USBPO U.S. BURNING PLASMA ORGANIZATION

eNews

September 17, 2010 (Issue 47)

CONTENTS

Dear Burning Plasma Aficionados:

This newsletter provides a short update on U.S. Burning Plasma Organization activities. E-News is also available online. Comments on articles in the newsletter may be sent to the Editor (Tom Rognlien) or Assistant Editor (Rita Wilkinson).

Thank you for your interest in Burning Plasma research in the U.S.!

Director's Corner by Jim Van Dam

Burning Plasma Events at the APS-DPP Annual Meeting

The USBPO will sponsor the following events at the APS Division of Plasma Physics Meeting (November 8-12, 2010, Chicago, IL):

- Tuesday (November 9), 7:30-9:30 p.m.: Town Meeting on ITER Status *(Session LE2,Grand Ballroom CD)*
- Thursday (November 11), 2:00-4:12 p.m.: ITER-I Contributed Oral Session *(Session UO4, Grand Ballroom A)*
- Friday (November 12), 9:30 a.m.-12:30 p.m.: ITER-II Contributed Oral Session *(Session XO4, Grand Ballroom A)*

The Town Meeting on ITER Status on Tuesday evening will feature talks by three speakers. Gyung-Su Lee, Chair of the ITER Council's Management Advisory Committee and President of the National Fusion Research Institute in Korea, will talk about the new ITER baseline and related issues, including risk mitigation. Alberto Loarte, Senior Scientific Officer for Transport and Confinement Physics in the Department of Fusion Science and Technology of the ITER Organization, will talk about the scientific status of ITER. Then, yours truly will talk about

U.S. contributions to ITER R&D. The three talks will be followed by an open discussion period. Michael Mauel, Chair of the USBPO Council, will chair the Town Meeting.

Each of the two ITER contributed oral sessions will feature 11 ten-minute talks. Of the 22 contributed orals, only one is from a non-US institution—significantly fewer than last year, probably due to the fact that the IAEA Fusion Energy Conference will have just been held the month before, in October. You can find the lists of contributed orals at ITER-I and ITER-II.

Our thanks to Raffi Nazikian and Dylan Brennan for organizing these two contributed oral sessions. Please mark the ITER Town Meeting and these two ITER oral sessions on your schedules.

IAEA Fusion Energy Conference

The biennial Fusion Energy Conference, sponsored by the International Atomic Energy Agency, will be held this year in Daejeon, Korea, October 11-16. Information about the conference can be found at two web sites: the IAEA web site and the Local Organizers web site.

As in 2008, a special session of invited talks about ITER is scheduled on the first day. There will also be poster presentations about ITER science and technology. ITER-related work from the ITPA Topical Groups will also be featured.

The following week, all seven ITPA Topical Groups will hold their fall meetings, six in Seoul, Korea, and one in Naka, Japan. The schedule of these meetings is given in the table below.

ITPA Topical Group	Date (2010)	Location
Diagnostics	October 18-21	JAEA, Naka, Japan
Transport & Confinement	October 18-20	Seoul National University, Seoul, Korea
Integrated Operation Scenarios	October 18-21	Seoul National University, Seoul, Korea
Divertor and SOL	October 18-21	Hanyang University, Seoul, Korea
Energetic Particles	October 18-20	Seoul National University, Seoul, Korea
MHD	October 18-21	Seoul National University, Seoul, Korea
Pedestal and Edge Physics	October 18-20	Seoul National University, Seoul, Korea

Several of the ITPA Topical Groups have scheduled their meetings so as to have joint sessions with each other. For example, Transport and Confinement will have a joint session on particle transport and fueling with Integrated Operation Scenarios, Pedestal and Edge Physics, and Divertor and SOL. Also, Energetic Particles will hold a joint session with MHD on the topic of runaway electrons connected with disruption events.

Remember that the new web site for the ITPA is now being hosted by ITER. This web site has further information about upcoming ITPA Topical Group meetings.

