DUNE detector, cryogenics, cryostat interfaces

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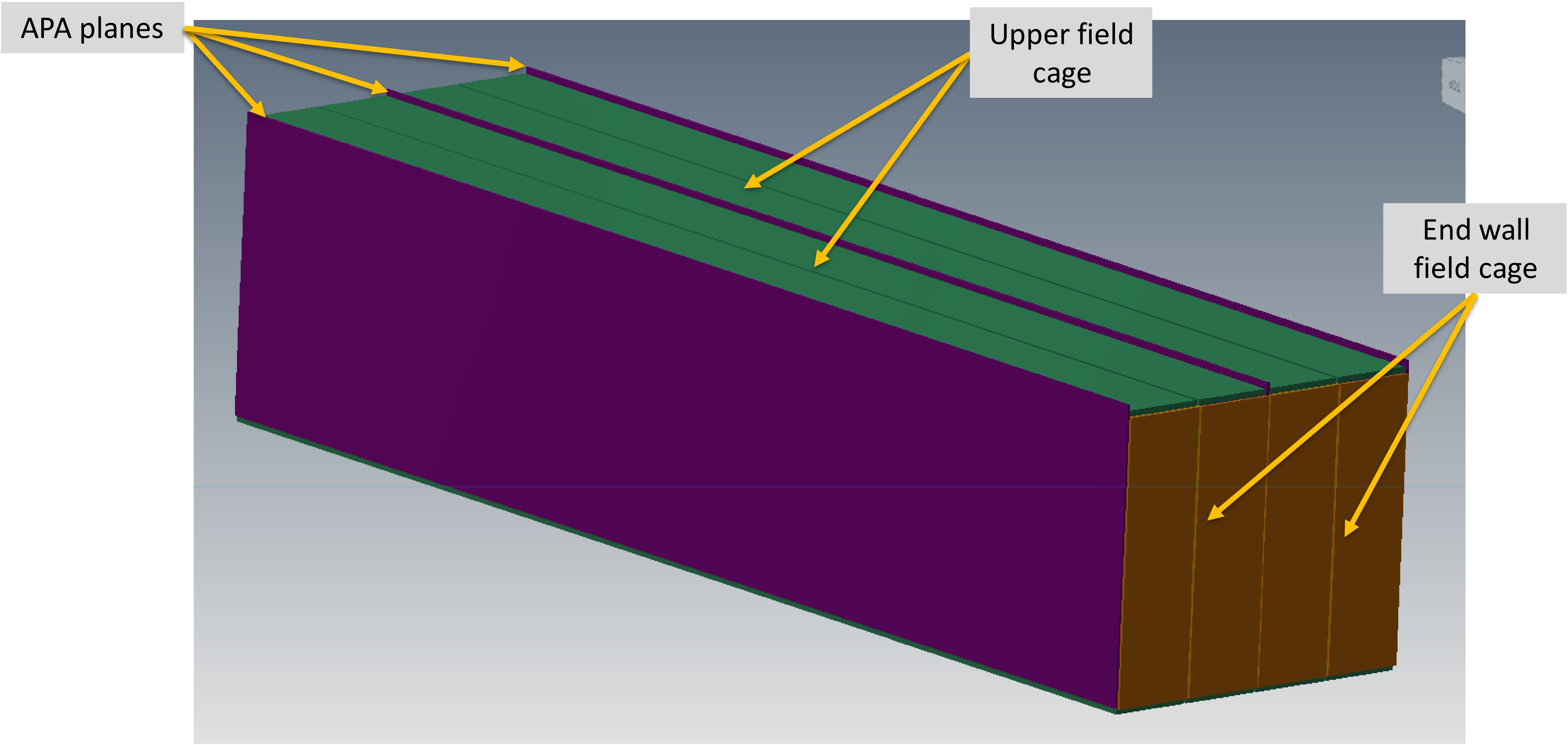
LBNC
23-June-2017

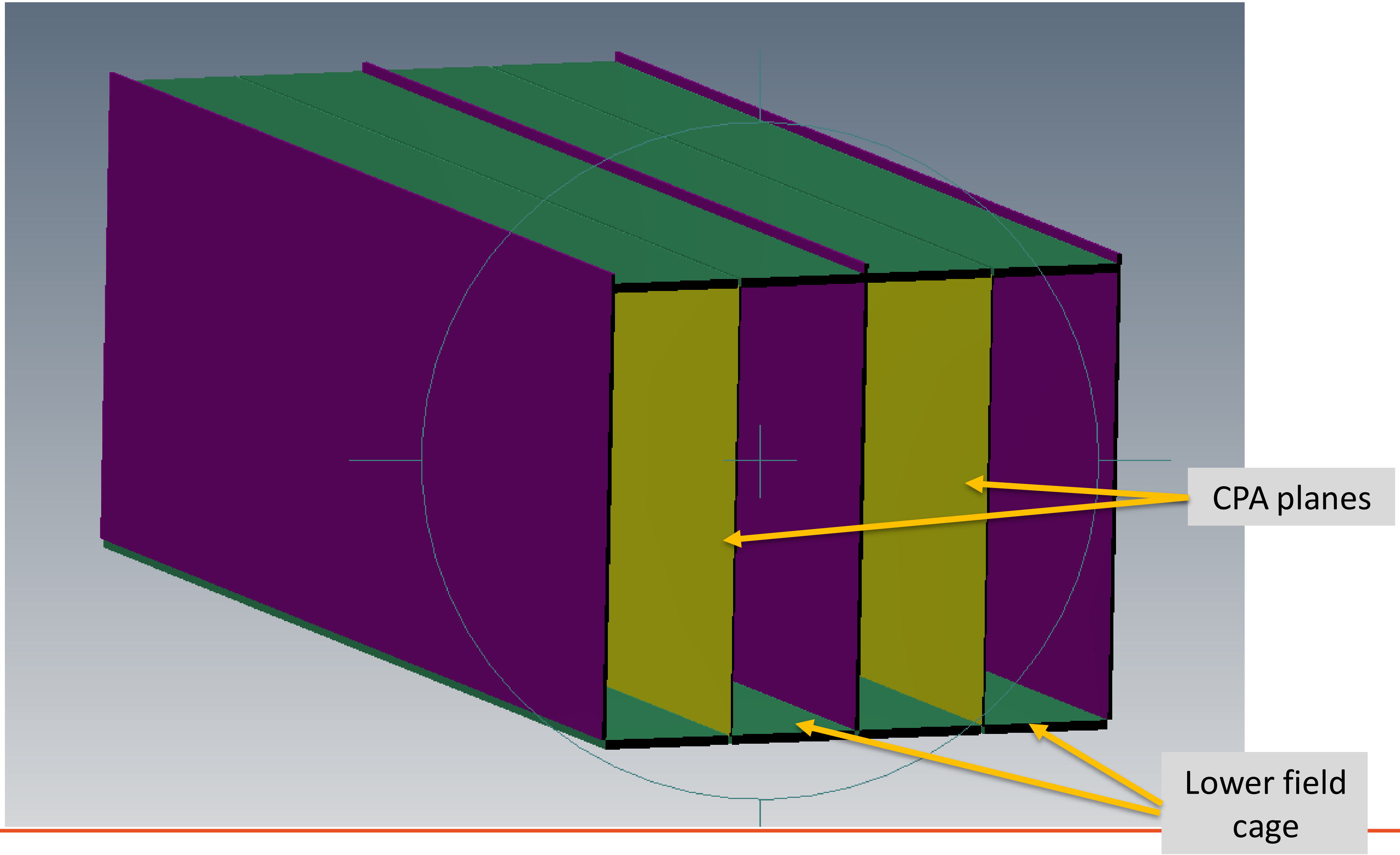
Discussion points

- SP detector envelopes – scaled from ProtoDUNE elements. Develop envelope detector drawings for integration. (B Flight)
- Cryostat feed thrus for detector (E Seletskaya, B Lacarelle, D Mladenov, M Nessi)
  - Detector support – adequate to support installation rail system. Support at least every 4 m.
  - Cable and electronics – one feed thru for 2 APAs, or 75 total. One electronic rack per feed thru.
- Cryostat feed thrus for cryogenics (D Montanari)
  - Supply piping for liquid and cooldown.
  - Return manifolds to improve Argon purity.

