USBPO U.S. BURNING PLASMA ORGANIZATION

eNews

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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 (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

23rd IAEA Fusion Energy Conference

The biennial 23rd meeting of the Fusion Energy Conference, sponsored by the International Atomic Energy Agency, was held October 11-16, in Daejeon, Korea. The National Fusion

Daejeon Convention Center, the excellent venue for the 2010 Fusion Energy Conference.

Research Institute (NFRI) of Korea served to organize the meeting—and did an outstanding job. In particular, thanks are due to Dr. Gyung-Su Lee (President of NFRI) and the members of the Local Organizing Committee.

To kick off things, on the afternoon of the day (October 10, 2010 = "ten/ten/ten") preceding the conference, a Green Forum on 21st Century Environment and Knowledge-Based Energy was held, with the following four distinguished experts talking about the world energy situation and how fusion fits in:

- Werner Burkart, Deputy Director-General of the IAEA, talked about how safe, reliable, clean energy is the foundation for achieving the goals outlined in the United Nations Millenium Declaration, which was adopted in 2000 and updated in September 2010.
- Chris Llewelyn-Smith of Oxford University spoke on "The Case for Fusion," arguing that with the declining world reserves of fossil fuels and the looming climate change, large-scale use of nuclear energy (fission as well as fusion) is urgently necessary.
- Bernard Bigot, Chair of the French Atomic Energy Commission, described the French scenario for carbon-free energy consumption in the 21st Century and how fusion offers an attractive alternative for large-scale base-load power production, with ITER being the next step in this path.
- Kun-Mo Chung, twice the former Minister of Science and Technology for Korea, talked about the Korean initiatives for global nuclear renaissance, including the "Low Carbon, Green Growth" vision recently adopted by the Korean Government, the nuclear power reactor enterprise, and the KSTAR tokamak research program.

Assembly hall at the Daejeon Convention Center, showing the audience immediately prior to the Opening Ceremony on the first day of the 2010 Fusion Energy Conference (photograph courtesy of Tom Rognlien)

It was refreshing to see how many young people were in the audience for the Green Forum, which was held in conjunction with a two-day International Youth Forum on Fusion Energy, to which about 150 high school, university, and graduate students had been invited from several countries. In fact, the Green Forum was also part of a weeklong Green Festival at the Daejeon Convention Center, which featured daily cultural events, including a Festival of Lights, Hot-Air Balloon Festival, Hi-Tech Fair, and Deli Tour Show (with foods from around the world).

In Korea, fusion is green. This theme was evident throughout the Fusion Energy Conference, as well as the Green Forum and Green Festival. You can also see it prominently displayed on the web site for the National Fusion Research Institute. During the Conference, the NFRI organized several tours of its KSTAR tokamak facility.

The Fusion Energy Conference officially began on Monday morning with an Opening Ceremony, which featured an inspirational five-minute movie about fusion energy (you can watch it on the FEC 2010 local web site, click on Fusion Movie). This was followed by a stunning display of sand artistry (you have to see this to believe it: click on the Opening Performance video posted on the IAEA web site for FEC 2010).

Concluding image from the sand artistry program given at the beginning of the conference (photograph courtesy of Tom Rognlien).

This year's Fusion Energy Conference demonstrated the impressive support of the Korean Government for fusion research. The Prime Minister of Korea, the Minister for Science and Technology, and the Mayor of Daejeon City all spoke at the Opening Ceremony. The Mayor of Daejeon also sponsored a very nice out-door sit-down dinner reception for all FEC participants, complete with professional entertainment, in the park directly across the river from the Daejeon Convention Center, where the conference was held. The official sponsors for the conference included the NFRI and the International Atomic Energy Agency, as well as the Ministry of Education, Science, and Technology (MEST), the City of Daejeon, WooriBank, and four other Korean government ministries and two Presidential committees. Their generous spon-sorship also extended to the fabulous entertainment at the Gala Dinner held in Yurim Park on Thursday evening and the different music groups each day on the outdoor terrace during the afternoon coffee breaks. (The many outdoor social events attested to the fine weather during that week.)

The first scientific session of the conference featured over-view talks about four major fusion facilities, leading off with a report about initial experiments on KSTAR, the Korean superconducting tokamak, which had First Plasma in June 2009. Another of these first-session talks was entitled "DIII-D Contributions toward the Scientific Basis for Sustained Burning Plasmas," presented by Chuck Greenfield (USBPO Deputy Director). During the afternoon session on the first day, Professor Motojima, the new Director-General of the ITER Organization, described the pro-gress in the construction of the ITER facility.

