

# NCSX Field Period Assembly

October 31, 2007

Mike Viola  
Field Period Assembly Manager



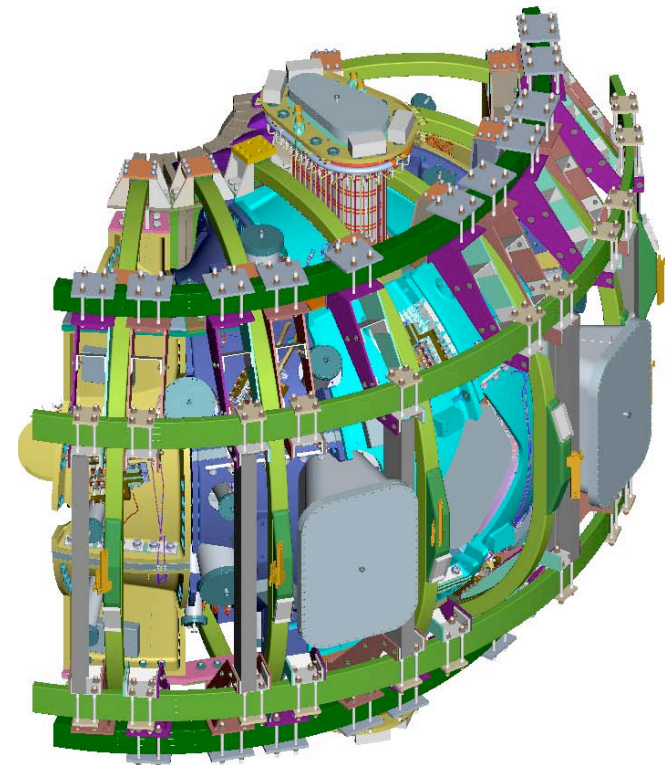
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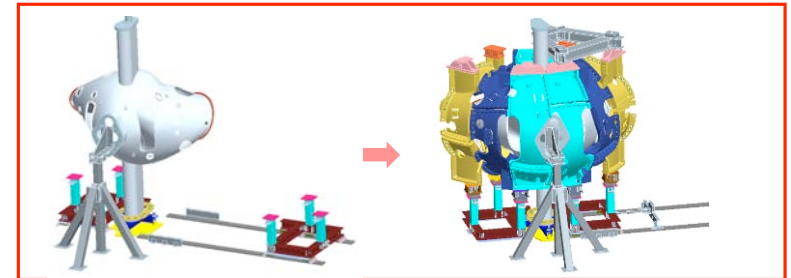
# FPA is Accomplished in Four Stages



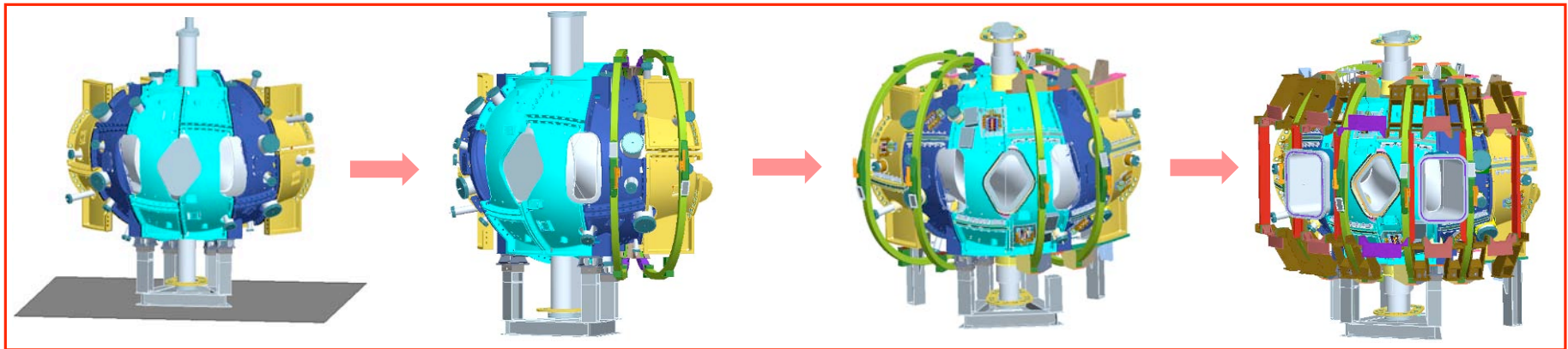
**Station 1 –  
Vacuum Vessel (VV)  
Prep**



**Station 2 –  
Modular Coil Half Period  
(MCHP) Assembly**



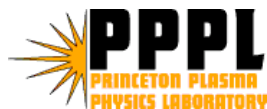
**Station 3 - MCHP  
installation over VV Period**



