Excavation Scope Final Design

David Vardiman

Arup Final Design Kick-Off Meeting

November 7, 2017

Changes from what you've seen in the PDR

The design has matured since you last received it. There have been numerous refinements, below is a list of significant changes to excavation design elements.

- **Design Drawing Format**
  - Include Fermi Lab Research Alliance (FRA) Project Numbering System to all design drawing deliverables.
- **Cost and Schedule**
  - Include 3.5% CCIP to all construction costs.
  - Include 2% SD Excise Tax.
  - Include a line item for SD Sales and Use Taxes at 6.5%.
  - Do Not Include; Builder's Risk, Auto Insurance, Contractor's Equipment Insurance, Excess Liability, or Fire Marshal in EXC Indirects.
  - Include scheduled availability of infrastructure systems to support start of cryostat installation.
    - Monorail **(EXC)**
    - Ventilation (BSI)
    - Fire & Life safety systems (BSI)
    - Lighting (BSI), (task lighting in detector pit to be supplied by cryostat)
    - Power grounding network, (interface point is the CF supplied buss bar) (BSI)
    - Concrete invert in pits and drifts **(EXC)**
    - Rail system for moving cryostat pieces **(EXC)** (already addressed in Arup drawings UG-PDR-C-130 and 311 located in DocDb 136, EXC Underground Drawings)
    - CUC control room to allow for a meeting/refreshment space for the cryostat installers (BSI)

- **Surface**
  - Include a geotechnical assessment of the Ross Shaft foundation to inform BSI design. (EXC)
- **4850L Infrastructure (EXC)**
  - Remove Yates Shaft brow scope. Not required as per logistics report.
  - Remove 5000L ramp drift scope. A system has been designed to manage skip rock spillage within the shaft, eliminating the ramp drift requirement. Add water management system.
  - Remove 4850L 17 Ledge exhaust path scope of work to a "below the line" option
  - Include Ross Shaft Brow Isolation Study findings, Drift Optimization Study findings and Underground Electrical Substation Relocation Feasibility Study/Conceptual Design findings, ie: drift height/crown radius, drift intersections and relocation of maintenance shop and electrical substation.
  - 4550L Batch Plant location to be defined by CM/GC no later than 30% deliverable.
  - Include geotechnical core drilling hole abandonment.
- **Cavern (EXC)**
  - Remove blast wall between chambers 1 and 2 and chambers 3 & 4 excavate each chamber concurrently, realign access drifts to align to the center line of the septum pillar. Keep Cavern 1 & 2 isolation in tact.
  - Include reduction in septum pillar width to 14.4m, increasing each chamber length by 0.3m without changing anything else.
  - Include addition of drift-width (minimum) 3m deep "antechambers" to both ends of detector caverns, extend monorail into space and move AHU's accordingly.
  - Electrical Grounding;
    - Remove WWM in detector caverns below the 4850L sill
    - Use fiber reinforced shotcrete below sill
    - Include 0.96m (24") gap between shotcrete and concrete invert
    - Include nonmetallic rebar in invert construction
    - Include WWM in connecting drifts between CUC and caverns
    - Remove WWM in CUC
  - Include bridge connection/support design for cryostat-provided bridge between cryostat and rock (cryostat ends only).

- **Cavern Cont. (EXC)**
  - **Mezzanine;**
    - **Include connections/supports and wall mounted supports design for 10m x 35m mezzanines on the CUC side of each detector chamber. (please see DUNE DocDB 464 - Control Drawing F10043159)**
    - **Include a pattern of 10 - metric ton capacity lifting eyes above each mezzanine, and 2 - metric ton capacity lifting eyes above each cryostat bridge, for material lifting at each location. (please see DUNE DocDB 464 - Control Drawing F10043159)**
  - **Monorail;**
    - **Include 15 – metric tons minimum capacity.**
    - **Include two sets of three 15 – metric tons capacity monorail hoists (chamber 1 & 2).**
      - **Verify hook height/width clearance envelope and monorail beam locations shown on DUNE DocDB 464 - Control Drawing F10043159.**
      - **Verify all other clearance envelope dimensions shown on DUNE DocDB 464 - Control Drawing F10043159.**

- **Pending Development of DUNE Design Specifications TBD from lists below.**
    - **See list below**

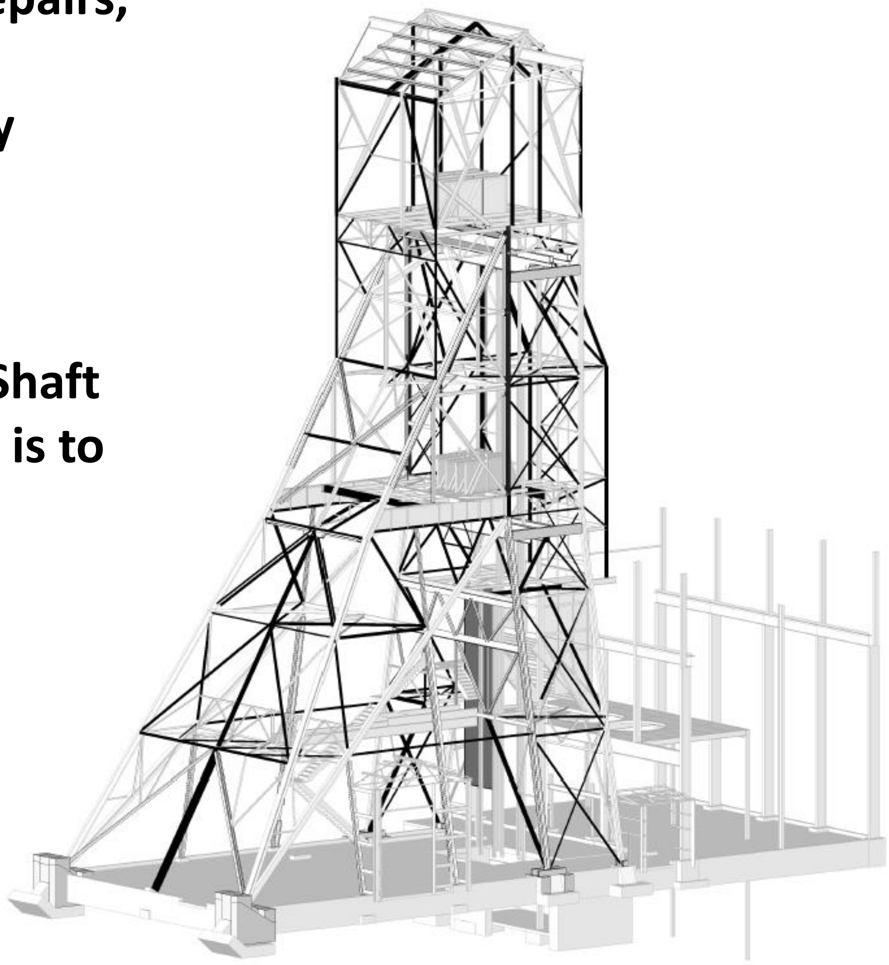
Pending Development of DUNE Design Specifications TBD

- CF to provide permanent Alimak type elevators for each chamber (Assume chamber 3 and 4 would be scope options).
- Design accommodations for a bridge crane
- Additional monorail hoists?
- Mezzanine shift 4.8 m from end wall.
- Add a ninth and tenth connection points for mezzanine supports on rock wall and vertical connection point (horizontal and vertical connection points)
- Mezzanine load increase
- Eliminate blast wall between chambers 1 and 2, shift central access drift to center of pillar
- A trade study comparing the cost of running all utilities below the 4850L across the rock pillar with the cost of three monorail hoists (the bridge crane is provided by Marzio, so doesn't factor into the cost).
- D&D a temporary grounding network down into each detector pit
- Infirmary and recreation rooms
- Machine Shop (mucking ramp?)
- Survey network to allow positioning of the various components
- Please see Nandhini Dhanraraj's presentation on DUNE Requirements – DocDB-112

Changes to EXC scope – Surface – Ross Shaft Headframe

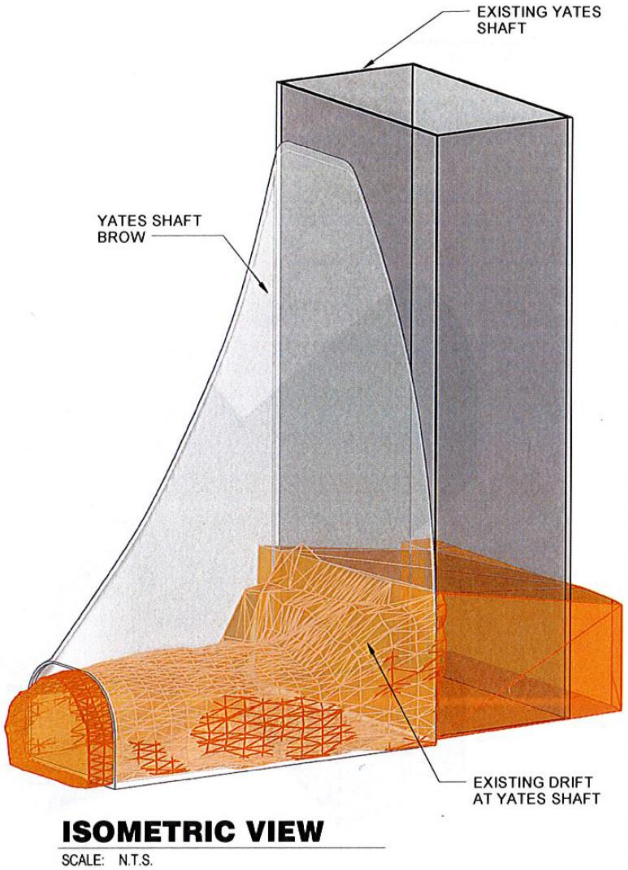
- **A design is provided for foundation repairs, but some additional geotechnical investigation is planned that will likely reduce that scope.**

- **The Final EXC Design shall include a geotechnical assessment of the Ross Shaft foundation to inform BSI design. This is to be managed under EXC.**



Changes to EXC scope – Infrastructure – 4850L Yates Shaft Brow

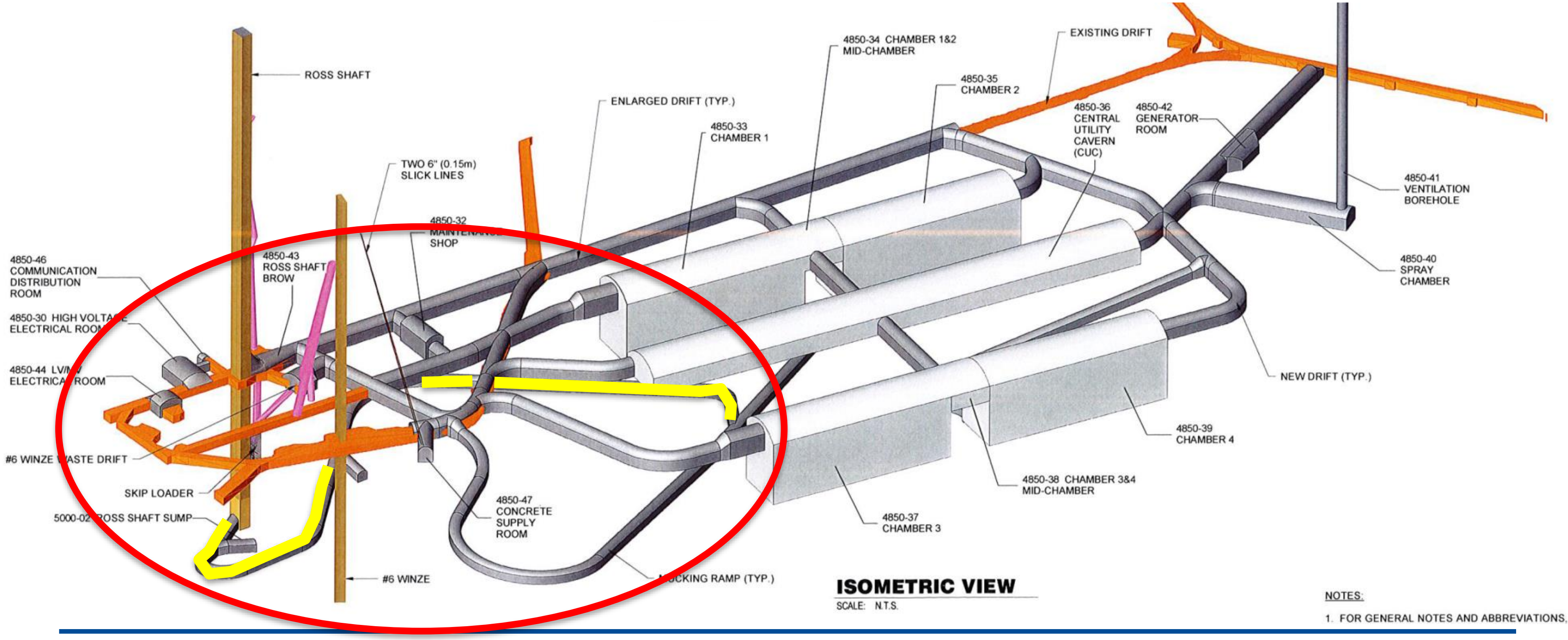
- **The Preliminary Design included the excavation of the Yates Shaft brow. The completed logistics study determined this was not required.**
- **Final Design shall remove the 4850L Yates Shaft Brow excavation from the scope of work.**



Changes to EXC scope – Infrastructure – 5000L Decline Drift

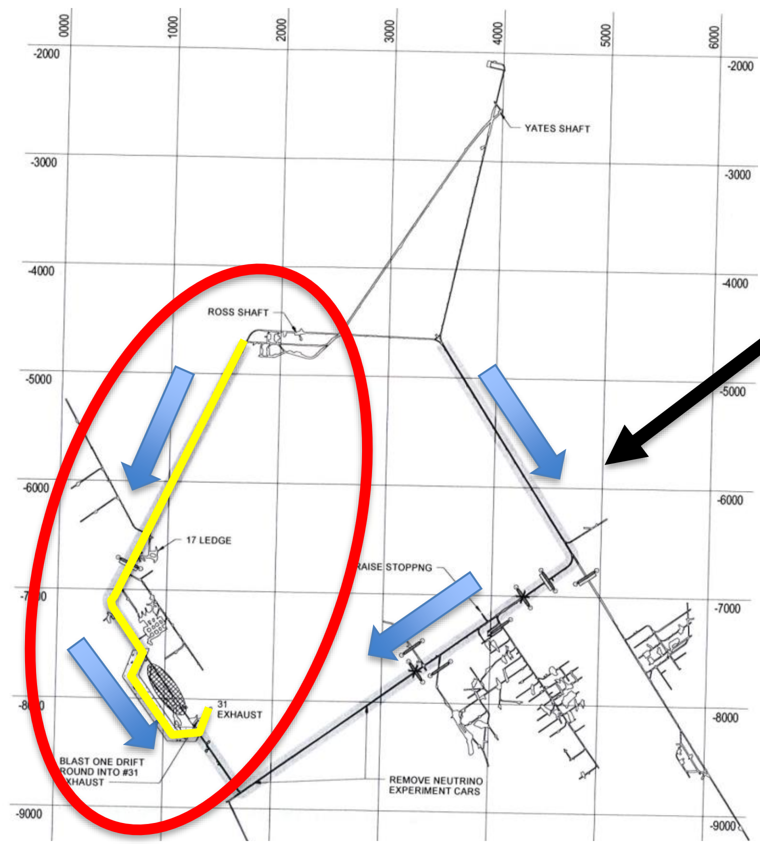
- **The installed Ross Shaft collection system will eliminate the 5000L decline drift previously included in the PDR and may influence ventilation design.**

- **The Final EXC Design shall remove the 5000L decline drift from the scope of work.**
- **The Final EXC Design shall include a water management system to replace the collection system included into the 5000L ramp.**



Changes to EXC scope – Infrastructure – 4850L 17 Ledge Ventilation Route

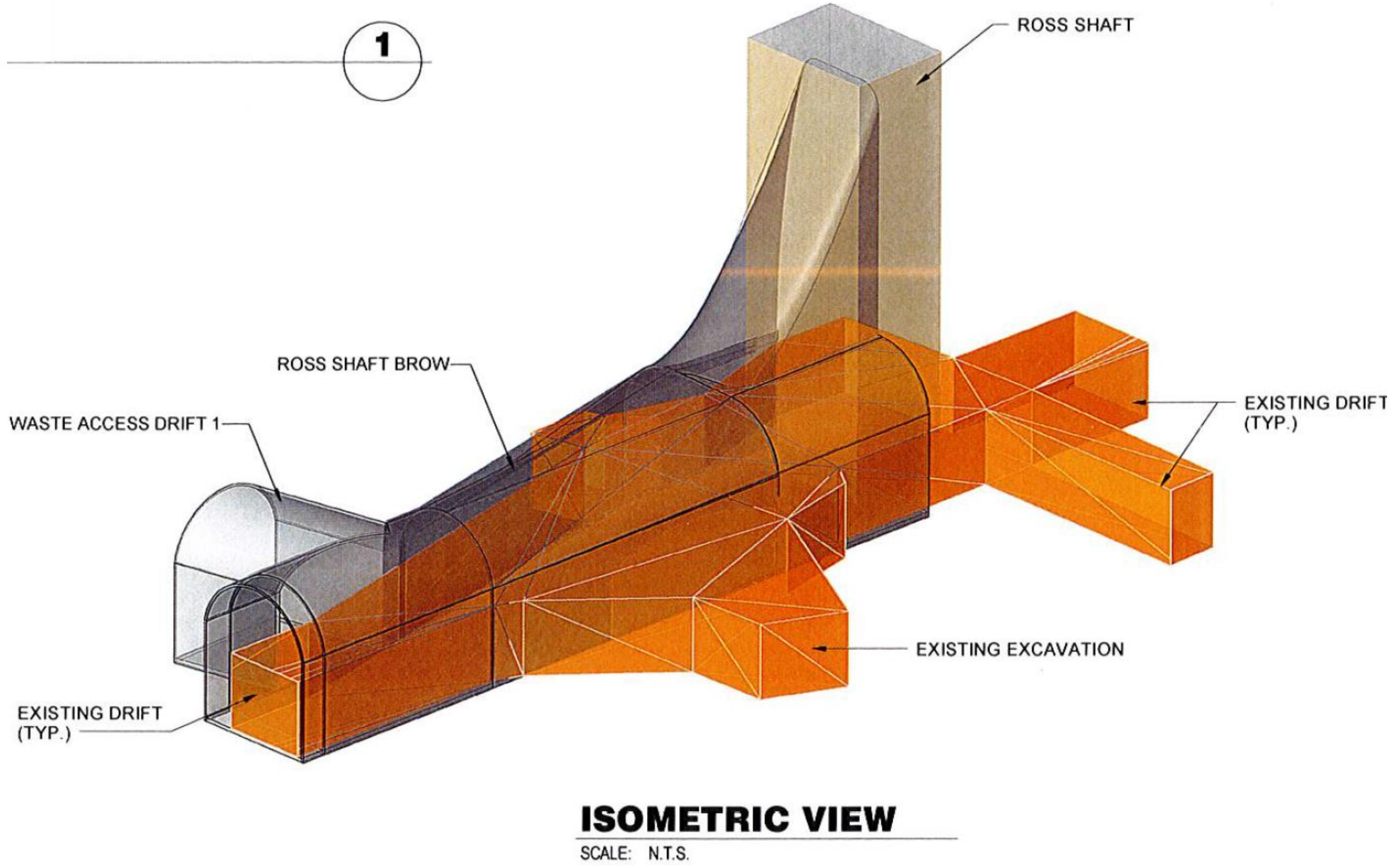
- **The Preliminary Design included rehabilitation of 4850L 17 Ledge exhaust ventilation route for ventilation support for the LBNF excavation.**
- **The Final Design shall remove this from the scope of work.**



9 & 11 Ledge Ventilation route to be rehabilitated by SDSTA 2017 - 2018

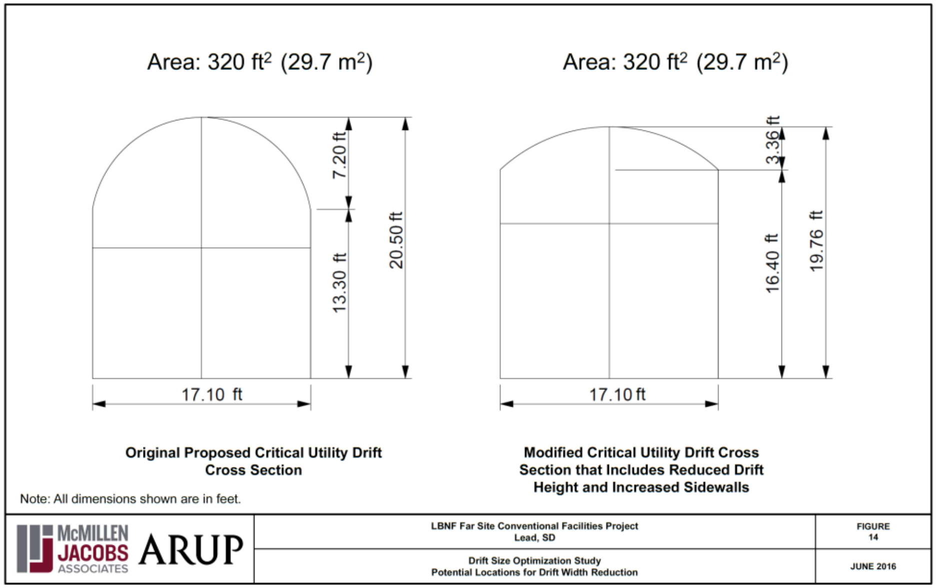
Changes to EXC scope – Infrastructure – 4850L Ross Shaft Brow & Access Drift Design

