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LBNF Remote Handling Systems

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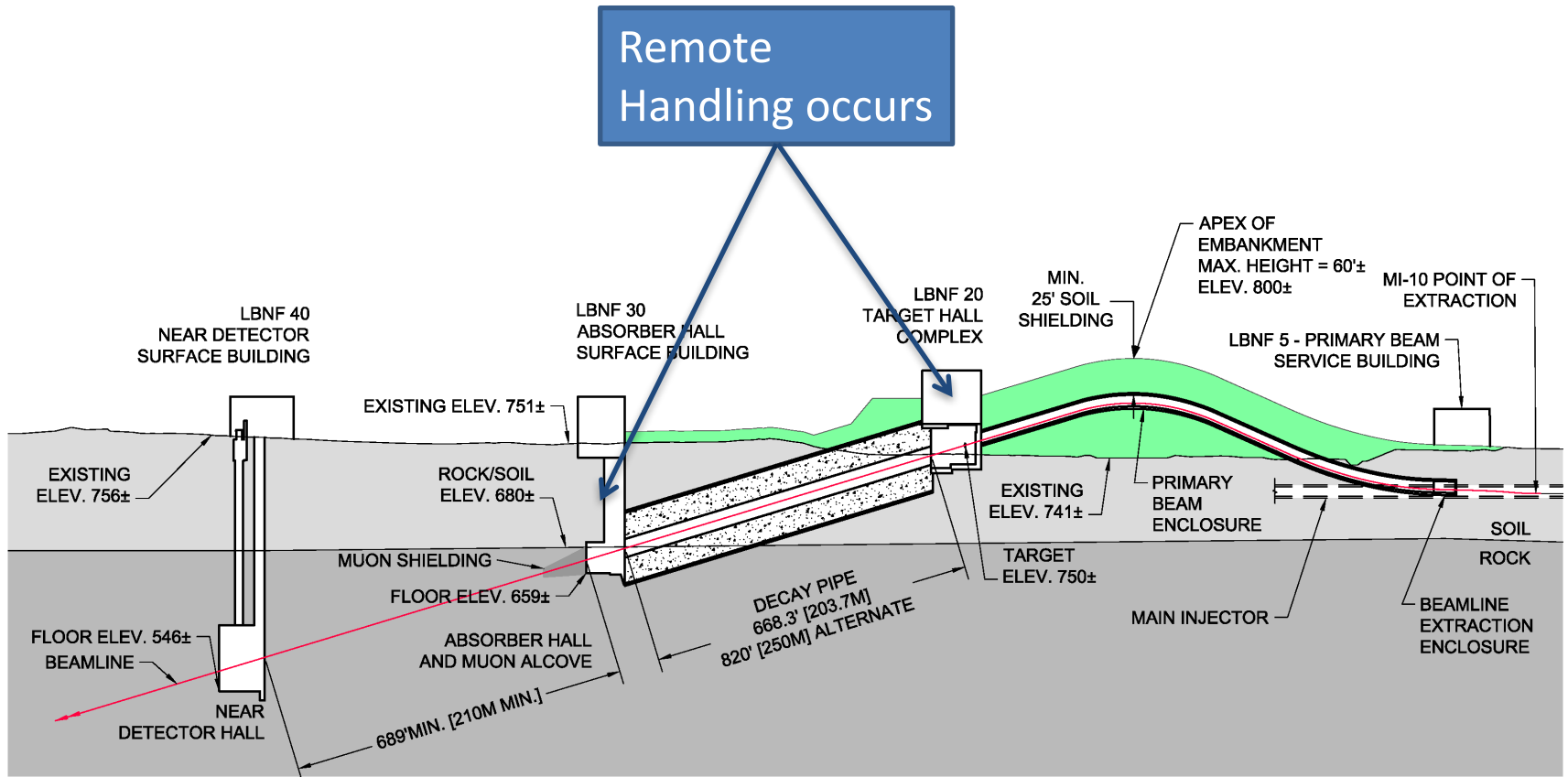
10th International Workshop Neutrino Beams and Instrumentation

19 September 2017

Remote Handling Scope

- Target Hall Remote Handling
 - RH Requirements
 - TH complex RH Facilities
 - *Work Cell*
 - *Work cell door system*
 - *Target exchange fixture*
 - *Horns exchange structure*
 - *Casks*
 - *Components storage morgue*
 - Vision system
 - T-block Storage Pit
 - Shield doors
- Absorber Hall Remote Handling
 - Absorber Hall RH Facilities
 - *HM RH facility*
 - *Absorber hall morgue*
 - *HM replacement procedure*
 - Absorber Hall RAW Shield Door
 - Absorber Hall Access Shield Door

LBNF Beamline Map



Remote Handling Equipment Requirements(2.4 MW Beam Operation)

Reference Design

Component Name	Weight (kg)	Replacement Frequency (per yr)	Dose Rate 10 day (R/hr)
Target/Baffle Carrier	500	2.5	40
Horn 1	1,500	0.3	900
Horn 2	2,000	0.3	110
Horn 1 Stripline Block	10,000	0.3	1,000

Optimized Design

Target	50	2.0	40
Horn A	2,000	0.3	1420
Horn B	4,000	0.3	900
Horn C	3,000	0.3	2,500
Horn-A Stripline Block	10,000	0.3	1,000

Target Complex Remote-Handling Facilities

The Target Hall (left side of picture) and Service Building (right side) make up the Target Facility Complex. They are joined by a large hallway, equipped with a rail system and a sealed, shield door to enable transfer of components and casks between the two sides.

Target Hall

- Work cell
- Remote Operations Center
- T-blocks pit

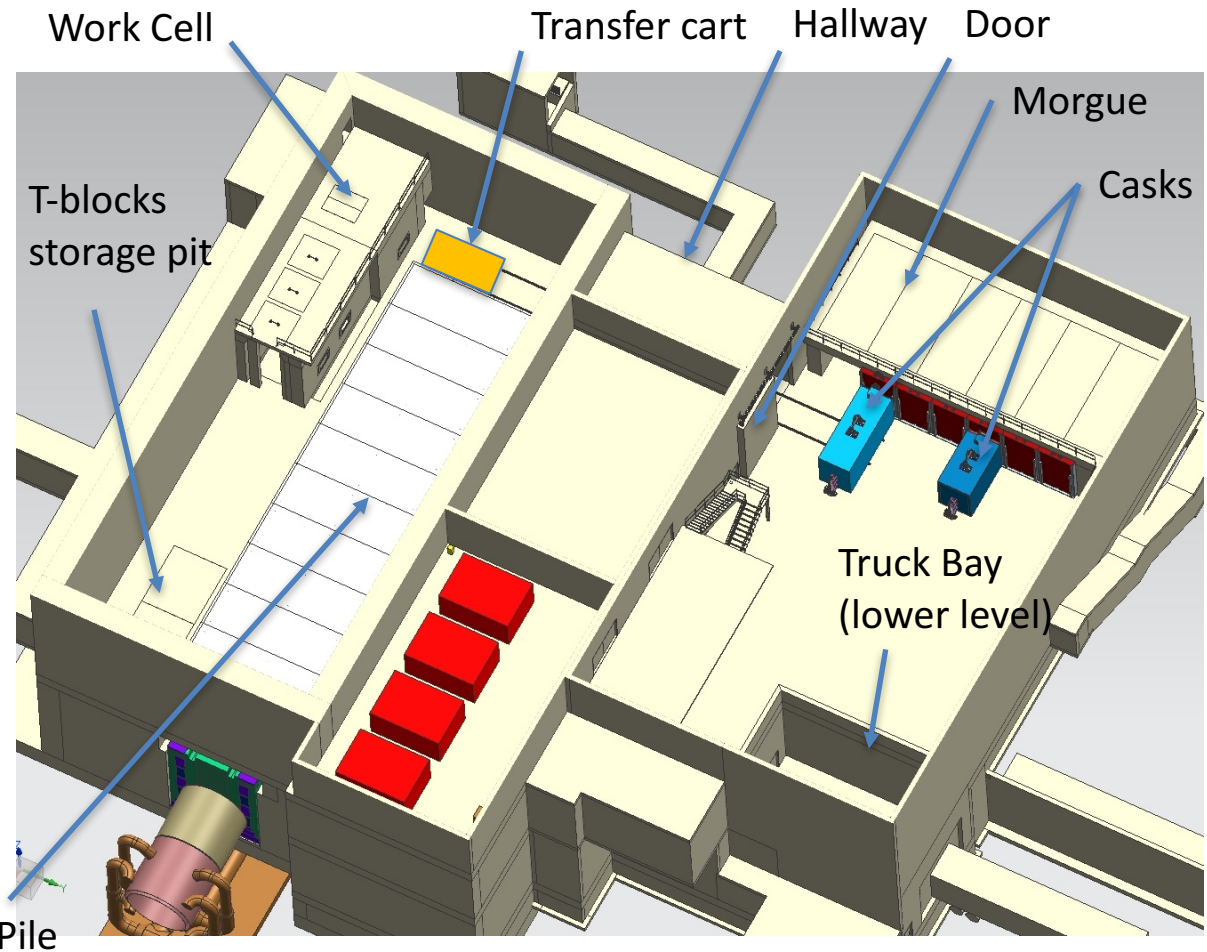
Service Building

- Morgue (short-term storage)
- Truck Bay
- Access to Utilities rooms

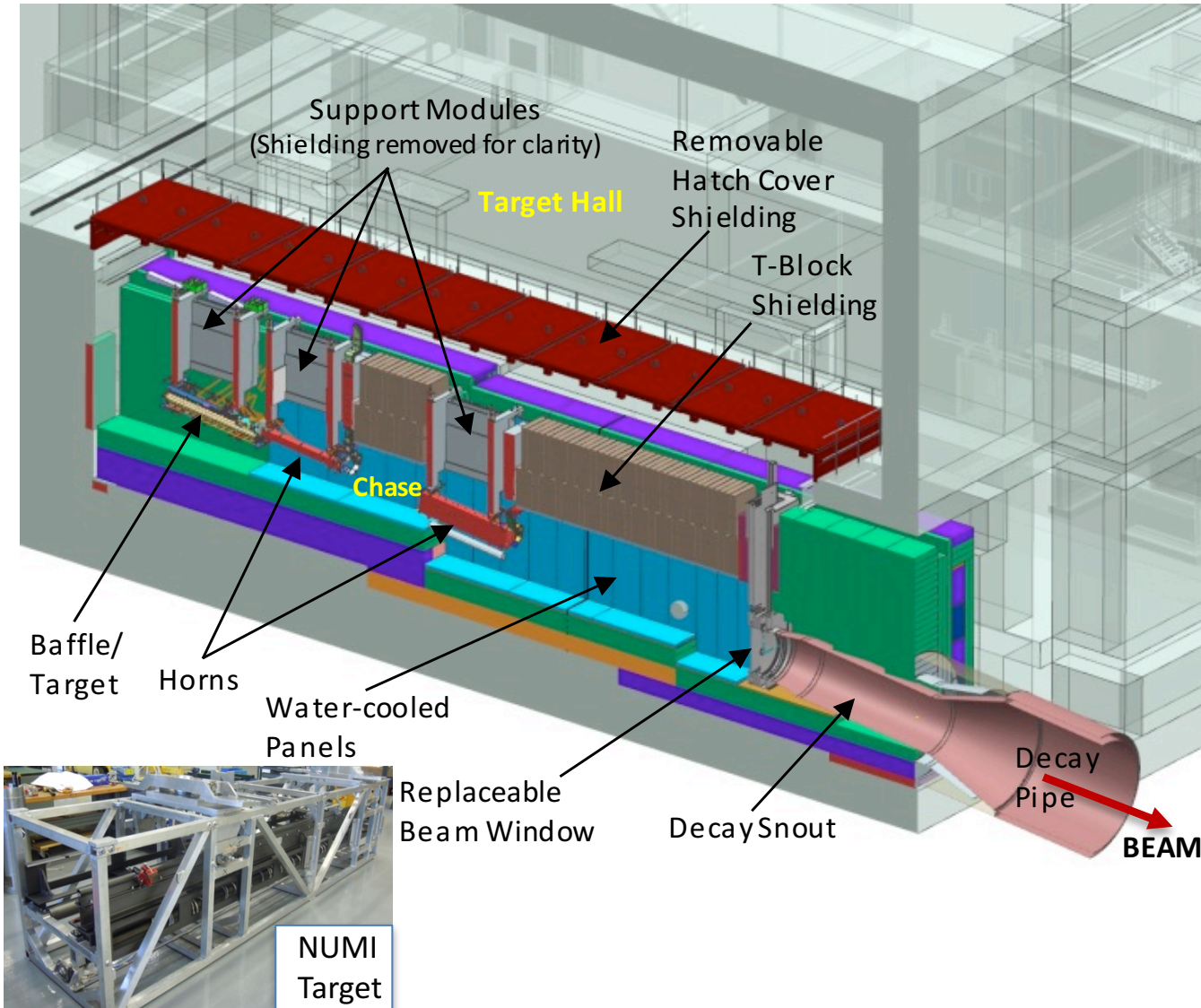
Equipment

- Casks
- Transfer cart & rail system
- Lifting fixtures
- Remote vision systems

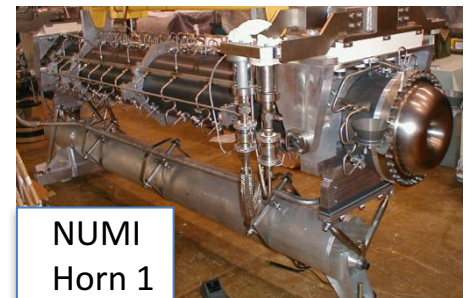
All Remote-Handling operations are provided by using the bridge cranes (60 ton) with redundant drives in both the target hall and the morgue/maintenance area.



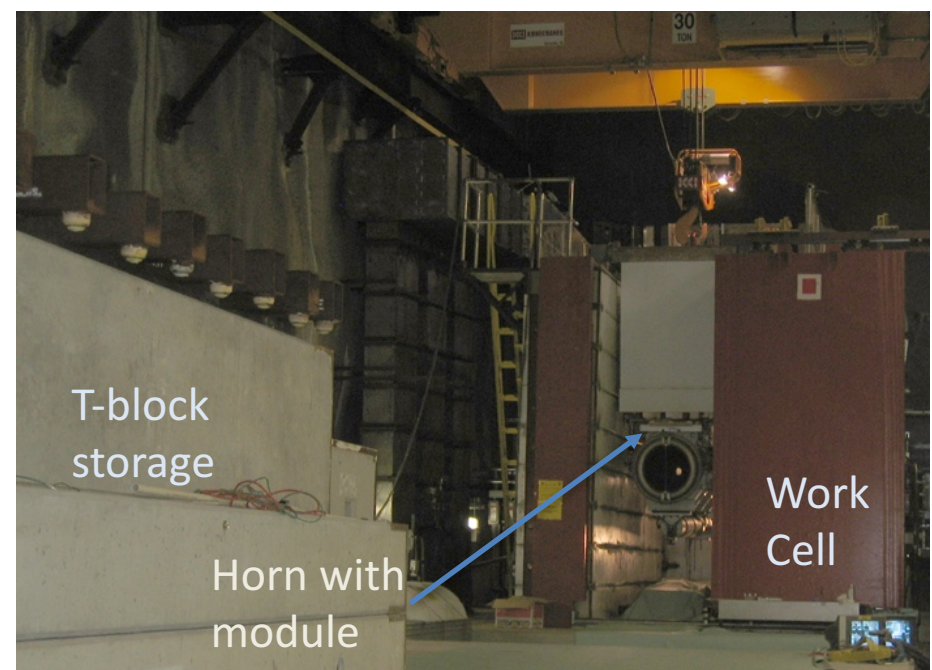
Target Shield Pile layout ,Reference design



The reference design of the LBNF beam components was based on the NUMI style target and horns. The Remote Handling equipment such as lifting fixtures, transportation cask, transfer cart could be used in the LBNF target hall. Target Chase: 2.2 m/2.0 m wide, 34.3 m long.



