Cryostat Penetration

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Cold Electronics Mechanical Review

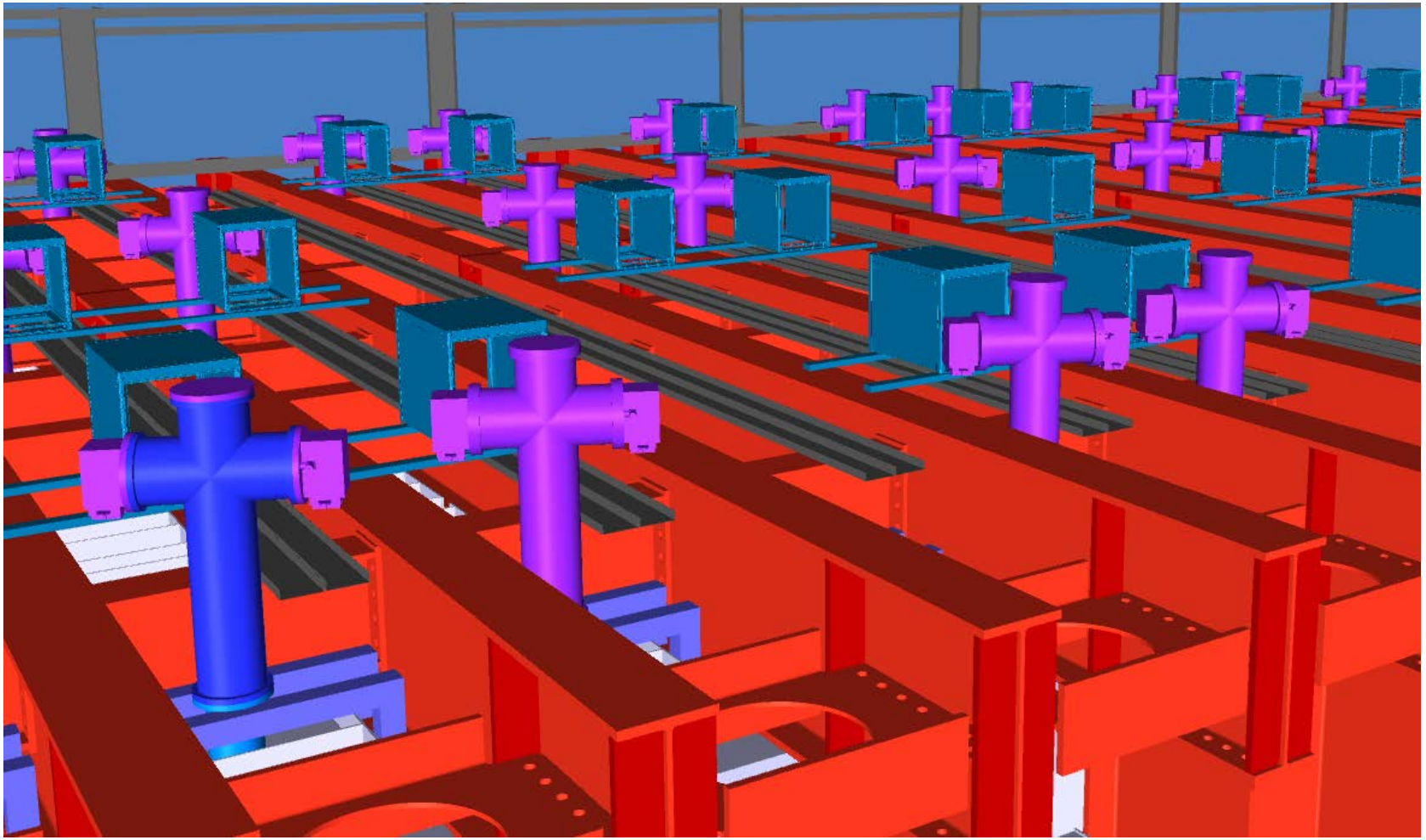
Feb 11th, 2019

Requirements

The cryostat penetration shall meet the following requirements:

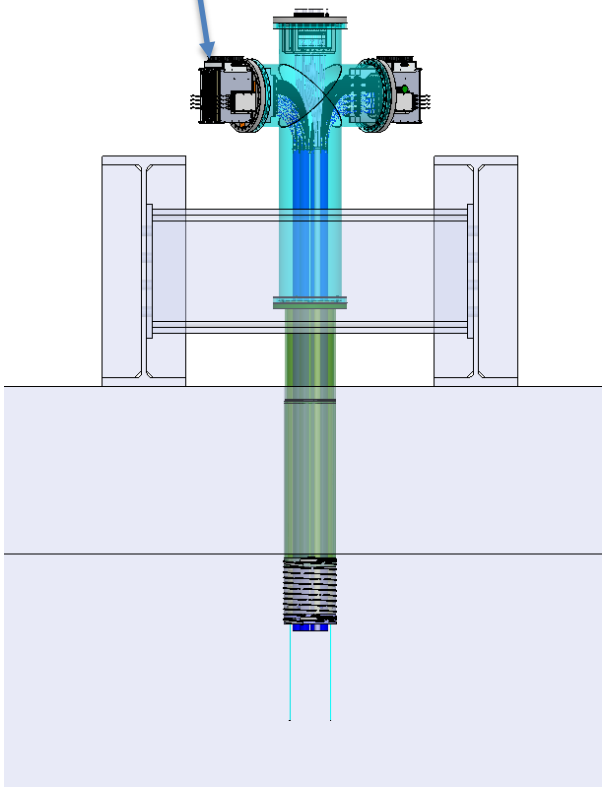
- Provide a seal of the cryostat with a maximum leak of 1.0E-9 std.cc/sec He @ 1atm diff.
- Provide a separation of 5 mm between the cryostat crossing tube and the crossing tube of the cryostat penetration
- The cross-shaped spool piece and CE crossing tube shall fit on the cryostat crossing tube flange.
- Provide enough space to route the CE cables and PDS cables for 2 APAs.
- The cross-shaped spool piece shall have sufficient strength to support the weight of two CE flange/crates and one PDS flange.
- The CE crossing tube shall have sufficient strength to support the weight of cables inside the cryostat penetration.

