

## Agenda:

- Program Update and Organizational Changes - J. Menard
- Recovery Project Status and Plans - R. Hawryluk
- Recovery Project Management Perspective - L. Hill

# NSTX-U Program Update and Organizational Changes

J. Menard

# Outline

- Program Update
- Recovery Organization Changes

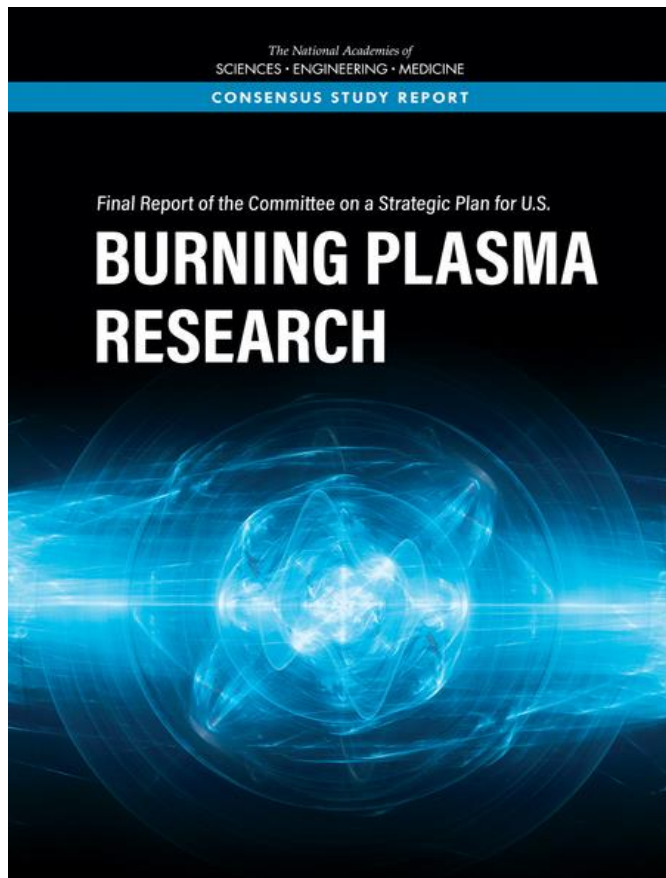


# Outline

- Program Update
- Recovery Organization Changes



# NAS Strategic Plan Report Released in December 2018



- “Final Report of the Committee on a Strategic Plan for U.S. Burning Plasma Research”
- Two main recommendations:
  - (1) The United States should remain an ITER partner as the most cost-effective way to gain experience with a burning plasma at the scale of a power plant.
  - (2) The United States should start a national program of accompanying research and technology leading to the construction of a compact pilot plant that produces electricity from fusion at the lowest possible capital cost.

# Follow-up to NAS report → FESAC Charge

- DOE Deputy Director for Science, Dr. S. Binkley, requests:
  - “that the Fusion Energy Sciences Advisory Committee (FESAC) undertake a new long-range strategic planning activity for the Fusion Energy Sciences (FES) program.
  - The strategic planning activity—to encompass the entire FES research portfolio (namely, burning plasma science and discovery plasma science)—should identify and prioritize the research required to advance both the scientific foundation needed to develop a fusion energy source, as well as the broader FES mission to steward plasma science.”
- FESAC report due December 2020



# APS-DPP Community Planning Process

- The APS-DPP Community Planning Process (DPP-CPP) is a strategic planning process with the goals of:
  - Identifying scientific and technological opportunities in the fields of Plasma Physics and Fusion Energy Science
  - Making consensus recommendations to FESAC for strategy to address these opportunities
- Expect preparatory meeting(s) summer/fall
- “Snowmass” meeting in winter
  - Tentatively early next calendar year

## DPP-CPP Program Committee Co-Chairs

**Nate Ferraro – PPPL**

Lauren Garrison – ORNL

Nathan Howard – MIT

Carolyn Kuranz – U. Michigan

John Sarff – U. Wisconsin - Madison

Earl Scime – West Virginia U.

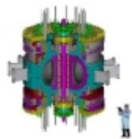
Wayne Solomon – General Atomics

# Snowmass meetings can have major programmatic impact

## Three Options for a Major Next Step in Magnetic Fusion

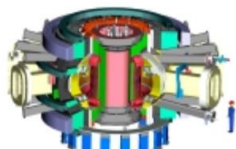
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2002



