INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER NEWSLETTER

VOL.3, No.9 SEPTEMBER 1990

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

Editor's Note

The summer joint work session at the ITER technical site in Garching has reached its mid-point. Comprehensive design work, aiming at the completion of the conceptual design by November, is on-going in all main areas of the machine design. This work is being supported by specialists' meetings and workshops helping to better assess critical issues and to justify solutions being made. Summaries of two specialists' meetings are given below.

ITER SPECIALISTS' MEETINGS IN GARCHING

1. MEETING ON VERTICAL DISPLACEMENT EVENTS AND DISRUPTION-GENERATED RUNAWAY ELECTRONS

by G.W. Pacher, Leader, Physics Task Group on Disruptions

From the beginning of the ITER activity, disruptions have been recognized by the ITER designers as a problem in a large tokamak because of the resulting high thermal loads and considerable impulsive forces produced by the rapid loss of thermal and magnetic energy from the plasma. The open questions remaining after the ITER Specialists' Meeting on Disruptions of September 1989 were considered to require a longer-term R&D programme, with regard especially to disruption control. Nevertheless, two areas in which information was particularly sparse were identified during the winter 1990 Joint Work Session. A meeting dedicated to these topics, vertical displacement events and disruption-generated runaway electrons, was organized so that the relevant ITER physics guidelines could be validated or modified.

Vertical displacement events

The strongly elongated plasma configurations to be used in ITER are vertically unstable unless active feedback on the vertical position is applied. A malfunction of this feedback system for any of a variety of reasons, such as noise in the position detection circuits, saturation of the control or power supply system, or abrupt changes in plasma parameters, can lead to a rapid vertical displacement. As the plasma comes into contact with the plasma-facing components at the top or bottom of the vacuum vessel, the current is rapidly forced to zero. This phenomenon constitutes the vertical displacement event.

The phenomenon could be well explained if, and only if, currents in the scrape-off layer (the plasma "halo"), closing poloidally through the first-wall components, were present. The time behaviour of vertical displacement events in present machines can then be derived from the electromagnetic behaviour of coupled circuits, and satisfactorily reproduced by a full MHD code incorporating force-free currents in the halo.

Results from an electromagnetic code demonstrate the complex nature of the stabilizing effect of the twin-loop passive stabilizer concept. The eddy currents induced by a plasma current quench or rapid radial displacement stabilize the plasma radially but destabilize it vertically, whereas the reaction to vertical plasma motion at constant current is stabilizing. In the final phase of a vertical displacement event, if the plasma current is decreasing rapidly, the net effect of the twin-loop may therefore be destabilizing vertically.

A new characterization for vertical displacement events was developed at the meeting. It can be summarized as follows:

Upon loss of vertical position control, the plasma moves vertically at constant plasma current with a growth rate (approx. 30 s^{-1}) determined by eddy currents in the passive structures. When the safety factor of the plasma current inside the last closed flux surface reaches ≈ 1.5 due to decrease of the plasma cross-section, a low-q disruption occurs. The plasma thermal energy is lost mainly at the point of contact. The magnetic energy is partially radiated (≈ 50%), and the rest is lost where the plasma touches a surface during current quench. Halo currents are expected to occur. Their maximum magnitude is approximately 20% of the initial plasma current and their toroidal distribution is expected to be uniform if the plasma-facing components are not insulated from each other.

It is unlikely that vertical displacement events can be completely avoided, but their number can be minimized if ITER operates at a reasonable distance from vertical stability limits. Future work should establish a more quantitative criterion.

Disruption-generated runaway electrons

Highly energetic runaway electrons are frequently produced by the high electric fields resulting from the suddenly increased resistivity of the plasma after a thermal quench. Because of the high particle energies and intensities predicted for ITER, this may be a determining element for the first wall components.

In Tore Supra most of the plasma disruptions during 1990 generated runaway electrons. In contrast, during the lower toroidal field operation period of 1989, less than 5% of the disruptions were followed by runaways. DIII-D has never observed runaway electrons and operates at similar plasma parameters and toroidal fields as the first, lower toroidal field phase of Tore Supra. The absence of runaway electrons in DIII-D disruptions might thus be attributable to its low toroidal field, rather than to its large density rise. No theoretical explanation for the toroidal field dependence was proposed.

Theoretical analyses of runaway behaviour predict that the runaway current may rise immediately after thermal quench, in a time of the order of one millisecond, to a large fraction (≈ 50%) of the pre-disruption plasma current but that the particle energy of the runaway electrons would rise in a longer time, of the order of 10-20 ms, to its limiting value of several hundred MeV. The runaway current and energy depend sensitively on plasma temperature and density after the thermal quench.

The disruption characterization for ITER was reviewed by the participants, but present information on scaling was deemed too sparse to warrant modifications in maximum runaway energy (300 MeV), maximum runaway current (0.5 x I), or maximum heat load from runaways (30 MJ/m^2).

It was agreed that a detailed investigation of the data base should be effected by the participants, and that the avoidance of runaway electrons and the development of control methods should be a priority item in the physics R&D programme.

2. MEETING ON FUELLING AND PLASMA OPERATION CONTROL

by F. Engelmann, V. Parail, J. Perkins, and R. Yoshino

Requirements and ways to control a burning tokamak plasma

A meeting on Fuelling and Plasma Operation Control in ITER was held at Garching from 9 to 19 July 1990. This meeting was dedicated to a comprehensive analysis of the requirements and ways to control a burning tokamak plasma. The three main areas covered were the control of the plasma particles and density profile, of the current profile and of the operation point, as well as the physics underlying these control issues. In this latter context, the pellet ablation physics, the transport properties of hydrogenic ions, helium and impurities, as well as the physics of the bootstrap current and of non-inductive current drive by external means (neutral beams and RF waves) was discussed. In all areas a considerable effort has been made by research workers in the home countries of the ITER Parties to collect the available data base and to perform detailed simulations of the conditions encountered in ITER.

The meeting was structured according to the above three main areas. The total number of research workers attending, not counting ITER participants, was about 40, but the broad scope of the meeting did require a continuously changing attendance so that typically only half this number of participants was present at any given time. This organization turned out to be optimal for the work at the meeting.

