CERN COURIER

International Journal of High Energy Physics

VOLUME 30 JANUARY/FEBRUARY 1990

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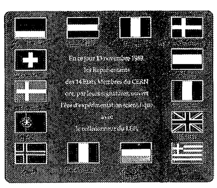

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Deed of inauguration for CERN's LEP electron positron collider, signed by representatives of CERN's 14 Member States. Clockwise from top left: Minister for Research and Technology Heinz Riesenhuber for the Federal Republic of Germany, Minister for Science and Research Erhard Busek for Austria, Secretary of State for Scientific Policy Pierre Chevalier for Belgium, Minister for Education and Research Bertel Haarder for Denmark, Minister for Education and Science Javier Solana Madariaga for Spain, President François Mitterrand for France, Secretary of State for Education and Science John MacGregor for the United Kingdom, Ambassador Euripide Kerkinos for Greece, Princess Margriet for the Netherlands, Council of Ministers Vice-President Claudio Martelli for Italy, Crown Prince Harald for Norway, Secretary of State for Research and Technology Sucena Paiva for Portugal, King Carl XVI Gustaf for Sweden, President Jean-Pascal Delamuraz for Switzerland.

Laboratory correspondents:
Argonne National Laboratory, USA
M. Derrick
Brookhaven National Laboratory, USA
A. Stevens
CEBAF Laboratory, USA
S. Corneliussen
Cornell University, USA
D. G. Cassel
DESY Laboratory, Fed. Rep. of Germany
P. Waloschek
Fermi National Accelerator Laboratory, USA
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China
Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China

Federal Republic of Germany
Gabriela Martens
DESY, Notkestr. 85, 2000 Hamburg 52

Italy
Mrs. Pieri or Mrs. Montanari
INFN, Casella Postale 56
00044 Frascati, Roma

United Kingdom
Su Rooke
Rutherford Appleton Laboratory,
Chilton, Didcot, Oxfordshire OX11 0QX

USA/Canada
Margaret Pearson (B90904 at FNALVM)
Fermilab, P.O. Box 500, Batavia
Illinois 60510

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En ce jour 13 novembre 1989,
les Représentants
des 14 Etats Membres du CERN
ont, par leurs signatures, ouvert
l'ère d'expérimentation scientifique
avec
le collisionneur du LEP.

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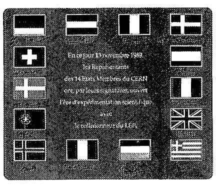

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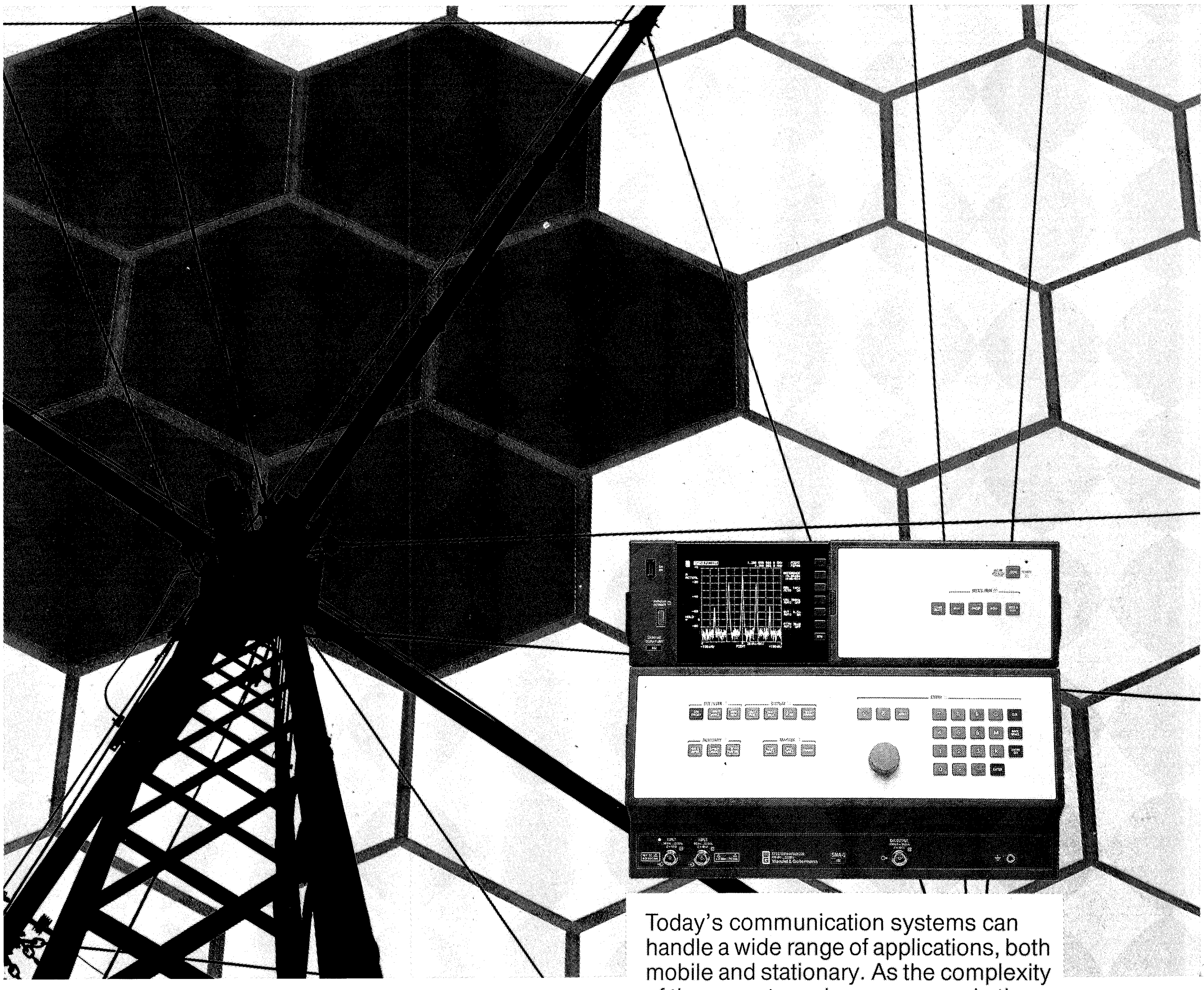
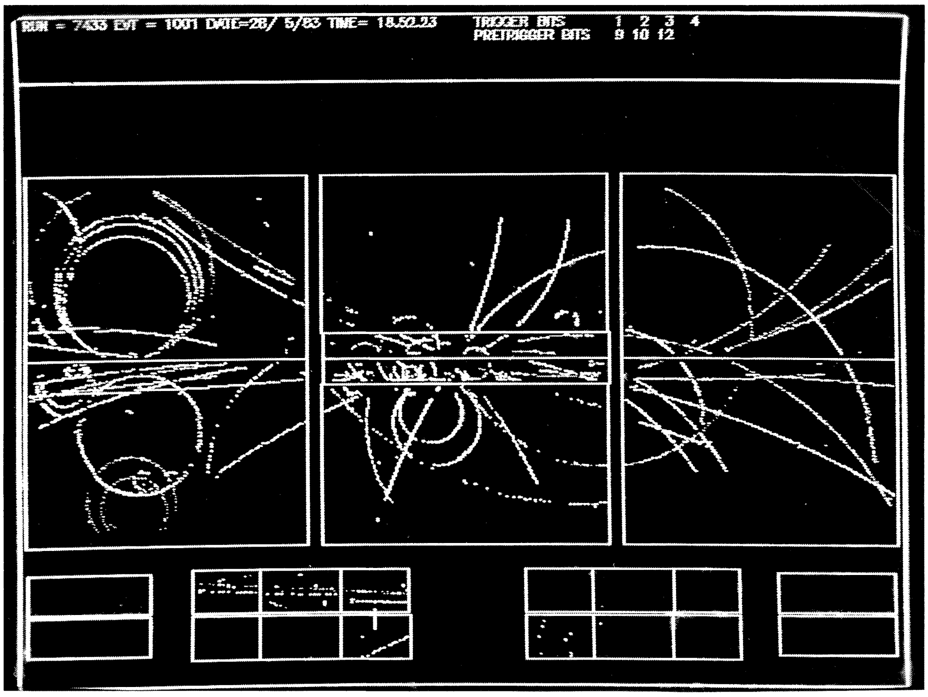


The 1980s – diary of a dramatic decade

In May 1983 the UA1 experiment saw a Z particle – the electrically neutral carrier of the weak nuclear force – for the first time. In 1989, CERN's LEP electron-positron collider was supplying about a thousand Zs per day to each of its four experiments. Such was the pace of the physics of the 80s.



The 1980s saw, centre stage, ambitious proton-antiproton collider schemes; a first act at CERN exceeding expectations, and a second act at Fermilab with a promising newcomer – superconducting magnets – in the leading role; the action punctuated by new electron-positron colliders and largely delieated by the discussion, approval, construction and commissioning of the biggest of them all, the LEP ring at CERN: all this against a backdrop motivated by a growing awareness that new accelerator schemes were, and still are, urgently needed to keep particle physics thriving: in the wings, positive action towards more collaboration with industry; development of superconducting magnets and radiofrequency acceleration cavities; the demise of bubble chambers and the advent of promising new detection techniques and materials – semiconductors, optical fibres,.....; the virtual disappearance of the traditional Cockcroft-Walton injector in favour of the radiofrequency quadrupole: while the planning and subsequent go-ahead for the 87-kilometre US Superconducting Supercollider (SSC) set a scene for the coming decade.

During the decade accelerators and colliders came and went, new Laboratory Directors were appointed and even new Laboratories established, Nobel Prizes were awarded, and new personalities appeared while others sadly vanished. In this rich tapestry of thriving science two major themes dominated. For the physics itself, the 'Standard Model' reigned supreme, while on the international scene, the spotlight shifted.

The Standard Model – the electroweak synthesis of electromagnetism and the weak nuclear force linked with the quantum chromodynamics field theory of inter-quark forces – had come into use towards the end of the 70s as a handy way of packaging modern particle physics. During the 80s, the Model was periodically challenged, but no renegade phenomena stood the test of time. So well is the Standard Model packaged that physicists are now eager to unravel it to find out what makes it tick.

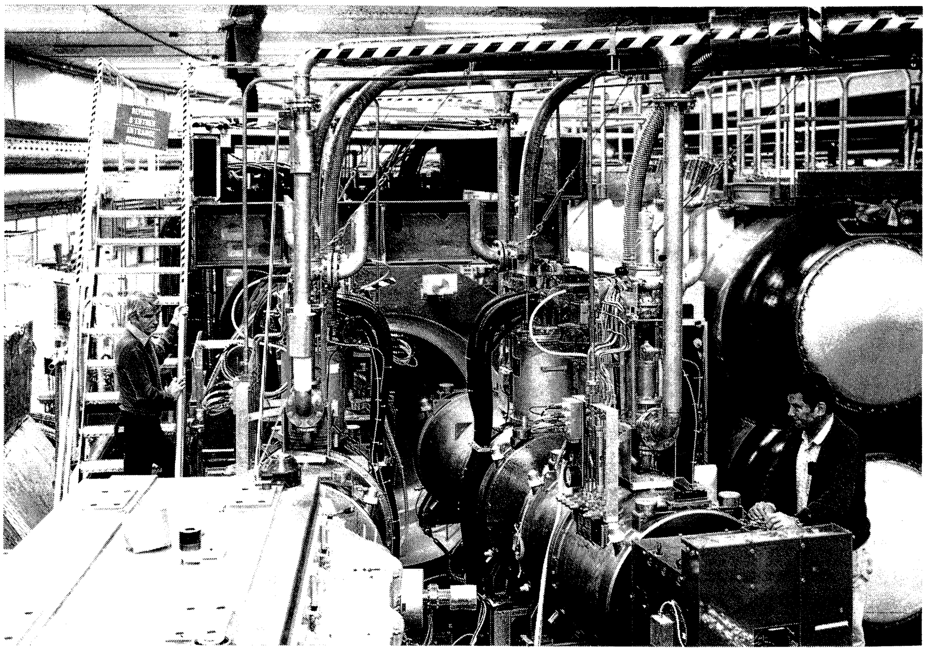
Back in 1980, the US was the mecca of high energy physics. But at CERN, the vision of Carlo Rubbia, the invention of new beam 'cooling' techniques by Simon van der Meer, and bold decisions under the joint Director-Generalship of John Adams and Leon Van Hove had led to preparations for a totally new research assault – a high energy proton-antiproton collider. In 1983 this far-sighted plan uncovered the long-awaited W and Z bosons – the carriers of the weak nuclear force. This epic discovery underpinned the foundations of the Standard Model, earned the Nobel Prize for Rubbia and van der Meer in the following year, and, for the first time since the Second World War, nudged the centroid of particle physics towards Europe. Meanwhile LEP, and the HERA electron-proton collider at the German DESY Laboratory in Hamburg, were built to help keep it that way.

The US subsequently wrested back the high energy proton-antiproton pole position with Fermilab's Tevatron, the world's first large scale superconducting particle accelerator. The Superconducting Supercollider (SSC) project was launched to 'regain lost US supremacy', but, with Europe casting off the final shackles of its war-torn past, a trend had been established. With major projects in the pipeline in the US, Europe, the USSR and Japan, the future of particle physics has become truly international.

A brief diary of the decade from scanning a hundred issues of the CERN Courier:

1980 – Experiments preparing for CERN's Antiproton Project, Antiproton Accumulator tested. Plans for similar scheme tabled at Fermilab. Initial presentations of HERA at DESY and of LEP at CERN. PEP and VEPP-4 electron-positron colliders at Stanford and Novosibirsk respectively in operation. Radiofrequency quadrupole successfully tested at Los Alamos. CERN's Intersecting Storage Rings (ISR) give 62 GeV alpha-particle collisions. Jets not seen in fixed target, hadron beam experiments at CERN's SPS. ISR use a superconducting quadrupole to squeeze colliding beams. First workshops on experiments for LEP. Brookhaven's ISABELLE scheme for colliding 400 GeV proton beams pushes ahead.

1981 – Evidence for B mesons at Cornell's CESR ring. Herwig Schopper takes over as CERN's Director General from John Adams and Leon Van Hove. Volker Soergel takes over from Schopper as Director of DESY. Ten years of the ISR at CERN. TRISTAN electron-positron collider at Japanese KEK Laboratory approved for construction. PETRA electron-positron collider at DESY achieves collision luminosity of 10^{31} per sq cm per s. First proton-antiproton collisions in CERN's ISR (April). Stanford Linear Accelerator Center (SLAC) workshop for a new 'linear' collider (SLC) for electron-positron collisions using two-mile linac. First proton-antiproton collisions in CERN's SPS (July). LEP experiments workshop in Villars, Switzerland. Candidate proton decays reported in India. 50th anniversary of the Lawrence Berkeley Laboratory. Death of Hideki Yukawa. Initial results from CERN's SPS proton-antiproton collider. December Council session approves construction of LEP.

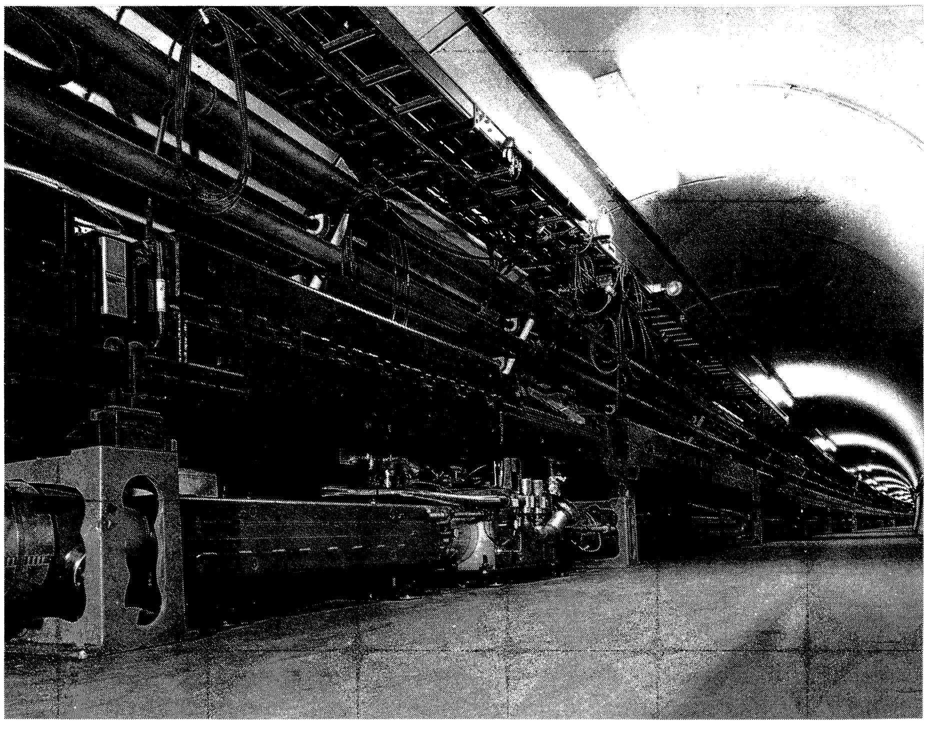


▲ In 1980 CERN's Intersecting Storage Rings showed how a superconducting magnet (right) could squeeze beams to boost collision rates. The ISR were phased out in 1984.

(Photo CERN 397.10.80)

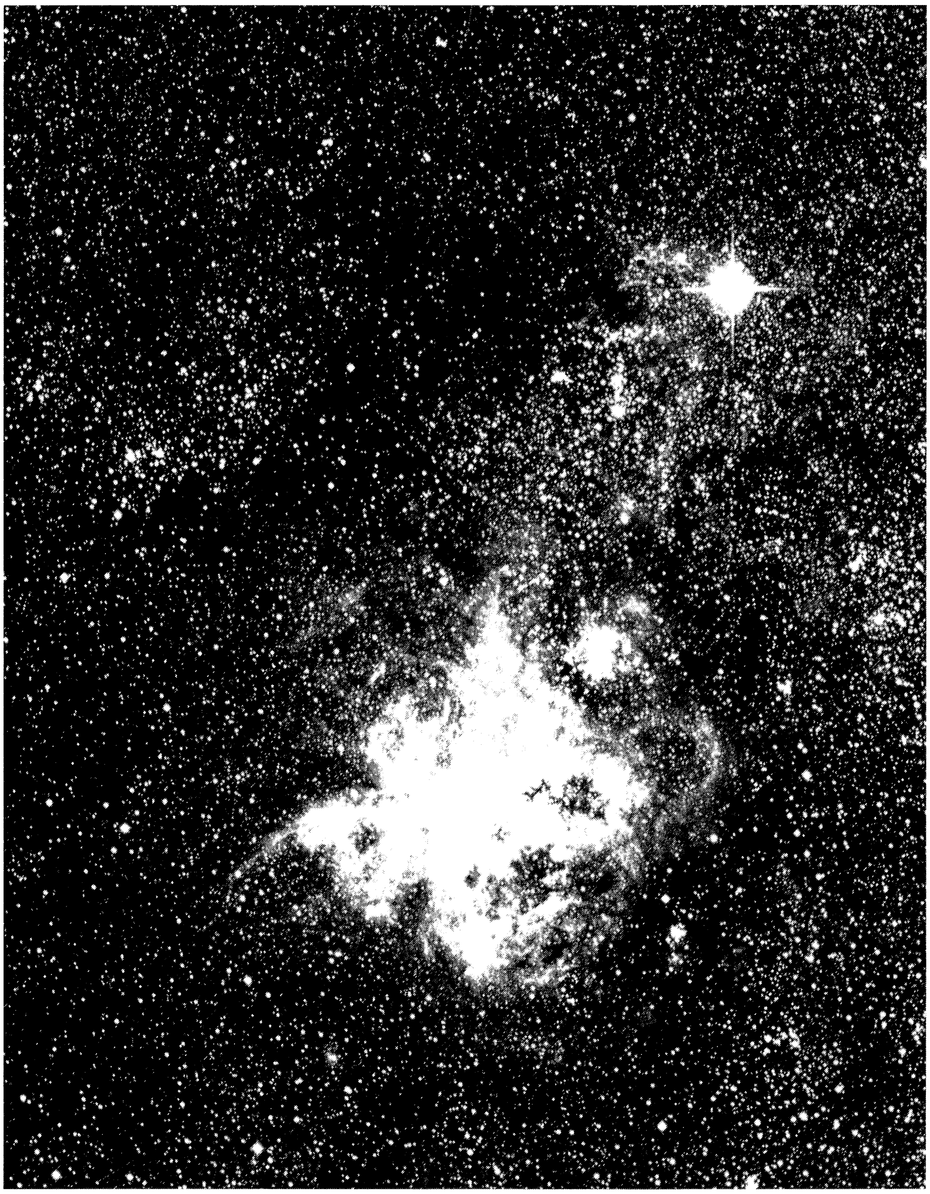
▼ Fermilab's Tevatron (lower ring) – the world's first high energy accelerator based on superconducting magnets – came into operation in 1983.

(Photo Fermilab)



24 February 1987 – a supernova explosion was just what was needed to cement the increasing links between particle physics and cosmology.

(Photo European Southern Observatory)



1982 – Nick Samios takes over from George Vineyard as Director of Brookhaven. Groundbreaking for TRISTAN. Report of magnetic monopole at Stanford. Pope visits CERN. Clean jet signals from experiments at the ISR and the proton-antiproton collider. Letters of intent for LEP experiments. European Muon Collaboration at CERN sees that quark content depends on nuclear environment – the 'EMC Effect'. Four experiments Aleph, Delphi, L3, and Opal selected for LEP. CERN proton-antiproton luminosity attains 5 x 10^{28}. Ken Wilson of Cornell receives Nobel Prize.

1983 – W boson found at CERN (January). Stanford experiment confirms EMC Effect using archive data. Initial go-ahead for HERA. ISABELLE renamed Colliding Beam Accelerator (CBA). Z boson found at CERN (May). Superconducting magnet installation complete for Fermilab's Tevatron. CERN proton-antiproton luminosity attains 1.6 x 10^{29}. Cosmologists and particle theorists get together. ITEP (Moscow) reports definite mass for electron neutrino. Fermilab Tevatron attains 500 GeV. Proton decay search turns pessimistic as problems of neutrino background loom large. Plans for experiments at HERA. Dalai Lama visits CERN. Spain rejoins CERN.

1984 – PETRA attains 45 GeV collision energy. John Adams dies (March). Final ISR run. Fermilab Tevatron attains 800 GeV, experiments underway. HERA funding approved. First workshop for proposed LHC proton collider using CERN's LEP tunnel. Construction of LEP experiments underway. Spin effects at Brookhaven. Half a century of weak interactions. Thirty years of CERN. Nobel Prize for Carlo Rubbia and Simon van der Meer at CERN. Wolfgang Panofsky retires as Director of Stanford Linear Accelerator Center (SLAC), succeeded by Burton Richter. First magnet work for proposed US Superconducting Supercollider (SSC). CBA at Brookhaven in 'cold storage'. Paul Dirac dies (October).

1985 – Discussions on HERA experiments. Groundbreaking for Beijing electron-positron collider. CERN proton-antiproton luminosity reaches 3.6 x 10^{29}, beam energy increased from 270 to 315 GeV, reaching 450 GeV in special runs. First LEP tunnelling machine begins work. 25 years of Brookhaven. Carlo Rubbia heads new working group on long-range future of CERN. Portugal joins CERN. Particle signals from Cygnus-X3. Initial antiprotons at Fermilab. TRISTAN and

SLC nearing completion. Kendrew Report in UK on CERN activities. SSC magnet design selected. Fermilab 1.6 TeV proton-antiproton collisions. CERN prepares for high energy heavy ion beams.

1986 – Ten kilometres of LEP tunnel complete. CEBAF project proposed in the US, KAON project in Canada. CERN Review Group set up under Anatole Abragam. Brookhaven goes for RHIC heavy ion scheme. New neutrino mass limits question ITEP result. SSC design goes to US Department of Energy. Zeus and H1 emerge as experiments for HERA. LEP injector supplies first beam. CERN's PS handles electrons and oxygen ions. SLC almost ready. First TRISTAN collisions at 50 GeV. PETRA machine closes. Questions on a 'fifth force'. LEP tunnelling hits water under the Jura mountains.

1987 – President Reagan approves SSC. Supernova (24 February). High temperature superconductor interest. First W at Fermilab. First SLC beams. Death of Louis de Broglie. CESR attains luminosity of 5 x 10^{31}. Jacques Chirac and Pierre Aubert install first magnet in LEP ring. TRISTAN inauguration. First magnets for HERA electron ring. Proposals for B factories. LHC magnet design. HERA tunnelling complete. Twenty years of SLAC. Forty years of pions. Sulphur ions accelerated at CERN to 200 GeV/nucleon. 43 site proposals for SSC. LEP embarks on crash installation programme. Forty years of Brookhaven. New neutral kaon results from CERN SPS. LAA project launched. Abragam report published.

1988 – New impetus to Soviet physics – UNK priority, VLEPP for Serpukhov. LEP excavation complete. Circulating beam in Beijing electron ring. Seven SSC sites selected. Richard Feynman dies. First SLC collisions. New results from EMC on quark spin. Beam injected into first LEP segment. Cooling rings commissioned at Indiana and Heidelberg. Viktor Weisskopf, Edoardo Amaldi 80. Nobel Prize for Leon Lederman, Jack Steinberger, Mel Schwartz. Texas selected for SSC site. CERN and Fermilab proton-antiproton luminosities exceed 10^{30}.

1989 – Carlo Rubbia takes over from Herwig Schopper as CERN Director General. Cold fusion interest. First Zs at SLC. Death of Emilio Segré. John Peoples takes over from Leon Lederman as Director of Fermilab. End of one-year Fermilab antiproton run brings harvest of Ws and Zs. First beam in LEP. Z mass and neutrino counting results from SLC. HERA electrons attain 27.5 GeV. Funding for SSC. Z mass and neutrino counting results from LEP. SLAC hit by earthquake. Nobel Prize for Norman Ramsey, Hans Dehmelt and Wolfgang Paul. LEP inauguration. Death of Edoardo Amaldi, Andrei Sakharov.

CERN's LEP electron-positron collider – delineating the 1980s.

(Photo CERN 138.1.89)

LEP inauguration

French President François Mitterrand on arrival at the LEP Inauguration Ceremony, after being greeted by CERN Director General Carlo Rubbia (left) and Council President Josef Rembser.

As briefly mentioned in the previous issue (page 1), 13 November saw the culmination at CERN of weeks of intricate planning to put together a fitting formal inauguration of LEP, CERN's 27-kilometre electron-positron collider. The day was to witness an event worthy of the many years of assiduous endeavour to bring into being the world's largest scientific machine, a prime example of international collaboration and the portent of a new era in fundamental research.

From early that morning, CERN had seen many unaccustomed visitors – bomb squads, riot police, marksmen..., the full panoply of security that attends top level delegations. For among the 1500 guests at the inauguration ceremony were Heads of State and Government and Ministers from CERN's fourteen Member States, together with representatives from the growing community of countries further afield involved in CERN's research programme.

Scene of the ceremony was the soccer-pitch size SM18 hall, built as an assembly shop for major LEP components, including its thousands of magnets, prior to their descent into the tunnel for final installation. For 13 November, SM18 had been decked out in full finery, hinting at the spectacle to come.

A fleet of buses ferried the guests, their CERN hosts and more than 200 press and media representatives from their assembly points to SM 18, where while waiting for the ceremony to begin they could follow the arrival of the VIP contingents outside via widescreen TV coverage, beamed also live across Switzerland and exported via Eurovision.

After being greeted by CERN Director General Carlo Rubbia and Council President Josef Rembser and introduced to prominent CERN personalities, the guests of honour admired a specially-mounted LEP exhibition, where much of the expertise and technology now hidden in the tunnel fifty metres below could be displayed and explained.

Shortly after eleven o'clock, the final convoy drew up. Two cars and eleven motorcycle outriders preceding a heavy black Citroen carrying the French tricolor, with ten lesser vehicles and an ambulance in its wake, announced the arrival of the large national delegation led by President François Mitterrand.

With the Member State principal representatives – Austrian Minister of Science and Research Erhard Busek, Belgian Secretary of State for Scientific Policy Pierre Chevalier, Danish Minister of Education and Research Bertel Haarder, Federal German Minister for Research and Technology Heinz Riesenhuber, French President François Mitterrand, Greek Ambassador Euripide Kerkinos, Vice-President of the Italian Council of Ministers Claudio Martelli, Princess Margriet of the Netherlands, Crown Prince Harald of Norway, Portuguese Secretary of State for Research and Technology Sucena Paiva, Spanish Minister for Education and Science Javier Solana Madariaga, King Carl XVI Gustaf of Sweden, President of the Swiss Confederation Jean-Pascal Delamuraz, and UK Secretary of State for Education and Science John MacGregor – on the rostrum, Carlo Rubbia, speaking in French, welcomed the guests before going on to review CERN's achievements.

