NSTX

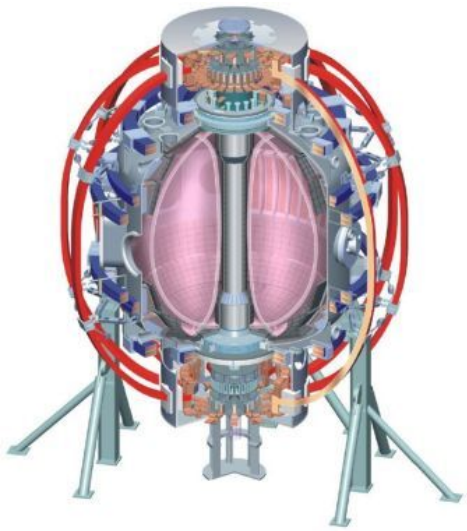
Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX Program Update

J. Menard

NSTX Team Meeting
B318, PPPL
March 16, 2010



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

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

NSTX Program Update Topics

- PAC-27 comments and recommendations
- Meetings / events

PAC comments/recommendations – general (1)

- The PAC is grateful for the clear and informative presentations, appreciate the many references to prior PAC recommendations and efforts made in addressing these recommendations
- The PAC wishes to express again its continued strong support for the NSTX Upgrade Project.
- Give increased emphasis to activities that build confidence that NSTX has a viable divertor boundary solution that
  - (i) controls particle and impurity influx
  - (ii) manages divertor heat flux (peak and integrated), and
  - (iii) meets performance targets.

PAC recommendations – general (2)

- Additionally, NSTX has an opportunity to establish the physics basis and understanding for Li pumping with a fully toroidal Li surface and to study high heat flux and long-pulse
- As part of this effort, to control impurities the PAC supports the plans to install sample molybdenum divertor tiles to gain experience with Li-coated Mo tiles and its effect on carbon impurities in NSTX.
- The PAC urges the NSTX Team to demonstrate density and impurity control, within the next two years, in discharges characteristic of your post-upgrade operation.
  - We suggest you consider combining the forces of several physics tasks groups to address these critical divertor and boundary issues.
  - For example, the ASC Task Group could add to the boundary and Li task groups to strengthen the integrated understanding of LLD ops

PAC recommendations – general (3)

- should identify quantitative goals for pumping and impurity control, both short-term (e.g. before Upgrade) and long-term.
  - Achievement of such targets would build confidence in the divertor solution for high-power, long-pulse post-upgrade NSTX discharges and the ST concept.
  - These targets might specify the density maintained with LLD pumping, the characteristics of an "ideal" LLD:
    - *e.g.* an LLD that is supplied Li directly rather than spraying 90% of the Li around the vessel
    - … and an LLD that allows for the strike point to be on it.
- …impurity control quantitative goals could include:
  - the divertor heat flux limits, quantification of the level of core impurities and impurity sources as well as source mechanisms.
- …identify other discharge and physics targets that will optimize operation of NSTX past the Upgrade. These include:
  - control metrics related to shaping, low l_i, and RWM control.

Boundary Recommendations

- Get more people involved, perhaps by redirection/merging of effort from other NSTX topical areas (such as scenarios and control) or possibly from outside of NSTX.
- Deploy the new Thomson channels ASAP for SOL profiles.
  - Develop a means to diagnose the width in the main SOL to check its currently assumed relationship to the measured width at the divertor.
- Look for correlations of SOL width with turbulence levels and other SOL characteristics.
- For discharges with blobby edge transport, further quantify where the particles and power go, resultant surface response.
  - It would be best if this were a coordinated effort between experiment and modeling, for example, BOUT simulation coupled with post-processing of the fluxes onto the walls with a wall code.
- More generally, determine the fraction of power and particles that go to the main wall versus plasma parameters.

Lithium and divertor recommendations

- If Mo tiles are used, they should be installed as soon as possible, probably on a small scale (small fraction of the toroidal circumference) to gain experience.
  - The tiles should be installed where there is proper spectroscopic coverage to determine Mo influxes to be correlated with core Mo levels.
  - In parallel, an improved set of camera views of the 360-degree circumference of the vessel should be installed and followed to determine any hot spots and correlate with C and other impurity measurements in the core plasma.
  - Utilizing the IR camera in 2D mode to evaluate leading edges and peaking factors should be pursued as this will base the extrapolation to doubling the power and 5x longer pulse lengths more on reality as opposed to assuming uniform temperature rises.
  - Additional IR cameras would help in that effort as well. Also, modeling of sputtered Mo transport, prior to installation, would seem highly feasible and desirable.