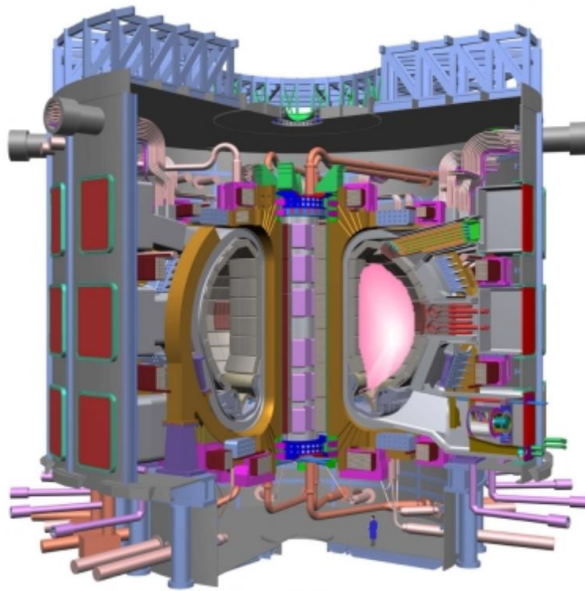
**IGNITOR**

Italian Based  
Int'l Collaboration



**FIRE**

US Based  
International Portfolio



**ITER**

EU, JA or CA Based  
International Partnership



*The ITER Agreement signed in  
Paris on 21 November 2006.*

- 2002 Snowmass led to decision for US to rejoin ITER-FEAT

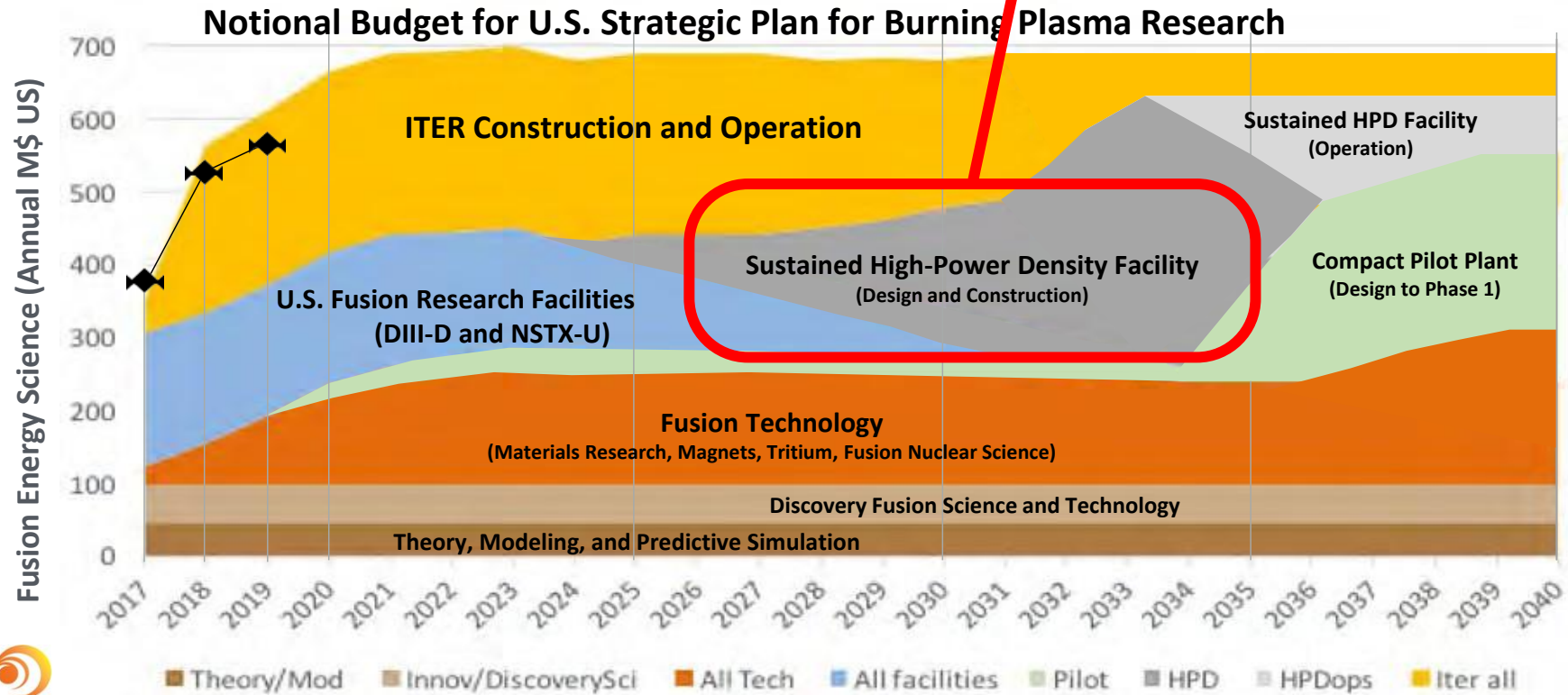


# PPPL FESAC RESPONSE TASK FORCE

- Task Force Goals
  - Prepare lab to contribute effectively to the community strategic planning activity, with a focus on initiatives that are responsive to the FESAC charge and are able to gain widespread community support and eventual consensus. Initiatives of interest include:
    - Leadership Class initiatives, i.e. that are national and of substantial scale (hundreds of \$M and up nationally over 10 years), contain PPPL programs and facilities of significant scale (10s of \$M per year), and have the potential for PPPL national leadership.
    - Initiatives for which the leadership is likely to reside elsewhere than at PPPL, but in which PPPL may participate.
    - Fusion initiatives that are on a path that exploits innovation and that leads to less costly electricity-producing plants.
    - Non-fusion initiatives that maintain or expand PPPL leadership in important areas of plasma science.
    - Inform Laboratory strategic planning.
- Schedule:
  - Jan 23 Kickoff meeting
  - Feb-Mar Develop Mission Need cases, by reviewing/helping to strengthen ideas being developed
  - Mar 29 Issue draft Mission Need documents for comment.
  - Apr-May Prepare white papers and/or presentations, as needed, for national activities.

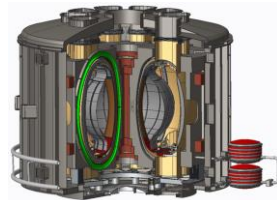


# Recent National Academy study recommends next-step Sustained High Power Density (HPD) Facility for U.S.



# W. Guttenfelder spearheading Tokamak Initiative strategy development for PPPL – taking NAS strategy as guidance

- HPD facility (DD) would establish physics basis and demonstrate operating scenarios for follow-on DT-capable Pilot Plant facility
- Optimal size, configuration, aspect ratio, etc for HPDF not decided
  - U.S. national effort to establish the detailed mission and pre-conceptual design
- But, there is likely agreement that an HPD facility would integrate:
  - Sustainment – very long pulses from high to full non-inductive operation
  - High power density – high core and edge plasma pressure w/o transients
  - Exhaust/PMI solution – compatible with sustainment and high pressure
- **NSTX-U important for design, operation, physics of next-step!**
- Brown/Menard investigating an HPDF emphasizing ability to test several liquid-metal divertor/first-wall concepts in same device



# Outline

- Program Update
- Recovery Organization Changes



# FY2019 Notable Outcome Status

1	FES: <b>Prepare an NSTX-U Recovery Project cost estimate</b> that is deemed by external review to be well documented, comprehensive, accurate and credible, as defined by GAO – 09 – 3SP and DOE Order 413.3B, by <b>March 31, 2019</b>	COMPLETED
2	FES: For the NSTX-U recovery project, complete a <b>final design review(s) for the integrated casing assembly</b> including the heat-transfer tubing and plates and associated attachment hardware, the vertical and angled sections of the center-stack casing, the horizontal divertor end-flanges, bellows, collars, and organ pipes by <b>December 31, 2018</b> . (Objective 2.1)	COMPLETED
3	FES: For the NSTX-U recovery project, <b>award a sub-contract(s) for the procurement of the integrated casing assembly</b> including the heat-transfer tubing and plates and associated attachment hardware, the vertical and angled sections of the center-stack casing, the horizontal divertor end-flanges, bellows, collars, and organ pipes by <b>March 31, 2019</b> . (Objective 2.2)	Maybe... (see Rich's presentation)
4	FES: For the NSTX-U recovery project, <b>fabricate at least one production inner poloidal magnetic field coil. Verify the quality of the coil</b> through electrical testing and dimensional inspection by <b>September 30, 2019</b> . (Objective 2.2)	OFF-TRACK
5	PSO: Establish an effective and appropriately tailored <b>Accelerator Safety Order Implementation Plan</b> for the NSTX-U Recovery Project and obtain DOE's concurrence <b>by September 30, 2019</b>	ON TRACK

FY2018 DOE PEMP feedback on Recovery management:  
Not meeting expectations on getting to baselining rapidly enough



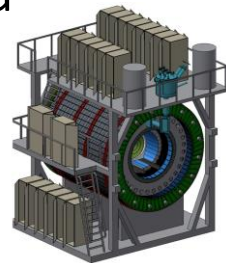
# Recovery Project leadership transitions

- **Nearly all Recovery Project scope will be through FDR this year → project preparing to baseline, transition from design to procurement / fabrication**
- Jon: Increasingly assisting in FESAC strategic activities, scoping for possible U.S. next-steps building on pilot plant studies, (still) NSTX-U Research Head

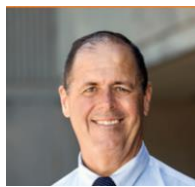


Russ Feder: New job at Brookhaven National Lab starting 4/15

- Chief Mechanical Engineering for superconducting sPHENIX detector project - one of two large detectors on RHIC