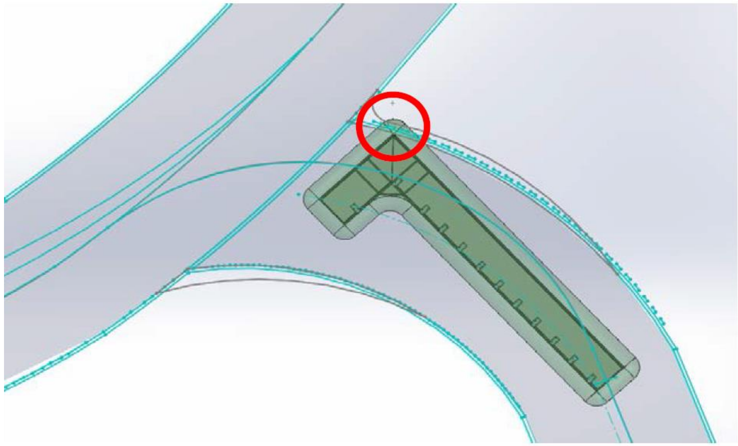
- **The Final EXC Design shall include the findings of the Ross Shaft Brow Isolation and Drift Optimization Studies. KAJV to provide input.**



Changes to EXC scope – Infrastructure – 4850L Ross Shaft Brow & Access Drift Design

- **The Final EXC Design shall include the findings of the Ross Shaft Brow Isolation and Drift Optimization Studies.**
- **“It is recommended that the critical utility drift cross section shown in Figure 14 be considered going forward to improve drift stability. Further, it is recommended that a five ft. (1.5m) radius is adopted for pillar chamfers and minor modifications needed made to cure radii at intersections to accommodate transportation of beams.” KAJV to provide input.**

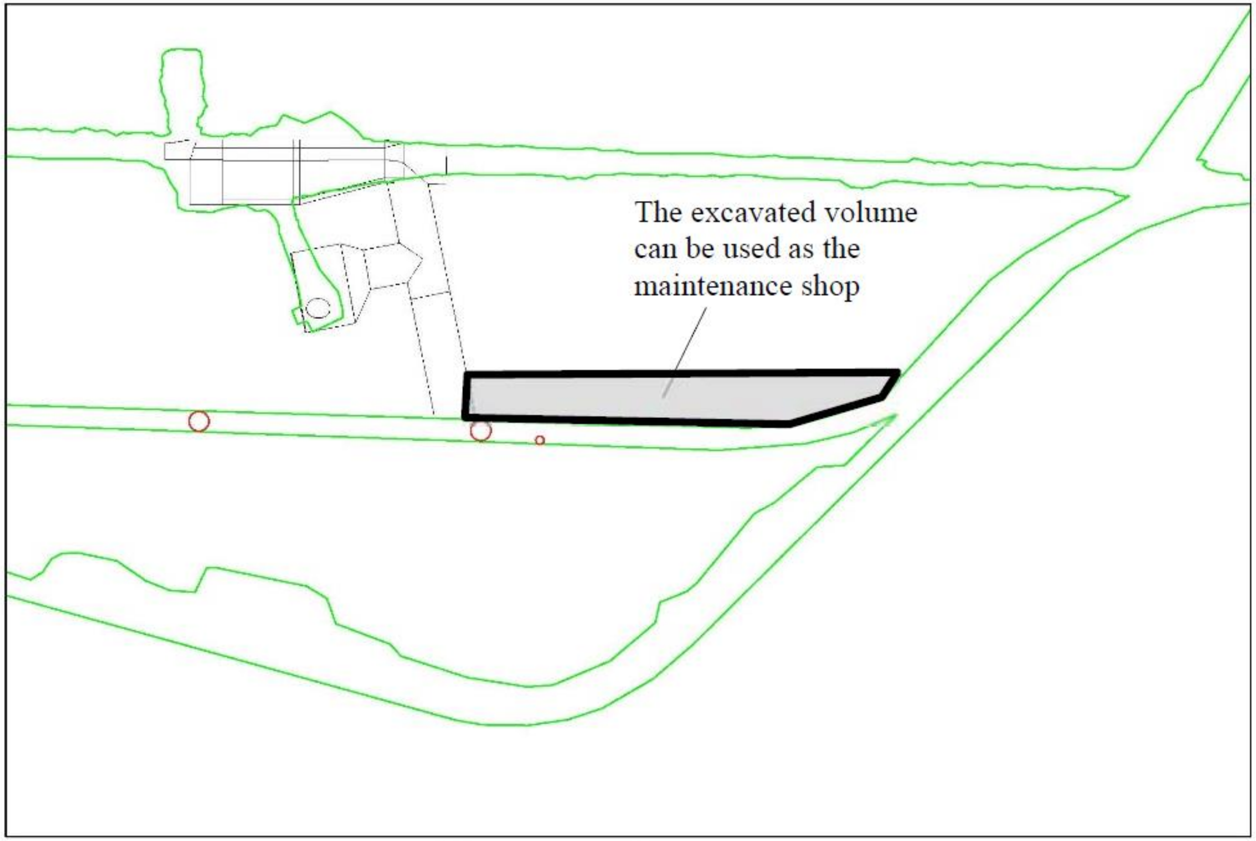




Corner Beam Transported through Intersection 12 on Side. Sidewall of drift encroaches into 1.5-foot clearance envelope.

Changes to EXC scope – Infrastructure – 4850L Ross Shaft Brow & Access Drift Design

- **The Final EXC Design shall include the findings of the Underground Electrical Substation Relocation Feasibility Study/Conceptual Design. KAJV to provide input.**

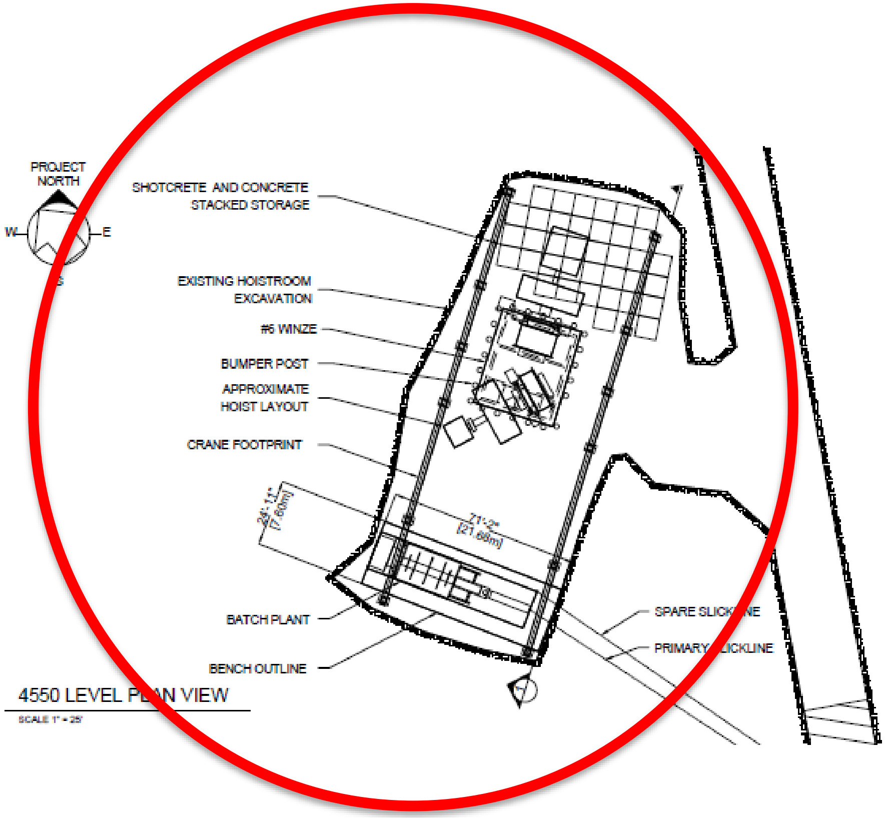


Changes to EXC scope – Infrastructure – 4550L Concrete Batch Plant

- **The Preliminary Design includes a batch plant in the #6 winze hoist room on the 4550L, with boreholes delivering product to a remix bay on the 4850L.**

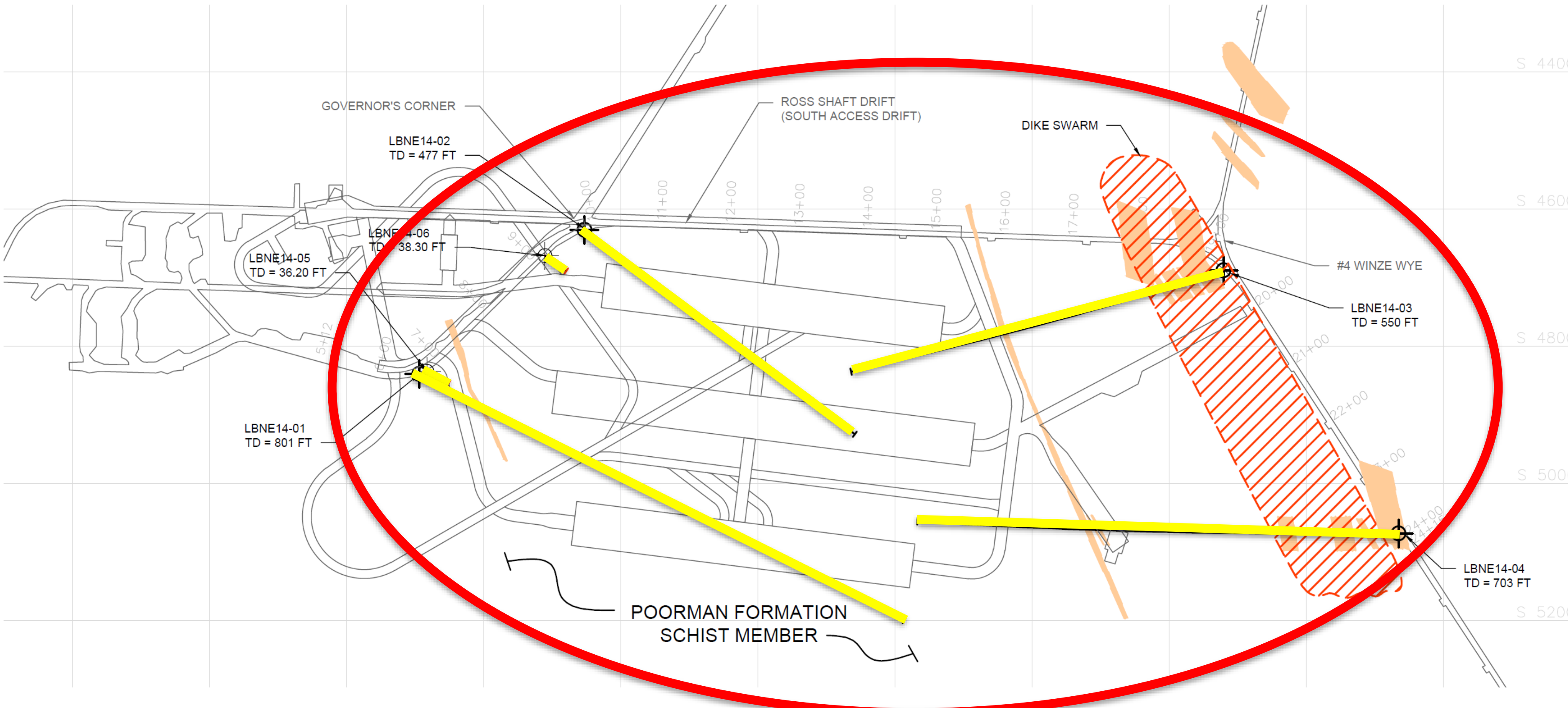
- **This is planned to be installed during the Pre-Excavation (1A) period, but KAJV may elect to postpone this if it's not deemed necessary to prevent interference with the main excavation process later.**

- **During the Final Design (by 30% design) KAJV is to inform FRA whether to further develop this method.**



Changes to EXC scope – Infrastructure – Geotechnical Site Investigation Core Drilling Hole Abandonment

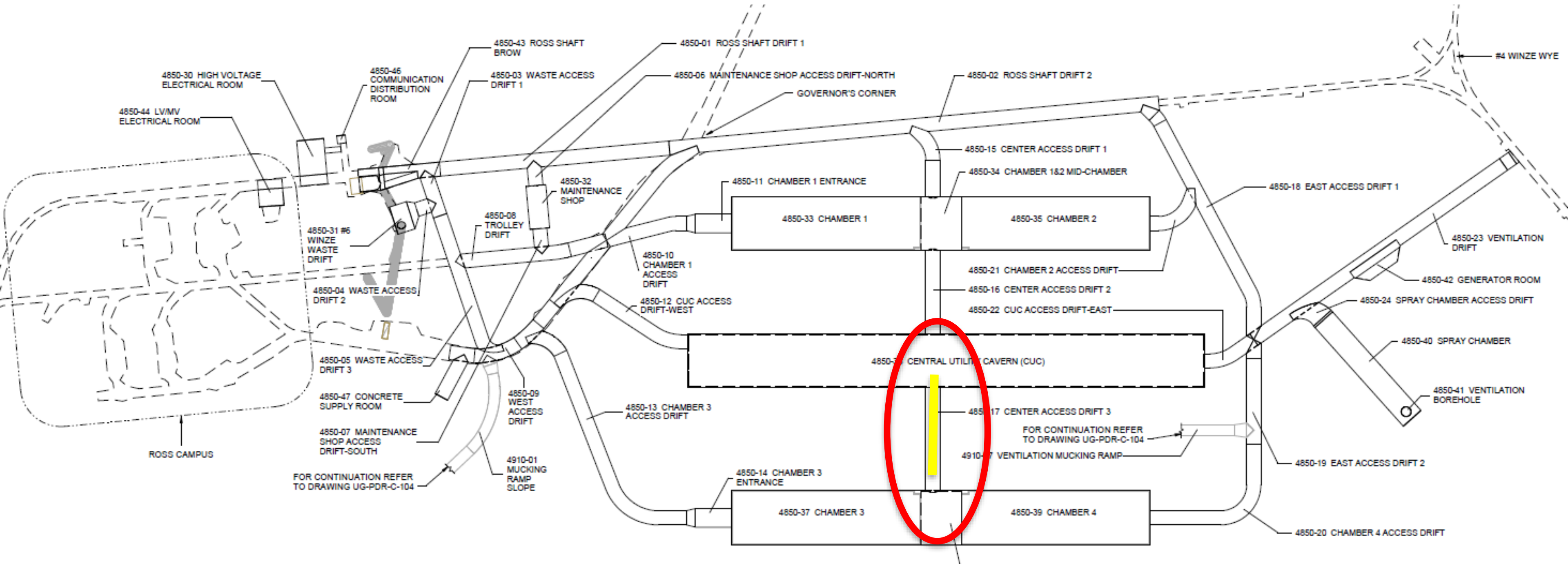
- **The Final EXC Design shall include the full abandonment (drill hole terminus to collar) of the six LBNE Geotechnical Site Investigation core drill holes, or repurposing of these for geotechnical monitoring during excavation and long-term.**



Changes to EXC scope – Cavern Design – Chamber 3 & 4 Bulkhead & Mid-Cavern Access Drift

- **The Preliminary Design includes a bulkhead between Chambers 3 and 4 to allow construction of a cryostat structure with concurrent excavation of chamber 4. This bulkhead required the access drift to be designed with an offset from the center alignment of the septum pillar.**

- **The Final Design shall remove this bulkhead design from the scope of work and include a shift of the center line for the mid-cavern access drift to the center of the septum pillar.**

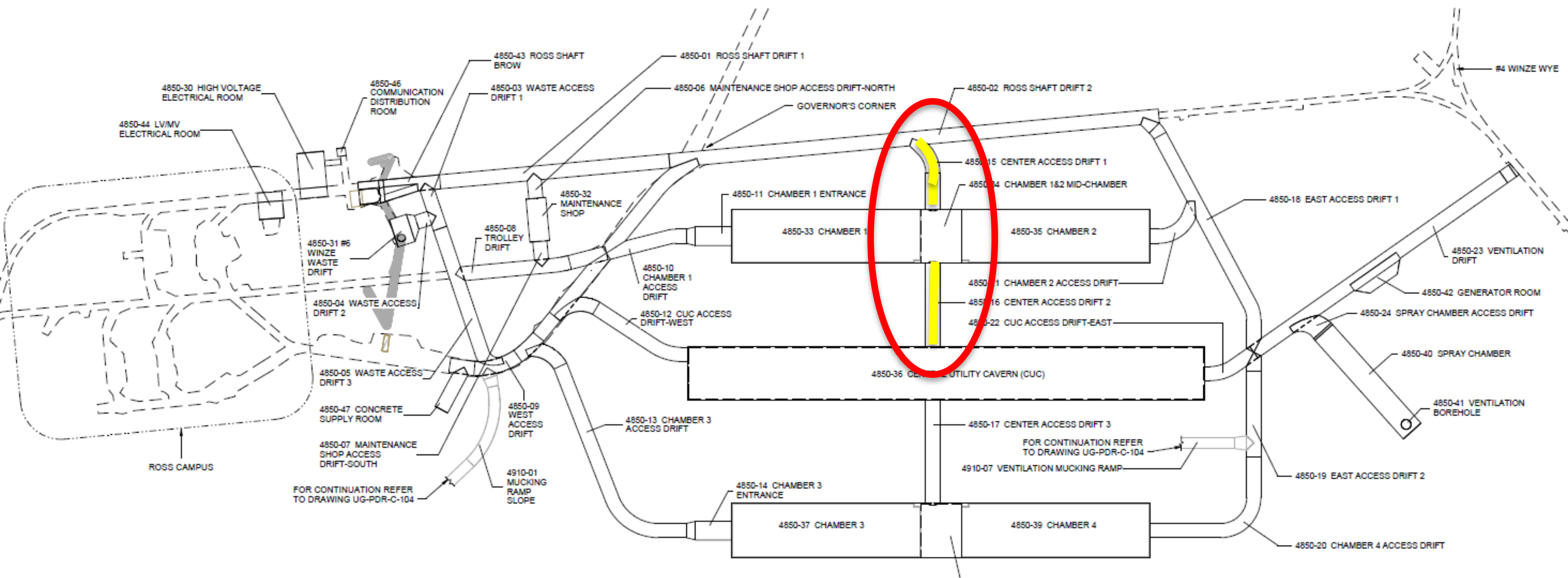


PLAN VIEW

Changes to EXC scope – Cavern Design – Chamber 1 & 2 Bulkhead & Mid-Cavern Access Drift

