ITPA Topical Group on Diagnostics
Report on Activities in the period 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 on 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 by 71 participants drawn from Russia (29), EU (21), India (4), Japan (7), Korea (1), USA (4), and the ITER IO (5).

In addition to the special sessions topics, the key topics reviewed and discussed at the TG meeting were:

- Progress and plans in meeting the goals of the Physics Voluntary R&D tasks in Diagnostics and especially the high priority topics;
- Developments in the ITER measurement requirements and justifications of these measurements;
- Review of critical areas of ITER diagnostic design and integration;
- Recent progress in ITER relevant diagnostic development and application in the Parties;
- Review the status of key elements of ITER diagnostic design and integration;
- Review the responses to the action items from the previous meetings of the ITPA Diagnostic TG and plan future actions;
- Review progress by the Specialist Working Groups in Diagnostics;
- Discussion on the date of the 17th meeting and location of the 18th meeting of the TG;
- Future activities.

2. High Priority Topics

Good progress has been made in the tasks designated as high priority:

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

2.1.1. Escaping α-particles

One key task that was identified over the last year corresponded to the need to identify proper alpha particle orbits that can reach a potential detector. These orbits were calculated in 2 scenarios, and show that a smooth/flat outer wall would prevent a direct detection of particles. Options including wall

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.

2.1.2. Confined α-particles

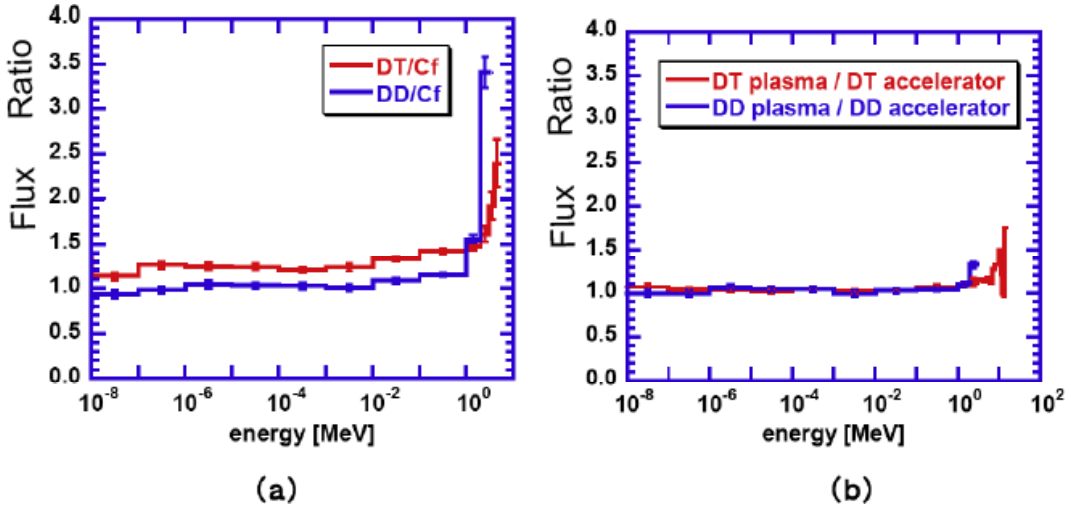
The status of the ITER fast ion Collective Thomson scattering system has been changed to enabled system, which covers the front end interface at this time. As part of the changes arising from the design review process, the in-port components of this system are included in the revised ITER diagnostic system. In view of this change, the work on confined α-particles has been moved to intermediate priority. The work will focus in further developing the CTS concept and continue proposing alternate techniques.

2.2. Assessment of the calibration strategy and calibration source strength needed

The Neutron Working Group has further developed the calibration strategy and begun to specify the needed source strength of the calibration source. Also the necessity and location of the neutron test area have been further evaluated. Calibrations with a neutron source mounted in the vacuum vessel were will be required and a determination of the optimum number of calibration points is now approaching a conclusion point. This determination requires numerical simulations which are time consuming and subject to changes in ITER overall configuration. Even with the best calibration strategy that can be devised and implemented, extensive modelling using neutronics codes will be needed to correct for the heavy support structure of the neutron generator and other components that needs to be moved within the vacuum vessel. In addition these simulations will be needed to account for any changes to the machine structure that occur after the calibration, e.g. additional port plugs.

