MVTX PRR Integration

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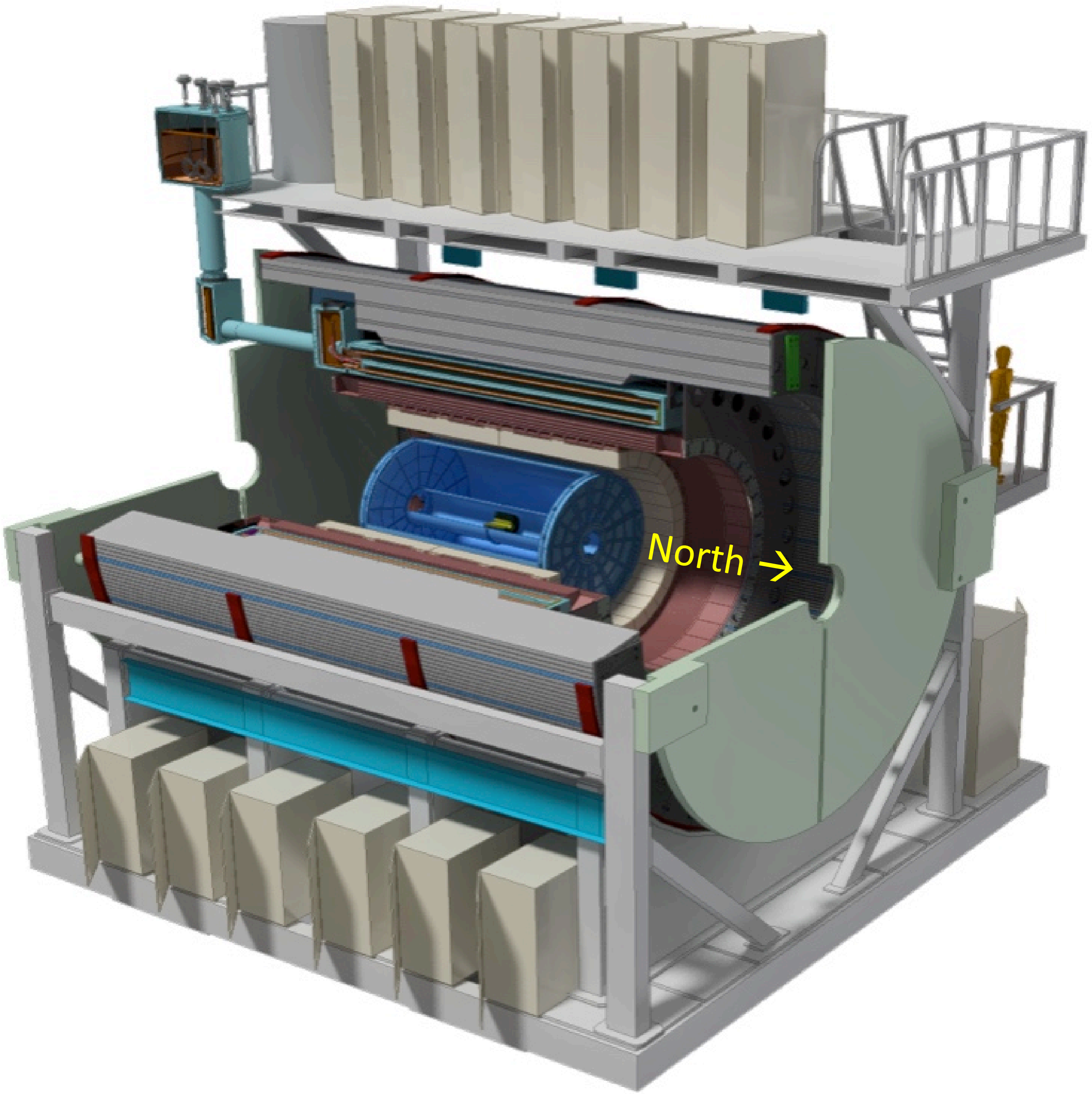
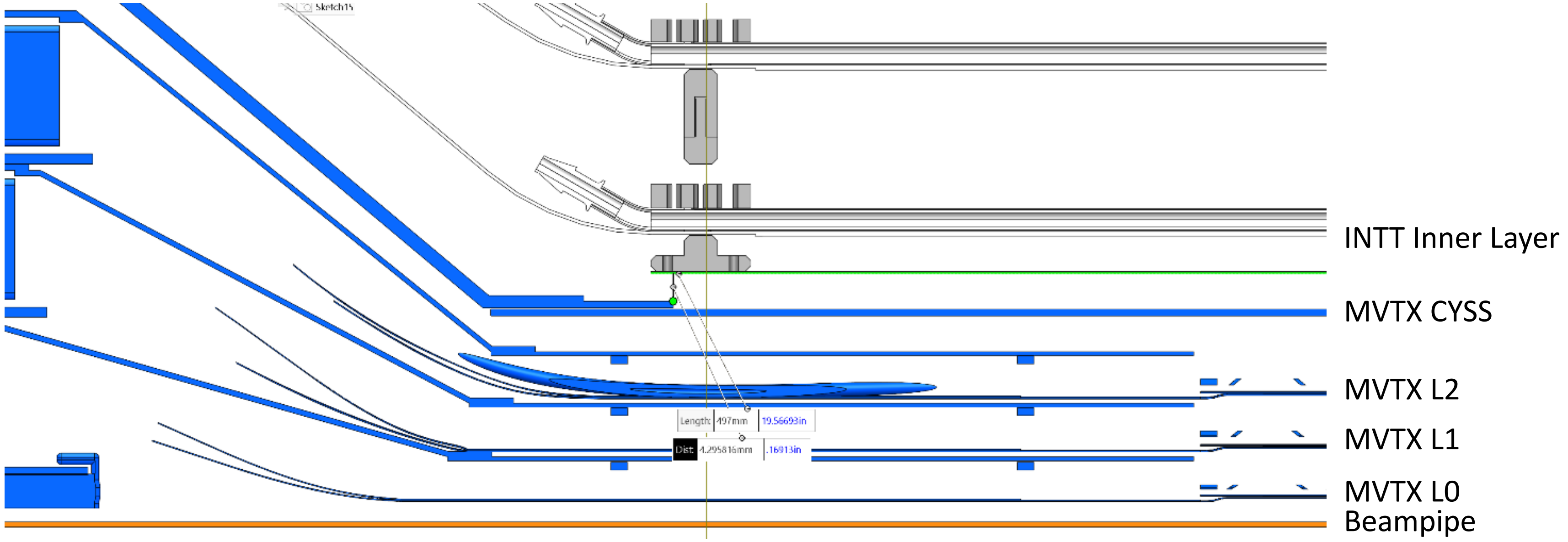
Overview

1. Interfaces
   - Interface to INTT
   - Interface to beampipe
   - Interface to iHCAL
   - Services
2. MVTX Support Structure
3. MVTX Installation
   - Hardware
   - Sequence of operations



1.1 Interface to INTT

- Minimum clearance to INTT is 4.3 mm once installed
  - This is much greater than our predicted deflection
  - Need to coordinate with INTT to ensure sufficient gap is maintained
- Access to MVTX during installation complicated by INTT electronics

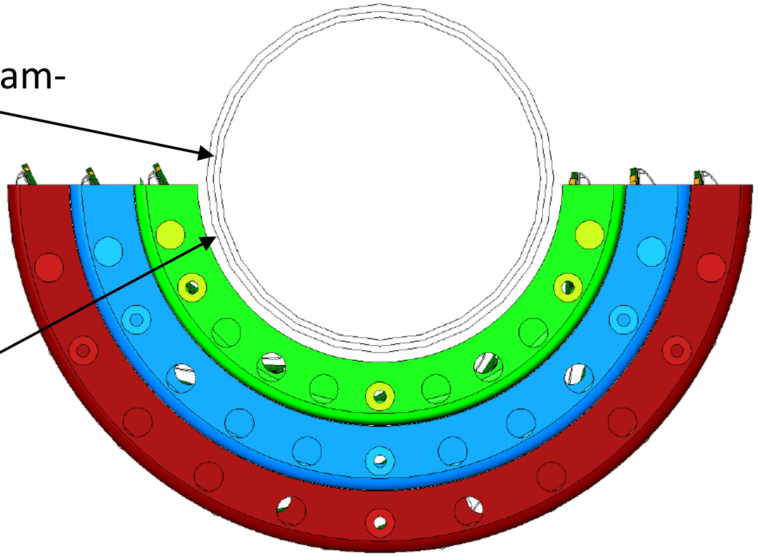


Cross section through MVTX and INTT near interaction point

1.3 Interface to Beampipe

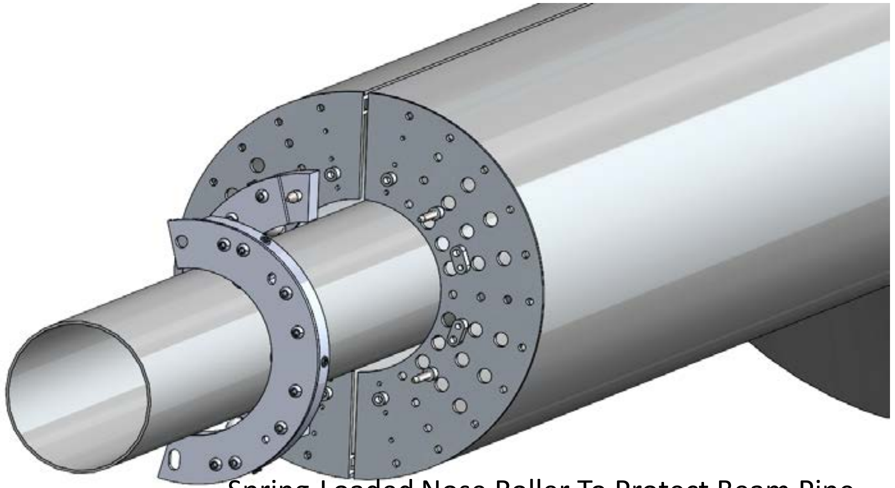
- Small clearances to beampipe (on the order of 2 mm)
- Beampipe protection (nose roller)

R=21.6 mm, aluminum beam-pipe extensions to sPHENIX beryllium beam-pipe



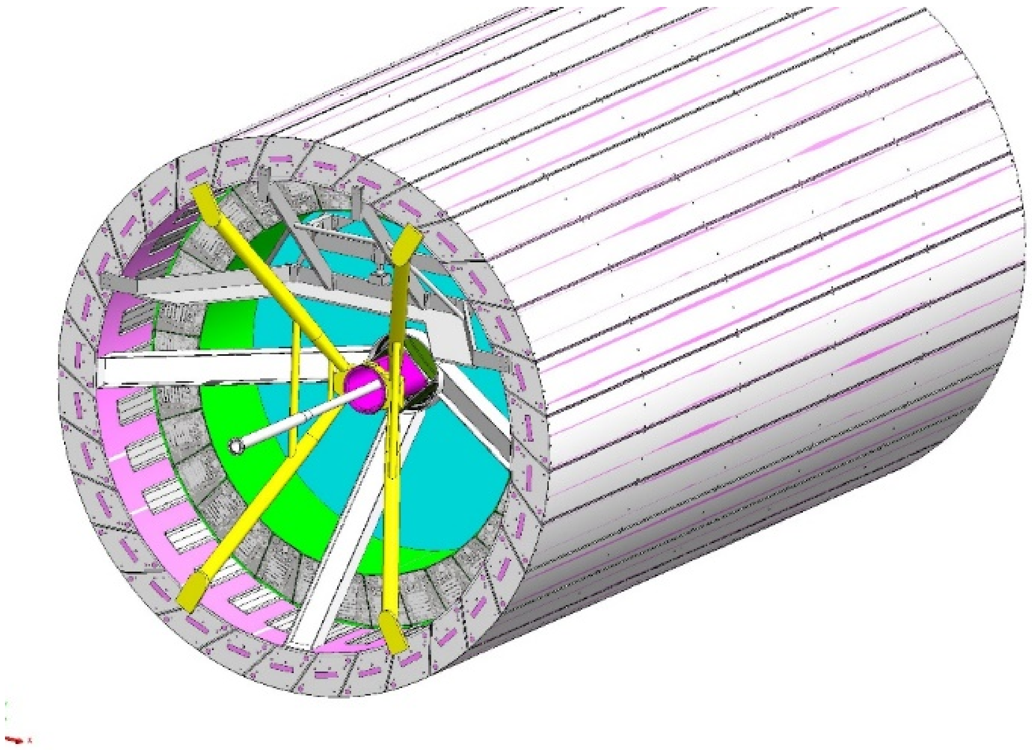
R=22.8 mm, layer 0 end flange, this delta **= 1.15 mm**

**Note: this is smaller than the Layer 0 sensors radius*



Spring-Loaded Nose Roller To Protect Beam Pipe

1.2 Interface to iHCAL



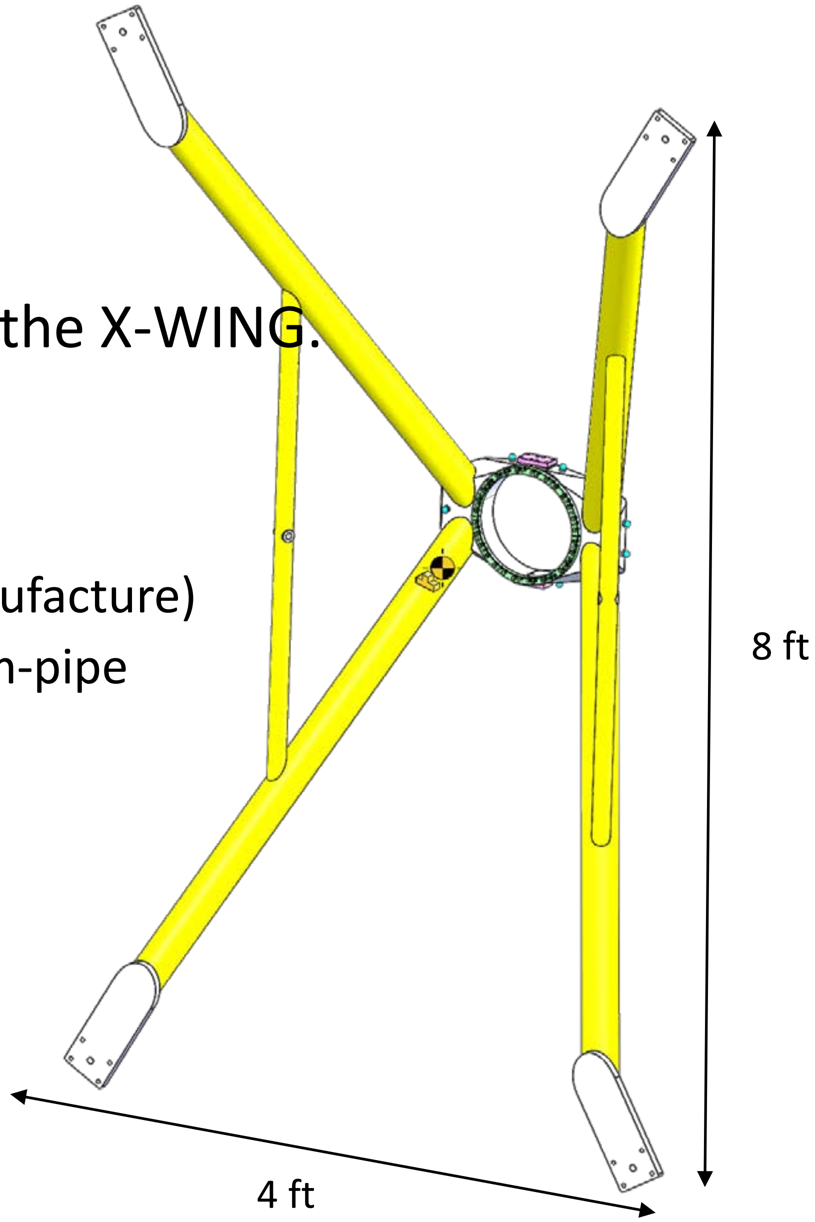
	Requirement	How Accomplished
1	Deflection less than 0.1 mm vertically	Design / analysis
2	Deflection of MVTX Service Barrel – X-Wing interface flange of less than 0.01 deg from vertical	Design / analysis, angular adjustment can compensate for deflection
3	Minimal magnetic material	Built primarily of 316 stainless steel. Welds will be annealed to μ ≤ 1.05
4	Adjustment range of +/- 2 mm in x and y	Available through mounting hole bolt clearance
5	Adjustment range of +/- 2 mm in z	Accomplished with shims at mounting surface to inner HCAL
6	Must install around beampipe	Structure designed in two mirror-image halves, coupled together at main flange
7	Must mount to inner HCAL, not interfere with TPC and INTT supports	Mounts to inner HCAL face at +/- 30.9 deg from vertical. Concurrent design with INTT and TPC engineers to ensure no interference

We have a support design that satisfies these requirements

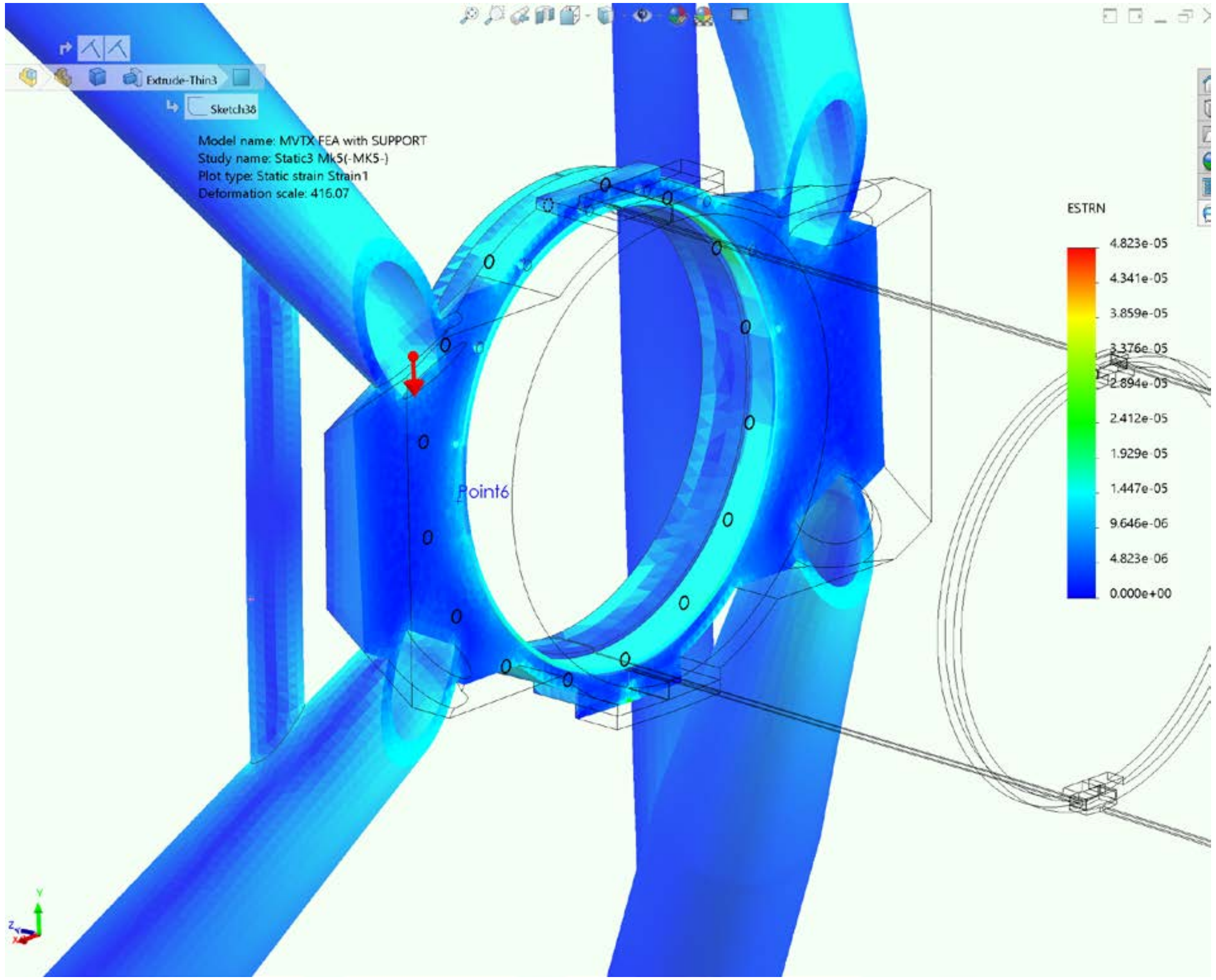
Support Structure

- MVTX is mounted to the iHCAL through a structure known as the X-WING.