**Station 5 - Final Assembly in NCSX Test Cell**

**Station 6 – Final Machine Assembly – Erik Perry**

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# FPA Process Definitions

- FPA Manufacturing, Inspection, Test, Quality Assurance Plan (MIT/QA) Complete
  - Input (Station specific):
    - Dimensional Control Plan (Art Brooks)
    - FPA Assembly Sequence Plan (Tom Brown)
    - FPA Specification and Assembly Drawings (Mike Cole)
  - MIT/QA Plan provides basis for individual procedures to perform tasks then revised to include developed improvements.
- FPA Procedures
  - FPA station 1 procedure is complete and active
  - FPA station 2 trials are providing input to procedure development

# Design Philosophy

- We carefully assure that our designs are adequate.
  - Utilize outside reviewers to participate in design reviews
  - Complete designs early to minimize configuration changes
    - not rely on concurrent engineering as much during assembly phase
- We schedule time to test the designs in advance.
  - Added trials to discover problems BEFORE the critical path.
    - E.g. Added stud tension, bushing, and nose weld trials
  - Measure all modular coils in advance of assembly
    - developed new alignment techniques
- We allow time to reinforce tooling or make adjustments as needed.



# NCSX Vacuum Vessel Station 1

**97% Complete**

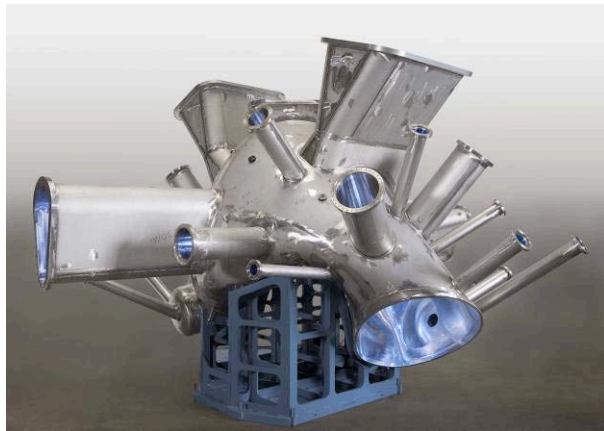
- VV #1 and VV #2 98% Complete
- VV #3 95% Complete
- Cooling tube testing and final scans remain



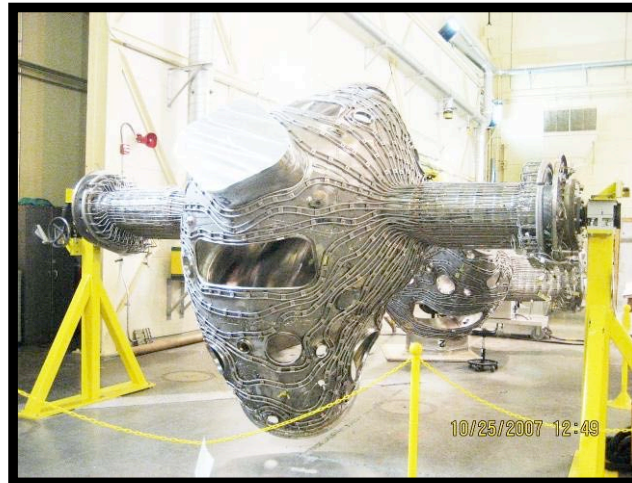
VV #1



VV #2



VVSA with ports welded



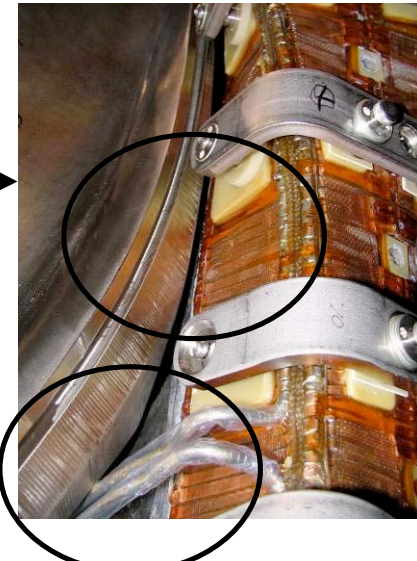
VV #3 complete

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# Station 2 Trials are Successful

- Station 2 FPA trials were enhanced and are well in progress:
  - ✓ Gross fit individual mating coils
    - ✓ found a few minor interferences
- Joint design trials for Station 2 (useful for Station 3 also):
  - ✓ Install and torque bolts – assess accessibility **SUCCESSFUL**
  - ✓ Develop shim technique **SUCCESSFUL**
  - ✓ Pillow shims **SUCCESSFUL**
  - ✓ New welded design for inboard interface (nose) **SUCCESSFUL**
    - Install Alumina coated metal shims
      - **Shims on order**



# Station 2 Assembly Sequence



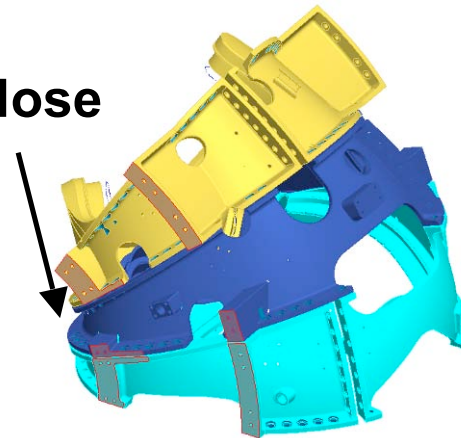
## Preparation Steps/ Major Activities

- MC Fit-up Check
  - ✓ Verify will come together (Gross Fit-ups)
- Pre-Measurement of MHCP Type A/B/C Coil Flanges & Interfacing Type A Coil Flange
  - ✓ Individual coils have been racked into proper shape. (within +/- .005")
- Alumina Shim Sizing & Preparation
  - Measure shim thicknesses to arrive at a satisfactory shim set for MCHP assembly.