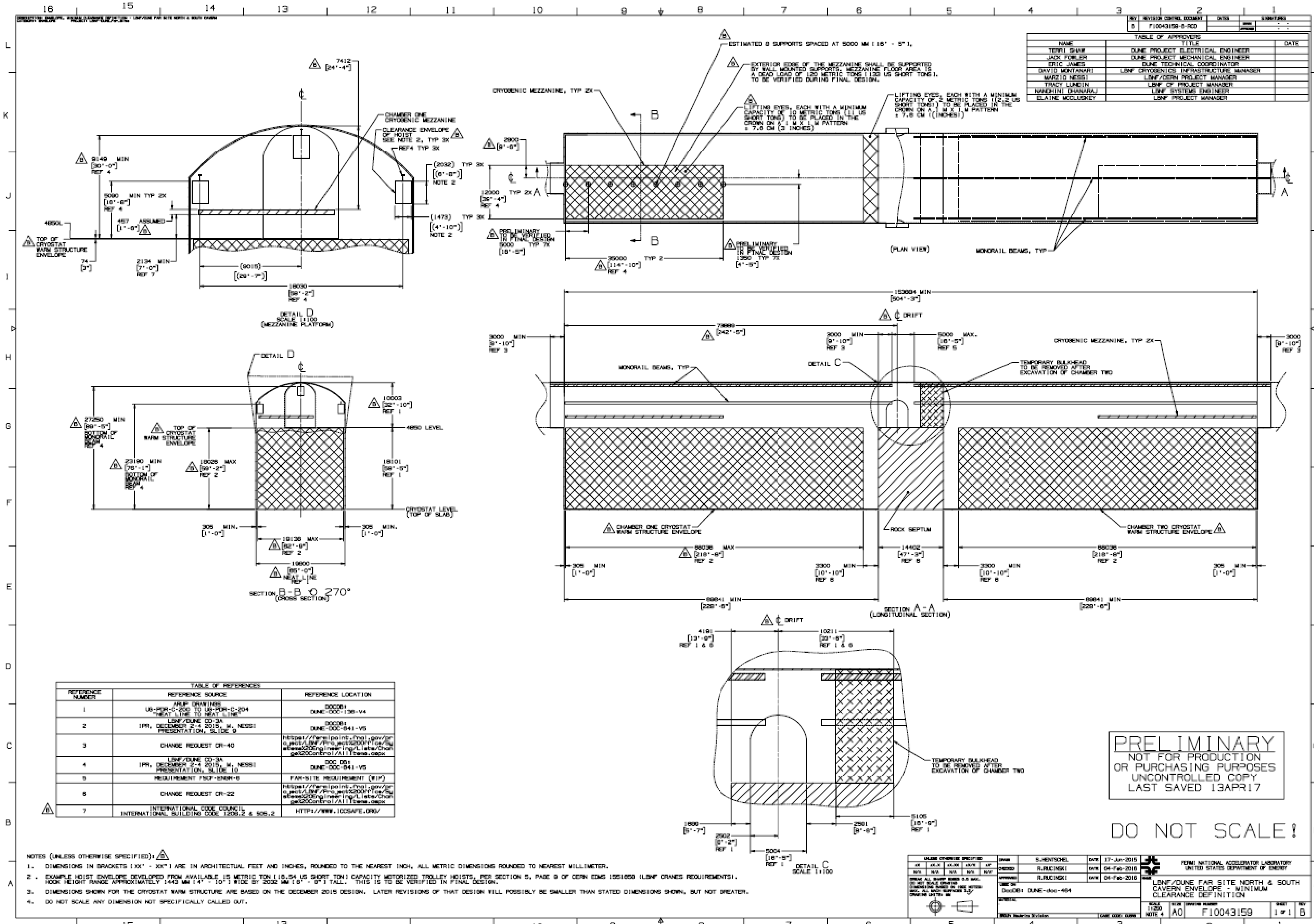
- **The Preliminary Design includes a bulkhead between Chambers 1 and 2 to allow construction of a cryostat structure with concurrent excavation of chamber 2. This bulkhead required the access drift to be designed with an offset from the center alignment with the septum pillar.**

- **The Final Design shall remove the bulkhead design from the scope of work and include a shift of the center line for the mid-cavern access drift to the center of the septum pillar.**



PLAN VIEW

DUNE DocDB 464 - Control Drawing F10043159



REV	REVISION CONTROL DOCUMENT
B	F10043159-B-RCD

TABLE OF APPROVERS		
NAME	TITLE	DATE
TERRI SHAW	DUNE PROJECT ELECTRICAL ENGINEER	
JACK FOWLER	DUNE PROJECT MECHANICAL ENGINEER	
ERIC JAMES	DUNE TECHNICAL COORDINATOR	
DAVID MONTANARI	LBNF CRYOGENICS INFRASTRUCTURE MANAGER	
MARZIO NESSI	LBNF/CERN PROJECT MANAGER	
TRACY LUNDIN	LBNF CF PROJECT MANAGER	
NANDHINI DHANARAJ	LBNF SYSTEMS ENGINEER	
ELAINE MCCLUSKEY	LBNF PROJECT MANAGER	

TABLE OF REFERENCES		
REFERENCE NUMBER	REFERENCE SOURCE	REFERENCE LOCATION
1	ARUP DRAWINGS US-POR-C-200 TO US-POR-C-204 "NEAT LINE TO NEAT LINE"	DOCDB: DUNE-DOC-138-V4
2	LBNF/DUNE CD-3A IPR, DECEMBER 2-4 2015, M. NESSI PRESENTATION, SLIDE 9	DOCDB: DUNE-DOC-841-V5
3	CHANGE REQUEST CR-40	https://fermipoint.fnal.gov/project/LBNF/Project%20Office/Systems%20Engineering/Lists/Change%20Control/AllItems.aspx
4	LBNF/DUNE CD-3A IPR, DECEMBER 2-4 2015, M. NESSI PRESENTATION, SLIDE 10	DOC DB: DUNE-DOC-841-V5
5	REQUIREMENT FSCF-ENGR-6	FAR-SITE REQUIREMENT (WIP)
6	CHANGE REQUEST CR-22	https://fermipoint.fnal.gov/project/LBNF/Project%20Office/Systems%20Engineering/Lists/Change%20Control/AllItems.aspx
7	INTERNATIONAL CODE COUNCIL INTERNATIONAL BUILDING CODE 1208.2 & 505.2	HTTP://WWW.ICCSAFE.ORG/

NOTES (UNLESS OTHERWISE SPECIFIED):

1. DIMENSIONS IN BRACKETS [XX' - XX"] ARE IN ARCHITECTUAL FEET AND INCHES, ROUNDED TO THE NEAREST INCH, ALL METRIC DIMENSIONS ROUNDED TO NEAREST MILLIMETER.
2. EXAMPLE HOIST ENVELOPE DEVELOPED FROM AVAILABLE 15 METRIC TON [16.54 US SHORT TON] CAPACITY MOTORIZED TROLLEY HOISTS, PER SECTION 5, PAGE 9 OF CERN EDMS 1551658 (LBNF CRANES REQUIREMENTS). HOOK HEIGHT RANGE APPROXIMATELY 1443 MM [4' - 10'] WIDE BY 2032 MM [6' - 8"] TALL. THIS IS TO BE VERIFIED IN FINAL DESIGN.
3. DIMENSIONS SHOWN FOR THE CRYOSTAT WARM STRUCTURE ARE BASED ON THE DECEMBER 2015 DESIGN. LATER REVISIONS OF THAT DESIGN WILL POSSIBLY BE SMALLER THAN STATED DIMENSIONS SHOWN, BUT NOT GREATER.
4. DO NOT SCALE ANY DIMENSION NOT SPECIFICALLY CALLED OUT.

DRAWN S.HENTSCHEL 17-Jun-2015
CHECKED R.RUCINSKI 04-Feb-2016
APPROVED R.RUCINSKI 04-Feb-2016

DocDB: DUNE-doc-464

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

LBNF/DUNE FAR SITE NORTH & SOUTH CAVERN ENVELOPE - MINIMUM CLEARANCE DEFINITION

SCALE 1:250 NOTE 4 | SIZE A0 | DRAWING NUMBER F10043159 | SHEET 1 OF 1 | REV B

Changes to EXC scope – Cavern Design – Septum Pillar Width

- **The Final EXC Design shall include a reduction in septum pillar width to 14.4m, increasing each chamber's overall length by 0.3m. The overall Cavern length does not change.**
- **See DUNE DocDB 464 - Control Drawing F10043159**

Changes to EXC scope – Cavern Design – Antechambers

- **The Final EXC Design shall include addition of drift-width (minimum), 3m deep, “antechambers” to both ends of the detector caverns, extend monorail into that space, and move the AHU’s accordingly.**
- **See DUNE DocDB 464 - Control Drawing F10043159**

Changes to EXC scope – Cavern Design – Mezzanines

- **The Final EXC Design shall include addition of connections/supports and wall mounted supports design for 10m x 35m mezzanines on the CUC side of each detector chamber.**
- **The <u>Pending Change</u> of a shift in location of the mezzanine by 3m may potentially add 1 or 2 additional support points. Please see David Montanari's presentation slides # 6 thru #10.**
- **The Final EXC Design shall include a pattern of ten – 100 metric ton capacity lifting eyes above each mezzanine, and two – 100 metric ton capacity lifting eyes above each cryostat bridge, for material lifting at each location.**
- **Each anchorage (lifting eye) to be designed and installed to provide 100 metric ton capacity.**
- **Please see David Montanari's presentation slide # 19 for details on attachments.**
- **See DUNE DocDB 464 - Control Drawing F10043159**

Changes to EXC scope – Cavern Design – Monorails & Hoists

- **The Final EXC Design shall include 15 – metric ton minimum capacity monorails and hoists.**

- **The Final EXC Design shall include two sets of three 15 – metric ton capacity monorail hoists (chamber 1 & 2).**

- **The Final EXC Design shall verify hook height/width clearance envelope and monorail beam locations shown on Control Drawing F10043159.**

- **The Final EXC Design shall verify all other clearance envelope dimensions shown on Control Drawing F10043159.**

- **The <u>Pending Change</u> to accommodate a bridge crane will be in addition to the monorails stated above.**

- **See DUNE DocDB 464 - Control Drawing F10043159**

Backup Slides – Josh Willhite

Chamber 1-2 Bulkhead Removal

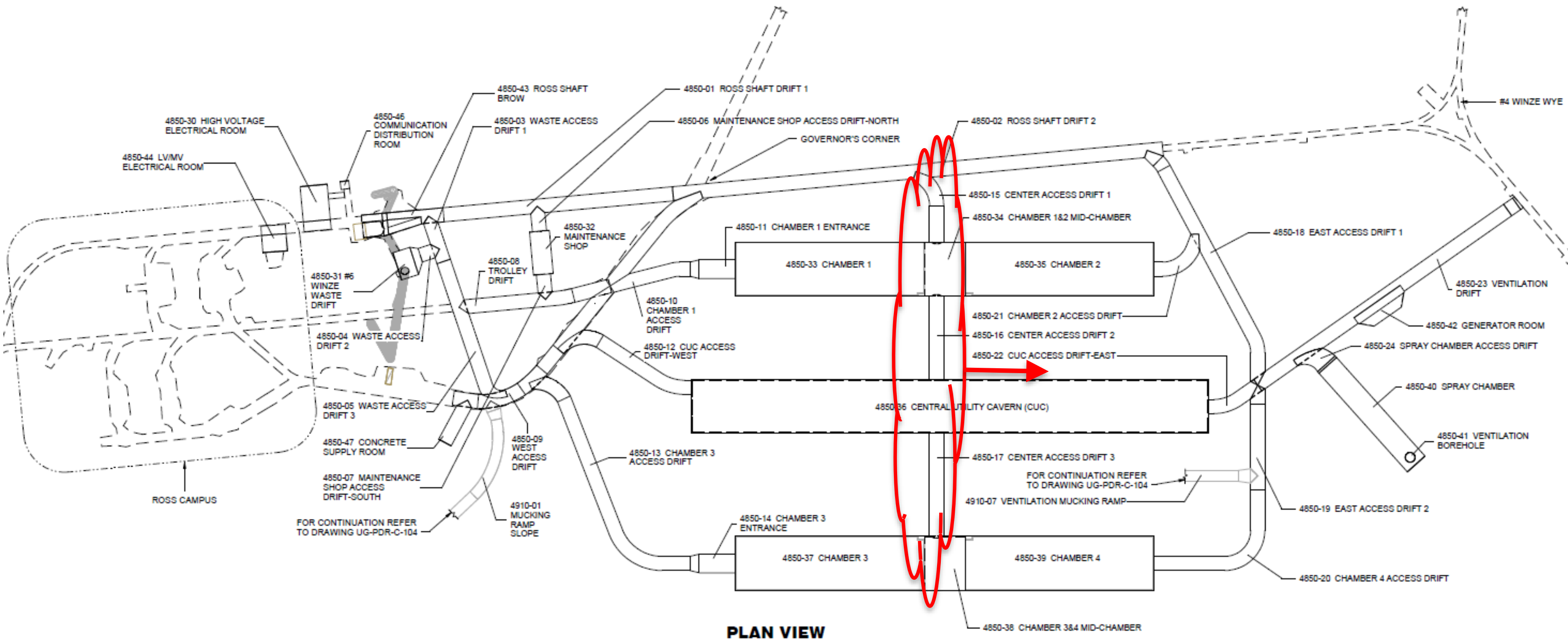
Joshua Willhite, Adam Helander

EFIG

November 11, 2017

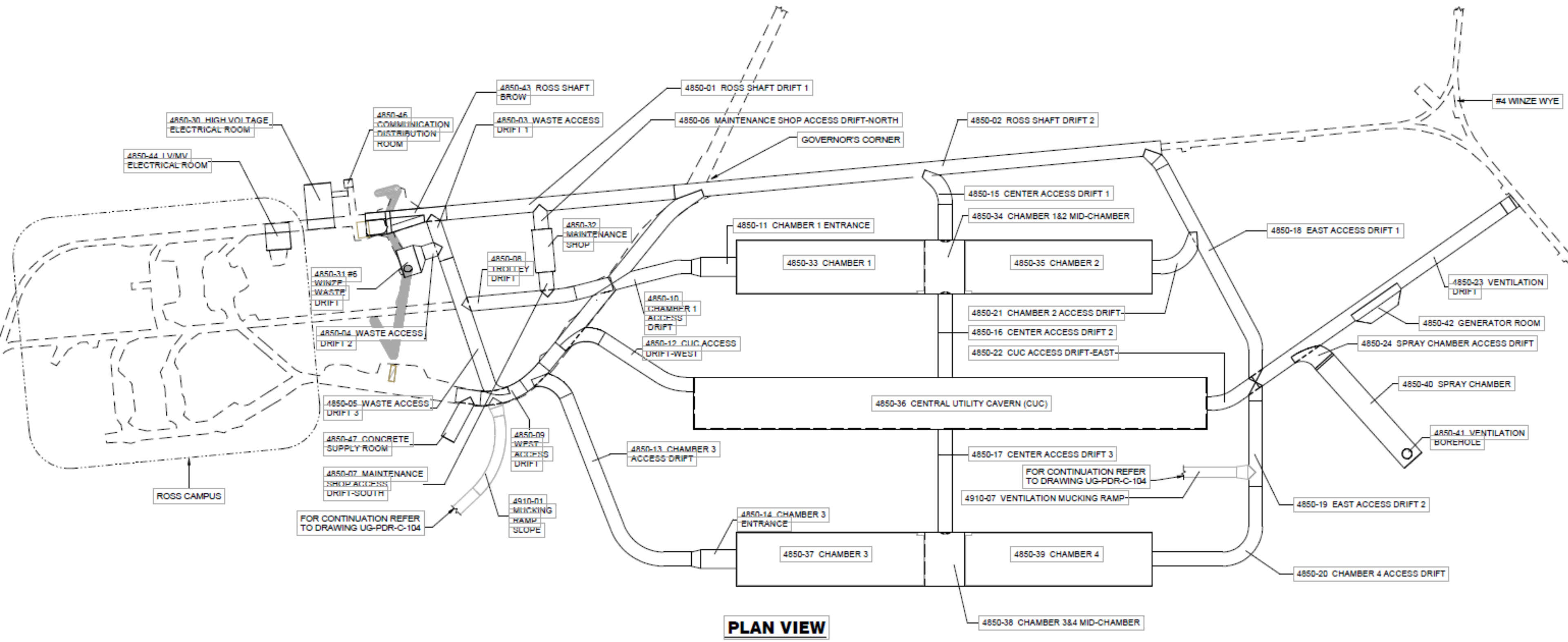
LBNF Preliminary Design Layout

The Preliminary Design planned to incorporate a bulkhead between Chambers 1 and 2 to allow construction of the cryostat warm structure to begin while excavation of chamber 2 completed. This bulkhead required the access drifts to be offset from center. A change is proposed to eliminate this bulkhead and shift the drifts to center.



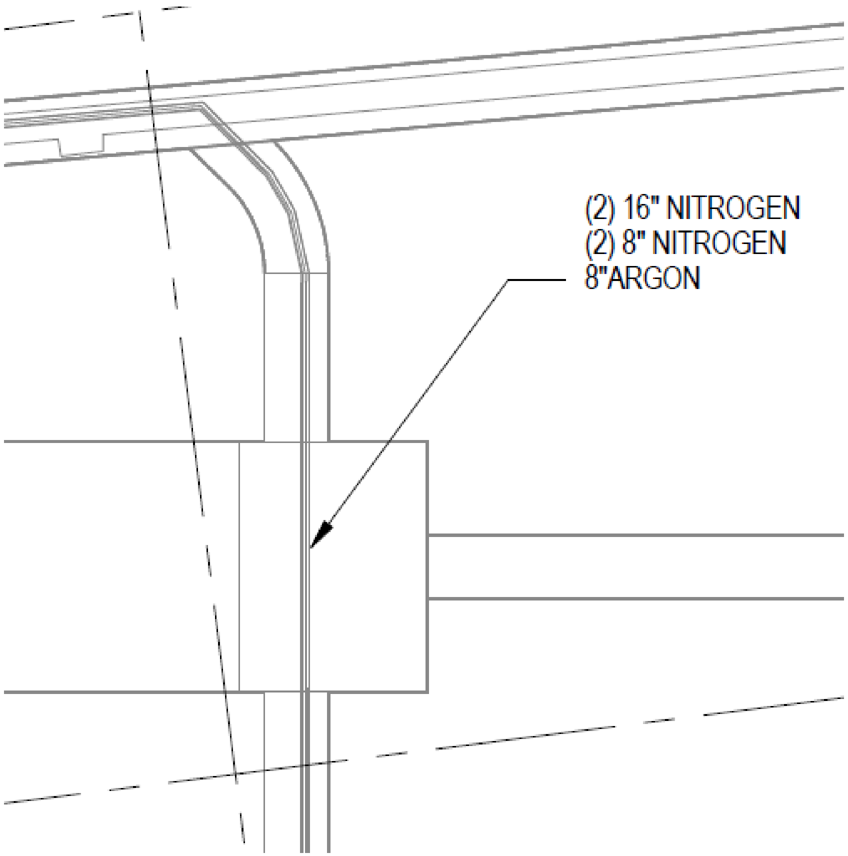
LBNF Proposed Layout

The subtle change of shifting these drifts has a number of advantages as described in the following slides.

