ND cavern

CREUS-PRATS, Joaquim

Phase II ND Workshop

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jprats@fnal.gov

Reviewed by F. Matichard

Who am I

Joaquim CREUS-PRATS – Cryogenics Engineer for APS-TD/Cryo division, Fermilab

- Industrial Engineer with 10 years experience in cryogenics, certified Project Management Professional (PMP);
- Fermilab cryogenics at APS-TD since 2019 with roles:
  - **DUNE-ND Cryogenics L2 manager** (overseeing cryo plants for ND-LAr and SAND detectors)
  - PIPII cryoplant integration L4 manager;
  - Cryogenics spokesperson for IOTA/FAST facility (NML);
  - Cryogenics Safety Panel chair for Minos Hall;
  - Cryomodule Test Facility (CMTF) operations team;
- Engineer in the CERN Neutrino Platform cryogenics team (BREMER, CHALIFOUR, FABRE):
  - Work Package leader: Proximity cryogenics integration and tests for ProtoDUNE Single Phase NP04 & Dual Phase NP02;
  - In-kind contributions to Fermilab: SBN-FD "Icarus" NP01 & SBN-ND NP03.

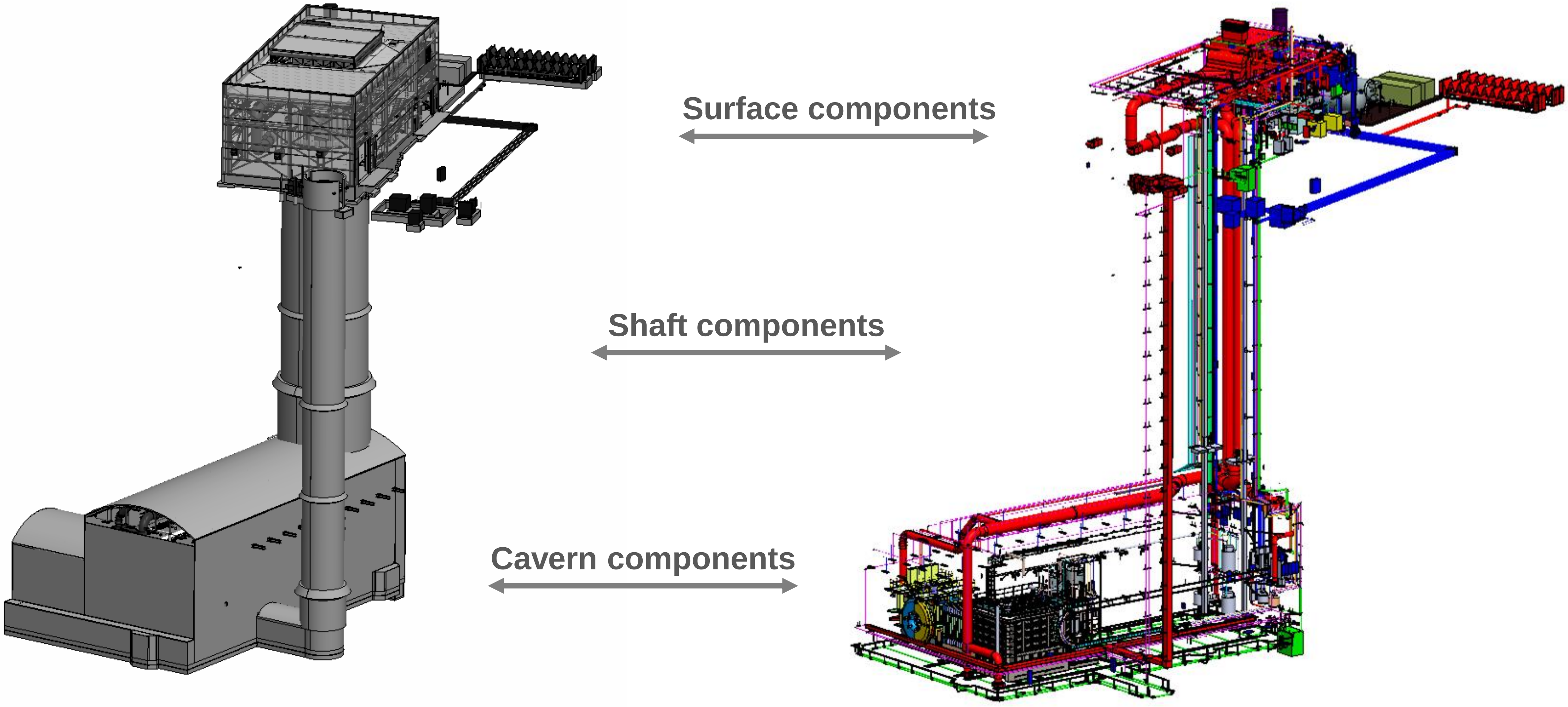
Outline

- Scope
- Introduction to ND Cavern
- Interfaces and requirements
- Features designed for MPD
- Near Site ES&H
- Challenges
- Summary

Scope

- Acronyms:
  - MPD (aka ND-GAr or MCND, a large SC solenoid-based gas TPC system)
- Near Site Conventional Facilities (NSCF) infrastructure currently includes MPD general requirements related to: space claims, cooling, ventilation and power distribution.
  - Near Detector Integration and Interoperability (I&I) has been in charge of this task.
- PRISM engineering related to MPD covered in a separate talk by Mike Wilking.
- Cryogenics scope with MPD has been limited to defining interfaces and requirements from the cryogenic perspective.
  - Assumptions on the magnet requirements will be presented in this talk

