SUMMARY OF THE FIFTH INTERNATIONAL SYMPOSIUM ON FUSION NUCLEAR TECHNOLOGY (ISFNT-5)

by Dr. J.E. Vetter, Member, International Steering Committee

The ISFNT-5 was held in Rome at the Augustianum Conference Centre on 19–24 September 1999. It has displayed valuable and detailed information on the topics around the central theme "Fusion Nuclear Technology".

The Symposium was attended by about 350 participants from 17 countries. About 350 contributed papers were presented. In the four plenary sessions, distinguished speakers presented review papers as well as papers of general interest; 48 oral presentations on specific subjects related to the conference topics were given in the parallel sessions. About 300 posters divided into 6 sessions were displayed during the symposium. It should be emphasized that more than 50 % of the contributions to this conference were a result of, or inspired by, ITER. The progress in all fields is remarkable. Database and modelling tools are steadily improving, the output from the experiments is impressive.

The ITER project has greatly helped in achieving a common understanding of what a next step shall aim at, and what can realistically be built. Through its large projects, industry has impressively contributed to a demonstration of technical feasibility and capability of larger and more complex components. Careful engineering, designing and modelling have preceded these fabrication processes.

The result, as far as already available on ITER R&D, fully corroborates the design assumptions: ITER is ready to be built.

The Reduced Technical Objectives / Reduced Cost (RTO / RC) ITER, as it is more compact than the previous design (ITER FDR), will imply re-designing of the magnet systems, the shield blanket, the vacuum vessel, the divertor and some handling equipment. Re-designing gives, however, the opportunity for improvements. Considerable improvements could be attained in the building layout and fabrication methods for the components. The R&D basis for ITER remains fully relevant, even though engineering of the divertor and remote maintenance equipment have to be modified.

Much progress was made in the fabrication and qualification of actively cooled components for the divertor. Results from fatigue testing with heat loads of 10 to 20 MW/m^2 and up to many thousand cycles are promising, and the realization of larger modules is also in progress. The discussion on the type of plasma facing material is continuing. Strong erosion and excessive tritium hold-up tends to move the swing in favour of high Z materials rather than carbon or Be.

After many years of preparation and development it can now be stated that the out-of-machine fuel cycle systems are well in hand. The purification system for plasma off-gas has demonstrated its performance by using combined gas separation and catalytic decomposition methods. Prototypical cryopumps are undergoing their first test. However, tritium behaviour inside a Tokamak is an issue for further work, as is detritiation of components on a large scale. High tritium hold-up and migration via dust, as experienced in JET, is a matter that needs better understanding and has an impact on the choice of wall materials in the future.

When mentioning JET, one has to remember that this is still the only machine that has the capability of tritium operation. Therefore, it is not only suited to giving a valuable contribution to the plasma physics program, but also fulfils an important technology mission during the next 3 years' program, especially with its tritium operation campaign. The remote exchange of the complete set of divertor elements in JET has greatly increased the confidence in the capabilities of "hot" intervention. Improvements in computer software, but also in methodology and in development of more sophisticated sensors, give by far better means of plasma control today than a decade ago. This is being impressively shown by the ITER large project on divertor remote handling development.

The continuous work on improving the database and the computational tools was a pre-requisite for the ITER design and will be of benefit for any later hardware project. Finite element programs were developed to model loads, stresses and temperatures, quantities which act as the backbone for the choice of materials, fabrication methods and the overall machine design. The tools for neutronics have been refined to an extent that it is possible today to determine neutron multiplication factors within a few per cent or perform shielding calculations over many orders of magnitude attenuation with an accuracy of 30 %.

It was the amount and quality of detailed work on ITER that makes it possible today to make clear statements on the environmental impact of a large fusion device. From the study of several beyond-design-dose-accidents, it could be concluded that evacuation of the population in the vicinity of the plant needs not to be foreseen for any hypothetical event. This important feature is transferable to a future fusion power plant, provided that proper engineering of the containment is applied.

Studies reported at the ISFNT-5 have also shown that waste, qualified for geological permanent depositories, can be reduced to almost negligible quantities, provided that appropriate materials are chosen and recycling is used.

As a consequence of the debate on an economically attractive reactor, the number of studied options of blankets increases rapidly. Improvements of already well-developed blanket concepts to obtain, inter alia, high power densities could be seen side by side with rather ingenious solutions, whose practicability needs to be proven. In fact, designing, manufacturing and qualifying a blanket is a result of many considerations that have to be simultaneously taken into account. The more traditional blankets — either based on liquid metal coolant breeder concepts or on optimized arrangements of Be and lithium compounds, mostly in form of pebble beds — entrain specific problems that are being tackled by modelling and experiments. Many contributions have addressed these issues. For the liquid metal blankets MHD effects continue to play an important role as does the prevention of tritium permeation. The pebble bed systems have to prove that thermomechanical stresses and irradiation effects do not negatively affect their functions. Progress could be seen in all the issues mentioned, but much needs to be done to obtain a reliable component.

Structural materials play a meaningful role in blanket design. Though a number of general con-tributions in this field were hosted and invited by this conference, the lack of a fusion-relevant neutron source to study irradiation effects, may jeopardize any progress in this essential part of research effort in a while from now. If the fusion community will not be able to build new facilities for testing components and modules, the field of fusion nuclear technology will dry out. Dry out in results and human resources.

In conclusion, my judgement is that the message from the papers presented at the symposium is that the fusion program is now technically ready to take an experimental step such as ITER (i.e. to enter in a regime of long-burning D-T plasma, with a-particle heating being the dominant factor), on the basis of the remarkable results obtained in six years of joint work under the ITER EDA Agreement both in design and R&D activities. For DEMO, however, nuclear technology needs a new dimension of research for which decisions on an appropriate testing facility are imminent.

IAEA TECHNICAL COMMITTEE MEETING ON ELECTRON CYCLOTRON RESONANCE HEATING (ECRH) PHYSICS AND TECHNOLOGY FOR FUSION DEVICES

by Dr. T. Dolan, Head, Physics Section, IAEA

The Meeting of the IAEA Technical Committee "Electron Cyclotron Resonance Heating (ECRH) Physics and Technology for Fusion Devices" was held in Oh-arai, Japan, 4–8 October 1999. About 96 people from 13 countries attended this Technical Committee Meeting (TCM), which was combined with the 11th Joint Workshop on Electron Cyclotron Emission (ECE) and ECRH. There was a substantial ITER participation in the Meeting, including Members of the ITER Joint Central Team (A. Costley, K. Ebisawa, and G. Vayakis, all from Nāka JWS, and N. Kobayashi from Garching JWS.) and scientists working for the ITER Home Teams at their national laboratories.

Drs. T. Imai and K. Sakamoto of the Japan Atomic Energy Research Institute (JAERI) hosted the meeting. The following topics were discussed:

- Theoretical studies of wave-plasma interactions
- Plasma diagnostics using ECRH frequency waves