INTERNATIONAL TOKAMAK PHYSICS ACTIVITY (ITPA)

International Tokamak Physics Activity (ITPA) Briefing Book

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International Tokamak Physics Activity (ITPA)

General Background:

- ITPA started as a joint activity of four Participants: (Japan (JA), European Union (EU), the Russian Federation (RF), and the United States (U.S.)). Now it also includes Korea (KO) and China (CH).

- The ITPA evolved from the ITER Physics Expert Groups through discussions among the representatives from the US, EU, JA, RF over the period of 2000-2001.

- ITPA aims at cooperation in development of the physics basis for burning tokamak plasma physics, covering designs and issues broader than that represented by ITER.

- The ITPA now includes a broader participation of tokamaks than the ITER Expert Groups.

- ITPA is also connected to the Stellarator community.

- The legal basis for the U.S. participation in ITPA is provided through the various U.S. bilateral agreements in fusion.

- The IAEA International Fusion Research Council (IFRC) affirmed its support of ITPA at its meeting in Vienna on June 18, 2001 and the IEA Fusion Power Coordinating Committee (FPCC) endorsed it in January 2002.

- An ‘Agreed Principles for Conducting the International Tokamak Physics Activity (ITPA’ is attached as ITPA Charter.

Appendix A - Charter

Agreed principles for conducting
the International Tokamak Physics Activity (ITPA)

September 3, 2001
Coordinating Committee

The International Tokamak Physics Activity (ITPA) aims at cooperation in development of the physics basis for burning tokamak plasmas. The ITPA continues the tokamak physics R&D activities that have been conducted on an international level for many years resulting in achievement of a broad physics basis useful for all fusion programs, for the ITER design, and for general tokamak research worldwide.

With the introduction of the ITER project, these activities were focused on the ITER Physics R&D activities, which have been well organized and successfully conducted to develop the physics basis for the ITER design and to coordinate general tokamak research worldwide. Further development of these voluntary physics activities is important to continue an internationally coordinated approach to tokamak research and to advance the databases for future burning plasma research, including ITER.

The ITPA shall consist in providing :

- validated experimental data according to an agreed format;
- analyzed results of experiments to advance understanding of fusion plasma physics;
- the organization, management, and updating of qualified databases;
- theoretical models and simulation results to explain and reproduce experimental results;
- studies of fusion plasma performance in burning plasma tokamak devices, such as ITER; and
- identification and resolution of key diagnostics issues which might arise both in plasma control and in analysis of a burning plasma experiment, such as ITER.

The IFRC supports the ITPA, which is a joint activity of fusion programs in EU, Japan, RF, and U.S.* (the participants). The IFRC receives annual progress reports on the ITPA activity. The organizational structure of the ITPA consists of one Coordinating Committee and several Topical Physics Groups.

- The role of the ITPA Coordinating Committee is to oversee the Topical Physics Groups in conducting their tasks as described above. It is composed of three members from each participant. An additional three members can be also appointed from the ITER International Team (IT) through the participants . The Chairman of the Committee is selected from the Committee members by consensus. The Committee

* The U.S. activity in ITPA is carried out within the existing U.S. bilateral agreements with Japan, European Union, and Russian Federation.

can select its secretary (or secretariat). The Committee holds at least one meeting per year.

- The Coordinating Committee shall determine the number and subject of the Topical Physics Groups. Each Group should coordinate tokamak physics research in its specific subject, analyze the database, carry out modeling, and develop materials for its report to the CC. The Coordinating Committee selects the chair and co-chair of the Topical Physics Groups. Each Group consists of 3-5 scientists per Participant, named by each Participants. The Groups may invite the participation of additional scientists, if necessary. Each Group holds an average of two meetings a year. Meeting locations and dates must be approved by the Coordinating Committee. The agendas of Group meetings can include physics issues specific to burning plasma experiments, including ITER. The Group should issue to the Coordinating Committee a succinct summary of each meeting promptly within two weeks after the Group meeting. Group activities should be reported at each meeting of the Coordinating Committee. Groups are encouraged to make their work available to the broader fusion community in a timely manner.

Each participant in the ITPA agrees to perform the following duties:

- Support the purposes, processes, and infrastructure of ITPA as described above.
- Host the meetings of the Coordination Committee and several Physics Groups alternately. No participation fee shall be charged. The host partner shall provide support of the meeting in terms of services such as conference room, computers with internet connection, secretarial support and other meeting arrangements.

The Coordinating Committee will consider the participation of additional participants and take actions based on readiness of that possible participant to satisfy the duties enumerated above.

The initial duration of this activity shall be two years starting on July 1, 2001.

Background documents:

IFRC Position on “The International Tokamak Physics Activity (ITPA)”

Oct., 2000

Tokamak physics R&D activities have been conducted on an international level for many years resulting in achievement of a broad physics basis. With the introduction of the ITER project, these activities were focused into the ITER Physics R&D Activities, which have been well organized and successfully conducted to provide both the physics basis for the ITER design and general tokamak research worldwide.

Further development of coordinated voluntary physics activities is important to confirm the physics basis from a view-point of current tokamak research progress and to update the databases for future burning plasma research, including ITER.

According to the IFRC Terms of Reference, Item 2.2: "The council shall seek to promote international cooperation in controlled nuclear fusion research and its applications." Toward this end the IFRC supports the following Activity to accomplish an essential international fusion task. Building on the existing coordination with the IEA, the IFRC invites the IEA Fusion Power Coordinating Committee to encourage participation by its members in the Activity.

The International Tokamak Physics Activity (ITPA) aims at cooperation in development of the physics basis of burning tokamak plasmas: construction, management and updating of databases; and development of scaling and modeling to enhance worldwide tokamak research progress.

The Activity shall be to provide:

- validated experimental data according to an agreed format
- analyzed results of experiments to understand and predict fusion plasma performance
- construction, management, and updating of qualified databases. (The participants should develop the procedures to be used for producing and maintaining the databases.)
- theoretical models and simulation results to explain and reproduce experimental results
- predictions of fusion plasma performance in tokamak devices, such as ITER.

The participants should agree among themselves of an appropriate structure for their work. Participants should make the necessary arrangements to facilitate the conduct of this activity. Participants are encouraged to publish data promptly for availability to the broader fusion community. The Activity should commence soon, so that the IFRC can discuss the progress of the voluntary collaboration and possible evolution (towards existing or proposed IAEA or IEA mechanisms) at its next meeting in June 2001.

The relevant part of the draft minutes of the IFRC meeting

June, 2001

7. International Cooperation

International Tokamak Physics Activity (ITPA)

Dr. Roberts discussed the ITPA Progress Report and the "Agreed Principles for Conducting the ITPA". The first meeting could be called by any one of the participants. The IFRC welcomes the beginning of the ITPA.

Organizational Structure

- The ITPA organization includes a Coordinating Committee and seven Topical Physics Groups (Appendix B). While the membership of these international Topical Groups is limited to 5 from each party in order to maintain a continuity and coherence, the meetings are open to other scientists also.

- Management support is provided by the ITER International Team

Members of ITPA Topical Physics Groups

As of 19 November, 2004

	EU	JA	RF	US	CN	KO	IT
Coordinating Committee	D. Campbell† F. Romanelli H. Zohm	Y. Nakamura† H. Ninomiya† S. Takamura	N. Ivanov† S. Konovalov S. Mirnov	E. Oktay† N. Sauthoff R. Stambaugh*	Yuping Huo Jiangang Li† Chuanhong Pan	M. Kwon† J. H. Han Y. S. Hwang	Y. Shimomura M. Shimada**
Transport Physics	J. Connor X. Litaudon B. Unterberg	T. Fujita T. Fukuda A. Fukuyama Y. Sakamoto K. Toi	Y. Esipchuk N. Kirneva S. Lebedev K. Razumova V. Vershkov	E. Doyle* P. Gohil J. Kinsey J. Rice E. Synakowski D. Mikkelsen☆	Jiaqi Dong Aike Wang Shaoji Wang Deng Zhou Younian Wang	J. Y. Kim G. Y. Park	V. Mukhovatov**
Confinement Database and Modelling	J. Cordey F. Imbeaux F. Ryter C. Hidalgo☆	Y. Ogawa H. Takenaga T. Takizuka M. Yagi H. Yamada	A. Chudnovskiy Y. Dnestrovskij V. Leonov	W. Houlberg* J. Deboo S. Kaye R. Budny J. Snipes	Zhengyin Cui Jinhua Zhang Changxuan Yu Yaojiang Shi Ze Gao	S. S. Kim B. H. Park C. B. Kim	A. Polevoi**
Edge Pedestal Physics	L. Horton H. Wilson G. Saibene	K. Ida Y. Kamada* Y. Nakashima N. Oyama H. Urano A. Komori☆	M. Osipenko R. Shurygin	A. Leonard ** P. Guzdar A. Hubbard T. Rognlien M. Wade	Xiang Gao Longweng Yan Bili Lin Guosheng Xu	C. M. Ryu S. H. Seo S. H. Ku	M. Sugihara
Scrape-off-layer and Divertor Physics	A. Loarte Ph. Ghendrih A. Kallenbach G. Matthews V. Philipps K. McCormick☆	N. Asakura* T. Kato T. Nakano S. Takamura T. Tanabe	V. Kurnaev G. Kirnev	S. Krasheninnikov B. Lipschultz** D. Whyte M. Fenstermacher P. Stangeby	Yu Yang Yudong Pan Shizeng Zhu Jianshen Hu	S. H. Hong S. W. Yoon K. S. Chung	A. Kukushkin
MHD	O. Gruber T. Hender* J. Lister A. Fasoli S. Günter A. Jaun	S. Iio N. Nakajima Y. Ono T. Ozeki M. Takechi	N. Ivanov S. Konovalov V. Lukash S. Mirnov V. Pustovitov	E. Strait R. Granetz G. Navratil J. Menard W. Heidbrink E. Lazarus☆	Yi Liu Qindi Gao Liqun Hu Xiwei Hu Yuan Pan Xiaogang Wang	H. G. Jhang O. J. Kwon	Y. Gribov** M. Sugihara
Steady State Operation	A. Bécoulet C. Gormezano A. C. C. Sips* A. Tuccillo	S. Ide** A. Fukuyama K. Hanada T. Suzuki Y. Takase Y. Nakamura☆	V. Kulygin V. Vdovin A. Zvonkov	T. Luce P. Bonoli C. Kessel M. Murakami R. Prater	Xianzhu Gong Xuantong Ding Xiaodong Zhang Xianming Song Jiarong Luo	K. I. You Y. S. Na J. M. Kwon	T. Oikawa
Diagnostics	A. Donné* F. Orsitto R. Pitts F. Serra H-J Hartfuss☆	K. Kawahata Y. Kawano Y. Kusama A. Mase M. Sasao	G. Razdobarin A. Krasilnikov V. Strelkov K. Vukolov V. Zaveriaev	D. Johnson R. Boivin G. Wurden G. McKee A. Peebles	Junyu Zhao Qinwei Yang Yan Zhou Baonian Wan Yinxian Jie	S. J. Yoo S. G. Lee H. G. Lee W. H. Choe	A. Costley** T. Sugie

*** Chair; ** Co-Chair ; †Coordinating Committee Contact Person ; ☆Stellarator**

U.S. Members of the International Tokamak Physiscs Activity (ITPA) - February 5, 2005

ITPA Topical Groups

Coordinating Committee (CC)	Oktay
Erol Oktay	**OFES**
Ned Sauthoff	**PPPL**
Ron Stambaugh	**GA**

Transport Physics (TP)	Bolton
Ed Doyle	**UCLA**
Ed Synakowski	**PPPL**
John Rice	**MIT**
John Kinsey	**Lehigh**
Punit Gohil	**GA**
Dave Mikkelsen-Stell.	**PPPL**
Catherine Fiore	MIT
Larry Baylor	ORNL
Wendell Horton	Texas
Chuck Greenfield	GA
T.S. Hahm	PPPL
Bill Nevins	LLNL
Martin Peng	PPPL/ORNL
Ron Waltz	GA
Jim Callen	Wisconsin

Edge Pedestal Physics (EPP)	Crisp
Tony Leonard	**GA**
Amanda Hubbard	**MIT**
Parvez Guzdar	**Maryland**
Tom Rognlien	**LLNL**
Micky Wade	**ORNL**
Xueqaqio Xu	LLNL
Phil Snyder	GA
Rich Groebner	GA
Rip Perkins	PPPL
Tom Osborne	GA
Jim Drake	Maryland
Ben Leblanc	PPPL

MHD	Dagazian
Ted Strait	**GA**
William Heidbrink	**UCI**
Robert Granetz	**MIT**
Jon Menard	**PPPL**
Gerry Navratil	**Columbia**
Ed Lazarus-Stellarator	**ORNL**
Chris Hegna	Wisconsin
Eric Frederickson	PPPL
John Wesley	GA
Steve Jardin	PPPL
Boris Breizman	Texas
Raffi Nazikian	PPPL
Doug Darrow	PPPL
Nicolai Gorelenko	PPPL
Steve Sabbagh	Columbia

ITPA Topical Groups, Cont.

Confinement, Database, and Modeling (CDBM)	Eckstrand
Wayne Houlberg	**ORNL**
Jim DeBoo	**GA**
Stan Kaye	**PPPL**
Joe Snipes	**MIT**
Robert Budny	**PPPL**
Tom Casper	LLNL
Craig Petty	GA
Lynda Lodestro	LLNL
Glenn Bateman	Lehigh
Dale Meade	PPPL
Arnold Kritz	Lehigh
Martin Greenwald	MIT

Diagnostics	Markevich
Dave Johnson	**PPPL**
Rejean Boivin	**GA**
Tony Peebles	**UCLA**
George McKee	**Wisconsin**
Glenn Wurden	**LANL**
Don Hillis	ORNL
Ray Fisher	GA
Ken Young	PPPL
Jim Terry	MIT

Scrape-off-layer & Divertor Physics (DSOL)	Finfgeld
Bruce Lipschultz	**MIT**
Peter Stangeby	**LLNL/GA**
Dennis Whyte	**Wisconsin**
Sergei Krasheninnikov	**UCSD**
Max Fenstermacher	**LLNL**
Rajesh Maingi	ORNL
Ali Mahdavi	GA
Daren Stotler	PPPL
John Hogan	ORNL
Gary Porter	LLNL
Charles Skinner	PPPL
Henry Kugel	PPPL
Jim Strachan	PPPL
M. Groth	LLNL
Steve Lisgo	MIT

Steady State Ops (SSO)	Oktay
Tim Luce	**GA**
Paul Bonoli	**MIT**
Ron Prater	**GA**
Chuck Kessel	**PPPL**
Masanori Murakami	**ORNL**
Randy Wilson	PPPL
Mike Zarnstorff	PPPL
Pete Politzer	GA
Joel Hosea	PPPL
Cary Forest	Wisconsin U

Notes:
1. The first five persons in each group are the core members
2. The first person in each group is the U.S. Leader
3. The second person is the U.S. deputy leader
4. An OFES Contact person has been identified for each TG for communication and information.
4. The membership is open to all members of the U.S. community
5. Everyone on the list will receive communication on ITPA and be able to contribute to it.

Meetings and Workshops

- The Topical Groups hold about two meetings annually to review the world wide progress in their topical area, to discuss open scientific issues, and to recommend research topics that should be carried out and their priorities. One of these meetings is usually around a major international conference to minimize travel.

- The Coordinating Committee meets about once a year to review the work of Topical Physics Groups, to consolidate their recommendations, and to develop an annual list of ITPA research tasks for the world tokamak community to work on. Attached is the report from the 2004 meeting of the Coordinating Committee held in Shanghai, China.

ITPA Topical Group Meeting Schedule (Spring-Summer 2005)

Topical Group	Date	Place	Comment
Diagnostics	14-18 March 2005	Culham, United Kingdom	Approved
Pedestal	18-21 April 2005	Kyoto, Japan	Proposed on 28 Dec. Revised proposal on 11 Jan. Approval due on 25 Jan. Approved by Dr. Shimomura.
Confinement DB and Modelling	18-21 April 2005	Kyoto, Japan	Proposal made on 13 Jan. Revised on 14 Jan. Approval due on 27 Jan.
Transport Physics	18-21 April 2005	Kyoto, Japan	**Proposal approved by Dr. Shimomura. Sent to CCCP on 24 Jan. Approval due on 7 Feb.**
Steady State Operation	4-6 May 2005	Como, Italy	In conjunction with TM on ECRH application to ITER (organized by S. Cirant). The emphasis of this meeting is on CD benchmarking and performance and current control aspects
Coordinating Committee	6-7 June 2005	Moscow, Russia	
MHD	4-6 July 2005	Tarragona, Spain	The week following EPS Joint session on disruption with Sol&Divertor TG Joint session on fast particle instabilities with IEA Workshop on Burning Plasmas **Proposal is approved**.
Sol and Divertor	4-**7** July 2005	Tarragona, Spain	The week following EPS

Prepared by M. Shimada on 24 Jan. 2005

ITPA Topical Group Meeting Schedule (Fall 2005)

Topical Group	Date	Place	Comment
Pedestal	3-5 Oct. 2005	St. Petersburg, Russia	The week following H-mode Workshop
Confinement DB and Modelling	3-5 Oct. 2005	St. Petersburg, Russia	The week following H-mode Workshop
Transport Physics	3-5 Oct. 2005	St. Petersburg, Russia	The week following H-mode Workshop
MHD (sub-Group)	3-5 Oct. 2005	St. Petersburg, Russia	The week following H-mode Workshop Joint session on ELM stability with Pedestal TG
Diagnostics	Autumn 2005	Taejon, Korea	The date will be fixed during the March meeting

Fifth Meeting of the ITPA Coordinating Committee
10-11 June 2004, Shanghai, China

1. Presentation by the Chair:

Dr. Campbell welcomed the participants and thanked Prof. Huo and Prof. Jiangang Li for the arrangement of the meeting. Dr. Campbell also welcomed the Chinese delegates, Prof. Huo, Prof. J. Li and Dr. Pan. Prof. Huo welcomed all the delegates. Dr. Campbell welcomed the new member of CC, Prof. Yukio Nakamura of Japan, and thanked Prof. K. Toi for his contribution as CC member. The agenda has been approved (Appendix A). The member list has been approved (Appendix B). Apologies have been received from:

RF: S Konovalov,
EU: F. Romanelli, A. Donné
JA: N Asakura
US: T. Leonard

Dr. Campbell mentioned with pleasure that Korea has formally indicated their wish to join ITPA via a letter from Dr. G.S. Lee (attached as Appendix C). The ITPA CC accepted the application from Korea. The CC Chair will reply on behalf of the CC. Focused efforts have been given to writing and reviewing the Tokamak Physics Basis, which will be discussed during this meeting. Dr. Campbell has consulted Dr. Chris Schueller, the NF editor. How the page charges will be paid is an issue. Last November, ITPA-IEA Coordinating Meeting was held in Naka, where the experiments proposed in the areas of ITPA High Priority Research Tasks were discussed. The collaboration has produced many useful results and publications. Dr. Campbell urged continued attention to the joint experiments. Dr. Stambaugh asked for the joint experiments summary table to be filled in by representatives of ASDEX-Upgrade, JET, and JT-60U at this meeting. The collaboration of ITPA-IEA proved to be a successful mechanism in generating and executing experiments. 12 IAEA abstracts have been submitted from ITPA TGs, and have been accepted by the International Program Committee. Dr. Campbell announced that he has accepted a new post in the European Commission services in Brussels, which has necessitated his resignation as Chair of the ITPA CC. US has nominated Dr. Ron Stambaugh as the new CC Chair, which has been unanimously accepted by CC. Dr. Ron Stambaugh commended Dr. Campbell for the outstanding chairmanship which Dr. Campbell has performed since the beginning of the ITPA. Dr. Campbell thanked all the ITPA CC members and TG members for their support and the ITPA Co-chair, Dr. Michiya Shimada for his carrying on ITPA matters during the last few months in view of Dr. Campbell's new post.

2. Presentation by ITER IT Leader:

Dr. Shimomura gave a status report on ITER. Progress has been made in the Negotiations, but the site selection has not been made yet. The Joint Implementation Agreement, Project Resource Management Regulations, Decommissioning, Procurement Allocations, Procurement Systems/Methods, Intellectual Property Rights, Management Structure, Staff Regulation and Risk Management have been drafted. The partners' possible contributions to the construction cost for each proposed site have been agreed upon. The sharing of the Diagnostics has been agreed upon and a proposal for procurement responsibilities has been proposed by the Diagnostics Working Group and agreed by Participant Team Leaders. Some options for broader collaboration have also been discussed.

3. Discussion on « Tokamak Physics Basis for Burning Plasmas »:

Most of the sections have been drafted and circulated among contributors. The sections however show a wide range in the degree of completeness. Overlaps on the content need to be reduced or eliminated. All the draft manuscripts of TPB for Chapters 1-9 have been uploaded to the ITPA web site. While some of the sections still need to be drafted, there are sufficient numbers of manuscripts, justifying the start of editing work by Chairs, Co-chairs and Editors. Most chapters need a summary section to be written. The summary section should include 1) outstanding issues pointed out in the ITER Physics Basis, 2) progress made on those issues, 3) progress made on new issues, and 4) remaining issues. At present, the page length appears likely to be about a factor of two more than the original plan when the full manuscripts are completed. It was agreed by the CC that the TGs should aim to reduce the overall page length to less than 150% of the allocated pages. The references should, in the main, be limited to those after 1998. Colour figures can be used when colour printing is justifiable. It is suggested that the references are formatted in the form [Einstein, 1905] until the last stage, when the references could be numbered sequentially within each chapter. It would be useful to discuss consistency of the text via an Editorial Meeting. The CC agreed on a target date of Mid-September for an Editorial Meeting in Naka. All the sections should be ready and the TGs should aim to have completed the text editing to the point that the length is reduced to within 50 % of the target length by the time of the Editorial Meeting.

The discussion of the individual presentations on the drafting of the TPB highlighted the fact that the TGs should refer to the minutes of the 4th ITPA CC meeting for the resolution of several issues relating to overlaps in TG responsibility within the TPB. Specific comments made in the course of the discussion of the presentations made by the TG Chairs/Co-Chairs were:

Chapter 1: - forms the Introduction to the whole TPB, but should also be readable as a stand-alone document by the wider scientific community;
- should clearly define the overall aim of the TPB;

Chapter 2: the discussion of turbulence and turbulent transport models in sections 2.1, 2.2, and 2.3 should strongly make the case for a large increase in our predictive ability from the turbulence codes; specifically ability to predict that ion transport arises from ITG modes, that turbulence is statistical in nature with infrequent long scale avalanches and more frequent short scale burst, that zonal flows arise from the radial turbulence, that zonal flows can quench the long scale avalanches and so regulate the net transport seen, that equilibrium ExB flows can also quench turbulence, that the Shafranov shift effect can also quench turbulence.
needs a demonstration of theory-based and experimentally-validated model prediction of ITER performance;
the implications of the Borrass model for the density limit in ITER should be discussed more widely within the expert community and the relevant text should be adapted to reflect the consensus;
the consistency of the style of the conclusions drawn in the various sections of the chapter should be checked and made consistent by the chapter editors;

Chapter 3: heat loads associated with disruptions should be detailed here (see minutes of 4th ITPA CC meeting) to provide a coherent overview of the physics of disruptions;
should also contain an overview of the physics of the density limit (see minutes of 4th ITPA CC meeting);
reference can be made to the fishbone instability, but the physics should be discussed in chapter 5 (see minutes of the 4th ITPA CC meeting);

Chapter 4: should deal with the implications of disruption heat loads for first wall materials (see minutes of 4th ITPA CC meeting);

should discuss both the characterization of ELM heat loads and the implications for first wall materials (see minutes of 4th ITPA CC meeting);

Chapter 5: needs to discuss the physics of the fishbone instability, though not much progress has been made recently;

Chapter 6: should discuss integrated scenarios for hybrid and steady state operation in ITER (transport, stability, current drive, fuelling and divertor);
needs to present modelling analysis of steady-state and hybrid scenarios in self-consistent way (to avoid conveying impression of disjointed code activity);

Chapter 7: needs to have a clear link with diagnostic implications of Chapter 6 and Chapter 8; This chapter is to be circulated to the lead authors of the other chapters for them to review and comment on diagnostic requirements and content.

Chapter 8: needs a draft on wall conditioning techniques in present tokamaks and ITER;

Chapter 9: should address ITER's ability to provide the physics basis for DEMO in its concluding section, but a careful presentation is required which is consistent with the strategies of the ITER partners; a clear distinction should be made between the performance expectations for DEMO and parameters targeted for power plants; this section should therefore be reviewed by Contact Persons in the ITPA participants and contact should be made with the ST and stellarator communities to ensure consistency with the overall strategy of the international fusion programme;

4. Brief Reports on status and plans of Programs in CN, EU, JA, RF and US

CN (Huo Y.)
China would like to collaborate with ITPA and contribute to ITER. HT-7 has installed 1.5 MW of ICRF. Error fields were corrected by ferritic steel inserts. Limiter area has been enlarged with active cooling. Four minutes discharge has been demonstrated. The EAST tokamak (Hefei, ASIPP) is under construction, with a plan for first plasma at the end of 2005. The plasma current is over 1 MA, the total heating power is ~ 16 MW and the pulse length is over 500s. HL-2A(Chengdu, SWIP) started operating in 2003. Next year NBI heating will be installed. The focus of theoretical work includes ELM Modes, ITBs and the bootstrap current with the aim of developing control schemes required for steady state plasmas. Further information on the Chinese contacts (list of names of researchers and e-mail addresses) for specific areas of fusion R&D was requested by the TGs to facilitate collaboration.

EU (D. Campbell)
The major focus of the activities in the EU fusion programme is support to the ITER Negotiations and to the ITER Physics and Technology Bases. The enlargement of the EU to 25 members which occurred on 1 May 2004 is a significant event for the EU fusion programme. Within the Sixth Framework Programme an extensive programme of design and R&D on ITER H&CD and Diagnostic systems is underway. New EU-wide task forces have been established to provide improved co-ordination of R&D in certain key areas for ITER: the EU PWI TF aims to conduct in a coordinated way research aiming at the quantitative understanding of the PWI processes; the EU Integrated Tokamak Modelling TF has been formed to coordinate the development of a coherent set of validated simulation tools for the purpose of benchmarking on existing tokamak experiments. JET is currently in shutdown to harden the divertor and to enhance diagnostics.

Installation of the ITER-like ICRF antenna has been postponed to early 2006. 70% of AUG vessel has been covered by tungsten. An ITER-like PAM launcher for LHCD has been installed in FTU and initial experiments completed, demonstrating effective power coupling and current drive. The scaled power density ($50MW/m^2$) is greater than is required for ITER ($33 MW/m^2$).

JA (H. Ninomiya)
Prof. Nakamura has joined CC and has become JA contact person for the university side. The pulse length in JT-60U has been extended to 65 s with 30 s NB injection. The total injected energy is up to 358 MJ. β_N of 1.9 has been sustained for 24 s (> 100 τ_E), much longer than the current penetration time. An ELMy H-mode has been sustained for ~ 30 s. Gas puffing is reduced but the density increases after a certain time, suggesting wall saturation. β_N ~ 3 has been sustained with good reproducibility even in low-q condition (~3). A high bootstrap current fraction of 75 % has been sustained for 7 s. Real time q-profile control has also been demonstrated. TRIAM-1M has demonstrated a plasma pulse of 5 hours and 16 minutes. LHD has achieved significantly improved plasma parameters; stored energy reaching 1.3 MJ, electron and ion temperature ~ 10 keV, pulse length of 756 s and beta value of 4 % at B= 0.45 T have been obtained in different shots. No disruption has been observed with betas up to 4 %. The Local Island Divertor has been implemented and a steep plasma gradient is observed at the edge. JT-60U is contributing to Inter-machine experiments and International Profile and Scalar Databases. Some tungsten tiles have been installed in the divertor.

RF (N. Ivanov)
T-10 tokamak has investigated plasma turbulence, electron heat transport, radial transport in the SOL, etc. Positive and negative spikes of plasma fluxes are observed near the LCFS. A negative applied halo current increases the irregularity of the mode rotation and produces mode locking, while a positive halo current eliminates the rotation irregularity. The T-11M tokamak (TRINITI) investigated the plasma interaction with lithium and carbon limiters. The TUMAN-3M (Ioffe Institute) studied the relationship between the radial electric field and the H-mode using a HIBP and Langmuir probes. HIBP measurements show very slow central potential development, while the edge E_r develops very rapidly. Globus-M (Ioffe Institute) has installed an increased level of NB heating. Theory and modelling activity continues to contribute to ITER analysis, including RWMs, NTMs, disruptions and disruption mitigation by noble gas injection. The T-15M project has been suspended due to lack of funding.

US (E. Oktay)
DOE has issued the report "Facilities for Science – a 20 Year Goal" in which ITER is the first priority among 22 facilities needed for science. DoE's Office of Science issued a Strategic Plan in Feb. 2004. The Fusion Energy Sciences program emphasises the knowledge base needed for an economically and environmentally attractive fusion energy source. The U.S. has been actively participating in the ITER R&D activities, including assignments to ITER International Team. A decision on the ITER Project Office for the U.S. is expected in the near future. The U.S. goals on Predictive Capability for burning plasmas and configuration optimisation contribute to ITER. The program emphasis on increased operations for DIII-D, C-MOD and NSTX. Their aim is to contribute to ITPA/IEA Joint Experiments. Construction of NCSX has been approved, with Initial operation expected in May 2008. New Plasma Science Centers have been approved to encourage closer interaction with other scientific disciplines. Participation in SCIDAC is anticipated.

5. Semi-Annual Report of Control Working Group (Y. Gribov)
The Electronic Working Group on Control (**EWGC**)has been formed within the ITPA activity to provide a basis for preparation of plasma control in ITER. The EWGC has 32 members nominated by the TGs. At present there are two Subgroups working electronically: NTM control and RWM control. A draft list of control simulators has been distributed for comment. In future, code development and benchmarking will be carried out. Benchmarking on ECCD is continuing and groups working with a total of 7 codes are

participating (EU, RF, US and JA). A factor of two difference is observed in the driven current and driven current width. More detailed benchmarking of ECCD codes has been therefore been started and significantly better agreement has been achieved. Formulation of reference terms of the modified Rutherford equation for the ITER plasma of inductive scenario and given profile of ECCD has been initiated and a task description has been sent to the experts. Benchmarking of RWM codes is continuing, with groups working with 3 codes participating. Rather good agreement for the RWM growth rate has been obtained, but the VALEN code yielded a lower value of the "ideal wall" beta limit than those calculated with MARS-F and KINX.

6. Semi-Annual Report of ITPA Profile Database Oversight Group (W Houlberg**)**

Participating TGs include CDBM, TP, SSOEP and Pedestal. A new data submission procedure has been implemented to facilitate the uploading of data. The variable list has also been extended and the 0-D variable list will evolve more rapidly in future. The Pedestal and Edge Group is starting to collect a profile database which includes equilibria. The goal is to enable time dependent transport and stability analysis in the pedestal region through the ELMs. Requests for access to the Working Database have been received from unknown users and these have been requested to make an application via a TG. Guidelines for access to the ITPA databases have been developed.

Friday, 11 June 2004

7. Semi-Annual Reports by Topical Physics Group Chairs/Co-Chairs :

Diagnostics

The main meeting of the Topical Group in February in Naka and the Sub-meeting in April in San Diego were both very well attended and productive. There has been progress on all high priority topics. Task1: considerable progress has been made with the selection of a technique and the design of a system to measure the confined alphas with collective Thomson scattering. In principle, this system should meet the requirements for measurements of confined alphas. Further development is needed for measurement of escaping alphas. Task 2: measurements on JET show that the neutron emission cannot be relied on to be a constant on a flux surface and so the installation of a vertical viewing camera may be essential. Work is needed to (i) determine precisely what can be done using the upper ports, (ii) estimate the extent of the asymmetries that can be expected in the neutron source profile; (iii) design the installation of a VNC adjacent to divertor port, and (iv) predict the performance of the VNC in the measurement of the asymmetries. Task 3: continued progress is reported on the first mirrors. Measurements have been made of actual deposition on test mirrors in some existing tokamaks. Cleaning methods and shutters for first mirrors are under investigation but need further work. Task 4: New irradiation tests in the JMTR reactor have confirmed the earlier result that probably RITES dominates over RIEMF. Although there are still aspects of the results not fully understood, on the basis of the work carried out, it is probable that coils can be developed for ITER in which the combined action of RIEMF, RITES and other related effects is tolerable, and it may be possible to use the coils for measurements on long (> 1000 s) pulses. The development of steady state sensors also shows progress and it is likely that Hall sensors can be developed for applications outside the ITER vacuum vessel. Installation of a plasma position reflectometer is also maintained as a backup. Task 5. The results of the EU irradiation tests performed in the period 1989 – 2002 have been gathered in a detailed electronic table. The database now needs to be extended with the work done in the other ITPA Partners. It is proposed to keep Tasks 1 through 4 as high priority and to reduce Task 5 to intermediate. The measurement of dust and erosion are considered to be very important for ITER but progress in defining the measurement requirements and developing the required techniques is slow. It is proposed to raise this to a high priority task. The present status and open issues in the field of Charge Exchange Recombination Spectroscopy (CXRS), Beam Emission Spectroscopy (BES), and Motional Stark Effect (MSE), and particularly their planned application on ITER, have been reviewed. Considerable progress has been made with the design of the relevant systems and studies have shown that, in principle, most of the related ITER measurement requirements (ion temperature, ion densities, rotation velocities, He-ash distribution, current profile etc.) can be met with the planned implementations. However, there still remain a number of important aspects where further work is required. Thus far it has been planned that the DNB would be a negative ion beam. However, there are some advantages (and disadvantages) in using a positive ion source and the choice of the ion sign is being reviewed. The Diagnostics Database continues to be updated. For the IEA collaboration, it is recommended that techniques including the following should be tested on existing devices: divertor reflectometry, divertor thermography using multiplex approach, divertor erosion measurement (e.g. optical radar), fast wave reflectometry and dust diagnostics. As part of the ITER preparations for procurement, a proposal for the procurement of diagnostics on a per port basis has been developed. It is hoped that this will lead to a considerable enhancement of the dedicated work on ITER diagnostics on-going in the laboratories of the ITER partners. Two papers will be presented in IAEA Fusion Energy Conference. The 7th meeting of the TG will be held on 11-15 October 2004 in Hefei, China (approved). The 8th meeting is provisionally planned to be held at Culham in the spring of 2005.

MHD, Disruption and Control

TG meeting #4 was held on 2-6 Feb 2004 at JAERI, Naka, in combination with US-Japan MHD workshop and LT WS on Current Holes. TG meeting #5 is proposed on 8-10 Nov. 2004 at Lisboa after IAEA 2004 (Portugal). Joint session with Transport TG is planned. The focus would be on beta/stability limits with strong reversed shear/current holes in connection with transport determined kinetic profiles, MHD effects in CH formation and current diffusion, and combination of ITBs with H-mode edge. Joint experiments under ITPA/IEA implementing agreements have been successfully implemented in the programmes of involved devices. A specific question on the feasibility of start up at 0.3 V/m with assistance of ECH has been addressed to be positive and is documented in TPB. A lot of efforts has been made to complete TPB. Concerning the HP research areas, 2/1 NTM has higher threshold of beta_N but is more dangerous than 3/2 mode once destabilized. Aspect ratio comparison on the onset of NTM is ongoing. The marginal limit beta for NTMs with positive magnetic shear is investigated jointly in AUG, DIII-D, JET, JT-60U, NSTX and MAST, and a combined beta_pol scaling in local variables will be derived.. The power required for direct NTM stabilization by ECCD is investigated on JT60-U, DIII-D, AUG. Preliminary estimates for 2/1 mode in ITER is 25 MW (dc) and 10 MW (ac), which depends on deposition width. Sawtooth control methods for NTM suppression have been investigated with ECRF, ICRF, NBI and recently mode-converted ICRF current drive. Stabilized sawtooth by fast ICRF created ions could be destabilized by ICCD applicable for α heating in ITER. Mitigation of NTMs by active triggered transition to 3/2 FIR mode is also a possibility. RWM stabilization is being investigated with comparison of JET, DIII-D and AUG. DIII-D continues RWM stabilization study with internal coils. C-Mod shows a more optimistic R-scaling for error fields than established at other experiments and confirms the Connor-Taylor scaling with Bt. In disruptions the divertor heat loads have a wide footprint and are highest in the short energy decay phase, while radiation contributes much more during the current decay. DINA simulations are compared with experiments in DIII-D, JT-60U, TCV and AUG. 3-d modeling of toroidal asymmetries of heat loads and halo current is producing first results. Neural nets are trained to predict time to disruption, but different discharge scenario lead to fast aging. Killer pellets induce runaways and require standby cryogenic system, which makes it unattractive for ITER. Strong gas jet experiments for disruption mitigation strongly reduce heat and force loads to values below type I ELM impact. A scaling for the pressure and size should be established for gas jet penetration from DIII-D, AUG, JET and C-MOD. A Disruption Databank is being set up with formats similar to other DBs. Contact persons will define content and variables. Results from simulations should also enter into DB. This DB should also give a platform for testing simulations.

Steady State Operation and Energetic Particles

Confinement has been improved in DIII-D steady state discharges. Steady state scenario with qmin~1.5-2 (very weak ITB) was obtained in AUG with q95 ~ 4.3. Substantial development has been made in hybrid scenarios. Similarity experiments have been carried out with AUG and JET, showing very similar performances. 3/2 and 2/1 NTMs have been observed in JET. 3/2 mode seems to limit beta. Operation at lower q95 ~ 3.2 with betaN~3 is achievable : possible extrapolation to Q > 10 in ITER. At high density, HH x betaN is kept constant. BetaN~1.9 for 24 s and 3 for 6 s sustained in JT-60U hybrid discharges. JET RF dominated hybrid scenarios have been demonstrated at low roh* with Ti =0.8Te. In DIII-D, H89 decreases from 2.6 to 2 when density is increased from 0.4 to 0.6 nG but $H\beta_N$ remains constant. Actuators are routinely used in SSO scenario development in JET, TS and JT-60U. Coupling of LHCD has been improved by deuterium gas puffing in JET. Data base for code benchmarking is increasing. ECCD and LHCD code benchmarking is in progress. Large progress is made in damping measurement and code comparison of frequency sweeping AEs, for n=0-2 (JET) and n=4-12 (C-MOD). Abrupt Large-amplitude Event (ALE) is now well diagnosed in JT-60U. The same priorities are proposed for 2004-2005. A meeting after IAEA 2004 is proposed in Lisboa. A joint session with the pedestal groups is planned to discuss AT scenarios and divertor compatibility. Three papers will be presented in IAEA 2004. An invited paper will be presented in EPS 2004. Many of the IEA experiments proposed have been carried out in collaboration with Transport Physics Group.

