Installing the FLArE cryostat and TPCs in the FPF tunnel

L. Bartoszek[1] and C. Daurer[2]

1. BARTOSZEK ENGINEERING
2. Hardline Ingenuity

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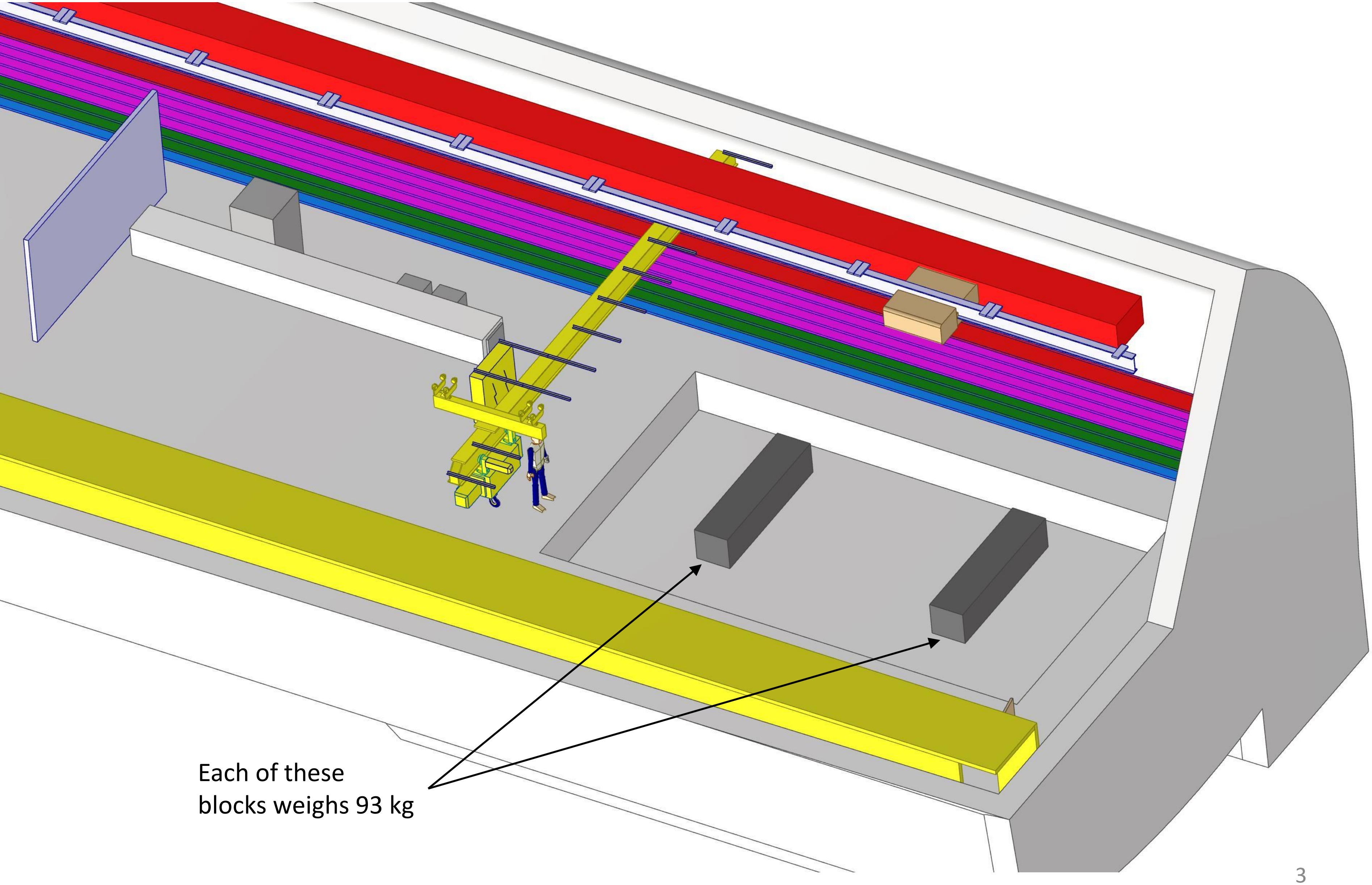
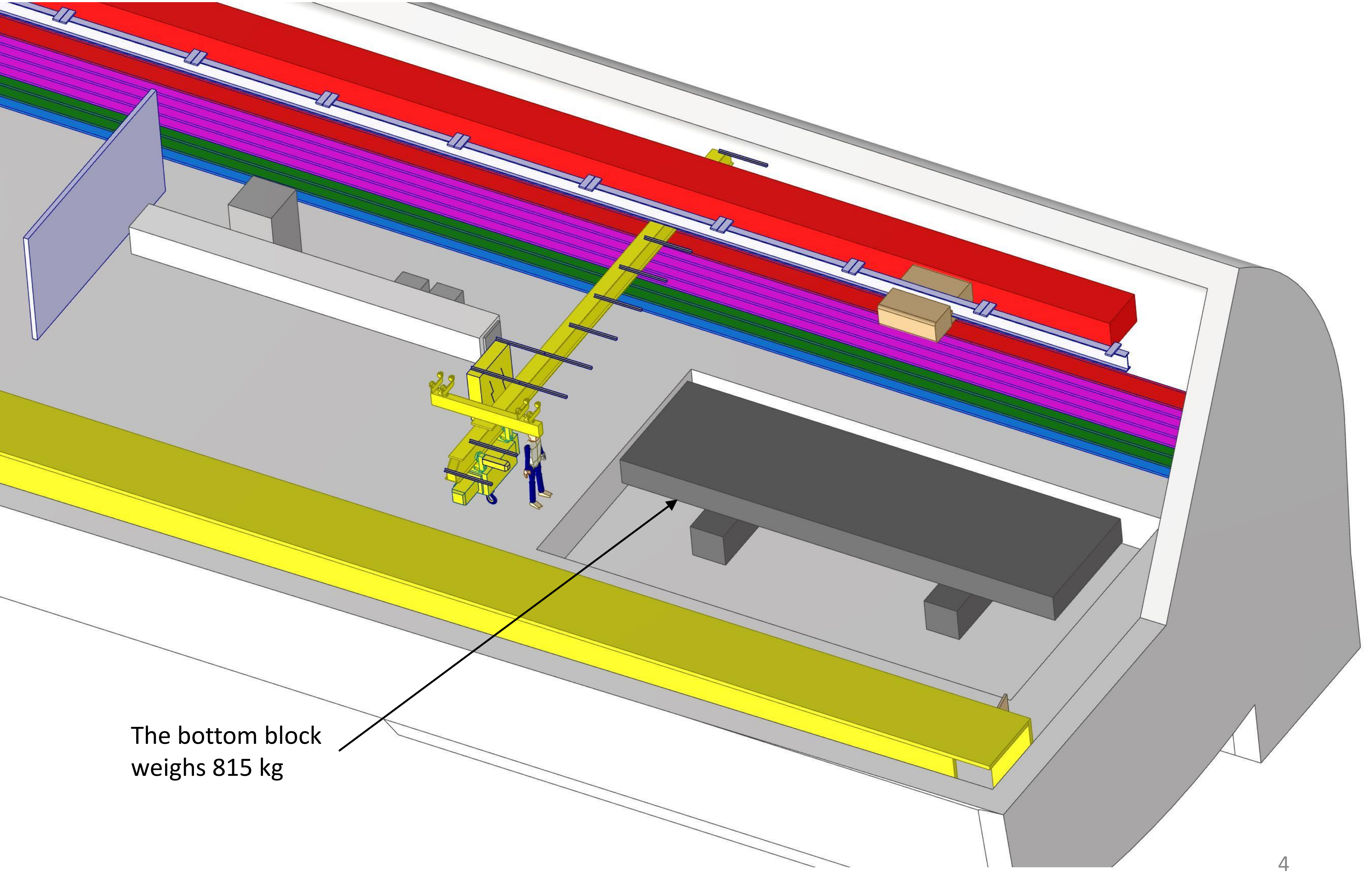
Summary

- This document summarizes the process of installing the major parts of the FLArE cryostat piece by piece, giving the weights of components to move
- It also shows a conceptual design for a machine to install or remove the FLArE cryostat TPC modules
- The steps indicate which processes need development to determine tooling needed for the rigging of components

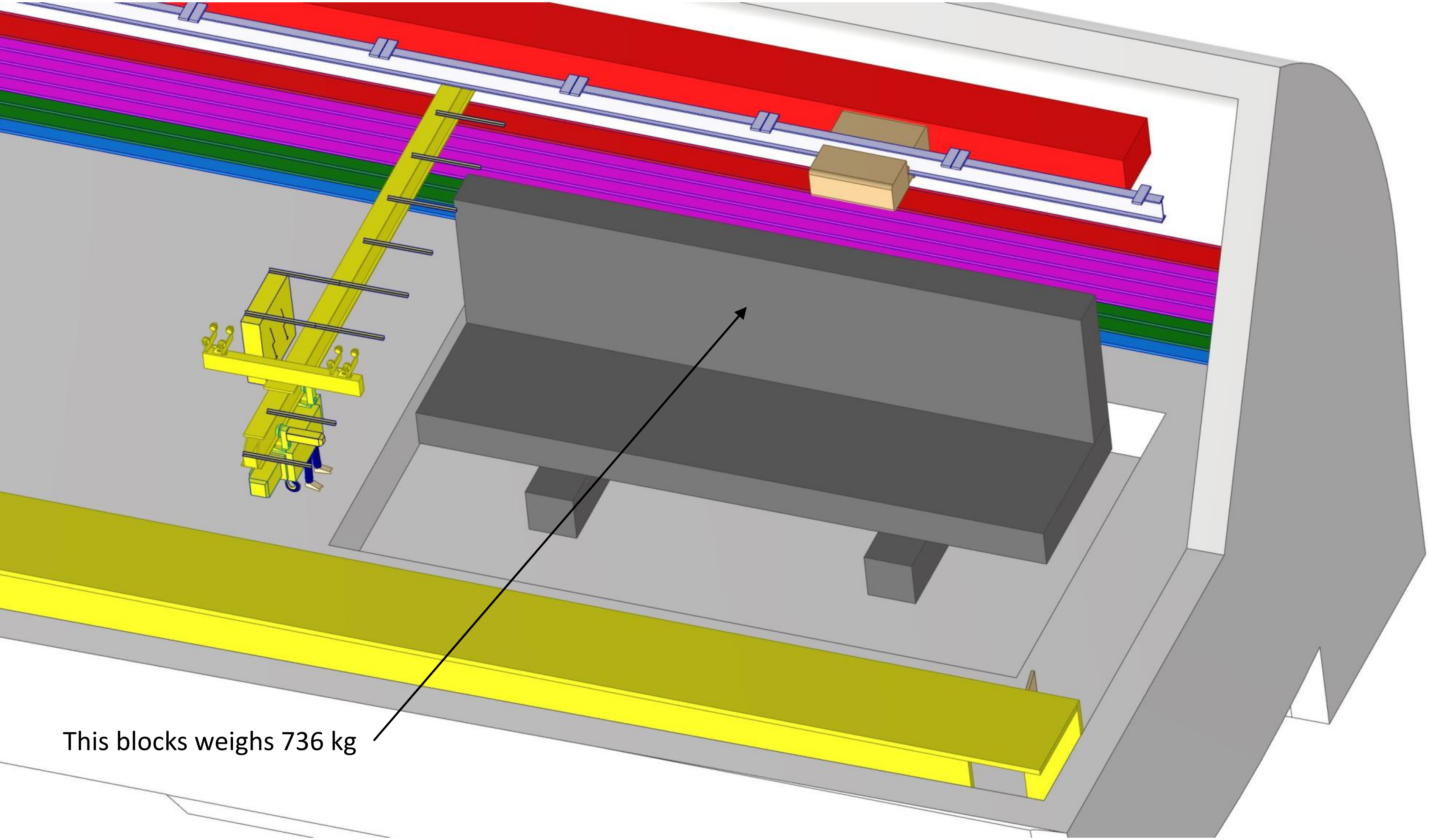
Step 1: Placing rigid foam blocks in the LAr containment pit to support the cryostat