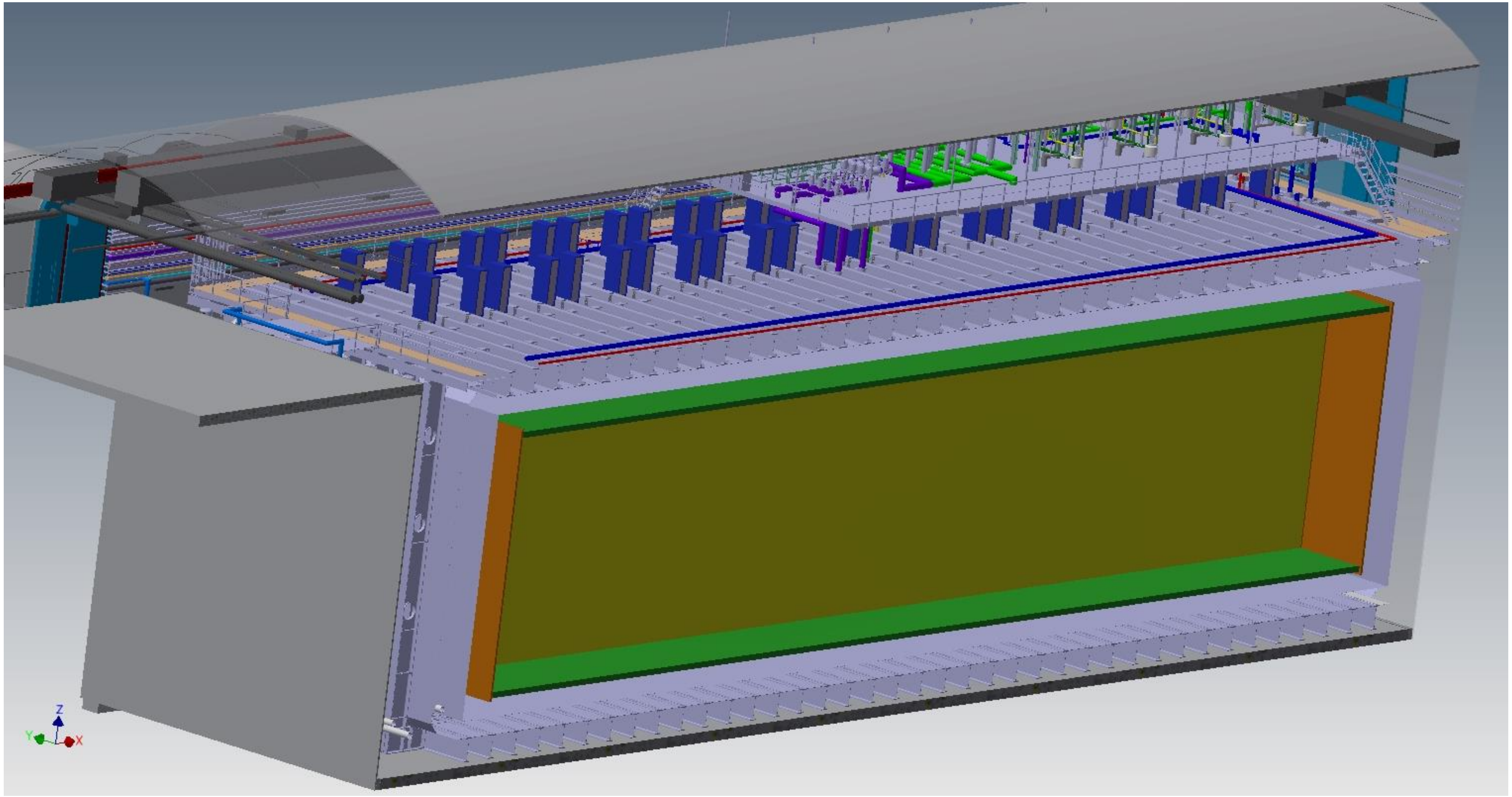
Detector envelope definition from ProtoDUNE components



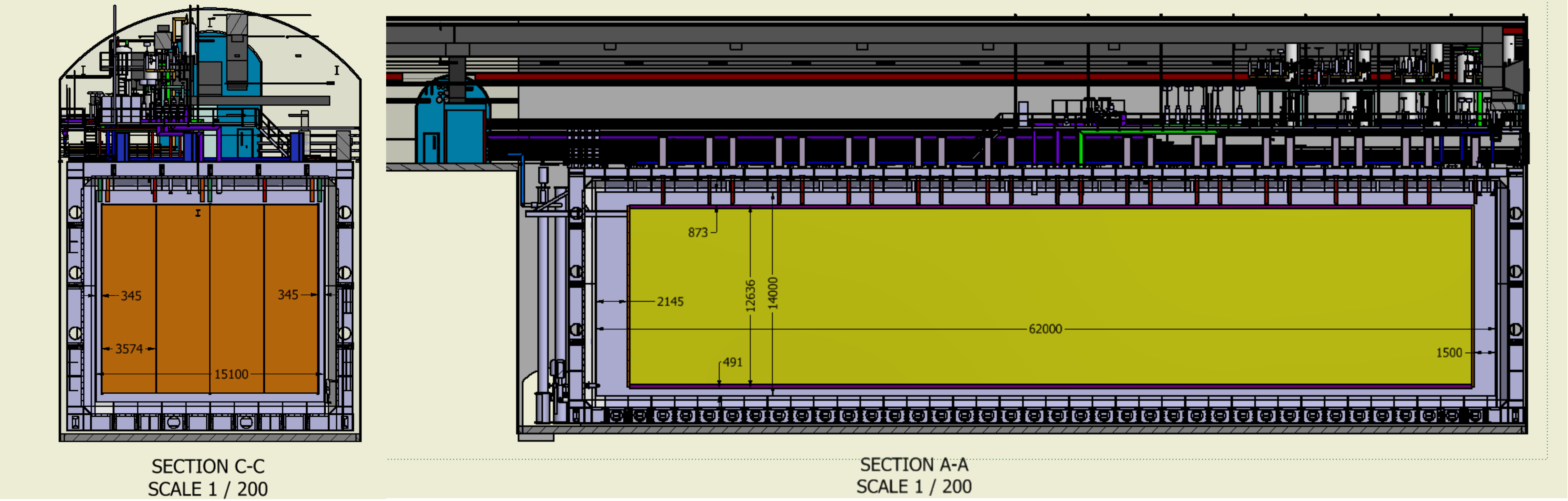
Sectioned view of detector envelope



Integrated Cryostat, Proximity Cryogenics and TPC



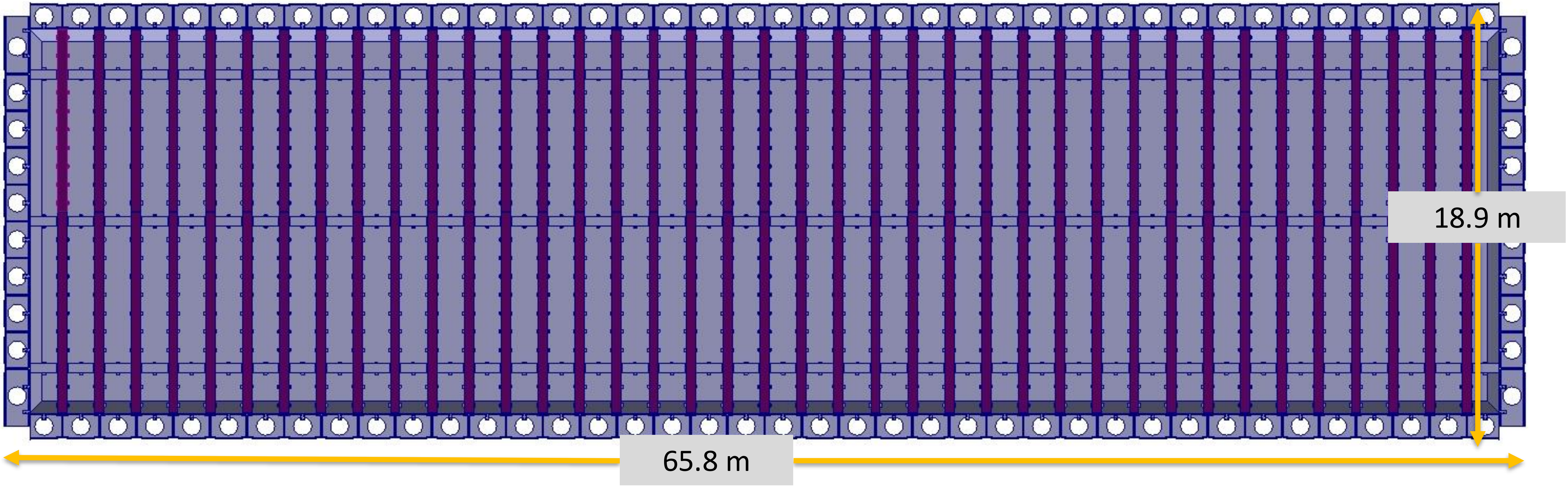
Integrated envelope drawings



Position of the detector.
LAr liquid level.

Cryogenic piping location and clearances.
Installation space/equipment.