Transport Physics

Stationary hybrid and steady-state AT scenarios have been investigated on DIII-D, both projecting to ITER target performance levels (Q~20 for hybrid and Q~5 for SS, using pure gyro-Bohm transport scaling). AT scenario with qmin =1.5-2 was demonstrated in AUG. JET Trace tritium experiments results show that "current holes" represent a loss of confinement for alpha particles, i.e. operating with a current hole is equivalent to operating at reduced current. BetaN~3 was sustained for ~ 6 s at low q95 in hybrid discharges on JT-60U. JET has produced an RF dominated hybrid scenario which addresses low momentum input and Ti/Te ~ 1 ratio questions. Transport modelling shows density ITB on CMOD is formed in several steps: starting with marginally stable ITG turbulence, a Ware pinch causes density peaking, leading to ITG suppression. As the density gradient increases, TEM turbulence is excited, and the final ITB density gradient is set by a balance between the Ware pinch and TEM turbulence. Hybrid experiments on AUG and DIII-D are favorable for operation in the high density and Ti~ Te regimes. Taken together, these results are very positive for reactor extrapolation. QH mode was obtained on JT-60U with co- and balanced NBI as well as with counter-NBI, possibly pointing to the effects of edge rotation. Transport is shown to be very sensitive to small current perturbations in TCV electron ITB discharges with bootstrap fraction > 70 %. The proposed research priorities for 2004-2005 are similar to those for 2003-2004, with a slight change in wording. Progress is made or experiments are planned for the TP ITPA/IEA experiments, some under collaboration with SSOEP TG. Joint sessions are proposed with MHD and CDBM groups in the TG meeting after IAEA. A new version 1.8 of the scalar 0-D ITB DB has been released with 1777 entries. Automated data submission tools will be required at major machines to facilitate uploading to the database. DIII-D and JET have such tools, but JT-60U and AUG do not. The review paper on ITB physics has been published in Nuclear Fusion. Paper from 9th IAEA TCM on H-mode Workshop has been published. An EPS paper is going to be presented on transport modeling of SS and hybrid discharges, using data from the ITPA DB. Two papers will be presented at the 2004 IAEA meeting, on transport modeling and on AT performance study using the ITPA database. More could be done on turbulence simulation/experiment comparisons. The next meeting is 8-11 November in Lisbon. Future meetings in spring 2005 in Kyoto and fall 2005 in St. Petersburg.

Confinement Database and Modeling

Efforts are being continued to assemble and manage multi-machine databases, analysis tools and physics models, evaluate global and local models for plasma confinement by testing against the databases, and using the models to predict the performance of BPX. The first Chinese contributions to the International Databases have been made. Beta degradation has been investigated in the confinement scaling of ELMy H-mode. As beta increases, the product of beta and confinement is increased in JET and DIII-D. Hydrogen data is being added to the database. nu* scans were performed on C-Mod and JET that show confinement is better described by its dependence on nu* than n/nG. The comparison between MAST and NSTX shows very low dependence of LH threshold power on wall-plasma distance. Ohmic identity experiments have been planned with potential contributions from 8 tokamaks to test the scaling. Comparison of AUG shots with dominant electron and ion heating at low density reveals a strong difference in threshold power. Ion heating is a necessary prerequisite for the LH transition. High Te hampers the LH transition. HFS pellet and D2 and argon gas reduces the heat load on the divertor in JT-60U. Density profiles are moderately peaked in ITER-like collisionality, ELMing-sawtoothing plasmas on JET, possibly indicating an anomalous particle pinch. The difference in toroidal rotation of ion species follows neoclassical predictions in DIII-D experiments. Integrated simulation codes are being developed in JA, EU and US. Four papers have been published in PPCF (H-mode WS). One paper will be presented in EPS 2004, 4 papers in IAEA 2004. Two papers are planned on the Profile and H-mode databases. The next meeting is proposed for 8-10 Nov. Lisbon, Portugal. Future meetings in spring 2005 in Kyoto and fall 2005 in St. Petersburg.

Pedestal

A variety of 2004 inter-machine experiments focusing mainly on the dimensionally identical comparison with matched plasma shapes have been started. According to the 2003 results, it seems that the normalized pedestal structure is almost the same if the dimensionless parameters are matched. In this year we are investigating the dependence on the dimensionless parameters. As for the density profile, the edge density barrier width correlates with the neutral particle source distribution. In order to improve the predictive capability of the pedestal structure including the neutral effects, the Pedestal TG is now establishing a high quality profile database to be modeled with the integrated codes. As the first step, we have started this project from the data taken in the AUG / DIII-D / JET comparison experiments. In addition, the inter-machine activities are studying the effects of the magnetic configuration (in particular A and SN/DN) on the pedestal structure and the L-H threshold. The dynamics of the ELM cycle and the ELM extent and flows are being investigated. Development of the small/no regimes is continued and applicability to ITER is assessed. 12 Inter-machine experiments are proposed in 2004, which are supported by participating machines. Dimensionless identity experiments and coordinated MHD analysis activities are continued between JT-60U and JET. Counter injection produces pedestal pressures lower than co-injection. Similarity experiments are performed between AUG and MAST. Dimension-less comparison of L-H transition and H-mode edge structure is underway in C-Mod and AUG. Comparison between C-Mod EDA and JFT-2M HRS regimes has been carried out. ELMy/HRS operation boundary occurs near the normalised electron collisionality of ~ 1 in the plasma edge region. QH-mode and QDB study was carried out with NBI and shaping in JT-60U and DIII-D. The QH-mode was observed in JT-60U with co-, balanced and counter- NBI. Other inter-machine experiments (JET/DIIID, MAST/NSTX/DIIID, JT-60U/AUG etc.) are planned in this year. One JET/JT-60U paper will be presented at the 20th IAEA conference sponsored by the TG. The next TG meeting is proposed on 8-10 November 2004 in Lisbon.

<u>Sol and Divertor</u>

The meeting in January focused on plasma-wall interactions and implications for materials used for the first wall & divertor for ITER, and discussion on TPB. Presentations and discussions were focused on issues of plasma wall interaction and T retention based on data from existing tokamaks. The aim was to identify similar trends across machines and implications for TPB and assumptions for predicting ITER performance. Tritium retention was very similar amongst most tokamaks – 3-10% of the D/T injected in the machine is retained. The singular difference is the result from JT-60U where the retained D/T is significantly lower (and also for metal PFC). A second piece of information that came out of the comparison or results from various experiments was that 50 % of the tritium was retained in the gap between divertor tiles in JET, TFTR and DIII-D. Cleaning methods for T-removal were compared for practical usage. The methods currently available show ~ 2 orders of magnitude lower removal rates than is required in ITER. More experience is needed to be able to make this extrapolation. Reduction of T/C codeposition by Be (seen in PISCES) was not evident in JET, probably because JET does not have as much beryllium as in PISCES. Erosion of high-Z PFCs is caused by low-Z impurities (AUG, C-MOD). W/Mo are mostly redeposited locally as opposed to C which tends to transport over large distances in the SOL. Most erosion of W (AUG) occurs during the limiter phase. Surface blistering and bubbles do not occur with proper orientation of material grains. Dust levels in metal PFC machine (C-MOD) is lower than C machine, but is still a concern. The gap between the first and second separatrix positions is 4 cm in ITER. It may not be a problem, but the heat load to the second divertor needs continued attention. A point of disagreement among tokamaks is the divertor heat load (and thus the main chamber and second divertor heat load). The energy fraction to divertor at disruption thermal quench is 10-35 % in JET while in smaller tokamaks (DIII-D, AUG) it is higher. More experiments are needed to clarify this and the scaling to a larger machine. There are other results indicating not all power goes to the primary divertor : ELM power fraction to divertor decreases with increasing ELM size, indicating that wall heat load may be enhanced for large ELMs. ELM radial propagation velocities range in 0.6-2 km/s. The ELM power load to the secondary divertor is observed in DIII-D with relatively small first-second separatrix gaps. The SOL/divertor TG priorities were not modified. Next meeting is proposed on 8-11, Nov. 2004 in Lisbon. A joint session on the effect of second separatrix was proposed (by the CC members) for the next meeting. After that 2005 in Hefei or GA/MIT. It has been suggested that experimental check should be made on the effect of He-DT elastic scattering on helium removal.

8. Discussion of Structure of the ITPA:

8.1 Structure of Topical Physics Groups

The leadership of Dr. Gormezano is appreciated for having formed a strong TG in Steady-State and Energetic Particles and producing significant results. Dr. Gormezano is retiring and stepping down as TG chair; the ITPA CC chair will coordinate the effort to name a new chair. EU has indicated a wish to nominate a new TG Chair. A proposal is made and CC has decided on the move of the performance control aspects from MHD, Disruption and Control TG to SSOEP TG and move of the energetic particle studies from SSOEP TG to MHD TG. MHD, Disruption and Control TG and SSOEP TG are requested to revise the TG name and charter and send them to CC chair by July 16, 2004. The ITPA CC Contact Persons are requested to revise the membership of these two TGs and send the revisions to CC Chair and Cochair.

8.2 Future of ITPA activity (including meeting site)

The relationship between ITPA and ITER International Team may be changed after the establishment of ITER Legal Entity. There is general agreement that an international activity coordinating wide ranging Physics R&D in support of ITER would be required in the future. This would not only respond to requests from the ITER International Organization, but would also continue to advance the physics basis for burning plasma experiments and advise the ITER International Organization on new developments in tokamak physics. The EU expressed the view that any Physics R&D activity should be integrated into ITER International Framework, which is expected to involve Physics R&D activities.

8.3 Progress on ITPA Website

The web site has been updated to allow uploading for registered users. Self-registration for discussion board at present is possible for everyone, but no automatic access to protected pages. Password protection for every page can be configured. Request for UserID for protected pages is queued for decision. Any inconveniences on the web site (e.g. access) should be addressed to Dr. Marc Maraschek, IPP(Maraschek@ipp.mpg.de). Link from the web sites of fusion labs should be promoted.

9. Action Items by the Coordinating Committee

9.1 Approval of Task and Scope descriptions for TGs

The revision of Task and Scope descriptions for MHD, Disruption and Control TG and SSOEP TG has been requested. A proposal should be made by July 16, 2004.

9.2 Approval of High Priority Research Tasks for 2004-2005 with the exception of the priority tasks for MHD, Disruption and Control TG and SSOEP TG that have to be submitted within a few weeks after CC.

The revised list (Appendix D) has been approved.

9.3 Review of Charge to ITPA Expert Groups

The revised list (Appendix E) has been approved. Particular attention was called to planning for the next round of ITPA/IEA joint experiments in 2005. The various TG groups should submit a half page report on each 2004 joint experiment and their plan for 2005 experiments by the end of their TG meeting in the fall of 2004.

9.4 Approval of meeting plans

The proposed meetings (Appendix F) have been approved. Joint meeting plans should be proposed within 3 weeks.

9.5 Preparation for the next CC meeting
The next CC meeting will be held in Russia in June. More specific proposal is expected in a month.

10. Discussion and Approval of Meeting Record
The Meeting Record has been approved.

Appendix A
Agenda

Fifth Meeting of the ITPA Coordinating Committee
10-11 June 2004, Shanghai, China

Thursday, 10 June 2004

1. **Presentation by the Chair:**
   9:00-9:20 Welcome and Brief report on the Status of ITPA (D. Campbell/new Chair)

2. **Presentation by ITER IT Leader:**
   9:20-9:35 Status Report on ITER (Y. Shimomura)

4. **Discussion on « Tokamak Physics Basis for Burning Plasmas »:**
   (The draft manuscripts of TPB for Chapters 1-9 have been uploaded to the ITPA web site.)

   9:40 – 12:00 with one coffee break
   12:00 - 13:00 lunch break
   13:00 - 16:00 with one coffee break
   TG proposals on revisions of the "ITER Physics Basis" (**30** min. for each TG)
   (1) Status of writing and interaction with TPB Editors
   (2) Outstanding progress & remaining issues pointed out in TPB
   Written Semi-Annual Report should include items (1) -(2)

4. **Brief Reports on status and plans of Programs in CN, EU, JA, RF and US**

   16:00-16:15 CN (Huo Y.)
   16:20-16:35 EU (D. Campbell)
   16:40-16:55 JA (H. Ninomiya)
   17:00-17:15 RF (N. Ivanov)
   17:20-17:35 US (E. Oktay)

5. **Semi-Annual Report of Control Working Group**

   17:40 - 18:00 Control WG (Y. Gribov)

6. **Semi-Annual Report of Database Oversight Group**
   18:05 – 18:20 W Houlberg

18.30 Adjourn

<u>Friday, 11 June 2004</u>

7. Semi-Annual Reports by Topical Physics Group Chairs/Co-Chairs :
(Written and Electronic Versions of Semi-Annual Reports Due at the meeting)

A) Progress in High Priority Research Tasks and expectations in the coming year, recommendation for High Priority Research Tasks 2004-2005, plans for publications, and plans for meetings Note: Status of international collaboration within the three tokamak related IEA Implementing Agreements (Large Tokamaks, Poloidal Divertors, and TEXTOR) and recommendations for IEA international collaboration should be discussed in the context of Progress in High Priority Research Tasks; the review of the results and planning of IEA experiments will be made at the IEA meeting in the fall)

B) Reports on TG meetings

9:00 – 9:20 Diagnostics
9:30 – 9:50 MHD, Disruption and Control
10:00 – 10:20 Steady State Operation and Energetic Particles

10:30-10:40 coffee break

10:40 – 11:00 Transport Physics
11:10 – 11:30 Confinement Database and Modeling
11:40 – 12:00 Pedestal

12:00 – 13:00 lunch break

13:00 – 13:20 Sol and Divertor

8. Discussion of Structure of the ITPA:
13:30 –15:00

7.1 Structure of Topical Physics Groups
7.2 Progress on ITPA Website
7.3 Future of ITPA activity (including meeting site)
7.4 ITER research operations and the relationship between the ITPA and the ITER construction and research activities

15:00-15:20 Coffee break

9. Action Items by the Coordinating Committee
15:20-17:00

8.1 Approval of Task and Scope descriptions for Tgs
8.2 Approval of High Priority Research Tasks for 2004-2005
8.3 Review of Charge to ITPA Expert Groups
8.4 Approval of meeting plans
8.5 Preparation for the next CC meeting

10. Discussion and Approval of Meeting Record
17:00-18:00

18:00 Adjourn

Appendix B: Members of ITPA Topical Physics Groups

As of 1 July, 2004

	EU	JA	RF	US	CN	Members from the ITER International Team	Participation of stellarator community
Coordinating Committee	D Campbell F Romanelli H Zohm	Y Nakamura H Ninomiya S Takamura	N Ivanov S Konovalov S Mirnov	E Oktay N Sauthoff R Stambaugh*	Huo Yuping Li Jiangang Pan Chuanhong	Y Shimomura M Shimada**	
Transport Physics	J Connor X Litaudon B Unterberg	T Fujita T Fukuda A Fukuyama Y Sakamoto K Toi	Y Esipchuk N Kirneva S Lebedev K Razumova V Vershkov	E Doyle* P Gohil J Kinsey J Rice E Synakowski	Dong Jiaqi Wang Shaoji Wu Xiwei Weng Yizhi	V Mukhovatov**	D Mikkelsen
Confinement Database and Modelling	J Cordey F Imbeaux F Ryter C Hidalgo	Y Ogawa H Takenaga T Takizuka M Yagi H Yamada	A Chudnovskiy Yu Dnestrovskij V Leonov	W Houlberg* J Deboo S Kaye M Murakami J Snipes	Cui Zhengyin Zhou Deng	A Polevoi**	C Hidalgo
Edge Pedestal Physics	L Horton H Wilson G Saibene	K Ida Y Kamada* Y Nakashima N Oyama H Urano	M Osipenko R Shurygin	T Leonard ** P Guzdar A Hubbard T Rognlien M Wade	Gao Xiang Yan Longweng Wang Long	M Sugihara	A Komori
Scrape-off-layer and Divertor Physics	A Loarte Ph Ghendrih A Kallenbach G Matthews V Philipps	N Asakura* T Kato T Nakano S Takamura T Tanabe	V Kurnaev G Kirnev	S Krasheninnikov B Lipschultz** D Whyte M Fenstermacher P Stangeby	Yang Yu Zhu Shijing Pan Yudong.	A Kukushkin	K McCormick
MHD, Disruption and Control	O Gruber* T Hender J Lister	S Iio N Nakajima Y Ono T Ozeki M Takechi	N Ivanov S Konovalov V Lukash S Mirnov V Pustovitov	T Strait R Granetz G Navratil S Jardin J Wesley	Gao Qindi Liu Yi He Yexi	Y Gribov** M Sugihara	E Lazarus
Steady State Operation and Energetic Particles	A Bécoulet C Gormezano* A Jaun A Fasoli	S Ide** A Fukuyama K Hanada K Shinohara Y Takase	V Kulygin V Vdovin A.Zvonkov	C Phillips P Bonoli C Forest W Heidbrink R Prater	Zhang Ziaodong Wu Bin Ding Xuantong	T Oikawa	Y Nakamura
Diagnostics	A Donné* F Orsitto R Pitts	K Kawahata Y Kawano Y Kusama A Mase	A Kisliakov A Krasilnikov V Strelkov	D Johnson R Boivin G Wurden	Yang Qinwei Wan Baonian Yu Qangxian	A Costley** T Sugie	H Hartfuss

	F Serra H-J Hartfuss	M Sasao	K Vukolov V Zaveriaev	G McKee T Peebles			

*** Chair; ** Co-Chair**

Appendix C

KOREA BASIC SCIENCE INSTITUTE
National Fusion R&D Center

June 8, 2004.

Dr. David Campbell
Chairman
ITRP Committee

Dear Mr. Campbell

As the representative of the Republic of Korea for IFRC, I am pleased to inform you that the Korean Fusion Community wish to participate the International Tokamak Physics Activity, which is now actively progressing with a coordinated efforts of devoted ITPA members.

Therefore, on behalf of the Korean National Fusion Program, I submit this letter of application to you for Korean participation in the International Tokamak Physics Activity(ITPA) and we will comply with a necessary step to join ITPA.

Thank you very much for your kind consideration in advance.

Yours faithfully

Gyung-Su Lee
Member of IFRC and
Director General
National Fusion R&D Center
Korea Basic Science Institute

Appendix D

ITPA High Priority Research Tasks 2004-2005

Diagnostics	• Develop methods of measuring the energy and density distribution of confined and escaping alphas • Review requirements for measurements of neutron/a source profile and assessment of possible methods of measurement • Dertermine life-time of plasma facing mirrors used in optical systems • Develop new methods to measure steady state magnetic fields accurately in a nuclear environment and assessment of thermal EMF on irradiated coils used for steady state magnetic field measurements • Develop requirements for measurements of dust, and assessment of techniques for measurement of dust and erosion
MHD, Disruption and Control	• Perform MHD stability analysis of H-mode edge transport barrier under Type I and tolerable ELM conditions. • Investigate/Determine island onset threshold of NTMs, stabilisation of (3,2) and (2,1) NTM islands at high β and β recovery, and possible operation with benign NTMs (FIR, seed island control); identify requirements for reactor plasmas. • Enhance understanding and mitigation of the effects of RWMs by analysis, experimental verification of control, determination of role of plasma rotation and error fields. Determination of control system requirements for diagnostics. • Construct new disruption DB including conventional and advanced scenarios and heat loads on wall/targets. • Develop disruption mitigation techniques, particularly by noble gas injection.
Steady State Operation and Energetic Particles	• Investigate hybrid scenarios for prolonged plasma operation and develop full current drive plasmas with significant bootstrap current: assess beta limits • Develop real time current profile control using heating and CD actuators: assess predictability, in particular for off-axis CD • Study fast particles collective modes in low and reversed magnetic shear configurations: Identify key parameters. Perform theory-data comparison on damping and stability, including non-linear mode dynamics and fast particle transport.
Transport Physics	• Improve experimental characterization and understanding of critical issues for reactor relevant regimes with enhanced confinement, by: - Obtaining physics documentation for transport modeling of ITER hybrid and steady-state demonstration discharges - Addressing reactor relevant conditions, e.g., electron heating, Te~Ti, impurities, density, edge-core interaction, low momentum input... • Contribute to and utilize international experimental ITPA database for tests of the commonality of hybrid and steady state scenario transport physics across devices • Encourage tests of 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 • Evaluate global and local models for plasma confinement by testing against the databases. • Predict the performance of Burning Plasma Experiments using the models, and include an estimate of the uncertainty of the predictions.
Pedestal and Edge	• Construct a Profile DB based on Inter machine experiment and perform tests of modeling using the profile DB as TG work. • Improve predictive capability of pedestal structure through profile modelling. • Construct physics-based and empirical scaling of pedestal parameters • Improve predictive capability for ELM size and frequency and assess accessibility to regimes with small or no ELMs.
Divertor and SOL	• Understand the effect of ELMs/disruptions on divertor and first wall structures. • Improve understanding of Tritium retention & the processes that determine it. • Improve understanding of SOL plasma interaction with the main chamber. • Develop improved prescription of SOL perpendicular transport coefficients and boundary conditions for input to BPX modelling.

Definition of High Priority Research Tasks: a small number of R&D tasks which provide a focus for the Topical Group's activities in 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.

Appendix E

Charge to ITPA Topical Groups for 2004-2005

1. Topical group meetings are intended to be working meetings to further develop the physics basis for burning plasma experiments and to focus international collaborations. They are not intended to be additional conferences. Each topical group should hold an average of two meetings per year, preferably with one meeting scheduled with other topical area groups and one meeting just for the work of the topical group. The Topical Group should aim to schedule every other meeting in conjunction with other major international meetings. Aim to schedule meetings at least six months in advance and obtain approval of the ITPA Coordinating Committee (ITPA CC) for the meetings' schedule and location.

2. Issue Meeting Executive Summary (a few pages) promptly after Meetings (within two weeks) to be distributed among the fusion community appropriate for unlimited distribution. Early distribution of Meeting Summary is also requested.

3. Prepare a scope and task definition for the topical group for submission to the ITPA CC. Identify opportunities for increased effectiveness, including revised scopes of topical areas, and choice of topical areas; identify how relevant databases will be maintained.

4. Bring important new results achieved in the Parties' Base Programmes to the ITPA Coordinating Committee's attention.

5. Identify and formulate Research Priorities for Physics R&D tasks relevant to next step tokamak burning plasmas. These priorities are to be endorsed by the ITPA Coordinating Committee.

6. Evaluate and document, from the Burning Plasma perspective, scientific progress regarding the Research Priorities and provide an annual written report to the ITPA Coordinating Committee. Arrange for a wide distribution of this report within their area of expertise after acceptance by the ITPA CC.

7. Communicate the importance of the 2004-2005 ITPA Physics Research Priorities to their respective Parties and fusion research establishments and foster collaborative research activities among international fusion research establishments.

8. Recommend the physics guidelines and methodologies for physics design calculations for burning plasma experiments.

9. Consider future directions of fusion research in their topical area and report to the Coordinating Committee on the opportunities afforded by proposed future experimental facilities to support those lines of research.

10. TG should submit a Meeting Proposal at least 3 months in advance to the CC Chair. CC Chair will send it to ITER IT Leader and then to ITPA CC Contact Persons for approval.

11. TG should submit a half page report on each of the joint ITPA/IEA experiments and a proposal on the Inter-Machine Experiments for 2005 by end of the fall Meetings after IAEA

Appendix F

Schedule of ITPA Meetings in Fall 2004

Title	Date	Location	Joint session
Diagnostics	12-15 Oct.2004	Hefei, China	
MHD, Disruption and Control	8-10 Nov.2004	IST, Lisbon, Portugal	Transport Physics
Steady State Operation and Energetic Particles	8-10 Nov.2004	IST, Lisbon, Portugal	
Transport Physics	8-11 Nov.2004	IST, Lisbon, Portugal	Confinement Database and Modeling/ MHD, Disruption and Control
Confinement Database and Modeling	8-10 Nov.2004	IST, Lisbon, Portugal	Transport Physics
Pedestal and Edge	8-11 Nov.2004	IST, Lisbon, Portugal	Sol and Divertor
Sol and Divertor	8-11 Nov.2004	IST, Lisbon, Portugal	Pedestal and Edge

ITPA High Priority Research Tasks 2004-2005

Revised 22 Dec. 2004

Diagnostics	• Develop methods of measuring the energy and density distribution of confined and escaping alphas • Review requirements for measurements of neutron/a source profile and assessment of possible methods of measurement • Determine life-time of plasma facing mirrors used in optical systems • Develop new methods to measure steady state magnetic fields accurately in a nuclear environment and assessment of thermal EMF on irradiated coils used for steady state magnetic field measurements • Develop requirements for measurements of dust, and assessment of techniques for measurement of dust and erosion
MHD	• Perform MHD stability analysis of H-mode edge transport barrier under Type I and tolerable ELM conditions. • Investigate/Determine island onset threshold of NTMs, stabilisation of (3,2) and (2,1) NTM islands at high β and β recovery, and possible operation with benign NTMs (FIR, seed island control); identify requirements for reactor plasmas. • Enhance understanding and mitigation of the effects of RWMs by analysis, experimental verification of control, determination of role of plasma rotation and error fields. Determination of control system requirements for diagnostics. • Construct new disruption DB including conventional and advanced scenarios and heat loads on wall/targets. • Develop disruption mitigation techniques, particularly by noble gas injection. • Study fast particles collective modes in low and reversed magnetic shear configurations: Identify key parameters. Perform theory-data comparison on damping and stability, including non-linear mode dynamics and fast particle transport.
Steady State Operation	• Investigate hybrid scenarios for prolonged plasma operation and develop full current drive plasmas with significant bootstrap current: assess beta limits • Develop real time current profile control using heating and CD actuators: assess predictability, in particular for off-axis CD
Transport Physics	• Improve experimental characterization and understanding of critical issues for reactor relevant regimes with enhanced confinement, by: - Obtaining physics documentation for transport modeling of ITER hybrid and steady-state demonstration discharges - Addressing reactor relevant conditions, e.g., electron heating, Te~Ti, impurities, density, edge-core interaction, low momentum input... • Contribute to and utilize international experimental ITPA database for tests of the commonality of hybrid and steady state scenario transport physics across devices • Encourage tests of 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 • Evaluate global and local models for plasma confinement by testing against the databases. • Predict the performance of Burning Plasma Experiments using the models, and include an estimate of the uncertainty of the predictions.
Pedestal and Edge	• Construct a Profile DB based on Inter machine experiment and perform tests of modeling using the profile DB as TG work. • Improve predictive capability of pedestal structure through profile modelling. • Construct physics-based and empirical scaling of pedestal parameters • Improve predictive capability for ELM size and frequency and assess accessibility to regimes with small or no ELMs.
Divertor and SOL	• Understand the effect of ELMs/disruptions on divertor and first wall structures. • Improve understanding of Tritium retention & the processes that determine it. • Improve understanding of SOL plasma interaction with the main chamber. • Develop improved prescription of SOL perpendicular transport coefficients and boundary conditions for input to BPX modelling.

Definition of High Priority Research Tasks: a small number of R&D tasks which provide a focus for the Topical Group's activities in 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.

Worldwide Planning of Joint Experiments
ITPA-IEA Joint Experiment Planning

- A meeting took place in November 2002 at MIT at which representative of the ITPA CC met with the tokamak program leaders from the IEA Large Tokamak and Poloidal Divertor Implementing Agreements to devise a process to foster increased joint experiments – experiments that require the closely coordinated work on two or more tokamaks. The resulting process has grown to involve all the IEA implementing agreements and nearly all tokamaks.

- In the fall of each year, the ITPA, through its Topical Groups, prepares a report on the previous year's joint experiments and a proposal for a set of joint experiments for the coming year.

- The ITPA CC chair, assisted by the TG chairs, presents this proposal to the world's tokamak program leaders in a meeting in the December time frame.

- At this meeting, the joint experiments are discussed. Commitments are sought from the various tokamak program leaders expressed as a color code
  - red means the machine is committed to the experiment
  - green means the experiment is being considered – probably will be done
  - blue means the machine probably will not do this experiment.

- An international participant team is identified and a spokesperson defined.

- The tokamak leaders seek to implement these joint experiments within their normal experimental planning processes.

Draft Roster of Invitees to the ITPA/IEA Joint Experiment Planning Meeting at GA in San Diego, November 1-2, 2005

Invitee List

Represents	Name	Email Address
JET	Jerome Pamela	Jerome.Pamela@jet.efda.org,
EU Commission	Susana Clement-Lorenzo	Susana.Clement-Lorenzo@cec.eu.int,
TEXTOR	Uli Samm	u.samm@fz-juelich.de,
TCV	Min Qhuang Tran	minhquang.tran@epfl.ch,
JET	Michael Watkins	Michael.Watkins@jet.efda.org,
JET	Domenico Frigione	domenico.frigione@jet.efda.org,
ASDEX-Upgrade	Otto Gruber	gruber@ipp.mpg.de,
FTU	Francesco Romanelli	romanelli@frascati.enea.it,
Tore-Supra	Andre Grossman	Andre.GROSMAN@cea.fr,
TCV	Ambrosio Fasoli	ambrogio.fasoli@epfl.ch,
MAST	William Morris	william.morris@ukaea.org.uk,
MAST	Brian Lloyd	brian.lloyd@ukaea.org.uk,
US DOE	Erol Oktay	Erol.Oktay@science.doe.gov,
ITPA CC	Ron Stambaugh	Stambaug@fusion.gat.com,
DIII-D	Tony Taylor	Taylor@fusion.gat.com,
NSTX	Martin Peng	mpeng@pppl.gov,
Alcator C-mod	Earl Marmar	Marmar@psfc.mit.edu
Alcator C-mod, ITPA SOL Group	Bruce Lipschultz	blip@psfc.mit.edu,
ITER-US	Ned Sauthoff	nsauthoff@pppl.gov,
JT-60U, Committee Chair	Mitsuru Kikuchi	kikuchi@naka.jaeri.go.jp,
JT-60U	Yukitoshi Miura	miura@naka.jaeri.go.jp,
Russia	Nikolay Ivanov	ivnick@nfi.kiae.ru,
ASIPP Hefei	Jiangang Li	j_li@ipp.ac.cn,
ASIPP Hefei	Baonian Wan	bnwan@ipp.ac.cn
KSTAR	Gyung-Su Lee	gslee@kbsi.re.kr,
KSTAR	Jung-Hoon Han	jhhan@kbsi.re.kr
ITPA Transport	Edward Doyle	doyle@apollo.gat.com
ITPA Transport	Vladimir Mukhovatov	mukhovv@itergps.naka.jaeri.go.jp
ITPA CDBM	Wayne Houlberg	houlbergwa@ornl.gov
ITPA CDBM	Alexei Polevoi	polevoa@itergps.naka.jaeri.go.jp
ITPA Pedestal	Yutaka Kamada	kamada@naka.jaeri.go.jp
ITPA Pedestal	Tony Leonard	leonard@gav.gat.com
ITPA SOL	Nobuyuki Asakura	asakuran@fusion.naka.jaeri.go.jp
ITPA SOL	Bruce Lipschultz	blip@psfc.mit.edu
ITPA MHD	Tim Hender	tim.hender@ukaea.org.uk,
ITPA MHD	Yuri Gribov	gribovy@itergps.naka.jaeri.go.jp
ITPA SSO	George Sips	ccs@ipp.mpg.de,
ITPA SSO	Shunsuke Ide	ide@naka.jaeri.go.jp
ITPA Diagnostics	Tony Donne	donne@huygens.rijnh.nl
ITPA Diagnostics	Alan Costley	costlea@itergps.naka.jaeri.go.jp
ITER Physics	Michiya Shimada	shimadm@itergps.naka.jaeri.go.jp

ID No	Topical Group	Proposal Title	Keypersons [1]	Devices [2]	2004 Ext	Ctg	Comments/ Recommendations/ Results
CDB-1	Conf DB & Mod	Effects of inside and vertical pellet launch	W A Houlberg and others	AUG, DIII-D, FTU, JET, JT-60U, Tore Supra	CLOSED	P	Regarded as programmatic, see also CDB-5
CDB-2	Conf DB & Mod	β confinement scaling in ELMy H-modes: β degradation	F Ryter, C C Petty, D. C. McDonald, T. Takizuka, G. T. Hoang(TS), M. Valovic, S. Kaye?	AUG, DIII-D, JET, JT-60U, Tore-Supra(L), MAST, NSTX	YES	E	Report
CDB-3	Conf DB & Mod	Improving the condition of Global ELMy H-mode and Pedestal databases	F Ryter, J DeBoo, J G Cordey	AUG, DIII-D, JET, JT-60U, ***C-Mod***	CLOSED	E	Report
CDB-4	Conf DB & Mod	Confinement scaling in ELMy H-modes: ν* scans at fixed n/n_G	J Snipes, C C Petty, J G Cordey, J. Stober	C-Mod, DIII-D(05,06), JET AUG	YES	E	Report
CDB-5	Conf DB & Mod	Effects of inside and vertical pellet launch: ELM behaviour	P Lang, L Baylor, G Saibene, A Loarte	AUG, DIII-D, JET, HT-7, JT-60U, MAST, HL-2A	CLOSED	P	Report
CDB-6	Conf DB & Mod	Improving the condition of Global ELMy H-mode and Pedestal databases: Low A	R Akers, S Kaye, C. Petty, M.Valovic, E. Synakowski	MAST, NSTX, DIII-D	NEW	E	Report, Coordinate with TP-9
CDB-7	Conf DB & Mod	Ohmic Identity Experiments: test of scaling with dimensionless parameters	F Ryter, M Romanelli, J G Cordey, H Weisen, F Imbeaux	AUG, FTU, JET, TCV, Tore Supra, HL-2A, ***C-MOD***	CLOSED	E	Report, Accept recommendation to abandon project
CDB-8	Conf DB & Mod	rho* scaling along an ITER relevant path at both high and low beta	D.C. McDonald, C. Petty, M. Greenwald, A. Staebler	JET, DIII-D(05/06), C-mod, AUG	NEW	E	Give priority to standard ELMy H-mode. Coordinate with TP 2.3 and SSO 2.3 in regard to hybrid mode.

