

Updates on CE Mechanical Design

Manhong Zhao

8-9-2021

SP TPC Electronics Consortium Meeting

Content

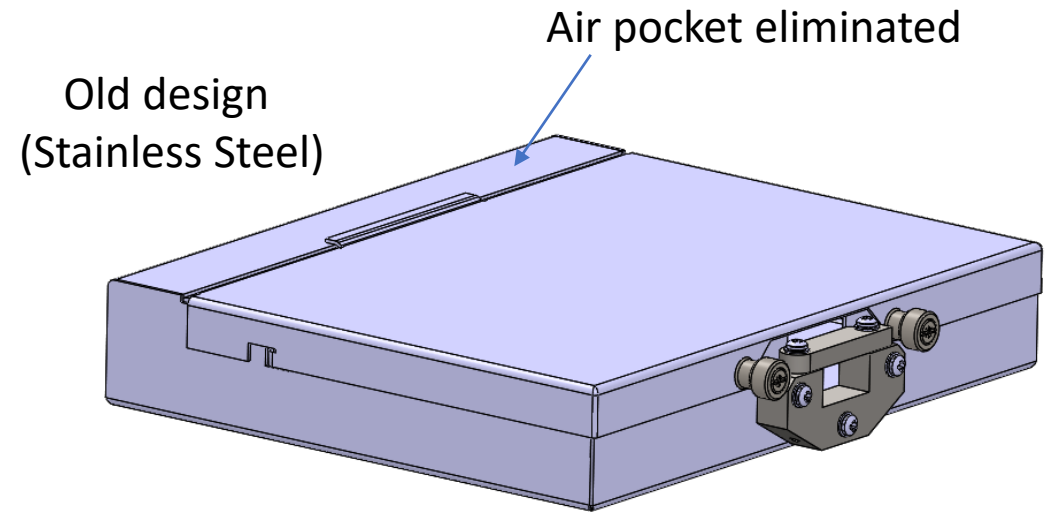
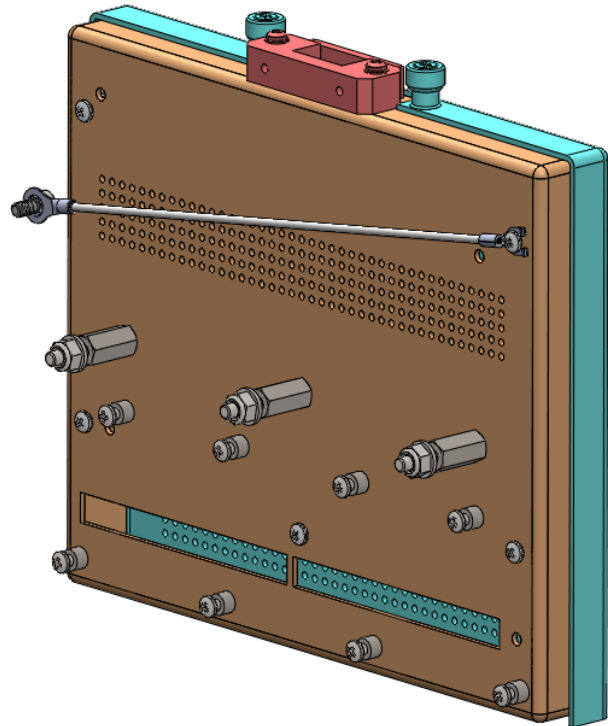
- Updates on CE box design
- Updates on feedthrough design
- Updates on cable tray system design

Updates on CE Box Design

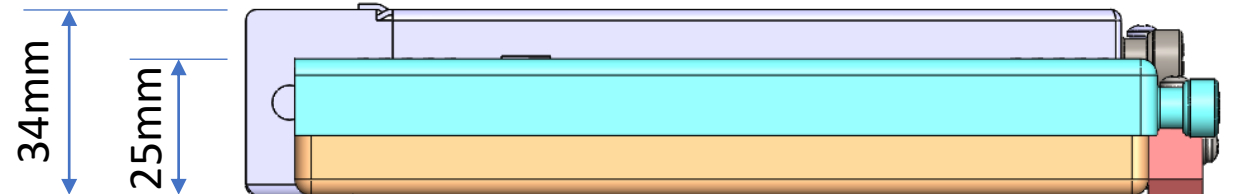
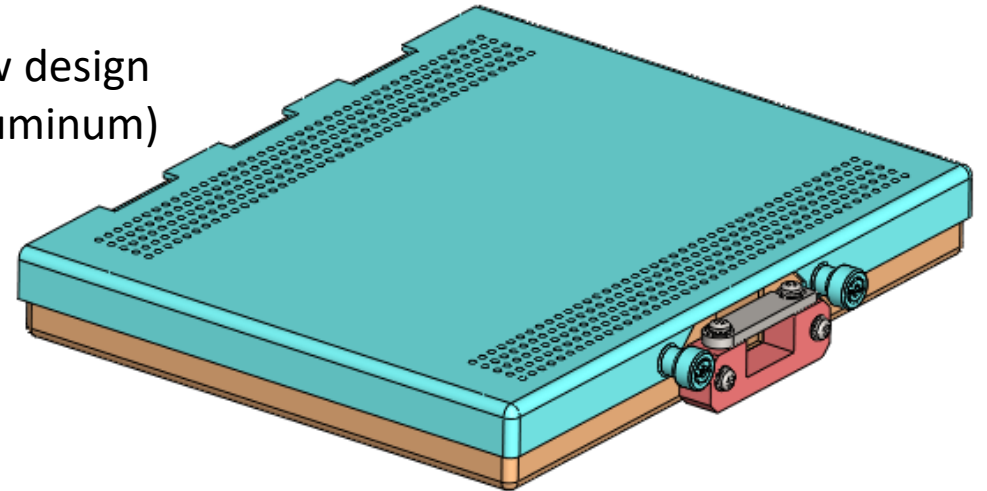
New CE box design is thinner (34mm -> 25mm) and ~50% lighter.

Air pocket eliminated.

Compatible with both FD1-HD APA and FD2-VD bottom CRP.

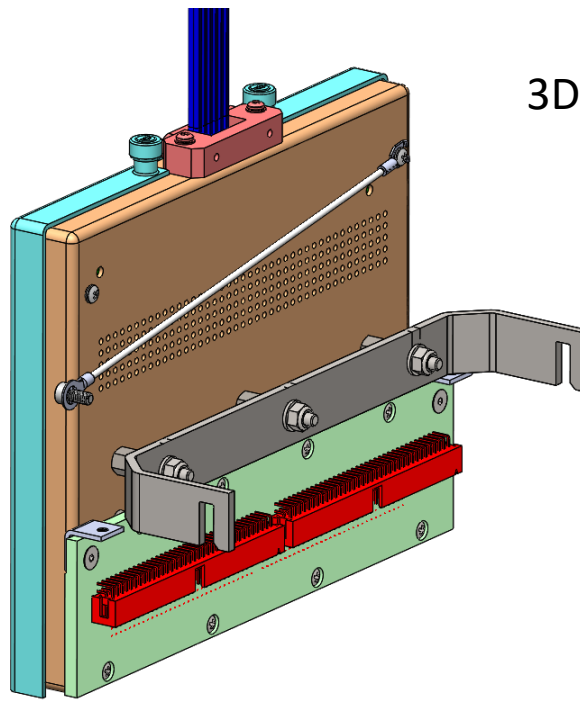


New design (Aluminum)

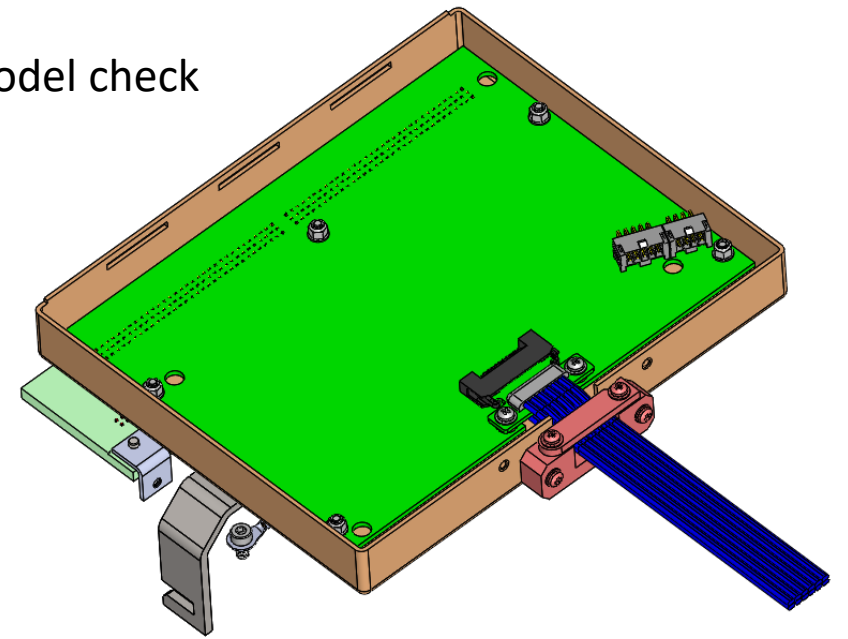


Updates on CE Box Design

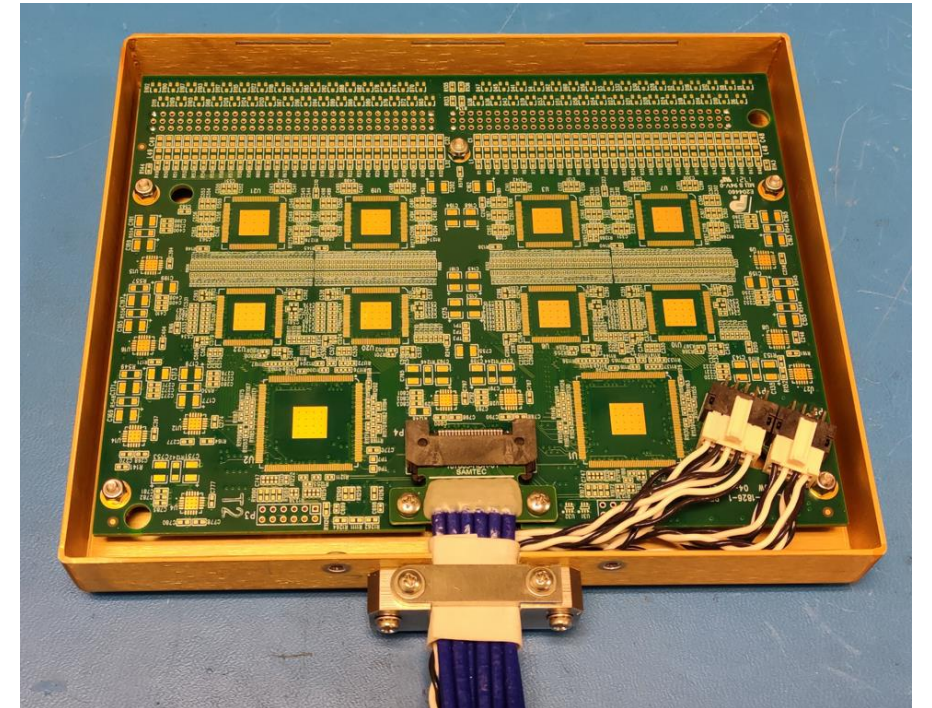
Fit check in 3D model and prototype.



3D model check



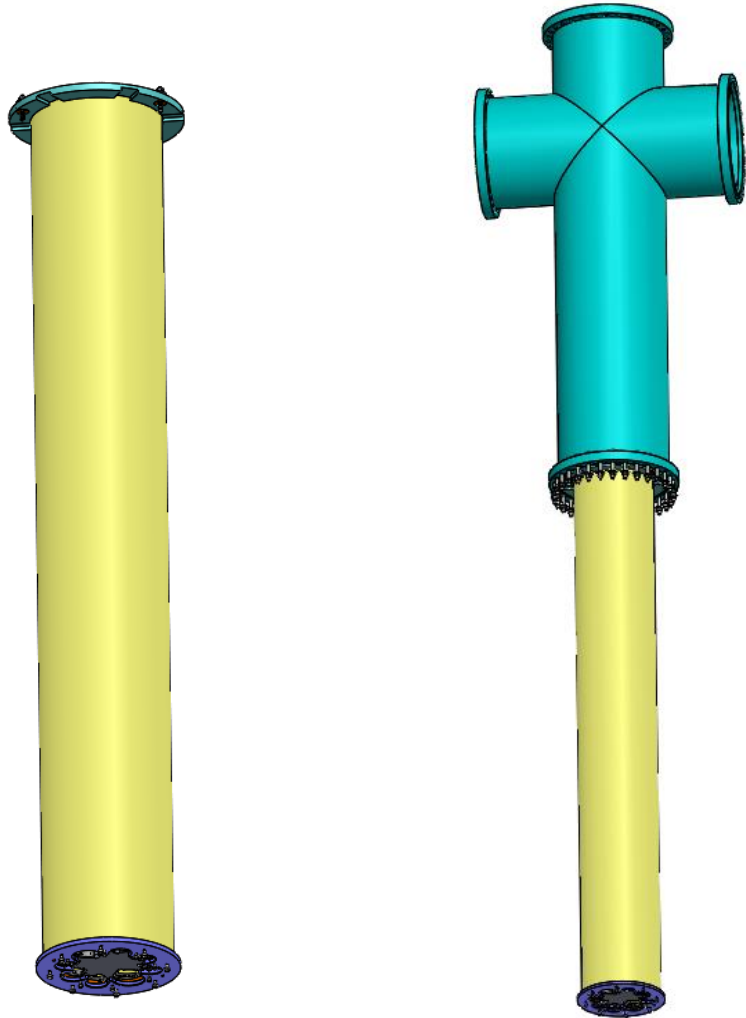
Prototype



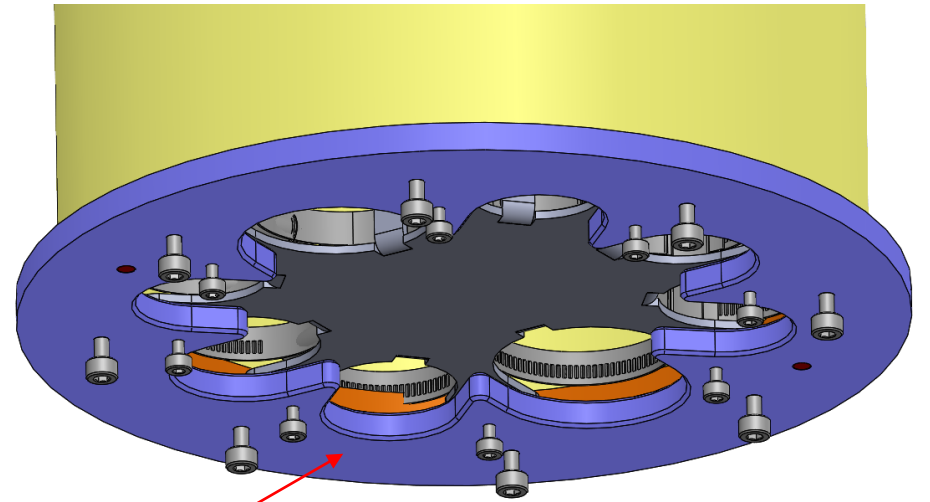
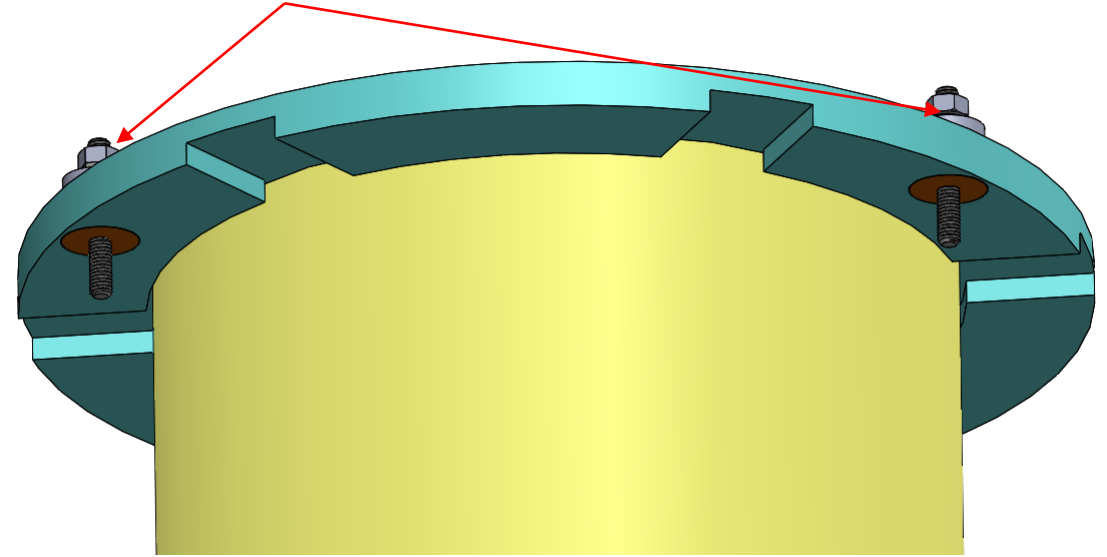
Updates on Feedthrough Design

Added features for tube concentricity adjustment.

