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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.!

Director's Corner by C. M. Greenfield

ITPA Coordinating Committee/CTP JEX/CTP ExComm

For the second time, the combined ITPA Coordinating Committee, IEA Implementing Agreement on Cooperation of Tokamak Programs (CTP) Joint Experiments, and CTP Executive Committee met together in Cadarache last month. During this meeting, we heard reports from the ITER Organization on progress on construction and a summary of research needs for ITER (the slides from this talk, by David Campbell, have been posted on the USBPO website with permission of the author). We also heard reports on status and plans from each ITPA Topical Group. In addition to the topical groups, reports were given on two interdisciplinary working groups: the Integrated Plasma Control Working Group (Joe Snipes) and the Working Group on Particle Confinement (Alberto Loarte). In addition, overviews were given of the national programs of each ITER partner.

Participants at the December 2011 meeting. Photo © ITER Organization.

One important development at this meeting was the turnover of leadership in each ITPA topical group following the completion of three-year terms. From the US, Réjean Boivin (Diagnostics), Bruce Lipschultz (SOL and Divertor), and Stan Kaye (Transport and Confinement) all completed their terms as topical group leaders; we wish to congratulate and thank each of them for their service to the community. Among the incoming leadership, Ted Strait is the new head of the MHD Stability Topical Group, Tim Luce became the deputy in the Integration Operational Scenarios Group, and Rajesh Maingi became the deputy in the Pedestal Group.

On the final day, the 2nd Executive Committee Meeting of the IEA Implementing Agreement for Cooperation on Tokamak Programmes (CTP) was held. India is the newest member of the IEA-CTP, joining in April 2011, and China and Russia are in the process of joining. At that point, all of the ITER partners will be members. This is important, since many of our international collaborations are carried out under the auspices of this agreement. Also at this meeting, Steve Eckstrand (DOE) was selected as the new CTP chair for 2013.

ITER construction progress

The ITER Seismic Pit Basemat (photo) was completed in December. The structure includes 18,000 cubic meters of concrete poured over a dense array of steel rebar and stirrups (3400 tons of metal!). It will support anti-seismic pillars and bearings that in turn will support the 360,000 tons of the ITER Tokamak Complex. Construction will continue over the next couple of months with completion of the remaining seismic bearings and the retaining walls. The Poloidal Field Coils Winding Facility is also nearing completion and is expected to be handed over by the contractors sometime this month.

An important milestone in the project's schedule: the pouring, on December 22, of the twenty-first and last concrete slab of the Seismic Pit Basemat. The ITER Headquarters building, also under construction, is visible in the background. Photo © ITER Organization.

ITER has posted an excellent video showing how the tokamak will be assembled.

USBPO Disruption Task Group and workshop

The USBPO charter allows for the formation of Task Groups, which focus on very specific Burning Plasma issues cutting across Topical Group boundaries. We are in the process of forming one such Task Group, on disruptions. Its initial focus will be on disruption mitigation techniques, but we anticipate that in the longer term, this group will include disruption prediction and avoidance.

The importance of disruption avoidance and mitigation is nothing new. The urgency has recently increased with the US being given responsibility for ITER's disruption mitigation systems. A conceptual design review of the port plugs, including some of the mitigation hardware, is anticipated in summer, 2013. As a kick-off to preparation for the CDR, we (the new USBPO Task Group, in conjunction with the Virtual Laboratory for Technology and the US ITER Project Office) are organizing a disruption workshop, to be held March 12-13 in San Diego. More information should come within the next few days, and we hope for broad participation from the physics and technology communities.

IAEA Fusion Energy Conference – call for papers

A call for papers has been issued by Jim Van Dam for this year's IAEA FEC, to be held in San Diego on October 8-13:

- The short abstracts and the two-page extended synopses should be sent to the U.S. Paper Selection Committee by COB February 8, 2012.

- The U.S. Paper Selection Committee will meet in Gaithersburg, MD, on February 21 and 22, 2012, to select the U.S. papers.
- The IAEA FEC 2012 International Program Committee, to be chaired by Dr. Paul Thomas, will meet in Vienna, Austria, during April 16–20, 2012 to make the final selection of the Conference papers.

More information is available on the USBPO website.