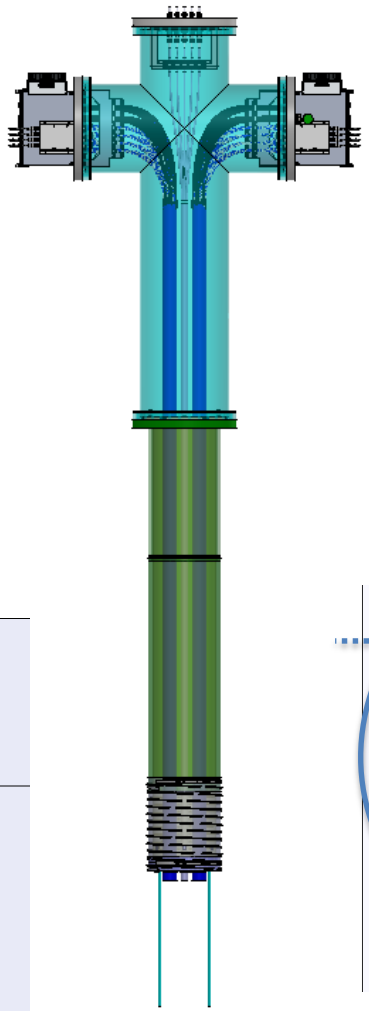
Layout of the Cryostat Roof

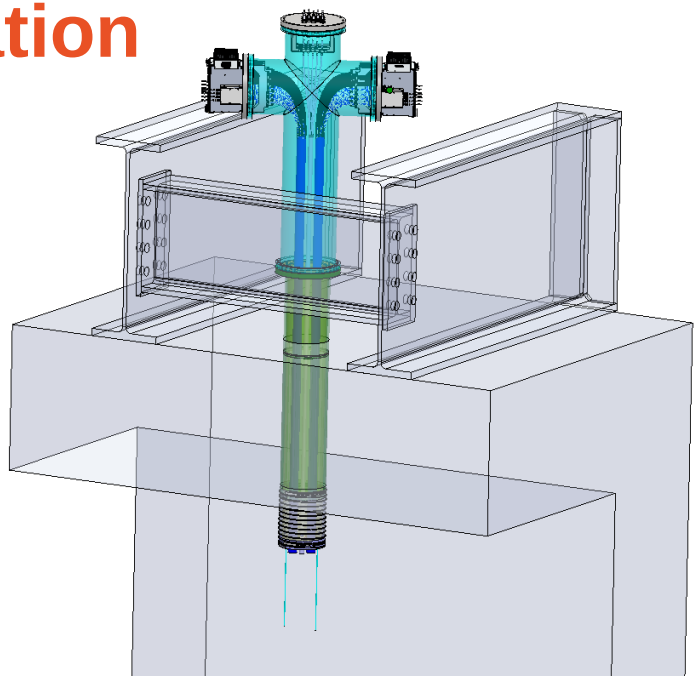


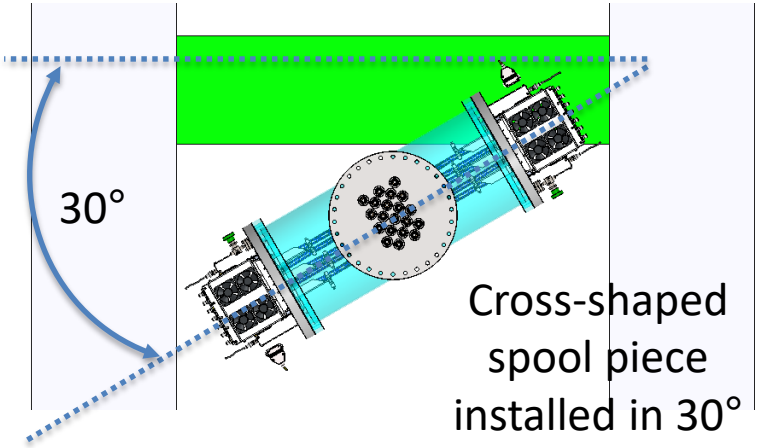
Overview of Cryostat Penetration

CE flanges stay above cryostat beam



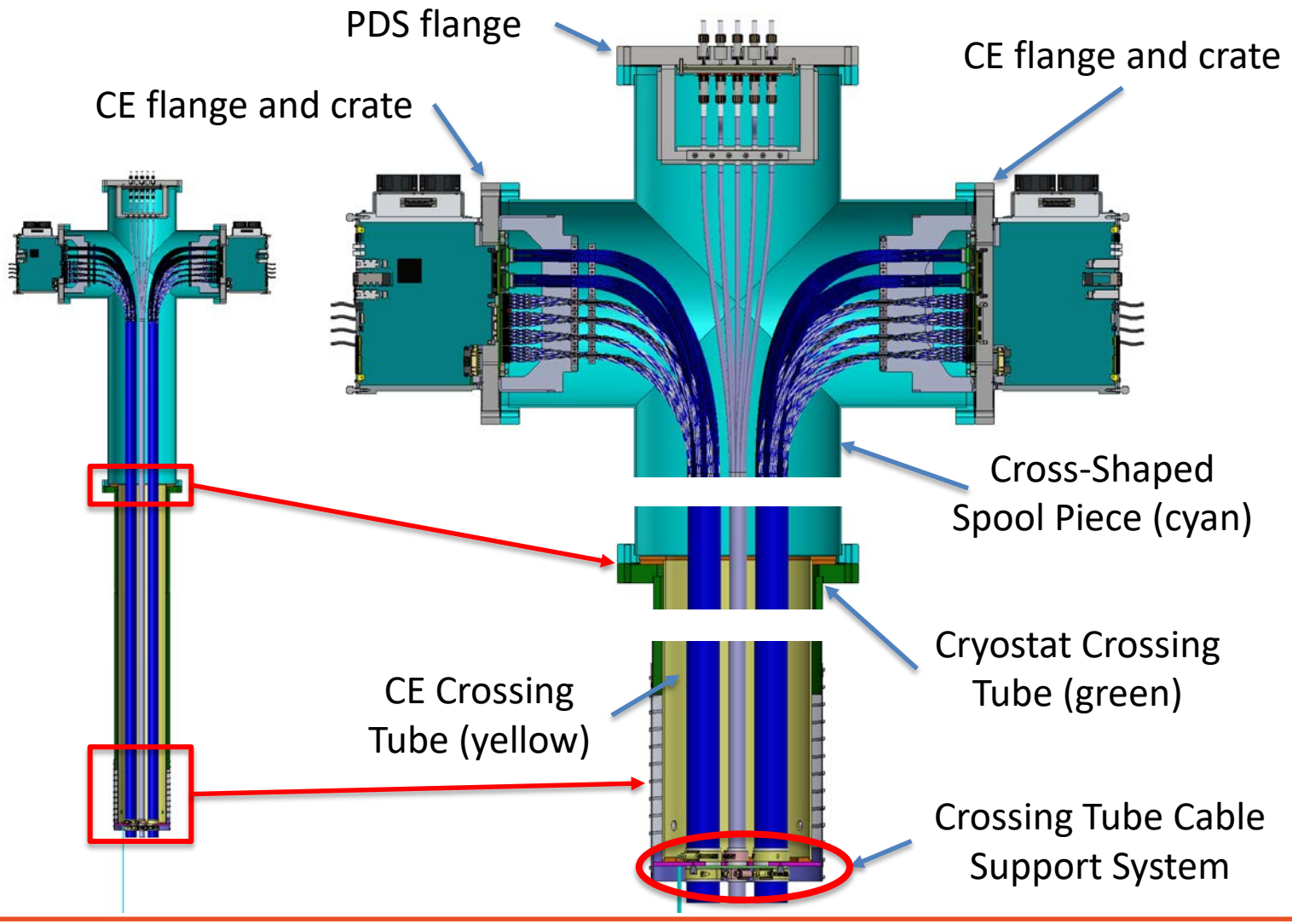




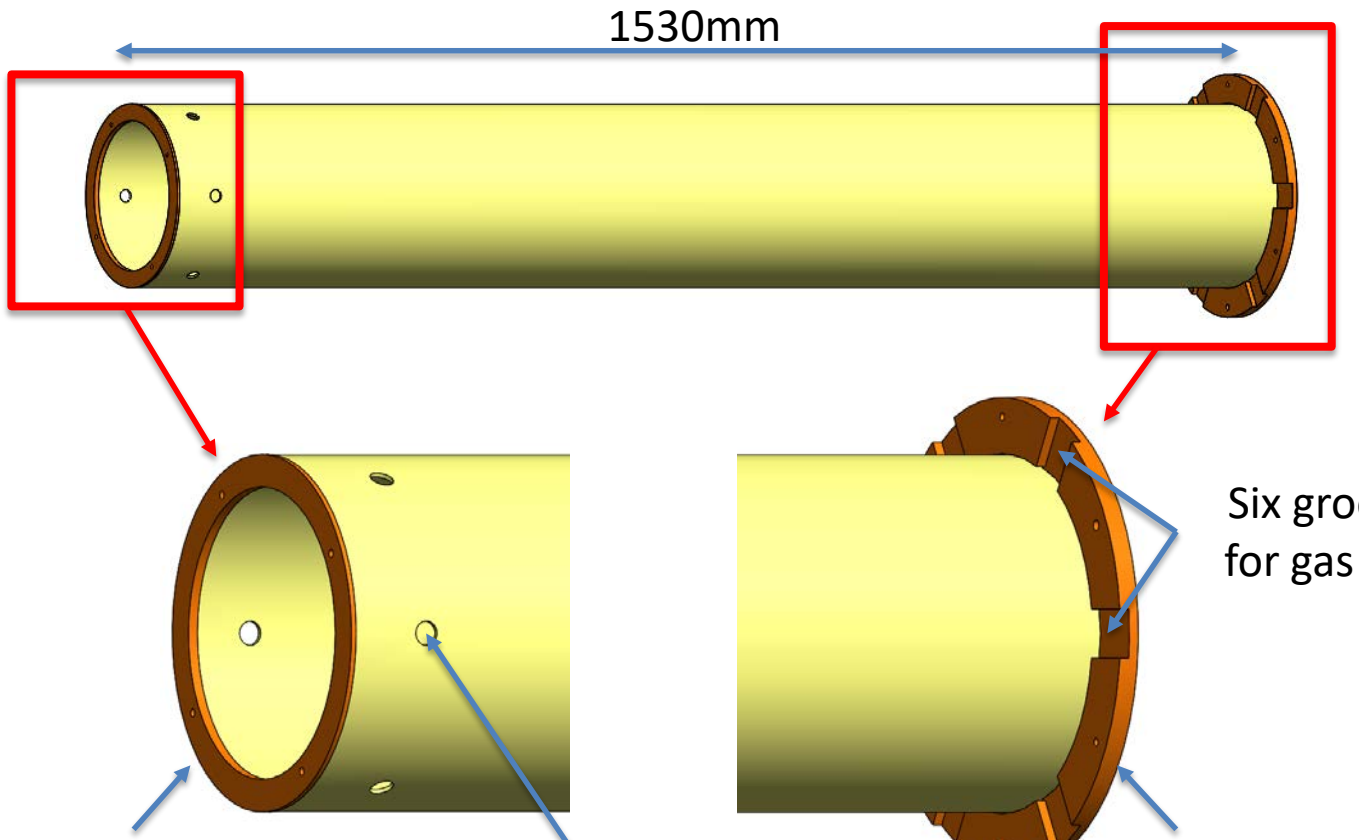


Cross-shaped spool piece installed in 30°

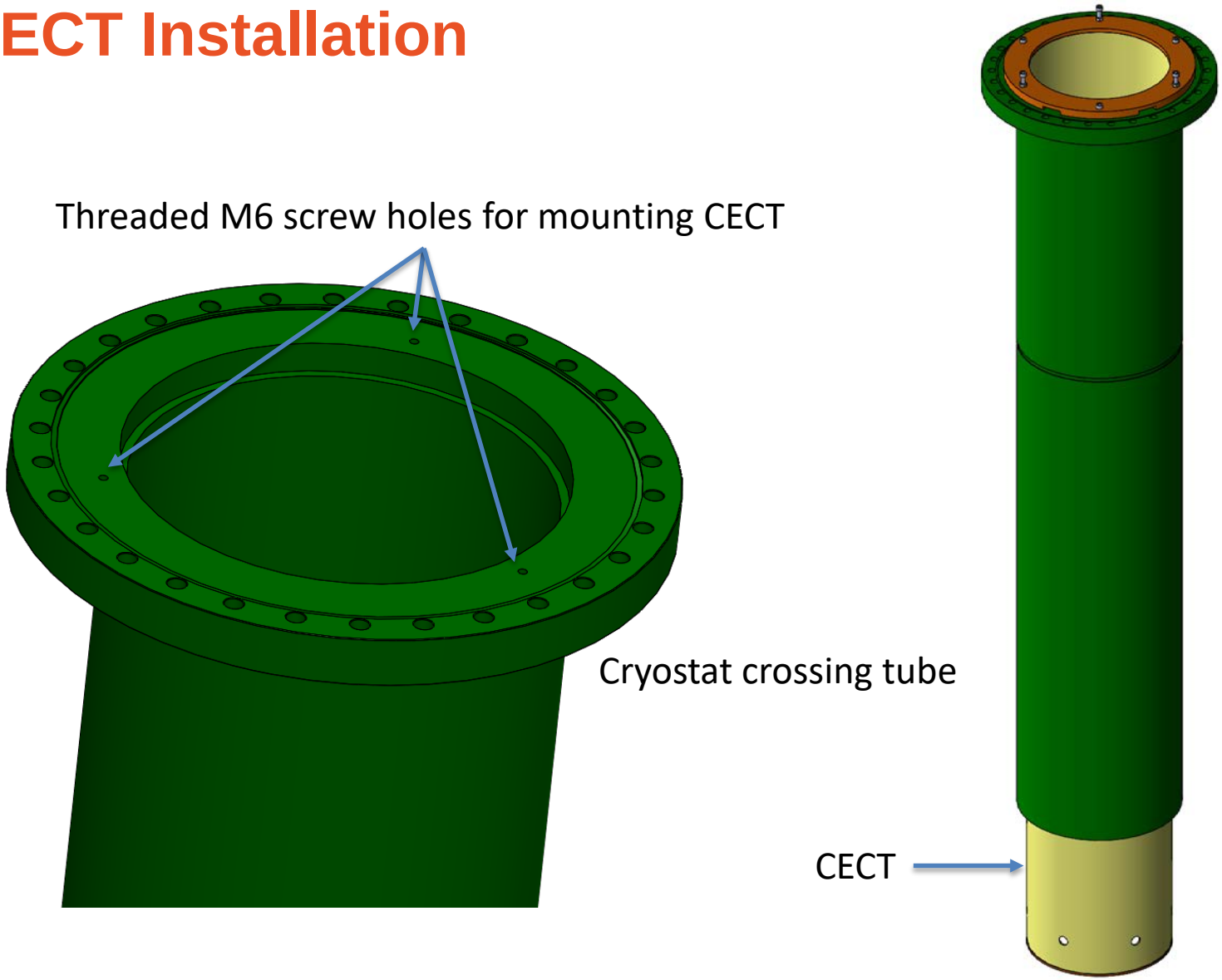
Anatomy of Cryostat Penetration



CE Crossing Tube (CECT)

