PAC-36 Agenda – June 23, 2015

- Roll call, welcome new members, FES comments – John Sarff, Mark Foster
  - 5-10 minutes
- Project events since PAC-35 – M. Ono
  - 20 minutes
- Program events since PAC-35 – J. Menard
  - 20 minutes
- Charge to PAC, Program Letter overview – J. Menard
  - 40 minutes
- PAC executive session – J. Sarff
  - 1 hour
- PAC verbal debrief to NSTX-U – J. Sarff
  - 20-40 minutes

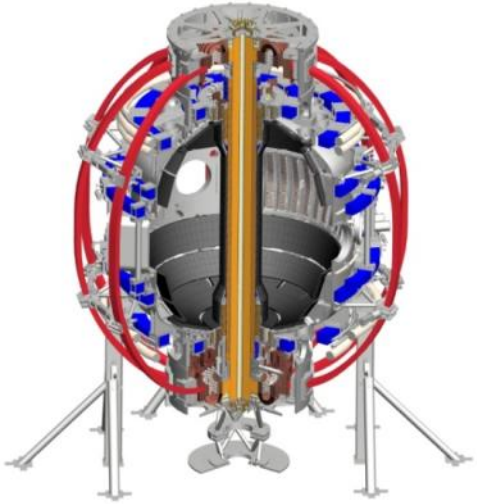
NSTX-U OH Arc Incident / Facility Status

Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin

Masa Ono and Jon Menard

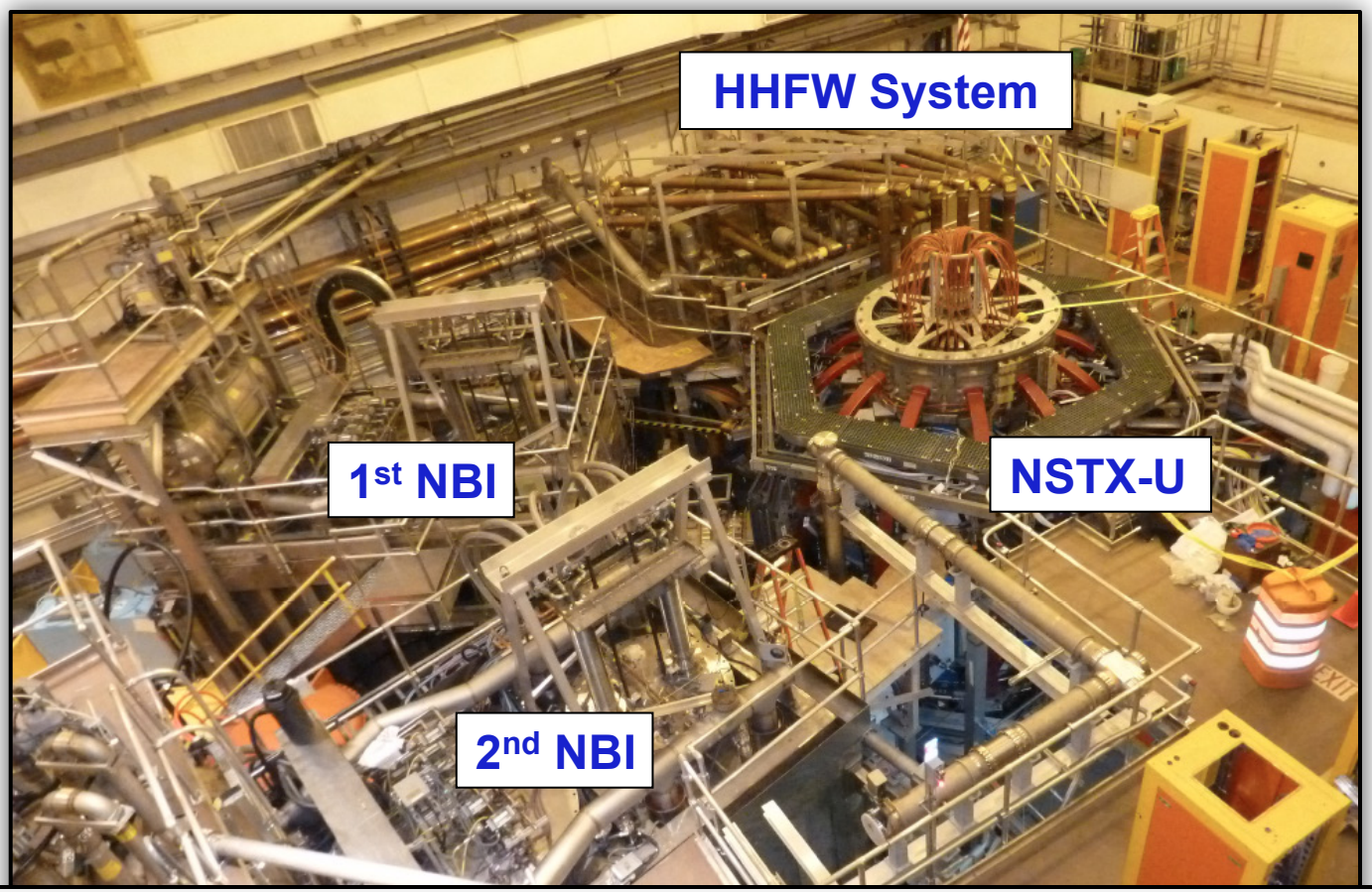
for the NSTX-U Team

NSTX-U PAC-36
June 23, 2015



Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Tsukuba U
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
NFRI
KAIST
POSTECH
SNU
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

