REPORT of March 11-12 MEETING of the FFCC

A meeting of the Fusion Facilities Coordinating Committee was held at GA on March 11-12. This report will summarize the Committee's discussions, recommendations, and conclusions. The major topics which were addressed at the meeting were: Program Plans for DIII-D, C-Mod and NSTX; research objectives for FY'99 and FY'00; and coordination among the facilities and international collaboration. In addition, a brief discussion of the status of the tokamak and ST strategic white papers took place.

FACILITY PROGRAM PLANS

DIII-D PROGRAM PLANS

by T. C. Simonen

The mission of the DIII-D national program is "to establish the scientific basis for the optimization of the tokamak approach to fusion energy production." The program's primary focus is advanced tokamak research. DIII-D research will advance the scientific understanding of magnetic confinement on a broad front.

The DIII-D 1999 experiment program focuses on six thrust areas and experiments in four science topical areas. In 1999, six new diagnostics are operational and a third megawatt level gyrotron is being commissioned. Feedback control of resistive wall modes will be operational this summer. We are now about a third of the way into the 1999 experiment program which will end on July 9 for the Snowmass meeting, at which time installation of the top divertor pump/baffle will begin.

The 1999 thrusts are aimed at establishing the physics principles and developing control techniques to enable full integrated advanced tokamak (AT) experiments using the ECH current drive and divertor capabilities available in 2001. A programmatic status check point in 2001 is identified to access advanced tokamak physics research progress to identify research pathways and new tool needs to efficiently advance the integrated AT program.

The three-year research plan was developed via the DIII-D Research Council, reviewed by the DIII-D Program Advisory Committee (February 8-9, 1999), and presented to FESAC (March 3, 1999). Both committees provided positive and helpful feedback. DIII-D advanced tokamak research thrusts are coordinated with research at other international tokamaks with each facility having differing emphases as appropriate to its unique capabilities and programmatic priorities. Mamy physics topics are investigated in more than one facility to provide needed cross checks and to develop physics scaling understanding.

Coordination of DIII-D and Alcator C-Mod continues with widely different physical parameters (size, magnetic field, density) and with differing divertor geometries and pumping capabilities. DIII-D research focuses on divertor particle control and plasma flow, while C-Mod focuses on power dissipation and plasma recombination. We are very pleased with the Alcator C-Mod MDSPlus common language database management system now being used at DIII-D. The collaboration with Alcator C-Mod will be facilitated when each facility has complementary off-axis current drive in 2001-02 (6 MW ECCD on DIII-D and 3 MW LHCD on C-Mod).

International collaborations are a key element of the DIII-D research strategy. Individual collaborations at the major international tokamaks are planned on many specific science topics, as well as four major collaborations: (1) JET—high performance operation with optimized shear; (2) JET/TEXTOR—radiative mantle experiments; (3) JT-60U—steady-state high performance for advanced operating scenarios; and (4) JT-60U—divertor and core studies of improved confinement at high density. In addition, several members of the DIII-D team will participate in the international ITER physics expert groups.

The DIII-D program has increased its national character. Besides about 50 ongoing collaborations, six new collaborating universities were added. Several labs are supporting 1999 operations and subsystem improvements: PPPL (MHD feedback power supplies, ECH and ICH, and diagnostics), ORNL (Pellets, ICH, and ECH), and LLNL (diagnostics).

ALCATOR C-MOD PROGRAM PLANS

by I. H. Hutchinson

The refurbishment of the Alcator C-Mod magnet and installation of the new ICRF antenna and divertor bypass controls (``flaps") was completed and plasma operation restarted on 22 Jan 99. The first segment of the FY99 campaign was completed on 5 Mar 99 after 3 weeks of physics operation. A total of 12 weeks is planned for this campaign.

The flaps are operating well and, as expected, show substantial effects on divertor neutral pressure. The new ICRF antenna has not yet been operated because of engineering difficulties with the fourth transmitter. We expect first operation during the next campaign segment. When fully operational, this additional antenna together with the original two dipole antennas provides for launching up to 8MW source. For the next two years we anticipate this capability will permit tokamak operation at high power and beta in support of transport and stability programs as well as specific ICRF experiments to explore core plasma flow control and mode conversion current drive, which will be a major program component. The diagnostic neutral beam has experienced serious unanticipated schedule slippage which means it cannot be ready before July 1999. This date is incompatible with DNB operation this campaign. It nevertheless retains high priority within the near-term program because of its potential for yielding critical data on field-, rotation-, and ion temperature-profiles.

