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11 September 2000

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

Subject: Report of the 9th NSTX Program Advisory
Committee Meeting – September 2000

Dear Rob:

The NSTX Program Advisory Committee (PAC) met at the Princeton Plasma Physics Laboratory on 7-8 September 2000 (agenda attached). In addition to receiving a status report on the NSTX Program and overviews of research at 4 other ST research programs (MAST, Pegasus, HIT-II, and CDX-U), our activities at this ninth meeting of the PAC focused on two areas in response to your charge to the committee (copy attached): (1) an assessment of the FY00 research and FY01 research plans to address the key research milestones set for NSTX; and (2) advise on a process to establish a three year cycle of 'rolling reviews' for present and potential new participants in the NSTX National Research Team.

Status of NSTX Project

We congratulate the NSTX Research Team on the completion of nearly all of the plasma & facility goals for the Inductive Phase of the Research Program (Phase I). This includes reaching the 1 MA ohmic current goal, producing more than 200 kA of CHI toroidal current, operating with peak plasma currents of 500 kA for a total discharge duration of over 0.5 seconds, operational control systems for plasma shape and position, and measurements of $T_e(r)$ and $n_e(r)$ with multi-point, multi-pulse Thomson scattering. NSTX

has also brought the HHFW system into operation with 2 MW of RF power delivered to the plasma, and is in a good position to reach the final Phase I milestone of delivering 4 MW of HHFW power in the final run period of FY00. In addition, the NBI system is well on the way to operation and is expected to inject power into the plasma ahead of schedule in the next few weeks. The NSTX Research Team has done an excellent job of keeping the research program on schedule in this first full year of operation of the NSTX facility, and is well on the way towards completion of several of the key milestones for the Noninductive Assisted Phase II of the NSTX Research Plan in FY01.

We received reports from the Program and Project Directors and FY00 Run Coordinators describing results of the 2000 experimental run period as well as reports on the progress on the few remaining open issues which were raised at our previous meetings. Our comments and/or questions on these are briefly summarized below:

Bakeout and Vacuum Conditioning: The Project reported that plans to provide 350 °C bake-out temperature to the passive structure and its PFC carbon tiles had again been modified to now use superheated steam instead of helium. As in previous reports, we encourage its implementation as soon as possible, which is now scheduled for the latter part of the FY01 experimental campaign. We were pleased to learn that the NSTX Team was able to advance the schedule for installation of a boronization system to reduce wall generated impurity levels in the near-term. Boronization was effective in MAST in reducing these wall generated impurities and we expect NSTX will benefit as well.

Diagnostic Plans: The committee is pleased to note that the Project has completed final design of a set of saddle loops for locked mode detection on NSTX with installation planned for early FY01 and has installed an EBW emission diagnostic to provide additional T_e information, as recommended at our previous meeting.

Neutral Beam Injection and Fast Ion Losses: In following up on a concern raised in several of our previous meetings, the Project reported on an analysis of possible serious fast ion losses in $q_0 > 2$ equilibria. This analysis showed

the fast ion losses are expected to be significant (42% at 1 MA plasma current) in the reference $q_0 > 2$ equilibria with an outer gap between the plasma and passive structure of ~ 4 cm. However, these losses can be very much reduced to a few % if the outer gap is increased to ~ 14 cm. This may be an effective way to address this problem, however, it is important for the Project to assess the effect of this larger outer gap on the wall stabilized beta limit for low- n kink modes and the compatibility with the HHFW system. Additional issues which need further work include an assessment of charge exchange losses and analysis of the optimal NBI injection angle for fast ion confinement.

CHI Insulator Issues: A new insulating plate was installed together with external circuit changes to reduce arcing problems with the CHI system. These changes were successful.

MSE Issues: At our previous meeting, we recommend the Project explore the MSE measurement sensitivity expected from the uncertainties in the poloidal flow estimates, and develop contingency plans as needed if this sensitivity is too low. The Project reported a dual track approach to MSE measurements with a conventional system installed in late Spring FY01 while work on a potentially more effective system using laser induced fluorescence MSE is being developed by the advanced diagnostic program of OFES. Since this is a very critical diagnostic system for NSTX, we would like more complete briefing and discussion on plans for MSE on NSTX at our next meeting.

NSTX Research for FY00 and Plans for FY01-FY02

The NSTX Run Coordinators presented summaries of the research results for the FY00 experimental campaign and plans for FY01. In general, we find these plans for FY01 to be well thought out and aimed at the completion of the key milestones established for the Phase II part of the NSTX Research Program which was reviewed in detail at our previous meeting in March 2000 (PAC8).

