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*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 ([Dylan Brennan](#)) Assistant Editor ([Rita Wilkinson](#)). Thank you for your interest in Burning Plasma research in the U.S.!

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## Director's Corner by C. M. Greenfield

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As many of you know, the last couple of months have been extremely busy, and not always pleasant. While all of this was going on, we missed a deadline, so this is our first eNews in two months. Meanwhile, I know many of you will be hoping to hear about the budget situation. This is a time of concern within our community, and many of you look to us to voice those concerns. We believe the US Burning Plasma Organization can best serve the community by continuing to promote burning plasma research within the U.S., and to fulfill our mission *to advance the scientific understanding of burning plasmas and ensure the greatest benefit from a burning plasma experiment by coordinating relevant U.S. fusion research with broad community participation.*

### US Disruption Mitigation Workshop

The US Disruption Mitigation Workshop, jointly sponsored by the US Burning Plasma Organization, Virtual Laboratory for Technology, and the US ITER Project Office, was held March 12-13 at General Atomics. Participants included about 35 scientists and technologists from the US, ITER, and some of our ITER partners. In addition, there was significant remote participation, with 29 different sites connecting via ReadyTalk for some, or all, of the workshop.

The goal of the workshop was to review and initiate work aiming to fulfill the US obligation to provide ITER's disruption mitigation system (DMS). Discussions ranged from the challenges of working in the ITER environment, thermal quench mitigation, and runaway electron suppression. A lot of ideas were discussed, and we can expect to see several of these turn into high priority topics for further research in the near future.

See the [USBPO web site](#) for more information about the workshop. Presentations from the workshop will be placed in the members-only USBPO Forum shortly. A more detailed report will appear in an upcoming eNews.

This workshop was just the first activity of the newly formed Disruption Task Group within the USBPO. The group is currently focusing on disruption mitigation techniques, but we anticipate that in the

longer term, the focus will expand to include disruption prediction and avoidance. Bob Granetz (MIT) and John Wesley (GA) are leading this group. Please contact them if you are interested in participating.

### **Coming Soon...**

We will shortly be starting another Task Group to work on a US community vision of modes of collaboration on ITER. This will build on recent work done by the FESAC subpanel on International Collaboration, and responds to one of its recommendations. Although planning has not yet started for how the partners will work together on ITER, there are many opinions within the US community based on years of experience. The idea is to work toward a US community vision before such discussions commence. Although we're still several years away from the beginning of the ITER research program, there is already some urgency, since the infrastructure for collaborative work on ITER is already being specified.

### **USBPO Membership and eNews Subscriptions**

Some of you may be confused about what it means to be a USBPO "member." Regular Membership in the USBPO is open to researchers and graduate students who are active in burning plasma science and technology research, and whose home institution lies within the U.S. Associate Membership in the USBPO is open to active fusion researchers whose home institution is outside the U.S. The only difference between the two classes of membership is that only regular members vote in USBPO elections (to date, the only elections held by the USBPO have been for Council membership).

Membership in the USBPO is established by joining one or more Topical Groups and participating in the activities of those groups. The [registration form](#) is on the USBPO web site. If you're not currently a member, I urge you to consider joining.

There is also a [separate list of subscribers](#) to the monthly eNews, which includes all regular and associate members, and additional non-members who subscribe to the eNews. Once again, if you are already a member, there is no need to sign up for the eNews separately. If you are not sure of your membership status, or your email address or affiliation may have changed since you initially registered, please contact our Communications Coordinator, [Jim DeKock](#).

### **USBPO Council Election**

Speaking of elections, nominations are still open for candidates to fill two positions on the USBPO Council. The [USBPO bylaws](#) define the role of the Council:

The Council represents the U.S. MFE research community in providing oversight of the USBPO activities, and, working with the Directorate, is the primary USBPO element responsible for long-term strategic planning of burning plasma research. The Council is responsible for setting the policies and procedures of the USBPO, including establishing the by-laws governing USBPO operations. It will receive regular reports on USBPO activities from the Director, and will provide feedback and assessment on those activities to the Director regarding progress, issues, priorities, and opportunities. When required, a simple majority vote of the Council shall serve to designate Council approval of a decision. When Council comment and recommendations are required, the Council Chair and/or Vice-Chair will work to convey the sense of the Council to the Director and the OFES.