Improved the design of the cable clamp plate.



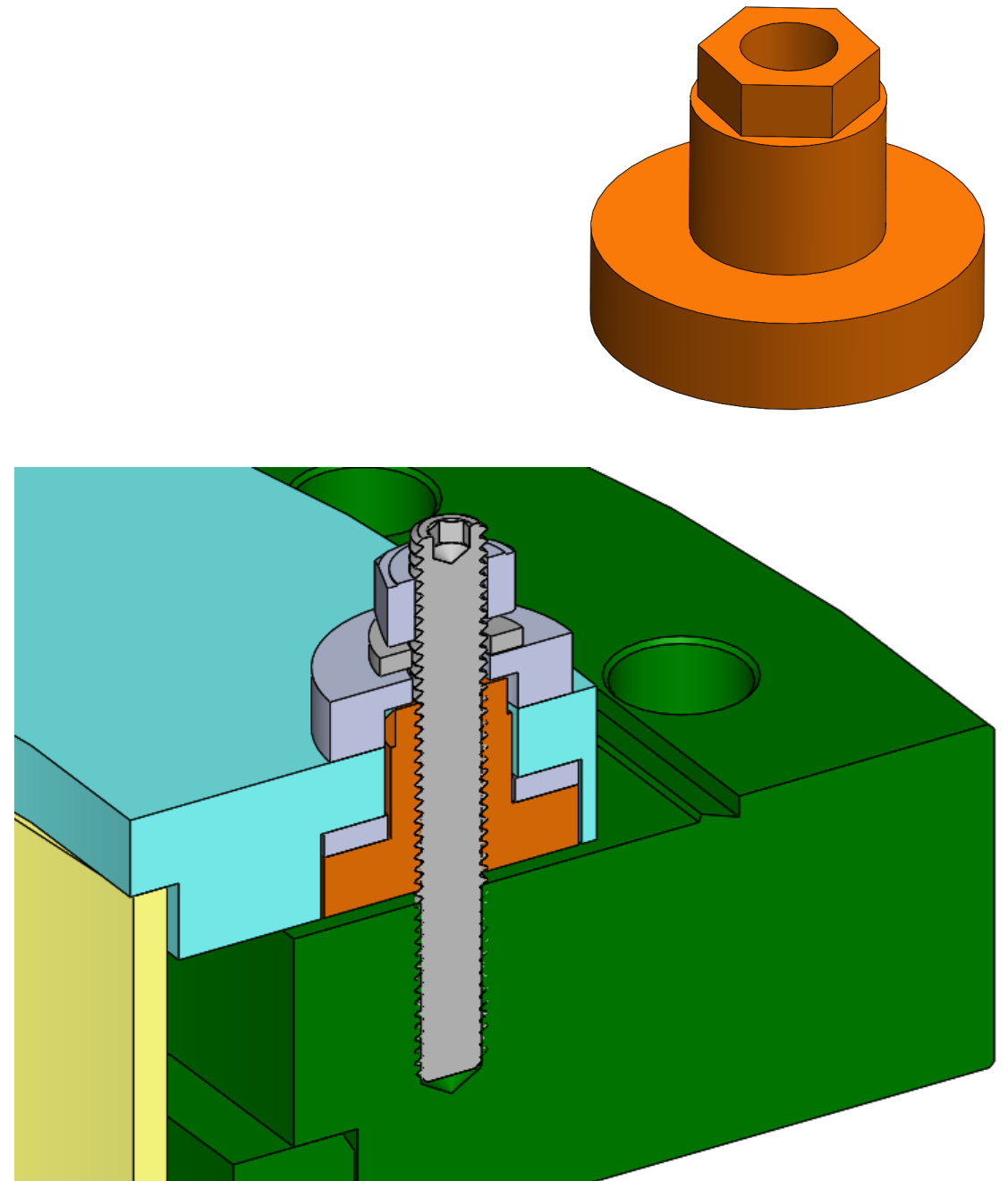
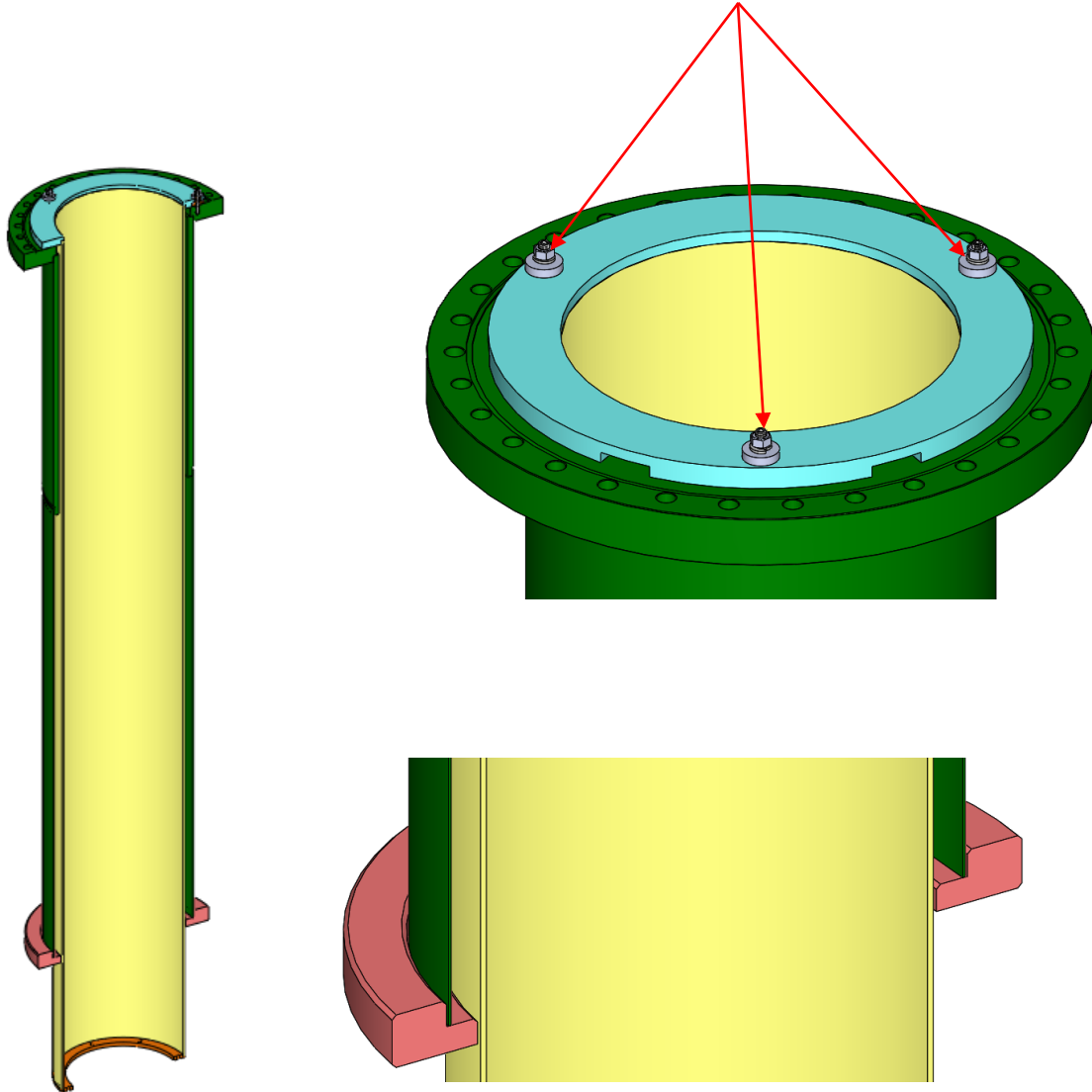
Height adjusting kits



New design of cable clamp plate

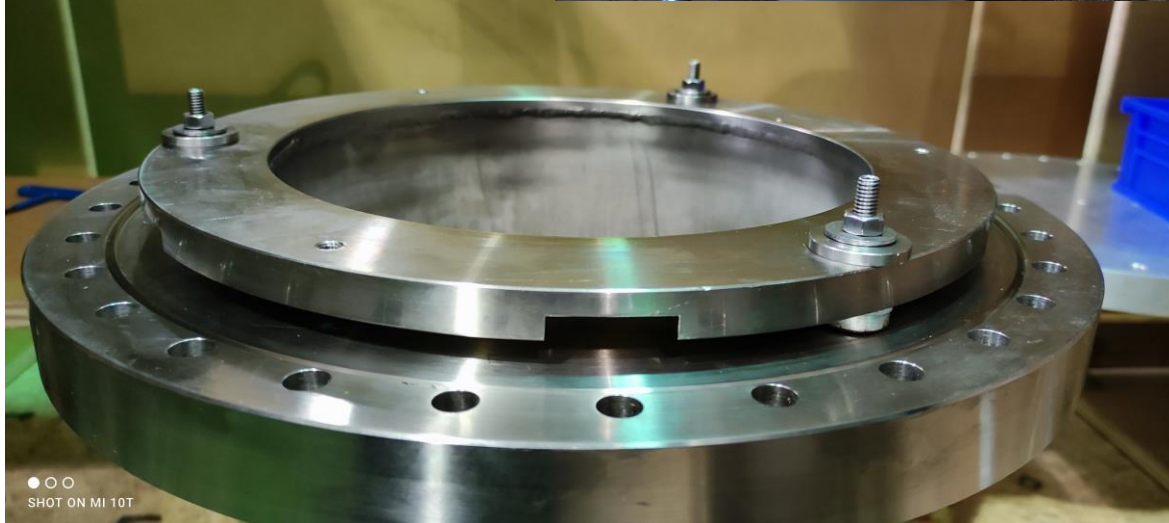
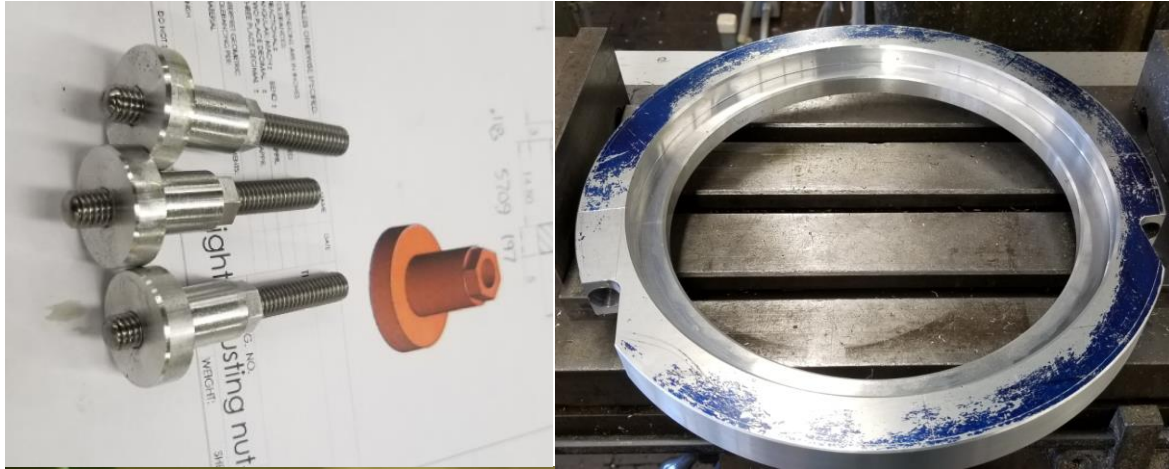
Updates on Feedthrough Design

Tube concentricity adjustment with three height adjusting kits.



Updates on Feedthrough Design

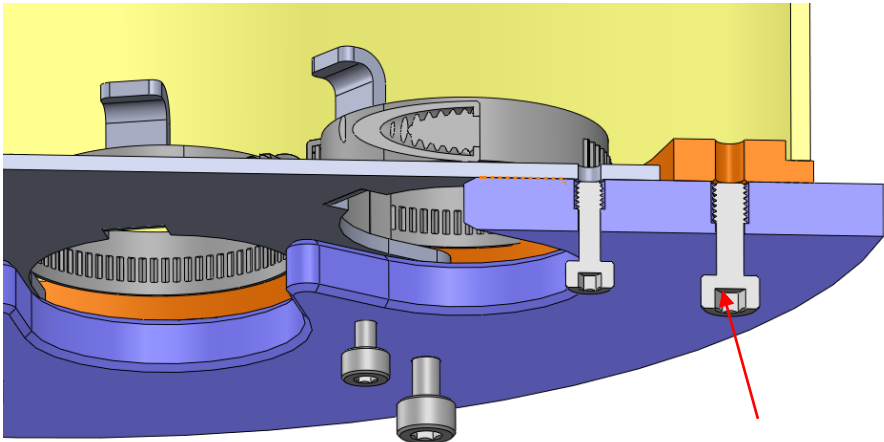
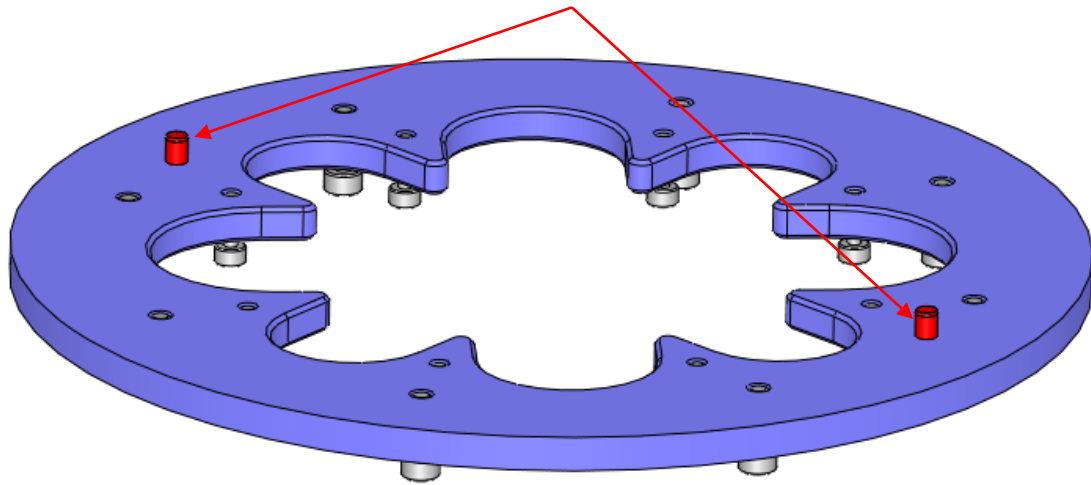
Tube concentricity adjustment mockup.



