Summary of the 2nd Joint Meeting of the ITPA CC and the IEA CTP ITER Organization, Cadarache, France, 5-7 October 2011

M. Shimada

I. OPENING SESSION

David Campbell, Yutaka Kamada and Myeon Kwon welcomed the Participants.

DG Motojima gave a presentation titled 'Innovations of ITER in Physics and Technology'. He first expressed his acknowledgement to the retiring Chairs of Topical Groups and the retiring IO Deputy, Wayne Houlberg. He then gave an overview on the ITER Project.

Since the IC-8 in June, the IO has focused its priority on the ITER Project Schedule Strategy through the Special Task Group (STG) in close collaboration with the Members. The new Level-0 Reference Schedule has First Plasma at the end of 2020 (one year delay) and DT Operation in 2027 (no delay). The IO proposes to install a W-divertor for 1st plasma (first priority), ~60 MW heating for 1st plasma, and to defer installation of some components and systems from the construction to the operation phase (potential items: elements of heating systems, T-Plant, Hot Cell Tools, ELM/VS coil & PS, and TBM).

Based on the work of the STG, the IO is now able to propose the schedule improvement strategies for the mitigation of schedule delays; in parallel, the IO has also developed the Lifecycle Project Cost Plan for the construction period. With the support of the IC-9 and the endorsement of the Members for the STG schedule strategies and the IO Lifecycle Project Cost Plan, and the three-year budgets, the IO will be able to maintain the momentum of the development of the project. As of end October 2011, the IO has a total of 469 staff members with 298 professional and 171 technical support staff members.

There has been on-going progress in the licensing process of the ITER Project. The final meeting of 'Groupe Permanent', a formal group of independent experts put together by ASN to analyze the safety of Nuclear Installations undergoing a licensing process took place on 30 November 2011. Following the formal positive acceptance of the ITER files by the French Environmental Authority, the Enquête Publique, (Public Enquiry) was organized by the French Authorities between 15 June and 4 August 2011 in 13 towns and villages surrounding Cadarache. On 19 September, the Public Enquiry Commission officially issued its Advisory Opinion, which was 'Favourable'. This is also a major step for the licensing process. On 20 July 2011, the Regulator made an inspection of the supervision carried out by the IO for the construction work. Their conclusion was also very positive; they underlined the robustness of the quality system developed by the IO and its full consistency with the French Quality Order 84.

Since IC-8, steady progress has been made on the construction site. Construction of the PF Coil Winding Building will be completed at the end of 2011. Excavation for the Tokamak Complex was completed in summer 2011 and the associated concrete works have been commenced by EU-DA. Construction of the Permanent ITER Headquarters Building by Agence ITER France is approximately 70% complete and on-schedule for completion in summer 2012. This building will house approximately 500 ITER staff. Delivery of the 500 seismic isolation bearings has commenced and these are being installed on the seismic isolation plinths in the Tokamak Pit On-site drainage, road networks and construction infrastructure have commenced under a contract awarded by the EU-DA. Construction of the 400 kV switchyard has also commenced on the ITER platform by the French Electricity Network (RTE), and is managed by the Host State via Agence ITER France.

Y. Kamada presented a brief report on the status of ITPA and ITPA activities. ITPA involves 305 scientists from 65 institutes. Its mission is to contribute to ITER R&D and the ITER

Research Plan. ITPA organizes and promotes Joint Experiments, Databases and Modelling validation and forms Working Groups to address urgent issues. New Chairs and Deputy Chairs of Topical Groups were introduced. Wayne Houlberg is retiring from the IO in March. He joined ITER Physics R&D efforts in 1994. In his remarks, he said that Physics R&D is a fundamental part of the ITER Design and Construction and will evolve into operation.

DG Motojima requested that the ITPA coordinate its meetings with the calendar of IC, STAC and MAC so that the meeting dates do not fall on the busiest time for the IO staff.

II. RESEARCH NEEDS OF ITER

D. Campbell reported on progress in the ITER Research Plan and ITER Physics R&D needs.

The implications of deferrals and recent design decisions for the ITER Research Plan development are being assessed. For the heating and current drive capability there is reduced headroom for achieving H-mode in the non-active phase, but current estimates indicate helium H-mode access remains viable at half-current and field. The foreseen H-mode and ELM-control testing programme remains possible, subject to results of on-going physics R&D. The diagnostic installation programme is being adapted to ensure required measurement capability is available as required by the experimental programme. Recent calculations indicate that new scenarios can be developed to mitigate possible performance limitations of the central solenoid CS3L module. The use of a tungsten divertor from the start of the non-active phase will necessitate adaptation of plasma scenarios, and adequate mitigation measures against transient heat loads will be required.

The project's decision to give priority to installation of a tungsten divertor from the start of the experimental programme gives added urgency to R&D in this area (IC-9 recommendation delays final implementation of the decision for up to 2 years). This will require: demonstration of robust integrated scenarios – power load control in long-pulse operation over range of scenarios by low-Z seeding; development of helium plasma scenarios (H-modes, ELM control); examination of impurity generation and core contamination in ELM-controlled regimes; assessment of the effect of divertor target damage on device operability; evaluation of fuel retention with all-metallic walls – the role of material erosion and migration; and dust generation.

Further emphasis is required on model validation activities. Better characterization and understanding of rotation of halo current asymmetries following disruptions / VDEs is needed, e.g. processes determining the current quench time and extrapolation to ITER, improved quantitative analysis of disruption heat loads, improved physics basis for choice of disruption/RE mitigation techniques, improved understanding of processes influencing confinement and losses of REs. An improved physics basis for ELM control requires exploitation of extended RMP coil capabilities to improve specification of requirements for ELM control in ITER, as well as studies of potential 'alternative' ELM control techniques.