Step 2: placing the bottom block of foam on the support blocks

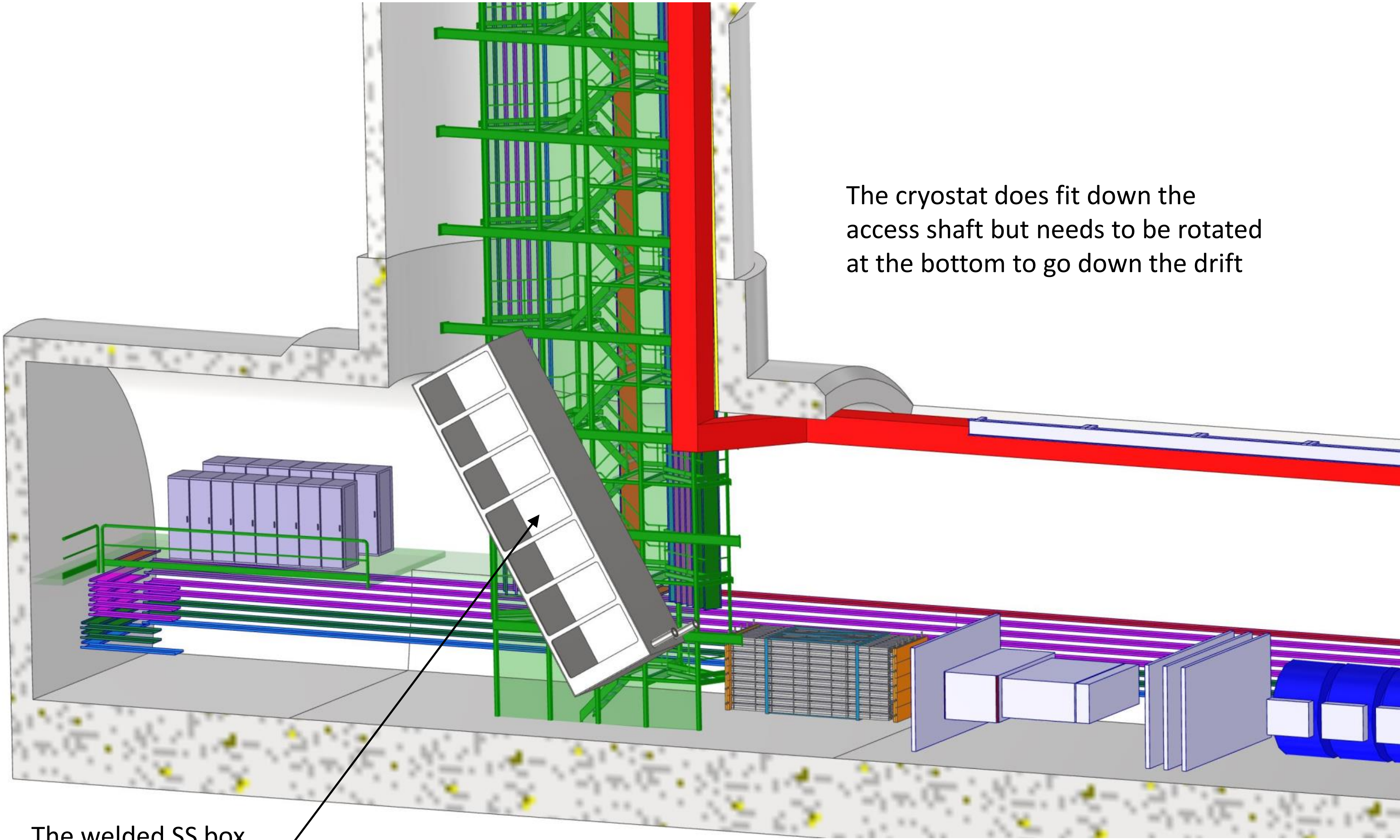


Step 3: Placing the back foam block on



This blocks weighs 736 kg

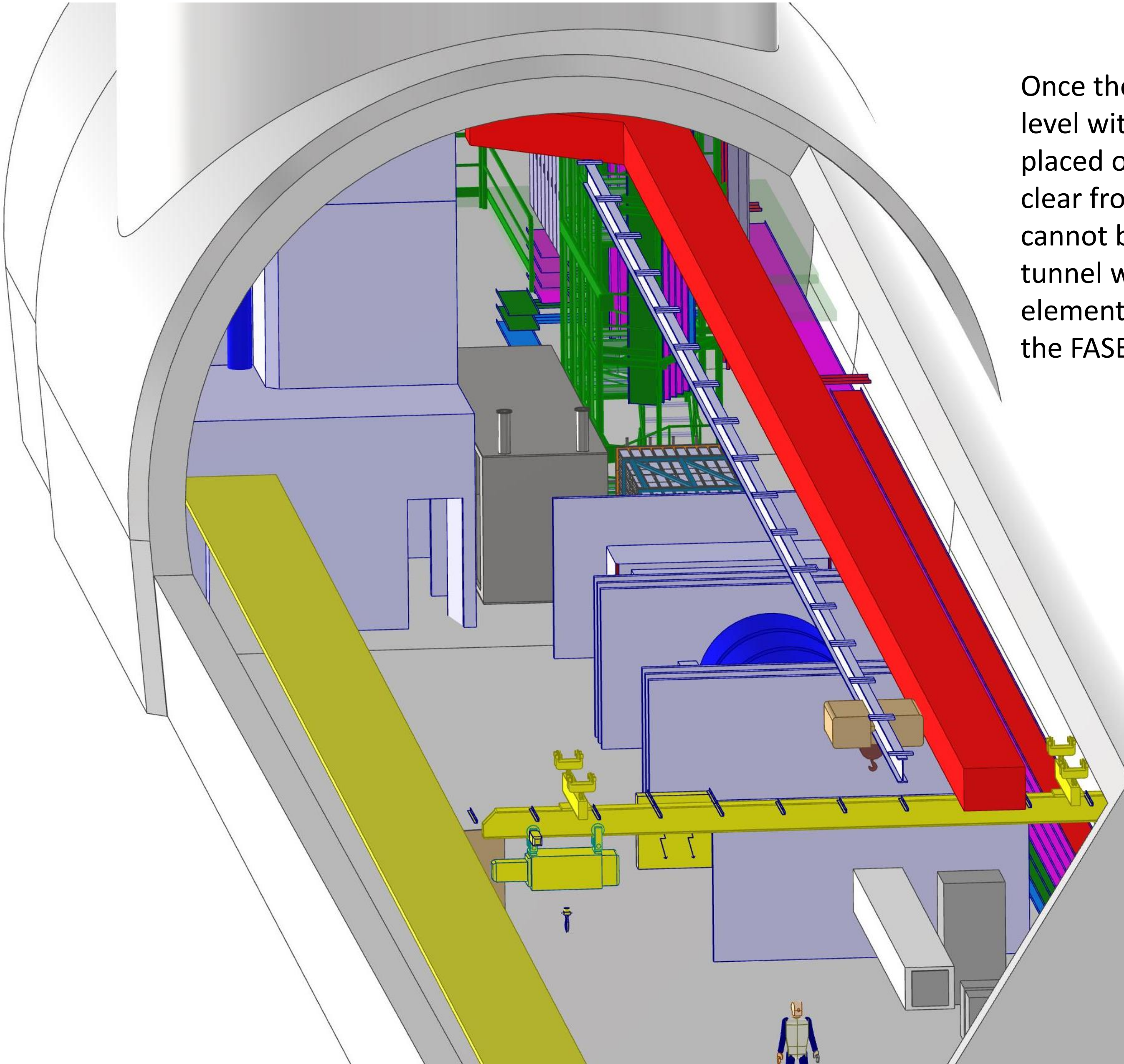
Step 4: Lowering the cryostat box down the access shaft



The cryostat does fit down the access shaft but needs to be rotated at the bottom to go down the drift

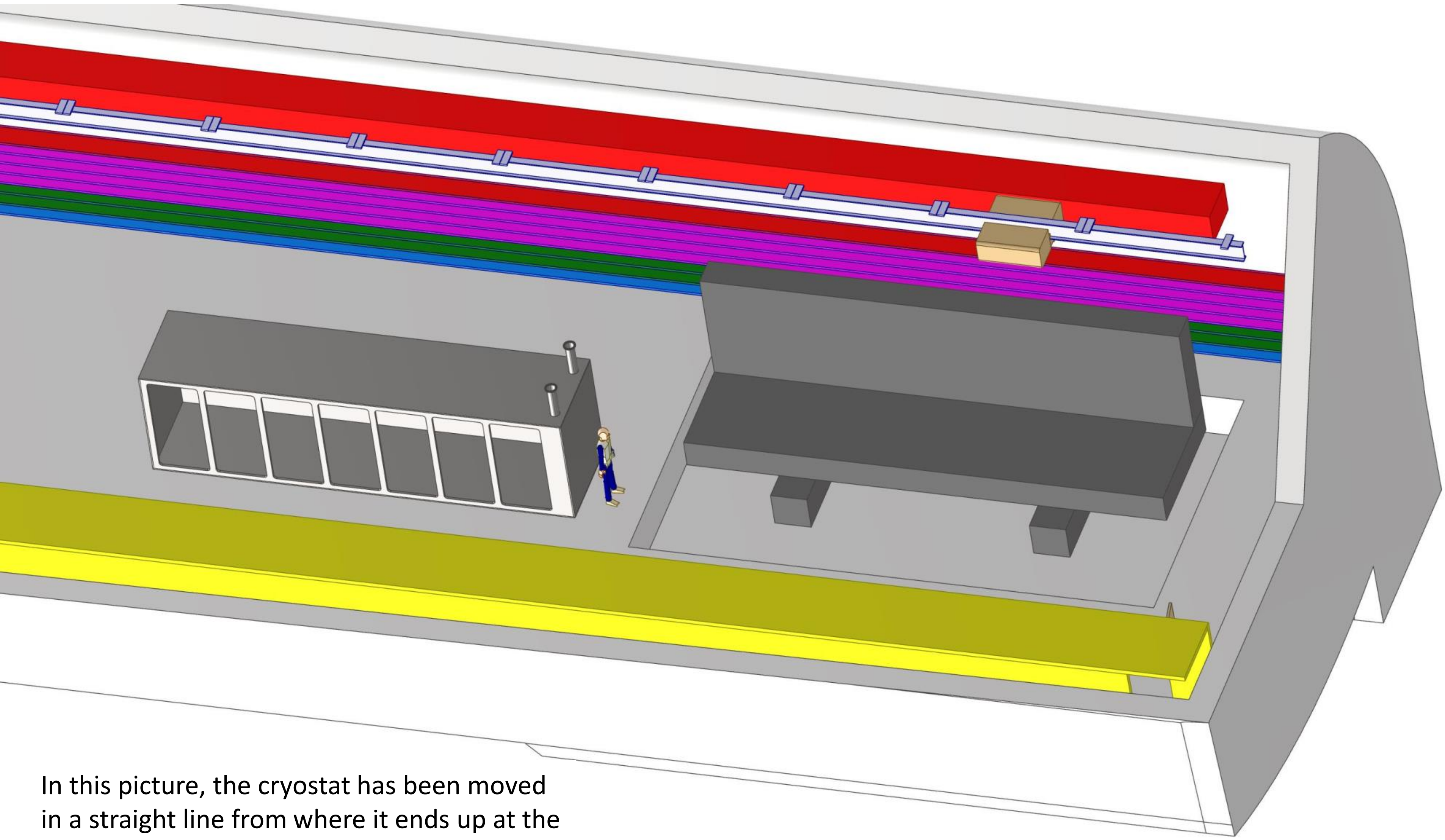
The welded SS box weighs 19.78 tonnes

View showing that the cryostat must be the first item in the beam line



Once the cryostat is rotated level with the floor and placed on a rolling dolly, it is clear from this picture that it cannot be rolled down the tunnel with the other beam elements in place, especially the FASER 2 tracker planes.

