



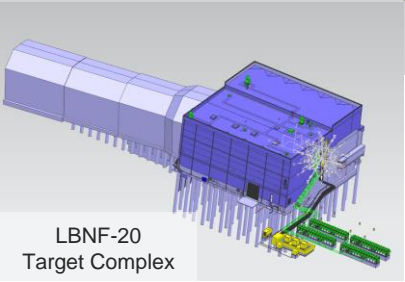
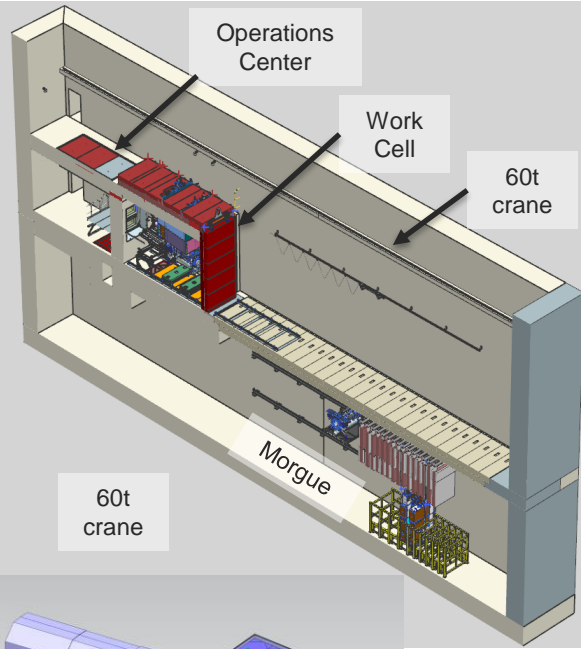
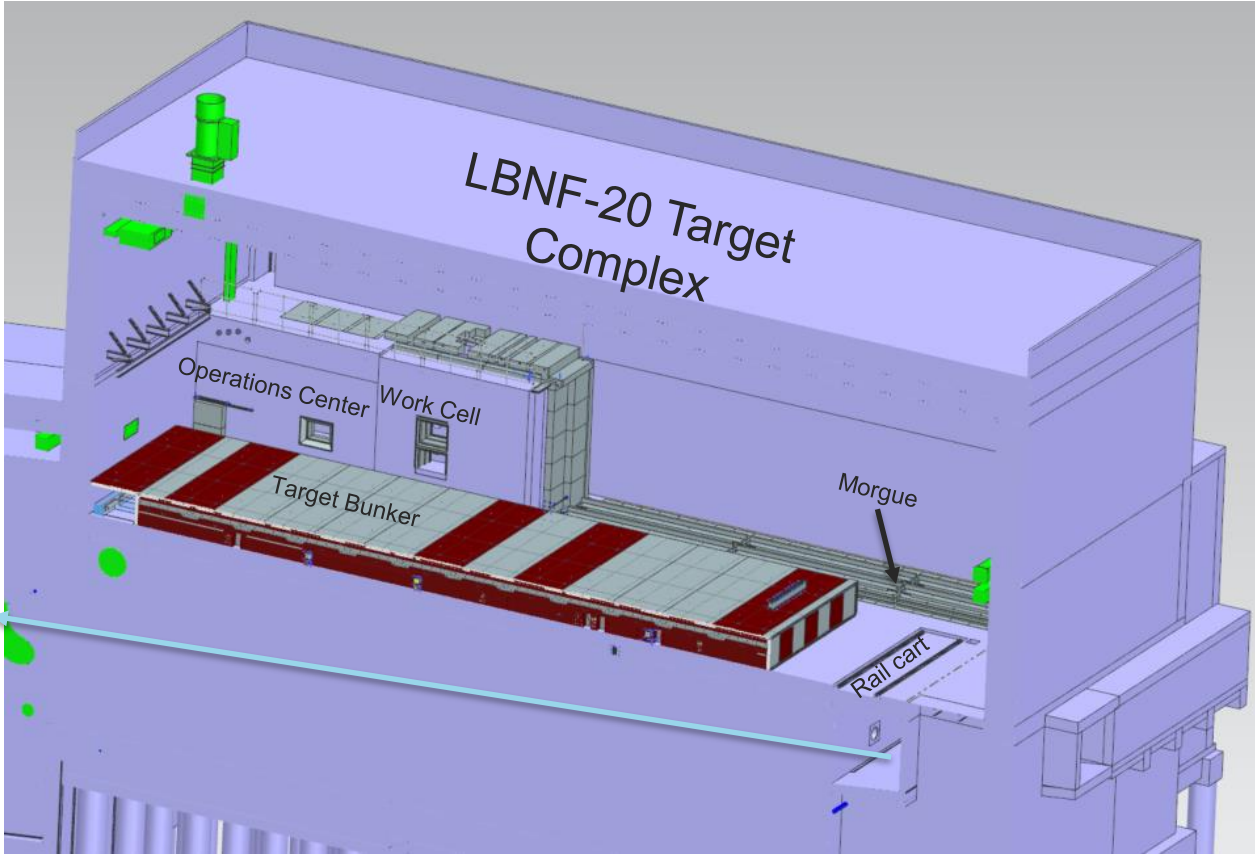
## **LBNF Target Complex Remote Handling**

