Facilitating Mu2e Integration via the 3D CAD model

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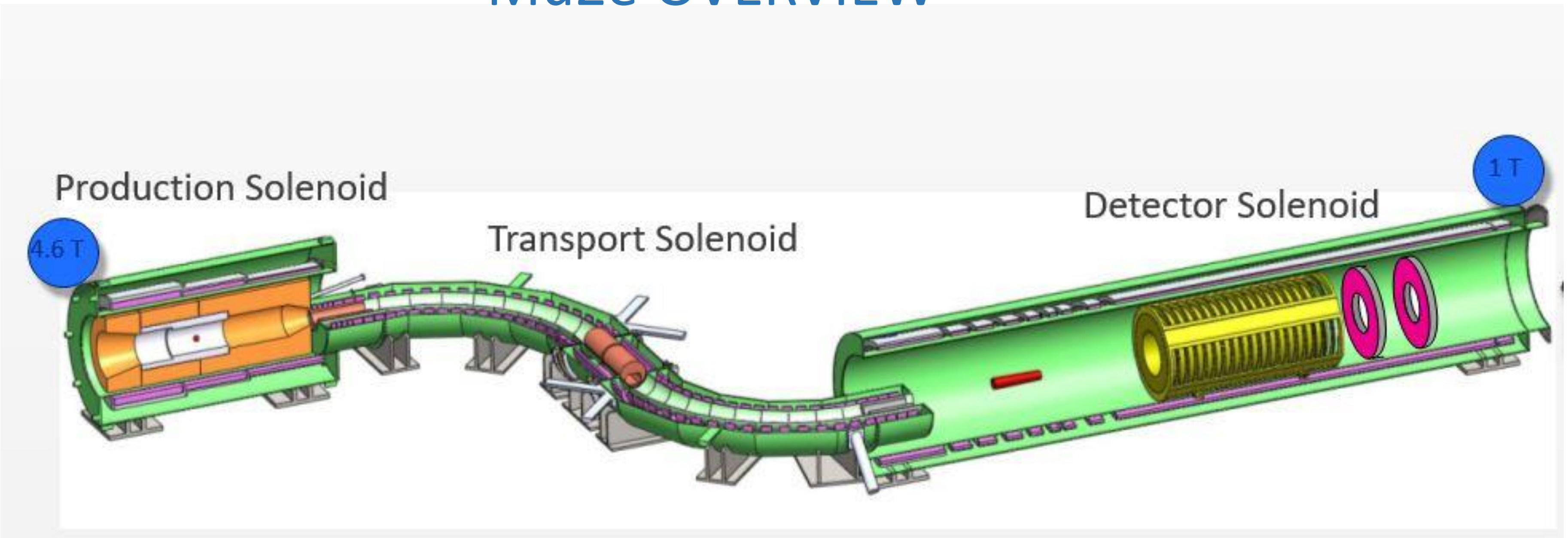
OVERVIEW OF MY WORK

- Become familiar with the Mu2e building and detector layout
- Control and refine the 3D CAD model of the Mu2e installation
- Add new components in the 3D CAD existing model to facilitate integration
- Investigate, explore and where possible resolve interferences
- Arrangement of Detector Train 3D CAD model
- Contribute to the concept design of Calorimeter services path

Mu2e OVERVIEW



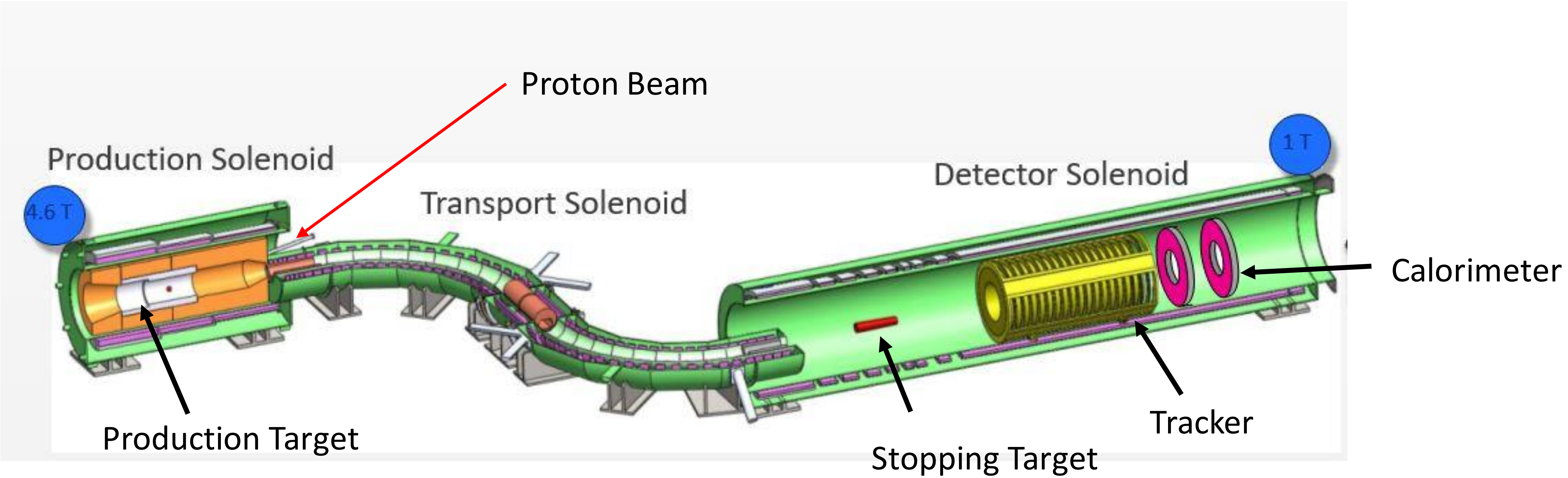
Three Superconducting Solenoids:

- **Production Solenoid (PS) - 4m long x 1,5m diameter**

- **Transport Solenoid (TS) – 13m long x 50 cm diameter;** S-shaped to move the detector solenoid out of the line of sight from the production solenoid (Suppresses neutrons and gammas produced at the production target entering the detector solenoid).

- **Detector Solenoid (DS) – 11m long x 2m diameter**

Mu2e OVERVIEW

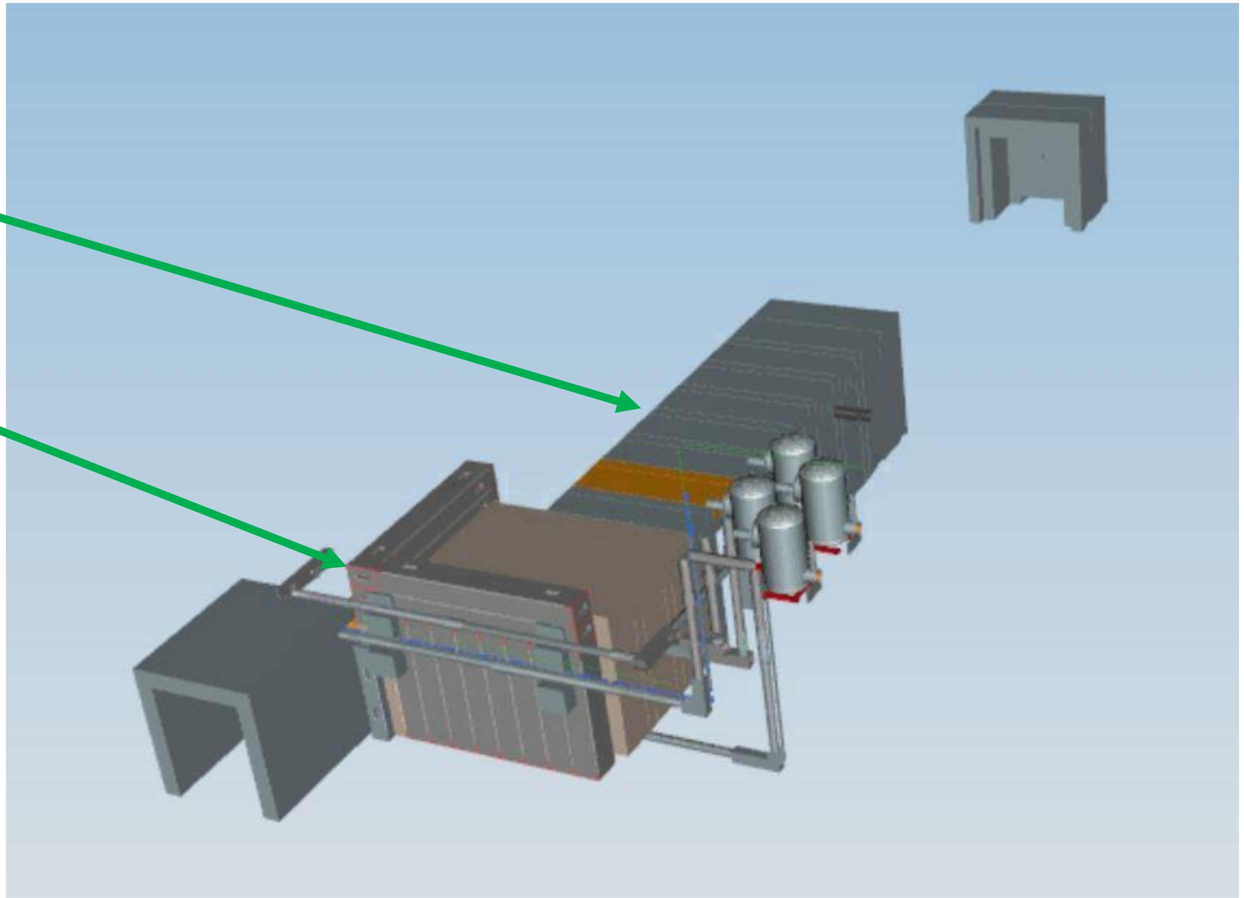


- A pulsed proton beam hits the production target to produce pions which decay into muons.
- The muons get transported via the transport solenoid to the detector solenoid where some stop in the aluminum stopping target.
- If neutrinoless conversion electrons are produced in the stopping target, they will move through the tracker to the calorimeter (measure momentum in tracker and energy in calorimeter)

OVERVIEW OF MODIFICATION TO MB SHIELDING

The changes made relate to two submodels of the entire Mu2e 3D CAD model:

- Downstream External Shielding
- Upstream External Shielding



BRIEF DESCRIPTION OF THE STRUCTURES EXAMINED - DOWNSTREAM EXTERNAL SHIELDING

Shielding needs to be placed around the downstream Transport Solenoid and the Detector Solenoid.
The **main requirements for the shielding** are as follow:

- Reduce the neutron and gamma background generated by muon stops incident upon the Cosmic Ray Veto (CRV) Counters.

- Provide a base for support of CRV modules

Material requirements depend upon a number of factors:

- Shielding performance

- Mass of the components

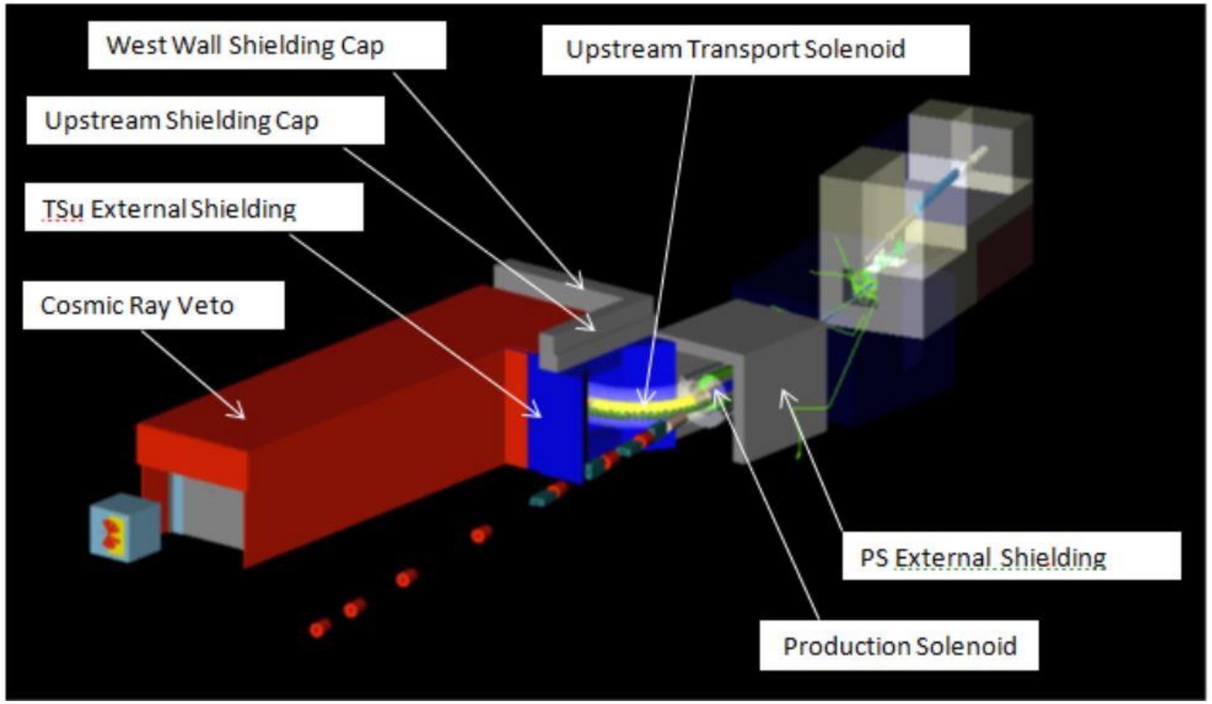
- Forces induced by effects of the solenoid magnetic field on the steel reinforcement bars

- Capacity to support CRV modules

BRIEF DESCRIPTION OF THE STRUCTURES EXAMINED - UPSTREAM EXTERNAL SHIELDING

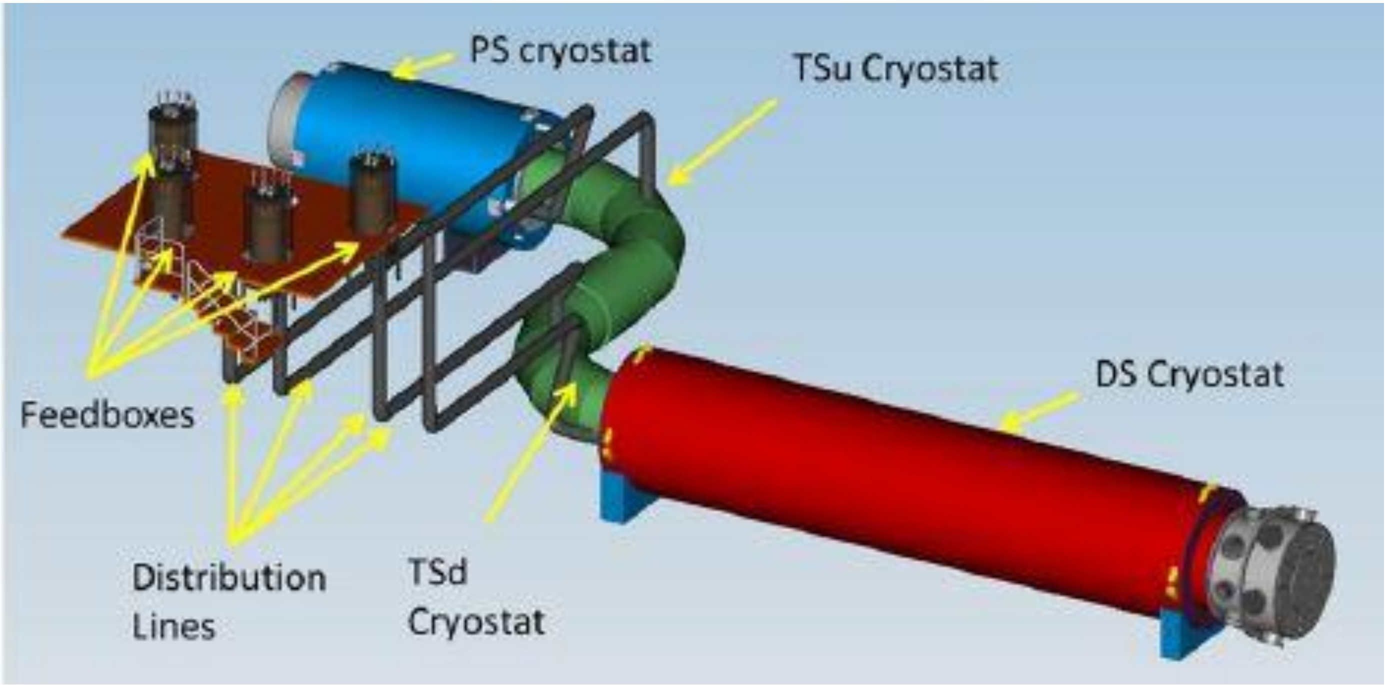
The upstream external shielding of the Muon Beamline surrounds the Production Solenoid and isolates the primary proton beamline from the Detector Solenoid hall while shielding the Cosmic Ray Veto (CRV) from radiation generated at the production target located in the Product Solenoid and resulting from the secondary beam transported by the upstream Transport Solenoid. The **primary purposes** of the Upstream External Shielding are:

- Shield the Mu2e detector
- Reducing the rate of neutron and gamma background impinging on the CRV to an acceptable level
- Isolate the primary proton beamline from the downstream muon beamline, dividing the lower level of the Mu2e Experiment Hall into two independent zones.



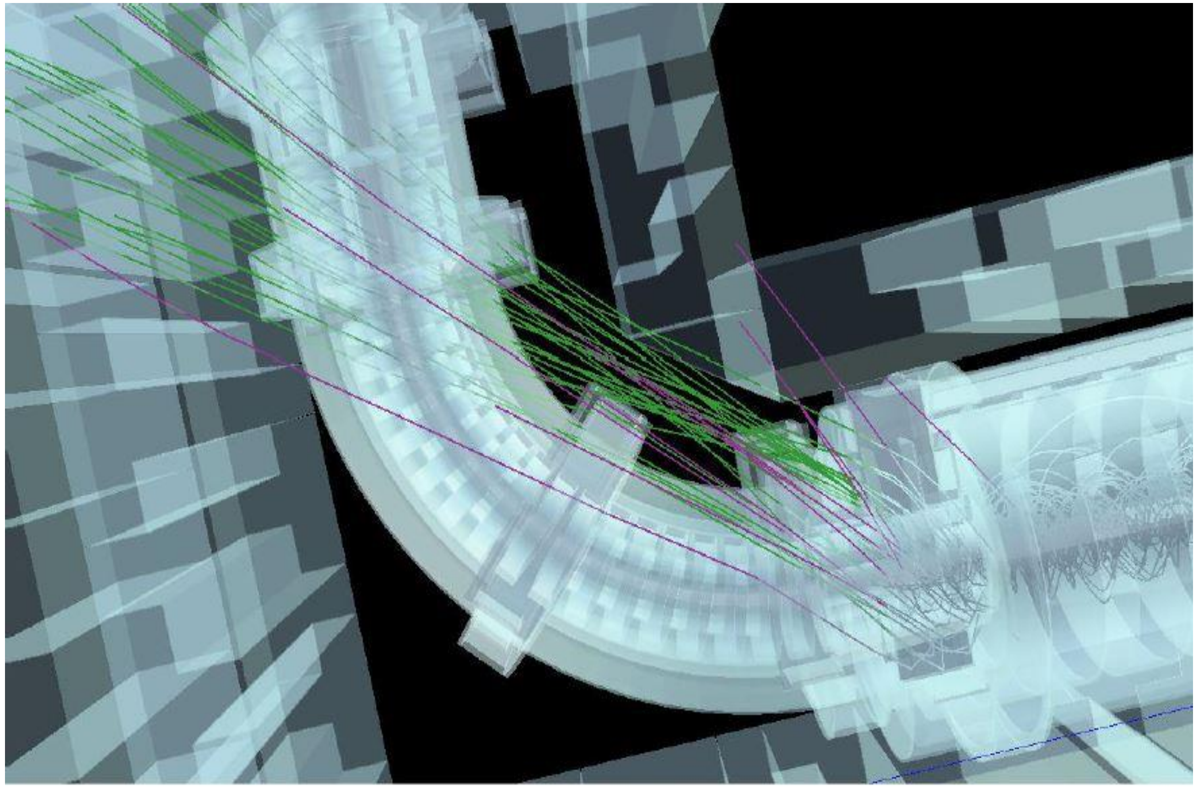
BRIEF DESCRIPTION OF THE STRUCTURES EXAMINED - CRYOGENIC DISTRIBUTION SYSTEM

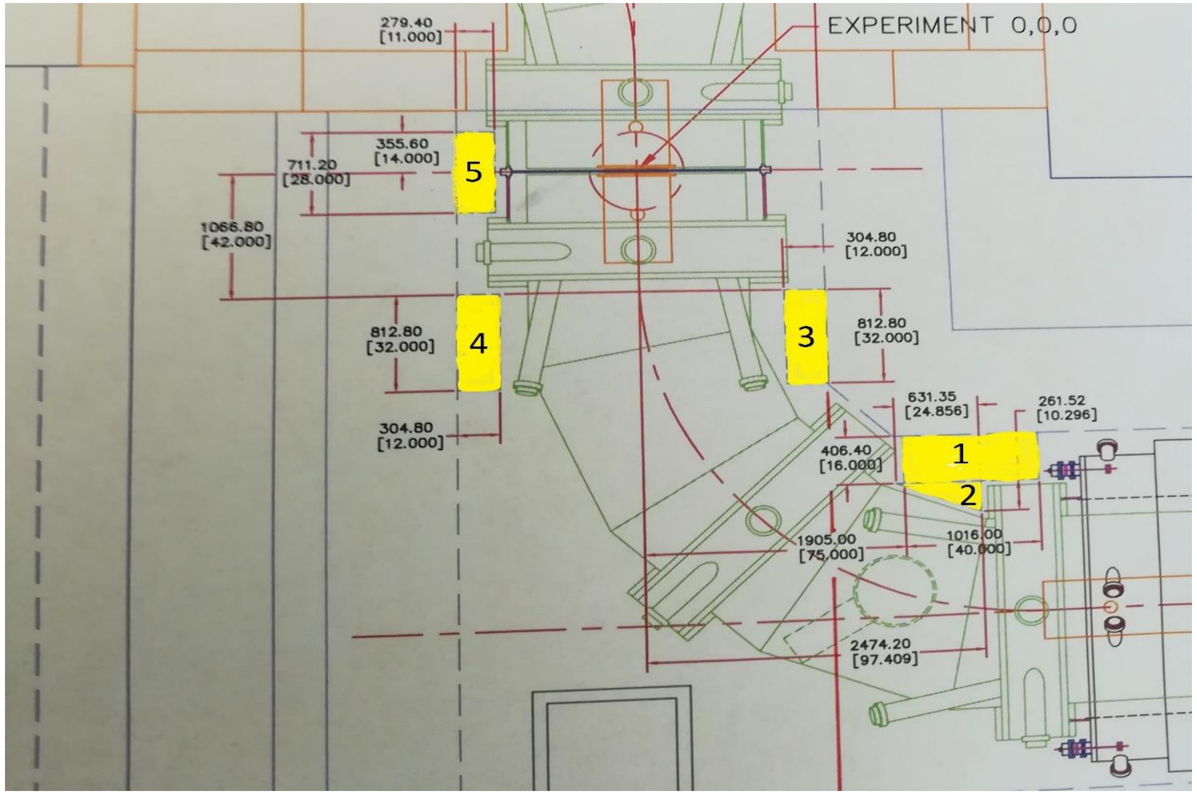
The superconducting solenoids require a cryogenic distribution system and supporting cryoplant for liquid helium and liquid nitrogen. The scheme is to divide the solenoids into 4 semi-autonomous cryostats. Cryostats can be cooled down or warmed up independent of the state of the other cryostats. Each cryostat will require 4.5 to 4.7 K liquid helium as well as 80 to 90 K liquid nitrogen for the cryostat thermal shields.



