DUNE Cable Routing

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Cold Electronics Mechanical Review

Feb 11th, 2019

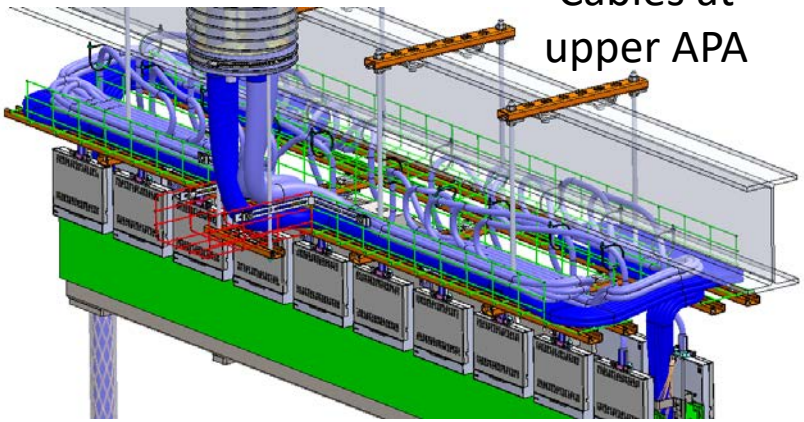
Requirements

- The cable trays need to support the majority of weight of the CE cold cables and the PDS cables.
- The cable tray system should be designed in such a way that it can be supported both by the APA yoke (while the APAs are in the integration area outside the cryostat and while the APAs are being moved to their final position inside the cryostat) and by the Detector Support System (DSS).
- The cable tray system should be designed in such a way that the cable left over in the cable trays after routing the CE and PDS cables through the cryostat penetrations and connecting them to the flanges is completely immersed in LAr, under the assumption that the LAr reaches a level of at least 95.5% of the total height inside the cryostat.
- The cable tray system should be designed in such a way that at least ~5 cm of space is left between the cable tray closest to the cryostat wall and the edge of the corrugation of the internal membrane of the cryostat.
- It should be possible to route the CE cold cables for the bottom APA through the frame tubes of both the bottom and top APA without damaging the cables. The bundle of cables for 10 APAs should fit within the cylindrical conduit of outer diameter 2.5” and wall thickness 0.035” that is inserted in the APA frame tubes.
- The CE cold cables for the bottom APA will be held by a restraint system at the head frame of the top APA. This restraint system shall be designed to avoid any slippage of the cables under their own weight, accounting for the shrinkage of the cables during immersion in LAr. The restraint system should not damage in any way the insulation of the cables.

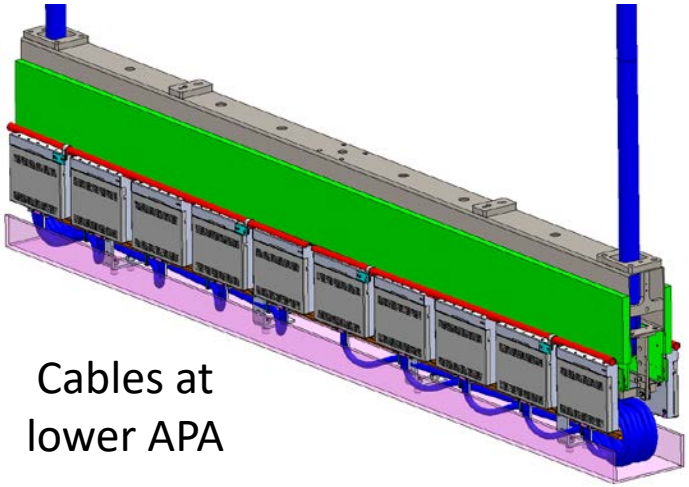
Requirements

- There should be a system to prevent the cables attached to the FEMBs on the bottom APA from dangling and possibly entering in contact with the surface of the cryostat. This system should contain the slack of the CE cold cables.
- The CE cold cables for the bottom APA should be installed leaving sufficient slack to compensate for the cable shrinkage when the cryostat is filled with LAr. The cables should be able to move freely within the conduit inserted in the APA frame such that no additional tension on the cable arises when the cryostat is filled with LAr.
- The slack for the cables on the top APA should be accommodated on the cable trays installed on the top APA.
- The cable trays and support systems should be designed to allow the cables to have bending radiuses that are larger than the minimal bending radius specified by the corresponding vendors.
- The cable trays should be designed in such a way that no torque is applied on the APA yoke after the APAs have been placed in their final position and the CE and PDS cables have been routed through the cryostat penetrations and attached to the corresponding strain relief systems.
- The cable trays and support systems should be designed to accommodate the eventual slack of the CE and PDS cables, including the slack necessary to allow for the shrinking of cables that occurs when the cryostat is filled with LAr.

