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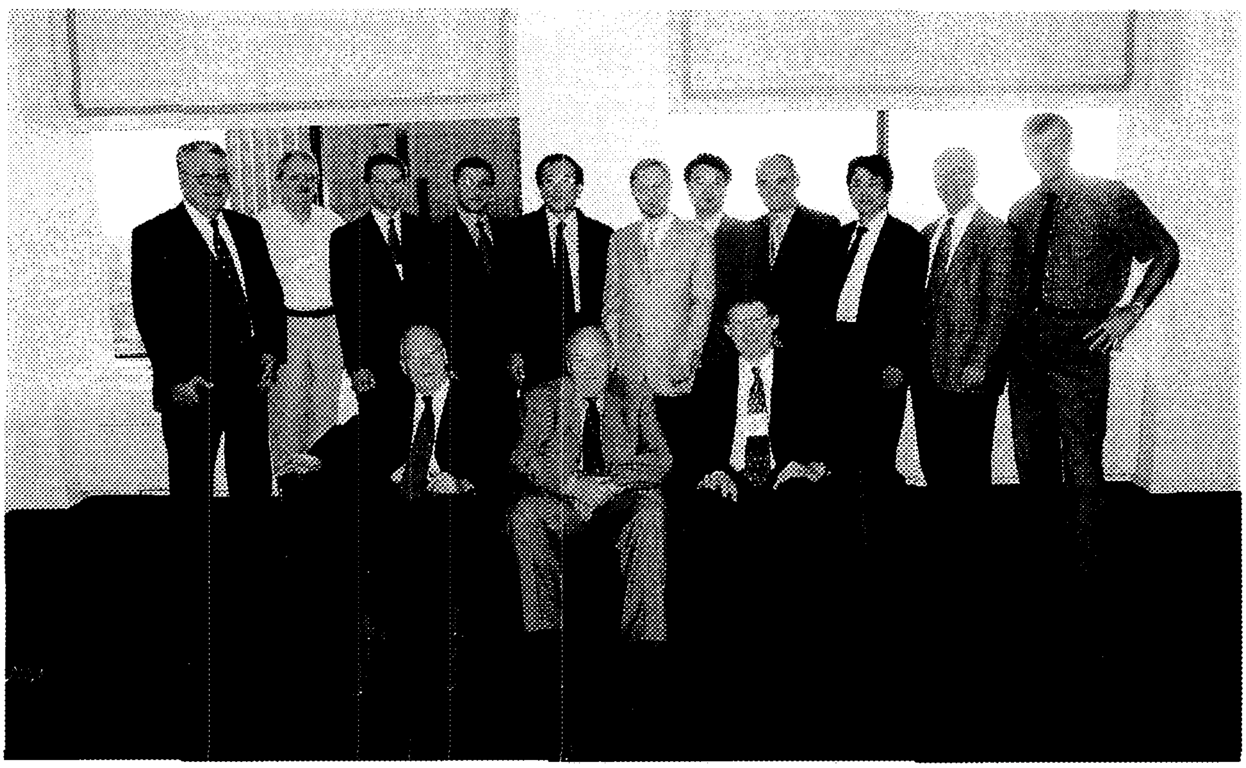
MEETING OF THE ITER CTA PROJECT BOARD

by Dr. V. Vlasenkov, Project Board Secretary

The meeting of the ITER CTA Project Board (PB) took place in Toronto, Canada on 16 September 2002 on the occasion of the fifth Negotiators Meeting (N-5). Thirteen participants, PB Members and experts from Canada, EU, Japan, RF and the International Team (IT) attended the meeting chaired by Acad. E. Velikhov.

The PB acknowledged the great contribution made by Dr. Peter Barnard to the development of the ITER project in Canada and elsewhere. The PB kept a minute of silence in his memory. Dr. M. Stewart was nominated as the Participants Team (PT) Leader for the Canadian Party and Dr. R. Hemmings as a member of the PB.