Profile and fuel mix control, impurity control and helium exhaust

During the first week the issues related to density profile and fuel mix control as well as impurity control and helium exhaust were addressed. An assessment of the knowledge on pellet ablation and particle transport was made. Recently obtained first results on helium transport from experiments on JT-60, TEXTOR and TFTR done as part of the ITER-related Physics R&D Programme, were presented and discussed. Overall, 31 contributions were presented. Important points that were made are:

1. The pellet penetration depth in a thermal plasma is well described by the neutral gas shielding model.

2. The decay time of a suprathermal electron population generated by lower hybrid waves may be by about a factor 10 longer than the slowing-down time as anticipated from a simple approach to wave-particle interaction and collisional effects. This may have an impact on operation scenarios combining the use of lower hybrid waves, and pellets for deeper penetration. Pellet penetration just across the separatrix has proven possible also in the presence of lower hybrid waves, and leads to a peaking of the density profile in the plasma core.

3. The first results on helium transport indicate that in L-mode plasmas, heated by neutral beams, the radial helium transport is on a time scale $\tau_{p,\alpha}$ which does not exceed the energy confinement time τ_E by a large factor; typically one has $\tau_{p,\alpha}/\tau_E < 3$.

4. Appreciable helium de-enrichment at the plasma edge and in pumping channels has not been observed in the helium transport and exhaust experiments carried out so far.

5. The radial density profile of an impurity species is strongly dependent on the presence of other impurities, in particular those having a higher electric charge; this may be important for the helium distribution in a burning plasma and hence for the helium exhaust efficiency.

For the ITER concept the following practical conclusions were drawn:

1. Pellet injection at low velocity (about 1 km/s), using a centrifuge, should be considered as it is the simplest and most reliable method allowing control of the ratio of the plasma density in the core to that in the scrape-off layer.

2. The present specifications for the maximum helium concentration in the core plasma ($n_\alpha/n_e \leq 10\%$) and of the minimum burn up fraction (3%) are realistic targets, to be confirmed by further R&D work which is needed for a definite quantification of these numbers.

Burn temperature control and emergency shutdown

The first two days of the second week were dedicated to the problems of burn temperature control and emergency shutdown of a burning discharge. 18 contributions were presented on conceptual issues and simulation analyses. The latter covered a wide range of situations and included the control of the operation point and ways to ensure its thermal stability as well as approaches to fast shutdown, on a time scale of 1 to 10 s as needed in case of technical failure of the device. While this activity has provided good insight in the problems encountered, it was apparent that the development of definite control concepts for ITER will require a more complete physics data base. The development of more sophisticated computational models, e.g., including a 1½ D plasma description, is also required and is already under way. In addition, plasma diagnostics and control schemes will have to be included in the analysis.

The overall conclusions for ITER were the following:

1. For the control of the operating point (i.e., to ensure power balance equilibrium) in ITER, adjusting the plasma current, magnetic field, impurity content etc. is anticipated to be a viable approach, but having some active control of energy confinement would be beneficial and may be unavoidable in a reactor.

2. The recommended method for burn stability control remains feedback-controlled heating of the core plasma (up to $Q \approx 40$, corresponding to a heating power of at least 25 MW) possibly in combination with the control of density, fuel mix and perhaps impurities.

3. Emergency shutdown over a time not longer than 1 to 10 s is possible, but convincing passive schemes need still to be developed and it appears difficult to avoid disruptive discharge termination.

Further modelling work to clarify the diagnostics requirements for burn temperature control was recommended. An iterative approach will be needed on this issue which requires close collaboration with the ITER diagnostics activity.

Current profile control

Current profile control was the theme of the last two days of the meeting. The topics addressed included: 1) global current profile control which is anticipated to be necessary because optimum performance is expected to require a current profile broader than that characteristic for an inductively driven current, 2) local current profile control to affect sawtooth activity and stabilize the m/n = 2/1 tearing mode, and 3) experiments on and modelling of the bootstrap current. Furthermore, the status of simulations of non-inductive current ramp-up by lower-hybrid waves, the data base for current drive by electron and ion-cyclotron waves as well as by helicity injection, and 1½ D simulation of the ITER reference operation scenarios was touched upon.

There were 18 contributions to this part of the meeting. Conclusions of practical importance for ITER were the following:

1. Operational scenarios with a safety factor appreciably above 1 should be considered, both in ITER design and in the R&D programme, as they may allow operating ITER with a bootstrap current exceeding 50% of the total current, and consequently for a longer pulse length and/or with lower external power for non-inductive current drive.
2. In a low aspect ratio device as is ITER, the degradation of the current drive efficiency of electron cyclotron waves by trapped particles may be such that control of the m/n = 2/1 tearing mode by current drive around the q = 2 surface is jeopardized if this surface is close to the plasma edge (typically, at r/a > 0.9 which corresponds to plasma currents approaching 22 MA or larger).

It was therefore felt that R&D work on the bootstrap current and on the stabilization of the m/n = 2/1 tearing mode by local non-inductive current drive should be performed with high priority.

Overall, the meeting provided a unique opportunity to discuss broadly the control requirements for burning ITER plasmas and to assess the approaches under consideration to fulfill them. While further R&D is essential to optimize the control schemes, and in some case to demonstrate the feasibility of approaches under consideration, basic concepts are available for all control issues.

Editor's Note

The following article is a continuation from the previous issue of the Newsletter. In the first part of the article, basic information and research programmes of tokamaks, JT-60 and JFT-2M were presented. Also the activities of JAERI's Superconducting Magnet Laboratory and the development of neutral beam injectors were described.

TOGETHER FOR THE FUTURE - ITER-RELATED ACTIVITY AND THE FUTURE AT JAERI

by T. Iijima, Director General, Naka Fusion Research Establishment, JAERI

Test facilities for plasma-facing components

JAERI Electron Beam Irradiation Stand (JEBIS) was constructed in 1988 to facilitate thermomechanical testing of plasma facing components for the simulation experiments of heat load on the first wall. JEBIS is capable of providing 400 kW electron beams from 1 ms to steady-state in a pencil-like sharply focused shape and in a sheet-like defocused shape. The heat flux obtained reaches 2.5 GW/m^2 in a short-pulse for disruption simulation experiments (Fig. 1). The long-pulse operation for more than 1 hr is also successfully performed in testing first wall mock-ups with a heat flux of 0.2 MW/m^2. Particle Beam Engineering Facility (PBEF) can deliver hydrogen beams of more than 4 MW from 10 ms to 10 s for testing divertor heat load.