All together, about a thousand scientists participated in the conference. There were 22 overview talks, 86 regular talks (with 21 of them rapporteured), and 468 posters. Two sessions of ITER-specific talks were held, with nine presentations, plus three other ITER papers that were rapporteured. In addition, 55 poster papers in the ITER category were presented at the conference. One of the ITER invited talks was about the ITER Test Blanket Module error field simulation experiments at DIII-D. The entire program for the meeting can be downloaded.

In the concluding session on Saturday afternoon, five world experts summarized the results presented at the conference:

- Rich Hawryluk—confinement; innovative confinement configurations
- Jean Jacquinot—stability; wave-plasma interactions; plasma-material interactions
- Xavier Garbet—magnetic confinement theory & modeling
- Kunioki Mima—inertial fusion
- Hideyuki Takatsu—ITER; fusion technology; safety and environment

Preparing these summary talks is an enormous effort, but they are quite helpful to remind the participants about the highlights of the conference.

Also during the Closing Ceremony, Dr. Guenter Mank was thanked for his past six years of service as the Physics Section head at the IAEA, in which capacity he has helped to organize several meetings of the Fusion Energy Conference as well as numerous IAEA Technical Meetings. Dr. Richard Kamendje now replaces him in this position. Both were present at this year's FEC and alternated as assistant chair of the morning and afternoon invited-talk sessions.

The Fusion Energy Conference was featured in several Korean newspapers, e.g., the *Korea Times* and the *Korea Intelligent Technology Times*. A photo of the South Korean Prime Minister Hwang-Sik Kim giving his congratulatory speech at the conference is posted here. One newspaper referred to the Fusion Energy Conference as the "World Cup of Nuclear Fusion Energy." During the conference, the local organizers published their own broadside, the *FEC2010 Times*, in three issues.

The IAEA has promised to post on the Internet all of the FEC written papers and also the invited-talk presentations.

The next (namely, 24th) Fusion Energy Conference will be held October 8-13, 2012, at the Hilton San Diego Bayfront Hotel in San Diego, California, with General Atomics as the local organizer. A web site for the 2012 IAEA FEC is already active.

John Rice (top photo, center) and Steven Sabbagh (bottom photo, center), the winners of the 2010 and 2009 Nuclear Fusion journal awards, respectively, receive their award certificates and trophies from Mitsuru Kikuchi, Chair of the Board of Editors of Nuclear Fusion, and Werner Burkart, Deputy Director General of the International Atomic Energy Agency (photo courtesy of the IAEA).

US Scientists Awarded Nuclear Fusion Journal Prize

During the Closing Ceremony of the recent IAEA Fusion Energy Conference, the *Nuclear Fusion* Journal Prizes for the past two years were awarded. The 2009 Prize went to Steven Sabbagh (Columbia University) for his paper about record plasma beta values in NSTX and an analysis of Resistive Wall Mode stability. The 2010 Prize was awarded to John Rice (MIT) for his paper on a universal scaling from experimental results to predict intrinsic rotation in tokamaks. Both of these papers have been highly cited. This Prize is awarded annually to recognize outstanding

work published in *Nuclear Fusion*. The Board of Editors makes the selection, based on citation record and scientific impact. It's worth noting that US scientists have now won four of the five awards since they were begun in 2006. Past awardees were Tim Luce (2006), Clemente Angioni (2007, the only non-US awardee so far), and Todd Evans (2008). Congratulations to all of them and especially Steve and John for their recent awards.

Recent STAC and MAC Meetings

The Science and Technology Advisory Committee (STAC) of the ITER Council held its ninth meeting October 25-27 in Cadarache, France.

The Council at its June 2010 meeting (IC-6) had formulated a set of charges for STAC-9 to report back to its IC-7 meeting in November. This initial set of charges consisted of five items:

- Evaluate the status, feasibility and risks of the plan for diagnostic systems and their integrated capability to meet the Project Requirement's measurement requirements.
- Comment on the community plans to improve theoretical and experimental understanding of steady and transient heat loads as they relate to the design of first walls.
- Comment on opportunities for the community to improve theoretical and experimental predictions of edge characteristics and H-Mode thresholds in ITER-relevant regimes.
- Evaluate opportunities to accelerate the start of DT research.
- As standing items of the STAC meeting, review the progress on key open STAC issues, this time including the Superconducting Coil Quality Assurance and Cold Testing, the design and R&D of in-vessel coils, and the Neutral Beam Test Facility.