Participants in the Meeting

The following comments concerning the status of the PTs and the IT were reported:

- The Japanese Government has prepared JA site proposal documents, and this proposal was presented to the N-5 meeting next day. A presentation on the JA site proposal for ITER has been made at the SOFT conference held in Finland. JA has been developing a boron-added structural stainless steel (JK2) as a heavy-walled jacket material option for the CS conductor. The improvement in the fracture toughness of the base metal after heat treatment for Nb_3Sn formation had been already confirmed by tests. As a next step, tensile and fracture toughness tests of an aged "weld" metal have been performed at 4 K this summer. The yield strength and fracture toughness at 4 K exceed the target values set for ITER. Therefore, it was demonstrated that there was no fundamental difficulty in applying boron-added JK2 to a heavy-walled jacket material for the CS coil. The PB commented that extrusion properties should be shown.
- CA is continuing the licensing process in close co-ordination with IT. The Joint Assessment of Specific Sites (JASS) process identified several areas which will require additional co-ordination between the proponent team and the IT. The JASS process was initiated in a co-operative atmosphere.
- The EU reported on the ongoing activities in the area of preparation and support for the EU sites.
- The RF reported that the current activities on the ITER project are conducted according to the Federal ITER Program. The travelling problems for the Russian IT members have been resolved from a legal and financial standpoint. The RF side continues its contributions to IT activities. It was requested that a report summarizing RF CTA activities be available for IT soon.

The IT reported on the progress in the CTA Work Programme focusing on the following major lines:

1) Preparation for management of documentation for ITER construction: two pilot projects have been initiated. The first uses the software already developed for the Large Hadron Collider (LHC) CERN Project Engineering Date Management Service (EDMS). The second pilot project is for the implementation of CATIA 5 in connection with the Product Management ENOVIA software package.

2) Preparation of procurement specifications, in particular:

   Concerning the magnet, the IT reported the reduction of margin observed from the testing of the model. The IT leader informed the PB on the possible need for the TF conductor to increase the specification of the current density in the strand from 650 to 800 A/mm^2 to regain the lost margin. The EU and RF PTs expressed their concern about possible consequences on industrial involvement.

   For the VV there is an ongoing review to simplify its design.

3) Also along the activity of procurement specifications, a number of design modifications have been implemented in various areas through decisions taken at Technical Coordination Meetings (TCMs):

   - Reduction of up to 9 ports in the divertor level eliminating the ports in the field joint region
   - Change of the VV support system
   - Elimination of the lower triangular element in the inboard of the VV
   - Improvement of the blanket module keys
   - Detailed design of the divertor rails
   - Elimination of double wall in some of the ports
   - Simplification of the tooling for the VV assembly
   - Improvement of the thermal shield structural design in its joint region
   - Integration of the tokamak building with the Diagnostic building.

4) Significant activity is ongoing in the field of tritium co-deposition. Encouraging results have been recently experimentally obtained indicating that some of the designed countermeasures may not be required.

The PB took note of the progress in the Work Programme and of the implemented design modifications. The PB also took note of the JA review of the design modifications presented by the IT Leader. The PB expressed the view that design changes which would have an impact on the licensing and cost should be endorsed at the PB level. It was agreed that the CTA IT Leader would provide the TCM documentation to the PB members following each TCM for their comments and questions. At a future PB meeting the IT Leader would present a summary of the design changes for endorsement by the PB.

The PB expressed appreciation to the EU side for presenting an extensive EU Participant Team Report describing support of the ITER CTA. The PB asked the RF and JA sides to present similar reports at the next PB meeting.

The IT Leader informed the PB that the study of the "Fast Track" approach is underway but that conclusions have not been reached in the analysis of possible extensions of the ITER programme or equipment in order to speed up the preparation of the next step after ITER. Nonetheless this analysis assumes that the operational ITER performance will be on the high side of expectations. The IT Leader will prepare a basis for discussion on this matter at the next PB meeting.

The PB supported collaboration between the EU, JA and RF Participant Teams on the ITER Neutral Beam Test Facility proposed by the EU side. The collaboration will be conducted within each PT's budgetary appropriations.