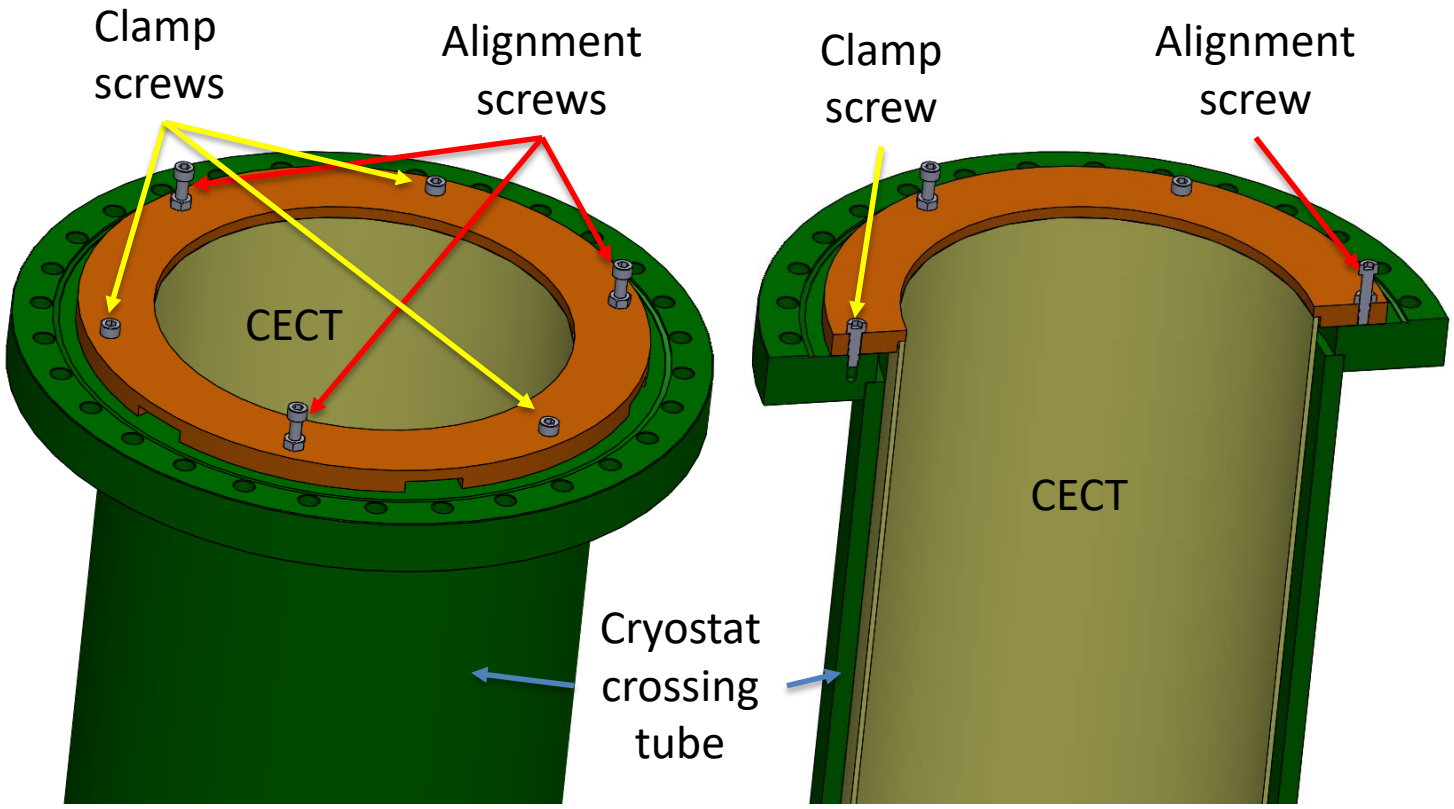


CECT Installation

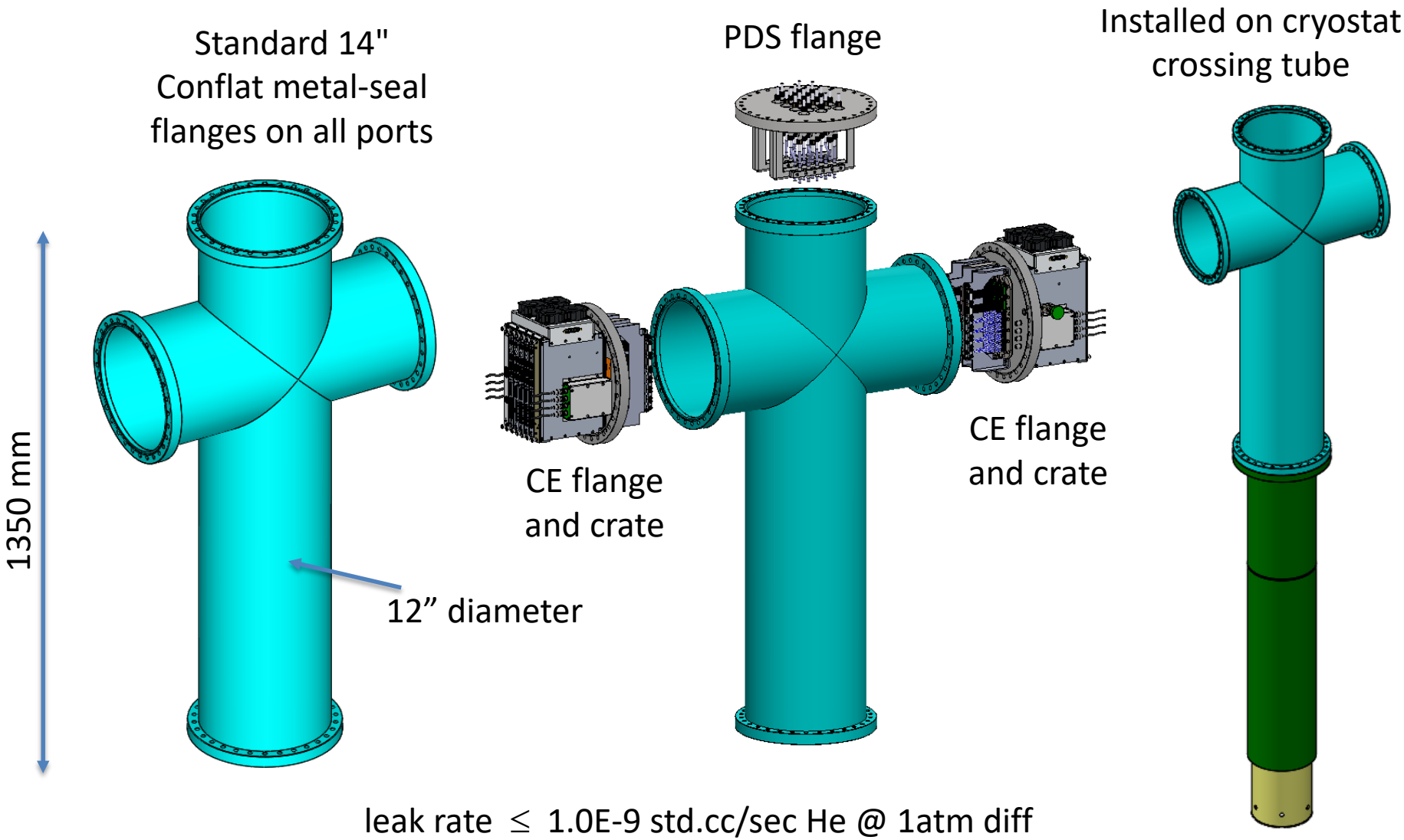


CECT Installation

Good concentricity achieved by adjusting the alignment screws to tilt the CECT for better alignment.

