Appendix A1

IEA Cooperation Among Large Tokamak Facilities
Reports and Plan on Task Assignment Programmes (June 2004 - June 2005)

Task 1: Transport and ITB Physics

International collaborative experiments were proposed by ITPA and coordinated through IEA IAs. In the experiments on hybrid scenario, duration of high beta sustainment has been extended in JT-60U; $\square_N$ = 2.5 (a figure of merit for fusion performance G = $\square_N$ H_{89}/q_{95}^2 = 0.4-0.5) was maintained for 15.5 s (~9.5$\square_R$; $\square_R$ is the current diffusion time), and $\square_N$ = 2.3 for 22.3 s (~13.1$\square_R$). In DIII-D experiments with collaboration with JT-60U, $\square_N$ = 2.6 (G = 0.58) was maintained for 9.5 s (~9.2$\square_R$). The effect of NTM on the current diffusion was investigated in DIII-D by NTM suppression with ECCD. In the experiments on steady-state scenario, a weak shear q profile with q_{min} ~ 1.5, q_{95} ~ 4.5, f_{BS} ~ 43-50% and $\square_N$ of 2.4 was successfully maintained for 5.8 s (2.8$\square_R$) under nearly full non-inductive current drive condition (f_{CD} >90%) in JT-60U. In DIII-D experiments on QH-mode with collaboration with JT-60U, the operating space was significantly expanded to higher density by using higher elongation plasmas, and the effects of squareness of plasma shape was investigated. In the experiments on spontaneous (no external momentum input) rotation, change of toroidal rotation to the co-direction was observed in the central region of L-mode discharge during ECH in JT-60U, while a hollow rotation profile was observed during ECH in DIII-D H-mode discharges.

There was one US to EU personnel exchange outside ITPA coordinated international collaborative experiments in this task. Dr. W. Houlberg visited JET for the transport modeling of JET trace tritium experiments. The diffusion and convection velocity were close to neoclassical values for high density plasmas, while a higher level of anomalous transport was found in lower density H-mode regimes

Task 2: Confinement, database and modelling

CDB-2	□ confinement scaling in ELMy H-modes: □ degradation
TG: Conf DB & Mod.	Spokesperson: C.C. Petty

Background - Previous results

Joint experiments in 2003 between JET and DIII-D measured the beta scaling of energy confinement in similar ELMy H-mode plasmas. For both devices, the beta scaling was found to be weak, possibly non-existent, regardless of the kind of ELMs (Type I or Type III). This result is in disagreement with the IPB98(y,2) scaling, but in agreement with electrostatic confinement scaling. In 2004, experiments on JT-60U in high beta-poloidal discharges measured a square-root beta degradation of energy confinement in H-mode plasmas. This result is intermediate between the JET/DIII-D result and the prediction of the IPB98(y,2) relation. Recently AUG did a database search to verify that a factor of 2 scan in beta is possible on that device. In addition to the experimental studies, a reanalysis of the H-mode database by Cordey, et al., showed that a weak beta scaling of energy confinement can be obtained from regression analysis using the error in variables technique.

Device	Period	Local Key Person
JET		D.C. McDonald
DIII-D		C.C. Petty
JT-60U		T. Takizuka
AUG		F. Ryter
MAST		M.Valovic
NSTX		S.Kaye
TS		G.T.Hoang

Outline of Experiment

JET: Drift wave theory of turbulent transport predicts that electromagnetic effects should become important as the ideal ballooning stability limit is approached, leading to a strong, unfavourable beta scaling of energy confinement in this regime. JET proposes in 2005 to look for this effect by extending their study to $\square_N$>2.5 using the Hybrid mode.

AUG: Proposes in 2005 to measure the beta scaling of confinement in the same regime as JET and DIII-D if the existing data do not provide the required data.

JT-60U: Will complete analysis of 2004 experiments

DIII-D: No proposed experiments in 2005.

MAST: Propose to complete a 2 point □ scans.

NSTX: Propose to do a □ scan in 2005

Tore Supra: Propose to do an L-mode □ scan in 2005.