Upcoming FESAC Meeting

The next scheduled meeting of the Fusion Energy Sciences Advisory Committee will be held February 28 and 29 in Bethesda, MD. Topics to be discussed include the FY 2013 Presidential Budget for the Office of Science and that for Fusion Energy Sciences. The response to the FESAC charges on (1) international collaboration and (2) materials science and technology will be presented, as well as an update on the status of the US ITER activities. Further details will be posted on the FESAC web site.

US STAC Membership

The ITER Science and Technology Advisory Committee (STAC) advises the ITER Council on science and technology issues that arise during the course of ITER construction and operation. The STAC is made up of "members" and "experts" from each party. The US members, Rob Goldston and Stan Milora, are continuing. At the next STAC meeting in May, the US will be represented by a new group of experts: Tony Taylor is stepping down, with the profound thanks of DOE and the community for his service since 2007. He will be replaced by Earl Marmar. Jim Van Dam is continuing as an expert, but moving to the "DOE slot" vacated by the retirement of Erol Oktay last year (Steve Eckstrand acted in that capacity for the Spring 2011 STAC meeting). I will be taking over Jim's previous slot.

Principality of Monaco / ITER Postdoctoral Fellowships

The ITER Organization has launched a competition for the 2012 Monaco/ITER Postdoctoral Fellowships. These Fellowships allow recent PhD graduates to join the ITER Organization for a period of up to two years.

The ITER project involves a wide range of cutting-edge research activities in fusion science and technology. As a Monaco Postdoctoral Fellow at ITER, you would be working with some of the leading scientists and engineers in fusion energy research and conducting a research program, which will contribute to the realization of one of the great scientific goals of the 21st century. The announcement and instructions for applications can be found on the ITER website at http://www.iter.org/monaco2012.

ITER International Summer School

This year's 6th 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.

USBPO Topical Group Highlights

(Editor's Note: The BPO Pedestal and Scrape-Off Layer Topical Group works to facilitate U.S. efforts to understand the boundary region of existing and future magnetic fusion devices via experiments and simulations [leaders are Tony Leonard and Rajesh Maingi]. This month's Research Highlight by Rajesh Maingi describes the current understanding of the inter-ELM evolution of the H-mode edge, and approach to instability, and summarizes ongoing work to identify the critical parameters that indicate the transition to ELM -free operation enabled by lithium coating the walls of the device.)

Pedestal dynamics in ELMy and lithium-enhanced ELM-free discharges in NSTX

Rajesh Maingi *(Oak Ridge National Laboratory)*

It has been predicted that the fusion performance in ITER depends strongly on the high confinement mode (H-mode) pedestal values. Motivated by the 2011 Department of Energy (DoE) Joint Research Target on pedestal structure, substantial progress has been made on pedestal research in NSTX in two main areas: pedestal and stability characteristics in edge localized mode active (ELMy) H-mode, and in the transition from ELMy to ELM-free H-mode enabled via lithium wall coatings.

The evolution[1,2] of pedestal height, width, and gradients, as well as density fluctuations, has been characterized during the inter-ELM cycle as a function of plasma current, I_p. It was found that the pedestal pressure height P_{tot}^{ped} saturates only in the last 30% of the ELM cycle at low and intermediate I_p, and not at all at the high $I_p > 1$ MA. The P_{tot}^{ped} increases ~ quadratically with I_p, and generally increases with lower divertor triangularity δ_l, but appears to be independent of toroidal field B_t. On the other hand, the pedestal pressure width in physical space, P_{tot}^{width}, increases during the ELM cycle, and appears to be independent of I_p. The pedestal pressure width in normalized poloidal flux (ψ_N) space, Δ, increases as the square root of pedestal β normalized to the poloidal magnetic field, β_θ^{ped}; the leading coefficient is notably higher than in C-Mod and DIII-D[3]. Note that the maximum pressure gradient saturates early in the ELM cycle, but increases with I_p. Finally, we note that a coherent density fluctuation at the plasma edge was observed on reflectometry; the amplitude of this fluctuation was a maximum after the ELM crash, and it decayed during the rest of the ELM cycle.

