
DUNE-ND LArTPC Cryostat TPC Mezzanine

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U.S. DEPARTMENT OF
ENERGY

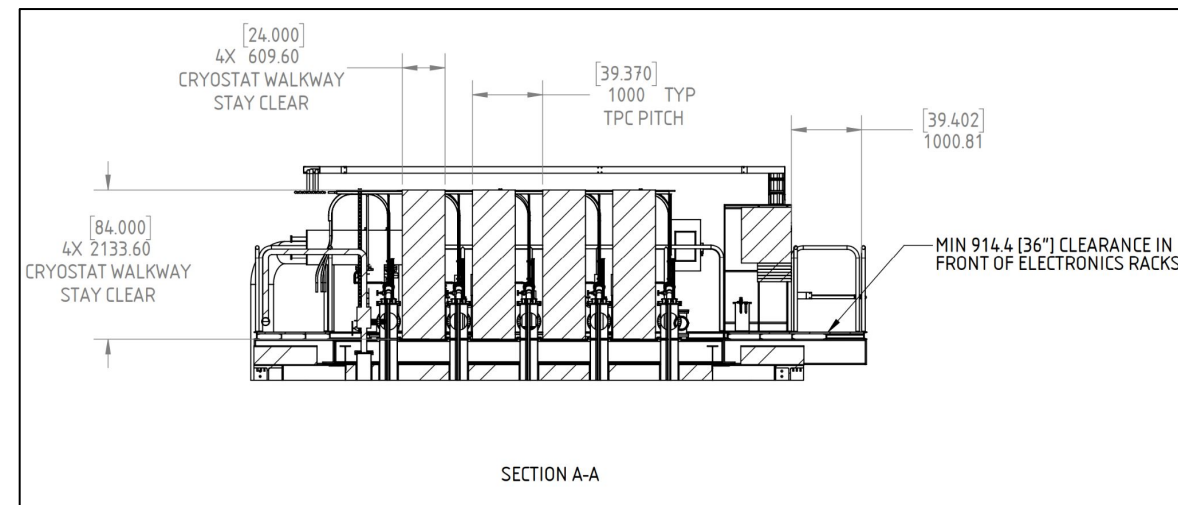
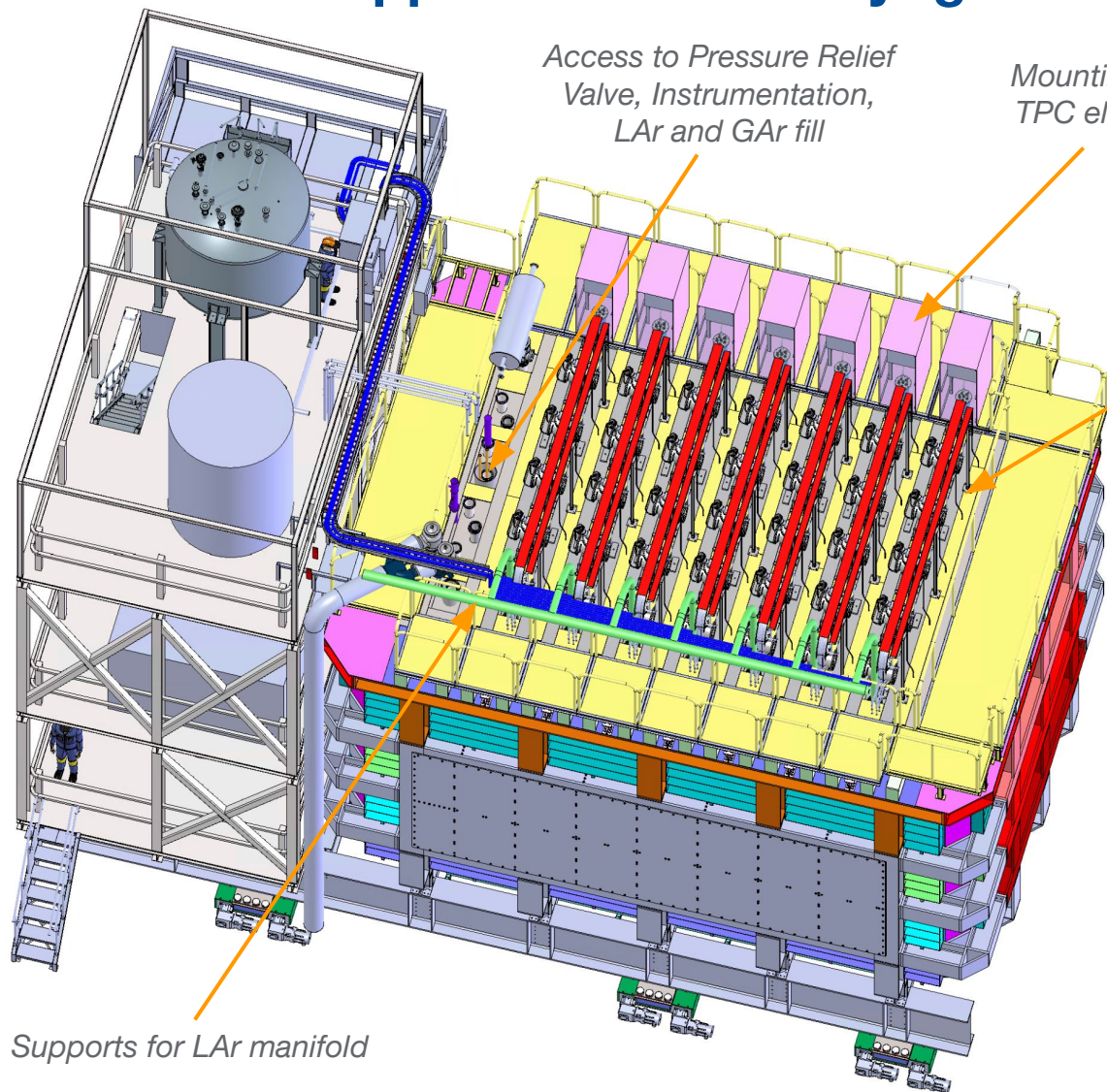
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Requirements and Interfaces

