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ITER PHYSICS R&D

by Dr. F. Perkins, Head of the Physics Integration Unit, ITER San Diego Joint Work Site

Perhaps the most striking feature of ITER is that it is simply a lot larger than any existing tokamak - almost a factor-of-three in linear dimensions in comparison with the largest existing tokamaks. This simple fact has a simple consequence - that projections of ITER performance and margin for ignition call for extrapolation of data from present tokamaks to ITER via physics principles which preferably both rest on established theory and have been validated by experiment. Physics work in the base experimental and theoretical research programs of the four ITER Parties is a crucial part of the validating Research and Development required for ITER. This research is undertaken at the discretion of each Party as an integral part of its domestic fusion program outside of the framework set up by the ITER Council for the implementation of technology R&D and design tasks for ITER.

Each of the Parties has designated a person (or two people in the case of Japan) to interact with the ITER Director on Physics for ITER. To help oversee the Physics activities, the ITER Physics Committee has been established, chaired by the Director, and comprising the Designated Persons and the Head of the Physics Integration Unit, with the participation as experts of the TAC Chair, eight senior scientists from the Parties, the Chairs of Physics Experts Groups and senior physicists from the JCT.

Although the Outline Design provides sufficient margin to assure fulfilment of ITER's mission under moderately pessimistic projections, extrapolation principles must be established across a broad front of tokamak physics to gain confidence in how ITER will operate and to design specific components, notably the ITER divertor. The very broadness of this front calls for efficient contributions from existing research facilities and a sharing of the needed research among the Parties within a co-operative framework. To guide turning this concept into a reality, the ITER Director, in consultation with the ITER Physics Committee, has created seven Expert Groups in various disciplinary areas of tokamak physics. These Groups, listed in Table 1, have Chairs drawn from the Parties' Physics programs and Co-Chairs from the Joint Central Team.

TABLE 1. ITER EXPERT GROUPS

Disciplinary Area	Chair	JCT Co-Chair
Confinement and Transport Physics	M. Wakatani	V. Mukhovatov
Confinement Database and Modeling	G. Cordey	D. Boucher
Disruptions, MHD, Plasma Control	S.V. Mirnov	J. Wesley
Energetic Particles, Heating, and Current Drive	J. Jacquinot	S. Putvinski
Diagnostics	K. Young	A. Costley
Divertor Physics	R. Stambaugh	G. Janeschitz
Divertor Database and Modeling	M. Shimada	D. Post

The initial mission of the Experts Groups, stated briefly, is to assist the ITER Physics Committee in reviewing, refining and prioritising an initial JCT list of research needs within their disciplinary areas. The Expert Groups will further evaluate whether the research needs can be met by the planned research in the world-wide magnetic fusion research programs, or whether additional efforts are needed. At a roughly annual interval, Expert Group Chairs will report on their deliberations to the ITER Physics Committee. In this way, the leaders of the base programs in the Parties will understand how the research they undertake within their fusion programs fits into ITER's overall research needs. ITER will benefit from the expertise the Group members bring to the formulation of an efficient, shared physics program and from the informal communications that develop among the Parties' physicists.

At this writing, four of seven Expert Groups have met and minutes have been widely distributed through the ITER community.*) The Confinement and Transport Physics Group is a good paradigm. This Group identified two research areas as particularly urgent, requiring resolution by December 1995: (1) Size scaling of confinement and (2) scaling of the H-mode power threshold. Planning is underway to address these issues in a co-ordinated way through major tokamak experiments around the world - JET, JT-60U, ASDEX-U, DIII-D, ALCATOR C-Mod, COMPASS. The global emphasis is particularly valuable here in that it takes tokamaks of different sizes and shapes to definitively establish the scaling principles needed to extrapolate to a device of ITER size.

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*) Persons wishing to receive Expert Group Minutes should contact Ms. Lori Miller at the ITER San Diego Joint Work Site (e-mail: millerl@iterus.org).