Fusion Neutronics Source Facility

An intense D-T neutron source with the energy of 14 MeV, Fusion Neutronics Source (FNS), has been operated at Tokai Research Establishment. D-T neutrons are produced by bombarding a water-cooled triitium-titanium target loaded up to 950 Ci with a 330 keV deuteron beam. The maximum neutron strength at the target is $5x10^{12}$n/s with a deuterium beam current of 23 mA. The FNS Facility consists of a 400 keV high-current electrostatic deuteron accelerator, heavy-duty tritium metal target assemblies, tritium handling,

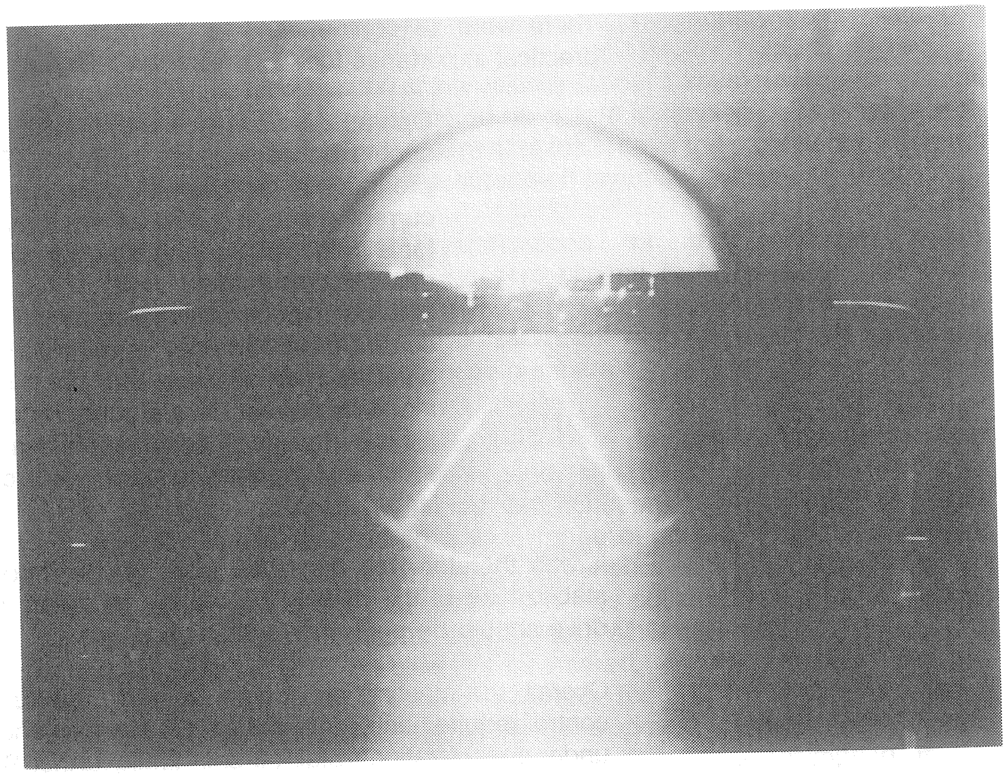


Fig. 1. Experiment at JAERI Electron Beam Irradiation Stand (JEBIS) - 16 MW/m^2 and 1.5 s. The specimen (CFC/Cu; 250 mm) is irradiated by the beam from the top.