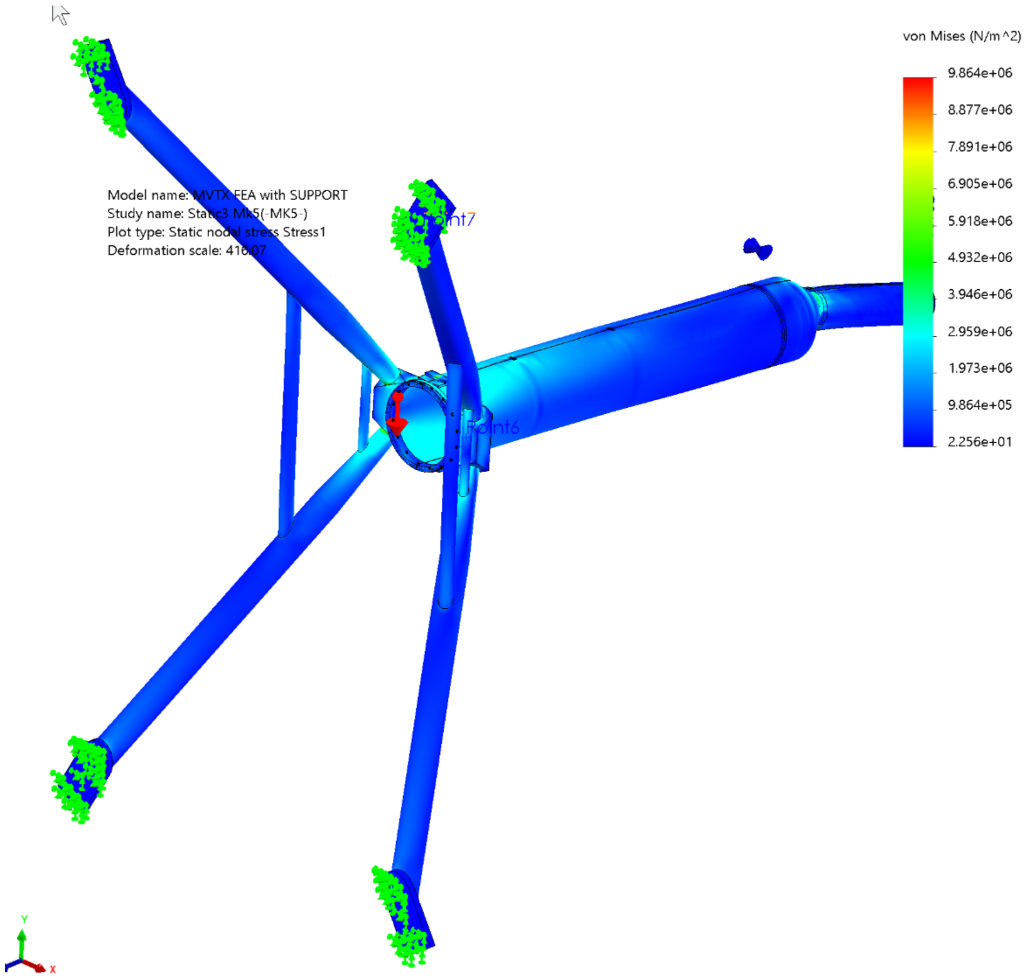
- **The X-wing**
  - is made of stainless steel, approx. 25 kg per side (fairly simple to manufacture)
  - will be split down the middle to allow installation around in-situ beam-pipe
  - has lifting points on each half
  - shims at mounting feet for angles
  - has provisions for up to 10 fiducial reflector balls
  - will be surveyed into position



X-wing: FEA



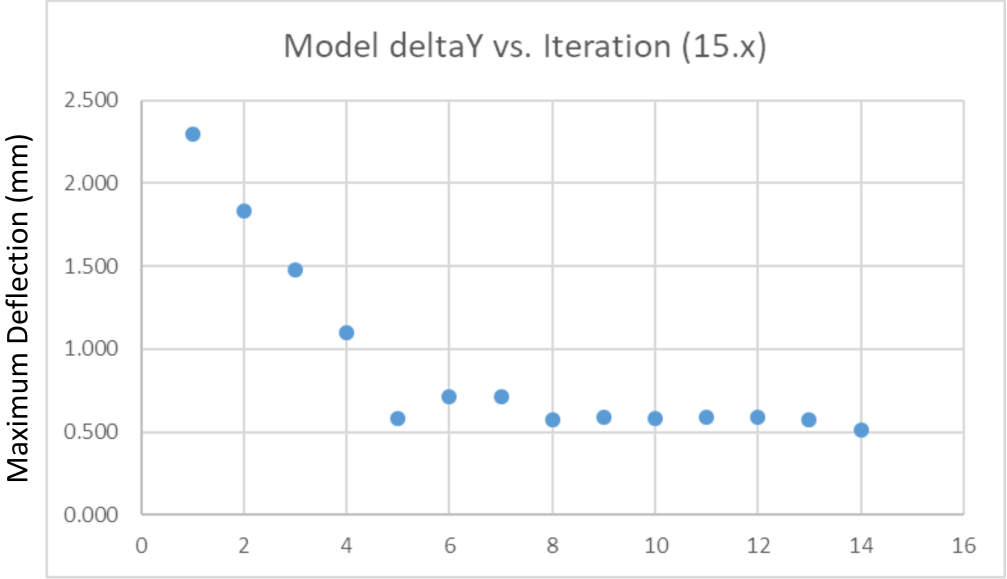
Strain Plot



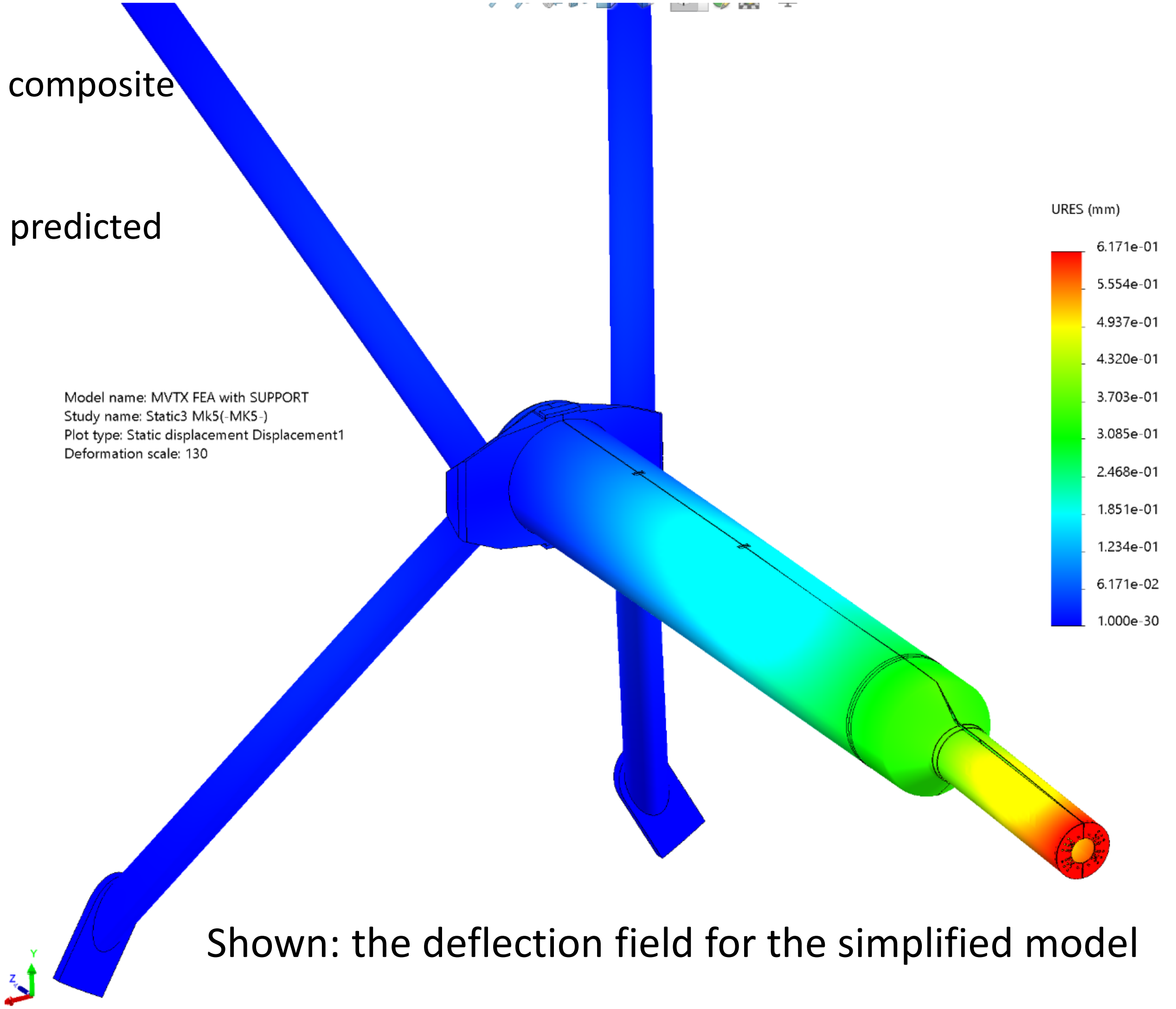
Stress Plot

X-wing: FEA

- Study shown is done with a simplified MVTX model:
    - MVTX with isotropic titanium in place of orthotropic carbon fiber composite
    - it uses 1/8” thick tubes; (final design uses ¼”)
    - Shown maximum deflection is <u>0.617 mm</u>
- After correcting for thicker tubes and simplified MVTX model, the total predicted deflection is **0.37 mm** (nb, clearance to BP ~1.15mm)



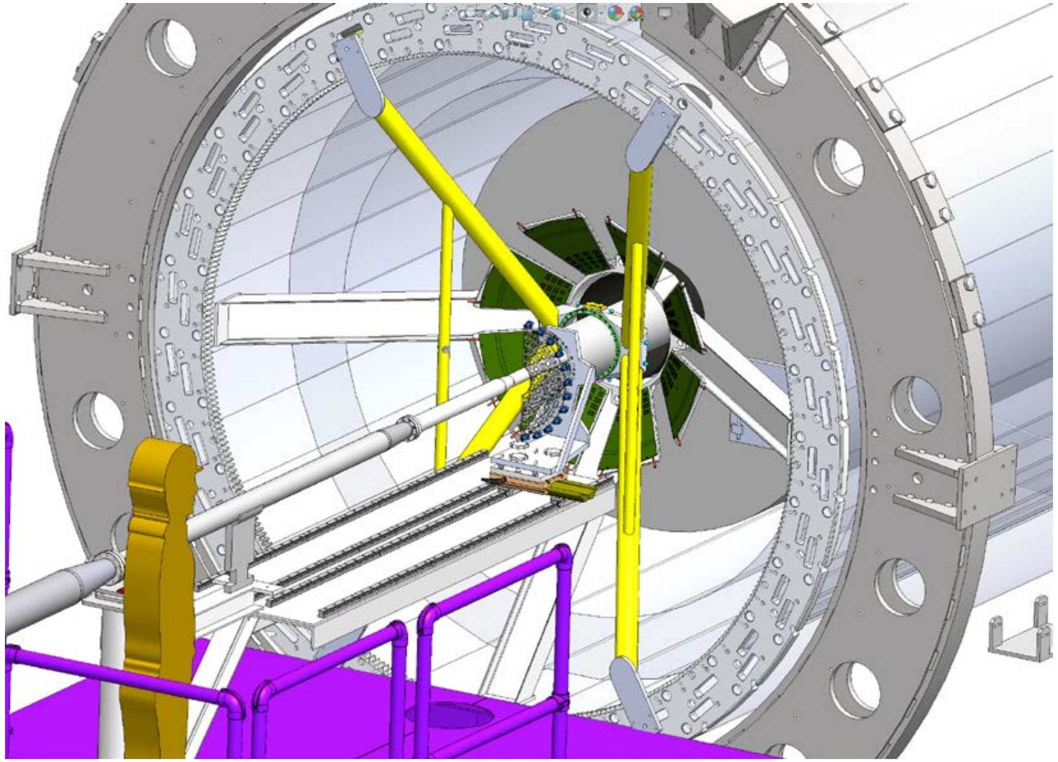
Design Iteration



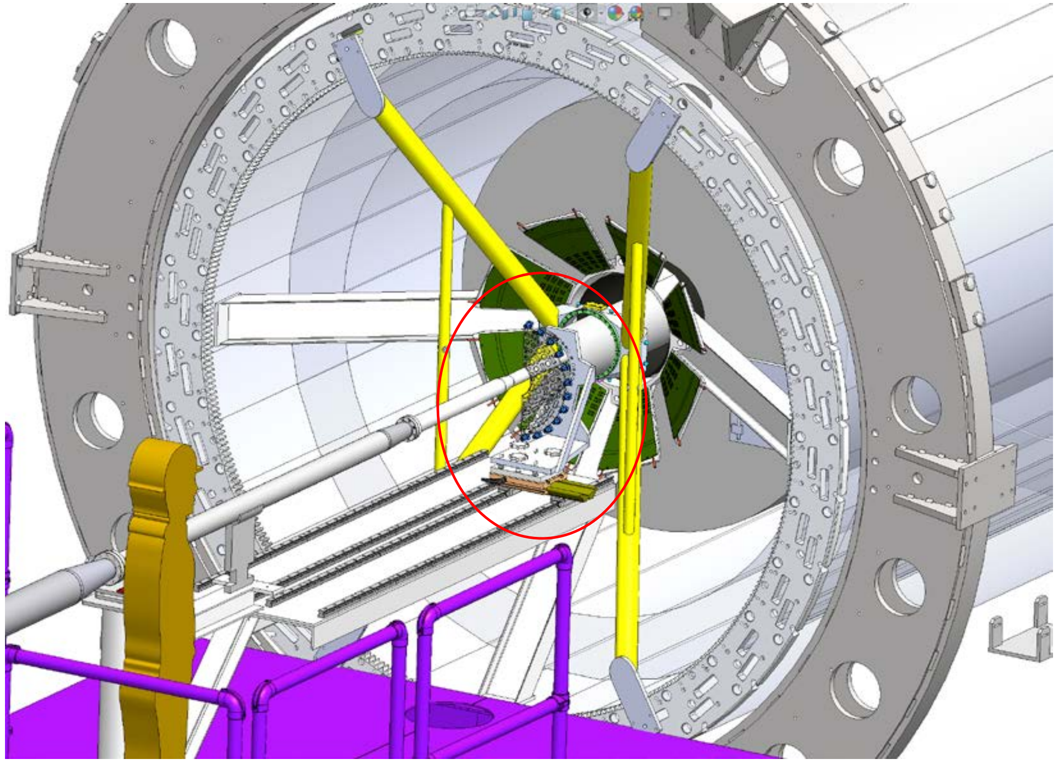
Shown: the deflection field for the simplified model

Installation

- The MVTX will be installed after all other detectors and services have been installed so space will be tight
- Care must be taken not to damage MVTX sensors in proximity to beampipe
- A linear rail table will need to be temporary installed on the work platform
- MVTX group is designing an insertion bracket to ride on these rails and guide MVTX into place
- We are working closely with BNL engineers to ensure there is room for everything.



Installation System - Carriage

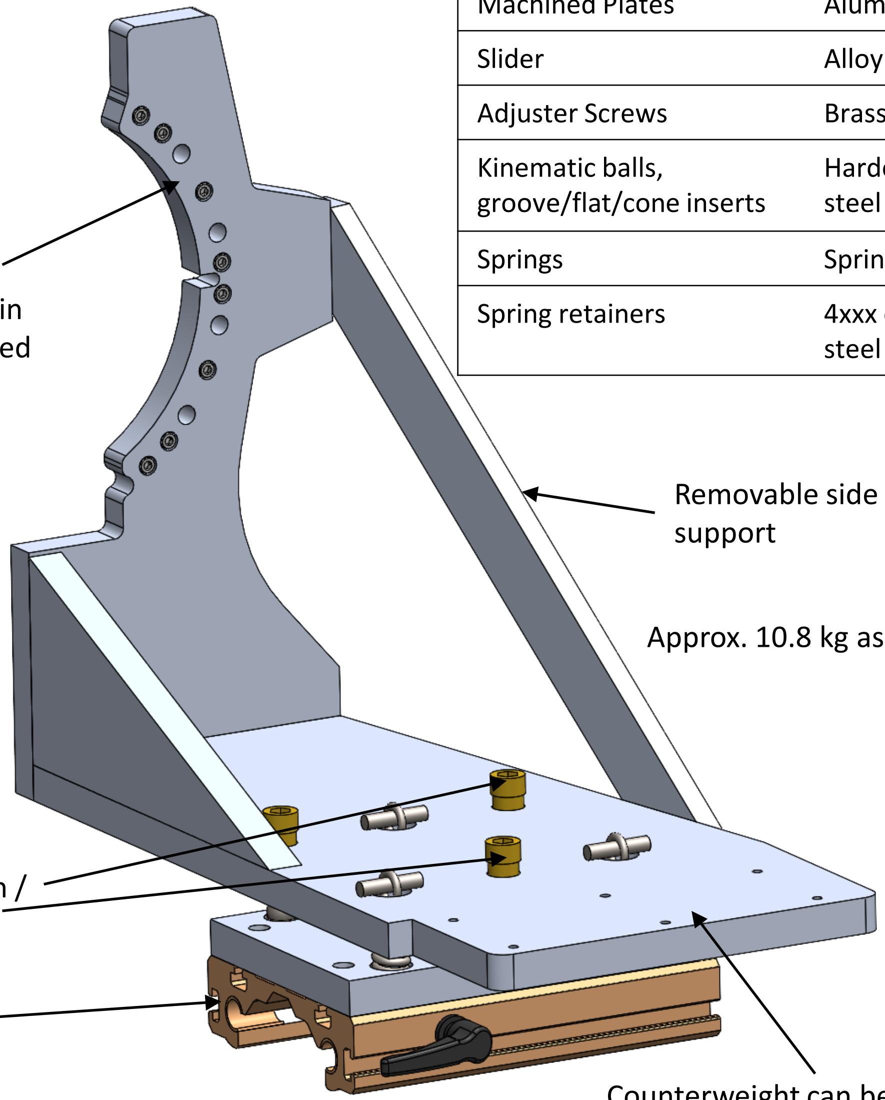


PBC Linear

Removable front plate
Mounts to MVTX flange
Clearance holes allow Main support bolts to be installed through this plate

Kinematic roll / pitch / yaw adjustment

Locking slider



Materials	
Machined Plates	Aluminum
Slider	Alloy Steel
Adjuster Screws	Brass
Kinematic balls, groove/flat/cone inserts	Hardened tool steel
Springs	Spring Steel
Spring retainers	4xxx cold-rolled steel

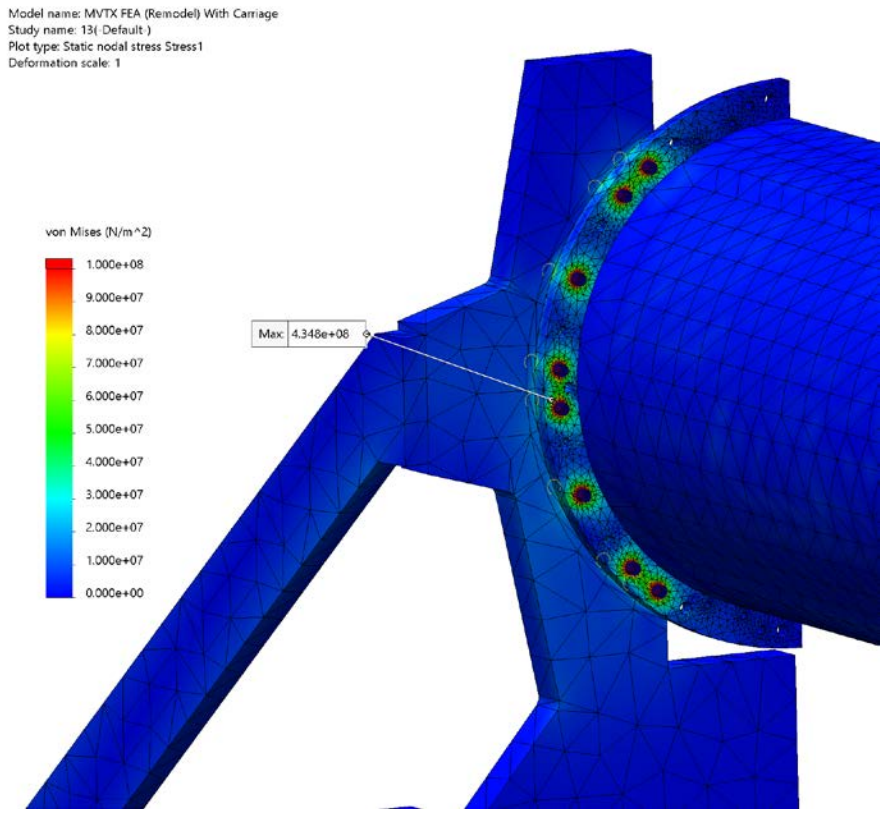
Removable side support

Approx. 10.8 kg as-shown

Counterweight can be attached here

Installation System: FEA

- Stress analysis of bracket (Sy = 572 MPa, stresses near bolts will be lower than reported due to simulation method)



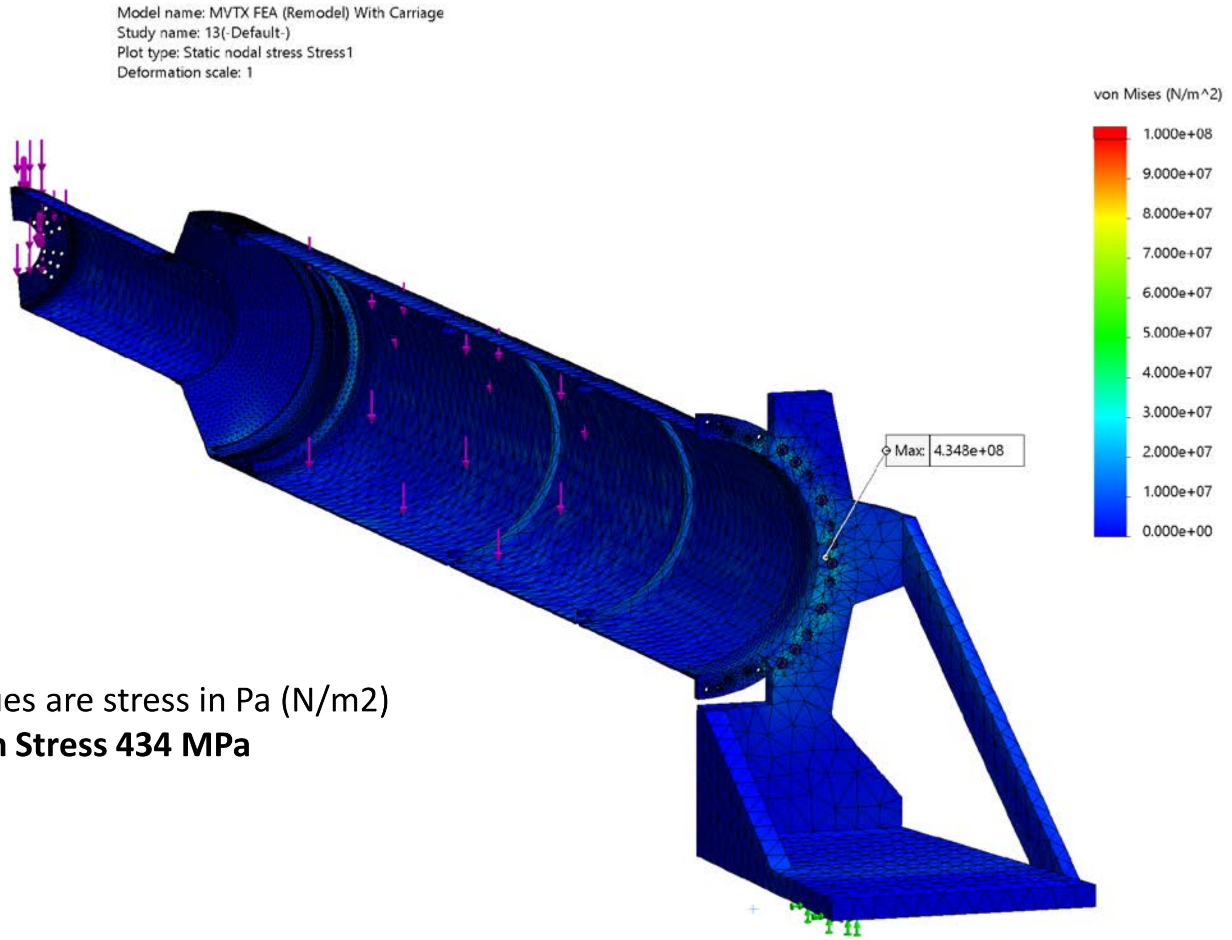
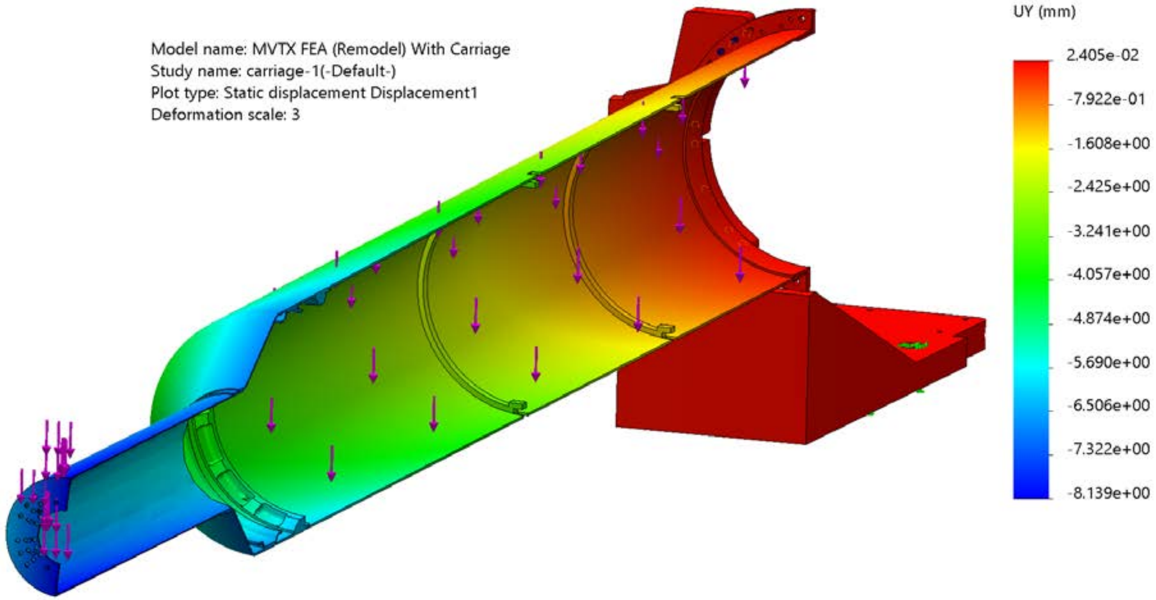
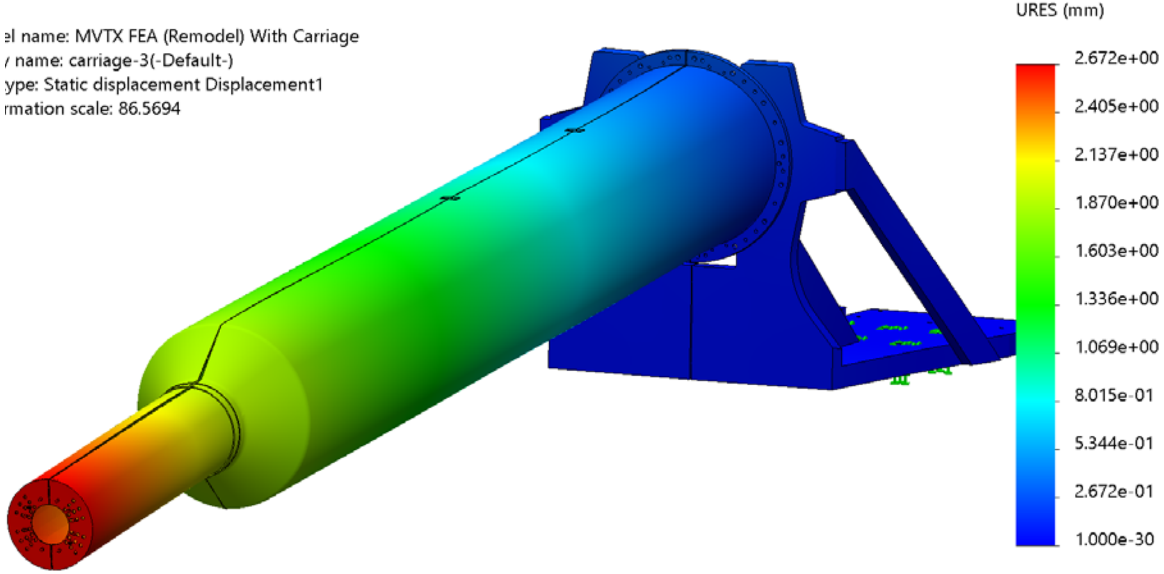


