

# NCSX

## Construction Overview

NCSX Team

L. Dudek

April 8-10, 2008

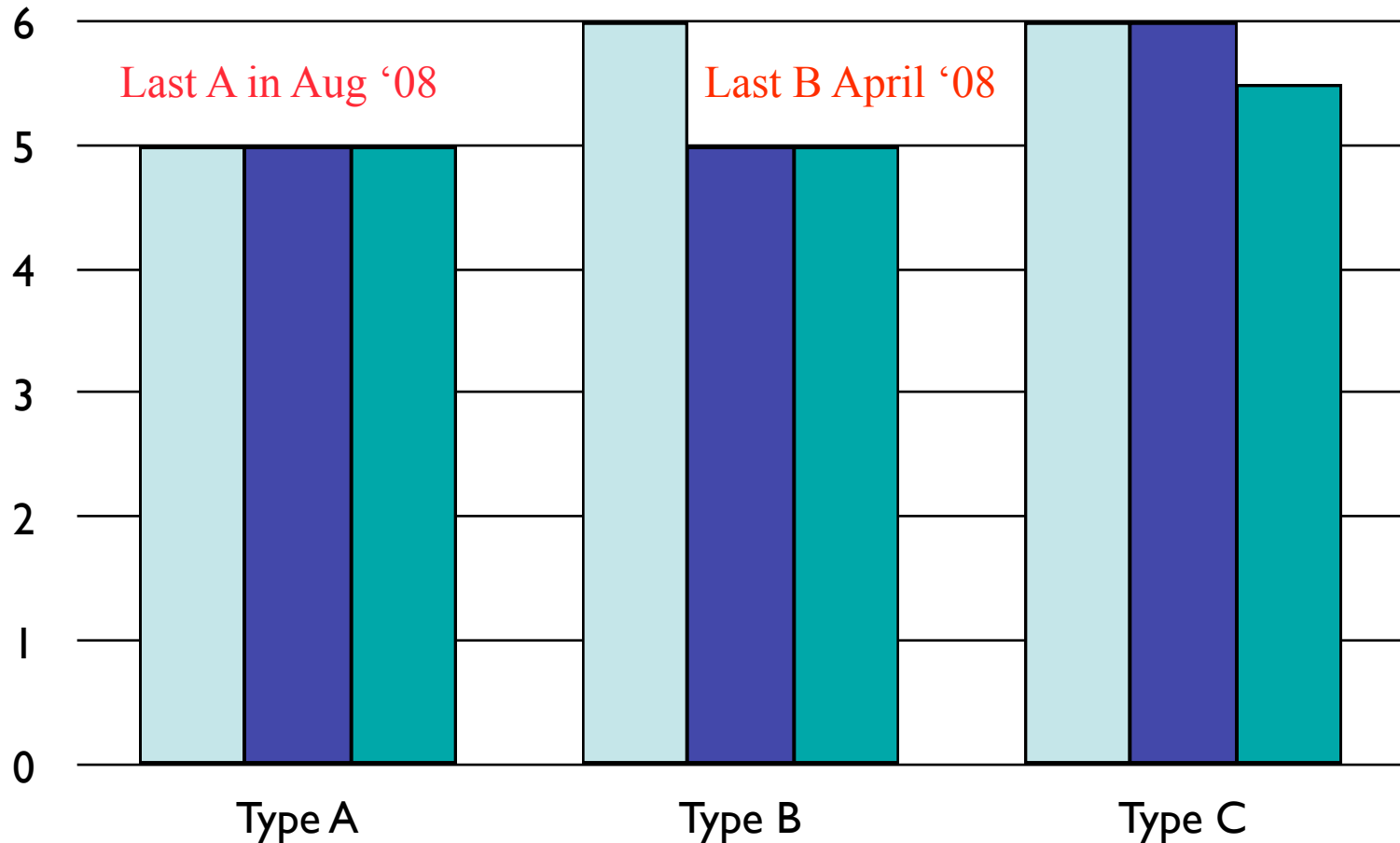
# Outline



- Modular Coil Assembly
- Procurements: TF & PF Coils
- Field Period Assy
- Machine Assembly
- Startup
- Staffing
- Risks
- Conclusion

# Modular Coil Assy Status

WBS 14 J. Chrzanowski



# Modular Coil Status & Achievements

- MC production line scheduled to be shut down in August.
  - Sta. 4 & Autoclave will be left in place.
  - Tooling for 1 coil in storage; remainder scrapped.
  - Area is gradually being turned over to Field Period Assembly
    - Sta. 2 now; Sta. 1 B in May; Sta. 3 end of June.
  - Technicians are also gradually being shifted to Assembly.



