U.S. DEPARTMENT OF ENERGY | Office of Science

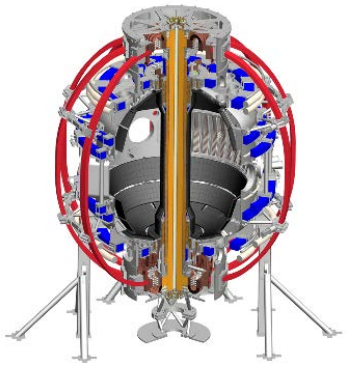
NSTX-U

NSTX-U Team Meeting

J. Menard, R. Hawryluk, M. Ono, S. Gerhardt, S. Kaye

MBG Auditorium
December 2, 2016

PPPL



Agenda

- Masa (for Jerry) - Safety update
- Rich, Jon, and Masa - NSTX-U organizational changes, new roles for Masa
- Rich - Overview of Recovery Project
- Stefan - Outage status, PF1AU forensics
- Jon - Program status, collaborations, 5YP prep

Safely, Safely, Safely

- Safety message from Jerry Levine – It is timely for everyone to review his or her areas for housekeeping issues and clutter that have arisen, and to take the time to clean them up. Having lots of clutter around is not only unsightly, but can cause safety problems such as trip, slip and fall hazards and possibly fire hazards, to name a few consequences. Also, when our housekeeping improves, we work more efficiently. So please take the time to clean your workspaces regularly.

- You can find the lessons learned link on the PPPL Employee Home Page, 2nd bullet under "Environment, Safety & Health (ES&H)". The direct link is https://fmp-srv.pppl.gov/fmi/webd#LessonsLearned .

- Winter weather is here!

- Ware proper protective clothing / equipment for outdoor work, and keep warm!
- Slippery road and walk-way conditions – Wear rubber sole shoes and be mindful of surfaces conditions – slips and falls are most frequent cause of injuries!
- Proper exercise – to relax muscles and warm up to reduce the chance of injury

NSTX-U Organizational Changes

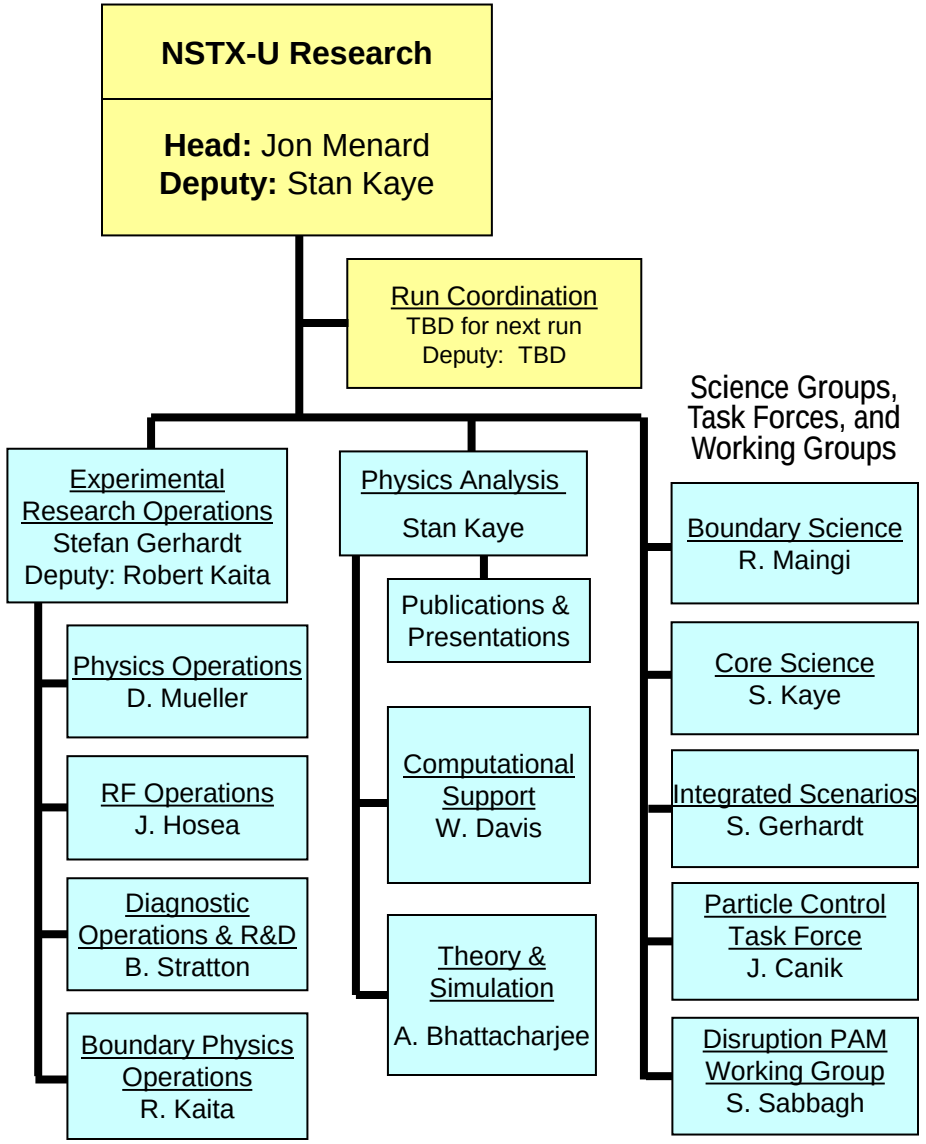
NSTX-U Recovery Project

To be described by Rich Hawryluk

Motivations for Org changes

- Recovery Project has grown sufficiently far-reaching in scope and institutionally important to require its own department
- Organization should reflect department responsibility and functionality, and have single line of authority in dept.
- Organization needs to be changeable to be responsive to present needs, and is also subject to change in the future

Research and Recovery will work closely to incorporate research priorities into NSTX-U recovery



Roles and Goals for Masa Ono

- Assist Research and Recovery efforts as requested
- Aid long-term planning for facility and diagnostics
  - Begin prep of diagnostic and actuator plan for next Five Year Plan
  - Work with team by holding brainstorming meeting(s) spring of 2017
  - Continue exploring 1-2MW gyrotron, associated JA collaborations
- Assist in outgoing collaboration management during Outage
- Aid in improving NSTX-U facility as a collaboration / user facility
- Advance international collaboration on Asian STs
  - Participate in CHI experiment on QUEST
  - Develop opportunities for ECH / EBW and hot wall collaboration experiments on QUEST
  - Explore collaboration on other STs in Japan, Korea, also JT60-SA
- Integrate lithium divertor and lithium loop concept research into PPPL liquid metal strategy and plan(s)
  - Aid assessment of options / impacts for NSTX-U LM divertor

NSTX-U weekly highlights note

Starting this week (i.e. today!), please send:

- NSTX-U Research highlights to Jon
- Recovery Project highlights to Rich

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NSTX-U Team Meeting

R. J. Hawryluk

Dec. 2, 2016

This presentation describes plans and approaches that are under development and should be considered preliminary.

What are My Aspirations?

- NSTX-U be the facility that scientists from around the world will want to work on.
  - ***Safe,*** *reliable and predictable operation*
- NSTX-U be renown for world-class research
  - *Strive to define the standard in research*

Notable Outcomes Issued Sept 20, 2016

- *EXTENT OF CONDITION*
  - *FES: Complete an extensive extent-of-condition review of NSTX-U to identify all design, construction, and operational issues. Prepare corrective action plan (CAP) to include cost, schedule, scope, and technical specifications of actions. Complete the CAP review and report to DOE by March 31, 2017.*

- *EXTENT OF CAUSE*
  - *SC/PSO: Conduct a review of policies and procedures for design, construction, installation, commissioning and operations of NSTX-U and other construction activities and projects. Develop corrective actions to ensure the highest quality project management across the lab.*

Strategy - Extent of Condition Process

- Strategy
  - Structured process to identify issues with NSTX-U
    - Update and generate Systems Design Descriptions
    - Collect data describing the design and existing components
    - Identify all issues with the components
  - Perform "Design Validation & Verification Reviews" to identify other potential issues
  - Develop Corrective Action Plan (CAP)
    - Risk based approach
  - Convene External Extent of Condition Review
  - Revise Corrective Action Plan in response to review findings and deliver to DOE
- **Imperative that we get moving on this immediately.**
  - **Training will occur next week.**

