ITPA Topical Group on Diagnostics
Report on Activities in the period January 2012 – November 2012

The coordinated activities of the Topical Group on Diagnostics were continued over the period of January 2012 to November 2012, 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 Twenty-second Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by the Kurchatov Institute from May 14 thru 17, 2012. The meeting was combined with a Progress Meeting on ITER relevant diagnostic developments in Europe, which took place on May 23rd 2011. The meeting was opened by Dr. K. Vukolov and was attended by 49 participants drawn from EU (8), Japan (5), Korea (2), RF (30), USA (2) and the ITER IO (2). Due to entry visa processing time, participants from China, India and a few others had a problem obtaining the entry visa in time.

The Twenty-third Meeting of the ITPA Topical Group (TG) on Diagnostics was organized by the ITER-India/IPR from November 27 thru 30, 2012. The meeting was combined with a Progress Meeting on ITER relevant diagnostic developments in India, which took place on November 27th 2012. The meeting was opened by Dr. P. Vasu, and was attended by 37 participants drawn from EU (4), Japan (1), Korea (1), RF (1), India (28) and the ITER IO (1). Increasingly, the entry visa processing time became an issue for this meeting and participants from China, US and a few others had a problem obtaining the entry visa in time.

A special attention was given to the High Priority Items. In addition to the special sessions, 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, and their physics implications;
- Recent progress in ITER relevant diagnostic development and application in the Parties;
- 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 24th meeting and location of the 24th meeting of the TG;
- Future activities.

2. High Priority Topics

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

2.1. HP#1: Development of methods of measuring the energy and density distribution of escaping α-particles

The key task in this task is to identify a proper diagnostic systems for both confined and lost alpha particle In presioud meeting, extensive calculation on orbits that can reach a potential detector and possible techniques applied to the devices up to now. However, most of the techniques employed in fusion devices will not be applicable to ITER due to the harsh wall conditions. In this course of exercise, many elements of the techniques for measuring lost alphas has been intensively discussed over the last

several meetings have been documented and the assessment can be completed with some more effort to document the measurement feasibility (achievable S/N, time resolution etc.). A few new proposals for the lost alphas as well as the confined alphas were discussed at this meeting; 1) the idea of reciprocating probe with the detector inside requires further detailed engineering study due to uncertain reliability and feasibility of features such as active cooling below ~350°C on ITER. Possible implementation schemes are being explored. This idea has a limited time resolution. The measurement technique based on activation is also lacking sufficient time resolution. 2) A method to achieve a reliable information on the confined alphas using NPA measurements of the fast neutralized knock-on D^+ and T^+. There was some concern expressed on whether, if these pre-feasibility studies turn out to be sufficiently promising, ITER is able to integrate any of these systems within the planned diagnostic ports.

This high priority activity will continue.

2.2 HP#2: Determination of life-time of plasma facing mirrors used in optical system

The First Mirror Working Group reported significant progress on several tasks of the Working Plan (WP), including test results from AUG and international efforts on various operating devices. A First exposure of diagnostic mirrors for ITER in a tokamak with all-metal plasma-facing components was successfully performed in AUG. Four molybdenum and four copper mirrors were installed in pairs: at the high field side above divertor baffle, under divertor dome facing the inner and outer target plates and at the entrance to the pump-duct near the divertor. The mirrors were exposed for 945 discharges in the divertor configuration. After exposure the degradation of reflectivity was detected on all mirrors. Mirrors in the pump duct almost preserved their reflectivity unlike mirrors in the dome facing the outer divertor. These suffered from the highest deposition and the strongest reflectivity degradation. Remarkably, only on the mirror facing the inner divertor and having very thin deposition layer of 15 nm, the carbon fraction was about 50 %. On all other mirrors this fraction did not exceed 20 %. The exposure of diagnostic mirrors in the tokamak with all-metal PFCs demonstrated a positive trend to reduction of net deposition and minor changes in the reflectivity of mirrors located in the pump-duct far away from divertor plasmas. However, the degradation of all exposed mirrors underlines the necessity of an active mirror recovery. Urgent R&D is needed to address the lifetime issues of mirrors in ITER divertor. This activity is being made in the collaboration of ASDEX Upgrade and TEXTOR teams in the frame of IEA ITPA Joint Experiments Program, task DIAG 2 with the help and support of the ITPA TG of diagnostics and the IO.

