Status of LBNF Beam

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Outline

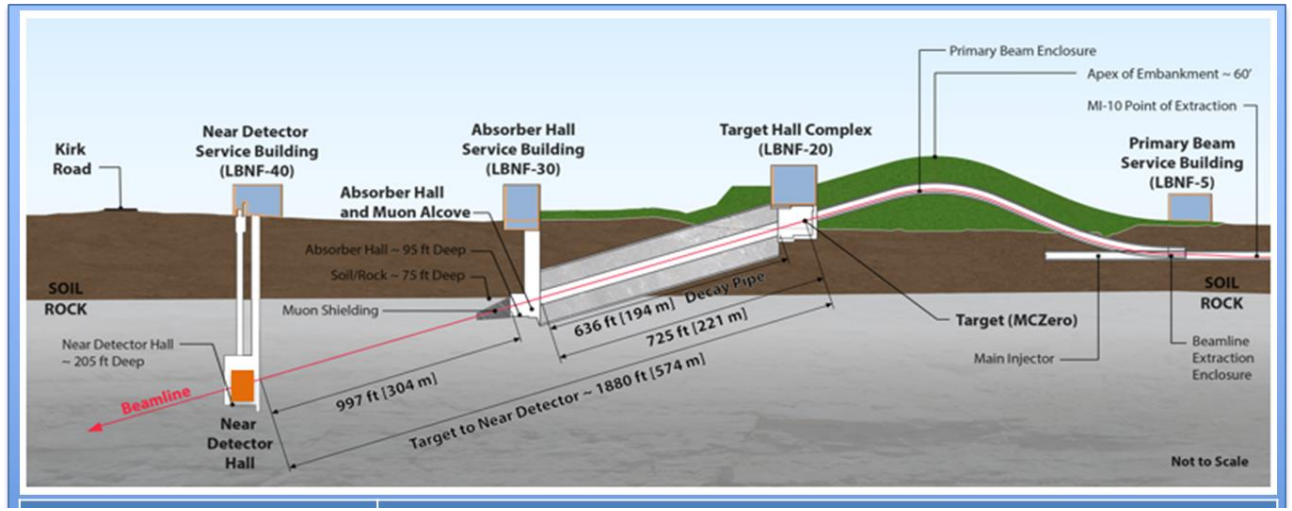
- Requirements
- Primary Beam
- Target Complex
- Decay Volume Structure
- Absorber Complex
- Instrumentation & Monitoring
- Civil Facilities

LBNF Beamline Requirements & Optimization of Parameters

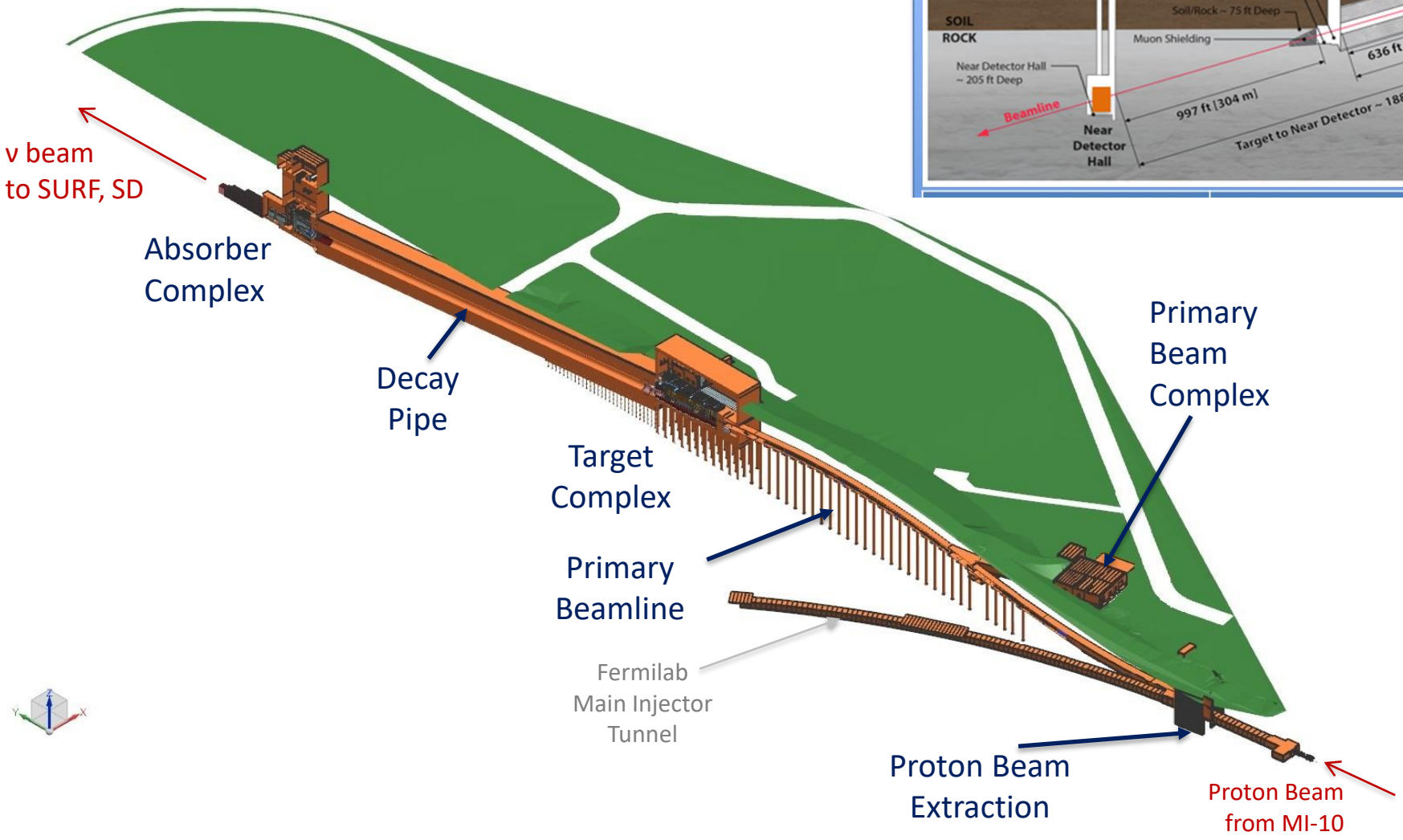
- Design for initial delivery of 1.2 MW beam power; upgradeable to 2.4 MW.
- Proton beam energy between 60 GeV and 120 GeV
- Pulse length of ~10 μsec
- Proton beam size on target tunable 1.0 – 4.0 mm rms

- Beam Optimization was performed to maximize DUNE physics (with some engineering constraints)
  - Three focusing horn system (geometry and spacing part of optimization)
    - Target inserted in first horn
    - Magnetic field generated by a 300,000 A pulse (half-sine wave of 800 μsec; beam at flattop)
  - Target to be cylindrically symmetric
    - Graphite material
    - Length of target desired to be four interaction lengths