ITER Site Update

In July, France signed two deeds that granted to the ITER Organization the rights to the property and buildings of the ITER through October 24, 2042. The site is approximately 100 hectares (1 km^2) in size, with an additional 62 hectares in reserve, if needed. (Note: 1 hectare = 10,000 m^2.)

Construction activity on the ITER site is now in full swing. The tokamak pit for ITER is being excavated, down to a depth of 20 meters. The foundation for the future permanent ITER Headquarters building is being prepared. The 10-meter high concrete beams for the Coil Winding Facility have been installed; this facility will be for the construction of the poloidal field coils on site.

Aerial view of the ITER site as of September 2010 (courtesy of ITER Organization)

ITER Conference in Monaco

Two years ago, the Principality of Monaco offered to provide funds for ITER Postdoctoral Fellowships and also for ITER conferences. The postdoctoral program is already into its second two-year cycle. The first ITER conference in Monaco will be held this year, November 23-25.

The conference, titled "ITER Monaco International Fusion Energy Days," is being jointly organized by ITER and the Principality of Monaco, in cooperation with the International Atomic Energy Agency. The first day of the conference will feature high-level talks on the global energy context and how fusion fits into the energy policies of the ITER Member countries. The second day of the conference will focus on the ITER Baseline and on industrial aspects such as procurement policies and calls for tender. The third day of the conference, organized with the IAEA, will be an ITER-IAEA Technical Meeting on Analysis of ITER Materials and Technologies, to be organized by Richard Kamendje (IAEA), Bastiaan Braams (IAEA), and David Campbell (ITER).

Top 10 Best Jobs of the Future

The magazine *Popular Science* has published a gallery called "10 Best Jobs of the Future" in its August 6, 2010, issue. Number nine on the list is "Fusion Worker." The accompanying paragraph states that when ITER starts up and works, then "fusion jobs will

boom." In another punful statement, the article notes that jobs such as diagnostic physicist and magnet auxiliary officer will "radiate." The USBPO provided background information to the Popular Science reporter, Ben Paynter, who wrote the article. (*Illustration courtesy of Popular Science*)

"News Alert" Newsletter from US ITER Project Office

The US ITER Project Office has begun to publish a newsletter, called "News Update." It will be issued on a quarterly basis. The first issue, for September 2010, was recently published.

If you wish to subscribe to the US ITER Project Newsletter, send an email with "subscribe" in the subject line of the email. An email will then be sent to you, to which you need to reply in order to confirm the subscription.

USBPO Topical Group Highlights

(Editors note: This contribution is part of our on-going coverage of research activities relating to different BPO Topical Groups, this month being Integrated Scenarios. The group seeks to facilitate U.S. efforts to understand and predict the behavior of whole-device operation in existing and future fusion devices (leaders are John Ferron and Amanda Hubbard). This month's research highlight by Gary Jackson and colleagues describes results from experiments on the DIII-D tokamak to demonstrate the desired control of ITER-relevant plasma discharges from startup, then flattop, and, finally, through rampdown phases.)

Access to and Termination of ITER Burning Plasma Scenarios

G.L. Jackson, P.A. Politzer, D.A. Humphreys, J.R. Ferron, A.W. Hyatt, and T.C. Luce (General Atomics)

Much work has been focused on burning-plasma operating scenarios for ITER. However, this is all moot if there is not a way to reach plasma current (I_p) flattop and the conditions to start the burn, or to successfully ramp down a pulse to a "soft landing" so that there is no damage to plasma facing components (PFCs) that would affect subsequent discharges. The topic of startup and rampdown of ITER discharges has recently been receiving increased attention and both experimental work and modeling indicate that such startup and rampdown scenarios do exist [1–3].

Technical considerations for large fusion devices place several constraints on ITER startup and rampdown not encountered in most present day tokamaks: (a) the inductive toroidal electric field is 2–3 times lower in ITER (less power available at the start of a pulse), (b) there are fewer coils and, hence, less flexibility in shaping and control, (c) operation is closer to the vertical stability limits, and (d) higher heat fluxes to PFCs require careful control of plasma shape to avoid damage, especially to first wall components when the discharge is not magnetically diverted.

