

Summary of the 12th Meeting of the ITPA Coordinating Committee Château de Cadarache, St Paul-lez-Durance, France, 28-29 June 2010

M. Shimada

I. OPENING SESSION

The Chair, R. Stambaugh, welcomed all the participants. The agenda was approved.

Welcoming Remarks: ITER Organisation and ITER baseline (K. Ikeda)

Throughout 2009, the ITER Organization (IO) and the Domestic Agencies (DAs) have worked in close collaboration on all elements of the Construction Schedule, which could be agreeable to all Parties with minimized risk. With the support of the Heads of Delegation (HOD) meeting in February 2010, the Improved Updated Schedule was endorsed by the MAC-7 in March. As requested by MAC-7, a Working Group was set up to review the IO Assembly Plan in order to increase confidence in the Improved Updated Schedule. The Group held a review meeting in Cadarache from 12-16 April and in general found the 2019 First Plasma Schedule to be achievable. With all above efforts, the IPS for the Construction Phase was developed in close collaboration between the IO and the DAs. Based on the IPS, the OPS (Overall Project Schedule) including the phases of Construction, Operation, Deactivation and Decommissioning, has been updated and endorsed by the MAC-8 in May.

Cost optimization measures following recommendations by the Briscoe Panel have been taken in parallel with the schedule development, and the further cost cut by 10% on the estimate submitted to the Briscoe Panel in October 2009 has also been implemented. After MAC-7 in March, the IO completed its new Overall Cost Estimates based on the IPS. The Additional Direct Investments (ADIs) – which have already been approved, as well as the open ADI to be approved at future IC meetings – are already included in the new Overall Cost Estimates. MAC-8 in May endorsed the Cost Estimates, and recommended that Additional Resources up to 373.2 kIUA be made available by the Members, if necessary, upon decision of the IC to ensure successful and timely completion of ITER construction. The OPC (Overall Project Cost) for the phases of Construction, Operation, Deactivation and Decommissioning was prepared. The total cost estimates: 4584.7 kIUA.

The final Baseline package, including the OPS and OPC was reported to IC-6. However, the Baseline was not approved at IC-6 in view of the on-going process within EU to find financial solutions. The ITER Baseline will be submitted for approval at the extraordinary IC Meeting on 27-28 July 2010 at Cadarache.

The draft Annual Work Plan (AWP), which had been prepared for 2011 jointly by the IO and the DAs, was endorsed at the IC-6 and will be formally submitted for the approval at the Council in November.

As of end May 2010, the ITER Organization had a total of 457 staff members (300 professional and 157 technical support staff members).

The Financial Audit Board (FAB) conducted an IT system audit with Indian experts and an on-site audit on the 2009 Financial Report in Cadarache respectively in March and April 2010. In order to fulfill all the milestones as scheduled while finishing the Baseline, the supplementary payment budget for 2010 for the IO was approved by the IC-6 in June.

Up to today, the IO and relevant DAs have signed 45 Procurement Arrangements (PAs) in total, amounting to 1732.5 kIUA, approximately 60% of the total procurement value for construction of ITER.

The Tokamak Excavation and the construction of Annex Buildings are expected to begin in July 2010.

The ITER CLI (Commission Locale d'information) held its first General Assembly meeting on 7 December 2009 and the second meeting on 24 February, both in Cadarache. The IO submitted the updated Safety Files and RPrS documentation to the French Nuclear Authorities on 26 March as required by the licensing process for the 'Demande d'Autorisation de Creation'.

The IO and CERN have continued their collaboration in the areas of cryogenics, CODAC, conductor, feeders and high voltage engineering.

On 12 January, His Serene Highness Prince Albert II of Monaco visited the IO. Within the framework of the Partnership Arrangement with Monaco; selection of the second group of Monaco Fellows is on-going; the first Monaco ITER Fusion Energy Days Conference, jointly organized by the IO and IAEA, is planned on 23-25 November 2010 in Monaco.

The IO signed a Memorandum of Understanding on Technical Cooperation with the National Fusion Research Institute (NFRI) of Korea on 20 April 2010.

Over the past two years, the operation of the ITPA under the auspices of ITER has been very effective. Therefore the Coordinating Committee is invited to prolong the present arrangement for a further 2 years.

Brief report on the Status of ITPA and ITPA Activities (R. Stambaugh)

All attendees were encouraged to review the most recent ITPA Membership list of November 24, 2009 and report corrections to the Secretariat. The list of ITPA meetings completed and planned in 2010 was reviewed. The list of ITPA Databases was presented and the agenda item to discuss the proposal to relocate these databases to the ITER-IO site was noted. It was noted that the ITPA website has been migrated to the ITER-IO and that a report on the status of that website was to be made by Masanari Hosokawa. The status of the Joint Experiment Planning was discussed and it was noted there was an agenda item on the idea of combining the Joint Experiment Planning Meeting with the ITPA CC Meeting and possibly with the IEA EXCOM Meetings.