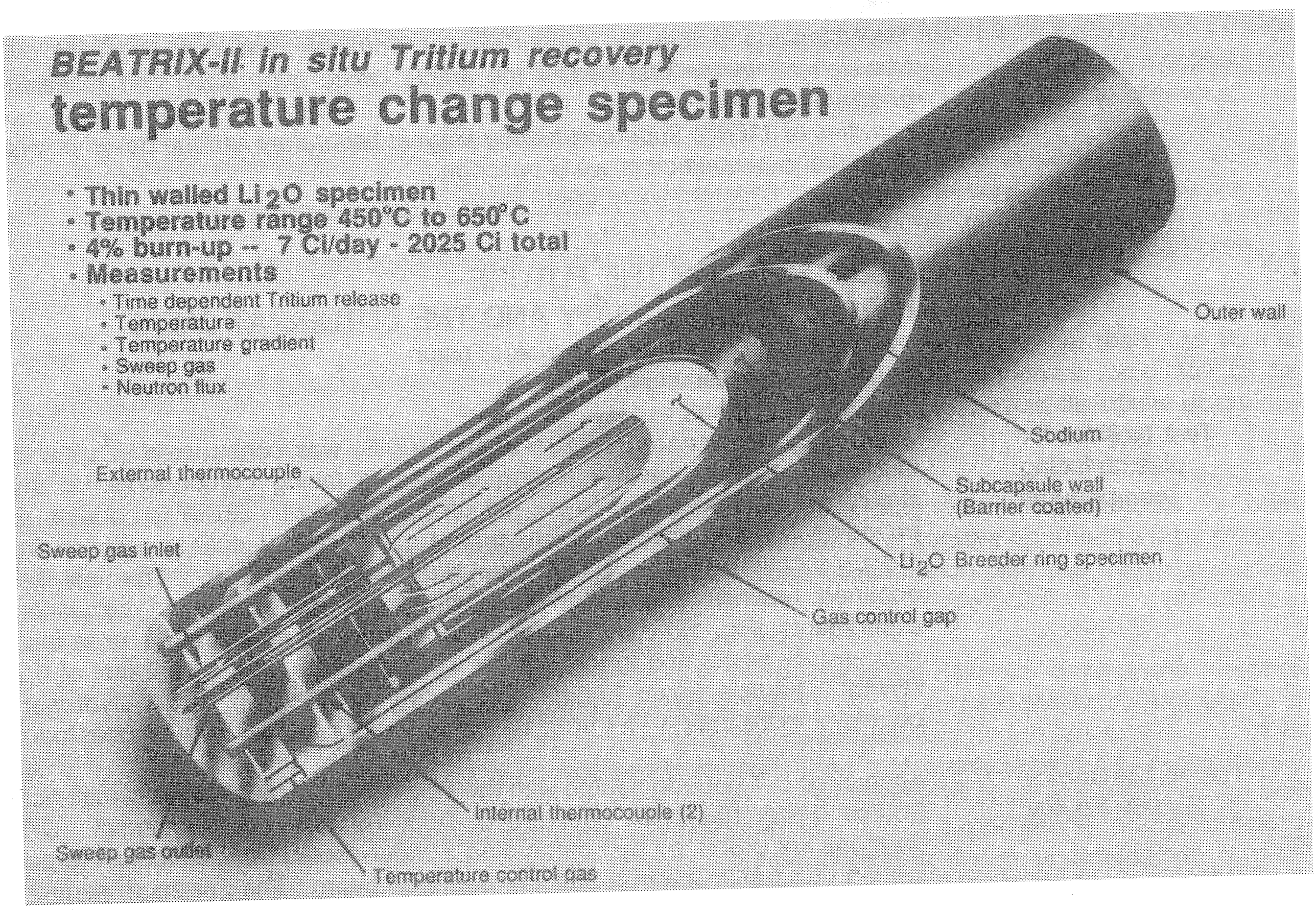


Fig. 2. Ring specimen canister in BEATRIX-II experiments to provide tritium release and thermal stability data on Li_2O.

processing devices and experimental equipment. The building itself with its shield structure and various ports imbedded therein plays an important role in arranging the experiments. Several integrated experiments have provided basic data for the nuclear design of ITER. The experimental programme for the coming R&D works includes: 1) basic experiments on blanket and shield materials, 2) engineering-oriented experiments for the blanket design, 3) shield research and 4) irradiation experiments.

BEATRIX-II experiment

BEATRIX-II (Breeder Exchange Matrix II) is an IEA sponsored experiment on in-situ tritium recovery and irradiation damage to solid breeder materials in Fast Flux Test Facility (FFTF) reactor. The objective of the experiments is to measure the tritium release characteristics and the thermal stability of Li_2O and Li_2ZrO_3 as a function of neutron exposure, temperature, gas composition and flow rate of sweep gas in the fast neutron environment. The other experiment is to analyze irradiation damage and to evaluate the irradiation effects on thermal conductivity, tritium diffusion and compatibility with beryllium metal. The ring specimen canister in form of a vented capsule (shown in Fig. 2), is being designed to provide tritium release and thermal stability data on Li_2O.

Computing and network systems

The computing system for the fusion research at Naka Establishment is a subsystem of the computer center in Tokai. The two main computing systems at Tokai and Naka are linked by optical lines to transfer jobs and files. The system at Naka consists of two main computers, a Front-End-Processor (FEP) FACOM M-780/10S and VP-2600/10. The M-780 is an IBM compatible computer with the speed of 35 MIPS and is used for TSS, job entry and small job processing. It is also used for the data base management of JT-60, where the data files are shared with an Inter-Shot-Processor (ISP) in the JT-60 data processing system. The FEP system is connected to the VAX 8350 network managing computer which is connected with work stations and CAD systems at Naka via Ethernet and with other networks such as MFEnet and DATEX-P via PSI (Packet Switching Interface). The VP-2600/10 supercomputer is a vector processing type of uni-processor with the peak speed of 4-5 GFLOPS and clock period of 3.2 ns. Many analysis codes such as ANISN, NASTRAN, eddy current analysis code etc., and data base such as JENDL-3, as well as the plasma analysis codes are available for users.

Other facilities

The activities for ITER at JAERI are also supported by Tritium Engineering Laboratory, Plasma Heating Laboratory II for RF heating, Plasma Engineering Laboratory and Plasma Theory Laboratory. The irradiation experiments for the diagnostic instruments, using the JMTR fission reactor at Oharai Establishment, are being planned .

JAERI has a long experience in the construction-oriented projects which require consecutive R&D from basic research to fabrication through tight collaboration with industries. JAERI will contribute to ITER both in the coming physics and engineering R&D and in the engineering design work of ITER, as an integrative fusion research center, where dedicated fusion research can be incorporated with relevant research in fission technology.

Naka and Tokai areas where JAERI is situated have been developed for advanced research on atomic energy in historical and pastoral atmosphere. The surroundings provide traditional atmosphere in towns and temples, and recreational and cultural opportunities. Visit us and enjoy staying in Naka!

PLASMA PHYSICS AND FUSION RESEARCH AT KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY

by O.S. Pavlichenko, Deputy Director of the Institute and Head of the Plasma Physics Department

History

Kharkov Institute of Physics and Technology (KhIPT), established in 1928 by the initiative of A.I.Ioffe, is the largest physics research center in the Ukraine. Nuclear physics and low temperature physics have been the main selected areas of scientific research at the institute from the time of its foundation. In 1932, nuclear fission of lithium was demonstrated at KhIPT for the first time in the Soviet Union. The research on fission reactor materials and plasma physics was started at the institute in the fifties. At present time, KhIPT is conducting research and development (R&D) programmes on fission and fusion reactor materials, elementary particles, nuclear physics, plasma physics and controlled fusion.

Plasma Physics Department

Since 1965, the main tasks of the Plasma Physics Department of KhIPT have been the study of plasma heating and confinement in stellarators ("Sirius", "Saturn" and "Uragan-1, -2 and -3") and basic research of RF phenomena in magnetized plasma. Now the experimental research is focused on RF currentless plasma production and heating in the torsatron with helical divertor, "Uragan-3M". This device is the upgrade of the previous device, "Uragan-3". On "Uragan-3", the concept of currentless plasma production and heating by RF power excited by helical frame antennas in the vicinity of IC and Alfven frequences was studied. Plasma with ion temperature up to 1.1 KeV and beta of 0.6% was obtained and studied at confining field of 0.5 T. The new helical winding of "Uragan-3M" will allow higher values of the confining field, up to 2 T.

Construction of the new generation stellarator-torsatron with additional toroidal field, "Uragan-2M" is now in its final phase. Main parameters of "Uragan-3M" and "Uragan-2M" are given in Table 1. It is planned that a number of stellarator confinement issues, such as low collisional transport, beta limits and impurity transport, will be addressed in the frame of the research programme at the new device.

RF plasma heating and current drive

The theory of RF plasma heating and current drive in toroidal magnetic traps is being developed in the division headed by Prof. K. Stepanov. The scientists of the division contribute in this field by originating new valuable ideas and by developing theoretical models. A linear and a quasilinear theory of ion-cyclotron resonance in toroidal and open magnetic trap plasmas have been developed by K. Kasilov, A. Pjatak, and K. Stepanov. New scenarios of ion-cyclotron resonance (ICR) heating and current drive using ion-Bernstein-wave propagation (direct excitation by low field side antenna or fast mode conversion) and ICR for high-energy minority ions have been proposed by A. Longinov and S. Pavlov.

