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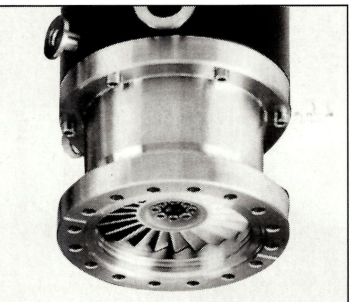

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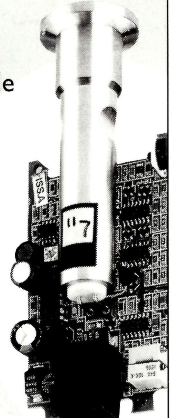

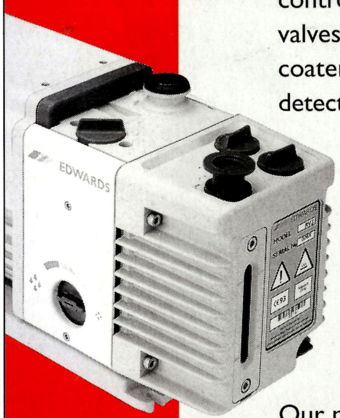

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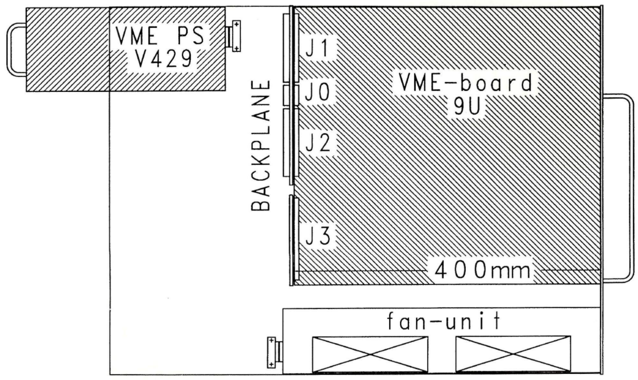

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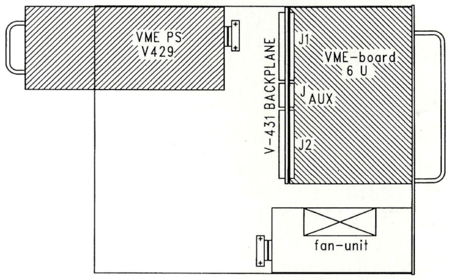

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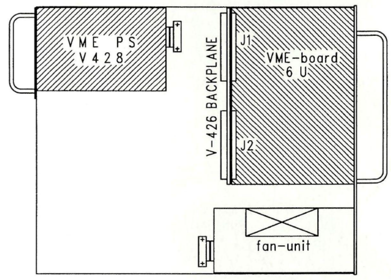

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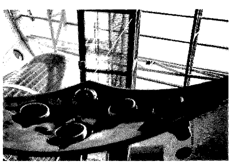

Cover photograph: A module of the CHOOZ reactor neutrino experiment swings menacingly in the atrium of the Laboratory of Particle Physics at Annecy (LAPP), France. This summer LAPP proudly celebrated its 20th anniversary (see page 39 - photo G. Fraser).

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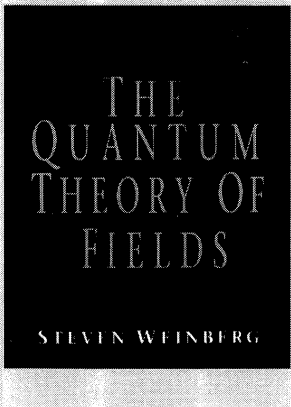

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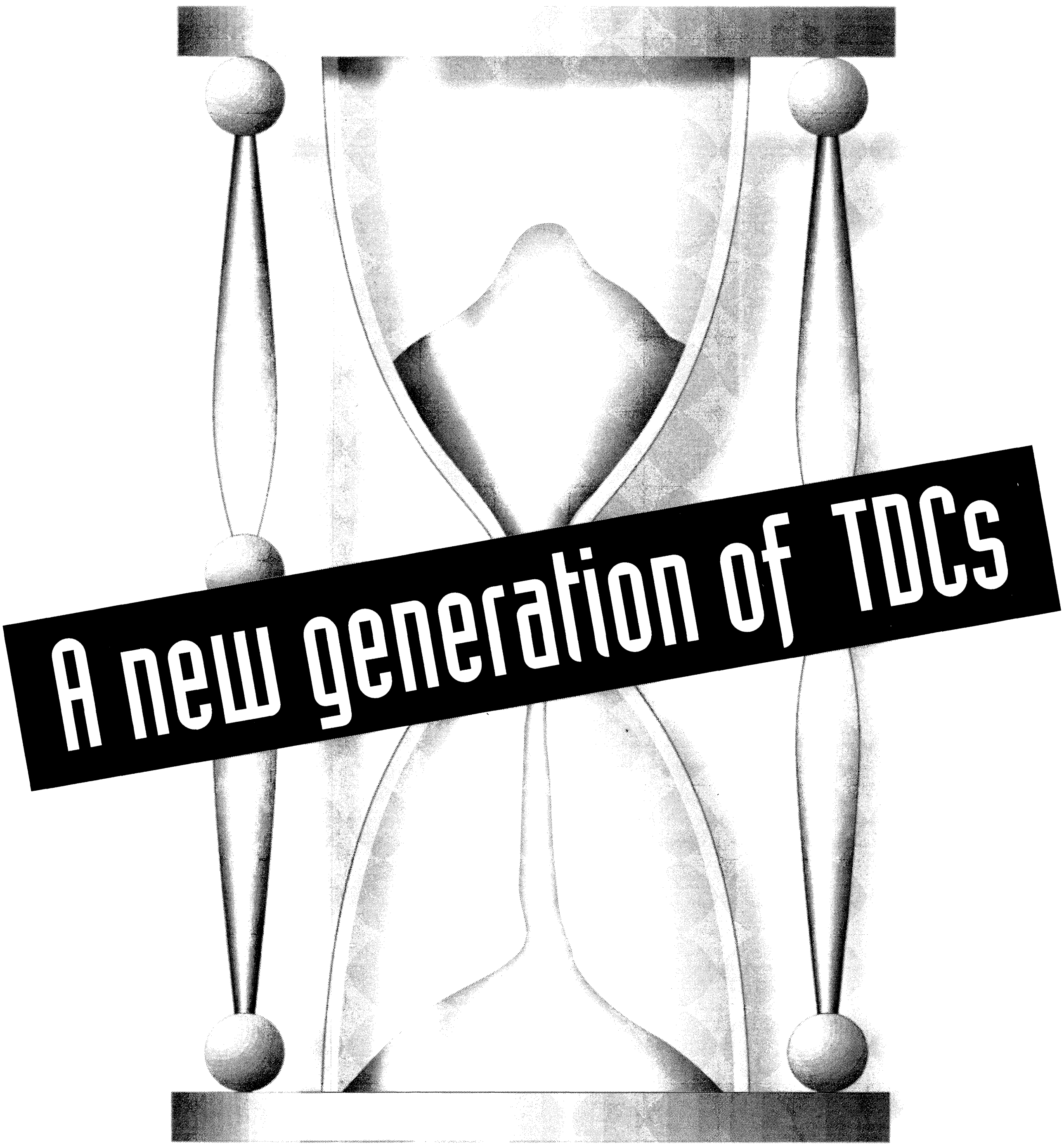

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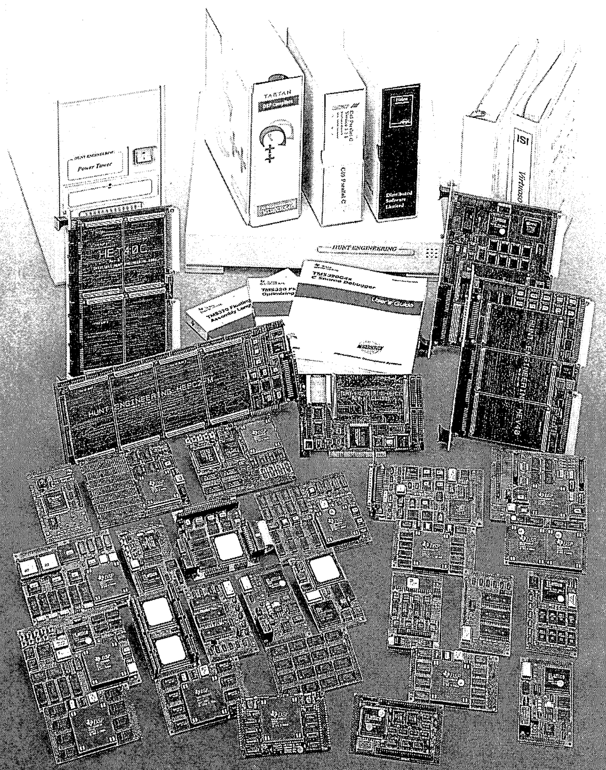

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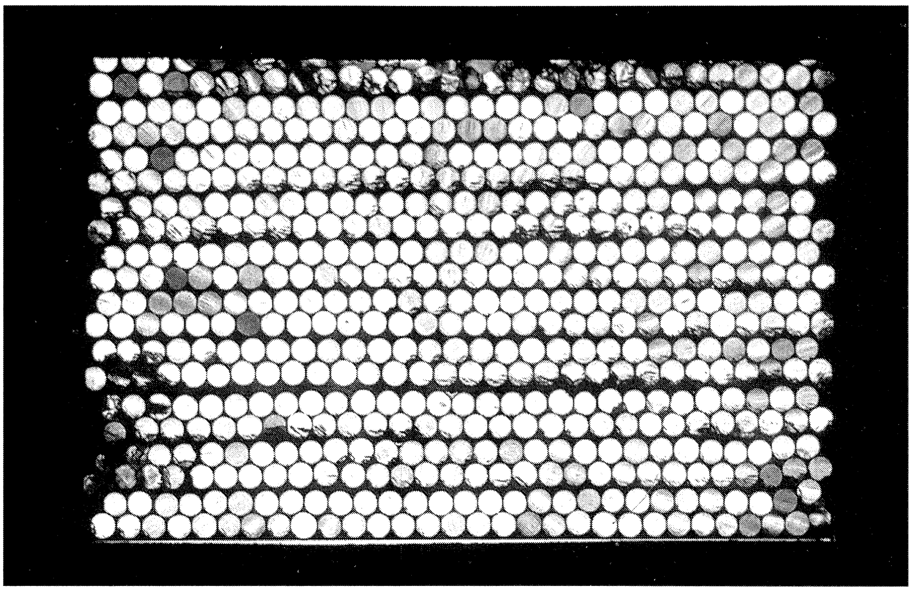

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Warsaw conference

Preliminary report

They came to bury the Standard Model, not to praise it, but at the end of the year's major high energy physics jamboree, the 28th 'Rochester' conference, held in Warsaw from 25-31 July, the Standard Model was in its best shape for years.

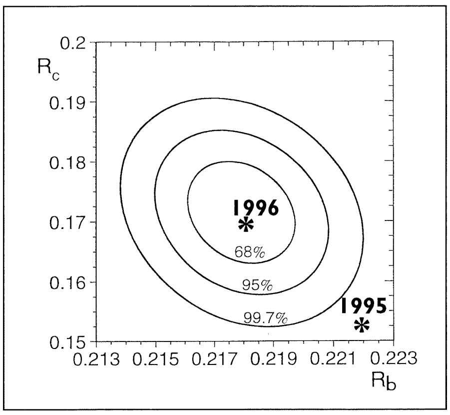
The Standard Model is a 20 year old collection of theories which has enjoyed remarkable success, agreeing with experiment to extra-ordinary precision. But recently, a few small cracks have appeared. Physicists came to Warsaw eager to hear of widening gaps between experiment and theory, but left with the message that the cracks have disappeared.

First to go was the so-called R_b anomaly. R_b is the fraction of quark producing Z decays producing pairs of heavy b-quarks. Last year, results from CERN's Large Electron-Positron Collider, LEP, seemed to indicate that this happened far too often (October 1995, page 1). The most promising explanation involved supersymmetry, a theory linking particles and forces which introduces a new 'supersymmetric' partner for each ordinary particle. In this model, the Z can decay into supersymmetric particles, which in turn decay to b-quarks, but even this could not explain an effect as big as that seen at LEP.

At Warsaw, the Aleph and L3 experiments presented new R_b values closer to the Standard Model prediction. The Aleph result matches precisely at 21.58%, but the new world average is still uncomfortably high at 21.78%. The mood of the conference was one of wait and see, but supersymmetry enthusiasts pointed out that the new world average is exactly what their model anticipates.

Another apparent deviation from the Standard Model appeared at Fermilab's Tevatron proton-antiproton collider last year, when the CDF experiment observed an excess of high transverse momentum jets. The Tevatron's other experiment, D0, did not see the same effect. In Warsaw, Raymond Brock showed the CDF and D0 data to be entirely consistent, and suggested that the effect arises from the models used to interpret the data, in particular, the description of gluons inside the proton. Brock's conclusion that more information is needed about the gluon was a recurring theme of the conference.

Summarizing recent spectroscopy results, Rolf Landua said that a particle made only of gluons, a glueball, is now established, but it is not yet possible to say which of two particles it is. Sergey Levonian and Halina Abramowicz both drew attention to the Pomeron, much in vogue in the 1970s for understanding elastic scattering and now making a comeback. Data from the Zeus and H1 experiments at HERA in Hamburg continue to show the structure function of the proton, which measures the momentum distribution of the proton's constituents, to rise sharply at low momentum fraction.



This phenomenon, according to Levonian, could be accounted for by a Pomeron with a large gluon content.

The Warsaw conference was the first Rochester to feature all the Standard Model particles in their place, with the top quark now in the physics mainstream. Paul Tipton presented the latest value of the top mass as 175±6 GeV, paradoxically making it the most accurately measured quark mass of all.

Giving a taste of things to come, Alain Blondel showed the first events from the new high energy LEP2 (see page 15), and Yoshiro Suzuki reported that Japan's Super Kamiokande neutrino detector is working well, having started data taking on 1 April (July, page 22).