As further described in the bylaws, each year two new Council members will be elected by the USBPO regular membership, and two will be appointed by the USBPO Director (currently Chuck Greenfield, GA). The members each serve a three-year term.

The four Council members now completing their terms are: Michael Bell (PPPL), Mike Mauel (Columbia), Wayne Meier (LLNL), Phil Snyder (GA). The continuing Council members are: Richard Buttery (GA), Troy Carter (UCLA), Chris Hegna (Wisconsin), Jerry Hughes (MIT), Steve Knowlton (Auburn), Cynthia Phillips (PPPL), Tom Ronglien (LLNL), Don Spong (ORNL). The terms of the continuing members as well as a [list of ex-officio members](#) can be found on the USBPO web site.

Your nominations are critically important to the USBPO's contribution to the U.S. Fusion Energy Science Program. Nominees for Council must come from among the USBPO regular membership. Candidates for election may also be considered for appointment by the Director.

Schedule for this year's election process:

1. By April 16: Email your nomination(s) to Michael Bell (mbell@pppl.gov) and François Waelbroeck (flw@mail.utexas.edu).
2. May 7 - May 14: Election by USBPO regular members from a slate of candidates using web-based poll software.
3. May 31: USBPO announces the results of the election and the new Council members both elected and appointed.

### **ITER Poloidal Field Coil Winding Facility Completed**

The Poloidal Field Coil Winding Facility on the ITER site has been completed and handed over to the ITER Organization during a ceremony on February 14. The building is larger than 2½ football fields and will house the assembly of ITER's poloidal field coils starting at the end of this year. This marks an important milestone, as this is the first building to be completed at the ITER site.



*The newly completed Poloidal Field Coil Winding Facility is the first building to be completed on the ITER site.  
Photo © ITER Organization.*

### **ITPA meetings**

We're currently in the busy part of the ITPA meeting season. Since the beginning of 2012, the Divertor and SOL, Energetic Particle, and MHD Topical Groups have already met. Additional upcoming meetings include:

- Week of April 2: Transport and Confinement TG and Pedestal and Edge TG will meet at ASIPP in Hefei, China
- Week of April 16: Integrated Operational Scenarios TG will meet at CIEMAT in Madrid, Spain
- Week of May 14: Diagnostics TG will meet at Kurchatov Institute in Russia

Reports on these meetings should appear in eNews soon afterward. We will continue to organize web seminars to report on the work being done by the Topical Groups.

Six of the seven Topical Groups will hold their next meeting (following the above) in San Diego following the IAEA Fusion Energy Conference.

### **ITER International Summer School**

This year's 6<sup>th</sup> ITER International Summer School will be held in December, in Ahmedabad, India. The theme will be RF Heating in Burning Plasmas. Check back here for more information as it becomes available.

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## USBPO Topical Group Highlights

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*(Editor's Note: The BPO Diagnostics Topical Group works to facilitate U.S. efforts in developing advanced measurement techniques for existing and future magnetic fusion devices [leaders are Jim Terry and David Brower]. This month's Research Highlight by Max E. Austin and Hitesh K.B. Pandya presents the significant challenges of designing and implementing a viable ECE diagnostic system for ITER. The ECE diagnostic plays a key role in various physics analyses of current tokamak experiments, and the extrapolation of current designs to a useful configuration in ITER is not trivial. In particular, the losses due to the physics of the waveguide structure and mode propagation must be understood and mitigated in advance of implementation.)*

