ITPA Topical Group on Diagnostics
Report on Activities in theperiod July 2008 – June 2009

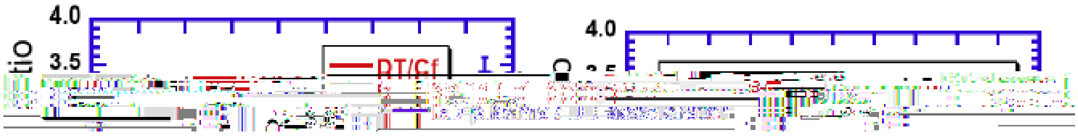
The coordinated activities of the Topical Group on Diagnostics were continued over the period of July 2008 to June 2009, with an emphasis being placed designated high priority topics. There were two meetings of the ITPA Topical Group (TG) on Diagnostics during that period.

1. Meetings of the Topical Group on Diagnostics

The Fifteenth Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by ITER-India and the Institute for Plasma Research and held in Ahmedabad, India, from 17 to 20 November 2008. The meeting was combined with a Progress Meeting on ITER relevant diagnostic developments in India, which took place on 7 November. The meeting was opened by Prof. A. Sen, Deputy Director of IPR, and was attended by 53 participants drawn from India (24), EU (17), Japan (2), Russia (3), USA (3), and the ITER IO (4). A special attention was given to the formulation of work plans for the High Priority Items.

The Sixteenth Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by the Efremov and Ioffe institutes in St-Petersburg, Russian Federation, from 20 to 24 April 2009. The meeting was combined with a Progress Meeting on ITER relevant diagnostic developments in the Russian Federation, which took place on 20 April. The meeting was opened by Prof. M. Petrov, Director of the Plasma Physics Division, Ioffe Institute, and was attended modifications are being evaluated. Orbit calculations will be continued which would include a quantification of alpha particle populations in the relevant orbits.

It was agreed that a significant push on orbit calculations along with detection efficiency is required in order to assess the possibility of direct loss detection. An evaluation of activation techniques is continuing but is likely to lack time resolution. This would require the introduction and removal of samples from the vacuum vessel after a certain number of discharges. This high priority activity will continue.



These preliminary findings were described at the 16th meeting during a special session dedicated to the topic. A final report of these findings is scheduled for the 17th meeting in October 2009. This will close this HP item, although it is expected that discussions would pursue for the foreseeable future, until probably its final implementation.

2.3. Determination of life-time of plasma-facing mirrors used in optical system

The report of the Specialist Working Group on First Mirrors gave an overview of all activities in the field of first mirrors. Much ITER-diagnostic specific research is in progress at many laboratories worldwide, but in general more solution-oriented research is needed and should be supported. More refined geometries are continuously being introduced for predictive modelling, although gas/plasma background conditions need considerable refinements. The efforts in this field should be intensified and accelerated to serve the rising needs. Further progress was reported in the field of deposition mitigation (e.g. by flowing gas in front of the mirror) and mirror cleaning, coated mirrors, mirror manufacturing and irradiation testing of mirrors. With the progress accomplished so far, it was agreed that the development of mitigation methods for metallic (beryllium, tungsten) deposition is fast becoming urgent.

A roadmap to direct the international R&D in the field of first mirrors has been prepared and has been further detailed and evolved in special break-out sessions during both TG meetings. The road map is now actively used to direct the international research in the field of first mirrors and the priority of these activities has been established and agreed upon. One step proposed is to cluster the various diagnostic mirrors in groups with approximately the same functional requirements and operational environment in order to recommend baseline solutions for each group on the basis of present knowledge. Furthermore, it was agreed that candidate mitigation methods against deposition need to be reviewed to identify the most promising ones for further development.

Recent developments and research plans in the area of diagnostic mirrors were reviewed in the regular report of the FM SWG. The report outlined the progress in fulfilment of the Work Plan (WP) - the coordinated and prioritized plan of R&D on first mirrors.

The WP contains of 6 main areas (tasks):

- Performance under erosion-and deposition-conditions: material choice
- Predictive modelling of mirror performance in ITER
- Mitigation of deposition

- Cleaning of deposited layers on the mirror - surface recovery
- Tests under neutron, gamma and X-ray environment
- Engineering and manufacturing of ITER first mirrors.

The current research is already largely aligned with the areas of the work plan. In particular, promising results were presented on active control over carbon deposition in diagnostic ducts and remote areas – the complete suppression of carbon deposition was attained in the prototype of diagnostic duct by the deuterium gas feeding in the duct interior. Encouraging results were achieved on the cleaning of mirrors exposed in tokamaks: softer carbon films formed on the surfaces of the mirrors exposed in the divertor of DIII-D were cleaned completely and the reflectivity was restored, whereas harder films originating from TEXTOR were largely removed leading to the significant increase of the mirror reflectivity. Large work on the irradiation testing is started in various Russian and EU institutions. Promising results from laser cleaning were reported from HL-2A tokamak where Nd:YAG laser was used to remove carbon deposits. Applicability of these techniques to ITER conditions should be assessed.

A new task has been undertaken to assess the present risk associated with First Mirror failures (erosion/deposition) and their impacts of diagnostic performance. Preliminary findings were based on three main criteria, wavelength of interest, location, solid angle sustained by the mirror. By assigning a risk level (high, medium, low) for each criterion, one could then identify the high-risk areas (systems) and direct resources to address the most urgent cases. The preliminary findings using this approach were presented at the 16th meeting, and will be constantly refined as understanding if progressing in this area.