- External search for new Project Director initiated Feb. (position not yet filled)
- Rich interim PD, Stefan deputy PD, Les Hill as interim PM (recent IOI/PMO head)



NSTX-U Team Meeting

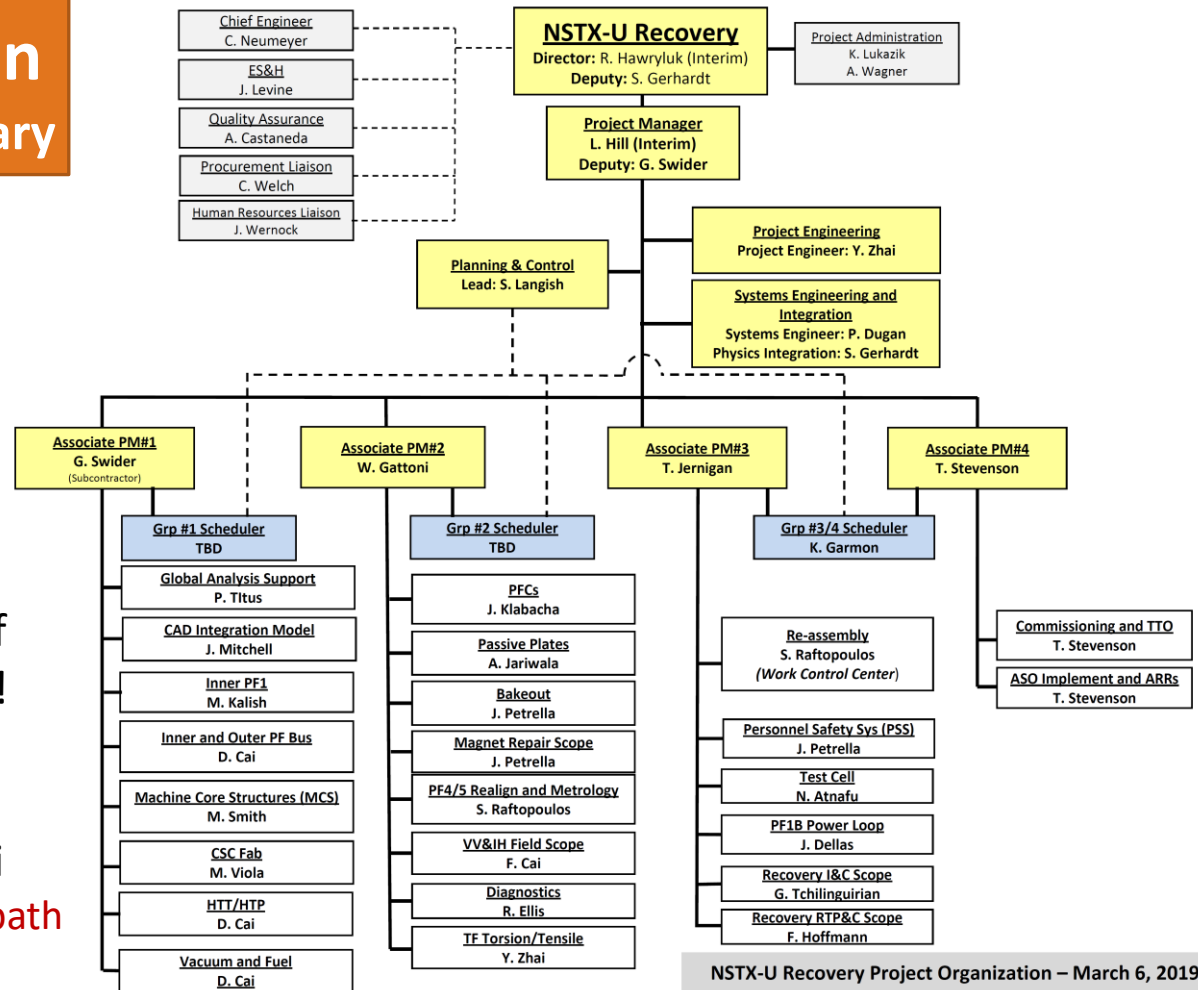


March 29, 2019

# Recovery Organization

## additional changes since January

- QA Liaison: Andres Castaneda
- HR Liaison: Jean Wernock
- Unchanged: Associate Project Managers (APMs)
- New Scheduler Lisa Glazatcheff started on Monday – welcome!
- Accelerating TF Torsion/Tensile analysis/testing – COG = Y. Zhai
  - This scope is now on critical path – see Rich's presentation



NSTX-U Recovery Project Organization – March 6, 2019



# Thank you!

## Any Questions?





# NSTX-U Recovery Update

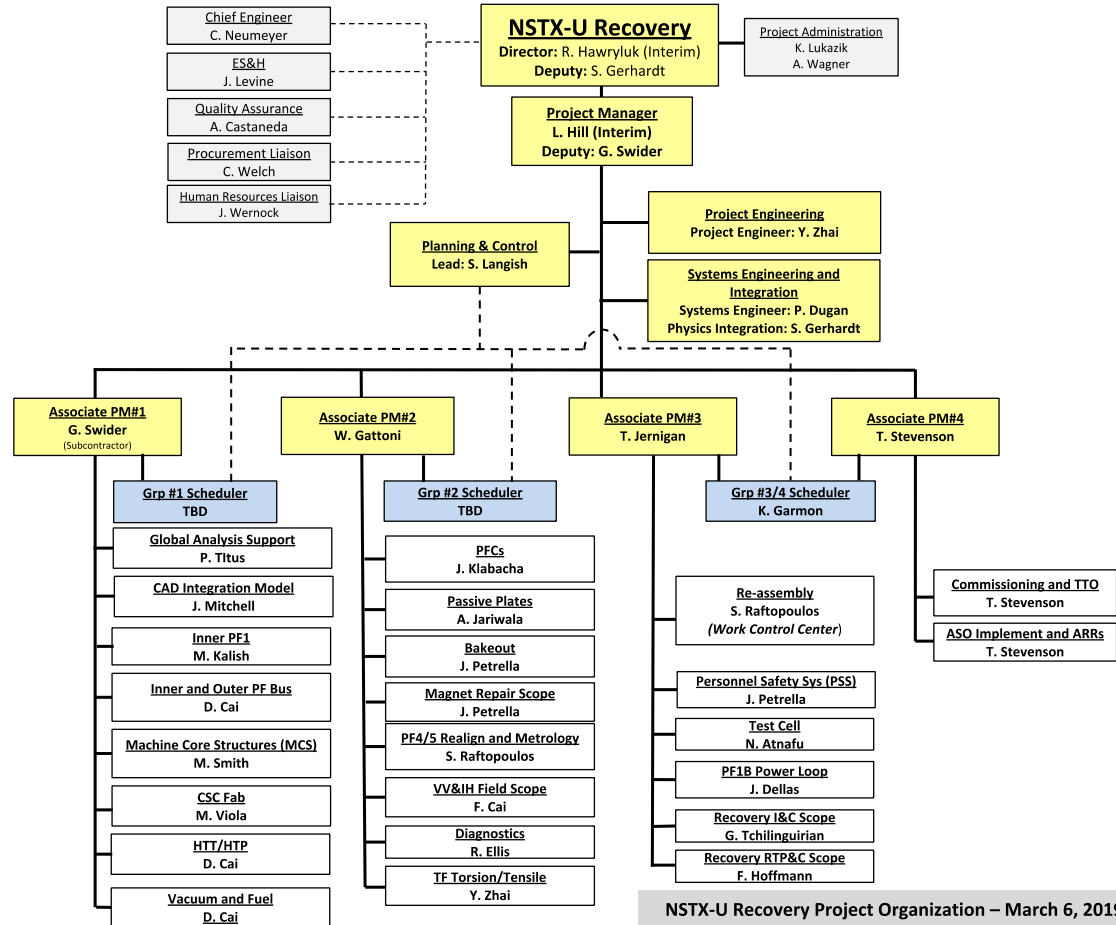
R. J. Hawryluk, S. Gerhardt, L. Hill  
and the NSTX-U Recovery Team