# Metrology usage during modular coil winding



## Dimensional casting characterization



- ~8000 measured points characterize winding surface

## Winding Measurement & Re-Sizing



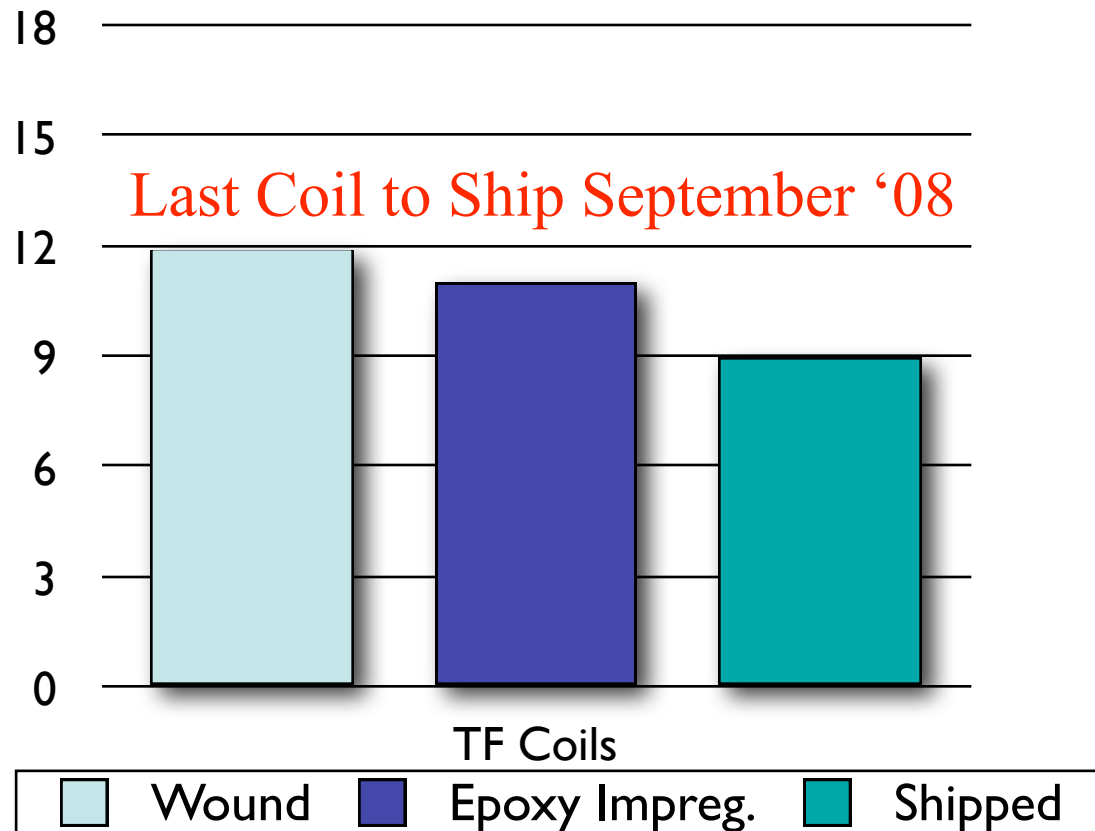
- Adjustable clamps allow tailoring of the cross section of the winding pack on either side of the septum.
- As-built winding form measurements are used to set clamp positions.
- Clamp positions define a cross section of the winding pack.
- Compliance of the insulation, prior to potting, allows for adjustments.

# Modular Coil Tolerance Compensation

- Knowing the as-built dimensions, we are compensating for resonant errors by realigning the coils during FP assembly.
  - In this way, the tolerance allocated to the modular coils is made available for assembly.

