NSTX FY 2010 Run Plan

E. D. Fredrickson (Run Coordinator)
PPPL

S. A. Sabbagh (Deputy)
Columbia University

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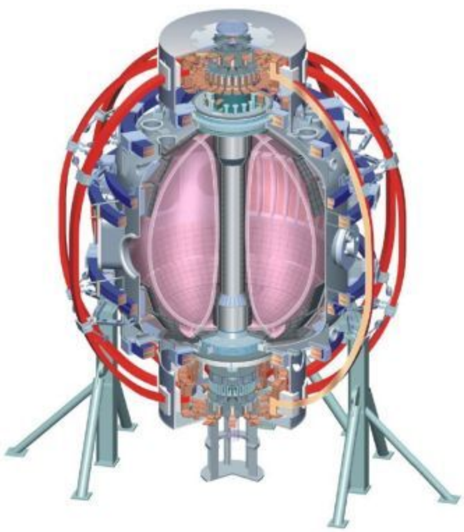

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Outline

- Development of research program
- FY 2010 Research goals
- Allocation of run time
- Overview of 2010 campaign
- Topical Science Group (TSG) research priorities

Program Planning Steps

- NSTX 2009 Results Review (Sept. 15-16, 2009)

- NSTX 2010 Research Forum (December 1-3, 2009)
  - *OFES and NSTX Milestones, ITER high priority research & ITPA contributions, ST-specific needs (ReNeW), and needs for NSTX upgrade* used to guide research plan
  - 156 experimental ideas, requesting a total of 161 days
    - 84 experimental ideas were proposed by 40 collaborators

- 15 Run Weeks (75 days) during 2010
  - Condensed to 55 priority-1 proposals, 17 priority-2 proposals
    - Guided by milestones, ITPA, NSTX-U and ReNeW
  - Expect to complete the 55 priority 1 proposals (≈60 days)
  - Availability of run time for priority 2 experiments could be impacted by time needed to learn to operate with LLD.

NSTX 2010 campaign will address issues and opportunities offered by recent major upgrades

1. **Liquid Lithium Divertor**: Evaluate the effectiveness of the LLD for density control
   - Lithium will take place of Boron for oxygen removal at start-up
   - Design studies predicting pumping efficiency need to be validated
   - Techniques to optimize LLD pumping will need to be developed
     - Density (collisionality) control, ELM suppression, improved confinement
2. **HHFW antenna upgrade**: Upgrade completed towards end of last campaign; much work remains to evaluate and exploit added capability.
   - Reduced SOL density w/LLD could improve coupling to beam heated plasmas
   - Parametric decay instability could increase LLD loading
   - Improved discrimination between ELMs and arcs; more resilient H-mode heating
     - Heating for current drive, non-inductive start-up experiments
3. **BES diagnostic to be commissioned**: Many experiments look forward to this new capability for internal measurement of mode structures and low-k turbulence
   - Measurement of internal structure of low-k turbulence, *AE instabilities, and MHD during H-mode plasmas; data previously unavailable.
     - Benchmarking turbulence, transport, stability codes.

Run Plan Addresses NSTX FY2010 Research Milestones

- DOE Joint Research Milestone: *"Understanding of divertor heat flux, transport in scrape-off layer"*
  - 3.5 days (2-color IR camera measurements of heat flux profiles, GPI turbulence)

NSTX Research Milestones:

- R(10-1) Assess sustainable beta and disruptivity near and above the ideal no-wall limit:
  - 5.0 days
- R(10-2) Characterize HHFW heating, current drive and current ramp-up in deuterium H-mode plasmas.
  - 7.0 days
- R(10-3) Assess H-mode pedestal characteristics and ELM stability as a function of collisionality and lithium conditioning.
  - 3.5 days

NSTX participation in International Tokamak Physics Activity (ITPA) benefits both ST and tokamak/ITER research

Actively involved in 21 joint ITPA experiments – contribute/participate in 30 total

MHD, Disruption Control

- MDC-2 Joint experiments on resistive wall mode physics
- MDC-4 Neoclassical tearing mode physics – aspect ratio comparison
- MDC-12 Non-resonant magnetic braking
- MDC-14 Rotation effects on neoclassical tearing modes
- MDC-15 Disruption database development
- MDC-17 Physics-based disruption avoidance

Transport and Confinement

- TC-4 H-mode transition and confinement dependence on ionic species
- TC-9 Scaling of intrinsic plasma rotation with no external momentum input
- TC-10 Experimental ID of ITG, TEM and ETG turbulence + comparison with codes
- TC-12 H-mode transport and confinement at low aspect ratio
- TC-14 RF rotation drive