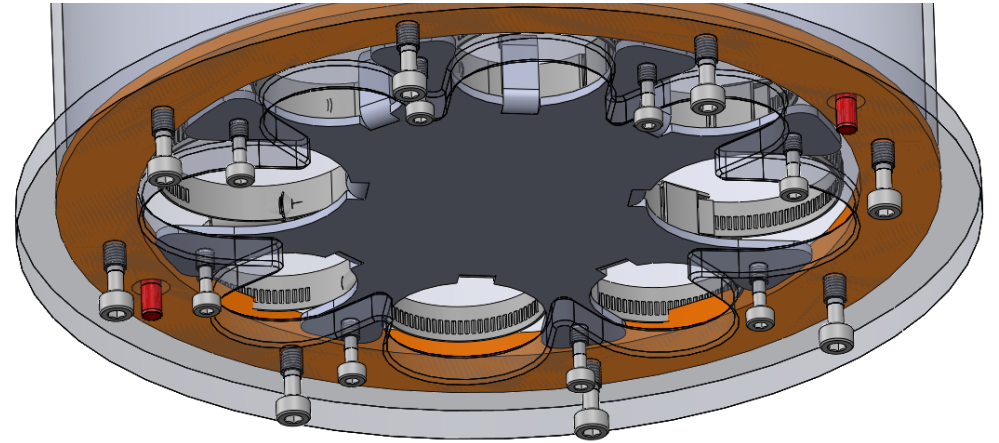
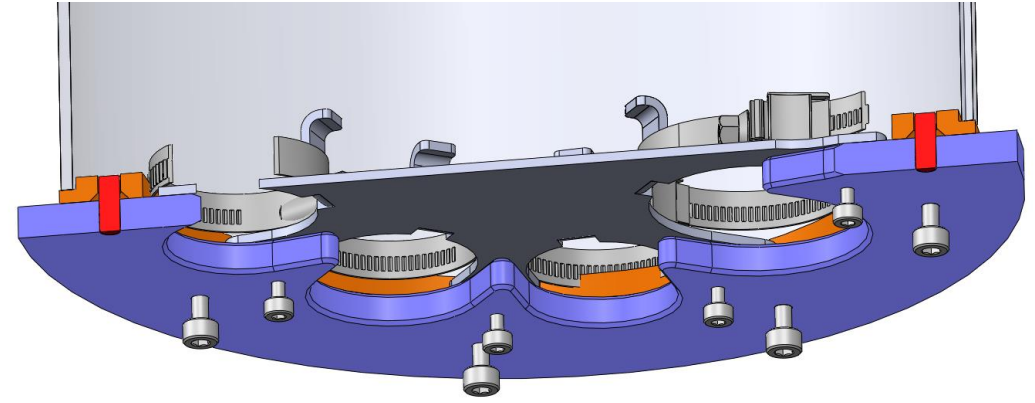
Updates on Feedthrough Design

Improved the design of the cable clamp plate.

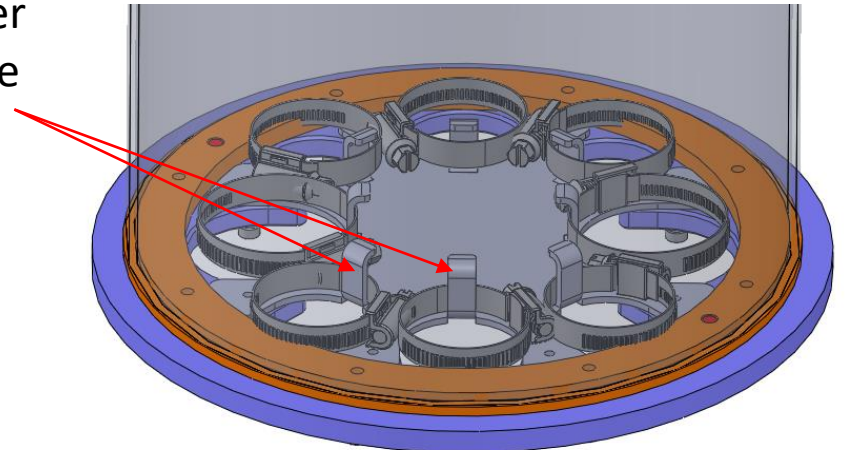
Guide pin for alignment



Captive screw

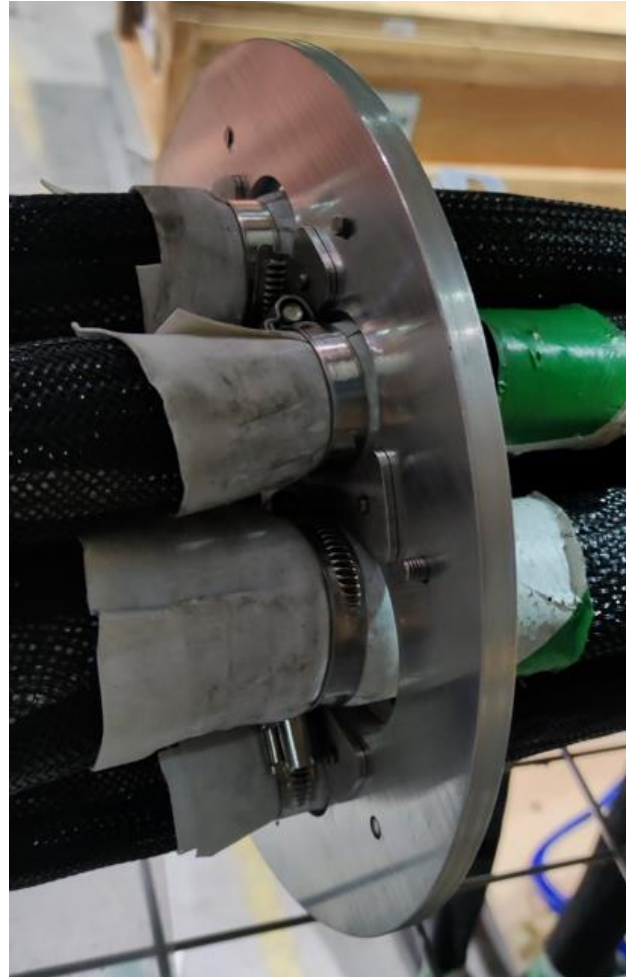


Tabs for better securing cable bundles



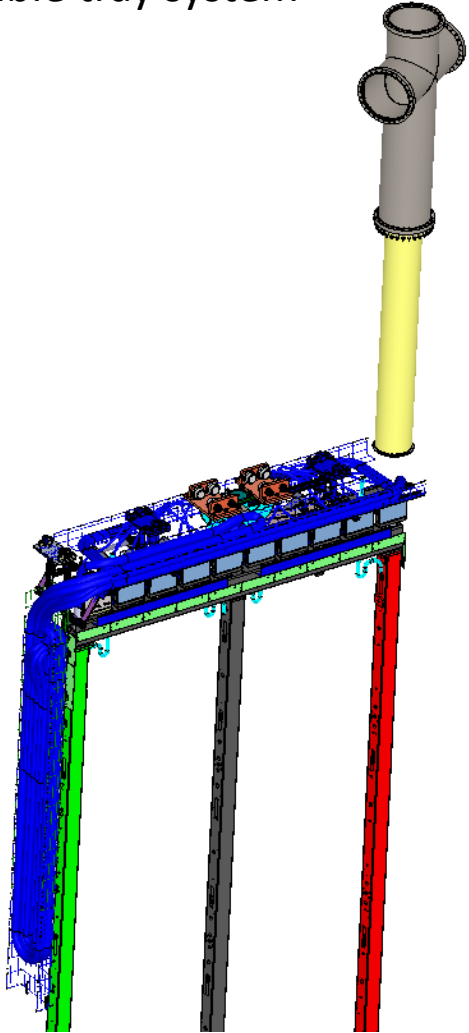
Updates on Feedthrough Design

Mockup test of cable clamp plate installation with cable bundles.

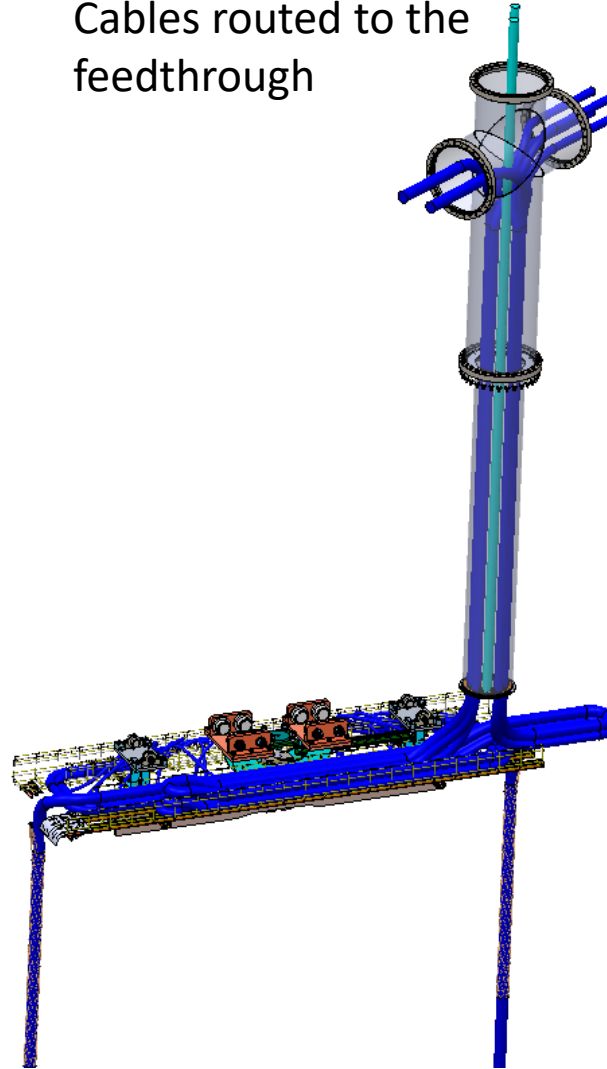


Updates on Cable Tray System Design

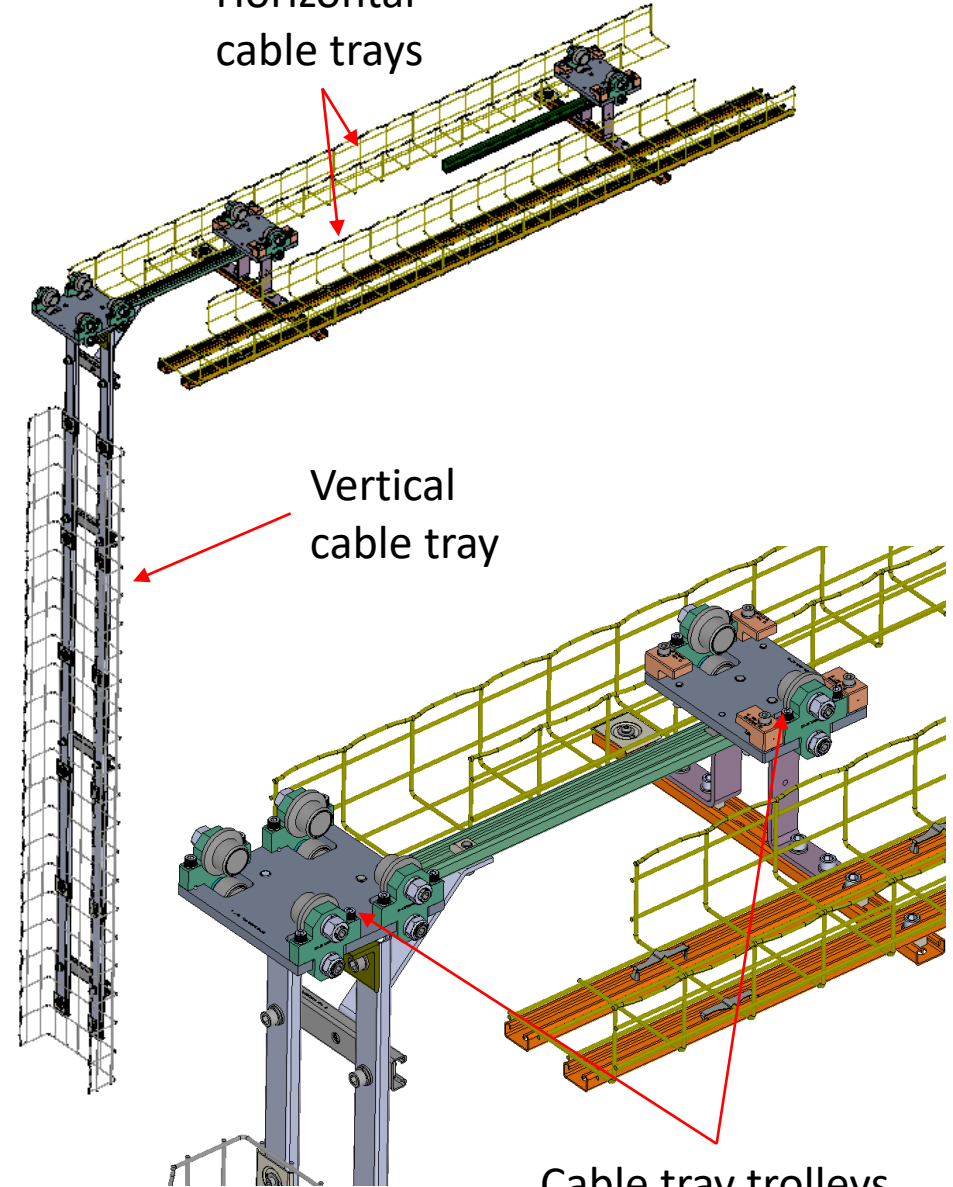
All cables placed in the cable tray system



