NSTX-U

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Program update - with emphasis on collaboration plan during Upgrade outage

J. Menard

NSTX-U FY2012 1st Quarter Review
B205 - PPPL
January 27, 2012

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
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U Colorado
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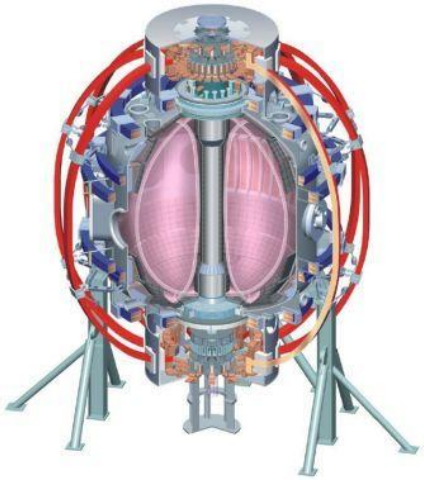
U Rochester
U Washington
U Wisconsin

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
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
NFRI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep



Outline

- Overview of researcher activities for 2012-13
- FY2012-14 milestones
- PAC-31 charge issues/questions
- Schedule for 5 year plan preparation
- Collaboration overview
- Summary

Staff plans for FY2012-13 analysis and research

- Complete analysis and publication of FY2011-12 data
- Develop, write NSTX Upgrade 5 year plan for 2014-18
- Planning and design studies supporting post-Upgrade ops:
  - Start-up: CHI upgrades, point helicity injection (plasma guns)
  - Boundary: Divertor cryo-pumps, divertor diagnostics
  - Lithium: Additional Mo tiles, upward Li evaporators, next-gen LLD
  - Transport, EP: New high-k scattering, polarimetry, assess solid-state NPA
  - MHD: 3D-coil physics design for RWM/RMP/TM/EFC/NTV/TAE + disruption force diagnostics, disruption precursor ID
  - Control: Rt-MSE for NBI J-profile control, rt-control of heat flux
- Update/extend physics design of ST-FNSF
  - LDRD to further develop configuration/concepts, utilize NSTX team expertise
  - Predictive modeling of start-up, sustainment, transport, stability, divertor
  - *Will be topic of future Monday AM videoconference*
- Collaborate on domestic and international facilities
  - Initial collaboration plans described with research plans

FY2012-14 research milestones emphasize analysis, simulation, and projection to and preparation for NSTX-U

	FY2012	FY2013	FY2014
Expt. Run Weeks:			12
Transport and Turbulence		Perform integrated physics+optical design of new high-k_θ FIR system	
Macroscopic Stability	Investigate magnetic braking physics and toroidal rotation control at low ν^* (with ASC TSG)		Assess access to reduced density and ν^* in high-performance scenarios (with ASC, BP TSGs)
Boundary and Lithium	Project deuterium pumping using lithium coatings and cryo-pumping	Assess relationship between lithium-conditioned surface composition and plasma behavior	
Waves+Energetic Particles		Perform physics design of ECH & EBW system for plasma start-up & current drive in advanced scenarios	Assess reduced models for *AE mode-induced fast-ion transport
Solenoid-free Start-up/ramp-up	Simulate confinement, heating, and ramp-up of CHI start-up plasmas (with HHFW TSG)		
Adv. Scenarios and Control			Assess advanced control techniques for sustained high performance (with MS, BP TSGs)
ITER Needs + Cross-cutting		Identify disruption precursors and disruption mitigation & avoidance techniques for NSTX-U and ITER	
Joint Research Target (3 facility)	Understand core transport and enhance predictive capability	Stationary regimes w/o large ELMs, improve understanding of increased edge particle transport	TBD

NSTX-U PAC meeting – April 17-19, 2012

Preliminary ideas for PAC charge topics/questions:

- NSTX-U team scientific productivity during Upgrade outage
  - Analysis, publications, present and upcoming milestones
- NSTX-U team participation and utilization of collaboration with other facilities to prepare for NSTX-U operation and contribute to fusion science generally
- Preliminary ideas and preparation for 5 year plan:
  - Initial operation of NSTX-U = 2014-15
  - Longer term: later stages of 5 year plan = 2016-18

Draft schedule for 5 year planning preparation

- Jan-Mar 2012 – define physics program, needed diagnostic and facility upgrades for initial ops (2014-15) and 2016-18
- April 2012 – get initial feedback from PAC on long-term plans
- May 2012 – formulate/finalize plan elements and outline, identify/finalize authors, begin writing chapters
- October 2012 – First drafts of plan chapters due
- Nov-Dec 2012 – internal review/revision/editing of plan
- Jan/Feb 2013 – 5 yr plan presentation 'dry-run' to PAC-33
- Plan presented to Review committee and FES Mar/Apr 2013

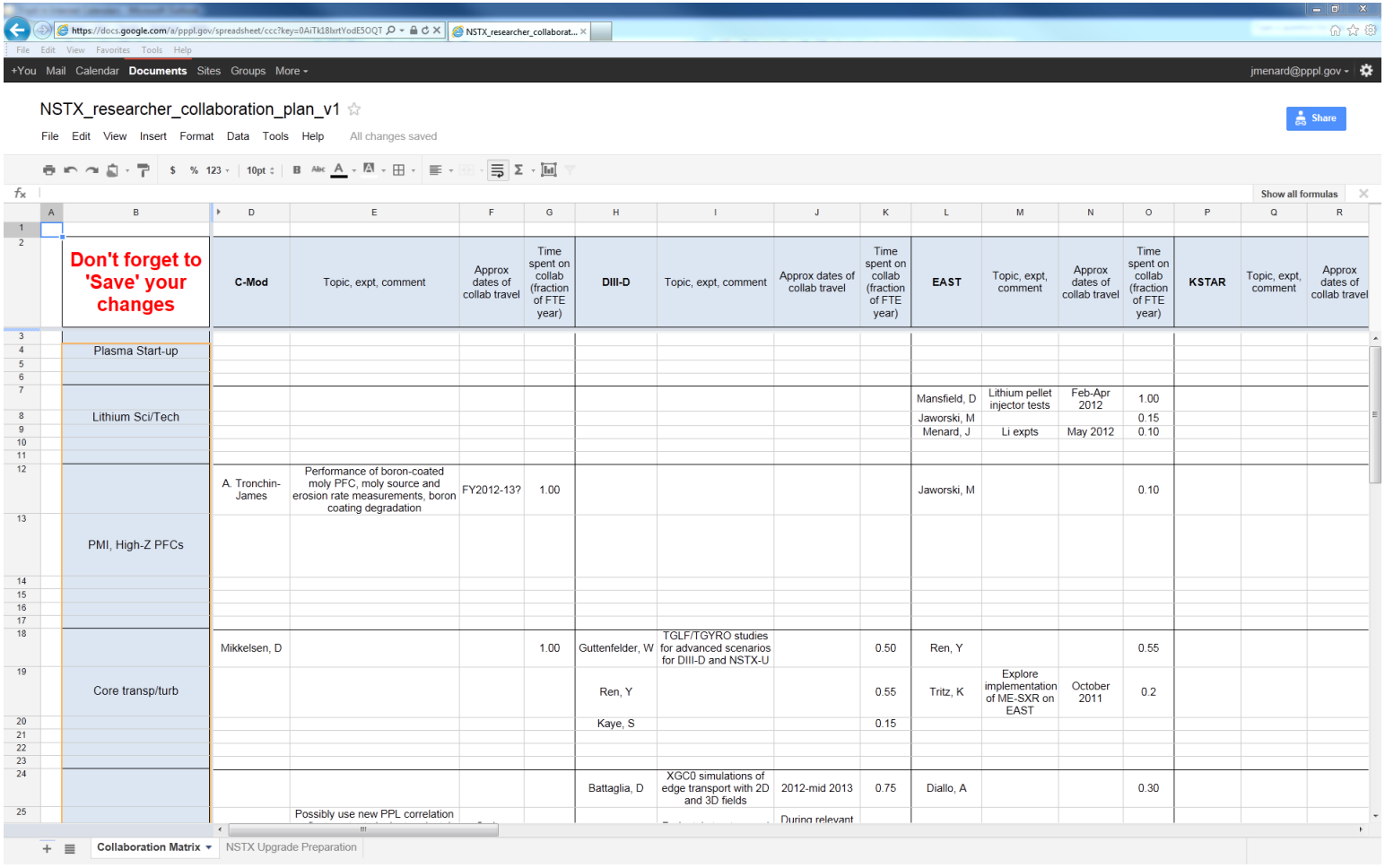
Collaborations: Held team-wide discussion on FY12-13 opportunities and expectations in Sep-Dec 2011