The experimental validation of ITER plasma scenarios entails validation of revised current ramp-up scenarios on a tungsten divertor and the development of hybrid / steady-state scenarios with their implications for H&CD upgrades. We need to extend the physics basis for helium H-mode operation, understand 3-D ripple effects such as produced by TBMs and RMP coils, and improve the diagnosis of hydrogenic retention and dust production.

There have been several recent ITPA contributions to the ITER design and physics basis. The results of ITPA R&D activities have provided a substantial physics basis for the ITER design over the past decade, which has been formalized in the report 'Progress in ITER Physics Basis'. ITPA database activities have been fundamental to establishing guiding physics principles for the tokamak design (e.g. the H-mode threshold and H-mode confinement). The disruption database has provided crucial input to the ITER Load Specification and

Preliminary Safety Report (RPrS – licensing documentation). Supporting R&D implemented through the ITPA made an important contribution to numerous aspects of physics analysis during the ITER Design Review: the ‘Plasma Performance Assessment’ and ‘Heat and Nuclear Load Specifications’. The ITPA has been active in supporting IO's responses to Council's Charges to specific STAC Charges – the scope of the ITPA R&D activities has been essential to building a substantial physics case for ITER's approach to resolving key physics issues in these areas. IC-9 has issued a Charge to ITER STAC for the STAC-12 meeting in May 2012 which includes, inter alia, the following request: ‘Assess whether the worldwide research program on carbon and tungsten divertors, including tritium-retention and transient heat loads, is sufficient for making a timely decision on the ITER divertor, and suggest improvements in the program’.

The ITER Research Plan will also be revised to reflect in greater detail the implications of deferrals and design decisions. Input from the ITPA on key aspects, such as operation with all-metal walls, disruption mitigation, ELM control, H-mode access and plasma scenarios would be invaluable. A work programme is being drawn up to prepare reports in response to this Charge, with a deadline around end-April 2012. ITPA experts are welcome to contribute to the preparation of these reports.

The 24th IAEA Fusion Energy Conference will take place in San Diego in October 2012. As at previous conferences, the intention is to organize an ITER session integrating contributions from the IO, ITER DAs and ITPA. An ITER review committee will be established by IO and ITER DAs to review synopses and make recommendations for oral presentations. The ITPA TGs are welcome to submit papers to the ITER session. ITPA papers submitted to ITER session should be endorsed by TG Chair. A formal announcement of conference deadlines is not yet available, but based on previous experience, the deadlines for the ITER system would be (approximately):

- Submission of synopsis to ITER review committee: mid-February 2012 (following all necessary clearance).
- Recommendation by review committee: early-March 2012.
- Submission to the conference website: start-April 2012.

In discussion following the presentation, M. Wade confirms that up to the initial DT operation ITER only uses one divertor and that up to the DT phase, the exhaust gas will be stored to be processed during the DT phase. B. Lipschultz suggested a more detailed list of issues to be addressed in relation to the tungsten divertor. (IO will prepare this for the ITPA Divertor and SOL TG meeting in January). The DG welcomes the research plan proposal to start from the tungsten divertor. E. Tsitrone and B. Lipschultz pointed out there are concerns about starting with a full tungsten divertor. D. Campbell commented that the non-active phase should be used as much as possible to address the open issues, such as disruption loads, runaway electrons and mitigation schemes; the exact scenarios of testing should be developed in the coming years. E. Strait asked for constraints on the disruption tests. D. Campbell commented that there will be a practical limit on how much material one can inject for disruption mitigation; the turn-around time after disruption mitigation should be shorter than ~3 hours; DG Motojima commented that a sufficiently robust scenario to mitigate disruption should be developed. N. Oyama commented that ELM experiments should be supported by the Programme Leaders. S. Ide asked whether we should continue to develop scenarios with full CS capability. D. Campbell commented that the analysis that has been done even with conservative assumptions suggests that we can still achieve 300-500 s burn duration (the precise burn duration depends on parameters such as the current ramp-up rate, as well as the heating power and Z_{eff} during the ramp-up phase). Since IC-9 made the recommendation to build the CS3L module from the existing CSJA2 conductor while developing an improved conductor for the remaining modules, IO is following this strategy. So, this should be the basis of further scenario analysis. The DG stresses that no reduction in scope is foreseen. R. Boivin commented that the impact of deferral of diagnostics will be analysed. G. Vayakis commented that the change of the divertor material does not impact on the diagnostics.

III. TOPICAL GROUP ANNUAL REPORTS, JOINT EXPERIMENT REPORTS 2011 & JOINT EXPERIMENT PROPOSALS 2012

3.1 Divertor and SOL (B. Lipschultz)

The task groups address 5 major PWI priority areas:

1. Tritium retention and removal (leaders: R. P. Doerner, K. Schmid).
2. Tungsten (leaders: A. Kallenbach, Y. Ueda).
3. Dust (leaders: N. Ashikawa, D. Rudakov).
4. Heat fluxes to plasma-facing surfaces (leaders: M. Lehnen, A. Leonard).
5. Material migration (leaders: V. Philipps, P. Stangeby).

Steps forward have been made in a number of areas:

- First attempt to bring molecular dynamics modellers into the ITPA activities, notably for the analysis of retention and damage experiments.
- Studies of tungsten fuzz characteristics and effects.
- Tungsten melt dynamics, effects on the plasma and properties of damaged material.
- Allowable heat load limits for tungsten under large numbers of ELM-like heat pulses.
- Advances in scaling SOL parallel power e-folding widths for both limiter and divertor plasmas.
- Examination of efficiency of flash heating of surfaces for T removal.
- Modelling and experiments for understanding material migration and lifetime limit.