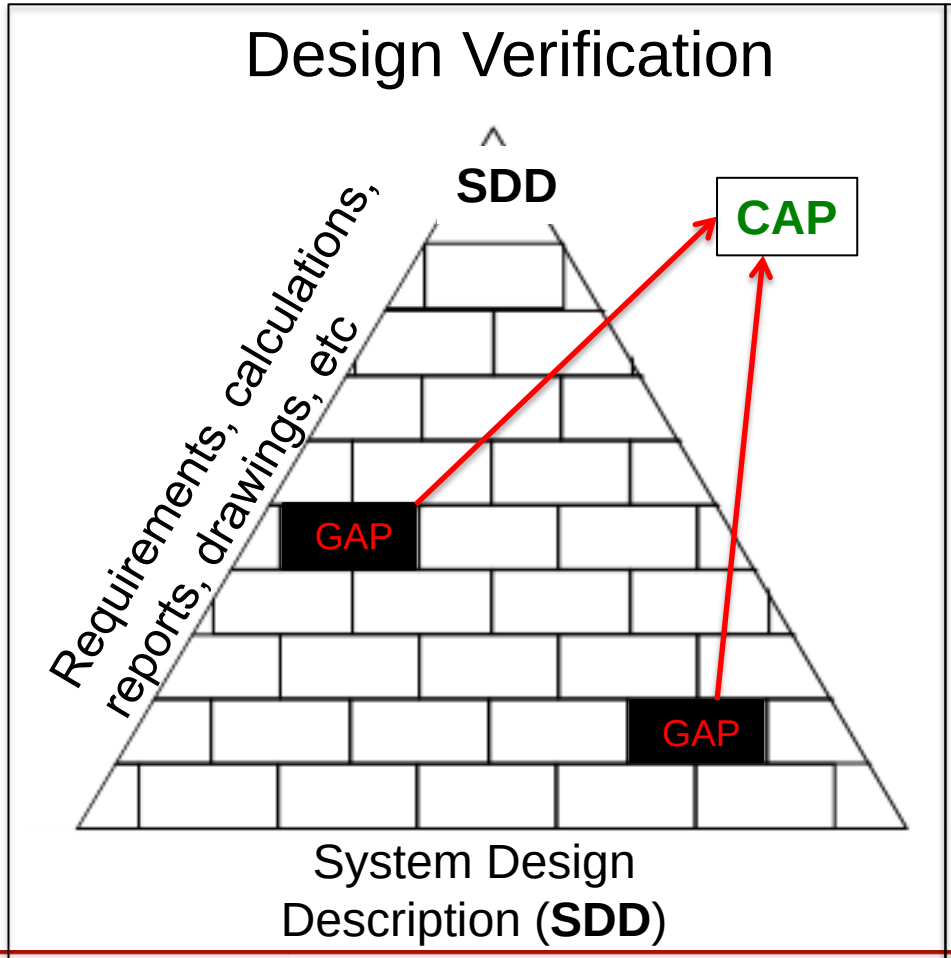
- We need everyone's input to ensure safe and predictable operation!

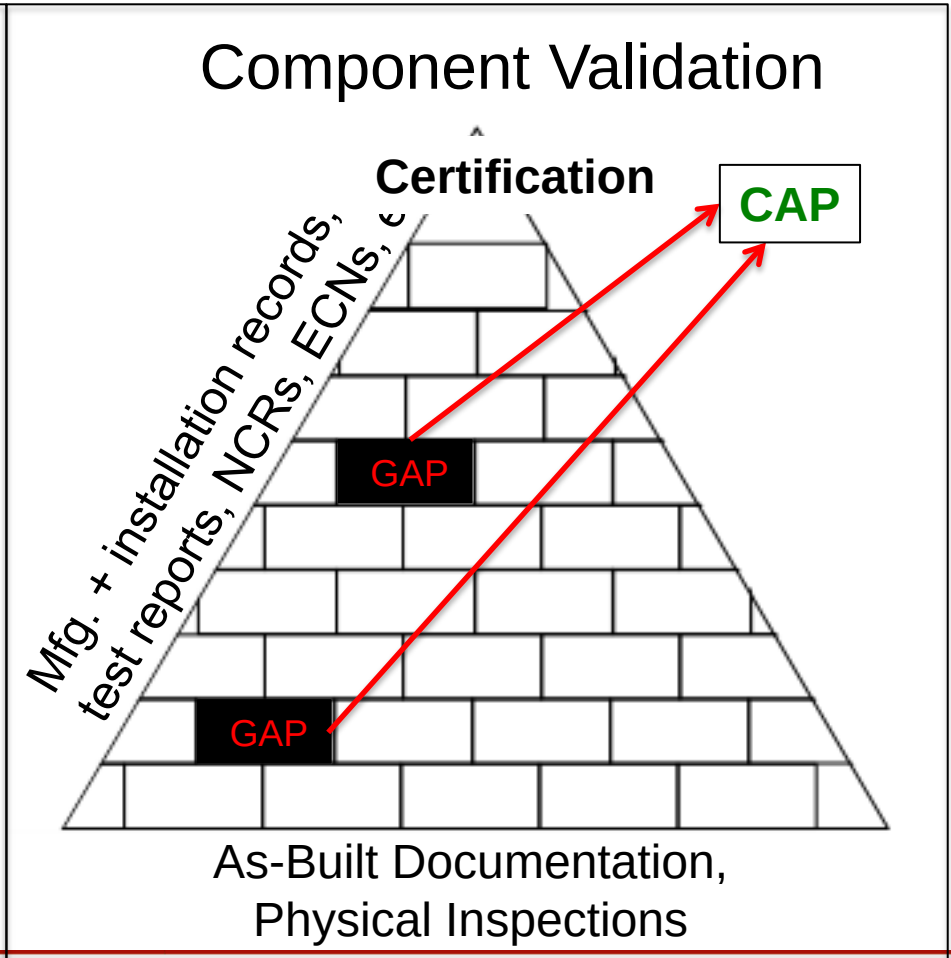
Design Verification & Validation Review (DVVR)

- DVVR looks for potential gaps in design basis or as-built configuration
- Corrective Action Plan (CAP) determines path forward

Does the design satisfy project requirements?

Is the component fit for function?





Component Classification Strategy

Category 1	Category 2	Category 3	Category 4
Design OK: **Y** Function OK: **Y** Remaining life: **Y** *No further action required*	Design OK: **Y** Function OK: **Y** Remaining life: **N** *Deferred maintenance plan*	Design OK: **U** Function OK: **U** Remaining life: **U** *Testing or analysis plan required*	Design OK: **N** Function OK: **N** Remaining life: **N** *Replacement plan required*

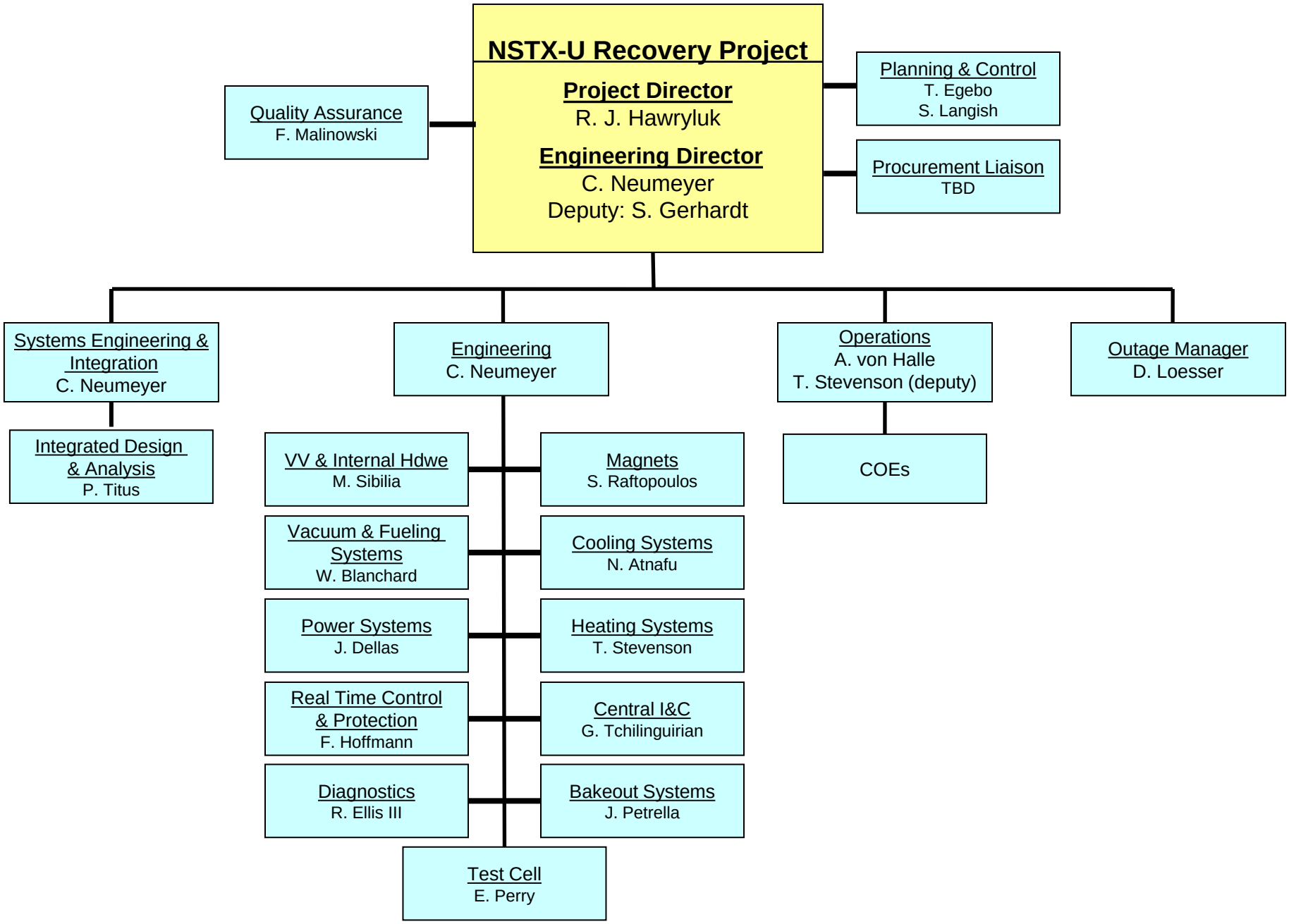
Risk-based decisions required

Need to Define Scope of Recovery Project

- Without a well defined scope, we cannot organize this as a project.
  - Scope
  - Cost
  - Schedule
- This is a critical and urgent first step
  - Needed to establish a baseline
- Responsible Engineers will take the lead on this but we will be involving many many people in this effort.