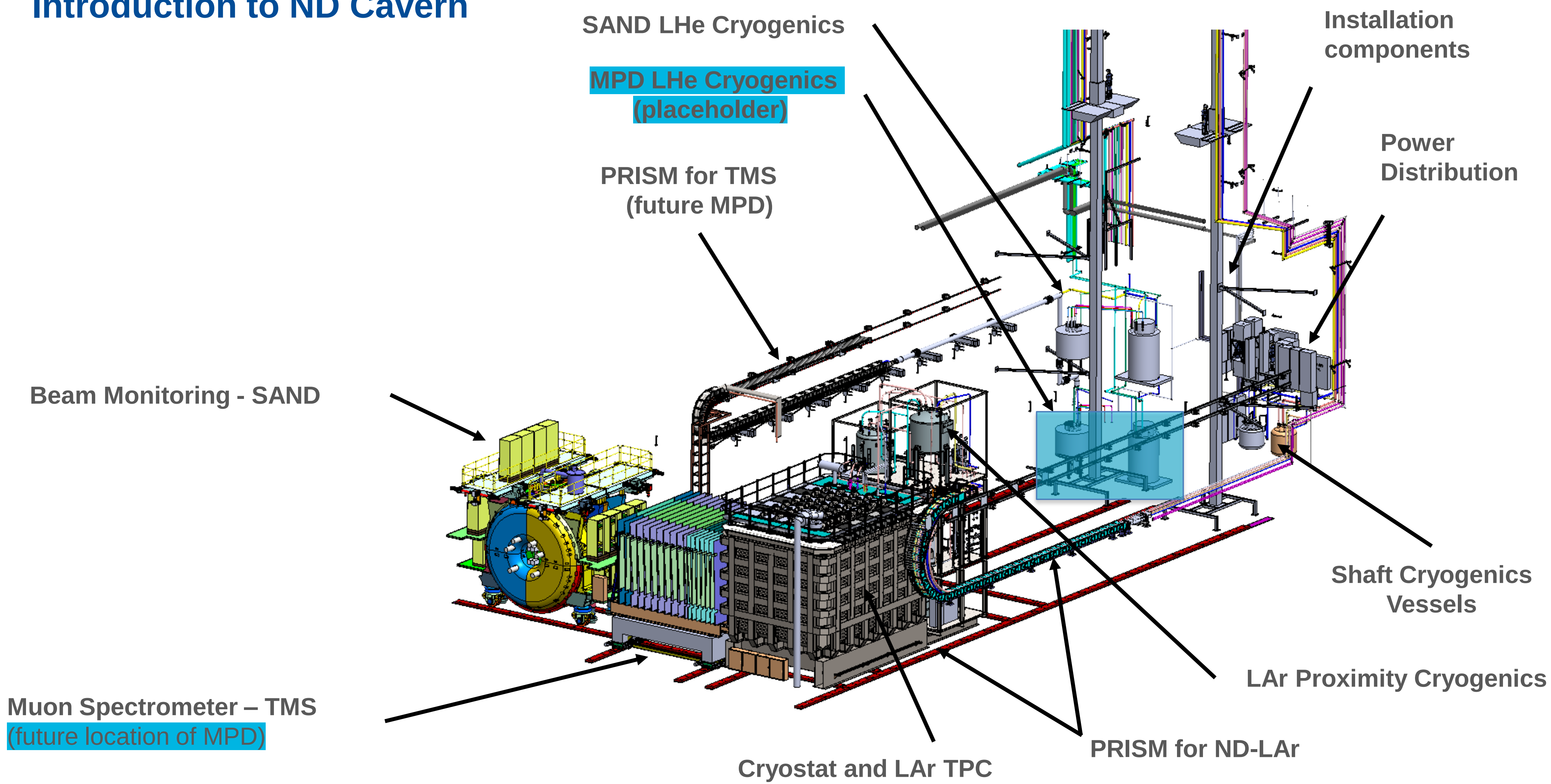
Introduction to ND Cavern



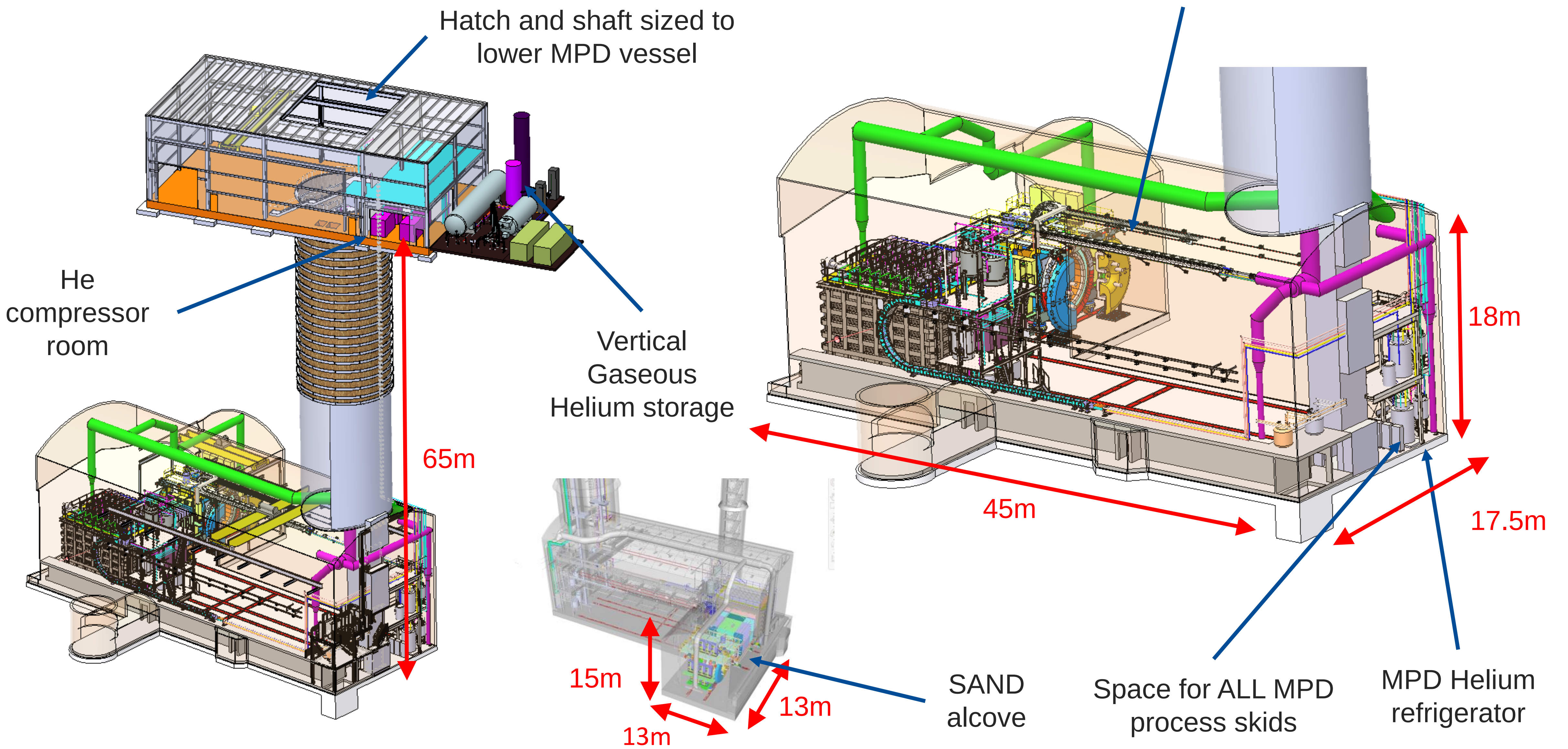
NSCF has reached 100% final design

Near Detector and NSCF combined model

Introduction to ND Cavern



Introduction to ND Cavern



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Introduction to ND Cavern