The international activities became clearly focused on the critical directions of work plan of the first mirror R&D: material choice of diagnostic mirrors, deposition mitigation and mirror cleaning and industrial mirror manufacturing. The facility for the mirror plasma exposure both under erosion- and deposition- dominated conditions is commissioned in Basel. The facility is featuring the *in-situ* reflectivity measurements and control over surface composition. Multi-machine tests of industrially produced coated mirrors are started as a collaboration program of CEA IRFM, University of Basel, IPP Kharkov, FZJ, DIFFER and other partner laboratories. The produced mirrors demonstrated very good uniformity of their optical properties over their surface.

Large actively-cooled coated mirrors with a diameter of up to 10.9 cm are produced. Significant success was attained in the manufacturing of a large single crystal molybdenum mirrors. A single crystal, industrially produced molybdenum mirror with a diameter of 10 cm was exposed under erosion-dominated conditions in TEXTOR tokamak in the framework of collaboration between FZJ and Kurchatov institute. The mirror demonstrated superior reflectivity properties after the exposure.

Results of laser cleaning of mirrors were reported for hydrocarbon and Alumina deposits (positive) as well as B_e deposits (negative). The poor results with B_e are attributed to an over-long laser pulse, so further tests with shorter pulses are needed. The system of exchanging sealed capsules containing Be-contaminated mirrors was proven effective, thus allowing round-robin tests of Be-coated mirrors in multiple facilities.

Assemblies of diagnostic ducts with various duct geometries to mitigate the impurity deposition - the so-called "Mirror stations" were manufactured by FZJ and are being installed in several tokamaks for the experimental benchmarking of ITER mirror codes. Some of the ducts are protected with shutters. This effort is made in the frame of IEA ITPA Joint Experiments program, task DIAG 2 and involving TEXTOR, DIII-D, ASDEX Upgrade and EAST tokamaks. This HP item will remain.

2.3. HP#3: 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. Effects of reflections were discussed in the case of the IR/visible survey system, especially in the divertor area. Derived local temperature can appear much higher when reflections from a hot surface onto the target are included. Studies of the H_α system were also presented, showing typical levels of reflected divertor emission two orders of magnitude above direct emission observed from equatorial views of the inner wall. Viewing dumps and/or techniques employing Zeeman splitting were identified as mitigation options.

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 (ECH) radiation, from the W7-X testing facility (MISTRAL) were presented. In the case of bolometers, it was found that shielding the detectors (foils) with 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 (reach the appropriate level). Many further tests are planned on key internal components, including cabling (e.g. MI cables). However, it is clear that the remaining issues are an accurate estimation of ECH loads and development of the protection methods from stray ECH powers for the diagnostic systems and in-vessel components of ITER. This HP item will remain.

This HP item will remain.

2.4. HP#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. No significant progress was reported at this meeting. This HP item is closed.

2.5 HP#2 (New): Assessment of the Plasma Control System measurement requirements.

This is a new High Priority item that has been added in this meeting and development of the plasma control parameter measurement requirements in conjunction with the ITPA Integrated Plasma Control Working Group which develops the ITER PCS system, is the main objective of this mission.
When the neutral beam source is tilted for off-axis injection, the presently planned MSE coverage may miss the core region of the plasma (r/a<0.3). Performance assessment of the current profile measurement based on two methods (Motional Stark Effect (MSE) and Faraday rotation based on poloidal array) was carried out for cases of both on- and off-axis injection.