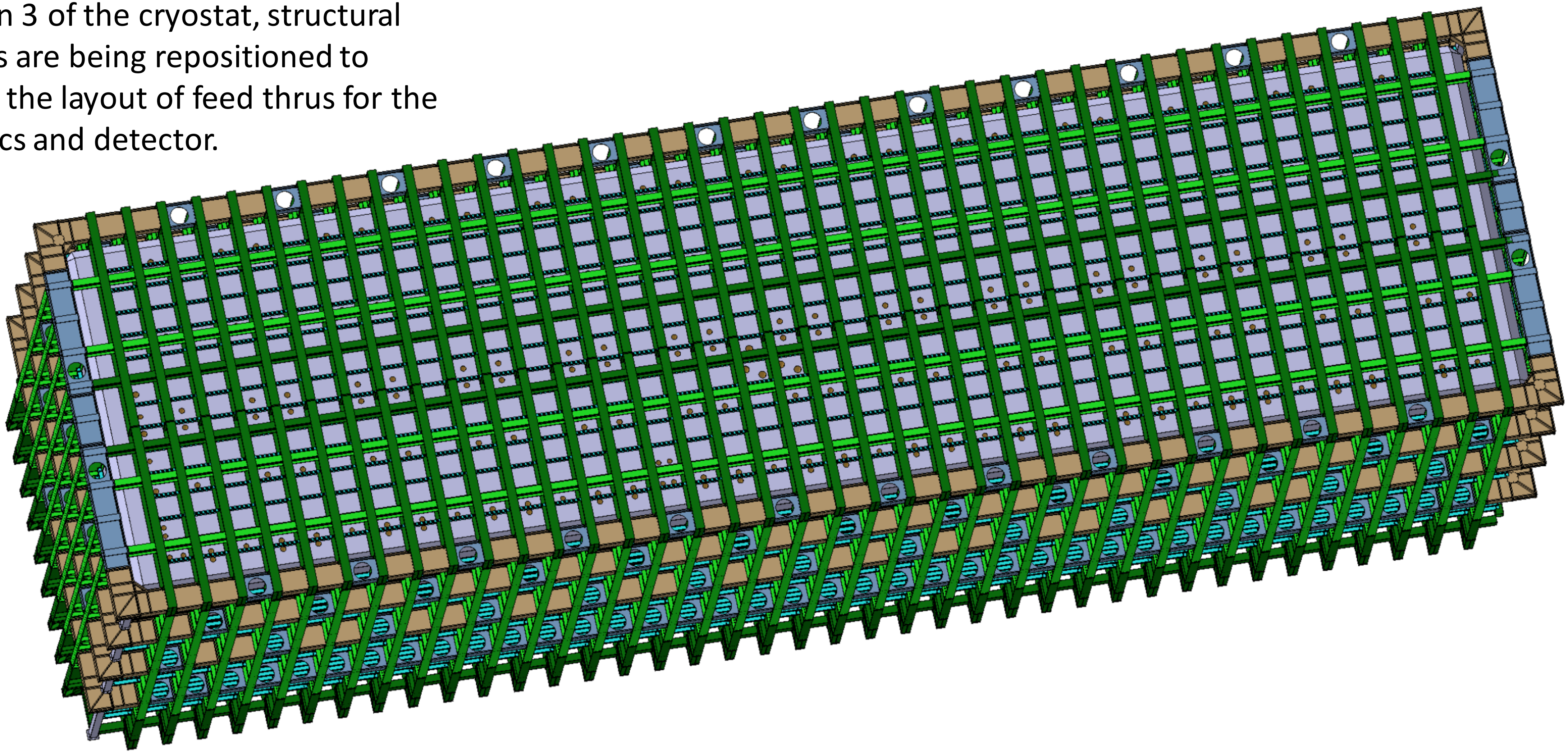
Current FD cryostat layout



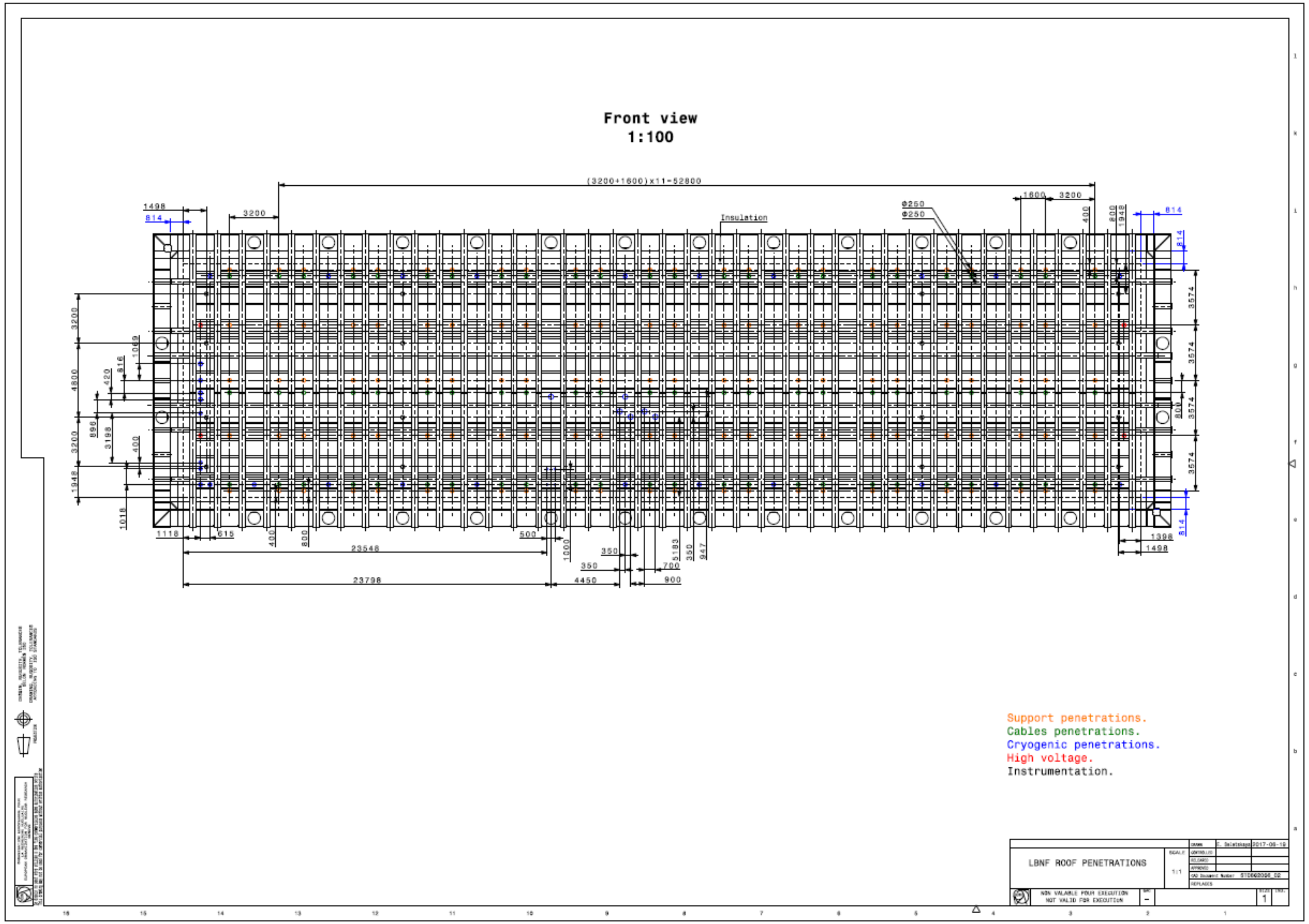
- Large I-beam belts on 1.6 m pitch.
- I-beams are 1118 mm tall and 402 mm wide.
- Yields 1198 mm clear space between.
- Short I-beams suppressed in view above.
- Detector is 58 m x 14.7 m

Changes in cryostat design

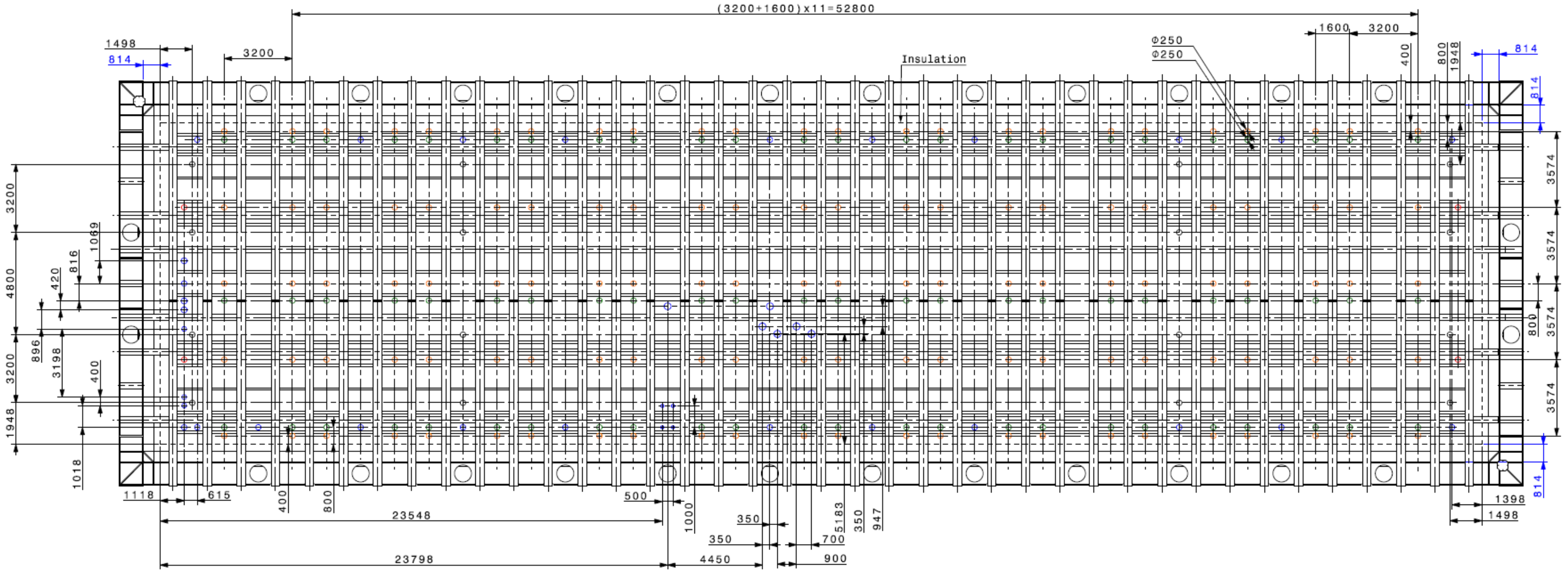
In version 3 of the cryostat, structural elements are being repositioned to facilitate the layout of feed thrus for the cryogenics and detector.