Status April 05

JET: experiments planned for late 2005 or early 2006

AUG: experiments postponed to 2006

NSTX: experiments planned for 2005 if operation at higher field is allowed

JT-60U: Experiments done, no new experiments in 2005, analysis continuing

MAST: TBD

TS: TBD

CDB-4	Confinement scaling in ELMy H-modes: □* scans at fixed n/n_G
TG: Conf DB & Mod.	Spokesperson: J. Snipes

Background - Previous results

Recently C. Petty published a comparison of data from DIII-D and JET which indicated that □* governed transport rather than n/n_G. This favours applying the principle of scale invariance to ITER confinement predictions whereas the ITER projections to date have been based on scaling with n/n_G. Joint experiment between JET and C-Mod. JET began work in Jan. 2004 with a discharge to be used for a JET/C-Mod identity comparison. C-Mod is considering these experiments for their 2005 campaign, and further follow up experiments may be required on JET.

Device	Period	Local Key Person
JET		J.G. Cordey
DIII-D		C.C. Petty
C-Mod		J. Snipes
AUG		J. Stober

Outline of Experiment

Determine □* scaling with the two tokamaks that can achieve the widest range in □*, JET and C-Mod and study the issue of whether □* or n/n_G is the relevant scaling parameter. □* scans will be completed on JET and C-Mod starting from a JET/C-Mod identity discharge pair. The scans would be continued until the Greenwald fraction reached that of the identity discharge of the other device. This involves decreasing □* from the identity discharge on JET and increasing □* from the identity discharge on C-Mod. If these experiments are successful then AUG and DIII-D could produce the midrange matches.

Status April 2005

A suitable C-Mod discharge (1001018013) has been compared to a number of C-Mod/JET identity discharges in JET and good matches to □* and n/n_G were obtained. These comparisons indicate that □* provides the best match. To obtain conclusive results, C-Mod intends to do a □* scan with the JET shape and MP392 was approved for these experiments. If the proper machine conditions are reached, the experiment should be run before July 2005. EPS paper on these experiments submitted by JET and C-Mod. Both DIII-D and AUG experiments possibly in 2006.

CDB-6	Improving the condition of Global DBs: Low A
TG: Conf DB & Mod.	Spokesperson: S.Kaye

Background - Previous results

Initial experiments have been performed on NSTX and MAST to establish low aspect ratio confinement scalings and to connect to conventional aspect ratio tokamak data in the ITPA database. Results of NSTX experiments indicate that the parametric dependences with respect to current and power are consistent with those observed at conventional aspect ratio, although confinement enhancement values can be high and the confinement exhibits a stronger toroidal field dependence than is observed at conventional aspect ratio. Analysis of the MAST data with respect to the conventional aspect ratio data in the ITPA database confirmed the aspect ratio scaling previously derived from only the high and conventional aspect ratio data. The analysis in dimensionless variables shows a strong interplay between beta and aspect ratio scalings introduced by MAST. The MAST data show a correlation between confinement enhancement and reduction of collisionality. The data that have already been contributed to the ITPA database have extended the range of inverse aspect ratio in the database by a factor of 2.2 (up to values of 0.7), and have also extended the range of beta by a factor of 5 (up to values of approximately 20%).

Device	Period	Local Key Person
NSTX	2005	S. Kaye/E. Synakowski
MAST	2005	M Valovic/R. Akers
DIII-D	2005	C. Petty

Outline of Experiments

Identity experiments will be carried out between MAST and NSTX in order to establish parametric confinement scalings at low aspect ratio. The experiments will be performed using both engineering and dimensionless variables. Of particular importance is to establish the scaling of confinement with both toroidal beta and collisionality in L and H-mode discharges. NSTX and MAST operate at comparable engineering parameters (it is expected that MAST will have increased beam powers, up to 5 MW, in 2005).

The *scaling of confinement with aspect ratio* will be investigated by joint experiments with DIII-D. It is proposed to perform a dimensionless parameter scaling experiment between DIII-D and NSTX, matching all dimensionless parameters except aspect ratio (match poloidal rather than toroidal dimensionless parameters such as beta). DIII-D will match an existing NSTX discharge in order to determine the aspect ratio scaling. Both devices will then individually perform a rho-star scan to determine scaling with toroidal rho-star. MAST is planning also to participate in this experiment. A separate MAST-DIII-D aspect ratio scaling experiment, in which ρ^*, ν^* and *toroidal* beta are matched, has also been proposed. It is planned to begin this study in 2005.

