

Columbia University in the City of New York | New York, N.Y. 10027

DEPARTMENT OF APPLIED PHYSICS
TEL (212)854-4457, FAX (212)854-8257

Seeley W. Mudd Building
500 West 120th Street

15 March 1999

Dr. Robert J. Goldston, Director
Princeton Plasma Physics Laboratory
P. O. Box 451
Princeton, NJ 08543

Subject: Report of the 6th NSTX Program Advisory
Committee Meeting – February 1999

Dear Rob:

The NSTX Program Advisory Committee (PAC) met at the Princeton Plasma Physics Laboratory on 11-12 February 1999 (agenda attached). In addition to receiving a status report on the NSTX Project and Project Physics, our activities at this sixth meeting of the PAC focused on four areas in response to your charge to the committee (copy attached): (1) the FY99 (Phase-I) experimental plan ; (2) the FY00-01 (Phase-II) research program; (3) critical areas for expansion of the NSTX National Team in FY00; and (4) the plans for organization of the NSTX National Research Team to carry out the scientific program on NSTX. This meeting was also the first to be held with the membership rotation as specified in the PAC charter.

Status of NSTX Project and Project Physics

The NSTX experimental facility achieved its first plasma discharge shortly after the end of our meeting on 12 February 1999. The progress made in completing the assembly of NSTX since our last meeting in September 1998 and now being ready to achieve the first plasma two months ahead of schedule has been truly remarkable. We congratulate the NSTX Project technical and scientific staff for this demonstration of extraordinary skill and

dedication, and we join with you in anticipation of celebrating the arrival of a new major fusion research facility in the world fusion program.

In our discussion of the NSTX design and physics modeling progress was reported on the few unresolved issues raised at our previous meetings. These are briefly summarized below:

Neutral Beam Injection and Fast Ion Losses: At our previous meetings we raised some questions related to the use of neutral beams in NSTX:

- (i) For the voltages planned for NBI in NSTX, what are the minimum toroidal current requirements necessary for good confinement of the planned co-injection neutral beam ions?
- (ii) Based on the large levels of counter-injection losses for the high- β , $q_0 > 2$ equilibria, what is the level of bulk ion losses at the highest ion temperature expected in NSTX?

We were concerned about that the effects of the anticipated radial electric field and finite Larmor radius on the toroidal and poloidal distribution of fast ion losses which should be included in an assessment of the fast ion losses to the stabilizing plate edges and including, particularly to the RF antenna Faraday shields and BN insulators. The Project has carried out full orbit calculations which indicate that 25% of the fast ions may be lost in low- l_i , $q_0 > 2$, high β equilibria. Further work is needed to analyze the distribution of these losses and assess their effect on the RF antenna and other internal structures.

Modeling CHI Start-up: Progress was reported in using EFIT and the soak-through code in a linked way to model the CHI start-up in NSTX, which earlier used a fixed profile shape that was ramped up in magnitude. The effects of a time dependent current profile should be included in the simulation of CHI startup, as an extension of the previous results.

Breakdown of Plasma: At our previous committee meetings an issue regarding the effect of the radial magnetic field generated by non-axisymmetric eddy currents in the vacuum vessel and stabilizing plate

structure on magnetic field null during the breakdown phase of the discharge was identified. A 3D eddy current model is being developed for NSTX with the VALEN code to answer this question.

HHFW and CHI Insulator Issues: At our previous meeting an issue was raised concerning the effect of carbon deposition on the BN insulator surfaces of the HHFW RF antenna and CHI electrodes which might result in shorting to the vacuum vessel. The project is continuing to assess this issue, and we recommend a review of experience on TdV, DIII-D, and PBX.

FY99 (Phase-I) Experimental Plan

We reaffirm our support for the scientific goals set by the Program for Phase-

I. These goals include:

- Begin ohmic plasma tests leading to 1 MA operation
- Begin CHI start-up tests leading to significant current
- Begin HHFW plasma heating tests leading up to 4 MW input power
- Extend the duration of the plasma to 0.5 seconds
- Document time dependent profile information on $T_e(r)$ and $n_e(r)$

Task Force Structure for Phase-I:

The Project described to us their preliminary plans for organizing the NSTX Research Team for the planning and execution of experiments on NSTX. We realize the plan for experimental operation is still being formulated, and will continue to develop. We offer the following general advice as the initial year of operation is organized.