### **Waveguide transmission measurements for the ITER ECE diagnostic**

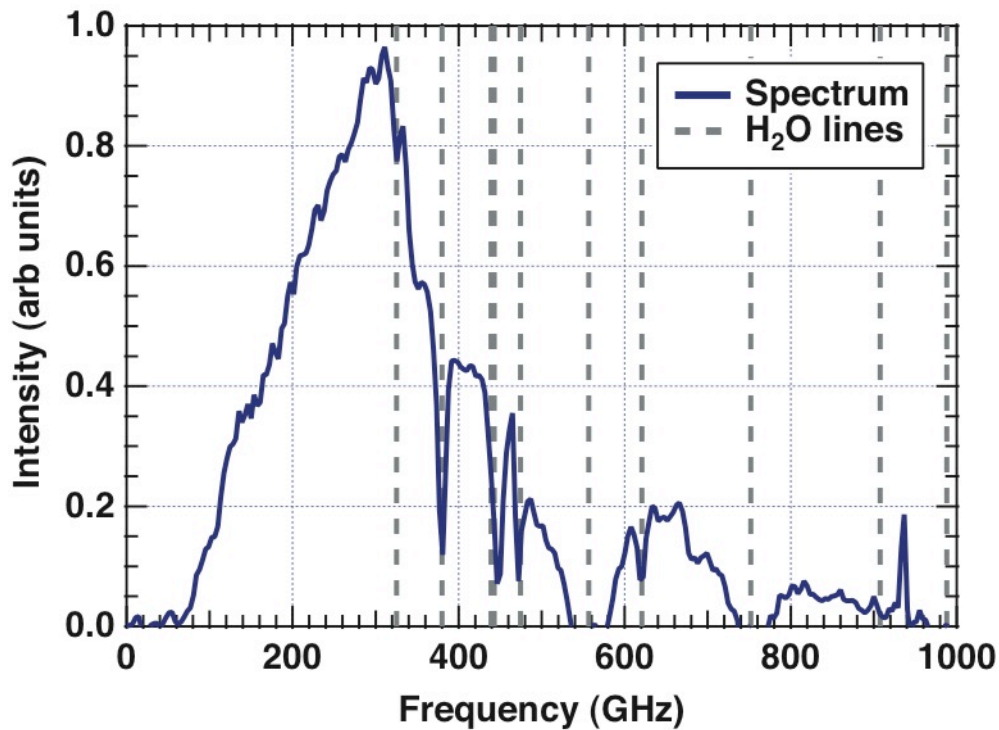
*Max E. Austin (The University of Texas at Austin) and Hitesh K.B. Pandya (ITER India)*

The electron cyclotron emission (ECE) diagnostic on ITER will provide crucial measurements of electron temperature ( $T_e$ ), its fluctuation amplitude ( $\delta T_e$ ) for various MHD modes, as well as provide information on non-thermal electrons and the cyclotron power loss for the expected high temperature plasmas. In order to operate optimally the ITER ECE diagnostic will require a low-loss transmission line that can operate over a broad millimeter wave frequency range. This transmission line needs to be able to couple directly to the front-end optics in the port plug and be physically robust and stable in its transmission losses.

One of the prime candidates for such a transmission line that has been used successfully for the ECE systems on a number of current fusion plasma devices is the so-called corrugated waveguide [1]. This type of waveguide has regular periodic grooves in the wall that produce a high surface reactance and thus low loss. It is constructed from metal tubing, typically aluminum, hence is rigidly strong and generally has good stability over the frequencies it is designed for. Due to the periodic deformations in the wall, this waveguide is susceptible to Bragg scattering, which occurs when the half wavelength of the radiation approaches a corrugation period. However, for the lowest order-propagating mode it was expected that Bragg scattering would only produce large losses only over a few narrow bands at and above the Bragg frequency [2].

The DIII-D Michelson interferometer ECE diagnostic has employed a corrugated waveguide transmission line since 1993 with stable low loss that permits good calibration of the instrument [3]. This transmission system has characteristics similar to one that was envisioned for ITER: a waveguide diameter of 63.5 mm, a narrow corrugation period of 0.38 mm with a depth of 0.25 mm, and a modestly long waveguide run containing several miter bends (15 m with 7 bends). For DIII-D ECE measurements only the range 70-300 GHz is used. However, since the Michelson interferometer is capable of measurements up to 1000 GHz, covering the ITER range, the opportunity was taken to test the broadband attenuation of this line. This task was completed as part of a collaborative effort between the India and US ITER groups.