- Collaboration should aim to support NSTX-Upgrade mission
  - Also support toroidal physics generally, ICCs, and non-fusion applications
- For all researchers, use Upgrade outage as opportunity to:
  - Extend and improve your ongoing and future research on NSTX
  - Learn about other facilities – bring back knowledge, best practices
  - Try or learn something new – new physics, diagnostics, analysis, …
- Aim to form small teams from NSTX (PPPL + non-PPPL)
  - Coordinate research plans, analysis, travel, and participation
- Expectations for researchers:
  - Select 1 primary and 1 secondary/backup collaboration project
  - Aim for 1st author papers, invited talks – PRL/NF/PoP, APS/IAEA
  - Present your results periodically to NSTX, PPPL research seminars
- Facilities: MAST, DIII-D, C-Mod, LHD, EAST, KSTAR, JET, more to come
- Funding: PPPL covers salaries of PPPL NSTX researchers by default
- Challenge: no additional NSTX funding dedicated to collaboration
- Working closely with PPPL off-site research department

Google docs used to share collaboration plan – organized by topic, facility, person, date, FTE-yrs

https://docs.google.com/a/pppl.gov/spreadsheet/ccc?key=0AiTk18lxrtYodE5OQTJkeVFsdU42eWN0alVnaHFyWUE#gid=0

- ***Click the link above (should be available to all), or e-mail me at jmenard@pppl.gov if you have trouble***
- ***Entries with topics and travel dates are the most well defined, others may be place-holders***



NSTX_researcher_collaboration_plan_v1

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Share

	Don't forget to 'Save' your changes	C-Mod	Topic, expt, comment	Approx dates of collab travel	Time spent on collab (fraction of FTE year)	DIII-D	Topic, expt, comment	Approx dates of collab travel	Time spent on collab (fraction of FTE year)	EAST	Topic, expt, comment	Approx dates of collab travel	Time spent on collab (fraction of FTE year)	KSTAR	Topic, expt, comment	Approx dates of collab travel
	Plasma Start-up															
	Lithium Sci/Tech									Mansfield, D	Lithium pellet injector tests	Feb-Apr 2012	1.00			
										Jaworski, M			0.15			
										Menard, J	Li expts	May 2012	0.10			
	PMI, High-Z PFCs	A. Tronchin-James	Performance of boron-coated moly PFC, moly source and erosion rate measurements, boron coating degradation	FY2012-13?	1.00					Jaworski, M			0.10			
	Core transp/turb	Mikkelsen, D			1.00	Guttenfelder, W	TGLF/TGYRO studies for advanced scenarios for DIII-D and NSTX-U		0.50	Ren, Y			0.55			
						Ren, Y			0.55	Tritz, K	Explore implementation of ME-SXR on EAST	October 2011	0.2			
						Kaye, S			0.15							
						Battaglia, D	XGC0 simulations of edge transport with 2D and 3D fields	2012-mid 2013	0.75	Diallo, A			0.30			
			Possibly use new PPL correlation					During relevant								

Collaboration Matrix | NSTX Upgrade Preparation

Collaborations in materials/PMI, boundary physics

- EAST is only other divertor H-mode facility using lithium
  - Li/transport expts on EAST – D. Mansfield, J. Menard, M. Jaworski, K. Tritz
- Li surface chemistry issues on LTX, working with PU, Purdue
  - Use Purdue MAPP on LTX + surface/PMI studies – C. Skinner, M. Jaworski
  - Improve equilibrium reconstruction/control on LTX – Gerhardt, Menard
- Assess high-Z PFCs for NSTX-U through collaboration on C-Mod
  - LLNL group to assess: Mo with low-Z coatings, study cryo-pump for density control with moly PFC (particle balance, supersonic gas jet fueling), possibly radiative divertor control development
- Develop NSTX-U snowflake control on DIII-D
  - V. Soukhanovskii + E. Kolemen
- Test LLNL SPRED, NIR for NSTX-U divertor diagnosis
  - LLNL to work with Y. Raitses' LTP source
- Pedestal/SOL transport, turbulence, stability research for ITER and NSTX-U
  - Pedestal turbulence using correlation reflectometer on C-Mod - A. Diallo
    - A. Diallo also planning XPs on DIII-D (R. Groebner), possibly MAST
  - XGC0 simulations of DIII-D edge transport w/ 2D & 3D fields - D. Battaglia
  - SOL turbulence measurements with GPI on EAST, C-Mod - S. Zweben

Collaborations on core transport and turbulence

- Pursue TGLF/TGRYO studies for scenario prediction for NSTX-U and DIII-D, also DIII-D transport studies
  - W. Guttenfelder, Y. Ren, and S. Kaye
- Comparison of NSTX and MAST transport physics, BES data
  - S. Kaye, W. Guttenfelder, D. Smith/Univ. Wisconsin
- Exploration of new/needed turbulence diagnostics for NSTX-U
  - PCI for intermediate $k_\theta \rho_s$ (C-Mod) – Y. Ren
  - Polarimetry for δB from μ-tearing (DIII-D & C-Mod) – Ren, Guttenfelder
- Impurity transport studies, perturbative transport
  - Exploring use of ME-SXR on EAST for profile meas. – K. Tritz (JHU)
- 3D field effects on transport and turbulence
  - Transport simulations on LHD - D. Mikkelsen & (maybe) W. Guttenfelder