Real life examples from NUMI Target Hall

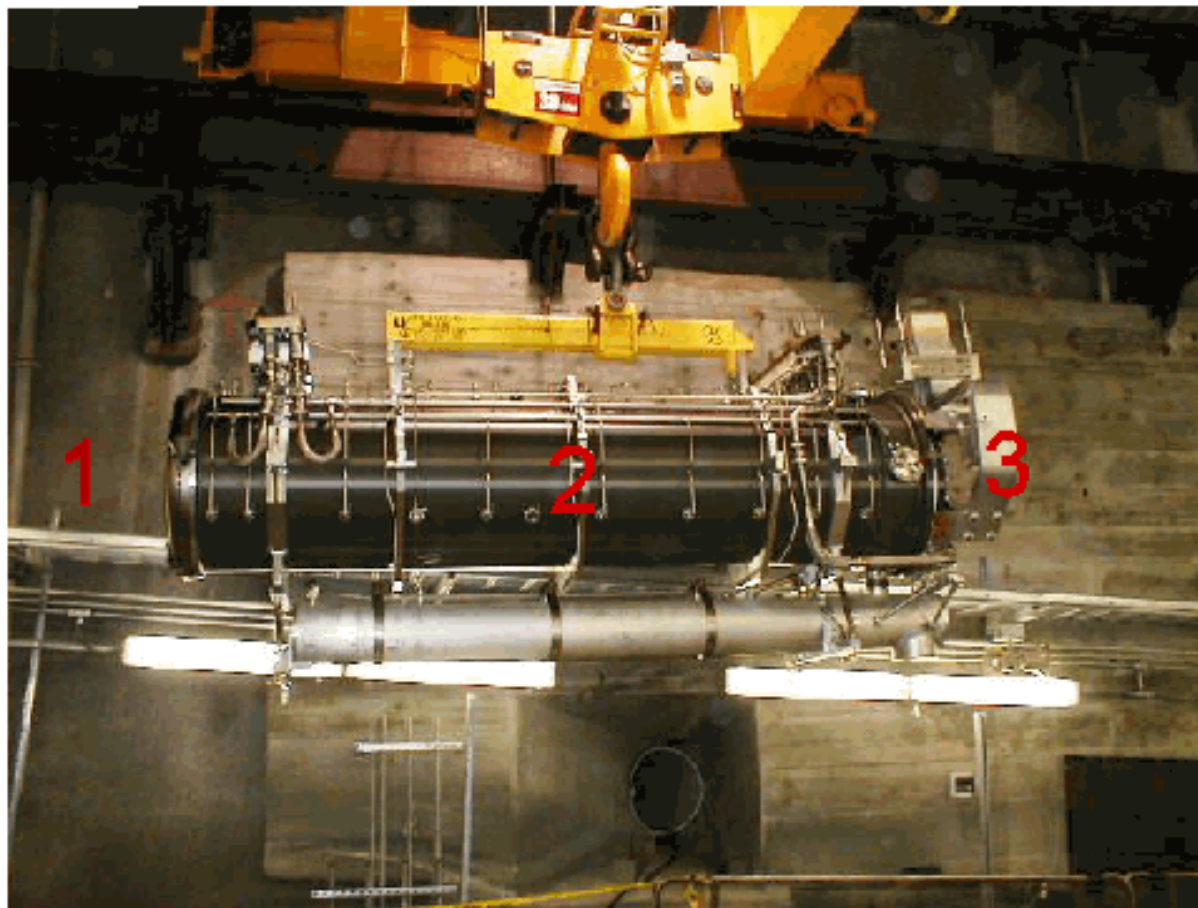


Numi Horn 2-01

Doserates
@ 1 foot (mr/hour)

Point

1	3000
2	3000
3	5000



All Dose Rates Below <u>N/A</u> mR/hr Unless Noted.		Bgnd <u> </u> cpm		Highest Dose Rate Found <u>5000</u> mR/hr at 1 ft.	
Inst Type: <u>Teletector</u> Inst No: <u>4</u> Batt/Source Chk: <u>SAT</u> Cal Due Date: <u>6/2011</u>		Wipe # <u> </u> Reading <u> </u> cpm <u> </u> <u> </u> cpm <u> </u> <u> </u> cpm <u> </u> <u> </u> cpm <u> </u> <u> </u> cpm <u> </u> <u> </u> cpm		Note: RSO approval required to work in areas where it is: >100 mR/hr @ 1 foot OR >100 CCPM on a wipe. Comments: <u> </u> <u> </u> <u> </u>	
LEGEND Numbers appearing on map are mR/hr @ 1 ft readings unless denoted with symbols below * = mR/hr @ contact A = Air Sample ○ = Wipe ⊙ = Floor wipe				Surveyed By: <u>Busch</u> Reviewed By: <u> </u>	

Operations remote viewing system

The video system is integral to all remote handling steps.

Video Center



Video cameras



Target
Hall



Crane

Work cell



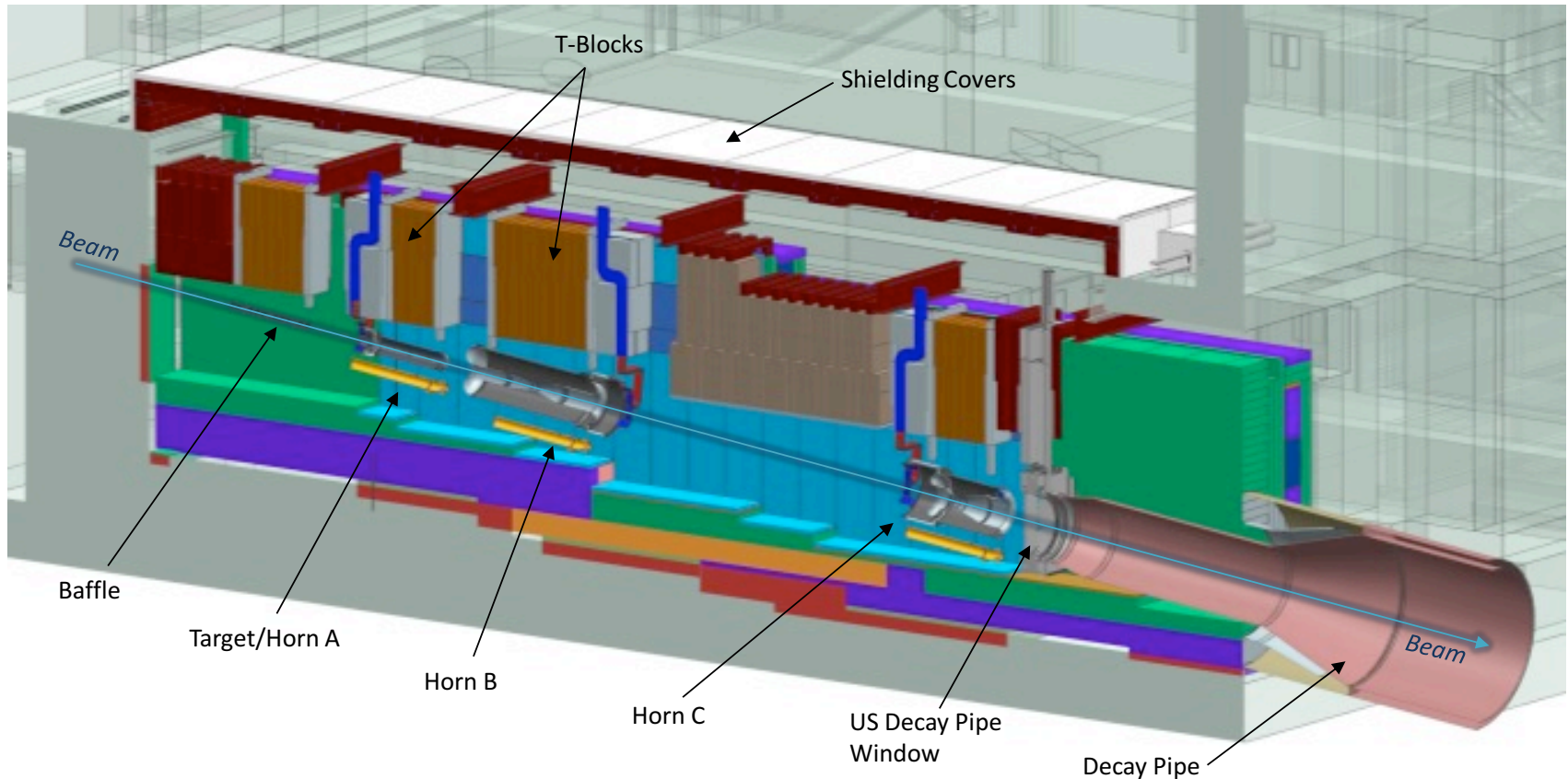
PELCO SD4-W0 SPECTRA



SD4-W0

Optimized Design Target Pile Enclosure

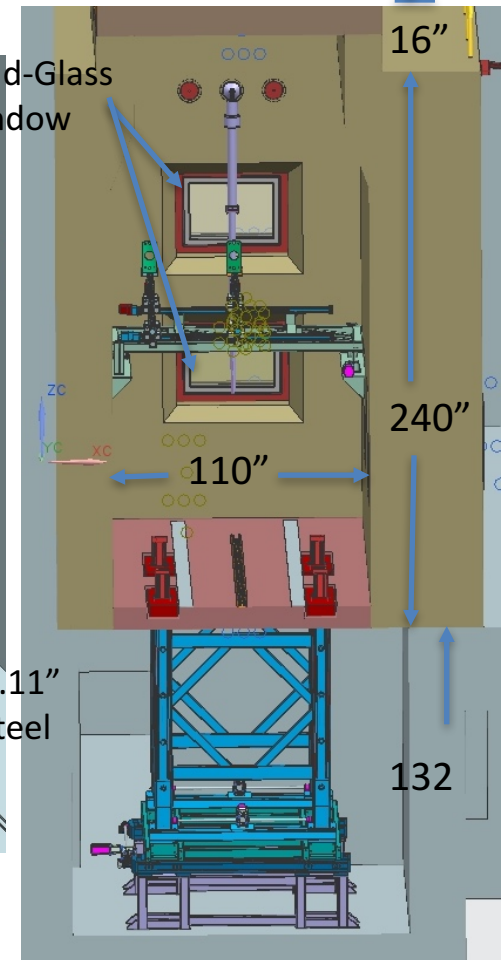
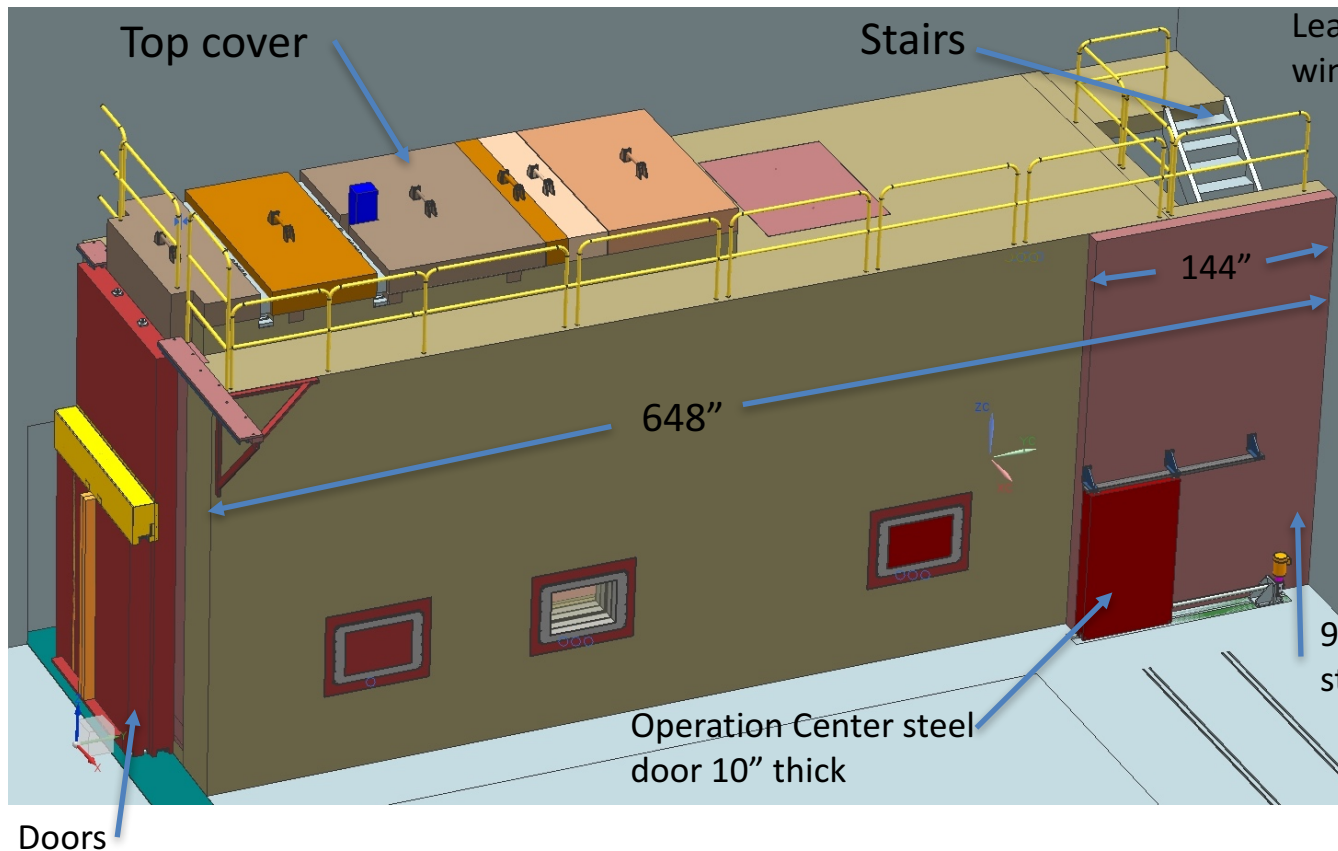
The new design of the LBNF beam components requires larger Remote Handling facilities and new equipment.



Horn A is relatively normal in proportion to NUMI horns.
Horn B has larger diameter and is longer.
Horn C has the same as Horn 2 diameter but is shorter.

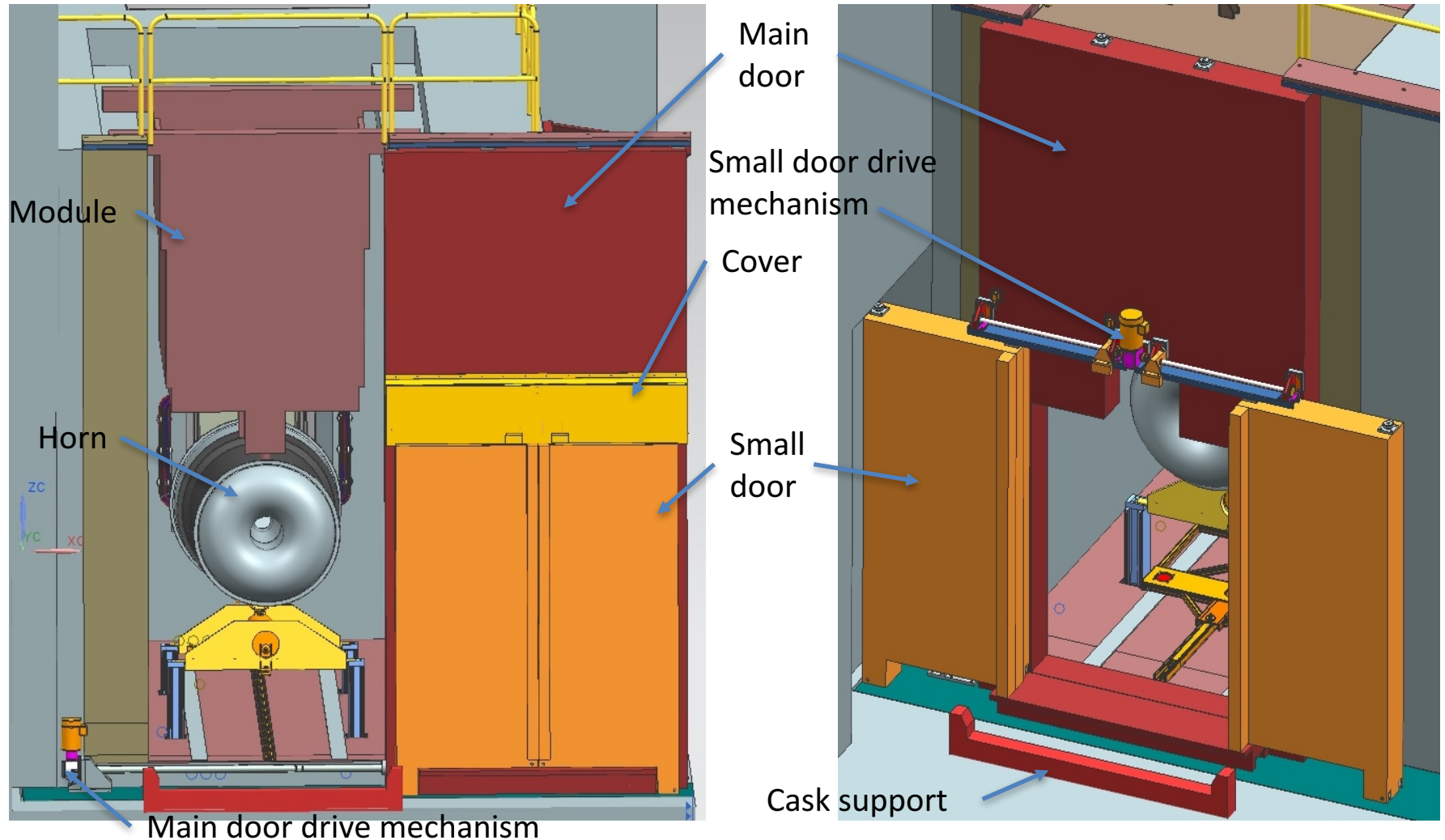
Work Cell

The Work Cell and Operation Center are located in the right corner of the upstream end LBNF Target Hall. The Work Cell is equipped with remotely operated door assembly, remotely operated horns exchange structure, remotely operated target exchange fixture, manipulator, and video cameras. Three Lead-Glass windows are installed instead two in the reference design. The top shielding covers (14" thick steel blocks) are installed and removed by crane remotely. The Optimized design Work Cell is longer, wider and taller than reference design work cell.



