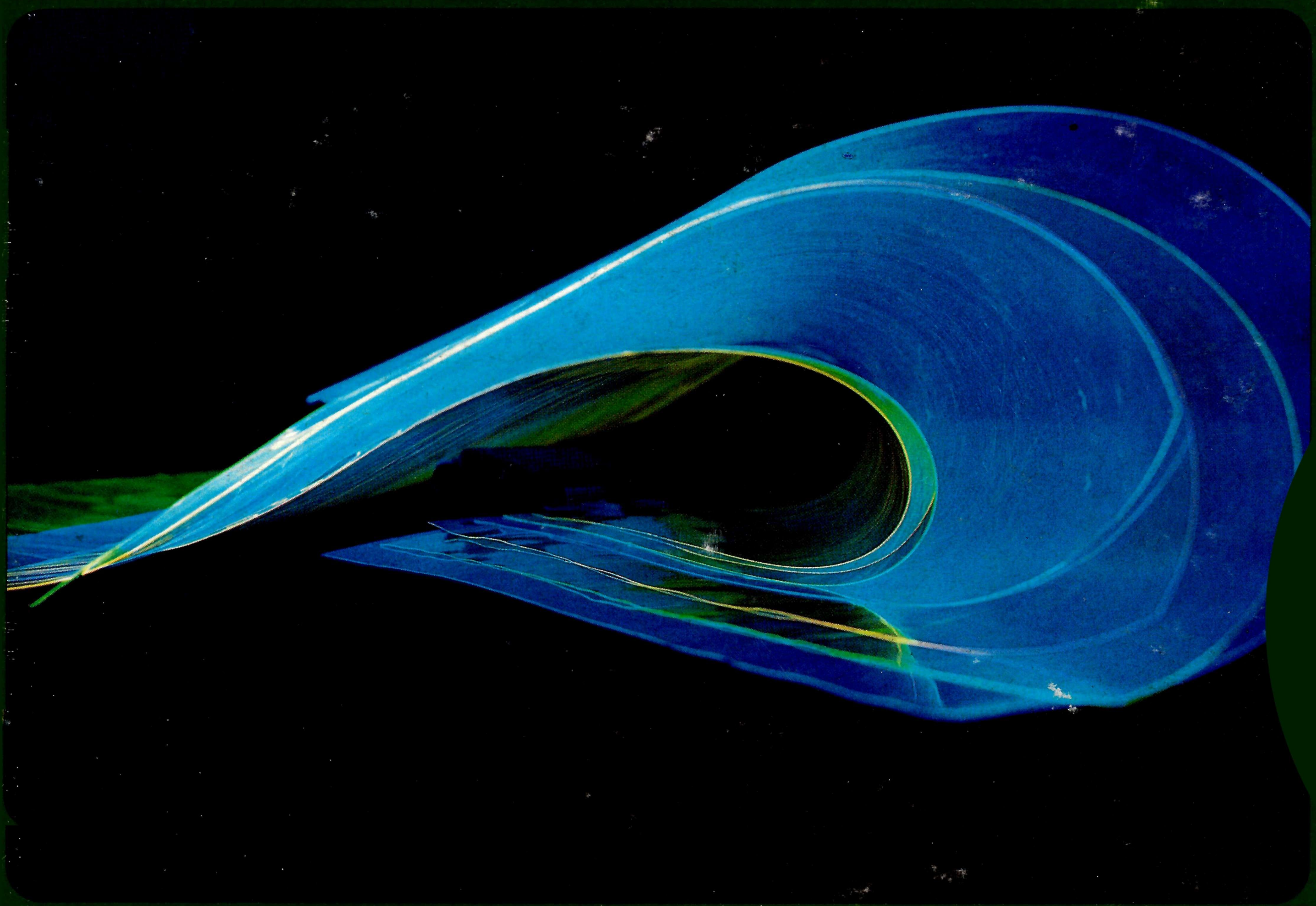
CERN COURIER

International Journal of High Energy Physics



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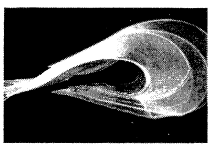

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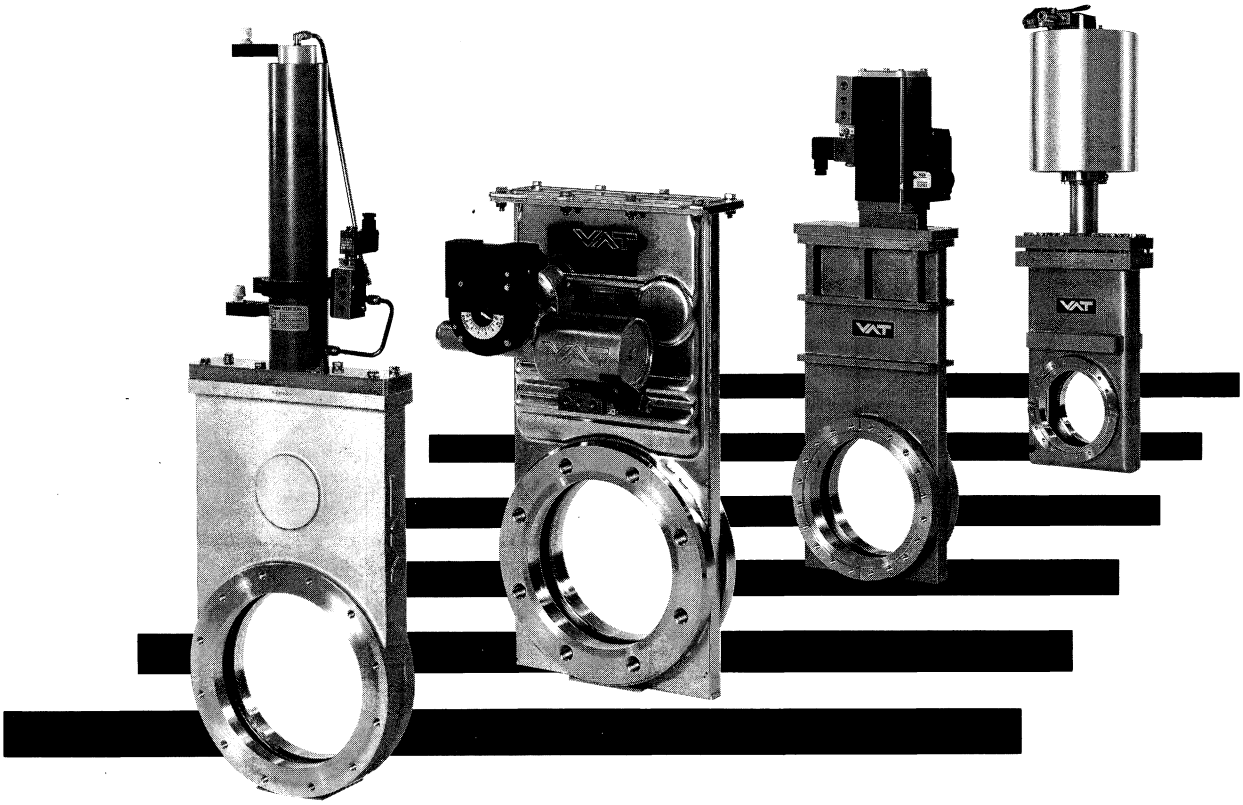

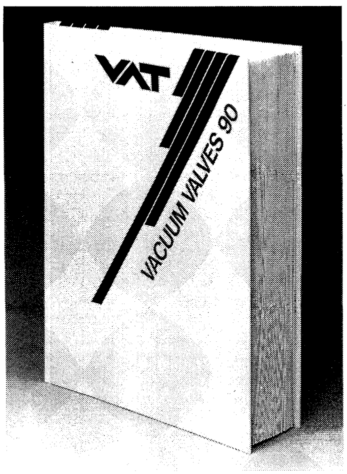
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Higgs for the masses

Encompassing electromagnetism and the weak nuclear force, explaining phenomena ranging from a bolt of lightning to the beta decay of a nucleus, the electroweak picture is one of the big success stories of twentieth-century physics. However it is still incomplete, and new information from CERN's new LEP electron-positron collider in the final decade of the century could fill in the gaps.

The setting for the picture is the way quantum labels such as isospin and electric charge may be transformed in space and time, known as Yang-Mills gauge theory. This was an attempt to generalize the success of quantum electrodynamics, but always seemed to demand that the carriers of the field (the gauge bosons), analogous to the photon in quantum electrodynamics and carrying one unit of intrinsic angular momentum (spin), were massless.

Final magnets for LEP

On 26 May, the final magnets for CERN's new LEP electron-positron collider moved smoothly into position guided by Director General Carlo Rubbia and by Herwig Schopper, who as CERN's Director General from 1981-88 oversaw so much of the preparation and construction work for the 27-kilometre machine.

The installation ceremony was a fitting focus for a 'Schopper fest' in honour of the retired Director General.

LEP magnet installation symbolically began on 4 June 1987 when then French Premier Jacques Chirac and Swiss President Pierre Aubert helped put the first magnet into position. In the intervening two years, LEP's impressive inventory of 3280 ordinary dipoles, over 800 quadrupoles, 500 sextupoles, over 600 correcting dipoles and various other magnets has been precision placed in the 27-kilometre ring.

The next major LEP milestone is the vacuum system, scheduled for completion in June, except for finishing touches in the regions around the four experiments, themselves the scene of final preparations for the injection in July of the first beams into the completed ring.

LEP physics

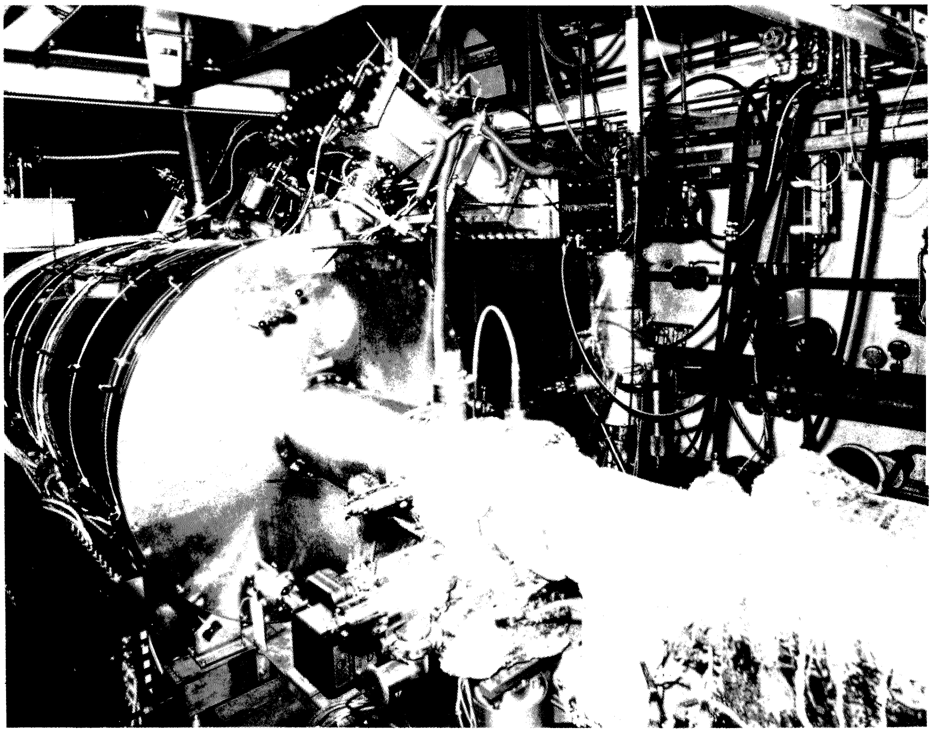
CERN's new 27-kilometre LEP ring will soon be supplying its first electron-positron collisions. This is the first in a series of articles outlining some of the physics objectives.

CERN Director General Carlo Rubbia (left) and Herwig Schopper, CERN's Director General from 1981-8, activate the machine to install the final magnet for CERN's new LEP electron-positron collider, scheduled to become operational in July.

(Photo CERN 441.5.89)

Superconducting radiofrequency accelerating cavities will push LEP's collision energy higher and provide more scope for finding the essential 'Higgs' spontaneous symmetry breaking mechanism at the heart of the electroweak theory. Here a cavity is under test in the SPS ring.

(Photo CERN 281.8.88)



Under everyday conditions, the electroweak picture must ensure that the long-range electromagnetic force, mediated by the massless photon, carrying unit spin, looks very different to the short-range weak nuclear force, carried by a trio of heavy particles, but each also carrying one unit of spin. The trio – the positive and negatively charged W and the electrically neutral Z bosons – were discovered at CERN's proton-antiproton collider in 1983. The problem was to accommodate the W and Z masses without spoiling the underlying symmetry.

The essential ingredient is spontaneous symmetry breaking – when a theory with symmetric equations has solutions that are not symmetric. For example the equations of electromagnetism are symmetric but their magnetic solutions need not be – selecting an orientation of electron spins in the ground state of a ferromagnet spontaneously breaks the symmetry.

In quantum field theory, spontaneous symmetry breaking produces massless and spinless ('Goldstone') particles, whose usefulness for electroweak unification was not immediately apparent.

In the mid-60s, several theorists (including P. Anderson, R. Brout, F. Englert, G. Guralnik, C. Hagen, P. Higgs and T. Kibble), helped piece together another symmetry breaking scheme which eliminates unwanted massless particles. Apparently massless 'Goldstone' particles would combine with apparently massless gauge bosons to make field particles with mass, while retaining the underlying symmetry.

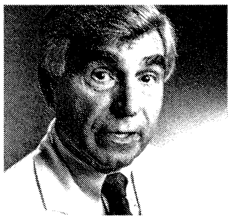
In the electroweak picture, the Higgs mechanism contrives to give masses to the W and Z bosons, while keeping the zero mass photon, by selecting out a preferred isospin direction with the Higgs field, leaving the electromagnetically neutral photon unaffected.

Within these guidelines, there is still a lot of room to manoeuvre, and as it stands the electroweak picture gives no handle on the Higgs particle masses. As yet no sign of any Higgs particle has been found. Light Higgs, in the few MeV range, would show up in precision analysis of muonic atom X-ray spectra, in the decay of excited nuclear states and in very low energy neutron-nucleus scattering. Meson decays are another potential source of Higgs particles. Unsuccessful searches in kaon decays, for example by the NA31 experiment at CERN, probably rule out Higgs lighter than a few hundred MeV. With heavier mesons, such as B-particles and upsilons, the mass limits can be pushed higher. Most Higgs options below 3.6 GeV now can be ruled out, and the continuing search has to await the opening of new energy frontiers.