NSTX-U construction complete, coil testing started

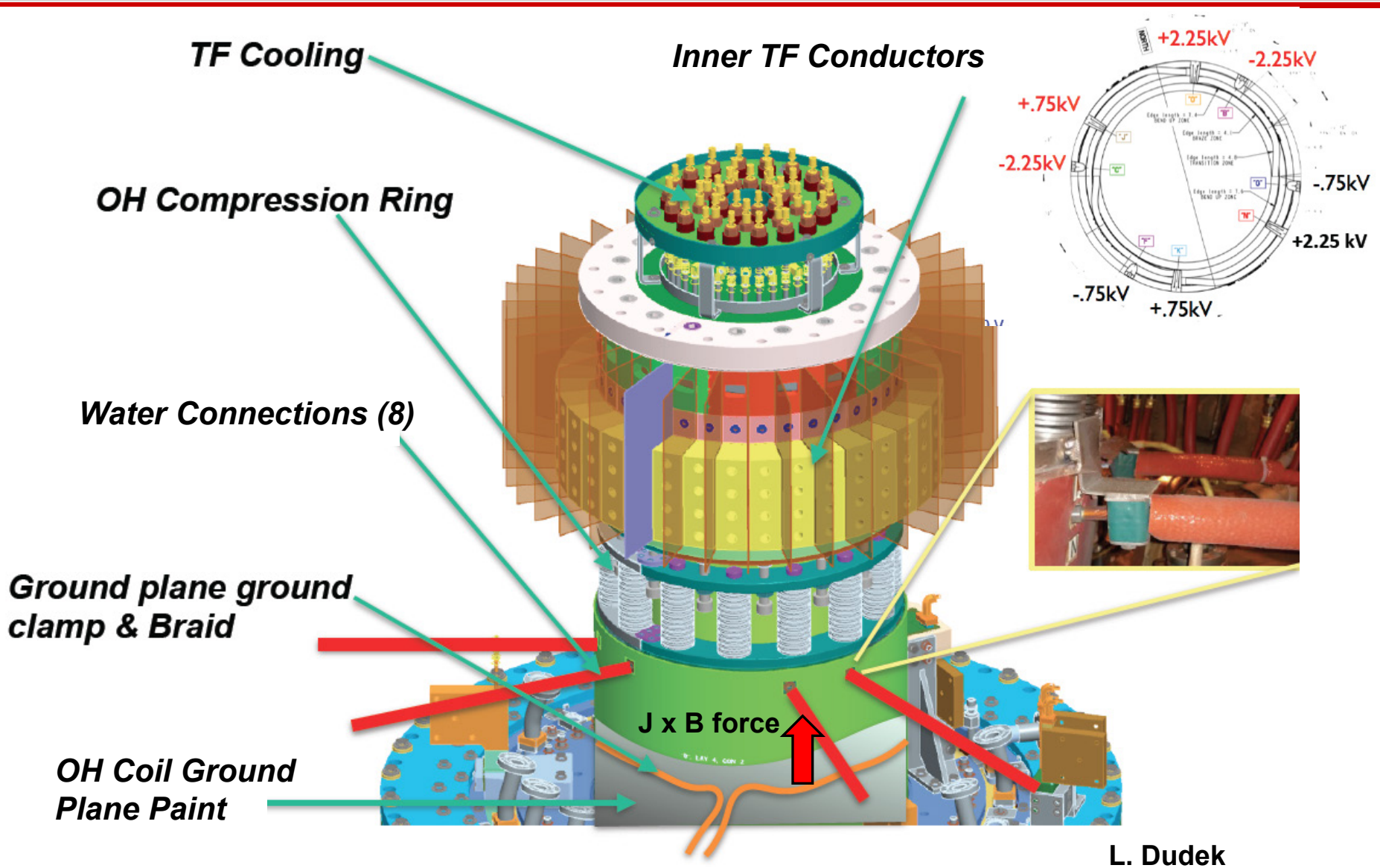


- 1 shot away from 1st plasma attempt, had arc on OH water cooling leads
- OH and other coils ok, working on redesign / re-installation / restart
- More details on subsequent slides

Activities leading up to the OH arc on April 24th

- We had successfully completed the NSTX-U machine Integrated System Test Procedure (ISTP) on Tuesday, April 21, 2015.
- On Friday, April 24, 2015, we were performing test shots in preparation for the CD-4 KPP attempt when an arc occurred.
  - **200183, 200184: Successful 8% and 50% test shots**
  - **200185 (100% test shot): First OH Ground Current Trip**
    - **Machine inspections found no water leaks.**
    - **Did a low-pot of the OH coil from rectifier room.**
  - **200187: Second Trip**
    - **Discussion, increased the threshold on the instantaneous ground fault relay from 50 mA to 100 mA**
  - **200189: Trip again**
    - **Discussion, noted the previous good low-pot and lack of water leaks.**
    - **OH Instantaneous ground fault relays were taken out of circuit.**
  - **200190: Shot with the damaging arc**

