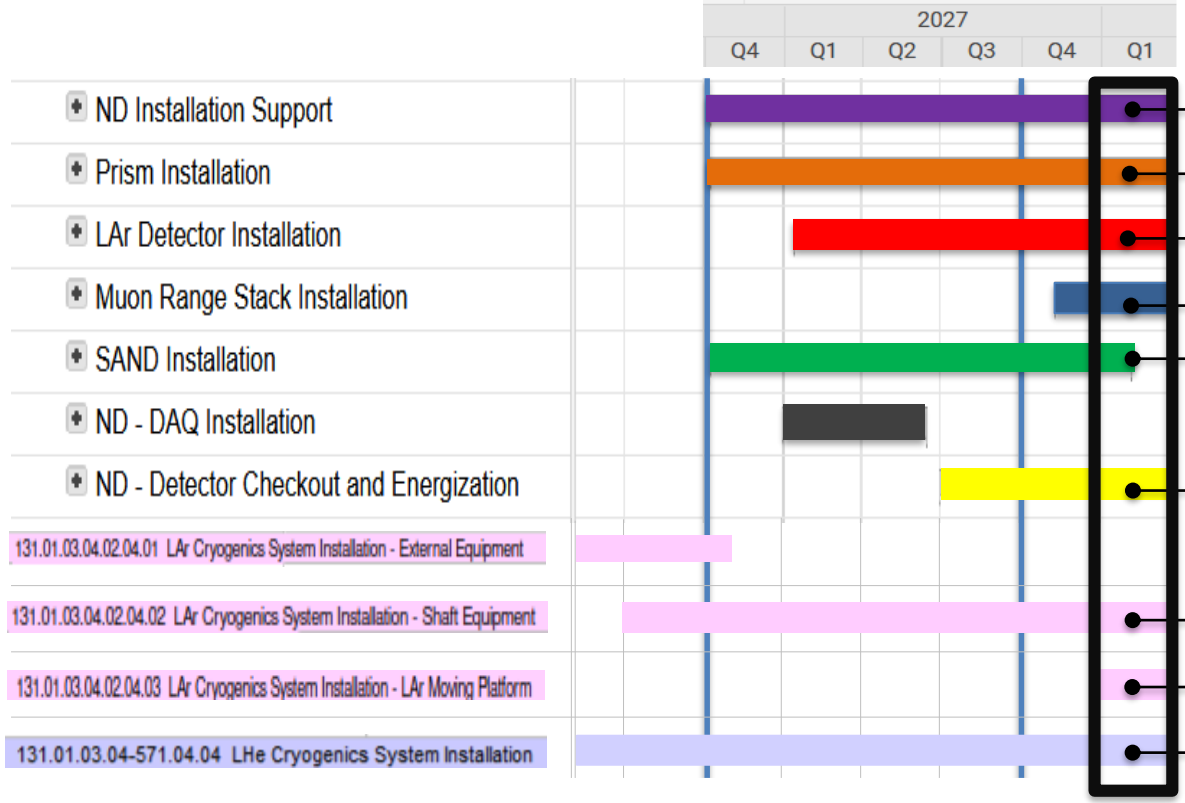
ND-LAr energy chain installation

Cold Membrane (July-Oct 2027)

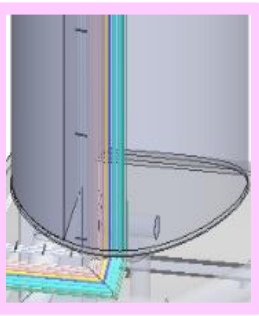


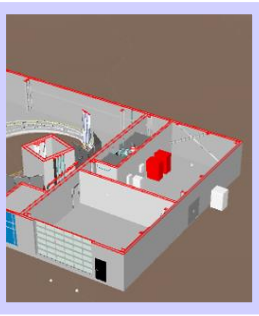
Checkout (Oct-Nov 2027)
Mezzanine (Oct 2027)
Top Flange (Dec 2027)

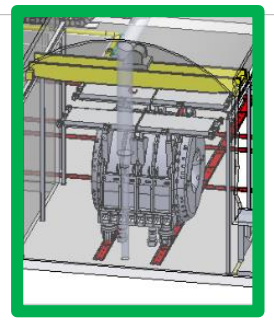
Install Sequence – Q4 2027

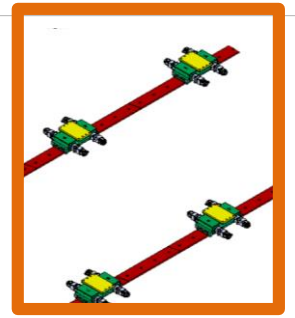


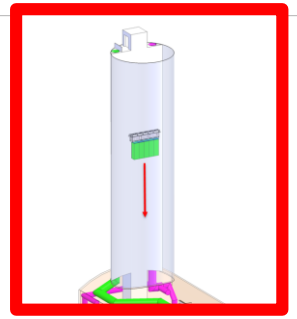
Location	Equipment	I&I Support	Consortia	Others
Cavern				
Surf./Shaft/Cav.				
Surface				
Alcove				
Mezzanine				
Shaft				
Cavern				
Surface				