Closing the conference, Gabriele Veneziano of CERN concluded that "The Standard Model's health, already excellent, keeps improving as it gets rid of a little cold, or a small headache."

(A full report of the Warsaw conference will appear in next month's issue.)

One of the cracks in the Standard Model, the fraction of Z particles decaying to b-quarks (R_b) or c-quarks (R_c) has almost disappeared. The contours show statistical levels of confidence around the new result (1996). Last year's values (1995) are plotted in the bottom right hand corner.

Accelerated diversification

The long lead time of major accelerator projects gives the field a natural rhythm, with its own seasons - development, design, approval, construction and exploitation. This year's European Particle Accelerator Conference (EPAC), held at Sitges, near Barcelona, from 10-14 June, fell at a time when major projects have either been approved and are already in the pipeline, or are so distant that research and development work has yet to bear its full fruit.

The biennial EPAC meetings, established in 1988 and alternating with the American Particle Accelerator Conferences, testify how Europe has graduated to the front rank of world accelerator regions. With specific projects taking a back seat, the picture which emerged was of the increasing use of accelerators, large as well as small, as applications tools rather than their original rationale of machines expressly for generating high energy particle beams.

In this applications sphere, accelerators are poised to take over a range of tasks traditionally handled by nuclear reactors, but which are now nearing the end of their useful lives.

At the previous EPAC, held in London in 1994, CERN's LHC proton collider had been poised on the brink of official approval, and a major effort at that conference had helped the LHC light to turn green. At Sitges, the LHC emphasis turned to technical matters, while the most visible new project was a Spanish synchrotron radiation source proposed for Barcelona and based on a 2.5 GeV electron machine. Joan Bordas pointed out how a country the size of Spain already has some 87 user groups from 11 different applications areas. While in the short term these can be accommodated by beamlines at existing synchrotron radiation facilities, a national source is the logical aim.

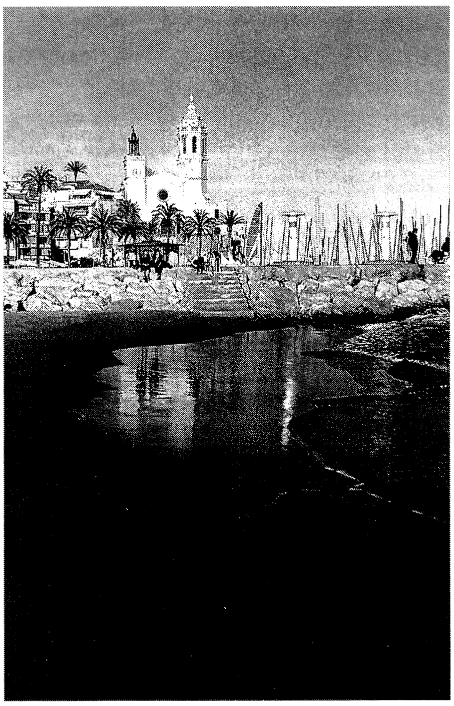
Synchrotron radiation, the electromagnetic skid marks produced when beams of high energy electrons are tightly bent, is a handicap for particle physics. High energy electron machines have to be built large to minimize synchrotron radiation losses, with energy having to be fed in to compensate for these losses. But particle physics' synchrotron radiation loss is a gain for scientists of all kinds studying the structure of condensed matter.

The first synchrotron radiation sources were parasitic at high energy electron machines, but special synchrotron radiation requirements and large user communities led to purpose-built synchrotron radiation sources being built all over the world. The synchrotron radiation child outgrew parental influence and has flown the nest.

This burgeoning synchrotron radiation field was the largest single topic at EPAC, and after the official opening speeches, the conference proper began with a talk by Yves Petroff of the European Synchrotron Radiation Facility (ESRF), Grenoble, describing the new applications areas being opened up at third generation X-ray sources. These include extreme pressure conditions which simulate planetary atmospherics. An opening talk on synchrotron radiation was an EPAC innovation and surely a sign of the times.

Later in the meeting, a whole morning of special sessions on synchrotron radiation covered the sources and their applications. Originally, the parasitic synchrotron radiation from high energy machines came from the bends in the machine, but in purpose-built machines the radiation is produced instead by special 'insertion devices' (undulators or wigglers) to 'shake' the electron beam and concentrate the radiation into beamlines. Latest developments in insertion devices were described by Joel Chavanne of ESRF.

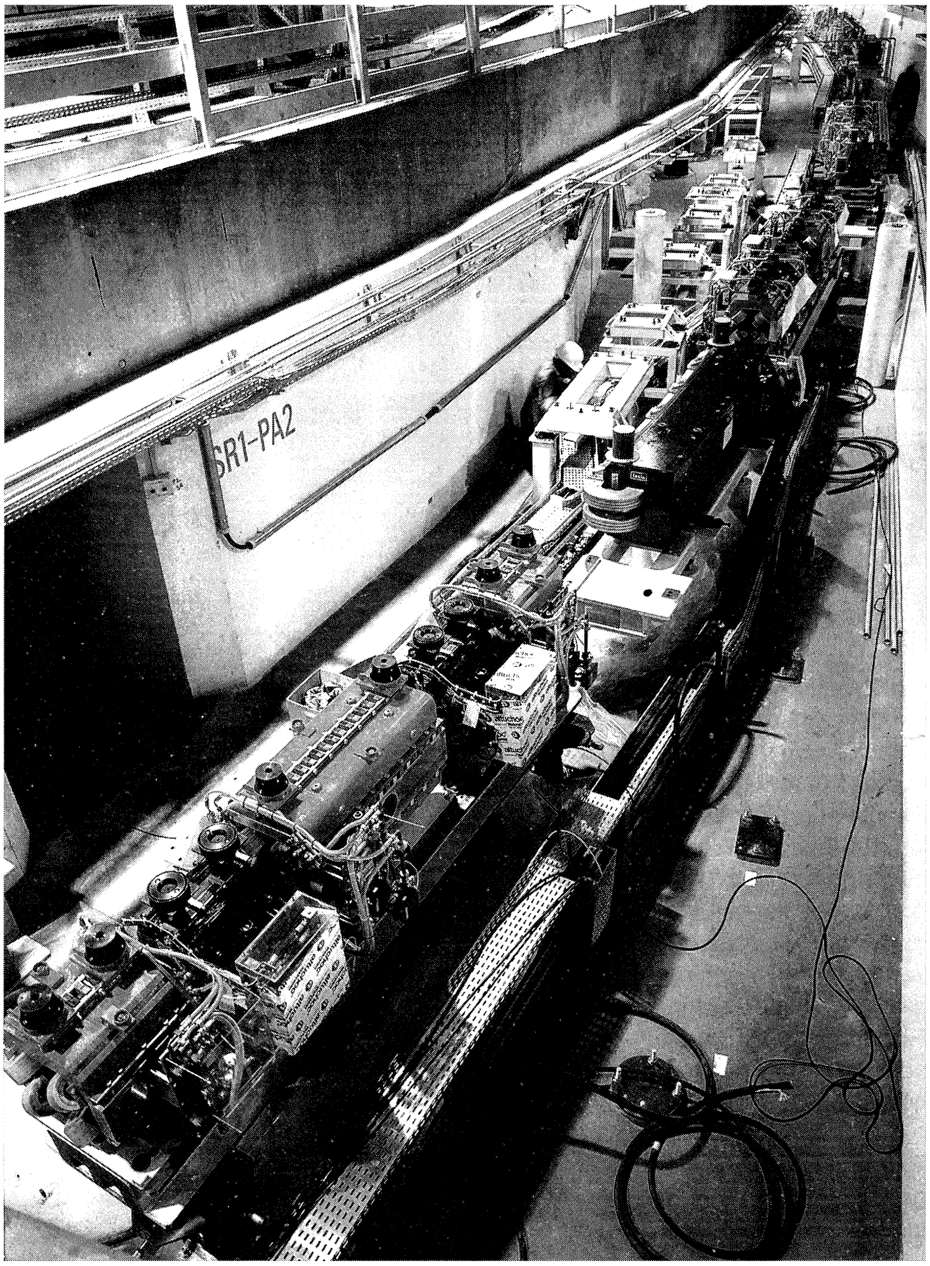
A widening synchrotron radiation horizon is the use of free-electron lasers, which can be tuned across a wide wavelength band, avoiding the constraints of conventional lasers where the output wavelength is determined by the lasing medium's atomic, ionic or molecular structure. At Sitges, Marie-Emmanuelle Couprie of LURE (Orsay) described free-electron laser schemes based on storage rings while Alberto Renieri



Sitges, near Barcelona, was the idyllic setting for this year's European Particle Accelerator Conference.

(Photo S. Hegarty)

The European Synchrotron Radiation Source (ESRF) Grenoble - synchrotron radiation dominated the EPAC programme.



of ENEA (Frascati) covered opportunities using electron linear accelerators.

Electron linacs

After synchrotron radiation sources, electron linear colliders were the next most evident EPAC machine theme. With goals of TeV-range energies and luminosities in the 10^{34} per sq cm per s region, development work is pushing ahead on several fronts in laboratories in Europe, the US, Japan and Russia. After an introduction from CERN's Jean-Pierre Delahaye on the major design issues, talks covered the status of individual test facilities.

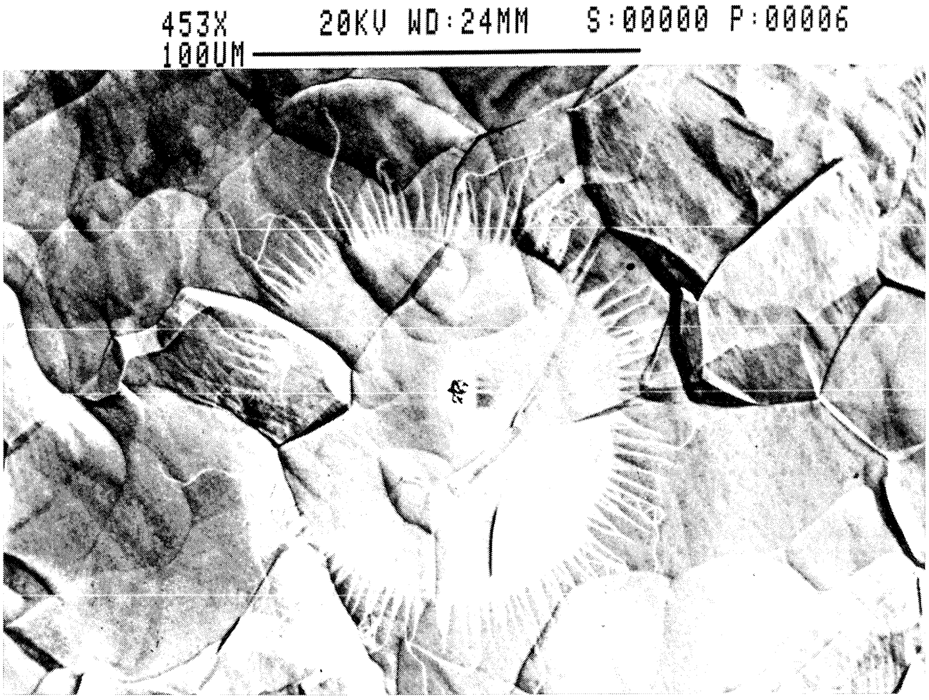
Hans Braun described CERN's Linear Collider (CLIC), which would use a parallel drive linac rather than klystrons to supply radiofrequency accelerating power. The initial CLIC Test Facility (CTF), using a laser-irradiated photocathode, has achieved 76 MW of 30 GHz radiofrequency power with acceleration of 94 MW/m. A new CTF2 CLIC Test Facility will now take over for the next stage of acceleration tests.

En route to the Next Linear Collider (NLC) at the Stanford Linear Accelerator Center (SLAC), Ron Ruth could point to mighty 11.4 GHz (X-band) klystrons designed to achieve 50 MW and having attained 75. Soon to come into action is the NLC Test Accelerator, which will aim to integrate radiofrequency (pulse compression) and beam dynamics systems.

For Japan's KEK Laboratory, Hitoshi Hayano described the KEK Accelerator Test Facility, with a 1.54 GeV linac operating in the S-band range. Commissioned late last year, it has attained accelerating gradients of 25.5 MV/m, about half the foreseen maximum. A damping ring is also being installed.

At DESY, Hamburg, electron linac development work is proceeding on two independent fronts. Bernard Aune spoke for the superconducting TESLA option, the subject of a China/Europe/Russia/US collaboration aiming for 500 GeV beams. The best result so far using superconducting accelerating cavities is 26 MV/m and a resonance quality factor (Q) of 3×10^{10}. For the normal conducting S-band approach at DESY, the subject of a SLAC/Darmstadt collaboration with industry, Norbert Holtkamp described progress with a 5.2 metre test structure, the 150 MW klystrons and the injectors.

A major preoccupation in all these electron linacs is the need for precision beam alignment systems. While storage rings cannot compress their colliding beams too tightly for fear of deleterious beam-beam effects, the collide-once-and-throw-away approach of linear machines means their colliding beams can be squeezed as tightly as possible to maximize the collision rate. Electron linear colliders (and some circular machines too) use active micro-alignment systems to ensure that beams whose dimensions can be measured in nanometres remain locked onto each other. V. Shiltsev of DESY and Novosibirsk gave a micro-alignment overview.



A microphotograph of a field emitting 'explosion' in niobium. The materials (mainly niobium) for superconducting radiofrequency cavities have to be carefully processed to avoid such defects.

(Photo Cornell)

Radiofrequency and beams

The challenges of high performance machines, both for the new linacs and for the new generation of high luminosity 'factory' storage ring machines, with high currents and small bunches, keeps radiofrequency experts on their toes.

For the machine component sector, radiofrequency, both room temperature and superconducting varieties, attracted the largest number of invited talks at Sitges. In the drive for high performance, instabilities driven by the accelerating field and higher order resonances are high on the list of unwanted customers. K. Akai of KEK showed some futuristic-looking designs for reducing higher-order mode effects. Roberto Boni of Frascati also offered advice for minimizing unwelcome higher-order mode effects.