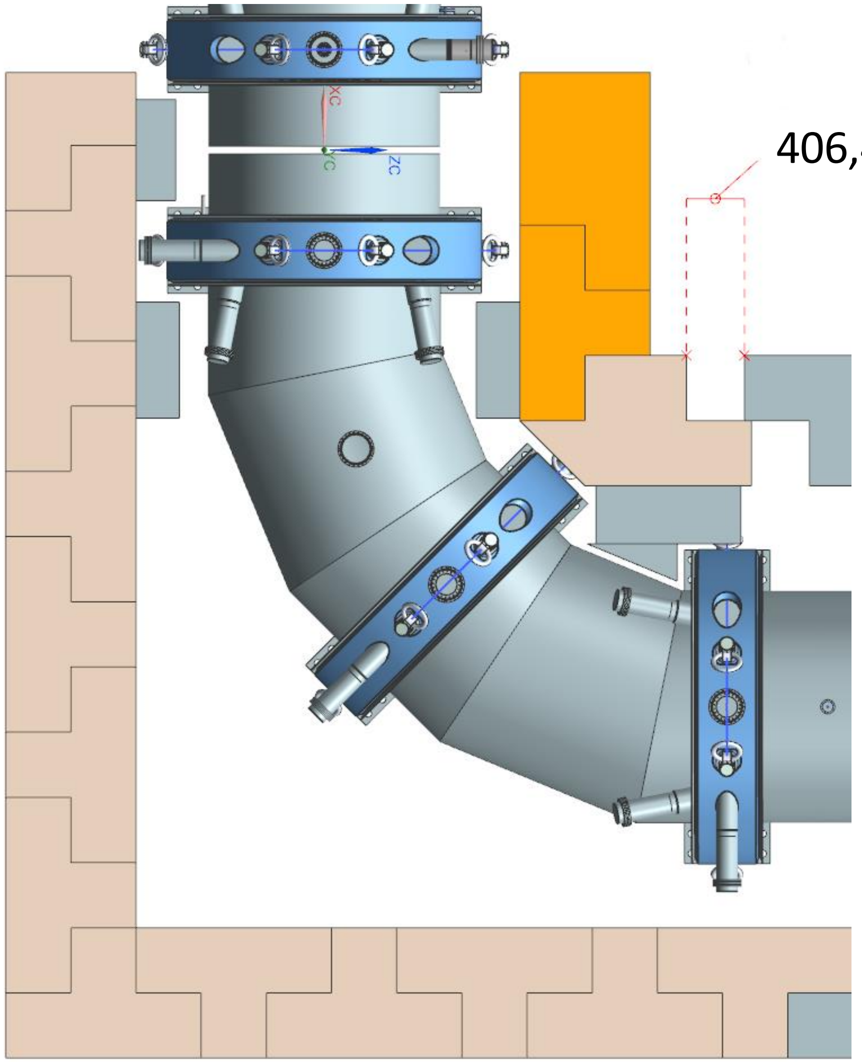
DOWNSTREAM EXTERNAL SHIELDING

To suppress backgrounds generated by cosmic ray muons incident through TS aperture, propose to add additional blocks and move few blocks.





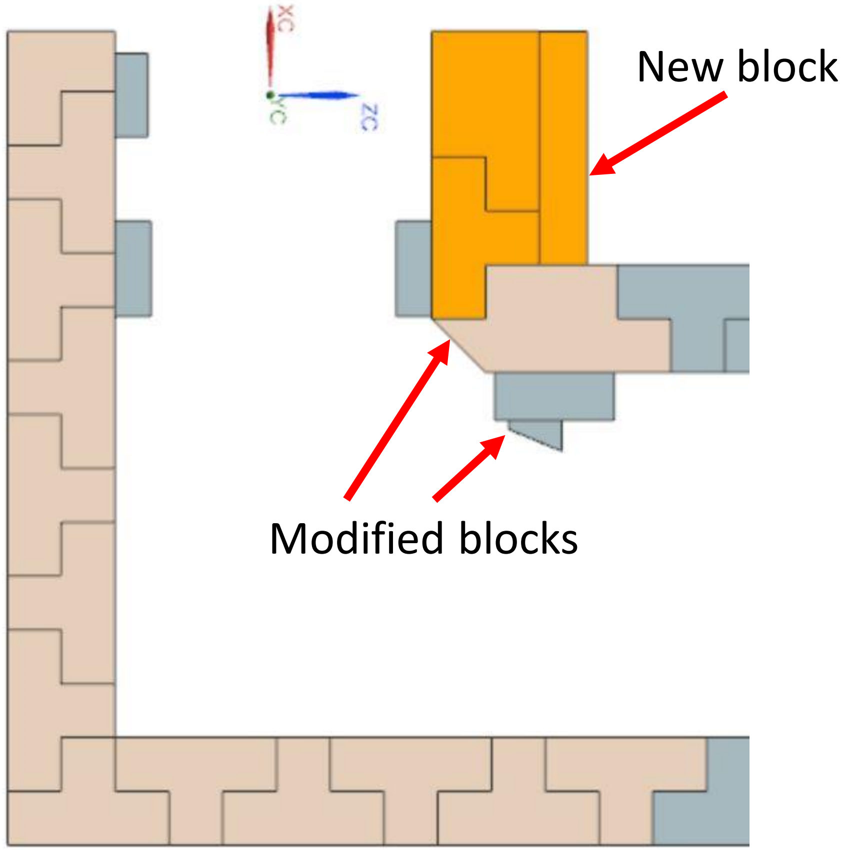
DOWNSTREAM EXTERNAL SHIELDING



DETECTOR SOLENOID

DOWNSTREAM EXTERNAL SHIELDING

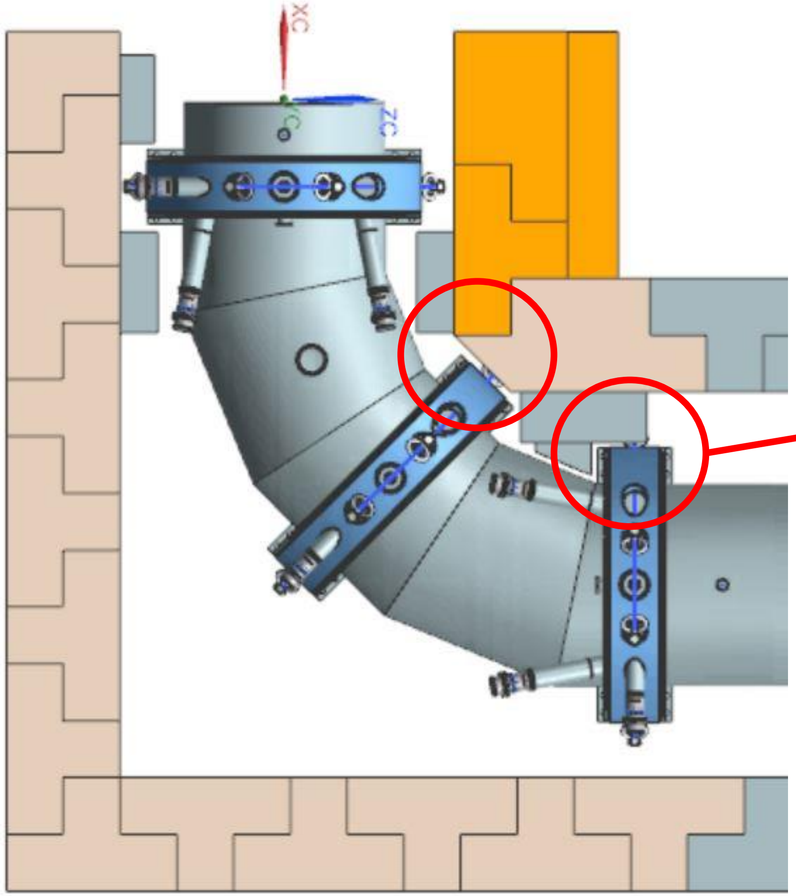
To eliminate the gap, one block of the wall has been modified and another block added. The material of the new block is Heavy (Barite) Concrete.

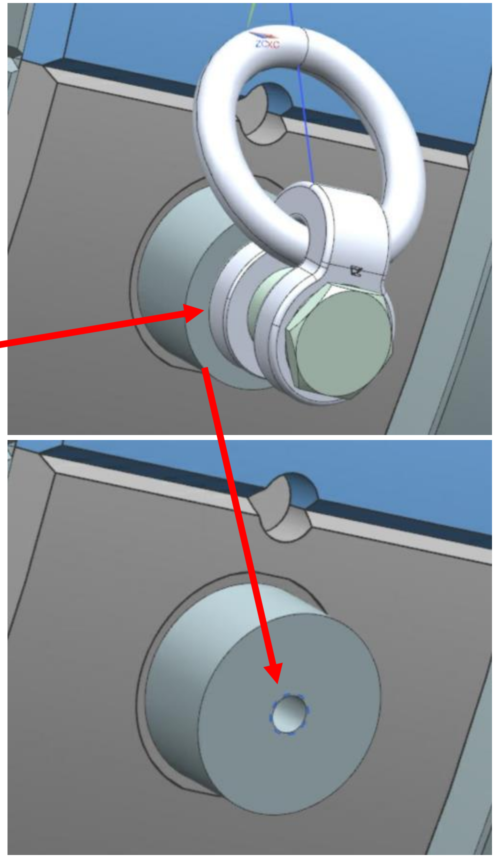


The changes made to the 3D CAD model are only temporary, they are mainly used to represent the filled volumes and verify the clearances in the facility.
Another thing to take into consideration, for the final model, is how to install the blocks in the structure.

CHECKING FOR POTENTIAL INTERFERENCES BETWEEN TS AND DOWNSTREAM EXTERNAL SHIELDING

Structure Overlap

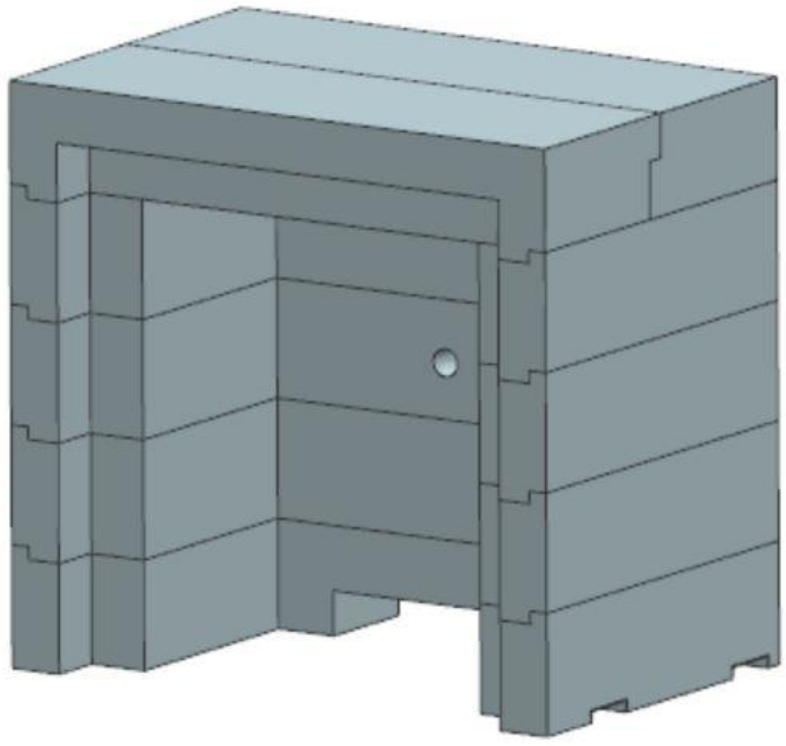




DOWNSTREAM EXTERNAL SHIELDING

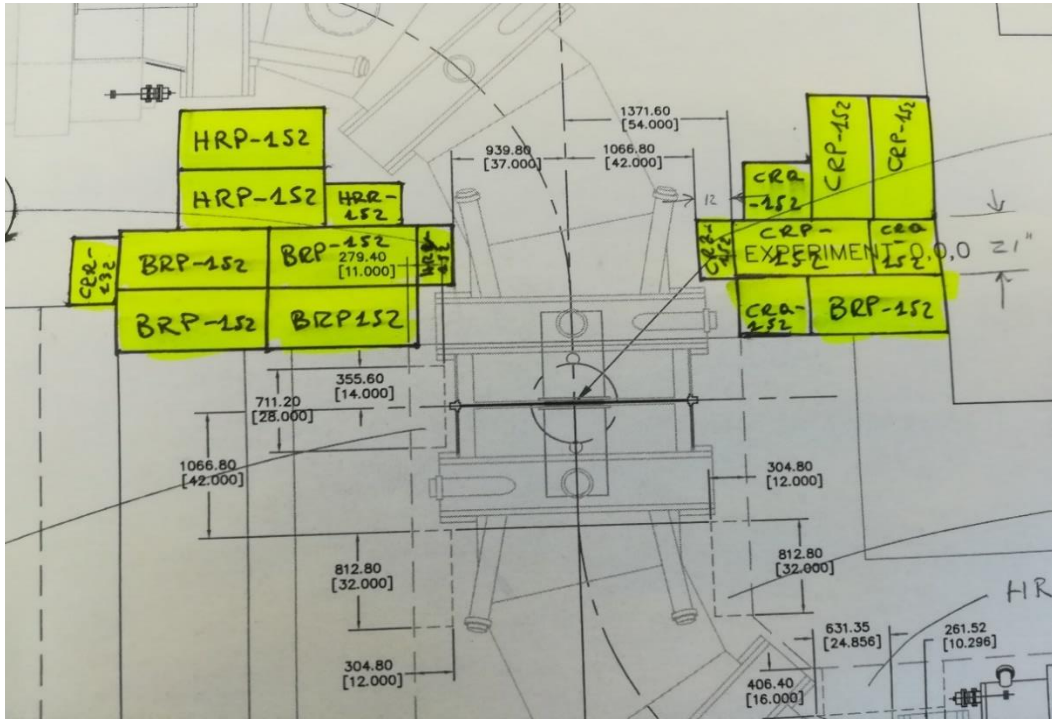
Parts of the End Cap Shielding Assembly have been changed, and the newest version is the following

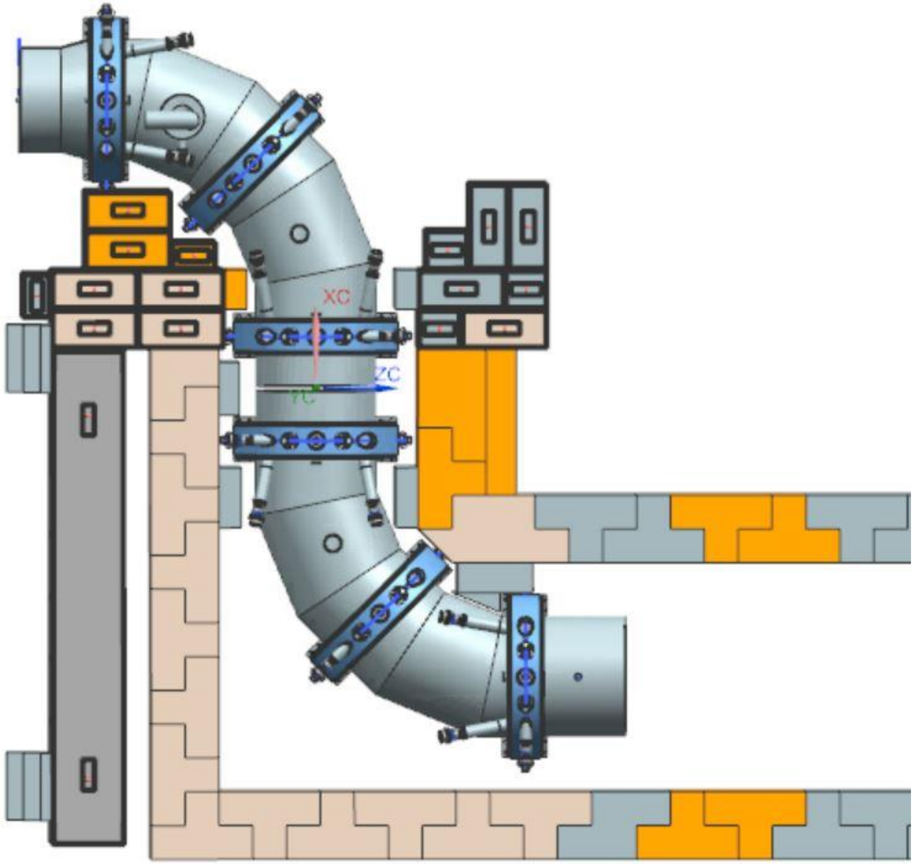
- Reduced the thickness of the capturing lips
- Increased the diameter of the beam exit hole



UPSTREAM EXTERNAL SHIELDING

Reassign the material composition of the various shield blocks to reflect the current plan to reduce rates on CRV

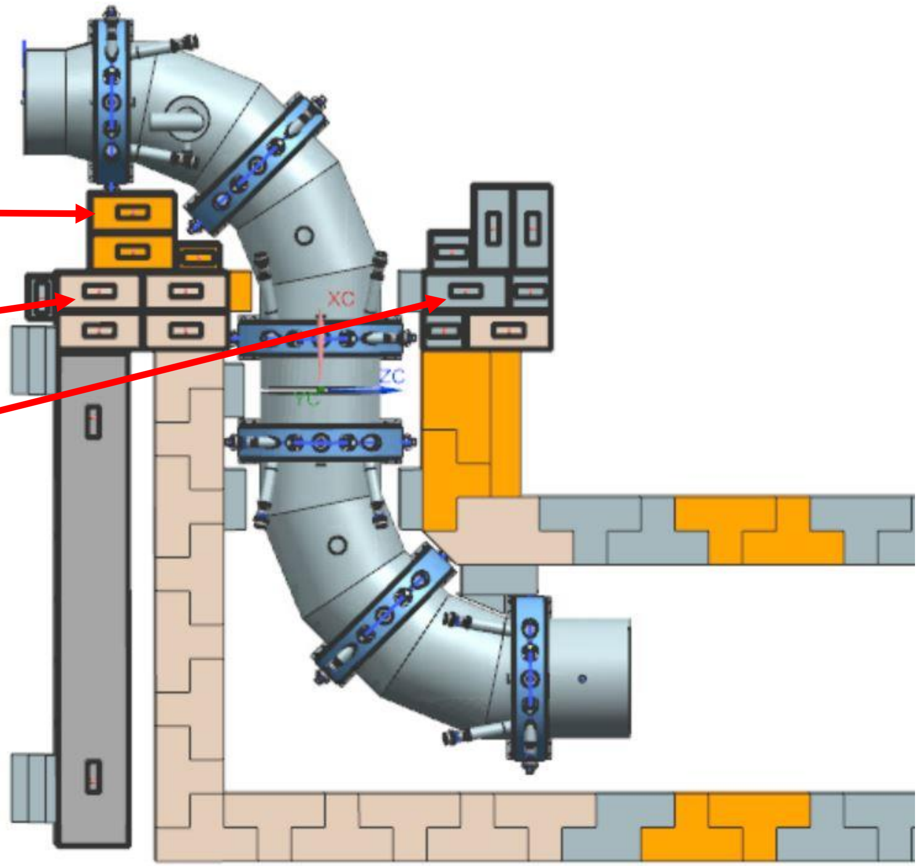




UPSTREAM EXTERNAL SHIELDING

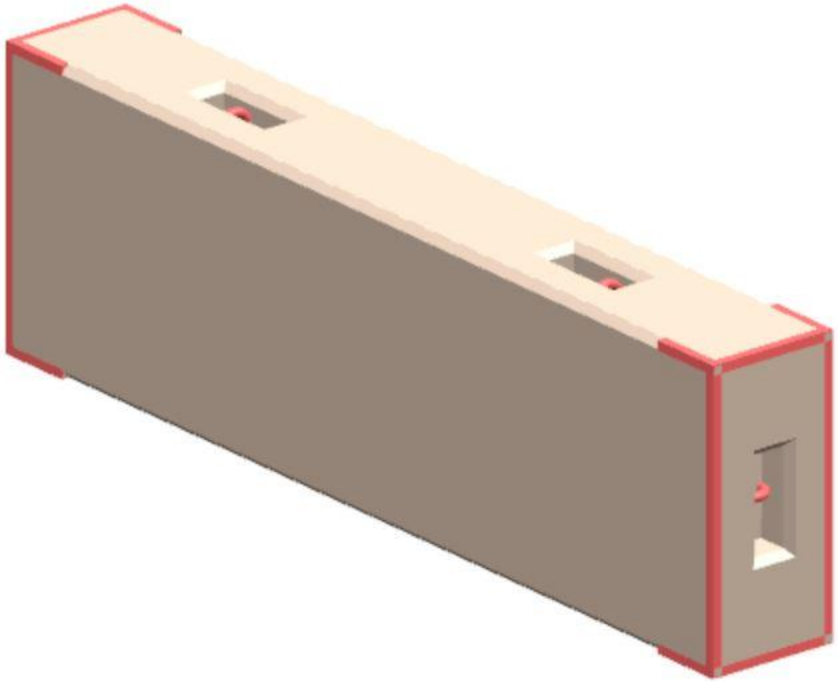
There are currently three types of concrete used in this version:

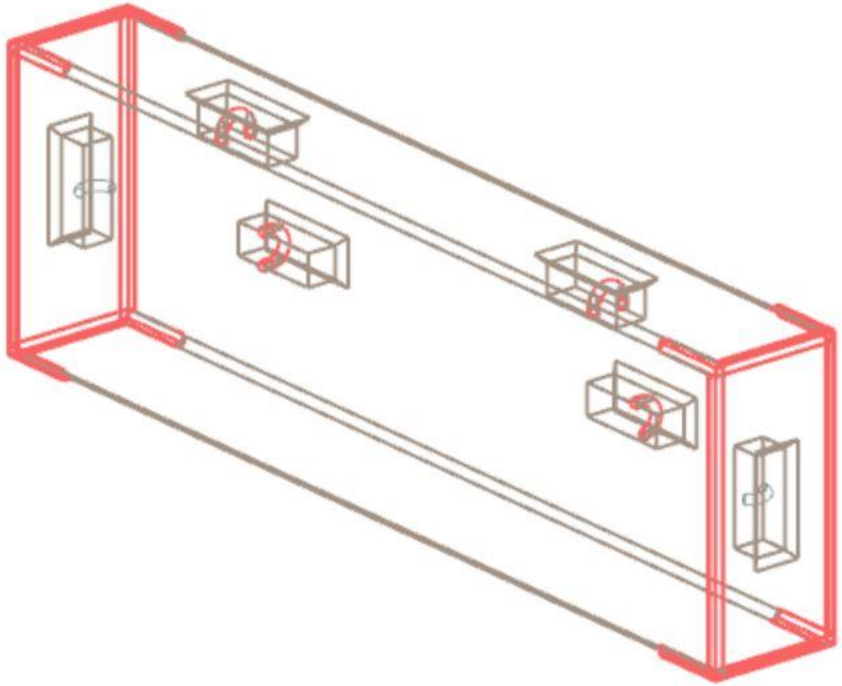
- Heavy Barite Concrete
- Boron Loaded Concrete
- Normal Concrete



UPSTREAM EXTERNAL SHIELDING

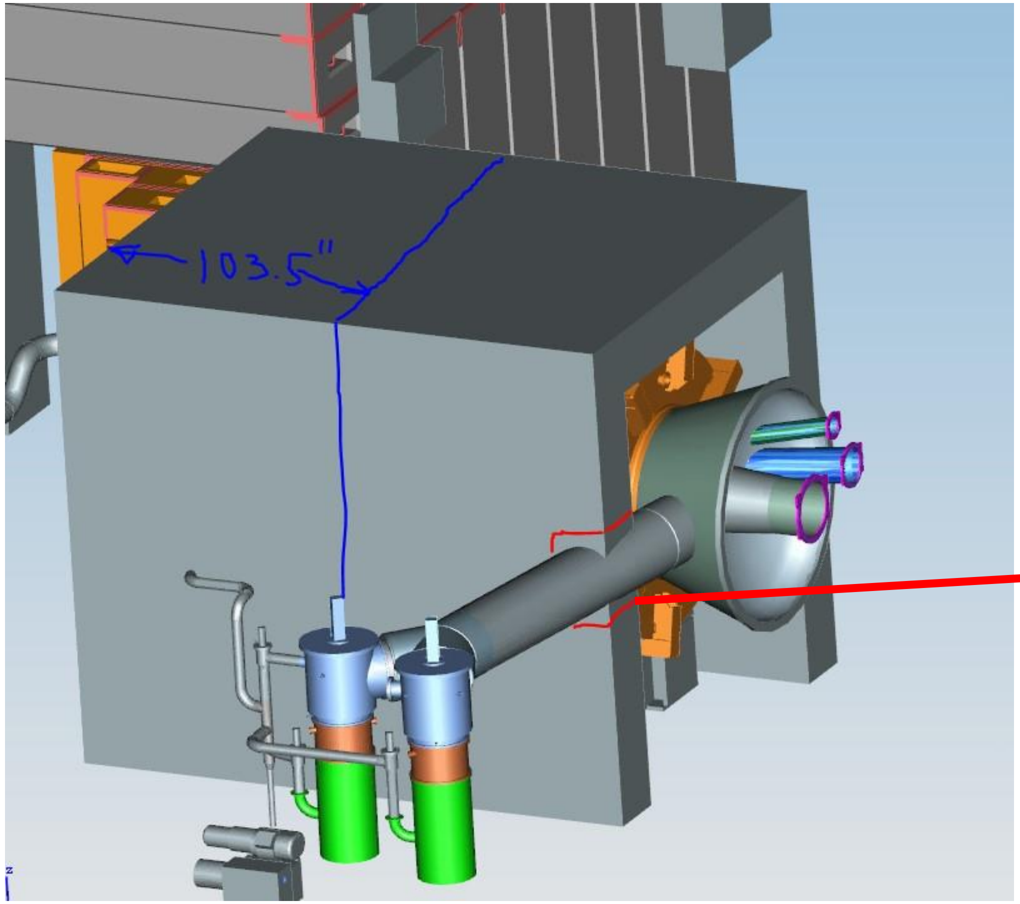
Example of one of the blocks in particular BRP-152 (composed of Boron Loaded Concrete). Note the presence of the lifting features for the placement of the blocks.



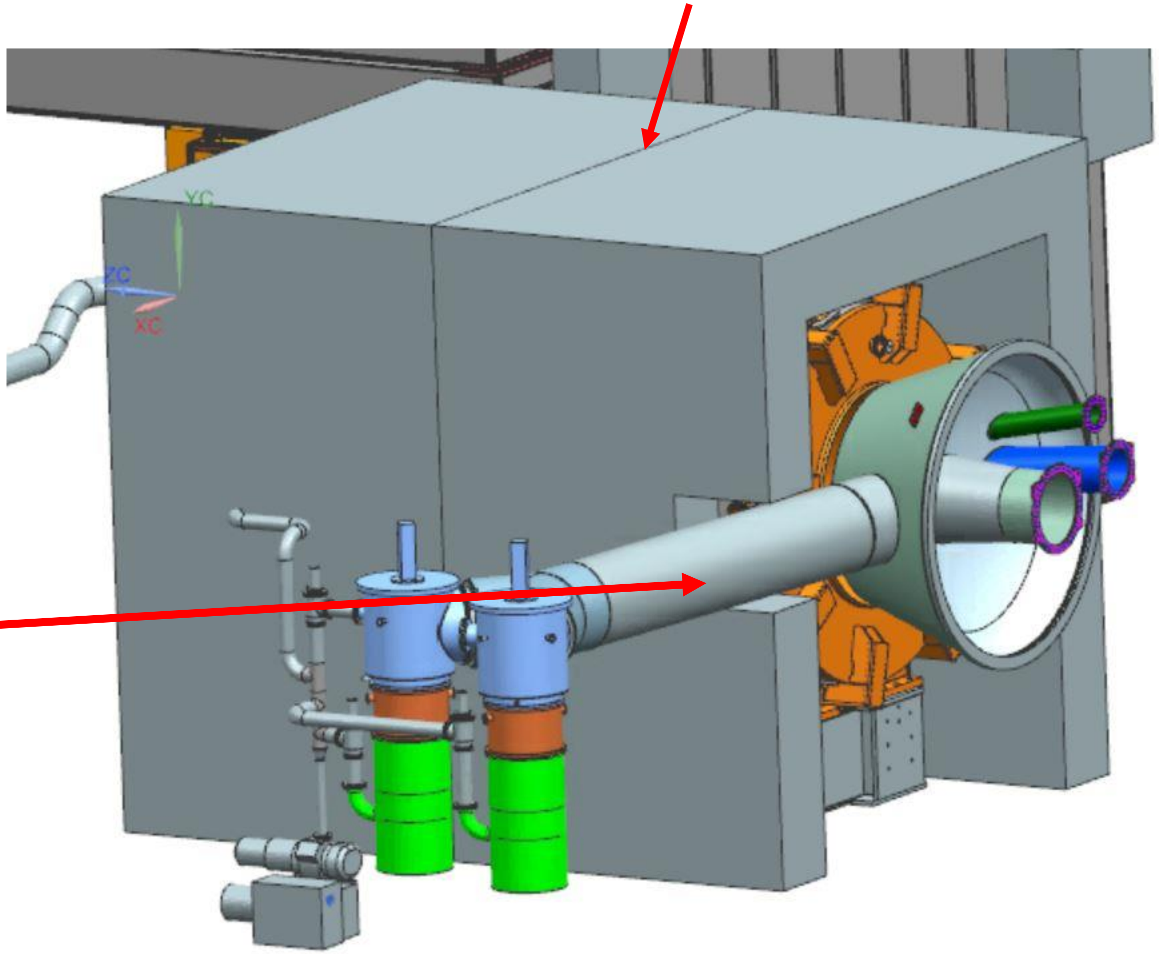


UPSTREAM EXTERNAL SHIELDING

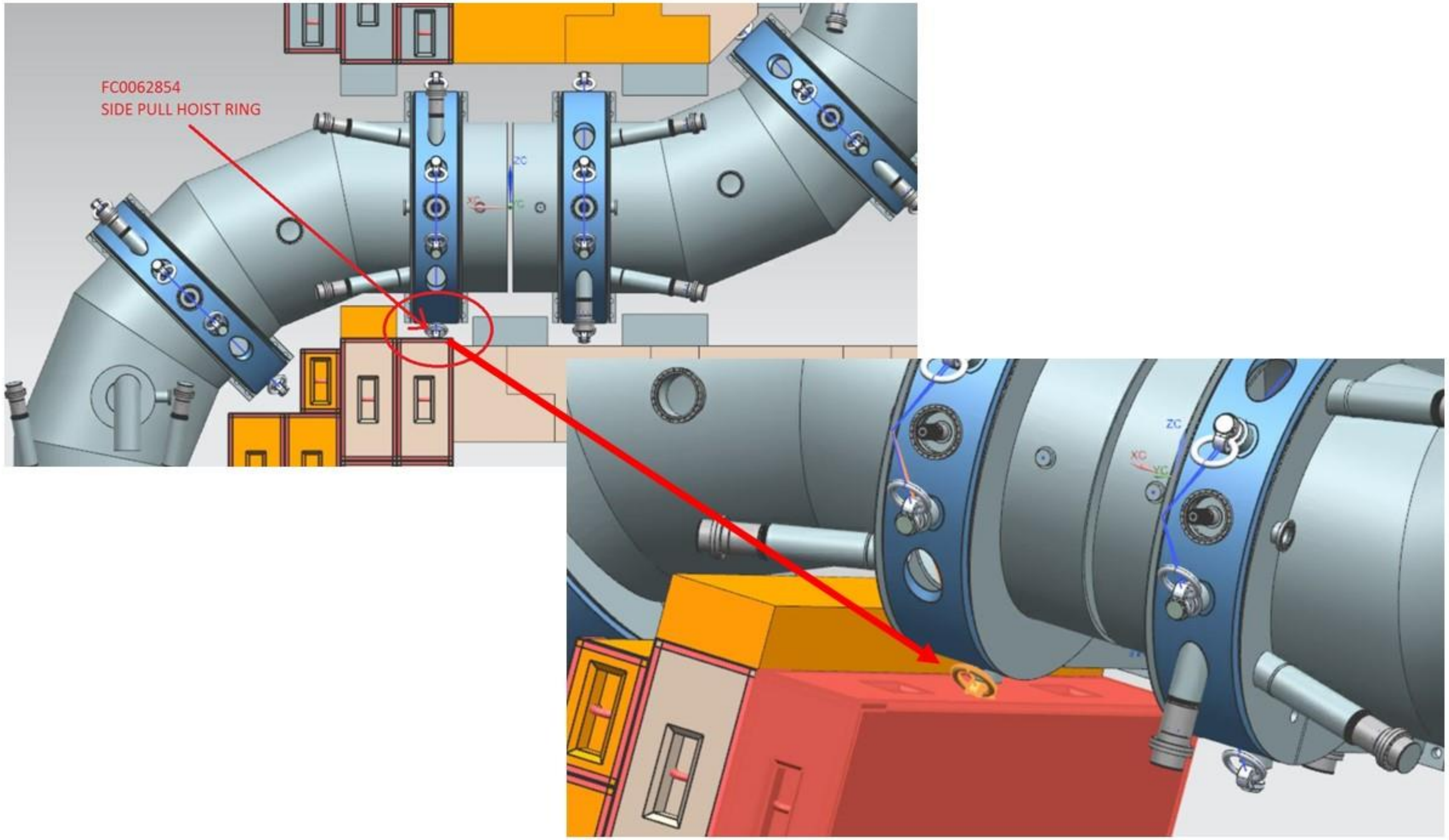
Elimination of interference



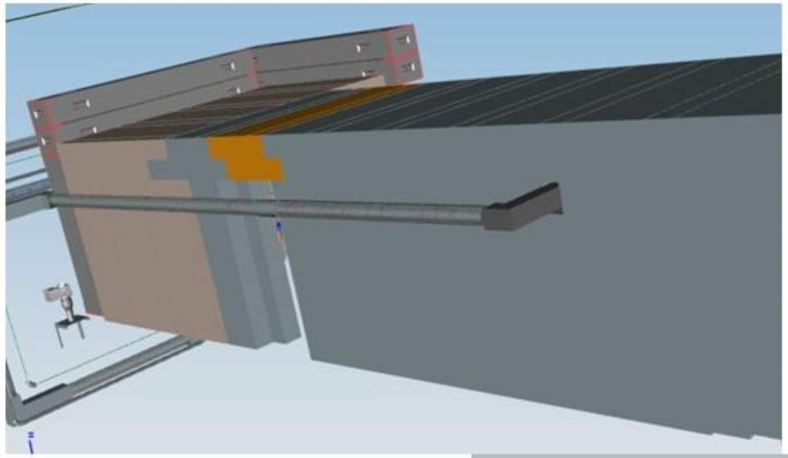
Split into two pieces for ease of fabrication

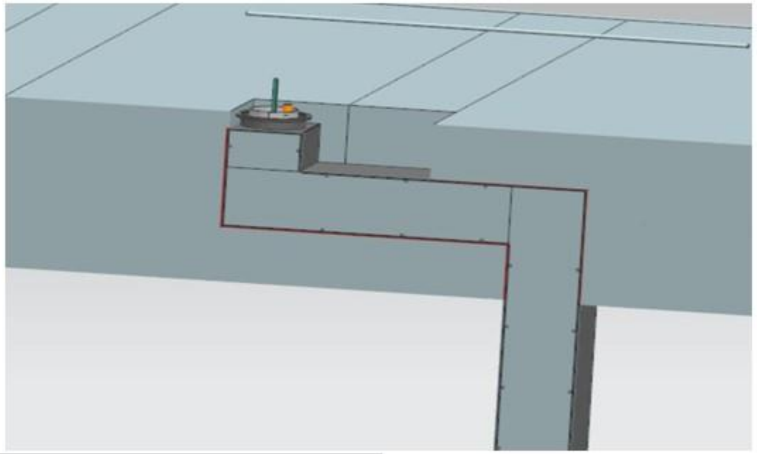


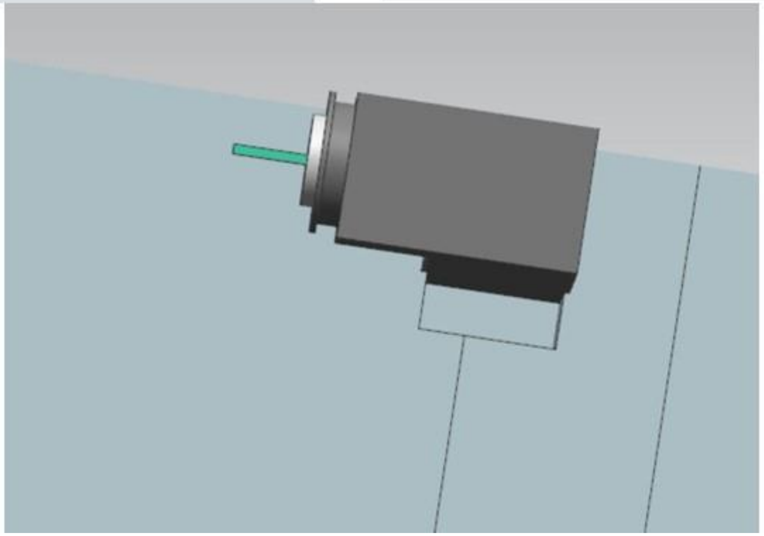
CHECKING FOR POTENTIAL INTERFERENCES BETWEEN TS AND UPSTREAM EXTERNAL SHIELDING



CHECKING FOR CLEARANCES FOR DS TRANSFER LINE THROUGH DOWNSTREAM EXTERNAL SHIELDING







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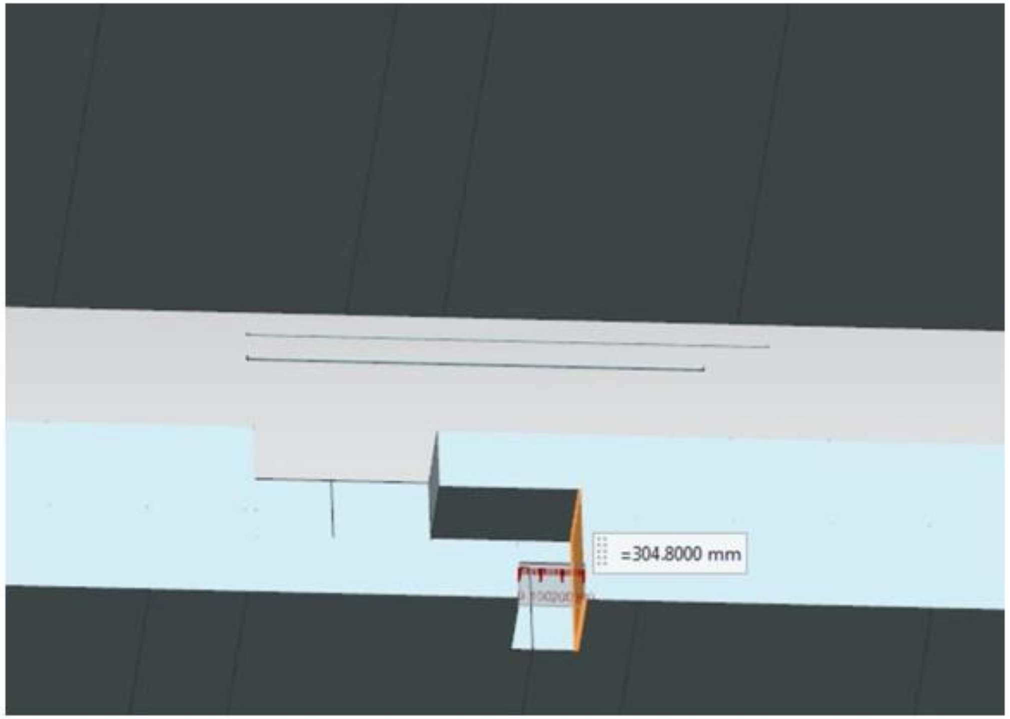