## Potential Issues and Mitigation Plans

- Tooling not rigid enough – **RETIRED**
  - wedges determined to be adequate
- Coils still too flexible – **RETIRED**
  - physically racked (twisted) coils to re-establish their coordinate system
- Alignment not within tolerances bars- **RETIRED**
  - successfully met requirements

•Nose



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# Station 2 Assembly Sequence

## A-B Modular Coil Assembly Steps/Major Activities

- Rack A coil & measure fiducials.
- lower B coil into place onto outboard shims
- Measure shim puck height with bore gauge
- Install nose shear plates & lightly tack weld
- Lift B & flip to ready for nose welding.
- Establish A & B coil fiducials – weld flex shims to plasma side both coils, recheck fiducials. Back Office assess part for compliance.
- Place B coil back on A coil and align
- Install alumina shims and bushings
- Weld A/B nose region solenoid side & re-measure.

**REPEAT FOR C TO A-B ASSEMBLY**





# Station 2 Assembly Sequence

## A-B Modular Coil Assembly

### Potential Issues and Mitigation Plans

- **Alignment not within tolerances - *RETIRED***
  - Able to achieve +/- .005” lock-in
- **Weld distortion excessive**
  - Install wing chairs to offset distortions
  - If required, coil welds can be ground out & coil separated

# Station 2 Assembly Sequence

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## Final Assembly Steps/Major Activities

- **Inflate All Shim Bags**
- **Complete Local Services & Interface Details**
  - Install sealant to fill all shim spaces to trap VV/MC insulation.
- **Final Measurements and transfer to MCHP holding area.**

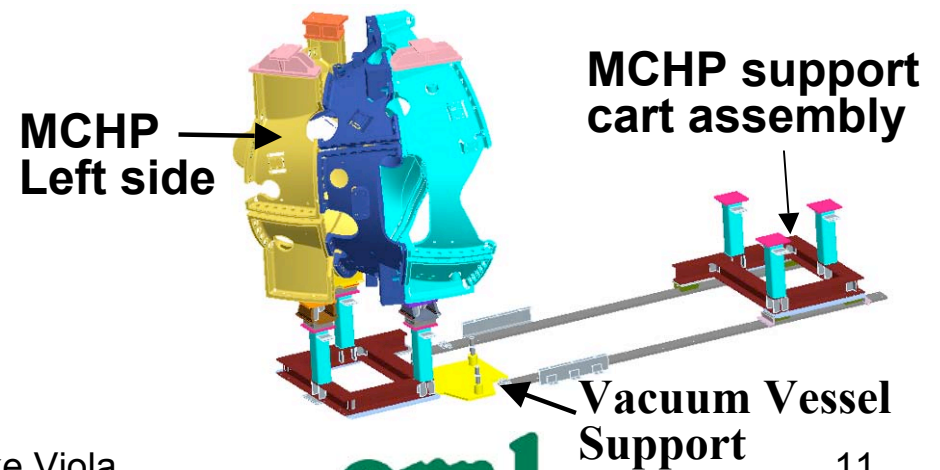
# Station 3 Assembly Sequence

## Pre-Assembly Steps/Major Activities

- **Pre-Installation Set-Up**
  - Install monuments, floor mounted tracks & Vacuum Vessel base support, measure MCHP CG
  - Anchor tooling (floor mounted tracks, support carts, adjuster bar, temporary scaffolding, etc.)
- **Pre-Assembly of Left MCHP**
  - Establish global coordinate system and install laser screens.
  - Measure MCHP in vertical orientation, including A-A flange
  - Perform Metrology and align

## Potential Issues and Mitigation Plans

- **Tooling not rigid enough**
  - Reinforce/redesign tooling if necessary
- **Left or Right MCHP changes shape**
  - Back Office review changes & provides new left to right MCHP orientation