Bill Paley, Vladimir Sidorov

13<sup>th</sup> Neutrino Beam Instrumentation Workshop

Oct 9th 2024

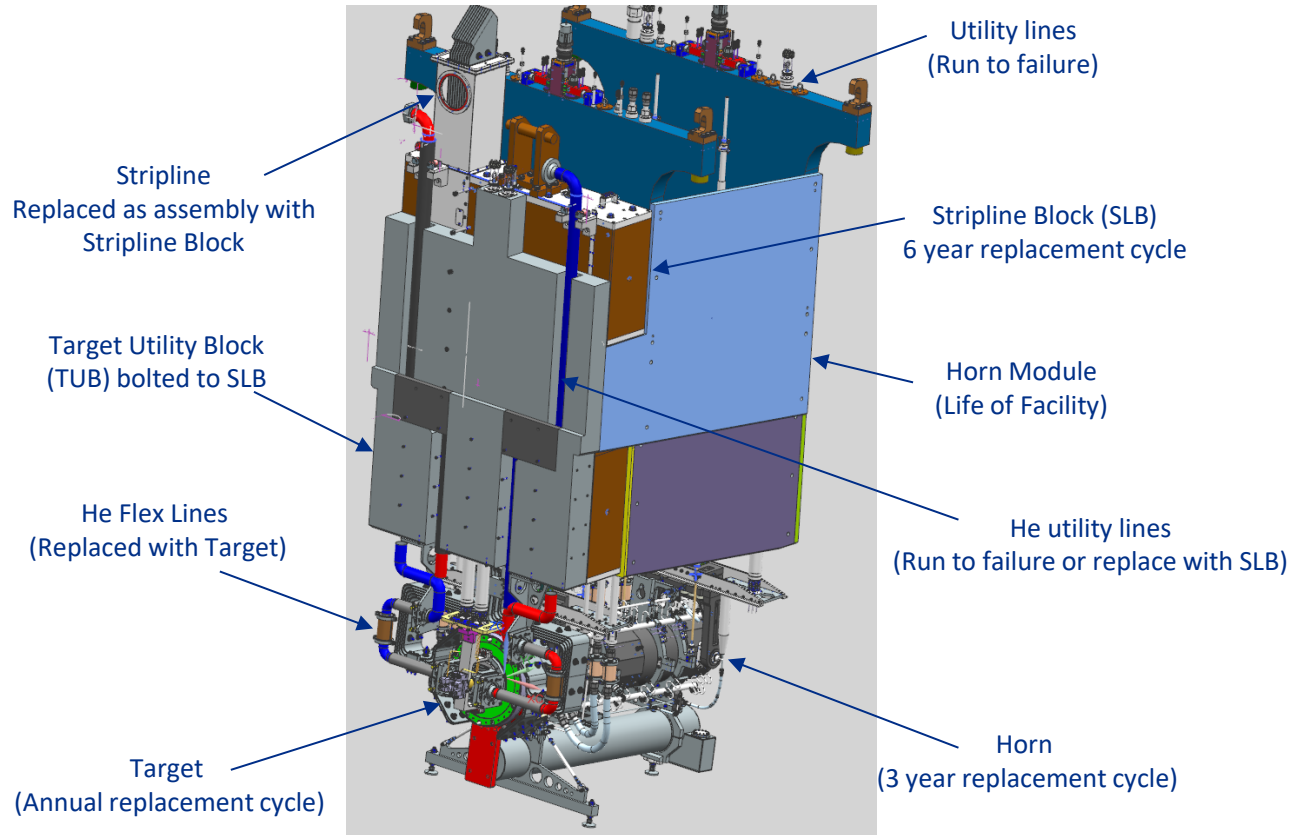
# Background: LBNF-20 Target Complex



# Background: Horn A Module

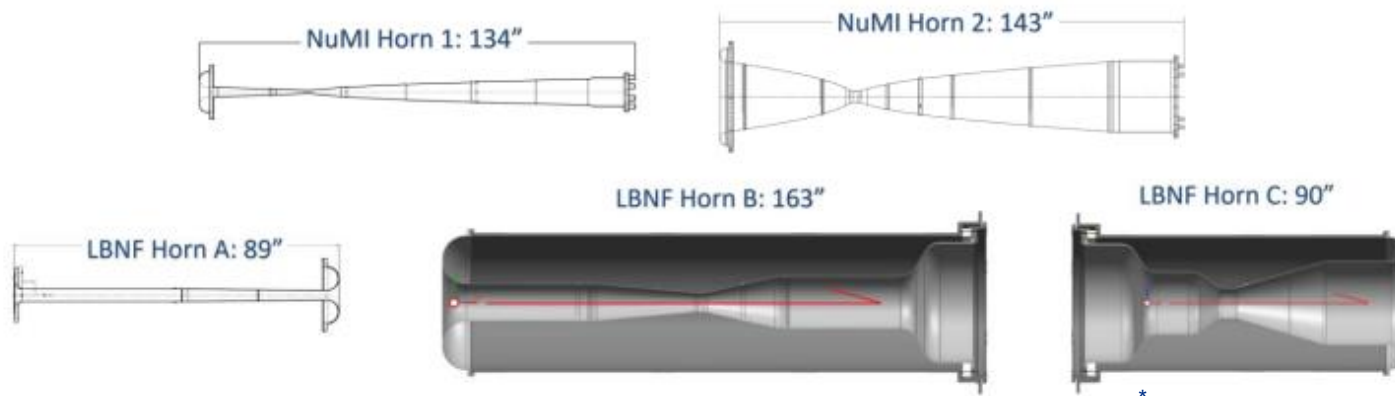
Horn Module Assembly designed to allow for sub-assemblies to be replaced on different frequencies:

- Target
- He Flex Lines
- Horn
- SLB + TUB
- He Through lines
- Utility lines
- End wall cooling panel



## What makes Remote Handling @ LBNF different?

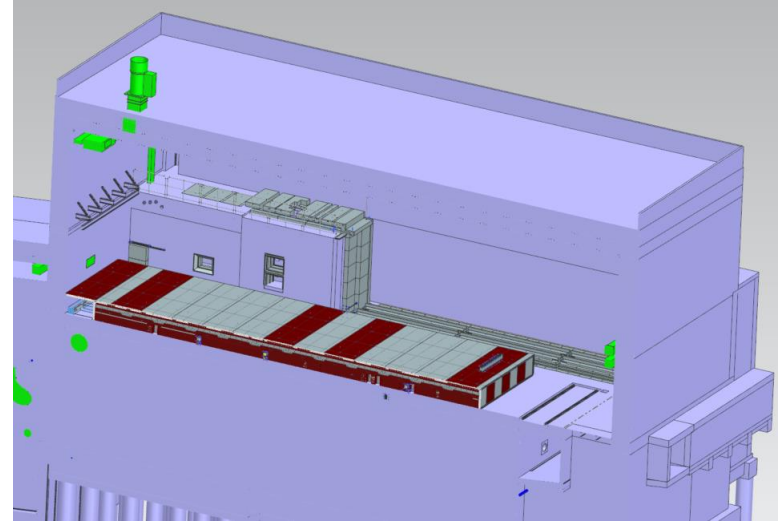
- Horns and Modules are bigger than NuMI
- Insertion clearances are tighter (due to higher prompt dose)
- Annual Target Replacement (re-using Horn A)
- Dedicated Remote Operations Center (Reduced dose to personnel)
- Remote decay pipe window replacement
- Increased degree of remote control



# Remote vs. Hands-on Operations

Target Hall is one of four modes:

1. Beam Ready
2. Hands-on Maintenance WC prep
3. Hands-on Maintenance WC in use
4. Remote Maintenance

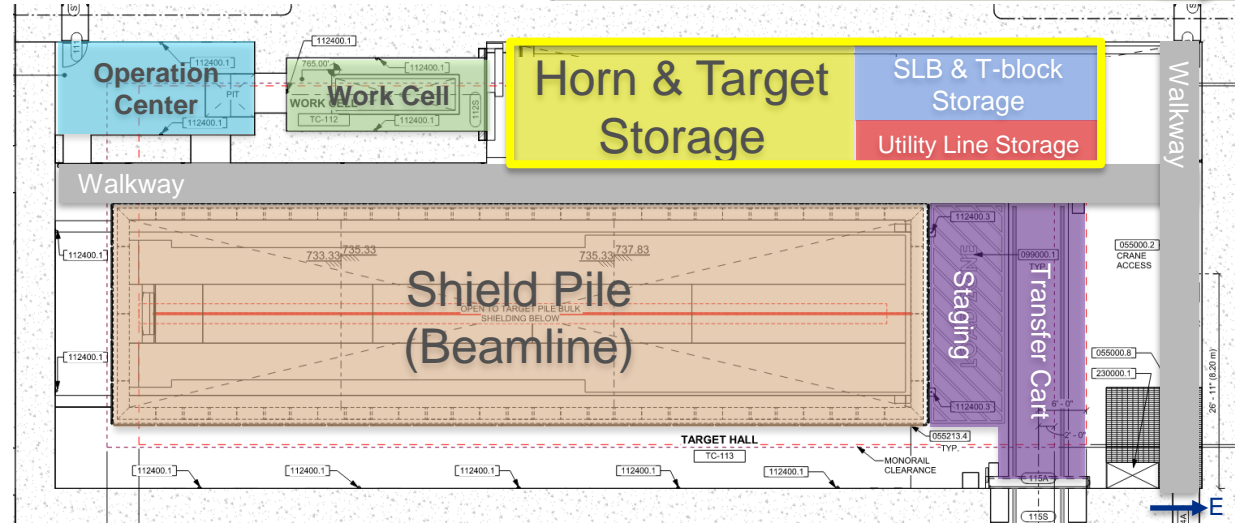
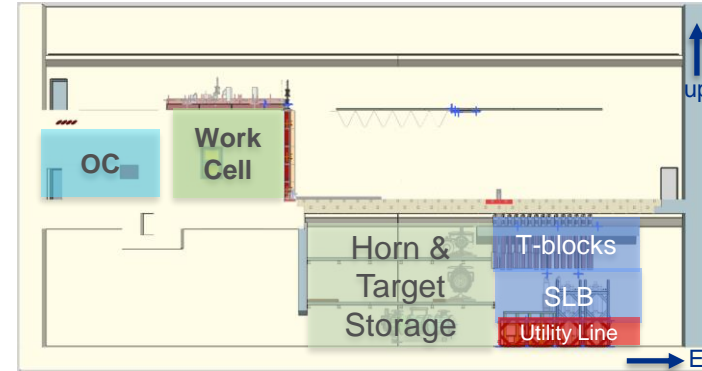
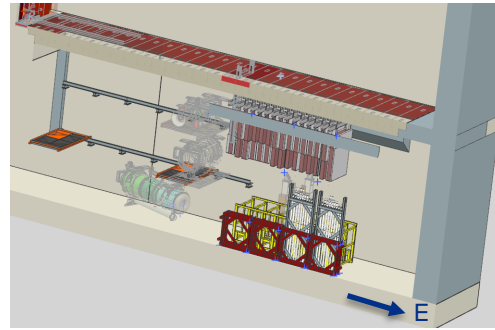


		Target Hall	Operation Center	Station (Bunker)	Work Cell	Morgue
		personnel	personnel	personnel	personnel	Hatches
<b>Beam Ready</b>		Interlocked	Interlocked	n/a	n/a	Closed
<b>Hands-on</b>	<b>WC prep</b>	Permitted	Permitted	Permitted	Permitted	Closed
	<b>WC in use</b>				Prohibited	Closed
<b>Remote Maintenance</b>		Prohibited	Permitted	n/a	n/a	Open



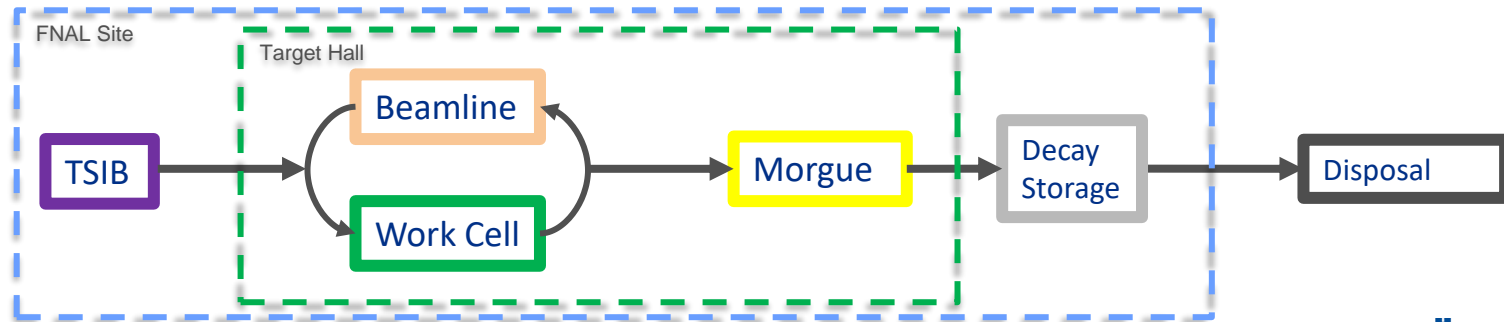
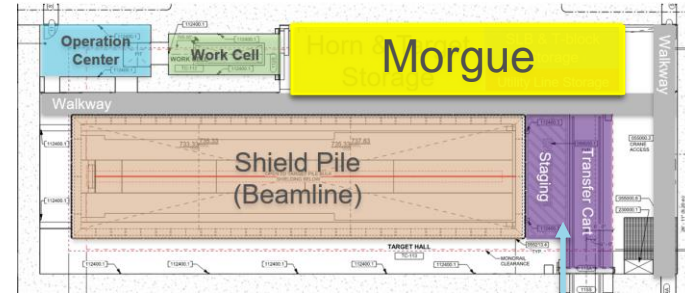
# Target Hall Zones

1. Operation Center
  - Crane control
  - WC manipulators
2. Work Cell
  - hands-on preparation pre-operation
  - Shielded for radioactive workpiece
3. Morgue
  - Initial storage for hot items removed from service
  - 3 levels of reconfigurable horn / target storage
  - SBL, T-block, utility line storage
  - Contents must be remotely handled
4. Shield Pile
  - Cover blocks manually rigged
  - Seals  $N_2$  internal volume from target hall air (during beam)
5. Transfer Cart & Staging
  - 60t cart transfers equipment to and from the truck-bay
  - New equipment, lifting fixtures, etc. staged prior to operation



# Flow of Equipment

- Assembly at Target System Integration Building (TSIB)
- Transferred to Target Hall via:
  - On-site road transport
  - Truck Bay @ lower level of LBNF-20
  - 60t crane
  - 60t powered Transfer Cart
- Installed Beamline or in Work Cell
- Spent items remotely placed in Morgue
- Road transport to on-site decay storage
- Shipped off-site for final disposal



# Remote maintenance operation model processes

Maintenance Operations grouped into representative cases:

A. Horn A SLB replacement

B. US Decay Pipe Window Replacement

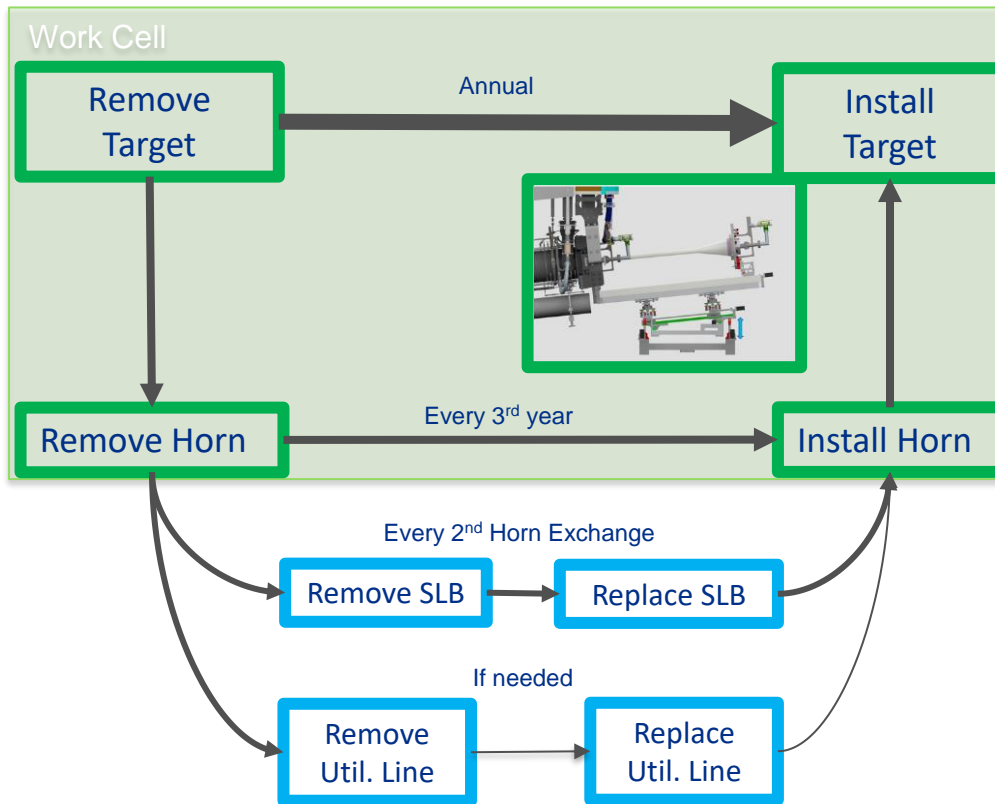
C. Transfer components out of LBNF-20

Model Process	Example Task
<b>A</b>	Target Exchange
<b>A</b>	Horn A replacement
<b>A</b>	Horn B replacement
<b>A</b>	Instrumentation line replacement
<b>B</b>	Inspect US decay pipe window
<b>B</b>	Replace US decay pipe window
<b>C</b>	Transfer spent target to medium term storage
<b>C</b>	Transfer spent horn out of complex

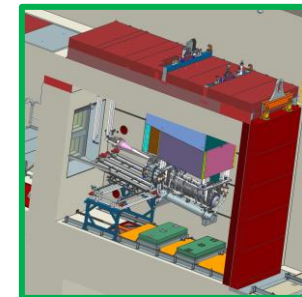
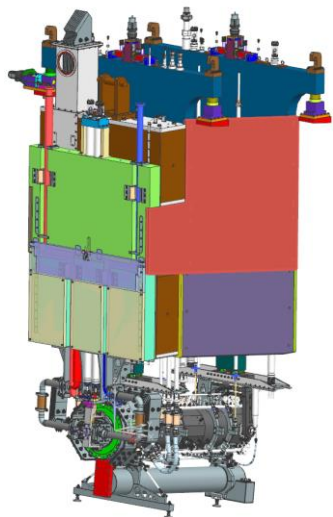


# Model Maintenance Process A

Disconnect  
Target Module



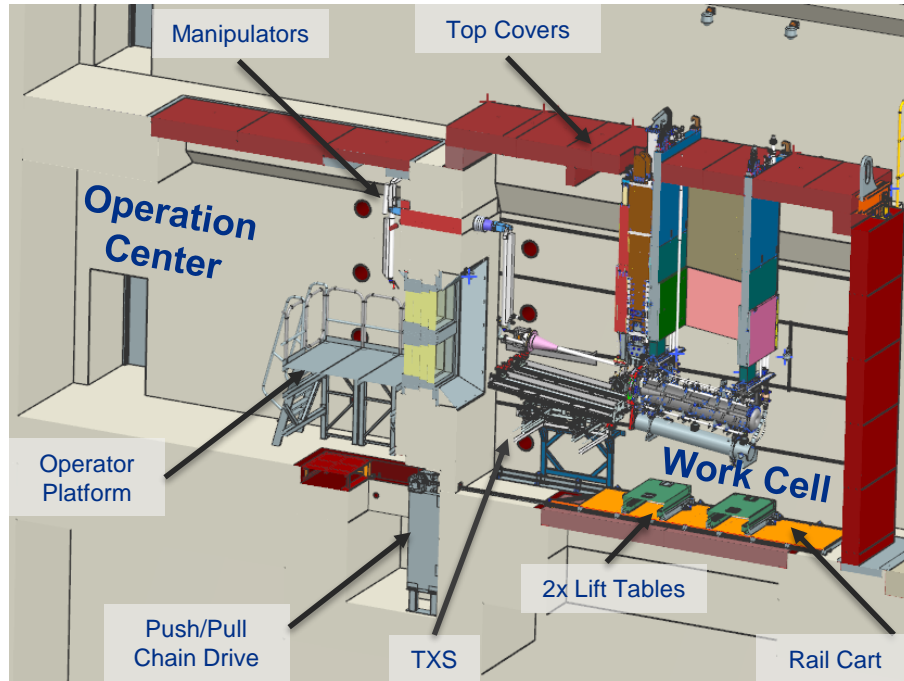
Connect Target  
Module



Work Cell

Beamline

# Remote Operations: Work Cell



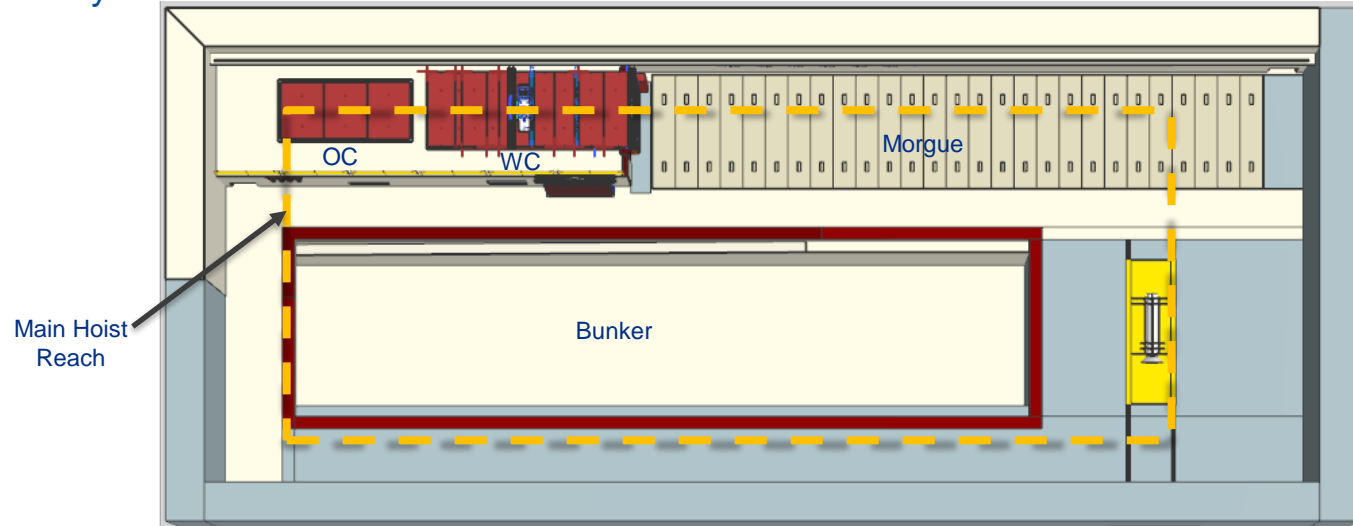
- Key operational uses
  - Target exchange (with TXS)
  - Horn replacement
  - Utility line disconnection
  - Inspection
- Equipment
  - Rail cart
  - Serapid Push/Pull chain drive (rail cart)
  - Lift Tables (on rail cart)
  - Reconfigurable Top Covers