Cables routed to the feedthrough



Horizontal cable trays



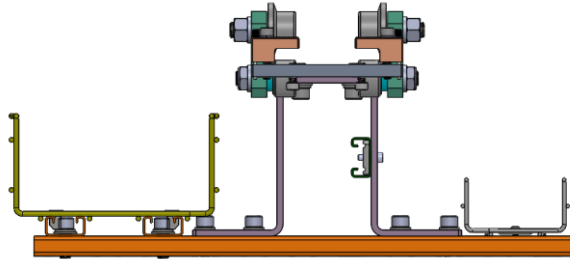
Vertical cable tray

Cable tray trolleys

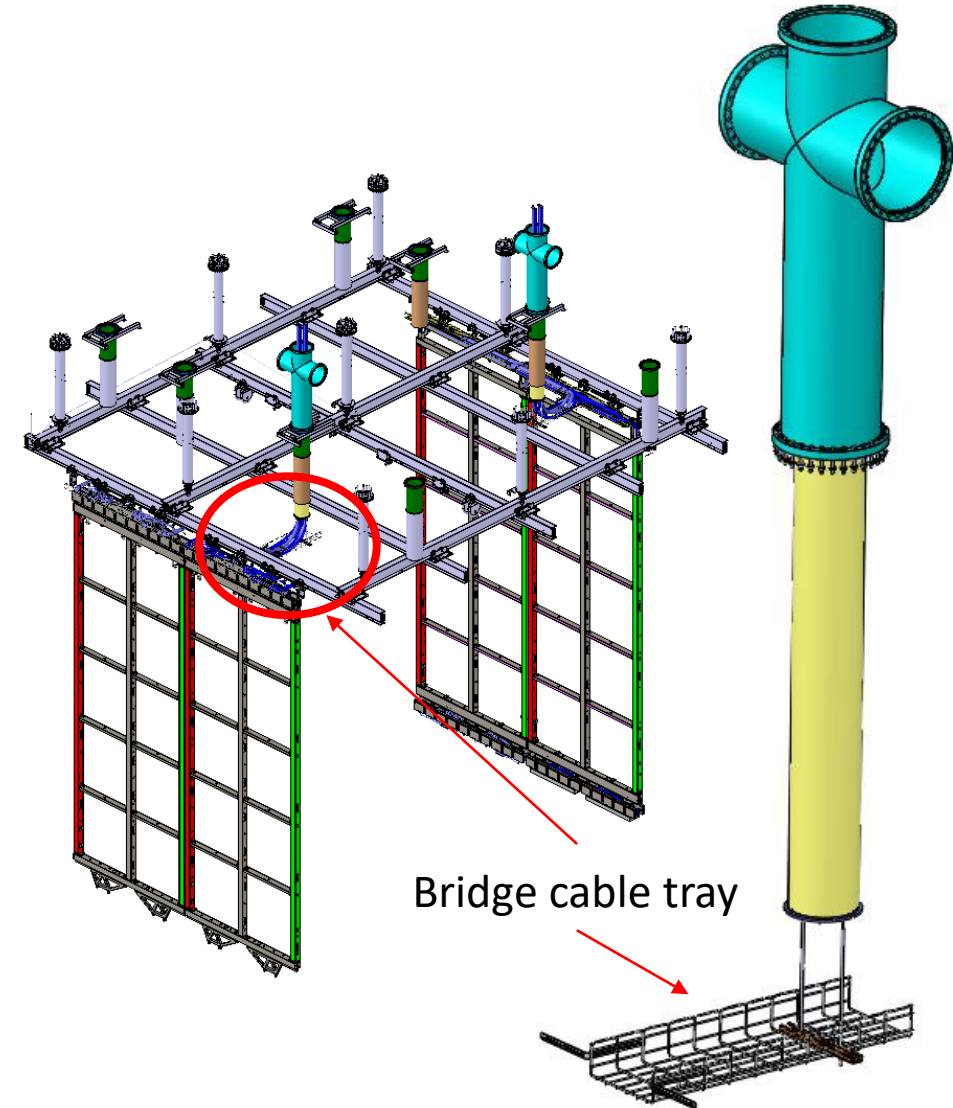
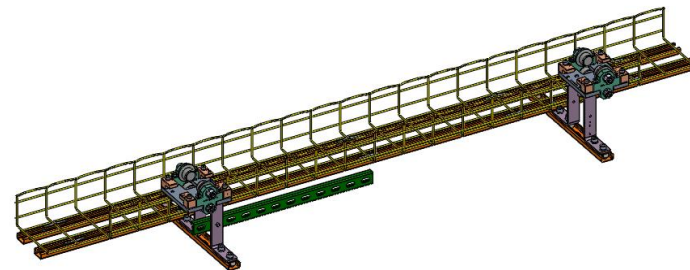
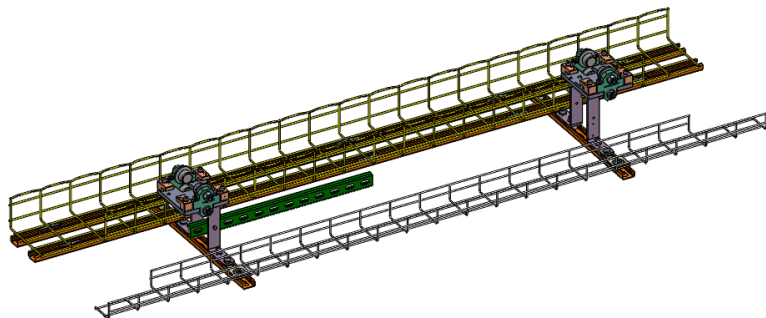
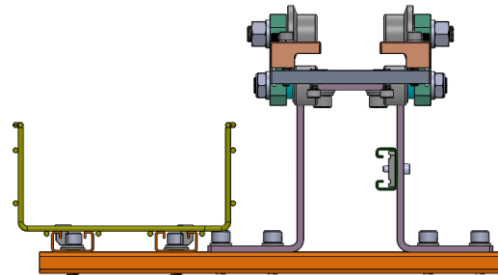
Updates on Cable Tray System Design

Cable tray system for protoDUNE II

For upper APA



For reversed APA



Bridge cable tray

Updates on CE Mechanical Analysis

Manhong Zhao

8-9-2021

SP TPC Electronics Consortium Meeting

Content

- Load cases of Cross-shaped Spool Piece
- Load cases of Cold Electronics Crossing Tube
- Load cases of Upper Cable Trays and Cable Tray Trolleys
- Load cases of CE Boxes
- Load cases of CE Flange
- Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

Load cases of Cross-shaped Spool Piece

LC-CSSP-01: The CSSP is installed on the Cryostat crossing tube flange, with all flanges attached but no WIEC.

LC-CSSP-02: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and one WIEC in its final position.

LC-CSSP-03: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and two WIECs in their final positions.

LC-CSSP-04: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and two WIECs in their final positions, and with all PD and CE cables attached.

LC-CSSP-05: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and one WIECs in their final positions, and with the other CE crate on extension fixture during cabling (this case differs from **LC-CSSP-04** because the weight of the WIEC is moved far out from the vertical axis of the CSSP).

LC-CSSP-06: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and two CE crates on extension fixture during cabling (this case differs from **LC-CSSP-04** because the weight of both WIECs is moved far out from the vertical axis of the CSSP).

LC-CSSP-07: Fully loaded CSSP with force pushing down on one of the two CE flanges.

LC-CSSP-08: Fully loaded CSSP with force pushing laterally on one of the two CE flanges.

LC-CSSP-09: Fully loaded CSSP with force pushing down on the PDS flange.

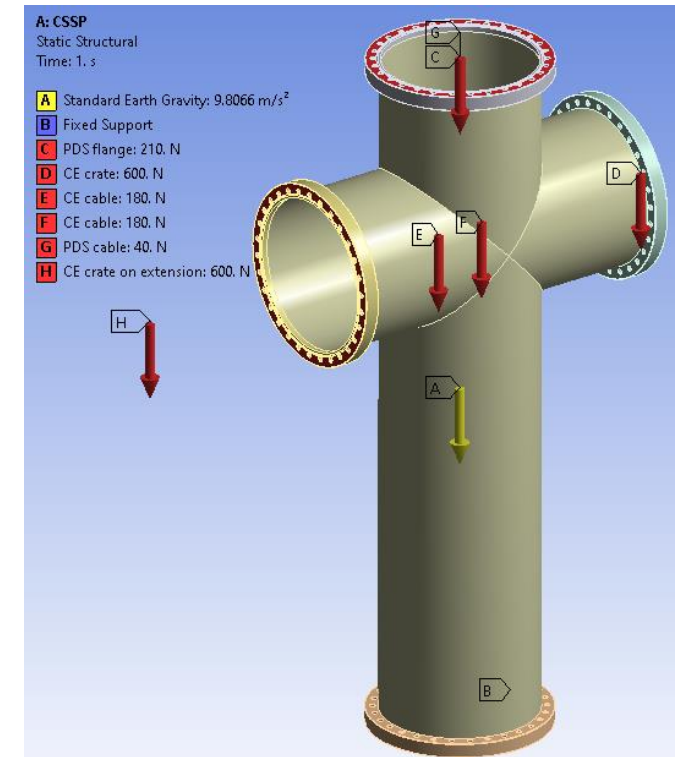
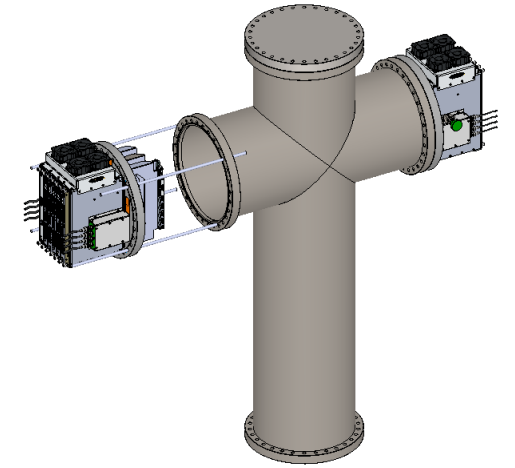
LC-CSSP-10: Fully loaded CSSP with force pushing laterally on the PDS flange.

LC-CSSP-11: The CSSP is installed on the Cryostat crossing tube flange, with all flanges attached but no WIEC. A -1 psig negative pressure is applied inside the CSSP.

LC-CSSP-12: The CSSP is installed on the Cryostat crossing tube flange, with all flanges attached but no WIEC. A +5 psig positive pressure is applied inside the CSSP.

LC-CSSP-13: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and two WIECs in their final positions, and with all PD and CE cables attached. A -1 psig negative pressure is applied inside the CSSP.

LC-CSSP-14: The CSSP is installed on the Cryostat crossing tube flange, with all flanges and two WIECs in their final positions, and with all PD and CE cables attached. A +5 psig positive pressure is applied inside the CSSP.



Load cases of Cold Electronics Crossing Tube

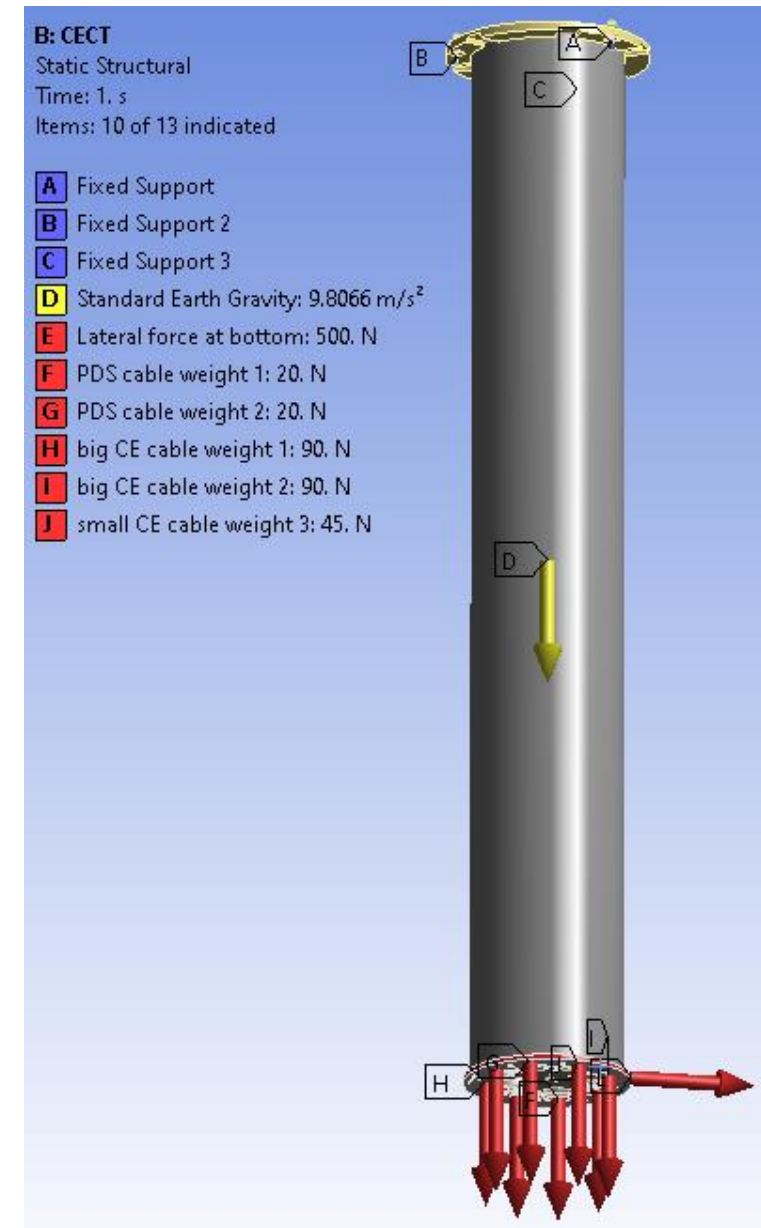
LC-CECT-01: The CECT is installed on the cryostat crossing tube flange.

LC-CECT-02: The CECT is installed on the cryostat crossing tube flange with lateral forces applied at the bottom of CECT.

LC-CECT-03: The CECT is installed on the cryostat crossing tube flange with cables clamped at the bottom of the CECT.

LC-CECT-04: The CECT is installed on the cryostat crossing tube flange with cables clamped at the bottom of the CECT and lateral forces applied at the bottom of CECT.

LC-CECT-05: The CECT is installed on the cryostat crossing tube flange with cables clamped at the bottom of the CECT. Temperature gradient from LAr to room temperature is applied.



Load cases of Upper Cable Trays and Cable Tray Trolleys

LC-UCTCTT-01: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with all cables loaded in the front, the back, and the vertical cable trays.