'Today European physicists have ..... developed the most sophisticated instruments for research and CERN has become a centre of excellence of international importance

On the inauguration podium, left to right, Princess Margriet of the Netherlands, President Jean-Pascal Delamuraz of Switzerland, King Carl XVI Gustaf of Sweden, CERN Director General Carlo Rubbia, President Mitterrand of France, Crown Prince Harald of Norway, Vice President of the Italian Council of Ministers Claudio Martelli.

which has enabled Europe to resume its proper place, worthy of its traditions, in the exchange of international scientific knowledge,' he averred.

Going on to outline the development of CERN's research aims, Rubbia stressed the 'dynamism of innovative ideas' which have complemented technical achievements. When thinking turned to colliders as the main research tool, 'two 'complementary paths were open....CERN wisely took the decision to pursue both, successively.'

One path, the SPS proton-antiproton collider, led to the discovery of the W and Z bosons in 1983. 'Once the existence of intermediate bosons had been proved, the parallel path – LEP – assumed its full significance,' he affirmed.

Turning from physics to CERN's role in the world, the Director General accented the growing popularity of CERN as a world research centre, particularly for young physicists, and introduced a short video sequence highlighting both the youth and national diversity of CERN's science.

Looking to the future, with major projects being groomed in the US, the Soviet Union and Japan, Rubbia pointed to CERN's plan to capitalize on the LEP tunnel by installing a second, complementary, ring – LHC (December 1989, page 1).

'CERN's success must now be built on and decisions taken to consolidate it in the future and to blaze a trail for future successes,' he concluded.

King Carl XVI Gustaf of Sweden, speaking in English, looked to LEP's initial scientific discoveries, with the number of quark-lepton families now limited to three. 'But I am quite sure that (physicists) will not consider the limited number of quark-lepton families as a serious constraint on the future development of elementary particle physics,' he commented.

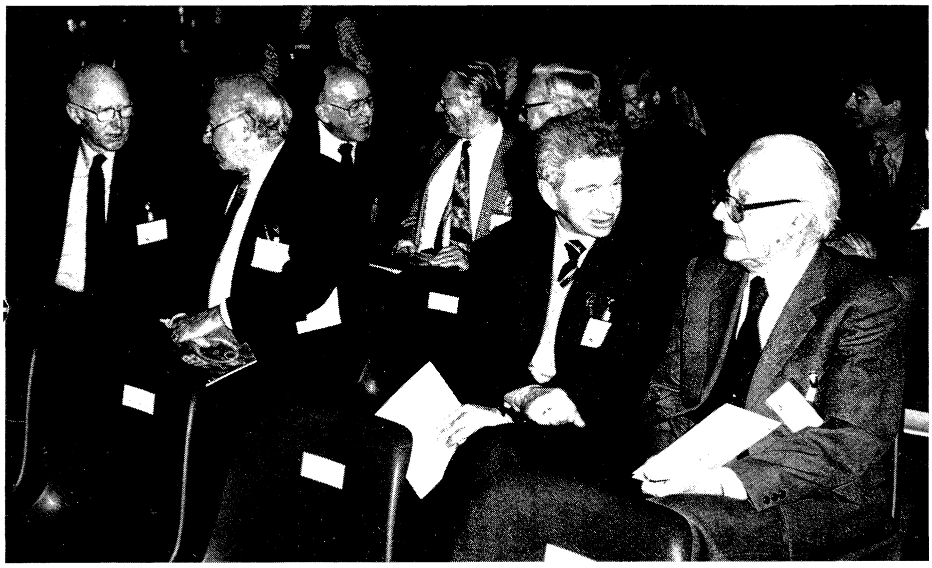
The King was also able to recall with pleasure his contact with CERN physicists through his role in presenting Nobel Prizes.

After the talent of its researchers and the power of its machines, CERN's success also lies in its role in creating a framework for European collaboration, concluded the King. 'Europe as a political idea can perhaps mean many different things, but Europe in terms of scientific endeavour is today a very real community.'

Jean-Pascal Delamuraz, President of the Swiss Confederation, emphasized the indefatigable march forward of science, catalysed by the spark of creative instinct and imagination which fires discovery. 'This teamwork, this explosion of

The buffet lunch for 1700 guests.

Among the guests: left to right- Alan Astbury representing Canada, Giorgio Salvini of Rome, Giacomo Morpurgo of Genoa, and CERN pioneer Edoardo Amaldi, visiting the Laboratory for the final time before his death on 5 December (see page 27).



so many imaginations,....' illustrates Europe's ability to play a dynamic role without losing the richness and diversity of its cultures. 'Scientists have always known how to look beyond frontiers,' he continued. As a symbol of European unity 'CERN is at the same time the oldest and the most lively...'.

The technological prowess which makes scientific projects like LEP possible, 'should be encouraged and supported by large-scale initiatives, open to participation by all nations,' he said.

French President François Mitterrand recalled the day just more than six years ago, 13 September 1983, when together with Swiss President at the time Pierre Aubert he had formally initiated LEP construction.

'Paradoxically, this collider buried a hundred metres underground constitutes a remarkable observatory of the Universe,' he declared, reflecting the growing links with between particle physics and astrophysics which have confirmed the 'brilliant intuition' that the microscopic structure of matter and the evolution of the cosmos were intimately related.

Enumerating the various problems facing humanity today, 'one asks sometimes if fundamental research in general, and CERN in particular, is not a luxury.....' the President asked rhetorically. 'There is no progress in biology without progress in chemistry and in physics, in chemistry without physics,....' he affirmed, going on to list some of the important spinoff benefits (X rays, lasers, superconductivity, transistors,....).

'Fundamental research,....complex and difficult, constitutes I believe one of humanity's most exalting adventures. It shows that when men of all races and cultures unite to fulfil their furthest ambitions, nothing is impossible,' he concluded.

Following the speeches, Emilio Picasso, Leader of the LEP Project since its approval by CERN Council in 1981 and with this onerous duty creditably discharged, offered the Director General the 'electronic key' – a diskette of computer code – to LEP.

Carlo Rubbia then invited each of the 14 Member State representatives to sign a declaration – 'This day, November 13 1989, in their presence and signatures the representatives of the 14 Member States of CERN have opened up the era of scientific experimentation with the LEP collider', the document and subsequent signatures being relayed to the giant screen above, to the discreet accompaniment of a wind ensemble under the direction of Luigi di Filippi.

The lights dimmed as the final item on the agenda was triggered. 'Electrons-Positrons', with music by French physicist and composer Jean-Claude Risset and animation by Richard Beaudemont, brought to life the ring of screens around the arena.

The public portion of the ceremony complete, the guests of honour broke into four contingents, each visiting one of the four LEP experiments, before coming together again for lunch at one of the CERN restaurants, catered by a team under the direction of French master chef Georges Blanc.

Away from the public eye and the TV cameras, but no less important for that, were the toasts and messages at the lunch. Carlo Rubbia paid tribute to his predecessor as Director General, Herwig Schopper, who from 1981 to 1988 oversaw the planning and preparations for LEP. 'Thanks to his constancy, drive and imagination,... we can be here today to celebrate the completion of a work which to the greatest extent was his own,' declared Rubbia.

Claudio Martelli, Vice-President of the Italian Council of Ministers, said that Europe must promote the necessary conditions to stay competitive in physics in the 90s, advocating a rigorous long-term study 'at the highest level of political re-

CERN Host State Presidents – François Mitterrand of France and Jean-Pascal Delamuraz of Switzerland.

sponsibility' to plan CERN's activities, and proposed a special meeting of Member State Ministers, which could take place in Italy towards the end of 1990.

Federal German Minister for Research and Technology Heinz Reisenhuber, speaking for the Member States, said 'we feel our responsibility for the future of this beautiful equipment'.

The extent of the research collaboration at LEP, extending far beyond the community of CERN Member States was underlined in the toasts by Finnish Minister of Education C. Taxell, R.A. Roe (Chairman of the US House of Representatives Committee for Space, Science and Technology), and Soviet Minister for Atomic Energy and Industry V. Konovalov.

Meanwhile other guests had migrated to the back half of the SM18 hall, there to enjoy a buffet lunch including specialities of all 14 CERN Member States, topped with a giant 380-kilo LEP cake, paraded round the hall under a travelling crane before being cut up.

The day, impeccably organized by a committee chaired by Robert Klapisch, went without a hitch. LEP had been switched off at only 6 a.m. that morning and was back in action the next day, taking the showpiece inauguration in its stride. By the end-year shutdown, the four LEP experiments had intercepted 100,000 Z particles.

Around the Laboratories

BROOKHAVEN R&D for RHIC detectors

As Brookhaven prepares for construction of the Relativistic Heavy Ion Collider (RHIC), expected to begin later this year, research and development work for the project is in high gear.

For the past three years the Laboratory has been receiving R&D funds from the US Department of Energy to prepare the way for construction. A detailed conceptual design has emerged and the superconducting magnet designs have been tested in an extensive series of prototypes (September 1987, page 23). These magnets are now being readied for industrial production once the President and Congress give the green light, hopefully for fiscal year 1991.

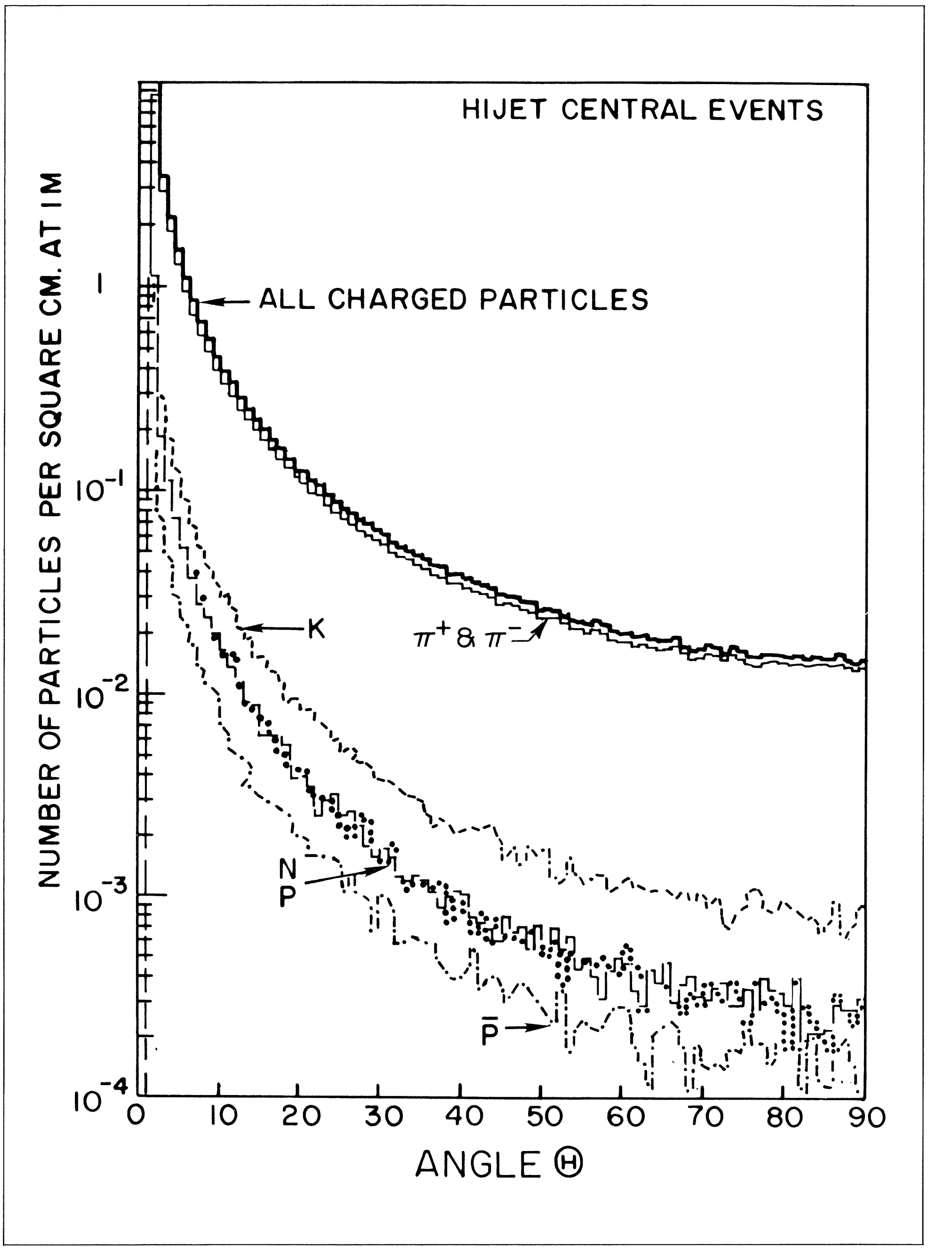
In the meantime preparations for experiments are underway, with a substantial part of the R&D effort being turned to detector development, shared widely among potential RHIC users, as some 17 groups responded to Brookhaven's call for proposals for detector R&D.

After review by a Detector Advisory Committee (P. Braun-Munzinger, Stony Brook; M. Breidenbach, SLAC; M. Gilchriese, SSCL; H. Gutbrod, GSI/CERN; R. Klanner, DESY; B. Mecking, CEBAF; and L. Schroeder, Berkeley, as Chairman) ten projects were funded, attacking the most pressing issues for detector R&D identified in RHIC workshops. These are the first steps on the long road to the first experiments at the collider – planned to begin in 1997. A call for proposals for major RHIC detectors should follow this year.

For 1989, detector development funding amounted to about a million dollars. This is expected to increase eventually to about 15 million dollars.

RHIC will collide beams of heavy nuclei at ultra-relativistic energies, subjecting nuclear material to extreme conditions where the familiar structure of neutrons and protons is expected to be fleetingly transformed into a 'plasma' of quarks and gluons.

Recording such events with sufficient sensitivity to pick up signals for new plasma phenomena will require extending known techniques for particle detection. With beam energies up to 100 GeV per nucleon and with ions containing 200 nucleons or more, the total



The challenge for detectors at the proposed RHIC heavy ion collider at Brookhaven – a simulation of the charged particle flux at one metre from collisions of gold ions carrying 100 GeV per nucleon.

energy per collision can reach up to 40 TeV, far beyond that of any present accelerator or existing detector.

Although the Superconducting Supercollider (SSC) will accelerate particles to this energy and produce hundreds of very high energy particles, the most interesting RHIC collisions are expected to produce tens of thousands of particles, with proportionately less energy carried away by each particle.

In addition to very high production levels, experiments in a heavy ion collider have to confront plasma signals from particles whose transverse momenta and thermal energies are relatively small, and similar to that of the background. This contrasts to hard scattering in particle colliders, where high transverse momentum triggers can cut out most of the background.

RHIC detectors will require new approaches to tracking, calorimetry, particle identification, fast trigger decisions and on-line data processing. In a series of workshops over the past five years, a number of ideas and concepts have emerged and subsequent development work has identified specific targets to attack.

One of the most urgent and universal needs is in the area of readout electronics. Here, RHIC poses two principal challenges. The first is the short time between bunch crossings, 114 nanoseconds compared with the several microseconds enjoyed by today's colliders. RHIC (like future particle colliders), will need to store analog signals while trigger decisions are made.

The second challenge is the very large number of channels to be read out, upwards of 10^4 per detector. Handling such a vast number of detector elements by conventional techniques, if not prohibitive in cost, would severely constrain the detector configuration due to the sheer size and mass of the cabling.

In response to these challenges, a number of groups have proposed developing compact, low-power, low-cost circuits using VLSI techniques to store signals in analog memory devices on a small chip – rather than in a long cable – and make it possible to amplify, store, and ultimately digitize data directly on the detector, with serial transfer of 'processed' signals to storage only after several levels of trigger decisions.

The basic technologies exist, and to produce circuits matched to RHIC's requirements will take the coordinated efforts of a number of research centres over 4-5 years. This is clearly a high priority item.

Experiments with ion beams both at Brookhaven and CERN have emphasized the importance of 'energy flow' measurements using fine-grain calorimetry over large solid angles, and of particle identification, distinguishing for example protons and kaons from the large numbers of pions produced. These methods are expected to have equally important roles in RHIC where, in contrast to fixed-target experiments, most of the particles of interest will have rather low momenta. This poses formidable problems which are not being attacked in the detector development work for other high energy collider schemes, such as the Italian-funded LAA effort at CERN or the SSC detector R&D in the US. The detailed response of calorimeters to large numbers of low energy particles,

The control room for Brookhaven's AGS synchrotron has been remodelled and expanded to cover all linked machines (Linac, Booster). It features five general purpose consoles based on networked Apollo workstations, plus a special safety console (centre rear). In the foreground are AGS operations head Peter Ingrassia (left), and AGS controls section head Don Barton.

and the development of time-of-flight and ring-imaging Cherenkov techniques capable of handling very high particle densities as well as rates, are examples.

Important RHIC measurements will centre on the lepton pairs radiated electromagnetically from inside a volume of dense hadronic matter. These measurements are also among the most difficult, as the relevant lepton pair masses and transverse momenta are not large enough to be easily separated from the background due to pion decays.

At RHIC workshops complementary lepton pair scenarios have been worked out – one involving electrons and the other muons. For efficient electron pair measurements in the high multiplicity environment it may be possible to apply the 'hadron-blind' detection technique using light, highly segmented ring imaging Cherenkov counters with a suitable radiator. Such a device is being developed for a heavy ion experiment at the CERN SPS, but collider application would require considerable further development. A RHIC dimuon experiment could consist of a carefully designed instrumented hadron absorber surrounding the collision point, followed by detectors to track penetrating muons.

From T. Ludlam

First results from ATF electron gun

Brookhaven's Accelerator Test Facility (ATF – April 1987, page 21) passed a major milestone last year when it produced its first beam of photoejected electrons. With the initial phase of construction completed later this year, the ATF should provide a low emittance beam of 50 MeV electrons for studies of new radiation sources and advanced accelerator concepts.

The major components of the ATF are the electron gun, low energy beam transport, linear accelerator, laser systems, and synchronization systems. The electron gun uses a laser-irradiated yttrium photocathode on one of the end walls of a radiofrequency cavity with a 2856 MHz standing wave. The configuration is designed so that the electrons are emitted when the electric field is nearly maximum so that the bunch reaches relativistic velocities as soon as possible. The design goal calls for a field of 100 MV/m on the cathode to help control space-charge blow-up of the emittance.

In its initial configuration the bunch leaving the gun passed through a quadrupole triplet to capture and focus the beam, followed by a 90-degree bending magnet, a quadrupole singlet, momentum slit, profile monitor, and Faraday cup. The initial energy of the electrons exiting the gun was 3.6 MeV.

When the necessary construction is complete, the low energy injection system will take the beam from the r.f. gun and bend it through two 90 degree-dipoles into the linac, allowing the laser light to follow the electron beam axis to the photocathode.

Power for the linac sections and the r.f. gun is supplied by a single 20 MW klystron, provided by SLAC. The modulator was assembled on-site using several important components from SLAC. The system can run at repetition rates up to 6 Hz.

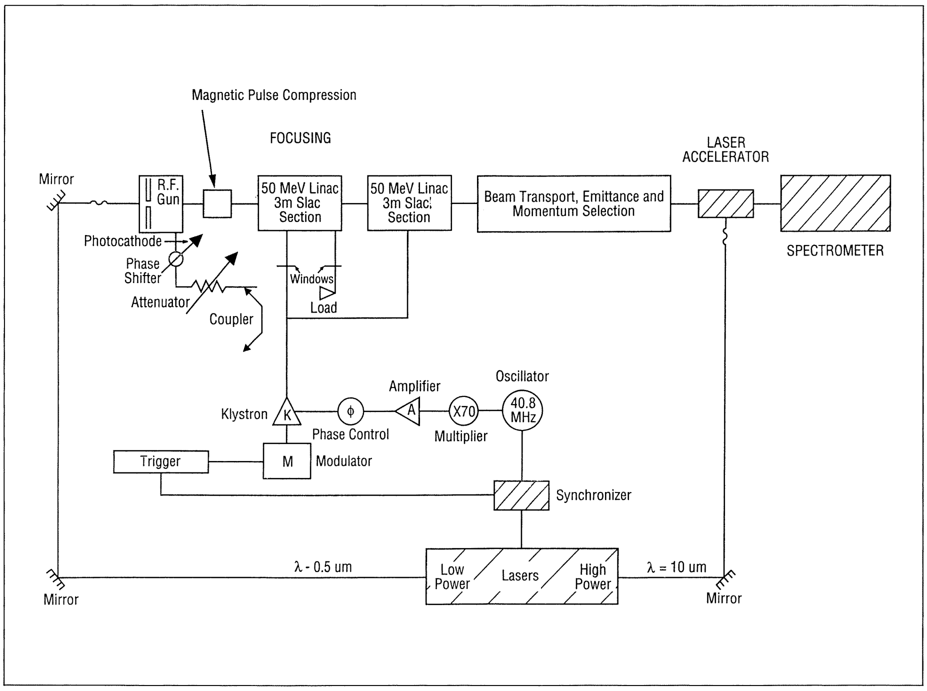
At least three types of experiments for the ATF have been discussed or are under construction. Prominent are investigations of new methods for particle acceleration, including laser acceleration and focusing of electrons using 10-micron etched silicon structures, to allow a longitudinal electric field

Schematic of the electron and laser beam systems at Brookhaven's Accelerator Test Facility (ATF). The low-power (YAG) laser simultaneously produces photoelectrons in the r.f. gun and selects a portion of the high power (CO_2) laser pulse for experiments.

near the electron beam trajectory. Another experiment studies the inverse of the acceleration mechanism (Smith-Purcell effect). Other proposals cover acceleration using the inverse free electron laser, inverse Cherenkov and switched power approaches.

A second class of experiments concentrates on coherent radiation. A free electron laser (FEL) study will use an 8 mm-pitch superconducting microwiggler to produce visible light. Other FEL experiments are under discussion.

The third type of experiment looks at fundamental photon-electron physics, including measurements of the non-linear Thomson scattering of an electron meeting an intense laser focus head-on.

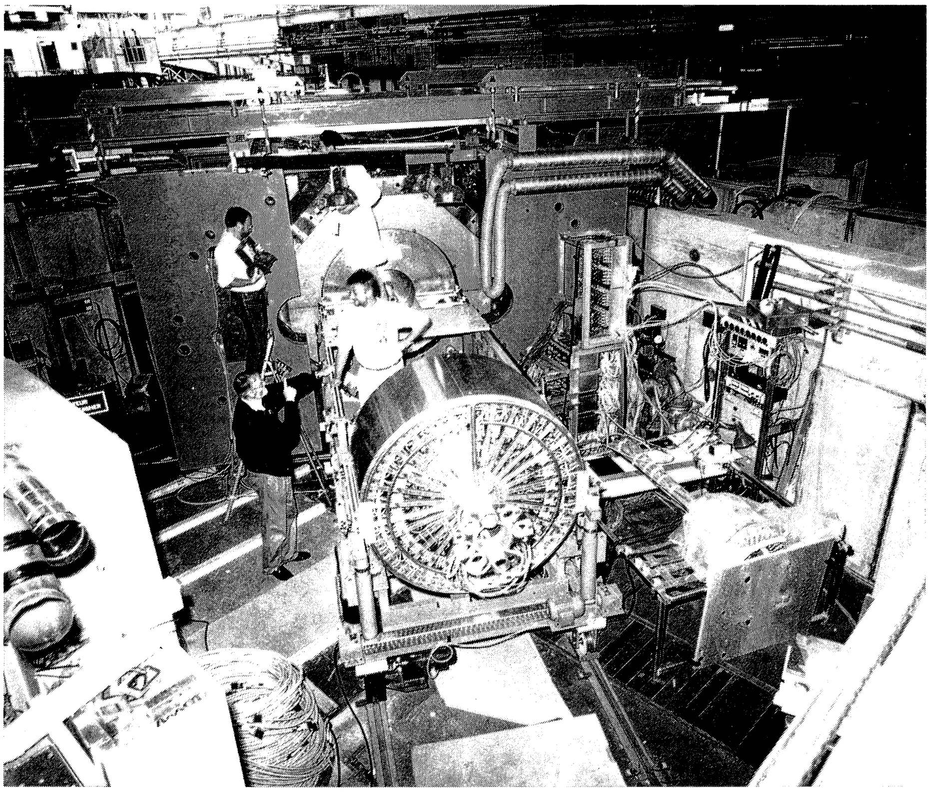


Electron beam R&D

The technological problems of producing 1 TeV electron beams are under attack at Laboratories all over the world, and new facilities are under construction to provide testbenches for novel techniques. As well as the Accelerator Test Facility at Brookhaven (see accompanying article), a Test Accelerator Facility is under construction at the Japanese KEK Laboratory (November 1989, page 13). At CERN, the long-term goal of a CERN Linear Collider (CLIC) is steadily being pushed, and a CLIC Test Facility (CTF) is being built to house experiments on laser techniques for a CLIC driver beam, and on 30 GHz radiofrequency generation. At the Stanford Linear Accelerator Center, a Final Focus Test Beam will use the business end of the SLC Stanford Linear Collider to look at the problems of making and monitoring sub-micron beams. At Argonne, accelerator studies with an electron linac have given significant results (June 1988, page 16). In the Soviet Union, a branch of the Novosibirsk Institute of Nuclear Physics has been established at the Institute for High Energy Physics at Serpukhov, near Moscow, scene of the construction of the multi-TeV UNK proton machine. The aim is to develop a linear electron-positron collider, VLEPP, alongside UNK, initially to provide 500 GeV beams for 1 TeV collisions, but with the door open for an upgrade to 1 TeV per beam. Complementing these projects is a healthy level of international collaboration.

The Crystal Barrel detector at CERN's LEAR low energy antiproton ring, showing the cesium iodide calorimeter withdrawn from the magnet.

(Photo CERN 306.8.89)



CERN
Crystal barrel in action

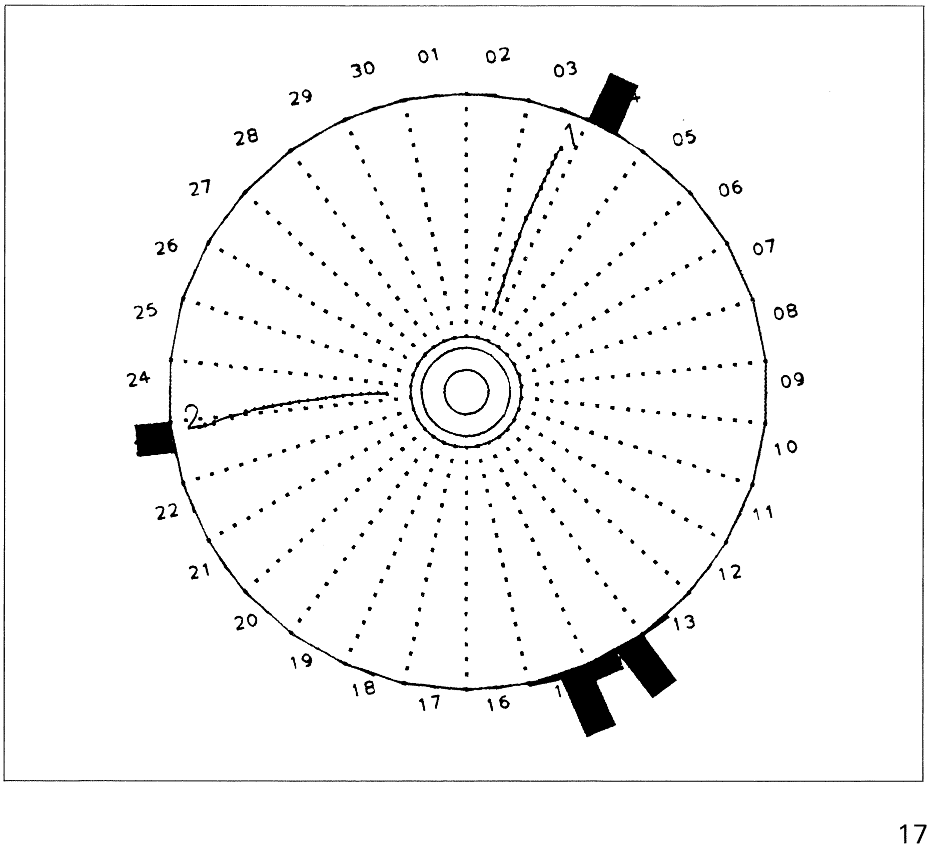
Three years after the start of the project, the Crystal Barrel detector at CERN's LEAR low energy antiproton ring has taken its first batch of data.

