

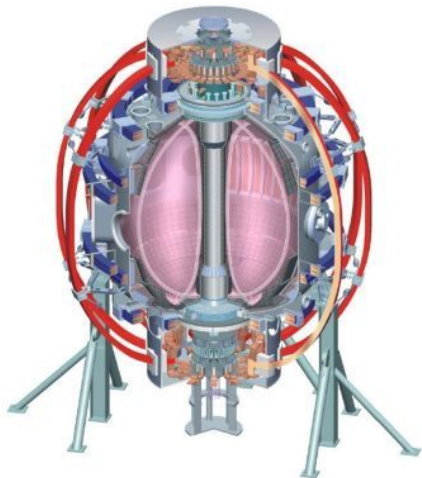
# Overview of NSTX FY2011-13 Program Letter for University and Industry Collaborations

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 Colorado Sch Mines  
 Columbia U  
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**Project Overview: M. Ono**  
**Program Overview: J. Menard/S. Kaye**

*For the NSTX Research Team*

**NSTX PAC-28 Teleconference**  
**PPPL – B205**  
**July 20, 2010**



Culham Sci Ctr  
 U St. Andrews  
 York U  
 Chubu U  
 Fukui U  
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 Hyogo U  
 Kyoto U  
 Kyushu U  
 Kyushu Tokai U  
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 ASIPP  
 ENEA, Frascati  
 CEA, Cadarache  
 IPP, Jülich  
 IPP, Garching  
 ASCR, Czech Rep  
 U Quebec

# Project Overview

# Operational challenges during FY10 run

- FY 2010 Experimental Run started on March 31

- **Apr. 16: Daily Hi-pot test revealed a water leak at the OH leads area**

- **Apr. 21: Flexible TF joints, hub structure removed and two pin holes discovered**

- **May 6: FDR held for the repair**

- **May 8: Leak repaired with a sealant; Support bracket and monitors added**

- **May 27: Restarted plasma operation**

- **July 1: Daily Hi-pot test revealed elevated OH leakage current – impedance ~ 100 MOhm.**

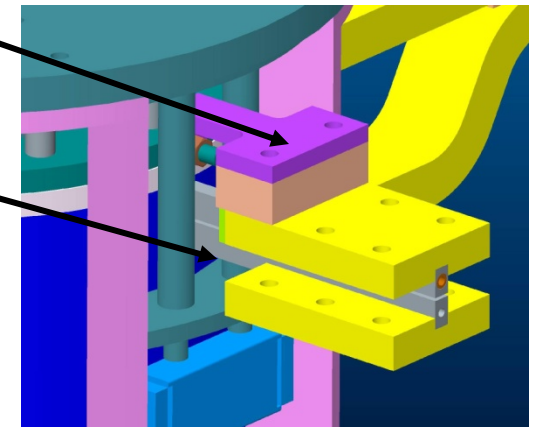
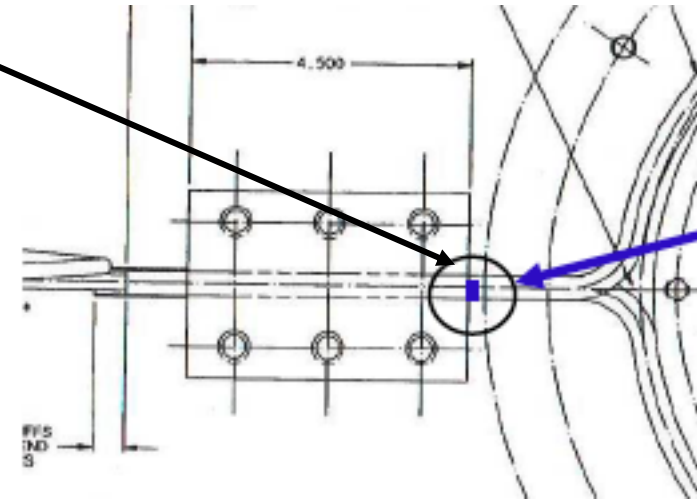
- **July 9: Damaged insulation in the lead area found due to cycling cooling down motion.**