Work Cell Door System Design

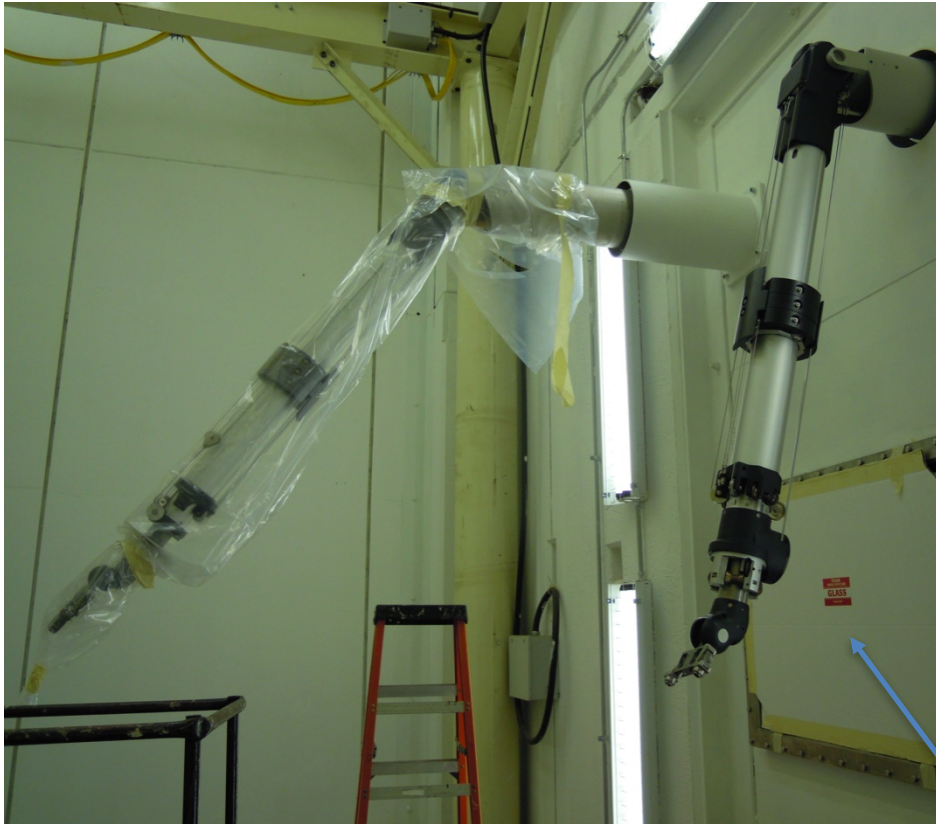
The work cell door has two separate door systems. The main door dimensions are 12"x112"x240". The main door has hole covered by two small doors. The main door weight is 33.25 ton . Small doors weight is 12 ton. The main door is equipped with four 15 ton capacity Hillman rollers. Small doors utilize four 3" diameter rollers . Both doors are moved by the main door drive mechanism. Small doors have independent drive mechanisms located on the main door.



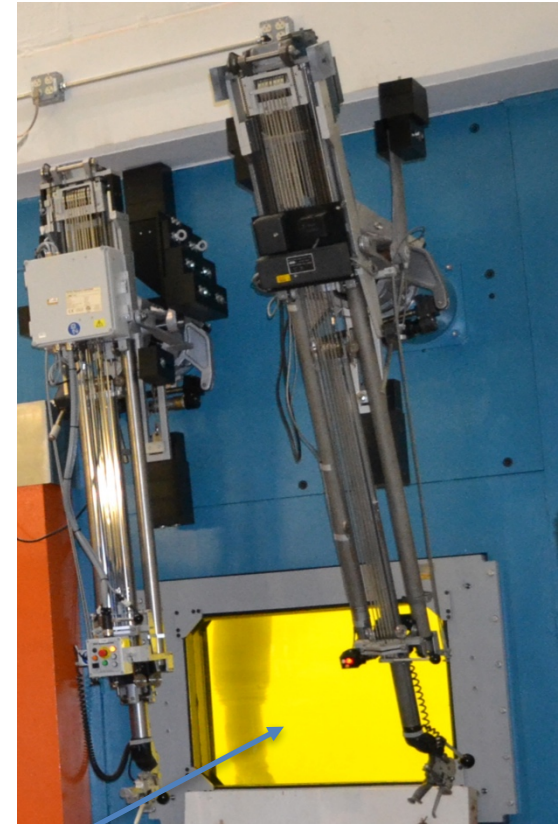
Fermilab C-0 long term storage Facility Hot Cell

Pb-glass window and manipulators

“Hot” side / Slave side

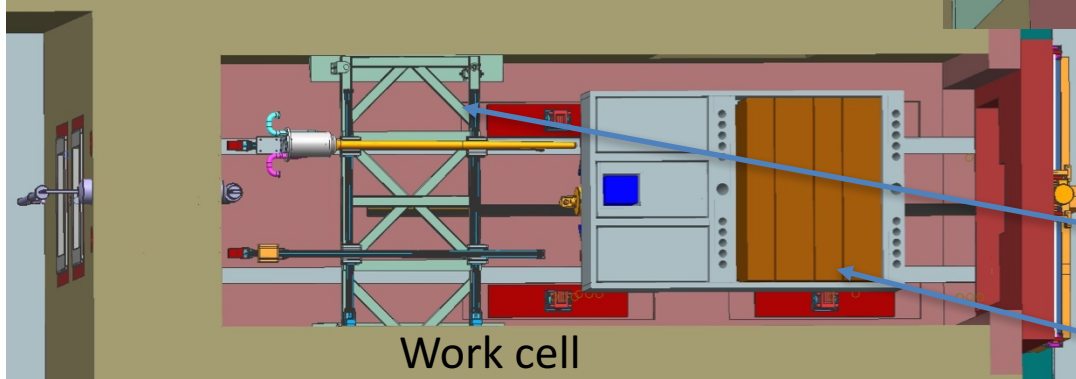
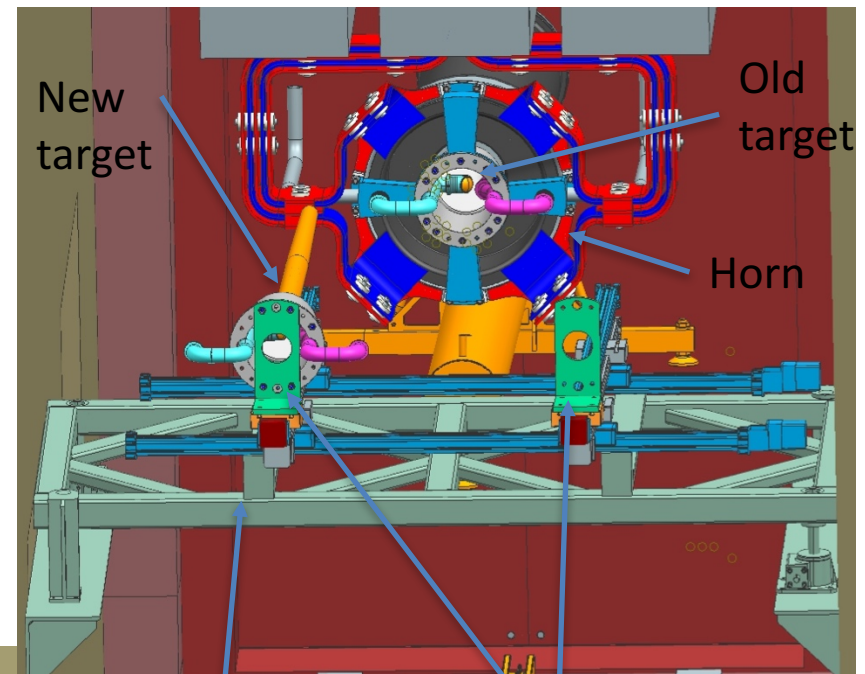
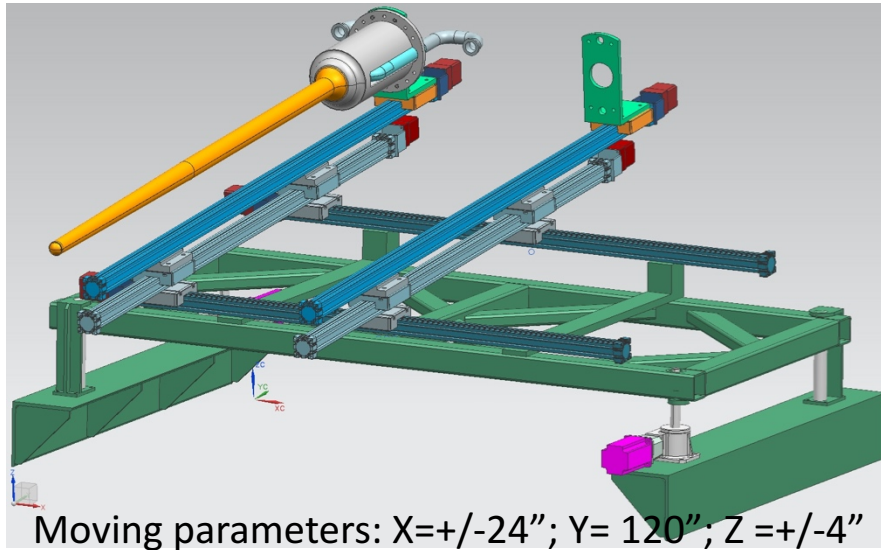


“Cold” side / Master side



Pb Glass
window

Target exchange fixture (based on successful T2K design)



Angle bracket

Target exchange fixture is installed in the front of the Horn A.

Module

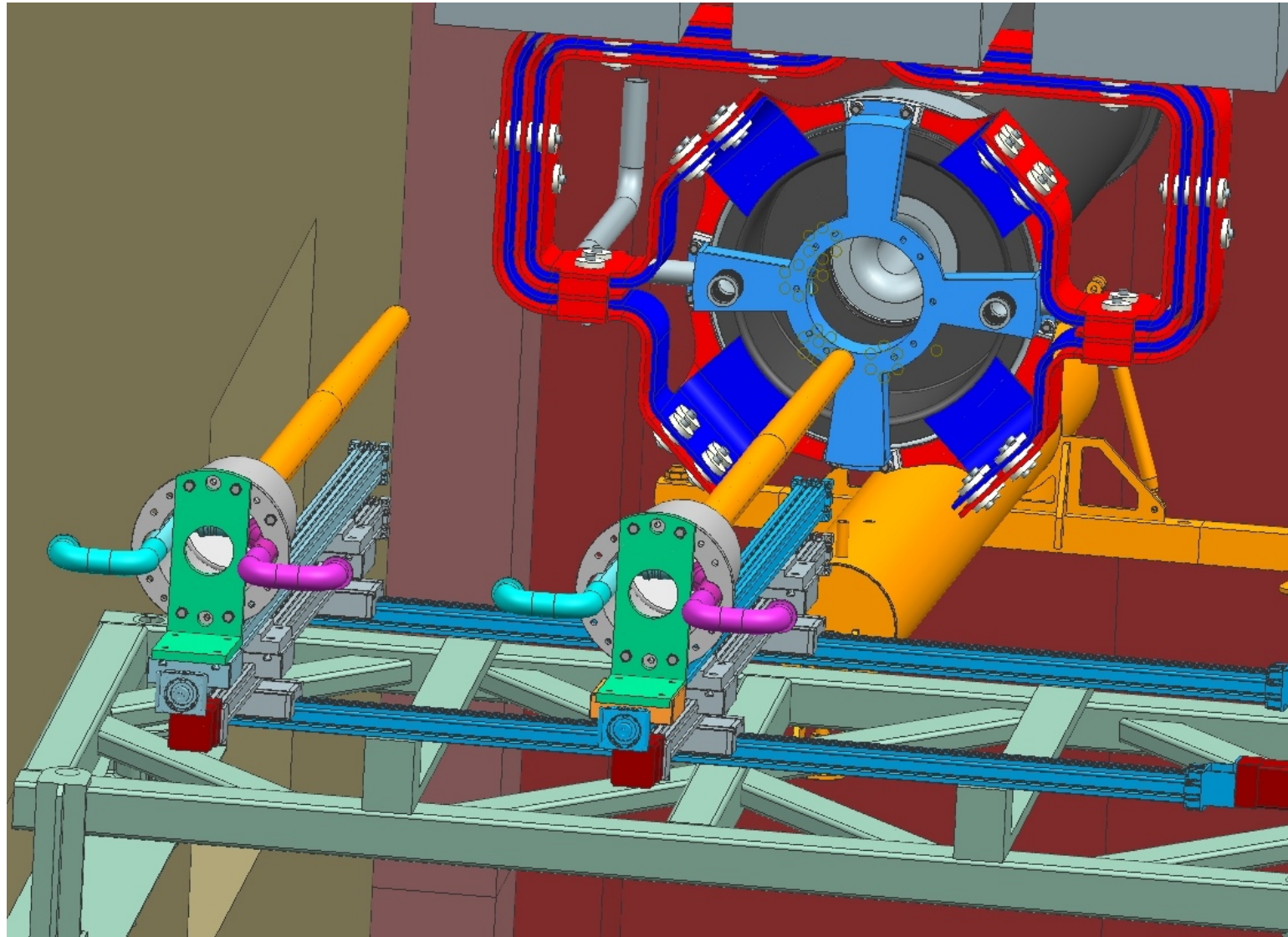
- Two pairs of linear actuators provide target exchange during RH operation.
- Another two actuators move the targets transversely to exchange position of old and new targets.
- Two screw jacks and two guide rods providing a vertical movement.

Target exchange procedure

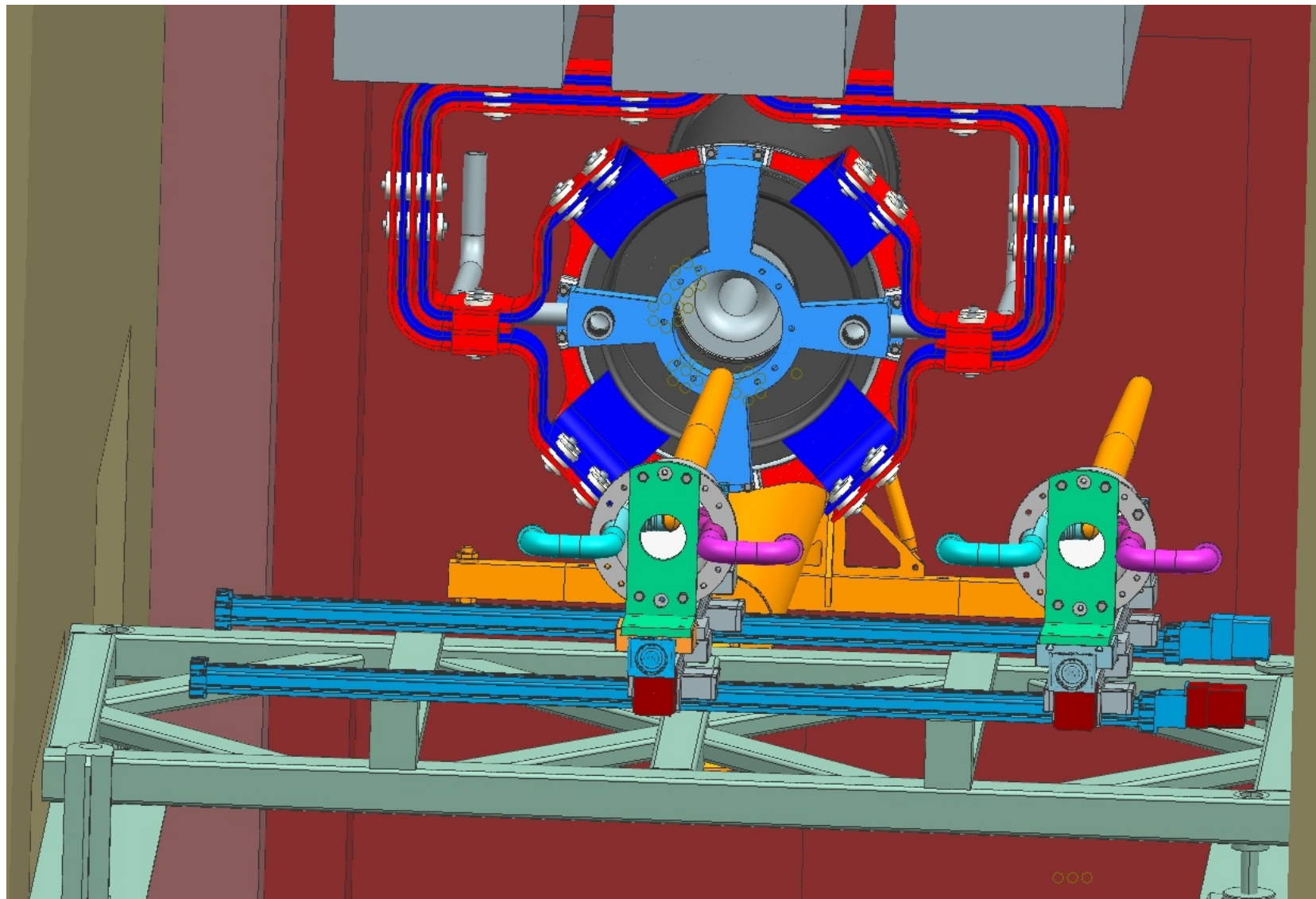
An angle bracket is aligned, moved toward the target till contact and bolted to the target.
The target holding screw are unscrewed and He lines disconnected.



