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27 October 1997

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

Subject: Report of the NSTX Program Advisory Committee – September 1997

Dear Rob:

The NSTX Program Advisory Committee met at the Princeton Plasma Physics Laboratory on 17-18 September 1997 (agenda attached). Our activities at this meeting focused on three areas in response to your charge to the committee (copy attached): (1) a discussion of the physics requirements for the NSTX design; (2) plans for the NSTX diagnostic set; and (3) comments on the NSTX research planning for FY98 and FY99. Our response to the part of your charge requesting us to comment on the NSTX research plan in the context of the plans for other new ST experiments has been deferred until our next meeting after we obtain input from the Pegasus program.

This report summarizes issues raised during discussion and our comments and recommendations in these three areas.

NSTX Design Requirements

The NSTX Project has made substantial progress on addressing most of the issues and questions raised at our previous two meetings. The design has been changed in several important respects to address concerns relating to diagnostic access, bakeout specifications, and capability for between shot He-glow cleaning. The present design is now quite mature. The committee is also very

pleased to note that this project had begun to “cut metal” and has moved into the construction phase on schedule.

The committee was given a tour of the site of the NSTX facility which uses the former TFTR Hot Cell. This area is quite large and provides ample space and facilities for the baseline machine installation as well as the possibility of neutral beam heating upgrades.

In the course of an update on some of the NSTX physics design issues raised at our earlier meetings a few comments and suggestions were made which are summarized below:

Divertor Power Loading: An analysis of the expected divertor power loading was presented to the committee. We concur with the assessment that the power loading expected in NSTX is challenging, but within acceptable levels based on our present understanding of divertor performance.

Machine Baking Design Specifications:: The committee supports 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.

He Glow Capability: The committee supports the change in the baseline design which will incorporate the capability for between shot He-glow discharge cleaning.

Neutral Beam Injection: Present plans for the NSTX hot cell facility will permit only co-injection neutral beams on NSTX. Since the diamagnetic contribution to the radial ExB shear at very low aspect ratio is expected to be significantly larger than in moderate aspect ratio tokamaks, the capability to vary the toroidal momentum input may be an important control variable for plasma transport. We suggest the Project explore the feasibility of use of counter-NBI in NSTX and the possibility of maintaining a counter-injection NBI option in layout of the NSTX test cell.

Breakdown of Plasma: At our May 1997 meeting an issue was raised regarding the loop voltage induced by the OH coil while it is being “biased” prior to breakdown which may generate an unwanted, early reverse-current discharge. The Project has studied this issue and it can be fully addressed either by application of small transverse field prior to the breakdown period or by rapid gas programming. A related issue which remains unresolved is an

analysis of $B_{\perp}(R)$ including eddy current effects during start-up, which may interfere with the breakdown process.

Capability for High Elongation: The $n = 0$ stability of κ=3 plasmas in NSTX was examined by the Project and found to be much more unstable ($\tau_{growth} < 1$ msec) than lower elongation plasmas nearer to κ~2 where $\tau_{growth} > 100$ msec. An open question is whether this high elongation plasma is in fact ideally unstable to an $n = 0$ mode with the present conducting wall geometry? Also, what is the highest value of κ that NSTX can achieve while maintaining control of the $n = 0$ mode?

Baseline κ=2 Equilibria Midplane 'Bulge': It was noted at our last meeting that many of the baseline equilibria presented to the committee have a characteristic feature of a 'bulge' in the outer flux surfaces at the outer mid-plane. The Project has explored variations in coil position and the baseline design location appears to minimize this feature. However, the effect of this local region of increased bad curvature in the magnetic field has on stability is unknown and should be investigated including cases where β approaches 40% with high bootstrap fraction.

Stabilizing Plate Structure: The edges of the stabilizing plates nearest the mid-plane may present a localized target for escaping energetic ions. Consideration should be given to changing the plate angle or shielding this edge with graded PFC material.

Modeling of HHFW Heating: Results of time dependent modeling of HHFW heating in NSTX were presented which show a very rapid increase in the electron temperature from a few hundred eV to 4 keV. Examination of the stability of these plasmas during the rapid beta increase shows it to near or above the stability limits depending on small variations in the assumed pressure profile, particularly for the n=3 mode. Further analysis of these start-up scenarios would be helpful in assessing whether this stable window for HHFW start-up is small and may pose a problem.

Modeling of CHI Start-up: CHI start-up equilibria have been modeled with and without charging of the OH solenoid showing that the coil currents are within the design limits for both cases. A remaining question is whether at all times during full start-up sequences this is still the case: double swing OH coil at full current using CHI with and without NBI.

Data Access & Display: The committee supports the efforts being considered by the NSTX project to adopt common data access and display systems used on other major fusion experiments.