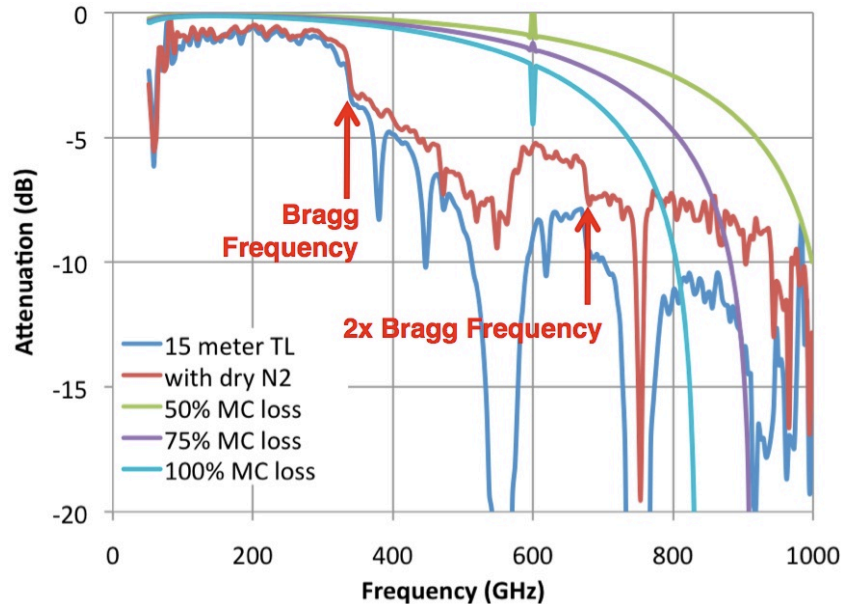
The millimeter wave source for these tests was a liquid nitrogen ( $\text{LN}_2$ ) blackbody source. To measure the transmission line loss the source was placed at the front end of the line near the tokamak and at the back end directly in front of the Michelson instrument. A spectrum from a coherently averaged set of 10,000 scans was recorded for both the front and back end locations and the difference spectrum was calculated to get the total attenuation of the transmission line. A typical spectrum for the front-end measurement is shown in Figure 1. One problem for this test was the absorption of microwaves by water vapor since the DIII-D line is operated in air. Above 300 GHz there are several absorption lines, shown in the figure, that strongly attenuate the signal. However there are frequency windows not affected by these lines, around 600-700 GHz and 800-900 GHz for example, that still allow a measurement up to high frequency. One set of measurements was done with a partial nitrogen purge of the line, which helped reduce the water absorption.



*Fig 1. Intensity spectrum from LN<sub>2</sub> source located at the front end of the DIII-D corrugated waveguide transmission line.*

Figure 2 shows the difference spectrum for the transmission line of total length 15.4 m containing seven miter bends, for the measurements with and without the nitrogen purge. Immediately apparent is the sharp drop in transmission at the Bragg frequency and continuing up to the maximum frequency. As noted the water absorption lines hamper the measurement over some frequency ranges but the overall trend is visible and a loss of roughly -8 dB is observed near 1000 GHz. Shown also in the figure are theoretical losses due to mode conversion for several assumed levels. It is clear that this type of loss does not fit the observed transmission; the losses exceed that expected for even 100% mode conversion and the trend is wrong. For a well-aligned transmission line with precision miter bends one would expect mode conversion losses well below 50%.

Extrapolating the measured losses to a similar transmission line for ITER with an expected length of 35 m implies an attenuation of -24 dB, and adding in losses for windows and minimal mode conversion gives an attenuation of greater than -34 dB for the 500-1000 GHz range. This will be unacceptable for the ECE measurements needed at these frequencies. The loss level should not exceed -10 dB at high frequency to satisfy diagnostic requirements and it is clear the corrugated waveguide cannot achieve this. Although this attenuation at high frequency is not completely understood, it is believed to be due to Bragg scattering of high order modes; a large number of possible modes, increasing with frequency, leads to a continuum of losses. These results have led the ITER ECE group to consider other types of transmission lines, including the dielectric waveguide which has similar properties as the corrugated waveguide but without the effects of Bragg scattering.



**Fig. 2.** Measured attenuation of DIII-D transmission line with and without dry nitrogen purge and compared with theoretical losses due to mode conversion. A sharp increase in attenuation is seen near the Bragg frequency.

These tests underscore the importance of measuring diagnostic components over the expected range of their use before committing to use them on ITER. Many current diagnostics will be used outside of their “standard” operating range, and their viability needs to be confirmed with experimental measurements.