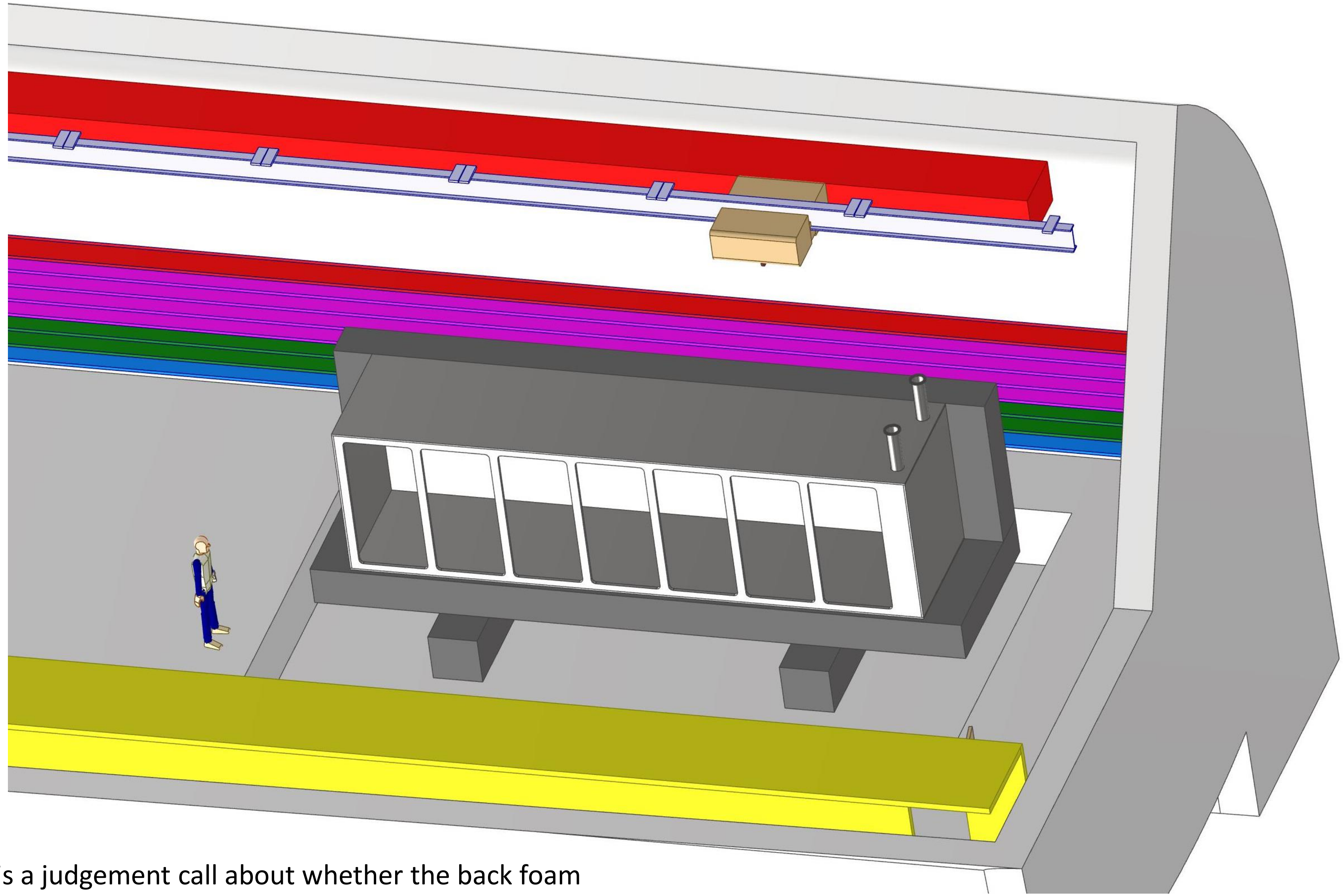
Step 5: Cryostat moved down the tunnel near the LAr pit



In this picture, the cryostat has been moved in a straight line from where it ends up at the bottom of the access shaft to this location. It is not clear that the crane in the top middle of the tunnel can move this mass.

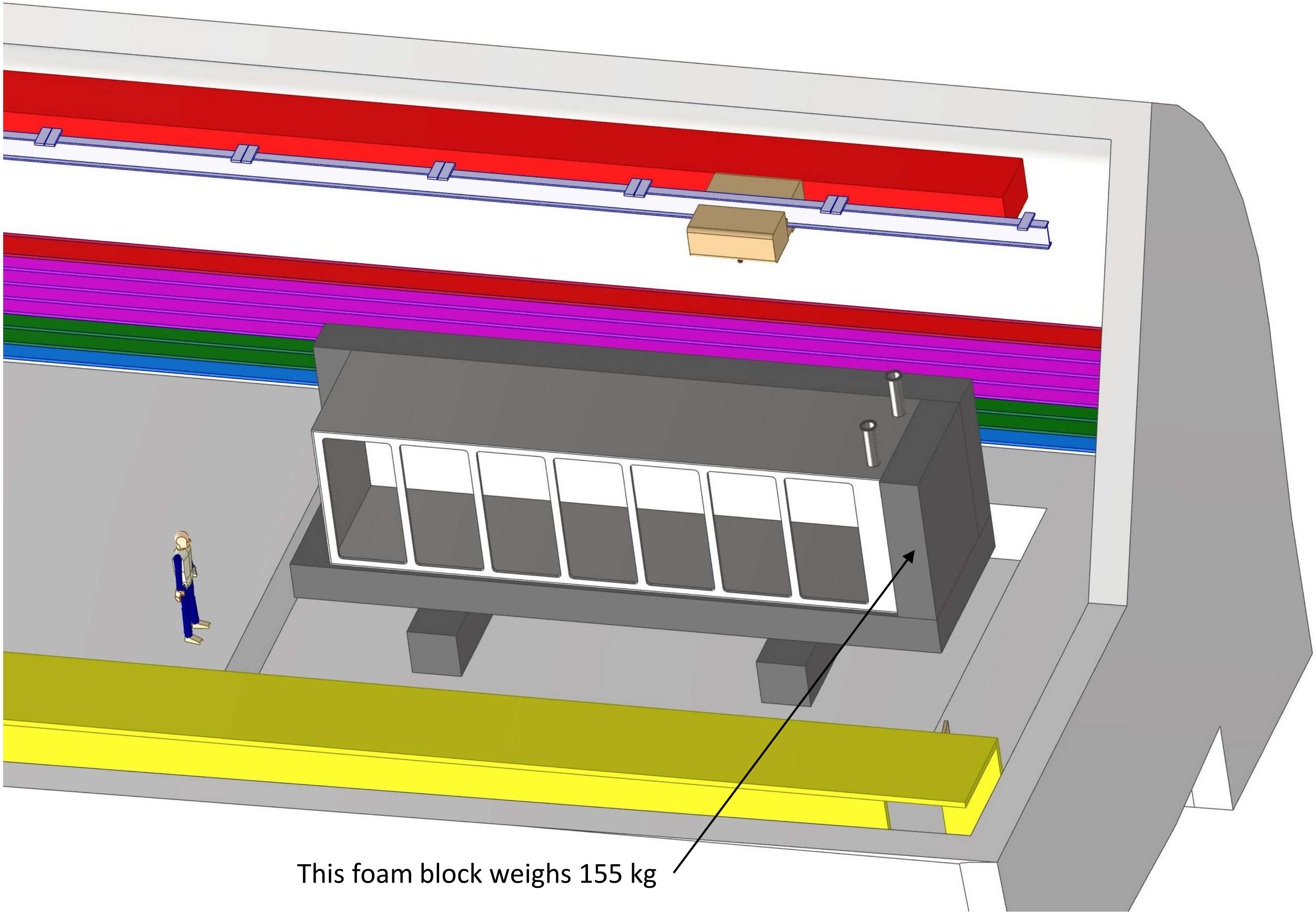
We have to figure out how to place the cryostat on the bottom foam.

Step 6: placing the cryostat on the bottom foam

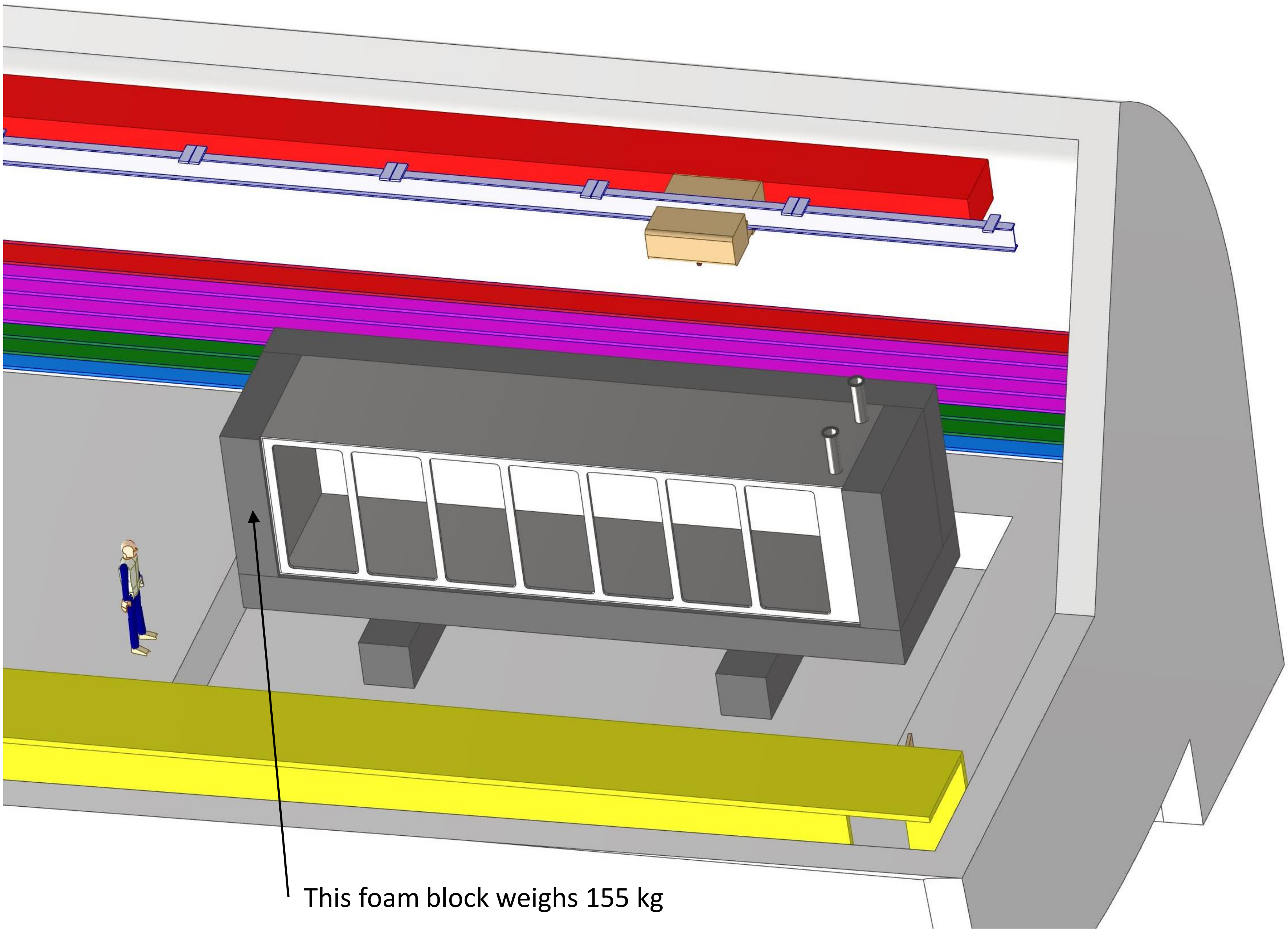


It is a judgement call about whether the back foam or the cryostat gets placed on the bottom foam first. It depends on the fixturing required to do the moves.