The evolution of global and edge plasma parameters during scans of increasing lithium deposition, during which plasmas transitioned slowly from ELMy to ELM-free, was also analyzed. The affinity of lithium for hydrogen reduced the divertor recycling and core fueling with increasing lithium evaporation between discharges[4]; interpretive modeling with the SOLPS code showed that the edge cross-field electron thermal diffusivity χ_e and particle diffusivity D near the top of the pedestal decreased with increasing lithium evaporation[5]. Effectively the minimum level of transport in the steep gradient region of the H-mode barrier was extended inward from $\psi_N = 0.94$ to $\psi_N = 0.8$. Furthermore, density fluctuations measured from reflectometry and high-k scattering at the top of the pedestal were reduced[5] by ~ 90%. Edge stability calculations[6] with ELITE of this transition showed that the ELMy discharges were all near the kink/peeling boundary, far from the ballooning boundary; ELM-free discharges were removed from the kink/peeling stability limit[6], confirming earlier analysis[7] of the end points of this sequence.

Figure 1 illustrates the ELM frequency in discharges as a function of increasing lithium deposition (panel a); above 300 mg deposition, discharges were uniformly ELM-free up to the β_N limit of 5.5-6. The electron density, temperature and pressure, n_e, T_e, and P_e composite profiles from those discharges were fitted[6] with a 'standard' modified hyperbolic tangent ("mtanh") function[8], which includes both a tanh component and a linear component. The ELM frequency from the data points is shown as a function of these pedestal widths in panels 1 (b), (c), and (d). The (ELM-synchronized)[9] n_e and P_e profile widths are both shown to separate the ELMy and ELM-free data, with larger widths corresponding to ELM-free profiles. On the other hand, the T_e profile widths do not separate the ELMy and ELM-free profiles. In addition to the profile widths, the mtanh profile fitting yields the pedestal top value and its location, the peak gradient and its location, and the pedestal bottom value and its location. Furthermore ELMy and ELM-free discharges were also organized by the location of the peak n_e and P_e gradients[6], i.e., the symmetry point of the tanh function. Panels 1(e) and (f) show the ELM frequency vs. distance of the n_e and P_e symmetry point from the separatrix; indeed, there is a threshold distance that separates the ELMy and ELM-free data. This is unsurprising, because as the characteristic width of a profile grows, the location of its peak gradient shifts also, provided the location of the bottom of the profile remains fixed. It is relevant, however, because the location of the symmetry point coincides with the location of the peak