Energetic Particles

- EP-2 Fast ion losses and Redistribution from Localized AE
- EP-4 Effect of dynamical friction (drag) at resonance on nonlinear AE evolution

Pedestal and Edge Physics, Divertor, Scrape-off Layer

- PEP-6 Pedestal structure and ELM stability in double null
- PEP-19 Edge transport under the influence of resonant magnetic perturbations
- PEP-23 Quant. of the requirements for ELM suppression by magnetic perturbations from off mid-plane coils
- PEP-25 Inter-machine comparison of ELM control by magnetic field perturbations from midplane RMP coils
- PEP-26 Critical edge parameters for achieving L-H transition
- PEP-27 Pedestal profile evolution following L-H transition
- DSOL-21 Introduction of pre-characterized dust for dust transport studies in divertor and SOL

Integrated Operation Scenarios

- IOS-5.2 Maintaining ICRH coupling in expected ITER Regime

Operational Logistics

- Organization of run by Topical Science Groups (TSGs)
  - Advanced Scenario and Control (ASC)
    - S. Gerhardt, M. Bell, E. Kolemen
  - Boundary Physics (BP)
    - V. Soukhanovskii, R. Maingi, D. Stotler
  - Lithium Research (LR)
    - C. Skinner, R. Kaita, D. Stotler
  - Macroscopic Stability (MS)
    - S. Sabbagh, J. Menard, J-K Park
  - Solenoid-Free Startup and Rampup (SFSR)
    - R. Raman, D. Mueller, S. Jardin
  - Transport and Turbulence (T&T)
    - H. Yuh, S. Kaye, T.S. Hahm
  - Wave-Particle Interactions (WPI)
    - G. Taylor, M. Podesta, N. Gorelenkov
- Run time also explicitly allocated to
  - ITER relevant experiments
  - Cross-cutting and enabling activities

(Collaborators)

Run-time guidance for FY2010 run

- FY2010 run-time allocation = 15 run weeks = 75 run days
- Complete 1st priority experiments with ≈80% of total → 60 run days
  - Joint and NSTX research milestone XPs are highest priority, and should be completed within this run-time allocation
- Final allocation will be adjusted at mid-run assessment

TSG	1st priority XP run days	1st + 2nd priority XPs	Milestones
Advanced Scenarios and Control	6	8	R(10-2)
Boundary Physics	8	10	Joint, R(10-3)
Lithium Research	5.5	8	
Macroscopic Stability	6	8	R(10-1)
Solenoid-free Start-up and Ramp-up	4.5	6	R(10-2)
Transport and Turbulence	5.5	7	
Wave-Particle Interactions	6	8	R(10-2)
ITER high priority	5	5.5	
Cross-cutting & Enabling	13	14.5	
Total	**59.5**	**75**	

Structure of the NSTX FY2010 Run

- Early Run (weeks 1-3)
  - Commission and learn to operate with LLD
    - Partially load with Lithium at beginning of run to ensure wetting
    - Complete commissioning of strike-point control
    - Avoid high power operation on LLD
  - Complete diagnostic calibrations for BES/MSE
  - Develop new fiducial plasma
  - LLD pumping experiments
  - LLD survey experiment

  - For more detail, see LR TSG talk

Structure of the NSTX FY2010 Run

- Mid Run (weeks 4-12)
  - Proceed with high priority OFES and NSTX research milestones
  - Complete priority-1 ITPA and ITER oriented experiments
  - Goal is to complete research milestones during first 10 weeks, first priority XPs by week 12 (60 days)
- Mid-run assessment (around week 10)
  - Evaluate progress towards milestones
  - Reevaluate priorities for remainder of run
- Late Run (weeks 13-14)
  - Complete remaining priority-1 XPS
  - Begin priority-2 experiments

Boundary Physics (8/10 days)

- 9 Priority-1 XPs, 2 priority-2 XPs and 3 ITER XPs
- Determine the relationship of ELM properties to discharge boundary shape, lithium conditioning, and 3D resonant magnetic perturbations (RMPs), and compare stability of pedestal/ELMs with model calculations (Milestone R10-3)
- Compare divertor heat flux widths to midplane density and temperature widths and edge turbulence characteristics, and determine the scaling of SOL and divertor heat transport (FY10 Joint Research Milestone)
- Understand and develop a predictive capability for the physics mechanisms responsible for the structure of the H-mode pedestal (FY11 Joint Research Milestone)

Lithium Research (5.5/8 days)