# Remote Operations: Crane

- Operated Remotely from Operation Center
- 60t Class D with Removable Electronics
- Power rotating hook
- 5t auxiliary hoist
- Redundant System capable of taking over in the event of primary system failure.
  - Execution to be proposed by successful bidder.

**Crane Control**

	Hoist		Bridge		Trolley	
	min	max	min	max	min	max
ft/min	0.2	16	0.2	100	0.2	60



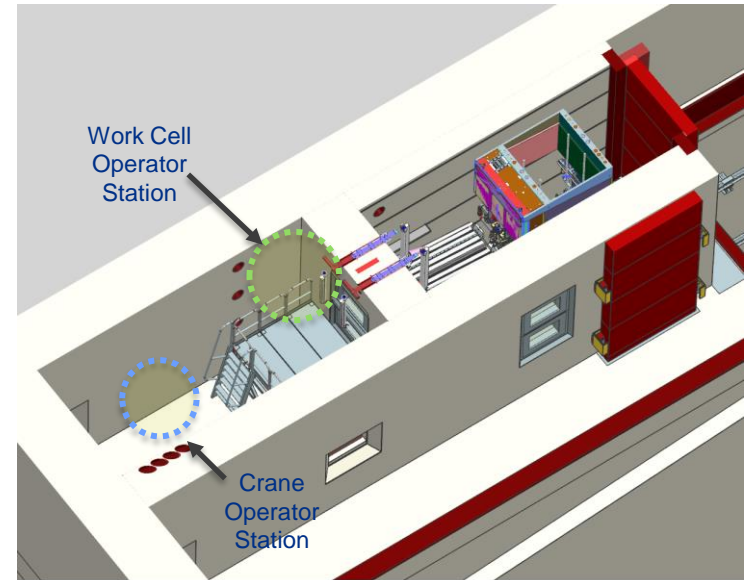
# Remote Vision System

- Remote installation of equipment using visual alignment:
  - Horn modules,
  - Stripline Blocks
  - T-blocks,
  - Morgue covers,
  - WC door,
  - Horns
- Nominal insertion clearance: 18mm all around
- 2 viewing stations:
  - Crane Operator
  - Work Cell Operator
- Multi-channel switching



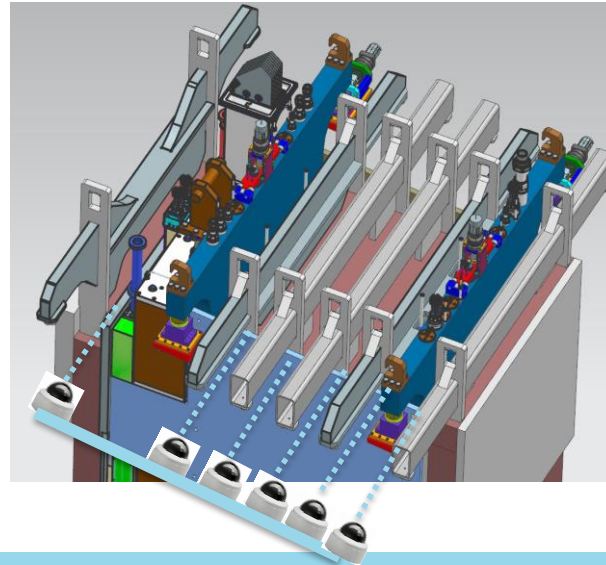
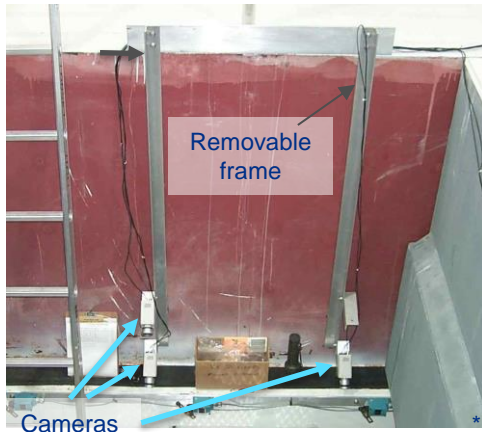
Monitoring station at NuMI

Insertion Clearance	
NuMI	2" (50mm)
LBNF	3/4" (18mm)
TRIUMF (ISOL)	3/8" (10mm)



# Remote Vision System: Task Specific Cameras

- Precision viewing with task specific fixed camera mounting frames
- Camera view aligned to edges to minimize perspective effects
- Paint / shade surfaces for contrast of shiny surfaces on monitors
- Mark cardinal direction in frame to orient remote crane operators