Strategy - Extent of Cause (L. Hill)

- Objective: Review and develop plan to revise/realign programmatic infrastructure as needed to deliver PPPL project outcomes that consistently meet high standards of performance
- Program review is project management-centric but will necessarily extend to supporting policies, programs, procedures and work practices in areas such as engineering design, configuration management, conduct of operations, etc.
- Phase approach adopted to support NSTX-U recovery, restart
  - Phase I: Critical review of NSTX-U issues and identification/implementation of near-term actions to preclude recurrence of equipment deficiencies on time line needed to support NSTX-U recovery schedule
  - Phase II: Balance of program reviews and development of corrective action plan by end of FY17


NSTX-U Recovery Project
Project Director
R. J. Hawryluk
Engineering Director
C. Neumeyer
Deputy: S. Gerhardt
Quality Assurance
F. Malinowski
Planning & Control
T. Egebo
S. Langish
Procurement Liaison
TBD
Systems Engineering & Integration
C. Neumeyer
Integrated Design & Analysis
P. Titus
Engineering
C. Neumeyer
VV & Internal Hdwe
M. Sibilia
Magnets
S. Raftopoulos
Vacuum & Fueling Systems
W. Blanchard
Cooling Systems
N. Atnafu
Power Systems
J. Dellas
Heating Systems
T. Stevenson
Real Time Control & Protection
F. Hoffmann
Central I&C
G. Tchilinguirian
Diagnostics
R. Ellis III
Bakeout Systems
J. Petrella
Test Cell
E. Perry
Operations
A. von Halle
T. Stevenson (deputy)
COEs
Outage Manager
D. Loesser

Safety

- Yes, there will be a great deal of work to do.

- Safety must and will take precedence over schedule pressure.
  - Cannot afford to take shortcuts that endanger anyone.

Thank you!

Any questions on Recovery Project?

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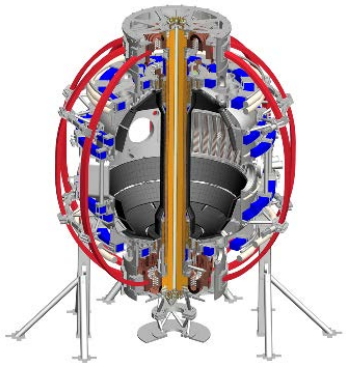
NSTX-U

NSTX-U Team Meeting
Some Research & Engineering Operations Updates

Stefan Gerhardt

NSTX-U Team Meeting
MBG Auditorium
12/2/2016

PPPL



Outline of This Talk

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PF-1aU Was Removed on 8/24/16

Diagnostic Calibrations Were Complete on the Advertised 3 Week Schedule

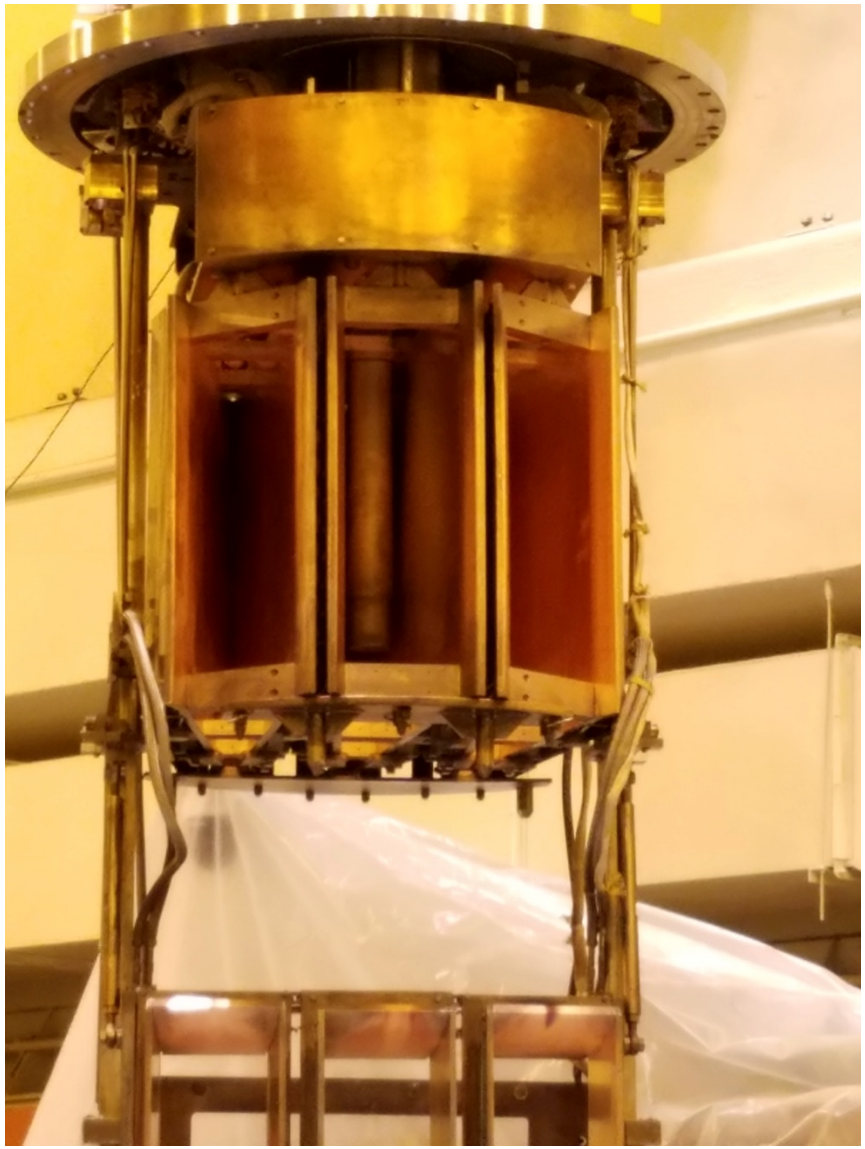
Week 1						
	9/19/2016	9/20/2016	9/21/2016	9/22/2016	9/23/2016	9/24/2016
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
6:00-8:00					ORNL Reflectometer (C. Lau)	
8:00-10:00	BES (D. Smith)	UTK Spectroscopy (K. Gan)	CHERS/pCHERS/ERD/RTV/v-FIDA Spatial Calibration (Bell, Podesta, Liu)	H-Top IR Camera (Grey)	Bay L T-FIDA Spatial Calibration (Liu, Podesta)	DTI whiteplate, ENDD whiteplate, Bay H bottom whiteplate , DTI metrology (Scotti, Maqueda)
10:00-12:00		CHERS/pCHERS/ERD/RTV/v-FIDA Spatial Calibration (Bell, Podesta, Liu)		CHERS/pCHERS/ERD/RTV/v-FIDA Spatial Calibration (Bell, Podesta, Liu)		
12:00-2:00					Bay E Top White Plate (Scottti)	
2:00-4:00				Bay F T-FIDA Spatial (Liu, Podesta)		
4:00-6:00						
6:00-8:00						
8:00-10:00						

Week 2						
	9/26/2016	9/27/2016	9/28/2016	9/29/2016	9/30/2016	10/1/2016
	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00-10:00	All Hands Meeting	absolute calibration (Labsphere) of Bay H bottom, DTI, and Bay E top, metrology of Bay J mid (both divertor viw and LGI view)	All Hands Meetings	WhitePlate photometric calibration for toiroidal CHERS, rtVPhi, ERD (Bell, Podesta)	T-FIDA Photometric Calibration	In-Vessel Metrology
10:00-12:00	I top whiteplate and labsphere (TWICE II), J top whiteplate and labshpere (TWICE I), H Bottom Labsphere (Scotti)		WhitePlate photometric calibration at Bays A-B for the vertical pCHERS/vFIDA/ERD systems. (Bell, Podesta, Liu)			
12:00-2:00					Shunt Tile Calibration	
2:00-4:00						
4:00-6:00						
6:00-8:00			Contingency	CHERS/ERD	Contingency	Contingency
8:00-10:00						

Week 3						
	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6:00-8:00				ORNL Reflectometer (C. Lau)		
8:00-10:00	SSNPA Spatial Calibration (Liu)	SSNPA Spatial Calibration (Liu)	ENDD+GPI	MAPP Metrology	Shunt Tile Inspection	Contingency
10:00-12:00				Filippo Tile Metrology		
12:00-2:00					Contiongency	
2:00-4:00				UTK Spectroscopy (K. Gan)		
4:00-6:00						
6:00-8:00						

Thanks to everybody who worked together to make this efficient.