TP-1	Transport Physics	Steady-state plasma development	J. Hobirk, M Wade, T Luce, A.Hubbard, A Isayama, E Synakowski, X.Litaudon(JET), Sakamoto, S. Ide, P. Politzer, D. Moreau(JET), E. Joffrin(TS), O. Sauter (TCV)	AUG, C-Mod, DIII-D, JET, JT-60U, NSTX	YES	E	See SSO proposals and reports
TP-2	Transport Physics	Hybrid Regime development	J Hobirk, T Luce, X Litaudon, S Ide, A. Sips, M. Wade,E. Joffrin(JET), J. Menard,S. Guenter, R. Buttery, Isayama, C. Petty, D. McDonald, A. Stäbler	AUG, DIII-D, JET, JT-60U	YES	E	See SSO proposals and reports.
TP-3.1	Transport Physics	Obtain and sustain high performance operation with Te~Ti, including in hybrid/AT discharges	J Hobirk, C Greenfield, S Ide, C Challis,	AUG, DIII-D, JET, JT-60U	YES	P	Report, Need for coordination between machines is not clearly made. Specific direction not apparent.
TP-3.2	Transport Physics	Physics investigation of transport mechanisms with T_e~T_i at high density	N. Kirneva (T-10), R. Jasper(TEXTOR), J. Rice (CMOD), F. Imbeaux (TS) , M. Romanelli(FTU), M. de Baar (TEXTOR)	T-10, CMOD, Tore-Supra, FTU, TEXTOR	YES	D	Report, Emphasis is on circular machines and specific diagnostics?? Please clarify if experiments are coordinated.
TP-4.1	Transport Physics	Similarity experiments with off-axis ICRF-generated density peaking	J Stober, J Rice	AUG, C-Mod	YES	E	Report

TP-4.2	Transport Physics	Low momentum input operation of hybrid/AT plasmas	G. Sips/J. Stober (AUG), H. Takenaga (JT-60U), M. Wade (DIII-D), F. Crisanti (JET+FTU), O. Sauter (TCV), E. Joffrin(TS), de Baar(JET),	JT-60U, JET DIII-D(05/06), AUG, TCV,FTU,Tore-Supra	YES	P/D	Report, Can well defined experiments be posed or is more rf power needed?
TP-4.3	Transport Physics	Electron ITB similarity experiments with low momentum input	T. Donne (TEXTOR), K. Razumova (T-10), G. T. Hoang (TS), M. Romanelli(FTU),**X.T.Ding(HL-2A),B.J.Ding(HT-7)**	T-10, TEXTOR, Tore-Supra, FTU,**HL-2A,HT-7**	YES	E	Report
TP-5	Transport Physics	QH/QDB plasma studies	P. Gohil/L. Lao (DIII-D), N. Oyama/Y. Sakamoto (JT-60U), W. Suttrop (AUG, JET), A. Kirk (MAST)	DIII-D (Jan 2005), JT-60U, AUG, JET MAST	YES	E	See also PEP-14. Report
TP-6	Transport Physics	Obtain empirical scaling of spontaneous plasma rotation	J. Rice (CMOD), J. deGrassie (DIII-D), F. Crisanti (JET), Y. Koide (JT-60U), Hobirk/JM Noterdaeme (AUG), A. Melnikov (T-10), A. Scarabosio (TCV)	C-MOD, DIII-D, JET, JT-60U, AUG, T-10, TCV	NEW	D/P?	This research is encouraged. Can more specific proposals be made?
TP-7	Transport Physics	Measure ITG/TEM line splitting and compare to codes e ITG/TEM line splitting and compare to codes	C. Angioni (AUG), J. DeBoo/R. Waltz (DIII-D), V. Vershkov (T-10), Conway(JET)	AUG, DIII-D (2005/2006), T-10, JET	NEW	E	
TP-8.1	Transport Physics	ITB Similarity Experiments	M. Peng (NSTX), A. Field (MAST)	MAST, NSTX	YES	E	Report

TP-8.2	Transport Physics	Investigation of rational q effects on ITB formation and expansion	M. Austin (DIII-D), E. Joffrin (JET), K. Rasumova (T-10)	JET, DIII-D, T-10	YES	E	
TP-9	Transport Phsyics	H-mode aspect ratio comparison	E. Synakowski (NSTX), C. Petty (DIII-D), M. Valovic(MAST)	NSTX, DIII-D, MAST	NEW	E	Initially, NSTX, DIII-D, expansion to MAST possible later. Coordinate with CDB-6.
PEP-1+3	Pedestal & Edge	Dimensionless identity experiments in JT-60U and JET	G Saibene, V Parail, J Lonnroth and A Loarte (EFDA JET); N Oyama – H Urano, K Kamiya, K Shinohara (JAERI)	JET, JT-60U	YES	E	studies of ripple effects and rotation. Report
PEP-2	Pedestal & Edge	Pedestal comparison experiment and rho-star scan	T. Osborne, R. Groebner, A. Leonard (DIII-D) and A. Loarte(JET), G. Saibene (JET-EFDA)L. Horton, A. Kallenbach (ASDEX-Upgrade)	JET, DIII-D (2005/2006), ASDEX Upgrade	YES	E	Report, Same DSOL-1, JET to define shape, then AUG and DIII-D match, maybe in 2006
PEP-4	Pedestal & Edge	Stability analysis with improved edge treatment	L Lao, Y Kamada	AUG, DIII-D, JT-60U, MAST	CLOSED	P	
PEP-5	Pedestal & Edge	Dimensionless identity experiments with JT-60U type II ELMy H-modes in DIII-D	T Osborne, T Hatae	DIII-D, JT-60U	CLOSED		
PEP-6	Pedestal & Edge	Pedestal Strucure and ELM stability in DN (MAST and AUG)	L Horton, H. Meyer, R. Maingi?. I. Nunes	AUG, MAST, NSTX, JET	YES	E	Report
PEP-7	Pedestal & Edge	Pedestal width analysis by dimensionless edge identity experiments on JET, ASDEX Upgrade, Alcator C-Mod and DIII-D	G P Maddison(JET), W Suttrop (AUG), A Hubbard (MIT), A Leonard (GA), T. Osborne(GA).	JET, ASDEX Upgrade, Alcator C-Mod and DIII-D	YES	E	***Report, Resolve conflict with PEP-2 in regard to interpretation of density and temperature widths. Related to CDB-4***
PEP-8	Pedestal & Edge	Parameter similarity studies Quiescent H-mode regimes)	TBD	AUG, DIII-D, JET, JT-60U	CLOSED		
PEP-9	Pedestal and Edge	NSTX-MAST-DIII-D pedestal similarity	T Osborne, A Kirk, R Maingi	DIII-D, MAST, NSTX	YES	E	Report

PEP-10	Pedestal and Edge	The radial efflux at the mid-plane and the structure of ELMs	Andrew Kirk, Albrecht Herrmann	AUG, MAST	NEW	E	Report
PEP-11	Pedestal and Edge	Dimensionless comparison of L-H threshold and H-mode pedestals on C-Mod and ASDEX Upgrade	W Suttrop, F Ryter, A Hubbard	AUG, ***C-Mod***	CLOSED	E	
PEP-12	Pedestal and Edge	Comparison between C-Mod EDA and JFT-2M HRS regimes	K. Kamiya, N. Oyama, (JAERI) and A. E. Hubbard	C-Mod, JFT-2M	YES	E	***Report***
PEP-13	Pedestal and Edge	Comparison of small ELM regimes in JT-60U and AUG and JET	N. Oyama, H. Urano (JT-60U), L.D. Horton (AUG), A. Loarte , P.J. Lomas(JET)	AUG, JT-60U, JET	YES	E	*Report*
PEP-14	Pedestal and Edge	QH/QDB COMPARISON IN JT-60U AND DIII-D	P. Gohil, L. Lao (DIII-D) and N. Oyama, Y. Sakamoto (JT-60U), W. Suttrop(AUG)	DIII-D, JT-60U, AUG	YES	E	Report
PEP-15		Testing influence of particle source on pedestal density profile	R Groebner, L D Horton	MAST, JT-60U	CLOSED	P	
PEP-16	Pedestal and Edge	C-MOD/NSTX/MAST SMALL ELM REGIME COMPARISON	A. Hubbard, R. Maingi, H. Meyer	NSTX,MAST,C-mod	NEW	E	
DSOL-1	Divertor & SOL	Scaling of Type I ELM energy loss and pedestal gradients through dimensionless variables	A. Loarte(JET), M. Kempenaars, G. Saibene, A. Kallenbach, L. Horton, A.Leonard, T. Osborne, M. Fenstermacher, P. Snyder, H. Urano, G. Counsell and A. Kirk	JET, DIII-D (2005/06), ASDEX Upgrade , JT-60U, MAST	YES	E	Report, same as PEP-2.

DSOL-2	Divertor & SOL	Hydrocarbon injection to quantify chemical erosion	V. Philipps FZJ Juelich (Coordinator), S. Brezinsek FZJ Juelich, M.Stamp (JET), R. Pugno (AUG), Nakano (JT-60U), M.Fenstermacher (DIII-D)	TEXTOR, JET, AUG, DIII-D, JT-60U	YES	E	Report
DSOL-3	Divertor & SOL	Scaling of radial transport	B. Lipschultz, G. Matthews, T. Leonard, S. Lisgo, A. Kallenbach, R. Pitts(TCV), N. Asakura	C-mod, JET,MAST, DIII-D, AUG, TCV, JT-60U	YES	E	Report, Mainly programmatic, some specific experiments.
DSOL-4	Divertor & SOL	Disruption energy balance in the most likely disruptions in the ITER QDT = 10 scenario	A. Loarte, P. Andrew, V. Riccardo, A. Kellman, D. Humphreys, G.Pautasso, G. Counsell, D. Whyte, K. Tsuzuki,A. Herrmann	JET, DIII-D, ASDEX Upgrade, MAST, JT-60U	NEW	E	Report
DSOL-5	Divertor & SOL	Role of Lyman absorption in the divertor	D Reiter, J Terry, G Matthews, S Lisgo	C-Mod, JET, TEXTOR/FZJ	YES	E	Report
DSOL-6	Divertor & SOL	Parallel transport in the SOL	G Porter, B LaBombard, K Erents, N Asakura	DIII-D, JET, *JT-60U*, MAST and others	CLOSED	D	Report
DSOL-7	Divertor & SOL	Multi-machine modeling and database for edge density and temperature profiles	Arne Kallenbach (AUG), G. Porter (DIII-D), A. Hubbard (C-Mod), N. Asakura (JT60-U), A. Kirk (MAST), W. Suttrop, L. Horton, T. Osborne, D. Coster , W. Fundamenski(JET)	Analysis,	NEW	P	Report
DSOL-9	Divertor & SOL	^{13}C injection experiments to understand C migration	Guy Matthews, JET , P. Stangeby (DIII-D), V. Philipps (Textor), K. Tsuzuk, V. Rohde, C. Skinner	JET, DIII-D, TEXTOR, ASDEX-Upgrade, JT-60U, NSTX	NEW	D	Report, Important work but what will be done in the future is not defined. Please define.

DSOL-10	Divertor & SOL	Modeling of different gasses effects on disruption power deposition	D. Whyte (UW-Madison), M. Bakhtiari (JT-60U), K. Tsuzuki, Y. Kawano(JT-60U),P. Andrew (JET), Martin (TS), E. Tsitrone(TS),Matthews (JET), Hollmann (DIII-D)	DIII-D, JT-60U, Tore Supra, JET	NEW	P	Report, ITPA Coordinated research, Modelling in support of DSOL-11?? Combine? Into 11?
DSOL-11	Divertor & SOL	Disruption mitigation experiments	D. Whyte (UW-Madison), T. Jernigan (ORNL), E. Hollmann (UCSD), M. Bakhtiari (JT60-U),K. Tsuzuki, Y. Kawano(JT-60U), G. Martin (Tore Supra), F. St-Laurent(TS),V. Riccardo (JET), P. Andrew (JET), R. Granetz (MIT), J. Terry (MIT), K. Erents (JET), G. Matthews (JET), K.H. Finken (Juelich), G. Pautasso(AUG),**Z.Y.Chui(HL-2A),G.S.Xu(HT-7)**	DIII-D, JT-60U, Tore Supra, JET, Alcator C-Mod,TEXTOR, AUG,**HL-2A,HT-7**	NEW	E	Report, More specifics on the future proposals would have been welcome. Should be jointly done with MDC-1.
DSOL-12	Divertor & SOL	Oxygen wall cleaning	Peter Stangeby, U of Toronto/GA/LLNL, V. Philipps (Textor), J. Li (Hefei, HT-7), J. Roth (AUG)	TEXTOR, HT-7, DIII-D, AUG	NEW	E	
DSOL-13	Divertor & SOL	Deuterium codeposition with carbon in gaps of plasma facing components	K. Krieger (ASDEX-Upgrade), A. Litnovsky (Textor), C. Wong (DIII-D), B. Lipschultz (C-Mod), E. Tsitrone(TS), K. Masaki,Y.Yang(HT-7)	AUG, TEXTOR, DIII-D, C-mod, Tore-Supra, JT-60U,HT-7	NEW	P	Report, Experiments apparently do not require coordinated shots between machines.

DSOL-14	Divertor & SOL	Benchmarking of Edge Simulation Codes Topical Group	David Coster(JET/AUG), Xavier Bonnin, (Aki Hatayama), (Hisato Kawashima), Tom Rognlien, Jim Strachan, R. Pitts (TCV),S.Z.Zhu(EAST)	Codes only, AUG,JET,EAST	NEW	P	We are very pleased to see this kind of coordinated benchmarking to experimetns work and look forward to specific experiment proposals in the future.
DSOL-15	Divertor & SOL	Inter-machine comparison of blob characteristics	J. Terry (C-Mod), S. Zweben (NSTX), C. Hidalgo (TJ-II, JET), R. Maqueda (NSTX), O. Grulke, D. D'Ippolito, J. Myra, P. Ghendrih(TS), N. Asakura, C. Skinner	C-Mod, NSTX, TJ-II, Tore-Supra(06), JT-60U, JET	NEW	E	
MDC-1	MHD, Disruptions & Control	Disruption mitigation by massive gas jets	R Granetz (Cmod), D Whyte, P Andrew (JET), K.H Finken (TEXTOR), Y. Kawano (JT60U), E Hollmann (DIII-D), G Pautasso (AUG),Q.W.Yang(HL-2A),X.Z.Gong(HT-7)	C-Mod, JET, JT-60U, TEXTOR, AUG, DIII-D,HL-2A,HT-7	YES	E	Report, Should be jointly done with DSOL-11.
MDC-2	MHD, Disruptions & Control	Joint experiments on resistive wall mode physics	H Reimerdes, M Okabayashi (DIII-D), M Gryaznevich(JET), S D Pinches (JET), R Koslowski (TEXTOR), M Takechi (JT60-U), S Sabbagh (NSTX), H Zohm (AUG)	DIII-D, JET, TEXTOR, JT-60U, NSTX. AUG	YES	E	Report,
MDC-3	MHD, Disruptions & Control	Joint experiments on neoclassical tearing modes (including error field effects)	R Granetz (C-Mod), R Buttery(JET), M Maraschek (JET), M Maraschek (AUG), R La Haye (DIII-D)	C-mod, JET, AUG, DIII-D	YES	E	***Report, DIII-D done***

MDC-4	MHD, Disruptions & Control	Neoclassical tearing mode physics - aspect ratio comparison	M Maraschek (AUG), D Howell (MAST), E. Frederickson, R. LaHaye	AUG, MAST, NSTX(05,06), DIII-D (05/06)	YES	E	Report, Maybe NSTX and DIII-D in 2006
MDC-5	MHD, Disruptions & Control	Comparison of sawtooth control methods for neoclassical tearing mode suppression	O Sauter, R Pinsker, R La Haye (DIII-D), A Mueck, H. Zohm (AUG), S. Coda(JET), R Buttery (JET), ,J Menard (NSTX), T Goodman (TCV), Yi Liu (HL2A), Wukitch(C-mod)	AUG , DIII-D, JET, NSTX, TCV and HL2A, C-mod	YES	E	Report
MDC-6	MHD, Disruptions & Control	Low beta error field experiments	S Wolfe, I Hutchinson (C-Mod), T Hender(JET), T Scoville (DIII-D), R Koslowski (TEXTOR), D Howell (MAST), Menard (NSTX)	C-mod, TEXTOR, MAST, DIII-D, NSTX, JET	YES	E	***Report, DIII-D and JET done***
MDC-7	MHD, Disruptions & Control	Improving NTM modelling/ extrapolation to ITER	H Zohm and others	AUG, DIII-D, JET, *JT-60U,* MAST	CLOSED	P	Report
MDC-8	MHD, Disruptions & Control	Current drive prevention/stabilisation of NTMs	Buttery (JET), Isayama (JT60-U), Maraschek, Zohm (AUG), La Haye (DIII-D)	JET, AUG, JT-60U, DIII-D	NEW	E	
MDC-9	MHD, Disruptions & Control	Fast ion redistribution by beam driven Alfvén modes and excitation threshold for Alfvén cascades	A.Fasoli, D.Borba(JET/AUG), S.Pinches and D.Testa (JET), K. Shinohara (JT60-U), W.Heidbrink (DIII-D),R. Nazikian(DIII-D) E. Frederickson	JT-60U, JET, AUG, DIII-D, NSTX	NEW	E	
MDC-10	MHD, Disruptions & Control	Measurement of damping rate of intermediate toroidal mode number Alfvén Eigenmodes	A.Fasoli(JET) and D.Testa (TCV/ JET), J.Snipes (C-Mod), M.Gryaznevich (MAST)	JET, C-Mod, possibly MAST,	NEW	E	Specific antennas are needed.
SSO-1.1	Steady-State Operation	Document performance boundaries for steady state target q-profile	X.Litaudon(JET), J. Hobirk, T. Luce, Sakamoto	JET, AUG, DIII-D, JT-60U	YES	E	Report

SSO-1.2	Steady-State Operation	Qualify other q-profiles for steady state operation	S. Ide, X.Litaudon,B.J.Ding(HT-7)	JT-60U, JET,HT-7	NEW	E	Report
SSO-1.3	Steady-State Operation	Control of high bootstrap plasmas	P. Politzer, D. Moreau(JET), E. Joffrin(TS), S. Ide, J. Hobirk, O. Sauter (TCV)	DIII-D(05,06), JET, Tore-Supra, JT-60U, TCV, AUG	NEW	E	Report,Clarifiy that this means very high bootstrap (>70%) and/or transformerless operation.
SSO-2.1	Steady-State Operation	Complete mapping of hybrid scenario	E. Joffrin(JET), S. Ide, M. Wade, A. Sips, J. Menard	JET, JT-60U, DIII-D, AUG, NSTX	YES	E	Report,
SSO-2.2	Steady-State Operation	MHD effects on q-profile and confinement for hybrid scenarios	S. Guenter, R. Buttery, M. Wade, Isayama	AUG, JET, DIII-D, JT-60U	NEW	E	Report, The subject here is how MHD effects control the current profile and why the confinement is improved??
SSO-2.3	Steady-State Operation	_* dependence on confinement, transport and stability in hybrid scenarios	C. Petty, D. McDonald, A. Stäbler, S. Ide	DIII-D, JET, AUG, JT-60U	NEW	E	Report, Coordinate with CDB-8 which has aspecific betaN target. Hybrid work led by SSO Group.
SSO-3	Steady-State Operation	Real-time q-profile control in hybrid and steady state scenarios	D. Moreau(JET), E.Joffrin(JET),D. Mazon(TS), A. Sips,(AUG), J. Ferron, T. Suzuki, X.D.Zhang	JET, Tore-Supra, AUG, DIII-D, JT-60U, HT-7	NEW	D	We encourage this exchange of experts to prepare specific proposals for next year.
SSO-4	Steady-State Operation	Documentation of the edge pedestal in advanced scenarios	L. Horton, C. Maggi (AUG), R. Sartori(JET), M. Wade, Kamada	AUG, JET , DIII-D, JT-60U	NEW	P/E	Important database activity. Are specific proposals needed?

PROPOSAL

FROM THE INTERNATIONAL TOKAMAK PHYSICS ACTIVITY (ITPA)

TO THE IEA IMPLEMENTING AGREEMENTS COORDINATING COMMITTEES

FOR JOINT EXPERIMENTS BETWEEN VARIOUS TOKAMAKS

FOR 2005

Proposal submitted by Ronald Stambaugh representing the ITPA Coordinating Committee

At the Third IEA Large Tokamak Workshop (W58) on
"Implementation of the ITPA Coordinated Research Recommendations"
Joint Workshop of Large Tokamak, Poloidal Divertor and TEXTOR IA's
8-10 December 2004, Eynsham Hall, Near Oxford, UK

Proposals submitted by the ITPA Topical Group Chairs, representing their various Groups.

Confinement Database and Modelling	W. Houlberg
Transport Physics	E. Doyle
Pedestal and Edge Physics	Y. Kamada
Scrape-off Layer and Divertor Physics	N. Asakura
MHD, Disruption, and Magnetic Control	T. Hender
Steady-State Operation	G. Sips

Confinement and Database ITPA-IEA Joint experimental proposals for 2005

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

CDB-2	**β confinement scaling in ELMy H-modes: β degradation**
CDB-4	**Confinement scaling in ELMy H-modes: ν^* scans at fixed n/n_G**
CDB-6	**Improving the condition of Global DBs: Low A**
CDB-8	**rho* scans in ITER geometry at both high and low beta**

CDB-2	**β confinement scaling in ELMy H-modes: β 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

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 β_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 β scans. NSTX: Propose to do a β scan in 2005 Tor Supra: Propose to do an L-mode β scan in 2005.

CDB-4	**Confinement scaling in ELMy H-modes: ν^* 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 ν^* 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 ν^* scaling with the two tokamaks that can achieve the widest range in ν^*, JET and C-Mod and study the issue of whether ν^* or n/n_G is the relevant scaling parameter. ν^* 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 ν^* from the identity discharge on JET and increasing ν^* from the identity discharge on C-Mod. If these experiments are successful then AUG and DIII-D could produce the midrange matches.

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.

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 (ρ^*) is the only parameter needs to vary from present day tokamaks to ITER. The energy confinement time is strongly dependent on ρ^*; confinement scaling relations imply $B\tau_E \sim \rho^{*-2.7}$ while perfect gyro-Bohm scaling is $B\tau_E \sim \rho^{*-3}$. 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 ρ^* scan possible in an individual machine (factor of 1.6) the uncertainty in the ρ^* scaling ITER is large. The plan is to combine ρ^* scans from different machines to form a continuous path to an ITER target discharge having the same shape, β, collisionality and safety factor. The large range in ρ^* from C-Mod to JET (~5) will then enable the ρ^* scaling to be accurately determined.

Device	**Period**	**Local Key Person**
JET		D.C. McDonald
DIII-D		C.C. Petty
C-Mod		M. Greenwald
AUG		W. Alexander

Outline of Experiment

A series of similarity ρ^* scans will be performed on several machines with matched, ITER relevant, β_N, ν^*, plasma shape and safety factor. As well as the baseline β_N=1.8 ELMy H-mode, a higher β_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.

Transport Physics ITPA-IEA Joint experimental proposals for 2005

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

SSO-1/TP-1	**Steady state plasma development**
TP-1.1	**Document performance boundaries for steady state target q-profile**
TP-1.2	**Qualify other q-profiles for steady state operation**
TP-1.3	**Control of high bootstrap plasmas**
SSO-2/TP-2	**Hybrid regime development**
TP-2.1	**Complete mapping of hybrid scenario**
TP-2.2	**MHD effects on q-profile and confinement for hybrid scenarios**
TP-2.3	**ρ^* dependence on confinement, transport and stability in hybrid scenarios**
TP-3	*Assess performance with Te~Ti operation and/or dominant electron heating*
TP-3.1	*Obtain and sustain high performance operation with T_e~T_i, including in hybrid/AT discharges*
TP-3.2	*Physics investigation of transport mechanisms with T_e~T_i at high density*
TP-4	*Investigation of high performance operation with low external momentum input*
TP-4.1	*Similarity experiments with off-axis ICRF-generated density peaking*
TP-4.2	*Low momentum input operation of hybrid/AT plasmas*
TP-4.3	**Electron ITB similarity experiments with low momentum input**
TP-5/PEP-14	**QH/QDB plasma studies**
TP-6	**Obtain empirical scaling of spontaneous plasma rotation**
TP-7	**Measure ITG/TEM line splitting and compare to codes**

TP-8 ITB similarity experiments

TP-8.1 NSTX/MAST ITB similarity experiment

TP-8.2 Investigation of rational q effects on ITB formation and expansion

TP-9 H-mode aspect ratio comparison

TP-1 Steady state plasma development

As in 2004, TP proposals in this area have been integrated with the corresponding SSO proposals (for details see SSO proposals). For convenience, the main subtask headings are repeated here.

A primary TP concern in these experiments remains the collection of well characterized discharges for transport modelling.

TP-1.1 Document performance boundaries for steady state target q-profile

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Continuation of previous collaboration experiments.

TP-1.2 Qualify other q-profiles for steady state operation

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Proposed before, but no joint experiments performed so far.

TP-1.3 Control of high bootstrap plasmas

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Proposed before, but no joint experiments performed so far.

TP-2 Hybrid regime development

As in 2004, TP proposals in this area have been integrated with the corresponding SSO proposals (for details see SSO proposals). For convenience, the main subtask headings are repeated here.

A primary TP concern in these experiments remains the collection of well characterized discharges for transport modelling.

TP-2.1 Complete mapping of hybrid scenario

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Continuation of previous collaboration experiments.

TP-2.2 MHD effects on q-profile and confinement for hybrid scenarios

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: New collaboration experiments.

TP-2.3 ρ^* dependence on confinement, transport and stability in hybrid senarios

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: New collaboration experiments.

TP-3 Assess performance with Te~Ti operation and/or dominant electron heating

TP-3.1 *Obtain and sustain high performance operation with T_e~T_i, including in hybrid/AT discharges*

Topic Group: Transport physics

Status: Continuation of existing collaboration

Background: This experiment seeks to demonstrate that sustained high performance (better than conventional ELMy H-mode) operation is possible with T_e~T_i. Experiments in hybrid and AT discharges are of particular interest. Previous work has shown promise for the techniques listed below, which need to be pursued.

Contact persons: **J. Hobirk (AUG), C. Greenfield (DIII-D), C. Challis (JET), S. Ide (JT-60U)**

Experiments: **AUG, DIII-D, JET, JT-60U**

Outline and aims: Experimentally, three approaches have been used, all of which are of interest:

(a) Add electron heating to existing hot-ion target discharges, so as to increase T_e

(b) Raise operating density, either by gas puff or pellet injection. Systematic density scans to vary the T_e/T_i ratio are of particular interest

(c) Add ion heating to plasmas with existing electron barriers.

TP-3.2 *Physics investigation of transport mechanisms with T_e~T_i at high density*

Topic Group: Transport physics

Status: Continuation of existing collaboration

Background: This experiment seeks to document transport and turbulence characteristics in plasmas with reactor relevant conditions, e.g. T_e~T_i and n_e~n_{GW}, and also to examine confinement saturation and compare to scaling laws and transport models.

Contact persons: **N. Kirneva (T-10), M. de Baar (TEXTOR), J. Rice (CMOD), F. Imbeaux (TS)**

Experiments: **TEXTOR, T-10, CMOD, TS?, +?**

Outline and aims: Characterize transport and confinement as function of P_e/P_i and density (heating and density scans). Document associated turbulence, particularly electron modes. These scans should be done in a variety of confinement regimes, from L-mode through H-mode to advanced regimes. The initial T-10/TEXTOR collaboration is addressing L-mode regimes, and will use new fluctuation diagnostics in 2005.

TP-4 Investigation of high performance operation with low external momentum input

TP-4.1 Similarity experiments with off-axis ICRF-generated density peaking

Topic Group: Transport physics

Status: Continuation of existing collaboration

Background: This work addresses two questions: (a) Is the density peaking regime observed with off-axis ICRF on CMOD a true ITB?, and (b) is the physics of this regime consistent between devices, specifically AUG and CMOD? Initial similarity experiments in 2003 demonstrated that AUG could reproduce the CMOD density peaking/ITB regime with off-axis ICRF heating.

Contact persons: **J. Rice (CMOD), J. Stober (AUG)**

Experiments: **CMOD, AUG**

Outline and aims: The objective for 2005 is expand on the limited previous experiments on AUG, concentrating on the formation mechanism and interaction with sawteeth. No AUG work was performed in 2004.

TP-4.2 Low momentum input operation of hybrid/AT plasmas

Topic Group: Transport physics

Status: Continuation of existing collaboration

Background: High performance with low momentum input is critical for successful reactor operation, yet currently high performance operation is typically obtained with significant momentum input from NBI sources. The objective of this experiment is to obtain high performance operation with low momentum input using RF sources, balanced-NBI or N-NB in hybrid and AT plasmas. In addition, these experiments can also address a second topic of reactor relevance; particle transport with low central fuelling.

Contact persons: **G. Sips/J. Stober (AUG), H. Takenaga (JT-60U), M. Wade (DIII-D), F. Crisanti (JET), O. Sauter (TCV)**

Experiments: **JT-60U, JET (2006, with ICRF upgrade?), DIII-D, AUG, TCV**

Outline and aims: Experimentally, two approaches have been used: (1) Transitioning from NBI dominated to RF/balanced-NBI/N-NB dominated within a single discharge, or (2) Development of discharges with low momentum input at all times. Some work already performed on JET and AUG, this needs to be expanded to other devices making use of local RF heating and balanced-NBI capabilities. Documentation of particle transport in such plasmas with low central fuelling is also of interest.

TP-4.3 *Electron ITB similarity experiments with low momentum input*

Topic Group: Transport physics
Status: Continuation of existing collaboration
Background: This collaboration seeks to determine the similarity of electron ITB formation conditions and physics when operating with low momentum input. JET similarity experiments with FTU and TS led to the widely reported JET RF dominated hybrid results, while TEXTOR/T-10 continue to study electron ITBs in the ECH switch-off regime.
Contact persons: **T. Donne (TEXTOR), K. Razumova (T-10)**
Experiments: **T-10, TEXTOR**
Outline and aims: Work continues on the T-10/TEXTOR similarity experiment on the electron ITB observed in the ECH switch-off regime. In 2005, new fluctuation and MSE diagnostics will be available on TEXTOR to complement existing T-10 results.

TP-5/PEP-14 QH/QDB plasma studies

Topic Group: Transport Physics and Pedestal TGs
Status: Continuation of existing collaboration
Background: Determining the operational boundaries and unique physics of QH/QDB operation has been facilitated by coordinated experiments and personnel exchanges on the four major devices (AUG, DIII-D, JET, JT-60U), which has made efficient use of unique capabilities such as balanced-/co-/counter-NBI on JT-60U and detailed edge profile measurements on DIII-D.
Contact persons: **P. Gohil/L. Lao (DIII-D), N. Oyama/Y. Sakamoto (JT-60U), W. Suttrop (AUG, JET), A. Kirk (MAST)**
Experiments: **DIII-D (Jan 2005), JT-60U, AUG?, JET?, MAST**
Outline and aims: 2005 experiments on DIII-D and JT-60U will continue to stress understanding the unique physics of ELM suppression in

QH-mode operation via studies of the edge current and electric field profiles, as well as attempting to expand the QH/QDB parameter to include co-NBI operation on JT-60U and DIII-D. A new feature for 2005 is attempts at QH/QDB operation on MAST. In addition to this planned work, the TP group would like to encourage attempts at QDB (i.e. ELM-free edge plus ITB) operation on JT-60U and AUG.

TP-6 Obtain empirical scaling of spontaneous plasma rotation

Topic Group: Transport Physics
Status: New collaboration
Background: Future reactors and ITER may operate with little or no momentum input. In such plasmas, spontaneous plasma rotation may still occur, as observed on current devices (CMOD, JET, DIII-D, TS, etc). It is very important to establish whether this spontaneous rotation will be at a sufficient level to affect RWM and NTM stabilization in ITER, which can only be done at present by establishing an empirical database and/or employing dimensionally similar techniques.
Contact persons: J. Rice **(CMOD), J. deGrassie (DIII-D), F. Crisanti (JET), T. Fujita (JT-60U), Hobirk/Stober (AUG), A. Melnikov (T-10)**
Experiments: **CMOD, DIII-D, JET, JT-60U, AUG, T-10, etc**
Outline and aims: The purpose of these experiments is to document the intrinsic or spontaneous plasma rotation (with no external momentum input) on a range of devices, as a function of plasma current and stored energy, from which empirical scalings can be derived. Impurity rotation measurements have already been made on CMOD, DIII-D and TS as a function of plasma current/stored energy. Similar AUG, JET and JT-60U data are desired to more accurately determine possible size scalings. The use of dimensionally similar experiments to investigate the scaling of the intrinsic rotation should also be pursued, with CMOD/DIII-D/JET being initial possibilities.

TP-7 Measure ITG/TEM line splitting and compare to codes

Topic Group: Transport Physics

Status: New collaboration

Background: The current "standard" turbulent transport model relies on the existence of ITG/TEM and possibly ETG mode components. However, experimental evidence for these modes is limited. Additional direct evidence could be obtained from measuring the mode phase velocity (or frequency for a given wave numbers). However this is generally obscured by the error in determining the flow induced Doppler rotation velocity. In this experiment, we propose to find discharges in AUG, DIII-D and possibly T-10, in which both the ITG and the TEM modes are simultaneously unstable at the same core plasma radius. By measuring the exact frequency "line split" between the ITG and TEM modes (which will be independent of the Doppler rotation) and precisely comparing with code predicted split frequencies, we will have direct evidence for these modes (or not).

Contact persons: F. Ryter/C. Angioni (AUG), J. DeBoo/R. Waltz (DIII-D), V. Vershkov (T-10)

Experiments: **AUG (2005), DIII-D (2005?, or 2006), T-10, +?**

Outline and aims: The GS2 and GYRO codes can determine the exact frequency of ITG and TEM modes given experimental density and temperature profiles. ExB shear will likely have some important stabilizing role, but a GYRO nonlinear simulation will hopefully match the experimental transport levels within error bars on the experimental gradients. GYRO will also predict the line widths and fluctuation levels. If all of these elements can be matched to experiment and benchmarked, a new level of precision will be brought to the standard model. This experiment needs to be performed on machines with fluctuation diagnostics capable of resolving these modes, e.g. AUG, DIII-D and T-10. Collaborative experiments on different machines are sought because of the importance of benchmarking this fundamental aspect of the standard turbulent transport model. On AUG, plasmas have already been identified that are predicted to have both ITG and TEM modes present, these plasmas need to be characterized with fluctuation diagnostics, with similar work to be performed on DIII-D.

TP-8 ITB similarity experiments

Topic Group: Transport Physics

Status: Continuation of existing collaboration

Background: Similarity experiments provide a powerful tool with which to check physics consistency across devices. This approach was applied to ITB plasmas for the first time with AUG/JET ITB similarity experiments in 2004. For 2005, it is intended to extend the approach in two directions: **TP8.1** To NSTX and MAST ITB plasmas. Core transport in NSTX/MAST plasmas is characterised by a region of reduced ion transport with $\chi_i \sim \chi_i^{NC}$ associated with a strong gradient of NBI-driven toroidal rotation. The formation and evolution of this ITB region is governed by the influence of the resulting $E \times B$ flow shear and the magnetic shear on the anomalous transport due to micro-turbulence. Results from this joint experiment will form a basis for comparison with ITB data and experiments on AUG, DIII-D, JET, and JT60-U. **TP8.2** To the investigation of rational q effects on ITB triggering and expansion, via a DIII-D/JET collaboration.

TP-8.1 NSTX/MAST ITB similarity experiment

Contact persons: Martin Peng (NSTX), Anthony Field (MAST)

Experiments: MAST, NSTX

Outline and aims: Investigate role of NBI-driven toroidal rotation, the associated $E \times B$ flow shear and the magnetic shear on ion ITB formation and evolution in sustained H-mode identity discharges on MAST and NSTX devices by scanning the applied NBI power and torque. The NSTX part of joint experiment was executed in part on 14/7/2004 with a scan of injected NBI power (2.4, 3.6, 4.8 MW) with 1–3 sources at energies of 60–100 keV in order to vary the NBI torque by a factor ~ 4 (0.6–2.2 Nm). Target H-mode plasmas of 800 kA plasma current with 0.3 T toroidal field in an LSN 'MAST-identity' magnetic configuration. Formation of an ion ITB (region of reduced $\chi_i \sim \chi_i^{NC}$) in the core plasma ($r/a \sim 0.5$) which subsequently evolves to large radius ($r/a \sim 0.7$-0.9) was diagnosed with high-resolution 51-channel CHERS system. The region of reduced χ_i is associated with a region of strong gradient of toroidal rotation and associated $E \times B$ flow shear.

Proposed experiments:

NSTX: Complete NBI momentum scan (MAST match cases at 2.4/3.6 MW, 60/70 keV) at 0.3 T and execute further experiments at 0.45 T.

MAST: Execute MAST identity experiments at 0.3/0.45 T (2.5/3.6 MW, 50/70 keV).

TP-8.2 **Investigation of rational q effects on ITB formation and expansion**

Contact persons: **M. Austin (DIII-D), E. Joffrin (JET), K. Rasumova (T-10)**

Experiments: JET (complete), DIII-D, T-10

Outline and aims: The triggering of ITBs at rational q values has been extensively observed, and is routine on JET and T-10. ITER may operate in a similar power limited regime to JET, so it is desired to assess the commonality of the physics of ITB triggering and expansion at rational q values at moderate NBI input power. An experiment is planned to examine this issue with the extensive diagnostic set on DIII-D (with JET remote participation), which will enable comparison to previous JET , T-10 and other results.

TP-9 H-mode aspect ratio comparison

Topic Group: Transport Physics

Status: New collaboration

Background: Obtaining the aspect ratio scaling of confinement from regression analysis of multi-machine databases has proven difficult. A dedicated experiment is needed to measure the change in core transport properties between plasmas of different aspect ratio while keeping the other key physics parameters constant. NSTX and DIII-D are well suited to an aspect ratio comparison experiment since they have nearly the same poloidal cross-section but different major radii. This transport experiment is now feasible owing to the progress in the NSTX diagnostics, such as the 51-channel charge-exchange spectroscopy, that has enabled detailed studies of the NBI heated H-mode plasmas.

Contact persons: **E. Synakowski (NSTX), C. Petty (DIII-D), A. Field (MAST)**

Experiments: Initially, NSTX, DIII-D, expansion to MAST possible later

Outline and aims: The focus will be on matching poloidal quantities (e.g. poloidal beta, poloidal ion gyroradius), plasma shape parameters, collisionality, and other dimensionless parameters. An ensemble of applied torques and densities will be used on DIII-D to ensure a good match in the end. The NSTX and DIII-D plasmas will have different toroidal ion gyroradii, however. As part of the similarity study, the strategy includes bridging this gap by performing a gyroradius scan on each device and assessing if the observed transport changes point to a continuous set of trends between the two machines. Expansion of this activity to MAST will be explored.

Proposed experiments:

NSTX: The NSTX target plasma is already in hand. The NSTX component of this scan will be carried out in the upcoming run period this spring.

DIII-D: The DIII-D part of the run is scheduled for late January 2005.

Pedestal and Edge Physics ITPA-IEA Joint experimental proposals for 2005

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

PEP-1 and -3	**dimensionless identity experiments in JET and JT-60U: studies of ripple effects and rotation**
PEP-2	**JET/DIII-D Pedestal Comparison and Rho-star Scan**
PEP-6	**Pedestal Structure and ELM Stability in DN**
PEP-7	**Pedestal width analysis by dimensionless edge identity experiments on JET, ASDEX Upgrade, Alcator C-mod, and DIII-D**
PEP-9	**NSTX/MAST/DIII-D Pedestal Comparison Similarity mapping of hybrid scenario**
PEP-10	**The radial efflux at the midplane and the structure of ELMs**
PEP-12	**Comparison between C-mod EDA and JFT-2M HRS regimes.**
PEP-13	**Comparison of Small ELM Regimes in JT-60U and AUG**
PEP-14 (TP-5)	**QH/QDB Comparison in JT-60U and DIII-D**
PEP-16	**C-mod, NSTX, MAST Small ELM Regime Comparison**

PEP 1 + PEP 3: dimensionless identity experiments in JET and JT-60U: studies of ripple effects and rotation

Topic Group: Edge and Pedestal Physics Topical Group
Background and Previous Results: this proposal is the continuation of the work carried out in PEP 1/3 in 2003 and 2004. Dimensionless identity experiments in ELMy H-mode in JET and JT-60U indicated that differences in pedestal pressure (and pressure profiles) as well as power and particle losses during and between ELMs may be due to toroidal field ripple effects. In fact, in JT-60U, the large major radius plasmas used for the identity with JET have B_T ripple ~1.2% at the outer separatrix compared to ~0.1% for JET. Ripple losses in these JT-60U plasmas (of the order of ~MW for prevalent positive perpendicular NB injection) and the resulting radial electric fields are believed to be a counter-rotation source for the plasma, as well as possibly affecting thermal ion transport.
Contact persons**:** G Saibene, V Parail, J Lonnroth and A Loarte (EFDA JET); N Oyama – H Urano, K Kamiya, K Shinohara (JAERI)
Tokamaks: JET and JT-60U. Experiments in JET could take pace toward the end of 2005.
Outline of Proposed Experiments, Purpose and Goals: The configuration of the power supplies to the 32 toroidal filed coils of JET (normally fed in series) can be changed in such a way to control independently the current in the odd and in the even coils. This allows to change the toroidal field ripple in the JET device in a controlled way, from the standard ~0.1% of the 32 coils configuration to up to 10% with only 16 coils used (even within the same pulse). We propose to use this unique flexibility of the JET device to investigate further physics mechanisms potentially affecting the pedestal pressure and ELM size/frequency, with the aim of identifying the “hidden variables” that makes it very difficult for JET and JT-60U to achieve identity in the pedestal. The experiments in JET should hopefully allow separating direct effects of ripple on transport from indirect effects, such as effects on pedestal of the changes in rotation. Moreover, these experiments could hopefully clarify differences in the core plasma profiles, in particular in the outer plasma regions, systematically encountered between the two devices. For this particular experiments, matching of the ripple magnitude (1.2% in JT-60 JET identity configurations), as well as of ripple losses are foreseen. Specifically, we will measure the effects of B_T ripple on ELMs size, frequency, as well as on inter-ELM transport and pedestal characteristics. New JET edge profile diagnostics as well as improved edge CX spectroscopy should allow to collect information in profile changes as well as on poloidal and toroidal rotation required for modelling of the observed effects. In JT-60U, an installation of ferritic steel to reduce the B_T ripple is planned in 2005. This modification will provide us another comparative H-mode studies also in the JT-60U device. We also foresee to carry out an extensive series of simulations of ripple losses of both fast and thermal ions for JET plasmas with a different level of toroidal ripple in preparation to experiment. This simulation is mandatory to ensure tokamak safety requirements and we rely on a vast experience of our Japanese colleagues in conducting these simulations.