Status April 2005

Experiment has been performed recently on DIII-D. Reasonably good discharge matches in plasma shape and poloidal dimensionless parameters to NSTX/MAST were obtained in H-mode discharges. It is expected that a further iteration will be needed in NSTX and MAST to obtain the best possible matches. DIII-D also performed a □* scan to match □* in NSTX and a □* scan to allow confinement results at fixed poloidal parameters to be extrapolated to a comparison at fixed toroidal parameters. Transport analysis of the DIII-D discharges is expected to be completed by the next ITPA meeting in the fall. MAST/NSTX comparison will be performed in 2005.

CDB-8	Title: rho* scaling along an ITER relevant path at both high and low beta
TG: Conf DB & Mod.	Spokesperson: D.C. McDonald

Background - Previous results

The dimensionless gyroradius (□*) is the only parameter needs to vary from present day tokamaks to ITER. The energy confinement time is strongly dependent on □*; confinement scaling relations imply $B\tau_E \sim$ □*$^{-2.7}$ while perfect gyro-Bohm scaling is $B\tau_E \sim$ □*$^{-3}$. Dedicated experiments in H-mode plasmas on JET, JT-60U, ASDEX-Upgrade, DIII-D and Alcator C-Mod generally support gyro-Bohm scaling of transport, but owing to the small □* scan possible in an individual machine (factor of 1.6) the uncertainty in the □* scaling ITER is large. The plan is to combine □* scans from different machines to form a continuous path to an ITER target discharge having the same shape, □, collisionality and safety factor. The large range in □* from C-Mod to JET (~5) will then enable the □* scaling to be accurately determined.

Device	Period	Local Key Person
JET		D.C. McDonald
DIII-D		C.C. Petty
C-Mod		M. Greenwald
AUG		A.Staebler

Outline of Experiment

A series of similarity □* scans will be performed on several machines with matched, ITER relevant, □$_N$, □*, plasma shape and safety factor. As well as the baseline □$_N$=1.8 ELMy H-mode, a higher □$_N$ =2.5 value will be attempted using the hybrid mode. Although the precise configuration has not yet been agreed between the four devices it is expected that a high shape C-Mod like scenario will be used.

Status April 2005

AUG: No experiment planned for 2005, will be considered for 2006
JET: Experiments planned for late 2005 or early 2006
DIII-D: Experiments will be considered for 2006 campaign
C-Mod: Experiments planned for 2005
NSTX would like to participate (S.Kaye). Experiments to be performed preferably in 2005 than after

Task 3: MHD, Disruptions and Control

MHD physics tasks proposed by the ITPA and implemented under the IEA LTA have been conducted in a range of areas.

Resistive Wall Modes: Experiments were conducted between DIII-D and JET with matched plasmas (shape, q and pressure profile) to measure resonant field amplification (RFA) from externally applied error fields. When geometric differences are taken into account there seems to be relatively good agreement. This work was presented at the 2004 EPS and APS conferences.

Low $\tilde{\beta}$ error fields: A non-dimensional error field scaling experiment has been completed on Alcator C-MOD, DIII-D and JET, with identity matched plasmas and a good match of the error field spectra. The error field thresholds on C-MOD and JET agree rather well, while DIII-D has a somewhat larger threshold. The origin of this discrepancy is under investigation. This work was presented at the 2004 IAEA and APS conferences. Studies are also on-going to resolve the influence of aspect ratio on the error field threshold using MAST and NSTX data.

NTM physics and error fields at high β: Cross-machine experiments have been completed on JET, DIII-D and ASDEX Upgrade, to study the critical β below which the 2/1 and 3/2 NTM are unconditionally stable. Results were presented at the 2004 EPS and IAEA conferences. A further influence on 2/1 NTM thresholds originates from error fields. On JET and DIII-D, deliberately applied error fields lowered 2/1 NTM β_N thresholds significantly. Data from DIII-D (subsequently supplemented by data from ASDEX Upgrade, JT-60U and JET) was used to predict the coefficients in the modified Rutherford equation, which are needed for predictions of ECCD feedback power in ITER. The results show that the proposed 20MW ITER system is adequate to substantially control the 2/1 NTM and that precise alignment and modulation would leave sufficient power for 3/2 NTM control too. Equivalent fitting for JT-60U alone gives a somewhat higher estimated power for 3/2 and 2/1 NTM stabilisation in ITER, but this can be reduced to 12MW by optimisation of the injection angle. Extended ECCD feedback of 2/1 NTMs has recently been successfully demonstrated on DIII-D. Also NTMs have been suppressed, at high β_N (~3), by early ECCD injection in JT-60U.