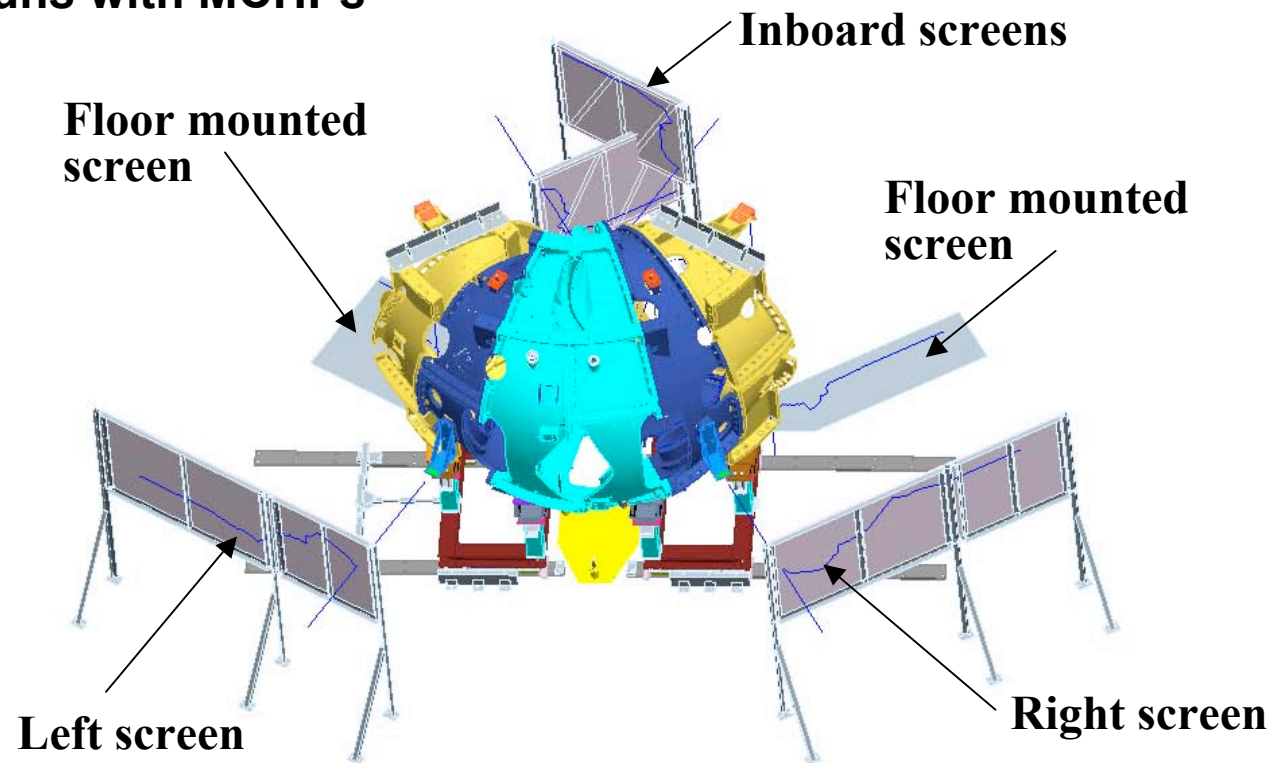




# Station 3 Assembly Sequence

## Pre-Assembly Steps/Major Activities

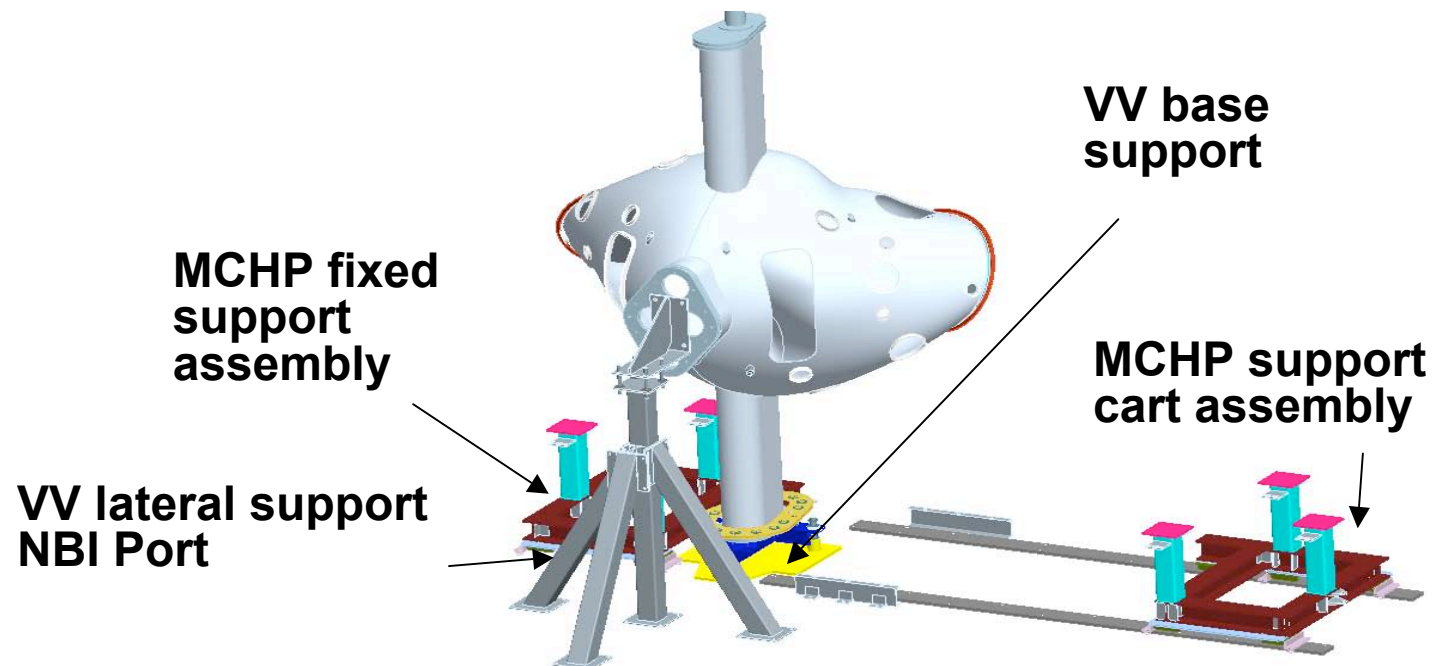
- Install Laser Screens
- Perform Dry Runs with MCHPs