Following the recommendation of the Moscow PB meeting (22 April 2002) to re-establish the Test Blanket Working Group the Project Board invited the RF side to send their nominations to the IT Leader within one week.

The IT Leader cautioned the PB that some of the fusion community had been using ITER internal unpublished material in papers presented to the public without review of the IT. The PB passed this reminder to the PTs.

The IT Leader indicated, in response to a JA observation, that as not all ITER reference documents were available in electronic form, the IT had instituted a programme to ensure the availability of all such documents, to be finished by the end of 2002.

SECOND MEETING OF THE ITPA COORDINATING COMMITTEE

by Drs. D.J. Campbell, EFDA Close Support Unit, Garching, and M. Shimada, ITER Naka Joint Work Site

The second Meeting of the International Tokamak Physics Activity (ITPA) Coordinating Committee (CC), consisting of representatives from the ITPA Participants and the Topical Physics Group Chairs and Co-chairs, was held in GA Technologies, San Diego, USA on 1-2 March 2002. The purpose of the Coordinating Meeting was to review the progress of Physics R&D, especially in the High Priority Research Areas, for burning plasma experiments including ITER, and to discuss the plans for pursuing necessary R&D.

The CC heard reports on the most significant recent developments in the areas of responsibility of the Topical Groups (for the ITPA High Priority Research Areas 2002 see the chart on the next page).

Diagnostics. Extensive design analysis has been performed on the implementation of polarimetry and MSE for measuring q(r). The apparent high levels of radiation induced electromotive force (RIEMF) observed on magnetic coils may have been due to systematic errors in the measurements. Good results were reported for mirrors made from metallic coatings such as Mo and Rh. However, redeposition of divertor and wall material on diagnostic mirrors remains a potential problem. Coherent documents on the specification and justification of the measurement requirements have been prepared and are under review by the ITPA Topical Groups (TGs), indicating that further refinements in diagnostics are required in some areas of divertor measurements. Design improvements have established the feasibility of helium ash measurement in the core by charge exchange recombination spectroscopy with the diagnostic neutral beam. Real-time control schemes for burning plasmas need to be continually developed in collaboration with other TGs.

ITPA High Priority Research Areas 2002

Diagnostics	Determine requirements for measurement of q(r) and assess possible methods that can be applied to a BPX. Determine measurement requirements in divertor region and recommend diagnostic techniques. Assess impact of RIEMF on magnetic measurements and perform improved measurements on prototype coils. Determination of the life-time of plasma facing mirrors used in optical systems. Development of methods of measuring the energy and density distribution of confined and escaping alpha particles.
MHD, Disruption and Control	MHD stability analysis of H-mode edge transport barrier under Type I and tolerable ELM conditions. Neoclassical tearing mode (NTM) island onset threshold scaling and theory. Stabilization of NTM islands at high ß and ß recovery. Requirements on RF stabilization of 3/2 and 2/1 NTMs in reactor plasmas and control system requirements for diagnostics. Resistive wall mode (RWM) analysis and experimental verification of control. Disruption DB extension:- prediction of maximum current quench rate, especially at q=2.7-3.2; - disruptions in advanced scenarios.
Steady State Operation and Energetic Particles	Steady state plasma operation in existing devices: Define proper figures of merit for high fusion gain, high bootstrap fraction plasmas. Investigate full current drive plasmas with significant bootstrap current including real time current profile control. Compare model predictions with experimental data for heating and current drive. Study ECCD off-axis beyond r/a~0.4. Assess off-axis NBCD localization. Optimize ICRH coupling through experiments and models. Studies of fast particle collective modes in low and reversed magnetic shear configurations: Identify key parameters. Use/identify the necessary modelling code.
Transport and ITB	Improve experimental characterization and understanding of critical issues for reactor relevant regimes with ITBs, including: ITB formation and sustainment conditions, impurity accumulation (low- and high-Z), compatibility with divertor requirements ($n_{sep}/n_G \geq 0.3$). Develop, manage and analyze the new international experimental ITB database in order to test predictive theory-based models. Study experimental plasma results that challenge whether ion transport is fully understood, such as flat core profiles. Test simulation predictions via comparisons to measurements of turbulence characteristics, code-to-code comparisons and comparisons to transport scalings.
Confinement Database and Modelling	Assemble and manage multi-machine databases, analysis tools and physics models (global L-mode and H-mode confinement and the H-mode Threshold and, through collaboration with other Topical Groups, the Joint Pedestal/H-mode and Profile Databases). Develop more sophisticated global scaling models (e.g. taking into account profile effects, pedestal parameters and non-linear dependencies) to identify physical reasons for machine-to-machine differences, and develop and test physics based transport modes against the profile data. Use the models to predict the performance of burning plasma experiments, including an estimate of the uncertainty of the predictions.
Pedestal and Edge	Improving predictive capability of pedestal structure through profile modeling. Constructing physics-based empirical scaling of pedestal parameters. Improving predictive capability for ELM control and accessibility to small ELM regimes.
Divertor and SOL	Understanding the effect of ELMs/disruptions on divertor and edge structures. Tritium retention and the processes that determine it. Improve understanding of SOL plasma interaction with the main chamber separatrix density and divertor performance (or edge profile modelling) for high density H-mode.

