Fermilab

May 8, 2025

Deep Talks
LBNF/DUNE – Project Update

Jolie Macier (Fermilab), Sanmitra Pingulkar (Fermilab), Jeff Barthel (SURF)

U.S. DEPARTMENT of ENERGY

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01

Project update

Jolie Macier, FDC Project Manager

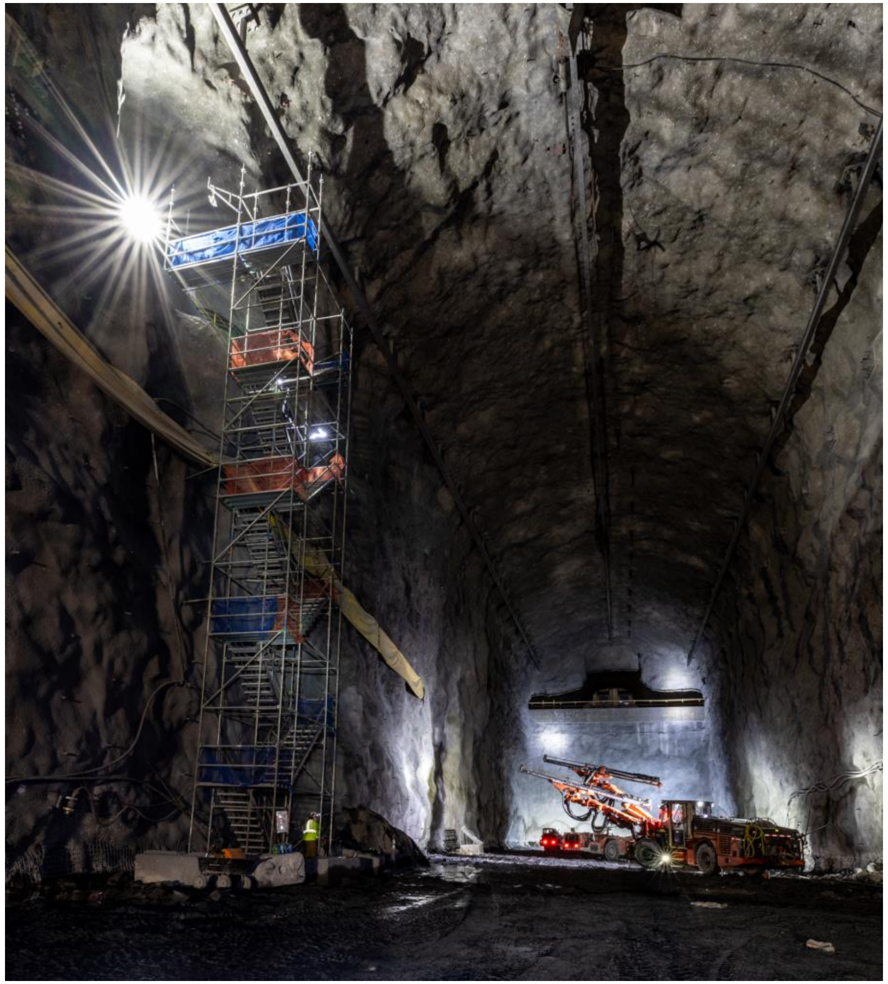
Project Footprint

LBNF/DUNE-US Project

- Excavation subproject created the underground cavern space, installs cranes, wall supports & ceiling anchors for cryogenics mezzanine
- Buildings & Site Infrastructure subproject installs all house services: electrical, ventilation, architectural, chilled water, fire protection
- **Far Detector & Cryogenics subproject builds & installs cryostats, detectors & cryogenics; liquid argon filling**

Anode Plane Assembly (APA) Production Facility at University of Chicago

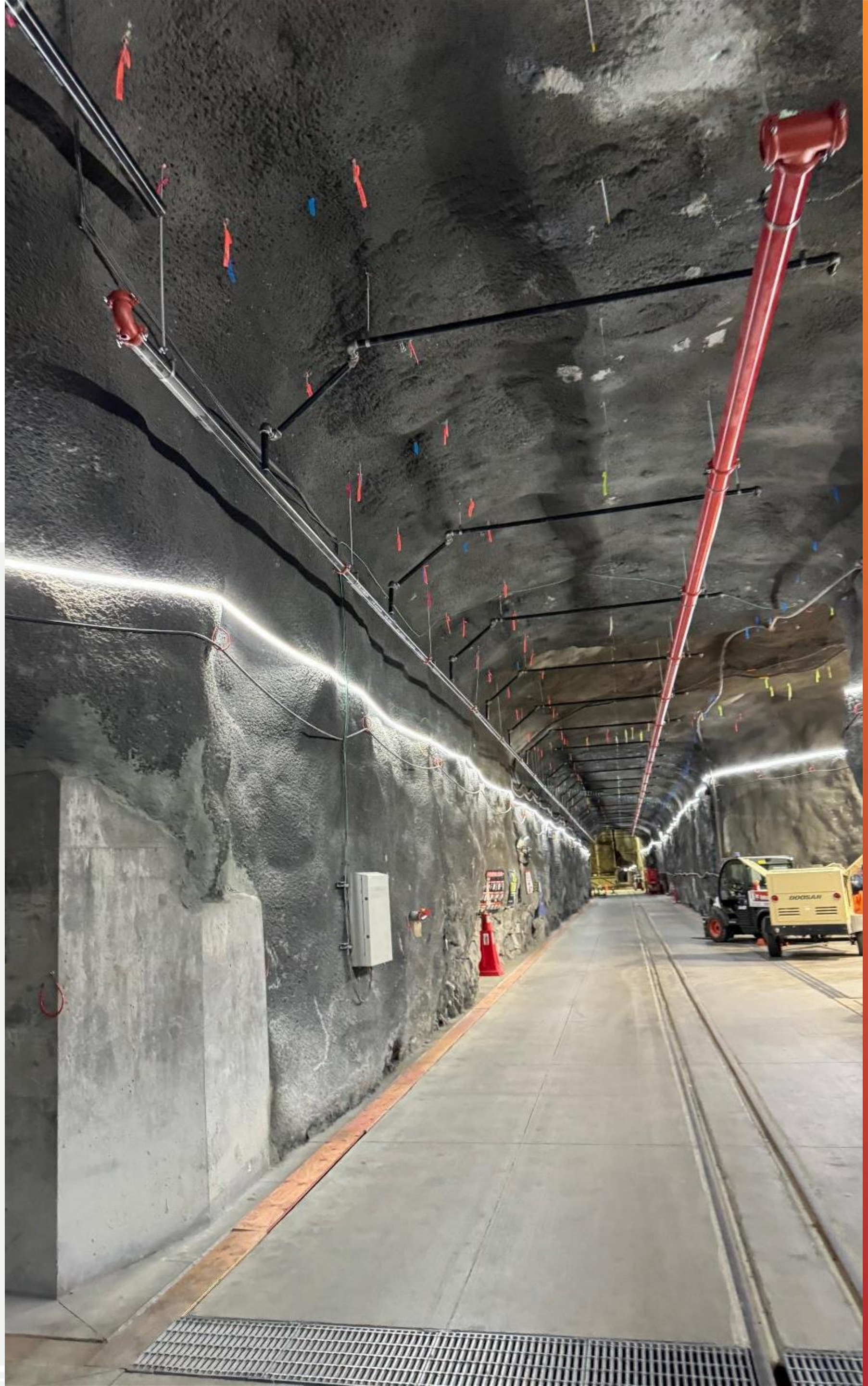
2024 Milestone – Excavation 100% Complete!



Ribbon Cutting for completion of LBNF/DUNE Excavation, August 2024

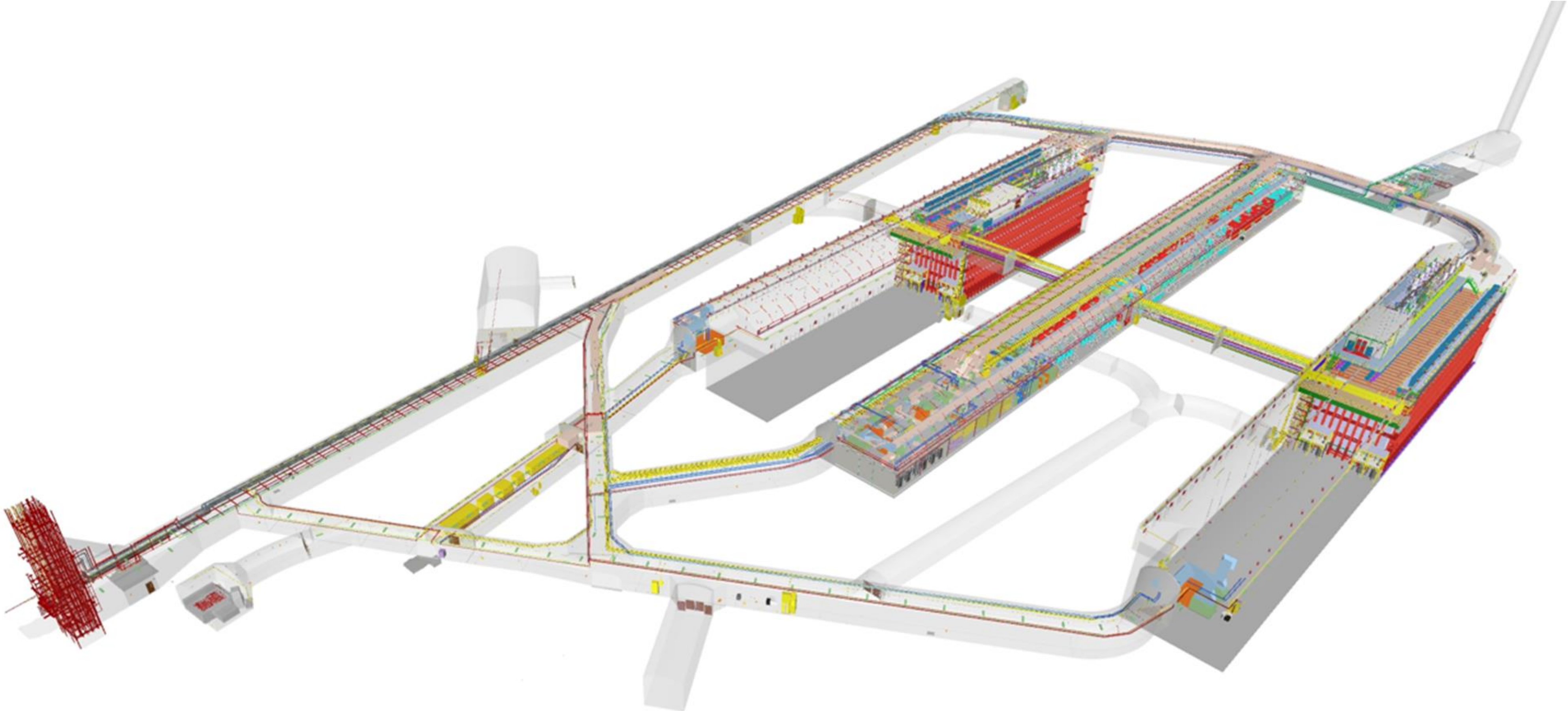
BSI - Underground

- Most surface work already complete, focus is underground
- Mostly regional contractor pool
- Anticipate similar number of staff as during excavation (~150-200 divided between day and night shift)
- Generally working 5 days/week, 2 shifts/day. Occasional Saturday day shifts as well
- Type of work being performed:
- Civil, architectural, and structural features
- Mechanical and plumbing including HVAC, Chilled water and Water Supply
- Electrical including Normal, Emergency, Standby
- Fire Detection, Protection and Alarm
- Cyberinfrastructure
- Security
- Argon gas pipe (incl shaft)