2D drawings for cryostat and feed thru positions



Details of drawings



Feed thru details

Detector penetrations

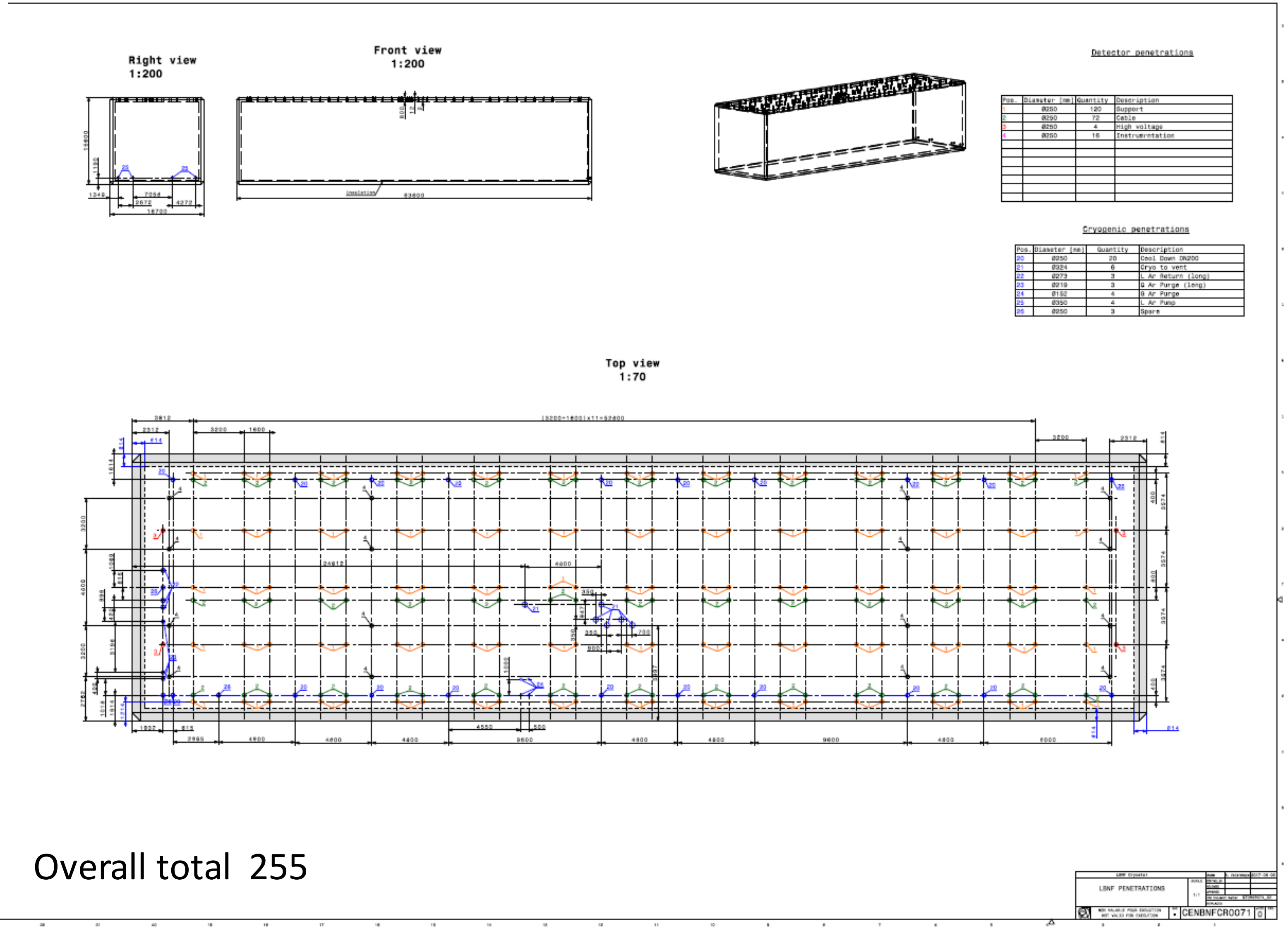
Pos.	Diameter [mm]	Quantity	Description
1	Ø250	120	Support
2	Ø250	72	Cable
3	Ø250	4	High voltage
4	Ø250	16	Instrumrntation

Detector Total 212

Cryogenic penetrations

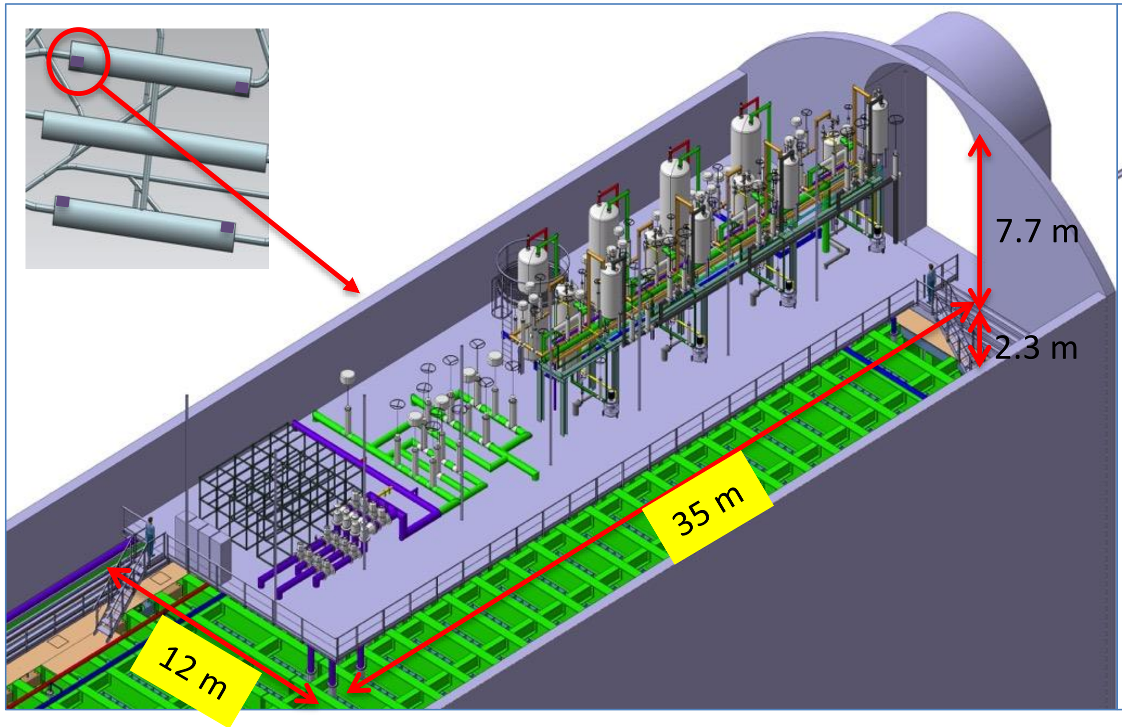
Pos.	Diameter [mm]	Quantity	Description
20	Ø250	20	Cool Down DN200
21	Ø324	6	Cryo to vent
22	Ø273	3	L Ar Return (long)
23	Ø219	3	G Ar Purge (long)
24	Ø152	4	G Ar Purge
25	Ø350	4	L Ar Pump
26	Ø250	3	Spare