Calorimeter Removals Followed on 10/12 & 10/13



Calorimeters Are Now Located in TTC For Repairs

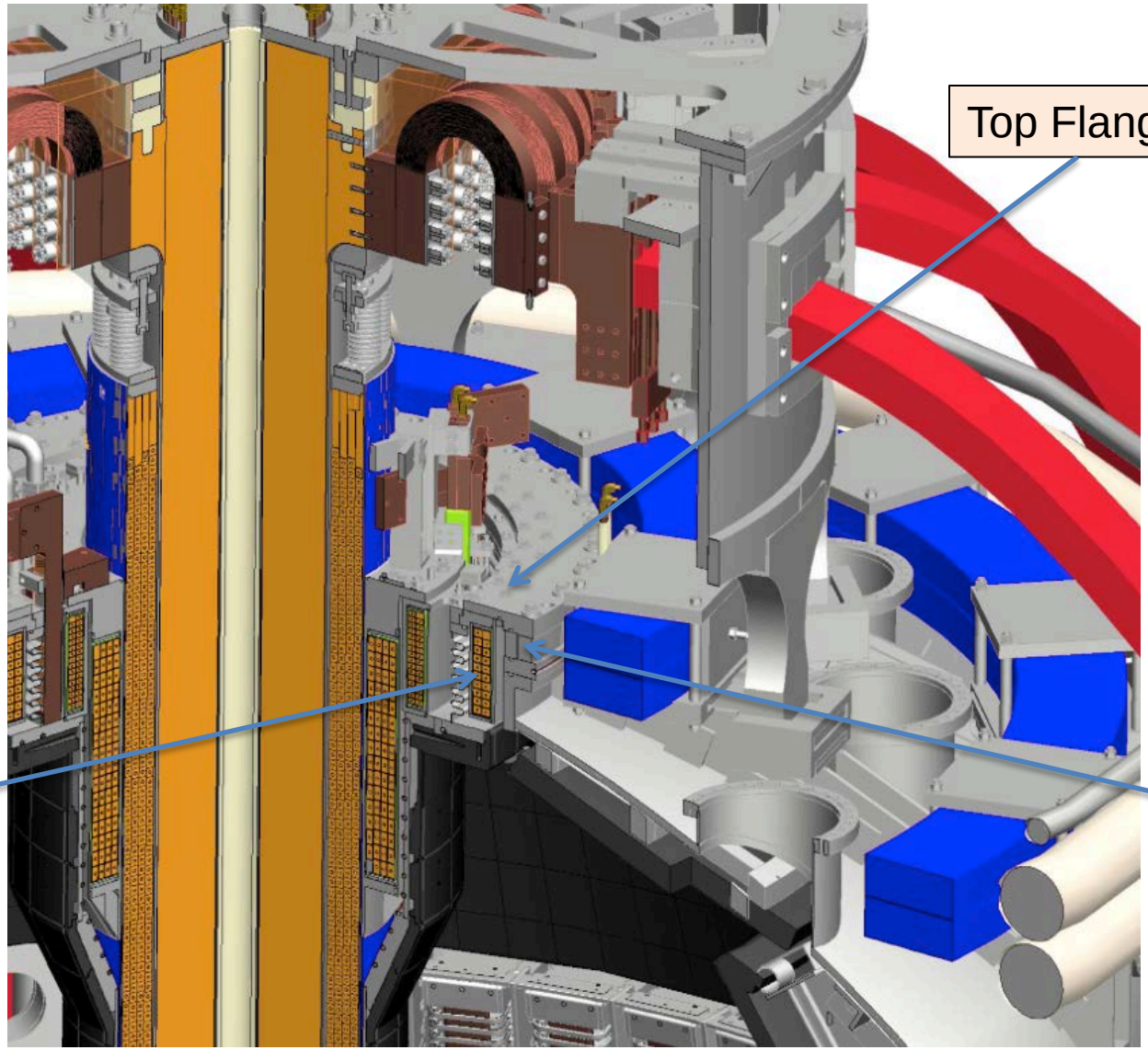
Calorimeter #1

Water leaks under repair

Calorimeter #2

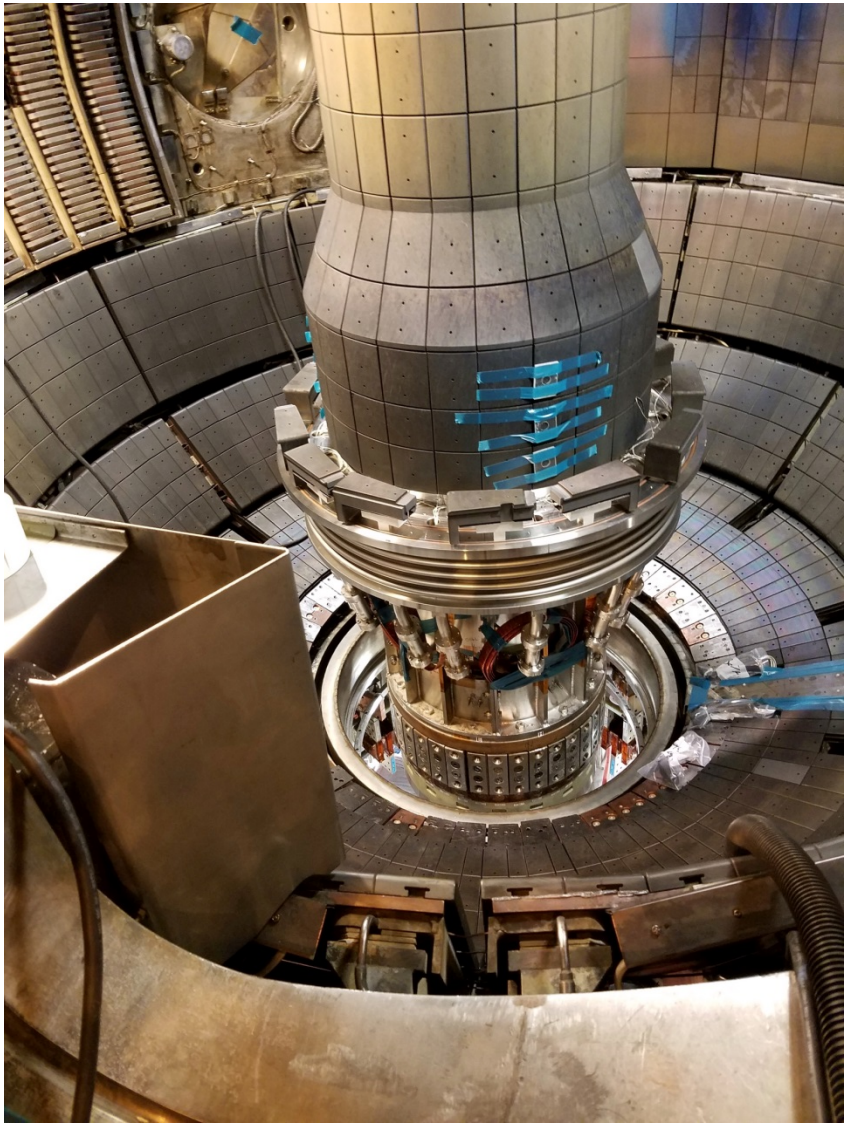
Bearings and alignment have been repaired

Ceramic Break Assembly Holds the Inner-Outer Vessel Insulator, the PF-1c Coil, and Various Connection Parts



Upper Ceramic Break was Removed on 11/14/16

CS Was Removed on 11/17



CS on Stand

This is what you will see if you go to the south high bay right now

- Inspections showed that one of the PF-1aL leads was bent
- Will be addressed as an extent-of-condition issue

Coil Shop is Preparing to to Wind PF-1a Coils Following their FDR

- Winding line set up in the C-Site Test Cell
- Winding line uses parts from the OH coil winding system.
- In process of making modifications to account for single conductor
  - OH was wound two in hand.
- Conductor has arrived at PPPL
  - we are now working on SoW/RFP on the grit blasting and priming

Considerable Progress Has Been Made in Preparation for Coil Fabrication

Setup for mixing the CTD-425 Epoxy/Cyanate Ester for VPI

Oven for curing following VPI

Clean room for preparing kapton/glass tape combination

PF-1a Mandrels are Nearly Finished

PF-1aU Mandrel in Final Machining at Vendor, Shipping in ~2 Weeks

PF-1aL Mandrel Ready for Final Machining at the PPPL Shop

Near Term Activities

- Week of December 5th: Begin installation of OH water heater in NTC
  - There will be significant access restrictions next Tuesday-Thursday due to some stair removals.
- Week of December 5th: Remove casing from magnet bundle
- Week of December 12th: Remove the PF-1aL coil

Outline of This Talk

- Field work since the last team meeting
- PF-1a forensic analysis
- Metrology results
- Other updates

Forensic Analysis Overview

- Goal of Phase 1:
  - Identify locations with potential issue
  - Section the coil in ways that do not destroy regions of interest
  - Do visual, electrical, pressure, and vacuum testing on the section.
- Desired to not destroy any faulted regions in the coil.
- Have documented the results of these tests, discussed with various parties, developing next step plans.

