

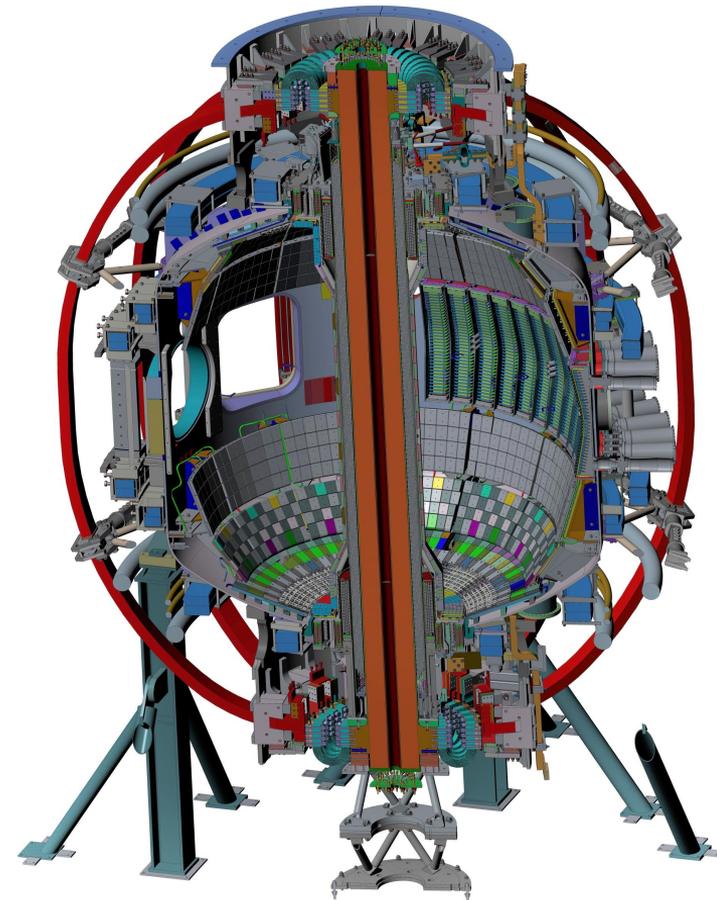
NSTX-U Project: May 2023 Performance + PF-5 Update

Dave Micheletti, Project Director

Covered in this briefing:

- Summary of project performance and highlights
- Progress on the new bundle
- Schedule and near term activities

- Procurement of Center Stack Casing (complete)
- Fabrication, procurement, and installation ahead of magnet delivery (ongoing)
 - Component fit-up, passive plates, transition plates, vessel blackening, SIS, instrumentation, etc.
- TF/OH bundle delivery (ongoing)
- Machine Reassembly (pre-fit activities started)
- Commissioning (not started)





- Project rebaseline and CDE-3C approved Dec 19, 2022
- Project is progressing well and is on track to deliver per the baseline

	ESAAB Basis	Through May
CDE-4 Date	December 2026	December 2026
Schedule Contingency	19 months	17 months
Project % Complete	69%	77%

- Performance through May 2023:

	May	Total
CPI	0.98	1.01
SPI	0.88	0.98



- Safety: Worker injured knee while entering the vacuum vessel; safety assessment performed of vessel entrance area and interviews were conducted with coworkers. A satisfactory staircase, platform, and landing were confirmed with no improvements identified. The employee was initially returned to work with restrictions, but has since been released to full duty.

- TF/OH bundle is moving ahead

Elytt - Bundle Fabricator

- Completed VPI of the four quadrant mockup
- Completed preparation for the first VPI of the OH mockup - sealed and leak checked the mold for TF ground wall surrogate that is the winding base of the OH coil mockup
- Entered the final assembly of the quadrant mockup in the mold

Visioneering - Conductor Machining

- Selected heat treatment vendor to stress relieve the TF conductors
- Provided samples to heat treat then machine to determine effectiveness of heat treatment