This is where LEP comes in. The immediate goal is to provide 46-47 GeV beams and home in on the Z boson near 93 GeV, the electrically neutral carrier of the weak nuclear force. The Z is coupled to the Higgs mechanism, and if the associated particles are light enough, they could show up in Z decays accompanied by a pair of muons, a pair of neutrinos, or a photon. As well as uncovering the Higgs particle, this search would also show how it can decay, providing additional valuable information.

Unless the Higgs particle is very light, the interesting Z decays are quite rare, and would need about a year's accumulation of Zs, even with LEP operating near its design luminosity of 1.7×10^{31} (the initial level will be lower, see May issue, page 5).

The long-awaited sixth ('top') quark has yet to make an appear-



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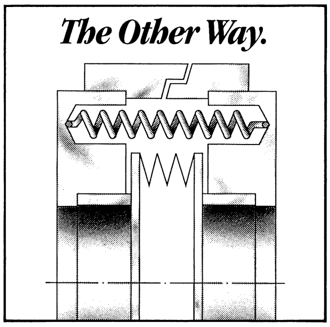

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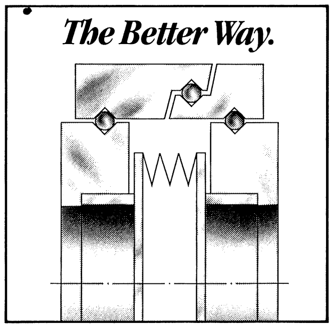

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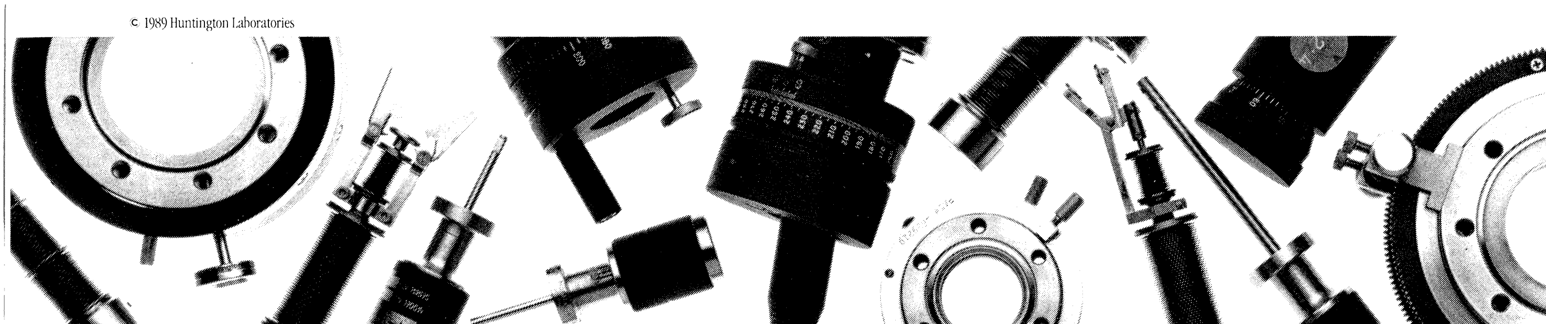
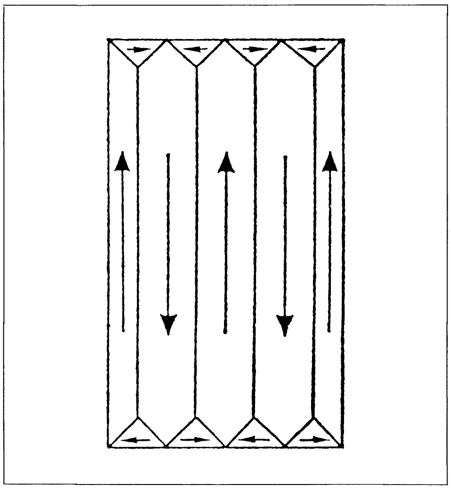


Spontaneous symmetry breaking happens when a theory with symmetric equations has solutions that are not symmetric. For example the equations of electromagnetism are symmetric but their magnetic solutions need not be – selecting an orientation of electron spins in the ground state of a ferromagnet spontaneously breaks the symmetry inside each microscopic 'domain'.



ance, and LEP's collision energies (approaching 100 GeV initially) could at last cross the top threshold and open up a new particle spectroscopy. This would be a major physics achievement in itself, but in addition the decay of some of the top quark-antiquark bound states could be sources of Higgs particles. However investigations at the proton-antiproton colliders at CERN and Fermilab suggest that the top quark may be so heavy that decays into Higgs particles would be relatively infrequent. In addition, if top quark spectroscopy perversely brackets the Z mass, then physicists will have to carefully unravel the two effects.

A subsequent LEP goal will be to increase the beam energy using superconducting radiofrequency cavities so that the colliding electrons and positrons can produce a pair of W particles, the electrically charged carriers of the weak nuclear force. If the Higgs mass is in the right area, the colliding particles should also produce Z/Higgs pairs.

With the advent of LEP, physicists are eagerly waiting the first tangible information on the vital but mysterious symmetry breaking mechanism behind the so successful electroweak theory.

Computing in high energy physics

Computing in high energy physics has changed over the years from being something one did on a slide-rule, through early computers, then a necessary evil to the position today where computers permeate all aspects of the subject from control of the apparatus to theoretical lattice gauge calculations.

The state of the art, as well as new trends and hopes, were reflected in this year's 'Computing In High Energy Physics' conference held in the dreamy setting of Oxford's spires. The 260 delegates came mainly from Europe, the US, Japan and the USSR. Accommodation and meals in the unique surroundings of New College provided a special atmosphere, with many delegates being amused at the idea of a 500-year-old college still meriting the adjective 'new'.

The conference aimed to give a comprehensive overview, entailing a heavy schedule of 35 plenary talks plus 48 contributed papers in two afternoons of parallel sessions. In addition to high energy physics computing, a number of papers were given by experts in computing science, in line with the conference's aim – 'to bring together high energy physicists and computer scientists'.

The complexity and volume of data generated in particle physics experiments is the reason why the associated computing problems are of interest to computer science. These ideas were covered by David Williams (CERN) and Louis Hertz-

David Williams (CERN) sets the scene at the Oxford Conference on Computing in High Energy Physics.

(Photo RAL)

berger (Amsterdam) in their keynote addresses.

The task facing the experiments preparing to embark on CERN's new LEP electron-positron collider is enormous by any standards but a lot of thought has gone into their preparation. Getting enough computer power is no longer thought to be a problem but the issue of storage of the seven Terabytes of data per experiment per year makes computer managers nervous even with the recent installation of IBM 3480 cartridge systems.

With the high interaction rates already achieved at the CERN and Fermilab proton-antiproton colliders and orders of magnitude more to come at proposed proton colliders, there are exciting areas where particle physics and computer science could profitably collaborate.

A key area is pattern recognition and parallel processing for triggering. With 'smart' detector electronics this ultimately will produce summary information already reduced and fully reconstructed for events of interest.

Is the age of the large central processing facility based on mainframes past? In a provocative talk Richard Mount (Caltech) claimed that the best performance/cost solution was to use powerful workstations based on reduced instruction set computer (RISC) technology and special purpose computer-servers connected to a modest mainframe, giving maybe a saving of a factor of five over a conventional computer centre.

Networks bind physics collaborations together, but they are often complicated to use and there is seldom enough capacity. This was well demonstrated by the continuous use of the conference electronic mail service provided by Olivetti-Lee Data. The global village nature of the community was evident when the news broke of the first Z particle at Stanford's new SLC linear collider (May issue, page 2).

Hands-on experience at the DEC demonstration.

(Photo NPL Oxford)

The problems and potential of networks were explored by François Fluckiger (CERN), Harvey Newman (Caltech) and James Hutton (RARE). Both Fluckiger and Hutton explained that the problems are both technical and political, but progress is being made and users should be patient. Network managers have to provide the best service at the lowest cost. HEPNET is one of the richest structures in networking, and while OSI seems constantly to remain just around the corner, a more flexible and user-friendly system will emerge eventually.

Harvey Newman (Caltech) is not patient. He protested that physics could be jeopardized by not moving to high speed networks fast enough. Megabit per second capacity is needed now and Gigabit rates in ten years. Imagination should not be constrained by present technology.

This was underlined in presentations by W. Runge (Freiburg) and R. Ruehle (Stuttgart) of the work going on in Germany on high bandwidth networks. Ruehle concentrated on the system at Stuttgart providing graphics workstation access through 140Mbps links to local supercomputers. His talk was illustrated by slides and a video showing what can be done with a local workstation online to 2 Crays and a Convex simultaneously! Ruehle also showed the importance of graphics in conceptualization as well as testing theory against experiment, comparing a computer simulation of air flow over the sunroof of a Porsche with a film of actual performance.

Computer graphics for particle physics attracted a lot of interest. David Myers (CERN) discussed the conflicting requirements of software portability versus performance and summarized with 'Myers' Law of Graphics' – 'you can't have your performance and port it'. René Brun (CERN) gave a concise presentation of PAW (Phy-

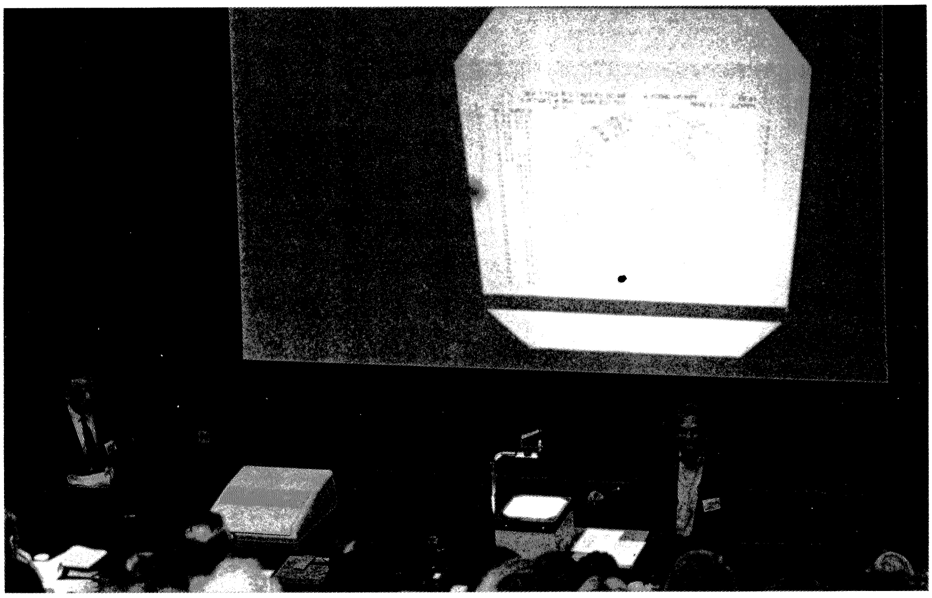
sics Analysis Workstation). Demonstrations of PAW and other graphics packages such as event displays were available at both the Apollo and DEC exhibits during the conference week. Other exhibitors included Sun, Meiko, Caplin and IBM. IBM demonstrated the power of relational database technology using the online Oxford English Dictionary.

Interactive data analysis on workstations is well established and can be applied to all stages of program development and design. Richard Mount likened interactive graphics to the 'oscilloscope' of software development and analysis.

Establishing a good data structure is essential if flexible and easily maintainable code is to be written. Paulo Palazzi (CERN) showed how interactive graphics would enhance the already considerable power of the entity-relation model as realized in ADAMO. His presentation tied in very well with a fascinating account by David Nagel (Apple) of work going on at Cupertino to extend the well-known Macintosh human/computer interface, with tables accessed by the mouse, data highlighted and the corresponding graphical output shown in an adjacent window.

The importance of the interface between graphics and relational databases was also emphasized in the talk by Brian Read (RAL) on the special problems faced by scientists using database packages, illustrated by comparing the information content of atmospheric ozone concentration from satellite measurements in tabular and graphical form – 'one picture is worth a thousand numbers'.

The insatiable number-crunching appetite of both experimental and theoretical particle physicists has led to many new computer architectures being explored. Many of them exploit the powerful new (and relatively cheap) RISC chips on the market. Vector supercomputers are very appropriate for calculations like lattice gauge theories but it has yet to be demonstrated that they will have a big impact on 'standard' codes.



Terry Schalk (SCIPP and SLAC) shows the first Z from the SLC Stanford Linear Collider at the Oxford Computing Conference.

(Photo NPL Oxford)

An indication of the improvements to be expected – perhaps a factor of five – came in the talk by Bill Martin (Michigan) on the vectorization of reactor physics codes. Perhaps more relevant to experimental particle physics are the processor 'farms' now well into the second generation.

Paul Mackenzie (Fermilab) and Bill McColl (Oxford) showed how important it is to match the architecture to the natural parallelism of a problem and how devices like the transputer enable this to be done. On a more speculative note Bruce Denby (Fermilab) showed the potential of neural networks for pattern recognition. They may also provide the ability to enable computers to learn. Such futuristic possibilities were surveyed in an evening session by Phil Treleavan (London). Research into this form of computing could reveal more about the brain as well as help with the new computing needs of future physics.

With powerful new workstations appearing almost daily and with novel architecture in vogue, a machine-independent operating system is obviously attractive. The main contender is UNIX. Although nominally machine independent, UNIX comes in many implementations and its style is very much that of the early 70s with cryptic command acronyms – few concessions to user-friendliness! However it does have many powerful features and physicists will have to come to terms with it to exploit modern hardware.

Dietrich Wiegandt (CERN) summarized the development of UNIX and its important features – notably the directory tree structure and the 'shells' of command levels. An ensuing panel discussion chaired by Walter Hoogland (NIKHEF) included physicists using UNIX and representatives from DEC, IBM and Sun. Both DEC and IBM support the development of UNIX systems.

