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Design and Installation of the Mu2e Extinction Monitor

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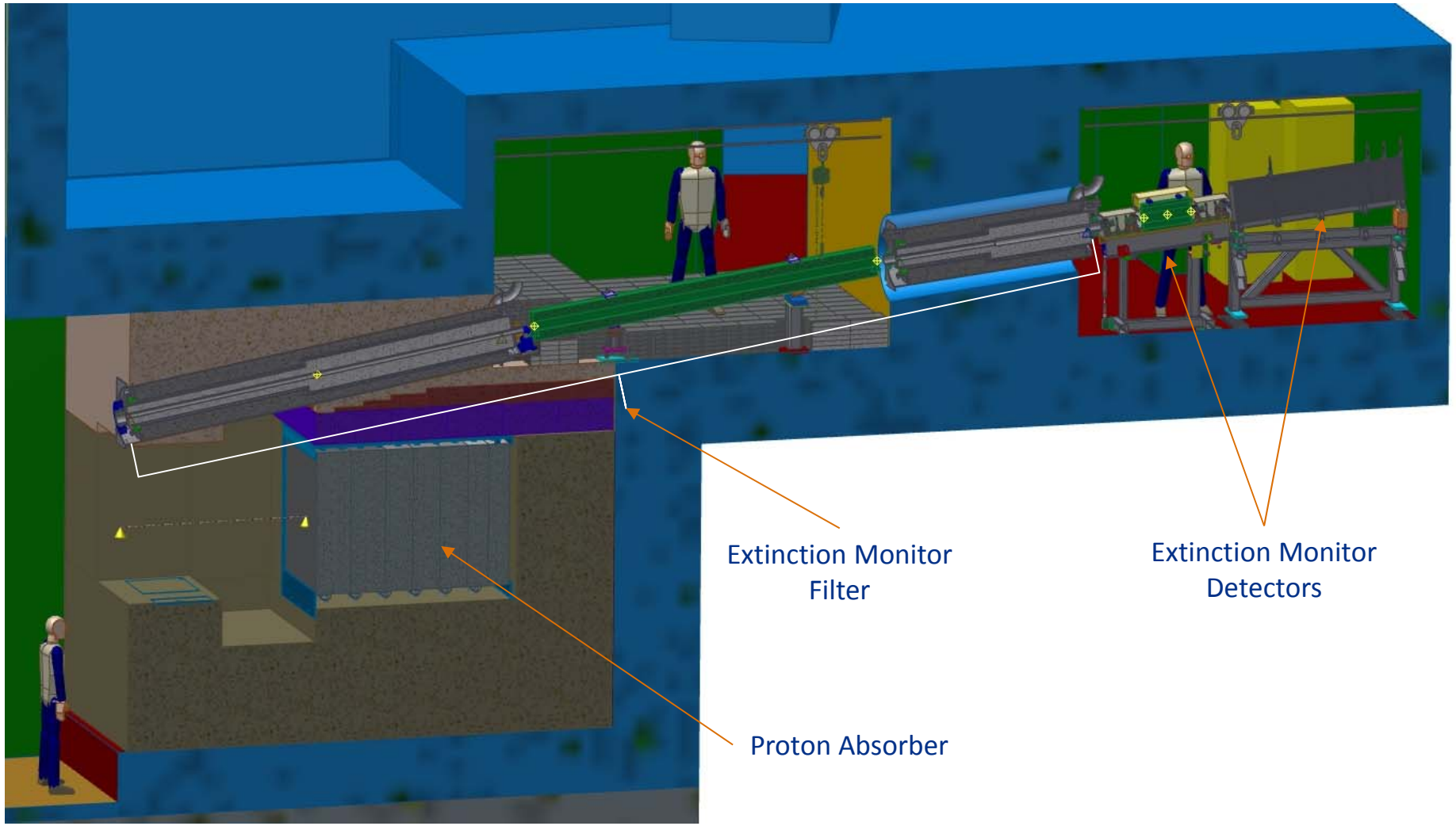
Mu2e Extinction Technical Design Review

2 November 2015

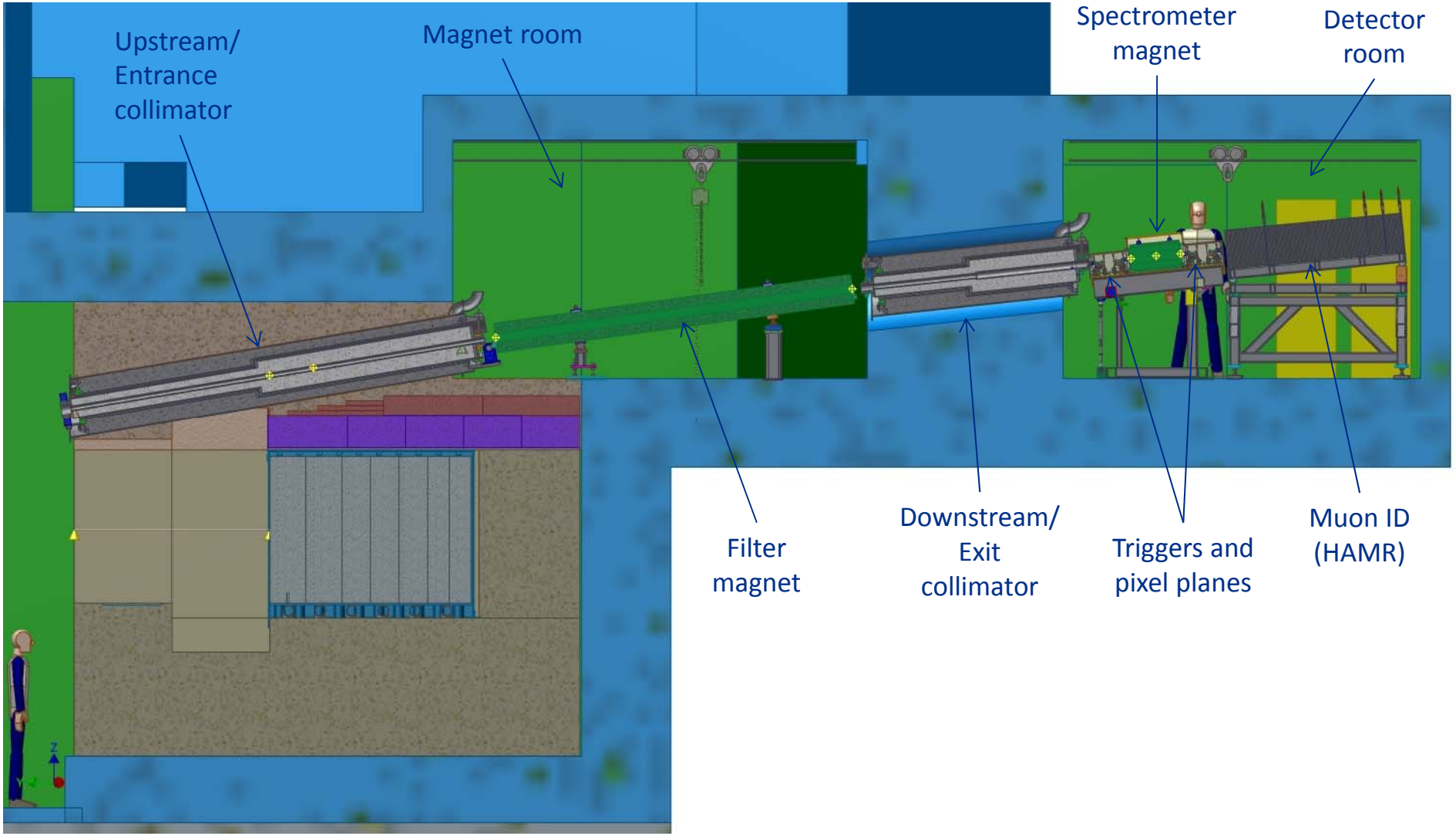
Overview of slides

- The next set of slides shows the overall and detailed design of extinction monitor components
- The set after shows details of how some of the major components will be installed
- The requirements are to be able to position each of the devices to coordinates determined for the extinction monitor to tolerances typical of accelerators at Fermilab (±0.005” transverse to beam)
  - Every component has the ability to be positioned in all six degrees of freedom (in some cases in multiple layers) to the required accuracy

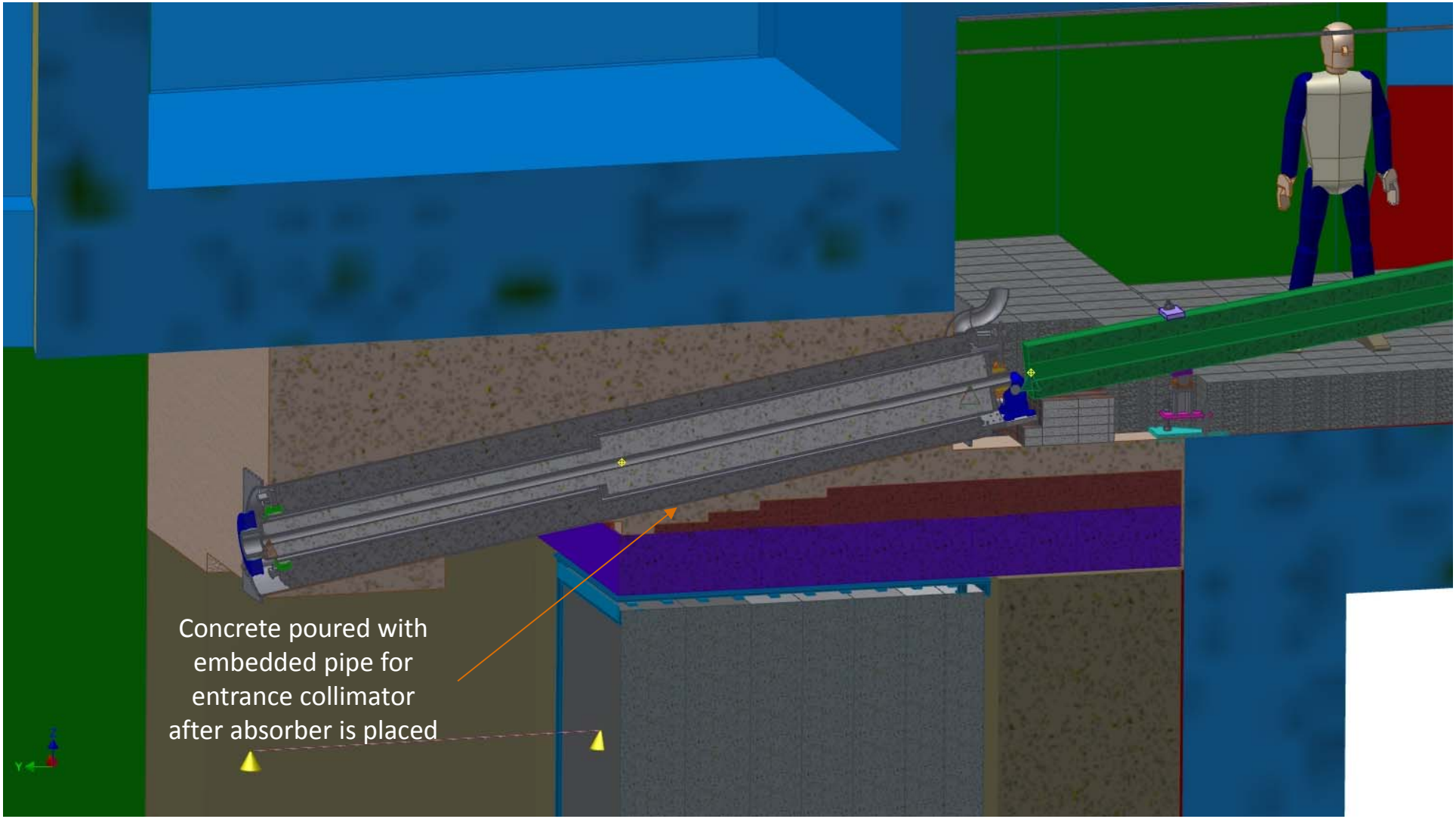
Cross section overview through the Extinction Monitor



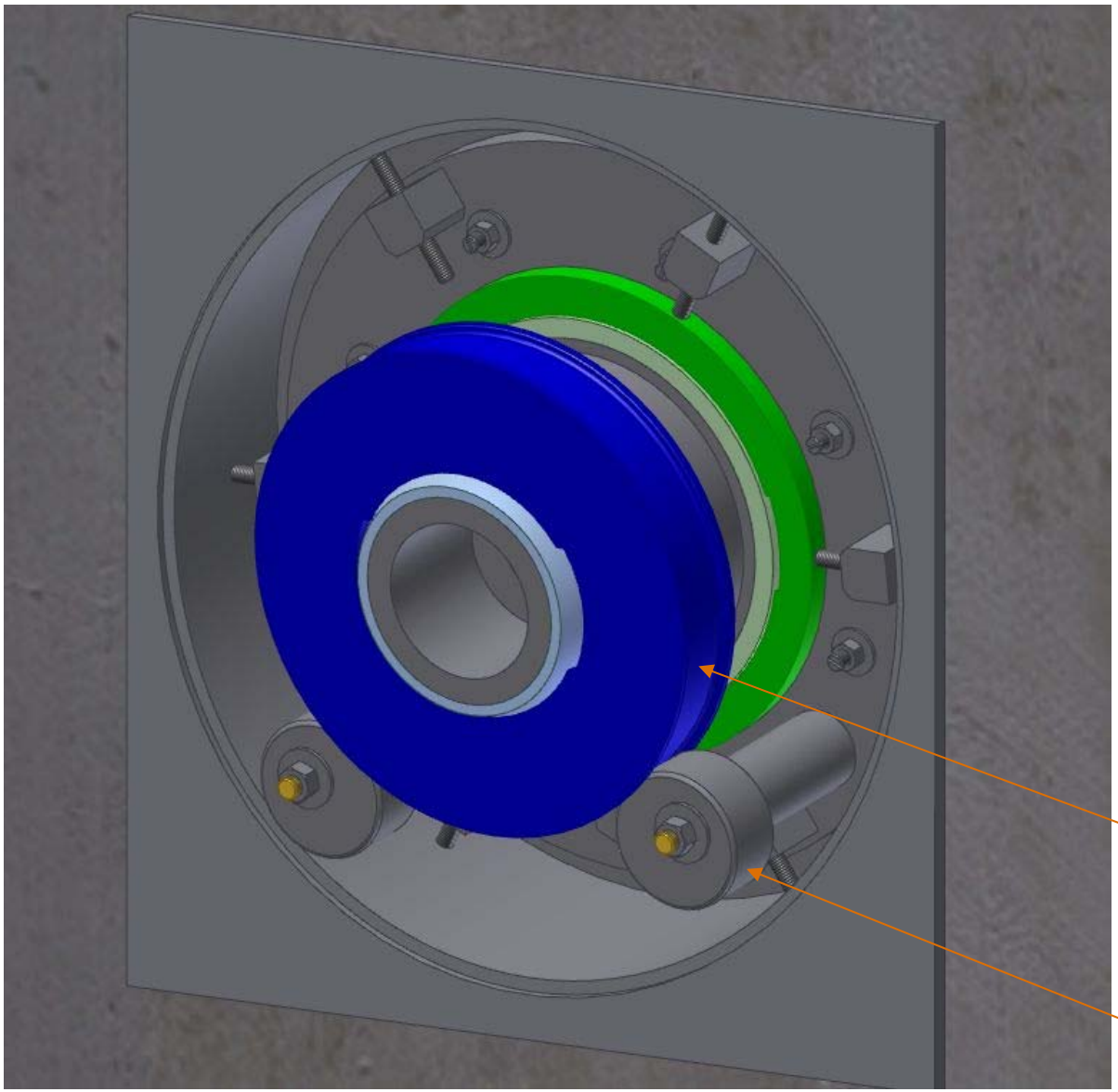
Major components of the Extinction Monitor