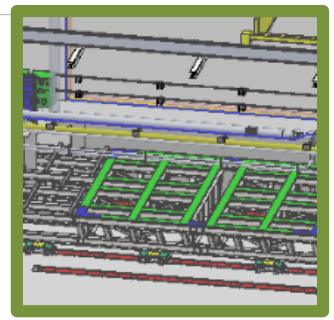

Shaft Cryogenics

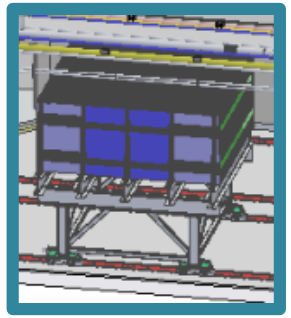

Helium Room

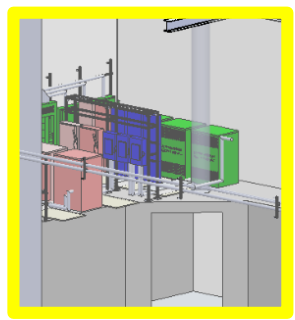

SAND in Alcove


PRISM


LAr - Shaft

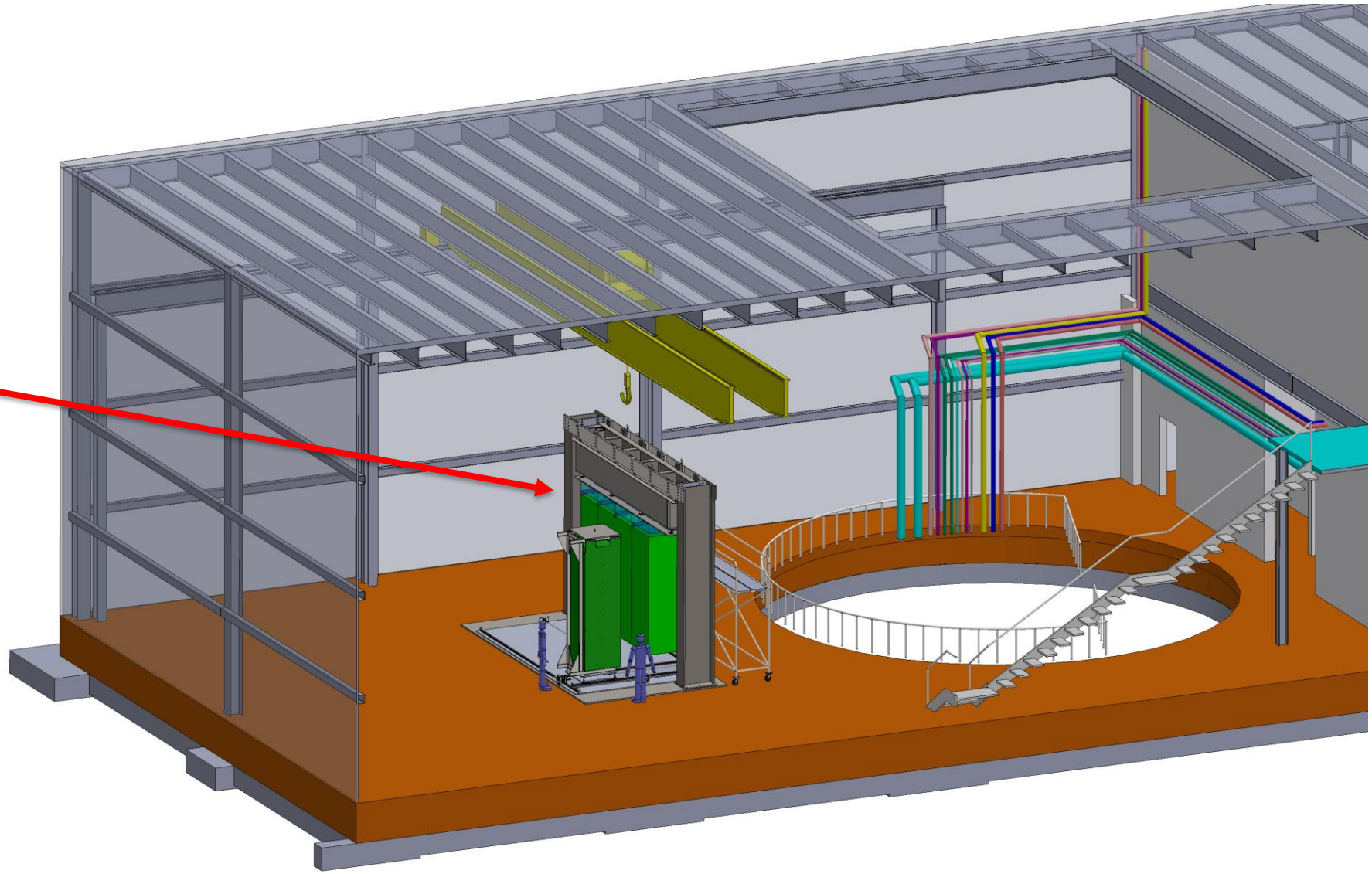

Cryostat


TMS

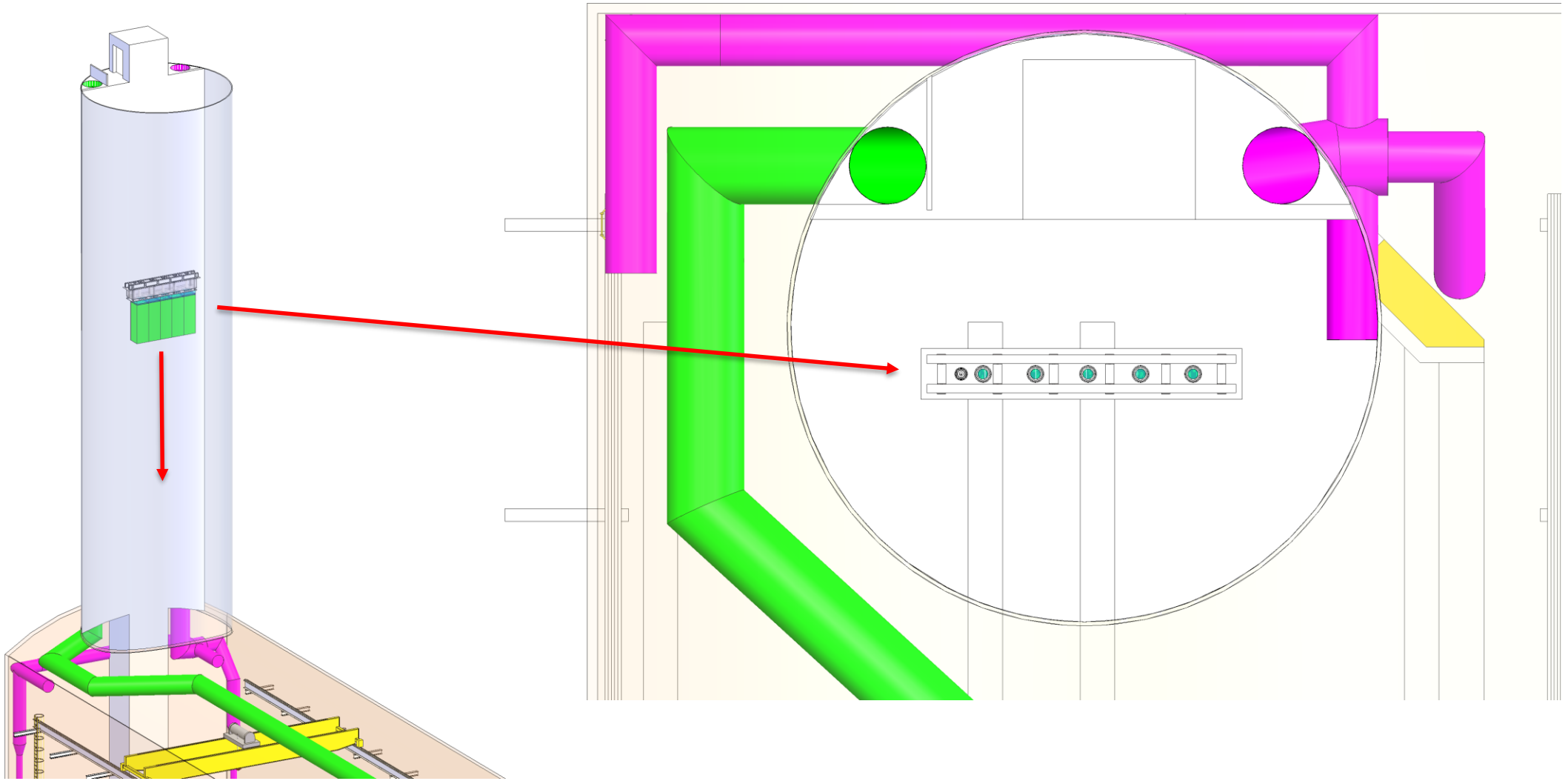

Energization