Disruption Mitigation: Recent DIII-D experiments used a directed jet, which has the advantage of being aimed more at the plasma centre. It is found that an instability appears to be involved in transporting the ionized impurities to the centre and/or heat from the centre towards the edge. In ASDEX Upgrade, disruption mitigation by gas injection is developed to the point of being used for machine protection. Reduced runaway signatures using mixed-species gas injection was observed in JT-60U, with Kr showing the best performance. This work was reported at the 2004 IAEA conference. Experiments on TEXTOR have shown pre-existing runaway electrons are suppressed within 0.5ms of the fast gas valve activation.

With regard to future plans from June 2005 to May 2006, it is expected that joint experiments on Disruption Mitigation, Neoclassical Tearing Modes, Resistive Wall Modes and Error Fields will continue, together with the related personnel exchanges.

Task 4: Edge and Pedestal Physics

Coordinated experimental activities/exchange of personnel took place during the period June 2004 - May 2005 in the following ITPA pedestal and edge topics:

PEP 1 & 3: JET/JT-60U pedestal identity experiments and modelling;
PEP 12: Comparison between C-MOD EDA and JFT-2M HRS regimes;
PEP 13: Comparison of small ELM regimes in JT-60U, ASDEX Upgrade and JET; and
PEP 14: QH/QDB comparison in JT-60U and DIII-D.

PEP1 & 3 (September 2004): New experiments in JT-60U with the JET identity shape were carried out. The scope was to understand the mechanism for the improvement of pedestal performance and change of ELM characteristics observed when perpendicular Positive-NBI was replaced by tangential Negative-NBI, in particular regarding the role of rotation and ripple loss on the pedestal and ELMs. Due to non-optimal wall conditioning, only marginal H-modes were obtained, without clear Type I ELM phases. Never-the-less, the general results of the previous experiments were confirmed, although the aim of producing data to distinguish the effect of rotation and ripple losses on pedestal parameters was not achieved. A. Loarte, G. Saibene and J. Lonnroth participated to the experiments. J. Lonnroth also carried out numerical modelling of the pedestal identity plasmas, as well as initiating collaboration between JET and JT-60U for ripple loss analysis using JAERI expertise and the OFMC code. The numerical modelling reinforced the earlier understanding that the differences in pedestal performance between JET and JT-60U is apparently not explained by differences in MHD stability (rotation effects), whereas large ripple losses of thermal ions in JT-60U seem to play a major role. These results indicate that a ripple experiment in JET, in collaboration with the JT-60U team, could provide unique information on pedestal physics and ELM control.

PEP 12: On both C-MOD and JFT-2M, boronization has been found operationally to be necessary for steady EDA or HRS regimes. However, the corresponding physics reason is not well understood, since both experiments use this conditioning technique routinely. This may be important for small ELM regimes on ITER. During the recent opening, C-MOD cleaned the boron coating from its metal plasma-facing surfaces and removed boron nitride components. H-mode experiments with the JFT-2M shape have been repeated, with on-site participation by K. Kamiya and N. Oyama of JAERI. As expected, the global character of the discharge was different, and a steady EDA regime was not achieved, although some quasi-coherent modes were seen. Comparison of pedestal parameters with

2004 experiments is ongoing. Further post-boronization experiments are planned later in the current C-MOD campaign to complete this inter-machine activity.

PEP 13: Collaborative experiments between JT-60U and ASDEX-Upgrade were carried out in June 2004. Part of the experiment was aimed at the verification in ASDEX Upgrade of the □ scaling of pedestal width found in JT-60U. Data analysis is not yet complete, but first indication is that pedestal widths in ASDEX Upgrade do not follow a □ scaling. High $\square_p$ H-mode plasmas were also established in ASDEX Upgrade, to investigate the JT-60U grassy ELM regime. Small ELMs at high pedestal pressure were obtained in ASDEX Upgrade by operating at high q_{95} (~6), high □ □0.4) and high $\square_p$ (1.8-2.0), following the JT-60U recipe. However, these small ELMs were obtained only when operating in a QDN shape. In SN, Type I ELM activity persisted, although sparse. External participants in the experiments were N. Oyama (JAERI), and A. Loarte and G. Saibene (EFDA, for the small ELM experiments).