Neutron transport calculations were performed to study the effect of the calibration source spectrum on absolute measurement of fusion output by neutron detection, to evaluate the effect of neutron emission profile change, and to estimate the calibration time. In this approach, the micro fission chambers were used as the typical detector. Other detectors are more sensitive and will require less calibration time.

A Cf source can be used for the calibration in DD energy region, but not in DT energy region (See Fig. (a)). However, DD/DT generators give more accurate calibration results. Self-shadow effect of the accelerator itself was evaluated for a DD/DT generator of the size such as ING07 (10^{10}n/s), and overall the effect appears to be small (See Fig. (b)). These effects will require corrections based on MCNP calculations.



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 effort 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 main 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 for 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, and 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 within 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 such as edge emission. The modelling calculations remain to be confirmed by measurements on at least one set of completely characterised tiles in order to study whether or not in-situ checks of the evolution of the reflectance with exposure to plasma discharges are possible. Since the wavelength dependence of the reflectance is different from that for bremsstrahlung, measuring at several wavelengths should help to assess the impact in the experiment. For edge emission, imaging should be supported by Zeeman spectroscopy to localise the true source of the emission.

Recently, measurements and modelling have been performed for IR measurements (3-5 m) on Tore-Supra. Without this analysis, false readings of temperatures can be made on internal surfaces and introduce serious errors in protection schemes based on thermographic measurements. Further work is needed to standardize this approach for ITER, and to have a data bank of reflectivity coefficients for a variety of materials.

2.6. 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. This task aims at assessing these needs, and identifying any gaps in the associated proposed techniques.

Of particular interest is the need for measurements between discharges (e.g. wall conditioning, gas composition, erosion, etc), at breakdown (e.g. null structure, impurity levels, etc), at the ramp-up phase (density, current profile, etc), and ultimately at the ramp-down phase (e.g. density, radiation levels, etc).

We plan a special session on this topic at the Fall meeting where a wide experience exists from existing devices. Inputs from new devices (e.g. EAST, KSTAR) would be particularly important in this aspect.

2.7. Summary on High Priority Issues

We continue to have good and steady progress in the HP items. Nevertheless, dedicated support by all parties is required for timely completion of these tasks, especially in supporting dedicated work on first mirror issues. In addition to reviewing the progress with the high priority topics, progress with the intermediate and long-term tasks has also been reviewed.

3. Party Reports

During the Progress Meetings on ITER relevant diagnostic developments in India (combined with the 15th meeting) and in Russia (combined with the 16th meeting) Indian and Russian scientists, respectively, presented their work on a large variety of diagnostic systems in preparation for ITER. Many of these presentations were directly related to the high priority research topics of the TG.

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, reflectometry, Thomson scattering, neutron diagnostics, first mirrors and radiation effects). Good progress was reported by the SWGs for many of the current action items. Most of the work described above under the high priority issues has been the result of the coordinated effort within the various SWGs. The work on many action items has been completed and a number of new action items were formulated at the meetings.

The update of the SWGs has been undertaken this year. The working groups were realigned and new leadership has been selected in many groups, while retaining sufficient "institutional" memory to carry through important tasks. Five groups remained largely the same (active spectroscopy, passive spectroscopy, neutrons, first mirrors, and radiation effects). Two groups were broadened (microwave- formerly reflectometry, and laser-aided diagnostics – formerly Thomson scattering). Finally, an eighth group was formed (First wall diagnostic) in order to cover an area where experts are needed. Together, the realignment was needed in order to better fulfil the needs for ITER, while remaining more attuned to generic burning plasma diagnostic issues.

Table 1 summarizes the selection of chairs, and co-chairs. In a similar way than last year changes to the topical groups, a second co-chair has been identified in the IO diagnostic group in order to facilitate communications between the SWGs and the IO.

SWG	**Chair**	**Co-Chair**	**IO Co-Chair**
Active Spectroscopy	N. Hawkes (EU)	S. Tugarinov (RF)	D. Thomas
First Mirrors	A. Litnovsky (EU)	V. Voitsenya (RF)	D. Thomas
First Wall	C. Skinner (US)	D. Rudakov (US)	R. Reichle
Laser Aided	M. Walsh (EU)	Y. Kawano (JA)	G. Vayakis
Microwave	G. Conway (EU)	M. Austin (US)	V. Udintsev
Neutrons	M. Sasao (JA)	S. Popovichev (EU)	L. Bertalot
Passive Spectroscopy	B. Stratton (US)	W. Biel (EU)	R. Barnsley
Radiation Effects	B. Brichard (EU)	T. Nishitani (JA)	C. Walker

Table 1. Chair and co-chairs for the Specialist Working Groups (July 2009)

5. Progress in other fields

5.1. Protection of diagnostic in presence of large microwave fields (ECH)

The presence of high power microwave energy within the tokamak from ECH sources could create additional hazards to diagnostics, which are not limited to microwave-based diagnostics. The first version of a microwave protection plan has been elaborated by the SWG on reflectometry.