# TF Coil Fabrication Status

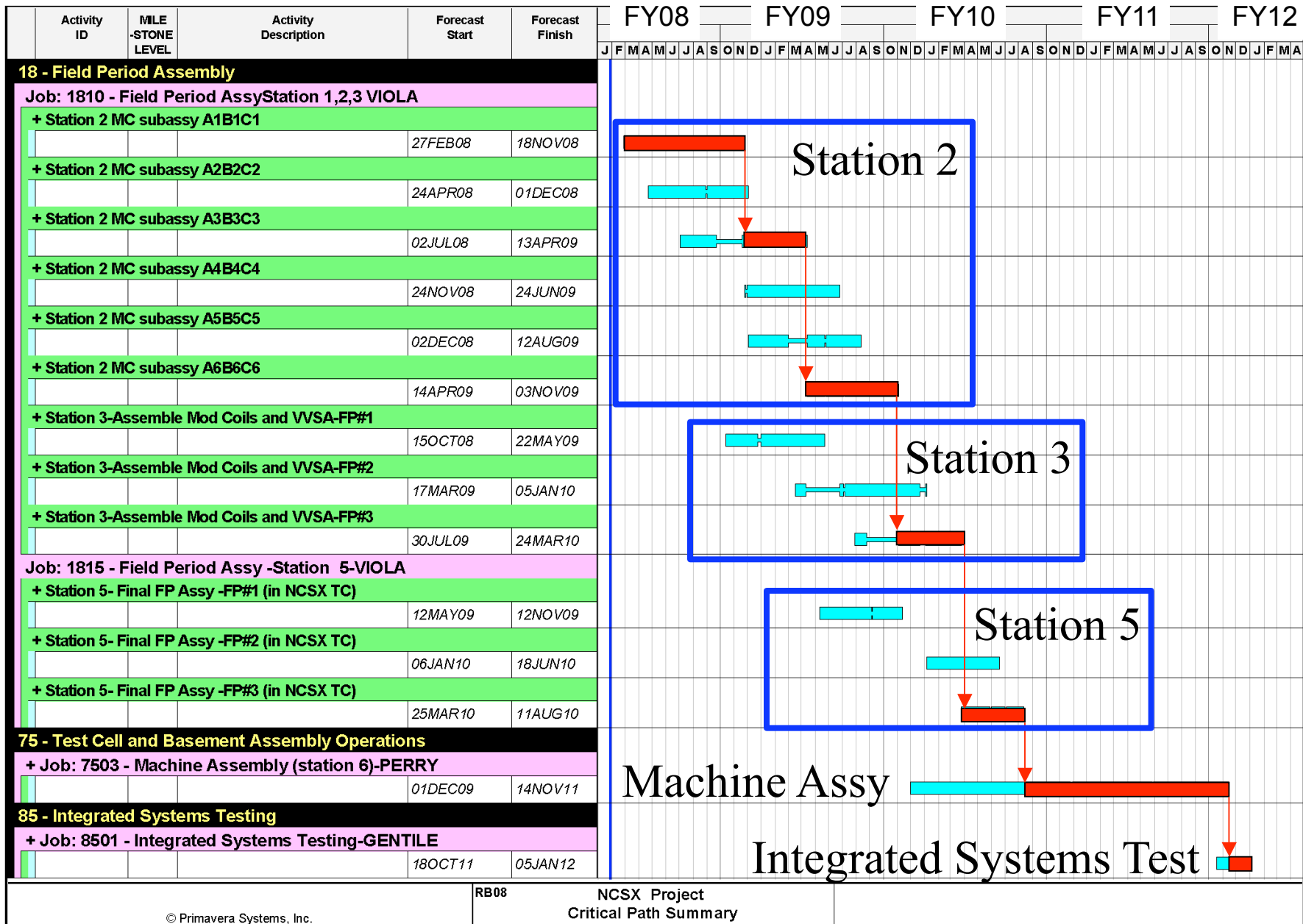
## WBS 13 M. Kalish



- All coils shipped to date have been of high quality and within tolerance

# PF Coil Procurement Plans

- Subcontract Procurement Evaluation Board is active.
  - Released Request For Proposal by 3/7.
    - Bidder's conference was held on 3/17
  - Award contract: 5/30 (DOE milestone Aug 08)
    - Options : Just PF 5&6's, just PF 4's, all together.
  - Delivery dates: PF 5&6 L Feb. 09
    - Balance 9/09.
- Requisition for conductor is placed
- Kapton and Fiberglass requisition has been placed