- 1) The proposed organization and process of Task Forces and formal Experimental Proposals (XPs) with emphasis on scientific publications, may be too “structured” for a device in its start-up year. The process should allow for Machine Proposals to develop machine operational capability.
- 2) The establishment of reliable ohmic operation with desired target parameters (q , shape, l_i , divertor geometry, *etc.*) within Experimental task Force 1 (ET1) would appear to be necessary to support successful

experiments in HHFW Studies (ET2) and CHI Studies (ET3). It was not clear from the presentations how ET1 coordinates with ET2 and ET3, and this needs to be clarified as the experimental plan is developed.

- 3) Specific comments on each of the Experimental Task Force Goals are summarized below:

ET1: Ohmic Optimization

This task force should include a goal to identify control capability for both single null and double null plasmas.

ET2: HHFW Studies

The goals of this task force were well structured and we had no additions to recommend.

ET3: CHI Studies

The scientific goal for Phase I should clearly state that the studies seek to make progress towards ~200 kA of CHI current, but do not commit to achieve 200 kA in this initial phase.

The CHI studies need to measure edge current penetration as a key physics mechanism. This has recently emerged as an important physics issue in sustainment of Advance Tokamak plasmas on DIII-D. The Project should consult and coordinate with DIII-D in selecting an optimal approach to measurement of the edge plasma current on NSTX.

FY00-01 (Phase-II) Research Plan

An issue was raised about the relation of the presently planned NSTX research program for Phase-I through Phase-III and the anticipation of a decision point in the national fusion program to proceed with a major next step in about the 2003/2004 time frame. The PAC strongly recommends that the best way for the ST program to prepare the scientific basis for a future decision in fusion energy development, is to continue to base its research program planning on addressing the key fusion science issues in the ST.

We reaffirm our support for the scientific goals set by the Project for Phase-II. These goals include:

- Extend plasma current to 1 MA operation
- Begin studies of NBI leading to 5 MW of injected power
- Extend HHFW plasma heating tests to 6 MW input power
- Extend the duration of the plasma to 1 second
- Demonstrate non-inductive operation
- Approach average β of 25%
- Document time dependent profile information on $J(r)$ and $T_i(r)$

NSTX National Team in FY00 & Funding Issues

As part of the background information on FY00 funding, the Project informed us that the projected funding is lower than originally expected in the second year of experimental operation. If this reduced funding occurs in FY00, it will reduce the size and scope of the anticipated experimental team carrying out the Phase I research plan on NSTX, and severely limit the opportunity to bring in additional collaborators as originally planned. In responding to this reduced budget situation we offer the following comment and advice:

We strongly endorse the project decision to maintain the one-third collaborator and two-thirds PPPL relative effort on the national research team.

In describing the FY00 cut from the original FWP level the Project should clearly indicate the reduction of the Collaborator effort level from \$5 million to \$3.68 million in addition to the cuts in facility operations and PPPL scientific effort. These staff cuts from the anticipated collaborator effort on NSTX from the FWP plan reduce the expected capability of the NSTX team just as do the reductions in PPPL staff.

We support maintaining the schedule for Neutral Beam Injection installation.

In reviewing the possible high priority areas for additional FY00 funding, we support the following:

- the Reciprocating probe from the advanced diagnostic set.
- work on EBW/ECH previously identified as an important back-up to CHI for noninductive start-up.

We are unable to make recommendations on the other areas of high priority suggested to us by the Project without more complete analysis of the status of the installation plans for the primary NSTX diagnostics and research program needs in Phase II.

Organization of the NSTX National Research Team

Data Analysis and Management: We strongly endorse the decision by the Project to adopt as standard widely used data management and analysis tools in its plan for NSTX and to collaborate with other major facilities (MIT and GA) in the sharing of existing software and development of new analysis and display tools.