- **July 12: OH lead insulation repair was successful**

- **July 15 Restarted plasma operation**

- **July 16-?: OH and/or  $I_p$  Rogowski isolation problem**

***NSTX will need to operate through most of September – possibly later into calendar year***



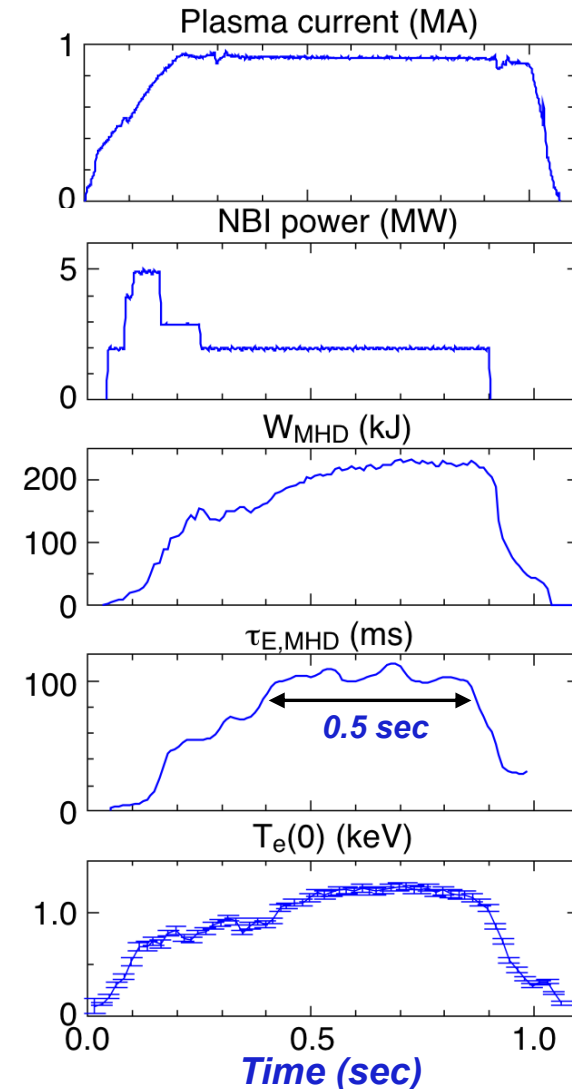
•G-10 support bracket which moves with OH growth added

# Plasma Operations Summary

- 6.36 run weeks with 1191 shots completed out of 15 run weeks (~ 20% more shots per week).
- Quick plasma start-up, obtained good discharges using lithium instead of boronization
- LLD Experiments start on April 2:
- Successfully commissioned controls and diagnostics
  - Partially loaded LLD with lithium from LITERs
  - Three quadrants operated reliably well above 180°C
  - Forth plate heater developed short. A backup hot air heater being developed and heater to ~ 180°C
  - Quick argon vents carried out to replace LITER shutter



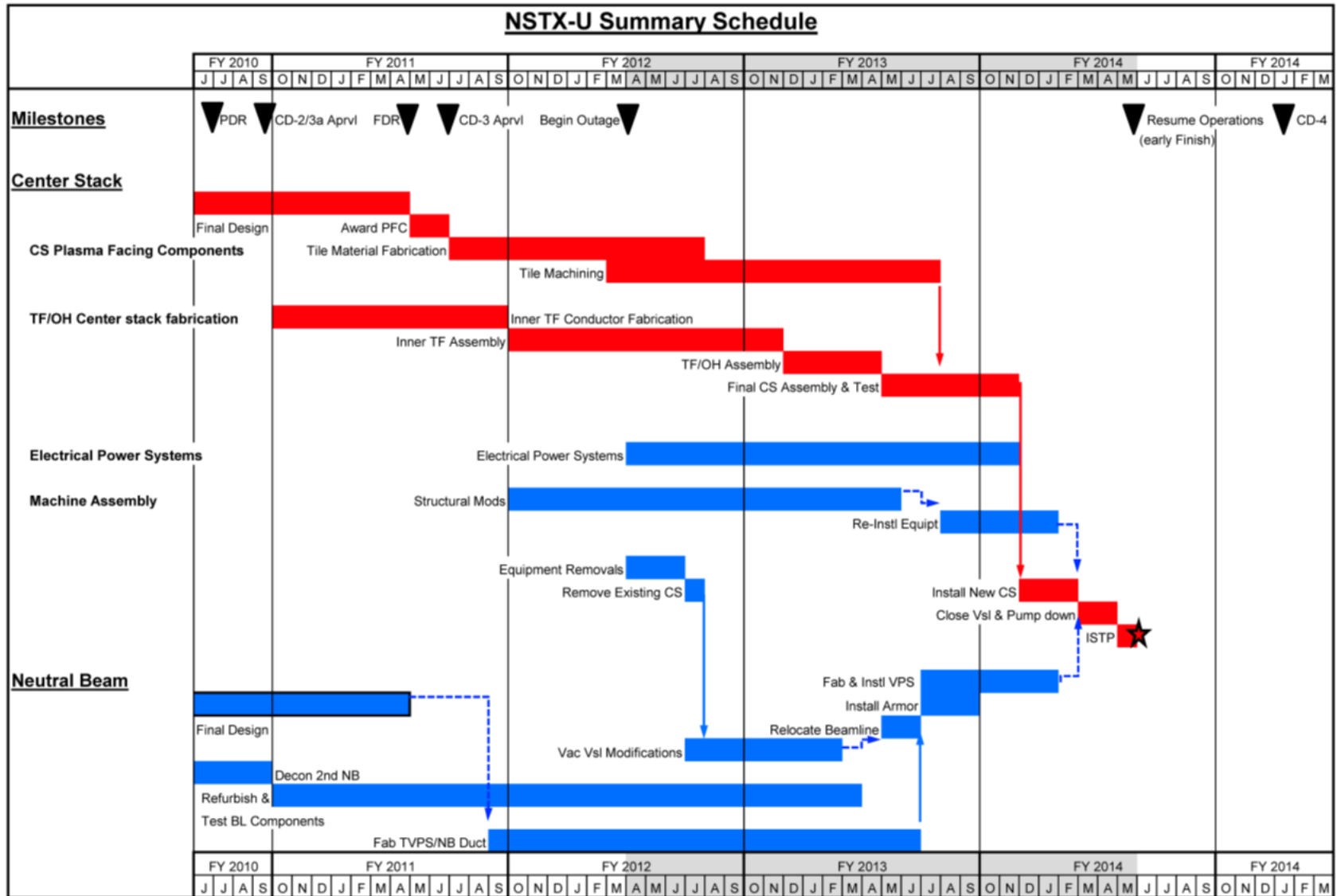
Shot 137565 (7-Apr-2010)