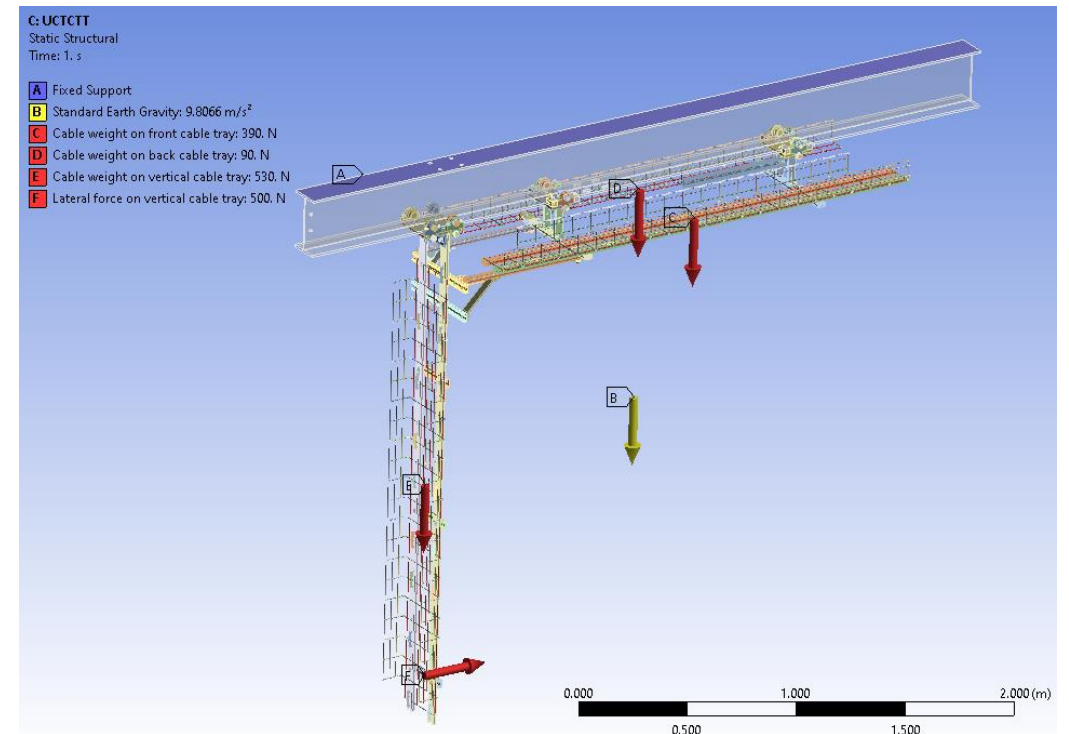
LC-UCTCTT-02: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with all cables loaded in the front, the back and the vertical cable trays, and lateral force applied on the vertical cable tray toward the APA.

LC-UCTCTT-03: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with some cables removed from the vertical cable tray and connected to patch panels for cold box test.

LC-UCTCTT-04: The horizontal cable trays are supported on cable tray trolleys with cables partially removed from the cable trays and routed through the signal penetration.

LC-UCTCTT-05: With the final connection to the DSS, the cable tray trolley wheels are removed and all the cable load on the cable tray is supported by the cable tray clamps.

LC-UCTCTT-06: Same loading scenario as LC-UCTCTT-05 but at cryogenic temperature.



Load cases of CE Boxes

LC-CEB-01: CE box is installed on the upper APA.

LC-CEB-02: CE box is installed on the upper APA at cryogenic temperature.

LC-CEB-03: CE box is installed on the upper APA, with lateral force applied on the cable clamp block.

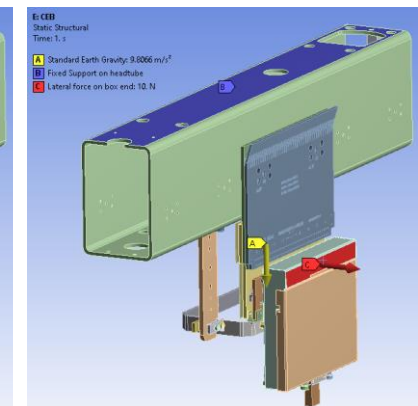
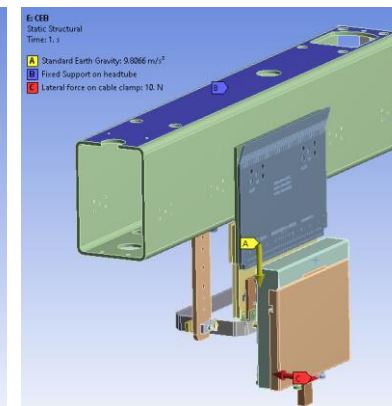
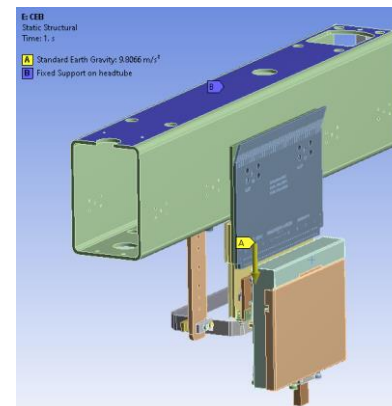
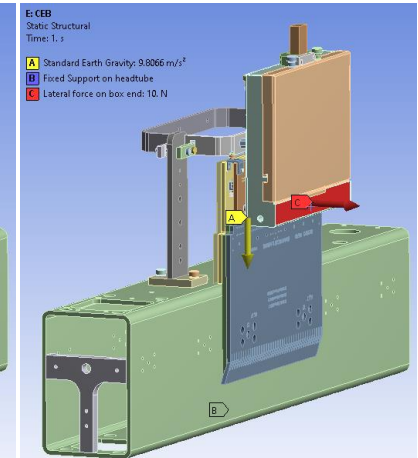
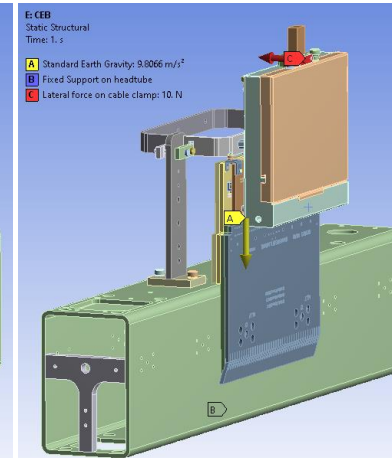
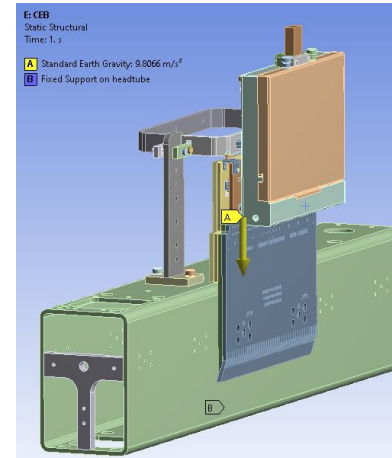
LC-CEB-04: CE box is installed on the upper APA, with lateral force applied on the end of the CE box opposite to the cable clamp block.

LC-CEB-05: CE box is installed on the lower APA.

LC-CEB-06: CE box is installed on the lower APA at cryogenic temperature.

LC-CEB-07: CE box is installed on the lower APA, with lateral force applied on the cable clamp block.

LC-CEB-08: CE box is installed on the lower APA, with lateral force applied on the end of the CE box opposite to the cable clamp block.

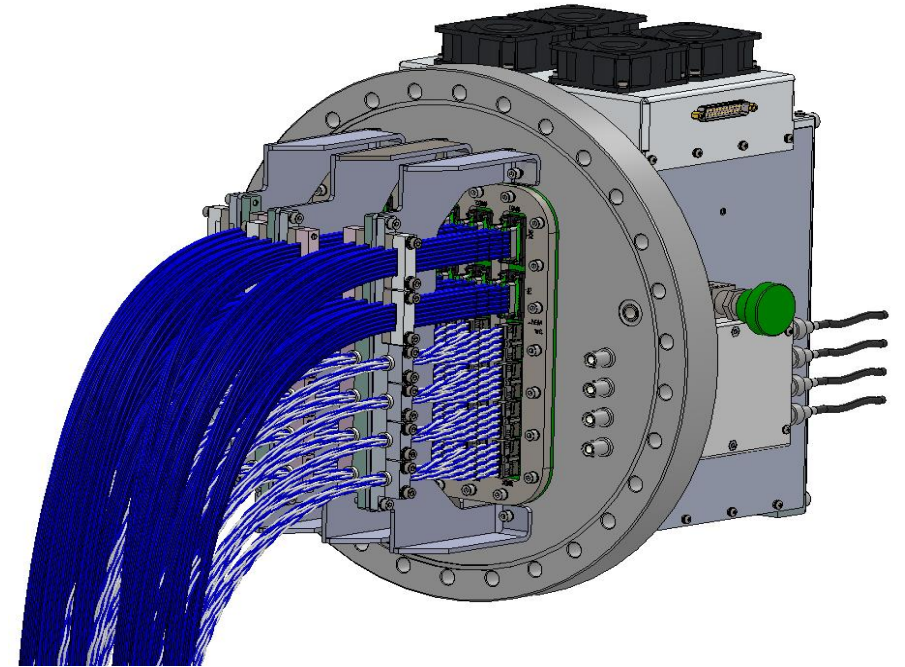
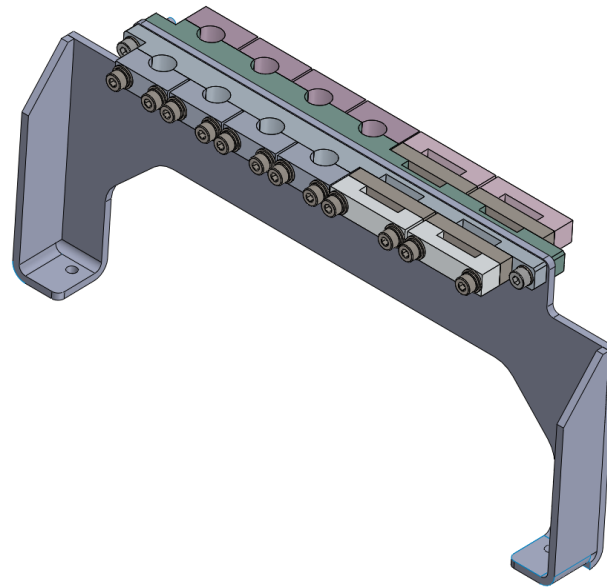
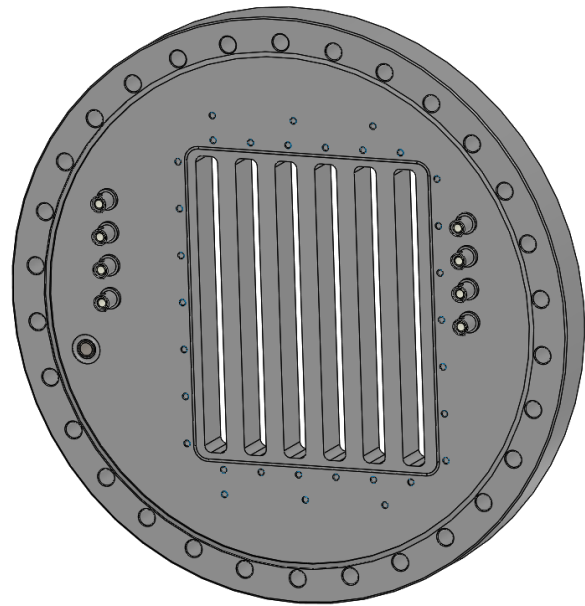


Load cases of CE Flange

LC-CEF-01: Cable weight is applied on the CE flange cable clamp brackets.

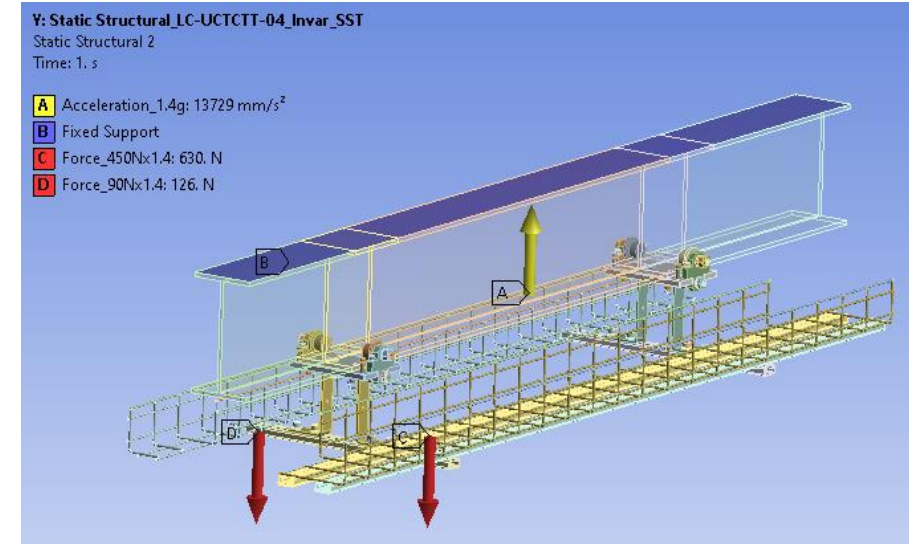
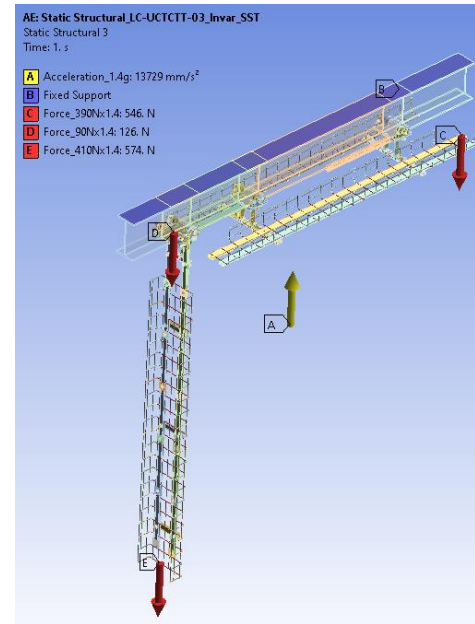
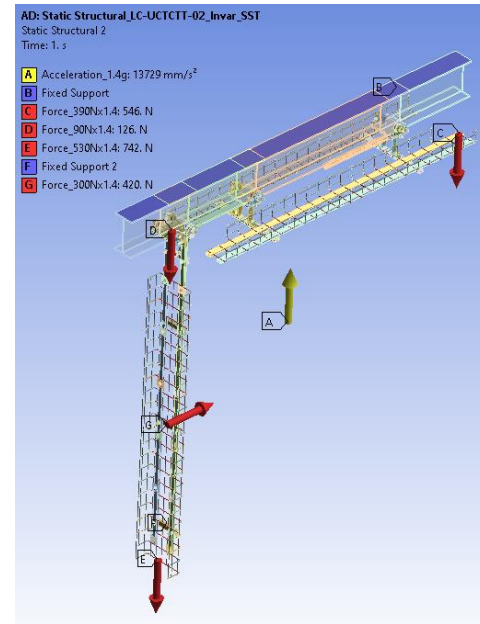
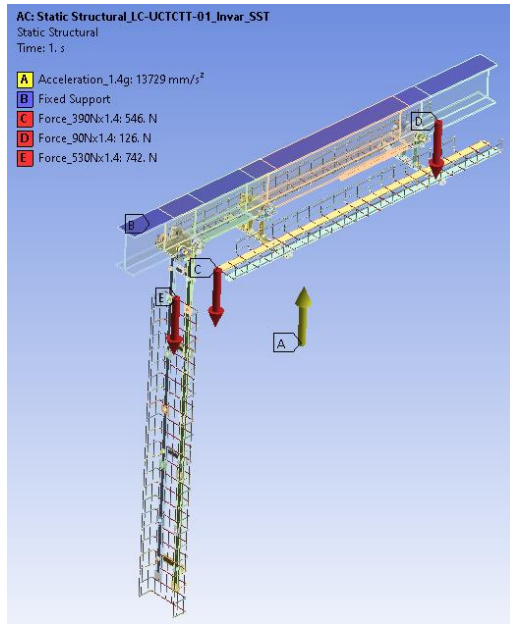
LC-CEF-02: A pressure of 1 psig applied on the outside of the CE flange.