NSTX Diagnostics Plan

The Project presented an update on its plans for both the baseline (part of the TPC) and upgrade/advanced diagnostics (outside the scope of the TPC). The present plan for NSTX is to have all baseline diagnostics installed and operating in May 1999. The availability of these baseline diagnostics (together with the multi-pulse Thomson scattering system) when plasma operations begin in FY99 will be required in order to achieve the goals which have been set for the FY99 research plan. At our next meeting, the committee requests that the Project describe the plan and timetable for the installation of these baseline diagnostics. Below are summarized more detailed comments and recommendations for specific diagnostic systems:

Multi-pulse Thomson Scattering: As discussed in the report of our May 1997 meeting, the committee believes that the temperature and density profile information provided by this diagnostic will be essential to accomplish the goals which have been set for the FY99 research plan; it should be installed as soon after plasma operations begin as possible. A plan for the installation of the Thomson scattering system using a single midplane access port was presented. The committee is concerned that this system may not be optimized for spatial resolution, and recommends that the NSTX Project explore alternative observation locations to improve the spatial resolution and possibly achieve a resolution approaching 0.5 cm in the plasma edge region.

Magnetic Diagnostics: Considerable progress has been made in the conceptual design of this system. Two issues which were raised include the need to deal with the embedded magnetic coil in a tile during tile replacement and whether the frequency response of the coil sensors could be raised above 20 kHz.

CHI Diagnostics: The Project described its plans to install a set of magnetic probes on the inner wall to study possible instabilities during CHI. These probes should provide reasonable coverage to diagnose the range of poloidal mode numbers expected. In addition to this set of magnetic probes, we recommend the project consider the installation of video camera viewing of the CHI interaction region.

Current Profile Diagnostic for NSTX: The Project summarized the conclusions and recommendations which emerged from its summer research forum to discuss approaches to current profile measurements in NSTX. The first of the research forum recommendations was that the NSTX Project "...should develop the capability (for example, using TSC and EFIT) to study self-consistently the sensitivity of an equilibrium reconstruction to various types of diagnostic input data..." The committee endorses this recommendation and would like to receive an update on progress at our next meeting. Among the other recommendations, we understand that the project presently views Collision Induced Florescence Motional Stark Effect (CIF/MSE) as the primary approach being considered for NSTX. We recommend that the project assess the capability of this system to measure E_r.

NSTX Research Program Planning

There was considerable further discussion about the proposal by the NSTX Program to establish a process for the formation of the NSTX National Research Program and a National Research Team. In "Step 3" of the plan the NSTX PAC was called upon to review the preliminary proposal for an NSTX program based on letters of interest submitted in January 1998 by prospective members of the NSTX National Research Team. In order to clarify the role of the NSTX PAC in this process, we proposed the following plan which has been accepted by PPPL and the DOE:

1. The NSTX Program will present to the PAC the proposed research program and priorities together with an organization of the Letters of Interest to cover the proposed program. There will be NO evaluation of the relative merits of any prospective participant in the NSTX Program at this time by either the NSTX Program or the PAC.

   The material to be reviewed (which will also include copies of all submitted Letters of Interest) will be provided to the NSTX PAC at least 2 weeks in advance of our February meeting to provide adequate time for committee members to prepare for the meeting.

2. At the NSTX PAC February 1998 meeting, the PAC will review and comment on the plan for the NSTX National Research Program and priorities.

3. At the NSTX PAC February 1998 meeting, the PAC will review and comment on the coverage by prospective participants on the proposed

NSTX National Research Program. There will be NO evaluation of the relative merits of any prospective participant in the NSTX Program by the PAC.

In preparing for this next step in the development of the NSTX National Research Program, the committee offers the following advice:

- The NSTX Program needs to set clear targets for the FY99 run which support the early scientific goals of NSTX.

- Because of the inherent uncertainties in bringing the many systems which comprise a new facility into operation, we do not believe it is useful to carefully schedule the timing of specific FY99 run activities.

- The draft Notice of Available Research that will be issued to the community to solicit Letters of Interest from prospective NSTX National Research Program participants, should be circulated to the PAC for comment before distribution to the community.

Next Meeting of the NSTX PAC

We expect that the next meeting of the committee will take place in February 1998. The primary activities at this meeting will be the review of the NSTX Research Program Plan and an update and discussion on the plan for baseline diagnostic installation.

Sincerely yours,

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

cc: Richard J. Hawryluk, PPPL
John Schmidt, PPPL
Hutch Neilson, PPPL
Dale M. Meade, PPPL
Stan Kaye, PPPL
NSTX PAC Membership
N. Anne Davies, DOE/OFES
John W. Willis, DOE/OFES
Jeffrey C. Hoy, DOE/OFES
William F. Dove, DOE/OFES
Jerry Wm. Faul, DOE/PG
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M E M O R A N D U M

TO: NSTX Program Advisory Committee

FROM: Robert J. Goldston

SUBJECT: Third Meeting of NSTX PAC, September 17-18, 1997

DATE: September 10, 1997

The third meeting of the NSTX Program Advisory Committee will be held at the Princeton Plasma Physics Laboratory on Wednesday and Thursday, September 17-18. This meeting will be an important opportunity for NSTX to receive advice on the physics design, upgrades, and research preparation.

