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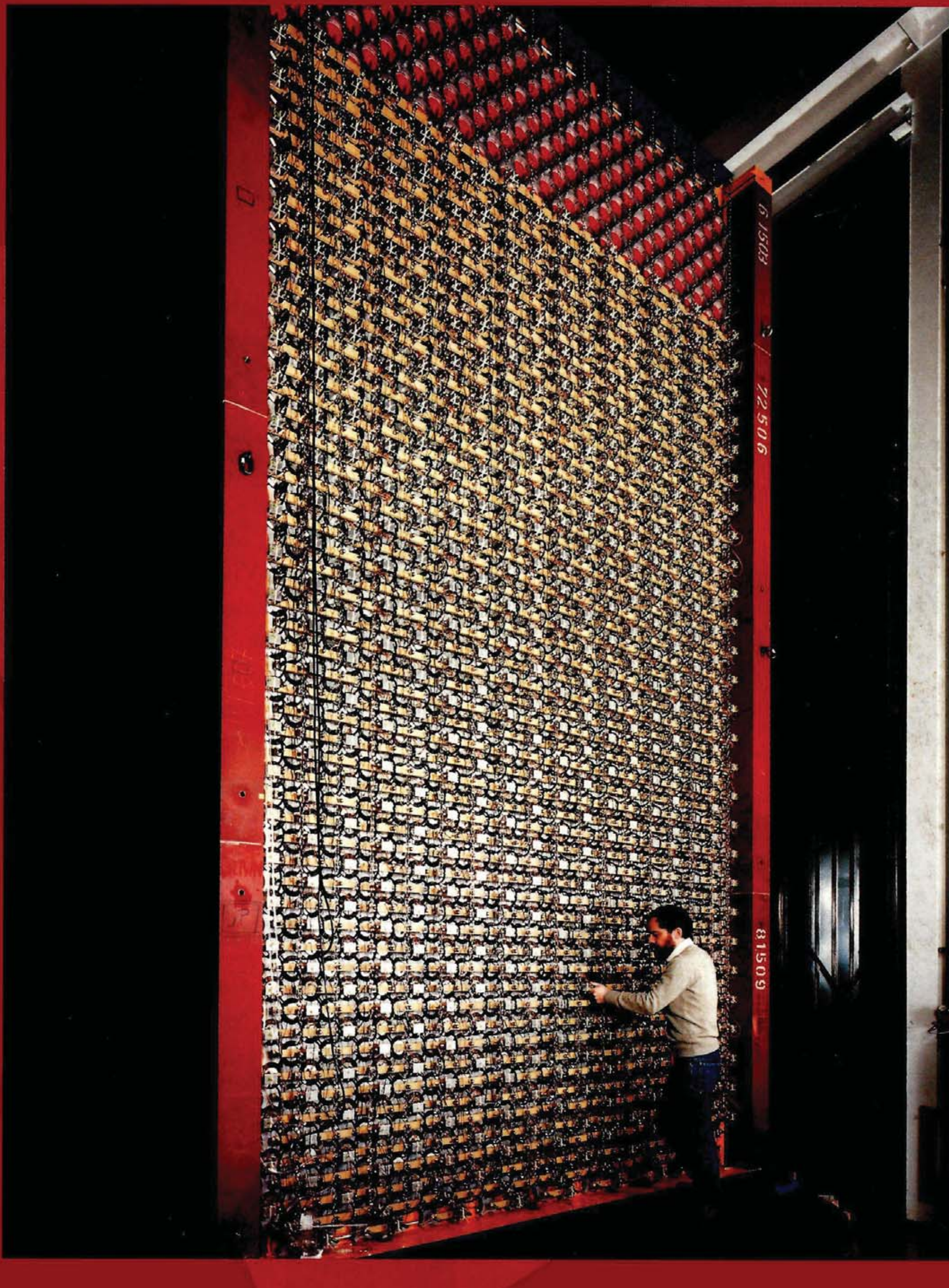

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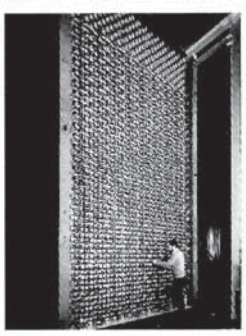


Cover photograph: A major neutrino experiment that unfortunately slipped through the net in our November Neutrino Physics Special. In a major UK/Germany collaboration, the 60 ton liquid scintillation KARMEN calorimeter at the UK Rutherford Appleton Laboratory's ISIS facility is investigating neutrino-induced excitations of carbon-12. The liquid scintillator volume is subdivided by an optical segmentation into 512 modules read out by a total of 2048 fast 3" phototubes. (Photo RAL Photoservices)

Superconducting superconvulsion

Shock US decision

SSC dipole magnets on test, with the cryostat tubes mounted one above the other to simulate what the collider would have looked like.

After a baffling succession of see-saw decisions which saw the mood swing from the depths of pessimism to supreme optimism and back, on 21 October a US House of Representatives Committee proposed $640 million for the 'orderly termination' of the Superconducting Supercollider (SSC) project in Ellis County, Texas.

By next July, the US Secretary of Energy is requested to produce a plan to 'maximize the value of the investment in the project and minimizing the loss to the US, including recommendations as to the feasibility of utilizing SSC assets in whole or in part in pursuit of an international high energy physics endeavour.'

The SSC was to have been the biggest of them all - two 87-kilometre rings of superconducting magnets to collide proton beams at a total energy of 40 TeV (40,000 GeV) and search for the mechanisms underlying the behaviour of the quark constituents deep inside the colliding particles.

It was from the start an ambitious project. It was meant to be. Conceived in the early 1980s amid all the Reagan euphoria of 'junk' bonds and heavy government borrowing, the SSC idea was in some ways a scientific parallel for the audacious technology of the Strategic Defense Initiative - 'Star Wars'.

On the physics side, the emerging picture of electroweak and quark interactions in the 'Standard Model' suggested that something fundamental had to happen when quarks smashed together at collision energies of about 1 TeV. Since the quarks cannot be liberated from their proton prisons, this means colliding proton beams with much higher energies. The outcome was anybody's guess, but physicists were convinced that a new door had to open. It was heralded as a 'no lose' opportunity.

Underlined by these convincing physics arguments and propelled by national pride, the SSC idea pushed ahead. It would be a US scientific flagship for the world. Inside the US, it would create jobs and boost national science education.

In the intervening ten years, the scientific foundations remained rock firm, but the financial setting shifted completely. The US found itself staggering under a burden of budget deficit, while Star Wars evaporated along with the Cold War (or vice versa?).

The immense task of finding a politically acceptable site for the giant machine, and excavating and equipping the giant tunnel took too long. In the cost-conscious 1990s, the project was too visible. Rather than a beacon of scientific prestige, its price tag made it a sitting duck for symbolic cost cutting.

The final confrontation began in June 1992, when SSC funding, wrapped in a national package of energy-related issues, was voted down by the House of Representatives. For the US high energy physics community, it was an unexpected body blow.

After vigorous lobbying, funding was voted back by the Senate. When the two US Houses disagree, a 'Conference' committee has to produce a mutually acceptable compromise. In 1992 conferencing, the SSC triumphantly came out ahead, with $517 million in its pocket for financial year 1993.

While the SSC proponents patted each other on the back, they steeled themselves for what lay in store. With the arrival of the Clinton administration in 1993, and with many new faces in both Houses, the next round was going to be tough. Hopefully the SSC might slip through, hidden inside the US annual energy package. But as the first 1993 blows began to be exchanged, opponents in the House soon singled out the SSC for special treatment.

B factory

On 4 October, President Clinton announced the decision of Energy Secretary Hazel O'Leary and Presidential Science Advisor Jack Gibbons to build a 'B-factory' at Stanford's Linear Accelerator center, SLAC, (June 1991, page 8). Projected cost is $177 million in current dollars, spread over the five financial years 1994-98.

While the B factory's initial tranche of $36 million was rejected along with the SSC in the House of Representatives Energy vote on 19 October, unlike the SSC it survived the subsequent 'conferencing' compromise.

Led by its champion, Senator Bennett Johnston, the SSC moved back ahead in the Senate. It was classic SSC, with deft legislative footwork. On 14 October, the Conference Committee duly recommended giving the SSC everything it had asked for.

But this time the opponents were not finished. Incensed by what they saw as biased conferencing, the Lower House was clearly looking for trouble and, in some skillful parliamentary procedure, rejected the recommendations.

Then on 21 October came the KO punch, when a new Conference Committee voted for the 'orderly termination' of the project. $640 million of winding-down money is to be made available.

From Desertron to SSC

In the early 1980s, it was clear that the proton-antiproton collider at CERN was where the action was. Even though the W and Z particles had not been found, they were going to turn up any day. In the wings, the LEP electron-positron collider was being prepared to mass-produce Zs. For the first time since the early 1930s, Europe was the focus of world research on the inner structure of matter.

To attack the next layer of physics objectives and to restore US preeminence, what was to become the SSC was unwrapped, and the more modest Isabelle proton collider at Brookhaven abandoned.

The ambitious new project for colliding 20 TeV beams was earmarked as number one priority in the US programme. The initial recommendation said '(the SSC) appears to reflect the universal aspirations of the US high energy physics community'.

The big machine would need a home where land was cheap, and soon earned the name 'Desertron'. 'Desert' was also the physics name coined for the unexplored territory between the electroweak unification scale and the next unification point, when the quark constituents of nuclei would also join the picture.

To get the research and development programme for superconducting magnets off the ground, a design group was set up at Berkeley. In 1984, first design options were chosen, and President Reagan's blessing given in 1987.

Meanwhile the search began to find a home for the gigantic machine. 43 initial proposals from 25 states were subsequently whittled down to seven, including Illinois, where the SSC could be built alongside Fermilab, the world's highest energy proton ring and an ideal SSC injector.

But politicians were more interested in pork barreling than scientific economy. In December 1988 the decision was made to put the SSC in Texas. With the Lone Star State hungry for culture, the SSC would provide a prime academic focus. State money rolled in to augment Department of Energy funding. But the Texas label increased the SSC's visibility back in Washington.

Conceived as a national project, the SSC realized too late that it would need international collaboration, and the project was on the agenda at several high level diplomatic visits. Some countries signed up. Russia became involved in the work for the injectors. India and China put contributions on the table, and negotiations began with Korea. But Japan remained aloof.

Magnet designs firmed and plans for the experimental programme got underway. With US physics manpower fully mobilized, plans took shape for two mighty detectors - SDC and GEM.

Tunneling machines arrived on the Ellis County site and began work last year. At the 1992 international high energy physics meeting in Dallas, hundreds of physicists admired the preparations on site.

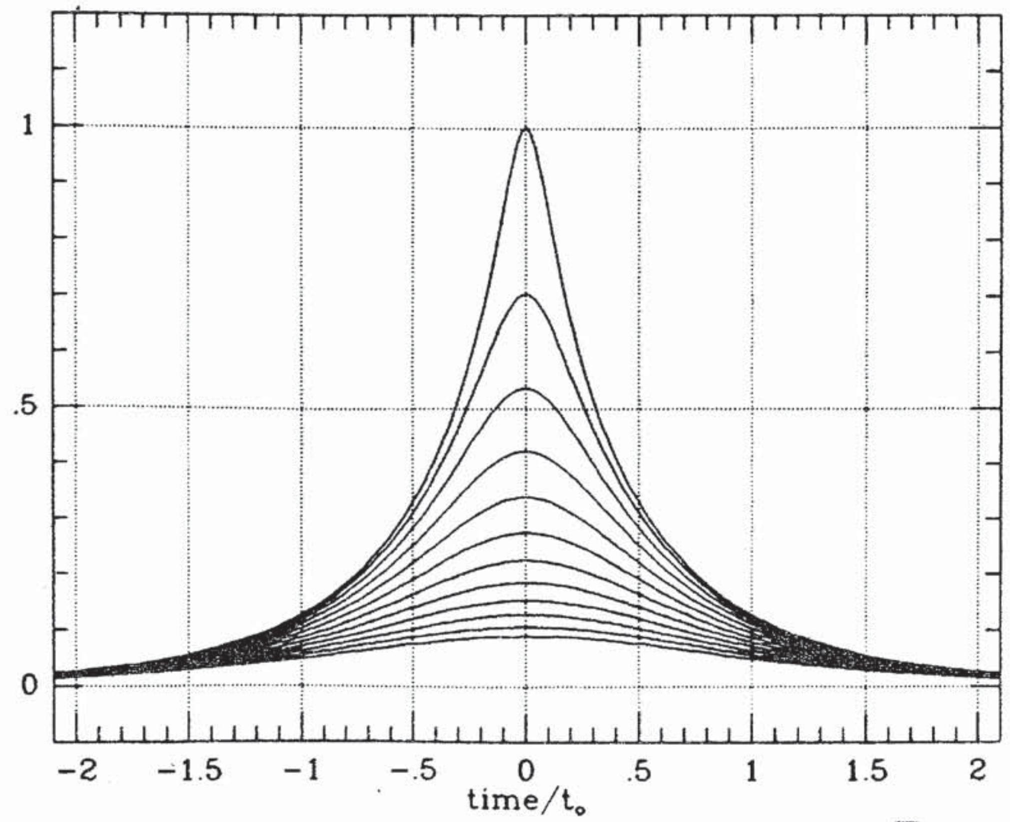
Despite funding problems because of this year's uncertainty, by October 1993 some 23 km of tunnel had been bored. Now they will remain empty. Careers are in ruins. 'Do you know what we have done to these people?' thundered Bennett Johnston in the House-Senate Conference debate, going on to underline the importance of planning for new directions and exploiting what had been done for the SSC.

CERN management said 'the European physics community hopes that collaboration can continue in this field which American physicists have been instrumental in creating and have led, with characteristic vigour, for several decades.'

The SSC's scientific goals are still valid. With CERN's LHC proton collider to be built in the 27-kilometre LEP tunnel, and with world-wide efforts still pushing ahead to obtain the 1 TeV threshold by firing electron and positron beams at each other, this science will be the inheritance of the early 21st century.

MACHOS and brown dwarves

A light on dark matter? In 1986 Bohdan Paczynski of Princeton suggested that invisible objects might show up indirectly through 'gravitational microlensing' if they pass across the line of sight of a distant star. The diagram shows the expected amplification for different offsets from the distant star as the invisible object passes across the field of view.



Preliminary results from the French EROS ("Expérience de Recherche d'Objets Sombres") and the US/ Australia MACHO collaborations hint that small inert 'brown dwarf' stars in our galactic halo could provide one answer to the missing 'dark matter' which is thought to make up most of the Universe.

Since Jan Oort's suggestion some 60 years ago, many observations have convinced astronomers that there are probably considerable quantities of such invisible matter in the outer halo of our galaxy and other spiral galaxies. This provides the gravitational pull to explain their observed behaviour and counteract the explosive power of the Big Bang, ensuring that the Universe does not keep expanding for ever.

If this matter is invisible, the problem is how to see it. But if dark matter operates primarily through gravitation, then maybe that is how to look for it.

One dark matter candidate category is small inert stars called MACHOs - Massive Astrophysical Compact Halo Objects). Although MACHOs are not themselves luminous, extragalactic star images could be affected when intervening MACHOs cross or approach the line of sight of distant stars. The MACHO gravitational pull affects the distant light - the "gravitational microlens" effect - temporarily amplifying the star image.

To look for such events, EROS recorded the luminosities of ten million stars in the Large Magellanic Cloud, the nearest galaxy to our own, over a three-year period using 350 photographic plates exposed at the one-metre Schmidt telescope at the European Southern Observatory (ESO) in Chile.

These plates were measured automatically by the specially developed "MAMA" ("Machine Automatique à Mesurer pour l'Astronomie") and the huge amount of data (comparable to particle physics samples) was processed at French Atomic Energy Commission and IN2P3 (National Institute for Nuclear and Particle Physics) computer centres.

EROS also monitored some hundred thousand stars using 10,000 CCD exposures.

From the analysis of 4 million light curves, representing a thousand million luminosity measurements, just two stars show what would be expected from a gravitational microlens phenomenon (with a single, achromatic and symmetrical peak).

The two events each lasted about 30 days with a maximum amplification of 2.5, typical of what would be expected from brown dwarfs - inert stars with about one tenth the mass of the sun.

Even if our galaxy's halo is filled with these, just a few microlensing events are expected from the quantity of data so far analysed. The interpretation of the results obviously needs confirmation by more detailed analyses, including the closer observation of the two stars concerned and the analysis of a larger number of stars.

A similar event has been seen by the MACHO collaboration at the Mount Stromlo Observatory in Australia, with an amplification of 6.8 and a duration of 34 days, and looks to correspond to a tenth of the mass of the Sun.

With only a few events seen so far, the possibility of having observed changes in the luminous intensity of a so far unknown type of variable star, rather than the expected gravitational microlens phenomenon, cannot be discounted.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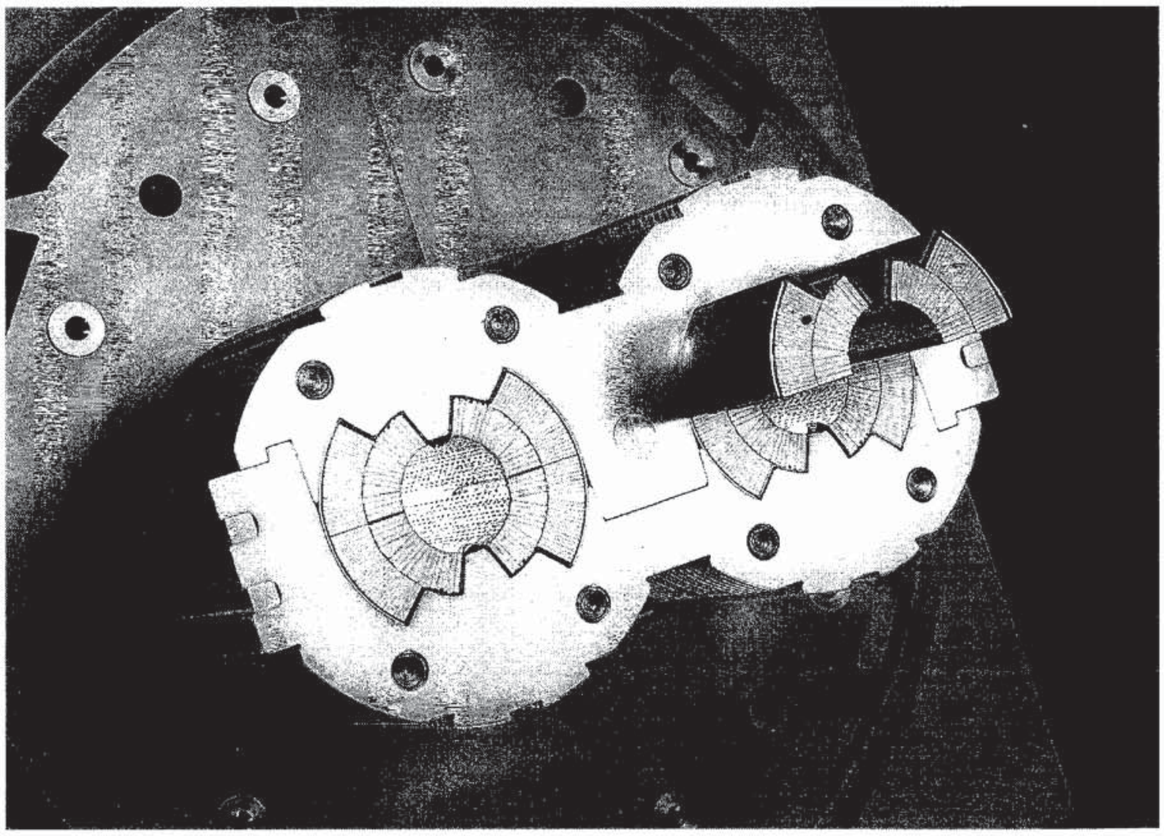
LHC - latest in a long line of rings

In LHC's 'twin-aperture' designs, the channels for the separate proton beams are held in a single magnetic and cryogenic structure. (Photo Pons, Paris)



The LHC - Large Hadron Collider - ring in CERN's 27-kilometre LEP tunnel is the natural next link in an accelerator chain first forged in the mid-1950s with the decision to build Europe's first state-of-the-art high energy synchrotron at CERN.

A lot of ground has been covered since the LHC idea was launched over a decade ago. While the basic machine design has moved through several iterations, preparations for the experimental programme are well underway.

CERN is now responding to the December 1991 request from its governing body, Council, to supply detailed information on the technical feasibility of the machine, its costs, and its experimental programme.

Long range planning

In the late 1970s, when plans for CERN's LEP electron-positron collider were being pieced together, far-sighted people were already looking further ahead. With the LEP tunnel itself a major investment for the future, the circumference of the ring and the tunnel cross-section were kept as large as possible, so that another ring could be fitted in when the time came.