- [FESHM 5100 Structural Safety](#)
 - Mezzanine to meet [International Building Code \(IBC\)](#) and AISC 360
 - Design to safety factor >2 on yield strength as conservative simplification of code
 - Licensed structural engineer to evaluate final design against IBC before release to fabrication
- Occupational Safety and Health Administration (OSHA)
 - [1910.36 Design and construction requirements for exit routes](#)
 - Egress path minimum 28" [71 cm] wide, 90" [229 cm] high
- National Electric Code (NEC): 36" [91 cm] stay clear in front of electrical components
- ND-LAr TPC interfaces
 - Provide flexible personnel access to top of detector
 - Support TPC electronics

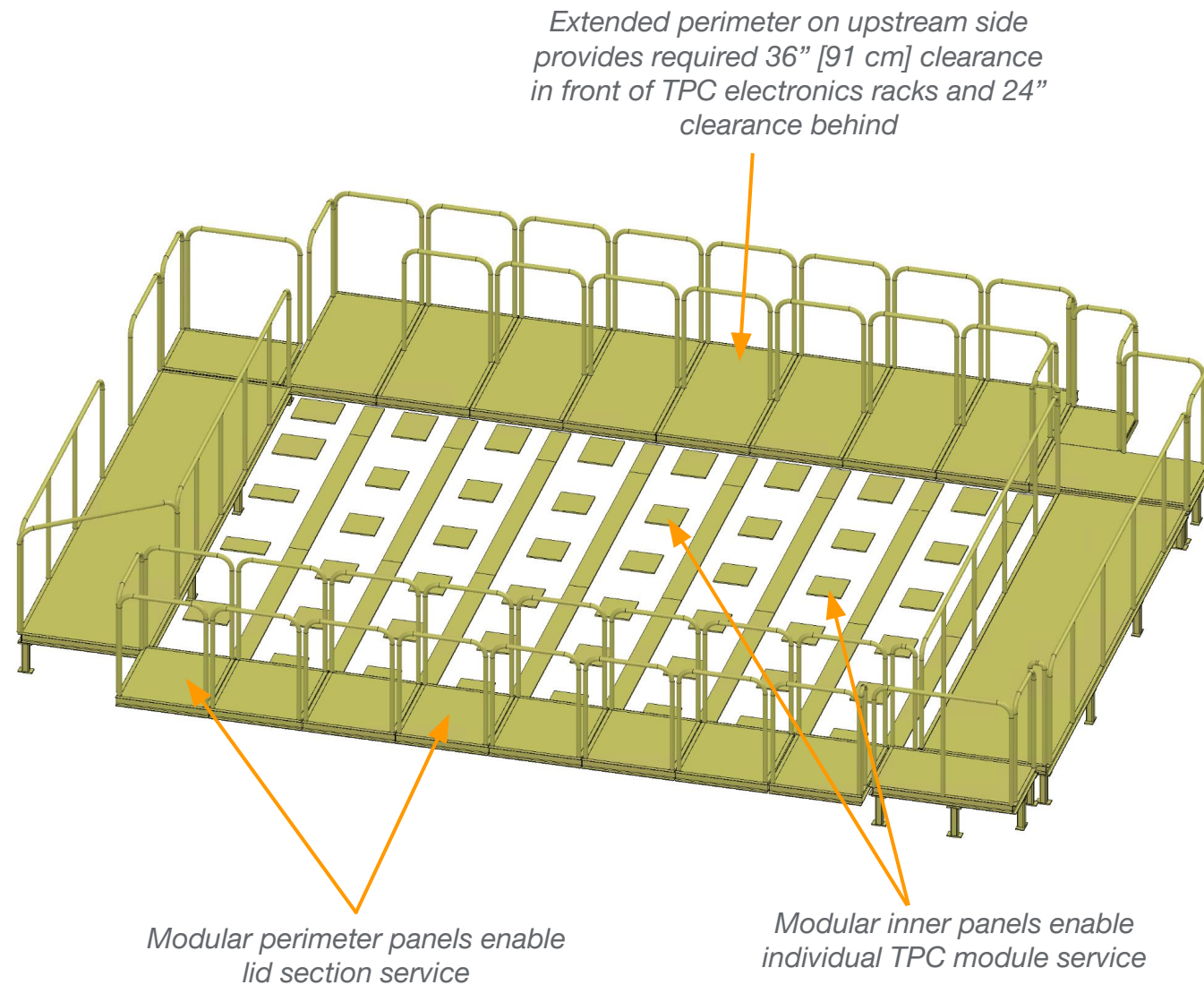
The TPC mezzanine provides personnel access during installation and operation and supports TPC and cryogenic components