PEP 2: JET/DIII-D Pedestal Comparison and Rho-star Scan

Topic Group: Edge and Pedestal Physics Topical Group
Background and Previous Results: This proposal is a continuation of PEP-2 from 2003 and 2004. The proposal is expanded to formally include ASDEX-Upgrade and now includes the issue of shape. It is also a joint proposal with DSOL-1 to simultaneously study ELM size and other characteristics, also a continuation from 2004. Previous experiments have shown that discharges with identical pedestals in dimensional variables have pedestal temperature gradients which scale with machine size (i.e. determined by plasma transport). Density pedestals do not scale this way and are more consistent with being determined by neutral ionisation. Scaling of the pedestal gradients and ELM energy losses with ρ^* remain unclear. Dependences on input power and plasma shape in this type of experiments have not been studied.
Contact persons**:** T. Osborne, R. Groebner, A. Leonard (DIII-D) and A. Loarte, G. Saibene (JET-EFDA) A. Kallenbach (ASDEX-Upgrade)
Tokamaks: JET (2005/2006), DIII-D (2005/2006), ASDEX Upgrade (2005/2006)
Outline of Proposed Experiments, Purpose and Goals: The purpose of these experiments are : a) to determine the ρ^* dependence of ELM energy loads and of the edge pedestal gradients by carrying out comparable experiments in smaller and larger devices, b) to assess the role of plasma shape in determining the edge gradients and ELM behaviour in discharges with similar dimensionless parameters and different device size and c) to determine the effect of the level of additional heating (and pedestal β) on edge gradients and ELM losses. This will be done by discharges with matched pedestal parameters, shapes and q_{95} in all devices and by exploring the ρ^* dependence within every device. Emphasis will be taken into obtaining good measurements of the pedestal plasma parameters, main plasma ELM energy losses and divertor energy fluxes.

PEP06: Pedestal structure and ELM stability in DN

Topical Group: Pedestal & Edge

Background:

This proposal is a continuation and expansion of PEP-6 experiments carried out in 2004. In MAST and AUG a reduction of the L/H threshold in DN of 50% and 20% respectively was found (PEP-6/2004). In L-mode apart from the radial electric field edge profiles remained unchanged by the configuration change. The change of the L-mode E_r by –1 kV/m between SN and DN was of similar magnitude in both devices. In the previous experiment the emphasis was on the L/H threshold and the proof of principle of a threshold reduction in DN. The continued experiment intends to study the profile differences in H-mode between SN and DN. On both devices a change in ELM characteristics and pedestal stability is observed. Furthermore, there are indications on AUG that the confinement is slightly higher in DN than in SN. Studies of the effect of the magnetic configuration on peeling-ballooning stability on MAST suggest that the profile changes in H-mode between SN and DN rather than the vicinity of the 2nd X-point cause the difference in edge stability. Therefore, a comparison between SN and DN in stable conditions on both devices is needed.

Contact: H Meyer, L. Horton

Tokamaks: MAST, AUG (2nd half of 2005)

Proposed Experiments:

Compare the pedestal structure between MAST and AUG in similar shaped exactly balanced DN and SN with similar global parameters. Determine the ELM stability and confinement in both configurations.

PEP-7 Pedestal width analysis by dimensionless edge identity experiments on JET, ASDEX Upgrade, Alcator C-Mod and DIII-D

(Pedestal & Edge TG)

G P Maddison (Euratom/UKAEA Fusion Association), W Suttrop (IPP Garching, Euratom Association), A Hubbard (PSFC, MIT), A Leonard (GA).

Background and previous results: Initial investigation (2002 - 2004) of H-modes with identical values of dimensionless pedestal variables ρ_*^{ped}, ν_{*e}^{ped}, β^{ped} on JET and C-Mod was impeded by lack of edge diagnostic resolution at the scaled conditions ($B_t \approx 0.9$ T, $I_p \approx 0.65$ MA) on JET. However indications were that density and temperature pedestal gradients were equal for corresponding heights in each machine, while widths appeared to be increasing with heights. These features suggest dominance of plasma processes in their (density) pedestal formation, in contrast to strong dependence on edge neutral-particle density observed on DIII-D and MAST. This can be qualitatively understood in the context of recent kinetic and fluid modelling of neutral sources in the pedestal region. Simultaneously, some coherent edge fluctuations between 10 - 30 kHz were seen in conjunction with steady pedestal density during long ELM-free phases on JET, potentially recalling quasi-coherent modes found in C-Mod. Resolving the mechanisms controlling pedestal properties remains imperative for reliable extrapolation to the ITER standard ($Q = 10$) scenario. An opportunity to improve and extend preceding studies is particularly offered by new high-resolution Thomson scattering coverage of the pedestal on JET from 2005, plus the intended collaboration of up to four tokamaks. These would test the effect of varying neutral-particle fluxes in a common dimensionless parameter space, including scans in collisionality and q_{95}.

Participating devices and timing: Planned for JET, ASDEX Upgrade, Alcator C-Mod, DIII-D. Respective schedules still to be decided.

Outline & goals of proposed experiments: The primary aim is to provide complete and consistent datasets suitable for testing models of fuelling and pedestal formation, which is currently a top priority for the Pedestal ITPA group. Data would be provided in a common format via the new pedestal profile database. Measurements from up to four tokamaks with common shape and dimensionless parameters, but quite different dimensional parameters (factor more than 4 in size), will provide a strong tests of models. The experimental plan is as follows: (*i*) Establish a common single-null equilibrium (ε , κ , δ , q_{95}) for all four tokamaks, with triangularity as high as possible for ITER relevance. Field (hence ICRH frequencies) and current in each device are given by size (minor radius a) scalings yielding dimensionless identity, viz $B_t \sim a^{-5/4}$, $I_p \sim a^{-1/4}$, $P_{in} \sim a^{-3/4}$, $n_e \sim a^{-2}$, $T_e \sim a^{-1/2}$. (*ii*) Step heating and fuelling to obtain requisite n_e^{ped}, T_e^{ped}, and hence pedestal dimensionless quantities. With these data, inter-machine comparisons of normalized pedestal widths and gradients will be made, notably exploiting the new JET diagnostics, and analyses including 2-D Monte Carlo modelling of neutral-particle source distributions applied.

A second aim which could, depending on machine resources, be carried out on fewer than four devices, is to to probe changes in the pedestal balance between plasma versus source effects as well as fluctuation characteristics by limited scans in key dimensionless parameters known to be crucial for edge transport and stability: ν_{*e}^{ped}, q_{95}.

(iii) Scan ν_{*e}^{ped} downwards at constant ρ_*^{ped}, β^{ped}, q_{95} by raising T_e^{ped} with P_{in} and adjusting B_t, I_p in proportion to square root of edge temperatures, plus fuelling to maintain constant n_e^{ped}. (iv) Scan q_{95} downwards by increasing I_p then adjusting heating and fuelling to recover constant ρ_*^{ped}, ν_{*e}^{ped}, β^{ped} – hence check effects of changing edge current density and magnetic shear. (v) Repeat some of cases with NBH (JET, AUG, DIII-D) to test sensitivity to heating profile / electron-ion ratio.

PEP 9: NSTX/MAST/DIII-D Pedestal Similarity

Topic Group: Edge and Pedestal Physics Topical Group
Background and Previous Results: Edge stability calculations (e.g. ELITE - Snyder, Wilson) repeatedly show that higher edge beta should be achieved at low aspect ratio. Previous database analysis (Hatae) suggest a strong dependence of Te width on aspect ratio. Recent analysis (Kirk) has shown that the MAST T_e width does not agree with multi-machine scalings. These results indicate a need to assess the effect of aspect ratio and wall proximity on pedestal height, widths and gradients in ELMy H-mode. This comparison was proposed for 2004 but it has not yet been carried out.
Contact persons: A. Kirk (MAST), R. Maingi (NSTX) T. Osborne (DIII-D)
Tokamaks: DIII-D is scheduled for this experiment in January 2005. both NSTX and MAST April-June 2005.
Outline of Proposed Experiments, Purpose and Goals: The goal is to compare pedestal parameters (focus on β and T_e width) at same ν** * and ρ* , matched at the top of the outboard midplane pedestal for two values of ν*. Shape parameters such askappa and delta will be matched in a common double-null shape.

PEP10: The radial efflux at the mid-plane and the structure of ELMs

Topical Group: ITPA Pedestal TG
Contact Person: Andrew Kirk, Albrecht Herrmann
Devices: ASDEX Upgrade, MAST (Sometime in 2005)

Background

The radial extent and spatial structure of type-I ELMs in ASDEX Upgrade has been investigated using data from the mid-plane manipulator equipped with Langmuir probes and a fast visible imaging camera. Plasmas with toroidal magnetic fields of 2 and 3 T have been studied. The radial extent of the ELM efflux is up to 10 cm and there is evidence that the extent is largest at the smaller toroidal magnetic field. A series of shots with different plasma edge to wall separations have been studied but no effect on the radial extent has been observed. The data from the mid-plane manipulator data and from visible imaging are consistent with the non-linear ballooning mode theory, which predicts that the ELM has a filament like structure. These filaments are extended along a field line in such a way that at any toroidal angle it appears to be poloidally localised and at any poloidal position it appears to be toroidally localised. These filaments are measured to have a typical toroidal mode number of ~15 and are found to accelerate away from the plasma edge with accelerations in the range 1.5×10^6 - 6.5×10^6 ms^{-2}.

Goal

Investigate further the radial expansion and structure of type-I ELMs by confirming the magnetic field dependence. Investigate the effect of magnetic configuration i.e. Upper Single Null and Connected Double null. Study pellet induced ELMs and type-II ELMS and investigate if the structure and radial extent is different. The images obtained during 2004 had a small plasma wall gap. To improve the visualisation of the ELM structure these pictures should be obtained with a larger gap.

PEP-12: Proposal for inter-machine experiment 2005

1. **PEP-12: Comparison between C-Mod EDA and JFT-2M HRS regimes**
2. **Pedestal ITPA Group**
3. **Background and previous results**

This experiment will complete the productive comparison started in 2004, with the purpose of comparing the EDA and HRS regimes more systematically in terms of access conditions, fluctuation characteristics and global properties, to see if they are the same physical regime. Comparing devices of different sizes and plasma parameters should help to clarify the important dimensionless parameters and prospects for extrapolation to burning plasma experiments. In 2004, JFT-2M, investigated the access conditions for the HRS regime in terms of the pedestal parameters by scanning both density at three values of q_{95} (2.9, 3.5 and 5). It was found that the ELMy/HRS operational boundary occurred near at a normalized electron collisionality of ν_e^*~1 in the plasma edge region, also depending on q_{95}. On C-Mod, a range of plasma conditions at medium q_{95}~3.5 was scanned. The H-mode operating space in terms of ν_e^* was very similar to JFT-2M. This strongly suggests that the EDA and HRS regimes, and the 'mixed' ELM regimes on the two devices have common physics. Due to limited run time, only a limited scan was conducted at q_{95}=2.9, and the q_{95}~5 part of the proposal was not started.

4. **Contact Persons:** K. Kamiya, N. Oyama, (JAERI) and A. E. Hubbard (MIT)
5. **Contributing devices:** JFT-2M (analysis of 2004 data), C-Mod (new experiments, planned for March 2005)
6. **Proposed Experiments**

It is proposed to complete the C-Mod part of the comparison experiments originally proposed for 2004. Power and density scans will be completed at low q, and conducted at high q. It will be of interest to see if the collisionality boundary is reduced at higher q as on JFT-2M. JAERI personnel (K. Kamiya and N. Oyama) plan to travel to MIT, tentatively in March 2005, to participate in these experiments. Analysis will be completed and a joint publication is planned.

PEP-13: Comparison of Small ELM Regimes in JT-60U and AUG

Topical Group: ITPA Pedestal TG
Background and Previous Results: This proposal is a continuation and expansion of PEP-13 for 2004. Small ELMs have been obtained at AUG by operating at high safety factor (q95~6), high triangularity (δ~0.4) and high βpol (1.8-2.0), following the JT-60U recipe. In addition, however, the AUG Type II ingredient of operating in near-DN configurations has also been necessary. The pedestal-top collisionality of these discharges is as low as any so far achieved in AUG. A setup discharge at moderate q95 also showed small ELM characteristics while maintaining good confinement. This suggests that access to more relevant safety factors is possible. Since the high power in these discharges suppresses sawtooth activity, these discharges merge in this limit to double null version of the improved H-mode regime.
Contact Persons: N. Oyama, H. Urano (JT-60U), L.D. Horton (AUG), A. Loarte (EFDA)
Devices: ASDEX Upgrade, JT-60U Uncertain time for completion, perhaps in 2005
Goals:

1) Attempt to transfer the JT-60U grassy ELM regime to AUG with the particular goal of extending small ELM regimes on AUG to lower collisionality.
2) Given a successful result to the first goal, study the access conditions for grassy ELMs and compare them to those for the AUG Type II ELM regime.
3) Attempt to extend the operating range for small ELMs to lower safety factors.

Experimental Goal: Main effort will be further experiments to better document this at more relevant safety factors.

PEP-14 (TP-5): QH/QDB COMPARISON IN JT-60U AND DIII-D

Topic Group: Edge and Pedestal Physics Topical Group (Transport Physics Group)

Background and Previous Results: This proposal is a continuation of PEP-14 (and TP-5) from 2004.

2004 Related Work:

1. By optimization of plasma configuration, QH-mode plasmas were produced in JT-60U with both counter- and co-NBI.
2. The mix of co- and counter-NBI was used to change the toroidal rotation and the ELM behavior in JT-60U.
3. DIII-D results suggest that ELM suppression may be linked to QH-mode plasmas being marginally stable to peeling-ballooning modes.
4. DIII-D results indicate that impurity transport at the plasma edge is faster during QH-mode with EHOs than during H-mode with ELMs

Contact persons**:** P. Gohil, L. Lao (DIII-D) and N. Oyama, Y. Sakamoto (JT-60U)

Tokamaks: DIII-D and JT-60U (DIII-D plans on doing 2 days of QH-mode physics between Jan-Mar, 2005; the date for JT-60U is to be determined)

Outline of Proposed Experiments, Purpose and Goals: To improve the understanding and to expand the parameter space of QH/QDB plasmas by multi-machine experiments and comparisons.

Experiments on DIII-D will stress detailed measurements of the edge current using the Li beam diagnostic in order to more accurately determine the effect of edge currents on the edge plasmas stability. Also, work will focus on high triangularity to further increase the performance of these plasmas. These experiments will be performed with participation from JT-60U scientists (Y. Sakamoto, H. Urano) at DIII-D.

Experiments on JT-60U will complement the DIII-D experiments by performing comparisons of the characteristics of the pedestal parameters and edge fluctuations by changing the plasma configuration (shape including triangularity and outer gap), plasma density (or collisionality), and plasma current (including current ramp up/down). In particular, experiments at JT-60U will investigate QH-mode operation with co-NBI in further detail. These experiments will be carried out with participation from DIII-D scientists (P. Gohil, L. Lao, and P. West).

To guide the experiments, a comparison of the edge stability during QH as well as the ELMing phases in both devices will be carried out, including the effects of plasma toroidal rotation.

PEP16: C-MOD/NSTX/MAST SMALL ELM REGIME COMPARISON

Topical Group: Pedestal & Edge

Background:

A variety of small ELM regimes on various devices have been reported such as grassy ELMs (JT-60U, JET), type-II ELMs (JET, AUG, DIII-D), HRS-mode (JFT-2M, C-MOD), EDA (C-MOD), and type-V ELMs (NSTX) mostly at high collisionality $\nu_{e,ped}^* > 0.5$. The physics leading to these different regimes and, hence, the scalability towards ITER is not fully understood. A recent ITPA-sponsored dimensionless comparison between C-MOD and JFT-2M (PEP-12) showed much commonality between EDA- and the HRS-mode, despite different aspect ratios. The recently announced type-V ELM regime in NSTX (and possibly also observed in MAST) may well be another incarnation of HRS, EDA or type-II, although the details seem to be different. A similar comparison between C-MOD, NSTX and MAST would help to understand the differences and commonalities of these regimes, improving the reliability of extrapolations to ITER and, reducing the zoology of ELM regimes. The difference in field line pitch between small and large aspect ratio would highlight the role of q_{95} for the instabilities.

Contact: A. Hubbard, R. Maingi, H. Meyer

Tokamaks: C-MOD, NSTX, and MAST

Proposed Experiments:

Comparison of ELM characteristics and pedestal structures in small ELM regimes in C-MOD, NSTX and MAST. The experiment would match plasma shapes (targets $\kappa \sim 1.75$, $\delta \sim 0.4$, single null with $dr_{sep} \approx 2$cm), apart from aspect ratio, and include limited scans of power and density to vary pedestal parameters. The scans would be based on discharges with identical $\nu^*_{ped} \approx 0.5$-3, $\beta_{ped} \approx 0.65\%$ and $q_{95} \approx 5$-6 or $\rho^*_{ped} \approx 0.004$-0.007 ($\beta$ and ρ^* have to be defined as flux surfaces averages in small aspect ratio, since large aspect ratio approximations are invalid). Points of comparison would be the operational spaces of ELM and fluctuation regimes, and the ELM and fluctuation characteristics. About one run day would be devoted on each device. All three devices have extensive diagnostics of edge profiles and fluctuations which should make this comparison fruitful.

Scrape-off Layer and Divertor Physics ITPA-IEA Joint experimental proposals for 2005

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

DSOL-1	**Scaling of Type I ELM energy loss and pedestal gradients through dimensionless variables**
DSOL-2	**Hydrocarbon injection to quantify chemical erosion**
DSOL-3	**Scaling of radial transport**
DSOL-4	**Disruption energy balance in the most likely disruptions in the ITER Q_{DT} = 10 scenario**
DSOL-5	**Role of Lyman absorption in the divertor**
DSOL-7	**Multi-machine modeling and database for edge density and temperature profiles**
DSOL-9	**Carbon-13 injection experiments to understand C migration**
DSOL-10	**Modelling of different gasses effects on disruption power deposition**
DSOL-11	**Disruption mitigation experiments**
DSOL-12	**Oxygen Wall cleaning**
DSOL-13	**Deuterium codeposition with carbon in gaps of plasma facing components**
DSOL-14	**Benchmarking of Edge Simulation Codes**
DSOL-15	**Inter-machine comparison of blob characteristics**

DSOL-1 proposal. Scaling of Type I ELM energy loss and pedestal gradients through dimensionless variables

Topical Group. Divertor and edge + Pedestal

Contact Persons : A. Loarte, M. Kempenaars, G. Saibene, A. Kallenbach, A.Leonard, T. Osborne, M. Fenstermacher, P. Snyder

Background of previous results : Previous experiments have shown that discharges with identical pedestals in dimensional variables have pedestal temperature gradients which scale with machine size (i.e. determined by plasma transport). Density pedestals do not scale this way and are more consistent with being determined by neutral ionisation. Scaling of the pedestal gradients and ELM energy losses with ρ^* remain unclear. Dependences on input power and plasma shape in this type of experiments have not been studied.

List of tokamaks relevant to the experiments : JET (2005/2006), DIII-D (2005/2006), ASDEX Upgrade (2005/2006?)

Outline of Proposed experiments, purpose and goals : The purpose of these experiments are : to determine the ρ^* dependence of ELM energy loads and of the edge pedestal gradients by carrying out comparable experiments in smaller and larger devices, b) to assess the role of plasma shape in determining the edge gradients and ELM behaviour in discharges with similar dimensionless parameters and different device size and c) to determine the effect of the level of additional heating (and pedestal β) on edge gradients and ELM losses. This will be done by discharges with matched pedestal parameters, shapes and q_{95} in all devices and by exploring the ρ^* dependence within every device. Emphasis will be taken into obtaining good measurements of the pedestal plasma parameters, main plasma ELM energy losses and divertor energy fluxes.

1. Experiment: DSOL-02 Hydrocarbon injection to quantify chemical erosion, plans for 2005

2. Topical group: Divertor and SOL

3. Background Quantification of the primary chemical erosion source under divertor plasma conditions in dependence on the substrate target temperature, the plasma conditions, the impinging flux and the impurity composition. Injection of hydrocarbons (CH_4, C_2H_y) to quantify the spectroscopic signals and evaluate absolute photon efficiencies (D/XB-values).. In the past, in situ hydrocarbon injection has been done for quantifying chemical erosion in TEXTOR, AUG, JET, and JT-60U, mainly for erosion dominated attached conditions. Evaluated yields show still a scatter between 4% (JET) and 0.3% (AUG) at surface temperatures of >500K and <350 K respectively, which needs further work. In addition the chemical erosion for cold, detached conditions must be addressed.

4. Contact persons V. Philipps FZJ Juelich (Coordinator), S. Brezinsek FZJ Juelich, M.Stamp (JET), A.Kallenbach (AUG), Nakano (JT-60U), M.Fenstermacher (DIII-D)

5. Devices: TEXTOR, JET, AUG, DIII-D, JT-60U

6. Proposed experiments:

TEXTOR: injection and hydrocarbon formation under cold, detached conditions, injections of higher hydrocarbons **DIII-D**: experiments under attached and detached plasmas conditions with the porous plug injector in the DIMES manipulator, injection of different hydrocarbon species is foreseen. **AUG:** hydrocarbon injections into detached plasmas (outer divertor). These experiments will allow a direct comparison under similar plasma conditions with experiments in DIII-D. **JET:** it is proposed to follow up the hydrocarbon formation by hydrocarbon injection into the detached inner divertor and investigation of the “history effect”, to detect the layer formation and disintegration. **JT-60-U:** Measurements of D/XB by CH_4 and C_2H_6 injection are planned till end of 2004, JT-60U will not be operated for one year from December 2004 on.

DSOL-3 2005 proposal (Scaling of radial transport)

Topical Group: Divertor/SOL

Background and Previous Results continuation of 2004 work

Contact Persons: B. Lipschultz, G. Matthews, T. Leonard, S. Lisgo, A. Kallenbach

Tokamaks involved (timing of planned expts): C-Mod (2 run days, spring 2004), JET (1/2 session, spring 2005), MAST (1 run, spring 2005) DIII-D (no experiment – analysis of extant data), ASDEX-Upgrade (5-7 shots, spring 2005).

Proposed Experiments: The goal is a better prediction of how radial transport in the SOL scales. This may help us understand the underlying physics. We are trying to move ahead on several fronts – more comparisons of discharges across tokamaks, Plans for the next year:

1) New experiments on C-Mod over a range in SOL opacities to neutrals (and ν^*). This will better pinpoint the effect of neutrals on the SOL profile shape. It will also be a coordinated study comparing 'blob' velocities to the underlying, time-averaged, transport covering a wide range of ν^* and β.
2) New experiments in JET at higher current will allow variations in the SOL opacity to neutrals – again to understand the effect of neutrals on the SOL density profile.
3) New experiments in MAST and ASDEX-Upgrade are being discussed to provide more data points for comparison to data already obtained on JET, DIII-D and C-Mod. The main issue is diagnostics.
4) 'Off-line' analysis of DIII-D data taken this year with ELMs.

DSOL-4. Disruption energy balance in the most likely disruptions in the ITER Q_{DT} = 10 scenario

Topical Group. Divertor and edge + MHD

Contact Persons : A. Loarte, P. Andrew, V. Riccardo, A. Kellman, D. Humphreys, G.Pautasso, G. Counsell, D. Whyte

Background of previous results : Previous experiments have shown that thermal quench energy fluxes are much smaller than expected from the ITER Physics Basis analysis. This is due to a combination of various factors : the poor energy confinement of the plasma by the time of the thermal quench, the broad power deposition footprint at the thermal quench and the timescales for power flux which are longer than that of the main plasma temperature collapse by ECE.

List of tokamaks relevant to the experiments : JET (2005/2006), DIII-D (2005/2006), ASDEX Upgrade (2005/2006?), MAST(2005/2006?)

Outline of Proposed experiments, purpose and goals : The purpose of these experiments is to determine the disruption energy balance (including pre-disruptive loads on PFCs) and thermal quench power deposition spatial and temporal characteristics for the most relevant disruption types in the ITER ELMy H-mode Q_{DT} =10 reference regime. In order to identify size scaling of these energy loads and spatial/temporal characteristics and specify device dependent features a series of similar disruption experiments will be carried out and repeated identically several times to determine disruption-to-disruption variability. This will be done for the most common type of disruptions in the ITER ELMy H-mode Q_{DT} =10 reference regime, namely : density limit by over-fuelling, radiative collapse by excessive impurity puffing (Ne/Ar) and NTM triggered disruption (by excessive P_{inp}).

DSOL-5 Role of Lyman absorption in the divertor

Divertor & SOL

A continuation of DSOL-5 activities. Photon transport simulations for a "medium-density" C-Mod discharge have been conducted (2001-04). Further code analysis of existing C-Mod data and a new JET experiment are proposed.

D Reiter, J Terry, G Matthews, S Lisgo

C-Mod: experiments complete, ongoing code analysis in 2005; JET: proposed experiment for 2005 campaign (August-December), code analysis in 2006

Proposed C-Mod activities involve continued (de)validation of the analysis codes: quantitative comparisons with Lyman:Balmer line ratio data, modelling higher density C-Mod shots (experimental data has been supplied for 980116023, 27), and including the effect of Zeeman line-broadening on photon transport.

JET divertor densities are a factor ~10 lower than for C-Mod, but the divertor spatial scale length is a factor ~5 larger, which suggests that Lyman series trapping may be significant. An experiment has been proposed for the 2005 JET campaign (S Lisgo) that is similar to the Lyman:Balmer line ratio measurements done on C-Mod. The attempt will be made to gather sufficient divertor diagnostic data so that plasma reconstruction methods used in the C-Mod analysis can also be applied to JET.

DSOL-7 proposal - Multi-machine modeling and database for edge density and temperature profiles

Divertor and SOL Topical Group

Background and Previous Results:
Edge profiles of electron temperature and density mainly from Thomson scattering of ELMy H-mode discharges have been collected from ASDEX Upgrade, C-Mod, DIII-D, JET, JT60-U and MAST. Parametrization by a modified tanh function allowed a uniform processing of the data in terms of profile parameters. Statistical evaluation of the database revealed the machine size as the leading parameter for the edge barrier widths and decay lengths. The density profiles showed some effects related to neutral penetration physics. The results of this study have been presented at the PSI 2004 Conf. and will appear in JNM.

Contact Persons: Arne Kallenbach (AUG), G. Porter (DIII-D), D. Mossessian (C-Mod), A. Korotkov (JET), N. Asakura (JT60-U), A. Kirk (MAST)
W. Suttrop, L. Horton, T. Osborne (Pedestal Topical Group), D. Coster (modeling)

Tokamaks Relevant to the Experiment:
Experimental time is currently not requested. To continue the work, uniform software interfaces are required to store experimental data under a common MDSplus tree architecture and to interface edge code input and output with those. Software interface development is requested, ideally for the machines which already provided data (see above) and the code EDGE2d, B2-Eirene and UEDGE.

Outline of Proposed Experiments, Purpose and Goals:
Modeling of edge profiles of multiple machines with the same code and code-code comparisons using the standardized MDSplus interfaces, in collaboration with the Pedestal Topical Group and the edge modeling community. In the near future, already existing discharges will be analyzed. One major goal is to determine transport coefficients in the ETB region for different devices in a coherent way ant to assess the question of the importance of neutral penetration physics on density pedestal formation.

1. **DSOL9. ^{13}C injection experiments to understand C migration**
2. Divertor and Scrape-Off Layer Topical Group
3. Background: ^{13}C-tracer experiments involve injection of $^{13}CH_4$ from various locations in a tokamak at the end of an experimental campaign prior to an in-vessel intervention. Tiles are then removed for surface analysis. This is a very useful tool for studying carbon co-deposition which is primarily motivated by the tritium retention issue. Comparison experiments among different tokamaks are needed to advance analysis methods and to identify common patterns of co-deposition.
4. Contact: Guy Matthews, JET facility, , P. Stangeby (DIII-D), V. Philipps (Textor),
5. Tokamaks: JET, DIII-D, TEXTOR, ASDEX-Upgrade.
6. Outline of Proposed Experiments, Purpose and Goals: **JET** (M.Rubel) First experiment (2001) with $^{13}CH_4$ injection into ohmic plasmas at the top showed that 99% deposition in the inner divertor and no sign of migration to remote areas. More recently $^{13}CH_4$ was injected at the outer target in H-modes and ^{13}C was detected on the side of the top reciprocating probe facing the outer divertor only. The divertor tiles are not yet analysed but will allow comparison with ASDEX Upgrade experiments with similar geometry. **DIII-D** (P. Stangeby) Similar results to JET but using toroidally-symmetric $^{13}CH_4$ injection. A number of independent analyses indicate carbon plumes and deposition requires SOL Mach number around 0.5 for consistency; most of the ^{13}C has been found. H-mode plasmas will be used next. Oxidation and ^{13}C studies will be combined. **TEXTOR** (V.Philipps) $^{13}CH_4$ was injected from a test limiter and the surface subsequently analysed. ERO-TEXTOR modelling requires low sticking probability to explain low levels of ^{13}C found on the surface. **ASDEX Upgrade** (K.Krieger) $^{13}CH_4$ was injected at the outer divertor target and almost all of the ^{13}C was accounted for on the outer target surface, injection from the outer mid-plane produced a more balanced distribution. Future work needs to ensure consistent inter-machine comparisons and focus on what factors lead to migration into remote areas.

DSOL-10 proposal - 'Modeling of different gasses effects on disruption power deposition'

2. Topical Group: Divertor & SOL
3. Contact persons: D. Whyte (UW-Madison), M. Bakhtiari (JT60-U), P. Andrew (JET), Martin (ToreSupra), Matthews (JET), Hollmann (DIII-D)
4. Devices participating: DIII-D, JT-60U, Tore Supra, JET
5. Time period: 10/04 – 9/05.
6. Goal: Determine the positive and negative effects of using different combinations of injected gas species for optimizing heat load distributions to plasma-facing components during disruptions.
7. Description of results:
   - Benchmark more rigorously present radiation models on timescale and spatial uniformity (toroidal & poloidal) of thermal energy dissipation, including newest results on gas jet / plasma interaction.
   - Examine possibility of exploiting core plasma opacity, likely after He gas injection, in order to slow down thermal quench time and avoid Be melting in ITER.
   - Include MHD force calculation on thin Be melt layers caused by ~1 ms radiative thermal quench in ITER in order to predict stability and losses of melt layer.
   - Further model effects of plasma radiative energy dissipation on surface heating of low-Z films for tritium recovery.
   - Use models to design experiments on DIII-D, JET and ToreSupra for localized tests of the tritium recovery
8. **Executive summary:**

Personnel: Whyte, Bakhtiari, Martin, Andrews, Matthews, Hollmann
Time period: 10/04 to 9/05.
A wide range of scenarios with different gases and injection rate need to be explored to optimize thermal mitigation, runaway suppression and rapid radiative surface heating for tritium recovery in ITER.

DSOL-11 proposal - 'Disruption mitigation experiments'

2. Topical Group: Divertor & SOL
3. Contact persons: D. Whyte (UW-Madison), T. Jernigan (ORNL), E. Hollmann (UCSD), M. Bakhtiari (JT60-U), G. Martin (Tore Supra), V. Riccardo (JET), P. Andrew (JET), R. Granetz (MIT), J. Terry (MIT), K. Erents (JET), G. Matthews (JET), K.H. Finken (Juelich)
4. Devices participating: DIII-D, JT-60U, Tore Supra, JET, Alcator C-Mod
5. Experiments implemented 10/04 – 09/05.
6. Goals: Use extensive empirical experience on present devices to optimize disruption mitigation in ITER.
7. Description of results:
    - JET and Alcator C-Mod will both implement high volume/pressure gas injection systems for disruption mitigation studies this upcoming year. This will allow for important empirical tests of gas jet mitigation on large, high Te device (JET) and high current density and magnetic field device (C-Mod).
    - Continue to develop methods to diagnose the complicated interaction between the jet neutrals, impurity ions, the plasma and the MHD induced by the large radiation. This includes better imaging capability of the jet (C-Mod) and correlations between rapid radiation pulses and MHD (DIII-D, C-Mod, JET).
    - Provide further tests on runaway avalanche suppression during current quench. JET and C-Mod with high Ip and j respectively provide good scaling tests of the present models.
8. **Executive summary**: Personnel: Whyte, Jernigan, Hollmann, Bakhtiari, Martin, Granetz, Terry, Riccardo, Andrews, Finken, Time period: 07/04 to 09/04. Summary: Cross-machine comparisons of gas jet designs and target plasmas continue, now including JET and C-Mod, in order to provide better empirical extrapolation to ITER.

7. **DSOL-12 proposal Oxygen Wall Cleaning**
8. Divertor and Scrape-Off Layer Topical Group
9. Background: T-retention by co-deposition with C is a potential show-stopper for ITER. O_2-baking is a potential solution to this problem. Development of the method requires cross-device experimental comparisons in present tokamaks.
10. Contacts: Peter Stangeby, U of Toronto/GA/LLNL, V. Philipps (Textor), J. Li (Hefei, HT-7)
11. Tokamaks: TEXTOR, HT-7, DIII-D.
12. Outline of Proposed Experiments, Purpose and Goals: It is necessary to establish, for a given 'severity' of O_2-baking (pressure, bake temperature, duration): (a) How much of each type of co-deposit is removed? (b) How much and what type of wall re-conditioning is required to recover tokamak performance? (c) If there is long-term damage done to non-carbon materials and components in the tokamak, and if there is damage - how much? (d) The removal efficiency of O_2-baking is a strong function of temperature, and vessel temperature is restricted in ITER. Is there a window of applicability? (i) TEXTOR. (V. Phillips) use RF plasmas, $B \neq 0$, in He/O mixtures also standard He/O GDC to compare with O_2-bake; insert pre-characterized surfaces at 3 locations in TEXTOR to quantify the removal by post mortem analysis and to compare with the more global analysis using RGA. Will study ozone exposure in lab experiments to remove C-deposits from TEXTOR tiles. (ii) HT-7. (J. Li) comparing O_2-baking, O-ICR exposure and O-GDC at ~450K, i.e. substantially cooler than used in TEXTOR. (iii) DIII-D. (P. Stangeby) puff $^{13}CH_4$ into repeat H-mode shots, creating isotope-marked co-deposits; remove set of tiles and measure ^{13}C deposits on faces and sides (tile-gaps); then expose tiles to O_2-baking in lab to quantify removal rate for different deposit types as function of baking parameters.

DSOL-13 proposal: Deuterium codeposition with carbon in gaps of plasma facing components

Topical group: Divertor & SOL

Background and results: The main objective is the investigation of the influence of gap geometry on the formation of D/C deposits in the gaps.

The total amount and spatial distribution of hydrocarbon layers in gaps of plasma facing surfaces and the dependency of deposition rates on surface temperature was investigated in 2004 by exposure of probes in TEXTOR, ASDEX Upgrade and DIII-D.

Contact persons & tokamaks: K. Krieger (ASDEX-Upgrade), A. Litnovsky (Textor), C. Wong (DIII-D), B. Lipschultz (C-Mod)

Proposed Work: First results have been obtained but detailed analysis is still ongoing and will extend into 2005. At TEXTOR and ASDEX Upgrade probes with W monoblocks are currently under construction, which allow variation of the gap geometry. Both employ a modular design to allow disassembly of the monoblock structure for surface analysis of side faces.

Additional experiments are also planned with the heatable gap probe in DIII-D (contact person C. Wong) to extend the parameter range of the previous experiments. Specific shots will be needed.

In Alcator C-Mod (contact person B. Lipschultz) W brush tiles will be installed for a full campaign in 2005. A W-brush component with similar gap size (0.5 mm) is installed in ASDEX Upgrade for the campaign 2004/5. From these components campaign averaged results on gap deposition will be obtained (without specific machine time).

DSOL-14 proposal: Benchmarking of Edge Simulation Codes

Topical Group: Divertor and Edge

Background: Edge simulation codes are being used as a bridge between current experimental results and predictions for the ITER divertor. Several edge simulation codes (SOLPS a.k.a. B2-Eirene, EDGE2D-NIMBUS, UEDGE, …) are in widespread use but have not been extensively benchmarked against each other for realistic cases, although some basic numerical benchmark tests exist. The benchmarking of the two European codes (SOLPS and EDGE2D-NIMBUS) has started within the EFDA-JET framework, and Stage I results reported at the 2004 PSI meeting. The intention of this proposal is to broaden the comparison to include, at a minimum, the USA edge code UEDGE, in the benchmarking process, as well as to push the codes in the direction of validation for ITER conditions. The inclusion of additional, equivalent, codes would be welcomed.

Contact Persons: David Coster, Xavier Bonnin, (Aki Hatayama), (Hisato Kawashima), Tom Rognlien, Jim Strachan [“()” indicate possible collaborators]

Experimental Time: No experimental time is requested at this stage. Phase I is intended to concentrate on basic comparisons of the codes, with fours stages of increasing physics complexity. Phase II, which should overlap the later stages of phase one, will extend the code-code comparisons to code-code-experiment comparisons. In this phase, well diagnosed shots from a number of machines and a number of experimental conditions will be required. In phase III, issues related to the specific ITER divertor conditions will be tested. Phase I will require no experimental data. Phase II will probably not require additional experimental discharges, though “repeats” with better diagnostics might be desirable. Phase III might produce specific experimental proposals to test the physics basis underlying the code predictions for ITER (*e.g.* semi-detached divertor conditions, opacity effects, mixed materials, He pumping).