Module Row Integration Fixture in Surface Building

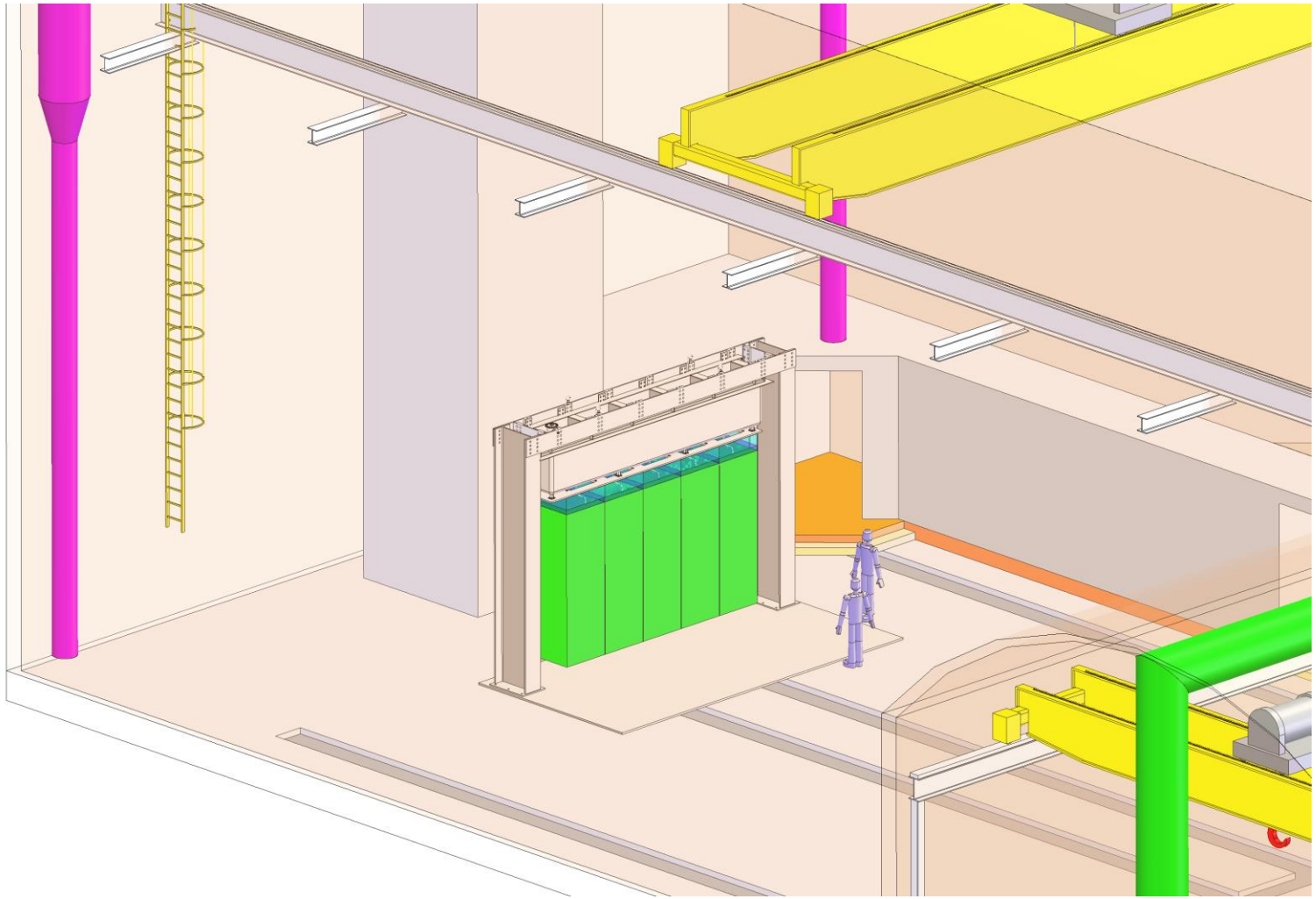
ND-LAr TPC module integration to cryostat lid sections in Near Site Surface Building