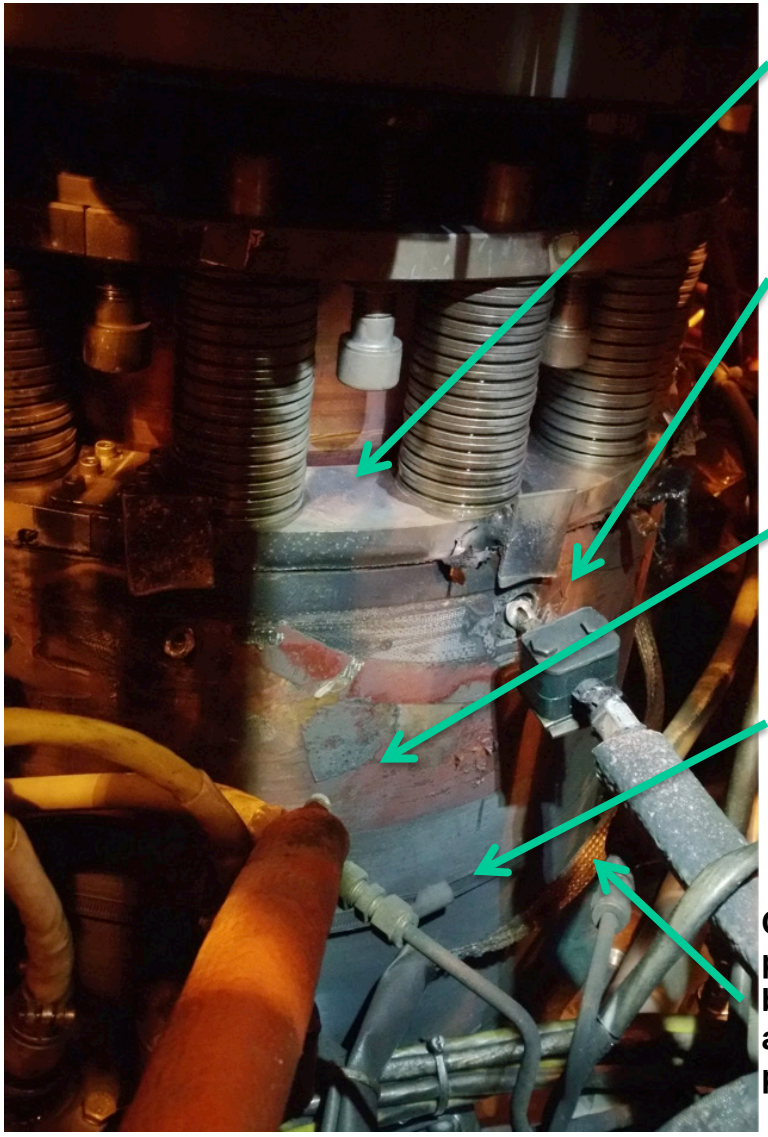
Upper OH Coil Arrangement



L. Dudek

Direct Causes of Arc: Summary

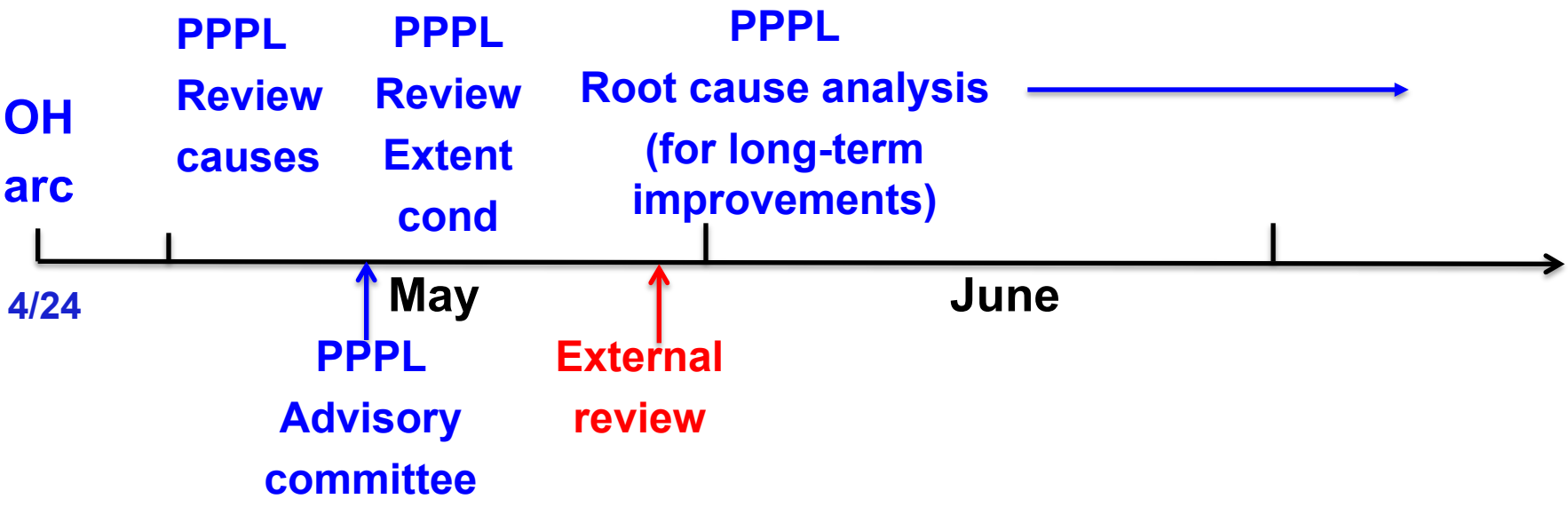
- **The OH ground plane braid had a continuous toroidal loop.**
  - **Currents induced by OH coil flux swing during the shot.**
  - **Experienced a JxB force that pushed it up into the exposed coil cooling water fittings *during the shot*.**
- **The Belleville washer stack assembly was not grounded.**
  - **Communication between OH coil and assembly could not be detected by high-pots or ground fault interlocks.**



Present OH Arc Status Summary

- **The overall health of the NSTX-U machine appears good.**
  - **The damage was contained to**
    - **four OH water coolant tubes that are readily replaced.**
    - **Some other water hoses were not penetrated, but showed some damage and will be replaced.**
    - **Ground braid itself…and gets a design upgrade.**
    - **Soot covering cables, pre-load assembly, OH coil, other items inside the umbrella.**
    - **Water flowing within and out of the upper umbrella.**
  - **Electrical continuity/insulation and hydrostatic testing of the ohmic heating coil (and other coils nearby) indicate the coils are fine.**
  - **Magnetic diagnostics check out OK.**
  - **Cleanup of the area is nearly complete.**
- **A number of "Extent of Condition" issues have been identified.**
- **Recovery activity being pursued at highest priority.**

Review activities since the arc event



On causes: technical, procedural, process (April 30 – May 13)

R. Ellis (chair, ME) ,J. Delooper (best practices), J. Hosea (phys.), C. Neumeyer (EE), M. Bell (phys.)

On extent of condition (May 13 – May 22)

J. Hosea (chair, phys), R. Ellis (ME), N. Greenough (EE),D. Mueller (phys)

Root cause analysis (May 4 – mid-July)

I. Zatz (chair, ME), J. Lacenere (EE), J. Malsbury (QA), M. Mardenfeld (ME)

NSTX-U Arc Event External Review (May 28, 2015)
External Review Committee Report

Committee Members

Arnie Kellman (Chair), General Atomics

Jim Irby, MIT Plasma Fusion Center

Brad Merrill, Idaho National Laboratory

George Ganetis, Brookhaven National Laboratory

General Comments

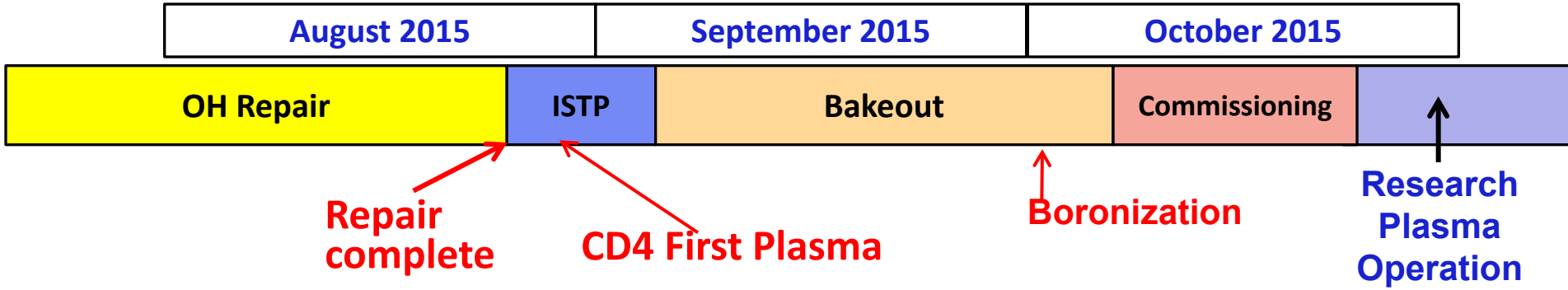
The committee was impressed with the thorough, high quality effort presented by the team and the larger lab personnel to address the fault event. We believe that they are addressing the right issues, both technically and procedurally. We were also impressed by the extent that they are addressing issues beyond the immediate fault and using this opportunity to improve the system.