DR. ROBERT C. IOTTI

In July 1994, Dr. Robert C. Iotti was appointed the Administrative Officer of the ITER Project. He is responsible for supporting the Director in the management and the administration of ITER.

During his 23-year career with Ebasco he held progressively challenging engineering and management assignments. His technical expertise is wide-ranging, and has been applied to fission power plants, fusion experiments, and accelerators, as well as other advanced energy producing, energy research and physics research projects.

In December 1993, Raytheon acquired some aspects of Ebasco Services. Dr. Iotti became the Vice-President of Nuclear & Advanced Technology Department of Raytheon Engineers & Constructors, Inc.

Dr. Iotti was a member of the US Industry Council for ITER, an advisory group to the US ITER Home Team Leader. He also serves on committees for the American Society of Mechanical Engineers, the American Nuclear Society, and the American Institute of Aeronautics and Astronautics.

He holds bachelor's, master's, and doctor's degrees in nuclear engineering from Kansas State University and has authored numerous papers.

FIRST MEETING OF THE ITER DIVERTOR PHYSICS AND DIVERTOR MODELLING AND DATABASE EXPERT GROUPS

by D. Post, G. Janeschitz, ITER JCT, R. Stambaugh, General Atomics, and M. Shimada, JAERI

The first meetings of the ITER Divertor Physics Group and the ITER Divertor Modelling and Database Expert Group were held jointly at the San Diego ITER Join Work Site on July 25-29, 1994. The purpose of the groups is to facilitate the participation of the international fusion community in the development of the physics concept for the ITER Divertor. The ITER Divertor Physics Group will develop and co-ordinate the Physics R&D program for divertor experiments to be carried out by the tokamak research programs of the four ITER Parties and encourage theoretical work on divertor physics. The ITER Divertor Modelling and Database Expert Group will co-ordinate both the physics modelling studies and assessments that will be used to extrapolate from present divertor experiments to the conditions of the ITER divertor and the formation of an international database of edge physics data to aid in the validation of the divertor models and to compare the results of different divertor experiments.

The membership of the groups is drawn from senior experimentalists, theorists and modellers actively working on divertor issues and associated with the major tokamak divertor experiments as well as from members of the ITER Joint Central Team (JCT) working on the ITER Divertor Design. The members of the groups are listed in Table 1.

TABLE 1. MEMBERSHIP OF ITER DIVERTOR EXPERT GROUPS

ITER Parties	Physics	Modelling and Database
JA	N. Ohyabu	K. Itami (JT-60/U)
	N. Hosogane (JT-60)	M. Shimade (JT-60/U), Chair
	S. Takamura	H. Tawara
EU	J. Neuhauser (ASDEX/U)	A. Loarte
	G. Vlases (JET)	D. Reiter
	J. Winter (TEXTOR)	J. Neuhauser
US	R. Stambaugh (DIII-D), Chair	G. Porter (DIII-D)
	S. Krasheninnikov	C. Karney
	S. Cohen	B. Braams
	B. Lipschultz (Alcator C-Mod)	T. Rognlien
RF	A.Yu. Pigarov	A.V. Pozharov
		V.A. Abramov
JCT	G. Janeschitz, Co-Chair	D. Post, Co-Chair
	Y. Igithkanov	G. Janeschitz
	F. Perkins	A. Kukushkin
	D. Post	M. Sugihara
	J. Dietz	
	S. Putvinski	

Since there is a close coupling of the responsibilities of the groups, the two groups met jointly for much of the week to cover topics of mutual interest and then met separately to discuss their specific topics. At the beginning of the meeting the groups developed charters for their work. In addition to the items mentioned above, the groups will participate in the development of ITER Physics Basis documentation for the ITER divertor. Recent experimental results from JT-60/U, JET, DIII-D, ASDEX/U and Alcator C-Mod were presented and the impact of these results on the evolution of the ITER divertor concept was discussed. All of the experiments have been able to achieve "detached" plasma operation (prototypical of the reference ITER divertor operational conditions) in which the power on the divertor plates was reduced because of impurity radiation from the edge plasma and the plasma is "detached" from the divertor plate, but at power levels below those expected for ITER. Next, results from simulations of these experiments using the B2/EIRENE,EDGE2/NIMBUS,UEDGE/DEGAS,UEDA,DDC83 and DDic91 codes of "detached" and "attached" (in which most of the heating power is deposited on the divertor plates) plasma operation were presented and discussed. Generally, the simulations were more successful in matching "attached" conditions than "detached" conditions.