Module Row down Cavern Shaft

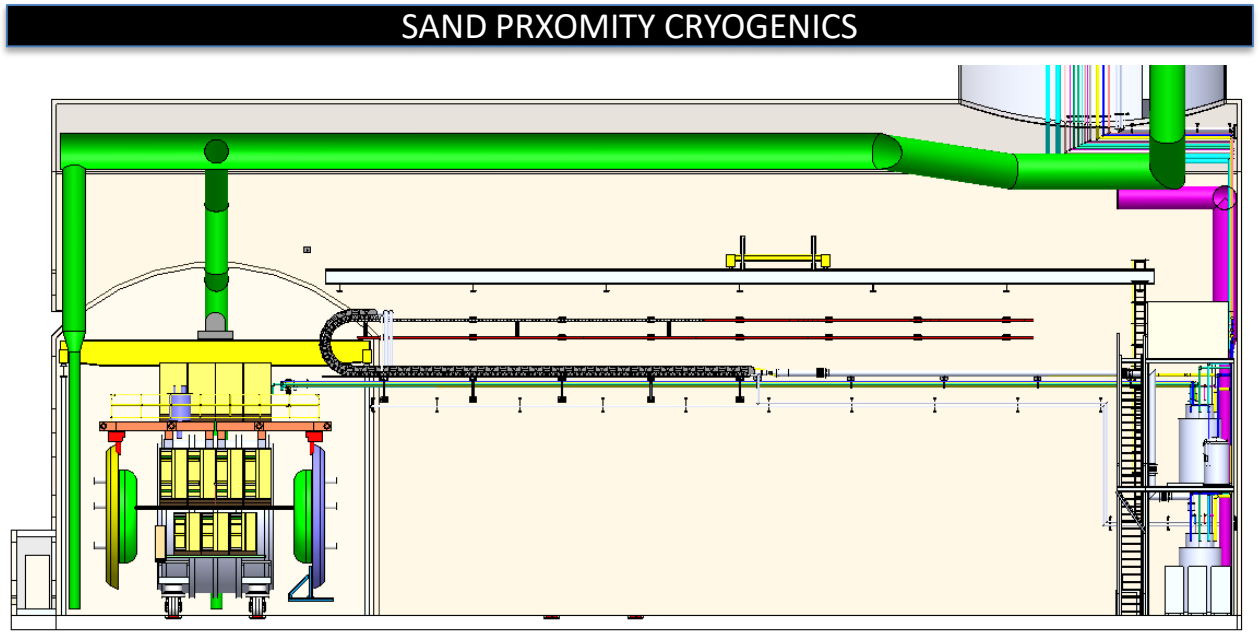


Module Row on Cavern Floor → Ready to Install to Cryostat



Install Row 1 (April 2028)
Install Row 2 (May2028)
…
Install Row 7 (July 2028)

SAND Proximity Cryogenics



Underground work area

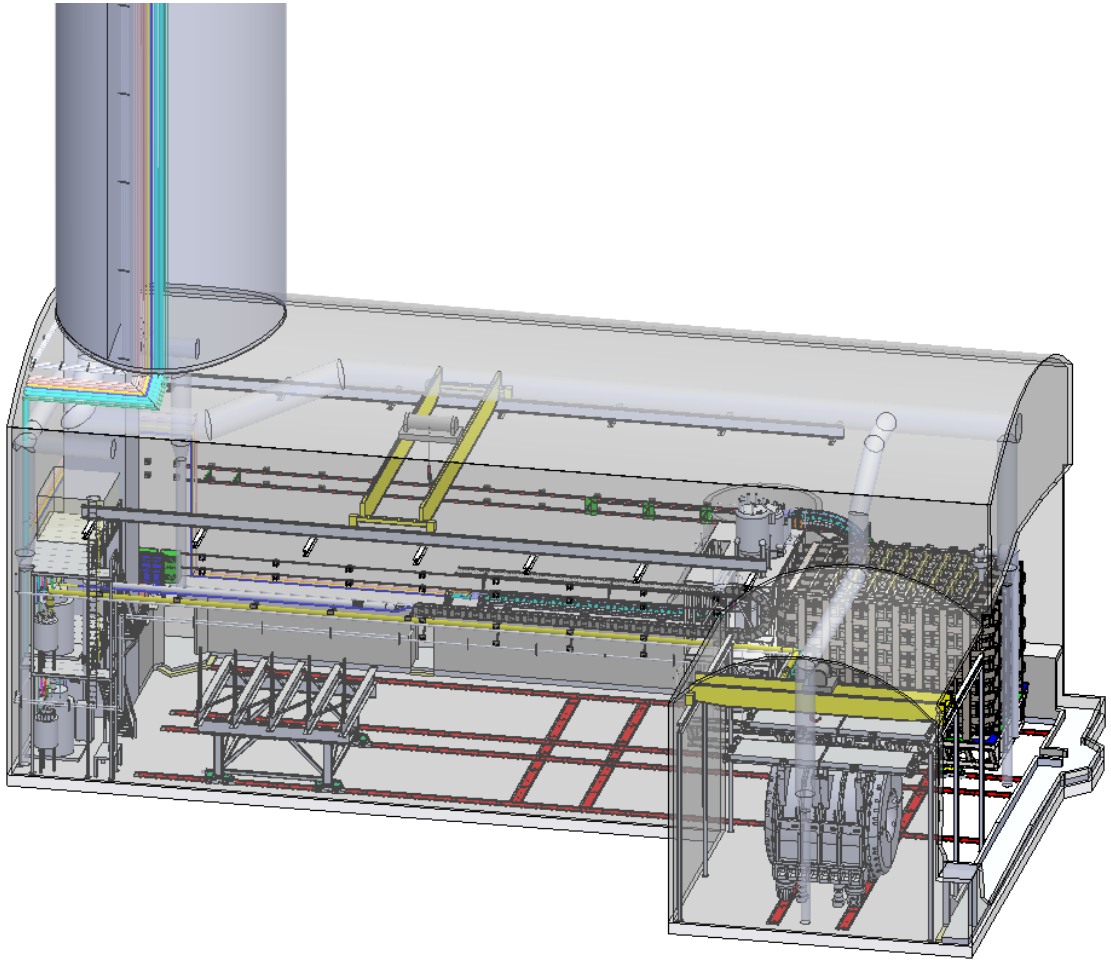
- Spools for SAND

- Assembly & Installation of SAND
- Connect MCTL to SAND

#	Description	Reasoning	Preceding Activity
	CAVERN		
1	Install the SAND MCTL He transfer line, cold box and valve box before SAND detector is assembled and installed, and TMS is installed.	Once TMS is in place there is no clean footprint for a scaffold.	13142.A1624 Finish-to-Start
2	Connect SAND MCTL to magnet only after SAND and SAND valve box are in place	Can't connect without an interface point.	13142.A1650 Finish-to-Start