Nuclear Fusion on the PIPB Impact (M. Shimada)

The Nuclear Fusion Board Chair has announced that the Impact Factor of the Nuclear Fusion Journal has been increased to 4.27, to which the high number of citations of Progress in ITER Physics Basis has contributed significantly.

II. RESEARCH NEEDS OF ITER

STAC/IC Actions and ITER Research Plan (D. Campbell)

Key issues for ITER Physics R&D remain:

- Extended physics basis for helium H-mode operation.
- Disruptions: (i) improved modelling capability (including runaway electrons); (ii) improved physics basis for choice of disruption/RE mitigation techniques.
- Improved physics basis for ELM control ('alternative' ELM control).
- Improved diagnosis of hydrogenic retention and dust production => tritium removal techniques.
- Development of operational scenarios with all metallic PFCs.
- Understanding of 3-D ripple effects such as produced by TBMs.
- Development of hybrid and steady-state scenarios => implications for H&CD upgrades.

Simulation and validation of the generation, confinement and loss processes for (post-disruption) runaway electrons requires increased effort. The potential impact of REs on PFCs in ITER justifies a significant allocation of resources to improve the physics basis for simulation of their behaviour in ITER.

IC-6 agreed on a charge to ITER STAC for the STAC-9 meeting in October 2010 which includes, inter alia, the requests: (i) Comment on the community plans to improve theoretical and experimental understanding of steady and transient heat loads as they relate to the design of first walls; (ii) Comment on opportunities for the community to improve theoretical and experimental predictions of edge characteristics and H-Mode thresholds in ITER-relevant regimes.

In order to prepare appropriate input to STAC, we recommend a collaboration between the relevant ITPA TGs and the IO: (i) The aim would be to prepare a report on each of these points to summarize the key outstanding issues, R&D activities underway and additional needs within the fusion programme to support progress; (ii) Deadline would essentially be end of September.

The timescale of ~three years is associated with design specifications. The timescale of ~8 years is associated with operation scenarios and possible upgrades.

III. REPORTS OF ITPA CHAIRS

These reports by the ITPA Chairs include reports and proposals on R&D activities in response to ITER's needs.

Diagnostics (R. Boivin)

Alpha particle diagnostics. Present day lost alpha detectors do NOT extrapolate to ITER. A detector within 1-2 cm of the FW would be extremely difficult to integrate. The basic option is measurements with a IR/visible camera system. Activation probes may contribute to loss detection.

Neutron detectors. In order to meet the required accuracy of 10%, the neutron calibration would require 2 periods, of approximately 2 and 8 weeks duration, respectively.

Determination of life-time of plasma facing mirrors. In high erosion areas, single crystal molybdenum mirrors are promising, while in low erosion areas, Rh coating is promising. Preventive and corrective mitigation measures are under study.

Measurement of hot dust. Cold dust may be measured with capacitive microbalance (Joint Experiment), while hot dust is proposed to be controlled by water steam injection. Other dust and erosion systems still require R&D.

In-vessel wall reflections on diagnostics. Evaluate existing software for the calculation of light reflections, and assess impacts of these reflections. ECH stray power will introduce similar reflection issues and new ones.

Assessment of the measurement requirements for plasma initiation and identification of potential gaps in the planned measurement techniques. Information has been gathered on what measurements are needed (list not exhaustive yet). Coordination with FST Operation is planned.

Possible new items:

- Optical and microwave calibration issues.
- Fuel composition (core).
- Effects of local gas puffing on diagnostic performance.

Specialist Working Groups have been formed: 8 groups with a total of more than 200 members. We need to identify a mechanism to collaborate with IO in the Design Reviews on Diagnostics.

Energetic Particle Physics (S. Günter)

Heat loads to the wall due to fast ion losses are well below the critical level with the present design of the FIs and TBMs (with no toroidal asymmetry caused by FIs). Simulations for TBM mock up coils at DIII-D will be continued with several codes. There is good agreement for AE frequency and eigenfunctions between experiments and linear codes: the ratio of poloidal harmonics and parity of modes are almost identical. The calculated damping rates are about of a factor of 2 smaller than measured, but within experimental error bars.

Experiments show stronger fast ion losses if several modes are present (TAE, BAE), even if there is a strong frequency mismatch and no strong overlap in radial eigenfunctions. Fast ion orbits average over turbulent eddies and are thus not influenced by background turbulence for gyro-averaging, but not for drift orbit averaging. The discrepancy between classical slowing down and FIDA measurements increases with heating power/temperature. If electromagnetic transport is dominant, there is substantial broadening of the alpha heating profile and NBI current profile may occur. The influence of background turbulence on runaways is being investigated in collaboration with the MHD TG.

Integrated Operation Scenarios (S. Ide)

The number of ITER demo discharges is increasing and the variation is extended. Impurity seeding effects have been investigated. In AUG, nitrogen seeding in hybrid discharges improves confinement, with smaller and shorter ELMs.