On the physics front, the ultimate quest was the mysterious higgs mechanism which controls electroweak symmetry breaking. The symmetry of the vacuum is broken by the higgs field. Somewhere along the line, this fundamental field has to show itself as one or more higgs particles.

To explore this mechanism means having constituent particles - quarks and gluons, or their lepton (electron) counterparts - colliding at energies of about 1 TeV (1000 GeV). To provide 1 TeV collisions between the quarks and gluons hidden deep inside protons, the colliding protons have to have energies of about 10 TeV.

The LHC idea for a proton collider in the LEP tunnel was first heard in public in March 1984 at a workshop at Lausanne. The following year, CERN Council asked Carlo Rubbia to chair a Long Range Planning Committee to explore options for the future of the Laboratory. This committee evaluated the lepton and quark routes to 1 TeV collisions.

The electron-positron collider route is well signposted, which is why CERN built LEP. Interactions of the pointlike electrons and positrons are 'clean', while the collision energy is concentrated in elementary projectiles and not shared out, giving a 1 TeV electron-positron collider roughly the same physics reach as a 10 TeV proton machine.

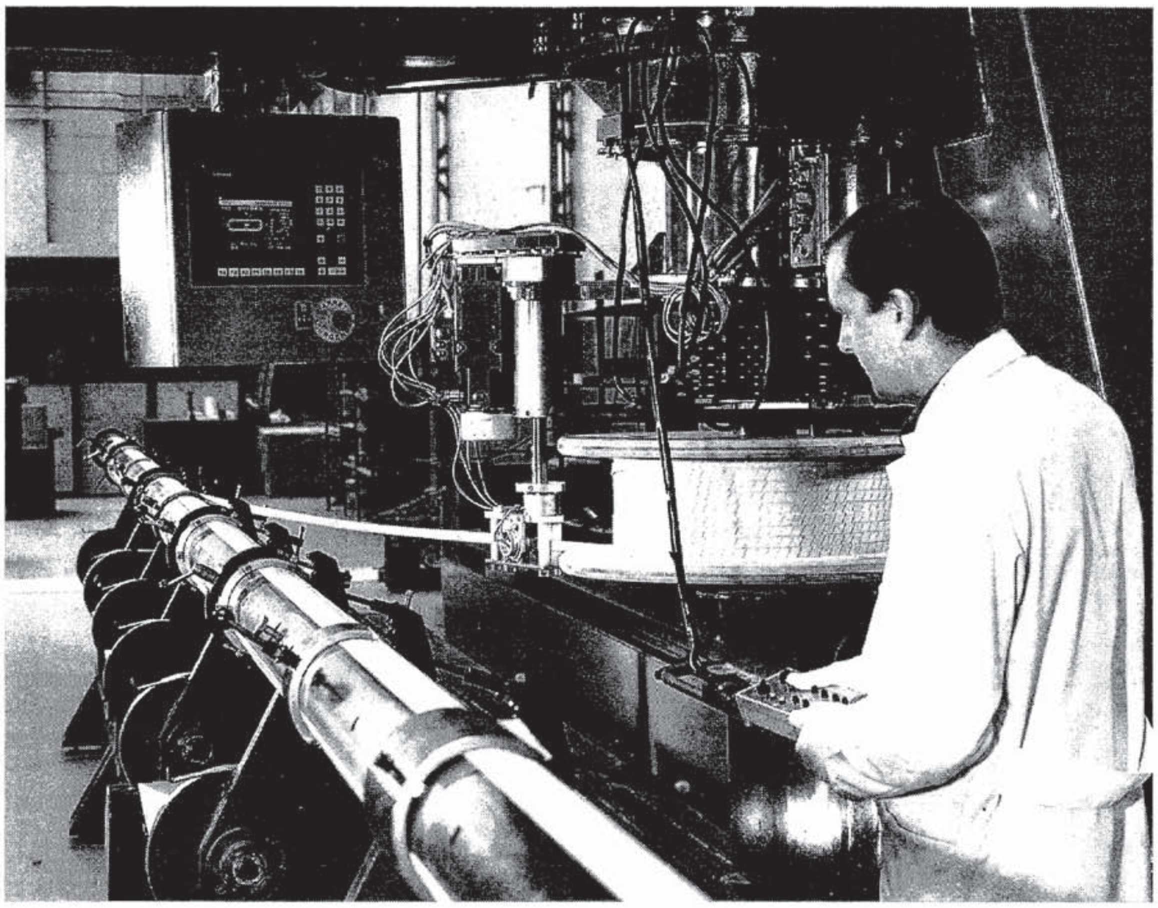
However LEP is definitely the last word in electron-positron storage rings. Electrons lose lots of energy, as synchrotron radiation, as they 'skid' around tight curves. LEP was made big to minimize this expensive energy loss. To go beyond LEP energies means using linear colliders, firing electron and positron beams at each other, with virtually no synchrotron radiation losses.

However such linear colliders are out of reach in today's technology, requiring the prior development of high gradient accelerating structures, high intensity beams and nanometre focussing techniques.

The Rubbia Committee acknowledged the attraction of the electron-positron route, recommending a vigorous R&D programme to push towards a long-term goal of a CERN Linear Collider, CLIC, which is now producing encouraging results (September, page 1).

For the proton route to 1 TeV quark/gluon collisions, the less demanding R&D programme is still no cinch. Getting to the required constituent collision energies means straining the bending magnets, necessarily

Coil winding for LHC magnets at one of CERN's industrial partners. (Photo Jeumont Industrie)



superconducting, to the limit. To ensure the physics aims needs a plentiful supply of collisions, implying a hefty job of work for the detectors.

This was a big technological bite, but it was chewable. A proton collider, with its inherent range of constituent quark/gluon collision energies, has no sharp behaviour threshold and is less likely to 'miss out'.

The existing LEP tunnel and CERN's flexible proton supply system also pointed to a proton collider as an obvious choice. The LHC option therefore emerged as the Committee's priority recommendation.

As well as opening a new collision regime, LHC would pay additional dividends. Feeding nuclei into the LHC ring would extend CERN's heavy ion programme, while having LHC and LEP in the same tunnel would give an electron-proton collider 'for free'.

LHC's high field superconducting magnets appeared feasible on the timescale of a decade or so and would anyway benefit from the effort mounted for the proton ring at DESY's HERA collider. To ensure that the LHC proposal fell on fertile ground, the Rubbia Committee proposed intensifying R&D, involving other laboratories and industry. The goals were high fields and 'twin-aperture' designs, with the magnetic channels for the separate proton beams held in a single cryogenic structure. In parallel a push began towards detectors to cope with the high collision rates. 'It is time to get our hands dirty,' urged Carlo Rubbia in 1987.

In June 1990 CERN's Scientific Policy Committee endorsed the LHC proposal and recommended that Council should give an early indication of support. After valuable groundwork by the European Committee for Future Accelerators (ECFA), a major demonstration of LHC support came in October 1990, when some 500 participants attended the ECFA LHC Workshop in Aachen, Germany.

In 1991 a detailed technical report, the so-called 'Pink Book', was favourably received by a specially appointed LHC Review Committee of fifteen leading experts from Europe, the USA and Japan. In December 1991 Council concluded 'the LHC is the right machine for the advance of the subject and of the future of CERN'.

The machine

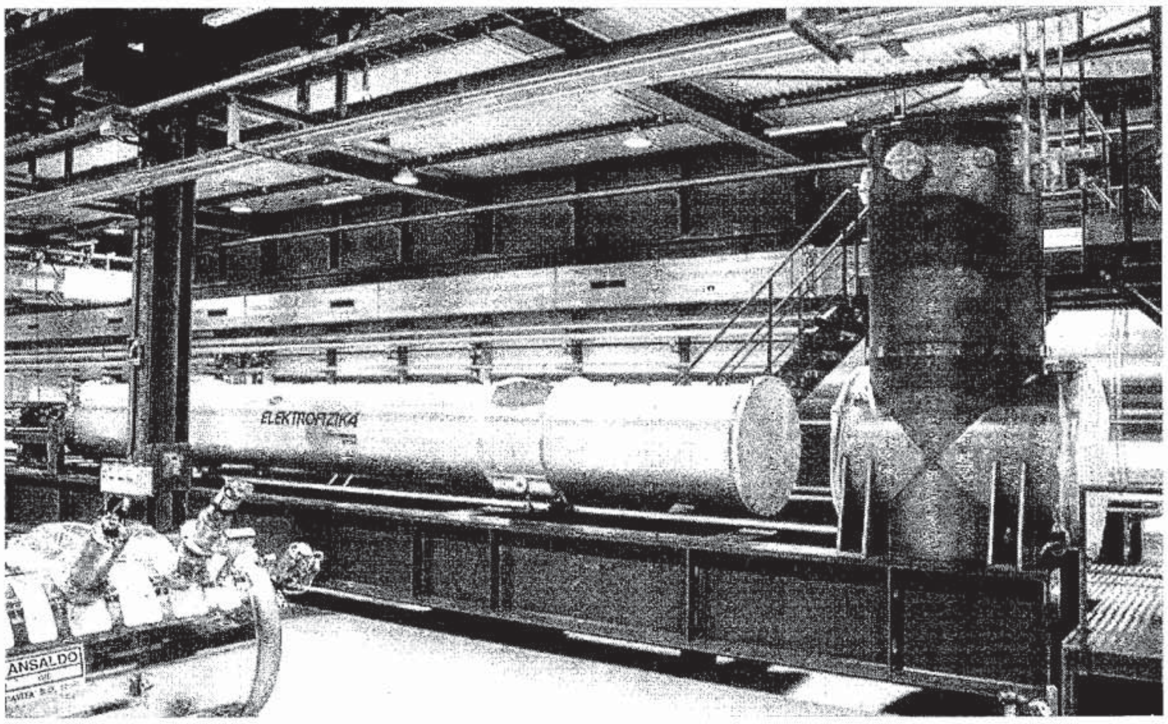
The LHC's twin interlaced synchrotrons in the 27 km LEP tunnel will be filled with protons supplied by the existing CERN accelerator chain at 0.45 TeV. Locked in their twin superconducting magnetic channels, a unique configuration that saves space and money, the particles will be taken to 7 TeV, and unleashed to collide at designated points.

In the tight confines of the LEP ring, LHC's 'stiff' high energy beams need high magnetic fields to bend them. Packing a maximum bending power into the ring helps, but steering 7 TeV protons needs dipole fields of 8.65 tesla. The only feasible solution is superconducting magnets, with their minimal power consumption.

The trail for superconducting magnets was blazed by Fermilab's Tevatron, commissioned in 1983. Tevatron magnets reach peak fields of 4.5 Tesla at liquid helium temperature, 4.2 K. The proton ring magnets at DESY's HERA electron-proton collider, commissioned in 1991, work around 5.5 tesla.

To go to higher fields, LHC magnets will operate at superfluid helium

For LHC magnet measuring, a superfluid helium facility has been built at CERN exploiting cryogenics originally installed for testing superconducting cavities for the LEP200 scheme.
(Photo CERN IT48.6.93)



temperature,1.9 K, putting new demands on cable quality and coil assembly.

LHC magnet coils will be long, some 13m, to maximize bending power in the ring. The initial plan was to fill the ring with magnet modules, or cells, each containing four 9.45 metre dipoles. Adopting a cell configuration with three 13.58 metre magnets gave a 5% saving in maximum field. Model prototype magnets have attained fields as high as 10.5 tesla, showing the validity of the twin magnetic channel design and promising a comfortable operating margin.

After looking at alternative dimensions, design work homed in on an inner diameter of 56 mm to accommodate the envisaged beam emittance.

The 1991 'Pink Book' design envisaged three collision regions. Early discussions on the experimental programme quickly established that the most probable configuration for high luminosity would instead have two collision regions.

This, combined with the realization that the electronics of several detectors would be integrating over more than one bunch crossing, questioned the reasoning behind the originally specified proton bunch spacing of 15 ns. With the two beams converging on either side of each collision point producing beam-beam perturbations, Carlo Rubbia asked whether performance would not benefit from the reduced long range beam-beam force with fewer, albeit more intense, bunches.

A new analysis of machine performance for only two high luminosity experiments confirmed that a longer gap between bunches could lead to higher luminosity per experiment. The final result is that with a 25ns bunch spacing the beam-beam limited luminosity in each of two collision points can be expected to be around 2.5×10^{34} $cm^{-2} s^{-1}$ instead of 1.6×10^{34} $cm^{-2} s^{-1}$. This modest increase requires only a slightly higher bunch intensity, felt to be within the possibilities of the injectors and still far from single bunch instabilities.

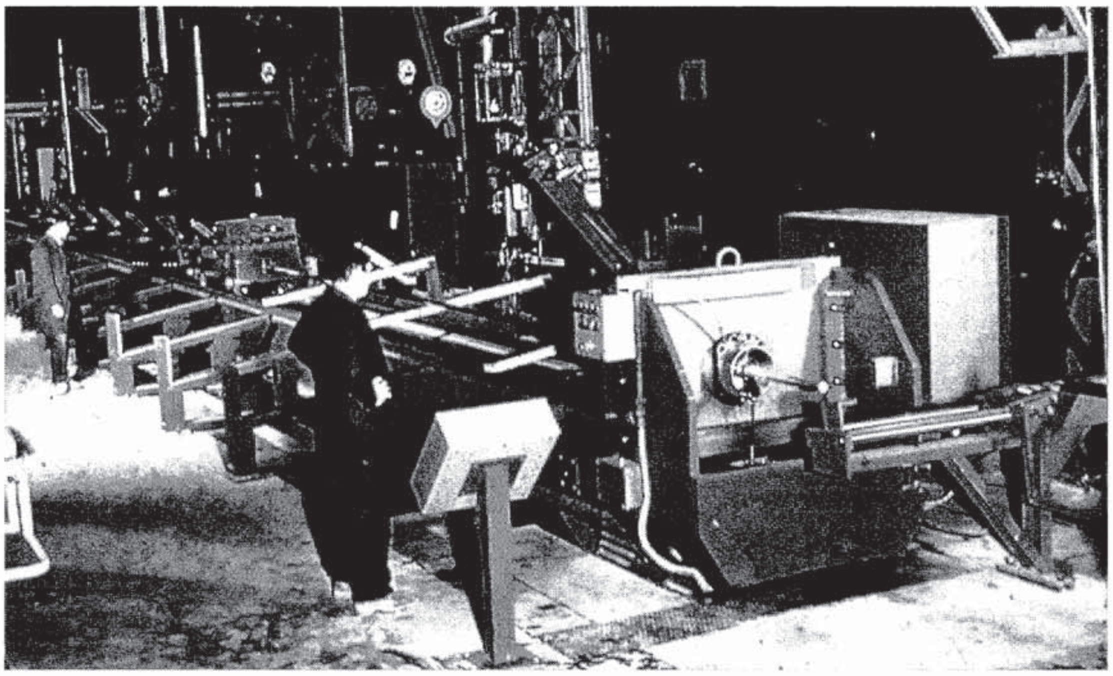
In the R& D programme for the development of LHC high field dipoles, the emphasis is changing towards finding cost-effective solutions. The latest of a line of some 10 short magnets was recently tested at CERN and showed substantially improved performance. With coils wound by one of CERN's industrial partners using improved superconducting cable, the magnet was assembled and tested at CERN. Cooled to 1.9K, it passed 9T before quenching, reached 9.5T in five quenches and finally achieved a record 10.5T. After full training and a complete thermal cycle all further quenches occurred above 9.75T. This is largely adequate for the required 8.65T operating field and with the origin of all quenches in the ends, in particular at the connection end, full length magnets can be confidently expected to behave in a similar way.

The programme of model construction will continue to try and improve the end structure and increase the margin between operating and quench field. In the meantime seven 10m dipoles are being completed by four different manufacturers. These magnets have differing structures and do not, of course, use the latest cable or incorporate all the latest improvements. However their performance is expected to be more than adequate to confirm - at full scale - field quality, cooling and powering schemes, and quench protection, and demonstrate that European manufacturers have mastered the demanding superconducting magnet technology.

Experiments and detectors

Early on, CERN learned the lesson that major new accelerator projects have to march in step with prepara-

A 70-tonne drawing bench for LHC superconductor
(Photo Alsthom Intermagnetics)



tions for the experimental programme. It is no good having a gleaming new machine delivering beam on Day 1 if there are no adequate detectors in place to exploit them.

In 1986, a physics subpanel (chaired by John Mulvey) of the Rubbia Committee looked at the promise and the challenge of LHC physics, where discoveries would need detectors braving luminosities of 10^{34} or more per sq cm per s.

As well as demonstrating the support for LHC, the October 1990 ECFA LHC Workshop in Aachen also reflected the LHC experimental dilemma - attractive physics goals tempered by the intricacies of handling bunches of 10^{11} protons crossing every 15 nanoseconds or so.

As the nuclei of experimental teams began to form, CERN set up the Detector Research and Development Committee (DRDC) to supervise the allocation of resources for detector technology projects. Organized along the lines of a conventional experiments committee, this was the first time that detector resources had been managed in this way at CERN.

DRDC proposals have been approved at an average rate of about one per month, and are strongly correlated with components for LHC detectors. The work presently involves collaborations among almost 200 institutes in over 30 countries, with strong participation from industry. Financial investment is about 10 million Swiss francs per year, with CERN contributing about one third, the rest being spent outside the Laboratory.

With the physics aims clear and detector R&D underway, the time had come to start stitching a realistic experimental programme together. In March 1992, a major meeting on LHC physics and detectors at Evian, France, attracted over 600 specialists. Researchers from over 250 institutes around the world presented Expressions of Interest for LHC experiments, exploiting the full potential of the machine. Four ideas were for proton-proton experiments, others were for heavy ion collisions, beauty physics, and the use of extracted LHC beams.

To push home the Evian message and widen international involvement in the research programme, special 'mini-Evian' roadshows were organized in Russia, China and Japan.

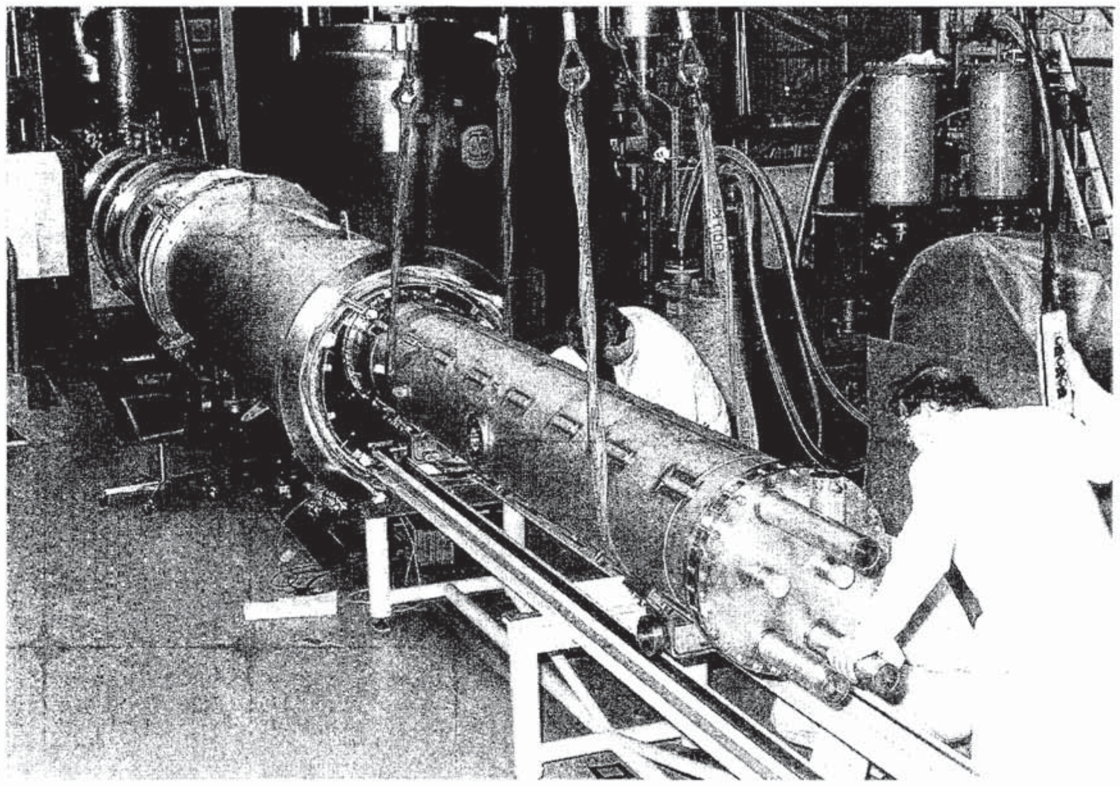
With feedback from this effort, the next stage was to submit Letters of Intent for consideration by CERN's LHC Experiments Committee LHCC, set up during the summer of 1992 under the chairmanship of Jean-Jacques Aubert of Marseille. The target date for Letters of Intent for the major proton-proton experiments was 1 October 1992.