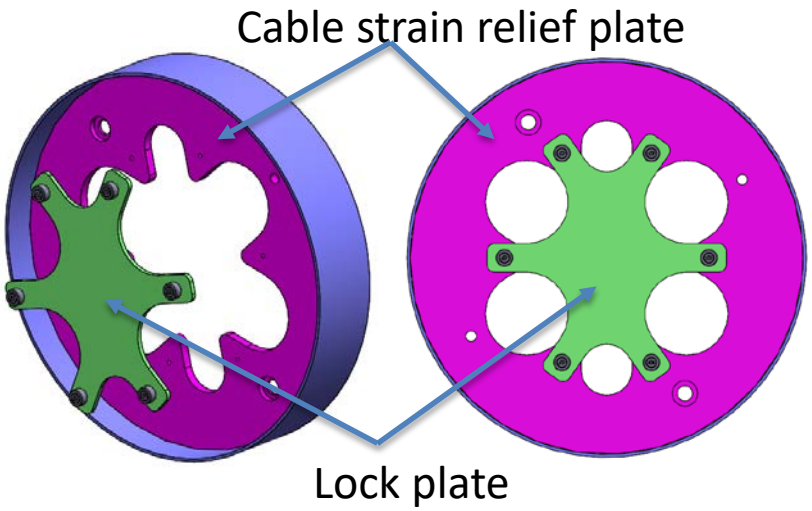


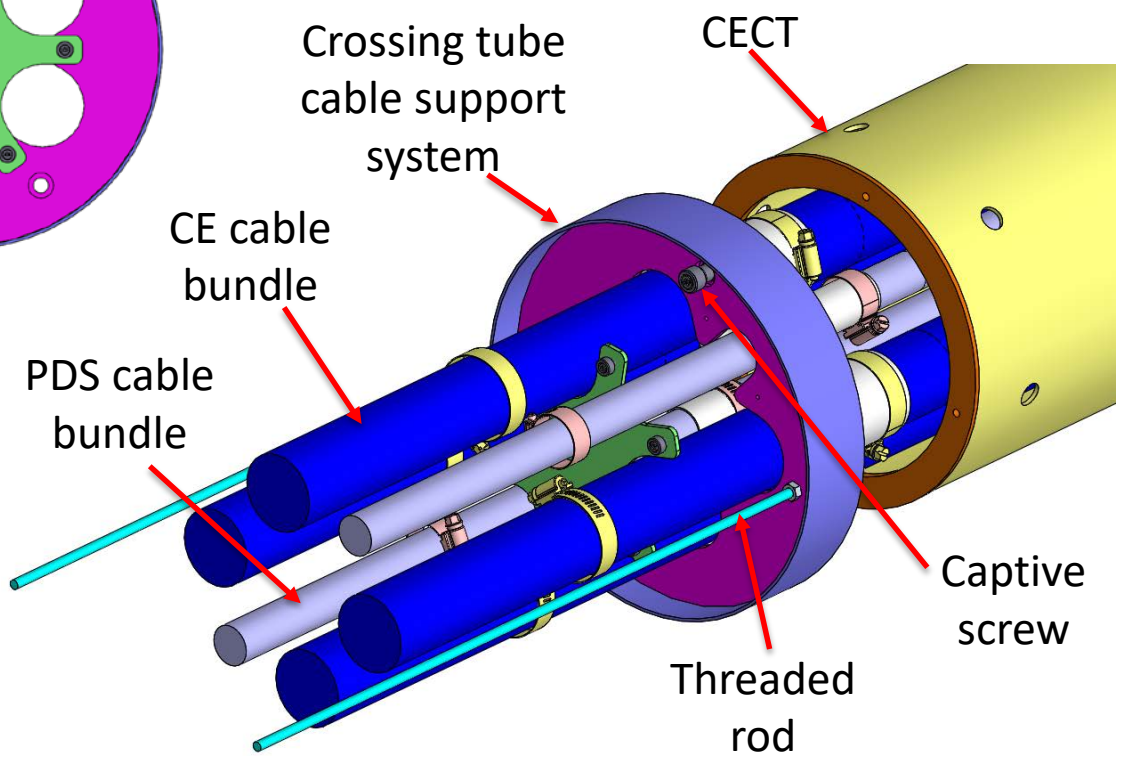
Cross-Shaped Spool Piece



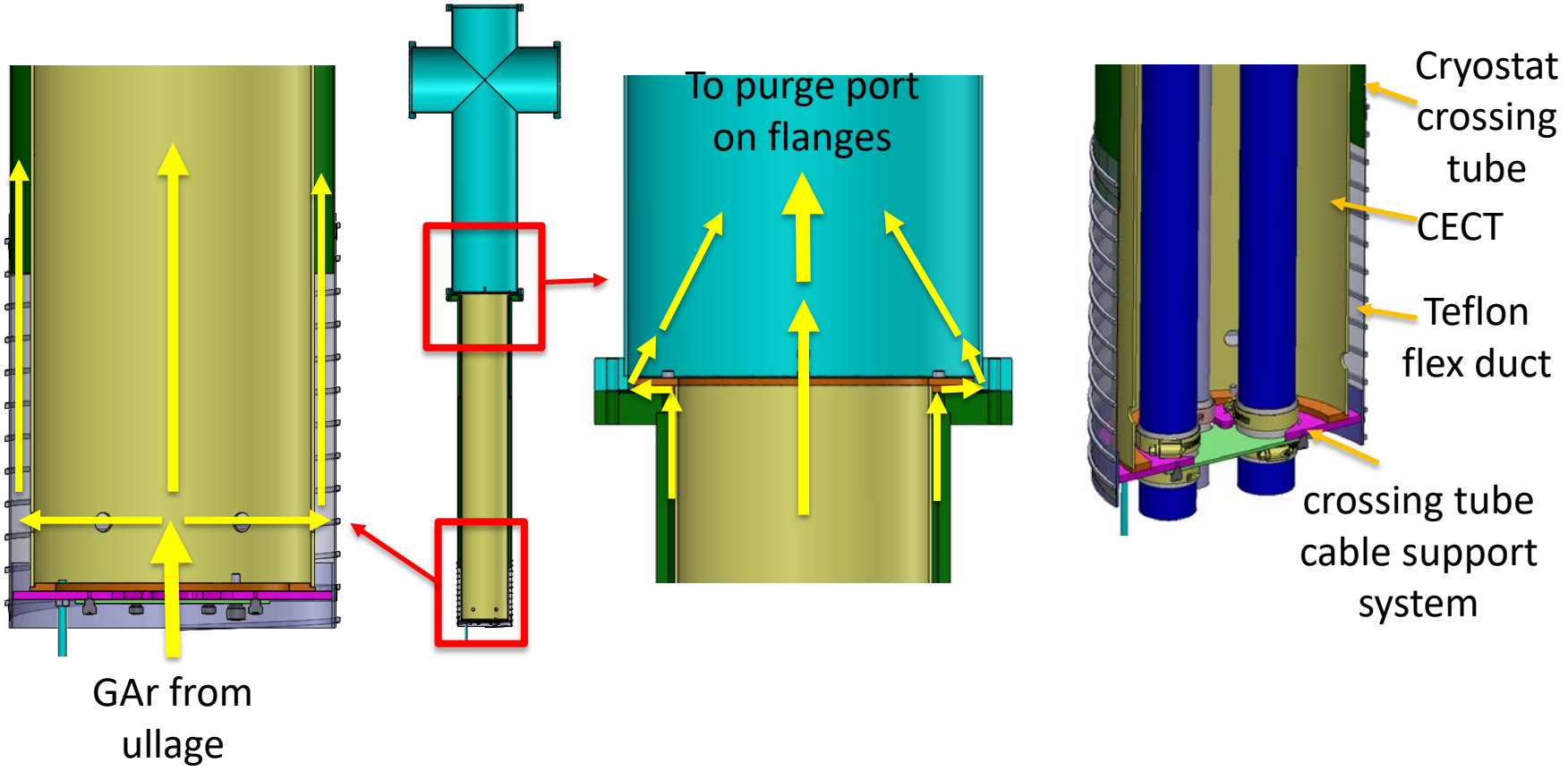
leak rate $\leq$ 1.0E-9 std.cc/sec He @ 1atm diff