# Working My Way Back To My First Job



# NSTX-U Recovery Project

**Message for COGs:**  
If you have not yet met your  
APM, please do so NOW!  
(they are here to help you)



March 29, 2019

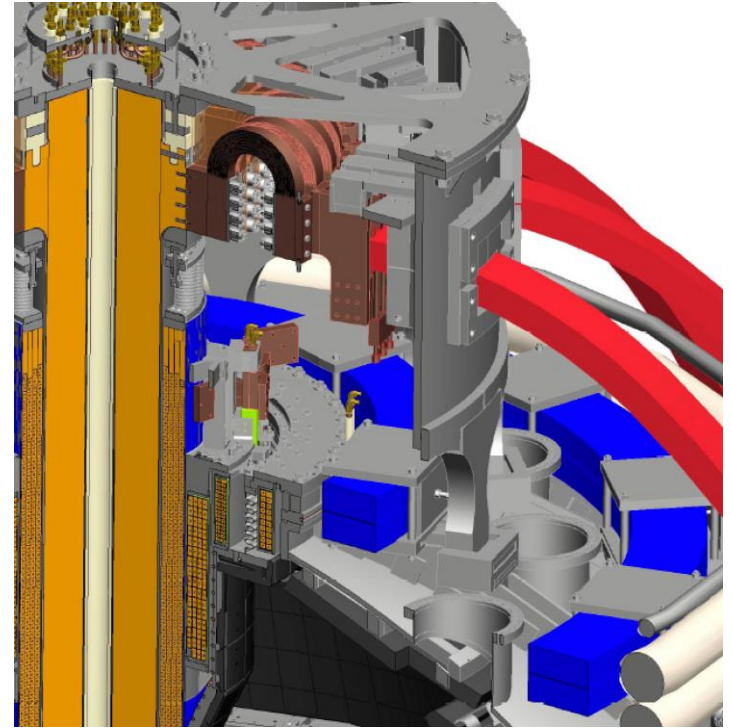
# Outline

- Technical progress
  - Response to TF bundle issue
- Overview and impact of Director's Review
- Project cost and schedule overview
- Results from Basis of Estimate review
- Plans for CDE-2/3A



# What is NSTX-U “Recovery”?

- Technical failures halted initial operations of NSTX-U in FY2016
- PPPL performed extensive technical reviews and developed corrective action plan in FY2017
- **Recovery = implementation of corrective actions to achieve high performance, reliable user facility**



Cross-section of upper region of NSTX-U

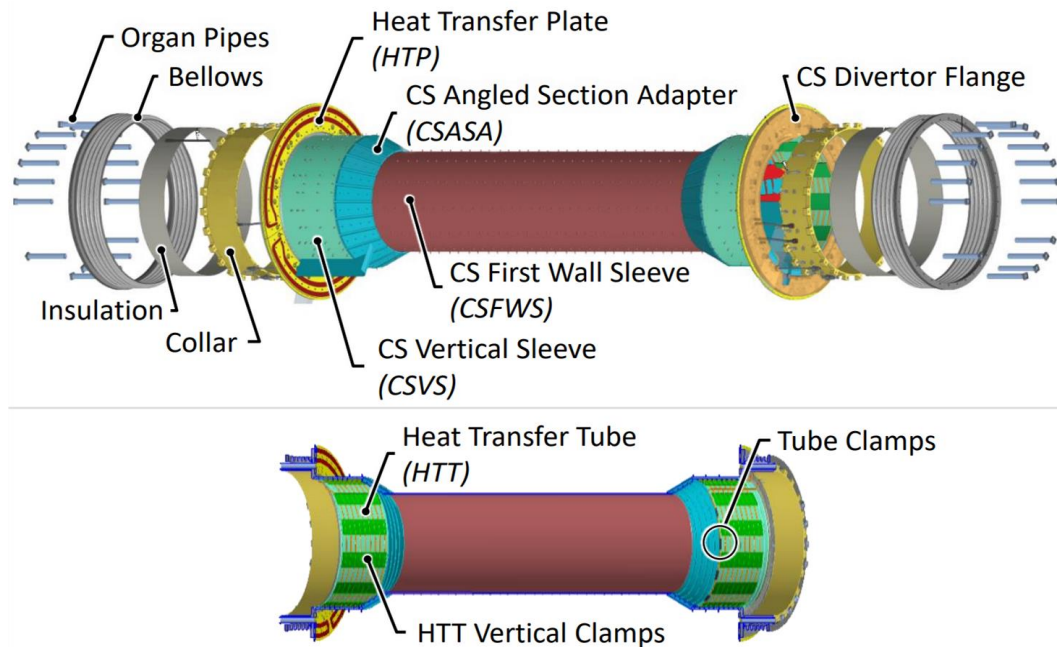
# Recovery Project Accomplishments

1. Preliminary Project Execution Plan approved October 2018
2. Completed 80% of preliminary and 50% of final design under more rigorous engineering design and quality assurance processes
3. Key technical designs and testing completed:
  - a. Replacement production coil design\*, prototype coil testing\*
  - b. Design/prototype high performance plasma facing components\*
  - c. Design of new center stack casing\*
  - d. Design of test cell shielding using state of the art codes
4. Engaged outside expertise to advance project

