When the cost of a fair-sized facility was of the order of 50 MSFR or less, proponents could work at obtaining approval and funding by following specific local rules. The rules for new facilities are now very different, for in order to be competitive and to explore new ground they cost up to 500 MSFR, and sometimes much more. Assuming clear scientific needs, approval can only be envisaged if there is a sufficiently large constituency of potential users, which in Europe at least, nearly always requires international collaboration. So it is important to have concertation and advisory structures which can assess the needs and the sizes of potential user communities and formulate recommendations. The conference highlighted the increasing number of advisory bodies, and their members learnt much about each other.

Some participants from outside Europe openly expressed recognition of the strength and the apparent health of "heavy" physics in Europe, and that this was reflected by the conference. Such strength is important because, sadly, the end of the cold war which could have resulted in increasing support for heavy science appears instead to have prompted an increasing questioning of its value. What is clear, however, is that funds saved on large facilities will not be transferred to small-scale science, but will be lost to basic research. With such issues in mind, participants were made aware of the challenges that lie ahead, and of the sometimes very different ways they are being approached.

Fig. 2 — Herwig Schopper, the conference chairman, with R.M. Bonnet (on the left), Director of the European Space Agency's Science Programme. In addressing the opening ceremony of the Large Facilities in Physics Conference, Professor Schopper saw the main challenges as being:
– to adjust to the fact that more and more fields in physics need facilities;
– to make the best use of resources as they are under pressure;
– to find new ways to co-ordinate as the need for more international cooperation makes political procedures more difficult.

Hubert Curien opened the *EPS Large Facilities in Physics Conference* in Lausanne (12-14 September 1994) by describing the difficult, but not insurmountable, realities that promoters and users of facilities must face.

There Should Be No Illusions

Hubert Curien.

Our reflection on the significance of facilities in physics comes at an appropriate time because the European Synchrotron Radiation Facility in Grenoble recently held its official inauguration. The source works beautifully and represents a remarkable success for our continent. We are also in the final stages of deciding upon the Large Hadron Collider (LHC) at CERN. Discussions are coming to an end; all involved understand that we need such a machine and that we need to make a rapid decision.

In discussing large facilities one should first say what they are. A quantitative definition in terms of say the part of the national science budget that is spent on a certain facility is possible. But the amount depends very much on the size of the country, so a reasonable criterion could be to say that a facility is considered as large if it needs say 0.5% of the annual science budget.

But there are other — essentially qualitative — criteria. One is the need for consultation. If a facility has a significant size it will generally be discussed by various ministers within a country. There is also a need for a pluriannual programme: money is required not only for construction but also to run a facility. The problem here is that most countries have annual budgets while a facility has to have a commitment for a long period. However, this internationalisation may help to stabilise a situation as it tends to persuade governments to continue funding.

Structures at All Levels

There has been a blossoming of interest these last few years in discussing facilities. At the national level, almost all medium-sized countries now have a forum where facilities are analysed. For instance, in my country (France) a committee for large instruments looks at all instruments across several fields. This is understandable because public-sector investments in large facilities are substantial (close to 10% of GDP in most industrialised countries). In large countries such as the USA there even tends to be specific committees for given fields (*e.g.*, the US Department of Energy's High-Energy Physics Advisory Committee). Regional bodies may exist and a good example is the European Science Foundation that initiated and piloted the discussions that led to the creation of the ESRF. Finally, some global structures have emerged. I shall mention three. The Organization for Economic Co-operation and Development (OECD) Megascience Forum started from an idea of Allan Bromley, the Scientific Adviser to a former US President. He thought that the OECD was a good place to promote discussions: decisions could not be taken but analysis and recommendations were possible, as in a true forum. He was confident that the OECD could handle the task because it was heavily involved in very respected country-by-country assessments of science. The Forum has held expert meetings and made recommendations in several fields. I am less enthusiastic about its plenary sessions (which unfortunately cannot be avoided) where the "rule of inverse proportionality" seems to be the case (the less one has to say, the longer it takes to say it). UNESCO has created a Physics Advisory Council and in the field of space activities, the coordinating body for the 1992 International Space Year has now evolved into the Space Agency Forum.

Difficulties Remain

Nonetheless, there remain certain difficulties as regards large science. We should look at the causes and come up with proposals to remedy the situation. I shall consider two fields, namely space science and particle physics. The first does not entirely concern physics, but there is much involved. There has been a dramatic change since the end of the cold war period when Europe was very much an adjunct to the US and the USSR. Few now care about the space station: no political conquests are needed and few scientists would have been involved in experiments in the station. Some scientists naturally think that with the same money one could do many other things. The problem is that one will never have the same money; if money is not spent in one field in science, there is no hope of transferring it to another. The pots simply do not

ACKNOWLEDGEMENTS

The *1994 EPS Large Facilities in Physics* conference benefitted greatly from the help of Professor C. Joseph and Mrs. B. Rothen of the University of Lausanne who took charge of the local arrangements. The EPS nature of the conference was stressed by having the organizing committee composed of representatives of EPS Divisions and Interdivisional Groups. The Society also received much advice and help from The Physical Society of Japan and from The American Physical Society. Thanks to the generous support of the European Commission, the Divisions and Groups were able to sponsor several young participants; other support from various organizations was used for participants from central and eastern Europe and from the former Soviet Union. The proceedings, to be published early in 1995 by World Scientific, will include the review talks and summaries of the round-table discussions.

communicate any longer.