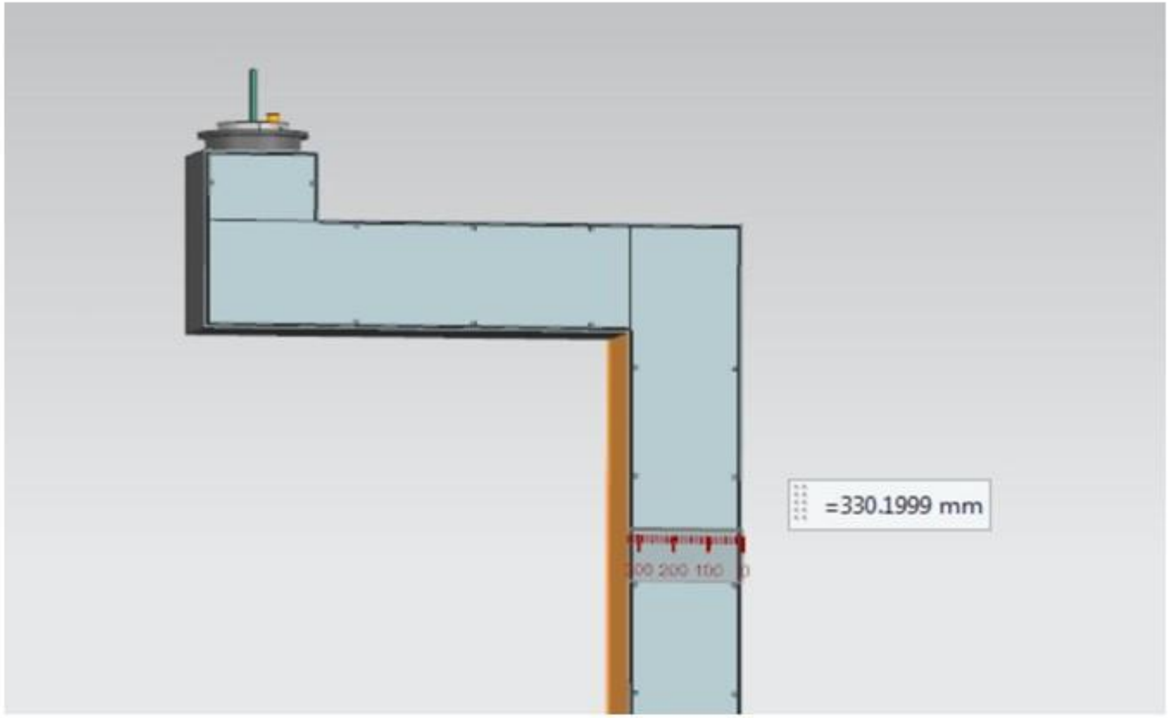

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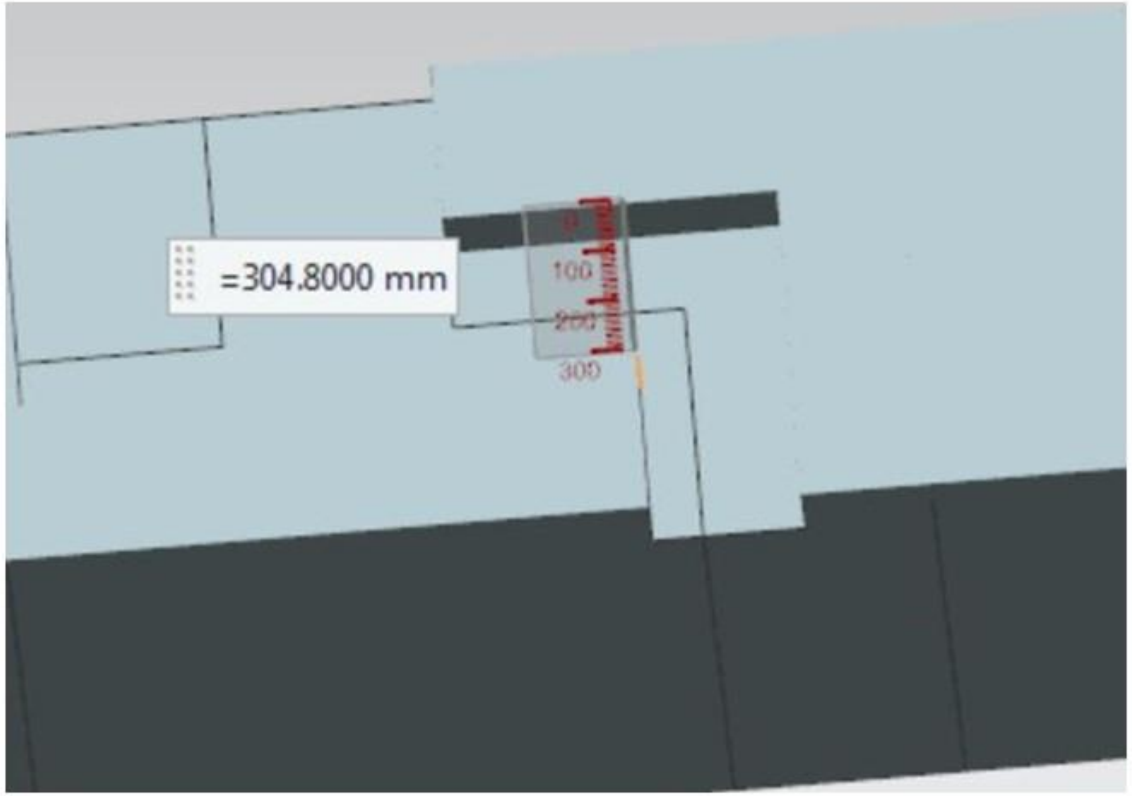
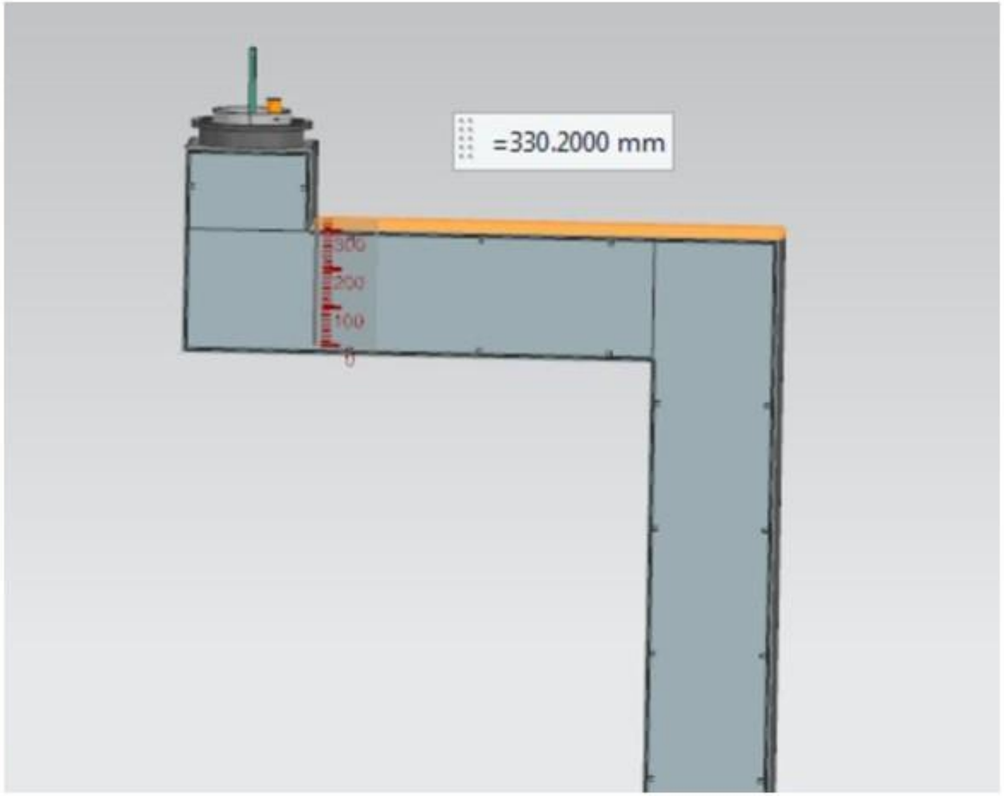
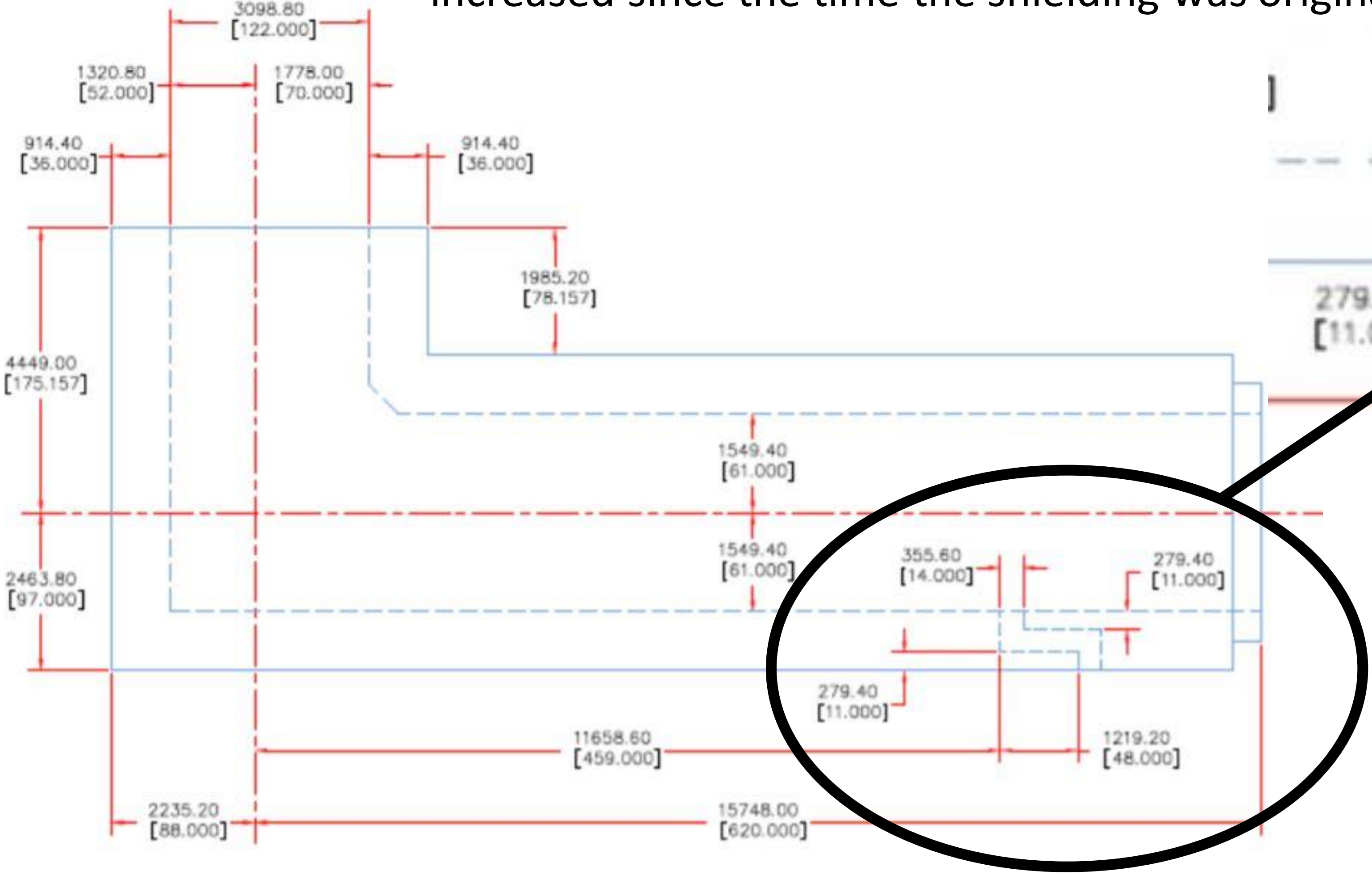
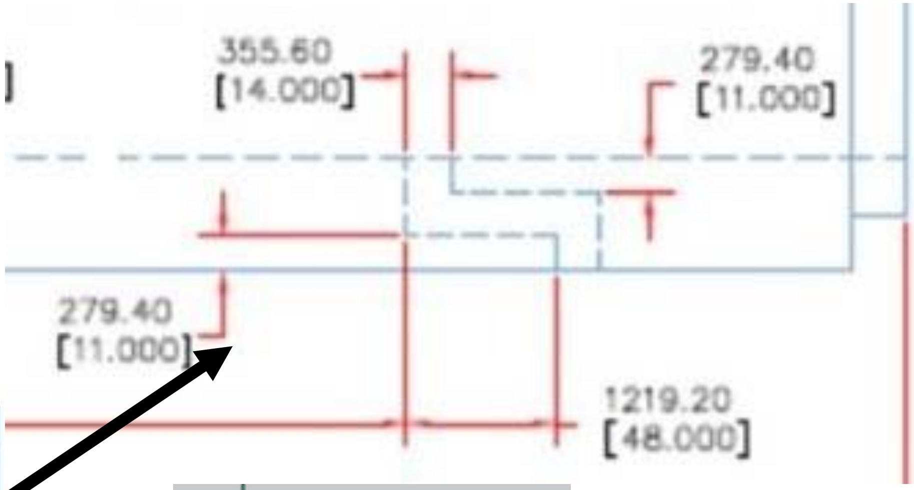


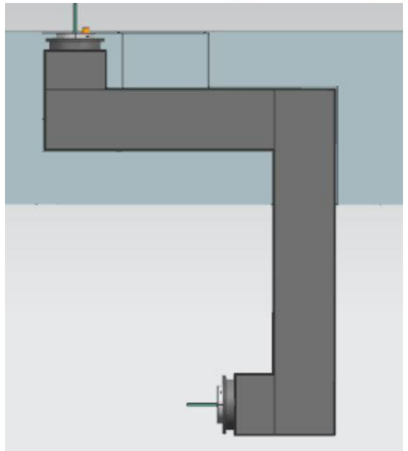


CHECKING FOR CLEARANCES FOR DS TRANSFER LINE THROUGH DOWNSTREAM EXTERNAL SHIELDING

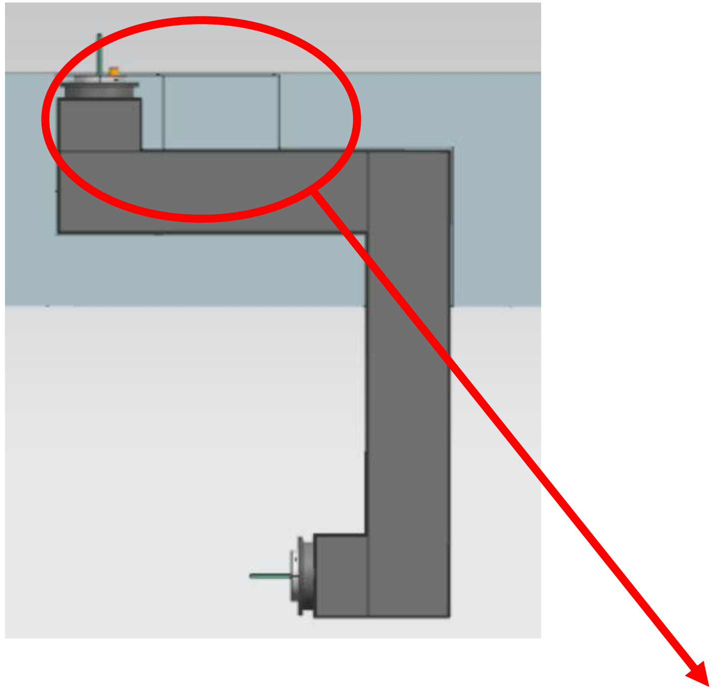
Changes done on the Downstream External Shielding (because the transfer line dimensions had increased since the time the shielding was originally modeled)

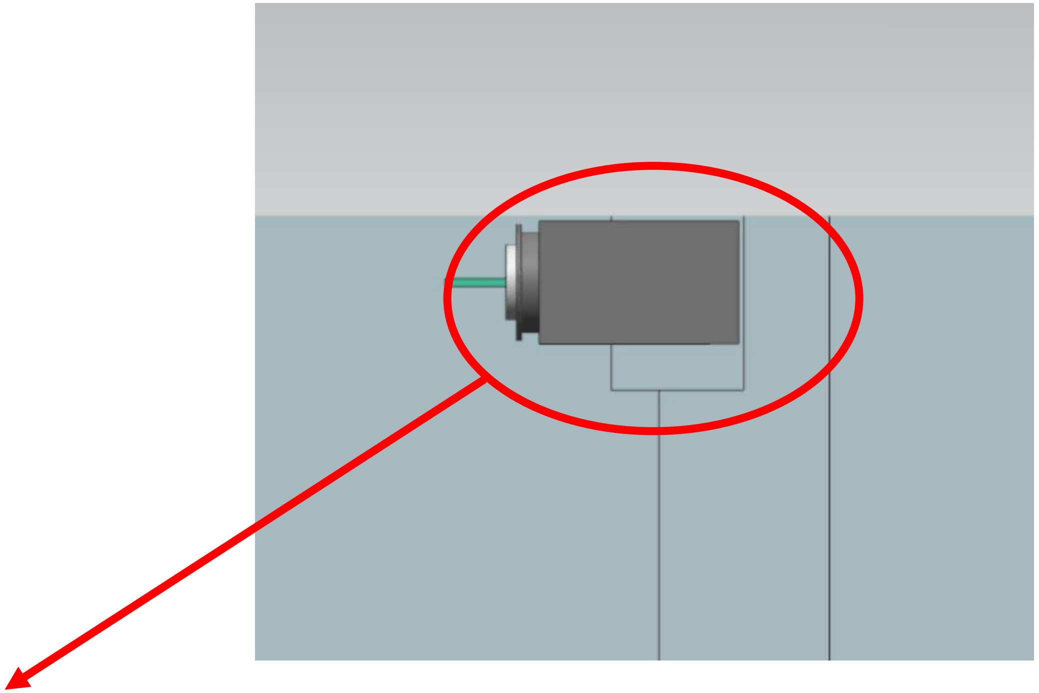






BLOCK INSTALLATION

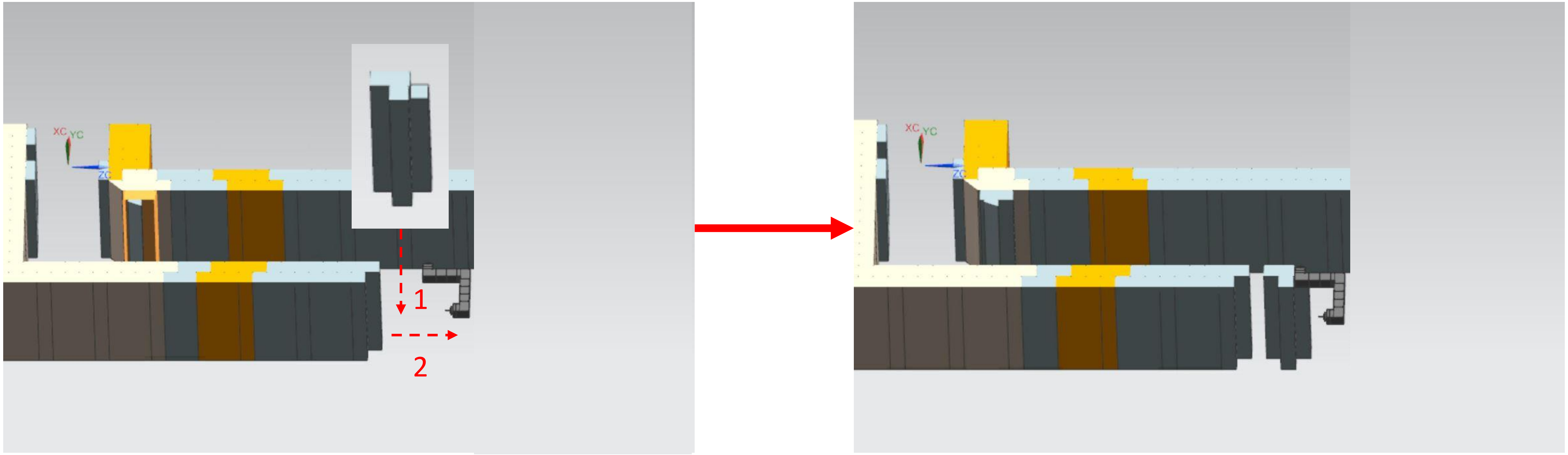




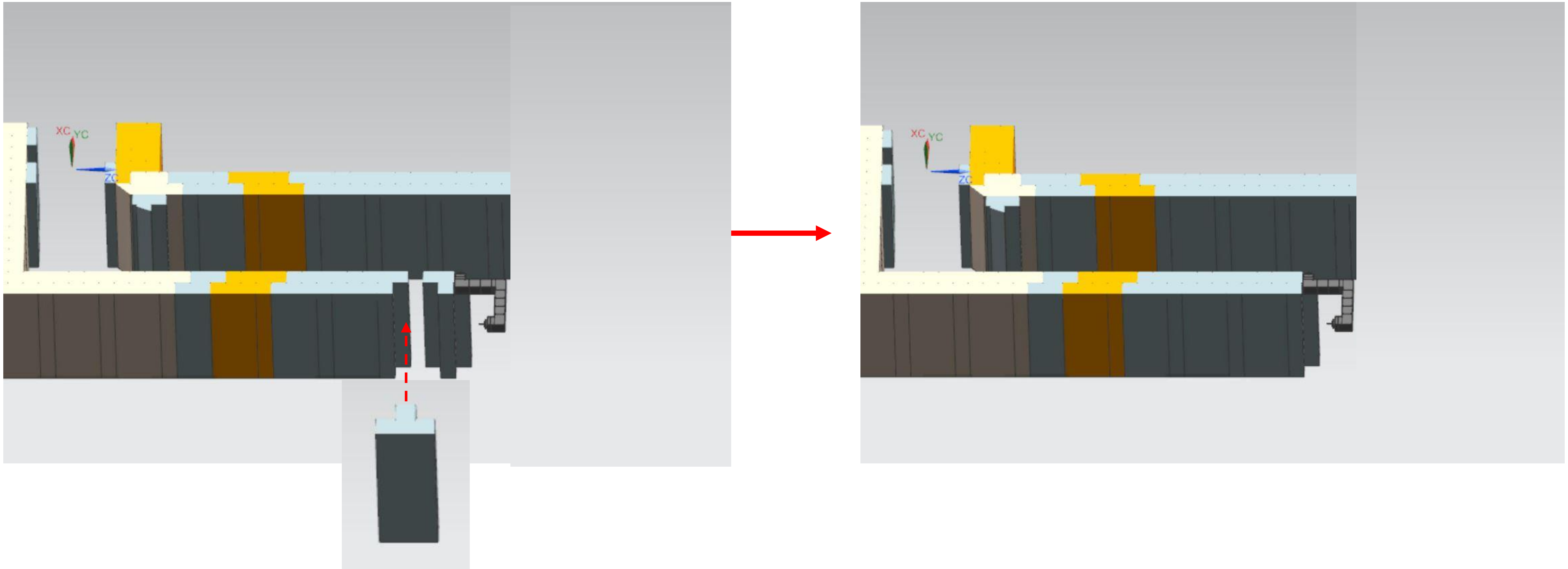
Space required for the block installation.