One area of concern which was raised at our March 2000 meeting was how the NSTX program planned to deal with the possibility that budget reductions may not allow completion of the 19 weeks of experimental operation per year in FY01 and FY02 needed to complete the Phase II research plan. We were presented with a plan for running 13 weeks per year and stretching out the Phase II research plan from 2 years to 3 years. While this plan is technically sound in pacing the research emphasis and achieving key milestones over a longer period of time, we note that such a plan significantly reduces the cost effectiveness of the NSTX facility. Availability of run time is clearly the pacing item in this plan. The Project presented an estimate that 6 experimental run weeks per year has an incremental cost of order \$1 million per year. We hope a way can be found to permit NSTX to operate close to the original timetable for completion of Phase II.

In our discussion of the experimental plans presented to us for FY00 and FY01, a few specific issues were raised which are summarized below:

CHI Experimental Plans. The CHI system has now demonstrated capability to start-up a plasma and drive toroidal currents up to 240 kA with pulse lengths of order 150 msec. Since a key goal for NSTX is to use CHI to assist in the non-inductive start-up the plasma, achieving a transition from the CHI driven edge current on largely open field lines to current flowing on closed flux surfaces held in equilibrium is an important experimental milestone. While such a state may form naturally if the CHI pulse is extended, use of inductive currents applied late in the CHI pulse as was tested on HIT-II may also help to establish the CHI driven current in an equilibrium. Outstanding issues include gas fill, plasma density, and electron temperature achieved. The Project should clarify goals of CHI target plasmas for the near-term and long-term, and we would like a follow-up discussion on this issue at the next PAC meeting.

Transport Experiments. In planning for research on transport in FY01, the program should follow the work on global scaling planned for the early part of the FY01 experimental campaign, with a more detailed analysis of local thermal diffusivity and power balance.

HHFW: The installation of the NBI system on NSTX will provide an exciting new capability for extending the plasma parameters achieved in NSTX. In planning the research program for FY01 and FY02, it is important as the NBI system comes into operation, not to diminish the emphasis on bringing the HHFW into full operation and used routinely in experiments, since this system is also critical for achieving not only plasma heating, but the noninductive current sustainment required to complete Phase III of the NSTX research plan.

Activity in Support of the ST PoP Program: At our previous meeting we pointed out that it is important to recognize in developing the NSTX research plan, that NSTX is part of a national Proof of Principle program to develop the ST concept. In particular, there are activities on concept exploration class devices, in the Advanced Tokamak program, and in the theory and modeling program which relate directly to important scientific issues in NSTX. The NSTX plans presented to us now include more explicitly recognition of this parallel research activity, which in several areas supports plans for future activity on NSTX.

NSTX National Research Team and Review Process

At our previous meeting in March 2000, you asked us to provide advice on the process to strengthen the NSTX National Research Team and on the research planning process used by the National Research Team, which consists of the integrated effort of 14 collaborating institutions together with scientists from PPPL. While it was clear that the team members are pleased with the way the National team is working, proud of the success they have enjoyed so far, and enthusiastic for the moving on to the next phase in the research program, we offered a few suggestions for improvement. We are pleased that the Project has accepted these suggestions which include: (i) the appointment of "...a very proactive facilitator as part of the NSTX management who makes sure that each member of the Team is informed of decision making activities that need their input or affect them in an important way. This role will be played by the Deputy Program Director. (ii) a well defined process has been established for selection of paper submissions to major meetings (*e.g.* APS invited papers, IAEA papers, EPS papers) led by the Deputy Program Director with input from Division Leaders.

We also note that NSTX has adopted a system where a Deputy Run Coordinator is appointed to assist the Run Coordinator and this Deputy Run Coordinator will become the Run Coordinator in the next year of operation. This is very effective approach providing opportunity for professional development, and insuring well experienced personnel fill the very important position of Run Coordinator. We are also pleased to note that both PPPL staff and members of a collaborating institution have been chosen to fill these positions.

A key part of our recommendations to strengthen the NSTX National Team at our March 2000 meeting, was “...that NSTX and the PPPL Host organization work with the DOE to develop a process of “rolling reviews” with an annual opportunity for new participants to compete. This process should begin shortly after the start of the fiscal year with the objective of putting funding in place by beginning of the next fiscal year. We endorse the model used in the solicitation of the initial National team members in 1998,...” You have now asked us for our advice on specific options for carrying out this recommendation.