Step 1: NSCF Inspection at beneficial occupancy

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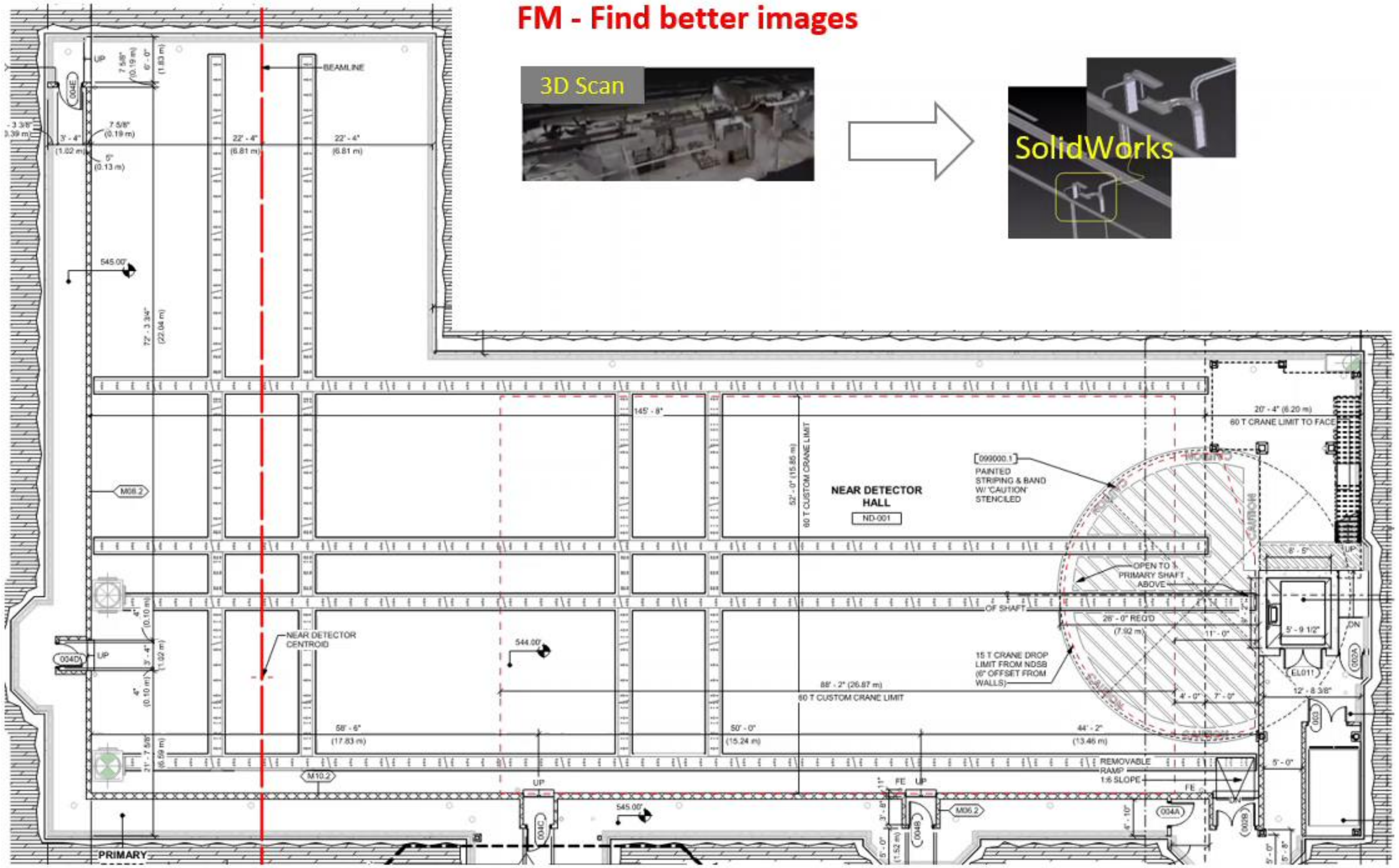
FM - Find better images



Contribution credit:
Fabrice Matichard, Gordon Cline, Joe Angelo

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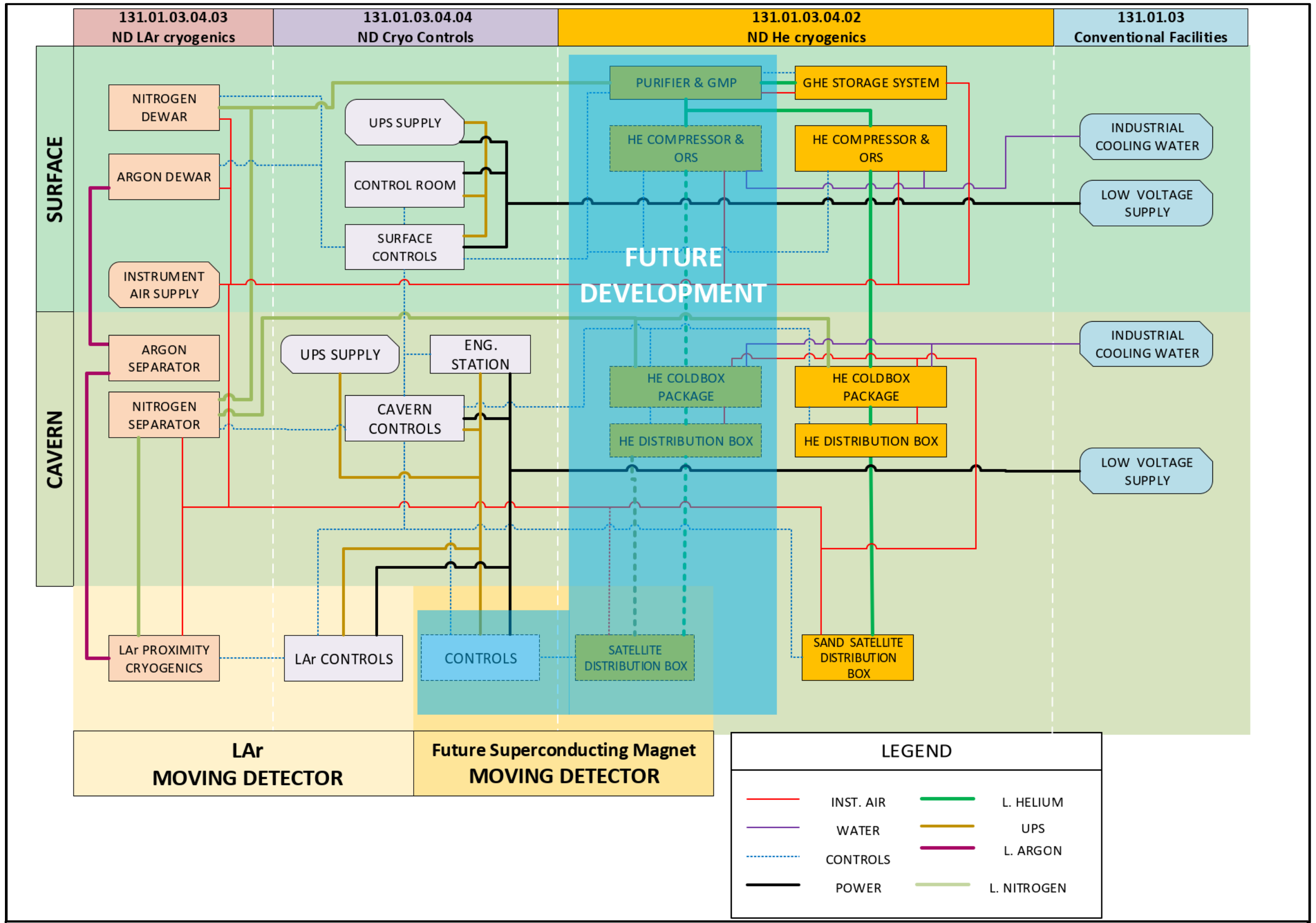
Requirements and Interfaces