The reference ITER divertor concept was presented and group members from each major divertor facility discussed their assessment of the reference concept. The ITER divertor concept emphasizes reduction of the peak heat loads by transferring the plasma energy from the divertor plasma to the divertor chamber walls by impurity radiation, similar to "detached" operational regime in present experiments. Control of the impurity radiation level and the location of the radiating region is facilitated by localizing and controlling the plasma recycling in a "closed" or "gas bag" divertor chamber. A back-up design in which the plasma is terminated on vertically inclined divertor plates was also presented. The group members from each of experiments gave their perspective on the concept and the issues that need to be resolved. These issues included the need for a high plasma density at the plasma edge to realize the postulated operating conditions in ITER, the importance and difficulty of minimizing the backflow of recycling neutrals to the main plasma, the difficulty of controlling the position of the radiating region, achievement of high levels of impurity radiation with acceptable impurity levels in the main plasma and the desirability of study of back-up designs such as the one presented which did not rely so strongly on completely "detached" operation. Finally, presentations were made of the edge databases being assembled at each facility and of the planned structure of the ITER edge database. There was general agreement that, while assembly of such a database would be a major task, such a database would be useful, particularly if the JCT were able to provide the centralized computer and programming support necessary to realize the database. Then the groups broke up into four working groups (divertor experiments, theory, divertor simulation, and edge database) to discuss the status of the work and to develop workplans.

Each group developed a list of issues, tasks and a schedule for accomplishing the tasks. The first priority tasks for the experimental group emphasized the control of impurity radiation from the plasma edge and the achievement of controlled "detached" plasmas and identification of good scaling parameters. Plans for future modifications of the divertor configuration were also discussed. The theory sub-group developed a list of issues for the theorists to address. The modelling sub-group developed plans for carrying out three benchmark studies for: 1. a simple box geometry, 2. a more realistic ITER-like geometry, and 3. two experimental shots each from JET, ASDEX/U, JT-60/U, DIII-D, and Alcator C-mod. Working groups for the development of atomic and surface interaction data were also organized. The database sub-group developed workplans for the assembly of a time-dependent global profile database, a database of modelling results, a scalar database, and a simple, short-term profile database for model validation.

The groups then met together and set a tentative time for the next meeting at the end of January or beginning of February in 1995 to assess the results of the work that was planned and to develop further plans. The presentations, the results of the discussions, and the workplans were summarized in a report of the meeting which was distributed to all of the members of the group and to interested persons on the JCT and in the four ITER Parties.

FIRST MEETING OF THE ITER PHYSICS EXPERT GROUP ON DIAGNOSTICS

by A.E. Costley, ITER Joint Central Team (JCT), San Diego Joint Work Site, and K.M. Young, Princeton Plasma Physics Laboratory

The ITER Physics Expert Group on Diagnostics held its first meeting on July 18-22, 1994 at the ITER JWS in San Diego. This group has been set up to advise and assist the JCT in the selection and development of the diagnostic designs required for the EDA. The members of the Group are drawn from the ITER Parties and are experienced experimental tokamak physicists with specialized knowledge of diagnostics. JCT members responsible for the design of diagnostics are also members of the Expert Group. Several of the members have experience in developing extensive diagnostic packages for existing large tokamaks.

Since this was the first meeting of the Group, the first part of the proceedings was used to inform the members of the status of the ITER design in general and the diagnostic work in particular. The objectives and method of working were thoroughly discussed and a comprehensive list of objectives was developed. It was agreed that since diagnostics involve both physics and design aspects and have an extensive range of interfaces with the tokamak and machine subsystems, a wide range of objectives was essential. The list of objectives was agreed and the remaining part of the meeting was used to address them.