PEP 14: The aim of these experiments was to compare the pedestal parameters by matching the plasma shape of JT-60U and DIII-D QH-modes. The experiments took place in January 2005 in DIII-D, with the participation of the JT-60U scientists Y. Sakamoto and H. Urano. Based on scans of squareness and triangularity, responses of the QH-mode on the plasma shape were studied. The detailed data analysis is in progress.

Task 5: SOL and Divertor Physics

Some of the particularly active SOL and divertor physics tasks proposed by the ITPA and implemented under the IEA LTA agreement are described. DSOL Task No. 7 (Study on separatrix density and edge density profiles): one of the most important tasks of this topical group is projecting the ITER SOL power width and separatrix density from existing machines - an ongoing activity whose latest update has been published in the Proceedings of the 16th PSI Conference "Multi-machine comparisons of H-mode separatrix densities and edge profile behavior in the ITPA SOL and Divertor Physics Topical Group", A. Kallenbach (AUG), with 6 co-authors contributing data from JT-60U, MAST, JET, DIII-D and C-MOD, J Nucl Mater 337-339 (2005) 381. This new data base exploits the general availability of main-SOL n_e and T_e radial profiles from Thomson scattering (power width λ_q ~ 2/7 λ_{Te}, assuming parallel power transport is largely due to electron heat conduction). This new database, in contrast with earlier ones, finds a quite simple scaling relation, specifically λ_{Te} ~ 0.003R, with only weak dependencies on other parameters such as density and field. This projects to λ_{Te} ~20 mm and λ_q ~6 mm for ITER. The separatrix density is also found to follow rather simple scaling: $n_{e.ped}/n_{e,sep}$ decreases from ~3 to ~1 as $n_{e,sep}/n_{Greenwld}$ is raised from 0.1 to 0.6; this curve falls slightly below the previously projected ITER operating point. This important database will continue to evolve along with the process of identifying all the controlling parameters of the edge – as needed to improve projections to ITER.

Tritium retention by co-deposition with carbon is a serious issue for ITER. O_2-baking is a potential solution; it may be able to recover tritium from all types and locations of co-deposit within the vessel. A new DSOL Task No. 12 (Oxygen wall cleaning) has been undertaken, initiated by the encouraging results of the accidental air-bakes on JET over past years, which occur when loss of vacuum can allow air to enter the heated vessel: plasma operation has been quickly recovered and no long term damage has been found. The JET findings lead to dedicated O_2-bake experiments on TEXTOR, 1999/continuing, on HT-7, 2004/continuing, and on DIII-D, initially with *ex situ* O_2-

baking of removed tiles – ones on which measured ^{13}C co-deposits have been formed under controlled and measured plasma conditions. The latter ^{13}C-tracer studies were also initiated through collaboration with JET and TEXTOR. JET tiles, loaded with measured ^{13}C co-deposits, will also be assessed and compared using the same *ex situ* O_2-baking analysis (Toronto). These *ex situ* data will be used to optimize *in situ* tests.

Recently discovered fast parallel flow was unsuspected, particularly at locations far from the divertor. A theoretical explanation is still sought. Such fast flow has major implications for co-deposition tritium retention and presumably also for impurity screening and power transport. Under DSOL Tasks No. 6 (Parallel transport in the SOL) and No. 9 (^{13}C injection to understand C migration) a database is being assembled on parallel flows based on data from Mach probes (JET, JT-60U, C-MOD, AUG and DIII-D), on plume shapes from impurity injection (DIII-D, C-MOD) and on ^{13}C deposition patterns (DIII-D, JET, TEXTOR, AUG).

Task 6: Steady State Operation

International collaborative experiments coordinated through IEA IAs have made significant progress and expanded multi-machine data sets for further analysis in view of steady state operation development. It should be noted that in this period no experiment had been carried out because of machine shutdown.

Preparation of ITER steady-state scenario; On JT-60U, study of ITER steady-state operation relevant discharges, which have a weak shear q profile, has been carried out in a framework of IEA/ITPA joint experiments (SSOEP-1). A nearly full non-inductive current drive state with a large fraction of bootstrap current (f_{BS} ~ 45%) with q_{min} ~ 1.5 was sustained for 5.8 s in a high □$_p$ plasma without any neo-classical tearing mode.

