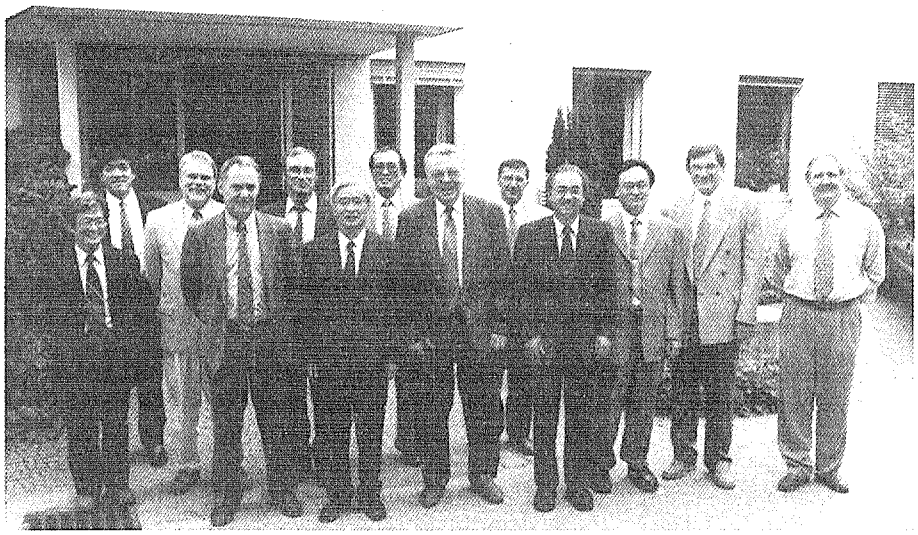
Schedule of ITER Meetings

MAC reviewed and supported the schedule of Technical Meeting and Workshops. MAC noted that proposals are being developed to permit continued interaction of Physics Expert Groups with US physicists under appropriate auspices. The mechanism or framework for the continued interaction with US physicists will be discussed in the PD's meeting in 28-29 July 1999.



Participants in the Meeting

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SNOWMASS FUSION SUMMER STUDY GROUP WORKSHOP

by Dr. S Clement, International Relations (Fusion), Directorate D0 "Preserving the ecosystem", DG XII Science, Research and Development, European Commission, Brussels

The Snowmass Fusion Summer Study Group workshop, organised by senior US fusion community scientists, with the endorsement of the Division of Plasma Physics of the American Physical Society and the support of the USDOE and virtually all US fusion institutions, has taken place at Snowmass, Colorado, July 11-23, 1999. Its purpose was to discuss opportunities and directions in fusion energy science for the next decade. About 300 experts from all fields in the magnetic and inertial fusion communities attended, coming mostly from the US, but with some foreign participation.

In the opening plenary session, it was clearly expressed by the organisers that the main aim of the Snowmass exercise was to build a consensus in the fusion community over both the issues faced by fusion research in all fields (physics, technology, energy, environment, etc) and on the opportunities and means to solve these issues. Summer Study co-chair Mike Mauel (Columbia University) told the group that "by the end of Snowmass, we should be able to explain technically to the general fusion community (1) why these issues are key and important, (2) how resolution of these key issues will advance fusion energy science, and (3) how existing and possibly future facilities and programs can address the key issues."

References to ITER made during the opening session are reflected in the summary of the session prepared by S. Dean, Fusion Power Associates, available through the Internet.

Dr. F. Wagner, Institute for Plasma Physics, Garching Germany, summarized his view of the European program strategy, saying, "The European Union's fusion program is reactor oriented." He said the mandate from the EU Council of Ministers was "The long-term objective of the fusion activities....is the joint creation of prototype reactors for power stations." However, he noted that the actual activities in Europe were "both reactor-oriented and science based." He further clarified: "There is a distinct diversification within the main line and a strong representation of alternatives" and said that "Fusion research is rich in science, but most is applied science." He emphasized that "Fusion research without reactor orientation and application has a shaky fundament" and explained that "the large devices, designed about 20 years ago, have fulfilled their mission, and have more or

less reached their goals and come to an end. The next step is urgently needed." He is sure that, "In the EU, ITER has the support of the majority and this majority is also the carrier of the technical and scientific knowledge." He noted that, "ITER is the only credible next step. It has been developed by a large team over many years which has access to the available knowledge in fusion and industry." He said, "ITER has been realized professionally and by political mandate; it is not the product of an unsupported individual and subjective view on how fusion should be continued" and concluded by stating that, "The next step device must provide the basis for DEMO to be realized in a single further step."