Three Letters of Intent were received and formally presented at the first open session of the LHCC, in November 1992. They were from L3P, CMS and ATLAS, a post-Evian merger of the earlier ASCOT and EAGLE groups. The LoIs were signed by more than 1750 scientists from about 160 institutes, with a strong participation from non-Member States, an impressive indication of world-wide interest in LHC physics (January, page 6).

The LHCC began the arduous task of assessment and adjudication. As well as physics suitability, main magnets, cost estimates, and timetables were all scrutinized.

Especially important in these cost-conscious times is staging, building a detector in a series of steps to spread costs over a longer period while ensuring useful physics at start-up. With a guideline of 300 million Swiss francs for the cost of a general-purpose detector at turn-on, staging showed how detectors with fewer tracking planes, coarser calorimeter granularity, or reduced coverage in the forward and backward regions could be eventually upgraded to attain final design goals.

By April of this year the LHCC was ready for the next step. At least two proton-proton experiments were essential, so that physics claims



The first LHC quadrupole prototype on the test bench cryostat at the French Saclay Laboratory.

could be checked. However more than two would be difficult to fund.

Despite the impressive effort that had gone into the L3P approach, the Committee felt that the detector concepts of ATLAS and CMS addressed the basic physics issues more convincingly. The LHCC made provisional recommendations in June that ATLAS and CMS should proceed towards Technical Proposals.

While proton-proton collisions are the main thrust of LHC physics, its other possibilities have not been neglected. For ion-ion collisions the main physics goal is the quark-gluon plasma, which is thought to have existed in the early Universe before nuclear matter was formed.

The ion community quickly formed a single collaboration, ALICE, which presented its LoI at an LHCC Open Session in April 1993 (July, page 4).

The third major interest is the physics of B particles - containing the fifth ('beauty') quark - copiously produced by LHC's proton-proton collisions and probing the Standard Model from a new direction. The major proton-proton experiments could cover this sector, but not optimally. Three specialized B experiments were discussed, each using a different beam scenario. COBEX would run in the proton-proton collider; GAJET would use a gas jet target squirted across one of the LHC proton beams; LHB would use an external target, shaving off part the circulating beam with a bent crystal.

Overall, LHC cost estimates also depend on the long term plan, including the destiny of LEP. Project approval during 1994 would imply that LEP200 physics would be concluded in the summer of 1999 and LHC commissioning would be complete in the spring of 2002.

SACLAY
First LHC quadrupole test

The first cold mass of the "two in one" quadrupole for the LHC demonstration half-cell (one quadrupole and three dipoles) has been successfully tested at the French Saclay Laboratory. The magnet reached 15,060A, its nominal intensity, during its second ramp; the first ramp had been stopped by transition in one of the quadrupoles at 14,437A, 96% of its nominal current. The 15060A level was maintained for several hours.

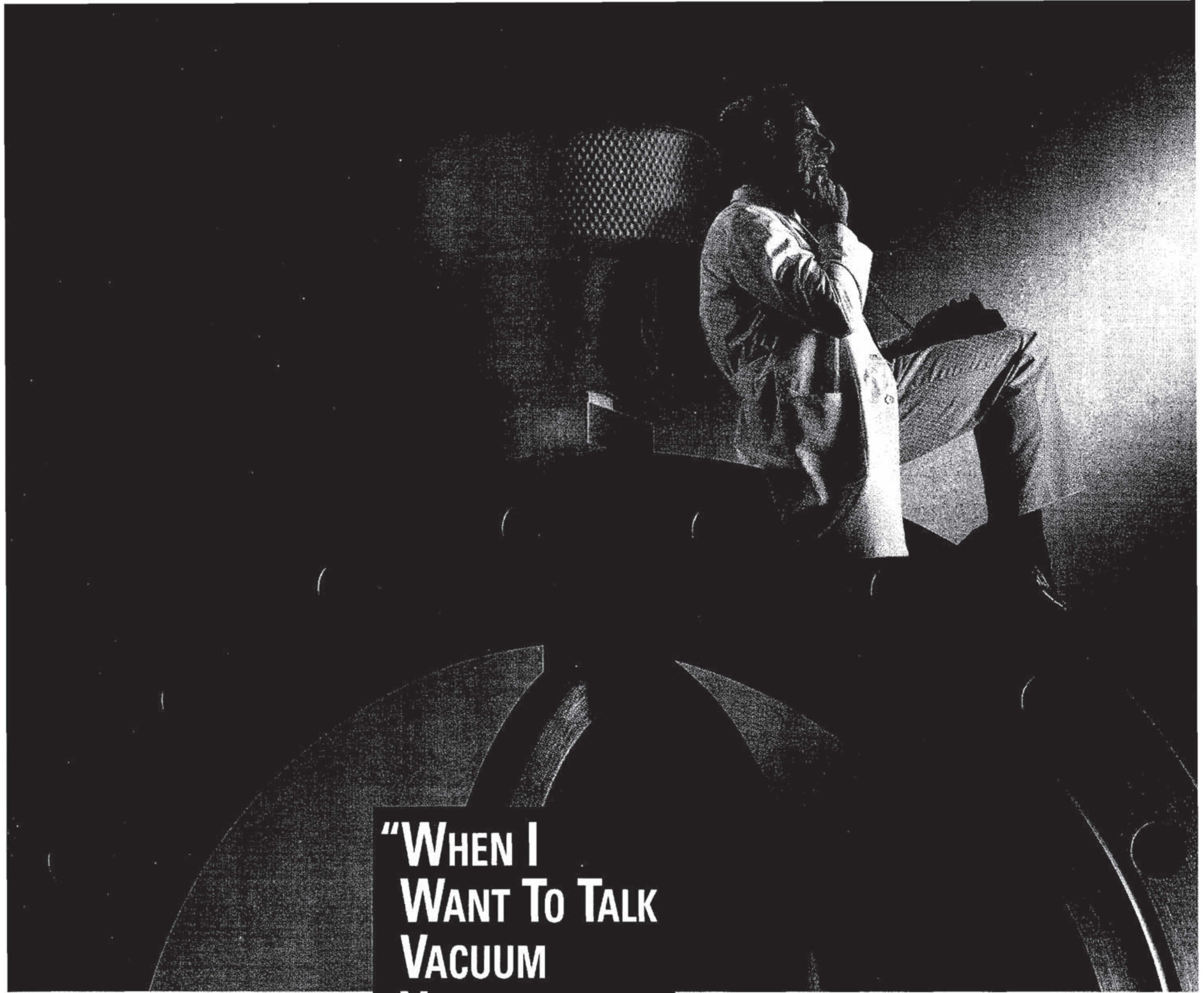
The current was subsequently increased to 15,100A without problems. The nominal gradient of 252T/m is already 17% higher than the new LHC requirements (8.65T). The resulting first magnetic measurements show that the magnets are very close to specifications. The 252T/m gradient obtained in the 56mm aperture is claimed to be a new world record.

This quadrupole has been designed in a CERN/CEA (Commissariat à l'Energie Atomique) collaboration (DSM/DAPNIA/STCM) at Saclay. The basic elements and the tooling have been manufactured by European industry, while winding, assembly and testing have been undertaken entirely at Saclay.

The LHC quadrupole design is largely inspired by those for DESY's HERA electron-proton collider, prototypes for which were also designed and developed at Saclay. The more demanding LHC requirements, for instance the fourfold increase in electromagnetic constraints over HERA, needed improvements, such as modifications of the coil retaining rings, which use a double system of pins per quadrant.

The magnetic circuit design uses seamless single metal sheets without welds. The cold mass is ready for delivery to CERN and for mounting in the cryostat of the short straight section of the demonstration half-cell. The second cold mass included in the contract is completed and will be available for testing as soon as the first has left the test bench.

Principal characteristics	
Nominal gradient	252T/m
Coil aperture	56mm
Field quality in a 30mm diameter	10^{-4}
Magnetic length	3m
Nominal current (88% of critical intensity)	15060A
Mean coil current	530A/mm^2
Maximum field	7.76T
Operating temperature	1.8K
Stored energy	890KJ



Bookshelf

John Adams biography

John Adams, engineer extraordinary, by Michael Crowley-Milling, Gordon and Breach Science Publishers, ISBN 2-88124-875-6 (hardback), 2-88124-876-4 (paperback)

When John Bertram Adams died on 3 March 1984, CERN lost one of its principal architects. The late Sir John Adams was a very private person who rarely confided in his colleagues. This made the job of his biographer particularly difficult. Michael Crowley-Milling has succeeded admirably, and has performed a very important service.

Is it a potted history of CERN, or the story of the building of the PS, or of the SPS? Yes, all of these, but most of all it is a thoughtful and discerning biography and a fitting tribute to a veritable giant of European science and technology. The sub-title, ' Engineer Extraordinary' refers not only to John's outstanding ability as a builder of accelerators, but perhaps even more importantly, as a builder of teams and an 'engineer of opinions'.

The book describes how John's attention to detail and intuitive engineering skills developed during the early part of his career, when working in radar research, and how he emerged as a natural leader in the building of the CERN PS.

Then later, how his statesmanship enabled him to "...rescue it (the 300 GeV Programme) from seeming political disaster and nurse it through technical problems to a successful conclusion." One crucial part of this process described is the visit to CERN in 1970 by Margaret Thatcher, at that time UK Secretary of State for Education and Science, and her subsequent letters of thanks, not only to Bernard Gregory as Director General, but also to John. It is interesting to speculate to what extent the good impression made on that occasion helped many years later, when as Prime Minister Mrs Thatcher decided that Britain should stay in CERN!

After the successful commissioning of the SPS, the book goes on to describe the period when the two CERN Laboratories were merged under two Directors General. Unfortunately I found this part a little too low key, given that John and Leon van Hove presided over what was undoubtedly CERN's 'finest hour', with the launch of the proton-antiproton programme leading to the discovery of the W and Z particles, the consequent award of the Nobel Prize to Carlo Rubbia and Simon van der Meer, and the conception of LEP.

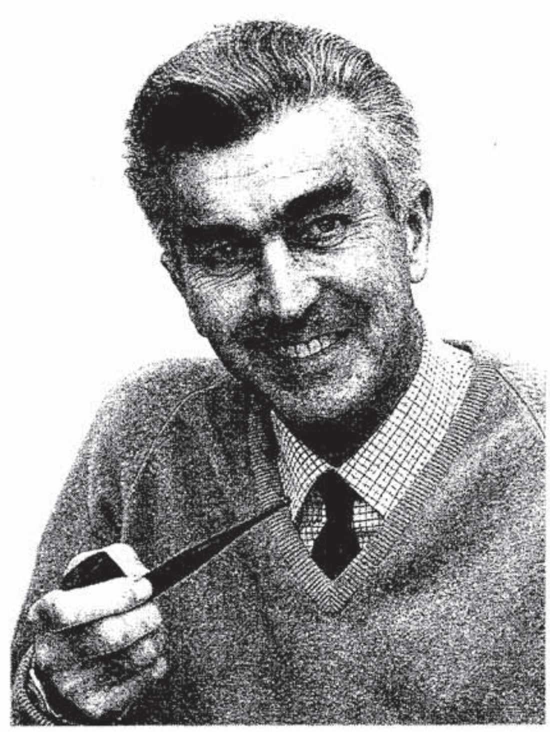
Nevertheless, before reading the book, I had my own recollections of John, both as a member of his SPS team, and from our occasional walks and cross country ski outings in the Jura. I was very pleased to find that the book brought out clearly his most important qualities: meticulous attention to detail, love of nature, quiet authority, ...

In order to make the book more readily understandable to the general public, Michael has included a couple of appendices, covering the machines and the physics. These are extremely well written without sacrificing accuracy. To have covered accelerators from Cockcroft and Walton to CLIC and LHC in six pages is a considerable achievement, only surpassed by covering particle physics from Democritus to Rubbia and Higgs in a similar space!

I can highly recommend this book for anyone interested in CERN, or the development of post-war European scientific cooperation, or more generally to anyone fascinated to learn about great men of our times. My only regret is that the book is not longer.

Roy Billinge

John Adams, engineer extraordinary.



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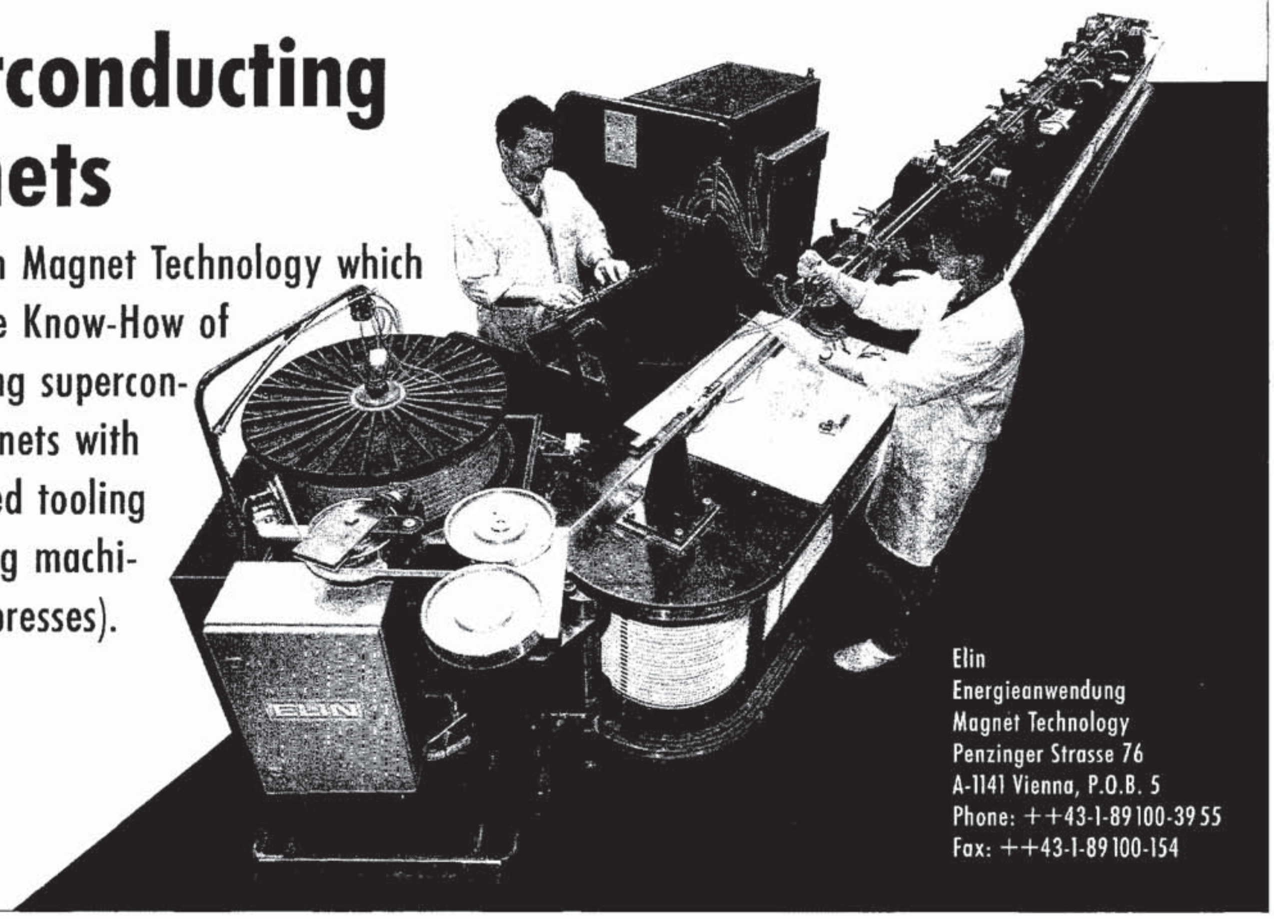

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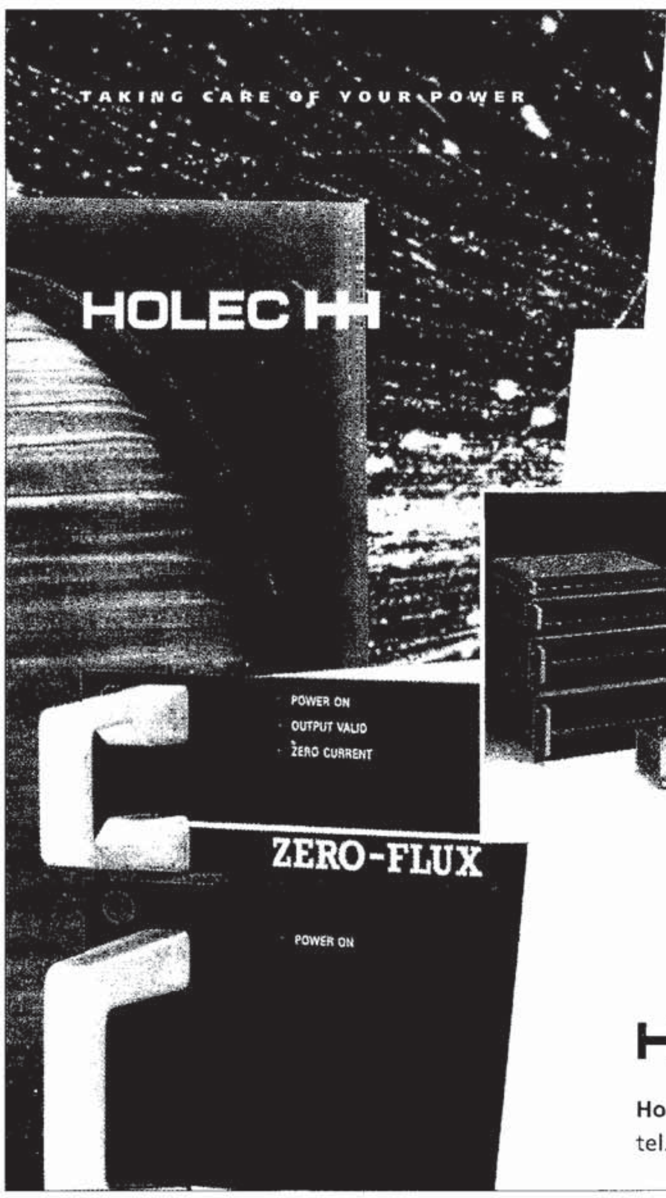

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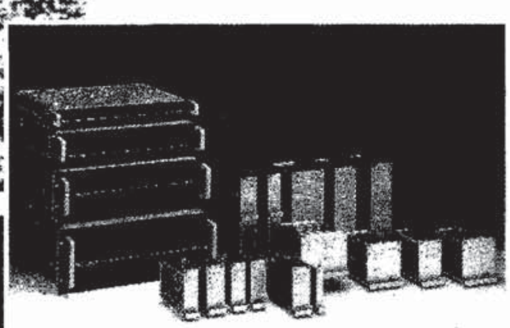

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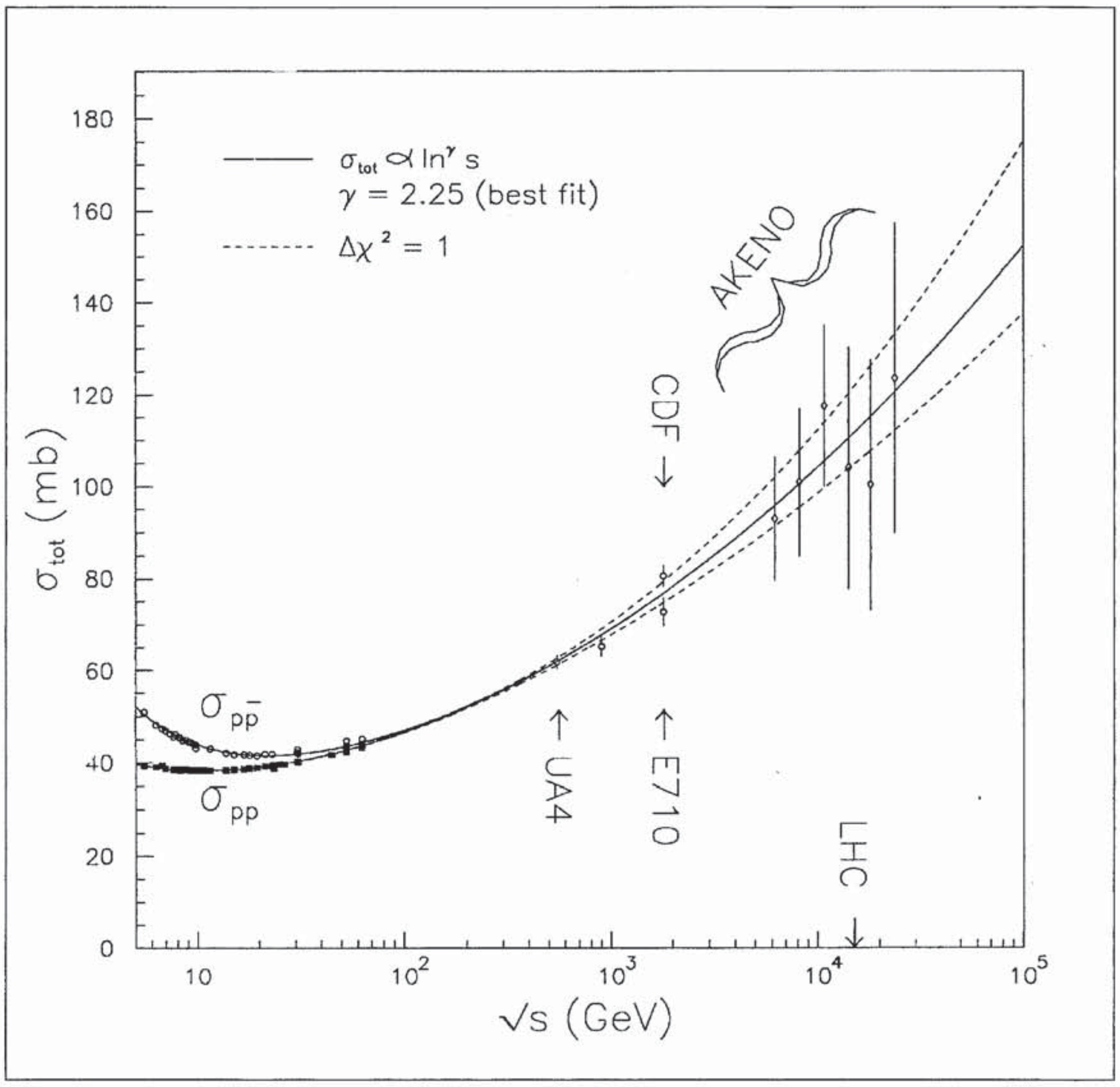
Around the Laboratories

Variation of proton-proton and proton-antiproton reaction rate (total cross-section) with energy, with the result from the UA4 experiment at CERN's proton-antiproton collider giving a good indication of the trend at higher energies for planned proton-proton colliders and even cosmic rays (AKENO experiment).