For superconducting cavities, Dieter Proch of DESY outlined the stringent processing required for superconducting radiofrequency cavities and the spectacular improvements this can bring. Defects and bad weldings provoke quenches, while micro-deposits generate field-emitted electrons. The recipe is ultra-clean fabrication conditions and scrupulous cleaning. Recommended treatments include high temperature firing, high pressure rinsing with ultra-clean water, and high radiofrequency processing. Like losing weight, there is no short cut. It is a long, long winding road, but the payoff is good health, and better and more consistent performance. The accelerating field record - 40 MV/ metre - belongs to the Japanese KEK Laboratory. The care needed in handling superconducting cavities was underlined by Enrico Chiaveri of CERN who described how the complex procedures for fabricating niobium coated copper cavities to boost the beam energy at CERN's LEP electron-positron collider has been transferred to high technology firms.

Comparing the benefits of superconducting and room temperature radiofrequency solutions, Robert Jameson of Los Alamos observed that the superconducting route is the 'emerging technology', especially in Japan, where cryogenics is seen as being especially influential.

Alexander Gamp of DESY sketched advances in the klystrons and modulators, pointing out the different requirements in the various wavelength bands.

The continual requirement for high quality beams brings its own demands, such as improved diagnostics (Hermann Schmickler, CERN), and better control of multibunch instabilities (Mario Serio, INFN). Klaus Bongardt of Jülich looked at the special requirements of high intensity proton machines.

High energy physics

In the Sitges invited papers, CERN's LHC was covered by Jacques Gareyte, who concentrated on the accelerator issues needed to achieve the luminosity goal of 10^{34} per sq cm per s, some 30 times the current world luminosity record (held by Cornell with electrons, rather than protons).

Wilhelm Bialowons of DESY covered progress at the HERA electron-proton collider at DESY, Hamburg, where the 1996 run had recently begun but where it was too early to describe progress. The healthy accumulated luminosity has produced a physics harvest (see page 21), with polarized electron beams now routine.

For CERN, Daniel Boussard traced the history of the LEP2 scheme to boost the energy of the LEP elec-

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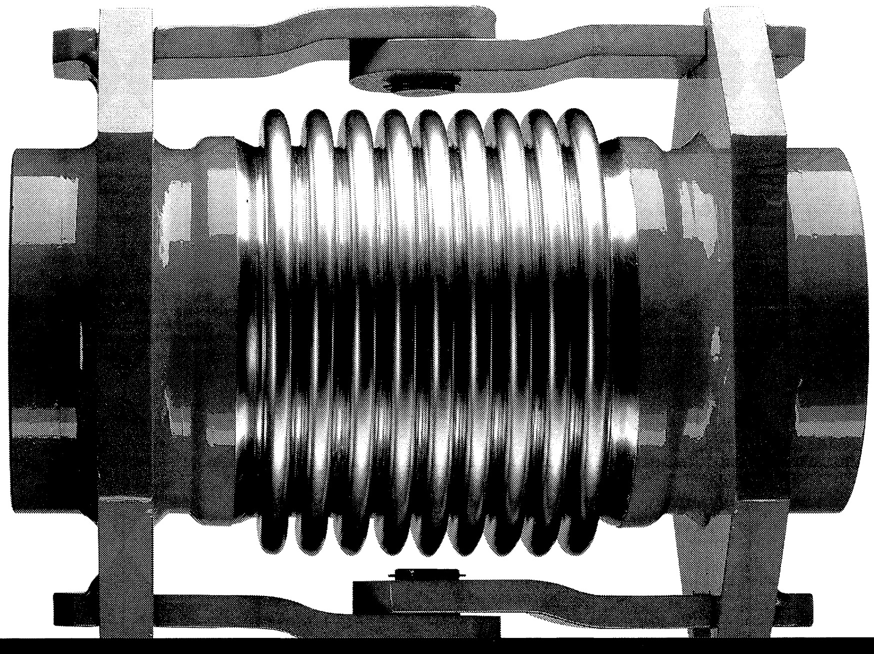

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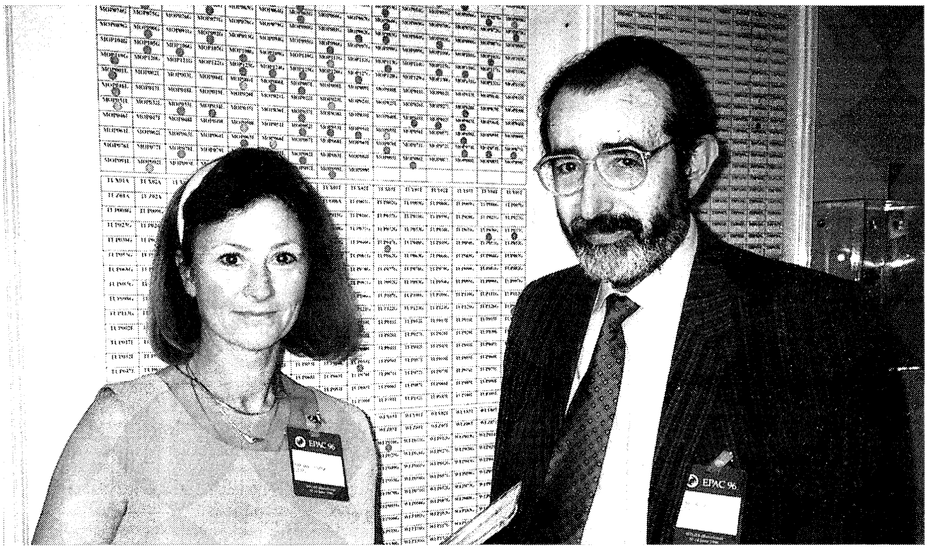


tron-positron collider to above 81 GeV per beam and study the production of pairs of W particles, rather than the single Zs which have been the diet of LEP experiments since 1989. His talk preceded LEP2 commissioning (see page 15).

Other invited talks on projects in high energy physics and related fields covered antiprotons for Fermilab's Tevatron (Stephen O'Day), where major upgrades are in the pipeline en route to the new Main Injector; Brookhaven's RHIC Relativistic Heavy Ion Collider (Michael Harrison), where the new superconducting ring is scheduled to come into operation in 1999; the recirculating electron linacs at the Continuous Electron Beam Accelerator Facility (CEBAF) recently commissioned at Newport News, Virginia (March, page 12) and now renamed the Jefferson Lab (July/August, page 18) and described by Robert Legg; the DAPHNE phi meson factory at Frascati (Gaetano Vignola), where ring installation should be complete this winter; and progress towards a B factory at the CESR electron-positron storage ring at Cornell (David Rice). The S-Dalinac superconducting linac at Darmstadt, operating for several years, was described by Achim Richter.

Norbert Angert of GSI Darmstadt had plenty of material to review for his laboratory's heavy ion programme, where beams of 15 different parent isotopes were used last year and where many more daughter products are intercepted in the downstream ESR storage ring. The GSI radiotherapy facility (January, page 16) is now preparing for beam and dose control tests, with a goal of catering for some 70 patients per year.

Applications and industry

Running through the Sitges programme was a strong thread on the applications to which accelerators can be harnessed. A seminar for industry, chaired by Dewi Lewis of Amersham International, sketched the wide range of different applications now handled by accelerator beams. It was introduced by Francisco Castro of Spain's Ministry of Industry and Energy who pointed out the accelerator components now provided by Spanish industry for CERN and for ESRF (see box, page 8).

Other selected topics included manufacture of electron accelerators for industrial use and the processes to which they can be applied, industrial use of synchrotron radiation, and a generous slice of medical applications, including cyclotrons for medical isotopes, positron emission tomography, and cancer therapy.

Later in the programme, Dewi Lewis (who was Guest Editor of the special 'Applying the Accelerator' July/August 1995 issue of the CERN Courier) illustrated the medical aspects of accelerators. The increasing need for total systems involves a wide range of different communities, from the university or research centre which develops the initial machine, through the specialist spinoff company which manufactures it, another specialist organization which operates it, the purveyor of the product (e.g. radioisotope) or service (e.g. irradiation), and finally the consumer or client, who may not even know that an accelerator is a vital part of the chain.

With many nuclear reactors reaching the end of their useful lives and with environmental concerns looking for alternative sources, attention is turning naturally to the possibility of making increased use of accelerators, for instance in the production of radioisotopes.

The use of accelerators for medical applications was also highlighted by Ugo Amaldi of CERN. With radioisotopes having been well covered in other talks, Amaldi turned to the use of machine-generated beams for therapy. Here an increasing use of small linear accelerators for X-ray and electron therapy in the US has yet to make its impact in Europe. For proton therapy, the Loma Linda hospital in California now handles about a thousand patients each year, with other new centres for deep proton therapy in Boston, Japan and Rome. Ion beams provide accurate and effective targeting, with carbon-12 the nucleus of choice. Although heavy ion therapy has a relatively long history, the HIMAC facility in Chiba, Japan, is a world first, with GSI Darmstadt having now joined the race. Other projects in Europe are the Italian TERA scheme and use of the proposed Austron machine.

Earlier in the EPAC programme, Kozo Morita had introduced the Japanese HIMAC scheme, now carrying out clinical trials of carbon ions from 290 to 400 MeV per nucleon beams on a range of tumours. Encouraging results were reported from the hundred patients treated so far. Irradiation is a lengthy process, involving some 18 doses over a period of six weeks or so, and can be combined with chemotherapy for additional effect.

Other important, and potentially the largest, applications areas are in energy and the environment. Ingo Hofmann of GSI described the possibilities for using high energy heavy ion beams to catalyse thermonuclear fusion, a goal which is conventionally dominated by the magnetic confinement in a tokamak, but where alternative approaches could soon emerge as the need for new energy sources becomes more pressing.

In what he described as the 'biggest potential takeoff area for accelerators', Charles Bowman of Los Alamos covered the push to develop accelerator-based systems for three important goals: energy production from fission using thorium, where Carlo Rubbia's group at CERN is prominent; accelerator transmutation of fission waste into more manageable radioactivity; and plutonium disposal, where with plutonium no longer 'safely' packaged in nuclear weapons, there is an urgent need for systems which can 'digest' plutonium.

As well as the refined plutonium from existing weapons stockpiles, the lower grade material from fission reactors is also a security risk. A bomb only half as powerful as a state-of-the-art weapon would not unduly worry a nuclear pirate. The immediate technological problem in this work, said Bowman, is to develop effective target blanket systems.

High power targets are also needed for neutron spallation sources for a wide range of applications, condensed matter research and tritium production as well as treatment of radioactive waste and energy production. Timothy Broome of the UK Rutherford Appleton Laboratory reviewed this technology.

In the search for new accelerator techniques, Robert Bingham of the UK Rutherford Appleton Laboratory looked at recent development in laser and plasma accelerators, a route which had once been heralded as the way to go. First generation experiments have shown that wakefield and plasma beat wave techniques do work and can generate accelerating fields of the order of 1 GV/m, accelerating electron to 40 MeV in just one millimetre! However Bingham was of the opinion that the resultant beams might not attain the quality required for high energy physics.

With accelerator history now sufficiently long for conferences to look back as well as forward, Ted Wilson of CERN recalled the operation of the first synchrotron half a century ago (see page 10) and sketched the history and evolution of the synchrotron idea, where the invention of strong focusing and the development of colliding beams have been major milestones.

Posters

Comprehensive poster sessions are a traditional EPAC feature. Each afternoon more than 200 posters provided a fairground-like atmosphere, and there was a flood of contributions on LHC cryogenics. Each day a handful of posters were accorded a miniscule oral presentation, while another half-dozen or so subjects earned a 12-minute oral presentation. The posters provide a shop window for new ideas or developments. Hidden somewhere could be innovative ideas and revolutionary solutions. The problem was to find them!

An example is the 'Rhodatron' compact electron accelerator now widely employed for producing intense electron beams for industry. A brainchild of development work at Saclay, the Rhodatron has its accelerating cavity at the centre of the machine rather than in the fixed electron orbit, so that the electrons trace out compact flower-like patterns. The Rhodatron was a poster at the first EPAC meeting in Rome in 1988.

The accelerator awards to Jeffrey Hangst and Rolf-Dieter Kohaupt, made at Sitges, were described in the previous issue - July/August, page 10. Closing the meeting, Enrique Fernandez of Barcelona outlined the physics message of the third generation of quarks and leptons, including the beauty and top quarks and the tau lepton, now the target of

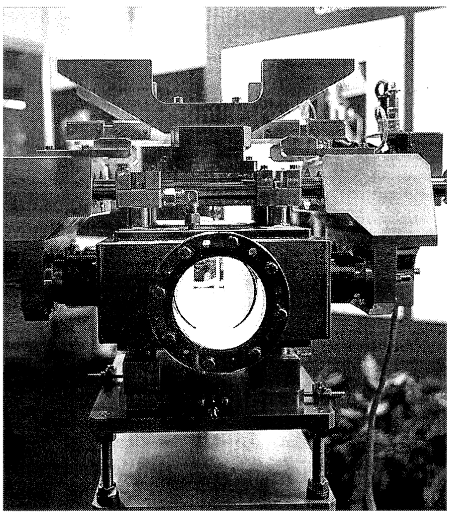
Spanish case history

Ingovi Ultra-High Vacuum Systems in Valencia have risen to the challenges of front-line physics research. The Ingovi metal engineering group first made contact with the world of particle beams at an industrial exhibition in Hanover, and two Ingovi engineers spent two years at CERN from 1991-2 absorbing the special technological requirements for this work. Ingovi now provide a variety of special equipment for CERN's LEP electron-positron collider, including radiofrequency couplers for increasing energy running using superconducting cavities, as well as beamline equipment for the European Synchrotron Radiation Facility in Grenoble. As well as scientific experiments, this vacuum technology is also seen as being important in surface treatment, pharmaceutical production and the food industry. Managing Director Jose Gomez stresses the importance of the specialist training and hands-on experience needed to keep abreast in this demanding but rewarding field. A recent agreement between CERN and the Spanish Centre for Technological and Industrial Development (CDTI) covers training of Spanish technical graduates in technologies related to particle physics.

choice for many ongoing high energy physics programmes.