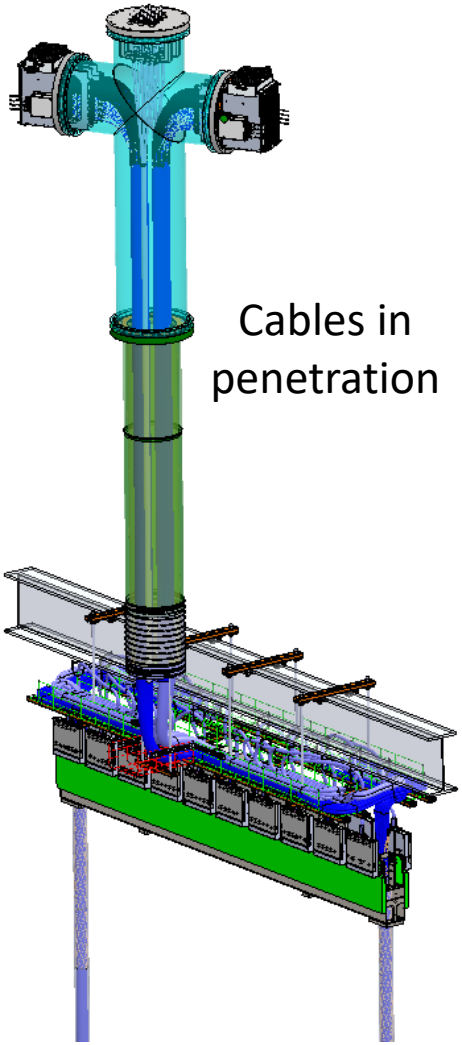
Overview of CE cabling



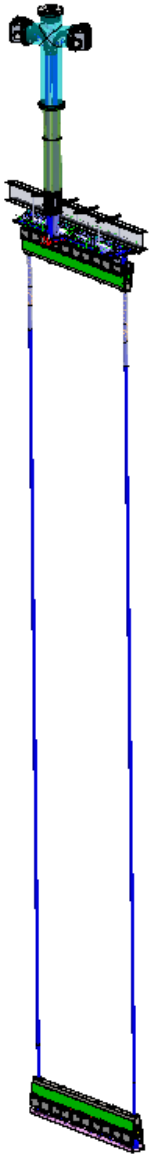
Cables at upper APA



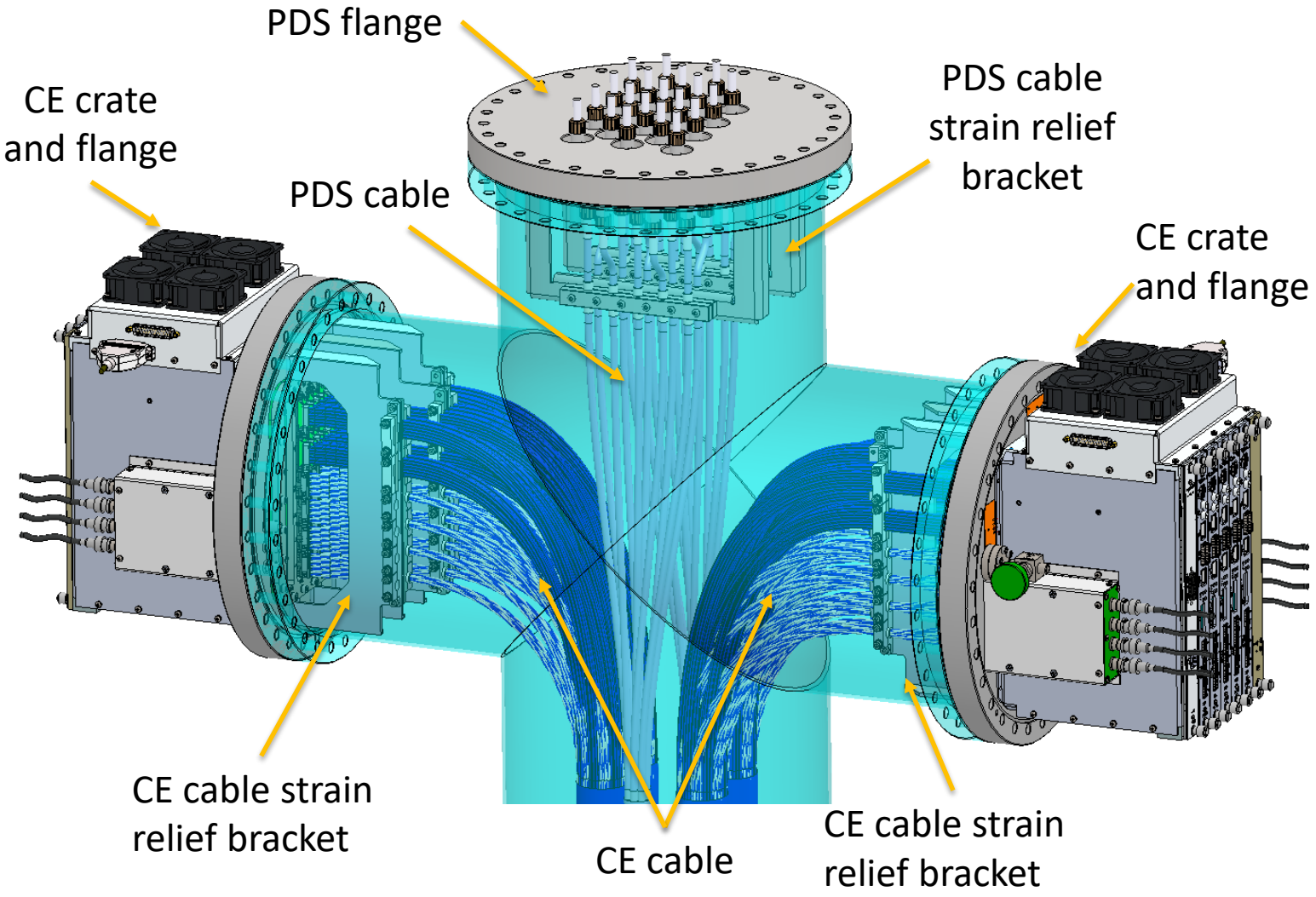
Cables at lower APA



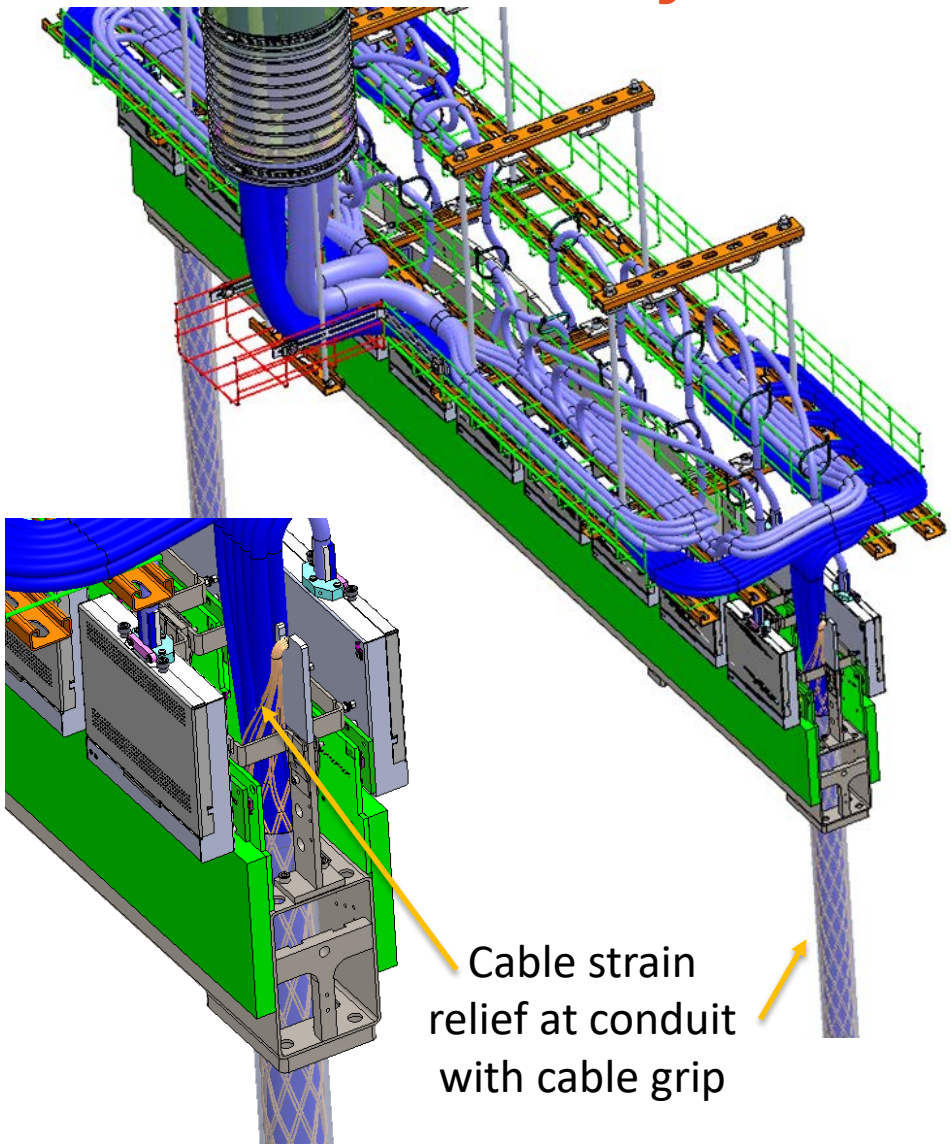
Cables in penetration



Cable connection to flanges and strain relief



Cable in cable trays and strain relief