# NSTX Upgrade Project Status

- CD-1 Approved April 15th
- Preliminary Design Peer Reviews in June, 2010
  - NBI, NB Decontamination, Centerstack
- Prepared a preliminary CD-2 baseline package (WAF's, Cost/schedule estimate, PEP, risk registry, Prelim Design, long lead procurements)
- Successful Preliminary Design Review June 23- 24, 2010
- Conduct Office of Fusion Energy Science (OFES) – Office of Project Assessment (OPA) Review (Lehman Review) August 10-11th
- Submit CD-2/CD3a recommendation August 2010
- Receive CD-2/CD3a Approval September 2010
- Final Design Review April 2011
- Receive CD-3 Approval July 2011
- Begin Outage April 2012

# NSTX Upgrade Schedule (as presented at the PDR)



# Program Letter Overview

# Proposed NSTX FY2010-12 Research Milestones

(base and *incremental* )

	FY2010	FY2011	FY2012
Expt. Run Weeks:	15 w/ ARRA	14 (20)	14 (20)
1) <u>Transport &amp; Turbulence</u>		Measure fluctuations responsible for turbulent ion and electron energy transport	Compare measured turbulence fluctuations to theory & simulation
2) <u>Macroscopic Stability</u>	Assess sustainable beta and disruptivity near and above the ideal no-wall limit	<i>Assess RWM and rotation damping physics at reduced collisionality</i>	
3) <u>Boundary/Lithium Physics</u>	Assess H-mode characteristics as a function of collisionality and lithium conditioning	Assess relationship between lithiated surface conditions and edge and core plasma conditions <i>Assess pedestal and SOL response to externally applied 3D fields</i>	Assess very high flux expansion divertor operation
4) <u>Wave-Particle Interaction</u>	Characterize HHFW heating, CD, and ramp-up in deuterium H-mode (joint with solenoid-free start-up TSG)		<i>Assess predictive capability of mode-induced fast-ion transport</i>
5) <u>Solenoid-free start-up, ramp-up</u>			Assess confinement, heating, and ramp-up of CHI start-up plasmas (joint with WPI-HHFW TSG)
6) <u>Advanced Scenarios &amp; Control</u>		Assess integrated plasma performance versus collisionality	Investigate physics and control of toroidal rotation at low collisionality (joint with MS TSG)
<b>Joint Research Targets (3 US facilities):</b>			
	Understanding of divertor heat flux, transport in scrape-off layer	Characterize H-mode pedestal structure	Understanding of core thermal and particle transport



## High Priority Research Areas Identified in Program Letter:

- Operation/understanding of Liquid Lithium Divertor
- Understanding H-mode pedestal structure
- Ion-gyro-scale turbulence and transport
- Utilize HHFW+CHI for  $I_p$  start-up/ramp-up
- NSTX research in preparation for NSTX Upgrade
  - Advanced divertor configurations for improved power-handling, reduced impurity production, density control

*Subsequent pages summarize the “Key Collaboration Opportunity” text from the program letter with **most important elements highlighted in red***

# Key Collaboration Opportunities in I. Macroscopic Plasma Physics

- **RWM stability dependence** on kinetic resonances, core electron/ion collisionality, fast-ion beta, and toroidal rotation and rotation shear.
- Physics of rotational shear **stabilization and triggering of the NTM** including the effects of externally applied 3D fields.
- **Disruption precursor identification** and disruption evolution – especially the **thermal quench and halo-current dynamics**. Develop techniques for disruption mitigation via **efficient edge and/or core fueling**.
- **Real-time control of the plasma rotation** using NBI and magnetic braking to enable controlled variations of the plasma rotation for RWM and NTM stability, confinement research, and as a potential means to avoid disruptions.