CERN
Real and imaginary parts

Elastic scattering (where particles bounce off each other) has implications which go far beyond the deceptive simplicity and inconsequence of this process.

Several years ago, an elastic scattering result by the UA4 experiment at CERN's proton-antiproton collider (January 1988, page 32) set the high energy world talking. In quantum mechanics, the forward elastic scattering amplitude is a complex number whose real and imaginary parts can be related. The powerful 'optical theorem' relates the total reaction rate (cross-section) to the imaginary part of the forward scattering amplitude, while the ratio of the real and imaginary parts gives an indication of where the total reaction rate is going at higher energies, independent of what the actual mechanisms are. Thus, for example, elastic scattering measurements at CERN's Intersecting Storage Rings pointed the way to the behaviour eventually seen at the proton-antiproton collider.

In the 1985 run, UA4 found the ratio (rho) between the real and the imaginary parts to be 0.24, about twice the theoretical prediction. At face value, this suggested that the total reaction rate would increase dramatically at higher collision energies. With such a prediction at stake, confirmation with a more precise measurement was necessary and the UA4/2 experiment (Genoa/Palaiseau/Prague/Rome/Valencia collaboration) was launched.

The real part of the scattering amplitude is obtained via measurements of elastic scattering in a four momentum transfer domain where strong and electromagnetic interactions are comparable. This corresponds to scattering angles of 100 microradians, with the detectors inside "Roman pots" close to the circulating beams, and using special beam optics.

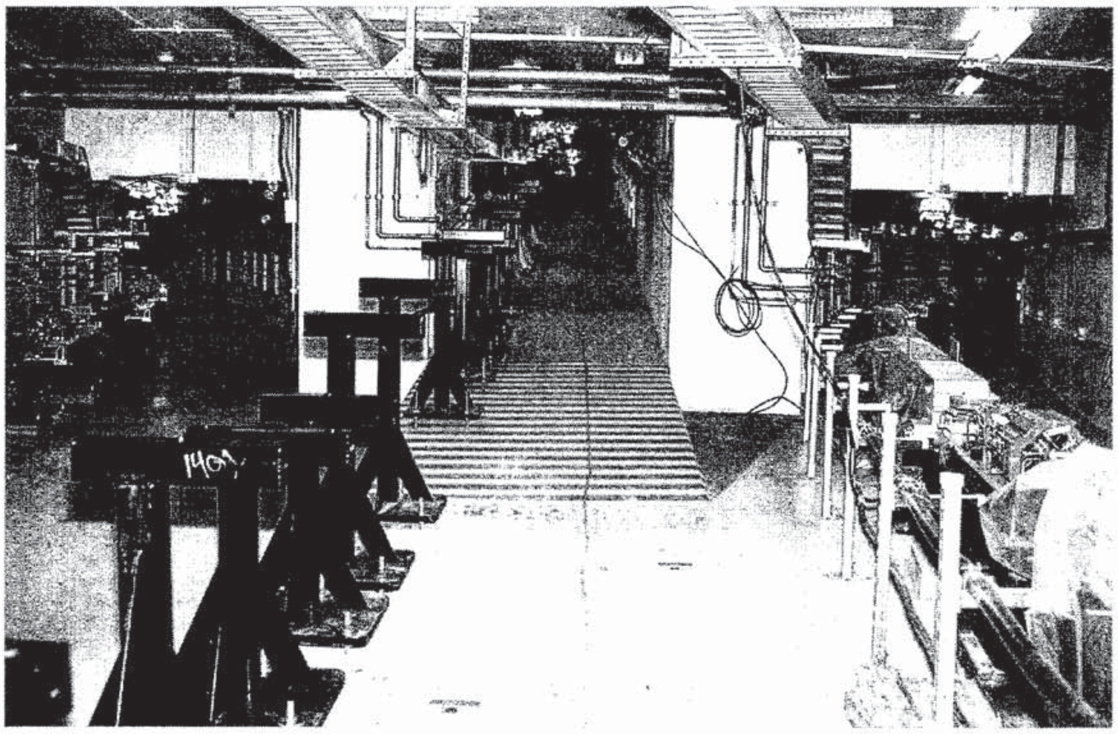
The new experiment took place in a five-week run late in 1991. With the Roman pots within 2mm of the beams, about a million elastic events were recorded. Several months later, a special dedicated run fixed the SPS energy to a few parts in ten thousand.

After careful analysis, the new rho value of 0.135 ±0.015 was first presented earlier this year, and agrees with most theoretical expectations. It gives precise predictions for the total cross-section at the LHC collider and even for very high energy cosmic rays.

CEBAF
Commissioning preparations

With the superconducting electron accelerator nearing completion at the Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, Virginia, activities preliminary to commissioning the five-pass

Beams from CEBAF's recirculating linacs will feed three experimental halls, left to right, C, B, and A.



recirculating machine are intensifying.

CEBAF will use beams at 4 GeV and above in three experimental halls to explore the region between nuclear and particle physics — between seeing the nucleus as a bound state of nucleons and seeing it as an assembly of quarks and gluons.

CEBAF's first major commissioning goal is single-pass beam to Hall C in 1994. By October, only the final four of 42 1/4 eight-cavity, nominally 20 MeV cryomodules remained to be installed in the racetrack-shaped machine. Each antiparallel linac will have 20 cryomodules, with the remaining 2 1/4 in the 45 MeV injector. Also nearly complete is the beam transport system, with over 2300 room-temperature magnets and 4.5 km of beamline under vacuum. Nine recirculation beamlines in two semicircular arcs link the linacs for five passes.

During linac testing earlier this year, one cryomodule accelerated beam with an energy gain above 32 MeV - 160% of specification - showing that an energy well above the machine's specified 4 GeV may be reached. In vertical dewar tests prior to cryomodule assembly, cavity pairs have averaged 10.5 MeV/m accelerating gradient and resonance (Q) of 5.7×10^9 - well above the specified 5 MeV/m and 2.4×10^9. No significant degradation is observed between vertical tests and pre-operational tests of installed cryomodules.

During the most recent round of testing, which ended in April, installation went ahead in the rest of the accelerator and in the end stations while (c.w.) beam up to 120 MeV was run in the first linac and its spreader/ extractor region. The first re-circulation beamline was operated with beam at low average current. This testing had several highlights:

- The linac was run at relatively high current (above 100 microamperes) for extended periods. This demonstrated the accelerator's substantial inherent operating stability, given the minimal involvement of active correction mechanisms, which were still being implemented.

- The external resonance quality factor (Q) of two cavities was increased, permitting study of the radiofrequency control module under conditions equivalent to full beam loading in the complete five-pass accelerator. The module worked well under these conditions.

-The high-precision calibration of r.f. control modules was demonstrated. After exchanging two calibrated modules, the beam returned precisely to its previous state.

-A precise method was demonstrated for measuring the recirculation beam transport isochronicity, the degree to which different momenta are synchronized upon emerging from an arc. The isochronicity was shown to be better than needed.

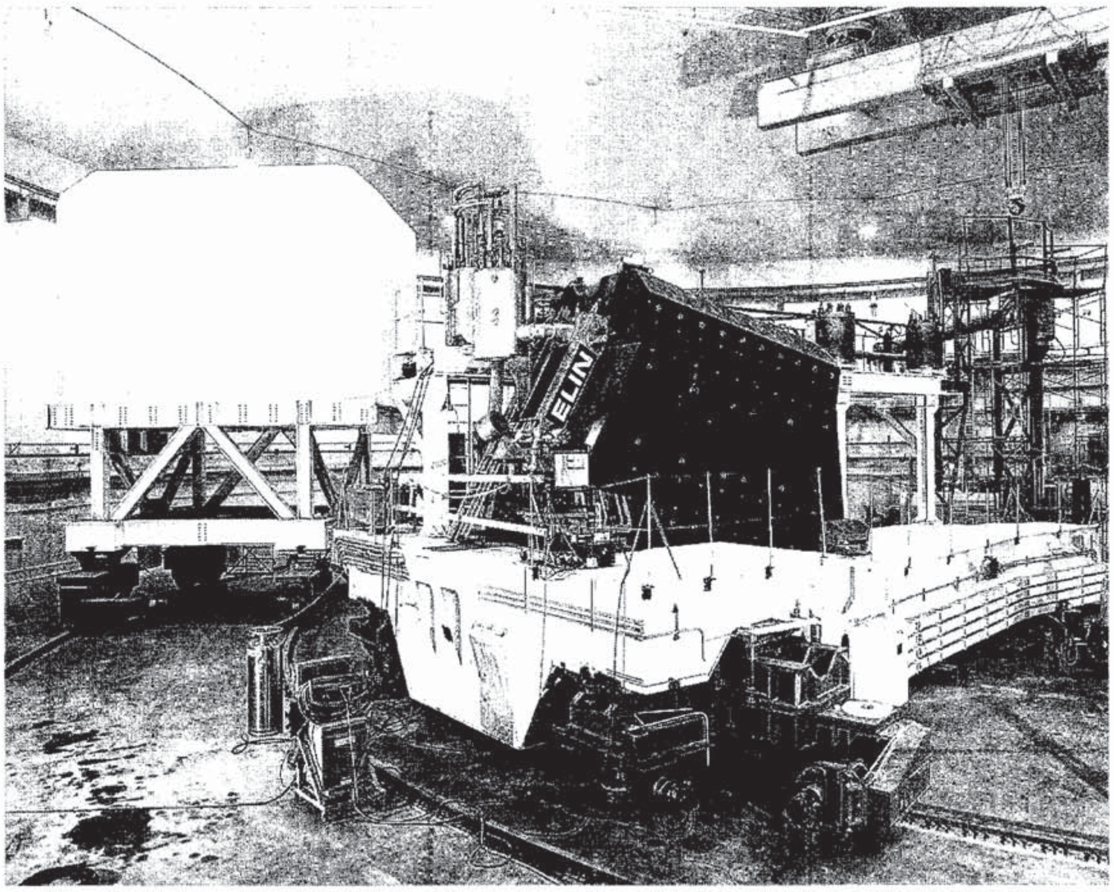
-For both the linac and the arc, optics tune-up procedures were developed.

Another recent highlight has been the reconfiguration of the 45 MeV injector into a three-beam system permitting independent control of the c.w. beam current to each experimental hall. A port was added to accommodate a polarized source developed at the University of Illinois for studies of parity violation, and a bypass chicane was installed to accommodate a 10 MeV source for both high-micropulse-charge experiments and a possible future free electron laser system (a wiggler magnet would receive beam diverted from the injector for infrared light production.)

Both of the injector's cryomodules - the earliest installed systems, which had performed well - were replaced with units containing higher-performance cavities, the result of accumulated experience developing the accelerator.

CEBAF's experimental equipment commissioning will begin in Hall C, the first endstation to receive beam. Hall C's major equipment consists of

The largest component of the High Momentum Spectrometer in CEBAF's Experimental Hall C is a 450-ton superconducting dipole magnet.



the High Momentum Spectrometer (HMS), a three-quadrupole plus dipole (QQQD) design using superconducting magnetic elements, and the Short Orbit Spectrometer (SOS), a QDD design (similar to the Medium Resolution Spectrometer at LAMPF) using resistive elements and opposite bends in the two dipoles. The 450-ton HMS dipole was recently mounted on the spectrometer carriage and tested to full current (2.0 tesla), with field mapping imminent. The first of the superconducting quadrupoles was shipped in October. The detector elements - drift chambers, scintillators, gas Cherenkov counters, and lead glass shower counters - will be mounted in a massive concrete and lead shield house.

The SOS dipoles are planned to be mapped and mounted on their carriage shortly.

Currently approved for Hall C, with 307 days of beam time awarded, are 15 experiments in areas including the neutron electric form factor, colour transparency, deuteron photodisintegration, and hypernuclear production.

DESY
ARGUS bows out

Last year the ARGUS experiment at DESY's DORIS electron-positron storage ring stopped taking data after ten years of fruitful physics. Analysis and new results will continue for some time, but members of the group are already looking to new physics horizons.

The ARGUS collaboration was formed in 1978 by groups from DESY, Dortmund, Heidelberg (IHEP), Lund, Moscow (ITEP), and South Carolina under the leadership of Walter Schmidt-Parzefall. Later groups joined from IPP Canada, Kansas, Ljubljana, Karlsruhe, Erlangen/Nürnberg, Heidelberg (MPI) and Dresden.

The detector was conceived to investigate the physics of the beauty and charm quarks and the tau lepton at the upgraded DORIS II electron-positron storage ring.

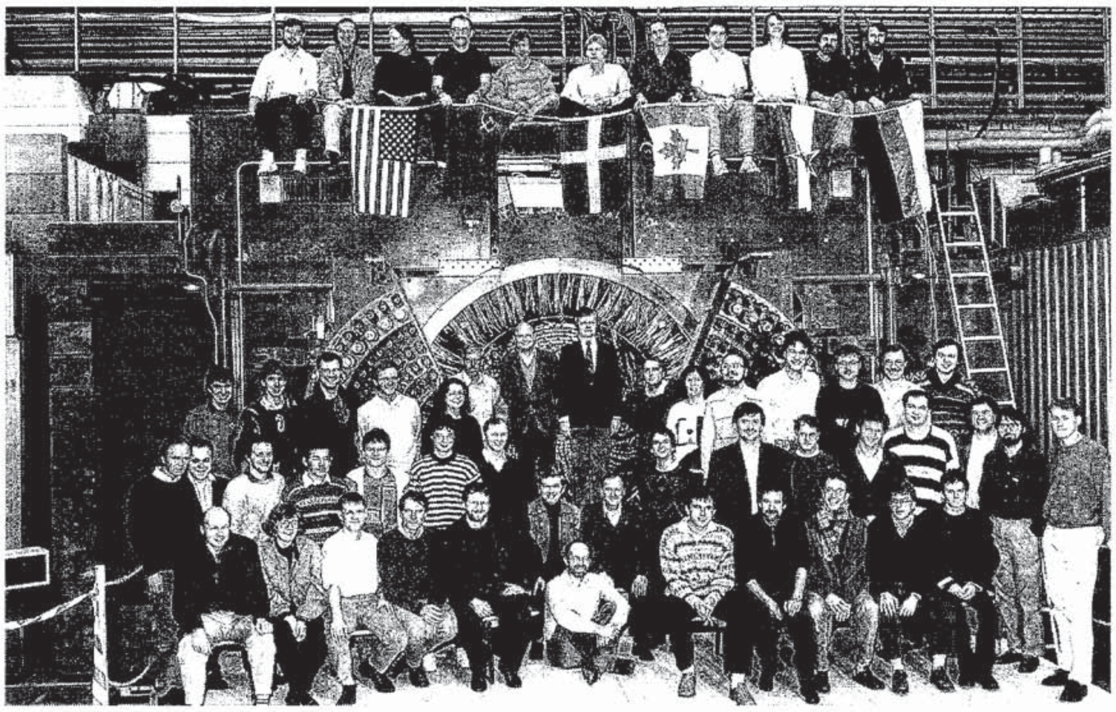
With a similar programme started by the CLEO collaboration at Cornell's CESR electron-positron collider, the resulting competition ensured good physics.

ARGUS rolled into the beam in October 1982 and took data until October 1992. In May 1993 the decision was taken to stop further ARGUS running. During those ten years a broad spectrum of physics has been covered, including weak decays of beauty and charm quarks and tau leptons, hadron spectroscopy, quark/gluon mechanisms, photon-photon interactions and particle searches.

In particular, ARGUS has made valuable contributions to determination of many fundamental constants of the Standard Model. These comprise measurements of quark transitions (CKM matrix elements) in the decays of B mesons (containing the beauty quark), the determination of the properties of the tau lepton and its neutrino, as well as a measurement of the quark coupling constant. The charm study has resulted in first observations of many charmed hadrons and decay modes. The study of quark and gluon mechanisms (fragmentation) has yielded valuable input for future experiments, while the first observations of new final states in photon-photon interactions have created much interest.

A total luminosity of 520 inverse picobarns has been collected at collision energies around 10 GeV.

The ARGUS experiment at DESY's DORIS electron-positron storage ring has stopped taking data after ten years of fruitful physics. The collaboration was formed in 1978 by groups from DESY, Dortmund, Heidelberg (IHEP), Lund, Moscow (ITEP), and South Carolina under the leadership of Walter Schmidt-Parzefall. Later groups joined from IPP Canada, Kansas, Ljubljana, Karlsruhe, Erlangen/Nürnberg, Heidelberg (MPI) and Dresden.



This data has yielded 208,000 B meson pairs, 500,000 tau lepton pairs, 600,000 charmonium events, 400,000 ground state upsilon decays and 130,000 excited (2S) upsilon decays, as well as continuum processes.

The first successful B meson reconstruction came in 1986 by ARGUS. Since then many exclusive as well as inclusive B meson decays have been observed for the first time by ARGUS. These results along with studies of other B meson properties, like the ratio of lifetimes of charged and neutral particles, have contributed significantly to our understanding of the interplay of strong and weak interactions in decays of heavy quarks.

The study of complete (exclusive) semileptonic B decays was pioneered by ARGUS with the observation of the neutrino decay of the neutral B in 1987. The method developed to handle the reconstruction of this decay with its unobserved neutrino opened up the Lorentz structure of the weak decay current of beauty to charm.

Only those models equivalent to Heavy Quark Effective Theory (HQET - where light quark masses become negligible) give a satisfactory description of the decay. The kinematics of this decay provided a model-independent determination of of important quark transition parameters.

Beauty to up quark transitions were measured simultaneously by ARGUS and CLEO in 1989. This measurement opened up another sector of the CKM quark transition matrix. In these transitions the leptons accompanying quark transitions can have larger momenta than those from beauty-charm transitions. The evidence for beauty-up transitions was strengthened through the complete reconstruction of several B decays.

The most important ARGUS result is the observation of neutral B oscillations in 1987. In this process, the neutral B and its antiparticle, two separate particles from a strong interaction viewpoint, get interchanged in weak interactions, as also happens with neutral kaons. This mixing was observed by completely reconstructing an upsilon(4S) decay which contained two neutral Bs both decaying into a charm meson plus leptons, and by detecting upsilon(4S) decays containing pairs of similarly charged leptons, which come from the same kind of neutral B mesons. In about 17% of the upsilon(4S) decays a neutral B meson and its antiparticle had exchanged roles.

This measurement underlined the need for and gave new insight into the unseen sixth ('top') quark, whose mass must be more than 50 GeV, much heavier than hitherto believed.