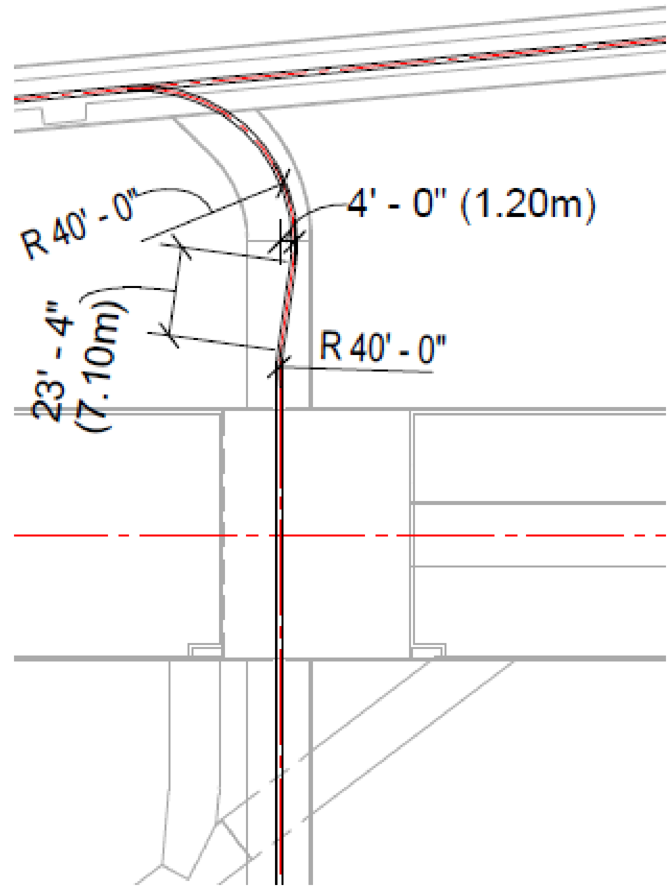


Impacted infrastructure

Plumbing



Rail

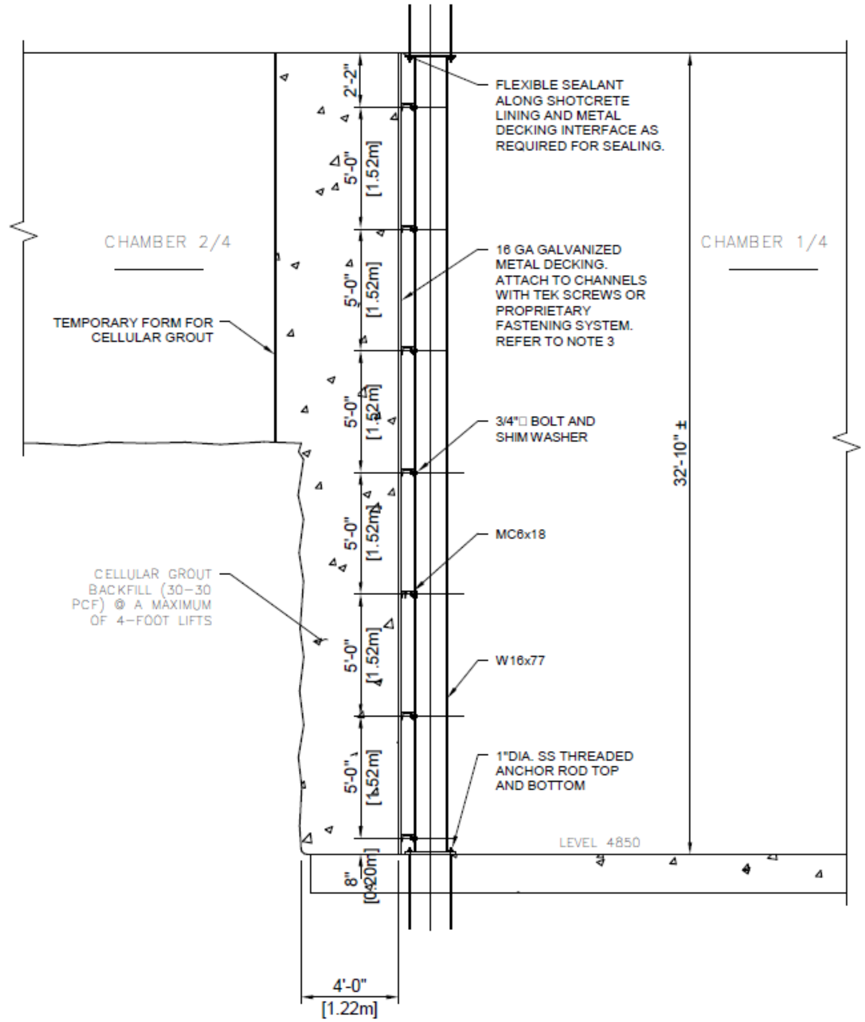


Advantages of eliminating bulkhead and centering the drifts

- Reduced cost (see next slide)
- Symmetrical access for DUNE construction
  - Crane coverage is equal on both side of the rock pillar between the detectors, allowing for all planning to be equivalent.
    - Note that several utilities, including the large argon and nitrogen gas pipes, cross chamber 1 and 2 on their way to the CUC. These are overhead, interfering with crane coverage
  - Rail for transportation is centered, providing equal smooth floor on either side
- Lower project risk.
  - A barrier is technically feasible, but a failure would result in significant delays at the very least.
  - Removing the bulkhead has additional risks for contamination of the relatively clean first chamber and any assembled equipment
- More flexibility in Excavation schedule (more on upcoming slide)

Cost Impacts

- This is a substantial bulkhead, required to withstand blast pressures of 1.5 psi (10.3 kPa) and impact from flying rock.
- Arup estimated the cost to install a bulkhead at $304,819 direct cost. Adding taxes, indirect costs, and escalation results in a total estimated cost of $478,092.
- Eliminating the bulkhead may reduce labor costs through shared resources, but this has not been estimated

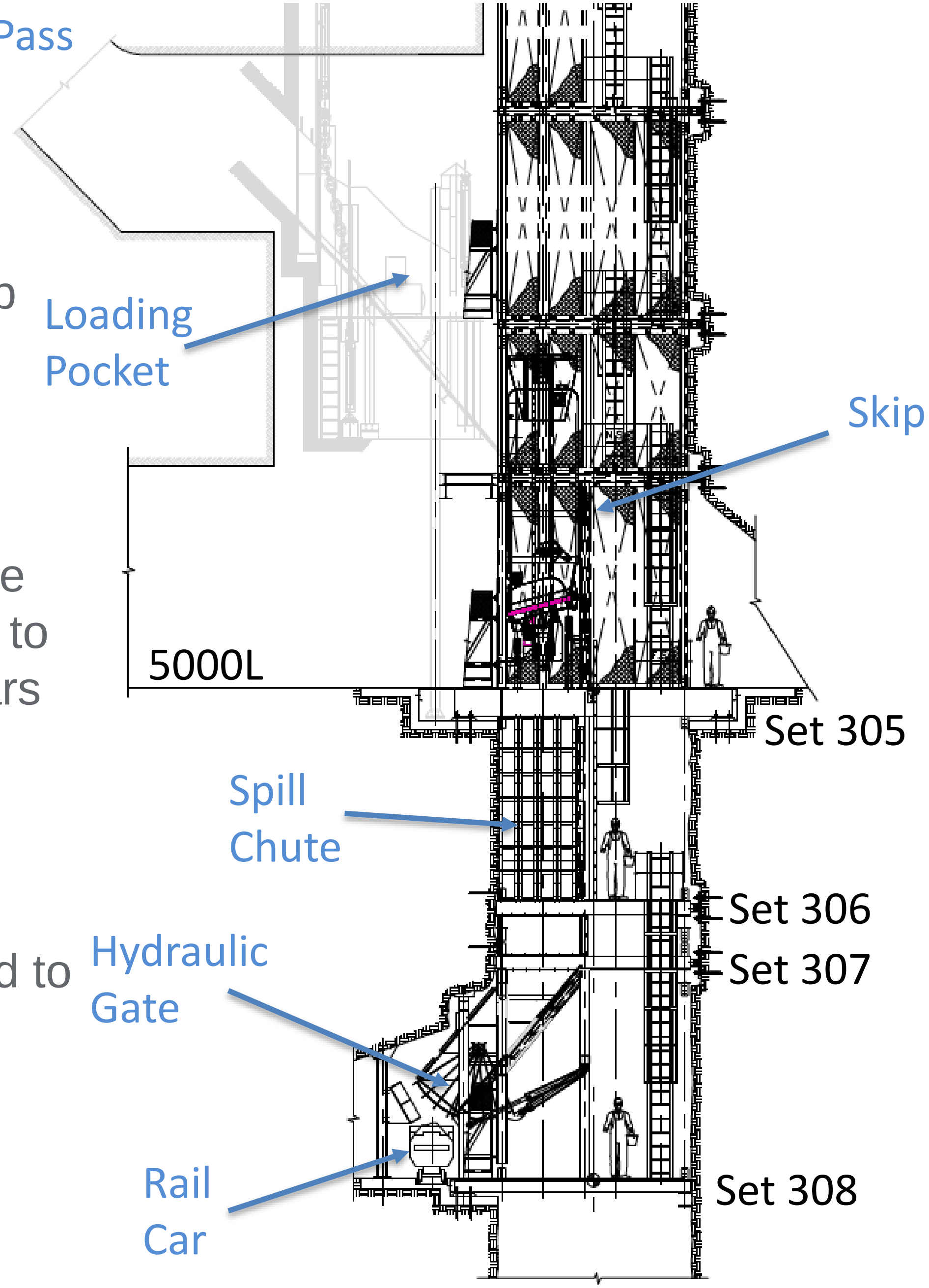


Schedule Impacts

- The general schedule philosophy used during preliminary design was to prioritize Chamber 1 and the Central Utility Cavern (CUC) using two crews, with Chamber 2 starting after the first of these completes (using the same crew as whichever completes first).
- The CUC completed three months ahead of Chamber 1, so that crew started on Chamber 2. Since excavation of chamber 2 only takes ~ 6 months, the net result is three months between completion of Chambers 1 and 2.
- There was also a 3 month lag between completion of Chamber 1 and beneficial occupancy for the cryostat to allow time for infrastructure installation (lights, power distribution, HVAC, fire sprinklers, etc.), so **Chamber 2 excavation is already complete before the cryostat begins based on the preliminary schedule**.

Rock Spill Collection System Change #2

- The preliminary design included a ramp from the bottom of the detector to the bottom of the shaft to collect rock that spills while loading skips.
- We realized that we needed a system much earlier than this provided, so have designed a system internal to the shaft to store spilled rock and load it into rail cars for disposal. This system allows elimination of the ramp, which is in the budget at ~$3.6M
- Without this system (and LBNF excavation), the SDSTA would not need to rehabilitate below the 5000L (Set 305)
- GL Tiley has estimated this work as described on the following slide.



Rock Spill Collection System Costs

Since all work below the 5000L (Set 305-308) is only required for establishing the spill collection system, all of this work is proposed in a separate change request. This includes:

- SDSTA will install sets 305-308 and rehabilitate the sump level. The SDSTA is expected to subcontract a small portion of this work associated with complex concrete work. Costs included in this change include material, labor, and subcontract.
- The CM/GC will install the chutes within these sets and all mechanical, electrical, and plumbing to make the system operate.

Backup Slides Josh Willhite

Pre-Excavation Scope Review

Joshua Willhite

Base Services for Pre-Excavation Construction Kick-Off Meeting

August 29, 2017

Changes from what you've seen

The design has matured since you last received it. There have been numerous refinements, below is a list of significant changes.

- Surface Rock Handling
  - Using a single conveyor through a new adit rather than a transfer station
  - Conveyor system is being procured directly by FRA, but installation is still by KAJV
- "SURF Reliability projects"
  - 4850L Ventilation path has been presented as being performed by SDSTA. This is now planned to be part of KAJV scope.
  - Shaft piping and other shaft utilities were also planned to be performed by SDSTA, but are now planned as KAJV scope
- Rock Spill Collection System
  - Rather than driving a ramp to the base of the shaft, a system has been mostly designed to captured any rock spilled within the shaft and allow it to be handled from below the skip loading system.
- 4850L Brow and Nearby Excavation
  - This had been included as part of pre-excavation (1A), but is now envisioned to be part of the main 1B scope. No significant excavation is included in 1A.
- Surface Substation
  - Had planned a full substation upgrade as part of pre-ex, now only partially included
    - Note that we would like a scope option proposed for performance of all of this work during Pre-ex

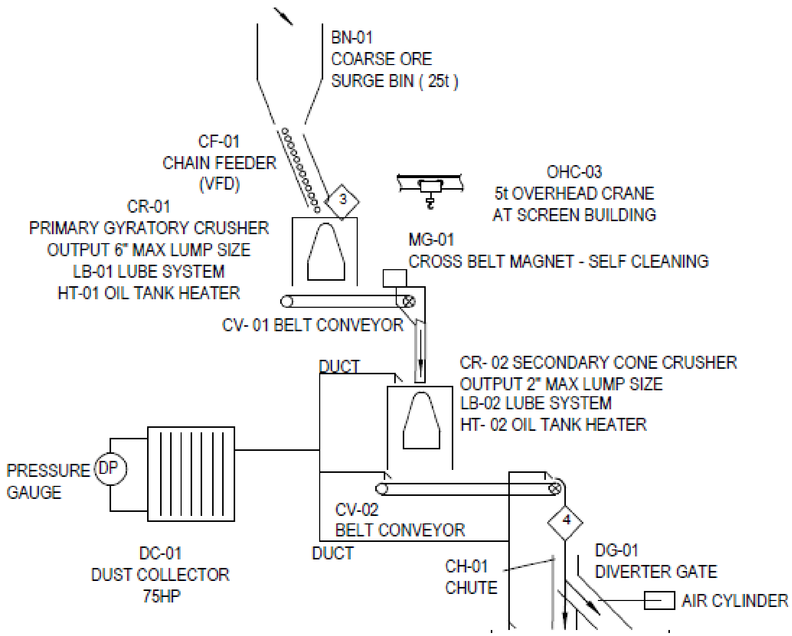
Surface Scope – Crushing System

A two staged approach has been envisioned for the crushing system. Stage 1 – Investigation. This would include disassembly of all major equipment to define the scope for rehabilitation. A proposal for the actual rehabilitation will be defined after this stage.

Stage 2 – Rehabilitation, screen removal, and installation of a new diverter gate

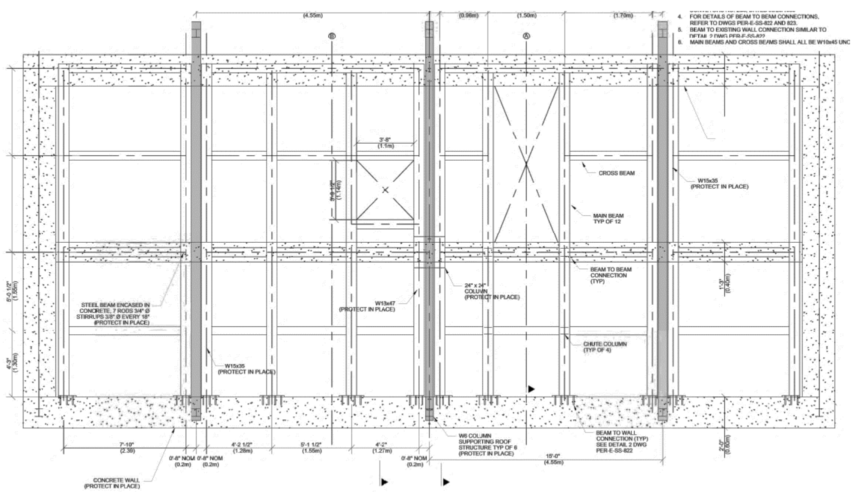
We have allowed 6 months lead time between the end of stage 1 and the start of stage 2 based on information from Metso.

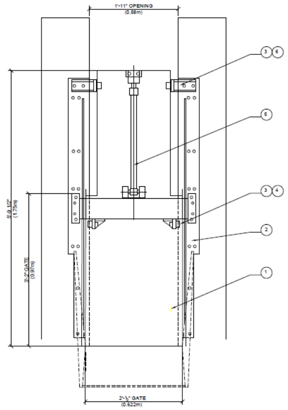
The information contained in drawings is primarily for guidance, with more detail described in the specifications (Section 011113)



Surface Scope – Rock Storage Bin

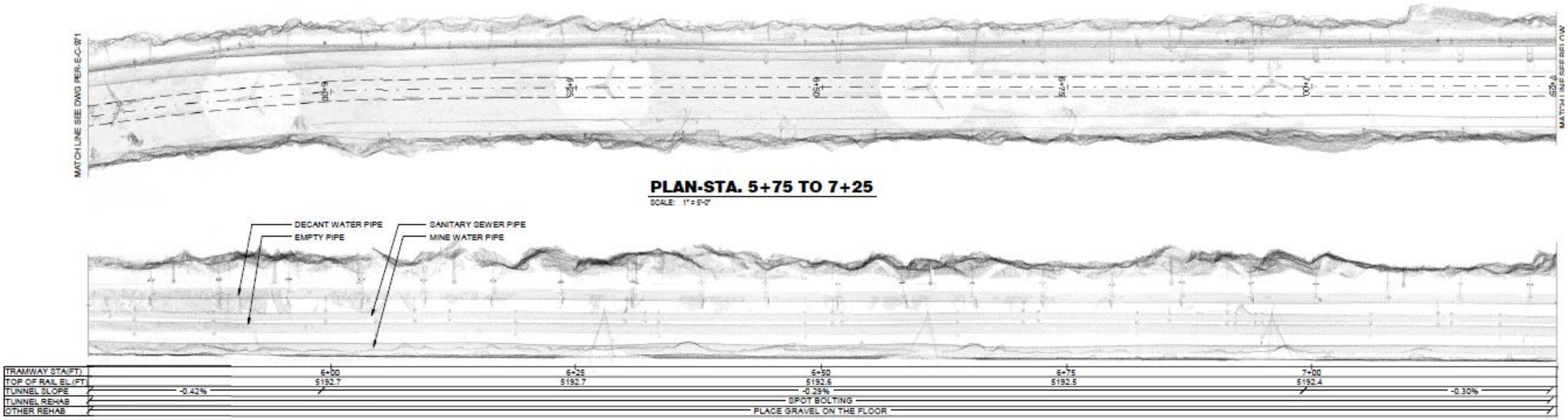
- The bin that the crushing system discharges into requires some work at top and bottom.
  - At the top, the roof must be replaced for structural integrity.
  - At the bottom, the bin must be cleaned enough to allow flow. The discharge gates must also be repaired.



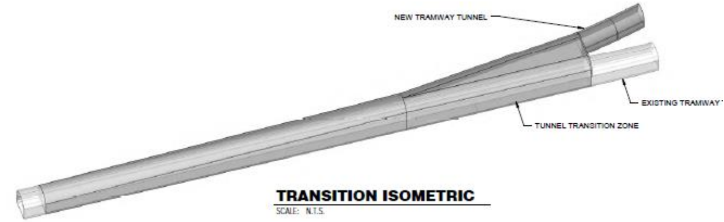


Surface Scope - Tramway Rehabilitation

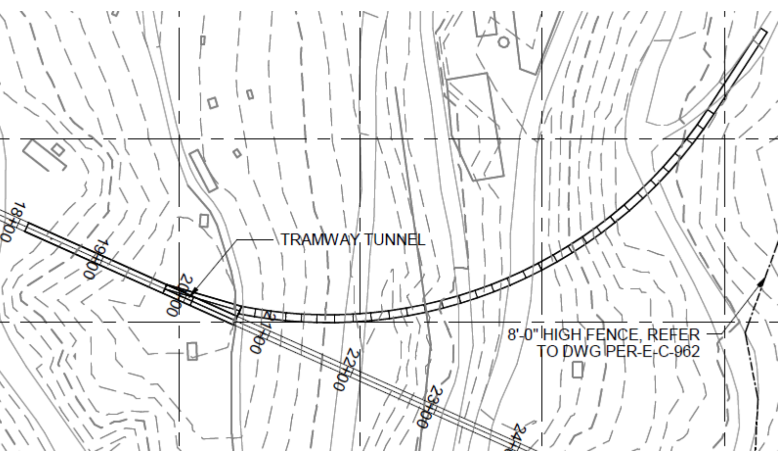
- In preparation for installation of the conveyor system, the entire existing underground “Tramway” route is to be rehabilitated. This scope consists of removal of degraded timber, installation of modern ground support systems, portal replacement (including some snow shed work), and installation of ballast.
- A Geotechnical Data Report for this area has been provided.
- The scope is described in detail using laser scans in the drawing package.

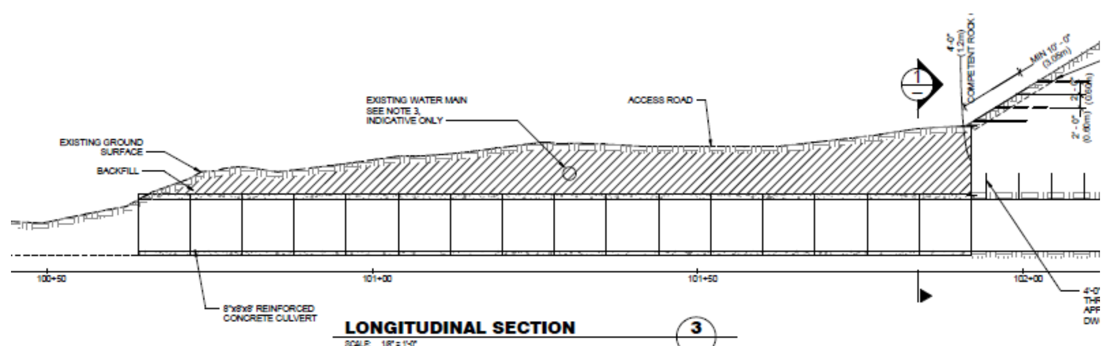


Surface Scope – Ellison Portal



- A new portal is required to allow the use of a single conveyor from the rock bin to the final repository at the open cut. This includes excavation of ~ 700 feet of new tunnel, as well as installation of a cut and cover tunnel for ~130 feet and increasing the back height of ~170 feet of the existing tramway.
- This work must be controlled to minimize disruption to the community, including only working during the "day" (~7AM to 5PM), and controlling blast vibrations at neighboring homes.