# Station 3 Assembly Sequence

## Assembly Steps/Major Activities

- Install VV NBI support stand & install VVSA to base support structure.
- Using metrology, take tooling ball readings to properly position VVSA to global coordinate system.

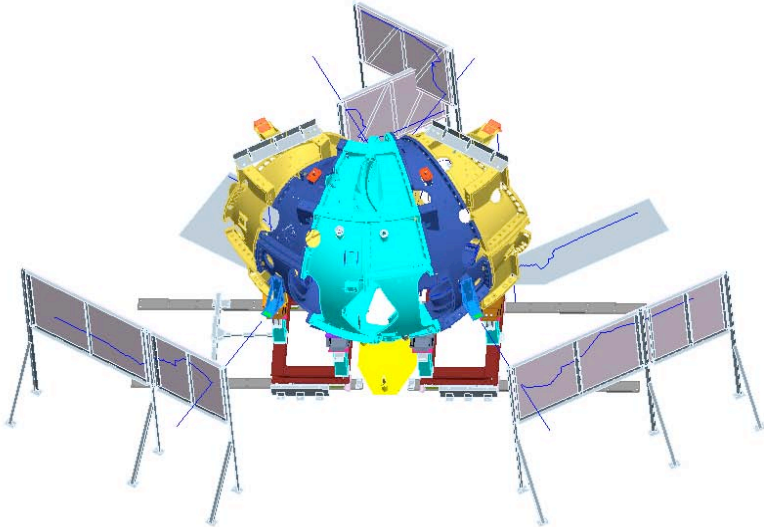


# Station 3 Assembly Sequence



## Assembly Steps/Major Activities

- Install Left then Right MCHP over VVSA
- Weld Inboard Shims and re-measure alignment



## Potential Issues and Mitigation Plans

- **Components damaged during assembly (*highly unlikely due to very slow motion*).**
  - remove MCHP from vessel & repair damaged component with existing spare component e.g. cooling tube or clamp.
- **Weld distortion excessive**
  - Install wing chairs to offset distortions
  - If required, coil welds can be ground out & coil separated

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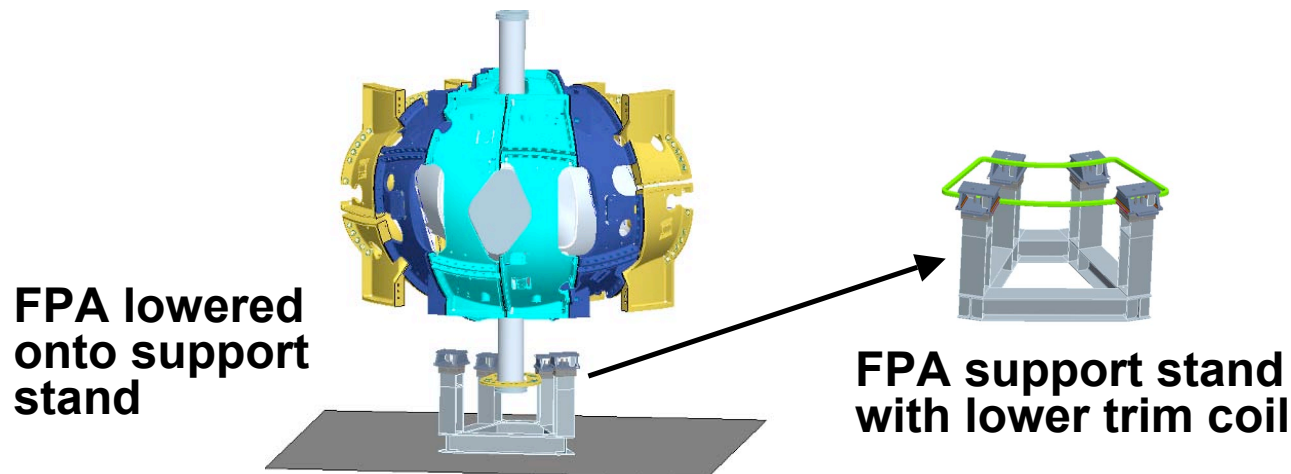
# Station 5 Assembly Sequence

## Pre-Assembly Steps/Major Activities

- **Pre-Installation Set-Up**
  - Install period support fixture
  - Install FPA on support stand & engage base of MC.
  - Install internal & external working platforms

## Potential Issues and Mitigation Plans

- **Floor not stiff enough**
  - Will be tested in advance with a concrete block; reinforcing can be added to substructure
  - Photogrammetry will allow a bundle adjustment independent of the floor.