- MPD general NSCF requirements collected by I&I
  - Space claims
  - Heat rejection (HVAC and water cooling)
  - Ventilation
  - Power distribution
- MPD Cryo requirements to PRISM
  - Piping to be transported in energy chain
- MPD Cryo He Refrigerator package requirements to NSCF
  - Cooling water
  - Electric power

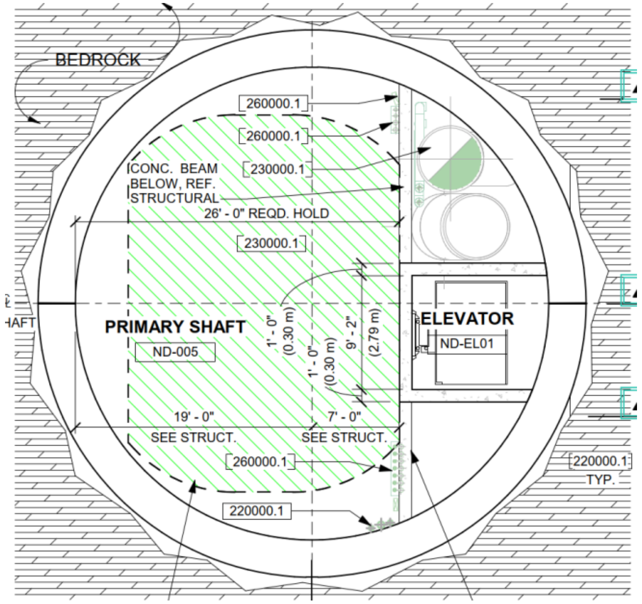


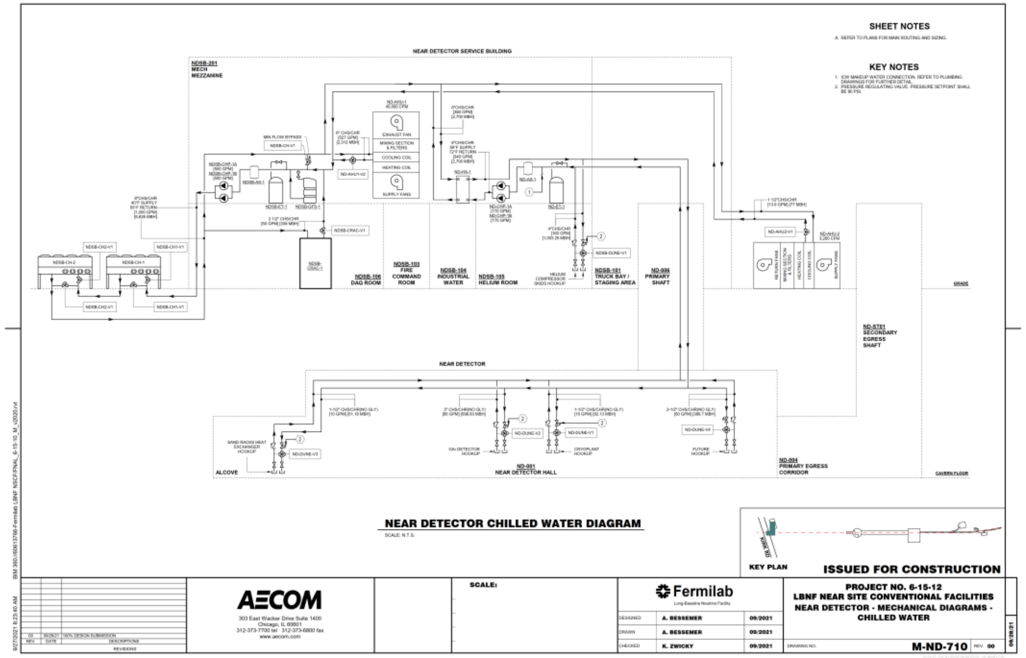
ND CRYOGENICS INTERFACE WITH UTILITIES

Features built-in for MPD

Conventional facilities

- Shaft dimensions for MPD vessel
- Cooling water circuits to reject heat from detector cooling system
- The cooling water system supplied by NSCF has a requirement of operating under 150psig.
  However water column = 93 psi and pump ΔP=80psig.
  Suggestion: Size MPD water cooling systems to be capable to run at 300psig water pressure rating.
- Oxygen Deficiency Hazard (ODH) fans capable to deal with ODH (see next slides)





Requirements summary

Disclaimer: The values stated here are indicative only. Contact the ND I&I group for more detailed discussions on facility limitations.