Leading scientists take part in ITER-related activities

Many scientists and engineers of the Plasma Physics Department take part in ITER-related activities. Prof. O. Pavlichenko is the member of the OTR/ITER Executive Committee*, responsible for co-ordination of work on ITER Diagnostic Conceptual Design in the USSR. Yu. Kuznetsov is the co-ordinator of the international working group on magnetic diagnostics for ITER.

The main contribution of KhIPT in the ITER design process is being made through participation in ITER Diagnostic Conceptual design.

Magnetic diagnostic for ITER

Plasma equilibrium model analysis for tokamak with a double null divertor was performed. Therefrom resulted the definition of the number and locations of

* see organizational structure of the USSR OTR/ITER Executive Committee in the "ITER Newsletter", Vol. 2, No. 4.

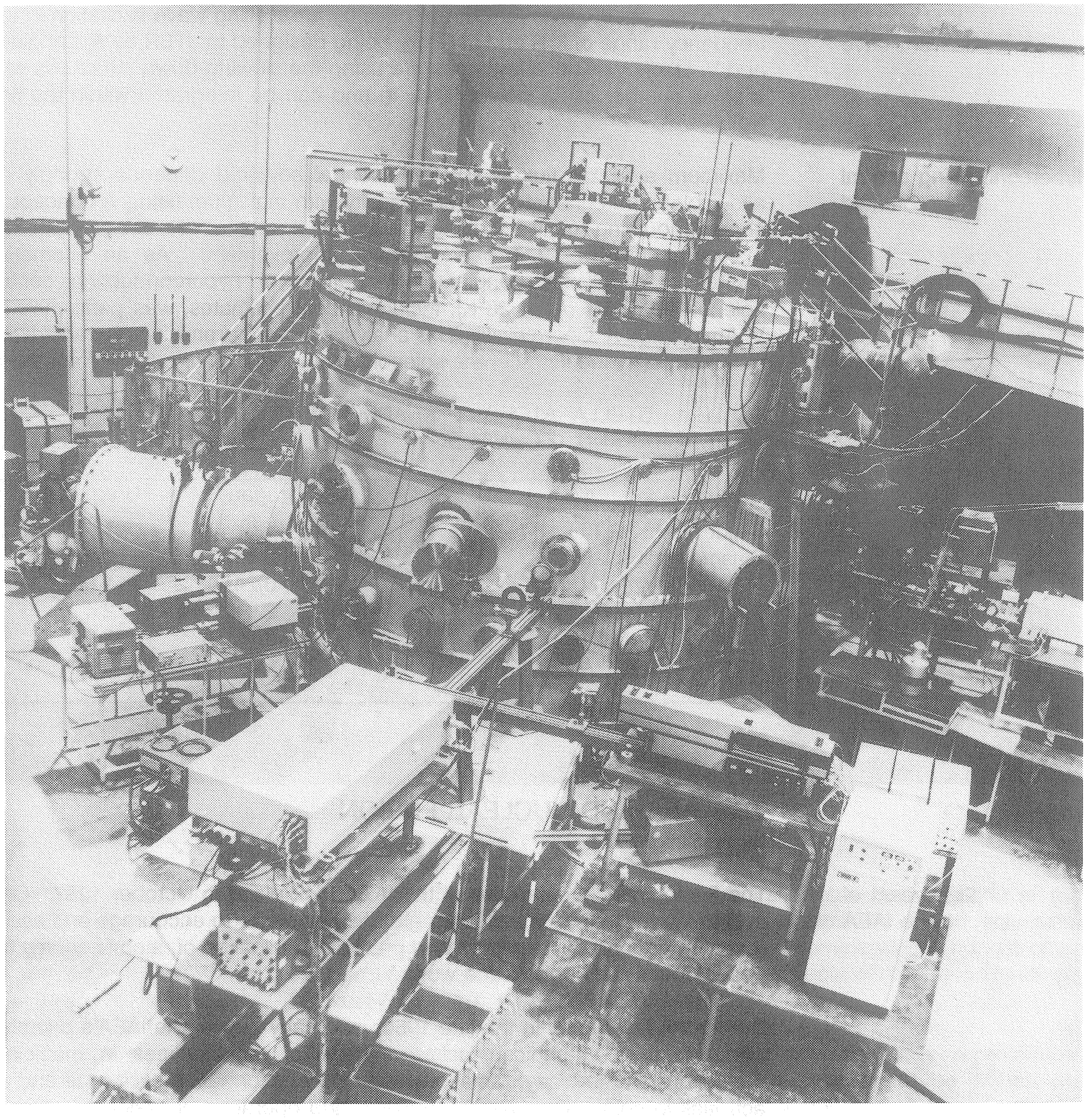


Fig. 1. Torsatron "Uragan-3M"

magnetic field sensors measuring current, plasma shape and position with sufficient accuracy for plasma monitoring during current ramp-up and in the stationary phase. Yu. Kuznetsov proposed the use of vibrating sensors for magnetic field measurements during the current stationary phase.

Microwave reflectometry

Dual polarization (O- and X-mode) reflectometry for measurements of radial profiles of the electron density and total magnetic field along the mid-plane diameter of ITER plasma was proposed by O. Pavlichenko, A. Skibenko, and D. Grekov.

Full plasma equilibrium determination from external (magnetic diagnostic) and internal (dual polarization reflectometry) magnetic field measurements was studied in the numerical experiment by Yu. Kuznetsov and O. Pavlichenko. It was shown that current profile reconstruction within an error range of 10% is possible if the cut-off layer position is determined by reflectometry with an error range of 1%.

ICR and LH current drive

New types of antennas for current drive by a travelling wave excitation in the frequency range of ICR and LHR are being designed for ITER by A. Longinov and V. Lukinov. These antennas are using the slowing-down structures with a small number of RF power feeds-in and can be integrated within the first wall.

Hyperconducting central solenoid

Maximum available flux in ITER PF central solenoid depends strongly on allowable superconductor current density with maximum field. A concept of superconducting central solenoid adopted in the ITER design with the maximum field of 12 T needs further improvement. As an alternative approach, a full-scale engineering analysis of hyperconducting central solenoid for ITER (Al at 20 K), including cost estimates, was performed by V. Amelin and A. Georgievski. This analysis showed promising characteristics of the hyperconducting central solenoid, both in terms of reliability and cost.