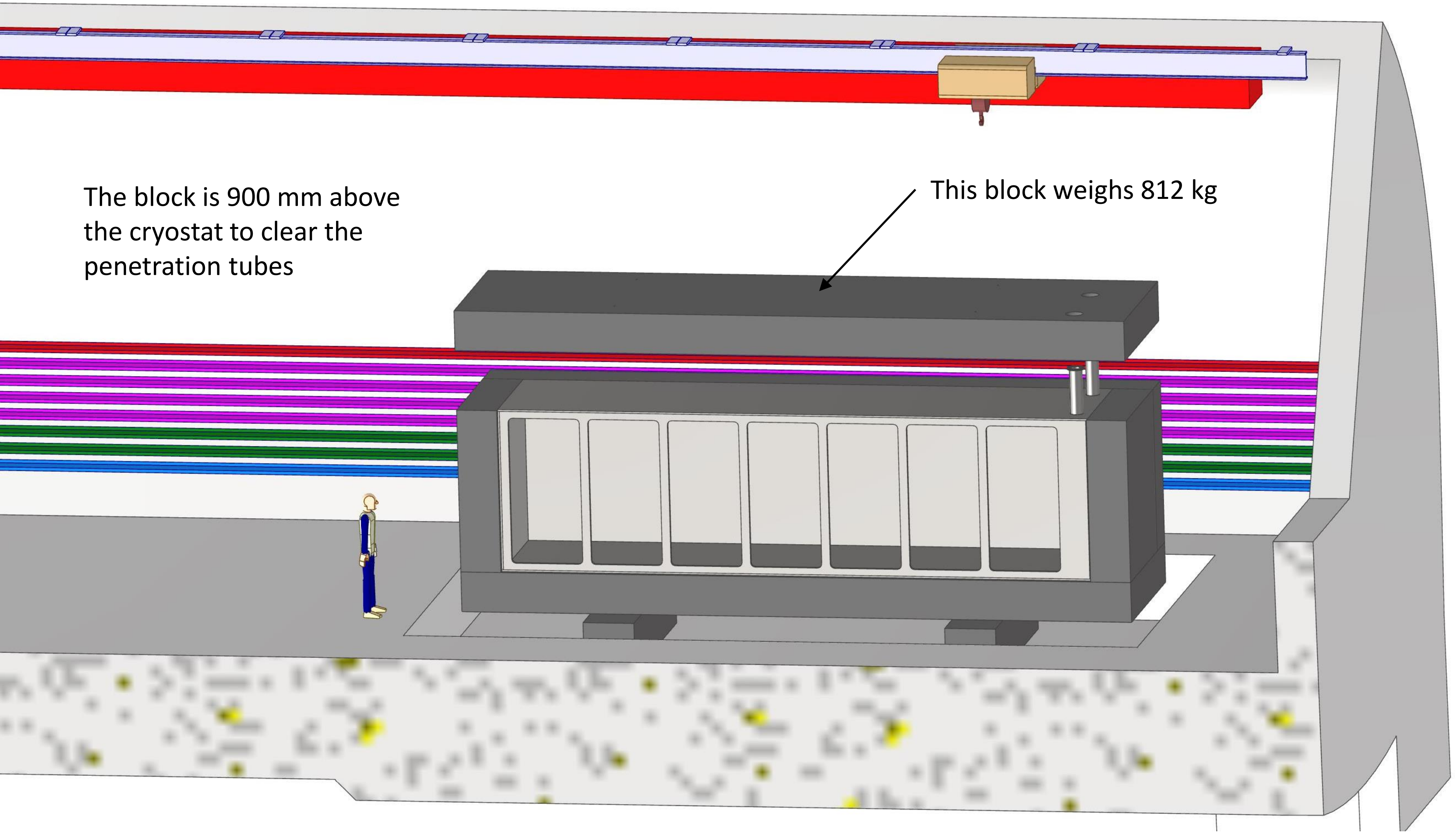
Step 7: Placing the US end block of foam



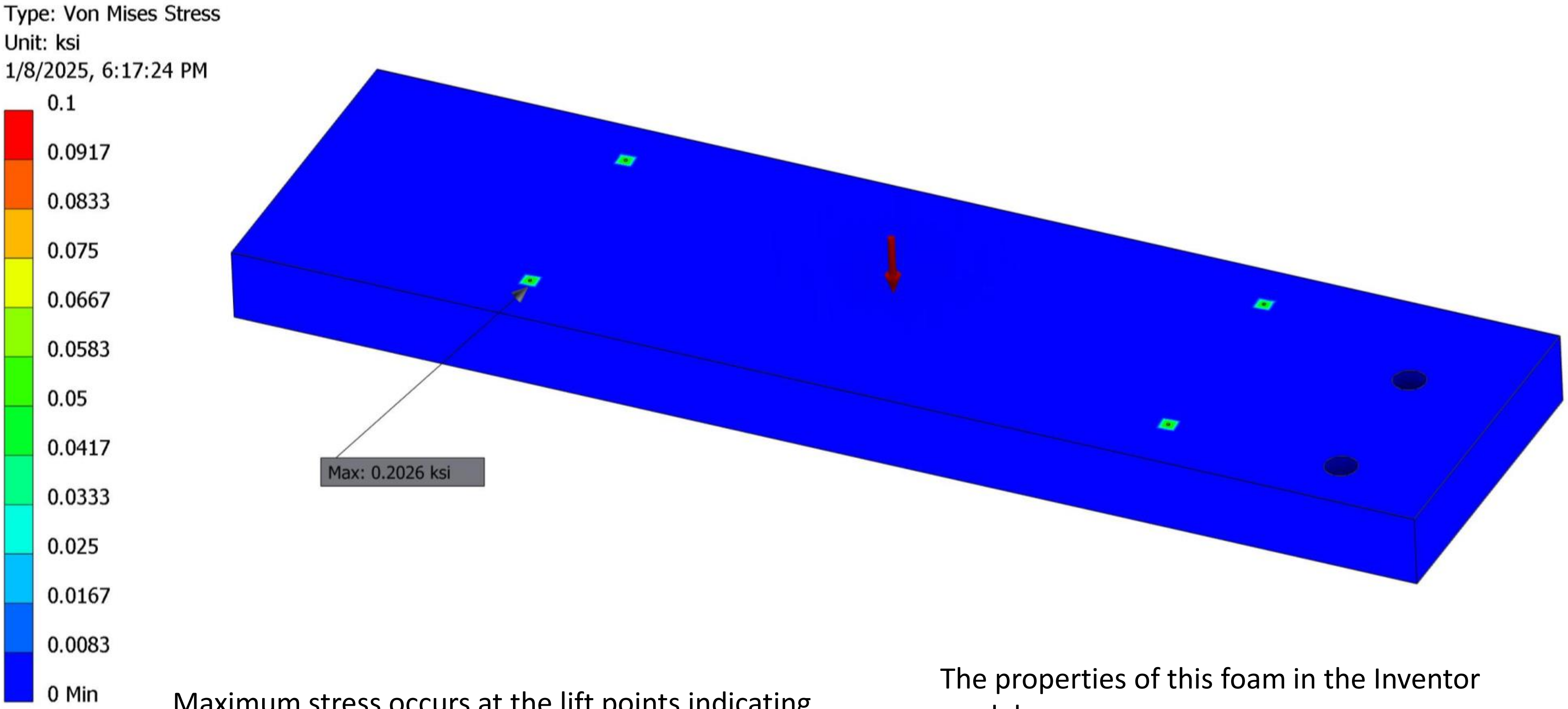
Step 8: Placing the DS foam block



Step 9: Placing the top block of foam above the cryostat



Check of bending stress in the top block when rigged from four points

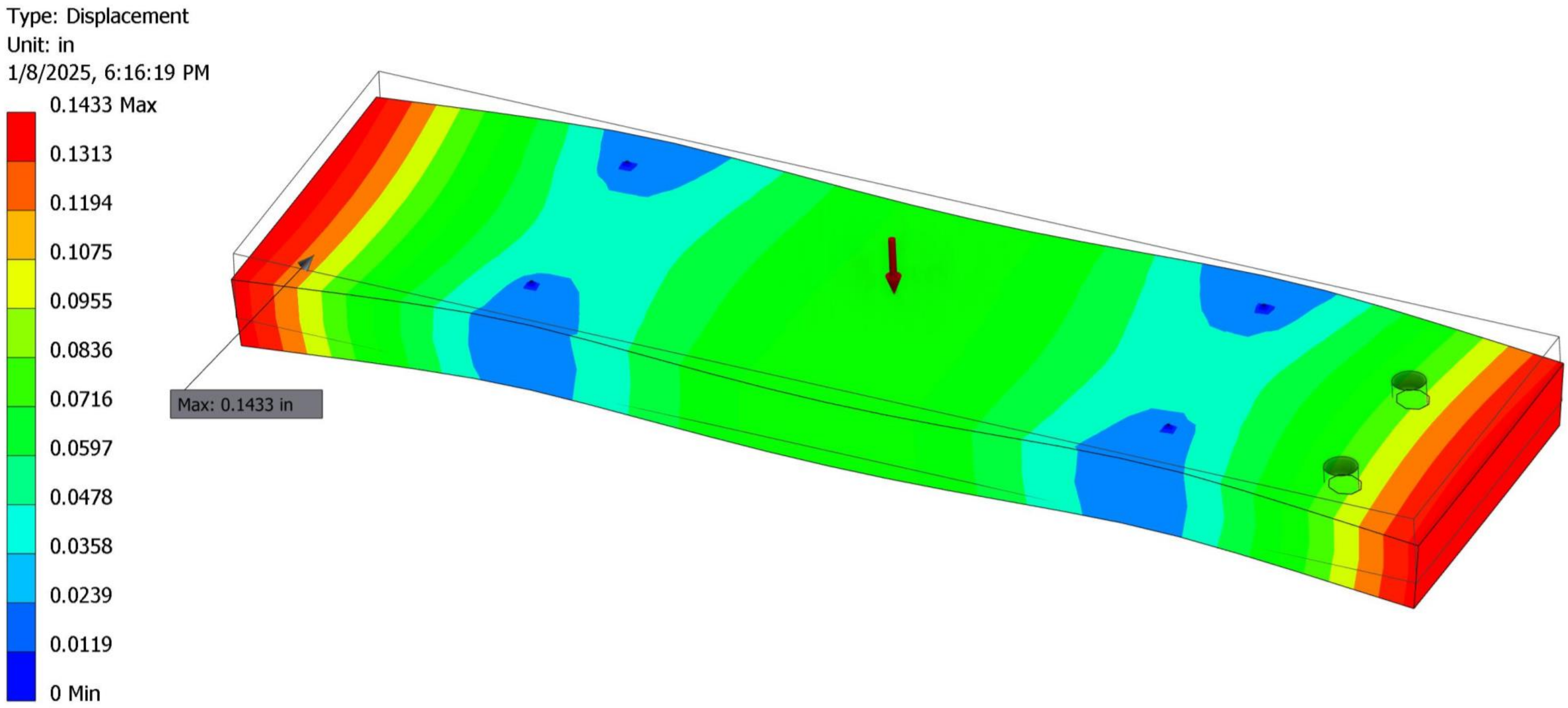


Maximum stress occurs at the lift points indicating that they have to be engineered to spread the load to avoid exceeding the pull-out stress of the foam. These points were simple 1 inch diameter holes 2 inches deep that the boundary conditions were applied at.

The properties of this foam in the Inventor model:
Density = .002 lb/in3
Yield strength = 130.5 psi
UTS = 159.5 psi

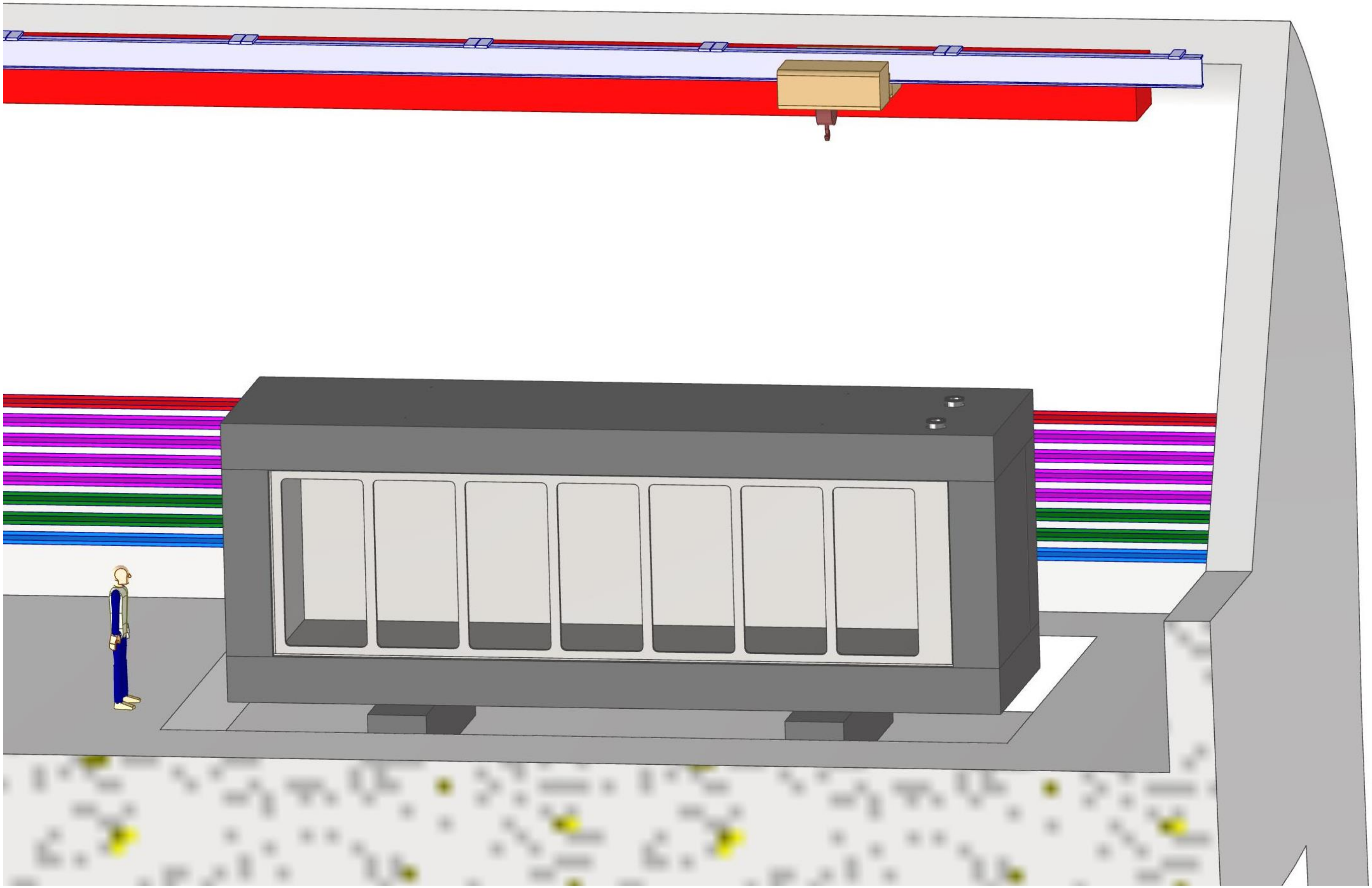
This is in the middle of the range of real foam values.