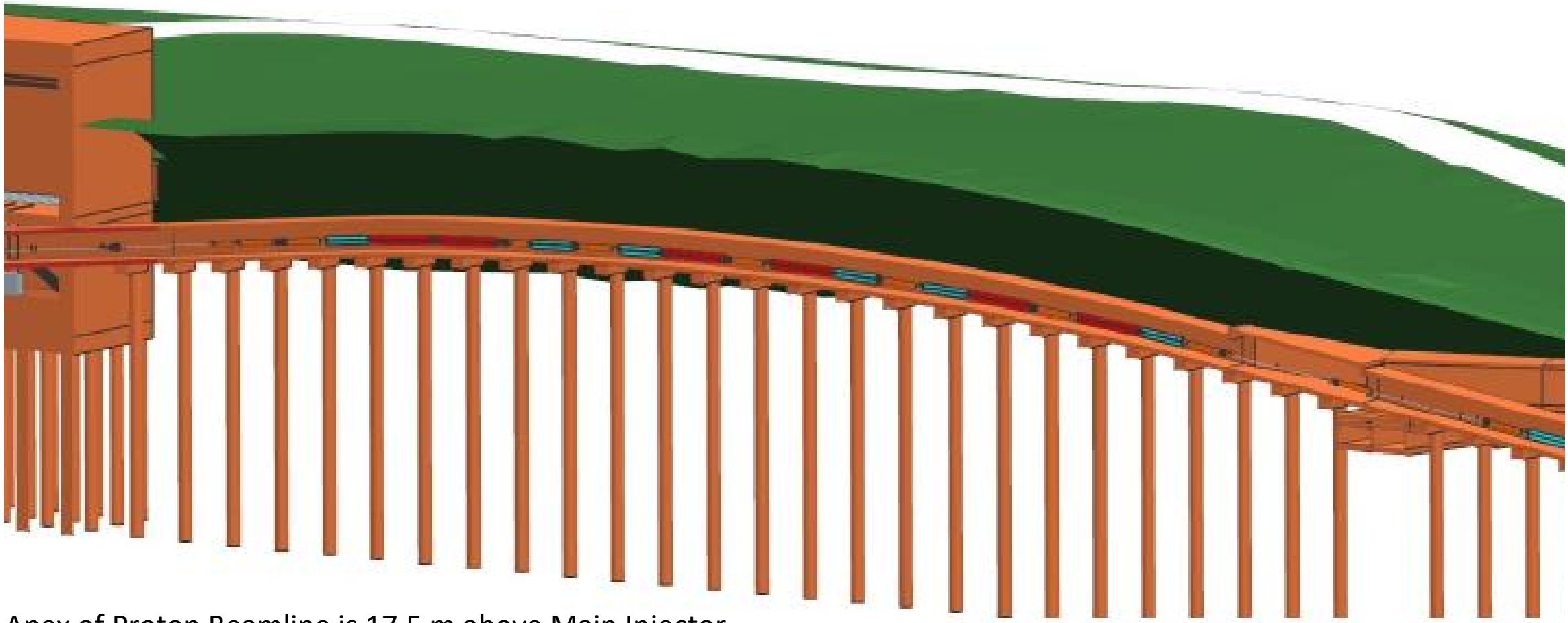
LBNF Beamline



LBNF Near Site



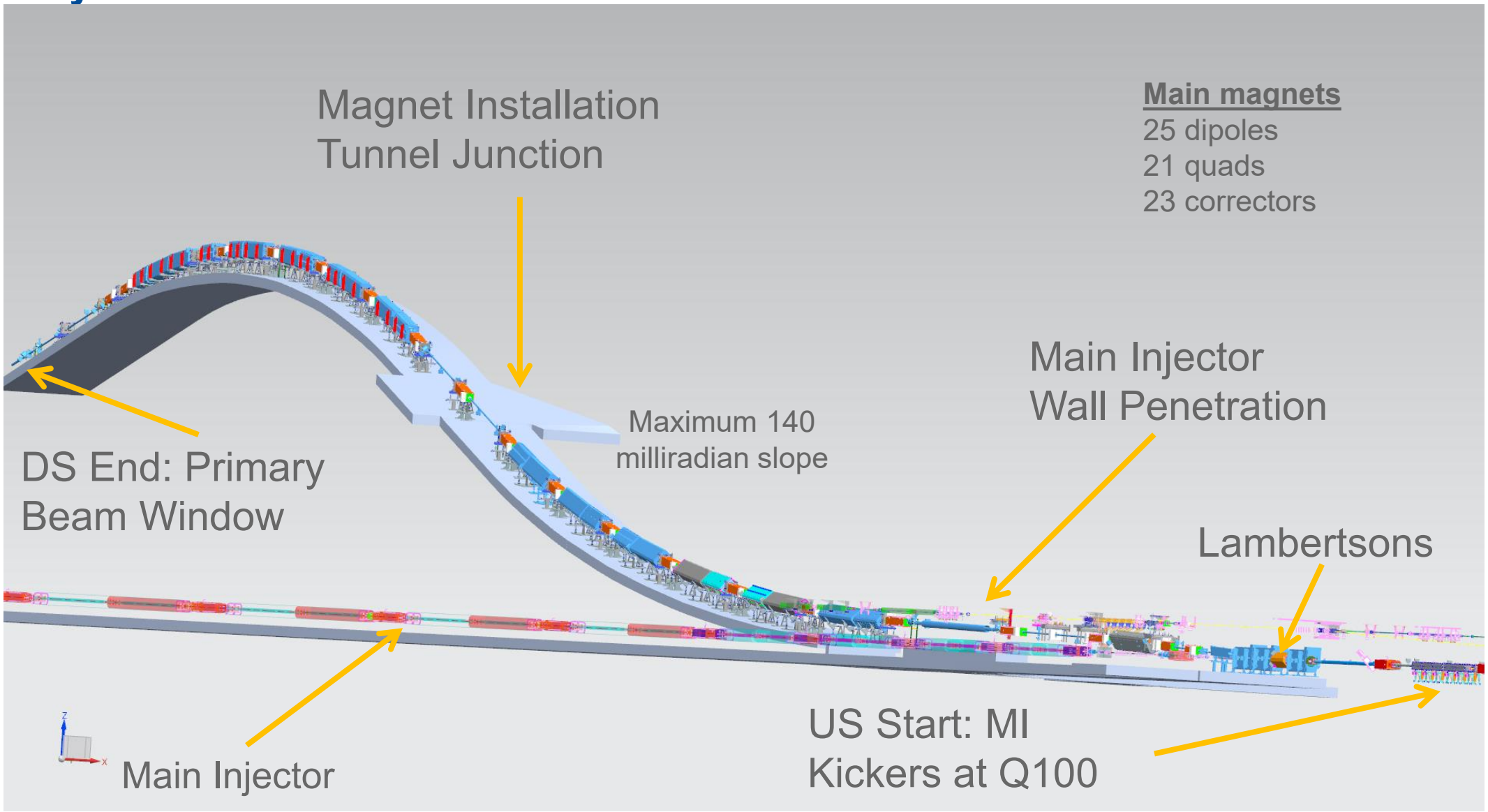
Primary Beam



Apex of Proton Beamline is 17.5 m above Main Injector

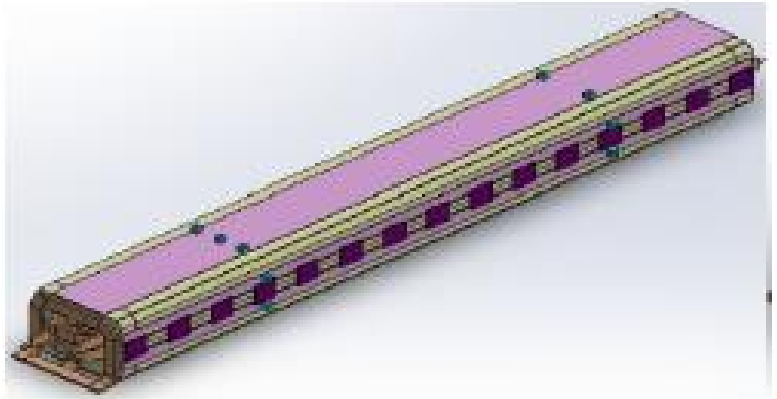
From Apex to target, beam drops 6 m & is at correct downward angle (101 milliradian) directed at DUNE detectors

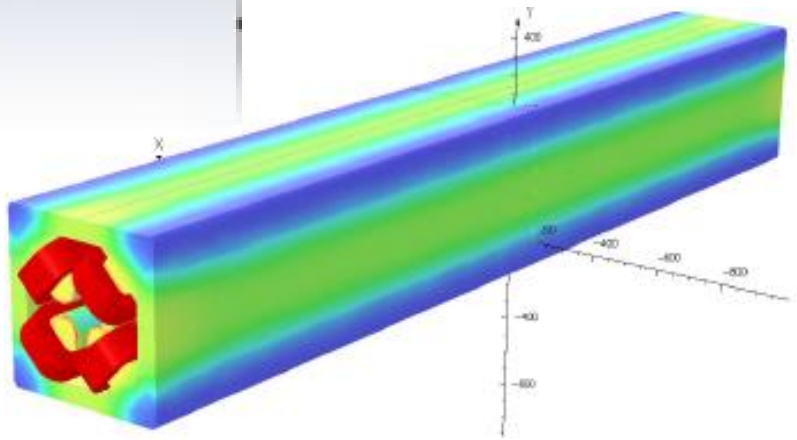
Primary Beam



International Partners for Magnets

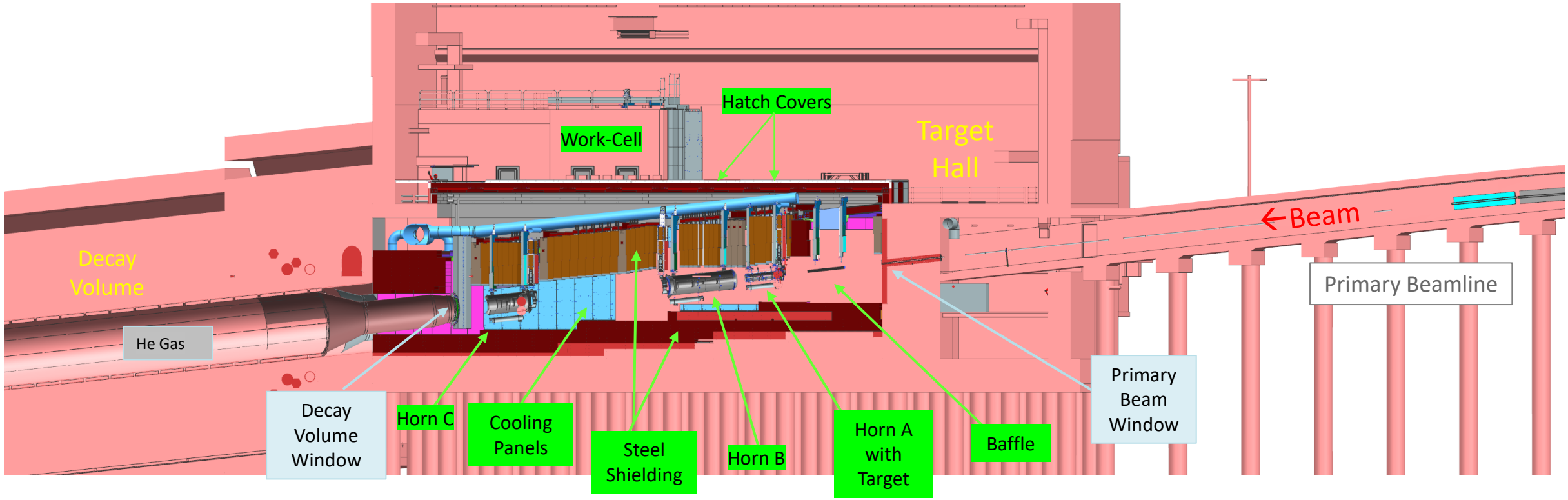
- Dipoles and Quads
  - BARC of India
  - Based upon previous Fermilab designs
  - Prototype fabrication about to begin