Dr. M. Kikuchi (Japan Atomic Energy Research Institute) reminded the group that, on the time-scale of human history, we are in the midst of "a very short Fossil Energy Era." He noted that Japan's climate was such that solar energy in Japan will be a minor contributor, mostly used "to cut peak power demand." He said that "Fusion still has some advantages over other sources" and that the "low cost ITER is worth the investment."

Some speakers at the plenary session referred to the necessity of a much stronger emphasis on fusion technology development. The most outspoken on the issue was Acad. D. Ryutov, Russian scientist, now at LLNL, who echoed the admonition of the previous speaker, Prof. R. Conn, UCSD, "You cannot come up with a viable fusion power plant design if you only do plasma physics", saying "Plasma physics is necessary, but not sufficient for fusion." He said that "Fusion research is much bigger than plasma physics" and described a number of possible higher risk paths to fusion for the community to consider, including "much stronger emphasis on fusion technology development."

The Study Group was then broken into six Discussion Groups. Each Group presented a summary talk on the last day of the workshop, outlining the main conclusions reached on issues, and opportunities. Based on these summary talks the results of the Group discussions can be presented as follows:

Magnetic Fusion Energy (MFE) Concepts

The goals of this group were defined by the participants as: a) to determine the optimum magnetic configuration(s) for attractive energy production, to be prepared to move forward with the next stage, whether this be a burning plasma experiment, a steady state machine, or both, that is an integrated test of sustained burning plasma, and, b) to provide a fertile ground for innovation and new ideas in MFE.

The group was divided into subgroups covering the issues of transport, MHD stability, plasma boundary, steady state operation, burning plasmas, and concept integration and performance measures. All the subgroups agreed on two points: a) the need to improve on the physics understanding, and to increase the predictive capability in order to develop the scientific basis of fusion energy; b) the need to develop and experiment with plasma control tools.

Discussions in each subgroup individuated specific concerns, such as disruptions, MHD modes, tritium retention in the divertor materials, etc.. None of these problems, however, was considered by the relevant subgroup to be a showstopper for a burning plasma experiment, though several heated discussions took place before the group endorsed, by an overwhelming majority, the statement "the tokamak is technically ready for a high gain burning experiment".

Inertial Fusion Energy (IFE) Concepts

This group was divided into four subgroups, covering the subjects of Targets, Drivers and Stand-off Issues, Power Plant Concepts, and Metrics and Pathways. The summary talk of this group gave a comprehensive assessment of the stand-off issues faced by the different driver, target and chamber concepts, and of the criteria to judge the success of each of the concepts. It also emphasised the desire of the IFE community to proceed in the near future with an Integrated Research Experiment (IRE). The aim of an IRE would not be to implode capsules, as this is the aim of the NIF facility, currently under construction. An IRE would have a 1/10 scale full driver, and its aim would be to validate an integrated concept and so help in the choice of the driver, target and chamber for the following step, the Engineering Test Facility (ETF). Detailed roadmaps and rules for judging and funding projects were proposed.

Emerging Concepts

The Emerging Concepts group was subdivided into subgroups on Physics Issues, Reactor Issues, Next Step and Metrics, and Technical Opportunities.

As could be expected, this was the group that endorsed more enthusiastically the turn towards a science oriented programme taken by the US fusion programme in the last few years. The group endorsed innovation at all levels and made a good case for a continued supply of genuinely alternative concepts to invigorate the fusion programme. An emerging concept was defined as one being significantly different of the mainline concepts and not having reached the Performance Extension level (PE). The classification into mainline and emerging concepts could seem arbitrary sometimes (why is the spherical tokamak mainline, and not the reversed field pinch? why is "conventional inertial" mainline when it has not reached yet the Proof of Principle (POP) level?); the answer being probably in the current levels of funding in the US for each concept. It was stressed that every funded emerging concept project should manage promotion into the next stage (for instance, from Concept Exploration (CE) stage to POP stage), or be terminated. However, most of the so called emerging concepts are as old as the tokamak.