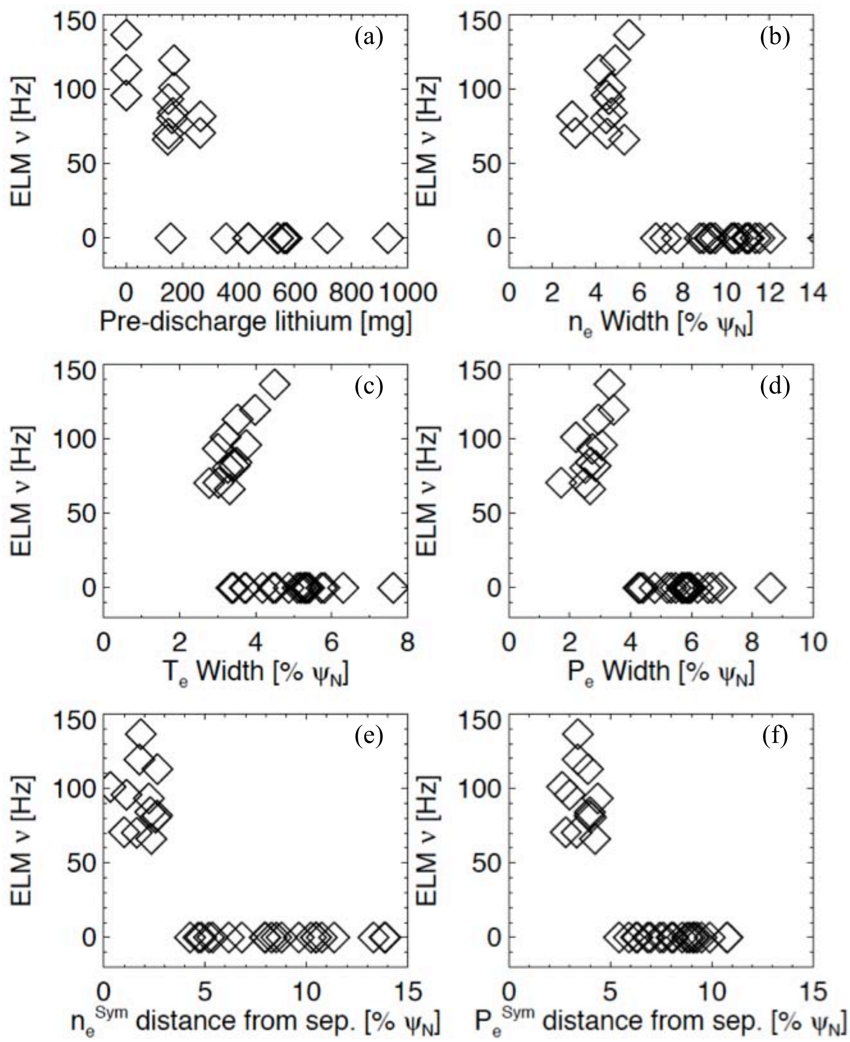

Figure 1: (a) Average ELM frequency as a function of pre-discharge lithium deposition. (b) ELM frequency dependence on the fitted widths of the (b) n_e, (c) T_e, and (d) P_e profiles. Panels (e) and (f) show the ELM frequency vs. the distance of the n_e and P_e tanh function symmetry points from the separatrix.

bootstrap and local parallel current in the kinetic equilibria; increasing the separation between this current and the separatrix improves stability to kink/peeling modes.

These results encourage the continued use of lithium for wall conditioning and edge studies in NSTX-Upgrade. It is noted, however, that techniques to reduce impurity accumulation in the ELM-free H-mode are needed. One technique[10] that successfully controls the edge impurity density in NSTX is the use of pulsed 3-D fields to reintroduce controlled ELMs; other continuous impurity expulsion methods will be sought in NSTX-Upgrade.

In addition, it is likely that studies that target the reason for the confinement improvement, including the continuous dependence on the pre-discharge lithium evaporation amount, will receive initial priority. Moreover the location of NSTX discharges on the kink/peeling side of the peeling-ballooning diagram parallels that expected in ITER. One qualitative conclusion then is that control of the density profile could be critical for pressure profile and ELM control in ITER, just as it appears to be in NSTX.

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ITPA Reports

Summary of the 21st Meeting of the ITPA Diagnostics Topical Group

Réjean Boivin *(General Atomics)*

The Twenty-first Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by the ASIPP Institute, Hefei, China from October 17 through 20, 2011.

Presentations concentrated on tasks designated as high priority (HP):

1. *Development of methods of measuring the energy and density distribution of escaping α-particles*.

A review of the present understanding of issues and possible techniques for escaping alpha detectors has been presented. Standard escaping loss detection techniques (Faraday cups and scintillator based) do not extrapolate to ITER. Presently the best prospects remain in using so-called proxies, an intermediate medium for the diagnosis of alphas, possibly on escaping trajectories. These include: Ion Cyclotron Emission (passive and possibly active) and FIDA-like charge exchange (edge) measurements. However, the feasibility of these concepts will require dedicated studies.

A brief summary of operational experience from the thin foil Faraday cup Lost Alpha detectors on JET was also presented. Clear alpha particle loss has been seen with the Faraday cup system under a configuration where helium beam ions were heated to MeV energies using 3rd harmonic ICRH. Significant noise in the system has been observed, due to the high gain of the amplifiers in the system. Pickup during ion cyclotron resonance heating (ICRH) was eliminated by installation of radio frequency (RF) low pass filters on each channel. Low frequency inductive coupling was also observed. The coupling coefficients (mutual inductances) have been determined and can be used for digital subtraction of the induced noise. Inductive pickup from magnetohydrodynamic (MHD) modes has also been seen; this contribution has been found to be nearly impossible to separate from real fast ion loss current.

2. *Assessment of the Plasma Control System measurement requirements*.

One of the more urgent items of discussion was to review and update the needs for diagnosis of very fast electron populations (e.g., runaways) that could be generated during ramp-up and/or disruptions. Proposals for updating the measurement requirements include changes to energy (maximum and average) measurements, total current, and position and shape of the runaway channel. These changes will be iterated within the Topical group and with the ITER operations (IO) plasma control system (PCS) working group. In addition, potential measurement techniques have been assembled and will be evaluated against the requirements after they are reviewed. This will be part of the contribution to Charge 5 of the science and technology advisory committee (STAC) 10. Additional discussions will include avoidance scenarios and measurement requirements, and any special need associated with disruption mitigation.