Conference Dinner in New College Hall Oxford – left to right Paul Kunz (SLAC), Hans Hoffmann (DESY), Brian Davies (RAL), Geoff Manning (AMT), Robin Devenish (Oxford), Tom Nash (FNAL), Rudy Bock (CERN), Fred Bullock (UCL) and Yoshiyuki Watase (KEK, back to camera).

(Photo RAL)

David McKenzie of IBM believed that the operating system should be transparent and looked forward to the day when operating systems are 'as boring as a mains wall plug'. (This was pointed out to be rather an unfortunate example since plugs are not standard!)

Two flavours of UNIX are available – Open Software Foundation version one (OSF1), and UNIX International release four (SVR4) developed at Berkeley. The two implementations overlap considerably and a standard version will emerge through user pressure. Panel member W. Van Leeuwen (NIKHEF) announced that a particle physics UNIX group had been set up (contact HEPNIX at CERNVM).

Software engineering became a heated talking point as the conference progressed. Two approaches were suggested: Carlo Mazza, head of the Data Processing Division of the European Space Operations Centre, argued for vigorous management in software design, requiring discipline and professionalism, while Richard Bornat ('SASD – All Bubbles and No Code') advocated an artistic approach, likening programming to architectural design rather than production engineering. A. Putzer (Heidelberg) replied that experimenters who have used software engineering tools such as SASD would use them again.

Paul Kunz (SLAC) gave a thoughtful critique of the so-called 'software crisis', arguing that code does not scale with the size of the detector or collaboration. Most detectors are modular and so is the code associated with them. With proper management and quality control good code can and will be written. The conclusion is that both inspiration and discipline go hand in hand.

A closely related issue is that of verifiable code – being able to prove that the code will do what is intended before any executable version is written. The subject has not yet had much impact on the physics community and was tackled by Tony Hoare and Bernard Sufrin (Oxford) at a pedagogical level. Sufrin, adopting a missionary approach, showed how useful a mathematical model of a simple text editor could be. Hoare demonstrated predicate calculus applied to the design of a tricky circuit.

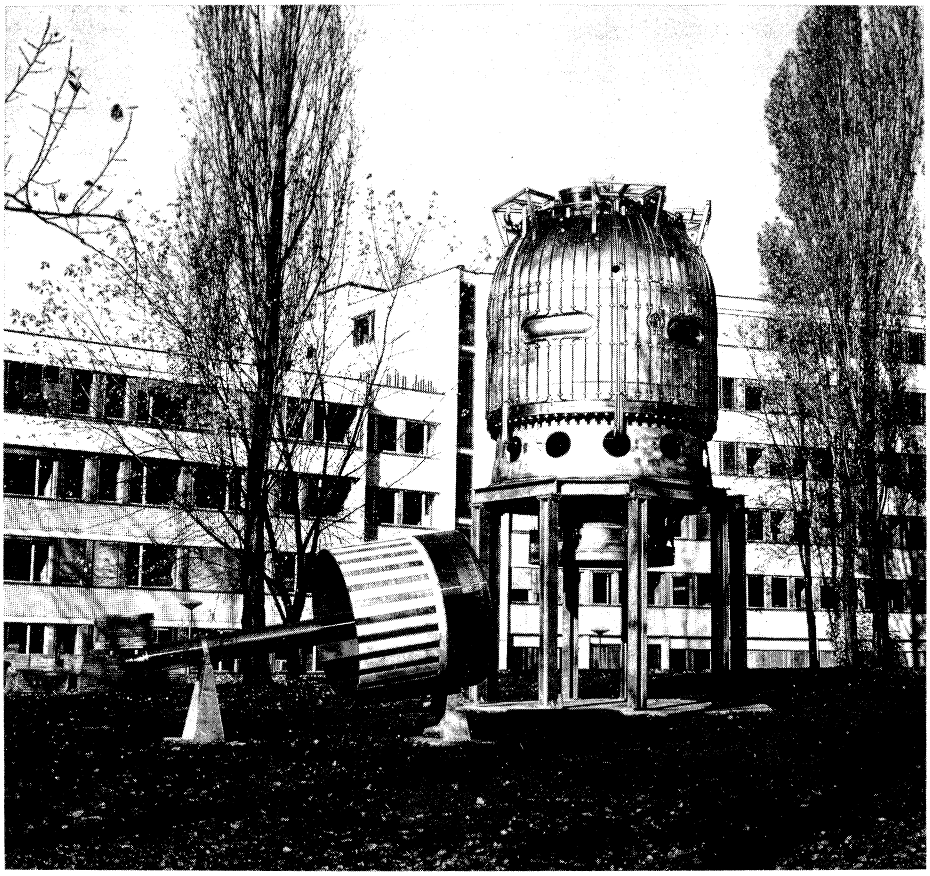
Less high technology was apparent at the conference dinner in the candle-lit New College dining hall. Guest speaker Geoff Manning, former high energy physicist, one-time Director of the UK Rutherford Appleton Laboratory and now Chairman of Active Memory Technology, believed that physicists have a lot to learn from advances in computer science but that fruitful collaboration with the industry is possible. Replying for the physicists, Tom Nash (Fermilab) thanked the industry for their continuing interest and support through joint projects and looked forward to a collaboration close enough for industry members to work physics shifts and for physicists to share in profits!

Summarizing the meeting, Rudy Bock (CERN) highlighted novel architectures as the major area where significant advances have been made and will continue to be made for the next few years. Standards are also important provided they are used intelligently and not just as a straitjacket to impede progress. His dreams for the future included neural networks and the wider use of formal methods in software design. Some familiar topics of the past, including code and memory management and the choice of programming language, could be 'put to rest'.

A subsequent meeting agreed that an electronic clearing house for information on conferences on computing in high energy physics would be set up on the IBM machine at the Rutherford Appleton Laboratory. This may eventually become part of the HEPDATA database. Next year's conference will be in April at Santa Fe, New Mexico, organized by Los Alamos (contact Tom Kozlowski via CIHEP at LAMPF). The Japanese KEK Laboratory has indicated its willingness to host the 1991 meeting.

By Sarah Smith and Robin Devenish of Oxford University's Nuclear Physics Laboratory

Around the Laboratories



The park at CERN's new 'Microcosm' visitor centre, dominated by decommissioned but nonetheless still futuristic-looking equipment including the body and piston of the BEBC bubble chamber, phased out for physics in 1985.

(Photo CERN 154.11.88)

CERN
Shop window

Public support is vital for the future of big science. The man in the street should understand what motivates physicists, what new knowledge has resulted and what are the key issues ahead. With today's big international collaborations providing young scientists with hands-on experience in management and frontier technology as well as physics, it is important, especially for the younger generation, to see how this physics is done.

Now taking shape at CERN is the nucleus of a new visitor centre, designed to improve the presentation of CERN and its work to the ever-growing number of sightseers and science students attracted to the Laboratory – over 20,000 last year. This number has been increasing fast and the trend shows no sign of slackening.

An international Laboratory financed by 14 West European States and used by scientists from all over the world, CERN is situated on the Swiss-French frontier just outside the Swiss city of Geneva, itself one of the major crossroads of Europe. Most visitors come from France, Switzerland and nearby Italy, while the strong international community in Geneva assures an English-speaking contingent.

To handle the language mix (English, French, German and Italian are standard options) and to fit in with CERN's own working schedule, these visits are organized in advance. Volunteer guides take care of the groups, providing introductory explanations and arranging transport to suitable viewing points round the site. However this free attraction is becoming a victim of its own success, with bookings for Italian-speaking parties, for example, taken one year in advance! In addition, the completion of the 27-kilometre ring of the LEP electron-positron collider, the world's largest scientific machine, means that CERN's installations are even more widely scattered, making sightseeing more difficult.

To handle this increasing influx of visitors and to overcome the problem of distance on-site, CERN has embarked on the 'Microcosm' project, eventually to be equipped with a full range of audio-visual aids and exhibits.

New insights from particle physics have led to important developments in astrophysics and cosmology, extending our understanding of the creation of the Universe in an initial Big Bang and its subsequent development. The interplay between the two complementary physics horizons of the infinitely small and the infinitely large will be a basic theme in the Microcosm project.

Microcosm visitors will be able to stroll in off the street with little or no prior arrangements necessary, and concentrate on what interests them. CERN's key role in higher education will be extended by the new centre acting as a natural focus for groups of high school and college students. Language difficulties will be overcome by cassette packs.

With some infrastructure already in place and thanks to financial and material assistance from authorities in CERN's two host states (France and Switzerland) and from industry, the centre is taking shape. After

The superconducting coil manufactured by the UK Rutherford Appleton Laboratory for the H1 experiment arrives at the North Hall of the HERA electron-proton collider at DESY.

leaving the reception area, visitors will walk through a fifteen-metre tunnel, a full-size mock-up of a section of LEP, to reach the 640 square-metre exhibition hall, dividing into four main permanent themes – the universe of physics and the physics of the Universe; the people, ideas and equipment of the quest to probe the infinitely small; CERN's installations and activities; and CERN as an international organization.

Attractions lined up include a spark chamber triggered by cosmic rays, and an online link (loaned by Apollo Computers) to the OPAL experiment at LEP, showing electron-positron collisions as they happen. Proton-antiproton collisions will be screened on a Megatek display.

The important links between particle physics and cosmology will be illustrated by exhibits designed by astrophysicists from Geneva University's Observatory. Illustrations of the technological spinoffs from particle physics will focus on developments and applications of superconductivity. Here the University of Geneva is providing help.

The permanent display covering two-thirds of the available space will be supplemented by temporary exhibits. LEP will be featured this year and next, giving way to displays organized by the European Southern Observatory and the European Space Agency.

Large-screen video material is being prepared in collaboration with the well-known Palais de la Découverte science centre in Paris and Saclay's Institute of Fundamental Research. Additional specialized material will be viewed on TV screens. Computer-aided displays will also play a key role.

A small park outside the hall is already the home for decommissioned, but nevertheless still impressive equipment, including the Cockcroft-Walton high voltage generator previously used to give CERN's protons their first nudge on the way to high energy, and the mighty BEBC bubble chamber, phased out in 1985.

In its initial form, Microcosm will be ready for the public this autumn, but completion should take several more years, depending on the rate of funding.

The steering group (Guy Hentsch, Maurice Jacob and Rafel Carreras, with Werner Kienzle as project leader) hopes that its project will eventually triple in size, providing a natural focus for a display of European collaboration in all branches of fundamental research.

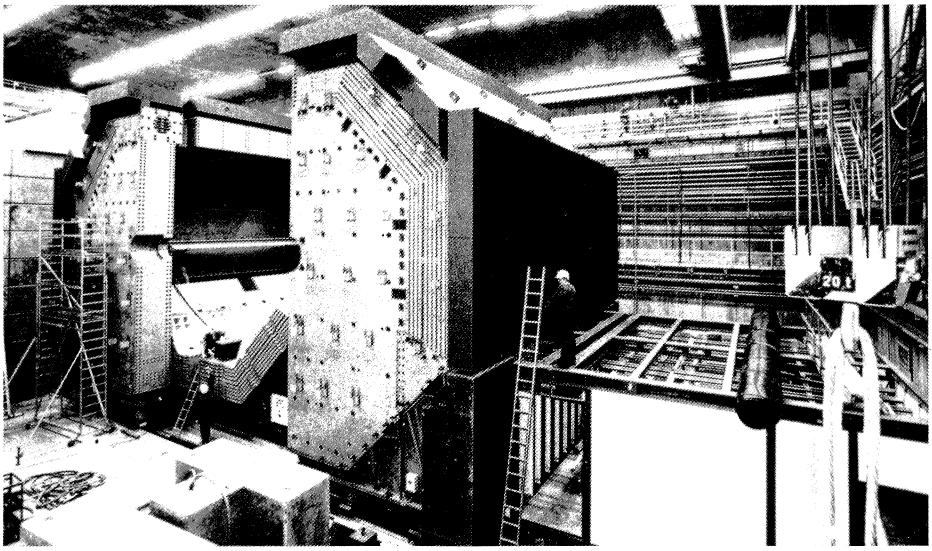
DESY
H1 and Zeus

The two big experiments for the HERA electron-proton collider under construction at DESY (Hamburg) have been in preparation for several years, but progress is now very visible (for a basic description of the experiments see July/August 1986, page 16 for Zeus and September 1986, page 11 for H1).

In the two underground halls (North for experiment H1 and South for ZEUS) the iron structures are now ready and the 'rucksacks' housing the electronics (a three-storey steel building attached to each detector) are being prepared.

The 6 m diameter superconducting coil for H1 (very similar to that of the DELPHI experiment at CERN's LEP ring) has been completed at the UK Rutherford Appleton Laboratory, cooled down and successfully tested at 40% of the nominal current (without an iron yoke) in April before shipment to DESY in May to be installed in the iron structure. The thin superconducting solenoid coil for Zeus (1.7 m diameter) moves from Ansaldo's factory in Genoa to Hamburg this summer.

Both detectors have central tracking with cylindrical and planar drift and proportional chambers,



The North Hall at the HERA electron-proton collider being built at the German DESY Laboratory in Hamburg, where the H1 detector is taking shape.

and construction involves many research centres. The central Zeus tracking chamber is constructed by the UK groups. Mechanical assembly has been completed and wire stringing will be finished at Oxford in November. The forward drift chambers and transition radiation detectors are under construction at Bonn. Bologna and Siegen are building the time expansion vertex chamber. Central tracking devices for H1 are being made by groups at DESY, Zeuthen (DDR), Zürich and Brussels, with the forward parts coming from Liverpool, Manchester, Rutherford and Orsay. In both collaborations series production of chambers has already begun.

Calorimetry (energy deposition measurement) is by far the greatest challenge in HERA detector construction. Zeus will use the depleted-uranium (DU)/scintillator type, while H1 prefers liquid argon technology with iron and lead plate absorbers.

Production of the Zeus DU plates (wrapped in stainless steel) is well underway. The fabrication of the other components is a multi-institute effort, with the optical and electronic readout elements coming from DESY, Bonn, Freiburg, Hamburg, Louisiana, Madrid, Nevis, Ohio, Manitoba, McGill, Tokyo, Toronto, TRIUMF and Wisconsin. Stacking of the calorimeter modules has begun in Argonne, NIKHEF and York (Canada). A fourth stacking centre is being prepared at Jülich. Production of the backing calorimeter is in the hands of Warsaw and Cracow; the first 200 chamber modules have arrived at DESY in March and are being prepared for installation in the iron yoke. The silicon detector to be inserted into the calorimeter is under construction at DESY, Tokyo and Weizmann with help from Brookhaven.