# Field Period Assembly

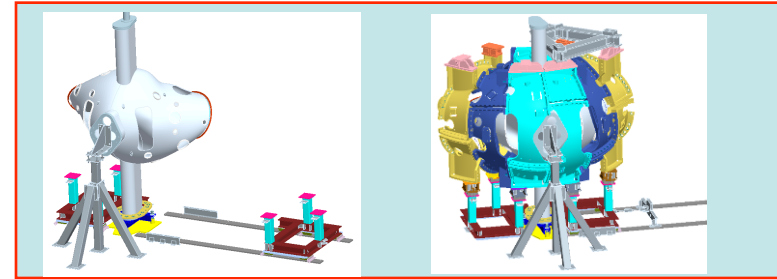
WBS 18 M. Viola



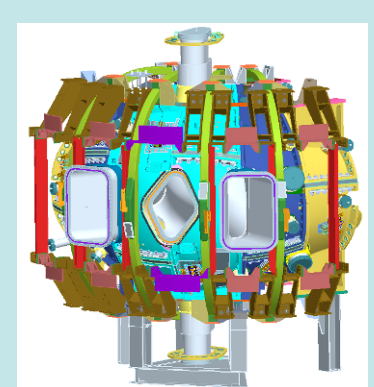
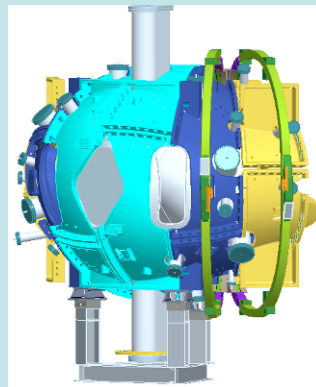
**Station 1 –  
Vacuum Vessel  
(VV) Prep**



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



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

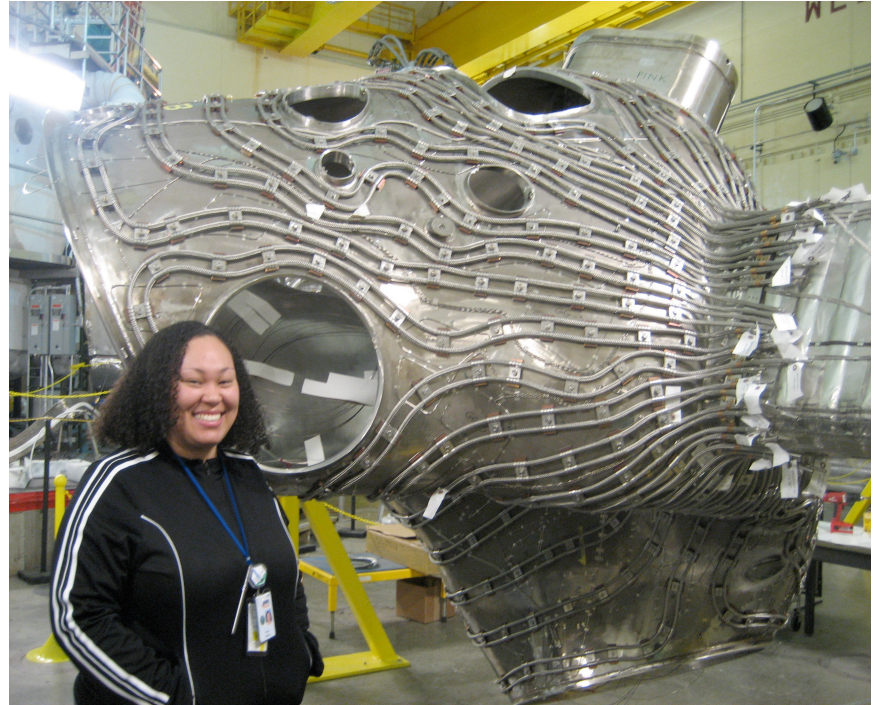


**Station 5 - Final Assembly**

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

# Station 1 Assembly Progress

- All 3 vessel segments were delivered by September, '06.
- All 3 VV Segments Ready for Assembly
- Diagnostic loops, heating & cooling lines, and thermocouples have been installed. (Stratton, Labik WBS 3)