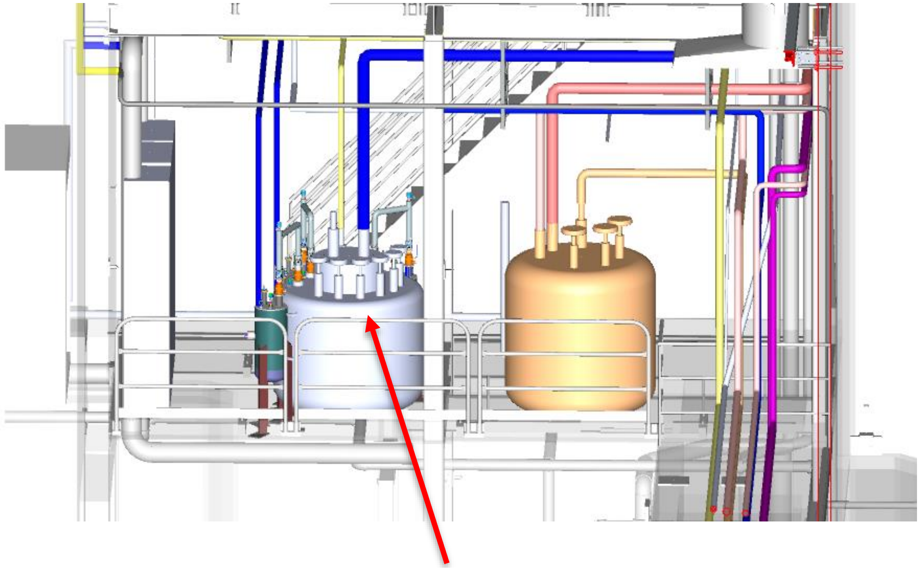
NSCF Parameters		Value	Units	Notes
	Corbel Height	33.3	ft	To top of energy chain corbel. Allowances required under this elevation for corbel steel and cryogenics for SAND.
	Corbel Length	6	ft	Length that steel corbel stands out from the wall.
	Crane Clearance Height	49	ft	Floor to bottom of the hook
	Shaft Diameter	38	ft	Some ND services run along the shaft sides, see integrated model for clearance requirements.
	Shaft Center to Septum Wall	7	ft	Septum wall that divides the open shaft from the elevator and services.
	Stay Clear			
	Width	27	ft	Allowable width of detector, does not include required 1ft gap on either side.
	Length	143	ft	Total available length for ND-GAr/TMS travel
	Weight	200	US tons	Load per roller
	Power	225	kVa	Two 112.5 kVa transformers
	Heat Rejection			
	Air	29.4	kW peak	Stated values are for peak loading, steady state heat rejection to cavern air is assumed to be lower.
	Cooling Water	162	kW peak	Stated values are for peak loading, steady state heat rejection to cavern cooling water system is assumed to be lower.

Contribution credit:
Fabrice Matichard fmatichard@lbl.gov

Features designed for MPD

Cryogenics

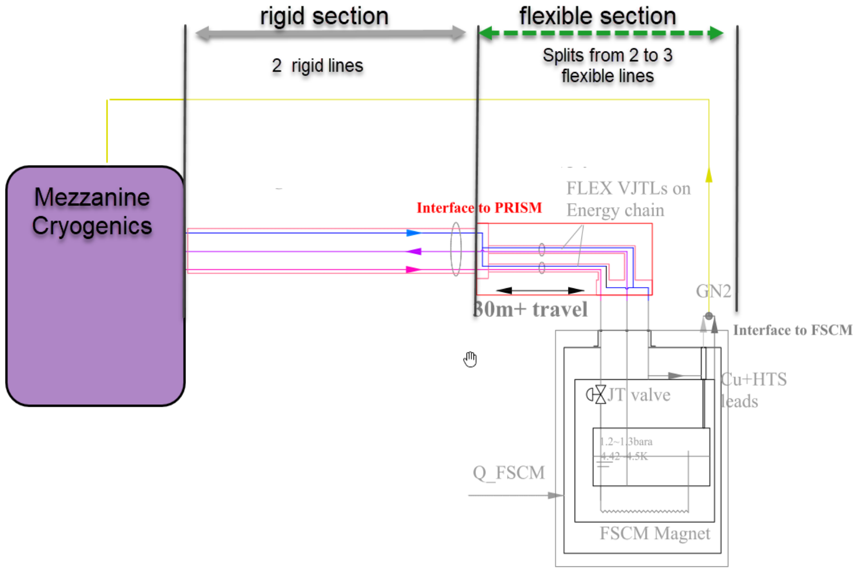
- Design assumptions
- Instrument air distribution
- Liquid Nitrogen supply underground



LN2 phase separator has an outlet and regulation valve to supply MPD

Cryogenic system assumptions used to size MPD magnet cryogenics equipment space and load requirements.
(no design or procurement currently in scope)

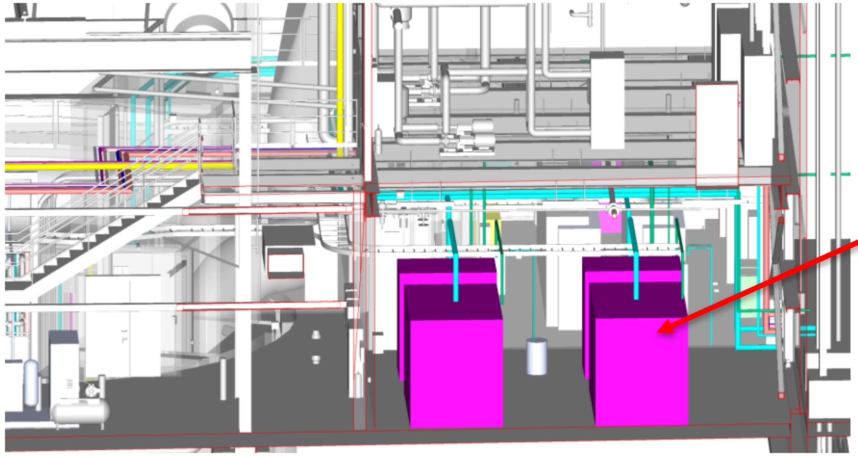
- Heat load assumptions
  - 200W at 4.5K [magnet 50W + HTS leads 25W]
  - 1200W at 80K [magnet 500W + HTS leads 500W]
- Operating temperature at 4.5K (not sub atmospheric)
- LN2 use:
  - pre-cooling of cryoplant,
  - thermal shield for helium transfer lines
  - HTS magnet leads cooling
- Total helium inventory: TBD