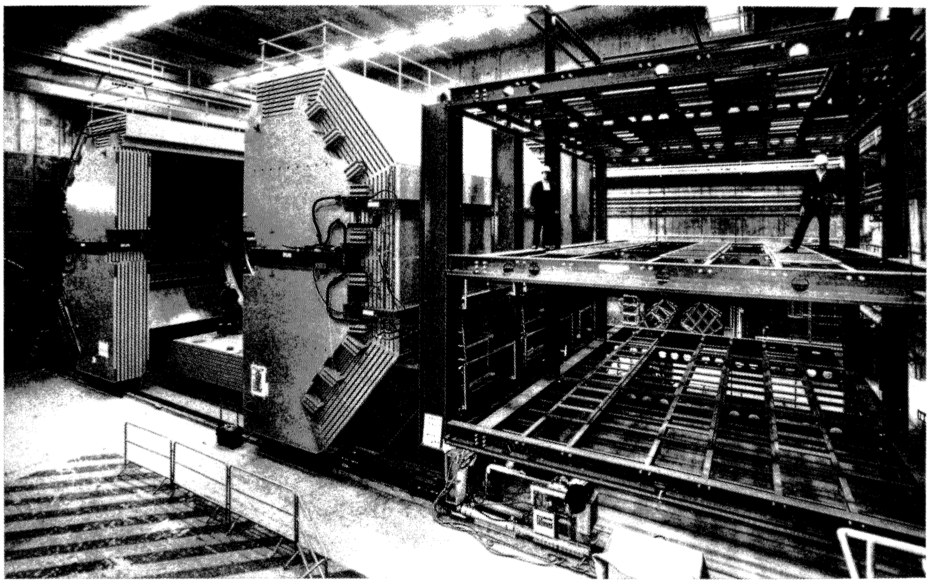
The iron and lead stacks for H1 are assembled at Munich (MPI), Aachen, Dortmund, DESY, Orsay and Saclay with support from ITEP, Prague and Cosice. Saclay supervised construction of the cryostat by French industry. A factory cold test with nitrogen precedes the move to DESY in August.

Extensive tests using both CERN and DESY beams have optimized and checked the calorimeter designs. For Zeus, testing of the DU and backing calorimeter and the muon chambers continues, while calibration of calorimeter modules starts this summer at CERN and continues at CERN and Fermilab through next year. H1 calorimeter stacks have also been tested at the CERN SPS. Module installation starts in November for H1 and in January for Zeus.

In parallel goes preparation of the trigger electronics, the readout system, simulation and analysis software and at each experiment a forward muon spectrometer using an iron toroid and tracking chambers.

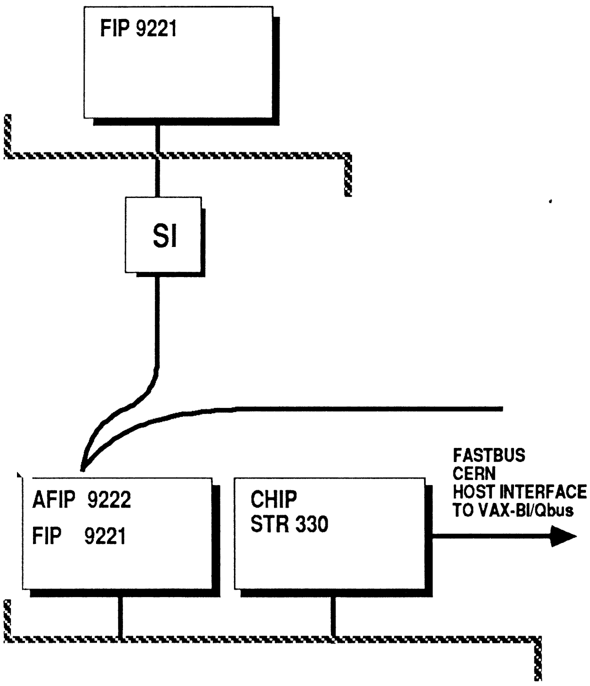
Elaborate muon detection systems are being built at both collaborations – by Italian groups for Zeus and for H1 by Aachen, DESY, Hamburg, Rome and Wuppertal. A leading proton spectrometer for Zeus is being prepared by Bologna, Turin and Santa Cruz, and the experiment's luminosity monitor built by Cracow will have its first exposure to the HERA electron beam this summer.

Zeus now involves 50 institutes and over 350 physicists while about 250 physicists from 29 institutes contribute to H1. In fall 1990 both groups will be ready to catch HERA's initial collisions of 820 GeV protons and 30 GeV electrons.



HERA Hall South with ZEUS.

FASTBUS Products from CES



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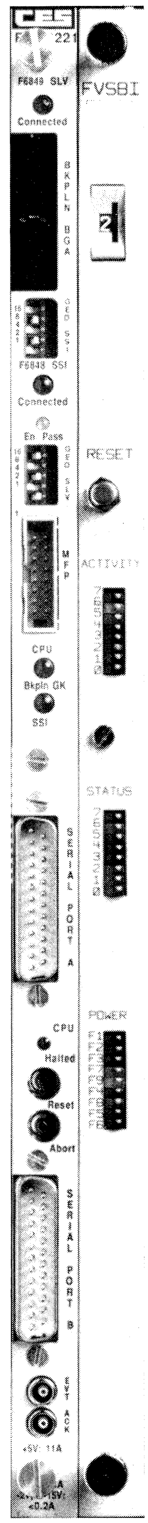

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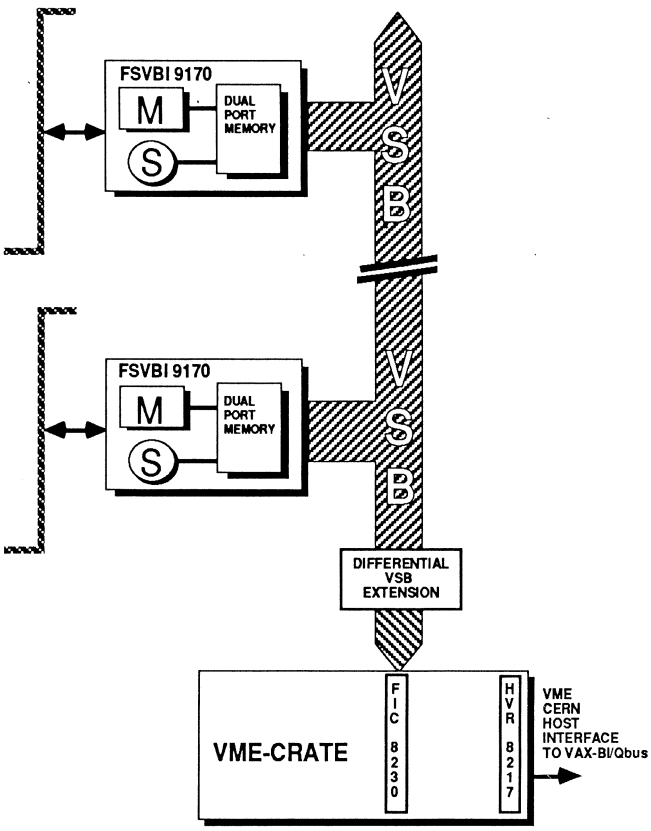

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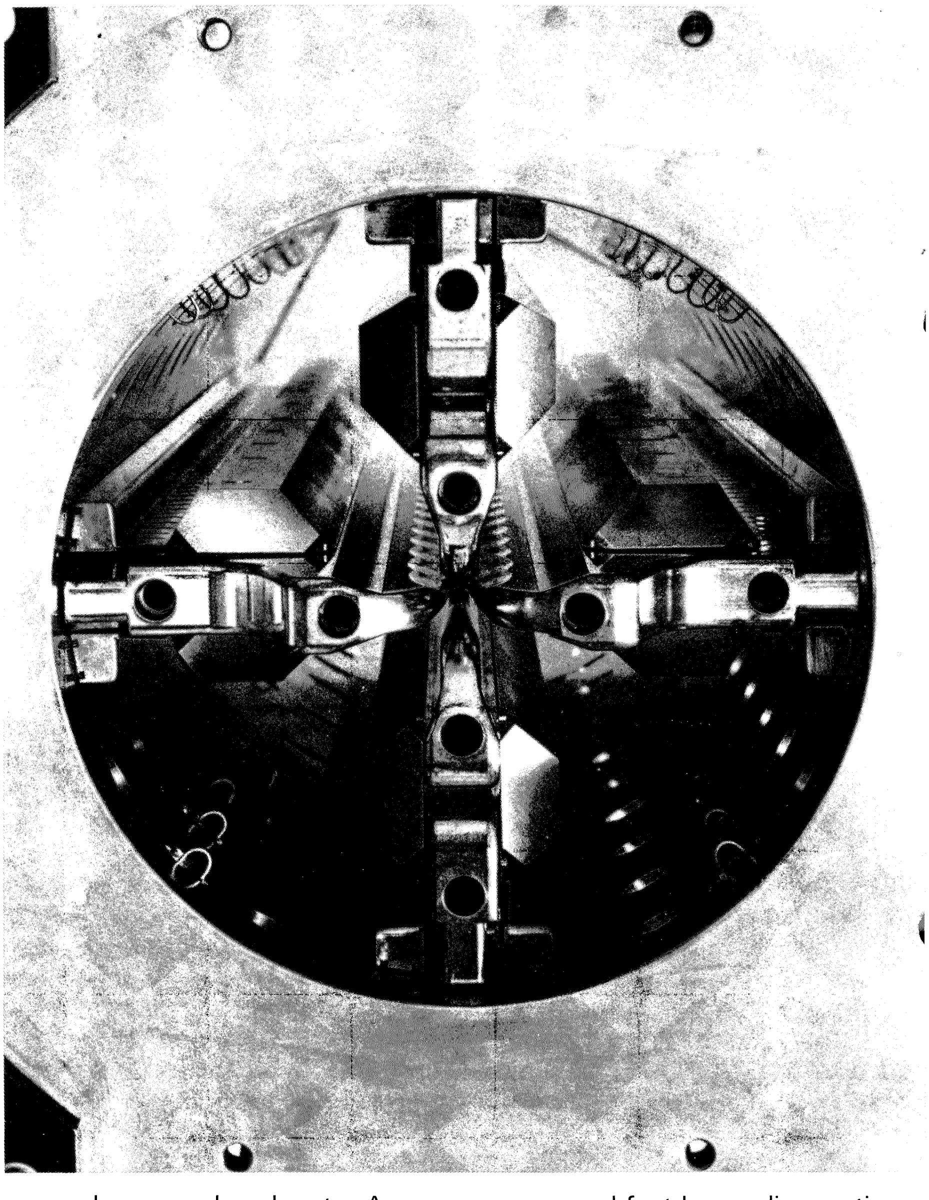
CREATIVE ELECTRONIC SYSTEMS

A radiofrequency quadrupole now gives Brookhaven's protons their first kick on the way to high energy.

(Photo Brookhaven)



BROOKHAVEN
Upgrade progress

A major upgrade now pushing ahead at Brookhaven's Alternating Gradient Synchrotron aims to prepare the 29-year-old machine for Booster injection with an increase in the proton intensity to 6 x 10^{13} particles per pulse. This for a new generation of experiments (rare kaon decay, neutrino physics, the magnetic moment of the muon (April, page 7),.....); to increase polarized proton intensity to 10^{12} particles per pulse for multi-target spin physics; to accelerate heavy ions up to gold for heavy ion physics; and to improve flexibility and reliability.

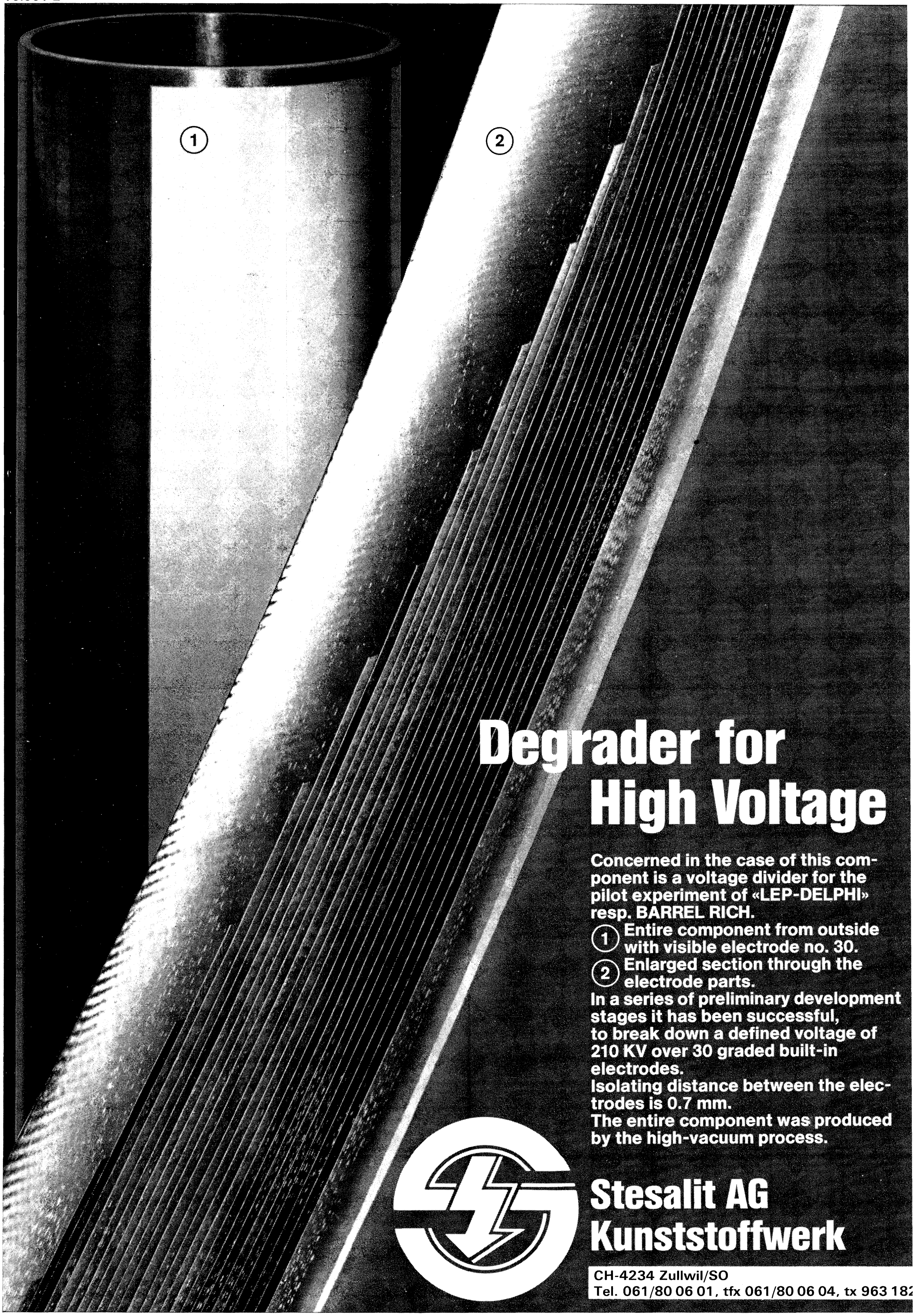
With a view toward substantial completion in 1993, two years after the planned debut of the 1.5 GeV Booster, the upgrade proceeds in parallel with Booster construction. The final step will be new AGS radiofrequency cavities.