The Cryogenic Distribution System will be installed before the Downstream External Shielding

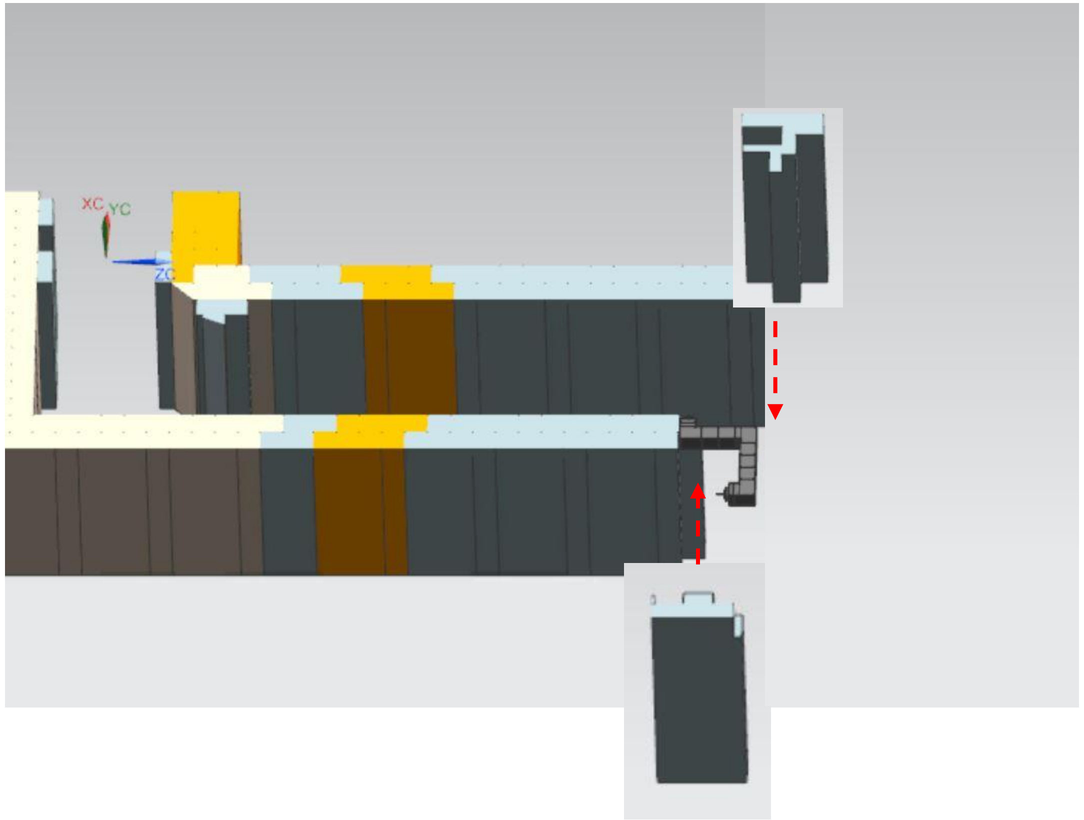
BLOCK INSTALLATION SEQUENCE



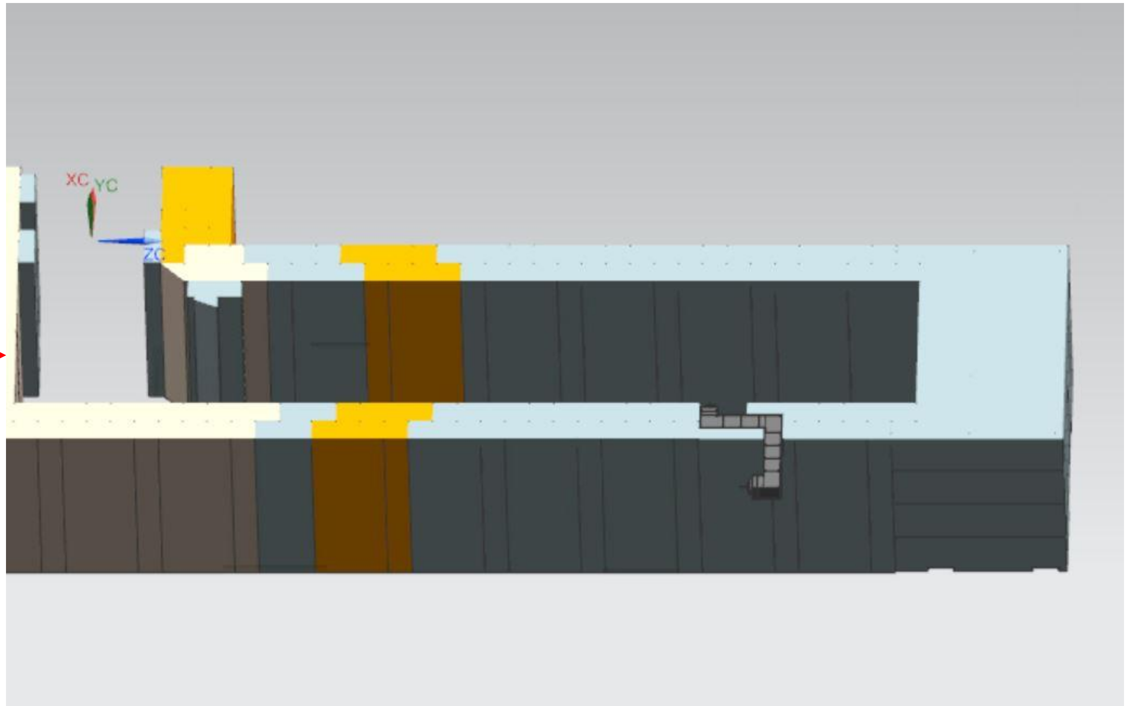
BLOCK INSTALLATION SEQUENCE



BLOCK INSTALLATION SEQUENCE

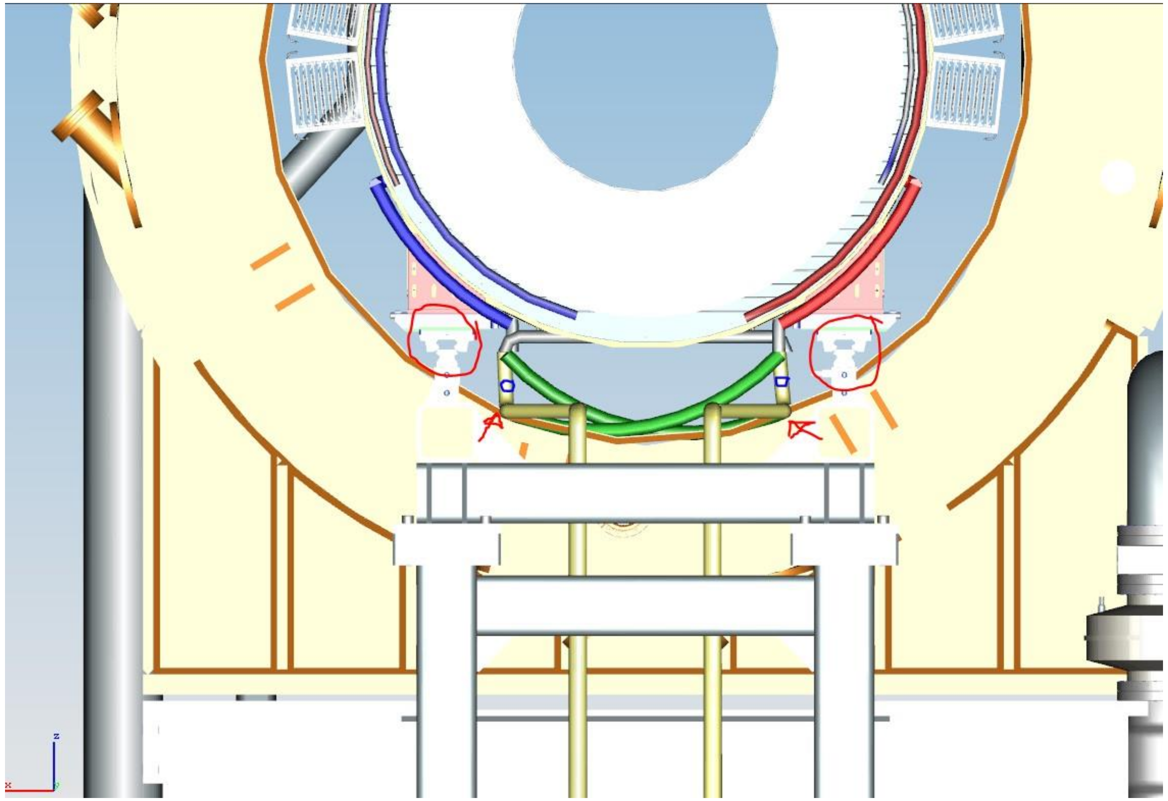


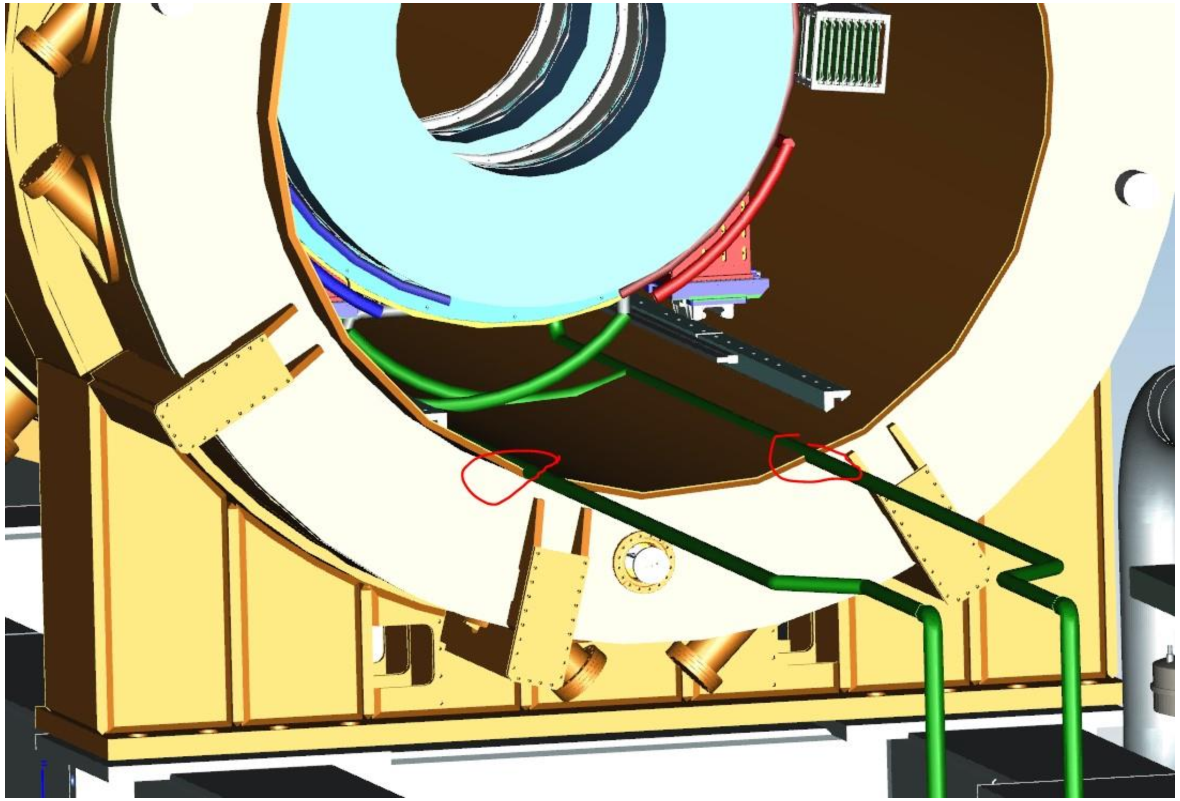
Final assembly



CALORIMETER

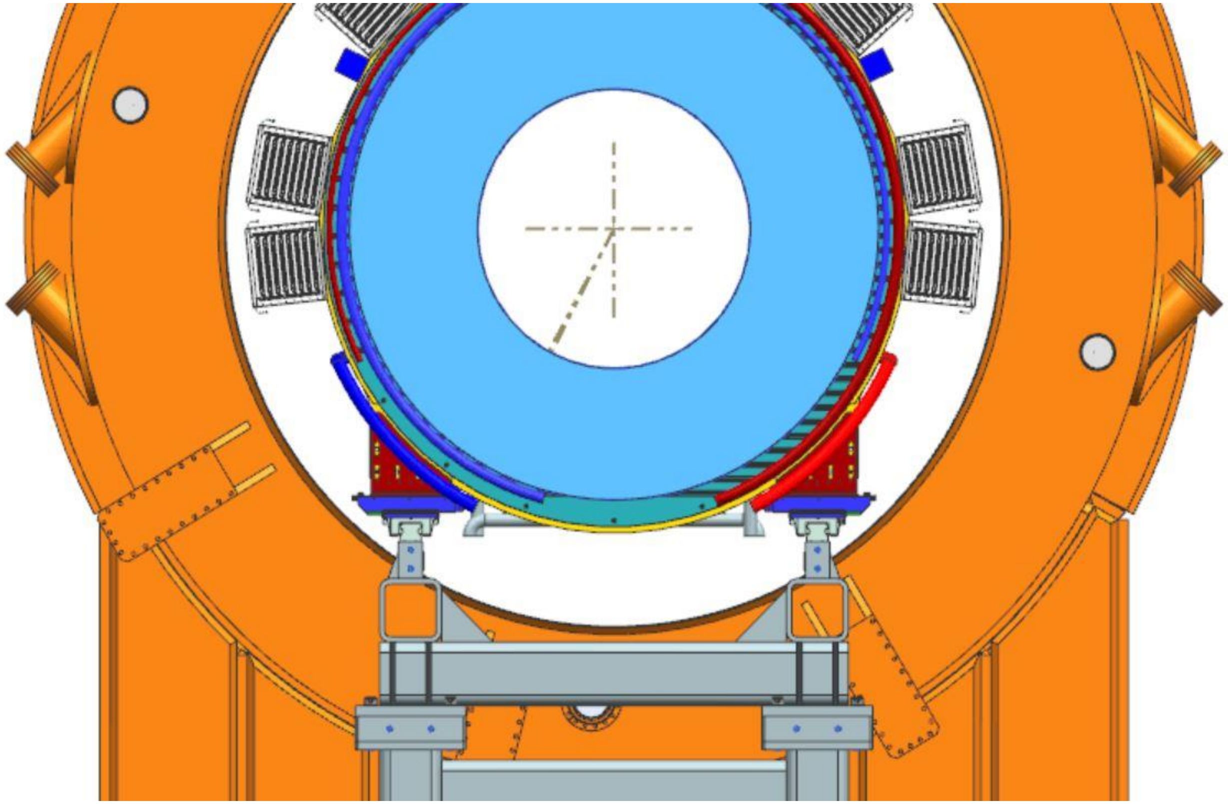
Interference between calorimeter mechanical services and DS bore

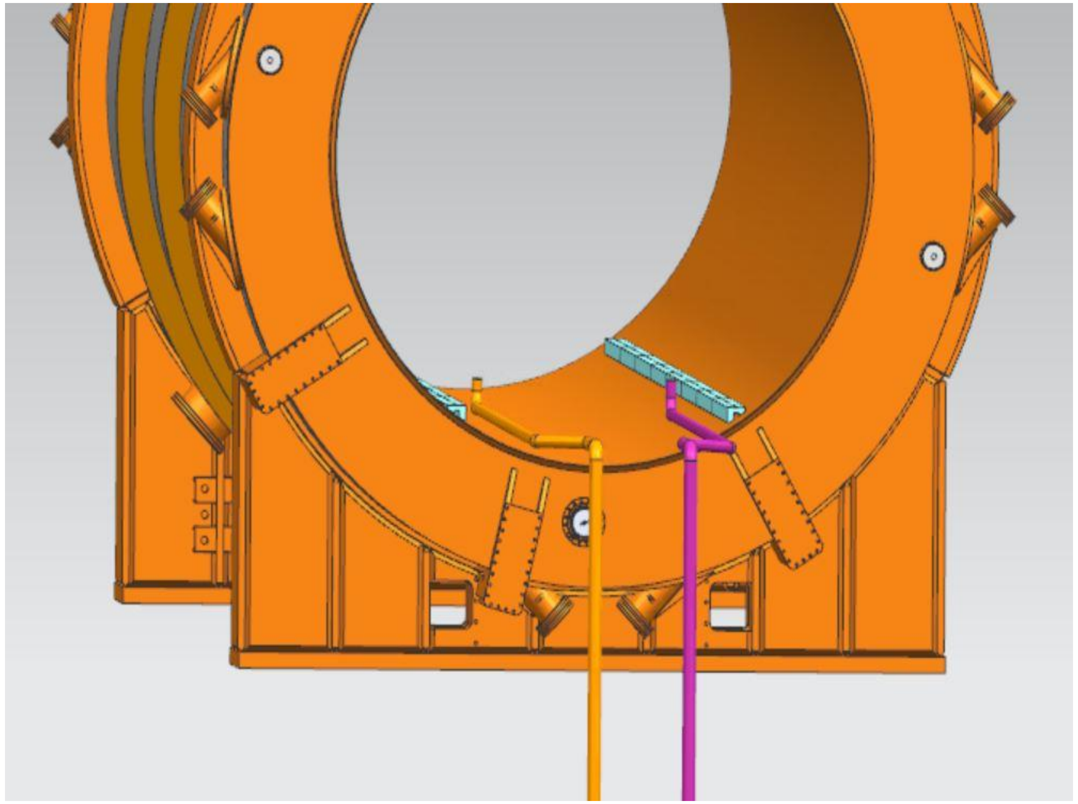




CALORIMETER

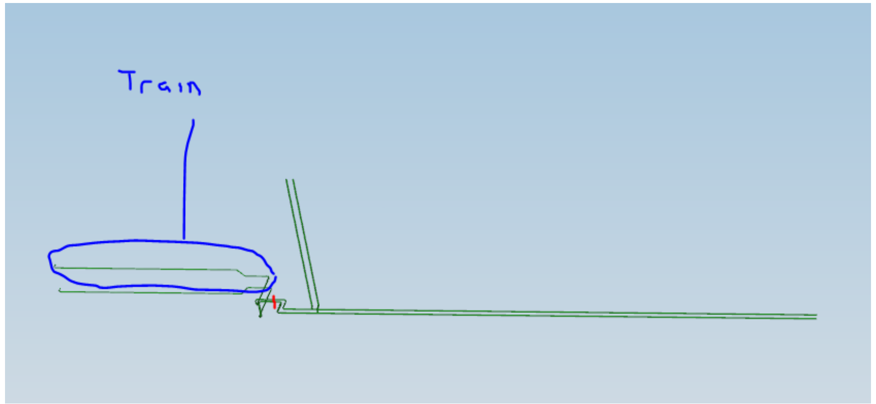
After corrections



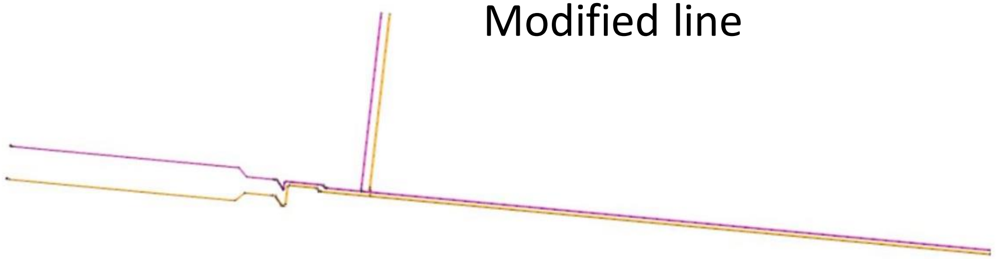


CALORIMETER

Assigned different colors to the source supply and source return line, and split into two sub-assemblies: "On-Train Source" and " Fixed Source Services ".