Crossing Tube Cable Support System

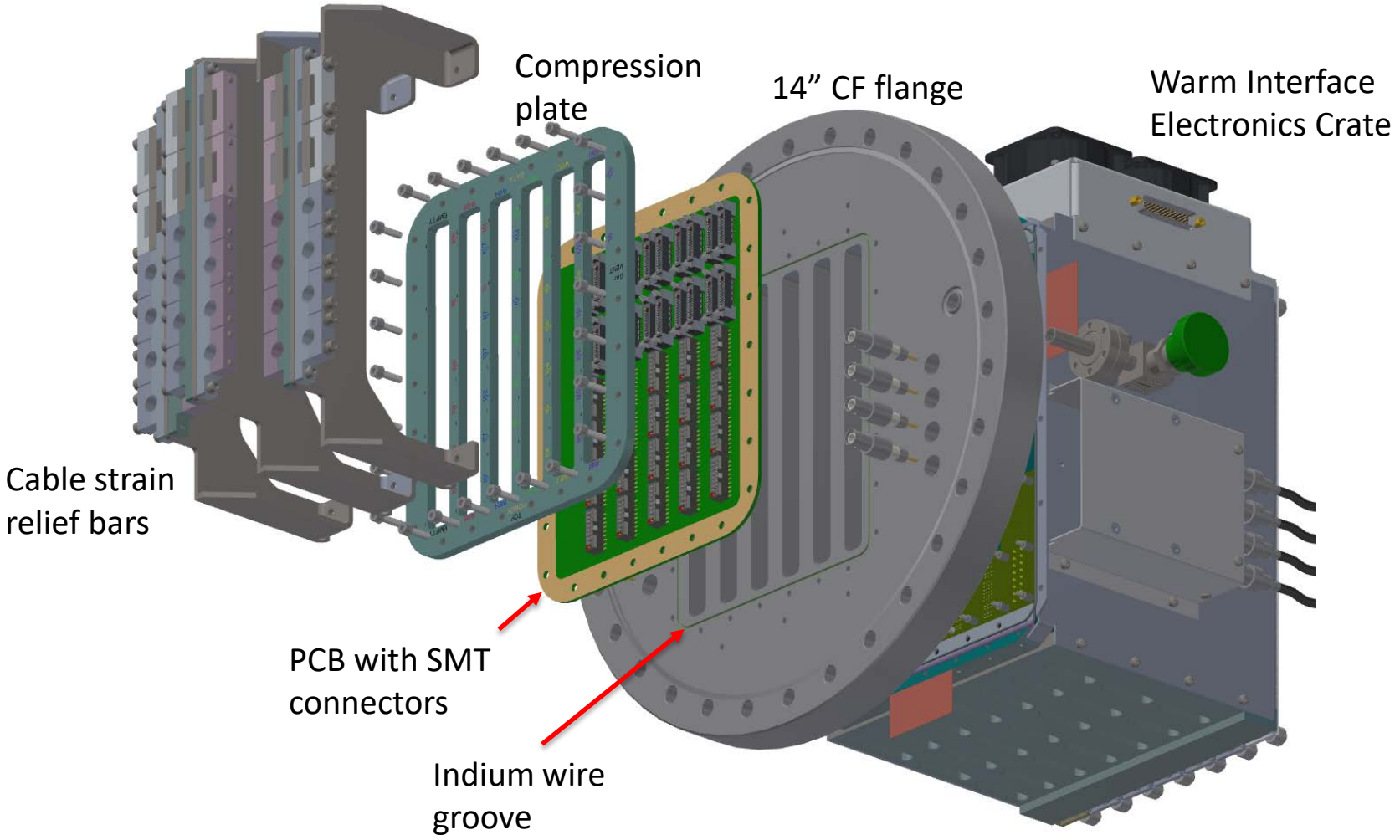




Gas Flow Path in the Cryostat Penetration



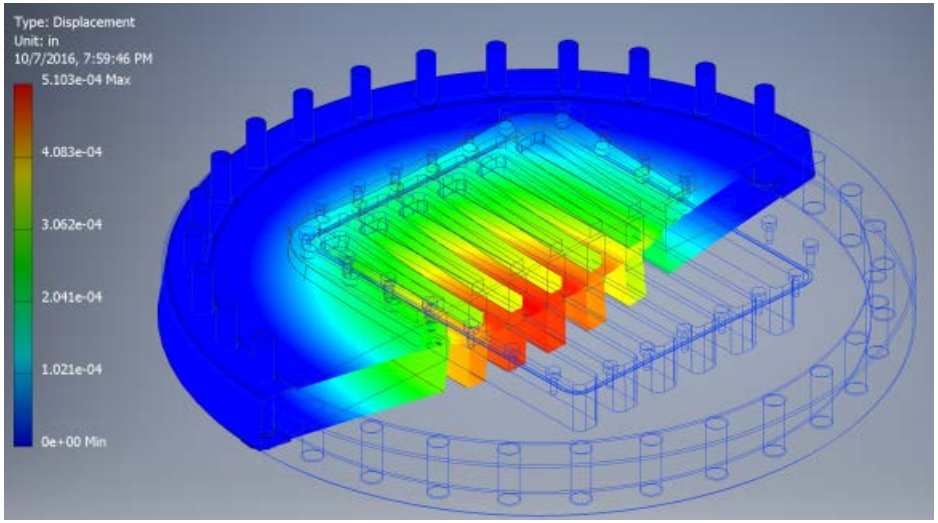
CE Flange Design

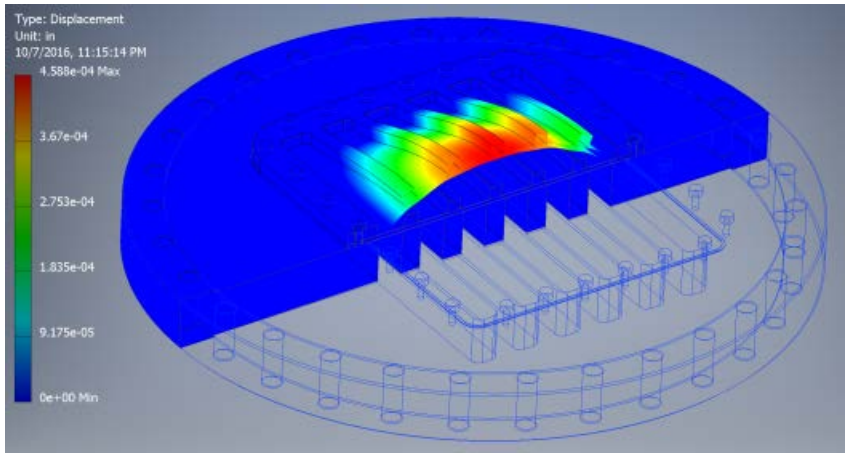


CE Flange FEA

Cryostat design pressure range: 950 – 1350 mbar

5 psi from inside cryostat: ~13μm max deflection
Max stress: ~ 2000 psi

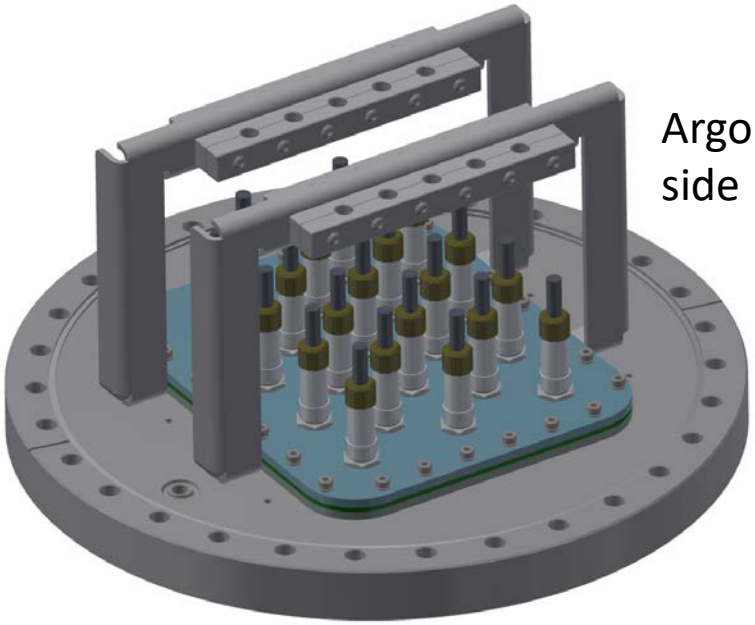




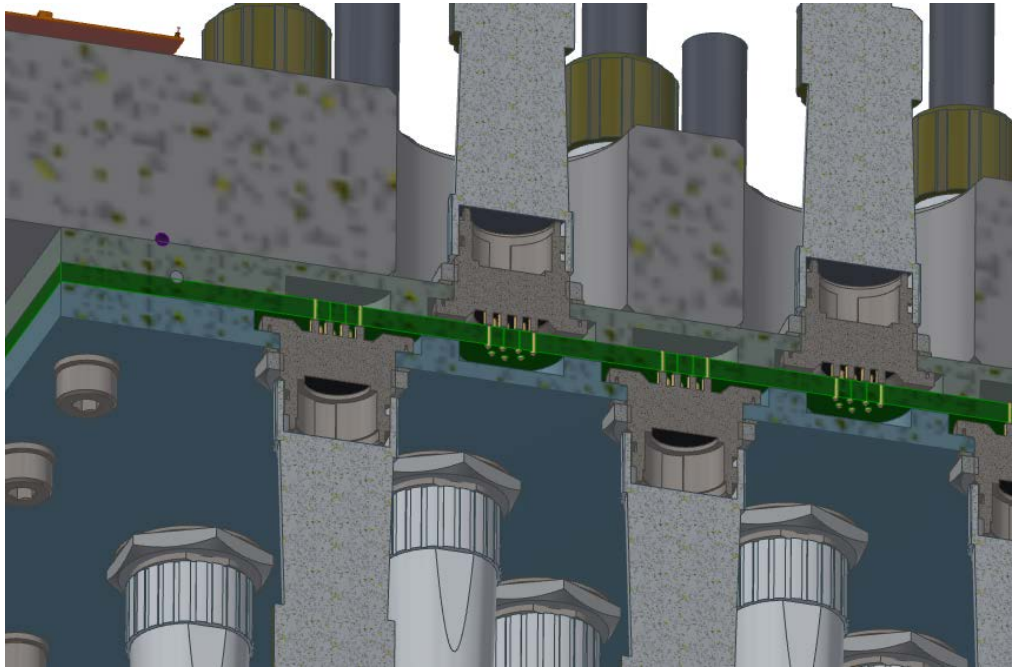
1 psi from outside cryostat: ~12μm
Max stress: ~ 900 psi

PD Flange Design

- Joint effort with ANL PDS group
- Up to 20 Hirose LF10WBR-12 connectors (through hole)
- PCB + double layer stiffening plate sandwich sealed against the 14” CF flange with indium wire
- Cable strain relief bars on the argon side
- Heaters and venting port



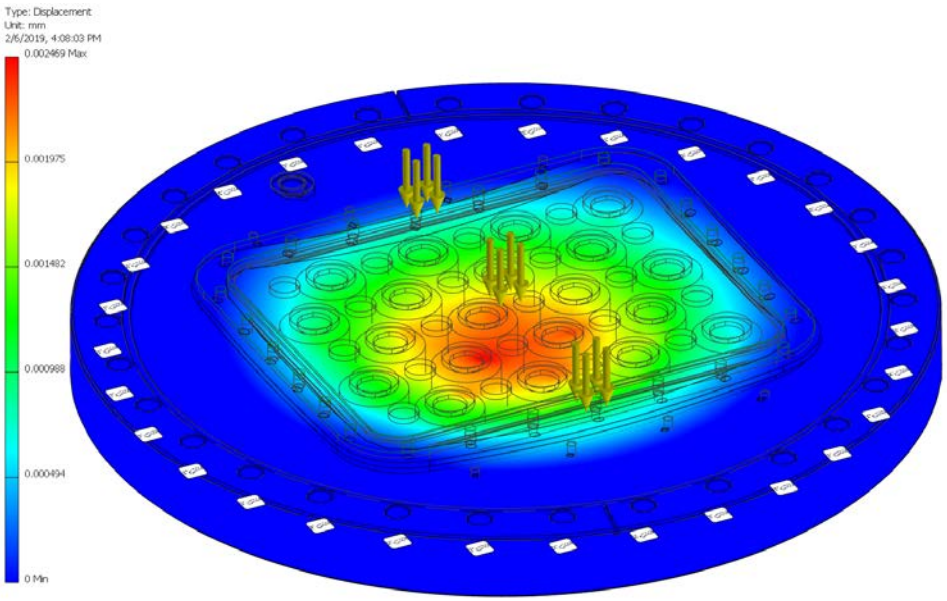
Argon side

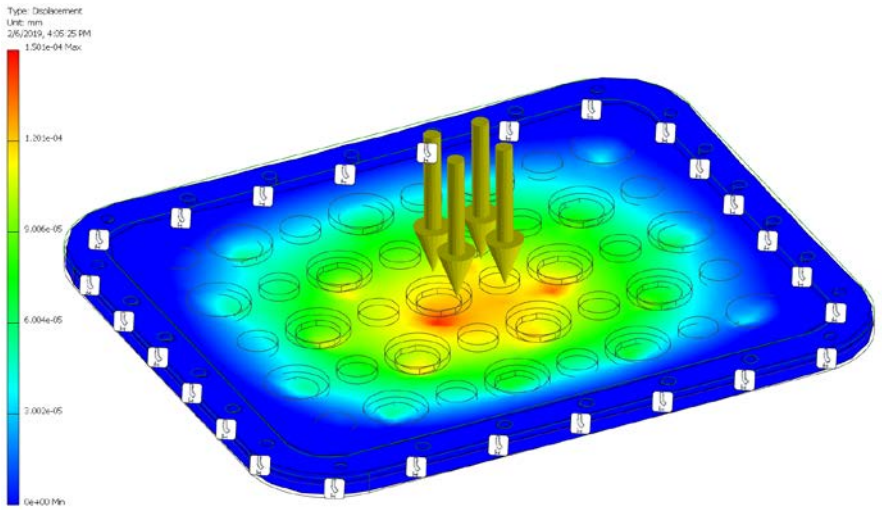


Air side

PD Flange FEA

5 psi from inside cryostat: ~2.5µm max deflection

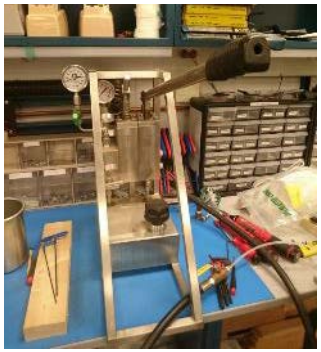


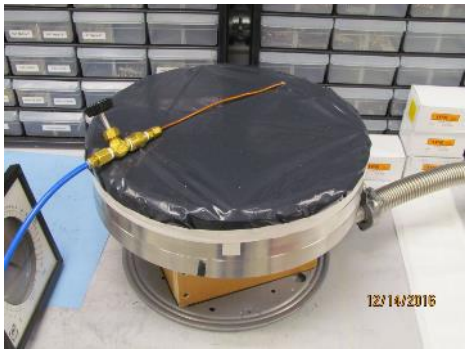


1 psi from outside cryostat: ~0.2µm displacement

Tests Performed on the CE Signal Flanges

- Leak tests
  - Vacuum leak rate at or below ~2e-9 mbar.l/s
- Pressure tests
  - 120 psi hydrostatic test on an SBND flange without surface mount connectors @ BNL for LARIAT VST. (SBN docdb 6873)
  - 80 psi pneumatic test of a ProtoDUNE CE flange, a PD flange, and a Tee @ FNAL for ICEBERG
- Units in use
  - 6 @ ProtoDUNE, one on the cold box
  - 1 @ LARIAT VST (SBND version)
  - 1 @ ICEBERG (DUNE version)





Finite Element Analysis of CECT

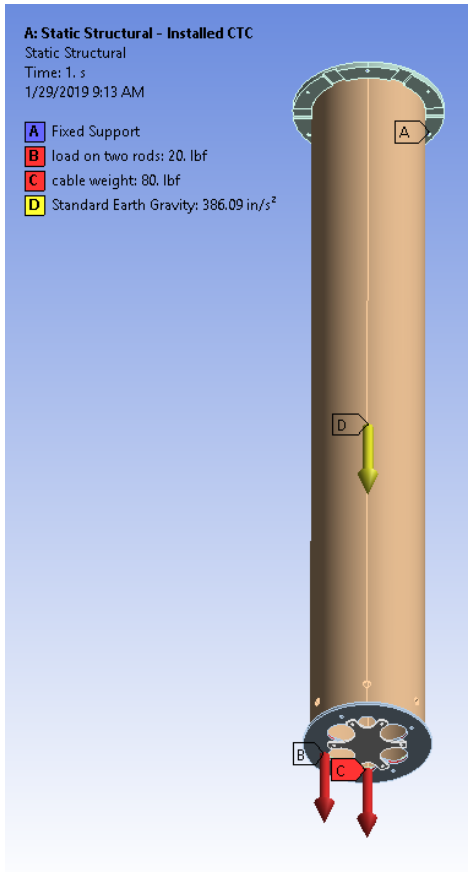
Two loading scenarios of CETC are simulated:

The CECT supports ~50 Kg cable weight.