Check of deflection in top rigid foam block (exaggerated deflection plot)

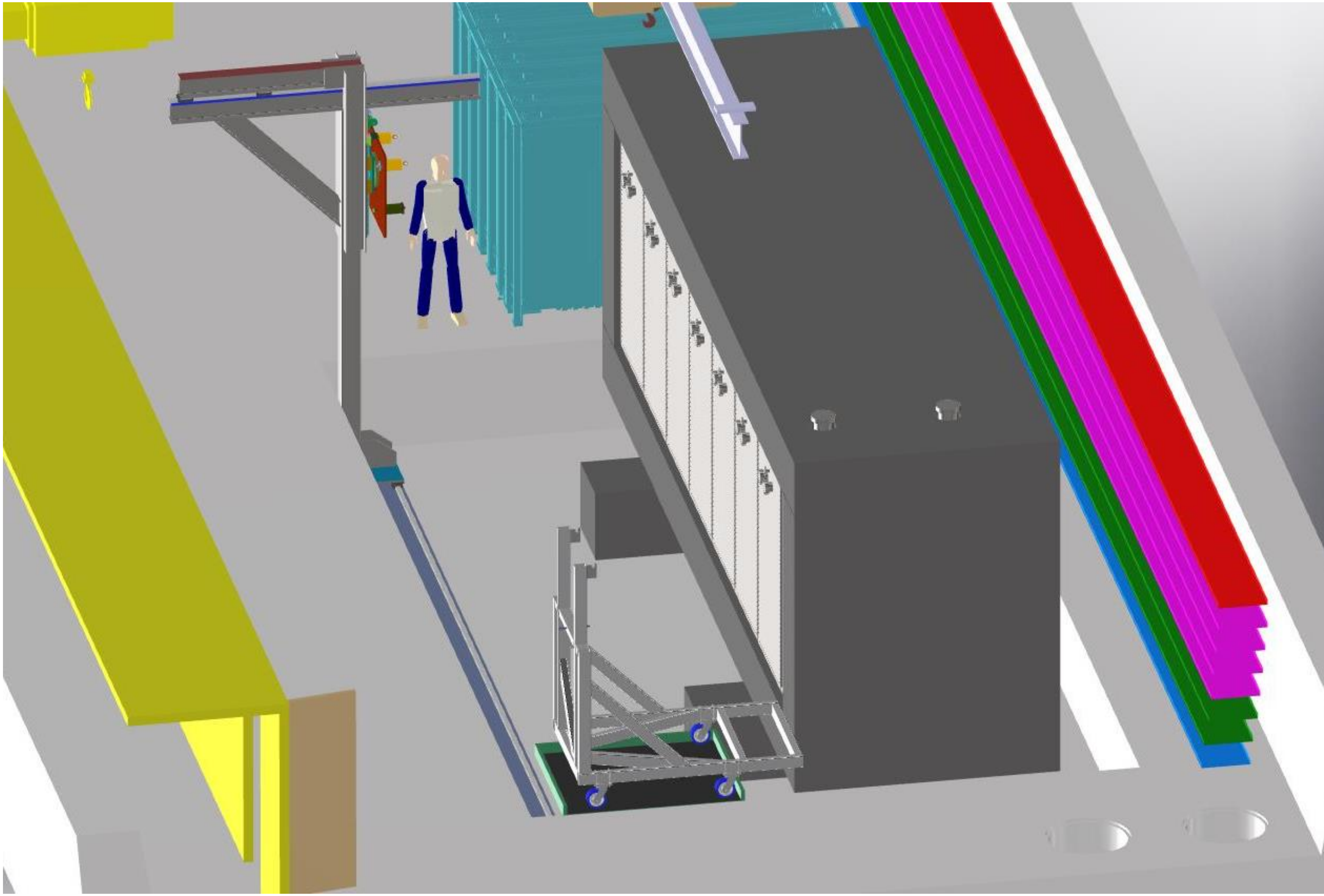


The maximum deflection of the block is quite reasonable for this material in this size. A spreader bar will be needed to lift from the four points shown.

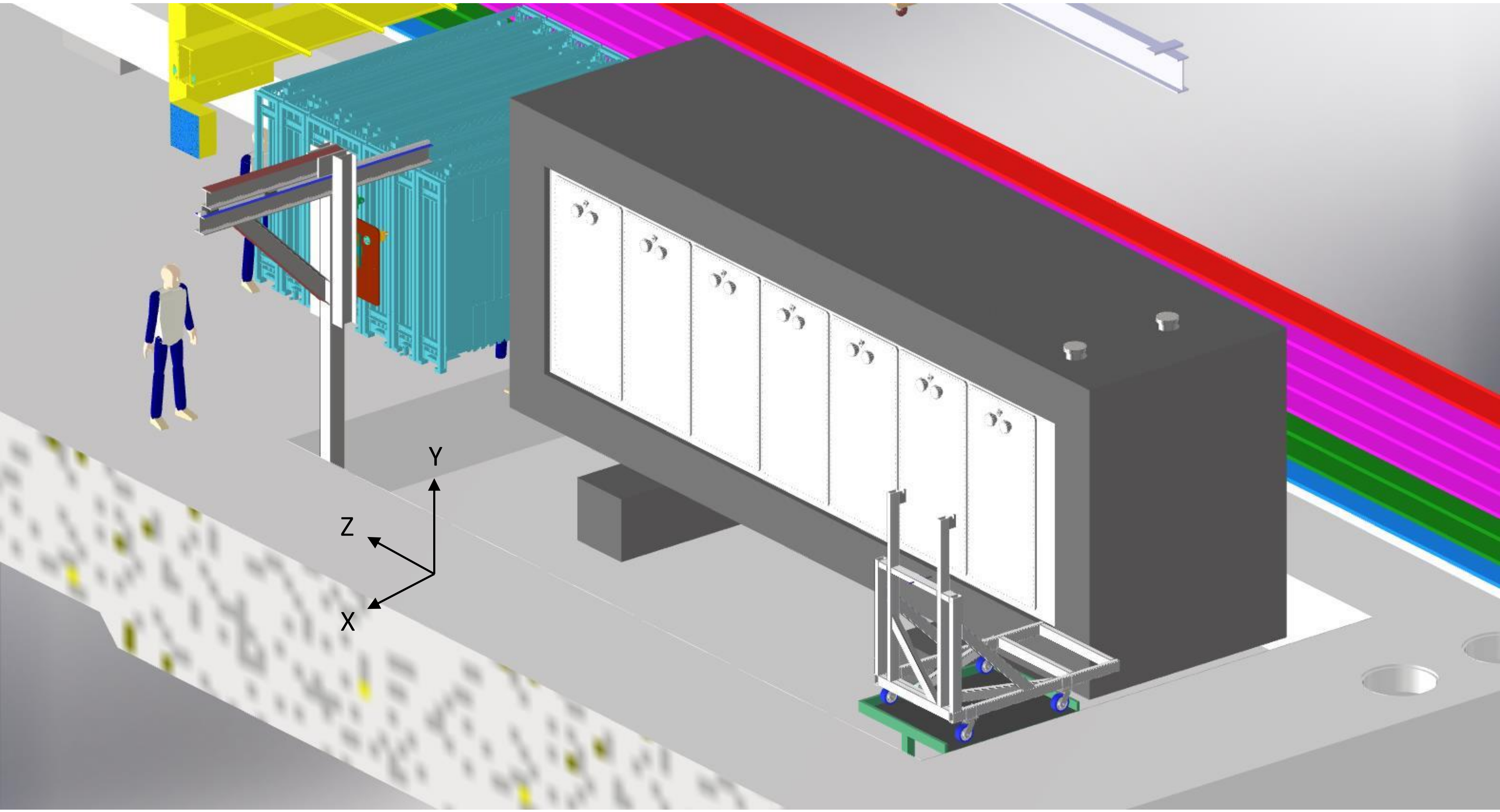
Step 10: lowering the top block onto the cryostat



TPC removal from Cryovessel procedure (Installation is the reverse of this process)

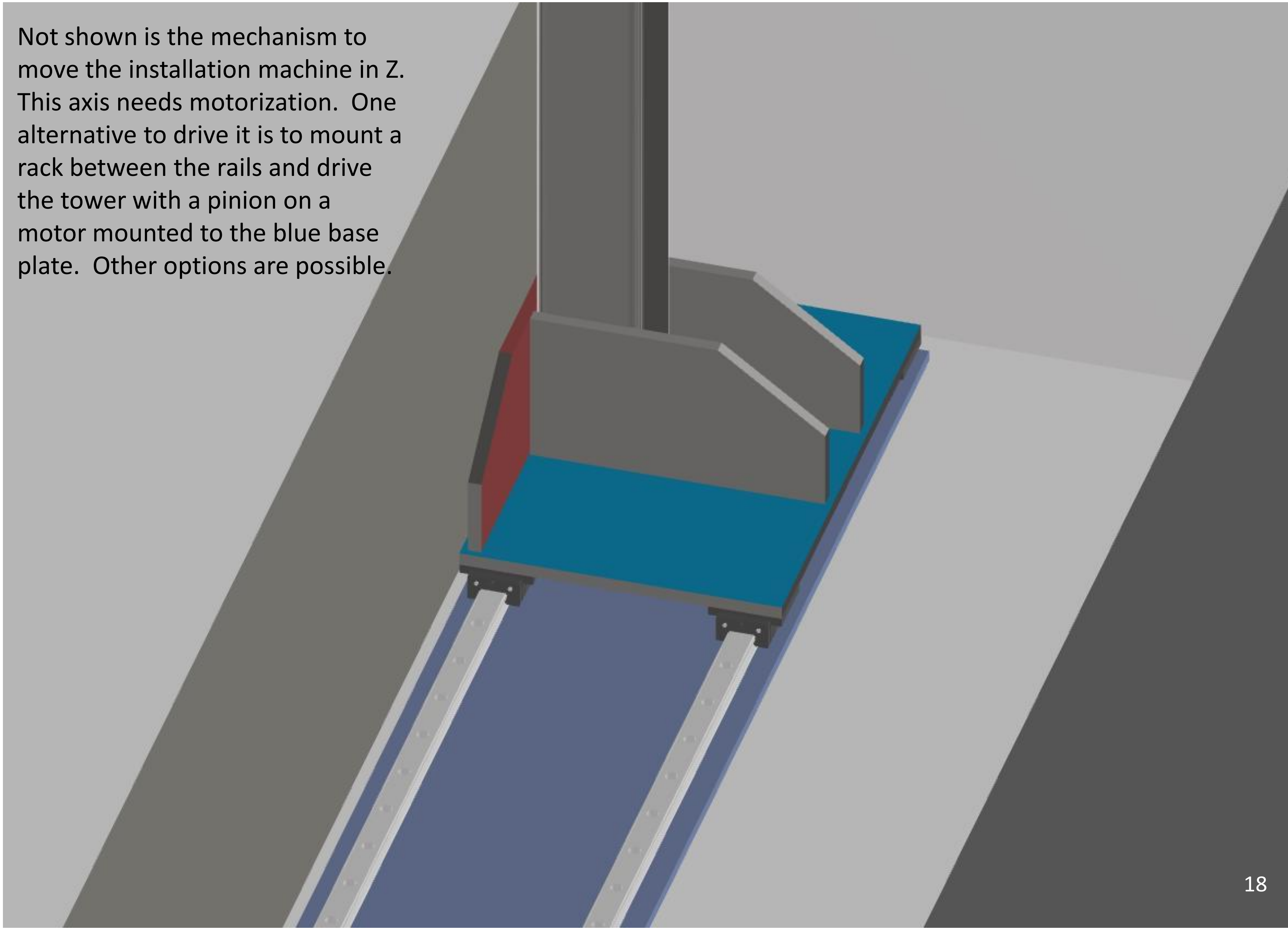


The Installation Machine is stored or assembled at the DS end of the Z travel in the corner of the LAr pit. The TPC Assembly Cart sits on the Transfer Platform waiting to receive a TPC Module from the Installation Machine.