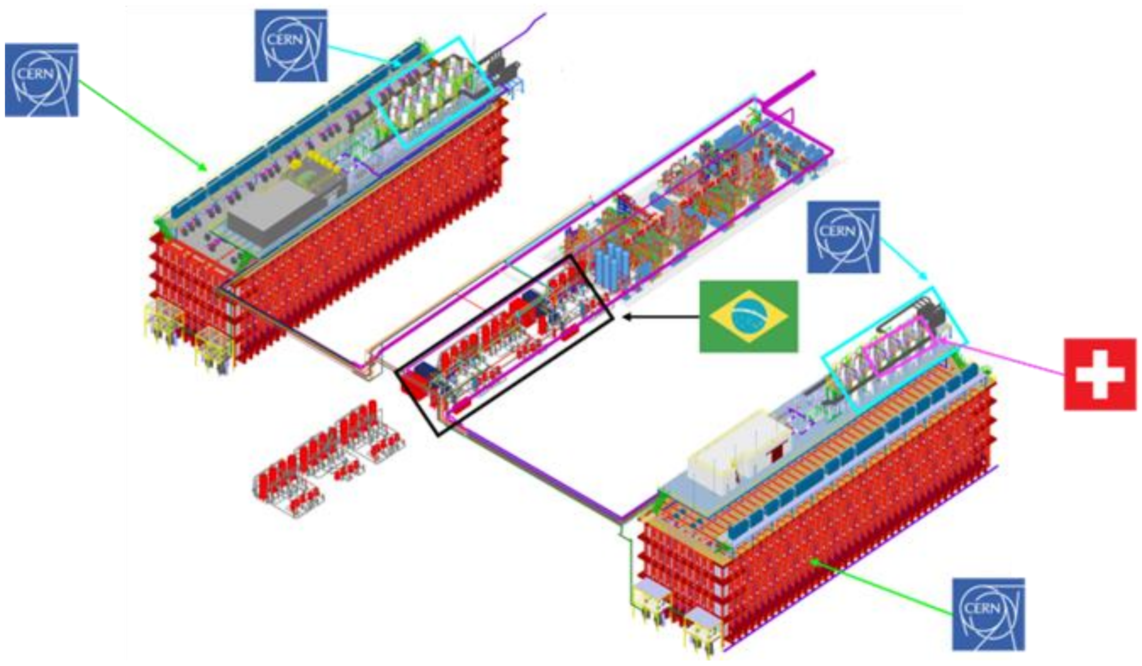
Next Phase: Far Detectors & Cryogenics (FDC)

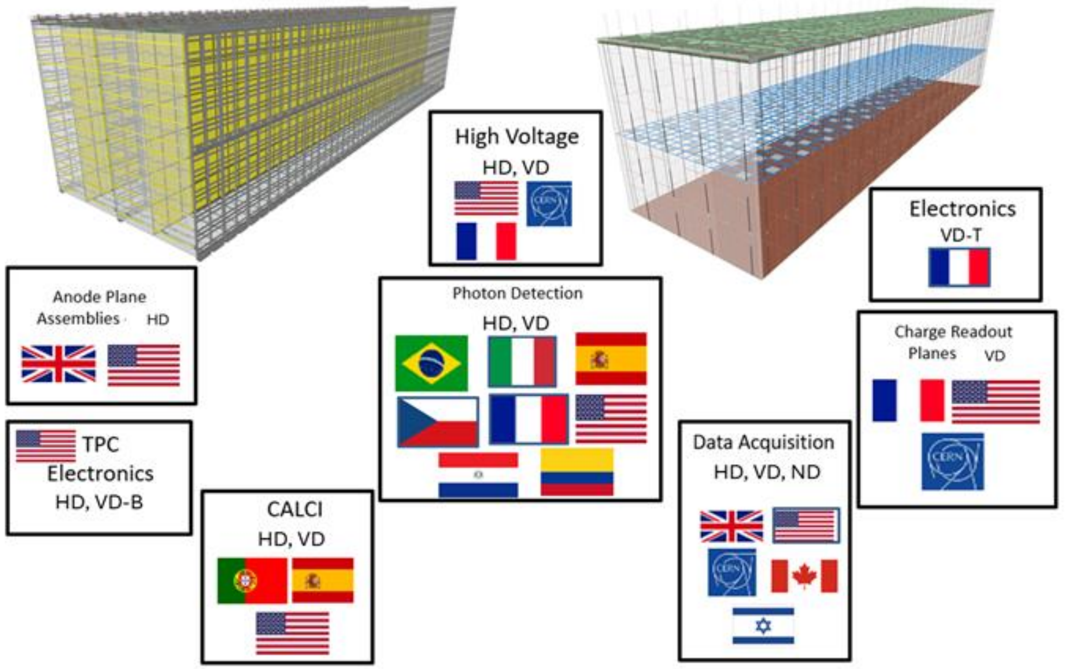
Installs **cryostats**, **cryogenics**, two time-projection chamber **detectors**
EACH filled with 17,000 metric tons of LAr



FERMI NATIONAL ACCELERATOR LABORATORY

FDC includes international partners





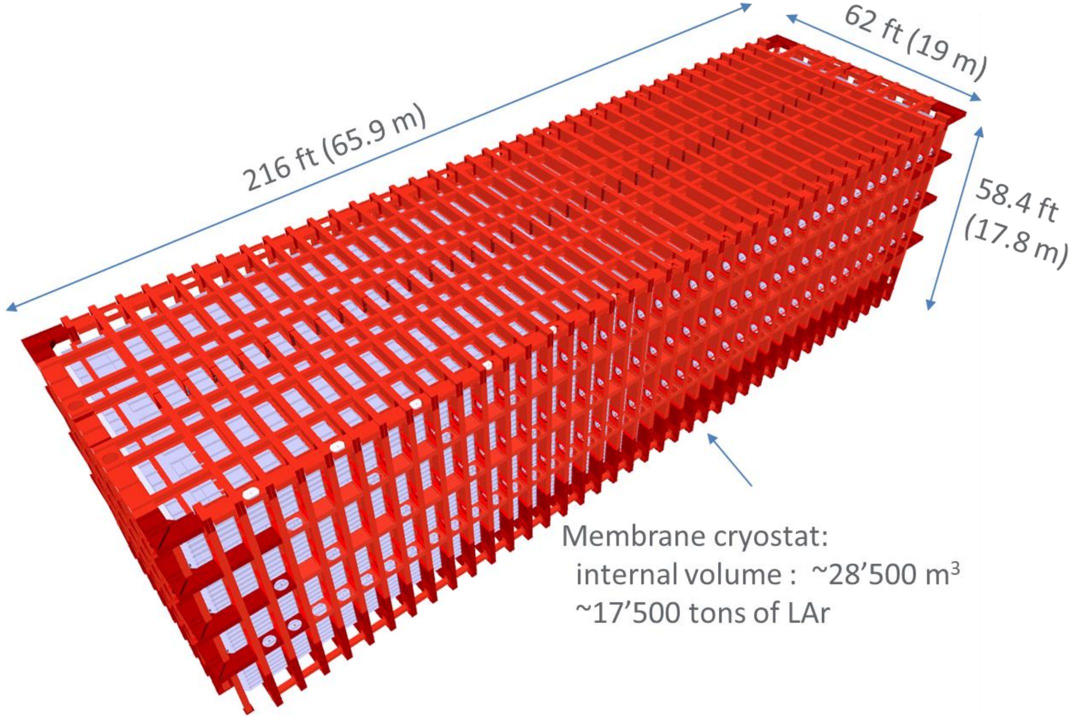
FDC Planning for Underground Work

Installation Prototyping at University of Minnesota’s NOvA facility in Ash River Minnesota

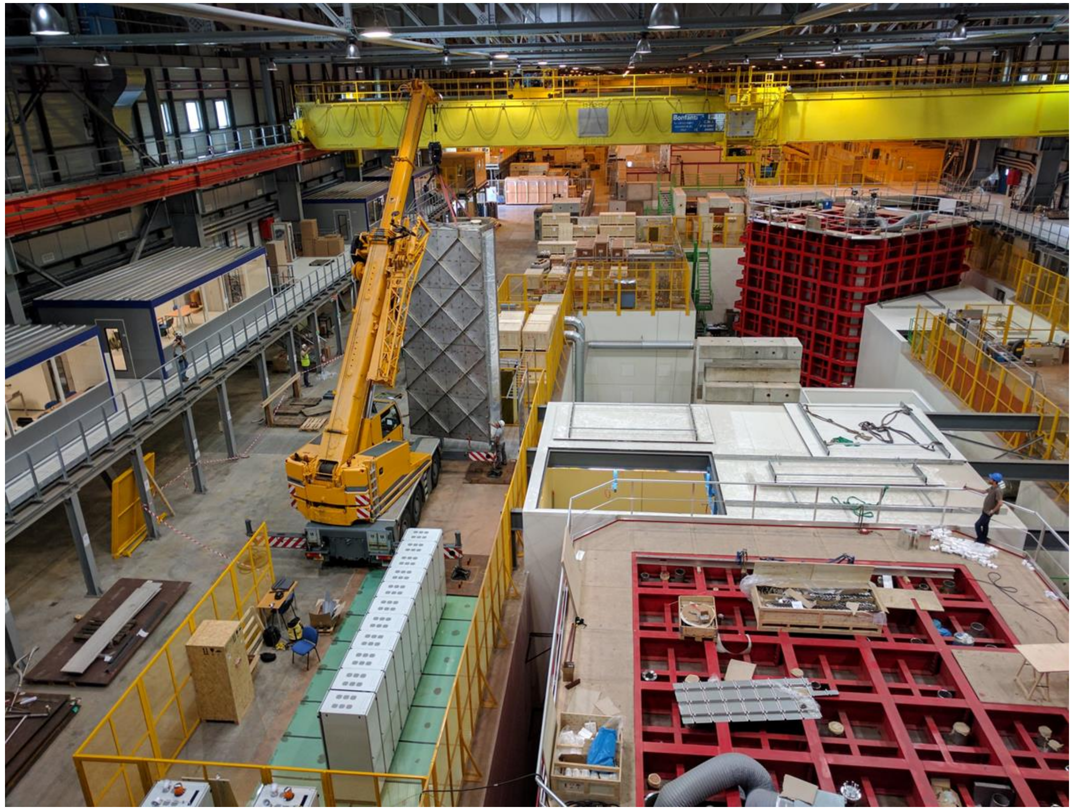
Each Detector is housed in a Cryostat

- CERN contribution
- Material & installation
- Two components
- Steel
- Insulation
- Each is 3 million pounds of steel
- 5 stories high
- Each is two basketball courts long

- CERN = European Organization for Nuclear Research, located in Geneva Switzerland