Gave a strong endorsement of internal reviews and a vote of confidence for the team to repair and restart NSTX-U safely. Get the job done correctly and do not squeeze the research plan (MO)

OH arc recovery action activities

- 73 action items suggested by the internal and external reviews
- 26 main action items combining similar ones together.
- 11 main items before CD-4 and the rest are 15 are after CD-4.
- There is a hold point (touch point with OFES) before the TF flex bus installation. Could/should be this week.
- External committee recommended to have the root cause analysis feeds into ACC before CD-4. That is the present plan.
- The present schedule shows CD-4 to be end of August. We will try our best to start as soon as possible. But we will take necessary time to get the job done correctly.

Present Plan
Pre-CD-4 / research operation activities



Dummy load testing

MPTS R&R

NBI 1 & 2

MAPP, Fast Mirnov, X-ray, bolometer, plasma TV, VIPS, etc.

Boronization, GDCs, gas Injector-4, LITER, SGI, Divertor inj., MGI, CGI, etc.

Bakeout: June 2011- 367 hours (15 ays),
February 2010 - 472 hours (20 days)
Need 3 days to set-up and 2 days to remove

The CD-4 plasmas can be used to commission diagnostics if ready.

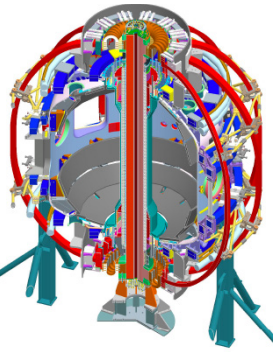
Five Year Facility Enhancement Plan (green – ongoing)

2015: Engineering design for high-Z tiles, Cryo-Pump, NCC, ECH

•Fiscal Year:	2015	2016	2017	2018	2019
	Upgrade Outage	1.5 → 2 MA, 1s → 5s			
Run Weeks:		14-16	16-18	12-16	10-12

Major enhancements:
- ● Base funding
- ○ +15% incremental

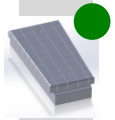
New center-stack



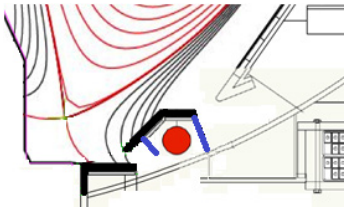
2nd NBI

Boundary Science + Particle Control

- Pulse-burst MPTS
- Boronization
- Li granule injector
- MAPP
- Upward LiTER
- High-Z tile row on lower OBD



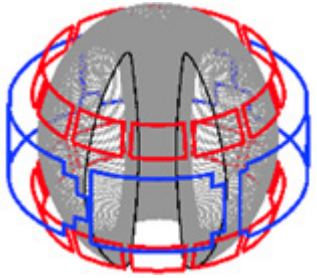
- ● Lower divertor cryo-pump
- High-Z PFC diagnostics
- LLD using bakeable cryo-baffle



Core Science

- MGI disruption mitigation
- Upgraded halo sensors
- δB diag. - incremental
- Laser blow-off
- 42 ch MPTS
- High k_θ
- 48 ch BES
- Charged fusion product
- MSE/LIF
- 4 coil AE antenna

- Off-midplane 3D coils (NCC) ○ →
- Enhanced MHD sensors
- DBS, PCI, or other intermediate-k
- Neutron collimator



Integrated Scenarios

Establish control of:
- Rotation
- q_{min}
- Snowflake
- FIReTIP
- $\bar{n}_e$
- 1 MW ECH/EBW ○ →
- Upgraded CHI for ~0.5MA
- 0.5-1 MA CHI

- HHFW limiter upgrade
- Divertor P_{rad}
- up to 1 MA plasma gun

NSTX-U

Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U Research Program Status*

Jon Menard, Masa Ono
For the NSTX-U Team

NSTX-U PAC 36
June 23, 2015

*This work supported by the US DOE Contract No. DE-AC02-09CH11466

Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
Old Dominion
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC

Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
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NIFS
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JAEA
Inst for Nucl Res, Kiev
Ioffe Inst
TRINITI
Chonbuk Natl U
NFRI
KAIST
POSTECH
Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

NSTX-U Research Team Has Been Scientifically Productive

Very Active in Scientific Conferences, Publications, and Collaborations

- Strong APS meeting participation in the fall 2014: 1 ST review talk, 5 invited talks, 44 additional presentations. Three NSTX APS-DPP press releases available on the web.
- Significant collaboration research contributions are being made in diverse science areas by the NSTX-U research team.
- On-going active research collaboration particularly with DIII-D and C-Mod. Several activities resulted in 2014 IAEA papers.
- Strong NSTX-U and ST-FNSF related engineering / technology presentations at the 2014 PSI, SOFE and TOFE meetings.
- All of the FY 2014 milestones were completed on schedule
- 54 refereed publications for CY 2014
- NSTX-U will host next International ST workshop - November 2015

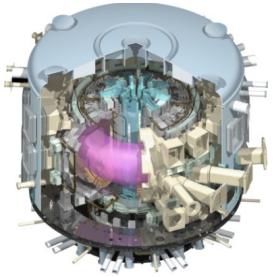
Substantial leadership and participation in FES workshops by NSTX-U, collaborators, PPPL

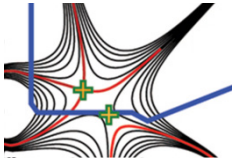
- **Transients: 36% of 67 whitepapers: 13 for disruptions, 11 for ELMs**
  - Co-chair: R. Nazikian
  - Disruptions: D. Brennan (co-lead), S. Sabbagh, D. Gates
  - ELMs: R. Nazikian (lead), J. Canik (co-lead), O. Schmitz, W. Solomon
- **PMI: 29% of 56 whitepapers - evenly split among topical areas**
  - **Chair: R. Maingi ← hosted by PPPL**
  - SOL / Div: R. Goldston, J. Myra, V. Soukhanovskii
  - PMI / Div. Simulators: J.P. Allain (leader), M. Jaworski, B. Wirth
  - Engineering Innovation: C. Kessel (leader), R. Ellis, R. Majeski
  - Core-edge integ: J. Canik, M. Kotschenreuther, R. Majeski, R. Wilson
  - Cross-cutting: R. Maingi, J. Menard, H. Neilson
- **Integrated Modelling: 24% of 119 whitepapers – Disruptions, WDM**
  - Disruptions: D. Brennan (co-lead), S. Gerhardt, S. Jardin
  - Boundary: J. Canik, C-S Chang, G. Hammett
  - Whole Device Modelling: C. Kessel (co-lead), B. Grierson, S. Kaye, F. Poli
  - Multi-hysics, multi-scale: G. Fu, G. Hammett
  - Data Management / Software Integration: S. Kaye / F. Poli