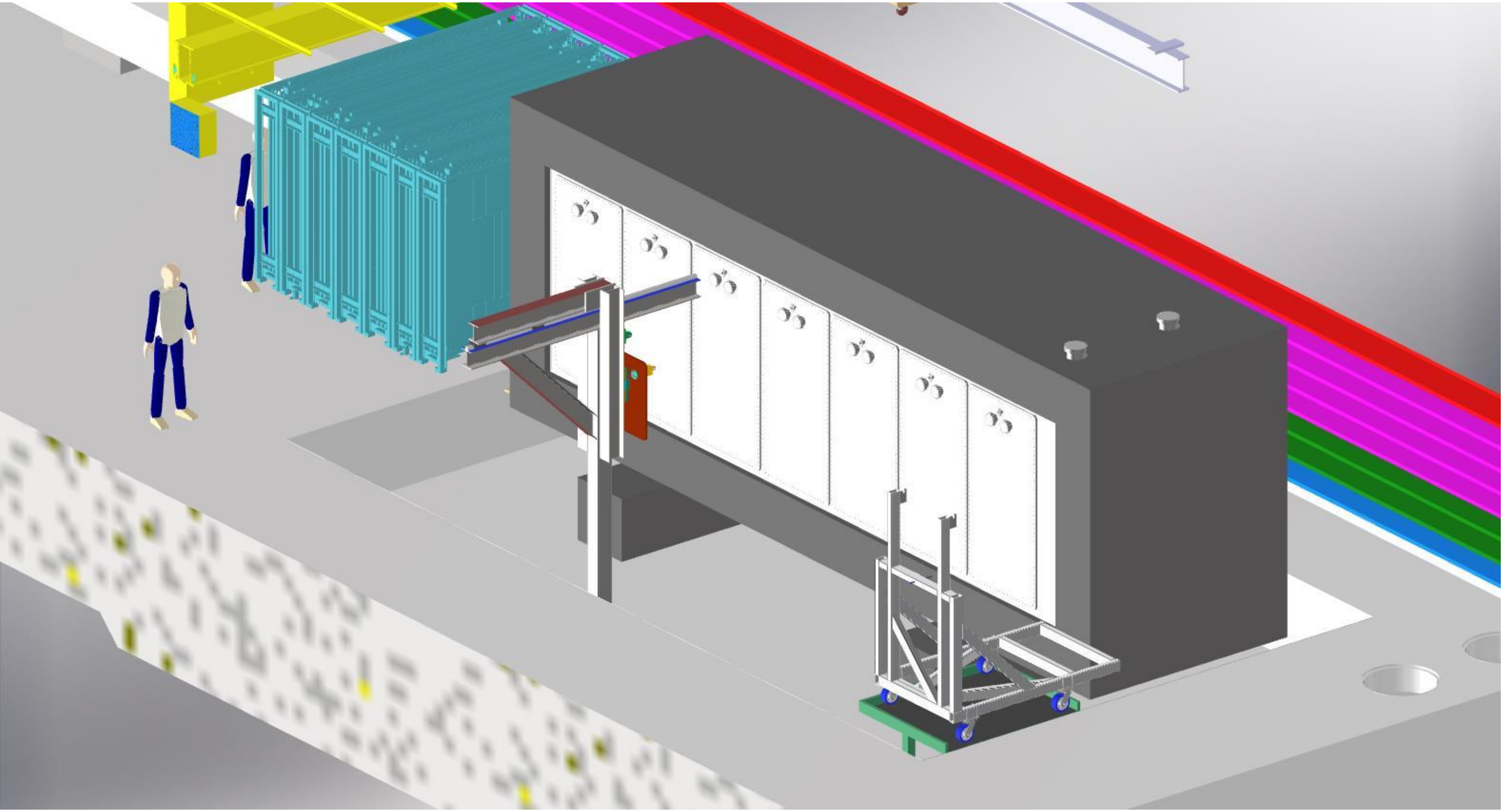


Close-up of the base of the Installation Machine on linear bearing rails

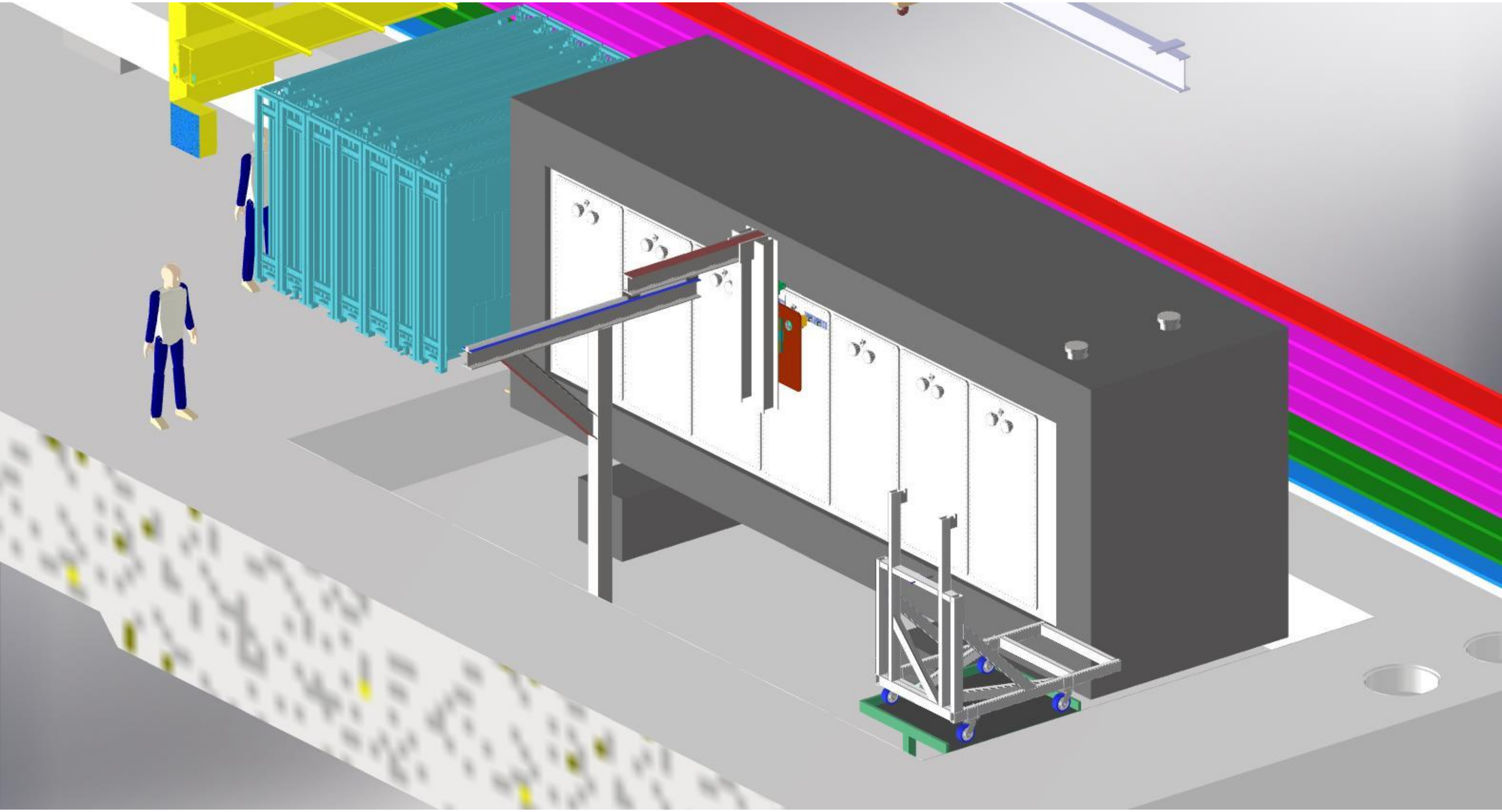
Not shown is the mechanism to move the installation machine in Z. This axis needs motorization. One alternative to drive it is to mount a rack between the rails and drive the tower with a pinion on a motor mounted to the blue base plate. Other options are possible.



The Installation Machine translates on the Beam Z axis to the position of the TPC Module to be removed.



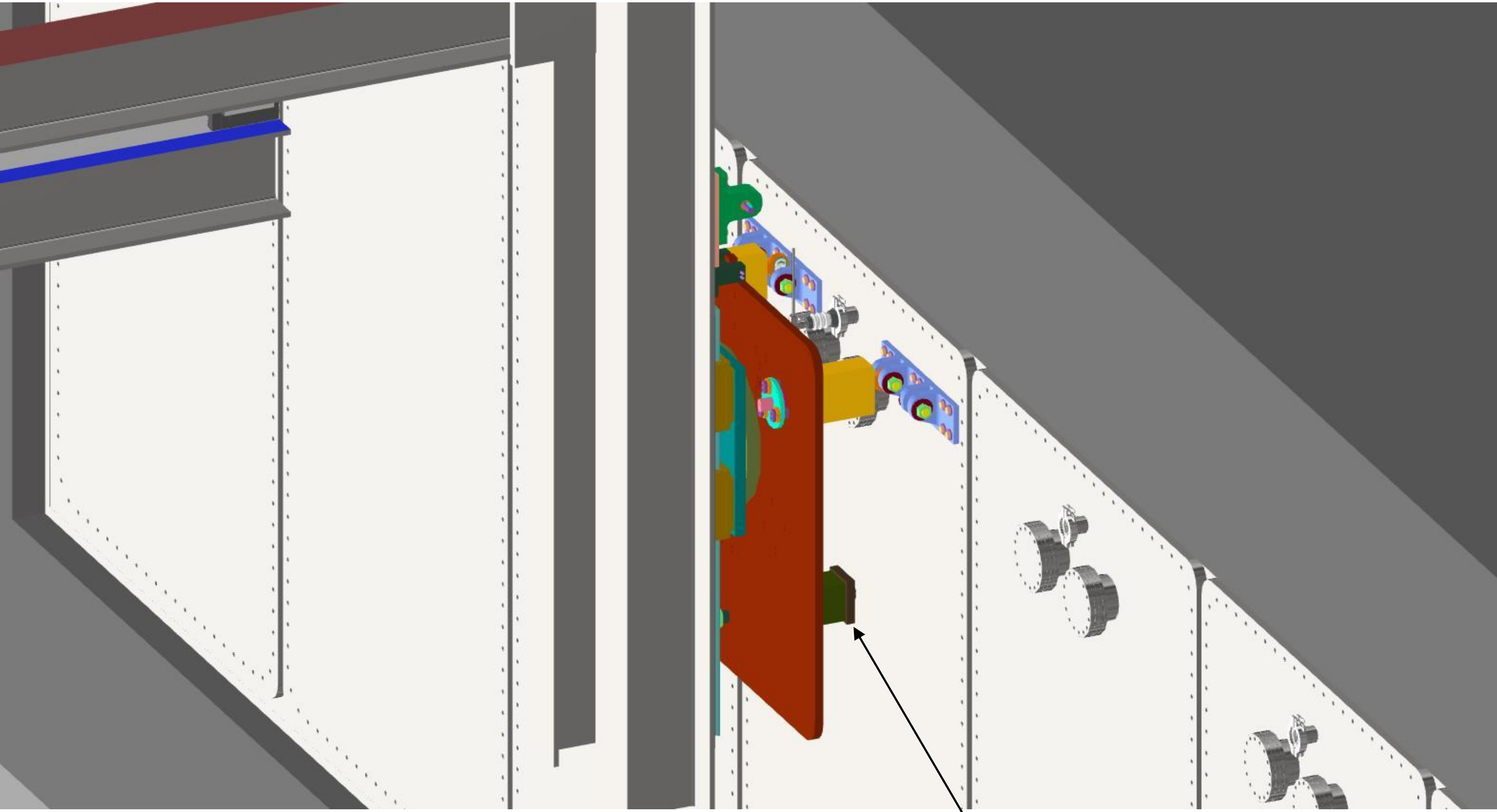
The Installation machine extends in X translation to the TPC Module where it pins to attachment lugs on the face of the TPC Module



The adjustments of all of the degrees of freedom on the installation machine line up the machine to the position of the TPC module lift points.