3. Party Reports

During the Progress Meetings on ITER relevant diagnostic developments in Moscow (combined with the 22nd meeting), and in Gandhinagar (combined with the 23rd meeting), and Korean, Japanese, European, US and Chinese 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 the 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 and development of alternate techniques.

4. Specialist Working Groups

The eight Specialist Working Groups (SWGs) continue to work in a focussed manner in their specific fields (active spectroscopy, passive spectroscopy, neutrons, first mirrors, first wall, laser-aided, 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 SWGs include now more than 200 participants distributed amongst all parties and the IO.

Table 1 summarizes the current list of chairs, and co-chairs (December 2011).

SWG	Chair	Co-Chair	IO Co-Chair
Active Spectroscopy	N. Hawkes (EU)	S. Tugarinov (RF)	M. von Hellermann
First Mirrors	A. Litnovsky (EU)	V. Voitsenya (RF)	R. Reichle
First Wall	C. Skinner (US)	D. Rudakov (US)	R. Reichle
Laser Aided		Y. Kawano[1] (JA)	G. Vayakis
Microwave	G. Conway (EU)	M. Austin (US)	V. Udintsev
Neutrons	S. Popovichev (EU)	D. Darrow (US)	L. Bertalot
Passive Spectroscopy	B. Stratton (US)	W. Biel (EU)	R. Barnsley
Radiation Effects			C. Walker

Table 1. Chair and co-chairs for the Specialist Working Groups (December 2011). [1] Expected to be replaced over the next year

5. Progress in other specific fields

5.1. Current profile measurement Issues

Concerns continue to be raised for the capability of measuring current profiles during ramp-up (see also HP#6). Extensive simulations were presented for the expected performance of the poloidal polarimeter system. Two aspects were discussed: the first one concerns the measurement of the current profile during ramp-up, and the second one relates to the performance of the system with reduced number of chords. For the first aspect, it was recognized that the current profile during ramp-up would likely be measured by the polarimeter. For the second aspect, although the loss of some polarimeter chords can be accommodated, the loss of the upper port view may jeopardize the system, especially while considering constraints added to the MSE system (e.g. beams).

5.2 Coherence imaging and divertor flow measurements

First results of the coherence imaging technique on TEXTOR and DIII-D have been obtained. This technique allows the extraction of ion temperature and rotation velocity across a 2-D field using charge exchange emission. The technique is also being applied the analysis of the polarisation characteristic of MSE emission, again in two dimensions. As well as the extra physics information available from 2-D measurements, this technique offers the possibility of excluding parts of the image, which can be polluted by reflected light. This could be applied to presently unmet flow measurement requirements in ITER.

5.3 Fuel ion ratio measurements

Much progress has been reported in the last few years regarding the needed measurements of the ion fuel ration during D-T discharges. In the past these measurements appeared to be very difficult to perform. The proposed techniques for measuring the fuel ion ratio include neutron spectrometry, collective Thomson scattering, and CXRS. Each technique exhibits limitations, although perpendicular CTS probing may be possible through ion Bernstein excitation.

The collective Thomson scattering (CTS) group at Association EURATOM-Risø DTU, Denmark, has demonstrated that the isotopic composition (or fuel ion ratio in reactors) can be inferred from CTS diagnostic measurements. Under certain measurement geometries the CTS spectrum becomes sensitive to ion Bernstein waves and ion cyclotron motion, which in turn is sensitive to the ion species in the plasma. The proof-of-principle measurements were done at the TEXTOR tokamak in collaboration with FOM and Forschungszentrum Jülich, and is an important step towards a new diagnostic method, able to measure the fuel ion ratio spatially (approx 200 mm) and temporally (approx 100 ms) resolved in the core of a burning plasma. The ^{3}He content in the plasma were inferred from the CTS spectra and found to be consistent with values obtained from passive spectroscopy.