The upgrade began in 1985 with the vacuum system, which had been responsible for much of the unscheduled down time. Also, to minimize electron capture during heavy ion acceleration and for stable, high intensity proton beam acceleration, pressures in the 10^{-9} torr range are required. Finally, high intensity operation needs a low maintenance, radiation-hardened all-metal vacuum system.

Upgrading the vacuum system is one of the more complex and time-consuming tasks. Basically it entails reducing the outgassing from the existing vacuum chambers, together with an increase in the pumping capacity. It means rework and/or replacement of practically all vacuum chambers, new ion pumps, all-metal valves, new vacuum clamps and seals, etc. A new computerized vacuum control system was installed last summer, and completion is foreseen during a four-month shutdown next year.

In 1986, development began of a new preinjector for the 200 MeV linac to replace the obsolete 750 keV Cockcroft-Walton. The centrepiece is a high current radiofrequency quadrupole (RFQ), constructed at Berkeley. With a rotationally symmetric magnetron source and fast beam diagnostics, performance this year has been excellent, with linac output now routinely in excess of 25 mA. Being commissioned is a 35 keV fast beam chopper (to remove undesirable 200 MeV beam between bunches that are otherwise dumped in the AGS ring). With a 750 keV chopper, the linac can also deliver single 200 MeV microbunches of less than a nanosecond every ten microseconds to the

10.001 E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Radiation Effects Facility for neutron time-of-flight experiments.

In the AGS, about 5 to 10% of the beam is lost passing through transition at 8.4 GeV. Two complementary correction systems – a high frequency r.f. dilution cavity and a fast quadrupole jump scheme, both initiated in 1987 – should cut these losses. The 93 MHz dilution cavity will reduce potential instabilities by reducing beam density (in longitudinal phase space) at selected times before, during, or after transition. This cavity was installed last summer and is being commissioned.

The other correction scheme makes a quick jump through transition with the help of three fast pulsed quadrupole doublets equally spaced around the ring. It is expected to avoid transition beam losses up to intensities of 3×10^{13} protons per pulse. Now under construction, it will be commissioned during the next financial year.

About one percent of the beam is lost during fast extraction and about three to four percent in slow extraction. Reducing these beam losses is difficult. With Booster injection, the beam size is likely to increase, and the present fast extraction equipment will have to be modified for the muon magnetic moment experiment.

For higher intensities, the present transverse damping is inadequate. A new broadband feedback system is under construction to control the resistive wall instability, to suppress coherent oscillations due to any beam injection errors with the Booster, and to help avoid possible bunch-to-bunch instabilities. Installation of the new damper is planned for the next financial year.

The ten existing r.f. accelerating cavities were built to handle beams of 10^{13} particles per pulse. This system operates well and has supported intensities up to 1.9 times this figure. To reduce beam loading at the higher intensities expected with the Booster, the power amplifiers have to be rebuilt and the r.f. drive system has to be improved, while the monitoring system will also be updated. The new system will be designed next year for construction from 1991-3.

Another improvement underway is for the Siemens main magnet power supply. The existing out-of-date excitron rectifiers will be replaced with the more efficient Silicon Controlled Rectifier (SCR) modules, also from Siemens, in 1991.

Other AGS improvements include injection kicker and septum magnets; an improved low and high field tune correction system with highly accurate regulated monopolar and bipolar power supplies; shortened quadrupoles and sextupoles to provide space for additional injection, extraction, and diagnostics equipment; an improved internal beam dump and kicker; the computer control system, using Apollo workstations and new device controllers; an enlarged and modernized main control room; and, finally, a general overhaul and springclean of equipment in the tunnel.

The project has already begun to pay dividends with increased AGS operating efficiency.

SYMPOSIUM
Particle identification

Typical elementary particle experiments consist of a source of interactions (an external beam and a fixed target or two colliding beams) and a detector system including most of the following components: a tracking system and analysis magnet, calorimetry (measurement of energy deposition), hadron and electron identification, muon detection, trigger counters and processors, and data acquisition electronics.

Experiments aimed at future high luminosity hadron collider (proton-proton or proton-antiproton) projects such as an upgraded Tevatron at Fermilab, the Large Hadron Collider (LHC) idea at CERN, and the proposed US Superconducting Supercollider (SSC), must ideally cover the entire solid angle and be capable of not only surviving the collisions, but also providing high resolution event information at incredible interaction rates.

The Symposium on Particle Identification at High Luminosity Hadron Colliders held at Fermilab from 5-7 April (sponsored by Fermilab, the US Department of Energy, and the SSC Central Design Group) focused on this single facet of detector technology and was attended by about 125 physicists and engineers from the United States, Latin America, Europe, and Japan.

The main goal was to exchange information on the 'non-destruc-

The keynote talk on physics at the proposed US Superconducting Supercollider (SSC) came from Chris Quigg of the SSC Central Design Group, who gave a theorist's point of view.

(Photos Fermilab)

Left to right, Gordon Thompson (Rutgers), Georges Charpak (CERN), and Dave Anderson (Fermilab) confer after Charpak's closing words at the recent Fermilab symposium on particle identification.

tive' identification of particles in the high luminosity hadron collider environment. Non-destructive in this case means that the particle emerges relatively unscathed, without excessive energy loss, multiple scattering, or interaction probability, so that it can continue being tracked or subsequently detected in a total absorption calorimeter. Such a scheme will allow higher momentum resolution measurements and the combination of initial identification followed by calorimetry can further help to differentiate between electrons and hadrons.

In a keynote talk on SSC physics, Chris Quigg gave a theorist's viewpoint of the particles experimentalists should be planning to identify. He was not directly concerned with garden variety pions, kaons, protons, neutrons, etc., except for the usefulness of neutral pion identification as a possible background for electrons, and the detection of single, direct photons coming from constituent interactions. The theorist's ideal would be to detect and identify electrons, muons, tau-leptons, neutrinos, charm-quarks, and bottom-quarks. In addition, throw in Ws, Zs, and top-quarks directly, and through their most likely decays into hadron jets. Especially important is the measurement and identification of leading hadron fragments and electrons within jets. This tall order is a challenge for experimentalists, but is needed to fully explore the zoo of new particles and possible new interactions made accessible by such new machines.

Specific topics covered at the meeting included ring imaging Cherenkov (RICH) detectors, transition radiation detectors (TRD), and synchrotron radiation (SR), time-of flight (TOF), and energy loss techniques, as well as electronic readout applications and designs.

The RICH technique identifies electrons, pions, kaons, and protons from the Cherenkov light produced as these particles pass through a radiator. This light is optically imaged into a ring whose diameter is correlated with the particle's mass and momentum. If the momentum is known, the Cherenkov ring provides particle identification by mass.

The session on RICH counters benefited from two of the founding fathers of this technique, T. Ypsilantis and J. Seguinot, both of Collège de France, who discussed the general techniques, optimizations, limitations, and outstanding problems. D. Leith of SLAC described the high technology and stringent quality control aspects going into the SLD RICH system. A. Breskin and V. Peskov spoke of R&D programs into low pressure RICH systems and the search for new photosensitive detector materials, respectively.

Transition radiation is produced when a particle passes through an interface between two media, the amount increasing as the particle becomes more relativistic. The emitted transition X-rays can be produced coherently from a series of thin, closely spaced polypropylene foils. Since electrons give off more TR than pions, the main application is in electron/pion discrimination. The discussion on transition radiation detection (TRD) included reports of performance of existing large aperture-low rate or small aperture-high rate TRDs as applied in CERN and Fermilab collider and fixed-target experiments. Also presented were fabrication status of the TRD for the Venus detector at the Japanese KEK Laboratory and initial R&D studies for an SSC TRD system. It is apparent that at the higher fixed-target and SSC energies, this technique can provide good discrimination, not only between electrons and pions, but also between pions and kaons.

Synchrotron radiation (SR) is emitted by ultra-relativistic particles bending in magnetic fields. For particle detection, it finds its main application, like TRD, in electron/hadron discrimination, as electrons emit SR copiously. Techniques for detecting SR photons were described by R. Handler, with a conventional analysis magnet with electron energies of 8 – 28 GeV. With SR typically 20 keV X-rays, the xenon proportional chamber was the detector of choice. R. Ru-

Pictured inside the SRS Synchrotron Radiation Source ring at the UK Daresbury Laboratory are participants at the recent course 'Synchrotron Radiation and Free Electron Lasers' organized by the CERN Accelerator School and the Daresbury Laboratory.

(Photo Daresbury)

sak, on the other hand, is designing for 100 GeV electrons in a 5 tesla superconducting magnet, leading to SR above 10 MeV, to be detected in a very fine grained shower counter in which the photons convert into electron-positron pairs.

With the application of these devices at high luminosity colliders still in its infancy, much preliminary R&D still has to be done before a full acceptance detector utilizing such techniques can be seriously considered. The overall detector R&D programme for the SSC was described by Gil Gilchriese.

The symposium was summarized by Georges Charpak of CERN, the father of the multiwire proportional, drift, and gated multistep avalanche chambers. He underlined the great technical challenges of the SSC with its 15 nanosecond crossing times, huge event multiplicities, and huge rates. Innovative high resolution detector technologies will continue to find productive application far beyond the particle physics environment. In closing, Charpak commented, 'In response to the theorist's promise of gauginos and squarks, we experimentalists are supposed to provide gadgetinos and swire chambers....Thank God for the young people!'.

ACCELERATOR SCHOOL
Casting light

A booming spinoff from high energy physics is the synchrotron radiation sector which exploits the intense radiation given off when beams of charged particles are bent. With particle physics and the applications of synchrotron radiation very different, and with new dedicated laboratories being built for the latter, there is a natural tendency for the two communities to drift apart. However a step in the other direction came with the course 'Synchrotron Radiation and Free Electron Lasers' organized by the CERN Accelerator School (CAS) and the Daresbury Laboratory, held in Chester, UK.

As well as an opportunity to review the fundamental theory of particle accelerators and learn the subtleties of light sources and free electron lasers, the course revives and broadened contacts between the sometimes divergent communities.

This dual role of teaching and promoting contacts was also appreciated by industry, with five firms (Acer Freeman Fox, EEV, Oxford Instruments, ICI and Tesla) sponsoring the course, and with a large contingent from industry among the participants. The specialized technologies needed for optical systems in unconventional frequency domains, permanent magnet undulators, superconducting compact machines, etc., provide useful targets for industrial innovation.

CAS is now organizing a new specialized course on power converters to be held in Montreux, Switzerland, from 26-30 March 1990. This is a field where the exigencies of accelerators have pushed the criteria for stability, reproducibility and reliability far beyond those of standard industrial practice.

CAS is also registering participants for its next Advanced Accelerator Course, to be held in Uppsala, Sweden, from 18-29 September. Proceedings of some previous courses (Antiprotons for Colliding Beam Facilities, Applied Geodesy, Superconductivity in Particle Accelerators) are still available. Contact Mrs. S. von Wartburg, CERN Accelerator School, LEP Division, CERN, 1211 Geneva 23, Switzerland.

CERN
States new and revisited

Despite the challenge of higher energy frontiers, the accurate charting of meson resonances in the range 1-2 GeV is still a major particle physics objective. There are many states in this band, many of them yet to have their quantum numbers measured definitively. Some states overlap so that in some mass intervals the situation is still confused.

Proton-antiproton annihilation has traditionally been a good place to look for meson resonances, and this continued with a series of experiments at the LEAR low energy

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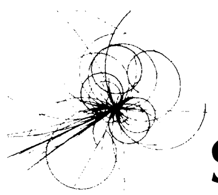

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Supercollider

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Our responsibilities in OPAL include the high-resolution vertex drift chamber and a cylindrical barrel of z-measurement drift chambers, components of the central track detector system. We are also involved in the software for data and physics analysis.