D. McDonald pointed out that heat load widths compared with Goldston theory show some vertical scatter and suggested that this might be indicative of some missing physics in the model. Y. Kamada asked about the status of the modelling effort in divertor detachment, which has previously been discussed at ITPA CC meetings. B. Lipschultz replied that indeed there is such activity underway but that major discrepancies still remain between experiment and modelling. He pointed out also that this has knock-on effects in the capability to properly model material migration, since many of the experimental studies of the latter are conducted in partially detached or detached scenarios. M. Wade pointed out that no further joint experiments have been proposed inside the DivSOL TG with regard to heat flux scaling and asked why not. R. Pitts replied that at present all experiments (including the activities inside the US Joint Research Task) have concentrated on inter-ELM, attached (hot) divertor conditions to reduce the complications due to divertor dissipation and ELM averaging when extrapolating divertor power loads back upstream to the main SOL. At present we are still not at the position where we have thoroughly studied the existing data and come to some conclusions regarding either its validity and self-consistency and more work is required here before requesting more machine time. In the meantime, emphasis should be placed rather on the ELM-mitigated (ergodized) edge, where very little data exists and yet this is a regime in which ITER expects mostly to operate in H-mode. A question was asked about efforts on wall conditioning, about which nothing was presented in the DivSOL report. B. Lipschultz answered that this area was not part of the Helsinki meeting (the only DivSOL TG meeting in 2011) but that activities continue nevertheless (e.g. the usual ICWC work and high frequency GDC).

3.2 Diagnostics (R. Boivin)

The Diagnostic Topical Group has refocused its efforts, which are:

- Specific needs:
    - Unmet measurement requirements, e.g. divertor flows.
    - New developments/techniques.
    - Contribute to address physics issues encountered in CDRs & STAC.
    - Present day lost alpha detectors do NOT extrapolate to ITER.
    - JET experience showed that activation probes may contribute to measuring losses.
    - The mission of 10% accuracy of neutron calibration would require a functional link of several types of neutron measurements and well planned calibration processes.
- Mitigate environmental effects: radiation; deposition/erosion; and stray ECH and reflections.
- Integrate measurements for: the Plasma Control System and ITER operations aspects; and calibration and data analysis.
- DEMO specific issues.

V. Chuyanov asked about the status of hot dust measurement. R. Boivin commented that now the measurement requirements are being discussed. A. Kallenbach asked about the castellated wall for lost alpha diagnostics. R. Boivin replied that now a number of ideas are being discussed. Y. Kamada asked about whether it is reasonable to re-examine the requirements of measurements. R. Boivin commented that revisiting of requirements is carried out during the CDR (Conceptual Design Review). G. Sips asked the resolution of the divertor heat profile measurement. R. Boivin commented that the resolution is adequate for measuring the divertor heat profile.

3.3 Edge Pedestal (H. Wilson, N. Oyama)

New H-mode results were reported from EAST, which achieved H-mode with LH alone and LH +ICRF, and HL-2A, which achieved H-mode with ECH + NBI.

The structure of the H-mode pedestal was an area that received increasing attention. The EPED pedestal width model continues to perform well when compared with data. It agrees within 20% when compared to a wide range of tokamak data, and thereby provides a more reliable extrapolation of pressure pedestal height in ITER. Gyro-kinetic simulations aim to put the EPED model on a firmer theoretical basis. An extensive DIII-D and JET data set on pedestal width has been supplemented by AUG and C-Mod this year.

There are conflicting messages about inter-ELM pedestal evolution. In MAST the pedestal gradient is fixed and the pedestal width broadens. AUG also sees saturation of the pedestal height, but the width is difficult to assess; the density builds faster than the temperature. In DIII-D the pressure gradient broadens somewhat, and also increases, but notes that the electron density and temperature pedestals just broaden. In JET the gradient steepens through ELM cycle, yet the pedestal width narrows.

Several other aspects of ELM physics are being investigated. I-mode shows high confinement without the ELMs. Li coatings on NSTX improve the pedestal performance: 40% increase in confinement is found with suppressed ELMs. The ELM size prediction remains elusive. JOREK simulations show that broadening of the strike point increases for larger ELMs. ECEi images of ELMs on KSTAR reveal new physics: during the first three time slices, a precursor mode grows that is consistent with linear theory and is followed by a short saturated state, and then filaments begin to erupt.

New RMP ELM control results were reported from AUG: ELMs are mitigated provided the density exceeds a threshold. New RMP ELM control results from DIII-D show that low ν* ELM suppression is obtained in windows of q_{95} for n = 2. A scan in q demonstrates a resonance condition on DIII-D. ELM mitigation was established on MAST using RMPs with n = 4 or n = 6 on LSND discharges. Plasma braking is very much less on MAST with n = 6 RMP compared to n = 3. In KSTAR: ELM suppression by n = 1 when the magnetic perturbation is well-aligned.

Pellet pace-making experiments have focused on DIII-D activity. A new injector was installed on DIII-D this year (ITER-like geometry) and the triggered ELMs were investigated. Alternative ELM control strategies were explored on KSTAR; vertical jogs greater than 1 cm trigger ELMs and the ECH can increase ELM frequency at low ν* by factor ~2 (~20 - 40 Hz).