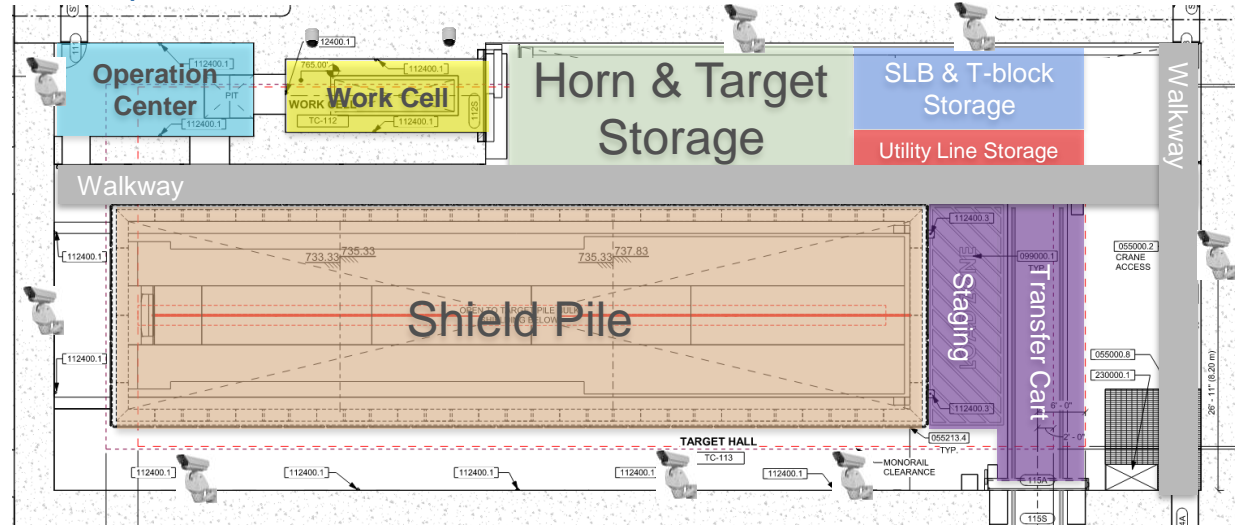


Camera views along edges



# Remote Vision System: General & Wide Angle

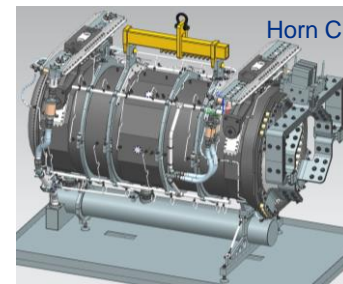
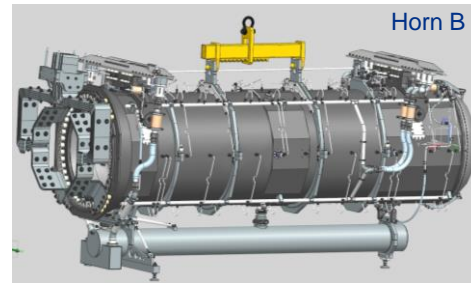
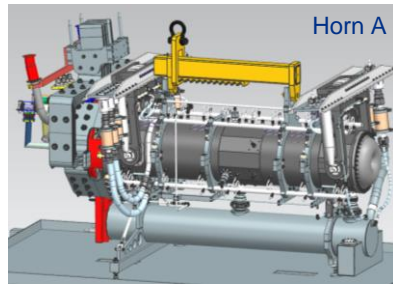
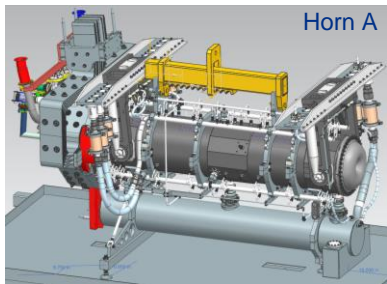
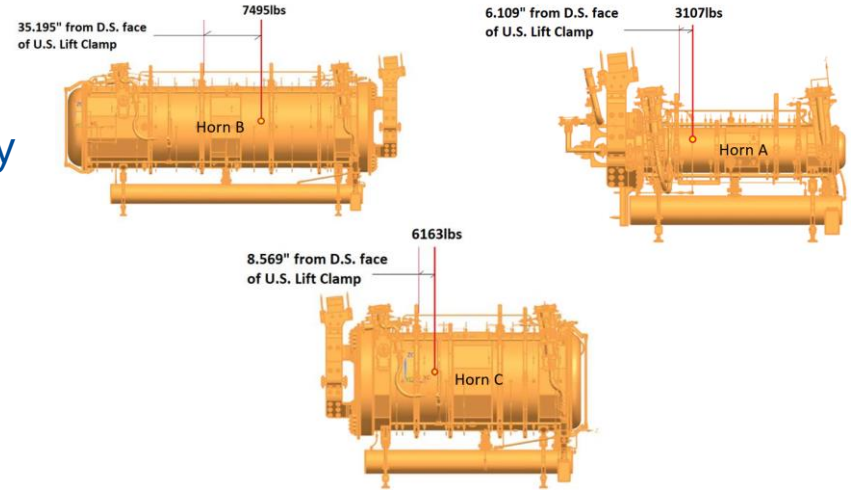
- Cross-hall equipment moves monitored with Pan-Tilt-Zoom
- controlled from Operation Center
- Provide flexibility and redundancy for task specific cameras
- Remotely controlled supplementary lighting
- Positions configured in commissioning
- Positions over Morgue manually adjustable per task





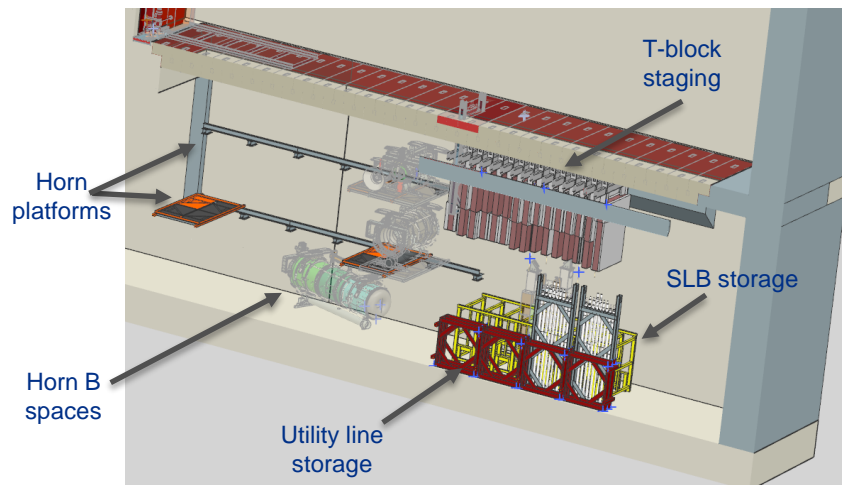
# Remote Lifting: Fixtures

- 16 remotely lifted loads
- ~ 6 Lifting Fixtures
- Remote exchange of lifting fixtures required
- Use common lifting fixtures based on geometry and procedural sequence efficiency
- Horn Lifting Fixture – special case
  - Horn A/B/C, Baffle, Target & Horn containment boxes
  - Common attachment point
  - Remotely adjustable pick-point using overhead crane

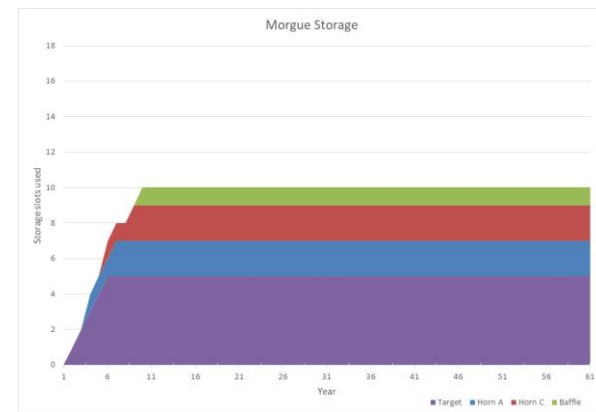


## Morgue Storage - Accumulation

- Morgue storage duration to fit available space & replacement frequency
- 2 “spare” spaces for operational flexibility
- Decay storage on-site until ready for off-site disposal



Item	Repl freq [yr]	Morgue storage period [yr]
Horn A	3	6
Horn B	3	12
Horn C	3	6
Baffle	5	6
Target	1	5



# Summary

- LBNF requires remote rigging of loads and precise placement
- Model remote maintenance processes to guide design decisions
- Remote vision system using fixed task specific and controlled PTZ cameras
- Flexible camera placement adjusted during commissioning
- Initial cooldown of spent items in Target Hall prior to decay storage (on-site).