The large neutral B mixing rate encouraged projects for B factories, because the result implies that a measurement of CP violation in B decays is in reach, opening up new windows on the Standard Model.

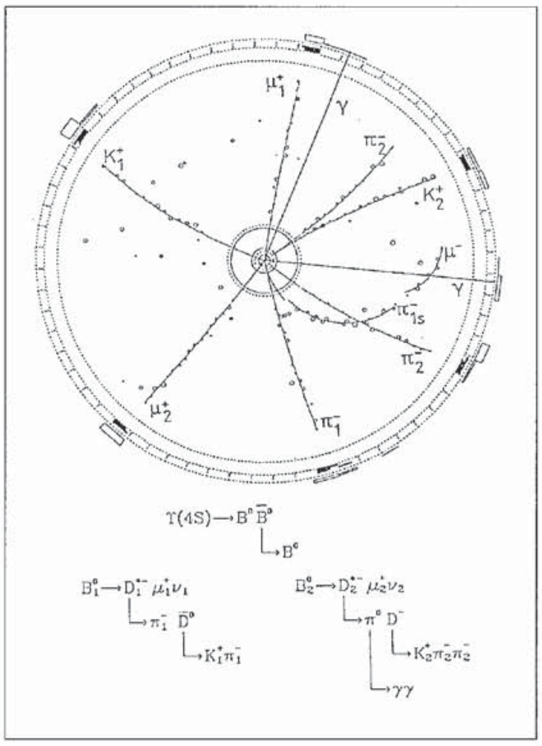
ARGUS was very active in charm particle spectroscopy. The first new charmed meson, the D**(2420), was found in 1985 and the first excited charmed baryon in 1993. Other charmed mesons and baryons were discovered by ARGUS in intervening years and precision measurements of the properties of various charmed hadrons have significantly enlarged our knowledge of charm spectroscopy.

ARGUS has investigated many weak decays of charmed hadrons, yielding more precise branching ratios and observations of new decay channels. An important contribution came in 1985 with the first observation of the decay of a neutral D into a phi and a neutral kaon.

In pure spectator models this decay is strongly suppressed, contrary to the measured branching ratio of about 1%, which still waits for a convincing explanation.

ARGUS has used its large tau sample to determine basic properties of this heavy lepton and its neutrino as well as the space-time structure of

1987 - this complete ARGUS reconstruction of the decay of an upsilon (4S) particle into a pair of neutral B mesons showed how a neutral B meson can 'mix' with its own antiparticle.



its decay. In 1992 the tau mass was determined by ARGUS (and by Beijing) to be about 8 MeV less than previously thought, tidying up some inconsistencies.

ARGUS made the first measurements of parity violation in tau decays, showing for the first time that the tau neutrino is left-handed with spin 1/2 - as expected in the Standard Model.

From the measurement of the decay of a tau into its neutrino and five pions, ARGUS deduced that the mass of the tau neutrino is less than 31 MeV, a result which has implications for cosmology. Observations of new tau decays, detailed analysis of other processes and the determination of the tau's weak parameters have contributed to our present understanding of the tau lepton.

With upsilon decays sensitive to the strong coupling constant, ARGUS deduced its value at the ground state upsilon energy. This result, when compared with others from higher energies, reflects how the quark force depends on energy. Precision measurements of beauty quark-antiquark states have contributed greatly to our knowledge of quark-antiquark forces.

ARGUS has published more than 120 papers. Although the detector will run no more, its large and high quality data sample will continue to be a source of new and interesting results.

HERA physics with internal targets

The 6.3 kilometre HERA ring at the Hamburg DESY Laboratory was built primarily as an electron-proton collider, but with HERA's collider operation getting into full swing - the collision count collected by each of the two experiments (H1 and ZEUS) has already exceeded last year's figure tenfold! - other HERA physics options can be studied.

An international workshop at DESY looked at the additional physics reach of HERA's unique 30 GeV electron and 820 GeV proton beams. Early arrivals on the scene are the recently approved HERMES experiment to precision measure the spin quark structure of nucleons, and a letter of intent to study CP violation in B mesons using an internal target in the HERA proton ring.

Close to 200 participants spent three days (September 21-23) discussing HERMES physics potential, including nuclear physics possibilities, the B-meson physics accessible with an an internal target in the proton beam, and detector techniques for the hostile environment of a high rate fixed target experiment.

Using HERA's polarized electron beam, HERMES aims to probe the origin of the spin of protons and neutrons. Extensive measurements in 1992 and 1993 have shown that self-polarization of the stored electrons (through the Sokolov-Ternov mechanism) leads to a stable and highly reproducible transverse polarization in HERA exceeding 60% (March 1992, page 18). The necessary longitudinal polarization will be achieved with the help of a pair of spin rotators to be installed and tested next year.

The second key HERMES ingredient is a polarized internal gas target using hydrogen, deuterium or helium 3. Such targets have been successfully developed by the collaboration. After workshop reviews by Emlyn Hughes and Robert L. Jaffe on the status of theoretical and experimental understanding of the origin of nucleon spin, Michael Dueren concluded that the high target polarization and the undiluted target atoms are major assets and will minimize systematic errors.

To be installed in one of HERA's two vacant interaction regions, HERMES is scheduled to begin in 1995, and by 1996/97 accumulated data from CERN, DESY and Stanford (SLAC) should have resolved the nucleon spin structure.

As well as making a precise measurement of the scattered electron, HERMES will also look hard at the final hadrons. This will provide important additional information, such as the relative contribution of the valence and sea quarks to the nucleon spin.

Physics issues beyond the approved HERMES programme, using nucleons or nuclei as targets, were addressed in a large number of contributions and reviewed by Thomas Walcher and Dieter von Harrach. Prerequisites are HERMES' ability to analyse hadronic final states, and the ability to scatter polarized as well as unpolarized electrons on a range of nuclear targets with different polarization states. Probing the timescale of the inner quark processes (fragmentation) through the measurement of nuclear dependence is just one example of many ideas which will be studied.

On another physics front, the violation of CP symmetry (combined particle-antiparticle and left-right reversal) is one of the fundamental features of the Standard Model. So far CP violation has only been seen with kaons, and a full understanding of this mechanism, which plays a vital role in particle physics, requires detailed study of the effect in other quark systems. Neutral B-mesons provide such a possibility.

The necessary high event rates require high luminosity electron-positron colliders, or 'factories' (June, page 16). Hadron accelerators offer an alternative route, but with B production only a tiny fraction of the total yield, experiments are considerably more challenging.

Members of the ARGUS collaboration, a veteran DESY experiment which stopped taking data this year (see previous story), are looking at the possibility of using HERA protons as a source of B-mesons to measure CP violation.

At the workshop theoretical and experimental aspects of measuring CP violation at colliders, electron-positron and proton were reviewed by Ahmed Ali, Thomas Mannel, John Jaros and Jeff Spalding. Werner Hofmann summarized the status of the feasibility studies. A major new result is the efficiency of a wire target in the HERA proton beam halo, showing that the required interaction rate is in reach.

Detailed simulations indicate that a significant measurement of the CP violation parameter should be possible with five years' data, however the required high interaction rates are a challenge for detector design and operation. Five working groups, convened by Boris Dolgoshein, William Haynes, Roland Horisberger, Fabio Sauli and Joachim Spengler, studied radiation-hard silicon detectors, gas tracking detectors, transition radiation and ring imaging cherenkov detectors, calorimeters, muon identification, triggering and data acquisition.

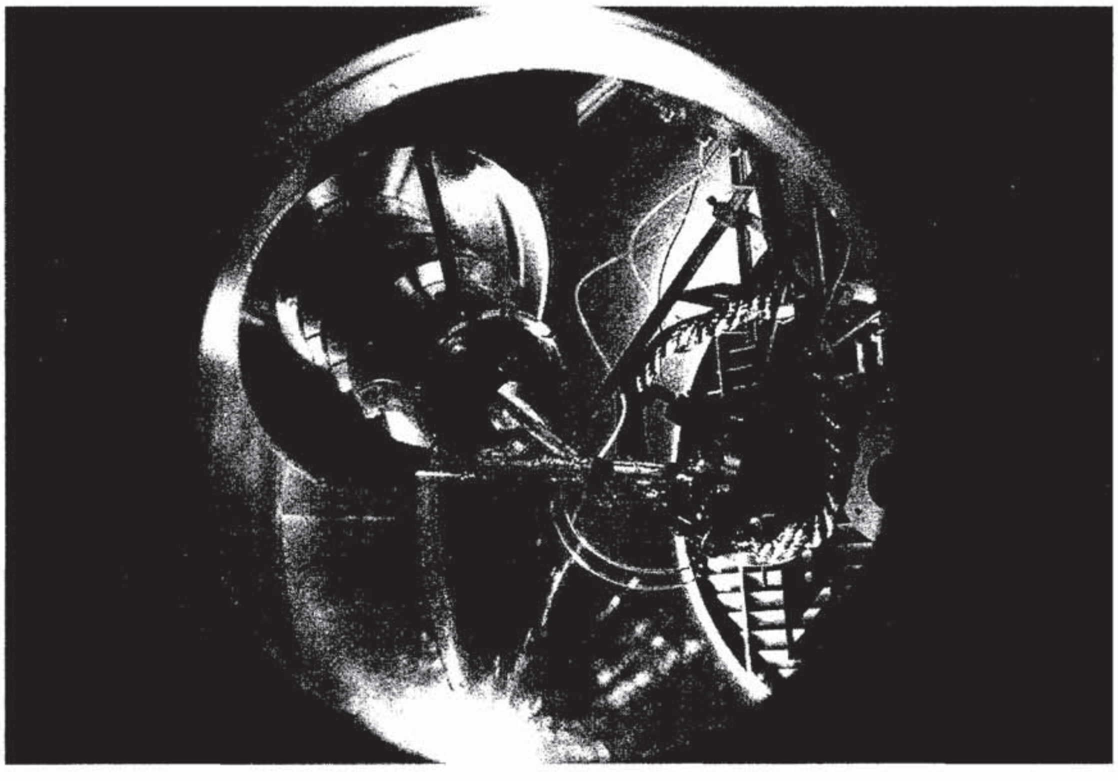
The requirements resemble those of detectors for large hadron colliders, and the design will profit considerably from the R&D work for LHC and SSC.

It became clear that a HERA fixed target experiment, in addition to measuring CP violation, could also make significant contributions to quark transition parameters (CKM matrix) and B_s mixing.

This view was shared by DESY's Physics Research Committee (PRC) which met a few days after the workshop and encouraged proponents to continue their studies and strengthen their efforts. In its next two meetings (February and May) the PRC will review progress so that the DESY Directorate can take a decision by the end of May.

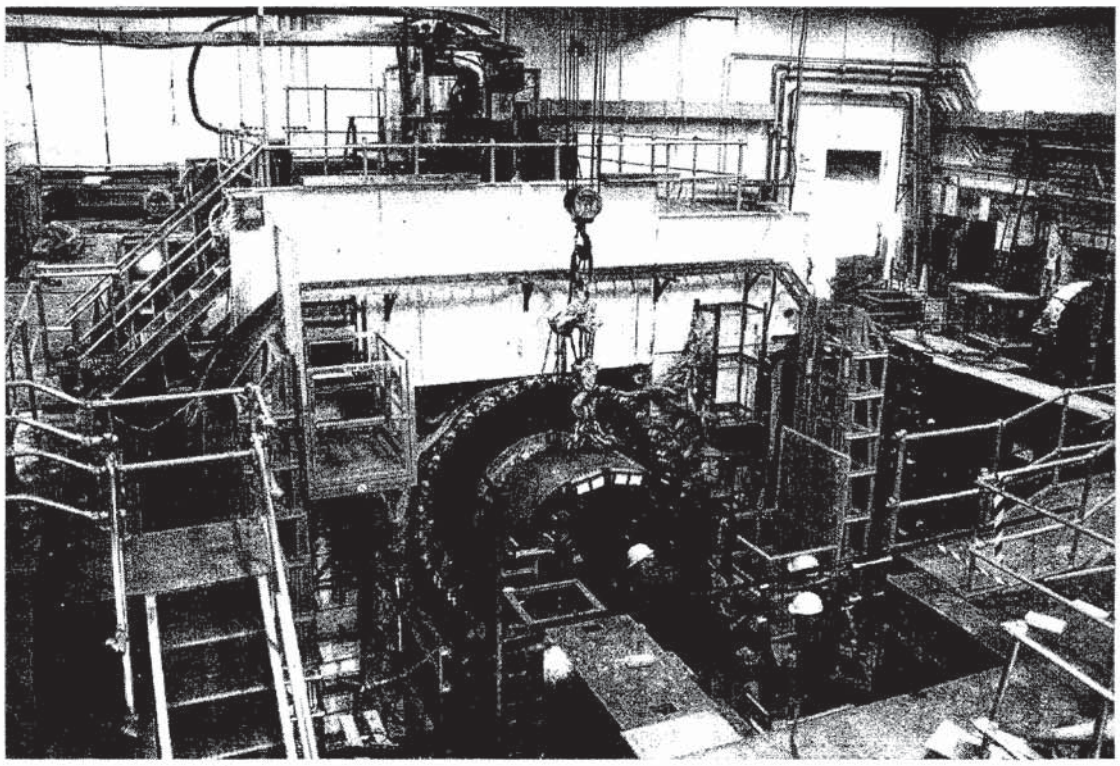
The workshop spanned two quite different fields of research, and the animated discussions on physics and detector issues showed that fixed target experiments will be an exciting addition to the new world of HERA physics.

Albrecht Wagner



A view into the target chamber - a prototype for the HERMES cell at DESY's HERA ring - used for tests at Heidelberg. Centre is the T-shaped storage cell. Polarized hydrogen atoms are injected from the upper left using an encapsulated permanent sextupole. On the right is the storage cell cooling mechanism and cryo pump.

Installing the CLEO II detector at Cornell's CESR electron-positron storage ring.



CORNELL
B physics

Good news from the National Science Foundation assuring future B physics productivity at Cornell's CESR electron-positron collider and the CLEO detector followed almost immediately after the US Department of Energy's announcement that SLAC (Stanford) had been selected as the site for the proposed US asymmetric B Factory, as a part of a package of federal projects for California (see page 2).

(The proposed factory schemes envisaged colliding electron and positron beams of different energies, hence the adjective asymmetric. Normally electron-positron colliders have equal energy - symmetric - beams.)

In parallel with the B Factory idea, CESR and CLEO have for several years been pursuing a staged upgrade programme for improved symmetric-energy collider operation through the 1990s and beyond. Phase I of the programme, recently completed, had the goal of increasing the peak luminosity of the ring to exceed 2×10^{32} cm^{-2} sec^{-1} (currently 2.5×10^{32}) and increasing the data rate capabilities of the CLEO detector to match.

Phase II, now underway, involves a doubling or tripling of the CESR luminosity by storing larger beams. The scheme for increasing beam current is based on an idea by Cornell accelerator physicist Robert Meller. Presently, the two beams circulate in separate "pretzel" orbits that weave around each other so that seven beam bunches can be stored in each beam without colliding with those in the other beam except at the experiment (October 1992, page 17).

In Meller's scheme the pretzel orbits cross at a 2 milliradian angle instead of intersecting head on, as in existing electron-positron rings. This allows one to replace each beam bunch by a train of closely spaced bunches, increasing the frequency of bunch-bunch collisions. Tests at CESR have verified that the luminosity per bunch-bunch collision is negligibly affected by the small crossing angle.

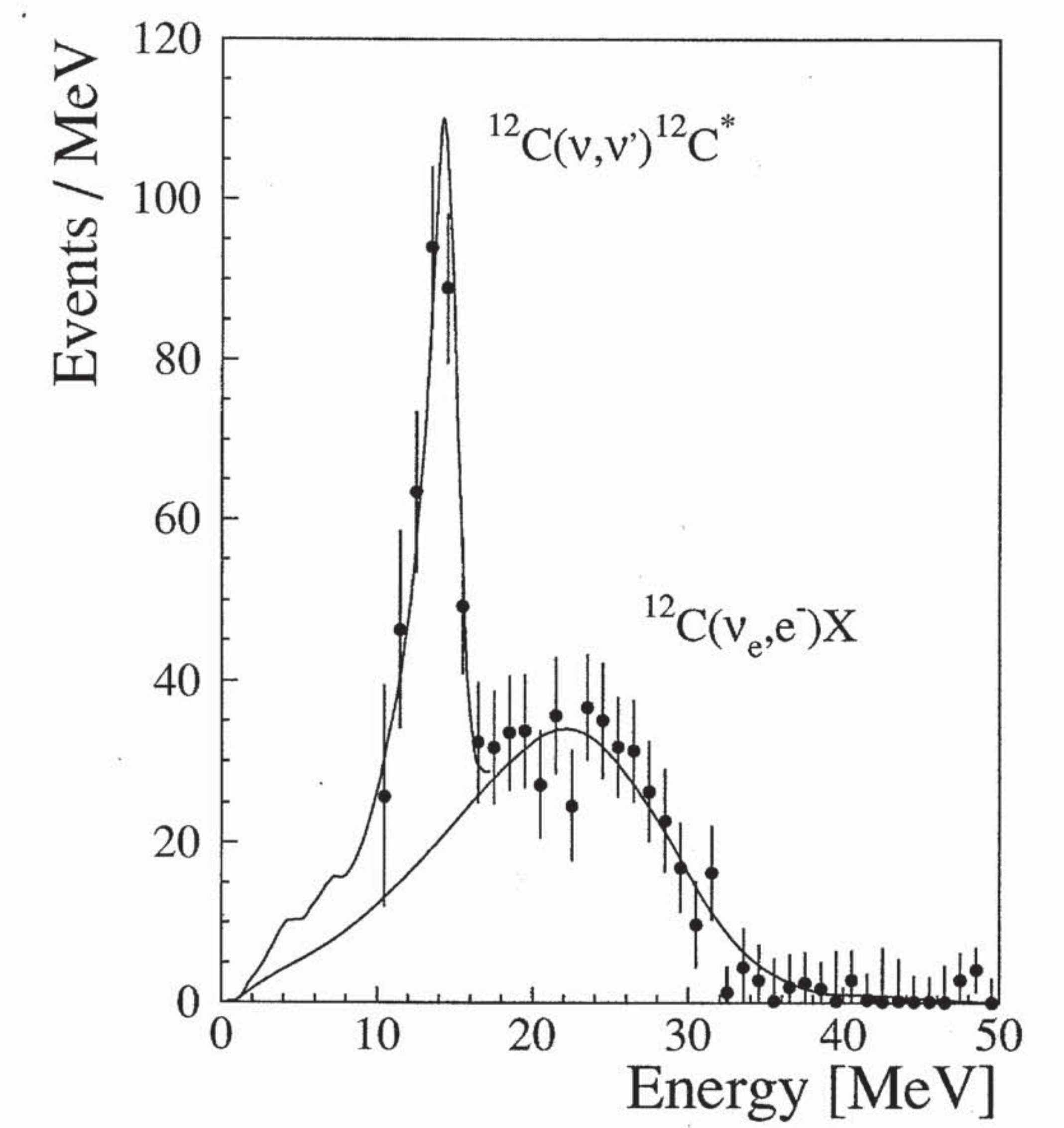
As a part of the Phase II upgrade, the CLEO detector will be adding a three-layer, double-sided silicon vertex detector to improve the identification of charmed particles and reduce the background in the reconstruction of B decays. Installation of the Phase II CESR and CLEO equipment will be completed next year.

Details of Phase III have been worked out during the past year. This is a more ambitious and costly scheme to further double or triple the CESR luminosity, taking advantage of the crossing angle orbits to store even more bunches per train. The resulting circulating currents, in the ampere range, will require new superconducting radiofrequency cavities of the kind proposed and prototyped (December 1992, page 16) for the B Factory, as well as extensive vacuum system modifications. The goal is a peak luminosity of at least 10^{33}, and perhaps higher. Phase III also involves rebuilding the inner tracking and hadron identification components of CLEO to increase significantly its performance in measuring rare B meson decays and other low rate processes.

In October the National Science Foundation approved a five-year operations and upgrade programme which should lead to completion of Phase III. This assures the continued productivity of CESR/CLEO at the forefront of B physics into the next century.

Thanks to the record luminosity of the CESR collider, CLEO has recently become sensitive to one-loop weak decays with the discovery of the first "penguin" decays (June, page 1). Rates for such exotic processes depend on the presence

One of the major achievements of the KARMEN experiment by a German/UK collaboration at the Rutherford Appleton Laboratory ISIS source has been the first observation of a neutral current excitation of a nucleus.
The neutral current excitation of carbon-12 shows up as a clear peak around 15 MeV in the energy spectrum of neutrino-induced reactions in the muon decay time window. The broad bump structure is due to charged current reactions to the ground state as well as to excited levels of nitrogen-12.



of intermediate heavy particles, invisible but still playing a role - the top quark, the W boson, and perhaps exotic objects like Higgs bosons or supersymmetric partners.