Effort led by Joe Petrella and Irv Zatz
Lots of great help from tech shop, FCPC techs

X-Rays Identified a Number of Anomalies (9/1/16, 9/8/16)

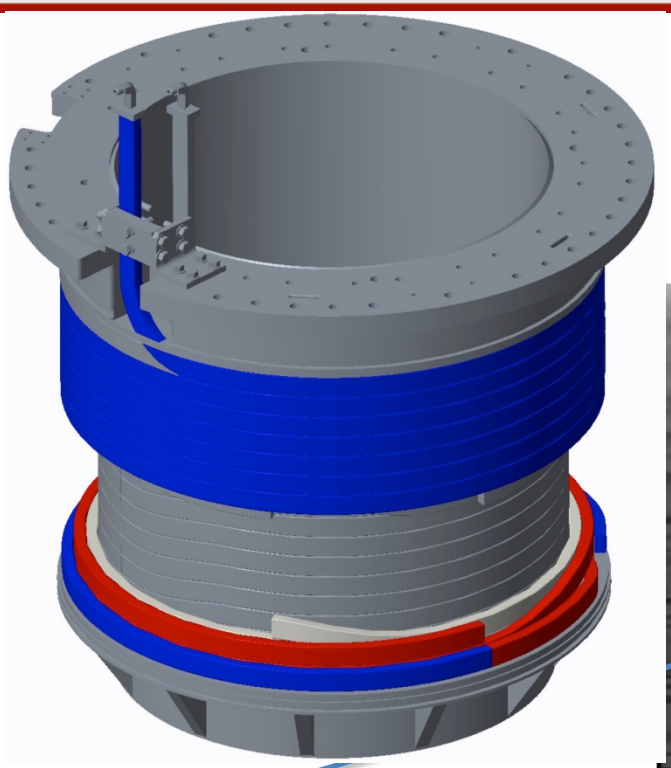
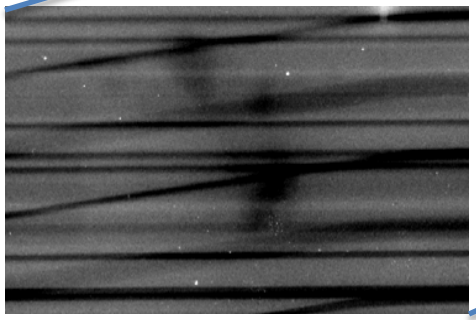
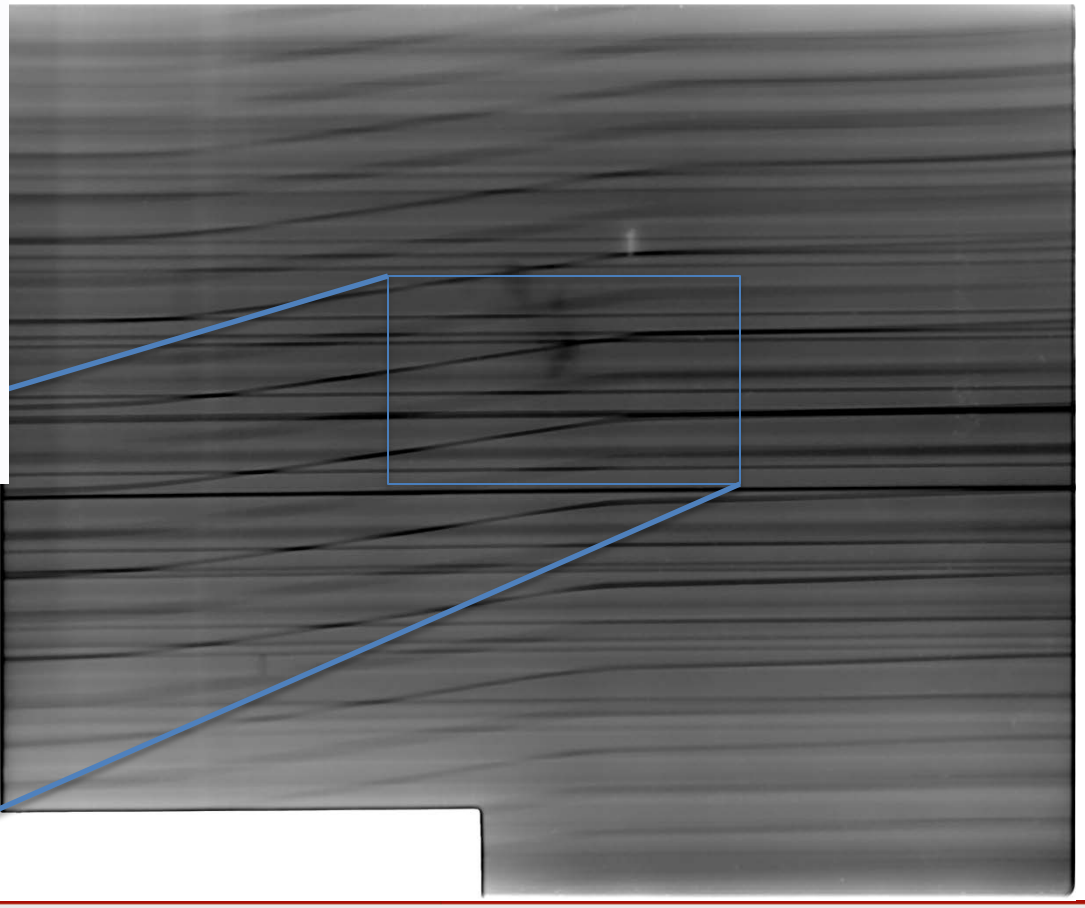


Image shows:

- Joggles (semi-abrupt transitions in conductor height)
- Region of apparent lower density

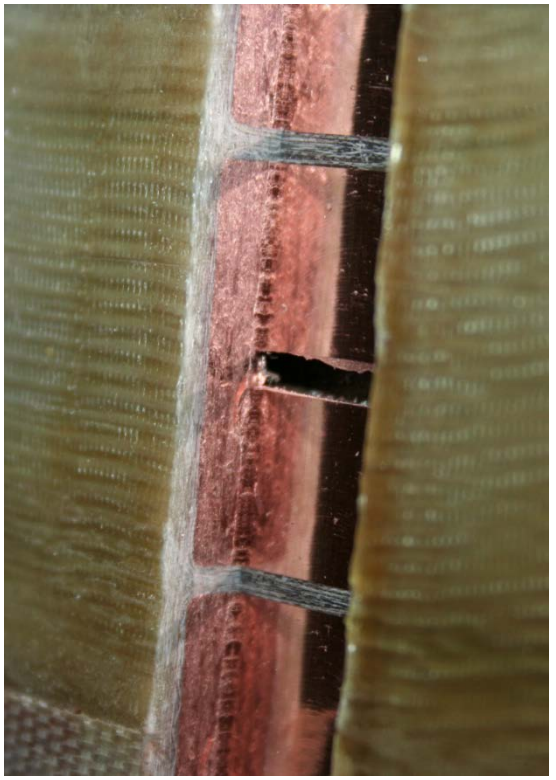
Other X-rays located all braze joints.





