THE SSC: POLITICS AND SCIENCE

All Eyes on Europe

H. Schopper argues that the particle physics community can look forward to a positive future in spite of the decision to terminate the SSC project.

The dust has settled on the long drawn-out and painful decision of the US Congress, Senate and Government to cancel the Superconducting Super Collider. It is now the time to reflect on the lessons that can be learnt from what Hazel O'Leary, the US Secretary of Energy, referred to as "devastating blow to basic research and to the technological and economic benefits that always flow from that research". The decision was indeed tragic — for science but especially for the SSC Laboratory's employees and for the many university groups who had linked future activities to the project. The scientific justification had never been seriously placed in doubt throughout the SSC's history, so we do not need to discuss this aspect. What then were the reasons for the failure of the project? In my opinion it was a very unfortunate interaction between science and politics, with mistakes made on both sides. It is here that the main lesson is learnt!

A Basic Ambiguity

A major factor might have been the ambiguity which was inherent in the project right from the beginning: the SSC was proposed as an international cooperation, but was considered to be the only means to reestablish North American leadership in elementary particle physics. After leading the field with much vigour for several decades, the USA felt that its position had been lost to Europe. In addition, the construction of the SSC was to boost American industry and technology. The ambiguity became clearly evident when in 1982 the Head of States of the G7 group set up a working group with a sub-panel on elementary particle physics (the "Attali panel"). All the partners apart from the USA were in favour of immediately establishing a worldwide, coordinated programme for large facilities in high-energy physics, but the US Administration thought that the SSC should go ahead as a national project since otherwise approval by the President was in doubt. However, financial contributions from other countries were asked for, even at a hearing in the US Congress to which European representatives had been invited. These never materialised since Japan and Europe thought they were not offered an appropriate rôle.

One additional aspect which made it difficult to find partners is the way in which the US system handles major projects. Parliaments in democratic countries naturally insist on their right to approve every year the budget proposed by government. But mechanisms have been developed in most countries which at the same time allow for planning several years ahead, and make it possible for the government to enter into long-term commitments with partners who need to be confident of some continuity in common activities. The battles between the US Congress, Senate and Administration have certainly not provided this reassurance.

Another important aspect of the SSC's death was undoubtedly the ever increasing cost, which more than doubled from the original 4400 M$ to a final estimate of 11000 M$. High-energy laboratories are proud to have realized in the past essentially all their major projects within budget and on schedule. Why was it different with the SSC? In these earlier projects, the entire responsibility for not only design and technical development but also management and procurement lay in the hands of a laboratory. This was not the case for the SSC which was organized and executed more in the style of a NASA or defence project. These difficulties would maybe have been avoided in Fermilab had been chosen as the SSC site instead of a "greenfield" in Texas.

The SSC was unfortunate in that while being too large and too costly it still could not fulfill expectations. It was difficult to justify to politicians and taxpayers the high cost of such a project in fundamental science, and on the other hand it was too small to provide adequate returns to a majority of US States. Essentially only two States would have profited (Texas and Louisiana) — something that was apparently a crucial aspect in the negative decision of Congress. For otherwise how can one understand the continuation of some NASA projects, which cost much more than the SSC and do not have high scientific expectations or technological value, but give returns to many States?

No Effective Forum

Another deficiency also became evident during the international negotiations. Large projects require a close interaction between scientists, politicians and government administrators. Whereas mechanisms may exist for bilateral projects, the only platform which was available for truly international enterprises, namely the Attali panel, had disappeared. UNESCO and the OECD have recently taken initiatives to establish new ways to discuss and prepare decisions for large scientific projects. The experience with the SSC has demonstrated that they require the support of the entire scientific community and not only of those people who are directly interested. Physical societies in Europe, America and Japan as well as science foundations and academies should play a larger rôle in developing the necessary consensus. The Presidents of EPS and The American Physical Society signed a letter to this effect which was consigned by the President of The Physical Society of Japan.