Close-up of the Entrance Collimator



View of the upstream end of the entrance collimator

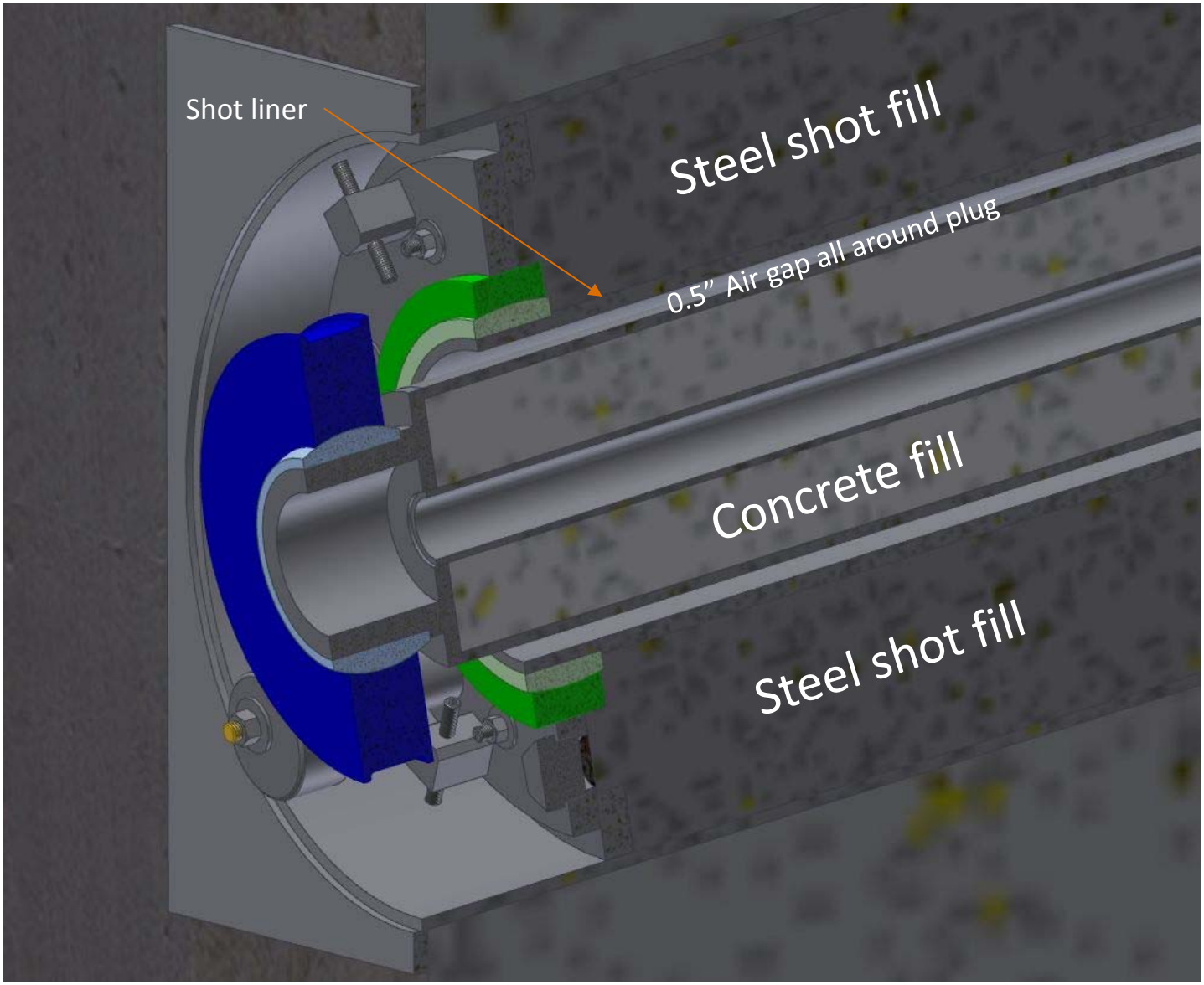


The entrance collimator has one end in the PS room right above the absorber. Alignment of this end from within the PS will not be possible because of radiation levels. This end of the collimator is supported by two eccentric cams that are driven by gearboxes in the magnet room. The cams can position this end of the collimator anywhere within the ½" annular space around the collimator.

Spherical plain bearing on end of plug collimator

Cam support/alignment with Grafoil bearings

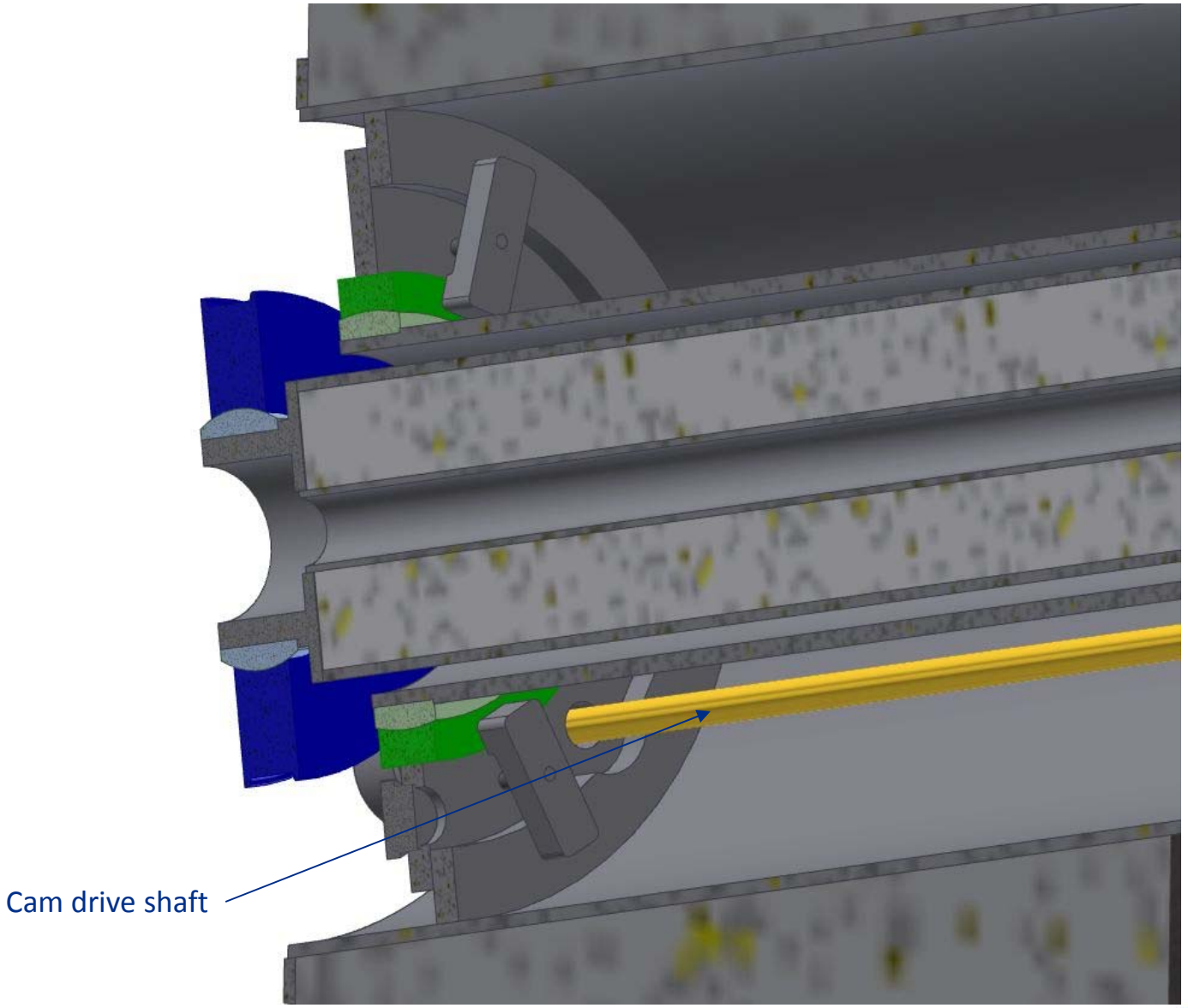
Cross-section through upstream end of entrance collimator



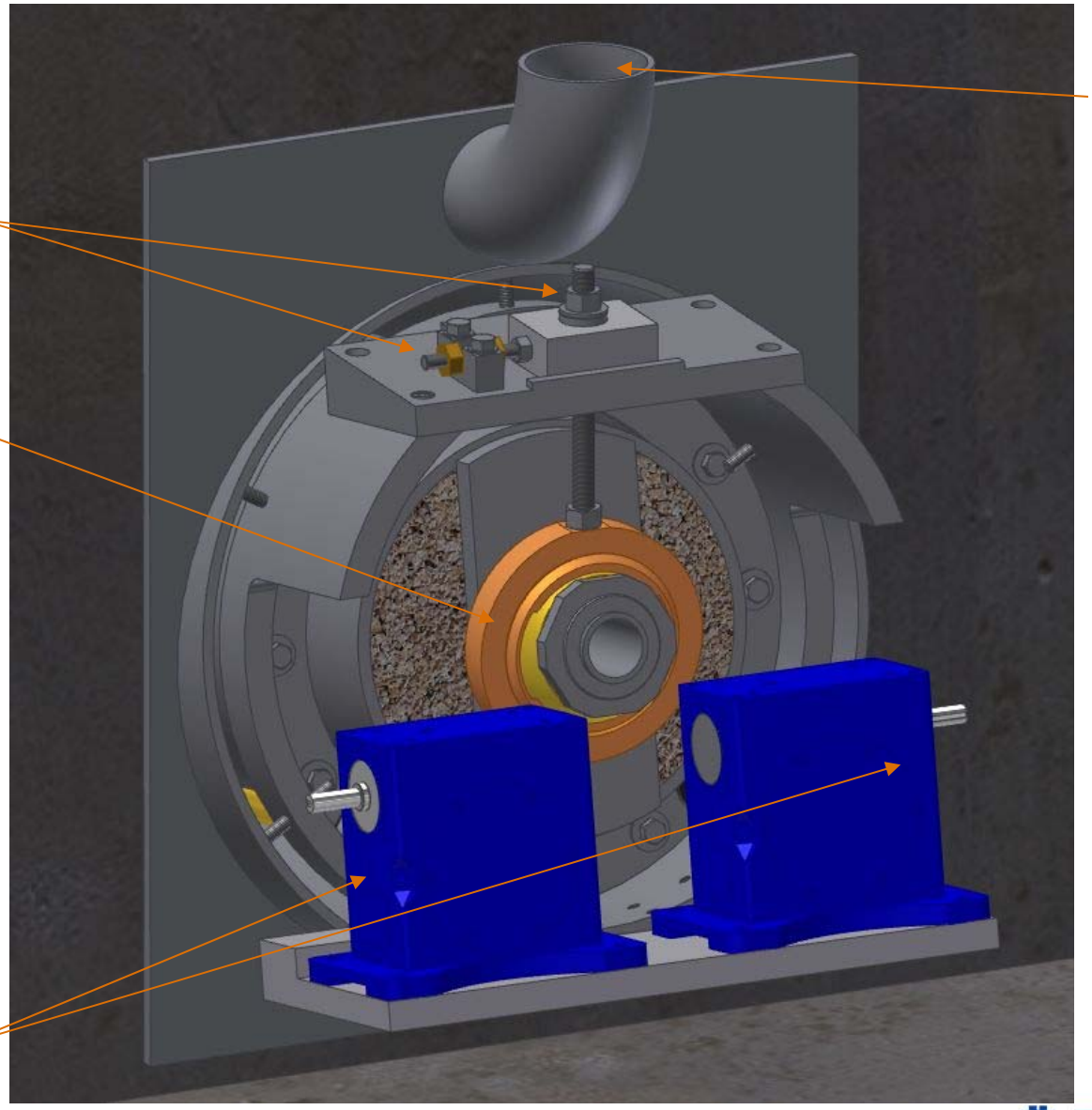
As shown below, the shot liner is installed first and has a ±1" adjustment at both ends. The green object is a spherical bearing allowing angular adjustment. This adjustment is fixed when the steel shot is poured in.

The entrance collimator is installed after the shot liner and it has ±0.5" of adjustment which is only locked after the air barrier at the DS end is installed.