3. *Determination of the life-time of plasma facing mirrors used in optical systems.*

The First Mirror Working Group presented the newest developments in the area of diagnostic mirrors. At previous meetings, modelling results indicated that using fins within small ducts would be effective in reducing particle flux to mirrors. Tests are presently being designed and implemented at various devices (e.g., TEXTOR, EAST, LHD, DIII-D). These dedicated experiments, made with various geometries of diagnostic ducts exposed under well-diagnosed plasma conditions, are important in validating these predictive models.

A few options for corrective mitigation of deposition have been described. These include laser cleaning, cascaded-arc source and microwave source particle flux cleaning. Tests are presently underway at many laboratories, worldwide, including recently within ASIPP. An outstanding task is to demonstrate these techniques within conditions similar to what will be found in ITER (e.g., vacuum, with large static magnetic fields, etc.). Also, in view of the present design cycle (conceptual design reviews), it is now urgent to accelerate the R&D efforts in mitigating Be, Be-like and mixed deposits on mirrors, including model validation. A formulation of urgent tasks is being developed and resources sought to complete these in a timely fashion. Contributions from facilities/devices are particularly sought after. In addition, the evaluation of the impacts due to an early tungsten divertor installation needs to be undertaken.

4. *Assessment of techniques for measurement of hot dust.*

This HP item is now closed. However, a Joint Experiment is underway on this topic and further discussion is expected as results are received, and related action items completed.

5. *The assessment of impacts of in-vessel wall reflections on diagnostics.*

Many of the optical diagnostics will have to work against the background of stray light coming from the plasma and, because the ITER plasma is much larger than existing tokamak plasmas, this problem will be more severe than that experienced thus far. The problem needs to be evaluated through a process of modeling and measurements on existing machines, and measurements of the reflectivity of relevant materials.

Modeling and calculations have been performed to further quantify the effects of reflection in visible systems such as the charge exchange recombination system (CXRS), and H_{α}. Possible mitigation could include adding high resolution spectroscopic measurements and elaborate spectral modeling and fitting. Adequate chord selection (collection optics) may require viewing dumps that take advantage of existing features within the vacuum vessel.

We are now poised to start elaborating some possible strategies (guidelines) to limit the impacts of reflection.

The expected ECRH stray radiation during heating and current drive has been crudely estimated to be ~5% of the heating power of 24 MW, i.e., 1.2 MW @ 170 GHz, and 0.5 to 1 MW at 60 GHz from the collective Thomson scattering (CTS) gyrotron(s). With ITER having a larger wall surface but being a highly reflective all-metal machine, the stray radiation problem can be expected to be very similar to the situation expected in W7-X. Furthermore, recent results from the tests of effects of electron cyclotron resonance heating (ECRH) stray radiation experiments in the MISTRAL test chamber at Wendelstein 7-X has been given. Details of the in-vessel cables, material, geometry and construction were found to be important to avoid overheating and/or arcing. Guidelines for protecting windows and instruments behind them were also shown. These included using metallic meshes, special ceramic coating and using etalon techniques. Large area stray radiation sinks may also help in reducing overall levels of microwave power.

6. *Assessment of the measurement requirements for plasma initiation and identification of potential gaps in planned measurement techniques.*

The early phase of plasma formation and control may require additional or special measurements different than during the flat top phase. More discussions were held at this meeting to discuss plans and capabilities envisioned for the diagnostic techniques for supporting plasma initiation.

The first aspect of plasma initiation relates to the planned implementation of diagnostics for first plasma and/or first campaign. The second related aspects are related to the initial part of every discharge (i.e., breakdown, ramp-up).

In regard to the first aspects, discussions were held on the current diagnostic implementation plan. Still of concern is the lack of density measurement, and possibly a reduced visible/IR viewing coverage. In the case of density measurements, it may be possible to mitigate the lack of standard interferometry by using the low field side reflectometer and/or a simple Bremmstrahlung measurement using the spectroscopic systems (visible and vacuum ultraviolet (VUV)). Issues may arise in the measurements of radiated power as levels may be too low for the standard set, an increased aperture system could be used for that purpose. Concerns have been expressed for diagnosing run-aways/slide-aways during that phase, and action items have been generated to help in further defining the requirements for this measurement (see HP#2).

These discussions were also made in the context of the proposed deferrals (cost containment) and how they could affect physics performance and research programs. In addition, the impacts on diagnostics of going directly to a tungsten divertor without going through a carbon version need to be examined.