The EPAC proceedings, with contributions submitted electronically should be available in record time on CD-ROM. The 1996 European Particle Accelerator Conference was organized by the Universita Autonoma de Barcelona under the auspices of the European Physical Society's Interdivisional Group on Accelerators. Conference Chairman was Michel Olivier of the French CEA, who has now retired, succeeded by Sergio Tazzari of Frascati. Chairman of the Programme Committee was Steve Myers of CERN. Ramon Pascual of Barcelona chaired the local organizing committee.

By Gordon Fraser



A collimator for CERN's LEP2 electron-positron collider manufactured by Ingovi Ultra-High Vacuum Systems in Valencia.

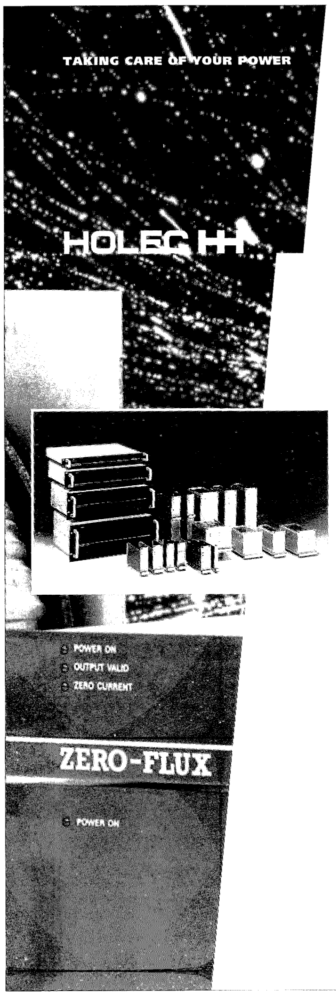
Accelerated electronic publishing

For many years the organizers of accelerator conferences have felt the need to publish electronically and the first major conference to do so, last year's Particle Accelerator Conference (PAC 95 - September 1995, page 23), published their CD-ROM this spring.

In late 1994 the organizers of the EPAC European conference agreed that they too would publish electronically. It was decided to use Adobe Acrobat Software as the basis for preparing CD-ROMs and these would be offered as an alternative to the kilos of paper conventionally produced.

In preparation for this venture, the proceedings of the LEP Performance Workshop (Chamonix) in January 1995 were published electronically, although not on CD-ROM. The aim is to produce a highly performant 'document' which is also attractive to users. To achieve this, authors have had to follow strict guidelines and learn new techniques. The finished CD-ROM will contain all papers, but more importantly will provide powerful search facilities based on keywords as well as the text. Boolean searches of the type 'heavy-ion' AND 'optics' AND 'collective-effects' BUT NOT 'linac' will very rapidly return a relevant list of papers. These features, combined with convenient size and low cost, make the CD-ROM a very attractive proposition.

In the year leading up to EPAC'96, 'volunteer' co-ordinators were located in all major laboratories and instructions and guidelines, published via the World Wide Web, were tested and improved. Building on the experience of PAC and the '95 and



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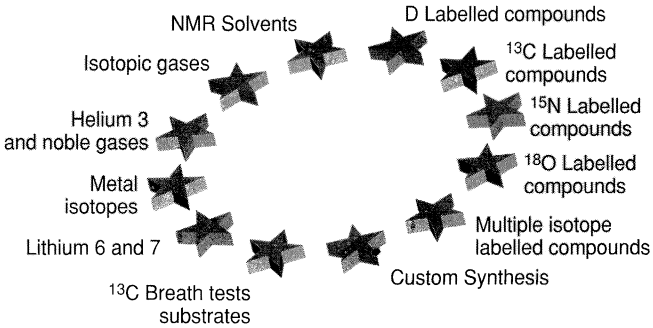

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'96 Chamonix workshops it was decided to try and process all contributions at the conference in Sitges. This was not an attempt to publish the proceedings very rapidly but more to discuss problems with the authors so that there would be fewer difficulties next time.

The success rate, measured as electronic processing successful at first attempt, was higher than we had hoped for, at more than 70%. The proceedings team worked systematically through the papers, solving outstanding problems before handing over the finished version to the publisher (UK Institute of Physics Publishing) and at the same time making the files available on WWW. Some 700 papers were heroically processed in Sitges from a total of about 800, representing some 3000 pages of proceedings! The Abstracts and Papers can be accessed through the EPAC WWW pages: http:\\www.cern.ch\EPAC\Welcome.html

By John Poole

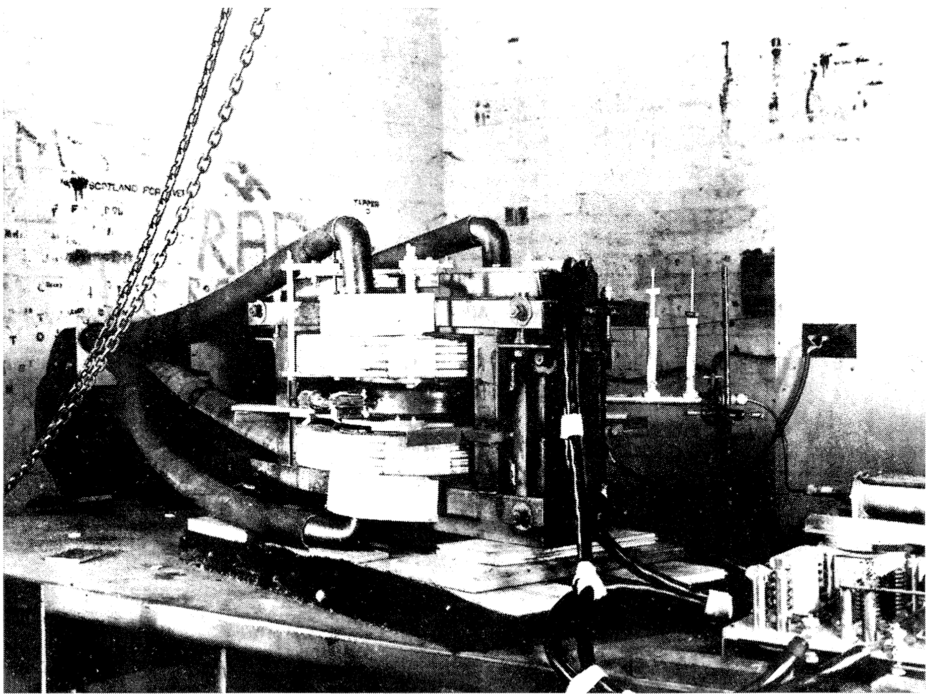
Half a century of synchrotrons

In August 1946, a benchtop machine at the UK Telecommunications Research Establishment supplied electrons at 8 MeV. It was the world's first synchrotron. From this modest beginning, synchrotrons have gone on to become the accelerator workhorse and to attain LEP/LHC proportions. This article traces the early history of circular particle accelerators, the introduction of the synchrotron principle and its initial impact on the physics scene.

In 1929 at Berkeley, Ernest Orlando Lawrence turned his attention to the acceleration of charged particles by electric fields. The objective was to use the particle beams to pierce the nucleus, where Rutherford had long realized that alpha- and beta-particles from ordinary radioactive decay were insufficient, and had foreseen the need to accelerate particles to high energy. Lawrence stumbled across a 1927 article in Archiv für Elektrotechnik by Rolf Wideröe, a Norwegian scientist working in Aachen.

Wideröe had succeeded in accelerating charged particles by passing them through a series of increasingly long tubes with appropriate polarities, the forerunner of the linear accelerator, or linac. This was the first time a charged particle had been accelerated to an energy beyond that of the highest voltage in the device. Wideröe's device stemmed from an idea proposed by Gustav Ising in Sweden in 1924.

Lawrence could not understand the German of Wideröe's article, but soon got the gist of the idea. To produce a high energy beam, the Wideröe apparatus would be far too long to fit into a laboratory. Somehow the particles had to be made to travel



The first synchrotron - in 1946, Frank Goward and D.E. Barnes at the UK Telecommunications Research Establishment converted this bench-top betatron, imported from the US, to an electron synchrotron, attaining 14 MeV.

(Photo UKAEA plc)

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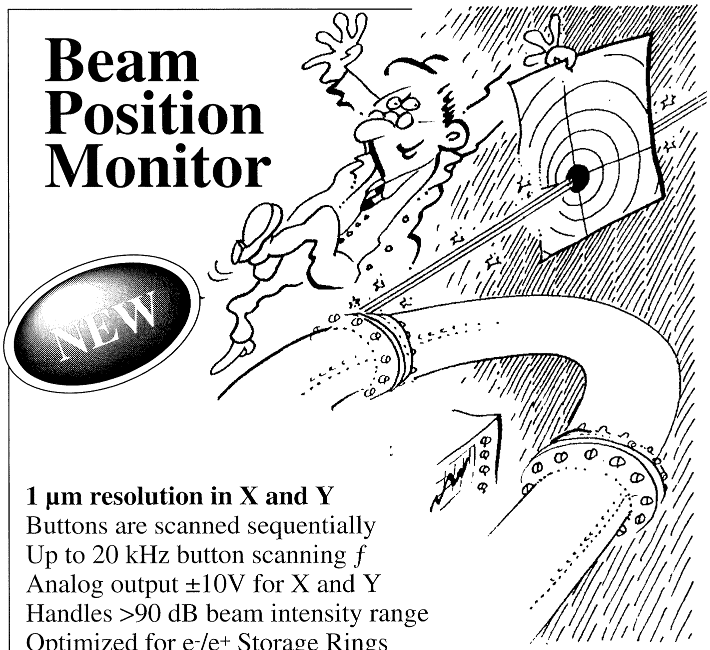

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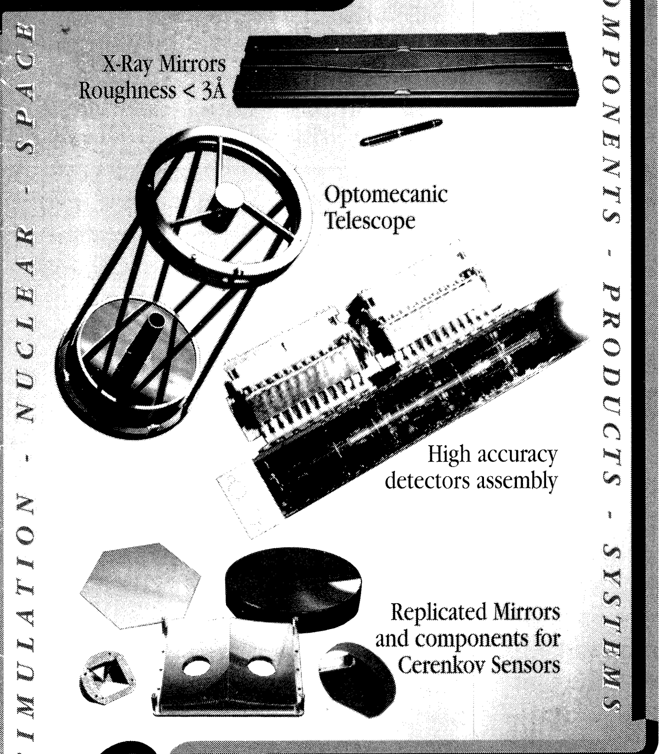

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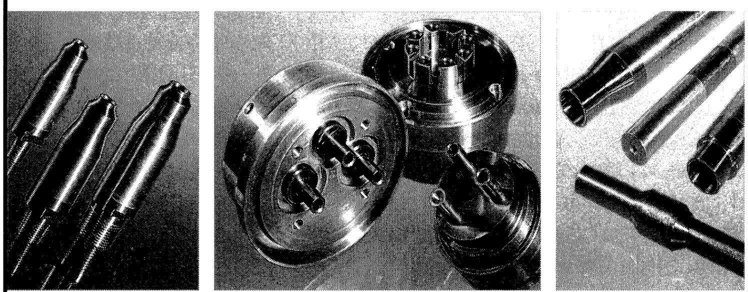

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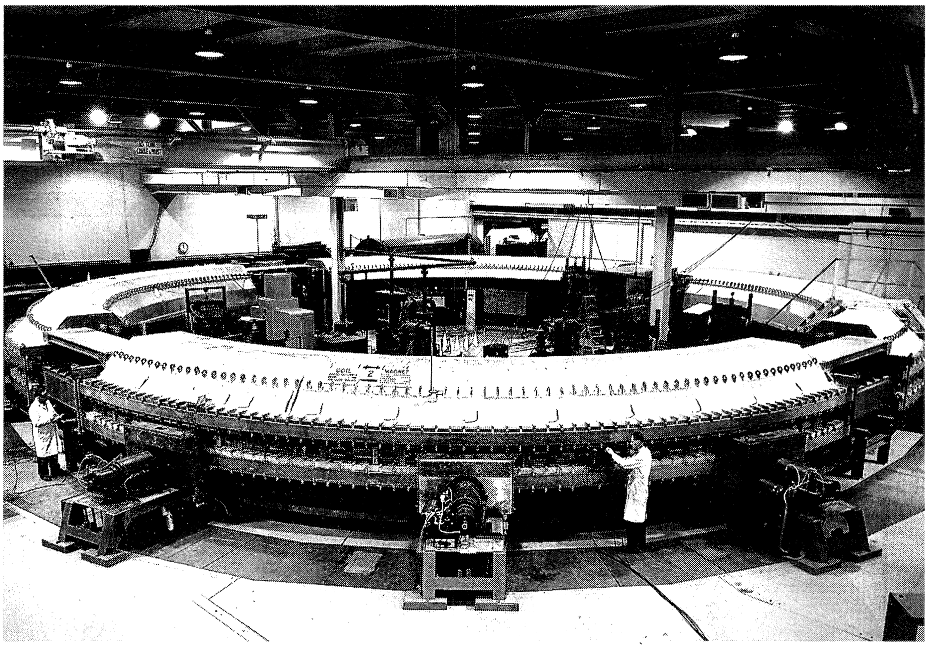
The Brookhaven Cosmotron, named as it was the first terrestrial machine capable of supplying energies which hitherto had only been seen in cosmic rays, began supplying 3 GeV protons in 1952.



a long distance. Lawrence's brainwave was to make the charged particles rotate in a magnetic field and then apply Wideröe's idea. The particles would then spiral round and round, receiving a kick in energy each time they passed through the voltage gap of an oscillator. Instead of a tube a block long, the idea could be made to work on a table top, and the development of radio technology meant that the necessary radiofrequency oscillators were available.

