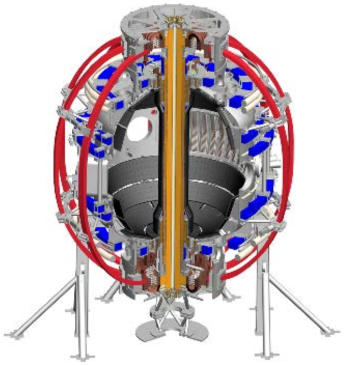
NSTX-U PAC-38 Videocon

J. Menard, S. Gerhardt, R. Hawryluk

January 6, 2017



Agenda (approximate)

- 11AM - 1PM Eastern – NSTX-U presentations
  - NSTX-U mission
  - Selected highlights from 1st NSTX-U run
  - Progress toward DOE/FES Notable Outcomes
  - Collaborations
  - NSTX-U technical challenges
  - Recovery effort
  - 5 year plan discussion
- 1-2PM (≤ 2:30PM) – PAC executive session
- 2ish PM – verbal debrief from PAC to NSTX-U

Charge

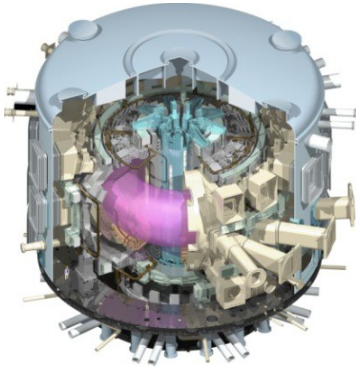
- This videoconference is meant to provide the PAC with an informational update on the recent history, status, and plans for the NSTX-U program and facility
- The NSTX-U program welcomes PAC comments / recommendations on any aspect of this presentation
- As NSTX-U embarks on preparing for the next 5 year plan (FY2019-FY2023), the program would benefit from including US University PIs/leaders in the scientific goal and strategic planning of the research program, and we request PAC ideas/suggestions on how best to solicit and include this additional input
- A brief written PAC report is requested by Jan 20, 2017

Outline

- NSTX-U mission
- Selected highlights from 1st NSTX-U run
- Progress toward DOE/FES Notable Outcomes
- Collaborations
- NSTX-U technical challenges
- Recovery effort
- 5 year plan discussion

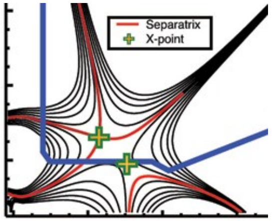
NSTX-U Mission Elements:

- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond



ITER

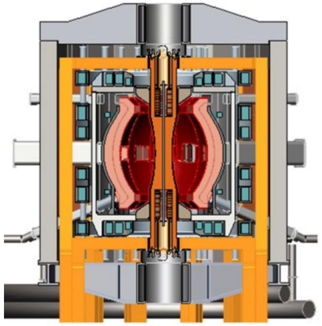
- Develop solutions for plasma-material interface (PMI)



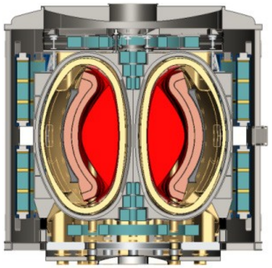
Snowflake/X

Liquid metals / Li

- Advance ST as Fusion Nuclear Science Facility and Pilot Plant

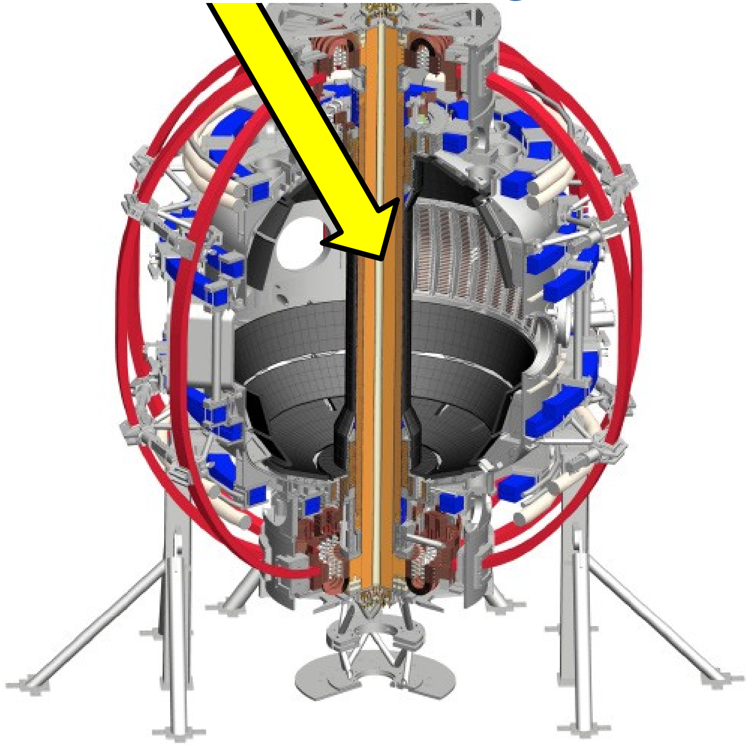


ST-FNSF / Pilot-Plant



NSTX-U will access new physics with 2 major new tools:

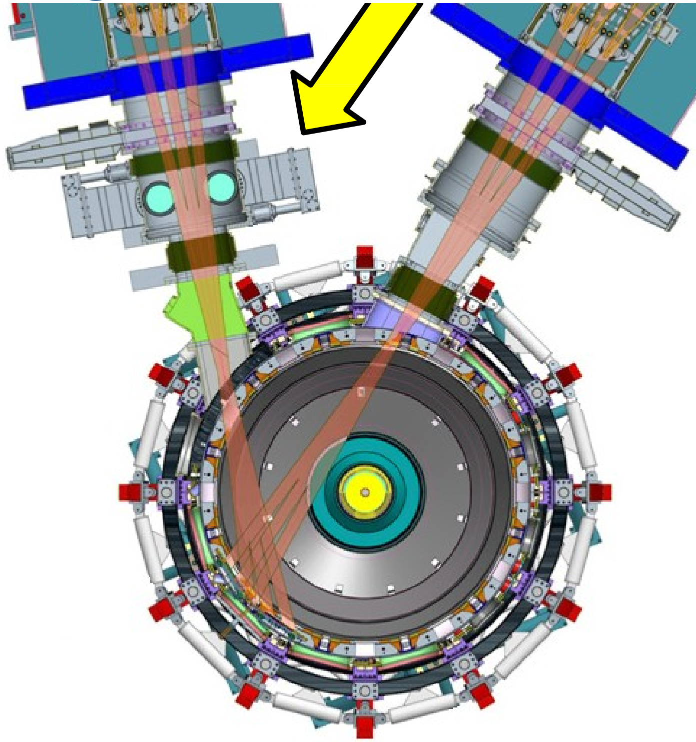
1. New Central Magnet



Higher T, low ν^* from low to high β

→ Unique regime, study new transport and stability physics

2. Tangential 2nd Neutral Beam



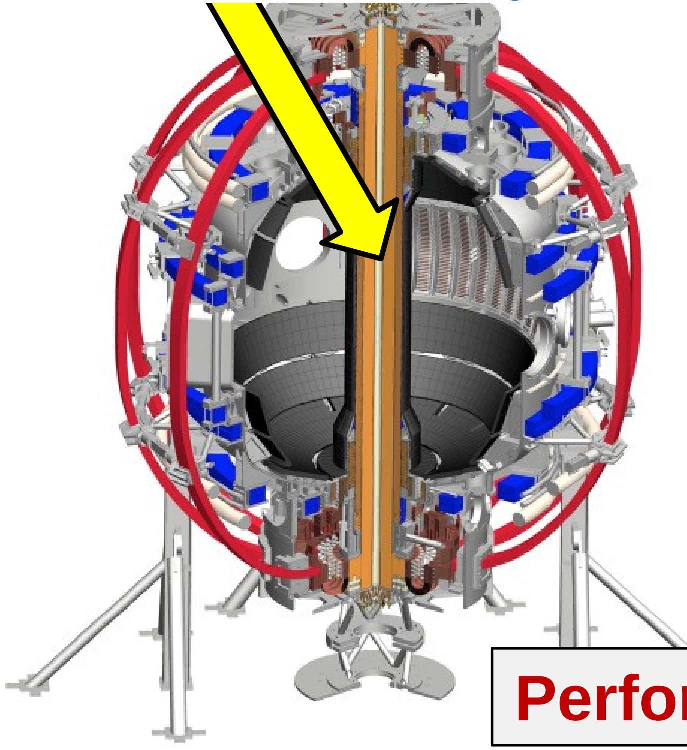
Full non-inductive current drive

→ Not demonstrated in ST at high-β_T

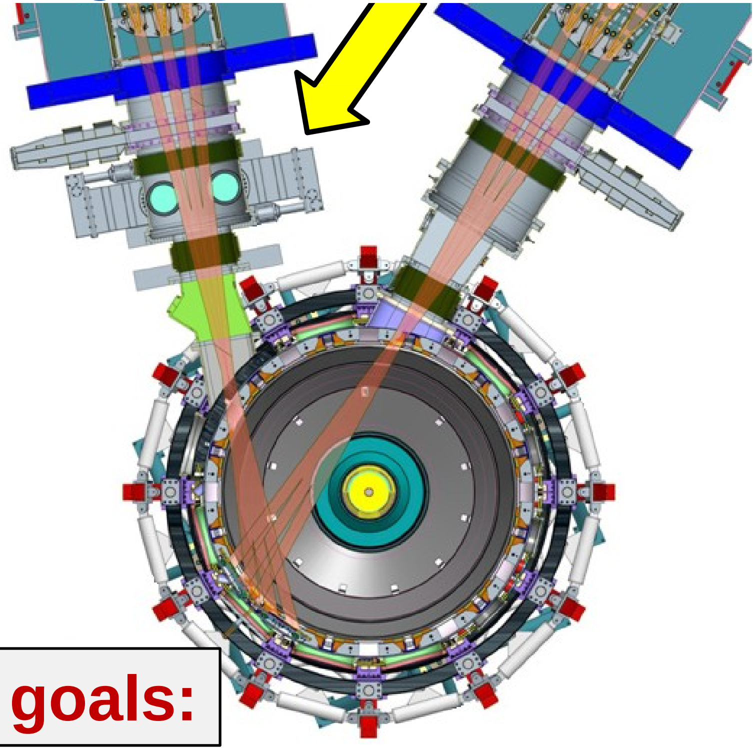
Essential for any future steady-state ST

NSTX-U will have major boost in performance

1. New Central Magnet



2. Tangential 2nd Neutral Beam



Performance goals:

- ➢2× toroidal field (0.5 → 1T)
- ➢2× plasma current (1 → 2MA)
- ➢5× longer pulse (1 → 5s)
- ➢2× heating power (5 → 10MW)
  - Tangential NBI → 2× current drive efficiency
- ➢4× divertor heat flux (→ ITER levels)
- ➢Up to 10× higher $nT\tau_E$ (~MJ plasmas)

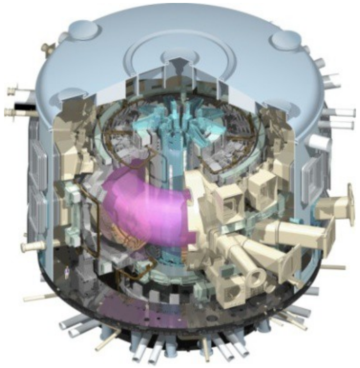
NSTX-U had scientifically productive 1st year

- Achieved H-mode on 8th day of 10 weeks of operation
- Surpassed magnetic field and pulse-duration of NSTX
- Matched best NSTX H-mode performance at ~1MA
- Identified and corrected dominant error fields
- Commissioned all magnetic and kinetic profile diagnostics
- New 2nd NBI suppresses Global Alfven Eigenmodes (GAE)
- Implemented techniques for controlled plasma shut down, disruption detection, commissioned new tools for mitigation

- Run ended prematurely (10/18wks) due to divertor PF coil fault
  - Coil + other issues → major reviews of design, fab, procedures
  - Coil forensics complete, preparation for new coil fabrication underway
  - Aim to resume plasma operation during CY2018, but still TBD

NSTX-U Mission Elements:

- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond



ITER

Topical science areas:

– Scenario Development
– Macroscopic Stability
– Transport and Turbulence
– Energetic Particles

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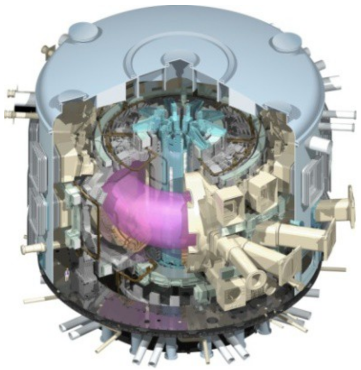

ITER

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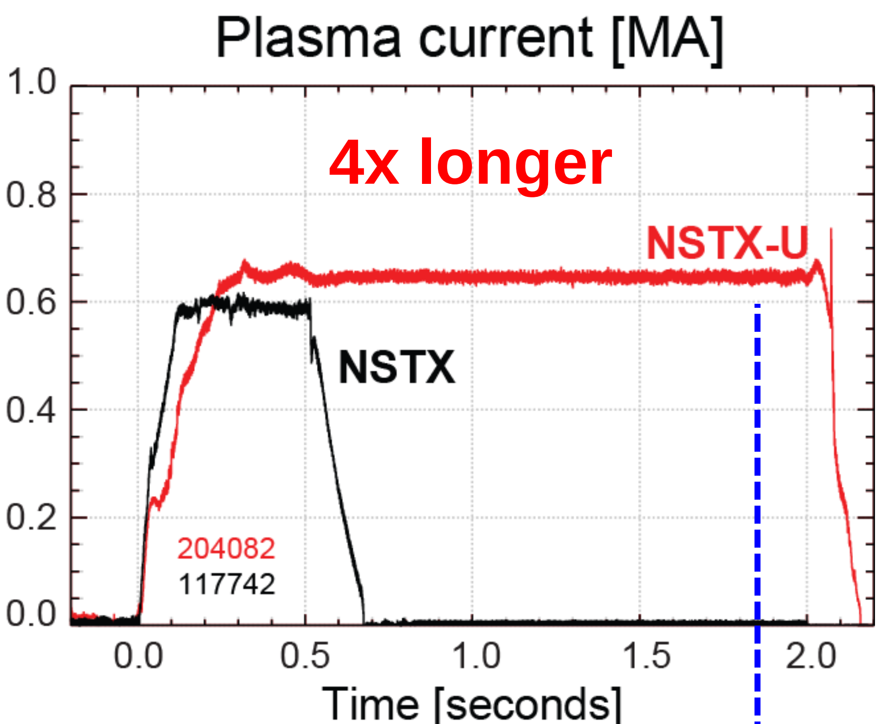
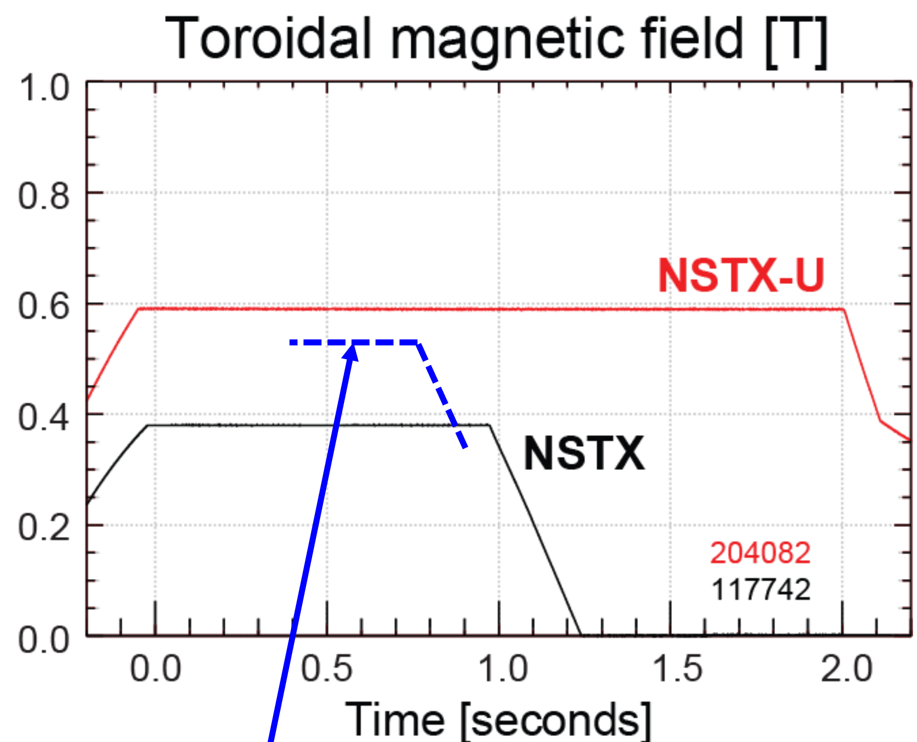
NSTX-U has surpassed maximum pulse duration and magnetic field of NSTX

