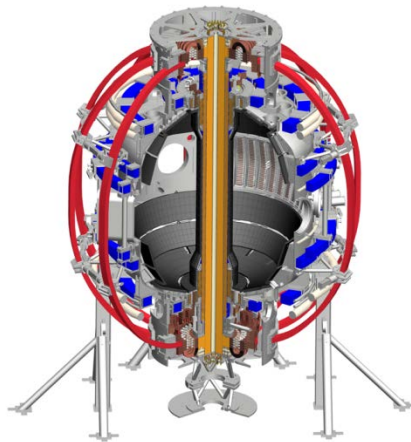


NSTX-U 2015 Research Program Overview*

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

Jon Menard
 NSTX-U Program Director
 For the NSTX-U Team

NSTX-U Research Forum for 2015
Plenary Session
February 24-27, 2015



Culham Sci Ctr
 York U
 Chubu U
 Fukui U
 Hiroshima U
 Hyogo U
 Kyoto U
 Kyushu U
 Kyushu Tokai U
 NIFS
 Niigata U
 U Tokyo
 JAEA
 Inst for Nucl Res, Kiev
 Ioffe Inst
 TRINITY
 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

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

Outline

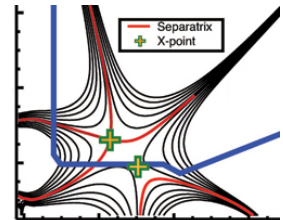
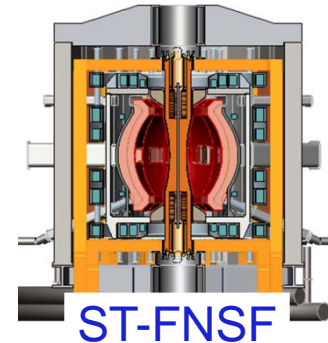
- Overview of the Forum
- NSTX-U Mission
- Organizational Structure
- Milestones
- Preliminary Run-time Guidance
- Idea Submission Statistics
- Some Guidelines for Prioritization
- Meeting Agenda / Logistics
- Summary

NSTX-U Research Forum Goal: Develop preliminary prioritization / assignment of 2015 experiments

- Cross-cutting eXperimental Machine Proposals (XMPs) for commissioning / calibrations discussed at pre-forum meetings
 - Scheduling / prioritization of (most) XMPs will be handled after Forum
- Researchers submit brief eXperimental Proposal (XP) ideas and present them at the forum
 - Motivation, goal, shot plan, # of run days, diagnostics, analysis...
- Topical Science Groups will nominally prioritize XPs according to detailed plans developed for 5 year plan (until obsolete...)
- Science Groups will look for opportunities for multi-TSG XPs
- Goal: ~70-90% of prioritization completed by end of forum
 - Highest priority research in research milestones / task forces
 - Proposals that address milestones will receive the most run time
- Expect ~1/3 of all XPs for year to be approved, ready at start of physics campaign (mid-May 2015), then roll forward

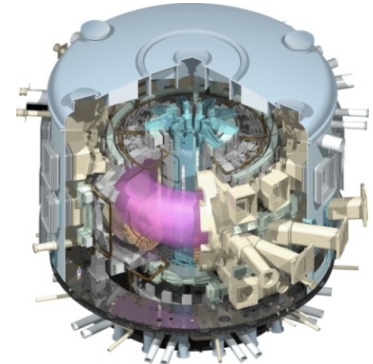
NSTX Upgrade mission elements

- Advance ST as candidate for Fusion Nuclear Science Facility (FNSF)
- Develop solutions for the plasma-material interface challenge
- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond
- Develop ST as fusion energy system



Liquid metals/Li “Snowflake/X”

ITER



New organizational structure w/ 3 Science Groups + Task Force aligns with Mission Elements, 5YP Goals

NSTX-U
Science
Groups:

Integrated
Scenarios

Boundary
Science

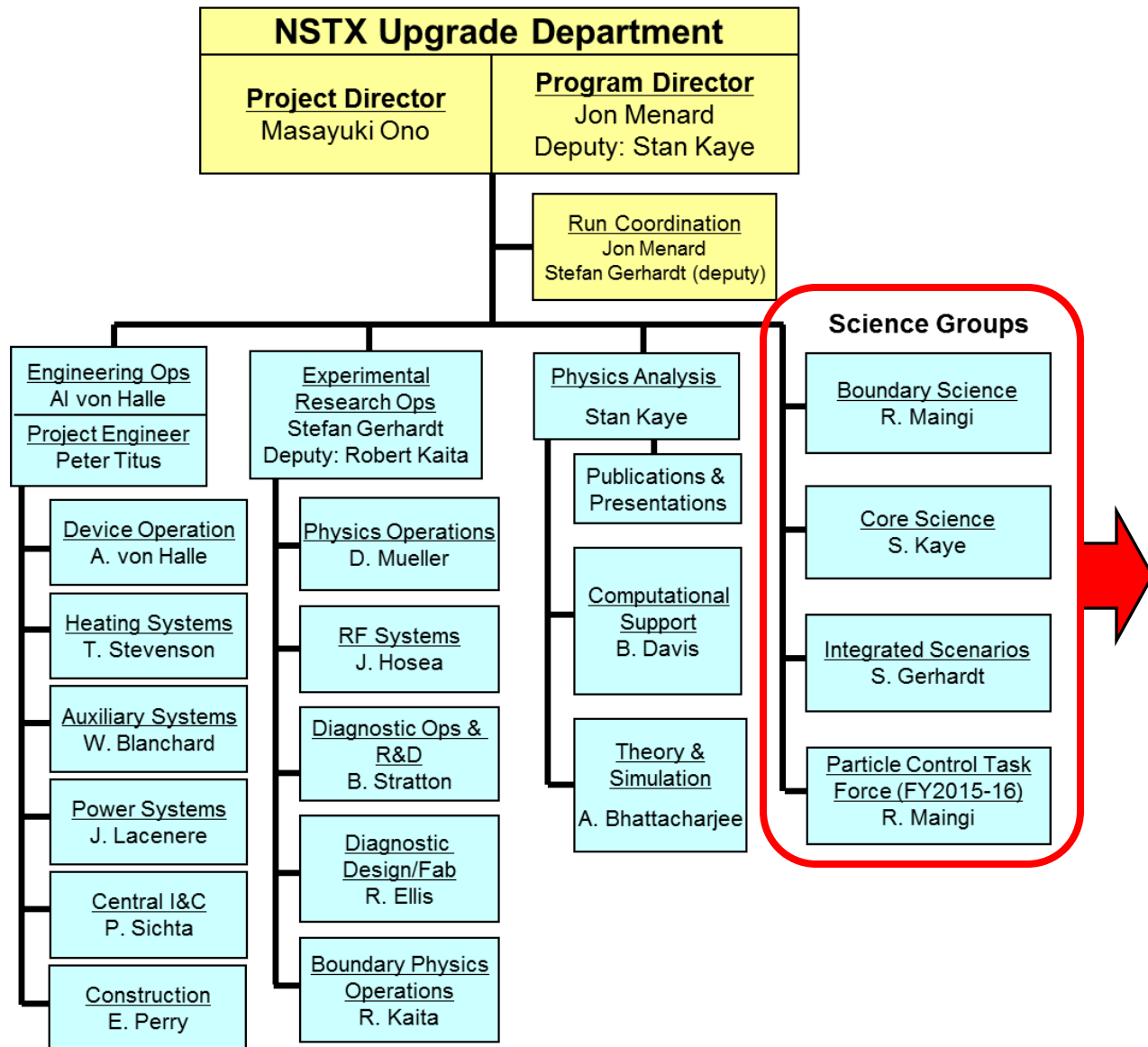
Core
Science

Particle Control Task Force