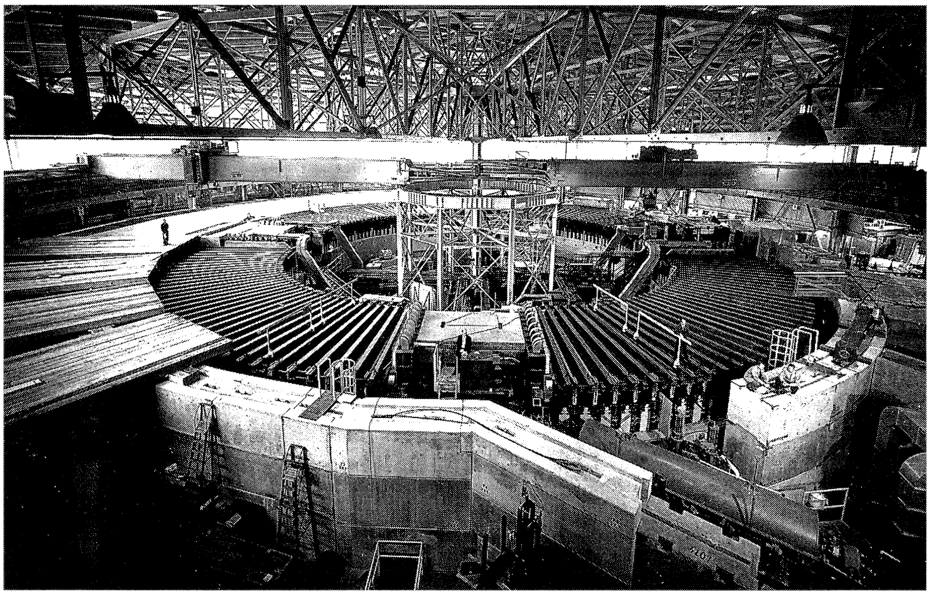
During 1930 Lawrence tinkered with the new 'cyclotron' idea, and his successful demonstration the following year with Stanley Livingston put Berkeley on the physics map.

During the 1930s at Berkeley, Lawrence's cyclotrons steadily increased in size. The diameter of their magnet pole tips went from 27 inches to 37, to 60, while plans had been prepared for a mighty 184-inch (467 cm) machine, limited only by the size of steel plates which could be milled at the time. This large machine would not fit anywhere on the Berkeley campus, and a new site had been selected up in the hills overlooking the San Francisco Bay, and 10,000 tons of concrete had been poured for it in 1940. With the advent of war, obtaining the steel for this machine became a problem, but in any case there was a more fundamental limitation it would run up against.

An even earlier Wideröe idea had been for a 'beam transformer', in which a circulating beam of electrons acted as a secondary winding. Wideröe tried valiantly to make the idea work but was beaten by electrons piling up on the sides of the ring. Gregory Breit and Merle Tuve at the Carnegie Institution in Washington, Ernest Walton at the Cavendish Laboratory, and Leo Szilard and J. Tuck at Oxford had also tried to coax such a technique along. Such 'induction accelerators' were eventually made to work by Donald Kerst and Robert Serber at the University of Illinois in 1940, and production, under the name 'betatrons' switched to the General Electric Company. Unlike Lawrence's cyclotron, where the beam spirals out from the centre, a betatron holds its beams in a circular orbit. Sturdy betatron X-ray machines went on to find widespread application in industry and hospitals. In 1944 a US-built betatron was shipped to Woolwich Arsenal, London, where the original idea was to use it as a portable X-ray machine for examining unexploded bombs or for detecting flaws in armour plate.

The fundamental limitation which Lawrence's big cyclotron came up against was not logistics, but relativity. As the effects of special relativity come into play, the particles accelerated in the cyclotron start to get out of step with the applied impulses, and no more acceleration is possible. This would have severely hampered the energy reach of Lawrence's planned 184-inch machine.

In 1943, Mark Oliphant thought this might be overcome by suitably changing the magnetic field and the radiofrequency of the electric field to compensate for relativity, accelerating the particles in a doughnut-shaped torus. An Australian, Oliphant carried out milestone work with Rutherford at the Cavendish Laboratory, Cambridge, before moving to Birmingham, where, following an Oliphant suggestion, John Randall and Henry Boot developed their famous cavity magnetron, producing microsecond pulses at a wavelength of 10 centimetres with enough power to light a cigarette and which revolutionized wartime radar. Later in the war, Oliphant moved to the US to work with Ernest Lawrence.



The Bevatron at Berkeley, with a 10,000 tonne ring magnet, started up in 1954. Its design energy of 6 GeV was aimed at finding the antiproton.

With Oliphant distracted by these wartime pressures, the idea lay dormant until it was reinvented and further developed by Vladimir Veksler in Russia (1944) and Edwin McMillan in Lawrence's Berkeley laboratory in 1945. Veksler and McMillan's important innovation was the idea of 'phase stability', in which particles injected at a suitable point during the r.f. cycle remain bunched throughout the acceleration cycle.

With conventional cyclotrons, using a fixed magnetic field, the relativity barrier had to be overcome by modulating the radiofrequency of the field to keep pace with relativity, the synchronized cyclotron or 'synchrocyclotron' method. Unlike the cyclotron, where the particles were accelerated continuously, the synchrocyclotron is a pulsed machine, giving particles in bursts. Lawrence's 184-inch dinosaur was saved. Using a generous post-war cash injection from the Manhattan project, the synchrocyclotron technique was applied to the giant Berkeley installation which had lain dormant during the war. In November 1946 this machine began supplying 190 MeV deuterons.

As well as modulating the cyclotron radiofrequency field, the ideas of McMillan and Veksler also showed how the magnetic field which made the particles rotate could be synchronized with the increase in energy, so that the particles could be held on a fixed circular orbit rather than spiralling their way through the machine. In such a machine, the 'synchrotron', the magnet only has to enclose the doughnut-shaped ring in which the particles orbit, compared to the synchrocyclotron, in which the magnet has to be a flat pancake, and for very high energies gets prohibitively expensive. But unlike the synchrocyclotron, where particles naturally fly out of the magnet, synchrotron beams are held captive in their magnetic torus, and have to be sucked out by external magnets.

In post-war Britain, a new atomic energy research laboratory was set up at Harwell under the directorship of John Cockcroft, where among other things new particle accelerators would be built. To prepare for Harwell, a panel on accelerating particles was set up under Oliphant, with representatives from universities and industrial firms, and a group at the Telecommunications Research Establishment, Malvern, released from valuable wartime work on radar, began to plan for new equipment. In charge of this physics was Frank Goward.

Goward realized how the betatron at Woolwich could be adapted into a McMillan/Veksler electron synchrotron, and with D.E. Barnes of Woolwich in August 1946 showed how the nominal betatron electron energy of 4 MeV could be doubled. The modest machine was subsequently moved to Malvern, where it eventually achieved 14 MeV. In October of that year, an electron synchrotron built by the US General Electric Company, which had previously been building betatrons under Kerst's direction, reached 70 MeV. Such early synchrotons retained their betatron heritage, using betatron techniques for injection before switching to synchrotron mode.

But in the US, flush with post-war funds, new particle accelerators were springing up like mushrooms. At Berkeley, McMillan had ambitious plans for an electron synchrotron, while Luis Alvarez pushed ahead with linear accelerators for protons, a giant version of Wideröe's 1927 idea. At Cornell, Robert Wilson, returning from Los Alamos, built an electron synchrotron. Cyclotrons at Princeton and the University of California at Los Angeles (UCLA) were converted to synchrocyclotrons. Other electron synchrotrons were either operational or soon to be so at General Electric, Ames (Iowa), the Massachusetts Institute of Technology and Purdue. As well as at Berkeley, US synchrocyclotrons were built at Rochester, Harvard, Columbia, Chicago and the Carnegie Institute.

In Canada, one was built at McGill, Montreal. (Cyclotrons, many dating from the pre-war era, were too numerous to mention. A 1948 survey listed 21 machines in the US and 14 in Europe.)

In the early 1950s, the formidable array of synchrocyclotrons in the United States was complemented elsewhere in the world by those at Harwell, by the 156-inch synchrocyclotron at Liverpool which began operations in 1954 and could attain 400 MeV, by a small machine in Amsterdam designed by Cornelis Bakker at Philips, a 200 MeV machine at Uppsala and a 650 MeV machine at Dubna. Veksler built a series of electron machines in Moscow, and in Europe there were several electron synchrotrons in the UK, including Glasgow (300 MeV) and Oxford (140 MeV), while Stockholm had a 35 MeV machine.

The synchrocyclotron technique, calling for a large disc magnet, could not be continued indefinitely, and for higher energies the synchrotron was the only route. In 1948, the US Atomic Energy Commission recommended that two big proton synchrotrons be built, one at Brookhaven and the other at Berkeley. Oliphant in the UK as usual had been a hive of industry and had launched a project to build a major proton synchrotron at Birmingham. This 1 GeV machine began operations in 1953. But Oliphant had meanwhile returned to his native Australia, where he immediately launched an ambitious project for the Australian National University, Canberra, which was not completed.

The new Brookhaven machine, the Cosmotron, named as it was the first terrestrial machine capable of supplying energies which hitherto had only been seen in cosmic rays, began supplying 3 GeV protons in 1952, and was soon seeing the strange 'V particles' previously reported in cosmic rays. Not far behind the Cosmotron was the Bevatron at Berkeley, whose 10,000 tonne ring magnet was five times larger than that of the Brookhaven machine. When the Bevatron started up in 1954, it was the world's most powerful proton machine.

While the Cosmotron had been under construction, over in Europe a new idea had taken hold, an idea which was to become CERN. With the Cosmotron having been commissioned apparently so easily, confidence in the new technology was high. At its meeting in 1952, CERN Council advocated aiming for a scaled-up Cosmotron to operate in the energy range 10-20 GeV.. Responsibility for the new CERN machine was vested in Odd Dahl in Bergen, with Goward in Harwell as Dahl's deputy.

If Dahl's group was going to make a scaled-up version of the Cosmotron, it was important for them to go to Brookhaven to admire that machine. In August 1952, Dahl and Goward made what would be an eventful trip. Also passing through Brookhaven was Wideröe, returning from Australia.

To receive the European visitors, Stanley Livingston at Brookhaven organized a think tank. One of his suggestions concerned the Cosmotron's C-shaped magnets. These all faced outwards, making it easy for negatively charged particles to be extracted, but not positive ones. Why not have the magnets alternately facing inward and outward? Ernest Courant, Hartland Snyder and John Blewett seized on the suggestion and quickly realized that a sequence of alternatively focusing and defocusing magnets (like optical lenses) produces a net focusing effect. This led to the invention of quadrupole magnets which dispensed with the bending field but retained the focusing gradient. This increased focusing power allowed the proton beam to be squeezed into a pipe a few centimetres across, compared with the 20 x 60 centimetres of the Cosmotron beam pipe.

(Unknown to all concerned, these ideas had in fact been proposed earlier by Nick Christofilos, a Greek elevator engineer who used to read the Physical Review for fun in the American Library in Athens. He convinced an initially sceptical Brookhaven team that he had thought up the strong focusing idea two years before, and was offered a job at Brookhaven.)

Suitably impressed by what he had seen and learnt at Brookhaven, on his return to Europe Dahl insisted that the new strong focusing technique had to be used for the new CERN machine. It would gain energy, opening up the prospect of at least 20 GeV, possibly going as high as 30, and it would save money. The only problem was that nobody had built one yet, anywhere. Undeterred, Dahl kept his sights firmly on this new goal. Although a gamble, it turned out to be one of the most influential decisions in the history of CERN. Had Dahl and CERN played safe, the outcome would have been very different.

Although Brookhaven naturally adopted strong focusing into their repertoire, this was not the case elsewhere. Other big machines on the drawing boards at Harwell, at Argonne and at Dubna, near Moscow, retained weak focusing. Almost half a century after the invention of strong focusing, these final examples of weak focusing synchrotrons have either disappeared or have become

Around the Laboratories

scientific museum pieces. However the prototype strong focusing machines at CERN and Brookhaven are still pumping out beams and play essential roles in the complex of interconnected particle beam supply systems at their respective laboratories.

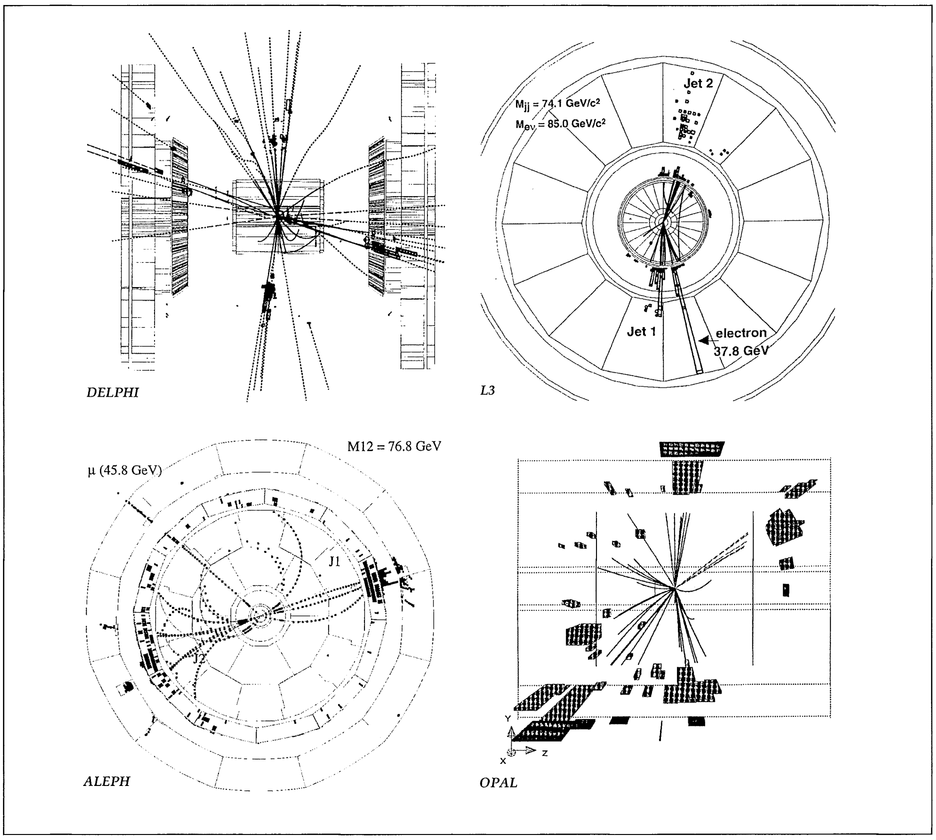
(The Editor is grateful to Kjell Johnsen for authoritative assistance)

CERN
LEP2 arrives

There was excitement in the air when CERN's LEP electron-positron collider was sealed at the end of May ready for physics. After seven years at the forefront of particle physics research, sealing the 27-kilometre ring is an ordinary enough event, but 1996 promised to be anything but an ordinary year. Over the winter shutdown, 84 new superconducting accelerating cavities had been installed around LEP, bringing the total of such cavities to 144 and transforming the accelerator into a new machine - LEP2.