Edison Welding - Friction Stir Welding

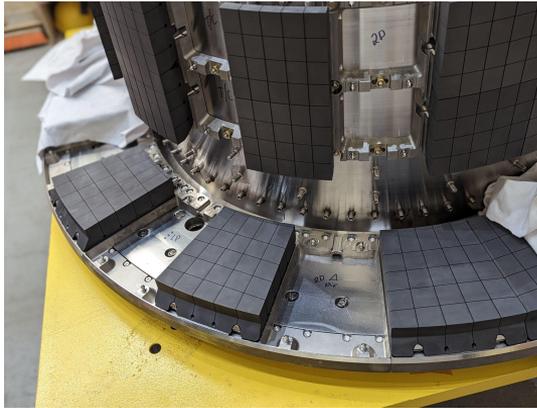
- Completed weld qualification documentation for the normal weld and two repair weld processes
- Welded upper and lower flags on first of two test conductors.



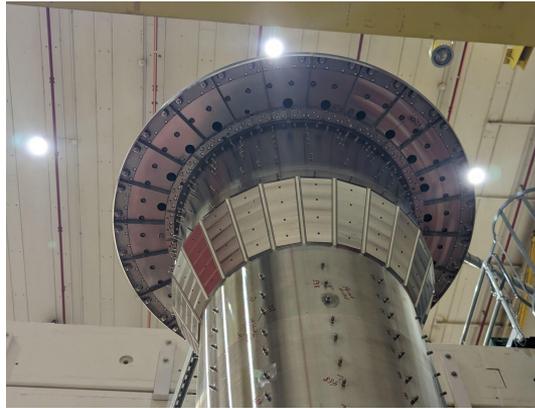
- Completed a round of tile fit-up on the casing
 - Identified some modest interferences on the frames
 - Metrology checks complete and showed good tile-to-tile alignment.
 - Three tiles fractured - assessing the potential causes (excessive preload, etc)
 - Started rounding off some sharp edges on welded brackets inside the casing
- Divertor tile rework is moving forward
 - Completed refinement of the as-built legacy divertor structure metrology data;
 - Used those tools for design refinement, including potential hardware interferences
 - Issued RFPs for spare graphite and for transition plate manufacturing; bid received for graphite machining
- In-vessel work is progressing ahead of TF/OH bundle arrival
 - Completed final fit-ups on the secondary passive plates; this completed in-vessel work on the passive plate control account
 - Initiated the (off-project) reinstallation of the HHFW antenna



- Other items are progressing well
 - Drilled 18 of 36 holes in the upper flange
 - Pressure tested (360 psi) $\sim\frac{3}{4}$ of the test cell He manifolds; deferred final test to June
 - Finalized contract for flange seal repair
- Continued troubleshooting of PF-5 per plan; series of tests have led us to focus on removal of coil surface contamination
- Conducted Neutral Beam Internal Readiness Review
 - Review focussed on the readiness for off-Project stand alone operation of the neutral beam system.
 - Review proper is an on-Project activity
 - Team agreed with the PPPL assessment that we are not presently ready, but was positive regarding completed work and plans for work-to-go.
 - Made specific pre-start recommendations on a number of topics, on topics such as i) the USI process, ii) crediting of Oxygen Deficiency Hazard alarms, etc



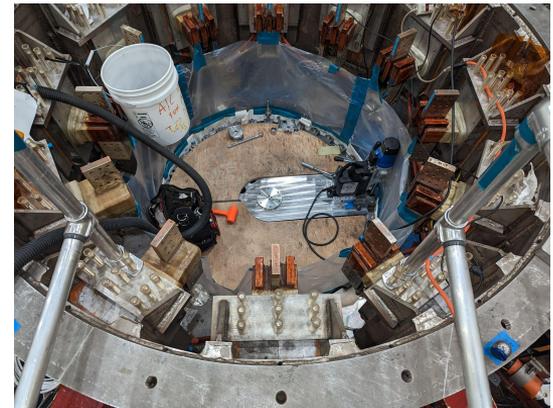
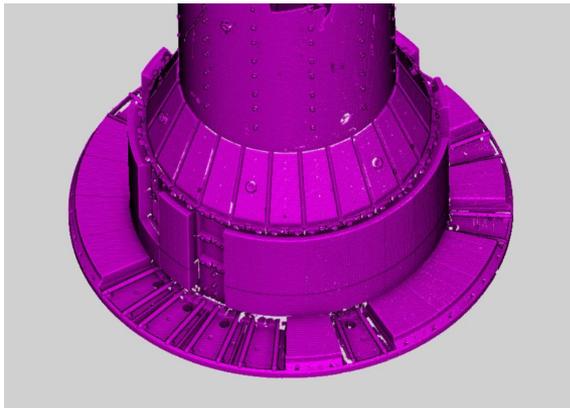
Tile fitups on the casing - including metrology