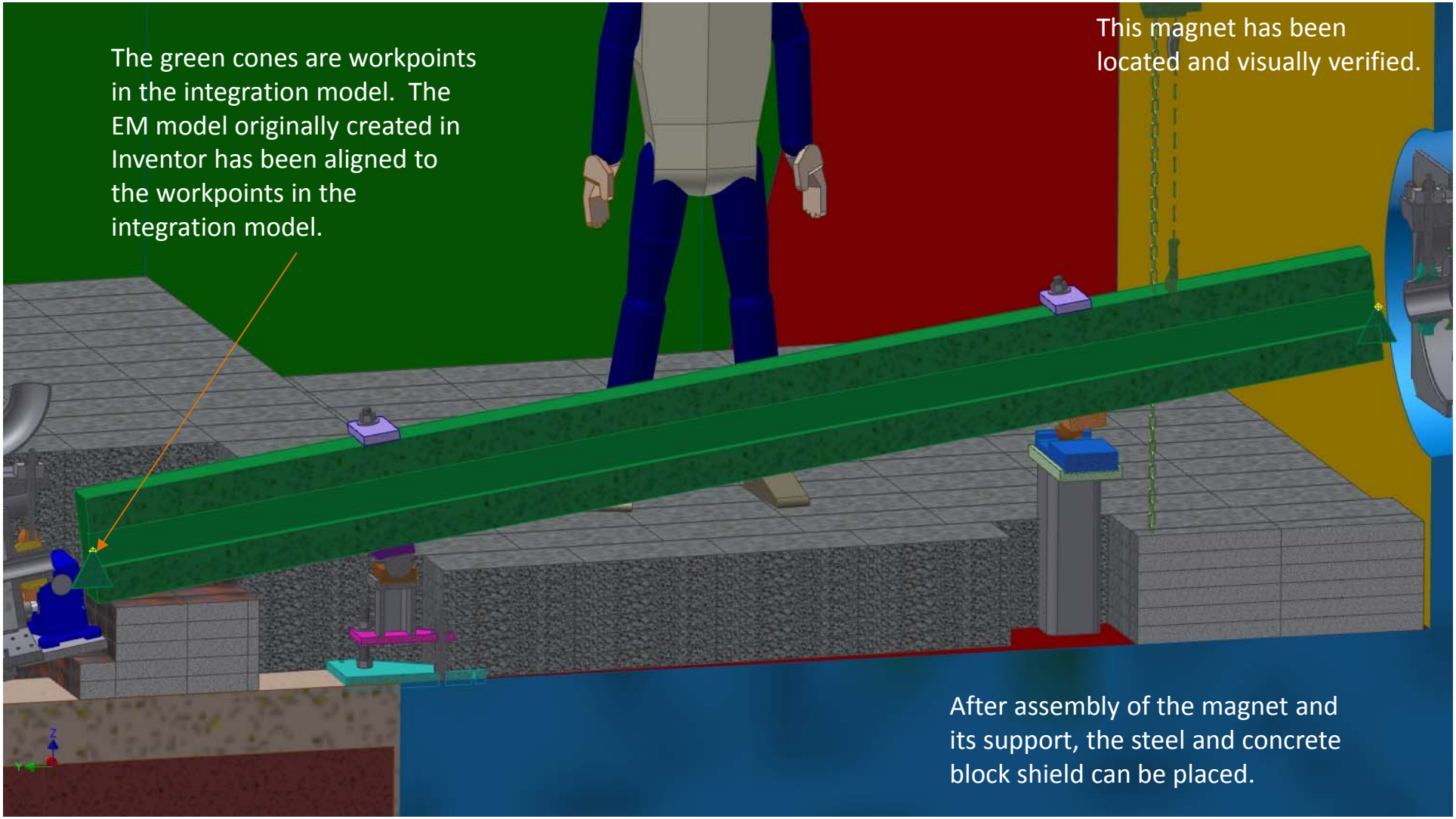
Section view with shot removed showing cam drive shaft



View of the downstream end of the entrance collimator

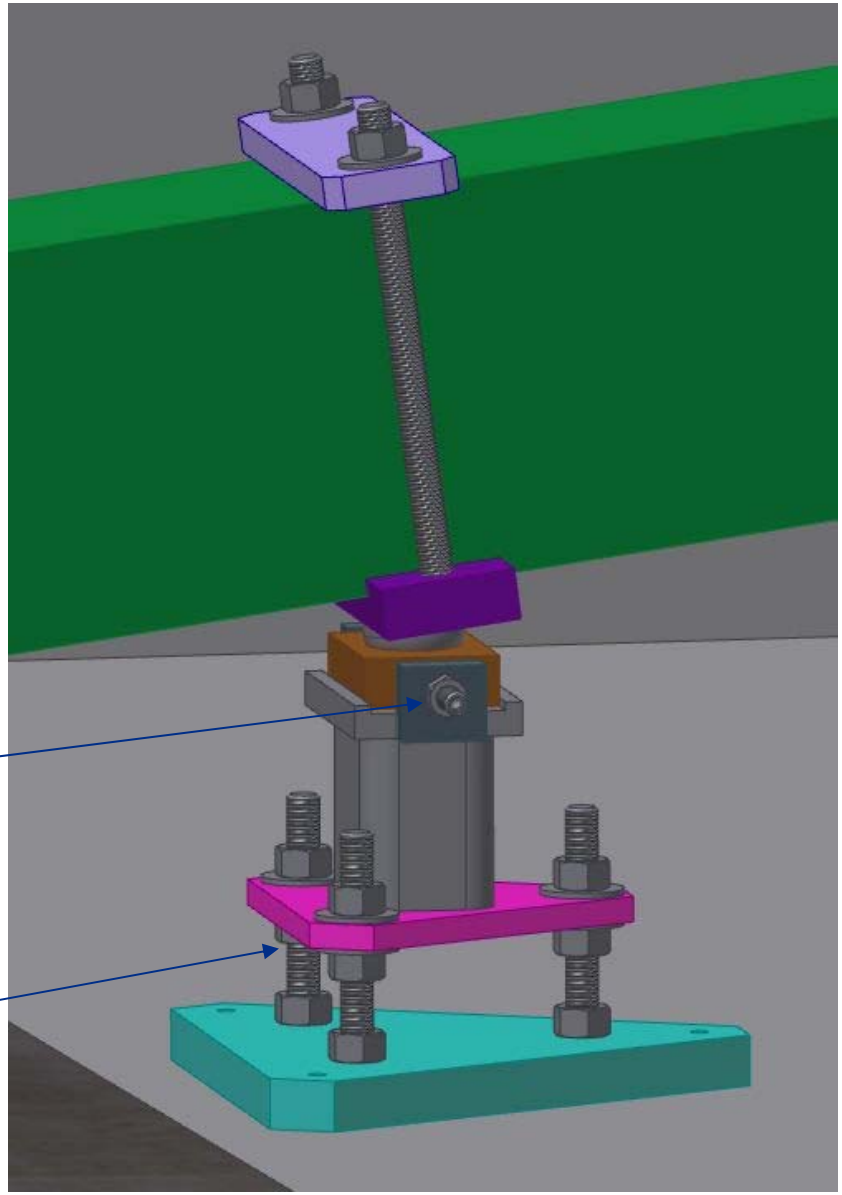


Close-up of the filter permanent magnet



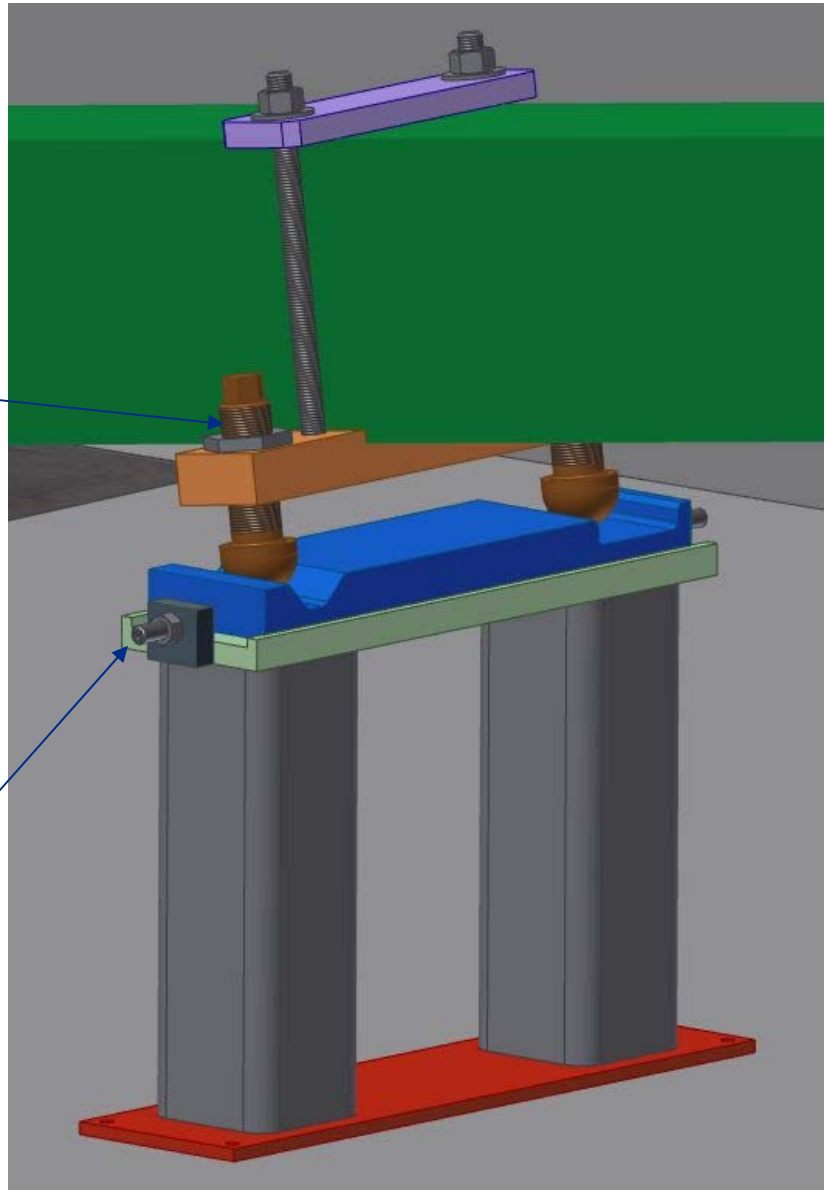
Filter magnet at magnet storage

Upstream end Filter Magnet Support ball and socket joint



The three point support for the permanent filter magnet is a kinematic mount allowing the magnet to be moved away from its stand and replaced in the same location. This end is the ball and socket.

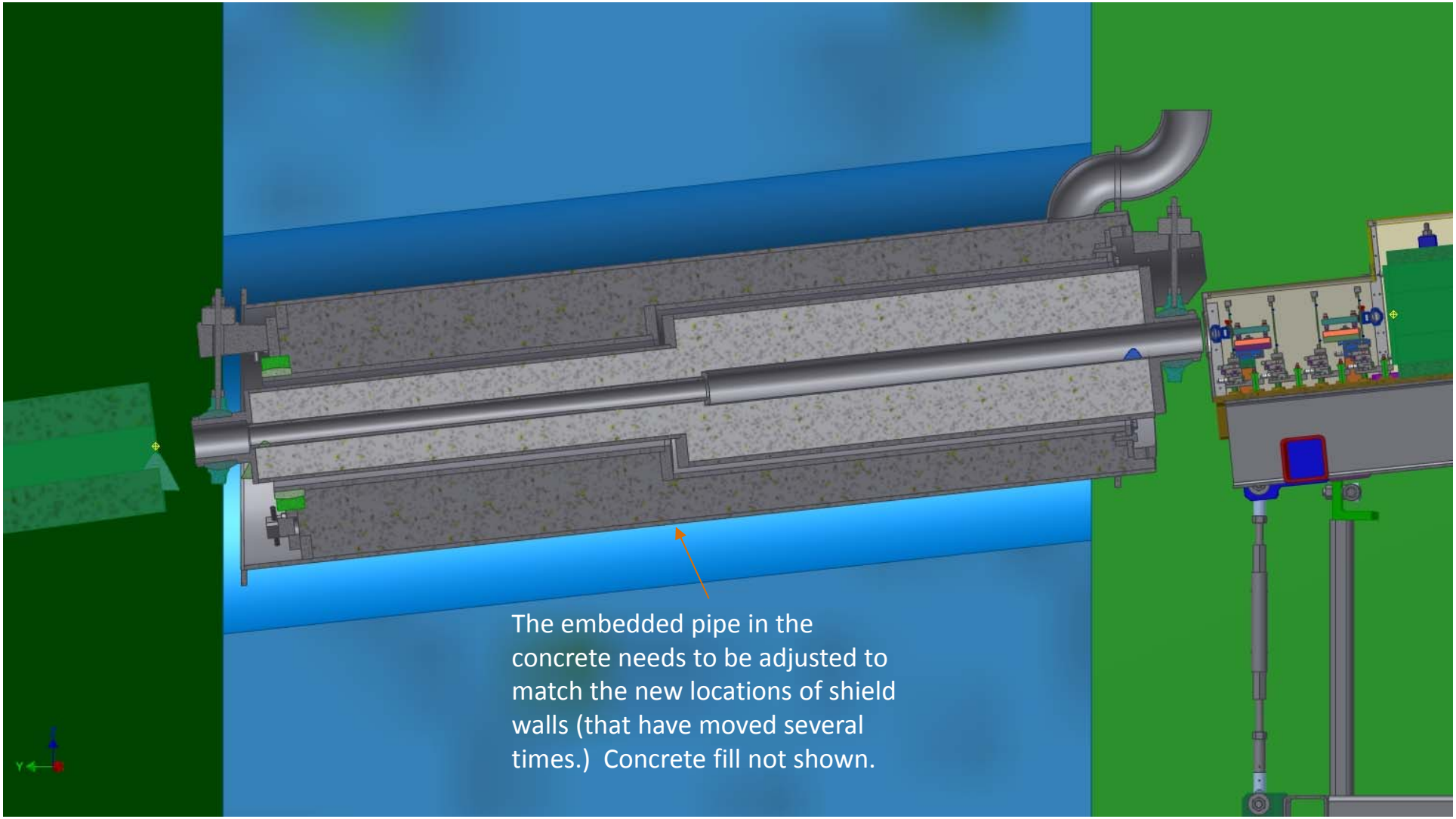
Downstream end Filter Magnet Support vee groove and flat joints