Other diagnostic upgrades, particularly those designed for H-mode pedestal measurements, are now operational, including an additional soft x-ray camera and the high-spatial-resolution edge Thomson scattering. These additions together with Helium jet measurements will give greatly increased detail of the pedestal profile, for understanding its stability and transport properties.

A shift of the longer term program plan has been triggered by additional faculty interest and a reduced-cost plan for reinstalling the Lower Hybrid system. For some time we have been unable to proceed with this important Advanced Tokamak initiative for lack of funds. However, we now think that we can and must find the resources to proceed even in the absence of additional funds. We therefore are developing a plan to move forward next fiscal year with engineering and aim to complete a 3MW source and launcher capability for operation in early FY2002. The key scientific objective will be to demonstrate quasi-steady-state, high bootstrap-fraction, high performance plasmas using Lower Hybrid current profile control. To proceed on a flat budget requires reduction of scope in other areas. Current planning cancels the divertor septum and delays the divertor cryopump. The divertor upgrade necessary for higher current operation will not be installed on present plans till FY2000.

NSTX RESEARCH PROGRAM

By Martin Peng

The mission of the NSTX Research Program is to prove the physics principles of the following attractive ST properties:

- Plasma startup without complicated inboard solenoid magnet,
- Efficient heating and non-inductive current drive for steady-state operation,
- High plasma pressure in low magnetic field for high fusion power density and low cost,
- Nearly fully self-driven (bootstrap plus diamagnetic) plasma current for economic operation,
- Good energy confinement to permit small-size fusion plasma, and
- Dispersed heat and particle fluxes.

First plasma was achieved on NSTX in February 1999, ten weeks ahead of schedule and surpassed the DOE performance milestone by reaching ~300 kA in current. Experimental research is planned to begin in July 1999. Other new ST experiments worldwide (MAST/U.K., Pegasus/U.S., Globus-M/R.F., and

ETE/Brazil), with varying research capabilities and emphases, are to achieve first plasma in a similar time scale and join NSTX, HIT-II, and CDX-U in ST research.

Since the last meeting of the FFCC, the NSTX National Research Team has been selected as a result of a competitive peer review process and are working with the host institution, PPPL:

- Columbia University
- Fusion Physics & Technology
- General Atomics
- Johns Hopkins University
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Massachusetts Institute of Technology
- Oak Ridge National Laboratory
- Princeton Plasma Physics Laboratory
- Sandia National Laboratory
- University of California at Davis
- University of California at Los Angeles
- University of California at San Diego
- University of Washington

The NSTX Research Program is envisioned to encompass three experimental phases through the next 5 years: I) Startup and Ohmic Heating; II) First Stability Regime; and III) Advanced Physics Regime. FY99-01 will be devoted to the first two phases. Phase I will consist of 15 research run weeks to test Ohmic operation, CHI startup, and injection of modest levels of HHFW power. Phase II will require 21 research run weeks to develop and begin investigating plasmas characterized by average toroidal betas up to 25% for q ~ 10 with significant bootstrap current fraction ~ 40%, without wall stabilization, and confinement at par with those indicated by the tokamak scaling expressions (such as the ITER power law 98P). Detailed control of plasma profiles and wall stabilization are not anticipated to be necessary in this regime. The results from Phases I and II are key to the success of Phase III which will begin in FY'02. Phase III plasmas are expected to be characterized by average toroidal betas up to ~40% for q ~ 10-15 with wall stabilization, nearly full bootstrap current fraction ~70% well aligned with the total current profile. Detailed control of all plasma profiles is anticipated to be necessary to reach this regime. The installation of a new center column on NSTX to produce very high beta plasmas with elongation ~3 will enable the study of plasmas characterized by betas approaching 60% and bootstrap current fraction approaching 90%.