As a starting point it was agreed to order the measurements required by ITER into three categories reflecting their role in the operation and evaluation of the machine.

(i) Measurements for Plasma Control and Machine Protection
These measurements are defined to be those that will be used in feedback loops for real-time control of

key plasma parameters. Key measurements of the condition of the first wall and the tokamak vacuum, which will be checked between plasma pulses, were also included. The diagnostic systems that provide these measurements will require very high reliability and some redundancy in the measurements will be justified. The development of the designs of these systems will have the highest priority within the EDA diagnostic activity.

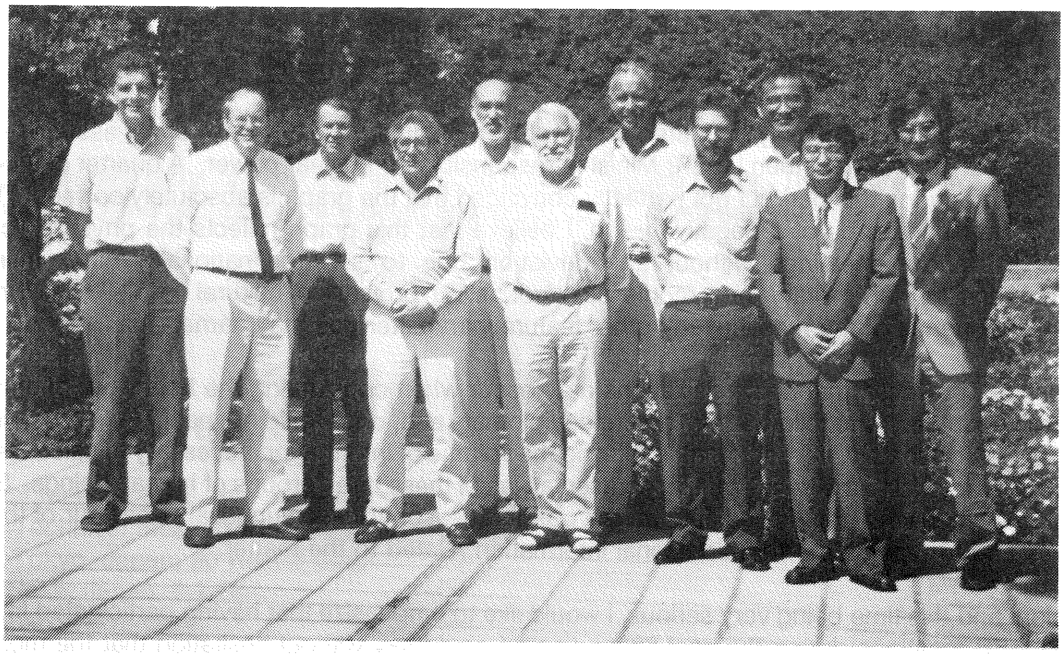
(ii) Measurements for Performance Evaluation and Optimization
These measurements are defined to be those necessary for evaluating the plasma performance and for determining the best course of action for improving it. During the discussions it became apparent that some of these measurements could be used in an advanced control system to allow a more detailed plasma control than shown in category (i) and these were identified.

(iii) Additional Measurements Required for Understanding Important Physical Phenomena Which May Limit ITER Performance
Experience with previous tokamaks has shown that new physics phenomena can occur when enhanced regimes of plasma performance are achieved. Some of these phenomena can be deleterious to plasma performance while others can offer opportunities for improved performance. In order to give the best chance of maximizing the performance of ITER and subsequent machines, a range of measurements will be made aimed at improving our understanding of the important phenomena.

All measurements in categories (i) and (ii) are considered essential for the operation of ITER. As many as possible of category (iii) measurements should be included to give ITER the best chance of dealing with unexpected problems or exploiting opportunities which may emerge under high performance plasma operation.