Note: The definition of High Priority Research Areas: a small number (≤3) of R&D issues which provide a focus for the Topical Group's activities on a timeframe of 1-2 years and which should be determined on the basis of their likely importance, both in increasing understanding of fusion plasmas and in providing increased confidence in achieving significant fusion gain in proposed long-pulse burning plasma facilities, as well as on the probability of achieving significant progress within this timeframe.

MHD, Disruption and Control. Stationary high confinement regimes have been found in ASDEX Upgrade and JET at $\beta_N \approx 2.5$ in spite of (3,2) NTMs. In plasmas with higher plasma triangularity and a peaked density profile, the onset β_N of NTMs is reduced. In DIII-D, the use of internal poloidal field sensors has improved the controllability of RWMs via error field reduction and, as a result, by sustained toroidal rotation. Strong impurity gas puffs have been shown to mitigate halo currents without generating substantial runaways. Prediction of the maximum current quench rate, especially at q_{95} = 2.7–3.2, and investigation of disruptions in advanced scenarios are high priorities. The DINA code for disruption modelling has been tested against DIII-D experiments, and analysis of JT-60U, TCV and ASDEX Upgrade plasmas is in progress. An expansion of the Disruption Database and the 3D-modelling of toroidal asymmetries are planned.

Energetic Particles, Heating & Current Drive and Steady State. Benchmarking of ripple loss modelling codes has proceeded under a collaboration of JAERI and the Kurchatov Institute. Optimized ferritic steel inserts are predicted to effectively eliminate ripple loss in ITER. A substantial reduction in beam divergence enabled high power, long pulse (10 s) negative ion based neutral beam operation in JT-60U and improved the operational reliability. Third harmonic ICRF acceleration of helium beam ions up to energies of ~3 MeV enabled the simulation of a-particle behaviour in JET. ECCD efficiency does not decrease as much as expected with radius in high-ß plasmas (relative to low-ß plasmas) in DIII-D. LHCD was very effective in the formation of ITB plasmas in JET, and LHCD was demonstrated at high density (~0.8 x 10^{20} m^{-3}) in FTU. Plasmas relevant for steady state operation, characterized by high plasma performance, high bootstrap current fraction and full current drive, were demonstrated in JT-60U, JET and ASDEX Upgrade.

Transport and Internal Transport Barrier. The Internal Transport Barrier (ITB) Database Working Group has studied trends in ITB formation conditions, such as a multi-machine comparison of the loss power at the time of ITB formation. On JET and JT-60U, high-Z impurities accumulate inside the ITB, which is consistent with neoclassical transport with the inward pinch velocity increasing with Z. Demonstrated solutions to this impurity accumulation issue are a high priority. In addition, as the achievable stability limit increases with ITB radius, ITB based burning plasmas will require a moderate ITB at large radius - this implies the need to control both the ITB gradient and radius.