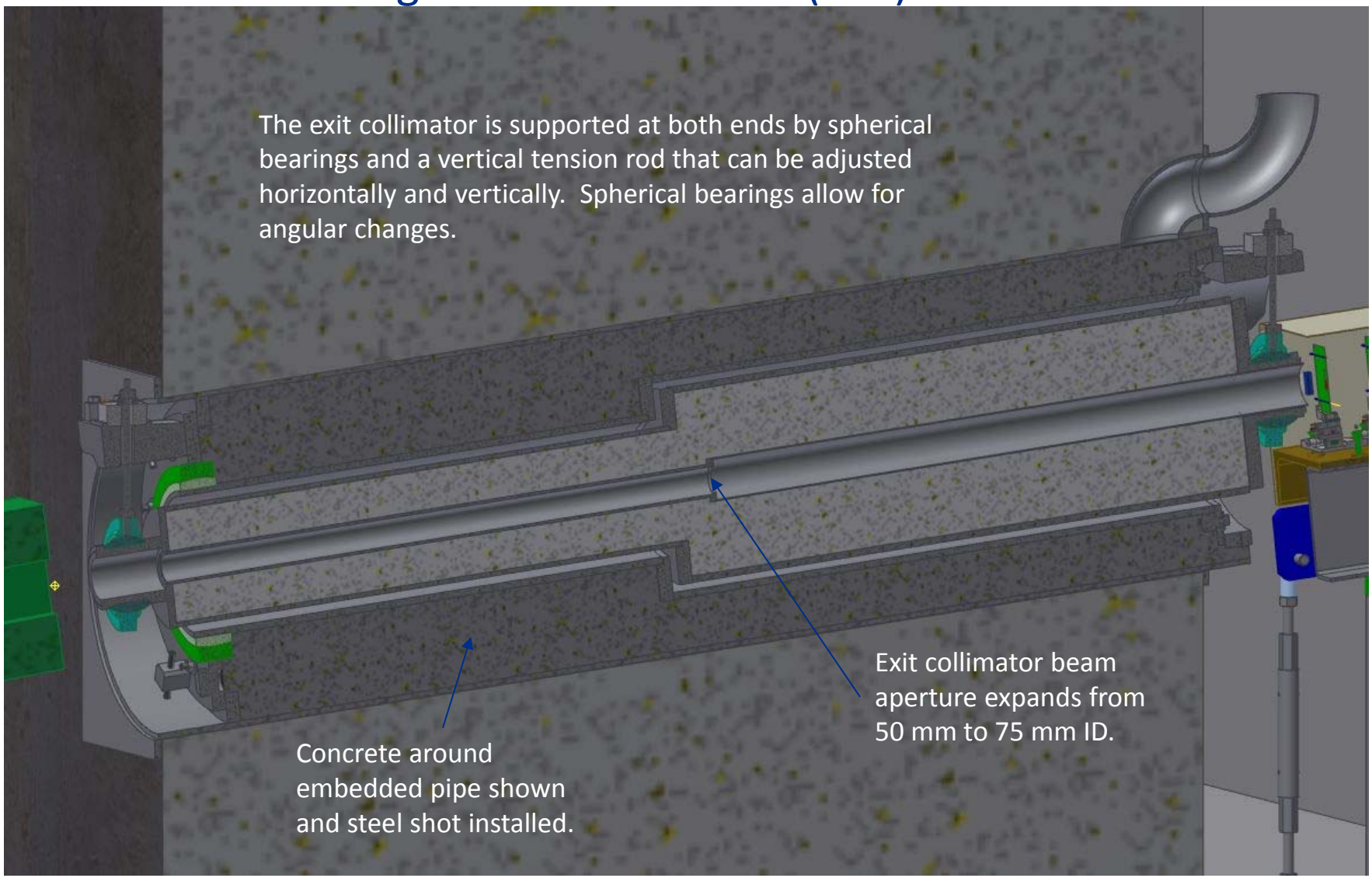
This end of the kinematic mount is the vee groove and flat surface.
The kinematic mount allows any adjustment to be made without binding another adjustment.

Changing the horizontal/yaw adjustment does not cause a change in the pitch or roll of the magnet.

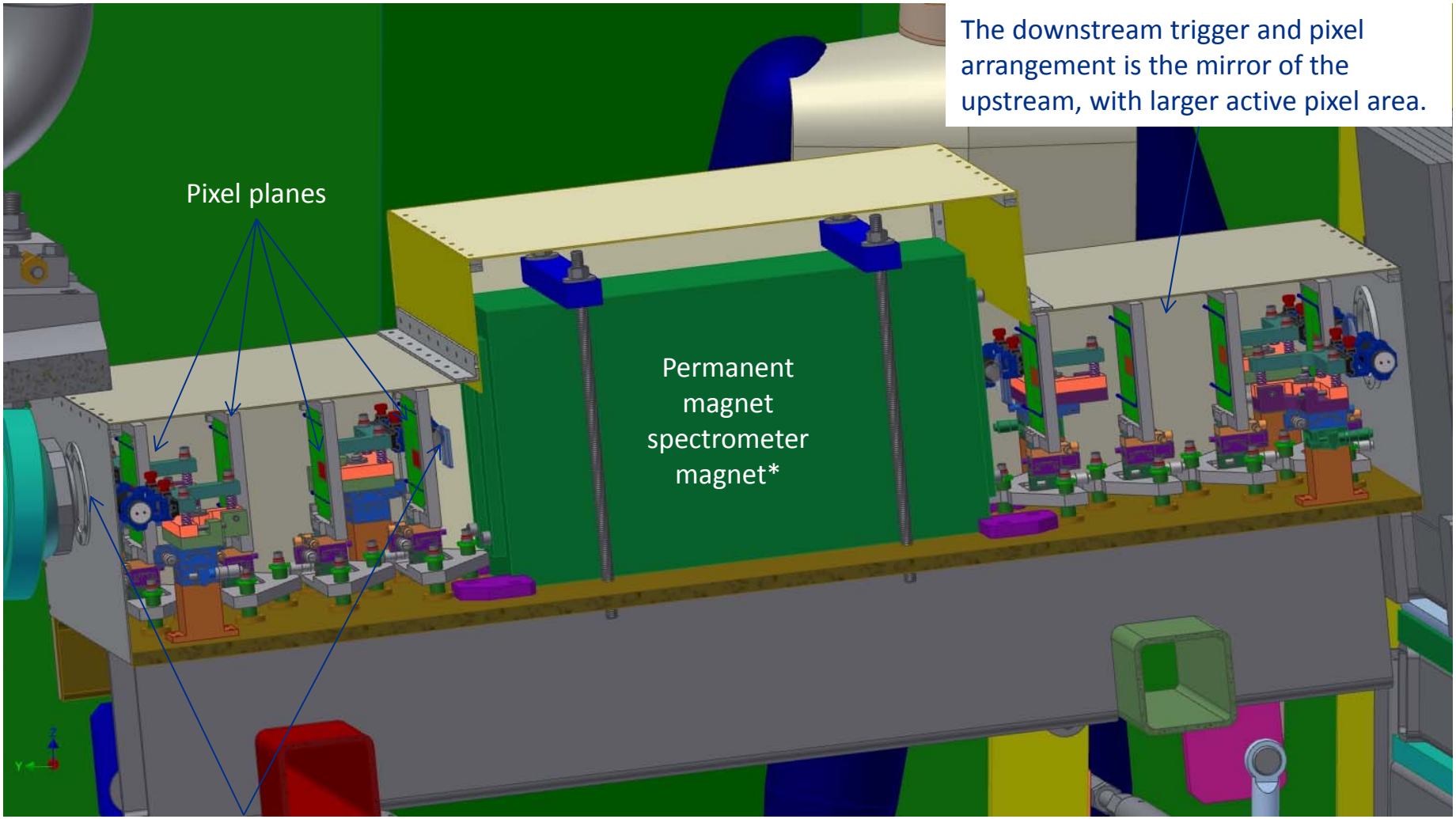
Close-up of the Exit Collimator in the Integration Model architecture



Cross-section through the Downstream (exit) collimator



Section view showing the trigger, pixels and spectrometer magnet



The downstream trigger and pixel arrangement is the mirror of the upstream, with larger active pixel area.

*This magnet has been located in storage.

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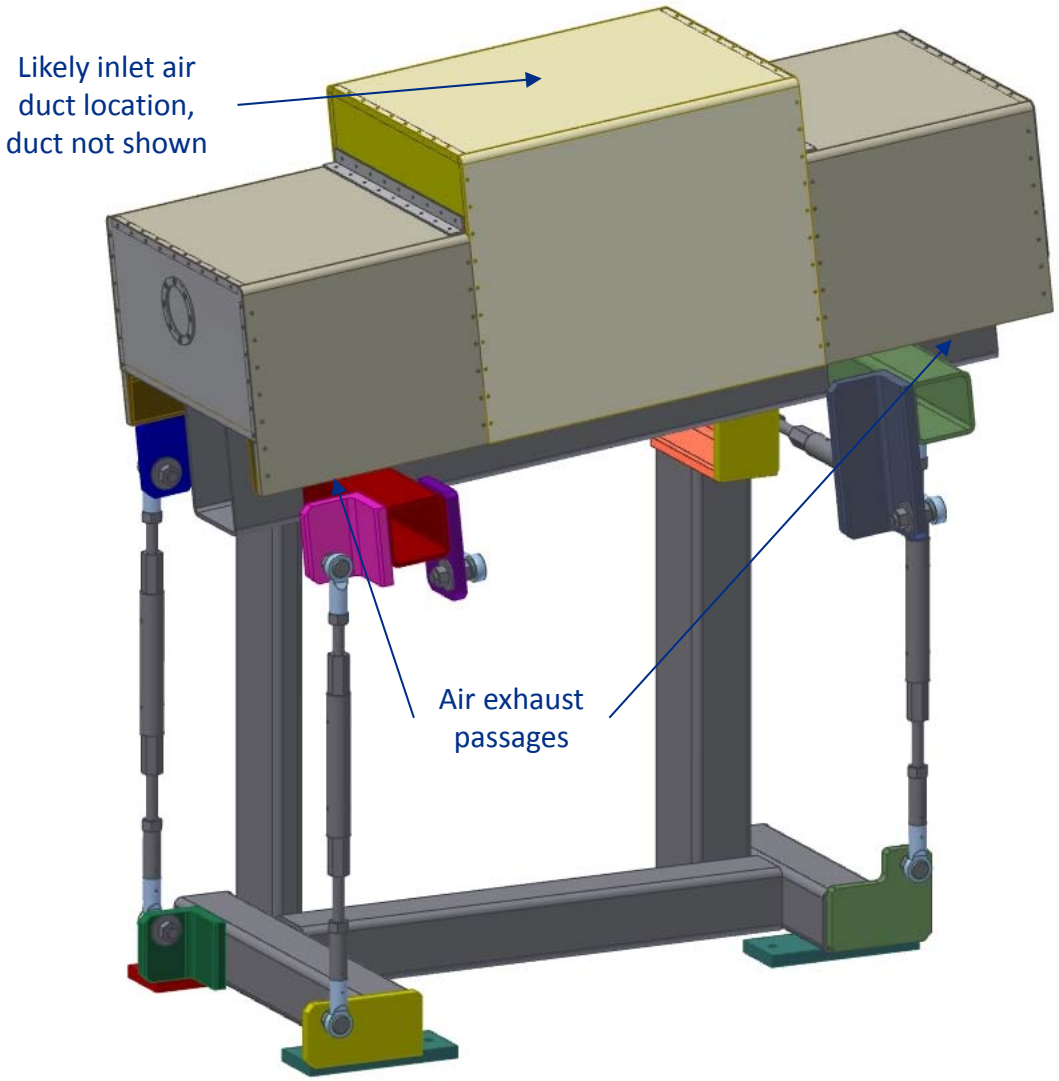
The six strut support of the spectrometer magnet and pixels

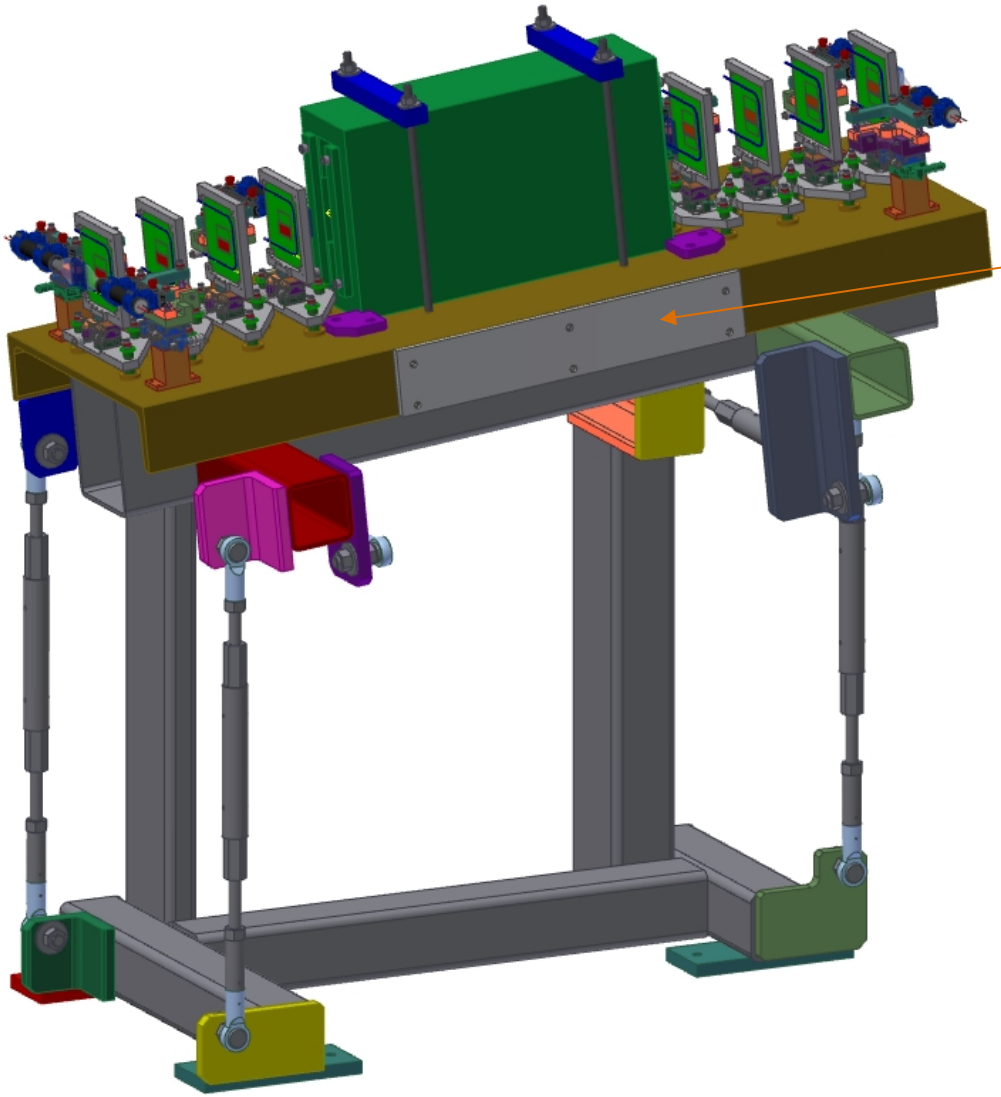


The cover is to allow dry air flow around the pixel planes. Dry air is needed because the pixel planes are liquid cooled to below room temperature.