Coil Was Sectioned Using a Milling Machine

Section Planes Chosen to Avoid Any Regions of Interest

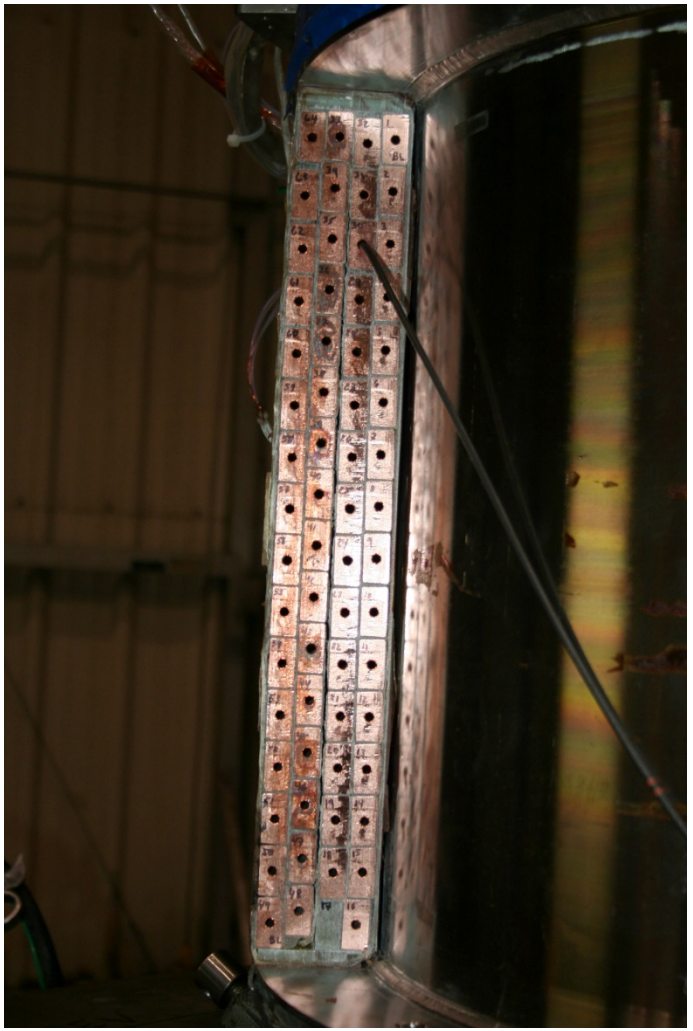


Detail of an Initial Cut

A Battery of Tests Was Performed on the Three Sections

Electrical Tests

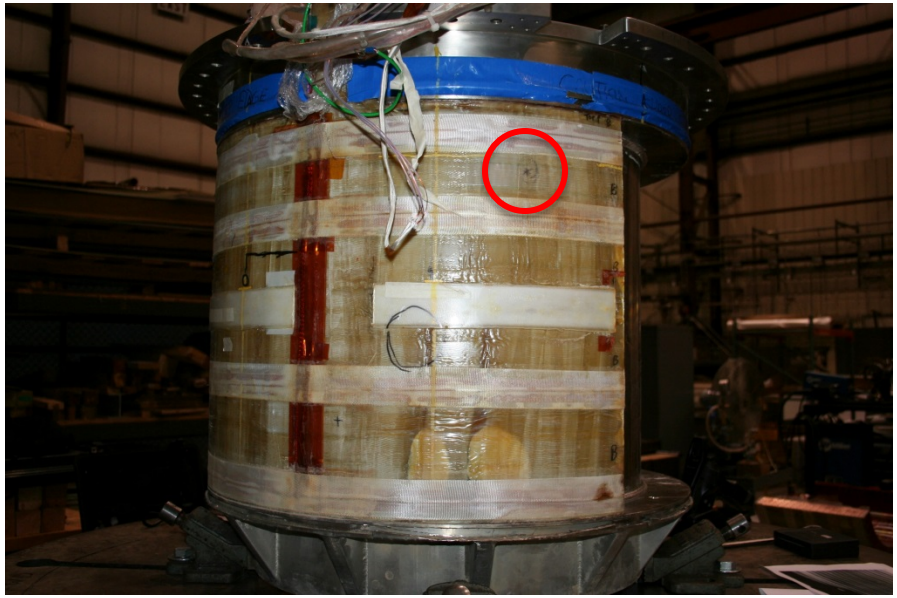
Videoscope Tests

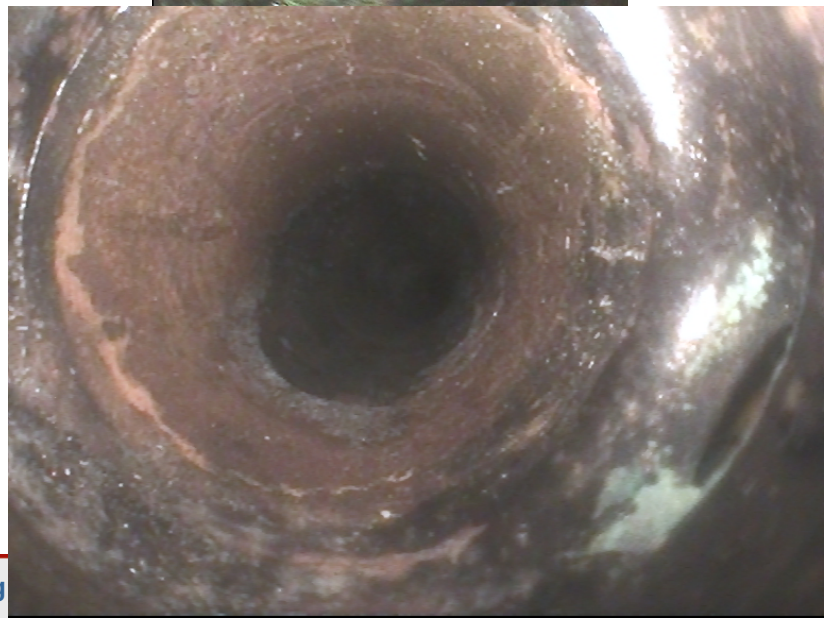


Also vacuum & pressure testing on individual channels

Anomalies Found Via Videoscope in Four Locations (1)

Section A-B, Layer 2, Row 3
Anomaly in Braze Joint

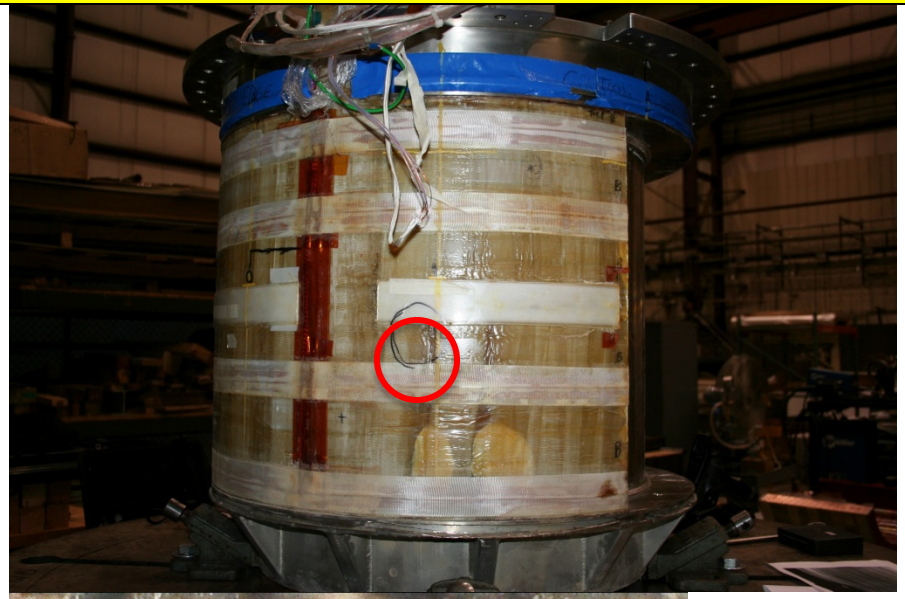


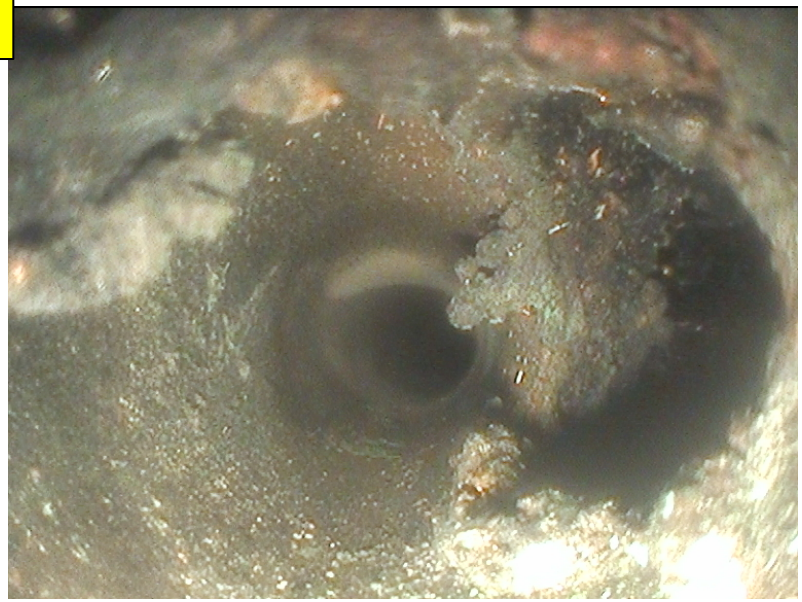


Braze joint passed pressure & vacuum test

Anomalies Found Via Videoscope in Four Locations (2)

Section A-B, Layer 3, Row 9 Void Anomaly



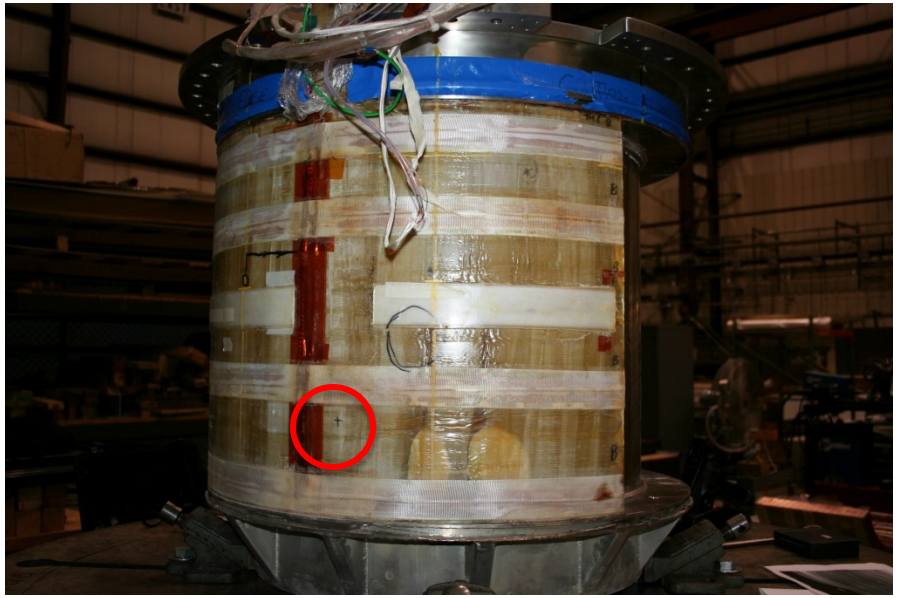


Note: this turn did not hold vacuum

This is at the void location identified by X-rays

Anomalies Found Via Videoscope in Four Locations (3)

Section A-B, Layer 3, Row 13
Material Anomaly at Braze Joint



After Debris Removal

Before Debris Removal

Braze joint passed pressure & vacuum test

Anomalies Found Via Videoscope in Four Locations (4)

Proximal to Braze Joint #1 (Section C-A, Layer 1, Row 15)

Material Anomaly at Braze Joint

Braze joint passed pressure & vacuum test

After Debris Removal

Before Debris Removal

Other Observations

- Some apparent separation between layers 2 & 3 at some locations
- Large group of turns are electrically communicating
  - *Approximately* in red box region
- Some regions of dry glass and imperfect VPI.