Collaborations in start-up, scenarios/control, MHD

- Plasma start-up
  - Work with Pegasus on plasma guns, possibly DIII-D to improve PF-only + EC start-up and inform proposed NSTX-U ECH/EBW – D. Mueller
  - Investigate application of CHI on QUEST – R. Raman (U. Wash)
  - EBW startup experiments on MAST - G. Taylor
- Advanced Scenarios and Control - E. Kolemen (relocated to GA)
  - Prepare for current and rotation profile control in NSTX-U through collaboration on DIII-D using off-axis NBI (and counter-NBI), NTV
  - Contribute to development of ITER plasma control specification
  - MAST vertical control analysis/experiments – prep for NSTX-U/MAST-U
  - Long-pulse tokamak ops/control experience (EAST/KSTAR) – D. Mueller
- MHD Physics
  - Assist DIII-D in new 3D δB sensors - N. Logan, J-K Park, J. Menard
  - 3D field physics in long-pulse H-mode in KSTAR – J.-K. Park, S. Sabbagh
  - RWM physics at reduced ν^* on DIII-D, NTV on MAST – S. Sabbagh/CU

Collaborations in waves and energetic particles, and diagnostic development

- RF coupling and edge-loss studies in DIII-D for NSTX-U, ITER
  - J. Hosea, R. Perkins, G. Taylor
- RF-only H-mode in EAST – R. Wilson, G. Taylor
  - Supports RF-only plasma heating/start-up studies for NSTX-U
- Energetic particles and Alfvén eigenmode physics
  - Study fast-ion physics on JET (2 year relocation), prep for possible DT campaign, beam ion loss measurements on LHD - D. Darrow
  - Several fast-ion/AE physics opportunities on MAST
    - Assess operation of MAST *AE antenna, participate in expts – E. Fredrickson
    - Assess performance of neutron collimator, NBI fast-ion redistribution models – M. Podesta
    - Fusion product loss detector – D. Darrow, W. Boeglin
- Diagnostic development
  - Assist with ITER diagnostics – B. Stratton
  - Assist with MPTS on JET, LTX, maybe KSTAR & Pegasus – B. LeBlanc
  - Develop/prepare new Accurate Wavelength Lens Spectrometer (AWLS) on LTX for installation/usage on NSTX-U – R. Bell

Some statistics, and issues going forward

- Tracking 30-35 researchers, including on-site collaborators
  - ~90% of researchers have definitive plans well-aligned with NSTX-U and/or PPPL research goals
- Approximate order of collaboration emphasis by facility:
  - DIII-D, C-Mod, EAST, MAST, KSTAR, LHD, LTX, …
  - U.S. facilities most mature in diagnostics, tools, analysis, and are therefore often most attractive to researchers
- EAST and KSTAR have expressed strong interest in collaboration from PPPL/NSTX researchers
  - EAST, KSTAR still developing diagnostics, heating systems, organization for integrating collaborators – improving
- Prep for NSTX-U operation highest priority by late 2013
  - Also tracking who/what is needed for operations and diagnostics

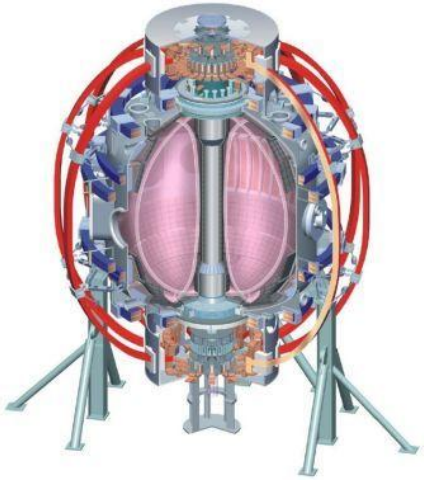
Summary

- Physics analysis and publication progressing well
  - Papers published Oct-Nov 2011: 21+
  - Papers submitted (in review): 13
  - APS-DPP
    - Invited talks: 7
    - Contributed Orals: 13
    - Contributed Posters: 48
  - APS April Meeting (upcoming): 1 invited talk (momentum transport)
- Brainstorming/planning for 5 year plan underway
- Collaboration planning & preparation progressing well
  - Many opportunities and interested researchers identified
  - Strong support of NSTX-U/PPPL/FES strategic goals

NSTX Facility Update

College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
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

NSTX-FES FY 2012 Q-1 Review
January 27, 2012



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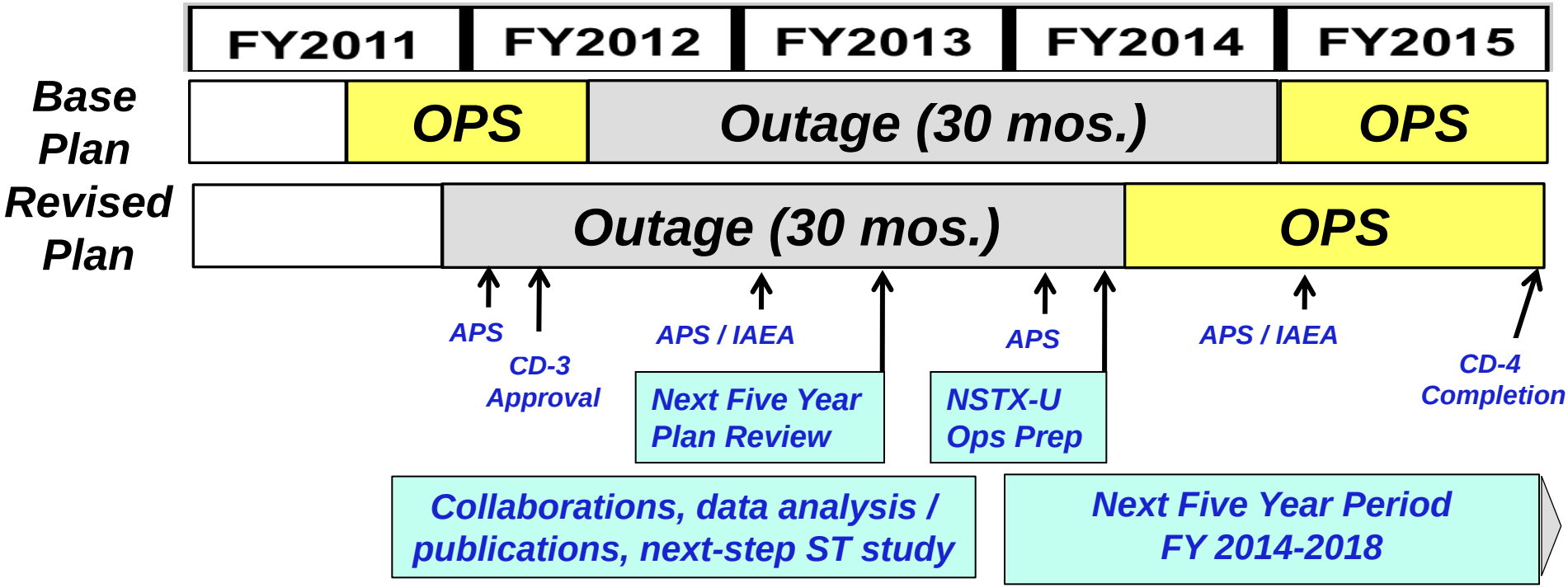
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Outline

- FY 2012 Facility Summary and Status
- ARRA Upgrade Project Final Report
- FY2012-14 Facility and Diagnostic Planning

Upgrade acceleration maximizes NSTX run time and scientific productivity over next 5 yr period (2011-15)



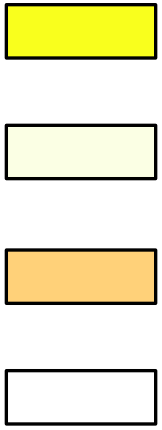
After the TF fault, the NSTX Upgrade outage started six month earlier.
Revised schedule aligns well with the next 5 year plan period.
A good progress was made in removing and storing diagnostics and related racks with adequate documentation for re-installation planned in FY 2013.
NSTX-U activities are generally going very well.

