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5 October 1999

Dr. Robert J. Goldston, Director
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P. O. Box 451
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Subject: Report of the 7th NSTX Program Advisory Committee Meeting – September 1999

Dear Rob:

The NSTX Program Advisory Committee (PAC) met at the Princeton Plasma Physics Laboratory on 23-24 September 1999 (agenda attached). In addition to receiving a status report on the NSTX Project and Project Physics, our activities at this seventh meeting of the PAC focused on four areas in response to your charge to the committee (copy attached): (1) the planned schedule for key operational and diagnostic capability in support of Phase-I; (2) the planned balance of activity between the experimental task forces in CY99; (3) the compatibility of NBI and HHFW heating systems; and (4) areas of potential emphasis in planning for an expansion of the NSTX National research Team.

Status of NSTX Project and Project Physics

The NSTX experimental facility has now resumed experimental operation after the completion of the installation of the internal passive stabilizer, the HHFW antenna, and CHI ceramic insulators. All TPC tasks were completed on budget in July 1999. Since the resumption of plasma experiments on 3 September 1999, ohmic plasmas with up to 0.520 MA sustained for about 0.1 sec have been achieved. These results now establish a new record for current supported in an ST device and mark the beginning of the study of new

ranges of ST plasma parameters in NSTX as CHI and HHFW systems are brought into operation. We congratulate the NSTX Project technical and scientific staff for their success so far in bringing this new facility on-line and look forward to results from this initial experimental operation in CY99.

The committee also notes that the NSTX National Team has come together as an effective research group in these past few months and this group of collaborations among many institutions and individual scientists and engineers has been quite successful in the formulation of a detailed research plan and the initial execution of experiments on NSTX.

We discussed the planned schedule for key operational and diagnostic capability in support of NSTX Phase-I research objectives as well as the physics modeling progress on the few open issues raised at our previous meetings. These are briefly summarized below:

Bakeout and Vacuum Conditioning: In our earliest committee meetings we supported the changes proposed by the NSTX Project in the baseline design requirement that all internal carbon surfaces be capable of bakeout to 350˚C and the metal vacuum vessel (except for ports locations) be capable of bakeout to 300˚C. However, the original plan to provide these bakeout conditions has presented an unexpected safety problem due to the possibility of a fire hazard with the Dowtherm heat transfer fluid. An alternative plan was presented which would rely in the near term on resistive heating of the center stack wall to 350 ˚C which would radiatively heat the carbon tiles on the passive stabilizer to 250 ˚C, the divertor tiles to 200 ˚C, and the vessel wall to 150 ˚C with the installation of a thermal insulating blanket on the vacuum vessel. Longer term a supplementary resistive heater of about 40 kW would be installed to heat the passive stabilizer and divertor carbon tiles to 350 ˚C, but the vacuum vessel wall will be heated to only 150 ˚C with a safer heat transfer fluid.

(1) We support the strategy proposed, and suggest that rigorous vacuum standards be maintained for the installation of diagnostics on NSTX and a key individual responsible for enforcing these standards be identified.

(2) Since this system is essential to clean, low density operation needed for high T_e (*e.g.* HHFW studies), we strongly recommend that this plan be implemented during the FY00 vacuum opening.

Another area of concern is the use of deuterium glow with the consequent fogging of the viewing windows and the mobilization of carbon "soot" in NSTX. We recommend continuing consultation with experts on this topic in the community with experience on high temperature carbon PFC machines take place such as DIII-D, JET, and TEXTOR and the installation of viewing window shutters at the earliest opportunity.

Diagnostic Plans: The committee notes that the initial set of magnetic diagnostics does not include any non-axisymmetric saddle flux loops needed to diagnose the occurrence of locked modes. Since these modes have been observed to limit the operation in many toroidal devices, we recommend that the Project install before the end of CY99 a set of saddle coils on the mid-plane for locked mode analysis.

Since the measurement of the electron temperature is quite important for HHFW heat deposition measurements, we recommend that the Project consider expediting the installation of an EBW emission diagnostic to provide additional T_e information.

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?