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Ottawa, Ontario, CANADA
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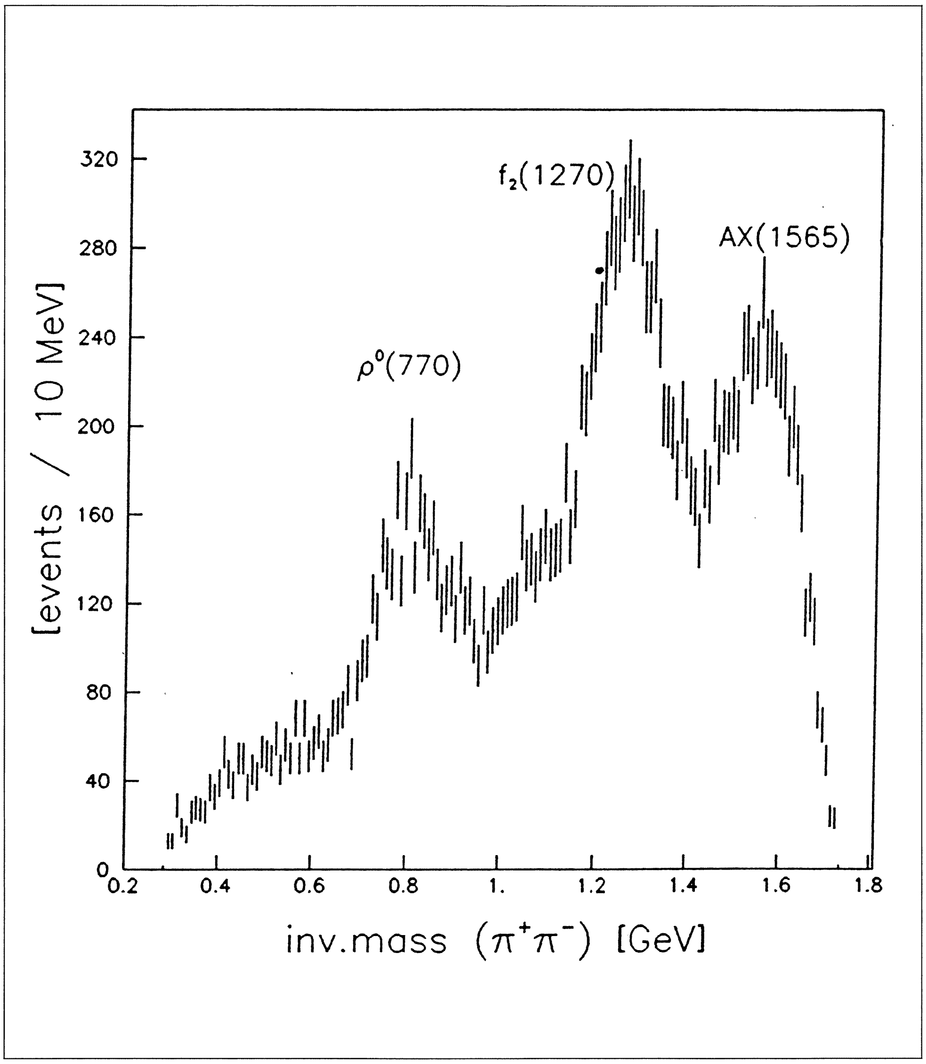
A new state, the AX at 1565 MeV, shows up in the analysis by the Asterix experiment at CERN's LEAR Low Energy Antiproton Ring of the charged pion pairs from the annihilation of protons and antiprotons into three pions.



antiproton ring looking at annihilation via the formation of protonium – antiprotonic 'atoms' – where the antiproton is snared into orbit by the electromagnetic field of a target proton (December 1986, page 11).

The quantum levels of these atoms tag the subsequent production of hadronic states. The 'Asterix' study produced protonium atoms in a gas target and observed annihilations from both P and S states (carrying one and zero quantum units of angular momentum respectively). Using the atomic X-ray spectra to select P states, the physicists looked at annihilations producing three pions (two charged and one neutral) and saw the f_2 meson at 1270 MeV, together with a striking new peak in the distribution of the two charged pions at 1565 MeV. (The f_2 and the new state are not visible in annihilations from S states.) An angular momentum breakdown of the two-pion system suggests an intrinsic angular momentum (spin) of two units, and positive parity, hinting at a state made up of two quarks and two antiquarks, or a nucleon-antinucleon resonance.

Another window on resonance production comes from the WA76 (Athens/Bari/Birmingham/CERN/Paris) experiment at CERN using the Omega spectrometer to look at the production of slow-moving central 'blobs' formed by the overlap of the outer reaches of two colliding protons.

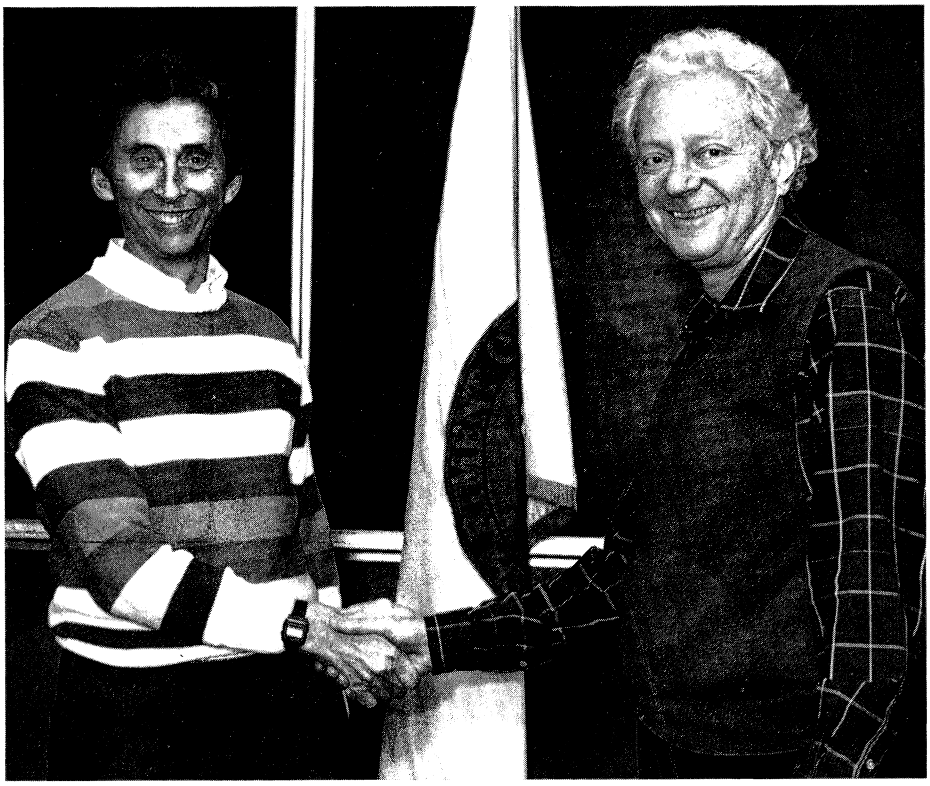
The experiment has also made a preliminary survey of two-pion and two-kaon systems near their production threshold for signs of the multiple resonance structure first seen in a detailed angular momentum analysis of two-pion and two-kaon states produced almost at rest in proton-proton collisions in the Axial Field Spectrometer at CERN's old Intersecting Storage Rings (January/February 1987, page 16).

One of these resonances has been proposed as the long-awaited lightest 'glueball' state – a particle made up of the gluons responsible for inter-quark forces rather than the conventional component quarks themselves. Other states in the 1-2 GeV mass range are in the queue for recognition as glueballs, one candidate being the f_2 meson near 1720 MeV (previously known as the theta particle) seen first in electron-positron annihilations.

WA76 has now seen this particle for the first time in hadronic reactions. Using 300 GeV protons and looking at the spectrum of pairs of kaons, both of the charged and the short-lived neutral type, the experiment sees a resonance near 1710 MeV, with a width of 100-200 MeV.

Careful analysis of the angular distributions favours a spin-parity assignment of two-plus, in line with previous determinations. The same analysis also attributes a two-plus assignment to the f_2 prime at 1525 MeV.

People and things



New Fermilab Director John Peoples (left) with former Director Leon Lederman.

John Peoples becomes Fermilab's Director

John Peoples becomes Fermilab's Director for a five-year term, following the retirement of Leon Lederman on 1 July after his second five-year term. Fermilab's founding Director, Robert R. Wilson, served from 1967-78.

After physics at Columbia and Cornell, John Peoples has made important contributions at Fermilab to both experimental and accelerator physics. He led the team which designed the Laboratory's Antiproton Source, going on to become Deputy Head of the Accelerator Division. In October 1987 he was nominated Head of the Magnet Division for the proposed US SSC Superconducting Supercollider and last year became Fermilab's Deputy Director.

On people

Herwig Schopper, CERN'S Director General from 1981-8, received a doctorate honoris causa of Geneva University on 8 June.

Theorist Michael Green of London's Queen Mary College was among the 40 scientists elected this year to Britain's prestigious Royal Society.

Our May issue (page 26) wrongly described C. Becchi as a student of Raymond Stora, winner of this year's Alexandre Joannides Prize. The Becchi/Rouet/Stora scheme work was worked out when C. Becchi was visiting Marseille from Genoa.

Michael Moravcsik

Michael Moravcsik died unexpectedly on 25 April in Torino, Italy, where he had been visiting the university while on leave from the University of Oregon. His long and energetic contribution to high and intermediate energy theoretical physics as well as science policy and development will be sorely missed. Generations of graduate students and post-docs from third world countries will remember his efforts on their behalf. Theoreticians who knew and worked with him will miss his enthusiasm and insight and dedication to understanding.

From Gary R. Goldstein

Louis Pons

Louis Pons, Professor at the University of Caen, died on 13 May, aged 61. He played a crucial role in the launching of the Institut d'Etudes Scientifiques de Cargèse in 1958.

Fluorine-18 for hospital use

CERN's 600 MeV Synchro-Cyclotron (SC) is to make fluorine-18 for radiopharmaceuticals used to develop positron-emission tomography (PET) imaging techniques at Geneva's Cantonal Hospital. PET itself is a spinoff from particle physics ideas: CERN and the Geneva hospital closely collaborated in the development of the technique.

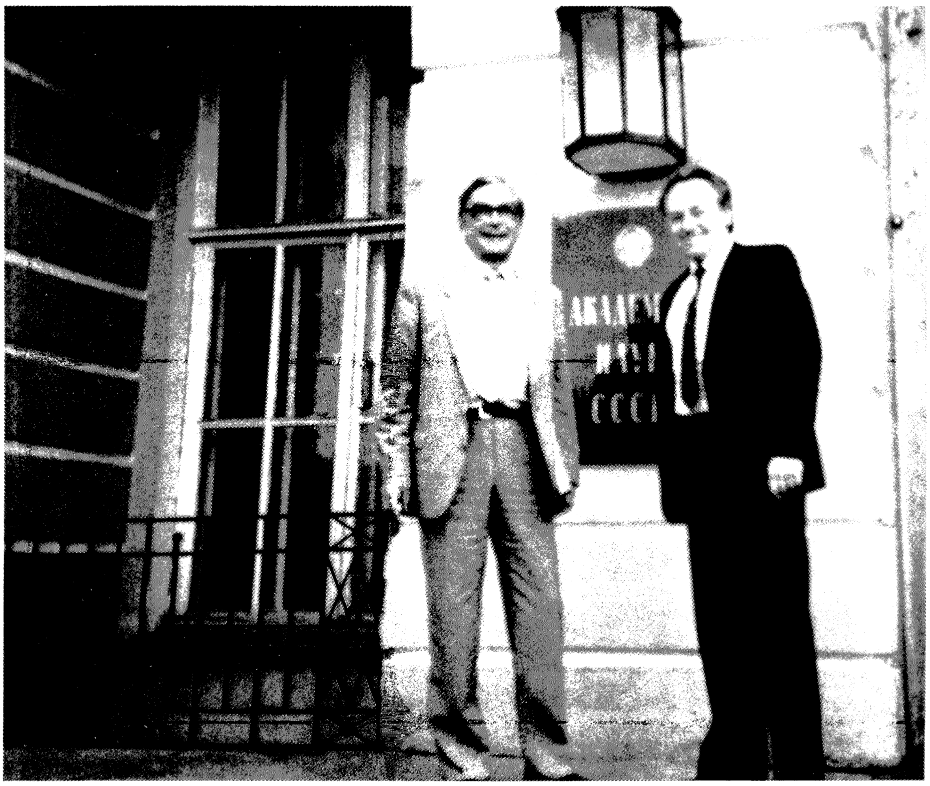
Fluorine-18 for the hospital has been supplied by the Paul Scherrer Institute three hours away in the north of Switzerland, but with the half-life of the isotope being only 110 minutes, not much time or fluorine remained when the samples arrived. At the SC, the fluorine is manufactured using a target enriched with oxygen-18.

The CERN exhibition was in Italy in May as guest of the Fine Arts Conservation organization of the city of L'Aquila in a collaboration with INFN and the nearby Gran Sasso Laboratory. The stand was designed to integrate into a large underground hall of the restored Fort Espagnolo. At the exhibition inauguration, CERN was represented by LEP Project Director Emilio Picasso, with many personalities from Italian scientific and political authorities.

Real time award and conference

At the Real-Time Conference at Williamsburg, Virginia, in May, René Brun of CERN's Data Handling Division was presented with the second CANPS Award attributed by the 'Computer Applications in Nuclear and Plasma Sciences' technical subcommittee of the Nuclear and Plasma Sciences Society of the IEEE for outstanding achievements in the applications of computers in nuclear and/or plasma sciences. Brun's award is in recognition of the development of the GEANT computer program to simulate high energy physics events – one of the mainstays of particle physics computing.

The next Real-Time Conference will be held at Jülich, West Germany starting on June 18 1991, contact Klaus Muller, KFA Jülich ZEL/NE, Postfach 1913, D-5170 Jülich, Germany. For information on CANPS award nominations contact Chris Gould, North Carolina State Univ., Department of Physics, Box 8202, Raleigh, NC 27695, USA, telephone 919-737-2512, bitnet: GOULD at NCSUPHYS.