Ramp-down in divertor shape, starting in H-mode using a strong kappa reduction to 1.3-1.4, has been investigated. Demo discharges have been obtained. Scan ramp-down rate, H-L timing etc. is being examined in IOS-2.2. JET / DIII-D identity experiments carried out to get the largest possible variation in *rho;* for confinement scaling and stability boundary scaling studies. Benchmarking various models against experimental results mainly on ramp-up has been extensively and more systematically carried out. Benchmarking of steady-state scenario modelling is in progress; weak magnetic shear scenario and ITB scenario are considered. Modelling of hybrid scenarios is being carried out, covering the whole discharge.

ICRF code benchmarking and applications to ITER are in progress with scenarios for heating DT, H and He plasmas. The control of minority species is essential to maintain good coupling.

Recent LHCD experiments on Alcator C-Mod, FTU and JET have shown a decrease in non-thermal tails and CD with density, which is stronger than expected based on recent models; parasitic absorption at the plasma edge (SOL) is the leading candidate to explain the results. For ITER, large uncertainties in SOL n_e and T_e can lead to large uncertainties in the estimate of the power loss in the SOL. The LHRF PAM (Passive-Active Multi-junction) launcher has been installed and tested on Tore Supra.

Joint experiments are being carried out under IOS-6.1 Modulation of actuators to qualify real-time profile control methods for hybrid and steady state. New joint experiments are being launched: IOS-6.2 I_\parallel controller (I_p ramp) with primary voltage and additional heating; IOS-6.3 Control of experimentally simulated burning state.

Modelling activities require resources (data, manpower, codes, cpu ...) from the labs that need approval.

Seven papers from the IOS have been accepted for presentation at the IAEA FEC. In light of the importance of integrated control, David Campbell has requested to draft a work plan.

MHD, Disruptions and Control (A. Sen)

Six Working Groups have been formed to address very specific issues related to ITER design and construction:

- WG-1 Waveforms of current in error field correction coils. Hypothetical waveforms were developed that represent the extreme limit of what the error field correction coils might be asked to do with feedback-driven ‘dynamic error field correction.’ If evaluation by the ITER magnet group of these preliminary results shows that the resulting AC losses would be unacceptable, more realistic waveforms will be developed for further evaluation. A report has been submitted to IO.
- WG-2 Guideline for optimization of distribution of ferritic inserts. The possible effects of resonant and non-resonant field errors that could arise from irregular ferritic inserts in some sectors were evaluated in the light of the recent test blanket module mock-up experiment in DIII-D. TBM brakes rotation across the entire plasma, consistent with non-resonant braking.
- WG-3 Power requirements for ECRH and ICRF control of sawteeth. Nine subtasks were identified and begun, including NTM trigger scaling with sawtooth period.
- WG-4 Diagnostic requirements for MHD stability control. It was agreed that the output would be requirements for the physical quantities that should be measured, and not specific recommendations on the type, quantity, or location of the sensors.
- WG-5 Halo currents caused by disruptions. Recent experimental data for halo current fraction and toroidal peaking factor is being evaluated, including upper bounds, frequency of proximity to upper bounds, and discussion of one exceptional case.
- WG-6 Sideway forces on VV and magnets caused by disruptions. Experimental data (primarily from JET) have been developed toward a recommendation on the envelope for asymmetric halo current in the worst cases and the least bad 94% of cases. A recommendation on scaling of the time dependence from present machines to ITER has also been developed. A significant worry is that essentially all data is from JET. The physics of the asymmetry and wall current is not fully understood. The Wall Touching Kink Mode Model (Hiro Currents) is qualitatively consistent but a quantitative validation is needed. The sink and source model used remains totally empirical. Smoothing of I_{asym} by +/- 2 ms remains somewhat arbitrary and should be put on a firmer basis.

Joint experiments address key issues for ITER in several areas:

- Disruption characterization and mitigation. Initial halo current and electromagnetic impulse data have been submitted from several tokamaks (AUG, DIII-D, NSTX). Variables related to Massive Gas Injection are being defined. Delay and avoidance of disruptions have been demonstrated with ECRH/ECCD at the rational surface of the dominant MHD instability (AUG, DIII-D, FTU). Stabilization of a locked mode has been demonstrated with combined ECCD and magnetic perturbations (DIII-D). Divertor heat loads and halo currents are reduced with noble gas (Ar, Ne), pure or mixed with light species (He, D₂) (MAST, TEXTOR, JET). Radiated power becomes symmetric within a few ms (C-Mod, DIII-D, JET). Runaway electron de-confinement experiments with RMP give mixed results (JET, DIII-D). Position control helps to sustain the runaway beam (Tore Supra, DIII-D).
- Neoclassical tearing mode stabilization. The 2/1 NTM marginal island width for stability scales with the ion banana width (NSTX and DIII-D). Cross-machine studies show the role of rotation shear (DIII-D, JT-60U, JET, NSTX). The error field threshold decreases as β rises or rotation decreases (DIII-D, NSTX). ECCD

destabilization of fast ion-stabilized sawteeth has been demonstrated (AUG, HL-2A). ICRH destabilization of NBI-stabilized sawteeth is a fast ion effect (JET).