Attached is the committee's charge for this meeting. Also attached is a draft agenda. If you need assistance with local arrangements, please contact Dolores Lawson at 609-243-3554 (FAX: 609-243-2749).

I would like to thank Gerald Navratil and the Committee members for having conducted an excellent second meeting in May of this year, and I look forward to having this committee continue their critical role in advising the PPPL Director as NSTX establishes research priorities and develops its research programs.

Attachments (3)

cc: Richard J. Hawryluk, PPPL
John Schmidt, PPPL
Hutch Neilson, PPPL
Dale M. Meade, PPPL
Masa Ono, PPPL
Martin Peng, ORNL
Stan Kaye, PPPL
N. Anne Davies, DOE/OFES
John W. Willis, DOE/OFES
Jeffrey C. Hoy, DOE/OFES
William F. Dove, DOE/OFES
Jerry Wm. Faul, DOE/PG
Greg Pitonak, DOE/PG

CHARGE TO THE THIRD
NSTX PROGRAM ADVISORY COMMITTEE MEETING
SEPTEMBER 17-18, 1997

The PAC is requested to provide advice on the following timely topics:

1. Physics Requirements for the NSTX Design

As the NSTX Project begins fabrication, physics design requirements for plasma-facing components (PFC), power and particle handling, and other physics designs are being finalized. Are these consistent with the initial NSTX research priorities?

2. NSTX Diagnostics

Plans for baseline magnetics diagnostics are being finalized, and discussions for J(r) profile measurements and multi-pulse Thomsen Scattering have made progress. Do these NSTX diagnostic plans support the initial NSTX research priorities?

3. NSTX Research Priorities and Preparation

Recent progress in ST experimentation and fabrication projects has heightened interest in ST research in the fusion community. Research on several new ST experiments is being planned. Is the initial research planned for NSTX appropriate in view of these related activities? What elements of collaboration should NSTX research emphasize, in the U.S. and in the world?

National Spherical Torus Experiment
Program Advisory Committee Meeting
September 17-18, 1997

Princeton Plasma Physics Laboratory
Director's Conference Room, LOB-333

DRAFT AGENDA

Wednesday, September 17

8:15 AM	Arrival	
8:30 AM	Welcome	R. Goldston
8:40 AM	DOE Comments	W. Dove
8:50 AM	Agenda and Comments	G. Navratil (Chair)
9:00 AM	Action Items	M. Peng
9:20 AM	Break	
9:30 AM	Project Status and Remaining Design Decisions	M. Ono
11:00 AM	Tour of NSTX Test Cell	E. Perry
12:00 Noon	Lunch	

Physics Update

1:00 PM	Issues from last PAC Meeting	S. Kaye
1:40 PM	SOL and Divertor Plasma Estimates	R. Maingi
2:00 PM	Break	

Diagnostics

2:10 PM	Issues from last PAC Meeting, Magnetics, Multi-Pulse Thomsen Scattering, J(r) Diagnostic Recommendation	R. Kaita
3:40 PM	Pegasus Research Program	R. Fonck
4:20 PM	Discussion	
5:00 PM	Adjourn	
7:00 PM	Dinner	

Thursday, September 18

NSTX Program Activities ..... M. Peng

9:00 AM	Recent ST-Related Meetings
9:20 AM	FY 1999 Research Run-Weeks
10:00 AM	FY 1998 Research Preparation and Building National Team
11:00 AM	PAC Caucus
12:00 Noon	Lunch
1:00 PM	PAC Preparation
1:30 PM	PAC Briefing

NATIONAL SPHERICAL TORUS EXPERIMENT
PROGRAM ADVISORY COMMITTEE

Dr. Gerald A. Navratil, Chair
Columbia University

Dr. Kenneth Gentle
The University of Texas at Austin

Dr. Edward A. Lazarus
Oak Ridge National Laboratory

Dr. Farrokh Najmabadi
University of California, San Diego

Dr. William Nevins
Lawrence Livermore National Laboratory

Dr. Stewart C. Prager
University of Wisconsin, Madison

Dr. Ronald C. Stambaugh
General Atomics

Dr. Alan Sykes
Culham Laboratory

Dr. Yuichi Takase
Massachusetts Institute of Technology

Dr. Stewart Zweben (on behalf of Steve Scott)
Princeton Plasma Physics Laboratory

Dr. Masa Ono (ex officio)
Princeton Plasma Physics Laboratory

Dr. Martin Peng (ex officio)
Oak Ridge National Laboratory