\* indicates FES Notable Outcome achieved on schedule

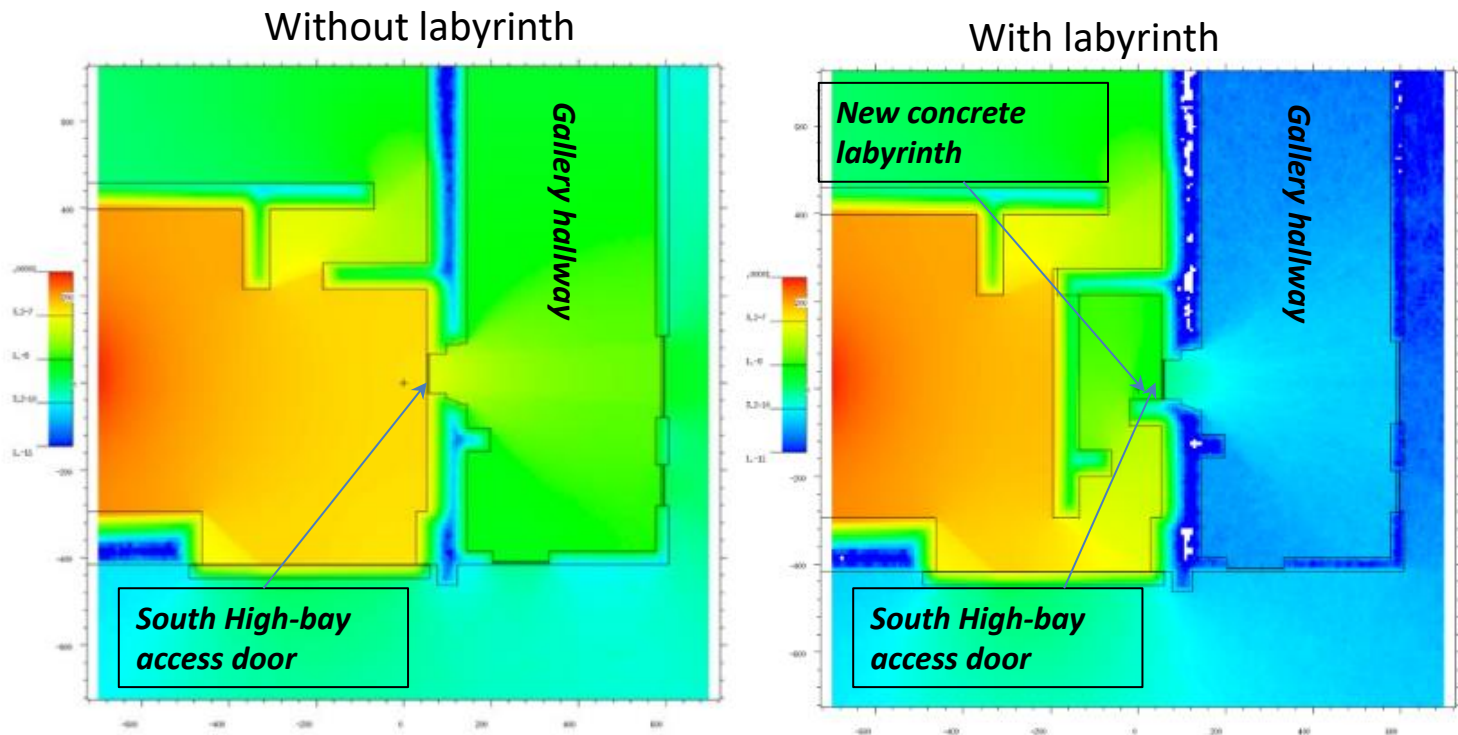


# New center-stack casing supports full performance



- Review of welds in existing center-stack resulted in a new casing
  - rather than a repair
- Final design completed December 2018 in collaboration with ORNL

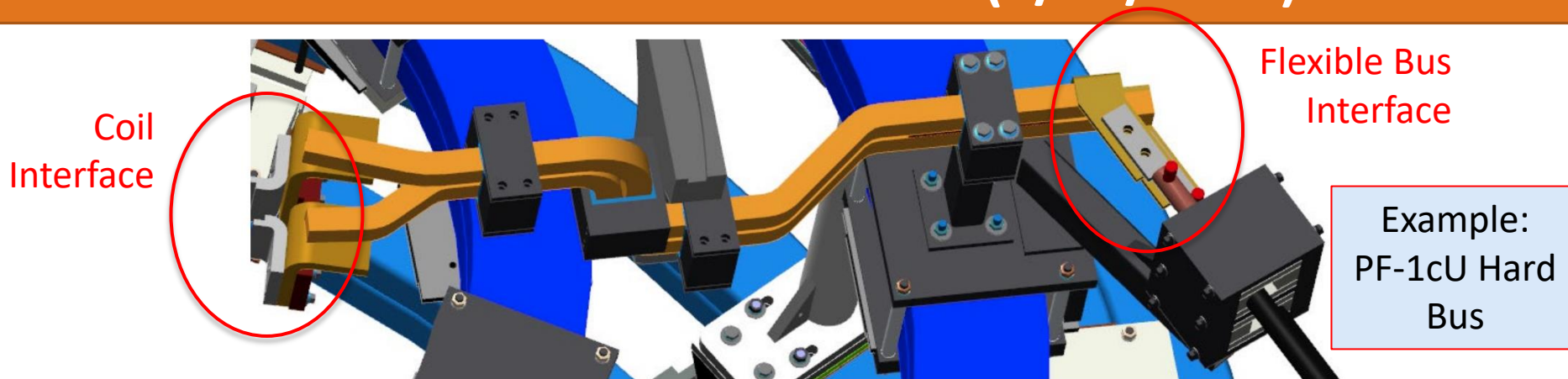
# Improved shielding supports full power operation



- Final design completed January 2019
- Neutronics code MCNP used to evaluate improvements to shielding



# Inner-PF Bus Work PDR Retired Design Integration Risk for Inner-PF Coil Procurements (2/28/2019)

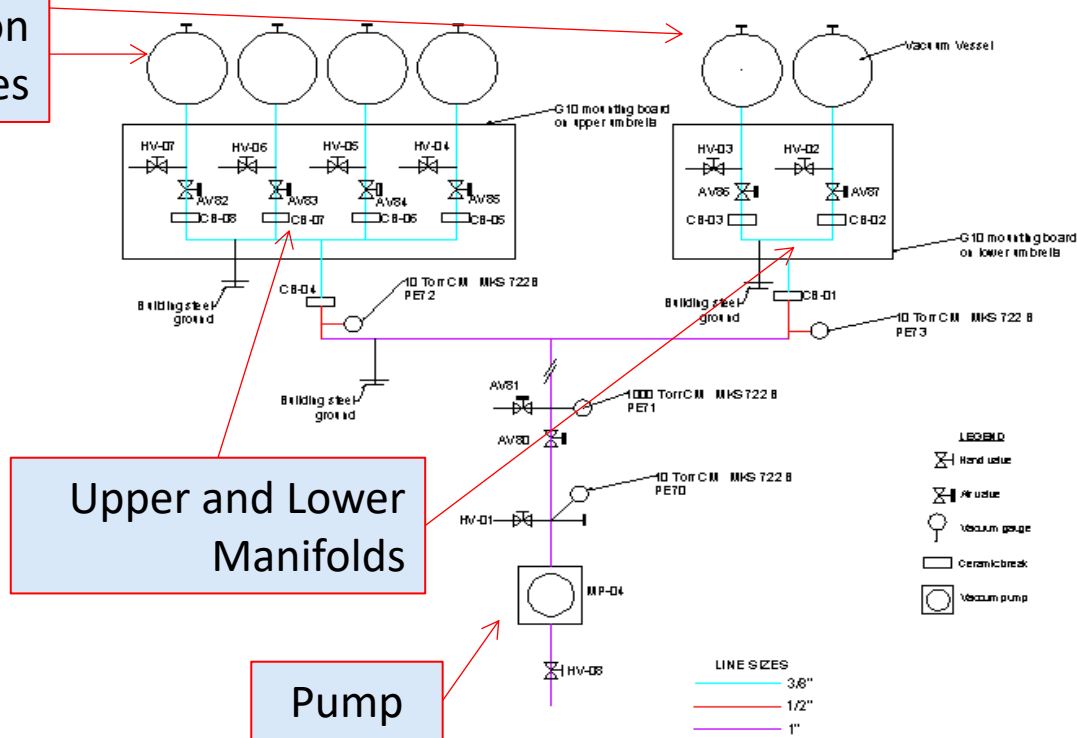


- Review addressed the connections to the six upper and lower inner-PF coils.
  - EM and thermal conditions, FMEA, interferences and interface management, fabrication all covered
  - Successful pending resolution of chits
- Bakeout and outer-PF bus work scope being addressed at a follow-on review
  - This review focused on removing interface risks for the inner-PF coils