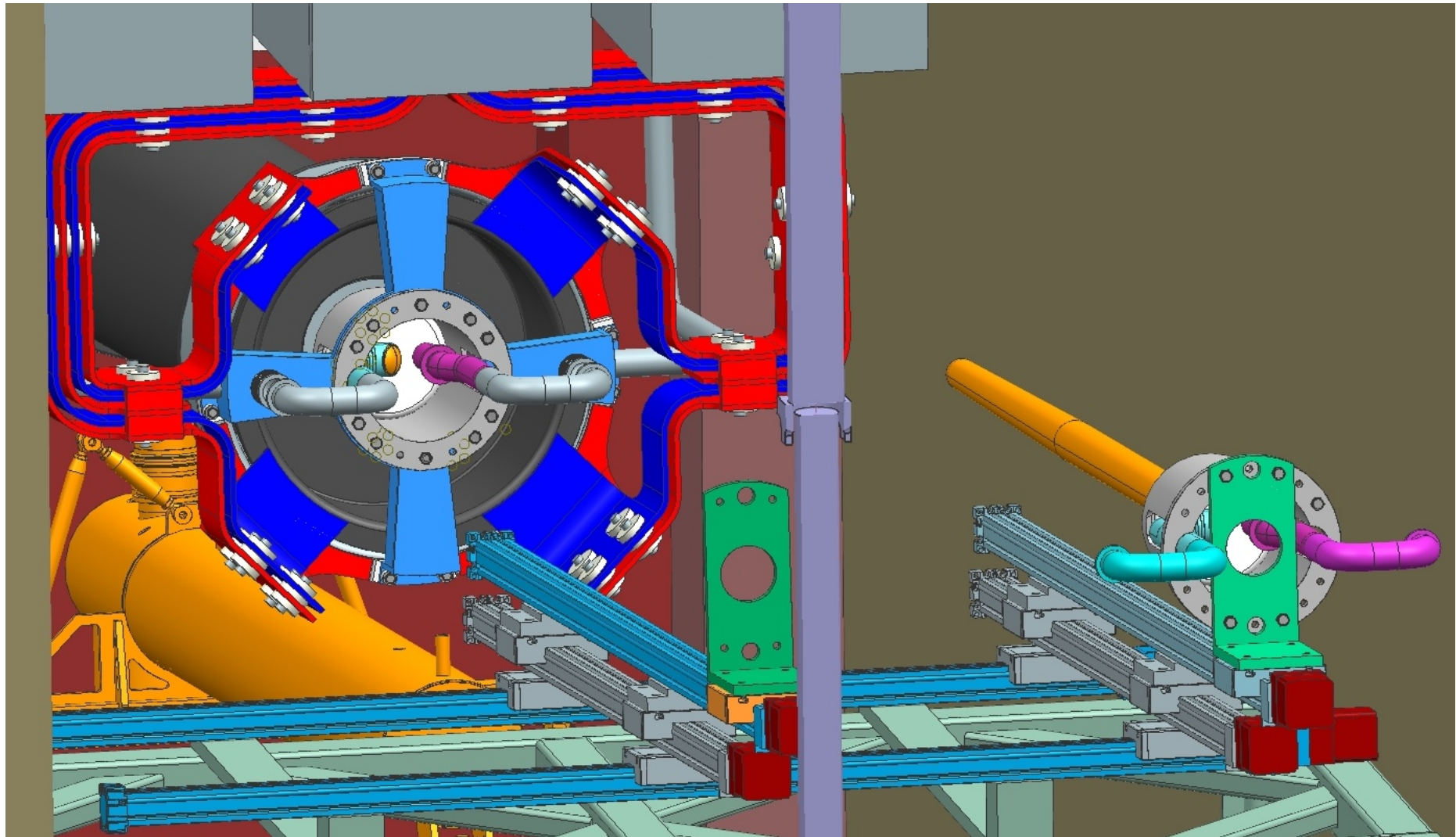
The target is pulled out from the horn



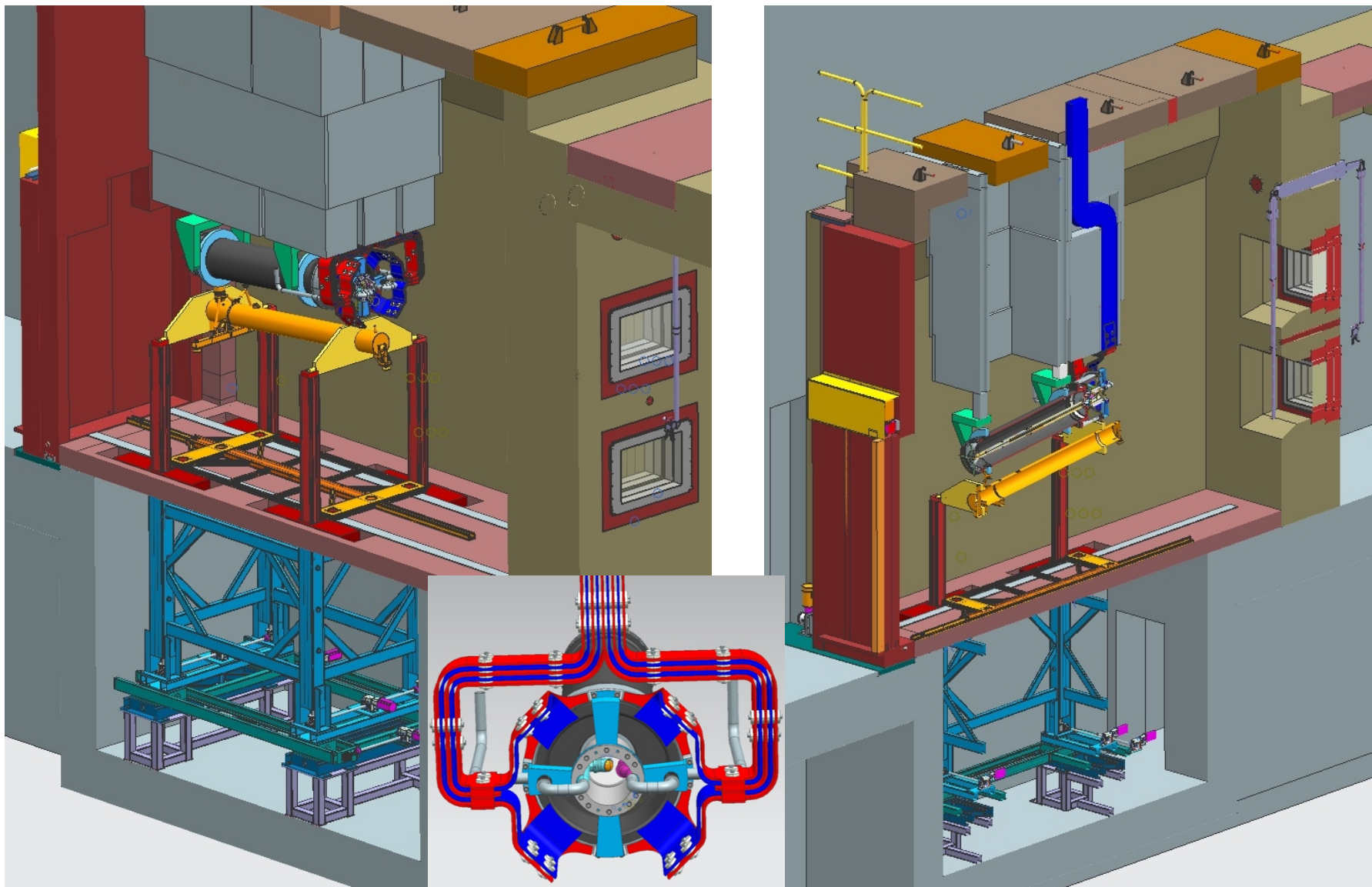
Old target is moved to the side and new target is aligned with horn



The new target is bolted to the horn and connected to the He lines.
After the Horn A installation in the target pile, the old target can be moved out from work cell by using the Horn A cask and stored in the morgue.



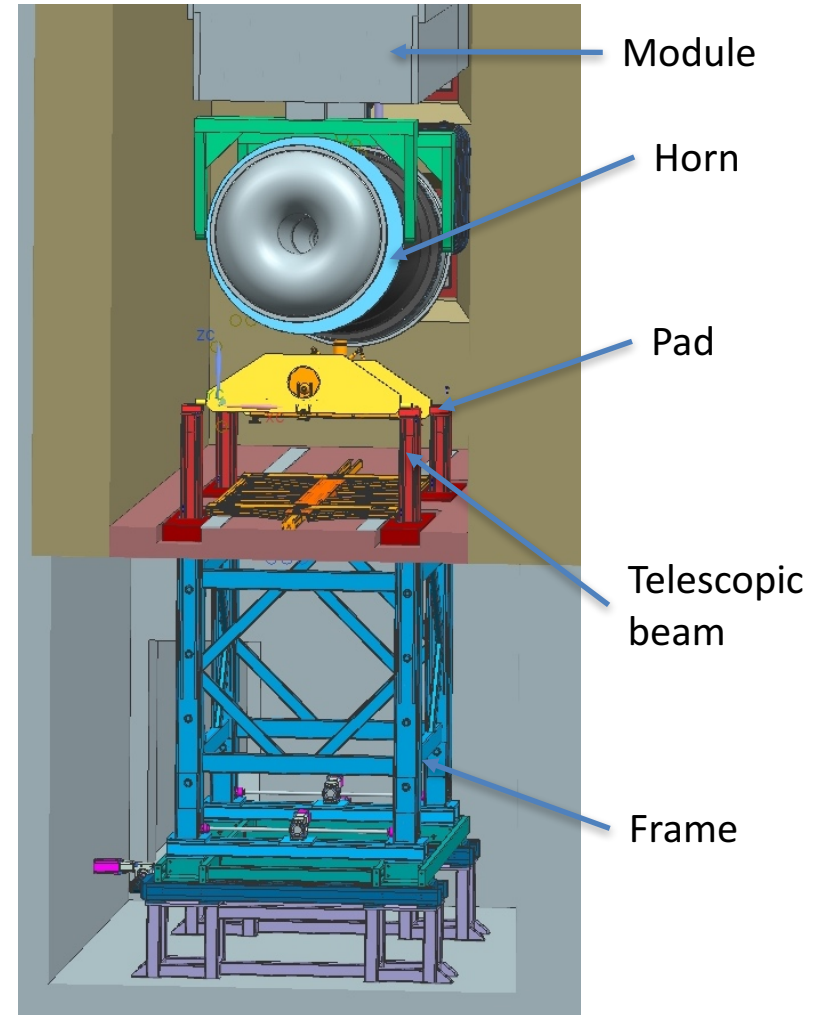
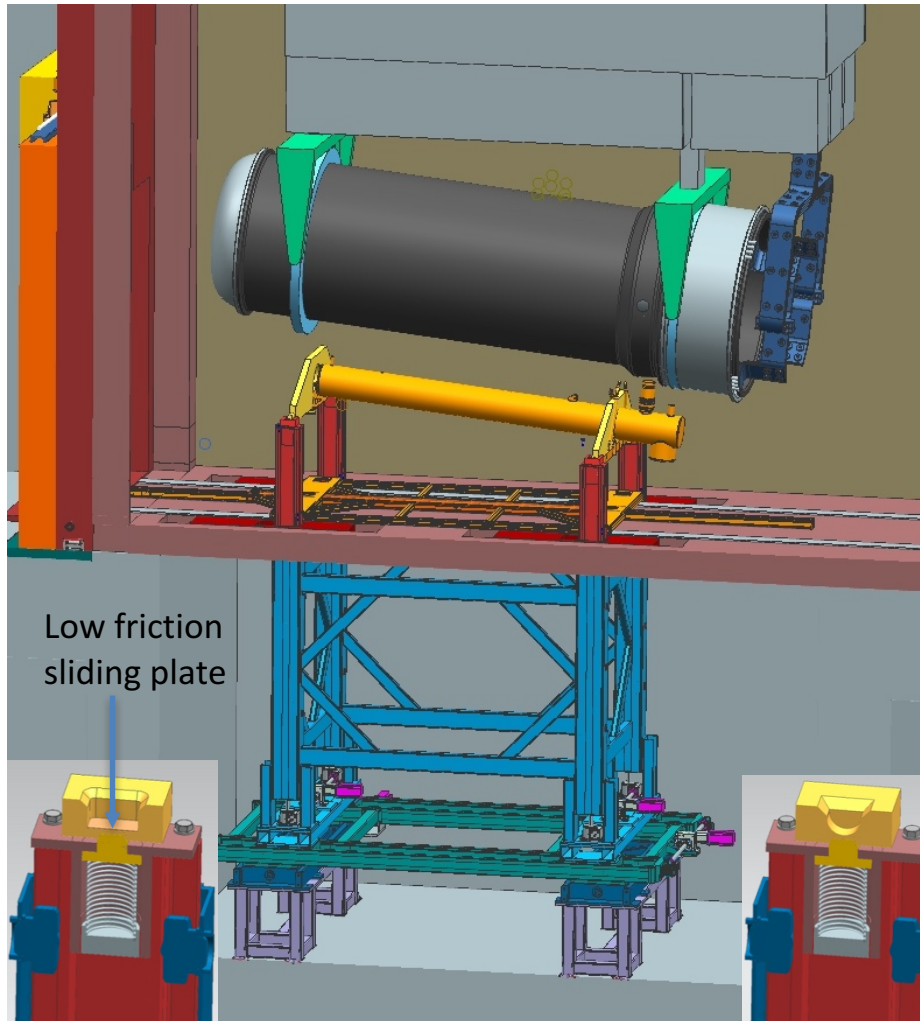
The failed Horn A can be replaced with target together. In this case the target exchange fixture isn't installed in the work cell and the horn replacement procedure will be followed.



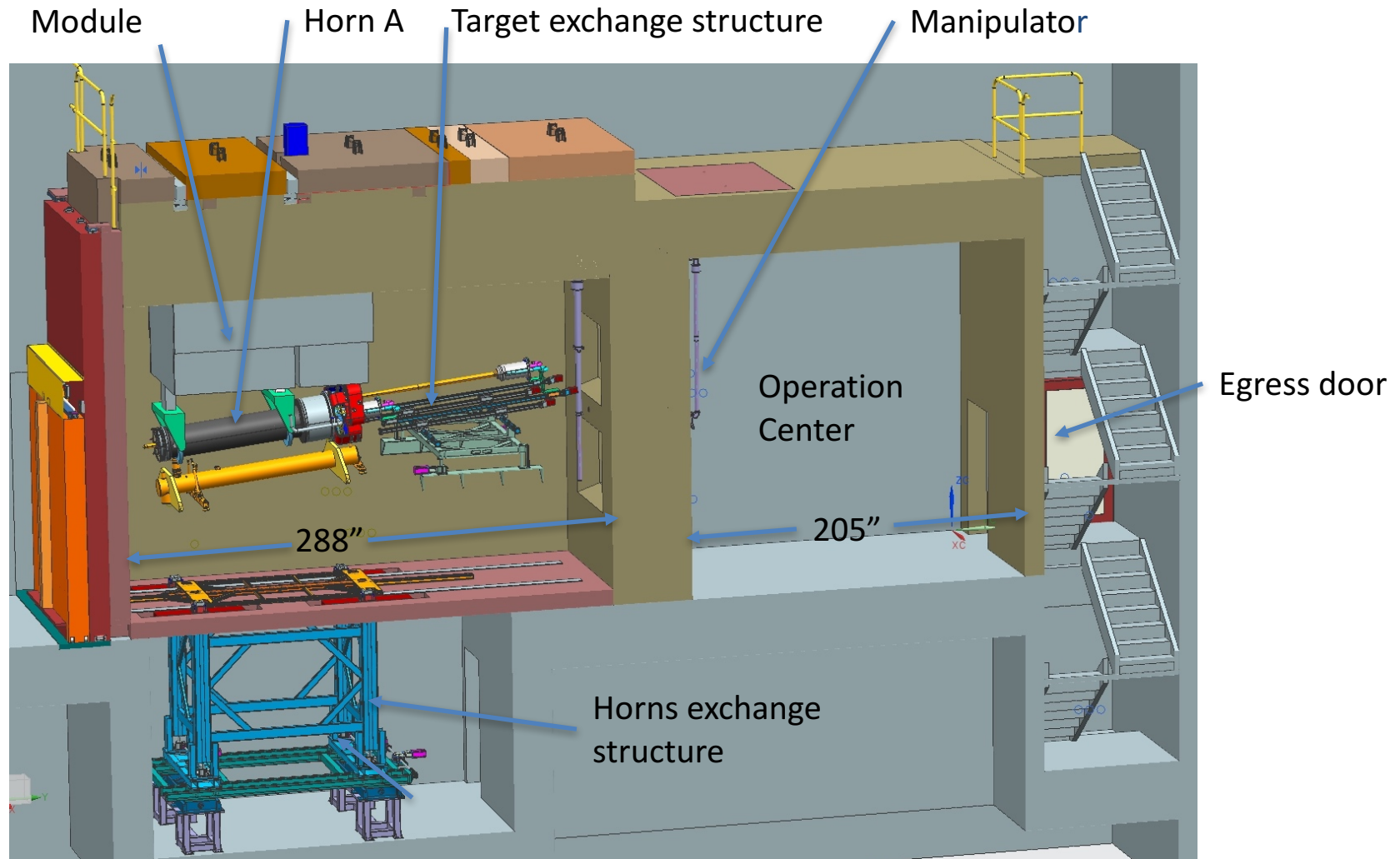
Optimized design horn exchange structure

The exchange structure is located in a room under the work cell floor. The frame with motorized screw jacks is mounted to the floor. The screw jacks move the telescopic beams vertically and can create a needed angle for attaching horn to the module. Pads with slotted grooves are bolted to the top of beam to hold the horn.