LC-CEF-03: A pressure of 5 psig applied on the inside of the CE flange.

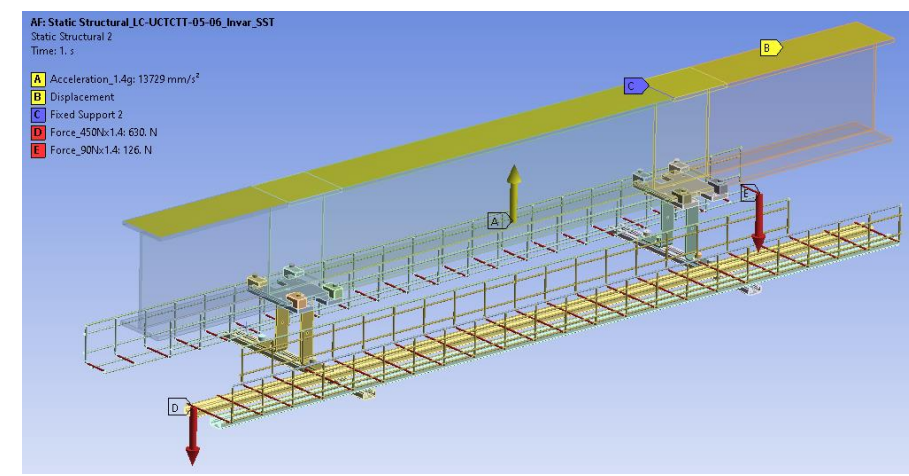
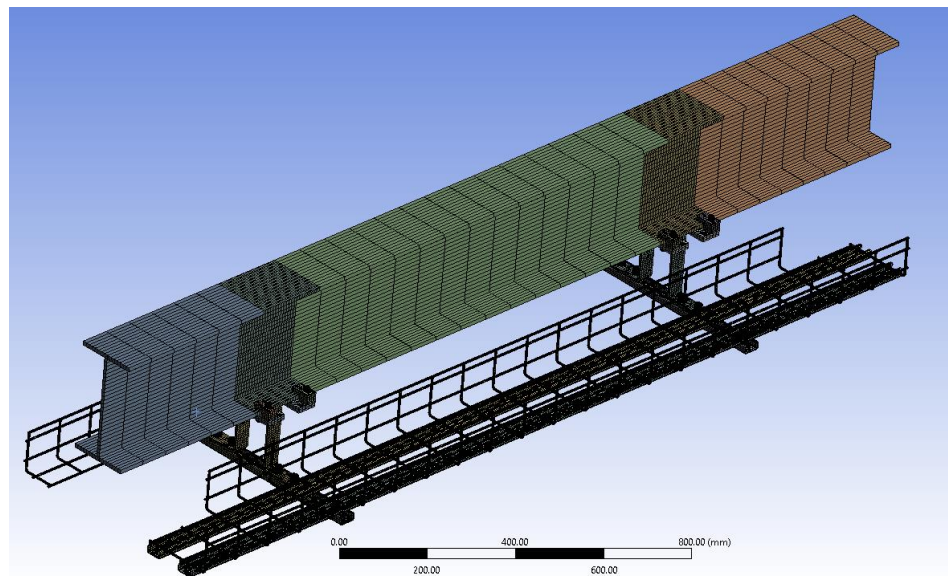


Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

Six identified load cases



FEA Mesh



Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

Material properties

Invar 36 Alloy

E=148 GPa

$\nu=0.3$

Density=8050 kg/m³

Stainless Steel 304

E=193 GPa

$\nu=0.29$

Density=8000 kg/m³

Yield strength=215 MPa

Chart of Properties Row 4: Isotropic Instantaneous Coefficient of Thermal Expansion

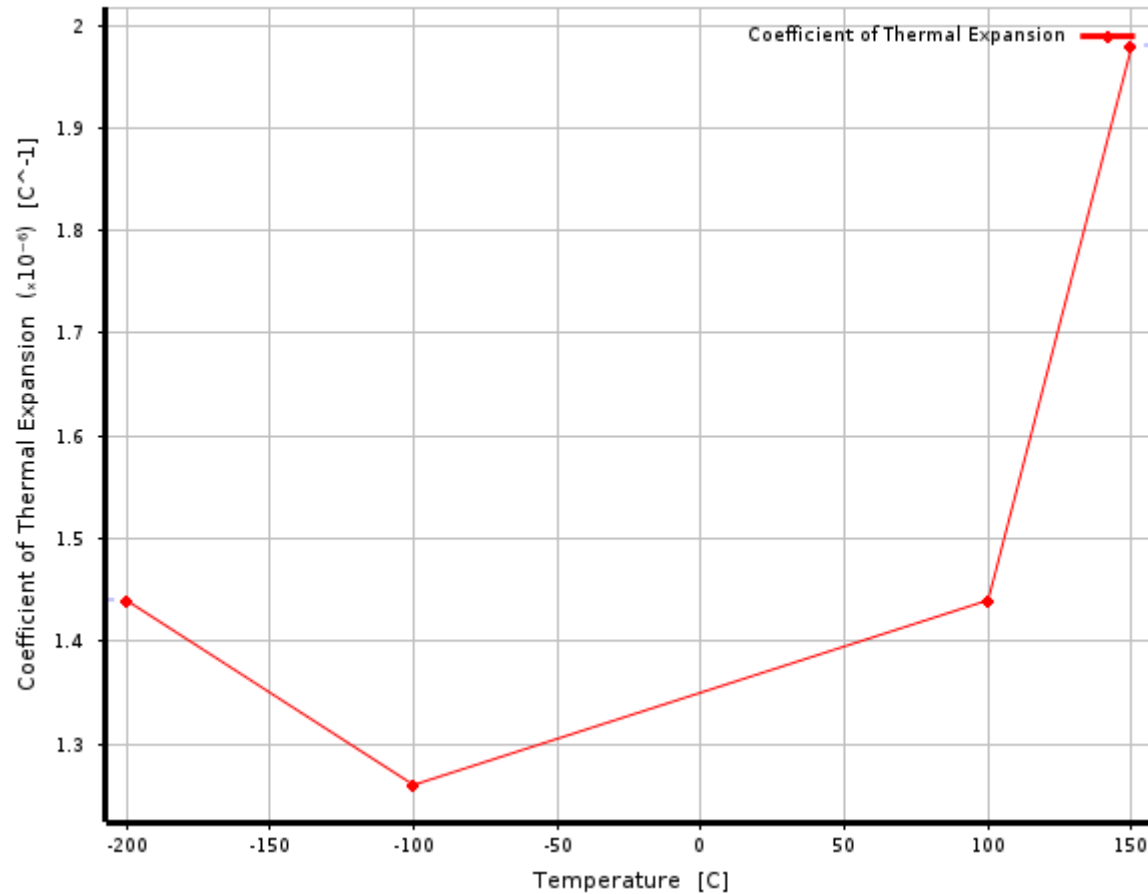
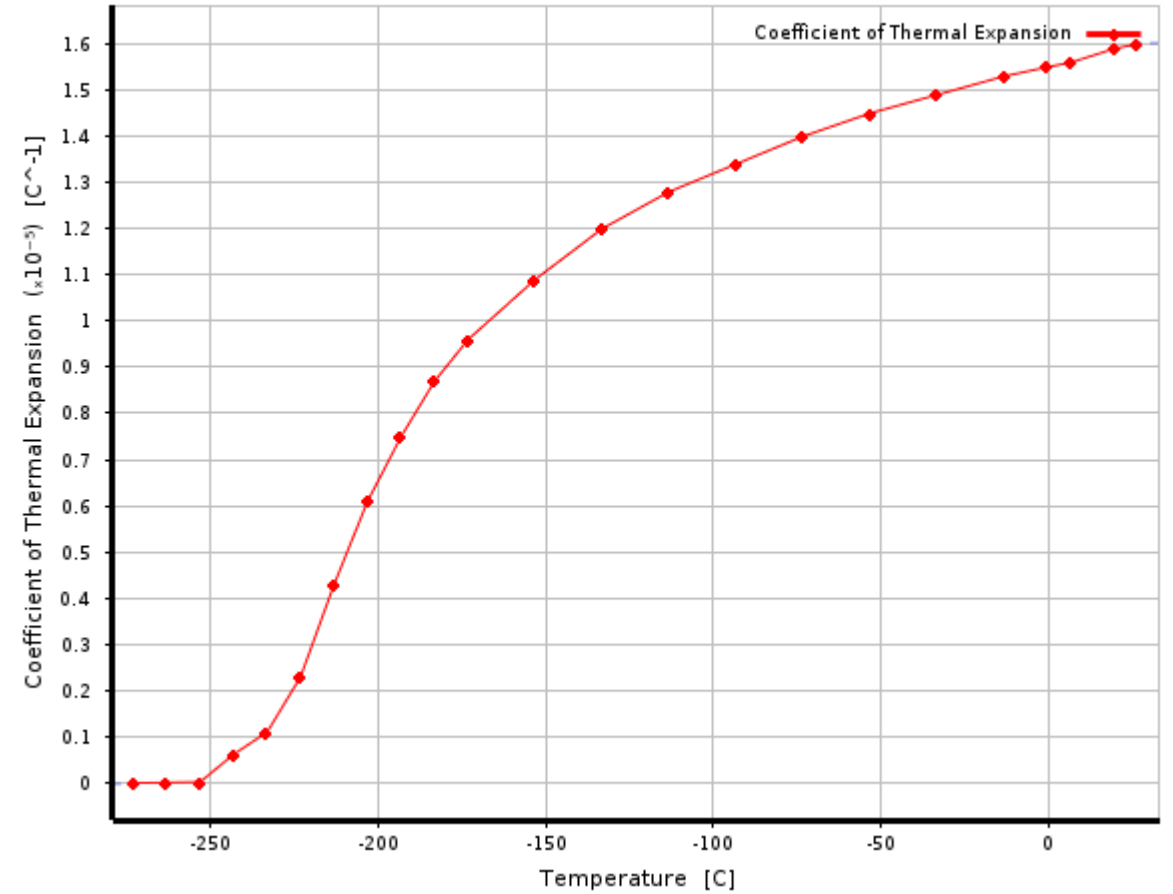


Chart of Properties Row 4: Isotropic Instantaneous Coefficient of Thermal Expansion



Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

Design Codes

Analyses are done following

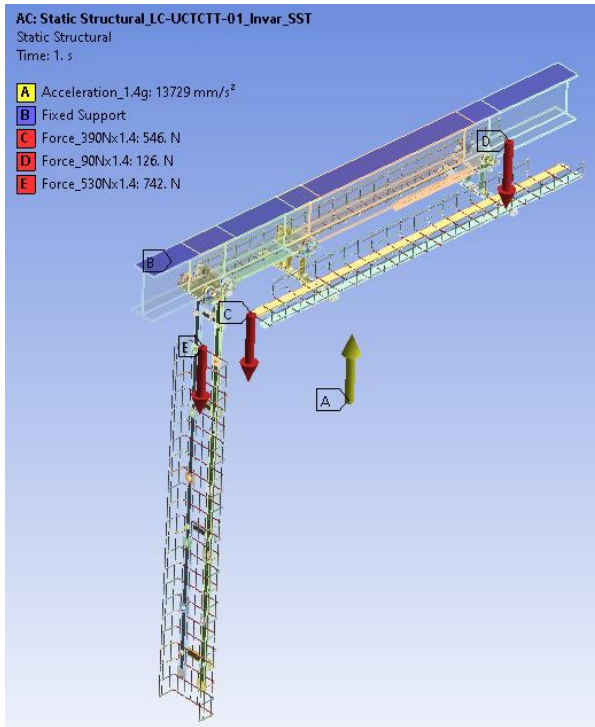
- ANSI/AISC 360-16 - American Institute for Steel Construction - Specification for Structural Steel Buildings.
- ASCE 7 – American Society of Civil Engineers - Minimum design loads for buildings and other structures.

All loads (forces and weights) used in the finite element analyses are multiplied by a factor of 1.4.

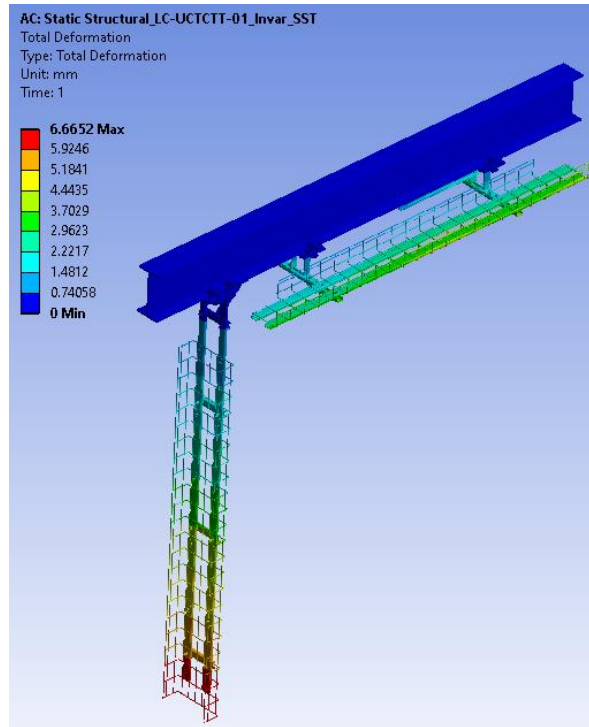
Material strength (yield strength) is multiplied by a factor of 0.9.

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

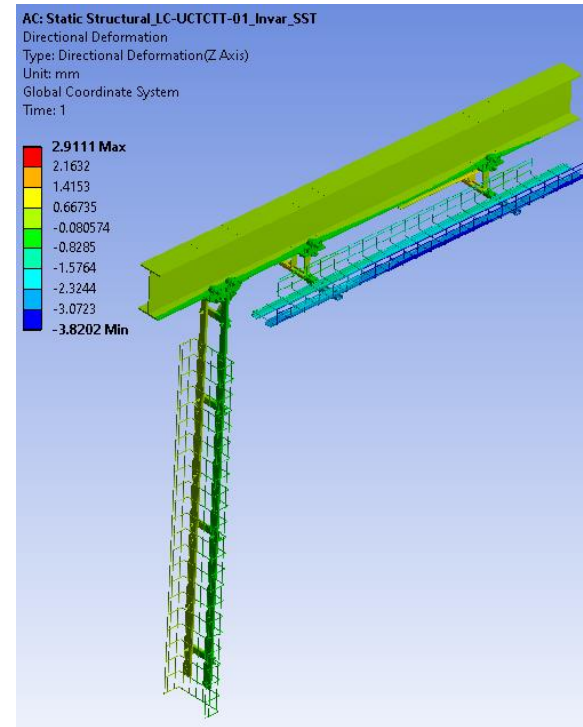
LC-UCTCTT-01: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with all cables loaded in the front, the back, and the vertical cable trays.