TABLE 1. STELLARATORS OF KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY

	Uragan-3M	Uragan-2M
Major radius, R_o(m)	1.0	1.7
Plasma radius, a(m)	0.11	0.22
Plasma volume, $V_p(m^3)$	0.24	1.62
Magnetic field, B_o(T)	2.0	2.4
Pulse duration, t_p(s)	0.5	2.0
Absorbed power, P_{abs} (MW)	1.2	5.0

THE IAEA AND NUCLEAR FUSION

by H. Seligman

First years of the IAEA

The first General Conference of the IAEA took place in October 1957. One of the IAEA's major tasks according to the Statute is "to encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world."

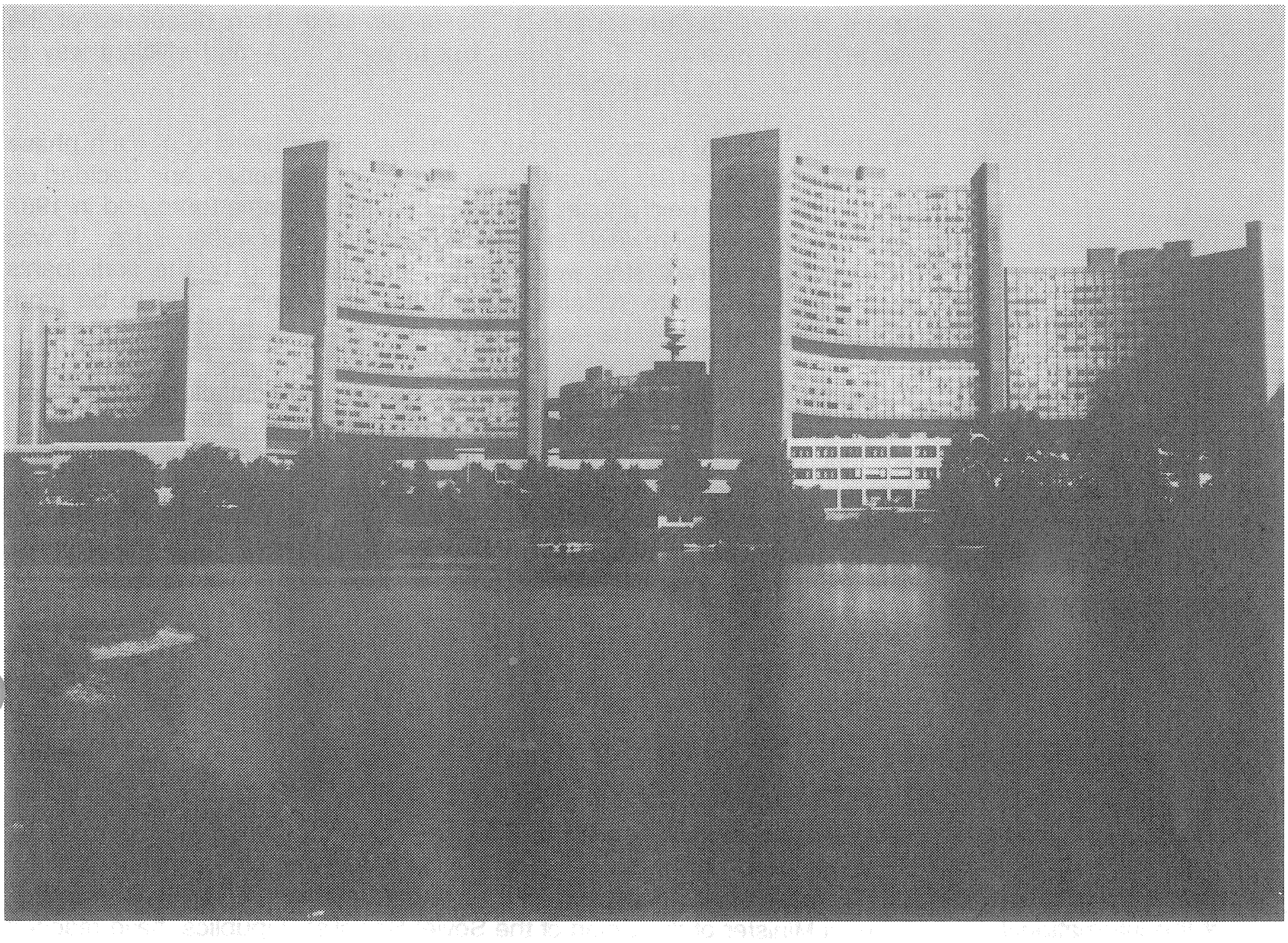
During the first years, in the late 1950s and early 1960s, the IAEA's priorities were obvious: technical assistance, use of radionuclides in medicine, agriculture and industry, radiation safety rules, information exchange and all activities in connection with the building and operating of fission reactors.

In the late 1960s, all aspects in connection with safeguards became of paramount importance, incidentally an enormous task for a relatively small scientific body.

Initial steps in co-ordinating fusion activities

Scientific research co-ordination being part of the Statute, the IAEA had to anticipate and act on future important developments. Controlled nuclear fusion and its application was intriguing and possibly a future energy source. It was one of the first subjects where the IAEA tried to help to co-ordinate the relatively small national activities. This was achieved by organizing one of the first larger IAEA conferences on thermonuclear fusion research which promised to be a useful activity since in 1957 "magnetic confinement" had been declassified and so, for the first time, free exchange of information on this subject was permitted. This first conference took place in Salzburg in 1961 and was so successful that it became a recurring event, eventually every second year.

By the end of the 1960s it became obvious that in addition to the IAEA's activities in fusion - the creation of the Journal of Nuclear Fusion being one of the most important ones - the IAEA could do more to further the small



Vienna International Center

international fusion community's work. A first Status Report made at the request of the Director General by the most eminent fusion scientists, Academician Artsimovich being one of them, recommended amongst other suggestions to foster "large scale international projects with common funding." (J.Nucl.Fusion 10 (1970) 413-421).