Continued CESR progress and detector performance will open up a new window on physics beyond the Standard Model. There are also exciting opportunities in the study of the tau lepton and charmed hadrons.

A symmetric energy CESR will likely have produced more than 60 million Bs even before an asymmetric B Factory could be near its design goals, and will still be an effective competitor afterward.

KfK KARLSRUHE/ RUTHERFORD APPLETON
New neutrino physics

The Karlsruhe-Rutherford Medium Energy Neutrino Experiment (KARMEN) at the UK Rutherford Appleton Laboratory's ISIS spallation neutron facility studies the interactions of neutrinos with nuclei in an energy range of particular importance for neutrino astrophysics.

After its first three years of data-taking the German/British experiment has analysed more than 1000 neutrino-nucleus interactions. The spectroscopic quality of neutrino data complemented by an extremely low background allows reliable cross-section measurements down to 10^{-42} cm^2 as well as precision tests of the standard model.

Having reached its design value of 200 microamps average proton beam current at 800 MeV, ISIS is the world's most powerful pulsed medium energy neutrino source. The proton beam stop delivers extremely short but intense bursts of neutrinos. A prompt burst of 30 MeV muon neutrinos from pion decay at rest is followed by a pulse of electron and muon antineutrinos from muon decay at rest with energies up to 53 MeV. This allows separation of different neutrino 'flavours' by time measurement. In addition, cosmic ray background is highly suppressed.

Neutrinos are detected by a 60 ton high resolution liquid scintillation calorimeter 17.5 m from the beam stop and housed in a massive 6000 ton iron blockhouse. Consisting entirely of hydrocarbons, the calorimeter is an all active target of carbon-12 and hydrogen nuclei. Nuclear excitations by neutrino interactions with carbon-12 nuclei through weak charged or neutral currents can be identified by the subsequent deexcitation processes.

At beam stop energies nuclear charged current reactions can only be induced by electron neutrinos. A prototype example is the charged current transition from carbon-12 to the ground state of nitrogen-12. The delayed coincidence of this reaction allows clear identification of electron neutrinos. The flux-averaged as well as the energy dependence of the absorption cross-section both agree with calculations using standard model neutrino-nucleus couplings. In addition, the reaction kinematics can be used to measure the energies of electron neutrinos. Thus the first spectrum of electron neutrinos from muon decay could be derived from 240 neutrino charged current events. Analysis of the spectral shape of electron neutrinos near the kinematic endpoint shows no significant deviation from the standard (V-A) helicity structure of charged currents, thereby putting stringent upper limits on non-standard effects in muon decay.

One of KARMEN's major achievements has been the first observation of a neutral current excitation of a nucleus. Within the first year of data-taking the experiment could clearly identify neutral current excitations of carbon-12 (to the isovector T=1 level at 15.1 MeV above ground state), the signature being the 15.1 MeV gamma quanta from the decay of the excited carbon-12 level.

Focusing on the muon decay time window, the experiment has measured the sum of neutral current excitations induced by electron neutrinos and muon antineutrinos. The flux-averaged cross-section for the sum of both neutrino species is in excellent agreement with recent calculations.

A thorough test of flavour universality of the neutrino neutral current coupling comes from comparing neutral and charged current channels. The experimental ratio clearly indicates that both neutrino flavours participate with equal strength in the neutral current channel. As neutrinos from muon decay are the closest terrestrial analogue of supernova neutrinos, these results are also of great relevance to neutrino astrophysics.

The second major KARMEN activity is a high sensitivity search for oscillations between muon- and electron-type neutrinos and antineutrinos. Oscillation of muon- into electron-type neutrinos would be signalled by monoenergetic electron neutrinos in the prompt time window of pion decay using the charged current reaction on carbon-12. Oscillations of muon into electron type antineutrinos would be identified by the inverse beta-decay reaction on the free protons of the scintillator.

In both reaction channels no positive evidence for neutrino oscillations has so far been detected. Taking full advantage of the unique time structure of ISIS the experiment will, after three more years of data taking, provide good limits for mixing of electron and muon neutrinos.

The future programme will also cover new fields, including measurements of muon-neutrino-induced neutral current excitations of carbon-12 and of electron-neutrino-induced charged current reactions to excited levels of nitrogen-12, testing the significance of neutrino-induced nucleosynthesis in core collapse supernovae.

The KARMEN collaboration includes groups from the Kernforschungszentrum and University of Karlsruhe, Erlangen, the Rutherford-Appleton Laboratory, Queen Mary and Westfield College London, and Oxford.

CENTRAL EUROPE
Role models

Hungary is one of the newcomers to the CERN fold, having joined in 1992. The country's contributions are naturally in line with its slender resources and are not as immediately visible as those of the major Western European Member States. However the approach used and its consequent successes provide a good role model for a smaller nation in an international research environment.

This was reflected on 24 September at a meeting of the European Committee for Future Accelerators (ECFA) convened in Budapest, continuing an ECFA tradition of holding meetings in national centres to learn more about the physics programmes of different countries. This tradition started with visits to major West European Centres, but last year ECFA held a meeting in Warsaw, its first in a central European country.

By far the largest Hungarian population centre, Budapest is also a hub for national research in this sector, with university centres and the KFKI Research Institute for Particle and Nuclear Physics of the National Academy of Sciences. However important research work is also carried out in the eastern city of Debrecen.

Hungarians look back to the classic investigations of Eötvös early this century as the starting point of their national tradition in fundamental physics. (In the mid-80s, these experiments briefly came back into vogue when there was a suggestion of an additional 'fifth force' contribution to nuclear masses.) After Eötvös, Bay and Jánossy also displayed the

This year's European School of High Energy Physicists at Zakopane was the first in a new series organized annually in collaboration with CERN and JINR, Dubna. The traditional poster session attracted local high school students and teachers.

characteristic ingenuity that is now a staple national resource.

On the contemporary scene, Hungary first became involved in accelerator experiments as a Member State of the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow. Contact with CERN came piecemeal through Hungarian participation in teams which were part of collaborations working at CERN. Teams at Dubna, Annecy, Saclay and Munich all had some Hungarian contribution.

György Vesztergombi, head of KFKI particle physics, points to a 'key experiment principle', where a major detector provides a bridgehead for new involvement. In Hungary's case at CERN, this was the European Muon Collaboration experiment (1976-82), where an Annecy team included Hungarian specialists.

After EMC, the L3 collaboration at LEP was the focus of the Hungarian effort at CERN, which still retains close ties with Annecy, while the Crystal Barrel experiment at the LEAR low energy antiproton ring and the NA35 heavy ion study also have Hungarian participation. Future projects include the NA49 heavy ion study, where the specific Hungarian goal is to optimize hadron identification, and research and development work for LHC detectors. Here a project for fibre readout could have interesting industrial spinoff applications.

People often allege that Big Science, with its huge projects, long timescales and giant collaborations, smothers small contributions. While to some extent this is true, the outcome can also work the other way. Big collaborations are full of opportunities where individuals or small groups can carve out special niches. The Hungarian contribution to CERN reflects this well.

A slightly different picture had emerged from ECFA's autumn meeting in Warsaw last year. Polish physicists have a longer CERN tradition - their nation was granted Observer status in 1963 and became a Member State in 1991, maintaining its membership in the Joint Institute for Nuclear Research (JINR) Dubna, near Moscow (which Hungary has abandoned).

Groups from Warsaw and Krakow are no strangers at CERN, where bubble chamber participation began in the early 60s, moving to counter experiments in the 70s. Wroclaw and Lodz are also active.

Polish involvement now centres on the Delphi experiment at LEP and the Spin Muon Collaboration at the SPS proton synchrotron. Polish physicists are also active in ongoing heavy ion studies and in research and development work for future experiments at the LHC proton collider.

At the German DESY Laboratory, Hamburg, Poland is involved in both major experiments at the HERA electron-proton collider.

The links of Polish physicists with the world community are strengthened by regular schools and symposia, such as those at Zakopane, and the internationally known Kazimierz Symposium.

Hungary and Poland both have strong traditions in theory and phenomenology and have been able to build up an impressive infrastructure in computing and networking in a short time. Both have suffered from a migration of talent westwards.

Polish school

From 12-25 September the European School of High Energy Physicists was held at Zakopane, the first in a new series organized annually in collaboration with CERN and JINR. CERN/Norwegian physicist Egil Lillestol is the Head of the School, which will go on to be held in European countries, including those of the former Soviet Union.

The symbolic value of choosing Poland for this first event was appreciated nationally and drew enthusiast

EPAC94

FOURTH EUROPEAN PARTICLE ACCELERATOR CONFERENCE
Queen Elizabeth II Conference Centre, London,
27 June to 1 July 1994

After Rome, Nice and Berlin, the fourth conference in the series will be held at the prestigious Queen Elizabeth II Conference Centre, opposite Westminster Abbey and only a short walk from the Houses of Parliament, in the city of Westminster, London.

The conference aims to provide a comprehensive overview of research, technology and special applications in the field of accelerators. In the planning of the programme special emphasis is placed on excellent review papers and particular attention will be paid to high-intensity accelerators. The programme will include invited talks, contributed papers, oral poster presentations and poster sessions. Parallel sessions will be kept to a minimum.

Papers from the whole field of accelerators are sollicited, including low- and high-energy machines and accelerators for medical and industrial purposes. The deadline for the receipt of Abstracts at the Scientific Secretariat is 15 December 1993.

An industrial exhibition, as well as an exhibition of CERN's proposed LHC Project, will be held during part of the conference and the conference programme will include a special session whose theme will be the transfer of technology from accelerator laboratories to industry. Information regarding the exhibition and seminar may be obtained from the Exhibition Manager.

Local organization is in the hand of the RAL and Daresbury laboratories. The registration fee is £225 if received before the deadline of 27 April 1994 and is increased to £250 thereafter. Due to the huge demand for accommodation in London in June and July, requests for accommodation should also be made prior to this date. Complete information concerning registration and accommodation may be obtained from the Conference Secretariat.

World-Wide Web (W3) and Internet Gopher will be used as additional means of disseminating information on the conferences as it becomes available. Indications as to how to use these systems, as well as complete information on the conference are given in the First Announcement and Call for Papers available from the Conference Secretariats.

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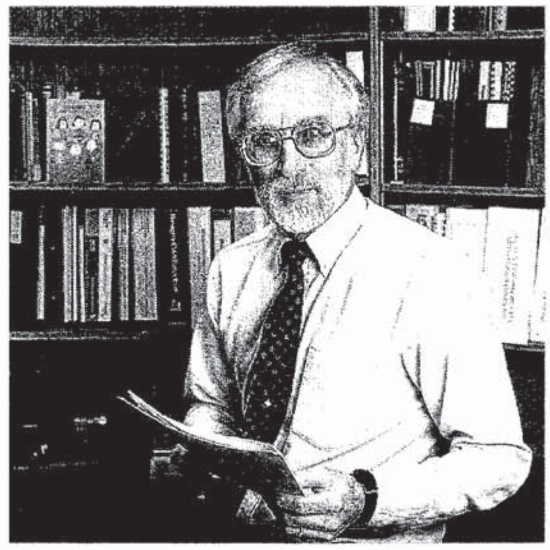
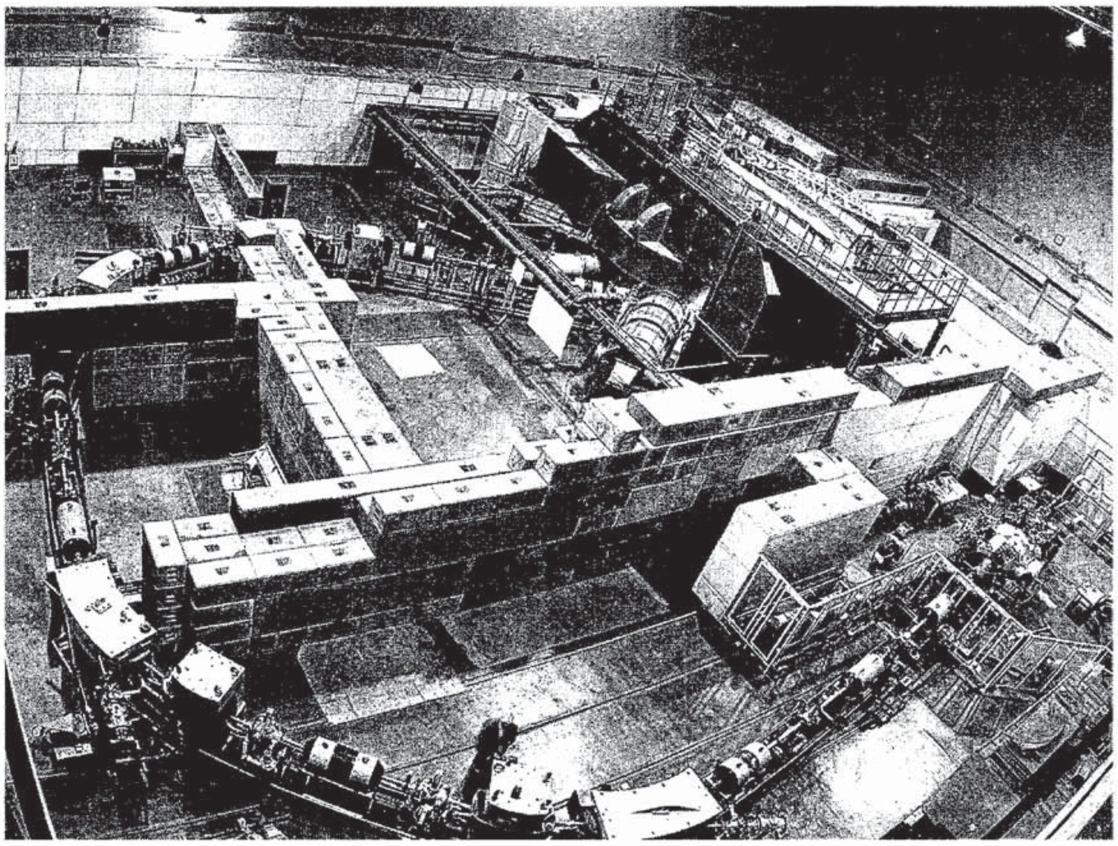
Stanley O. Schriber is Director of Los Alamos' new Accelerator Operations and Technology Division.



The recently commissioned U400M cyclotron at the Joint Institute for Nuclear Research, JINR, Dubna, near Moscow.



media coverage.

Visiting dignitaries included the President of the National Atomic Agency and a Director of the Ministry Office for European Integration. The local organizing committee under M. Turala ensured the school's success, with more than a hundred students.

DUBNA
Heavy ion cyclotrons

The new Nuclotron superconducting heavy ion machine (July, page 9) is only one facet of the heavy ion facilities available at the Joint Institute for Nuclear Research, JINR, Dubna, near Moscow.

A twin cyclotron heavy ion complex has been developed at the Flerov Laboratory. This complex - U400+U400M - is designed to produce beams from protons to uranium nuclei with energies from 20-100 MeV per nucleon.

The U400M post-accelerator uses the 310cm electromagnet of a classical Flerov cyclotron dating from 1960. Rebuilding began in 1989 as a four-sector isochronous cyclotron. To decrease the power of the correcting coils and simplify the accelerator structure, the magnetic field was shaped by iron inserts for acceleration over the range 6-100 MeV per nucleon. The accelerating and vacuum systems have been rebuilt and upgraded. Beam is extracted by magnetic deflectors or by a locally-developed and very efficient technique using ion stripping in a thin foil.

U400M began operations in 1992 using an ionization gauge source and providing nuclei from helium to argon. As well as using U400 as an injector, U400M will also be equipped with a 14 GHz electron cyclotron resonance source being developed in collaboration with the French GANIL heavy ion Laboratory.

LOS ALAMOS
Reorganization

A few months ago Los Alamos National Laboratory embarked on a major reorganization. All upper management was invited to submit their resignations and reapply for new positions, of which there are only about one third as many.

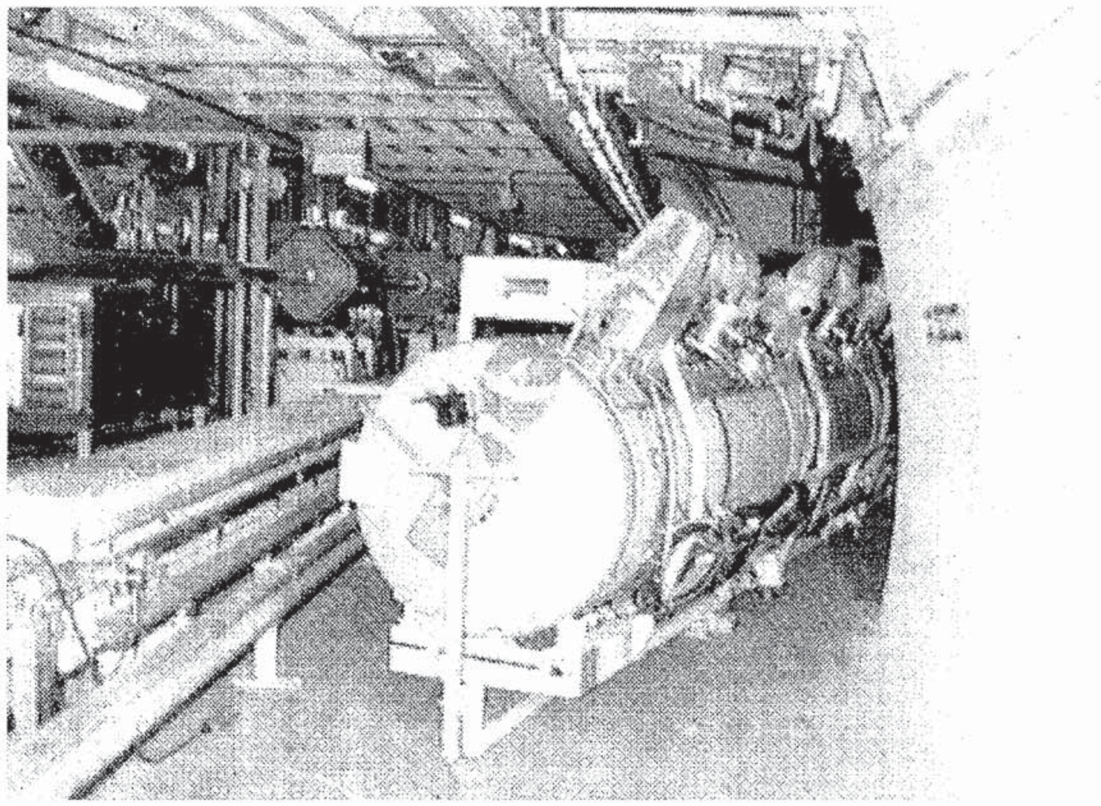
This action was coordinated with an attractive early retirement incentive so that displaced managers, as well as any other employee, could choose to retire if they were unhappy with the reorganization, or for any other reason. About 850 of the Lab's 7,700 employees have chosen retirement.

MP (Meson or Medium Energy Physics) and AT (Accelerator Technology) Divisions have been combined into the AOT (Accelerator Operations and Technology) Division. Stanley O. Schriber is its new Director.

AOT Division is responsible for operations and improvements at the Los Alamos Meson Physics Facility (LAMPF) and supports traditional users, LANSCE (the Los Alamos Neutron Scattering Center), and the emerging neutron applications community. Advanced accelerator development, including beam transport theory, instrumentation, free electron laser technology, and engineering for research, defence, industrial, and medical applications will be a major focus.

Physics monitor

Superconducting radiofrequency accelerating cavities are important in the push for higher energies. The LEP200 programme to boost collision energies at CERN's LEP electron-positron collider passed a major milestone at the end of September when the first series-produced niobium-coated superconducting r.f. cavity was installed in Point 6.



WORKSHOP Radiofrequency superconductivity

With superconducting radiofrequency playing a major role in the push for new machines to break fresh physics frontiers, it has become a tradition for experts and newcomers in this field from all over the world to meet every second year to hear progress reports from laboratories and to discuss common problems and possible solutions.

The sixth such workshop was held from 4-8 October under the chairmanship of Ron Sundelin at the Continuous Electron Beam Accelerator Facility (CEBAF) under construction in Newport News, Virginia. With 170 participants from 14 countries including Eastern Europe and China, it reflected the growing interest in the field - looking back to 1984, when CERN was the host laboratory, the second workshop had less than 100 participants.

The CEBAF meeting began with laboratory status reports, covering both high beam energy ('high beta') applications with 'spherical' cavities (as with CERN's LEP200), all using niobium as superconductor and working between 352 MHz and 3 GHz, and lower energy ('low beta') applications with geometrically more complicated shapes such as quarter or half wave, split ring or spoke resonators, some using electro-deposited lead as superconductor and working around 100 MHz.