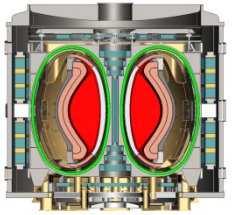
Planned research supports missions and 5 highest priority goals of NSTX-U 5 year plan:

Mission Elements and 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 burning plasmas
  2. Understand energy confinement at high normalized pressure
- **Develop solutions for PMI challenge**
  3. Dissipate hight edge power loads using advanced divertors + radiation
  4. Compare performance of solid vs. liquid metal plasma facing components
- **Advance ST as possible FNSF / DEMO**
  5. Form and sustain plasma with small or no transformer for steady-state ST







Overview of FY2015-17 NSTX-U research milestones

- **FY2016**
  - Obtain first data at 60% higher field/current, 2-3× longer pulse:
    - Re-establish sustained low l_i / high-κ operation above no-wall limit
    - Study thermal confinement, pedestal structure, SOL widths
    - Assess current-drive, fast-ion instabilities from new 2nd NBI
- **FY2017**
  - Extend NSTX-U performance to full field, current (1T, 2MA)
    - Assess divertor heat flux mitigation, confinement at full parameters
  - Access full non-inductive, test small current over-drive
  - First data with 2D high-k scattering, prototype high-Z tiles
- **FY2018**
  - Study low-Z and high-Z impurity transport
  - Assess causes of core electron thermal transport
  - Test advanced q profile and rotation profile control
  - Assess CHI plasma current start-up performance

See backup for detailed Research Milestone timeline

New NSTX-U Science organizational structure for 2015-16: 3 Science Groups, 9 Topical Science Groups, 1 Task Force

Science Group (SG)

Topical Science Group (TSG)

Task Force (TF)

Boundary Science Group
R. Maingi, C.-S. Chang (deputy)

Pedestal Structure and Control
A. Diallo, R. Maingi
Theory/Modelling: J. Canik[1]
University Rep: D. Smith[2]

Divertor and Scrape-Off-Layer
V. Soukhanovskii[3], J.-W. Ahn[1]
Theory/Modelling: D. Stotler
University Rep: O. Schmitz[2]

Materials and PFCs
M. Jaworski, C. Skinner
Theory/Modelling: B. Wirth[4]
University Rep: J.-P. Allain[5]

Core Science Group
S. Kaye, S. Sabbagh[6] (deputy)

Macroscopic Stability
J. Berkery[6], J.-K. Park
Theory/Modelling: S. Jardin
University Rep: D. Brennan[7]

Transport and Turbulence
W. Guttenfelder, Y. Ren
Theory/Modelling: W. Wang
University Rep: K. Tritz[8]

Energetic Particles
M. Podestá, D. Liu[9]
Theory/Modelling: N. Gorelenkov
University Rep: N. Crocker[10]

Integrated Scenarios Group
S. Gerhardt, R. Raman[11] (deputy)

Advanced Scenarios and Control
D. Battaglia, S. Gerhardt
Theory/Modelling: F. Poli
University Rep: E. Kolemen[7]

Solenoid-free Start-up & Ramp-up
D. Mueller, R. Raman[11]
Theory/Modelling: F. Ebrahimi[7]

Wave Heating and Current Drive
R. Perkins, J. Hosea
Theory/Modelling: N. Bertelli
University Rep: P. Bonoli[12]

Particle Control Task Force (FY2015-16)
Leader: R. Maingi, Deputy: J. Canik[1]

Goal: Develop pumping and fueling tools, operating scenarios, and control systems to achieve main-ion and impurity density control for long-pulse

Collaborators in Science Program Leadership:

1 ORNL
2 University of Wisconsin
3 LLNL
4 UT Knoxville
5 University of Illinois
6 Columbia University
7 Princeton University
8 Johns Hopkins University
9 UC Irvine
10 UC Los Angeles
11 University of Washington
12 MIT

Each TSG has a leader, deputy, theory rep, **and at least 1 university rep to enhance university participation**

12 collaborating institutions engaged in NSTX-U science program leadership

Successful Research Forum held Feb 24-27, 2015

- Plenary → TSG parallel → TF / SG parallel → summary
  - Included extensive inter-TSG and SG discussion to reduce overlap
  - Before / during / after forum developed several cross-cutting XPs to identify scans of plasms conditions usable by multiple groups
- Completed ~70-90% of prioritization by end of forum
  - Highest priority research in research milestones / task forces
  - Proposals that addressed milestones received the most run time
- Prioritization, nominal run-time, expected run-month for all experiments documented and shared openly with team
  - See this link: Master Spreadsheet of XMPs and XPs
- Chosen first 30 experiments to review: order based on Priority 1 + expected period to be run during campaign
  - Reviews ongoing April thru July, will have 2-3 months of XPs ready prior to beginning of research operations, see backup for more detail

Very strong interest in NSTX-U research

Requested research time exceeds available time by 4-5×

Requested / Available Run Time:

Total: 273 / 80 = 3.4×

Research: 248 / 55 = 4.5×

Areas of highest interest / need

Topical Science Group or Task Force	Run Days Requested	Fraction
Macroscopic Stability (MS)	40.75	14.9%
Cross-cutting and Enabling (CC)	34.85	12.8%
Divertor and Scrape-off-layer (DS)	33.5	12.3%
Advanced Scenarios and Control (ASC)	33	12.1%
Pedestal Structure and Control (PS)	25	9.2%
Particle Control Task Force (PC)	23	8.4%
Energetic Particles (EP)	22.5	8.3%
Turbulence and Transport (TT)	21	7.7%
Materials and PFCs (MP)	15.5	5.7%
Solenoid-free Start-up and Ramp-up (SR)	14.5	5.3%
Wave Heating and Current Drive (RF)	9	3.3%
	272.6	100%

