

## **US BPO Workshop Diagnostics Breakout Group Summary December 8, 2005 – David Johnson, Steve Allen**

27 attendees registered at the diagnostic breakout session at various times during the day - 12 from universities (4 from MIT), 13 from national labs, and 2 from industry (GA). The average attendance was between 10-15.

### **1. What major BP-related developments (in theory, modeling, experiment and technology) have occurred in this area since the Snowmass 2002 study?**

For the first two hours, the diagnostics and control breakout groups met together in a discussion designed to clarify issues arising from the plenary talk, largely addressing progress since Snowmass. Much of the diagnostics discussion centered on the ITPA activities, including an ongoing redefinition of ITER measurement requirements, and an assessment of capability of ITER diagnostics to meet the requirements. Potential USBPO roles in complementing the ITPA activities in these areas were discussed, as well as a request for a role in facilitating US participation in non-US diagnostics and ‘uncredited’ diagnostics. In our joint session, M. Greenwald told us about about a multilateral, one-year activity to recommend a conceptual design of the ITER CODAC system, which was later recommended by the group as a Task Area.

### **2. What issues remain to be resolved for a successful BP experiment in ITER?**

Before the two groups split, we agreed that there was a need to confirm that ITER measurement requirements properly reflect the sensor needs for plasma control.

The diagnostics ITPA group has identified ‘high priority’ tasks, and these were reviewed by the diagnostics breakout group. The issues include 1) development of techniques for measuring lost and confined  $\alpha$ 's, 2) assessment of the survivability of ITER first mirrors, 3) assessment of radiation effects on magnetic diagnostics, 4) development of techniques for measuring dust, 5) assessment of justification for ITER design change to accommodate a vertical neutron camera. The group generally endorsed these as important issues and would later recommend tasks in some of these areas.

The US has interest and expertise in developing an ITER lost alpha system and a collective scattering system for confined alphas, both of which are ‘uncredited’ systems on ITER. The USBPO could recommend more focused US work on such systems.

Development of a  $q(r)$  measurement technique, previously on the ITPA high priority list, was recommended for placement back on the list, because the vertical angular spread of heating beams is a serious problem that is not yet solved.

US expert review of ITER diagnostics design was presented by K. Young as an important issue – not only for US-allocated systems but for non-US systems as well. Advocating for a pool of US diagnostic experts (and associated funding for assessment and travel) for such reviews was viewed as a possible role for a USIPO. An element of such reviews will likely be performance simulations, and T. Casper presented motivations for such tools and examples of how they might be used. It was generally agreed that the use of such simulation tools to assess diagnostic performance expectations would be a high leverage use of US expertise. A sensible suggestion was to develop this capability in two parts. The first calculates the signals from the plasma (eg. visible

emission for MSE), for many ITER scenarios. The second simulates the diagnostic specific aspects. This would facilitate comparison between several diagnostic design variants using a standard set of ITER discharges.

Other tools needed to assess ITER diagnostics include efficient CAD access to designs, and efficient neutronics analysis of diagnostic port plug labyrinths, and B. Nelson presented status and plans in these areas. D. Johnson presented variants in diagnostic shield module concepts that might simplify diagnostic integration and future maintenance. Brad also talked about the need for a common port plug test facility, which could also be used for prototyping.

K. Young then presented significant problems with the present design concepts for the ITER heating beams and the DNB that impact active spectroscopy diagnostics. Specs for the heating beams are very demanding and unlikely to be met without significant R&D and specs for DNB look impossible. The group agreed that a report from a USBPO Task Group of experts would be very helpful.

### **3. What are the consequences of resolving these issues, or not, in the next ~10 years?**

The impact of not resolving the issues mentioned above is generally the inability to meet measurement requirements defined by ITER physics needs. Led by R. Boivin, the group had a discussion of the development, within the ITPA, of the measurements requirements and a requested review of changes recently recommended by various ITPA physics groups. Several group members said the requirements table was too simple, and would benefit from a more nuanced approach, e.g. with different requirements for machine protection than for physics studies. D. Johnson then pressed a need to more formally document whether presently defined ITER diagnostic techniques meet the requirements. Both the requirement definition and the performance assessment would benefit from US expert participation through the USBPO Task Groups.

### **4. What issues should be resolved by a successful BP experiment?**

K. Young explained that successful diagnostic experience on ITER will form the basis for planning to diagnose DEMO. With its more severe environmental constraints and more stringent reliability requirements, a reduced set of diagnostics is envisioned for DEMO. Ken advocated a dedicated diagnostic test port plug in the test blanket evaluation phase late in ITER's life to prototype DEMO diagnostics.

### **5. What contributions can/should the U.S. fusion program make to resolving these issues?**

First mirror survivability is a key ITER diagnostics issue. C. Skinner and J. Brooks (supported by material from D. Rudakov) presented examples of ways that US experts could contribute to a world-wide effort to understand and mitigate risk in this area. Parallel efforts are needed involving measurements on existing fusion devices, development of modeling tools that use the experimental data to develop predictive capability, and development of mitigation techniques. These include ITER compatible shutters and baffles, and the development of in-situ mirror cleaning and calibration technologies.

D. Johnson presented examples of how concepts developed in support of each of the

US-allocated ITER diagnostics could be prototyped on US fusion devices. He suggested that the USBPO could facilitate this involvement.

New diagnostic techniques will be needed to fill gaps in presently planned capability and ITER relevant development is urgently needed for the 'uncredited' diagnostics. The US has traditionally played a strong role in development of diagnostics. The "transport initiative" had a significant impact on our field. D. Markevich sent a slide mentioning her initial thinking on a workshop to discuss BP diagnostic development needs in the context of ongoing development for the base program. The group thought such a workshop would be beneficial, and suggested possibly scheduling it during the May, 2006 HTPD meeting in Williamsburg. She also sent a slide reminding the group of the need to ramp up the number of graduating PhDs in our field, due to anticipated increased retirement rates and ITER and NIF needs. This led to a discussion of how the BPO could encourage university participation in diagnostics BPO tasks and in providing US in-kind diagnostic contributions.

#### **6. How should the BPO be structured to best help the community make these contributions?**

The break-out group endorsed the proposed USBPO structure, with a topical group in diagnostics and various focused diagnostic task groups. There was consensus on a need for clarification of the communications channels between BPO, ITPA, DOE and IPO.

Several suggestions were made without consensus:

- have topical group meetings at APS and HTPD meetings
- have a Diagnostics Topical Group member assigned to interact with each of the other TGs to push issues coming out of requirements definitions and performance assessments
- diagnostics task groups should work for topical groups rather than reporting to Directorate

Candidate Diagnostic Task Groups recommended were:

- review revised ITER measurement requirements (initial review to be discussed at May HTPD meeting in Williamsburg) and perform initial assessment of performance with planned techniques
- ITER first mirror survivability
- DNB feasibility, heating beam issues
- review CODAC conceptual design
- lost alpha conceptual design
- diagnostic performance simulation tools

The first two tasks were considered the highest priority.