5.4 Microwave systems

A report (ITER_D_33ZRFR / MWG-55F-0902) was prepared on the generic calibration and test requirements of the ECE/Reflectometer microwave transmission system. The report highlights the importance for all ITER diagnostics to have established test and calibration procedures. For the generic antenna/waveguide transmission line systems of the microwave-based diagnostics the report identified some 18 specific sets of procedures and tests to be performed before, during and after the diagnostic system installation. These include testing and documenting individual component performance (to allow subsequent monitoring of component degradation) as well as the antennae and overall system performances. The diagnostic safety features (such as stray radiation protection) and the specific in-situ

calibration hardware will also require periodic testing for correct functionality.

The MWG also presented the results from ASDEX-upgrade on the proof of performance of the position reflectometer technique. Results showed reasonable control of the plasma radial position, in L and H-mode conditions.

5.5 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. Particular attention is being devoted to calibration, data validation, prediction and automatic identification of events (for the management of large databases).

5.6 International Diagnostic Database

The activity levels of the International Diagnostic Database have been relatively low. Discussions are presently onging between the IO and the TG in regards to long term plans for the database.

5.7 ITPA TG web site

The migration of the TG web site to its new home at ITER is progressing well. We are continuing to transfer the large number of files from the previous meetings to the new location, including more general documents of interest to the group. The access point for the web site can be found at https://portal.iter.org/departments/FST/ITPA/DG/DIAG/default.aspx . The presentations and other files are behind individual usernames and passwords.

5.8 Joint ITPA/IEA Experiments

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

Headings, spokepersons and devices are detailed in Appendix 2.

DIAG-2, which covers first mirror tests and mitigation techniques, has been already covered within HP#3.

A joint experiment (DIAG-3) 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 last year. New results from C-Mod have been reported, under a variety of RF heated heating schemes (minority heating and mode conversion heating). No discrepancy has been observed up to T_e<8keV.

DIAG-4 covers the test of capacitance micro-balances in tokamaks (AUG and KSTAR). This diagnostic aims at measuring cold dust contents and is presently scheduled to be installed in ITER, but lacks testing in fusion devices. No experimental data is available yet, but operation of these balances is expected in 2012.

DIAG-5, which proposes the test of (fast ion) activation probes, has not been taken by any device at this stage.

Discussions are ongoing for the possible inclusion of a new Joint Experiment (DIAG-6), which would involve operating devices with no or reduced set of inner wall magnetics.

6. Publications

Two papers co-ordinated by either the TG or by the SWGs have been presented at the 2010 FEC IAEA Conference on the following topics: progress in HP issues, and first mirrors. Also a paper from the IO on the implementation of diagnostics systems on ITER has been presented. New synopses, presently four, are being prepared for the 2012 FEC IAEA conference to be held in San Diego, USA. They are:

- *Overview of the ITPA TG diagnostics activities* – by H. Park and the TG
- *Overview of the First Mirror development activities* – by A. Litnovsky and the First Mirror SWG
- *Overview of microwave diagnostic design and selection* – by G. Conway and the Microwave SWG
- *Analysis of current profile measurement capability on ITER* – by R. Imazawa et al.

Titles and authors are tentative at this point. A companion paper is expected from the IO on *Progress in ITER diagnostic* (author TBD).

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

7. Plans for Future Meetings

The 24th meeting of the Diagnostics TG has been approved and will be organized by the GA, USA from 4 - 7 June 2013. A special session will be held on the assessment of the measurement requirements for plasma control (HP#2). The meeting will be combined with a Progress Meeting on ITER Relevant Diagnostic Developments on-going in Russia. The 24th meeting is tentatively scheduled to be held at IO on the Fall of 2013.