Chart values are stress in Pa (N/m2)
Maximum Stress 434 MPa

Installation System

- FEA Study Showing Deflections





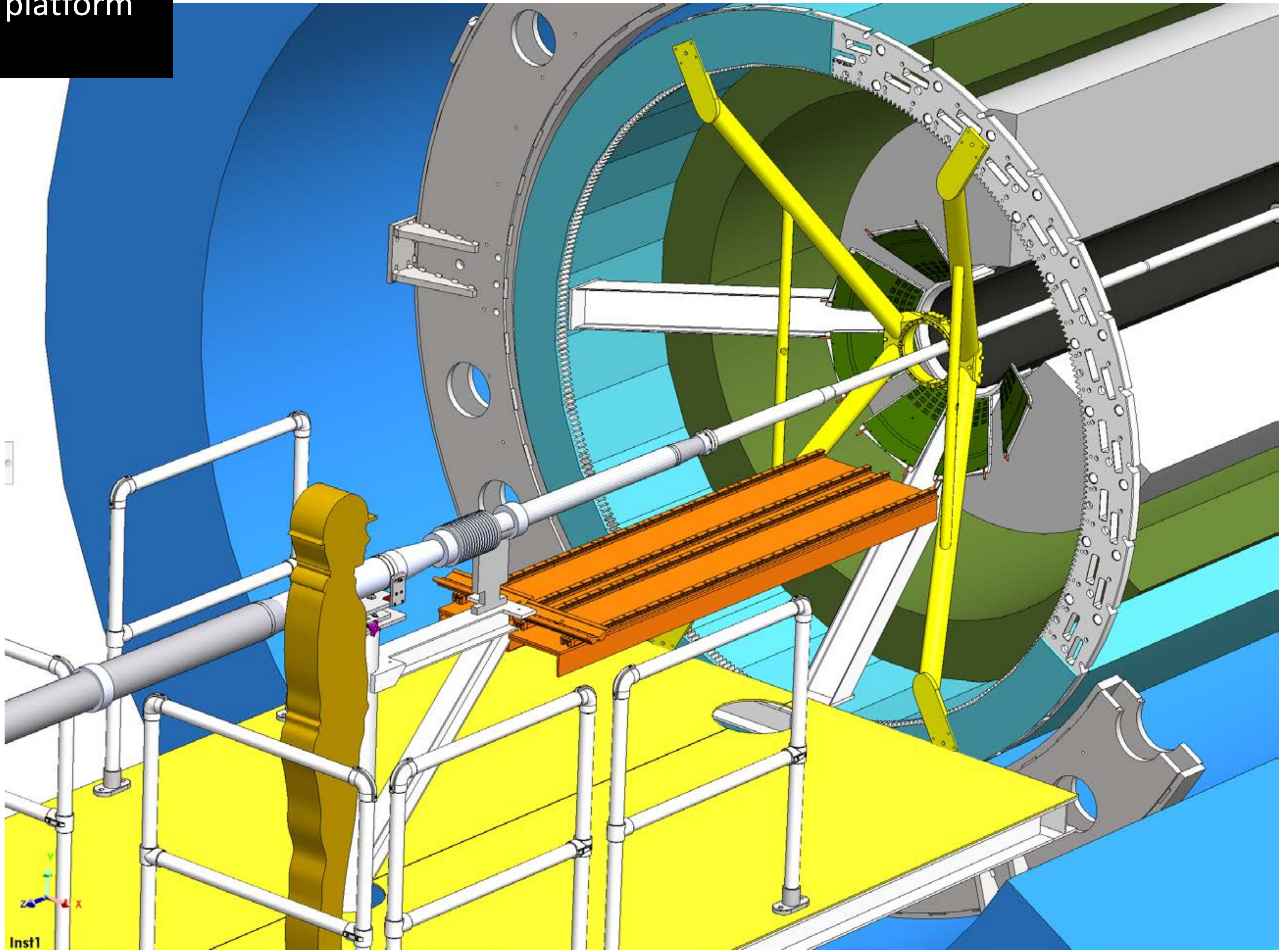
Maximum Sag one half**: 8.1 mm**

Maximum Sag two halves connected**: 2.7 mm**

Sag exceeds beampipe clearance Mostly due to deflection of the insertion bracket
→ **Kinematic adjustment on carriages will be used to set flange in vertical plane so that actual deviation from nominal position equals the sag of the MVTX alone**

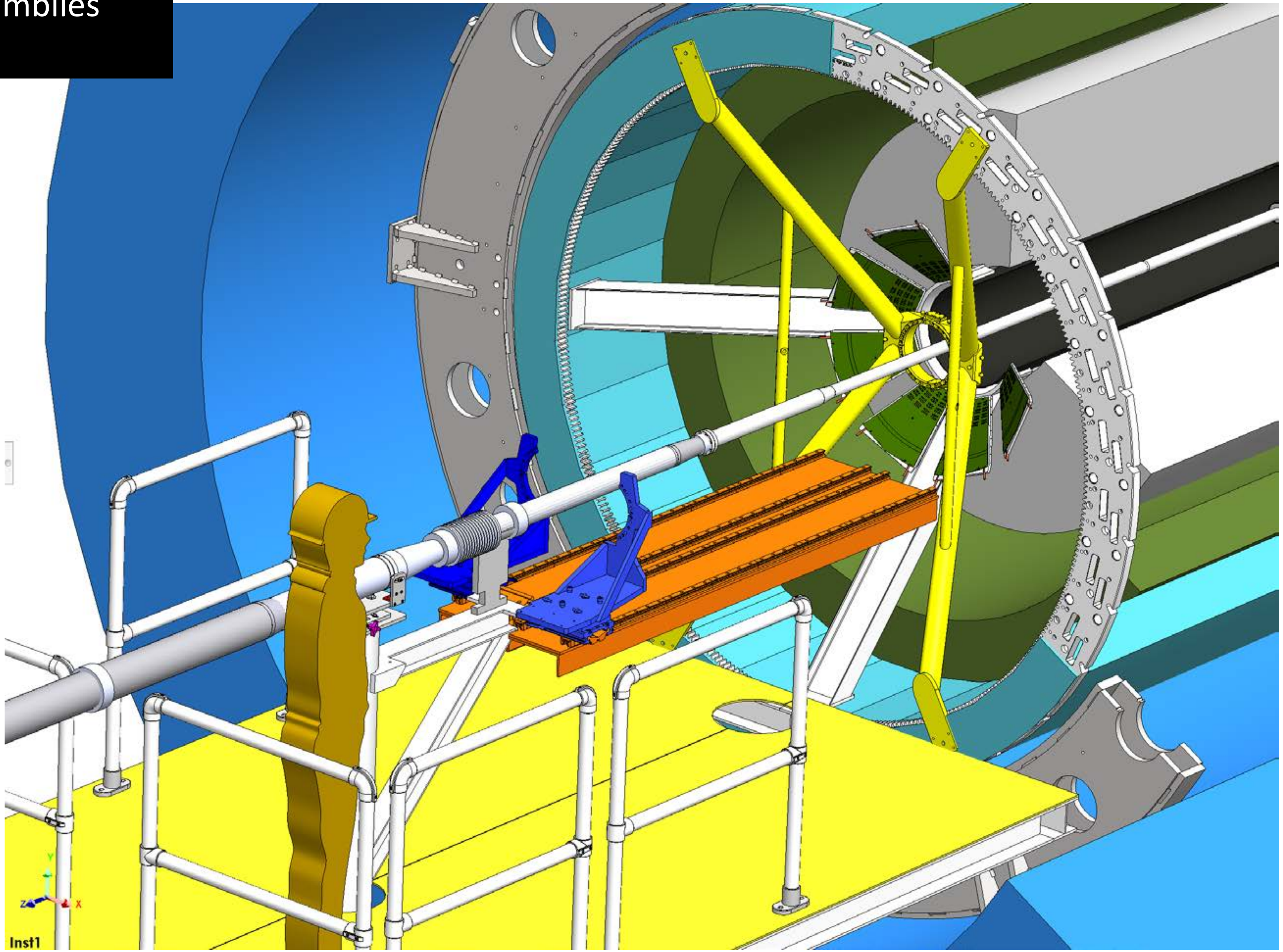
Installation Sequence STEP 0

Rail table installed on platform
Cross slides installed



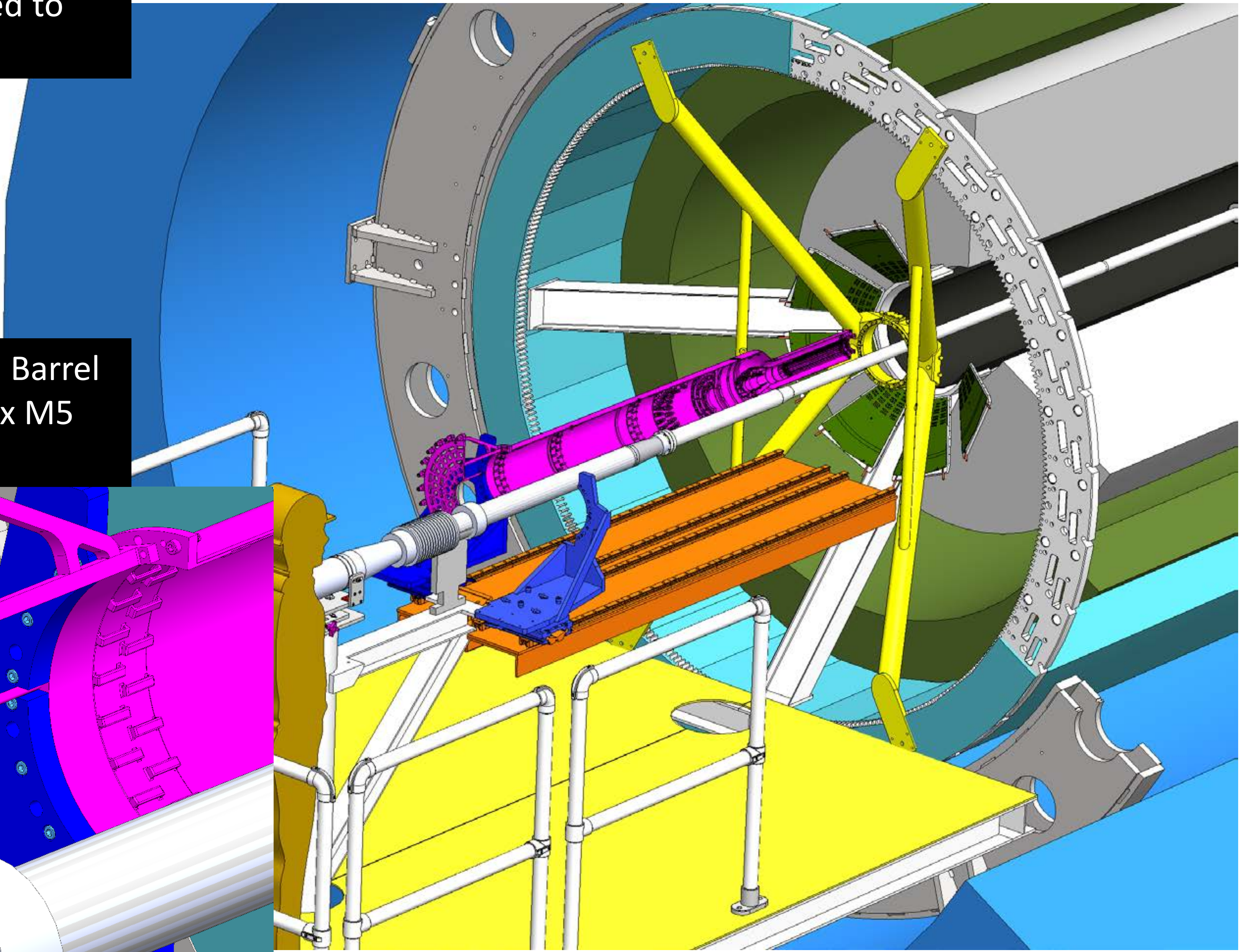
Installation Sequence **STEP 1**

Insertion bracket assemblies installed

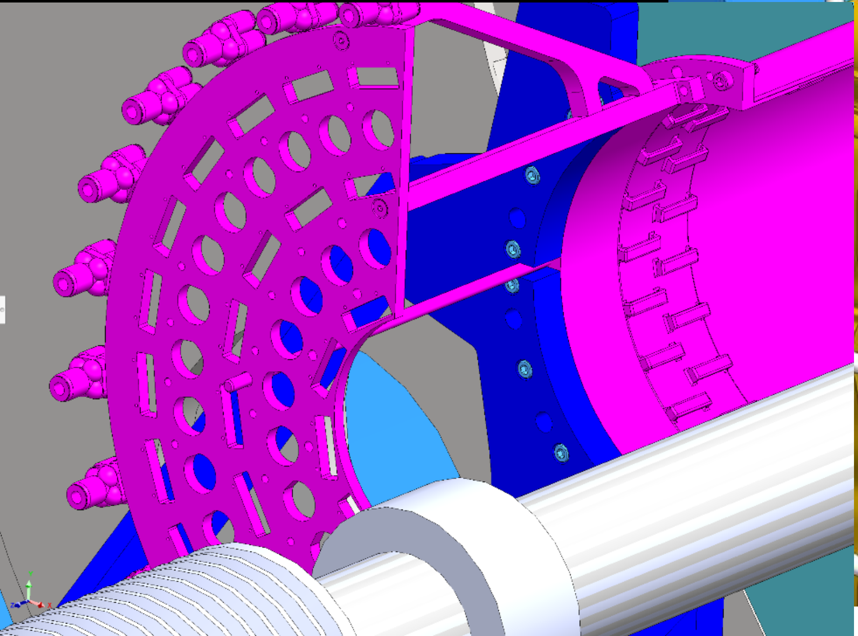


Installation Sequence STEP 2

Left side MVTX connected to installation bracket*



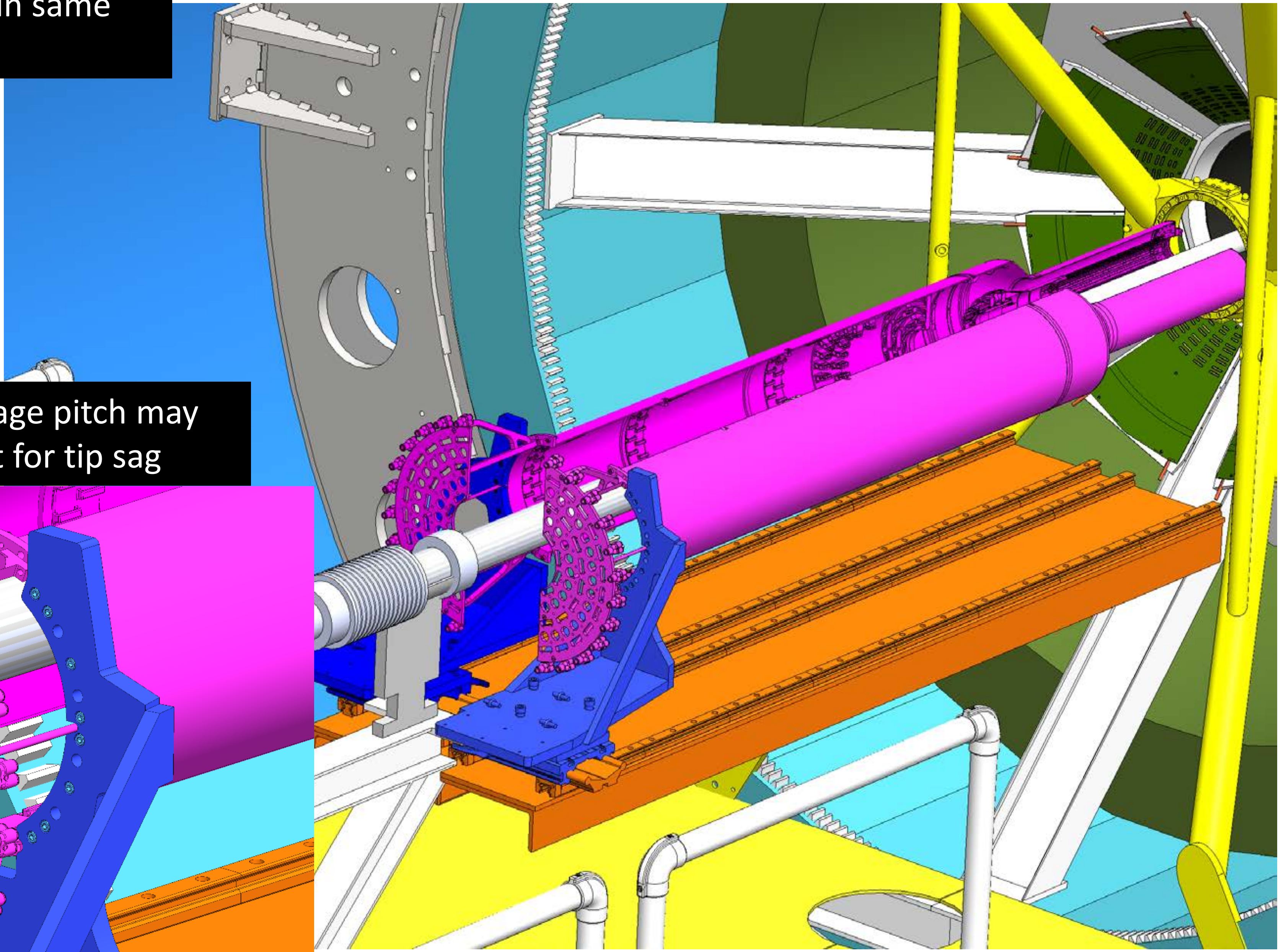
Connection from Service Barrel flange to bracket using 8x M5 screws