Compare similar **NSTX** / **NSTX-U** Boronized L-modes, P_{NBI}=1MW



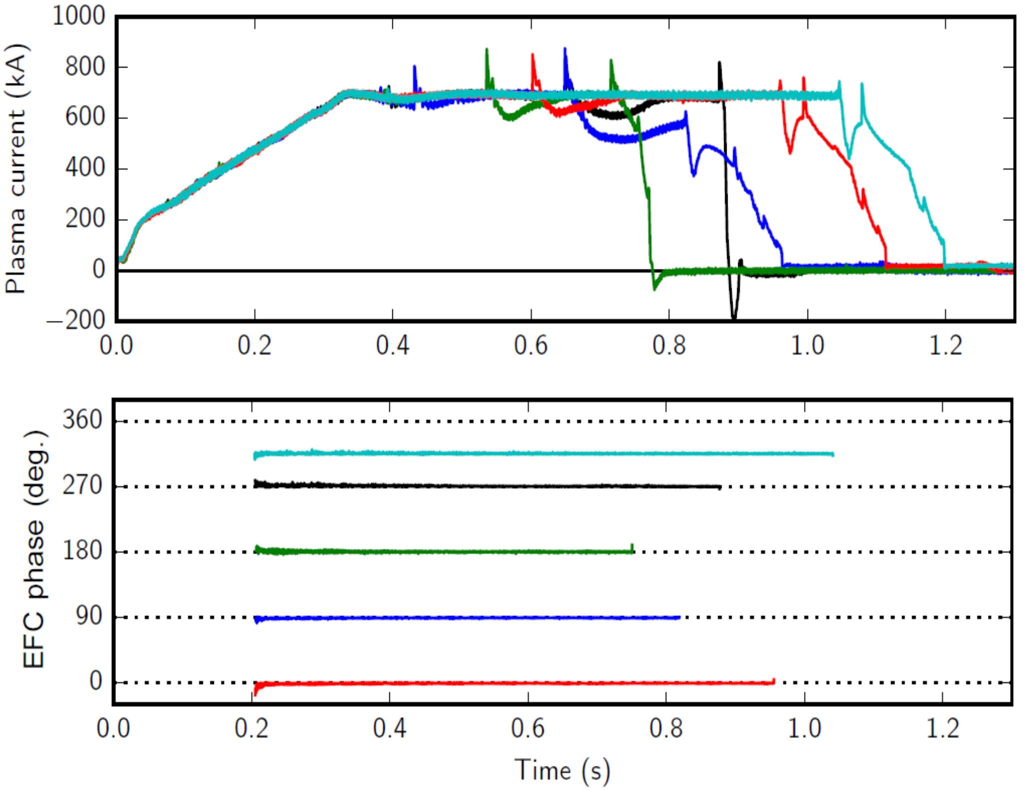


NSTX-U L-mode duration exceeds longest NSTX H-mode

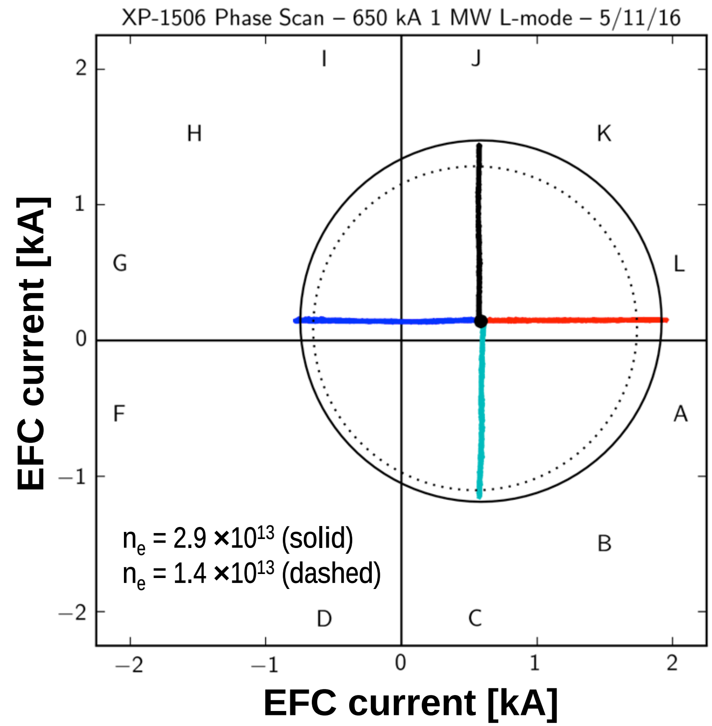
NSTX-U B_T > highest NSTX B_T

n=1 error field correction (EFC) optimized to maximize pulse length, discharge performance

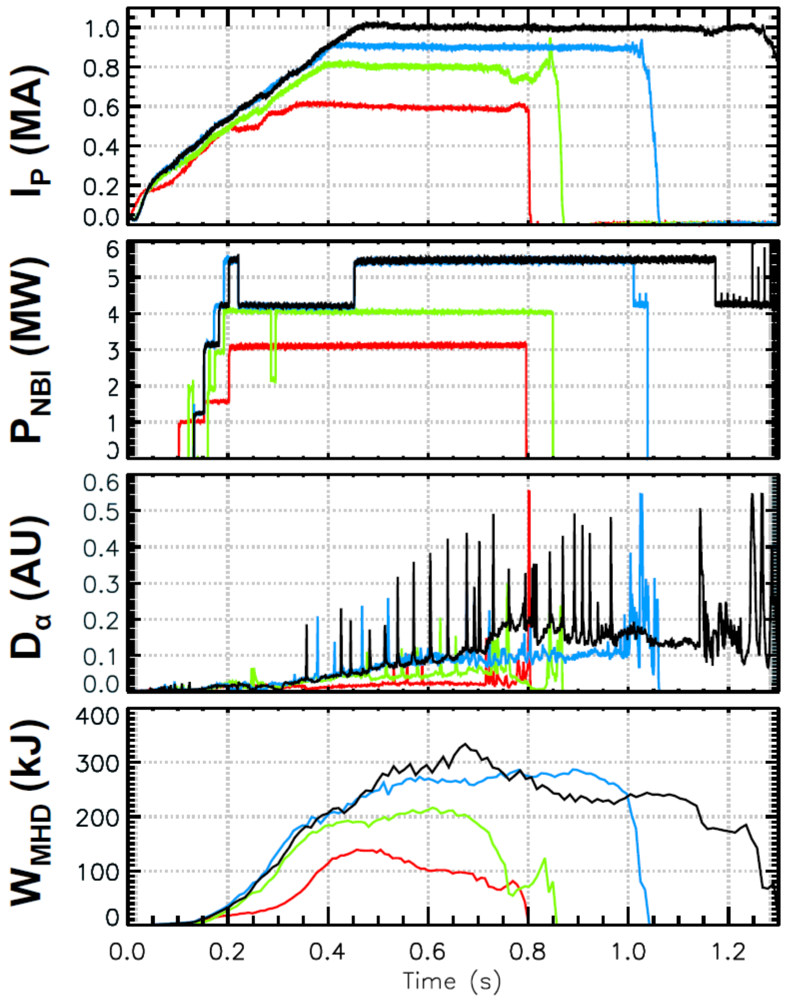
- L-modes used to identify optimal correction amplitude, phase



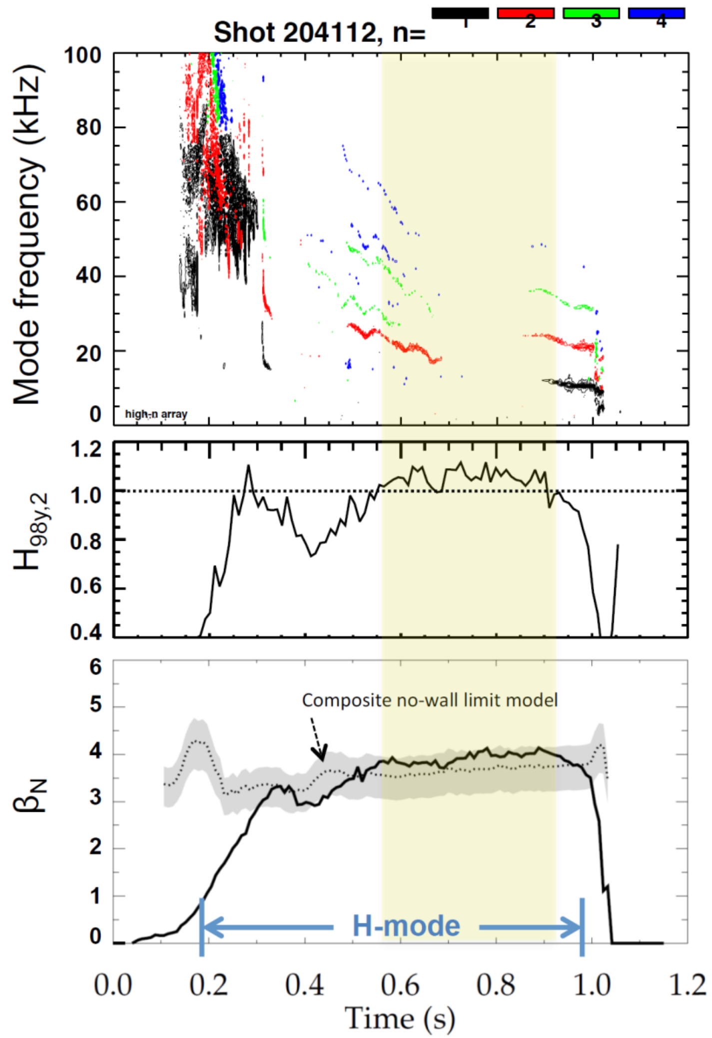
- Multiple compass scans confirm optimal L-mode EFC in flattop



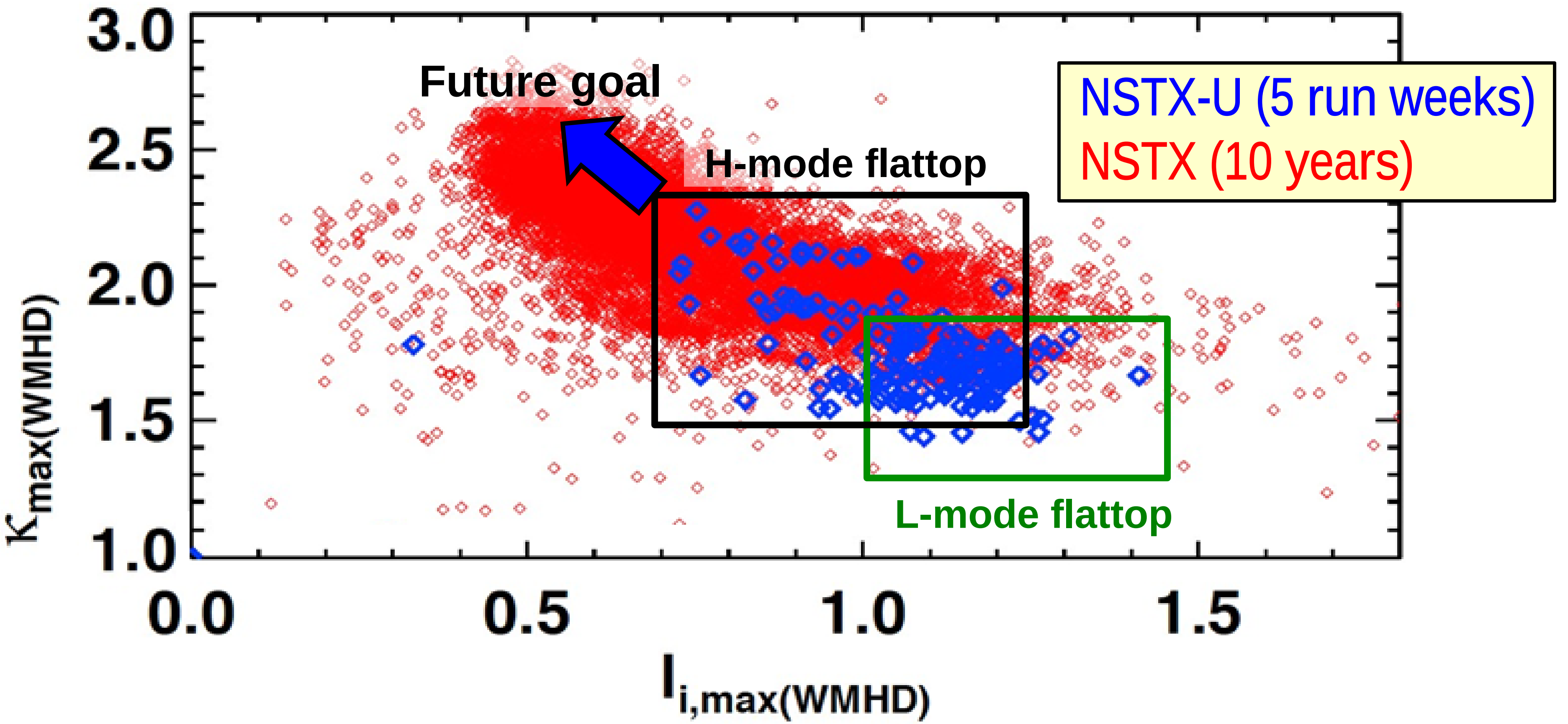
Recovered ~1MA H-modes with weak/no core MHD



$H_{98} \geq 1$, $\beta_N \geq$ n=1 no-wall limit



Accessed low l_i and high κ using progressively earlier H-mode and heating + optimized EFC

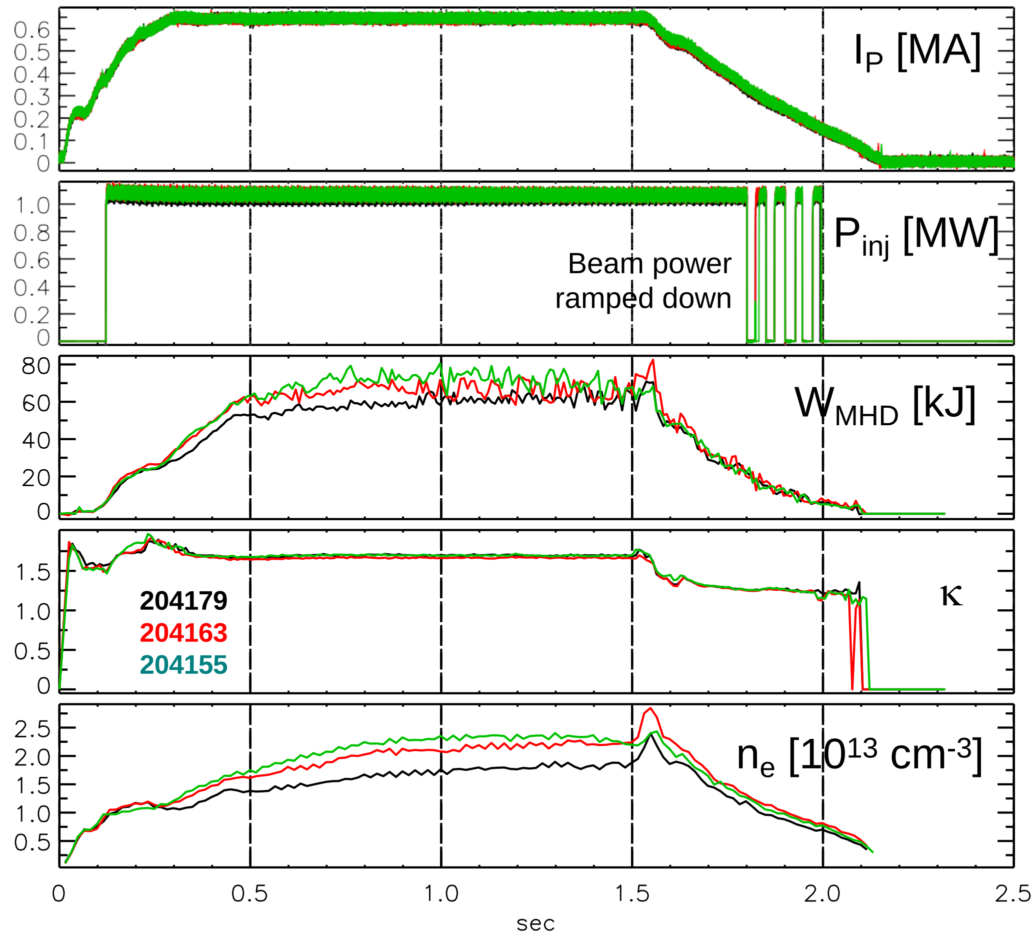


- **NSTX-U: Additional sensors improve estimation of Z, dZ/dt**
- **Goals for next run:**
  - **Access l_i = 0.5-0.7, κ=2.4-2.7, B_T = 0.75-1T, I_P = 1.5-2MA**

Shutdown handler used for well-controlled disruption-free L-mode ramp-down

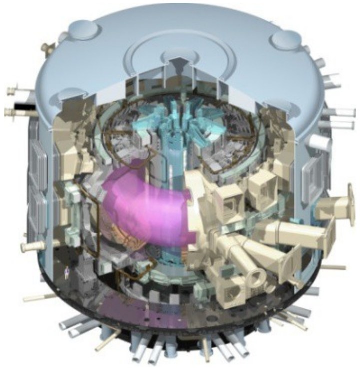
- Three morning fiducials
- One operator waveform used to start ramp-down at t=1.5s
- Ramp-down is inner-wall limited, power and current slowly ramped off

L-mode Rampdowns Triggered By a Single Switch



NSTX-U Mission Elements:

- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond


ITER

Topical science areas:

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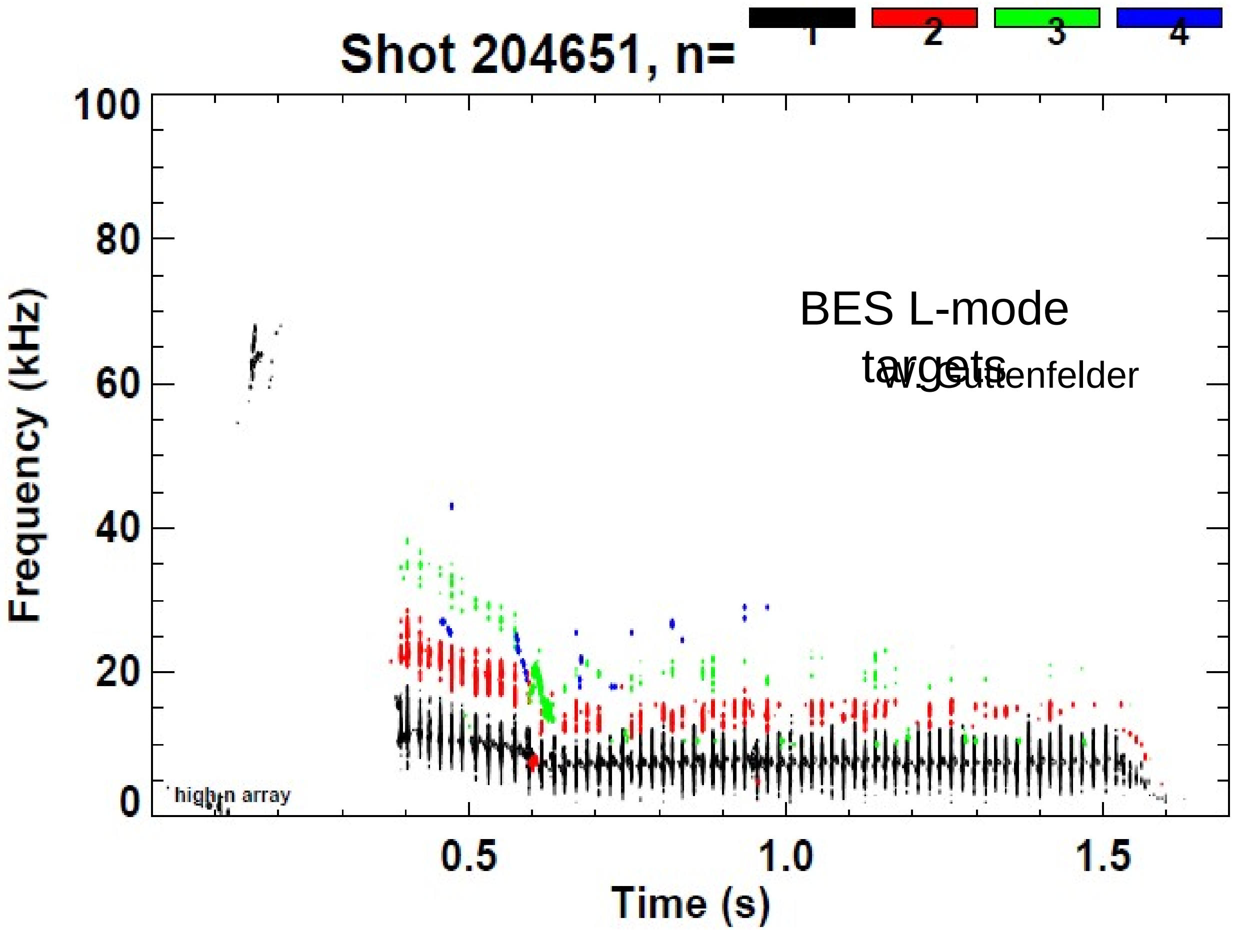
- – Energetic Particles