# Station 5 Assembly Sequence

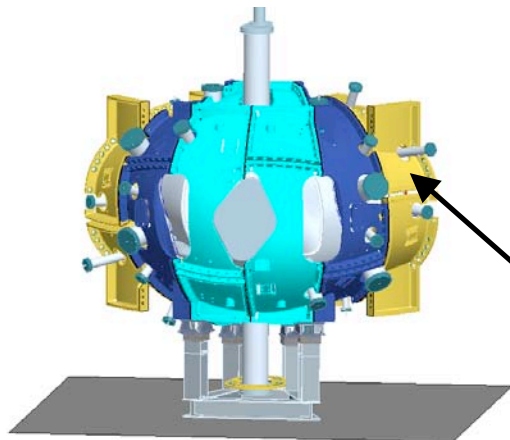


## Assembly Steps/Major Activities

- VV Port Installation
  - Install circular ports.
  - Install domes, inserting the long port through the MC hole opening & weld dome shell to VV.
  - Leak check all port welds.

## Potential Issues and Mitigation Plans

- Difficulty of welders working inside VV in contorted positions may pose ergonomic & confined space hazards
  - Ergonomic / confined space hazards – prior Job Hazard Analysis (JHA) will consider all hazards
- Leak check fails on one or more ports
  - Identify leak point (s), repair weld and re-test



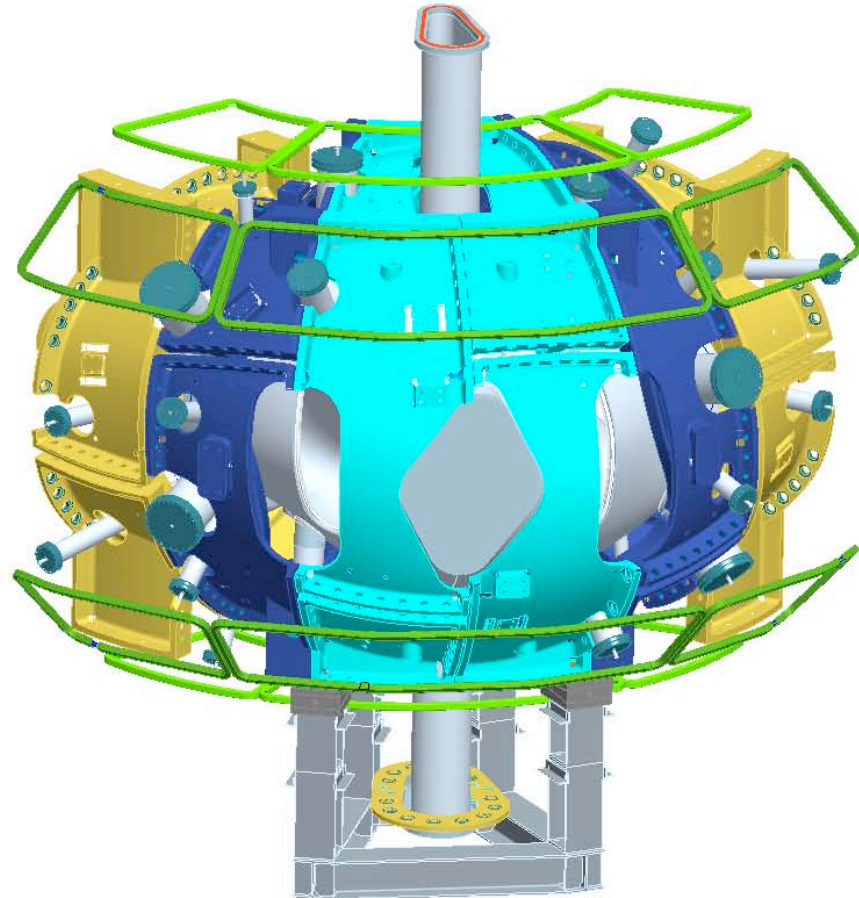
1" – 2" clearance around all ports

# Station 5 Assembly Sequence



## Assembly Steps/Major Activities

- **Trim Coil Installation**
  - Install trim coils - mounted to the MC shells using local field fit support brackets