Subsequently, the ITER Council requested STAC-9 to address a sixth charge, related to proposals from the ITER Organization about measures for Cost Containment and Cost Savings, which the ITER Organization had prepared in response to the request from the ITER Council at its July 2010 Extraordinary Meeting. This additional sixth charge was the following:

- The ITER Council invites STAC, at its ninth meeting scheduled for 25-27 October 2010 to review the technical scope of the IO's proposals for cost containment considering their possible impact on the Project's scientific and technical mission goals. STAC should address, in particular:
  - The justification for cost containment proposals in terms of the revised evaluations of associated technical risks;
  - The consistency of the modified technical scope resulting from the cost containment proposals with the goals of achieving First Plasma in late 2019 and full DT operation in early 2027.

The STAC completed the first draft of its report by the end of its October meeting. The final form was to be submitted to the seventh meeting of the ITER Council (IC-7), held November 17 and 18, 2010, in Cadarache, France.

The Management Advisory Committee (MAC) held its ninth meeting October 27-29, also in Cadarache. The topics of Cost Containment (i.e., keeping the cost from rising) and Cost Reduction (i.e., lowering the cost) were among the agenda items. Immediately following the MAC meeting, the Contact Persons Working Group met for one day to make preparations for the upcoming Council meeting.

Burning Plasma Events at the APS-DPP Annual Meeting

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

- Tuesday (November 9), 7:30-9:30 p.m.: ***Town Meeting on ITER Status*** (Session LE2)
- Thursday (November 11), 2:00-4:12 p.m.: ***ITER-I Contributed Oral Session*** (Session UO4)

- Friday (November 12), 9:30 a.m.-12:30 p.m.: ***ITER-II Contributed Oral Session*** (Session XO4)

The speakers and their respective topics for the ITER Town Meeting on Tuesday evening were as follows:

Time	Speaker	Topic
7:30–7:35 p.m.	Michael Mauel (USBPO)	Opening Remarks by the Moderator
7:35–8:00 p.m.	Gyung-Su Lee (Korea and ITER MAC)	New ITER Baseline and Risk Assessment
8:00–8:25 p.m.	Alberto Loarte (ITER Organization)	Scientific Status of ITER
8:25–8:50 p.m.	Brad Nelson (US ITER Project Office)	US Engineering, Technology R&D, and Design Activity for ITER
8:50–9:15 p.m.	James Van Dam (USBPO)	US Contributions to ITER R&D
9:15–9:30 p.m.	All	Q&A and Discussion

Approximately 140 people attended the ITER Town Meeting. The concluding discussion session was quite lively, with many questions and comments—especially concerning the potential use of in-vessel coils in ITER for controlling edge localized modes (ELMs), vertical stability, resistive wall modes, rotation, and error field effects. All four of the presentations are posted on the USBPO web site. I would like to express special appreciation to G. S. Lee and Alberto Loarte, who came from outside the US to participate in the meeting, and to Brad Nelson, who traveled from the US ITER Project Office expressly for this meeting.

Each of the two contributed oral sessions for ITER-related research had about 80 people in attendance. The chairs for the Thursday and Friday sessions were Steve Wukitch and Rich Hawryluk. I'd like to repeat my thanks to Raffi Nazikian and Dylan Brennan for organizing these contributed oral sessions, with the help of the APS-DPP Program Committee (chaired by Steve Allen).

USBPO Topical Group Highlights

The BPO Operations and Control Topical Group works to facilitate U.S. efforts to understand and control the operation of existing and future fusion devices (leaders are David Gates and Michael Walker). This month's research highlight by David Humphreys describes results from experiments on the DIII-D tokamak to control the loss of runaway electrons via changes in magnetic field coils.

Runaway Electron Current Channel Control in DIII-D

Dave Humphreys (General Atomics)

The cold post-thermal quench plasmas and resulting high electric fields that typically follow plasma discharge disruptions can produce conversion of large fractions of the thermal current into relativistic "runaway" electrons. For example, in the DIII-D tokamak delivery of large amounts of impurity ions in the form of cryogenic pellets or massive gas injection to test preemptive mitigation of disruption damage via line radiation can convert > 30% of the pre-disruption equilibrium current to runaway electron current. In ITER, post-disruption runaway electron channels up to 12 MA are estimated to be possible in standard operating scenarios with15 MA of thermal plasma current. Methods of suppressing runaway electrons before they form, or causing them to be lost over a period of time in a controlled manner after they form, are

urgently needed for ITER to avoid potential damage resulting from localized deposition of the runaway electron energy when they are lost in a single event.