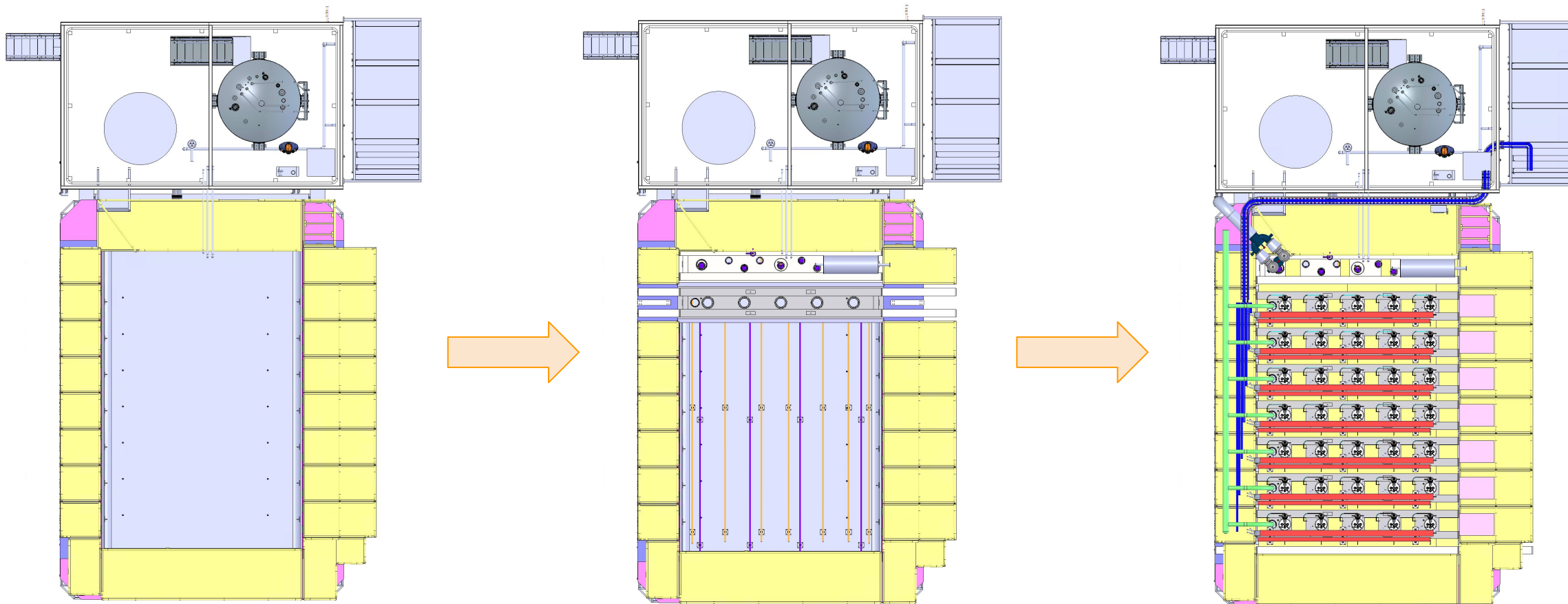
Excerpt from TPC Mezzanine Interface Drawing ([EDMS 2679314](#))

Design Overview

- 11.1 x 8.8 x 1.2 m (L x W x H) outside dimensions
- 2.7 metric tons [3 US tons] of beams, plates, floor panels and railings
- S460ML steel for I beams and warm structure
 - 460 MPa [67 ksi] yield strength
 - Safety factors assume alternate A572-65 steel at 65 ksi [448 MPa]
 - 17% elongation at failure
- Fiberglass grating floor panels
- Plywood floor panels
- Manufacturing methods
 - I beams and box beams cut and machined
 - Plates and gussets machined
 - Railings and floor panels sourced and integrated
 - Welded subassemblies
 - Bolted final assembly
 - Painting



Modular panels and railings allow mezzanine configuration to be tailored to assembly steps