important for all missions

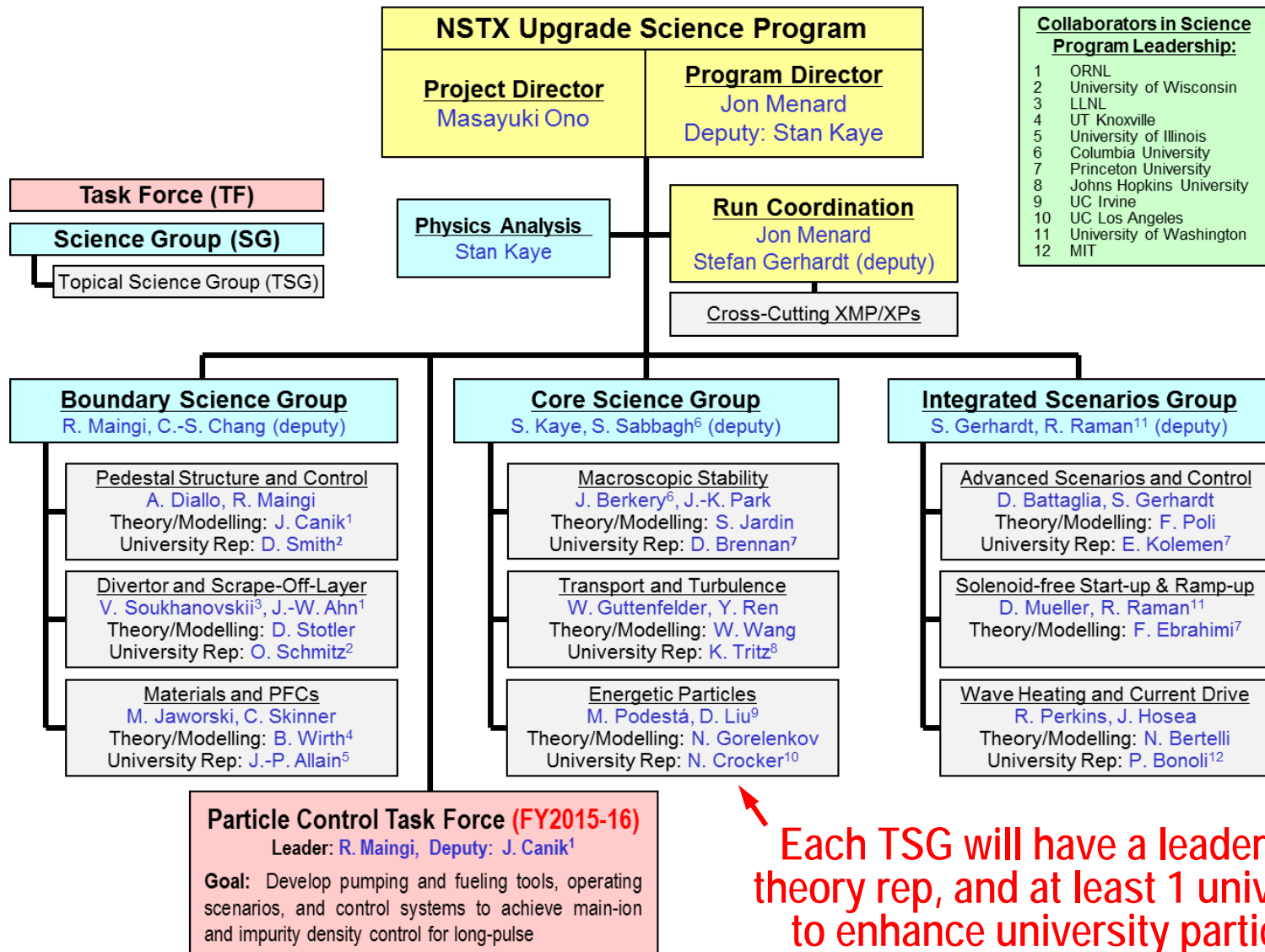
Mission Elements and 5 Year Plan 5 Highest Priorities