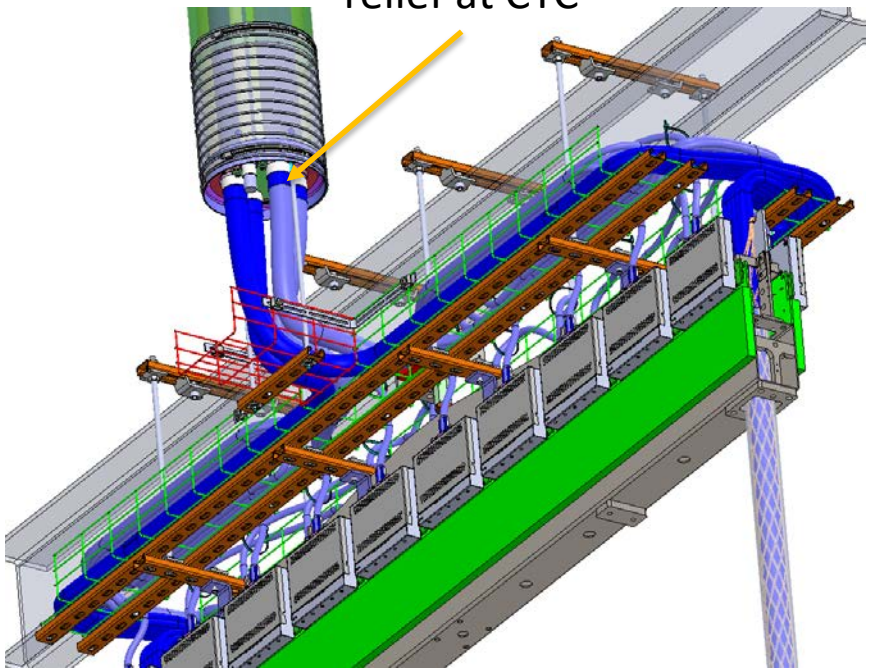


Light blue:

cables from upper APA

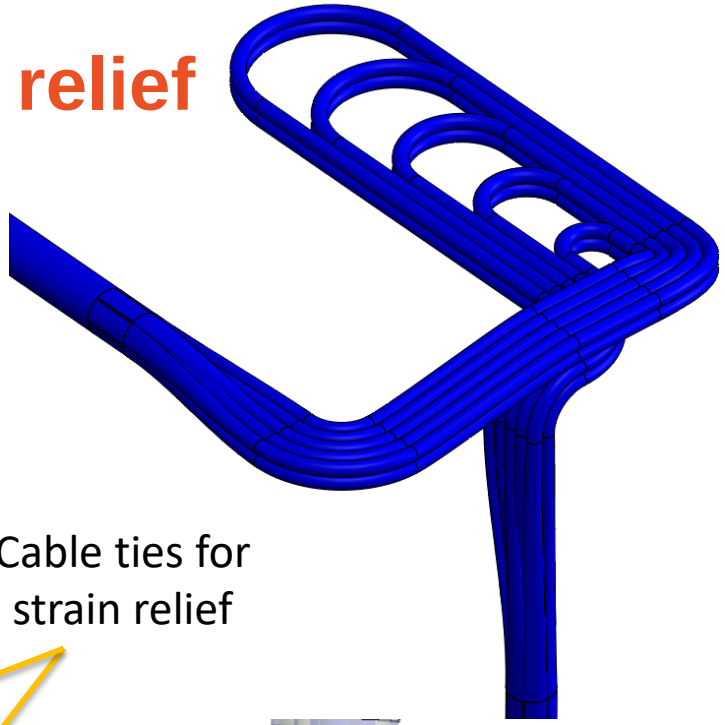
Blue:

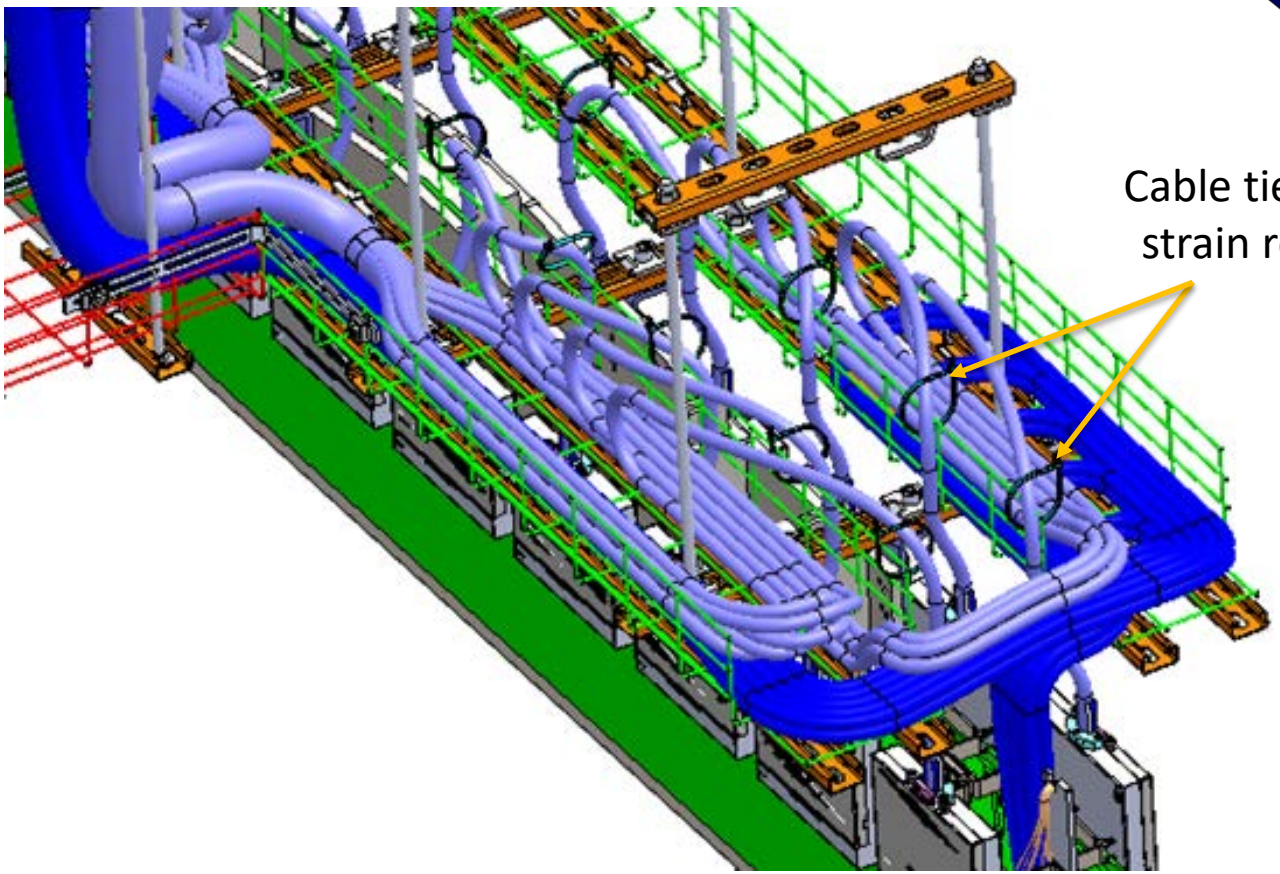
cables from lower APA



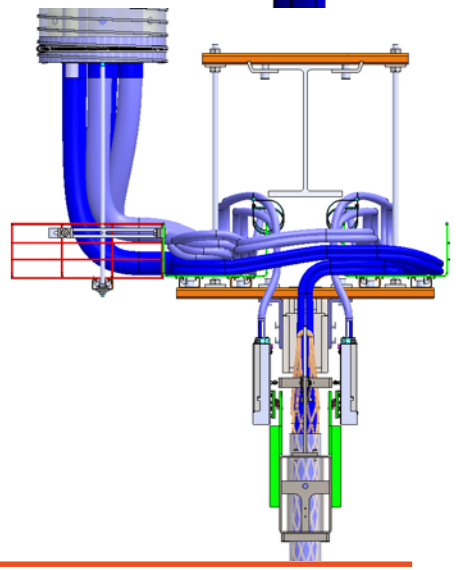
Cable in cable trays and strain relief

Cable arrangement in cable tray delivers differential cable lengths for CE boxes mounted on the lower APA.