The Crystal Barrel team (a Berkeley/CERN/Hamburg/Karlsruhe Mainz/Munich/Queen Mary (London)/Rutherford/Strasbourg/UCLA/Zurich collaboration) aims at a detailed study of proton-antiproton annihilation, especially for the production of neutral particles.

Covering the complete solid angle and sensitive to both charged and neutral particles, the Crystal Barrel is one of a new generation of magnetic detectors using crystal calorimetry to pick up the energy deposited by emerging particles, and the first of its kind to be used in low energy proton-antiproton physics.

LEAR's 200 MeV/c antiprotons annihilate in the detector's liquid hydrogen target, surrounded in turn by two cylindrical multiwire proportional chambers with a total of 300 wires (for fast triggering on charged particle multiplicity) and by a 690-sense-wire cylindrical jet chamber to measure charged particle momenta. Energy loss in the chamber differentiates pions from kaons up to 500 MeV/c.

The chambers are embedded in a cesium iodide electromagnetic calorimeter made of 1380 individually-sealed crystals, each read out



End-on view of a low energy proton-antiproton annihilation into two charged and one neutral pion as seen in the jet drift chamber of the Crystal Barrel detector, showing the tracks of the two charged pions. The towers show the energy deposited in the cesium iodide.

by a single photodiode mounted on the side of a wavelength shifter. Efficient light collection gives good energy resolution (4 MeV at 100 MeV) and resolution to within two degrees, even for low energy photons. Covering 98% of the solid angle, the calorimeter gives good reconstruction of annihilations, even when large numbers of particles are produced. The surrounding coil provides a magnetic field of 1.5 tesla along the beam.

Handling charged particles as well as photons, Crystal Barrel gives a reconstruction of all annihilations, including those where several neutrals (pions or etas) are produced. This should help in the search for new meson states, including those containing gluons instead of or in addition to the conventional quark constituents (glueballs and hybrids respectively).

The first physics run last October intercepted two million proton-antiproton annihilations. As well as boosting the data supply, future runs will use multiplicity and photon pair mass triggers to select interesting events. Runs with hydrogen gas and deuterium targets, as well as with antiprotons in flight (up to 2 GeV/c) are planned to extend the range of the studies.

Smart pixel detector

With the big proton colliders now on the drawing board aiming to provide very high collision rates, the problem facing detector specialists is to develop new techniques to make the most of these rates.

For particle tracking, these techniques must supply fine enough resolution to pinpoint individual particle tracks inside concentrated jets, with micron precision in three dimensions, capable of operating within a hundred or so nanoseconds, and with low power consumption, at the same time standing up to the incessant bombardment by high energy particles and radiation. A tall order.

One line of attack being explored uses silicon arrays, which have already shown their worth for precision tracking in the form of silicon 'microstrips', or as CCD pixels (May 1986, page 3).

In the context of the Italian-funded LAA project at CERN, a CERN/Lausanne (EPFL)/Zurich (ETH) team have developed a readout chip, with 'smart' elements only 200 microns across, which, coupled to a silicon matrix pixel array, would provide a potentially very powerful detector.

The smart elements each contain active circuitry to pick up the typical 10^4 electrons (1.6 fC) which would be generated by a charged particle passing through 120 microns of silicon. Using only 30 microwatts, signal processing gives a single-bit output signal for a fast trigger and selective readout.

This smart pixel approach has great potential for particle physics progress beyond more conventional charge-accumulation devices now used for solid-state imaging, requiring large numbers of cells to be scanned before extracting position information.

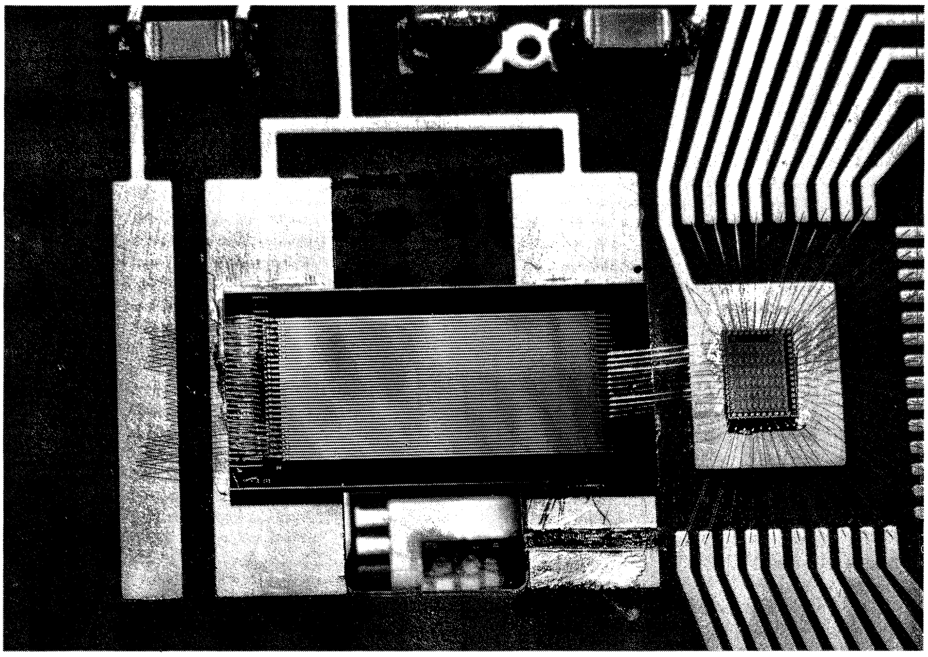
The circuitry, coupled to the pixel detector chip by modern 'bump' bonding, consists of a micropower analog amplifier, a latched comparator (for synchronization and timing) and an addressable digital memory element.

Output signals can be produced every 200 ns for each pixel element, reducing dead time. To simulate some future collider conditions, input pulses corresponding to 10^4 electrons were applied, and with 30 ns clock pulses at 10 MHz for timing, output signals were available within 100 ns.

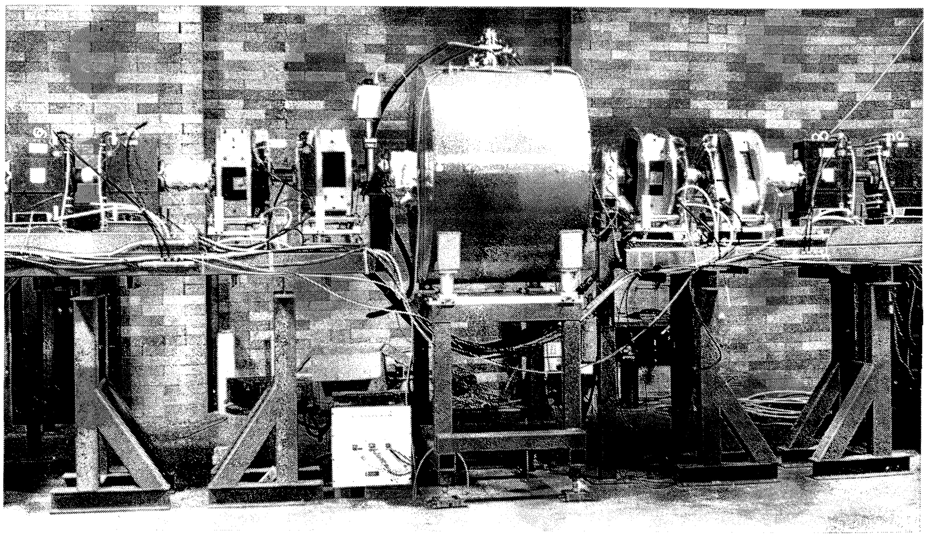
In radiation tests minimum ionizing particles were easily picked up, while even low energy X-ray si-

An active pixel detector readout chip developed at CERN in the framework of the Italian funded LAA project has given promising results. The chip (right) is seen mounted on a test board with a small silicon microstrip detector. Signals from particles passing through the 100-micron strips are picked by electronics in the 200 micron cell. The wire bonds connecting the 12 strips to the pixel can just be seen.

(Photo CERN 3.10.89)



The Michigan/Indiana Siberian Snake in the Indiana University Cooler Ring. The large central superconducting solenoid which rotates the spin direction by 180° is flanked by eight quadripoles to correct the beam orbit distortions caused by the strong solenoid.



gnals (10-20 keV) dominate over noise, estimated equivalent to less than 400 electrons.

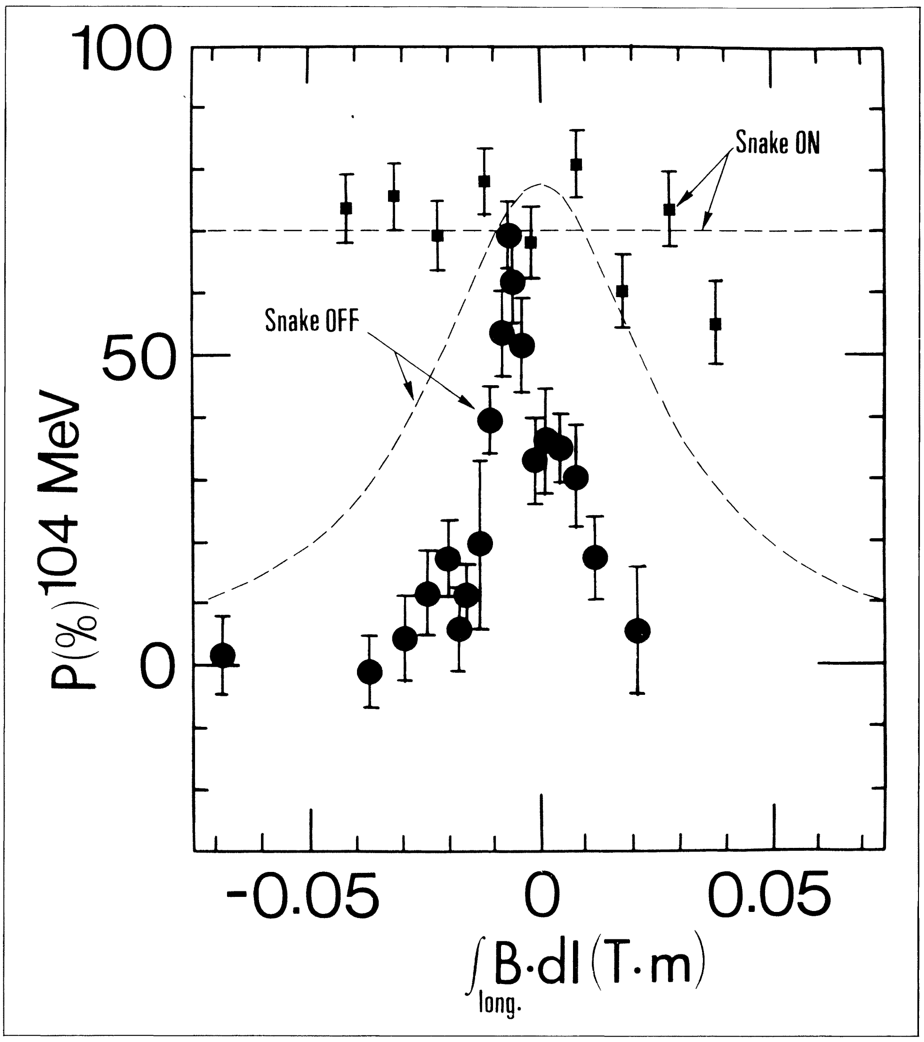
Other pixel developments are underway, notably at Stanford and at Berkeley, in the context of vertex detectors for the Superconducting Supercollider (SSC) to be built in Texas.

This LAA-funded development at CERN is a good example of the innovative techniques required for physics at the big machines expected to come into operation towards the end of the decade.

INDIANA
Siberian Snake saves spin

A team working at the Indiana University Cooler Ring (July/August 1988, page 13) has used a 'Siberian Snake' system to accelerate a spin-polarized proton beam through two depolarizing resonances with no loss of spin. The Michigan/Indiana/Brookhaven team under Alan Krisch overcame their first imperfection resonance hurdle at 108 MeV, and in a subsequent run vanquished a further resonance at 177 MeV.

First proposed by Yaroslav Derbenev and Anatoli Kondratenko of the Soviet Novosibirsk Laboratory in 1974, the Siberian Snake idea is to rotate the spin through 180° on each turn in the ring. With these successive spin flips, the depolarizing effects encountered in one turn should be cancelled by an equal but



Variation of beam polarization in the Indiana ring with imperfection magnetic field just below a depolarizing resonance at 108 MeV, showing how the sharp polarization change is overcome by the 'Siberian Snake' spin flip system.

opposite effect on the subsequent turn.

The success points towards polarized proton beams at higher energies. Classically, depolarizing resonances had to be eliminated one at a time in hours of tricky work at Argonne, Brookhaven, KEK and Saclay. However with the US Superconducting Supercollider (SSC) promising tens of thousands of such resonances en route to 20 TeV beams, an alternative approach was called for.

The 6.3-metre straight section in the Indiana Cooler provided just enough room for the 6-metre Snake. Following this success, Indiana is looking at the idea of a 15-20 GeV Light Ion Spin Synchrotron (LISS) with Siberian Snakes maintaining the beam polarization. Meanwhile Krisch and the Michigan group have signed an agreement with Soviet scientists to participate in the Neptun-A experiment at the UNK proton ring being built at the Institute for High Energy Physics, Serpukhov, near Moscow. Neptun will use a polarized proton jet target in the unpolarized UNK beam.

WORKSHOP
Keeping track of particle beams

Organizers and some speakers from the recent US National Workshop on Accelerator Instrumentation, held at Brookhaven. Standing, from left – Marc Ross, Stanford Linear Accelerator Center; Oscar Sander, Robert Shafer, Los Alamos; Gregory Stover, Berkeley; Gerald Bennett, Brookhaven, organizing committee co-chair; seated, from left – John Galayda, Brookhaven, invited speaker; Marvin Johnson, Fermilab, invited speaker; Olin Van Dyck, Los Alamos; James Hinkson, Berkeley; Richard Witkover, Brookhaven, organizing committee co-chair; Robert Weber, Fermilab. Missing from the picture is Joan Depken, Brookhaven, workshop secretary.

How to monitor the beam in a particle accelerator – to measure beam position, intensity, profile, transverse and longitudinal emittance, and losses – was the topic of the first US National Workshop on Accelerator Instrumentation, at Brookhaven in October. Sponsored by the US Department of Energy, the meeting drew more than a hundred physicists and engineers from other national labs and from industry.

Lectures reviewed the fundamentals and described some advanced implementations. Dick Talman (SSC) covered beam current measurement, illustrated by Klaus Unser's DC current transformers from CERN. Bob Shafer (Los Alamos) followed with electromagnetically-coupled beam position monitors; advanced implementations, such as those at Fermilab, reach 10-100 micron resolution.

Beam profile measurements were covered by John Galayda (Brookhaven), especially the non-intercepting high-resolution methods for synchrotron radiation sources. Measurement of particle distribution in energy and phase was described by Bob Webber (Fermilab), with a detailed explanation of how to achieve 6 GHz bandwidth in a wall current monitor.

Transverse emittance measurement methods were examined by Oscar Sander (Los Alamos), including studies from intense beam machines. Finally, beam loss measurements by radiation detection were detailed by Marvin Johnson (Fermilab).

Another goal at the meeting was to promote inter-Laboratory collaboration, industrial involvement, and standardization. A panel discussion including representatives from major Laboratories and from industry revealed that direct instrumentation costs, at 1-2% of total accelerator plant investment, has been too small to focus management's attention or to attract major businesses. This may change when development and support costs are considered, especially for projects such as new synchrotron radiation sources, which may come without a ready supply of detector specialists, or a project on the scale of the US Superconducting Supercollider (SSC).

With US spending on accelerator construction now booming (about a billion dollars annually), the time may be ripe for commercial production of NIM- and CAMAC-like readout electronics. A representa-

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tive of the US Department of Energy reviewed the DOE seed-money programme for attracting industry into this field.

The workshop should become an annual event.

NEUTRINOS
Heavy water detector

The proponents of the Sudbury Neutrino Observatory (SNO) received a welcome Christmas present when William Winegard, Canadian Minister for Science and Technology announced the final details of the funding for this project, totalling 48 million Canadian dollars and including contributions from the US and the UK.

The SNO experiment will extend significantly the study of solar neutrinos, using some 1,000 tonnes of heavy water to be installed more than two kilometres below ground in a nickel mine at Sudbury, ntario.

Until recently, the only detector homing in on neutrinos from the sun was the 600-tonne tank of chlorine-rich dry cleaning fluid used by Ray Davis' team in the Homestake mine in South Dakota.

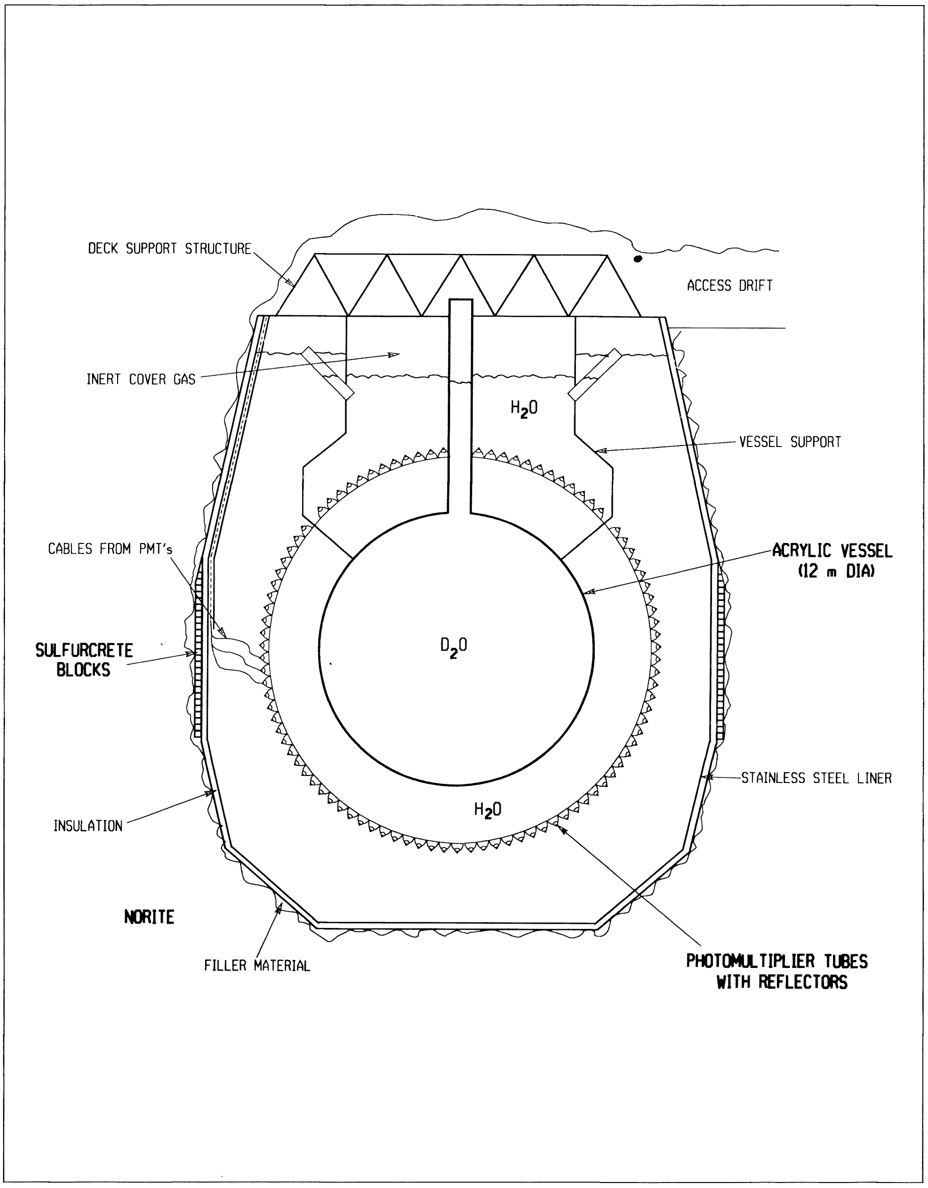
Picking up solar neutrinos through induced transformations of chlorine nuclei into argon, the detector does not see the level predicted by confident calculations of solar neutrino processes. In a scenario of modern physics which otherwise looks very neat, this 'solar neutrino puzzle' needs to be explained.

Recently the Japanese Kamioka underground experiment, using specially developed 20-inch photomultipliers to pick up Cherenkov radiation from neutrino-electron scattering in a 2000-tonne water target, has begun to provide an alternative source of solar neutrino information. Sensitive to all kinds of neutrinos, (the chlorine transformations in the Homestake mine experiment are triggered by only electron-type neutrinos) and in addition giving directional information, Kamioka nevertheless confirms the result of the pioneer experiment.

As well as scattering off electrons (as in the Kamioka study) to give information on the neutrino flux, electron neutrinos encountering the Canadian heavy water target could also transform the nuclear deuterons into proton pairs, releasing an electron. This particle would carry off most of the neutrino energy and would provide valuable spectral information.

However neutrinos (of all types) hitting a deuteron could also break

Design for the new Sudbury Neutrino Observatory to be built 2000 metres underground in a Canadian nickel mine, showing the inner heavy water target vessel surrounded by the ordinary water vessel and banks of photomultipliers.



it up into a proton and a neutron. This reaction will be monitored by detecting the results of the energetic gamma rays following the capture of the released neutron.

Thus the Sudbury scheme will provide important additional neutrino information. Sensitive to all neutrino types, it will probe the possibility of neutrino 'oscillations' – under certain conditions, neutrino types may not be immutable, but may switch back and forth, providing an alternative scenario, if not an explanation, for the solar neutrino problem.

Oscillations would show up by comparing the flux of electron- and other types of neutrino. If, as has been suggested, these neutrino transitions occur deep inside the sun, this would be reflected in the shape of the spectrum.

The Sudbury underground detector is expected to pick up about 10,000 neutrino interactions per year, with the resulting light flashes recorded by an array of 2,000 large photomultiplier tubes. Construction and installation will take about five years.

In the Italian Gran Sasso underground Laboratory (May 1987, page 26), other new detectors using sophisticated materials and detection techniques are being prepared to provide additional new insights into the nuclear mechanics of the sun's interior.

LISBON Supercomputer for Portugal financed from 'CERN Fund'

A powerful new computer is now in use at the Portuguese National Foundation for Scientific Computation (FCCN Lisbon), set up in 1987 to help fund university computing, to anticipate future requirements and to provide a fast computer at the National Civil Engineering Laboratory (LNEC) as a central node for remote access by major research institutes.

Taking into account especially the requirements of Portuguese physicists involved in research at CERN, a specification was drawn up for a 10 Mflop, 32 Mbyte scientific machine operating under UNIX. After proposals from most major computer manufacturers, a solution based on a Convex C220 supercomputer was selected, and passed its acceptance tests at the end of September.

As well as high energy physics, the machine will also cater for computational mechanics and molecular chemistry, and serves as the central node of the Network for the National Scientific Community (RCCN), using both dedicated and public lines.

After Portugal became CERN's fourteenth Member State in 1985, the country's annual contributions to the Organization's budget increase gradually over ten years to the full amount specified by CERN's Convention. During this time, the difference between the actual and full contribution levels is earmarked (the Portuguese 'CERN Fund') for the development of particle physics in Portugal, so that the country's physicists can make full use of the Laboratory's resources, and for projects where Portuguese researchers on other areas (electronic welding, fast electronics, geodesy,....) can benefit from CERN know-how. Most of the money for the new supercomputer came from this Fund, where it was first mooted by the Fund's Scientific Committee in 1986.

The Committee, with a balanced membership from CERN and Portugal, and with a tradition of public presentations, has been a driving force in the administration of the Fund.

25 years at Trieste

Towards the end of October 1964, the International Centre for Theoretical Physics (ICTP) came formally into being in Trieste. With less than 200 scientific visitors in its first year, the Centre, under the inspired Directorship of Abdus Salam and supported by the International Atomic Energy Agency (IAEA), UNESCO, and Italian national and regional authorities, has grown into a veritable world centre of scientific excellence, attracting over 4000 active researchers each year.

In 1960, a chance meeting with Trieste Professor Paolo Budinich convinced Salam that this city, sited in the far north-eastern corner of Italy but with a vivid international political history, was a highly appropriate place for an illustrious scientific future.

The establishment of the centre was approved at the 1962 General Conference of the International Atomic Energy, and subsequent local and national support enabled the new Centre to move into temporary headquarters in 1964.

In the mid-60s, Trieste research concentrated on particle physics and plasma physics, but over the years as interest, support and accommodation have expanded, these interests have widened to give a truly multidisciplinary centre with active groups in fundamental physics, condensed matter physics, mathematics, climatology, aeronomy and microprocessors.

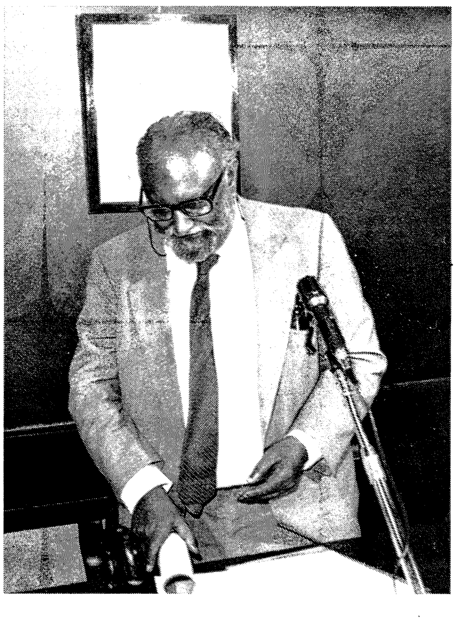
In the past ten years, the emphasis on practice and experimental work has increased. In 1987, the first physics instrumentation school, organized by the Instrumentation Panel of the International Committee for Future Accelerators (ICFA) took place at ICTP.

Questioned about the role of the Centre, Salam speaks frequently of his experience when, after his promising early research career at Cambridge and Princeton, he decided to return to his homeland and the newly created country of Pakistan. After several years of largely fruitless efforts, he felt stifled and isolated by the intellectual loneliness which besets scientists cut off from the main stream of modern research.

This experience helped seed the idea for the Trieste centre, where kindred spirits from developing countries far and wide could regroup to replenish their ideas and motivation to return refreshed and inspired to their work.

A statement by Robert Oppenheimer underlines this motivation – 'we have all of us to preserve our competence in our own professions, to preserve what we know intimately, to preserve our mastery. That is, in fact, our only anchor in honesty.'

Fond of parallels, Salam often cites the example of the pre-renaissance world, when modern geographical roles were somewhat reversed. The thirteenth century saw intrepid scholars like Michael the Scot, who ventured far from the familiar but impoverished confines of his home glens to seek out and ascend the scholastic heights of the Arab University of Toledo in Spain, there to leave his mark on the research of the day.



Despite the immense success of the Trieste venture, Salam's ambitions are still set high. Through improvements in science transfer, Salam aspires at least to redress the unwieldy concentration of modern expertise in a few developed countries (June 1985, page 189).

With initial funding for three new Trieste Centres, for Chemistry, for Earth Sciences and the Environment and for High Technology and New Materials, already in place, Salam looks ahead to a world network of such centres. On 26 October, he expressed these hopes before the UN General Assembly.

To mark the Centre's 25th anniversary a five-day meeting on contemporary physics brought together many illustrious names, with Italian Prime Minister Giulio Andreotti and International Atomic Energy Agency Director General Hans Blix among those attending the opening ceremony. In one of his final public appearances before his death on 5 December (see page 27), Edoardo Amaldi introduced Salam's talk 'A life of physics'.

Abdus Salam – living for physics

SUPER COLLIDER ENGINEERS & PHYSICISTS

The Superconducting Super Collider Laboratory has immediate openings for experienced Mechanical and Electrical Engineers, Engineering Physicists, and Computer Scientists to work on the design and development of "state-of-the-art" systems, equipment, and facilities for the 20 TeV particle accelerator.

Qualifications and Experience

Current engineering or software experience in Systems Design, Development, using the latest technologies. Proven ability and dedication to engineer long term projects, involving multiple technologies, from conception to completion. Experience with CAD and analytical engineering design programs used in your field. A BS, MS, or PhD in Mechanical Engineering, Electrical Engineering, Physics, Computer Science, or an equivalent degree and experience is required. Those with experience in particle accelerator systems and technologies are especially sought.