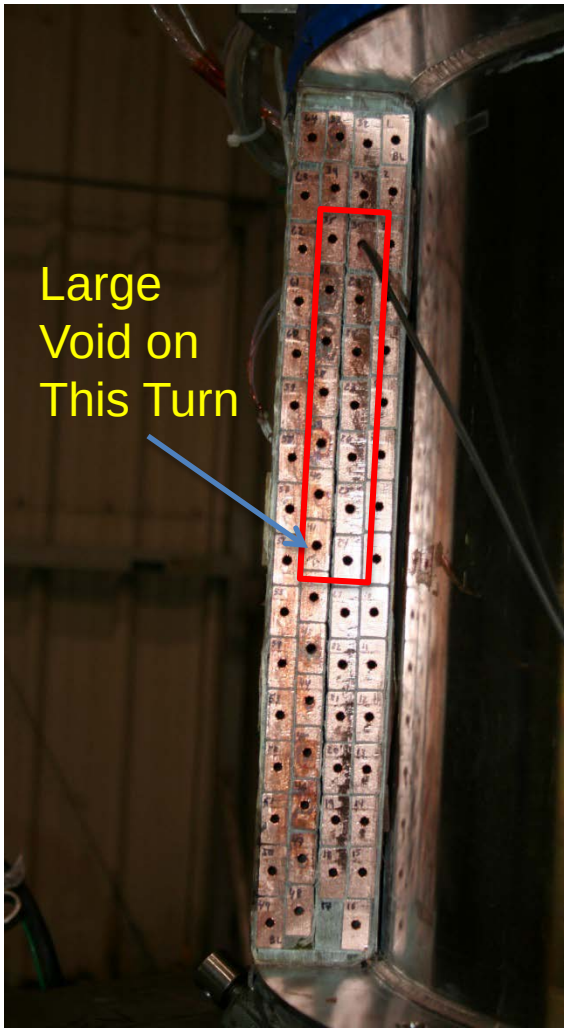
Preliminary Observations

- The large breach is not near any braze joint, “joggle”, or lead…no clear cause yet determined.

- Considering strategy for further disassembly of the section with the breach, following consultation with all interested parties

Layer 2-3 Separation

Region of Shorted Turns



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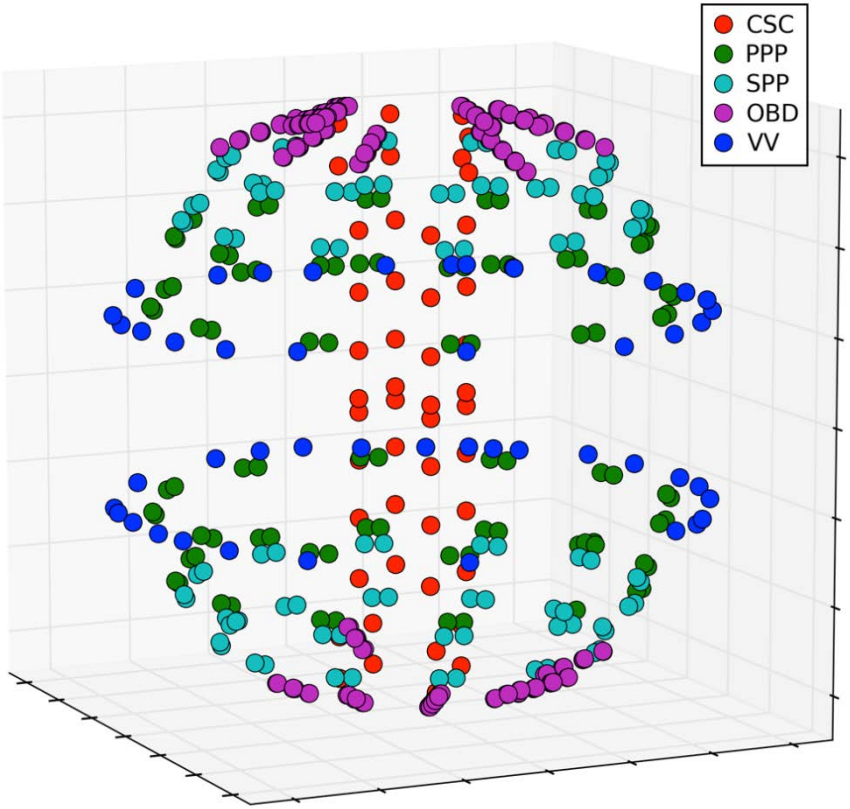
Precision Metrology Done on Magnetic Field Coils and Passive Structures

- The performance of the plasma is maddeningly sensitive to small field errors.
- The plasma behavior in NSTX-U indicates multiple error field sources
  - Need to identify and correct
  - Leading candidates: PF5, TF tilt
- Use a precision probe (a ROMER Arm) to measure in-vessel components
- Used rulers to measure from the vessel outer wall to the PF-5 ID & OD
  - Can thus assess the PF-5 (non-)circularity in the same frame

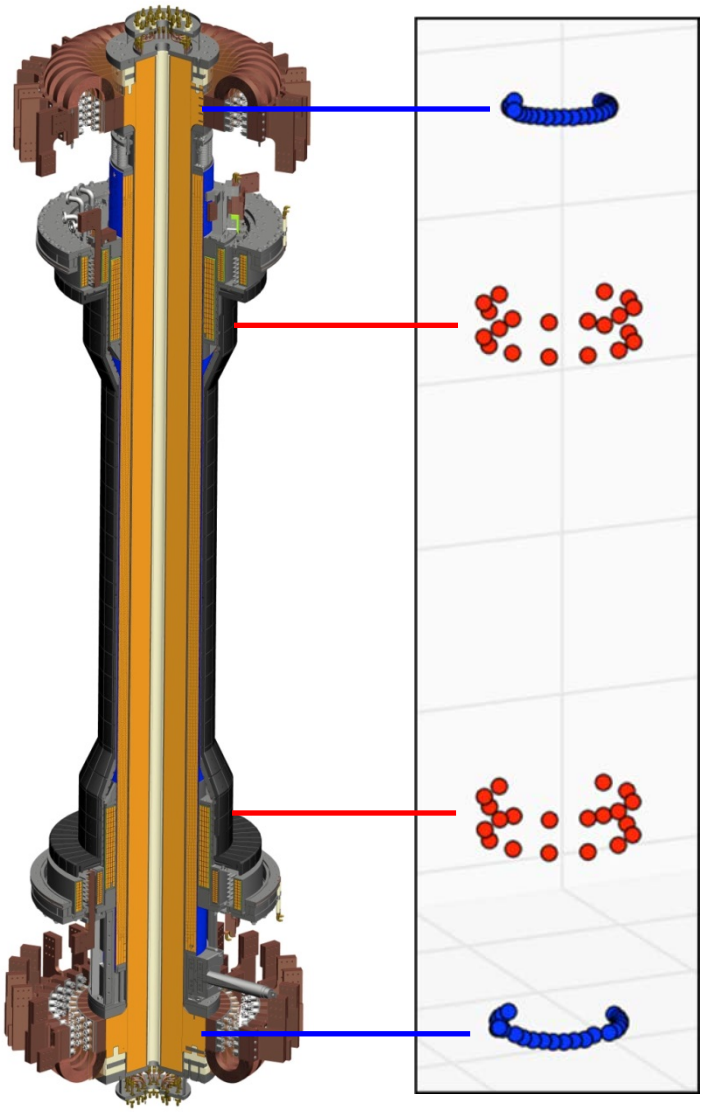


In-vessel ROMER Arm measurements
NSTX-U – October 2016

C. Myers

This Week: Tilt of the TF center rod

- The TF bundle (gold) is *slightly* tilted inside the casing (black)
- Performed metrology to quantify the tilt:
  - Laser tracker used to measure the tile surface (red) and the TF bundle (blue)
    - Note: tile surfaces previously located via ROMER arm
  - The tilt is ~5 mm over ~5 m
  - Seems small, but the plasma cares
- The tilt can be corrected since the center stack is out for repairs.