Stray (unabsorbed) microwave radiation generated during off-normal tokamak operation will have a major detrimental impact on the ITER microwave based diagnostics, such as reflectometry and ECE. Stray

radiation can arise from non or poorly absorbed ECRH/CTS gyrotron beams (e.g. low plasma density during breakdown assist, exotic heating schemes or fault conditions) as well as from fast/runaway electron generated Bremsstrahlung during breakdown and disruption events. Moderate radiation will cause signal corruption, while at extreme levels sensitive semiconductor detectors and waveguide components face destruction from power overload, cavity arcing and thermal heating. Other non-microwave diagnostics and in-vessel components also face potential damage.

Standard microwave protection techniques employed on present-day machines, such as waveguide isolators and filters, may not be suitable for ITER applications due to the unprecedented levels of stray radiation expected in ITER. In addition, several protection systems may be required in parallel to cover different fault conditions and different diagnostic weaknesses. Various protection options for ITER are proposed; these include fast-acting waveguide shutters, hardened filters, fuses or sacrificial elements and exotic radiation absorbing materials and gases. However, some options will require extensive R&D. A particular high priority is the development of high power rejection filters. Effort must also be devoted to the development of simulation and prediction codes for calculating individual diagnostic exposure levels. Use should also be made of experimental high power microwave test facilities/stands to expose and identify diagnostic weaknesses for hardening prior to tokamak installation. A fuller risk-assessment of the frequency and degree of fault generating, as well as the inherent, stray radiation is also needed to define the appropriate response and degree of protection to be expended.

5.2. Data Analysis and Validation

Efforts are continuing in developing techniques for the data analysis of data sets encountered in present and future fusion experiments, including ITER. It is expected that the amount of data generated in each ITER discharge can exceed present-day approaches of data analysis and/or handling. A variety of issues are envisioned, such as fault conditions, pattern recognition, large data set handling, etc. These issues lend naturally to the necessary data validation and processing for advanced control, as expected to be developed and required in ITER.

5.3. International Diagnostic Database

The activity in the International Diagnostic Database has been relatively low. Only a few diagnostics have been added. The IN PT has started an analysis of the data in the IDD for a number of different diagnostics. First results of the analysis were shown at the 15th meeting, and further analysis of the International Diagnostic Database is scheduled for the 16th meeting.

5.4. Joint ITPA/IEA Experiments

The Joint ITPA/IEA experiments in the field of diagnostics were discussed in both meetings.

Multiple experiments on first mirrors are in progress and are reported in Sec 2.3.

A joint experiment to resolve the discrepancy between measurements made by ECE and Thomson scattering that occurs at high temperature under some conditions was launched by the end of 2007. First results of this activity were reported at the EC-15 workshop in March 2008 in Yosemite, USA. A full report can be found in appendix 2.

A new joint experiment is being further developed which includes the design, fielding and testing of capacitance micro-balance in existing devices. This diagnostic aims at measuring cold dust contents and is

presently scheduled to be installed in ITER, but it lacks testing in fusion devices. Details in regards to this proposal were not available at the 2008 Joint Experiment Meeting (MIT, December 2008), and a full proposal will be made at the next meeting in late Fall 2009.

6. Publications

Three papers co-ordinated by either the TG or by the SWGs have been accepted for poster presentation at the IAEA Conference on the following topics: progress in HP issues, first mirrors, and on Thomson scattering. Also a paper from the IO on the implementation of diagnostics systems on ITER has been accepted.

An overview of other publications by the ITPA TG on Diagnostics is included as Appendix 1.