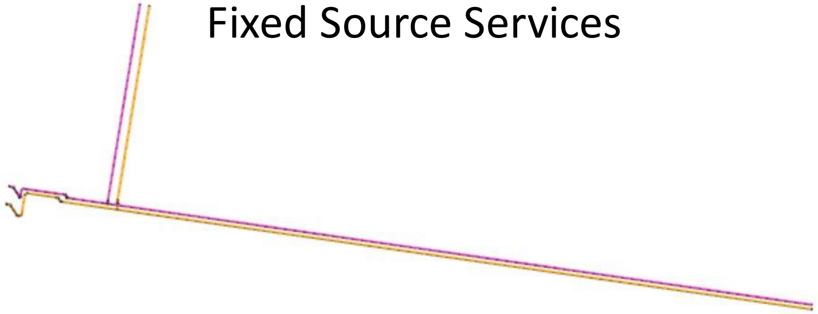


Modified line

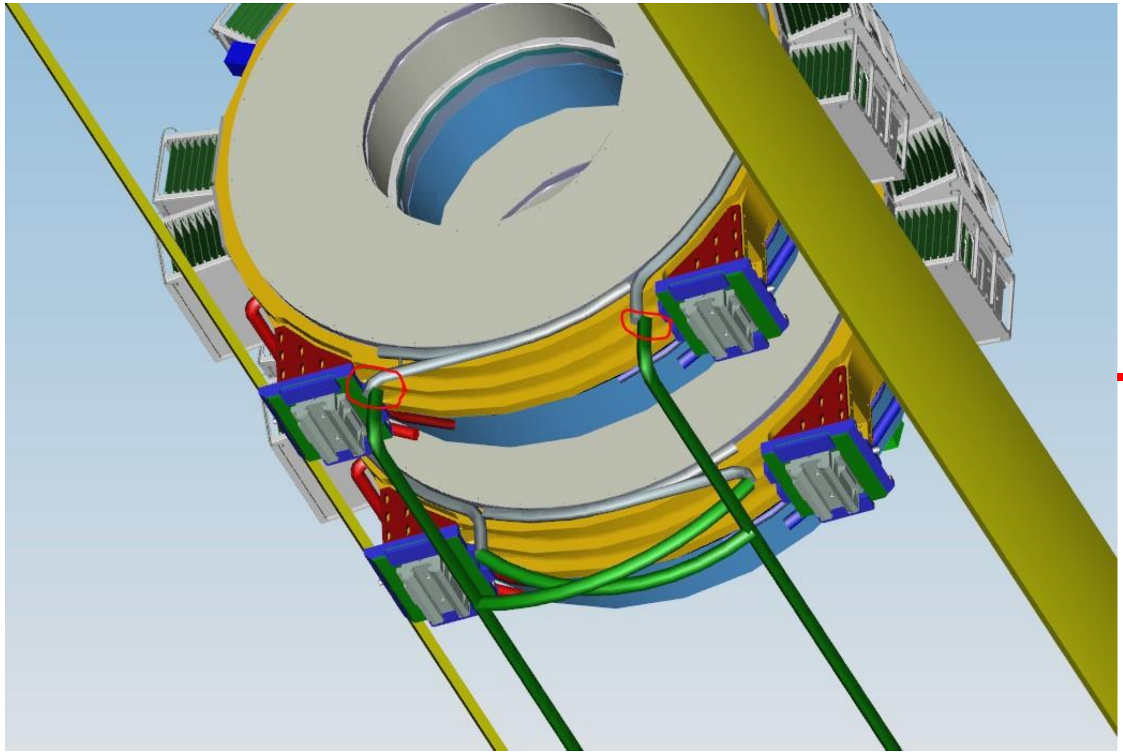


On-Train Source

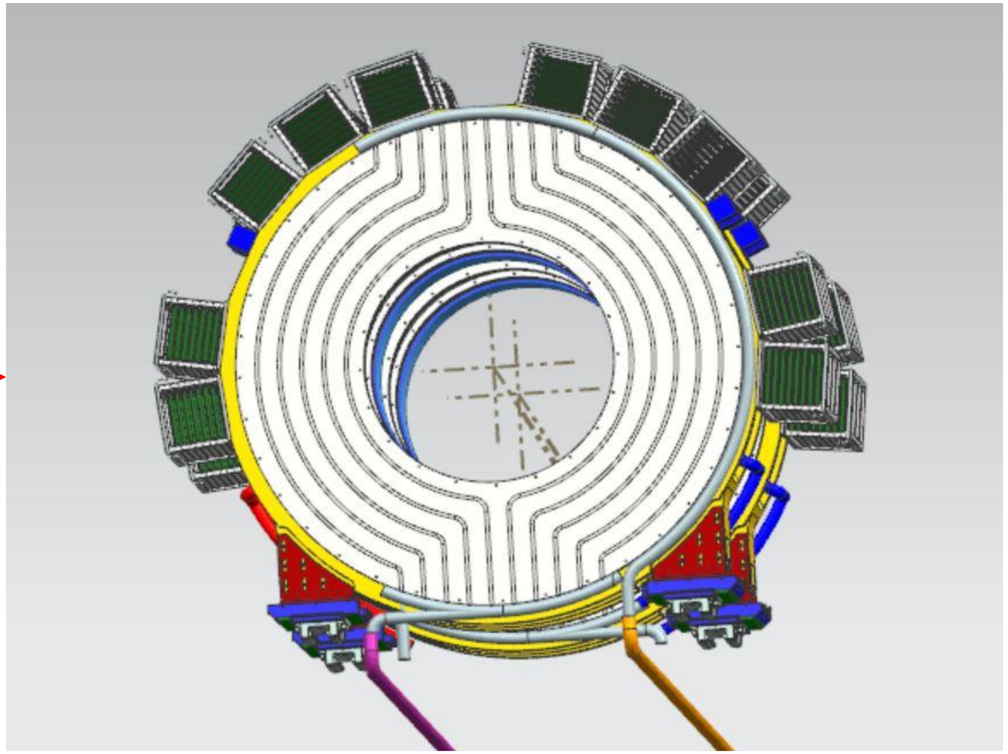
Fixed Source Services



CALORIMETER



After correction



DETECTOR SUPPORT AND INSTALLATION SYSTEM

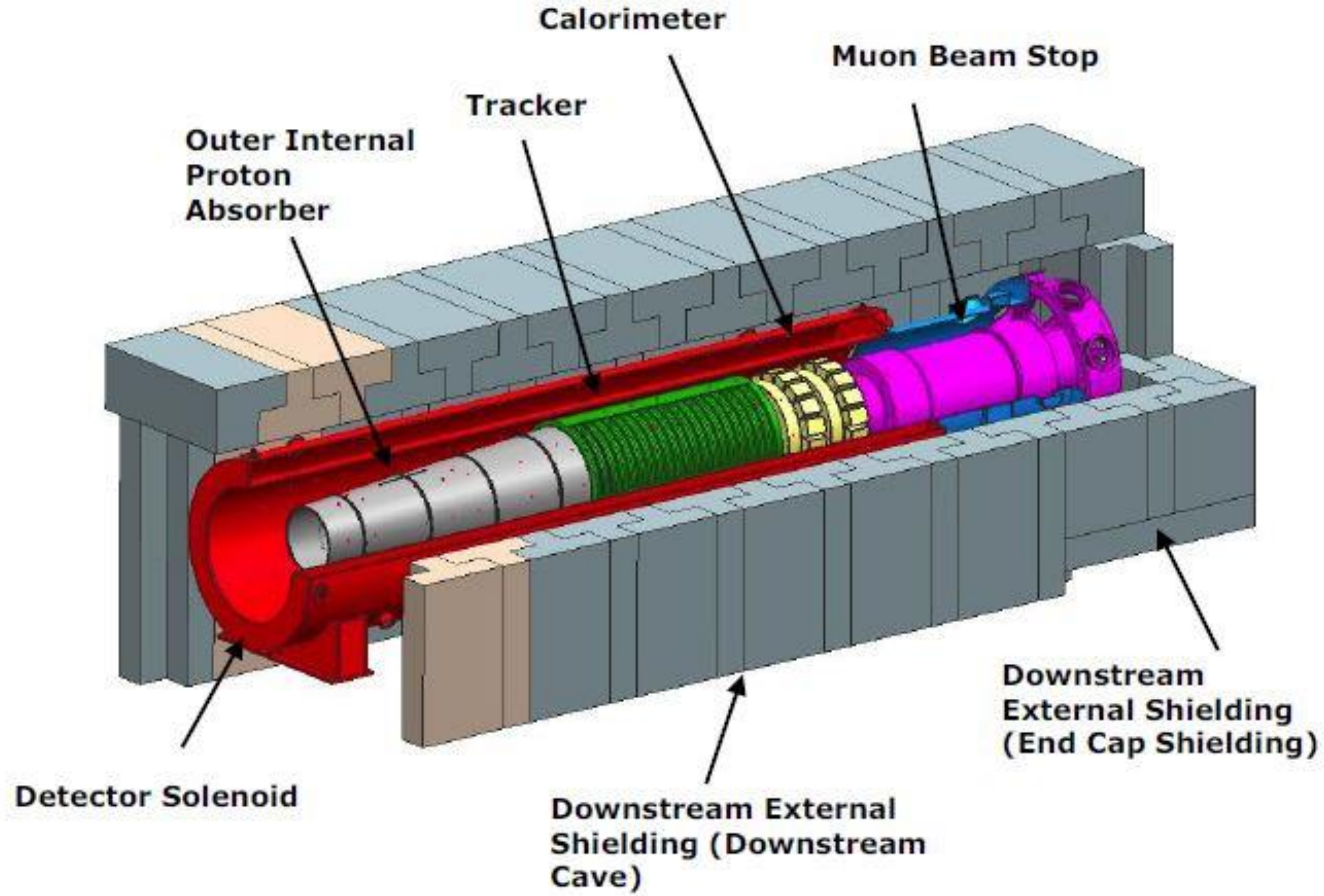
The detector support and installation system is required to transport and align components within the Detector Solenoid warm bore, and facilitate access to these components for servicing.
The Detector Train is composed by:

- Muon Stopping Target
- Proton Absorbers
- Tracker
- Calorimeter
- Muon Beam Stop

These components will be supported by the inside wall of the Detector Solenoid cryostat when the detector train is inserted into the DS bore.

DETECTOR SUPPORT AND INSTALLATION SYSTEM

Cut-away view of the Detector Solenoid region illustrating the relative position of various components



DETECTOR SUPPORT AND INSTALLATION SYSTEM

- Verify location of various key elements/ features and correct as necessary
- 3D CAD model arrangement of all the existing part of the Detector Train
- Insertion of some missed components
- Modification of some components
- Clean up folder structure/organization of 3D CAD model

DETECTOR SUPPORT AND INSTALLATION SYSTEM

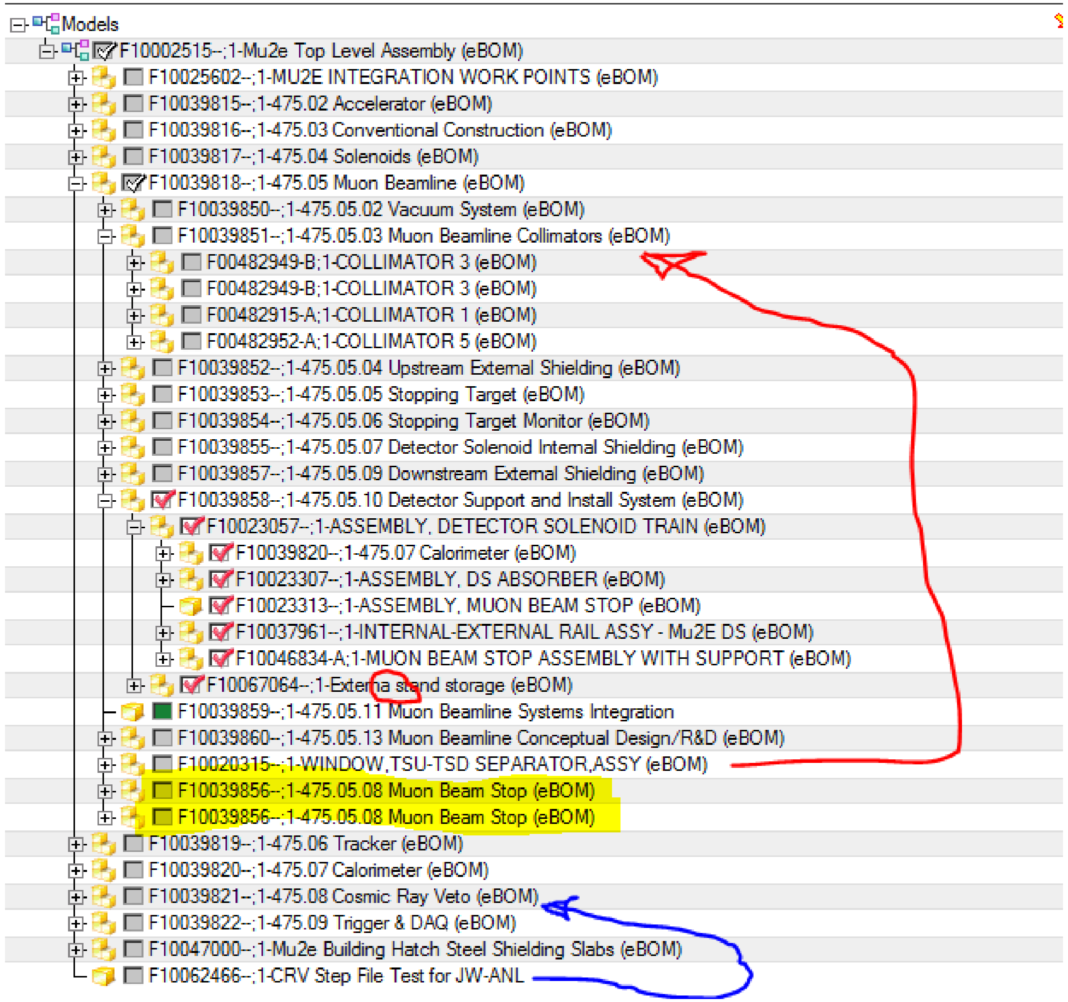
VERIFY LOCATION OF VARIOUS KEY ELEMENTS / FEATURES AND CORRECT AS NECESSARY

- Detector Solenoid
- VPSP
- Tracker
- Calorimeter
- Muon Stopping Target
- OPA (Outer Proton Absorber)
- IPA (Inner Proton Absorber)
- IFB (Instrumentation Feedthrough Bulkhead)
- Muon Beam Stop

DETECTOR SUPPORT AND INSTALLATION SYSTEM

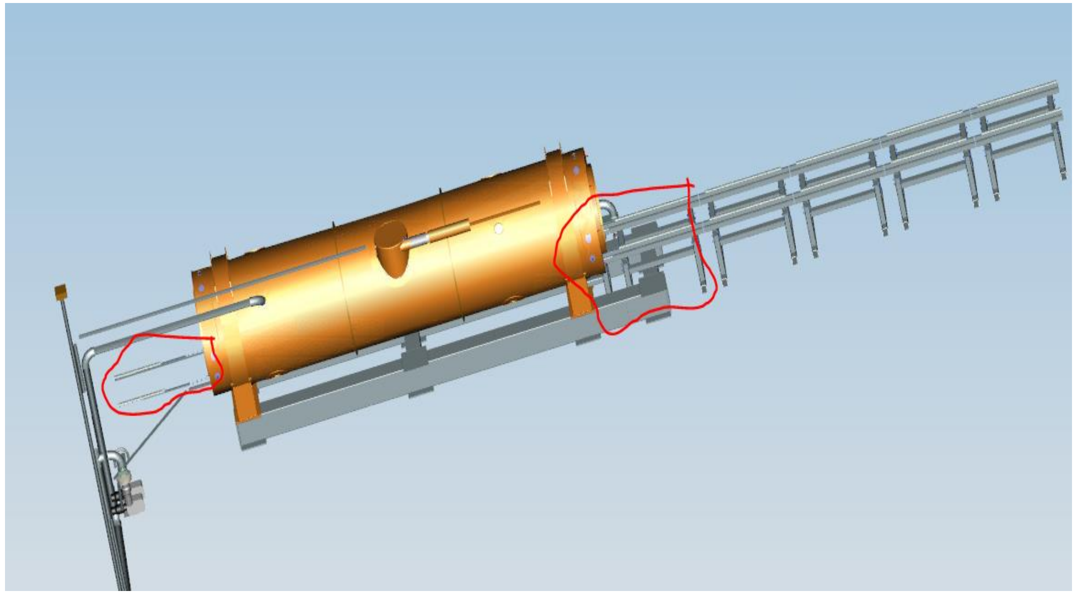
CLEAN UP ORGANIZATION OF INTEGRATION MODEL