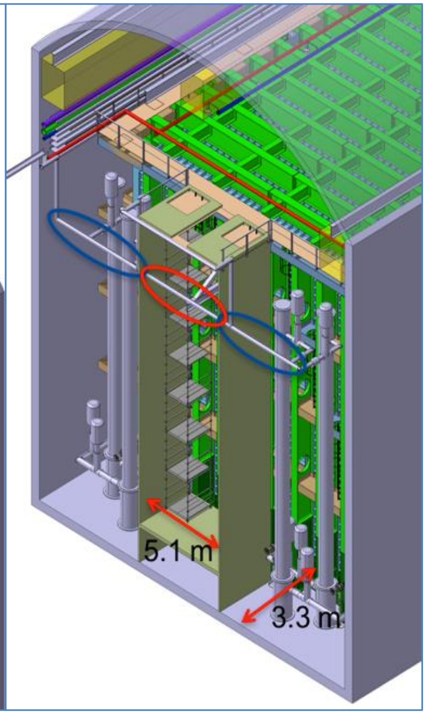
Cryogenic Total 43

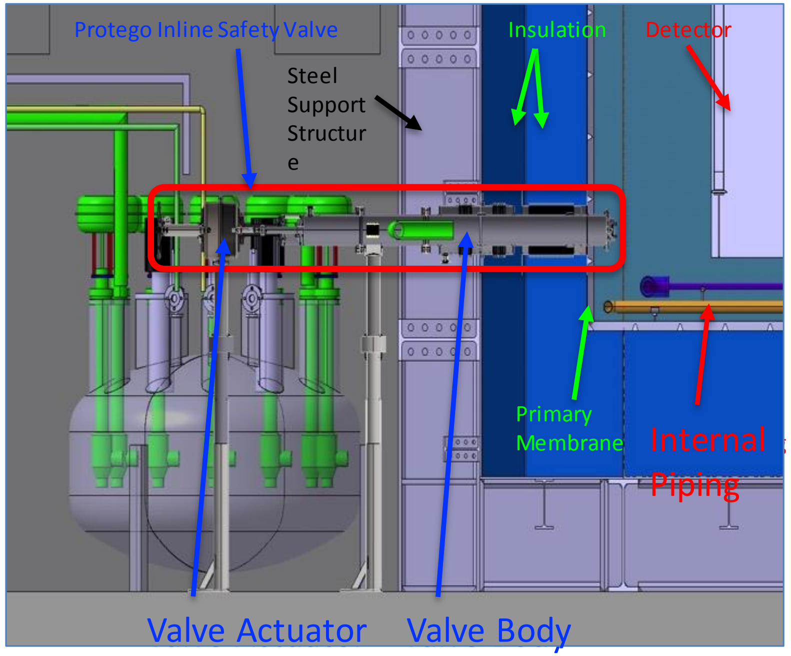


Overall total 255

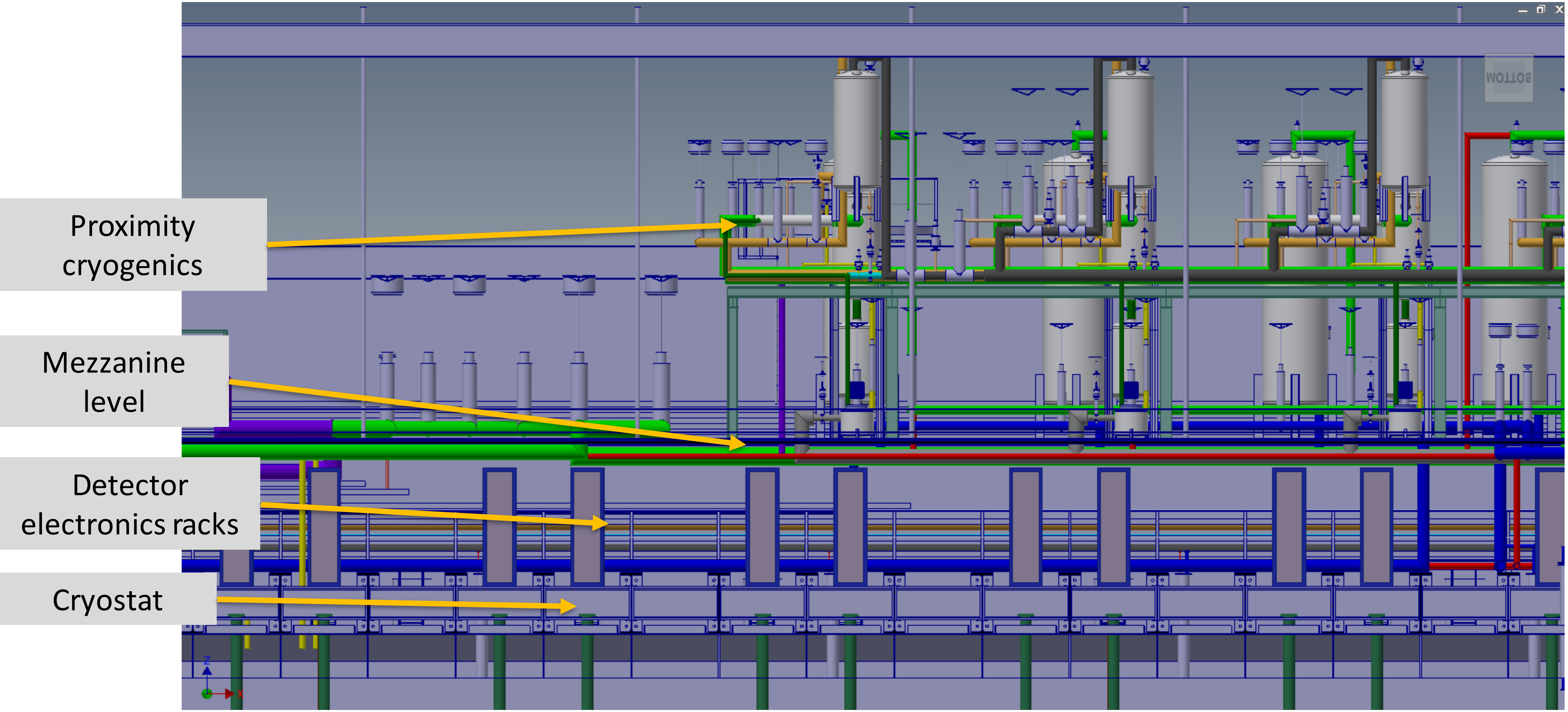
LBNF cryostat and cryogenics



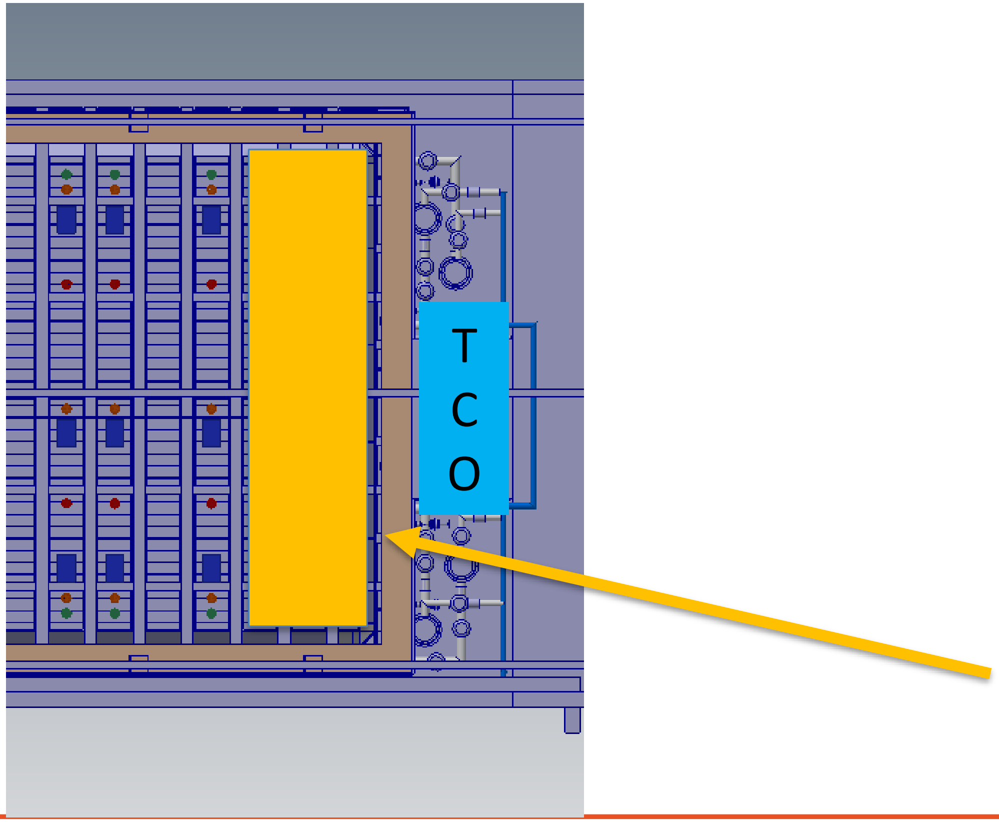




Clearance under proximity cryogenic mezzanine



Detector installation

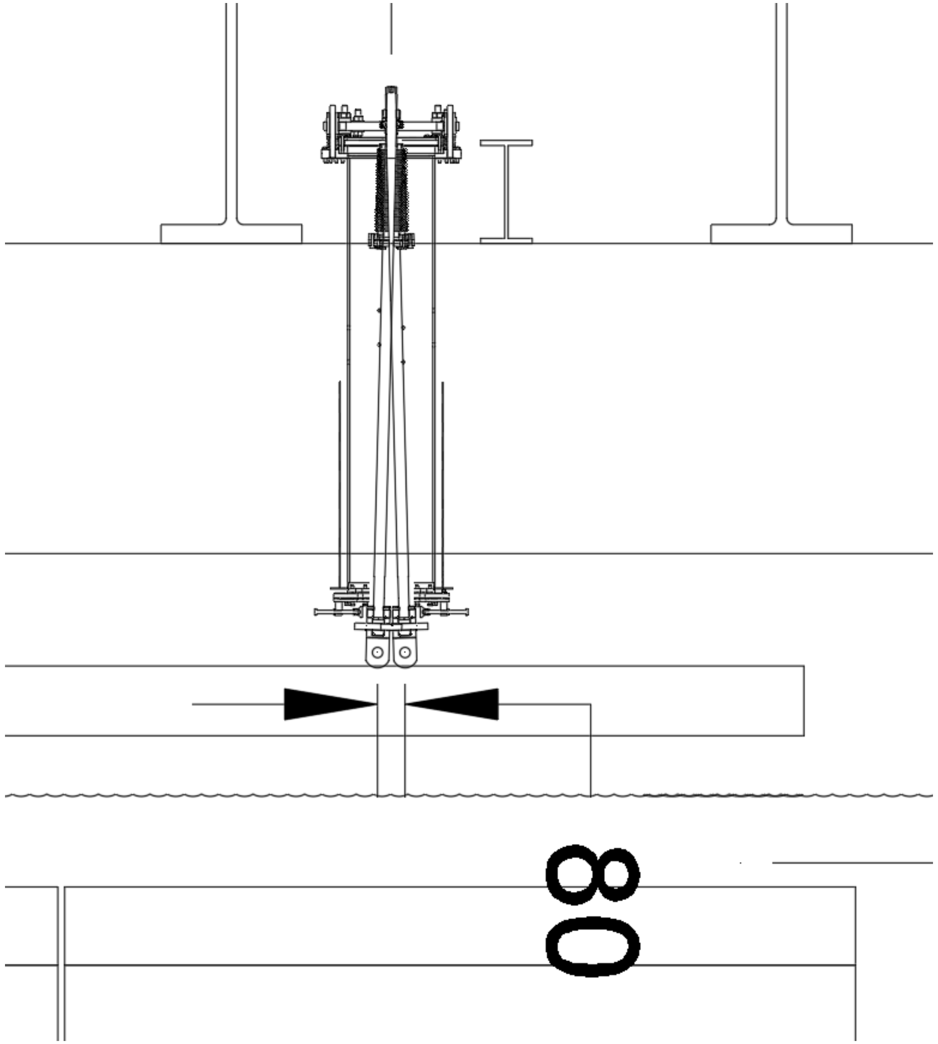


Future work and next steps (from last LBNC)

- TPC motions and dynamics. How to constrain and position. (in progress)
- Need to understand the routing and plans for cabling for SP. If lower APA cables will be routed through the upper APA or will they be routed up the side walls of the cryostat or.. (Currently being studied at BNL)
- Integrate and iterate cryogenic external and internal piping. (in development with FNAL and CERN)
- For all potential configurations, evaluate the thermal loss, LAr fluid dynamics, temperature gradients and LAr purity. (in progress)
- Add cathode HV feed thrus. (Done)
- Understand the cryogenic monitoring system, calibration system, installation tooling, access requirements and infrastructure. (Preliminary feed thrus added. ProtoDUNE systems were used as a reference.)

Detector motion and shrinkage

Dan Wenman
Univ of Wisconsin



Lateral accommodations

200 mm crossing tube allows +/- 3cm
250 mm crossing tube allows +/-5.5cm
300 mm crossing tube allows +/- 8.1 cm

For DUNE, +/- 2 cm for positional tolerance and +/- 4 cm for CTE

For protoDUNE a 200 mm tube was used for +/-2cm to accommodate tolerances for the position and tipping of the cryostat flanges. This left +/-1 cm for shrinking.

For DUNE the position and parallel tolerances of the flange are important interface parameters to understand before defining the tube sizes. It may be possible to decouple this tolerance if the attached to the beam is made adjustable.

Detector Support initial thoughts

Vic Guarino - ANL

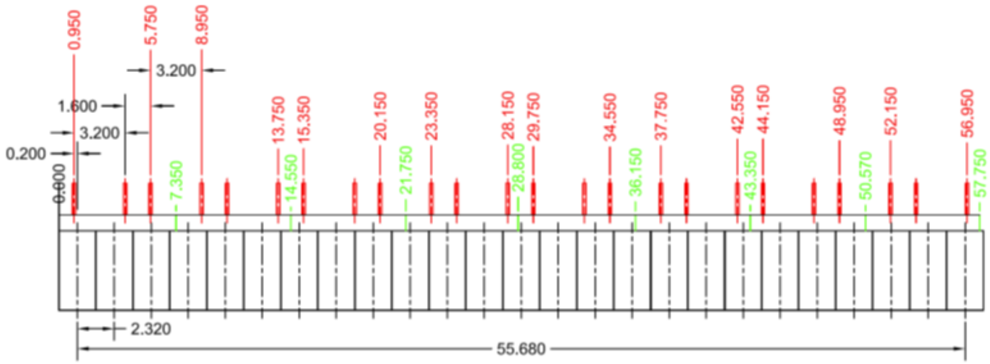


Figure 2 – Layout of Roof Penetrations and Detector Hangars

2. Layout of beams

An initial layout of the DSS beams is shown in Figure 2 in green. The goal of the layout was to get beams that were roughly 6.4m long because 20ft is a standard beam length and this is a length that could be reasonably be handled. The layout also had a goal of having the beam supported by the feedthroughs roughly 20% from the ends which minimizes the deflections and bending moments. This is difficult to achieve because the pitch of the feedthroughs and the detectors do not match. One challenge of not supporting the beams at the ends but rather having a section of the beam extend past the supports is that during installation before the beam is fully loaded the weight of a an APA/CPA being slid onto the beam could potentially cause the support at the far end to go into compression. We have to check that the self weight of the beam and distance between supports is sufficient to prevent this from happing.