Recent experiments in DIII-D have demonstrated the ability to control the position and amplitude of runaway electron current channels following their formation in disruptions triggered by cryogenic Ar pellet injection [1]. Target plasmas limited on the inboard wall and having low vertical elongation (kappa ~ 1.4) were used in these experiments, as they appear to confine seed runaway electrons better than magnetically diverted discharges, and therefore produce post-thermal quench runaway electron current plateaus more reliably. In the absence of any applied loop voltage, the runaway electron current decays on a much longer timescale (50-100 ms) than the usual thermal current quench time (typically 5-10 ms). Application of large positive voltage from the Ohmic coil was able to counteract this loss and maintain or even raise the current during the runaway electron plateau phase. Regulation of the runaway electron current amplitude at a constant value of 300 kA through feedback control of the loop voltage was successfully demonstrated. Use of a specially designed position control algorithm during this phase enabled control of the runaway electron channel vertical position. Relatively poor performance of the radial control loop suggests the need for improvement of feedback gains and possibly position estimators. However, open loop programming of inboard poloidal field shaping coil currents was able to prevent radial loss, demonstrating the fundamental capability of DIII-D coils and power supplies to provide full positional control of the runaway electron beam. The combination of positive loop voltage, vertical control, and radial control was able to sustain runaway electron plateaus up to 150 ms beyond the initial current quench. In all cases the runaway electron plateau phase was observed to eventually terminate in a "secondary disruption" via a VDE or a kink-like instability.

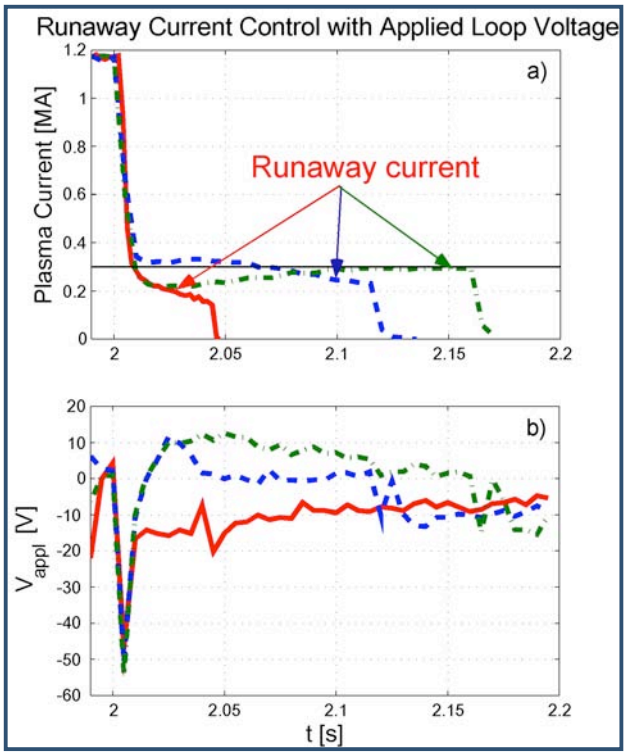

Figure 1. Comparison of runaway electron plateau phases for three DIII-D discharges with varying applied loop voltage [1]. (a) runaway current histories for negative applied loop voltage (red), zero applied loop voltage (blue), and positive loop voltage (green); (b) applied loop voltages (calculated from Ohmic coil current) for the three discharges in (a).

These experiments may point to a possible scenario for mitigation of runaway electron current in ITER, in which a combination of vertical control with the in-vessel coils and radial control with the ex-vessel poloidal field coils may enable slow, controlled de-confinement that limits the energy deposition to an acceptable level. Challenges to sustained control in ITER include limited loop voltage capability, constraints on the rate at which the vertical field can be varied by the poloidal field coils, and the possible onset of instabilities such as those observed to terminate the runaway electron current in DIII-D.

Reference:
[1] N. Commaux, et al., "Novel Rapid Shutdown Strategies for Runaway Electron Suppression in DIII-D," Proc. 23rd IAEA Fusion Energy Conf., Daejeon, Korea (2010), EXS/P2-02.