- Advance ST for FNSF
 1. Demonstrate 100% non-inductive sustainment at performance that extrapolates to $\geq 1\text{MW/m}^2$ neutron wall loading in FNSF
 2. Develop and understand non-inductive start-up and ramp-up (overdrive) to project to ST-FNSF with small/no solenoid
- Develop solutions for PMI challenge
 3. Develop / utilize high-flux-expansion "snowflake" + radiative detachment to mitigating high heat flux
 4. Begin to assess high-Z PFCs + liquid Li to develop high-duty-factor integrated PMI solutions
- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond
 5. Access reduced ν^* + high- β + varied q and rotation to dramatically extend ST understanding

NSTX-U Organization for FY2015



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



Motivations for restructuring science program

- TSGs provide expertise in broad range of topics, but expect program will benefit from better coordination between TSGs
 - SG leader responsibility: Coordinate TSG physics research plans, experimental/shot plans, diagnostic coverage & usage
- Experiments that engage more than one TSG will receive increased priority for run-time – **2 run weeks set aside**
- Efficient shot usage especially important during first run year (many systems need to be re-commissioned)
- Incorporate much wider set of University researchers/PIs in planning + coordination of research program (FES/PPPL goal)
- NEW: Task-force for long-pulse particle control → multi-TSG goal supporting entire research program

Particle Control Task Force (PC-TF)

- Leader/Deputy: Rajesh Maingi, John Canik
- Task force goal:
 - “Develop pumping and fueling tools, operating scenarios, and control systems to achieve main-ion and impurity density control for long-pulse”
- Scope includes XPs related to (for example):
 - Main-ion fueling optimization via PCS and/or real-time control
 - Wall coating and preparation optimization for increased particle pumping
 - Reduction / control of impurity ion source rates
 - Natural and paced ELMs for impurity and main ion flushing
 - Real-time density measurements for density feed-back control
 - Physics design and performance characterization of divertor cryo-pump (if/as resources permit implementation of cryo-pump)
- Due date: ASAP, end of FY16 run for non-cryo elements

FY2015/16 research milestones are highest priority, target exploitation of new capabilities, exploration of new regimes

Incremental (full ops)

Expt. Run Weeks:

FY2015

12 14

FY2016

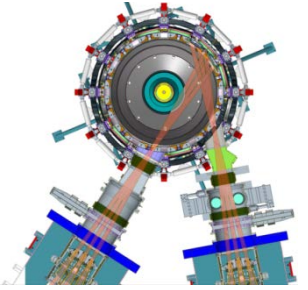
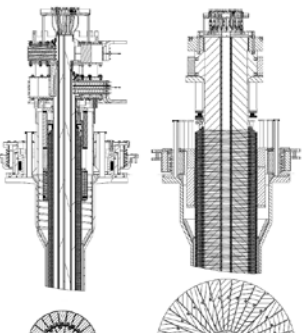
14 16

Boundary Science

Core Science

Integrated Scenarios

Previous center-stack New center-stack



Present NBI New 2nd NBI

R15-1

Assess H-mode confinement, pedestal, SOL characteristics at higher B_T , I_p , P_{NBI}

Develop snowflake configuration, study edge and divertor properties

IR15-1

R15-2

Assess effects of NBI injection on fast-ion $f(v)$ and NBI-CD profile

R15-3

Develop physics + operational tools for high-performance discharges (κ , δ , β , EF/RWM)

R16-1

Assess scaling, mitigation of steady-state, transient heat-fluxes w/ advanced divertor operation at high power density

R16-2

Assess high-Z divertor PFC performance and impact on operating scenarios

IR16-1

Assess confinement and local transport and turbulence at low v^* with full range of B_T , I_p , and NBI power

R16-3

Assess fast-wave SOL losses, core thermal and fast ion interactions at increased B_T , I_p

