NSTX

Supported by U.S. DEPARTMENT OF ENERGY Office of Science

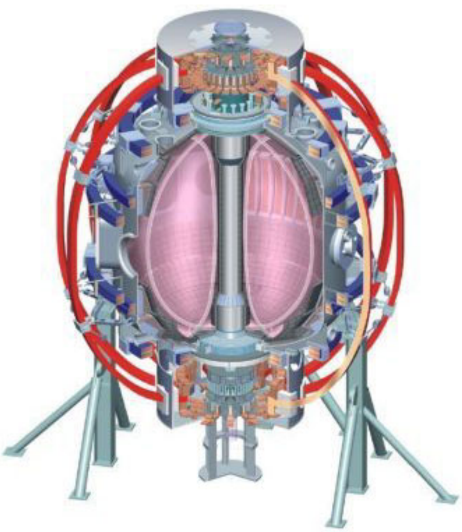
Overview of NSTX FY2011-13 Program Letter for University and Industry Collaborations

College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INL
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

Project Overview: M. Ono
Program Overview: J. Menard/S. Kaye

For the NSTX Research Team

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

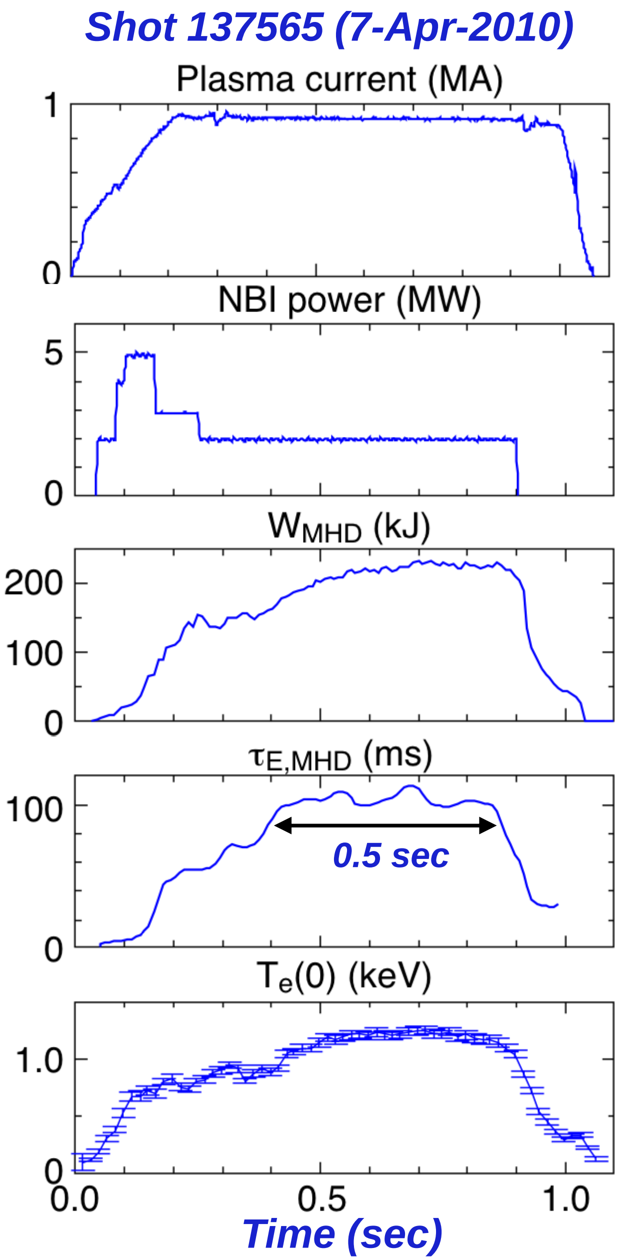


Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Project Overview

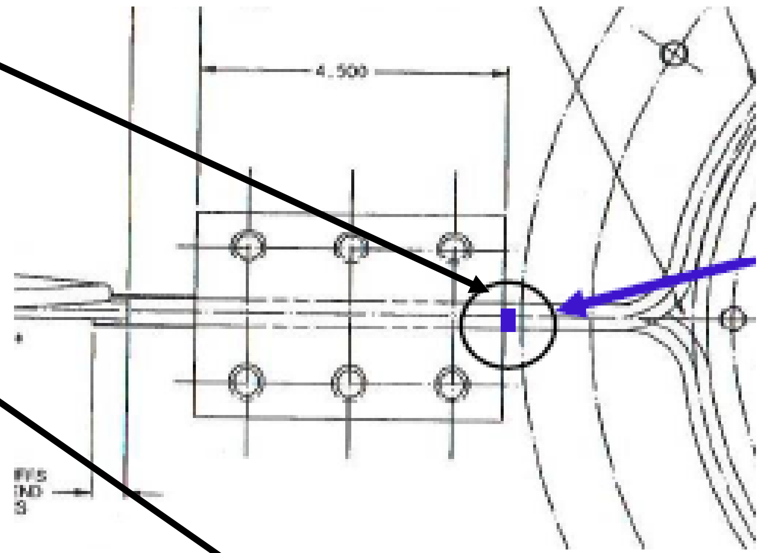
Plasma Operations Summary

- 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



Operational challenges during FY10 run

1. Apr. 16: Water leak developed in the OH lead area

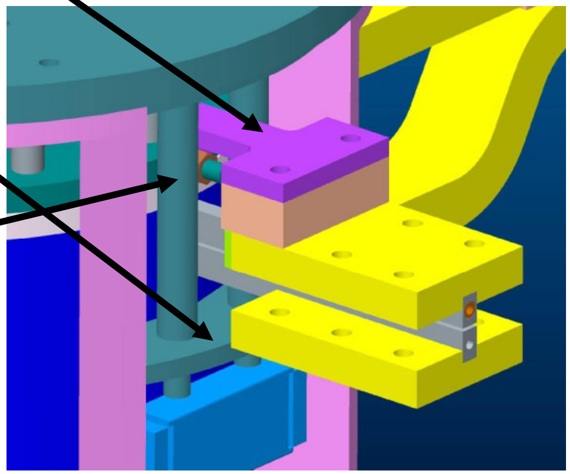


2. May 27: Resumed operation after water leak seaked and G-10 support bracket which moves with OH growth added

3. July 1: **Daily Hi-pot test revealed an elevated OH leak current detected ~ 100 Mohm due to relative motion of OH leads and the horizontal bar of the old support structure**

4. July 15: Resumed operation after the lead insulation repaired and the horizontal bar removed.

5. July 16: **Daily Hi-pot test revealed an elevated OH leak current detected ~ 4 - 10 Mohm due to relative motion of OH leads and the "old" vertical support rods**



6. July 19: The OH leakage restored to original value ~ 900 Mohm at 9 keV after the vertical side rods were separated and insulation inserted into the OH lead gaps

Plan to restart operation next week and complete the FY 2010 run by mid-September.