In the second aspects, concerns have been raised in the capability of measuring current profiles during ramp-up. Extensive simulations were presented for the expected performance of the poloidal polarimeter system. Two aspects were discussed: the first one concerns the measurement of the current profile during ramp-up, and the second one relates to the performance of the system with reduced number of chords. For the first aspect, it was recognized that the current profile during ramp-up would likely be measured by the polarimeter. For the second aspect, although the loss of some polarimeter chords can be accommodated, the loss of the upper port view may jeopardize the system, especially while considering constraints added to the motional Stark effect (MSE) system (e.g. beams).

Progress was also reported in other areas

A critical issue was brought forward by the STAC (Charge 3- STAC 10) to review and comment on the impacts of tilted operation of the negative ion based neutral beams (NNB) on MSE performance (current profile). In the present configuration, when both beams are tilted, the MSE system would be unable to measure the profile (no overlap). If the MSE is allowed to tilt down with the beam, only the outer part (rho>0.3) of the profile can be diagnosed. Options include tilting only one beam, or allowing one beamlet (out of 4) to be kept at/near the midplane for MSE diagnosis of the full profile. Further discussions are expected at the next STAC meeting.

The laser aided specialist working group reported in many areas. The outstanding issue on zero-offset interferometry was discussed. The main issue relates to possible unwanted feedback impact on laser operation. Recent discussions point towards the use of single-mode lasers which should be relatively immune to these effects. Tests are planned to verify this hypothesis. The results from the simulation study on the expected performance of the Poloidal Polarimeter have been discussed for some cases of the reduced number of chords. In the case of that the number of chords are reduced from 15 to 10, the measurement requirements for current profile would be satisfied when accuracies of detected signals are good enough.

The microwave working group (MWG) has been collating the history and performance of in-situ ECE and reflectometer calibration techniques. A final compilation of the results has been completed and internally published. The group is also looking at feasibility of refractometry, and interim progress has been reported. The group also presented the results from ASDEX-upgrade on the proof of performance of the position reflectometer technique. Results showed reasonable control of the plasma radial position, in L and H-mode conditions.

In the First Wall (FW) area, a report on speckle interferometry has been presented. This technique, which is proposed for measuring erosion (target), is capable to reach the measurement requirements, but has never been used and/or proven in a tokamak environment. Initial design studies were performed at CEA to evaluate the possible integration in ITER. A test is being prepared to be fielded at the Magnum-PSI facility to verify the performance of the technique in presence of plasma and erosion. A careful analysis of the system vibration is also important for these tests.

Efforts are continuing in devising ways to optimize required time for in-situ neutron calibration, while meeting the required accuracy. Options are being developed which may include use of stronger sources (x10), use of two DD (or Cf^{252}) and DT calibration sources simultaneously and optimization of time necessary for source/RH tool movement. If all these are applied, it is expected that savings of about 1 week in phase 1 calibration (out of 2), and up to 3 weeks (out of 8) in phase 2 can be achieved.

It is proposed to hold the 22nd meeting in Russia, on May 14th – 17th 2012. Kurchatov Institute has kindly offered their support to act as host. The provisional location of the 23rd meeting in the Fall of 2012 would be India. Starting with the next meeting, Prof. H. Park and Dr. Y. Kawano will become the next Chair and Co-Chair of the Topical Group. Dr G. Vayakis will remain as the IO Co-Chair.

Announcements

Submit BPO-related announcements for next month's eNews to Dylan Brennan.

Upcoming Burning Plasma Events

2012 Events

Mar 5-9, 2012 NEW
US-Japan MHD Workshop, NIFS
Toki, JAPAN

Mar 5-9, 2012
ITPA Energetic Particles Topical Group Meeting, NIFS
Toki, JAPAN

Mar 5-9, 2012
ITPA MHD Topical Group Meeting, NIFS
Toki, JAPAN

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

Aug 27-31, 2012 NEW
American Nuclear Society 20th Technology of Fusion Energy Conference (TOFE)
Nashville, TN

Oct 8-13, 2012
24th IAEA Fusion Energy Conference
San Diego, CA

Oct 15-17/18, 2011
ITPA T&C, MHD, PEP, EP, IOS, DSOL
San Diego, CA USA

November
ITPA Diagnostics
INDIA

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

Directories of Other Plasma Events

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

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