Cryogenic Engineers

Cryogenic Systems Design and Analysis, Component Design, Coldbox and Piping Design, Process Design, Process System Modeling, Process Control System Engineering, Cryogenic Instrumentation Systems, Cryogenic System Commissioning and Operation.

Electrical Engineers

Analog Circuits, High Power DC Power Supplies, High Voltage AC Power Distribution and Installation, Pulsed Power Circuits, High Performance Feedback Systems, Instrumentation, Low Level and High Power RF Systems, Magnet and RF Structure Design.

Physicists

Accelerator Design, System Specification, Magnet and RF Structure Design, Theoretical Analysis, Project R&D Leadership, Computer Simulations, Applications Programs, Beam Instrumentation Systems Design, Beam Transport Design.

Engineering Physicists

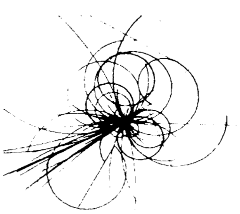
Particle Beam Instrumentation, RF Feedback Systems, Quench Protection Systems, Accelerator Systems Operation and Development, Magnet String Tests, Magnet Measurement Systems, Survey and Alignment Systems, and other accelerator related needs.

Computer Scientists and Engineers

Real Time Digital Control Systems, Interface Circuit Design, High Speed Data Acquisition, Expert Systems, Network Design, Database Design and Management, Human Interface Systems and other related areas.

Mechanical Engineers

Magnet Structural and Support Systems, Vacuum Systems, LCW Cooling Systems, Survey and Alignment Systems, Welding Sytems, Heavy Equipment Transportation and Installation, Tooling and Hydraulics, and other related systems.



Send complete resume with references and salary history to:

SSC Laboratory
2550 Beckleymeade Ave.
Suite 125
Attn: Dept. Ad/CC
Dallas, Texas 75237

Super Collider

SSC is an Equal Opportunity, Affirmative Action Employer

UNIVERSITY OF MONTREAL

The Nuclear Physics Laboratory of the University of Montreal invites applications for a

RESEARCH ASSOCIATE POSITION

with an experimental group working at TRIUMF (Vancouver) on weak interaction physics and rare decays. The present activity is a measurement of radiative muon capture on hydrogen using a large solid angle drift chamber spectrometer.

The successful applicant will have experience in hardware (modern fast electronics and detectors, data acquisition systems) and in data analysis (tracking algorithms, Monte Carlo Simulations using GEANT, etc.).

Although based at TRIUMF, the candidate must be prepared to spend some time at the University of Montreal.

Please send application, with curriculum vitae and the names of three referees by February 28th to:

Professor Pierre DEPOMMIER
Laboratoire de Physique Nucléaire
Université de Montréal
Case Postale 6128, Succursale "A"
Montréal, Québec, Canada H3C 3J7

In accordance with Canadian Immigration requirements priority will be given to Canadian citizens and permanent residents of Canada.

SENIOR ELECTRONICS DESIGNER ENGINEER

The Continuous Electron Beam Accelerator Facility (CEBAF), presently under construction, is a world class 4 GeV continuous electron beam accelerator for nuclear physics research.

Currently, the CEBAF beam diagnostics and instrumentation group is seeking an experienced electrical engineer to design and oversee the production of complex electronic systems for monitoring the electron beam performance.

The position requires an advanced degree in electrical engineering with a minimum of five plus years experience in analog circuit design pertaining to low noise receivers and signal processing in the MHz and low GHz ranges. In addition, some experience with digital circuit design and the CAMAC or VME interface system is helpful.

Located fifteen minutes from historic Williamsburg, Virginia, CEBAF provides an excellent working environment with opportunities for rapid advancement. Outstanding benefits include four weeks vacation annually, medical and dental insurance, and a generous relocation program.

Qualified candidates should submit their resume to: Employment Manager, CEBAF, 1200 Jefferson Avenue, Newport News, VA 23606.

CEBAF

The Continuous Electron Beam Accelerator Facility

An Equal Opportunity, Affirmative Action Employer

Edoardo Amaldi 1908-89

Edoardo Amaldi, right, with Gilberto Bernardini at a CERN Council session in 1965.

Edoardo Amaldi, one of the driving forces of European science and a pioneer of CERN, died on 5 December.

He began his career in the 1930s with Enrico Fermi in Rome, where he helped discover that slow neutrons were more readily captured in target nuclei.

After the premature death of Ettore Majorana and the decision of Fermi and other prominent Italian physicists to emigrate in the 1930s, Amaldi took essential steps to maintain the spirit of Italian physics. Gian Carlo Wick was invited to take up the Rome chair left vacant after the departure of Fermi. Gilberto Bernardini at Bologna commuted regularly to the Italian capital to continue the cosmic ray tradition pioneered by Bruno Rossi. Under their guidance, dramatic wartime research exploits under difficult conditions nevertheless made important contributions to physics, culminating in the epic 1946 discovery of the muon by Marcello Conversi, Ettore Pancini and Oreste Piccioni.

In 1955, while the experiment of Owen Chamberlain, Emilio Segré, C. Wiegand and T. Ypsilantis that was to discover the antiproton was being set up at the new Berkeley Bevatron, an emulsion stack study by a Berkeley/Rome collaboration went ahead at the new machine, and a particle with antiproton-like properties was revealed in subsequent analysis in Rome. An Amaldi group had also seen an antiproton candidate in cosmic ray studies.

In later years, Amaldi pointed out how the novelty and intimacy of physics at cosmic ray mountain observatories and nuclear emulsion laboratories in the immediate postwar years had suggested wider and more ambitious collaborations. Putting these ideas into action, he had led the small but vigorous group of scientists and politicians who promoted the idea of a European Laboratory in the early 1950s, and it was fitting that he held the position of Secretary General when CERN formally came into being in 1954. His vision and wisdom in helping to create the Organization and its guiding document, the Convention, were important factors in enabling CERN to respond to all the challenges of the past 35 years.

Following a 1963 proposal by CERN Director General Viktor Weisskopf and Scientific Policy Committee Chairman Cecil Powell, Amaldi was the first chairman of a new body, the European Committee for Future Accelerators (ECFA), a 'little parliament' of physicists which under his guidance produced the famous 'Amaldi Report', with recommendations for new machines – the Intersecting Storage Rings and the 300 GeV machine (the SPS) – that secured CERN's future. It took many years before final agreement on the latter was reached, but it was symbolic that Amaldi was President of the CERN Council when the SPS was finally approved in 1971. Subsequently he was a regular visitor, still involved in experiments, and a necessary presence at all CERN's great events, including most recently the LEP Inauguration on 13 November (see page 6).

From 1957-60 he was President of the International Union of Pure and Applied Physics. In his home country, he was President of the INFN from 1960-65, a member of the prestigious Accademia dei Lincei, becoming its President in 1988, and the Accademia Nazionale dei XL.

For a man of great vision who could transform his ideas into reality, he was very modest. At his 80th birthday celebrations at CERN in 1988 he concluded simply, 'It has always been a joy to work for CERN'.

TRIUMF

MESON RESEARCH FACILITY

University of Alberta
Simon Fraser University
University of Victoria
University of British Columbia

RESEARCH ASSOCIATES

University of Alberta
Nuclear Research Centre
Dept. of Physics

The Subatomic Physics group at the University of Alberta has three openings for experimental and theoretical Research Associates. The group's interests include rare kaon decay tests of the Standard Model at Brookhaven, the spin structure function of the nucleon at HERA, parity violation and charge symmetry breaking at TRIUMF, elastic and inelastic NN scattering at TRIUMF, and photonuclear studies at the Saskatoon CW electron accelerator.

Of the successful candidates who have received their Ph.D. degrees in physics within the last two years, two experimentalists and one theorist will be appointed. The successful applicants will be expected to make major contributions to the projects in which they choose to participate, and will be based accordingly at either Edmonton or Vancouver. Salary will be commensurate with experience.

Candidates should send their resume and three letters of reference as soon as possible to:

Research Associate Search Committee, Nuclear Research Centre, The University of Alberta, Edmonton, Alberta, CANADA T6G 2N5.

The deadline for receipt of applications is **April 1, 1990** and the positions will be filled as soon as possible thereafter.

We offer equal employment opportunities to qualified male and female applicants.

INTERNATIONAL PHYSICS PROGRAM LIBRARY

containing over 1100 *refereed* programs in Physics and Physical Chemistry submitted by scientists from all over the world.

Detailed descriptions of all programs are published in the North-Holland journal Computer Physics Communications.
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The library offers the following services:

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- an individual request scheme for scientists who require programs relevant to their research
- an on-line information and program request scheme.

For further information about the library contact:

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The library was established in 1969 as a non-profit making organisation with support from the UK Science and Engineering Research Council.

1990 INTERNATIONAL INDUSTRIAL SYMPOSIUM ON THE SUPER COLLIDER (IISSC)

SSC – AMERICA'S NEW RESEARCH PARTNERSHIP

Fontainebleau Hilton Resort and Spa
Miami Beach, Florida
March 14-16, 1990

The purpose of the second International Industrial Symposium on the Super Collider (IISSC) is to foster a continuing dialogue among the scientific, administrative, legislative, and industrial sectors on the goals, status, technical challenges, and requirements of the Superconducting Super Collider (SSC). The symposium program will present industrial opportunities for participation in the various technologies involved in the design, construction, and operation of the SSC and its experimental detector system.

Topics at the symposium's plenary sessions will include:

Accelerators • Detectors and Associated Electronic Systems • Superconducting and Conventional Magnets • Cryogenics/Refrigeration • Computation • Operations/Systems/Controls • Management Plan/Project Management • International Involvement • Education • Technology Spin-offs.

An exhibit of technical products will be held in conjunction with the symposium.

For registration information please contact:

Ms. Pamela E. Patterson, Conference Manager, International Industrial Symposium on the Super Collider (IISSC),
P.O. Box 171551, San Diego, CA 92117
TEL. (619) 490-0164; FAX (619) 490-0138.

Uppsala University, Uppsala, Sweden

announces openings for

(a) PROFESSOR OF NUCLEAR PHYSICS
(b) PROFESSOR OF NUCLEAR CHEMISTRY AND NUCLEAR PHYSICS

The Professor of Nuclear Physics will be responsible for research and teaching in the Division of Nuclear Physics at the Department of Radiation Sciences, which also has chairs in High Energy Physics, Intermediate Energy Physics, Theoretical Subatomic Physics, Ion Physics and Physical Biology. The adjacent The Svedberg Laboratory has three accelerators: a 6 MV tandem accelerator, a K = 200 cyclotron for protons and heavy ions and the storage and cooling ring CELSIUS. The latter is designed to accelerate protons up to 1.36 GeV and other ions to 470 MeV per nucleon.

The Professor of Nuclear Chemistry and Nuclear Physics will be responsible for research and teaching in the Department of Neutron Research, which also has chairs in Applied Neutron Research and Neutron Scattering Physics. The area includes the study of nuclear reactions and the products of nuclear reactions. The position is, for the most part, experimentally oriented and will be located at the Department of Neutron Research at the Reactor Research Center at Studsvik.

The applications should be directed to the Swedish Government and should be received no later than February 12, 1990, at the following address:

The Registrar's Office
Uppsala University
Box 256
S-75105 Uppsala, Sweden.

They should contain (in four copies) a curriculum vitae and a written account of research and teaching activities with certified copies of degrees and other documents that the applicant wishes to supply, a numbered list of scientific publications and four separate parcels of these publications.

For further information, please contact Professor Gunnar Tibell, Department of Radiation Sciences, Box 535, S-75121 Uppsala, Sweden, telephone ++46-18-183849, telex TSLISV S 76088, for position (a), and Dr Birger Fogelberg, Department of Neutron Research, S-61182 Nykoping, Sweden, telephone ++46-155-21842, for position (b).

Andrei Dimitrievich Sakharov 1921-1989

Andrei Dimitrievich Sakharov, talented and versatile scientist, fearless activist and staunch proponent of human rights, figurehead for Soviet perestroika, described in the citation for his 1975 Nobel Peace Prize as 'spokesman for the conscience of mankind', died on 14 December.

Beginning research at Leningrad's Lebedev Institute in 1945 under Igor Tamm, he first came to prominence with his early 1950s contributions to thermonuclear fusion with Tamm, including the idea to contain plasma in a magnetic 'bottle', later to become known as the tokamak. For his fusion work he became an Academician in 1953 at the age of only 32, the youngest ever to be so honoured.

On the particle physics front, his contributions included the suggestion that the asymmetry of matter and antimatter in the Universe could reflect the delicate violation of charge-parity (CP) symmetry in the weak nuclear interactions, applications of the quark model, and pioneer ideas in the quantum theory of gravity.

He was not able to receive his Nobel Award in person. From 1980, during his exile in Gorki, he tried to keep in touch with developments in science, receiving physics literature, including the CERN Courier, by registered mail.

With the new direction in Soviet policy he reemerged as a popular champion in the USSR. Last year, accompanied by his wife Elena Bonner, he embarked on a visit of major world physics Laboratories.

In a message entitled 'The responsibility of scientists' to a 1981 New York meeting in his honour, he wrote 'scientists are not only better informed than the average person, but also strive for and enjoy more independence and freedom. Freedom, however, entails responsibility'. With steadfast ideals and indomitable courage, Sakharov never shirked this duty.

Andrei Sakharov in his Gorki apartment in 1985.

(Soviet TV)

People and things

CERN elections and appointments

At its December meetings, CERN Council elected C. Lopez, Rector of the Autonomous University of Madrid, and E.W.J. Mitchell, Chairman of the UK Science and Engineering Research Council, as Vice-Presidents, and Chris Llewellyn-Smith of Oxford as Chairman of the Science Policy Committee.

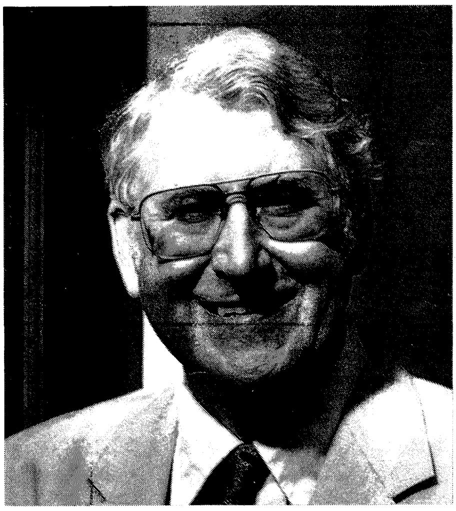
In 1990, the CERN Directorate consists of Research Directors Pierre Darriulat, Walter Hoogland and John Thresher; Günther Plass as Director of Accelerators; Georges Vianès as Head of Administration; and Hans Hoffmann as Director for Technical and Administrative Tasks.

This reflects a reorganization at divisional level into research, accelerator and technical administration sectors: Theoretical Physics (Leader, John Ellis), Experimental Physics (Jim Allaby), Electronics Facilities (Pier G. Innocenti), Computing Centre (David O. Williams), Mechanical Technologies (Gérard Bachy), Proton Synchrotron (Roy Billinge), SPS and LEP (Lyndon Evans), Accelerator Technologies (Horst Wenninger), Technical Services (Fritz Ferger), Administrative Support (Frans Heyn), Personnel (Georges Michel), Finance (André Naudi), Technical Inspection and Safety Commission (Keith Potter), Pension Fund (Christian Cuénoud).

On people

John S. Toll, Chancellor Emeritus of the University of Maryland and long-time member of US federal

Howell Pugh 1933-1989



Directors of several Yugoslav physics research centres recently signed agreements providing a framework for continued collaboration in CERN research. Left to right – Gabrijel Kernel of the University of Llubljana; Tomaz Kalin, Director of Llubljana's Jozef Stefan Institute; Guy Paic of Zagreb's Ruder Boskovic Institute; Krunoslav Pisk, Director General of the Ruder Boskovic Institute; CERN Director General Carlo Rubbia; CERN coordinator for Eastern Europe Owen Lock. Similar bilateral agreements are being drawn up to consolidate ongoing collaboration between CERN and research centres in other East European countries.

(Photo CERN 524.11.89)

science advisory bodies, has been appointed President of Universities Research Association, the Governing Body of both Fermilab and the Superconducting Supercollider (SSC) Laboratory, succeeding Edward K. Knapp.

This year's UK Institute of Physics Awards include the Rutherford Medal and Prize to theorist Roger Phillips of the Rutherford Appleton Laboratory, the Harrie Massey Prize (awarded jointly with the Australian Institute of Physics) to Richard Dalitz of Oxford and the Maxwell Medal and Prize to Cambridge astrophysicist and cosmologist George Efstathiou.

CERN theorist Luis Alvarez-Gaume shares UNESCO's Javed Husain Prize for young scientists.

Among the Doistau-Blutet Award recipients of the French Academy of Science last year (April 1989, page 23), were Paul André Chamouard, Michel Olivier and André Tkatchenko of the French National Saturne Laboratory, Saclay, for their work in developing the MIMAS injector, and Jean-Bernard Zuber of Saclay for his work in quantum field theory.

Promising Italian theorist Giorgio Gamberini of Pisa died tragically last year, aged 28, just three days after having formally presented his doctorate.

Howell Pugh 1933-1989

Howell Pugh of Berkeley, who died on 7 November, was one of the pioneers of the new field of relativistic (high energy) heavy ion collisions, having realized very early the potential of CERN's machines for this work. Most of the US participation in CERN's ion programme was due to his enthusiasm and leadership, quite apart from the role played by the Berkeley Laboratory. Participating in one of the early experiments at CERN's Intersecting Storage Rings in 1972-3, he saw the potential of high energy techniques for nuclear physics, and went on to become Scientific Director of the Berkeley Bevalac in 1979, where he played a vital part in setting up what was to become a highly successful programme of heavy ion studies.

Vossfest at DESY

Electron accelerator maestro Gus Voss, long-time member of the Board of Directors at DESY, actually celebrated his 60th birthday last summer during a spell at Stanford. On return to the DESY Laboratory in Hamburg in August, he was immediately caught up in the commissioning of the HERA electron ring at its nominal energy of over 27 GeV (November 1989, page 4). His official birthday celebrations at DESY were therefore postponed to November.

At a special colloquium, Maury Tigner of Cornell sketched the history of electron-positron colliders from the pioneer AdA ring in Rome in the early 1960s through to today's big machines, LEP at CERN and the SLC Stanford Linear Collider.

Thomas Weiland, formerly of DESY and now at Darmstadt, took over to describe new acceleration techniques, particularly the promising wakefield transformer he developed with Voss at DESY in 1982.

The final speaker, Paul Söding of DESY, outlined the new insights in physics that electron-positron col-

GROUP LEADER FAST ANALOG ELECTRONICS

The Continuous Electron Beam Accelerator Facility in Newport News, Virginia is searching for an electrical engineer or physicist to establish and lead a group charged with developing fast analog front end electronics to be utilized with various particle detectors. These detectors will be employed in the nuclear physics research program to be carried out at the 4 GeV superconducting electron accelerator now under construction.

Required is an applicable degree plus several years experience in development of such circuits for use in physics research. Additional experience in obtaining small scale industrial production of them would be useful. The group will be part of the CEBAF Physics Division and will be expected to work closely with the physicists developing the detectors.

We offer a very competitive total compensation package and a stimulating work environment.

For prompt consideration, please send resume with salary history to: Employment Manager, CEBAF, 1200 Jefferson Avenue, Newport News, VA 23606.

CEBAF

The Continuous Electron Beam Accelerator Facility

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UNIVERSITÉ DE MONTRÉAL

Research Associate in Particle Physics

Applications are invited for a Research Associate position in experimental particle physics, for participation in the OPAL collaboration, at LEP. The candidate will be required to contribute to the analysis. Experience in collision physics and in online data acquisition will be an asset.

The initial appointment will be for a period of 2 years.

Please send a c.v. and the name of 3 references before March 1st, 1990, to :

Prof. L. LESSARD
Laboratoire de Physique Nucléaire
Université de Montréal
C.P. 6128

MONTREAL P.Q. H3C 3J7
Canada

bitnet : LESSARD@UMTLVR
fax : (514) 343-6215
tél. : (514) 343-6722

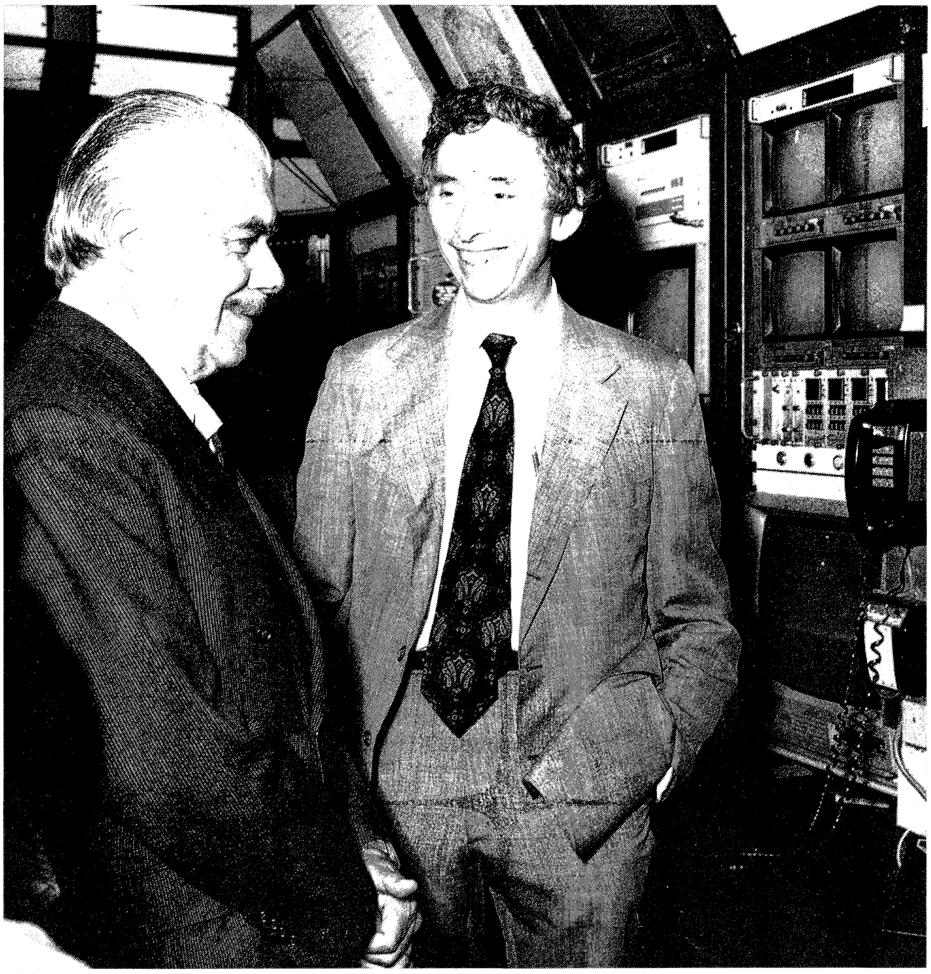
POSTDOCTORAL RESEARCH ASSOCIATE OR VISITING SCIENTIST POSITION IN EXPERIMENTAL NUCLEAR PHYSICS

At the Kernfysisch Versneller Instituut (KVI) in Groningen, the Netherlands, nuclear physics is done with light and heay ion beams from a K-160 MeV variable energy cyclotron. In addition physicists collaborate in experiments at GANIL and GSI. For these activities applicants are invited for a postdoctoral, respectively visiting scientist position. Applicants are asked to submit their curriculum vitae, three letters of recommendation and a list of publications as soon as possible to prof. R.H. Siemssen, Director of the KVI, Zernikelaan 25, 9747 AA Groningen, the Netherlands, telephone 31 50 633556, Bitnet: SIEMSSEN KVI.NL.

POSTDOCTORAL RESEARCH ASSOCIATE THEORETICAL NUCLEAR PHYSICS

The theory group of the KVI invites applications for a postdoc position. The successful applicant will be working on the project "Quantum transport theory of hadronic matter".
Candidates are asked to submit their curriculum vitae, three letters of recommendation and a list of publications as soon as possible to prof. R.A. Malfliet, Zernikelaan 25, 9747 AA Groningen, the Netherlands, telephone 31 50 633554, Bitnet: MALFLIET KVI.NL.

After the opening last year of the United Nations General Assembly in New York, President Jose Sarney of Brazil (left) visited Fermilab, where he was shown round by Laboratory Director John Peoples. Following the initiation of a cooperation programme with Latin American research institutions ten years ago, about 30 Brazilian physicists now work at Fermilab.



liders have brought, from modest beginnings to today, when high energy machines provide a main line of attack.

Voss has played an important role in the construction of DESY's electron machines, first the 6 GeV synchrotron, then the PETRA collider, and now the electron ring for HERA, where Bjorn Wiik is in charge of the 820 GeV proton ring. At Cambridge, Mass., Voss was one of the team which transformed the CEA electron machine into a collider in the early 1970s, exploiting the 'low-beta' scheme to compress the beams and boost the collision rate, a 1966 brainchild of Voss and Ken Robinson.

Meetings

An international workshop on software engineering, artificial intelligence and expert systems for high energy and nuclear physics will be held from 19-24 March at the Computing Centre of the French IN2P3, Lyon/Villeurbanne. Further information from Mme. Michele Jouhet, EP Division, CERN, 1211 Geneva 23, Switzerland, phone Geneva 767 2277, fax Geneva 782 4439, bitnet jouhet at cernvm.cern.ch

The 9th International Symposium on High Energy Spin Physics will be held from 10-15 September in Bonn, West Germany, hosted by the Physikalisches Institut der Universität Bonn. Further information from the Local Organizing Committee, Chairman K.-H. Althoff, Secretary Mrs. D. Fassbender, Physikalisches Institut, Nussallee 12, 5300 Bonn 1, F.R. Germany, phone/fax Bonn 733247/737869, bitnet spin 90 at dbnpib 5.

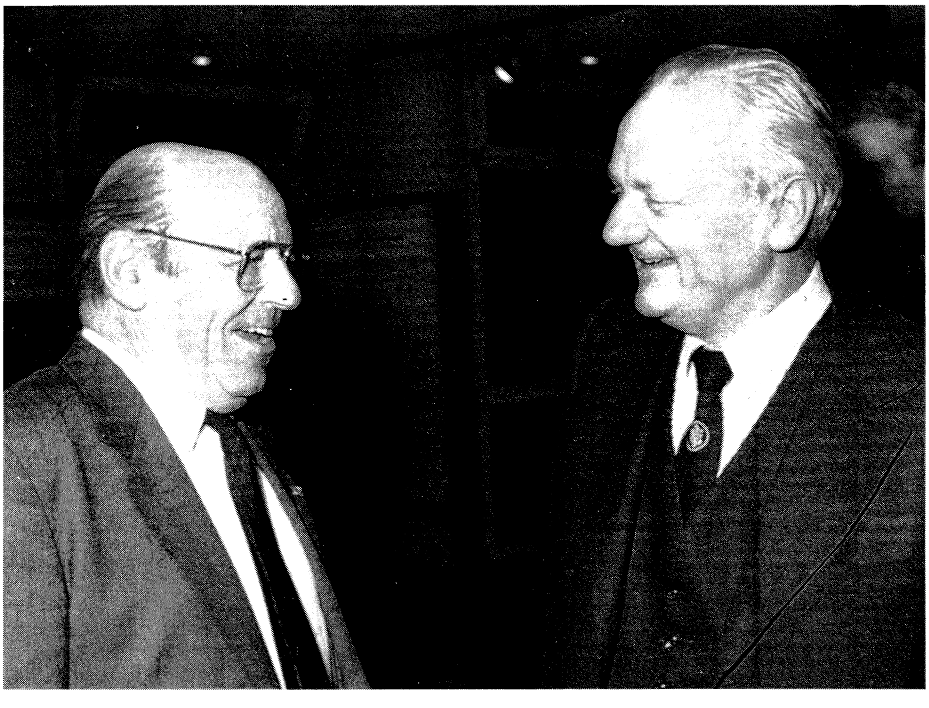
An international conference on gamma ray astronomy will be held in Ann Arbor, Michigan, from 2-5 October to review recent data and discuss new theoretical ideas and experimental techniques applicable above 1 GeV. Further information from Carl Akerlof, University of Michigan, 500 East University, Ann Arbor, Michigan 48109-1120, USA.