- 3 Priority-1 XPs, 5 priority-2 XPs, and 3 CC XPs
- Develop and understand high-performance operating scenarios utilizing a liquid lithium divertor (LLD) for particle control
- Understand and minimize the sources and accumulation of plasma impurities arising from lithium conditioning of the PFCs
- Assess the relationship between lithiated surface conditions and edge and core plasma conditions (Milestone R11-3)

Macroscopic Stability Physics (6/8 days)

- 7 priority-1 XPs, 3 priority-2 XPs and 2 ITER XPs
- Assess active and passive RWM stabilization physics for improved mode control (Milestone R10-1)
- Develop an understanding of the deleterious effects of disruptions in an ST, including halo current generation and the properties of the thermal quench
- Evaluate MHD sources of plasma viscosity and assess the impact of plasma rotation on plasma stability, including the NTM

Wave-Particle Interactions (6/8 days)

- 9 priority-1 XPs, 2 priority-2 XPs and 1 ITER XPs
- Utilize HHFW heating and current drive for non-inductive plasma current ramp-up and sustainment (Milestone R10-2)
- Characterize and optimize High-Harmonic Fast Wave (HHFW) coupling in deuterium H-Mode plasmas using the new double-feed antenna configuration and lithium edge density control.

Transport & Turbulence (5.5/7.5 days)

- 8 priority-1 XPs and 2 ITER XPs
- Investigate the mechanisms governing electron transport
- L-H transition physics
- Study relationship between particle/impurity transport and momentum pinch
- Beta scaling of confinement using dimensionless parameter scans in ELMy/ELM-free discharges
- Aspect ratio dependence of confinement scaling (DIII-D similarity, ITPA)

Solenoid-free startup and rampup (4.5/6 days)

- 2 priority-1 XPs
- Develop operating conditions aimed at improving the control of CHI
- Increasing the current and closed poloidal flux production of CHI
- Increase ohmic flux savings using CHI by reducing impurity influx
- Increase high-performance plasma pulse lengths using CHI startup

Advanced Scenarios and Control (6/8 days)

- 6 priority-1 XPs, 2 priority-2 XPs, 2 ITER XPs and 2 CC XPs

- Achieve long-pulse density control for increased neutral beam current drive fraction using improved fueling and lithium conditioning
- Develop high non-inductive current fraction plasmas with high-beta and high bootstrap fraction under sustained conditions
- Develop scenarios utilizing High-Harmonic Fast Waves for core electron heating, impurity reduction, and current drive
- Assess the dependence of integrated plasma performance on collisionality (Milestone R11-2)
- Develop and implement improved plasma control techniques to achieve advanced operating scenarios

ITER (5/5.5 days) and Cross-Cutting (13/14.5)

- ITER experiments (5 days + 0.5 days)
  - L-H power threshold studies (1 day)
  - ELM stability studies, shaping, 3-D fields, collisionality (2 days)
  - RMP and edge transport of impurities and heat (1.5 days)
  - HHFW coupling in presence of ELMs (0.5,0.5)
- Cross-cutting experiments
  - Plasma control development (1 + 0.5 days)
  - LLD and Lithium experiments (5.5 + 0.5 days)
  - Power limiting mechanisms for HHFW (0.5 days)
  - HHFW conditioning to high power (4 days)
  - BES/MSE calibrations (2.5 days)

FY10 NSTX campaign addresses important NSTX mission elements

- Experiments will increase understanding of the unique physics properties of STs
  - Energetic particle studies will benchmark *AE stability and fast particle transport codes, new diagnostics extend this capability
  - New and upgraded diagnostics give NSTX a unique capability to measure the full k spectrum of turbulence across the plasma profile and correlate with transport
- Emphasize ITPA tasks, OFES milestones, which complement tokamak physics and support ITER
  - HHFW experiments have demonstrated improved HHFW coupling, making RF heating available for wide range of physics goals
  - New SOL diagnostics complement the existing set and enable extended studies of edge heat transport.
  - New experiments and control capabilities will help extend stable operating regime to and above no-wall beta limits

FY10 NSTX campaign addresses important research for ST development

- XPs will also help establish attractive ST operating conditions for future fusion applications
  - Advances in CHI start-up, coupled with improved RF coupling could lead to exciting results in non-inductive plasma startup and sustainment.
  - Develop LLD for pumping, particle control and possibly high-heat flux PMI solutions for next step devices
  - NSTX will explore physics of routine ELM-free H-mode operation, including the use of ELM pacing for impurity and density control
  - Extend stable operating space to no-wall limit and above with improved RWM feedback control and understanding
  - New control capabilities enable broad range of physics experiments