LEP was designed to study the weak force which fuels the sun and is responsible for some forms of natural radioactivity. The weak force is carried by charged W and neutral Z particles. Up to now, LEP has been tuned around the Z, with a mass of 91.1884 ± 0.0022 GeV, or about the same as 97 hydrogen atoms. At the end of May, LEP2 was ready to move up from the Z energy to the 161 GeV needed to cross the W-pair production threshold. But with all the new equipment, would it work?

Confidence was high. Late last year, a preliminary high energy run with 60 superconducting cavities took LEP's collision energy to 140 GeV without a hitch. Physicists were eagerly hoping for tell-tale signs of new physics to accompany CERN's first energy boost since 1989. A handful of unusual events was seen (January/February 1996, page 1), but not enough to tell whether new physics was at work, or whether the



With CERN's LEP electron-positron collider cruising at its new collision energy of 161 GeV, on 9 July the LEP experiments recorded their first-ever pairs of W particles.

events were simply background. With further energy increases scheduled at least once a year for the remaining life of LEP, hopes and heart rates will be running high with every start-up.

The initial plan for 1996 called for the first beam to be injected on 17 June, followed by a period of Z running for calibration, and moving up to the W-pair threshold by the end of the month. Preparations went well, and beams were ready for injection on 14 June, ahead of schedule. But then came a problem: beams would not circulate for more than a few laps. There was some kind of obstruction, and the machine had to be opened up. On 19 June, two empty beer bottles were found inside the beam pipe. How they got there remains a mystery.

This put LEP behind schedule, with a potential loss in physics time of 10% of the 1996 run. With no more time to lose, the ring had been sealed and vacuum re-established by the following day. A beam was circulating that evening, and LEP2 was ready to go. Friday 21 and Saturday 22 were devoted to machine development for the LEP2 team to get to know the new accelerator. As well as all the new hardware, the injection energy was higher, 22 GeV instead of 20. On Saturday night, a positron beam went to 45 GeV at the first try, and later, a second positron ramp to 58 GeV worked as well.

On 28 June, the experiments recorded their first Zs with the new machine and settled back to collect their calibration data. It was slower in coming than expected. With the machine optimised for 80.5 GeV per beam, LEP's Z flood was reduced to a trickle. By 7 July, hard work by the LEP team had improved the luminosity, and all experiments pronounced themselves ready to cross the W threshold, taking CERN into a new physics realm.

The first ramp to 80.5 GeV, with a single circulating beam, was on the afternoon of Monday 8 July. Later the same day two accelerated beams were brought into collision, and the four experiments were recording their first 161 GeV collisions early the following morning.

On Tuesday 9 July, CERN awoke wondering which experiment would detect LEP's first W-pair. After a power converter trip during the night, physics was re-established that morning, and at 12.14, Delphi struck lucky and recorded the first W-pair, with the other three experiments not far behind. The luminosity soon reached a healthy 2 x 10^{31} per sq cm per s, beam quality continued to improve as the machine became better optimized. LEP2 was in business.

After a nerve-racking five weeks for the LEP team, a new era of CERN physics had begun. The next LEP bottles should be full of champagne.

Closing the book on an Open Day

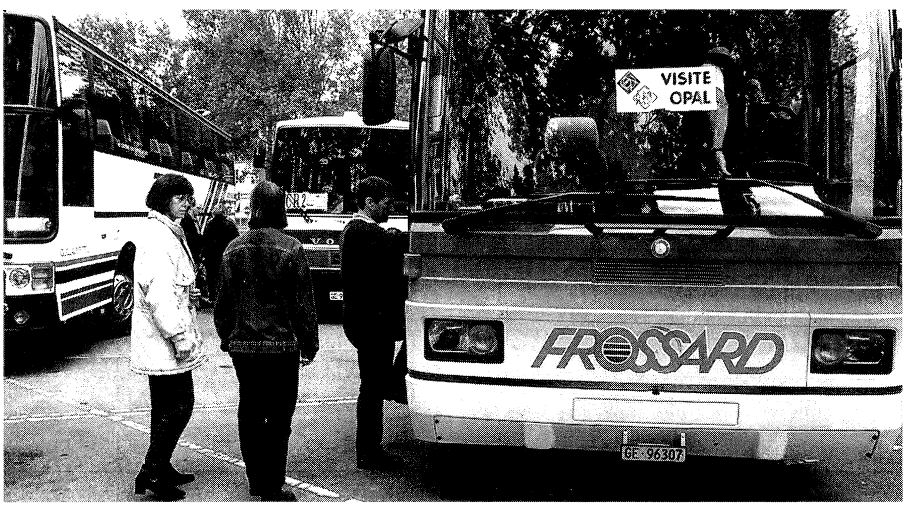
On any single CERN working day, keeping several thousand visiting scientists happy brings its own special demands. However even this throng was dwarfed earlier this year on CERN's Open Day (July, page 29), when an estimated tide of 25,000 eager visitors, ranging from enthusiastic Einstein-wannabes to local folk looking for something different to do on a Saturday, descended on the laboratory to see for themselves what everyday particle physics is all about.

Fifteen separate information points and over 400 CERN volunteers in distinctive red t-shirts anxiously stood by as the gates opened.

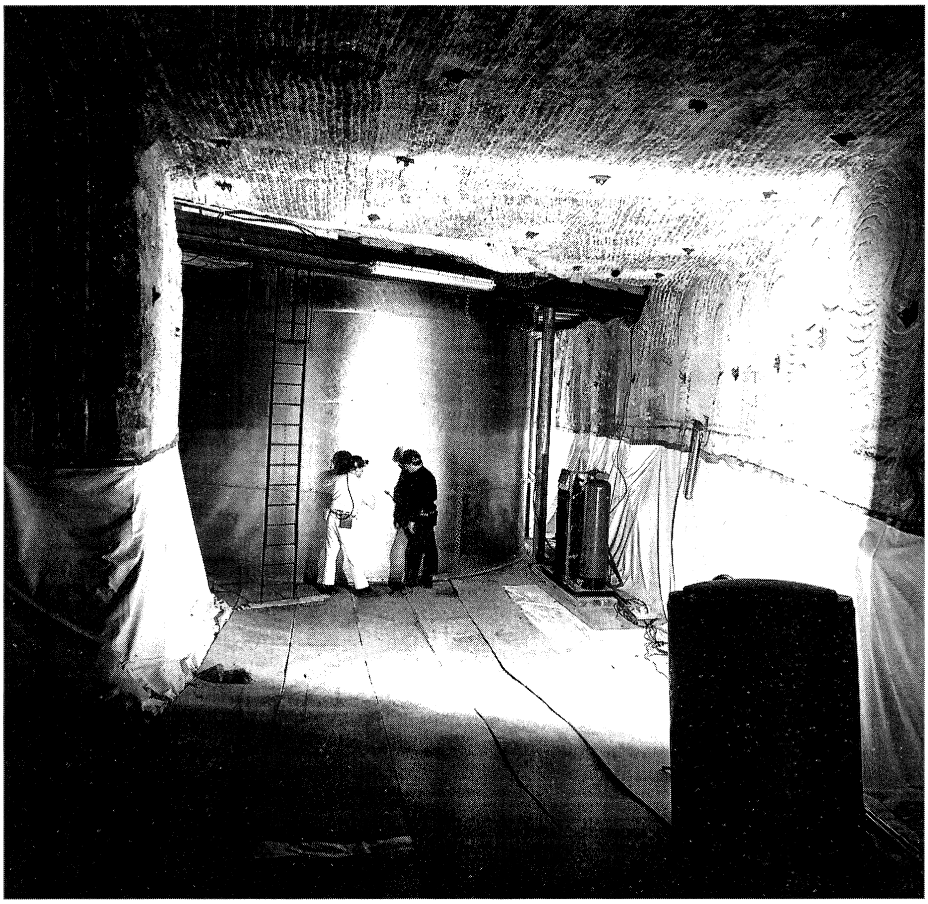
"The first arrivals on the site quickly submerged the first information point, but after a while people began to follow each other', explains resourceful Open Day coordinator Paola Catapano, who had been fazed by last-minute instructions by Geneva police to restrict the number of entrance points to the site.

A full itinerary had been arranged, with shuttle buses touring specially-

CERN Open Day - LEP aboard a bus



A low background detector in the 1100 metre-deep UK Boulby salt mine represent a significant step forward in experiments seeking to identify the nature of the non-luminous 'dark matter' which makes up 90% of the mass of our Galaxy. Careful shielding is required to screen off background. The Boulby mine shielding systems are of two types. One ***(Figure 1a)*** *is a 6m tank of purified water in which experiments can be suspended and which absorbs both gammas and neutrons from the cavern walls without adding activity of its own.*



staged attractions across the site ('Physics is Fun', the computer tape vault, major experiments, virtual reality, Web café, ...), while additional buses served the four LEP experiments. Trying to take in all the offered attractions would have taken more than a day, so there was ample choice.

These days most laboratories organize such events, but CERN's internationalism adds an extra language dimension. As well as the two official languages, English and French, talks and presentations were also organized in German, Italian, Dutch and Czech. The local population and schools in Switzerland and France had been targeted by mailings and through tourist offices, while a special Website brought another wave of enquiries.

At the end of a long day, Paola and her team breathed a sigh of relief. They certainly had a memorable day, while each of the 25,000 visitors had left with a very special impression of what exploring the innermost structure of matter means in everyday terms.

RUTHERFORD APPLETON
Dark matter search

New results[1] from a low background detector in the UK Boulby salt mine represent a significant step forward in experiments seeking to identify the nature of the non-luminous 'dark matter' which makes up 90% of the mass of our Galaxy.

This salt mine, in the north of England, is the most recent of the world sites for an increasing number of underground physics experiments, and the first to be funded specifically for dark matter searches. It is the deepest mine in Europe, reducing the cosmic ray flux to a level comparable with the Italian Gran Sasso and Japanese Kamioka sites. It is very much operational, employing over 1000 workers extracting both salt and potash 24 hours a day, and has a single level at 1100m depth with underground roadways extending over an area about 10 km square.

The company (Cleveland Potash Ltd) have given generous support to the work, both allowing use of surface facilities and making available three adjacent disused salt caverns, each about 10m x 20m, in which the current and future UK dark matter programme is being housed. These caverns have been dustproofed and equipped with control rooms, electrical supplies, and data links to a surface control room and from there to the participating groups at Rutherford Appleton Laboratory, Imperial College London, and Sheffield University.

The objective of the programme is to search for new heavy weakly interacting particles (WIMPs) which may constitute the majority of the dark matter. Direct gravitational lensing searches for low mass stars (MACHOs) have not seen sufficient events to indicate more than about 20-30% of the dark matter in that form[2] leaving a particle explanation

Figure 1b *Test detector being lowered into water shielding tank.*

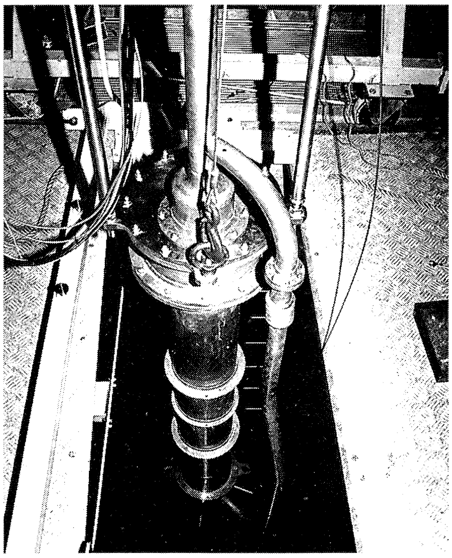
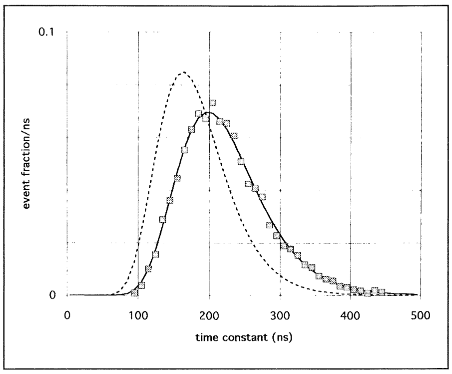


Figure 2 shows the time constant distribution for six months of background events together with the distributions obtained from gamma (full line) and neutron (dashed line) calibrations. The points are binned data for 13-16 keV energy span. The background pulses are consistent with zero nuclear recoil signal at all energies and new 90% confidence limits have been obtained on possible dark matter signals, arising from either spin-dependent or spin-independent interactions[1].



still favoured to account for the majority of the non-luminous density (about 0.4 GeV/cm^3 at our distance from the Galactic centre).