Confinement Database and Modelling. The H-mode Confinement Database DB3v10 now contains 2677 cases from 14 tokamaks. Agreement with the IPB98(y,2) scaling is still good, and this remains the recommended scaling. The joint Pedestal/H-mode database which has been developed together with the Pedestal TG has been expanded to ~300 shots from five tokamaks. The Profile Database has been up and running since July 2001. The GLF23 model shows a very good fit to L-mode and H-mode data, including ITBs (rms error of 12%). A primary achievement of the modelling effort to date has been the success of models based on ITG-driven turbulence to explain ion energy transport. A better understanding of other aspects of physics influencing confinement modelling of burning plasmas will be pursued, e.g. electron transport, the density profile, effects of TAEs, NTMs and cyclotron radiation transport.

Pedestal and Edge Physics. Among the many pedestal width scalings proposed, a scaling with the quantity (minor radius x poloidal ion Larmor radius)$^{0.5}$ seems to yield the best fit to the experimental data, but edge magnetic shear information is needed for further study. Pedestal Database v. 3.1 has been released for public access and is in use by collaborators. Further work is needed for an improved understanding of the ELM heat transport time and ELM heat loads. The small ELM regime with improved confinement has been expanded to lower safety factors in ASDEX Upgrade, JET and JT-60U. It was observed on DIII-D that the profile of temperature modulation by ELMs is in agreement with a stability limit based on medium/high-n ballooning modes. Cross-machine comparisons of pedestal parameters and ELM characteristics, keeping non-dimensional plasma parameters constant, have been carried out between DIII-D and C-Mod, and between ASDEX Upgrade and C-Mod.

Divertor and Scrape-off Layer Physics. The ELM amplitude seems to be determined by pedestal collisionality, though the underlying physics of this correlation remains uncertain. High triangularity discharges in JET show reduced ELM frequency at high density. ELMs at high density are associated with little reduction in temperature in DIII-D, suggesting that convective loss is dominant in this regime. Tritium retention has been investigated in JET, confirming that co-deposition is the responsible process. Flow reversal in the scrape-off layer (SOL) was measured in JT-60U and JET, and comparisons with modelling are in progress. Successful experiments with tungsten inner wall tiles were reported by ASDEX Upgrade. Although the feasibility of operating burning plasma experiments in the type I ELM H-mode regime was questioned, the present uncertainties associated with extrapolation to future devices remains significant, and it is premature to conclude that the type I ELM regime is not acceptable.

The CC also heard brief reports on the status and plans of programmes in the EU, JA, the RF and the US.

EU (D. Campbell). A fusion budget of 750 ME is expected for the 6th Framework Programme (FP6: 2003–2006), with increased focus on ITER-relevant activities in physics and technology. Major foci of the EU fusion programme were reported in relation to all the aspects of ITPA high priority research areas. These include tolerable ELMs with good confinement, stabilization of NTMs and ß recovery, improved characterization of disruption termination effects, analysis of RWMs and high priority diagnostics issues.

JA (M. Wakatani and H. Ninomiya). Recent upgrades in JT-60U include enhanced power in negative ion based NBI and ECRH. The goal is to contribute to all the aspects of R&D work under the ITPA. JFT-2M has tested the insertion of ferritic plates inside the vacuum vessel to reduce toroidal field ripple. As a second stage of the experiment, the wall is now fully covered by ferritic plates. Budgetary constraints allow only 4 weeks of JT-60U operation in 2002. The CC members expressed concern that this reduction in operation would be detrimental to the progress of Physics R&D within the ITPA framework, given the substantial contribution made by the JT-60U programme to all aspects of physics R&D, and, in particular, to the area of steady state operation. Fusion research in Japanese universities is highlighted by LHD results: electron temperature up to 10 keV and ion temperature up to 5 keV. The maximum toroidal ß obtained is 3.2%.