Once the parameters to be measured had been agreed upon, a best attempt was made to set the measurement accuracies and resolutions necessary to meet the requirements for measurements in categories (i) and (ii). The requirements for category (iii) measurements were not thought to be sufficiently well developed to warrant a detailed specification at this stage. The final values represent the Group members' best estimates of the resolutions and accuracies likely to be required in the operation of ITER and are made on the basis of experience with existing tokamaks. They serve as an initial specification of the ITER diagnostic system.

The Group then made an initial identification of candidate diagnostic techniques which have the potential to meet the measurement requirements. Under the severe conditions that will be present in ITER many established techniques will be difficult to apply. Some specific areas of critical concern were noted for future consideration and in developing designs.



Participants in the Meeting

Finally, the Group discussed possible strategies for developing the required designs. It was agreed that the first requirement is for the diagnostic specialists in the Home Teams to review and refine the initial definition of the ITER diagnostic system developed at this meeting and to make initial proposals for the design of the diagnostic systems. The JCT plans to place a small Task Agreement with each Home Team to cover this work. Once completed the JCT should be able to proceed with the selection of the individual systems for detail design.

All the participants agreed that, although it had been a difficult meeting, it was constructive. The JCT is particularly grateful for all the advice and help it received from the Group members. The next meeting is scheduled to be held February 6-8, 1995.

LIST OF PARTICIPANTS

A. Costley (JCT Co-Chair)
B. DeKock
E. Marmar
V. Mukhovatov
K. Muraoka
A. Nagashima
M. Petrov
P. Stott
V. Strelkov
S. Yamamoto
K. Young (Chair)

TO MEET OR NOT TO MEET? IF YES, FOR HOW LONG?

by Dr. L. Golubchikov, RF CP, MAC Member

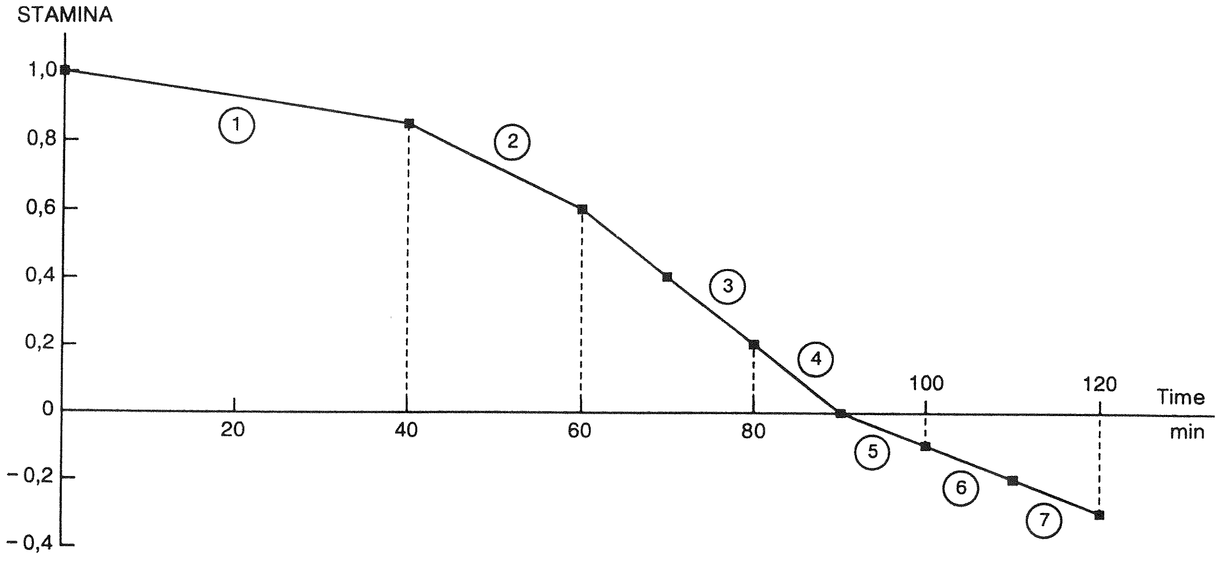
During their last meeting at the IAEA in Vienna in summer 1994, the Contact Persons (CPs) discussed, among many other subjects, the results of the ITER EDA Newsletter publication, which is now in its third year of production. The CPs considered these results to be satisfactory. They emphasized, however, that a wider coverage of "ITER life" including publications on ITER-related social and cultural events would be desirable. This prompted the author, having participated in the Newsletter discussions, to feel morally obliged to promote and facilitate the recommended approaches by writing this article. To some of the readers it may look somewhat funny and somewhat not enough substantiated. However, in essence the article is serious and, please, be aware that by ignoring the advice graphically presented overleaf, one may be facing some consequences. Actually, the so-called "rule of 90 minutes", which can be easily formulated on the basis of the graph is a very practical thing. I would strongly recommend not to forget it while sitting in a meeting room.