Preparation of ITER hybrid scenario; For the development of hybrid scenario demonstration discharges, which have a flat q profile with q_{min}>~1, sustainment of □$_N$ = 2.3 for 22.3 s with such a q profile was successfully demonstrated on JT-60U in a framework of IEA/ITPA joint experiments (SSOEP-2). In the discharge a figure of merit for fusion performance (□$_N \cdot H_{89p}/q_{95}^2$) maintained > 0.4. On DIII-D development of the hybrid operation relevant plasmas in collaboration with JET, sustainment of high performance (□$_N$ = 2.8, □$_N \cdot H_{89p}/q_{95}^2$ ~ 0.6) for 9.5 s was obtained at q_{95} = 3.2. Even at higher q95 = 4.4, which is more suitable for the hybrid scenario, sustainment of □$_N$ = 2.7 and □$_N \cdot H_{89p}/q_{95}^2$ ~ 0.4 is demonstrated for ~5 s.

As for the future plan from June 2005 to May 2006, the research on steady state operation will be continued. The ITPA “SSO” TG is proposing researches on the ITER steady state relevant plasmas and hybrid operation relevant ones in more depth.

Task 7: Tritium and Remote Handling

De-tritiation of plasma facing component: Laser de-tritiation via layer ablation is a very promising technique for in-situ de-tritiation, since ablation of 50µm of deposited layer was obtained in laboratory studies using a 20W (2J/cm^2) 1052nm high frequency laser on samples originating in TEXTOR. In 2004, a surface of 10x10mm^2 was automatically ablated at 0.2m^2/hour, without damaging the graphite substrate. Extrapolation of these results to 100W power laser leads to a

removal efficiency of $1m^2$/hour for a 50µm co-deposited layer in air. Based on the above-mentioned experimental results, an optimised system is under design and will be constructed by the end of 2005 for in-vessel de-tritiation by laser ablation using Remote Handling capabilities. This new system will be ready at the beginning of 2006 for tests on JET tritiated tiles in the JET beryllium handling facility.
Tritium concentration in the near-surface region of a TFTR D-T tile was measured by BIXS (β-ray-induced X-ray spectrometry) at JAERI TPL. The results showed that the maximum tritium concentration appeared at the depth of a few microns from the surface. This agreed well with that obtained previously by Eximer laser ablation.

Trials of flash lamp photonic cleaning have been conducted in 2004-2005 both inside the JET vessel and in the JET Beryllium Handling Facility using inner divertor and outboard poloidal limiter tiles. The results demonstrated clear co-deposit removal, and appear to confirm the $2.5J/cm^2$ cleaning threshold observed in laboratory studies. First rough estimates show that the removal rate is between $2.5\text{-}10m^2$/hr for a 10□m thick co-deposit using a single flash-lamp at 250J per pulse. In the absence of co-deposit removal, de-tritiation via heating appeared to be limited to only the surface <1□m layers due to the short pulse length of the flash-lamp discharge.

Exhaust gas from the JT-60 tokamak was analyzed to understand the behavior of fuel and impurity elements in the vacuum vessel. In the tokamak discharge, various hydrocarbons such as CD_4, C_2D_6, C_2D_4 and C_2D_2 were detected and possible relation with formation of codeposit is suggested. Introduction of 0.1% oxygen with Helium into the vessel and glow discharge cleaning with it was found to enhance the carbon removal. No effect of oxygen onto tokamak discharge was observed.

Diagnostics studies: Optical fibres offer an attractive practical solution to transport light through the complicated geometry surrounding a fusion reactor. However, they can suffer from serious radiation-induced optical absorption and radio-luminescence. Special fabrication and glass hardening techniques must be used to deploy suitable radiation-resistance fibre in tokamak ITER-like machine. Studies have been undertaken at JET to demonstrate the feasibility of using optical fibres in diagnostics systems during reactor operation and, in particular, the possibility of using large diameter fibres, i.e. with a core diameter of 600µm, acrylate coating and suitable hydrogen treatment to enhance radiation tolerance. As a result, a small but detectable loss in optical transmission (6% at maximum) was observed. When the radiation activity decreases, the fibre recovers totally its transmission capabilities, suggesting that no permanent damage has taken place. Direct measurements carried out in luminescence mode revealed the presence of radio-luminescence during the plasma pulse. Consequently, an increase of the optical transmission following the shape of the pulse is observed in all the pulse. However, no correlation was found between the radiation conditions and the luminescence intensity. This probably results from the non-uniformity of the irradiation conditions.