~85% of requested time

84 unique lead author names

#	Institution	Run Days Requested	Fraction
1	Princeton Plasma Physics Laboratory	112.1	41.1%
2	Oak Ridge National Laboratory	28.5	10.5%
3	Princeton University	20.5	7.5%
4	Lawrence Livermore National Laboratory	18	6.6%
5	General Atomics	17	6.2%
6	ITER (France)	12	4.4%
7	University of Washington	11.5	4.2%
8	Columbia University	10.5	3.9%
9	University of Wisconsin	9	3.3%
10	University of California - Irvine	7.5	2.8%
11	Nova Photonics	6	2.2%
12	University of Illinois	4	1.5%
13	Massachusetts Institute of Technology	4	1.5%
14	University of California - San Diego	3	1.1%
15	Johns Hopkins University	3	1.1%
16	University of Tennessee	2	0.7%
17	Lehigh University	1	0.4%
18	Florida International University	1	0.4%
19	University of California - Los Angeles	1	0.4%
20	University of York (United Kingdom)	1	0.4%
		272.6	100%

Operations assumptions for first 2 run-months

- Machine Commissioning – ~1 month (run weeks 1-4)
  - Develop basic breakdown, current ramp, shape/position control, diverted plasmas, H-mode access, basic fuelling optimizations.
  - Goal: 1 MA, 0.5 T, NBI-heated H-mode (i.e. ~NSTX fiducial levels)
  - Diagnostic commissioning
  - Boronized PFCs
  - Mostly XMPs

- 1st Month of Science Campaign (run weeks 5-8)
  - Boronized PFCs, possibly begin lithium coatings
  - Operations and basic profile diagnostics, neutron rate,…
  - Operation up to 1.4 MA and 0.65 T, 2 seconds
  - 6 beam sources up to 90 kV
  - HHFW available for commissioning

Latest run plan for 2016

Goal is to operate 14-16 run weeks as per research forum

➔ **Want as much data as possible for IAEA synopses (due Jan/Feb)**

- October: 3-4 run weeks
- November: 0-2 run weeks
  - May want to pause for ST workshop, APS, Thanksgiving
- December: 3 run weeks
- January: 2 run weeks
  - Mid-run assessment (if applicable), PAC-37
- Feb-Mar: 3-8 run weeks, complete FY16 run
- Mar/Apr: Start outage: install high-k, high-Z tiles, …
- Resume operations fall 2016 for FY17

Summary for science program

- Continue strong scientific productivity during outage
- Substantial leadership and participation in community workshops
- Successful Forum, XP prioritization complete, reviews started
- **Team excited about upcoming run!**

FES solicitation for U.S. University and Industry DIAGNOSTIC Collaboration on NSTX-U

- FES solicitation cycle divided into 3 groups:
  - **University & Industry → Diagnostics → National Laboratories**
- Expected Issue Date for FOA: 07/01/2015
  - Letter of Intent Due Date: Not Applicable
- Pre-Application Due Date: 07/29/2015 at 5 PM Eastern Time
  - Pre-Application is required, 2-3 pages (Title, abstract, collaborators, …)
- **Application Due Date: 09/18/2015 at 11:59 PM Eastern Time**

- NSTX-U gathered diagnostic ideas from team via Google form
  - Shared with SG/TSG leaders for final comment/consideration/inclusion
- PAC-36 review of draft Program Letter – June 23 (today)
- **Ideally, would like PAC report no later than July 1**
- Program letter needs to be available no later than July 7

Charge to PAC-36

- Assess Program Letter from perspective of potential collaborator (using your PAC knowledge of NSTX-U)
  1. Does the letter properly represent NSTX progress and the goals for utilization of NSTX-U, including schedule and expected performance?
  2. Are the priorities, background, and opportunities easily understood?
  3. Is there anything important missing? or that should be fixed or removed?
- Additional considerations for assessment of letter:
  - Letter is (purposely) sufficiently broad to attract new collaboration ideas
  - Research proposal recommendations are conveyed from Program to collaborator through comments section in "Record of Discussion"
  - Further, detailed hardware capabilities and preliminary requirements are agreed upon between the collaborator, the collaborator's research contact, and NSTX-U Program and Project directors using "Record of Discussion"
- Other concerns or comments about Program/Project?

Program Letter Overview

- Program Letter "Research Priorities" strongly aligned with the 5 year plan research "Thrusts"
  - But similar in structure and intent to previous/FY2012 diagnostic letter
- Letter covers 6 topical areas:
  I. Macroscopic Stability
  II. Multi-Scale Transport Physics
  III. Plasma Boundary Interfaces
  IV. Waves and Energetic Particles
  V. Plasma Start-up and Ramp-up without a Solenoid
  VI. Advanced Operating Scenarios and Control
- Next, will review and discuss "Research Priorities" and "Key Collaboration Opportunities" from program letter

Backup slides

(Milestones, XP reviews, facility and diagnostic info)

NSTX-U Milestone Schedule (as of June 15, 2015)

	FY2016	FY2017	FY2018
Run Weeks:	Incremental: 14 / 16	16 / 18	12 / 16
Boundary Science + Particle Control	R16-1: Assess H-mode confinement, pedestal, SOL characteristics at higher B_T, I_P, P_{NBI}	R17-1: Assess scaling, mitigation of steady-state, transient heat-fluxes w/ advanced divertor operation at high power density R17-2: Assess high-Z divertor PFC performance and impact on operating scenarios	R18-1: Assess impurity sources and edge and core impurity transport IR18-1: Investigation of power and momentum balance for high density and impurity fraction divertor operation
Core Science	R16-2: Assess effects of NBI injection on fast-ion f(v) and NBI-CD profile	R17-3: Assess τ_E and local transport and turbulence at low ν^* with full confinement and diagnostic capabilities	IR18-2: Assess role of fast-ion driven instabilities versus micro-turbulence in plasma thermal energy transport Begin ~1 year outage for major facility enhancement(s) sometime during FY2018
Integrated Scenarios	R16-3: Develop physics + operational tools for high-performance: κ, δ, β, EF/RWM	IR17-1: Assess fast-wave SOL losses, core thermal and fast ion interactions at increased field and current R17-4: Develop high-non-inductive fraction NBI H-modes for sustainment and ramp-up	R18-2: Control of current and rotation profiles to improve global stability limits and extend high performance operation R18-3: Assess transient CHI current start-up potential in NSTX-U
FES 3 Facility Joint Research Target (JRT)	C-Mod leads JRT: Assess disruption mitigation, initial tests of real-time warning, prediction	DIII-D leads JRT: TBD …likely something on energetic particles	NSTX-U leads JRT: TBD

Chosen first 30 experiments to review: Order based on Priority 1 + expected period to be run during campaign