- Non-axisymmetric fields. The radial profile of a driven $n = 1$ plasma response agrees with MARS-F (DIII-D). The rotation dependence of RWM stability is consistent with kinetic damping (NSTX). The CarMA prediction is in good agreement with the measured effect of proportional gain on RWM growth rate (RFX-Mod). $n = 3$ braking is in qualitative agreement with NTV theory (NSTX, DIII-D). NTV torque maintains rotation with no net NBI torque as predicted (DIII-D).

Priority tasks and work plan for 2009/2010:

- Disruption studies focus on modelling including halo currents and VDEs, control, runaways, and mitigation (MGI, pellet pacing etc.).
- Database development: RWMS – continue with code benchmarking and further experiments; NTMs – more experimental cross-machine analysis and theoretical modelling; and working group activities on various short term issues.

Pedestal and Edge Physics (H. Wilson)

The work for ITER is driven through 5 working groups:

- ELM control by RMP coils (Max Fenstermacher).
- Pellet pace-making of ELMs (Peter Lang).
- Ripple (Naoyuki Oyama).
- L-H transition (Roberta Sartori).
- Pedestal structure (Phil Snyder).

ELM suppression with RMP coils. ELMs are successfully suppressed on DIII-D with in-vessel coils. The L-H transition threshold with RMPs is slightly higher (MAST). The ELM-free plasma relaxes back to type-III ELMing on application of RMPs (MAST). There is a narrow q-range (where the RMP spectrum is well-aligned with the q profile) where density pump-out and an effect on ELMs is observed in DND (MAST). Resonant behaviour has also been observed on JET. ELM pace-making with RMPs has been demonstrated on NSTX and DIII-D. The energy loss does not appear to fall off as fast as $1/f_{\text{ELM}}$. However, pace-making is not perfect at higher frequencies. Future projects include: DIII-D plans to install a new set of coils on the inboard side, with the ability to rotate the perturbation; MAST will install 6 additional coils in the lower set; ASDEX Upgrade will have a staged introduction of 3 rows of 8 coils by 2012 (first stage complete by end 2010) and will have the ability to rotate the perturbation; internal RMP coils are being considered for JET. In regard to density pump-out, using a model form factor for the screened potential, modelling with the XGC code provides good agreement with the data.

Pellet pace-making. A key target of the working group is to demonstrate an increase in ELM frequency by a factor of 10. Pace-making on JET was demonstrated with the fuelling pellets (close to the natural frequency). On DIII-D, 14 Hz pellets (LFS) increased the ELM frequency from 5 Hz to 25 Hz. There is evidence for a threshold pellet size required to trigger the ELM on DIII-D and JET. A single filamentary structure is observed to develop from a plasmoid at the start of a pellet triggered ELM (cannot rule out other invisible filaments), consistent with non-linear MHD modelling by G. Huysmans.

Ripple. A mock-up TBM produces up to same ripple as double modules in three ITER ports, but a different spectrum (DIII-D). The TBM has little effect on the L-H threshold with NBI. Increasing the TBM ripple increases impact on confinement, beta and rotation.

Pedestal structure. The pedestal height and width is independent of heating source (NB, IC and EC). The EPED1 model for pedestal width/height is promising: (i) there is agreement over a wide range of width/height; this extrapolates to ~ 100 kPa for ITER; the pedestal height prediction for ITER is $n_{ped} = 7 \times 10^{19} \text{ m}^{-3}$, $T_{ped} = 4.1 \text{ keV}$.

I-mode. Suppressing access to standard H-mode on C-Mod (e.g. with unfavourable grad-B drift) results in the I-mode with an energy transport barrier, but without a particle transport barrier. There are no (or very small) ELMs with H-mode like confinement, but no sign of power degradation.

L-H transition. A key question for ITER is the quality of the confinement as one starts to exceed the L-H threshold. Experiments on JET indicate that ‘good H-mode’ is not achieved until up to a factor of two above the threshold power (subsequent discussions noted that in some JET regimes good H-mode is achieved closer to the threshold). The pressure gradient saturates before the ELM (AUG). A new TS system on MAST clearly indicates density pedestal formation in advance of the temperature pedestal.

SOL and Divertor (B. Lipschultz)

The DIV/SOL group research plan was drafted to address ITER needs (Fall 2008). Five task groups were formed and the DIV/SOL research plan revised (January-May 2009):

- Tritium retention and removal (leaders – R. Doerner, J. Roth).
- Tungsten (leaders – A. Kallenbach, Y. Ueda).
- Dust (leaders – N. Ashikawa, D. Rudakov).
- Heat fluxes to plasma-facing surfaces (leaders – M. Lehnen, A. Leonard).
- Material migration (leaders – V. Philipps, P. Stangeby).