In DIII-D (a smaller machine than ITER), we have scaled ITER parameters by the geometry of the two machines and their respective current diffusion times and experimentally simulated an entire ITER discharge, albeit with a shorter flattop time (Fig. 1). Using electron cyclotron (EC) heating during the initial phase, startup is robust, even at the ITER specified toroidal electric field, $E_\phi \le 0.3$ V/m (typical DIII-D discharges start up with 0.8 to 0.9 V/m). The discharge in Fig. 1 included neutral beam heating during the flattop phase, simulating the ITER High confinement (H-mode) burning-plasma scenario. Several changes to the original ITER design scenarios were developed to improve startup and rampdown performance and are discussed below.

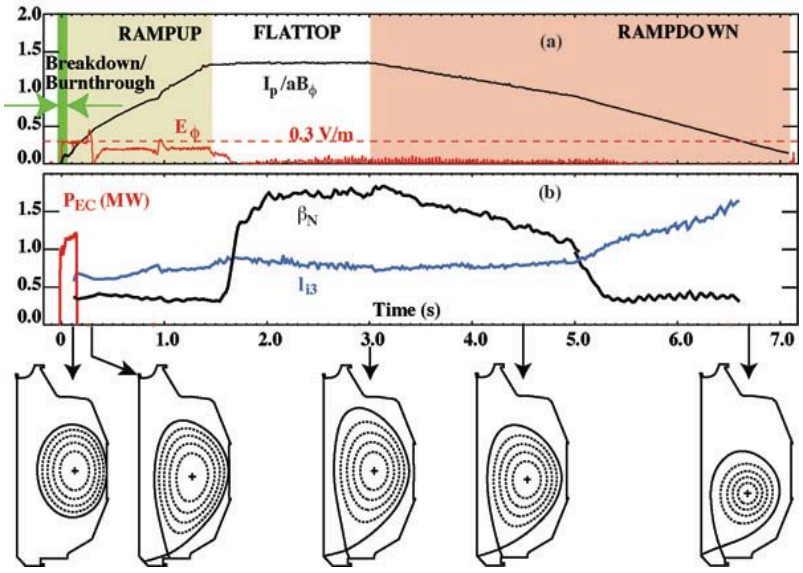

Fig. 1. DIII-D experimental simulation of an ITER scenario 2 discharge: (a) 4 phases are shown in different colors with E_ϕ and normalized I_p plotted, and (b) EC power, internal inductance, and normalized β (from Ref. [2]).

A "large bore" startup scenario, diverting earlier in time, was developed to reduce heat flux to plasma facing components [4]. The large bore scenario consists of a larger volume plasma (shown in the far lower left shape plot in Fig. 1) limited on the midplane of the device, from shortly after plasma formation until the discharge is diverted. Since the plasma minor radius was larger in this scenario, the startup gyrotrons (127 GHz) planned for ITER could be eliminated because the resonance location of the 170 GHz gyrotrons was now inside the plasma boundary, allowing effective heating from these sources. Experiments simulating rampdown showed that the ITER rampdown scenario could be reproduced, holding the plasma strike points fixed (lower right hand shape in Fig. 1 where the magnetic separatrix intersects the wall) as I_p was reduced. This control is an important demonstration for ITER since the strike points must be maintained on the high heat flux components during rampdown.