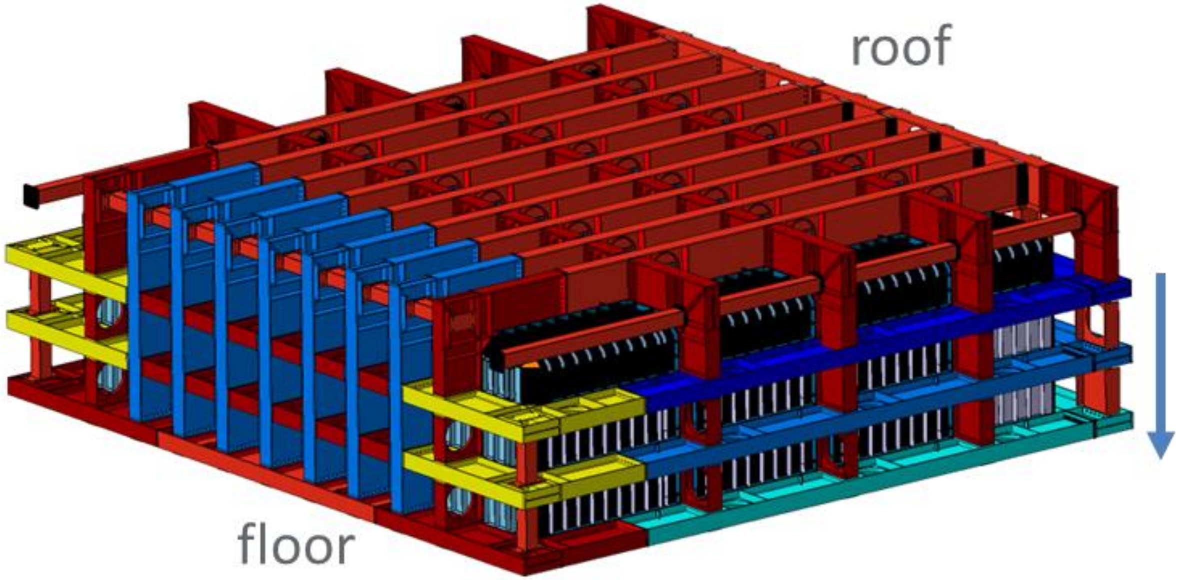


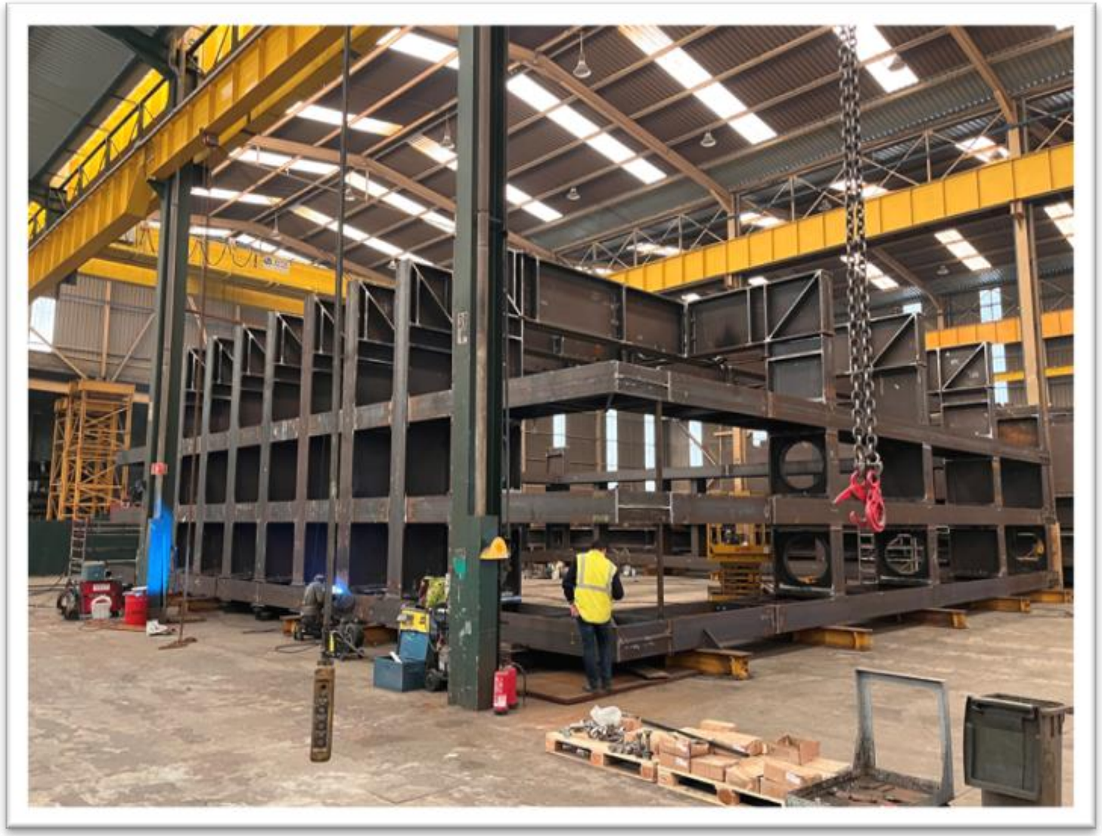
Prototyping precedes FDC underground activities in Lead



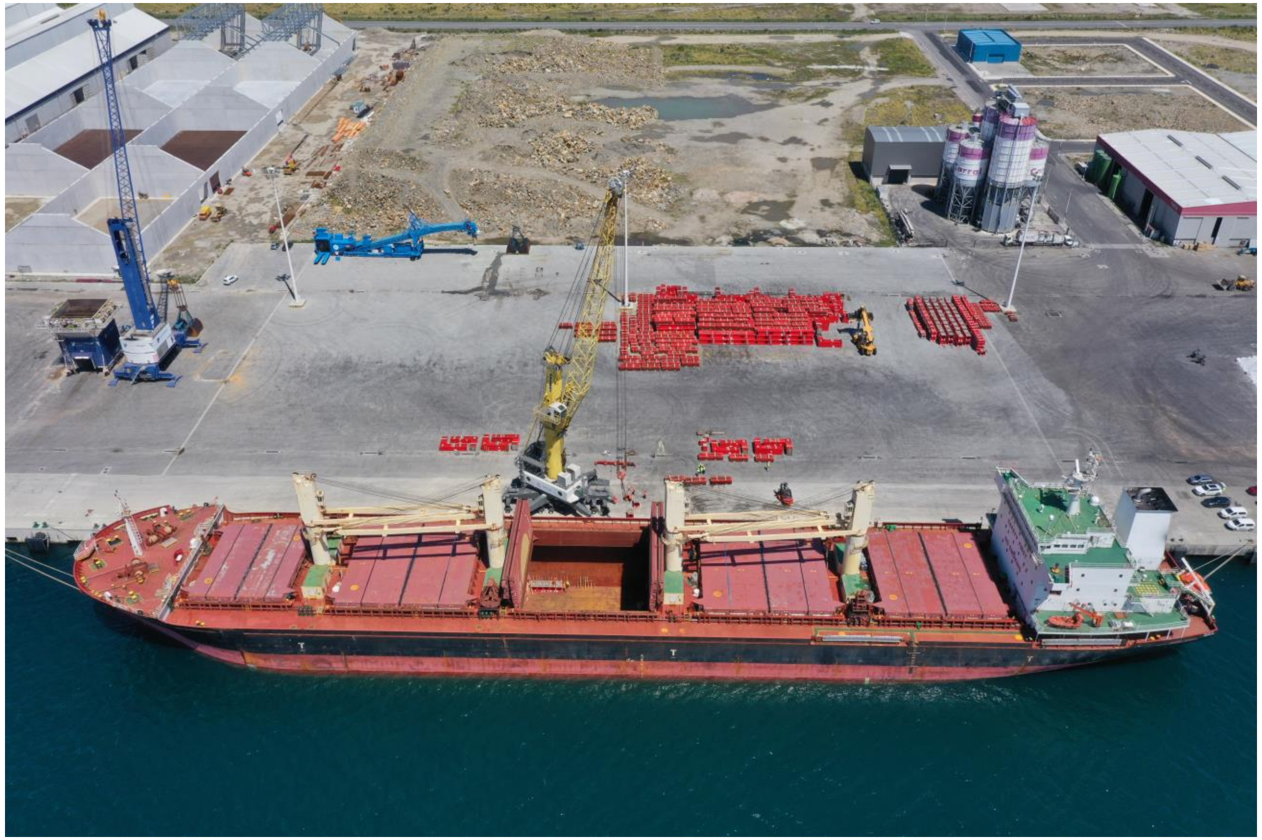
ProtoDUNE detectors (red boxes) at CERN (left); Anode Plane Assemblies in ProtoDUNE (right)

CERN-provided Cryostat Steel Fabricated in Spain and Shipped to Houston





Cryostat Steel Fabricated in Spain and Shipped to Houston



Steel arriving at the docks

Steel has arrived in Rapid City!

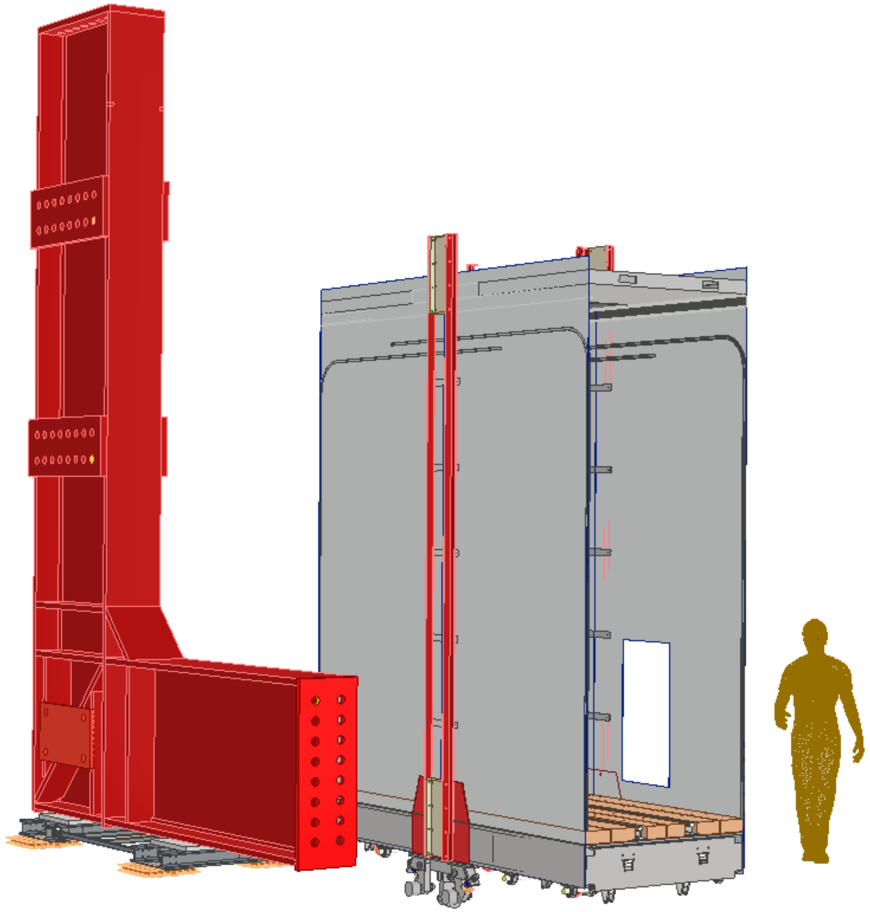
02

Moving Steel

Sanmitra Pingulkar (Fermilab Mechanical Engineer)
Jeff Barthel (SURF Rigging Specialist)