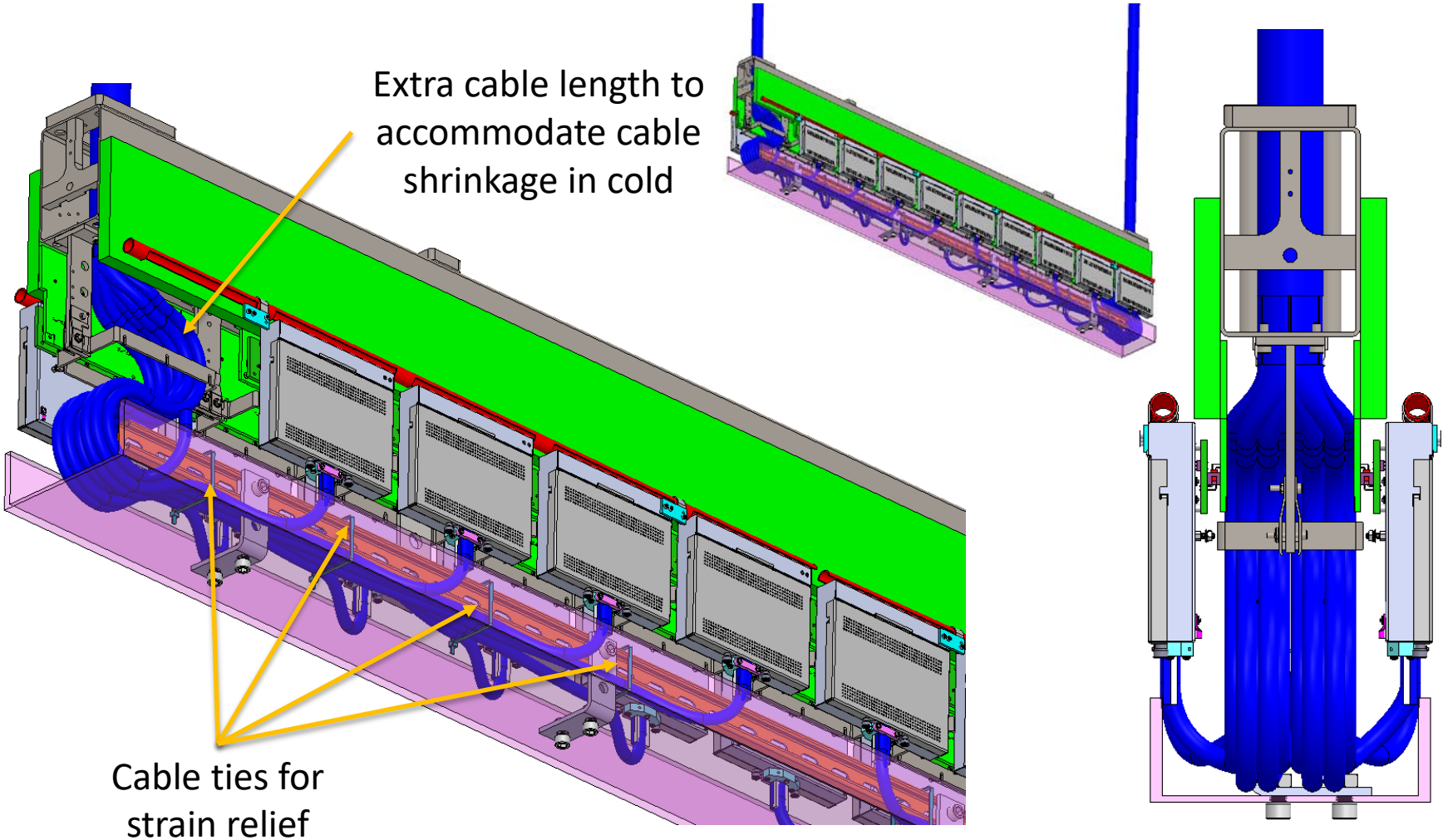




Cable ties for strain relief



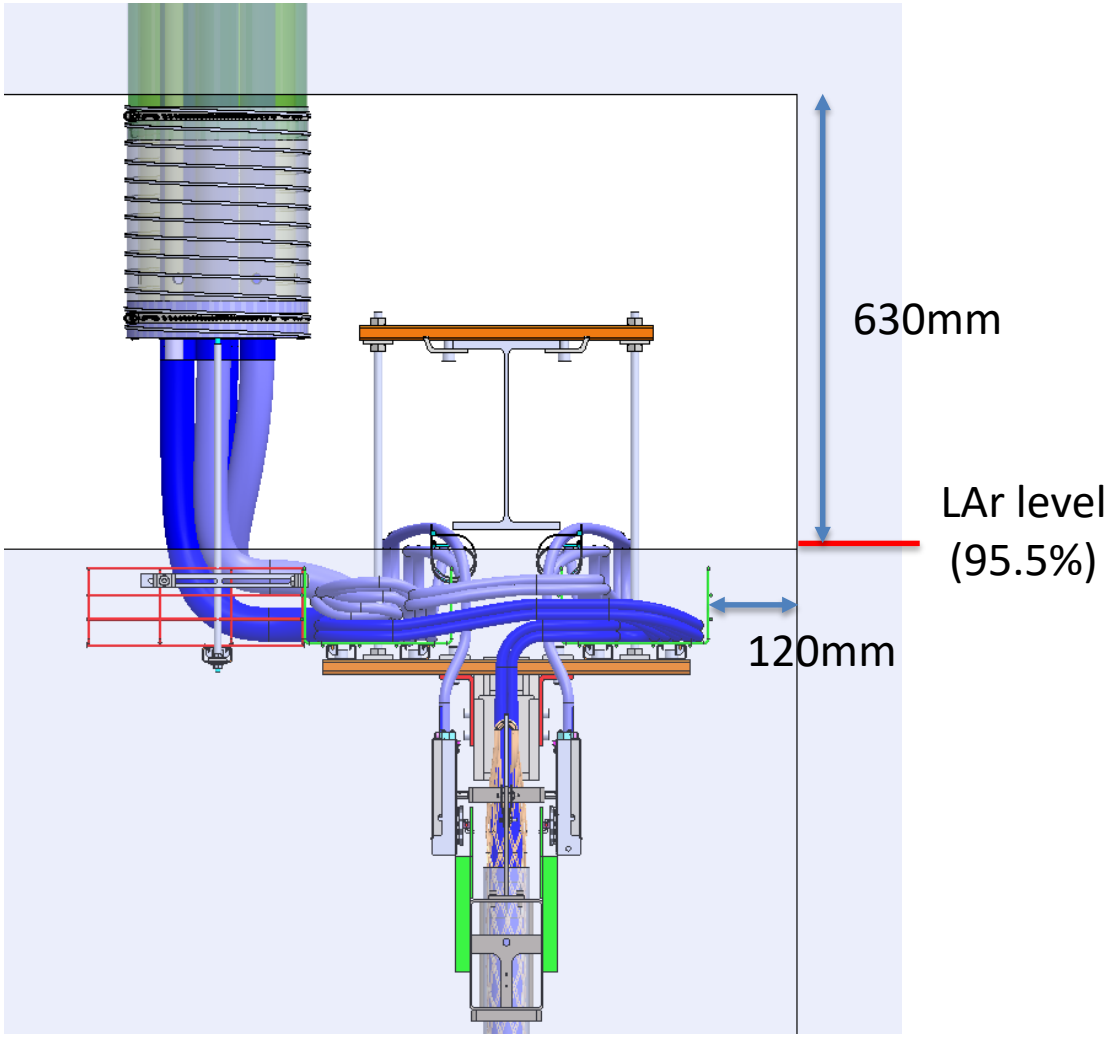
Cabling at lower APA



LAr level

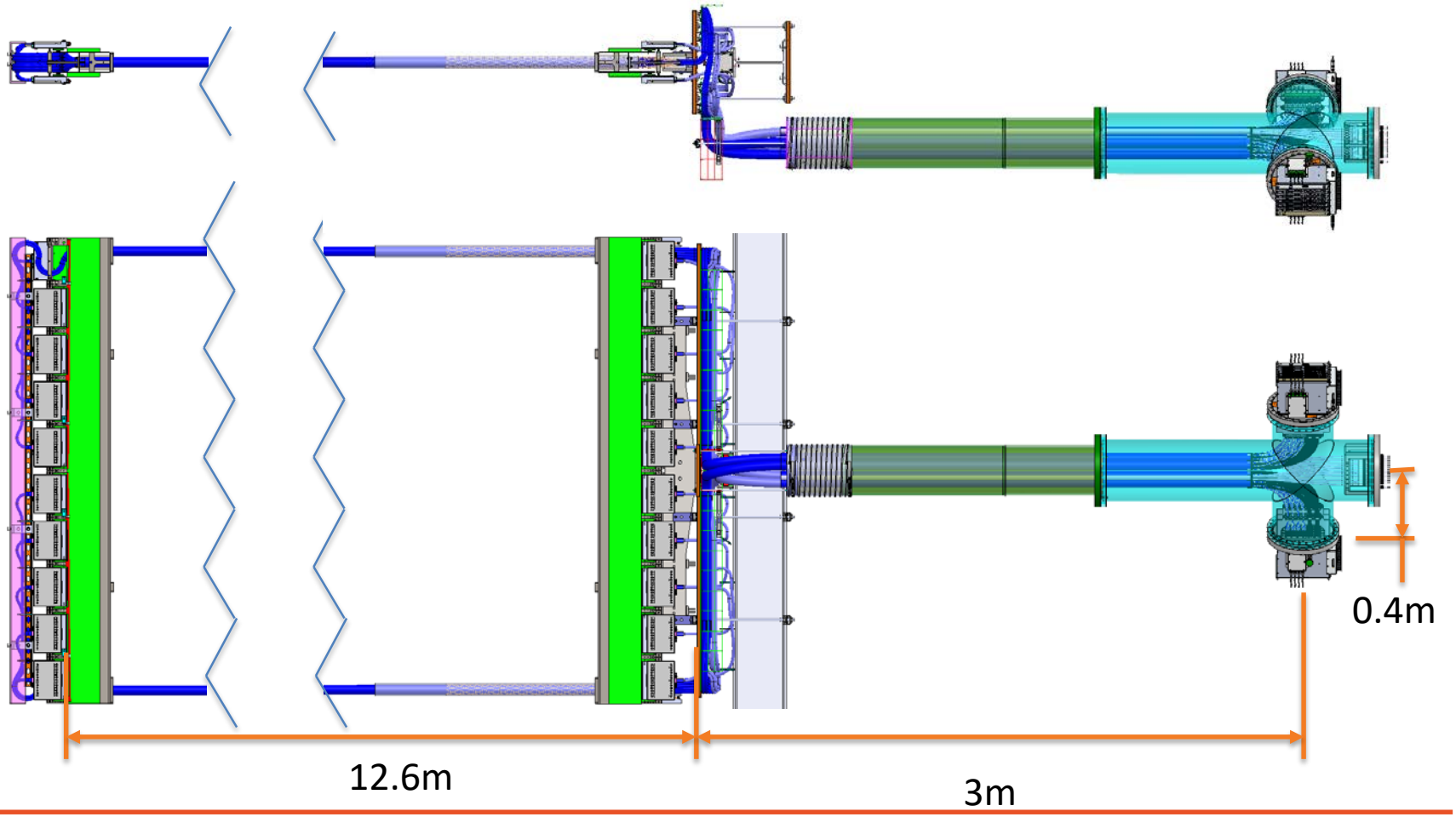
Assume LAr filled to 95.5% of the total height inside the cryostat.

Cable in the cable trays is completely immersed in LAr.



Cable length

Length of upper APA cables laid in cable tray = 3m
Length of lower APA cables laid in cable trays = 3.6m



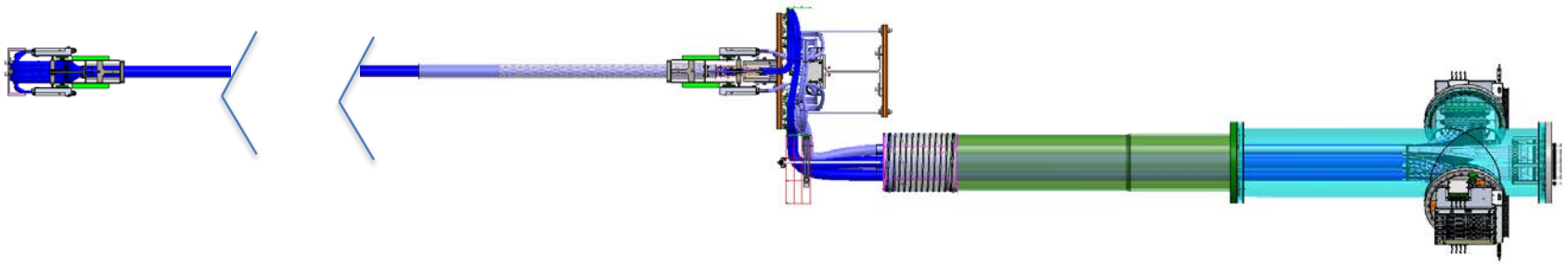
Cable length

Total cable length for upper APA = 3.4+0.3+3+1.6 = 8.3m (9m)

Length from CE flange to upper cable tray	3.4 m