RF (N. Ivanov). At T-10 confinement improvement is being investigated by pellet injection and ECRH. It was possible to demonstrate a 20% reduction of the (2,1) NTM amplitude with ECCD. Halo currents were observed to lock the (2,1) mode. Initiation of a discharge with a gyrotron operating at $2\omega_{ce}$ will be tested. Fueling by a cryogenic jet of hydrogen isotope injected from the high field side will be investigated. The design of T-15M is in progress. T-11M focuses on disruption studies and studies of a lithium limiter. TUMAN-3M is investigating the LH transition, and the density perturbation inside magnetic islands. FT-2 experiments are studying LHCD and LHH. GLOBUS-M in the Ioffe Institute is in operation with a low aspect ratio configuration. Theory and modelling work is focused on ITER-related issues. Diagnostics for ITER are being developed in collaboration with the ITER IT.

US (E. Oktay). The US Programme emphases are on scientific understanding, concept improvement and participation in a burning plasma experiment. DIII-D and C-Mod are major tokamak programs, which are very active and productive. The FESAC Review of Burning Plasma Physics issued its report in September 2001, recommending that, "Now is the time for the U.S. Fusion Energy Sciences Program to take the steps leading to the expeditious construction of a Burning Plasma Experiment". The issue of the US rejoining ITER is being considered at high levels. Physics and engineering work for FIRE and IGNITOR are continuing and the US is also participating actively in the ITPA. Snowmass 2002 will make a technical assessment of ITER, FIRE and IGNITOR to provide the technical basis for recommendations to the DOE through the FESAC.

At the meeting G. Cordey and Y. Kamada made a proposal for general guidance to the TGs on assembly of databases, co-ordination of the database activities across TGs, and access and publication policy. Issues, subsequently discussed, included the requirements relating to responsible officers and database managers, the existence of two versions of many databases (public and working), joint publication by the entire Working Group (WG) describing the database and the WG's analysis prior to the public release of the working version of the database. Any publication on the analysis results of the working database should be preceded by the WG's approval. An Oversight Group should be established by the relevant TGs for the Profile Database. Wayne Houlberg, chair of the Oversight Group, will establish the membership of the Group in consultation with other TG Chairs.

It was noted that the integration of research topics amongst TGs has emerged as a particularly important activity, and this can be considered as a sign of the accomplishments of the previous topical activity and of the inherent complexity of the high performance tokamak. In particular, the need to investigate self-consistent scenarios for steady state operation was recognized and it was agreed to rename the "Energetic Particles, Heating & Current Drive and Steady State TG" as the "Steady State Operation and Energetic Particles" TG.

This TG should now concentrate on studies of candidate steady state scenarios, while a subgroup of the TG continues to investigate energetic particles and TAE issues. Analysis of the performance of heating and current drive systems will remain in this TG, with specific needs, e.g. for NTM stabilization, being assessed by the relevant TG. Distribution of responsibilities for specific issues should be clarified by discussions amongst the relevant TGs.

The Status and Plan of the Physics Basis (Physics Guideline) Report was discussed under the working title, "Tokamak Physics Basis". The intention is to update the original ITER Physics Basis in areas where major progress has occurred, with the objective of providing a complete, unified and consistent review of experimental, theoretical and modelling results, as well as proposing methodologies for projection by ITPA TGs and the IT Physics Unit. It was agreed that a list of areas where significant progress had been made should be submitted to the CC by the end of July for discussion at the October CC meeting.

It was recognized that it is in the interest of magnetic fusion research generally that the ITPA activities are concentrated on strengthening the argument for early construction of a tokamak burning plasma experiment. Nevertheless, the commonality of many aspects of burning plasma physics (and technology) between tokamaks and stellarators and the rapid progress being made in many areas of the stellarator programme suggest that both communities can benefit from a shared effort to address the fundamental issues associated with the design and construction of a burning plasma experiment. It was decided that the stellarator community should therefore be invited to nominate one stellarator expert to each of the ITPA Topical Physics Groups.

List of Participants

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