During the next two years significant enhancements to the NSTX Facility are planned including commissioning of high HHFW system, high power neutral beam injection system, and a comprehensive set of diagnostics. The NSTX Facility plan is summarized in Fig. 1.

INTERNATIONAL COLLABORATIONS PROGRAM PLANS

by N. R. Sauthoff

The U.S. program in international collaborations focuses on the achievement of U.S. fusion program goals via international collaboration. The motivations include access to plasma conditions and device configurations that are unavailable domestically and extension of US discoveries and innovations to other plasma conditions and international programs. The international collaboration program should be integrated with and complementary to the domestic program.

At DOE's request, a US community working group compiled and suggested future directions for collaborations, basing its direction on the DOE Strategic Plan for International Collaborations in Fusion Research. The group characterized and quantified the on-going international collaborations and suggested directions for future collaborations, giving highest priority to the achievement of US fusion program goals consistent with the intents of the programs of the international facilities. The group developed recommendations in the areas of tokamaks, innovative/alternate concepts, theory, inertial fusion energy, and technology.

A survey indicated that the FY99 budget for experimental international collaboration can be structured as indicated below.

Experimental Area	Level of US Experimental Effort	Percentage of the Total Experimental International Collaborations Budget
Tokamaks	$8.M	33%
Alternate MFE Concepts	$2.M	8%
Inertial Fusion Energy	$0.4M	2%
Technology	$14.M	57%
TOTAL	$24.4M	100%

In tokamaks, collaborations currently exist in a broad range of areas on facilities worldwide. Control of transport barriers and analysis of the evolution of turbulence are pursued in devices including JT-60U (Japan), JET (Europe), and ASDEX (Germany); current profile measurements and studies of the effects of profile modification are underway on JET and JT-60U; studies of the size-scaling of transport barriers and stability are in place on JET and JT-60U, studies of the RI mode are underway on TEXTOR (Germany); and US physicists participate in all 7 of the ITER Physics Expert Groups. The community is assessing further opportunities on existing facilities and the benefits of US participation in future programs, such as KSTAR (Korea), HT7-U (China), and IGNITOR (Italy).

In innovative/alternate concepts, the US is studying size-scaling in LHD (Japan), and the effects of the varying stellarator configurations (transform, shear, and helical axis shift) in LHD, W7-AS (Germany), and TJ-II (Spain). The US is extending its domestic program in spherical toruses by work on MAST (UK), Globus-M (Russian Federation), TS-4 (Japan), and ETE (Brazil). The US RFP program is extending to RFX (Italy), TPE-RX (Japan), and T2 (Sweden).

In IFE, target physics work is pursued on the Gekko facility (Japan) and GSI (Germany). Heavy ion driver work is performed at GSI. Laser driver work involves the Laser Megajoule facility (France), and studies of diode-pumped solid state lasers in Japan.

In technology research, the materials irradiation studies benefit from use of reactor facilities abroad, such as the BOR-60 reactor in Russia. Heating, current drive and fueling work involves JET and may be extended on JET, KSTAR and other facilities. The US was a major partner (with Japan) on the ITER Central Solenoid Model Coil activities, on which the testing is beginning in Japan.

The US government decided to end US participation in ITER design and technology R&D activity. The US fusion program remains actively involved only in the ITER Physics Expert Groups due to the benefits to the US physics R&D program.

RESEARCH GOALS for FY99 -01

A good discussion was held on the need to convey both the accomplishments of the three facilities and the planned research goals. For reference, sections of the recent Congressional Budget were distributed and provided ideas on how other areas of science are conveying the excitement and importance of their research. The DIII-D group had a draft version of their research goals which was discussed at the meeting. Subsequently, both the C-Mod and NSTX groups distributed draft versions of their goals for comments as well as the DIII-D group, which updated their goals. We are all finding this task difficult. The problem is to avoid technical jargon and yet provide sufficient information such that knowledgeable people in the field can appreciate the advance. The plan is to collate the input from the facilities and reorganize the input along topical lines. The FFCC meeting after the FWP will review the research goals.