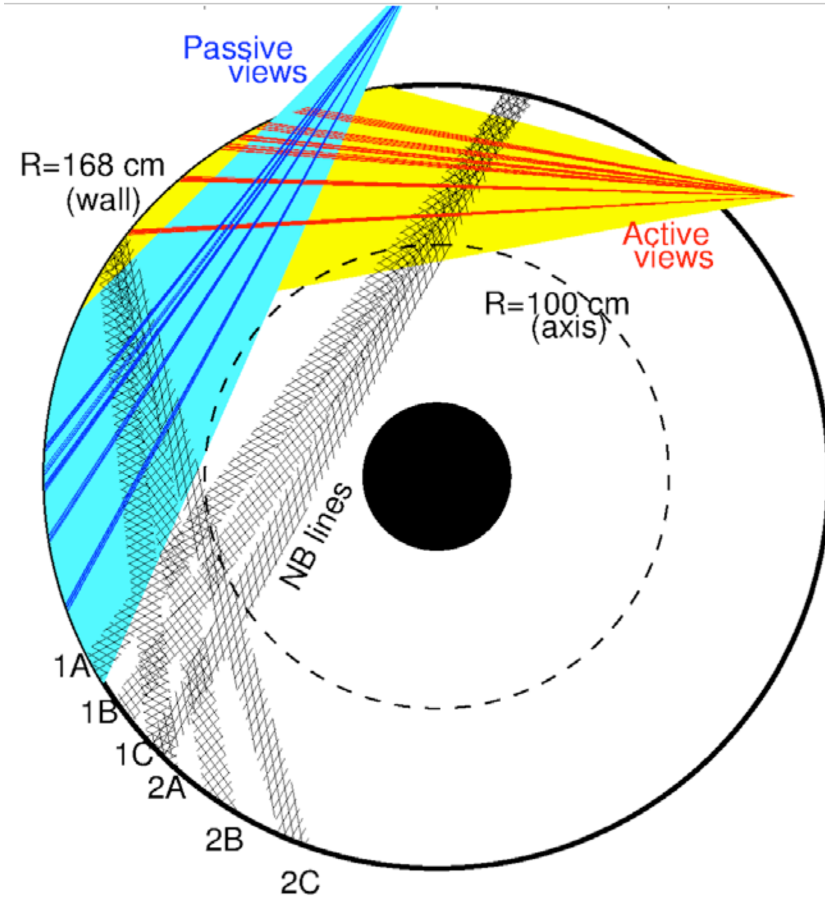
NSTX-U: Long-lived stationary sawtoothing discharges generated with core rotation f~15kHz



Previously very difficult to achieve in NSTX due to limited flat-top

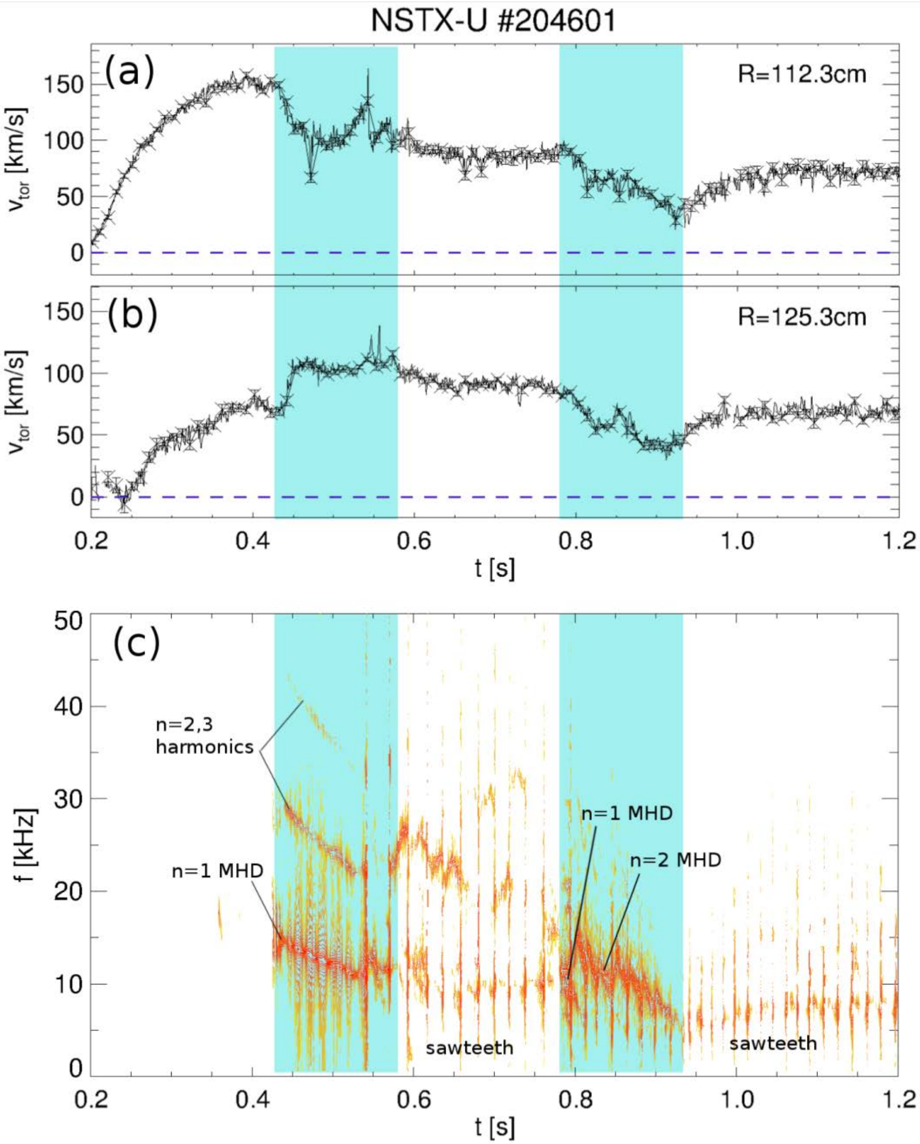
Real-Time Velocity (RTV) is a fast (up to 5kHz) system based on active spectroscopy

- System based on active charge-exchange spectroscopy (NB1 line)
- Monitor C VI, n=8-7 line @ 5291nm
- RTV views interleaved with CHERS views at midplane
- 4 views available
  - R=112, 125, 132, 140cm



M. Podestá

MHD, sawteeth compete in v_ϕ redistribution; different time scales, high f_{samp} or RTV enables separation



- Complex scenario
  - MHD n=1,2 modes act on ~10ms time scale
  - Sawteeth act on ~1ms time scale
- High f_{samp} of RTV allows to differentiate time scales
- Complements high spatial resolution CHERS profiles

M. Podestá

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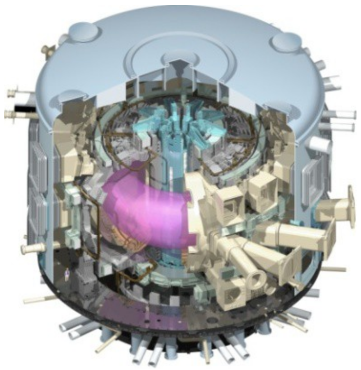

ITER

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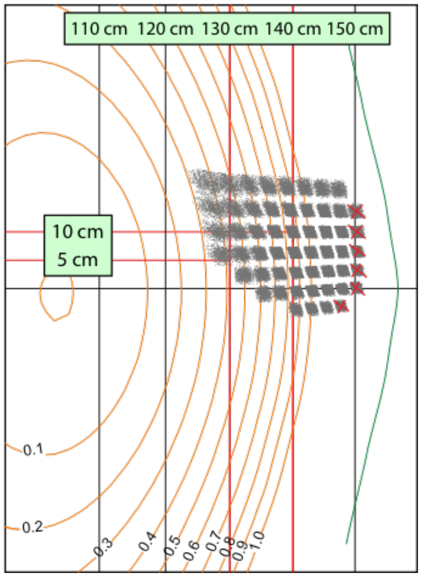
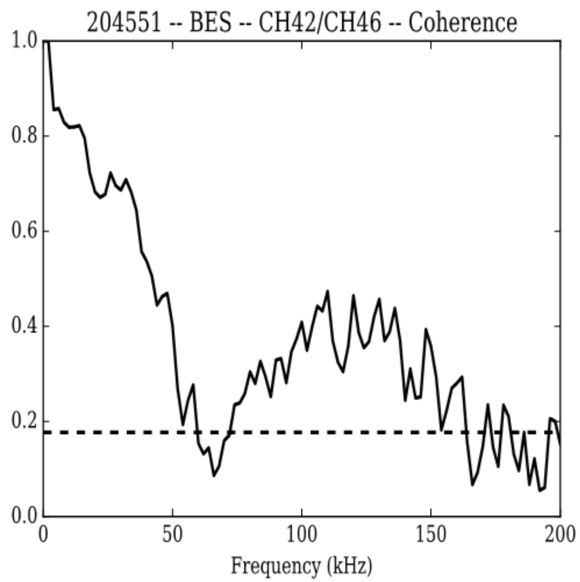
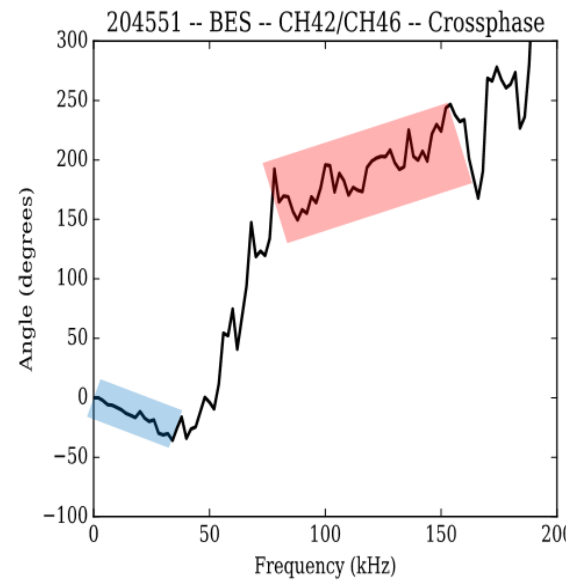
NSTX-U: Bimodal turbulence seen in some L-modes
using upgraded 48 channel Beam Emission Spectroscopy (BES) system







ΔZ = 3 cm
R = 142 cm
Δt = 24 ms

11 km/s in ion diamagnetic direction

13 km/s in electron diamagnetic direction

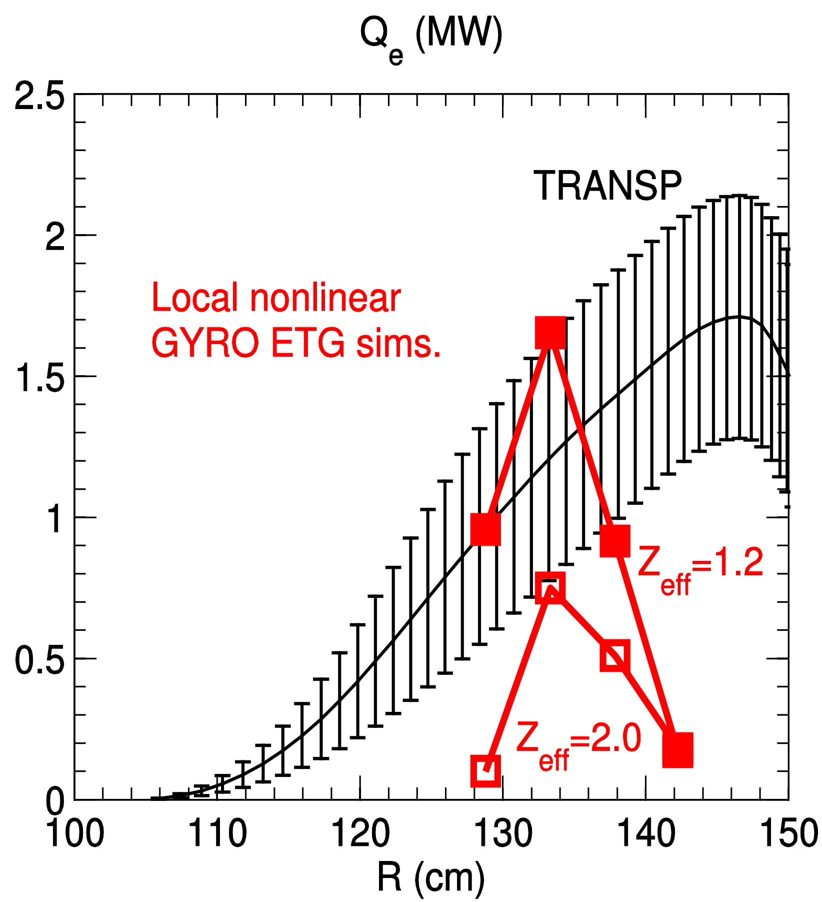
- Modes propagate in opposite directions
  - Similar spectra seen with DIII-D and TFTR BES
  - Potential link to grad B direction?
  - Gyro-kinetic modelling underway

Same NSTX-U L-modes: Nonlinear ETG simulations give significant transport (R=129-140 cm, r/a=0.47-0.67)

- $Q_{e,etg}$ large enough to account for $Q_{e,exp}$ if $Z_{eff}=Z_{eff,c}\approx 1.2$
  - Larger Z_{eff} (VB $Z_{eff}\leq 2$) → lower $Q_{e,etg}$

- New high-k microwave scattering diagnostic (for 2018 run) will be ideal for probing region of ETG turbulence

- *May require multiscale simulations for validation*



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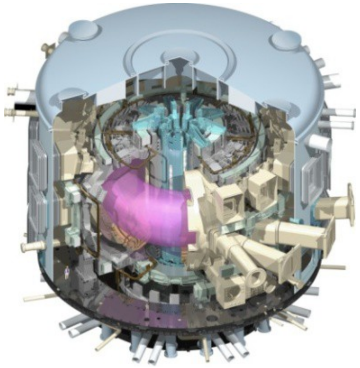

ITER

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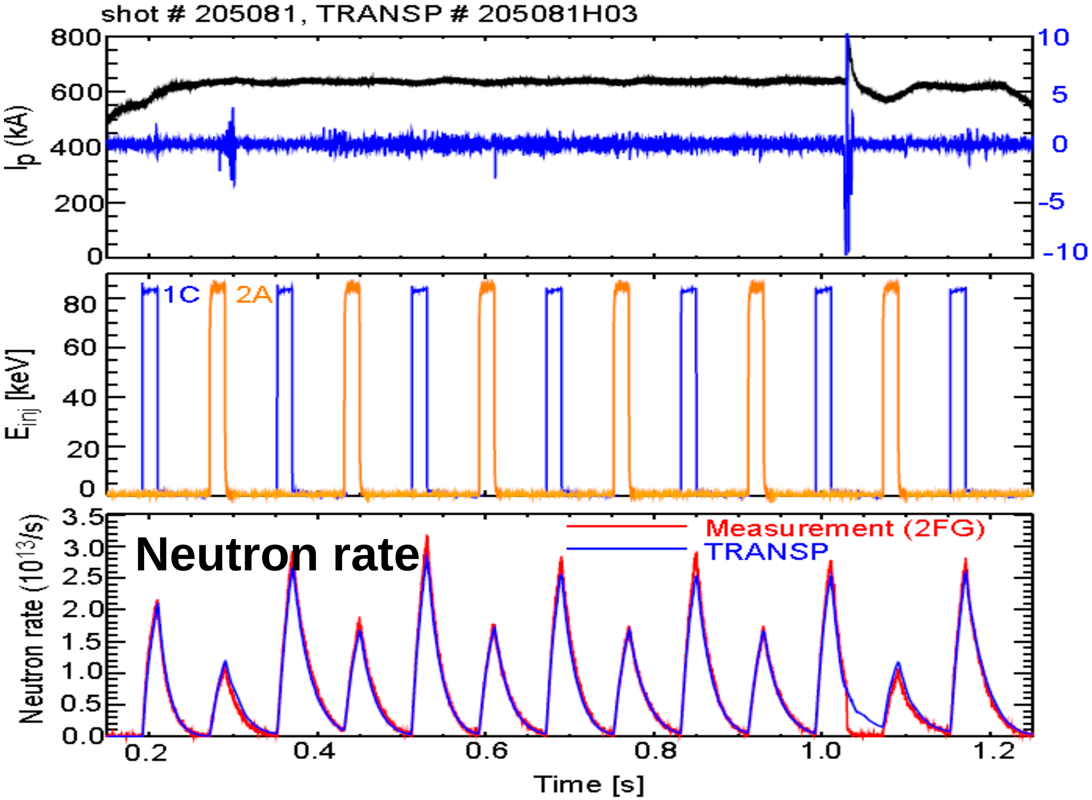
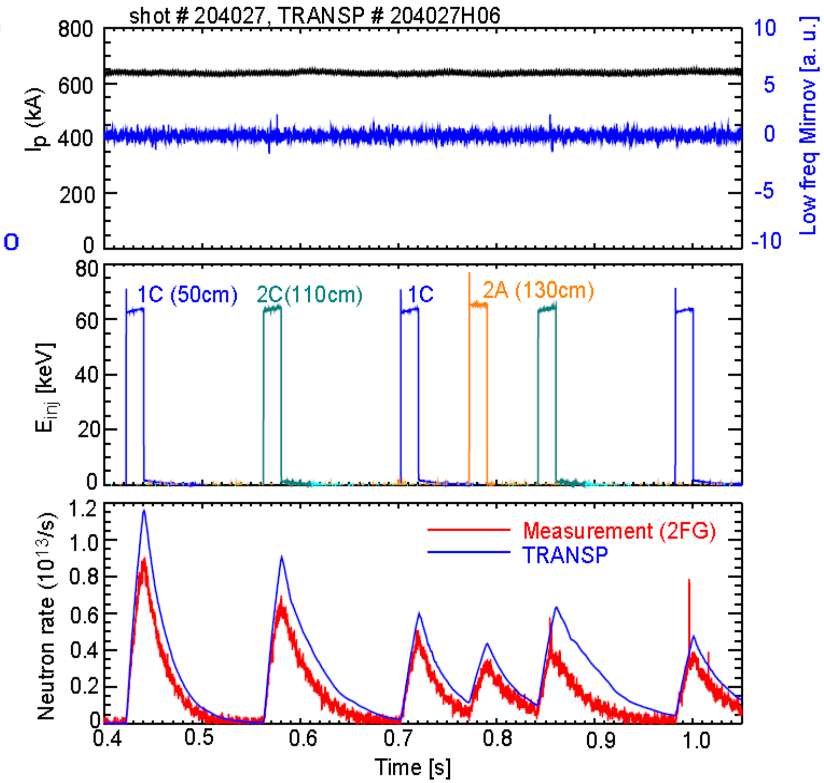
Explored fast-ion behavior with original and new NBI via beam blips with different NBI energies