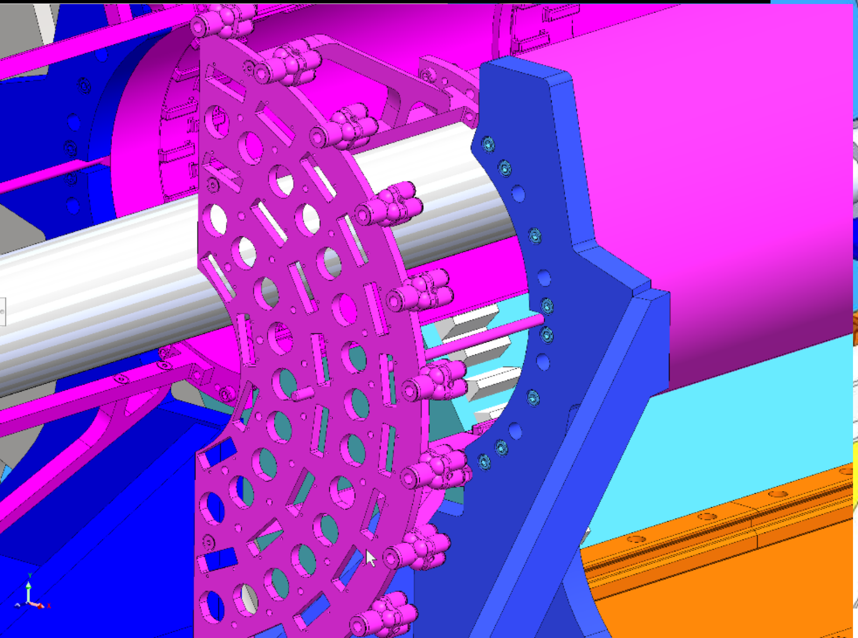


Installation Sequence STEP 3

Right side connected in same fashion

At this point the carriage pitch may be adjusted to correct for tip sag

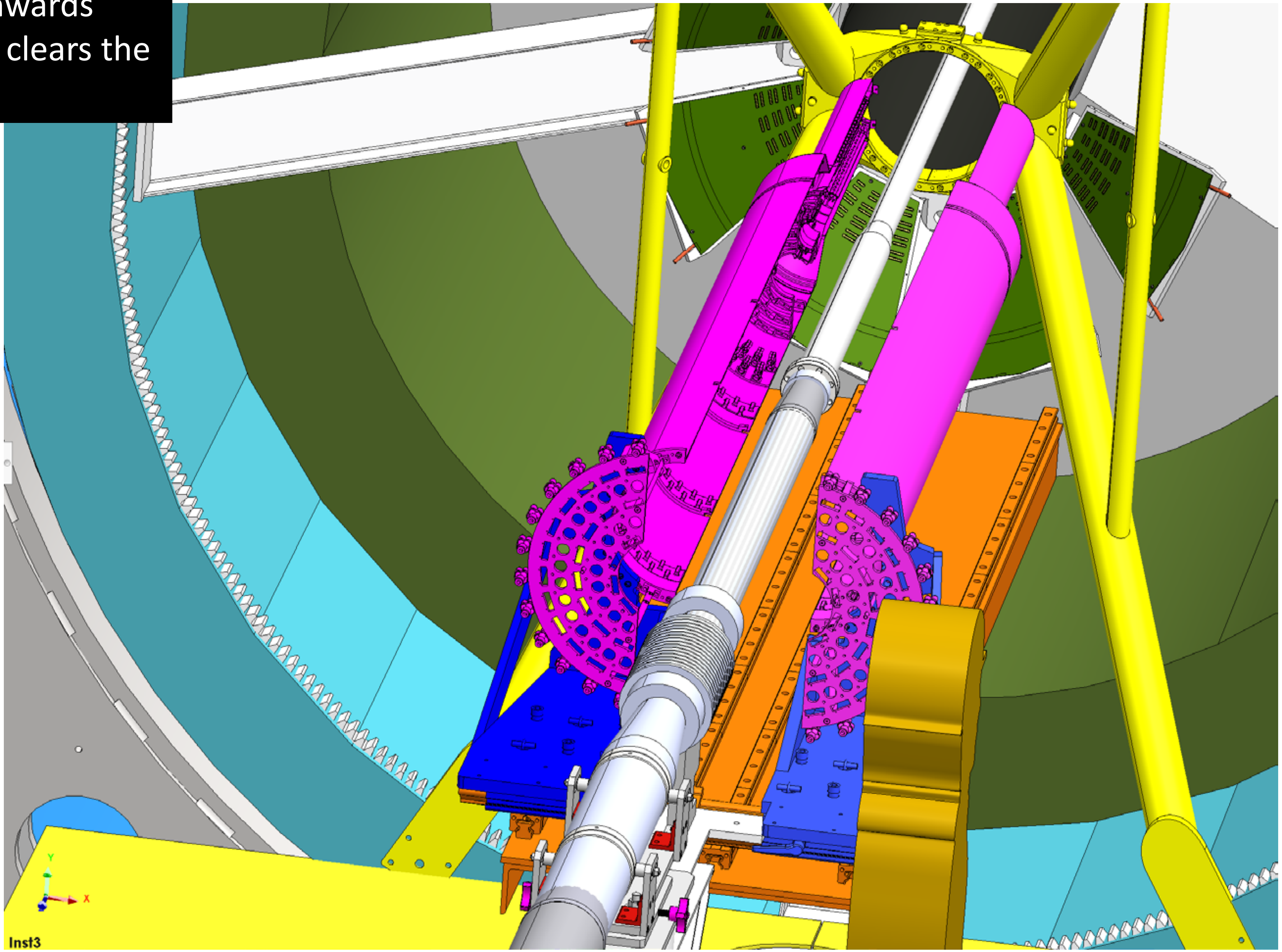




Installation Sequence

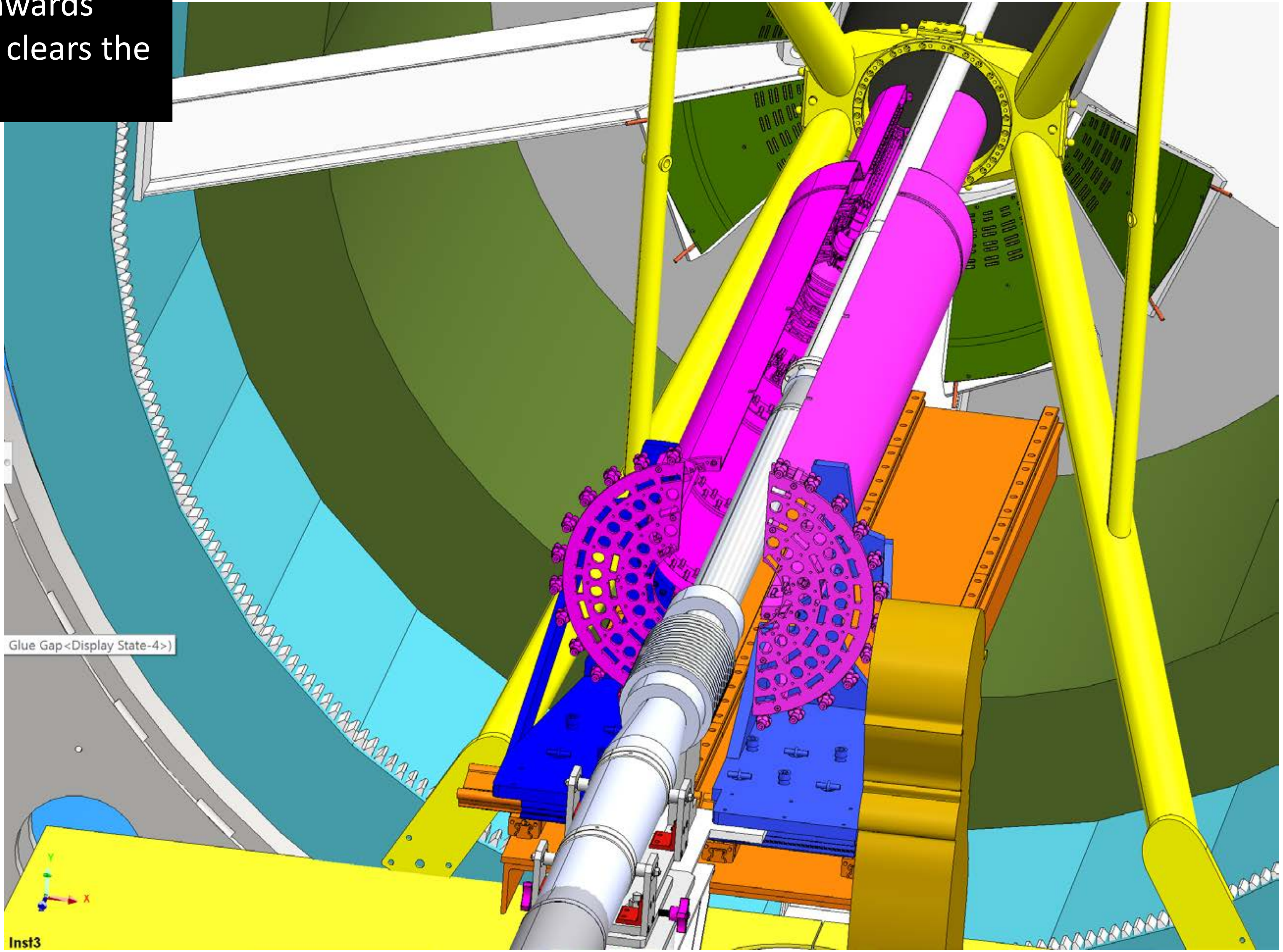
STEP 4

Both Halves are slid inwards until the nose section clears the X-Wing flange bore



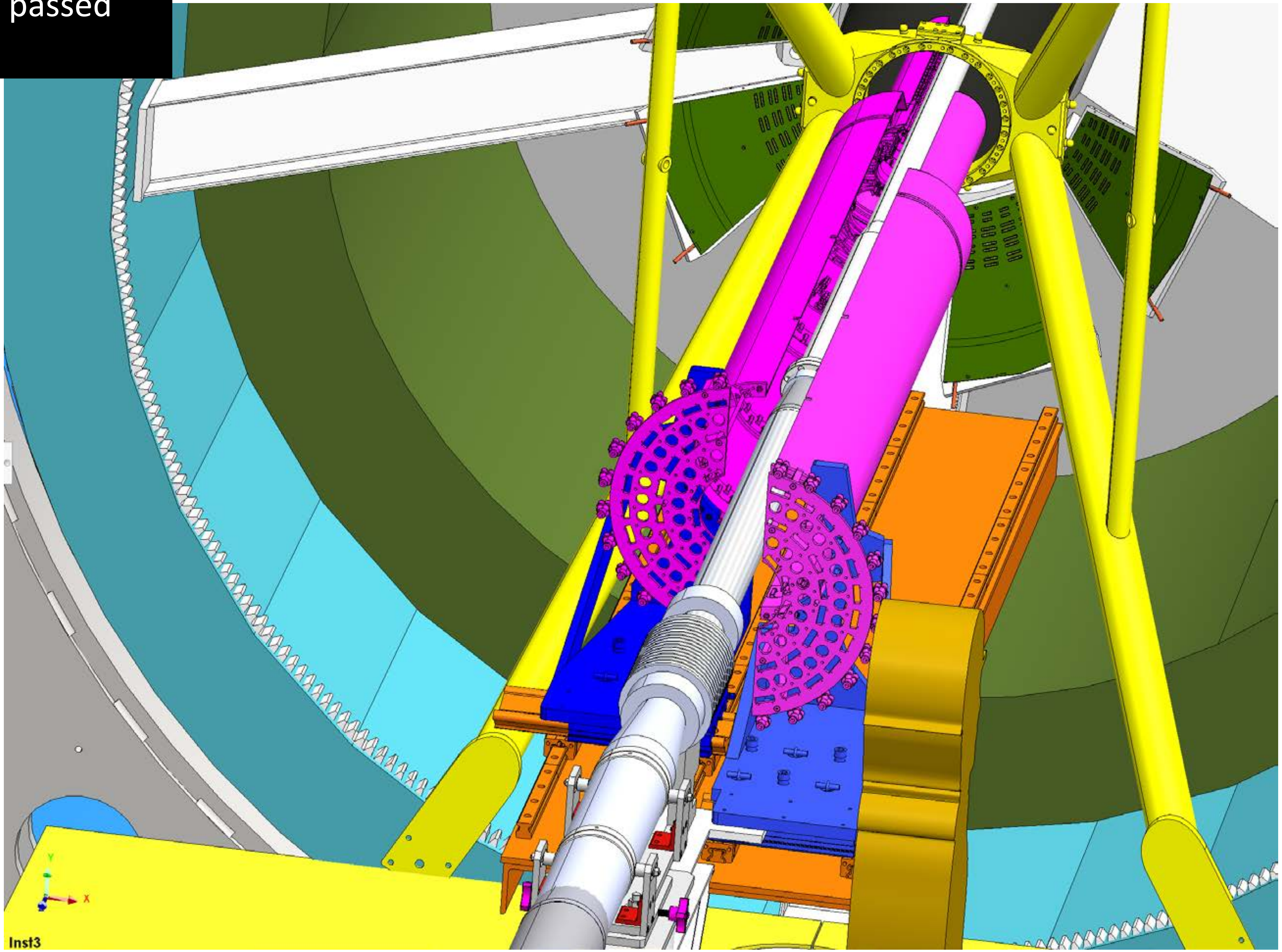
Installation Sequence **STEP 4**

Both Halves are slid inwards until the nose section clears the X-Wing flange bore



Installation Sequence **STEP 5**

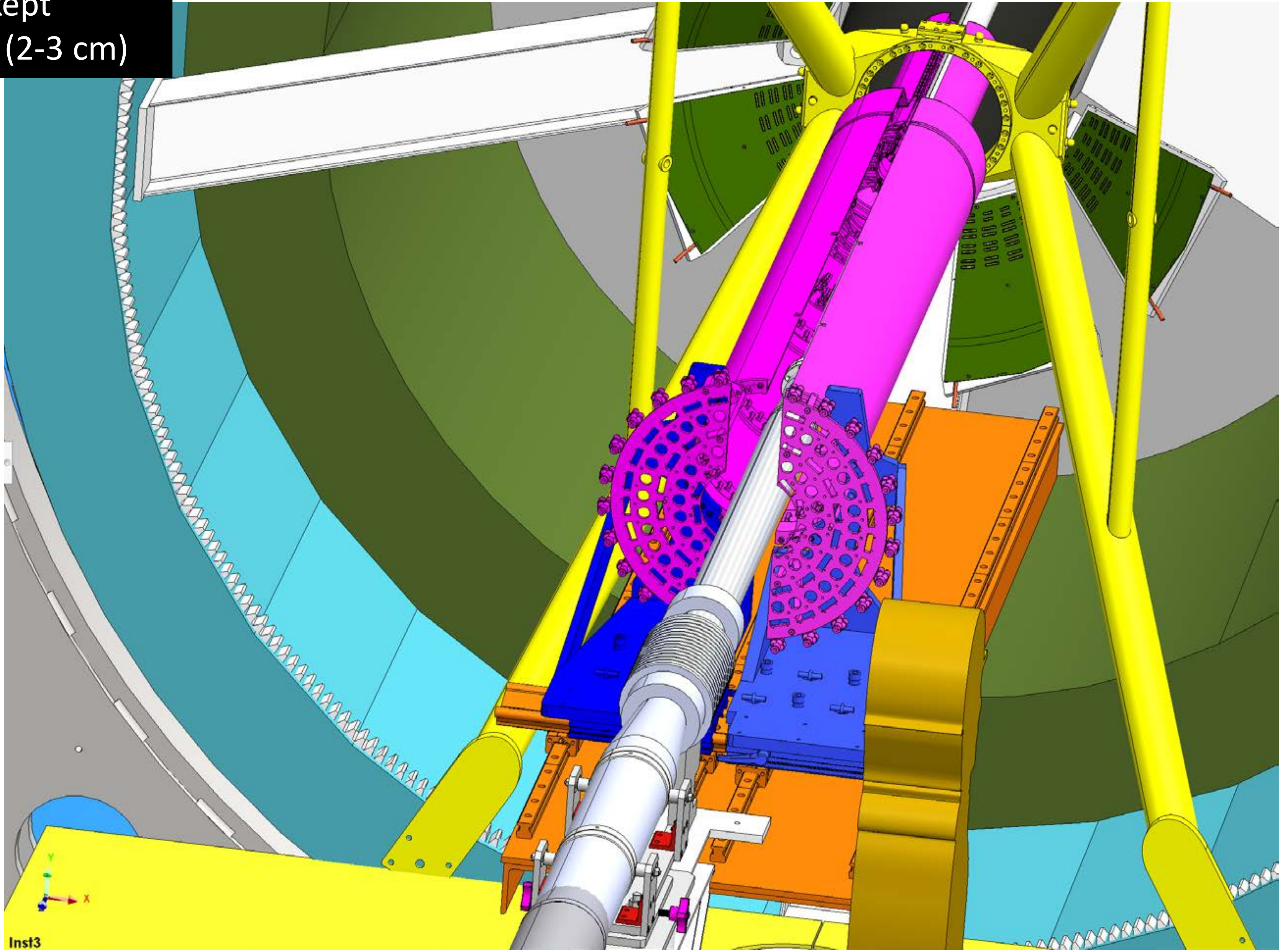
Left Side nose section passed through X-Wing bore



Installation Sequence

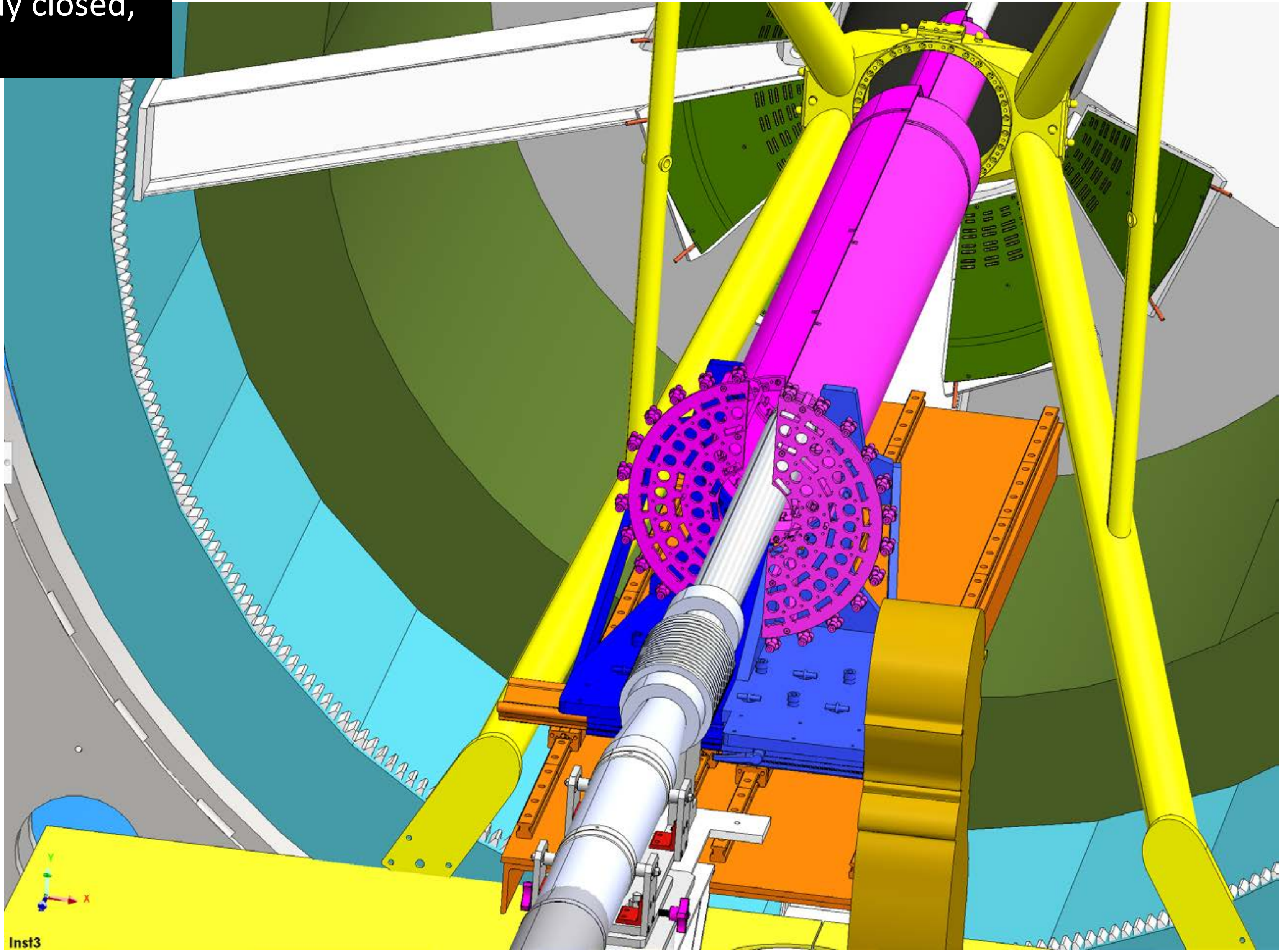
STEP 5

Right side moved in, kept slightly aft of left side (2-3 cm)



Installation Sequence STEP 6

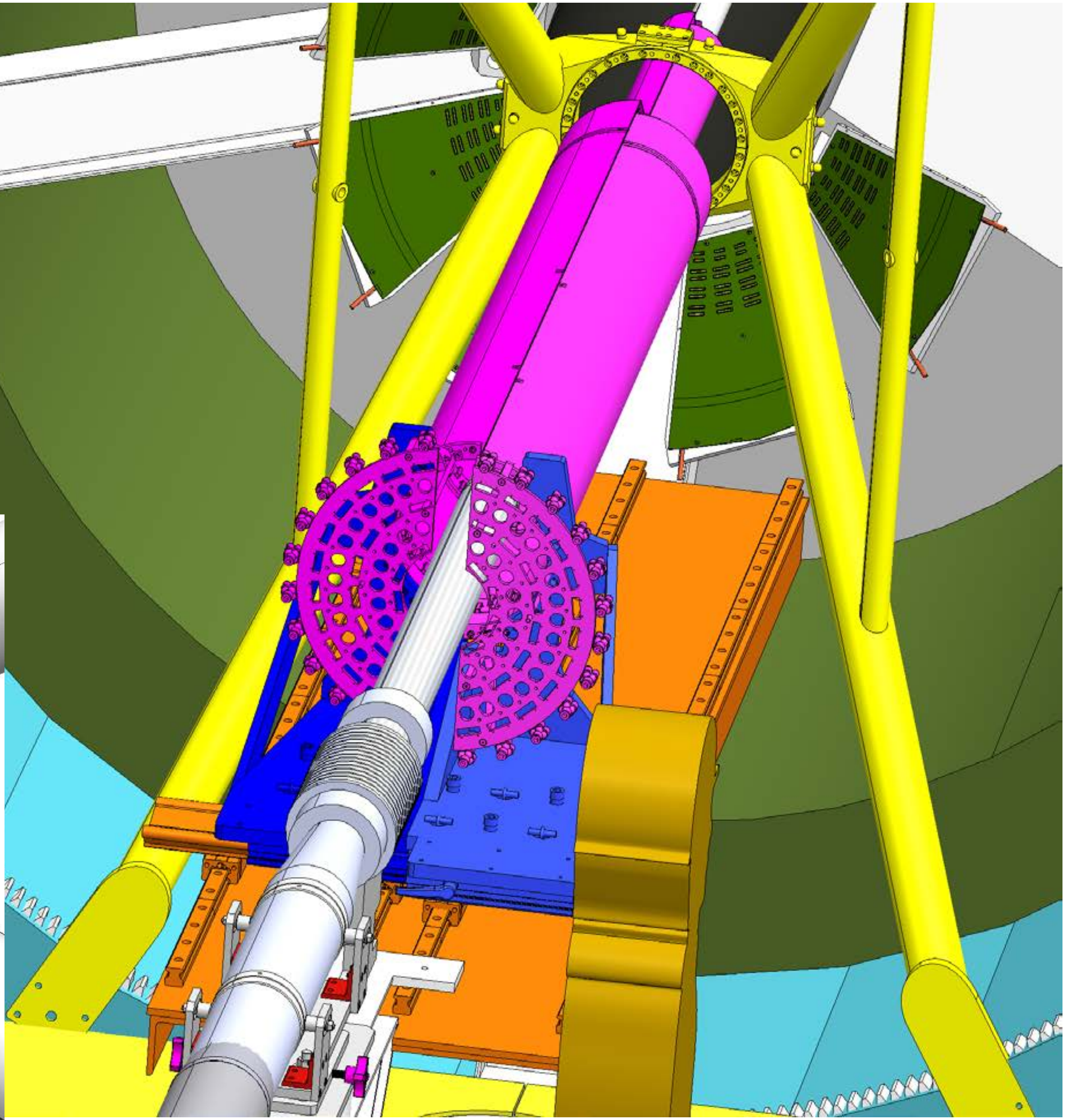
Both halves completely closed,
still offset 2-3 cm