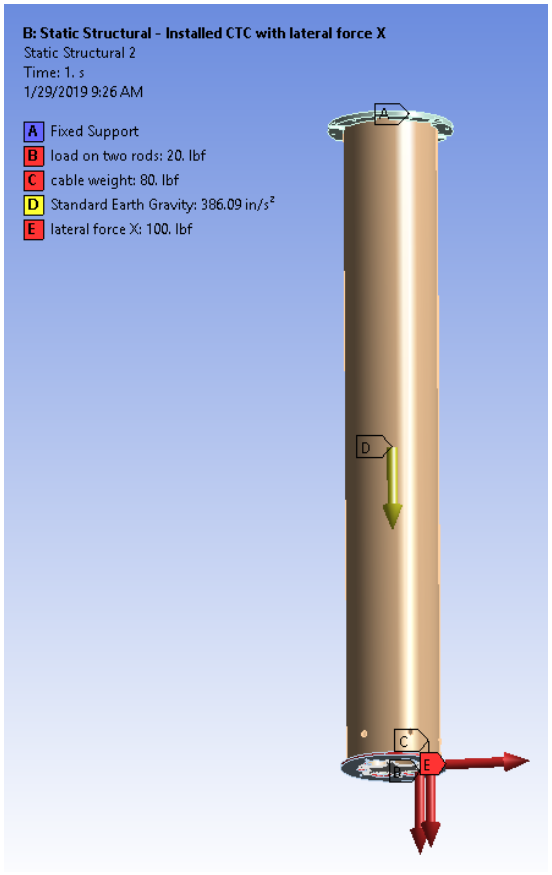
50 Kgf lateral force during installation and cabling.

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

1) 50 Kg cable weight



2) 50 Kg cable weight and 50 Kgf lateral force.

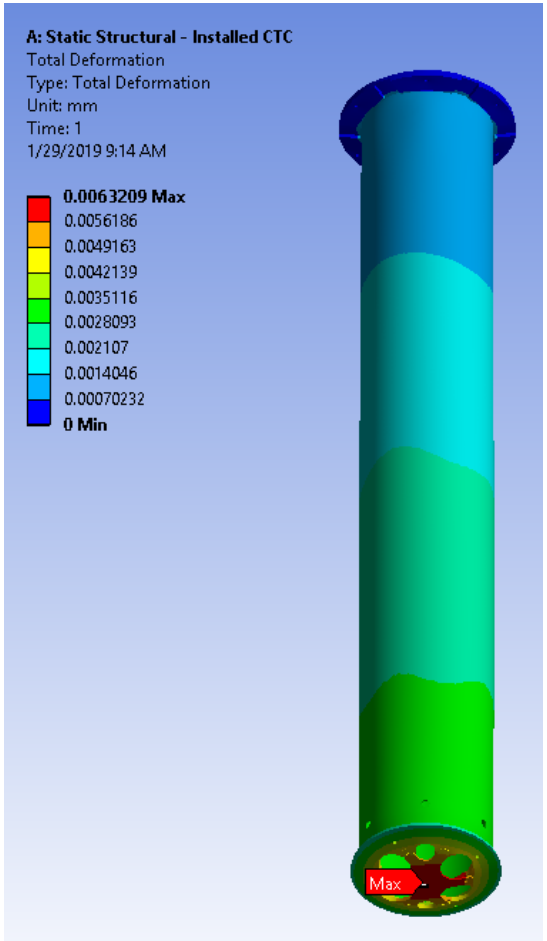


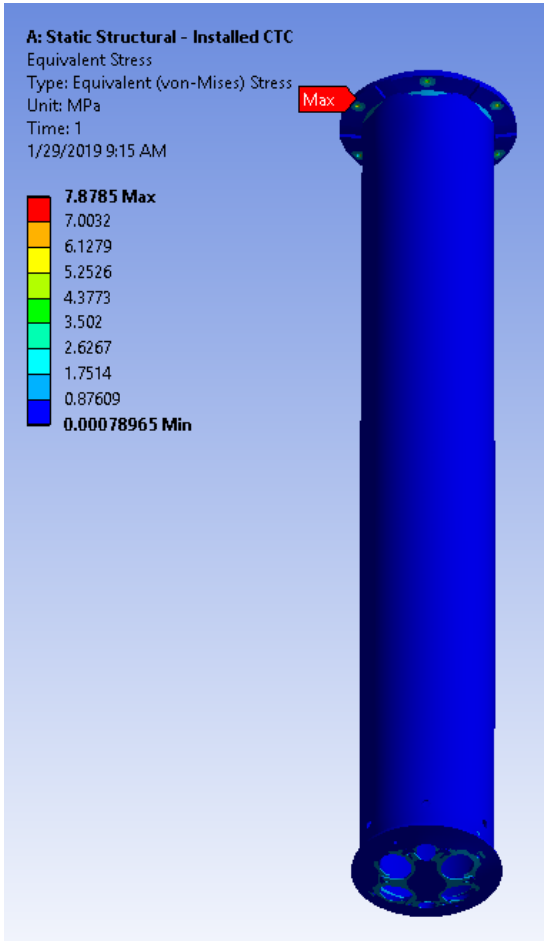
Stress and Deformation of CECT (1)

Loading scenario 1

50 Kg cable weight

Loading Scenario 1	
Max deformation (mm)	0.006
Max Equivalent Stress (MPa)	7.9
Safety Factor	27.2



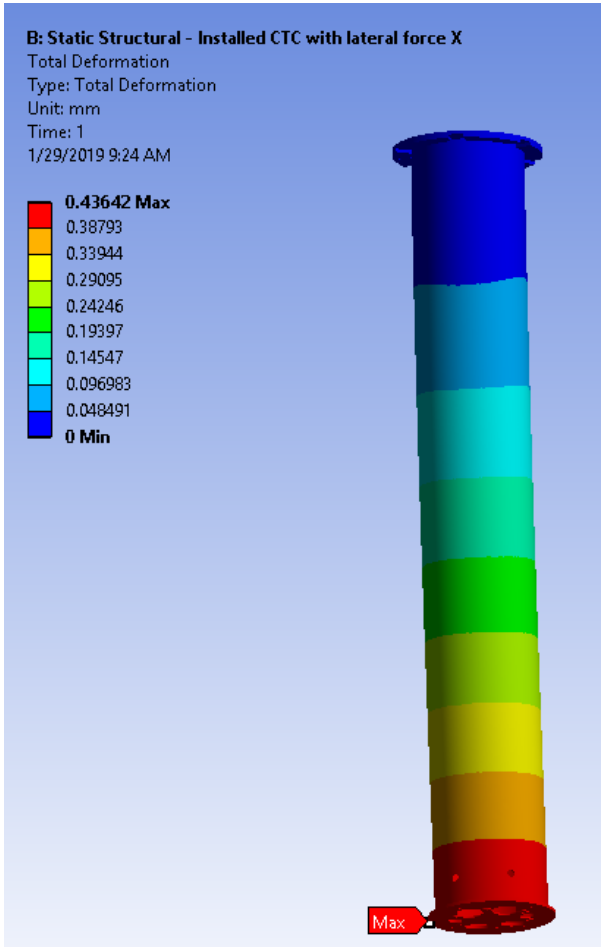


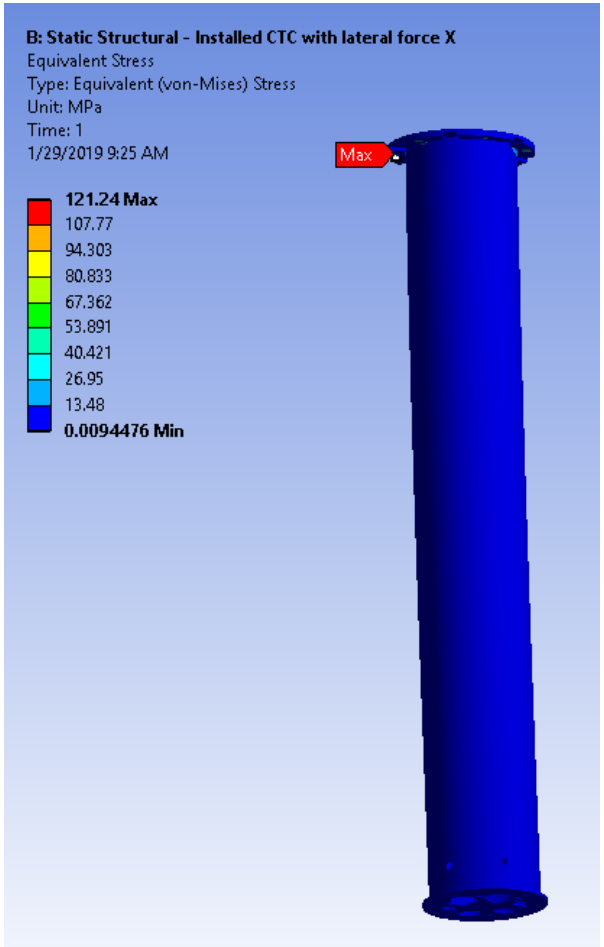
Stress and Deformation of CECT (2)

Loading scenario 2

50 Kg cable weight and
50 Kgf lateral force.

Loading Scenario 2	
Max deformation (mm)	0.4
Max Equivalent Stress (MPa)	121
Safety Factor	1.77