E_{NBI} = 85keV



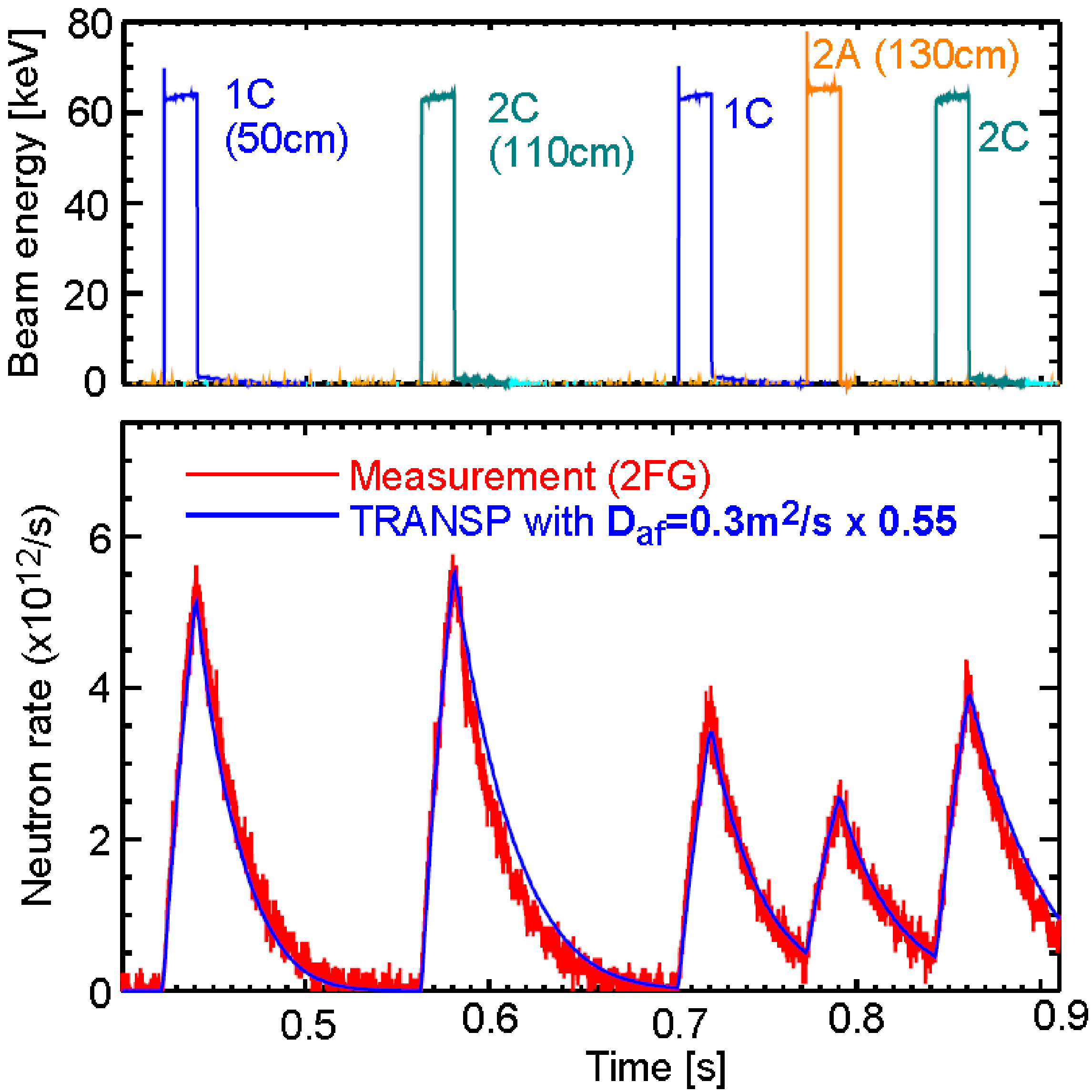
E_{NBI} = 65keV



- Good agreement between neutron measurement and TRANSP prediction
- ~20% discrepancy between data and TRANSP predictions

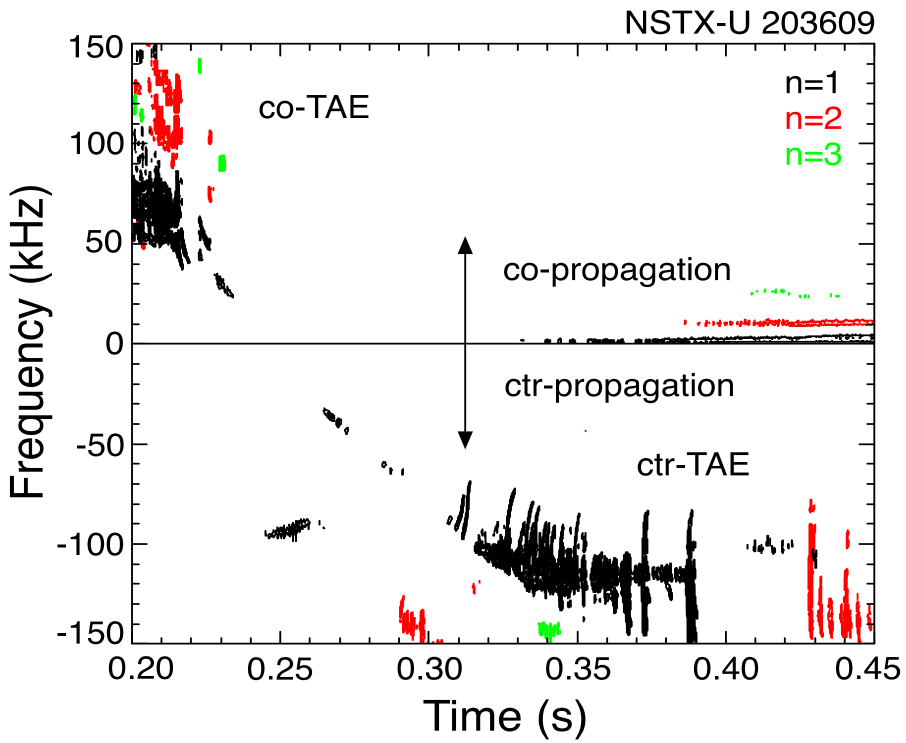
- Exploring possible causes, including NBI source energy split

Agreement improved for E_{inj} = 65keV using small anomalous fast-ion diffusion



- TRANSP decay time gets reasonable agreement with data when a small anomalous fast ion diffusivity (D_{af}=0.3m^2/s) is used
- → Beam ion behavior is still close to classical theory

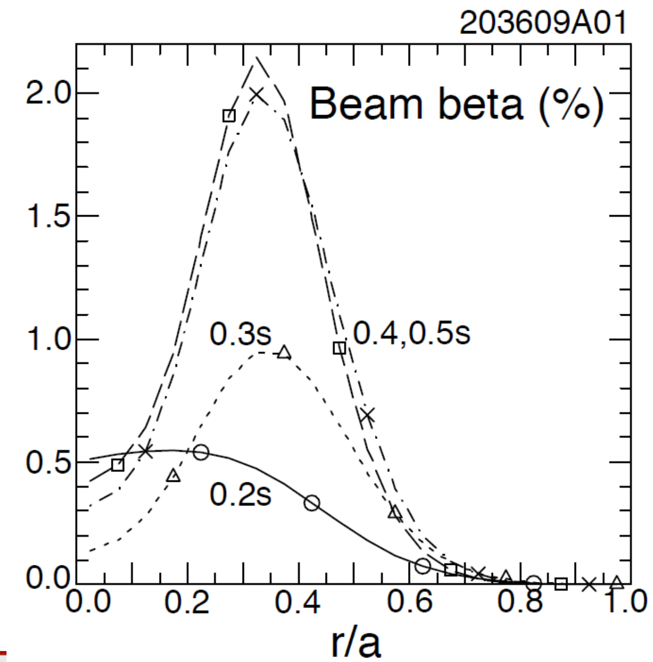
NSTX-U: Most tangential NBI generates counter-propagating Toroidal Alfvén Eigenmodes (TAEs)



- Counter-propagating TAE predicted for **hollow** fast-ion profiles

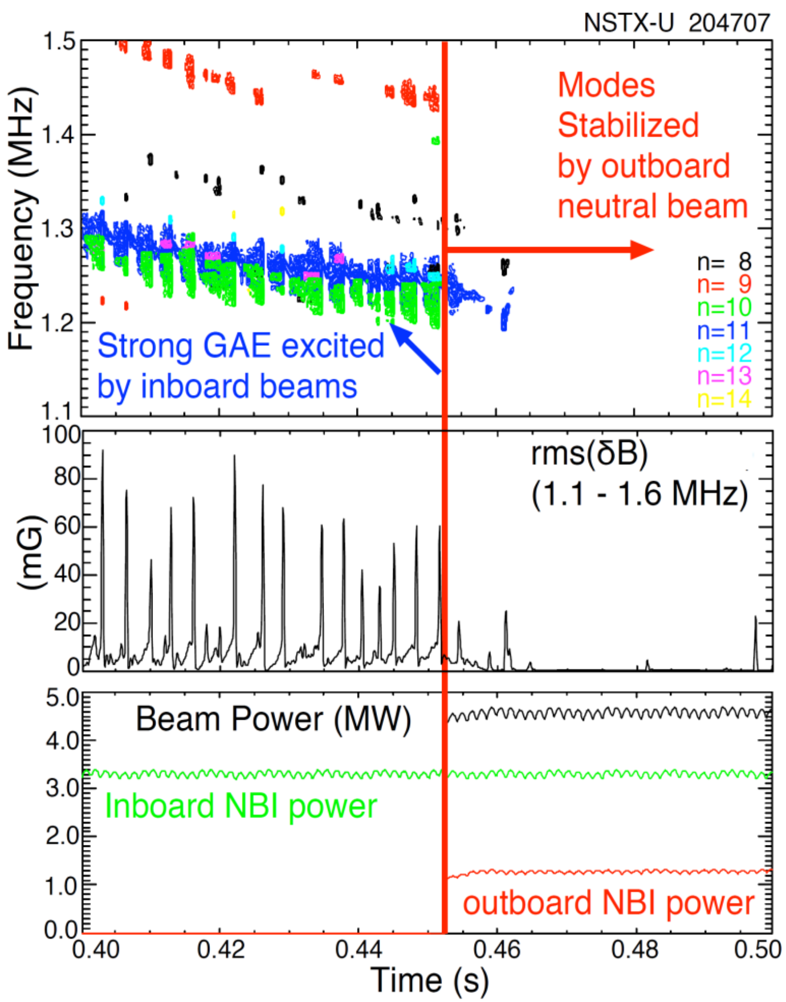
*H.V. Wong, H. Berk, Phys. Lett. A **251** (1999) 126.*

- TRANSP: As current builds up beam fast-ion beta profile predicted to become hollow

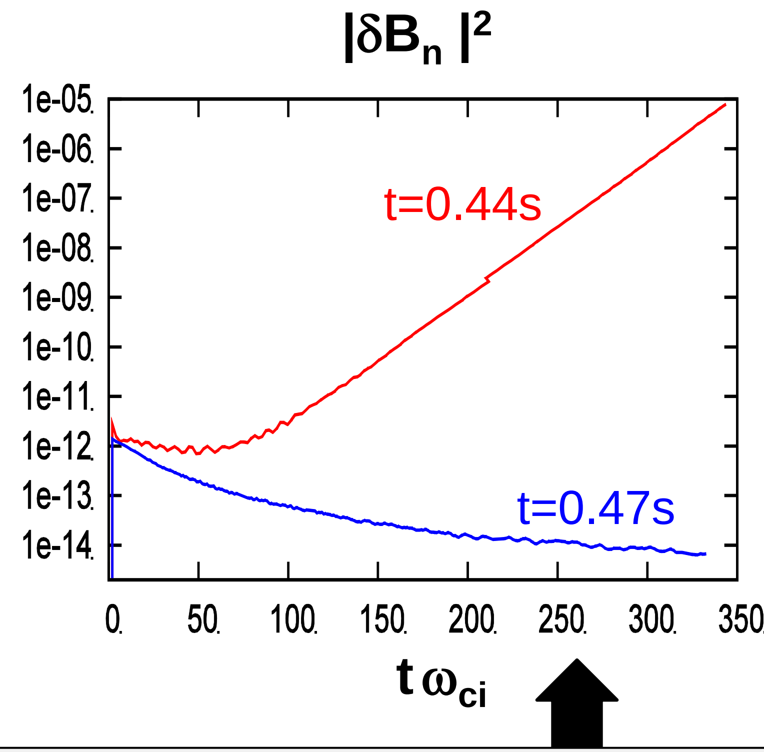


- **1st evidence of off-axis NBI in NSTX-U**

NSTX-U tangential 2nd neutral beam suppresses Global Alfven Eigenmode (GAE) – consistent with simulation



HYM code simulation of #204707, n=10



- HYM code: growth of n=10 counter-GAE from 1st NBI
- HYM: suppression of n=10 counter-GAE by 2nd NBI
- Most unstable *n*-number, mode ω consistent with HYM

New 2nd NBI already powerful tool for fast ion, AE physics

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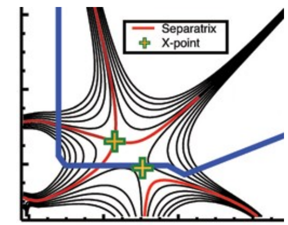
ITER

- Develop solutions for plasma-material interface (PMI)



Snowflake/X

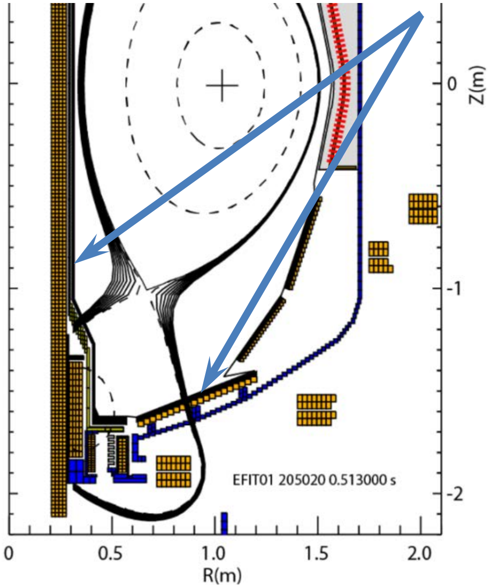
Liquid metals / Li

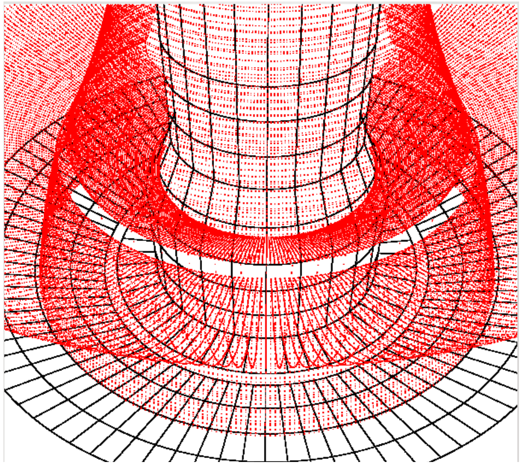
- Advance ST as Fusion Nuclear Science Facility and Pilot Plant

ST-FNSF / Pilot-Plant

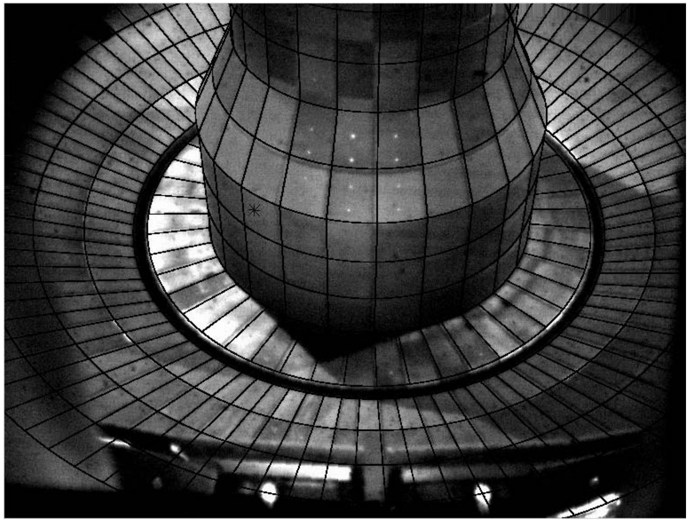
Throughput-optimized camera and high-X-point L-modes enabled <u>near-separatrix</u> turbulence imaging in NSTX-U

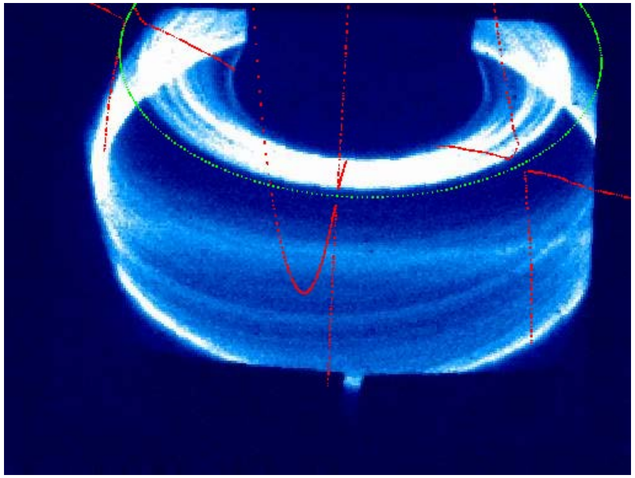
- Divertor turbulence imaging through different species/charge states provides information at different spatial locations
- Throughput-optimized setup enabled turbulence imaging via C III (up to 140kHz)
  - Filaments along divertor legs (vs. filament footprint on floor via Li I or Dα)