Frame fitups on the casing - and on the bench



Breaking edges on HTT clamps



Drilling upper flange



Wound glass layer



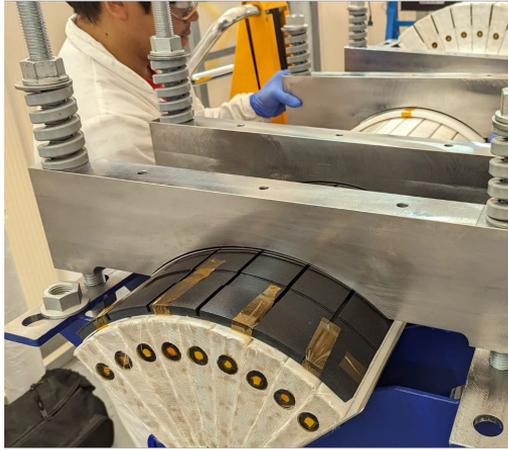
Building mold



Lifting mold



Preparing for curing

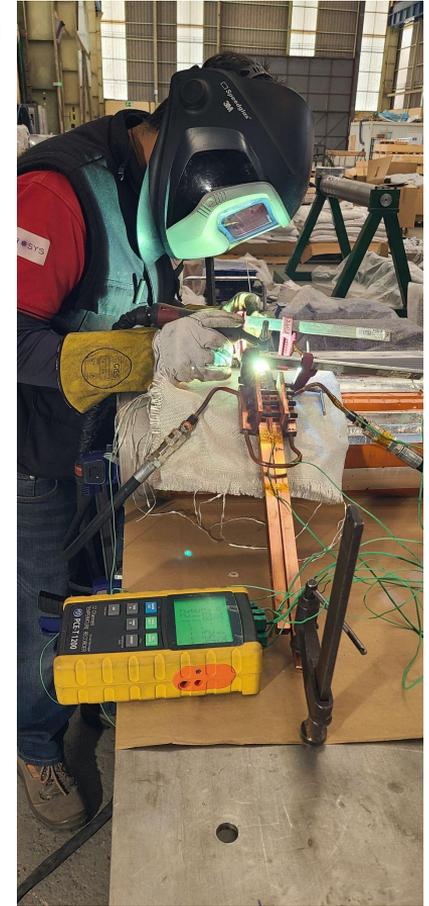
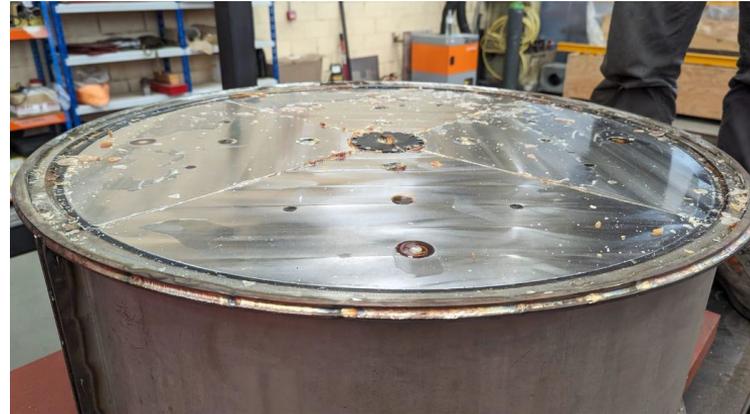