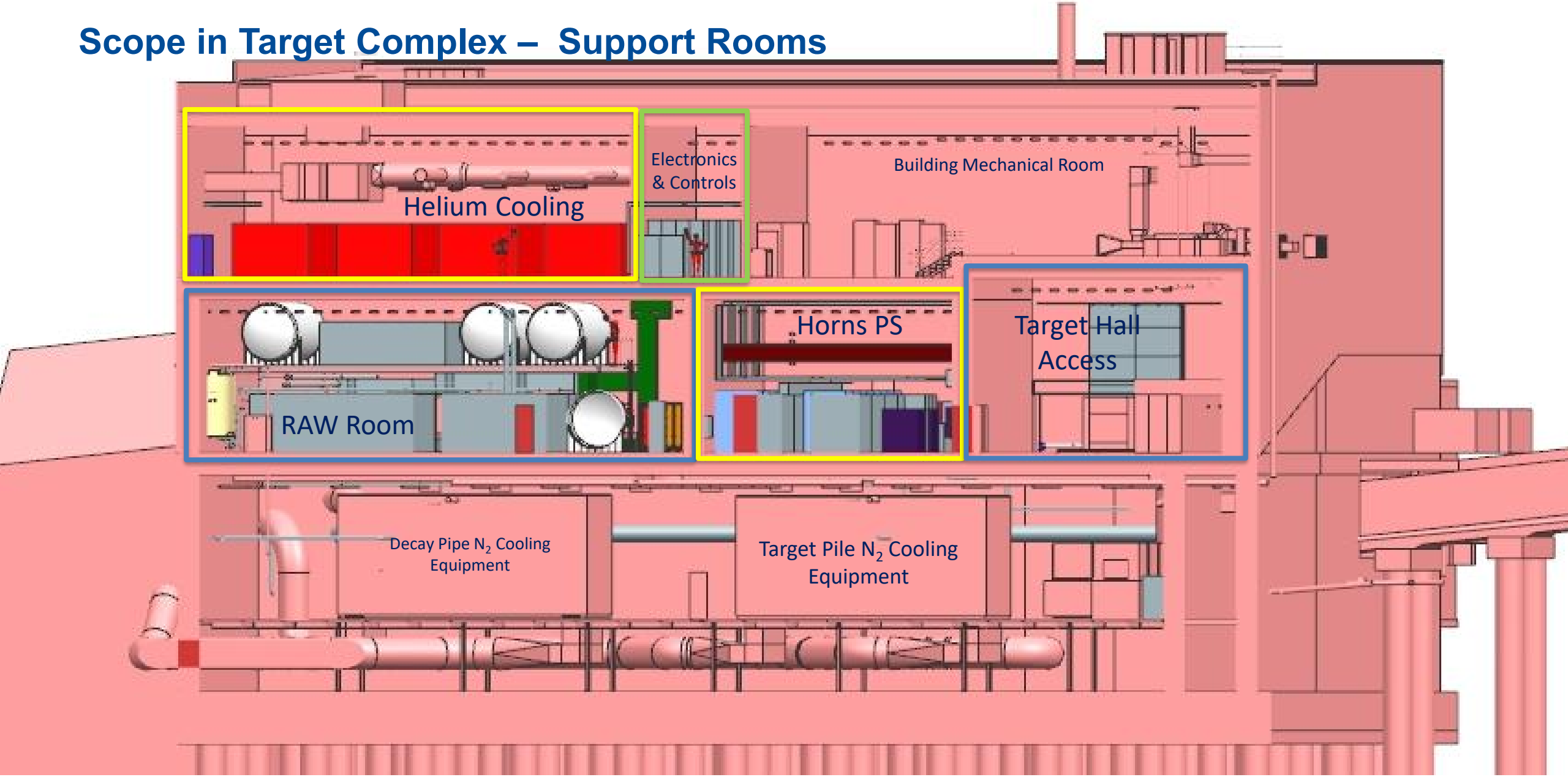


- Correctors
  - IHEP of China
  - Developed, produced, & delivered

Target Complex: Target Hall and Chase

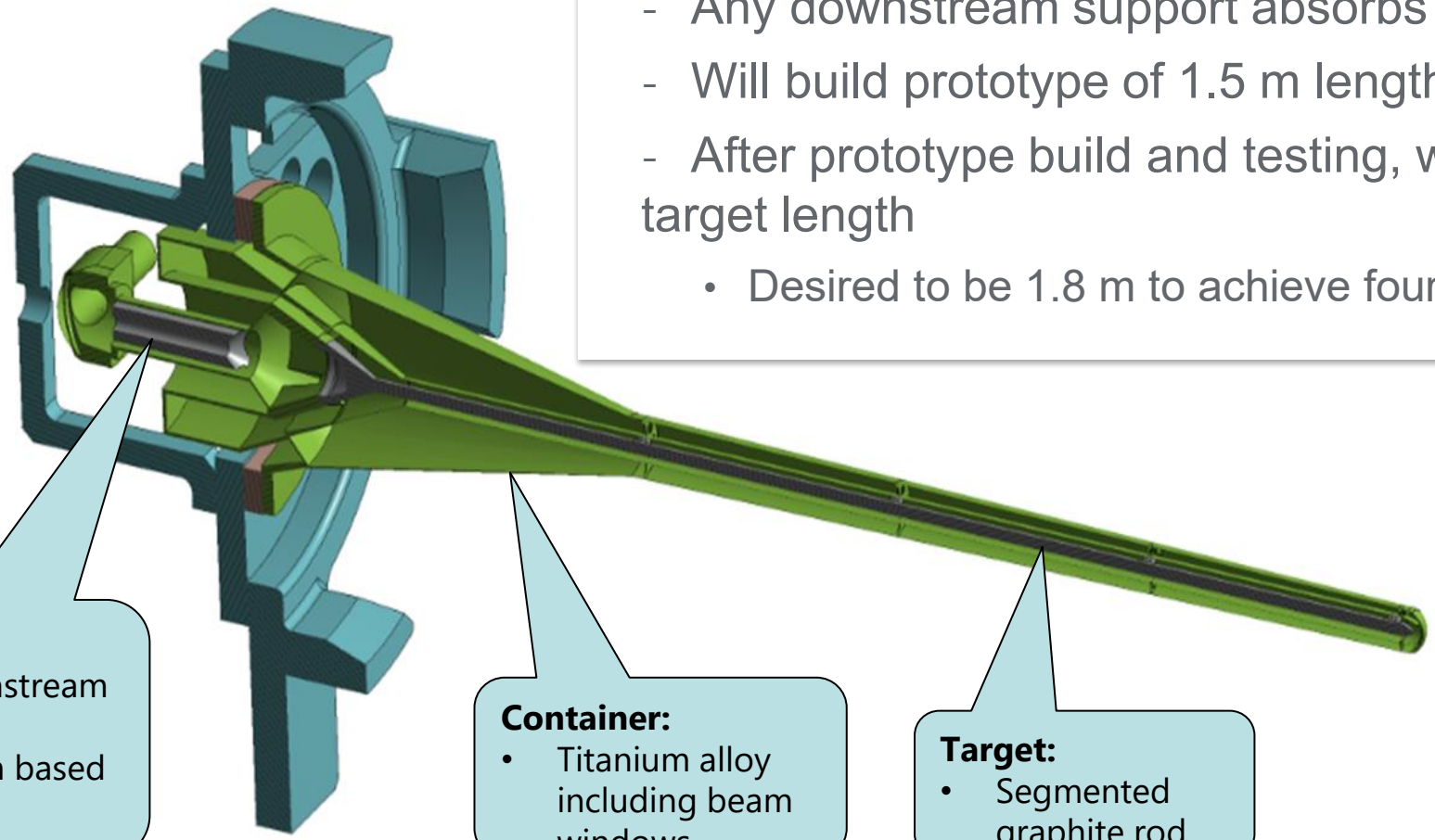


Scope in Target Complex – Support Rooms



Target

- UKRI is providing the Target (prototype and production)
- Settled upon using a cantilevered target based upon previous work (T2K)
  - Any downstream support absorbs too much
  - Will build prototype of 1.5 m length (50% longer than T2K)
  - After prototype build and testing, will decided production target length
    - Desired to be 1.8 m to achieve four interaction lengths

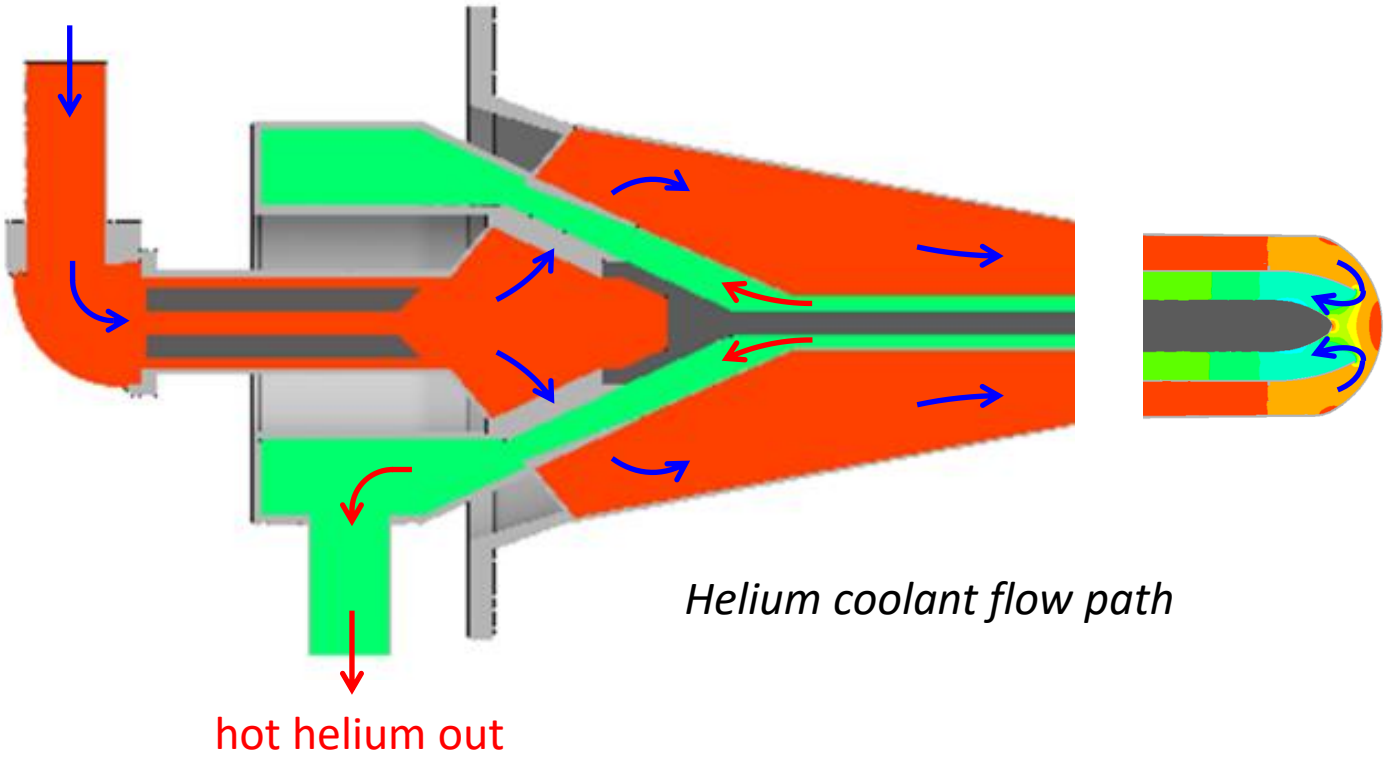


'Bafflette':
- Protects downstream elements
- enables 'beam based alignment'