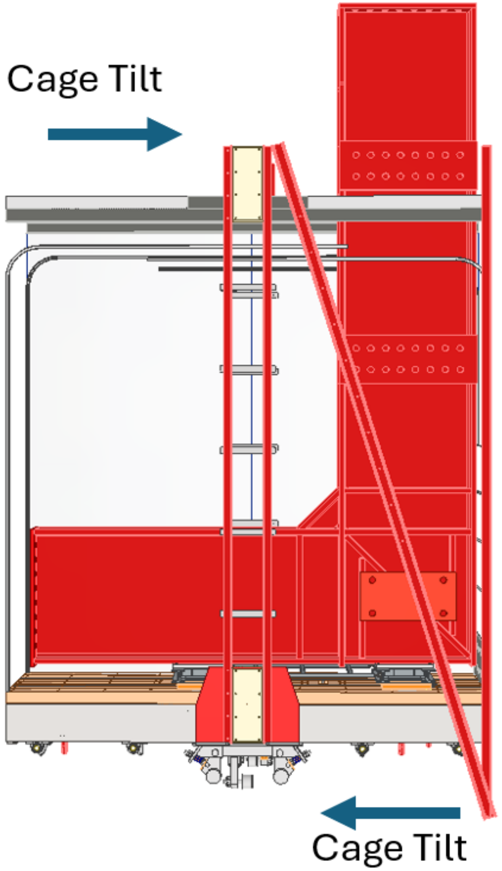
L-beam: Underground Transport

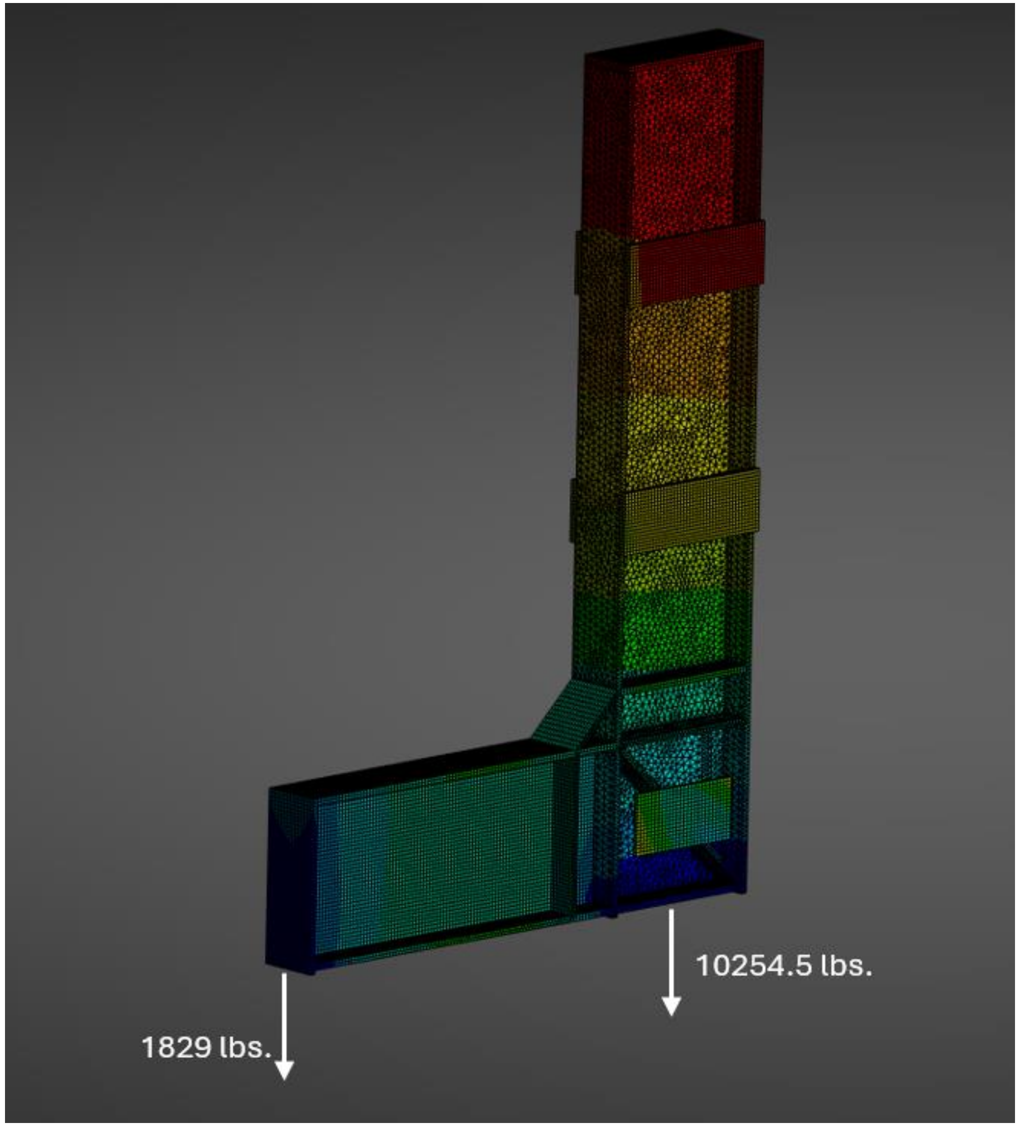
- L-beams are among the large steel structures that form the floor of the DUNE cryostat, which will hold 17,000 tonnes of liquid argon.
- Focus of this talk will be the movement from the Ross headframe to the 4850 level.
- L-beam dimensions: L:11.8', H:18', W:1.3'
- Ross Cage dimensions: L:12', H:12.1', W:4.75'
- Due to the narrow profile of the L-beam the tipping angle of the beam is 5 degrees.
- L-beam weight: 12083.5 lbs.
- Cage capacity: 13500 lbs (includes 4x safety factor)



L-beam: Underground Transport

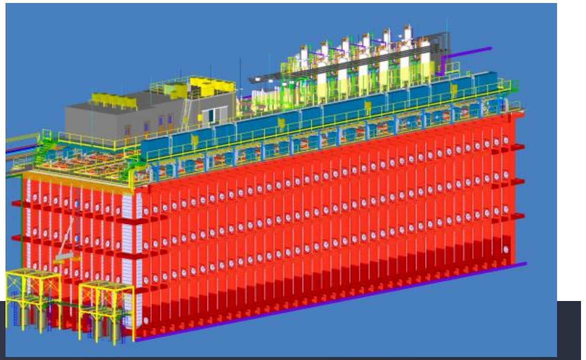
- L-beam load distribution
- Due to the shape of the L-beam, approximately 15% of the weight is distributed to the front of the cage and 85% to the rear.

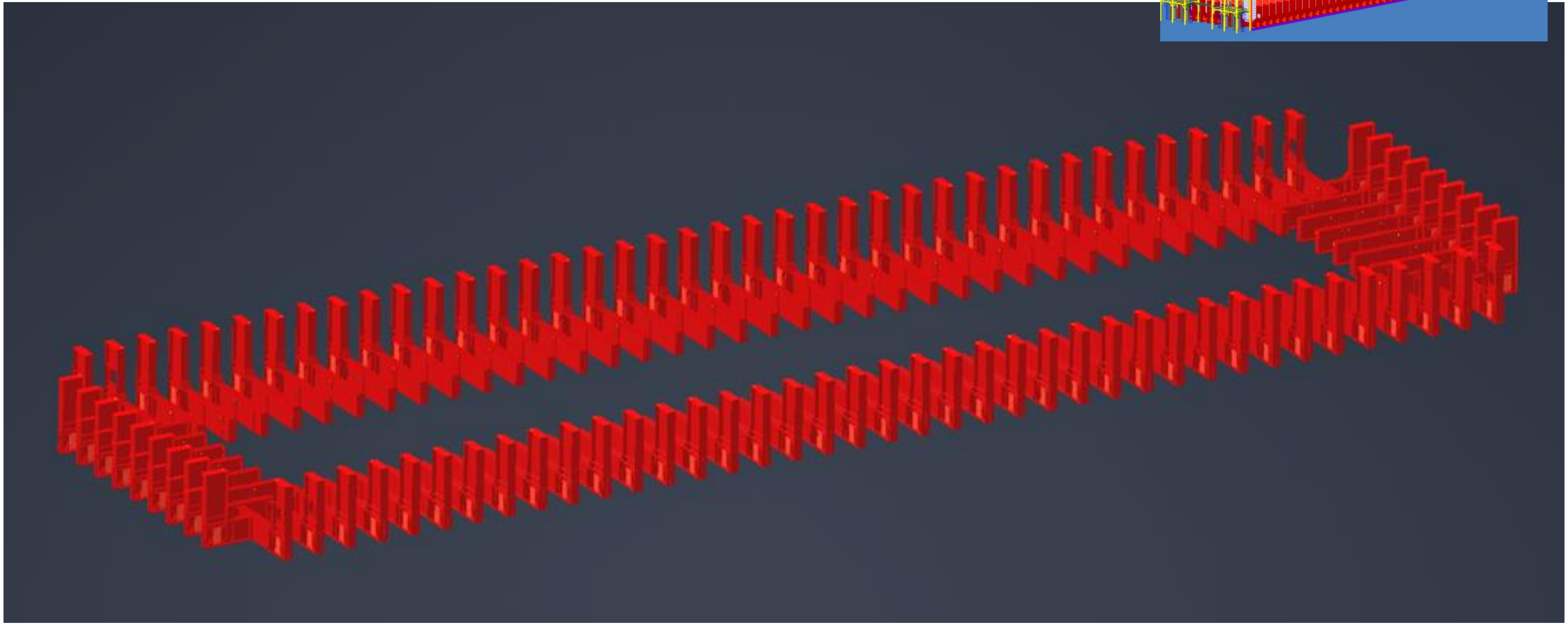




L-beams: Underground Transport

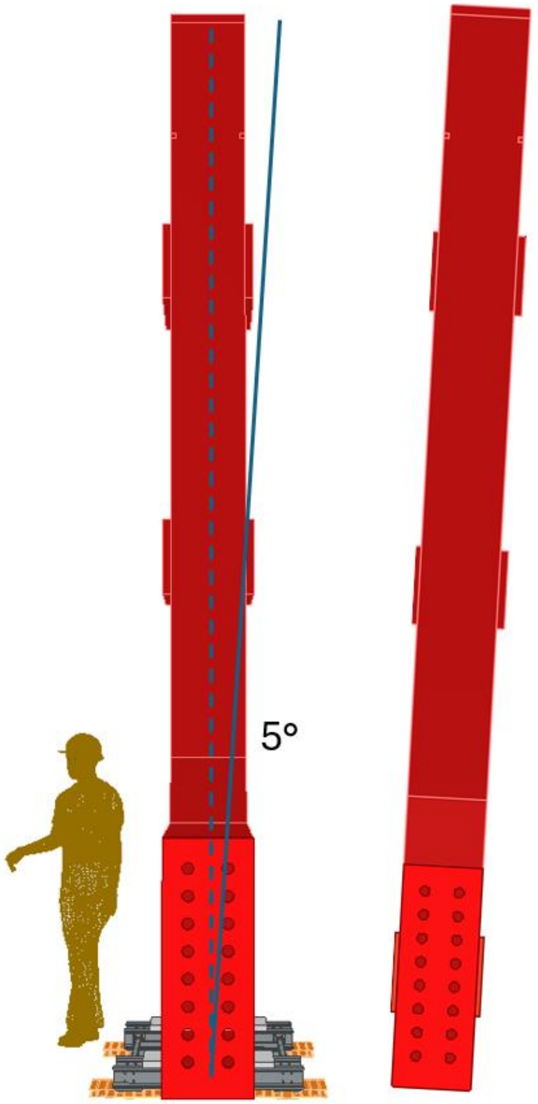
- The two DUNE Cryostats consists of 192 L-beams