At least 30 XPs will be fully reviewed prior to start of research campaign

XP number	XP title	Responsible Group	XP author first name	XP author last name	XP author e-mail	Priority	Run Weeks 1-4	Run Weeks 5-8	Run Weeks 9-12	Run Weeks 13-16
1501	Optimization of vertical control algorithm	ASC-TSG	Dan	Boyer	mboyer@pppl.gov	P1a	1			
1502	Tuning of the Automated Rampdown Software	ASC-TSG	Stefan	Gerhardt	sgerhard@pppl.gov	P1c	1			
1503	X-point control integration with shape control	ASC-TSG	Egemen	Kolemen	ekolemen@princeton.edu	P1a	1			
1504	Beam power and beta-N control	ASC-TSG	Dan	Boyer	mboyer@pppl.gov	P1b	0.5	0.5		
1505	Optimizing Boronization XMP	MP-TSG	Charles	Skinner	cskinner@pppl.gov	P1a	0.5	0.5		
1506	Low-beta, low-density locked mode studies	MS-TSG	Clayton	Myers	cmyers@pppl.gov	P1a	0.25	0.75		
1507	Maximizing the non-inductive current fraction in NSTX-U H-modes	ASC-TSG	Stefan	Gerhardt	sgerhard@pppl.gov	P1a		0.5	0.25	0.25
1508	Controlled Snowflake Studies	ASC-TSG	Egemen	Kolemen	ekolemen@pppl.gov	P1b		0.25	0.5	0.25
1509	Combined betaN and li feedback control	ASC-TSG	Dan	Boyer	mboyer@pppl.gov	P1b		0.25	0.25	0.5
1510	Characterizing the SOL Losses of HHFW Power in H-Mode Plasmas	RF-TSG	Rory	Perkins	rperkins@pppl.gov	P1a		0.5	0.25	0.25
1511	Multi-machine studies of the L-H power threshold dependence on aspect ratio	PS-TSG	Michael	Bongard	mbongard@wisc.edu	P1b		1		
1512	Characterization of the Pedestal Structure as function Ip, BT, and Pnbi	PS-TSG	Ahmed	Diallo	adiallo@pppl.gov	P1a		0.5	0.5	
1513	Effects of B-> Li transition on the pedestal structure	PS-TSG	Rajesh	Maingi	rmaingi@pppl.gov	P1a		0.5	0.5	
1514	Heat flux and SOL width Scaling in NSTX-U	DS-TSG	Travis	Gray	tkgray@pppl.gov	P1a		0.25	0.5	0.25
1515	High-beta n=1,2,3 feed-forward error field correction	MS-TSG	Clayton	Myers	cmyers@pppl.gov	P1a		0.5	0.5	
1516	Optimization of PID dynamic error field correction	MS-TSG	Clayton	Myers	cmyers@pppl.gov	P1a		0.5	0.5	
1517	Neoclassical toroidal viscosity at reduced collisionality (independent coil control)	MS-TSG	S.A.	Sabbagh	sabbagh@pppl.gov	P1a		0.25	0.5	0.25
1518	RWM PID control optimization based on theory and experiment	MS-TSG	S.A.	Sabbagh	sabbagh@pppl.gov	P1a		0.25	0.5	0.25
1519	Massive Gas Injection Studies on NSTX-U	MS-TSG	Roger	Raman	raman@aa.washington.edu	P1a			0.5	0.5
1520	Ip/Bt scaling	TT-TSG	Stan	Kaye	kaye@pppl.gov	P1a		0.5	0.25	0.25
1521	Validation of gyrokinetic codes in NSTX-U NBI-heated L-mode plasmas	TT-TSG	Yang	Ren	yren@pppl.gov	P1a		0.5	0.25	0.25
1522	Beam ion confinement of 2nd NBI	EP-TSG	Deyong	Liu	deyongl@uci.edu	P1a		0.75	0.25	
1523	Characterization of 2nd NBI line	EP-TSG	Mario	Podesta	mpodesta@pppl.gov	P1a		0.25	0.5	0.25
1524	AE Critical Gradient	EP-TSG	Bill	Heidbrink	wwheidbr@uci.edu	P1a		0	0.25	0.75
1525	Rotation effects on CAEs and GAEs	EP-TSG	Neal	Crocker	ncrocker@physics.ucla.edu	P1a				1
1526	Establish heat transmission pathways in high-Z reference shape	MP-TSG	Michael	Jaworski	mjaworsk@pppl.gov	P1a		0.25	0.25	0.5
1527	ELM pacing via multi-species granule injection and 3D field application for main ion c	PC-TF	Robert	Lunsford	rlunsfor@pppl.gov	P1a		0.75	0.25	
1528	Characterize plasma near planned plenum entrance position	PC-TF	John	Canik	canikjm@ornl.gov	P1a		0.75	0.25	
1529	Controlled introduction of Lithium into NSTX-U	PC-TF	Rajesh	Maingi	rmaingi@pppl.gov	P1a		0.5	0.5	
1530	Triggering ELMs with LGI and 3-D fields in lithiated discharges	PC-TF	Robert	Lunsford	rlunsfor@pppl.gov	P1a			0.75	0.25

Programmatic considerations for prioritization of experiments (in approximate priority order)

- Viability of proposal given available NSTX-U capabilities
- OFES Joint Research Targets / Milestones
  - Carry out JRT-15, preparatory experiments for JRT-16 (disruptions)
- NSTX-U Research Milestones
  - Annual milestones + other ST high priority research
  - NSTX-U Facility Enhancement design needs
    - High-Z tiles, cryo, NCC, high-k scattering, future (ECH, DBS/CPS, …)
- ITER and ITPA
  - ITER: Direct IO requests, ITPA: NSTX-U is lead/prominent experiment
- Experiments leading to high-profile publications/presentations:
  - PRL, Science, Nature Invited talks: **IAEA**, **APS**, EPS, Sherwood, …
- Career development: PhD thesis, post-doctoral research
- Any good idea generated during run – potential "break-thru" ?
- Maximize institutional / researcher breadth of XP leadership
  - Spread the wealth = get co-authors, help/mentor the less experienced

Projected timeline for achieving full NSTX-U parameters

Parameter	NSTX (Max.)	Year 1 NSTX-U Operations	Year 2 NSTX-U Operations	Year 3 NSTX-U Operations	Ultimate Goal
I_P [MA]	1.2	~1.6	2.0	2.0	2.0
B_T [T]	0.55	~0.8	1.0	1.0	1.0
Allowed TF I^2t [MA^2s]	7.3	80	120	160	160
I_P Flat-Top at max. allowed I^2t, I_P, and B_T [s]	~0.4	~3.5	~3	5	5