Good Progress on the Diagnostic Removal

62 Diagnostics - 45 removed, 5 partially removed, 6 remain

Beam Emission Spectroscopy (BES)
Bolometer - divertor array
Bolometer - midplane array
CHERS - poloidal
CHERS - toroidal
Edge bias & Langmuir probes - inter-LLD
Edge deposition monitors
Edge pressure gauges
Edge Rotation Diagnostic (ERD)
Fast cameras - divertor & LLD
Fast Ion D-Alpha (FIDA) Radial view
Fast Ion D-Alpha (FIDA) Tangential view
Fast lost ion probes
Filterscopes, 1-D D-alpha cameras (EIES)
FIReTIP - multi-chord interferometry
Gas puff imaging - divertor
Gas puff imaging - midplane
High-k scattering
Infrared cameras
Interferometry/forward scattering - 1 mm
Langmuir probes - PFC tiles
Langmuir probes - fast eroding
Langmuir probes (baffled) - outboard
Langmuir probes (high density) - inter-LLD
Magnetics - diamagnetism
Magnetics - flux loops
Magnetics - locked modes
Magnetics - outboard divertor halo current
Magnetics - Rogowski coils
Magnetics - RWM sensors

MAPP
Mirnov coils - high frequency
Mirnov coils - poloidal array
Mirnov coils - three-axis
Mirnov coils - toroidal array
MSE-CIF
MSE-LIF
Neutron detectors
NPA - E || B scanning
NPA - solid state
Plasma TV
Reflectometer - 65 GHz backscattering
Reflectometer - correlation
Reflectometer - fixed freq.
Reflectometer - FM/CW
RF Probe - lower dome
Spectroscopy - Divertor UV/visible
Spectroscopy - LOWEUS EUV
Spectroscopy - Lyman-alpha array
Spectroscopy - SPRED VUV
Spectroscopy - SWIFT 2D flow
Spectroscopy - VIPS visible
Spectroscopy - XEUS EUV
Spectroscopy - X-ray crystal - horizontal
Spectroscopy - X-ray crystal - vertical
Thomson scattering - MPTS
Visible bremsstrahlung
X-rays - "Optical" array
X-rays - Tangential TG spectrometer
X-rays - ultrafast pinhole camera
X-rays - Ultrasoft arrays
X-rays - bremsstrahlung spectrum



ARRA Funding Greatly Enhanced Research Capability

Planned ARRA Upgrades Completed on Schedule

- **Extra 12 channels for the multi-pulse Thomson scattering system** for improved H-mode pedestal and plasma edge spatial resolution to support the FY 11 joint research milestone.
- **Enhancement to the liquid lithium divertor target** capability for modifying edge collisionality, including two lithium evaporators, and LLD diagnostics.
- **Post Doctoral Fellows** to support the enhanced research capabilities.
- **2nd switching power amplifier system** for improved error field/resistive wall mode/resonant magnetic perturbation spectra to control the edge error field.
- **Motional Stark Effect Laser Fluorescence advanced diagnostic system** for internal magnetic and electric field measurements was installed and commissioned.
- **Inboard Divertor Molybderum Tiles** for assessing the viability of molybdenum tiles as a divertor PFC for NSTX-U (upper divertor being considered).
- **Li Granule Injector** for triggering ELMS in a controlled manner. Commissioned and planned to be tested in RFX (Italy), EAST and possibly on DIII-D

NSTX ARRA Upgrade Budget Summary ($M)

All of the Planned Upgrades Completed on Schedule

Baseline Plan for NSTX Upgrades contained in PEP								
	Base Estimate	Contingency	Budgeted Total		Costs 12/31/11		ETC 12/31/11	EAC 12/31/11
9419-****-A100 Upgrade MPTS for Improved Spatial Resolution	$1,211,800	$363,540	$1,575,340		$1,567,496			$1,567,496
Enhance LLD Capability	$804,000	$241,200	$1,045,200		$841,903			$841,903
9419-****-A200 LLD Cameras	$363,300	$108,990	$472,290		$253,966			$253,966
1190-****-A250 LITER Fill System	$200,600	$60,180	$260,780		$356,795			$356,795
9419-****-A290 Enhanced Divertor Spectroscopy	$240,100	$72,030	$312,130		$231,142			$231,142
1191-****-A300 Increase Post-Doc Staff	$551,200	$55,120	$606,320		$550,315		$55,757	$606,072
9419-****-A500 Allow Implementation of 2nd SPA	$1,647,800	$494,340	$2,142,140		$2,279,830			$2,279,830
9419-****-A600 Support Completion of MSE-LIF	$1,220,200	$366,060	$1,586,260		$1,459,215			$1,459,215
9419-****-A700 Inboard Divertor Molybdenum Tiles					$210,511			$210,511
1191-****-A800 Li Granule Injector					$32,053			$32,053
1191-****-*NUL Allocated Costs					$36,919			$36,919
Undistributed Budget	$78,740		$78,740					
Total	$5,513,740	$1,520,260	$7,034,000		$6,978,243		$55,757	$7,034,000

Facility and Diagnostic Upgrade Plans for FY 2012 – 2014 In Support of the NSTX-U Operation and Research Plan

Facility and Diagnostic Milestones:

- FY 12: Identify possible high priority facility and diagnostic enhancements for the post upgrade operations
- FY 13: Complete the conceptual design of high priority facility and diagnostic enhancements for post-upgrade operations
- FY 14: Implement high priority facility and diagnostic enhancements for post-upgrade operations as the resource permits (if for example, the upgrade project under runs)

Other Related Activities:

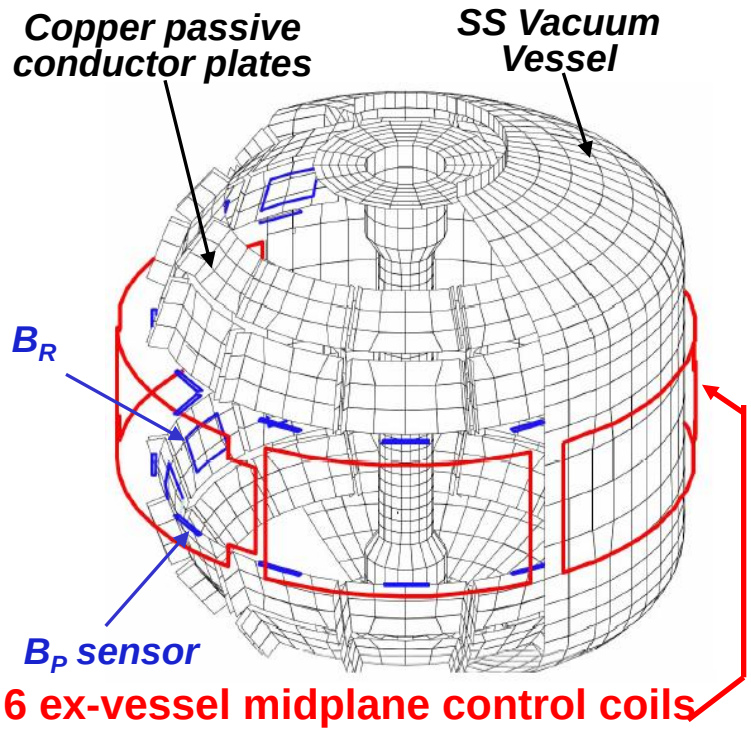
NSTX Team Facility – Diagnostic Upgrade Brainstorming Meetings in July 2011 and Feb. 2012.