A 'QCD 90' workshop in Montpellier, France, from 8-13 July will look at recent progress in both perturbative and non-perturbative QCD. Further information from S. Narison at the University of Montpellier, bitnet narison at cernvm.cern.ch or lpmont at frmop11.

Sponsored by World Laboratory (Lausanne, Switzerland), by the US National Science Foundation and by Pakisatani agencies, a School on Fundamental Physics and Cosmology will be held in Islamabad from 11-25 March. Further information from Pervez Hoodbhoy, World Laboratory School, Physics Dept., Quaid-i-Azam University, Isalambad, Pakistan.

▲ Guests at the dinner marking Georges Charpak's 65th birthday included the team from the first experiment at CERN to measure the anomalous magnetic moment of the muon in 1959-60 – left to right, Antonino Zichichi, Hans Sens, Val Telegdi, Georges Charpak, Francis Farley, Roger Bouclier, Richard Garwin and Leon Lederman. The photo was taken by indefatigable cameraman Maurice Jacob.

▼ A special colloquium at the German DESY Laboratory in Hamburg in November marked the 60th birthday of electron machine specialist Gus Voss (right), seen here with Wolfgang Paul of Bonn, who shared the 1989 Nobel Physics Prize with Norman Ramsey and Hans Dehmelt.



Jürgen May, formerly with the Aleph experiment at CERN's LEP electron-positron collider, moves to DESY to become Directorate Member for Technical Services, succeeding Hans Hoffmann, who has returned to CERN to become Director for Technical and Administrative Tasks.

The fourth meeting in the series of Topical Seminars on Experimental Apparatus for High Energy Particle Physics and Astrophysics will take place from 28 May to 1 June in San Miniato (Pisa), Tuscany, at the 'I Cappuccini' conference centre. Organized jointly by P. Giusti and F.-L. Navarria of Bologna (e-mail KAOS at VAXBO.infn.it) and by P.G. Pelfer of Florence (TOP90 at VAXFI.infn.it) the Seminar will cover the latest developments in detectors, electronics, data acquisition and data analysis for the special conditions at very high energy and/or luminosity accelerators, and in underground, surface and astrophysics experiments, with particular emphasis on particle identification, time and energy resolution, calorimetry, etc. for high flux conditions.

On the 50th anniversary of the French Centre National de la Recherche Scientifique (CNRS), CERN Director General Carlo Rubbia is made 'Officier de la Légion d'Honneur' by President François Mitterrand for his contributions to French science. Behind Carlo Rubbia is 1983 Nobel Prizewinner William Fowler, who also received the accolade.

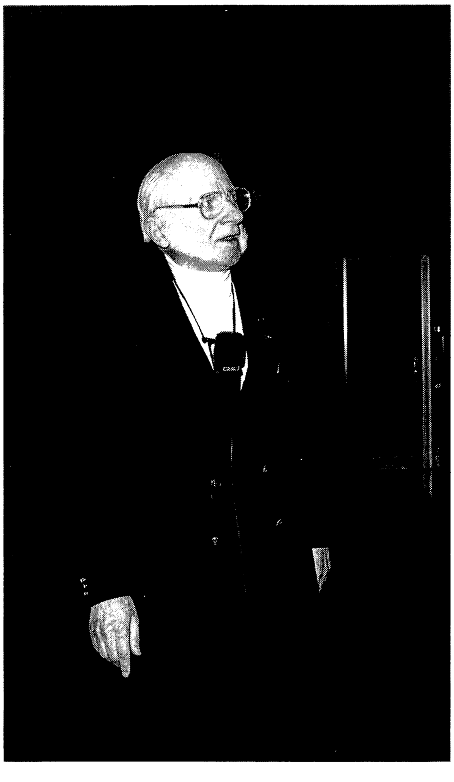
(Photo Présidence de la République française)

Cryogenic ion source

A cryogenic electron beam ion source (CRYEBIS) came into operation last year at the J.R. Macdonald Laboratory, Kansas State University, and went on to supply fully stripped argon ions for physics. The Laboratory studies atomic interactions using a range of ion energies.

CERN Courier index

This year, the index for the 1989 issues of the CERN Courier is not being distributed automatically to every reader. To obtain an index, write to Petra Pamblanco, Publications /DG, CERN, 1211 Geneva 23, Switzerland, fax Geneva 782 1906, bitnet monika at cernvm.cern.ch. Please specify whether you need the English or French version.



Books

The Experimental Foundations of Particle Physics, by Robert N. Cahn and Gerson Goldhaber of Berkeley, published by Cambridge University Press, uses reprints of some sixty classic papers to illustrate the advances of the past fifty years. Grouped into chapters with an accompanying introductory text, the papers make for informative reading by specialist and beginner alike.

Hans Dehmelt of Wahsington, who shared the 1989 Nobel Physics Prize with Norman Ramsey and with Wolfgang Paul (December 1989, page 23), visited CERN in December, where he gave a talk on 'Experiments with an isolated subatomic particle at rest.

TRIUMF

MESON RESEARCH FACILITY

University of Alberta
Simon Fraser University
University of Victoria
University of British Columbia

RESEARCH ASSOCIATE

University of Alberta,
Nuclear Research Centre,
Dept. of Physics

The Subatomic Physics group at the University of Alberta has an opening for a Senior Research Associate without fixed term. The successful candidate will be chosen from applicants with a Ph. D. in Physics and at least three years' demonstrated experience in detector design and construction and/or fast trigger electronics. Salary will be competitive and commensurate with experience, with a minimum of $33.000.00 (Cdn.) annually.

The group's interests include rare kaon decay tests of the Standard Model at Brookhaven, the spin structure function of the nucleon at HERA, parity violation and charge symmetry breaking at TRIUMF, elastic and inelastic NN scattering at TRIUMF, and photonuclear studies at the Saskatoon CW electron accelerator.

Candidates should send their resume and three letters of reference as soon as possible to:

Research Associate Search Committee, Nuclear Research Centre, The University of Alberta, Edmonton, Alberta, CANADA T6G 2N5.

The deadline for receipt of applications is **April 1, 1990** and the position will be filled as soon as possible thereafter.

We offer equal employment opportunities to qualified male and female applicants.

RESEARCH IN PARTICLE PHYSICS AT CEN - SACLAY

The Saclay High Energy Physics Department has a research programme at CERN, DESY and FERMILAB accelerators, as well as activities in the field of particle physics without accelerators.

The laboratory is offering a permanent position to a candidate with considerable experience in elementary particle physics. He should have proven his excellence in the field.

The candidate may wish to participate in one of the current or planned experiments within our programme or may establish a new experimental area here. The main features of the ongoing experimental programme are :

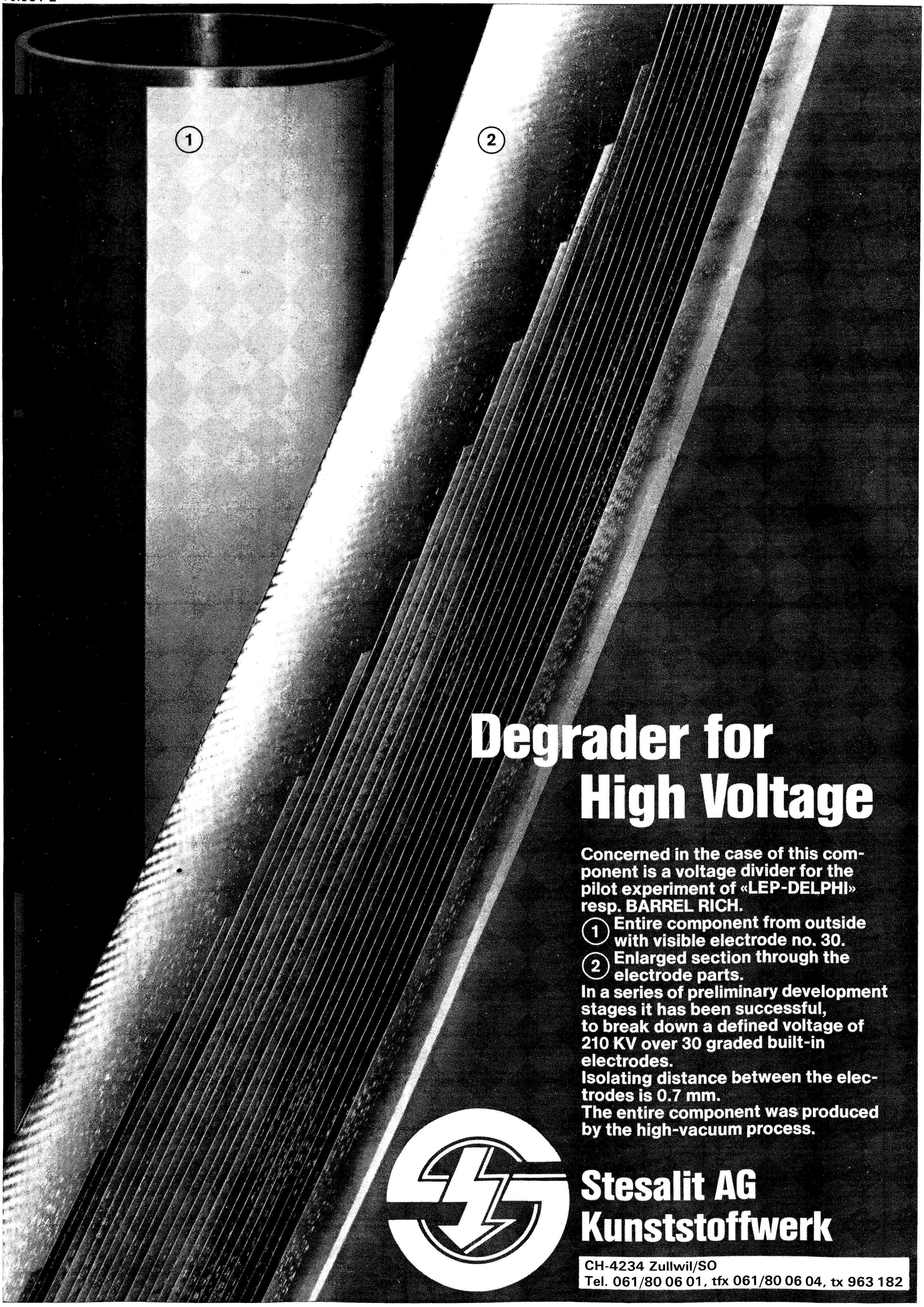
- at LEP : ALEPH, DELPHI, OPAL
- at the CERN : UA2, CP LEAR
- at DESY : H1
- at FERMILAB : D0 and E704

The non accelerator programme includes neutrino oscillations, solar neutrinos (Gallex), and dark matter searches.

Curriculum vitae and recommendation letters should be sent to ;

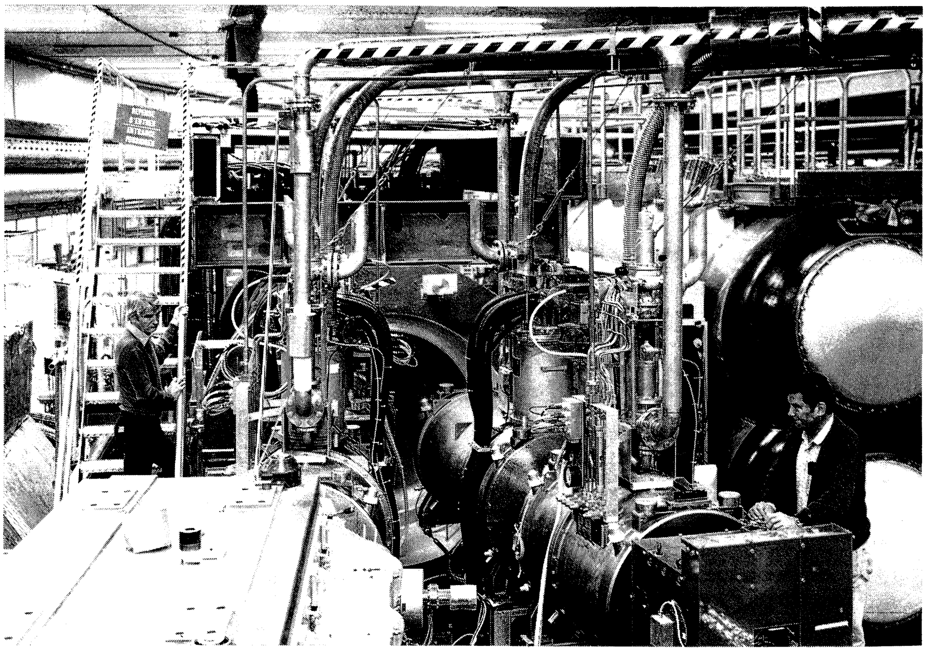
DPHPE/DIRECTION
CEN-SACLAY
91191 GIF / YVETTE CEDEX
FRANCE
Tel (33) 1 69 08 24 02
Telex PARTIC 603212F
FAX (33) 1 69 08 76 36

This position has to be filled in the year 1990


1
2
Degrader for
High Voltage
Concerned in the case of this component is a voltage divider for the pilot experiment of «LEP-DELPHI» resp. BARREL RICH.
1 Entire component from outside with visible electrode no. 30.
2 Enlarged section through the electrode parts.
In a series of preliminary development stages it has been successful, to break down a defined voltage of 210 KV over 30 graded built-in electrodes.
Isolating distance between the electrodes is 0.7 mm.
The entire component was produced by the high-vacuum process.
Stesalit AG
Kunststoffwerk
CH-4234 Zullwil/SO
Tel. 061/80 06 01, tfx 061/80 06 04, tx 963 182

1980 – Experiments preparing for CERN's Antiproton Project, Antiproton Accumulator tested. Plans for similar scheme tabled at Fermilab. Initial presentations of HERA at DESY and of LEP at CERN. PEP and VEPP-4 electron-positron colliders at Stanford and Novosibirsk respectively in operation. Radiofrequency quadrupole successfully tested at Los Alamos. CERN's Intersecting Storage Rings (ISR) give 62 GeV alpha-particle collisions. Jets not seen in fixed target, hadron beam experiments at CERN's SPS. ISR use a superconducting quadrupole to squeeze colliding beams. First workshops on experiments for LEP. Brookhaven's ISABELLE scheme for colliding 400 GeV proton beams pushes ahead.

1981 – Evidence for B mesons at Cornell's CESR ring. Herwig Schopper takes over as CERN's Director General from John Adams and Leon Van Hove. Volker Soergel takes over from Schopper as Director of DESY. Ten years of the ISR at CERN. TRISTAN electron-positron collider at Japanese KEK Laboratory approved for construction. PETRA electron-positron collider at DESY achieves collision luminosity of 10^{31} per sq cm per s. First proton-antiproton collisions in CERN's ISR (April). Stanford Linear Accelerator Center (SLAC) workshop for a new 'linear' collider (SLC) for electron-positron collisions using two-mile linac. First proton-antiproton collisions in CERN's SPS (July). LEP experiments workshop in Villars, Switzerland. Candidate proton decays reported in India. 50th anniversary of the Lawrence Berkeley Laboratory. Death of Hideki Yukawa. Initial results from CERN's SPS proton-antiproton collider. December Council session approves construction of LEP.

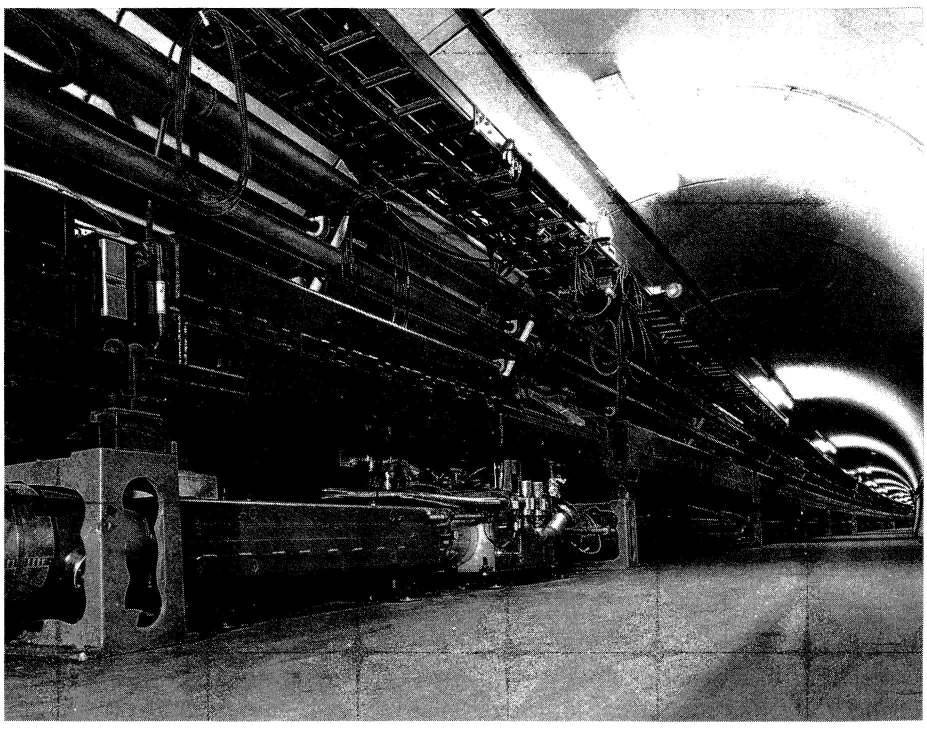


▲ *In 1980 CERN's Intersecting Storage Rings showed how a superconducting magnet (right) could squeeze beams to boost collision rates. The ISR were phased out in 1984.*

(Photo CERN 397.10.80)

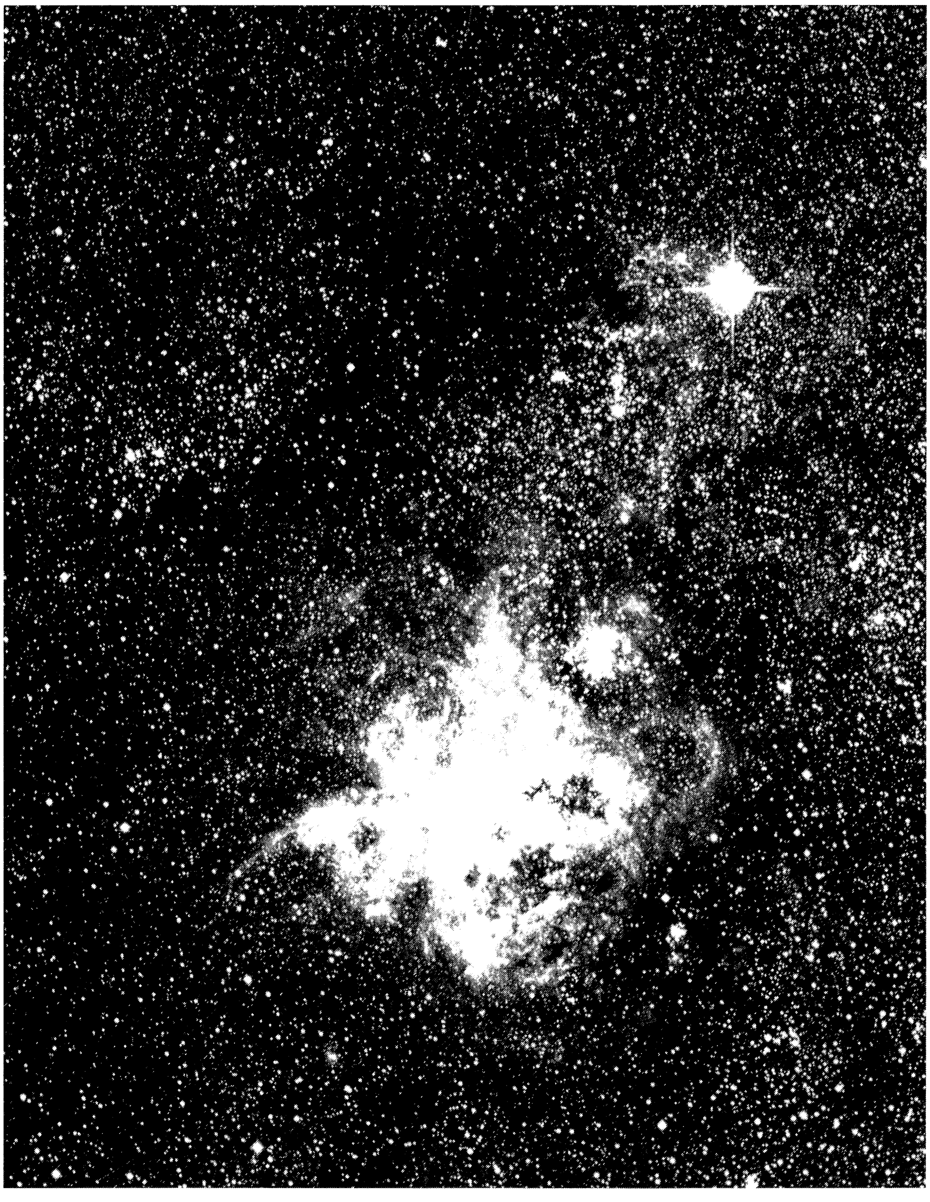
▼ *Fermilab's Tevatron (lower ring) – the world's first high energy accelerator based on superconducting magnets – came into operation in 1983.*

(Photo Fermilab)



24 February 1987 – a supernova explosion was just what was needed to cement the increasing links between particle physics and cosmology.

(Photo European Southern Observatory)



1982 – Nick Samios takes over from George Vineyard as Director of Brookhaven. Groundbreaking for TRISTAN. Report of magnetic monopole at Stanford. Pope visits CERN. Clean jet signals from experiments at the ISR and the proton-antiproton collider. Letters of intent for LEP experiments. European Muon Collaboration at CERN sees that quark content depends on nuclear environment – the 'EMC Effect'. Four experiments Aleph, Delphi, L3, and Opal selected for LEP. CERN proton-antiproton luminosity attains 5 x 10^{28}. Ken Wilson of Cornell receives Nobel Prize.

1983 – W boson found at CERN (January). Stanford experiment confirms EMC Effect using archive data. Initial go-ahead for HERA. ISABELLE renamed Colliding Beam Accelerator (CBA). Z boson found at CERN (May). Superconducting magnet installation complete for Fermilab's Tevatron. CERN proton-antiproton luminosity attains 1.6 x 10^{29}. Cosmologists and particle theorists get together. ITEP (Moscow) reports definite mass for electron neutrino. Fermilab Tevatron attains 500 GeV. Proton decay search turns pessimistic as problems of neutrino background loom large. Plans for experiments at HERA. Dalai Lama visits CERN. Spain rejoins CERN.

1984 – PETRA attains 45 GeV collision energy. John Adams dies (March). Final ISR run. Fermilab Tevatron attains 800 GeV, experiments underway. HERA funding approved. First workshop for proposed LHC proton collider using CERN's LEP tunnel. Construction of LEP experiments underway. Spin effects at Brookhaven. Half a century of weak interactions. Thirty years of CERN. Nobel Prize for Carlo Rubbia and Simon van der Meer at CERN. Wolfgang Panofsky retires as Director of Stanford Linear Accelerator Center (SLAC), succeeded by Burton Richter. First magnet work for proposed US Superconducting Supercollider (SSC). CBA at Brookhaven in 'cold storage'. Paul Dirac dies (October).

1985 – Discussions on HERA experiments. Groundbreaking for Beijing electron-positron collider. CERN proton-antiproton luminosity reaches 3.6 x 10^{29}, beam energy increased from 270 to 315 GeV, reaching 450 GeV in special runs. First LEP tunnelling machine begins work. 25 years of Brookhaven. Carlo Rubbia heads new working group on long-range future of CERN. Portugal joins CERN. Particle signals from Cygnus-X3. Initial antiprotons at Fermilab. TRISTAN and

SLC nearing completion. Kendrew Report in UK on CERN activities. SSC magnet design selected. Fermilab 1.6 TeV proton-antiproton collisions. CERN prepares for high energy heavy ion beams.

1986 – Ten kilometres of LEP tunnel complete. CEBAF project proposed in the US, KAON project in Canada. CERN Review Group set up under Anatole Abragam. Brookhaven goes for RHIC heavy ion scheme. New neutrino mass limits question ITEP result. SSC design goes to US Department of Energy. Zeus and H1 emerge as experiments for HERA. LEP injector supplies first beam. CERN's PS handles electrons and oxygen ions. SLC almost ready. First TRISTAN collisions at 50 GeV. PETRA machine closes. Questions on a 'fifth force'. LEP tunnelling hits water under the Jura mountains.

1987 – President Reagan approves SSC. Supernova (24 February). High temperature superconductor interest. First W at Fermilab. First SLC beams. Death of Louis de Broglie. CESR attains luminosity of 5×10^{31}. Jacques Chirac and Pierre Aubert install first magnet in LEP ring. TRISTAN inauguration. First magnets for HERA electron ring. Proposals for B factories. LHC magnet design. HERA tunnelling complete. Twenty years of SLAC. Forty years of pions. Sulphur ions accelerated at CERN to 200 GeV/nucleon. 43 site proposals for SSC. LEP embarks on crash installation programme. Forty years of Brookhaven. New neutral kaon results from CERN SPS. LAA project launched. Abragam report published.

1988 – New impetus to Soviet physics – UNK priority, VLEPP for Serpukhov. LEP excavation complete. Circulating beam in Beijing electron ring. Seven SSC sites selected. Richard Feynman dies. First SLC collisions. New results from EMC on quark spin. Beam injected into first LEP segment. Cooling rings commissioned at Indiana and Heidelberg. Viktor Weisskopf, Edoardo Amaldi 80. Nobel Prize for Leon Lederman, Jack Steinberger, Mel Schwartz. Texas selected for SSC site. CERN and Fermilab proton-antiproton luminosities exceed 10^{30}.

1989 – Carlo Rubbia takes over from Herwig Schopper as CERN Director General. Cold fusion interest. First Zs at SLC. Death of Emilio Segré. John Peoples takes over from Leon Lederman as Director of Fermilab. End of one-year Fermilab antiproton run brings harvest of Ws and Zs. First beam in LEP. Z mass and neutrino counting results from SLC. HERA electrons attain 27.5 GeV. Funding for SSC. Z mass and neutrino counting results from LEP. SLAC hit by earthquake. Nobel Prize for Norman Ramsey, Hans Dehmelt and Wolfgang Paul. LEP inauguration. Death of Edoardo Amaldi, Andrei Sakharov.

CERN's LEP electron-positron collider – delineating the 1980s.

(Photo CERN 138.1.89)

LEP inauguration

French President François Mitterrand on arrival at the LEP Inauguration Ceremony, after being greeted by CERN Director General Carlo Rubbia (left) and Council President Josef Rembser.

As briefly mentioned in the previous issue (page 1), 13 November saw the culmination at CERN of weeks of intricate planning to put together a fitting formal inauguration of LEP, CERN's 27-kilometre electron-positron collider. The day was to witness an event worthy of the many years of assiduous endeavour to bring into being the world's largest scientific machine, a prime example of international collaboration and the portent of a new era in fundamental research.

From early that morning, CERN had seen many unaccustomed visitors – bomb squads, riot police, marksmen..., the full panoply of security that attends top level delegations. For among the 1500 guests at the inauguration ceremony were Heads of State and Government and Ministers from CERN's fourteen Member States, together with representatives from the growing community of countries further afield involved in CERN's research programme.

Scene of the ceremony was the soccer-pitch size SM18 hall, built as an assembly shop for major LEP components, including its thousands of magnets, prior to their descent into the tunnel for final installation. For 13 November, SM18 had been decked out in full finery, hinting at the spectacle to come.

A fleet of buses ferried the guests, their CERN hosts and more than 200 press and media representatives from their assembly points to SM 18, where while waiting for the ceremony to begin they could follow the arrival of the VIP contingents outside via widescreen TV coverage, beamed also live across Switzerland and exported via Eurovision.

After being greeted by CERN Director General Carlo Rubbia and Council President Josef Rembser and introduced to prominent CERN personalities, the guests of honour admired a specially-mounted LEP exhibition, where much of the expertise and technology now hidden in the tunnel fifty metres below could be displayed and explained.

Shortly after eleven o'clock, the final convoy drew up. Two cars and eleven motorcycle outriders preceding a heavy black Citroen carrying the French tricolor, with ten lesser vehicles and an ambulance in its wake, announced the arrival of the large national delegation led by President François Mitterrand.