Any of the three cover sections can be removed independently of the others. Air duct inlet is not shown. Air flows out between the cover and the C-channel base. Cooling tubes for the pixels can also be routed out through the air exhaust gap. Beam goes through a thin foil at each end.

The support is a six-strut design modeled after the one that supports the MiniBooNE target at MI-8. The struts allow alignment without interference with each other and minimal interactions between adjustments. The rod ends and turnbuckles are designed to provide maximum rigidity and easy alignment.

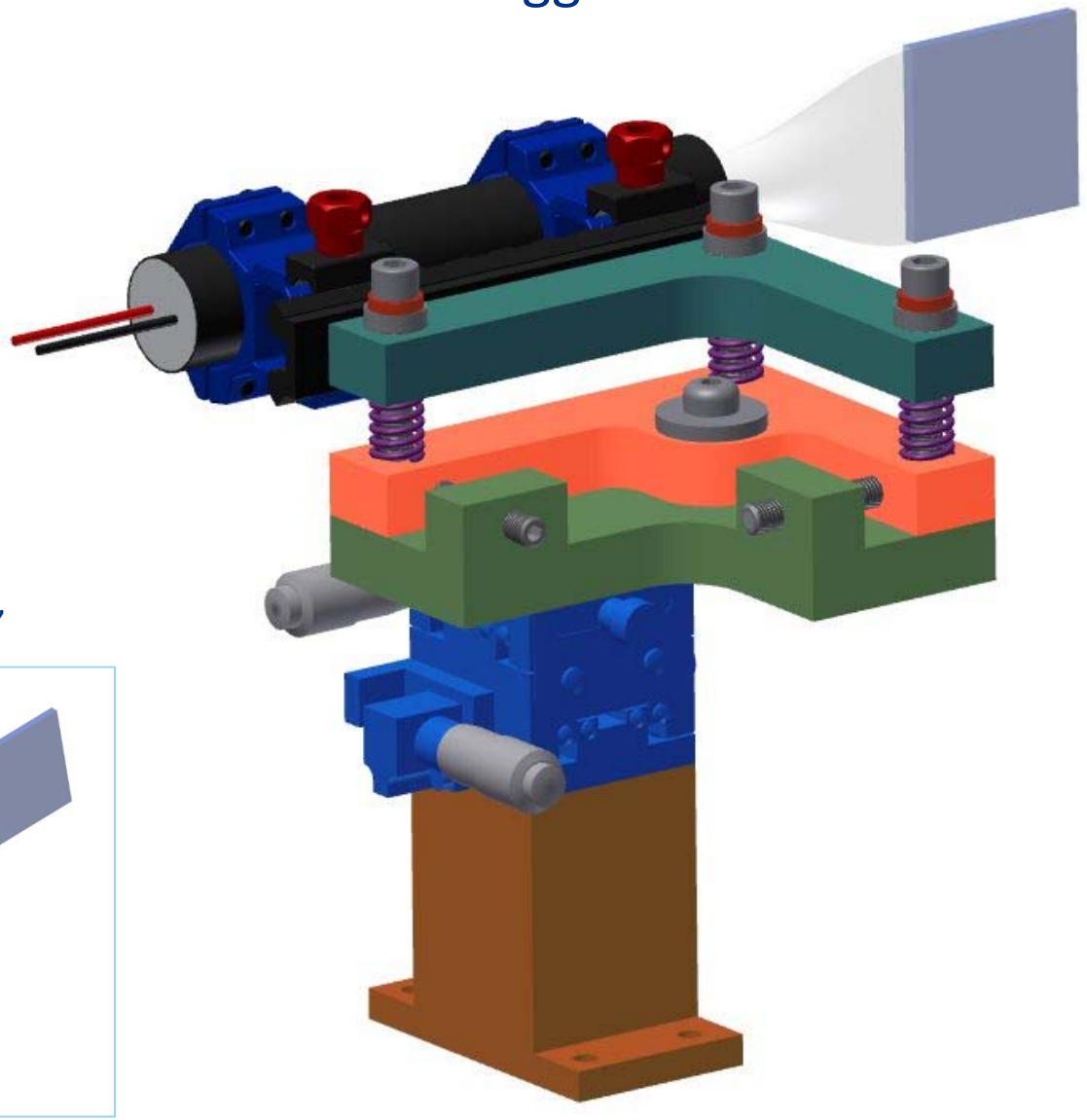
The cover removed from the spectrometer magnet and pixels



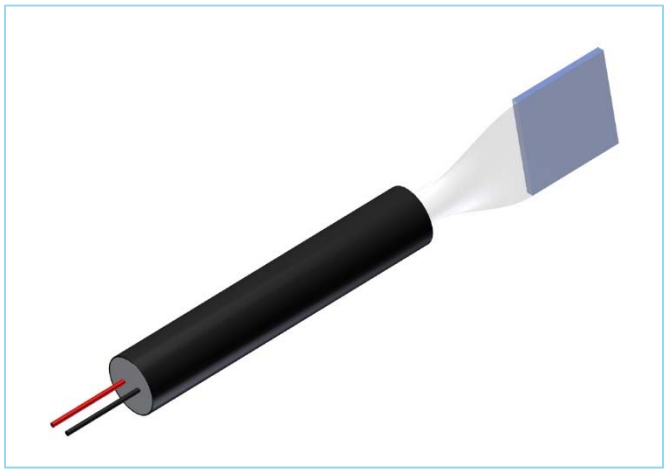
These plates block air from flowing out around the spectrometer. Air will probably be input through the cover above the magnet, but it needs to exit at each end of the channel so that it can flush dry air around the pixels.

Alignment/support structure for the trigger scintillator

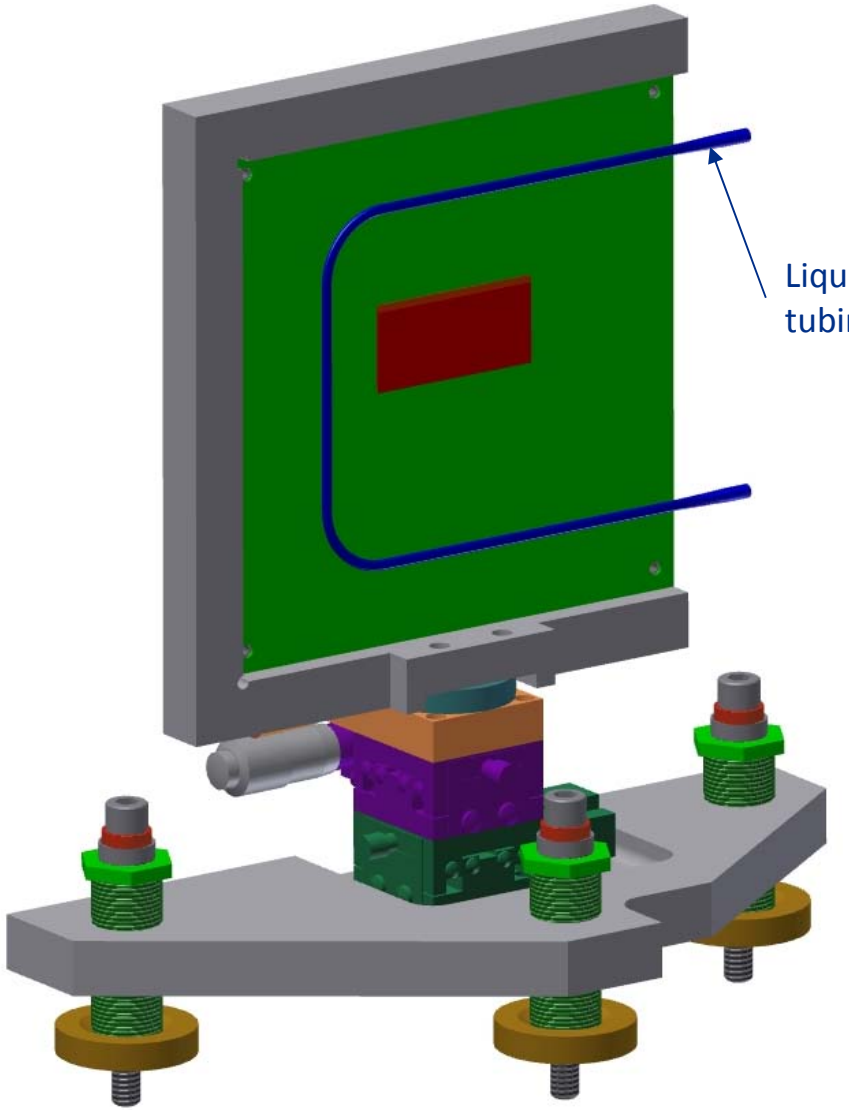
The support offers all six degrees of freedom of alignment of the scintillator paddle.



Trigger scintillator with light guide, PMT and mu metal shield



Pixel plane support/alignment mechanism



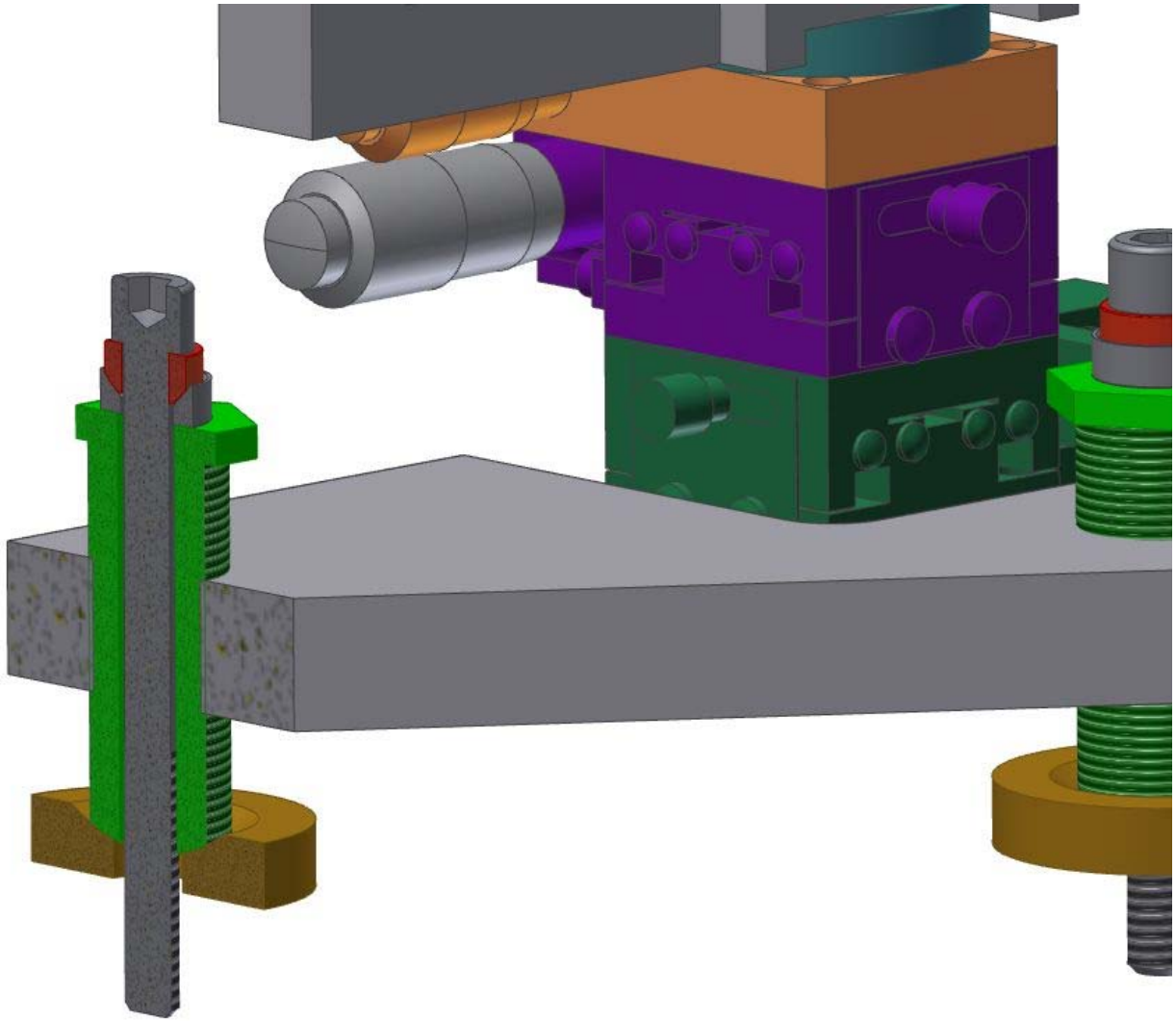
The support offers all six degrees of freedom of alignment of the pixel planes.

Details of connectors and mechanically gripping the circuit board by the support are still being worked out.

An ethylene glycol based coolant will be pumped through the blue tubing and cooled using a recirculating chiller.