Creation of the IFRC

The fusion scientists who had formed this advisory body were almost immediately, after completing their report, designated to be permanent members of the newly created International Fusion Research Council (IFRC). This important body had, from 1970 onwards, to guide all the IAEA's fusion activities, such as giving advice on relevant meetings and conferences, technical assistance projects, fellowships, research contracts and was active in the establishment of data bases of atomic and molecular data for fusion materials. The IAEA cannot be grateful enough for the excellent and hard work with which, over years, these scientists have advised the IAEA on all their fusion activities.

INTOR established in 1978

During the IFRC's discussions in 1977, as foreseen many years earlier, it was felt that the time may be right for closer international co-operation with the aim of building a bigger tokamak device and as a consequence the then Director General, Dr. Sigvard Eklund, sent a letter to all relevant governments to obtain their views on this issue. The response was positive and the International Tokamak Reactor Workshop (INTOR) was established in 1978.

The tasks facing the INTOR participants were rather broad and contained amongst many other objectives the assessment of a technical data base for the construction of a next major experiment beyond the present generation of large tokamaks. This type of close international co-operation was novel. Tasks were discussed by the group and the necessary work then performed at the sites of the participants. The results were then discussed at the group's next meeting. This turned out to be a quick and efficient way to solve some of the problems.

The INTOR activity was carried out in phases and at the end of each phase the participating parties reviewed the progress of the activity and decided on the details for the next phase. The INTOR activities came to an end in 1987 and their work is contained in reports covering some 4300 pages. It was obvious that the next step would involve major funding by the participants and a more elaborate system in which the governments had to be more closely involved had to be established.

ITER as a logical step in international co-operation

Research had progressed sufficiently and the political climate was very favourable so that after some discussions at the highest political level an efficient working system was quickly organized and established. ITER activities were started in May 1988 being an independent body, operating under the auspices of the IAEA, a solution which has proved to be excellent when viewing the work of ITER during these almost two and a half years. One can only congratulate all concerned for their great achievements in such a short time.

FUSION CO-OPERATION ADDRESSED AT THE JAPANESE-SOVIET TALKS IN TOKYO

Favourable assessment of the international co-operation in fusion

Dr. T. Nakayama, Foreign Minister of Japan, and Mr. E. A. Shevardnadze, Foreign Minister of the Union of the Soviet Socialist Republics, have reached a common understanding that the acquisition of thermonuclear fusion energy, a giant step in the field of energy technology from the standpoint of environmental protection and economic efficiency, will offer an essentially inexhaustible source of energy to mankind and open a new era in the history of human development.

They noted with satisfaction that the International Thermonuclear Fusion Experimental Reactor (ITER) Project, involving joint efforts by Japan, the USSR, the European Communities and the USA, under the auspices of the International Atomic Energy Agency (IAEA), is making progress successfully.

They expressed their hope that such international co-operation, which is a highly motivated and creative effort in science and technology, will be promoted further for the benefit of all mankind.

CHILDREN AT ITER JOINT WORK SITE

from interviews with participants

Many families brought children to Garching

A large fraction of the participants in the CDA joint work at Garching have young children. This gave many American, Japanese and Soviet families much to think about when considering whether they should move with the father to the Munich area for the six-month sessions. Many decided to bring the children and come. Nearly all parents coming to Garching expected their children to enjoy a rewarding experience and most looked forward, on the whole, to family fun in Europe. On the other hand, some came despite misgivings about coping with conditions of life in a foreign country. As it has turned out, both kinds of expectations have been fulfilled: both problems and rewards have been experienced by ITER children.

Some of the children of ITER participants at Garching

All have had broadening experiences

On the positive side, all of the ITER children from other parts of the world have had their outlooks broadened by at least a few glimpses of the culture and history of Europe. Furthermore, those families who have been so inclined have seen a great deal -- traveling extensively and becoming involved in interesting local activities. The scenery, the food, the automobiles and the rest of the transportation system -- so different in most cases from "back home" -- have made lasting impressions on the youngsters. Also broadening have been the everyday opportunities for contacts with other children from Germany and other ITER countries.

Overcoming "language barriers"

Naturally, life at Garching has not been all fun and no frustrations. When asked to identify problems, nearly all ITER families mention the "language barrier." Compared to this one, other problems are viewed as secondary. Few, if any, problems for children at Garching have been disruptive of family life. None has led to withdrawal of the parent from the ITER joint work.

Language differences remain a hindrance because most parents have decided against having their children systematically study German. Most feel that the six-month duration of the CDA sessions is so short and the incentives for doing other interesting things are so great that language courses are impractical for them.

Although hindered by language, friendships have developed between some ITER children and the German-speaking youngsters with whom they naturally come into contact. Teenage Germans generally have studied English and, in conversations with them, ITER teenagers pick up enough German to be useful. What they miss is the ability for in-depth conversations on weightier subjects.

Within the ITER community, language barriers have been partially overcome by the youngsters' venturesome spirits and parents' efforts at integration. Neighborhood life and planned events bring ITER children together. However, with the exception of the little ones, who play together oblivious of differences, activities tend to be mostly among those who speak the same language. Contacts with others are interesting and generally enjoyable, but limitation on abilities to convey thoughts and feelings prevent the development of many close friendships.

Attitudes toward future opportunities

So then, what is the overall evaluation by ITER parents of the Garching experience for their children? One indication is their expressions, in social gatherings, of attitudes toward the possibility of coming, with their children, to work on ITER in the EDA now under discussion. The Garching experience is viewed as generally positive but most parents are keeping open minds until they know more about the EDA joint work site. They expect that any site chosen by the four Parties will, of necessity, provide reasonably satisfactory accomodations: good, affordable residential housing and shopping and good schools. Their decisions, they say, will be based on other circumstances of the particular location and their personal perceptions of how an extended stay there would affect their families' lives. Having been at Garching, they have an appreciation of the possibilities for enjoyment and growth. They recognize that continuous residence for some years would give them and their children the incentive and perhaps the possibility of becoming bilingual. Thus they feel that the differences in languages need not be an over-riding problem, but only one factor to be considered along with others.

FOURTH LATIN AMERICAN WORKSHOP ON PLASMA PHYSICS

by V. Demchenko, Physics Section, IAEA

The Fourth Latin American Workshop on Plasma Physics was held in Buenos Aires, at the end of July 1990, with participation of 130 experts from 17 countries, including both developing countries and those leading in the world fusion research. A wide range of topics on plasma physics and controlled fusion was covered in academic lectures and invited reports.