In relation to the results showing that the L-H transition power becomes higher with current ramp-up, M. Wade asked whether there is any constraint on the ramp-up. He agrees with closure of QH mode studies but recommends that the results of DIII-D be tested in other devices. A. Loarte says the closure is not due to lack of interest. Y. Kamada suggests that integration of the inter-machine experiments on vertical-kicks and L-H transition physics is necessary. He suspects that the edge current could play some role in the L-H transition physics. In response to Y. Kamada's comment that some of the PEP joint experiments could be combined to create fewer of them, H. Wilson agreed that this might be possible in some cases, but the strategy of the group had been to move towards well-focused experiments, with well-defined goals, that could be completed and closed in a relatively short time. D. Campbell asked whether the change of the heating mixture has some influence on ELMs. A. Kallenbach commented that the experiments done so far do not show any change in ELM behaviour with heating mixture. DG O. Motojima suggested formal publication of Annual Reports from the ITPA with publication lists. Y. Kamada commented that Annual Reports are written by all Topical Groups and are made available in the web page.

3.4 Energetic Particles (K. Shinohara)

Two TG meetings were held in Frascati and Austin in 2011.

As diagnostic capabilities to measure fast ion redistribution and loss have improved across a range of devices, so a consistent set of results for different modes has started to emerge in support of the joint experiments of EP-2. on EP3, experiments have been carried out in AUG and DIII-D. The data is being analysed. ENUS-GENE is ready to be used as a common interpretative tool, and LAPD and TORPEX provided further theory-experiment comparisons. Gyro-kinetic codes will be benchmarked in 2012. For EP4, experiments on LHD and MAST showed dominant bursting evolution of AEs when V_A/V_{crit} >> 1, in agreement with theory. A similar conclusion was made on AUG for TAE driven by the $V_{||,beam} = V_A$ resonance. Steady-state and pitchfork splitting of GAE with n = 0 were seen often on LHD driven by counter-NBI. Occasionally, TAEs with n = 1, 2 were also steady-state with injection of counter-NBI; a possible explanation is being sought. For EP-5, Test Blanket Module experiments on DIII-D revealed significant potential heating on the front surface of TBM tiles due to beam ion loss. ASCOT, F3D-OFMC and SPIRAL codes agreed well on heat load. For EP-6, data in AUG, DIII-D and LHD suggest fast-ion loss due to edge perturbations under conditions of magnetic perturbations.

A benchmark effort between linear and non-linear codes for the non-linear interaction of fast ions and AE modes is being pursued. A predictive modelling effort using F3D-OFMC calculations suggests significant deterioration of fast ion confinement due to magnetic field perturbations. Following an assessment of diagnostics needs, the EP TG unanimously endorsed adding the HFS-FS CTS to the ITER diagnostic set.

Planned TG meetings in 2012 are: Spring, NIFS, Japan (Mar 5-9) with the MHD TG and US-Japan MHD workshop; Autumn, San Diego (Oct 15-17), after the IAEA FEC.

F. Romanelli asked why transport by micro-turbulence will be important in Demo. K. Shinohara and A. Fasoli commented that the Demo in this study is a specific one and that although the beam energies are similar and alpha energies are the same between Demo (in this study) and ITER, the electron temperature is higher in Demo, which makes the slowing down time longer in Demo with more redistribution expected.

3.5 Integrated Operation Scenarios (S. Ide)

ITER scenario development is largely underway in the JEs, and even outside JEs advanced inductive/steady-state scenario development is on-going in many machines. ‘Hybrid’ operation, which means operation with broader current profile and improved confinement, beta and plasma current lower than the standard Q = 10 scenario, is now named ‘Advanced Inductive Operation’, to make a distinction from the original ‘hybrid’ operation, which means longer pulse operation (~1000 s) with significant current drive and low plasma current.

Some issues of actuators are covered in the JEs. Assessment and optimization of the ITER actuators have been intensively discussed for improvement in close collaboration with the IO. Some issues of integrated control are also covered in the JEs in support of the Integrated Plasma Control Working Group. Modelling is covered in a more organized structure, and is/will be contributing in scenario development, actuators and control. These joint experiments are showing good progress.

D. Campbell commented that due to the aggressive research plan during the non-active phase of ITER, the IO is keenly interested in developing the helium and hydrogen operation scenarios to make a research plan with assumptions well validated in the present experiments.

Integrated Plasma Control Working Group (J.A. Snipes)

The mandate of the ITPA IPCWG will determine the physics requirements of the actuators and diagnostics of the ITER Plasma Control System (PCS) to permit the PCS to carry out its control functions and to meet the goals of the ITER reference scenarios. Its deliverable is to produce a document for input to the PCS design describing the physics requirements of the PCS actuators and diagnostics at the conceptual design level sufficient to show their feasibility to perform the PCS functions. Its timescale is to deliverable detailed spread sheets at the April 2012 IOS meeting. A final report at the October 2012 IOS meeting is expected to be in time for the PCS CDR in late 2012. The report is planned to be presented at the April IOS meeting. The TG Chairs are requested to nominate the key persons by the first week of January 2012.

In response to Y. Kamada's inquiry, J. Snipes commented that the WG aims at developing the control requirements of the non-active, deuterium and DT phases.

3.6 MHD Stability (A. Sen)

Disruptions and disruption mitigation are being covered by 4 joint experiments (MDC-1, 15, 16, 17) and 4 working groups (WG-5, 6. 8, 10). A better understanding and identification of ITER needs are being obtained through detailed experimental comparison of the principal characteristics of heat loads in un-mitigated and massive gas injection (MGI) – mitigated disruption scenarios. Experimental measurements of radiation asymmetry following MGI have helped provide a provisional estimate of the upper limit to local radiation heat loads in ITER and a guideline for allocation of additional ports for MGI. Improved theoretical modelling of halo currents and VDEs show satisfactory agreement with experimental data and provide a better estimate of electromechanical forces on the ITER vacuum vessel. Disruption prediction based on discriminant analysis of data from a large number of tokamaks shows >90% accuracy in predicting edge cooling disruptions. The concept of suppression of runaway electrons (REs) through repetitive injection of gas jets in the current quench (CQ) phase shows promise from the point of view of a reduced requirement of total gas injection as compared to collisional damping schemes. On the basis of current successful experiments on DIII-D and other tokamaks there appears to be no fundamental obstacles to a full RE current ramp-down. The use of ECH/ECCD to postpone/avoid disruptions has been successful on many tokamaks. A status report on disruption mitigation research and the challenges that remain is currently under preparation and will be submitted to IO shortly.