Extra length for CE crate installation	0.3 m
Length of cables in upper cable tray	3 m
Max offset between APA and FT port	1.6 m

Total cable length for lower APA = 3.4+0.3+3.6+12.6+1.6 = 21.5m (22m)

Length from CE flange to upper cable tray	3.4 m
Extra length for CE crate installation	0.3 m
Length of cables in upper cable tray and lower Unistrut beam	3.6 m
Length in cable conduit	12.6 m
Max offset between APA and FT port	1.6 m



Finite Element Analysis of Cable Tray Support

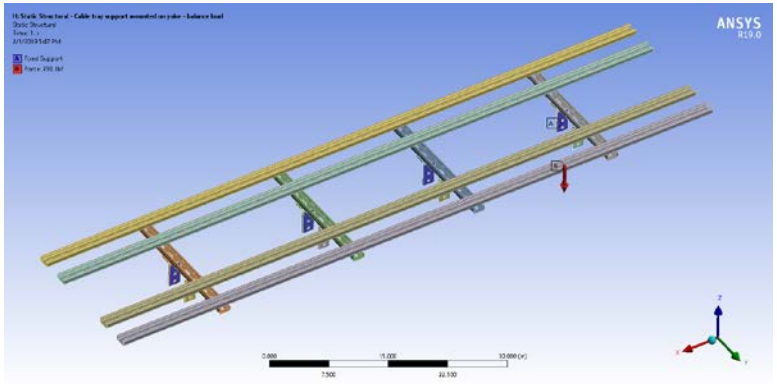
Total cable weight supported by the cable tray assembly: ~ 120 Kg.