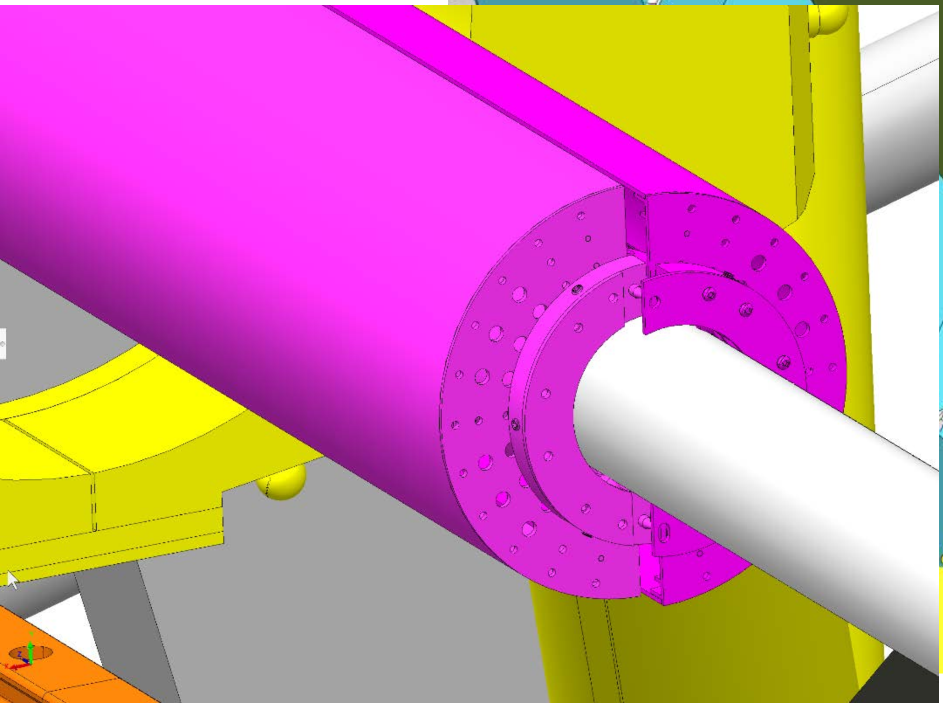


Installation Sequence

STEP 6

Halves are aligned in Z

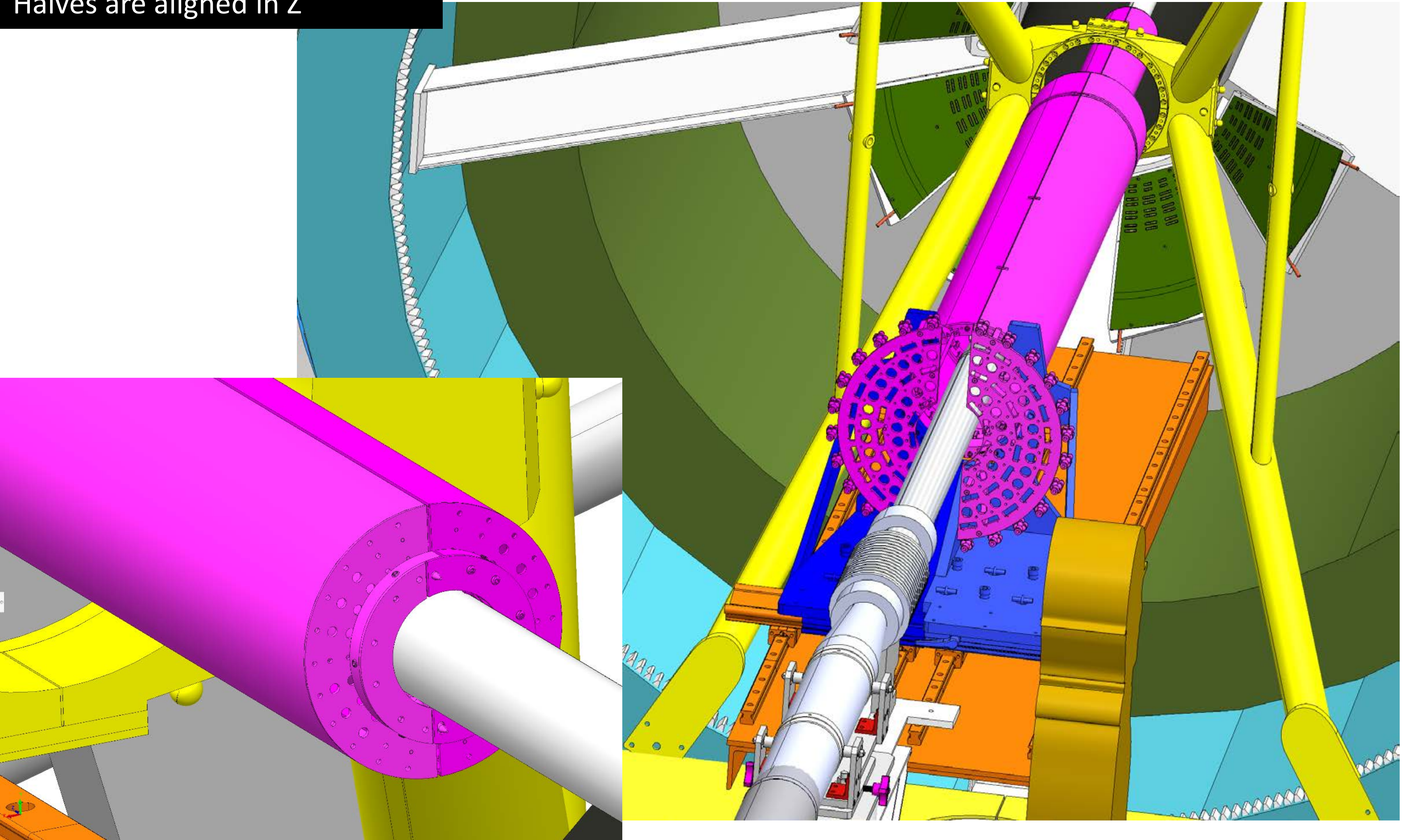




Installation Sequence

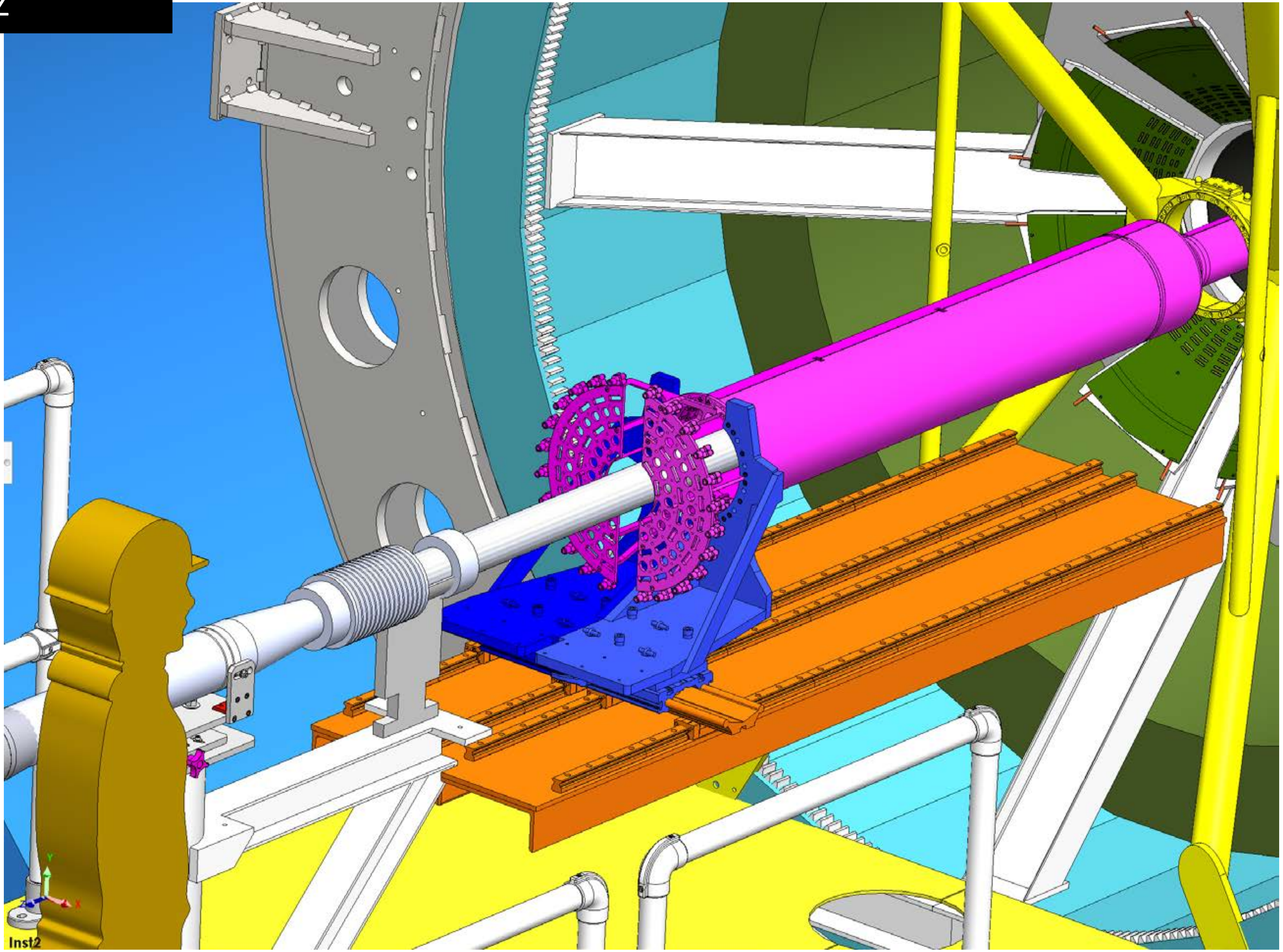
STEP 7

Halves are aligned in Z



Installation Sequence STEP 7

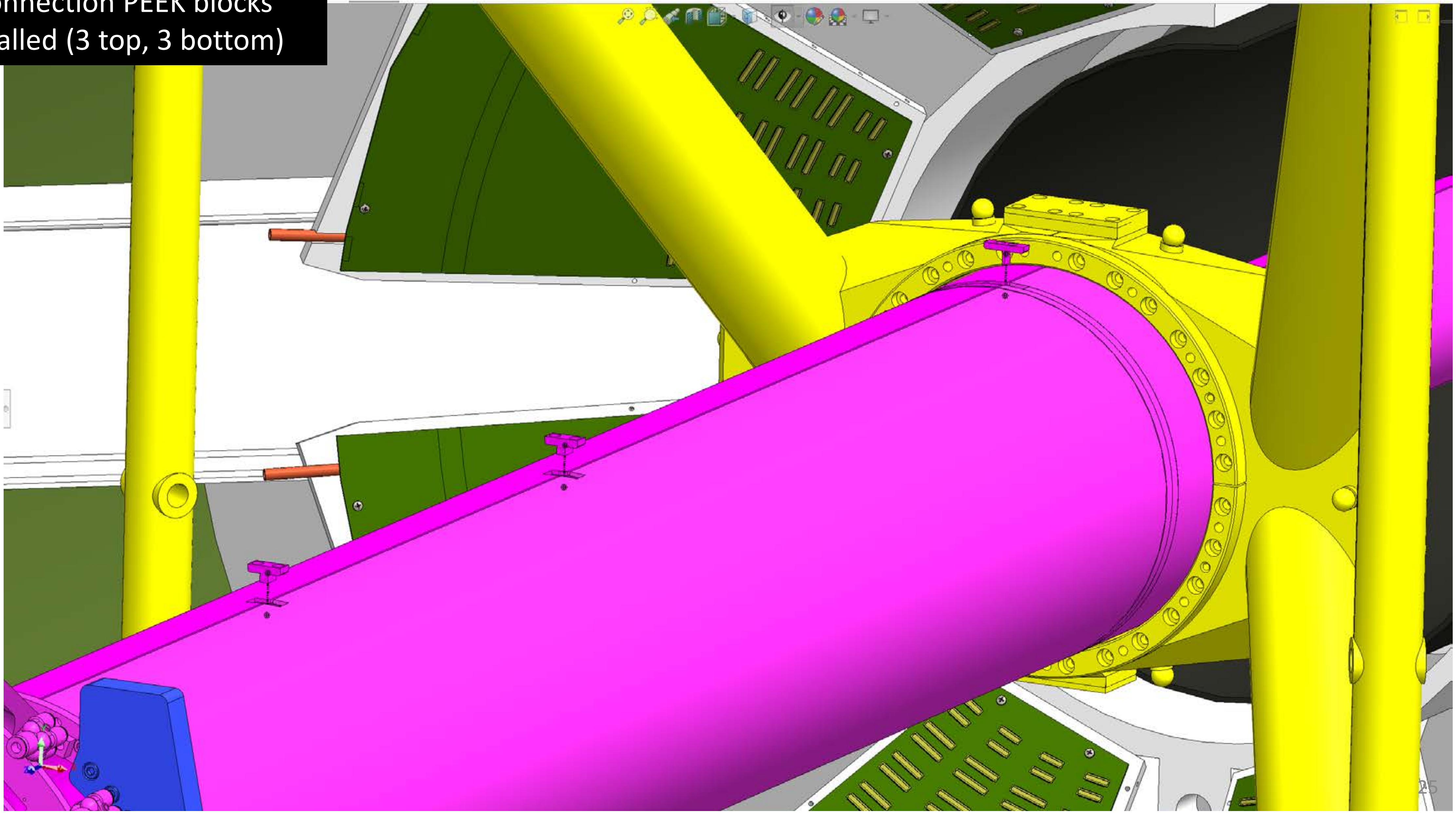
Halves are aligned in Z



Installation Sequence

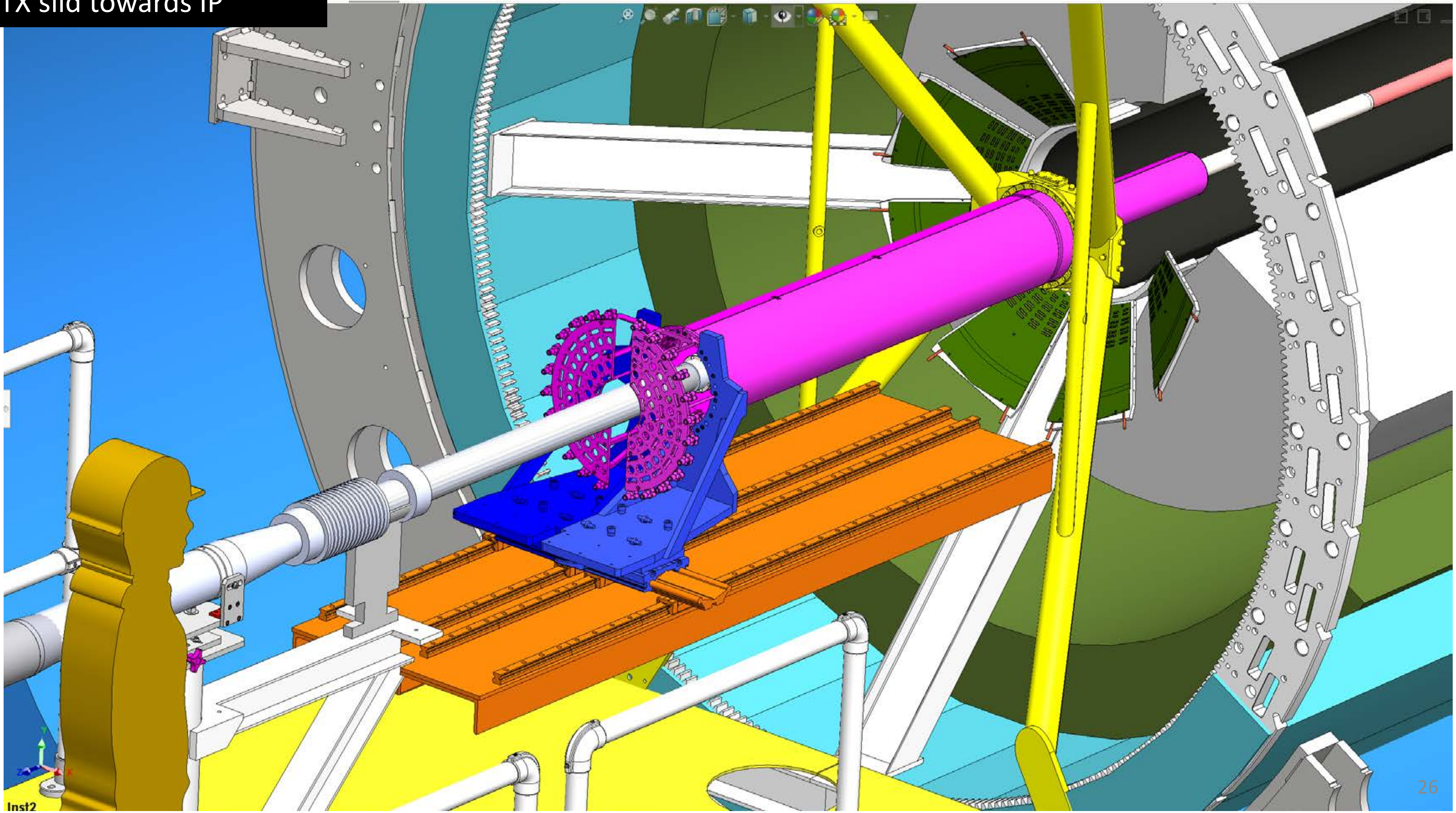
STEP 8

Inter-connection PEEK blocks are installed (3 top, 3 bottom)