Consider some features of the space station. Its cost was estimated at M$US 33000, and M$US 9000 has already been spent; the US Congress asked for a price cut and the cost is now estimated as M$US 19000. This is not the way to generate confidence in a project. In the case of particle physics, the closure of the Superconducting Super Collider project was a drama for many colleagues in the US: it was clearly a bit too expensive and its estimated price increased too rapidly. I shall not comment on its management, but merely note that Congress would not accept the cost. The price was too high because the project started from scratch. This is an important point as it is necessary to be progressive by making use of existing facilities. By contrast, the price of the LHC is not too high and I am sure that the machine will be achievable.

Some Illusions and Conclusions

I know of physicists who think that with the end of big programmes they will get more money. I repeat that "les vases ne communiquent plus". There are special decisions for large facilities so they stand alone. Meanwhile, the golden years of megascience have ended as there is no longer the concern of the general public, and hence of government. Many people feel that science cannot directly solve the unemployment problem. So while it is still evident to some that science is necessary, we cannot expect that its share of resources will increase faster than the average rate of growth of a country's wealth.

In expecting not to be appreciated as much as in the past, we have to demonstrate the usefulness of claims. Moreover, when arguing the case for facilities we must not forget that their running costs are important. The significance of this remark is easily appreciated by noting that CERN's annual operating budget of 900 MSFR is not very much smaller than the construction cost of LHC (about 2300 MSFR). With new investments, we have to be sure that the annual running costs are covered without jeopardising physics as a whole.

We must also remember that facilities are becoming more international. One has to start discussions on a new facility with all colleagues before promoting it. This was not exactly the rule in the past. Recognizing such issues is becoming vital to us all because it is becoming increasingly common for the average physicist to work at or in close contact with a facility.

Hubert Curien, the President of the CERN Council, was the President of Academia Europaea in 1988-93 and served as France's Minister of Science in 1984-86.

PLENARY TALKS

Key Issues Demonstrated

The technical presentations at the *1994 EPS Large Facilities in Physics Conference* illustrated — often in a dramatic way — the trend towards facilities that tackle world-class research goals, extend into a broad range of fields, exploit technology at its limits and even beyond to provide major increases in capabilities, and are increasingly based on multidisciplinarity and international cooperation from the start.

HIGH ENERGY PHYSICS

Frontiers Call for Commitments

C. Llewellyn Smith, CERN's Director-General, set the pattern in explaining why the standard model of particle physics is too "baroque" and logically incomplete despite its great success. CERN's LHC machine aims to address many of the open questions so it is undoubtedly the right machine at the right time, for new physics must emerge on approaching the 1 TeV bench-mark at the quark-quark level. He summarised the status of the negotiations to fund LHC with the hope that it will be "constructed as a global partnership". After summarising HERA's recent contributions towards unifying the electromagnetic and weak forces, he turned to other activities in high-energy physics (HEP) in Europe to illustrate the overall depth of the programme. This includes new work at CERN's LEAR which announced a week earlier a spectacular (10^4) improvement in the accuracy of the measured mass differences between the proton and the antiproton (to 1 in 10^9).

Françoise Praderie (on the left), Coordinator of the OECD Megascience Unit, with Günter Flügge, Chairman of the European Committee for Future Accelerators.

In the US, the Drell report on HEP has recommended a boost in spending as a way to recover from the closure of the SSC project (Congress has now to decide). According to S. Wojcicki from SLAC, some 75-85% of the US's HEP effort is spent at four main centres. It will ensure that the versatile accelerator complexes which have evolved over 25 years will remain at the frontiers for the decade to come. FERMILAB is carrying out a 300 M$US upgrade of its $p\bar{p}$-collider (by autumn 1998) and a new fixed-target facility is planned; Brookhaven is constructing the heavy-ion collider RHIC; SLAC has the go-ahead to build an ambitious B-factory, and Cornell will upgrade its CESR e^+e^- facility in three phases by 1998 to give a monopoly on e^+e^- collisions at the $b\bar{b}$ threshold.

International Cooperation a Major Item

The 14 M$US spent on overseas collaborations these last 10 years by Japan's HEP community demonstrates a strong commitment to international activities. And as H. Sugawara, the Director of Japan's national HEP laboratory (KEK), explained, this is carried out in parallel with a major national HEP programme. Under construction are the new Super Kamiokande detector (first data in late-1996) and a B-factory at KEK (commissioning at the end of 1998), where much effort was required to deal with a hitherto unknown instability arising from the very heavy beam loading. The Japan Linear Collider project (1000 M$US; 3-4 years construction) is still being planned as a national project (11 sites have recently been short-listed) in spite of the extensive international collaboration in the field. It has been decided to join RHIC, a 100 M$US τ-charm factory in China, and LHC's ATLAS experiment. A representative committee has recommended that any SSC engagement be replaced by LHC, but it may be hard to keep the government's high level of interest in LHC if the decision to go ahead is deferred for too long. The US is "psychologically" in the same position: there is momentum to support LHC (senior officials have talked about a 400 M$US contribution) but it will not last for ever.

Advanced Technology Essential

B.H. Wiik, the Director of DESY, Hamburg, discussed in more detail how R&D, largely at a technical level, for a future linear collider is progressing at several laboratories around the world in the framework of a collaboration. Physics machines of this type are now feasible owing to the development of control systems. Axel Daneels, who chairs the EPS Interdivisional Group for control systems, described how critical such systems have become; they are costly, essential for good performance and offer much *via* integration into an overall management system. D.J. Wallace (Loughborough) explained that the rate of technical development is also not easing up in supercomputing, where physics remains a driver owing to its computational needs. But it is the commercial and policy issues that interest him most. Europe is clearly well behind the US when it comes to supercomputing resources. This can be changed if funding agencies take into account the whole life cycle of a facility as witnessed by all participants. Telecommunications are also inadequate, largely owing to arbitrarily high tariffs and weak international initiatives.