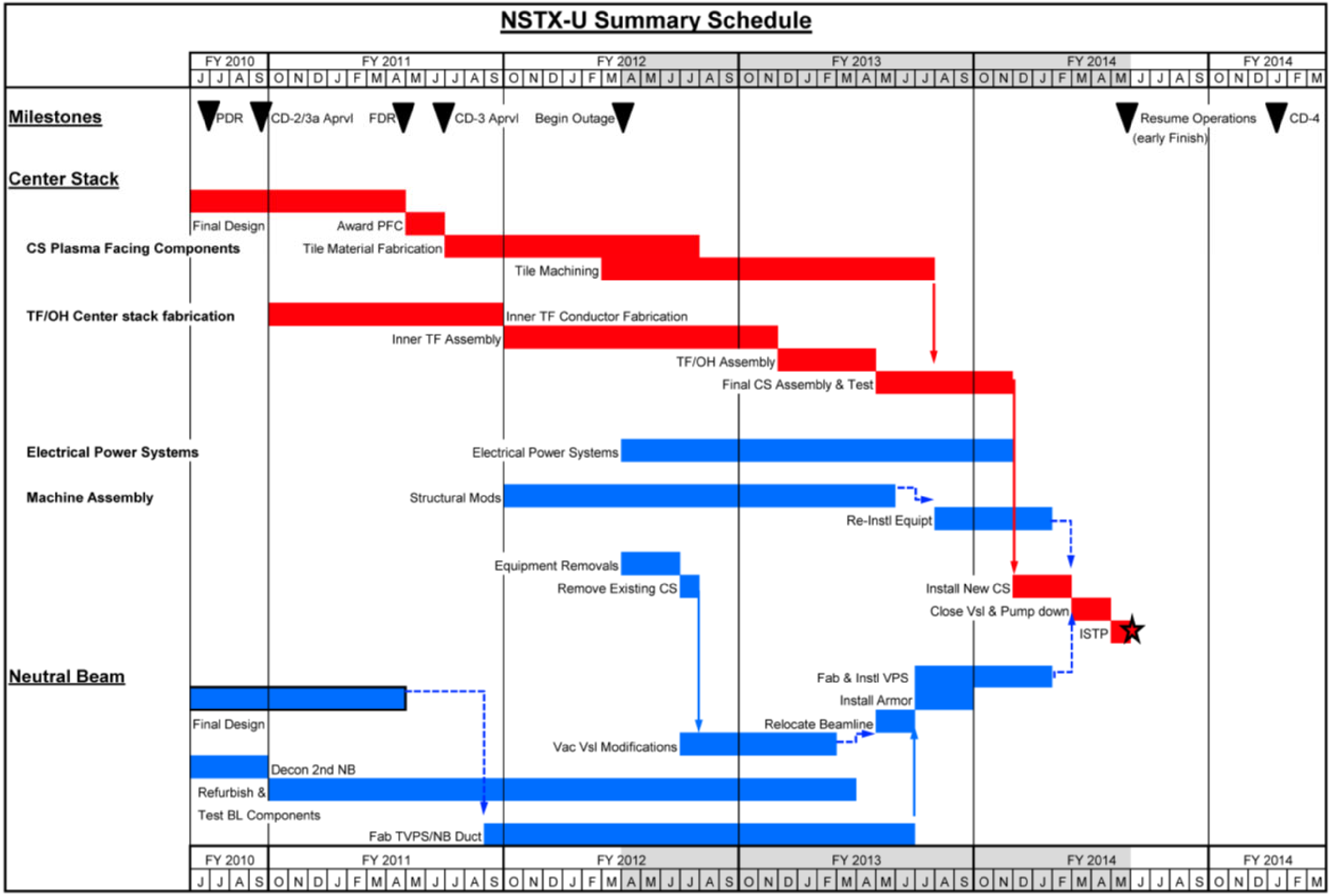
NSTX Outage Tasks for FY2011

- A second switching power amplifier (SPA) for the non-axisymmetric coils (EF/RWM/RMP): A SPA unit was delivered to PPPL, July 16, 2010.
- Extra channels for the multi-pulse Thomson scattering: Making good progress
- The MSE-LIF (motional Stark-effect diagnostic based on laser-induced fluorescence) - Making good progress (Nova Photonics)
- The tangential Fast Ion D-alpha - Plan to bore two tangential view ports (one for NBI and another for background) (UCI)
- The tangential soft-x-ray diagnostics - Modify the Bay I port (Johns Hopkins)
- Real time rotation diagnostic - data processing R&D on-going
- Moly tiles for the inner divertor.
- Moly shields over the stainless steel RWM sensor coil enclosures.

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