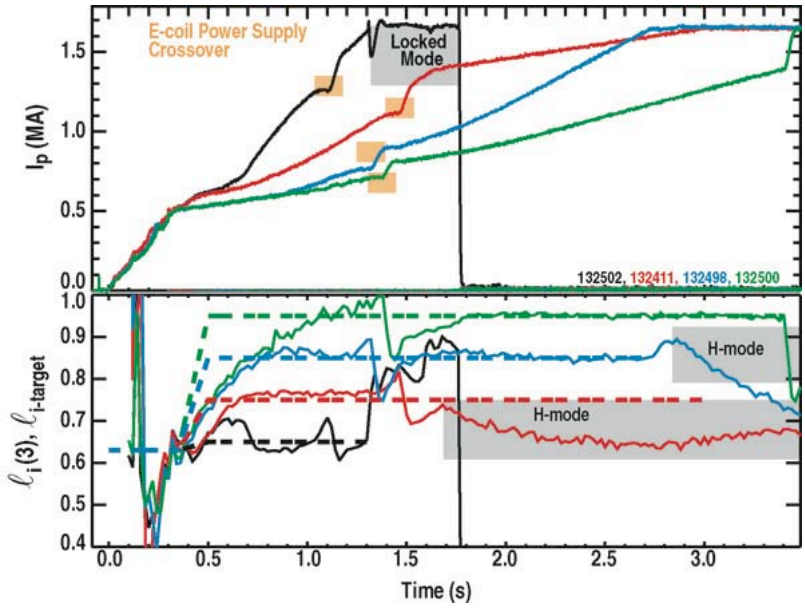

Fig. 2. Feedback control of normalized plasma internal inductance, $l_i(3)$, for 4 target values (dashed, b) within the acceptable range for ITER. Achieved value of $l_i(3)$ is shown (b, solid) and I_p is plotted in (a). Events where feedback is not possible (orange boxes) or is outside the allowed I_p ramp rate range (gray boxes) are also indicated.

Furthermore, the transition from H-mode back to L-mode could be controlled with no deleterious effects. Finally, vertical stability could be maintained to a plasma current below the ITER specified "soft landing" by using different vertical stability algorithms as the discharge shape was reduced. Rampdown scans were also carried out to demonstrate an improved scenario without increased currents in the central solenoid or inner poloidal field coils, an important consideration for ITER where the inductive flux is needed for the rampup and flattop phases [5].

Vertical stability is an important consideration for ITER. With the ITER coil set, modeling has identified a range of internal inductance, $l_i(3)$, where discharges are stable to vertical instabilities during I_p rampup and flattop. One method to stay within the specified internal inductance range during rampup is to vary the current ramp rate. A series of experiments (Fig. 2) demonstrated that internal inductance could be feedback controlled by using the DIII-D plasma control system to calculate $l_i(3)$ in real time and then control the plasma ramp rate by adjusting the applied voltage to the Ohmic solenoid, thus changing E_ϕ.

Although additional work remains, especially predictive modeling to extrapolate the DIII-D results to ITER, this work has shown that successful access to and termination of the burning plasma scenarios in ITER is possible within the presently envisioned capabilities of the ITER poloidal field coil set and power supplies.

Complementary research on plasma rampup, flattop, and rampdown scenarios for ITER is being carried out on several other tokamaks, including Alcator C-Mod in the US. An overview of related research as of the 2008 IAEA Fusion Energy Conference is given in Ref. [1], and a summary of more recent results will be given at the 2010 IAEA FEC in October [6]. Details of these joint experiments, and their simulation, are activities of the Integrated Operational Scenarios ITPA topical group, which will next meet in Korea October 18-21.

References

[1] A.C.C. Sips, et al., Nucl. Fusion **49**, 85015 (2009).
[2] G.L. Jackson, et al., Phys. Plasmas **17**, 056116 (2010).
[3] C.E. Kessel, et al., Nucl. Fusion **49**, 85034 (2009).
[4] G.L. Jackson, et al., Nucl. Fusion **48**, 125002 (2008).
[5] P.A. Politzer, et al., Nucl. Fusion **50**, 035011 (2010).
[6] J. Stober, et al., IAEA FEC, Oct. 11-16, 2010, Daejeon, Korea; to be presented.

REPORTS

(Editor's note: The Office of Fusion Energy Sciences (OFES) has asked Chuck Kessel to organize and lead a community effort to assess the research needs arising from operating a fusion power plant with special attention to nuclear issues. We have asked Chuck to provide a short summary of this beginning effort for eNews.)