One hypothesis is that the missing particle is the 'neutralino' - the lightest particle of supersymmetry theory (typical expected mass 10-10000 GeV) - which would have been formed in large numbers in the early universe, subsequently clustering in association with normal baryonic matter. Other possibilities are the axion - a boson of mass 10^{-5} - 10^{-1} eV, or one of the known neutrinos, for example a tau neutrino with a mass of about 30 eV.

Studies of experiments for all types of particle have been in progress in the UK since 1983, with detector research and development since 1987 and funding to establish the Boulby Mine laboratory starting around 1991 as the first UK joint programme between particle physics and astronomy. This underground programme is currently directed specifically towards WIMP searches.

If WIMPs constitute the Galactic dark matter they will be moving with a typical velocity 0.001 of that of light and could be observed by collisions with ordinary nuclei, imparting recoil energies in the typical range 1-50 keV. These recoils could be observed by ionization or scintillation detectors, or by low temperature phonon techniques. The problem lies firstly in the very low predicted event rates - typically 0.01-0.1 per kg per day for the neutralino, compared with shielded low energy background gamma and beta rates (from target and detector components) 10^3-10^4 times higher. Secondly, any underground neutrons (produced by uranium and thorium in the rock and by residual muons) can produce nuclear recoils indistinguishable from dark matter interactions.

The Boulby mine shielding systems are of two types. One (Figure 1) is a 6m tank of purified water in which experiments can be suspended and which absorbs both gammas and neutrons from the cavern walls without adding activity of its own. The other type consists of 'castles' of low-activity lead and copper, which surround specific detectors and are further surrounded by wax or polythene neutron shielding. However even the highest purity detector systems have too much intrinsic radioactivity to observe the very low predicted event rates, and methods must be found of distinguishing the nuclear recoil events from background.

In a low activity, low threshold, 6 kg sodium iodide detector running at Boulby since 1994, background rejection factors of 10-40 have already been achieved by means of pulse time constant discrimination. Although this technique has been known for 40 years as a method of distinguishing alphas from gammas in sodium iodide in the MeV range, below 20 keV it is more difficult since there are fewer photoelectrons to define the pulse shapes and statistical methods are necessary to search for a population of nuclear recoil events within a larger gamma background.

Figure 2 shows the time constant distribution for six months of background events together with the distributions obtained from gamma and neutron calibrations. The background pulses are consistent with zero nuclear recoil signal at all energies and new 90% confidence limits have been obtained on possible dark matter signals, arising from either spin-dependent or spin-independent interactions[1].

The current limits are now below 10 events/kg/day, and improvements in light collection and energy threshold will reduce this to below 1 event/kg/day. To reach the favoured neutralino rates of 0.01-0.1 event/kg/day it is proposed to construct a detector based on a liquid xenon target, for which a combination of scintillation and ionisation processes provides a more powerful method of discriminating nuclear recoils from background[3].

It is planned that this new experiment, which can subsequently be scaled up to larger masses to reach even lower event rates, will be carried out in collaboration with the liquid xenon group at UCLA, as the first of several future international collaborations under discussion for

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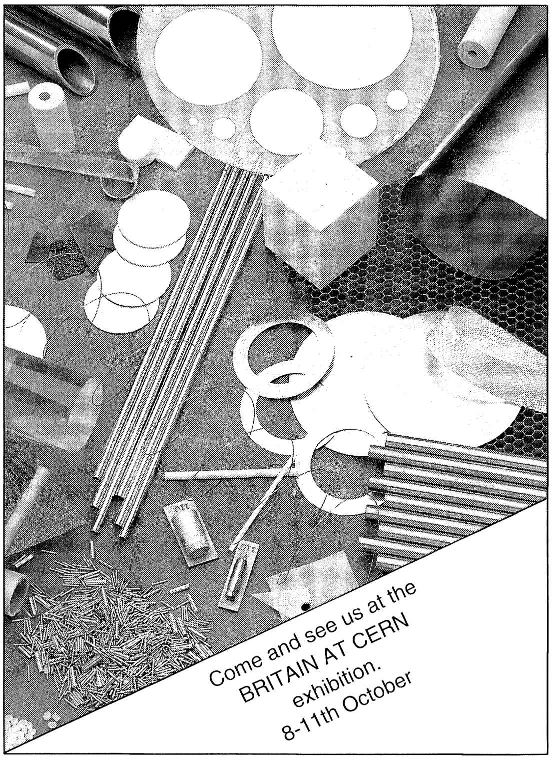

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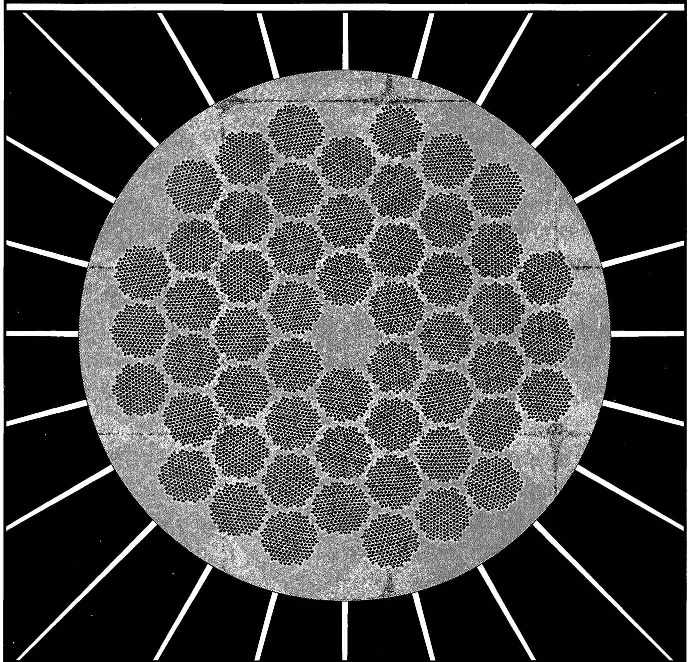

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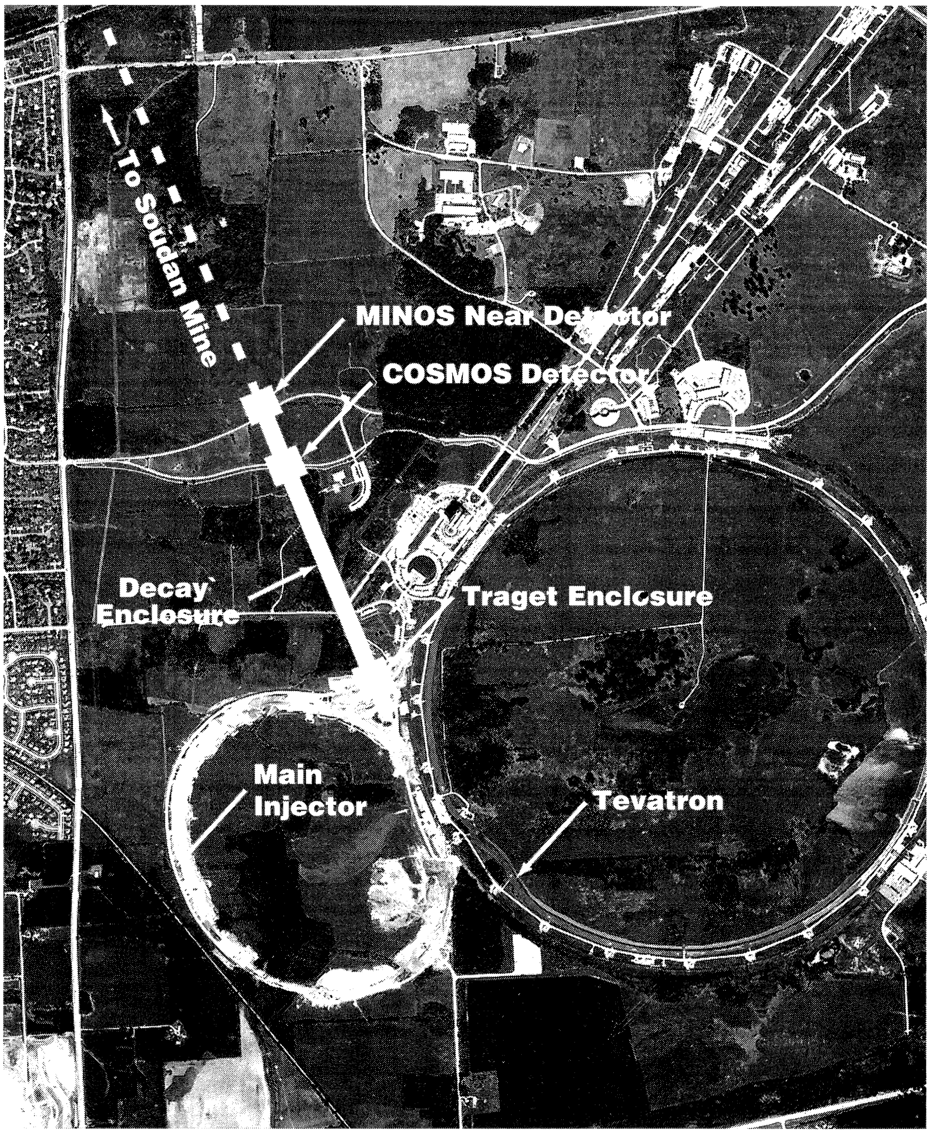
Aerial view of Fermilab, showing the 6.4-kilometre superconducting Tevatron, currently fed by the Main Ring, sharing the same tunnel. The Main Ring will be replaced in 1999 by the new 120 GeV Main Injector, whose new 3.6 kilometre tunnel has recently been completed. The Tevatron beamlines can be seen, top right. The Main Injector will also feed a new neutrino beamline, serving the COSMOS and MINOS detectors nearby and 730 kilometres further downstream, 700 metres underground in the Soudan mine in northern Minnesota's Iron Range.



the Boulby Mine, both for dark matter searches and for new supernova neutrino detectors.

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2 - E I Gates et al., Phys Rev D53 (1996) 4138
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(From P. F. Smith, Particle Physics Department, RAL)

FERMILAB
Next generation of neutrinos

With the history of neutrinos at Fermilab almost as long as the history of the laboratory, the stage is now being set for the next act.

Neutrinos made their debut at Fermilab with the presagefully labelled experiment 1A, led by David Cline, Al Mann and Carlo Rubbia, approved in 1970 and for which construction proceeded in parallel with work for Fermilab's Main Ring. This experiment ran in parallel with a Caltech/Fermilab detector and with bubble chamber studies.

After some 25 years, Fermilab's original 6.4-kilometre Main Ring, which now feeds the 900 GeV superconducting Tevatron, which shares the same tunnel as the Main Ring, is scheduled to be replaced in 1999 by the new 120 GeV Main Injector, whose new 3.6 kilometre tunnel has recently been completed. As well as feeding the Tevatron, the Main Injector will also cater for the NuMI - Neutrinos at the Main Injector - project, firing a proton beam towards a target 360 metres away. Neutrinos come from the decay of secondary pions and kaons produced in the target, with shielding at the end of an 800-metre decay tunnel ensuring that all other particles are removed.

Many facets of neutrino physics suggest that the three varieties of neutrino - electron- , muon- and tau-like - are not immutable but instead slowly 'oscillate' from one form to another. To check this means comparing the behaviour of the same neutrino beam at two points to see if the content of the beam has changed.

For NuMI, one experiment - COSMOS (Cosmologically Significant Mass Oscillation Search), using nuclear emulsion to detect tau leptons produced by oscillations of muon neutrinos - will be installed one kilometre downstream of the neutrino target, while the second - MINOS (Main Injector Neutrino Oscillation Search) - will be 730 kilometres further away, 700 metres underground in the Soudan mine in northern Minnesota's Iron Range.

Both experiments have been designed to detect the appearance of tau neutrinos in the NuMI beam, which should consist almost entirely of muon neutrinos unless oscillations change its composition.

Oscillations between two neutrino types are characterized by Δm^2 - the difference in the squares of the masses of the two neutrinos. Although massless neutrinos give an elegant theory, neutrinos must have some mass for oscillations to occur. COSMOS, like its sister experiment Chorus, now well into data-taking at CERN, will be sensitive to oscillations with Δm^2 values greater than about1 eV^2. Such large masses could account for much of the invisible 'dark matter' in the universe.

The MINOS experiment, because of its very long baseline,will be sensitive to much lower values of Dm^2, down to 0.001 eV^2, suggested by anomalies in cosmic-ray neutrinos produced in the earth's atmosphere.

The Soudan mine is no stranger to particle physics experiments. In 1981, it became the home of a 30-tonne detector searching for signs of proton decay. Over the years, the original motivation for proton decay gradually extended to cover neutrino physics as well, intercepting neutrinos from outer space or from cosmic ray interactions in the atmosphere, and in 1993 the new 1 kilotonne Soudan 2 detector was complete (April 1993, page 16).

For MINOS, Soudan will house a 10,000-tonne 50-metre long neutrino detector made of toroidally magnetized iron absorber planes interspersed by tracking chambers.

MINOS will be assembled in a cavern to be excavated adjacent to the existing Soudan 2 hall in 1998-1999. The detector must be solid enough to ensure a high neutrino interaction rate (25,000 events per year) so far from the neutrino source. This large detector must also be fairly coarse-grained to localize neutrino interactions while using simple, inexpensive technologies if it is to be built at reasonable cost.

Its 4-centimetre thick, 8-metre diameter magnetized steel planes and tracking chambers will still be able to provide good energy measurements of both the muons and the hadron and electromagnetic showers produced in neutrino interactions. The 32,000 square metres of chambers will probably be Iarocci tubes, but several alternative technologies are also being developed in hopes of achieving better performance for lower cost.

For reference, MINOS will also have a 'near' detector 1.5 kilometres downstream of the Fermilab neutrino target. This will be a smaller version of the large 'far' detector at Soudan, so that most detector-response effects will cancel out in the comparison of neutrino events recorded in the two widely separated detectors.