## References

- [1] P. J. B. Clarricoats *et al.*, Proc. IEE **122**, 1173 (1975).
- [2] J. L. Doane, Fus. Sci. Tech. **53**, 160 (2006).
- [3] M. E. Austin *et al.*, Rev. Sci. Instrum. **68**, 480 (1997).

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## Special Reports

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### USBPO Web Seminars

*Amanda Hubbard, USBPO Deputy Director*

Common questions from USBPO members include: *How do I know what is going on with burning plasma research? How can I get involved?*

Over the past year or so, and increasingly over recent months, USBPO has been using web seminars, in addition to other communication tools such as the web site and this e-News, to reach more interested people. The focus to date has been on ITPA activities, with reports of recent meetings, results and issues on given topical areas. USBPO Topical Groups are intended to be domestic extensions of our ITPA activities. Each Party can have only 7 ITPA members in each TG and, while other experts are welcome to attend international meetings and often do, time and travel constraints make this impractical for many.

Recent Web Seminars have covered the Transport and Confinement ITPA Topical Group (December 8, 2011) and the MHD, Disruptions and Control ITPA TG (February 9, 2012), with a short presentation followed by group discussion. Attendance is large and increasing, showing the broad interest

in ITPA activities. Slides are shown via ReadyTalk, and the most recent seminar had 40 separate connections, from at least 15 institutions. Since several sites set up videoconference rooms for groups of people, and others may have only been watching and listening via web streaming, we estimate at least 50-60 people participated! Multiple audiovisual participation options are offered (H323, telephone, streaming) to accommodate all users, including international sites, and we are grateful for the DOE sponsored ESnet capabilities that enable this broad participation.

We plan to continue the series on ITPA TGs, with the next expected to be on the Scrape-off-layer and Divertor TG, and hope to expand to other subjects of interest to our members, and perhaps outreach to the broader non-fusion community. Suggestions on topics or speakers of interest, and feedback on the seminars are welcome.

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## **Announcements**

Submit BPO-related announcements for next month's eNews to [Dylan Brennan](#).

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*"ITER Research Needs" a report by David Campbell, Plasma Operation Directorate, ITER Project, presented to the ITPA Coordinating Committee, Cadarache, France; December 12, 2011.*

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## **Upcoming Burning Plasma Events**

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### **2012 Events**

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#### **Apr 2-4, 2012**

ITPA Pedestal and Edge Physics Topical Group Meeting  
Hefei, CHINA

#### **Apr 2-5, 2012**

ITPA Transport and Confinement Topical Group Meeting  
Hefei, CHINA

#### **Apr 16-19, 2012**

ITPA Integrated Operation Scenarios Topical Group Meeting  
CIEMAT, Madrid, SPAIN

#### **May 14-17, 2012**

ITPA Diagnostics Topical Group Meeting  
Kutchatov Institute, RUSSIA

#### **Jul 8-12, 2012**

[39th IEEE International Conference on Plasma Science](#) (ICOPS2012)  
Edinburg, UNITED KINGDOM

#### **Jul 10 and 11, 2012** **NEW**

Sixth US-PRC Magnetic Fusion Collaboration Workshop (contact [Dr. George Tynan](#) for information)  
San Diego, CA

#### **Aug 27-31, 2012**

American Nuclear Society [20<sup>th</sup> Technology of Fusion Energy Conference](#) (TOFE)  
Nashville, TN

**Sep 2-7, 2012** **NEW**

[Joint IAEA NFRI Technical Meeting on Data Evaluation for Atomic, Molecular and Plasma-Material Interaction Processes in Fusion](#)

Daejeon, KOREA

**Oct 8-13, 2012**

24<sup>th</sup> IAEA Fusion Energy Conference  
San Diego, CA

**Oct 15-17/18, 2012**

ITPA T&C, MHD, PEP, EP, IOS, DSOL  
San Diego, CA USA

**November 2012**

ITPA Diagnostics  
INDIA

**December 2012**

ITPA CC & CTP-ITPA Joint Experiments and CTP  
Cadarache, FRANCE

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## **Directories of Other Plasma Events**

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[IEEE Directory of Plasma Conferences](#)

[Fusion Ignition Research Experiment \(FIRE\) Physics Meetings](#)

[Fusion Power Associates Meetings Calendar](#)

Please contact [the administrator](#) with additions and corrections.