Building resin paths onto quadrant prototype



OH brazing qualification

Four quadrant prototype coming out of its mold



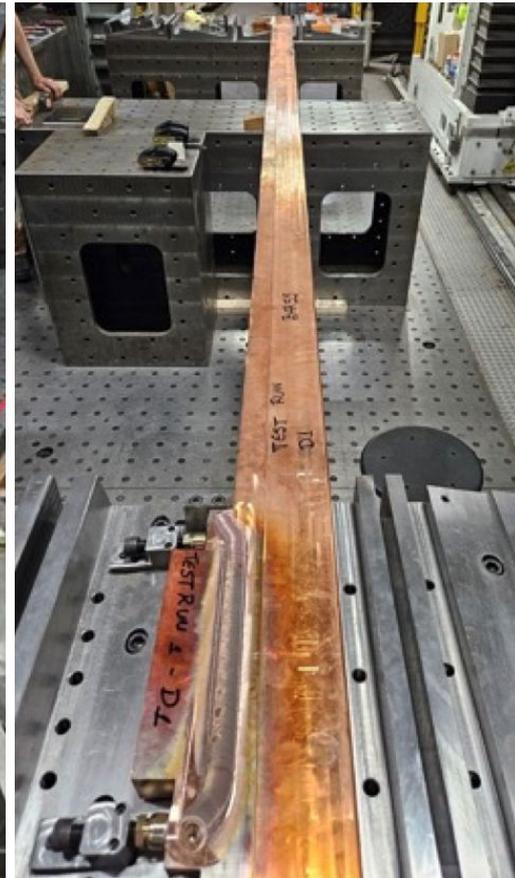
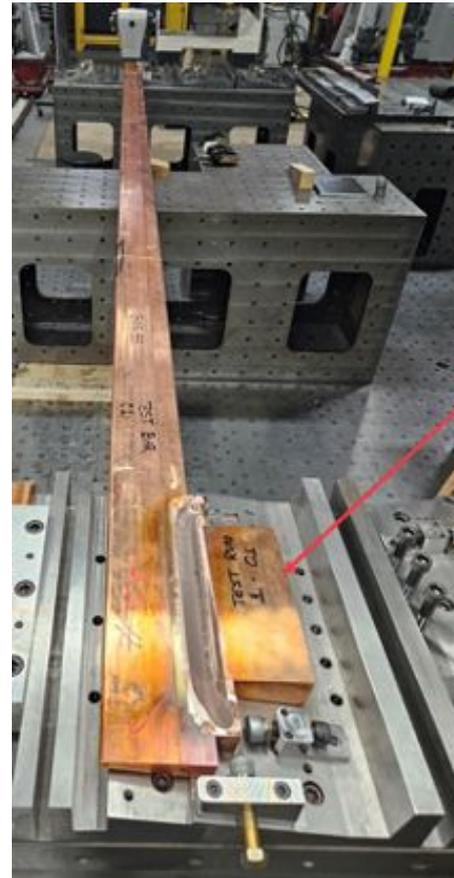
Conductor preparation (Visioneering and EWI)



Pre-weld machining prototype @ Visioneering



Project Manager @ EWI



Welding full length bars at EWI

TF/OH bundle components status - May 2023



Scope	Vendor	Contract in Place	Fabrication Start	Fabrication Finish	Comments
TF & OH Extrusions	Luvata (Finland)				Base scope complete
Gun Drilling	Dearborn (ME, USA)			Second bundle	Sixth lot of 12 units complete, 7th nearing completion; sufficient for two bundles
Pre-Weld Machining	Visioneering (MI, USA)				Trial runs in progress; heat treat parameters in review
CuCrZr Flag Material	CADI & IBC (CT & IN, USA)				Contract closed
Friction Stir Welding	EWI (OH, USA)				Completed two full length trial runs
Final Machining	Visioneering (MI, USA)				Setting up for trial runs
OH Conductor Grit Blast/Prime	TBD				Red book approved; award in progress