MHD instabilities and active control are being addressed in 5 joint experiments (MDC-2, 4, 5, 8, 15) and 2 working groups (WG-3, 7). Efficient stabilization of RWMs has been achieved through active feedback coils, and the role of passive stabilization (kinetic effects) is being investigated through experiments and theoretical modelling. A combination of the two might provide the best approach. Experimental observations and modelling efforts show that 3-D magnetic perturbations can significantly influence MHD instabilities and their control and also lead to novel helical equilibrium states (snakes) in tokamaks. There has been good progress in modelling work to assess the capability of ITER ELM coils to stabilize RWMs. Real-time control and pacing of sawtooth activity using ECCD and the concomitant suppression of NTMs has been experimentally demonstrated. New scaling for error field thresholds for NTM excitation in H-mode plasmas has been obtained.

Plasma magnetic control is being explored in WG-9 and MDC-18. Error field calculations for ITER using both the ‘3-mode’ and the ‘overlap’ error field criteria show that error fields expected in ITER need to be reduced by about a factor of 4. Work is in progress to improve the estimates and to optimize strategies for their reduction. Experimental and modelling results show the importance of plasma amplification of error fields in high β plasmas as well as the role of rotation in determining the error field (EF) threshold. Neoclassical Toroidal Viscosity (NTV) measurements have yielded important results on non-resonant field effects and in assessing the comparative capability of the error coils and the ELM coils on ITER.

Diagnostic needs are being addressed by WG-4, which has prepared recommendations of diagnostic requirements for control of vertical stability, RWM, NTMs, error fields, sawteeth, ELMs, Alfvén eigenmodes, and disruptions, including structured diagnostic requirements, actuator requirements, open issues and IO comments. The Report has been submitted to the IO.

In response to a question from F. Romanelli, T. Strait commented that the highest priority issue in the control area is RWM control with the RMP coils. S. Putvinski commented that the Rosenbluth density for RE suppression has never been measured, but it can be estimated with the loop voltage during massive gas injection experiments. M. Wade commented that the data from DIII-D is consistent with the Rosenbluth density and the experiments in this area should be continued. Y. Kawano commented that stable RE beams were created in JT-60U and measurements of electron density, temperature and Bremsstrahlung were done, which will be useful for analysis. M. Sugihara commented that IO requests electron temperature, density and Z_{eff} data during the current quench phase. M. Wade commented that the TBMs are the major source of error field; their effect on plasma toroidal rotation has been observed and more efforts are encouraged in this area.

D. Campbell commented that the efforts in this area are very valuable. D. Campbell further comments that the leadership of A. Sen of the MHD Topical Group, especially the organization of the Working Groups which produced reports with specific recommendations, are greatly appreciated.

3.7 Transport and Confinement (S. Kaye)

High priority was given to the effort of Working Groups. Physics model validation during current ramp-up phases of ITER ‘demo’ discharges (AUG, C-Mod, DIII-D, JET) was covered under TC-20. Turbulence and transport in core-pedestal transition regime (‘noperson's land’) was examined by TC-10. A group on 3-D effects on transport and turbulence examined stellarator vs. tokamak studies, and focused on defining JEXs between stellarators and tokamaks. Impurity transport (TC-11) was another high priority area.

Medium priority areas included momentum transport and rotation drive, and electron transport.

The TG started 2011 with 16 JEX/JACs, and will close out of four JEX (TC1-4). On TC-1, a range of beta scaling was found in various devices; the best correlation was with ν^*. No dependences on shape, beta, n/n_G, W_{ped}/W_{th} were found. Is this due to different turbulent modes being dominant at different beta (micro-tearing at high beta)? Non-linear GYRO results indicate good agreement with ITG, but not TEM dominant plasmas (DIII-D). For TC-2, several devices (C-Mod, AUG, JET, NSTX, TCV, …) have successfully performed experiments related to access to the H-mode with good confinement while keeping the power close to the L-H threshold. In TC-3, it was well established that each device sees a critical density for $P_{th,min}$ (generally around $3\text{-}4\times10^{19}$ m^{-3} but higher in C-MOD). On TC-4, recent experiments in C-MOD confirm $P_{L\text{-}H}(He) >> P_{L\text{-}H}(D)$. Three new JEX/JACs are proposed for 2012, and one on 3-D effects in stellarators/tokamaks is being discussed for 2013.

A Momentum Database (M. Yoshida) is being developed with global and local parameters. This will enable gyro-kinetic calculations to study the source of momentum diffusivities and pinches. A poster/paper was given at the H-mode workshop. No progress since last year was made on the L-H Threshold Database (J. Hughes, Pedestal TG), so it is proposed to transfer the effort to the Pedestal TG. The Profile Database (C. Roach) was expanded to include data from impurity/helium transport experiments. It was used as the basis for impurity transport simulations by C. Angioni. The DB is presently inactive, but being maintained. The L-mode and H-mode databases are still being maintained by K. Thomsen.

D. Campbell commented that the confinement characteristics during the current ramp-up phase are very interesting from the IO point of view and asks about the availability of impurity profiles during the current ramp-up. S. Kaye commented that while it is critical to have good impurity profile data during the current ramp-up for the modelling, it is not always available. S. Kaye also commented that although the L-mode, H-mode and L-H threshold databases are not very active these years, they should be very useful for the emerging tokamaks (e.g. EAST and KSTAR).