Container:
- Titanium alloy including beam windows

Target:
- Segmented graphite rod

Prototyping Helium Cooling Gas Manifold – Manufacturability

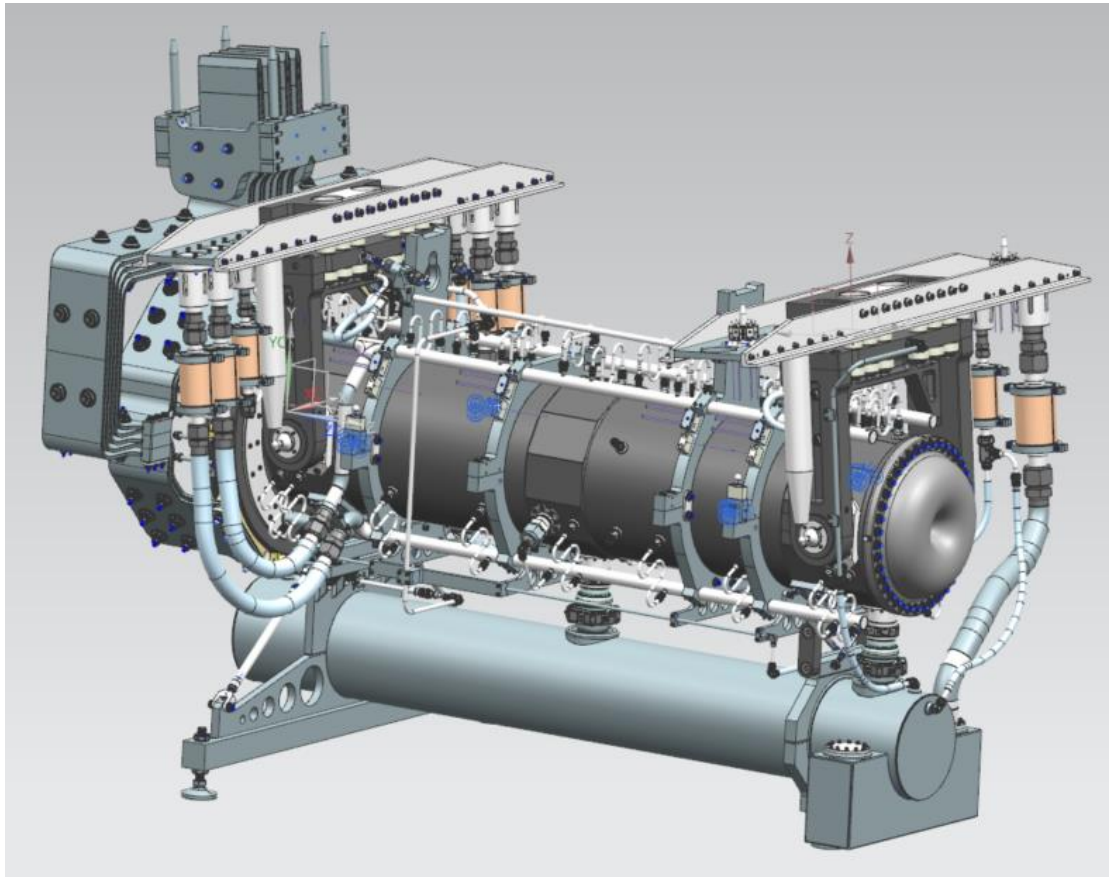


Helium coolant flow path

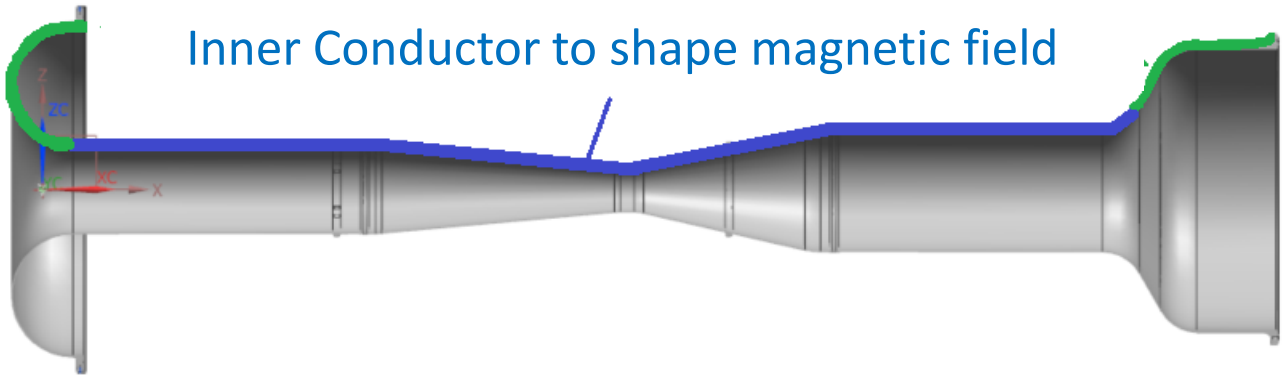
UKRI is moving forward with other prototyping before building a 1.5 m prototype T=target