Risk Category (per Baseline)	Mitigations taken and updates for reporting period
<p><u>TF/OH bundle procurement:</u></p> <ul style="list-style-type: none"> • Global supply chain impacts • Multiple vendors on Critical Path • Specialized means of fabrication • Logistics including customs clearance 	<ul style="list-style-type: none"> • Red book approved for final vendor (<i>not on CP</i>) • Completed first full-bar trial welds at EWI • Completed four-quadrant VPI, good progress on the other two VPIs.
<p><u>Reassembly scope:</u></p> <ul style="list-style-type: none"> • Potential fit-up issues among key components • Simultaneous work tasks at / in vessel • Tight tolerances for assemblies with multiple components 	<ul style="list-style-type: none"> • Completed remediation of secondary passive plates following trial fits • Completed ½ of the upper flange drilling • Initiated tile fitups on the CS Casing; identified issues to be resolved
<p><u>Readiness for Operations:</u></p> <ul style="list-style-type: none"> • First ASO implementation at a fusion facility • Reliance on legacy hardware systems • Operations team needs to be reconstituted 	<ul style="list-style-type: none"> • Completed NB IRR; much useful feedback to prepare for the ARR/IRR cycle which authorizes Project commissioning activities

130 open risks in the register in May, down from 134 in April



June

- Finalize pre-machining stress relief parameters
- Initiate TF quadrant mock-up VPI
- Complete TF ground wrap mockup (as part of OH VPI)
- Begin B-stage mock-up assembly
- Review path forward for PFC fit-up resolution
- Mobilize field seal repair contractor; commence work
- Complete vacuum vessel upper flange drilling

July

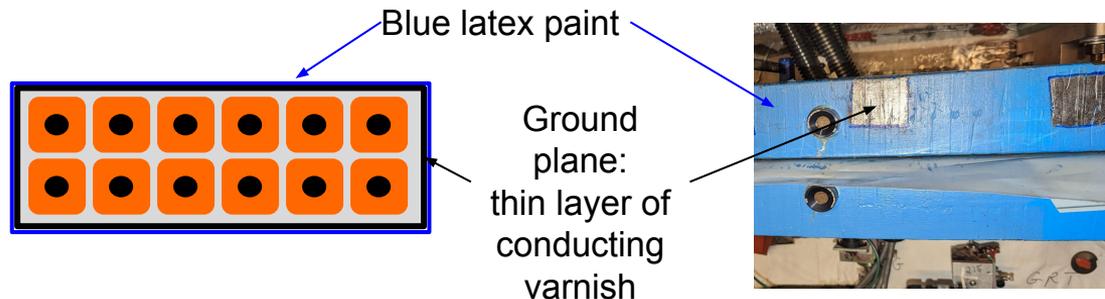
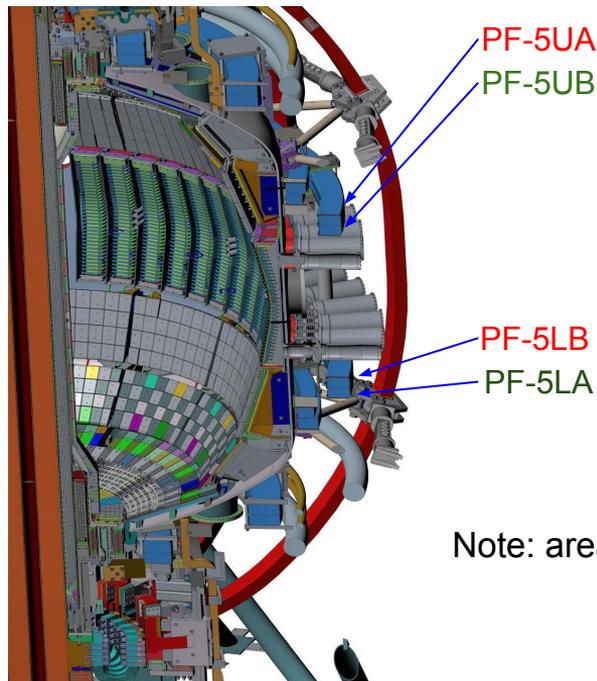
- Complete TF gun drilling
- Complete TF quadrant mock-up VPI
- Begin preparation for OH mockup winding
- Begin TF production conductor stress relief, pre-weld machining and friction stir welding
- Begin tile installation on Center Stack Casing
- Complete Bundle imbalance prototype testing
- Award OH conductor grit blasting and priming contract

August

- Begin vessel blackening stud installation
- Begin shipments of completed TF conductor assemblies to Elytt
- Conduct FDR for bundle imbalance
- Conduct FDR for OBDR1/2 & IBDH tile interface resolution
- Begin preparation for PF-1c fitups on NSTX-U
- Complete field seal repair welding

In April 2023 during planned testing, -5UA and -5LB showed ~ 10 s of M Ω s between the Cu of the coil and the ground plane.