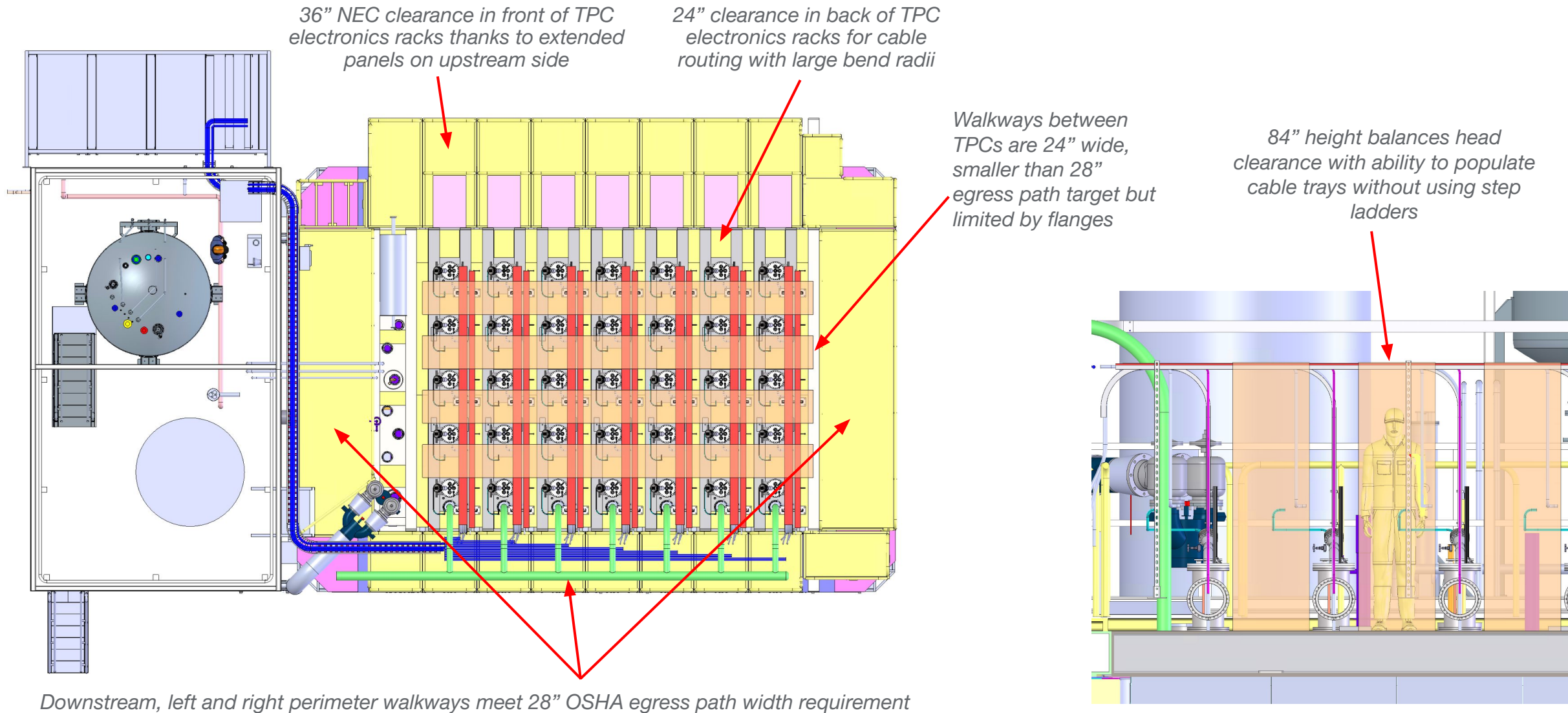


Perimeter panels are installed first to support personnel access. Inner and outer railings provide fall protection.

Perimeter panels selectively removed to install lid sections. Fall protection