H. Park
Y. Kawano
G. Vayakis

15 January 2012

Appendix 1
Publications by the ITPA TG on Diagnostics 2011-2012

Publications in peer-reviewed journals

- A. Litnovsky, M. Matveeva, A. Hermann, V. Rohde, M. Mayer, K. Sugiyama, K. Krieger, V. Voitsenya, G. Vayakis, A.E. Costley, R. Reichle, G. De Temmerman, S. Richter, U. Breuer, L. Buzi, S. Moller, V. Philipps, U. Samm, P. Wienhold and ASDEX Upgrade Team, *First studies of ITER diagnostic mirrors in a tokamak with all-metal interior-results of first mirror test*, Paper ITR/P5-42

Presentations at the 2012 IAEA Fusion Energy Conference, SanDiego

- H. K. Park, Y. Kawano, G. Vayakis, M. Beurskens, G.D. Conway, N. Hawkes, A. Litnovsky, S. Popovichev, B. Stratton, C.H. Skinner for the ITPA Topical Group on Diagnostics*, Overview of the ITPA R&D Activities for Optimizing ITER Diagnostic Performance,* Paper ITR-

- R. Imazawa, Y. Kawano, M. F. M. De Bock, F. M. Levinton, N. Hawkes, M. Beurskens, P. J. McCarthy, C. Watts, R. Barnsley, M. Von Hellermann, H. Park, G. Vayakis, R. Boivin, D. Johnson,Y . Kusama, M. Walsh, *Analysis of current profile measurement capability on ITER, Paper ITR-*

- G.D.Conway1, G.Vayakis2, V.S.Udintsev2, M.E.Austin3, G.R.Hanson4, A.Stegmeir1,W.A.Peebles5, V.Petrov6, T.Estrada7, and the ITPA Microwave Specialist Working Group*, Overview of ITER microwave diagnostic design and selection, Paper ITR-*

Internal reports submitted to ITER IDM system

This list does not include individual papers published by members on specific ITER diagnostics or non-ITPA R&D. Many additional publications and presentations were made at the IAEA meeting, HTPD conference 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

ITPA Joint Experiment Diagnostic Tasks

DIAG-2 **Environmental tests on Diagnostic First Mirrors (FMs)**

DIAG-3 **Resolving the discrepancy between ECE and TS at high T_e**

DIAG-4 **Field test of a Capacitance Diaphragm Gauge as a Dust Monitor for ITER**

DIAG-5 **Field test of an activation probe (new)**

DIAG-2 Environmental tests on diagnostic first mirrors

Spokes person: **A. Litnovsky**

Key persons: **I. Orlovskiy (T-10), A. Litnovsky (TEXTOR), Th. Loarer (Tore-Supra), M. Rubel (JET), D. Rudakov (DIII-D), J. Chen (EAST, HT-7), A. Herrmann (AUG), N. Ashikawa (LHD), C.Skinner (NSTX), V. Voitsenya, Y. Zhou (HL-2A), V.Kumar (Aditya), G. Maddaluno (FTU), G. De Temmerman (MAGNUM PSI).**

Devices: **T-10, TEXTOR, Tore-Supra, JET, LHD, AUG, FTU, NSTX, HL-2A, Aditya, EAST, MAGNUM PSI**

Purpose and goals:

Mirrors will be used in all optical and laser diagnostics in ITER to observe the plasma radiation. The performance of respective diagnostics will rely on the characteristics of mirrors outlining the need in high-performance robust mirror solutions for ITER. Recently, the prioritized work plan (WP) of the R&D on diagnostic mirrors was developed. The aim of the WP is to provide the set of measures to be fulfilled to ensure the maximum lifetime of the high-performance mirrors in ITER – to enable the so-called baseline mirror solution. The WP consists from six main directions – tasks:

- **Performance under erosion- and deposition- dominated conditions: material choice;**
- **Modeling of the impact of plasma, neutral and neutron environment on optical properties of diagnostic mirrors;**
- **Mitigation of deposition;**
- **Cleaning of deposited layers;**
- **Tests under neutron, gamma and X-Ray environment;**
- **Engineering and manufacturing of ITER first mirrors.**

DIAG-3 Resolving the discrepancy between ECE and TS at high T_e

Spokes person: A. White

Key persons: M. Austin (DIII-D), T. Hatae (JT-60U), A. Isayama (JT-60U), F. Orsitto (FTU), S. Prunty (JET, UCC), C. Sozzi (JET, CNR), W. Suttrop (ASDEX-UG), G. Taylor (TFTR), A. White (DIII-D, C-Mod)