Outline: In the first phase, UEDGE will be incorporated in the Stage I benchmarking (D plasma, no drifts) that has already occurred for SOLPS and EDGE2D-NIMBUS. As soon as possible, Stage II (D plasma, with drifts) will be started. Depending on the speed with which Stages I & II are completed, Stages III (D+C, no drifts) & IV (D+C, with drifts) will be pursued, though it is likely that the bulk of this activity will occur in 2006. Phase II will probably start by looking at a set of JET discharges with well characterised flow measurements; other machines will be asked to identify good candidates (Stangeby’s well characterised DIIID L-mode shots would be a good candidate as well). Of particular interest will be any similarity experiments between the various machines. As other groups with equivalent codes become interested, they will be encouraged to join the activity. It might also become important to benchmark the Monte-Carlo neutrals codes separately.

DSOL-15 proposal Inter-machine comparison of blob characteristics

2. Topical group: Divertor and SOL

3. Background - Intermittant turbulent transport seen on most tokamaks, commonly called blobs, has been shown to have a primary effect on perpendicular ion transport in the SOL. This has significant implications for main-chamber recycling, impurity sources and divertor design.

The radial vs. poloidal structure and motion of edge turbulence is quite similar in NSTX and Alcator C-Mod. The L-mode edge has highly turbulent 'blobs' which propagate radially toward the outer wall, while the H-mode edge is normally quieter.

4. Contact persons J. Terry (C-Mod), S. Zweben (NSTX), C. Hidalgo (TJ-II), R. Maqueda (NSTX), O. Grulke, D. D'Ippolito, J. Myra

5. Devices: C-Mod, NSTX, TJ-II

6. Proposed experiments:

Using high-speed camera and linear arrays - record the blob dynamics as a function of collisionality, magnetic geometry, magnetic field. Look for dimensional and dimensionless variations across the 2 machines and compare to models of blob dynamics. Should require a few days run time on both machines.

MHD,Disruptions, and Magnetic Control ITPA-IEA Joint experimental proposals for 2005

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

MDC-1	**Disruption mitigation by massive gas jets**
MDC-2	**Resistive wall mode physics**
MDC-3	**Neoclassical tearing modes (including error field effects)**
MDC-4	**Neoclassical tearing mode physics – aspect ratio comparison**
MDC-5	**Comparison of sawtooth control methods for neoclassical tearing mode suppression**
MDC-6	**Low beta error field experiments**
MDC-8	**Current drive prevention/stabilization of NTMs**
MDC-9	**Fast ion redistribution by beam driven Alfvén modes and excitation threshold for Alfvén cascades**
MDC-10	**Measurement of damping rate of intermediate toroidal mode number Alfvén Eigenmodes**

<u>ITPA-IEA Joint Experiment Proposal for CY2005</u>

1. **MDC1 Disruption mitigation by massive gas jet**s
2. *Topical Group:-* MHD
3. *Background and Previous Results:-* This is a continuation MDC1 from 2004 (and earlier) work
4. *Contact persons:-* R Granetz, D Whyte (C-Mod), K.H Finken, P Andrew (JET), K.H Finken (TEXTOR), Y Kawano (JT60U), E Hollmann (DIII-D), G Pautasso (AUG)
5. *Tokamaks Relevant to the Experiment:-* C-Mod (early 05), JET(late CY05), JT60-U, TEXTOR, AUG (no expts planned on DIII-D in 05)
6. *Outline of Proposed Experiment:-* New gas jet systems will be available on C-Mod and JET. Experiments on these machines will help elucidate the cross machine applicability of noble gas disruption mitigation, in terms of size effects, and high current density and TF; in particular effects on neutral penetration can be examined. JT60-U plan to study the possibility of mitigation of runaway tails by gas injection and JET and C-Mod experiments will also provide data on runaway avalanche suppression. TEXTOR and ASDEX Upgrade plan to study effects of gas jet location and number of injected particles. TEXTOR studies will be augmented by a new fast camera for investigating disruption dynamics. DIII-D has time scheduled to complete the 2003/4 experiments.

ITPA-IEA Joint Experiment Proposal for CY2005

1. **MDC2 Joint experiments on resistive wall mode physics**
2. *Topical Group:-* MHD
3. *Background and Previous Results:-* This is a continuation MDC2 from 2004 work, where an initial RWM (RFA) comparison was made between JET and DIII-D.
4. *Contact persons:-* H Reimerdes, M Okabayashi (DIII-D), M Gryaznevich, S D Pinches (JET), R Koslowski (TEXTOR), M Takechi (JT60-U), S Sabbagh (NSTX), H Zohm (AUG)
5. *Tokamaks Relevant to the Experiment:-* DIII-D (early 05), JET(late CY05), JT60-U, NSTX, TEXTOR and possibly AUG (if relevant scenarios can be developed).
6. *Outline of Proposed Experiment:-* The goal of these experiments is to benchmark RWM damping models used for ITER predictions. The experiments between JET and DIII-D will continue with a comparison of the critical velocity (from magnetic braking) for RWM formation. TEXTOR and JT60-U will vary the toroidal rotation (using co and counter NBI mixtures) to study the effect on RWMs and RFA. An aspect ratio comparison will occur between DIII-D and NSTX, which among other things may elucidate the role of trapped particles on RWM damping.

ITPA-IEA Joint Experiment Proposal for CY2005

1. MDC-3 Joint experiments on neoclassical tearing modes (including error field effects)

2. *Topical Group:-* MHD
3. *Background and Previous Results:-* This is a continuation MDC3 from 2004 (and earlier) work. Experiments on 3/2 NTMs are largely complete and analysis of the results is in progress. Experiments on 2/1 NTMs remain to be completed
4. *Contact persons:-* R Granetz (C-Mod), R Buttery, M Maraschek (JET), M Maraschek (AUG), R La Haye (DIII-D)
5. *Tokamaks Relevant to the Experiment:-* C-Mod (possible in 05 dependant on reaching high enough β), JET(late CY05), AUG (CY05) (no expts planned on DIII-D in 05)
6. *Outline of Proposed Experiment:-* Conduct experiments on the critical β for 2/1 NTMs (AUG and JET) to determine ρ^*, ν^* scaling. Run experiments at higher q_{95} (3.5 to 4.0) to avoid H-L transition being coincident with NTM stabilization. Conduct identity match experiments on 2/1 NTM thresholds between C-Mod and DIII-D/JET (using existing data on the latter 2 devices).

ITPA-IEA Joint Experiment Proposal for CY2005

1. **MDC4 Neoclassical tearing mode physics - aspect ratio comparison**
2. *Topical Group:*- MHD
3. *Background and Previous Results:*- This is a continuation MDC4 from 2004
4. *Contact persons:*- M Maraschek (AUG), D Howell (MAST)
5. *Tokamaks Relevant to the Experiment:*- AUG , MAST (Spring/Summer 05). It is possible in future years that an equivalent comparison will occur between NSTX and DIII-D.
6. *Outline of Proposed Experiment:*- Determine aspect ratio effects on NTM stability through an identity type comparison of 3/2 and/or 2/1 NTM on AUG and MAST. Experiments will be conducted on NTM thresholds and on critical β for unconditional NTM stability through NBI rampdown studies.

ITPA-IEA Joint Experiment Proposal for CY2005

1. **MDC-5 Comparison of sawtooth control methods for neoclassical tearing mode suppression**
2. *Topical Group:*- MHD
3. *Background and Previous Results:*- This is a continuation MDC5 from 2003/4
4. *Contact persons:*- O Sauter, R Pinsker, R La Haye (DIII-D), A Muck (AUG), O Sauter, R Buttery (JET), J Menard (NSTX), T Goodman (TCV), Yi Liu (HL2A)
5. *Tokamaks Relevant to the Experiment:*- AUG , DIII-D (early 2005), JET(late 2005), NSTX, TCV and HL2A
6. *Outline of Proposed Experiment:*- Demonstrate NTM suppression by sawtooth control. This will be done using ECCD near q=1 on AUG, TCV, HL2A and DIII-D; at least on AUG and DIII-D it is planned to raise the β sufficiently to demonstrate benefits of sawtooth control on NTMs. On JET experiments on the control of large fast particle induced sawteeth, via ICCD near q=1, are planned. Finally NSTX will contribute via investigating means to control sawteeth in the ramp-up phase.

ITPA-IEA Joint Experiment Proposal for CY2005

1. **MDC-6 Low beta error field experiments**
2. *Topical Group:-* MHD
3. *Background and Previous Results:-* This is a continuation MDC6 from 2004
4. *Contact persons:-* S Wolfe, I Hutchinson (C-Mod), T Hender, D Howell (JET), T Scoville (DIII-D), R Koslowski (TEXTOR), D Howell (MAST)
5. *Tokamaks Relevant to the Experiment:-* C-Mod (date TBD in CY05), TEXTOR (CY05), MAST (no expts planned on JET or DIII-D in CY05 since a sufficient dataset exists)
6. *Outline of Proposed Experiment:-* The goal of these experiments is to understand error field threshold scaling to ITER. A B_t scan of error field threshold on C-Mod (as final element of CY04 work)is proposed. TEXTOR experiments will be on rotation effects (using ability to balance beams)and Bt scaling of error field thresholds. MAST should complete the aspect ratio scan with DIII-D.

ITPA-IEA Joint Experiment Proposal for CY2005

1. **MDC-8 Current drive prevention/stabilisation of NTMs**
2. *Topical Group:-* MHD
3. *Background and Previous Results:-* This is a new proposal (though somewhat related to MDC-7)
4. *Contact persons:-* Buttery (JET), Isayama (JT60-U), Zohm (AUG), La Haye (DIII-D)
5. *Tokamaks Relevant to the Experiment:-* JET (late CY05), AUG (existing data exists on the effect of pre-emptive ECCD on NTMs on JT60-U and DIII-D)
6. *Outline of Proposed Experiment:-* Two comparison experiments are proposed:-

(i) Pre-emptive current drive to prevent or mitigate 3/2 NTMs. This has been studied in JT60-U (in 2003/2004) and previously on DIII-D. New data will be obtained from AUG (using dc and modulated ECCD) and JET (with LH).

(ii) Study influence of ECCD width relative to NTM island width. AUG (modulated ECCD), and possibly on JT60-U and DIII-D (in 2006)

Overall the aim is to provide a range of data to benchmark the Rutherford equation for NTM evolution, allowing predictions for ITER ECCD requirements to be further validated.

ITPA Joint Experiment Proposal for CY2005

1. MDC 9 Fast ion redistribution by beam driven Alfvén modes and excitation threshold for Alfvén cascades

2. *Topical Group:* MHD
3. *Background and Previous Results:* This is a new proposal. On JT60-U the interaction between beam ions and AEs can reach a regime in which Abrupt Large Events cause significant redistribution and losses of the resonant ions. Based on these observations, a similar regime in which fast beam ions are redistributed should be identified on JET.
4. *Contact persons:* A.Fasoli, D.Borba, S.Pinches and D.Testa (JET), K. Shinohara (JT60-U), W.Heidbrink (DIII-D)
5. *Tokamaks Relevant to the Experiment:* JT60-U, JET and possibly DIII-D
6. *Outline of Proposed Experiments, Purpose and Goals:*

The ALE regime should be investigated further on JT60-U, to characterize the exact nature of the modes that give rise to it. Coupling of the mode effects with those due to the TF ripple should also be assessed. A similar regime should be explored in JET, in which the effects of the modes on the ion distribution would be characterized quantitatively, and compared with the existing nonlinear theoretical models. Both machines would operate at a reduced toroidal field value, to have resonant passing particles.

A possible extension of this experiment, related to the interaction between NBI fast ions and AEs, would be the measurement of the threshold for excitation of frequency sweeping AEs (or Alfvén cascades). Such measurements, performed on JET, JT60-U and possibly on DIII-D, with different beam energies and resonant conditions, would reveal the nature of the drive of Alfvén cascades.

ITPA Joint Experiment Proposal for CY2005

1. MDC 10 Measurement of damping rate of intermediate toroidal mode number Alfvén Eigenmodes

2. *Topical Group:* MHD
3. *Background and Previous Results:* This is a new proposal. A new antenna will be available on JET for driving and detecting AEs in the toroidal mode number range (n<~15) that is predicted to be the most unstable for ITER. This system replaces the previous saddle coil apparatus, which was used to study the frequency, mode structure and damping rate of low-n AEs. On C-Mod, a localized antenna structures can be used to drive intermediate n AEs. A similar system is also planned on MAST
4. *Contact persons:* A.Fasoli and D.Testa (CRPP-EPFL and JET), J.Snipes (C-Mod), M.Gryaznevich (MAST)
5. *Tokamaks Relevant to the Experiment:* JET, C-Mod, possibly MAST in late 05
6. *Outline of Proposed Experiments, Purpose and Goals:*
   In order to predict unambiguously which damping mechanism will be relevant for high-n AEs in ITER, the parametric dependency of the AE damping and growth rate needs to be experimentally assessed.
   These experiments must be carried out without fast particle drive to provide more accurate comparison with models. Specific goal: measurement of γ/ω as function of

- plasma shape (test damping models based on edge mode conversion)
- plasma beta and bulk ion temperature (test ion Landau damping and core mode conversion regimes)
- normalized ion Larmor radius (test predicted scaling of most unstable n's as function of ρ_{*i} and radiative damping model)
- rotation shear and q-profile
- antenna-plasma distance

ITPA-IEA Joint experimental proposals for CY2005
(ITPA: Steady State Operation group, Chair G. Sips)

Operation of experiments in 2005:

JET:	September to December
JT-60U:	October to December
DIII-D:	December 2004 to April 2005
ASDEX Upgrade:	January to July.
Alcator C-mod	March to October
NSTX:	March to August
MAST:	January to May

The following experiments are proposed:

SSO-1.1	**Document performance boundaries for steady state target q-profile**
SSO-1.2	**Qualify other q-profiles for steady state operation**
SSO-1.3	**Control of high bootstrap plasmas**
SSO-2.1	**Complete mapping of hybrid scenario**
SSO-2.2	**MHD effects on q-profile and confinement for hybrid scenarios**
SSO-2.3	**ρ^* dependence on confinement, transport and stability in hybrid scenarios**
SSO-3	**Real-time q-profile control in hybrid and steady state scenarios**
SSO-4	**Documentation of the edge pedestal in advanced scenarios**

SSO-1.1 Document performance boundaries for steady state target q-profile

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Continuation of previous collaboration experiments.

Background: The target q-profile for non-inductive operation in ITER is proposed to have q_{min} in the range 1.5-2.5, with weak shear q_0-q_{min}=0.5 and q_{95} near 5. This scenario aims at obtaining > 50% bootstrap current fractions. Collaboration experiments on documenting the operational limits for this type of q-profile were successfully started in 2003.

Contact persons: **X.Litaudon, J. Hobirk, T. Luce, Sakamoto**

Experiments: **JET, AUG, DIII-D, JT-60U.**

Outline and aims: The objective of the ITER Steady state scenario is 100% non-inductive operation at Q>5. Joint experiments are proposed to define a common, reproducible, scenario in today's experiments with the specified q-profile to allow assessment for ITER. The four machines should map the existence domain of this steady state scenario aiming at close to 100% non-inductive conditions, with β_N near 3. The experiments should focus on sustained high performance, documentation of performance limits (including resistive wall mode studies), an assessment of the requirements for obtaining stationary q-profiles with proper current profile alignment of the non-inductive current fractions. Specific experiments to asses the influence of Ti/Te and momentum input should be performed (although this will go beyond 2005).

SSO-1.2 Qualify other q-profiles for steady state operation

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Proposed before, but no joint experiments performed so far.

Background: Advanced scenarios with strongly reversed q-profiles, are still being assessed for their capability to produce steady state operation for ITER or a reactor. Experiments with strongly reversed q-profiles can obtain fully non-inductive sustainment at high confinement. Although exchange of information has taken place, no real joint experiments were performed in 2003/2004.

Contact persons: **S. Ide, X.Litaudon**

Experiments: **JT-60U, JET**

Outline and aims: The purpose of joint experiments is to map the beta limits for this regimes with q_{95}, q_{min}, q_0-q_{min}, $\rho_{q\text{-}min}$, β_{ped}, $\rho_{q\text{-}min}$-$\rho_{ITTB\text{-}foot}$. Compare confinement improvement by ITB, (H-factors, ITB strength, effect of T_e/T_i) in this domain. Compare confinement of high energy ions, with N-NB in JT-60U and with ICRF in JET. Demonstration of the controllability of this scenario is key (control knobs?). The main aim is to develop common scenarios for the experiments involved, with exchange of personnel to optimise the discharges and allow cross machine physics studies.

SSO-1.3 Control of high bootstrap plasmas

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Proposed before, but no joint experiments performed so far.

Background: One of the key aspects of steady state operation for a reactor is the presence of a large bootstrap fraction (~ 50% and preferably more). Since the bootstrap current is generated by pressure gradients, these discharges are quite difficult to control.

Contact persons: **P. Politzer, D. Moreau, E. Joffrin, S. Ide, J. Hobirk?**

Experiments: **DIII-D, JET, Tore-Supra, JT-60U, AUG?**

Outline and aims: Operation at high beta without flux consumption (including transformer-less operation) have been developed in various experiments but under widely different conditions. The experiments in this kind of regimes need to be better co-ordinated and the operational limits for these discharges need to be documented. Another aim is to asses the capability of steady state scenarios to operate for long duration with a high bootstrap fraction while still maintaining the necessary current profile. The control requirements should be investigated as this is one of the major issues to assess the applicability of these scenarios in ITER or to future reactors.

SSO-2.1 Complete mapping of hybrid scenario

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: Continuation of previous collaboration experiments.

Background: Documentation of the hybrid scenario was one of the most successful collaboration experiments for 2003/2004. DIII-D and AUG have completed the mapping with q_{95}, and almost finished mapping of the scenario with plasma density. JET and JT-60U have hybrid scenarios, but not yet performed dedicated scans for the existence domain of this regime in their experiments.

Contact persons: **E. Joffrin, S. Ide, M. Wade, G. Sips**

Experiments: **JET, JT-60U, DIII-D, AUG**

Outline and aims: The aim of the continuation of these collaboration experiments is to perform q_{95} and density scans in JET and JT-60U. Together with AUG and DIII-D, to obtain more discharges with Ti=Te, and to extend the scans in q_{95} to extreme values (for example $q_{95} < 3$). Some effort should be made to define comparison discharges with standard H-mode discharges, which are similar in each device so a co-ordinated and proper comparison with ITER H-mode reference pulses can be made.

SSO-2.2	**MHD effects on q-profile and confinement for hybrid scenarios**
Topic Group:	Steady State Operation in collaboration with Transport Physics.
Status:	New collaboration experiments.
Background:	Hybrid scenarios in various experiments have small NTMs. The role of these NTMs in sustaining the current density profile is not conclusive (MHD has an effect, AUG, DIII-D) or different from other experiments (MHD not required to sustain q(r), JET). The effect of the NTMs on confinement is not documented
Contact persons:	**H. Zohm, R. Buttery, M. Wade, Isayama**
Experiments:	**AUG, JET, DIII-D, JT-60U**
Outline and aims:	Aim is to establish similar type of hybrid discharges in the four experiments with maximum duration. Variation in the heating and current drive (LHCD) or ECCD for NTM stabilisation should be able to create different MHD behaviour (NTMs, fishbones, 2/1 tearing). This would allow documentation of the effect of the MHD and the q-profile and confinement. The modelling of these pulses would be co-ordinated as well. The results may impact on the NTM stabilisation and q-profile control requirements for this scenario in ITER. In addition it will promote comparison /cross-check of q-profile calculations by codes. Here AUG and DIII-D could have specific experiments on NTM control, with JT-60U possibly joining this activity.

SSO-2.3 **ρ^* dependence on confinement, transport and stability in hybrid scenarios**

Topic Group: Steady State Operation in collaboration with Transport Physics.

Status: New collaboration experiments.

Background: The ability to create hybrid discharges in different experiments has now opened the way for co-ordinated studies on to the effect of ρ^* on the confinement, transport and stability of this regime

Contact persons: **C. Petty, D. McDonald, A. Stäbler, S. Ide**

Experiments: **DIII-D, JET, AUG, JT-60U**

Outline and aims: The aim of these experiments is to (i) make identity experiments at the same ρ^* for detailed transport studies (with common and improved diagnostics), and (ii) to get the largest possible variation in ρ^* for confinement scaling and stability boundary scaling studies. This would provide an extended database compared to experiments today. Maximising the range of ρ^*, will help to provide scaling of small NTMs (not triggered by sawteeth), and will allow first attempts to obtain a confinement scaling for this regime.

Remark: Confinement data from Hybrid scenarios should be included in the global confinement database, to take advantage of the operational capabilities of this regime (high beta).

SSO-3 Real-time q-profile control in hybrid and steady state scenarios

Topic Group: Steady State Operation

Status: New collaboration experiments.

Background: Various experiments have experiments planned (milestones) to demonstrate real-time q-profile control. Although these experiments have not yet been co-ordinated by the ITPA, exchange of personnel for these (planned) experiments is crucial.

Contact persons: **D. Moreau, D. Mazon, G. Sips, J. Ferron, T. Suzuki, Zhang?**

Experiments: **JET, Tore-Supra, AUG, DIII-D, JT-60U, HT-7?**

Outline and aims: To exchange experience and knowledge on: (i) development of control tools (sensors/actuators + integration in overall control system), (ii) control techniques, and (iii) simulations of control experiments (modelling is also key, to understand the control). This exchange of personnel will allow better definition of common experiments on control techniques and methods for > 2005. This in preparation for a more co-ordinated and unified real-time control of ITER advanced scenarios.

Remark: Longer term a more integrated control for burning plasmas will be encouraged, including pressure profile, plasma fuelling, pedestal, MHD and simulated burn control. This will strengthen the interaction with other ITPA groups.

SSO-4 Documentation of the edge pedestal in advanced scenarios

Topic Group: Steady State Operation and Pedestal

Status: New collaboration (experiments).

Background: The pedestal of advanced scenarios is not properly documented.

Contact persons: **G. Sips, R. Sartori, M. Wade, Kamada**

Experiments: **AUG, JET , DIII-D, JT-60U**

Outline and aims: The aims for these collaboration experiments are, using mainly an exchange of personnel: (i) Dedicated and detailed measurements of edge profiles in advanced scenarios in various machines, (ii) compare reversed shear, hybrid and conventional scenarios between machines, and (iii) Type I ELM mitigation demonstration in advanced scenarios with a survey of small ELM regimes. JET will have a high resolution TS system for improved pedestal measurements. This should allow common analysis techniques to be applied.

Remark: These experiments should be combined with, or even preceded by the following specific actions:

Pedestal scalar databases should include advanced scenarios. The SSO group to select pulses for inclusion. Pedestal group to define scalar parameters to be stored. Survey of the new initial data and comparison with standard scenarios.

REPORT

FROM THE INTERNATIONAL TOKAMAK PHYSICS ACTIVITY (ITPA)

TO THE IEA IMPLEMENTING AGREEMENTS COORDINATING COMMITTEES

FOR JOINT EXPERIMENTS BETWEEN VARIOUS TOKAMAKS

FROM 2004

Report submitted by Ronald Stambaugh representing the ITPA Coordinating Committee

At the Third IEA Large Tokamak Workshop (W58) on
“Implementation of the ITPA Coordinated Research Recommendations”
Joint Workshop of Large Tokamak, Poloidal Divertor and TEXTOR IA’s
8-10 December 2004, Eynsham Hall, Near Oxford, UK

Proposals submitted by the ITPA Topical Group Chairs, representing their various Groups.

Confinement Database and Modelling	W. Houlberg
Transport Physics	E. Doyle
Pedestal and Edge Physics	Y. Kamada
Scrape-off Layer and Divertor Physics	N. Asakura
MHD, Disruption, and Magnetic Control	T. Hender
Steady-State Operation	G. Sips

Confinement and Database ITPA-IEA Joint experimental reports for 2004

The following experiments are reported:

CDB-2	**β confinement scaling in ELMy H-modes: β degradation**
CDB-3	**Improving the condition of Global ELMy H-mode and pedestal Databases, in particular with H data**
CDB-4	**Confinement scaling in ELMy H-modes: ν^* scans at fixed n/n_G**
CDB-5	**Inside and vertical pellet launch: ELM behaviour**
CDB-6	**Improving the condition of Global DBs: Low A**
CDB-7	**Ohmic identity experiments: test of scaling with dimensionless parameters**

CDB-2	**β confinement scaling in ELMy H-modes: β degradation**
TG: Conf DB and Mod.	Spokesperson: C.C. Petty

Device	**Period**	**Local Key Person**
AUG		F.Ryter
JET	Nov 04	D. C. McDonald
JT-60U	Oct 04	T.Takizuka

Description of Experiment

Resolve difference between β scaling of global confinement databases and machine parameter scans

Results

AUG: The present AUG database reveals that β_N could be varied by a factor of about 2 for constant values of ρ* and ν* in the respective ranges $3\ 10^{-4} \le \rho^* \le 5\ 10^{-4}$ and $0.005 \le \nu^* \le 0.06$. This does not include dedicated discharges yet. Values for ρ* and ν* common to all participating devices should be identified for the planning of dedicated AUG discharges to be performed in 2005 if necessary. JET: Following 2003 experiments, a proposal to extend the study to β_N>2.5 has been made JT-60U: Experiments were performed Oct. 2004. Beta values were varied for Bt=2.1~2.5T (q~4) under constant rho* and nu*. Preliminary analysis shows the beta degradation; B tauE ~ 1/beta^(0.5-0.7). This degradation is a little weaker than that of IPB98(y,2) scaling, but remarkably stronger than that obtained from DIII-D and JET experiments. Analysis of the existing JT-60U experimental data (Bt~2T and Bt=2.5T) were also attempted. Both results of the previous and the present agree well with each other.

Executive Summary

Preliminary analysis of JT-60U experiments shows beta degradation. This degradation is a little weaker than that of IPB98(y,2) scaling, but remarkably stronger than that obtained from DIII-D and JET experiments.

CDB-3	**Improving the condition of Global ELMy H-mode and pedestal Databases, in particular with H data**
TG: Conf DB & Mod.	Spokesperson: K.Thomsen

Device	Period	Local Key Person
AUG	July 04	F.Ryter
JET	04	D C McDonald
JT-60U	Oct-Nov 04	T.Takizuka

Description of Experiment

Though there is some H data in the Global H-mode DB (AUG 4%, DIII-D 5%, JET 4%, C-Mod 0%, JT60U 0%) there is no H data in the pedestal DB.
Request one full hydrogen ELMy H-mode programme on each device, with particular emphasis to be placed on pedestal measurements.

Results

AUG: About 30 discharges in hydrogen were made in July 2004. They cover the ranges I_p=0.8 or 1.0MA for $1.4<B_T<2.7$ at different heating powers. Among them a few having good pedestal data could be selected and contributed to the databases for global confinement and pedestal.
JT-60U: Isotope effect on the pedestal structure is studied comparing D experiment in Oct and H experiment in Nov in 2004. The experiments for D discharges were performed with Bt=2.3T and Ip=0.9~1.5MA. PNB and ne values are varied. Also the experiments in Hydrogen H-mode have now been performed. The analysis of experimental results has just started.
JET: Hydrogen experiments have been performed in 2004 and pedestal data will be added in 2005

Executive Summary

The requested experiments on AUG, JET and JT-60U have now been done. The AUG results have been published and the data can be released to the ITPA databases. JT-60U have just started the analysis of the experimental results so these data cannot yet be released. JET will be able to release the data in 2005.

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

Device	**Period**	**Local Key Person**
AUG		J.Stober
JET		D C McDonald

Description of Experiment

Determine whether ν^* or n/n_G is the appropriate dimensionless parameter for global scaling

Results

AUG: no specific analysis done so far. The goal is not clear: what to compare if v* is varied? Is B*tau still the right quantity if Kadomtsev constraints are violated? How much variation of nu* is required? Difficulty: nu* and n/nGW are strongly correlated especially at constant beta. Discussion needed. JET: experiments were carried out in collaboration with Alcator C-Mod in 2004, but a good match was not achieved

Executive Summary

CDB-5	Inside and vertical pellet launch: ELM behaviour
TG: Conf DB & Mod.	Spokesperson: G. Saibene

Device	Period	Local Key Person
AUG		P.Lang
DIII-D	Summer 04	L.Baylor, C.Lasnier, M.Fenstermacher
JET		P.Lang
JT-60U		H.Takenaga

Description of Experiment

Test the effect of pellets on ELMs to see if the $\Delta W/W_{ped}$ vs collisionality scaling is similar on the different machines (see Polevoi NF 2003)

Results

AUG: Detailed investigations on ELM frequency controlling and mitigation. Application of the external trigger to probe ELM physics.
DIII-D: Small 1.8mm pellets were injected from the inner wall into ELMing H-mode plasmas to characterize the ELM behavior and divertor response to pellet induced ELMs. A few cases were obtained with fast diagnostic coverage of the pellet/ELM events. In general the ELMs induced by the pellets have smaller divertor Halpha bursts than the non-induced residual ELMs. The IR camera divertor heat flux diagnostic shows a lower heat flux to the divertor from the pellet induced ELMs. In addition some limited vertical injected pellets (from V+3 outside the magnetic axis) were attempted and shown to also induce ELMs leading to a future proposal to try very high repetition rate vertical injection to ameliorate high individual ELM heat flux to the divertor.
JT-60U: Data exist, new data can be accumulated in high density experiments in Aug. - Oct. FY2004. We have been waiting the action plan from a group responsible person of this
subject.

Executive Summary

DIII-D results of vertical launch confirm the AUG observation that vertical or inside launch can control ELMs. The ELMs induced by inner wall pellets have smaller divertor Halpha bursts and lower divertor heat flux than the non-induced residual ELMs on DIII-D.

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

Device	Period	Local Key Person
NSTX	2004	S. Kaye
MAST	2004	M. Valovic

Description of Experiment

Scaling of τ_E and pedestal characteristics are uncertain due to narrow range of A - global ELMy confinement and pedestal data at low A is needed

Results

Both NSTX and MAST have performed confinement scaling experiments in order to establish confinement scalings at low aspect ratio and to contribute data to the ITPA database for synthesis with data from conventional aspect ratio. To date, the number of contributions to the database from each machine has been relatively small; however significant amounts of data from one or both devices will be contributed over the next several months, once the data goes through its final validation. The data that have been contributed 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%). Experiments on NSTX consisted of systematic scans of plasma current (0.6 to 1.2 MA) and neutral beam power (up to 7 MW), showing confinement trends similar to those at conventional aspect ratio. The enhancement factors of the global confinement could reach to 3, while those for the thermal confinement times achieved values up to 1.4. The NSTX data exhibited a toroidal field dependence not seen at conventional aspect ratio, with indications that magnetic fluctuations could be influencing transport and confinement. These sets of data will be contributed to the ITPA database soon. MAST data has already been contributed to pedestal and global confinement databases. In pedestal database MAST data determine the pedestal energy scaling to Wped~$A^{2.13}$. The global confinement data exhibit thermal confinement enhancement values up to ~1.2. 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 data show a correlation between confinement enhancement and reduction of collisionality.

Executive Summary

Data from MAST (M. Valovic) and NSTX (S. Kaye) have been contributed to the ITPA database in 2004 and have extended the range of inverse aspect ratio contained in the database by a factor of 2.2 and the beta range by a factor of 5.

CDB-7	**Ohmic identity experiments: test of scaling with dimensionless parameters**
TG: Conf DB & Mod.	Spokesperson: J.G.Cordey

Device	Period	Local Key Person
AUG		F.Ryter
JET		G.Cordey

Description of Experiment

Does the principle of characterizing confinement in terms of dimensionless parameters work under Ohmic conditions?

Results

AUG: The discharges with circular cross-section required for the first iteration with JET, FTU and Tore Supra have been carried out in AUG in January 2004. All requirements on the control parameters were fulfilled (aspect ratio, plasma current, magnetic field, safety factor, density) as well as plasma shape. Accurate matching of the dimensionless parameters with the other tokamaks can therefore be started as soon as required.

JET: This proposal was placed in the JET programme for 2003/2004 and effort was expended in discharge design. Unfortunately machine time was not made available to complete the experiments due to pressure of other experimental programmes. It seems very unlikely that time will be made available in the 2005 JET campaign, hence regretfully we have decided to abandon this project

Executive Summary

Unfortunately machine time was not made available to complete the JET experiments due to pressure of other experimental programmes, and this project will be abandoned.

Transport Physics ITPA-IEA Joint experimental reports for 2004

The following experiments are reported:

TP-1	**Steady state plasma development**
TP-2	**Hybrid regime development**
	TP proposals in the above two areas were integrated with the corresponding SSO proposals, see SSO progress report for details.
TP-3	**Assess performance with Te~Ti operation and/or dominant electron heating**
TP-3.1 and 3.3	**Obtain and sustain high performance operation with T_e~T_i, including in hybrid/AT discharges**
TP-3.2	**Physics investigation of transport mechanisms with T_e~T_i at high density**
TP-4	**Investigation of high performance operation with low external momentum input**
TP-4.1	**Similarity experiments with off-axis ICRF-generated density peaking**
TP-4.2/4.4	**High performance operation with low momentum input in hybrid and AT plasmas**
TP-4.3	**Electron ITB similarity experiments with low momentum input**
TP-5/PEP-14	**QH/QDB plasma studies**
TP-8	**ITB similarity experiments**

TP-3 Assess performance with Te~Ti operation and/or dominant electron heating

TP-3.1 and 3.3 Obtain and sustain high performance operation with T_e~T_i, including in hybrid/AT discharges

Topic Group: Transport physics

Contact persons: J. Hobirk (AUG), C. Greenfield (DIII-D), C. Challis (JET), S. Ide (JT-60U)

Devices: AUG, DIII-D, JET, JT-60U

Purpose and Goal:
This experiment seeks to demonstrate that sustained high performance (better than conventional ELMy H-mode) operation is possible with T_e~T_i.

Results:
AUG: Operation at high density (0.8-0.9 of n_{GW}) in hybrid regime plasmas resulted in discharges with Te~Ti with no degradation in fusion performance (i.e. in "G"). Experiments with high power ICRH and ECCD at β_N~2.5-3.0 and P_{RF}>P_{NBI} are ongoing.
DIII-D: Similar hybrid results to AUG, though obtained via a systematic density scan. High density operation (up to 0.7 n_{GW}) resulted in Ti/Te~1.4. No degradation in overall fusion performance factor, G, with Ti/Te ratio (or density) was observed, though beta and H factor did change in opposite directions. Planned experiments with additional RF electron heating in AT and hybrid discharges were not performed.
JT-60U: More intense electron heating was attempted using N-NB and ECH. However, no conclusive results were obtained – work will be continued in 2005.
JET: Hybrid plasmas with ICRH heating resulted in Ti/Te~1.4 at somewhat lower fusion performance than NBI dominated hybrid discharges. See also TP-4.2 and 4.3 and SSO-1.5. JET also has ITB plasmas with Te~Ti, obtained transiently with pellet fuelling.

Summary:
Very encouraging results obtained with density scans in hybrid discharges, showing that fusion performance can be maintained at high density and low Ti/Te ratio. Need more work on obtaining low Ti/Te ratio with direct electron heating in hybrid and AT discharges.

TP-3.2 Physics investigation of transport mechanisms with $T_e \sim T_i$ at high density

Topic Group: Transport physics

Contact persons: N. Kirneva (T-10), M. de Baar (TEXTOR)

Devices: TEXTOR, T-10

Purpose and goals:

This experiment seeks to document transport and turbulence characteristics in plasmas with reactor relevant conditions, e.g. $T_e \sim T_i$ and $n_e \sim n_{GW}$, and also to examine confinement saturation and compare to scaling laws and transport models.

Results:

The initial T-10/TEXTOR collaboration is addressing L-mode regimes. In 2004, T-10 has studied density profile peaking observed with a density increase accompanying ECH, i.e. density peaking at high density. This effect is being studied with the aid of turbulence diagnostics. On TEXTOR, new advanced turbulence diagnostics are being commissioned for similar studies.

Summary:

This is an ongoing multi-year collaboration.

TP-4 Investigation of high performance operation with low external momentum input

TP-4.1 Similarity experiments with off-axis ICRF-generated density peaking

Contact persons: J. Rice (CMOD), J. Stober (AUG)

Devices: CMOD, AUG

Topic Group: Transport physics

Purpose and goals:
This collaboration is designed to address two questions: (a) Is the density peaking regime observed with off-axis ICRF on CMOD a true ITB?, and (b) is the physics of this regime consistent between devices, specifically AUG and CMOD? Initial similarity experiments in 2003 demonstrated that AUG could reproduce the CMOD density peaking/ITB regime with off-axis ICRF heating.

Results:
No progress since 2003, when AUG reproduced CMOD regime with very limited no. of discharges.

Summary:
Further progress depends on whether AUG is prepared to give this topic experimental run time.

TP-4.2/4.4 High performance operation with low momentum input in hybrid and AT plasmas

Topic Group: Transport physics

Contact persons: G. Sips/J. Stober (AUG), H. Takenaga (JT-60U), M. Wade (DIII-D), F. Crisanti (JET), O. Sauter (TCV)

Devices: JT-60U, JET, DIII-D, AUG, TCV

Purpose and Goals:
Demonstrate that high performance operation is possible with low momentum input

Results:
JET: RF dominated plasmas generated hybrid plasmas, with G~0.2. (See also TP-3.1, 4.3 and SSO-1.5).
AUG: Hybrid experiments with approx. 50:50% ICRF and NBI power were performed in the context of central impurity density control. RF dominated plasmas are contemplated for future continuation.
JT-60U: Experiments with least NB input have been pursued in the context of low central fuelling, but have not reached conclusion – will be pursued further in 2005.
DIII-D: Contemplated hybrid experiments using RF/ECH to replace NBI were not performed.
TCV: Interesting fully non-inductive ITB discharges with f_{BS}>70% are obtained in steady-state (>5 current redistribution times), using ECCD with no momentum input. (Result not obtained as part of collaboration).

Summary:
This reactor critical aspect of high performance operation needs further work, but progress is being made.

TP-4.3 Electron ITB similarity experiments with low momentum input

Topic Group: Transport physics

Contact persons: **F. Crisanti (JET), C. Gormezano (FTU), A. Becoulet (TS) T. Donne (TEXTOR), K. Razumova (T-10)**

Devices: **JET/FTU/TS, T-10/TEXTOR**

Purpose and goals:
This collaboration seeks to determine the similarity of electron ITB formation conditions and physics when operating with low momentum input.