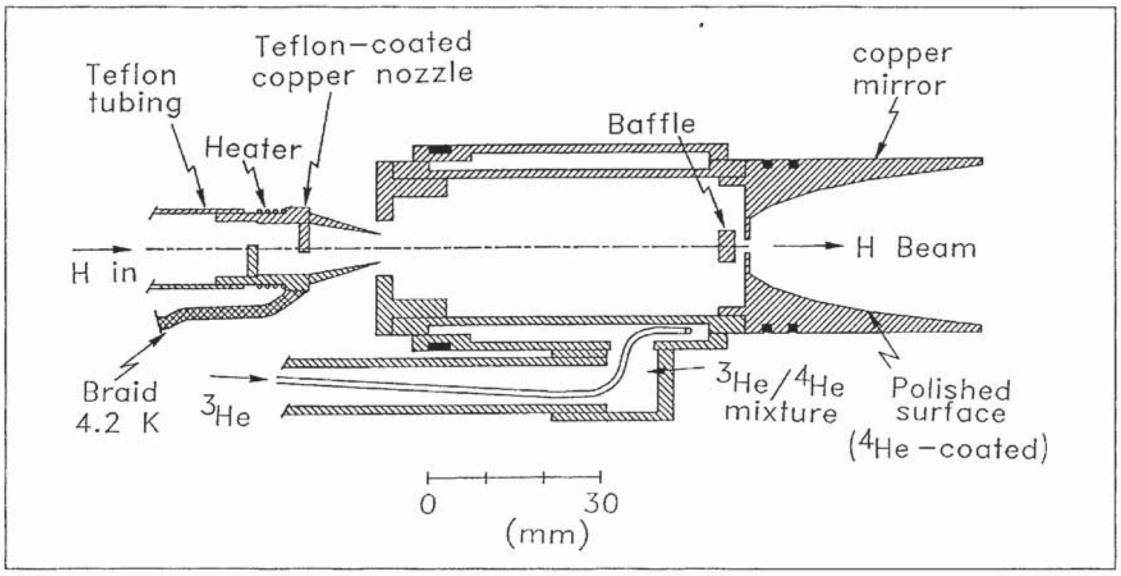
During these talks it became clear that more and more laboratories have focused on routine problems, such as reliable series production and testing, running cavities with ancillaries in the machines, or building complete prototypes for projects to be approved by critical funding authorities. This contrasts with the heady days just a few years ago when - at least in the high beta community - the main objective was to explore new ideas.

State-of-the-art summaries showed how at 1.3 and 3 GHz 25-30 MV/m have been reached by several laboratories using different preparation methods. Newer developments for common problems included r.f. windows, couplers, controls, and especially field emission, public enemy number one for several years. New ideas, such as 'high pressure (water) rinsing' and 'high pulsed power processing', attack on two different fronts - avoiding the creation of field emitters and removing existing ones. While first results are encouraging, the enemy is still very active! Although still futuristic, the application of high critical temperature superconductors was also on the agenda.

Afternoon poster sessions highlighted detailed work, too specialized for the morning talks, allowing direct discussion.

Two workshop days were given over to two special topics. One was high beam current applications (B-factories, spallation sources), where cavities operate at relatively modest fields but couplers will have to work above today's power levels. The second was the TeV linear collider project with exclusively superconducting cavities (TESLA) asking for 25 MV/m at 1.3 GHz with high resonance quality factor (Q) but low production cost. A world collaboration of several laboratories (including CERN) is building a test facility at DESY to study industry-made cavities. This building is nearly complete. The next stage will be construction and testing of 8-cavity modules in a prototype accelerator section with beam.

TESLA-type cavities are being built and tested in several laboratories. Greg Loew gave a status report on normal conducting competitors, such



The helium-coated quasi-parabolic focusing mirror at 0.3 kelvin in the gradient of the 8 Tesla solenoid of Michigan's Prototype ultra-cold spin-polarized atomic hydrogen jet should considerably boost the intensity of polarized atoms.

as NLC (Stanford - SLAC) and CLIC (CERN).

The next workshop will be held in 1995 at Saclay, under the chairmanship of Bernard Aune.

From Joachim Tückmantel (CERN)

SPIN PHYSICS
Magnification by superfluid helium mirror

A 'quasi-parabolic' mirror coated with superfluid helium-4 may have advanced the recently developed art of 'atomic optics'; it should certainly increase the intensity of the Mark II ultra-cold spin-polarized atomic hydrogen jet, which should travel to Russia in 1995. The Michigan team is now building the Mark II Jet to serve as the internal polarized target for both the NEPTUN-A experiment (Michigan, MIT, IHEP-Protvino, JINR-Dubna) led by Alan Krisch and the NEPTUN experiment (IHEP-Protvino, JINR-Dubna, Moscow, St. Petersburg) led by Vladimir Solovianov.

Both experiments will use the UNK-1 proton accelerator now being installed at IHEP-Protvino (Serpukhov) to study various spin effects in 400 GeV proton-proton scattering. The existing 70 GeV accelerator, U-70, will be the injector for UNK-1 which will first operate as a 400 GeV storage ring for NEPTUN and NEPTUN-A. Until the 600 GeV extracted beam programme begins a few years later, NEPTUN and NEPTUN-A will be the only experiments operating at the huge 21 km circumference accelerator. Thus the intensity of the Mark II Jet is quite important. If the jet reaches the expected thickness of 10^{13} polarized protons per sq cm, then the luminosity with UNK's planned 6×10^{14} stored protons will be 10^{32} cm^{-2} s^{-1}.

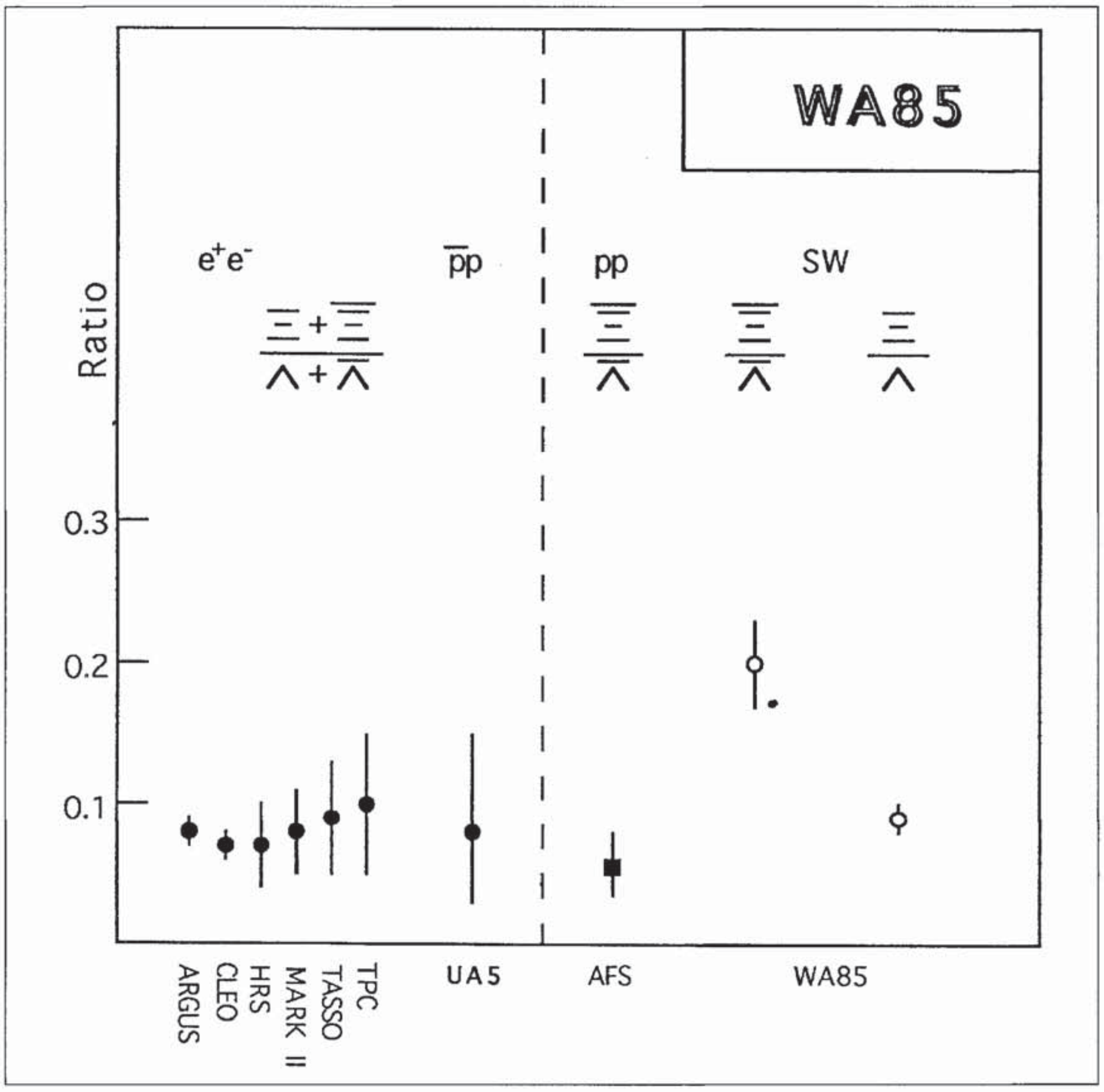
The use of ultra-cold techniques to produce high densities of spin-polarized hydrogen atoms was pioneered by atomic physics teams led by D. Kleppner (MIT), I. Silvera (Harvard), and J. Walraven (Amsterdam). Michigan's Mark-II Jet will use a 12 Tesla superconducting solenoid and a helium-3/helium-4 dilution refrigerator operating at about 0.3 K with a cooling power of about 100 mW. The strong magnetic field gradient at the solenoid's edge will accelerate those hydrogen atoms whose magnetic moments are parallel to the field; these spin-polarized atoms should emerge as a rather monoenergetic jet because the 12 Tesla solenoid's 'magnetic acceleration' energy is about 25 times larger than the thermal energy near 0.3 Kelvin.

The Michigan team first built a prototype to help maximize the intensity of the Mark II Jet. Vladimir Luppov, a Michigan visitor from JINR-Dubna, proposed using the new 'quantum reflection' technique developed by Walraven's team, which recently found that superfluid helium-4 reflected about 80% of incoming hydrogen atoms. Luppov suggested installing, at the Prototype Jet's exit aperture, a highly polished parabolic mirror coated with superfluid helium-4 to focus the emerging hydrogen atoms into a parallel beam. Unfortunately the parabolic copper mirror gave little intensity gain.

The Michigan team then realized that a parabola is the correct shape only when there is no magnetic field gradient; the strong gradient of the prototype's 8 Tesla solenoid distorted the path of the emerging atoms. So they next built a 'quasi-parabolic" copper mirror shaped to compensate for the field gradient of the 8 Tesla solenoid. This superfluid helium coated mirror worked much better than expected. The mirror increased the polarized hydrogen atom intensity by a factor of 7.5, measured by a small aperture compression tube detector about 80 cm downstream of the mirror.

This new technique was then immediately integrated into the Mark-II Jet's design. The mirror's focusing should allow a fairly small aperture (11 cm) superconducting sextupole

The WA85 heavy ion beam experiment at CERN has found increased yields of antihyperons, difficult to produce hadronically, compared to what is seen in other reactions.



to focus about half of the emerging spin-polarized hydrogen atoms; the resulting polarized proton jet of about 10^{13} cm^{-2} should give a luminosity of 10^{32} cm^{-2} s^{-1} when crossing the 400 GeV UNK-1 beam.

Quark matter 93

In his welcome address to the 10th International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions (Quark Matter '93), held in Borlänge, Sweden, from 20-24 June, Hans-Åke Gustafsson was puzzled why this year's conference was billed as the tenth in the series.

He had tried to count but could only find eight forerunners - Bielefeld (1982), Brookhaven (1983), Helsinki (1984), Asilomar (1986), Nordkirchen (1987), Lenox (1988), Menton (1990), Gatlinburg (1991), making this year's meeting at Borlänge the ninth.

The answer was given by Helmut Satz in his introductory talk, pointing out that at the time of the Bielefeld meeting, a few conferences dealing with similar topics had already been held.

The Bielefeld organizers thus did not consider their conference the first. Whatever its pedigree, the Borlänge meeting covered particle production in highly excited and compressed nuclear matter, fluctuations and correlations, quark phenomena (quantum chromodynamics - QCD) in nuclear collisions, probes and signatures of Quark-Gluon Plasma (QGP), future collider experiments and instrumentation.

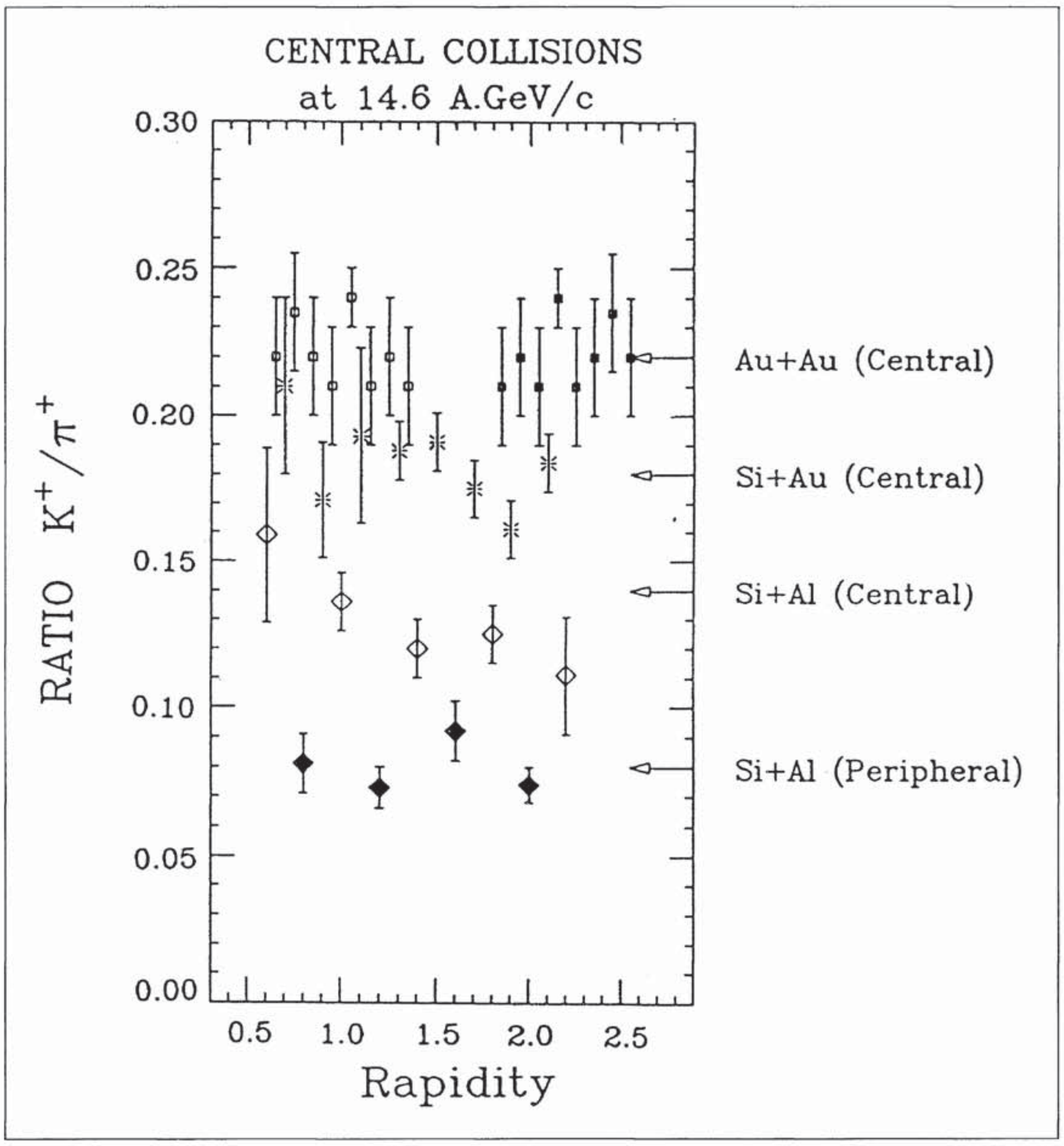
The theoretical talks were split between the fundamental properties of the hot and dense matter at or near equilibrium, and the interface between theory and experiment. The phenomenological modelling of heavy ion collisions seems to reproduce at least all the main features of the data with hadrons, resonances and strings as the degrees of freedom. However secondary interactions among the produced hadrons or strings need to be added. Hydrodynamic calculations lead to results which reproduce the main features of the collisions.

With increasing collision energy, the parton degrees of freedom become more important. Klaus Geiger described an ambitious scheme treating the whole nucleus-nucleus collision in terms of a kinetic parton (quark/gluon) cascade. The initial parton distribution at the beginning of the collision is determined from the quark-gluon nuclear structure and the evolution is followed in terms of perturbative QCD.

These calculations, as well as several others reported, reflect the ongoing effort to go beyond the simplified treatment of the initial stage of the collision as an ideal gas of quarks and gluons. As pointed out by Miklos Gyulassy in his talk on QCD transport theory, the possibility of two different production mechanisms can affect the subsequent evolution of produced matter.

Nuclear collision experiments have reported an enhancement in the pion yield at low transverse momentum (less than 300 MeV/c). Four CERN experiments (NA34, NA35, EMU05 and NA44) and three at Brookhaven (E810, E802/859/866 and E814) have studied single hadron distributions under these conditions. Jehanne Simon-Gillo concluded that the Brookhaven results are well described by models incorporating resonances. However the CERN results are not fully understood, leaving room for further speculations. Johanna Stachel reported a mysterious and significant low transverse momentum kaon enhancement in E814.

The role of interferometry using identical particles was emphasized by Scott Pratt. Without knowing the volume and lifetime of the produced



In heavy ion collisions at Brookhaven (E802/866) the positive kaon/pion ratio increases with increasing projectile mass.

matter there can be no reliable determination of the equation of state or the dynamics of the collision.

Many heavy ion experiments (NA35, NA44, WA80, E802/E859 and E814) presented data on two-particle interferometry. Tom Humanic (NA44) reported on multi-dimensional analysis of identified hadrons. As in many other experiments, NA44 finds a significant difference in the observed radii depending on whether pions or kaons are measured.

The radii for equivalent systems measured at Brookhaven (E802) are significantly smaller than the CERN results, showing that with increasing energy density the interacting systems expand. There is a significant radius/transverse momentum dependence of the pairs observed. A similar effect is also seen by NA35 at CERN.

Dieter Röhrich (NA35) mentioned that in head-on nucleus-nucleus collisions a large net baryon density is piled up in the central region. Shiva Kumar (E858/E878) reported that the antiproton yields scale as the number of interacting projectile nucleons.

QGP cooling may result in droplets of strange matter, or 'strangelets'. The possibility of producing metastable (stable against strong decays) strange plasma droplets was reviewed by Carsten Greiner. This is speculative, but metastable hypernuclei with several hyperons, called 'memos', seem quite likely from standard nuclear model calculations. E810, E858/E878 and NA52 gave upper limits for strangelet production.

NA35, NA36, WA85, E810, E859 and E866 reported on strange particle production. David Evans from WA85 presented data on strange and multistrange antibaryons, difficult to produce hadronically. Some antihyperon yields are more than three times those seen in proton-proton interactions. Omega minus (particle and antiparticle) candidates have been reported by WA85 for the first time.

In gold-gold collisions the measurement of strange particles is important and the positive kaon/pion ratio increases with increasing projectile mass. Ulrich Heinz reported on a strangeness analysis based on thermal (kinetic) equilibrium. The total number of strange particles could be unexpectedly high.

Carlos Lourenço from NA38 presented new results on lepton pair production below the J/psi resonance. In proton-proton and proton-nucleus collisions this can be understood in terms of known sources like Drell-Yan pairs and semileptonic decays of charm.

In sulphur-uranium collisions there is a clear and unexplained excess of pairs, significant since it is difficult to produce such heavy pairs in secondary hadronic collisions. The psi prime/J-psi ratio is found to be about 2% independent of the target mass in proton-nucleus collisions. This ratio decreases when going from proton-tungsten to sulphur-uranium reactions. The first phi mesons in heavy ion collisions at Brookhaven were reported by George Stephans (E859).

Photons are considered to be a sensitive probe of QGP formation. Rainer Santo from WA80 showed an excess of photons in central sulphur-gold collisions. The CERES (NA45) collaboration observes no such excess. WA80 also presented the first spectra of eta mesons. The neutral pion and eta transverse mass spectra are remarkably similar, supporting the phenomenological concept of transverse mass scaling.