Thank you: Vladimir Sidorov, Keith Anderson, Patrick Hurh, Keith Gollwitzer, Diane Reitzner, Julio Ortega, Austin McElderry, James Zahurones, John Anderson, Adam Newsome, Kennedy Hartsfield, Thomas Hamernik, Matt Sawtell,

# Questions?



Thank you: Vladimir Sidorov, Keith Anderson, Patrick Hurh, Keith Gollwitzer, Diane Reitzner, Julio Ortega, Austin McElderry, James Zahurones, John Anderson, Adam Newsome, Kennedy Hartsfield, Thomas Hamernik, Matt Sawtell,

Bill Paley. 13th NBI Oct 7-10 2024.

# Blank Slide

## Topics for discussion / open question

- Shielding requirements for surface road transport between LBNF-20 and Decay Storage
- Layout of Operation Center for efficient operations and ergonomics
- Criteria to evaluate crane redundancy solution ultimately proposed by bidder
- Optimal Configuration of Work Cell Windows
- What additional feedback is useful to crane operator?



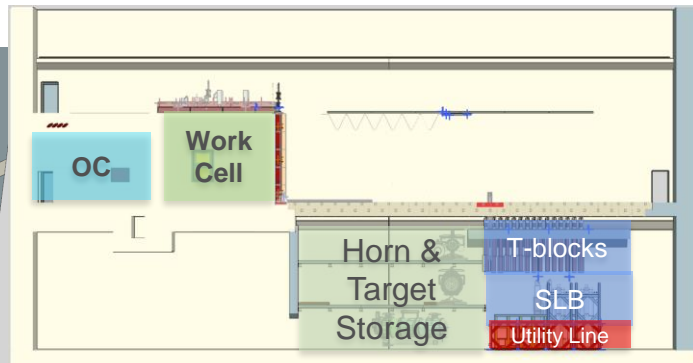
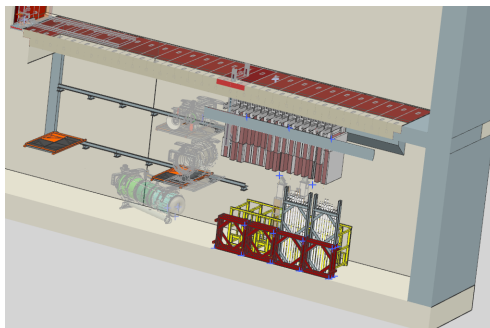
# Topics

- Background
- Framework for Remote Handling
  - Operation Modes
  - Hands-on vs Remote
  - Space / Staging
- Flow of Equipment
  - Remote Maintenance Types
  - Model Maintenance Processes
- Equipment:
  - Work Cell
  - Remote Crane & Lifting Fixtures
  - Video System
  - Morgue Storage
- Summary

# Staging of Shielding for Maintenance

## 1. Shield Pile

- 20x Shield Pile Covers (322t)
- 6x Work Cell Covers (52t)
- 2x Temporary Bunker shields (18t)

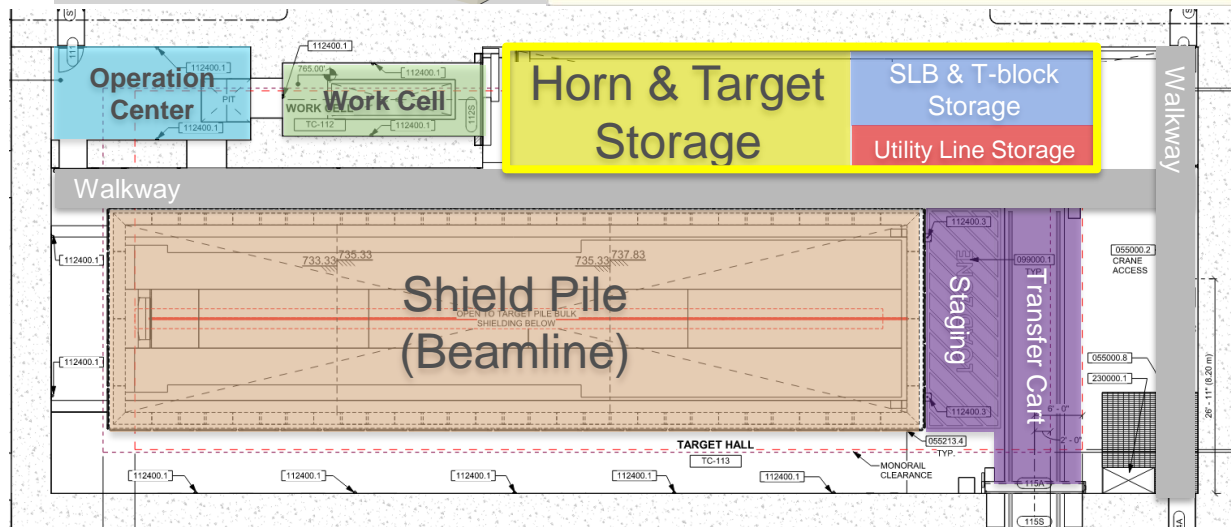


## 2. Morgue

- ~9x hatch blocks (90t) on top
- 6x T-blocks in stand
- Spent Targets on platforms

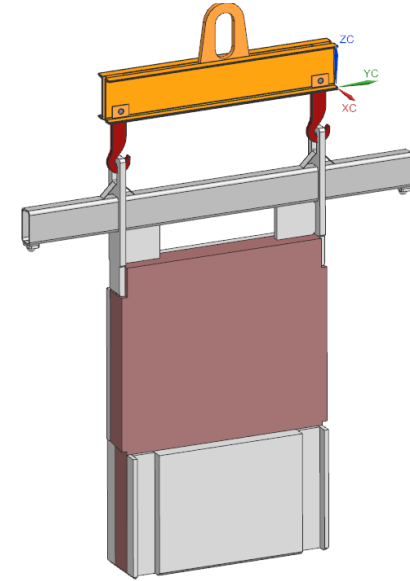
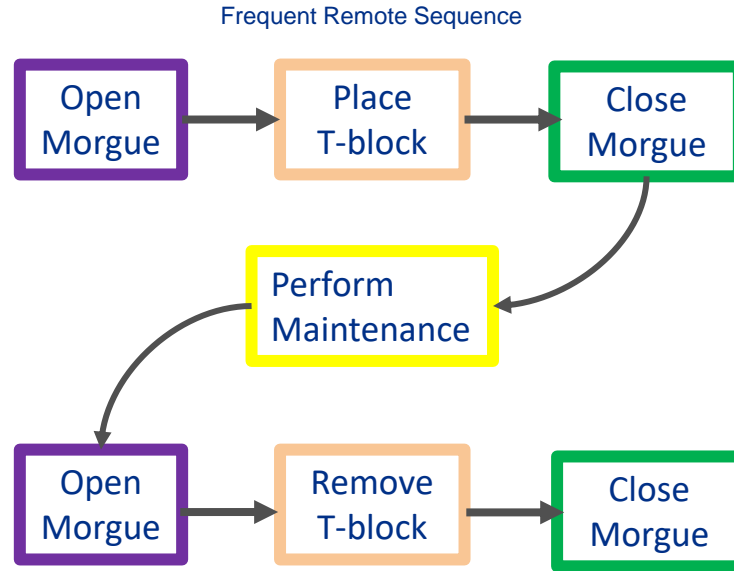
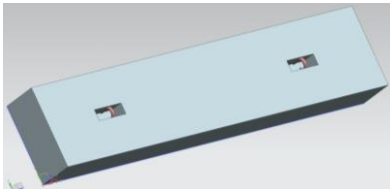
## 3. Transfer Cart Zone