NSTX collaboration diagnostic grants decision in Jan-Feb, 2012

DOE advanced diagnostic grant solicitation and NSTX laboratory collaboration proposal solicitation in 2013

NSTX physics collaboration grant solicitation in 2014

New MHD and Plasma Control Tools Available for NSTX-U
Sustain β_N and Understand MHD Behavior Near Ideal Limit



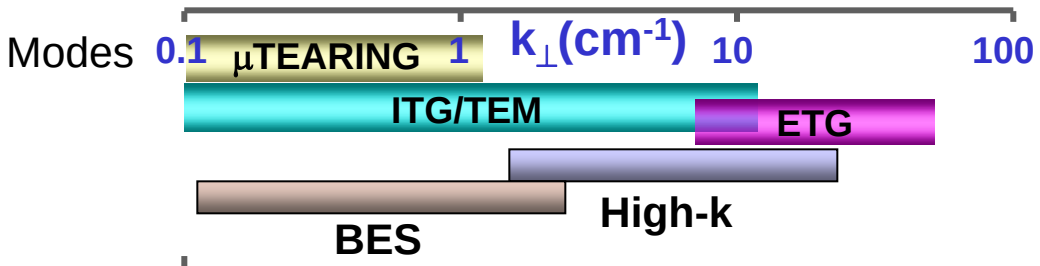
2nd 3-channel Switching Power Amplifier (SPA) commissioned in July 2011 powers independent currents in six EFC/RWM coils for simultaneous control of n = 1, 2, 3 field harmonics

- **RWM spectrum dependence**
- **Rotation and beta effects on NTMs**
- **Response to 3D fields for EFC, ELM and Neoclassical Toroidal Viscosity physics**
- **Disruption physics**

- **A Real-Time Velocity (RTV) diagnostic (commissioned in 2011) will be incorporated into the plasma control system for feedback control of the plasma rotation profile using the NBI and non-resonant magnetic braking as the actuators.**
- **A new Plasma Control System (PCS) platform with increased capabilities (e.g., 64-bit operating system and ability to support additional I/O points and real-time algorithms) will be implemented for NSTX-U. A similar system will be used for the Digital Coil Protection System (DCPS) for the Upgrade Project.**

Transport and Turbulence

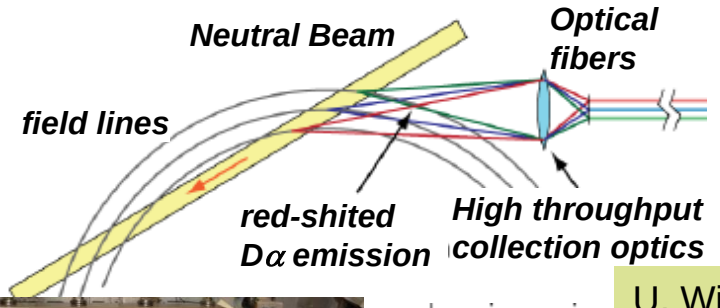
Increase and Understand H-mode Confinement at Lower n_e, ν^*



- **BES together with high-k to provide a comprehensive turbulence diagnostic set.**
- **High-k with a new solid-state source is running reliably.**

BES - 16 ch BES worked well in FY 2010 and at least 32 ch BES available for NSTX-U
High k Upgrade - Upgraded system with 2-D k spectrum for NSTX-U

A candidate new high-k scattering system for allowing 2 D k spectrum.



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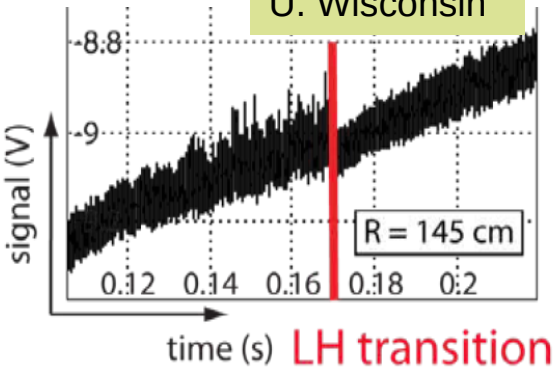