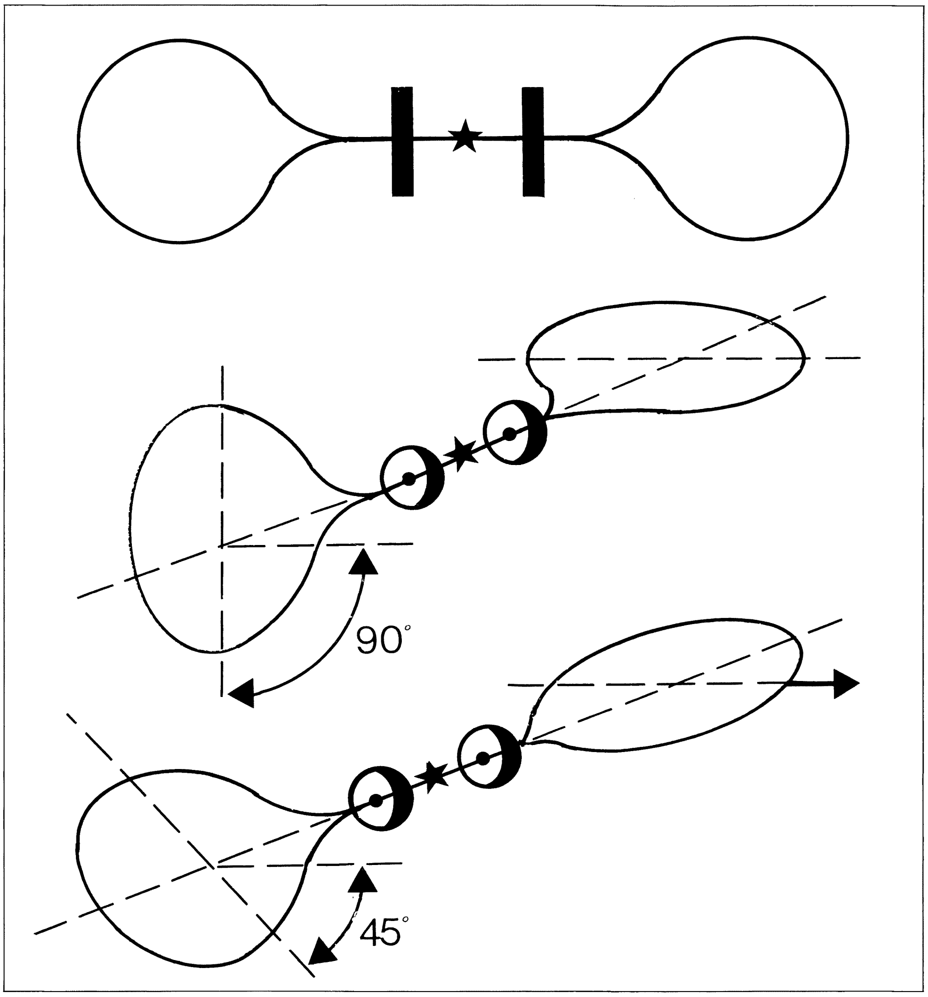
Nikolai Tyurin (right), one of the two Vice-Directors of the Institute for High Energy Physics at Protvino, near Serpukhov, Moscow region, with Lucien Montanet, CERN's coordinator for Soviet affairs, outside the Soviet Academy of Sciences in Moscow after a recent round of talks to extend CERN-Soviet collaboration in particle physics.

(Photo V. Hatton)

Particle factories

Physicists' attention is increasingly turning to the high luminosity frontier – providing enough collisions to amass sizable numbers of rare events – to complement the traditional quest for higher energies. This month we cover three areas where projects are now being considered.

Proposed 'dog-bone' schemes for small electron-positron colliders.



Phi-factory workshop

Following an initiative by Conrad Kleinknecht of Mainz, Guido Barbiellini of Trieste and Walter Hoogland of the Dutch NIKHEF Laboratory, the interesting possibilities opened up by a high-luminosity electron-positron collider operating near the phi resonance at 1020 MeV were investigated at a recent two-day informal workshop at NIKHEF.

Such a phi factory is being considered at the Soviet Novosibirsk Laboratory, where a collider is already operational at that energy range, and ideas are also being actively explored at Mainz, Trieste, Frascati and NIKHEF.

Associated physics objectives have to do with violation of the combined left-right reflection and particle-antiparticle reversal (CP) symmetry – a physics effect still not fully understood 25 years after its discovery.

The decay of a phi into a short-lived and a long-lived kaon, with both kaons decaying into two pions, produces unique interference effects due to the antisymmetric character of the phi. Experiments in this domain would have an impact if up to 10^{10} decays into two charged and two neutral pions could be collected. The workshop considered both the prospects to reach a high enough collision rate (luminosity well beyond 10^{32} per sq cm per s) and the design of suitable detectors.

The discussions on CP violation began with Heinrich Wahl (CERN) surveying past, present and proposed CP violation experiments. Detector designs covering a nearly complete solid angle for an electron-positron collider were described by Guido Barbiellini of Trieste and Claudio Santoni of Basel, Klaus Peters of Mainz and Frits Erné of NIKHEF. The kinematics of phi factories would provide interesting new opportunities to study delicate effects in the decays of short- and long-lived neutral kaons.

A lot of imagination has gone into the design of suitable circulating-beam colliders, described at the meeting by Andreas Streun of Mainz. The possibilities included circular rather than flat beam solutions, combined with separate rings for electrons and positrons, and bunches alternating between the two rings. Luminosities above 10^{33}, with large tune shifts, up to 0.12, seem possible with such schemes. A more conservative approach for NIKHEF (Jan Botman – Eindhoven) promises a few 10^{32}.

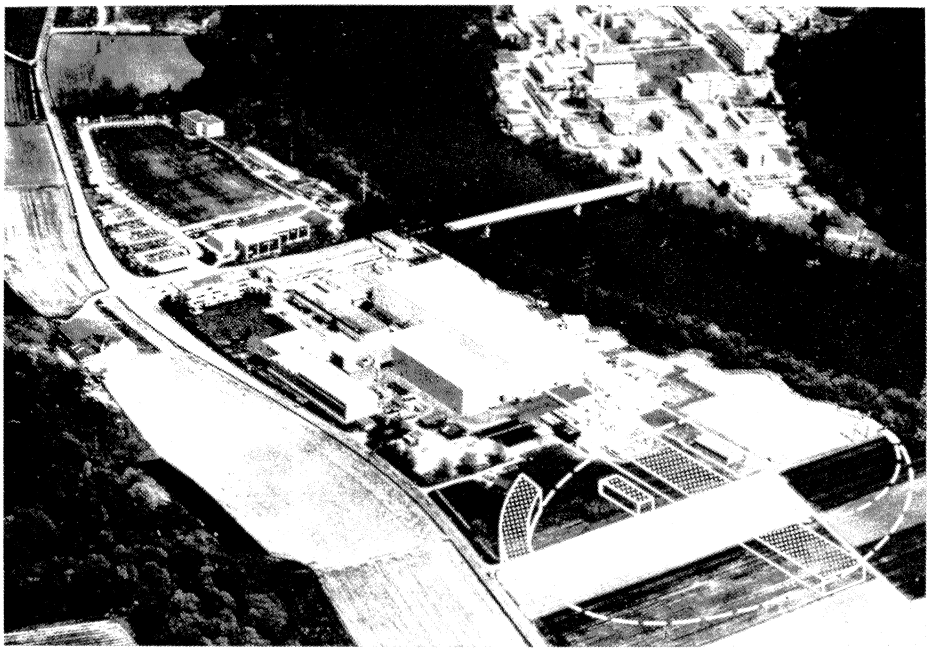
Antonio Dainelli from Padua considered the possibilities of positrons in a superACO ring colliding with electrons supplied by a superconducting linac. Such schemes originating from John Rees and recently revived by P. Grosse-Wiesmann of Stanford have been looked at for a phi-factory by Carlo Rubbia and Albin Wrulich in connection with the planned Elettra synchrotron light source at Trieste. Luminosities of a few times 10^{32} seem within reach, but Sergio Tazzari of Frascati underlined potential difficulties due to possible instabilities due to significant energy deposited in the interaction point, and a beam disruption parameter of the order of 50, leading to curled up beams.

John Jowett of CERN, summarizing this session, argued that the double storage ring machines looked more promising than schemes involving linacs. However these schemes to push storage ring technology to its limits were beginning to look almost 'conventional' compared with some of the other ideas presented at the workshop. Although no phi particle factory has yet been built, a luminosity of 10^{32} seems within reach.

A final session looked at other physics opportunities. Mike Albrow (Rutherford/Stockholm) considered radiative decays, with imaginative photon detection using liquid noble gases. Bernard Jean-Marie of Orsay reviewed physics results between 1 and 2 GeV achieved so far using relatively modest collision rates. Mario Greco showed the need for accurate hadron production measurements over a wide energy range to make precision corrections to the mass of the Z boson and the magnetic moment of the muon.

In conclusion, Frits Erné underlined how a phi-factory with luminosities in the 10^{32-33} area would give a substantial boost to CP violation measurements. Building an electron-positron collider to guarantee this performance is far from straightforward, and the first task is an extensive programme of calculations to firm up the existing proposals. NIKHEF Director Walter Hoogland remarked that the cost leaves room for only one such facility in Europe.

The Paul Scherrer Institute (formerly SIN) spanning the River Aare in Switzerland, showing the twin-ring structure of the proposed B-meson factory.



PSI
Planning for B meson factory

The rich physics potential of a copious supply of B mesons (containing the heavy b quark) has awakened interest in B-meson 'factories'.

Worldwide more than ten groups are looking at possibilities for electron-positron colliders with total energies around 10 GeV and with luminosities in the 10^{33-34} per sq cm per s range. These very high collision rates are necessary to see the violation of the combined left/right reflection particle/antiparticle (CP) symmetry in B-decays, should its strength be as predicted by the Standard Model. So far, CP violation physics has been confined to the neutral kaon sector.

But CP-violation is just one of many interesting topics at B-factories – neutral B mixing, rare B-decays and upsilon spectroscopy are also on the menu, while charmed baryons and the tau lepton wait for complete investigations.

In addition to high luminosity it is important to have lots of running time, a small diameter beam pipe at the interaction points for good resolution of the fine details of the collisions, and low background in the detectors.

A pioneer and now well advanced proposal is the double storage ring project at the Paul Scherrer Institute (PSI – formerly SIN) in Villigen, Switzerland. After endorsement by an international review committee, a physics, machine and detector proposal was

Worth a closer look...

No. 1/1989

LB Landolt-Börnstein NEWSLETTER

Printed Data Collections or Data Banks?

In the age of computer storage of scientific data the role of printed data collections has to be discussed. Will floppy disks and CD-ROM's take the place of printed books? Will the LANDOLT-BÖRNSTEIN Series be replaced by a data bank in the near future?

The answer can only be that both are necessary, printed data collections and computer stored data. Data banks are no substitute for printed information. Electronic retrieval can provide very fast access to individual items of information and large amounts of data can be stored and distributed on-line. However, if a broader scope is required, a computer search can lead to an avalanche of redundant information which the user then has to condense and to evaluate, not knowing who has – when and according to what criteria – put this information into the computer. Furthermore, such a search can be more expensive than the price of a good printed data collection on this field. Even, looking for a single value, it is often advantageous to have a table available with data collected, condensed and assessed by a well-known specialist.

Thus, printed data collections should not compete with data bases by presenting data in exactly the same way. Rather, they should complement one another. Since the first edition more than a hundred years ago, LANDOLT-BÖRNSTEIN has followed a policy consistent with this aim. It provides data with all information necessary for its assessment, e.g. the experimental conditions and method of measurement and evaluation as well as due reference to the original paper. Graphical representations are used to an increasing extent to replace tables of data. LANDOLT-BÖRNSTEIN thus presents an overall picture, permitting direct access to single items of data as well as a ready comparison between various data and providing a complete view of all relevant material on a particular physical quantity. Last but not least the reader is kept informed on who has chosen and assessed the data selected from the huge amount published in scientific papers.

Nevertheless, the great mass of data published does raise the question as to whether selected parts of the contents of LANDOLT-BÖRNSTEIN should not be made available on-line, in floppy disk or compact disk forms as well as (or instead of) the printed version. Discussions are currently in progress as to whether such changes can and should be implemented in the future. We will keep you informed in due course in one of our Newsletters.

Otfried Madelung
Editor-in-Chief

LANDOLT-BÖRNSTEIN NEWSLETTER

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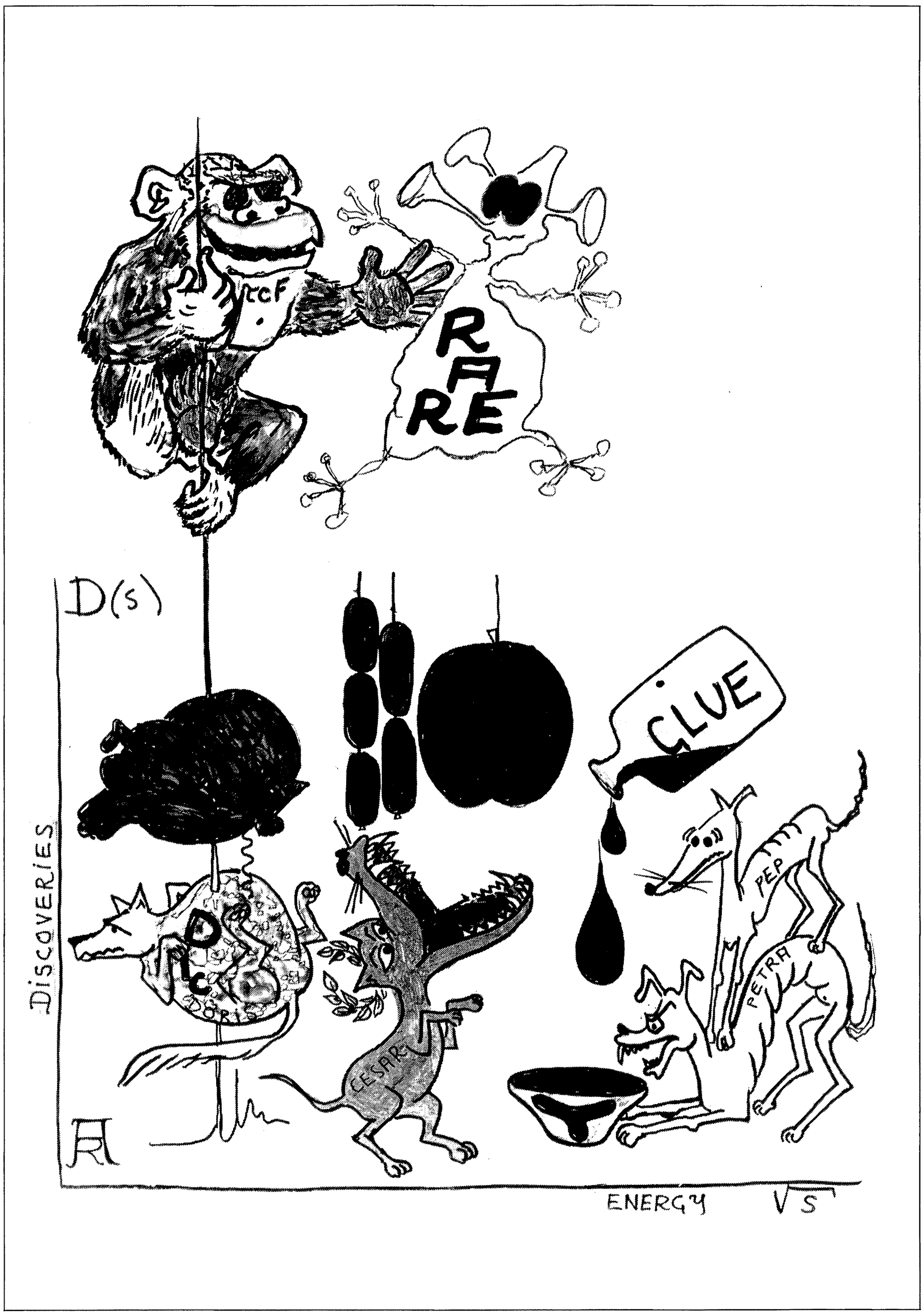

Alvaro de Rujula's view of lower energy electron-positron collider physics. Left, the DORIS (DESY) and SPEAR (SLAC) rings grew fat on charmonium resonances, while the proposed tau-charm factories (top) have a good chance of grasping rare physics. Centre, Cornell's CESR ring with a harvest of heavy quark fruits. Right, PETRA (DESY) and PEP (SLAC), lean and mean on a physics diet largely restricted to inter-quark glue.

recommended for further evaluation. Hopefully it will be formally forwarded to the Swiss government this fall, the final step being approval by the Swiss Parliament. Construction could begin at the earliest by the end of next year with first electron-positron collisions expected during 1995.