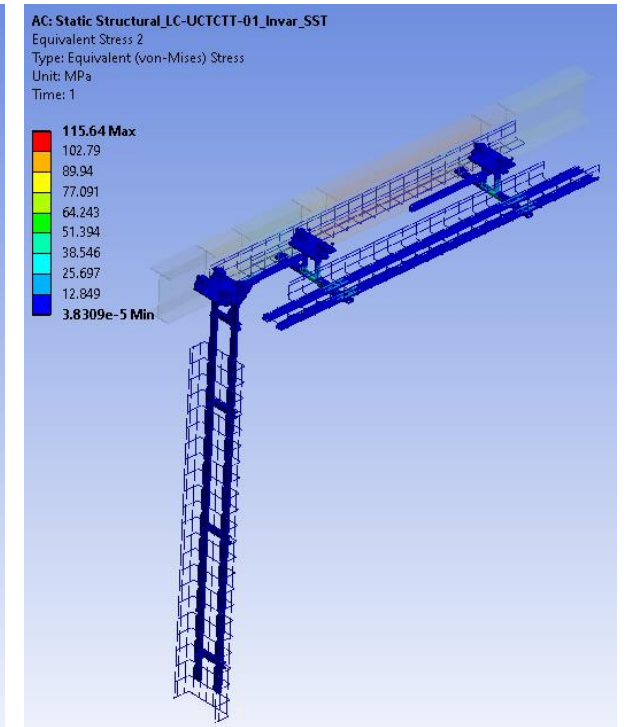
Loading and boundary condition



Total deformation



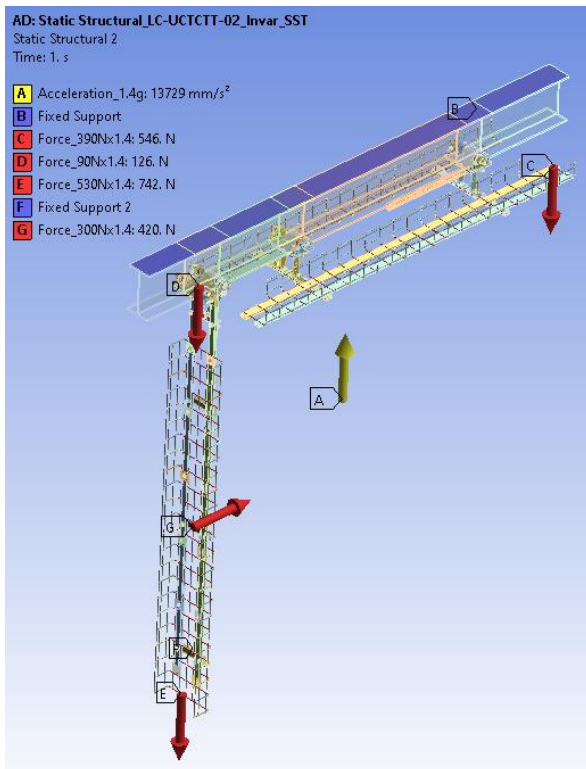
Deformation along Z axis



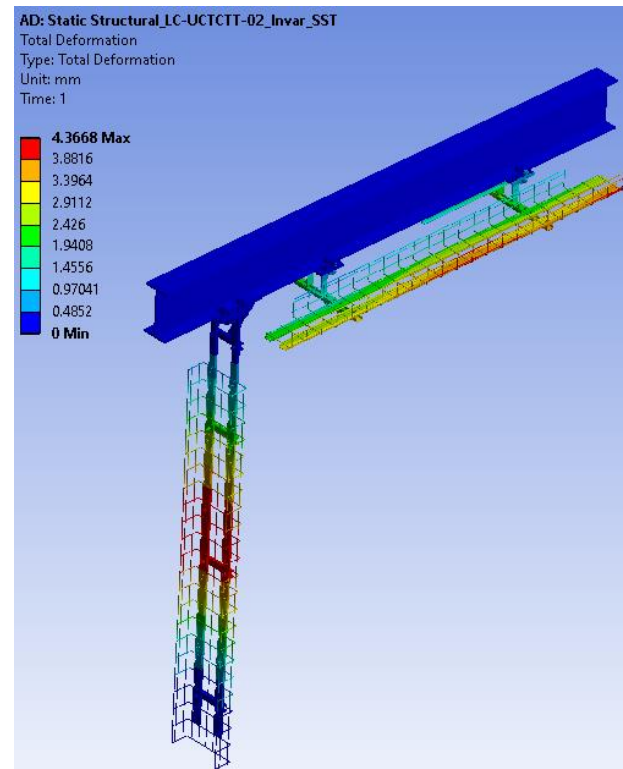
Equivalent (Von-Mises) Stress

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

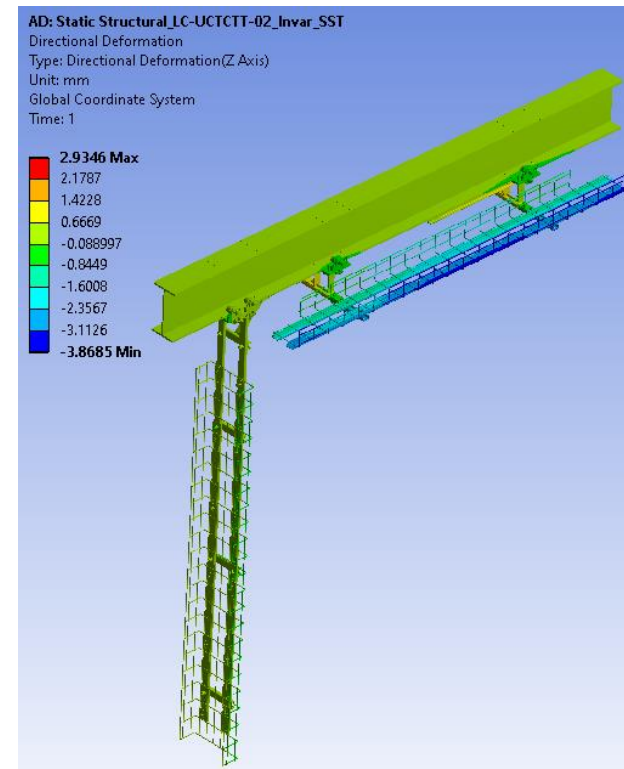
LC-UCTCTT-02: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with all cables loaded in the front, the back and the vertical cable trays, and lateral force applied on the vertical cable tray toward the APA.



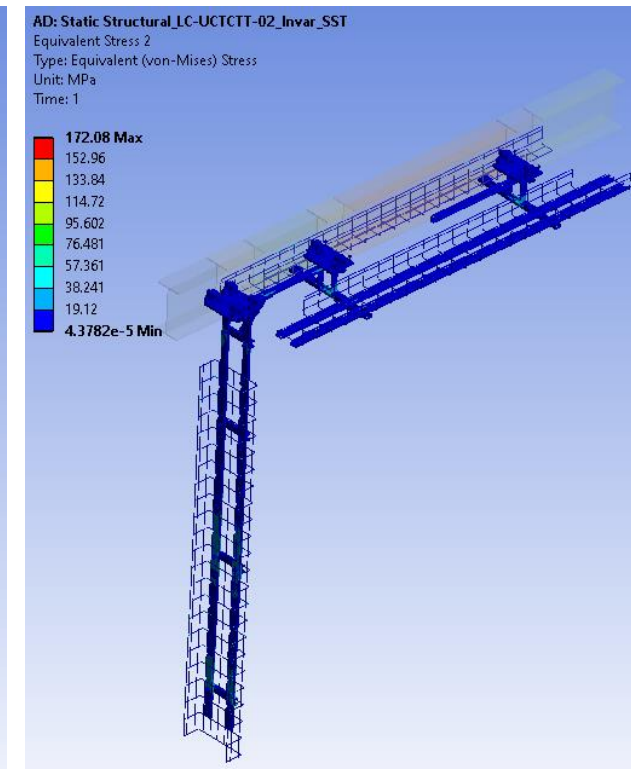
Loading and boundary condition



Total deformation



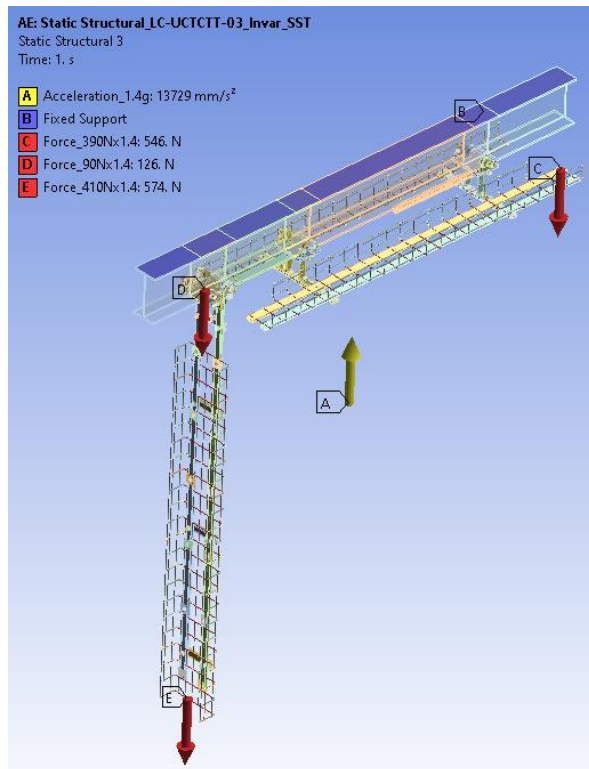
Deformation along Z axis



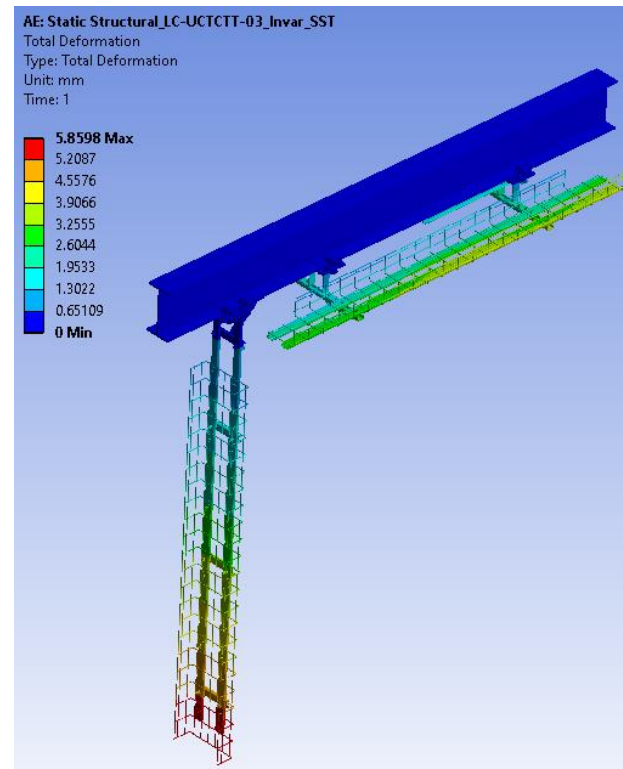
Equivalent (Von-Mises)Stress

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

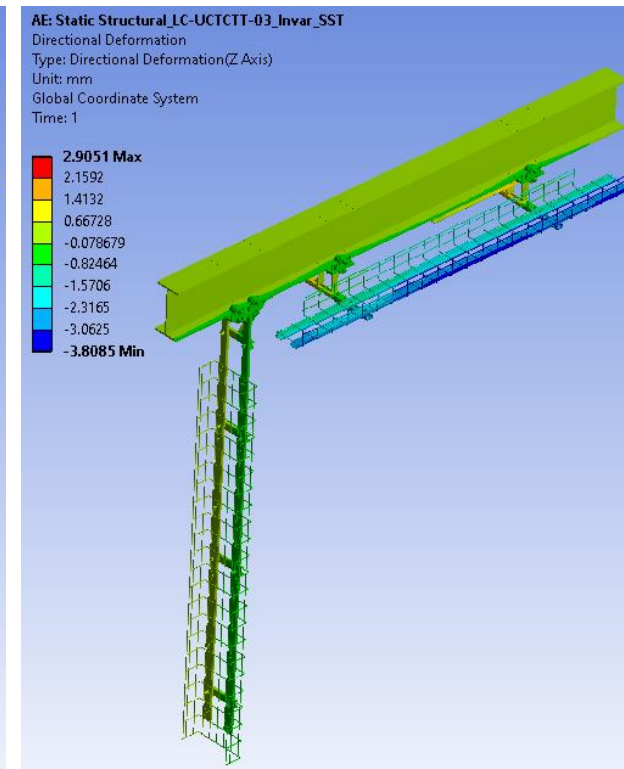
LC-UCTCTT-03: The horizontal cable trays and the vertical cable tray are supported on cable tray trolleys with some cables removed from the vertical cable tray and connected to patch panels for cold box test.



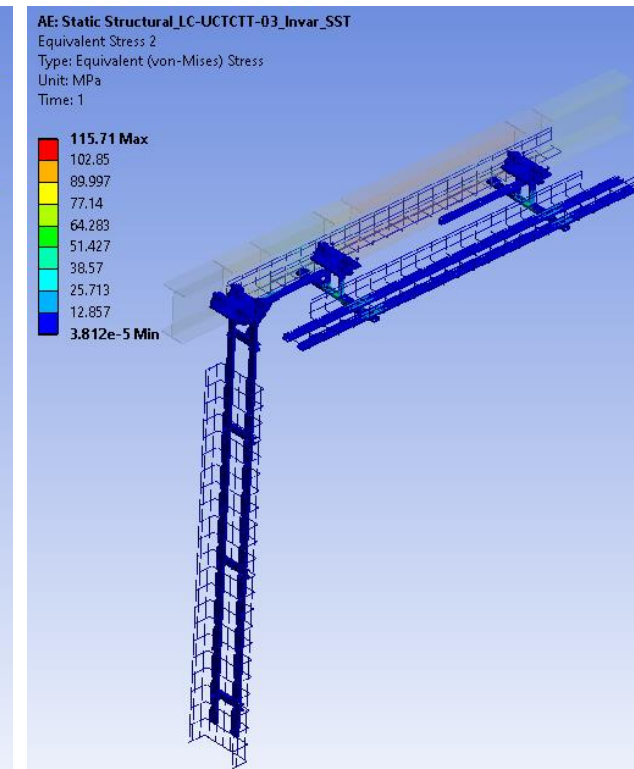
Loading and boundary condition



Total deformation



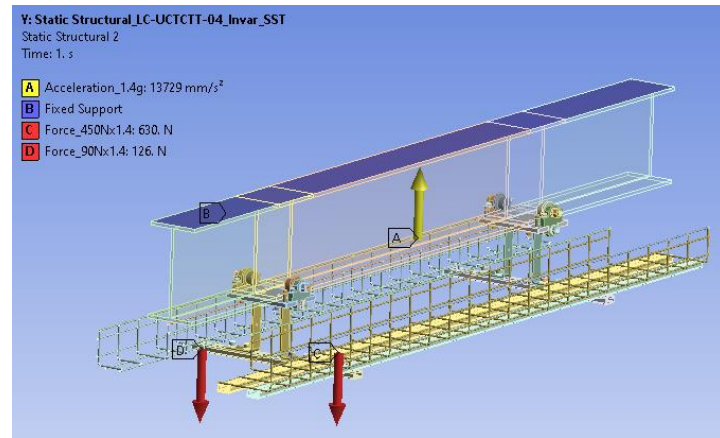
Deformation along Z axis



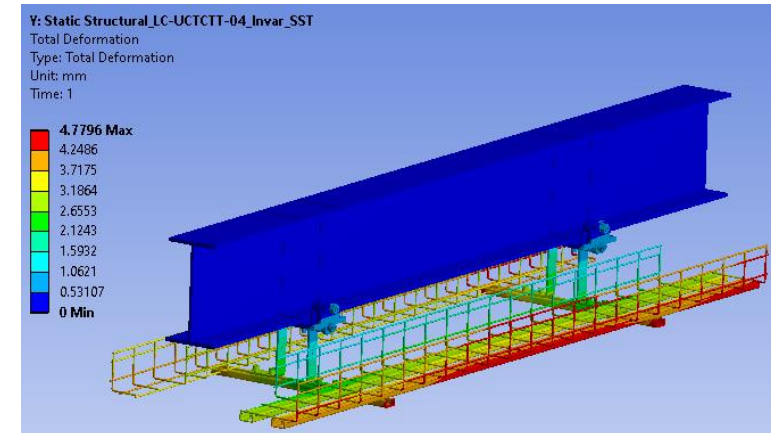
Equivalent (Von-Mises)Stress

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

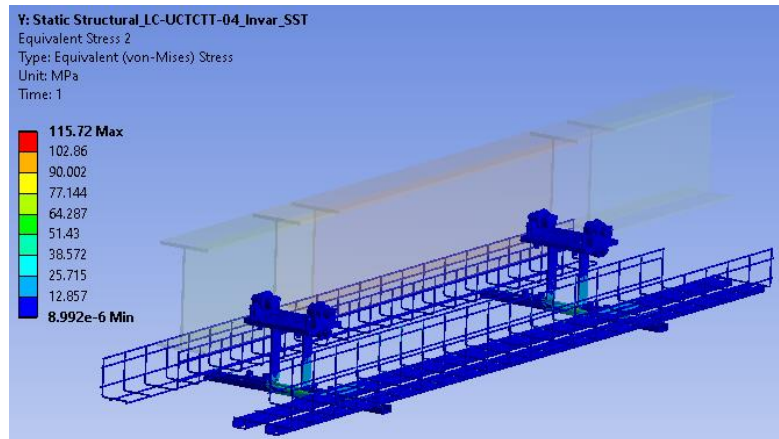
LC-UCTCTT-04: The horizontal cable trays are supported on cable tray trolleys with cables partially removed from the cable trays and routed through the signal penetration.