Focusing Horns

Have started building a Horn A Prototype



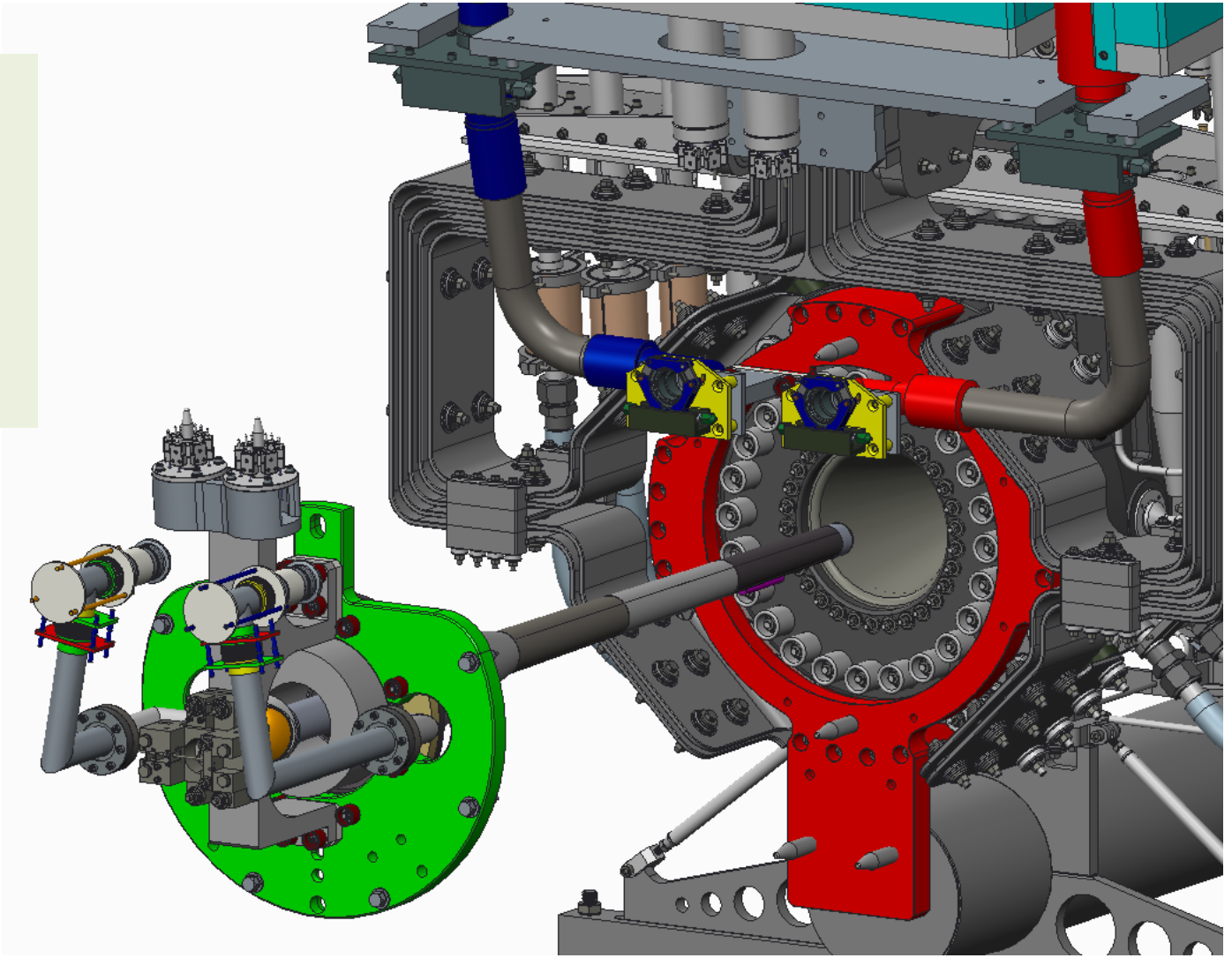
Horn A



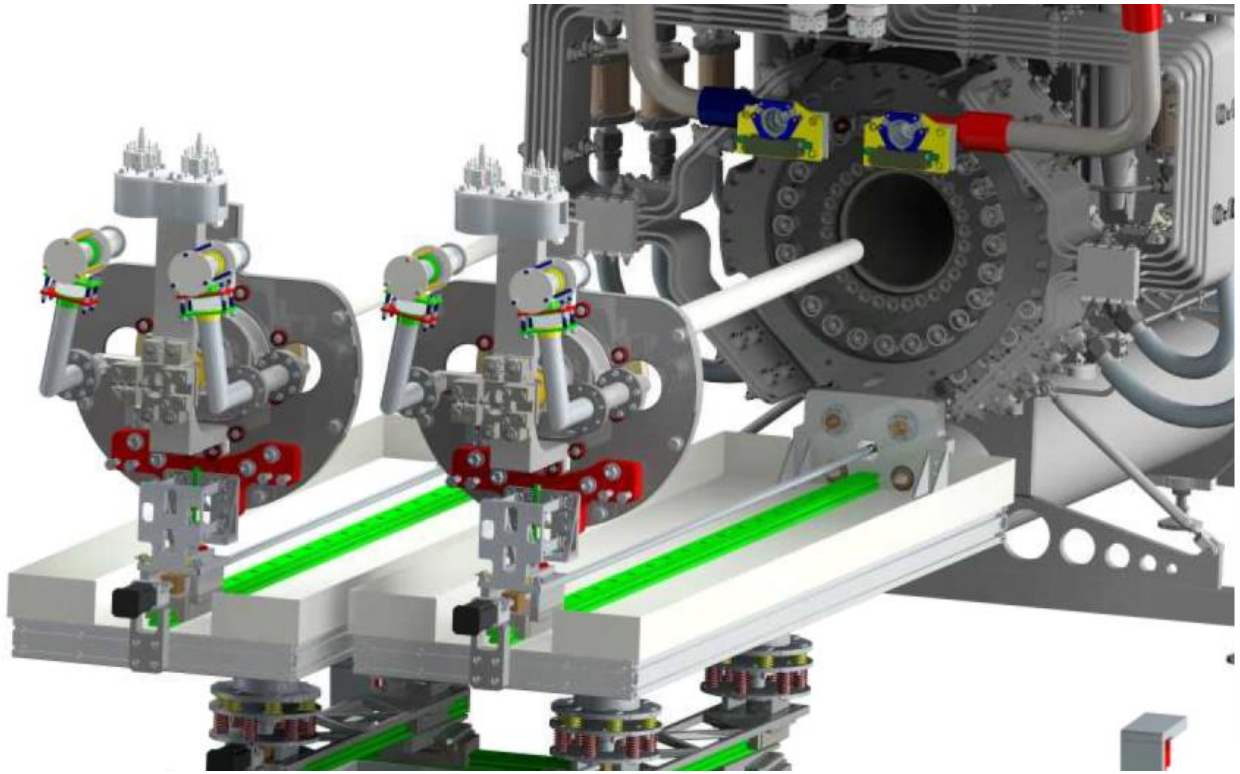
Horn B

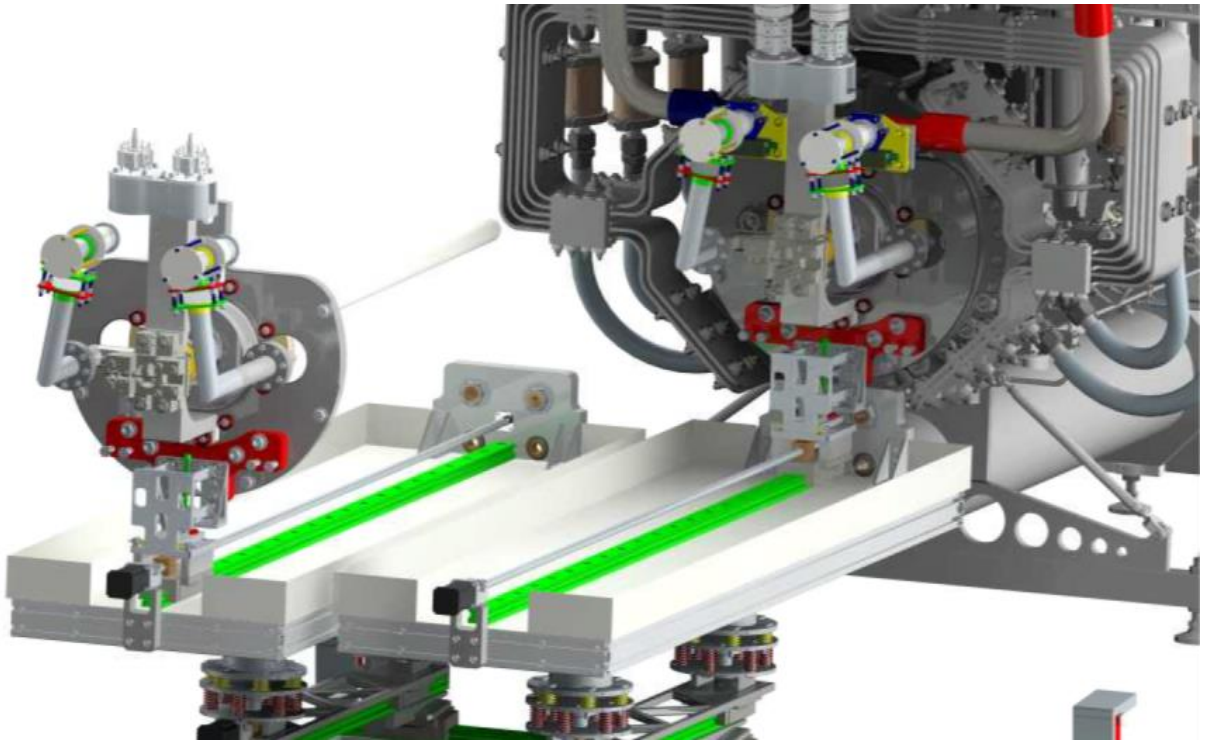
Integration of Target into Horn A

Green target module flange mates directly to red pre-aligned mounting plate on the horn.



Specialized Equipment to remove and install target assembly remotely

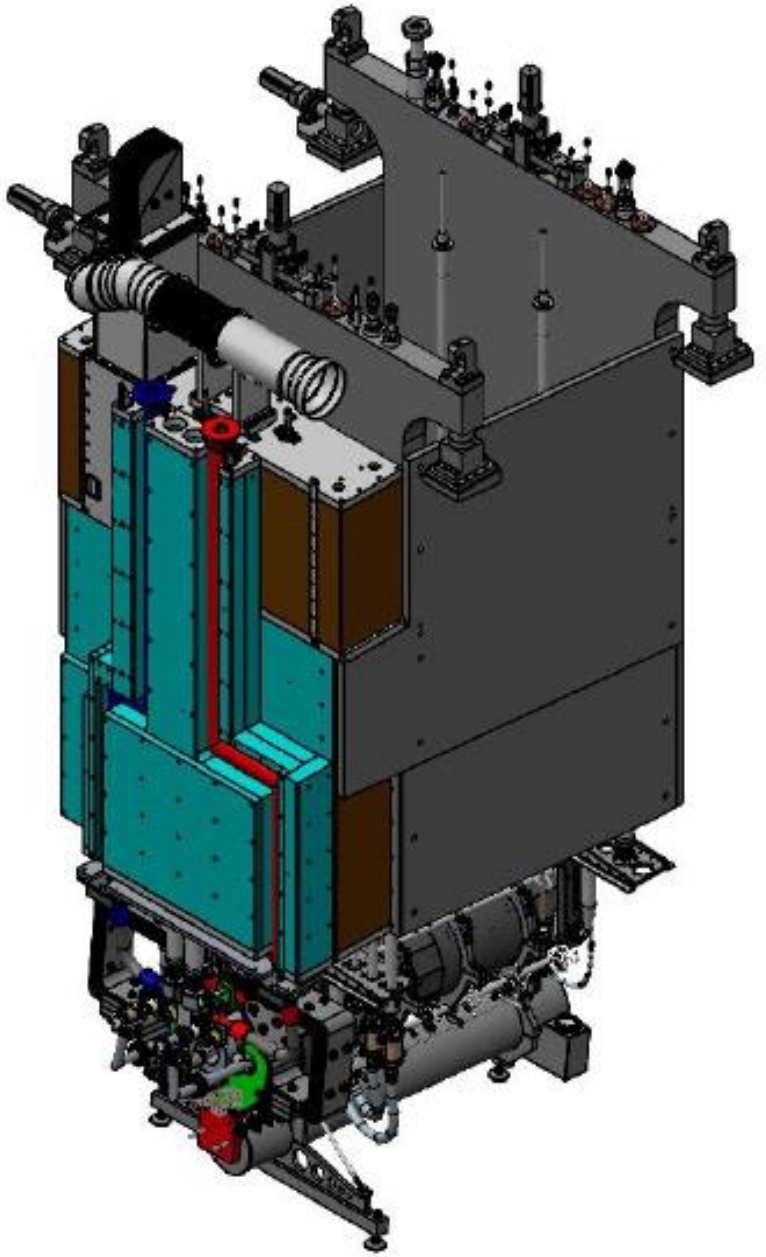




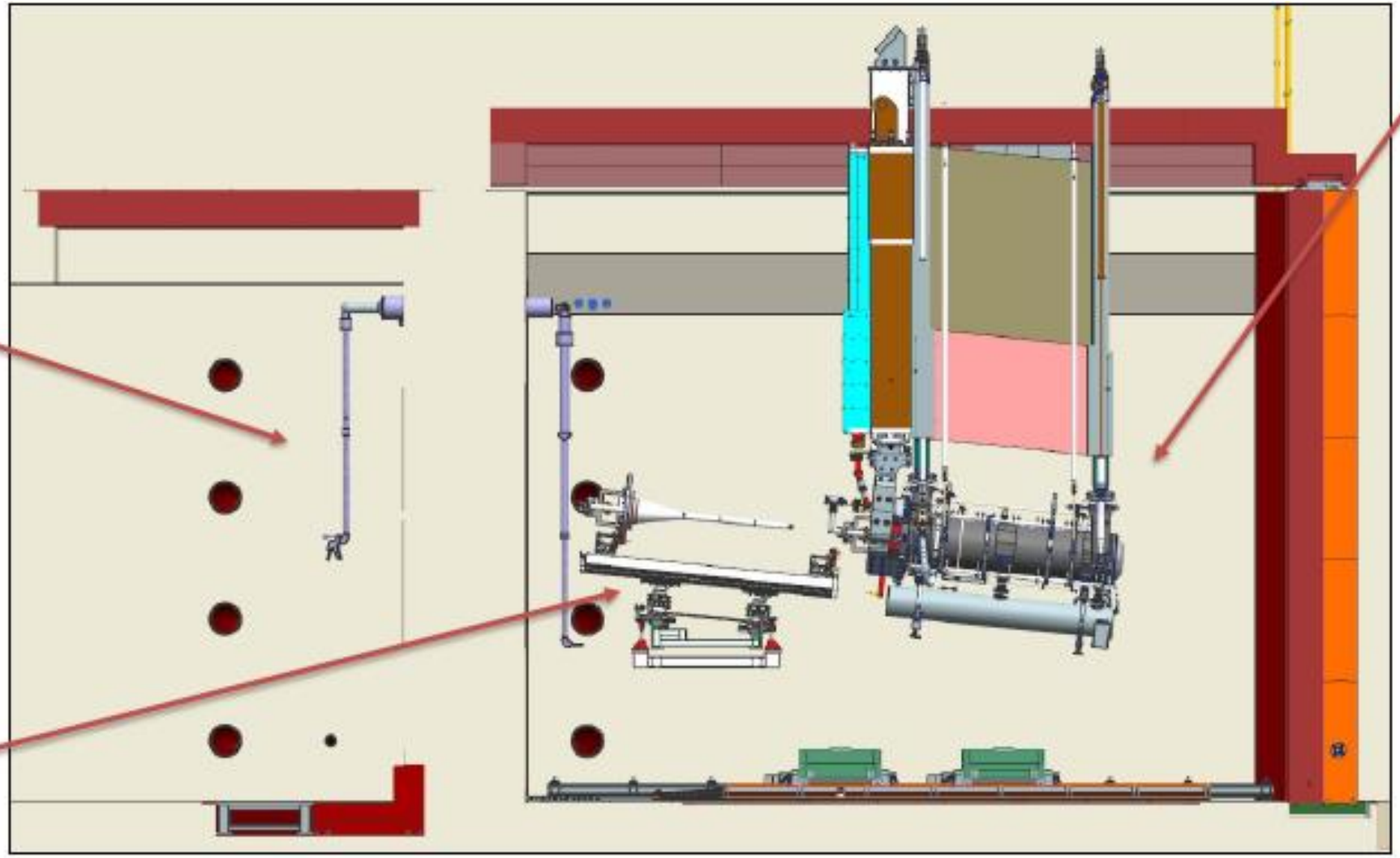
Need to remove/insert target without touching inner conductor, attach to flanges, connection of gas cooling line, & connection of instrumentation lines