harnesses only required while lid is being placed and welded.

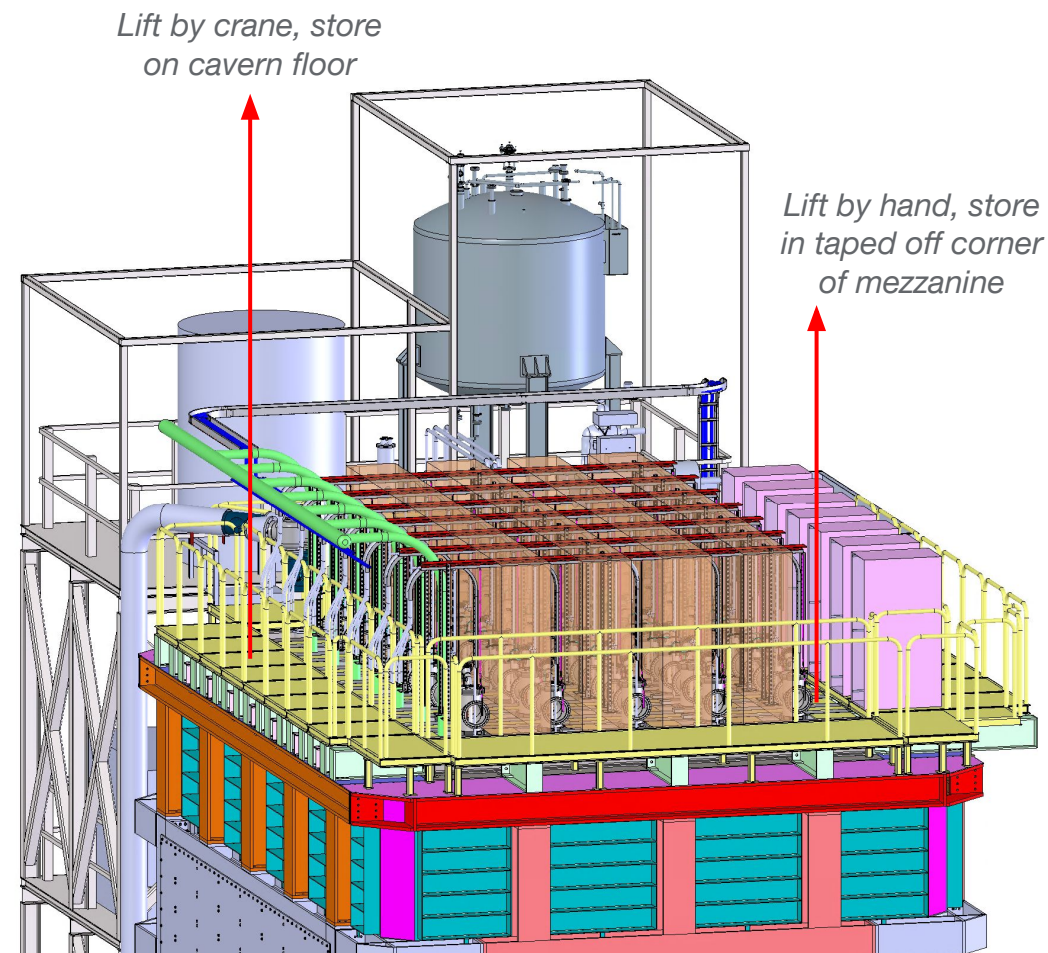
Once all lids are in place, inner panels provide access to interior for detector integration. Inner railings may be removed.