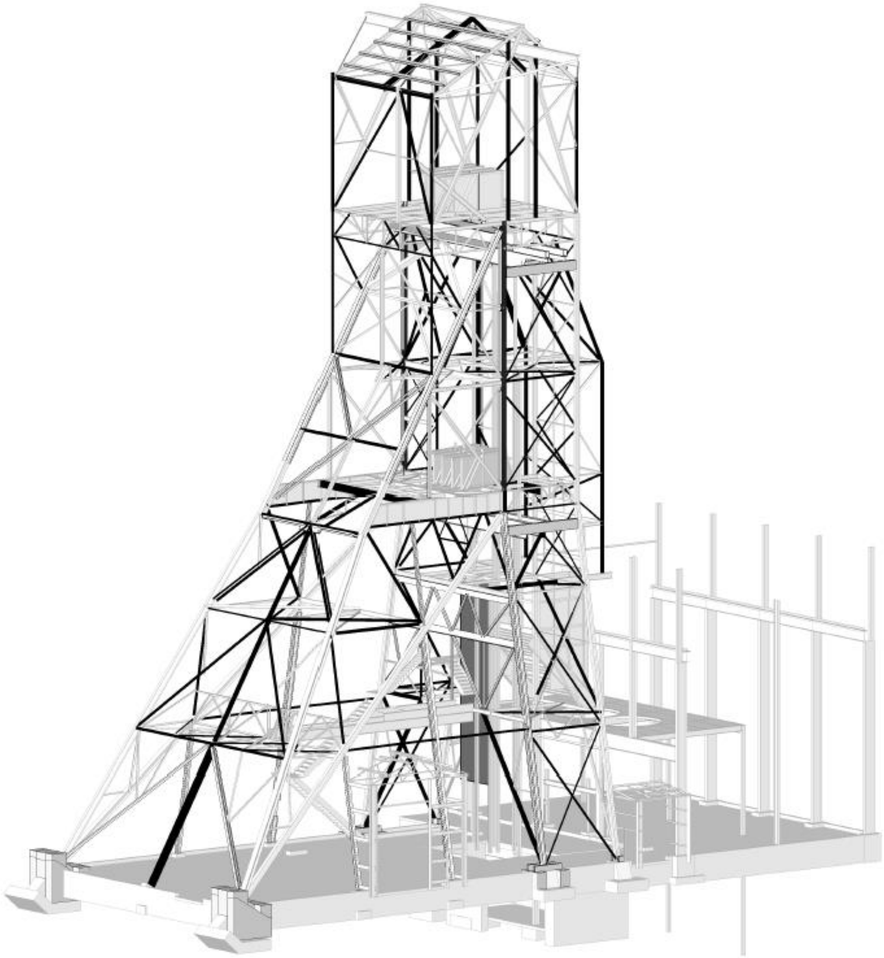


Surface Scope - Pipe Conveyor System

- North Alabama Fabricating Company (NAFCO) is in the process of detailed design for the conveying system, which includes vibrating feeders, a feeder conveyor, and a pipe conveyor to get material from the rock bin to the open cut. Their scope also includes supplying dust collection + suppression equipment. NAFCO will supply all materials above ground or concrete level, and will provide designs for foundations.
- KAJV is responsible for installing the system, including supplying all MEP up to the point of use, as well as lighting.
- The NAFCO contract does not include installation or commissioning support. It is anticipated that KAJV will secure this support.

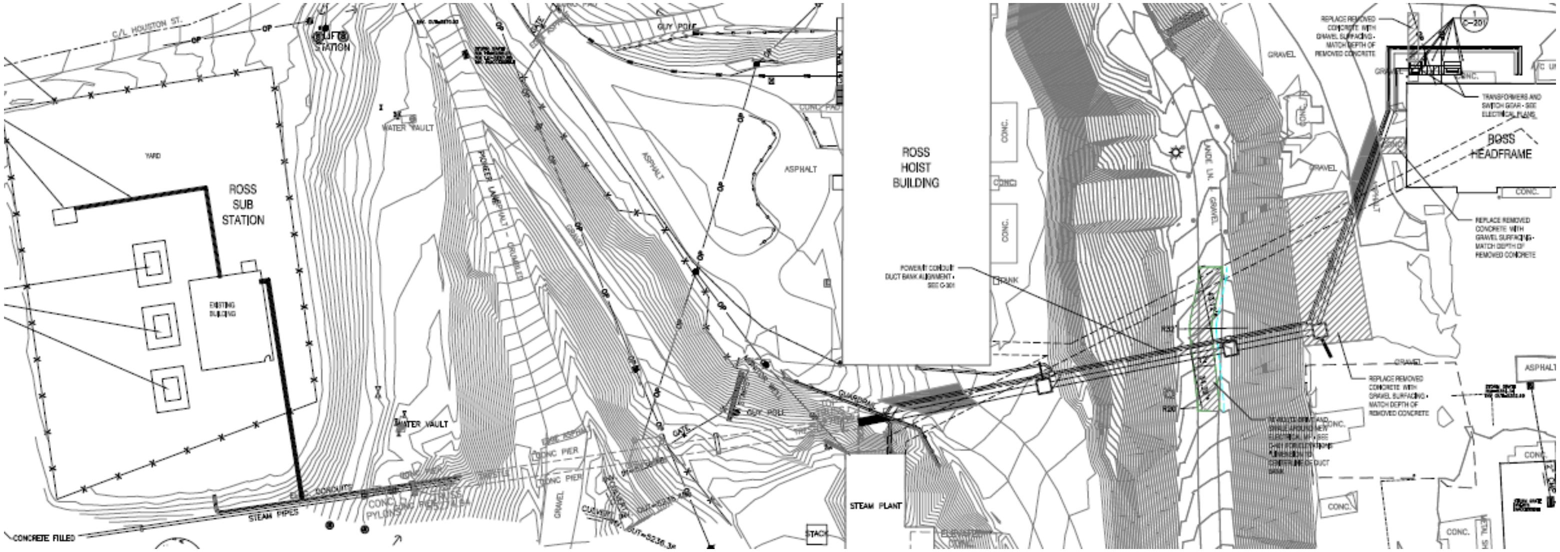
Surface Scope - Ross Headframe

- The Ross Headframe requires relatively minor modification to allow delivery of cryostat components underground. This modification requires that the building meet current code, requiring significant reinforcement. This work is planned early to avoid interference with other shaft activities.
- This task influences a number of activities both within and outside KAJV, so requires close coordination. Examples include
  - Any use of the shaft (such as underground rock handling)
  - Hoist drive, brake, and clutch replacement plus motor rebuild
- A design is provided for foundation repairs, but some additional geotechnical investigation is planned that will likely reduce that scope.



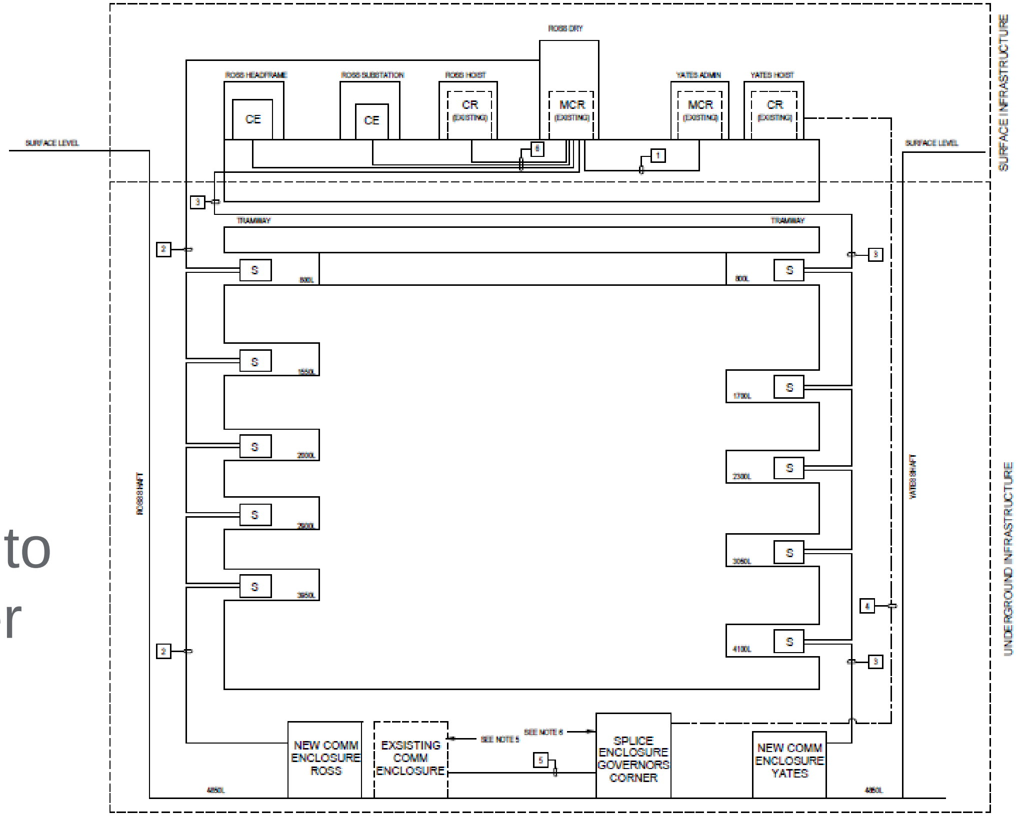
Surface Scope - Electrical Power

- Pre-Excavation (1A) includes supplying power to the crushing system and the underground.
- Red-lined drawings are provided denoting a change in approach that provides a new switchgear line-up in the substation and new conduit from the substation to the headframe.
  - As a scope option, we would ask KAJV to propose performing all of this work during pre-ex.
- Additional power supply for the conveying system is derived from the utility provider near the Open Cut.



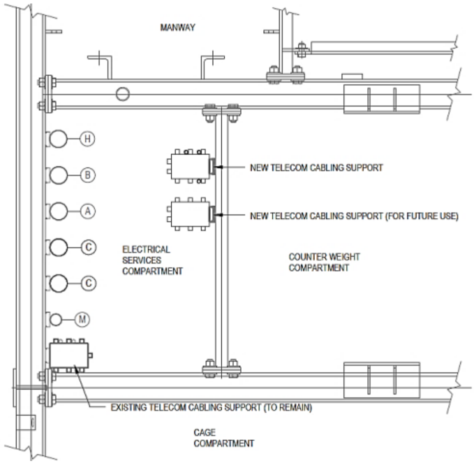
Fiber Optic Distribution

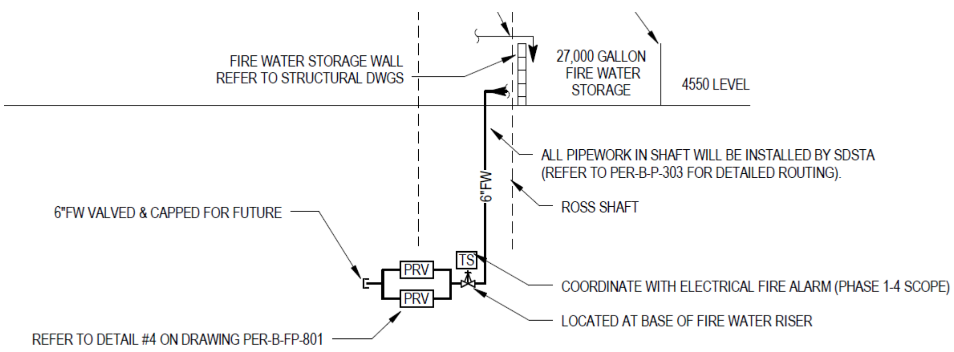
- Fiber Optic distribution spans the surface, shafts, and underground. A redundant loop of fiber is included through both shafts and connected across the Tramway level. While not needed during pre-excavation, much of the scope is included in Pre-ex to avoid interference with other activities later.



Shaft Scope - Utilities

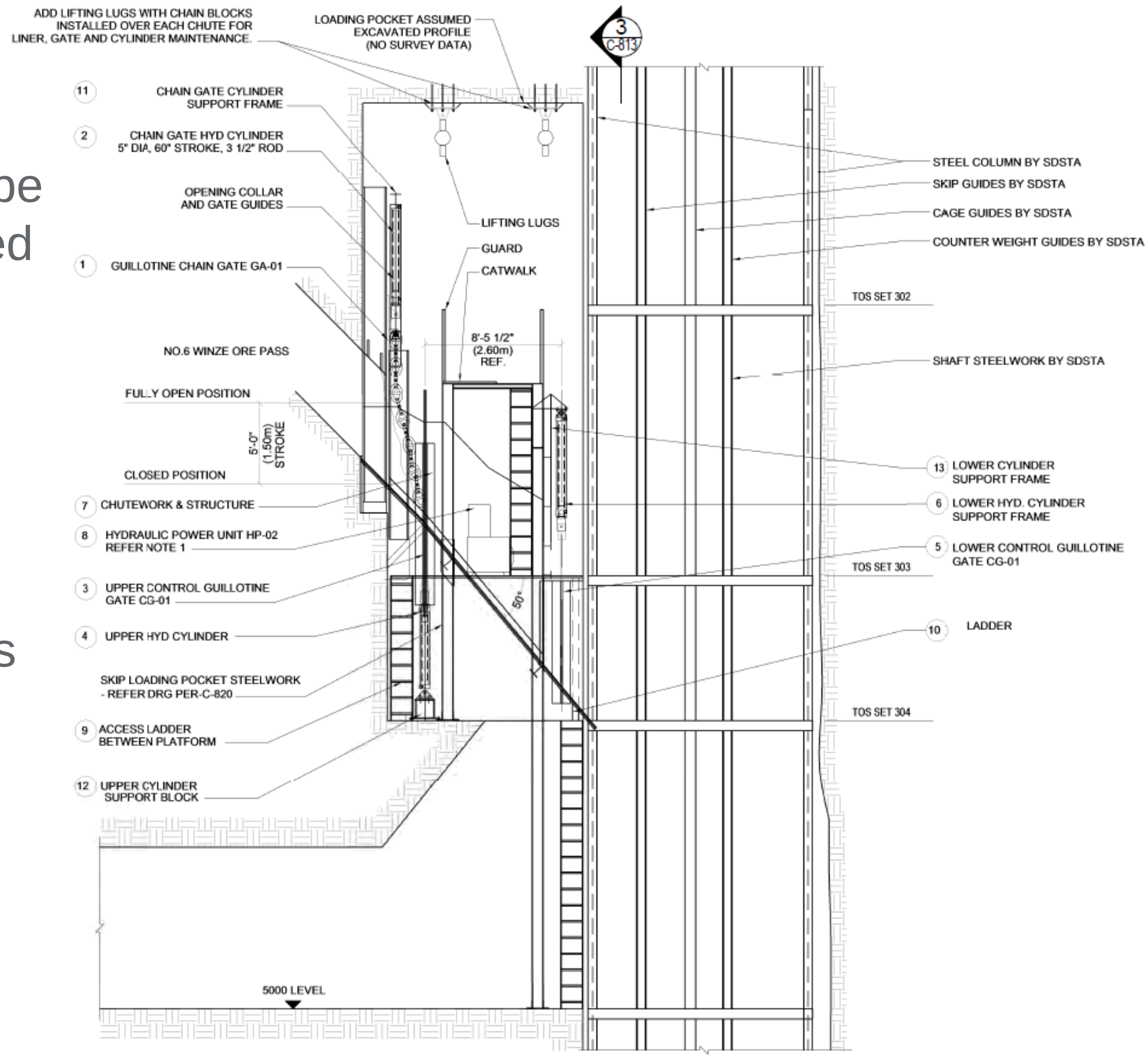
- Power and fiber
  - All of the power and fiber planned for the project is included in Pre-ex to avoid interference with skipping later
  - A fire protection water storage sump is to be built on the 4550L and plumbed through the shaft to the 4850L
  - Based on your schedule analysis, you can tell us whether it makes sense to install any of the additional pipe described in the design before excavation.





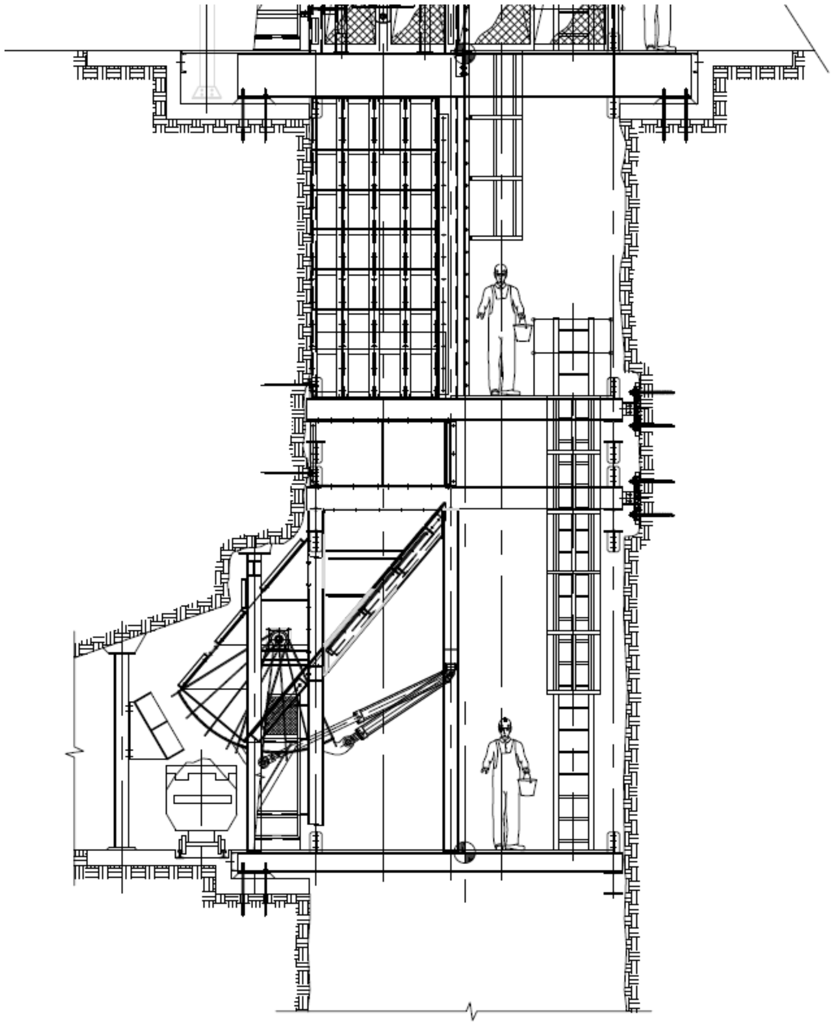
Shaft Scope - Skip Loading System

- The existing skip loading system is to be removed and replaced with essentially a slightly modernized duplicate system.
- The SDSTA is installing the shaft steel and will provide ground support in this area, KAJV will do everything else.



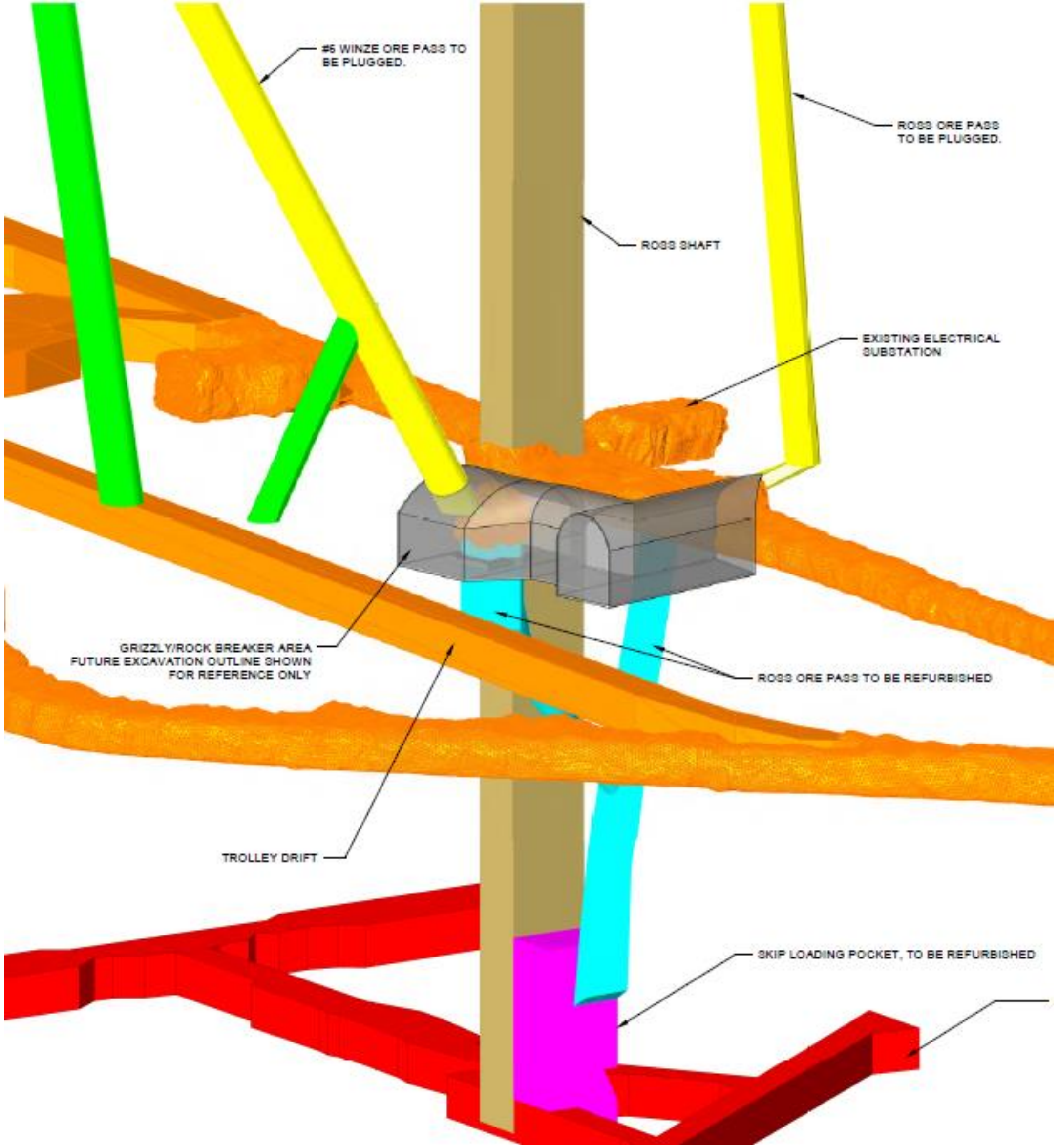
Shaft Scope – Spill Collection System

- The final design is almost complete for a system to catch any material spilled while loading skips in the shaft. This system then allows for loading the material into rail cars for transport back to the 4850L.
- The SDSTA will install the primary shaft steel to provide access to the sump level, while KAJV is to install the chutes, gates, and all MEP to make it work.