Support Structure

- Securely holds component
- Allows positioning component precisely
- Provide pathway for utilities
  - Stripline bus (300,000 A)
  - Cooling
    - Water cooling for horn
    - Helium cooling for target
  - Thermocouple instrumentation
- Wall are part of radiation shielding
  - Other shielding fill in
- Connections are all done via Remote Handling

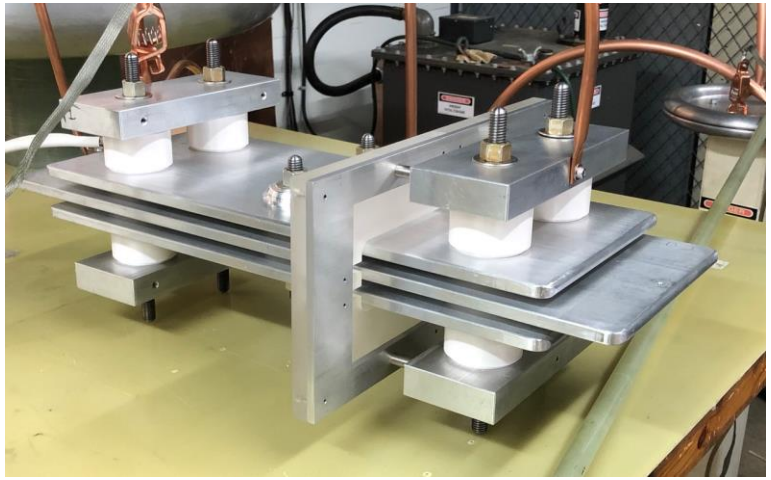


Remote Handling in Work Cell



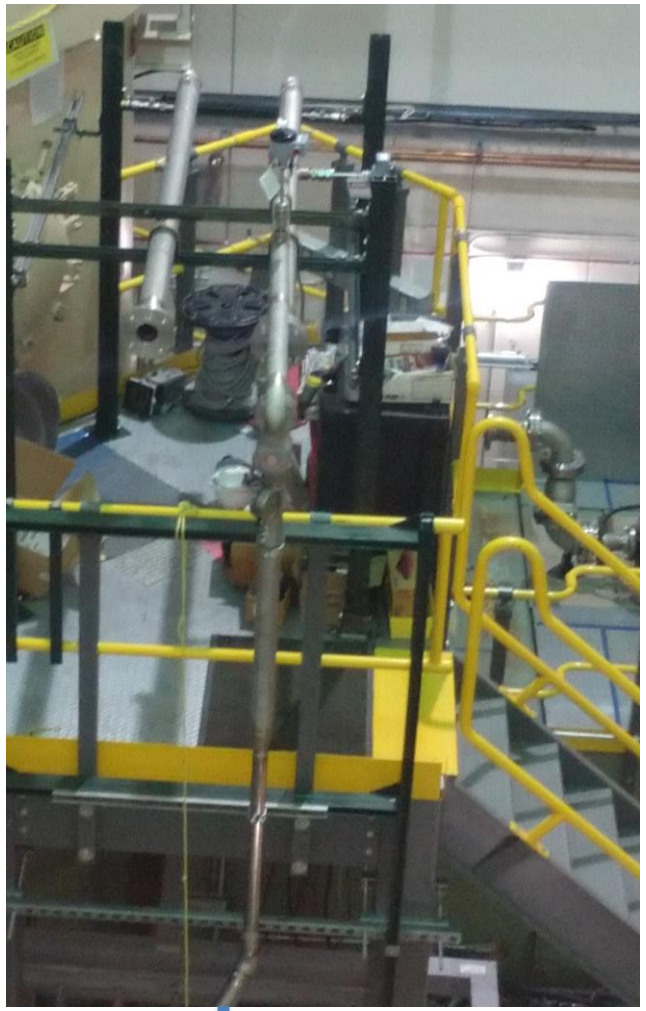
Other Recent Prototyping work

Electrical Bus & Ceramic Isolator Testing

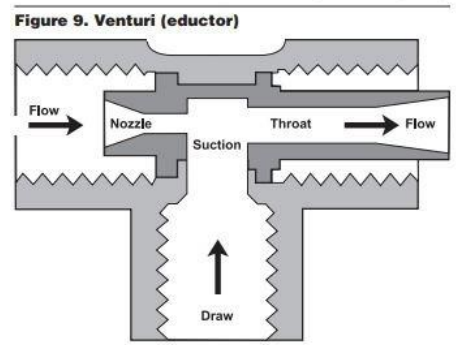