- Lifting Fixtures
- New Equipment (SLB, Horn, etc.)
- Containments boxes for spent items



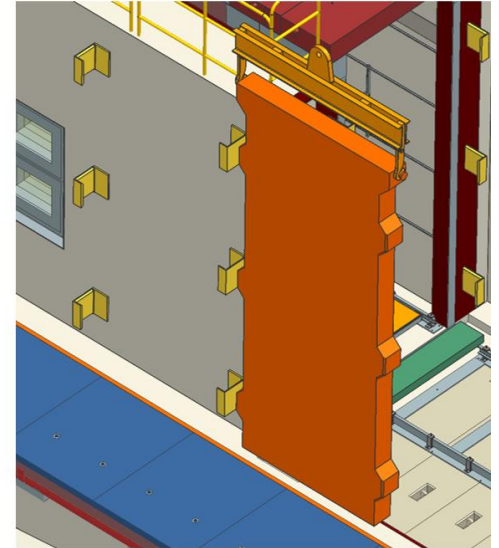
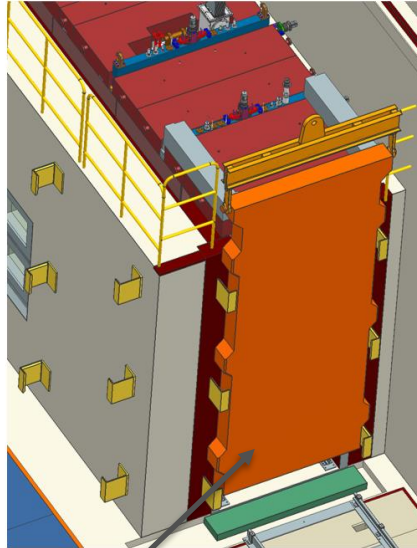
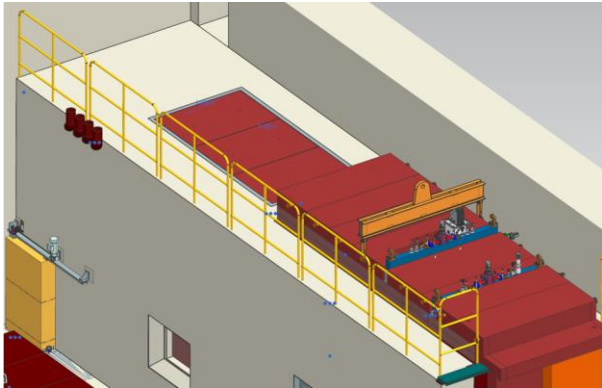
# Remote Lifting: Designing for common Fixtures

- T-blocks and morgue hatches usually lifted in sequence
- Design with common lift points
  - T-blocks
  - Morgue Cover blocks
  - Various in-morgue storage containers



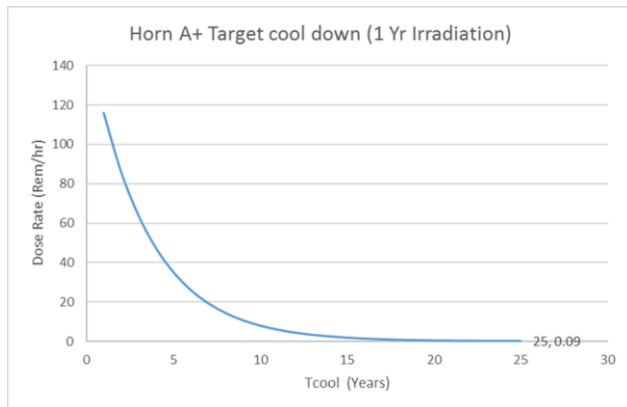
## Remote Lifting: Work Cell closure

- Typically lifted in sequence
- Remotely rigged lifts
- Common lift fixture:
  - Work Cell Door – 53t
  - Work Cell Covers – 15t

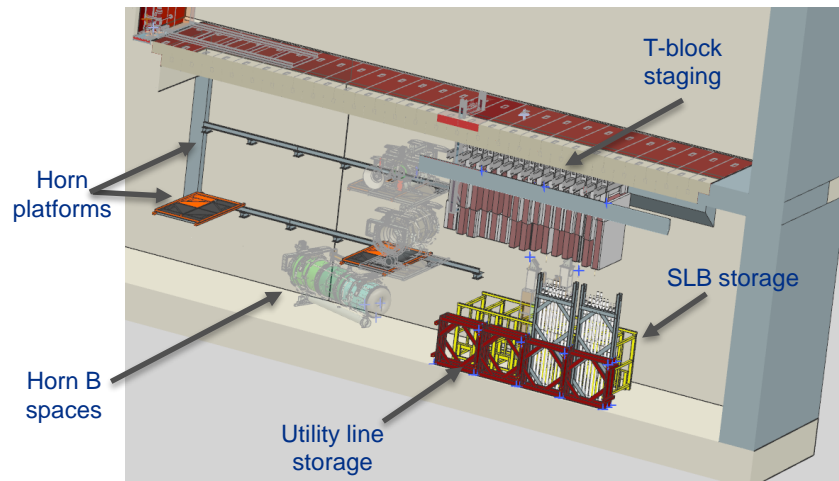


# Morgue Storage – Space Allocation

- 12x reconfigurable platforms for Horns A & C, Baffle, and Target
- 4x for Horn B
- 4x for SLB – A
- 6x for SBB – B & C



n lines



# Remote Vision System: Monitoring

- Monitoring Station modelled after NuMI:
  - Quick plug & play to removal for Beam-on
  - Monitor set for Crane control views
  - Monitor set for Reconfigurable Work Cell views
- Improvements:
  - More cameras
  - Multi-channel video switcher



NuMI PTZ motor controllers



Video switcher front (above) and rear (below)



Monitoring station at NuMI