Two mounting configurations:
(1) cable tray assembly mounted on the yoke and
(2) cable tray assembly supported by the DSS.

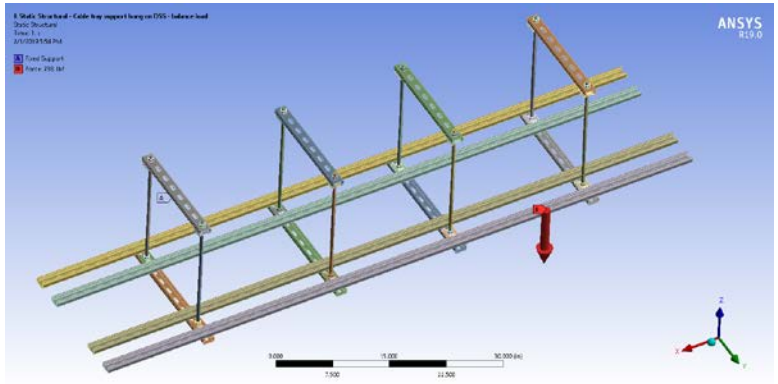
Stainless Steel 304	
Density (kg/m^3)	8000
Modulus of Elasticity (GPa)	193
Poisson Ratio	0.29
Yield Strength (MPa)	215

Two loading scenarios:
(a) cables placed in both front cable tray and back cable tray equally
(b) all cables placed on a single cable tray.

Cable trays supported on yoke

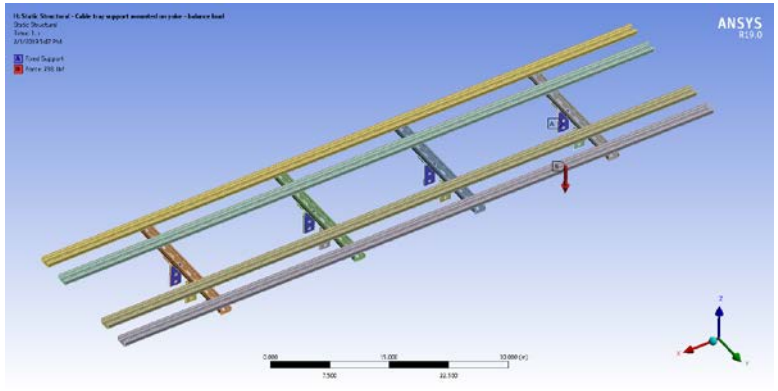


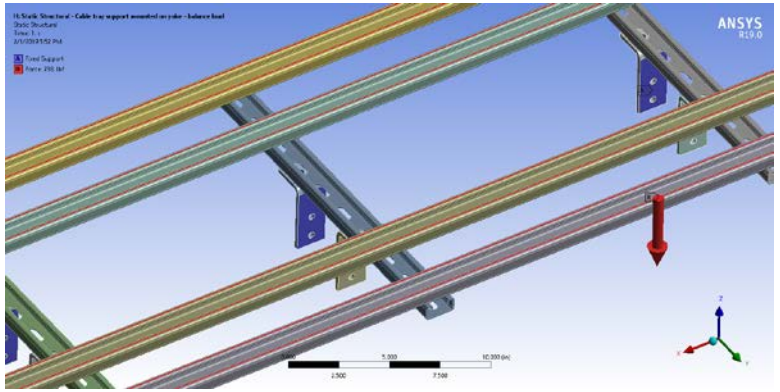
Cable trays supported on DSS

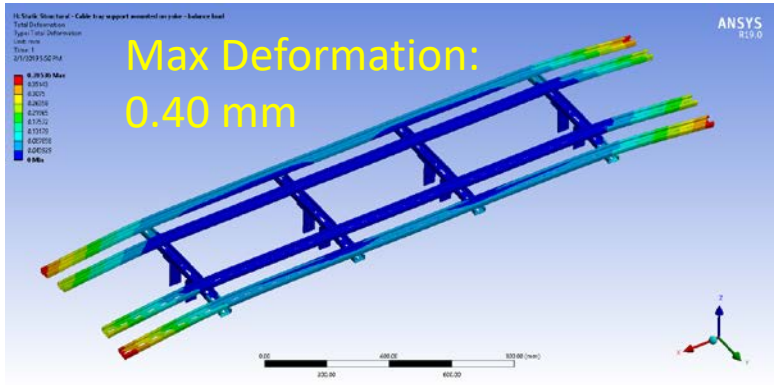


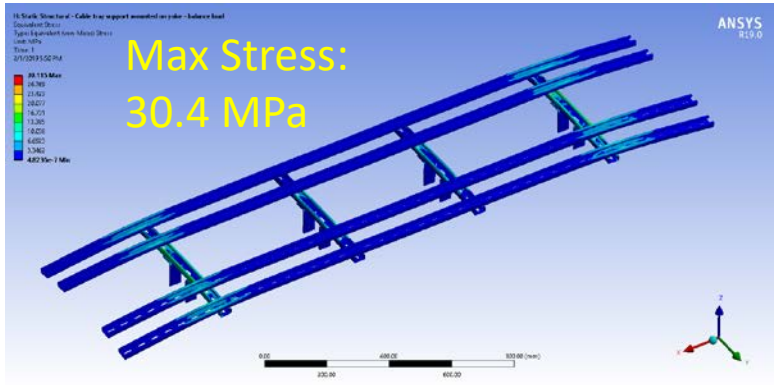
Finite Element Analysis of Cable Tray Support (1a)