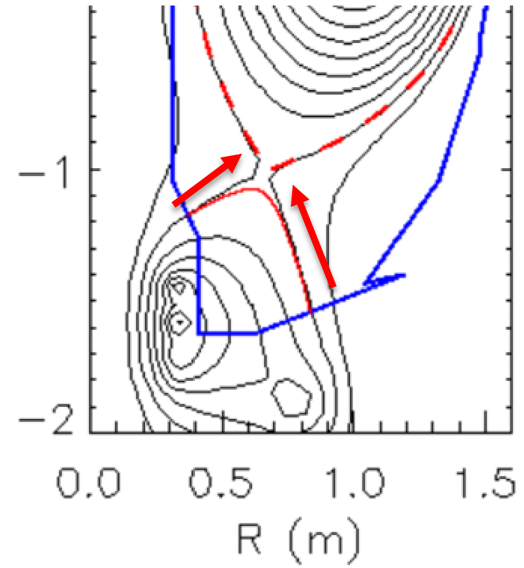
Reconstructed view + separatrix



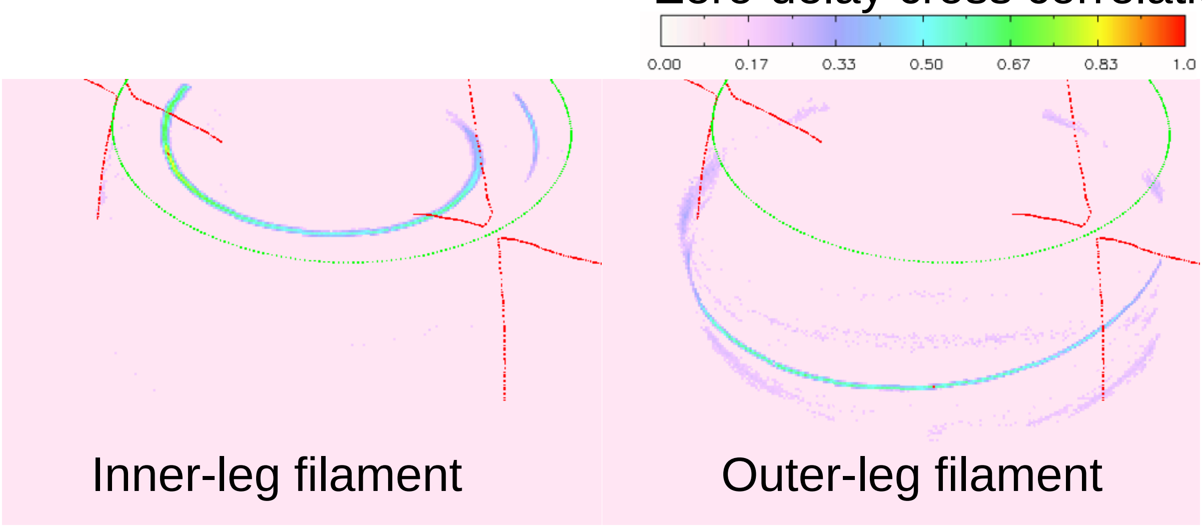


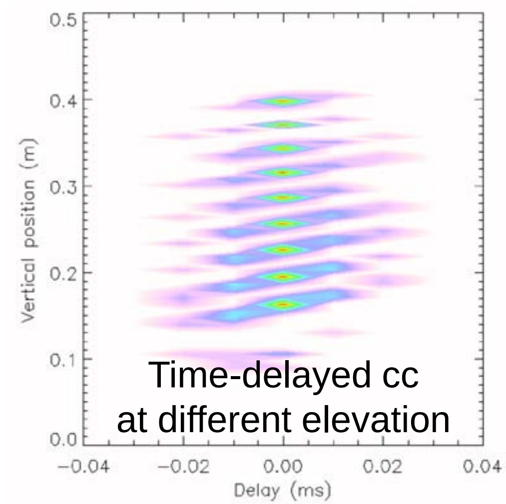
Time delayed cross correlation shows opposite toroidal rotation for inner/outer leg filaments

- Time-delayed cross correlation of single pixel with rest of image to show average filament propagation
- Apparent poloidal motion for both inner and outer leg filaments towards X-point (also in C-Mod, J. Terry, JNME 2016)
  - Or equivalently opposite toroidal directions
  - Inconsistent with flux tube rigid rotation (as in J. Terry JNME 2016)
- Poloidal velocity ~1km/s

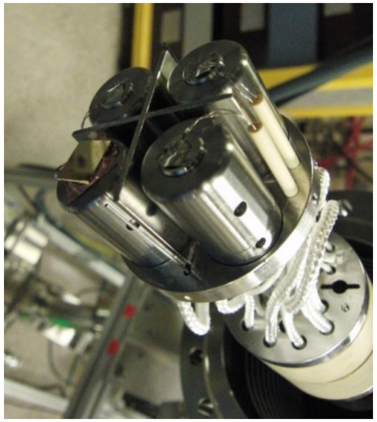


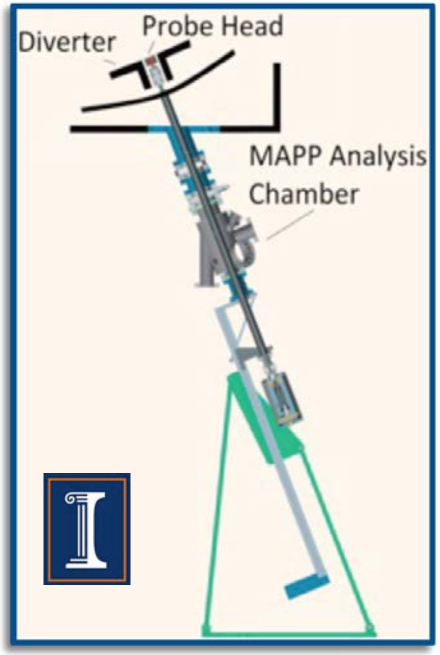
Zero-delay cross correlation

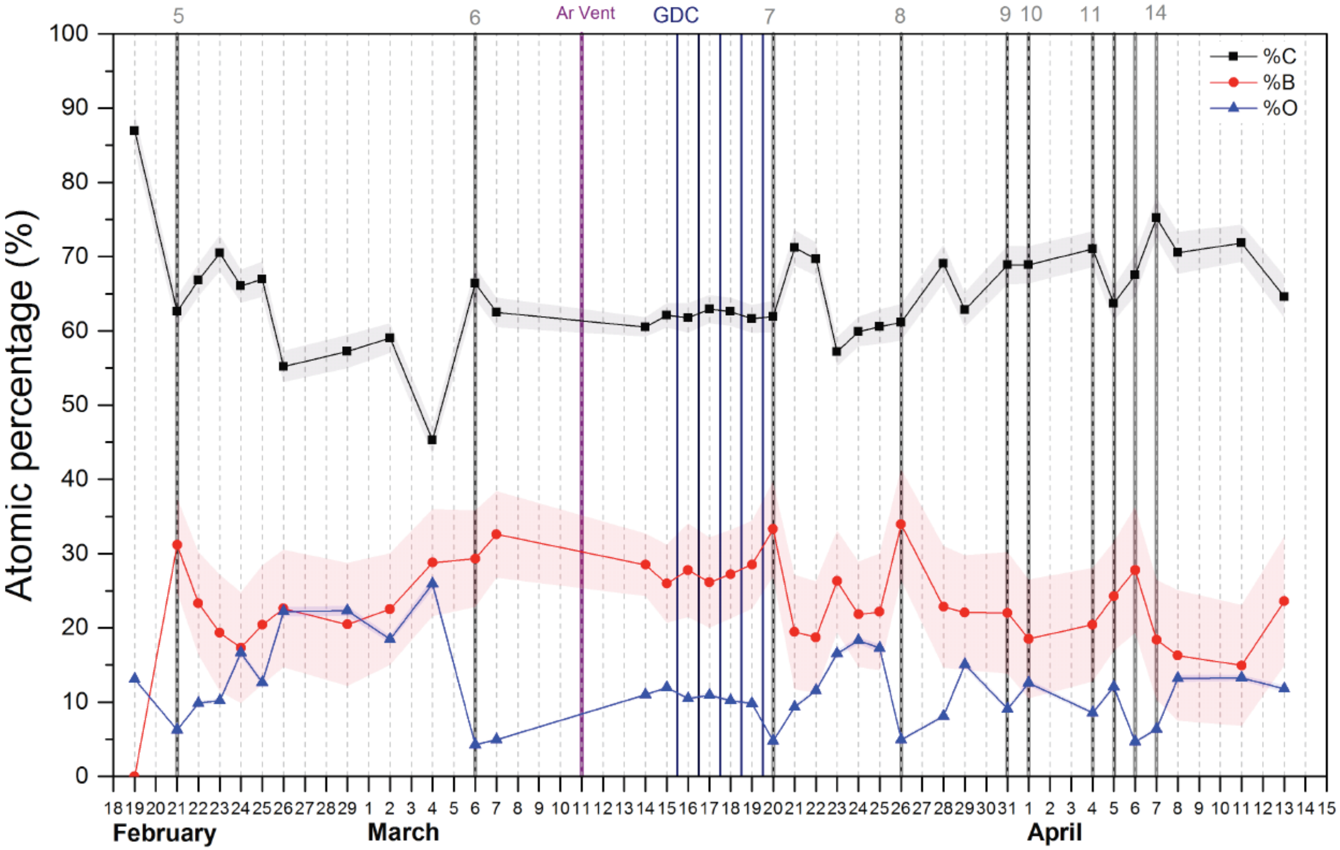




Material Analysis & Particle Probe (MAPP) providing new measurements of surface evolution in NSTX-U







- Tracked C/B/O evolution, correlated with plasma performance
- Implemented remote-control + between-shot MAPP analysis
- Future: Use with Li, understand complex Li chemistry/evolution

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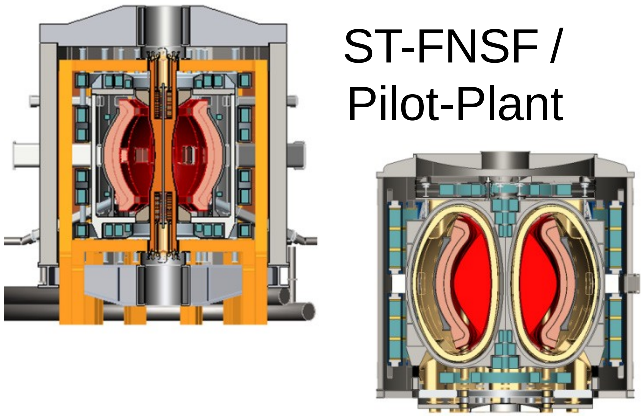
ITER

- Develop solutions for plasma-material interface (PMI)

Liquid metals / Lithium

Snowflake/X

- Advance ST as Fusion Nuclear Science Facility and Pilot Plant
  - ➢ Results of 5yr study published in Nuclear Fusion
  - ➢ Invited talk: TOFE 2016 - FNSF/Pilot Plant study
  - ➢ Invited talk: APS 2016 - Compact Pilot Innovations


ST-FNSF / Pilot-Plant

NSTX-U strongly supporting advancing predictive capability, ITER, PMI solutions, and next-step STs

- For more results info, see 2016 APS-DPP presentations here
- Productive first year of operations on NSTX-U
  - Rapid H-mode access, scenario development, error field correction
  - Surpassed NSTX maximum magnetic field and pulse-duration
  - New fast-ion physics with 2^{nd} NBI – GAE stabilization, counter TAE
  - Commissioned new advanced PMI diagnostics – MAPP
- Developing advanced predictive capability
  - New models for tearing stability, reduced models for RWM
  - Global ion-scale turbulence (GTS), ∇n ETG stabilization
  - GAE stabilization from 2^{nd} NBI consistent with simulation
  - Exploring SOL widths, advanced divertor interactions with 3D fields
- Developed attractive Cu, HTS ST-FNSF, Pilot concepts
- In 2017 will emphasize collaborations, 5YP prep
- Aim to resume NSTX-U physics operation in CY2018 - TBD

Progress toward FES Notable Outcomes

- **Notable Outcome 1:** Perform experimental research …at magnetic field, I_P, pulse length beyond that achieved in NSTX…
  - NSTX-U pulse lengths (>2s) exceeded NSTX (< 1.8s) at field (0.6-0.65T) exceeding maximum NSTX field (0.55T)
  - Achieved I_P ~ 1MA – **but did not exceed max NSTX I_P = 1.3MA**, will require more run time for early EFC + improved early H-mode scenarios

- **Notable Outcome 2: …**support the FES joint research target to "Conduct research to detect and minimize the consequences of disruptions in present and future tokamaks"
  - Automatic shutdown algorithms developed, detecting disruptions in real-time via I_P error, vertical motion, n=1 locked mode signature (future)
  - DECAF code progressing toward real-time application
  - MGI using an electromagnetic valve similar to ITER design
    - 2 MGI valves installed, commissioned, **not tested in plasma (PF1AU failure)**

Likely goals for next NSTX-U run campaign

Only a subset, and will decide as a team via next Research Forum

- Increase field to 0.8-1T, current to 1.6-2MA
- Develop early H-mode / low-l_i / high-κ scenarios
- Assess H-mode energy confinement, pedestal, and SOL characteristics with higher B_T, I_P, P_{NBI}
- Complete assessment of effects of NBI parameters on fast ion distribution, neutral beam driven current profile
  - Expand upon new physics already observed w/ tangential NBI
  - Increase NBI current drive, non-inductive fraction
- Key physics, operational tools for high-performance
  - Developed shape & vertical control, new inboard gap control, EFC, HFS & LFS fueling under PCS, automated shutdown
  - Need to commission: n=1 dynamic EFC, RWM control
  - Test Impurity Granule Injector (IGI), MGI, Li evaporation

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- NSTX-U technical challenges
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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 presented capabilities/opportunities in December, gathering ideas now

DIII-D National Campaign proposals assessed by NSTX-U

Initial guidance: 3+1 week 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
  - NSTX-U selections discussed with GA, FFCC in December
    - **12 days total: Priority 1 (8 days), Priority 2 (4 days)**
  - Final selections will be made in coming days

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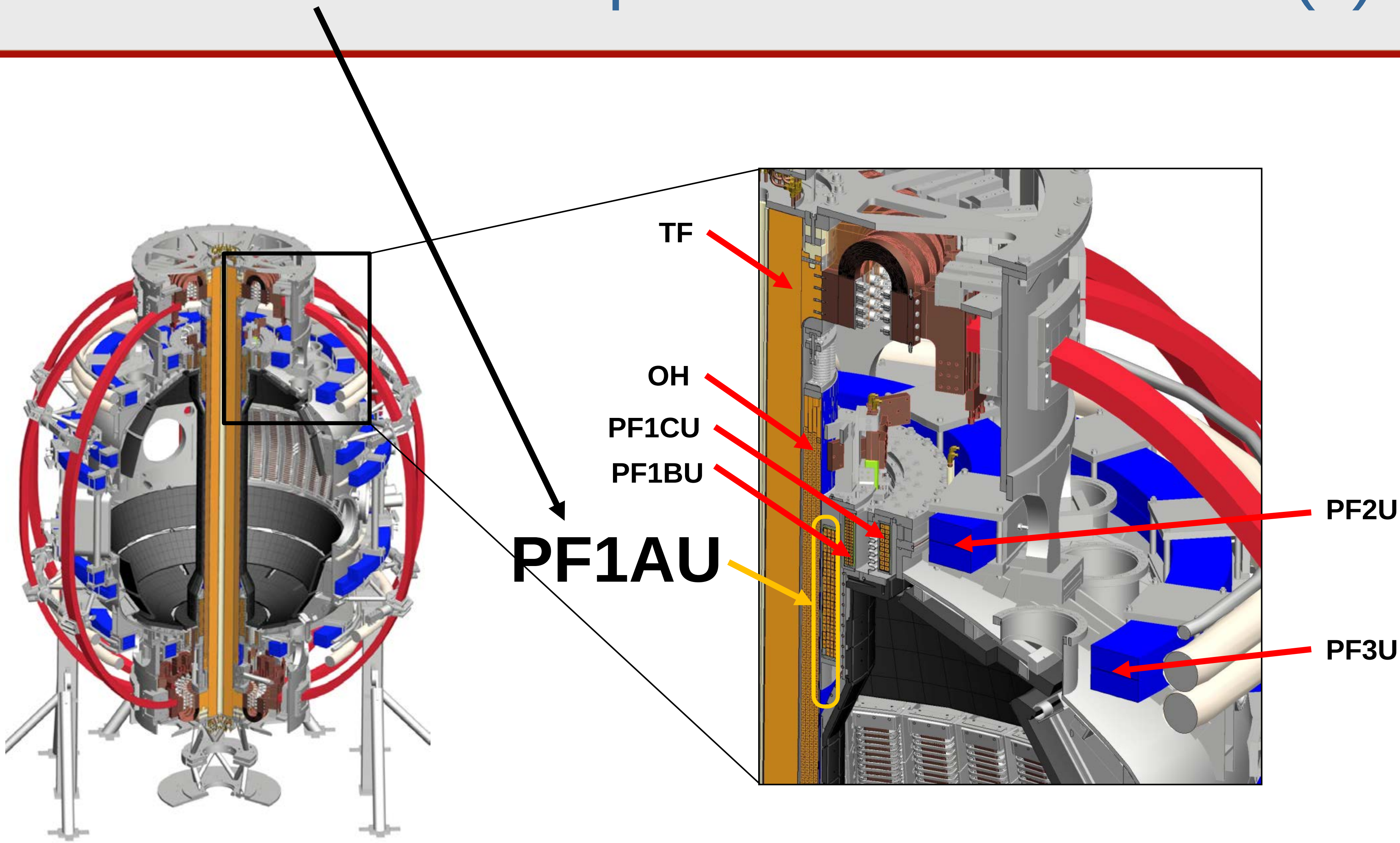
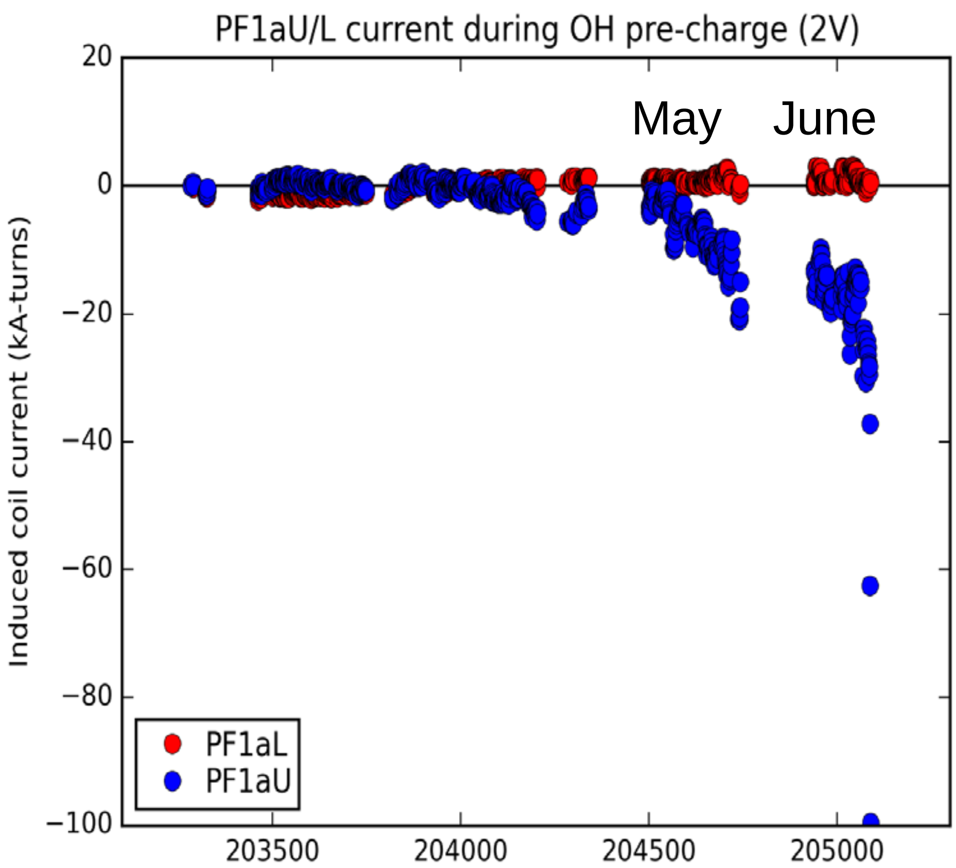
PF1AU coil developed turn-to-turn short(s)