An alternate beam layout is to have the beams supported at their ends. In this case the feedthroughs would support the ends of two adjacent beams.

3. Connections between beams

The ends of beams must be aligned and restrained wrt each other laterally in order to allow trolleys to pass over the joint.

Adjacent beam ends can be pinned together to transfer shear or left independent of each other which may make it difficult during installation because the end of one beam may drop under the weight of a CPA/APA and then not line up with the adjacent beam that is not loaded. Temporary pinned connections during installation could be used and then removed.

The end connections between adjacent beams is also dependent on how the thermal contraction is handled.

4. Thermal Contraction

The APA's are stainless steel and will shrink at the same rate as the DSS beams. In theory the APA's that are supported on the same beam can have zero gap between them. Gaps will only potentially open up between adjacent APAs that are supported on independent beams.

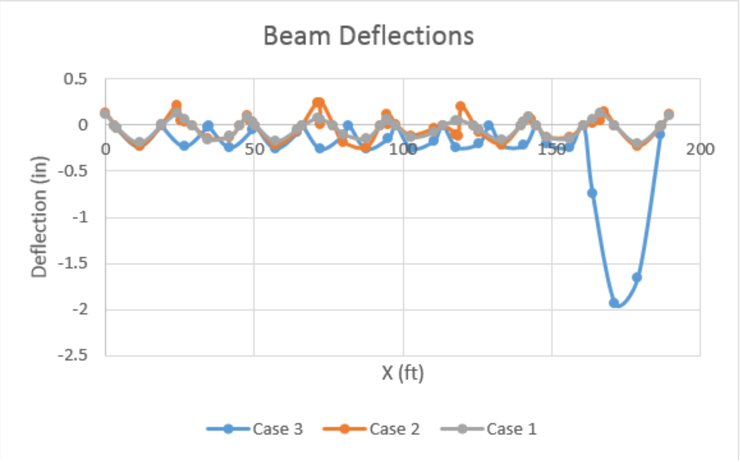
If the center of the detector is restrained and the ends contract to the center there must be an allowance of 79mm for the shrinkage from each end. If all of the beams are pinned together the ends of the beam at the endwall will shrink 79mm towards the center and the feedthrough supports will have to be able to

Detector Support initial thoughts (cont)

Case 3: Beams were supported at their ends by feedthroughs. Roughly only 2 APA's were supported per beam. Each support feedthrough would support the ends of adjacent beams. The beams were hinged at their ends and therefore were simply supported at the feedthrough support. The max stresses were roughly 12000psi and more feedthrough supports were needed.

Figure 3 – Load Case 3 – Location of Loads and Supports

The calculated deflections are shown below. Clearly an additional support is needed at the end of Case 3. The maximum deflections are roughly 0.2" and can be achieved with any end conditions by varying the number of feedthrough supports.



Two beams can be supported by a single feedthrough by the concept shown below. Rather than having a long rod we can have a more rigid connection by supporting directly off of the 6" tube. The same clevis/rod connection can be made to the beam. Thermal contraction in this case is roughly 12mm and could be accomplished by having the end of the rod on a swivel and having a horizontal slot in the beam web rather than a hole.

Future work and next steps

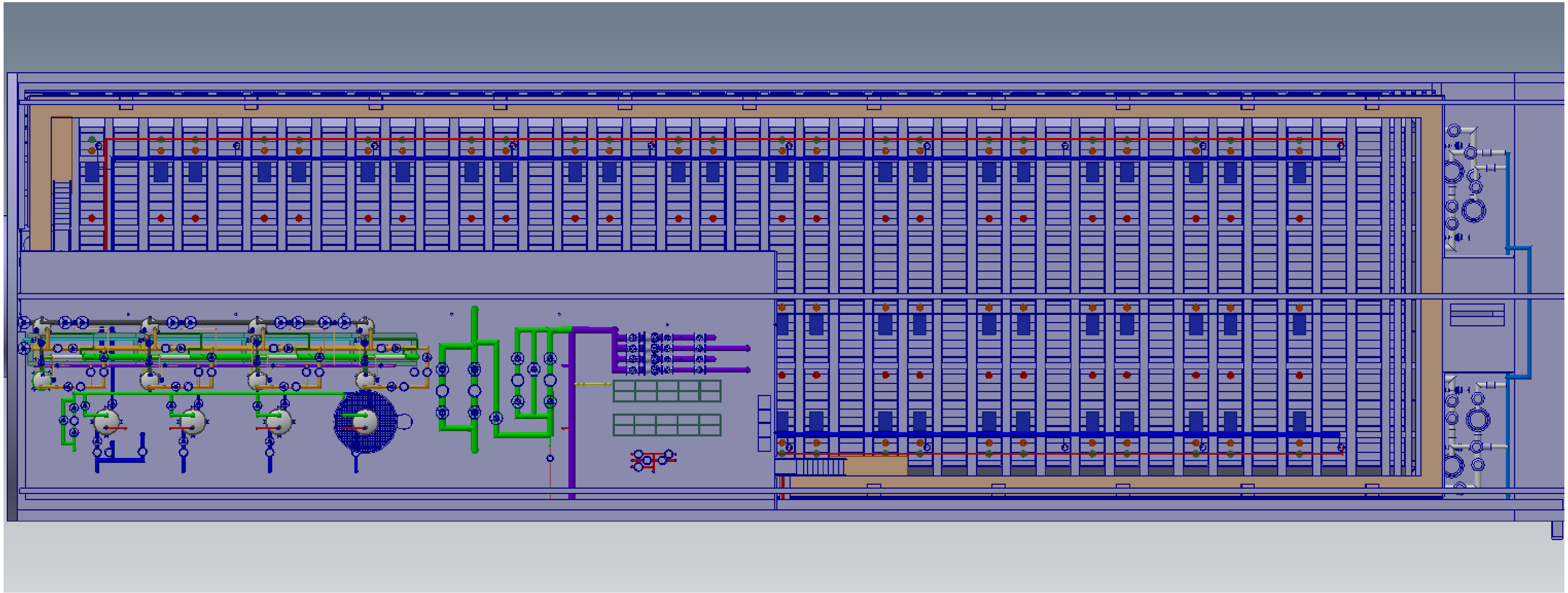
- TPC motions and dynamics. How to constrain and position. (continue work)
- Need to understand the routing and plans for cabling for SP. If lower APA cables will be routed through the upper APA or will they be routed up the side walls of the cryostat or.. (Evaluate mock up at BNL and determine if changes to the APA are required. Implications on installation.)
- Integrate and iterate cryogenic external and internal piping. (Mezzanine design, internal manifolds and spacing from detector)
- For all potential configurations, evaluate the thermal loss, LAr fluid dynamics, temperature gradients and LAr purity. (in progress)
- Understand the cryogenic monitoring system, calibration system, installation tooling, access requirements and infrastructure. (Continue to work with detector groups to develop requirements)
- Understand rack placement, cable placement and rack size requirements.
- Lift points for cryostat pieces, cryogenic equipment, detector components.

Back ups

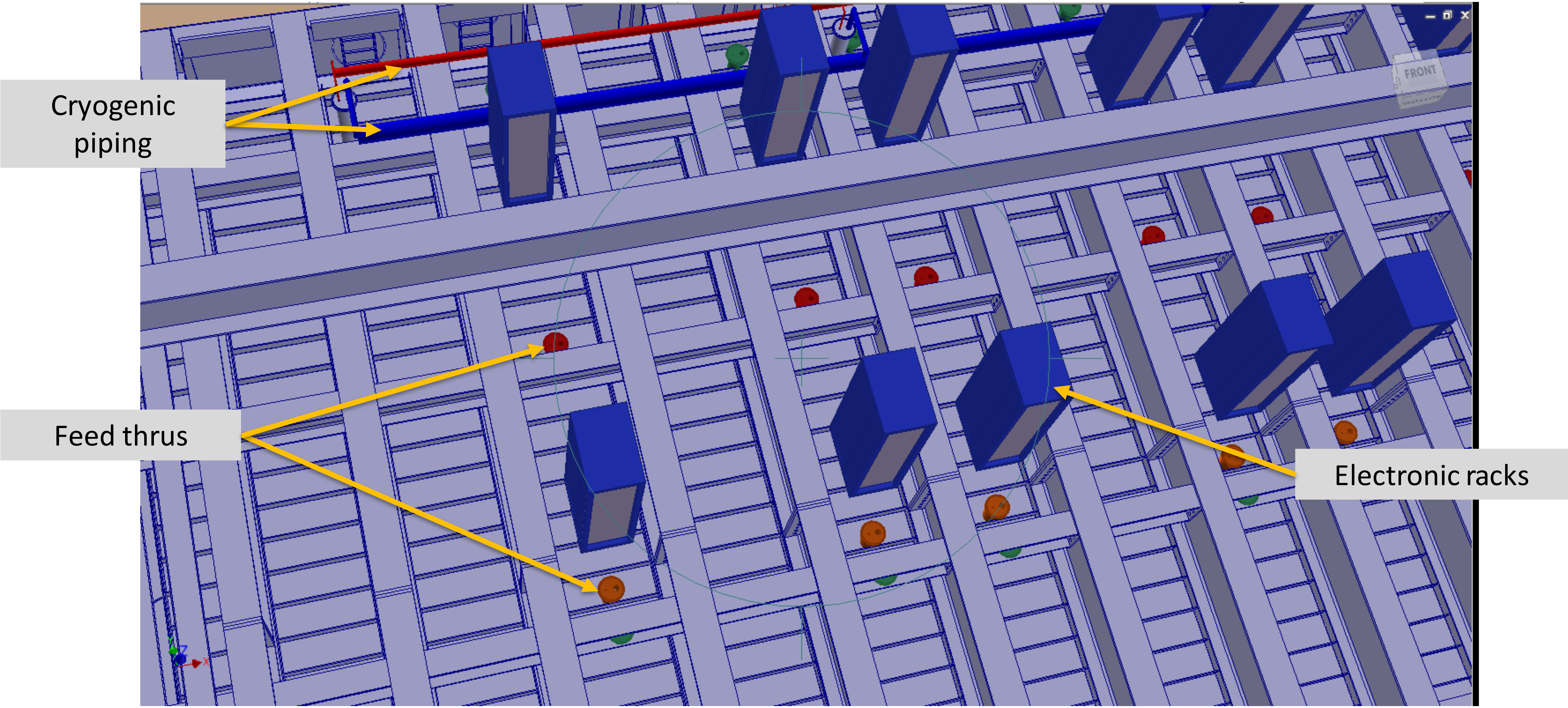
A first pass at defining feed thru locations

- Includes feed thrus for detector cables and support.
- Develop a common pattern to minimize versions of warm structure elements.