FACILITY COORDINATION

At our last meeting, the FFCC endorsed a meeting to discuss the plans and projected research for both the C-Mod lower hybrid system and the DIII-D ECH/ECCD system. The workshop organizers, Bonoli, Turnbull, and Synakowski, broadened the scope of the meeting which addressed many of the important issues facing the Advanced Tokamak program. This workshop began prior to the FFCC meeting and overlapped with it. Thus, the committee was able to hear the summary session of the meeting and some of the FFCC members attended parts of the meeting. The meeting was productive with a good technical discussion of the issues involved and methods to address them. The workshop organizers are writing a report summarizing the conclusions of the meeting. Plans for the lower hybrid system on C-Mod will be included in their Field Work Proposal, along with a complementary proposal from PPPL. The DIII-D group is installing a 6 MW ECH system and plans on having a decision point in 2001 on upgrading that system to 10 MW.

At this meeting, Erol Oktay announced the continued U.S. participation in the ITER Expert Groups. This has been strongly supported by the FFCC. One issue was the distribution of reports to members of the U.S. community to keep them informed about the work being conducted by the Expert Groups. Ned Sauthoff is following up with the U. S. ITER Expert Group members to have them distribute minutes and reports from the meetings.

Several recent examples of coordination of activities were identified at our meeting:

- Since our last meeting, all three facilities have had program advisory committee meetings, which not only provided advice to the Project Heads but also helped to communicate the status and plans of the facilities to the other groups.
- Since DIII-D run plans do not provide time for high li experiments during the present campaign, a discussion is underway with C-Mod to determine whether the exploration of this regime of operation should be conducted on C-Mod.
- DIII-D and C-Mod are doing related experiments on optimizing the performance of the core plasma and the divertor. In particular, they are studying the effect of divertor geometry and influx of gas. Continued discussion between the two groups is encouraged.
- DIII-D is planning on installing an inner divertor leg cryogenic pumping system. In order to support the installation of the Lower Hybrid system, the installation of the pumped divertor on C-Mod will be deferred. The results from the DIII-D experiments will be incorporated into the eventual C-Mod modifications. A pumped divertor on C-Mod may facilitate density control during the lower hybrid experiments.
- Each facility will directly provide input to the VLT on their requirements for enabling technologies. It was not clear that discussions at the FFCC, without members of the VLT being present, would be useful.
- MDS+, EFIT and TRANSP are widely used on all three facilities. The common use of data acquisition systems and computer codes is recognized as being necessary in response to tight budgets.

A new issue came up at our meeting related to professional development of staff on long-term assignment. Most institutions provide professional development for staff; however, that typically occurs at the home institution. For staff on very long term assignments, they may miss out on such opportunities. At times, the host institution provides training for collaborators. This is done for mandatory training such as ES&H or use of certain data acquisition and display tools. However, professional development training (for instance, management or presentation training) is not routinely done. This may be adversely impacting the professional growth of some members of our community. A common solution to this was not apparent; however, this should be addressed by the home institution in concert with the host institution. A related issue is providing the feedback on performance evaluation by the host institution to the home institution. It was clear that a uniform policy on this does not exist and is driven by the policies and desires of the home institution. PPPL has a practice of requesting input from the host institutions on their staff when they collaborate off-site. We learned from MIT that at least one institution was not interested in receiving such input. While a uniform practice can not be implemented nor enforced, such discussions are useful and place a responsibility on both the home and host institution to develop conditions such that the assignment is successful both professionally as well as programmatically.

As a result of the declining budgets in the fusion program, new people have not been entering the field. This is not healthy for the long term well being of our program. While this was noted, no solutions were proposed beyond increasing the funding for fusion.

The next meeting of the FFCC will be held on the last day of the Budget Planning Meeting on April 9th.

STATUS of STRATEGIC WHITE PAPERS for TOKAMAK and ST RESEARCH

The existing strategic white papers for tokamaks and STs were discussed. Since out last meeting, Tom has led the effort to update the tokamak white paper. After the meeting, Tom, Ian and Rich met to discuss how to address the outstanding scientific issues facing the tokamak concept in the white paper. Tom will continue to modify the white paper. Martin discussed his outline of the ST white paper

Neither paper is presently available for the SEAB review which begins on March 29th.