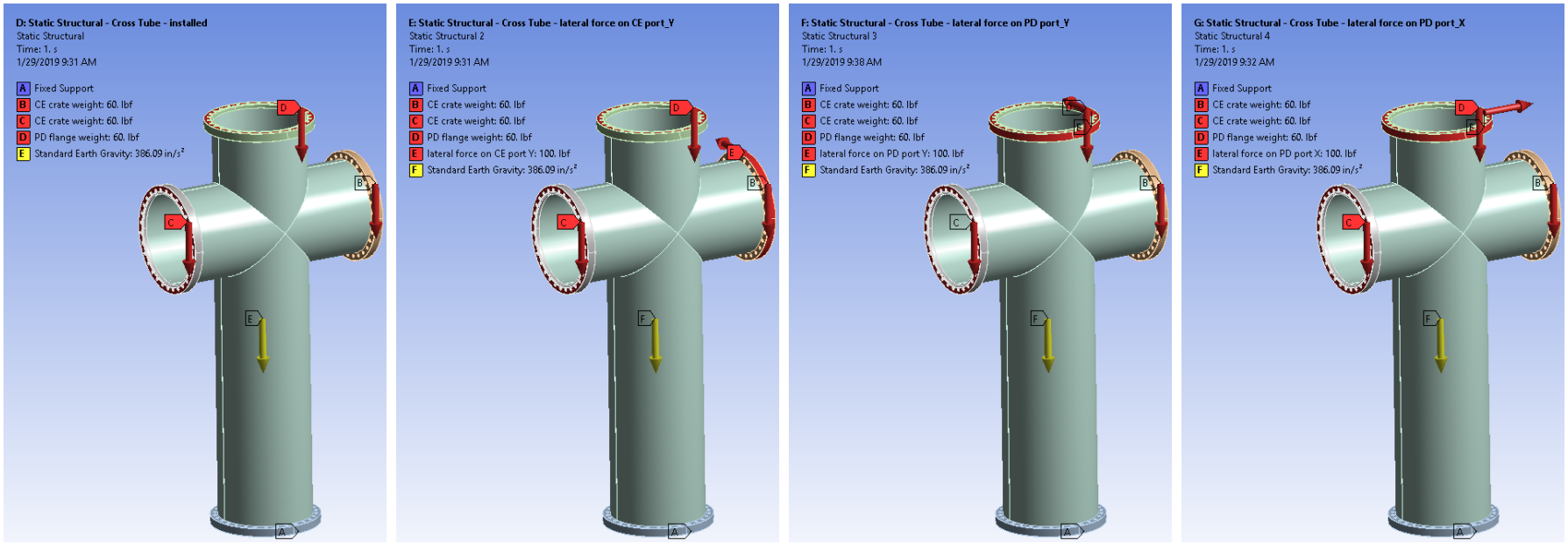


Finite Element Analysis of Cross-Shaped Spool Piece

Four loading scenarios in total of cross tube are simulated

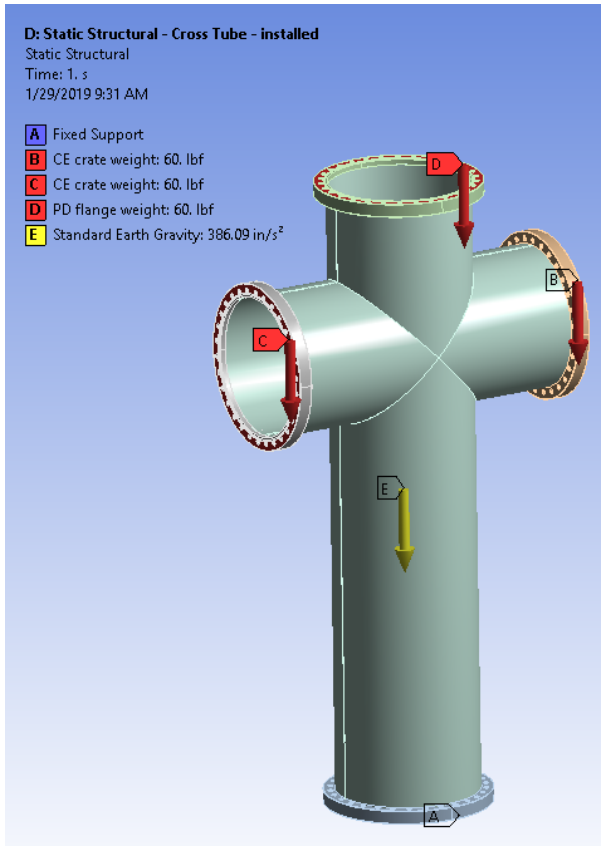
1) 90 Kg of flange weight,
2) 90 Kg of flange weight and 50 Kgf lateral force along Y direction on CE port,
3) 90 Kg of flange weight and 50 Kgf lateral force along Y direction on PDS port,
4) 90 Kg of flange weight and 50 Kgf lateral force along X direction on PDS port.

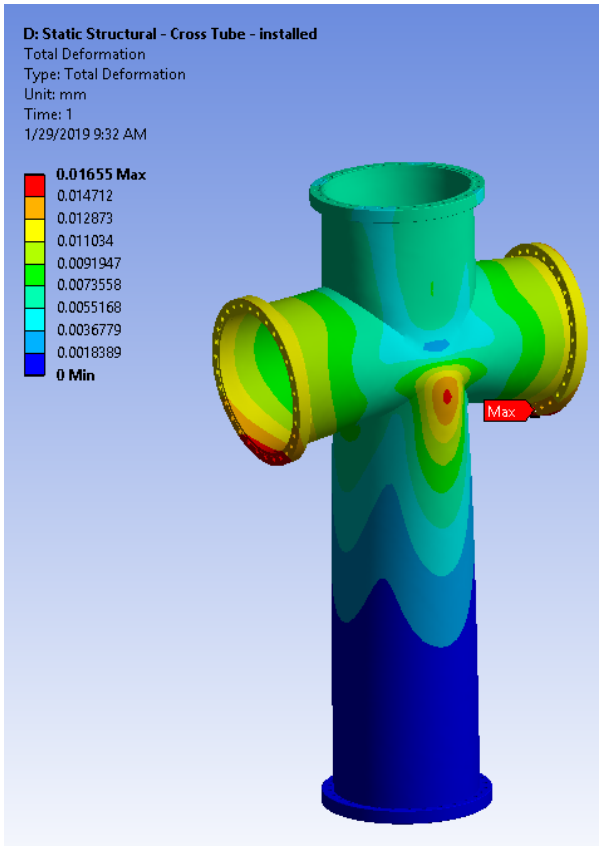
(1) (2) (3) (4)

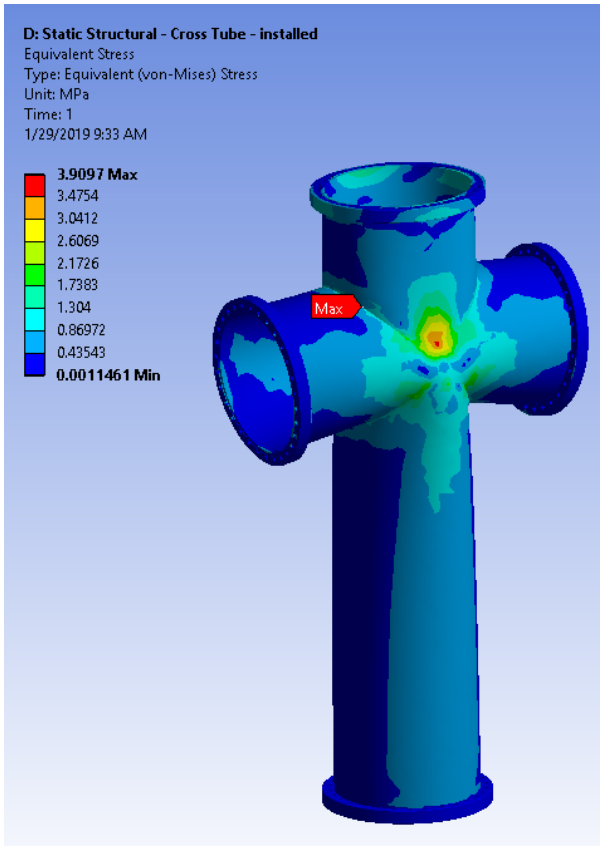


Stress and Deformation of Cross-Shaped Spool Piece (1)

Loading scenario 1: 90 Kg of flange weight



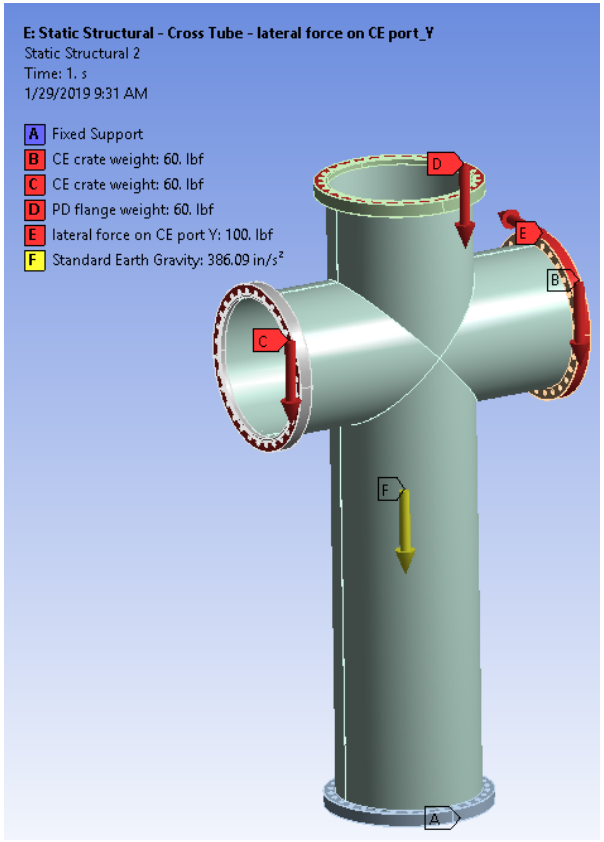


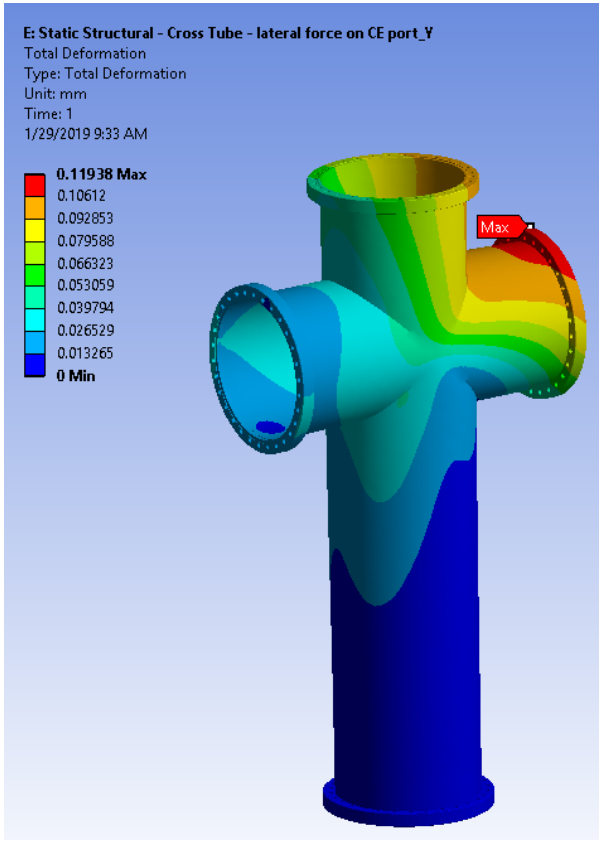


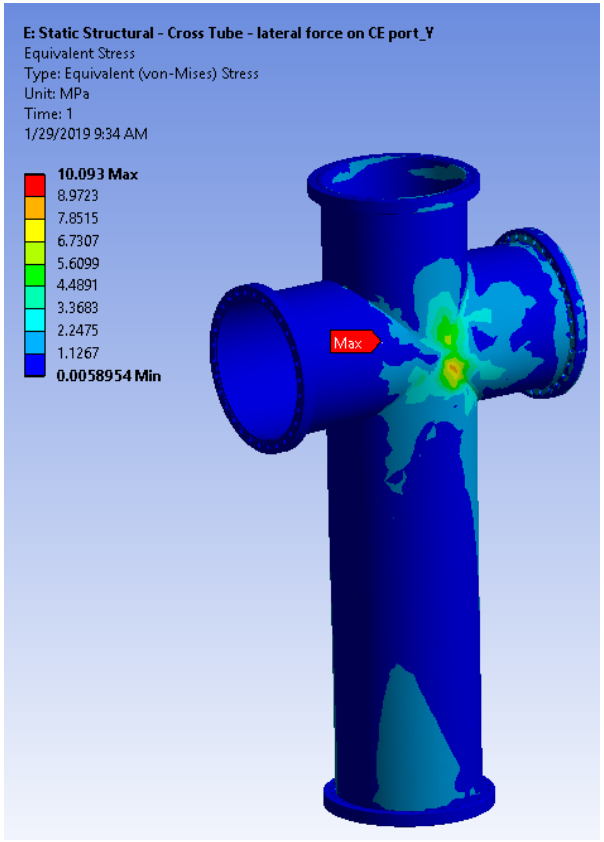
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 1	0.02	3.9	55.1