With the Member State principal representatives – Austrian Minister of Science and Research Erhard Busek, Belgian Secretary of State for Scientific Policy Pierre Chevalier, Danish Minister of Education and Research Bertel Haarder, Federal German Minister for Research and Technology Heinz Riesenhuber, French President François Mitterrand, Greek Ambassador Euripide Kerkinos, Vice-President of the Italian Council of Ministers Claudio Martelli, Princess Margriet of the Netherlands, Crown Prince Harald of Norway, Portuguese Secretary of State for Research and Technology Sucena Paiva, Spanish Minister for Education and Science Javier Solana Madariaga, King Carl XVI Gustaf of Sweden, President of the Swiss Confederation Jean-Pascal Delamuraz, and UK Secretary of State for Education and Science John MacGregor – on the rostrum, Carlo Rubbia, speaking in French, welcomed the guests before going on to review CERN's achievements.

'Today European physicists have ..... developed the most sophisticated instruments for research and CERN has become a centre of excellence of international importance

On the inauguration podium, left to right, Princess Margriet of the Netherlands, President Jean-Pascal Delamuraz of Switzerland, King Carl XVI Gustaf of Sweden, CERN Director General Carlo Rubbia, President Mitterrand of France, Crown Prince Harald of Norway, Vice President of the Italian Council of Ministers Claudio Martelli.

which has enabled Europe to resume its proper place, worthy of its traditions, in the exchange of international scientific knowledge,' he averred.

Going on to outline the development of CERN's research aims, Rubbia stressed the 'dynamism of innovative ideas' which have complemented technical achievements. When thinking turned to colliders as the main research tool, 'two complementary paths were open....CERN wisely took the decision to pursue both, successively.'

One path, the SPS proton-antiproton collider, led to the discovery of the W and Z bosons in 1983. 'Once the existence of intermediate bosons had been proved, the parallel path – LEP – assumed its full significance,' he affirmed.

Turning from physics to CERN's role in the world, the Director General accented the growing popularity of CERN as a world research centre, particularly for young physicists, and introduced a short video sequence highlighting both the youth and national diversity of CERN's science.

Looking to the future, with major projects being groomed in the US, the Soviet Union and Japan, Rubbia pointed to CERN's plan to capitalize on the LEP tunnel by installing a second, complementary, ring – LHC (December 1989, page 1).

'CERN's success must now be built on and decisions taken to consolidate it in the future and to blaze a trail for future successes,' he concluded.

King Carl XVI Gustaf of Sweden, speaking in English, looked to LEP's initial scientific discoveries, with the number of quark-lepton families now limited to three. 'But I am quite sure that (physicists) will not consider the limited number of quark-lepton families as a serious constraint on the future development of elementary particle physics,' he commented.

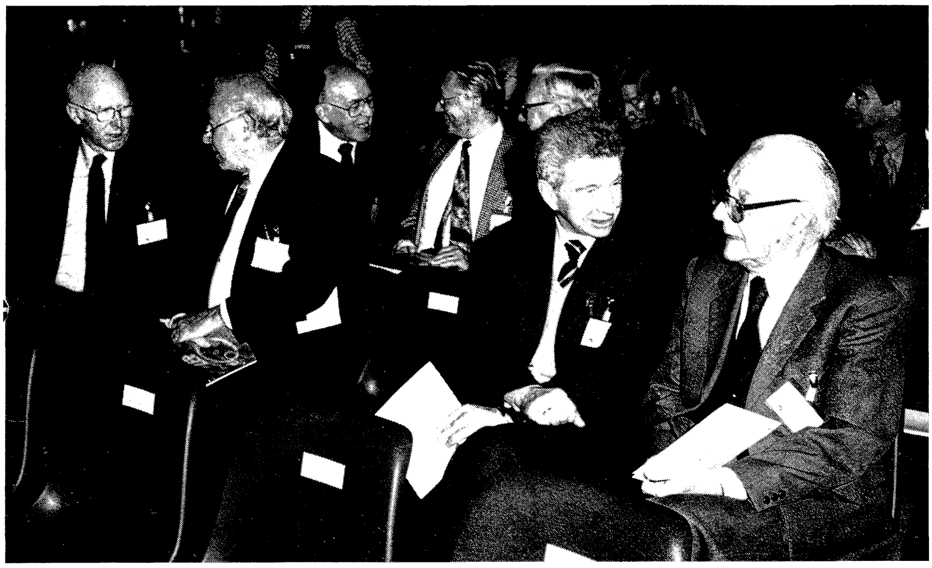
The King was also able to recall with pleasure his contact with CERN physicists through his role in presenting Nobel Prizes.

After the talent of its researchers and the power of its machines, CERN's success also lies in its role in creating a framework for European collaboration, concluded the King. 'Europe as a political idea can perhaps mean many different things, but Europe in terms of scientific endeavour is today a very real community.'

Jean-Pascal Delamuraz, President of the Swiss Confederation, emphasized the indefatigable march forward of science, catalysed by the spark of creative instinct and imagination which fires discovery. 'This teamwork, this explosion of

The buffet lunch for 1700 guests.

Among the guests: left to right- Alan Astbury representing Canada, Giorgio Salvini of Rome, Giacomo Morpurgo of Genoa, and CERN pioneer Edoardo Amaldi, visiting the Laboratory for the final time before his death on 5 December (see page 27).



so many imaginations,....' illustrates Europe's ability to play a dynamic role without losing the richness and diversity of its cultures. 'Scientists have always known how to look beyond frontiers,' he continued. As a symbol of European unity 'CERN is at the same time the oldest and the most lively...'.

The technological prowess which makes scientific projects like LEP possible, 'should be encouraged and supported by large-scale initiatives, open to participation by all nations,' he said.

French President François Mitterrand recalled the day just more than six years ago, 13 September 1983, when together with Swiss President at the time Pierre Aubert he had formally initiated LEP construction.

'Paradoxically, this collider buried a hundred metres underground constitutes a remarkable observatory of the Universe,' he declared, reflecting the growing links with between particle physics and astrophysics which have confirmed the 'brilliant intuition' that the microscopic structure of matter and the evolution of the cosmos were intimately related.

Enumerating the various problems facing humanity today, 'one asks sometimes if fundamental research in general, and CERN in particular, is not a luxury.....' the President asked rhetorically. 'There is no progress in biology without progress in chemistry and in physics, in chemistry without physics,....' he affirmed, going on to list some of the important spinoff benefits (X rays, lasers, superconductivity, transistors,....).

'Fundamental research,....complex and difficult, constitutes I believe one of humanity's most exalting adventures. It shows that when men of all races and cultures unite to fulfil their furthest ambitions, nothing is impossible,' he concluded.

Following the speeches, Emilio Picasso, Leader of the LEP Project since its approval by CERN Council in 1981 and with this onerous duty creditably discharged, offered the Director General the 'electronic key' – a diskette of computer code – to LEP.

Carlo Rubbia then invited each of the 14 Member State representatives to sign a declaration – 'This day, November 13 1989, in their presence and signatures the representatives of the 14 Member States of CERN have opened up the era of scientific experimentation with the LEP collider', the document and subsequent signatures being relayed to the giant screen above, to the discreet accompaniment of a wind ensemble under the direction of Luigi di Filippi.

The lights dimmed as the final item on the agenda was triggered. 'Electrons-Positrons', with music by French physicist and composer Jean-Claude Risset and animation by Richard Beaudemont, brought to life the ring of screens around the arena.

The public portion of the ceremony complete, the guests of honour broke into four contingents, each visiting one of the four LEP experiments, before coming together again for lunch at one of the CERN restaurants, catered by a team under the direction of French master chef Georges Blanc.

Away from the public eye and the TV cameras, but no less important for that, were the toasts and messages at the lunch. Carlo Rubbia paid tribute to his predecessor as Director General, Herwig Schopper, who from 1981 to 1988 oversaw the planning and preparations for LEP. 'Thanks to his constancy, drive and imagination,... we can be here today to celebrate the completion of a work which to the greatest extent was his own,' declared Rubbia.

Claudio Martelli, Vice-President of the Italian Council of Ministers, said that Europe must promote the necessary conditions to stay competitive in physics in the 90s, advocating a rigorous long-term study 'at the highest level of political re-

CERN Host State Presidents – François Mitterrand of France and Jean-Pascal Delamuraz of Switzerland.

sponsibility' to plan CERN's activities, and proposed a special meeting of Member State Ministers, which could take place in Italy towards the end of 1990.

Federal German Minister for Research and Technology Heinz Reisenhuber, speaking for the Member States, said 'we feel our responsibility for the future of this beautiful equipment'.

The extent of the research collaboration at LEP, extending far beyond the community of CERN Member States was underlined in the toasts by Finnish Minister of Education C. Taxell, R.A. Roe (Chairman of the US House of Representatives Committee for Space, Science and Technology), and Soviet Minister for Atomic Energy and Industry V. Konovalov.

Meanwhile other guests had migrated to the back half of the SM18 hall, there to enjoy a buffet lunch including specialities of all 14 CERN Member States, topped with a giant 380-kilo LEP cake, paraded round the hall under a travelling crane before being cut up.

The day, impeccably organized by a committee chaired by Robert Klapisch, went without a hitch. LEP had been switched off at only 6 a.m. that morning and was back in action the next day, taking the showpiece inauguration in its stride. By the end-year shutdown, the four LEP experiments had intercepted 100,000 Z particles.

Around the Laboratories

BROOKHAVEN
R&D for RHIC detectors

As Brookhaven prepares for construction of the Relativistic Heavy Ion Collider (RHIC), expected to begin later this year, research and development work for the project is in high gear.

For the past three years the Laboratory has been receiving R&D funds from the US Department of Energy to prepare the way for construction. A detailed conceptual design has emerged and the superconducting magnet designs have been tested in an extensive series of prototypes (September 1987, page 23). These magnets are now being readied for industrial production once the President and Congress give the green light, hopefully for fiscal year 1991.

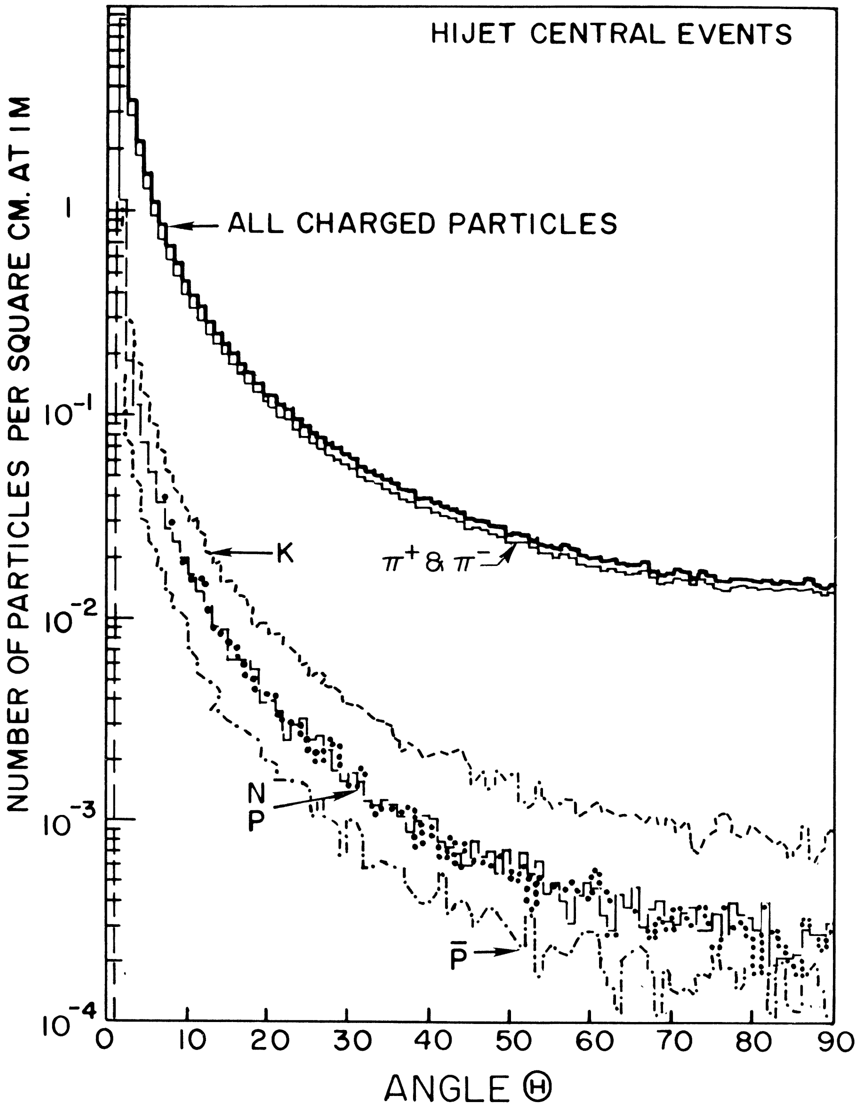
In the meantime preparations for experiments are underway, with a substantial part of the R&D effort being turned to detector development, shared widely among potential RHIC users, as some 17 groups responded to Brookhaven's call for proposals for detector R&D.

After review by a Detector Advisory Committee (P. Braun-Munzinger, Stony Brook; M. Breidenbach, SLAC; M. Gilchriese, SSCL; H. Gutbrod, GSI/CERN; R. Klanner, DESY; B. Mecking, CEBAF; and L. Schroeder, Berkeley, as Chairman) ten projects were funded, attacking the most pressing issues for detector R&D identified in RHIC workshops. These are the first steps on the long road to the first experiments at the collider – planned to begin in 1997. A call for proposals for major RHIC detectors should follow this year.

For 1989, detector development funding amounted to about a million dollars. This is expected to increase eventually to about 15 million dollars.

RHIC will collide beams of heavy nuclei at ultra-relativistic energies, subjecting nuclear material to extreme conditions where the familiar structure of neutrons and protons is expected to be fleetingly transformed into a 'plasma' of quarks and gluons.

Recording such events with sufficient sensitivity to pick up signals for new plasma phenomena will require extending known techniques for particle detection. With beam energies up to 100 GeV per nucleon and with ions containing 200 nucleons or more, the total



The challenge for detectors at the proposed RHIC heavy ion collider at Brookhaven – a simulation of the charged particle flux at one metre from collisions of gold ions carrying 100 GeV per nucleon.

energy per collision can reach up to 40 TeV, far beyond that of any present accelerator or existing detector.

Although the Superconducting Supercollider (SSC) will accelerate particles to this energy and produce hundreds of very high energy particles, the most interesting RHIC collisions are expected to produce tens of thousands of particles, with proportionately less energy carried away by each particle.

In addition to very high production levels, experiments in a heavy ion collider have to confront plasma signals from particles whose transverse momenta and thermal energies are relatively small, and similar to that of the background. This contrasts to hard scattering in particle colliders, where high transverse momentum triggers can cut out most of the background.

RHIC detectors will require new approaches to tracking, calorimetry, particle identification, fast trigger decisions and on-line data processing. In a series of workshops over the past five years, a number of ideas and concepts have emerged and subsequent development work has identified specific targets to attack.

One of the most urgent and universal needs is in the area of readout electronics. Here, RHIC poses two principal challenges. The first is the short time between bunch crossings, 114 nanoseconds compared with the several microseconds enjoyed by today's colliders. RHIC (like future particle colliders), will need to store analog signals while trigger decisions are made.

The second challenge is the very large number of channels to be read out, upwards of 10^4 per detector. Handling such a vast number of detector elements by conventional techniques, if not prohibitive in cost, would severely constrain the detector configuration due to the sheer size and mass of the cabling.

In response to these challenges, a number of groups have proposed developing compact, low-power, low-cost circuits using VLSI techniques to store signals in analog memory devices on a small chip – rather than in a long cable – and make it possible to amplify, store, and ultimately digitize data directly on the detector, with serial transfer of 'processed' signals to storage only after several levels of trigger decisions.

The basic technologies exist, and to produce circuits matched to RHIC's requirements will take the coordinated efforts of a number of research centres over 4-5 years. This is clearly a high priority item.

Experiments with ion beams both at Brookhaven and CERN have emphasized the importance of 'energy flow' measurements using fine-grain calorimetry over large solid angles, and of particle identification, distinguishing for example protons and kaons from the large numbers of pions produced. These methods are expected to have equally important roles in RHIC where, in contrast to fixed-target experiments, most of the particles of interest will have rather low momenta. This poses formidable problems which are not being attacked in the detector development work for other high energy collider schemes, such as the Italian-funded LAA effort at CERN or the SSC detector R&D in the US. The detailed response of calorimeters to large numbers of low energy particles,

The control room for Brookhaven's AGS synchrotron has been remodelled and expanded to cover all linked machines (Linac, Booster). It features five general purpose consoles based on networked Apollo workstations, plus a special safety console (centre rear). In the foreground are AGS operations head Peter Ingrassia (left), and AGS controls section head Don Barton.

and the development of time-of-flight and ring-imaging Cherenkov techniques capable of handling very high particle densities as well as rates, are examples.

Important RHIC measurements will centre on the lepton pairs radiated electromagnetically from inside a volume of dense hadronic matter. These measurements are also among the most difficult, as the relevant lepton pair masses and transverse momenta are not large enough to be easily separated from the background due to pion decays.

At RHIC workshops complementary lepton pair scenarios have been worked out – one involving electrons and the other muons. For efficient electron pair measurements in the high multiplicity environment it may be possible to apply the 'hadron-blind' detection technique using light, highly segmented ring imaging Cherenkov counters with a suitable radiator. Such a device is being developed for a heavy ion experiment at the CERN SPS, but collider application would require considerable further development. A RHIC dimuon experiment could consist of a carefully designed instrumented hadron absorber surrounding the collision point, followed by detectors to track penetrating muons.

From T. Ludlam

First results from ATF electron gun

Brookhaven's Accelerator Test Facility (ATF – April 1987, page 21) passed a major milestone last year when it produced its first beam of photoejected electrons. With the initial phase of construction completed later this year, the ATF should provide a low emittance beam of 50 MeV electrons for studies of new radiation sources and advanced accelerator concepts.

The major components of the ATF are the electron gun, low energy beam transport, linear accelerator, laser systems, and synchronization systems. The electron gun uses a laser-irradiated yttrium photocathode on one of the end walls of a radiofrequency cavity with a 2856 MHz standing wave. The configuration is designed so that the electrons are emitted when the electric field is nearly maximum so that the bunch reaches relativistic velocities as soon as possible. The design goal calls for a field of 100 MV/m on the cathode to help control space-charge blow-up of the emittance.

In its initial configuration the bunch leaving the gun passed through a quadrupole triplet to capture and focus the beam, followed by a 90-degree bending magnet, a quadrupole singlet, momentum slit, profile monitor, and Faraday cup. The initial energy of the electrons exiting the gun was 3.6 MeV.

When the necessary construction is complete, the low energy injection system will take the beam from the r.f. gun and bend it through two 90 degree-dipoles into the linac, allowing the laser light to follow the electron beam axis to the photocathode.

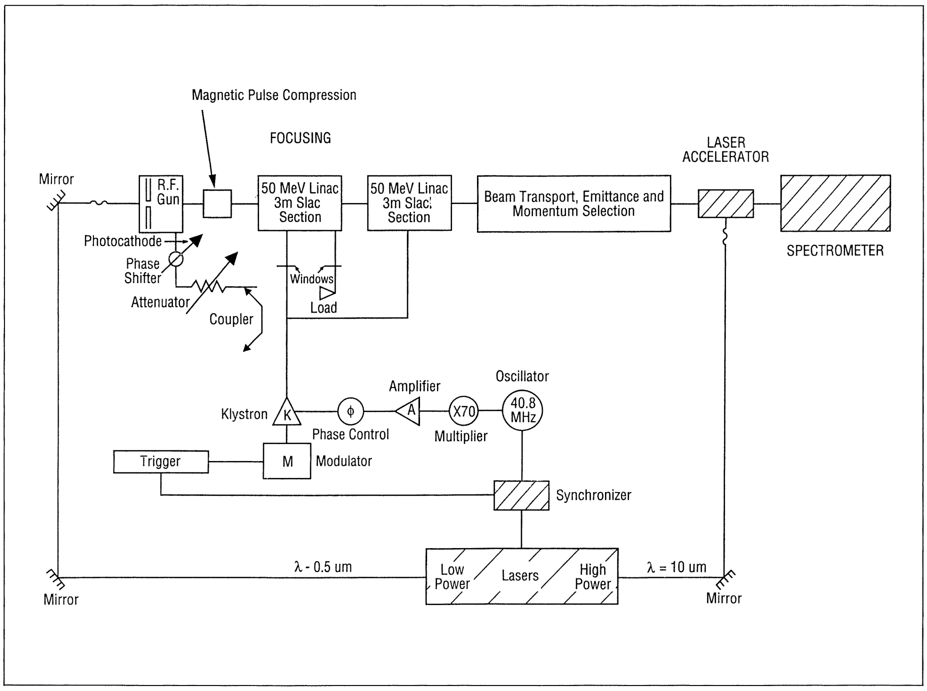
Power for the linac sections and the r.f. gun is supplied by a single 20 MW klystron, provided by SLAC. The modulator was assembled on-site using several important components from SLAC. The system can run at repetition rates up to 6 Hz.

At least three types of experiments for the ATF have been discussed or are under construction. Prominent are investigations of new methods for particle acceleration, including laser acceleration and focusing of electrons using 10-micron etched silicon structures, to allow a longitudinal electric field near the electron beam trajectory. Another experiment studies the inverse of the acceleration mechanism (Smith-Purcell effect). Other proposals cover acceleration using the inverse free electron laser, inverse Cherenkov and switched power approaches.

A second class of experiments concentrates on coherent radiation. A free electron laser (FEL) study will use an 8 mm-pitch superconducting microwiggler to produce visible light. Other FEL experiments are under discussion.

The third type of experiment looks at fundamental photon-electron physics, including measurements of the non-linear Thomson scattering of an electron meeting an intense laser focus head-on.

Schematic of the electron and laser beam systems at Brookhaven's Accelerator Test Facility (ATF). The low-power (YAG) laser simultaneously produces photoelectrons in the r.f. gun and selects a portion of the high power (CO_2) laser pulse for experiments.

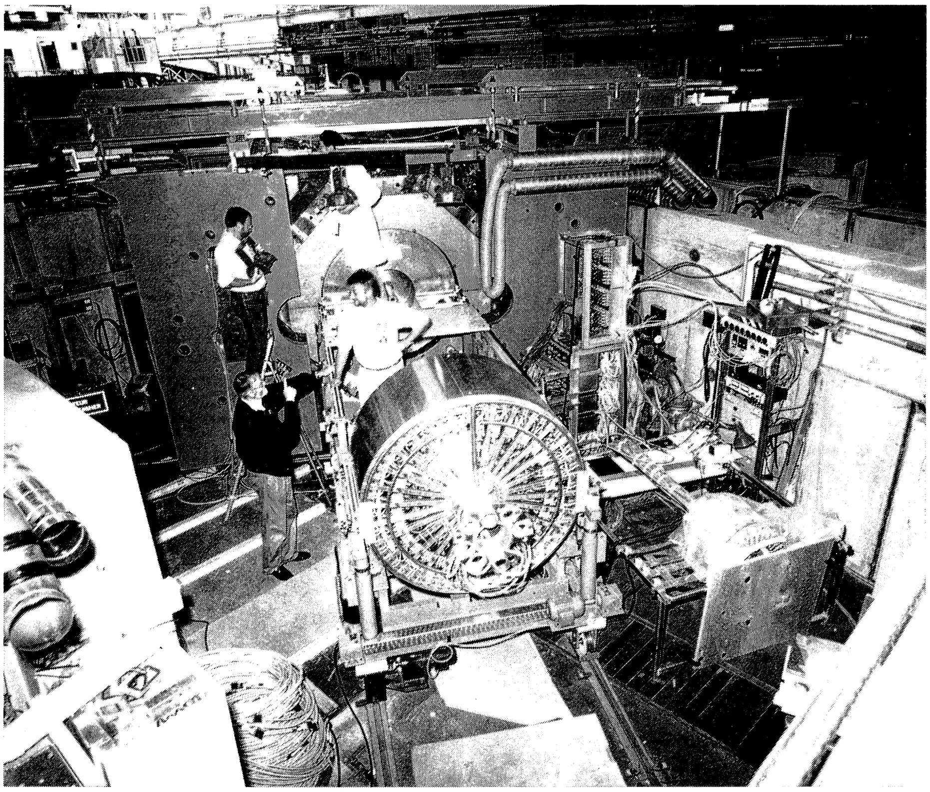


Electron beam R&D

The technological problems of producing 1 TeV electron beams are under attack at Laboratories all over the world, and new facilities are under construction to provide testbenches for novel techniques. As well as the Accelerator Test Facility at Brookhaven (see accompanying article), a Test Accelerator Facility is under construction at the Japanese KEK Laboratory (November 1989, page 13). At CERN, the long-term goal of a CERN Linear Collider (CLIC) is steadily being pushed, and a CLIC Test Facility (CTF) is being built to house experiments on laser techniques for a CLIC driver beam, and on 30 GHz radiofrequency generation. At the Stanford Linear Accelerator Center, a Final Focus Test Beam will use the business end of the SLC Stanford Linear Collider to look at the problems of making and monitoring sub-micron beams. At Argonne, accelerator studies with an electron linac have given significant results (June 1988, page 16). In the Soviet Union, a branch of the Novosibirsk Institute of Nuclear Physics has been established at the Institute for High Energy Physics at Serpukhov, near Moscow, scene of the construction of the multi-TeV UNK proton machine. The aim is to develop a linear electron-positron collider, VLEPP, alongside UNK, initially to provide 500 GeV beams for 1 TeV collisions, but with the door open for an upgrade to 1 TeV per beam. Complementing these projects is a healthy level of international collaboration.

The Crystal Barrel detector at CERN's LEAR low energy antiproton ring, showing the cesium iodide calorimeter withdrawn from the magnet.

(Photo CERN 306.8.89)



CERN
Crystal barrel in action

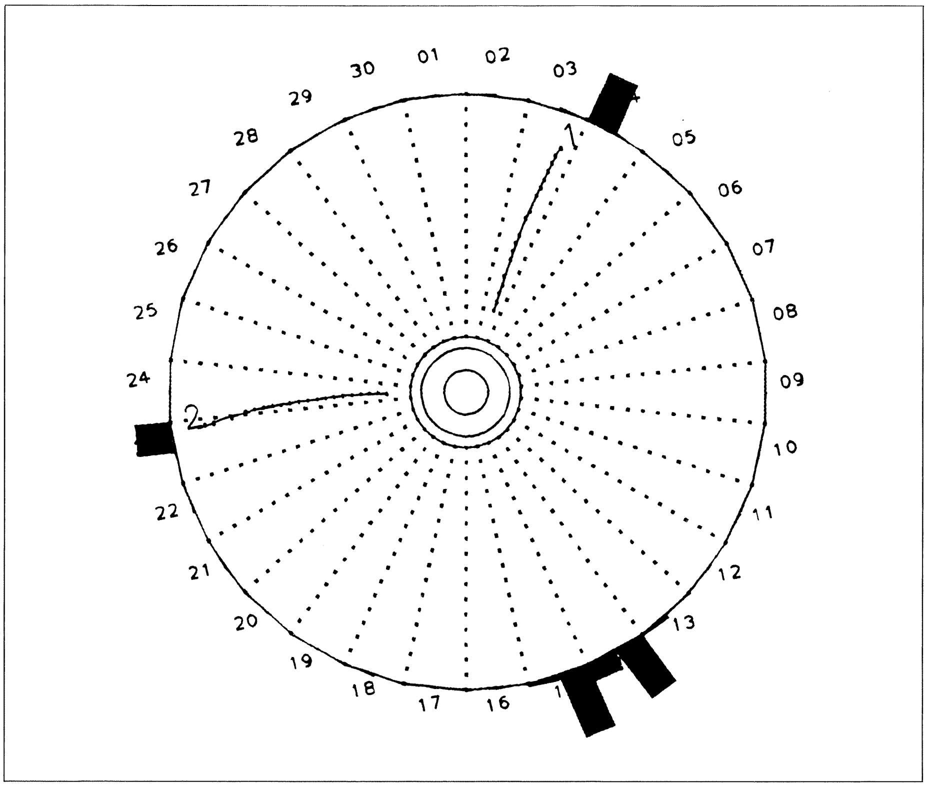
Three years after the start of the project, the Crystal Barrel detector at CERN's LEAR low energy antiproton ring has taken its first batch of data.

The Crystal Barrel team (a Berkeley/CERN/Hamburg/Karlsruhe Mainz/Munich/Queen Mary (London)/Rutherford/Strasbourg/UCLA/Zurich collaboration) aims at a detailed study of proton-antiproton annihilation, especially for the production of neutral particles.