**There are four different trim coil sizes.**

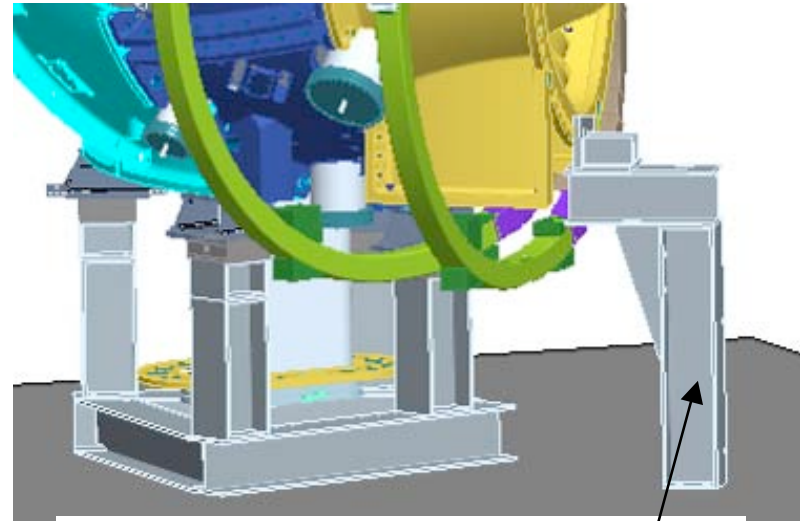


# Station 5 Assembly Sequence

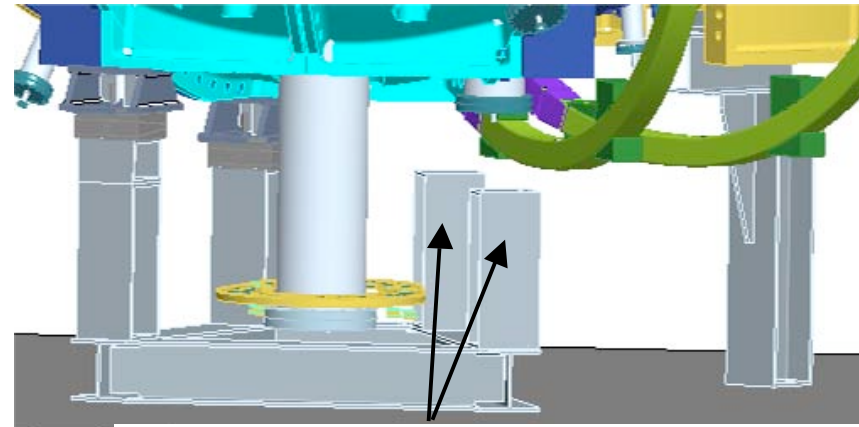


## Right & Left TF Coil Assembly Steps/Major Activities

- Attach temporary supports, disengage base of MC, & install TF support brackets
- Slide TF assemblies against TF support brackets one at a time
- Install machine support plates & re-engage base of MC



Temporary end support  
simplified with two TF coils)



Right side leveler pad with  
intermediate support removed

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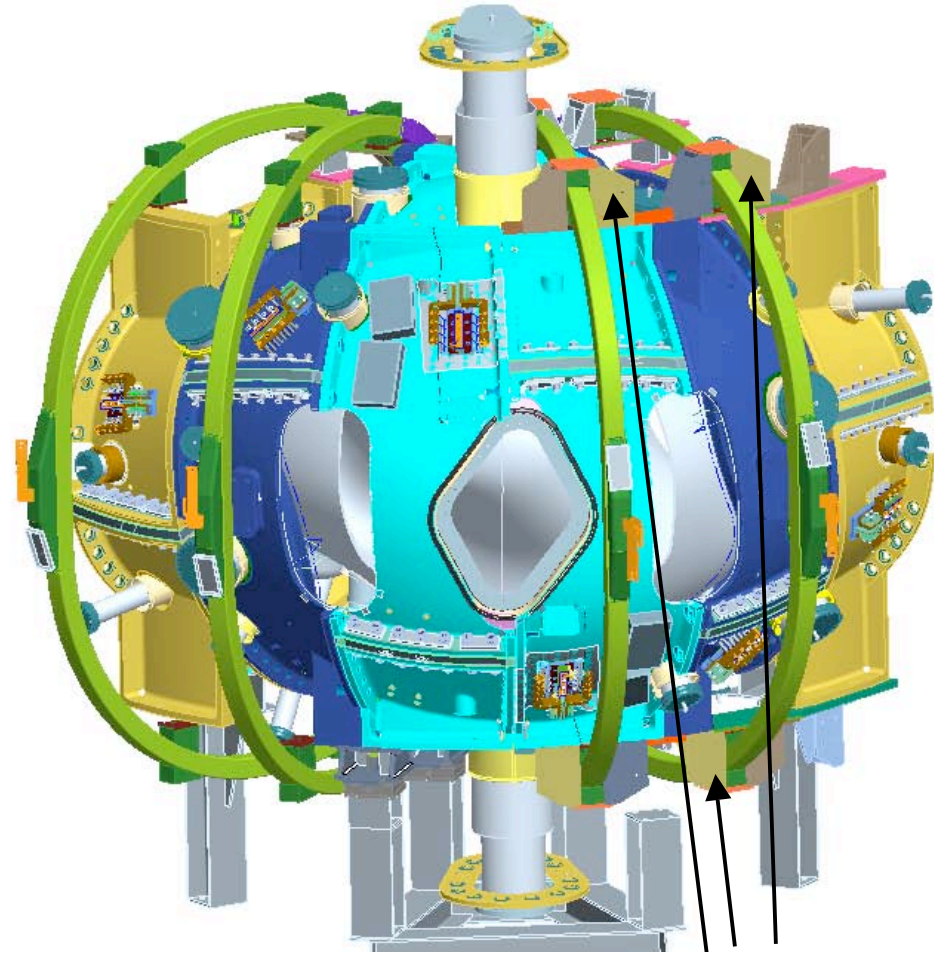