A Positive Future

I believe it is now time to close the books and look to the future. As usual, every negative event also has its positive side. Silenced are the critics who claimed that the SSC and the LHC project at CERN were part of an unreasonable competition instead of a fruitful cooperation. The door has now been opened again for a worldwide dialogue aiming at a complementary programme which would

First LHC Prototype Dipole Delivered

The photograph shows the first of the prototype, 10 m long, twin-aperture, 9.5 T, superfluid helium cooled bending dipoles for CERN's LHC machine on the day (1 February 1994) it was delivered. Called the CERN-INFN Dipole Prototype 1, manufacturing was managed by the INFN's Milan Section at its Laboratory for Applied Superconductivity (LASA) which engaged mainly Italian companies, notably LMI (superconductor), Ansaldo (magnet) and Zanon (cryogenic vessel). INFN will supply two prototypes as an approximately 4.5 MSF contribution to the LHC project (the second is expected to arrive at CERN in April). Both have an essentially classical design comprising a magnetic yoke split into two halves with a common aluminium collar supporting the magnet coils and the two beam tubes. Five other prototypes are due to be delivered this year by industry (Ansaldo, Noell, Elin/Holec, and Alsthom/Jeumont). The dipole design has naturally evolved over the years, so two of the five prototypes have the collars around the two beam pipes separated (they are made in one case from stainless steel and in the other from an aluminium alloy).

CERN is to test five of the prototypes and CEA, Saclay, will probably test the remaining two. If all goes well, the CERN-INFN prototype will start to be cooled down in March with the first magnet test results emerging in April or May. CERN has already begun testing the so-called LHC Dipole Thermal Model delivered by Zanon in December. It has essentially the same configuration as the normal dipoles, but with a simpler cold mass for easier testing. Several 1.3 m long, twin-aperture model dipoles as well as a full-length dipole made using large aperture coils of the HERA type [*EN* **23** (1992) 105] have also been evaluated, with the later reaching a record field of 10.5 T. Optimization of the LHC design since the first batch of prototypes was ordered in 1991 has led to an increase in the coil aperture from 50 mm to 56 mm and to a reduction in the field generated to 8.65 T. An external review of the machine design recommended in December that at least a further five prototype dipoles should be constructed, with three having the same design to test reproducibility. R. Perin who heads the LHC magnet development group at CERN says that it is intended to place orders for these new prototypes this year.

make the best and most efficient use of the resources available. In a time when financial difficulties appear just about everywhere, such an opportunity seems to be an indispensable ingredient.

LHC meets the condition in an excellent way. Although the energy is less than one-half of that of the SSC, the machine's discovery potential remains very high, especially since no definite thresholds for new physics are known at present in the energy gap between SSC and LHC. Maybe more important is the fact that the interesting events are not the collisions between the accelerated protons, but rather those between their constituents, namely quarks and gluons. These particles have a broad energy distribution inside the protons, with a tail at the high-energy end, so lower proton energies can partly be compensated for by higher collision rates. The cost of the LHC is very favourable since space had been left in the LEP tunnel to accommodate the LHC magnets. LHC thus guarantees a full exploitation of the initial investment. In addition, the whole injection system made up of several of CERN's accelerators is in place and meets all the requirements, not only for protons but also for heavy ions. Finally, the cryogenic system installed for LEP as well as other parts of the infrastructure can also be used. It therefore seems only reasonable that CERN Council confirmed in December that LHC is the future project for CERN; a positive decision to go ahead is envisaged for later this year.

The incoming Director-General of CERN of course now has the delicate task of finding ways to finance the project without a significant increase in contributions from CERN Member States. This raises the question of Non-Member State participation. There is full agreement that the LHC experiments should in principle be open to all physicists, but it is understandable that the Member States will request adequate contributions towards the construction of LHC, and maybe also for its operation. Since full membership seems to be unrealistic for some countries, new models for participation will have to be developed, especially for the USA and Japan. Since the LHC instead of "the SSC will be the flagship for the world's high-energy physics program" (O'Leary) let us hope that these problems can be settled in the near future.

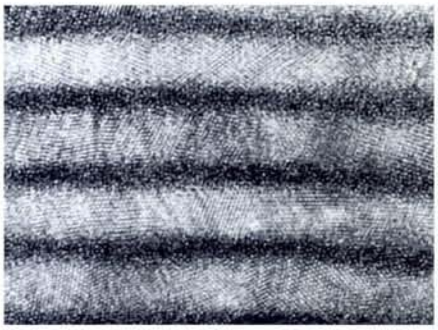
The operation of LHC is planned to start in 2002. In the meantime, several opportunities are offered to physicists and there is therefore no reason for defeatism because of the SSC decision. There is a strong hope that Fermilab's TEVATRON will soon discover the top quark (a determination of its mass would provide a very important input for the Standard Model). LEP is presently undergoing an upgrading to higher energies with the aim of measuring precisely the mass of the W-boson, another important parameter for the theory, and of studying other features of the Standard Model. HERA at DESY has only just started its research programme and exciting results can be expected. A B-factory has recently been approved for SLAC in the US, the approval of a second is imminent in Japan, and in China and Russia discussions for the construction of tau-charm factories are continuing. Elementary particle physics is still a flourishing field and we all hope that *New Scientist* will be proved right when it wrote "... the death of the SSC will leave the scientific community sadder but wiser — and perhaps fitter for the future".