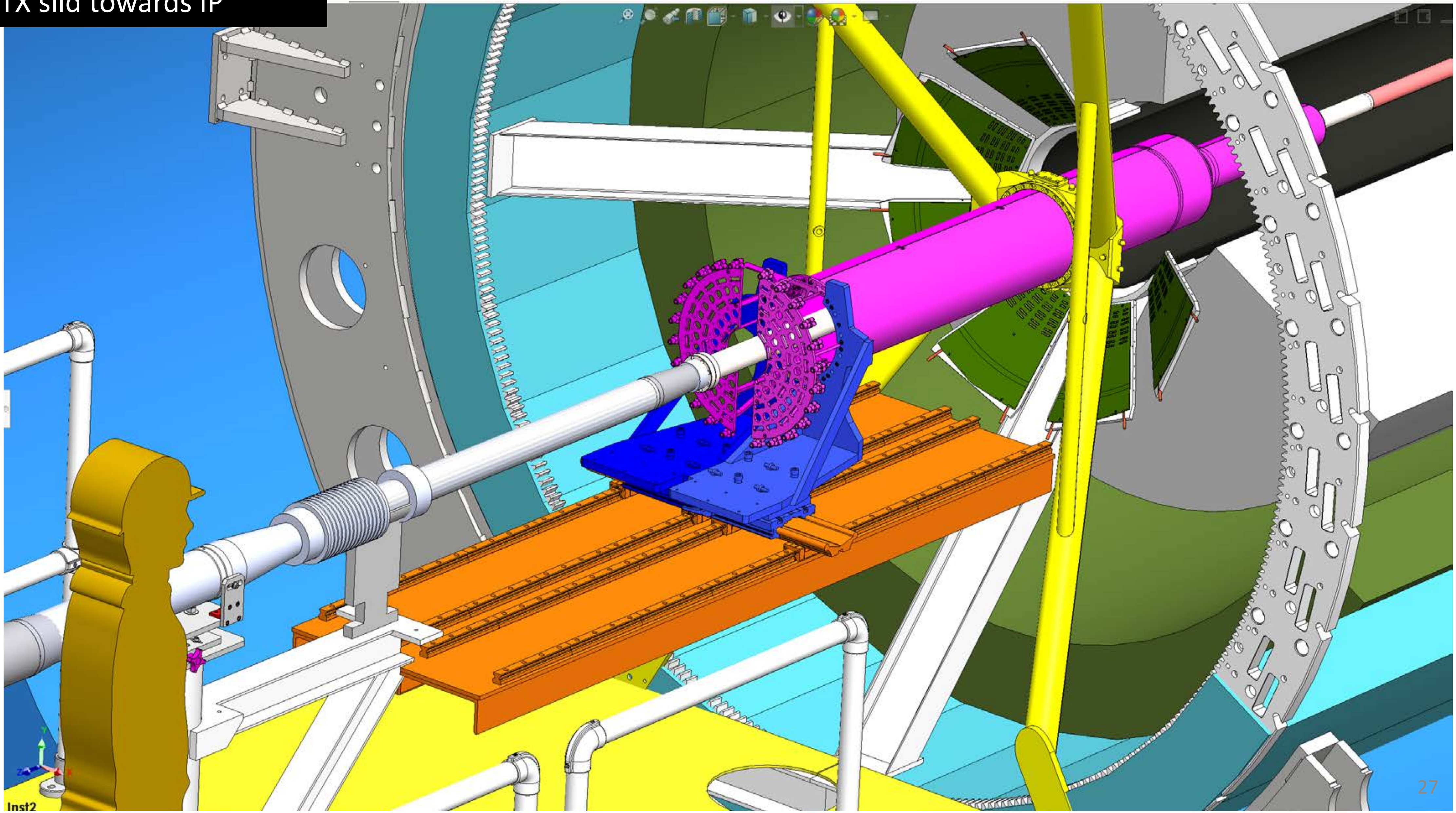
Installation Sequence STEP 9

Full MVTX slid towards IP



Installation Sequence STEP 9

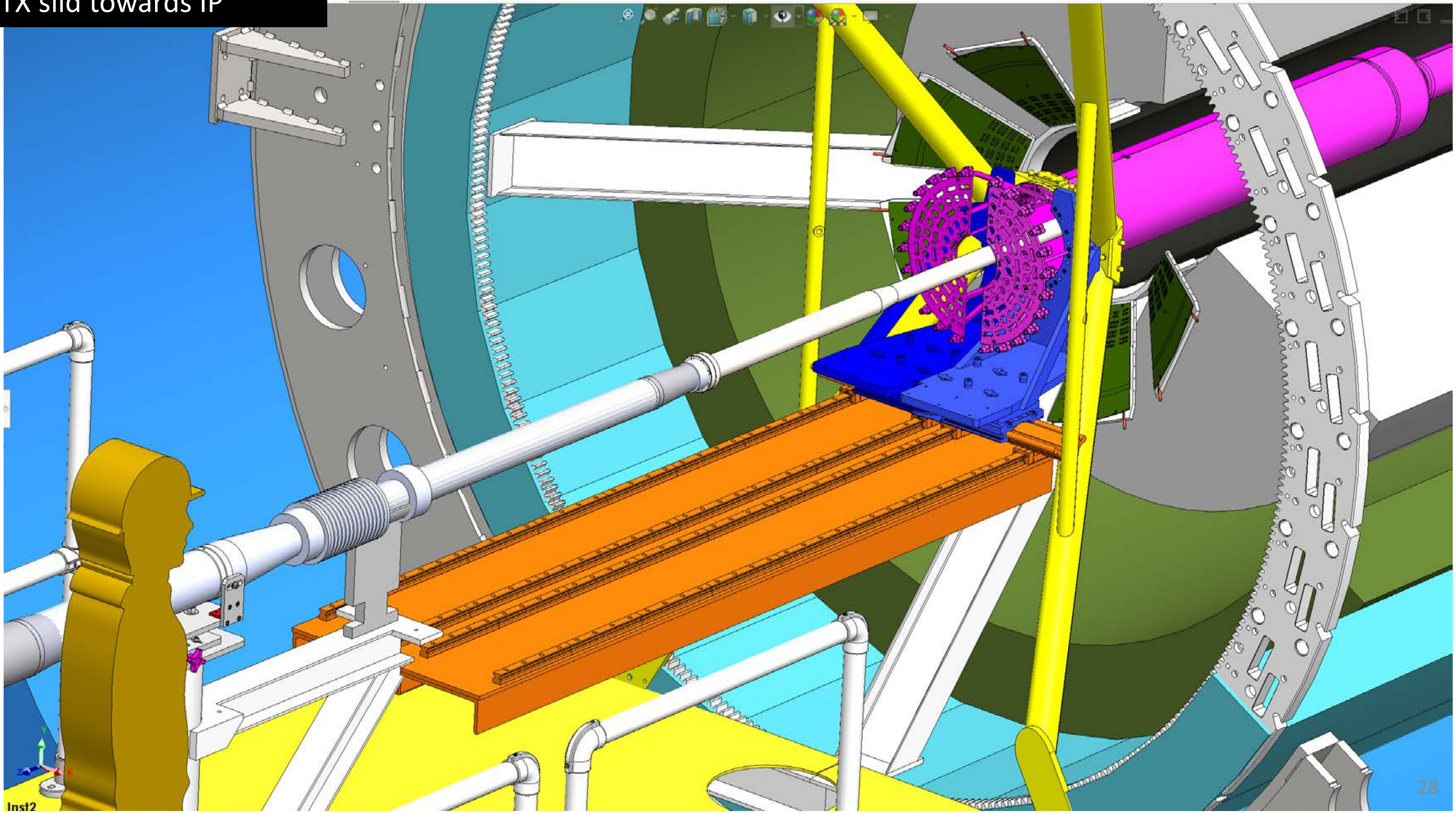
Full MVTX slid towards IP



Installation Sequence

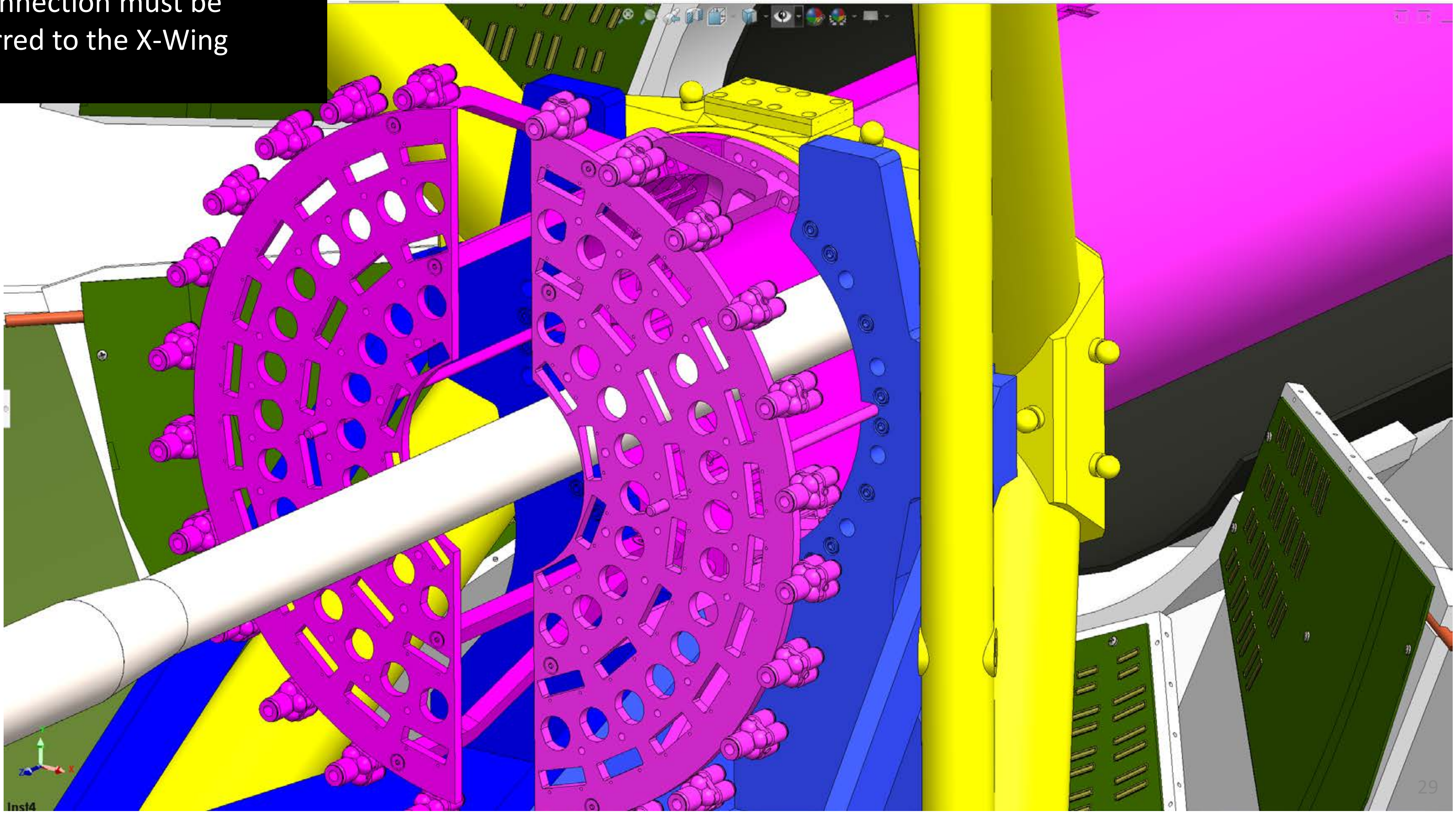
STEP 9

Full MVTX slid towards IP



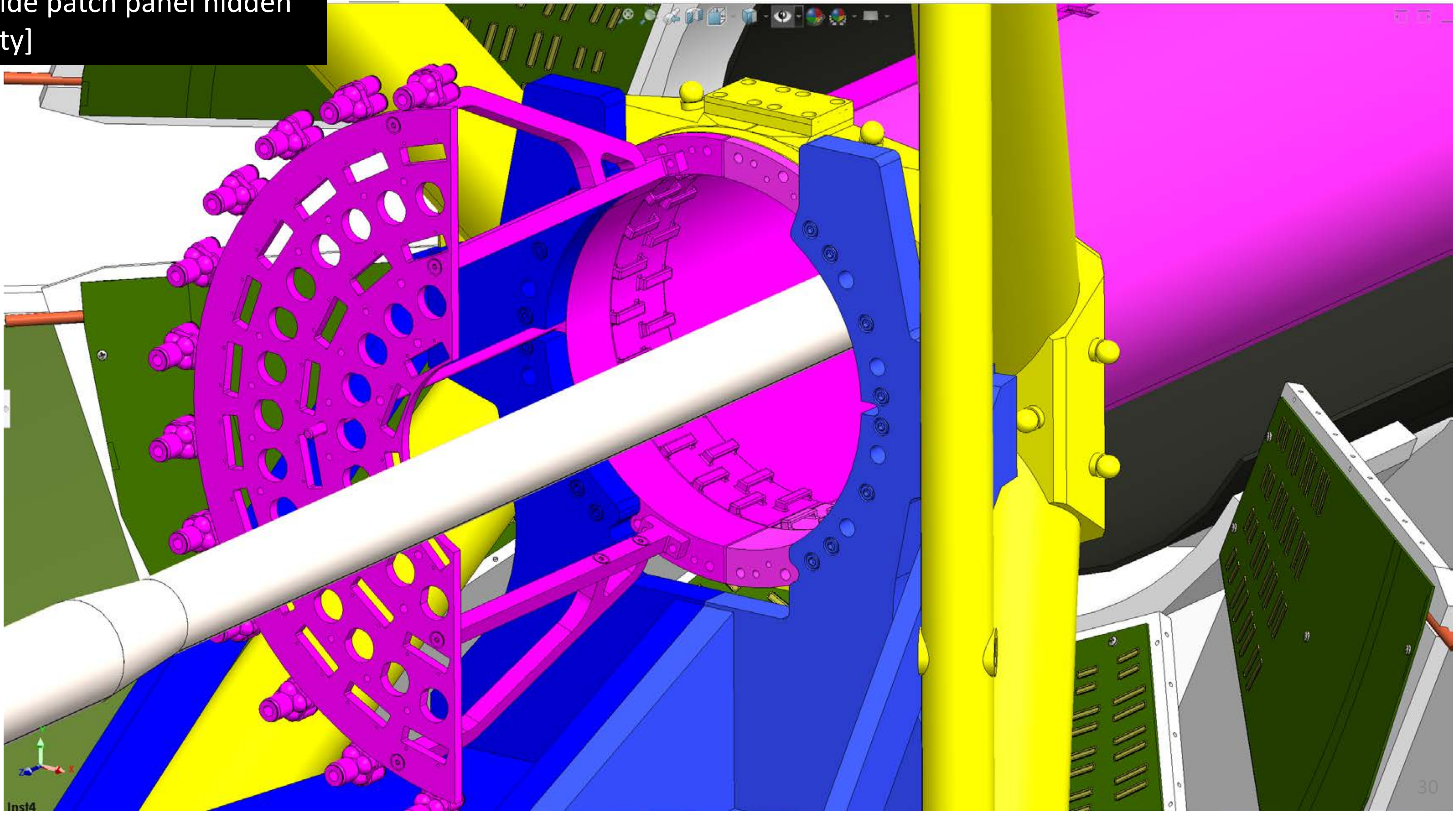
Installation Sequence STEP 10

Now connection must be transferred to the X-Wing flange



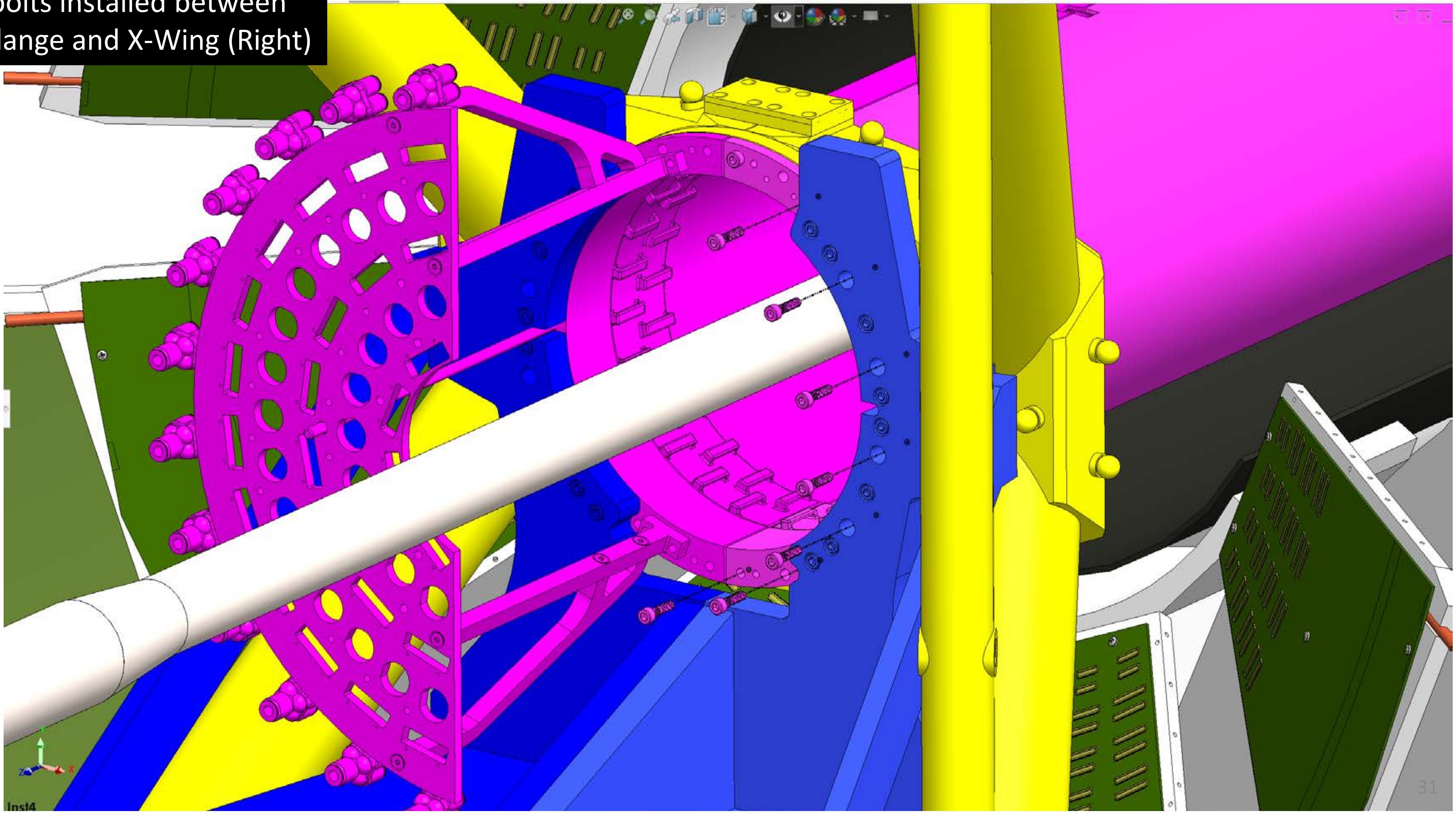
Installation Sequence STEP 10

[Right Side patch panel hidden for clarity]



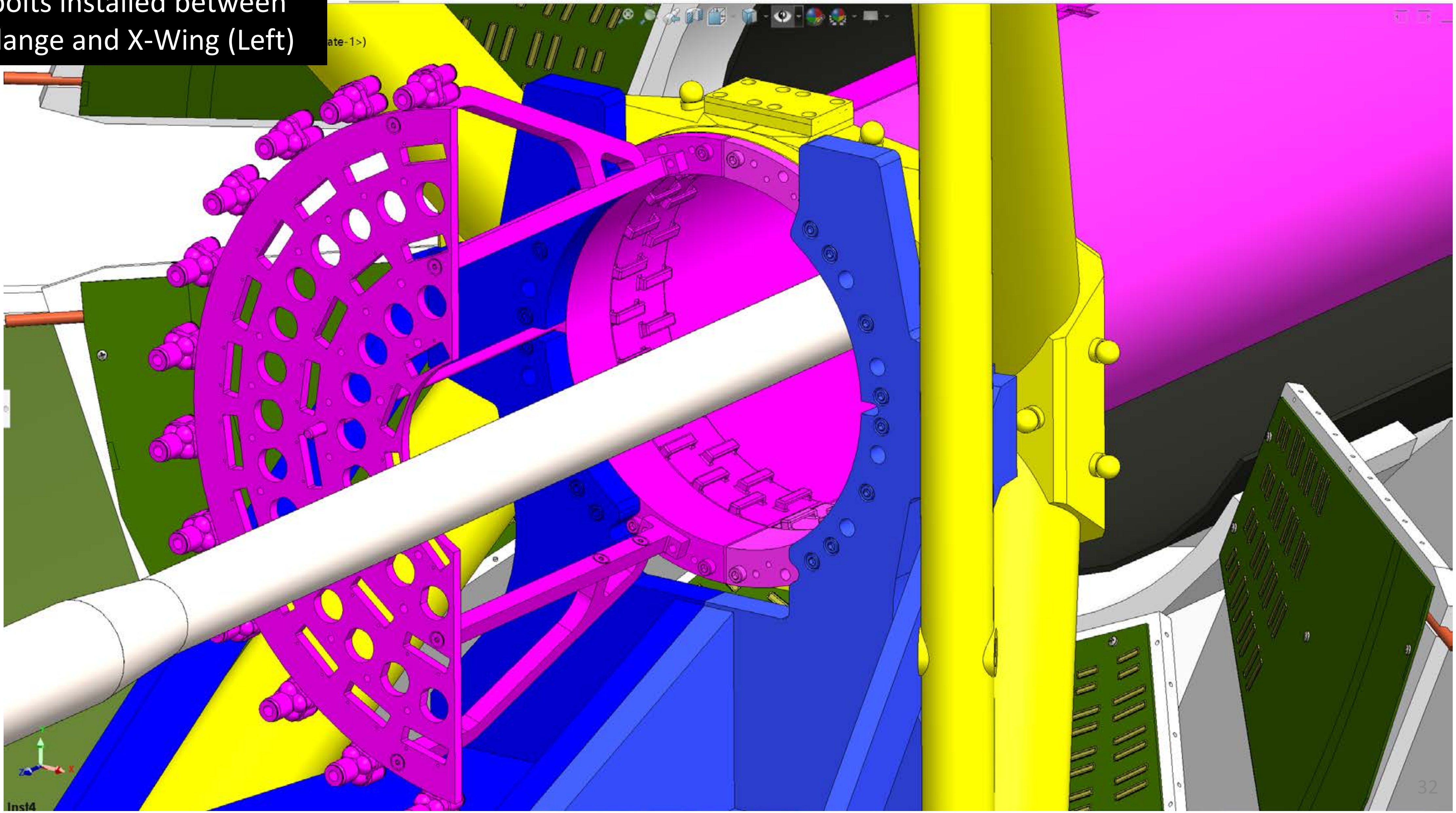
Installation Sequence **STEP 10**

8x M5 bolts installed between MVTX flange and X-Wing (Right)



Installation Sequence **STEP** **10**

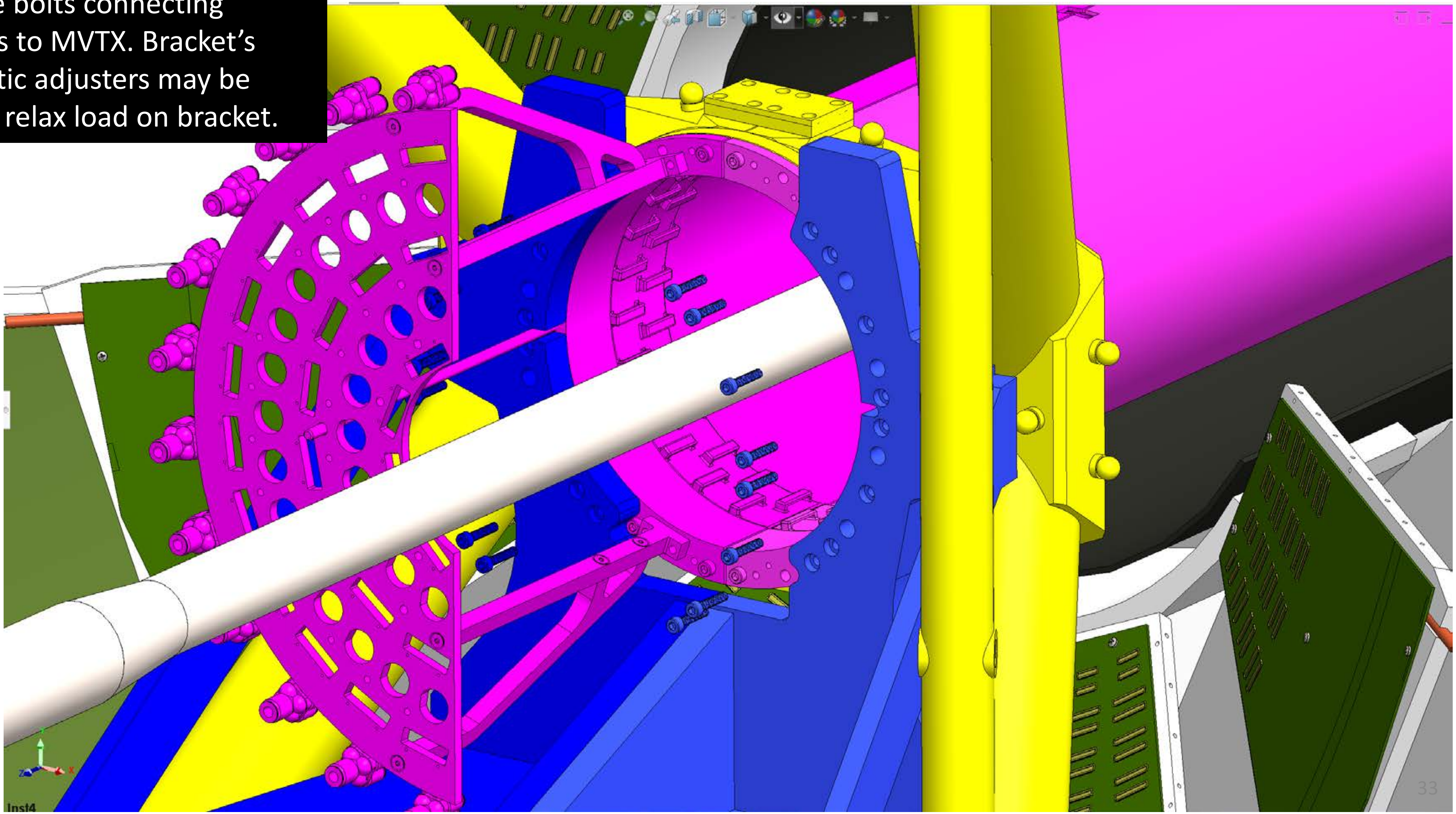
8x M5 bolts installed between MVTX flange and X-Wing (Left)



Installation Sequence

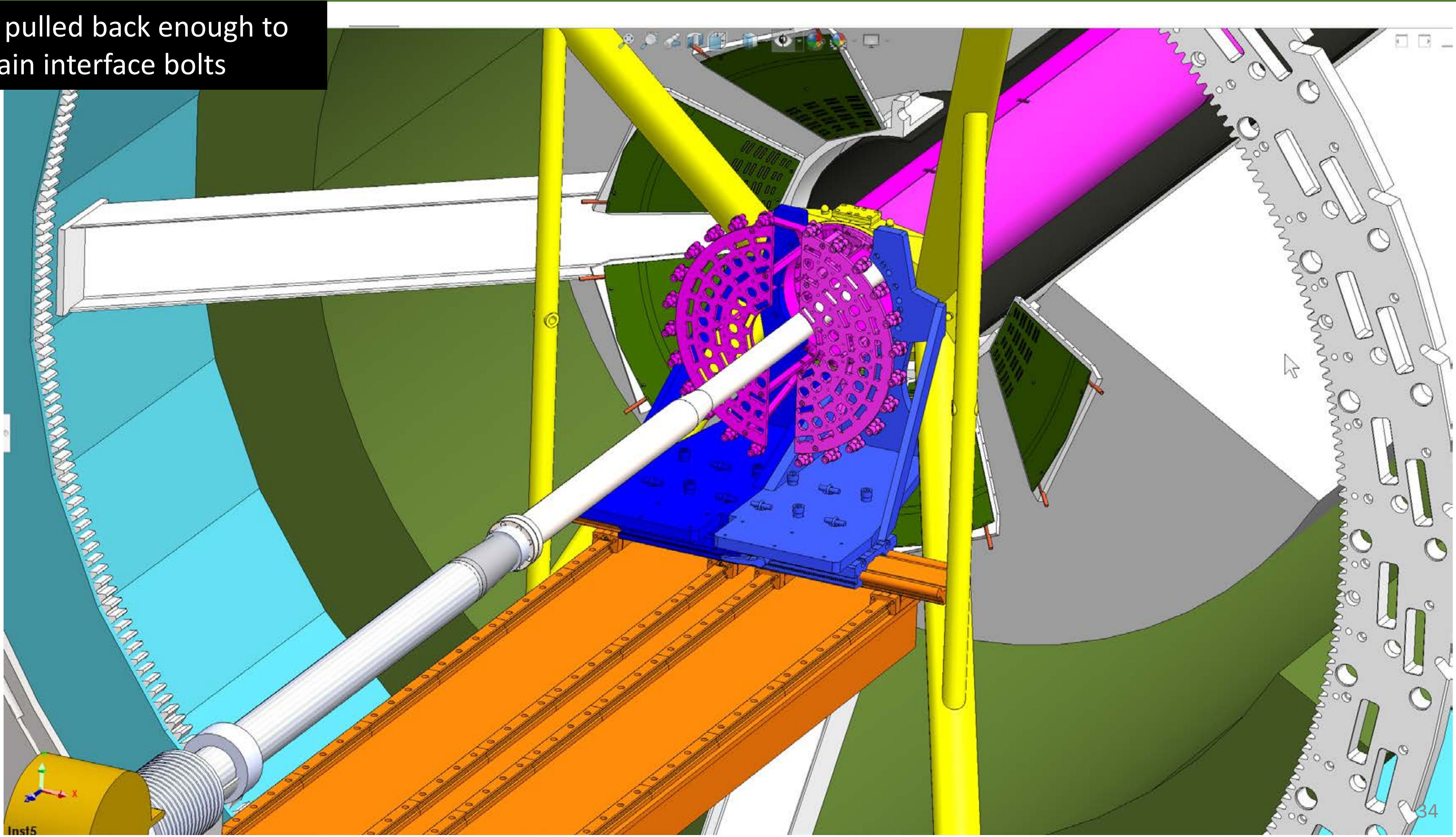
STEP 11

Remove bolts connecting brackets to MVTX. Bracket’s kinematic adjusters may be used to relax load on bracket.