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 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 further work to analyze the distribution of these losses and assess their effect on the RF antenna and other internal structures, reporting that the power density of fast ion losses to the

stabilizing plate edges is within allowable limits of a few MW/m^2, but that 80% of the fast ion losses occur on the HHFW antenna structure with peak power fluxes on the mid-plane edge of the antenna above 10 MW/m^2. This power level is large enough to be of concern, and we recommend that the Project consider the installation of additional BN on the sides of the antenna which is graded to distribute the fast ion heat load during the next major vacuum opening scheduled to begin in January 2000.

(ii) Based on the large levels of counter-injection losses for the high-β, $q_o >$ 2 equilibria, what is the level of bulk ion losses at the highest ion temperature expected in NSTX?

The bulk ion losses were previously reported to be small, but the Project plans to revisit this question with the EIGOL code.

Modeling CHI Start-up: Progress was reported in using EFIT and MFIT to model the effects of a time dependent current profile in the CHI start-up in NSTX, which earlier used a fixed profile shape that was ramped up in magnitude. The Project noted that inclusion of the vacuum vessel and passive plate currents was critical for accurate modeling of the CHI start-up scenarios and this work will continue.

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. The Project completed a study of this effect using a 3D eddy current model SPARK which showed that the original design of the passive stabilizer would produce a large (~ 100 Gauss) n=1 field perturbation during the breakdown phase which was unacceptable. The passive stabilizer design was modified to produce a more axisymmetric configuration, and this modification was installed in NSTX. The committee notes that this study involved the strong contributions from collaborators on the NSTX National Team and is another example of the effective research group which has been brought together around NSTX.

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 has completed its review of this issue and reports that experience in other devices (PBX-M and Phaedrus) showed no problems. This effect will be monitored in the initial HHFW studies.

FY99 (Phase-I) Experimental Plan

The primary goals of the Phase-I research on NSTX are:

- 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 @ 0.5 MA
- Document time dependent profile information on $T_e(r)$ and $n_e(r)$

We note the time available in CY99 to make progress towards these goals is very limited, and the plan being developed by the Experimental Task Forces proposes allocation of run time to each of the first three goals listed above. We support this balanced approach, but are concerned that the CHI and HHFW tasks may require significantly more time than available in CY99 to be successful. For this reason we feel that the addition of any other program elements into the research plan at this stage (such as developing low-q, high beta plasma targets) would be unwise.

HHFW/NBI Interaction

In our previous meeting of February 1999, the Project was requested to investigate the issue of possible interaction between the HHFW heating and energetic beam ions if these two systems were used simultaneously to heat the NSTX plasma. The report to us by the Project indicates that the interaction with the beam ions, which typically travel faster than the HHFW phase velocity, may not have s significant interaction. However, there may be a problem with HHFW heating interaction with the bulk ions which could interfere with delivery of heating and current drive for to the electrons in the locations desired. Two issues we recommend that the project address is to

evaluate whether the diagnostic set planned for NSTX in FY00 is adequate to study this issue, and whether sufficient emphasis is being placed on RF modeling applied to these HHFW experiments. This is an important area which should be given priority if additional resources are available to NSTX in FY00.

NSTX National Team in FY00 & Funding Issues

In the event that additional resources become available in FY00, we recommend the following areas be considered (with NO PRIORITY ORDER):

1) Install the full bake out system in FY00

2) Install set of external saddle coils for locked mode measurements

3) Install the Reciprocating probe from the advanced diagnostic set.

4) Work on EBW/ECH previously identified as an important back-up to CHI for non inductive start-up.

5) Augment the diagnostic set to support measurement of the local ion and electron heat deposition of the HHFW and provide for modeling tools for the analysis of these experiments.

6) Add an additional 3 weeks of run time to complete Phase I

7) Add additional (~ 10) channels to the Multi-Pulse Thomson Scattering system

8) Make the divertor plate Langmuir probes operational in FY00

9) Invest in Plasma Control System (hardware, run-time and manpower)

10) Bring the full magnetics diagnostic set into operation in FY00.

11) Install an EBW emission diagnostic for time dependent electron temperature measurements.