Covering the complete solid angle and sensitive to both charged and neutral particles, the Crystal Barrel is one of a new generation of magnetic detectors using crystal calorimetry to pick up the energy deposited by emerging particles, and the first of its kind to be used in low energy proton-antiproton physics.

LEAR's 200 MeV/c antiprotons annihilate in the detector's liquid hydrogen target, surrounded in turn by two cylindrical multiwire proportional chambers with a total of 300 wires (for fast triggering on charged particle multiplicity) and by a 690-sense-wire cylindrical jet chamber to measure charged particle momenta. Energy loss in the chamber differentiates pions from kaons up to 500 MeV/c.

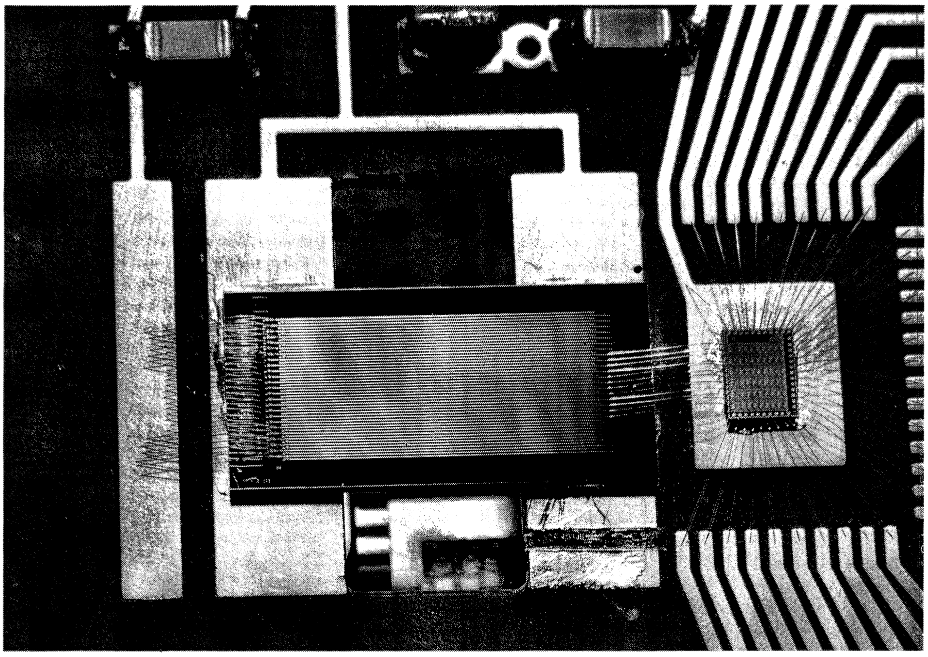
The chambers are embedded in a cesium iodide electromagnetic calorimeter made of 1380 individually-sealed crystals, each read out



End-on view of a low energy proton-antiproton annihilation into two charged and one neutral pion as seen in the jet drift chamber of the Crystal Barrel detector, showing the tracks of the two charged pions. The towers show the energy deposited in the cesium iodide.

An active pixel detector readout chip developed at CERN in the framework of the Italian funded LAA project has given promising results. The chip (right) is seen mounted on a test board with a small silicon microstrip detector. Signals from particles passing through the 100-micron strips are picked by electronics in the 200 micron cell. The wire bonds connecting the 12 strips to the pixel can just be seen.

(Photo CERN 3.10.89)



by a single photodiode mounted on the side of a wavelength shifter. Efficient light collection gives good energy resolution (4 MeV at 100 MeV) and resolution to within two degrees, even for low energy photons. Covering 98% of the solid angle, the calorimeter gives good reconstruction of annihilations, even when large numbers of particles are produced. The surrounding coil provides a magnetic field of 1.5 tesla along the beam.

Handling charged particles as well as photons, Crystal Barrel gives a reconstruction of all annihilations, including those where several neutrals (pions or etas) are produced. This should help in the search for new meson states, including those containing gluons instead of or in addition to the conventional quark constituents (glueballs and hybrids respectively).

The first physics run last October intercepted two million proton-antiproton annihilations. As well as boosting the data supply, future runs will use multiplicity and photon pair mass triggers to select interesting events. Runs with hydrogen gas and deuterium targets, as well as with antiprotons in flight (up to 2 GeV/c) are planned to extend the range of the studies.

Smart pixel detector

With the big proton colliders now on the drawing board aiming to provide very high collision rates, the problem facing detector specialists is to develop new techniques to make the most of these rates.

For particle tracking, these techniques must supply fine enough resolution to pinpoint individual particle tracks inside concentrated jets, with micron precision in three dimensions, capable of operating within a hundred or so nanoseconds, and with low power consumption, at the same time standing up to the incessant bombardment by high energy particles and radiation. A tall order.

One line of attack being explored uses silicon arrays, which have already shown their worth for precision tracking in the form of silicon 'microstrips', or as CCD pixels (May 1986, page 3).

In the context of the Italian-funded LAA project at CERN, a CERN/Lausanne (EPFL)/Zurich (ETH) team have developed a readout chip, with 'smart' elements only 200 microns across, which, coupled to a silicon matrix pixel array, would provide a potentially very powerful detector.

The smart elements each contain active circuitry to pick up the typical 10^4 electrons (1.6 fC) which would be generated by a charged particle passing through 120 microns of silicon. Using only 30 microwatts, signal processing gives a single-bit output signal for a fast trigger and selective readout.

This smart pixel approach has great potential for particle physics progress beyond more conventional charge-accumulation devices now used for solid-state imaging, requiring large numbers of cells to be scanned before extracting position information.

The circuitry, coupled to the pixel detector chip by modern 'bump' bonding, consists of a micropower analog amplifier, a latched comparator (for synchronization and timing) and an addressable digital memory element.

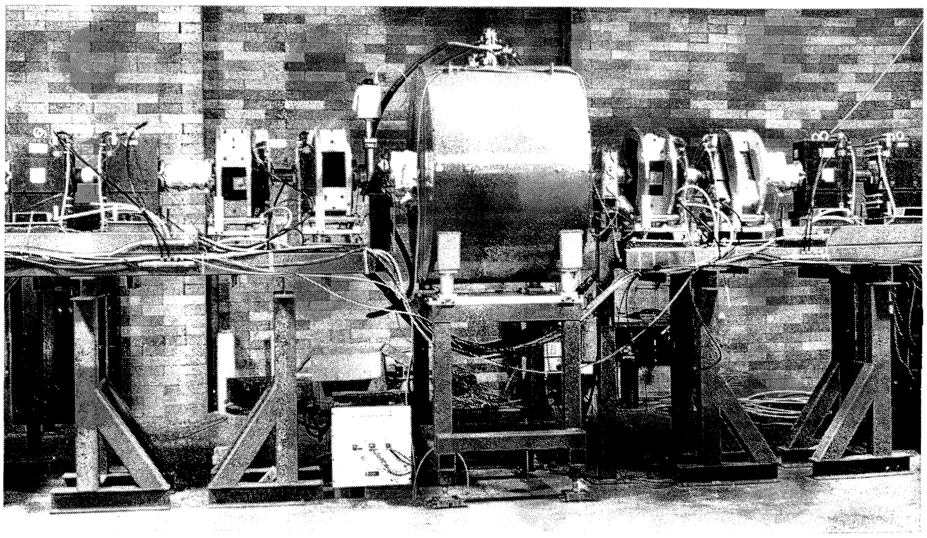
Output signals can be produced every 200 ns for each pixel element, reducing dead time. To simulate some future collider conditions, input pulses corresponding to 10^4 electrons were applied, and with 30 ns clock pulses at 10 MHz for timing, output signals were available within 100 ns.

In radiation tests minimum ionizing particles were easily picked up, while even low energy X-ray signals (10-20 keV) dominate over noise, estimated equivalent to less than 400 electrons.

Other pixel developments are underway, notably at Stanford and at Berkeley, in the context of vertex detectors for the Superconducting Supercollider (SSC) to be built in Texas.

This LAA-funded development at CERN is a good example of the innovative techniques required for physics at the big machines expected to come into operation towards the end of the decade.

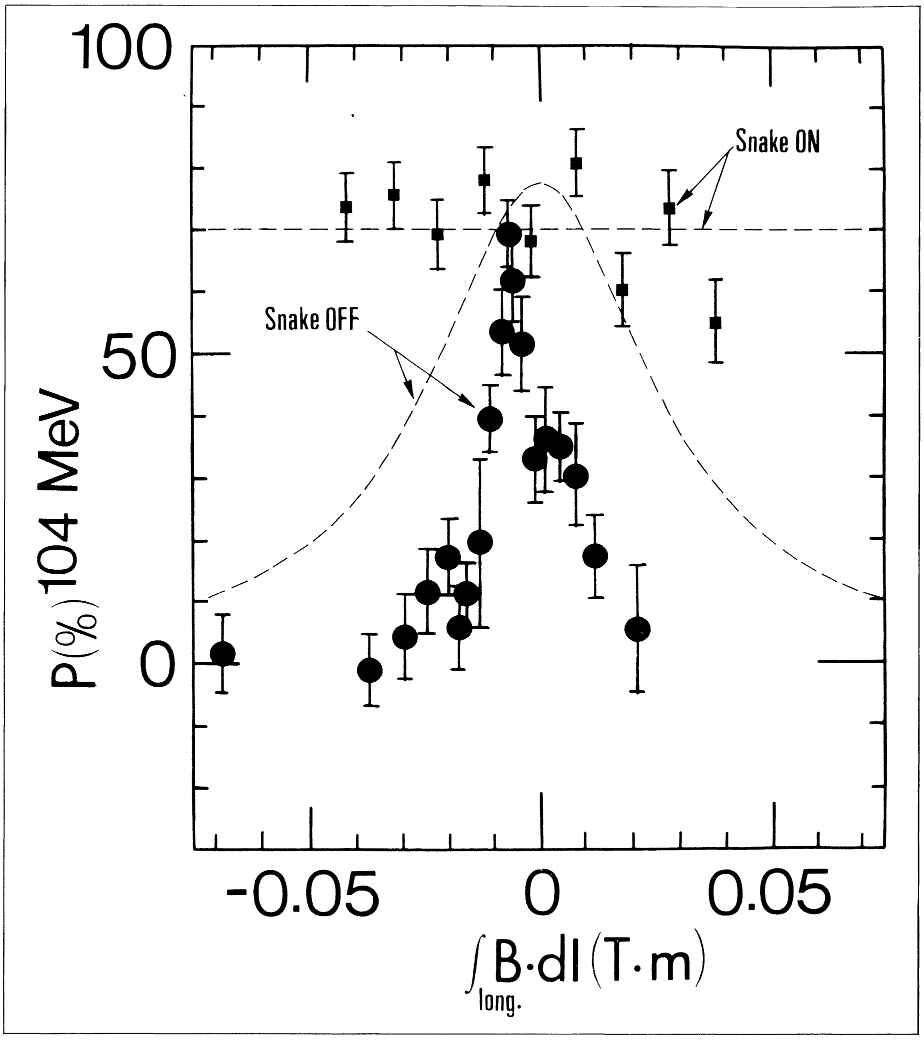
The Michigan/Indiana Siberian Snake in the Indiana University Cooler Ring. The large central superconducting solenoid which rotates the spin direction by 180° is flanked by eight quadripoles to correct the beam orbit distortions caused by the strong solenoid.



INDIANA
Siberian Snake saves spin

A team working at the Indiana University Cooler Ring (July/August 1988, page 13) has used a 'Siberian Snake' system to accelerate a spin-polarized proton beam through two depolarizing resonances with no loss of spin. The Michigan/Indiana/Brookhaven team under Alan Krisch overcame their first imperfection resonance hurdle at 108 MeV, and in a subsequent run vanquished a further resonance at 177 MeV.

First proposed by Yaroslav Derbenev and Anatoli Kondratenko of the Soviet Novosibirsk Laboratory in 1974, the Siberian Snake idea is to rotate the spin through 180° on each turn in the ring. With these successive spin flips, the depolarizing effects encountered in one turn should be cancelled by an equal but



Variation of beam polarization in the Indiana ring with imperfection magnetic field just below a depolarizing resonance at 108 MeV, showing how the sharp polarization change is overcome by the 'Siberian Snake' spin flip system.

opposite effect on the subsequent turn.

The success points towards polarized proton beams at higher energies. Classically, depolarizing resonances had to be eliminated one at a time in hours of tricky work at Argonne, Brookhaven, KEK and Saclay. However with the US Superconducting Supercollider (SSC) promising tens of thousands of such resonances en route to 20 TeV beams, an alternative approach was called for.

The 6.3-metre straight section in the Indiana Cooler provided just enough room for the 6-metre Snake. Following this success, Indiana is looking at the idea of a 15-20 GeV Light Ion Spin Synchrotron (LISS) with Siberian Snakes maintaining the beam polarization. Meanwhile Krisch and the Michigan group have signed an agreement with Soviet scientists to participate in the Neptun-A experiment at the UNK proton ring being built at the Institute for High Energy Physics, Serpukhov, near Moscow. Neptun vill use a polarized proton jet target in the unpolarized UNK beam.

Organizers and some speakers from the recent US National Workshop on Accelerator Instrumentation, held at Brookhaven. Standing, from left – Marc Ross, Stanford Linear Accelerator Center; Oscar Sander, Robert Shafer, Los Alamos; Gregory Stover, Berkeley; Gerald Bennett, Brookhaven, organizing committee co-chair; seated, from left – John Galayda, Brookhaven, invited speaker; Marvin Johnson, Fermilab, invited speaker; Olin Van Dyck, Los Alamos; James Hinkson, Berkeley; Richard Witkover, Brookhaven, organizing committee co-chair; Robert Weber, Fermilab. Missing from the picture is Joan Depken, Brookhaven, workshop secretary.

WORKSHOP
Keeping track of particle beams

How to monitor the beam in a particle accelerator – to measure beam position, intensity, profile, transverse and longitudinal emittance, and losses – was the topic of the first US National Workshop on Accelerator Instrumentation, at Brookhaven in October. Sponsored by the US Department of Energy, the meeting drew more than a hundred physicists and engineers from other national labs and from industry.

Lectures reviewed the fundamentals and described some advanced implementations. Dick Talman (SSC) covered beam current measurement, illustrated by Klaus Unser's DC current transformers from CERN. Bob Shafer (Los Alamos) followed with electromagnetically-coupled beam position monitors; advanced implementations, such as those at Fermilab, reach 10-100 micron resolution.

Beam profile measurements were covered by John Galayda (Brookhaven), especially the non-intercepting high-resolution methods for synchrotron radiation sources. Measurement of particle distribution in energy and phase was described by Bob Webber (Fermilab), with a detailed explanation of how to achieve 6 GHz bandwidth in a wall current monitor.

Transverse emittance measurement methods were examined by Oscar Sander (Los Alamos), including studies from intense beam machines. Finally, beam loss measurements by radiation detection were detailed by Marvin Johnson (Fermilab).

Another goal at the meeting was to promote inter-Laboratory collaboration, industrial involvement, and standardization. A panel discussion including representatives from major Laboratories and from industry revealed that direct instrumentation costs, at 1-2% of total accelerator plant investment, has been too small to focus management's attention or to attract major businesses. This may change when development and support costs are considered, especially for projects such as new synchrotron radiation sources, which may come without a ready supply of detector specialists, or a project on the scale of the US Superconducting Supercollider (SSC).

With US spending on accelerator construction now booming (about a billion dollars annually), the time may be ripe for commercial production of NIM- and CAMAC-like readout electronics. A representa-

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tive of the US Department of Energy reviewed the DOE seed-money programme for attracting industry into this field.

The workshop should become an annual event.

NEUTRINOS
Heavy water detector

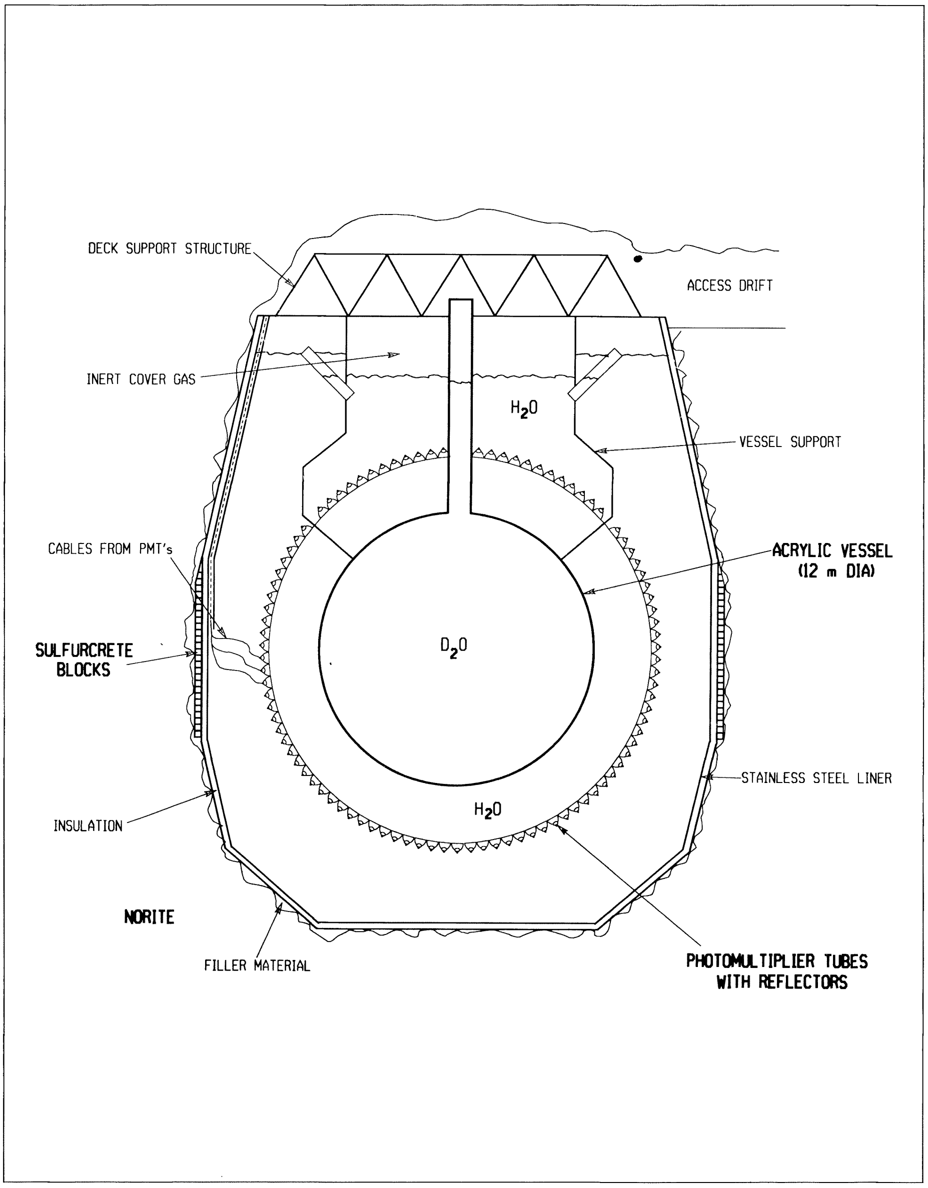
The proponents of the Sudbury Neutrino Observatory (SNO) received a welcome Christmas present when William Winegard, Canadian Minister for Science and Technology announced the final details of the funding for this project, totalling 48 million Canadian dollars and including contributions from the US and the UK.

The SNO experiment will extend significantly the study of solar neutrinos, using some 1,000 tonnes of heavy water to be installed more than two kilometres below ground in a nickel mine at Sudbury, ntario.

Until recently, the only detector homing in on neutrinos from the sun was the 600-tonne tank of chlorine-rich dry cleaning fluid used by Ray Davis' team in the Homestake mine in South Dakota.

Picking up solar neutrinos through induced transformations of chlorine nuclei into argon, the detector does not see the level predicted by confident calculations of solar neutrino processes. In a scenario of modern physics which otherwise looks very neat, this 'solar neutrino puzzle' needs to be explained.

Recently the Japanese Kamioka underground experiment, using specially developed 20-inch photomultipliers to pick up Cherenkov radiation from neutrino-electron



Design for the new Sudbury Neutrino Observatory to be built 2000 metres underground in a Canadian nickel mine, showing the inner heavy water target vessel surrounded by the ordinary water vessel and banks of photomultipliers.

scattering in a 2000-tonne water target, has begun to provide an alternative source of solar neutrino information. Sensitive to all kinds of neutrinos, (the chlorine transformations in the Homestake mine experiment are triggered by only electron-type neutrinos) and in addition giving directional information, Kamioka nevertheless confirms the result of the pioneer experiment.

As well as scattering off electrons (as in the Kamioka study) to give information on the neutrino flux, electron neutrinos encountering the Canadian heavy water target could also transform the nuclear deuterons into proton pairs, releasing an electron. This particle would carry off most of the neutrino energy and would provide valuable spectral information.

However neutrinos (of all types) hitting a deuteron could also break it up into a proton and a neutron. This reaction will be monitored by detecting the results of the energetic gamma rays following the capture of the released neutron.

Thus the Sudbury scheme will provide important additional neutrino information. Sensitive to all neutrino types, it will probe the possibility of neutrino 'oscillations' – under certain conditions, neutrino types may not be immutable, but may switch back and forth, providing an alternative scenario, if not an explanation, for the solar neutrino problem.

Oscillations would show up by comparing the flux of electron- and other types of neutrino. If, as has been suggested, these neutrino transitions occur deep inside the sun, this would be reflected in the shape of the spectrum.

The Sudbury underground detector is expected to pick up about 10,000 neutrino interactions per year, with the resulting light flashes recorded by an array of 2,000 large photomultiplier tubes. Construction and installation will take about five years.

In the Italian Gran Sasso underground Laboratory (May 1987, page 26), other new detectors using sophisticated materials and detection techniques are being prepared to provide additional new insights into the nuclear mechanics of the sun's interior.

LISBON
Supercomputer for Portugal financed from 'CERN Fund'

A powerful new computer is now in use at the Portuguese National Foundation for Scientific Computation (FCCN Lisbon), set up in 1987 to help fund university computing, to anticipate future requirements and to provide a fast computer at the National Civil Engineering Laboratory (LNEC) as a central node for remote access by major research institutes.

Taking into account especially the requirements of Portuguese physicists involved in research at CERN, a specification was drawn up for a 10 Mflop, 32 Mbyte scientific machine operating under UNIX. After proposals from most major computer manufacturers, a solution based on a Convex C220 supercomputer was selected, and passed its acceptance tests at the end of September.

As well as high energy physics, the machine will also cater for computational mechanics and molecular chemistry, and serves as the central node of the Network for the National Scientific Community (RCCN), using both dedicated and public lines.

After Portugal became CERN's fourteenth Member State in 1985, the country's annual contributions to the Organization's budget increase gradually over ten years to the full amount specified by CERN's Convention. During this time, the difference between the actual and full contribution levels is earmarked (the Portuguese 'CERN Fund') for the development of particle physics in Portugal, so that the country's physicists can make full use of the Laboratory's resources, and for projects where Portuguese researchers on other areas (electronic welding, fast electronics, geodesy,....) can benefit from CERN know-how. Most of the money for the new supercomputer came from this Fund, where it was first mooted by the Fund's Scientific Committee in 1986.

The Committee, with a balanced membership from CERN and Portugal, and with a tradition of public presentations, has been a driving force in the administration of the Fund.

25 years at Trieste

Towards the end of October 1964, the International Centre for Theoretical Physics (ICTP) came formally into being in Trieste. With less than 200 scientific visitors in its first year, the Centre, under the inspired Directorship of Abdus Salam and supported by the International Atomic Energy Agency (IAEA), UNESCO, and Italian national and regional authorities, has grown into a veritable world centre of scientific excellence, attracting over 4000 active researchers each year.

In 1960, a chance meeting with Trieste Professor Paolo Budinich convinced Salam that this city, sited in the far north-eastern corner of Italy but with a vivid international political history, was a highly appropriate place for an illustrious scientific future.

The establishment of the centre was approved at the 1962 General Conference of the International Atomic Energy, and subsequent local and national support enabled the new Centre to move into temporary headquarters in 1964.

In the mid-60s, Trieste research concentrated on particle physics and plasma physics, but over the years as interest, support and accommodation have expanded, these interests have widened to give a truly multidisciplinary centre with active groups in fundamental physics, condensed matter physics, mathematics, climatology, aeronomy and microprocessors.

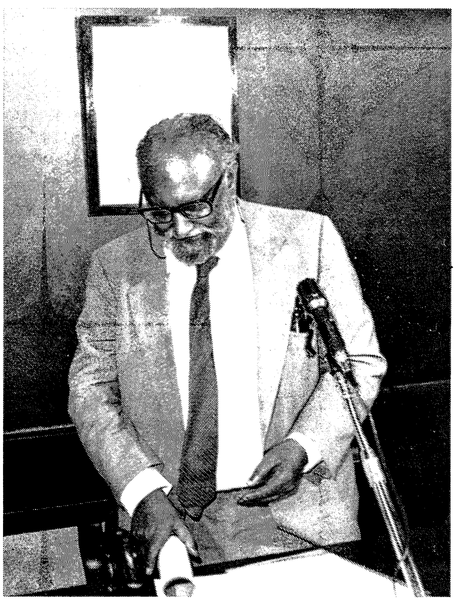
In the past ten years, the emphasis on practice and experimental work has increased. In 1987, the first physics instrumentation school, organized by the Instrumentation Panel of the International Committee for Future Accelerators (ICFA) took place at ICTP.

Questioned about the role of the Centre, Salam speaks frequently of his experience when, after his promising early research career at Cambridge and Princeton, he decided to return to his homeland and the newly created country of Pakistan. After several years of largely fruitless efforts, he felt stifled and isolated by the intellectual loneliness which besets scientists cut off from the main stream of modern research.

This experience helped seed the idea for the Trieste centre, where kindred spirits from developing countries far and wide could regroup to replenish their ideas and motivation to return refreshed and inspired to their work.

A statement by Robert Oppenheimer underlines this motivation – 'we have all of us to preserve our competence in our own professions, to preserve what we know intimately, to preserve our mastery. That is, in fact, our only anchor in honesty.'

Fond of parallels, Salam often cites the example of the pre-renaissance world, when modern geographical roles were somewhat reversed. The thirteenth century saw intrepid scholars like Michael the Scot, who ventured far from the familiar but impoverished confines of his home glens to seek out and ascend the scholastic heights of the Arab University of Toledo in Spain, there to leave his mark on the research of the day.



Despite the immense success of the Trieste venture, Salam's ambitions are still set high. Through improvements in science transfer, Salam aspires at least to redress the unwieldy concentration of modern expertise in a few developed countries (June 1985, page 189).

With initial funding for three new Trieste Centres, for Chemistry, for Earth Sciences and the Environment and for High Technology and New Materials, already in place, Salam looks ahead to a world network of such centres. On 26 October, he expressed these hopes before the UN General Assembly.

To mark the Centre's 25th anniversary a five-day meeting on contemporary physics brought together many illustrious names, with Italian Prime Minister Giulio Andreotti and International Atomic Energy Agency Director General Hans Blix among those attending the opening ceremony. In one of his final public appearances before his death on 5 December (see page 27), Edoardo Amaldi introduced Salam's talk 'A life of physics'.

Abdus Salam – living for physics

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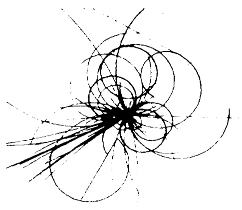

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UNIVERSITY OF MONTREAL

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RESEARCH ASSOCIATE POSITION

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The successful applicant will have experience in hardware (modern fast electronics and detectors, data acquisition systems) and in data analysis (tracking algorithms, Monte Carlo Simulations using GEANT, etc.).

Although based at TRIUMF, the candidate must be prepared to spend some time at the University of Montreal.

Please send application, with curriculum vitae and the names of three referees by February 28th to:

Professor Pierre DEPOMMIER
Laboratoire de Physique Nucléaire
Université de Montréal
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Montréal, Québec, Canada H3C 3J7

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Edoardo Amaldi 1908-89

Edoardo Amaldi, right, with Gilberto Bernardini at a CERN Council session in 1965.

Edoardo Amaldi, one of the driving forces of European science and a pioneer of CERN, died on 5 December.

He began his career in the 1930s with Enrico Fermi in Rome, where he helped discover that slow neutrons were more readily captured in target nuclei.