Walkway stay clear zones perpendicular to neutrino beamline are agreed upon in interface control documents



Railing segments and internal panels are small and light enough to be moved by hand. Perimeter panels will be moved by crane along with lid sections.

- Internal plywood panels approx. 5 to 20 lbs
- Can be stored on free area of mezzanine if storage space is clearly marked off and not blocking egress
- Numbered by row and column to ease reassembly



Analysis plan is similar to other systems but no studies have been performed yet

Approach

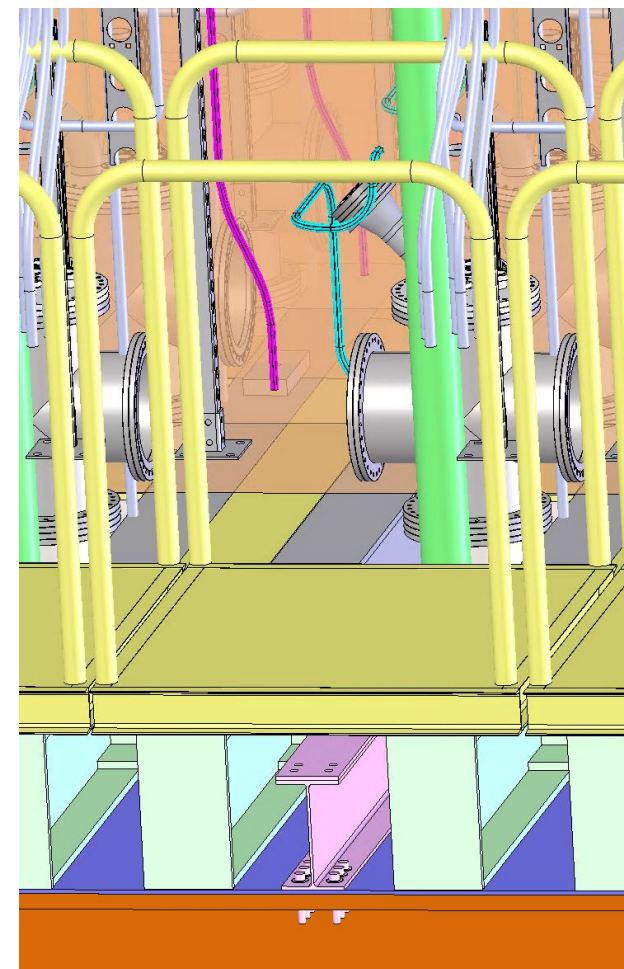
- Preliminary design: cryostat team analyzes with ANSYS and hand calcs, targeting safety factor >2 on yield strength
- Final design: Illinois-licensed structural engineer evaluates against IBC requirements