Cryopanel studies: The design of the ITER high vacuum system is based on a number of supercritical helium cooled cryosorption pumps providing a high pumping speed and capacity, and fast on-line regeneration. To pump helium, which cannot be condensed at the 5°K cooling conditions available, and to help hydrogen pumping, the pumping cryopanels (PCP) are coated with activated charcoal granules. This new PCP was first operated during the JET Trace Tritium Campaign of Autumn 2003, pumping gas from the torus and neutral beam injectors. PCP worked well according to the design specifications. Pumping efficiency is very high (estimated for D_2 to 23mbar-l/cm^2) leading to a high gas amount pumped: 140bar-l of D_2 in 245litres of PCP volume. Several tests with pre-defined gas feed from external supply in agreement with the ITER gas exhaust tritium concentration have also been performed. These tests have shown that the pumping mechanism for tritium is condensation. Tests will continue in 2005 in order to better characterise the competing behaviour between tritium and helium. In 2006, PCP will be dismantled and analysed to determine the tritium levels in the cryopanels. Specific de-tritiation methods will be also developed.

Surfece alalysis of plasma facing component: Tritium and deuterium distribution in the plasma facing material has been investigated in JT-60U in collaboration with Japanese universities. Deuterium concentrations and depth profiles in graphite tiles used in the divertor were investigated by nuclear reaction analysis (NRA) with a deuterium accelerator of Fusion Neutronics Source (JAERI-FNS). The highest deuterium concentration of $D/^{12}C$ of 0.053 was found in the outer dome wing tile, which is much less than those observed in other tokamaks.
Two reports of the JT-60U carbon dust analysis were presented at the 16th International conference on PSI (Portland Maine, USA, 2004), which had been collected and analysed in collaboration with INEEL in 2003.

Task 8: Others

The A key activity in this category was the successful completion of workshop W61 titled “Heating and Control for Long Pulse Operation in Large Tokamaks”. As the name implies, the workshop focused on the main technical challenges for developing reliable heating and control systems tokamaks. Significant technical progress was report from all three parties; Japan, US and the EU. From JT-60U, a major accomplishment was the operation of a gyrotron for 16 s at 0.4 MW by controlling the anode voltage through the discharge. The US reported on developments in the prototype of the "JET ITER-like antenna" and the Alcator C-MOD LHCD antenna. The EU participants reported that enhancements on JET have produced the following long pulse performance figures: 12MW-20s NBI, 8MW-20s ICRF, 3MW-20s LHCD. In 2005 a new ITER-like, ELM tolerant antenna will be installed.

Dr. Larry Grisham (PPPL) has for many years maintained a collaboration with the JT-60U tokamak in Naka, Japan to understand the physical processes which limited the performance of the first generation of high power negative ion neutral beam systems, and to use this knowledge to improve the performance of these systems, while enhancing the performance and reliability of future generations of neutral beam systems for such devices as ITER. During the past year, the JT-60U negative ion neutral beam system injected into the machine many shots of about 1.5 megawatts at about 356 keV with a duration of 10 – 20 second, and one pulse of variable power lasting 25 seconds. This marked a major extension of the pulse length capability, which in the early years was only a fraction of a second. This improvement was a result of many improvements suggested by both parties over the years, including recent changes to the cathode operation and grid extraction area.

A general problem for steady state tokamak research is the high heat loads that must be endured by plasma facing components. Dr. M.Seki visited JET to discuss the generic issue of excessive heat loads on LHCD launchers with Drs. Alan Kaye, Mark Nigtingale and Joelle Mailloux. Specific points of discussion related to the PAM launcher design for JET, which can be effectively cooled, and the newly developed LHCD launcher with eight 12-divided multi-junction modules made of carbon materials for JT-60U. Dr. M.Seki proposed that an arc monitor on JET would be helpful to protect the launcher from sudden heat loads due to RF break down.