NSTX National Research Team Review Process: The initial 14 collaborating institutions that became part of the NSTX National Research Team were funded for 3 years by the DOE and that funding will be up for renewal in FY02. A process needs to be established that allows for the opportunity for new participants to join the NSTX, while insuring the continuity and coverage of critical capabilities needed to maintain a robust national research team on NSTX. The project presented to us an approach which could be followed in FY01-FY02 to establish a three year rolling review cycle. We endorse this plan whose central features include:

- 1) Use of the open NSTX Research Forum supplements with other information channels to provide information to the community on collaboration opportunities.
- 2) Solicitation of letters of interest from present and prospective NSTX Team members similar to the process followed in the original NSTX National Team selection.

3) Request that "Record of Discussions" with the NSTX Project be included with all proposals to DOE for participation on NSTX similar to the process followed in the original NSTX National Team selection.

4) Proposals from present and prospective NSTX Team members would be submitted to DOE by 1 April 2001.

5) All proposals would be peer reviewed individually.

6) Proposals would be submitted for 2, 3, or 4 year periods. However, proposals for 3 years would include a schedule for deliverables for 2 years and 3 years. Proposals for 4 years would include a schedule of deliverables for 2 years, 3 years, and 4 years.

6) Peer reviewers would be asked for advice on appropriate term of funding. This information plus other criteria determined by the OFES would be used by the OFES to make funding decisions with the objective of distributing the funded collaborations evenly over the terms of 2, 3, and 4 years.

7) Beginning in FY04 a regular annual cycle of reviews of proposals from ~1/3 of the funded NSTX Team collaborators plus all prospective new participants would begin.

Next Meeting of the NSTX PAC

The next meeting of the NSTX PAC is expected to be in February-March 2001. As described in this report, we would like a briefing and discussion on plans for MSE on NSTX and target plasma goals (near-term and long-term) for CHI produced plasmas at our next meeting.

In closing, we again express our congratulations to the NSTX National Research Team for a very successful completion of the key research milestones set for FY00.

Sincerely yours,

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

National Spherical Torus Experiment
Program Advisory Committee
9th Meeting

Agenda

Princeton Plasma Physics Laboratory
Conference Room LSB-318
September 7 - 8, 2000

Thursday, September 7, 2000

8:30 Coffee & Donuts
9:00 PAC Executive Session
9:30 Goldston Welcome and Charge to the PAC
9:40 Priester Comments from DOE
9:45 Navratil Agenda
9:50 Peng Actions from PAC-8
10:10 Coffee Break

FY-2000 & 2001 Research

10:20 Peng Program Overview
11:00 Ono Facility Overview

12:00 Lunch

1:00 Sykes MAST Research Program and Latest Results
1:20 Fonck Pegasus Research Program and Latest Results
1:35 Jarboe HIT-II Research Program and Latest Results
1:50 Kaita/Majeski CDX-U Research Program and Latest Results
2:05 M. Bell FY-2000 Experimental Run and FY-2001 Research
Operation Plan

3:05 Cookie Break
3:15 Synakowski FY-2001 Research Program and Run Plan
4:30 PAC Caucus
5:30 Adjourn

6:30 PAC Party at the Peng's

Friday, September 8, 2000

8:30 Coffee & Donuts

9:00 Peng

Preparation for Collaboration Review and Renewal

10:00

Discussion with some NSTX on-site Collaborators

10:30 Coffee Break

10:40 PAC Caucus

12:00 Lunch

1:00 PAC Caucus

2:00 Navratil

Briefing for PPPL Director & DOE OFES

3:00 Adjourn

Charge to the Ninth NSTX Program Advisory Committee Meeting, September 7-8, 2000

NSTX has for FY 2000 planned and achieved substantial progress in initial research and facility upgrade. The research team has worked well in a broad front of efforts in ramping up and carrying out the research activities. Detailed planning of the research program and facility preparation is being carried out for FY 2001, when major heating power, operation capabilities, and diagnostics will become available. I therefore ask the PAC to review and advise me on the following issue during the meeting:

- 1) Does the research being carried out for FY 2000 and planned for FY 2001 effectively take advantage of the growing capabilities of the NSTX facility and address the key research milestones?

The PAC recommended during the previous meeting 'that NSTX and the PPPL Host organization work with the DOE to develop a process of "rolling reviews" with an annual opportunity for new participants to compete. This process should begin shortly after the start of the fiscal year with the objective of putting funding in place by beginning of the next fiscal year. We endorse the model used in the solicitation of the initial National team members in 1998, ...' In view of the crucial importance of a robust national research team to the success of the NSTX Program, I ask the PAC also to review and advise me on the following issue during the next meeting:

- 2) There can be identified a couple of approaches to distribute the collaboration efforts over a three-year cycle to enable a rolling review schedule in the future. This involves a one-time review and renewal of existing collaborations for 2, 3, or 4-year durations. Does our evaluation of these approaches adequately address the key interests of the present and future research collaboration, and build a robust and successful national research team?