# Interspace Vacuum System is Used to Evacuate Volumes Between Double O-rings (2/20/2019)

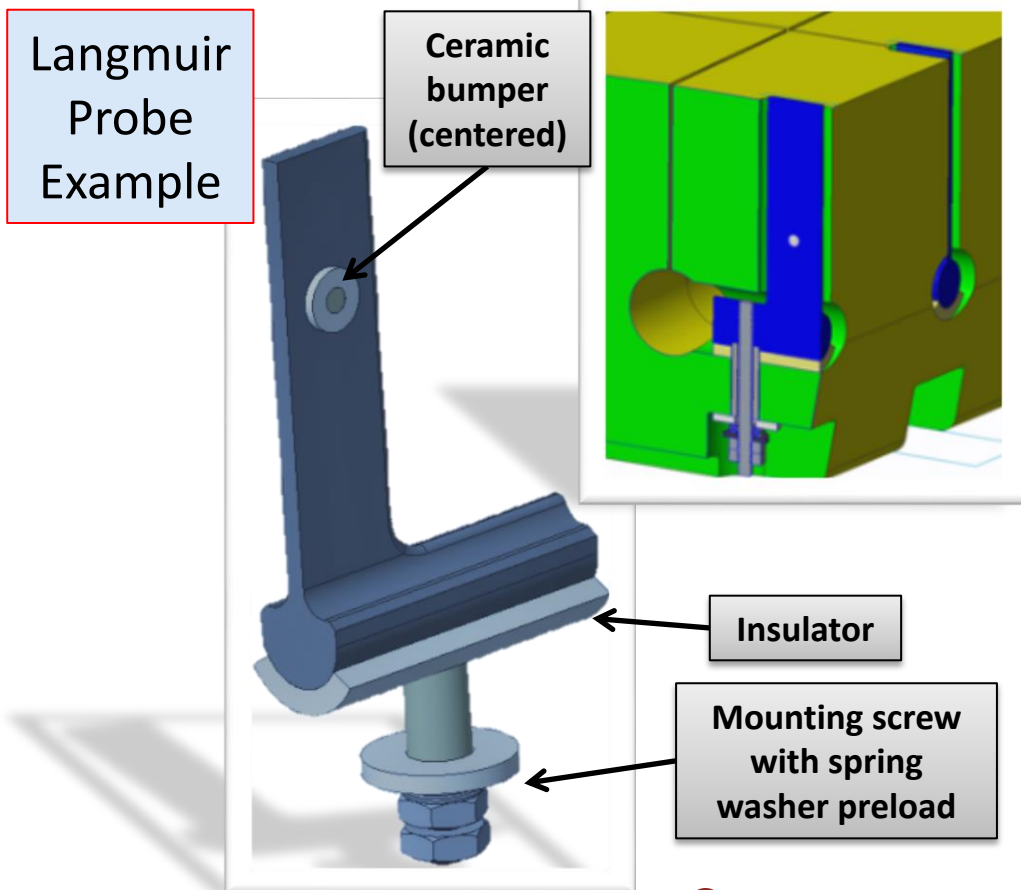
Four upper interspaces (includes on ceramic insulator), two lower interspaces

- FDR covered P&ID (shown), component selection, location of components in the test cell, pumping speeds and vacuum characteristics, PLC software, FMEA and procurement aspects
- Successful pending resolution of three minor chits
- Will be able to include in this in CDE-3A



# PFC Diagnostics FDR Eliminates Integration Risk on the PFCs (3/28/2019)

- FDR covers Langmuir probes, Mirnov Sensors, PFC thermocouples, halo current sensors, and the  $I_p$  Rogowski.
- Review aspects include electrical and mechanical design, fabricability, in-vessel wire routing, etc, incorporating lessons learned from previous designs.
- Will allow the PFC diagnostics to fall in the CDE-3A scope bucket, while dramatically reducing integration risks for the PFCs.



# ASO Implementation, Access Control System update under way

- Recovery is making good progress towards implementation of the ASO
  - Hired dedicated person to develop Accelerator Safety Order (ASO) elements (SAD, ASE, ARR,...)
  - Updated Accelerator Readiness Review (ARR) plans based on Director's Review feedback
  - Provided an updated ASO implementation plan to DoE/PSO for comment
  - Now → Updating the HAR (CDE-2 deliverable) as a step towards the development of a SAD
- Project responding to Director's Review recommendation to revisit re-use of legacy Access Control System → plan to significantly upgrade existing system
  - NSTX-U had used a legacy ACS from TFTR (and NSTX)
  - Conceptual design of upgraded ACS supported BOER



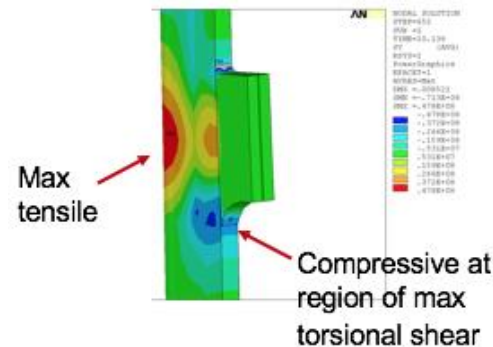
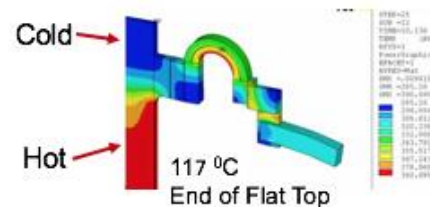
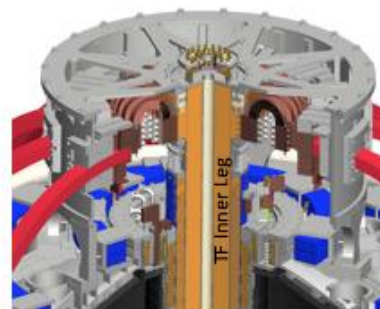
# New Emphasis on TF Bundle