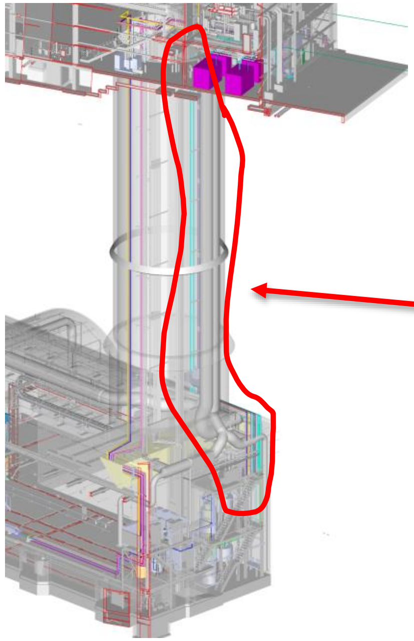
Features designed for MPD

Cryogenics

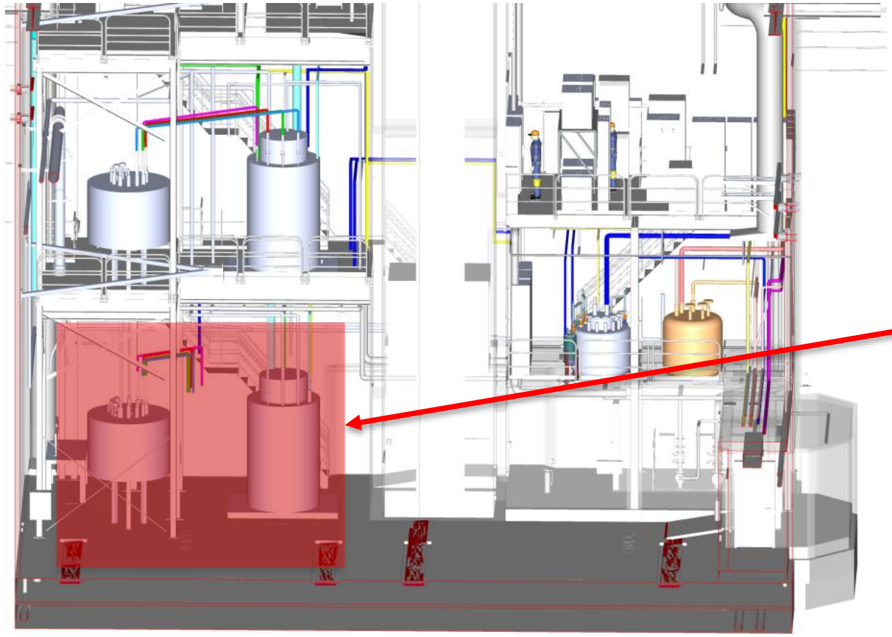
- Space claims
  - MPD helium piping
  - MPD helium storage
  - MPD compressor room
  - MPD helium refrigerator and cooling skids area



Space claim for MPD helium compressor, oil removal system and gas management panel



Helium shaft piping space claim



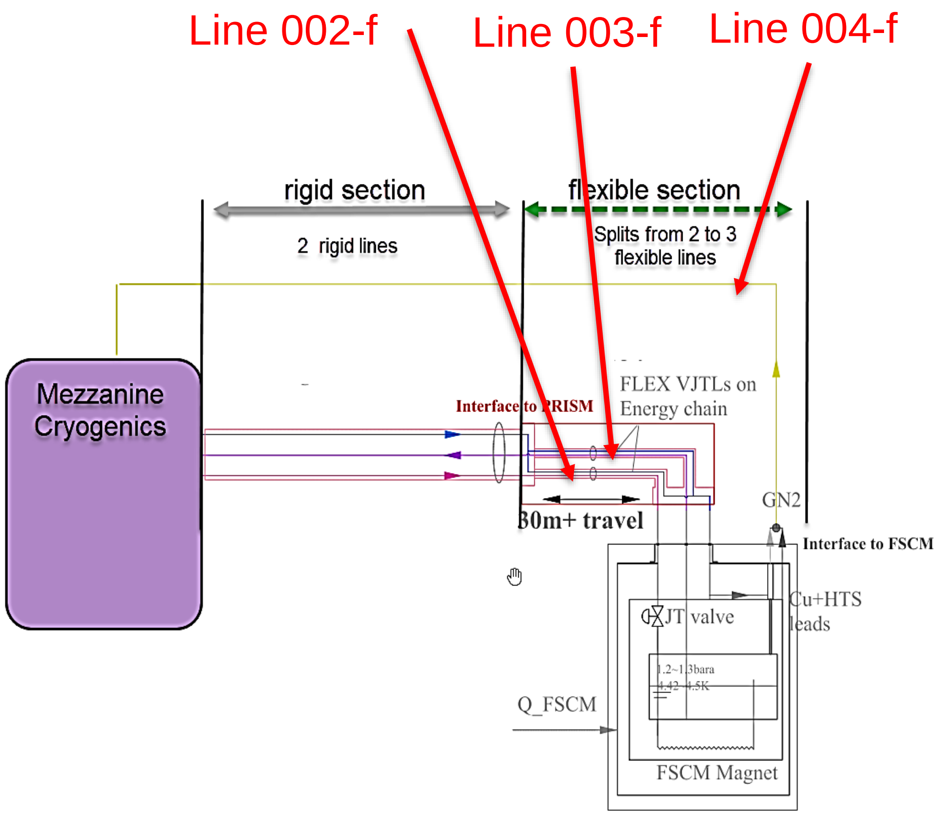
Space claim for turbine expander MPD
He refrigerator based on standard designs

Features designed for MPD

Cryogenics

- Cryogenics requirements for PRISM cable chain supporting MPD captured in **EDMS 2745433.**

- Includes LN2 and She supply. GN2 and GHe return .
- Exclusions: gas system, magnet shield suppy and instrument air



ID	Item	External Diameter	Mass per unit length	Construction	Note
001-rigid	Rigid line combines 5K SHe supply, 4K GHe return and LN2 supply. This splits later to flexible lines 002 and 003.	⌀323.8mm DN300	60 kg/m	Rigid vacuum jacketed line, welded in place.	This line is subject to loss of insulating vacuum thermal strains.
002-flexible	3bara/5K SHe supply line w/LN2 cooled thermal shield	⌀168.3mm DN150	20 kg/m	Flexible line Bending radius: 1500 mm	
003-flexible	4K He return line & magnet cool down return line w/LN2 cooled thermal shield	⌀219.1mm DN200	30 kg/m	Flexible line Bending radius: 1500 mm	
004-rigid	GN2 vent line from thermal shield cooling and HTS leads cooling to MPD Energy Chain	⌀76.1mm Internal DN25/1"	7 kg/m	Rigid line, bayonet couplings.	
004-flexible		⌀119.4mm	7 kg/m	Flexible line Bending radius: 500 mm	