Overview of the Fusion Nuclear Science Pathways Assessment

Chuck Kessel (Princeton Plasma Physics Laboratory)

The Fusion Nuclear Science Pathways Assessment (FNS-PA) is intended to provide information to the OFES on the research and development required to establish a basis for a demonstration fusion power plant. In the ITER era we are entering, the focus on plasma and nuclear science together is becoming more compelling and necessary. ITER will provide critical information on burning plasma physics, as well as a number of technological issues ranging from superconducting magnets to divertor survivability. The Test Blanket Module effort on ITER will provide experience with candidate blanket technologies, at neutron fluxes integrated over

time (ITER's total plant life) of 0.3 MW-years/m^2. For comparison, a power plant is expected to produce 120-160 MW-year/m^2 over its lifetime, requiring the first wall and blankets to be replaced several times. There is clearly a need to pursue the nuclear aspects of fusion and integrate it with the plasma in order to close this and many other gaps that exist between ITER and a fusion power plant.

The report on *Priorities, Gaps and Opportunities: Toward a Long Range Strategic Plan for Magnetic Fusion Energy* (Greenwald report) and the *Research Needs for Magnetic Fusion Energy Sciences* (ReNeW report) have identified the many issues and research needs for a wide range of topics in fusion science. The present exercise is to dig deeper into the specification of research and development to a level allowing OFES to solicit proposals from the community. In the process this will also provide information to accurately motivate the whats, whys, hows, and whens of this research. Naturally there is an emphasis on the fusion nuclear science, but this will include research to access the required plasma conditions that support this as well.

The three main thrusts are 1) identify DEMO/power plant characteristics in some detail (parameters, assumptions) and roll these back to identify gaps and identify required R&D, 2) examine a series of FNS facility missions at a systems-analysis level to identify possible steps and the associated R&D, and 3) compile a list of research and development activities required to support both the pathway to DEMO and an FNS facility(s). Various members of the FNS-PA group (see below) are in the process of pulling together the information in a number of topical areas ranging from plasma-material interface test stands to generic R&D elements in fusion nuclear science. As part of our mission analysis, we are reviewing the existing FNS-Facility proposals and their design philosophies, to identify what R&D these infer.

Expert groups will be assembled from the community in a number of areas to work with the FNS-PA group to address detailed questions about the R&D needed, available facilities and their capabilities, leverage of international collaborations, and other aspects.

As the assessment process evolves to the point of well-defined issues, time will be made available for overall community input and public discussion.

Members of the FNS-PA group:

M. Abdou	V. Chan	R. Fonck	R. Kurtz	S. Milora	J. Minervini
N. Morley	F. Najmabadi	H. Neilson	R. Nygren	M. Peng	D. Rej
R. Stambaugh	M. Tillack	G. Tynan	J. VanDam	D. Whyte	S. Willms
B. Wirth					

DOE FNS-PA group:

S. Eckstrand	C. Kessel	M. Koepke	G. Nardella	E. Oktay
A. Opdenaker	E. Synakowski			

Summary of: "International Workshop on Requirements for Next Generation PMI Test Stands in Fusion Research"

D.L. Hillis (ORNL), Chair; J. Brooks (Purdue); R. Doerner (UCSD); R. Nygren (Sandia); and B. Unterberg (FZ-Jülich)

This international workshop was held at ORNL on August 31–September 2, 2010, to identify opportunities for present and future linear facilities to provide critically needed plasma material interaction (PMI) information for ITER and prospective R&D facilities that develop the PMI basis for a fusion DEMO reactor. The workshop had approximately 48 participants with representatives from most of the major laboratories involved in PMI and fusion research from around the world. There where ~30 presentations over the 3 days. Descriptions of knowledge "gaps" in PMI science and technology, recently identified by research needs assessments in the

U.S. (via ReNeW) and the E.U., were extended to detail the needed capabilities in research, diagnostics, theory, and modeling using such facilities. Their unique research roles and limitations, including how they complement the more complex toroidal PMI research in tokamaks and stellarators, were addressed.