If the modules are sealed with bolts and a Jetseal metal o-ring, all bolts are removed at this point. If the modules are welded into the cryostat, the weld must be ground.

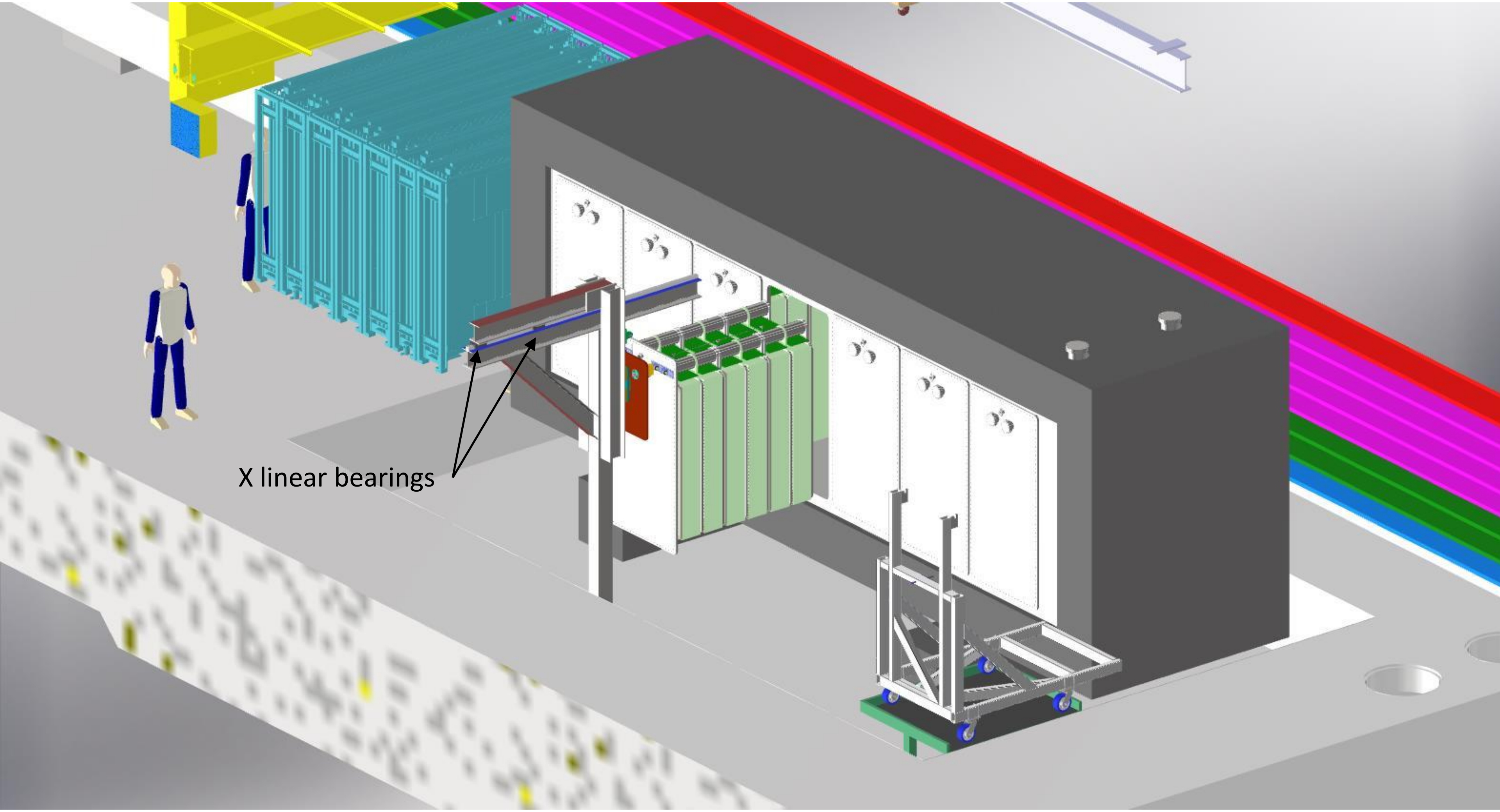
Close-up of attachment between the installation machine and the TPC module



The light blue attachment lugs may be a permanent feature of all TPC modules. Not shown on the others.

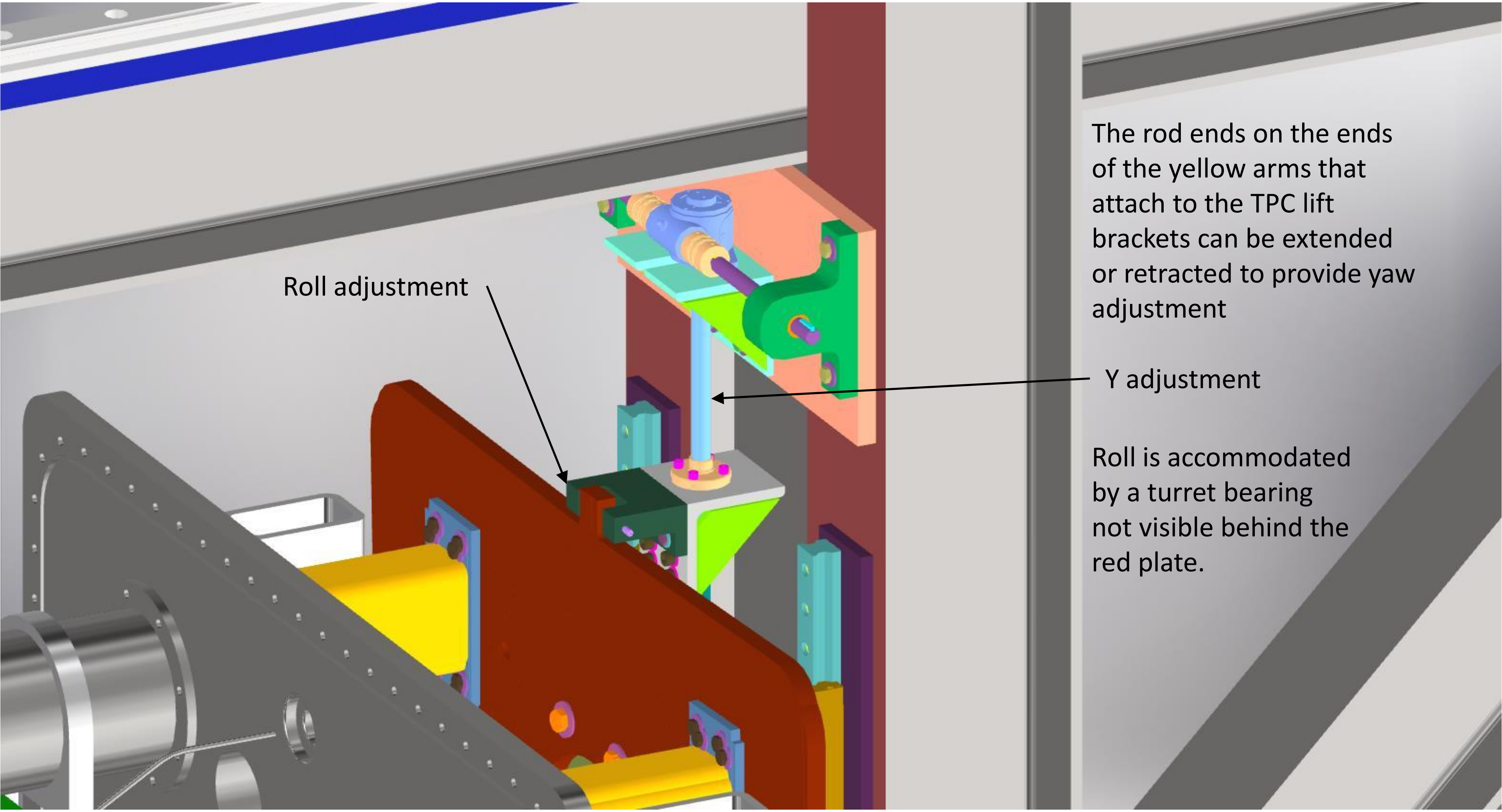
This leg absorbs the moment from the module

The TPC Module is translated out of the Cryovessel on the Installation Machine's linear bearings on the X axis.



TPC modules weigh 1,114 kg

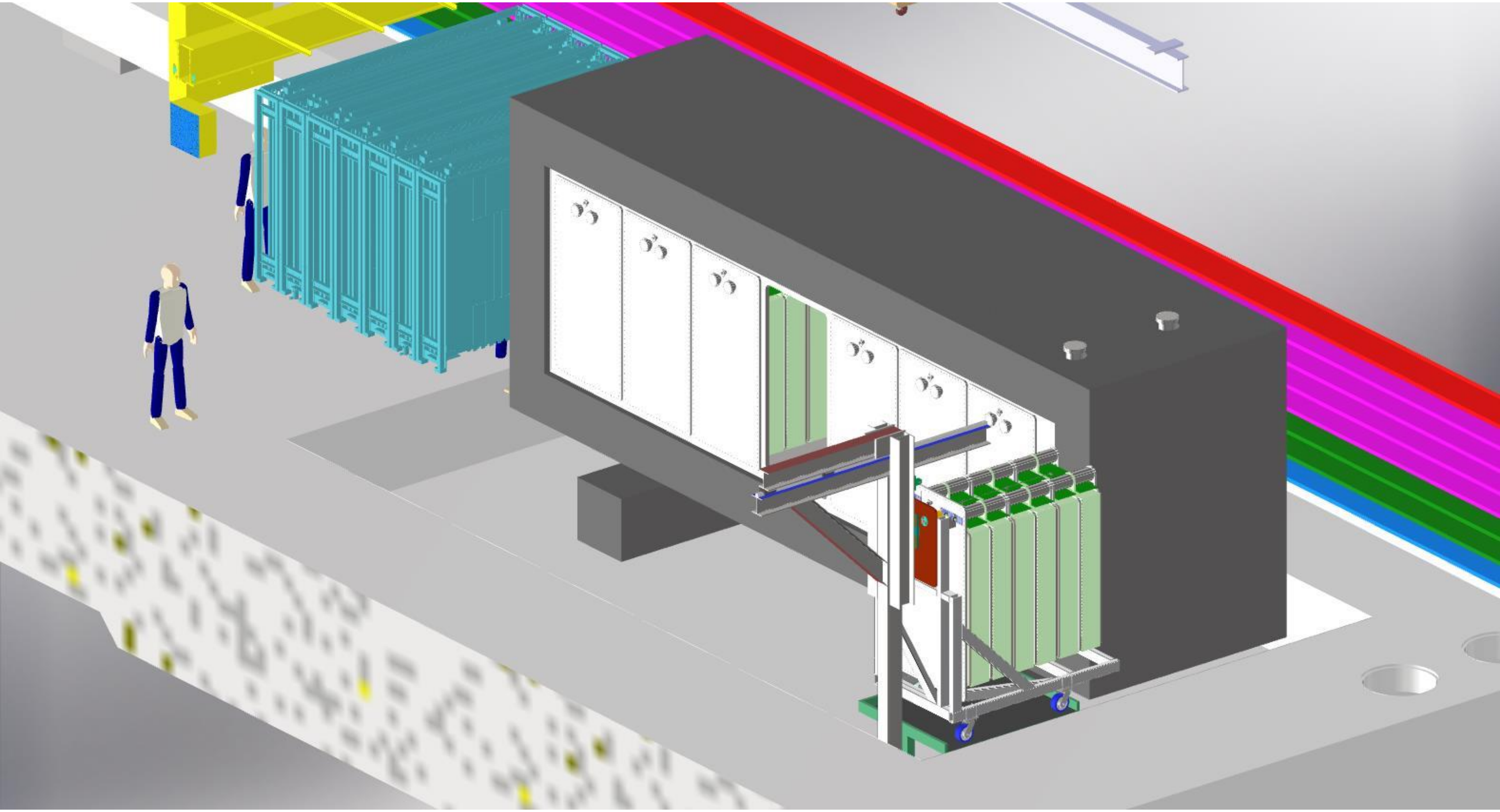
Close-up of roll, yaw, and Y translation mechanisms, looking US and to beam left



This mechanism is a conceptual model adapted from the installation machine built for the EXO cryostat. It will need further engineering to ensure the stability and capacity of the mechanism.