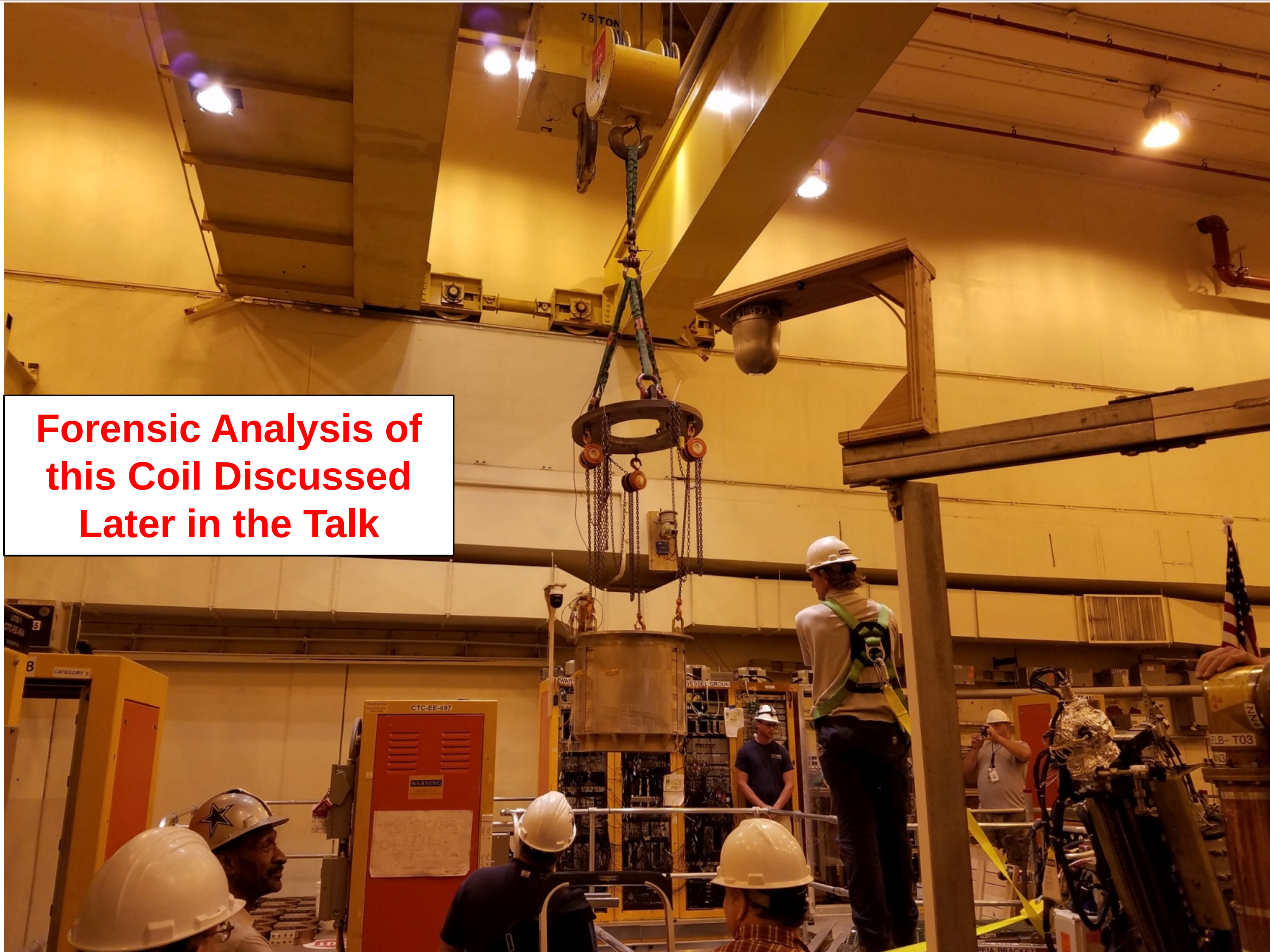
PF1AU coil failed gradually - coil inductance decreased 2-5% over three month period

- PF1AU carried current while open circuited during OH pre-charge phase
- Starts to conduct current at the end of ~March / April
- Very fast degradation on the final run day in June – 100kAt induced current
- PF1AL shows no anomalies



NOTE: Inductance change and induced current inferred from magnetics

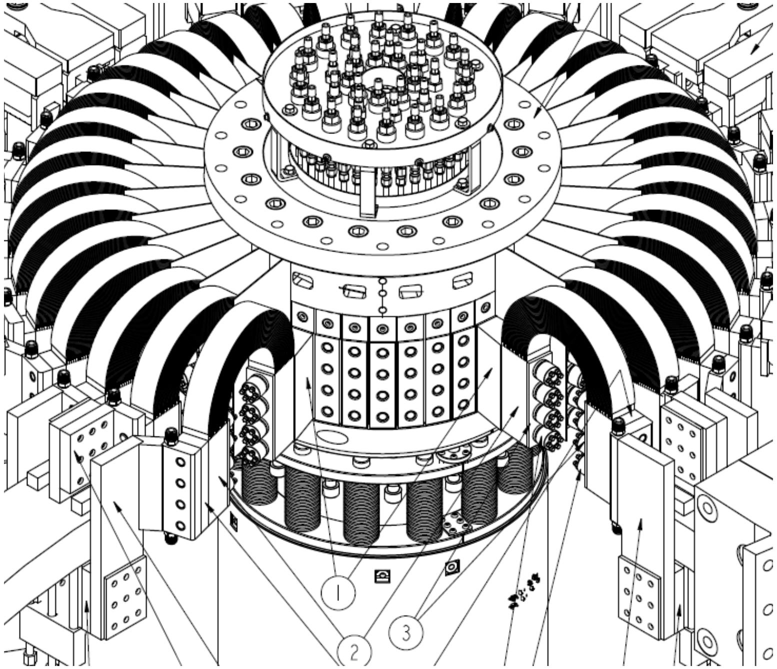
PF1AU removed 8/24/16

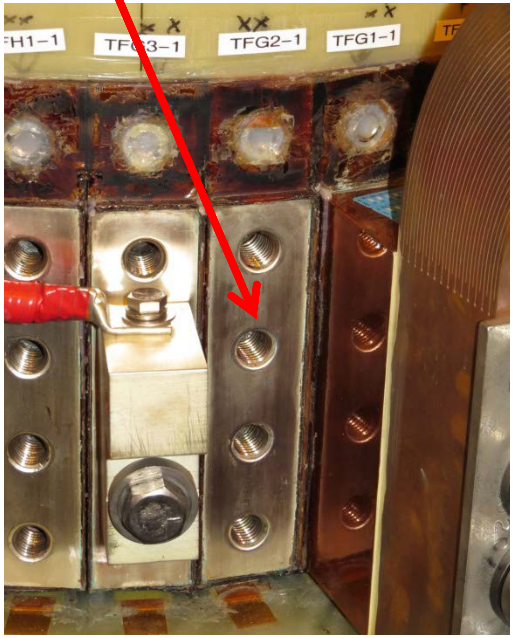


Forensic Analysis of this Coil Discussed Later in the Talk

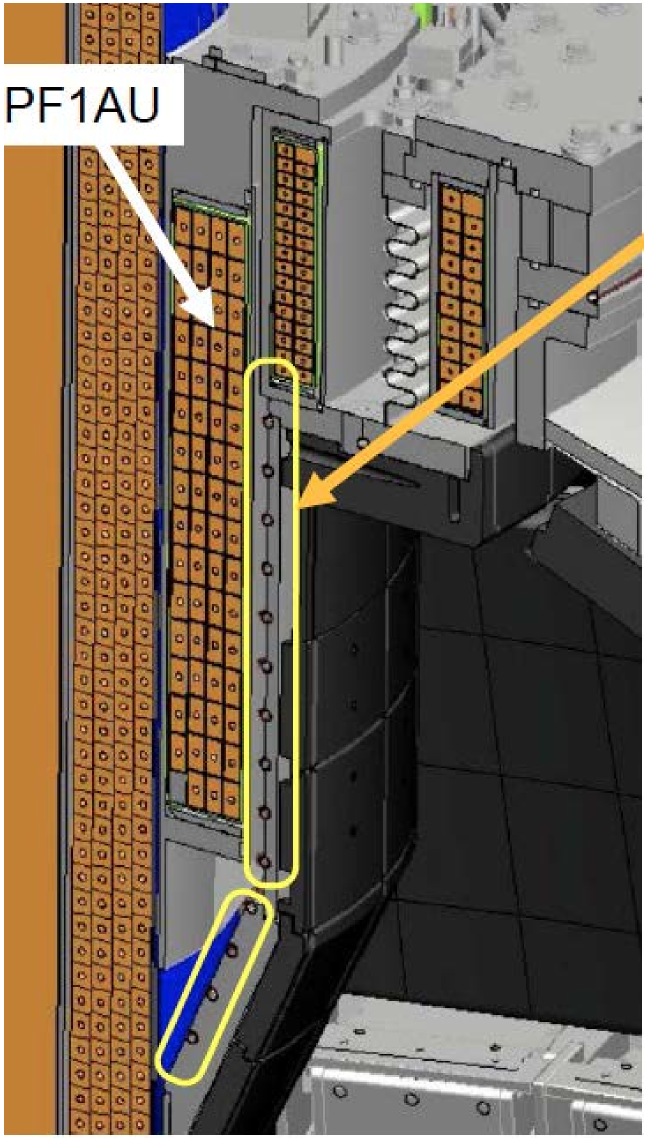
TF joints on CS bundle: All joint resistances and surface conditions were nominal after run

- In FY 2016, NSTX-U operated mostly at B_T ~ 6.5 kG up to ~ 2.2 s flat top for over 1000 shots
- TF joint measurements performed as TF joints were disassembled - joint surfaces in very good condition
- But, full performance will increase joint heating 5-6x





NSTX-U CS Divertor Cooling Tube Issues

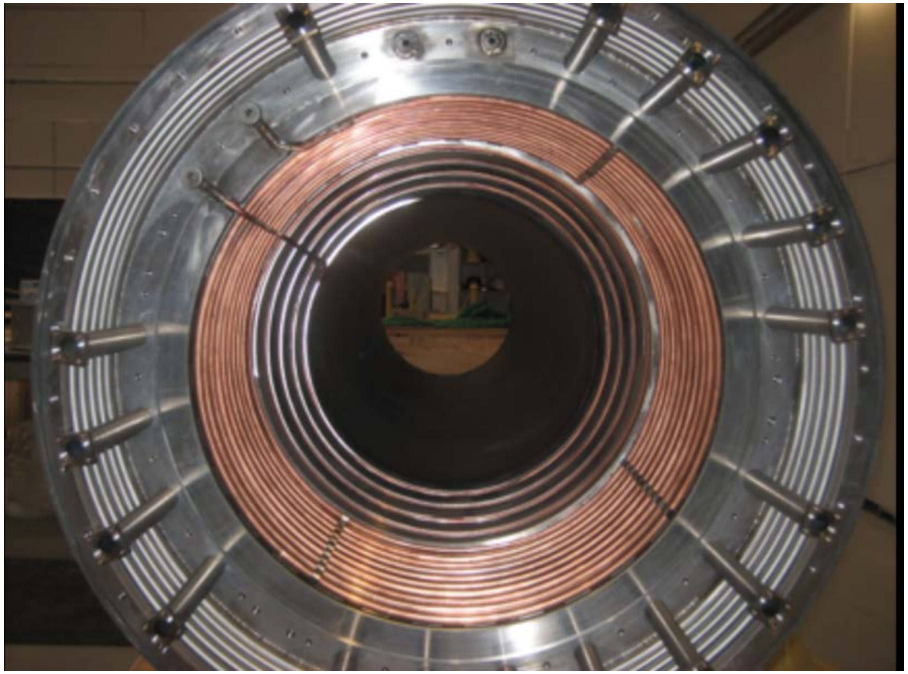


- NSTX-U has spiral cooling tubes on airside ID of center-stack casing ends to cool divertor region.
- Another set of vacuum side cooling tubes on the horizonal CS flanges (horizontal inboard divertor).
- Installed to cool PFCs between pulses to avoid thermal ratcheting over multiple high-power shots.
  - This cooling capability has not been needed or used yet, but will be needed in future.
- Similar tubing on bottom of CS casing near PF1AL coil.

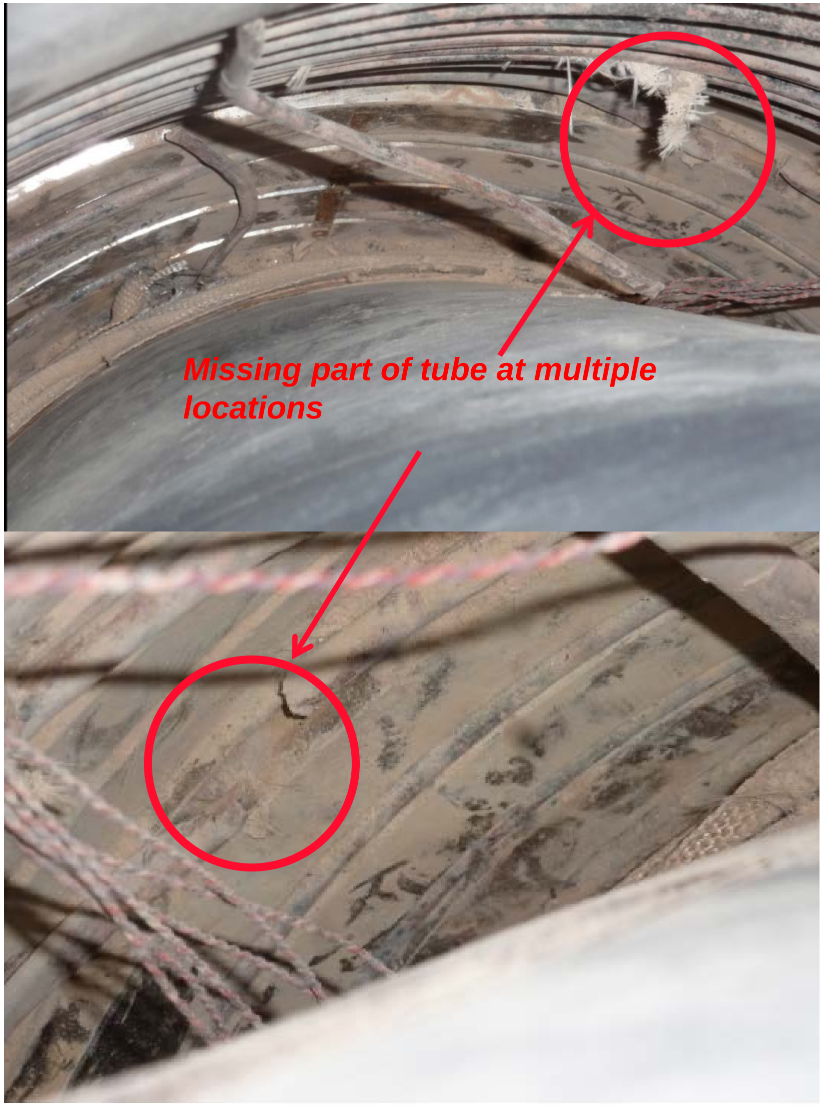
Divertor CS Cooling Tubes Severely Damaged

Induced currents in copper tube likely cause

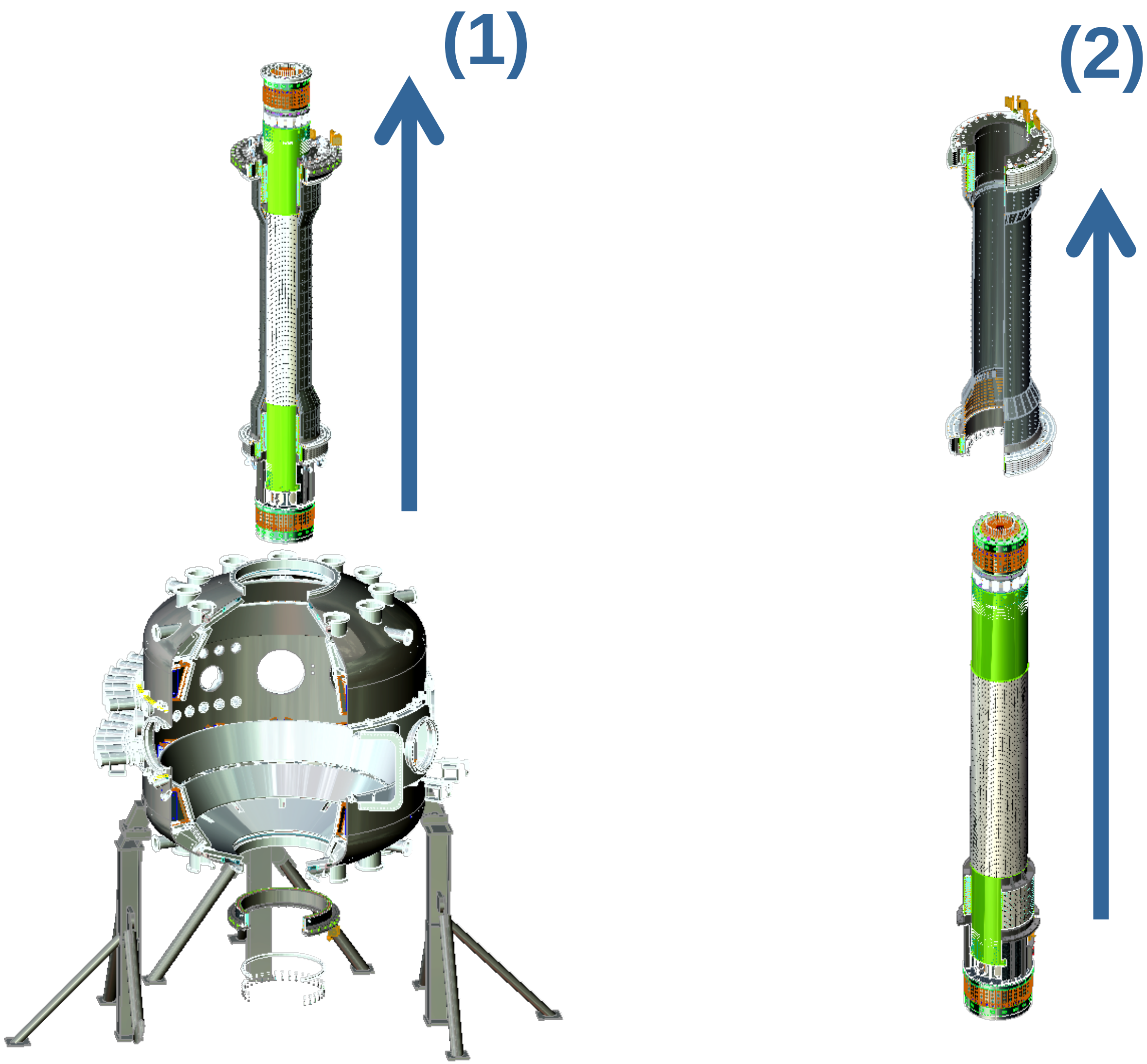
NSTX-U divertor CS cooling tube before installation