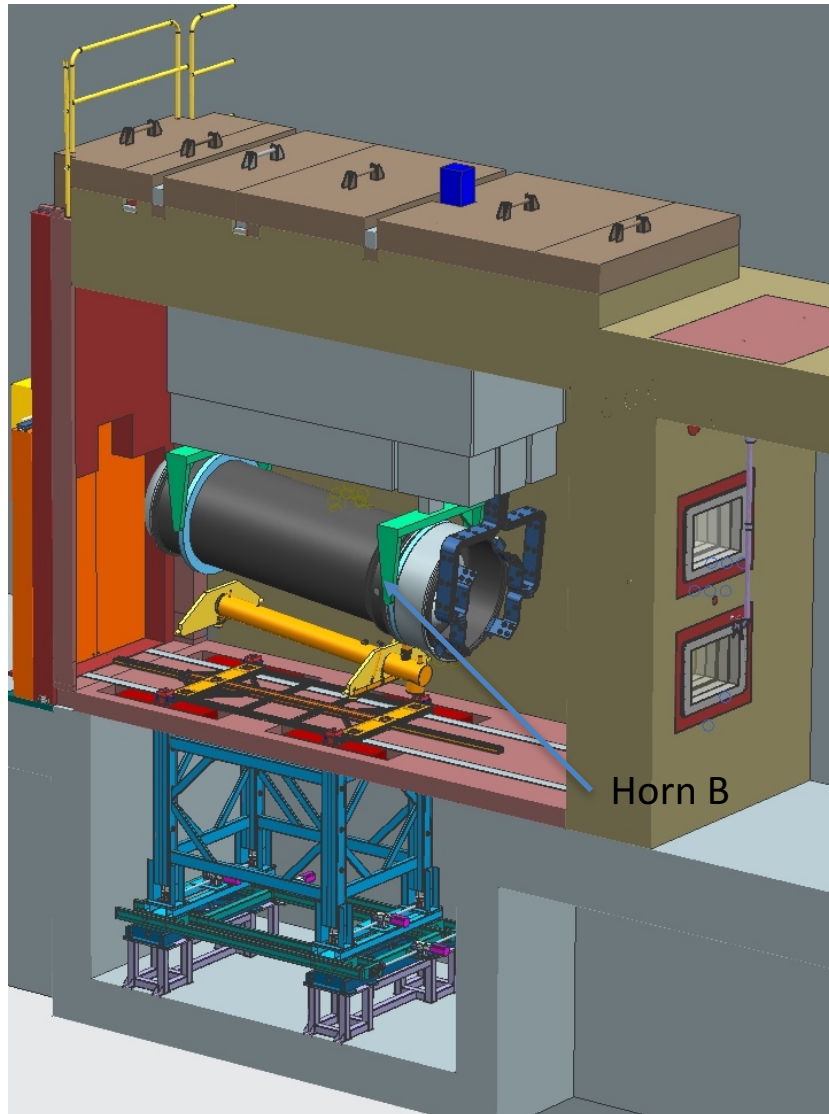
Structure movements: Vertical Z = 70in., Horizontal Longitude X = $\pm 10''$, Transversely Y = $\pm 2''$



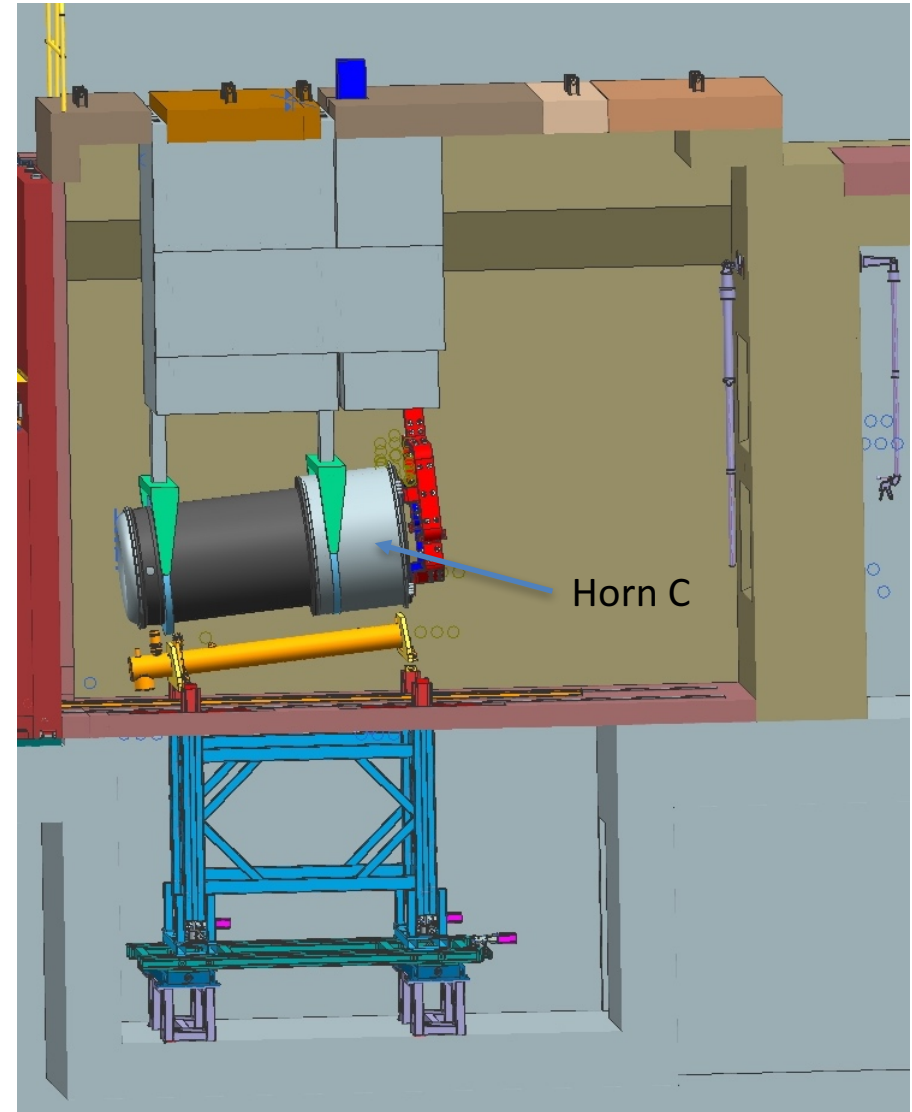
Horn A in the work cell



Horn B in the work cell



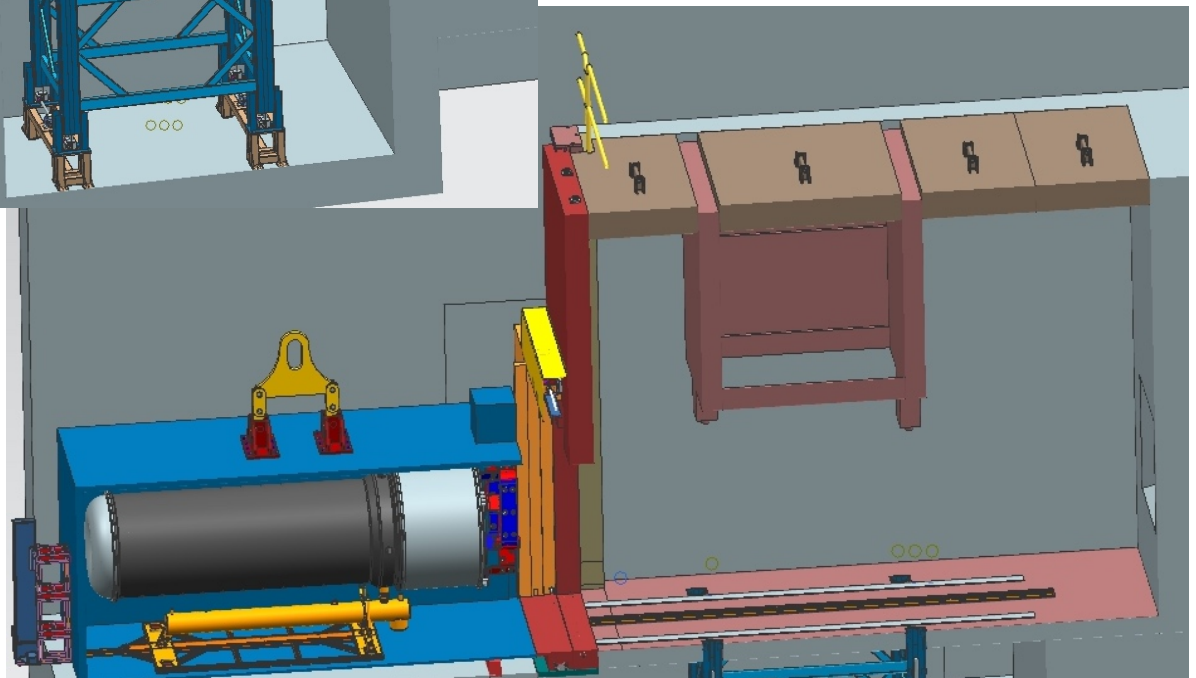
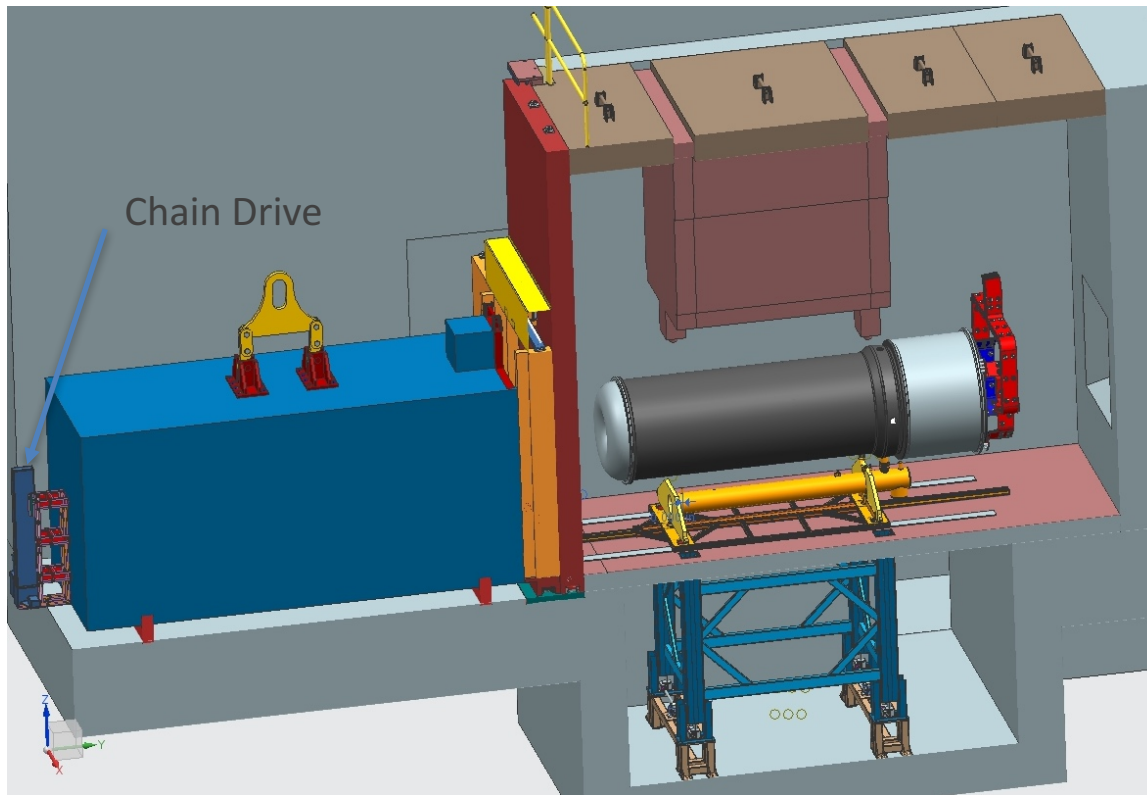
Horn C in the work cell



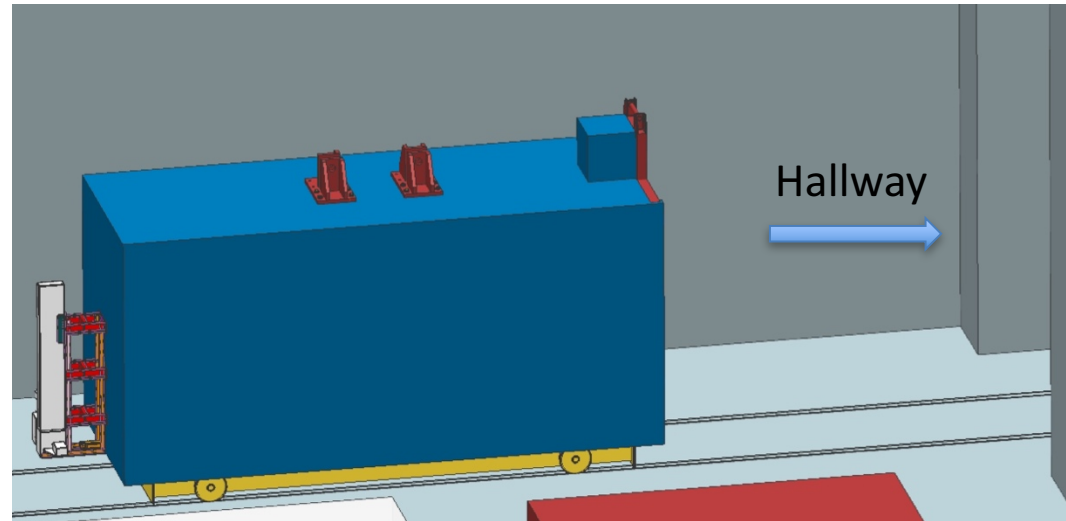
Horn exchange

The horn is disconnected from the module, lowered down by the structure and placed on the cart.

The cart with the horn is pulled into the cask by a chain drive mechanism. The small door of the work cell is open. The cask door open.



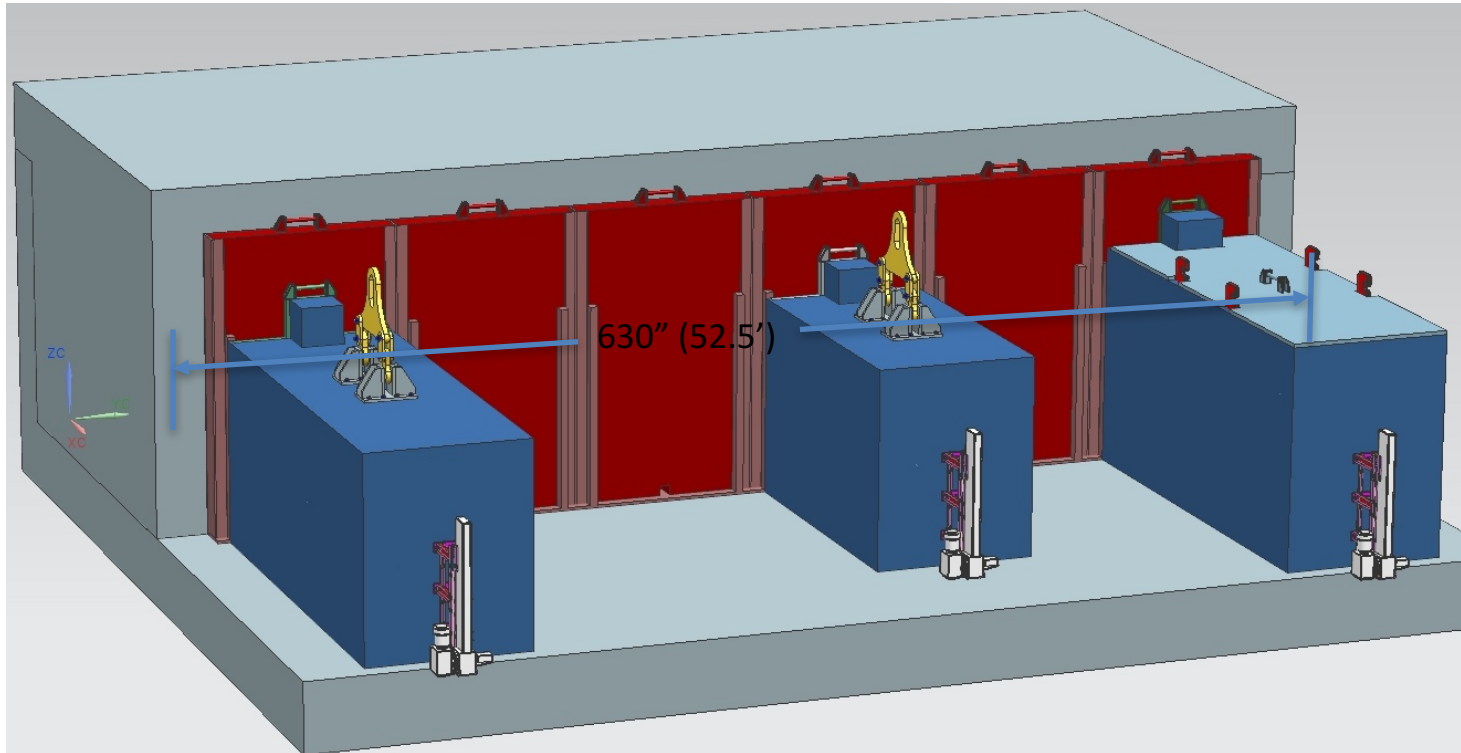
The cask with closed door is placed on the transfer cart by crane and moved from the target hall to the morgue area through the hallway, where the horn is uploaded into the morgue storage cell.