Tritium retention. Implantation of T into Be at higher temperatures lowers the amount retained and leads to a requirement of higher temperatures to remove the same fraction of implanted T. Small amounts of impurities in Be also raises the temperatures required for T removal. Ion cyclotron wall cleaning (ICWC) has been shown useful for cleaning the near surface (~ 5 nm) of T which corresponds to of order a gram T in ITER. Further development of ICWC and alternatives are needed for removal of T in co-deposited (T/C, T/Be) layers which are thicker – 1-100 microns.

Tungsten. Retention increases with dpa damage; H in traps saturate at high dpa. Increasing the implantation temperature strongly drops the T retained in nuclear damaged tungsten. Tungsten melt layer motion is increasingly important to understand. Melted regions form peaks which then melt more easily. Movement of the melted W is consistent with $J \times B$ forces. Spraying and splashing of tungsten is a serious issue for tungsten in the core (disruption).

Dust. Dust trajectory experiments show that different dust materials lead to different dynamics. Better diagnostics and comparison with models are required to make progress.

Heat fluxes to PFCs. The ELM-wetted area increases with increasing ELM energy. Mitigated ELMs do not significantly change the heat load profiles during ELMs in JET. Poloidal asymmetries of first-wall heat loads in disruptions are reduced by mitigation. The toroidal peaking factor is more of a concern than poloidal peaking of radiation during MGI disruption mitigation. The toroidal asymmetry lasts through the thermal quench. Recent limiter experiments confirm ITER assumptions for SOL power widths.

Material migration. $^{13}\text{CH}_4$ injection results confirm the suspicion that local co-deposition is a concern that needs more attention. This means that the erosion is occurring at the secondary divertor will likely lead to significant local co-deposition. Tungsten migration studies indicate that most of the eroded tungsten stays in the divertor.

Transport and Confinement (S. Kaye)

The Momentum database (M. Yoshida) is being developed with global and local parameters. This will enable gyrokinetic calculations to study the source of momentum diffusivities and pinches. The first results will be discussed at the Fall 2009 and Spring 2010 meetings. More data is needed to complete the database. Discussion focussed on the methodology for computing χ_φ and v_{pinch} to make sure everyone is doing the same thing. M. Yoshida is working with K. Thomsen to turn the database into a standard form for release to the group (the DB is still private).

The L-H threshold database (J. Hughes) is to be updated with profile information for model testing and reducing uncertainties in P_{L-H} . The plan is to discuss details (data, validation) at the Fall 2010 meeting.

The Profile database (C. Roach) has been expanded to include data from impurity/Helium transport experiments (no contributions yet). The use as resource to store ITER DEMO discharges for model validation work is still under discussion.

Presently inactive, but being maintained are the L-mode and H-mode databases, which are still being maintained by K. Thomsen.

L-H threshold studies. Several Joint Experiments are devoted to this high priority area, and important results extend beyond Joint Experiment work as well. Determining the species dependence of P_{L-H} was one of our most active areas. The same P_{L-H} was found in ^4He and D with ECH (AUG). Other devices have shown $P_{L-H}(\text{He})$ is greater than $P_{L-H}(\text{D})$, but in most cases not dramatically greater (MAST, DIII-D). H-mode confinement in ^4He is lower than that in D (AUG). High Harmonic Fast Waves (HHFW) were used to heat pure helium and deuterium plasmas (NSTX). Continuous ramping of HHFW power allowed for ‘fine’ determination of P_{L-H} and P_{H-L} (NSTX). A perturbation technique was used to determine HHFW heating efficiency ($<0.32>\pm0.1$) (NSTX). $P_{L-H}(\text{He}) \sim 1.2P_{L-H}(\text{D})$ (NSTX) with no indication of hysteresis. $P_{L-H}(\text{He}) \sim 1.8P_{L-H}(\text{D})$ (C-Mod). 2001 data shows $P_{L-H}(\text{He}) > P_{L-H}(\text{D})$, while 2009 data shows P_{L-H} is the same (JET). Is there a difference in critical density for P_{L-H} minimum between He and D? Applied non-axisymmetric fields lead to increase in P_{L-H} : a ~50% increase in P_{L-H} with $n = 3$ applied (NSTX). The applied $n = 1$ causes a delayed transition. ITER needs to carefully consider when to apply 3-D fields for ELM suppression. Other non-hidden parameters that can impact P_{L-H} are geometry, fuelling and wall conditioning, $E \times B$ flow shear, and edge parameters and gradients. $H \sim 1$ access depends on a number of factors (ELM type, strong gas puff, heating power, shaping). It is important to examine P_{loss}/P_{L-H} (actual), rather than $P_{\text{loss}}/P_{\text{scal}}$. The I-mode is obtained when P_{L-H} is high. The energy confinement enhancement factor in I-modes is often less than unity. Because the I-mode threshold power is greater than the typical P_{L-H} in the favorable direction, it does not appear to be an obvious option for future devices.

Impurity/helium transport. Experimental results indicate both neoclassical and turbulent processes are important; impurity density profiles less peaked than would be expected by neoclassical transport; transport in JT-60U ITBs show similar characteristics. Turbulent transport can reverse the sign, depending on type of turbulence.