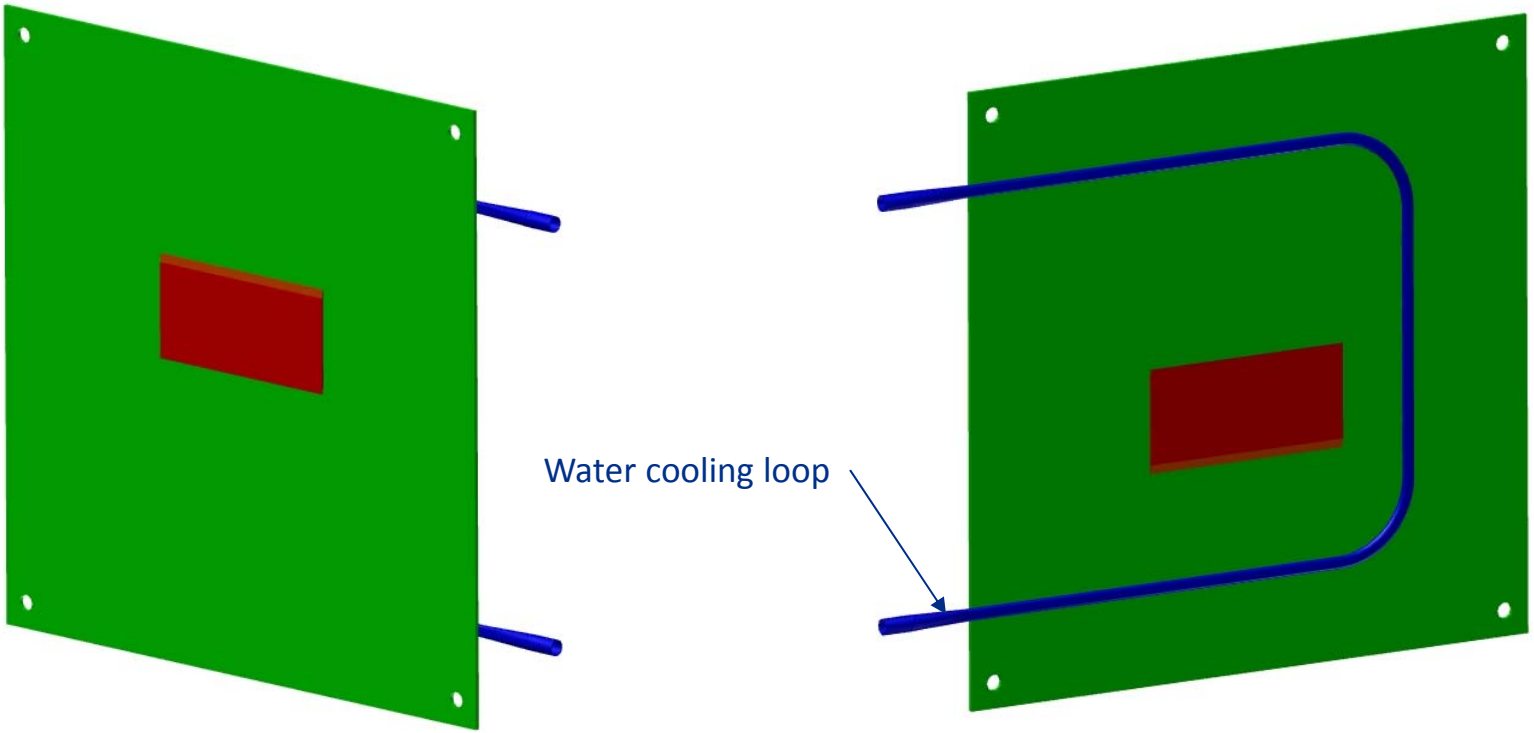
A cooling system is needed to prevent the readout chips from overheating. The leakage current in a silicon sensor drops quickly with temperature, improving the signal to noise ratio. The sensors will be cooled to an operating temperature of a few degrees Centigrade, safely above the dew point of dry air.

Cross-section through the shim bushing in the pixel alignment mechanism

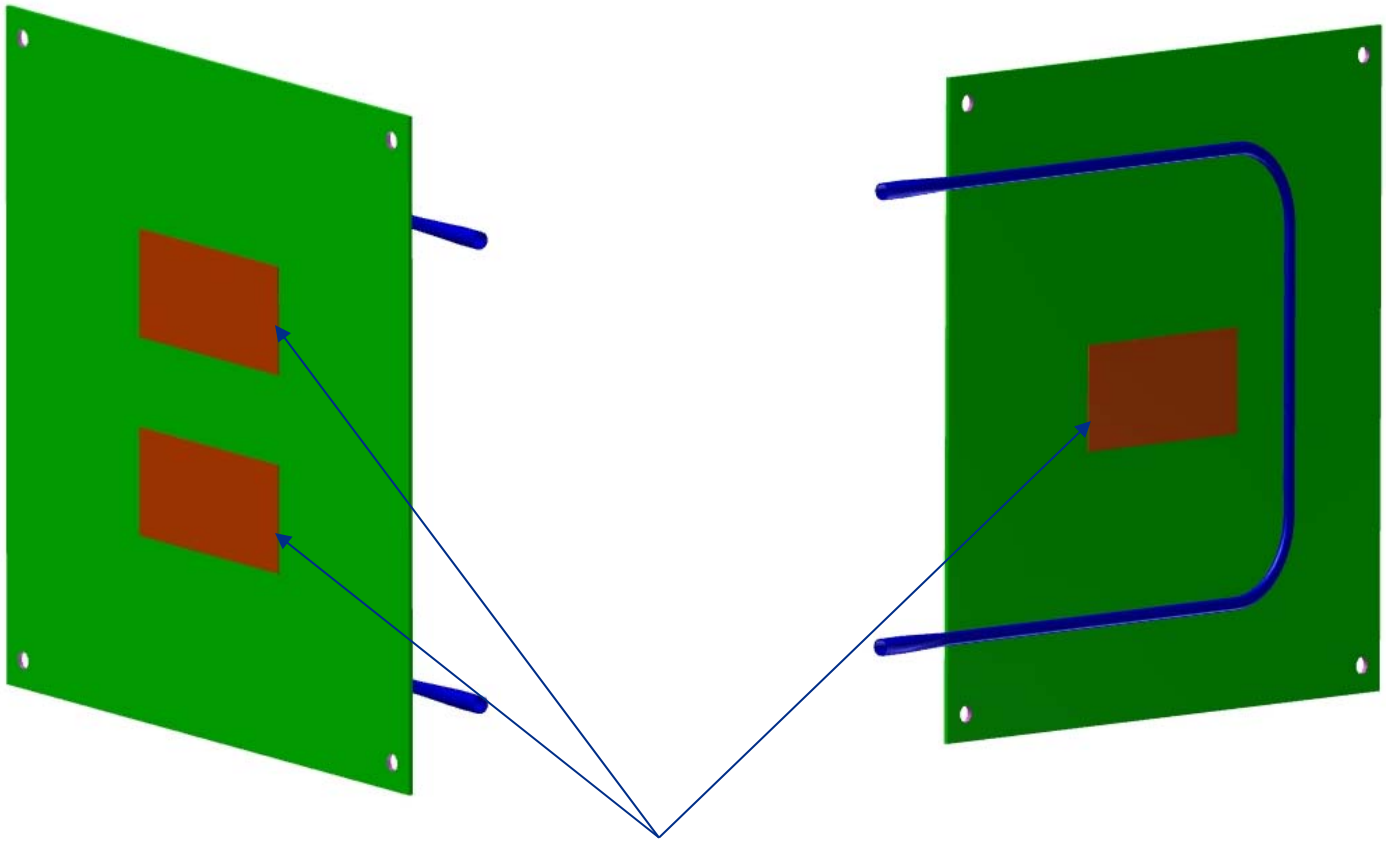


Rotating the green externally threaded bushing adjusts the pitch, height and roll of the pixel planes. The .250-20 socket head bolt locks the mechanism to the bottom beam.