Thanks to the crew that supported this activity

C. Myers

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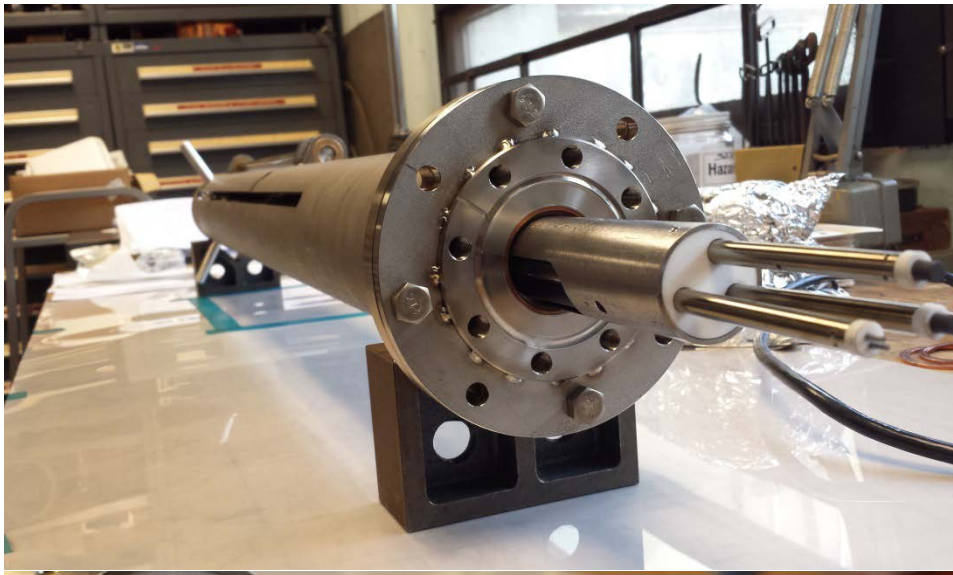
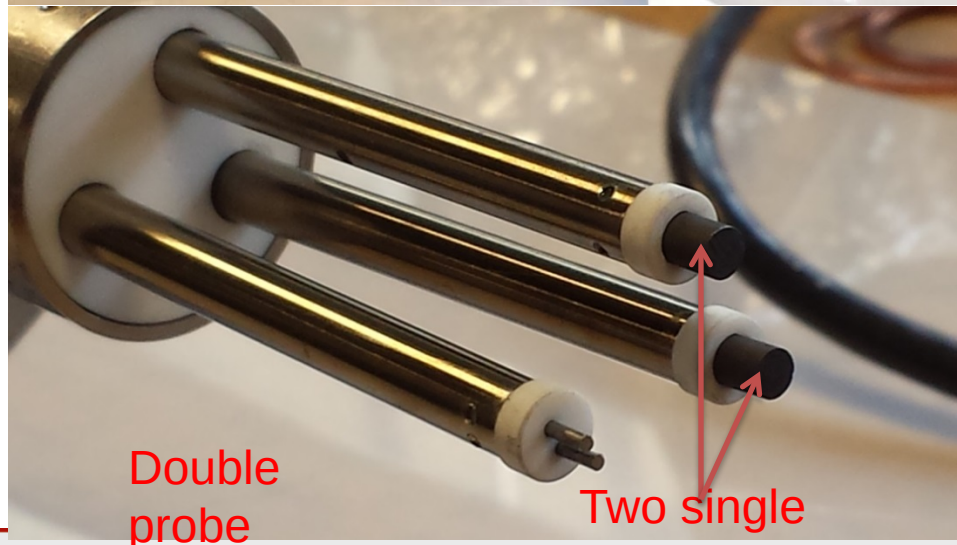
The RF Probe for Bay D has been assembled and vacuum prepped

- ORNL-PPPL collaboration.
- Based on existing RF probes.
- Three tips – two single and one double.
- Will be installed between antenna boxes at Bay D midplane.
- Testing on RF test stand in January 2017.
- Probe electronics installation is underway





J. Hosea

Diagnostics and Boundary Physics Operations

- Diagnostics
  - Continuing as possible with installations that were initiated during the run: FIReTIP, Charged Fusion Products, Divertor SPRED, others…
  - Working on a number of new systems to support the next run: Resistive Bolometers, High-k Scattering, PBLS,…
- Boundary Physics Operations
  - Electrical installation for LITER Filling Station in TFTR Test Cell nearly complete
  - Initial lithium loading tests of porous reservoir for new upward evaporator (ULITER) concept completed

B. Stratton, R. Ellis, R. Kaita

Update: Tritium Contamination in the Vessel

- On 10/10/16, some “debris” was collected from inside the vessel, placed on survey racks for release.
  - Flaking aerodag, some gold-toned flaking material on some diagnostics
- Tritium contamination was found in that material.
- All bioassays of potentially impacted employees showed no uptake.
- Two significant follow-on actions:
  - Vessel went through two rounds of cleaning
    - Vessel is no longer contaminated
    - Access is restored, but with enhanced HP-related controls and requirements.
  - Investigative committee was formed, lead by C. Gentile
    - Also D. Niemenski, G. Ascione, S. Gerhardt
    - Investigation focused on both the first-entry process (9/16/16) and the material sampling process (10/10/16)
    - Report is in near-final form, will be delivered to the director’s office very soon.

Agenda

- Masa (for Jerry) - Safety update
- Rich, Jon, and Masa - NSTX-U organizational changes, new roles for Masa
- Rich - Overview of Recovery Project
- Stefan - Outage status, PF1AU forensics
- Jon - Program status, collaborations, 5YP prep

Thank you for your many excellent NSTX/NSTX-U scientific contributions to IAEA and APS!

- IAEA-FEC
  - 3 invited
    - OV/5-2 - J. Menard, “Overview of First Results from NSTX-U and Analysis Highlights from NSTX”
    - FIP/2-5 - M. Ono, “Liquid Lithium Loop System to Solve Challenging Technology Issues for Fusion Power Plant”
    - EX/5-3 - A. Diallo, “Energy Exchange Dynamics across L-H Transitions in NSTX”
  - 26 Posters
- APS
  - 4 invited
    - J. Berkery: Resistive wall modes stability forecasting in NSTX and NSTX-U
    - I. Goumiri: A plasma rotation control scheme for NSTX and NSTX-U
    - F. Ebrahimi: Plasmoid formation in the laboratory and large-volume flux closure during simulations of Coaxial Helicity Injection in NSTX
    - J. Menard: Impact of physics and technology innovations on compact tokamak fusion power plants
  - 12 contributed orals + 1 ITER
  - 50+ poster presentations
- Now is time to start preparing for APS invited nomination ideas
- REMINDER: Publish your results! (+ do outreach seminars)

NSTX-U Program Status / Schedule

- Continue efforts with U.S. University Fusion Association (UFA) working group to enhance University opportunities on major facilities
- Planning Jan 2017 PAC video-conference to update PAC on NSTX-U status
  - Likely PAC charge on how to broaden university participation in defining and choosing scientific goals for next 5YP
- Spring 2017 – kick-off preparatory activities for development of next NSTX-U 5 year plan
- Full PAC - late spring / summer 2017
- Research Forum 2-3 months before next ops

Example enhanced collaborations for outage period
Building upon and informing NSTX-U research

- EAST: Edge physics, plasma material interactions (high-Z, Li)
  - Maingi + collaborators leading experiments this month / early next year
- JET: Energetic particle studies and plasma ramp-down scenario development and modelling
  - Podesta, Darrow, Poli
- KSTAR: Core MHD and rotation physics, plasma control
  - Sabbagh (Columbia) + group, J-K Park, J-W Ahn (ORNL)
- MAST-U: Control, scenario modelling supporting 1st plasma
  - Battaglia (+Boyer) tentatively planning visits/stays summer/fall 2017
- W7-X: 3D confinement and stability
  - Lunsford - alternate wall conditioning using boron powder dropper
- WEST: start-up, RF physics, high-Z PMI, real-time wall protection
  - Mueller going in spring, Reinke (ORNL) in fall, possibly PPPL RF physicists
- LAPD at UCLA - RF coupling and heating physics, cavity modes
  - R. Perkins leading RF development efforts
- HL2A in China offering significant run-time
  - Y. Ren will present capabilities/opportunities on 12/12

DIII-D National Campaign proposals assessed by NSTX-U
3+1 week guideline for campaign (4-day weeks)

- Solicited & received proposal synopses from team
- Run-time over-subscribed by factor of two to three
  - Boundary: 17 proposals, 17 days req.
  - Core: 12 proposals, 12 days req.
  - Integrated Scenario: 8 proposals, 7.5 days req.
- Prioritization process
  - NSTX-U recommendations: Based on near-term NSTX-U goals, well-defined ideas that require minimal operational development, Early Career considerations
    - Break into Priority 1 (12 days), Priority 2 (4 days)
  - Final selections thru discussions with GA, FFCC this month
- Questions or comments? See Stan + Steve Sabbagh

Note on FES-funded collaborators

- FES recently requested research plans for NSTX-U funded collaborators for Outage period
- FES will share plans with NSTX-U management
  - Will allow us to look for possible synergies, opportunities to field larger and more coordinated and impactful teams
- Should feel free to talk to / brainstorm with NSTX-U management on collaboration ideas

Notes on 5 year plan (5YP) process

- May have only 10 run weeks (mostly commissioning) for FY14-18 5YP
- FY19-23 plan due spring 2018, peer-reviewed summer 2018
- Begin brainstorming early 2017, then writing in summer / fall
- Need to generate research goals, prioritize facility enhancements

Mission Elements and Present 5 Year Plan 5 Highest Priorities

- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond
  1. Study energetic particle physics prototypical of ITER/FNSF burning plasmas
  2. Understand energy confinement and MHD stability at high normalized pressure
- Develop solutions for PMI challenge
  3. Dissipate high edge heat loads using expanded magnetic fields + radiation
  4. Compare performance of solid vs. liquid metal plasma facing components
- Advance ST as possible FNSF / DEMO
  5. Form and sustain plasma current without transformer for steady-state ST

Are these still the best missions and priorities for the next 5 year plan?

Thank you!

Any questions?