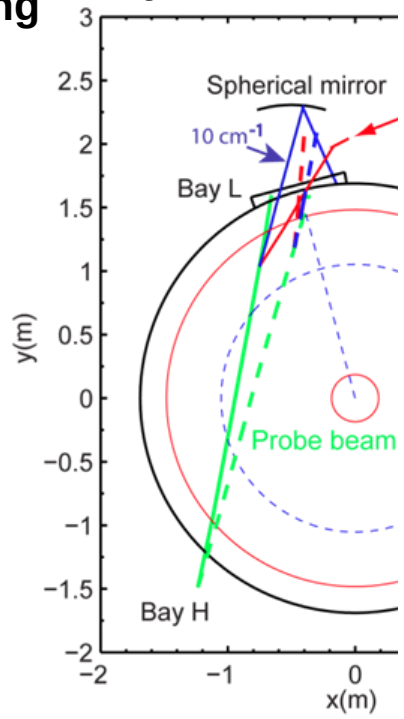

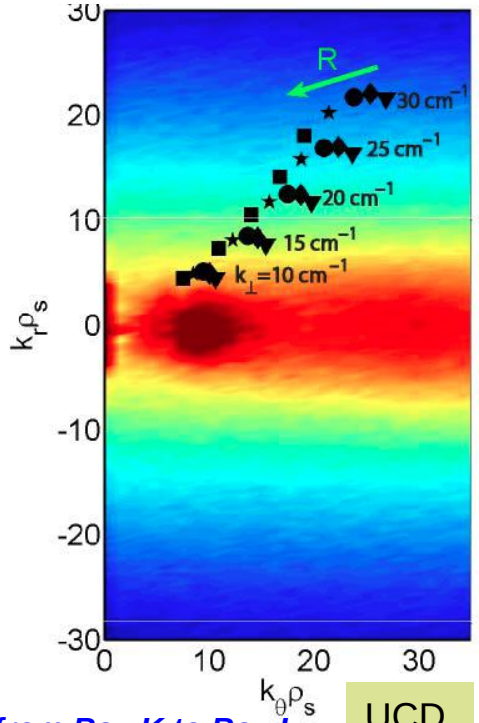

Receivers to relocate from Bay K to Bay L

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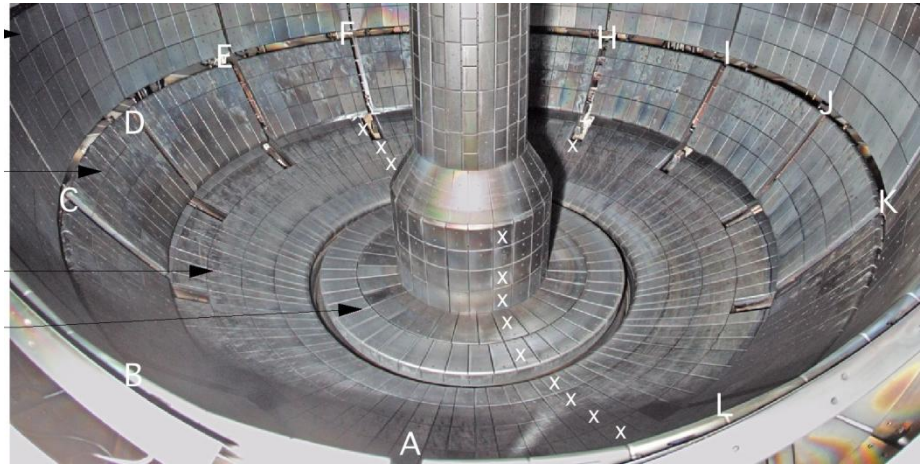
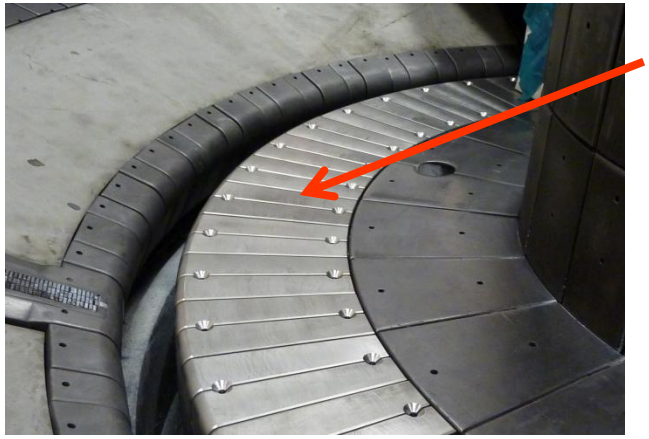
Boundary Physics

Need to Assess Heat and Disruption Loads for Advanced Divertor



- LLD removed due to the heat and disruption loads concerns
- Lower divertor to start with all graphite tiles for NSTX-U
- LITER system will be available for lower divertor as before



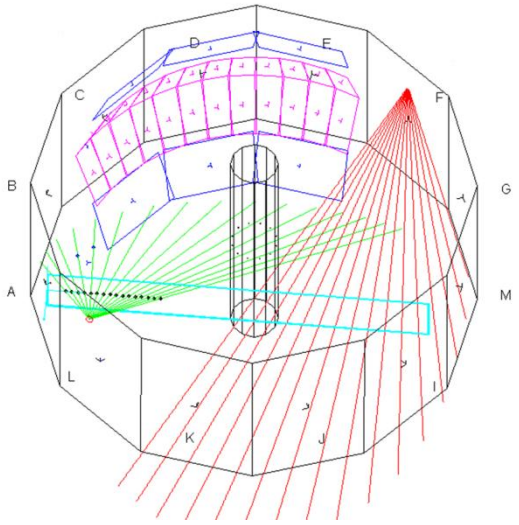
- Assessing installation of inboard divertor moly-tiles for upper divertor and associated upper divertor LITER system
- Moly armor for exposed SS flange surfaces in CHI gap being considered during the outage

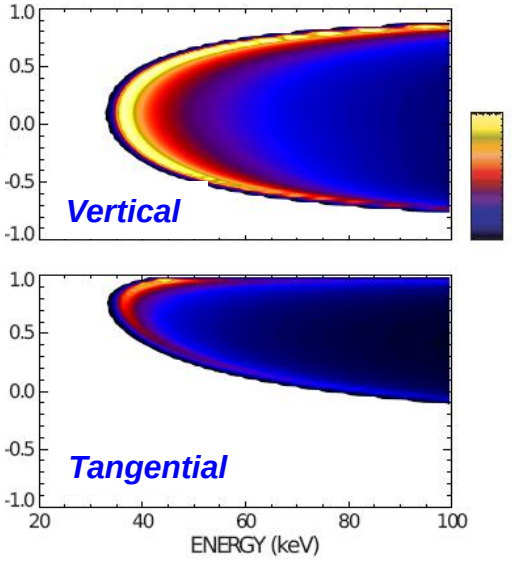
- For FY 12-14, advanced divertor upgrade conceptual design work will commence for the five year plan – e.g., moly-based PFCs, liquid lithium divertor, and closed divertor with cryo-pump.

Tangential-FIDA for Energetic Particle Research
For NBI fast ion transport and current drive physics

Tangential FIDA Views
UC Irvine

- **T-FIDA upgrade will provide two new views of plasma.**
- **Two new ports in vacuum vessel are being installed.**
- **Expect to have installation complete and ready for commissioning at start of next run.**



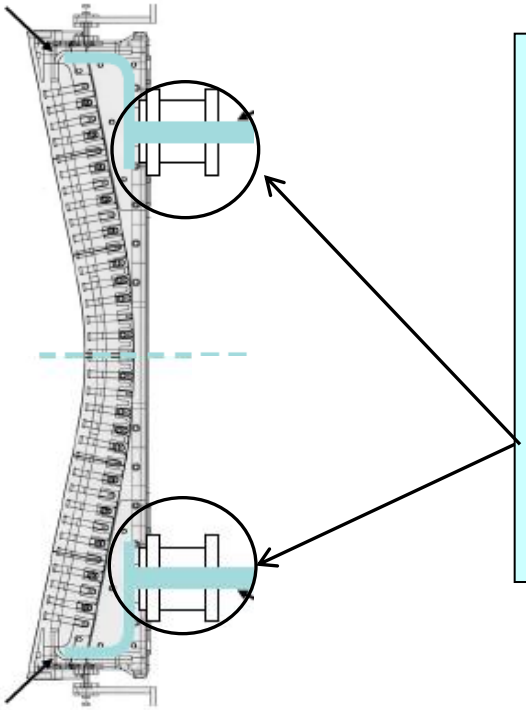


- **Better localization in velocity space weighted toward parallel velocity**
- **Well suited to investigate NBI fast ion transport and current drive physics**

FY 2013 - 14 Energetic Particle Conceptual Design and Diagnostic Upgrade
Active TAE antenna
Possible SS-NPA enhancement due to removal of scanning NPA (UCI)

Possible HHFW Antenna Refurbishment

Double Feed Antenna



- HHFW power system to undergo modest refurbishment
- Reliable high power operation in H-mode is high priority goal
- HHFW antenna may need structural enhancement against disruption loads in the feedthru area