Devices: JET, JT-60U, ASDEX-UG, DIII-D, FTU and TFTR (using old data)

Status: **Continued**

Background: In auxiliary heated high-temperature plasmas in JET and TFTR, clear discrepancies (up to several tens of %) have been measured between the electron temperatures measured by electron cyclotron emission (ECE) and Thomson scattering (TS). The discrepancy (in plasmas without ECCD or LHCD) has been seen in JET with ICRF plasmas, above electron temperatures of ~5 keV, and at TFTR in ICRF+NBI plasmas above 7 keV. No discrepancy has been found at C-Mod for ICRF plasmas up to ~8.5 keV. No evidence of deviations from a maxwellian distribution of the bulk electrons has been seen at DIII-D in NBI+FW plasmas up to 9.5 keV, or in ECRH +NBI plasmas up to 15 keV.

DIAG-4 Field test of a Capacitance Diaphragm Gauge as a Dust Monitor for ITER

Spokes person: E. Veshchev (previously P. Andrew)

Key persons: S. H. Hong (KSTAR), A. Herrmann (AUG).

Devices: KSTAR, AUG

Status: **Continued**

Purpose and goals:

The ITER dust strategy includes monitoring local dust levels in the bottom of the machine (under divertor targets). The aim is to correlate local levels with dust removal activities in early phases of operation to get some indication of dust inventory during operation.

A microbalance based on a capacitive diaphragm principle has been investigated as a diagnostic method, and has the advantage of measuring directly measuring the weight of the dust. Although this technique has shown promise in controlled laboratory tests, it has never been tested in a tokamak environment where thermal cycling and a noisy electromagnetic environment can affect the measurement.

Local dust monitors have been proposed for ITER and these are nominally expected to be of the capacitive diaphragm microbalance type.

The object of this joint experiment would be to demonstrate the operational functionality of a capacitance diaphragm gauge in existing devices.

DIAG-5 Field test of an activation probe

Spokes person: G. Bonheure

Key persons:

Devices: NEW

Status: **NEW**

Background

Measurement of energetic ion losses (e.g. alphas) remains difficult, and alternatives are sought for ITER. A number of techniques have been proposed and are being considered. The performance and reliability of the standard ion loss measurement techniques based on direct particle detection are questionable as the detectors will have to operate in the harsh ITER first wall environment. New and more robust techniques need to be developed in order to minimize risks and increase measurements' reliability.

Recent experimental studies on JET [1] have shown that a technique based on charged particle in-vessel activation is able to generate absolute measurements of fusion proton loss. The same technique could be developed and used for measuring the loss of alpha particles in ITER.

Appendix 3
Members of the ITPA TG on Diagnostics 2010-2011

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		
EU	Donné, Tony	FOM
EU	Ingesson, Christian	F4E
EU	Koenig, Ralf	IPP
EU	Litnovsky, Andrey	FZ-Jülich
EU	Murari, Andrea	ENEA
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	Vayakis, George	IO
JA	Itami, Kiyoshi	JAEA
JA	Kawahata, Kazuo	NIFS
JA	Kawano, Yasunori	JAEA
JA	Kusama, Yoshinori	JAEA
JA	Mase, Atsushi	Kyushu Univ.
JA	Peterson, Byron	NIFS
JA	Sasao, Mamiko	Tohoku Univ.
KO	Lee, HG	NFRI
KO	Lee, JH	NFRI
KO	Lee, SG	NFRI
KO	Nam, YU	NFRI
KO	Park, H	Postech
RF	Kaschuk, Yu	TRINITI
RF	Krasilnikov, A	RF DA
RF	Ljublin, B	Efremov Institute
RF	Petrov , M	Ioffe Institute
RF	Vukolov, K	Kurchatov Institute
RF	Zaveriaev, V	Kurchatov Institute
US	Allen, Steve	LLNL
US	Boivin, Réjean	GA

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