Ground plane is a conducting varnish; not required for our voltages and duty cycles.



Note: areas near exposed Cu are sealed with red glyptal paint

While potentially acceptable, this was a substantial deviation from legacy values $> 1 \text{ G}\Omega$

A period of trouble shooting has followed

- Leak checked and pressure tested the cooling channels on both coils
 - both passed; believe the cooling channels are sound.
- Inspected around/under the coil support clamps
 - No damage or evidence of an issue found
- Periodic electrical testing on the noted PF-5 pancakes
- Electrical testing of the balance of the installed coils
 - All tested successfully
- Developed a low-voltage electrical test method which provides a rough indication of the leakage location
 - Localization testing provides indication that the leakage is in the vicinity of the current leads

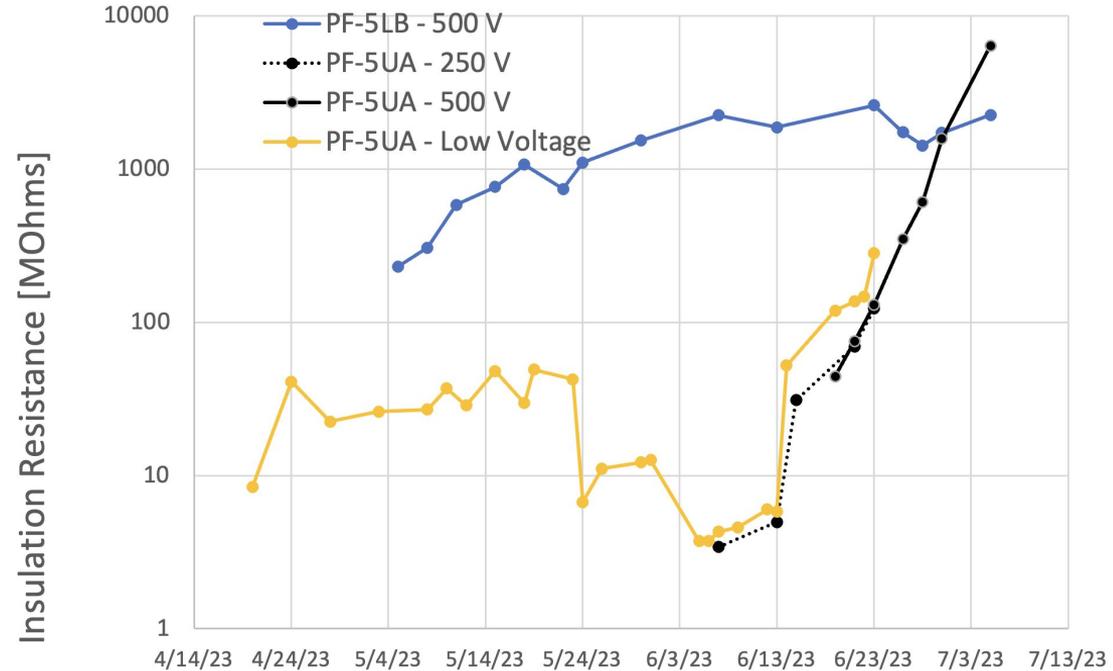


- Localization testing suggested that the issue may be in the vicinity of leads
- Removed glyptal in the vicinity of exposed Cu fittings
- Removed paint and ground plane in the area of interest
 - Frequent insulation measurement provided feedback on whether actions were providing beneficial results





- Utilized “voltage divider” method (AKA Sabilia method) to identify most likely area for low resistance on PF5-UA
- Removed external coatings and ground plane at selected area - 3 OoM improvement achieved
- Finalizing procedures to reseal the magnet and prepare for operations





Questions and discussion