Cable trays supported on the yoke – Cables in both cable trays





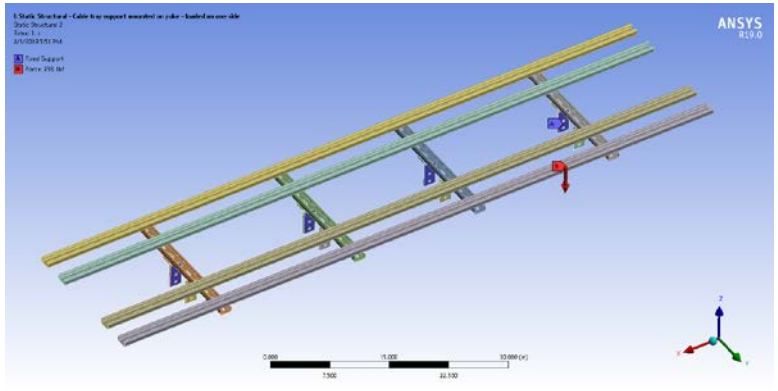


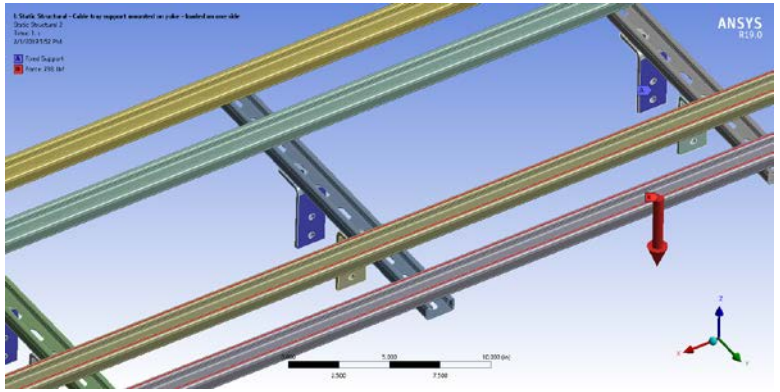


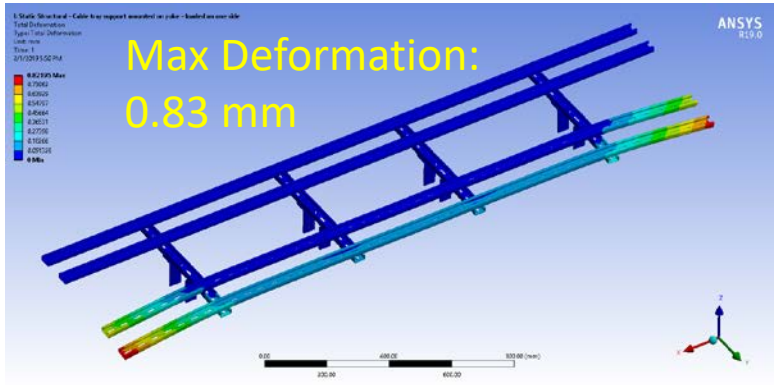
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 1(a) Cable on both cable trays	0.40	30.4	7.1

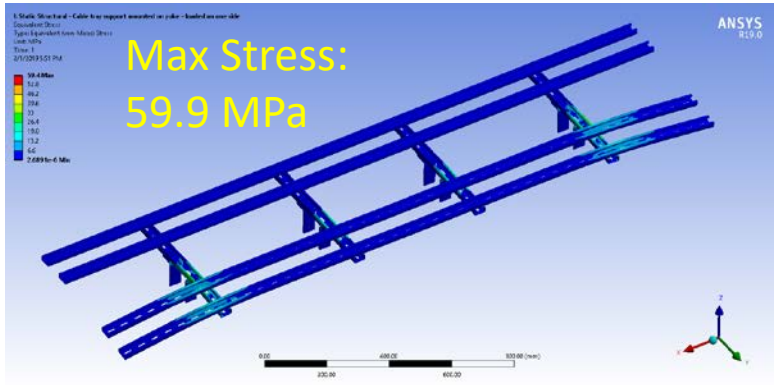
Finite Element Analysis of Cable Tray Support (1b)

Cable trays supported on the yoke – Cables in one cable tray









	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 1(b) Cable on one cable tray	0.83	59.9	3.6

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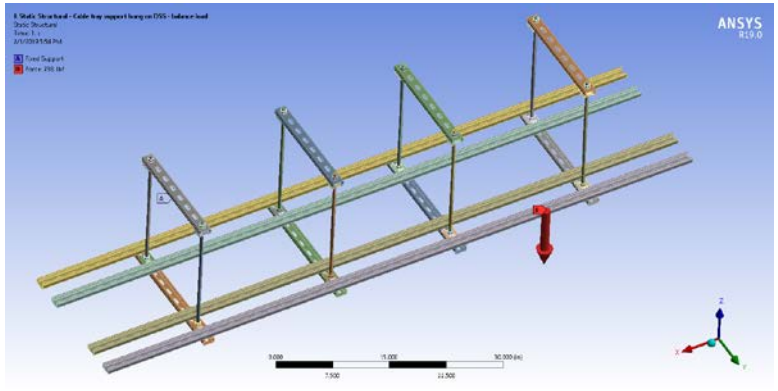
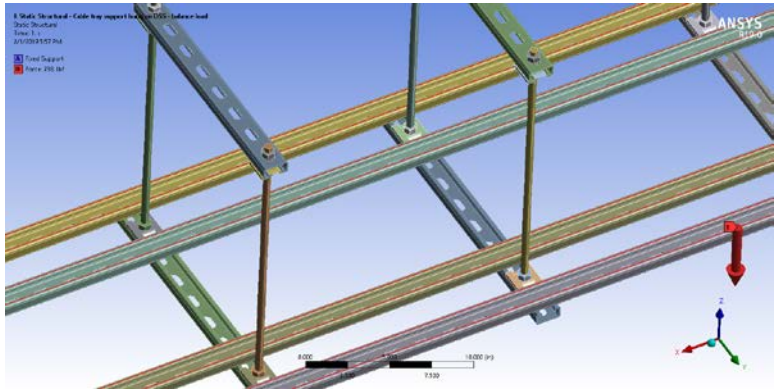
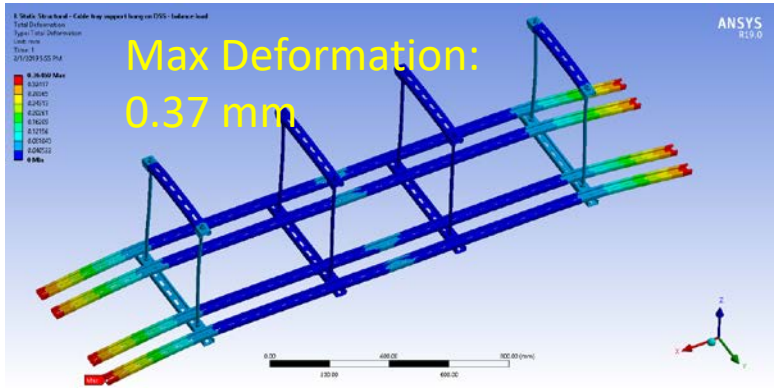
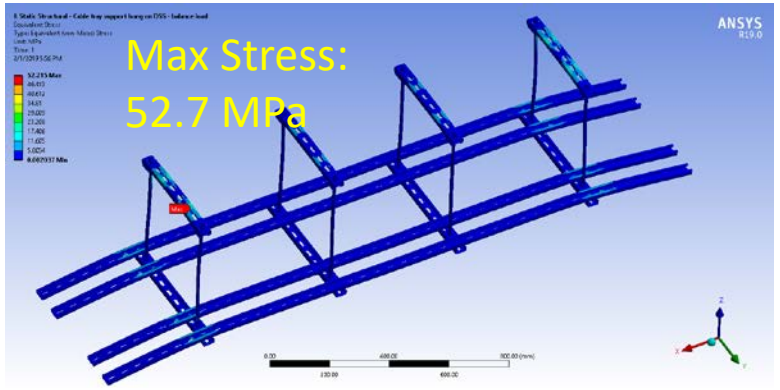
Finite Element Analysis of Cable Tray Support (2a)