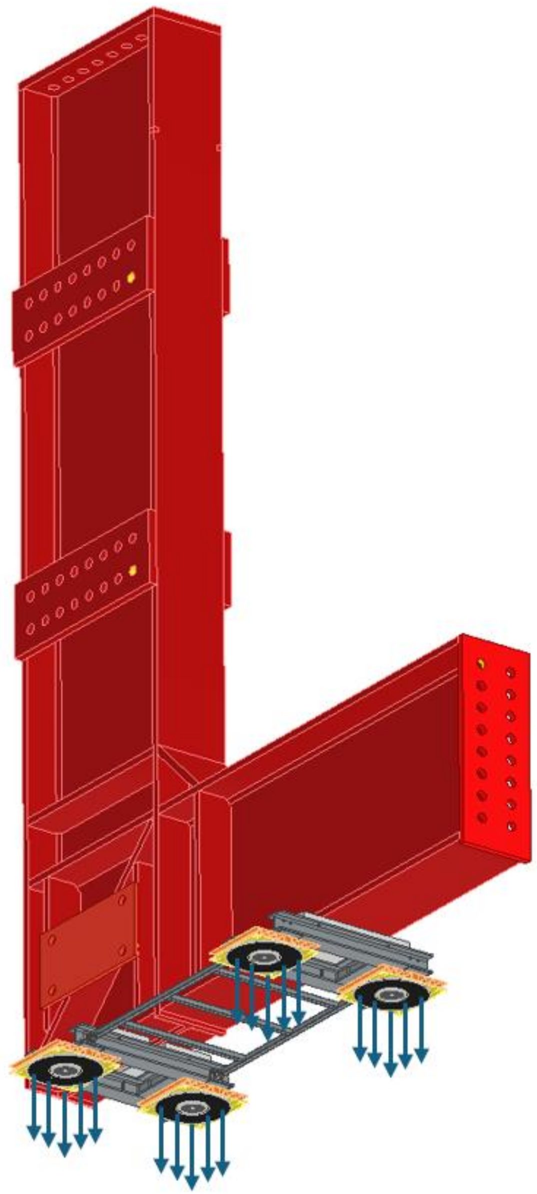
L-beam: Underground Transport Constraints

- Tools and equipment required for the movement and to support the L-beam must weigh less than 1000 lbs.
- The equipment used for the transport must prevent the L-beam from tilting more than 5 degrees.
- The load distribution of the L-beam must be adjusted to comply with the Cage limit.
- The L-beam must fit inside the cage.
- The movement must be safely repeatable for all 192 beams.
- All the tools and equipment must fit within the footprint of the cage.



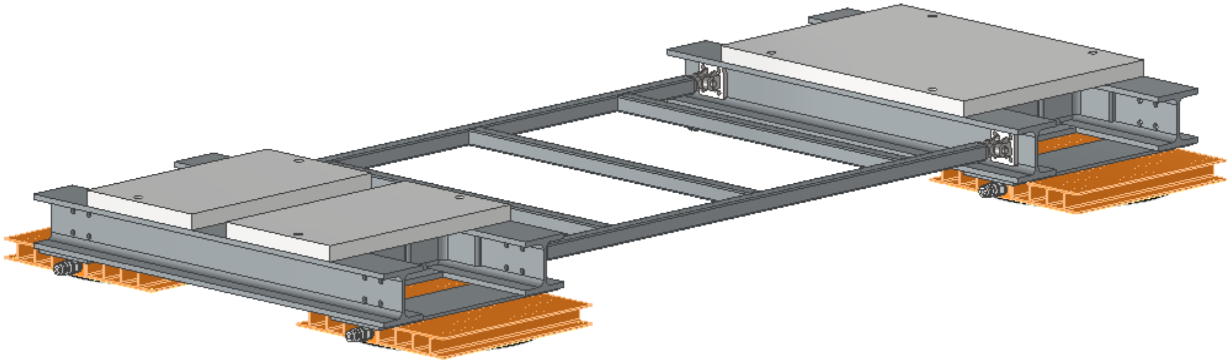
Sled (Maggie)

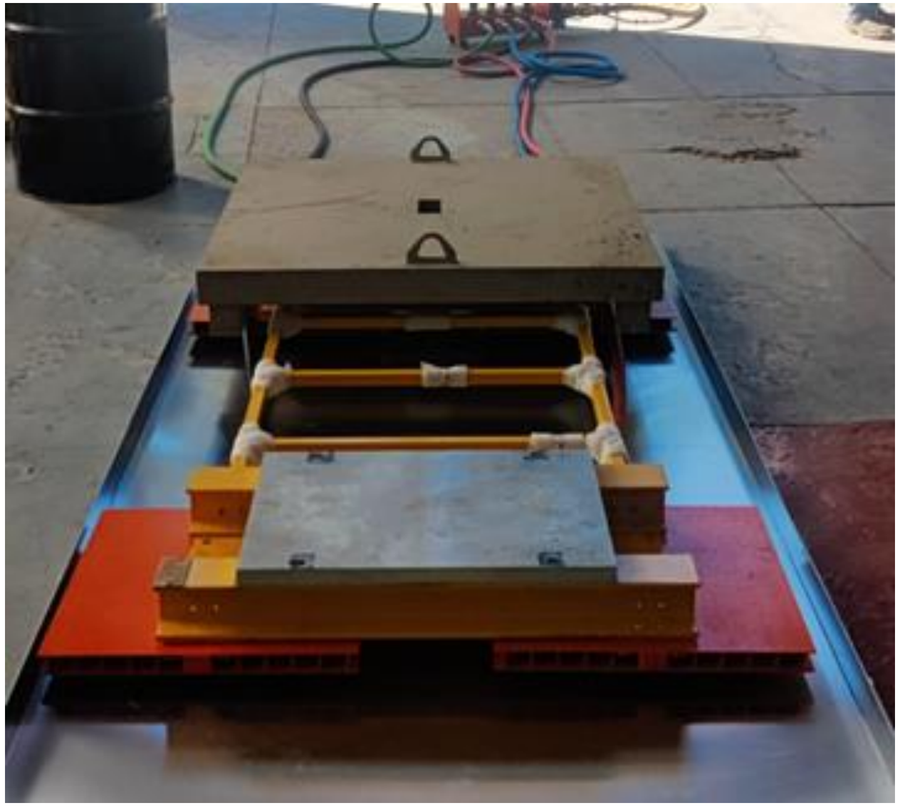
- Air-casters are pneumatic lifting devices used to move heavy loads.
- It uses compressed air to lift the load by creating a thin film of air underneath the load. Thus, reducing friction.
- A four air-caster based system was developed for this movement.
- Similar to an inverted air hockey table or a hovercraft.



Sled (Maggie)

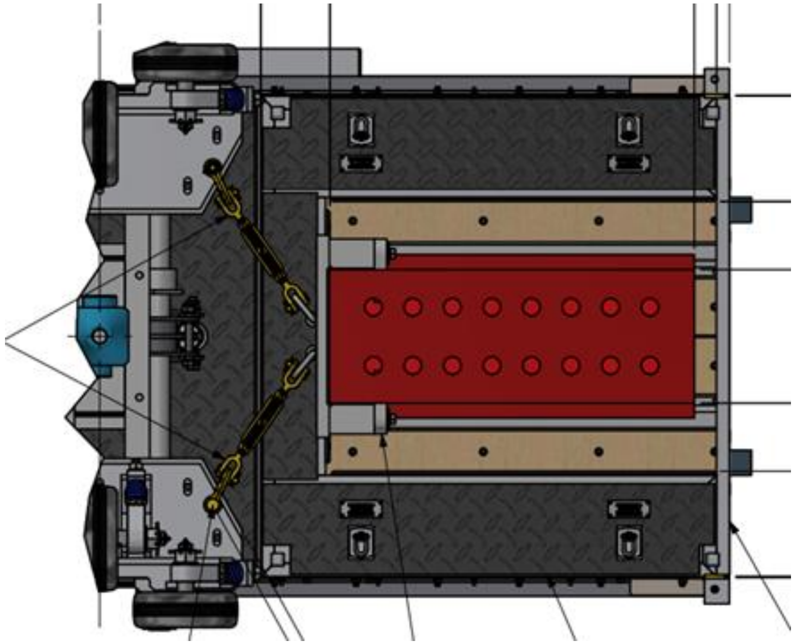
- An I-beam structure (sled)(Maggie) was developed to distribute the load of the L-beam on the four air-casters.
- Named after a Homestake mule, the sled structure was designed to be lightweight to stay within the Ross Cage load capacity and compact enough to fit inside it.
- It also enabled a load distribution that the cage could safely support, with the front air casters carrying 30% and the rear casters 70% of the total weight.

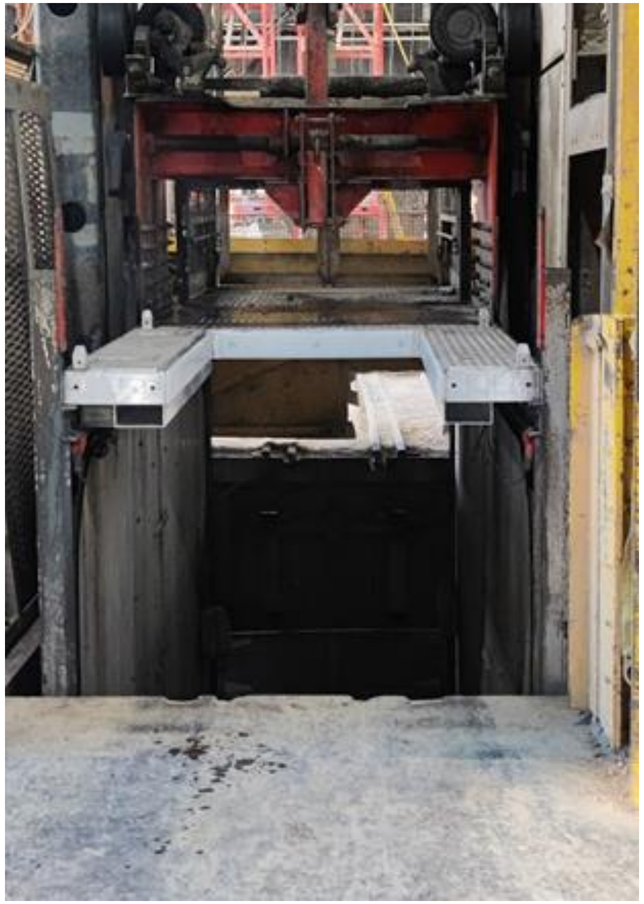


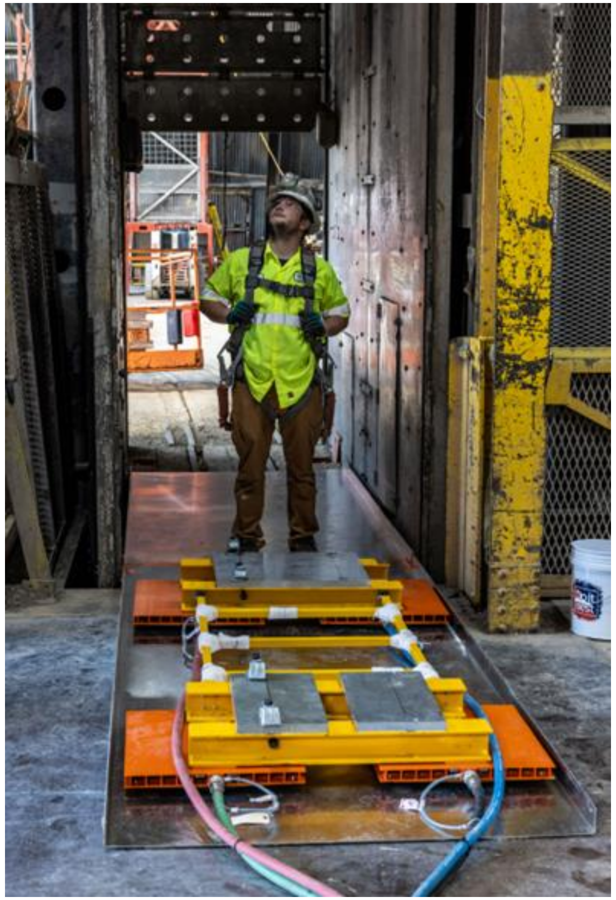


Sled (Maggie)

- Custom Ross Cage roof panel was developed to secure the L-beam inside Ross Cage.
- Floor plates with guide walls allowed for controlled movement and to provide a smooth surface for the air-casters.