Remote Clamp Joint

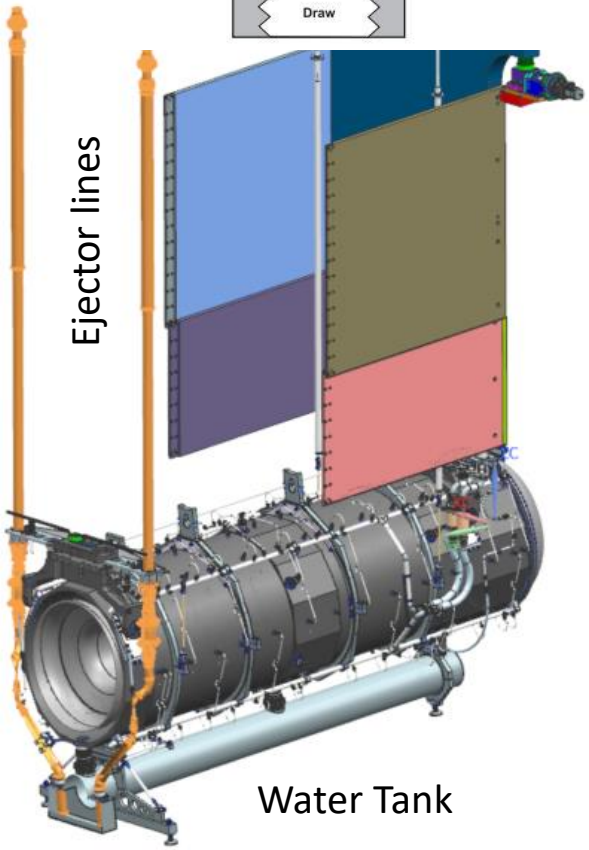
Ejection lines draw water ~8.2 meters



Water Tank



Ejector lines

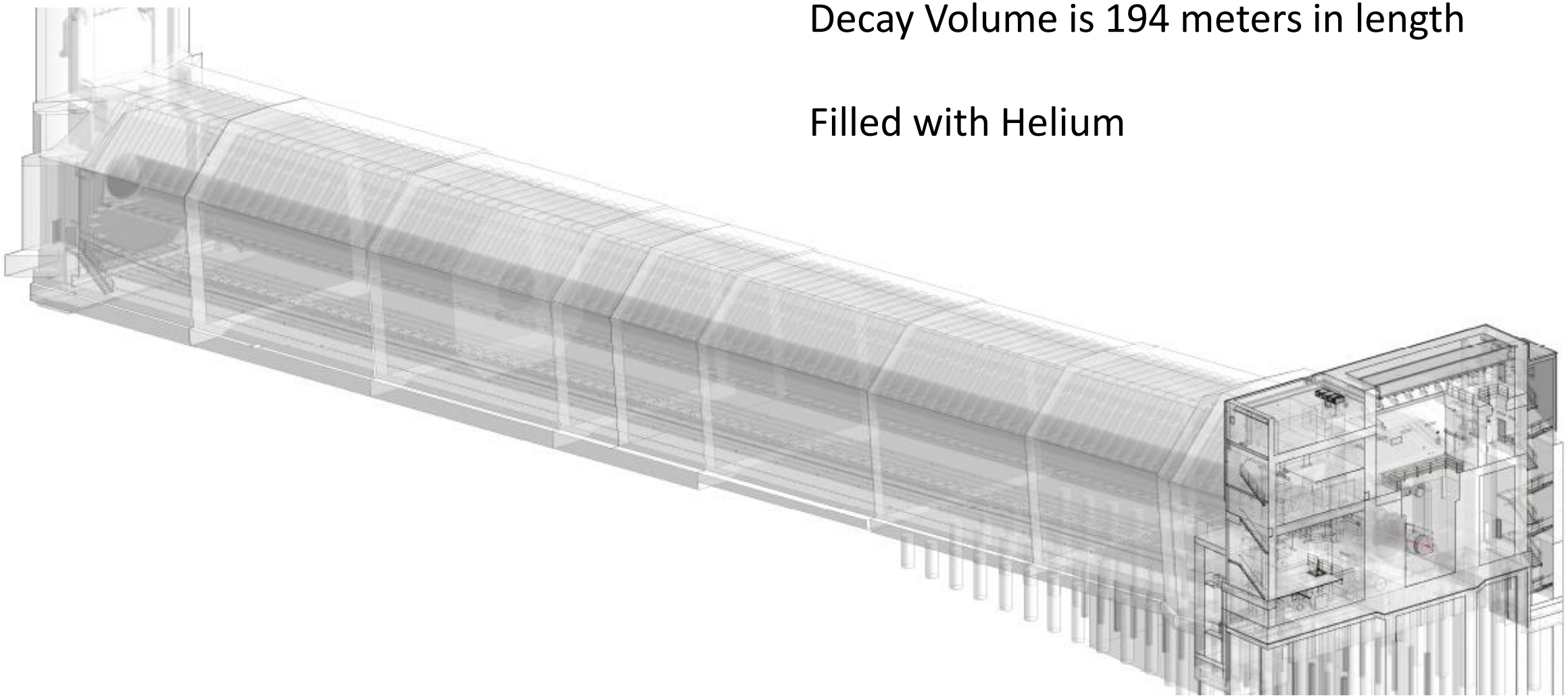


Water Tank

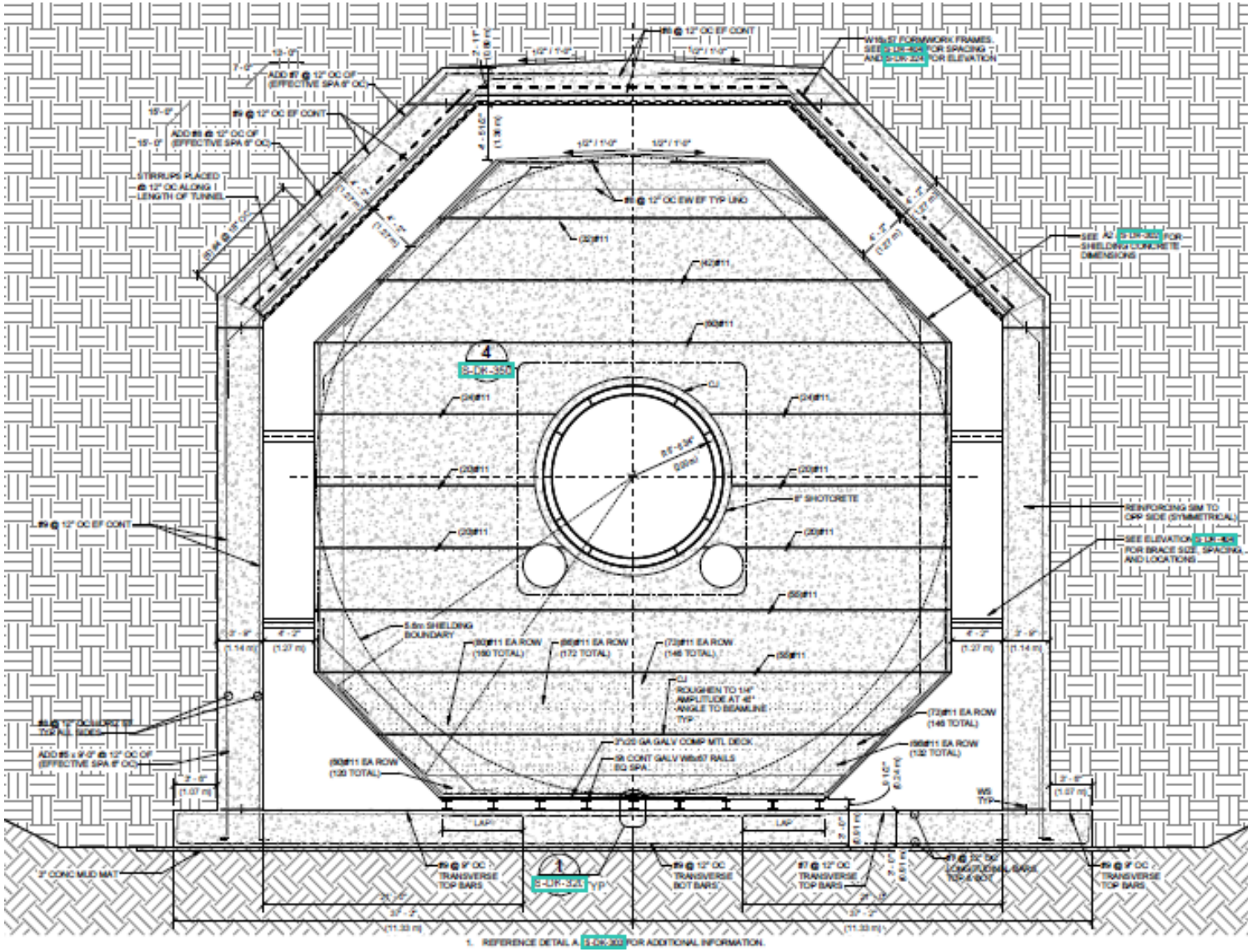
Decay Volume

Decay Volume is 194 meters in length

Filled with Helium



Decay Volume – Typical Cross Section



Decay Volume radius is 2.0 meters

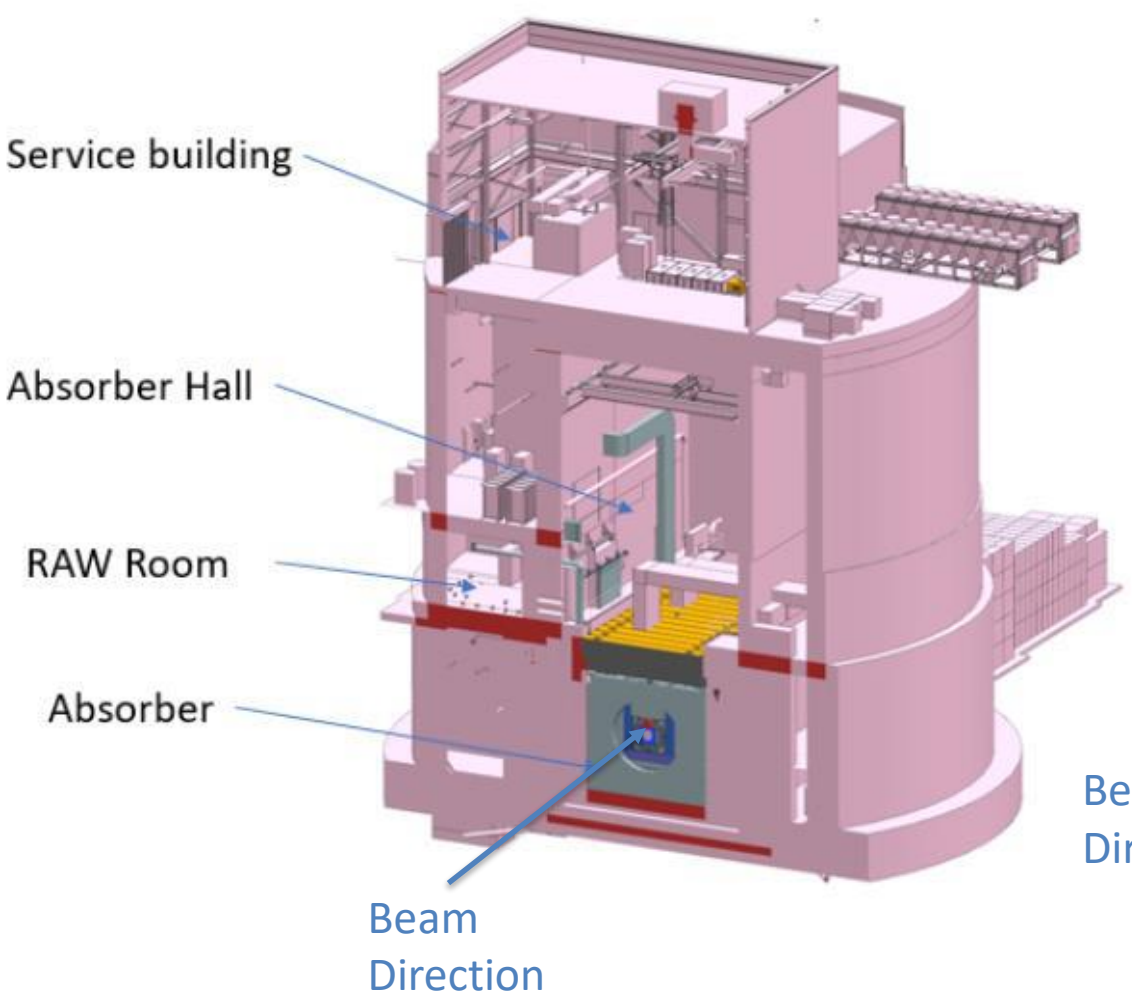
Two concentric steel tubes separate the helium volume from the shielding.

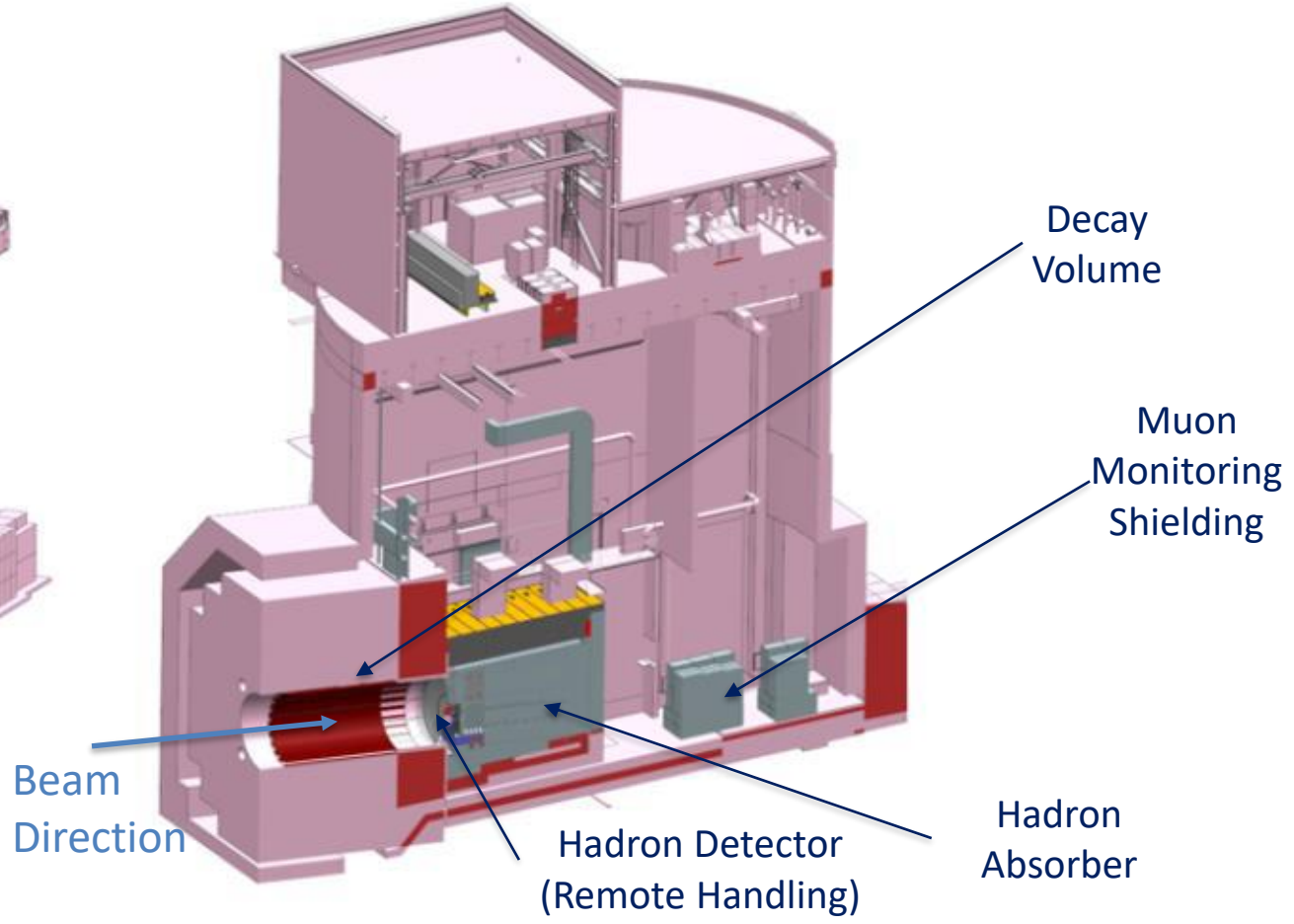
Surrounded by > 5.6 meters of concrete shielding.