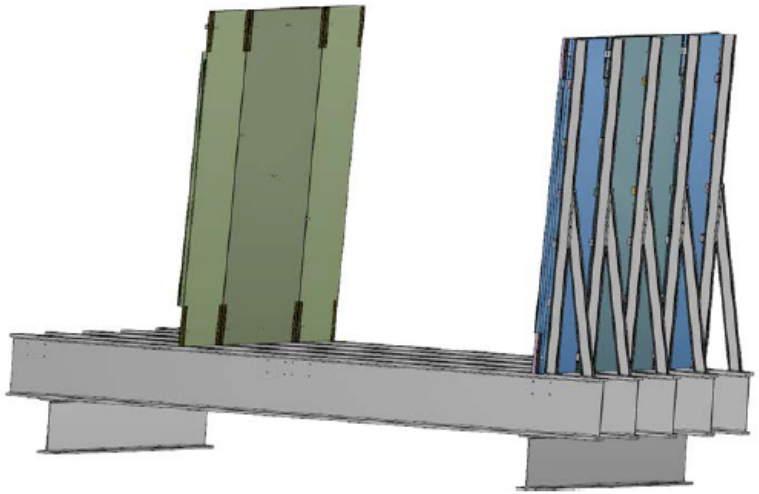
TMS

Install Steel Structure (Early 2028)

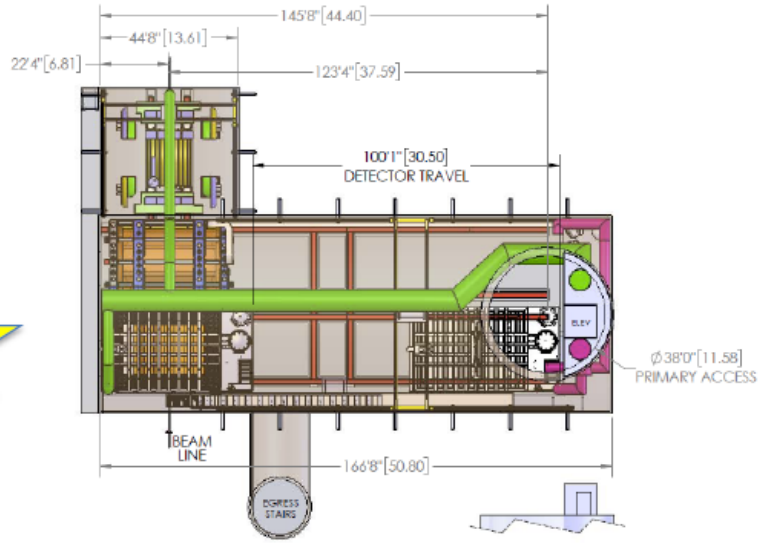


Installation

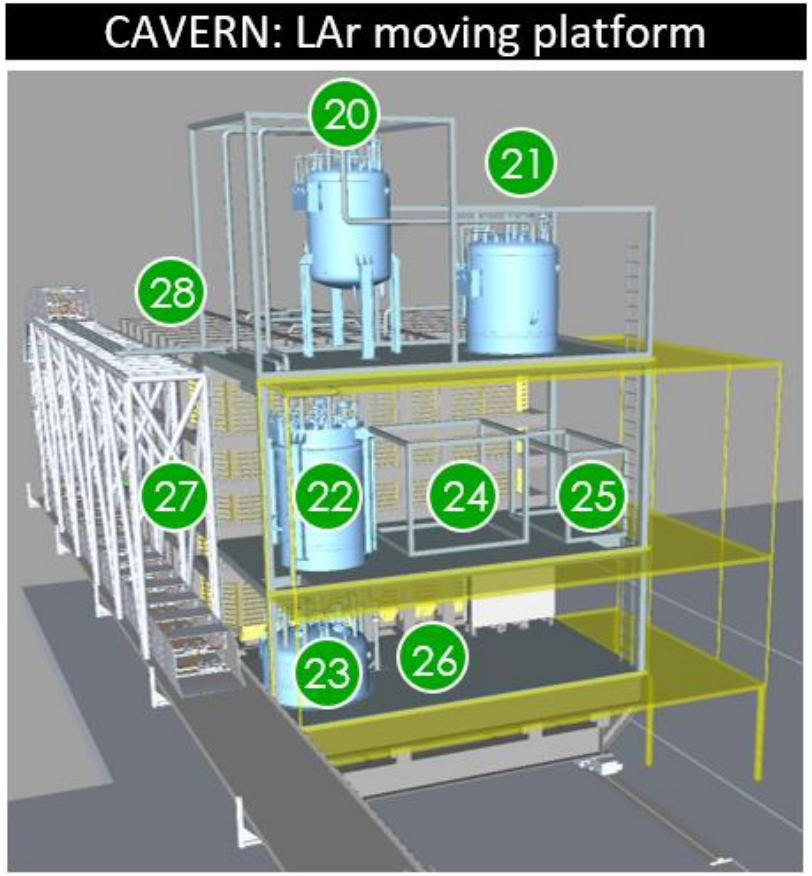
- First we build the supports (6-8 weeks)
- Then we build up the layers, back (west) to front
  - Three steel sheets + four panels per day
  - Run cosmic rays overnight before doing the next layer
- Then 4 weeks to install the six magnet coils