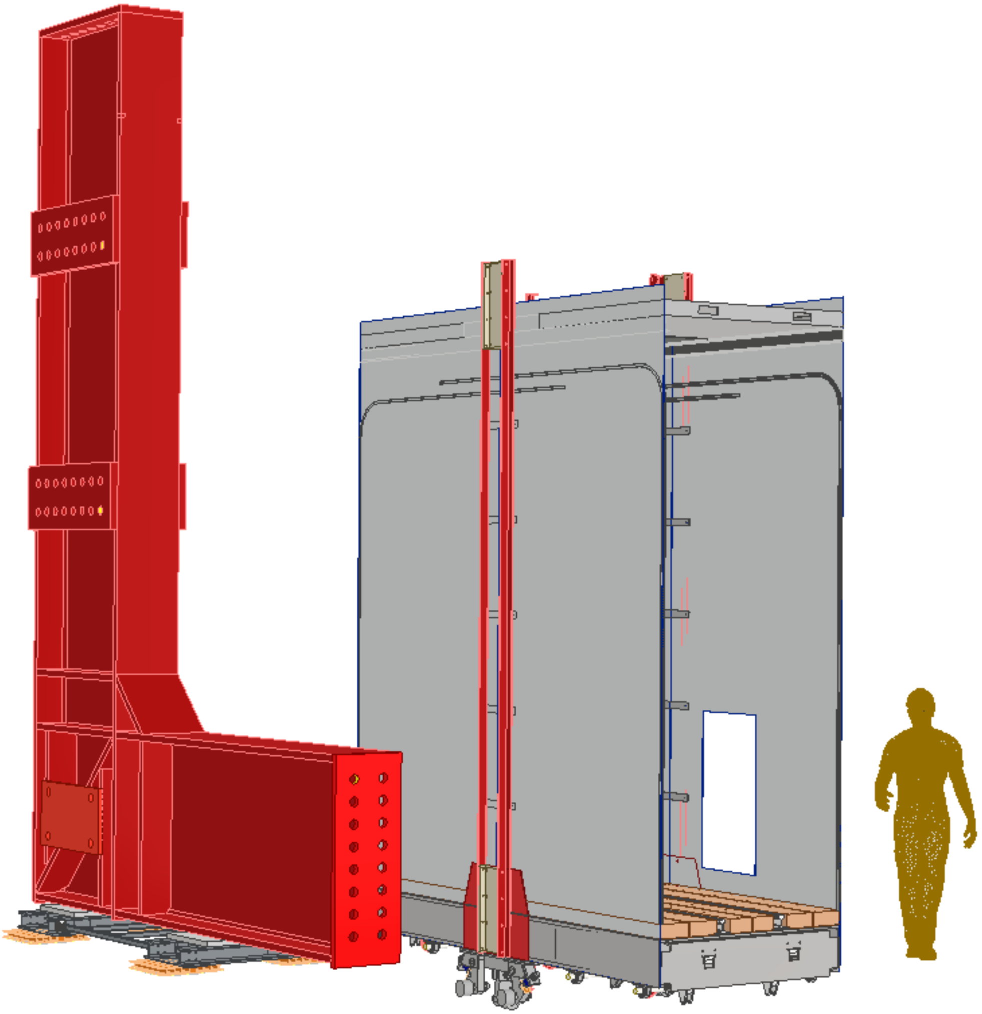




Sled (Maggie)

- Weight of the L-beam: 89.8 %
- Weight of tooling: 7.4%
- The beam was lowered to the 4850 level at a speed of 100 ft/min.

Components	Weight	
	Kg	Lbs
L-beam (CENBNFCR0277)	5500	12125.4
Sled (Metric)	176.9	423.694
Modified roof	39.92	88
Aluminum Floor plate	34.15	75.28
MDF board	15.88	35
4K21NL (Total) (aircasters)	72.57	160
Air caster console	13.61	30
Tubing	18.14	40
Beam Clamps	19.96	44
Manipulation points	49.89	110
Total	**5941.02**	**13131.37**



L-Beam Mock-Up Tests

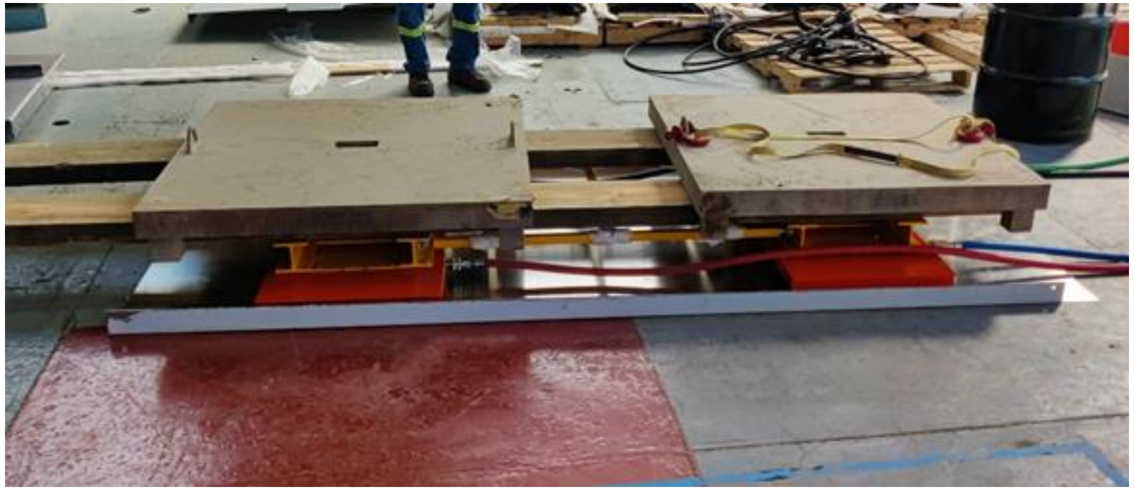
- A full-size L-Beam was constructed out of wood to test how the Beam would physically fit where it needed to go.
- Although it was less than one-tenth the weight of the actual Beam, the center of gravity was the same, so the Mock-Up reacted the same as the real Beam to lifting and maneuvering with equipment.

L-Beam Test Lifts

- Multiple test lifts were done to verify that the lifting points worked as designed and to ensure that the L-Beam would hang from level a single point.

Certifying Maggie

- Test weights were installed on the Air Cart weighing nearly 12,500lbs and distributed to mimic the weight distribution of an L-Beam.
- Several test runs were completed to establish starting points for adjusting air pressure and to get an idea how much force would be needed to move the loaded cart and turn and stop it.



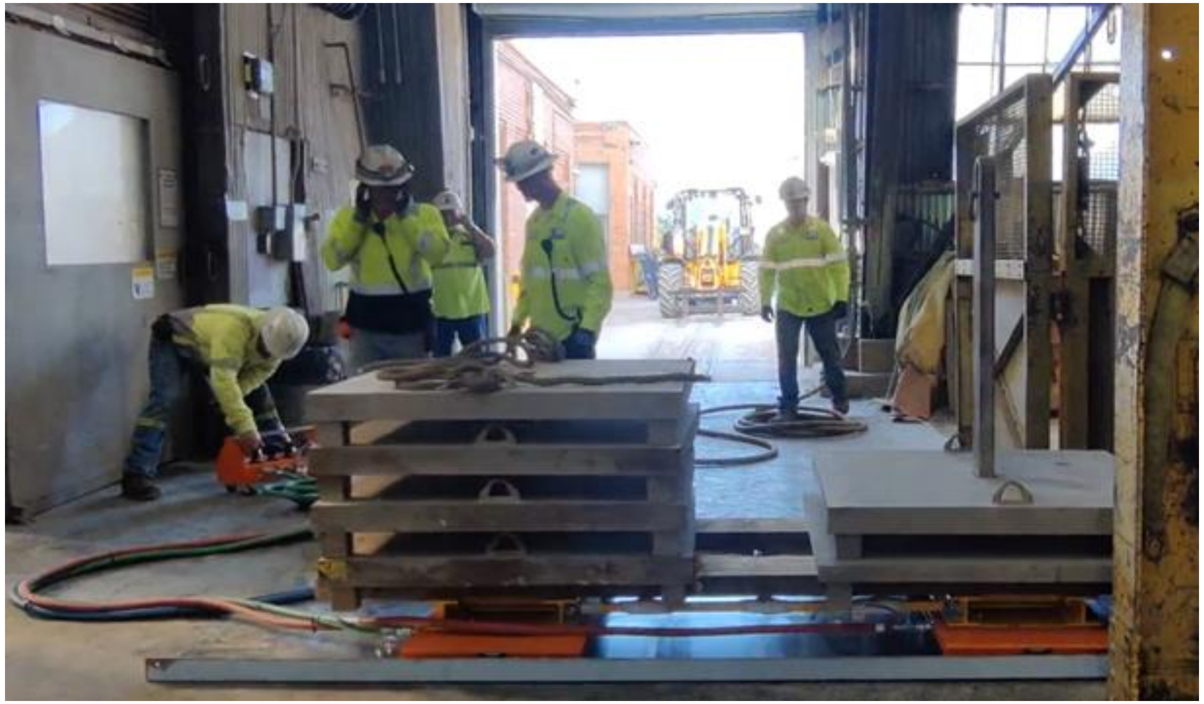
Maggie Movement Testing

- While doing movement tests, it was found that air pressure between 12-20psi was adequate to allow the cart to be moved by two people.



Cage Testing Maggie

- The cart was reassembled in the Headframe and multiple insertions into the cage were performed.
- We were able to experiment with air pressure and found that adjusting each individual caster affected how loaded cart was able to adjust for uneven flooring.



L-Beam Movement Testing

- The L-Beam was installed onto the air cart and moved with air pressure for the first time.
- We measured maximum angle deviation from vertical and tested how the Beam moved and how the air cart responded to the load.

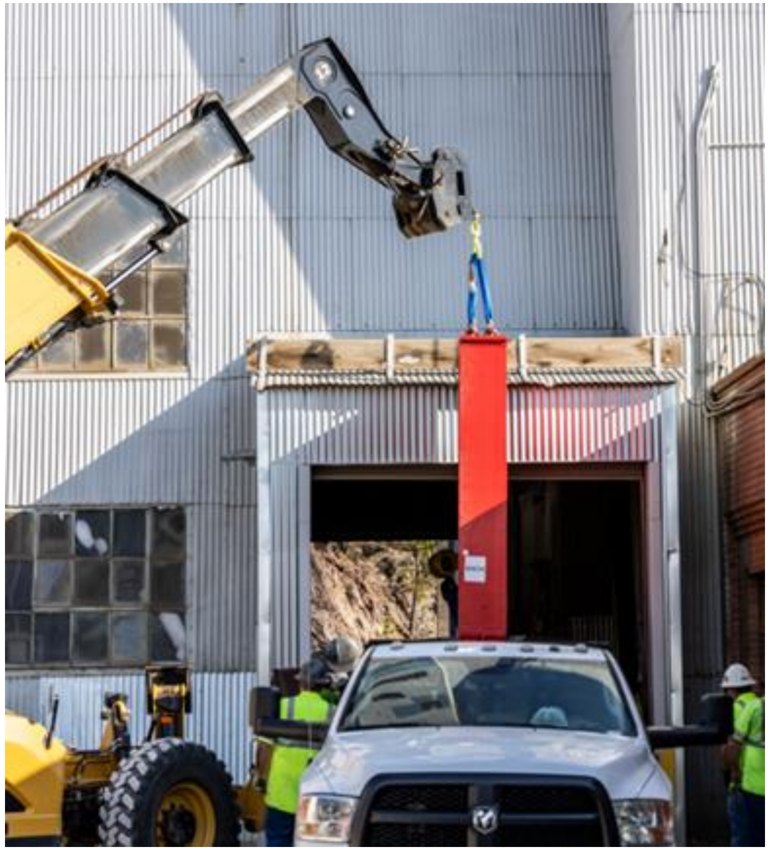
L-Beam arrival at the Headframe

- The trailer loaded with the L-Beam was driven to the Headframe and guided into the building.