ITPA Reports

Summary of the 5th Meeting of the ITPA Integrated Operation Scenarios Topical Group, Seoul, Korea

Chuck Kessel (Princeton Plasma Physics Laboratory)

The fall meeting of the ITPA Integrated Operation Scenarios (IOS) Topical Group was held October 18-20, 2010, at Seoul National University in Korea. This meeting, along with those of other ITPA groups, followed the IAEA Fusion Energy Conference in nearby Daejeon, Korea, and therefore took advantage of having multiple ITPA groups at the same location for interactive sessions. In general, the re-presentation of IAEA papers in the IOS group was discouraged and minimized, so that the meeting could address other issues. The ITER Organization (IO) representative gave a summary ITER issues related to integrated scenarios, such as heating and current drive systems descriptions, updates from the ITER Science and Technology Advisory Committee (STAC) meeting, updates on center-stack and poloidal field (CS/PF) coil maximum voltages, edge density profiles for radiofrequency (RF) coupling, and plasma control system planning, as well as a work plan for 2011-13 in plasma control, scenarios and heating/current drive (H/CD). Also, issues related to the non-activated phase (i.e., before deuterium/tritium) were presented. JET, DIII-D, C-Mod, AUG, NSTX, and KSTAR tokamak groups reported progress on joint experiments and future run schedules. The joint experiments were summarized.

A joint session with the Pedestal and Edge Physics, Transport and Confinement, and SOL/Divertor topical groups discussed the modeling of pedestals, L-H and H-L confinement-mode transitions, and integrating particle transport into ITER simulations. It is suggested to begin adding these aspects as part of the IOS simulation and experimental activities in the future.

The IO presented a series of ITER plasma control topics and is requesting more involvement of the IOS group in modeling these areas. These control areas range from shape and vertical position control of the plasma to heat flux and burn control, and finally to sawtooth and neoclassical tearing mode (NTM) control.

Another joint session was held with the Transport and Confinement group on the current ramp-up modeling of present experiments in support of ITER modeling. Presentations showed the range of errors in matching experiments, and emphasized the failure of theory-based transport models in this discharge phase. The reason for the failure of these models was identified roughly as being the invalidity of the model when the safety factor is high, which occurs in ramp-up and near the plasma edge. A session on internal transport barriers (ITB's) was also held, discussing models used in simulations of ITB plasmas, and experimental observations of requirements to trigger and sustain ITBs. The discussions showed that there was considerable disagreement about details of these operating regimes on different experimental devices.

A series of Joint Modeling Activities were identified and presented by various group members to begin an analogous format as for ongoing joint experiments. It ended up preferable to keep the joint modeling activities broader than typical Joint Experiment descriptions, and identify a series of subtopics within a Joint Modeling Activity. The range of activities include direct modeling support of experiments, benchmark exercises for H/CD sources, benchmark

exercises on integrated scenario codes, experimental and ITER discharge modeling, and plasma disturbances and control. Efforts are now underway to develop a Joint Modeling Activity description (roughly one page) similar to Joint Experiments for each modeling topic identified.

Finally, the status of the IOS-related IAEA FEC papers that will be submitted to *Nuclear Fusion* was discussed. The next ITPA-IOS meeting is proposed to be in Culham, UK, on April 11-14, 2011.

Summary of the 14th Meeting of the ITPA SOL/Divertor Topical Group, Seoul, Korea

Bruce Lipschultz (MIT)

The meeting was held over the period October 18-20, 2010, in Seoul, Korea, with over 50 participants. The local coordinator was Professor Na for the first day when the meeting was at Seoul National University. The second and third days of the meeting were held at Hanyang University, hosted by Professor Kyu-Sun Chung. We are in debt to both organizers for their efforts and those of their staff. The three-day meeting was split between discussions on the scrape-off layer (SOL)/Divertor R&D plans in support of ITER urgent needs and several research topics. Below is a summary of the meeting; a more extensive report of the issues and results is available on the ITPA/ITER website or from Bruce Lipschultz.

A joint session between SOL/Div, MHD, and Pedestal topical groups was held to review the current knowledge of edge localized mode (ELM) physics and their heat loads to material surfaces. The ITER assumption for rise/fall times of the divertor ELM heat load was a ratio of ~1, but the new data indicates a longer fall time, thus lowering temperature rises. ITER has also been assuming that the heat load footprint on the divertor for type I ELMs was the same as between ELMs, whereas the data indicated a scaling of broadening that increased with ELM energy. The implication of a combined scaling from DIII-D and JET tokamaks was that some broadening would occur (between a factor of 1 and 2). Any implied increase in the maximum allowed ELM power is still small compared to the projected 20 MJ ITER ELMs, implying a strong need for continued development of ELM mitigation. What was very clear is that more heat load footprint data, both on the divertor plates and also on the first-wall, is needed in order to make better predictions of plasma-facing component (PFC) lifetime and the requirements on mitigation techniques and PFC design. The joint nature of the session will hopefully reinforce the collaboration amongst the various groups in designing IEA/ITPA proposals.