- Extent of Condition review identified the need for more analysis of the TF bundle prior to start of operation and monitoring the behavior during operations
  - Potential for delamination of the insulation
  - Will this impact the operating range or the number of full power shots?
  - Confident that this will not impact the scientific mission but...
- DOE is concerned that our planned analysis in the future will not provide assurance that the machine will achieve  $I_p = 2\text{MA}$ ,  $B_T = 1\text{T}$ , duration = 5s simultaneously
  - Need to resolve this issue prior to establishing a baseline



# Background

- During a pulse the ends of the TF inner legs remain cold while the rest is heated by the TF current
- The resulting temperature gradient creates a tensile stress on the insulation that, based on existing data, could result in local delamination
- Delaminated region should remain local to the high tensile stress area but this has not been rigorously demonstrated
- The region of maximum tensile stress is away from region of maximum torsional shear, and the torsional shear is within the allowable but concern exists that delamination could propagate and compromise overall bundle mechanical integrity



# Task Force Established to Address the TF Bundle

- C. Neumeyer is leading the Task Force
  - Redirected mechanical engineers from other scope
- Developed an analysis plan supported by a material test plan
- Have external review of the analysis and material test plan on April 9th
  - Get agreement on the approach
- External review committee will review the results of the analysis and testing in June
- Assess whether the operating space in the General Requirements Document can be met
- This will impact the schedule for baselining the project as will be discussed
- Work was previously planned over 10 months
  - By focusing the scope and reallocating resources compressing it to 3-4 months



# Highlights from Director's Review (Sept. 5-7, 2018)

- Overall, the technical scope (PF1 coils, PFCs, PF1B power loop) was reviewed favorably and ready for CDE-3A and fabrication
- Noted that project risks were properly identified
- Key areas requiring additional development before CDE-2:
  - The basis of estimate was not yet fully documented
  - Risk mitigation strategies were not well documented
  - Recommended revisiting reuse of existing ACS vs new system (accepted)
- **This triggered the need for a separate Basis of Estimate review**





# Key Director's Review recommendations for the BOE implemented

- The basis of estimate has been fully documented
  - Detailed cost books developed for all project scope
  - Backup documentation now provided:  $\geq 160$  hr labor tasks,  $\geq \$10k$  for M&S
  - Basis of Estimate Document now lists all cost and schedule assumptions
- Risk mitigation strategies are now well documented
  - Risk Management Plan updated and improved - incorporates mitigation
  - Unmitigated risks and mitigation strategies now fully documented in risk registry
- Project determined existing Access Control System (ACS) inadequate
  - New Personnel Safety System (PSS) now included as additional project scope
  - PSS CDR completed: Significant scope increase (+\$9M), PSS on/near critical path

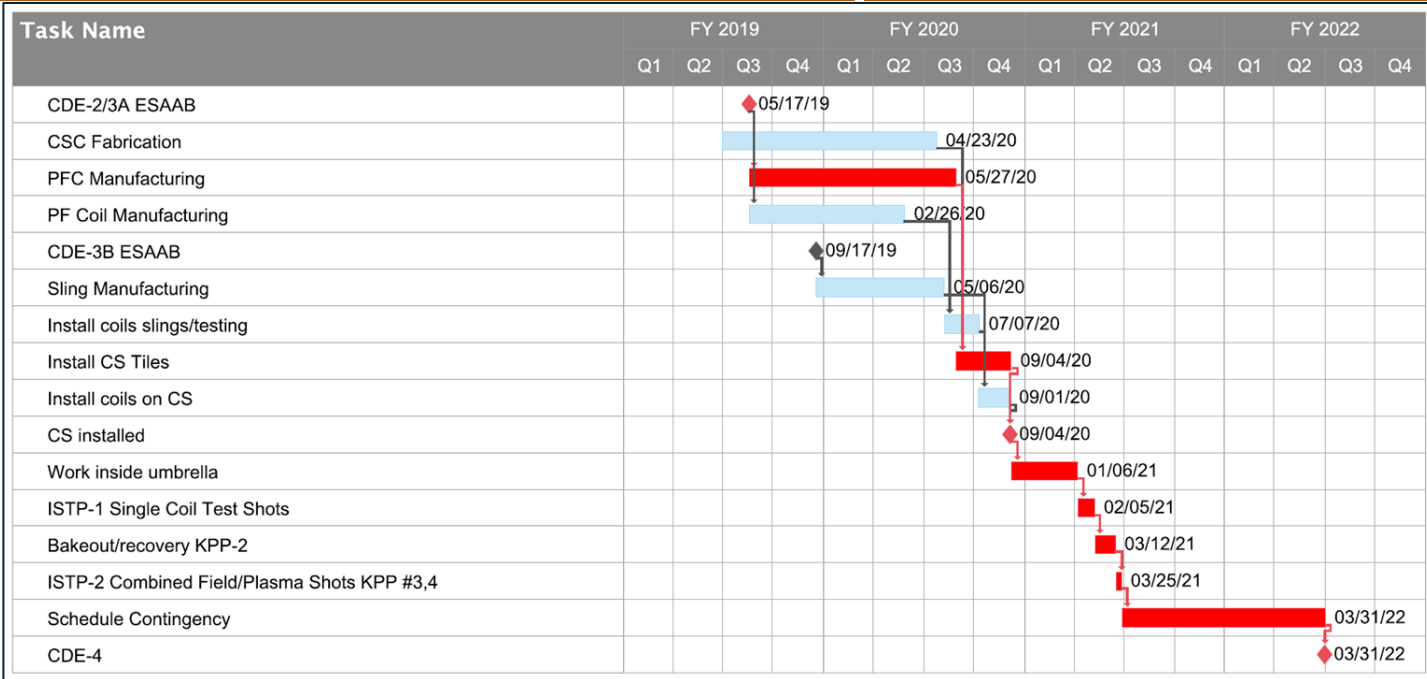


# BOE Review Was Conducted on March 18-20, 2019

1. Is there sufficient detailed information available and documented to support the cost estimates? **Met**
2. Are the estimates accurate, credible, comprehensive, and do they follow the GAO 12 Steps for Cost Estimating Best Practices? **Met**
3. Are project risks identified reasonable and included in the project cost? **Substantially Met**
4. Is the schedule resource loaded, identify a critical path, and include sufficient details to successfully achieve CD-4 on time? **Met**
5. Can you positively affirm the NSTX-U Recovery Project cost estimate is well documented, comprehensive, accurate and credible as defined by GAO-09-3SP and DOE Order 413.3B?
  - ***Basis of Estimate Review Committee response: The BOER Team affirms that the NSTX-U Recovery Project cost is well-documented, comprehensive, accurate, and credible.***