Results:
JET/FTU/TS: The JET similarity experiment to previous FTU and TS results using ICRF at high density proved highly successful. The resulting JET discharges have been categorized as being "hybrid regime" relevant and as such have also been reported in SSO-1.5, while the low Ti/Te ratio and low momentum input in these discharges have also made them relevant to TP-3.1 and TP-4.2.
T-10/TEXTOR: Work continues on the T-10/TEXTOR similarity experiment on the electron ITB observed in the ECH switch-off regime. ECH switch-off experiments on TEXTOR have shown similar behavior to that previously observed on T-10, and a paper on the joint experiments has been published, presenting detailed fluctuation measurements and physics interpretation (K. A. Razumova et al, Nuc. Fusion, 44, 1067, 2004).

Summary:
The JET/FTU/TS collaboration was highly successful, leading to a new RF dominated hybrid regime on JET, while the T-10/TEXTOR collaboration has made progress with detailed physics studies and interpretation of the ECH switch-off regime.

TP-5/PEP-14 QH/QDB plasma studies

Topic Group: Transport Physics and Pedestal TGs

Contact persons: **P. Gohil/L. Lao (DIII-D), N. Oyama/Y. Sakamoto (JT-60U), W. Suttrop (AUG, JET)**

Devices: **DIII-D (June, July 2004), JT-60U (December 2003, September 2004)**

Purpose and Goals:
This collaboration is aimed at determining the operational boundaries and unique physics of QH/QDB operation. Of particular interest to the TP group are confinement and transport properties, as well as the role of the radial electric field and plasma rotation in obtaining and maintaining QH-mode operation

Results:
JT-60U: Several important results were obtained in experiments performed with DIII-D participation. (1) QH-mode operation was observed with both balanced- and co-NBI. This substantially expands the operating regime for QH-mode operation – the observation of QH-mode operation with co-NBI is a significant breakthrough. (2) JT-60U measurements indicate that edge rotation may be playing a critical role in QH-mode formation; edge rotation is in counter direction even with co-NBI, because of ripple loss.
DIII-D: (1) Detailed edge measurements and stability calculations indicate that QH-mode plasmas are marginally stable to coupled peeling/ballooning modes. (2) QH/QDB operating space was significantly expanded to higher density (factor of more than two) by using higher elongation plasmas. (3) q(0) was controlled in QDB plasmas using ECCD and NBCD.
AUG: Continuing work, but has not been done jointly.

Summary:
Significant progress in understanding the formation of QH-mode plasmas (rotation measurements with co-/counter-/balanced-NBI on JT-60U, and stability calculations on DIII-D), as well as in expanding operating space (co-NBI QH-mode obtained on JT-60U, higher density operation on DIII-D). Obtaining these results was facilitated by coordinated experiments and personnel exchanges which made efficient use of unique capabilities such as balanced-/co-/counter-NBI on JT-60U and detailed profile measurements on DIII-D.

TP-8 ITB similarity experiments

Topic Group: Transport Physics

Contact persons: **C. Challis/E. Jofrin (JET), G. Sips (AUG), C. Petty (DIII-D), E. Synakowski/M. Peng (NSTX), A. Field (MAST)**

Devices: **JET (Dec 2003, Jan 2004) /AUG (July 2002), DIII-D/NSTX, NSTX (July 2004)/MAST**

Purpose and Goals:

Similarity experiments provide a powerful tool with which to check physics consistency across devices. This collaboration seeks to apply this approach to ITB plasmas for the first time, with similarity experiments proposed between AUG/JET, DIII-D/NSTX and NSTX/MAST.

Results:

JET/AUG: Here the objective was to compare the dynamics of the same type of ITB on JET and AUG. The goal was for JET to match a standard AUG hot-ion ITB, with NBI heating in current ramp, generating low magnetic shear and q>1, while matching plasma parameters as much as possible (shape, q-profile, rho*, nu*, beta, normalized heating/fueling/torque…). The experiment was successful, with JET replicating the dynamics and main features of the AUG ITB plasmas, i.e. both devices generated ion ITB at 7-10 MW, without an electron ITB, and the ITBs in both machines were transient, collapsing coincident with the onset of large ELMs. Differences were also observed, (e.g. on Te/TI ratio), calling for further analysis.

NSTX/DIII-D: Here, the NSTX target plasma is in hand, but the DIII-D replication attempt has been delayed from 2004 to 2005. The focus of this experiment has also changed somewhat, from being an ITB comparison, to being a test of aspect ratio scaling in H-mode. Because of this change in emphasis, this collaboration is split out as a separate proposal for 2005 (TP-9 H-mode aspect ratio comparison). The focus will be on matching poloidal quantities (e.g. poloidal beta, poloidal ion gyroradius), plasma shape parameters, collisionality, and other dimensionless parameters. An ensemble of applied torques and densities will be used on DIII-D to ensure a good match in the end. The NSTX and DIII-D plasmas will have different toroidal ion gyroradii, however.

MAST/NSTX: Here the goal was to investigate role of NBI-driven toroidal rotation and associated $E{\times}B$ flow shear on ion ITB formation and evolution in sustained H-mode identity discharges on MAST and NSTX devices by scanning the applied NBI power and torque. The NSTX part of joint experiment was executed in part in July 2004 with a scan of injected NBI power (2.4, 3.6, 4.8 MW) with 1–3 sources at energies of 60–100 keV in order to vary the NBI torque by a factor ~ 4 (0.6–2.2 Nm). Target H-mode plasmas of 800 kA plasma current with 0.3 T toroidal field in an LSN 'MAST-identity' magnetic configuration. An ion ITB with neoclassical ion transport levels was successfully formed. It is planned to complete the NSTX experiments in 2005 (discharges at 0.45 T) and also to execute the counterpart identity experiments on MAST in 2005.

Summary:

Similarity/identity experiments have been applied to ITB plasmas for the first time, with a successful replication of the dynamics of AUG ITB plasma on JET. This approach is also being applied to NSTX/DIII-D and NSXT/MAST comparisons.

Pedestal and Edge Physics ITPA-IEA Joint experimental reports for 2004

The following experiments are reported:

PEP-1 and -3	**Dimensionless identity experiments in JET and JT-60U:**
PEP-2	**JET/DIII-D Pedestal Comparison**
PEP-6	**Edge transport barrier formation and confinement in exact double null configurations**
PEP-7	**Dimensionless identity experiments on Alcator C-Mod and JET**
PEP-9	**NSTX/MAST/DIII-D Pedestal Similarity**
PEP-10	**The impact of the first wall on ELMs**
PEP-12	**Comparison between C-mod EDA and JFT-2M HRS regimes.**
PEP-13	**Comparison of Small ELM Regimes in JT-60U and AUG**
PEP-14	**QH/QDB Comparison in JT-60U and DIII-*D***

PEP 1 + PEP 3: dimensionless identity experiments in JET and JT-60U

Topic Group: Edge and Pedestal Physics Topical Group
Contact persons**:** G Saibene, V Parail and J Lonnroth (EFDA JET) and N Oyama – T Hatae (JAERI)
Devices: JT-60U and JET
Time periods: JET experiments carried out in April, September (T Hatae in JET) and December 2003 as well as in February 2004, for a total number of useful discharges ~ 45. JT-60U experiments took place in January (G Saibene in JT-60U) and September 2004 (G Saibene, A Loarte and J Lonnroth in JT-60U), for a total number of useful discharges ~ 32.
Experiment's Purpose and Goals: obtain dimensionless identical plasmas in JT-60U and JET in the ELMy H-mode regime. Compare pedestal parameters and profiles (including width and gradient scaling), as well as ELM characteristics (Type, size, etc.). Given the very similar size of the two devices, a dimensionless match is obtained in plasmas with very similar dimensional parameters. Verification of the completeness of the dimensionless description is therefore possible.
Results**:** Power and density scans were carried out in ELMy H-modes at two values of I_p, providing a q scan (q_{95}=3.1 and 5.1) with fixed (and matched) field. Contrary to expectations, a dimensionless match between the two devices was quite difficult to achieve. p_{ped} in JT-60U is lower than in JET and, at low q, the pedestal pressure of JT-60U with a Type I ELM edge is matched in JET only in the Type III ELM regime. At q_{95}=5.1, a dimensionless match in ρ^*, ν^* and $\beta_{p,ped}$ is obtained with Type I ELMs, but only with low-power JET H-modes. These results motivated a closer investigation of experimental conditions in the two devices, to identify possible "hidden" physics that prevents obtaining a good match of pedestal values over a large range of plasmas parameters. Ripple-induced fast ion losses of the large bore plasma used in JT-60U for the similarity experiments are identified as the main difference with JET. The magnitude of the JT-60U ripple losses is sufficient to induce counter-toroidal rotation even in co-NB heated plasma. The influence of ripple losses was demonstrated at q_{95}=5.1: reducing ripple losses by ~2 (from 4.2 to 1.9 MW) by replacing Positive with Negative Neutral Beam Injection at ~ constant P_{in}, increased p_{ped} in JT-60U, providing a good match to full power JET H-modes. At the same time, the counter-toroidal rotation decreased. Physics mechanisms relating ripple losses to pedestal performance are not yet identified, and the possible role of velocity shear in the pedestal MHD stability, as well as the possible influence of ripple on thermal ion transport are now being investigated via MHD and transport modelling.
Executive Summary: G Saibene, V Parail, J Lonnroth (EFDA JET) N Oyama – T Hatae (JAERI), experiments in 2003 and 2004 (JET and JT-60U). The difficulty achieving pedestal identity in the two devices probably due to ripple/rotation effects on pedestal stability and/or transport.

PEP 2: JET/DIII-D Pedestal Comparison

Topic Group: Edge and Pedestal Physics Topical Group
Contact persons**:** T. Osborne, M. Fenstermacher R. Groebner, A. Leonard (DIII-D) and A. Loarte, G. Saibene, M. Kempenaars, A. Kallenbach (JET)
Devices: DIII-D and JET
Time periods: Experiments carried out through 2002, 2003, and 2004
Experiment's Purpose and Goals: Obtain comparison of the pedestal characteristics in JET and DIII-D. In dimensionless similar pedestals systematically vary the ratio of rho-star between JET and DIII-D from unity to as large a value as possible. Optimize discharge shape for diagnostic analysis of two topics; pedestal density consistency with neutral penetration and pedestal transport barrier width dependence on rho-star.
Results**:** Data from similarity experiments between DIII-D and JET suggested that neutral penetration physics dominates in setting the relationship between the width, Δ_n, and height n_e^{ped} of the density pedestal. Density profiles from low-density discharges in the two devices overlay using the scaling for fixed β, ρ*, ν*, and q. Although the top of the n_e pedestal in JET could not be determined precisely, the top of the n_e pedestal in DIII-D was clearly further outboard than in JET. Simulation of these profiles using a neutral penetration model reproduced the shape of the profiles including this difference in the radial location of the top of the pedestal. The model predicts that the width of the density pedestal should scale as the inverse of the density at the top of the pedestal, $\Delta_{ne} \sim 1/n_e^{ped}$. This was observed in higher density similarity plasmas in both DIII-D and JET. For both of the density cases, the top of the temperature pedestal was inboard of the density pedestal in DIII-D. The n_e and T_e profiles were nearly aligned in JET for the low-density conditions but the top of the n_e pedestal was outboard of the T_e pedestal at high density. These variations in the radial location between the n_e and T_e barriers suggest that physics other than neutral penetration dominates in setting the T_e barrier. Plasma physics that scales with dimensionless parameters appears to dominate in setting the temperature pedestal width (transport barrier), Δ_T. Some theories suggest that neutral penetration also sets the temperature pedestal width. However, in these pedestal similarity experiments, Δ_T normalized to the minor radius, a, was the same in both machines, suggesting that plasma physics, not neutral penetration controls the transport barrier width. Also consistent with this interpretation was that $\Delta_T \sim a$ was independent of density. No obvious variation of Δ_T/a with $\rho*$ was seen for fixed (β, ν^*, q) at the top of the pedestal during scans of B_T in DIII-D and JET. A factor of 2 variation of $\rho*$ was obtained in DIII-D and a somewhat smaller variation was obtained in JET. No clear dependence on $\rho*$ in the normalized pedestal width, time-averaged over the ELM cycle was observed.
Executive Summary: T. Osborne, M. Fenstermacher (DIII-D) and A. Loarte G. Saibene, A. Kallenbach (JET). Period 2002-2004. Discharges with identical pedestals in dimensional variables have pedestal temperature gradients which scale with machine size (i.e. determined by plasma transport). Density pedestals do not scale this way and are more consistent with being determined by neutral ionisation.

PEP06: Edge transport barrier formation and confinement in exact double null configurations (MAST and AUG)

Topical Group: Pedestal & Edge
Contacts: H Meyer, L. Horton
Tokamaks: MAST, AUG
Time periods: Jul 2004 (AUG), Jul 2003- Mar 2004 (MAST)
Experiment:

Purpose and Goals:

Confirm the easier H-mode access in exact DN seen on MAST on AUG and investigate changes in L-mode leading to the change in L/H threshold. Investigate changes in confinement between SN and DN.

Description:

The vertical position of a discharge in AUG with similar shape, plasma current and line-averaged density as on MAST was changed from lower SN via exact DN to upper SN (-15 mm < ΔR_{sep}< 15 mm). The ICRH power was held constant just below the L/H threshold power in lower SN (ion ∇B-drift towards the X-point.) in order to see the L/H transition in DN. The power was than lowered to avoid the L/H transition in order to investigate changes to the edge profiles in L-mode due to the magnetic configuration. The L/H power threshold in AUG was measured in SN and DN using heating ramps with ICRH and NBI.

Results:

At constant heating power just below the L/H threshold power in lower SN a short period of H-mode close to exact DN was observed on AUG. This confirms the easier H-mode access in DN seen in the spherical tokamak MAST in a conventional tokamak. The reduction of the L/H power threshold in exact DN (P_{thr}= 1.0 MW, ΔR_{sep}≈0) compared to lower SN (P_{thr}=1.2 MW, ΔR_{sep}≈-15 mm) was measured to be about 20%. Hence, the effect on the power threshold is much more pronounced on MAST (~50% reduction) than on AUG.
In L-mode, none of measured edge profiles (n_e, T_e, T_i) apart from the radial electric field, E_r changed during the ΔR_{sep} scan. The minimum E_r (ψ_N=0.92) in DN is 1 kV/m more negative than in lower SN. This change is of similar magnitude to the change seen on MAST but further inward from the last closed flux surface. In upper SN a strong change of the E_r shear was observed with a positive field at ψ_N=0.92. The change of min E_r seems to be gradual with $\Delta R_{sep.}$ The improved H-mode access in AUG was found between -2 mm < ΔR_{sep}< 0.2 mm on AUG and -3 mm < ΔR_{sep}< 3 mm on MAST. The balance of the equilibrium was confirmed by measurements related to the SOL heat flux to all 4 target plates (thermoelectric currents on AUG, Langmuir probes on MAST).

Executive Summary:

The improved H-mode access in exactly balanced double null seen on MAST was confirmed on AUG. The effect on the L/H power threshold is more pronounced in tight aspect ratio than in conventional aspect ratio.

PEP-7: Dimensionless identity experiments on Alcator C-Mod and JET

(Pedestal & Edge TG)

D A Mossessian – Alcator C-Mod & G P Maddison* – JET (*Euratom/UKAEA Fusion Association)

Experiments: on JET initiated Oct. 2002, followed up in March 2003, related studies in Jan. 2004.

Goals: (*i*) Reproduce non-dimensionally identical pedestal plasma conditions in matching configurations between Alcator C-Mod and JET, firstly to seek recovery of EDA H-mode in a larger tokamak. (*ii*) Secondly compare normalized pedestal properties and so contribute more generally to identification of processes and scalings governing their heights & widths (both n_e, T_e).

Principal results: Well-matched equilibria (ε , κ , δ , q_{95}) between C-Mod and JET were obtained, but for the requisite scaled conditions in JET ($B_t \approx 0.9$ T, $I_p \approx 0.65$ MA) edge diagnostics were unable to resolve profiles with sufficient certainty to confirm local dimensionless variables ρ_*^{ped}, ν_{*e}^{ped}, β^{ped} were accurately reproduced. No clear EDA H-modes emerged on JET, although unusual ELM-free intervals with initially rising recycling and very steady pedestal density occurred. These could last for several τ_E but tended to end in short ELM bursts, owing to increasing density peaking and plasma radiation. A pronounced sensitivity to fine details of magnetic shaping and to heating scheme was also found; the latter may account for large differences still between C-Mod and JET core profiles sometimes, even when pedestals were estimated to be identical. Magnetic and density fluctuations in the edge of JET ELM-free, steady n_e^{ped} phases varied in strength and bandwidth, sometimes displaying just one or two coherent frequencies between 10 - 30 kHz, with toroidal periodicities n ≈ 2 - 4 and rotation in the electron diamagnetic drift direction. It remains unclear whether these might yet be related to washboard modes typically seen between ELMs in JET.

Substantial scatter in the estimated pedestal heights and widths on C-Mod (and DIII-D) reflects real variations in the edge profiles; hence exact matches between different machines cannot be expected. Within the significant error bars of JET measurements, however, reasonable agreement on scaled pedestal gradients $|\partial n_e / \partial\psi|$, $|\partial T_e / \partial\psi|$ for corresponding heights n_e^{ped}, T_e^{ped} suggests that matching dimensionless variables locally within the pedestal (eg at its top) does tend to yield similar profiles over the whole region. This, plus indications that widths Δ_n , Δ_T increase with heights n_e^{ped}, T_e^{ped}, contrasts with the edge-source-dominated interpretation of Δ_n observed on DIII-D and MAST. Preliminary 1-D modelling of recycling-source profiles on C-Mod and JET implies kinetic effects cause neutral-particle penetration into the pedestal to scale almost linearly with machine size a , thence yielding source functions always narrower than Δ_n ; in non-dimensionally identical cases, normalized widths Δ_n / a , Δ_T / a consequently can remain the same.

Closely related experiments examining global dimensionless identity between C-Mod and JET (J G Cordey, D C McDonald) crucially pointed towards more favourable scaling of confinement with collisionality than hitherto embodied in the IPB98(y,2) scaling.

Executive summary: D A Mossessian & G P Maddison, JET experiments 10/02, 03/03, 01/04. Reasonable agreement on pedestal gradients for corresponding heights indicates that non-dimensionally identical edge profiles match, supporting their control by plasma

processes. Substantiated by 1-D modelling of recycling sources. No EDA H-modes in JET, although some coherent fluctuations seen in ELM-free phases with steady pedestal density.

PEP 9: NSTX/MAST/DIII-D Pedestal Similarity

Topic Group: Edge and Pedestal Physics Topical Group
Contact persons**:** A. Kirk (MAST), R. Maingi (NSTX) T. Osborne (DIII-D)
Devices: NSTX, MAST and DIII-D
Time periods: The experiment was proposed for 2004, but they have not yet been executed.
Experiment's Purpose and Goals: The goal is to compare pedestal parameters (focus on β and T_e width) at same ν*and ρ* , matched at the top of the outboard midplane pedestal for two values of ν*. Shape parameters such as k and d will be matched in a common double-null shape.
Results**:** The experiments have not yet been carried out.

PEP-10: The impact of the first wall on ELMs (MAST & AUG)

Topical Group: ITPA Pedestal TG
Contact Person: Andrew Kirk
Devices: ASDEX Upgrade, MAST
Time period of data taking: December 2003-February 2004

Goals:

Search for the presence of long range effects at the LFS during ELMs in ASDEX-Upgrade, determining a velocity of radial expansion for any features observed. Compare this with similar measurements in MAST, to determine if the velocity and radial extent are related to the position of the wall or the magnetic field.

Results:

Measurements of the radial extent and spatial structure of type-I ELMs in ASDEX Upgrade and MAST have been measured. On MAST the radial extent of the ELM efflux is ~25 cm, no q_{95}dependence of the radial extent has been observed. The radial extent on ASDEX Upgrade has been measured at two different toroidal magnetic fields (2 and 3 T) and 4 different separations between the plasma edge and wall. The ELM efflux extends up to 10 cm from the plasma edge and there are indications that this extent is dependent on the toroidal magnetic field (the smaller the field the larger the extent). This maywould explain why on MAST, which has a much lower toroidal magnetic field at the outboard side (~ 0.25 T), the radial extent is larger.

Executive summary:

The effect of magnetic field and the first wall on the radial extent of ELMs has been studied. The radial extent seems to be largest at smaller magnetic field.

PEP-12: Report on inter-machine experiment 2004

1. **PEP12: Comparison between C-Mod EDA and JFT-2M HRS regimes**
2. **Pedestal ITPA Group**
3. **Contact Persons:** K. Kamiya, N. Oyama, (JAERI) and A. E. Hubbard (MIT)
4. **Contributing devices:** JFT-2M, C-Mod
5. **Dates of experiments:**
   28-Jan.-2004, 06-Apr.-2004 (C-Mod) / 24-Feb.–2004, 18-Mar.-2004 (JFT-2M)
6. **Experiment's purpose and goals**

It is now recognized that H-mode regimes with small, or no, ELMs offer a major advantage over the Type I ELM regime in terms of divertor erosion, as well as compatibility with advanced operation regimes. Such a regime on C-Mod is the Enhanced D_α, (EDA) regime characterized by increased particle transport due to a high m and n quasicoherent mode [Greenwald *et al*, Phys. Plasmas 1999]. At high powers, this evolves into an H-mode with small ELMs. A steady, quiescent regime has been attained on JFT-2M which has been named the High Recycling Steady (HRS) H-mode [Kamiya *et al*, IAEA 2002; NF2003]. It has attractive global characteristics and is quite similar to the EDA. It is of interest to compare the EDA and HRS regimes more systematically in terms of access conditions, fluctuation characteristics and global properties, to see if they are the same physical regime. Comparing devices of different sizes and plasma parameters should help to clarify the important dimensionless parameters and prospects for extrapolation to burning plasma experiments.

7. **Main results of the experiments and analysis**

In order to establish a better understanding of the relation between the EDA and HRS regimes, a systematic comparison between C-Mod and JFT2M at matched plasma shape is well underway. On JFT-2M, the access conditions for the HRS regime in terms of the pedestal parameters were investigated by scanning both density and I_P/B_T (i.e. q_{95}). In this study, it was found that the ELMy/HRS operational boundary occurred near at the normalized electron collisionality of ν_e^*~1 in the plasma edge region. It also depended slightly on q_{95}. Results were published in PPCF 2004 [Kamiya, et al.]. On C-Mod, a range of plasma conditions at medium q_{95}~3.5 was obtained, whose operating space in terms of ν_e^* was very similar to JFT-2M. This strongly suggests that the EDA and HRS regimes, and the 'mixed' ELM regimes on the two devices have common physics. Another run is necessary to fill in gaps and to explore the high q_{95}~5 part of the proposal, as well as a wider range at low $q_{95} \leq 3$ (Feb.-March 2005).

Detailed comparison in terms of access conditions, fluctuation characteristics and global parameters is in progress. Joint publication of results is planned.

8. **Executive Summary**

A systematic comparison between C-Mod and JFT-2M at matched plasma shape is underway. It was found that both EDA and HRS regimes had very similar access regimes in edge ν_e^* - q_{95} space.

PEP-13: Comparison of Small ELM Regimes in JT-60U and AUG

Topical Group: ITPA Pedestal TG
Contact Persons: N. Oyama, H. Urano (JT-60U), L.D. Horton (AUG), A. Loarte (EFDA)
Devices: ASDEX Upgrade, JT-60U
Time period of data taking: June 2003-July 2005
Goals:

1) Attempt to transfer the JT-60U grassy ELM regime to AUG with the particular goal of extending small ELM regimes on AUG to lower collisionality.
2) Given a successful result to the first goal, study the access conditions for grassy ELMs and compare them to those for the AUG Type II ELM regime.
3) Attempt to extend the operating range for small ELMs to lower safety factors.

Results:

Small ELMs have been obtained at AUG by operating at high safety factor ($q95 \sim 6$), high triangularity ($\delta \sim 0.4$) and high βpol (1.8-2.0), following the JT-60U recipe. In addition, however, the AUG Type II ingredient of operating in near-DN configurations has also been necessary. The pedestal-top collisionality of these discharges is as low as any so far achieved in AUG.

26 setup discharge at moderate q95 also showed small ELM characteristics while maintaining good confinement. This suggests that access to more relevant safety factors is possible. Since the high power in these discharges suppresses sawtooth activity, these discharges merge in this limit to double null version of the improved H-mode regime.

Executive summary:

Small ELMs have been obtained at low collisionality in AUG using a combination of the JT-60U grassy ELM and AUG Type II ELM recipes.

PEP 14: QH/DQB Comparison in JT-60U and DIII-D

Topic Group: Edge and Pedestal Physics Topical Group
***Contact persons*:** P. Gohil, L. Lao (DIII-D) and N. Oyama, Y. Sakamoto (JT-60U)
Devices: DIII-D and JT-60U
Time periods: December 16-19, 2003 and September 1-3, 2004 on JT-60U and June 7-14, 2004 and July 12-13, 2004 on DIII-D
Experiment's Purpose and Goals: To produce QH-mode plasmas on JT-60U and document parameter space for QH-mode plasmas on JT-60U. Compare to QH-mode characteristics on DIII-D. Joint proposal with TP-5
***Results*:** (a) QH-mode plasmas were produced in JT-60U; (b) QH-mode plasmas were produced with both counter-NBI and co-NBI; (c) the mix of co- and counter-NBI was used to change the plasma toroidal rotation and the ELM behaviour; (d) the production of the QH-mode in JT-60U is sensitive to the outside gap at the plasma midplane as also observed in DIII-D. On DIII-D (a) ELM suppression appears to be linked to QH-mode plasmas being marginally stable to coupled peeling/ballooning modes; (b) impurity transport at the plasma edge is faster during QH-mode with EHOs than during H-mode plasmas with ELMs; (c) the use of NBI and ECCD has led to control of q0 in QDB plasmas.
Executive Summary: Main persons involved-P. Gohil, and L. Lao (DIII-D) , N. Oyama and Y. Sakamoto (JT-60U) ; period-Dec 16-19, 2003 and Sep 1-3, 2004; QH-mode plasmas were produced in JT-60U with counter-NBI and co-NBI.

Scrape-off Layer and Divertor Physics ITPA-IEA Joint experimental reports for 2004

The following experiments are reported:

DSOL-1	**Scaling of Type I ELM energy loss**
DSOL-2	**Hydrocarbon injection to quantify chemical erosion**
DSOL-3	**Scaling of radial transport**
DSOL-4+14	**Comparison of disruption energy balance in similar discharges and disruption heat flux profile characterisation**
DSOL-5	**Role of Lyman absorption in the divertor**
DSOL-6	**Parallel transport in the SOL**
DSOL-7	**Multi-machine study on separatrix density and edge density profiles**
DSOL-9	**Carbon-13 injection experiments to understand C migration**
DSOL-10	**Modelling of different gasses effects on disruption power deposition**
DSOL-11	**Disruption mitigation experiments**
DSOL-13	**Deuterium codeposition with carbon in gaps of plasma facing components**

DSOL-1. Scaling of Type I ELM energy loss

Topical Group. Divertor and edge + Pedestal

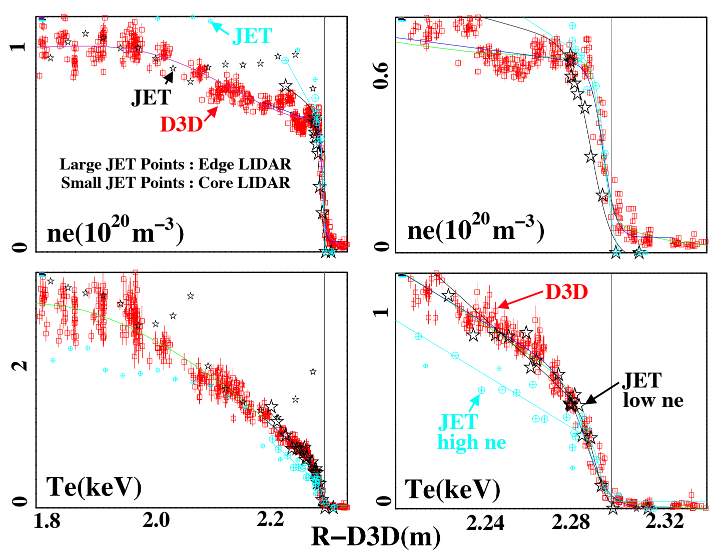
Contact Persons : A. Loarte, M. Kempenaars, G. Saibene, A. Kallenbach, A.Leonard, T. Osborne, M. Fenstermacher

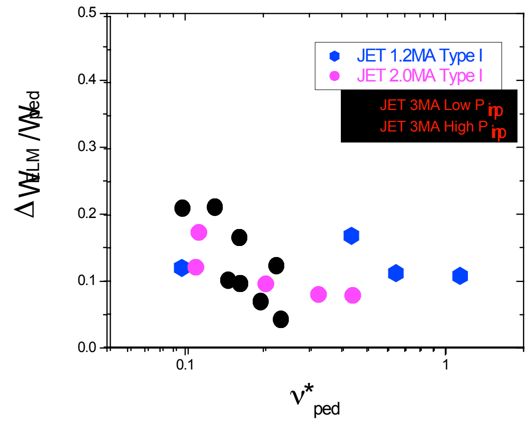
Devices that contributed to the Experiment : JET, DIII-D, ASDEX Upgrade

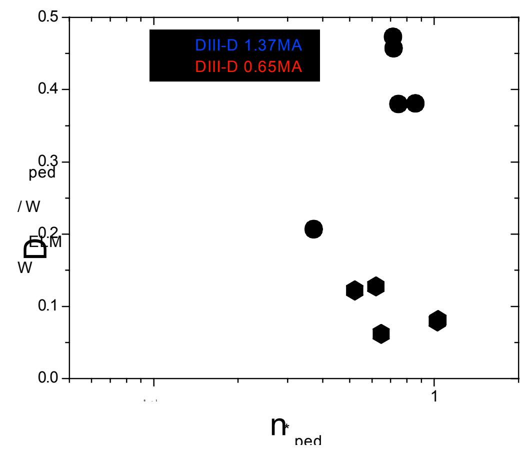
Time Periods when the research was done on the various devices : 2002, 2003 and 2004

Description of the Experiment's Purpose and Goals : The purpose of the experiment is to study ELM losses in discharges for which the pedestal plasmas are similar in the dimensionless sense and determine the physics processes that determine the pedestal edge gradients

Description of the Principal Results : Discharges have been done in JET, ASDEX Upgrade and DIII-D with dimensionally similar pedestal parameters. In these conditions the pedestal temperature gradients scale with machine size, as expected from plasma transport being dominant for this, while pedestal density gradients do not scale this way and are more consistent with being determined by neutral ionisation. ELM energy loads are similar for similar pedestal collisionalities but scale with ρ* differently between JET and DIII-D. At present the reason for







this difference is not clear and it may be related to the very low densities /long mean free paths in DIII-D and/or the required input powers.

Executive Summary : A. Loarte, M. Kempenaars, G. Saibene, A. Kallenbach, A.Leonard, T. Osborne, M. Fenstermacher. JET, DIII-D and ASDEX Upgrade. Period 2002-2004. Discharges with identical pedestals in dimensional variables have pedestal temperature gradients which scale with machine size (i.e. determined by plasma transport). Density pedestals do not scale this way and are more consistent with being determined by neutral ionisation.

1. Experiment: DSOL-02 Hydrocarbon injection to quantify chemical erosion

2. Topical group: Divertor and SOL

3. Coordinators: V. Philipps FZJ Juelich (Coordinator), S. Brezinsek FZJ Juelich, M.Stamp (JET), A.Kallenbach (AUG), *K. Tsuzuki* (JT-60U), M.Fenstermacher (DIII-D*)*

4. Devices: *TEXTOR, JET, AUG, DIII-D, JT-60U*

5. Purpose and goals: *Chemical erosion will determine the lifetime of the high flux areas of the divertor but, even more seriously, chemical erosion determines also the formation of hydrogen rich carbon deposits which can lead to unacceptable amounts of tritium retention. A reasonably consistent database exist for the chemical erosion of graphite under ion beam and thermal hydrogen impact but uncertainties still exist about the chemical erosion under fusion reactor conditions. Purpose of the joint experiments is the quantification of the primary chemical erosion source under divertor plasma conditions in dependence on the substrate target temperature, the near target plasma conditions, the impinging flux and the impurity composition. Injection of different type of stable hydrocarbons (CH_4, C_2H_y) will be used to quantify the spectroscopic signals, evaluate absolute photon efficiencies (D/XB-values) which include the dissociation chain and compare them with modelling calculations. Joint experiments allow to obtain data on hydrocarbon chemical erosion under a wide spread of plasma conditions and benefit also from different spectroscopic diagnostic and gas injection possibilities. This allows to establish a broader data base for extrapolation to ITER.*

7. Principal results:

CH_4 hydrocarbons have been injected through TEXTOR test limiters (graphite and tungsten)with typical plasma parameters from about 15-90 eV and densities from 10^{17}-5 10^{18} m^{-3}. Under erosion dominated conditions the methane yield is 2-3 % with a weak temperature dependence from room temperature to the maximum temperature. In DIII-D a porous plug injector (PPI) in a graphite probe in DIMES has been developed and first tests have been done in October 2004 with the simultaneous injection of CH_4 and He. In *AUG c*hemical erosion yields have been measured in the outer divertor with the calibrated CD emission via gas injection of CD_4 in H-mode discharges. The erosion yield was determined to be below 0.3 % with a flux dependence of $\Gamma^{-0.46}$ in the flux range 2-10 10^{22} D/m^2s (results published in PSI Portland). In JET chemical erosion in the outer divertor has been evaluated by CH_4 and C_2H_4 injection together with slow strike point sweeps across the location of injection. At the location of injection a methane yield of 3% has been evaluated (results published in PSI Portland). In Jt-60U, CD_4 was injected to the outer strike point in the common flux region and first evaluations of D/XB gave values of 100 − 200, increasing with T_e between 10 − 100eV.

8. Executive summary

Chemical erosion has been analyzed in TEXTOR (Philipps, Brezinsek), AUG (Kallenbach), JET (Stamp), DIII-D (Fenstermacher) and JT-60U (Tzuzuki). Hydrocarbon injection has reduced the uncertainties of spectroscopy, but the yields for erosion dominated, attached conditions show still a significant scatter between 4% (JET) and 0.3% (AUG) at surface temperatures of >500K and <350 K respectively. TEXTOR data indicate only a weak temperature dependence.

DSOL-3 2004 report (Scaling of radial transport)

Topical Group: Divertor/SOL

Contact Persons for the Experiment: Bruce Lipschultz, Guy Matthews, Dennis Whyte

Devices that contributed to the experiment: C-Mod, JET, DIII-D

Time Periods when the research was done: Experiments carried out in 2003. Analysis carried out in 2003-2004.

Experimental goal: Better prediction of how radial transport in the SOL scales. The goal is to understand the underlying physics. The idea is to collect data from a number of experiments and analyse them in a similar way.

Principal Results: Dimensionlessly similar discharges from C-Mod, DIII-D and JET were compared. It was found that the far SOL (more than 1 e-folding from the separatrix) transport was essentially the same for all three tokamaks. The transport is best represented by convection and the convective velocity profile correlates well with the radial velocity of turbulent filaments (‘blobs’). The variation in density profile shape was ascribed to the SOL albedo to neutrals. All of this information was used to generate 2 papers and a talk at the 16th PSI. The work included scalings to ITER. The predicted transport for ITER will be similar to present day machines (in far SOL, not in near SOL). The ITER SOL will be fairly opaque to neutrals (similar to C-Mod) and, under gas-fueled conditions, will likely have broad shoulders in density profile. Pellet-fueling should reduce this.

Executive Summary: Dimensionlessly similar discharges from C-Mod, DIII-D and JET were compared for which the far SOL transport was the same. Data points to plasma albedo to neutrals also playing a role in profile shapes. Scaled to ITER.

DSOL-4+DSOL-14. Comparison of disruption energy balance in similar discharges and disruption heat flux profile characterisation

Topical Group. *Divertor and edge + MHD*

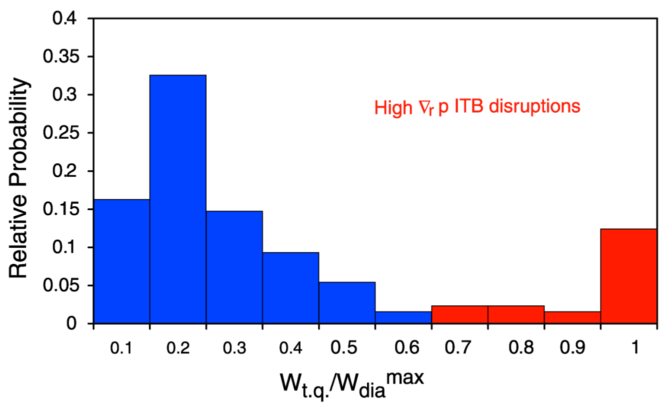
Contact Persons : A. Loarte, P. Andrew, V. Riccardo, G.Pautasso, G. Counsell, D. Whyte, K.H. Finken G. Maddaluno

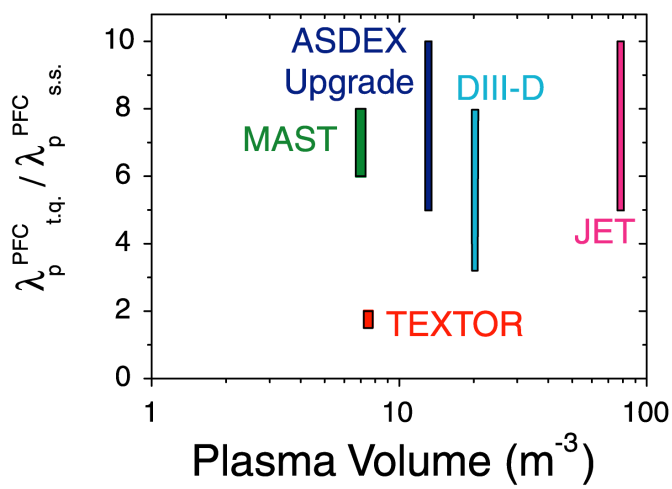
Devices that contributed to the Experiment : JET, ASDEX Upgrade, MAST, DIII-D, FTU and TEXTOR

Time Periods when the research was done on the various devices : 2002, 2003 and 2004

Description of the Experiment's Purpose and Goals : The purpose of these analysis of the experiments is to determine the amount of energy which flows to the plasma facing components during the thermal quench of plasma disruptions, its spatial distribution, and its time.