Off-loading

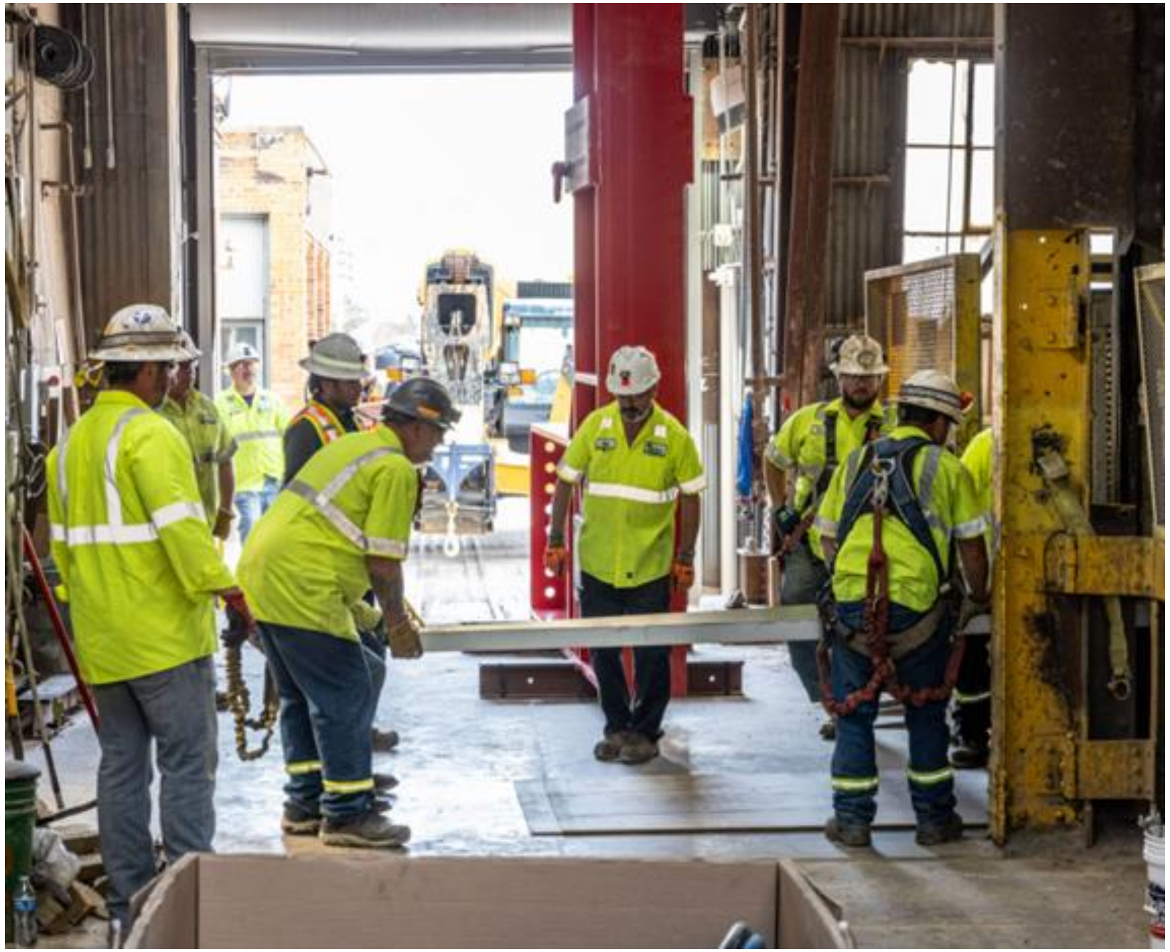
- Because the L-Beam is much taller than the existing door, it needed to be off-loaded with part of the Beam outside the door.
- Once the Beam was clear of the trailer, the trailer was pulled out from under the Beam and the Beam was set down on dunnage.
- To get the Beam into the building and sitting in the proper orientation, it was necessary to simultaneously lift the Beam with a hoist on one end and a telehandler on the other, so it could be lifted and rotated into the Headframe.

Lifting and rotating the L-Beam



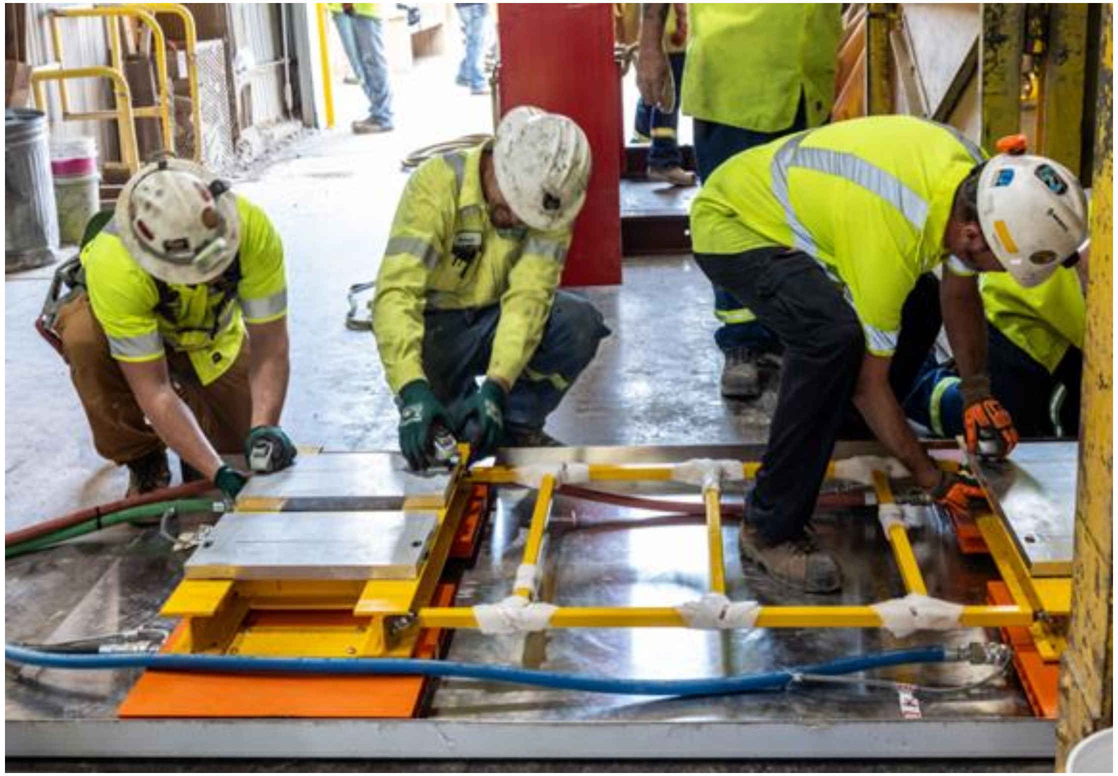
Setting up Maggie

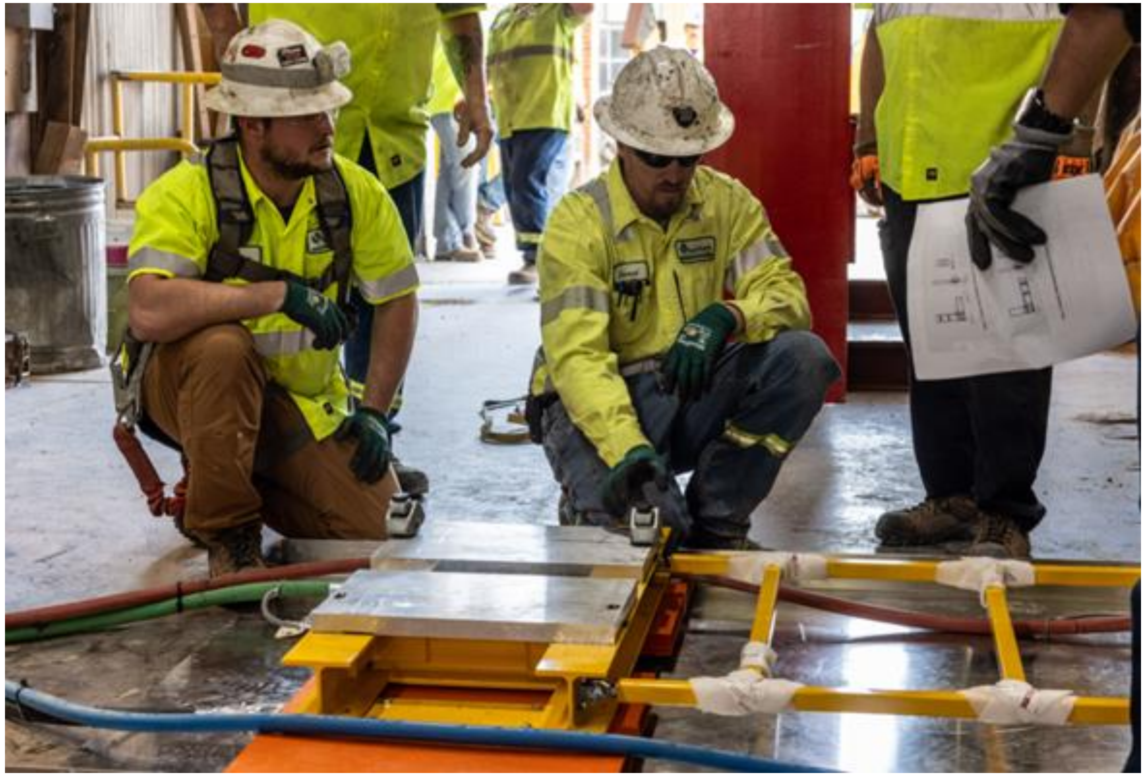
- The air cart glide plates were laid onto the floor of the Cage and on the Headframe floor leading into the Cage.
- To ensure the plates were as flat as possible, spacers were placed under the glide plates to make the transition into the cage as even as possible.