R16-4

Develop high-non-inductive fraction NBI H-modes for ramp-up & sustainment

FES 3 Facility Joint Research Target (JRT)

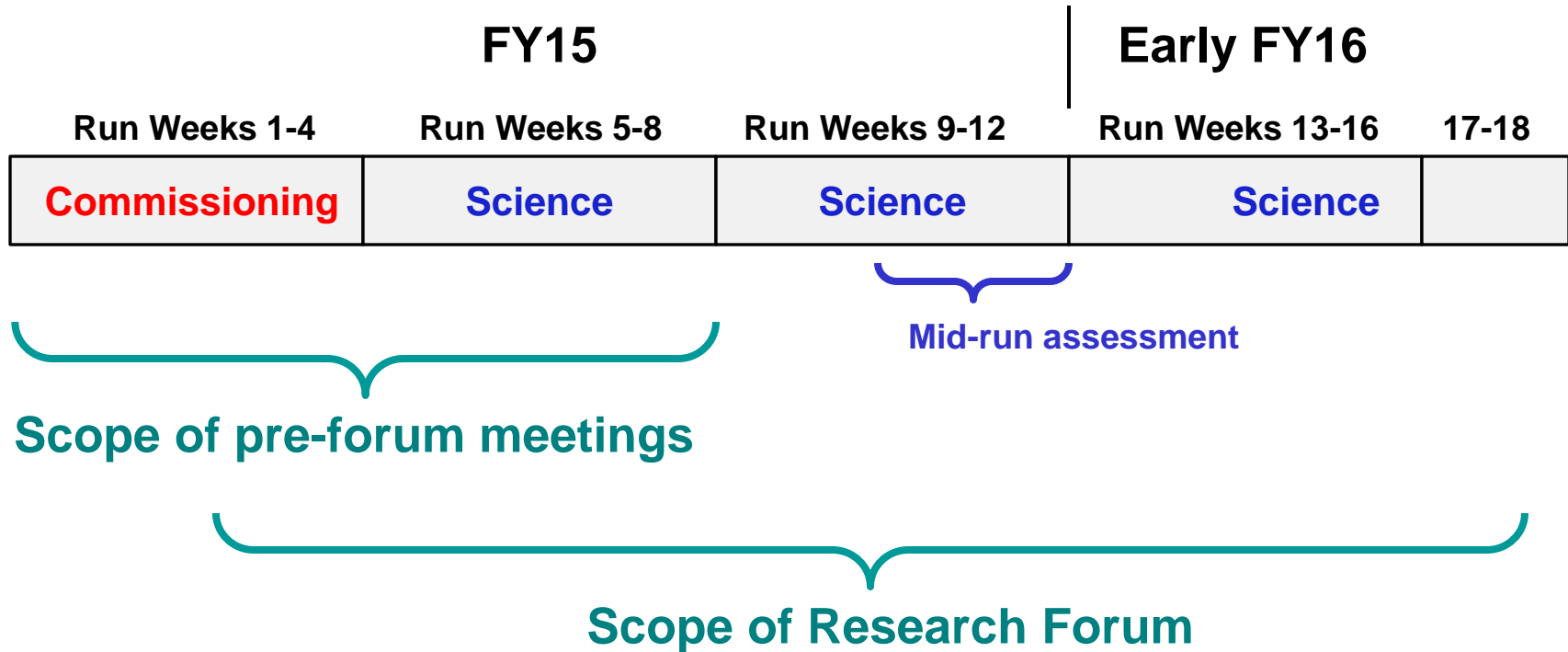
NSTX-U leads JRT

Quantify impact of broadened $J(r)$ and $p(r)$ on tokamak confinement and stability

C-Mod leads JRT

Assess disruption mitigation, initial tests of real-time warning and prediction techniques

FY15-16 run schedule assumptions



- Pre-forum meetings emphasized XMP/XP title, goal, author identification to cover first 2 run months (Weeks 1-8)
- Forum will emphasize prioritization of XPs for weeks 3-18, but also document commissioning XMP/XP goals + run-time
- Mid-run (re-)assessment after first 6-8 Science run-weeks