The schedule assumes there is no crane or shaft contention. This is likely not the case. This will move the need-by date and thus the go/no-go decision date earlier. Installation meetings have started to work this through.



LAr Proximity Cryogenics



CRITICAL PATH

Dependencies

- **FS precedence to** 13142-A1528 Install Mezzanine and Stair end date on 12/27/2027
- **FS precedence to** 13142.A1588 Detector Row 7 Cabling end date on 08/29/2028

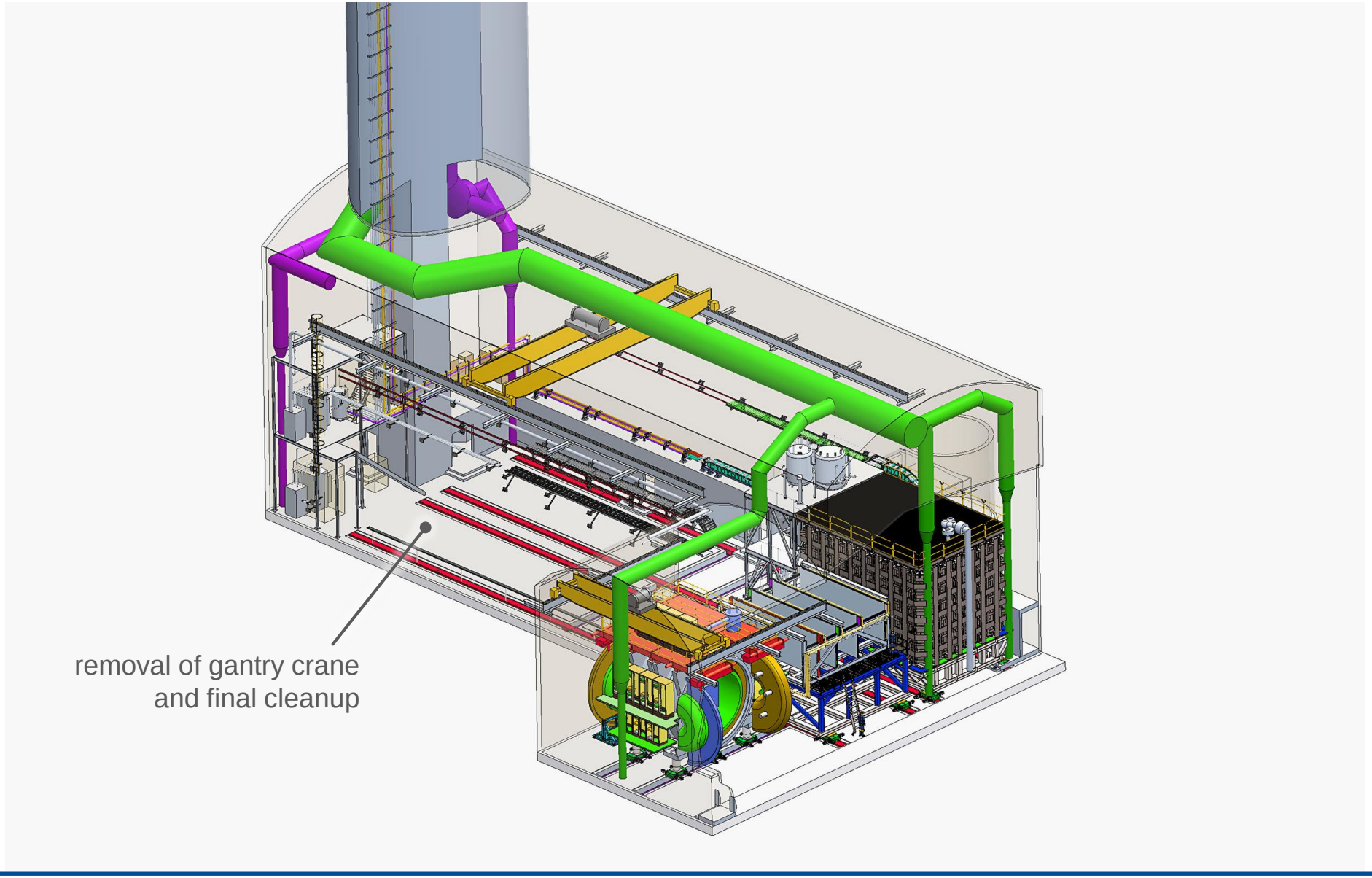
Unconstrained duration: 20 weeks
Duration with dependencies: 41 weeks