## Key Collaboration Opportunities in II. Multi-Scale Plasma Physics

- Relationship between the flow and flow-shear and turbulence in the core and H-mode pedestal region, improve understanding of the physics of the H-mode transition, flow-damping from 3D magnetic fields, and the possible transport of fast-ions by low-k turbulence.
- Utilization of high-harmonic fast-wave system for core electron heating for electron transport and turbulence studies in L-mode and H-mode, and as a means of producing low collisionality plasmas with reduced momentum and particle input for momentum and particle transport studies.
- Explorations of impurity transport from the edge to the core, and linkages to inward momentum pinch physics. Utilize existing and/or any new main-ion and impurity edge particle sources for perturbative particle transport experiments.

## Key Collaboration Opportunities in III. Plasma Boundary Interfaces

- Understanding impact of Li coatings and the LLD on divertor and wall pumping, retention, and impurity generation under both steady-state and transient conditions. Perform scoping studies and initial testing of high-efficiency core and edge fueling techniques for LLD operation.
- Development of predictive capability for SOL and divertor thermal, particle, and heat-flux widths. Develop high-heat-flux mitigation divertor concepts and operational techniques compatible with LLD, and for the operational scenarios of NSTX Upgrade and future fusion devices.
- H-mode pedestal structure studies + optimization of H-mode performance for confinement, small/no ELMs, density control, and acceptable impurity accumulation. Utilize solid/liquid Li, externally applied 3D fields, boundary shaping, and other techniques to develop ELM control.

## Key Collaboration Opportunities in IV. Waves and Energetic Particles

- Assessments of HHFW heating and current-drive efficiency – especially **interactions between fast-ions from NBI and the HHFW**. Understand effects of edge transients on HHFW coupling – in particular the **effects of ELMs**.
- **Predictive capability for fast-ion transport** by fast-ion-driven instabilities utilizing NBI fast-ion injection and HHFW fast-ion acceleration as tools to modify the fast-ion distribution and associated Alfvénic instabilities. Utilize measured moments of the fast-ion distribution function to **test linear and non-linear fast-ion instability models**. Also perform assessments of **possible fast-ion transport by electrostatic turbulence**.

## Key Collaboration Opportunities in V. Start-up and Ramp-up

- **Investigation and optimization of CHI plasmas** to improve start-up plasma energy and particle content to provide higher temperature and beta target plasmas for non-inductive ramp-up techniques such as HHFW and NBI. Assess the viability of **heating CHI plasmas to high temperature** with HHFW. Perform initial assessments (simulation and/or experiment) of **plasma gun start-up**.
- Understanding of **HHFW coupling/heating efficiency during current ramp-up**, assessment of the production/acceleration of fast ions by HHFW, and measure/model/infer the sources of non-inductive current drive during the RF + bootstrap-current driven current ramp-up.

## Key Collaboration Opportunities in VI. Physics Integration

- **Optimization and control of non-inductive current drive** utilizing Li/LLD and NBI current-drive redistribution from MHD and Alfvénic instabilities. Characterize energy, momentum, and particle **confinement properties and full spectrum of plasma turbulence of high-non-inductive fraction plasmas.**
- **Modification of core plasma collisionality** by integrating HHFW with NBI-heated H-mode and assess the effect of **RF heating on core impurity accumulation** and control. Measure and minimize fast-ion acceleration by the HHFW.
- **Development of real-time control tools** for improving the sustainability of integrated high-performance plasmas: shape and divertor exhaust control, rotation and current profiles, and proximity to stability limits to avoid and/or mitigate disruptions.

# Summary

- OH issues have delayed completion of FY2010 run
- Initial LLD operation technically successful – awaiting additional run-time to fully characterize performance
- FY10 Joint Research Target data obtained, under analysis
- Exciting FY11-13 opportunities in program letter emphasizing:
  - Operation/understanding of Liquid Lithium Divertor
  - Understanding H-mode pedestal structure
  - Ion-gyro-scale turbulence and transport
  - Utilize HHFW+CHI for IP start-up/ramp-up
  - NSTX research in preparation for NSTX Upgrade

*The NSTX program thanks the PAC for helpful suggestions to improve the program letter!*