Transport model validation. The transport model validation effort has focused on the ramp-up phase of ITER similarity discharges. No model does a good job reproducing I_i in AUG OH discharges. The T_e profiles in experiments are robust, which allows for extrapolation to ITER.

IV. REPORTS OF THE ITER PARTIES

These brief reports on the status and plans of programs in China, the EU, India, Japan, Korea, the Russian Federation and the US include summaries of the domestic mechanisms for supporting ITPA and responding to ITER needs.

China (G. Zhuang/B. Wan)

MOST has launched the domestic MCF program to support Chinese participation in ITER. MCF research is focused on two major machines (EAST and HL-2A) but extended beyond the two major institutes (ASIPP and SWIP). Several projects have been launched in the universities. A new project has been approved to support young scientists to participate in ITPA activities.

In EAST, an ICRF system of 4.5 MW at 20-70 MHz, an LHCD system of 1.5 MW and several new diagnostics are in operation. A new wall conditioning technique has been developed (High Frequency Glow Discharge). Up to 0.92 MA of plasma current is reached. GAMs at 5-15 kHz were detected at the plasma edge.

HL-2A observes ELM My H-mode. SMBI (Supersonic Molecular Beam Injection) fuelling is beneficial for the L-H transition. No clear difference is observed for the L-H threshold between EC and NB. The intensities of zonal flows and GAMs increase with EC power. The power of GAMs increases with the edge safety factor, but the power of zonal flows decreases with q .

J-TEXT will investigate the effects of RMP coils and SMBI.

European Union (M. Watkins)

The EU Fusion Programme is well focused in supporting ITER by addressing key issues:

- EFDA Task Forces (PWI and ITM) and Topical Groups (Transport, H&CD, Materials, Diagnostics, MHD).
- In ITM (Integrated Tokamak Modelling), the long term goal is to provide Europe with complete package for ITER modelling based on flexible software design.
- The PWI TF focuses on IETR high priority research needs (Disruption/Runaway Mitigation, ELM Control/Mitigation, Plasma Facing Materials and Diagnostics).

In preparing for ITER operation, JET is installing ITER-Like Wall materials; pump-down is expected in January 2011. Alternative scenario operation will be addressed beyond 2015.

A number of EU devices aim at achieving key objectives, including upgrades of JET and other devices, and refocusing the programmes of some devices in order to better address ITER issues. TEXTOR will be phased out in 2015.

Key results have been obtained recently in the areas of physics and technology. Impurity seeding allows high P/R (12 MW/m) with W-divertor in AUG. AUG will install 8 in-vessel B-coils. Conducting structures modelling (CarMa) has modelled RWM growth rates.

Collective Thompson Scattering has been used to measure the fuel ion ratio using ion Bernstein waves on TEXTOR. Suppression of high energy runaway electrons in disruptions by RMP has been demonstrated (TEXTOR). MAST showed ELM control by RMPs. Tore Supra PAM launcher has coupled 2.8 MW during 78 s. FTU demonstrated LHCD at ITER relevant density. TCV observed quasi-stationary ELM-free H-mode with EC.

India (A. Sen/P.K. Kaw)

SST-1 expects its First Plasma after December 2011. ADITYA observes Drift Alfvén Fluctuations. Loss of runaway electron is enhanced with $m = 3$ MHD mode growth as a result of gas puffing. Simulations of disruptions and VDEs are on-going with a new detailed ITER model including in-vessel VS coils. Theoretical work includes coupling of NTMs and GAMs, intrinsic toroidal and poloidal flow generation in a background of ITG turbulence and role of flow shear layer and edge plasma turbulence in density limit physics.

Japan (Y. Kamada)

The Broader Approach (BA) is being carried out with the objectives: (i) take the initiative of fusion research; (i) development of fundamental fusion technology; and (iii) human resource development. The JT-60SA project is conducted under the BA Satellite Tokamak Programme by Europe and Japan, and the Japanese National Programme. The project mission of JT-60SA is to contribute to early realization of fusion energy by supporting exploitation of ITER and by complementing ITER with resolving key physics and engineering issues for DEMO reactors. The First Plasma is foreseen in 2016. The goal of JT-60SA is simultaneous and steady-state sustainment of the key performances required for DEMO.

An energetic particle driven wall mode was observed in JT-60U high β_N plasmas, which can trigger RWMS. Slowing down of rotation by growth of NTM islands and hysteresis of island width and mode frequency were observed. ECRF drives co-rotation inside the EC deposition radius and CTR-rotation outside the EC deposition radius. Tungsten accumulates in the core with counter rotation. Progress is also made in the development of gyrotrons and negative ion beams.

In LHD, the Internal Diffusion Barrier (IDB) is being investigated. Quasi-steady state is obtained with IDB ($n_e \sim 2 \times 10^{20} \text{ m}^{-3}$ for 3 s). Impurity screening is observed with an ergodic layer on LHD.

Japan is also contributing to all the ITPA TGs.