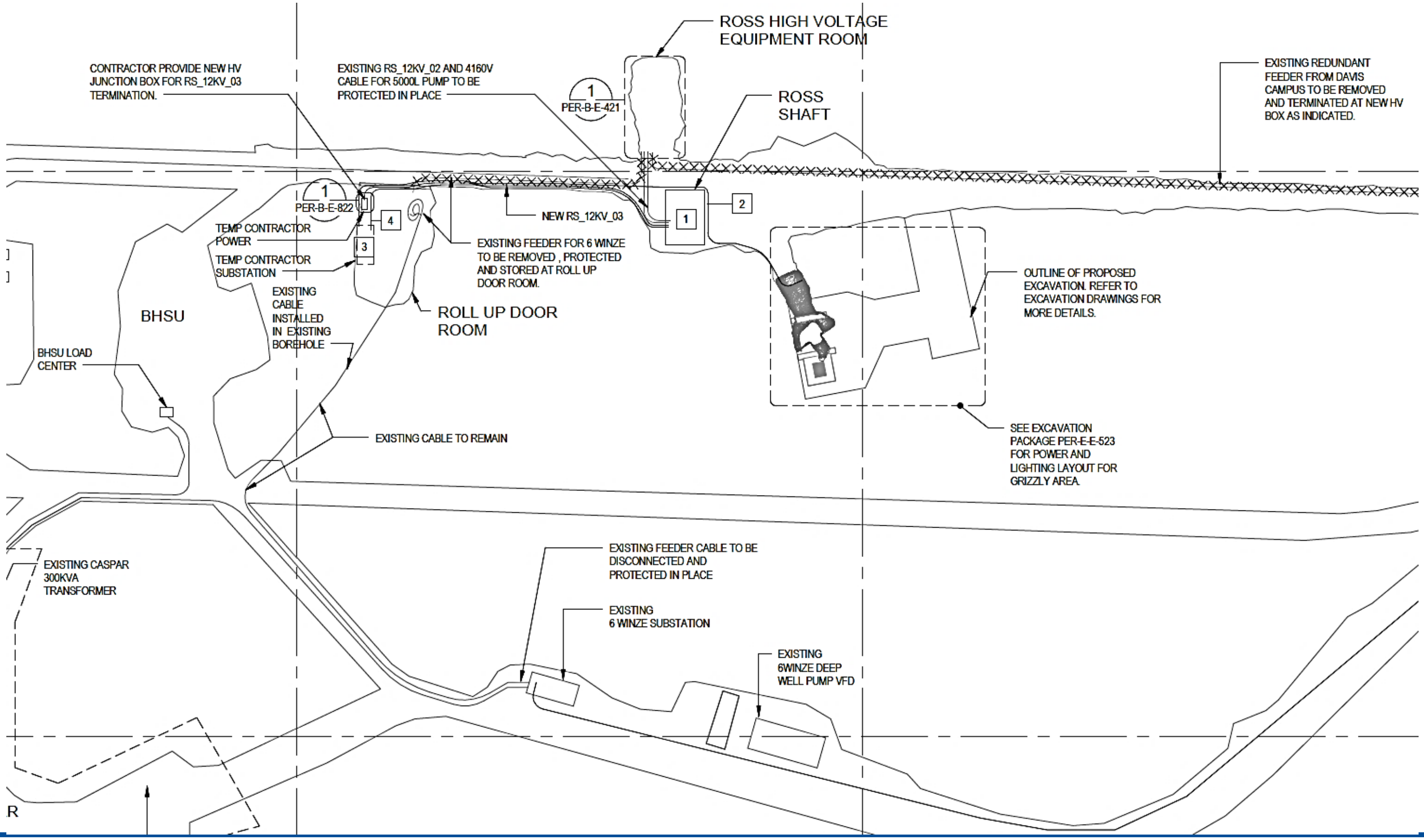
Underground scope – Ore Pass Refurbishment

- Note that this work cannot be done until a new cage is installed in the shaft except for areas accessible from the 4850L.
- A temporary Grizzly is to be installed during 1A
- While details are provided for the permanent grizzly, this design was only done to inform the ore pass refurbishment and is not part of 1A



Underground Scope – Utility Relocation & Temp Power

In preparation for excavation, a number of utilities are to be relocated and/or protected during Pre-Excavation (1A), and temporary construction power is to be established

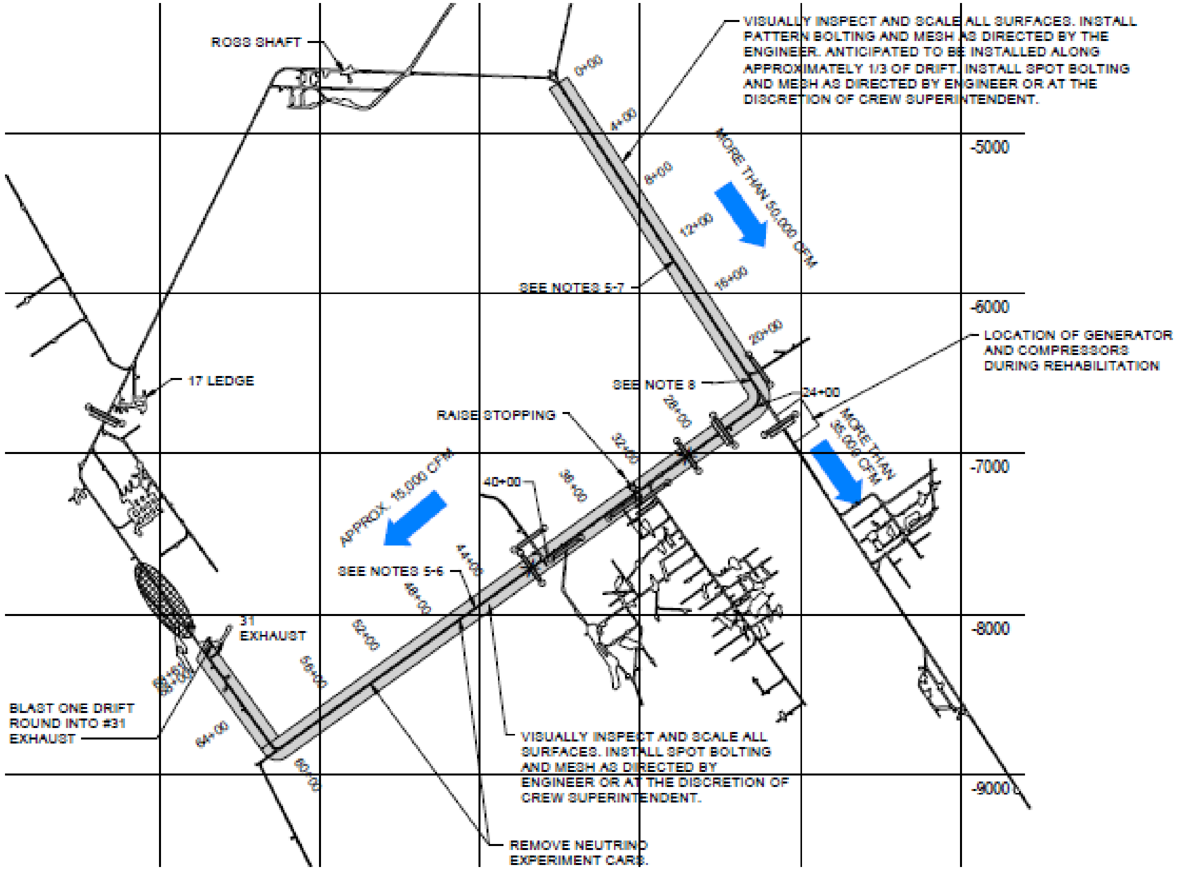


Underground Scope – Construction Water Settling

KAJV is to provide a system for managing the quality of water discharged to the facility dewatering system in preparation for excavation. This has not been designed, as it is viewed as a contractor responsibility.

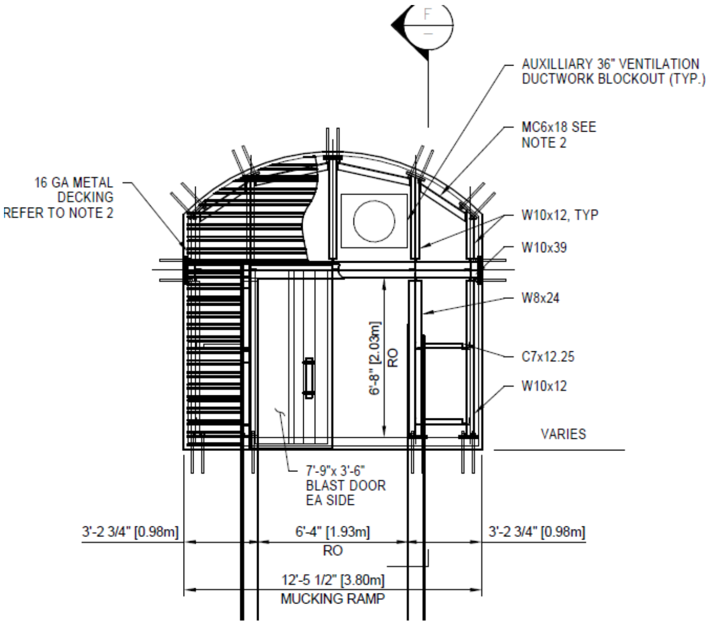
Underground Scope – 4850L Ventilation path

The existing pathways do not provide adequate ventilation for excavation, so a temporary pathway requires refurbishment in Pre-ex to provide ventilation until a borehole can be installed in 1B. This scope is not fully defined due to access limitations.



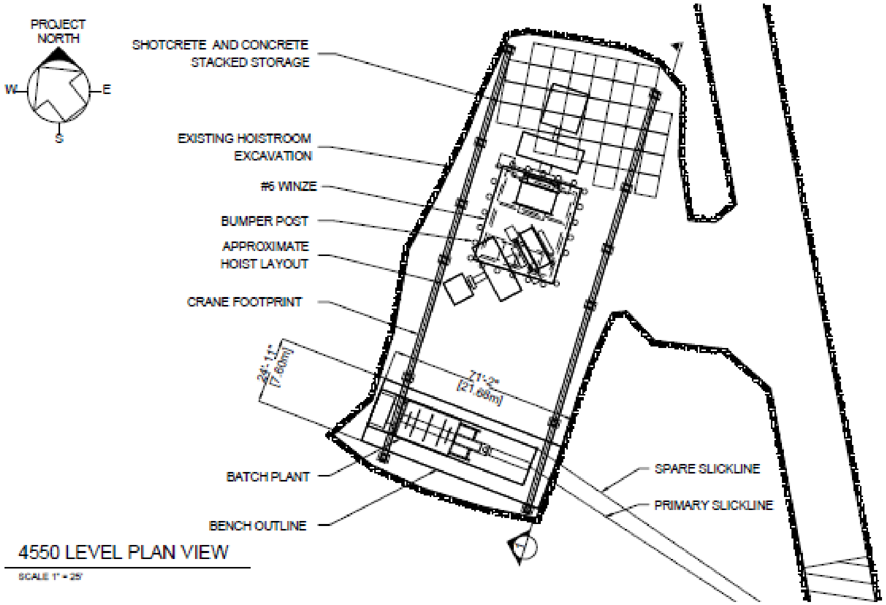
Underground Scope – Ventilation and Blast isolation

Some generic designs have been provided for ventilation walls that are appropriate to manage air blast overpressure. We expect to work with KAJV to refine these to meet specific needs. Adequate controls to protect existing facility infrastructure and users is required prior to excavation, so these are to be installed during the Pre-Excavation (1A) phase.



Underground Scope – Concrete Batch Plant

- A design was developed to a preliminary level to provide a batch plant in the #6 winze hoist room on the 4550L, with boreholes delivering this to a remix bay on the 4850L.
- KAJV is to inform FRA whether to further develop this method.
- This is planned to be installed during the Pre-Excavation (1A) period, but KAJV may elect to postpone this if it's not deemed necessary to prevent interference with the main excavation process later.



Backup Slides – David Montanari

Proximity Cryogenics on Mezzanine
Mezzanine structure

Jack Fowler
David Montanari
LBNC Review
26-28 October 2017

Thanks to

- Mark Adamowski (Fermilab).
- Aurélien Diaz (CERN).
- Kevin Haaf (Fermilab).
- Jan Hrivnak (CERN).
- Jean-Baptiste Mayolini (CERN).
- Dimitar Mladenov (CERN).

Outline

- Mezzanine.
- Views.
- Loads assumptions.
- Loads distribution.
- Loads table.
- Next Steps.
- Summary.

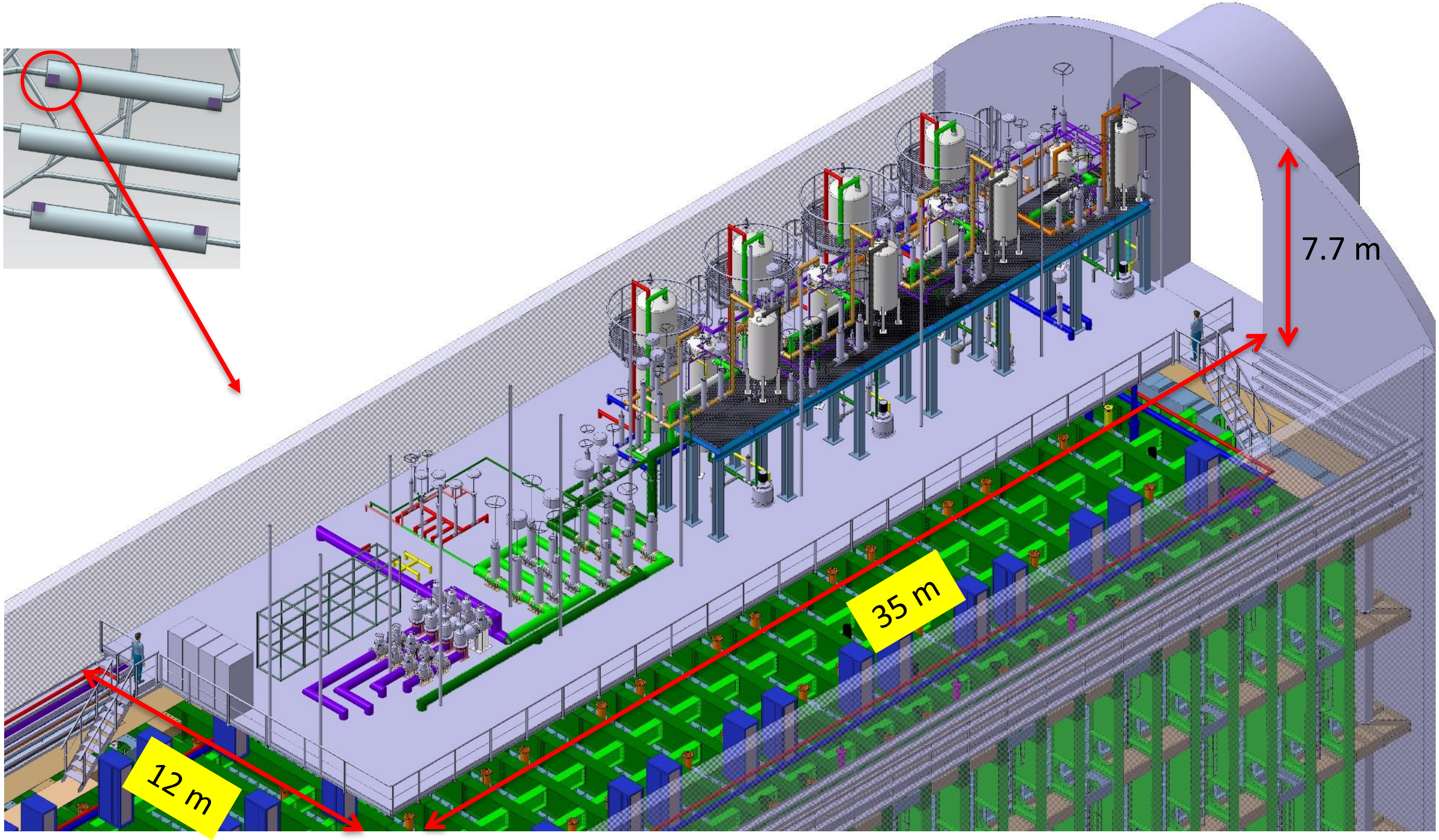
Proximity Cryogenics in Detector's Cavern – Mezzanine 1/2

- Design based on LBNF/DUNE requirements and real size components.
- All items transportable down the Ross Shaft.
- Preliminary installation sequence thought out (to be finalized).
- Lifting eyes on the roof of the cavern for equipment lifting and positioning.
- Connections to the cryostat feedthroughs on the roof.
- Main components:
  - LAr Phase Separators (return from purification).
  - LN2 Phase Separators.
  - Condensers.
  - Small LAr buffer tanks (for condenser pumps) and condenser LAr pumps.
  - Cryostat Pressure Safety Valves (PSVs), Piping and lockout valves.
  - Cryostat pressure control.
  - Frame for warm panel.
  - Valves and interconnecting piping.
  - PLC racks.
  - Working platforms around vessels for installation and maintenance of equipment.

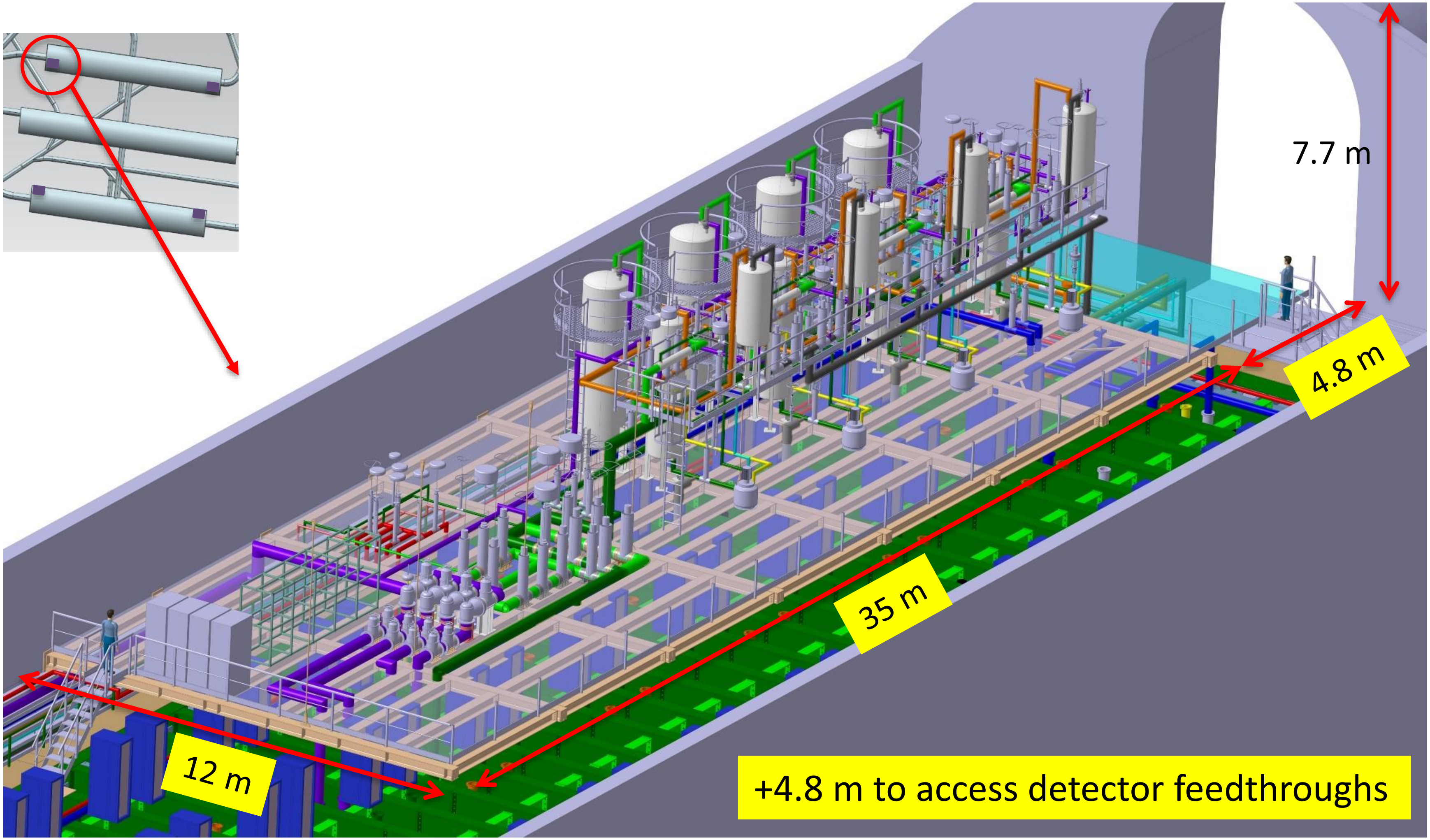
Proximity Cryogenics in Detector's Cavern – Mezzanine 2/2

- Updates from previous meeting:
  - Mezzanine platform shifted 4.8 m towards the center of the cryostat for detector access (vertical space available for feedthroughs insertion).
  - Design being updated to reflect updated cryostat feedthroughs layout.
- Design almost identical for Single Phase and Dual Phase. Dual Phase requires a few modifications because of the operating pressure range.

