25th meeting of the NSTX Program Advisory Committee

Princeton Plasma Physics Laboratory
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BACKGROUND and CHARGE

During the last year, considerable changes have taken place within the U.S. spherical torus program. In May 2008, DOE terminated the NCSX construction project and encouraged a "renewed focus on the Spherical Torus confinement concept", and stated that "proposed upgrades for NSTX can keep this facility at the forefront of fusion science research... well into the future." In the summer of 2008 the NSTX research team completed the "Research Program Five Year Plan for 2009-2013" which was successfully peer reviewed in July 2008. Two major facility upgrades were proposed in the 5 year plan: 1) a new center-stack (CS) for higher toroidal field, plasma current, and pulse duration to enable access to plasmas with reduced collisionality with relaxed profiles, and 2) a second more tangential neutral beam injection (NBI) system for increased non-inductive current drive and profile control enabling access to high beta at reduced collisionality. A few examples of the many scientific opportunities enabled by these upgrades include: the first opportunity to study NBI current ramp-up in an ST, new understanding of the modes responsible for electron transport, prototyping of heat and particle exhaust solutions for next-step facilities, and comprehensive studies of energetic particle transport induced by non-linearly interacting Alfvén Eigenmodes relevant to ITER burning plasmas and next-step STs.

The present NSTX plan is to implement the CS and NBI upgrades in a single extended outage period to minimize the resources required to complete both upgrades and to maximize NSTX capabilities resulting from the outage. An extended outage period of up to 2 years is likely required and could begin as early as FY2012. As a result, very few (possibly no) additional major facility or diagnostic capabilities beyond those already initiated will be possible in the FY10-13 time-frame. New capabilities already initiated include: a liquid lithium divertor (LLD) for particle pumping, higher-power fast-wave heating for current ramp-up studies and electron heating in advanced scenarios, a beam-emission spectroscopy (BES) diagnostic for low-k turbulence measurements, and a motional-stark-effect diagnostic using laser-induced fluorescence (MSE-LIF) to measure magnetic field pitch-angles and |B| without a heating beam – a capability that is highly useful for transport, energetic particle, and RF research. These new capabilities will become operational in the FY2009-11 time-frame, and it is vital that the FY2009-11 run period fully exploit these capabilities and collect the most complete data sets possible for analysis and publication prior to a possible major upgrade outage period.

Also during 2008, the FESAC Toroidal Alternates Panel (TAP) assessed the ITER-Era goal for the Spherical Torus (ST) which is to: "Establish the ST knowledge base to be ready to construct a low aspect-ratio fusion component testing facility that provides high heat flux, neutron flux, and duty factor needed to inform the design of a demonstration

fusion power plant." The ST physics issues identified for this goal are: start-up and ramp-up, plasma-material interface, electron energy transport, integration, disruptions, RF heating and current drive, 3D fields (ELM/EF/RWM), ion scale transport, fast particle instabilities, and NTMs. These prioritized issues clearly frame the NSTX research program in support of developing the knowledge base for a component test facility (CTF). Of comparable importance, however, are the significant contributions that NSTX makes to the knowledge base for ITER, for proposed next-step facilities to "Tame the plasma material interface" (such as NHTX), for an ST-based demonstration power plant (ST-Demo), and to fundamental toroidal confinement science.

NSTX has been productive in advancing fusion physics understanding for the Spherical Torus (ST) and for the broader range of magnetic configurations – including ITER. In 2008, NSTX achieved significant advances in understanding the impact of plasma rotation on confinement and stability, measured poloidal rotation to be consistent with neoclassical predictions, assessed scrape-off layer width and divertor heat-flux scalings, enhanced High-Harmonic Fast Wave (HHFW) coupling and heating in H-mode with Lithium conditioning, coupled Coaxial Helicity Injection (CHI) start-up to an inductively-driven NBI-heated H-mode plasma, and implemented error field correction and RWM control for a wide range of operating conditions to improve overall NSTX performance. Further, NSTX provided important vertical control data for ITER and developed new ELM control scenarios in which Lithium was utilized to suppress ELMs and 3D resonant magnetic perturbation (RMP) fields were used to trigger ELMs and expel impurities. The new understanding that the NSTX ELM control results are providing is also highly relevant to ITER. Thus, the ST concept in general and NSTX in particular are advancing a broad set of topics that are crucial to the advancement of magnetic fusion.

With these considerations in mind, we ask the NSTX Program Advisory Committee to address the following questions for both the upcoming run period (FY2009) and for the medium term (FY2009 – 2011):

1) Does the research plan provide the correct balance and focus to optimize the contributions of NSTX in the areas of: next-step ST development, ITER high-priority research needs, and fundamental toroidal confinement science?

2) Does the research plan fully exploit the upcoming (FY2009-2011) facility and diagnostic upgrades?

3) Is the NSTX research plan responsive to the four highest priority ST physics issues identified in the FESAC-TAP report - namely: start-up and ramp-up, plasma-material interface, (electron) energy transport, and integration?

Additional information:

The NSTX 2009-2013 Five Year Plan chapter text and presentations are archived at:
http://nstx.pppl.gov/DragNDrop/Five_Year_Plans/2009_2013/

The final report of the FESAC Toroidal Alternates Panel (TAP) is archived at:
http://www.ofes.fusion.doe.gov/Toroidal%20Alternates%20Panel%20Report.pdf

Information on NHTX can be found at:
http://nstx.pppl.gov/DragNDrop/NHTX_Information/

Information on ST-CTF can be found at:
http://nstx.pppl.gov/DragNDrop/CTF_Information/