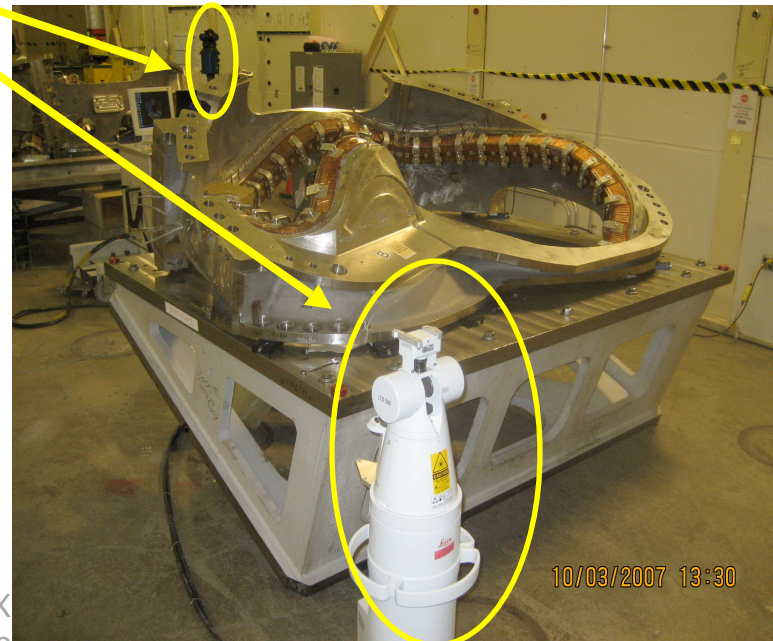




# Metrology Capabilities



- PPPL has recently added photogrammetry to its array of metrology tools:
  - Mechanical measuring arms are used for the coil manufacturing process.
    - PPPL has four.
  - Laser tracker systems are used for subsequent assembly operations.
    - PPPL has two.
    - A third is on order
  - Photogrammetry -Recent visits to CERN and W7X convinced us that photogrammetry is a very worthwhile addition to NCSX's metrology capabilities.
    - We have procured a GSI VSTARS /E4X.
    - Has the potential of speeding up metrology during assembly operations.