A similar review of disruption physics was held jointly amongst the SOL/Div, MHD and Energetic Particle topical groups. The poloidal and toroidal asymmetries engendered during massive gas injection (MGI) mitigation of disruptions are much better characterized as a result of recent work – the concern appears largest for toroidal asymmetries (of order 2) in terms of the total energy asymmetry with the asymmetry lasting through the thermal quench. The data from ASDEX-Upgrade (AUG) implies that the toroidal asymmetry is higher for He than for higher Z gases. Runaway electrons are much more poorly characterized leading to a large threat of melting deep within PFCs. There are several models (e.g., NIMROD), which may be applicable to predicting load amounts and locations. Several mitigation techniques were discussed including injection of gas, reversal of the loop voltage, and stochastic magnetic fields.

Fueling of the plasma was the subject of a short joint session amongst Div/SOL, Pedestal, Integrated Operation Scenarios (IOS) and, Transport and Confinement topical groups. Alberto Loarte (ITER) is forming a working group on this subject, and he will solicit representatives from all relevant ITPA groups.

Ion cyclotron discharge cleaning (ICWC) has been the subject of major research effort over the last three years. Results were presented from KSTAR, which supported this removal rate. The maximum hydrogenic [and thus projected tritium (T)] removal efficiencies have been of the

order of 10^{18} T/m^2/s, achieved both at high power with He-ICWC (e.g., Tore Supra) and also using the mixture of H-He ICWC (a number of tokamaks). Based on the session discussion, it is not clear exactly how the ICWC works; chemical erosion leading to material removal for flakes or near surface cleaning through isotope exchange are leading explanations. It is also not clear how well ICWC will work with Be layers and how uniform in terms of ion fluxes the method is. It was suggested (V. Philipps) that that the ICWC cleaning efficiency could be improved through biasing of the important surfaces. A new technique, high-frequency glow discharge cleaning (HFGDC) was presented by EAST representatives, which may be an alternative to ICWC for full-field surface conditioning, but it is not yet clear whether it can be made uniform nor its T removal rate. It would have the advantage of control over the ion impact energies through the cathode bias. Oxygen bake has been applied to multiple tokamaks over the last few years in addition to lab studies. The removal rates can be 2-3 orders of magnitude higher than ICWC, but it was clear from this meetings discussion that O-bake cannot be utilized in ITER due to the creation of tritiated water, which the ITER tritium plant cannot deal with (because it erodes gas piping). An alternative method was presented involving the use of NOx such that tritiated water may not be an issue (still to be shown conclusively) and only the C removal rate was shown – more information is needed. An update to the effect of the formation temperature on T retention and removal of mixed Be layers (with C and W) was presented. An IPP-Garching-PISCES study of the tradeoffs between operating and baking temperatures is needed. An additional update on T retention in nuclear-damaged tungsten was also presented by the FOM group.

Crack growth on tungsten surfaces under ITER ELM repetitive heat load in most cases saturates with the largest cracks forming at grain boundaries and small ones being intra-granular. Raising the surface temperature over a few hundred degrees C reduces crack growth. Modeling of the crack growth using the MEMOS code appears to do a reasonable job of matching the data. A new study from Troitsk alternated plasma (ion) fluxes with heat fluxes, and it was found that the plasma-induced damage enhanced crack growth with the largest width cracks to date (0.3 mm) and less saturation of crack width. The detailed studies of melt layer formation in TEXTOR point towards JxB forces moving the melt layer although the effect of plasma pressure cannot be ruled out under some conditions. Melt layer dynamics are also fairly well reproduced by modeling. A study of blisters using a focused ion beam that the blister cover tends to be ~ one grain thick and can be elastic. It would imply that gas is accumulating along grain boundaries much farther into the surface than implantation (~ 5nm). A new effort at the IPP-Juelich is experimentally determining S/XB rates from measurements of known W injection rates. New investigations of material migration were reported from JET (C13) and C-Mod (tungsten). As has been observed before, most of the injected C13 gas is either deposited locally near the injection point or pumped away. The JET results are still under analysis. The C-Mod results for toroidally uniform W source at the outer divertor point towards natural migration through the common SOL to the strike point, which means the W is finally deposited in the private flux region of the outer and inner divertor (likely ExB drifts transport the W to the inner divertor. An initial attempt at modeling Be migration in the limiter shadows of ITER was reported.