Load cases

- Static Floor Load: 20 US tons TPC components, 100 lb/ft² [4.8 kPa] live load
- Modal: 10-15 Hz natural frequency target

Requirements

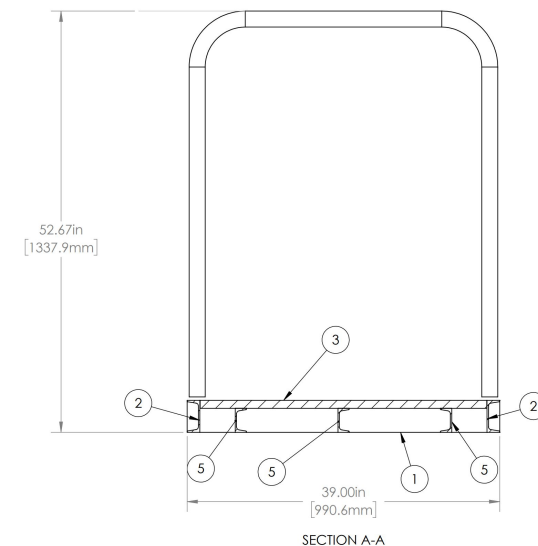
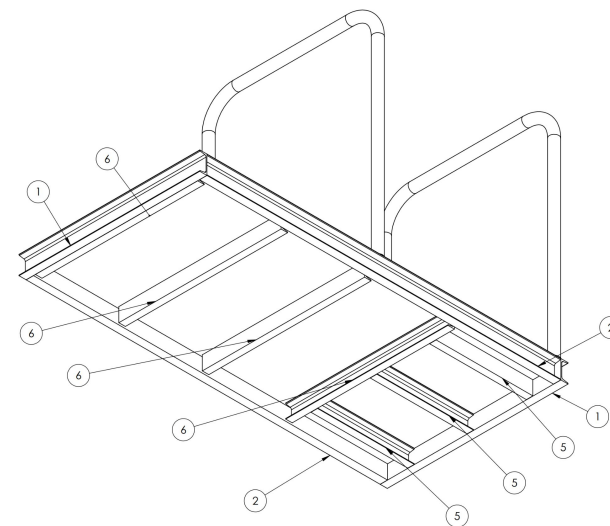
- Safety factor >2 on yield strength (best practice to ensure we meet IBC)
- 10 mm deflection limit as best practice for walking surface



Mezzanine panels are supported by W14x53 lid I beams, either bolted (perimeter) or nested (inner)

Manufacturing Plan

- Methods
 - C channel cut and machined
 - Plates and gussets machined
 - Railings and floor panels sourced and integrated
 - Welded subassemblies
 - Bolted final assembly
 - Painting
- Supplier pool
 - Experience in building construction, power plants, rail cars
 - Seeking design-build contract with engineering, procurement and construction (EPC) firm
 - Seeking single supplier for TPC and Cryogenics Mezzanines



Quality Assurance Plan

- Inspection reports for each panel subassembly provided before shipment
- No as-built survey planned as dimensions are not critical

- Interior and exterior perimeter railings on mezzanine mitigate fall hazard
- Adherence to IBC and AISC 360 codes mitigate mezzanine structural failure hazard