The collider design is based on a multi-bunch double storage ring with two interaction regions and zero degree beam crossing angle. Beam separation uses either electrostatic deflection plates or a radiofrequency magnet. Energy extends from 1.5 to 7 GeV per beam, with injection using two linear accelerators of 200 and 400 MeV, a 400 MeV accumulator ring and a 6 GeV synchrotron.

A luminosity of 10^{33} should be reached after one year of commissioning. Fivefold higher luminosities could eventually be attained by storing higher currents. The collider could operate either in a symmetric mode with beams of equal energy or asymmetrically with 4 on 7 GeV to produce B-mesons with a relaivistic boost.

According to designer K.Wille (Dortmund), the luminosity in the asymmetric mode is expected to be a few times lower than with symmetric operation. But experiments using the asymmetric mode would profit from a better reconstruction of short-lived B-meson decays.

The rings could accommodate two experiments. A contender for one of the intersections is the Crystal Barrel experiment now running at CERN's LEAR Low Energy Antiproton Ring. At PSI, this experiment would look at the physics of J/psi and psi prime particles.

About 50 interested physicists from Germany, France, Poland, Switzerland and the US are presently working towards a detailed proposal for the other interaction region. The detector aims for excellent vertex resolution of 20 microns for B decays using a thin silicon vertex detector, pion/kaon separation up to 2.5 GeV momentum with a fast ring imaging Cherenkov (RICH) counter and good neutral pion reconstruction in a finely segmented cesium iodide calorimeter. So far there have been eight plenary meetings of the detector study group, the latest having been in Paris at the end of March. The next one will take place in the last week of September at Fribourg, Switzerland. Further information from R.Eichler (ETH/PSI) and K.R.Schubert (Karlsruhe).

Tau-charm factory

Late in May a workshop at Stanford (SLAC) explored the idea of a high-luminosity electron-positron collider operating between 3.0 and about 4.2 GeV. Such a 'tau-charm factory' would manufacture up to 10^{10} J/psi particles (with 'hidden charm'), 10^{8} charmed mesons and almost 10^{8} tau leptons per year at its design luminosity of 10^{33} per sq cm per s.

First proposed by Jasper Kirkby at CERN, such a collider is now under consideration at SLAC, and by institutions in Japan, Spain and the

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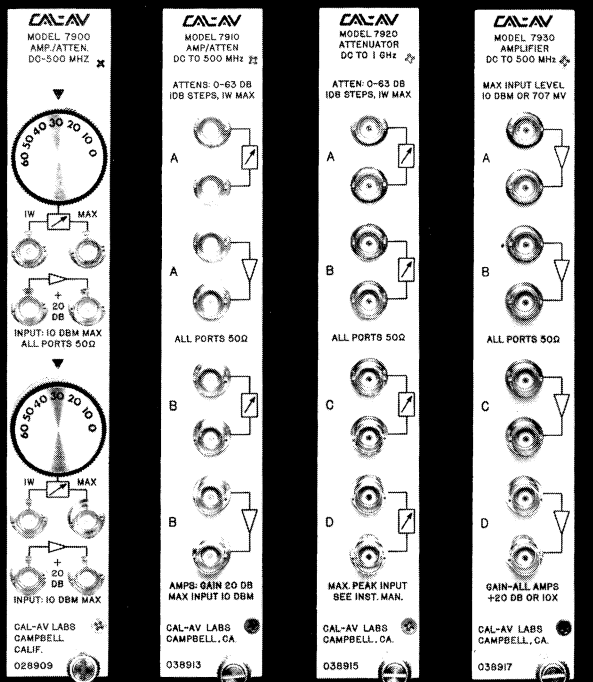

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Soviet Union, as a logical next step in storage ring development after the newly-commissioned BEPC machine in Beijing.

Attracting almost 200 participants from 12 countries, including 40 accelerator physicists, the workshop began with plenary sessions, with working groups subsequently examining various asoects of machine and detector design, and physics prospects.

Machine discussions began with John Jowett's design for a double ring machine with a single clashpoint. Electrostatic separators would enable each ring to carry 24 bunches and a fat beam current of half an ampere. Other designs also used a two-ring scheme. Gus Voss of the German DESY Laboratory suggested using about 400 bunches and 'crab crossing' to increase the luminosity to 5×10^{33}. Susumu Kamada of the Japanese KEK Laboratory outlined the idea of a tau-charm factory in the TRISTAN Accumulator Ring. During an evening session, Juan Antonio Rubio of CERN and CIEMAT (Madrid) utlined Spanish plans to build a tau-charm factory near Seville.

While the accelerator physicists deliberated how to build a tau-charm factory, the rest of the participants studied how to use it for research. CERN's Alvaro de Rujula launched discussions among the physics and detector groups, pointing out the complementary particle physics frontiers of high energy and high luminosity.

The working group on tau physics stressed how the tau lepton and its neutrino are less well understood than the other leptons, largely because of the small supply available so far. Current tau measurements still allow large deviations from the Standard Model, and 'new physics' could emerge from higher statistics. Tau decays would be an excellent testbed for the Standard Model, and the tau neutrino mass could also be fixed.

Led by Rafe Schindler, the charmed meson working group examined precision measurements of inter-quark couplings, leptonic decays of D mesons, neutral D mixing and rare D decays. There was also plenty of interest in the possibility of observing CP violation in the D meson system either directly or through mixing.

Fifteen years after its discovery, charmonium (charmed quarks and antiquarks bound together) is still an exciting field. A group led by Walter Toki examined the potential of a tau-charm factory for glueballs (particles composed of the gluon carriers of the inter-quark force), quark/gluon hybrids and exotic four-quark states. An enormous number of J/psi and psi-prime decays would provide a good probe of the force between charmed quarks.

Organized by Jasper Kirkby, the detector group produced a design using fairly low-risk technologies (a high-resolution central tracking chamber with large solid angle, and a crystal electromagnetic calorimeter) that nevertheless satisfied the stringent constraints imposed by the physics and accelerator groups. Particle identification and full coverage of all emerging particles (hermiticity) are stressed, the latter accomplished using an outer fine-grained neutral hadron tagger, and allowing good coverage of tau neutrinos.

On the final morning of the workshop, John Jowett concluded for the machine builders. A double-ring electron-positron collider operating in the tau-charm energy range could indeed be built with the desired luminosity, but it would require a dedicated injector/accumulator to 'top off' the beams frequently, keeping the machine near its peak luminosity. At the highest currents, multibunch instabilities and ion trapping in the electron ring would need a lot of attention.

In a final summary, Martin Perl of SLAC, who discovered the tau lepton more than a decade ago, estimated a tau-charm factory to have a useful research lifetime of 10 to 15 years. The physics, he observed, 'would be broad, deep, and exciting.'

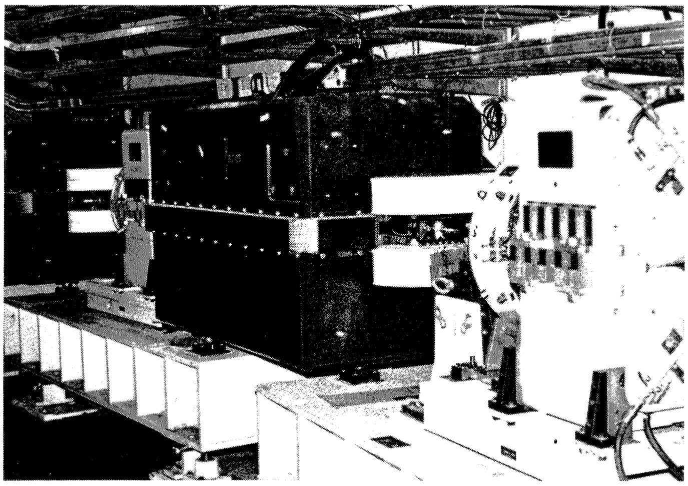
From Rafe Schindler

ANNIVERSARY
25 years without CP

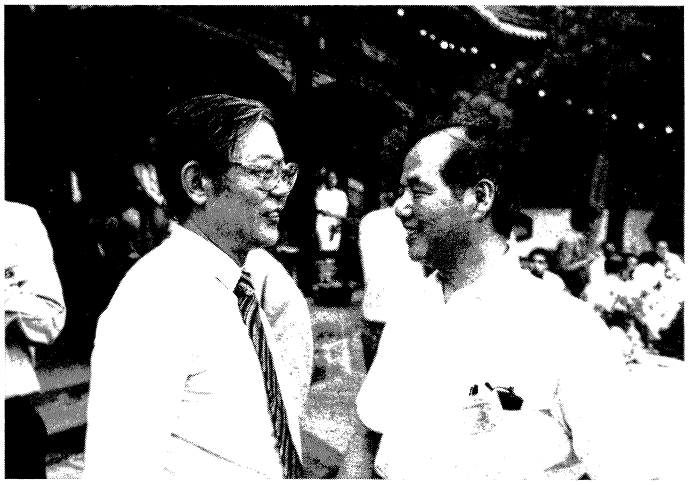
In 1964 a small group of Princeton University physicists led by Jim Cronin and Val Fitch performed a landmark experiment at Brookhaven. Using a double-arm spectrometer, they showed that long-lived neutral kaons occasionally decayed into a pair of pions – violating the hitherto sacrosanct CP symmetry of combined mirror reflection and particle-antiparticle switching (April, page 4).

From May 21-26 scientists gathered at the Château de Blois, southwest of Paris, to celebrate the 25th anniversary of this achievement. In an opening session, surveys and reminiscences of the principal experiments on CP violation were presented by Robert Adair, Abraham Pais and Jack Steinberger. Surprisingly absent from this nostalgia was any detailed discussion of the Cronin-Fitch experiment that started all the fuss.

That afternoon the four principals in the 1964 experiment outlined their current research pro-



A magnet cell of the new Beijing electron-positron collider.



Zhou Guang Zhao, left, president of the Chinese Academy of Sciences, and T.D. Lee, both directors of the new China Centre of Advanced Science and Technology (CCAST), pictured early in June at a Beijing physics symposium that was to end prematurely. (Photo M. Jacob)

CHINA

Early in June, two workshops organized in Beijing by the China Centre of Advanced Science and Technology (CCAST), a spin-off of World Laboratory, had to terminate abruptly. The meetings, on fields, strings and quantum gravity, and on relativistic heavy ion collisions, were scheduled to run for at least another week.

Participants at the meetings from abroad had been impressed by the new Beijing electron-positron collider, now in operation, and the achievements of their Chinese colleagues and Chinese industry, and hope that the road to further progress and collaboration will remain open.

jects. James Christenson sung the praises of DO, the next-generation detector due to start operation next year at the Fermilab proton-antiproton collider (May, page 16). Cronin discussed the Chicago Air-Shower Array being installed around the Fly's-Eye Detector in Utah, while Fitch reviewed the work of his group and others in the search for a fifth force. René Turlay of Saclay closed the day with a summary of the progress being made for CERN's new LEP electron-positron collider and the expectations for its first round of physics.

Ensuing sessions focussed on current research in CP violation and the B mesons (carrying the fifth 'beauty' quark). Prominent among these are the NA31 experiment at CERN and Fermilab E731, which looked for evidence of direct CP violation in neutral kaon decays. Ken Peach of Edinburgh reiterated the previously reported NA31 result (July/August 1988, page 7) giving an additional insight into CP violation. Bruce Winstein of Chicago looked at the emerging analysis of the Fermilab experiment, but would neither confirm nor refute the NA31 result.

Looking at the ratio of CP violating and CP conserving neutral kaon decays into pairs of pions, the phase difference between the results for neutral and for charged pions is a crucial test of CPT conservation (CP plus time reversal symmetry). Before the meeting, this difference hinted at a possible violation, but both experiments came in with values consistent with zero. The physics cornerstone of CPT could consider itself saved.

On Wednesday morning Henning Schroder of DESY and Persis Drell of Cornell presented updated results on B decays from the ARGUS and CLEO collaborations respectively. They found themselves in complete agreement on the level of neutral B mixing, while the ARGUS evidence for charmless B decay (September 1987, page 3) has withered away. Haim Harari of the Weizmann Institute explained the implications for the Standard Model, surmising that the long-awaited sixth 'top' quark is probably heavier than 100 GeV.

The meeting concluded with a day devoted to astrophysical and cosmological implications. Of central interest was the baryon asymmetry of the Universe during the first picosecond of the Big Bang. 'We are here,' noted Rocky Kolb of Fermilab, 'as a result of CP violation'.

Closing, Lincoln Wolfenstein of Carnegie-Mellon said that progress had come very slowly in 25 years of trying to understand CP violation. But progress was indeed being made, and would continue to be made by increasingly refined experiments and theoretical analysis. 'Nature has been performing an elegant striptease,' Fred Gilman had remarked a few days earlier. 'We just have to be patient and enjoy it.'

From Michael Riordan