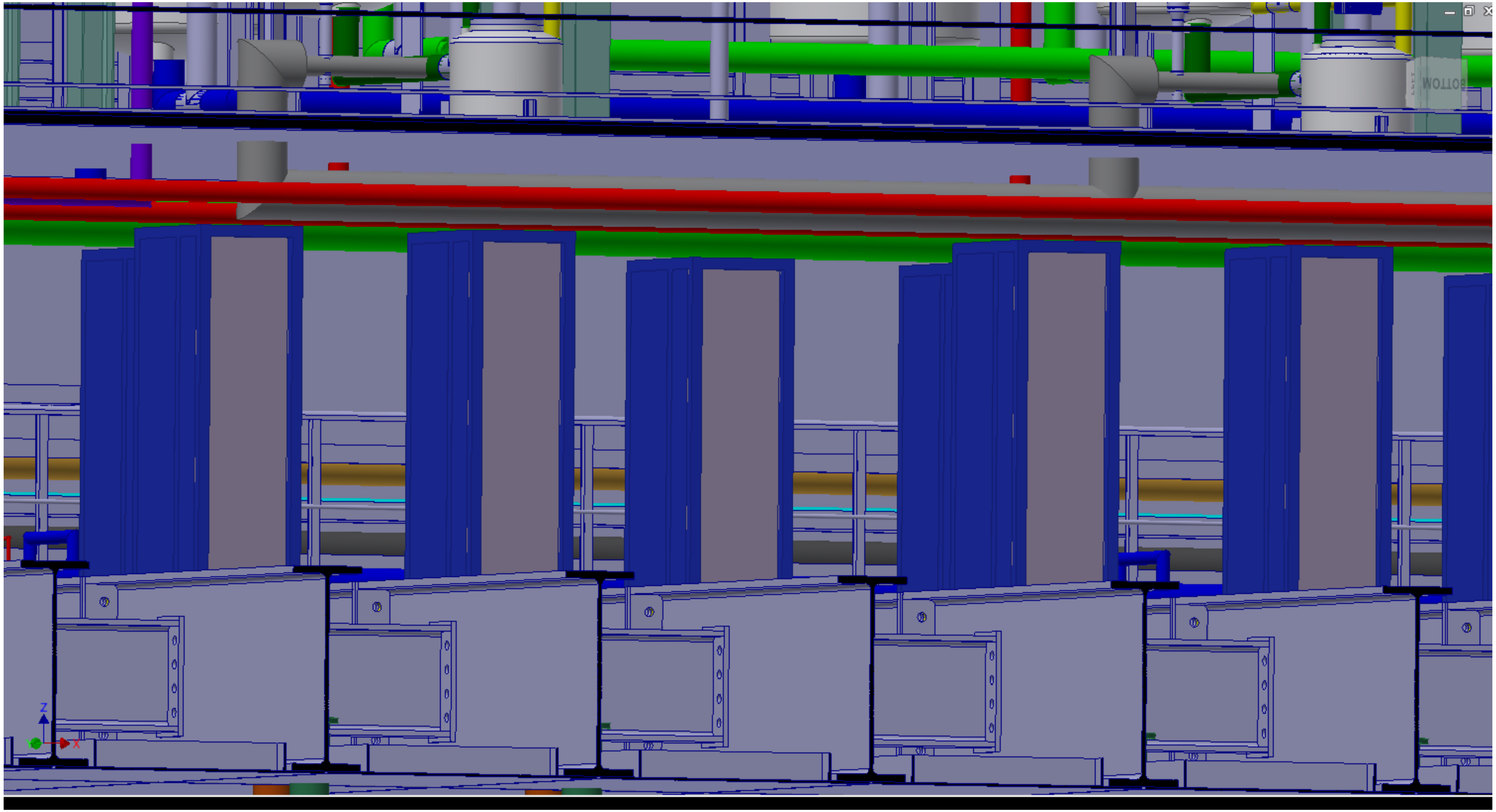
3D model of concept with cryogenics



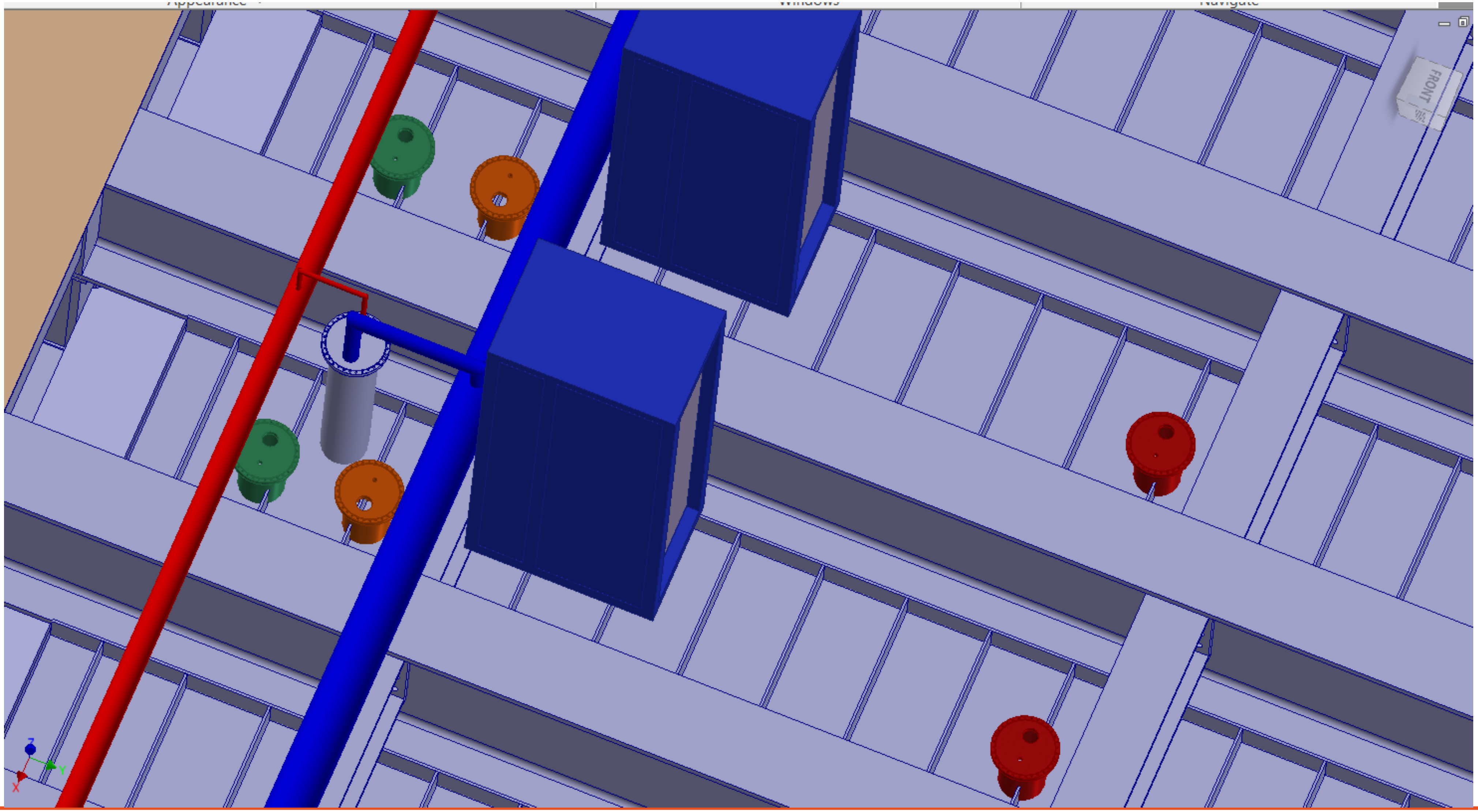
Inspection of clearance with cryostat structure