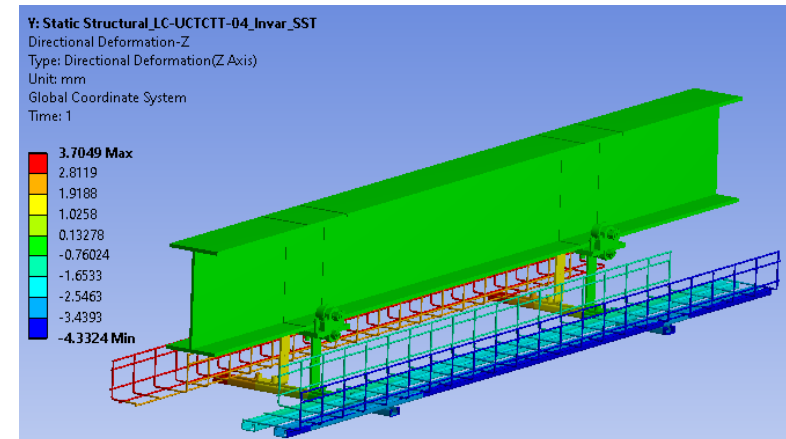
Loading and boundary condition



Total deformation



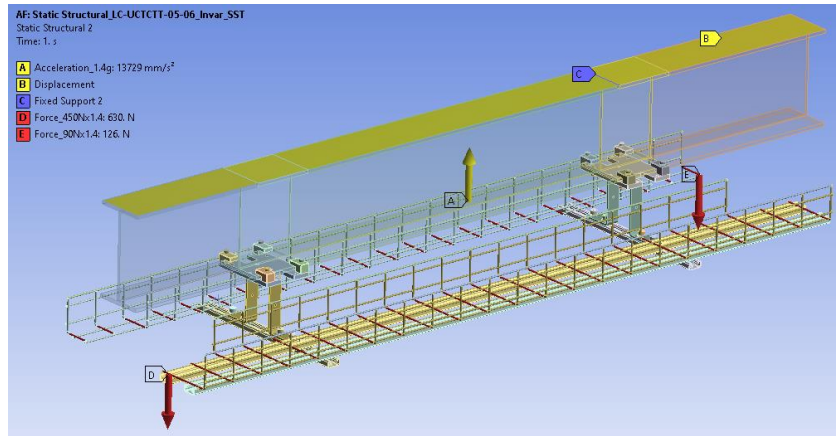
Equivalent (Von-Mises)Stress



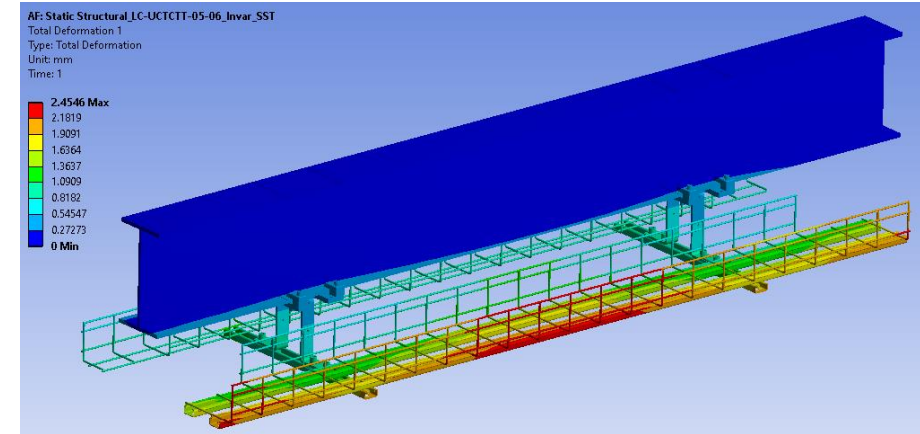
Deformation along Z axis

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

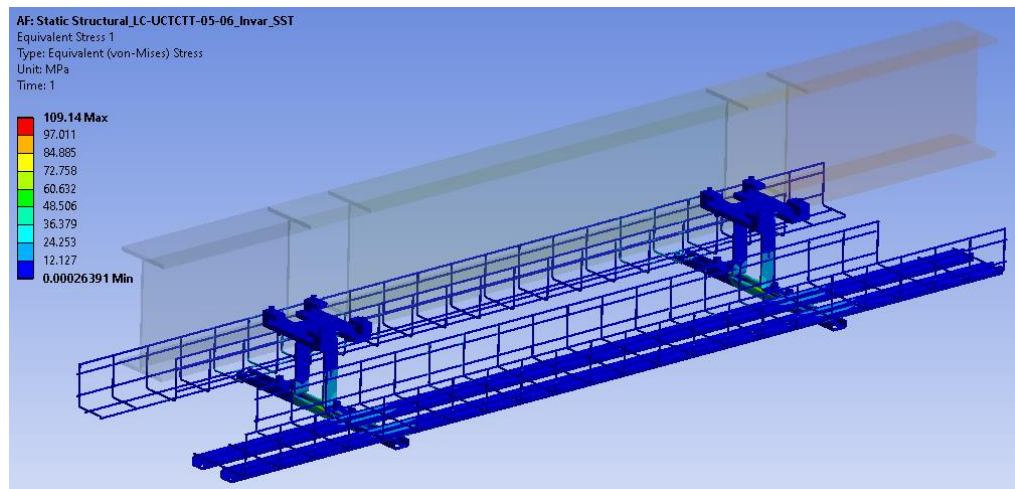
LC-UCTCTT-05: With the final connection to the DSS, the cable tray trolley wheels are removed and all the cable load on the cable tray is supported by the cable tray clamps.



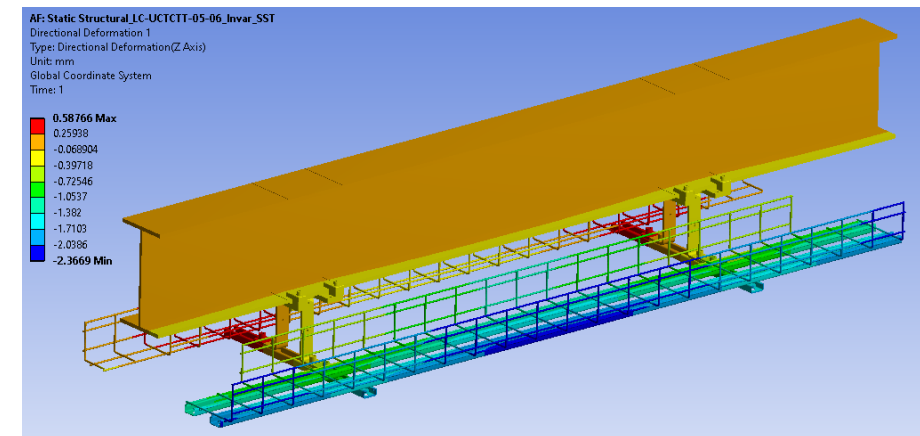
Loading and boundary condition



Total deformation



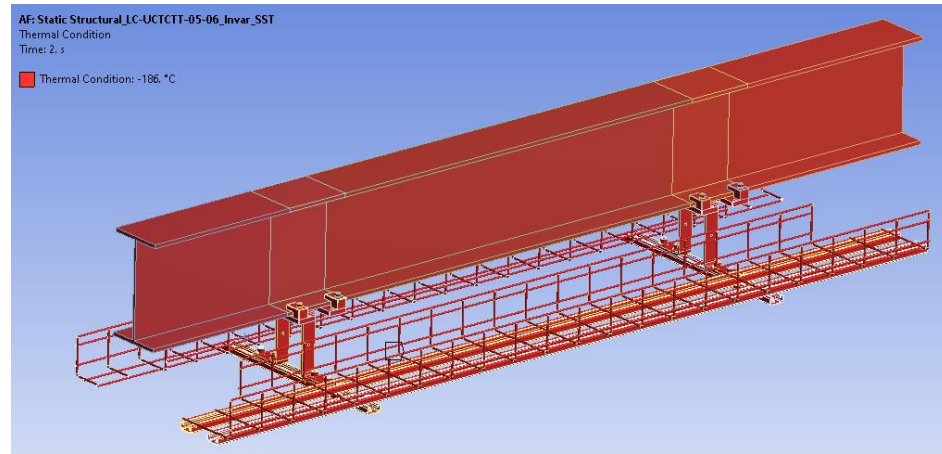
Equivalent (Von-Mises)Stress



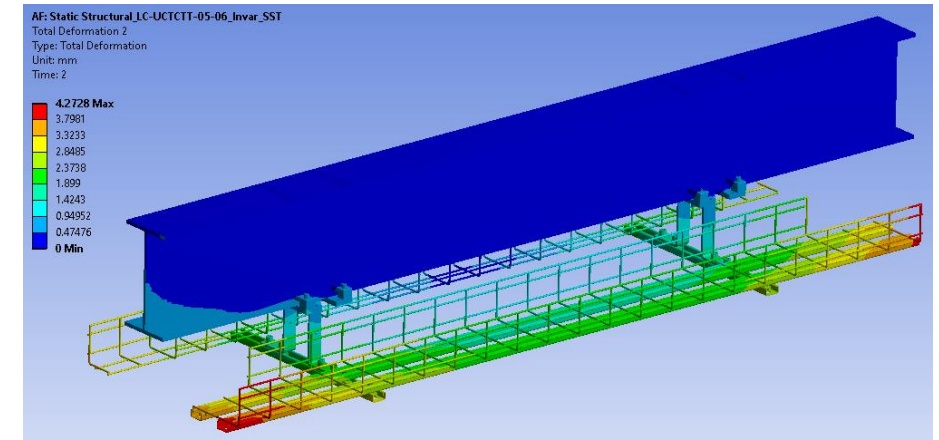
Deformation along Z axis

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

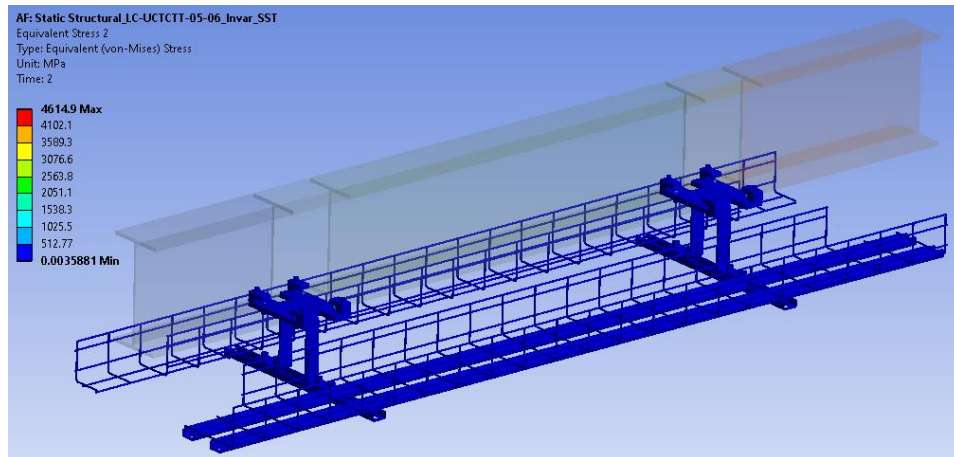
LC-UCTCTT-06: Same loading scenario as LC-UCTCTT-05 but at cryogenic temperature.



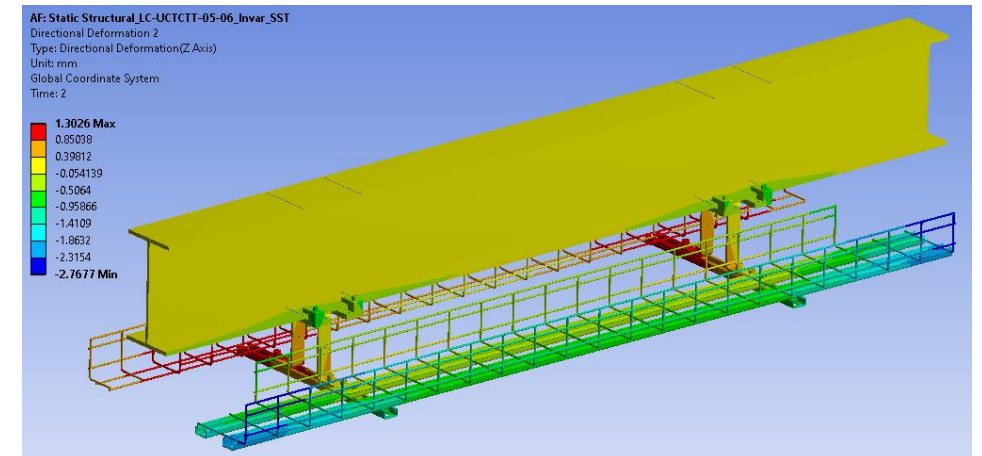
Thermal condition (22° -> -186°C)



Total deformation



Equivalent (Von-Mises) Stress



Deformation along Z axis

Progress on FEA of Upper Cable Trays and Cable Tray Trolleys

LC-UCTCTT-06: Same loading scenario as LC-UCTCTT-05 but at cryogenic temperature.