2. DUNE ND Hazard List				DUNE Near Detector Hazard List										DRAFT		
														Effective Date: 17-Dec-21 Print Date: 13-Sep-24		
Hazard Identification				Un-Mitigated Hazard and Risk Level				Mitigation Method / Updated Hazard and Risk Level				Verification				
#	Subsystem	Type	Title	Hazard Description	Severity	Probability	Risk Value	Risk Category	Mitigation Strategy	Mitigation Description	Severity	Probability	Risk Value	Risk Category	Verif Method	Verification Plan
3.01	NDLArCryoV	Mech	Fall from fully assembled cryostat	Cryostat work platforms are up to 30 ft above cavern floor, falls could result in serious injury or death.	1	D	8	Serious	Safety device	Use railings on stairways and elevated work platforms. If railings are removed for service procedures, use fall protection harnesses and anchor points on cryostat structure.	1	E	12	Medium	Audit	Verify railings and fall protection are compliant with relevant OSHA standards. Verify I&I process documents address fall protection.
3.02	NDLArCryoV	Mech	Fall from cryostat during construction	Cryostat work platforms are up to 30 ft above cavern floor, falls could result in serious injury or death.	1	D	8	Serious	Safety device	Use fall protection harnesses when working on scissor lifts, scaffolding and other elevated work platforms used to assemble cryostat.	1	E	12	Medium	Audit	Verify temporary work platforms and fall protection are compliant with relevant OSHA standards. Verify I&I process documents address fall protection.
3.03	NDLArCryoV	Env	Oxygen deficiency hazard inside of cryostat	Internal cryostat volume will be full of argon in operation. If volume is not adequately purged before personnel enter for service, ODH condition will exist.	1	C	4	High	Control hazard	All cryostat service to be performed from outside or after removing components from internal volume. No personnel access to inside of cryostat.	1	E	12	Medium	Audit	Verify no Cryostat elements require internal access for I&I or service. Verify no inspection, manufacturing and service documents reference accessing cryostat internals after lid is closed.
3.04	NDLArCryoV	Env	Confined space inside of assembled cryostat	Internal cryostat volume is a confined space with associated personnel extraction and access hazards.	3	C	11	Medium	Control hazard	All cryostat service to be performed from outside or after removing components from internal volume. No personnel access to inside of cryostat.	3	E	17	Medium	Audit	Verify no Cryostat elements require internal access for I&I or service. Verify no inspection, manufacturing and service documents reference accessing cryostat internals after lid is closed.
3.05	NDLArCryoV	Env	Confined space inside of cryostat during warm and cold structure installation	Internal cryostat volume is a confined space with associated personnel extraction and access hazards.	3	A	7	Serious	Safety feature	Use stair towers both inside and outside of cryostat when installing warm structure and cold structure into open tub.	4	A	13	Medium	Audit	Verify stair towers are compliant with relevant OSHA standards. Verify I&I process documents address confined space requirements.
3.06	NDLArCryoV	Env	Confined space under cryostat and between beams of PRISM frame	Area under cryostat and between PRISM frame is a confined space with associated personnel extraction and access hazards.	3	B	9	Serious	Control hazard	Limit PRISM frame assembly operations performed in cavern. Any ongoing inspection and service required on the PRISM frame to be performed from the outside.	3	D	14	Medium	Audit	Verify no PRISM frame elements require access underneath cryostat for inspection or service. Verify no inspection, manufacturing and service documents reference accessing area under cryostat after warm structure is built.
3.07	NDLArCryoV	Env	Confined space between cryostat and cavern wall	Area between cryostat upstream wall and cavern is a confined space with associated personnel extraction and access hazards.	3	B	9	Serious	Procedure, training	Limit cryostat upstream wall assembly operations performed in cavern. Lock out / tag out of energy chain while accessing area as energy chain passes through this area in operation.	3	D	14	Medium	Audit	Verify cryostat and PRISM I&I procedures require lock out / tag out when accessing area between cryostat and cavern wall. Verify no inspection, manufacturing and service documents reference accessing area between cryostat and cavern wall after warm structure is built.
3.08	NDLArCryoV	Press/ Vac	Cryostat overpressure leads to cryogen leak	Exceeding design pressure of cryostat may damage warm structure, resulting in cryogen leak into cavern and oxygen deficiency hazard.	1	C	4	High	Safety device	Dual pressure relief valves prevent cryostat gas pressure from exceeding design pressure. Structural safety factors and analysis draw upon accepted standards. Cavern moat contains potential argon spill so that ODH condition does not occur at cavern floor working level.	1	E	12	Medium	Test	Test pressure relief valve function during Cryostat I&I.

Excerpt of Cryostat entries from Hazard List ([EDMS 3165698](#))

Path to Final Design

- Bolted joint calculations and sizing
- Structural analysis of representative portions
 - Perimeter panels upstream and downstream
 - Interior panel (largest / worst case)
- IBC and AISC 360 analysis by structural engineer
- Vendor selection
- Vendor quotes and feedback