- 1st year goal: operating points with forces up to ½ the way between NSTX and NSTX-U, ½ the design-point heating of any coil
  - Will permit up to ~5 second operation at B_T ~ 0.65
- 2nd year goal: Full field and current, but still limiting the coil heating
  - Will revisit year 2 parameters once year 1 data has been accumulated
- 3rd year goal: Full capability

NSTX-U diagnostics to be installed during first year

MHD/Magnetics/Reconstruction

- Magnetics for equilibrium reconstruction
- *Halo current detectors*
- *High-n and high-frequency Mirnov arrays*
- Locked-mode detectors
- RWM sensors

New capability
Enhanced capability

Profile Diagnostics

- MPTS (42 ch, 60 Hz)
- T-CHERS: $T_i(R)$, $V_\phi(r)$, $n_C(R)$, $n_{Li}(R)$, (51 ch)
- P-CHERS: $V_\theta(r)$ (71 ch)
- *MSE-CIF (18 ch)*
- *MSE-LIF (20 ch)*
- *ME-SXR (40 ch)*
- Midplane tangential bolometer array (16 ch)

Turbulence/Modes Diagnostics

- *Poloidal FIR high-k scattering (installed in 2016)*
- *Beam Emission Spectroscopy (48 ch)*
- Microwave Reflectometer,
  Microwave Interferometer
- Ultra-soft x-ray arrays – multi-color

Energetic Particle Diagnostics

- *Fast Ion D_α profile measurement (perp + tang)*
- Solid-State neutral particle analyzer
- Fast lost-ion probe (energy/pitch angle resolving)
- Neutron measurements
- *Charged Fusion Product*

Edge Divertor Physics

- Gas-puff Imaging (500kHz)
- Langmuir probe array
- Edge Rotation Diagnostics (T_i, V_ϕ, V_{pol})
- *1-D CCD H_α cameras (divertor, midplane)*
- *2-D divertor fast visible camera*
- Metal foil divertor bolometer
- AXUV-based Divertor Bolometer
- IR cameras (30Hz) (3)
- *Fast IR camera (two color)*
- Tile temperature thermocouple array
- *Divertor fast eroding thermocouple*
- Dust detector
- Edge Deposition Monitors
- Scrape-off layer reflectometer
- Edge neutral pressure gauges
- *Material Analysis and Particle Probe*
- *Divertor VUV Spectrometer*

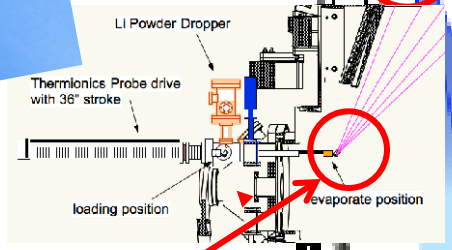
Plasma Monitoring

- FIReTIP interferometer
- Fast visible cameras
- Visible bremsstrahlung radiometer
- *Visible and UV survey spectrometers*
- *VUV transmission grating spectrometer*
- *Visible filterscopes (hydrogen & impurity lines)*
- Wall coupon analysis

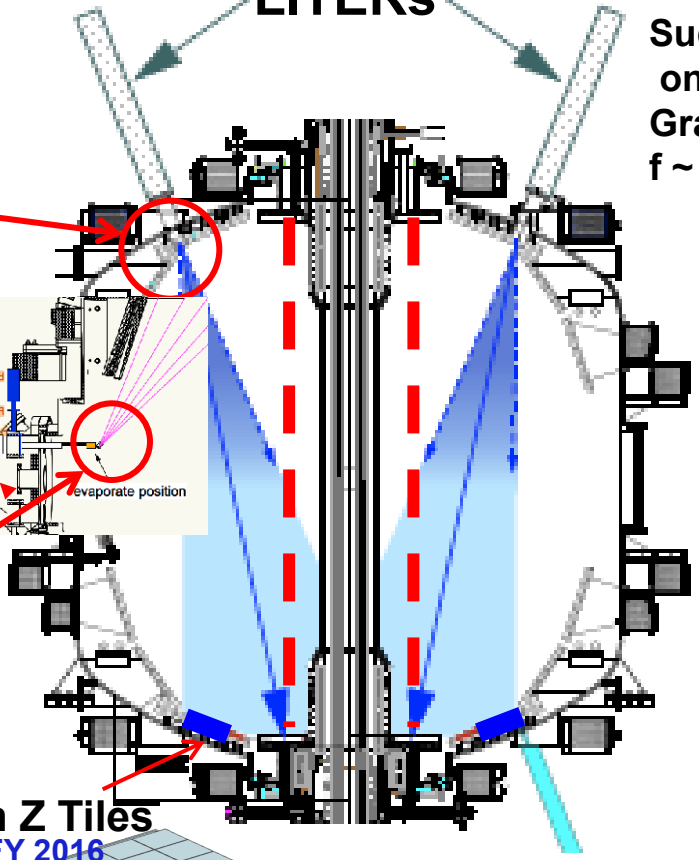
Comprehensive Boundary Physics Tools

Boronization, Lithium Evaporators, Granule Injector, High Z tiles

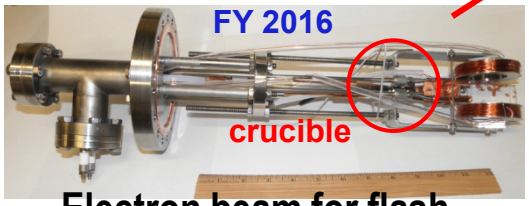
Lithium Evaporator (LITERs)



LITERs



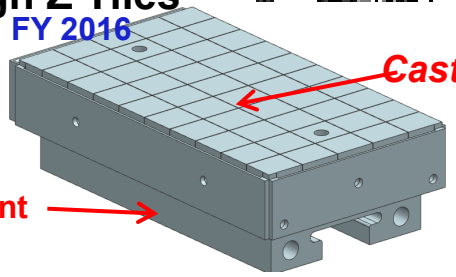
Upward Li evaporator



Electron beam for flash evaporation

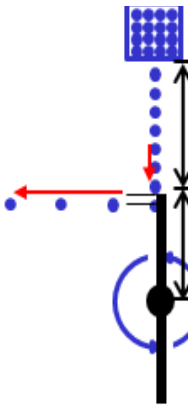
High Z Tiles

FY 2016



Granule injector (GI) for ELM pacing

Successfully tested on EAST and DIII-D
Granules: Li, B_4C, C
f ~ up to 500 Hz



Boronization System

dTMB Gas Cabinet.