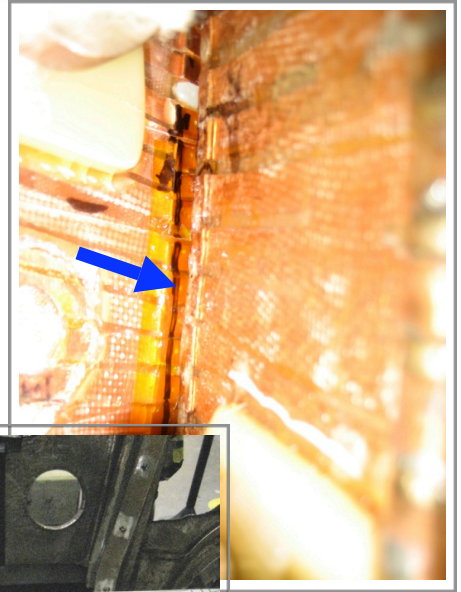




# Station 2 Trials

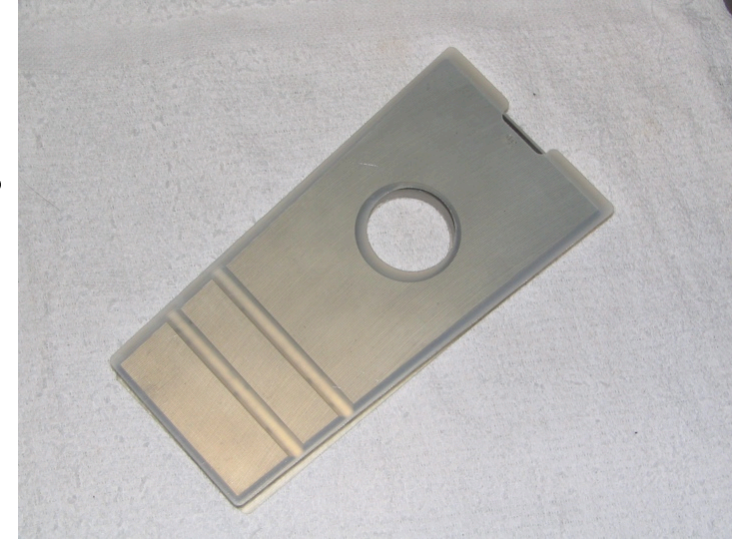


- Station 2 FPA trials were continued:
    - ✓ Gross fit individual mating coils
      - ✓ found and corrected some minor interferences
  - Joint design trials for Station 2 & 3:
    - ✓ Install and torque bolts – assess accessibility **SUCCESSFUL**
- 
- ✓ Develop shim technique **SUCCESSFUL**
  - ✓ Pillow shims **SUCCESSFUL**
  - ✓ New welded design for inboard interface (nose) **SUCCESSFUL**



# G-10 Insulator and Shim

- Permits insulator and cores to be fabricated in parallel
- Can use various insulator thicknesses to obtain the required size
- G-10 is much less expensive than alumina coating
- Insulators can be cut quickly on waterjet machining center
- Cores can be simplified by removing cut grooves (\$20/piece)
- Alumina version still required for last C-C joints for higher friction values



# Station 2 Assy Status



## A-B Modular Coil Assembly

- ✓ 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.
- ✓ Install shims
- ✓ Place B coil back on A coil and align
- Install bushings
- Weld A/B nose region solenoid side & re-measure.

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





# FPA Fixtures

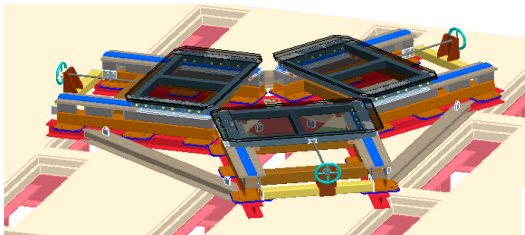
WBS 1803 Design T. Brown / 1805 Procurements  
L. Dudek

- The station 3 assembly fixture and the digitally controlled crane manipulator have been fabricated and have arrived at PPPL
- Second station 3 assembly fixture and a lifting fixture are in the procurement process
- Station 5 completed FDR, design work to finish Apr 08

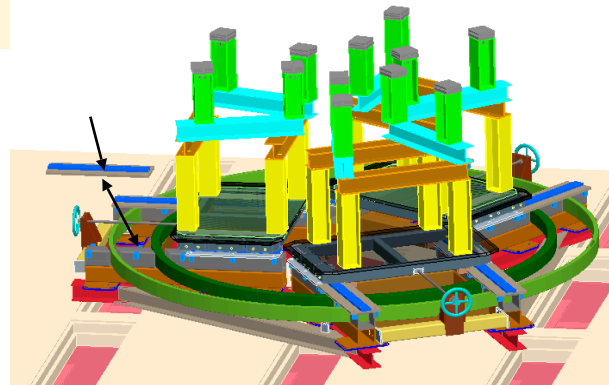
# Machine Assembly

## WBS 7 E. Perry

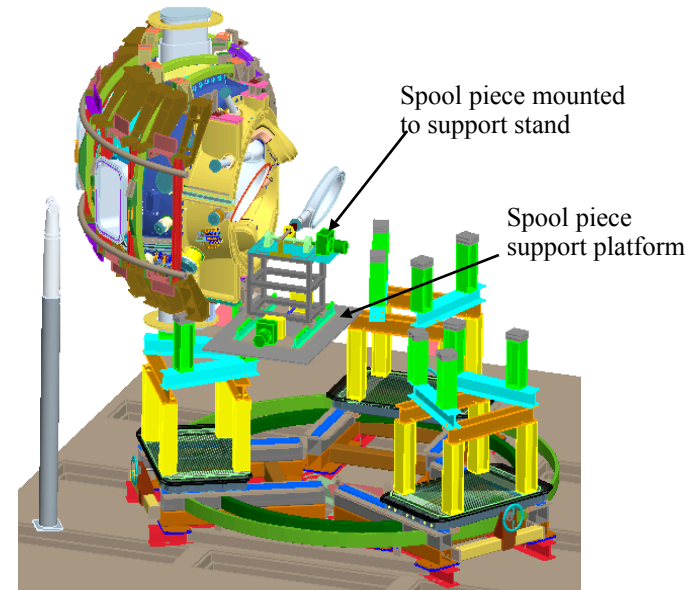
- Covers the final assy of the Field Period Assy's, Cryostat, test cell Utilities and AC Power
- This assembly plan provides much greater detail than was available at previous reviews



FPA assembly carts installed



Lower PF 5 and 6 positioned within the cart rail grooves.