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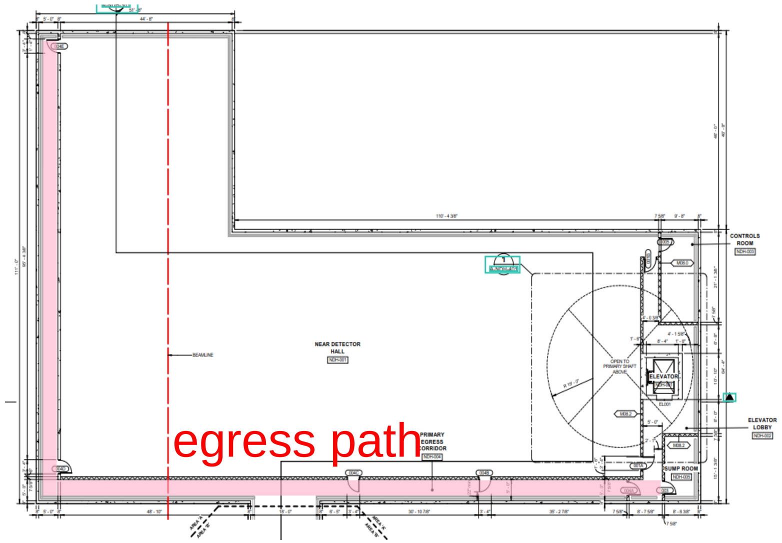
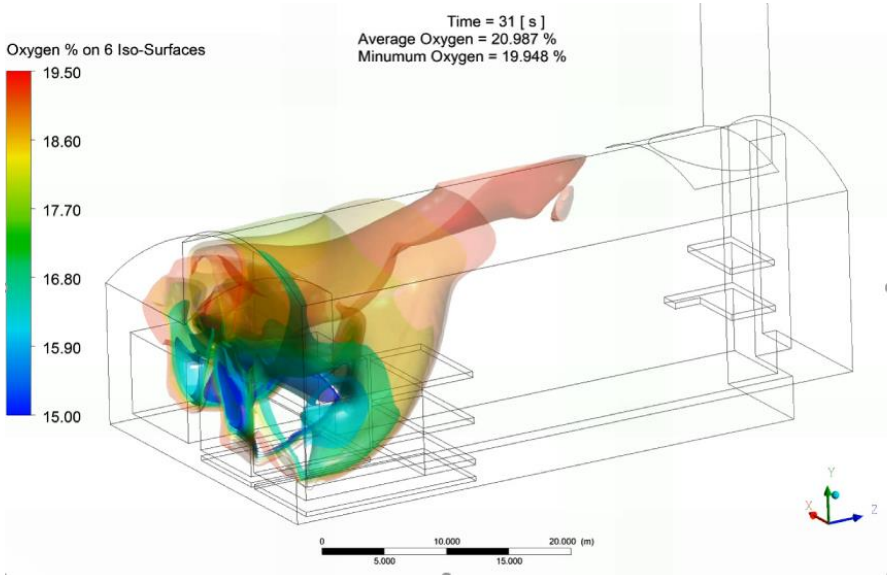
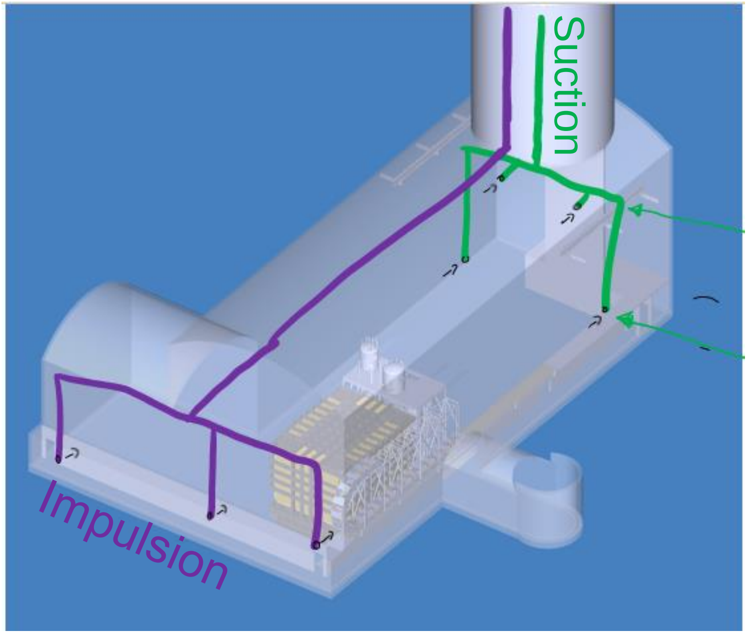
Near Site ESH

Oxygen deficiency hazards

- Cavern escape corridor for ODH or fire egress;
- Oxygen deficiency hazards:
  - ODH 1 + escape pack with;
  - Shared ODH mitigation with HVAC 40,000 CFM;
  - HVAC outside Air (OA) intake of 7500cfm with flow transmitter
  - ODH mitigation CFD analysis