# PFCs, CSC, Inner PF Coil and MCS slings fabrication define near critical path



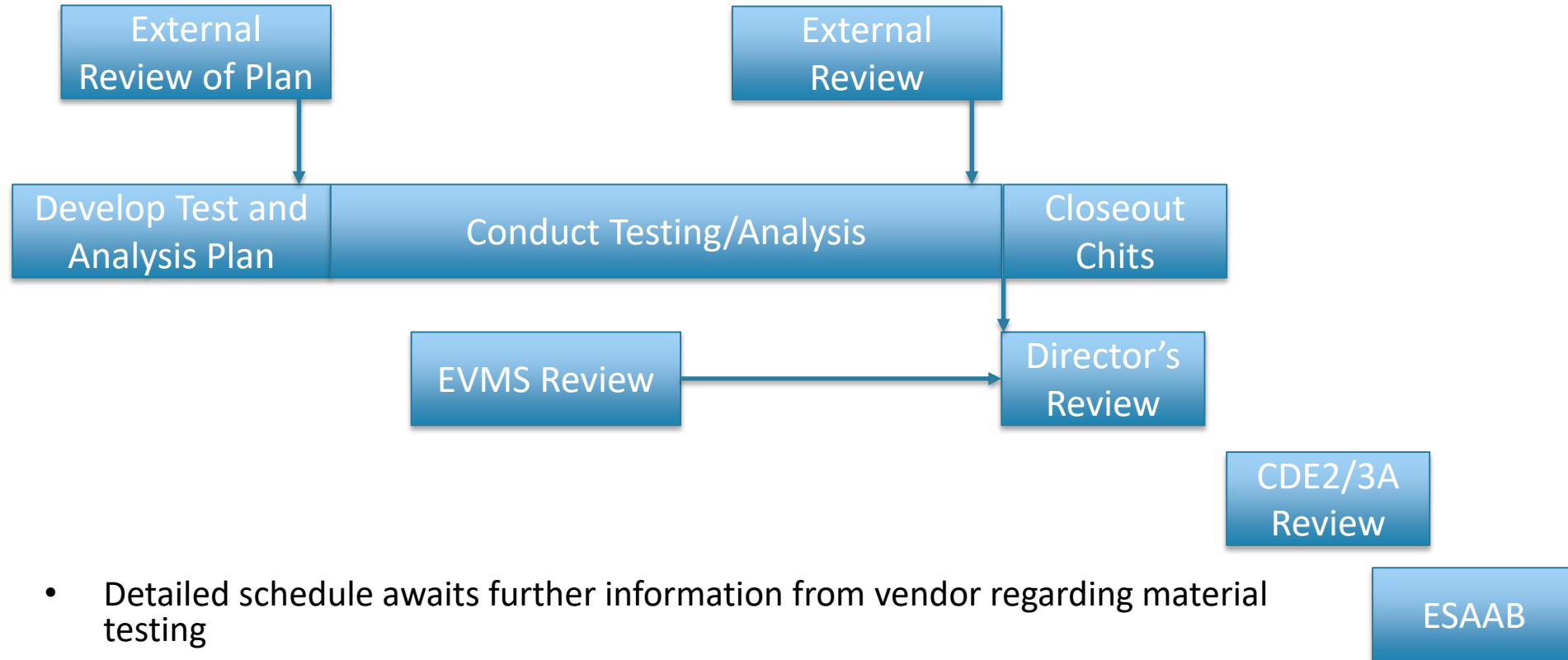
- The timing of CDE-3A and 3B approvals drives the schedule critical path scenarios

# Baseline approval is our top priority over remainder of FY2019

- ESAAB approval, CDE-2/3A approval, Baseline approval...it's all the same thing
- Baseline approval is a crucial step that is vital to DOE at all levels and to us
  - Signifies DOE acceptance and approval of our project plan
  - Authorizes us to begin a significant amount of work beyond engineering/design
  - Unencumbers us from interim spend limits
- We must Baseline this project



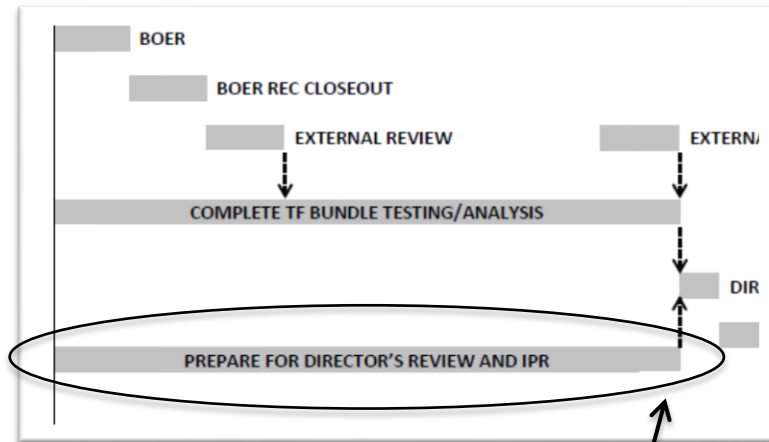
# Revising Strategy to ESAAB Approval



- Detailed schedule awaits further information from vendor regarding material testing
- Delay ESAAB Approval for CDE2/3A to September

# Preparation for the Baseline path involves a lot of hard work

- Advance design work (i.e. PDRs-FDRs) to extent practicable before the Director's Review
- Continue with long-lead procurements (e.g. center stack casing)
- Continue and advance (if possible) work on prototypes
- Plan, plan, plan the test cell and reassembly work where it all comes together
- Apply lessons learned from BOER – meticulous preparation required for Directors Review and IPR wins



Late June

# Must-haves as we head down the path to Baseline approval

- Emergent issues require immediate notification and resolution
- Need to demonstrate ability to work and execute to our plan – the next months leading up to Baseline approval is our proving ground
  - Work the plan
  - Identify barriers/obstacles...team at large
  - Remove barriers/obstacles...team with APMs, PM, DR and Laboratory
- Questioning attitude – need to find problems before problems find us



# The Project is making best use of the \$5M spending authorization

- \$5M previously authorized for long-lead procurements prior to Baseline approval - shift in approval date means the \$5M needs to last longer
- Commitments on significant long-lead procurements have already been made (e.g. PF coil conductor material, PFC graphite)
- Moving forward with CSC contract award along with associated hardware – this is on/near the project critical path
- Will move forward with Inconel 718 for PF coil straps
- Working to resolve or mitigate impacts of Baseline approval date shift
  - Other work is under evaluation





# The path to Baseline approval relies on the entire project team

Should be evident that everyone on the team has a vital role...

- Engineers
- Designers
- Technicians
- Administrative support
- COGs
- APMs



## Support/staff commitment from across the Laboratory

- Engineering
- Procurement
- QA/QC
- ESH
- HR
- Facilities & Site Services (FSS)
- PMO

## Some examples of Laboratory initiatives directed at NSTX-U Recovery

- Increased support by HR and Engineering on staffing shortages
- Procurement staff-up
- GPP projects run out of FSS will fix D-site leaking roofs and address long-standing HVAC issues

# Summary

- Technical scope has advanced significantly
- BOER was a huge win – we are applying lessons learned to get this project baselined this fiscal year
- TF bundle is an emergent issue that is now part of the project plan –
  - Laboratory talent is up to taking on this challenge
- The shift in approval date into September requires us to optimize the Baseline
- The Laboratory and DOE want us to succeed
- ***Project is deliverable and we need to get on with it.***



*Thank you!*

# DILBERT



BY SCOTT ADAMS