EUROPHYSICS INDUSTRIAL WORKSHOP

Exploiting X-rays at the Nanoscale Continues to Challenge

The convivial organization of the EIW entitled *Nanometre-scale Methods in X-ray Technology* (the 9th in the EIW series) held on 11-13 October 1993 in Veldhoven allowed a remarkably fruitful exchange of ideas concerning the various challenges facing those exploring and using the interaction of X-rays with solids at the nanometre scale. One only needs to consider some of the major applications of multilayer mirrors to understand the significance of the field. These mirrors are playing an increasingly important rôle in imaging and spectroscopic applications for X-ray solar and stellar astrophysics [Christensen, Danish Space Research Institute], soft X-ray spectroscopy of laser plasmas [Platonov, IAP, Nishnii Novgorod] and X-ray fluorescence spectrometry [Urch, University of London; Vrebos, Philips Analytical X-Ray]. Several projects dealing with multilayer optics for soft X-ray projection lithography are also being pursued [Heinzmann, University of Bielefeld; Platonov; Louis, FOM Rijnhuizen; Artyukov, Lebedev Physics Institute, Moscow]. They emphasize the preparation of high-reflectivity multilayers and laterally structured reflection masks.

Considerable theoretical and experimental work is also devoted to laterally structured thin films, crystals and multilayers. High-resolution XRD at both glancing incidence and large angles has been used to study crystal truncation rod scattering from surface gratings etched in semiconductor materials [van der Sluis, Philips Research Labs; Baumbach, ILL, Grenoble; Tolan, University of Kiel]. New devices based on multilayer surface gratings have been designed, and manufactured. Successfully tested are thick zone plates [Vinogradov, Lebedev Physics Institute], Bragg-Fresnel multilayer lenses, lamellar multilayer gratings, and beam splitters prepared using technology derived from microelectronics for the microstructure fabrication. A major effort has been made at the same time to explain the performance of these devices on the basis of dynamical theory [Erko, IPMT, Chernogolovka; André, University of Paris].

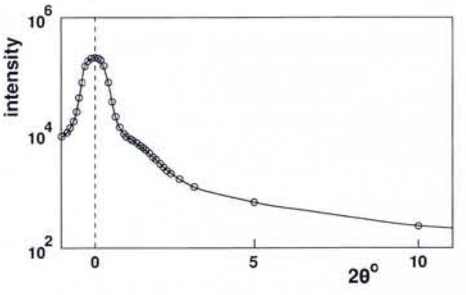


A nanoscale Co/W multilayer.

In general, the field of nanometre-scale methods in X-ray technology can be subdivi-

Out-of-Plane Scattering Offers Improved Characterization of Multilayers

Measurements over a large range of momentum transfers $Q_{\|}$ parallel to the sample surface are required to separate out the various components of the diffuse X-ray scattering from multilayers, so that structural features such as interface roughness, amorphicity, and the degree of conformality between successive layers can be characterized. However, in the standard method of rocking the sample about the position of specular reflection, the range of $Q_{\|}$ that can be achieved is limited by the sample surface. Secondly, the component of momentum transfer perpendicular to the surface varies so the observed scattering is affected by changes in the sample's transmissivity.



Low-angle diffuse scattering intensity, integrated over the exit angle, of an amorphous W/C multilayer for an angle of incidence of 1.48°. The intensity is plotted as a function of 2θ, where θ the angle between the incident beam and the detector in the plane of the surface, and $\sin\theta$ is proportional to the momentum transfer $Q_{\|}$ parallel to the surface.

A way around these problems was described at EIW-9 by Salditt *et al.* The new method is based on out-of-plane scattering, with a scattering geometry which is essentially the same as that used for grazing incidence diffraction (constant incident and exit angles on the sample; position sensitive detector moved out of the plane of reflection). Examining a multilayer sample comprising alternating layers of amorphous W (23.7 Å thick) and amorphous C (25 Å thick), they found that the intensity decreased continuously by over two orders of magnitude in the narrow-angle range (see figure). This behaviour can only be explained if, for the sample studied, at small Q diffuse scattering by rough interfaces is much greater than amorphous scattering. Some recent simulations of diffuse scattering by amorphous multilayers will thus need to be reconsidered, thereby illustrating the value of having an improved technique for identifying the various contributions to scattering in multilayers.