The committee supports the proposed delayed schedule for NBI operation planned for October 2000, and have not included acceleration of NBI installation in the list above, so as not to interfere with completion of the Phase-I experimental objectives.

NSTX National Research Team

Data Access Policy:: A policy regarding access to data and publication of results by NSTX National Team members has been established, which members of the Team must agree to and sign. We support this plan which establishes open access to all data by Team members, while insuring that scientists primarily responsible for the work have opportunity for lead authorship on initial publications. We recommend that this process include a well defined timetable for completion of the internal peer review process.

New Solicitation for NSTX Team Members: We support the Project intent to support a new solicitation of letters of interest for additional NSTX research team activity, following the process used successfully in FY98-99.

Next Meeting of the NSTX PAC

The next meeting of the NSTX PAC is expected to be in February 2000.

In planning the agenda for the next meeting of the committee, we anticipate including a discussion of the experimental run plan for the completion of Phase I, the status and plans for remote scientific collaboration and the plans for HHFW experimental and modeling studies.

In closing, we again express our congratulations on completing the NSTX construction project on cost and the resumption of the CY99 experimental

campaign. We look forward to learning about the results of the CY99 experimental campaign on NSTX at our next meeting.

Sincerely yours,

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

CHARGE TO THE SEVENTH NSTX PROGRAM ADVISORY COMMITTEE MEETING

SEPTEMBER 23-24, 1999

The NSTX has successfully completed the Design and Construction Project within the Total Project Cost. This meeting will mark the beginning of full NSTX operation and experimental research, which started on August 30. I expect the NSTX PAC to make a transition in advising me on the following issues of an operating NSTX.

1) Is the planned schedule for bringing online key operational and diagnostics capabilities (such as bake-out, Thomson scattering, etc.) in support of the Phase-I research goals of NSTX optimized, given funding constraints? What would be the optimal schedule of NBI installation in support of Phase-II research, in view of this consideration?

2) The Experimental Task Forces are preparing and implementing the initial Experimental Proposals (XPs) and Experimental Machine Proposals (XMPs), which comprise the NSTX run plan. Is the balance of activities between the task forces (Ohmic, HHFW, CHI) appropriate for this phase of the experimental run?

3) Intense heating and current drive power in HHFW and NBI are being implemented on NSTX. The physics of HHFW and its compatibility with NBI are new in high-temperature toroidal plasma research. Are the appropriate key physics issues identified? Is the planned approach to addressing these issues appropriate?

4) An open peer-reviewed competitive process was successfully carried out by DOE to establish the present NSTX National Research Team. However the levels of effort for both the collaborating and host teams are expected to be only 3/4 of the necessary and originally planned levels. In our efforts to work with DOE to expand the team, which areas of research should be emphasized as especially important to strengthen?

NSTX PAC-7
AGENDA

PRINCETON PLASMA PHYSICS LABORATORY
CONFERENCE ROOM LSB-318

SEPTEMBER 23-24, 1999

Thursday, September 23, 1999

8:30	Goldston	Welcome and comments
8:45	Priester	OFES comments
9:00	Peng	Summary of action items
9:15	Ono	Completion of TPC, Bake-Out Strategy, Facility Operation
10:15		Coffee
10:30	Kaye, et al	Physics Modeling
11:30	Mueller	Experimental Research Operation plan & XMPs
12:30	Lunch	
1:30	Bell	Task Force Activities, Experimental Run Plan, and Up-to-Date Results
3:00		Coffee
3:15	Ono/Menard	HHFW, NBI, Compatibility Issues, and Investigation Plan
4:15	Navratil	PAC Caucus
5:15		Adjourn
6:30		PAC Party

Friday, September 24, 1999

9:00	Kaye	Data and Publication Policy, etc.
9:30	Peng	Key ST Science Issues, Post Snowmass; Areas to Strengthen (including coffee break at 10:30)
11:00	Von Halle	NSTX Tour
12:00	Lunch	
1:00	Navratil	PAC Caucus
2:00	Navratil	PAC Briefing
3:00		Adjourn