Results of dust collection efforts on a number of tokamaks (TEXTOR, JET, JT-60U) and the linear device PISCES were reported. As in previous meetings, the conversion of gross erosion to dust production is the measure that is needed at the moment. The data presented still supports values of the conversion factor << 1. More localized measurements are needed at least between discharges correlating transient events and the appearance of dust on some collection diagnostic. A novel automated SEM/EDX statistical analysis was performed on AUG dust. Most dust was composed of tungsten with other materials also present. The size distribution peaked around 0.2 microns.

The next meeting of the ITPA SOL/Divertor Topical Group is tentatively planned for Helsinki, Finland, May 16-19, 2011 (3.5 days is the initial period). Taina Kurko-Suonio and Jari Likonen are the local organizers. Topics selected for emphasis (preliminary) include C13 injection

experiments (is a newer technique needed to provide more information for material migration, in particular for high-Z), review of old JET main chamber erosion/redeposition experiments, a general modeling session, molecular dynamics studies of the lattice structure in tungsten and how the ITPA might contribute to benchmark them, and radial transport studies in the EU and US.

Summary of the 19th Meeting of the ITPA Diagnostics Topical Group, Naka, Japan

Rejean Boivin (General Atomics)

The Nineteenth Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by the Japan Atomic Energy Agency (JAEA) and held in Naka, Japan, from October 18 through 21, 2010. Good progress has been made in the tasks previously designated as high priority, which were the focus of the meeting as summarized below.

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

We are continuing to assemble the key factors required for the evaluation of the basic feasibility of the techniques for measuring alpha losses. Many elements have been documented over the last few meetings and the assessment can now be completed. The relevant orbit codes have been developed and have been applied to the ITER geometry and internal magnetic structure. The efficiency of applicable scintillators (or equivalent detectors) has been documented for ion and/or gamma flux signal and for background radiation (neutrons and gammas). This measured efficiency coupled with the first wall geometry, can now yield quantitative evaluation of the expected Signal to Noise (SNR) ratio for the proposed methods. We are planning next to study systematically the expected response (signal levels) of the different proposed schemes and their respective SNR within the ITER environment. A work plan has been elaborated to include systematically all the numerical/quantitative components of such a technique when applied to the ITER case. Presently, the preliminary study indicates that a standard lost-alpha detector does not extrapolate favorably to ITER.

Further discussions were held on the possible use of activation probes for the measurement of losses. Recent progress with the JET probes system and future plans were presented and discussed. Activation techniques are based on helium (alphas) reaction with specific materials housed in a re-entrant probe. The accuracy of the measurements is rather high, but they presently lack sufficient time resolution. Possible implementation schemes are being explored.

2. *Assessment of the neutron calibration strategy and calibration source strength needed.*

The Neutron Working Group has presented the final report regarding the neutron calibration strategy. Considering that the needed dynamic range in neutron detection in ITER is large, and since available calibration sources and generators are limited in strength, cross-calibrations between detectors are necessary. Cross-calibration can be done with dedicated plasma discharges, and supported by appropriate Monte Carlo N-Particle code (MCNP) calculations. While taking into account reasonably available neutron generator yields and source strengths, it is presently proposed to have two neutron calibrations of approximately 2 and 8 weeks duration, respectively, not including the set-up time that is expected to be significant. Meeting the required 10% accuracy in total fusion-yield measurements largely drives these durations. Efforts are continuing in devising ways to optimize the number of calibration steps and to reduce the time necessary to complete it, while meeting the required accuracy. Options are being developed that may include additional or more sensitive detectors, additional calibration sources, or slight changes to detector configuration.

3. *Determination of the lifetime of plasma facing mirrors used in optical systems.*

The First Mirror Working Group presented the latest developments in the area of diagnostic mirrors. Significant progress was reported on several tasks of the existing work plan, in particular on predictive modeling of mirror performance in ITER, research and testing of candidate mirror materials, coatings under ITER-relevant conditions, and on mitigation of impurity deposition.

Recent modeling so far confirms that deposition remains the major issue for mirrors in ITER. Therefore, next efforts will focus in finding relevant techniques to mitigate the deposition. For example, both the predictive ITER modeling and experiments conducted at LHD show the effects of duct shaping on particle fluxes impacting the mirror. The dedicated experiments, made with various geometries of diagnostic ducts exposed under well-diagnosed plasma conditions, are important in validating these predictive models. The cleaning of diagnostic mirrors (e.g., from TEXTOR) presently indicates that sputtering is a good candidate for plasma cleaning of mirrors.