Operations assumptions for first 2 run-months

- Machine Commissioning...assume 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
 - **What science (aka XPs) can be done during this phase?**
- 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
 - **What critical XPs can/should be done during this phase?**

Initial Run-time Guidance for XP Prioritization

(Preliminary – can/will be tweaked/modified post-forum)

Baseline (12+4 weeks) # run weeks: 16
 Estimated total # run days: 80
 Estimated XMP run-days: 25
 Reserve for multi-TSG XPs: 10
 Contingency / director's reserve: 5
 Nominal total days for TSG/TFs to prioritize: 50
 Minimum # run days per TSG / TF: 2.5
 Milestone weighting for FY15-early FY16 run: 0.75

Cross-cutting commissioning, shot development, calibrations (may not include TSG-specific XMPs)

Priority #1 fraction
0.75

TSG / Task Force	FY 15 Milestones	FY16 Milestones	FY15 count	FY16 count	Milestone additional runtime	Forum Idea Count Increment	Nominal TSG / TF run days for single TSG XPs	Nominal TSG / TF run days for multi-TSG XPs	Nominal TSG / TF run days for all XPs	Nominal Priority 1 XP run time	Nominal Priority 2 XP run time	
Boundary	Pedestal	R15-1		1	0	0.75	0.5	3.5	1	4.5	3.5	1
	Divertor and SOL	R15-1	R16-1	1	1	1	1	4.5	1	5.5	4	1.5
	Materials and PFCs		R16-2		1	0.25	0	2.5	1	3.5	2.5	1
Core	Macroscopic Stability	JRT-15, R15-3	JRT-16	2	1	1.75	1	5	1	6	4.5	1.5
	Transport & Turbulence	JRT-15, R15-1		2	0	1.5	0.5	4.5	1	5.5	4	1.5
	Energetic Particles	JRT-15, R15-2	R16-3	2	1	1.75	0.5	4.5	1	5.5	4	1.5
Scenarios	Advanced Scenarios and Control	Notable, JRT-15, R15-2, R15-3	JRT-16, R16-4	4	2	3.5	1	7	1	8	6	2
	Solenoid-Free Start-up		R16-4	0	1	0.25	0	2.5	1	3.5	2.5	1
	Wave Heating and Current Drive		R16-3	0	1	0.25	0	2.5	1	3.5	2.5	1
Task Forces	Particle Control	R15-3		1	0	0.75	0.5	3.5	1	4.5	3.5	1
Total:								40	10	50	37	13

A few statistics on XMP/XP idea submissions:

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%

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%

Forum action items for SG / TSG / TF leaders, proposers, run coordination:

- ✓ Actively solicit input from the entire team – experimentalists, modelers, and theorists – to develop an extensive but goal-relevant list of ideas and proposals
- Organize, listen, question proposal presentation and plans
- Develop a prioritized XP idea lists based on run-time guidance for use in planning 2015 run
 - Determine XMP topics and XMP run-time required to support TSG-specific high-priority XPs not already discussed at pre-forum #2
- Forum summary session:
 - SG leaders or deputies: Present summary of key experiments, full list of run time requested and allocated, ID any issues/problems, and provide prioritized lists of experiments – make case for more run-time
 - Run coordination: Recap capabilities/milestones/run-time guidance, summarize # XPs and run-days requested, sketch out initial ops and first run-month, ID which XMPs/XPs need to be reviewed first

Some programmatic considerations for XP prioritization (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

Agenda (1)