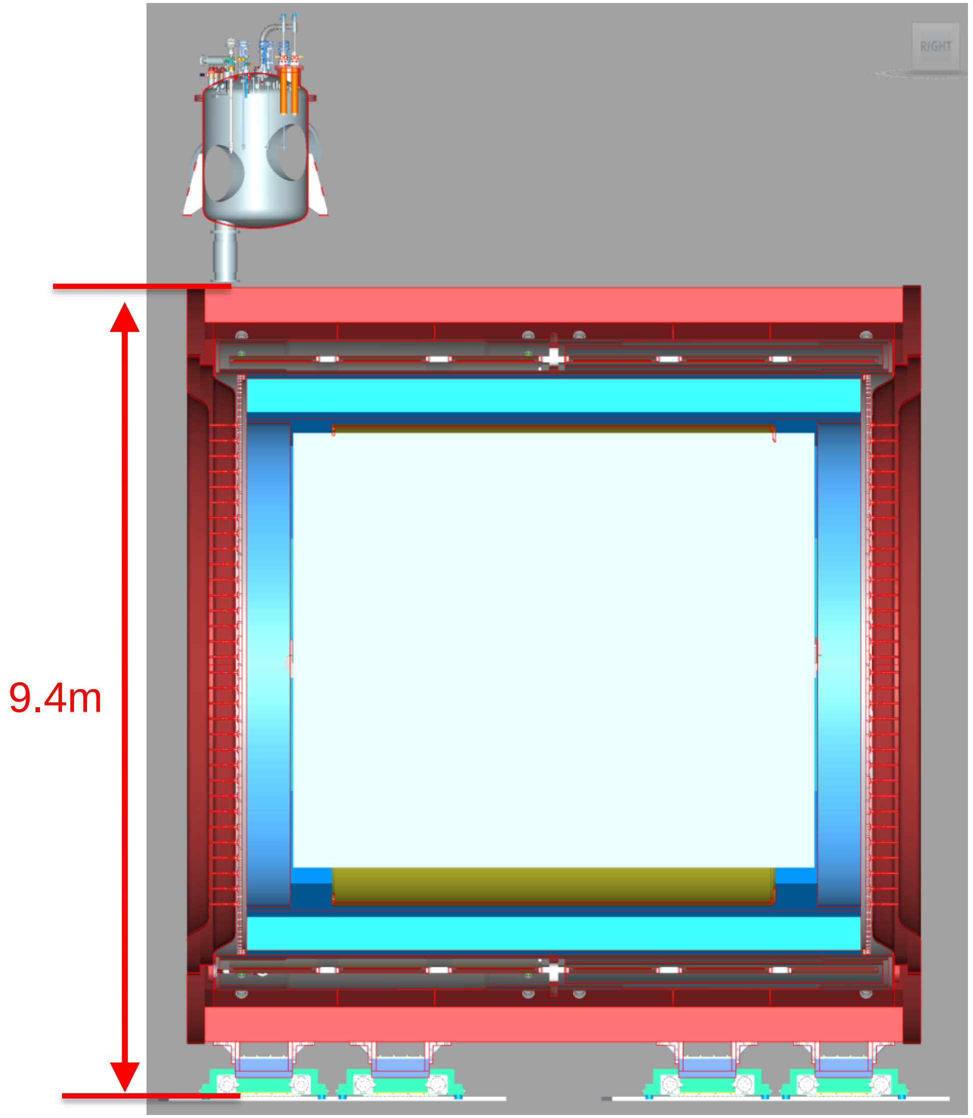
Near Site ESH

MPD specifics

- ODH mitigation in shared helium compressor room (serving SAND and MPD)
- ODH mitigation system capable to deal with puncture of MPD vessel after loss of insulating vacuum
  - Release of 5 tons of Gaseous Argon considered in the preliminary ODH analysis
- Other scenarios not considered but with smaller impact
  - GAr circulation system leak
  - If using CO2 or another gas to reject heat, leak into the cavern.
  - Heat exchanger failure in the heat rejection system.
    Two scenarios:
    1. Water in the process
    2. Pressurization of the water system via process.

Open questions

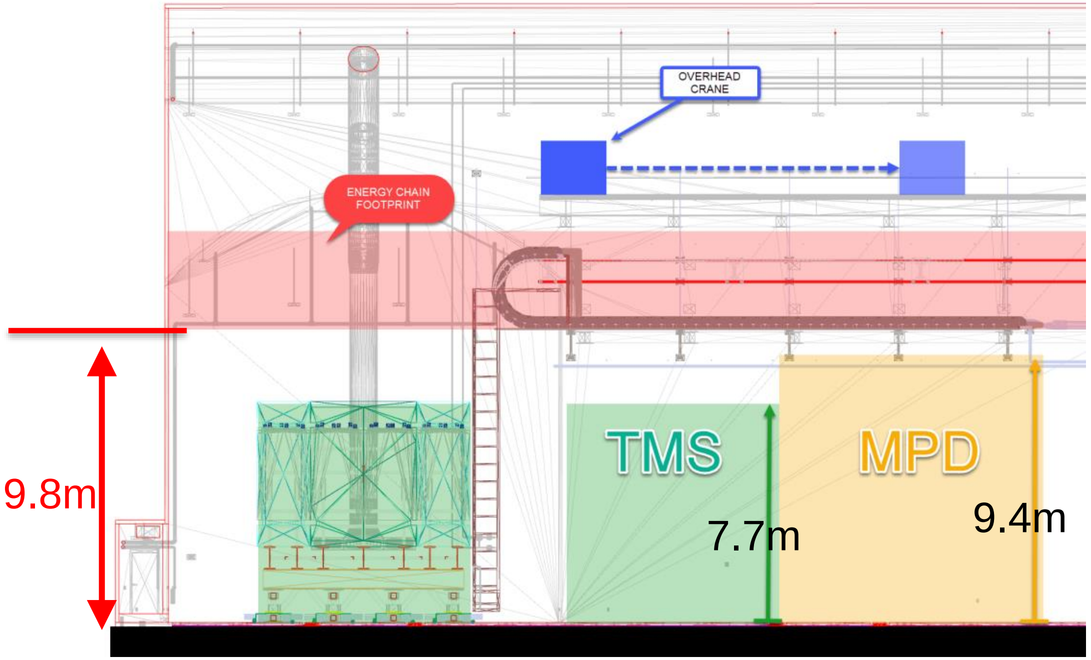
- Use of flammable gases or displace oxygen?
- Where is the gas system located?



Disclaimer: This is not the latest model

Challenges

- **Cryogenic refrigerator:** Based on experience with SAND refrigerator technical inquiries. MPD could benefit from using a nitrogen shield.
  - A Helium refrigerator customized for 80K shield support will have higher cost and larger footprint, limiting gas system footprint.
  - A 80K helium supply and return adds more scope in the prism cable chain.
- **Integration:** Fit all equipment in the designated envelope in the lower floor.
- **PRISM design:** Bending radius of PRISM energy chain with flexible helium multi channel transfer lines.
  - Cold He flexible line with LN2 jacket requires 1500mm bending radius
  - PRISM for TMS only has spacing for 1300mm bending radius, based on ND-GAr height.
- **Programmatic:** Installing MPD in an ODH 1 environment will require everyone to be trained, with medical checkup, wear portable ODH monitors and carry escape packs.



Summary

- Introduction to ND cavern presented thanks to I&I contributions
- Interfaces, requirements and assumptions are presented
- From an ES&H perspective, the release of 5 tons of GAr is considered in the preliminary ODH analysis
- Challenges related to available space and PRISM have been discussed