The linear facilities allow many advantageous capabilities, including: *i*) a simplified geometry for a wide range of well-controlled steady-state plasma and target conditions and orientations; *ii*) flexibility in target material choices and mock-up designs; *iii*) access for sophisticated diagnostics at the plasma material interface to reveal details of plasma-induced in-depth surface chemistry and morphology, hydrogen implantation and permeation, sputtering, erosion, re-deposition, impurity transport, and the effects of neutron-induced damages; and *iv*) extensive verification of theory and modeling through comparison with these comprehensive measurements.

The present-day portfolio of linear facilities has advanced PMI science in a broad front in concert with the toroidal PMI research. The above-mentioned advantages can be fully exploited if ITER and DEMO reactor-level PMI conditions can be delivered through a combination of development of new intense plasma sources including the use of RF heating, upgrades in existing facilities including diagnostics, tests of neutron damaged materials, and improvements in theory and modeling. The workshop participants recommended that the linear PMI research be strengthened in these directions and remain closely coordinated with toroidal PMI research.

A second workshop on linear devices was recommended for Fall 2011 by the workshop participants to be hosted jointly by the Magnum-PSI/Forschungszentrum-Jülich Groups and ORNL. The agenda, a more detailed workshop summary, and downloads of the talks presented at the workshop can be found on our website.

Announcements

Submit BPO-related announcements for next month's eNews to Tom Rognlien.

Upcoming Burning Plasma Events

2010 Events

Sept 27-Oct 1
26th Symposium on Fusion Technology (SOFT2010)
Porto, Portugal

Oct 11-16
23rd IAEA Fusion Energy Conference
Daejeon, Korea

Oct 18-20
ITPA Energetic Particles Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-20
ITPA Transport and Confinement Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA Divertor and SOL Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA Integrated Operation Scenarios Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA MHD Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-20
ITPA Pedestal and Edge Physics Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-22
ITPA Diagnostics Topical Group Meeting (in conjunction with IAEA FEC)
Naka, Japan

Oct 24-29
9th International Conference on Tritium Science and Technology
Nara, Japan

Nov 7-11
19th Topical Meeting on the Technology of Fusion Energy (TOFE 2010)
(embedded with 2010 ANS Winter Meeting)
Las Vegas, NV USA

Nov 8-12
52nd Annual Meeting of the APS Division of Plasma Physics
Chicago, IL USA

Nov 15-17, 2010
15th Workshop on MHD Stability and Control: "US-Japan Workshop on 3D Magnetic Field Effects in MHD Control"
Madison, WI USA

Nov 23-25, 2010 NEW
1st Joint ITER-IAEA TM on Analysis of ITER Materials and Technologies
Principality of Monaco

Dec 1-2, 2010
Fusion Power Associates Meeting
Washington, DC USA

Dec 6-10, 2010 NEW abstracts due Nov. 1, 2010
6th IAEA Technical Meeting on Steady State Operation of Magnetic Fusion Devices
Vienna, Austria

Dec 15
IEA-ITPA Joint Experiments Planning Meeting
Videoconference

2011 Events

April 6-9, 2011
ITPA Transport & Confinement Topical Group Meeting (following US/EU TIF)
San Diego, CA USA

May 2-4, 2011 NEW
2011 International Sherwood Fusion Theory Conference
Austin, TX USA

May 15-19, 2011
15th International Conference on Emerging Nuclear Energy Systems (ICENES)
San Francisco, CA USA

June 26-30, 2011
38th IEEE International Conference on Plasma Science (ICOPS) and the 24th Symposium on Fusion Engineering (SOFE)
Chicago, IL USA

Oct 16-21
15th International Conference on Fusion Reactor Materials (ICFRM-15)
Charleston, SC USA

Directories of Other Plasma Events

IEEE Directory of Plasma Conferences
Fusion Ignition Research Experiment (FIRE) Physics Meetings

Please contact the administrator with additions and corrections.