Assembling Maggie

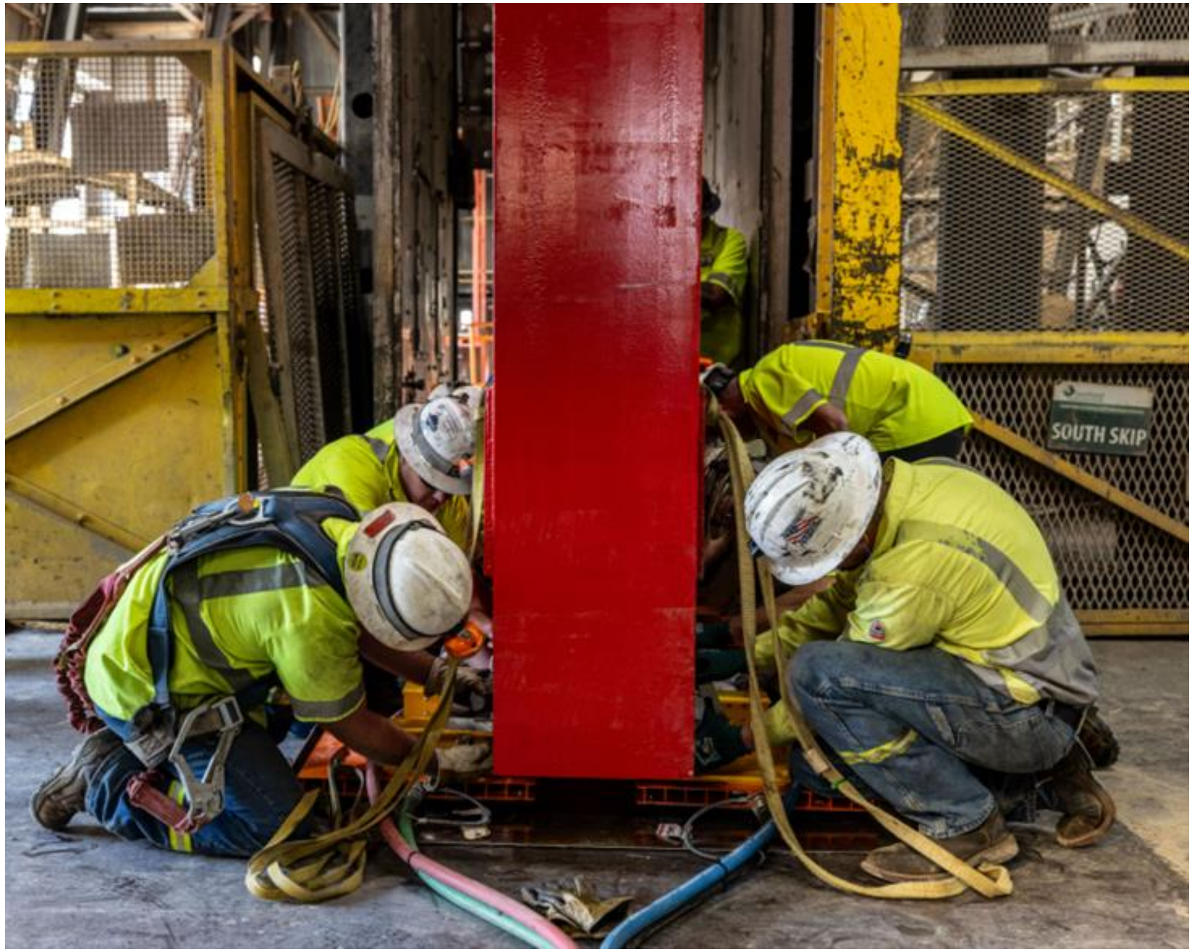
- The air cart was assembled directly in front of the cage so that the L-Beam could be attached to the cart to make the move into the cage.





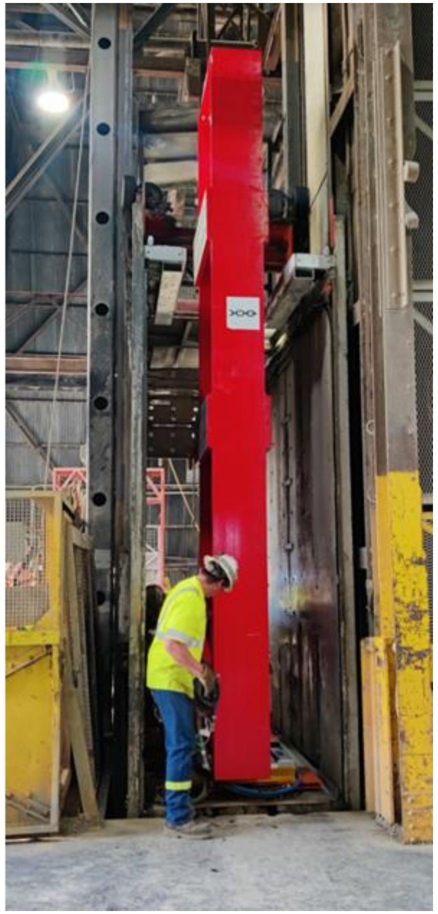
Attaching the L-Beam to Maggie

- The L-Beam was securely attached to the air cart in a predetermined configuration designed to keep the weight distribution within the design parameters.
- Each clamp was torqued to specification and final load angles were noted before raising the Beam on air.



Loading the L-Beam into the Cage

- The L-Beam was lifted on air and slowly pulled into the Cage.
- Some slight adjustments to air pressure were made to adjust the angle deviation.
- Once the Beam was fully loaded on the Cage, air pressure was released and the Beam sat on the air cart and was ready to be secured.

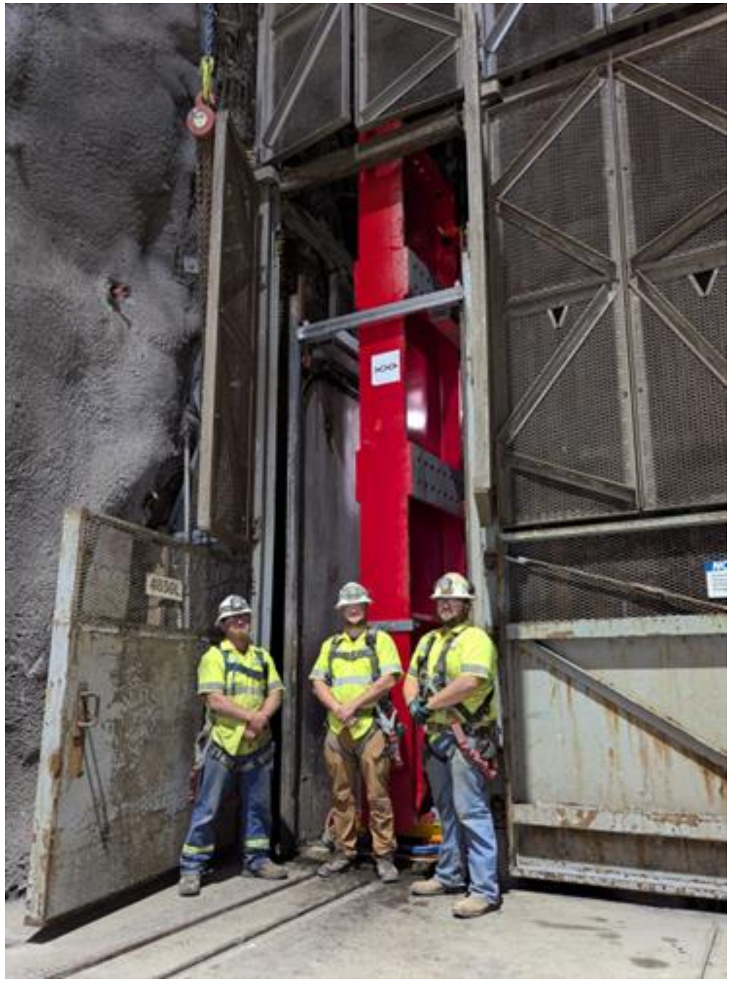


Securing the L-Beam

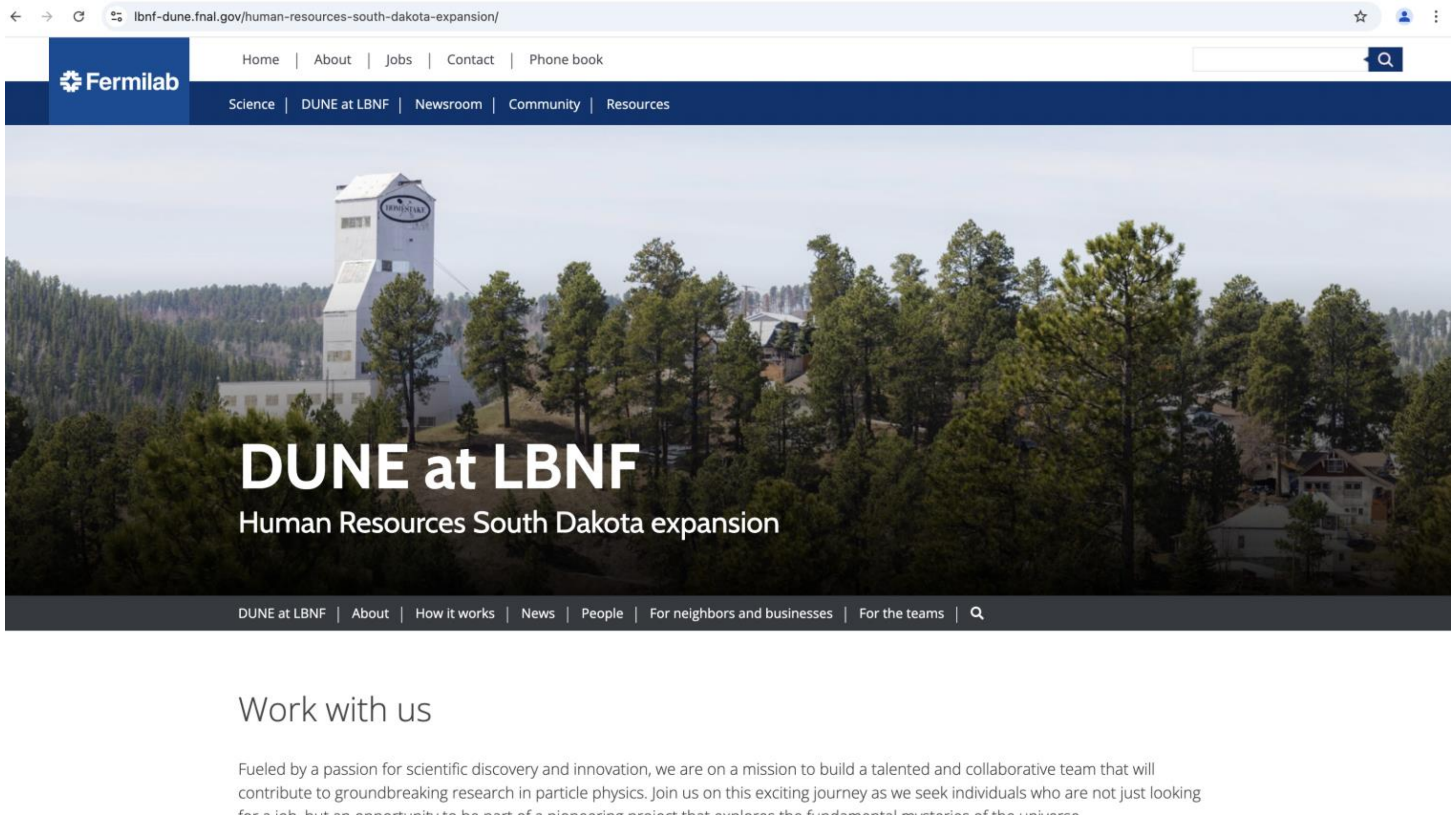
- The L-Beam was secured in multiple spots on the horizontal section of the Beam and near the cage roof on the vertical section.
- Once the Beam was secured, it was ready for its 100ft/minute transport to the 4850 station.

L-Beam arrival at the 4850 level

- The trip from the surface to the 4850 took approximately one hour.
- During the trip, the load was electronically monitored for vibration and shock loads.



Stay connected



Employment: https://lbnf-dune.fnal.gov/human-resources-south-dakota-expansion/

Contracts: [SAM.gov](SAM.gov)

Thank you! Questions?

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