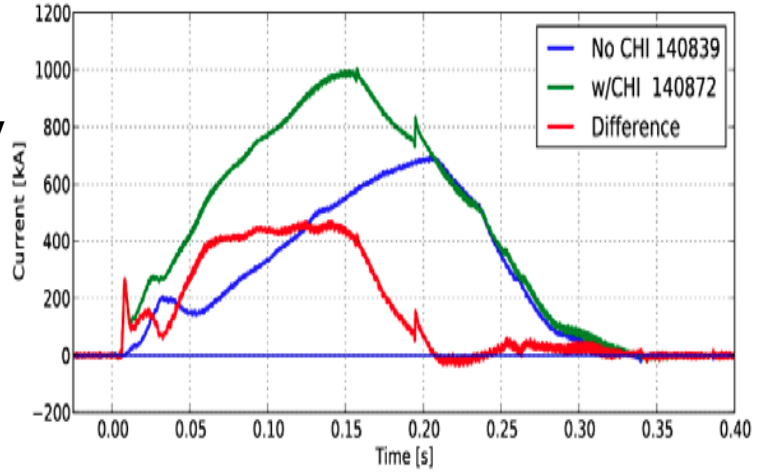
- FY 2012 - HHFW Antenna disruption load being analyzed
- FY 2013 – Perform necessary modification
- FY 2013/14 – Start MW-class ECH/EBW system design for non-inductive operations

Solenoid-free Start-up

High Priority Longer Term Goal for NSTX-U

Success of CHI aided by Low-Z Impurity Control

U Washington



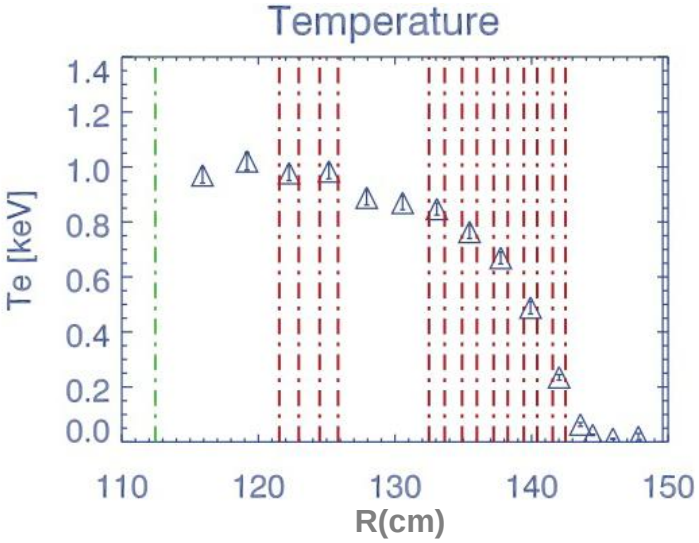
FY 2013-14 Non-Inductive Start-up Systems Design for Post-Upgrade Operations

- **NSTX-U scenario development**
- **Low-inductance Advanced Plasma Operations**
- **For longer term, MW-class ECH/EBW start-up and ramp up system envisioned**

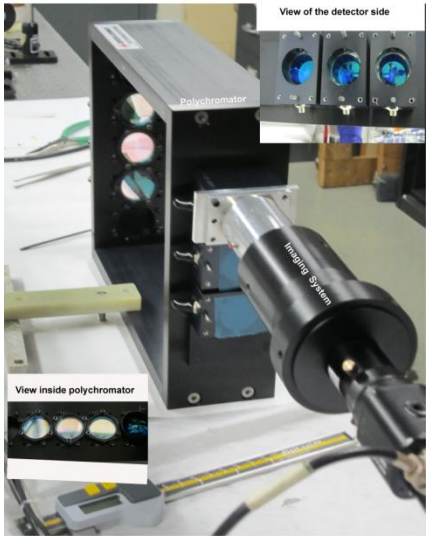
- **PEGASUS gun start-up producing exciting results Ip ~ 160 kA. The PEGASUS gun concept is technically flexible to implement on NSTX once fully developed.**
- **High current gun for the NSTX-U will be developed utilizing the PEGASUS facility in collaboration with University of Wisconsin**
- **Conceptual design of the MA-class ECH/EBW system to be performed in FY 13-14**

Backup Slides

Enhanced Pedestal / Profile Diagnostics for Pedestal and Core Transport Joint Research Targets



Additional 12 channels enhance resolution in pedestal to ~1 cm and improve diagnosis of ITB in plasma core

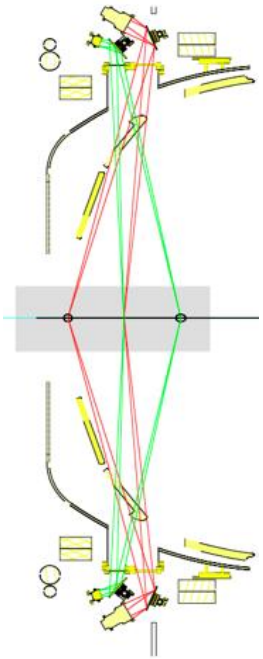


Polychromator assembly

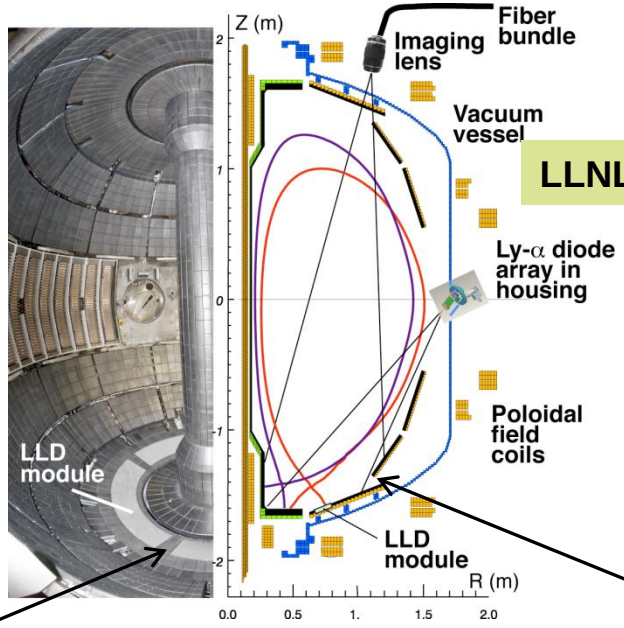
- **Twelve additional channels for the multi-pulse Thomson scattering (MPTS) system were installed and commissioned in July, 2011.**
- **Calibration was performed in situ by employing Rayleigh and Raman scattering of the light from the MPTS laser system by nitrogen and argon introduced into the vacuum vessel**

Enhanced Capability for LLD and Boundary Physics
Multi-Institutional Contributions