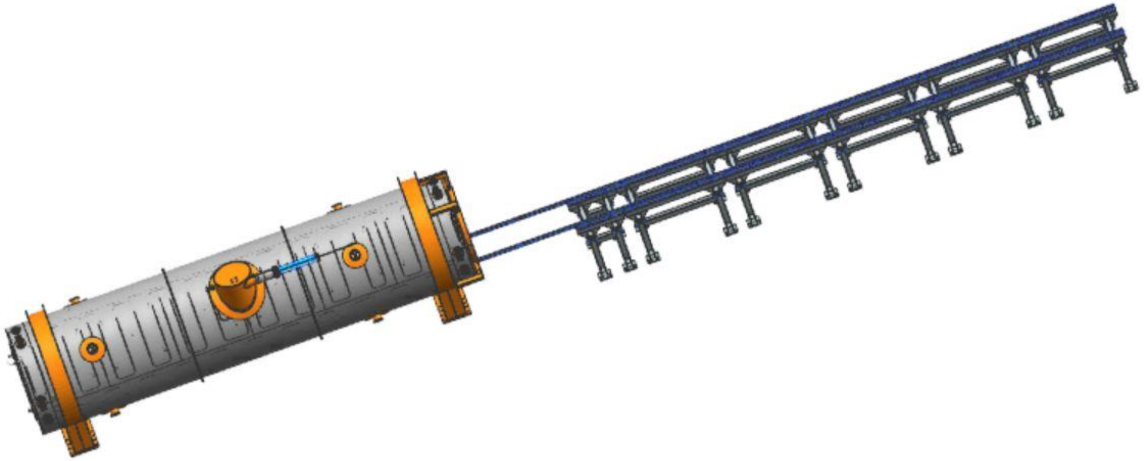
Example of the work done



DETECTOR SUPPORT AND INSTALLATION SYSTEM

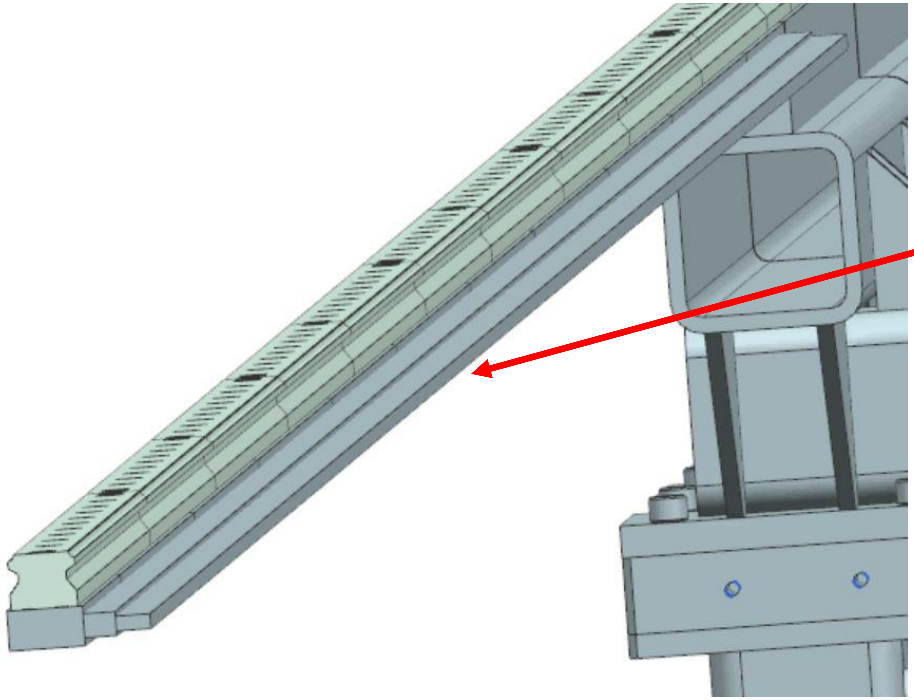
Placement of external stands

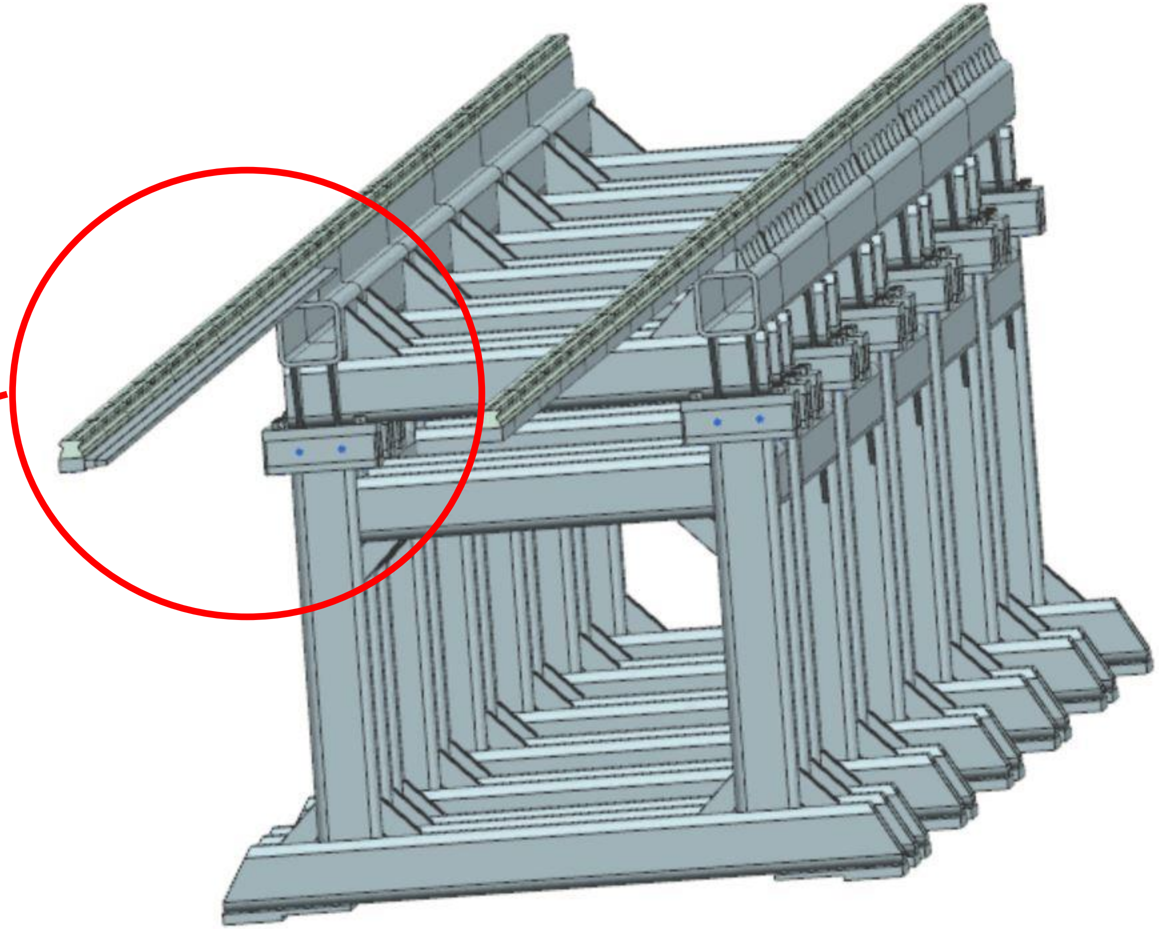




DETECTOR SUPPORT AND INSTALLATION SYSTEM

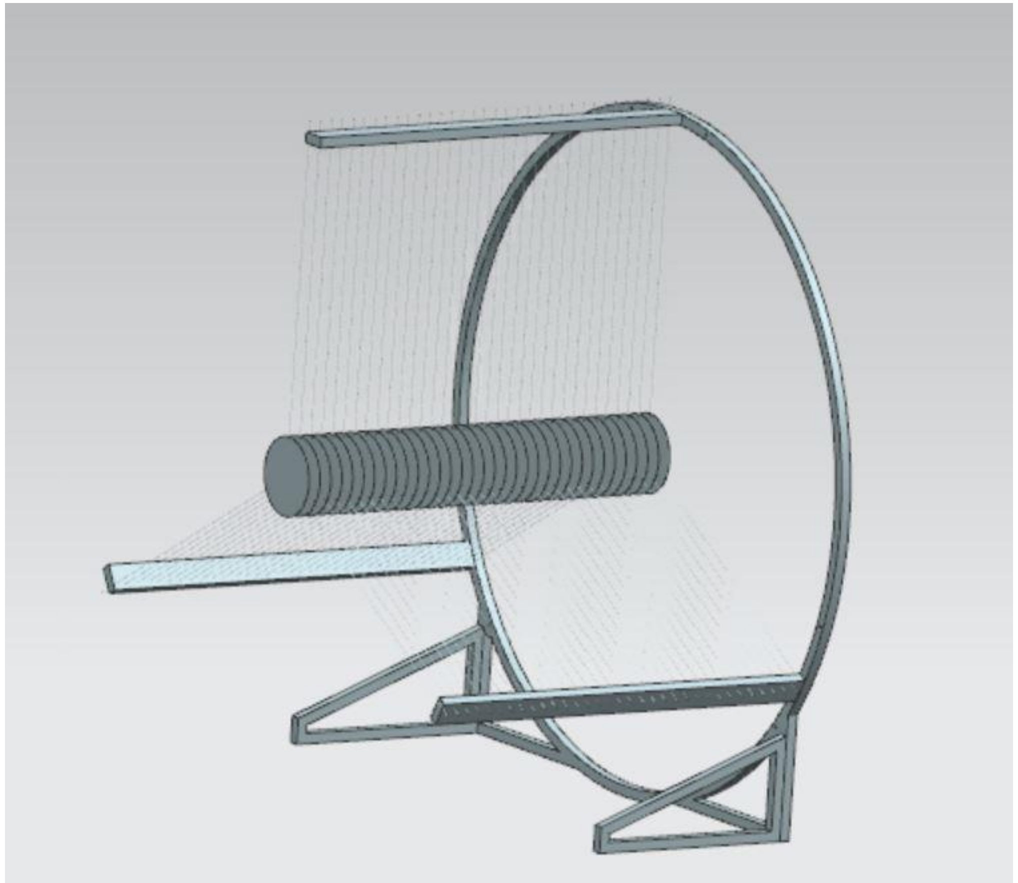
Detector Solenoid field map gear rack





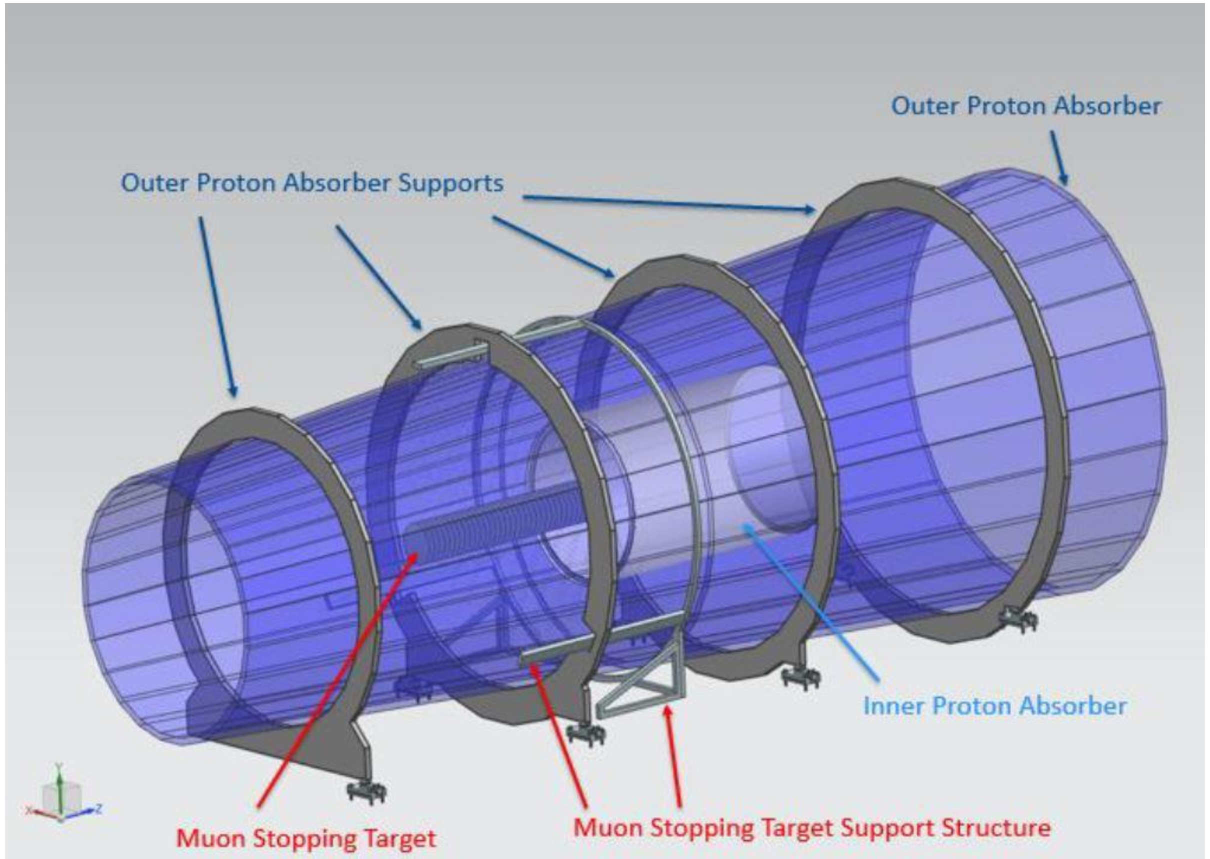
DETECTOR TRAIN COMPONENTS
MUON STOPPING TARGET

The muon stopping target is a central component of the Mu2e experiment. Interactions in the stopping target cause energy loss and the capture of the incident muons after they enter the DS. The stopped muons form muonic atoms in the stopping target, where they can potentially undergo neutrino-less conversion of muons to electrons. **The stopping target design goal is to maximize the number of stopped muons while minimizing the amount of material traversed by conversion electrons that enter the acceptance of the downstream detectors.** The muon stopping target support structure will be mounted on custom adjustment mechanisms mounted to four blocks riding on the detector rail system.



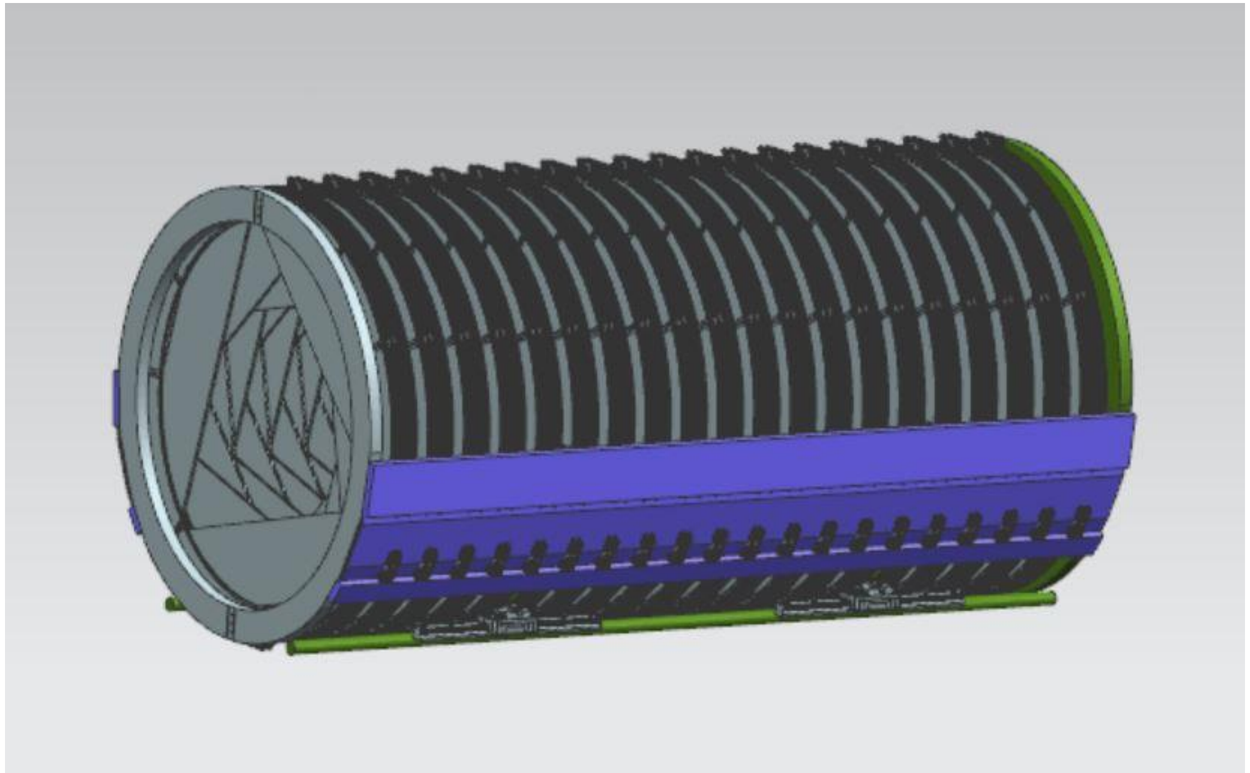
DETECTOR TRAIN COMPONENTS
PROTON ABSORBERS

A collection of absorbing materials is placed inside the DS warm bore **to suppress the rates of protons and neutrons. Excessive amounts of these particles will result in undesirable backgrounds in the tracker.** Both proton absorbers consist of HDPE (high-density polyethylene) surfaces of revolution aligned along the axis of the DS bore. The proton absorber support structure will be mounted on custom adjustment mechanisms on eight bearings blocks riding on the detector rail system. Laterally, only the four bearing blocks on one side will be adjustable during alignment (and then locked), while the other side will float freely.
The bearing blocks will include features to facilitate longitudinal connections to the surrounding Muon Stopping Target and tracker support structures.



DETECTOR TRAIN COMPONENTS
TRACKER

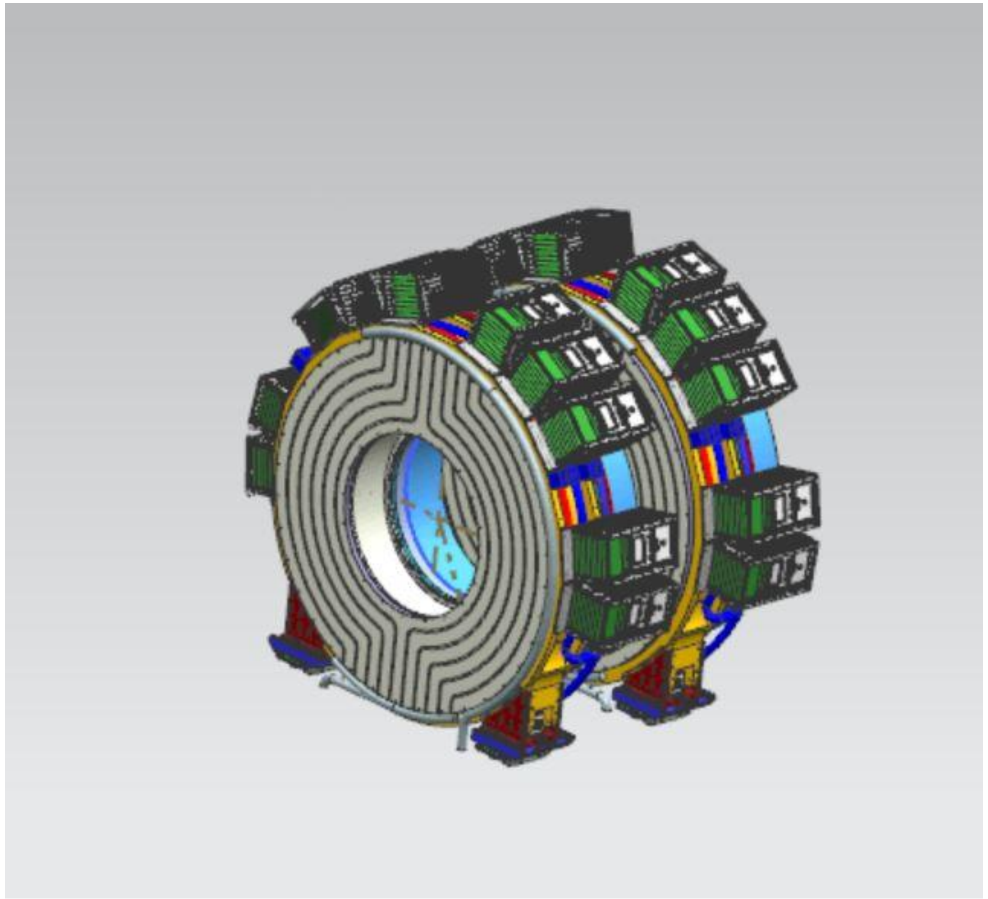
The Mu2e tracker provides the primary momentum measurement for conversion electrons. The tracker must accurately and efficiently identify and measure 105 MeV/c electrons while rejecting backgrounds. The Tracker detector support structure will be mounted on custom adjustment mechanisms on four bearings blocks riding on the rail system. The bearing blocks supporting the Tracker will provide features to facilitate longitudinal connections with the Proton Absorber and with the Calorimeter.



DETECTOR TRAIN COMPONENTS

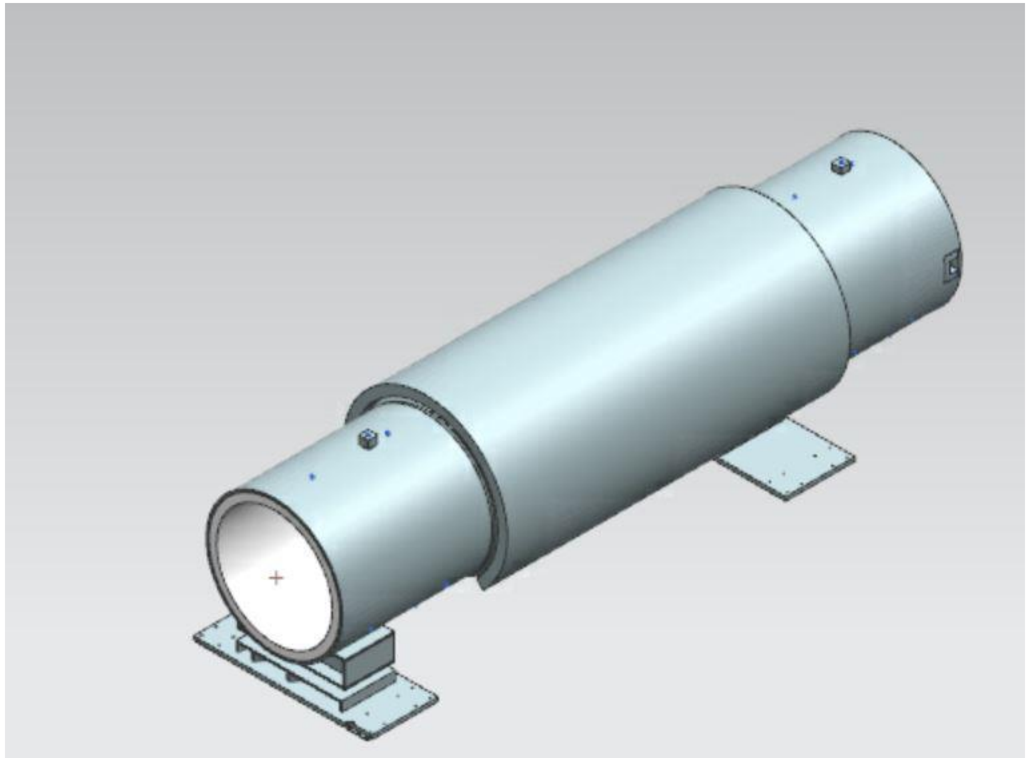
CALORIMETER

The calorimeter system is a vital link in the chain of background defenses. A background of particular concern is false tracks arising from pattern recognition errors that result from high rates of hits in the tracker. The accidental hits could combine with, or obscure, hits from lower energy particles, to create a trajectory consistent with a higher energy conversion electron. **Thus a primary purpose of the Mu2e calorimeter is to provide a second set of measurements that complement the information from the tracker and enable us to reject background due to reconstruction errors.** As are the other detector train components, the calorimeter support structure will be mounted on four bearings blocks fitted with custom adjustment mechanisms to accommodate adjustment in elevation and side to side. The bearing blocks provide features to allow longitudinal connections with the Tracker and with the Muon Beam Stop.



DETECTOR TRAIN COMPONENTS
MUON BEAM STOP

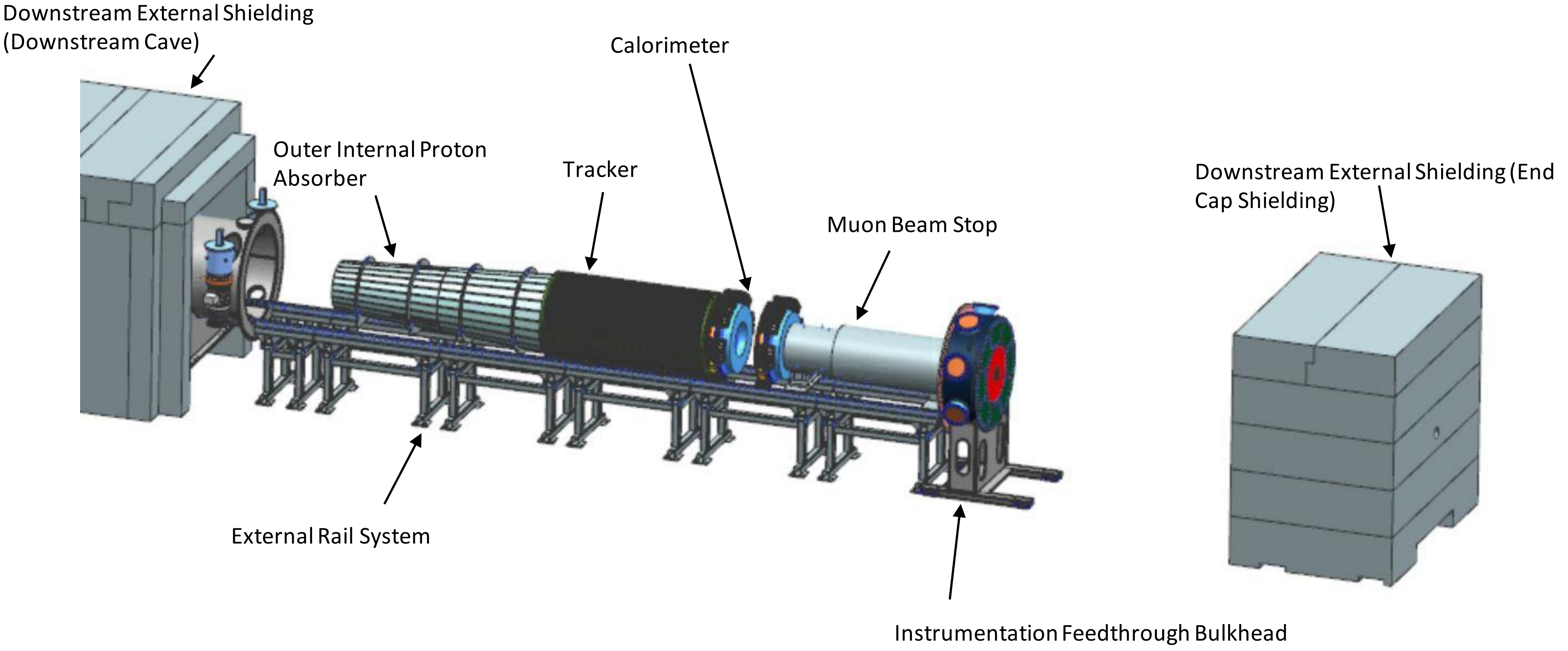
The muon beam stop (MBS) will be located within the bore of the DS, and **is designed to absorb beam particles that reach the downstream end of the solenoid while minimizing the background to the upstream detectors resulting from muon decays and captures in the beam stop.** The upstream (spherical) support for the muon beam stop will be mounted on bearings blocks riding the detector rail system. The bearing blocks provide features to accommodate longitudinal connections to the Calorimeter.