Cooling of the steel tubes is by nitrogen gas

Absorber Complex

Old plan; service building has changed

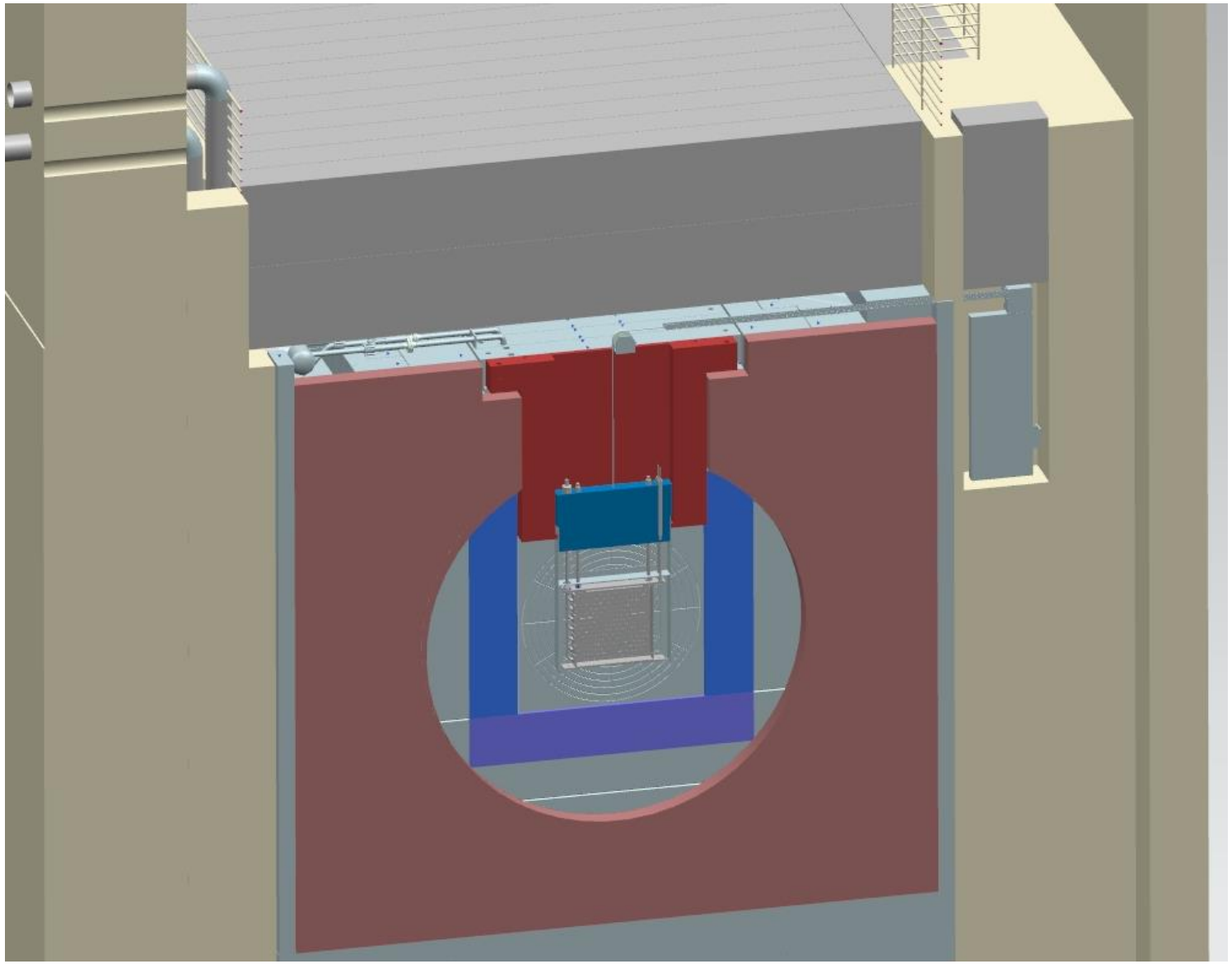




Absorber Hall Floor is 25 meters below ground

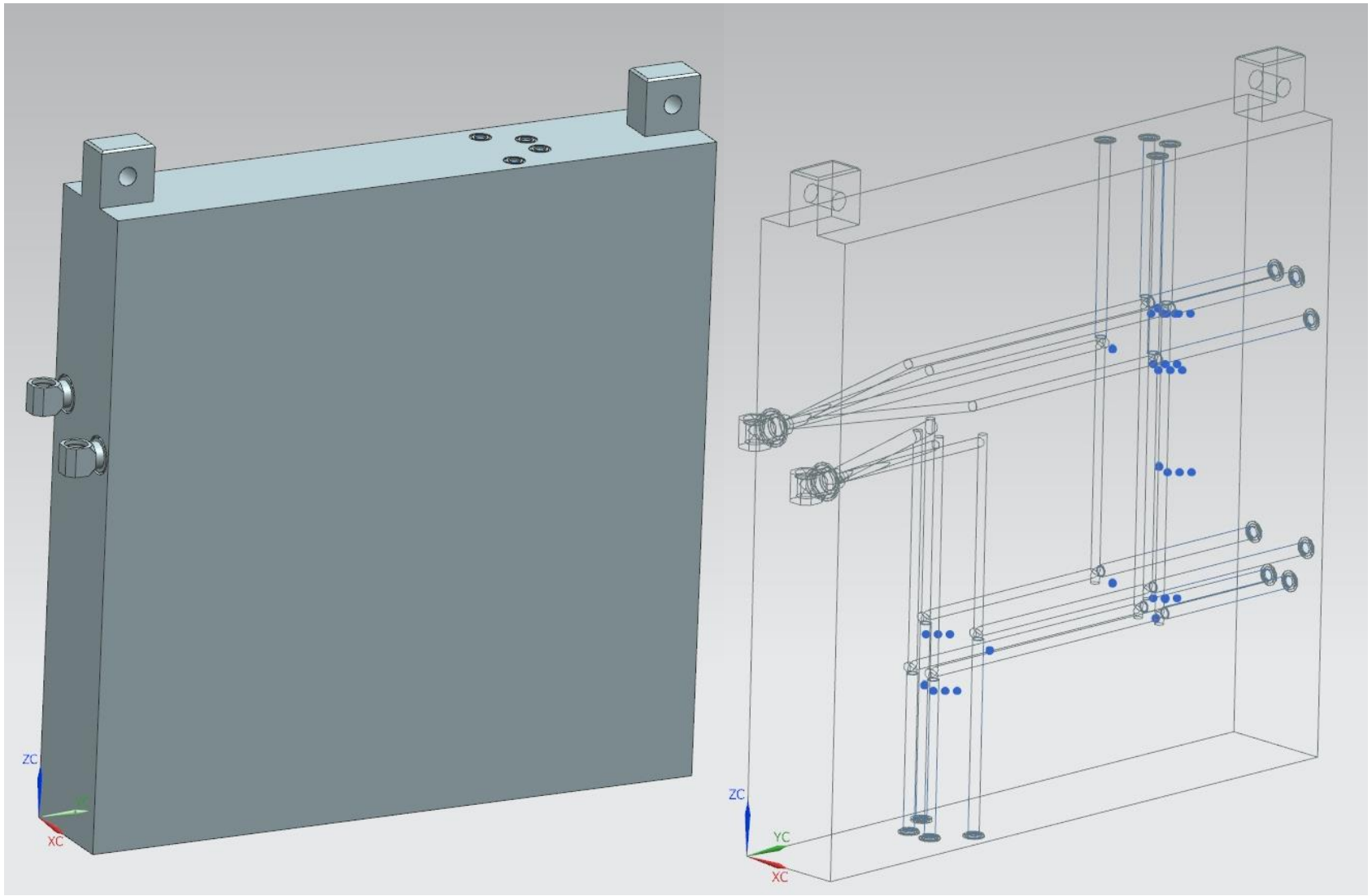
Hadron Detector in front of absorber

- Used for Beam Based Alignment
- Able to lower into position when needed
- Replaceable



Absorber is a series of Aluminum and Steel Panels

- Water cooled
  - Drilling pattern shown
  - Plug/weld 16 holes
- Replaceable panels
- Designed for 2.4 MW



Facility Instrumentation and Monitoring

- Three muon stations behind absorber
  - Samples high energy muons that are produced
  - Look for changes in muon distributions
  - Determine muons produced per proton on target
- Thermocouple array distributed through absorber
  - Able to monitor protons not interacting with the target
- Hydrostatic Level System
  - Monitor movement of Target Station components with respect to final focusing elements of proton beamline
  - Vertical movements of components due to motors and thermal expansion
- Beam Based Alignment System
  - Includes features on Horns, Target, & baffle to scan beam across
  - Includes retractable beam loss monitors in target chase area

Civil facilities

- Intense design work over the last year
- Concentration on radiological issues
  - Building has permanent shielding
  - Control of radioactive gases
    - Defining air flow path to allow isotopes to decay before release to atmosphere
    - Provide a buffer volume between the radioactive air path and the atmosphere
  - Control of water and ability to test water before directing to outside or to be captured
    - Water seepage into facilities
    - Condensate from air handling units

What is for 1.2 MW and 2.4 MW

- What is design for 1.2 MW and could be replaced with a future upgrade
  - Baffle
  - Target
  - Horns
  - Beam windows of Target chase
  - Instrumentation/Detectors
  - Some cooling Systems
- What is designed for 2.4 MW and should not have to be replaced
  - Proton beamline components
  - All shielding
  - Piping for cooling systems between support rooms and components
  - Decay Volume
  - Absorber
  - Power Supply

Final Remarks

- LBNF Beamline is part of the LBNF/DUNE-US Project
- The LBNF Beamline is based upon the experiences of other neutrino beamlines
- Prototyping is in progress
- Facility will support initial beam power of 1.2 MW and is upgradeable to 2.4 MW