Temporary Component Storage in Morgue

Fermilab to provide long-term storage and disposal of activated components after 2 years of temporary storage in the LBNF Target Complex Morgue

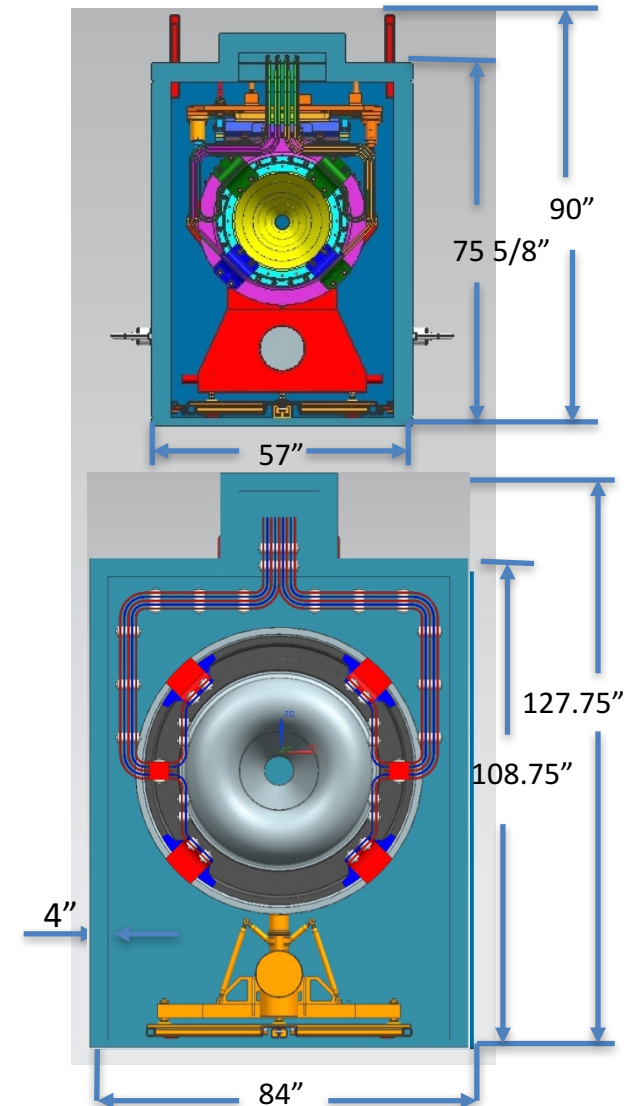
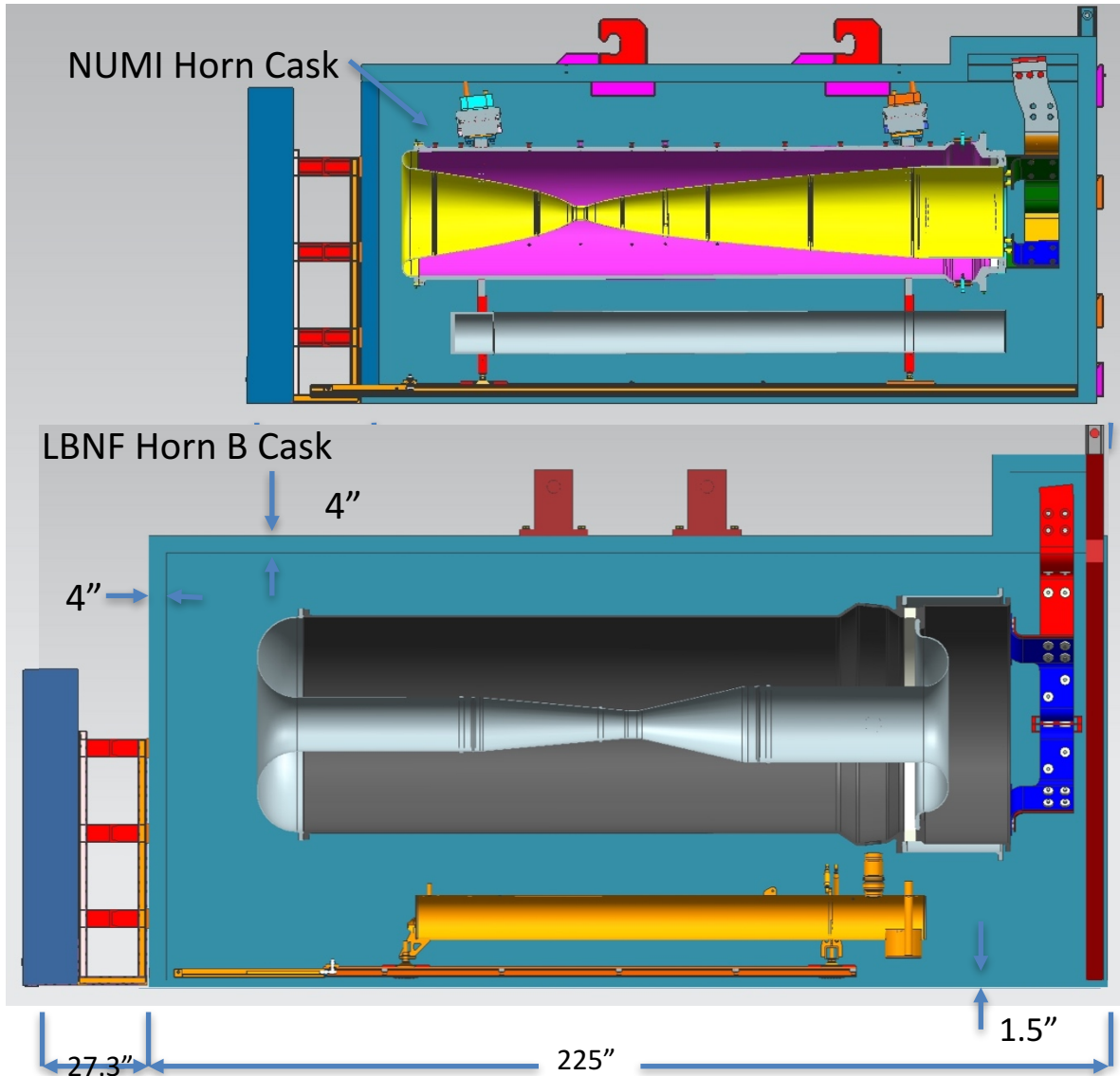
- 6 bays easily accommodate 2 horns and 2 targets expected in first 2 years



After 2 years Horns A and C will be transferred into the new long-term storage facility in the C-0. The target and stripline block will be stored in the old long-term storage facility TSB.

Horn B Cask

The LBNF Horn B cask is 53" longer, 27" wider and 34.75" taller than NUMI Horn cask. The NUMI cask with horn weight is 30 ton, the LBNF cask with horn weight is about 52 ton.



Absorber Hall Remote Handling Facilities

- 30 ton bridge crane
- Cask system
- Small transfer cart
- Hadron Monitor Exchange system

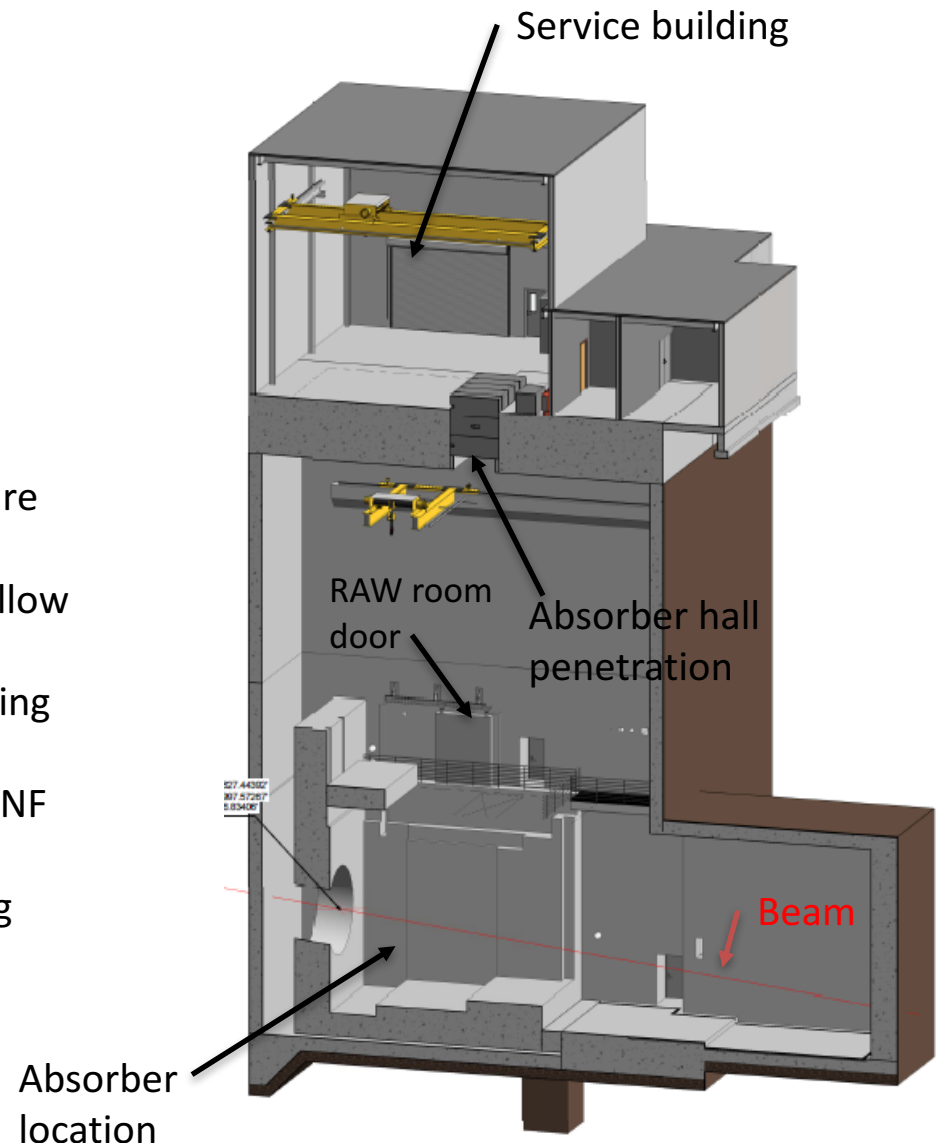
Absorber core components

- designed to last the lifetime of the facility
- redundant water-cooling lines
- low probability of complete failure

However, the consequences of complete failure are significant. Therefore:

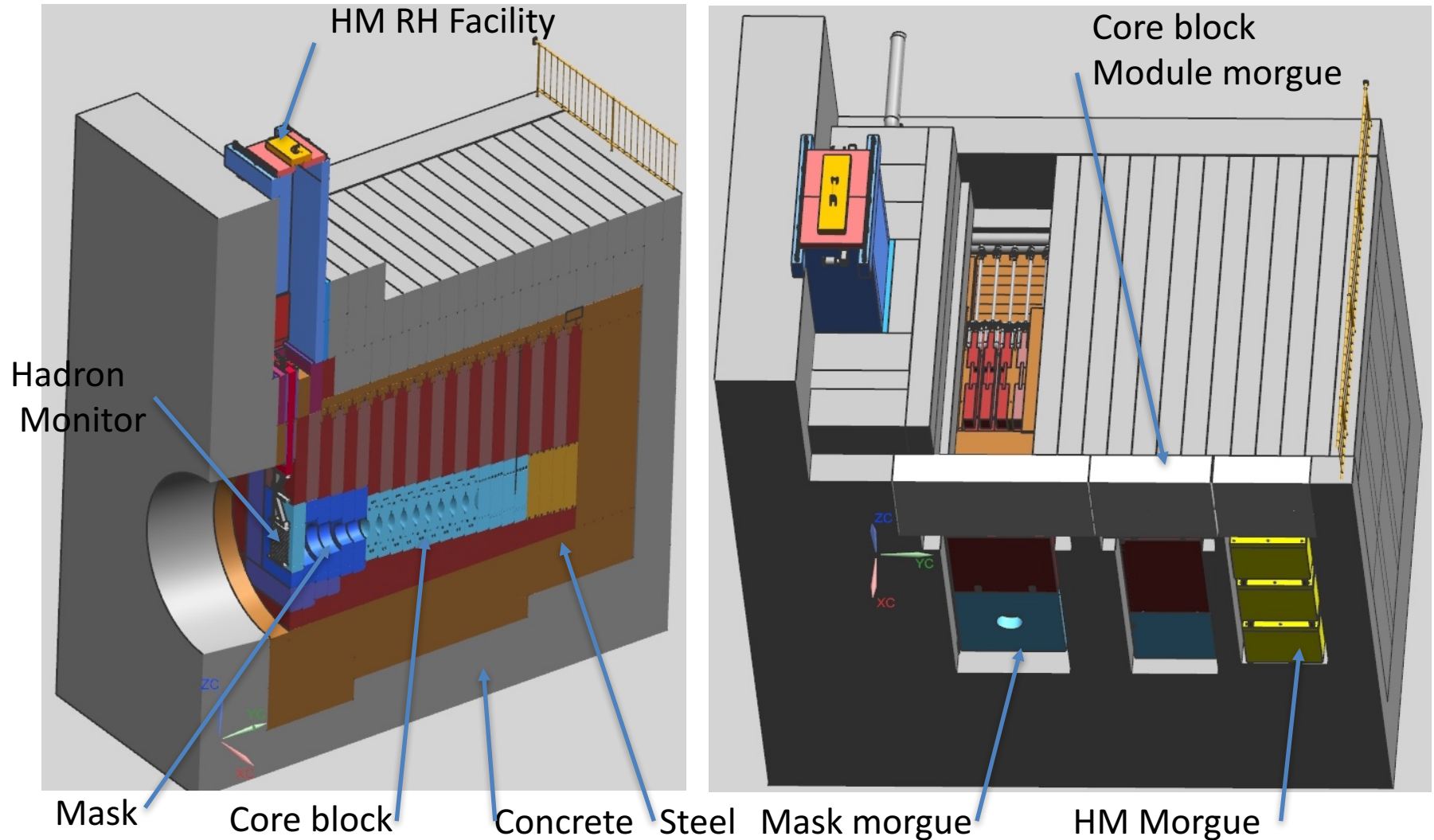
- preliminary design will include provisions to allow for core and module component replacement
- final design and construction of remote handling equipment for absorber modules and water-cooled shielding will not be included in the LBNF project.

If complete failure occurs during operation, a long downtime (6 months to 1 year) would then be required to complete final design, build, develop procedures and safely replace the failed component(s).



Absorber

The LBNF Absorber is built from water cooled Aluminum and Steel Core Blocks surrounded by steel and concrete shielding. The Hadron Monitor is located in the front of the Core blocks and can be removed and installed remotely by using the Remote Handling Facility. All core blocks can be replaced and temporarily stored in the morgue. Overall dimensions of the absorber are: Length-460in.; Width-408in.; Height-554in with RH facility.

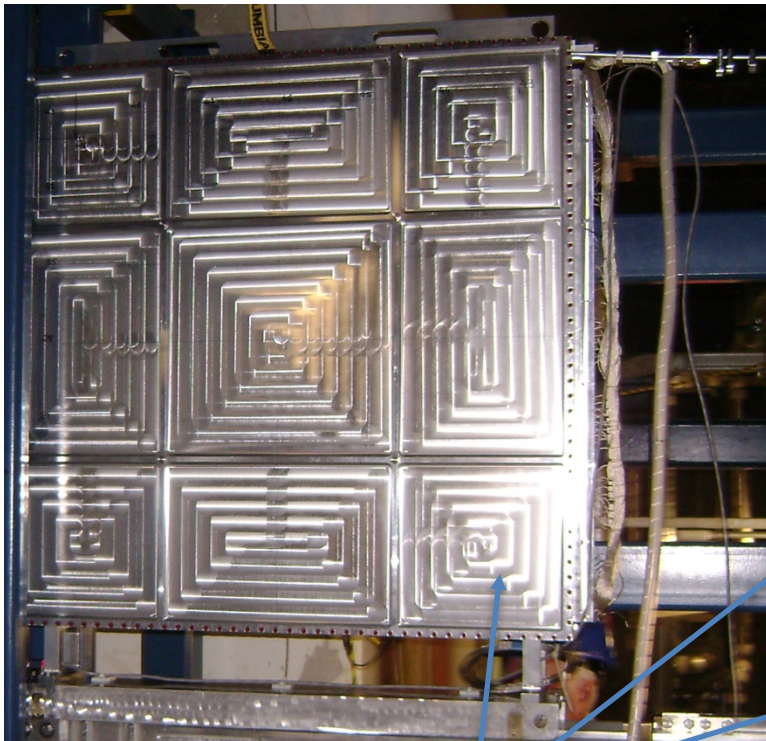
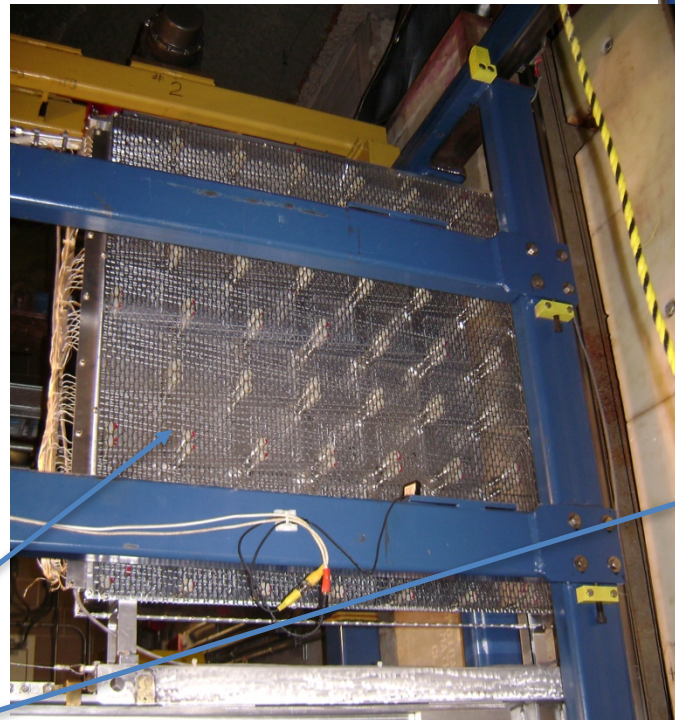