7. Plans for Future Meetings

The 17th meeting of the Diagnostics TG has been approved and will be held in Pohang, Korea from 12 - 16 October 2009. Postech has kindly offered their support to act as host. A special session will be held on the assessment of the measurement requirements for plasma initiation (HP#6). The meeting will be combined with a Progress Meeting on ITER Relevant Diagnostic Developments on-going in Korea. The 18th Meeting will be scheduled for May of 2010 in the US in conjunction with the High Temperature Plasma Diagnostic Conference.

8. Final Note

After numerous years of loyal and dedicated services in support of the ITPA and ITER expert groups, Dr. Alan Costley has stepped down as the co-chair. We are very much indebted to him and thank him for all his tireless efforts.

R.L. Boivin
H. Park
A. Costley
G. Vayakis

15 July 2009

Appendix 1
Publications by the ITPA TG on Diagnostics 2008-2009

Publications in peer-reviewed journalswww

- Litnovsky, V. Voitsenya, T. Sugie, G. De Temmerman, A.E. Costley, A.J.H. Donné, K.Yu. Vukolov, I. Orlovskiy, J.N. Brooks, J.P. Allain, V. Kotov, A. Semerok, P.-Y. Thro, T. Akiyama, N. Yoshida, T. Tokunaga and K. Kawahata, *Progress in research and development of mirrors for ITER diagnostics*, Nucl. Fusion **49** (2009) 075014

Presentations at the 2008 IAEA Fusion Energy Conference, Geneva, Switzerland

- A.J.H. Donné, A.E. Costley, for the ITPA Topical Group on Diagnostics, *Key R&D activities for ITER Diagnostics,* Paper IT/P6-20

- M. J. Walsh, M. N. A. Beurskens, T. Hatae, D. Johnson, E.E. Mukhin, R. D. Scannell, G. Vayakis, *Performance evaluation of ITER Thomson scattering systems,* Paper IT/P6-25

- A. Litnovsky, V. Voitsenya, T. Sugie, G. De Temmerman, A.E. Costley and A. Donné, *Progress in research and development of mirrors for ITER diagnostics,* Paper IT/P6-22

This list does not include individual papers published by members on specific ITER diagnostics. Many additional publications and presentations were made at the IAEA meeting, HTPD conference and Varenna meeting on diagnostics, and other various diagnostic workshops held during that period. That list is too long to describe in details here and are summarized in the working groups reports.

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 to identity the best representation of the electron distribution function for a particular plasma condition.

For the JET core LIDAR TS diagnostic, the theoretical TS signals, based on a Maxwellian velocity distribution, are fitted to the experimental signals to estimate the electron temperature and density. Work is currently being carried out to fit theoretical signals based on a number of different distributions to the experimental signals using the above model with the aims of identifying the best fit and, as a result, the possible error induced by assuming a Maxwellian distribution. The various distribution functions utilised include a bi-maxwellian (a sum of two Maxwellians), a Lorentzian (a 'tailed' distribution) and a non-Maxwellian bulk distribution. The non-Maxwellian bulk distribution was proposed by Krivenski [Fusion Engineering and Design 53, 23-33 (2001)] based on an analysis of the ECE spectra measured by the Michelson spectrometer at JET over several harmonics for a particular case where a TS/ECE discrepancy was observed. It was suggested that a 'flattening' of the Maxwellian profile in the low energy region could possibly cause the discrepancy but a neither physical mechanism responsible for such a distortion has yet been identified nor physics consequences of the flattening have been assessed.

The work for the near future is to use experimental signals for the analysis of a number of JET pulses in which the TS/ECE discrepancy is observed and compare with the results obtained in pulses where the discrepancy is not observed. It is hoped that the results of this analysis will highlight if a deviation of the distribution function from a Maxwellian could explain the discrepancy in the temperature measurements. For this analysis the database published in the 15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (10-13 March 2008, Yosemite National Park, California) by E. de la Luna will be used.

Plans for future work

Collecting more experimental data is still one of the main priorities if we want to progress in the understanding of this topic. Several experimental proposals are still on the list, although they are not included in the main program of the different machines and therefore it is not guaranteed they will be given the required experimental time. The proposed experiments are:

- JET: Experimental proposal to study the effect of ion tails on T_e measurements (it is still in the backup list of the C27 campaign)
- DIII-D: Experimental proposal (back-up experiment) to study the T_e discrepancies between ECE and TS in high T_e plasmas (low-density discharge with NB plus fast wave heating.)

- 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
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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
IO	Barnsley, Robin	IO
IO	Costley, Alan	IO
IO	Vayakis, George	IO
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