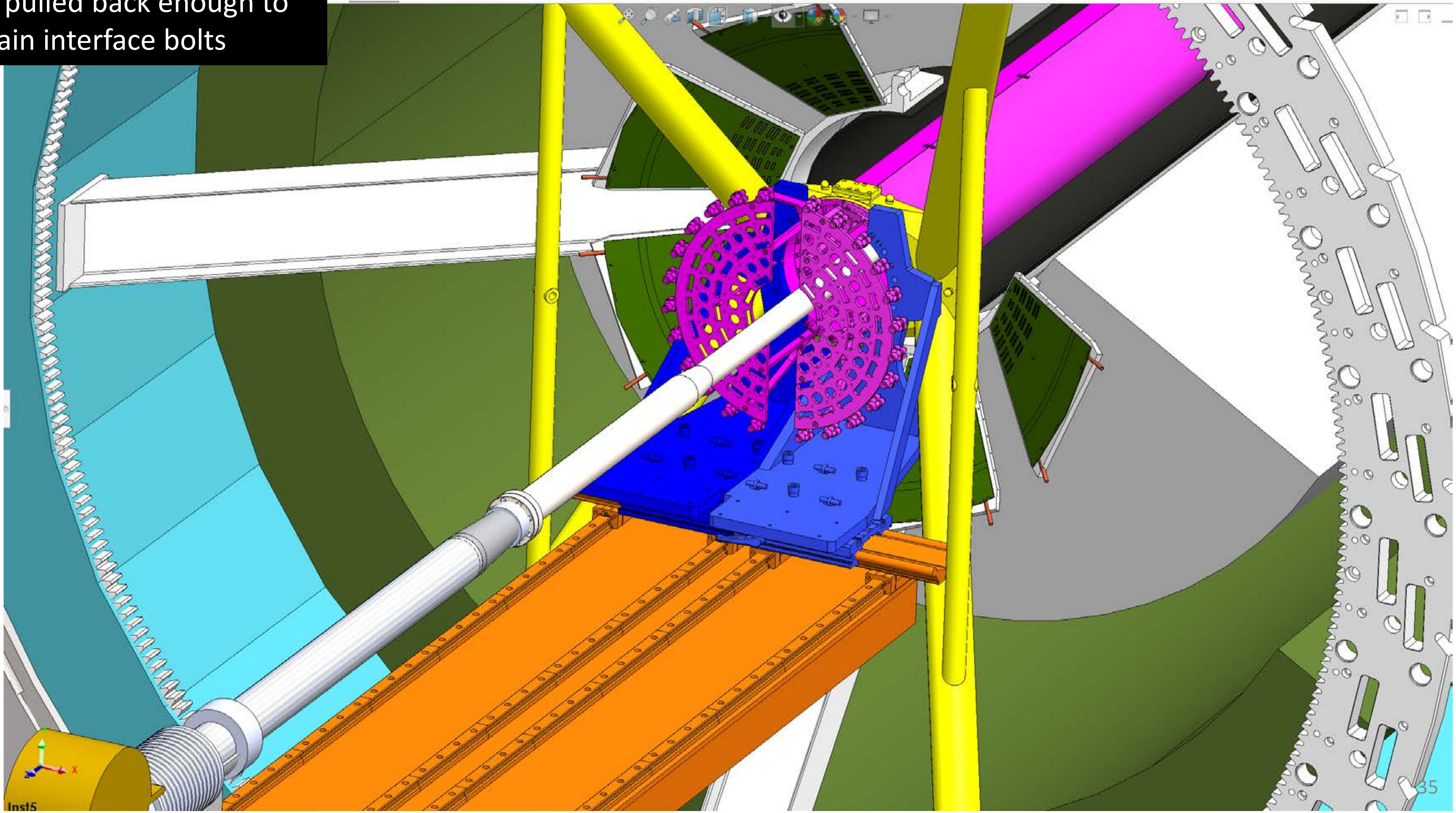
Installation Sequence **STEP 12**

Bracket pulled back enough to clear main interface bolts



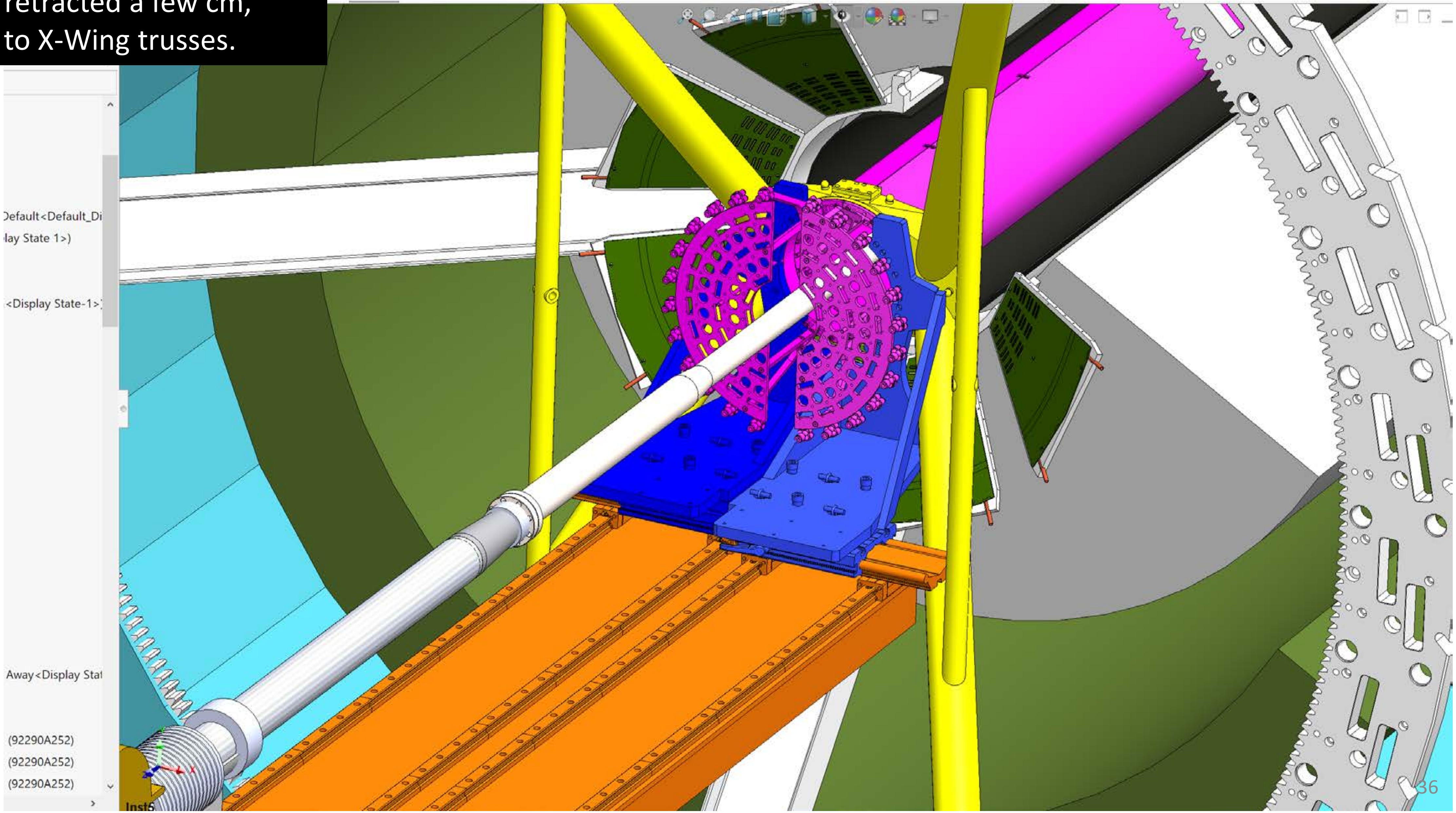
Installation Sequence STEP 12

Bracket pulled back enough to clear main interface bolts



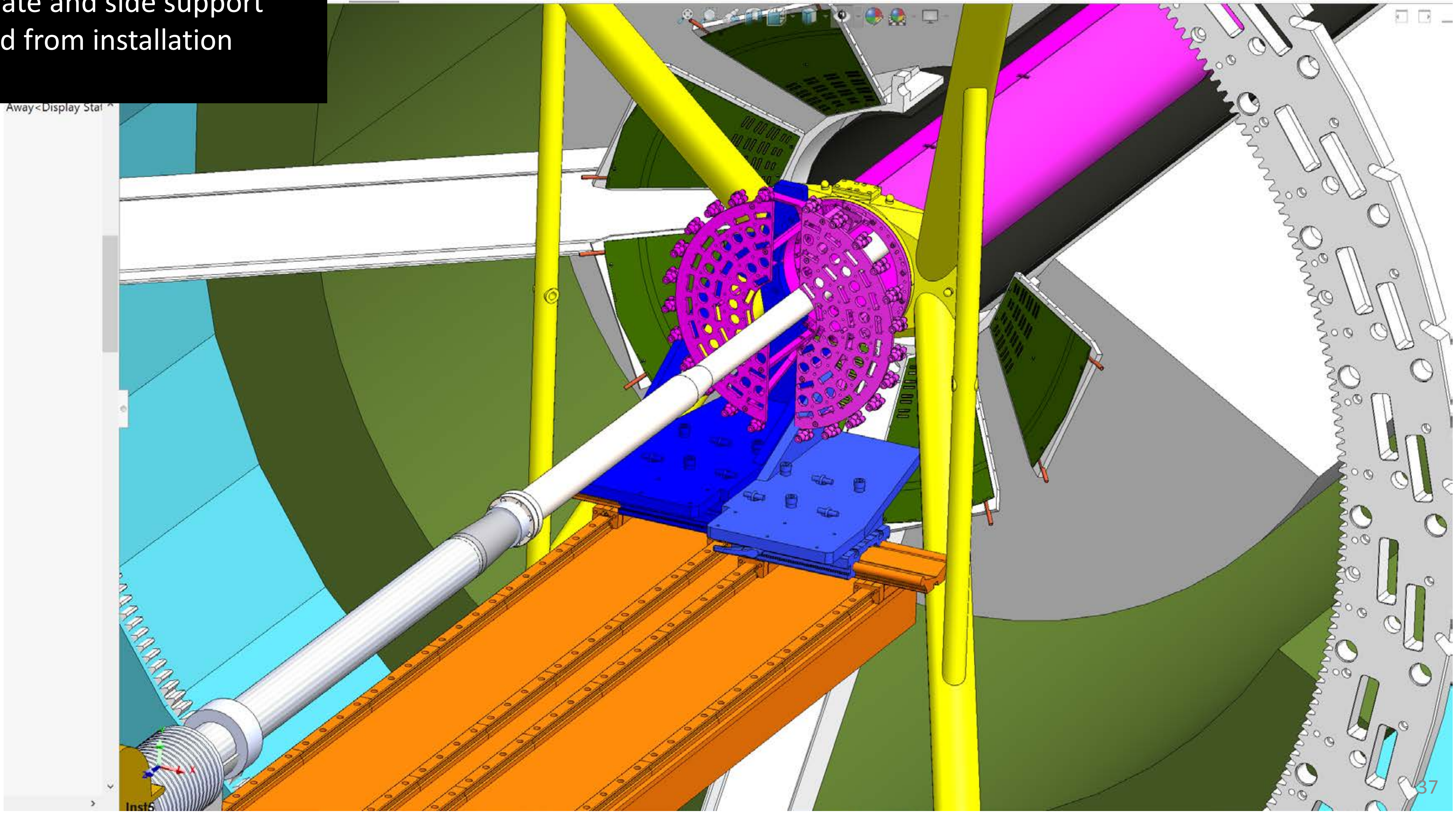
Installation Sequence STEP 12

Bracket retracted a few cm, parallel to X-Wing trusses.