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# Station 5 Assembly Sequence

## Assembly Steps/Major Activities

- Advanced TF Fit-Up Checks

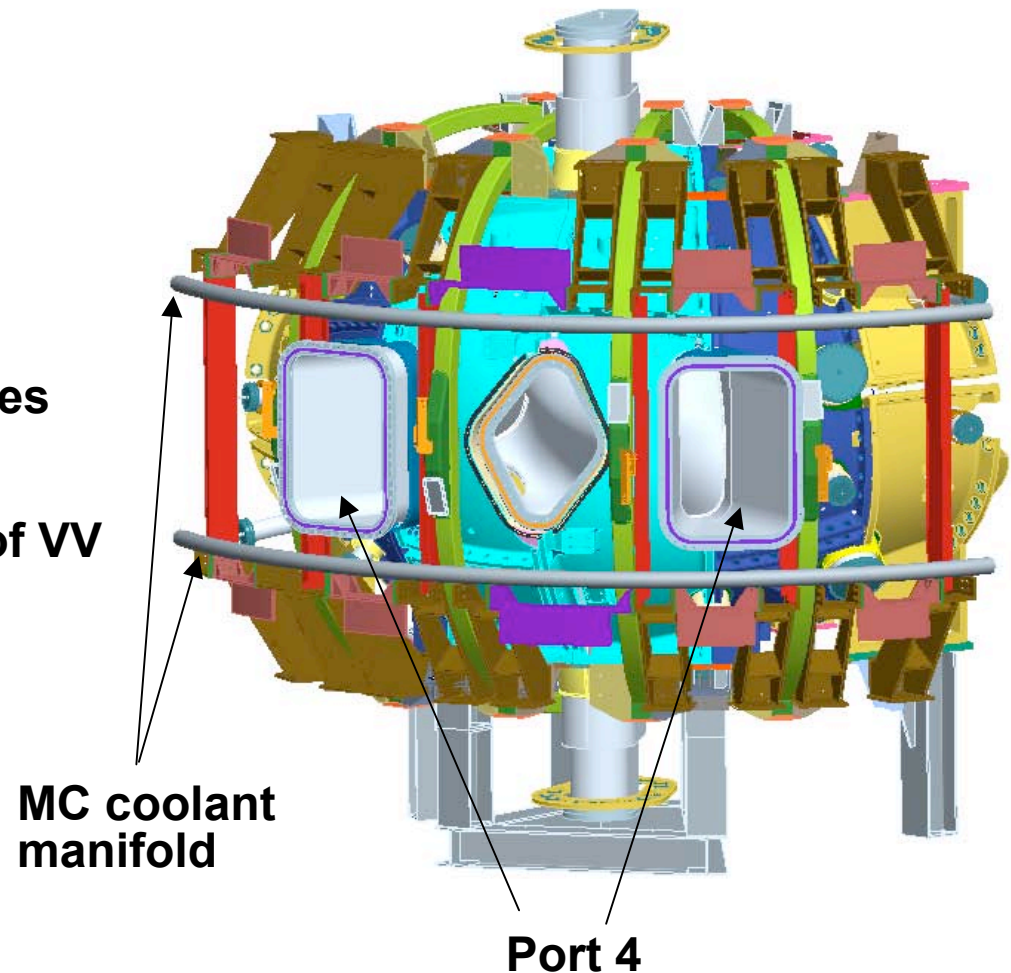


**Install TF support brackets on the sides of the coils, both on the top of the MC and on the bottom.**

# Station 5 Assembly Sequence

## Final Assembly Steps/Major Activities

- Tack Weld Ports 4's
- Install PF Structural Members
- Route MC leads and coolant lines
- Install MC Coolant Manifold
- Install Rogowski Coils on end of VV



# Station 5 Assembly Sequence

## Final Assembly Steps/Major Activities

- **Final Measurements**
  - Obtain set of Period 1 alignment fiducials for locating VV within the MC
  - Using monuments on VV for alignment, perform trial VV alignment, adjusting VV supports as necessary.
  - Make final measurement of all fiducials, VV end flanges, & Type C end flanges

**REPEAT FOR PERIODS 2 & 3**

## Potential Issues and Mitigation Plans

- **Final measurements not within tolerances**
  - Project assess steps necessary if unable to accept out-of-tolerance conditions

# Summary



- Station 1 vacuum vessel segments are nearly complete.
- Station 2 modular coil assembly trials are well underway, most risks are retired, and assembly steps are well defined.
- Station 3 installing the modular coil half period assembly over the vacuum vessel and Station 5 final field period assembly sequence plans have been developed in detail and include the necessary metrology and trial elements.
- We have a credible plan to assemble the field periods to the accuracy required.
- I have confidence in successfully performing the Field Period Assembly activities.