Severe damage in divertor CS cooling tubes



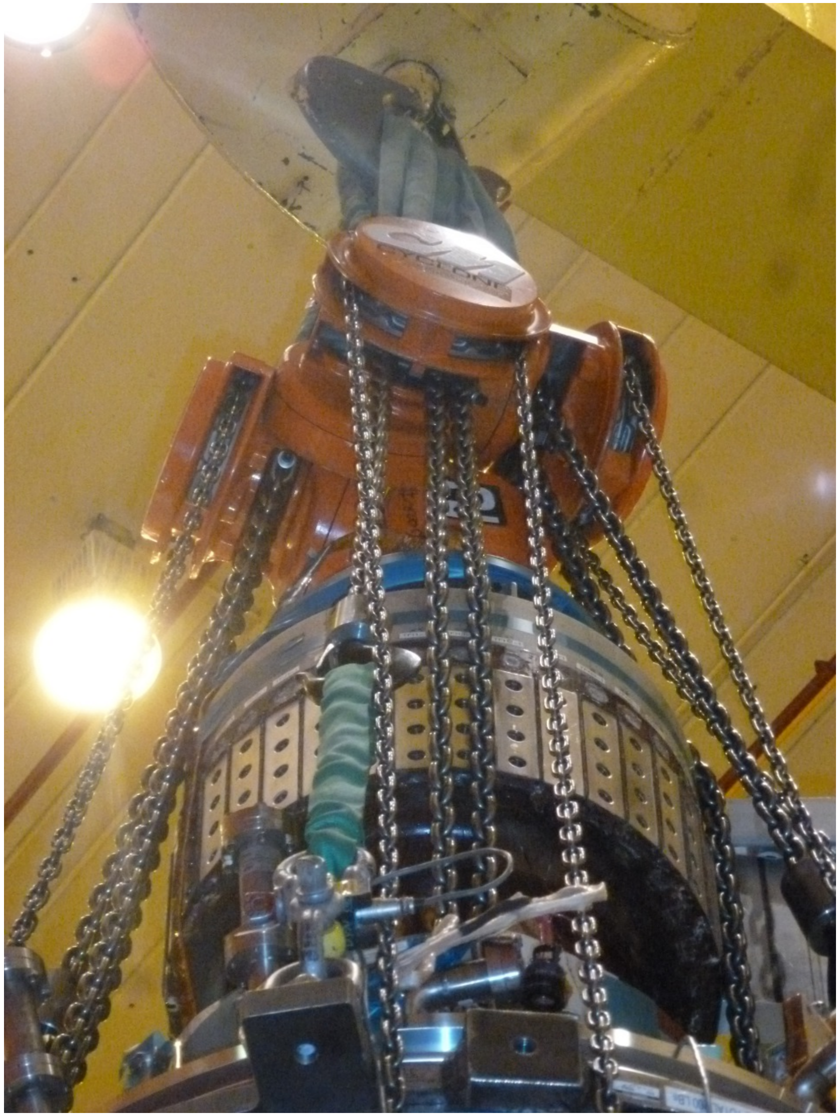
Lower cooling tube also breached → damaged → need to remove both CS and casing to access tube, PF1AL



Centerstack removed 11/17

CS on mounting stand after being pulled

CS casing lifted off



Casing fully separated from bundle

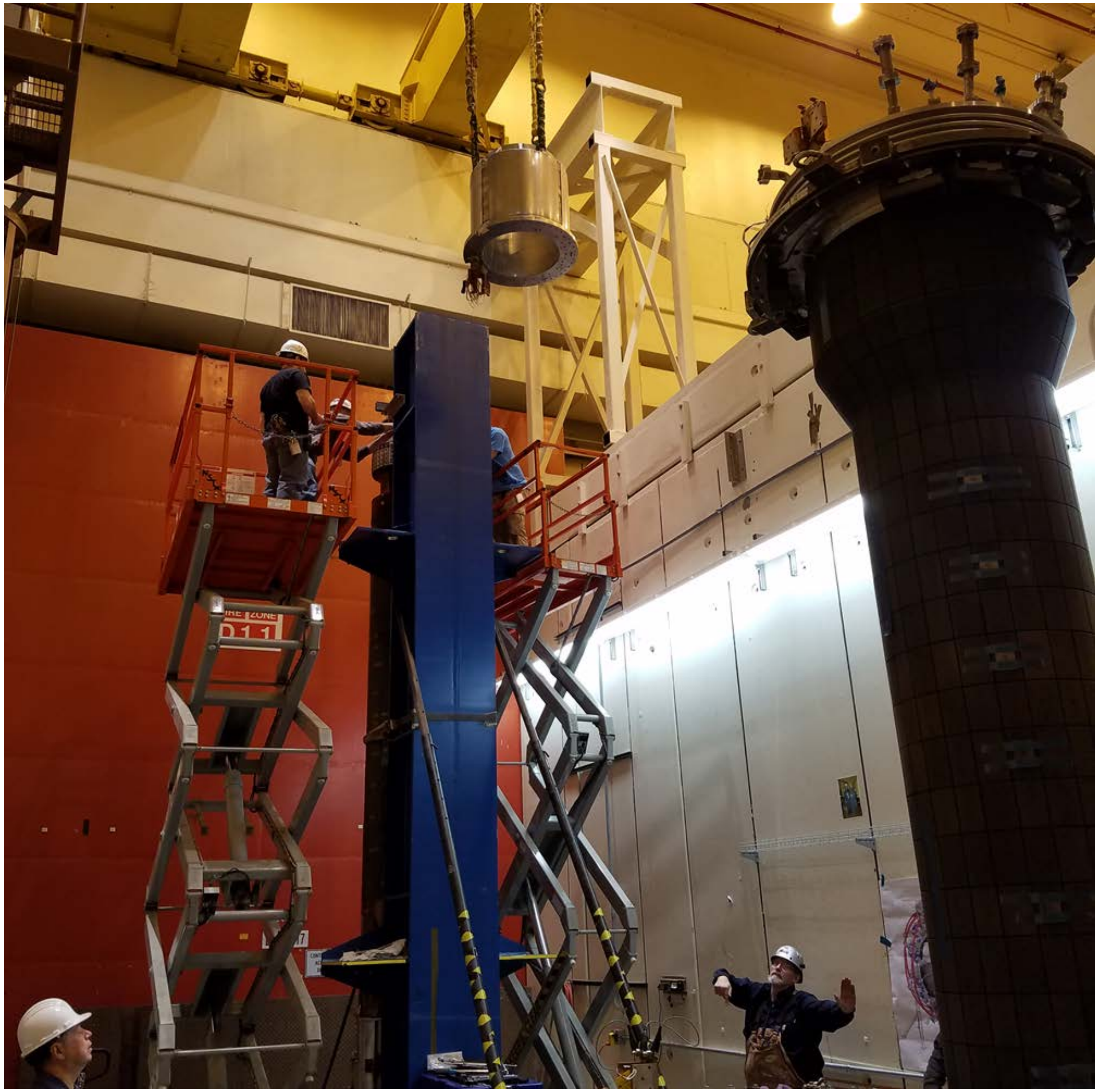
Lower cooling tubes also damaged

Failed Upper Cooling Tube
(Previously Reported)

Discovered a Failed Lower Cooling Tube
("powder" is microtherm insulation dust)

Note: This Result Anticipated Based on Pressure Testing of the Tube

PF1A lower successfully removed



PF1AU 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
+ great help from tech shop, FCPC techs

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

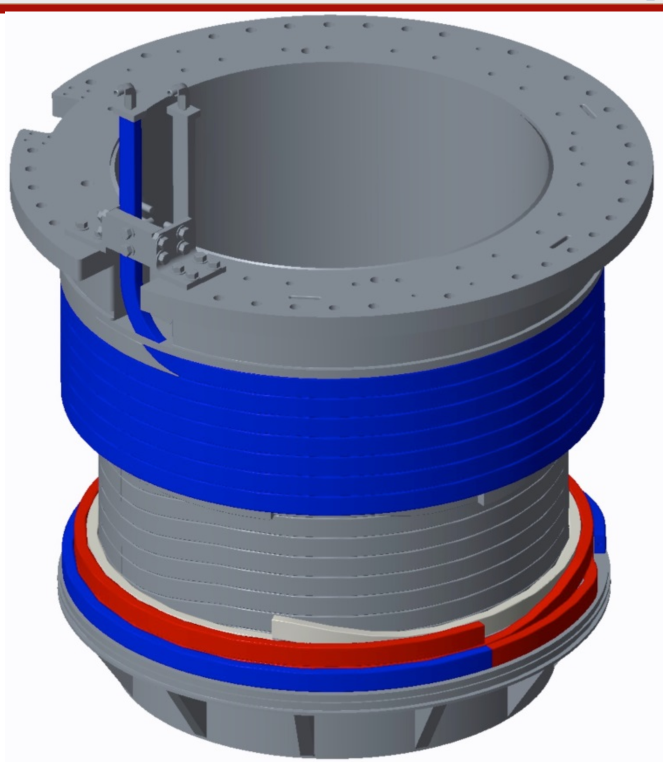
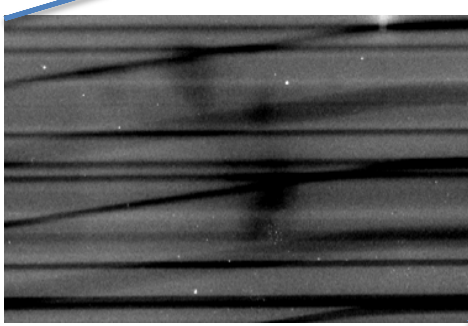
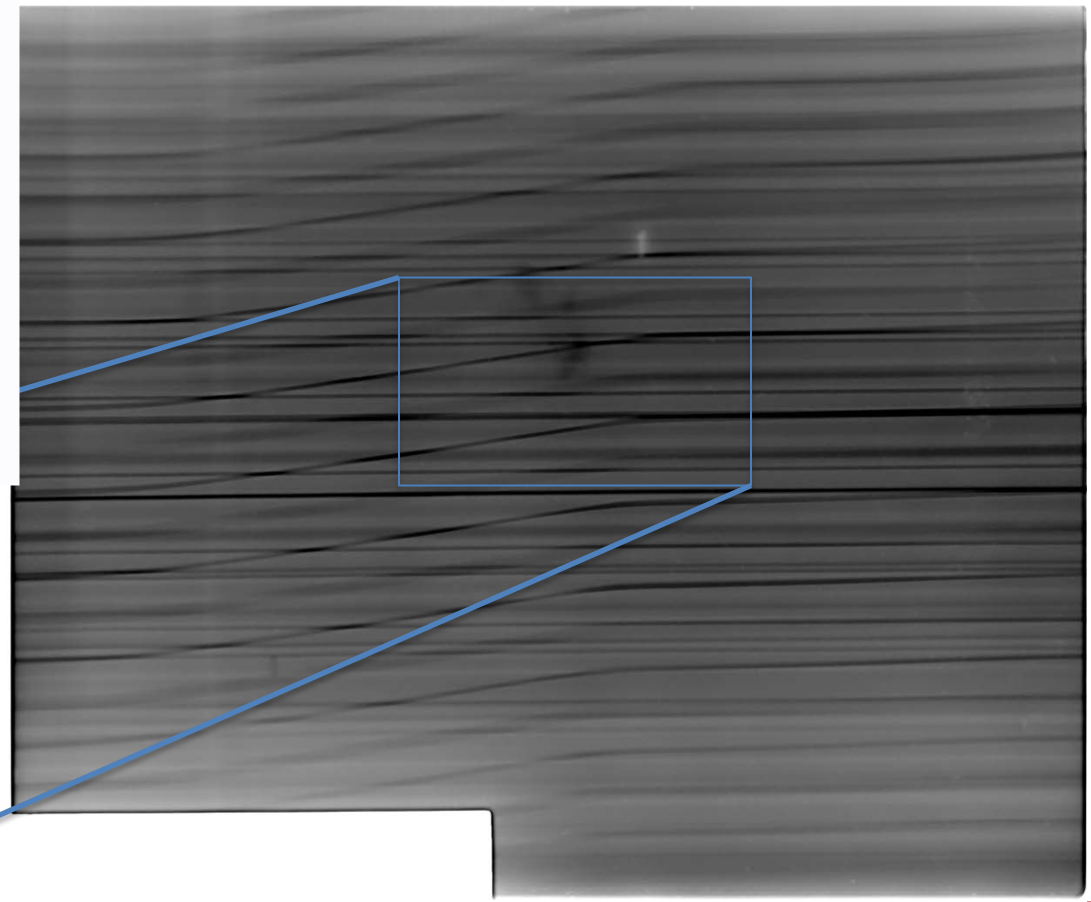


Image shows:

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

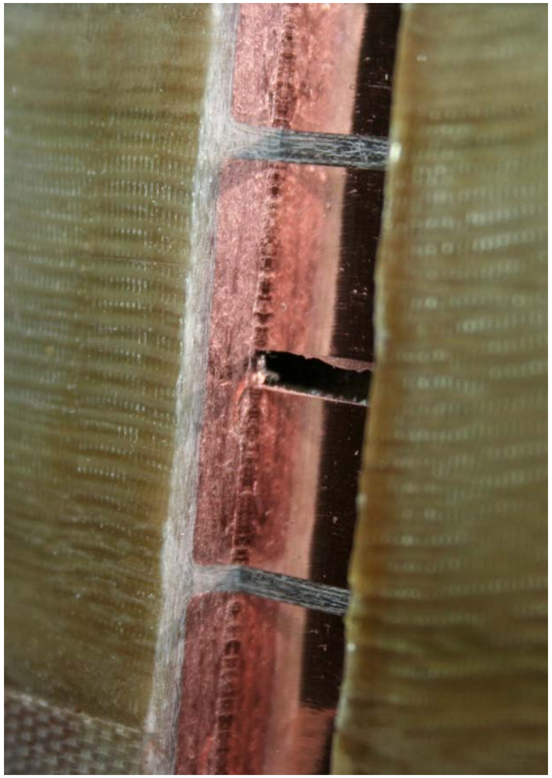
Other X-rays located all braze joints.





Coil Was Sectioned Using a Milling Machine

Section Planes Chosen to Avoid Any Regions of Interest

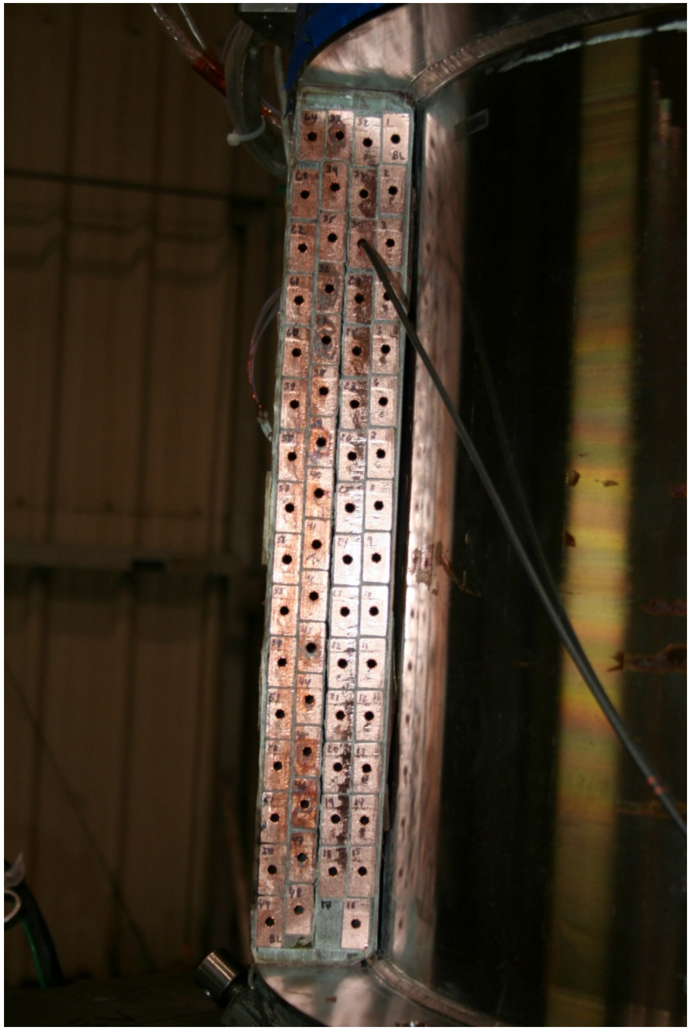


Detail of an Initial Cut

A Battery of Tests Was Performed on the Three Sections

Electrical Tests

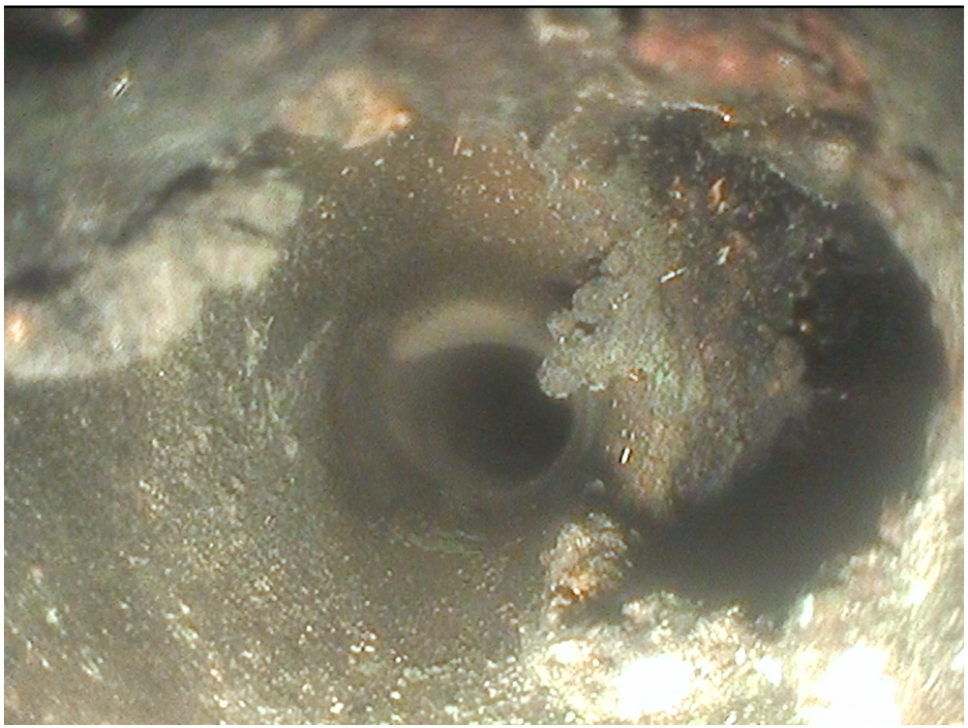
Videoscope Tests



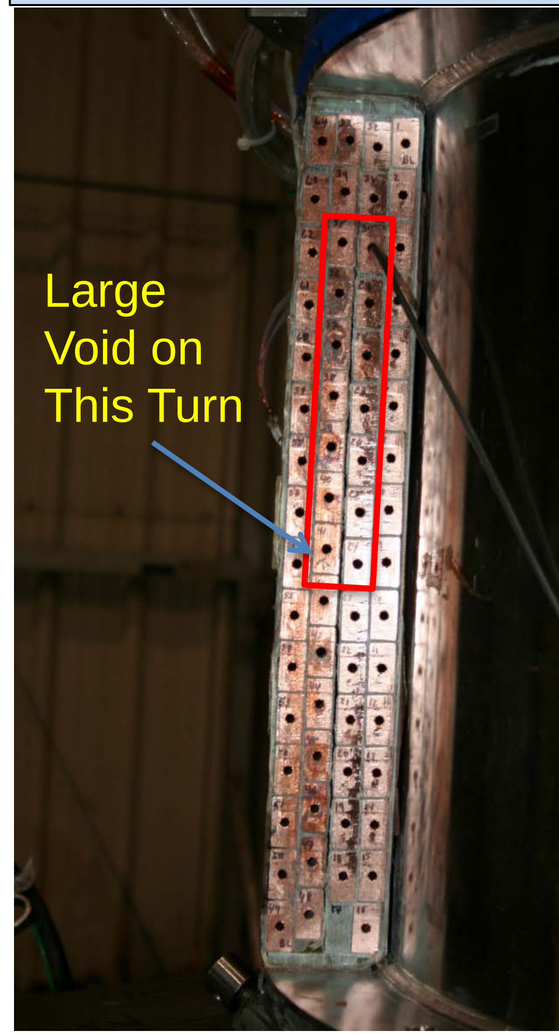
Also vacuum & pressure testing on individual channels