Description of the Principal Results : The energy of the plasma at the disruption thermal quench is usually much smaller than that of the full performing plasma, with the exception of high β ITB collapses. For most disruption types the power footprint at the divertor is very broad, typically 5-10 times larger than the steady-state power flux. The timescale for energy flux to the divertor scales with machine size but shows a large variability and it is not directly correlated with the collapse of the central temperature in the discharge as measured by ECE. As a consequence of the above factors, the energy fluxes at the divertor for the most likely disruption in ITER are in the range of ~ 3.3 MJm^{-2} with timescales of ~ 2ms. While these fluxes are not small they are much smaller than those expected following the prescriptions of the ITER Physics Basis document (~ 33 MJm^{-2} with timescales of ~ 1 ms). Remaining issues to address are correlated to : a) the large disruption-to-disruption variability of the observations (even for nominally identical disruptions), b) toroidal asymmetries of the energy deposition during the thermal quench, c) divertor energy loads in pre-disruptive events (L-H transitions, mode locking, etc.) which can be larger than those in the thermal quench and d) fluxes to PFCs outside the active divertor at the thermal quench.





Executive Summary : A. Loarte, P. Andrew, V. Riccardo, G.Pautasso, G. Counsell, D. Whyte, K.H. Finken G. Maddaluno. JET, ASDEX Upgrade, MAST, DIII-D, FTU and TEXTOR. Disruption thermal quench energy fluxes have been examined in various experiments and show that the estimates done for these loads in ITER following the IPB methodology represent a worse case scenario, which rarely takes place in the experiment. The most probable disruption loads in ITER are about one order of magnitude smaller than those estimated before and, correspondingly, the divertor target damage will be smaller.

DSOL-5 Role of Lyman absorption in the divertor

Divertor & SOL

D Reiter, J Terry, G Matthews, S Lisgo

C-Mod, JET

C-Mod: experiment 1998-99, code analysis 2001-04; JET: pending

The purpose is to improve understanding of Lyman series photon trapping (which can significantly affect ionisation rates for $T_e < 5$ eV) in collisional divertor environments, with the goal of (de)validating the modelling tools (EIRENE) via comparison with experiment.

C-Mod has the highest divertor plasma and neutral densities of present day tokamaks and strong Lyman alpha trapping has been inferred from Lyman:Balmer line ratio data (J Terry). EIRENE photon transport simulations (non-linear, iterative) were done (D Reiter) for a “medium-density”, static plasma solution. Strong volume averaged trapping of Lyman alpha (~90%) was indicated, with weaker trapping for higher n-state lines, as expected (Lyman epsilon trapped at ~15%). The resulting increase in ionisation rate reduced the divertor neutral pressure by a factor ~2. EIRENE development in 2004 included line mixing (H, D and T lines), Stark broadening, benchmarking against HID lamps, interfacing to a spectroscopic database, and Zeeman routines (not yet benchmarked). The C-Mod plasma profiles input to EIRENE were from interpretive modelling (S Lisgo), which was used to reconstruct the divertor plasma from experimental data.

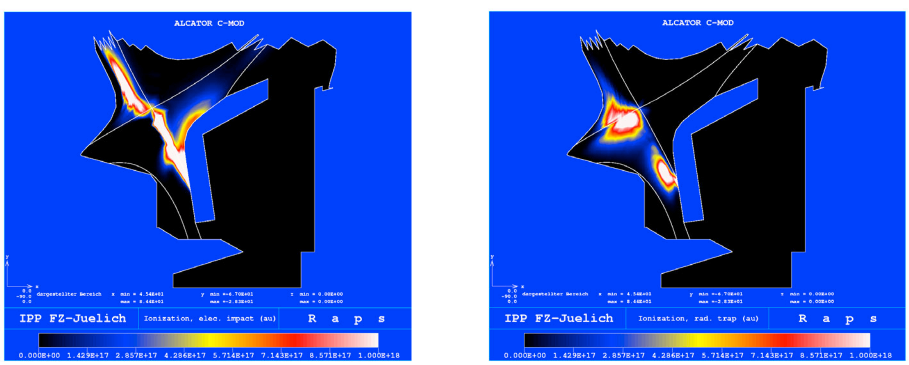


Figure 1: The ionisation distribution when the plasma is transparent to Lyman series photons (left), and the increase in ionisation in the colder regions of the plasma when Lyman series trapping is included in the EIRENE model (right).

JET work is forthcoming (see DSOL-5 experiment proposal).

Executive Summary

EIRENE photon modelling (D Reiter) conducted for a “medium-density”, static C-Mod divertor plasma solution (S Lisgo). Strong Lyman alpha photon trapping was indicated, which decreased the divertor atom density by a factor ~2. Lyman:Balmer line ratio data has been supplied (J Terry).

Summary report of IEA/ITPA multi-machine work 2004

1. **<u>DSOL-6 Parallel transport in the SOL (Category-D: detail proposal/plan is</u>** requested**)**

2. **Divertor and SOL physics TG**

3. JT-60U, JET, Alcator C-MOD, ASDEX-Upgrade, DIII-D

4. N. Asakura (JT-60U), K Erents (JET), B. LaBombard (Alcator C-MOD),
J Neuhauser (ASDEX-Upgrade), M. A. Mahdavi (DIII-D)

5.JT-60U(2004, Nov.), JET(2003, May), C-MOD(2003-2004?), ASDEX-U(2004)

6. Objective of this work: **determination of SOL flow pattern and understanding of the driving mechanism (focusing on drift effects).**

7. Principal results: **Flow patterns for Bt normal (FWD-Bt) and reversal (REV-Bt) operations in single null tokamaks shows that effects of the plasma drift appears largely at low-field-side (LFS) SOL rather than in high-field-side (HFS) SOL. The drift effects appears largely at lower density. Simple drift model can not explain the flow pattern and subsonic Mach number for the FWD-Bt case, producing the SOL flow from LFS SOL to HFS SOL (divertor) via plasma top.**

8. For executive summary**:**

There were no coordinated experiments for inter-machine so far. However, database for density and power scans are available in the above tokamaks. Experiment database of Mach numbers are summarized by local profile data such as Te (Ti), ne and Er, in order to understand effects of drifts and/or other factors such as diffusion/fluctuation.

There were no coordinated experiments for inter-machine so far since plasma configuration, power level and density were determined partly by priority of study objectives in each machine, and partly by different locations of edge diagnostics such as Mach probes. We will use recent existing database for comparison of SOL flow pattern.

In JET, systematic study of density and power dependences in Bt normal (FWD-Bt) and reversal (REV-Bt) operations were done in L-mode. Flow direction near separatrix was towards HFS diveror independent of the Bt direction, while it changed in outer flux surfaces <u>at the plasma top</u>: flow towards HFS divertor in FWD-Bt while it was stagnated in REV-Bt.

In Alcator C-MOD, flow measurements at HFS and LFS SOL in double null configuration showed in-out asymmetry of the plasma pressure (caused by ballooning-like diffusion). This would be a candidate to drive the SOL flow from LFS and HFS in FWD-Bt case. Change in flow patter in REV-Bt will be investigated from the view point of the mechanism. Influence of the SOL flow pattern will be investigated in new proposal.

In ASDEX-Upgrage, the flow direction, Mach number and the density dependence of new midplane Mach probe were consistent with other tokamaks such as JT-60U and C-MOD. All database of detailed profile of Mach number will explain effects of machine and SOL geometry and density/temperature gradient in SOL.

In JT-60U, new database under the condition of puff and pump in FWD-Bt and REV-Bt cases will be planned in Nov. 2004. In addition, fluctuation measurements will be planned, for the first time, in JT-60U to understand the poloidal distribution of diffusion.

Detail status report

JET: K Erents – (Paper is published in PPCF 46 (2004) 1757- 1780.)

The SOL flow at the top of the JET torus (in lower single-null, diverted plasmas) was systematically investigated both for forward (Fwd-Bt) and reversed toroidal field (Rev-Bt) directions. Mach number of the parallel SOL flow, M//, was evaluated from upstream and downstream flux densities measured by a retarding field analyzer. In Fwd-Bt, a strong parallel flow in the direction from the outer to the inner divertor was measured. M// was low (~0.2), close to the separatrix, but rises in the region of high magnetic shear to a maximum of M// ~ 0.5 (20 mm outside the separatrix). In contrast, for Rev-Bt, M// is small (close to zero) throughout much of the SOL, but rises near the separatrix to a value equal in both magnitude and direction to that observed in Fwd-Bt. Thus symmetry in the flow profile with an offset of M// ~ 0.2 was found out, and the drift effect appeared rather outside the separatrix.

Simulation result using the EDGE2D/Nimbus code, which predicts very low values of parallel flow M// at the top pf plasma. A possibility of impurities released from the probe surfaces increasing the flow velocity is also explored using the code.

2004-2005 plans:

Understanding of the SOL flow using EDGE2D/Nimbus code with drifts. E2D ITER cases (84 MW) with drifts will be investigated.

Alcator C-MOD: B. LaBombard – (Paper is published in Nucl. Fusion 44, (2004) 1047-1066)

SOL flows in a variety of magnetic configurations (ion grad-B drift down): lower single null (LSN), upper single null (USN) and double null (DN) has been investigated, using three scanning Mach probes, including a probe on the high-field side (HFS) .

Clear signatures of ballooning-like transport asymmetries are detected; plasma pressure e-folding lengths on HFS are short by a factor of ~4 in DN compared to LSN or USN; fluctuation levels are persistently lower on HFS (factor of ~3 or more), independent of topology. Near sonic flows are detected in HFS for LSN and USN, with direction consistent with flow from LFS to HFS regions. These observations suggest that ballooning-like cross-field transport is the underlying flow-drive mechanism.

The resultant SOL flow pattern appears to impose a topology-dependent toroidal rotation boundary condition on the confined plasma - central plasma rotation is affected by x-point topology, acquiring a portion (~1/2) of the toroidal flow velocity change in HFS. The link between SOL flows, toroidal rotation and topology is suggested as an explanation for the sensitivity of the H-mode power threshold on x-point location. The SOL flow pattern in plasmas that were limited near the bottom of the vacuum vessel is found identical to LSN. The L-H threshold power is also found identical, further implying that SOL flows influence L-H threshold physics.These results will be submitted for publication in Physics of Plasmas as part of an invited talk at the 2004 APS meeting.

ASDEX-Upgrade: J Neuhauser -

Reciprocating Mach probe measurements at LFS midplane in lower SN ohmic plasmas (normal Bt) indicated plasma flow from low to HFS (around the top of the plasma) with subsonic parallel Mach numbers (e.g.M//~0.4), with the maximum M// at 1-2 cm outside

the separatrix. A clear density dependence, i.e. M// increasing with decreasing density, was seen. In parallel, first measurements in H-mode plasmas was recently performed. Additional information from reciprocating divertor Langmuir probe (data being analyzed).
Bt reversal experiment is not yet done. Parallel transport will be investigated comparing Ip and Bt reversal at the same discharge parameters.

JT-60U: N Asakura –
Normal and reversal Ip and Bt experiments were recently performed during one day at Ip and Bt lower than previous campaign (2001). Zeff (2.1-2.3) and impurity (carbon) concentration (3-4%) in the main plasma were comparable for the two cases although the direction of the SOL flow pattern changed at LFS SOL. Recently experiment on this activity was permitted (only midplane Mach probe was permitted, the X-point probe operation not yet, and HFS Mach probe was not permitted to be repaired).
Previous SOL flow data during puff and pump with normal Bt was analyzed to investigate effect of the measured subsonic SOL flow on impurity shielding. For the case of small M// (0.1-0.2), carbon ions (C4+) are relatively concentrated near stagnation point in SOL. On the other hand, for the subsonic M//, C4+ is not concentrated in SOL.
Fluctuation measurements of Is and Vf (500kHz) during L- and H-mode were done for the first time in Oct. 2004. Strong puff and pump experiments with Ip and Bt reversals are planned in order to investigate enhancement of the flow velocity and impurity control in the end of Nov. 2004.

2005 plans:
Effects of (1) the plasma shape and (2) puff & pump on SOL flow and edge plasma at HFS and LFS will be studied if repair of HFS Mach probe is permitted. Effect of the subsonic flow with drifts on impurity transport will be calculated in the 2D SOL code with UEDGE.

DIII-D:M. A. Mahdavi--
There are no DIII-D experiments related to this activity scheduled in FY 2004. There are no experiments presently planned for FY 2005.

1. **DSOL-7 Multi-machine study on separatrix density and edge density profiles**

2. *ITPA Divertor and SOL Topical Group*

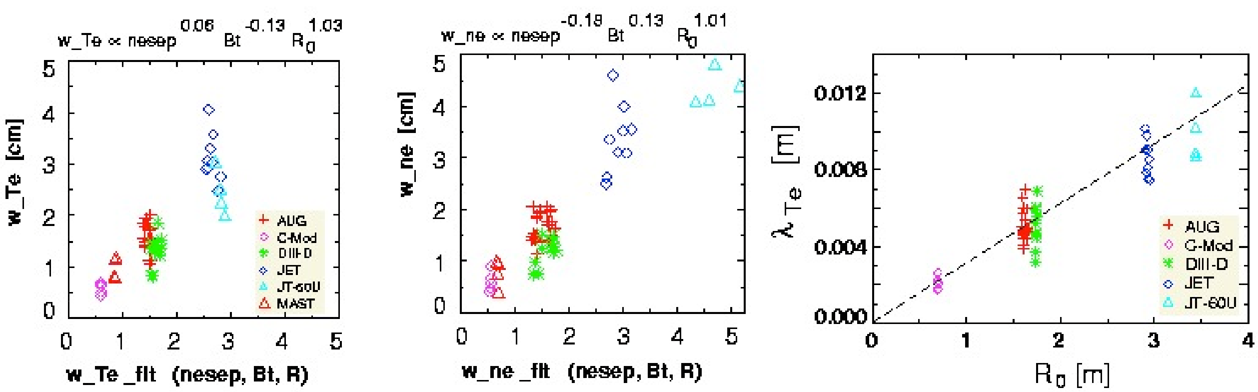
3. Contact person: Arne Kallenbach

4. Data collected from Alcator C-Mod, ASDEX Upgrade, DIII-D, MAST, JET, JT-60U

5. Data analysis in the period 2002-2004 from existing data from the devices listed above.

6. Purpose of the data analysis procedure was to search for a unified behaviour of edge density (and Te) profiles using Thomson scattering data plus additional diagnostics and a uniform data interpretation algorithm. One particular goal was the search for neutral physics effects in the density profile behaviour.

7. The main results have been presented at the PSI 2004 conference and will appear in Journal of Nuclear Materials, „Multi-machine comparisons of H-mode separatrix densities and edge profile behaviour in the ITPA SOL and Divertor Physics Topical Group", by A. Kallenbach et al. The major parameter for electron density and temperature widths appears to be the machine size.
The temperature e-folding length in the midplane scales linearly with machine size, plus a slight increase with increasing separatrix Greenwald fraction. The density width also scales with machine size, but an outward shift with respect to the separatrix position is observed which is attributed to some influence of neutral penetration physics.



8. Multi-machine edge profile analysis finds machine size to be the governing parameter for temperature and density barrier widths and T_e e-folding length at the separatrix. Some influence of neutral penetration physics is seen in the density profile. Results have been presented at the PSI 2004 conference.

1. **DSOL-9. ^{13}C injection experiments to understand C migration**

2. Divertor and Scrape-Off Layer Topical Group
3. Contact Person: Guy Matthews, JET facility, UKAEA Fusion
4. Devices involved: JET, DIII-D, TEXTOR, ASDEX-Upgrade
5. Time Periods: from 2001
6. Purpose and Goals

^{13}C-tracer experiments involve injection of $^{13}CH_4$ from various locations in a tokamak at the end of an experimental campaign prior to an in-vessel intervention. Tiles are then removed for surface analysis. This is a very useful tool for studying carbon co-deposition which is primarily motivated by the tritium retention issue. The benefits of this technique are as follows:

- Traditional deposition studies involve integration over entire campaigns and a wide variation of plasma conditions, making interpretation very difficult.
- ^{13}C expts can employ a single, well-characterized plasma condition.
- Fast SOL flow is a major aspect of the process. Most SOL flow data is from Mach probes, which have significant interpretation issues and, in any case, don't measure the *carbon* ion flow – which may differ from the fuel ion flow.
- ^{13}C experiments can tell us directly where the carbon itself goes.

Without the use of tracers like ^{13}C, the quantitative analysis and interpretation of the co-deposition process in tokamaks will be difficult or impossible.

7. Principal Results

JET (M.Rubel) First experiment (2001) with $^{13}CH_4$ injection into ohmic plasmas at the top showed that 99% deposition in the inner divertor and no sign of migration to remote areas. More recently $^{13}CH_4$ was injected at the outer target in H-modes and ^{13}C was detected on the side of the top reciprocating probe facing the outer divertor only. The divertor tiles are not yet analysed but will allow comparison with ASDEX Upgrade experiments with similar geometry.

DIII-D (P. Stangeby) Similar results to JET with top $^{13}CH_4$ injection into L-mode. A number of independent analyses indicate carbon plumes and deposition requires Mach number around 0.5 for consistency.

TEXTOR (V.Philipps) $^{13}CH_4$ was injected from a test limiter and the surface subsequently analysed. ERO-TEXTOR modelling requires low sticking probability to explain low levels of ^{13}C found on the surface.

ASDEX Upgrade (K.Krieger) $^{13}CH_4$ was injected at the outer divertor target and almost all of the ^{13}C was accounted for on the outer target surface.

Future work needs to ensure consistent inter-machine comparisons and focus on what factors lead to migration into remote areas.

8. Executive Summary. Consistency has now been demonstrated between the JET results showing strong ^{13}C transport to the inner divertor and recent experiments in DIII-D. Analysis of tiles just removed from JET following $^{13}CH_4$ injection at the outer divertor will allow comparison with ASDEX Upgrade results.

DSOL-10 report- 'Modeling of different gasses effects on disruption power deposition'

2. Topical Group: Divertor & SOL

3. Contact persons: D. Whyte (UW-Madison), M. Bakhtiari (JT60-U), G. Martin (Tore Supra)

4. Devices participating: DIII-D, JT-60U, Tore Supra

5. Experiments implemented 07/03 – 09/04.

6. Goal: Determine the effect of using different combinations of injected gas species for minimizing heat load damage to plasma-facing components during disruptions.

7. Description of results:

- Radiation calculations, benchmarked against present DIII-D and JET experiments, have shown that a uniform, rapid radiative shutdown of a Q=10, 15 MA ITER plasma will likely result in a uniform but thin (~10-50 microns) melt layers of the beryllium first wall. This constitutes a possibly significant quantity (10's of kg) of mobile, molten Be and is a result of the low melting temperature of Be. Melting will not occur if the induced thermal quench can be stretched to longer timescale (> 5 ms) and be kept spatially uniform.

- Radiation calculations have demonstrated the possibility to use surface heating from planned rapid radiative termination to recovery tritium from surface films containing trapped hydrogenic fuel.

- JT-60U showed that combining low-Z H2 gas with the noble gases (He, Ar, Ne) proved more efficient at suppressing runaway electrons, which pose a threat of localized power loads when lost to the wall in ITER.

- ToreSupra confirmed efficiency of He gas injection for runaway suppression.

8. **Executive summary:** Personnel: Whyte, Bakhtiari, Martin Riccardo, Andrews, Finken, Time period: 07/03 to 09/04. Summary: Runaway suppression is possible with many gases, but optimal dissipation of ITER thermal energy on longer timescale to avoid melting appears difficult.

DSOL-11 report - 'Disruption mitigation experiments'

2. Topical Group: Divertor & SOL

3. Contact persons: D. Whyte (UW-Madison), T. Jernigan (ORNL), E. Hollmann (UCSD), M. Bakhtiari (JT60-U), G. Martin (Tore Supra), V. Riccardo (JET), P. Andrew (JET), R. Granetz (MIT), K. Erents (JET), G. Matthews (JET), K.H. Finken (Juelich)

4. Devices participating: DIII-D, JT-60U, Tore Supra, JET

5. Experiments implemented 07/03 – 09/04.

6. Goals: Determine the optimal disruption mitigation schemes for burning plasma devices like ITER

7. Description of results:

- DIII-D, Tore Supra and JT-60U implemented and experimented with large gas injection systems for disruption mitigation.

- Further empirical studies on the suppression of runaway electrons (RE) show that if smaller quantities of pure noble gas are injected then RE are measured in the current quench. These results are in qualitative and quantitative agreement with modeling of the CQ evolution.

- DIII-D has tested a gas jet "directed" at the plasma center, but with a small entry tube (diameter ~ 1.5 cm) compared to the previous "open" jet (diameter ~ 15 cm). The new design allowed for better diagnostic access, but slower time response and a lower gas pressure/gas inventory (factor of 3-5). The principal result was that reduced gas jet pressure/inventory led to longer delays in initiating the thermal quench and allowed somewhat more RE in the current quench. This demonstrated that having high gas jet pressure seems to be most important factor in establishing reliable, rapid disruption mitigation.
- Studies on DIII-D suggest that injected gas jets of neon/argon are not fully penetrating to the central plasma as neutrals, but rather with a mixture of partial neutral penetration and MHD mixing. The thermal mitigation effectiveness remains >95% (i.e. energy radiated from core / initial plasma energy > 0.95) despite the partial neutral penetration. The scaling of this efficiency to ITER remains a key question awaiting cross-device comparison, but this new observation may reduce the pressure requirements for an ITER jet.

8. **Executive summary**: Personnel: Whyte, Jernigan, Hollmann, Bakhtiari, Martin Riccardo, Andrews, Finken, Time period: 07/03 to 09/04. Summary: Cross-machine comparisons of gas jet designs and target plasmas are needed for better extrapolation to ITER.

DSOL-13 report: Deuterium codeposition with carbon in gaps of plasma facing components

Topical group: Divertor & SOL

Contact persons: Coordinator - K. Krieger, TEXTOR - A. Litnovsky, V. Philipps,
ASDEX Upgrade – H. Maier, K. Krieger, DIII-D - C. Wong, W. Jacob

Contributing devices: TEXTOR, ASDEX Upgrade, DIII-D

Time periods of experiments: 2004

Experiment's Purpose and Goals:

In ITER, codeposition of tritium with carbon, which is envisaged as armour for divertor target plates, will lead to continuous growth of tritium inventories. If the safety limit for the vessel T-inventory is exceeded, the co deposited layers have to be removed. Co deposited hydrogen inventories are therefore particularly of concern in gaps of W castellated surfaces or macro brush components and C or Be tile-gaps which are not well accessible by most potential cleanup methods.

The goal of this experiment is the quantification of the total amount and spatial distribution of hydrocarbon layers in gaps of plasma facing surfaces and the investigation of the dependency of deposition rates on gap geometry, local plasma parameters, carbon concentration and surface temperature.

Principal Results:

In TEXTOR and ASDEX Upgrade tungsten monoblock structures with gap widths of 0.5 mm were exposed in the main plasma SOL. At the sidewalls of the tungsten monoblocks C:H layers are found after exposure. The thickness of these layers decreases exponentially as a function of gap depth with a fall-off length in the range of a few mm.

The fraction of the total amount (gaps plus plasma facing surface) of deposited D found inside the gaps ranges from 30% to 60%. In DIII-D a probe with a single slit of 2 mm width flush to the divertor floor was exposed. Again, carbon and deuterium is deposited at the sidewalls of the slit structure with an exponential decrease as function of depth into the gap. Two exposures were performed with the slit at room temperature and at 200 ºC where less deposition is expected. The analysis of these samples is, however, not yet complete.

Executive Summary:

In 2004 D and C deposition in gaps of tungsten monoblock structures were investigated in TEXTOR and ASDEX Upgrade. Spatial distribution as well as fraction of D/C retained in gaps could be measured. At DIII-D a gap probe was exposed primarily to study the effect of surface temperature on D/C deposition in gaps. chine time).

MHD,Disruptions, and Magnetic Control ITPA-IEA Joint experimental reports for 2004

The following experiments are reported:

MDC-1	**Pressure and size scaling of gas jet penetration for disruption mitigation**
MDC-2	**Resistive wall mode physics**
MDC-3	**Neoclassical tearing modes (including error field effects)**
MDC-4	**Neoclassical tearing mode physics – aspect ratio comparison**
MDC-5	**Comparison of sawtooth control methods for neoclassical tearing mode suppression**
MDC-6	**Low beta error field experiments**
MDC-7	**Improving NTM modelling/extrapolation to ITER**

1. **MDC-1 Pressure and size scaling of gas jet penetration for disruption mitigation**

2. *Topical group:-* MHD

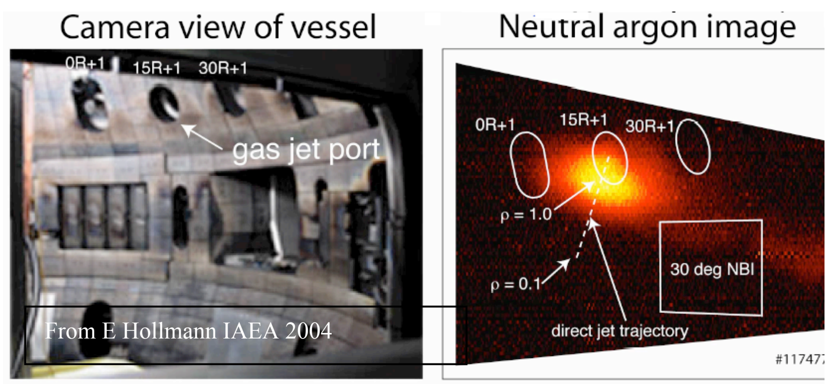
3. *Contact Persons for the Experiment :-* E Hollmann, D Whyte, (DIII-D), P Andrew (JET), M Bakhtiari, Y Kawano (JT60-U), K.H Finken (TEXTOR), G Martin (Tore Supra)

3. *Devices that contributed to the Experiment:-* In 2004 experiments done on DIII-D, AUG and JT60-U, in 2003 JET and TEXTOR experiments

5. *Time Periods:-* DIII-D March 04, JT60-U and AUG

6. *Experiment's Purpose and Goals:-* To demonstrate control of halos, thermal loads and runaways by massive gas injection. Specifically in 2004 to test a directed gas jet on DIII-D and gas mixtures on JT60-U.

7. *Principal Results:-* The 2004 DIII-D experiment used a directed jet, which has a longer rise time than the previous open geometry, but has the advantage of being aimed more at the plasma centre. With the directed jet filtered fast visible light images (see right) were obtained for Ar and Ne gas jets. The images show that, despite their high velocity, the bulk of the neutral gas is not penetrating to the plasma centre, but rather that an n=1 instability appears to be involved in transporting the ionised impurities to the centre and/or heat from the center towards the edge. In ASDEX Upgrade disruption mitigation by gas injection is developed to the point being used for machine protection and allows exploration of disruption mitigation in truly pre-disruptive plasmas.



In general the results show massive gas jet shutdown works well in present tokamaks:-

- Low conducted heat loads, low halo currents, and low runaway electron signature seen in DIII-D.
- Large reduction in runaway signature over normal disruptions observed in Tore Supra.
- Reduced runaway signature using mixed-species jets observed in JT-60U, with Kr showing the best performance in comparison with Ar and Xe. Experiments on

TEXTOR have shown pre-existing runaway electrons are suppressed within 0.5ms of the fast gas valve activation.
- Predicting performance of gas jet in ITER is still work in progress.
- Getting impurity neutrals into center of ITER challenging. However, mitigation can be good even without neutrals penetrating to center.

8. *Executive summary:-* Massive gas jet shutdown with low halo currents, heat loads and runaways have been shown variously on DIII-D, JT60U, Tore Supra and TEXTOR. Installation of new hardware on C-Mod and JET will allow major experiments in CY05.

ITPA-IEA Joint Experiments Report

1. **MDC-2 Joint experiments on resistive wall mode physics**

2. *Topical group:-* MHD

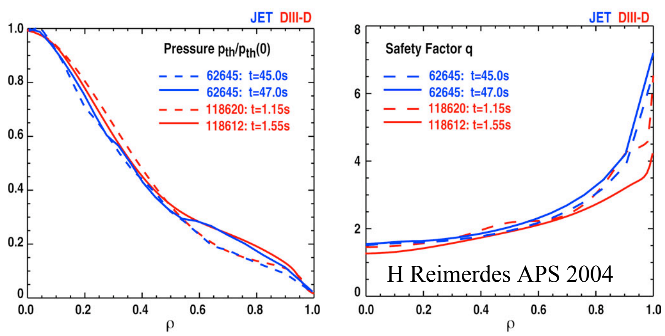
3. *Contact Persons for the Experiment :-* H Reimerdes, M Okabayashi (DIII-D), M Gryaznevich, S D Pinches (JET), M Takechi (JT60-U)

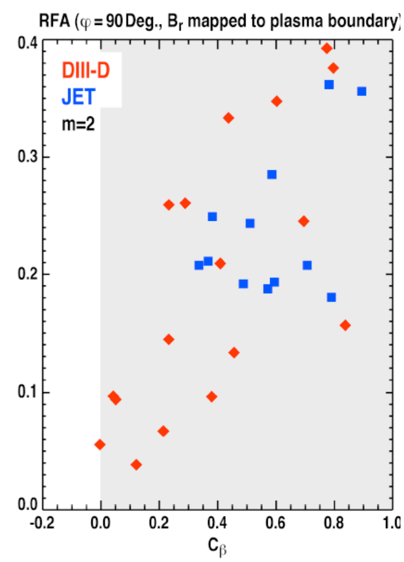
4. *Devices that contributed to the Experiment:-* JET, DIII-D

5. *Time Periods:-* Dec 03-Feb 04 (JET), April 04 (DIII-D)

6. *Experiment's Purpose and Goals:-* To study the size scaling of RWM damping through comparisons on resonant field amplification and critical velocity for RWM stabilization.

7. *Principal Results:-* A good match between DIII-D and JET was achieved in terms of plasma shape, q and pressure profile. The rotation profile was rather more peaked in DIII-D. Experiments were performed to measure resonant field amplification (RFA) from externally applied error fields (using the C-coils on DIII-D and the EFCCs on JET). Direct comparison of the RFA indicates smaller values in JET than DIII-D at the same C_β [C_β= (β_N- β_N(no wall))/(β_N (with wall)- β_N (no wall)]. However there are geometric differences in the relative distances of the detector coils in JET and DIII-D and when this effect is taken into account (using a simple cylindrical model) there seems to be relatively good agreement between the RFA values (see RHS figure). Further verification of the geometric corrections will made using the MARS code.





8. *Executive Summary:-* Initial RWM experiments between JET and DIII-D indicate good agreement on the variation of resonant field amplification with normalized β. Further studies including JET, DIII-D, NSTX, JT60-U and TEXTOR are planned in 2005.

ITPA-IEA Joint Experiments Report

1. **MDC-3 Joint experiments on neoclassical tearing modes (including error field effects)**

2. *Topical group:-* MHD

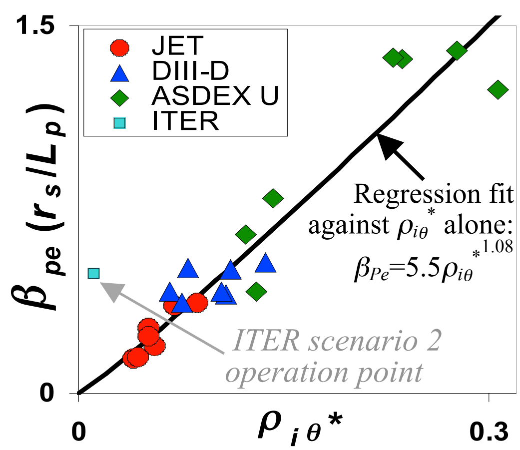
3. *Contact Persons for the Experiment :-* R Buttery (JET), M Maraschek (AUG), R La Haye (DIII-D), A Isayama (JT60-U)

4. *Devices that contributed to the Experiment:-* AUG, DIII-D, JET, JT60-U

5. *Time periods:-* Spring 04 (DIII-D), Winter 04 (JET)

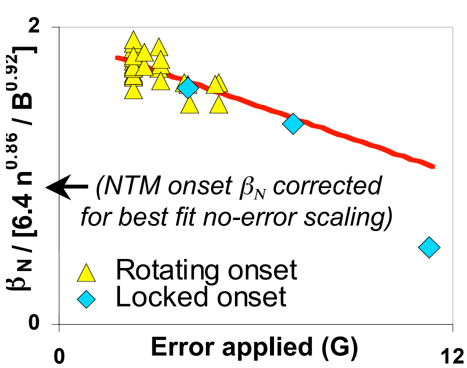
6. *Experiment's Purpose and Goals:-*Cross machine experiments on the scaling of the critical β (below which the NTM is unconditionally stable) for 3/2 and 2/1 NTMs. Also examine the effects of error fields on triggering 2/1 NTMs.

7. *Principal Results:-* New cross-machine experiments have been executed on JET, DIII-D and ASDEX Upgrade, to study the critical β below which the 3/2 NTM is unconditionally stable. Results show a clear trend with the metastability β threshold (see LHS figure, plotted in local parameters related to the underlying NTM bootstrap drive) falling with normalized poloidal ρ^*. Preliminary analysis also suggests that scale lengths for small island stabilization terms do not vary substantially with $\rho_{i\theta}^*$ [Buttery et al IAEA 2004]. Experimental data on 3/2 NTMs from power rampdown studies is also available from JT60-U and will be included in the analysis.



2/1 critical β experiments started on JET, AUG and DIII-D. The JET and DIII-D experiments have problems with H-L transition being coincident the NTM stabilization (and so further experiments on JET are proposed in 2005).

A further influence on 2/1 NTM thresholds originates from error fields (which arise from design asymmetries in a tokamak). On JET, deliberately applied error fields lowered 2/1 NTM β_N thresholds by ~35% and caused them to start in a locked state. This indicates that the two drives for island growth combine, with increased error field sensitivity (and plasma braking) at high β_N. A similar effect is seen on DIII-D (RHS figure),



Effect of applied error field on 2/1 NTM threshold on DIII-D.

although in this case there is a substantial region of lower NTM β thresholds with the mode still formed rotating. This suggests a more subtle mechanism, with the error field altering the NTM drive.

8. *Executive Summary:-* Cross machine experiments on AUG, DIII-D and JET show critical β for 3/2 NTMs ~ρ^*. For 2/1 NTMs results confused by H-L transitions. Error fields lower 2/1 NTM threshold (JET and DIII-D).

ITPA-IEA Joint Experiments Report

1. MDC-4 Neoclassical tearing mode physics - aspect ratio comparison

2. *Topical group:*- MHD

3. *Contact Persons for the Experiment :*- M Maraschek (AUG), R Buttery (MAST)

4. *Devices that contributed to the Experiment:*- AUG, MAST

5. *Time periods:*- N/A

6. *Experiment's Purpose and Goals:*-Determine aspect ratio effects on NTM stability through identity type experiments

7. *Principal Results:*- There were no direct experiments in this area yet. However, other coordinated experiments between AUG and MAST have established a suitable equilibrium match, which now needs to be extended to higher β, once a new faster vertical stability controller becomes available.

8. *Executive Summary:*- A suitable equilibrium match between AUG and MAST has been achieved and NTM experiments are anticipated in 2005.

ITPA-IEA Joint Experiments Report

1. MDC-5 Comparison of sawtooth control methods for neoclassical tearing mode suppression

2. *Topical Group:*- MHD
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8. *Executive Summary:*- There were no experiments on this area in 2004. There were a significant number of experiments in 2003 (AUG, JET and DIII-D), reported in detail to last year's IEA/ITPA coordinated experiments meeting. Further experiments are planned on DIII-D, NSTX, JET, TCV and HL2A in 2005.

ITPA-IEA Joint Experiments Report

1. MDC-6 Low beta error field experiments

2. *Topical Group:-* MHD

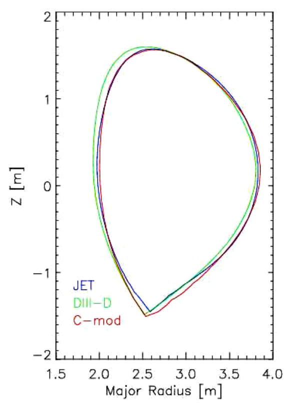
3. *Contact Persons:-*S Wolfe (C-Mod), T Scoville (DIII-D), T Hender and D Howell (JET)

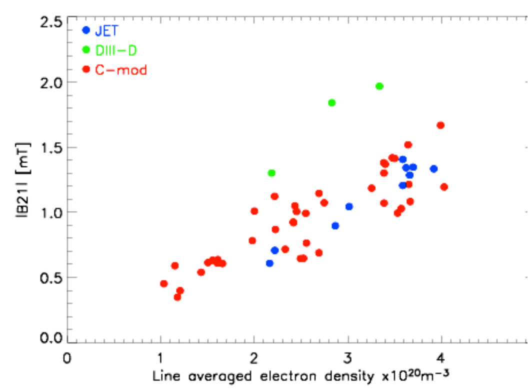
4. *Devices that contributed to the Experiment:-*C-Mod, DIII-D and JET

5. *Time Periods:-*Nov 03-Feb 04 (JET), Dec 03 – April 04 (C-Mod), April –July 04 (DIII-D)

6. *Description of the Experiment's Purpose and Goals:-*Perform an error field identity experiment to unambiguously determine error field threshold size scaling.

7. *Principal Results:-*In 2004 a non-dimensional error field scaling experiment was completed on Alcator C-Mod, DIII-D and JET. A good equilibrium match in terms of plasma shape and q was achieved. The flexibility of the error field coil systems on C-Mod and DIII-D was exploited to give a good match between the harmonic spectra of the error field on the 3 devices. The intrinsic error (with a spectrum which is treated as unknown) was accounted for by taking data with several phases for a given applied spectrum (this is less of an issue for JET where the intrinsic error is relatively small). At matched ρ* and ν* the density and temperature profiles scaled as (na^2 and $Ta^{0.5}$) match well. The figure to the right shows 2/1 error threshold for the 3 devices scaled to C-Mod parameters ($n \propto a^{-2}$ and $b(2,1)_{threshold} \propto B_t$). C-Mod and JET agree rather well, while DIII-D has a larger threshold. The origin of this discrepancy is under investigation. An outstanding issue is the B_t scaling on C-Mod (included in the C-Mod miniproposal but not studied); the inferred B_t scaling of the error threshold on C-Mod (from unrelated pulses) shows a possibly weaker scaling. This needs to be investigated to complete the study (along with resolving the discrepancy for the DIII-D results).