Korea (M. Kwon)

The operation goals of KSTAR are to operate the KSTAR tokamak and facilities in steady-state condition and to assess the superconducting tokamak operational characteristics as a pilot device of ITER and beyond. Plasma shaping and heating studies are planned in 2010 and H-mode achievement by 2011. Vacuum commissioning was also finished in late June. Baking will start from 2010-07-01 (up to 350 C). All the hardware of the 1st NBI system is ready(1 MW D, < 2 s). ICRF with the power up to 1 MW (< 5 s), ECH with the power up to 0.5 MW (5 s). Upgrade of power supplies for the 110 GHz ECH system is going on. The 84 GHz Gyrotron has been finished in the repair. The tube is under power test. The wall conditioning system was updated. Four carborane injection ports will be used for uniform wall boronization.

ICWC is effective at outboard, but the homogeneity of the ICWC plasma has to be improved. Fibers, flakes, metal droplets, carbon nanoparticles and nanostructures of metal droplets were observed on the PFC. PFC installation is completed. In-vessel control coils were installed.

Russian Federation (N. Ivanov)

Domestic mechanisms for supporting ITPA and responding to ITER needs are in place. The participation in ITPA is considered as an essential part of the ITER activity. It is supported by Rosatom State Corporation. The response to ITER needs in the fields of theory and modelling is provided by the collaboration between the RF physicists and ITER IO as well as by the participation in ITPA.

At the Kurchatov Institute, T-10 is examining: (i) the spatial structure of plasma turbulence with correlation reflectometry; (ii) anomalous transport of different core plasma species; (iii) discharge start-up assisted by second harmonic EC; and (iv) core and SOL plasma variations in experiments with Li. At TRINITI, T-11M is studying a liquid lithium limiter. The Ioffe Institute (Globus-M, Tuman-3M, FT-2) research efforts include: (i) fast particle confinement under NBI heating; (ii) error field correction and locked mode suppression; (iii) plasma jet injection (up to 250 km/sec); and (iv) non-inductive current ramp-up.

Theory and modelling includes a wide range of activities:

- Particle transport and fuelling relevant to ITER reference scenarios.
- Analysis and specification of plasma reference scenarios, including plasma initiation, start-up and ramp-down.
- Calculation of the ECE losses.
- 3-D modelling of disruptions/VDEs – evolution, FW loads, mitigation.
- Toroidal field ripple effects and implications for ITER performance and fast particle losses.
- Simulation of the runaway electron generation.
- Development of improved models of RE losses and resultant heat loads, mitigation algorithms.
- ELM characterisation and control schemes for ITER.
- TBM influence on plasma performance.

United States (E. Oktay)

The FES mission is to expand the fundamental understanding of matter at very high temperatures and densities and to develop the scientific foundations needed to develop a fusion energy source. The U.S. Burning Plasma Organization (USBPO) was created in 2005 as a community-based entity. It coordinates US burning plasma research to advance scientific understanding and to ensure the greatest benefit from ITER and is national base for US international activities in ITPA. Ten Topical Groups (MHD, Boundary, Fusion Engineering Science, Diagnostics, Plasma-Wave Interaction, Integrated Scenarios, Operations and Control, Modelling and Simulation, confinement and Transport, Energetic Particles) make up Research Committee.

DIII-D research includes:

- The impact of local TF ripple on plasma performance using TBM simulation module (International Task Force).
- Fast-particle instabilities and fast-particle losses.
- Test of co-deposit removal by thermal oxidation (Oxygen bake April, 2010).
- Improved fast wave coupling with smaller gaps and local gas puffing.
- TBM experiment was completed.
- Recent thermal oxidation experiment documented carbon deposit release during oxygen bake and subsequent plasma recovery.
- New instability control techniques (real-time steering of ECCD Mirror, locked mode toroidal steering and real time feedback control of PNBI to $n = 1$ plasma response) have been developed for disruption research for ITER.
- Transport theory community is closely engaged in turbulence and transport studies with novel diagnostics (turbulence and profile of T_e , n_e , T_i , E_r , rotation).

C-Mod research includes experiments to exploit key C-Mod features, e.g.: solid metal walls (Mo, W) to examine D retention and recovery; high divertor heat fluxes to study power handling, impurity generation; high density and neutral opacity to investigate pedestals and n_e control; ICRF and LHCD at ITER B_t , density for H&CD physics; high pressure (up to 1.8 atm) for disruption mitigation. Facility plans are to enhance steady-state non-inductive capabilities with Lower Hybrid upgrades to demonstrate fully non-inductive regimes with

active $j(r)$ control in ITER-relevant conditions. ICRF upgrades include an advanced 4 strap antenna rotatable and alignable with B to reduce or eliminate sheath-induced sputtering and real-time adaptive tuning. Outer divertor upgrade implements Demo-like continuous vertical plate with tungsten lamella plate in the high heat flux region, capable of handling higher power and energy.