Plasmas Science Issues

This group was divided into four sub-topical working groups: Turbulence and Transport, (Magneto) Hydrodynamic and Beam Equilibrium and Stability, Plasma Wave Interactions, and Plasma Boundaries and Interfaces. The subgroups had to identify cross cutting issues and establish a dialogue between the MFE and IFE communities. The four subgroups found some common themes: besides the universal agreement on the need to improve the comparisons between the experiment, theory and modelling, the need to improve diagnostics and visualisation, and the use of tera-scale computing. The four groups also favoured connections with non-fusion applications and proposed that a part of the budget should be spent in promoting collaboration with other fields of research.

The turbulence and transport group found that MFE and IFE shared similar techniques and identified a number of precise goals for the near future. There were less issues in common between the two communities in the fields covered by the other sub-topical groups, although MFE, IFE and other plasma research have basic plasma physics in common. There was a general consensus on the need to increase the basic plasma research, the need to achieve a higher visibility and recognition in the scientific community, by producing broadly applicable scientific ideas.

Technology Issues

The aims of the technology group were summarised as a) creating an improved vision for an attractive and competitive fusion product through performance enhancement, and cost and complexity reduction, b) to enable near term fusion progress and c) to advance science. The progress achieved, and the development needed in the fields of materials (including liquid walls), plasma control tools, magnet technology, tritium sufficiency, safety and environment issues, were discussed. The necessity to perform reactor studies based on the RAMI (Reliability, Availability, Maintainability, Inspectability) criteria was emphasised.

Energy Issues

The Energy Issues group was divided into subgroup A, termed "Long term Visions of Fusion Power", and subgroup B, termed "Development Path Issues".

Subgroup A discussed the projections of the energy needs of the world during the next century according to different scenarios, and the possibility of fusion becoming an attractive source of energy. The "attractiveness" of fusion depended on how much emphasis was put on environmental issues in the future (carbon dioxide concentration in the atmosphere) as much as on fusion achieving its full potential in terms of performance and safety. There was a need to agree in the fusion community on a plan to introduce commercial fusion energy by 2050, in order to be taken seriously by energy planners. The conclusions on this subject were that: a) the tokamak could lead to an attractive commercial reactor; b) the stellarator, spherical tokamak and IFE concepts were also candidates, but so far were behind in demonstrated performance; c) emerging concepts could lead to improvements in power plant attractiveness; d) it was to early to narrow down to one option, and a balanced program was necessary. The group was cautious on the potential role of advanced fuels in the energy applications of fusion. As for non-energy applications, neutron sources (for fusion-fission applications, and isotope production for medical applications) and deep space applications were discussed.

Subgroup B brought together participants of both the MFE and the IFE communities in discussions of near-term development paths. The summary talk presented the IFE roadmap as seen by the IFE community. There were discussions on the timing for construction of an integrated research experiment (IRE), with MFE scientists in favour of delaying the construction of IRE until the results of the NIF facility are available. In general,

the IFE community presented a smoothly united front, with no public disagreements between the representatives of different drivers or target concepts. This may or may not be due to the fact that none of these concepts has as yet reached the proof of principle stage.

In the MFE section, the readiness of the tokamak for a burning experiment was passionately discussed and finally endorsed by a vast majority of scientists. However, the proposed opportunities to study burning plasmas were limited to considering participation in international collaborations, either in an upgraded machine such as JET (if a decision was made to upgrade JET into a machine capable of achieving Q=2-3), or in ITER-RC/RTO, if construction proceeds in Japan or in Europe. The domestic plans were reduced to "continued design/studies of moderate cost burning plasma experiments (e.g. FIRE) capable of exploring advanced regimes".

Conclusions

The Snowmass Summer Study Group Workshop has certainly had the great merit of promoting encounters between members of the two fusion communities, MFE and IFE. It also has thrown together theoreticians, experimentalists, technologists and engineers: this interaction, which occurs naturally within large fusion projects, is more difficult to achieve in a science oriented approach, with many "small" independent experiments. The proceedings of this meeting will contain valuable information on the state of the art and the issues facing all fusion disciplines.

The conclusions of the meeting have been made available to the Fusion Energy Sciences Advisory Committee (FESAC) advising the US DOE through Martha Krebs, Director of the Office of Science, DOE, in fusion policies for the next decade. The impact of this Workshop on policy makers remains to be seen. The general climate was one of acceptance of all the recent past policy changes towards a science-oriented program, including thus implicitly the budget cuts.

In the MFE community, the majority of the participants felt that a burning experiment was the necessary next step, the timing and location of such an experiment being a matter of discussion.

Participants in the Workshop