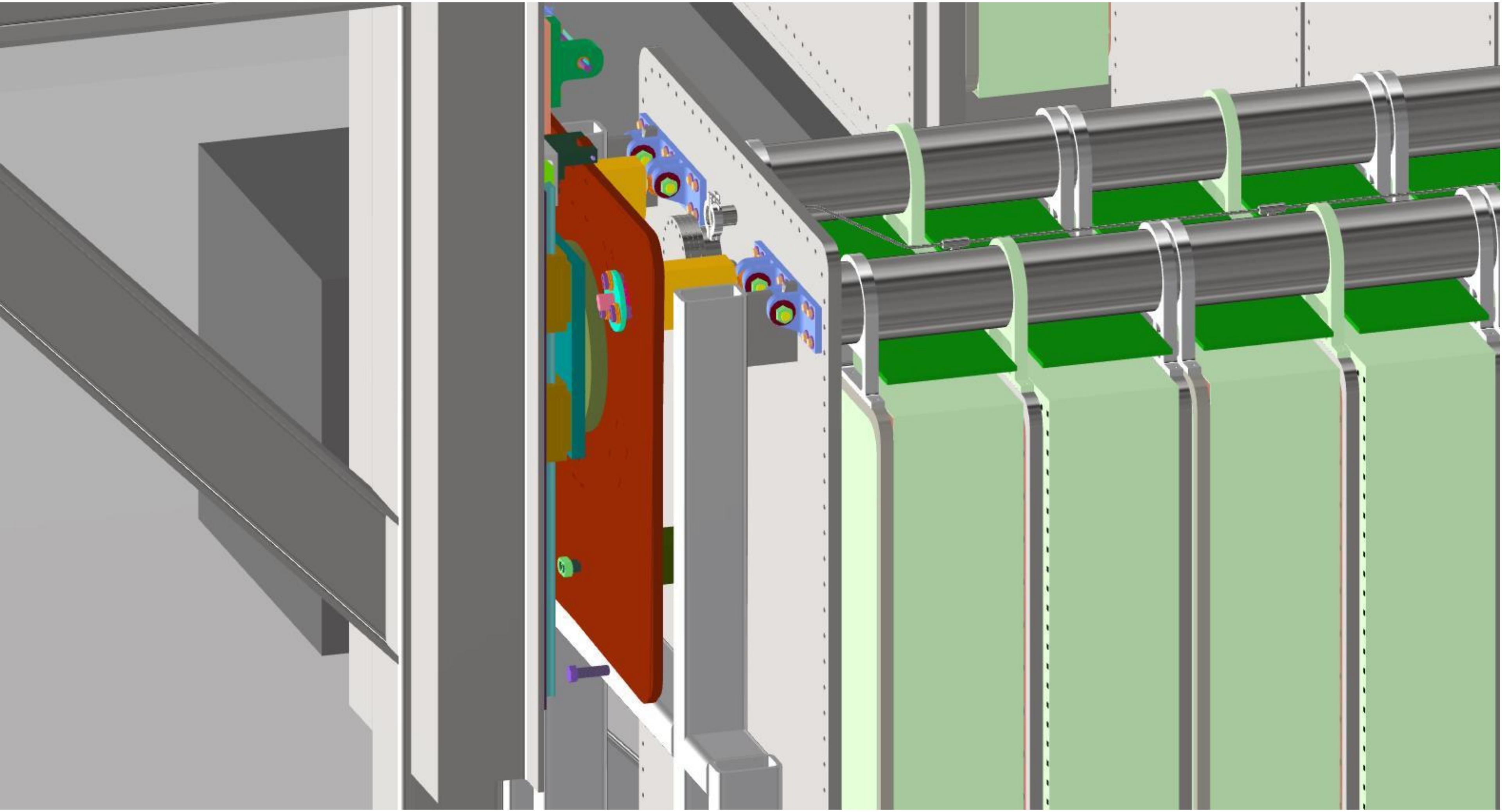
The EXO machine was all manually operated, being smaller and manipulating a smaller mass. It remains to decide which axes are motorized.

The Installation Machine translates the TPC Module on the Y axis to the Assembly Cart waiting on the Transfer Platform. The Installation Machine lowers the TPC Module onto open hooks of the Assembly Cart.

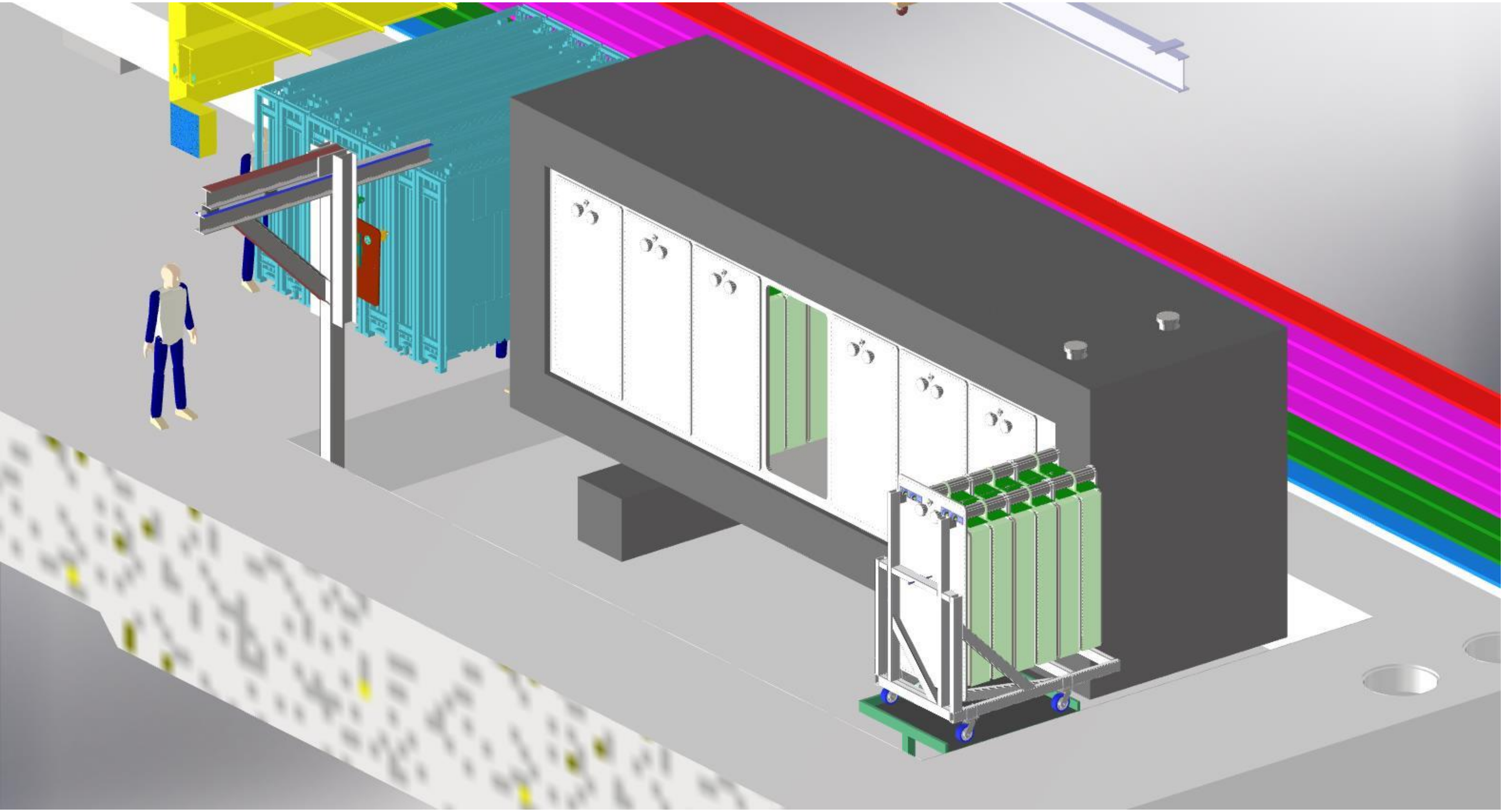


The handoff takes place by adjusting the Installation Machine to transfer the load to the Assembly Cart, then the pins are removed from the attachment lugs connected to the Installation Machine.

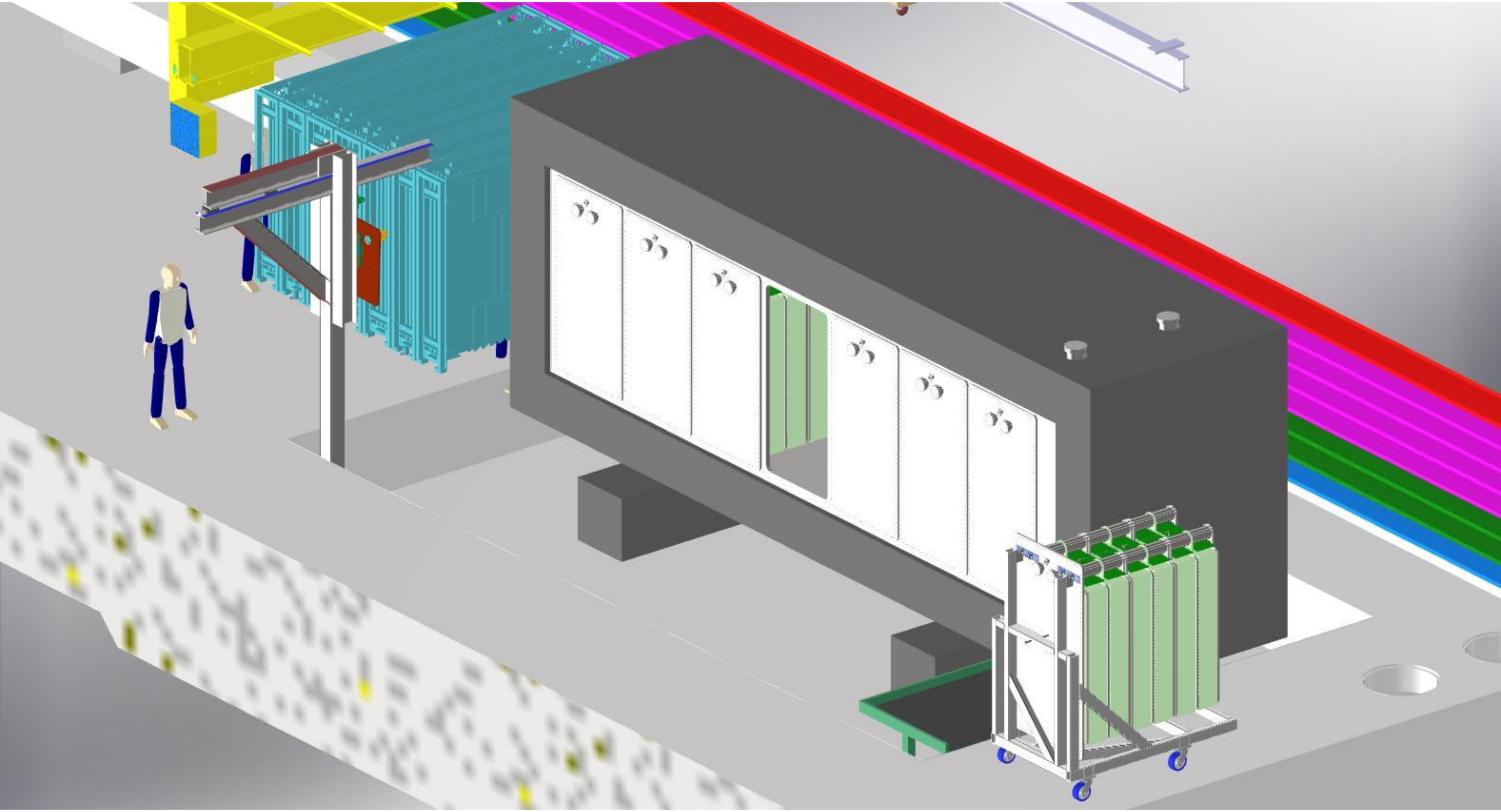
Close-up of the roll, pitch, and yaw mechanism shown. Both sets of attachment lugs are in use, connected to the Installation Machine and connected to the Assembly Cart when the TPC load transfer takes place



Installation Machine is retracted to its starting position



TPC Module on Assembly Cart is rolled off of Transition Platform and along the tunnel to work area, or to the access shaft for removal from the tunnel



Summary

- We have shown a conceptual design for a TPC installation/removal machine
- Much work remains to develop it into a final design
- The EXO installation machine had a single load cell to monitor load transfer. Other readbacks need to be thought out