Period 1 retracted with spool and support stand installed

# Integrated System Test / Startup



- Job 8501 Gentile
  - Integrated Systems Testing Procedures
  - Safety Assessment Document (SAD)
  - Startup costs
    - Engineering
    - Technician Labor
- Integrated System Testing to begin Nov 2011

# Staffing Plan

- Coil Winding crews are being transferred to FPA as the last few coils are completed
- New Engineer- M. Smith supporting FPA fixtures design
- Metrology
  - Open Metrology Engineer requisition for 2nd shift operations
  - Training coil winding techs in use of Laser Tracker / Photogrammetry

# Retiring Risks

Risk	Mitigation / Status
316LN Inboard Shim material not available to meet schedule (Job 1431)	Further analysis demonstrated 316L is acceptable
Welding the inboard shims could result in gaps opening up at the plasma-side end of the shims to an unacceptable degree. (Job 1810)	Welded shim design has changed to include a tightly fitted limiter and flex shim to react shear loads; these ensure against relative motion of flanges during operation and minimize cyclic loading of welds.
Station 2. As a result of the development trials for weld distortion, the welding time increases significantly above present allowance (Job 1810)	Welding time estimates consistent with time requirements for first R&D article which appeared to have very low distortion. Risk goes away at conclusion of ongoing weld development effort.
Station 2. Sizing shims will be challenging and will occur during tight schedule constraints. Any false starts will require immediate attention and resolution to solve problems quickly. (Job 1810)	Continue trial assembly with hardware to explore potential problems. Adopt G10 sandwich design.
Station 2. Interferences discovered during assembly; components don't go together as planned. Assemblies have to be taken apart, components moved or re-worked, re-assembled. (Job 1810)	Perform coil-to-coil fitup checks. Coils are being reworked to provide clearance
Station 6. TC floor is not adequately rigid for present metrology plan (Job 1810)	Copper sheet and spongy surface removed from TC floor. Fiducials will be placed. Concrete blocks will be placed to see if floor is adequately stiff. Assess adequacy of TC floor.



# Risks Going Forward

- Welding
  - Initial tests are good, but problems would have significant potential for cost and schedule growth
  - Still have some work to do on the vertical joint.
- Vacuum Vessel to MC Fitup
  - Original design clearances during assembly have shrunk due to as-built conditions
- *“The Details”*
  - Portions of the design have not yet been detailed
  - The shim is a good example of how a simple part can vary in cost by changing some simple features
    - Prototype alumina coating on shim quote \$20 (16 sq. in)
    - Current alumina coating on shim quotes \$40 - 400 (22 sq. in)

# Management Team Questions

- *Explain the approach to identifying and costing spares within the project budget.*
  - Spares for MC Interface and Field Period Assy hardware is 10-15 % (Heater tapes, Hoses, Shims, Studs, Nuts, etc)
  - Modular Coils: enough copper for two MC's was ordered so that a coil could be rewound if the VPI failed
  - PF and TF Coils Enough copper to wind one PF or TF coil was purchased
  - Trim Coils: one spare of each type of Trim Coil
  - Funds to cover the materials are included in the original cost estimates and WAF's
- *What key alternatives continue to be carried by the project? When do decisions have to be made on these alternatives? Are there specific milestones for these decision points? Is the decision-maker identified?*
  - Photogrammetry - will be discussed by M. Viola

# Conclusion

- One of the most challenging components to fabricate, the Modular Coils, are very near completion with only 2 of the 18 coils remaining to be potted
- The TF coils are more than 50% complete in fabrication and on schedule for early delivery
- The PF coils about to begin fabrication
- Field Period Assembly got off to a late start but early indications are that Station 2 assembly should progress relatively smoothly
- Risks are being retired as the assembly proceeds
- Future risks are being addressed with contingency plans that will ensure a successful project completion