ITER progress presented

Review of experimental programmes being performed on large-size tokamaks was presented on behalf of the IAEA. Progress of the ITER Conceptual Design Activities was reported as part of this presentation. ITER-related information caused notable interest of the audience and was followed by a lively discussion.

Suggestions aiming at North-South collaboration

In view of desirability of worldwide research and development of fusion as an energy source, representatives of the Latin American countries suggested steps in this direction. They suggested that a Steering Committee on North-South Collaboration on Controlled Nuclear Fusion (CNF) and Plasma Physics Research be created. This Committee would report to the International Fusion Research Council (IFRC) and have tasks as follows:

- evaluation of possible working schemes for North-South collaboration in CNF and plasma physics research,
- proposals to the IFRC of a North-South collaboration programme on the subjects that could be carried out under the auspices of the Council, and
- control and co-ordination of the activities resulting from the implementation of the North-South collaboration programme.

Willingness to contribute to ITER activities in the EDA phase

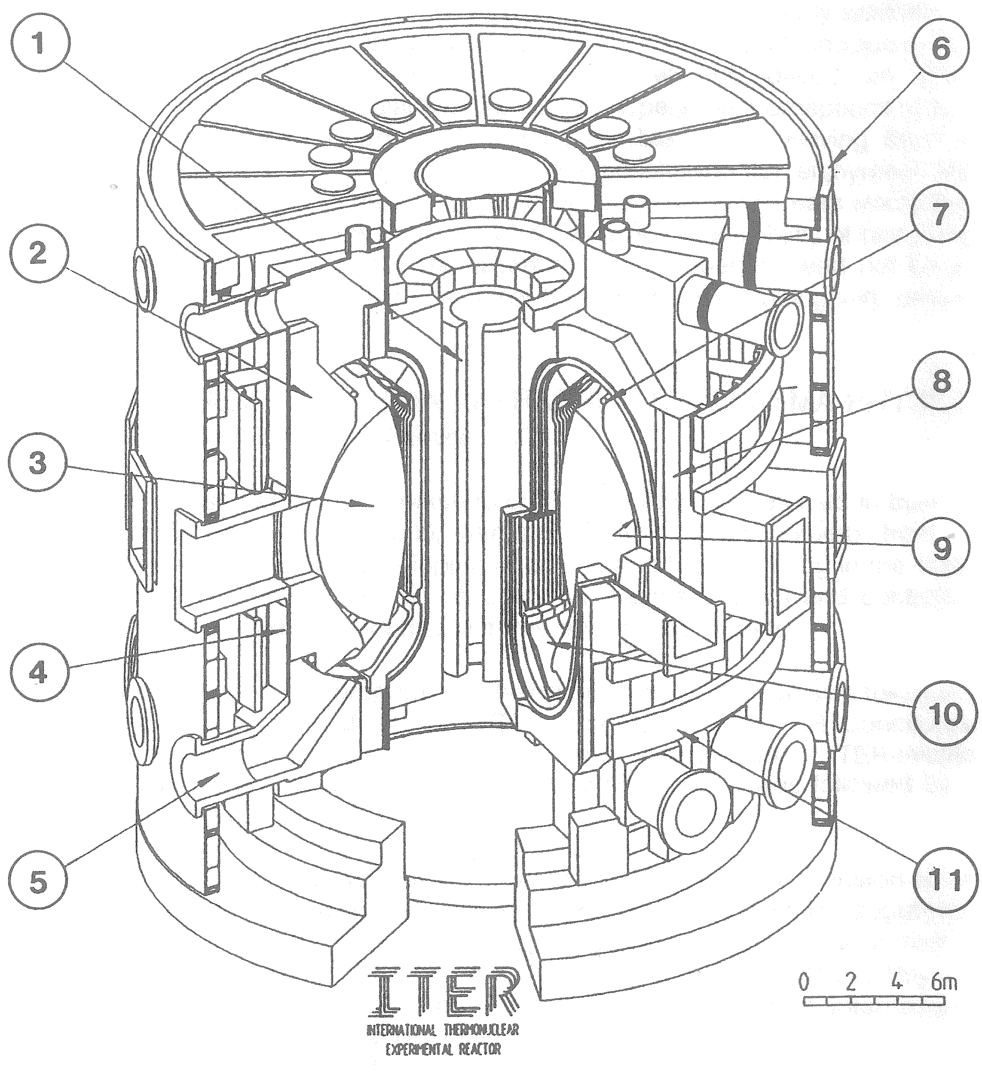
Aiming at possible participation in the ITER EDA phase, it was proposed to approach in future the appropriate ITER entity, equivalent to the present ITER Council, to enable also scientists and engineers from the developing countries to contribute in some ways to these international co-operative activities.

ITER MAJOR EVENTS - 1990

Joint Work Session	Garching	2 July - 16 Nov
ISTAC Meeting	Vienna	12 - 14 Sep
13th IAEA Conference on Plasma Physics and Controlled Nuclear Fusion Research (Special sessions on ITER will be held at the Conference)	Washington	1 - 6 Oct
ITER Council Meeting	Washington	8 - 9 Oct
ISTAC Meeting	Vienna	28 - 30 Nov
ITER Council Meeting	Vienna	11 - 12 Dec

ITER REFERENCE PARAMETERS

Plasma major radius, R (m)	6.0
Plasma half-width at midplane, a (m)	2.15
Elongation, 95% flux surface	1.98
Toroidal field on axis, B_o (T)	4.85
Nominal maximum plasma current, I_p (MA)	22
Nominal fusion power, P_f (MW)	1000



1- CENTRAL SOLENOID
2- SHIELD/BLANKET
3- PLASMA
4- VACUUM VESSEL-SHIELD
5- PLASMA EXHAUST
6- CRYOSTAT
7- ACTIVE CONTROL COILS
8- TOROIDAL FIELD COILS
9- FIRST WALL
10- DIVERTOR PLATES
11- POLOIDAL FIELD COILS

The ITER NEWSLETTER is prepared and published by the International Atomic Energy Agency, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria. Telex: 1-12645, Cable: INATOM VIENNA, Facsimile: 43 1 234 564, Tel.: 43 1 2360-6393/6394. Items to be considered for inclusion in the ITER Newsletter should be submitted to N. Pozniakov, ITER Secretariat.

Printed by the IAEA in Austria
September 1990

90-03847