A poster of this graph unexpectedly appeared on my office wall during the first days of my assuming the duties as a bureaucrat at the Russian (then USSR) Ministry, responsible for nuclear power. A quarter of a century has passed since and during this period I got perfectly convinced that the graph is absolutely correct. Though not being sure if stamina can be of a negative value, I believe that this graph reflects the physiological state of participants in various meetings without any deviation due to sex/age/nationality/party membership/ occupational position or military rank/confession/education/profession/cultural level/fitness/professional experience/importance of the meeting/any other feature/parameter you may name.

I have observed, however, that some deviations may occur when considering the behaviour of some natives of the eastern countries, who follow a yogi doctrine, diplomats and, one would not easily believe, secret service personalities. Unfortunately, my data bank is lacking the volume of information necessary to calculate the value of deviation characterizing the behaviour of representatives of these three groups of human beings. So, I would be grateful to anyone who could shed light on the possible reason for such unusual behaviour of this setup of personalities and to provide me with additional information related to the matter.

In conclusion, and this time being very serious, I would like to emphasize that having participated in numerous INTOR and ITER meetings during the past fifteen years I could say without hesitation that the most effective ones were those of the ITER EDA SWG-2 and CPs, both chaired by Dr. Michael Roberts, and during which the "90 minutes" rule has been consistently obeyed to.

HOW LONG SHOULD WE MEET?



1 0-40 minutes - The optimal duration of the meeting. Pulse, blood pressure - normal

2 40-60 minutes - First signs of fatigue. Development of interest in your "neighbours". A desire to quickly resolve all the questions unanimously. Response toward "the guilty": it was clear from the beginning...Pulse rate rises slightly.

3 60-80 minutes - Passiveness. Doodles of airplanes, houses, cars and fishes appear on business notes. Readiness to "forgive" the "guilty" without any further discussions.

4 80-90 minutes - Daydreaming, first signs of schizophrenia, despondency. Discussion is valueless. Eyes half-open.

5 90-100 minutes - Increase of "disruptive" activity...Random exclamations of the participants, incoherent discussion. Pulse rises. Hands are itchy. Constant ringing in the ears.

6 100-110 minutes - Growing dislike of, and aggressiveness toward, the chairman of the meeting. Calls from the participants toward each other - "And who the hell are you?!" Pulse rises.

7 110-120 minutes - State of deep depression...no pulse...eyes are blurry. The desire to leave the meeting by ANY means. Various decisions are being accepted, up to...continuation of the meeting!

FORTHCOMING EVENTS *)

- Technical Meeting on Safety and Environment, San Diego, USA, 10-14 Oct.
- Magnet Technical Meeting, Naka, Japan, 8-11 Nov.
- MAC-7, Tokyo, Japan, 30 Nov.-2 Dec.
- TAC-7, Naka, Japan, 5-7 Dec.
- IC-7, Japan, 14-15 Dec.

*) Attendance at all ITER Meetings by invitation only.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: 43 1 237762 (phone 23606392).

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