IV. REPORTS ON THE STATUS AND PLANS OF DOMESTIC PROGRAMMES, INCLUDING DOMESTIC MECHANISMs FOR SUPPORTING ITPA AND RESPONDING TO ITER NEEDS

4.1 CN (G. Zhuang)

The mission of EAST is 1 MA high-performance steady-state (>400 s) operation with >30 MW of heating and current drive power and more than 50 diagnostics. It is to play a key role in the understanding of advanced plasma physics and the development of technology for ITER and DEMO under steady-state operation conditions.

Several new capabilities of EAST were realized in the last campaign. An ICRF system of 4.5 MW at 20-70 MHz (three power generators, two double straps antenna) was implemented. Several new diagnostics enhance the research capabilities, including: a Thomson scattering system (25 polychromators, 5 J YAG laser at 10 Hz); a 2-D soft-xray crystal spectrometer-XCS (toroidal view sight); two Fast reciprocating probe systems (toroidally separated); a 2-D

ECEI (modified and extended from an existing HT-7 system); SX arrays (for kinetic equilibrium reconstruction); and more (optic and spectroscopic diagnostics, neutron, gamma-ray, …). A new wall conditioning technique was explored (Lithium evaporation, Li powder dropper in collaboration with PPPL).

100 s long pulse divertor operation was attained by slowly sweeping the strike point for heat load control and recycling control with internal cryo-pump and lithium powder injection. A 6.4 s long H-mode was achieved with LHCD (1 MW) + ICRF (0.5 MW). H-mode duration was limited only by hardware. The threshold power of EAST LHCD H-mode agrees with the prediction of International Scaling; the power threshold is similar for I_p ramp-up and flat-top; there is a lower power threshold for I_p ramp-down; and good confinement was observed in a small ELM regime even with power close to the L-H transition threshold.

HT-7 also used lithium injection for recycling/impurity control and effective ICRF heating. A Material and Plasma Evaluation System has been installed on EAST.

4.2 EU (F. Romanelli)

An Independent Panel, appointed by the DG of Research, has reviewed the potential contribution of JET to ITER and strategic orientation of the EU fusion programme in Horizon 2020 (2014-2020). It found that JET: is vital for ITER; provided strong support to the full exploitation of the ILW plus a DT phase; and can possibly be further extended provided an international framework for JET exploitation is established. There is strong support to fusion as an energy source but the IP requested a profound restructuring of the organization of the EU programme. A working group is being set up to prepare a new organization. A Commission proposal for Horizon 2020 was presented on November 30. An agreement on ITER funds was reached on December 1.

JET has new capabilities: NB power from 20 MW/short pulse to 30 MW/long pulse routine operation (24 MW to 35 MW maximum); a high frequency pellet injector (50 Hz); Enhanced Radial Field Amplifier (already commissioned in 2009); and ~20 new diagnostic systems. Experiments during this phase will be at moderate input power. It aims to demonstrate sufficiently low fuel retention of the ITER-like wall. The assessment of the power handling of the ITER-like wall will include: transient events (documentation) of ELMs and disruptions; and control and mitigation of these transient events (applicable to ITER). JET will investigate beryllium and tungsten erosion, migration and deposition and material mixing. Development of ITER regimes of operation with the ITER-like wall will include control of impurities, the use of extrinsic impurities for power exhaust, and dedicated physics studies. It will prepare for ITER operation with all the control tools foreseen in ITER.

ECRH power in AUG will be further increased to 8 MW. The ICRH antennae will undergo modifications to demonstrate W-compatibility. 2×8 in-vessel coils in 2012 will allow n = 4. ECCD deposition will be feedback controlled from 2012 on. The pellet injection system has been upgraded to allow >100 pellets/discharge with freely programmable timing. HFS MGI valves show promising results. The divertor will be equipped with solid W-tiles.

Tore-Supra will enhance its heating and CD capability in 2011 and test RE suppression by high pressure fast gas injection. FIRE (Fast Injection by Rupture disk Explosion Technique) was successfully developed in 2011. FTU installed a new ECRH launcher for real-time control with 2 steerable mirrors. TCV demonstrated control of individual sawtooth period with ECCD. MAST demonstrated ELM mitigation with RMPs.

4.3 IN (P.K. Kaw)

Repair and refurbishment work of SST-1 has been completed. Operation of SST-1 will be resumed in January 2012. On the ADITYA tokamak, electrode biasing experiments were performed to investigate the underlying physics of L-H transition and experiments on RF heating and pre-ionization were carried out. ETG-driven turbulence is being investigated in LVPD. Theory and modelling activities include: VDEs and disruptions; flow effects on sawteeth; and interaction between ETG and eGAMS in the pedestal region.

4.4 JA (Y. Kamada)

Under the activity of the JA-DA for the ITER Project, JAEA signed the procurement arrangements for the TF conductor, TF coil structures, TF coil winding, divertor outer target and CS conductor. The fabrication of the TF conductor is now in progress. In parallel, the optimization of fabrication processes and trial fabrication of TF coil structure and TF coil winding are being conducted.

The Broader Approach activity, composed of IFERC, IFMIF-EVEDA, and Satellite Tokamak, are in progress as scheduled. All the research buildings in Rokkasho were completed in March 2010, and installation of ‘in-kind’ components has been started. By September 2011, nine procurement arrangements have been concluded for the Satellite Tokamak project (JT-60SA), and the fabrication of PF magnet conductor, vacuum vessel and materials of in-vessel components, etc. is now in progress. The JT-60SA Research Plan (SARP) is being developed under the collaboration with EU and the Fusion Energy Forum of Japan. JT-60SA will be equipped with NB (34 MW × 100 s) and ECRF (110/138 GHz, 7 MW × 100 s).