Macro-stability recommendations

- Work towards a 'unified RWM picture' on NSTX, DIII-D and JT-60U is very important in establishing the scientific base for future experiments and also to give confidence for the assessment of RWM stability in NSTX-U.
  - continue work on the effects of fast particles, multi-modes for RWM stability.
  - Improved physics understanding of high-beta and MHD phenomena on NSTX should be used to assess RWM stability in NSTX-U scenarios.
  - Experiments towards lower li and Vφ should be foreseen in 2011/12 in prep
- Work in the areas relating to other ITER high-priority areas (e.g. disruptions, NTMs) is focused on NSTX specific needs.
  - The team is encouraged to assess even better the area(s) in which they can make unique contributions towards ITER needs in MHD, such as NTM thresholds, NTM excitation, and similar physics areas.
- The PAC observes that ELM research is spread over at least three groups (boundary, MHD and Integrated scenarios).
  - Because of the central importance of ELM research, the PAC suggests that the NSTX Team should make sure ELM studies are well coordinated, possibly by appointing a "research organizer" for ELM research.

Transport recommendations

- … see if the parametric dependence of the observed ETGs and GAEs on Bt and Ip to see if the different confinement scaling can be related to the proposed transport mechanisms.
- high-k scattering diagnostic will be removed during Upgrade…
  - PAC strongly encourages the exploration of possible replacements
  - …high-k fluctuations will play an important role in Upgrade confinement
- For L-H threshold studies
  - go beyond threshold scaling experiments and characterize also the fluctuations in order to understand the triggering mechanism for the transport barrier.
- …important to clarify the issues related to edge turbulence and its interplay with core turbulence, in view of the operation of NSTX with Li-coated PFCs
  - intensify study of impurity transport and investigate possible solutions (e.g., external coils, RF heating) to prevent impurity accumulation.

Energetic particle and HHFW recommendations

- An assessment should be made of the impact of Alfvén eigenmodes (other than GAEs) on electron transport.
- Identifying the importance of energetic particles on RWM stability in low rotation discharges could result in a breakthrough that might lead to reconciling the DIII-D and NSTX observations.
- A quantitative assessment should be made of Alfvén eigenmode physics for NSTX-U including linear thresholds and fast ion losses.

- The PAC recommends that NSTX continue to push the HHFW antennas to find the new limits to antenna performance... might include:
  - investigating impurity puffing to reduce high power arcing
  - studying trade-off between outer gap and pulse length with NBI
  - Revisit the absorption and propagation physics of HHFW in NSTX-U
    - harmonic resonances will be lower with the 1 Tesla magnetic field for the upgrade
  - continue to assess the level of parasitic losses in combined HHFW+NBI
  - continue to interact with the Boundary Physics Group to quantify RF sheath losses in NSTX and to aid in developing mitigation techniques if needed
  - evaluate the effectiveness of ELM/arc discriminating electronics to maintain antenna protection in the presence of ELM-induced transients

Start-up/Ramp and Advanced Scenarios Recommendations

- Understand effects of local field shaping in the absorber region
  - assessment made on whether CHI will be negatively impacted by the absence of these coils in NSTX-U. We also strongly urge the use of
- Urge the use of the LLD in CHI experiment in 2010, even if experiments with reversed toroidal field are not available

---

- ASC recommendations:
  - increased emphasis on integration of ELM pacing and high-β operation
  - reduction of uncertainties in expectations for density/impurity control
  - consider increased emphasis on determining compatibility of HHFW (in particular plasma-antenna gap) and long-pulse, high-power NBI
  - reinvigorate efforts to model discharge scenarios through improvements in transport modeling + benchmarking with experiment.
  - incorporate the performance capabilities of the NSTX upgrade
    - present plans use only 4 of 6 NBI sources, and reach targets of only 0.725 MA at a toroidal field of 0.55 T *(not true actually…)*
  - Investigate/develop backup options for density control if LLD incompatible with long-pulse, high-β operation

Meetings / events

- OFES Budget Planning Meeting held last week
  - STCC (Peng), NSTX Program/Project/Upgrade (Menard/Ono/Strkykowski)
  - http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Budget_Planning_Meetings/2010/
- 23rd IAEA Fusion Energy Conf.: 11-16 Oct 2010, Korea
  - **FORMS A & B due to OFES TODAY**
  - Synopsis + abstracts due to IAEA FEC: 01 March – 02 April 2010

Tentative locations/dates of future ITPA meetings

(info courtesy Rich Hawryluk)

• Transport and Confinement	Culham, UK	March 22- 25
• Pedestal	Naka, JA	April 21-23
• Integrated Operating Scenarios	Princeton, NJ	April 20-23
• Diagnostics	Oak Ridge, TN	May 10-15
• Transport and Confinement	Korea ?	October 18-22
• Integrated Operating Scenarios	Korea ?	October 18-22
• Diagnostics	Japan ?	October 18-22