After the premature death of Ettore Majorana and the decision of Fermi and other prominent Italian physicists to emigrate in the 1930s, Amaldi took essential steps to maintain the spirit of Italian physics. Gian Carlo Wick was invited to take up the Rome chair left vacant after the departure of Fermi. Gilberto Bernardini at Bologna commuted regularly to the Italian capital to continue the cosmic ray tradition pioneered by Bruno Rossi. Under their guidance, dramatic wartime research exploits under difficult conditions nevertheless made important contributions to physics, culminating in the epic 1946 discovery of the muon by Marcello Conversi, Ettore Pancini and Oreste Piccioni.

In 1955, while the experiment of Owen Chamberlain, Emilio Segré, C. Wiegand and T. Ypsilantis that was to discover the antiproton was being set up at the new Berkeley Bevatron, an emulsion stack study by a Berkeley/Rome collaboration went ahead at the new machine, and a particle with antiproton-like properties was revealed in subsequent analysis in Rome. An Amaldi group had also seen an antiproton candidate in cosmic ray studies.

In later years, Amaldi pointed out how the novelty and intimacy of physics at cosmic ray mountain observatories and nuclear emulsion laboratories in the immediate postwar years had suggested wider and more ambitious collaborations. Putting these ideas into action, he had led the small but vigorous group of scientists and politicians who promoted the idea of a European Laboratory in the early 1950s, and it was fitting that he held the position of Secretary General when CERN formally came into being in 1954. His vision and wisdom in helping to create the Organization and its guiding document, the Convention, were important factors in enabling CERN to respond to all the challenges of the past 35 years.

Following a 1963 proposal by CERN Director General Viktor Weisskopf and Scientific Policy Committee Chairman Cecil Powell, Amaldi was the first chairman of a new body, the European Committee for Future Accelerators (ECFA), a 'little parliament' of physicists which under his guidance produced the famous 'Amaldi Report', with recommendations for new machines – the Intersecting Storage Rings and the 300 GeV machine (the SPS) – that secured CERN's future. It took many years before final agreement on the latter was reached, but it was symbolic that Amaldi was President of the CERN Council when the SPS was finally approved in 1971. Subsequently he was a regular visitor, still involved in experiments, and a necessary presence at all CERN's great events, including most recently the LEP Inauguration on 13 November (see page 6).

From 1957-60 he was President of the International Union of Pure and Applied Physics. In his home country, he was President of the INFN from 1960-65, a member of the prestigious Accademia dei Lincei, becoming its President in 1988, and the Accademia Nazionale dei XL.

For a man of great vision who could transform his ideas into reality, he was very modest. At his 80th birthday celebrations at CERN in 1988 he concluded simply, 'It has always been a joy to work for CERN'.

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Nuclear Research Centre
Dept. of Physics

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Of the successful candidates who have received their Ph.D. degrees in physics within the last two years, two experimentalists and one theorist will be appointed. The successful applicants will be expected to make major contributions to the projects in which they choose to participate, and will be based accordingly at either Edmonton or Vancouver. Salary will be commensurate with experience.

Candidates should send their resume and three letters of reference as soon as possible to:

Research Associate Search Committee, Nuclear Research Centre, The University of Alberta, Edmonton, Alberta, CANADA T6G 2N5.

The deadline for receipt of applications is **April 1, 1990** and the positions will be filled as soon as possible thereafter.

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1990 INTERNATIONAL INDUSTRIAL SYMPOSIUM ON THE SUPER COLLIDER (IISSC)

SSC – AMERICA'S NEW RESEARCH PARTNERSHIP

Fontainebleau Hilton Resort and Spa
Miami Beach, Florida
March 14-16, 1990

The purpose of the second International Industrial Symposium on the Super Collider (IISSC) is to foster a continuing dialogue among the scientific, administrative, legislative, and industrial sectors on the goals, status, technical challenges, and requirements of the Superconducting Super Collider (SSC). The symposium program will present industrial opportunities for participation in the various technologies involved in the design, construction, and operation of the SSC and its experimental detector system.

Topics at the symposium's plenary sessions will include:

Accelerators • Detectors and Associated Electronic Systems • Superconducting and Conventional Magnets • Cryogenics/Refrigeration • Computation • Operations/Systems/Controls • Management Plan/Project Management • International Involvement • Education • Technology Spin-offs.

An exhibit of technical products will be held in conjunction with the symposium.

For registration information please contact:

Ms. Pamela E. Patterson, Conference Manager, International Industrial Symposium on the Super Collider (IISSC),
P.O. Box 171551, San Diego, CA 92117
TEL. (619) 490-0164; FAX (619) 490-0138.

Uppsala University, Uppsala, Sweden

announces openings for

(a) PROFESSOR OF NUCLEAR PHYSICS

(b) PROFESSOR OF NUCLEAR CHEMISTRY AND NUCLEAR PHYSICS

The Professor of Nuclear Physics will be responsible for research and teaching in the Division of Nuclear Physics at the Department of Radiation Sciences, which also has chairs in High Energy Physics, Intermediate Energy Physics, Theoretical Subatomic Physics, Ion Physics and Physical Biology. The adjacent The Svedberg Laboratory has three accelerators: a 6 MV tandem accelerator, a K = 200 cyclotron for protons and heavy ions and the storage and cooling ring CELSIUS. The latter is designed to accelerate protons up to 1.36 GeV and other ions to 470 MeV per nucleon.

The Professor of Nuclear Chemistry and Nuclear Physics will be responsible for research and teaching in the Department of Neutron Research, which also has chairs in Applied Neutron Research and Neutron Scattering Physics. The area includes the study of nuclear reactions and the products of nuclear reactions. The position is, for the most part, experimentally oriented and will be located at the Department of Neutron Research at the Reactor Research Center at Studsvik.

The applications should be directed to the Swedish Government and should be received no later than February 12, 1990, at the following address:

The Registrar's Office
Uppsala University
Box 256
S-75105 Uppsala, Sweden.

They should contain (in four copies) a curriculum vitae and a written account of research and teaching activities with certified copies of degrees and other documents that the applicant wishes to supply, a numbered list of scientific publications and four separate parcels of these publications.

For further information, please contact Professor Gunnar Tibell, Department of Radiation Sciences, Box 535, S-75121 Uppsala, Sweden, telephone ++46-18-183849, telex TSLISV S 76088, for position (a), and Dr Birger Fogelberg, Department of Neutron Research, S-61182 Nykoping, Sweden, telephone ++46-155-21842, for position (b).

Andrei Dimitrievich Sakharov 1921-1989

Andrei Dimitrievich Sakharov, talented and versatile scientist, fearless activist and staunch proponent of human rights, figurehead for Soviet perestroika, described in the citation for his 1975 Nobel Peace Prize as 'spokesman for the conscience of mankind', died on 14 December.

Beginning research at Leningrad's Lebedev Institute in 1945 under Igor Tamm, he first came to prominence with his early 1950s contributions to thermonuclear fusion with Tamm, including the idea to contain plasma in a magnetic 'bottle', later to become known as the tokamak. For his fusion work he became an Academician in 1953 at the age of only 32, the youngest ever to be so honoured.

On the particle physics front, his contributions included the suggestion that the asymmetry of matter and antimatter in the Universe could reflect the delicate violation of charge-parity (CP) symmetry in the weak nuclear interactions, applications of the quark model, and pioneer ideas in the quantum theory of gravity.

He was not able to receive his Nobel Award in person. From 1980, during his exile in Gorki, he tried to keep in touch with developments in science, receiving physics literature, including the CERN Courier, by registered mail.

With the new direction in Soviet policy he reemerged as a popular champion in the USSR. Last year, accompanied by his wife Elena Bonner, he embarked on a visit of major world physics Laboratories.

In a message entitled 'The responsibility of scientists' to a 1981 New York meeting in his honour, he wrote 'scientists are not only better informed than the average person, but also strive for and enjoy more independence and freedom. Freedom, however, entails responsibility'. With steadfast ideals and indomitable courage, Sakharov never shirked this duty.

Andrei Sakharov in his Gorki apartment in 1985.

(Soviet TV)

People and things

CERN elections and appointments

At its December meetings, CERN Council elected C. Lopez, Rector of the Autonomous University of Madrid, and E.W.J. Mitchell, Chairman of the UK Science and Engineering Research Council, as Vice-Presidents, and Chris Llewellyn-Smith of Oxford as Chairman of the Science Policy Committee.

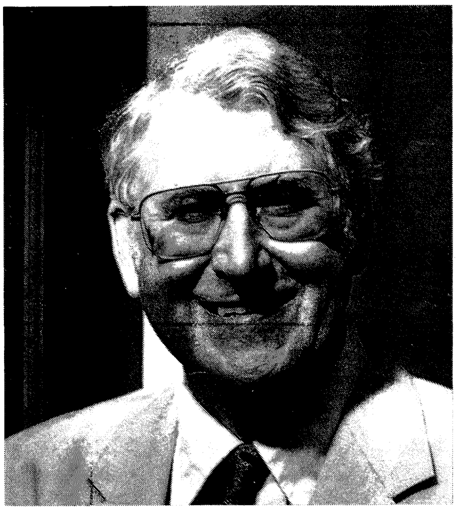
In 1990, the CERN Directorate consists of Research Directors Pierre Darriulat, Walter Hoogland and John Thresher; Günther Plass as Director of Accelerators; Georges Vianès as Head of Administration; and Hans Hoffmann as Director for Technical and Administrative Tasks.

This reflects a reorganization at divisional level into research, accelerator and technical administration sectors: Theoretical Physics (Leader, John Ellis), Experimental Physics (Jim Allaby), Electronics Facilities (Pier G. Innocenti), Computing Centre (David O. Williams), Mechanical Technologies (Gérard Bachy), Proton Synchrotron (Roy Billinge), SPS and LEP (Lyndon Evans), Accelerator Technologies (Horst Wenninger), Technical Services (Fritz Ferger), Administrative Support (Frans Heyn), Personnel (Georges Michel), Finance (André Naudi), Technical Inspection and Safety Commission (Keith Potter), Pension Fund (Christian Cuénoud).

On people

John S. Toll, Chancellor Emeritus of the University of Maryland and long-time member of US federal

Howell Pugh 1933-1989



Directors of several Yugoslav physics research centres recently signed agreements providing a framework for continued collaboration in CERN research. Left to right – Gabrijel Kernel of the University of Llubljana; Tomaz Kalin, Director of Llubljana's Jozef Stefan Institute; Guy Paic of Zagreb's Ruder Boskovic Institute; Krunoslav Pisk, Director General of the Ruder Boskovic Institute; CERN Director General Carlo Rubbia; CERN coordinator for Eastern Europe Owen Lock. Similar bilateral agreements are being drawn up to consolidate ongoing collaboration between CERN and research centres in other East European countries.

(Photo CERN 524.11.89)

science advisory bodies, has been appointed President of Universities Research Association, the Governing Body of both Fermilab and the Superconducting Supercollider (SSC) Laboratory, succeeding Edward K. Knapp.

This year's UK Institute of Physics Awards include the Rutherford Medal and Prize to theorist Roger Phillips of the Rutherford Appleton Laboratory, the Harrie Massey Prize (awarded jointly with the Australian Institute of Physics) to Richard Dalitz of Oxford and the Maxwell Medal and Prize to Cambridge astrophysicist and cosmologist George Efstathiou.

CERN theorist Luis Alvarez-Gaume shares UNESCO's Javed Husain Prize for young scientists.

Among the Doistau-Blutet Award recipients of the French Academy of Science last year (April 1989, page 23), were Paul André Chamouard, Michel Olivier and André Tkatchenko of the French National Saturne Laboratory, Saclay, for their work in developing the MIMAS injector, and Jean-Bernard Zuber of Saclay for his work in quantum field theory.

Promising Italian theorist Giorgio Gamberini of Pisa died tragically last year, aged 28, just three days after having formally presented his doctorate.

Howell Pugh 1933-1989

Howell Pugh of Berkeley, who died on 7 November, was one of the pioneers of the new field of relativistic (high energy) heavy ion collisions, having realized very early the potential of CERN's machines for this work. Most of the US participation in CERN's ion programme was due to his enthusiasm and leadership, quite apart from the role played by the Berkeley Laboratory. Participating in one of the early experiments at CERN's Intersecting Storage Rings in 1972-3, he saw the potential of high energy techniques for nuclear physics, and went on to become Scientific Director of the Berkeley Bevalac in 1979, where he played a vital part in setting up what was to become a highly successful programme of heavy ion studies.

Vossfest at DESY

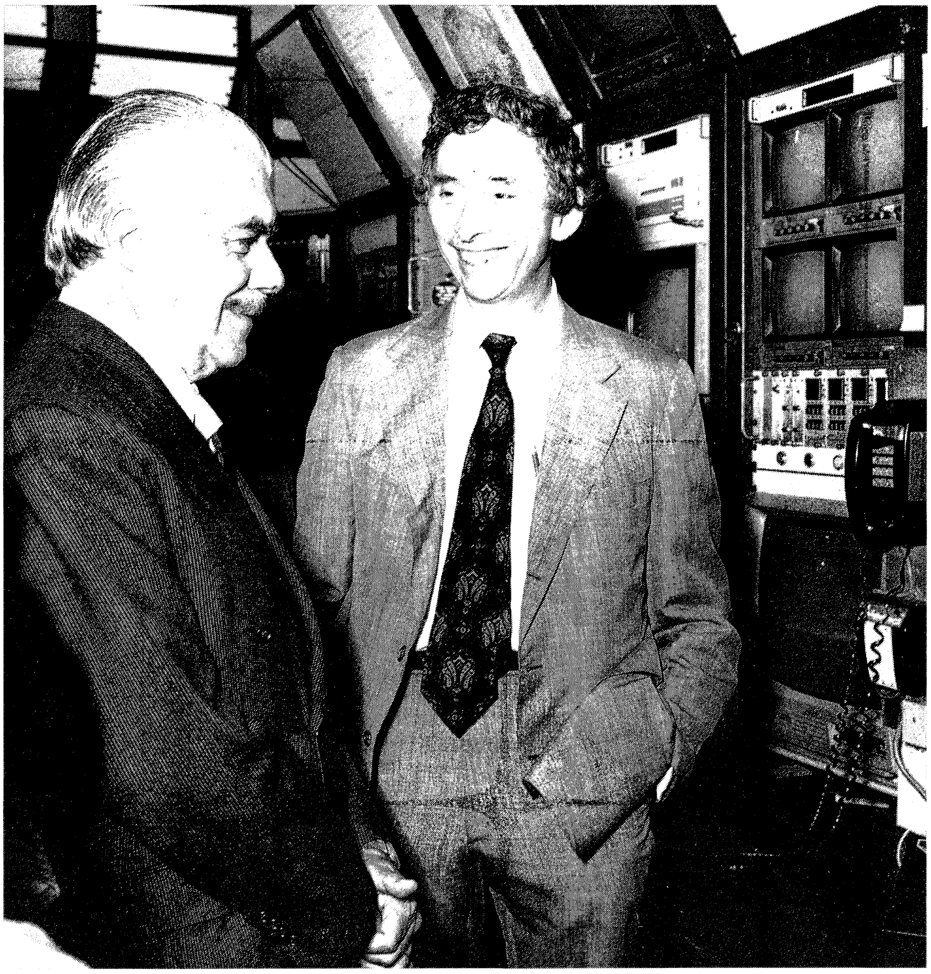
Electron accelerator maestro Gus Voss, long-time member of the Board of Directors at DESY, actually celebrated his 60th birthday last summer during a spell at Stanford. On return to the DESY Laboratory in Hamburg in August, he was immediately caught up in the commissioning of the HERA electron ring at its nominal energy of over 27 GeV (November 1989, page 4). His official birthday celebrations at DESY were therefore postponed to November.

At a special colloquium, Maury Tigner of Cornell sketched the history of electron-positron colliders from the pioneer AdA ring in Rome in the early 1960s through to today's big machines, LEP at CERN and the SLC Stanford Linear Collider.

Thomas Weiland, formerly of DESY and now at Darmstadt, took over to describe new acceleration techniques, particularly the promising wakefield transformer he developed with Voss at DESY in 1982.

The final speaker, Paul Söding of DESY, outlined the new insights in physics that electron-positron col-

After the opening last year of the United Nations General Assembly in New York, President Jose Sarney of Brazil (left) visited Fermilab, where he was shown round by Laboratory Director John Peoples. Following the initiation of a cooperation programme with Latin American research institutions ten years ago, about 30 Brazilian physicists now work at Fermilab.



liders have brought, from modest beginnings to today, when high energy machines provide a main line of attack.

Voss has played an important role in the construction of DESY's electron machines, first the 6 GeV synchrotron, then the PETRA collider, and now the electron ring for HERA, where Bjorn Wiik is in charge of the 820 GeV proton ring. At Cambridge, Mass., Voss was one of the team which transformed the CEA electron machine into a collider in the early 1970s, exploiting the 'low-beta' scheme to compress the beams and boost the collision rate, a 1966 brainchild of Voss and Ken Robinson.

Meetings

An international workshop on software engineering, artificial intelligence and expert systems for high energy and nuclear physics will be held from 19-24 March at the Computing Centre of the French IN2P3, Lyon/Villeurbanne. Further information from Mme. Michele Jouhet, EP Division, CERN, 1211 Geneva 23, Switzerland, phone Geneva 767 2277, fax Geneva 782 4439, bitnet jouhet at cernvm.cern.ch

The 9th International Symposium on High Energy Spin Physics will be held from 10-15 September in Bonn, West Germany, hosted by the Physikalisches Institut der Universität Bonn. Further information from the Local Organizing Committee, Chairman K.-H. Althoff, Secretary Mrs. D. Fassbender, Physikalisches Institut, Nussallee 12, 5300 Bonn 1, F.R. Germany, phone/fax Bonn 733247/737869, bitnet spin 90 at dbnpib 5.

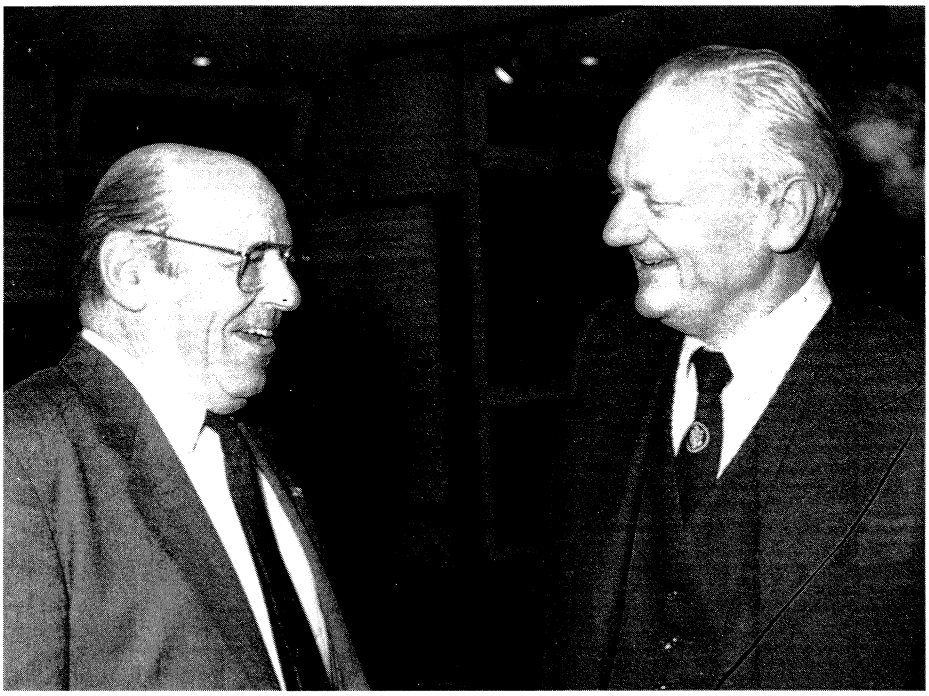
An international conference on gamma ray astronomy will be held in Ann Arbor, Michigan, from 2-5 October to review recent data and discuss new theoretical ideas and experimental techniques applicable above 1 GeV. Further information from Carl Akerlof, University of Michigan, 500 East University, Ann Arbor, Michigan 48109-1120, USA.

A 'QCD 90' workshop in Montpellier, France, from 8-13 July will look at recent progress in both perturbative and non-perturbative QCD. Further information from S. Narison at the University of Montpellier, bitnet narison at cernvm.cern.ch or lpmont at frmop11.

Sponsored by World Laboratory (Lausanne, Switzerland), by the US National Science Foundation and by Pakisatani agencies, a School on Fundamental Physics and Cosmology will be held in Islamabad from 11-25 March. Further information from Pervez Hoodbhoy, World Laboratory School, Physics Dept., Quaid-i-Azam University, Islamabad, Pakistan.

▲ Guests at the dinner marking Georges Charpak's 65th birthday included the team from the first experiment at CERN to measure the anomalous magnetic moment of the muon in 1959-60 – left to right, Antonino Zichichi, Hans Sens, Val Telegdi, Georges Charpak, Francis Farley, Roger Bouclier, Richard Garwin and Leon Lederman. The photo was taken by indefatigable cameraman Maurice Jacob.

▼ A special colloquium at the German DESY Laboratory in Hamburg in November marked the 60th birthday of electron machine specialist Gus Voss (right), seen here with Wolfgang Paul of Bonn, who shared the 1989 Nobel Physics Prize with Norman Ramsey and Hans Dehmelt.



Jürgen May, formerly with the Aleph experiment at CERN's LEP electron-positron collider, moves to DESY to become Directorate Member for Technical Services, succeeding Hans Hoffmann, who has returned to CERN to become Director for Technical and Administrative Tasks.

The fourth meeting in the series of Topical Seminars on Experimental Apparatus for High Energy Particle Physics and Astrophysics will take place from 28 May to 1 June in San Miniato (Pisa), Tuscany, at the 'I Cappuccini' conference centre. Organized jointly by P. Giusti and F.-L. Navarria of Bologna (e-mail KAOS at VAXBO.infn.it) and by P.G. Pelfer of Florence (TOP90 at VAXFI.infn.it) the Seminar will cover the latest developments in detectors, electronics, data acquisition and data analysis for the special conditions at very high energy and/or luminosity accelerators, and in underground, surface and astrophysics experiments, with particular emphasis on particle identification, time and energy resolution, calorimetry, etc. for high flux conditions.

On the 50th anniversary of the French Centre National de la Recherche Scientifique (CNRS), CERN Director General Carlo Rubbia is made 'Officier de la Légion d'Honneur' by President François Mitterrand for his contributions to French science. Behind Carlo Rubbia is 1983 Nobel Prizewinner William Fowler, who also received the accolade.

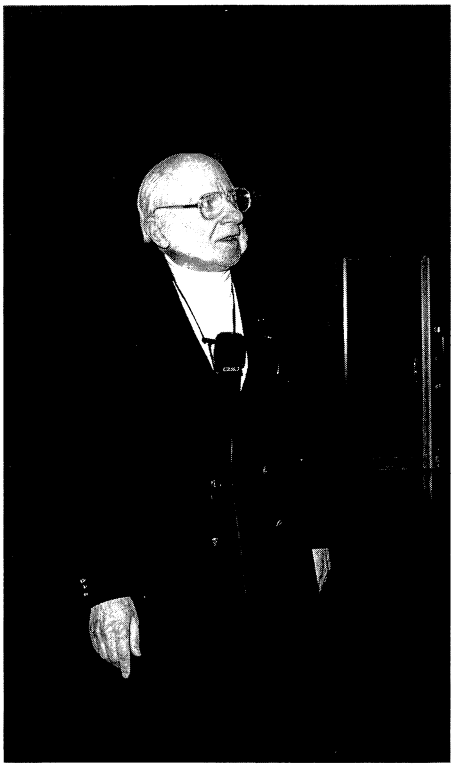
(Photo Présidence de la République française)

Cryogenic ion source

A cryogenic electron beam ion source (CRYEBIS) came into operation last year at the J.R. Macdonald Laboratory, Kansas State University, and went on to supply fully stripped argon ions for physics. The Laboratory studies atomic interactions using a range of ion energies.

CERN Courier index

This year, the index for the 1989 issues of the CERN Courier is not being distributed automatically to every reader. To obtain an index, write to Petra Pamblanco, Publications /DG, CERN, 1211 Geneva 23, Switzerland, fax Geneva 782 1906, bitnet monika at cernvm.cern.ch. Please specify whether you need the English or French version.



Books

The Experimental Foundations of Particle Physics, by Robert N. Cahn and Gerson Goldhaber of Berkeley, published by Cambridge University Press, uses reprints of some sixty classic papers to illustrate the advances of the past fifty years. Grouped into chapters with an accompanying introductory text, the papers make for informative reading by specialist and beginner alike.

Hans Dehmelt of Wahsington, who shared the 1989 Nobel Physics Prize with Norman Ramsey and with Wolfgang Paul (December 1989, page 23), visited CERN in December, where he gave a talk on 'Experiments with an isolated subatomic particle at rest.

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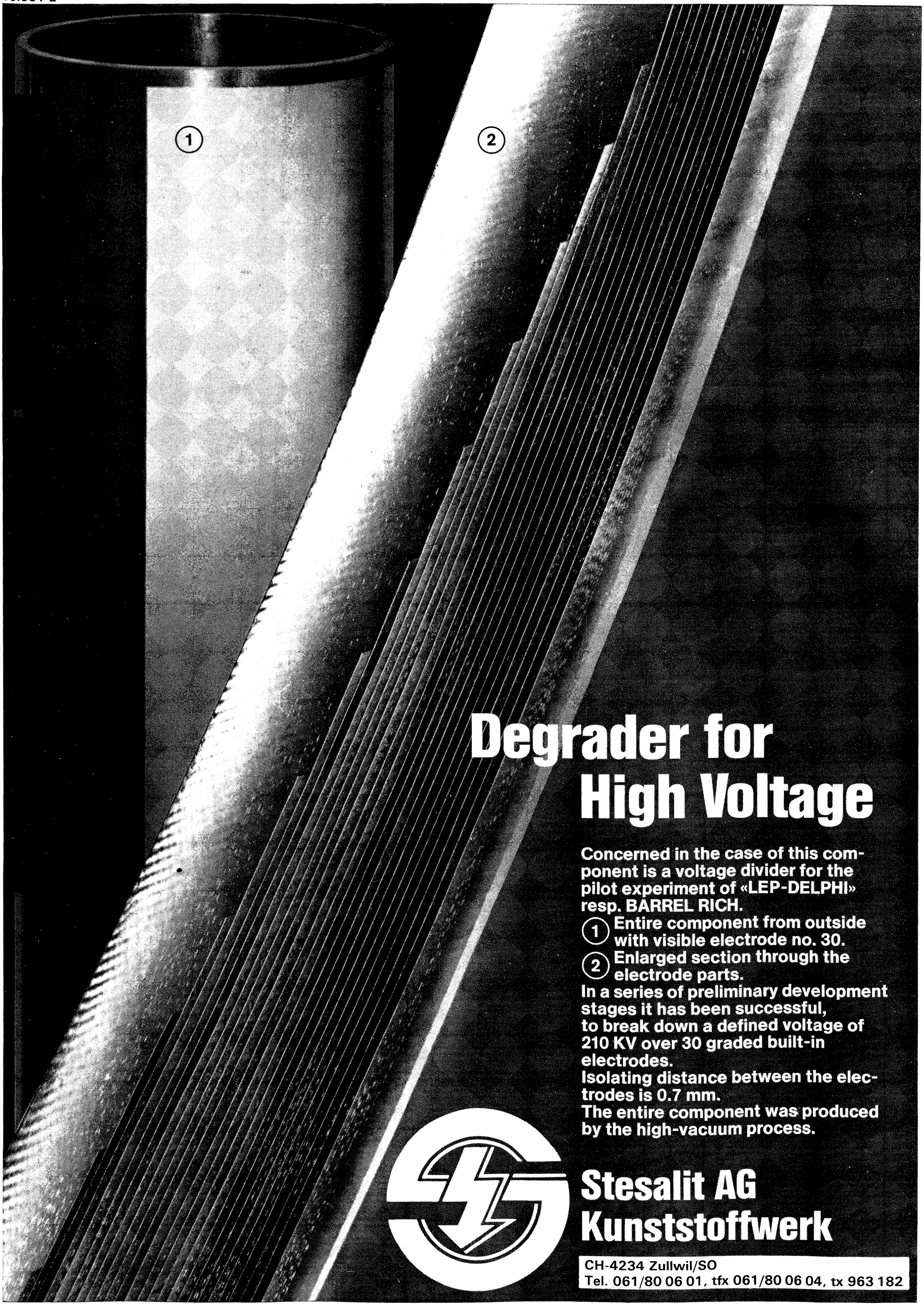
1
2
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