Not anticipated when this proposal was made in 2003 was the availability of error field coils on MAST. It is found that the spectra of the applied error fields is very similar with DIII-D and further that the unscaled plasma cross section agrees well between MAST and DIII-D. This has allowed a preliminary aspect ratio scaling to be estimated.

8. *Executive Summary:-* Experiments conducted on C-Mod, DIII-D and JET in first _ of 2004. T.Hender visited C-Mod and D.Howell DIII-D. Error thresholds for identity matched pulses on JET and C-Mod agree well, while DIII-D is higher; origin of this discrepancy is under investigation.

ITPA-IEA Joint Experiments Report

1. **MDC-7 Improving NTM modelling/extrapolation to ITER**

2. *Topical Group:-* MHD

3. *Contact Persons:-*H Zohm, R La Haye, A Isayama

4. *Devices that contributed to the Experiment:-* This is not directly experimental but is rather a coordinated analysis exercise. Data so far used is from AUG, DIII-D, JET and JT60-U.

5. *Time Periods:-* N/A

6. *Description of the Experiment's Purpose and Goals:-* To agree a common benchmarked (Rutherford type model) for NTM growth (including ECCD effects), thus allowing prediction of current drive requirements for NTM control in ITER.

7. *Principal Results:-* The main results of this exercise are summarized in the Tokamak Physics Basis section 3.2.2.4. Data from DIII-D (subsequently supplemented by data from AUG, JT60-U and JET) is used to predict the coefficients in the modified Rutherford equation. This benchmarking has been performed without and with (for AUG and DIII-D) ECCD NTM stabilization. There are some issues with q_{95} variation across the dataset and ASDEX upgrade has scheduled new experiments at lower edge-q (3.3 instead of 4.4). The results show that the proposed ITER 20MW, 170GHz ECCD system is adequate to substantially control the 2/1 NTM. Precise alignment and modulation of the RF power would leave enough power for 3/2 NTM control too. Further refinement to the model to include the effect of the ECCD on delta-primed is still needed and may lead to a more favorable result. Equivalent fitting to the modified Rutherford equation for JT60-U alone gives a somewhat higher estimated power of 30MW of ECCD for 3/2 and 2/1 NTM stabilization in ITER, which can be reduced to 12MW by optimization of the injection angle.

This is an important area which will be continued as a focussed study by the ITPA MHD Topical Group, but it will not be proposed as a coordinated experiment for 2005.

8. *Executive Summary:-* An NTM stability model benchmarked against DIII-D, AUG and JET suggests the ITER ECCD system should be able to substantially control the dangerous 2/1 NTM.

ITPA-IEA Joint experimental reports for CY2004
(ITPA: Steady State Operation group, Chair G. Sips)

The following experiments are reported:

SSEP-1.1	**Document performance boundaries for the agreed current profile in steady state scenarios**
SSEP-1.2	**Assess other promising scenarios with different q profiles in steady state scenarios**
SSEP-1.3	**Extension of duration of high bootstrap fraction discharges in steady state scenarios**
SSEP-1.4	**Investigate generation and sustainment of ITBs at large radius in steady state scenarios**
SSEP-1.5	**Investigations of Te/Ti effect on confinement in steady state scenarios**
SSEP-2.1	**Complete mapping existence domain in q and density in hybrid scenarios**
SSEP-2.2	**Compare effects of tearing modes, fishbones, and sawteeth in hybrid scenarios**
SSEP-2.3	**Investigations of Te/Ti effect on confinement in hybrid scenarios.**

ITPA-IEA Joint Experiment Report: SSEP1.1

Document performance boundaries for the agreed current profile in steady state scenarios.

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG)***
Contact Persons: J. Hobirk, A. Hubbard, S. Ide, X. Litaudon, T. Luce
Devices involved and time period: DIII-D->AUG (April, 2004), AUG->DIII-D (May, July, August, 2004), DIII-D->JT-60U (January 2004)
Experiment's purpose and Goals: The objective of the ITER Steady state scenario is 100% non-inductive operation at Q>5. Joint experiments are proposed to probe the performance limits of present scenarios with the following specifications on the q profile: q_{95}=4-5, q_{min} = 2+-0.5, $q_{(0)}$ -q_{min}~0.5. Discharges with this profile have demonstrated β_N>3 and f_{BS}>0.5 and are at present the most promising for ITER. It is important to assess the reproducibility of such discharges in several machines and to map the existence domain. Performance includes the assessment of the potential for each machine to achieve fully non-inductive operation with that q profile.

Principal Results:
AUG: a scenario similar to the one developed in DIII-D has been established with promising results: high beta (β_N=3, q_{95}~4.3 at 1MA/2.35T with qmin~1.5-2) and 80% full current drive. Such discharges seem very steady with very weak ITBs.
C-MOD: no joint experiments were performed since the LHCD system was not available in 2004.
DIII-D: A full non-inductive demonstration discharge has been established: q_{min}>1.5, pressure at the no-wall pressure limit (β_N~3.5), high bootstrap current (f_{BS}~0.6, f_{NI}~100%) and q_{95}~5 as foreseen for ITER. Note that a detailed analysis shows full non-inductive current. A series of studies on influence of q_{min}, pressure profile and shaping has been done. In particular the maximum sustained β_N decreases as q_{min} increases and the achieved β_N limits decrease strongly as the pressure profile becomes more peaked. Both results agree with theoretical predictions.
JET: Due to various technical problems, a scenario to study performance limits (with present heating & CD capability) has not been further developed
JT-60U: scenarios that were established in the past have been re-established in magnetic configurations similar to the prescribed one: weak shear configurations and q_{min}~1.5 at 1MA, 2.4T. Plasmas with high performances have been established: plasmas with f_{BS}~45% have been sustained for 5.8s (~2.8t_R) under nearly full CD (q_{95}~4.5): β_N~2.4 (β_p~1.75), f_{CD}>90% (f_{BS}~50-43%, f_{BD}>52-47%), $H_{H98(y,2)}$~1.0. No NTMs activity was observed.

Executive Summary: Very substantial progress has been made in most machines. Full or close to full non-inductive discharges at high beta have been developed in weak shear configurations (1.5<q_{min}<2). Mapping of the existence domain has started. Several effective joint experiments have taken place.

ITPA-IEA Joint Experiment Report SSEP 1.2

Assess other promising scenarios with different q profiles in steady state scenarios

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG)***

Contact Persons: X. Litaudon, S. Ide, C. Greenfield

Devices involved and time period: JET, JT-60U, JET->DIII-D (August, 2004)

Experiment's purpose and Goals: Experiments with q profiles different from the weak shear current profile leading to high beta operation have realized fully non-inductive sustainment and have achieved high H values. In particular discharges with strong reversed shear configurations (even with current holes) are candidate profiles for steady state operation. The purpose of joint experiments is to test consistency of these discharges with Q>5 in burning plasma conditions: beta limits, confinement of energetic particles, impurity accumulation, controllability.

Principal Results

JET: Discharges with current holes have been developed during the pre-heat phase leading to the development of two barriers; the inner ITB is in the negative shear area while the outer ITB in the positive shear area (close to q=2 or 3). A too strong inner ITB could lead to current hole re-formation and a subsequent disruption. Interesting transport experiments have been done with "current hole" type plasmas in the trace tritium campaign showing that the confinement of alphas was degraded as compared to standard plasmas at the same plasma current. A quantitative evaluation was given.

JT-60U: Reversed shear configurations with I_p=0.8MA, B_t=3.4T, q_{95}~8.6, δ~0.42 resulting in f_{BS}=75%have been sustained for 7.4s (2.8t_R) with almost full current drive. Very high confinement was achieved: H_{98}=1.7 and β_N=1.7. In this type of discharges, ITB control is a key issue, in particular to avoid a too large central zone with low plasma current and therefore low energetic particle confinement. As well ∇Ti reduction at the ITB using rotation control is essential to achieve long pulse duration. Similar experiments are planned in future aiming at operating with q_{95} in the range of 5-6.

DIII-D: Attempts to form and sustain current hole discharges with neutral beams alone or in conjunction with ECH showed that current holes could be formed and maintained for short periods with an H-mode edge. Attempts to sustain the current hole for long duration were unsuccessful. The duration was limited by MHD stability.

Executive Summary: A significant development has taken place in JT-60U and JET. Some operational limits have been studied: energetic particles confinement. Controllability is a key issue. Although exchange of information has taken place, the only joint experiments were between JET and DIII-D (on-site and remote participation).

ITPA-IEA Joint Experiment Report SSEP1.3

Extension of duration of high bootstrap fraction discharges in steady state scenarios

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG. From TP-2)***
Contact Persons: S. Ide, X. Litaudon, T. Luce
Devices involved and time period: DIII-D, JT-60U, JET
Experiment's purpose and Goals: One of the key aspects of steady state operation is the presence of a large bootstrap fraction: at least 50% and likely more. Since the bootstrap current is generated by pressure gradients, therefore quite difficult to control, it is important to asses the capability of steady state scenarios to operate for long duration with a high bootstrap fraction still maintaining the necessary current profile. In addition, some new scenarios are proposed to operate at very large bootstrap fraction. Operational limits in such scenarios are clearly important in order to assess their applicability to ITER or to future reactors.

Principal Results
DIII-D: A transformer-less operation shows control of high bootstrap fraction plasmas will be challenging. High beam power was applied early in the current ramp-up phase in a ~ 0.6MA plasma without any inductive drive, the plasma was moving toward its "natural" equilibrium over 4 seconds. At high safety factor (q_{95}~10) and high q_{min}(~3), a bootstrap fraction higher than 80 % has been maintained for as long as the beam power was applied. β_N was continuously increasing up to 3.3. Oscillations in the total current and pressure were observed, limited by stability.
JET: Simultaneous integrated real-time control on current profile and on electron temperature profiles has been developed to optimise the time duration of steady state scenarios. Long lasting ITBs have been attempted at 3T/1.8MA aiming at ~40% bootstrap current and ~40%LHCD combined with ~20% NBCD. Due to the poor conditioning of the walls, the ITB phase is lost ~6s after the application of the full power in the 20s duration discharges. However, 326MJ were injected.
JT-60U: A description of the results with reversed shear plasmas is given in SSEP 1.2. At a lower bootstrap fraction of f_{BS}=45%, but still corresponding roughly to the ITER demand, the maximum pulse length of a steady state type discharge has been extended from 15s to 65s thanks to modifications on controls in operation, H/CD and diagnostics systems, but not on major hardware. Results are given in SSEP1.1.The main control development was to avoid the occurrence of NTMs by optimizing the current profile in trying to align ∇p and q=m/n (3/2,2/1). This was done by feedback control of W_{dia} and by adjusting the timing of the NBI power.

Executive Summary: Development of high bootstrap scenarios is challenging. Good progress in JT-60U (weak shear operation) and in a lesser extent in JET(more reversed shear). Reversed shear in JT-60U successful but q_{95} marginal. Interesting start of transformer less operation in DIII-D. No real joint experiments.

ITPA-IEA Joint Experiment Report SSEP 1.4

Investigate generation and sustainment of ITBs at large radius in steady state scenarios

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG. From TP-2)***

Contact Persons: S. Ide, X.Litaudon, T. Luce

Devices involved and time period: DIII-D, JET, JT-60U

Experiment's purpose and Goals: Energy confinement of steady state scenarios with ITBs is likely to be improved if wide ITBs are produced. As well, wide ITBs will have lower pressure gradients and therefore will be less prone to impurity accumulation and MHD instabilities. A comparison of several techniques to do so is the purpose of joint experiments.

Principal Results:
DIII-D: Steady state scenarios are generally produced without ITBs. However, broader pressure profiles (and higher β_N) have been obtained by broadening the density profile with extra gas puffing.
JET: Wide ITBs have been produced in the current ramp-up phase or in the current plateau phase (at reduced current ~1.7MA) resulting in a lower rate of impurity accumulation. Results are discussed in SSEP 1.2. The development of wide electron and ion ITBs with neon injection at the edge has just started. Results appear promising: at high triangularity (δ~0.5), very wide ITBs (R~3.65-3.7m) close to the H-mode pedestal have been sustained for ~10τ_E but with H_{89}~1.8-2. These barriers survive the H-mode transition if the edge is moderate by neon injection at 1.5MA and if the total power is in excess of ~20MW.
JT-60U: Steady state scenarios are generally developed with wide ITBs. Therefore specific studies were not performed.

Executive Summary: Specific studies to produce wide ITBs started in JET. In JT-60U, wide ITBs are generally produced. Systematic studies and joint experiments remain to be done.

ITPA-IEA Joint Experiment Report: SSEP 1.5

Investigations of Te/Ti effect on confinement in steady state scenarios

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG; From TP-2)***

Contact Persons: F. Crisanti

Devices involved and time period: JET (January 2004)

Experiment's purpose and Goals: Many steady state scenarios are achieved with ITBs. Turbulence stabilisation is thought to be achieved with a combination of shear flow and negative magnetic shear. When Neutral Beam Injection is used, therefore with a substantial injected momentum, ion ITBs are normally produced and shear flow can play an important role. When RF techniques are used (ECRF, ICRF, LHCD), electron ITBs are generated. In ITER, energetic ions (alphas, NBI at 1 MeV and ICRF accelerated minority ions) will not provide an injected momentum as large as in present NBI dominated scenarios with ITBs. It is therefore important to establish if ion ITBs can be produced without injected momentum. When possible, an ICRH scheme allowing ions to be heated can be substituted to NBI power to document this point.

Principal Results:
JET: An ICRH scheme with $^{3}H_e$ minority was selected at B_t=3.45T and I_p=2.5MA. This scheme is the one anticipated for ITER. Up to 6 MW of ICRF (37Mhz) was applied in reversed shear magnetic configuration. An ion ITB was clearly produced (from the ion temperature profile) when the helium concentration was optimised and the ICRF reached its maximum available power. It has been estimated (from the TORIC code) that 50% of the ICRF power was coupled to the ion population. Further quantification of this RF generated ion ITB was prevented due to technical problems.

Executive Summary: An ion ITB has been produced with $^{3}H_e$ minority ICRF without significant momentum injection. More systematic studies needed. It was not a real joint experiment.

ITPA-IEA Joint Experiment Report SSEP2.1

Complete mapping existence domain in q and density in hybrid scenarios

TG: Steady State Operation and Energetic Particles ***(in collaboration with Transport Physics TG)***

Contact Persons: A. Isayama, E. Joffrin, G. Sips, M. Wade, S. Wolfe

Devices involved and time period: JET/AUG, JT-60U->JET (December 2003), AUG->DIII-D (May 2004), DIII-D->JT-60U (January 2004), JET/JT-60U, JET->DIII-D (July, August 2004), DIII-D->AUG (April 2004)

Experiment's purpose and Goals: The objective of the ITER Hybrid scenario is the maximum fluence/pulse. Therefore, there is a trade-off between requirements for high fusion yield (high current operation) and long time duration (lower plasma current). Scenarios leading to hybrid operation in ITER have already been established in several experiments: stationary plasmas with performance equal to the ITER baseline scenario have been obtained at 30% lower equivalent current when a wide area of low magnetic shear can be established. It is important to map the existence domain in terms of safety factor and of density. Performances can be benchmarked against a normalized fusion performance factor: $H_{89}\times\beta_N/ q_{95}^2$ (a value of 0.4 leads to a fusion gain of Q~10 in ITER).

Principal Results:
AUG: A scan of performances has been done for q_{95} varying from a 3-4 range to a 6-7 range. It has been found that AUG needs to operate at higher β_P than ITER to achieve high values of $H_{89}\times\beta_N/q_{95}^2$. Values up to G=0.6 have been achieved for $3<q_{95}<4$ as in DIII-D. A specific scan in density was not done. However, old results have spanned already a significant range in densities.
C-MOD: no joint experiments were performed since the LHCD system was not available in 2004.
DIII-D: Dependence of β_N and H_{89} versus q_{95} have been performed for discharges lasting at least one current diffusion time, showing that G varies from ~0.6 at q_{95}=3.2 to 0.3 at q_{95}=5.A similar dependence of β_N and H_{89} versus density ($0.3<n_e/n_{eGW}<0.7$) shows a much weaker dependence.
JET: Identity experiments between JET and AUG have been successfully done giving similar values in the two devices when the dimensionless parameters (ρ^*, q_{95}, shaping …) have been matched. The hybrid regime has been extended to lower values of ρ^*. A scan in ν^* has just started.
JT-60U: A systematic scan was difficult due to the limitation in B_t following the accident in one of the motor generator. Experiments have mainly aimed at optimizing high beta operation (β_N =3), in particular by minimizing MHD modes (NTMs), and by optimizing the time duration of hybrid discharges at lower beta: $H_{89}\times\beta_N/ q_{95}^2$ >0.4 (β_N =2.5) have been maintained for 15.5 s at q_{95}~3.4.

Executive Summary: The q_{95} scan is almost completed; lower values (with small sawteeth) give maximum $G=H_{89}\times\beta_N/ q_{95}^2$. However, G=0.4 (Q~10 in ITER) achievable with q_{95}~4 (no sawteeth) probably giving best fluence in ITER. Density scan (not completed) shows weak density dependence.

ITPA-IEA Joint Experiment Report SSEP2.2

Compare effects of tearing modes, fishbones, and sawteeth in hybrid scenarios

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG)***

Contact Persons: A. Isayama, E. Joffrin, G. Sips, M. Wade

Devices involved and time period: AUG, DIII-D, JET, JT-60U

Experiment's purpose and Goals: Hybrid scenarios are characterized by current profiles with a wide volume of weak shear and q_0 close to 1. Very often, the current profiles do not seem to vary during the pulse, including for pulse lengths exceeding the current diffusion time. A large variety of mild MHD events (tearing modes, NTMs, TAEs, fishbones, eventually sawteeth) are also observed in such configurations. It is important to assess if thee MHD modes are responsible for the "clamping" of these profiles preventing the current to peak, or if non-inductive current drives are "flattening" the current profile. A quantitative assessment would be necessary for extrapolation to ITER.

Principal Results:
AUG: An interpretative run of the ASTRA code gives values of q_0 significantly below the measured experimental values (MSE+CLISTE). Therefore the evolution of the q profile is not explained by current drive. A systematic study of the energy involved in the NTMs activity ($\Delta W/W$) indicates that the NTMs, which are generated through non-linear mode coupling of (3/2) NTM to (4/3) and (1/1) mode activity, have a negligible impact on performance at high β_N in the hybrid scenarios.
DIII-D: Sawteeth behaviour distinguishes hybrid regime from conventional regimes. A proper timing of the heating (early heating) permits to avoid them. Studies have also shown that a 3/2 mode plays a key role in avoidance of sawteeth. This has been evidenced by the use of co-ECCD (suppress the 3/2 mode and sawteeth develop) and counter-ECCD (enhances 3/2 mode and sawteeth do not appear). Central q is raised up to 1.1 when the 3/2 mode amplitude grows.
JET: Fishbones and 3/2 modes are also observed in hybrid scenarios. However, simulation with the CRONOS code indicates that NBCD and bootstrap current are sufficient to explain the steadiness of the current profile.
JT-60U: Experiments have shown the importance of suppressing the NTMs (3/2 mode) that might reduce the achieved β_N by 10-15%. Early ECCD is more effective to suppress the NTMs, in particular by requiring less power. Sawteeth when they exist are small.

Executive Summary: There is a large accumulation of new data with some contradictory conclusions. Assessment of self sustainment of current profile by mild MHD modes not yet possible. A systematic studies with proper joint experiments remains to be done.

ITPA-IEA Joint Experiment Report SSEP2.3

Investigations of Te/Ti effect on confinement in hybrid scenarios.

Steady State Operation and Energetic Particles Topic Group ***(in collaboration with Transport Physics TG)***

Contact Persons: C Gormezano, G.Sips

Devices involved and time period: AUG, JET (Tore Supra, FTU) January 2004

Experiment's purpose and Goals: Most of the hybrid scenarios achieved so far have been produced with mainly Neutral Beam Injection, therefore with dominant ion heating and also with a substantial injected momentum. In ITER, energetic ions (alphas, NBI at 1 MeV and ICRF accelerated minority ions) will mainly deliver their energy to the electrons. As well, the injected momentum will be low. It is therefore important to establish if hybrid scenarios can maintain their performance once electron heating is dominant. It is also important to assess if the key element in producing hybrid scenarios is the wide low magnetic shear volume and not injected momentum. When possible, ICRH or ECRF can be substituted to NBI power to document these points.

Principal Results:
AUG: Hybrid discharges have been produced with as much ICRF power as possible (5MW) at q_{95}=3.6. NBI power (~5MW) was also used to control β_{pol}: some occasional trips of ICRF were therefore compensated with NBI power. A small (5%) reduction in $H_{89}\times\beta_N$ was observed but impurity accumulation was avoided. However a detailed analysis of the ICRF power deposition (TORIC+ Fokker-Planck ASTRA) has shown that in these discharges central ion heating from NBI and ICRF was still dominant (up to 75%).
JET: Hybrid discharges have been produced with dominant RF heating systems: 10.5 MW of ICRF, 1.5MW of LHCD, 8MW of NBI at Bt=3.2T, Ip=2.6 MA q95=4 for ~6s. q profiles and MHD events were very similar to NBI dominated hybrid discharges. However, β_N reached only a value of 1.5 due to the limits in available power and beta limits were not tested. H_{89} values of 2 were obtained in spite of a very low pedestal and mild type III Elms in these RF dominated discharges..

Executive Summary: Some experiments substituting RF to NBI started in JET and AUG. No obvious influence on confinement. Beta limits not tested (JET). Impurity accumulation arrested (AUG). No real joint experiments between main devices. A more systematic study still needed.

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FOREWORD

ITER Physics Basis

The Nuclear Fusion journal, its Board of Editors and the International Atomic Energy Agency are pleased to present in the following pages the ITER Physics Basis, a comprehensive and scholarly account of the scientific analysis supporting the design of ITER – the International Tokamak Experimental Reactor – as of mid 1998. This publication is a milestone for Nuclear Fusion, the IAEA and ITER because it is the first time that a comprehensive account of science behind this large international project in fusion energy development reached the peer reviewed literature. It provides the international community with a survey and review of the tokamak physics relevant to next step fusion experiments.

Consistent with standard policy at Nuclear Fusion, a minimum of two anonymous referees examined the manuscript, and, consistent with the normal unfolding of events, significant changes were recommended, accepted, and implemented. For this particular project each chapter was reviewed by two or three referees, each of whom was on the Board of Editors while being otherwise anonymous.

In addition to copies of the entire work, bound and covered reprints of Chapter 1 are available.

D.W. Ignat,
Editor, Nuclear Fusion, for the journal, the Board of Editors, and the IAEA
Vienna, Austria

This publication of the ITER Physics Basis was conceived in 1997 and executed in 1998 and 1999 with the advice of external reviewers. The numerous contributors to this document have sought to draw together and to codify the current status of theoretical and experimental understanding of the physics of magnetically confined plasmas, as a basis for the design of a major next step fusion experiment aimed at demonstrating the scientific and technological feasibility of fusion energy for peaceful purposes.

While the wish to establish a wide ranging and rigorous physics basis for ITER motivated and oriented the work, the resulting interactions among the world's leading magnetic fusion experimentalists and theoreticians have yielded a body of information presented here that may be applied beyond the domain of the ITER project to general developments in the field of fusion energy research.

Work for ITER now focuses on the development of options for lowering the costs whilst still serving ITER's overall programmatic goal. The foundations of all such activity rest squarely on the physics basis and on the efforts of those who continue to develop theoretical understanding and to extend the experimental domains and databases in response to the project's needs.

As ITER Director I should like to express my appreciation and gratitude to all the contributors to this document for their past, present and continuing work on behalf of ITER. In particular, I should thank the nine chapter editors for their dedicated efforts to synthesize coherently the many and varied inputs as well as the editors, staff and referees of Nuclear Fusion for providing the means to present this vital element of the ITER project to a wider public.

R. Aymar,
ITER Director

Distribution of Editorial Responsibilities

Ch.	Title	Responsible TGs	Editors, Chairs and Cochairs (†: language, *: reference)
1	Overview and Summary	M. Shimada, V. Mukhovatov and Editors	M Fujiwara, N Uckan†, M. Shimada*, V. Mukhovatov
2	Plasma confinement and transport	Transport, CDB&M, Pedestal&Edge	N Kirneva, M Nagami, E. Doyle†, W. Houlberg†, Y. Kamada, A. Leonard†, V. Mukhovatov, A. Polevoi*
3	MHD stability, operational limits and disruptions	MHDD&C, Pedestal&Edge (ELM)	V Pustovitov, J Wesley†, O. Gruber, Y. Gribov*
4	Power and particle control (including tritium retention issues)	Divertor&SOL, Pedestal&Edge (ELM)	K Lackner, M Shimada, N. Asakura*, B. Lipschultz†
5	Physics of energetic ions	SSO&EP	D Campbell, N Uckan, C. Gormezano†, S. Ide*
6	Steady-state operation (including heating and current drive)	SSO&EP, Transport	M Fujiwara, N Kirneva, C. Gormezano†, S. Ide*
7	Measurement of plasma parameters	Diagnostics	D Campbell, M Nagami, T. Donne, A. Costley†*
8	Plasma operation and control	MHD, Diagnostics, SSO&EP, Divertor & SOL (wall conditioning)	V Pustovitov, J Wesley†, O. Gruber, Y. Gribov*
9	Opportunities for reactor scale experimental physics	IT Physics Unit (M. Shimada)	K Lackner, N Uckan†, M. Shimada, V. Mukhovatov*

5 July 2004, Prepared by M Shimada

1. Editorial Meetings will be held in Naka in September and December 2004. If necessary, an additional Editorial Meeting may be planned.
2. Editing responsibility resides in Chairs and Cochairs of the relevant TGs, including response to the Referee's comments.
3. Editors, Chairs and Cochairs are responsible for the technical integrity of each chapter. Members marked with † are requested to make correction of the language.
4. The format of reference in the text should be like [Shimada 2003] during the editing process. The reference will be formatted in the Nuclear Fusion style after the manuscript is accepted by Nuclear Fusion by those marked with *.
5. The Chief Editor (M. Shimada) and Deputy Chief Editor (V. Mukhovatov) will coordinate this editorial work and will check the consistency among the chapters.

Recent ITPA Publications

Journal/ID	Author	Title
IAEA IT/1-1	M. Shimada	Progress in Physics Basis and its Impact on ITER
IAEA IT/1-2	G. Saibene	Dimensionless Identity Experiments in JT-60U and JET
IAEA IT/P3-19	A. Donne	Progress with High Priority R&D Topics in Support of ITER/BPX Diagnostics Development
IAEA IT/P3-29	M. Sugihara	Analysis of disruption scenarios and their possible mitigation in ITER
IAEA IT/P3-32	G. Cordey	The Scaling of Confinement in ITER with Beta and Collisionality
IAEA IT/P3-33	W. Houlberg	Integrated Modeling of the Current Profile in Steady-State and Hybrid ITER Scenarios
IAEA IT/P3-34	A. Loarte	Expected energy fluxes onto ITER Plasma Facing Components during disruption thermal quenches from multi-machine data comparisons.
IAEA IT/P3-35	Y. Martin	H-Mode Threshold Power Dependences in ITPA Threshold Database
IAEA IT/P3-36	A.C.C. Sips	Study of Advanced Tokamak Performance Using the International Tokamak Physics Activity Database
Nucl. Fusion **44**, 1067-1074 (2004)	K.A. Razumova	Reduced Core Transport in T-10 and TEXTOR Discharges at Rational Surfaces With Low Magnetic Shear
IAEA IT/P3-37	J. Kinsey	Transport Modelling and Gryokinetic Analysis of Advanced High Performance Discharges
IAEA EX/7-1	R. Buttery	Cross-Machine NTM physics and implications for ITER
IAEA-CN-94/CT-3	T.H.Osborne, J.G.Cordey, et al	Characteristics of the H-mode Pedestal and Extrapolation to ITER
PPCF 2004	M. Sugihara	Edge safety factor at the onset of plasma disruption during VDEs in JT-60U
PPCF 2004	M. Sugihara	Scaling of H-mode edge pedestal Pressure for a Type-I ELM Regime in Tokamaks
EPS 2004	R. Buttery	NTM Paper

Publications ITPA TG on Diagnostics 2003-2005

Publications in peer-reviewed journals

A.J.H. Donné and A.E. Costley
Key issues in Diagnostics for Burning Plasma Experiments
IEEE Transactions on Plasma Science 32 (2004) 177 – 186

M. Sasao, A.V. Krasilnikov, T. Nishitamni, P. Batistoni, V. Zaveriaev, Yu.A. Kaschuk, S. Popovichev, T. Iguchi, O.N. Jarvis, J. Kallne, C.L. Fiore, R. Fisher, L. Roquemore, W.W. Heidbrink, A.J.H. Donné, A.E. Costley and C. Walker
Overview of neutron and escaping alpha diagnostics planned for ITER
Plasma Phys. Control. Fusion 46 (2004) S107 - S118

A. Malaquias, M. von Hellermann, S. Tugarinov, P. Lotte, N. Hawkes, M. Kuldkepp, E. Rachlew, A. Gorshkov, C. Walker, A. Costley, G. Vayakis
Active Beam Spectroscopy Diagnostics for ITER: Present status
Rev. Sci. Instrum. 75 (2004) 3393 – 3398

Conference proceedings

A.J.H. Donné, A.E. Costley, H. Bindslev, R. Boivin, R. Giannella, D. Johnson, H. Hartfuss, M. von Hellermann, E. Hodgson, L.C. Ingesson, K. Itami, Y. Kawano, A. Kislyakov, A. Krasilnikov, T. Kondoh, Y. Kusama, A. Malaquias, G. McKee, T. Nishitani, F. Orsitto, R.A. Pitts, G. Razdobarin, J. Sanchez, M. Sasao, F. Serra, V. Strelkov, T. Sugie, G. Vayakis, V. Voitsenya, K. Vukolov, C. Walker and V. Zaveriaev
Progress with High Priority R&D Topics in support of ITER/BPX Diagnostic Development
Proc. 20th IAEA Fusion Energy Conference, Vilamoura, Portugal, 1 - 6 November 2004, paper IT/P3-19

M. Shimada, D. Campbell, R. Stambaugh, A. Polevoi, V. Mukhovatov, N. Asakura, A.E. Costley A.J.H. Donné, E. Doyle, G. Federici, C. Gormezano, Y. Gribov, O. Gruber, W. Houlberg, S. Ide, Y. Kamada, A.S. Kukushkin, A. Leonard, B. Lipschultz, S. Medvedev, T. Oikawa and M. Sugihara

Progress in Physics Basis and its Impact on ITER
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M. Sasao, A.V. Krasilnikov, Yu.A. Kaschuk, T. Nishitani, P. Batistoni, V.S. Zaveriaev, S. Popovichev, T. Iguchi, O.N. Jarvis, J. Kallne, C.L. Fiore, L. Roquemore, W.W. Heidbrink, R. Fisher, G. Gorini, A.J.H. Donné, A.E. Costley and C.I. Walker
Status of ITER Neutron Diagnostic Development
Proc. 20th IAEA Fusion Energy Conference, Vilamoura, Portugal, 1 - 6 November 2004, paper PC/P3-23

A.J.H. Donné and A.E. Costley
Diagnostics for ITER: a Challenging Scientific Endeavour
Proc. 2nd Japan-Korea Seminar on Advanced Diagnostics for Steady-State Fusion Plasmas, Daejon, Korea (2004), pp. 133-146.

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High priority R&D issues in the field of ITER diagnostics
Proc. German-Polish Conference on Diagnostics of Plasmas, Cracow, Poland, (2004)

ITER ITA Newsletter

A.E. Costley and A.J.H. Donné
Fourth Meeting of the ITPA Topical Group on Diagnostics
ITER ITA Newsletter 3, (2003) 3-6

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Fifth Meeting of the ITPA Topical Group on Diagnostics
ITER ITA Newsletter 9, (2003) 4-6

A.E. Costley and A.J.H. Donné
Sixth Meeting of the ITPA Topical Group on Diagnostics
ITER ITA Newsletter 15, (2004) 5-9

A.E. Costley and A.J.H. Donné
Seventh Meeting of the ITPA Topical Group on Diagnostics
ITER ITA Newsletter 19, (2005) 3-6

ITPA Confinement Database and Modeling Topical Group
Publications 1 April 2003 – 1 April 2005
(Note that many of these publications are joint with other ITPA TGs)

Journal Articles

J.G. Cordey for the ITPA H-Mode Database Working Group* and the ITPA Pedestal Database Working Group**, (*Alcator C-Mod: J.A. Snipes, M. Greenwald; ASDEX/ASDEX Upgrade: F. Ryter, O.J.W.F. Kardaun, J. Stober; COMPASS-D/MAST/START: M. Valovic, A. Sykes, A. Dnestrovskij, M Walsh; DIII-D: J.C. DeBoo, T.N. Carlstrom; FTU: G. Bracco; JET/EFDA: E. Righi, J.G. Cordey, K. Thomsen, D. McDonald; JFT-2M/ JT-60U: Y. Miura, K. Shinohara, K. Tsuzuki, T. Fukuda, Y. Kamada, T. Takizuka, H. Urano; PBX-M/ PDX/TFTR: S.M. Kaye, C. Bush; TCV: Y. Martin; TdeV: A. Cote, G. Pacher; TEXTOR: J. Ongena; TUMAN-3M: S. Lebedev; T-10: A. Chudnovskiy. **Alcator C-Mod: A. Hubbard; ASDEX Upgrade: W. Suttrop, L.D. Horton; DIII-D: T.H. Osborne; ITER JCT: G. Janeschitz, M. Sugihara; JT-60U: T. Hatae, Y. Kamada), "A two-term model of the confinement in ELMy H-modes using the global confinement and pedestal databases ,"*Nucl. Fusion* **43** (2003) 670-674.

V. Mukhovatov, Y. Shimomura, A. Polevoi, M. Shimada, M. Sugihara, G. Bateman, J.G. Cordey, O. Kardaun, G. Pereverzev, I. Voitsekhovich, J. Weiland, O. Zolotukhin, A. Chudnovskiy, A.H. Kritz, A. Kukushkin, T. Onjun, A. Pankin, F.W. Perkins, "Comparison of ITER performance predicted by semi-empirical and theory-based transport models," *Nucl. Fusion* **43** (2003) 942-948.

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C.C. Petty, T.C. Luce, J.G. Cordey, D.C. McDonald, R.V. Budny, "Similarity in H-mode confinement: ν_* rather than n/n_{limit} should be kept fixed," *Plasma Phys. Control. Fusion* **46** (2004) A207-A213.

D. McDonald, J.G. Cordey, C.C. Petty, M. Beurskens, R. Budny, I. Coffey, M. de Baar, C. Giroud, E. Joffrin, P. Lomas, A. Meigs, J. Ongena, G. Saibene, R. Sartori, I. Voitsekhovitch, and JET EFDA contributors, "The beta scaling of energy confinement in ELMy H-modes in JET," *Plasma Phys. Control. Fusion* **46** (2004) A215-A225.

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G. Saibene, N. Oyama, Y. Andrew, J.G. Cordey, E. de la Luna, C. Giroud, K. Guenther, T. Hatae, G.T.A. Huysmans, Y. Kamada, M.A.H. Kempenaars, A. Loarte, J. Lönnroth, D. McDonald, A. Meiggs, M.F.F. Nave, V. Parail, R. Sartori, S. Sharapov, J. Stober, T. Suzuki, M. Takechi, K. Toi, H. Urano, "Dimensionless identity experiments in JT-60U and JET," 20th IAEA Fusion Energy Conference, Vilamoura, Portugal, Nov 2004, IT/1-2.

J.G. Cordey, J.A. Snipes, M. Greenwald, L. Sugiyama, O.J.W.F. Kardaun, F. Ryter, A. Kus, J. Stober, J.C. DeBoo, C.C. Petty, G. Bracco, M. Romanelli, Z. Cui, Y. Liu, J.G. Cordey, K. Thomsen, D.C. McDonald, Y. Miura, K. Shinohara, K. Tsuzuki, Y. Kamada, T. Takizuka, H. Urano, M. Valovic, R. Akers, C. Brickley, A. Sykes, M.J. Walsh, S.M. Kaye, C. Bush, D. Hogewei, Y. Martin, A. Cote, G. Pacher J. Ongena, F. Imbeaux, G.T. Hoang, S. Lebedev, A. Chudnovskiy, V. Leonov, "The scaling of confinement in ITER with β and collisionality," 20th IAEA Fusion Energy Conference, Vilamoura, Portugal, Nov 2004, IT/P3-32.

W.A. Houlberg, C. Gormezano, J.F. Artaud, E. Barbato, V. Basiuk, G. Bateman, A. Becoulet, P. Bonoli, L.G. Eriksson, A. Fukuyama, Yu. Gribov, F. Imbeaux, J. Kinsey, A. Kritz, V. Leonov, M. Murakami, A. Polevoi, R. Prater, H.St. John, "Integrated modeling of the current profile in steady-state and hybrid ITER scenarios,"20th IAEA Fusion Energy Conference, Vilamoura, Portugal, Nov 2004, IT/P3-33.

Y.R. Martin, J.A. Snipes, M. Greenwald, F. Ryter, O.W.F. Kardaun, J. Stober, M. Valovic, J.C. DeBoo, Y. Andrew, J. Cordey, R. Sartori, K. Thomson, T. Takizuka, Y. Miura, T. Fukuda, Y. Kamada, K. Shinohara, K. Tsuzuki, S.M. Kaye, C. Bush, R. Maingi, S. Lebedev, "H-mode threshold power dependences in ITPA threshold database,"20th IAEA Fusion Energy Conference, Vilamoura, Portugal, Nov 2004, IT/P3-35.

LIST OF ITPA DATABASES

DATABASE	TG	COMMENT
International Diagnostic DB	Diagnostics	Information on 119 diagnostics from 15 machines.
Radiation Effects Database	Diagnostics	
Disruption DB	MHD	
DB on Steady State Scenarios	SSO	
ITB DB	Transport Physics	
Transition DB	CDB & M	
Energy Confinement Time DB	CDB & M	
Profile DB	CDB & M	
Pedestal Scalar DB	Edge Pedestal	
Pedestal DB	Edge Pedestal	
ELM DB	SOL & Divertor	