In his review, Joe Kapusta discussed the importance of the early dense stage of the collision for electromagnetic emission from parton interactions and pointed out the possibility of using measurements of lepton pairs in the J/psi to upsilon mass range to study partons approaching thermal equilibrium by redistributing their momenta in secondary collisions. This, as well as the use of the photons as probes of secondary parton collisions, will

crucially depend on the detailed understanding of different backgrounds.

The character of the QGP phase transitions is still not completely clear. Frank Wilczek argued that with two massless quarks QCD has resemblances to the four-component Heisenberg antiferromagnet with its rather well known properties. This means that critical properties close to the critical temperature can be calculated precisely in QCD.

While a comprehensive review of lattice calculations was not included in the programme, some of the confusion on the behaviour and nature of excitations close to the critical temperature was clarified. According to the results presented by Graham Boyd, correlations in mesonic channels are observed also above the critical temperature, but the bound states disappear.

In his experimental summary Emanuele Quercigh said a 'heavy ion age' had begun in Spring 1992 with gold beams at Brookhaven and will continue with lead beams at the CERN SPS, while further ahead lie the comprehensive collider programmes, with the major STAR and PHENIX experiments at Brookhaven's RHIC, and ALICE at CERN's future LHC. Seeing the quark gluon plasma still needs hard work but there are good reasons for optimism.

At Quark Matter '93 a booklet 'High Energy Heavy Ion Experiments' was distributed, providing details of current high energy heavy ion experiments. It can be ordered from Evert Stenlund, Lund, (e-mail: evert.stenlund@kosufy.lu.se, fax +46 46104015).

The 11th Conference on Ultra-Relativistic Nucleus-Nucleus Collisions (Quark Matter '95) will be held in Monterey, California, in January 1995 with Art Poskanzer, LBL, as chairman. Germany was selected to host the 12th conference in this series.

From Ingvar Otterlund and Vesa Ruuskanen

CERN Courier contributions

The Editor welcomes contributions. As far as possible, text should be sent via electronic mail.

The address is courier@cernvm.cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

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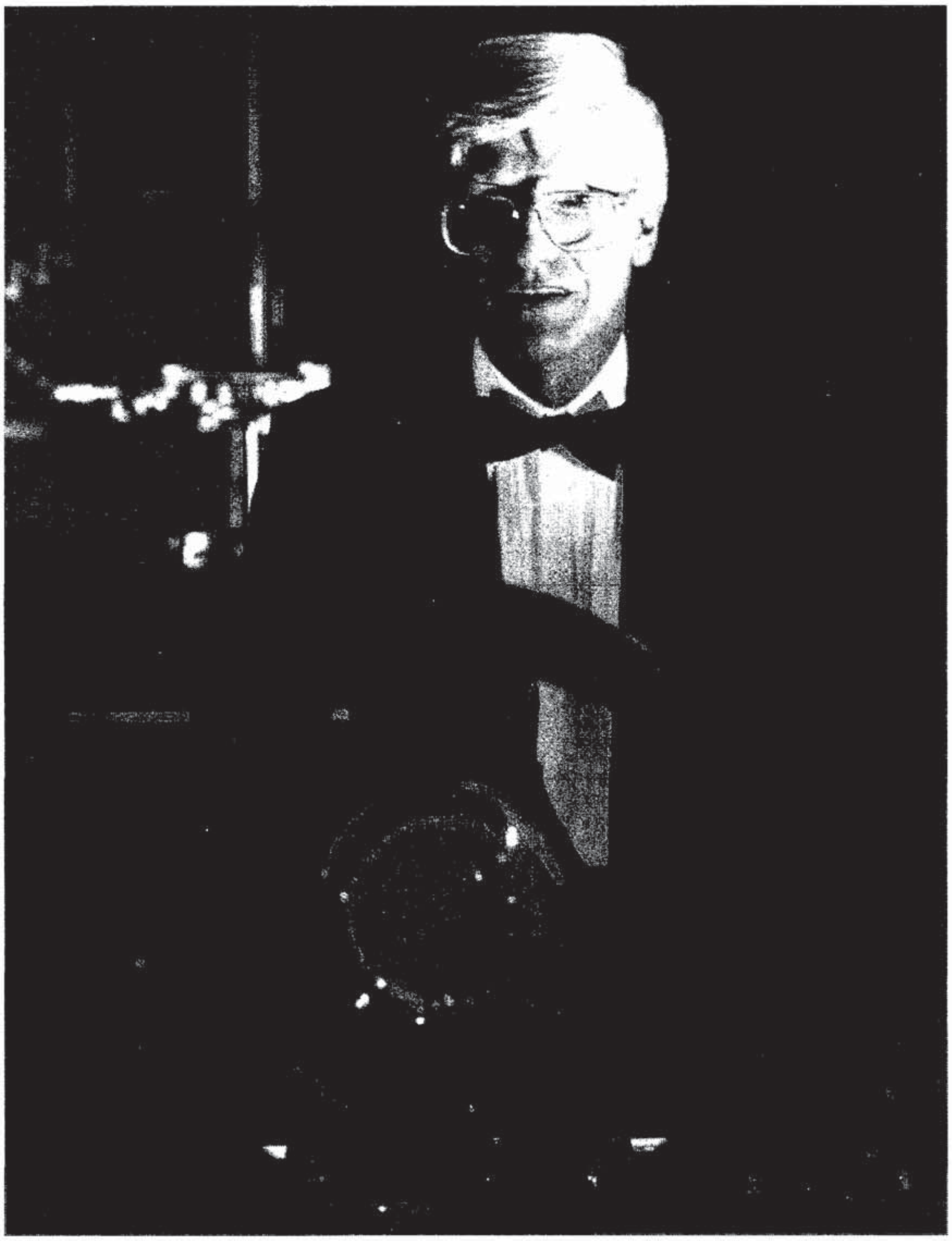
Stanford Linear Accelerator Center, (USA)
M. Riordan

Superconducting Super Collider, (USA)
N. V. Baggett

TRIUMF Laboratory, (Canada)
M. K. Craddock

People and things



CERN Director General Designate Christopher Llewellyn Smith 'discourses' at the Royal Institution, London.

DESY people

DESY Director Bjorn Wiik becomes a Foreign Honorary Member of the American Academy of Arts and Sciences. Meanwhile Julius Wess of MPI Munich becomes Chairman of DESY's Scientific Council.

CERN heavy ion preinjector in operation

The first part of the new injector linac (Linac3) of CERN's heavy ion facility is being commissioned and is well on the way to meeting its specifications. The electron cyclotron resonance ion source, built by the French heavy ion laboratory GANIL, and the Low Energy Beam Transport (LEBT), supplied by INFN, Legnaro, were initially tested with oxygen, argon, krypton and xenon ions.

At the end of August, soon after the heated lead sample (isotopically pure lead 208) was inserted into the source, the first beam of highly charged lead ions was produced at 20 kV (2.5 keV per nucleon).

Using the LEBT to analyse the charge states, a current of 65 microamps of lead 27+ (lead atoms stripped of 27 of their electrons) was obtained and this was later increased to 75 microamps.

The current, limited by ion recombination in the residual gas of the LEBT, should increase after the vacuum is improved.

Faraday's footsteps

Following in the footsteps of Michael Faraday, on 15 October CERN Director General Designate Christopher Llewellyn Smith gave one of the celebrated Friday evening discourses at the Royal Institution, London. These events were largely Faraday's creation, aimed at bringing scientific discoveries to a wider audience.

In his talk "Particle Physics Today - Quarks, Ws and Higgs bosons", Llewellyn Smith took his audience on a tour of particle physics, beginning with some of the basic principles of how we study particles and leading on to the present Standard Model, the questions it raises and how we might hope to answer them with the LHC proton collider to be built in CERN's 27-kilometre LEP tunnel.

The underlying theme of a unified description of particles and forces may well have appealed to Faraday, much of whose work led to the unification of electricity, magnetism and light. And no doubt he would have appreciated the demonstration of how an accelerator works, with the lecturer varying the energy and the controlling magnetic field of a glowing circular electron beam.

In an an accompanying exhibition, set up by Oxford University and the Rutherford Appleton Laboratory, an identical apparatus allowed people to try this for themselves. The exhibition also included a modern wire chamber and demonstrations of state-of-the-art silicon detectors.

Historic Tevatron

The American Society of Mechanical Engineers has designated the Cryogenic Cooling System of the Fermilab Tevatron an International Historic Mechanical Engineering Landmark.

On 8 September CERN Director General Carlo Rubbia formally opened the Microcosm exhibition centre at CERN.

Experiments at Low Energy Machines

An international workshop on Large Experiments with Low Energy Hadron Machines will be held from 12-15 April at the Paul Scherrer Institute, Villigen, Switzerland, to coincide with 20 years of PSI/SIN beams. Such experiments need suitable beams, and adequate funding and manpower. The workshop will aim to outline the available facilities, identify priority goals and coordinate collaborations, where involvement with Eastern countries offers interesting possibilities.

Contact the Conference Secretary, Mrs. Sabine Jährling, PSI-West, 5232 Villigen, Switzerland. Phone +41 56 99 32 54, fax +41 56 99 32 94, e-mail paris@cvax.psi.ch before Christmas please.

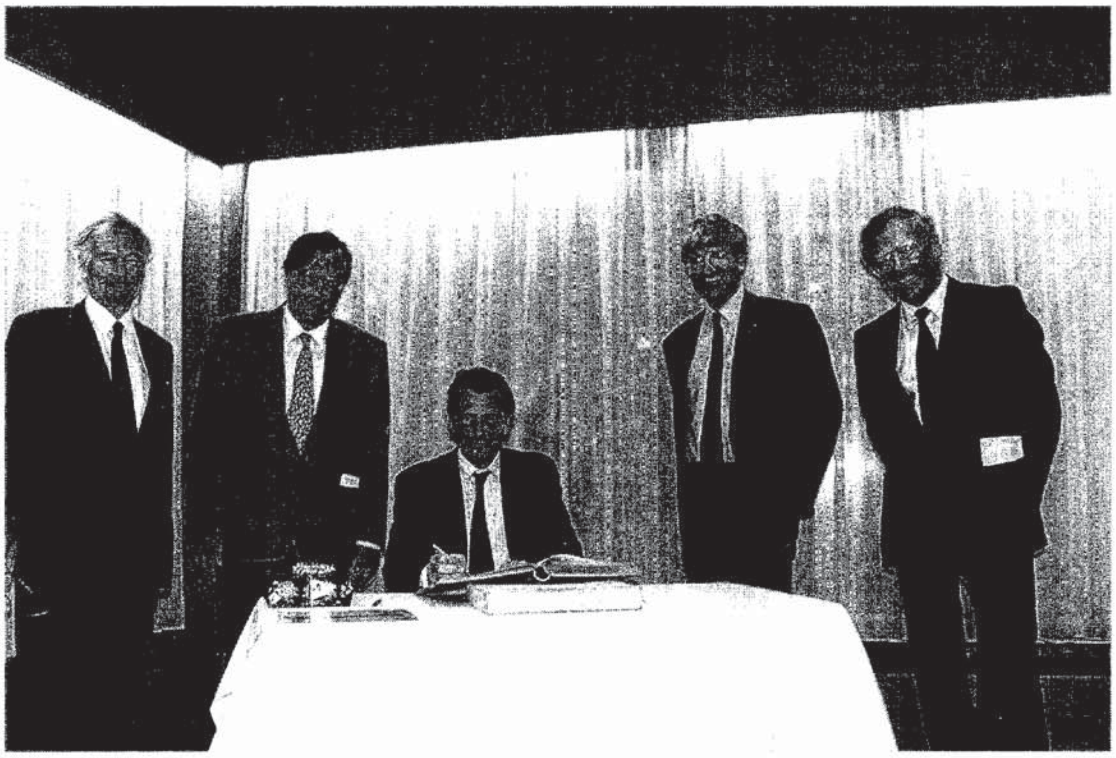
Meetings

The 5th Conference on the Intersections of Particle and Nuclear Physics will be held in St. Petersburg, Florida, from 31 May - 6 June 1994. Further information: Elly Driessen, Conference Secretary, TRIUMF, 4004 Wesbrook Mall, Vancouver, BC V6T 2A3 Canada. Fax +1 604 222 1074, bitnet driessen@triumfcl

An International Workshop on Superconductivity and Particle Detection will take place from April 20-24 1994 in Toledo, Spain. Contact Ms. M. Fatas, Instituto de Fisica Nuclear y Altas Energias, Universidad de Zaragoza, 50009 Zaragoza, Spain. Phone: ++ 34.76.35.83.21; Fax: ++ 34.76.56.80.60; E-mail: fatas@gae.unizar.es

The Second International Winter School "QCD: Perturbative and Non-Perturbative Topics" will be held at St.Petersburg Nuclear Physics Institute, Russia, from 20 February - 5 March. Lectures will be at the postgraduate and young postdoc level and include such topics as high

Admiring LHC technology at the opening of the Netherlands trade show at CERN on 12 October, left to right, H.L. Beckers, Chairman of the Dutch Government's Advisory Board for Research and Development; HOLEC Director H. Smit; J. Beenakku, Chairman of the Foundation for the Fundamental Research of Matter (FOM); CERN Research Director Walter Hoogland; and NIKHEF Managing Director J. Langelaar.



UK Public Service and Science Minister William Waldegrave signs CERN's VIP Visitors' Book on 13 September. With him, left to right, were CERN Council Chairman Sir William Mitchell, CERN Director General Carlo Rubbia, CERN Director General Designate Chris Llewellyn Smith and UK Public Service and Science Permanent Secretary Richard Mottram.

energy processes, heavy flavour decays, instantons, anomalies, chiral lagrangians. Lecturers include Profs. Anselm, Diakonov, Dokshitzer, Eides, Lipatov, and Uraltsev. For further information and applications contact eides@lnpi.spb.su

The 3rd Biennial conference on low-energy antiproton physics - LEAP '94 - will take place in Bled, Slovenia, from 12-17 September. Contact : Marko Mikuz, J. Stefan Institute; Jamova 39; SI-61111 Ljubljana, Slovenia, Tel : +386 (61) 12 59 199 Fax : +386 (61) 12 57 074, E-mail : marko.mikuz@ijs.si or marko@cernvm.cern.ch

Middle - On 16 September, a reunion at Birmingham marked the 40th anniversary of the university's 1 GeV proton synchrotron. First proposed by Oliphant as a 1.3 GeV machine in 1943, post-war frugality meant the machine only began operation in 1953, with space limitations dictating a 1 GeV energy limit. For five years (until the commissioning of the Saclay machine) it was the only European machine in the GeV range, making valuable contributions. Speakers at the event included (left to right) Bob van der Raay, George Morrison, Owen Lock, John Kinson, Bill Burcham, John Walker and John Lawson.

Below - Kampai! At the General Assembly of the International Union of Pure and Applied Physics (IUPAP), Nara, Japan, in September, left to right, past president Yuri Ossipian, 1993-96 President Yoshio Yamaguchi and president designate Ian Nilsson.

UNIVERSITY OF CALIFORNIA, RIVERSIDE

Postdoctoral Position in Theoretical High Energy Physics

The physics department at the University of California, Riverside, invites applications for a

Postdoctoral Researcher position in the field of Theoretical High Energy Physics

to begin in September, 1994. Please submit a resume and three letters of recommendation to Professor Jöse Wudka, Physics Department, University of California, Riverside, CA 92521-0413, USA.

The University of California is an Equal Opportunity, Affirmative Action Employer.

POSTDOCTORAL POSITIONS
UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF APPLIED MATHEMATICS AND THEORETICAL PHYSICS

RESEARCH ASSISTANTSHIP IN THEORETICAL ELEMENTARY PARTICLE PHYSICS

A 2-year post from 1 October 1994 in the Department of Applied Mathematics and Theoretical Physics, Cambridge. The post is associated with the High Energy Physics group which has diverse interests that include the following topics.

Phenomenology of elementary particles; cosmological models, lattice QCD and other properties of quantum field theory, string theory and its connections with conformal field theory; two-dimensional statistical mechanics and quantum groups.

Applications and supporting letters from at least two referees, should arrive not later than 13 December 1993 and be sent to

Ms. D. Stretch
Department of Applied Mathematics and Theoretical Physics
University of Cambridge,
Silver Street, Cambridge CB3 9EW
(email : danielle@damtp.cambridge.ac.uk
fax : + 44 223-337918)

UNIVERSITY OF BRISTOL

Department of Physics

EC Human Capital and Mobility Fellowship (Fixed Term)

The University of Bristol particle physics group wishes to appoint as soon as possible to a fixed term (23 months) Fellowship which is part of the EC Human Capital and Mobility programme. Eligibility is limited to citizens of EC and associated countries excluding the U.K. Applicants must not have been practising physicists in the U.K. for at least 2 years prior to the date at which the fellowship is taken up. The Bristol particle physics group consists of 8 permanent academic staff and postdoctoral, support and technical staff. The group is currently involved in the ZEUS experiment at the electron-proton collider HERA, hyperon beam experiments at Fermilab and CERN, preparation for the proposal for the CMS experiment at LHC and work on novel particle detection techniques.

The successful candidate will be expected to play a leading role in the work of the group both in the ZEUS experiment and in preparation for the CMS experiment. The division of time spent between these two activities will be a matter for discussion with the successful candidate. The position will be based in Bristol, but will involve extended visits to DESY and/or CERN.

The salary will be 3,801 ECU per month. Applicants should send a full curriculum vitae and the names and addresses of three referees to Dr B. Foster, H.H. Wills Physics Laboratory, Tyndal Avenue, Bristol, BS8 1TL, from whom further details can be obtained (email: 19711::bf (Decnet) or bf@siva.bris.ac.uk (Internet)). Applications should reach Bristol by 1st February 1994.

NSCL MSU

JOHN A. HANNAH DISTINGUISHED PROFESSORSHIP MICHIGAN STATE UNIVERSITY

The National Superconducting Cyclotron Laboratory and the Departments of Physics & Astronomy and of Chemistry invite applications for the award of this special chair. Among its privileges the chair carries a generous annual research award and the option, but not the requirement, to teach. We are looking for a person who can provide intellectual leadership in experimental or theoretical nuclear science and/or accelerator physics. The applicant should have a demonstrated ability to conduct innovative research and to lead others, including graduate students, in that research. Send vita to **Aaron Galonsky, Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824-1321, USA.**

CERN New Cooperation Agreement with Russian Federation

At the biannual meeting of the CERN-Russia Committee, under the co-chairmanship of Minister Boris Saltykov and CERN Director General Carlo Rubbia, a new Scientific and Technological Cooperation Agreement was formally signed on 30 October at the Institute for High Energy Physics (IHEP), Protvino, near Moscow. The three years of this agreement constitutes a reasonable transition period in further developing the long-standing relations between CERN and the Russian Federation with the ultimate goal of the Russian Federation becoming a full Member State of CERN.

At IHEP, the construction site of the UNK-600 machine, the two signatories expressed their satisfaction on excellent collaboration and called for increased participation in experiments both at CERN and in Russia.

Maintaining a vigorous experimental programme both at home and on CERN's machines requires a major commitment in the context of Russian resources for pure and applied scientific research, but Minister Saltykov expressed his firm intention to maintain the present level in both human and material resources for what he called the most fundamental of basic research: an endeavour of a highly cultural character, in which an active Russian presence is essential.

Strong scientific and technological collaboration between CERN and the former Soviet Union goes back almost thirty years, with a considerable part of these activities being carried out in the Russian Federation. Russian research institutes and physicists play an important role in many experiments at CERN, exemplifying the Geneva Laboratory's role as a truly international research centre.

Russian participation in CERN research involves a heavy investment of intellectual, and in many cases technological and industrial efforts, and CERN has benefited from this expertise.

Russian research institutes, with assistance from highly competent sectors of Russian industry, have the firm intention to make a major contribution to the construction and utilisation of the Large Hadron Collider (LHC), CERN's new superconducting accelerator project.

SSC Director

Fermilab Director John Peoples takes over from Roy Schwitters following the latter's request to be relieved of responsibilities as Director of the condemned SSC Laboratory (see page 1). Peoples remains Fermilab supremo, but expects to spend several days each week in Dallas to supervise the SSC wind-down. Both the SSC and Fermilab are managed by The Universities Research Association (URA) as contractor to the US Department of Energy.

Hans Hofer (centre) of ETH Zurich and a leading light of the L3 experiment at CERN's LEP electron-positron collider has recently received double honours from China, with a Doctor Honoris Causa from Shanghai University of Science and Technology, and an Honorary Professorship from the Chinese University of Science and Technology, Hefei. Hofer is seen here between (left) Shanghai University of Science and Technology Honorary President D.S. Dan and President Guo Ben-yu.

(Photo S. Ting)