Stress and Deformation of Cross-Shaped Spool Piece (2)

Loading scenario 2:
90 Kg of flange weight and 50 Kgf lateral force along Y direction on CE port





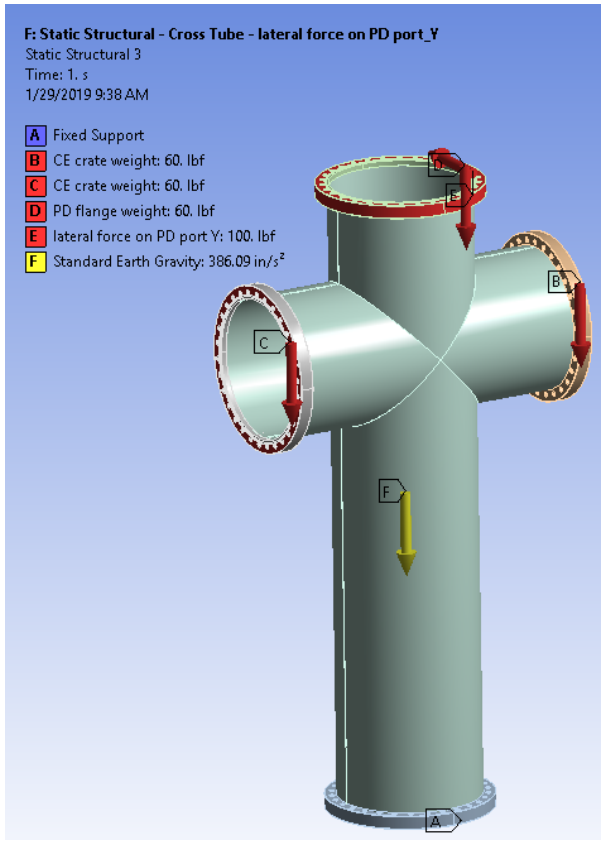


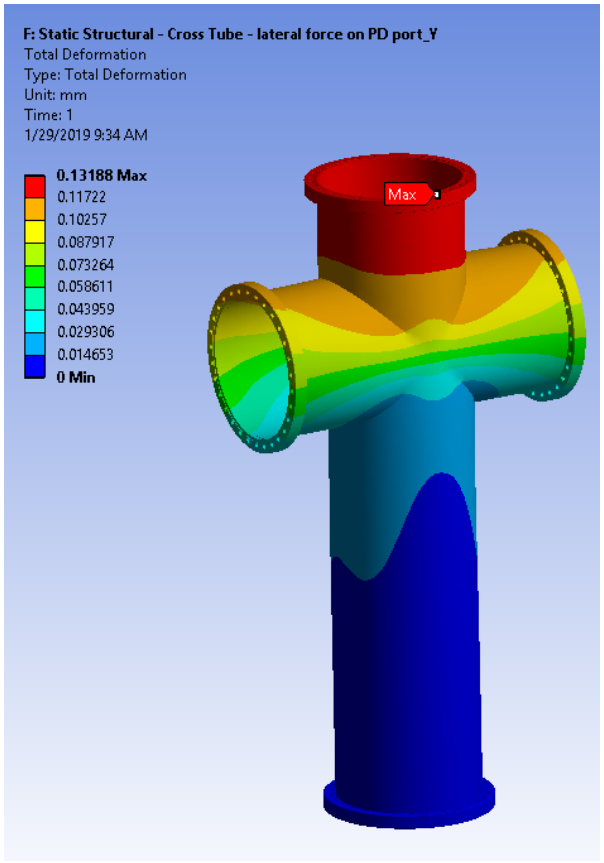
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 2	0.12	10.1	21.3

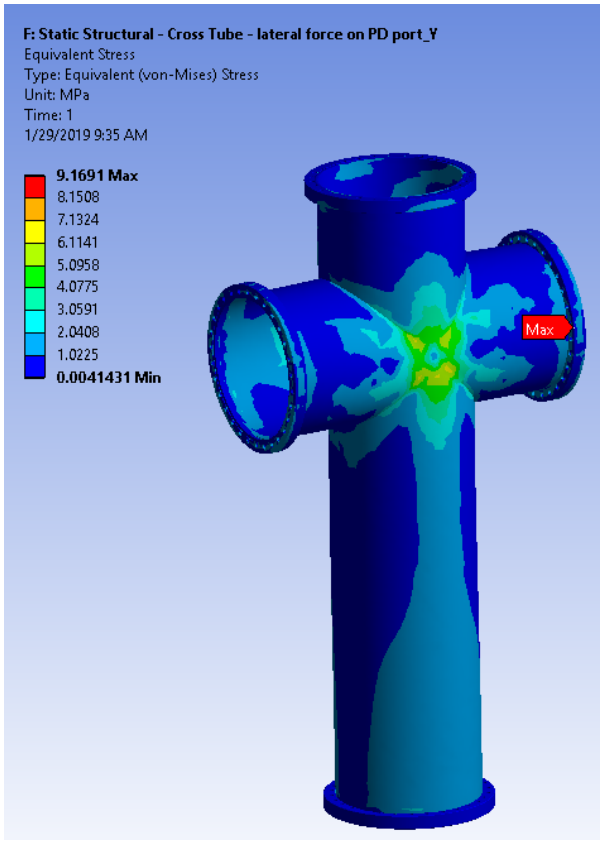
Stress and Deformation of Cross-Shaped Spool Piece (3)

Loading scenario 3:

90 Kg of flange weight and 50 Kgf lateral force along Y direction on PDS port



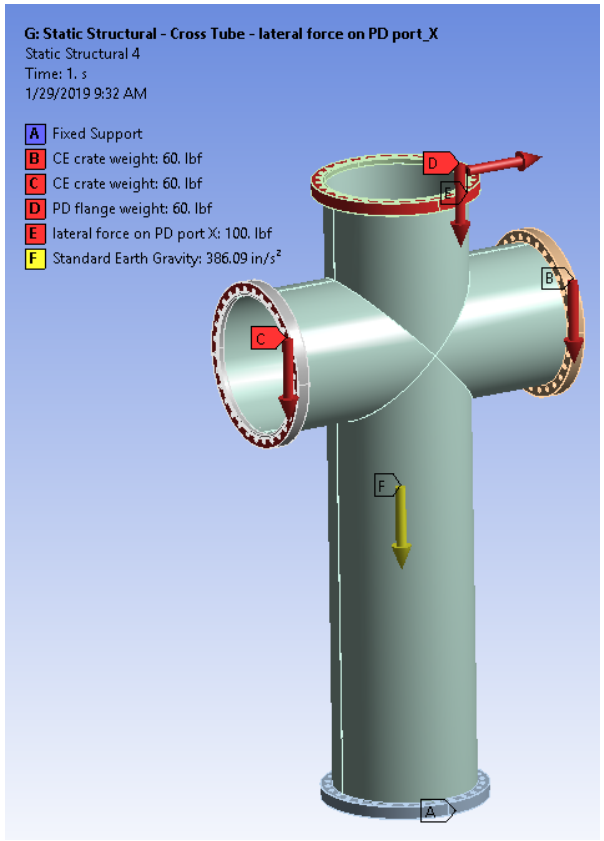


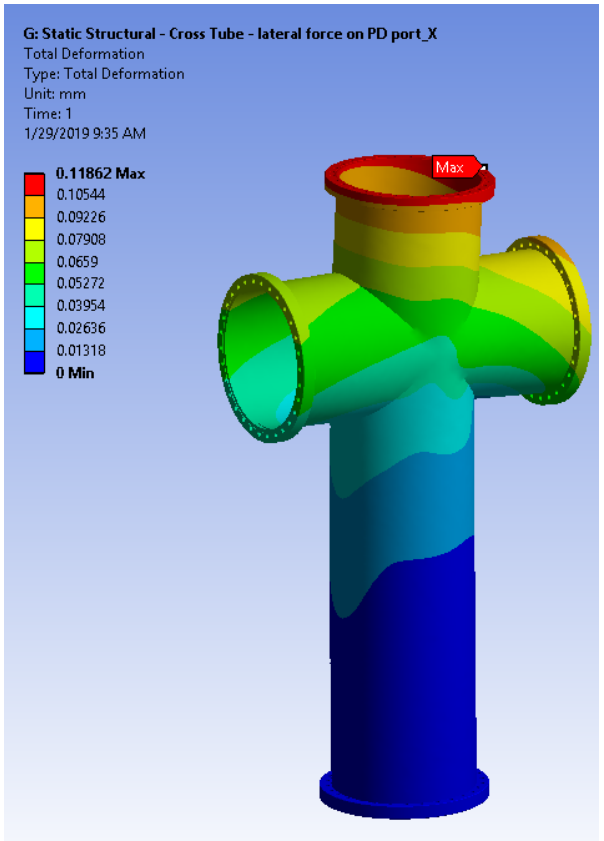


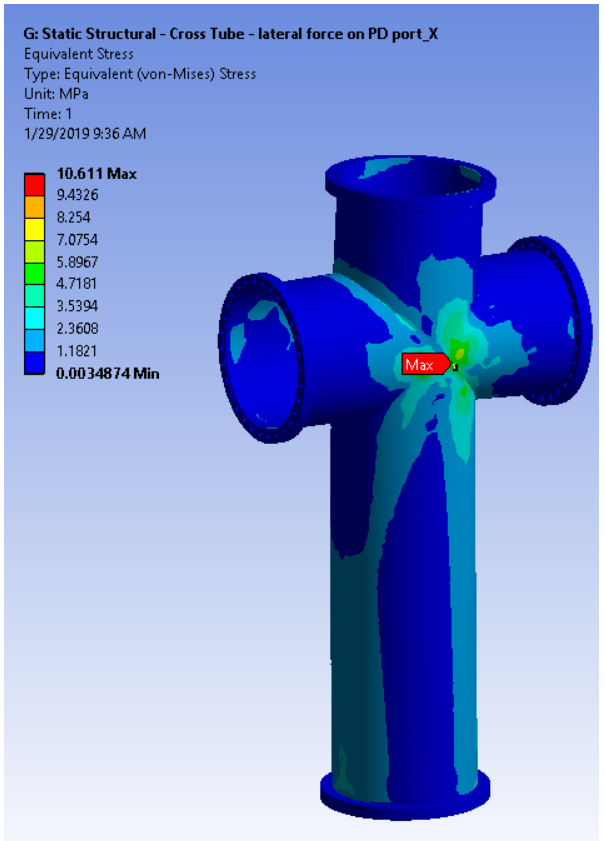
	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 3	0.13	9.2	23.4

Stress and Deformation of Cross-Shaped Spool Piece (4)

Loading scenario 4:
90 Kg of flange weight and 50 Kgf lateral force along X direction on PDS port







	Max deformation (mm)	Max Equivalent Stress (MPa)	Safety Factor
Loading Scenario 4	0.12	10.6	20.3

Thank You!