JT-60 experiments/data analyses and computer simulations contribute to ITER physics (ITPA) and the advanced tokamak physics for JT-60SA and DEMO. The TBM fabrication for ITER has progressed and the tritium recovery experiment was successfully performed. Gyrotron development is underway for JT60-SA; 31 s sustainment at 1 MW and 99 s sustainment at 0.3 MW; a dual frequency gyrotron is also being developed.

LHD has extended high temperature regimes (T_e up to 25 keV and T_i up to 7 keV). With RMP, the dynamic plasma response, the transition mechanism for magnetic island and edge radiation control are being investigated. The partial closed divertor has compressed the neutral gas to 0.7 Pa. LHD is making active contributions to the ITPA in collaboration research.

QUEST, the spherical tokamak in Kyushu University, is pursuing steady state operation. Divertor Simulation Experiments have been started by use of an end region of the GAMMA 10 tandem mirror. The characterization of the end plasma has been done. Making best use of the GAMMA 10 plasma, a new divertor test module will be installed in the end of this fiscal year.

4.5 KO (M. Kwon)

KSTAR H-mode is maintained for 5 s with an in-vessel cryo-pump. Roll-over of P_{th} at low density was observed. The ion temperature pedestal width is ~2.5 cm, and the toroidal velocity pedestal width is ~3.5 cm. Operation has been extended to higher β_N up to 1.8 in 2011. ELM mitigation with in-vessel RMP coils has been demonstrated. Application of ECH/ECCD on the pedestal plasma has increased the ELM frequency by a factor of two. ELM mitigation with Supersonic Molecular Beam Injection (SMBI) has been demonstrated. ELMs were triggered with vertical jogging. Large excursions triggered multiple ELMs. Initial test in Ohmic plasmas indicated that the error field in KSTAR may be very weak. Toroidal rotation was reduced by on-axis ECH in the H-mode plasmas. A start-up study with ECH was conducted. RE suppression by ECRH and RMP has been observed.

4.6 RF (N. Ivanov)

The participation in ITPA is considered as an essential part of the ITER activity. It is supported by Rosatom State Corporation. Responding to ITER needs is provided by the collaboration between the RF physicists and ITER IO as well as by the participation in ITPA.

T-10 experiments are carried out in Ohmic and ECRH discharges: spatial structure of plasma turbulence; plasma turbulence distribution by correlation reflectometry (CR); measurements of plasma potential, radial electric field and turbulence rotation velocity; plasma potential distribution by heavy ion beam probing (HIBP); experiments with lithium gettering; control of runaway electrons; ECR-assisted discharge start-up; and small magnetic island locking by error fields.

T-11M (TRINITI) conducted experiments with a liquid lithium limiter. Deuterium was recovered by heating to 500 ºC, suggesting that tritium can be removed from Li PFC by heating up to ~500 ºC. Globus-M (Ioffe Institute) conducted experiments on ion-beam driven instabilities and plasma start-up by RF. TUMAN-3M (Ioffe Institute) observed GAM evolution during the H-mode transition. FT-2 (Ioffe Institute) studied the spatial structure of GAMs. Tokamak T-15MD is being designed as a compact tokamak with flexible configuration with aspect ratio in the range of 2.2-3. The proposal to place the Italian tokamak IGNITOR in TRINITI by Moscow is under consideration.

Theory and modelling activities are continued in support of ITER in Kurchatov Institute, Efremov Institute, Keldysh Institute, TRINITI, SPbPTU, and Moscow State University. The integrated modelling program focuses on the ITER top priority issues, including disruptions, REs, VDEs, current ramp-up, ramp-down and ELMs. The modelling activities are coupled strongly to ITER engineering and diagnostics development. Future plans for theory and modelling include: continue supporting the ITER needs; code development for consistent simulation of disruption with REs in line with IMEG guidelines; supporting design and software development for diagnostic systems (Ha, NPA, neutrons – procured by RF); and cooperation with ‘virtual tokamak’ project – Moscow State University (code workflow, remote access, visualization, etc.).

In response to R. Pitts inquiry, S. Konovalov commented that DINA-SOL is an extension of DINA encompassing the SOL plasma.

4.7 US (S. Eckstrand)

The US is providing strong support for ITER construction and planning for operation. In-kind hardware contributions are on schedule, and US domestic research is targeted to ITER R&D needs. Impactful research is performed with US domestic fusion facilities – innovative diagnostic development coupled with theory/simulations for validated predictive understanding. DOE-FES is also the steward of general plasma science – fundamental plasma research and High Energy Density Laboratory Plasma. With FESAC advice, the US program anticipates enhancing international collaborations and fusion materials research.

Magnetic fusion burning plasma research is coordinated through joint research planning, including the national U.S. Burning Plasma Organization. The USBPO serves the community as the principal coordinating body for burning plasma (BP) research activities. It works with the ITPA, labs, USIPO, ITER, DOE, etc. The monthly BPO eNews newsletter has 542 subscribers. Community video/web seminars are conducted using ESnet H.323 and ReadyTalk, and activities are arranged at the annual APS-DPP conference. We are considering a Burning Plasma Workshop.