Cable trays supported on the DSS – Cables in both cable trays





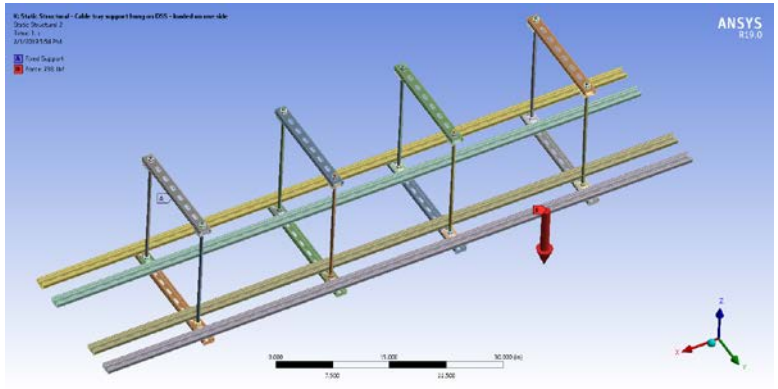


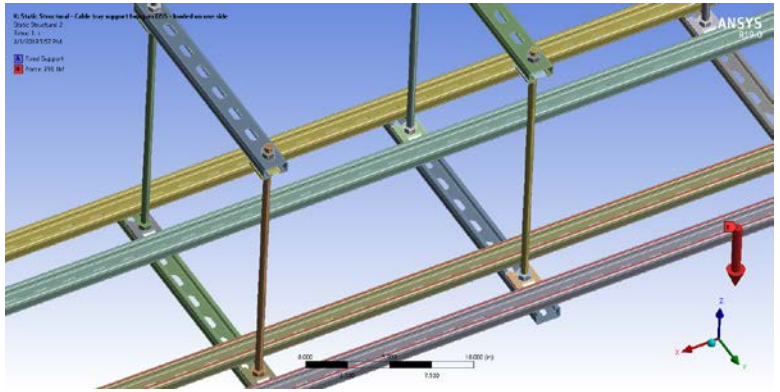


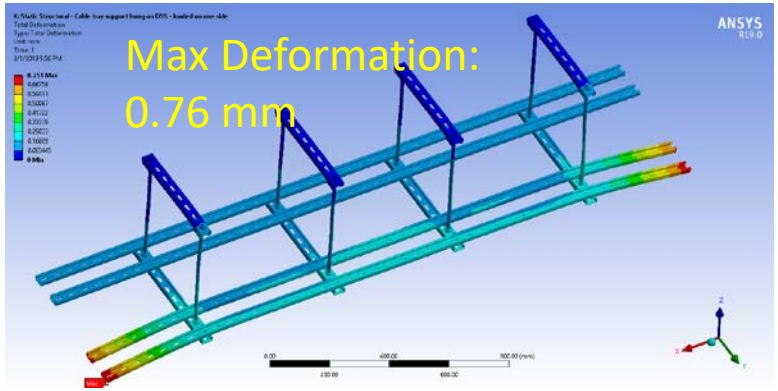
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 2(a) Cable on both cable trays	0.37	52.7	4.1

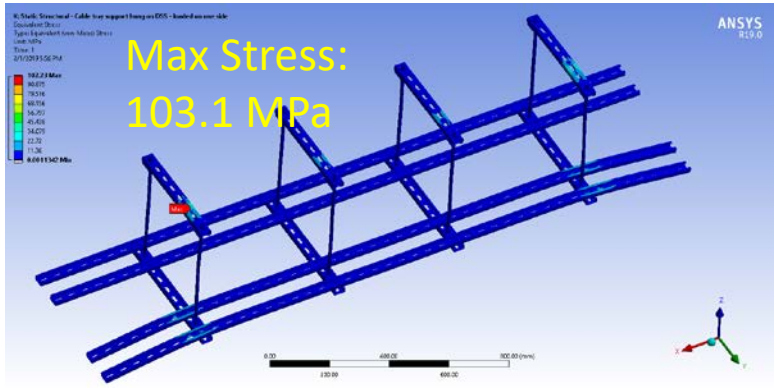
Finite Element Analysis of Cable Tray Support (2b)

Cable trays supported on the DSS – Cables in one cable tray









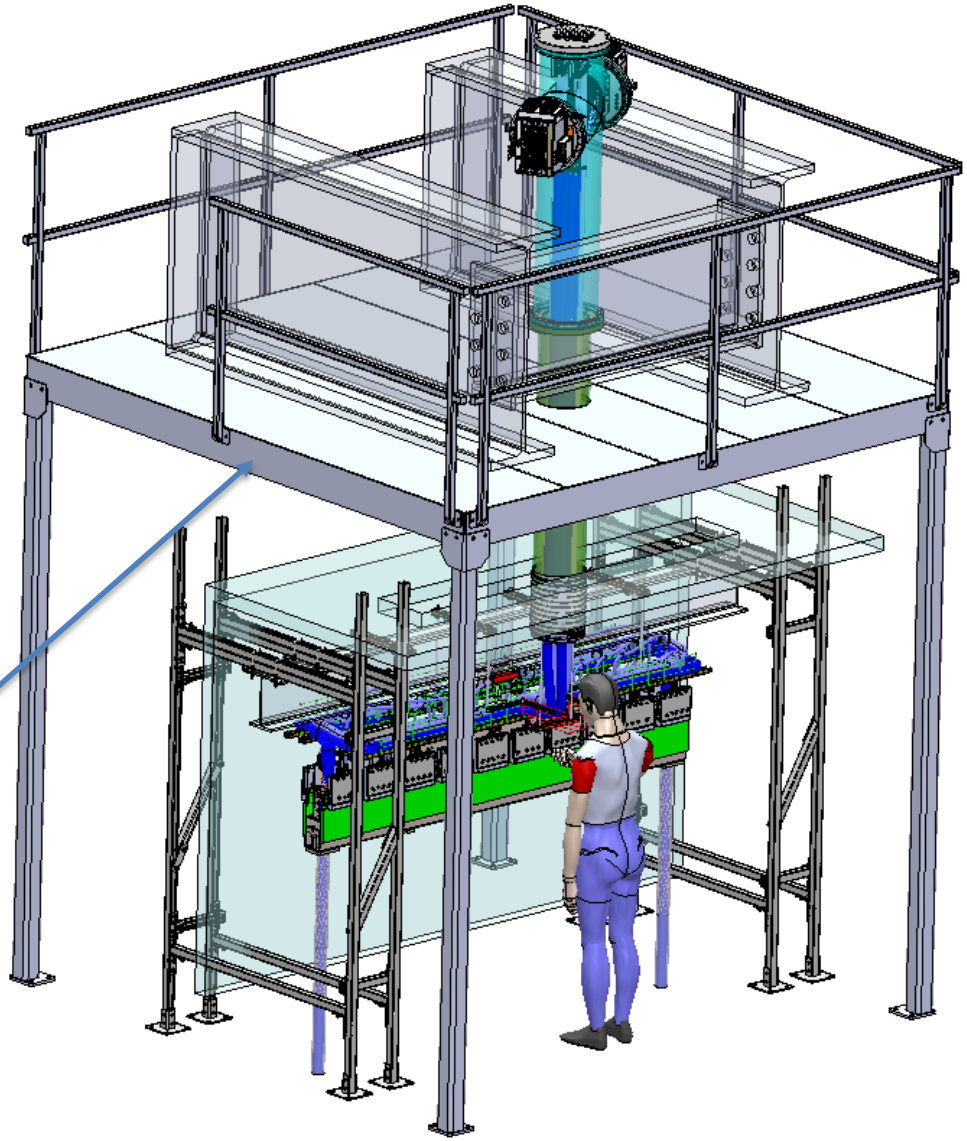
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 2(b) Cable on one cable tray	0.76	103.1	2.1

Mockup of cabling from upper APA to feedthrough port

Goals:

- Practice feedthrough installation
- Practice CE box installation
- Practice CE crate installation
- Practice cable routing
- Identify potential interface issues
- ……

Commercial mezzanine
10’x10’x10’
(stairs not shown)



Thank You!