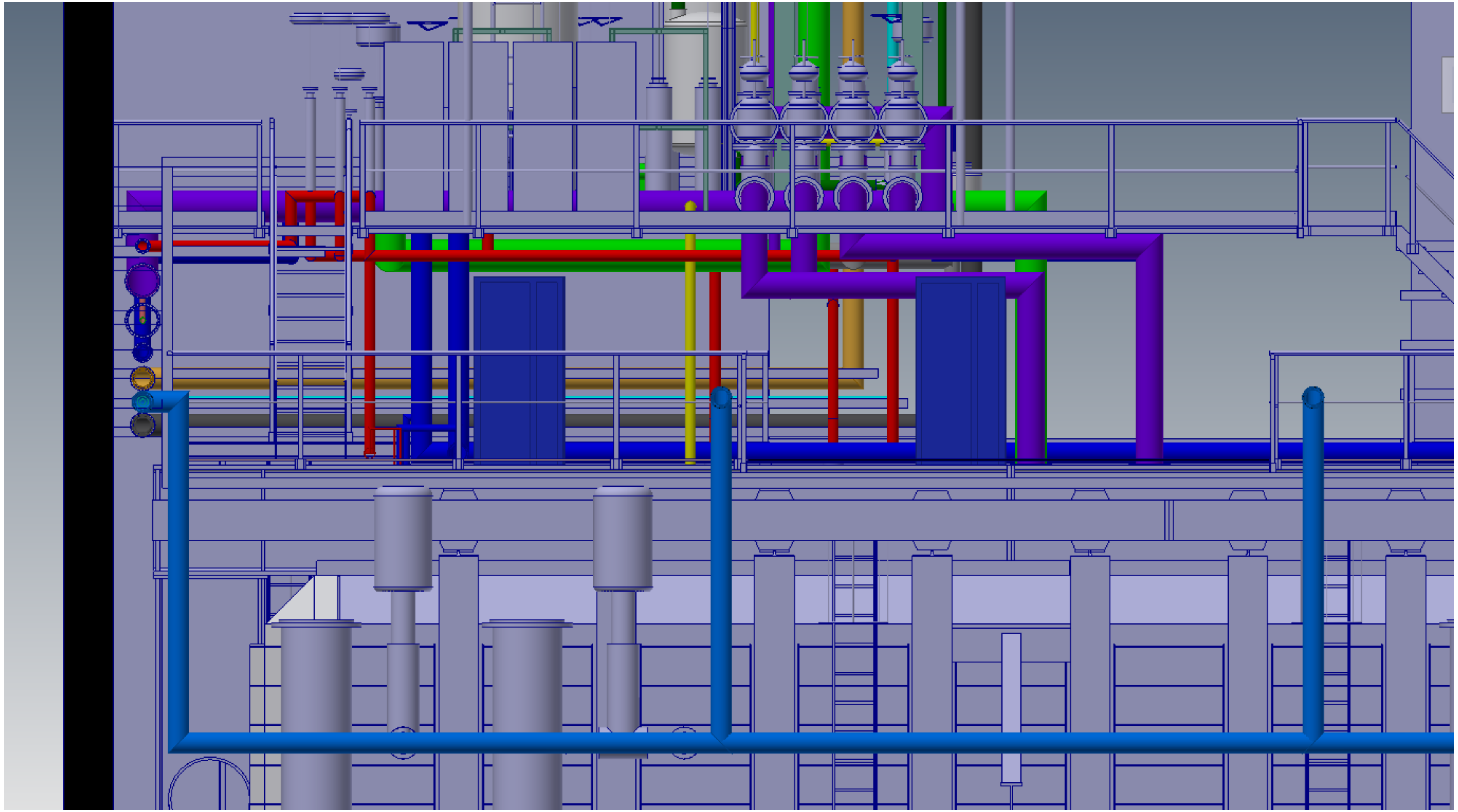
And proximity piping under mezzanine

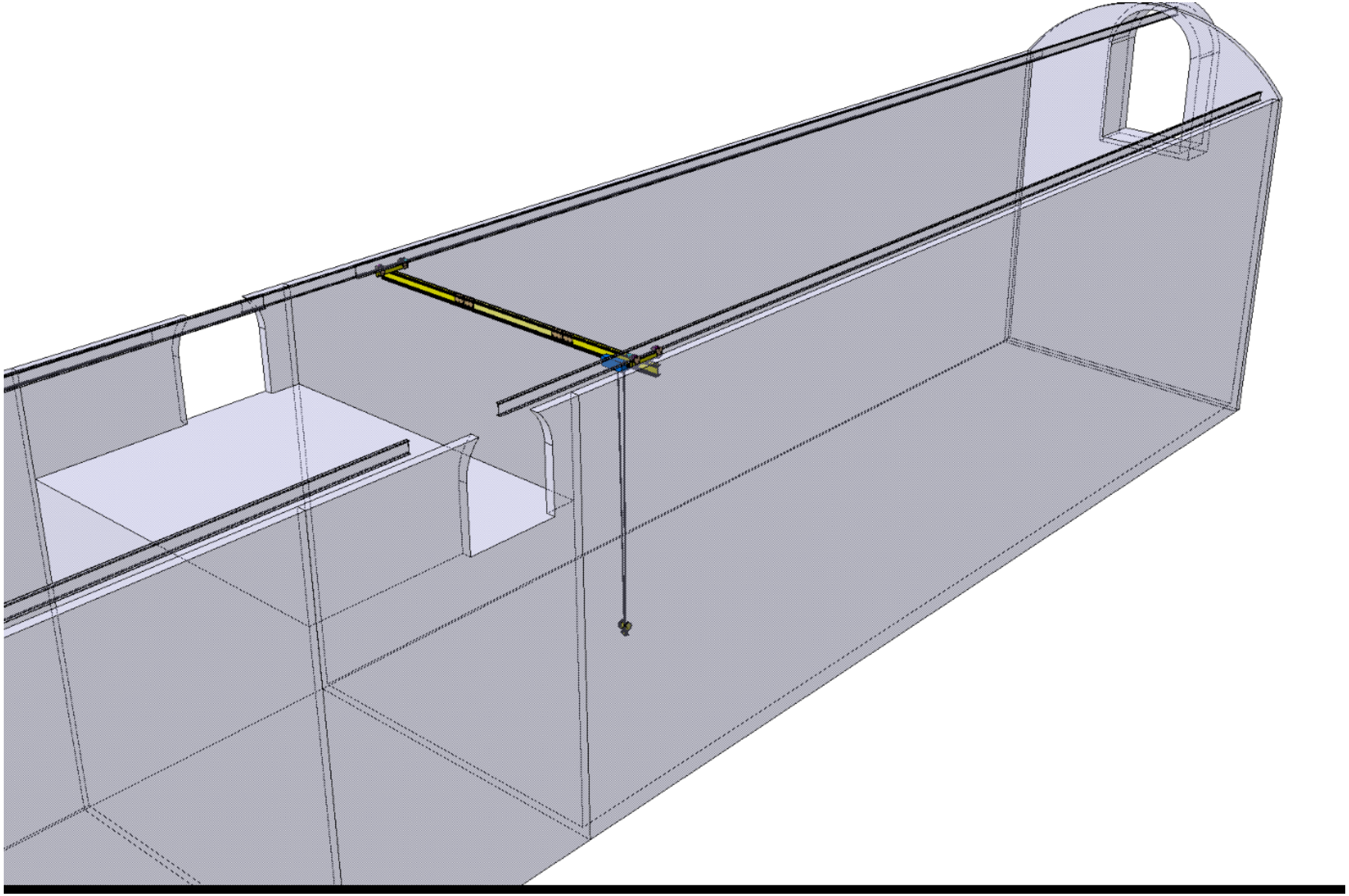


Interface with external cryogenic piping runs

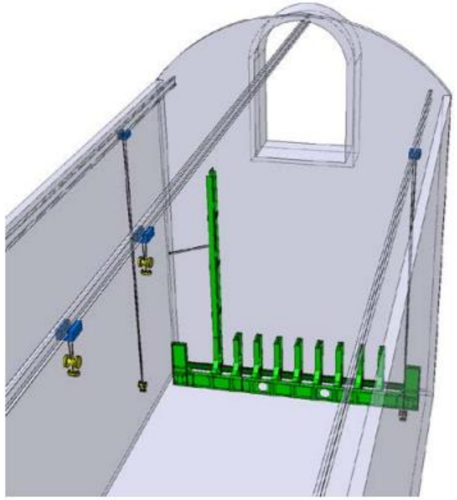


Elevation view east to west

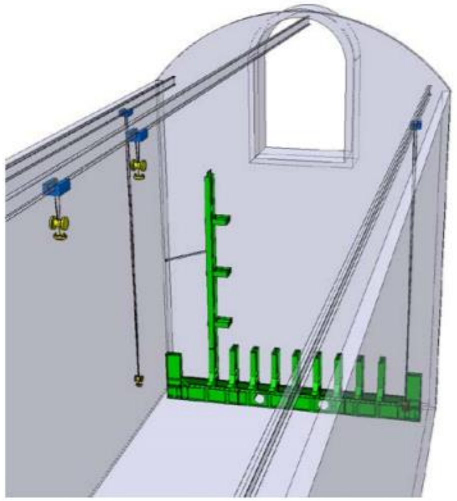




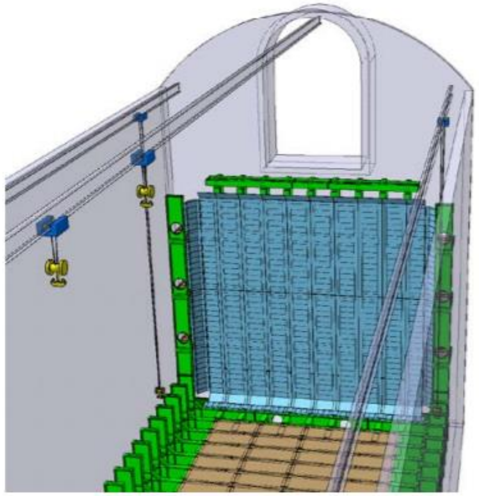
Example of beams to be installed in the cavern thanks to 3 rails



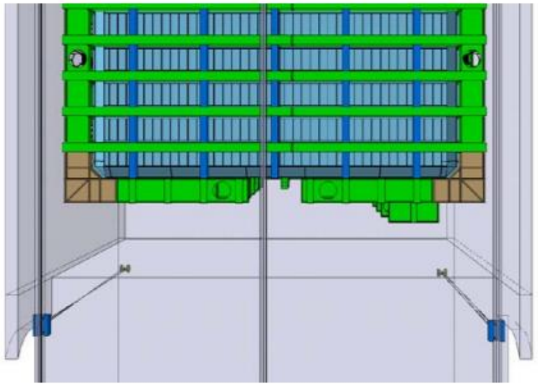
Step 8:
Small wall – 1st vertical beam



Step 9:
Small wall – 1st vertical beam spacers



Step 25: Warm membrane



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