2.4. Development of measurement requirements for measurements of hot dust, and assessment of techniques for measurement of hot dust.

Recent studies and discussions with the ITER Organization reached the conclusion that the inventories for dust and tritium are expected to reach their maximum limits on a timescale comparable to the target erosion lifetime. Based on this, a control strategy for dust and tritium has been formulated. Dust will be removed during the scheduled divertor replacements (approximately every 4 years). Additionally the dust will be monitored during and before shutdowns. Local measurements will be benchmarked versus the tritium and dust recovered during the replacement of the divertor cassettes. The first benchmarking will be done in the hydrogen phase.

Over the last year, a few additional diagnostics were enabled in ITER for measuring dust and erosion. They are the divertor erosion monitor, removable samples (dust generation), micro-balance (dust) and laser induced desorption (tritium). With this, the HP items related to the measurement of cold dust and erosion were completed. An outstanding issue remaining is the measurement of hot dust, for which a finalization of the requirements is still underway. Techniques to address these needs have not been identified. This HP item thus remains.

2.5. 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.

There is a growing consensus in developing an approach based on the bidirectional reflectance distribution function (BRDF), which widely used in other fields, for standardization of reflection coefficients. The specular reflectance lobe is the most difficult part of the reflectance behaviour to characterise. Using model functions established in the rendering community (i.e. virtual reality models used, for example in computer games), it appears that this lobe is not very important for extended sources like bremsstrahlung, but would be for localized sources

Representatives of the ITPA Party Teams (PTs) reported steady progress for many diagnostic techniques that are ITER relevant. It is clearly evident that many scientists working on diagnostics in the various PTs are becoming more aware of the problems and challenges of implementing diagnostics on ITER. This is again demonstrated by the large attendance to both meetings. Emphasis in the presentations is now shifting from detailed integration and implementation as needed in fulfilling procurement arrangements to more generic issues, including impacts of the selected design on scientific capability.

4. Specialist Working Groups

The seven Specialist Working Groups (SWGs) continue to work in a focussed manner in their specific fields (beam-aided spectroscopy, spectroscopy, reflec

Appendix 2

PROGRESS REPORT on the ITPA Joint Experiment Proposal
Resolving the discrepancy between ECE and Thomson Scattering at high T_e

E. de la Luna

Contributors: M. Austin, K. Beausang, A. Dinklage, L. Figini, R. Fischer, E. de la Luna, F. Orsitto, S. Prunty, S. Schmuck, C. Sozzi, A. White.

This report summarized the work carried out in this topic during the first half of 2009. Good progress has been achieved on the simulation of Thomson scattering data. Comparison of two codes for the calculation of incoherent Thomson scattering spectrum has been carried out and agreement has been found. One code has been written by K. Beausang (Cork University, Ireland) and the second one by S. Schmuck (IPP, Geisfswald). However no new experimental results have been obtained to date. One experiment to investigate the effect of ion tails on electron temperature measurements in JET (E. de la Luna and C. Sozzi) was included in the main JET programme during the C26 campaign (Jan-April 2009). Two sessions were scheduled but, due to technical reasons (lack of availability of the ICRH plant in one session and lack of density control due to problems with the cryoplant in a second session), none of the goals of the experiment were achieved.

1) Progress to date on the Thomson scattering data simulations (K. Beausang, Cork University)

The theoretical equations used in the JET core LIDAR TS system were studied in detail and it is agreed that all relativistic effects have been accounted for and therefore contain sufficient accuracy to be used in the analysis of high temperature plasmas. Particular attention has been given to the effect of non-Maxwellian electron distributions on the JET TS results and the possible temperature error induced as a result of their presence.

A model of the LIDAR TS electron temperature and density fitting procedure has been developed, which can be used to evaluate the theoretical TS signals in the six spectral channels for an arbitrary electron distribution function. These theoretical signals can then be compared with experimental TS signals in an attempt

- FT-U: There are plans to carry out high power density ECRH experiments.

Although the work on ECE and Thomson scattering data simulations has made good progress in the last year there is still very little progress on the modelling of the interaction between the fast ion tails generated by ICRH with the bulk electrons. The availability of new data from any of experiments proposed above would be very beneficial to stimulate advances in the theoretical understanding of the observed discrepancy.

Appendix 3
Members of the ITPA TG on Diagnostics 2008-2009

PARTY	FAMILY NAME, FIRST NAME	AFFILIATION
CN	Fan, Tieshuan	PKU
CN	Hu, Liqun	ASIPP
CN	Yang, Qinwei	SWIP
CN	Zhao, Junyu	ASIPP
CN	Zhong, Guangwu	SWIP
EU	Beurskens, Marc	UKAEA
EU	Donné, Tony	FOM
EU	Ingesson, Christian	F4E
EU	Koenig, Ralf	IPP
EU	Murari, Andrea	ENEA
EU	Serra, Fernando	IPFN
EU	Weisen, Henri	CRPP
EU	Zoletnik, Sandor	HAS
IN	Pathak, Surya K	IPR
IN	Rao, CVS	IPR
IN	Vasu, P	IPR

Ala /P <</MCID 30 >>BDC 160965 0 Td (IPR

US	Brower. David	UCLA
US	Hillis, Don	ORNL
US	Johnson, Dave	PPPL
US	Stratton, Brent	PPPL
US	Terry, Jim	MIT