- Position valve boxes with overhang lifting device. 4 tons
- Cryo installs scaffold around platform that provides stair access and overhang weld position access.
- Interface with energy chain not in general critical path.

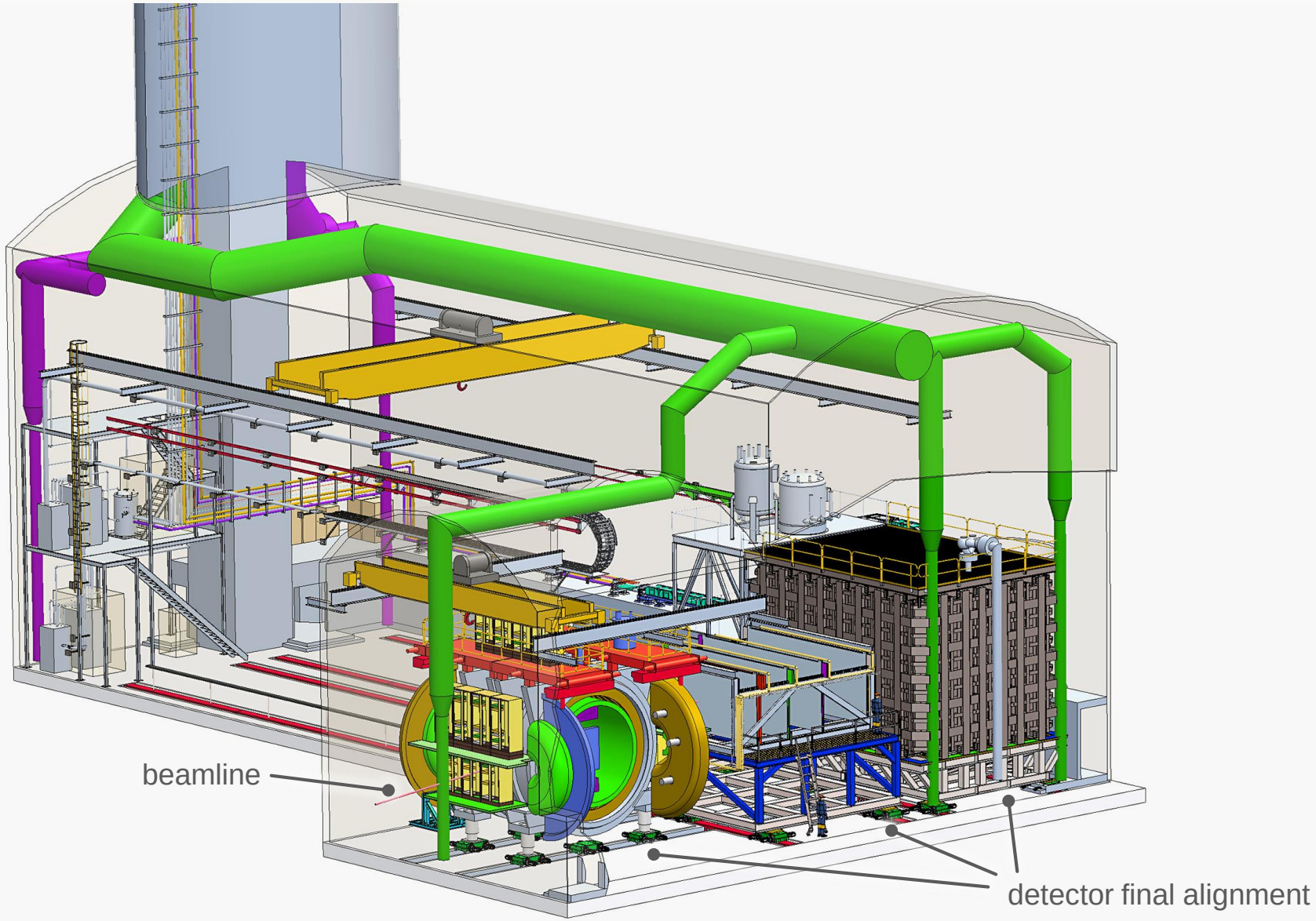
LAr proximity cryogenics (CRYO)

- Scaffold around moving LAr platform

Transition to Commissioning



I&I Wrap-up, Cleanup



Transition to operation