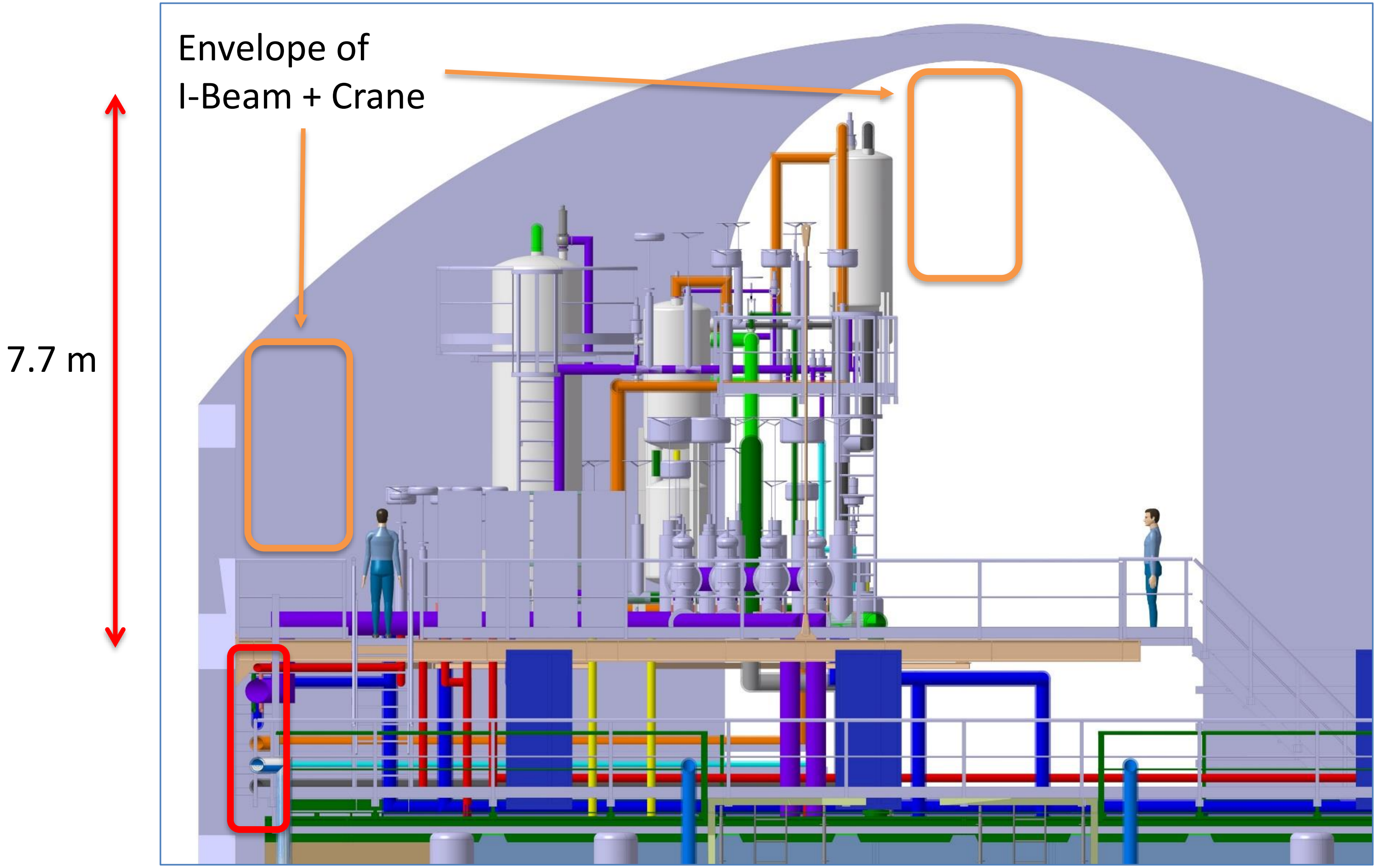
Iso View (Old)



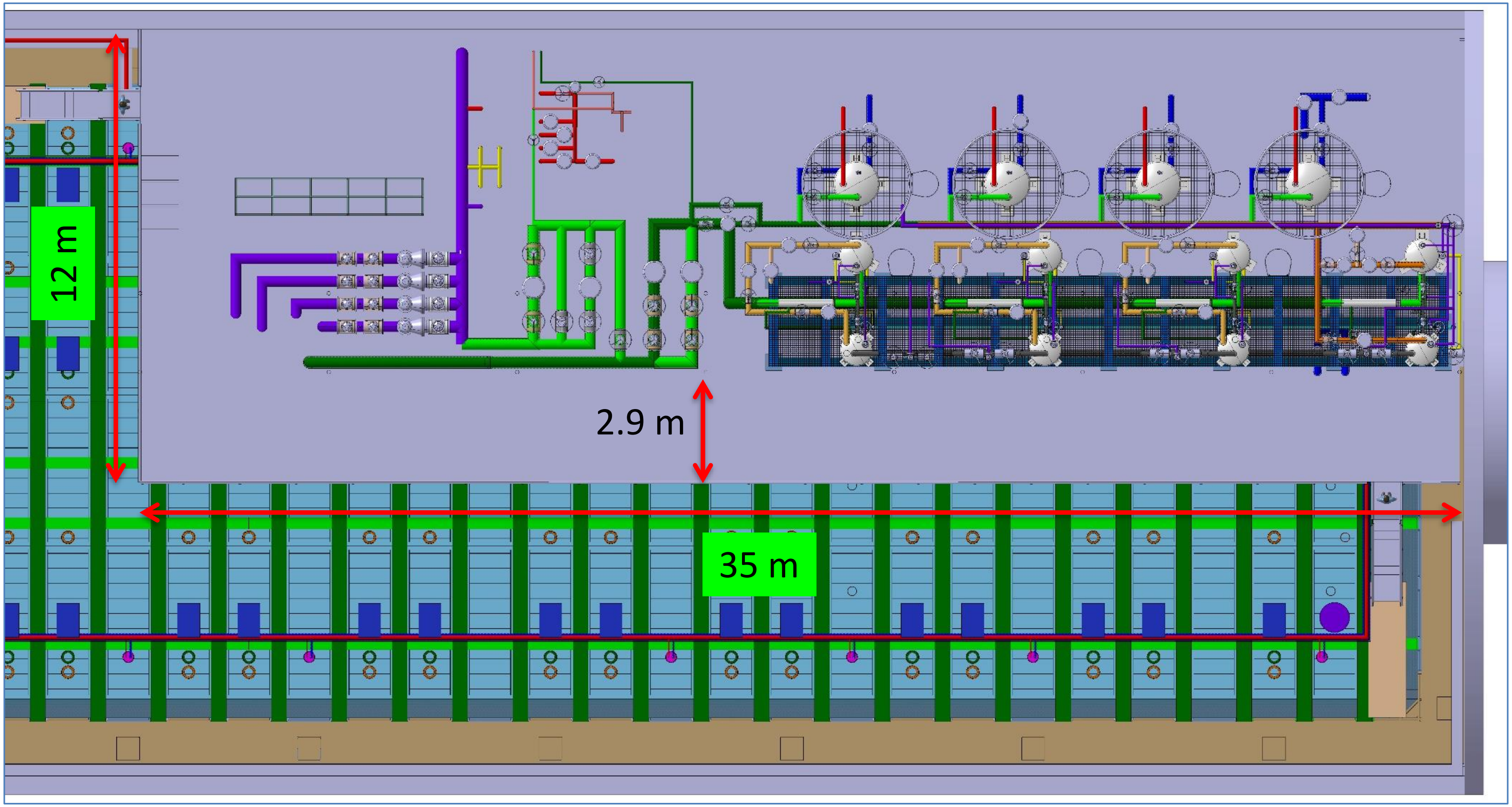
Iso View (Current)



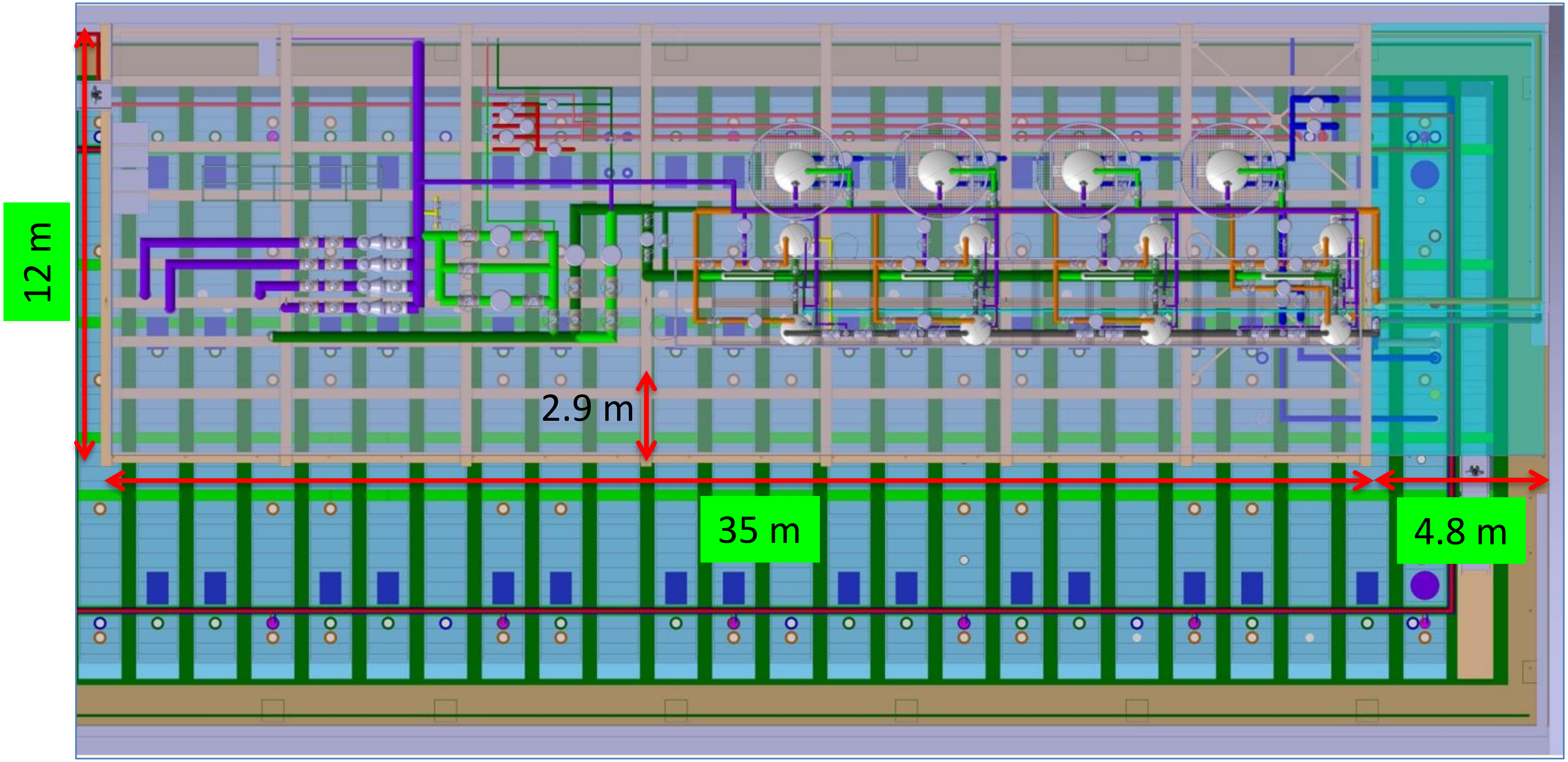
Side View



Top View (Old)



Top View (Current)

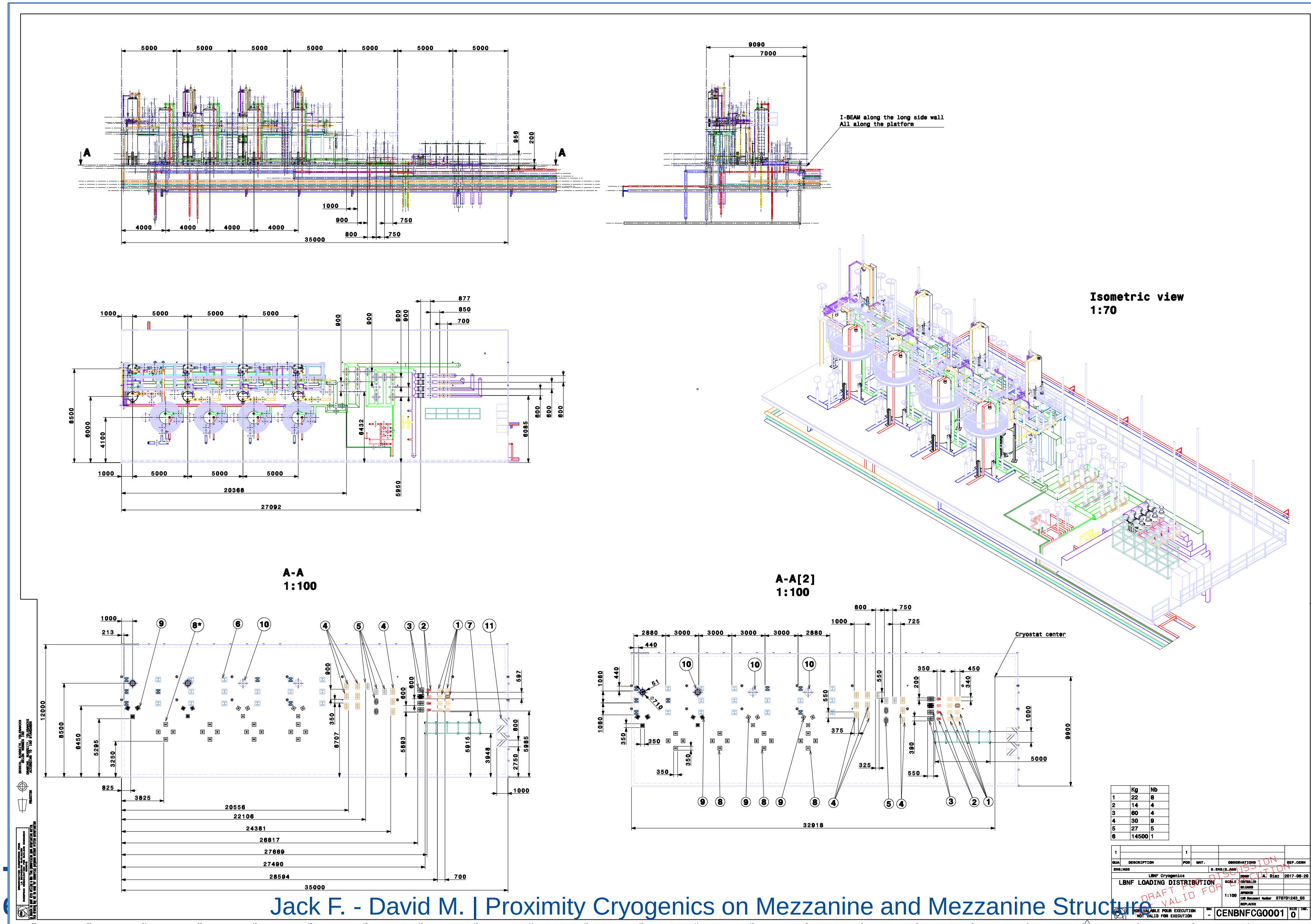


+4.8 m to access detector feedthroughs

Loads Assumptions (for mezzanine structure design)

- All vessels filled with respective cryogenic fluid (LAr, LN2).
- ID of vessels used to calculate amount of fluids.
- All pipes filled with respective cryo fluid (LAr, LN2, cold GAr, cold GN2).
- OD of pipes used to calculate amount of fluids.
- Pipes and vessels sizes from catalog.
- Weight compared with that of standard items (highest value selected).
- All welded connections (no flanges).
- Included estimate for instrumentation (no list yet).
- No purge lines, valves for chimneys (estimated in warm panel).
- Stands and supports for vessels, pipes, valves included. All cryo valves and majority of warm items included (smaller items missing).
- PSVs for cryostat and vessels included. Trapped volume PSVs and PSVs for VJs and pump out ports estimated.
- Main support structure (item 6) is a concept. Included but will need to be properly designed.
- MLI and process pipe holders in VJs estimated.
- There might be minor interferences still being worked out. Location of vessels and main valves is set. Smaller valves and pipes may need to move a bit.
- Included 20% uncertainty on length of pipes and 10% uncertainty on number of valves.

Mezzanine Requirements – Load Distribution



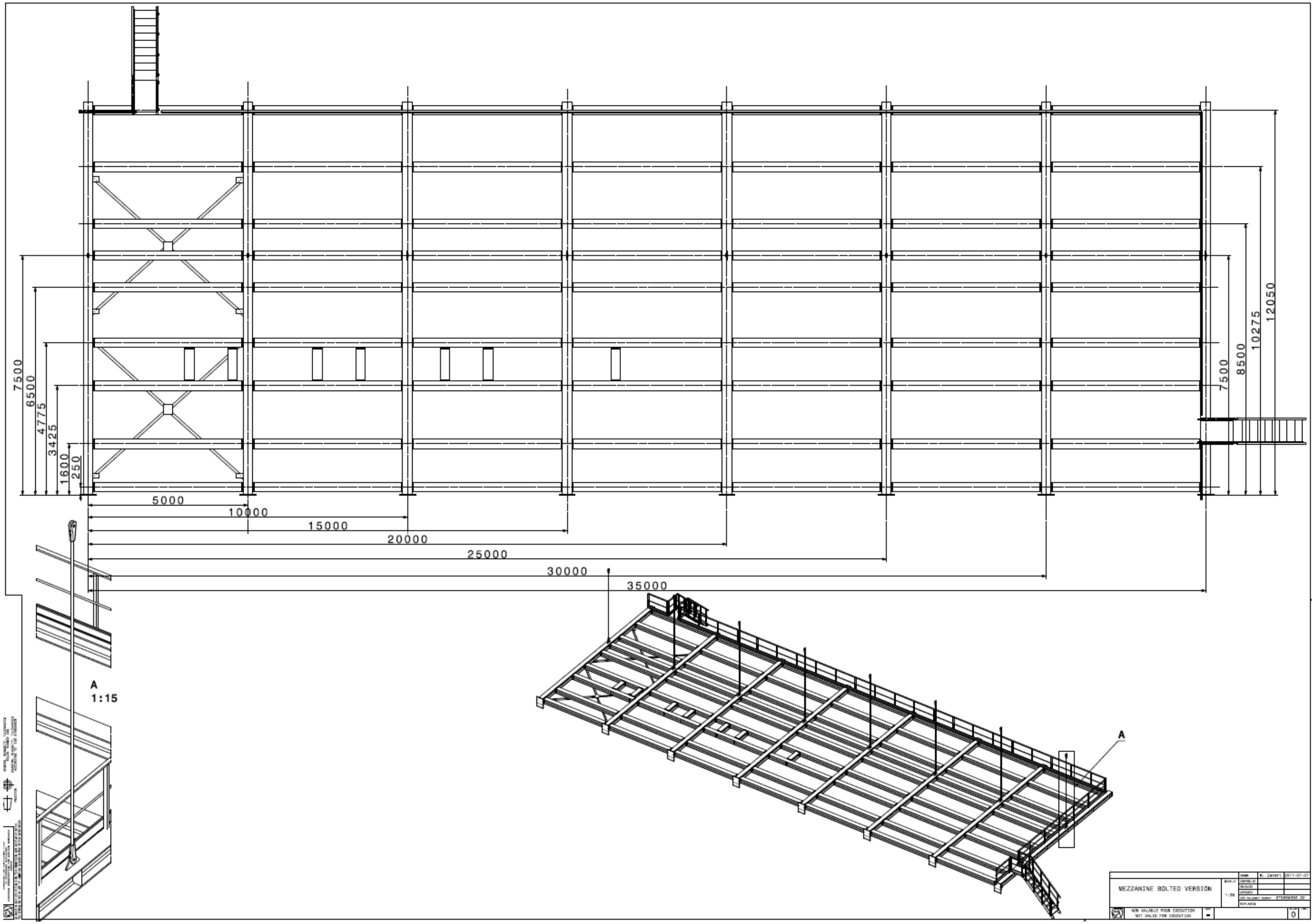
Mezzanine Requirements – Loads Table

Item ID	Name/Description	N. Items	Unit Load	Total Load
			kg	*kg*
1, 2, 3	PSVs block with valves, pipes (Purple)	16	721	11,531
4, 5	Vent block w valves, pipes (Green)	14	1,053	14,745
6	Main platform (LN2 Phase Separators, Valves, Pipes)	21	3,095	64,995
7	Warm panels w valves, pipes	1	3,600	3,600
8	LAr Phase Separators (2-4)	12	2,707	32,484
8*	LAr Phase Separator (1)	4	3,457	13,829
9	LAr Buffer and Condenser w valves, pipes	12	1,184	14,209
10	LAr Condenser Pump	4	1,385	5,540
11	PLC Control Racks	4	1,361	5,443
-	Other items distributed over/under mezzanine	-		15,987
	Total			**182,363**