Videoscope shows breach in cooling channel

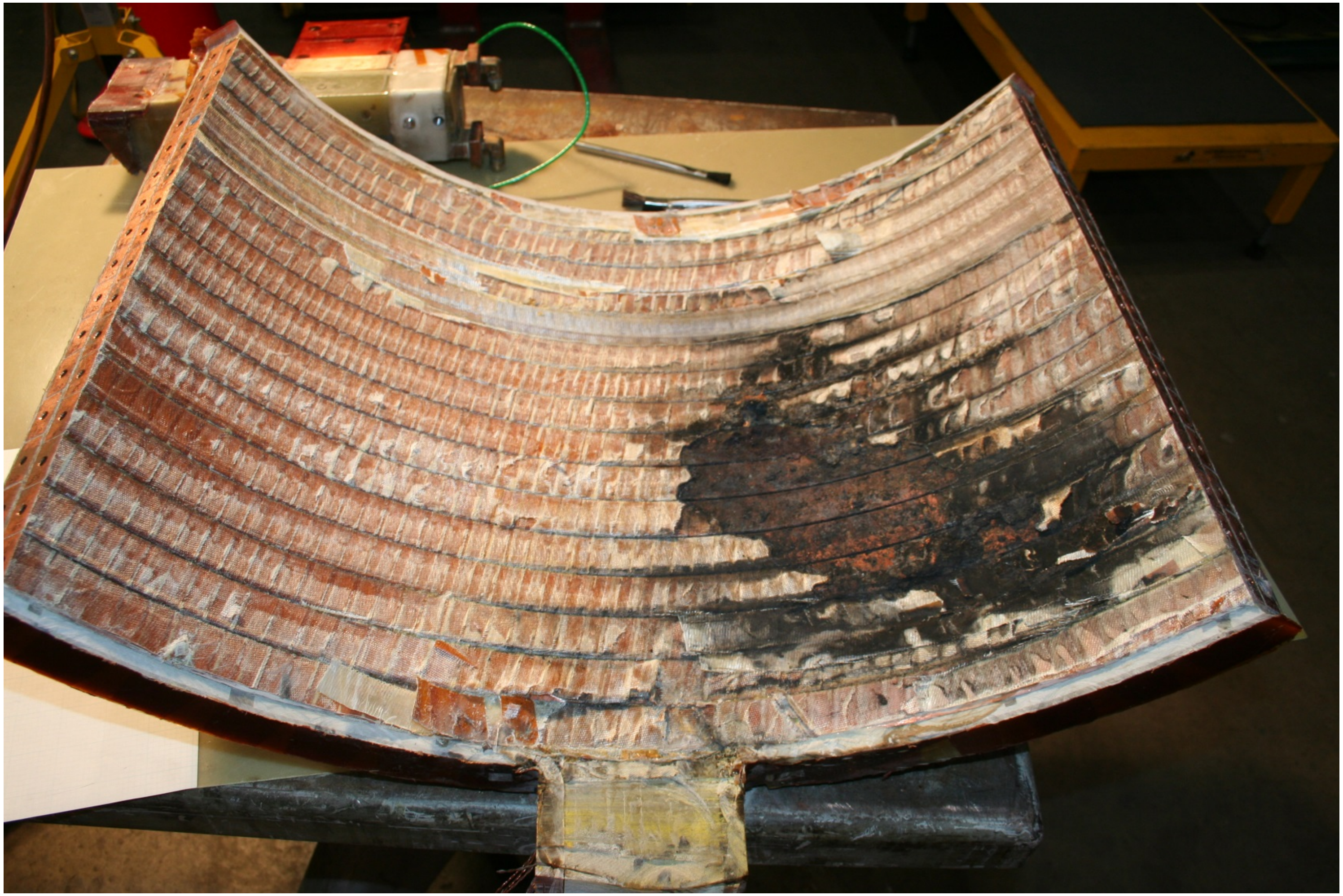
Section A-B, Layer 3, Row 9 Void Anomaly



Region of Shorted Turns



View of fault region - concave side



View of fault region - convex side

Hole in conductor from turn exterior

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NSTX-U / PPPL scored poorly in FY16 performance evaluation from DOE/FES

- "…serious flaws in the design revealed that PPPL had failed to apply its own basic engineering practices, ultimately causing the failure of several critical components..."
  - This resulted in subsequent construction (operation) problems....
- Failed to meet a Notable Outcome,… "prevented the performance of experimental research to address spherical torus issues at parameters beyond those achieved on NSTX"
- Positive aspects of FY16 run were also noted in performance evaluation, but these are outweighed by the systematic engineering / operational failures

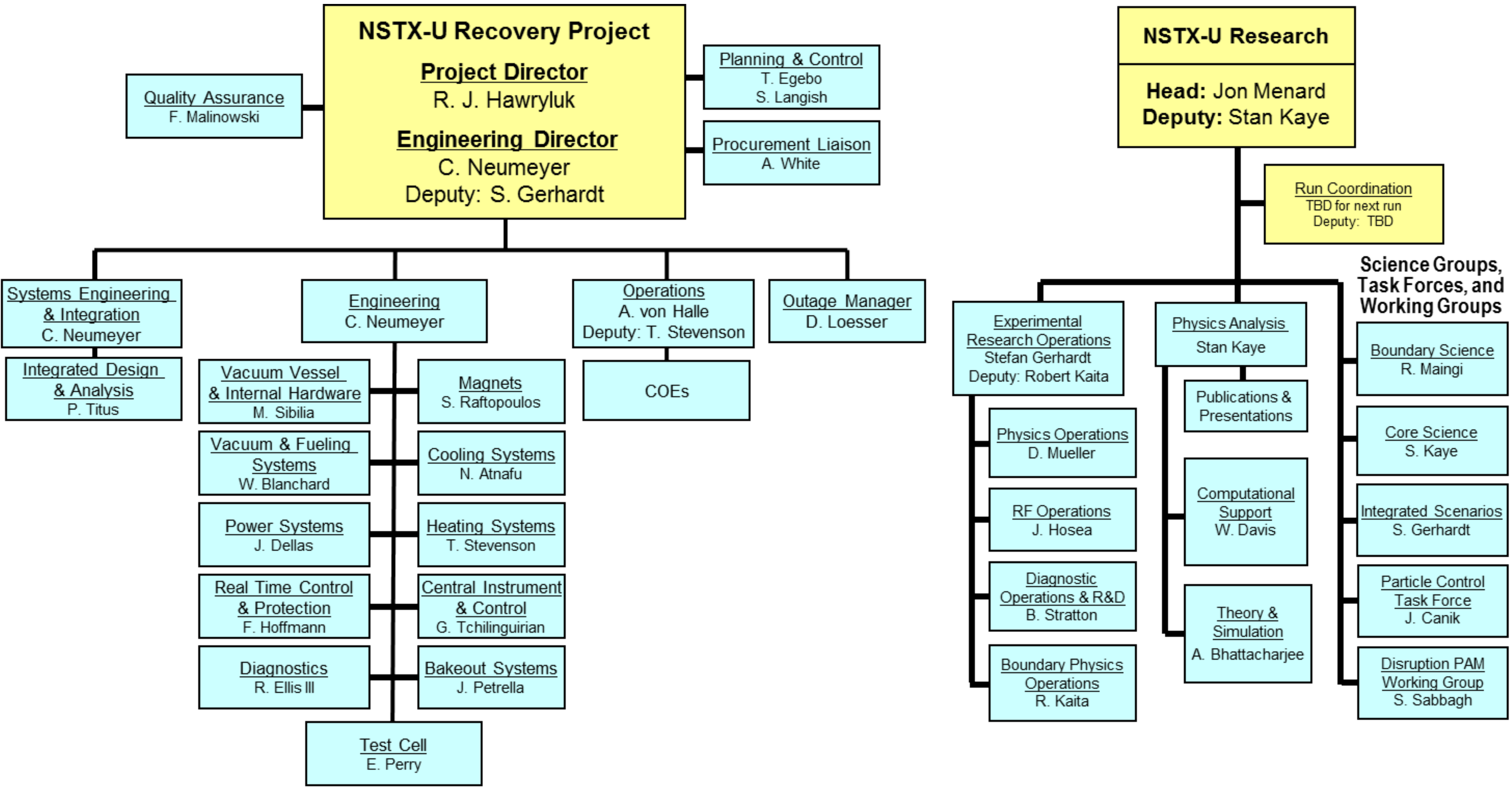
Comprehensive "extent of condition" and engineering policy & procedure reviews will be conducted in FY17

- EXTENT OF CONDITION
  - FES: Complete an extensive extent-of-condition review of NSTX-U to identify all design, construction, and operational issues. Prepare correction action plan (CAP) to include cost, schedule, scope, and technical specifications of actions. Provide an interim progress report by March 31, 2017 and complete the CAP review and final report to DOE by September 30, 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.

NSTX-U re-organized

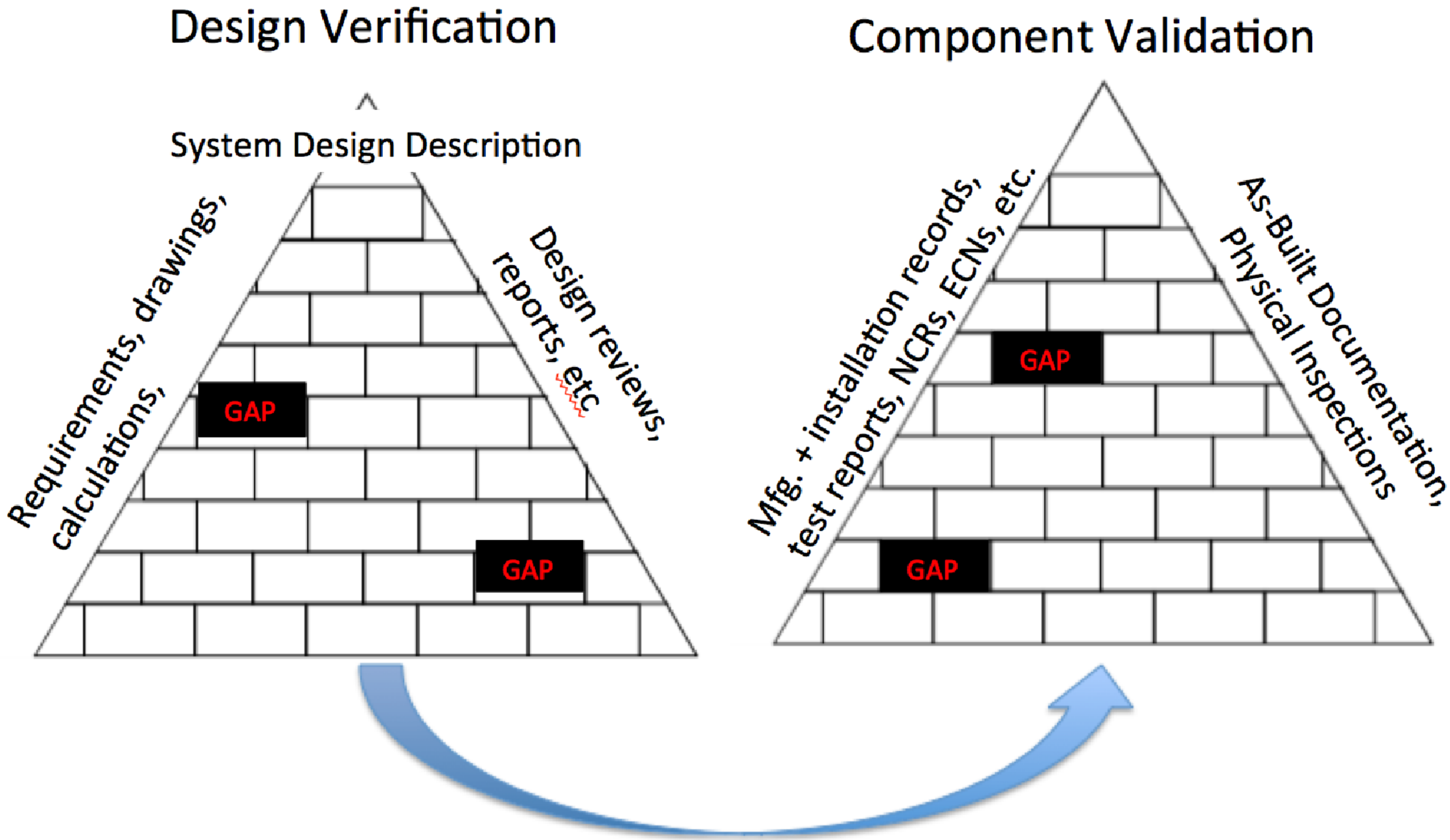
Rich Hawryluk leading NSTX-U Recovery Project



NSTX-U Recovery Project and Research Departments – December 2016 (v22)

Extent of Condition → implement via Design Verification & Validation Reviews (DVVR)

System Design Description (SDD) is key element



Research Staff supporting SDD development

SDD	Responsible Engineer (RE)	Assisting Researcher
Systems Integration / GRD	Charlie Neumeyer	Jon Menard
Vacuum Vessel & Internal Hardware	Marc Sibilia	Ron Bell
Magnets	Steve Raftopoulos	Randy Wilson
Vacuum & Fueling Systems	Bill Blanchard	Devon Battaglia
Cooling systems	Neway Atnafu	Clayton Myers
Power Systems	John Dellas	Dennis Mueller
Heating Systems	Tim Stevenson	NBI: Mario Podesta, RF: Rory Perkins/Joel Hosea
Real Time Control & Protection	Frank Hoffmann	Dan Boyer
Central Instrument & Control	Greg Tchilinguirian	Roger Raman (+ Devon Battaglia)
Diagnostics	Bob Ellis	Brent Stratton + Bob Kaita + Matt Reinke
Bakeout Systems	Joseph Petrella	Matt Reinke
Test Cell	Erik Perry	Randy Wilson
Operations	Al Von Halle	Walter Guttenfelder

FY17: Develop Corrective Action Plan based on gaps, review the CAP, then begin implementing CAP actions

	Reuse	Maintain	Rebuild	Test/ Analyze	Redesign
Design Acceptable	Y	Y	Y	Y	N
Fit for Function	Y	Y	N	?	-
Remaining Life	Y	N	-	-	-

- There will be external (+internal / PPPL) reviewer participation in all SDD / DVVR reviews
- Full external review(s) of the CAP and the SDD + DVVR process used to generate the CAP

Extent of Cause Review (Les Hill)

- 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 will not operate for at least 1 year, possibly significantly longer – depending on:

- Number of PF1 coils that will be replaced, schedule for replacement, and resource needs and availability
  - Key example: Existing PF1B coils incompatible with 350C bake of inboard horizontal divertor → need to eliminate or build smaller coils – analysis ongoing
- Any other major findings from ongoing SDD / DVVRs, and the Extent of Condition reviews
- Operational readiness - NSTX-U will (newly) be under DOE accelerator safety order (ASO)

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PF coil recovery schedule → 10 run weeks *(mostly commissioning)* during present FY14-18 five year plan

- FY19-23 plan due spring 2018, peer-reviewed summer 2018
- Begin brainstorming early 2017, then writing in summer / fall
- 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

Missions, priorities for next 5 year plan will be a major FY17 deliverable

Near-term schedule for 5 year plan preparation

- **By end of January – receive PAC report, discuss with science groups**
- **By end of February:**
  - Outreach to University PIs / UFA to discuss / plan external University participation in defining 5YP science goals
- **By mid-March 2017:**
  - Assess implications of EoC and CAP on NSTX-U 5 year plan, share report results and implications with team and PAC
- **By end of April 2017:**
  - Hold team-wide 5 year plan science mission, goal, and strategy brainstorming and prioritization meeting including experiment, theory, and University community representation.
  - Complete preliminary assessment of existing/planned facility, diagnostic, and simulation capabilities to achieve 5YP science goals.
- **By end of May 2017:**
  - Hold team-wide 5 year plan additional facility and diagnostic enhancement brainstorming meeting plus preliminary prioritization

Proposed / possible approaches for enhanced University PI (not already in team) engagement

- Ask UFA / university reps to generate ideas for how NSTX-U could be used explore new physics areas not already / typically part of the mainline program
- Present these ideas at a dedicated session(s) at mission / goal / strategy brainstorming meeting
- Debate ideas amongst full team, select (at least) a few
- Assess whether ideas can be supported with existing and/or planned facility and diagnostics
- Participate in facility enhancement brainstorming
- Contribute 5 year plan proposal text and plans
- If appropriate, lead dedicated NSTX-U task force(s) and/or generate milestones to carry out research

Any (more) questions?

Thank you!