LBNF Absorber Hadron Monitor remote handling

Hadron Monitor

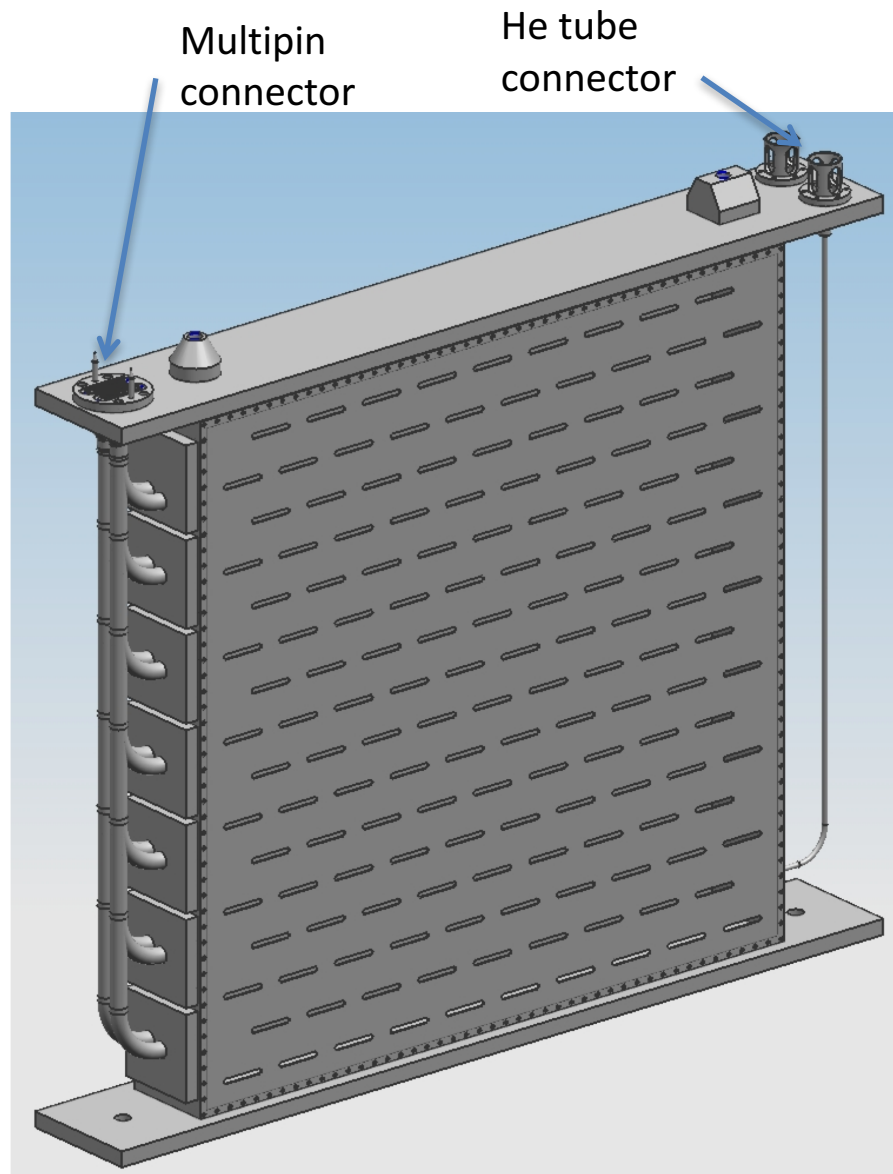
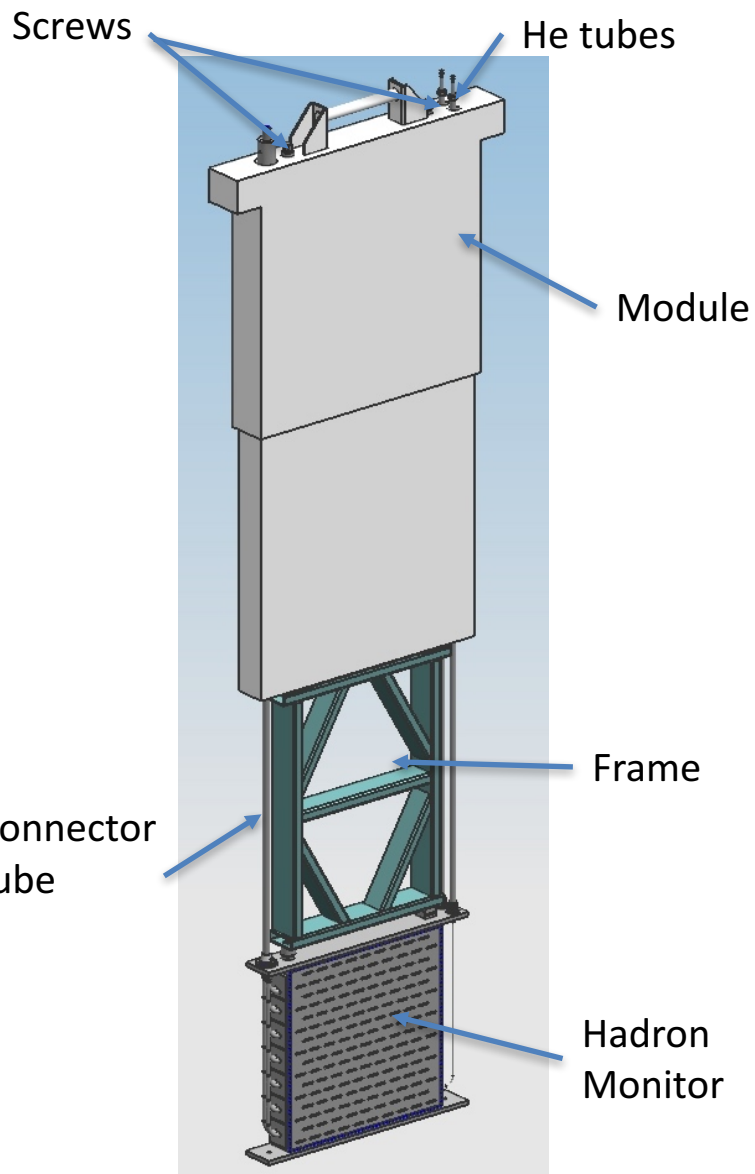
The Hadron Monitor is a 7x7 array of ion chambers inside a single Aluminum vessel. The Hadron Monitor is located in a small gap between a decay pipe and the absorber core blocks.

The NUMI absorber has the Hadron Monitor side loaded design.

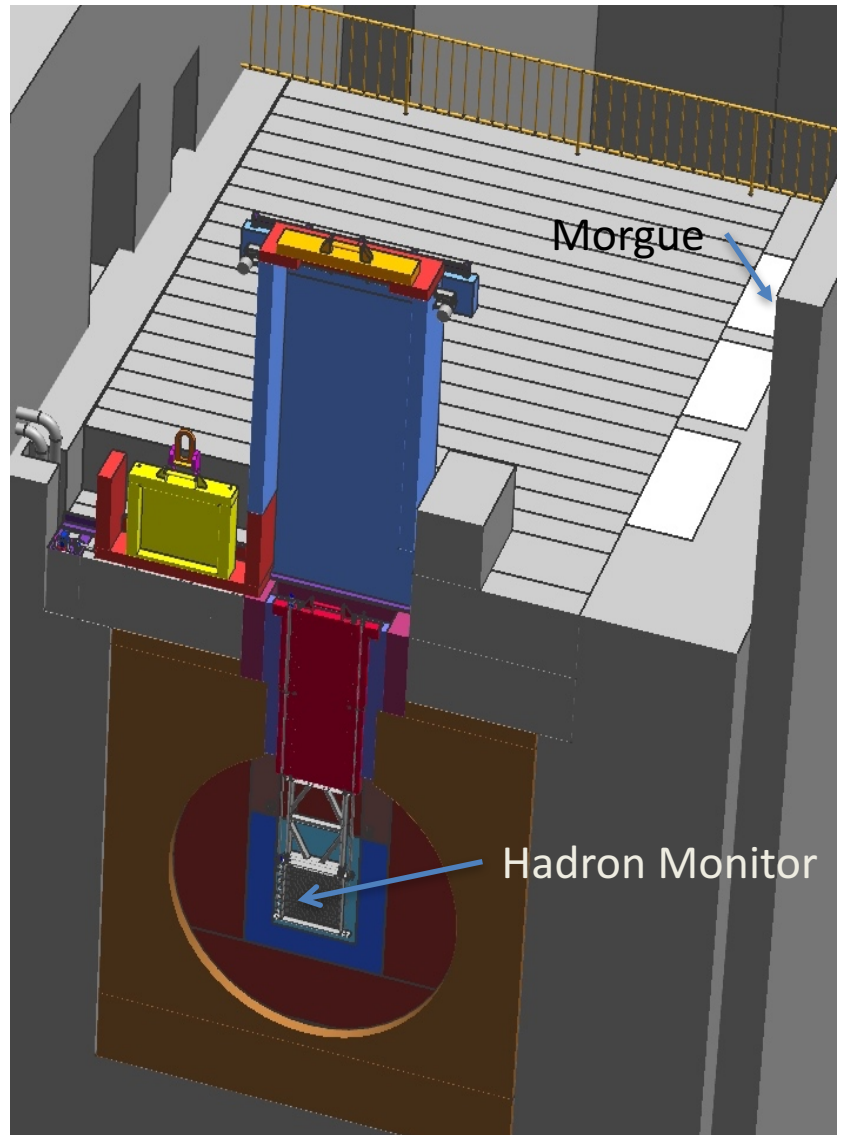
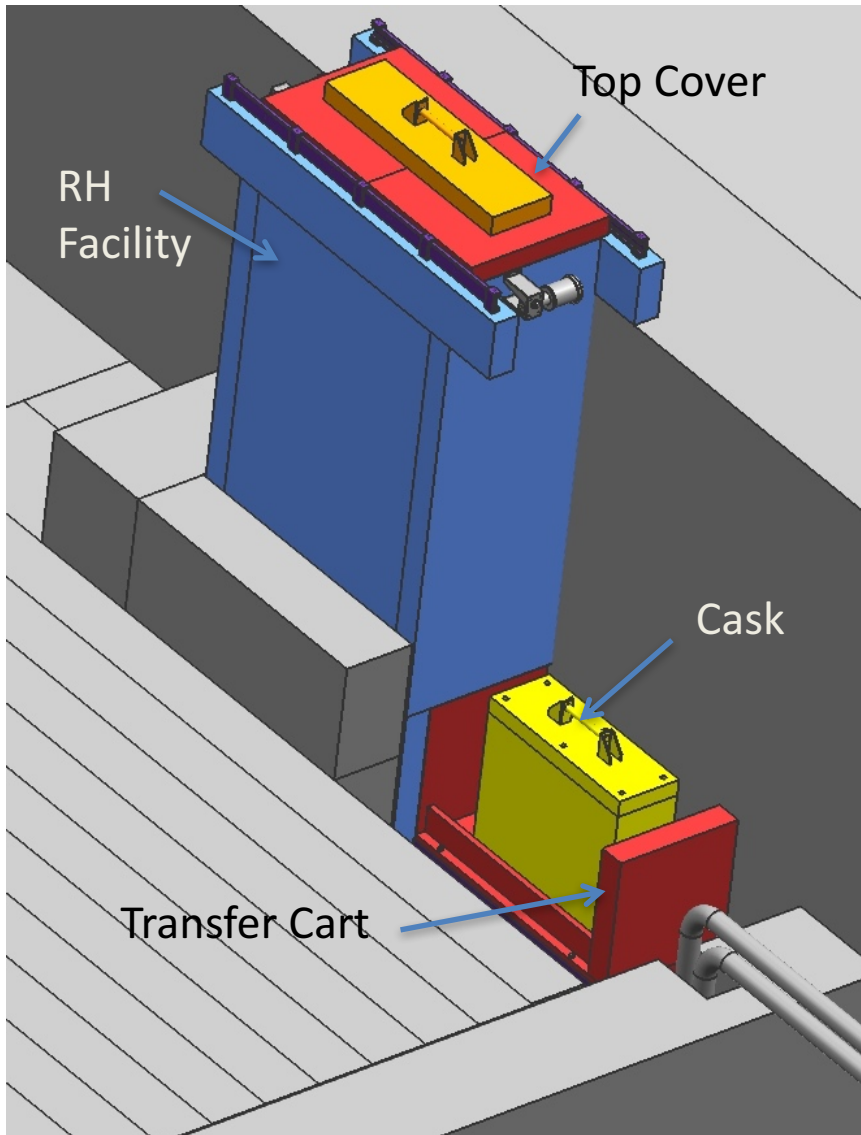


NUMI Hadron Monitor

LBNF Hadron Monitor- Hadron Monitor Module assembly

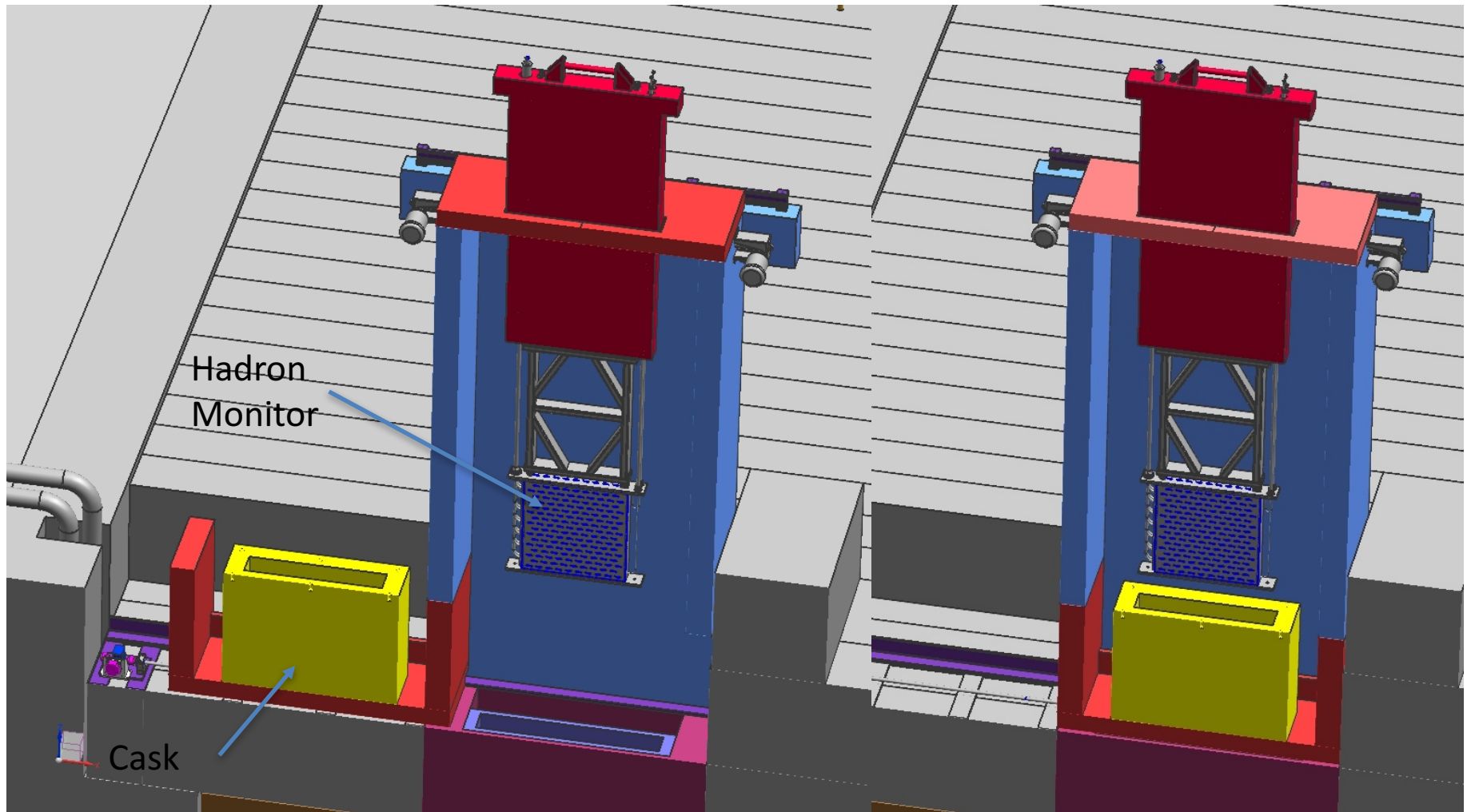


Hadron Monitor Remote Handling Facility

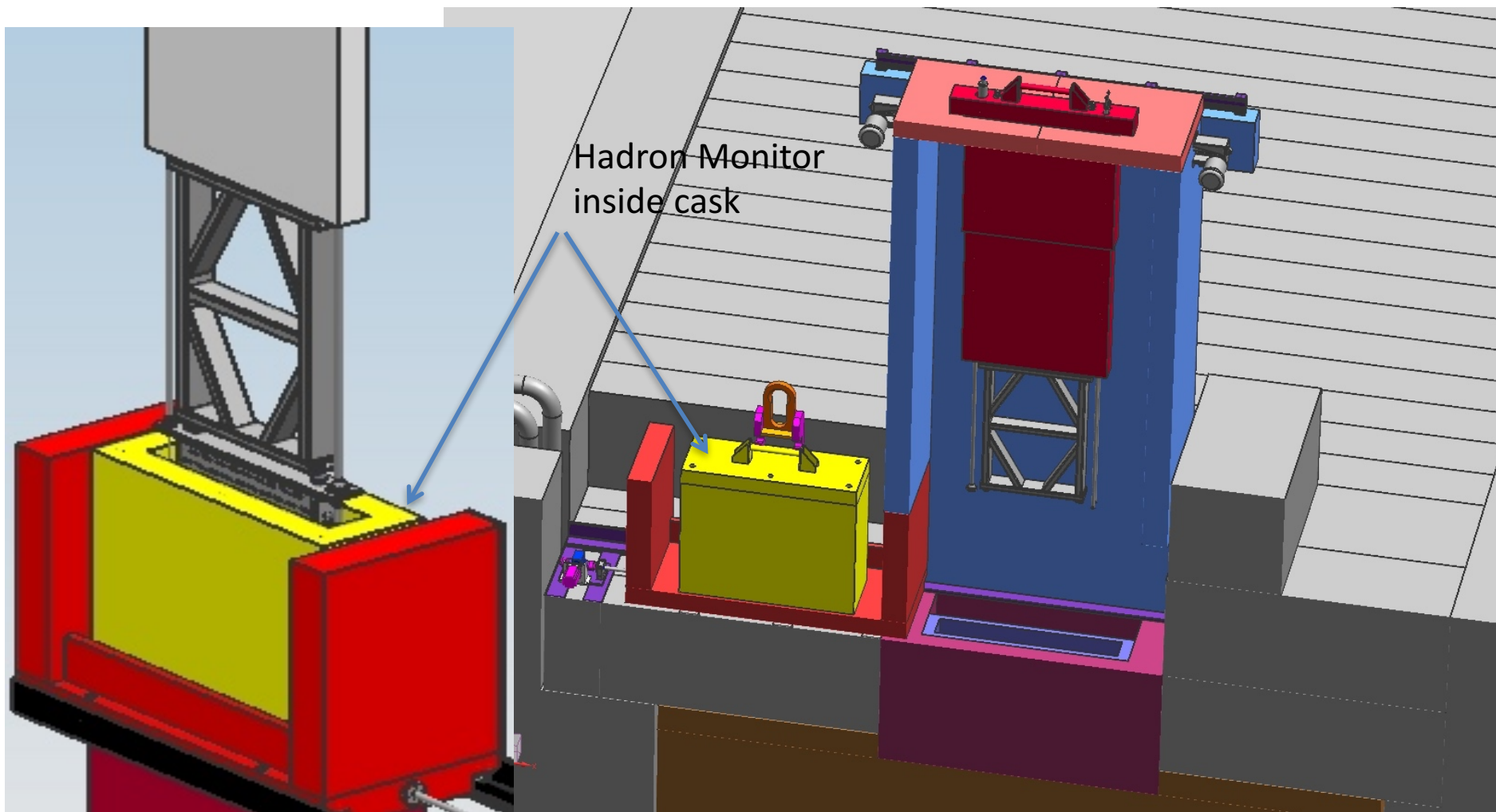


Hadron Monitor Removing Procedure

The HM-module assemble is lifted up into the facility, the facility top cover is open. The cask is moved into the facility under the HM.