Front and back views of the upstream pixel planes

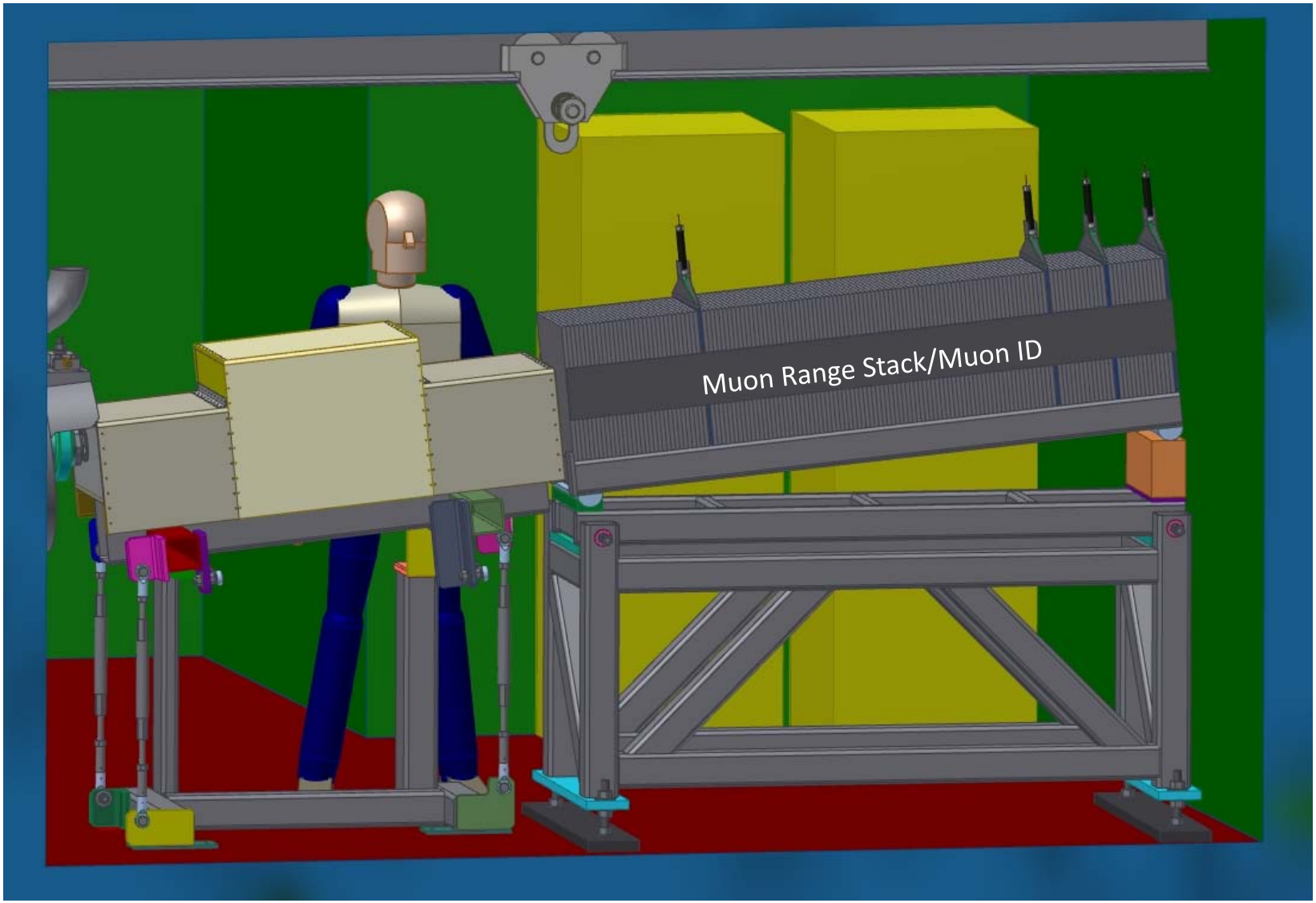


Front and back views of the downstream pixel planes

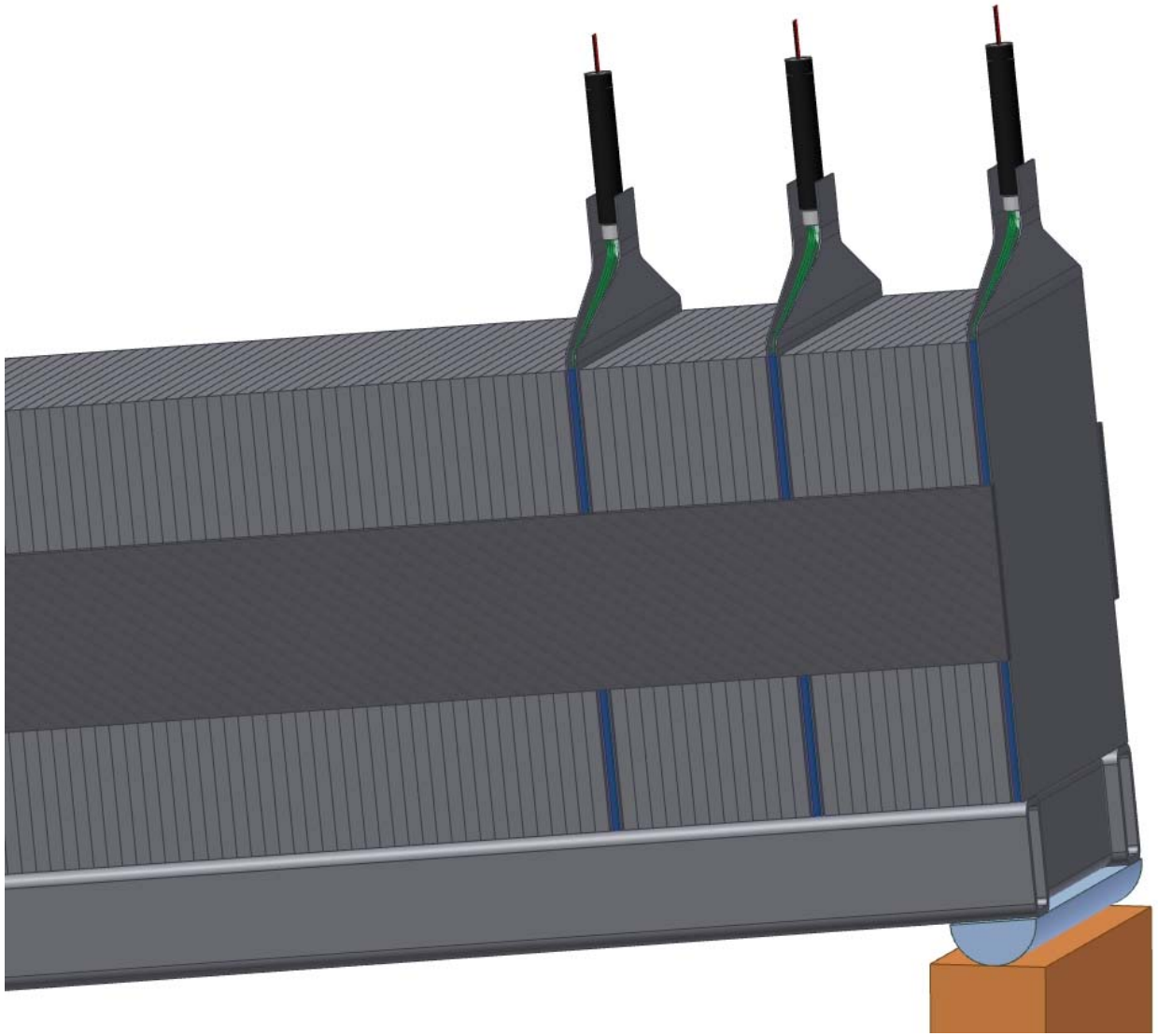


Three chips for larger active area

The Muon Range Stack/Muon ID

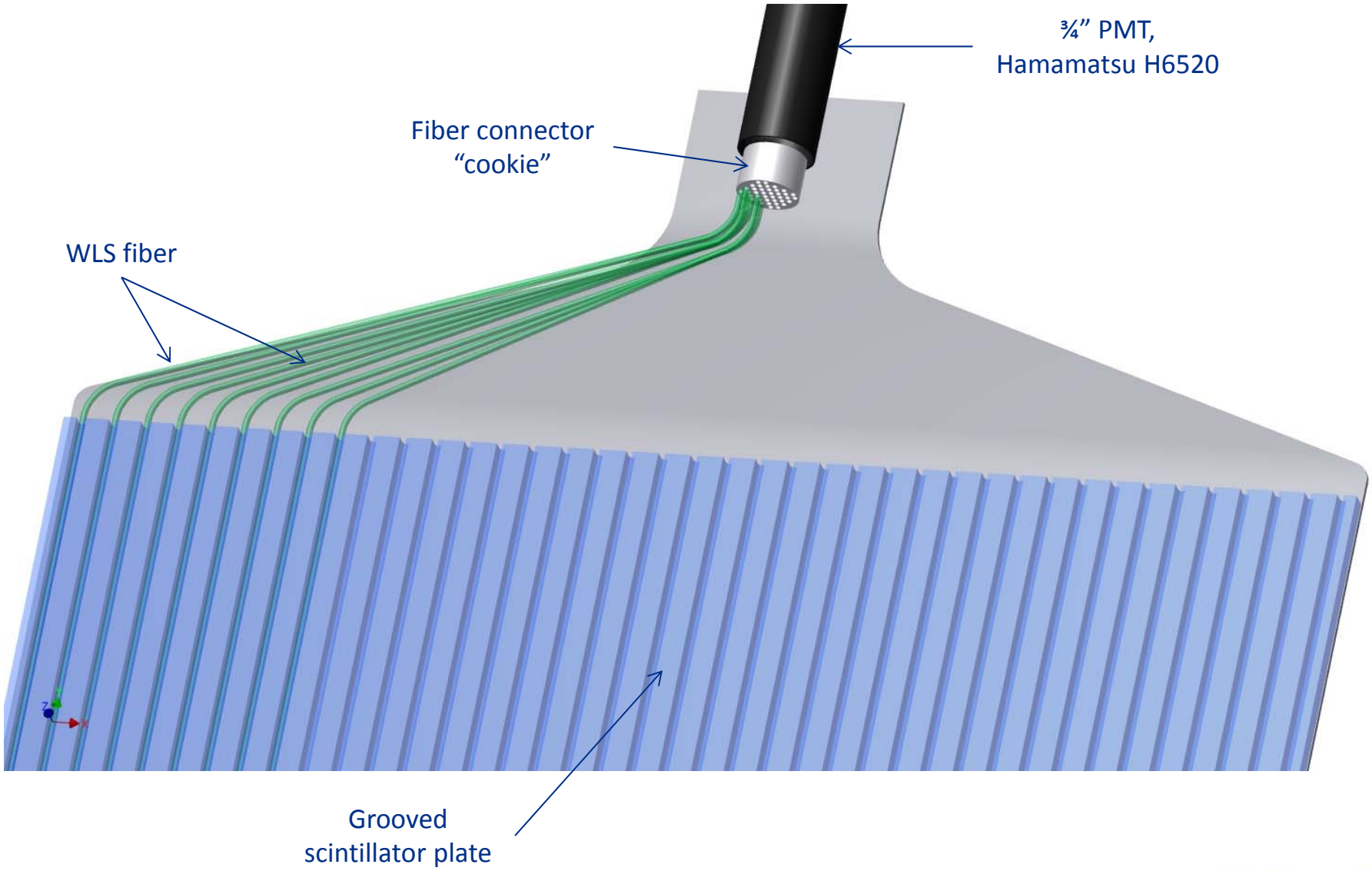


Close-up of the tile-fiber pans of the Muon ID



Half inch steel plates will be hand-stacked in the detector room and welded together to form a 5,000 lb block of steel with spaces to put scintillator tile assemblies.

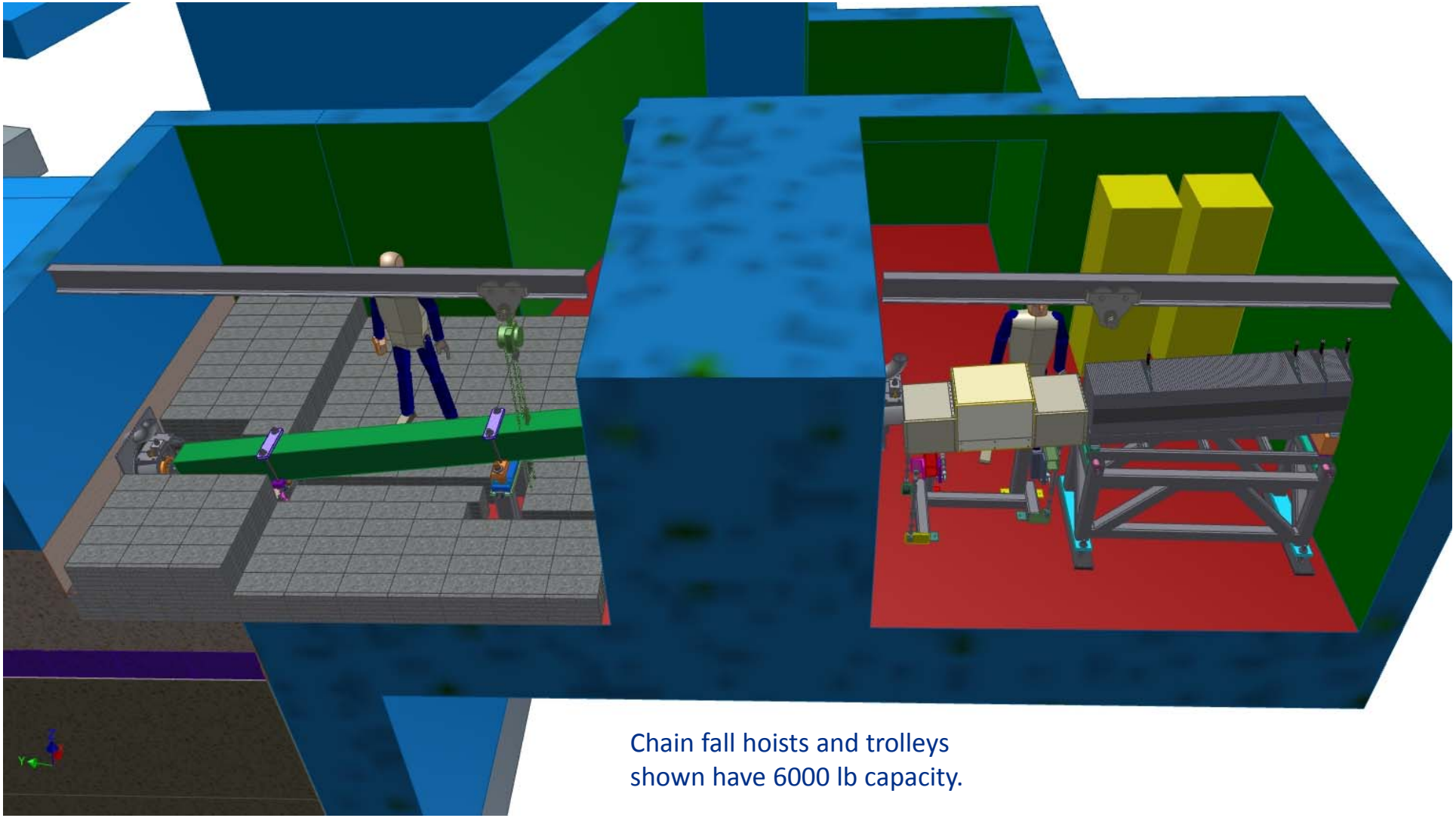
View inside the Muon ID tile-fiber pan



Details of Major Component Installation

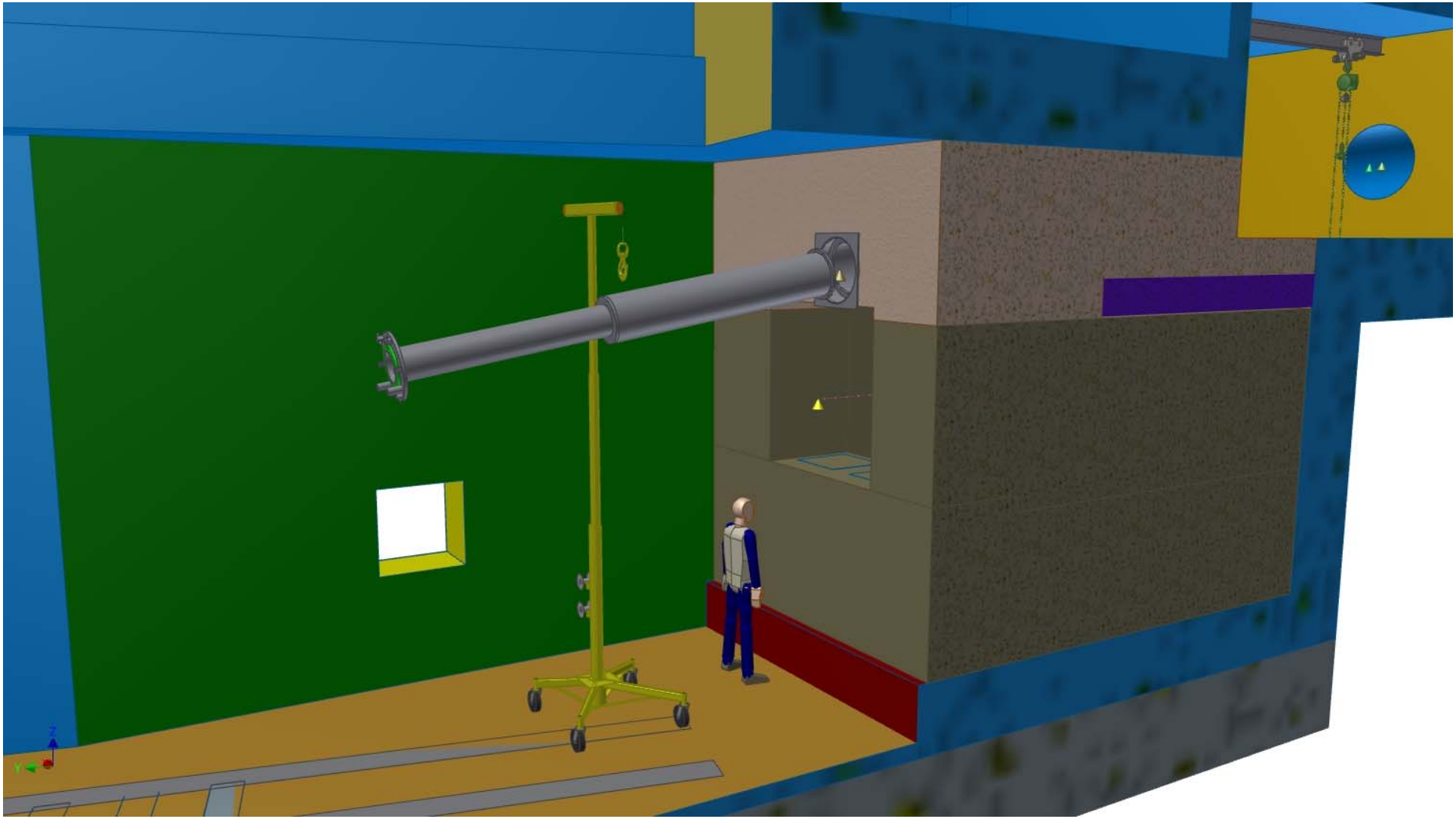
- The following slides focus on the rigging hardware that could be used to install the entrance collimator, the filter magnet and the heavier components in the detector room.
- Final choices will depend on whether FNAL technicians or contract riggers will do the component placement.

Beams and chain fall hoist trolleys on the ceilings in the rooms



Chain fall hoists and trolleys shown have 6000 lb capacity.

Using a Roust-A-Bout to install the US fixed shot liner



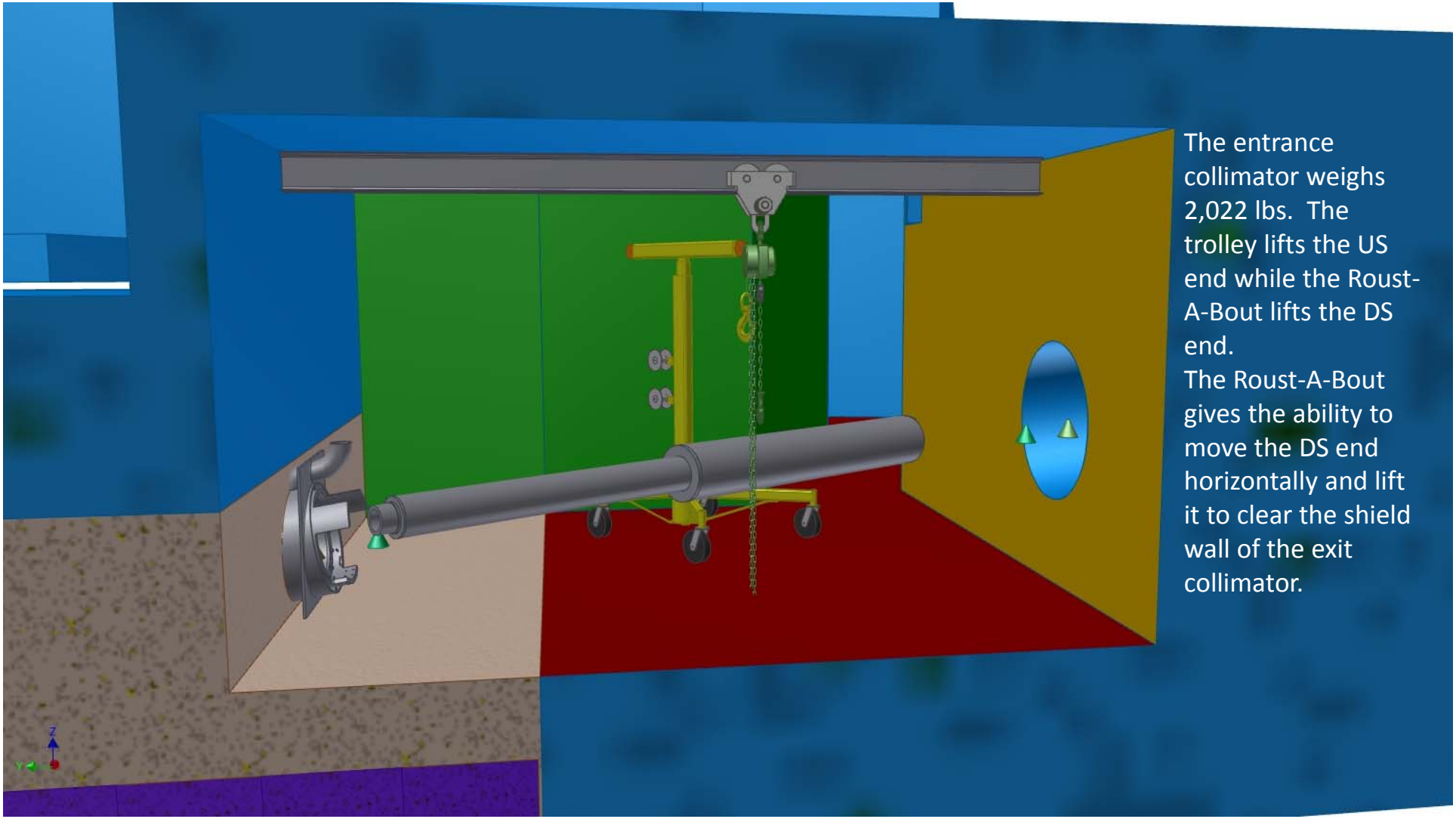
The Roust-A-Bout at Lab F

John Voirin has this useful lifting device at Lab F. It says 1,000 lb capacity on the top bar, but a different top bar that brings it up to 1,500 lbs can be purchased from Sumner. John does not have that piece.