Date & Time	Location	Topic
Tues, Feb. 24		<u>Plenary Session</u>
9 AM Eastern	Auditorium	Forum goals, priorities, agenda - J. Menard
9:30		NSTX-U facility & diagnostics status - M. Ono
10:00		MAST-U status, collaboration ideas - A. Kirk
10:30		Coffee Break
10:45		DIII-D status, collaboration ideas - R. La Haye
11:15		C-Mod status, collaboration ideas - B. LaBombard
11:45		Agendas for Boundary TSGs - Boundary SG
12:00 PM		Agendas for Core TSGs - Core SG
12:15		Agendas for Scenarios TSGs - Scenarios SG
12:30	Cafeteria	Lunch
		Topical Science Group Parallel Sessions
1:30 - 5 PM	B318	Pedestal Structure and Control
	B252	Energetic Particles
	B331	Advanced Scenarios and Control

Director's
Conference
Room (DCR)

Click links for
presentations

Holiday Inn vans will leave PPPL at 5:30PM and 6PM each day

Agenda (2)

Wed, Feb. 25		Topical Science Group Parallel Sessions
9 AM Eastern	B318	Macroscopic Stability
	B252	RF Heating and Current Drive
	B331	Materials and Plasma Facing Components
12:30 PM	Cafeteria	Lunch
		Topical Science Group Parallel Sessions
1:30 - 5 PM	B318	Divertor and Scrape-off Layer
	B252	Turbulence and Transport
	B331	Solenoid Free Start-up and Ramp-up
Thu, Feb. 26		Team-wide Sessions
9 AM Eastern	B318	Particle Control Task Force
	B252	<i>Room available if needed for TSG discussion</i>
	B331	<i>Room available if needed for TSG discussion</i>
	CR Annex	<i>Room available if needed for TSG discussion</i>
12:30 PM	Cafeteria	Lunch
		Science Group Parallel Sessions
1:30 - 5 PM	B318	Boundary Science + Particle Control Task Force
	B252	Core Science Group
	B331	Integrated Scenarios Group

TSGs can use these meeting rooms for additional discussion if necessary

This session is for discussion of multi-TSG XPs – SG leaders will organize, circulate agendas

Agenda (3)

Fri, Feb. 27		<u>Science Group Summary Session</u>
9 AM Eastern	Auditorium	Boundary Science Summary & Prioritization
9:45		Particle Control TF Summary & Prioritization
10:00		Core Science Group Summary & Prioritization
10:45		Integrated Scenarios Summary & Prioritization
11:30		Preliminary Run Plan
12:00 PM	Auditorium	Team Photo
12:30 PM		End of meeting

Can't attend the photo? See Elle Starkman for a portrait (or send her a picture with solid color background) and maybe she can Photoshop you in

Thank you for coming to the Forum!

- If you do not have a PPPL badge, please see Joanne Savino (at the registration desk or jsavino@pppl.gov) to get a **4 day visitor badge** with your photo on it (if you sent her a photo/selfie...)
 - Joanne is in room number B325A, Office phone: 609-243-3379
- For pppl-guest Wi-Fi you can list me as the host:
 - Jon Menard, jmenard@pppl.gov

Backup

Roles / Responsibilities for Science Groups

- Work with Program/TSGs to set run-time allocation guidance
- Coordinate research of TSGs within the SG – promote experiments / plans that achieve multiple scientific goals
 - Critical to maximizing scientific output per shot
 - “Coordinated” XPs will receive higher priority / more run time
- Inform Run Coordinator when XP is ready for final review
- Provide summaries and highlights of scientific progress at/for NSTX-U team meetings, FES/quarterly reviews, other venues
- Aid dissemination of results with Physics Analysis Division
 - Journal publications, invited talks, seminars, colloquia, conferences, ITPA, BPO
- Coordinate / down-select milestone ideas from TSGs in SG
- Provide feedback / comment on annual Field Work Proposal
- Assist / report to the NSTX-U Program and Project directors

Roles / Responsibilities for Topical Science Groups

- Lead brainstorming, organization, writing of 5 year plan topics
- Determine and address highest priority scientific issues through discussion and consensus at open meetings
- Organize the NSTX-U Research Forum sessions for the TSG
- Draft scientific milestone ideas utilizing expertise of the TSG
- Propose and execute experiments to achieve milestones and address priorities
- With SG leaders, define facility and theory resources to achieve research goals
- Present TSG / SG results and plans at NSTX-U PAC meetings
- Assist / report to the NSTX-U Science Group leaders