The DIII-D tokamak is the largest U.S. fusion experiment. It is operated by General Atomics Corp (San Diego) for 235 users (US and international, researchers and students). It has a highly flexible configuration, high-power heating (RF waves & beams), many diagnostics, a sophisticated control system, and strong coupling to theoretical studies. With these, it resolves ITER physics design issues, develops ITER operating scenarios and has been a pioneer in long-pulse, high-performance operation. DIII-D achieved stationary conditions in long pulse ITER baseline discharges at low torque. ELM suppression was demonstrated in the ITER baseline scenario (q_{95} = 3.14, β_N = 1.8, H_{89} = 1.8) with RMP. ELM pacing with 60

Hz pellets was demonstrated, showing substantial reduction in ELM size. High resolution data from the upgraded Thomson system enables detailed studies of pedestal evolution Runaway electron beam control allows for safe dissipation of beam energy.

NSTX is a 'compact' tokamak operated by Princeton Plasma Physics Laboratory as a collaborative facility for 145 users. Its tight-aspect-ratio magnetic geometry is ideal for studying electron turbulent transport and highly energetic ion dynamics, relevant to ITER. It has a very high ratio of plasma pressure to magnetic field pressure, which is also relevant to astrophysics. It is a candidate system for a future component testing facility. The first successful non-linear micro-tearing simulations for NSTX predict reduced electron heat transport at lower collisionality. Plasma characteristics change nearly continuously with increasing lithium evaporation inside vessel: global parameters (e.g. τ_E) generally improve; ELM frequency declines to zero; and edge transport declines and the transport barrier widens.

Alcator C-Mod (at MIT) has a very high magnetic field and compact size, providing the highest heat fluxes in the world to plasma-facing components. It conducts important dimensionless scaling studies relevant to ITER and future reactors. It has all-metal first walls, as planned for ITER. Its research emphasizes plasma-wall interactions and radio-frequency plasma heating methods. The research program is collaborative with many students (31 at MIT). Recent I-mode studies have expanded the operating range through changes in plasma shape and divertor topology. Tungsten 'fuzz' has been grown for first time in a tokamak experiment.

Recent theory/simulation research is highlighted by 3-D simulations of radio-frequency wave heating (NSTX), supported by DoE, Office of Science, Fusion Energy Sciences, SciDAC project.

H. Zohm suggested that the presentation style of the domestic programmes should be more uniform, focused on programmes rather than on physics results. Y. Kamada commented that he thinks that the style and content should be up to the representatives.

V. DISCUSSION ON THE JOINT EXPERIMENT PROPOSALS FOR 2012

A break-out session for Programme Leaders was arranged to discuss: the proposed list of Joint Experiments; identification and implementation of other experiments not on list of proposed experiments; and the level of prioritization or expectation of commitment by each device for the list of proposed joint experiments.

VI. WEBSITE

Relevant material has been collected from the IPP Garching site maintained by M. Maraschek since 2001. Additional material was collected from private files. All information is being organized in an HTML file for each meeting (participants, agenda, summaries) with links to reports and presentations. The meetings since the ITPA has been operating under the auspices of ITER (6/2008 to present) are all in this format except the Diagnostic TG meetings, for which the reorganization is still in progress. The conversion is being done as a voluntary activity by the Website Manager (W. Houlberg) and includes standardized organization and naming of presentations, and conversion of PowerPoint and Word files to PDF format for longevity and size reduction (53 meetings, ~2700 files, 3.7 GB). The reorganization of the meetings material since the beginning of the ITPA activity (9/2001-6/2008) is in progress.

Migration of Public material to the ITPA Public Website (on ITER Public Website) has some yet unresolved problems from the conversion to SharePoint 2010 (Publications, Meeting Calendar), which should be resolved in early 2012. The CC last year approved releasing Annual Reports, but these have not yet been migrated to the Public Website. Should TG Meeting Summaries be released to the Public Site? Discussion concluded that some of the

TGs include some information about unpublished work, so the complete summaries should not be public.

Presently, the CC and all TG Chairs and Deputies have read access to all internal sites. We would like to extend this privilege to all members of the POP Directorate and the Diagnostics Division in the IO. The Diagnostics TG has opened their site to all with ITER accounts. Ensuing discussion by the CC approved access to all ITPA material by POP and IO Diagnostics.

A new ITPA Website Manager will be needed 1 April 2012, unless the present Manager continues in a voluntary capacity.

VII. ACTION ITEMS

7.1 ITPA Database Access and Release Policies

Y. Kamada will circulate the draft policies among the ITPA CC Contact Persons.

7.2 Working Group on Particle Confinement (A. Loarte)

Activities of the ITPA Particle Working Group have had a slow start but they are now gathering momentum. Most of work done so far has been under the ITPA Pedestal Group but involvement of Divertor-SOL Group and Transport Group in 2012 will be required to progress further. Work in 2011 has already highlighted some issues and provided important output for ITER. The use of transients to determine edge particle transport looks challenging from modelling and measurement points of view (use of reflectometer?). Evolution of the plasma density after H-mode with low core fuelling points towards no major difficulty in access to burning plasma conditions in ITER – more experiments with low core source are required. Significant progress in another two areas (pellet fuelling and influence of ELM control on particle transport) is expected in 2012. Present ITPA Chairs/co-Chairs are gratefully acknowledged for their support and we look forward to collaborating with the new ones.

7.3 Approval of Meeting Plans

A tentative list of dates and venues of ITPA Topical Group meetings has been circulated. R. Pitts comments that Divertor and SOL Topical Group may hold its fall 2012 meeting in a place other than San Diego.

7.4 Preparation for the Next CC Meeting

The date of the next meeting, starting on Monday 10 December 2012, is tentatively agreed with the assumption that the ITER International Summer School does not fall on this date. Possible shortening the meeting to 3 days is suggested, which will be discussed during the ExCo meeting.

7.5 Discussion and Approval of Meeting Record

A draft summary of the meeting was circulated. The participants are requested to give comments to the Secretariat (michiya.shimada@iter.org).