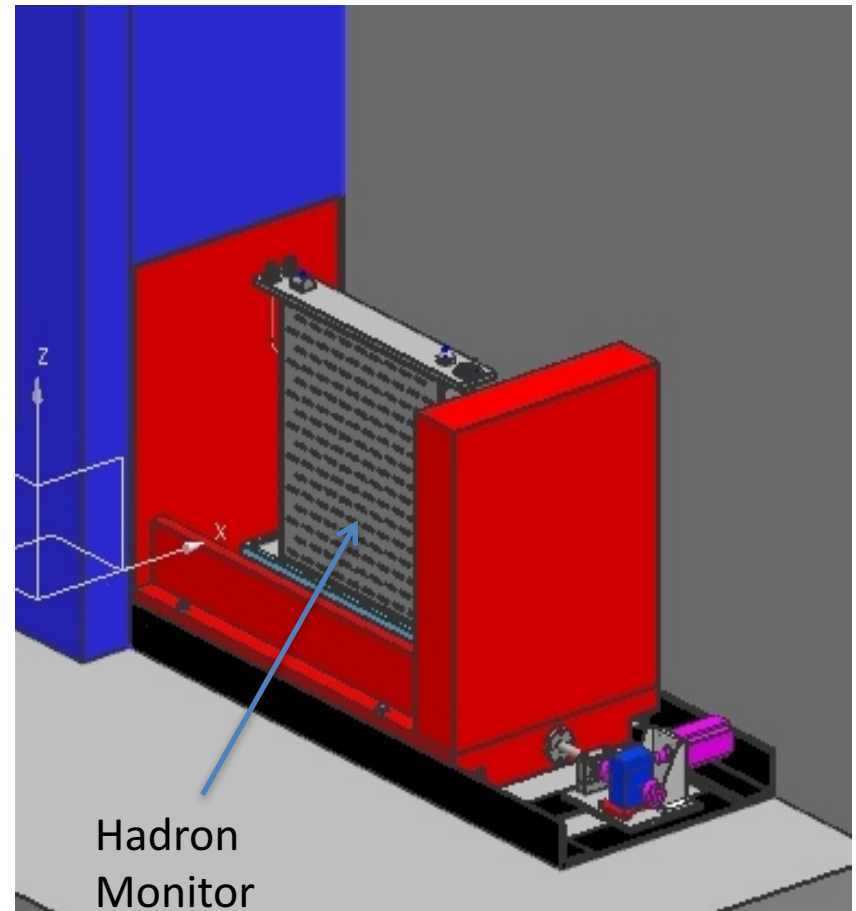
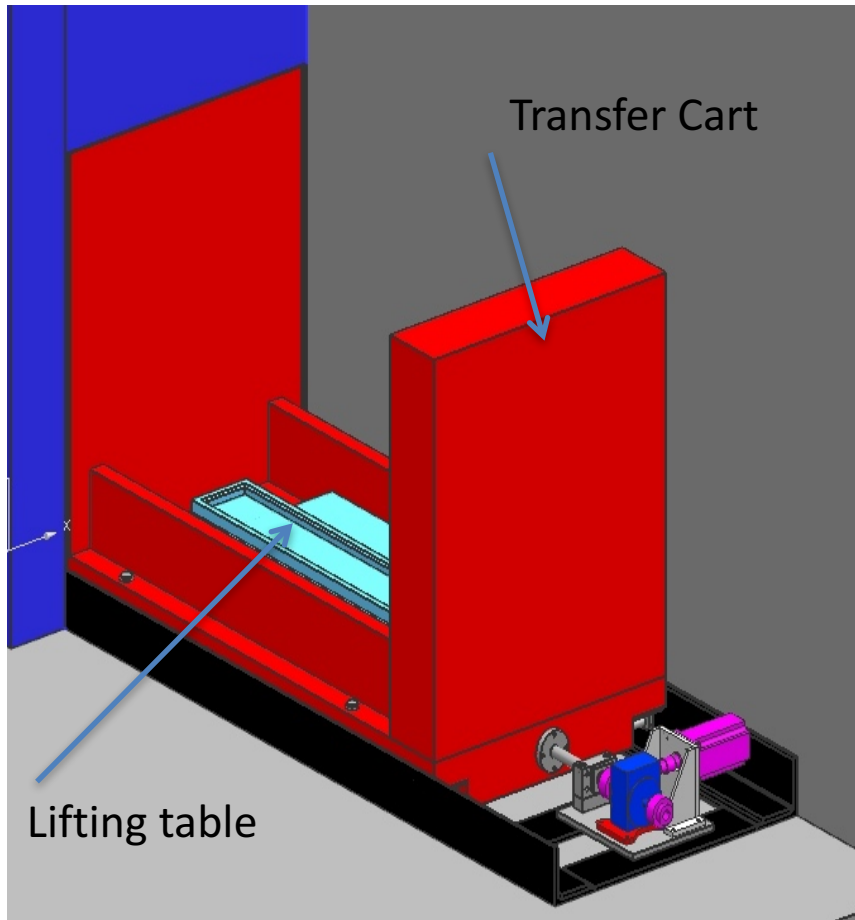


The HM is lowered down into the cask and disconnected from module.
The cask is moved out from the facility and closed by a cask top cover.
The cask with HM is moved to the morgue by crane.

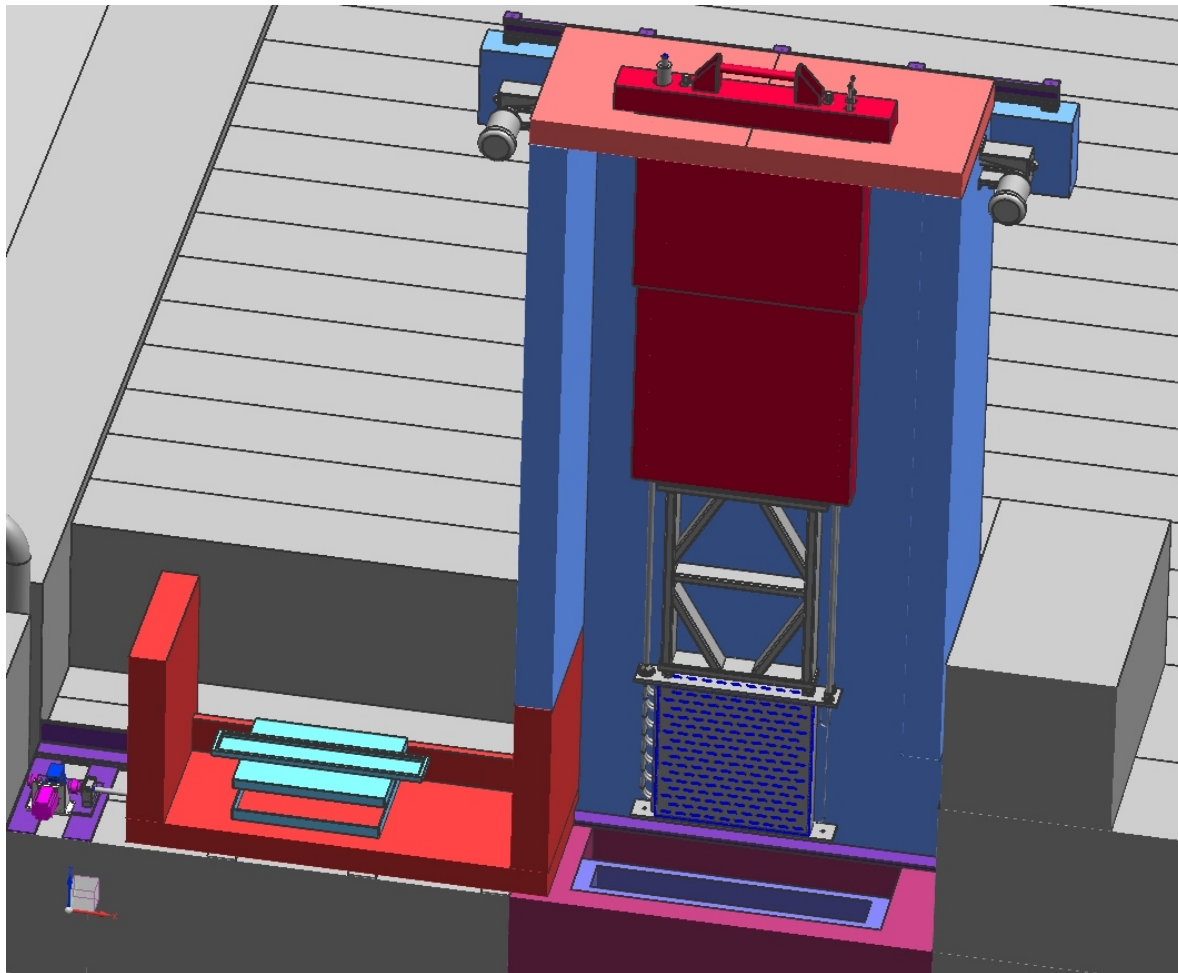
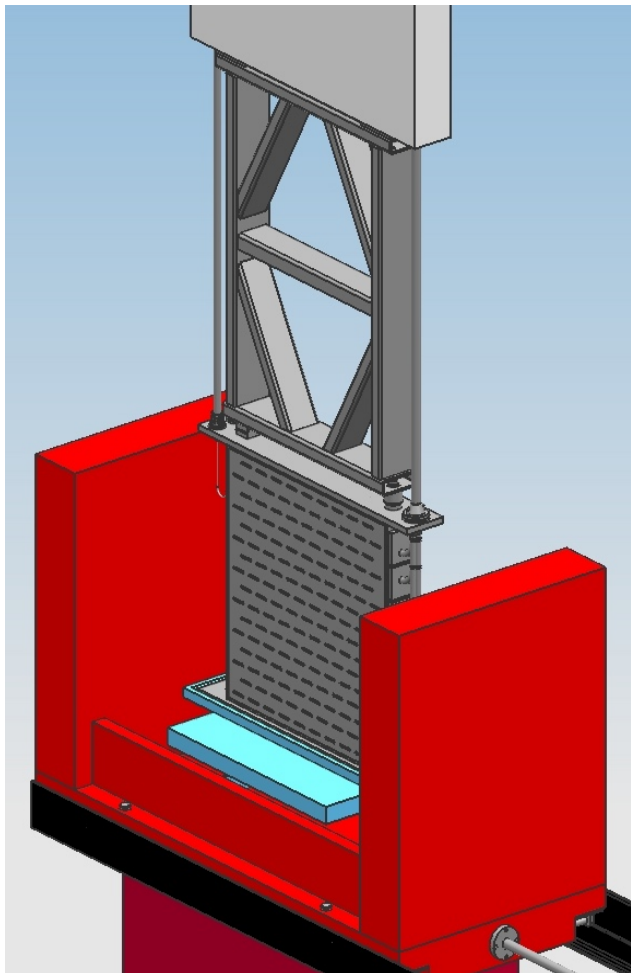


Hadron Monitor Installation Procedure

The HM is installed on the low profile lifting table located on the Transfer cart.



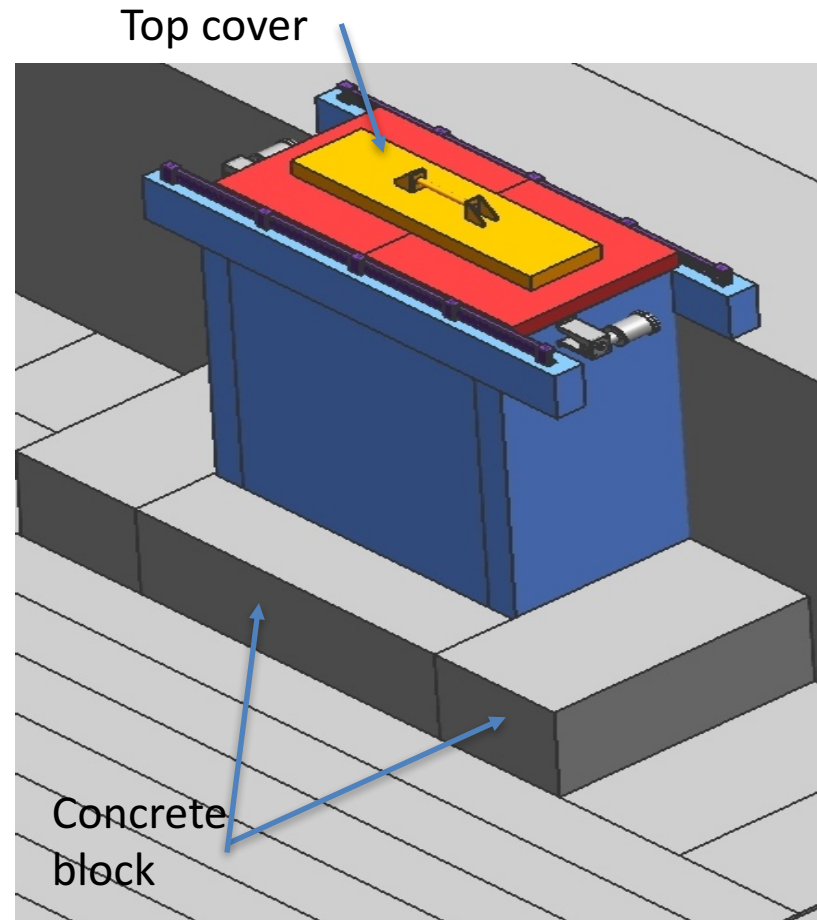
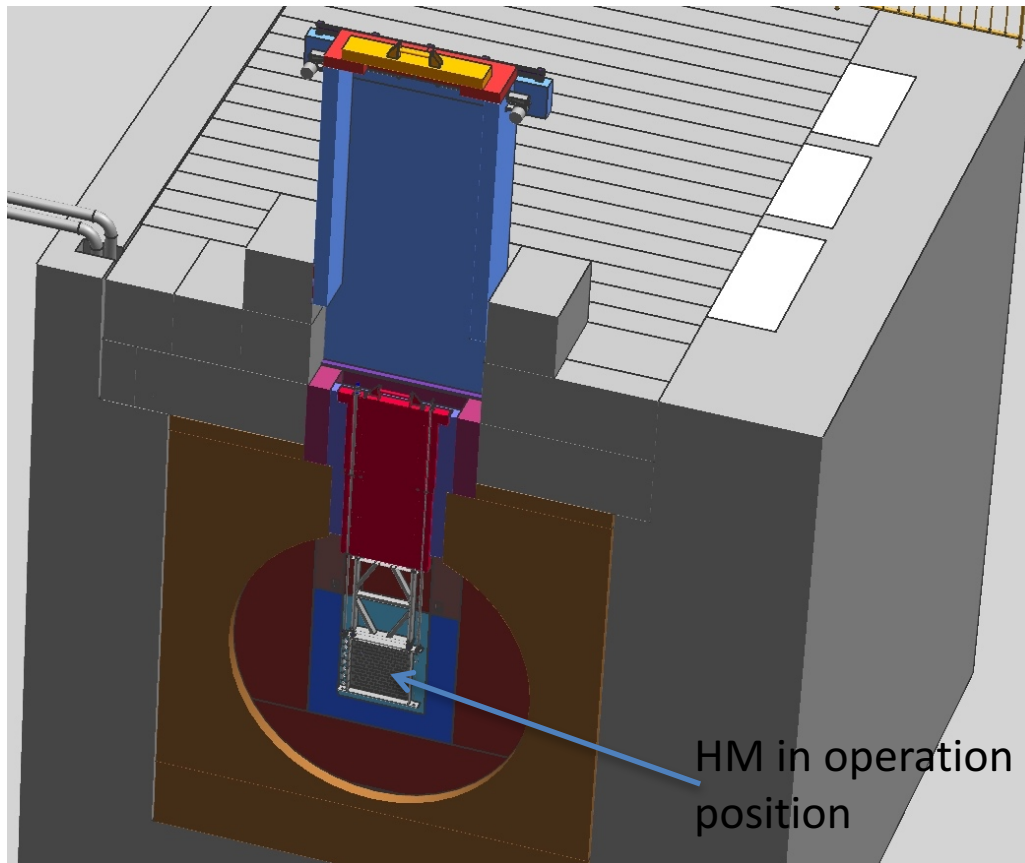
The transfer cart with HM is moved into the facility and HM aligned with the module.
The HM is lifted up and connected to the module
The module with HM is lifted up, the transfer cart is moved out from the facility.



The HM is lowered down and placed on the operation position.

The facility top cover is closed.

The transfer cart with driving system is disassembled and concrete blocks are installed.



Summary

- LBNF Target Hall and Absorber Remote Handling is based on NUMI Target Hall Remote Handling. All RH equipment (casks, lifting fixtures, cameras, video center) are similar with NUMI equipment.
- Work Cell ,Operation Center ,T-blocks storage pit, Morgue, Doors in the Target Hall and Morgue, Doors and Hadron Monitor RH Facility in the Absorber are parts of the infrastructure of both complexes.
- Work Cell, Operation Center, Casks, Doors, Morgues are designed for 2.4 MW beam operation.
- Each component of the Absorber can be replaced if failure occurs during operation.
- All RH operations in the target hall are provided by 60 ton capacity cranes with redundant motion systems and 30 ton crane in the absorber.