Lithium CHERS



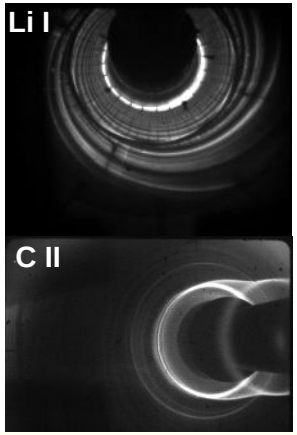
Divertor Imaging Spectrometer



LLNL

Two fast 2D visible and IR cameras with full divertor coverage

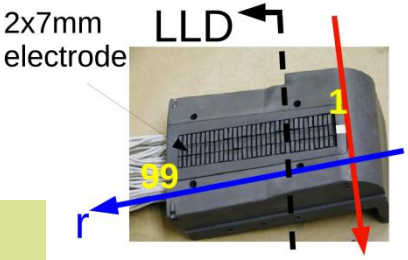
LLNL, ORNL



MAPP diagnostic systems

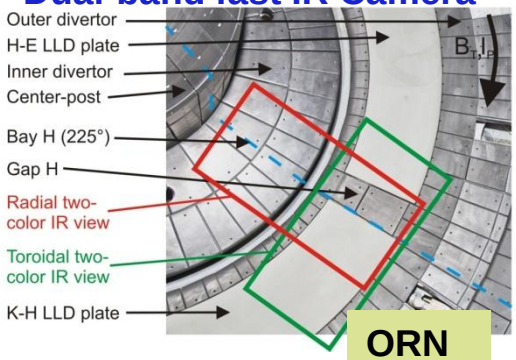
Dense Langmuir Probe Array

Will be replaced by simpler probe array



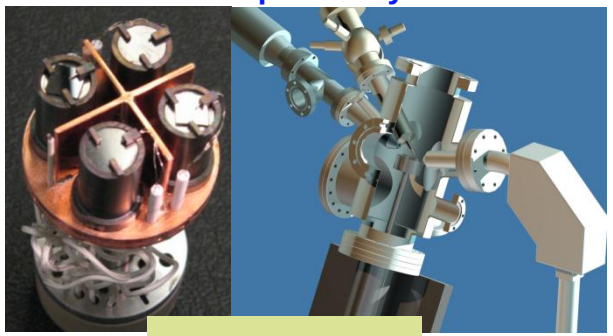
U. Illinois

Dual-band fast IR Camera



ORNL

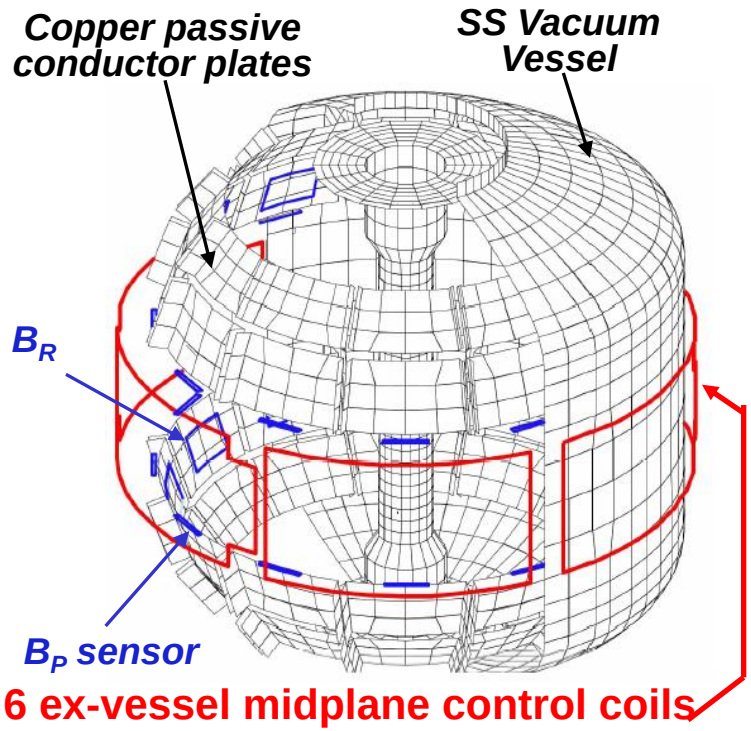
PMI Probe / to be replaced by MAPP Probe



Purdue U.

2nd SPA Successfully Installed and Commissioned

Sustain β_N and Understand MHD Behavior Near Ideal Limit

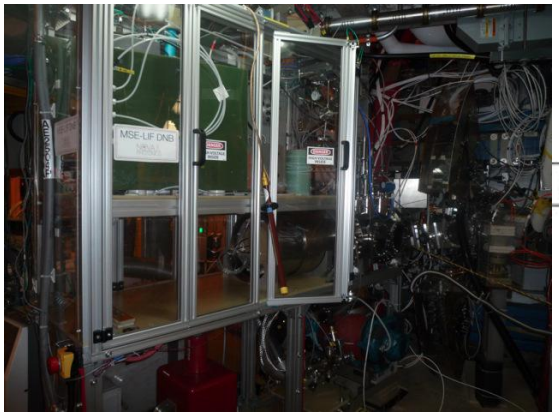


2nd 3-channel Switching Power Amplifier (SPA) comissioned in July 2011 powers independent currents in six EFC/RWM coils for simultaneous control of n = 1, 2, 3 field harmonics

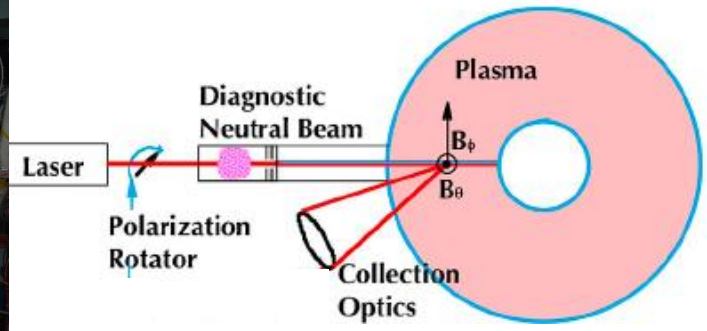
- RWM spectrum dependence
- Rotation and beta effects on NTMs
- Response to 3D fields for EFC, ELM and Neoclassical Toroidal Viscosity physics
- Disruption physics

MSE-LIF Installed for Enhanced Pedestal / Profile Diagnostics Installed and Commissioned on NSTX

The Motional Stark Effect measurement based on Laser Induced Fluorescence (MSE-LIF) diagnostic will provide measurements of the field line pitch angle profile without requiring injection of the heating neutral beam.

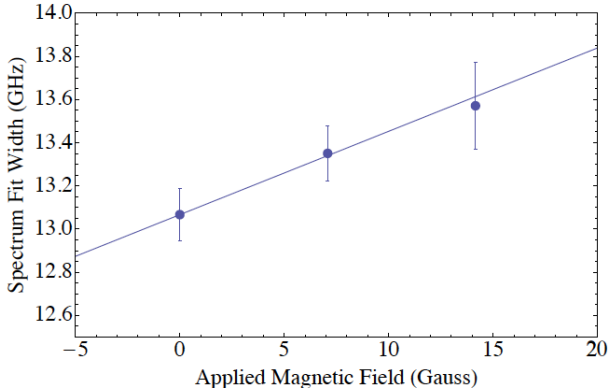


MSE-LIF DNB system on NSTX



Schematic of the MSE-LIF system

Nova Photonics



MSE-LIF Magnetic Field Calibration Scan with ~ 10 Gauss resolution on NSTX

MSE-LIF provides unique capabilities

- **Measure RF-driven current without the heating neutral beam.**
- **Measure total magnetic field in plasma to reconstruct total plasma pressure.**
- **Together with MSE-CIF, yield radial electric field profile**

Lithium Granules Injector for ELM Control Completed

Tests on fusion devices should proceed during 2012-13.

- Spherical Lithium granules (0.6 mm) have been horizontally redirected at speeds approaching 100 m/s.
- Dropping rates (pacing frequencies) of 500 Hz have been readily achieved.
- A dropper apparatus which allows the granule size to be changed between discharges has been built and is being tested.