Remote Collaboration: Providing the capability for collaborators participate remotely in experiments and meetings is critical for the effective performance of the NSTX National Team, as well as an important issue nationally for fusion research. This includes support for videoconferences with high quality slide projection capability and remote participation in NSTX experiments. We strongly support the community-based proposal to DOE to provide improved equipment to facilitate this remote collaboration and urge the NSTX Project to very aggressively pursue its implementation.

Data Access Policy: We strongly endorse the adoption of a policy of “open data access” for national research team members as proposed by the NSTX Project

Users' Group: The committee did not support the formation of a Users' Group. We see no clear need for this group and have some concern that its creation may interfere with the smooth working relationship within the national research team.

Process for Experimental Proposal (XP) Review. The use of meeting of the entire NSTX research team to review and approve each XP appears to us to be too cumbersome. Rather, we recommend that the primary review and approval of an XP occur within each task force, which is then followed by a run coordination review, which allocates run time and cuts across all task forces.

Next Meeting of the NSTX PAC

The next meeting of the NSTX PAC is expected to be in September 1999. Since NSTX will be well into its first year of operation at that time, it would be appropriate to advertise the meeting to the entire national research team and to plan to meet in a larger room to accommodate NSTX team members who may wish to attend the public portions of our meeting.

In planning the agenda for our next meeting, we wish to include a discussion of the issue of HHFW and NBI compatibility with respect to the possible interaction of the HHFW current drive and the fast neutral beam ions.

In closing, we again express our congratulations on achieving first plasma in NSTX 2 months ahead of schedule and look forward to learning about the results of the first experimental campaign on NSTX at our next meeting.

Sincerely yours,

Gerald A. Navratil, Chairman
for the NSTX Program
Advisory Committee

**National Spherical Torus Experiment
Program Advisory Committee Meeting (PAC6)**

**Director's Conference Room (LSB-331)
Princeton Plasma Physics Laboratory
February 11 - 12, 1999**

AGENDA

Thursday February 11, 1999

8:00 AM Coffee, Donuts, Bagels

8:30 AM Welcome **Goldston PPPL**

8:40 AM DOE Update **Priester, DOE**

8:50 AM Agenda **Navratil,**
Columbia U.

9:00 AM Actions from Previous Meeting **Peng, ORNL**

9:10 AM NSTX Project Approaching Completion (40 min) **Ono, PPPL**
- Remaining Issues (15 min) **Kaye, PPPL**
- Role of Physics Analysis Division (25 min) **Kaye, PPPL**

10:30 AM Break/Coffee

10:40 AM FY99 (Phase-I) Experimental Tasks and Planning **Peng, ORNL**
- Introduction (10 min) **Sabbagh,**
- ET1: Ohmic Optimization (30 min) **Wilson, PPPL**
Columbia U. **Raman, U.**
- ET2: HHFW (30 min)
- ET3: CHI (30 min)

Wash.

12:20 PM Lunch

1:20 PM NSTX Tour **Perry, PPPL**

2:20 PM Break/Coffee

2:30 PM FY00-01 NSTX Science and Facility Proposal **Peng, ORNL**
- Science Proposal (60 min) **Ono, PPPL**
- Facility Proposal (60 min)

**4:30 PM PAC Caucus
Columbia U.**

Navratil,

5:30 PM Adjourn

6:30 PM PAC Dinner

Friday, February 12 1997

8:00 AM *Coffee*

8:30 AM Building National Research Teamwork

- **Organization** (30 min)

Ono, PPPL

- **Run Coordination, Experimental Proposal** (45 min)

Synakowski,

PPPL

- **Experimental Research Operation, Machine Proposal**
(30 min)

Mueller, PPPL

10:15 AM *Break/Coffee*

- **Engineering Operation** (30 min)

Von Halle,

PPPL

- **NSTX User's Group, Team Contacts** (30 min)

Peng, ORNL

**11:25 AM PAC Caucus
Columbia U.**

Navratil,

12:00 *Noon*

Lunch

**1:00 AM PAC Caucus
Columbia U.**

Navratil,

**2:30 PM Briefing
Columbia U.**

Navratil,

3:30 PM *Adjourn*