It can also be disassembled and brought into the magnet room should that prove useful.

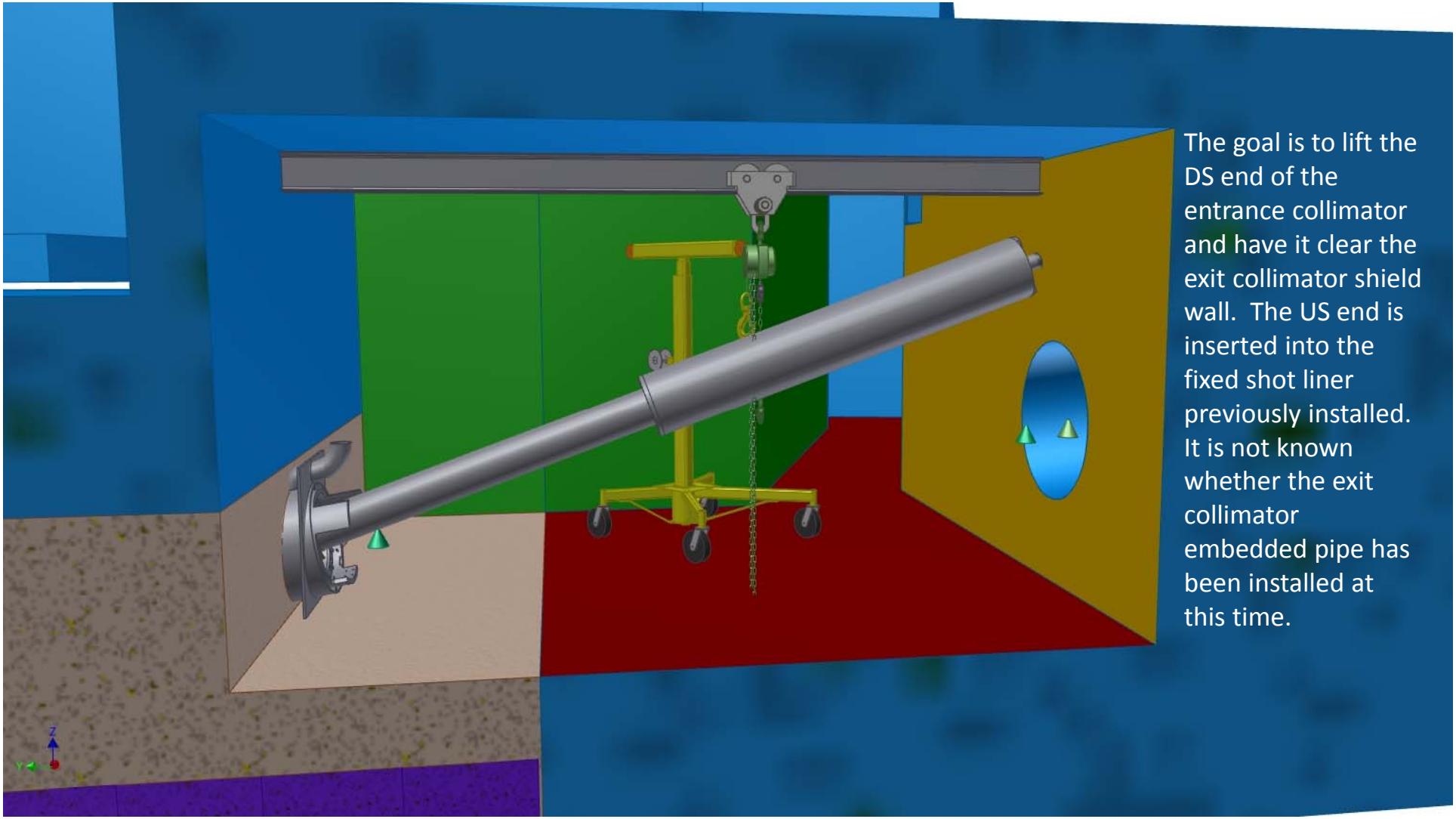
The shot liner weighs <1,100 lbs

The entrance collimator installed from the magnet room



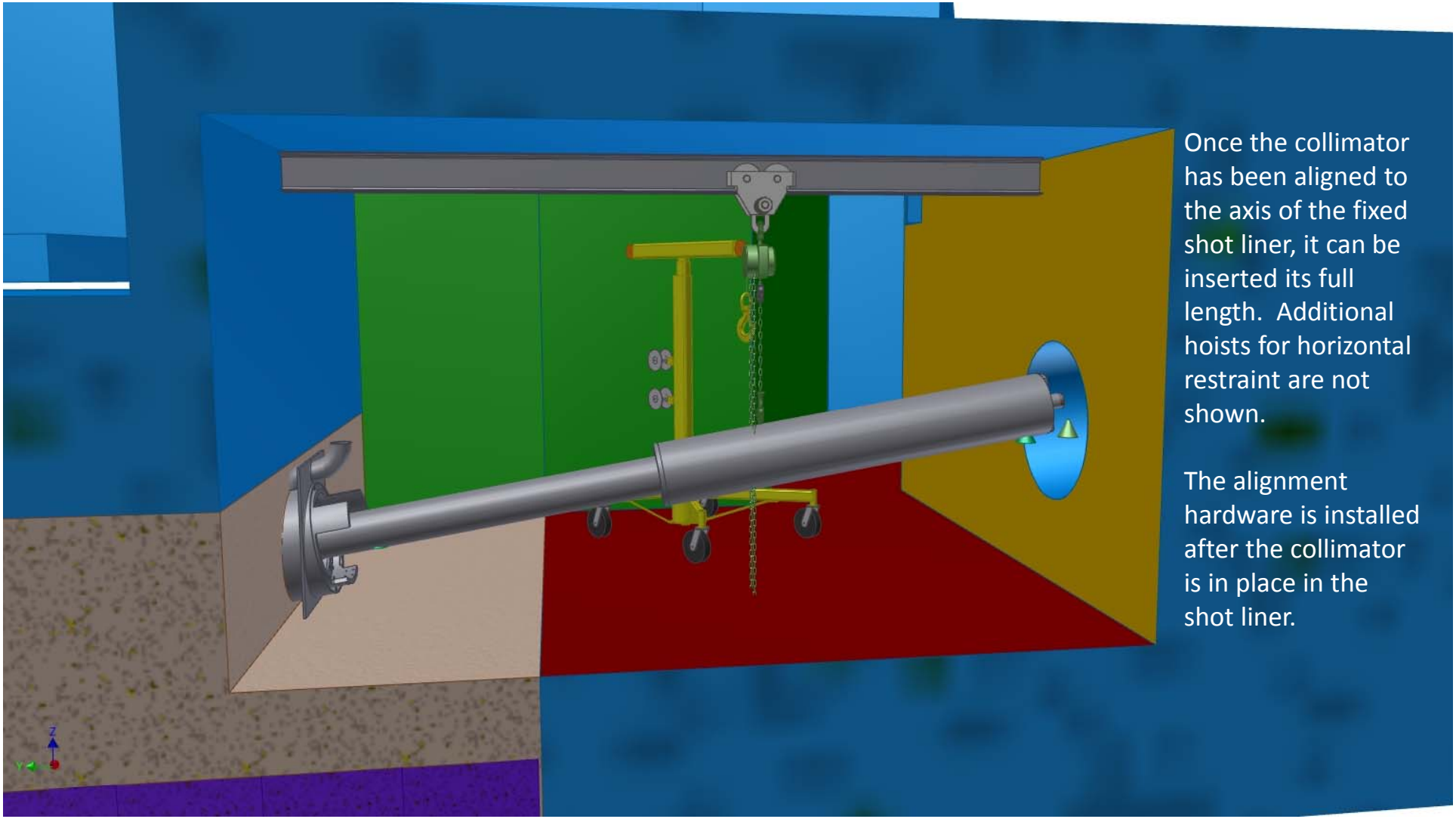
The entrance collimator weighs 2,022 lbs. The trolley lifts the US end while the Roust-A-Bout lifts the DS end.
The Roust-A-Bout gives the ability to move the DS end horizontally and lift it to clear the shield wall of the exit collimator.

Another step in Entrance collimator insertion



The goal is to lift the DS end of the entrance collimator and have it clear the exit collimator shield wall. The US end is inserted into the fixed shot liner previously installed. It is not known whether the exit collimator embedded pipe has been installed at this time.

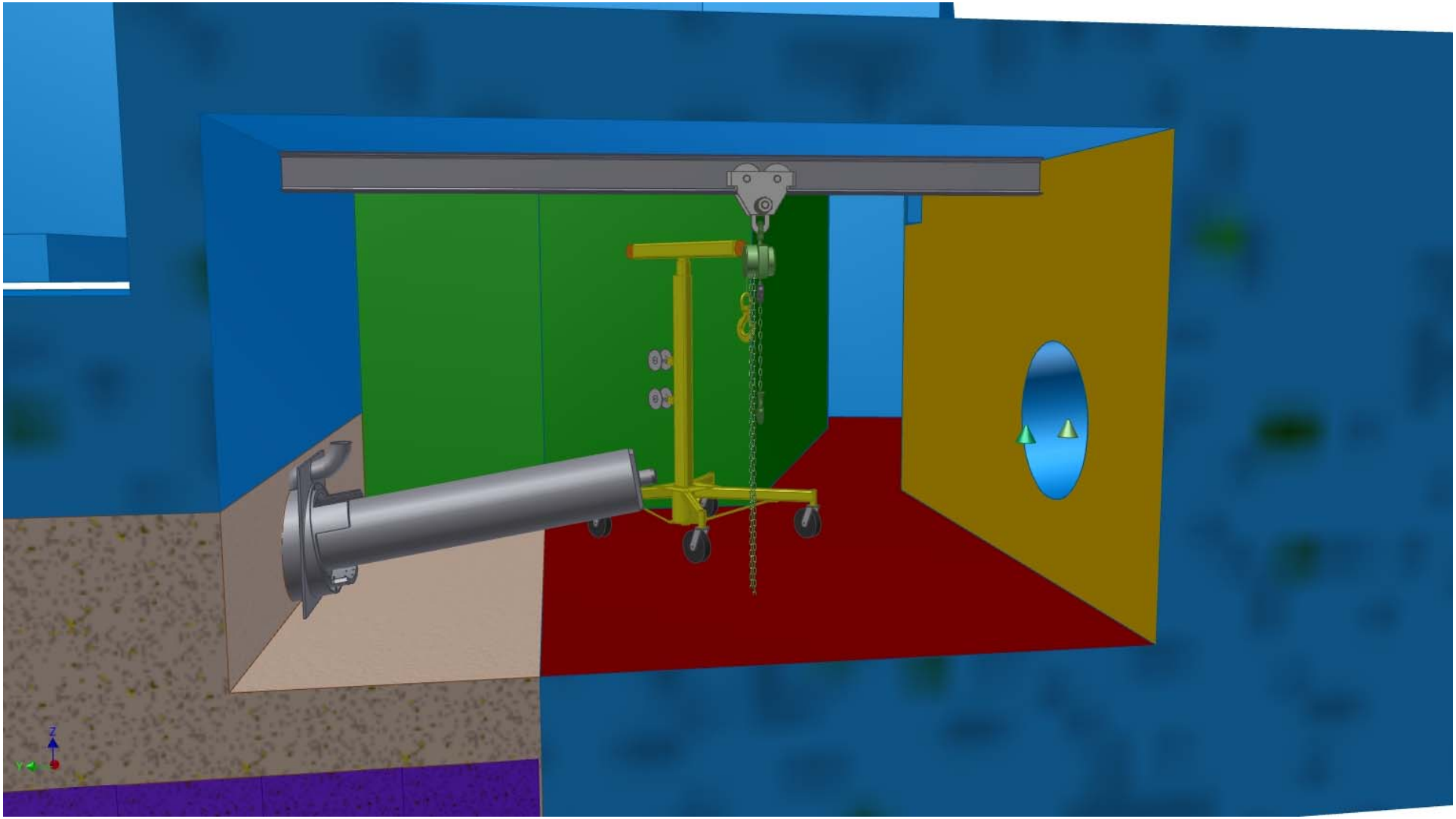
Entrance collimator insertion continued



Once the collimator has been aligned to the axis of the fixed shot liner, it can be inserted its full length. Additional hoists for horizontal restraint are not shown.

The alignment hardware is installed after the collimator is in place in the shot liner.

Entrance collimator about half way installed



Summary

- The mechanisms used to support and align the components of the extinction monitor will satisfy the positioning requirements
- The majority of the design work on these components is finished.
- ~5% design work is needed to:
  - finish the thrust collars that keep the entrance collimator from sliding down the fixed shot liner
  - Some redesign to adapt the collimators to the actual concrete walls of the enclosure
  - Design the alignment devices that mate to the concrete forms for the embedded pipes
  - Miscellaneous plumbing and electrical connections in the detector room
  - Additional tapped holes for rigging fixtures