NSTX has found that using lithium wall conditioning improves pulse length, increases τ_E , suppresses ELMs, but shows impurity accumulation. ELM triggering using $n = 3$ perturbations is being optimized to control density and radiation, and to maintain high confinement. Investigations on the Liquid Lithium Divertor will proceed in FY 10 (heated porous Mo surface holding thin film of liquid lithium to provide deuterium pumping). A upgrade is planned with a factor of two increase in current, field and power density. An upgraded divertor coil set is being designed to support conventional, snowflake and X/Super-X divertors.

V. WEBSITE

Website and Web Servers for the ITPA Internet and Intranet Websites are now hosted by ITER. These include a website for ITPA Home, 8 Websites for CC and TG Homes for ‘Public’ information and corresponding Restricted Websites for detailed working activities, and 15 Meeting Websites for groups of meetings dating back to creation of the original ITER Expert Groups in 1994. All ITPA Participants (>600) have been given ITER ‘Collaborator’ accounts with individual User IDs and passwords. This also provides access to additional ITER information for ‘Collaborators’ that is not available on the ITER Public Web. ITPA Groups (46) have been established to grant access privileges to relevant information and for use as e-mail lists (e.g. ITPA_CC@iter.org). An initial set of access policies were established to guide the development of the ‘Restricted’ material. A separate document requests ITPA (CC and TGs) to review these policies. ‘Public’ material has been edited for grammar, consistent style and presentation. The CC and each TG need to review the material, and update it if necessary.

All ITER web material is developed and maintained on the ITER Technical Website: <https://portal.iter.org/pages/>. A selection of this ITER material is ported to the ITER Public Website: <http://www.iter.org/>. Selection, review and presentation of ITER Public material is the responsibility of the ITER Office of Communication (PR). There are differences in presentation between the ITER Technical Website and the ITER Public Website. Distributed servers with DAs provide reliable access for all Parties. The ITPA Public web material is a subset of the material on the Technical Website. Selection and review of ITPA Public material is by the ITPA Website Manager (W.A. Houlberg) with guidance from ITPA. The presentation of ITPA Public material is the responsibility of the ITPA Webmaster (M. Hosokawa).

After extensive discussion, it was agreed that the detailed summaries of ITPA meetings would not be made public on the website. However, once a year at the time of the annual summary, a two page executive summary for each Topical Group would be prepared, vetted by the ITER-IO Deputy Topical Group Leader, and put in the public area of the website.

VI. ACTION ITEMS

ITPA Database Access and Release Policies

A proposed new Database Access and Release Policy Draft was presented for discussion by the ITPA-CC. This new policy is intended to apply equally for all Topical Groups, to provide for the secure storage and maintenance of the Tokamak databases gathered during the ITER Expert Group time and the succeeding ITPA time, and to provide for the use of common database management technology and access processes. There was general agreement on the

mechanics of the new proposed database policy, including management aspects and the various kinds of databases – public, private, working – and the access to those databases. It was recommended the databases be called International Physics Databases or just ITPA Databases. The sections about how the ITER-IO accepts databases need some rewording. Perhaps embryonic databases need not be located at the ITER-IO site. The idea of locating all these databases at the ITER-IO site and under the administration of the ITER-IO requires more study and discussion by ITER-CC.

Site and lodgings of ITPA Meetings after IAEA FEC 2010

M. Kwon gave a briefing on the site and lodgings of ITPA. SNU is proposed as the site for 5 TG meetings and HYU is proposed for the SOLDiv meeting. For joint sessions involving the SOLDiv TG, it would be better to have all 6 TG meetings at one site. However owing to the strong desire of HYU to host the SOLDiv TG meeting, the SOLDiv TG meeting will stay at HYU and an attempt will be made to schedule the joint meetings of the SOLDiv TG with Energetic Particles and MHD on Disruptions and with the Transport and Pedestal TGs.

Joint Experiment Planning Meeting

The original idea was to hold this JEPM electronically, which is probably not practical. R. Stambaugh proposes this meeting (JEPM), IEA EXCOM meetings and ITPA CC be held jointly once a year in one place, since many participants are common among all these meetings. JET, ASDEX Upgrade, NSTX, and DIII-D say that December is the right time to discuss the joint experiments, since many machines do program planning at that time. D. Campbell says that holding CC meetings in December is no problem. The Annual Meeting of Japan Society of Plasma and Fusion will be on the first week of December. The venue of 13-15 or 16 December 2010 in Cadarache is proposed and tentatively agreed for all three meetings. The IEA EXCOMs must discuss and ratify this proposal.

ITPA Meetings after IAEA FEC 2012

It is provisionally agreed that ~7 TG meetings will be held in San Diego after the IAEA FEC Conference to be held in San Diego in 2012. GA, the local host, will seek to make necessary reservations.

New Working Group on Particle Transport and Fuelling for ITER

Understanding of particle transport from the SOL to the plasma core and of the associated fuelling requirements for ITER high confinement discharges have important consequences for ITER performance and operation. CC approves the creation of this Working Group. CC looks forward to receiving a work plan proposal including work targets and timescales and how this Working Group will be organized from and will interact with its spawning Topical Groups.