DETECTOR TRAIN

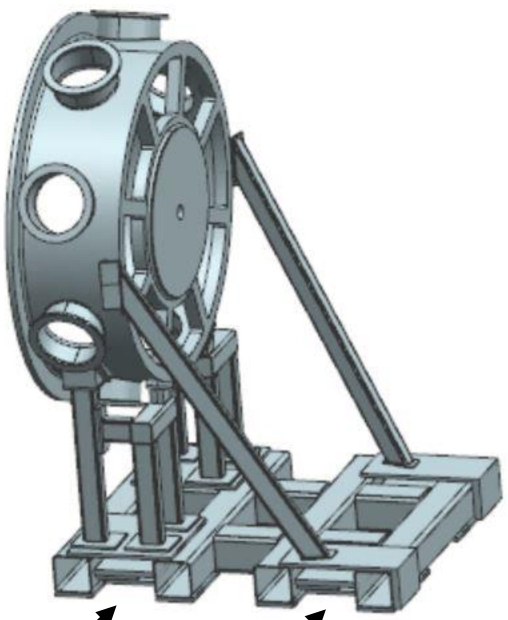
INTERNAL AND EXTERNAL RAIL SYSTEM

The components are supported by two rails and transported on linear ball bearings. Two separate rail systems will be implemented, the “internal” and “external” systems. Once installed, the alignment of all components will be maintained by the internal rail system. Below are shown detector components positioned on the external rail system



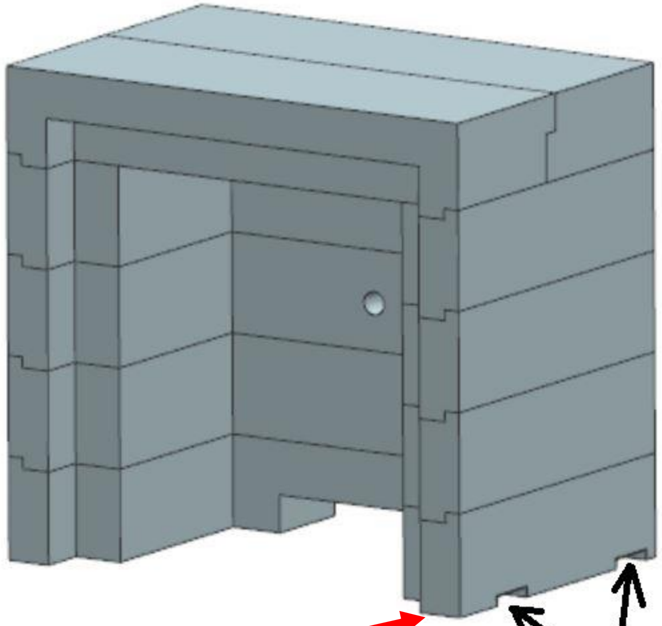
DETECTOR TRAIN COMPONENTS

Both IFB and End Cap External Shielding are supported and rolled on Hilman rollers



Space for Hilman Rollers

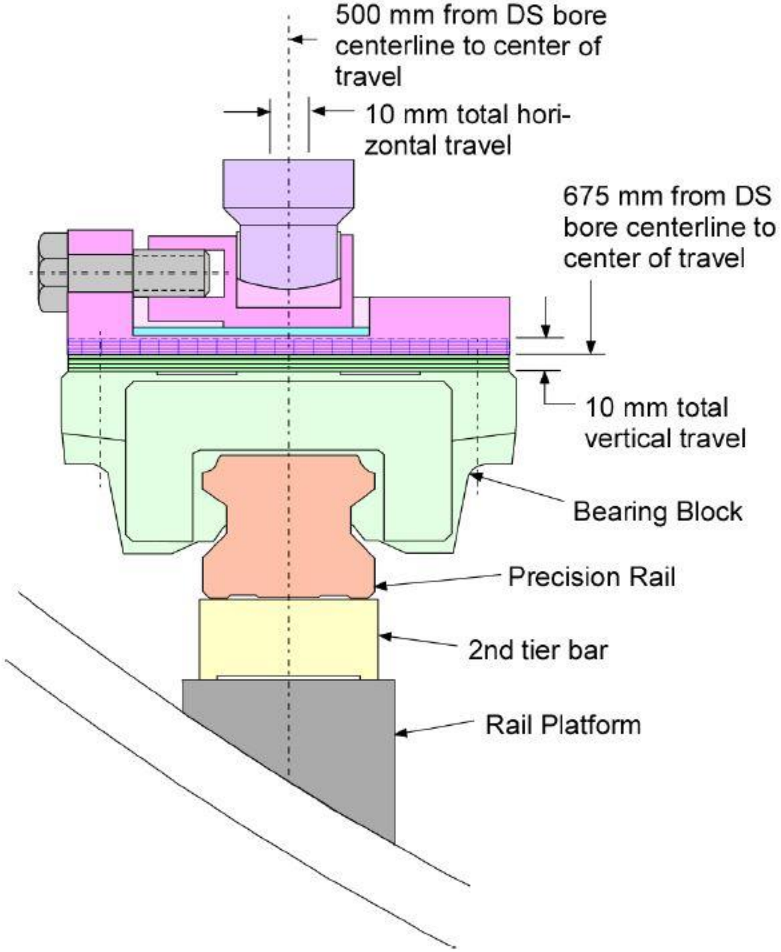
HILMAN ROLLERS



Cutouts for Hilman rollers

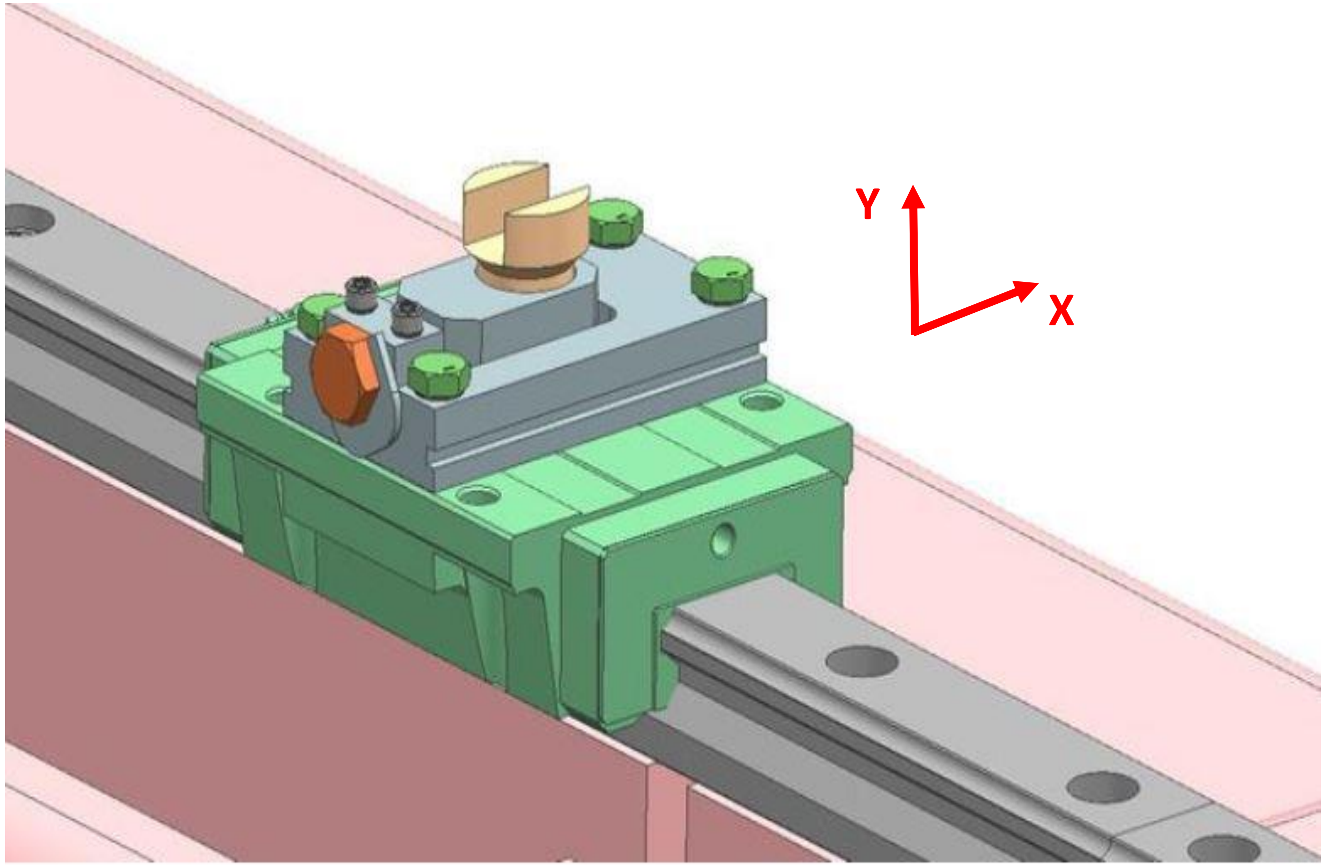
DETECTOR TRAIN
POSITIONING OF STRUCTURAL SUPPORT

Supports for the rail mechanism must be designed such that the DS bore can support the loads without unacceptable deflection or risk to the cryostat structural integrity. Although the stainless steel rail platform will be welded to the cryostat wall, the linear rail can be shimmed or adjusted as needed (using the 2nd tier bar) and bolted to this base to achieve the appropriate alignment.



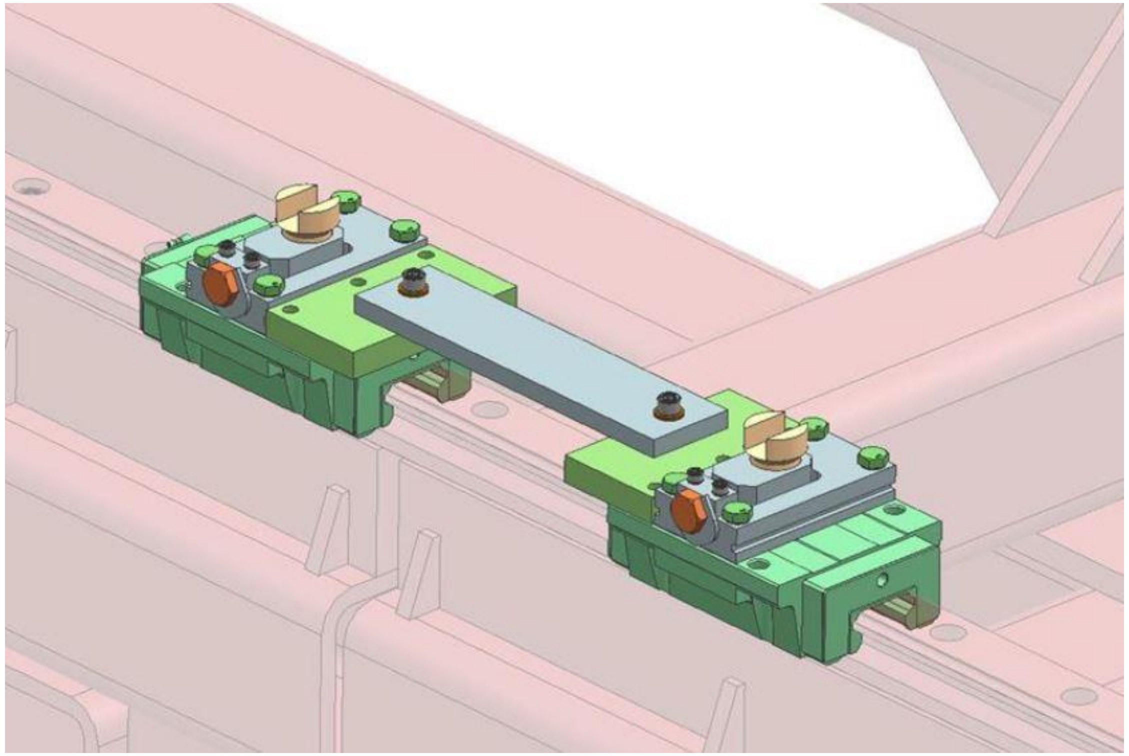
DETECTOR TRAIN
ADJUSTEMENT MECHANISMS

Vertical (Y) and lateral (X) adjustment of detector support structures will be accomplished with the custom adjustment mechanisms. Lateral adjustment is accomplished with a screw mechanism, which is locked once the adjustment is complete. Vertical adjustment is achieved by shimming between the bearing block and the adjustment
mechanism. The full range of adjustment is 10 mm in both the horizontal and vertical directions.



DETECTOR TRAIN
AXIAL ATTACHMENT OF COMPONENTS

Each detector component within the DS bore will be coupled axially to the adjacent components. Although each component will be aligned separately in X and Y, all detector support structures will be connected in Z on one side of the rail system by mechanisms. After initial alignment studies, all components will be inserted and removed from the DS internal bore as a single integrated unit (the detector train).



DETECTOR TRAIN
INSTALLATION

1. Measurement of Detector Solenoid.

2. Installation of Internal rail by use of specially machined 2nd tier bars bolted to the rail platforms.

3. During the initial installation, each component will be lowered onto the external rail system, rolled into the DS bore and placed into its approximate final axial position.

4. The components will be measured in X and Y with respect to the geometric bore of the detector solenoid.

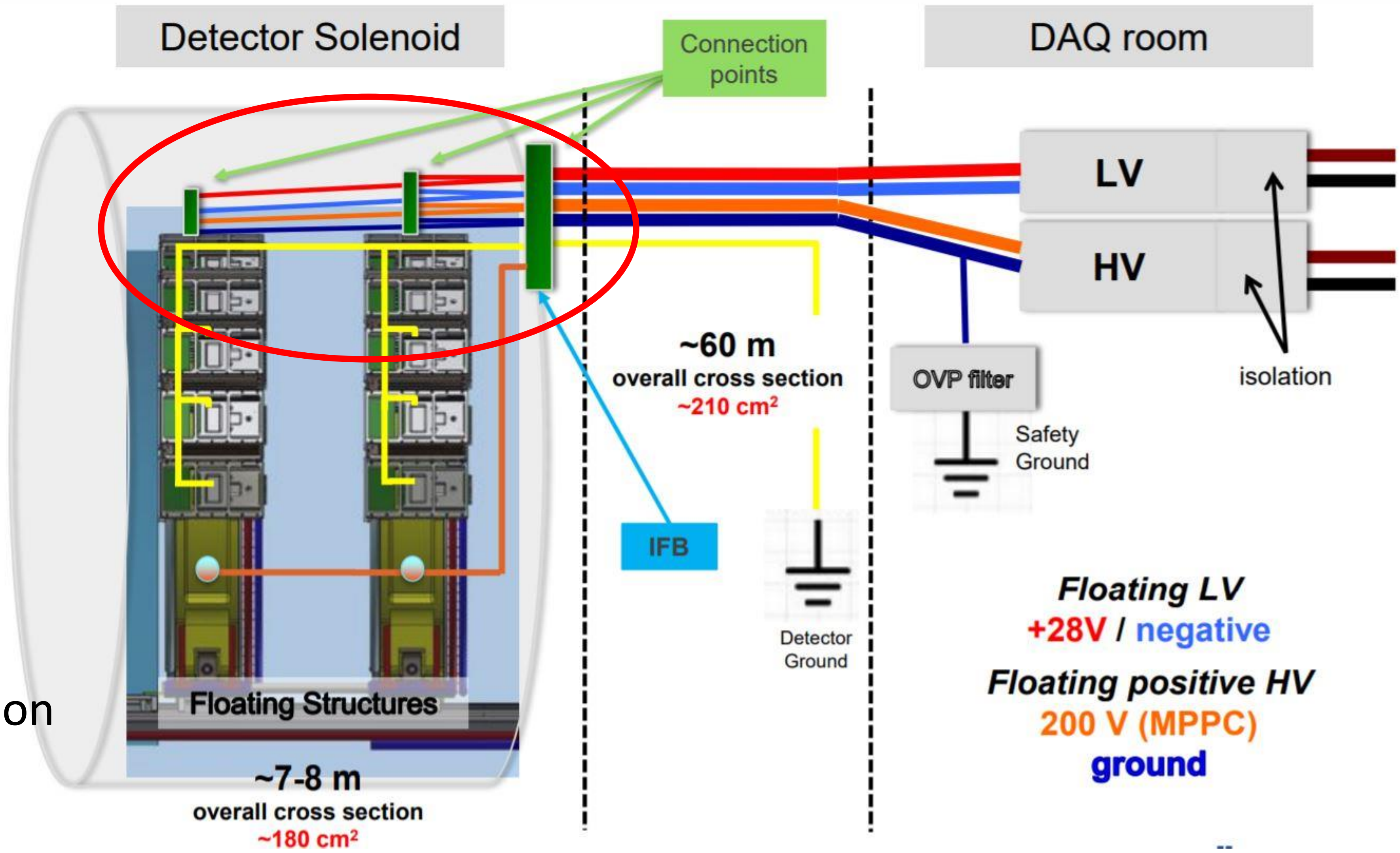
5. Several iterations may be required to achieve the alignment criteria.

After the initial installation has been completed, the detector train can be rolled out of and back into that position on the set of rails provided by the detector support and installation system. The rail system is designed to maintain the appropriate level of reproducibility every time the components are extracted and re-inserted into the DS bore.

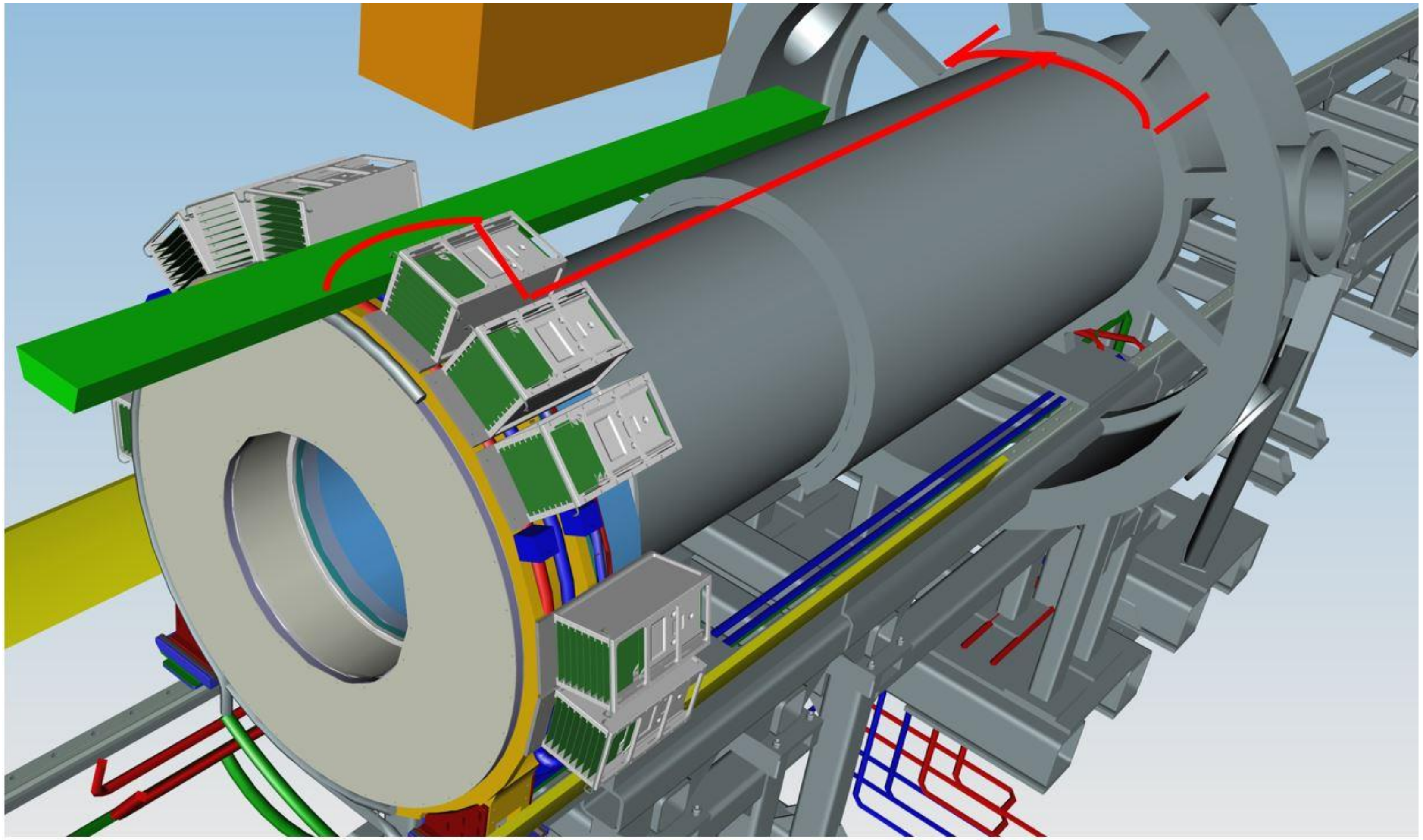
CALORIMETER SERVICES

Electrical Services

- HV
- LV
- TDAQ
- Laser
- Grounding Connection



CALORIMETER SERVICES



CONCLUSION

- I have learnt a new CAD software “NX”

- The net result is that the 3-D model now more accurately reflects the currently Mu2e plans, and the organization of the model more accurately reflects the project WBS structure, and these modifications will facilitate Mu2e integration activities.

- I have participated in various Mu2e meetings and discussions aimed at facilitating integration of aspects of the Mu2e subsystems, and learned techniques adopted by the project to support integration activities

THANK YOU FOR YOUR ATTENTION