Roles / Responsibilities for University Representatives

- Contribute to prioritization within TSGs
 - Help decide/draft milestones, XMP/XP prioritization
 - Help identify how your tools/codes/diagnostics/personnel can contribute to the group and the larger NSTX-U program
 - Advocate for your own research and for the needs of the larger NSTX-U research program
- Advocate for your TSG research outside of NSTX-U
 - Seek input/interest from those not funded by NSTX-U
 - Particularly from your own University and other universities
 - Includes giving seminars at other Universities / institutions describing NSTX-U and/or your research
- Help identify best tools for remote participation, and remote experimentation

Roles / Responsibilities for Task Forces

- Address specific operational and/or scientific goal that cuts across or impacts multiple SGs / TSGs
- Goal must be very high priority within research program
- Receives dedicated run-time, and has dedicated session at Research Forum
 - Similar to a TSG, but may not necessarily have theory/modelling or university representatives – depends on duration or scope
- Organizes experimental proposals to achieve goal
- Finite duration - nominally 1-2 years, renewable if necessary
- TF leadership should nominally have a leader and a deputy, and should include at least 1 collaborator if possible
- Reports directly to Program / Project

Roles / Responsibilities for Working Groups

- Responds to specific programmatic or technical charge from NSTX-U Program or Project
- Addresses issues that cross-cut more than one SG or TSG
- Nominal lifetime = 1-2 years, can be extended/renewed
- Provides points of contact between NSTX-U and other groups as necessary (e.g. PPPL theory, FESAC, ITPA)
- Does not have dedicated NSTX-U run time, but provides recommendations on XP prioritization, other resource needs
- WG leadership should nominally have a leader and a deputy, and should include at least 1 collaborator if possible

Non-axisymmetric Control Coil Specification Working Group (NCC-WG)

- Leader/Deputy: Jong-Kyu Park, John Canik
- Charges:
 - Specify required coil current, frequency, and location for NCC
 - Consider full set (24 coils) and partial set (12 coils)
 - Consider range of applications: NTV, EFC, RWM, RMP, ELM pacing, etc...
 - Specify required number of independent SPA channels vs. applications and requested capabilities
- Deliverables:
 - Organize summary presentation(s) on IPECOPT analysis results
 - Give presentation(s) making recommendations on NCC and SPA performance requirements, gather and incorporate team input
 - Generate written report (5-20pp Word file) documenting NCC and SPA requirements for use in developing engineering requirements document (GRD) to drive engineering design
- Due dates:
 - Initial written report April 2015 if possible (no later than May)
 - Consult with Project/engineers/designers as needed until implementation

Disruption Prediction/Avoidance/Mitigation Working Group (DPAM-WG)

- Leader/Deputy: Steve Sabbagh, Roger Raman
- Charges:
 1. How will NSTX-U interface to the upcoming FES workshops, and longer-term, address the FESAC/FES Tier 1 issue of "Transients" generally?
 - a. In which disruption research areas can NSTX-U make leading contributions?
 - b. What are the associated long-term resource needs from NSTX-U?
 2. What are the leading/highest priority NSTX-U contributions to JRT-16?
 - a. What are the required resources during FY15-16 to support JRT-16?
 3. How can NSTX-U minimize disruptivity rates?
 - a. What are leading causes of disruptions in NSTX & during initial NSTX-U ops?
 - b. What prerequisites / tools are needed to prepare NSTX-U to operate a large # of sequential shot-seconds (say 1-5 shot minutes) without a disruption?
- Tasks: Organize meetings/reports to address above charges
- Due dates:
 - 1a – March/April 2015, 1b May/June 2015
 - 2a – April 2015, 3a – end of CY 2015, 3b – TBD/long-term