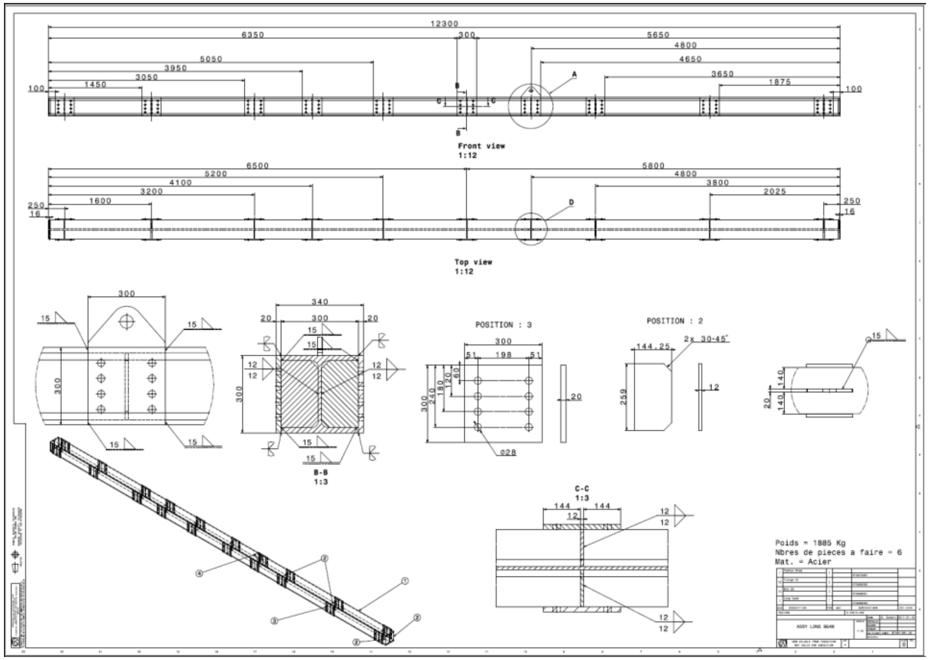
Mezzanine Structure

- CERN conceptualized the design of the mezzanine structure and presented it as part of the cryostat review in August.
- The design and calculations show that we need around 50 ton steel platform to support 183 ton load of cryogenic equipment.
- The design is compatible with the underground logistics constrains and the installation to the cavern, i.e. small pieces, bolted together, to create large surface. No welding operations underground.

The layout drawing

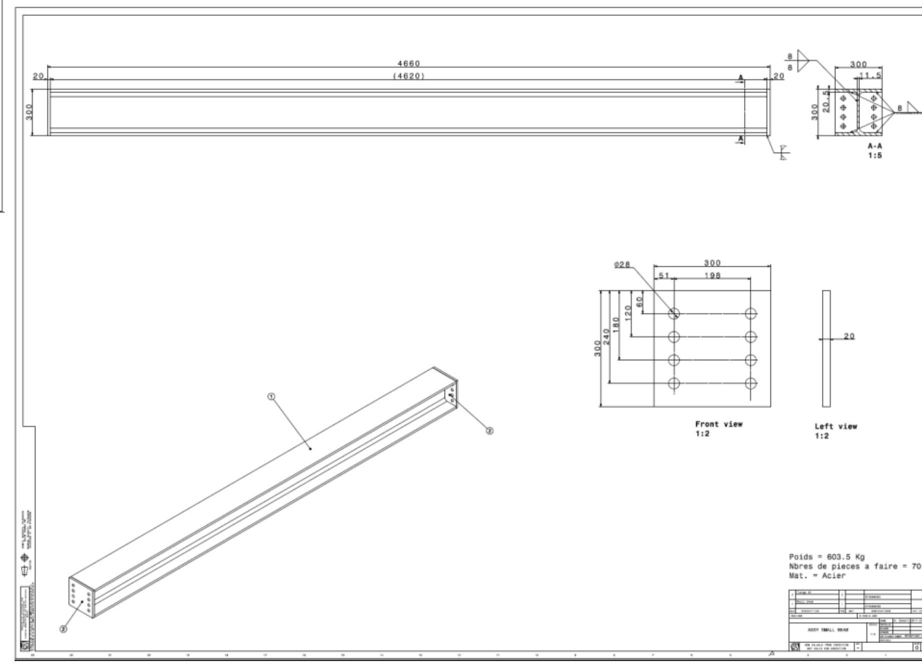


Design & manufacturing drawings



Main Beams **Qty**: 6

Crossing Beams **Qty**: 70



Material: ***S460ML*** (EN 10025)
Main profile: ***HEB300***
Total mass: ***50 ton***

The structural calculations

CENF 1834563	**Mechanical Integration**		
EDMS Document No:	*Institute Document No.*	*Created:* **25.07.2017**	*Page:* **1 of 7**
		Modified:	*Rev. No.:* **1.0**

Calculation note of the

LBNF - Mezzanine

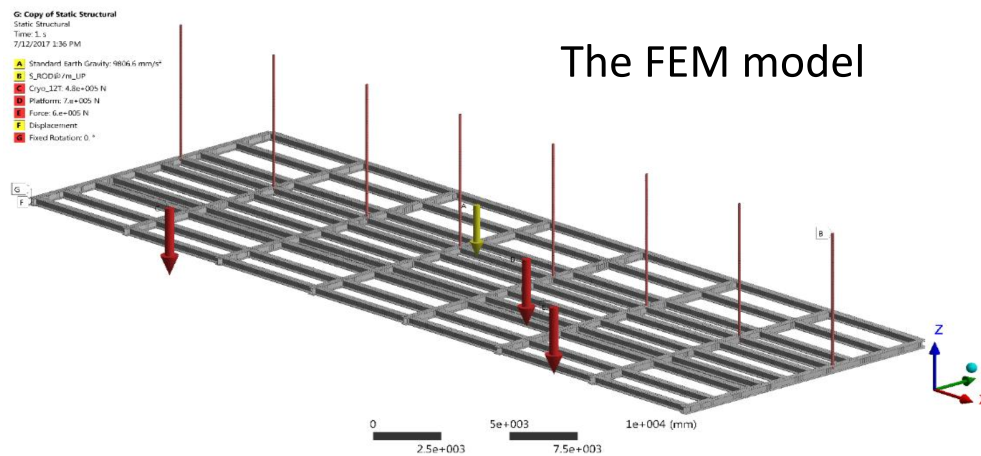
Abstract:

This note presents the results of the FEM simulations of the LBNF - Mezzanine.

Prepared by:	*Checked by:*	*Approved by:*
J. Hrivnak EP-DT-FS	**D. Mladenov EP-NU**	**M. Nessi RCS-PRJ-DI**

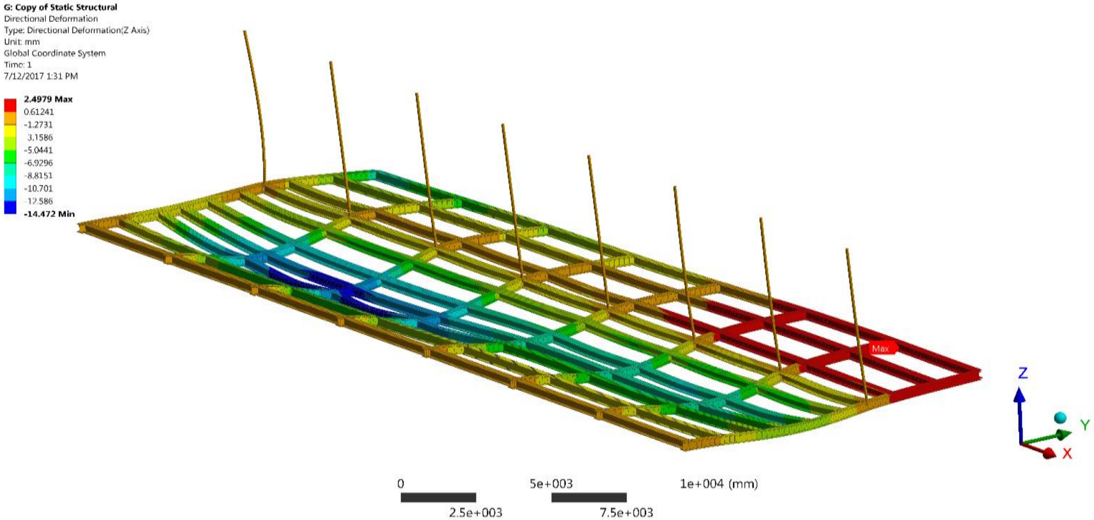
Distribution List

The 3D model

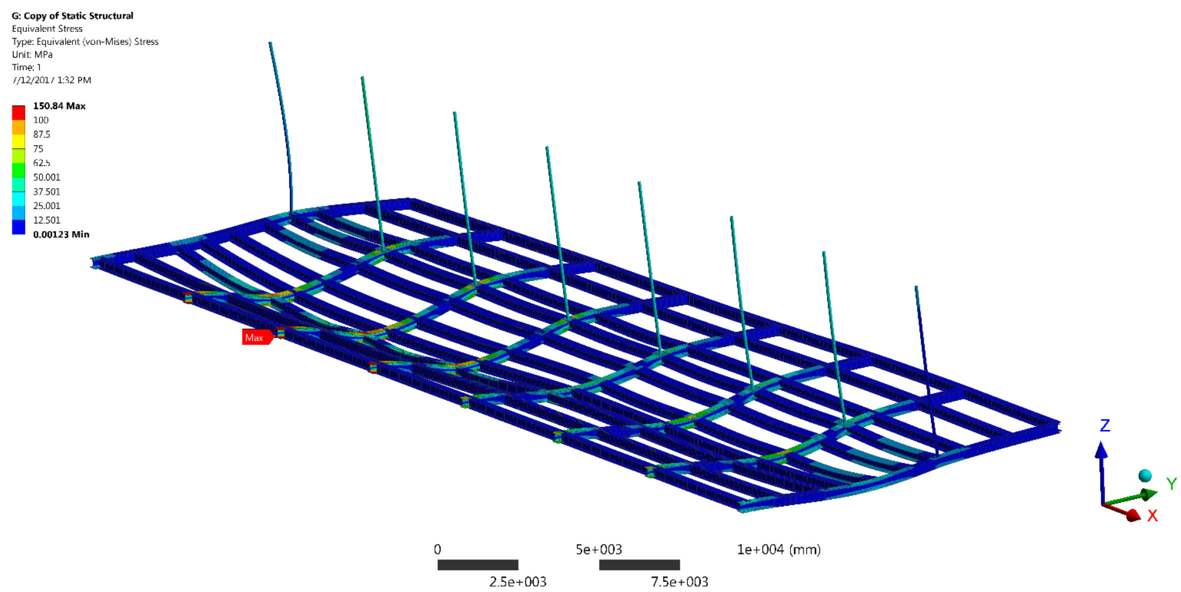


The FEM model

The results



Directional deformation [mm]
Maximum: ***15 mm***



Von-Mises stresses [MPa]
Maximum: ***100 MPa***

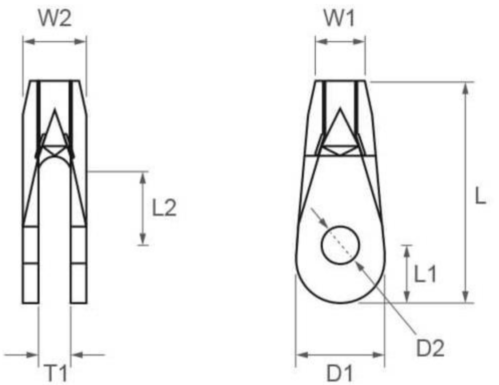
The Tie Rods

8 x 50 mm Tie Rods connected to the cavern ceiling each capable of supporting 100 metric tons.

Technical Data

***GEWI*® B500B & S555/700 Threadbar**

Nominal diameter Ø [mm]	Yield strength / tensile strength $f_{0,2k}/f_{tk}$ [N/mm²]	Cross-sectional area A [mm²]	Load at yield F_{yk} [kN]	Ultimate load F_{tk} [kN]	Weight [kg/m]	Weight DCP [kg/m]	Approval	
16	500/550	201	101	111	1.58	5.2	○	
20	500/550	314	157	173	2.47	5.9	○	
25	500/550	491	245	270	3.85	7.0	○	
28	500/550	616	308	339	4.83	8.6	○	
32	500/550	804	402	442	6.31	9.5	○	
40	500/550	1,257	628	691	9.86	13.6	○	×
50	500/550	1,963	982	1,080	15.41	21.0	○	×
63.5	555/700	3,167	1,758	2,217	24.86	32.4	○	×



	Name	M12	M16	M20	M24	M30	M36	M42	M48	M56	M64	M76	M90	M100
Yield load (design load) carbon	kN	30	82	127	184	292	425	583	766	1056	1392	1999	2879	3605
Fork length	L	90	112	132	155	189	217	238	266	313	348	420	498	575
Diameter	W1	18	22	29	35	43	52	60	68	80	91	108	129	143
Thickness	W2	24	28	35	42	52	62	74	84	95	120	148	170	181
Jaw gap (fork) +0/-2mm	T2	14	16	19	24	30	34	39	44	49	59	76	86	91
Width	D1	32	43	51	62	79	93	107	121	145	167	199	246	287
Pin hole diameter	D2	13	17	21	25	31	37	43	49	57	65	78	96	111
Projection	L1	21	27	33	41	52	61	69	78	96	110	131	161	188
Jaw depth (fork)	L2	25	30	42	50	59	70	78	87	105	120	141	171	197

	Units	M12	M16	M20	M24	M30	M36	M42	M48	M56	M64	M76	M90	M100
Yield load (design load)	kN	30	82	127	184	292	425	583	766	1056	1392	1999	2879	3605
Ultimate load (break load)	kN	51	104	162	233	370	539	740	972	1340	1766	2537	3654	4575
Stress area	mm²	84	157	245	353	561	817	1,121	1,473	2,030	2,676	3,844	5,537	6,932
Yield stress	N/mm²	355	520	520	520	520	520	520	520	520	520	520	520	520
Ultimate stress	N/mm²	610	660	660	660	660	660	660	660	660	660	660	660	660
Elongation	%	10	16	19	19	19	19	19	19	19	19	19	19	19
Max single bar length	m	6	6	12	12	12	12	12	12	12	12	12	12	12

DYWIDAG Tie Rods

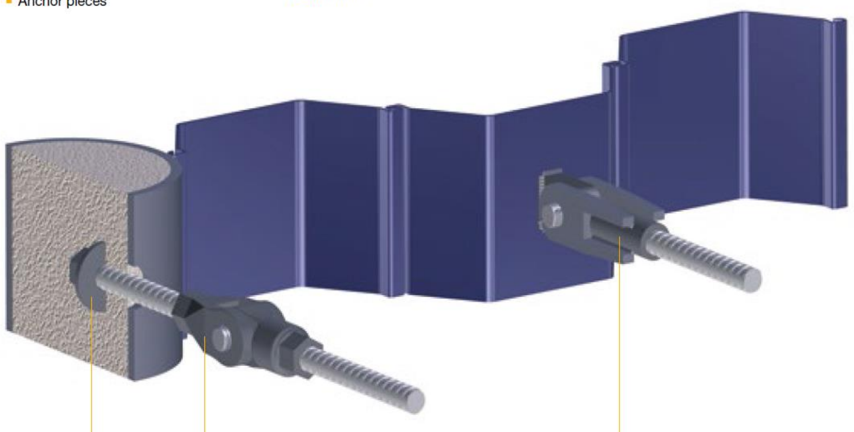
Tie Rod Connections

Anchorages in different variations for steel and concrete structures

- Clevis connections
- Eye pieces
- Anchor pieces

- Articulated
- With angle compensation
- Self-aligning under load
- Tensionable
- Weldable

- Corrosion protected
- Counter-sunk
- Embedded in concrete



Next Steps

- Continue to update the cryogenics on the mezzanine according to the latest feedthroughs layout.
- Prepare design documentation (Technical Specifications, 3D models with not-to-exceed envelopes, etc.).
- CERN to perform a detailed interface study of the mezzanine support to the cavern roof and the side walls.
- Provide the loading parameters of the mezzanine to CF for Final Design.

Summary

- The Proximity Cryogenics on the mezzanine has been conceptualized to fit in the available cavern space over the cryostat and in the Ross shaft. Minor adjustments to the HVAC layout needed. Envelope models available showing the keep-out zone for cryogenics use.
- Good understanding of size, weight and location of the components (installation and maintenance considered).
- Feedthroughs through the roof of the cryostat fixed.
- Requirements on mezzanine platform are understood and include uncertainty for unaccounted loads.
- Studying the air flow pattern around the cryostat to maintain the temperature of the steel support structure within the limits.

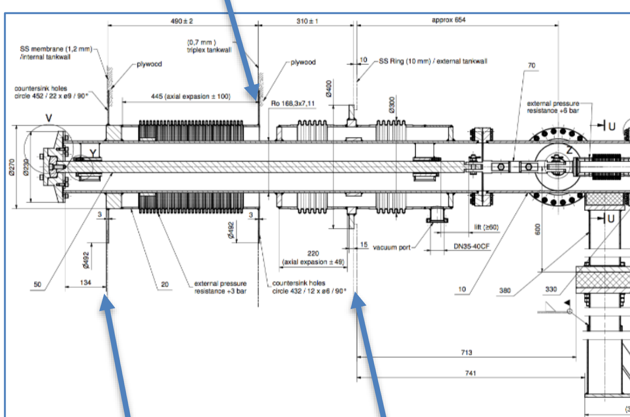
Thanks

Backup Slides

Proximity Cryogenics in Detector's Cavern – LAr Pumps & inline safety valves

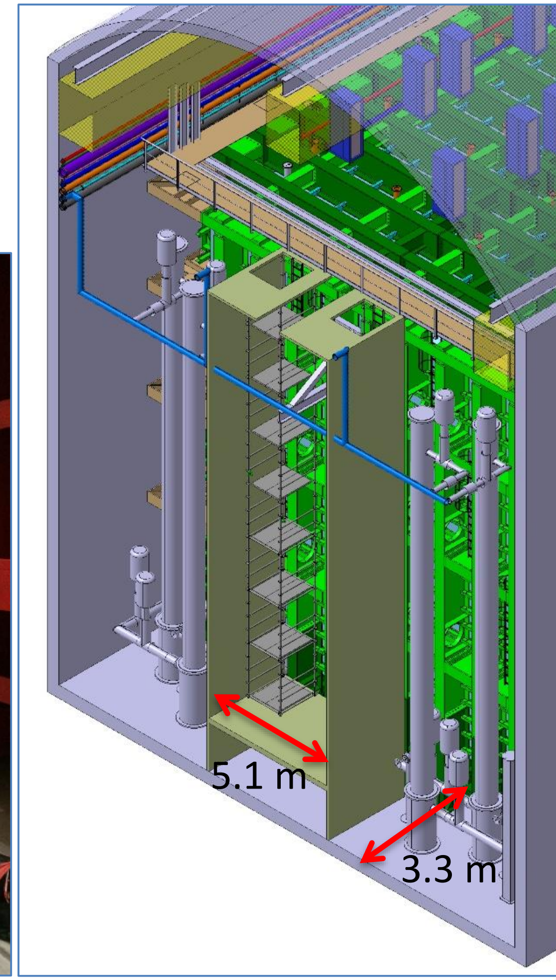
- LAr pumps.
- Concept of Clean Room (CR) for detector installation.
- Inline safety valves (one per penetration). Same as in ProtoDUNEs.

Cryostat Secondary Barrier



Cryostat Vapor Barrier

Cryostat Membrane



Documents and References

- Design of the Cryogenics on the mezzanine: EDMS 1834431, DocDB-583.
- 3D model of Cryogenics on mezzanine: EDMS 1749033, DocDB-583.
- Mezzanine Design Requirements: EDMS 1818308, DocDB-583.
- Detector's Cavern profile: DocDB-136.
- P&IDs: DocDB-212.
- Ross Shaft requirements: DocDB-328.
- Detector's Cavern Lifting eyes grid: DocDB-464.