A current risk analysis shows that for some of the ITER diagnostics, the lifetime of the first mirrors may be insufficient to meet maintenance interval targets. However, the single crystal molybdenum mirrors, when applied in erosion-dominated conditions, appear to be able to withstand the fluence corresponding to several thousands of ITER discharges. The proper shaping of the diagnostic duct may reduce the particle fluxes by many orders of magnitudes. Achieved removal rates for carbon implanted onto the mirror are already exceeding the maximum predicted deposition rates in ITER.

4. Assessment of techniques for measurement of hot dust.

An evaluation of the requirements for the allowable amount of dust on hot surfaces (i.e., hot dust) has been formulated. It was found that a maximum of ~18 kg of hot dust can be tolerated within the vacuum vessel. Separately, if one accounts for the total amount of dust that could be found within the vacuum vessel, it is estimated that up to ~40 kg of dust could be uniformly distributed on hot surfaces, which would be a factor of 2 above the safety limit given above. With these estimates and constraints, we are now ready to derive the relevant measurement requirements, which will be reviewed at the next meeting. The requirements will be the basis for the Topical Group's recommendations to the ITER Organization for inclusion in their full measurement requirements table.

Initial concepts for the development of a technique for measuring hot dust were also presented. Four techniques are presently under consideration: 1) Dust-steam reactivity measurement (controlled injection of water-steam), 2) Infrared methods (thermal analysis of surface emission), 3) Surface ranging by erosion monitor and 4) Ultrasonic detection (time-of-flight measurement within tile/shield module). To date, the most promising candidates are 2) and 3).

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. Hence, 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. Effects of reflections were discussed in the case of the infrared (IR)/visible radiation survey system, especially in the divertor area. Derived local temperatures can appear much higher when reflections from a hot surface onto the target are included.

Extensive R&D efforts are ongoing at W7-X to quantify and study the effects of stray microwave radiations onto diagnostics and other in-vessel components. An update on research plans was presented, indicating the importance of understanding these effects in W7-X, and likely in ITER as well. The latest results on reflections/stray microwave radiation (from electron cyclotron heating - ECH) in the W7-X testing facility (MISTRAL) were presented. In the case of

bolometers, it was found that shielding the detectors (foils) with a very fine mesh was not sufficient to mitigate the apparent heating due to ECH radiation. Internal coating with appropriate ceramic material (absorbers) can further reduce the effects of microwaves within the instrument (reaching acceptable levels). Many additional tests are planned on key internal components, including cabling [e.g., mineral-insulated cables]. However, it is clear there is an urgent need for the development of accurate measurement tools for stray radiation in testing and in final protection of in-vessel components.

Progress was also reported in other areas: for example, a comprehensive beam-tracing performance study was performed at the Institute für Plasmaphysik (IPP) of several low-field-side reflectometer antenna configurations, as reported by the Microwave Working Group. Acceptable performance and plasma-height variation coverage appears possible with single bistatic antenna pairs (one O-mode & one X-mode). Further analysis is expected at the next meeting(s).

It is proposed to hold the 20th meeting in Europe, on May 23-26, 2011. The FOM Institute (Netherlands) has kindly offered their support by acting as host.

Announcements

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

Upcoming Burning Plasma Events

2010 Events

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 7-10,2010 NEW
20th International Toki Conf (ITC20) on Advanced Physics in Plasma and Fusion Research
Toki, Japan

Dec 15, 2010
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 9-13, 2011 NEW
13th International Workshop on Plasma-Facing Materials and Components for Fusion Applications (PFMC-13) and 1st International Conference on Fusion Energy Materials Science (FEMaS-1)
Rosenheim, Germany

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

June 1-3, 2011 NEW
19th Topical Conference on Radio Frequency Power in Plasmas (CKPhil and JR Wils PPPL)
Newport, RI USA

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

Jun 27-Jul 1, 2011 NEW
38th European Physical Society Conference on Plasma Physics
Strasbourg, FR EPS

Sep 11-16, 2011 NEW
10th International Symposium on Fusion Nuclear Technology
Portland, Oregon USA

Sep 19-21, 2011 NEW
Plasma Edge Theory Meeting
South Lake Tahoe, CA USA

Oct 16-21, 2011
15th International Conference on Fusion Reactor Materials (ICFRM-15)
Charleston, SC USA

Nov 14-18, 2011 NEW
53rd APS Division of Plasma Physics Annual Meeting
Salt Lake City, Utah 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.