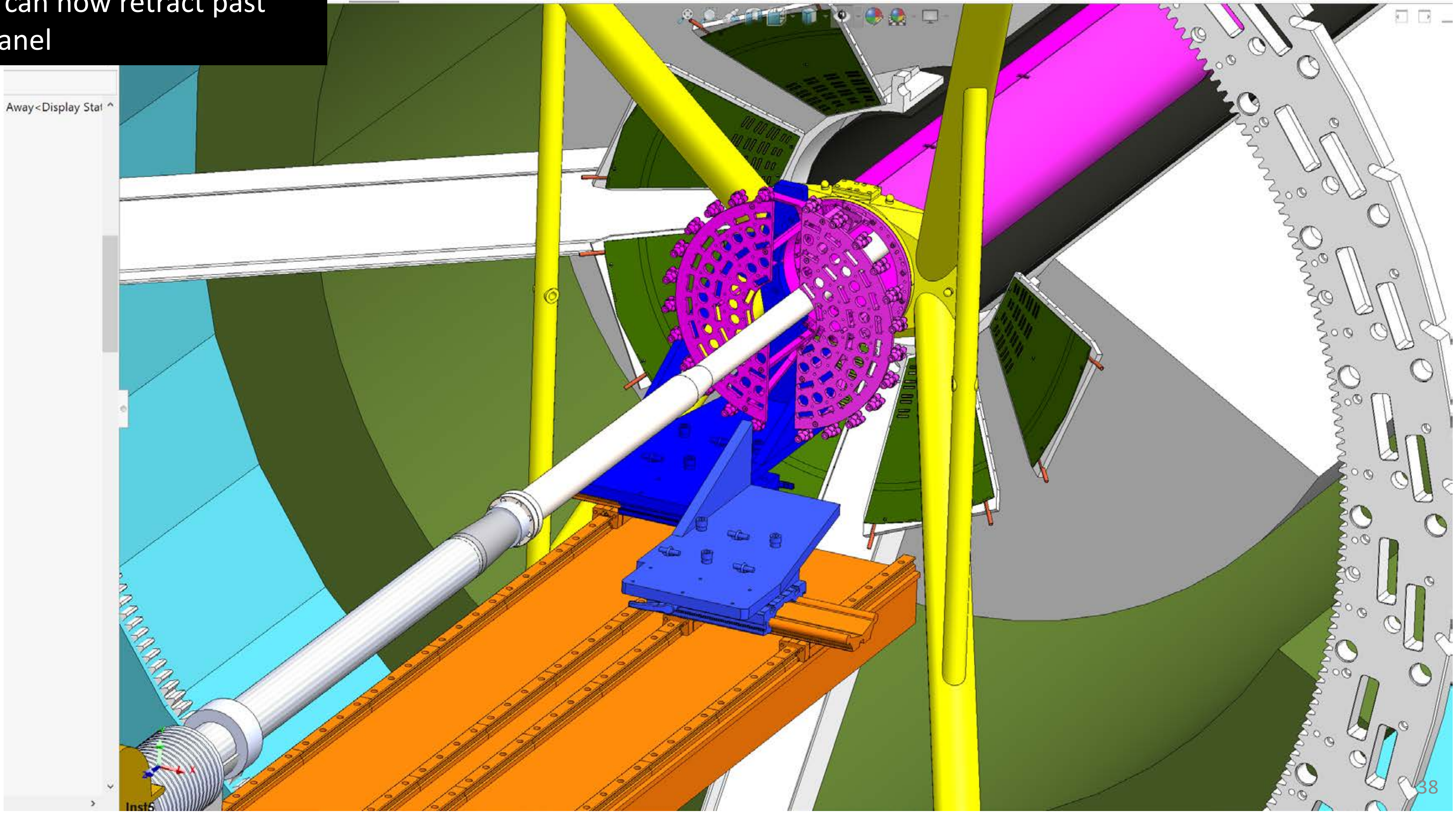
Installation Sequence STEP 12

Front plate and side support removed from installation bracket



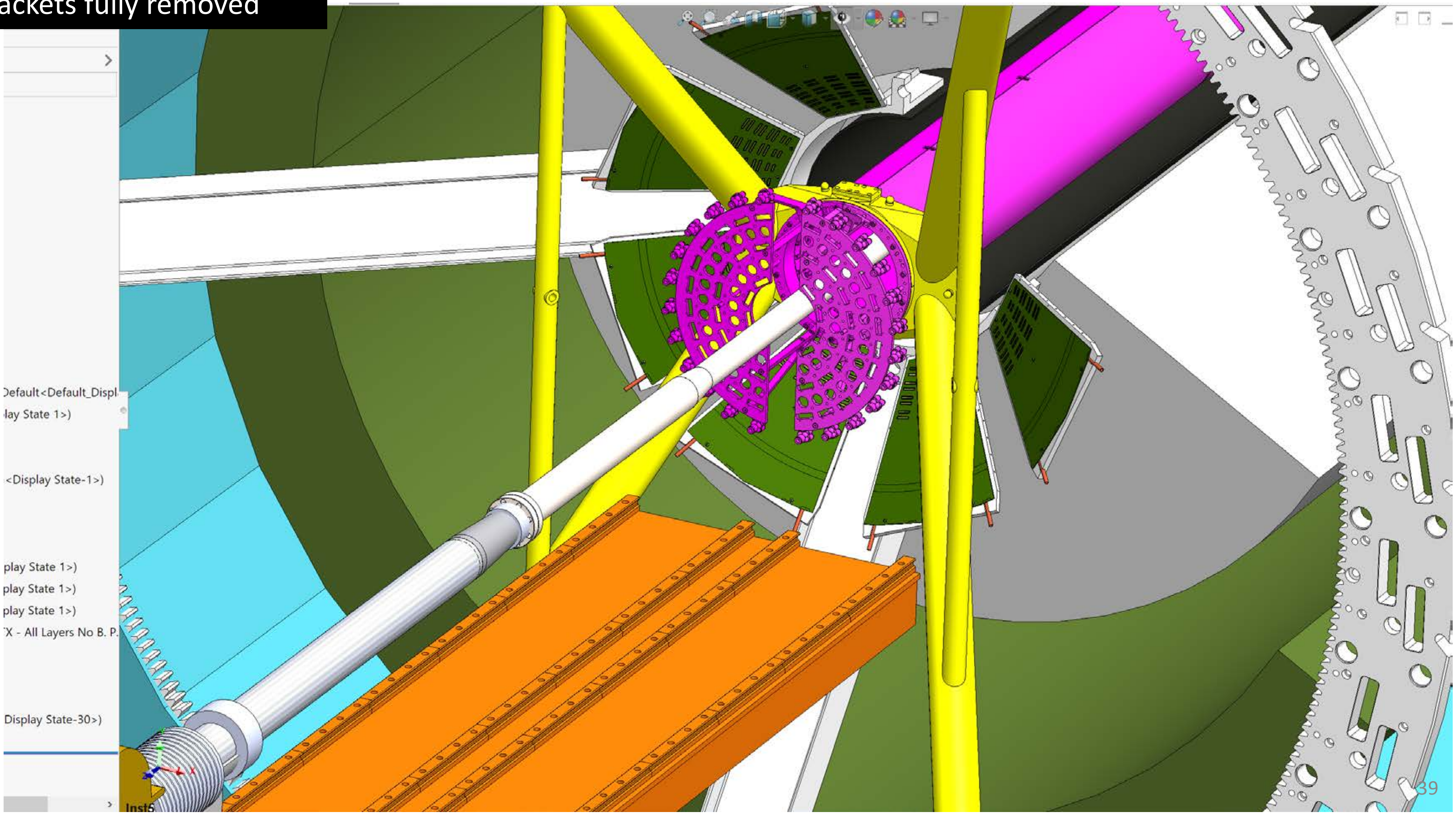
Installation Sequence STEP 12

Bracket can now retract past patch panel



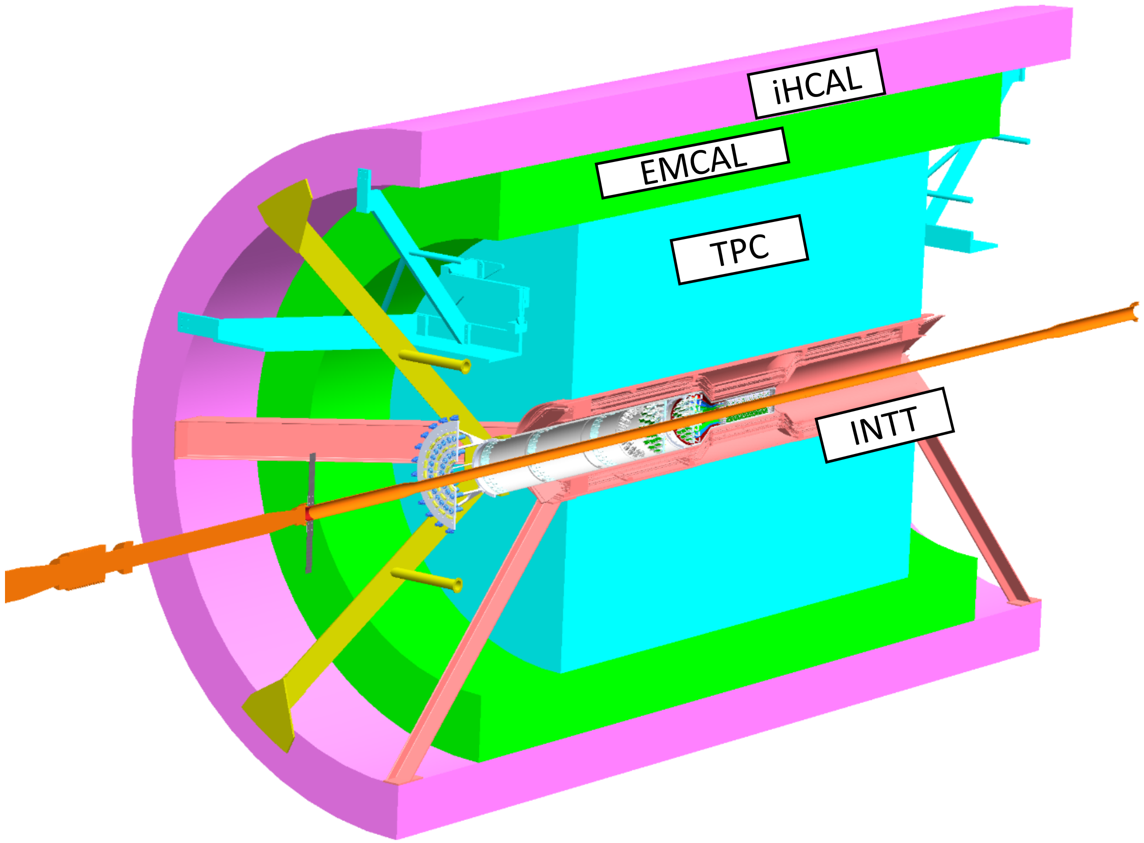
Installation Sequence **STEP 12**

Both brackets fully removed

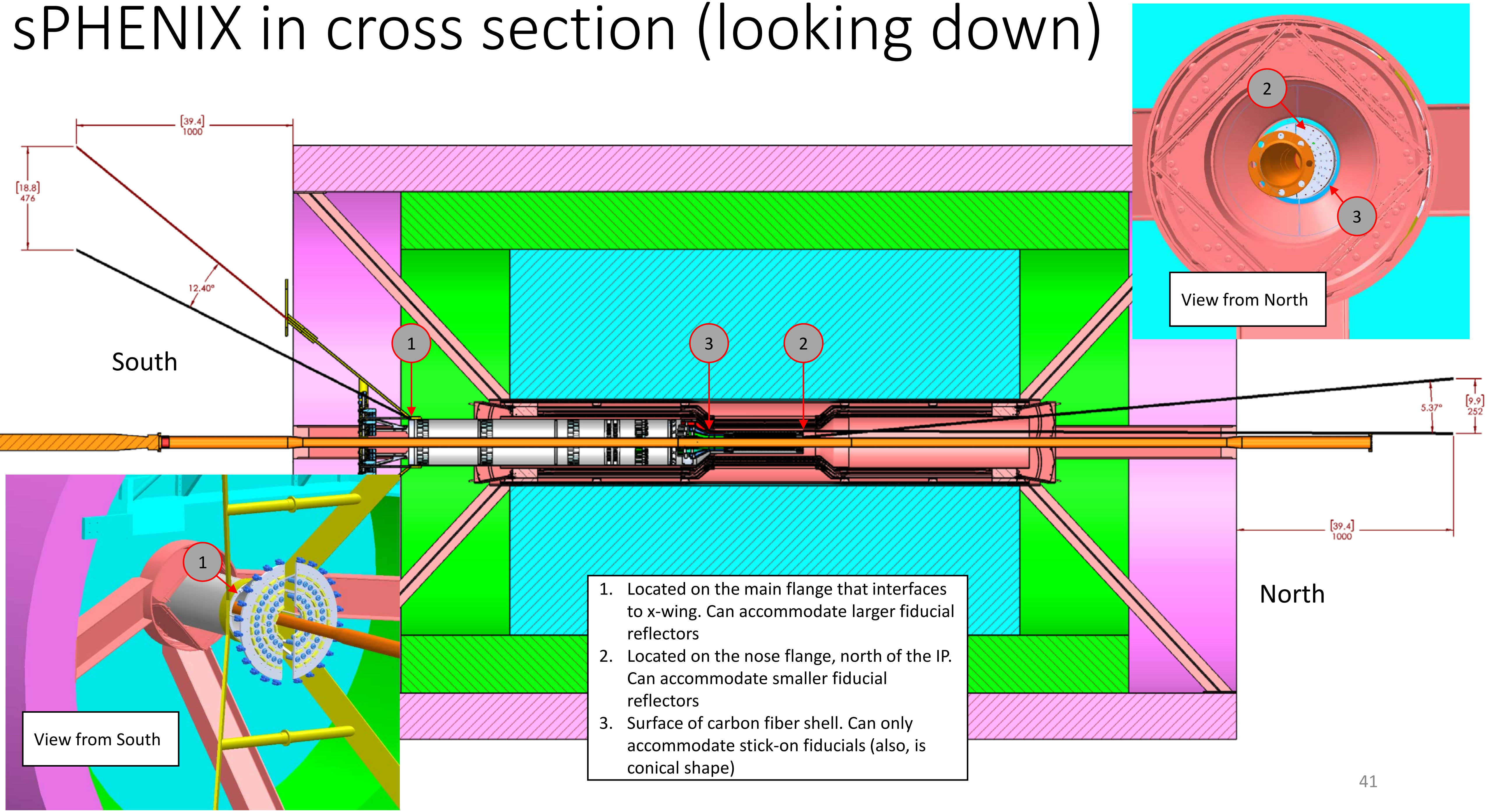


Survey

- MVTX is installed last, with beampipe and all detectors in-place.
  - TPC services will be installed; Unclear if INTT services will be installed before MVTX
- MVTX passes very close to beampipe: ~2 mm to aluminum section, 1.15 mm to beryllium (central) section
- MVTX installed using external insertion rails, moving parallel to beampipe. Mounted to external support (x-wing) and cantilevered into the IR.
- CMM / optical survey during installation will transfer position knowledge of sensors to fiducials on the MVTX outer shell
  - We would like to know the position of these fiducials to better than **50 µm in x and y**, **1 mm in z**.

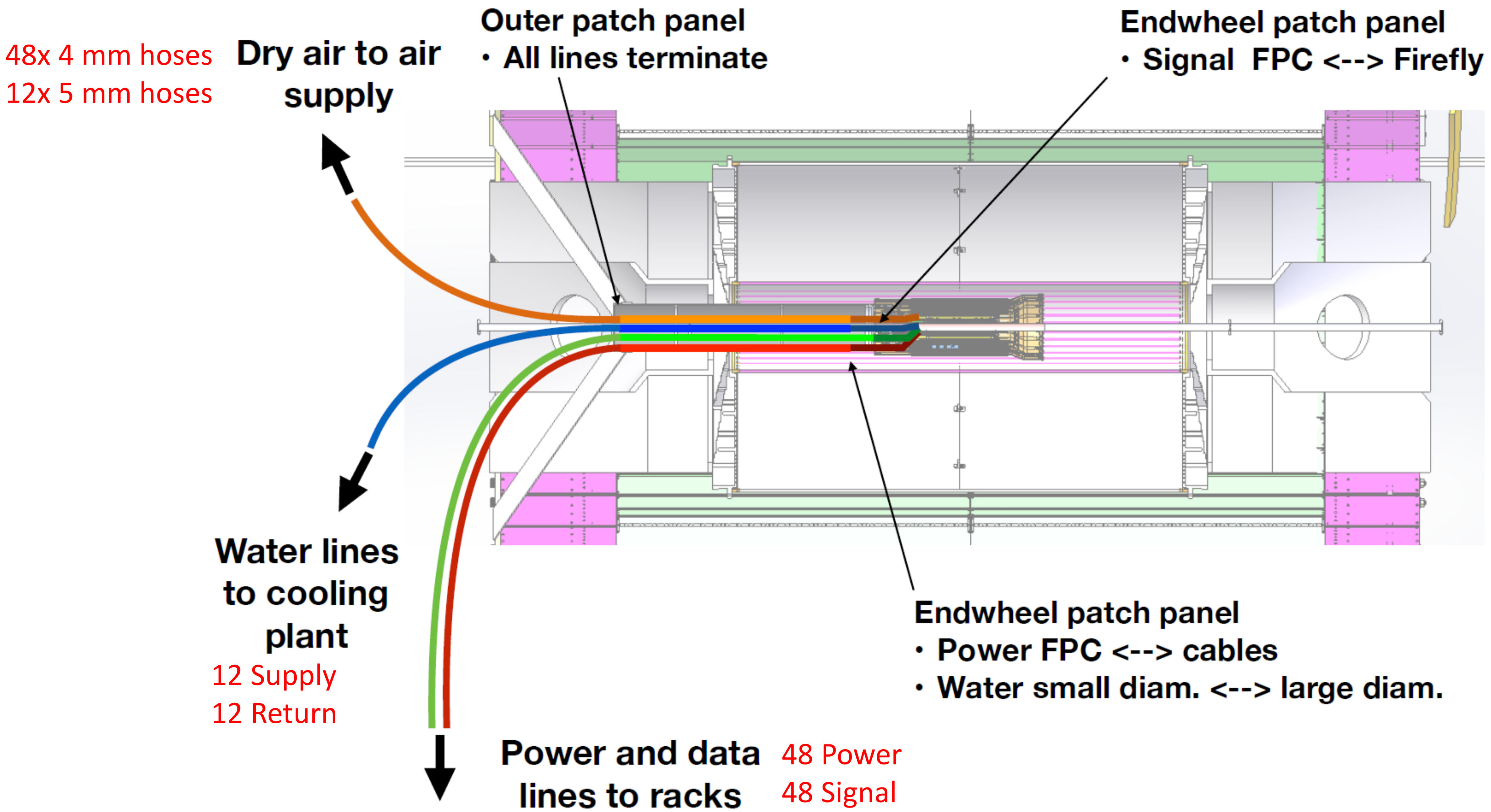


sPHENIX in cross section (looking down)

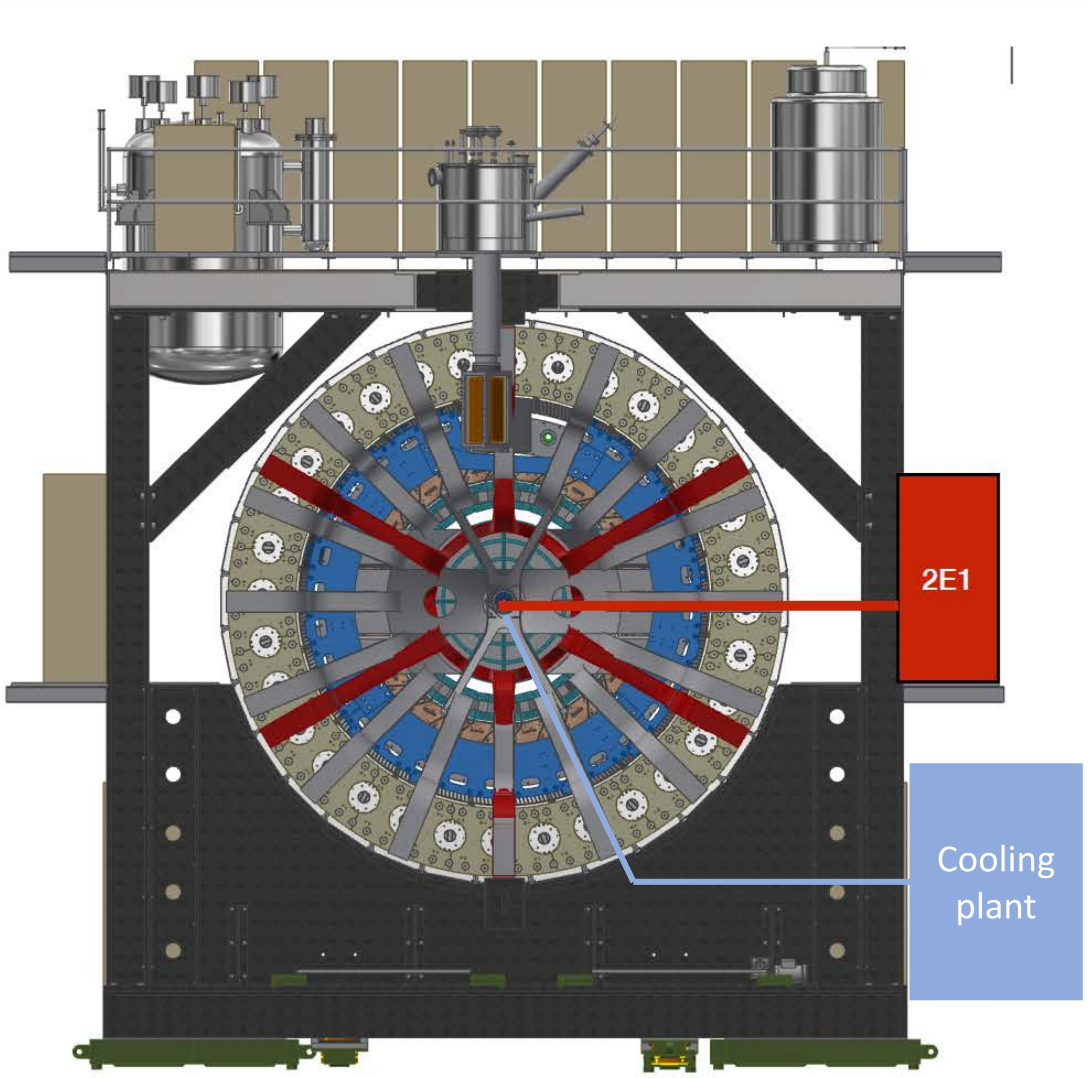


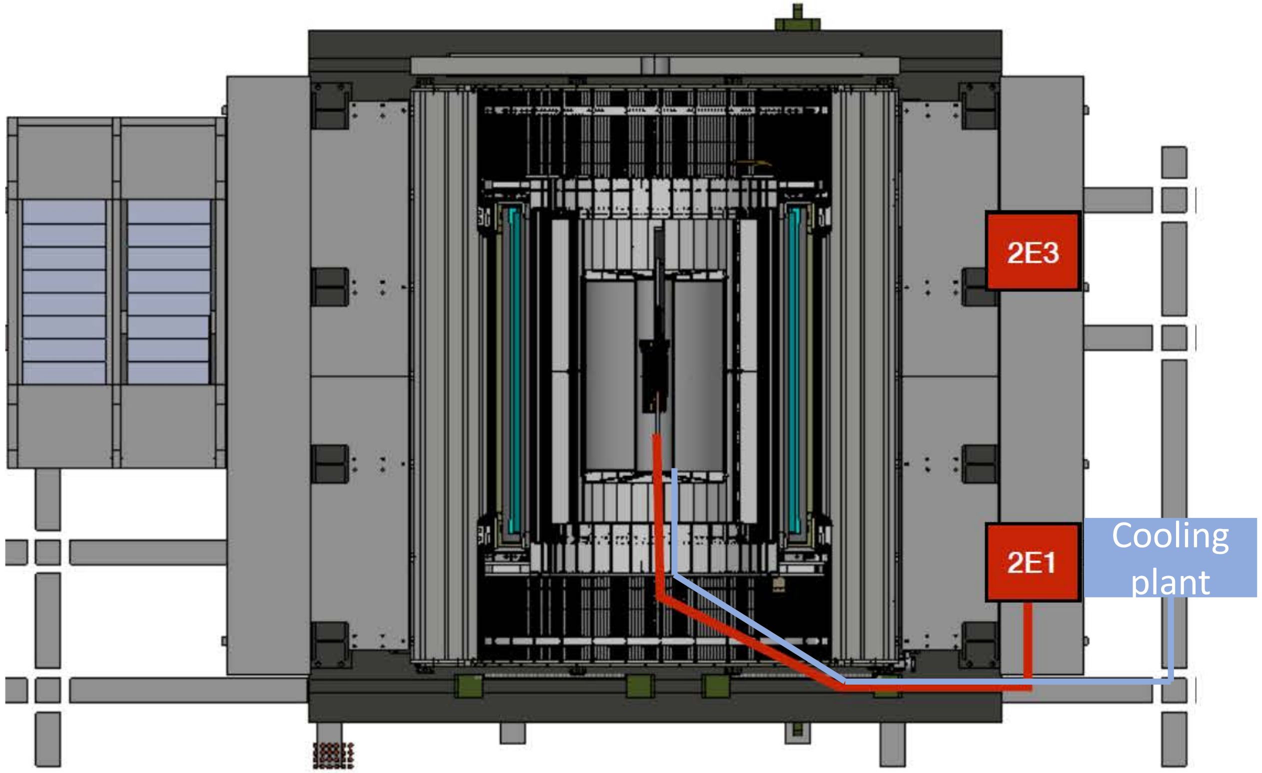
1. Located on the main flange that interfaces to x-wing. Can accommodate larger fiducial reflectors
2. Located on the nose flange, north of the IP. Can accommodate smaller fiducial reflectors
3. Surface of carbon fiber shell. Can only accommodate stick-on fiducials (also, is conical shape)

Summary

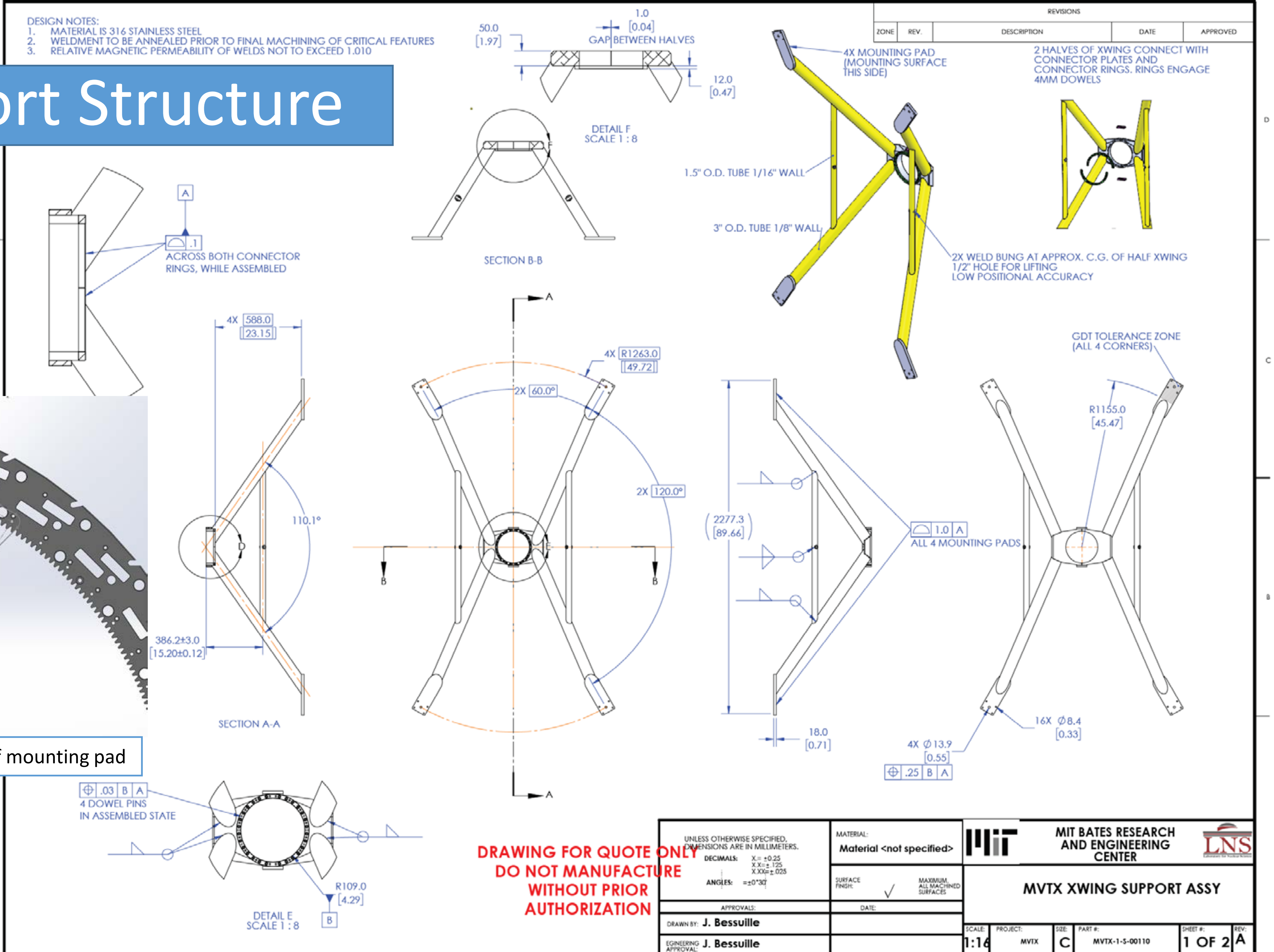


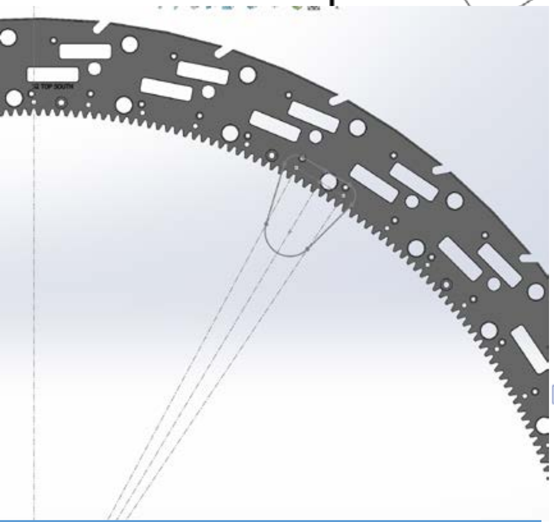
48x 4 mm hoses
12x 5 mm hoses
Dry air to air supply
Outer patch panel
• All lines terminate
Endwheel patch panel
• Signal FPC <--> Firefly
Water lines to cooling plant
12 Supply
12 Return
Endwheel patch panel
• Power FPC <--> cables
• Water small diam. <--> large diam.
Power and data lines to racks
48 Power
48 Signal


2E1
Cooling plant


2E3
2E1
Cooling plant

Support Structure





More accurate shape of mounting pad

Deflection field Shown

Maximum for displayed model using 1/8” tubes: 0.617 mm
Maximum for similar model using 1/4” tubes: 0.508 mm

Baseline just (simplified) MVTX for this model: 0.326 mm
Deflection due to support = 0.508 -0.326 =0.182 mm

Deflection of more accurate MVTX baseline: 0.186 +/-.022 mm
Predicted total deflection at tip: 0.368 mm