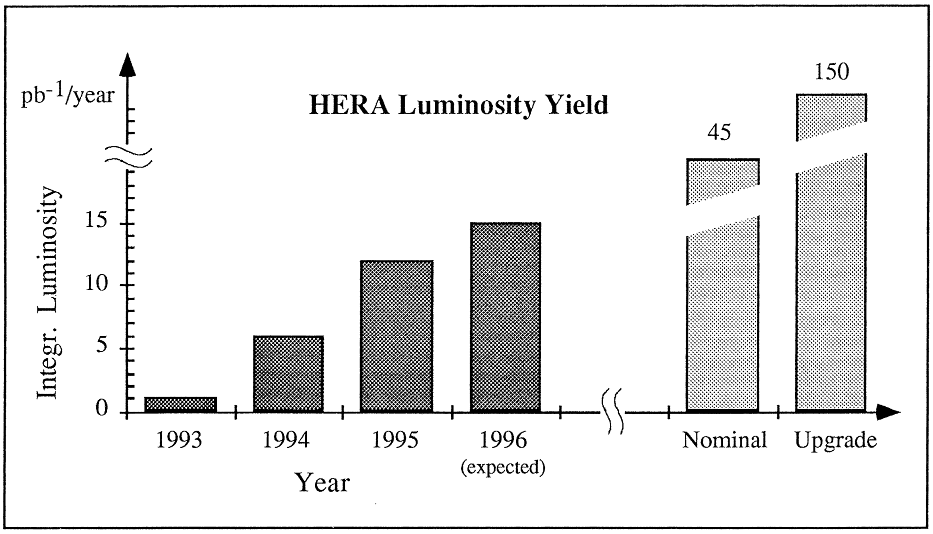
A major effort is underway to design a neutrino beam whose properties can be very well understood, and which will have very similar characteristics at Fermilab and at distant Soudan. In this way the observation of some unexpected difference in the characteristics of neutrino events in the two detectors - for example an increase in the number of tau-like or electron-like events at Soudan - will become more noticeable and signal the presence of oscillations.

Although Fermilab's Main Injector is assured of funding, NuMI has yet to have such comfort. But if everything proceeds according to plan, the experiment hopes to begin taking data in 2001.

Martha Krebs, Director of the US Department of Energy's Office of Energy Research, surprised the crowd at Fermilab's annual User's Meeting in June by donning a bright red T-shirt with the logo of the MINOS (Main Injector Neutrino Oscillation Search) collaboration. She recently visited the underground physics laboratory in Soudan, Minnesota where the 10,000 ton MINOS detector will be located. The neutrino beam from Fermilab, 730 km away, is scheduled to arrive there in 2001. At Soudan, Dr. Krebs met with a number of enthusiastic MINOS supporters from the Collaboration, the Minnesota Department of Natural Resources, the University of Minnesota (which operates the lab), and the surrounding community. The theme of her User's Meeting talk was "if we want to pull ahead, we have to pull together."

DESY
Future physics at HERA

The HERA electron-proton collider at DESY, Hamburg, the only machine of its kind in the world, has now been operational for three years, yielding steadily increasing luminosity (collision rate). The Zeus and H1 experiments have given a rich harvest of physics results: the intriguing rise in the proton structure at small x (momentum fraction carried by the struck quark); rapidity gap events (with a marked separation between two produced subsystems) and deep inelastic



Luminosity profile of DESY's HERA electron-proton collider for the first years of operation, and future expectations.

diffractive scattering (July, page 3); neutral and charged current electroweak cross-sections at large momentum transfer; high energy photoproduction; and the quark/gluon content of the photon.

Unexpected new physics beyond the Standard Model has been searched for, resulting in new limits, but so far no hints of new effects have been seen. The polarized (spin oriented) electron beam is now also used by the HERMES experiment to measure the spin structure of the proton using a gas target. The HERA-B experiment, now being installed, will soon use HERA's proton beam on a fixed target.

After such a successful start to the HERA physics programme, it is time to consider future opportunities. To this end the 'Future Physics at HERA' workshop began last September and had its final meeting from 29-31 May. The aim was to identify and review prospects with HERA running in collider and fixed target modes.

Options included high luminosity, polarized beams and beams of nuclei, and a range of working groups were formed: Structure Functions; Electroweak Physics; Beyond the Standard Model; Heavy Quark Production and Decay; Jets and High Transverse Energy; Diffractive Hard Scattering; Polarized Protons and Electrons; Light and Heavy Nuclei in HERA; and HERA Upgrades and Impacts on Experiment.

One possible future HERA option is polarized electron and proton beams. The electron beam, self-polarizing through the Sokolov-Ternov effect, is already routinely polarized to 60% or more and used by HERMES. One interesting question is the behaviour of the polarized structure functions in distant kinematic regions (low x) to test fundamental sum rules. Very low x values can only be reached in a collider. Since the proton beam is not self-polarizing, polarized protons have to be injected, accelerated to 820 GeV and stored for some hours in the HERA ring with the polarization intact. The thousands of potential depolarizing resonances may be avoided using 'Siberian snakes' (July, page 6).

Polarized electron-proton collisions at a collision energy of 300 GeV will allow study of both the low x and the large momentum transfer regions. HERA would then be the ideal place to measure the gluon contribution to the proton spin from interactions where a quark system links a gluon and a photon (the boson-gluon fusion process). A decision whether to proceed with polarized proton beams will be made towards the end of 1997 or beginning of 1998, when results of feasibility studies become available.

Another option for future physics at HERA is electron-nucleus collisions. Heavy ion sources and pre-accelerators would have to be built, but this could be done with available technology from other accelerator laboratories. This would give an opportunity to study systems with a large effective quark-gluon density, with possible shadowing effects in the nucleus at large momentum transfers.

Appealing measurements have been proposed to test the universality of the pomeron concept and to carry out quantitative tests on the interplay between soft and hard processes (July, page 3). Using the nucleus as a "femto-vertex" detector could open up the study of the space-time structure of strong interactions. The first step towards this physics could be taken with a heavy nucleus target in HERMES.

One clear requirement from the H1 and Zeus electron-proton collider experiments is increased luminosity. The HERA upgrade study group concludes that in two years HERA will routinely deliver 30 to 50 inverse picobarns per year and per experiment. A further 3-3.5 fold increase is possible by grooming the proton beam and having stronger focusing of the beams at the interaction point. Such a scenario could lead to a total integrated luminosity of an inverse femtobarn by the year 2005.

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Published from CERN, Switzerland, it also has correspondents in the Laboratories of Argonne, Berkeley, Brookhaven, Cornell, Fermi, Los Alamos and Stanford in the USA, Darmstadt, DESY and Karlsruhe in Germany, Orsay and Seclay in France, Frascati in Italy, Rutherford in the U.K., PSI in Switzerland, Serpukhov, Dubna and Novosibirsk in Russia, KEK in Japan, TRIUMF in Canada and Beijing in China.

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The structure function group reported progress on the theoretical side, and demonstrated how high luminosity data will allow precision studies of a range of quark and gluon structures as well as the strong coupling constant and several other items. Apart from high luminosity, data were requested at lower beam energies and with deuterons, which would improve the knowledge of nucleon structure.

Interesting prospects for various aspects of theoretical understanding are also provided by studies of the hadronic final state, as shown by the Jets and High Transverse Energy group. One exciting opportunity is the possibility of observing instanton-induced processes, oddball effects leading to spectacularly different states with high transverse momentum and democratic levels of strangeness and charm. Also very interesting is the continued exploration of the quark and gluon content of the photon through photoproduction. Furthermore, studying jet production could significantly improve measurements of the strong coupling and the proton's gluon distribution at low x.

The intriguing field of quark-gluon dynamics at low x, highlighted by the present HERA data, will gain from increased luminosity.

Since the observation of large rapidity gaps, HERA has played a key role in the understanding of diffraction. Questions on the soft or hard nature of diffraction, as well as on colour propagation and colour transparency are central questions. Higher luminosity and improved detection in the proton direction will lead to important advances.

Heavy quark production was considered both for HERA as an electron-proton collider and the fixed target experiment HERA-B. High luminosity at HERA will lead to substantial progress in the study of production mechanisms for particles containing the charm quark and for heavy quark-antiquark systems, as well as for the gluon density in the proton and photon.

HERA-B will look for violation of CP symmetry (a hypothetical mirror which reflects particles as antiparticles as well as left and right) in the decays of B particles containing the fifth ('beauty', 'b') quark. CP violation so far has only been seen with neutral kaons. In addition rare B decays can be observed or their limits substantially improved. Furthermore the experiment has a rich programme of other physics and will contribute to improved measurements of B lifetimes, neutral B mixing and quark mixing parameters.

The two groups that are perhaps most eagerly looking forward towards a boosted HERA luminosity are those which considered the opportunities for electroweak physics and physics beyond the Standard Model. Using polarized electron beams, it was shown that HERA is competitive with other accelerators in physics signatures such as couplings between the electromagnetic photon and the weak W and Z. The electroweak couplings of up and down quarks could be precisely measured and perhaps help understand the puzzling levels of heavy quark production in the decays of Z particles measured at CERN's LEP electron-positron collider.

With a luminosity upgrade, HERA remains the ideal place to look for new physics such as heavy leptons, excited electrons, new 'leptoquarks' and lepton number violating processes. Other physics problems could be tackled with polarized beams or beams of nuclei. It is not easy to set priorities among these options, but the outcome of the workshop will help.

From A. De Roeck, G. Ingelman, and R. Klanner

(The next issue will include an article on the upgrade plans for the H1 detector at HERA.)

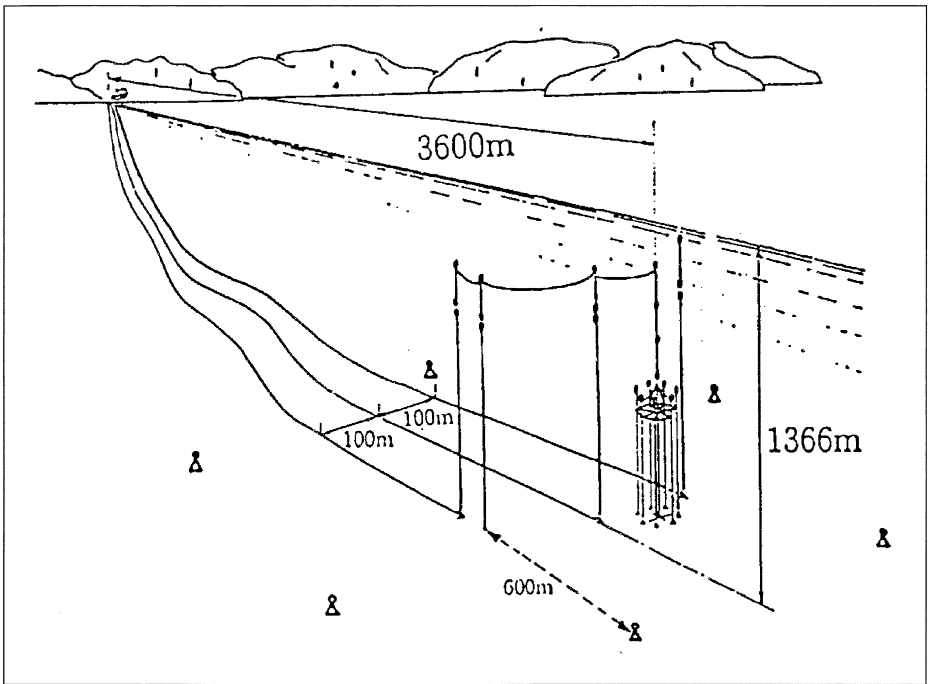
LAKE BAIKAL First underwater neutrinos

The detector carrying 36 large phototubes in three vertical strings which began operation in 1993 in the deep, clear water of the Siberian Lake Baikal has now recorded the first examples of underwater neutrinos.

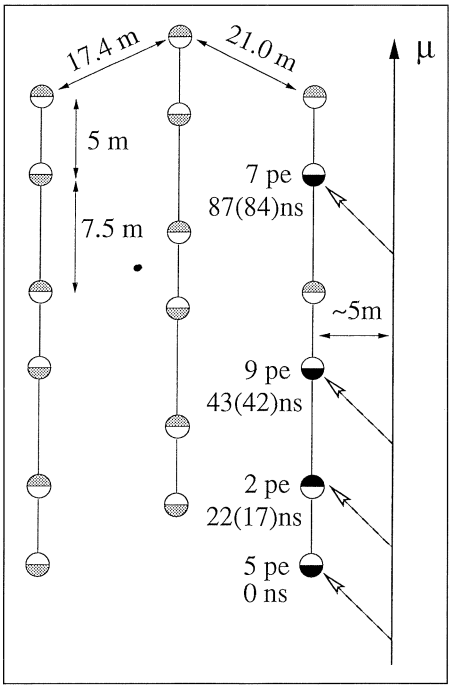
Such an underwater neutrino detector uses a lattice of photomultipliers in pressure-tight glass housings, and the direction of a particle is inferred from the arrival times and amplitudes of the Cherenkov light it emits. Since muons produced in high energy neutrino reactions closely follow the direction of the incident neutrino, such a detector works as a neutrino telescope.

The initial Baikal NT-36 (Neutrino Telescope with 36 Phototubes) was deployed in March/April 1993 at a depth of 1100 m and operated until March 1994. Slightly reconfigured, it continued data taking through 1994 and was replaced by an array twice as large in April 1995. In April the larger NT-96, carrying 96 phototubes at 4 strings, started operation. For 1997/98, the NT-200 telescope, with

Sketch of the neutrino search experiment at Lake Baikal, Siberia.



The first clear neutrino candidate identified with the Baikal neutrino telescope. A circle represents a photomultiplier tube (PMT) pair, with hit PMTs shown in black. The numbers refer to photoelectrons (p.e.) and the arrival time of the first hit PMT (with in brackets the time expected for a muon moving vertically upwards).



192 phototubes, is planned.

The Baikal Neutrino Telescope is being developed by several Russian research centres, notably Moscow's Institute of Nuclear Research, Irkutsk State University and Moscow State University, and DESY-Zeuthen, Germany.

Since 1980, when the site was inspected for the first time, much technological progress has been made. A robust deployment technology was developed, using the ice cover as a stable platform. Weights anchor the strings to the bed of the lake and buoys held them in vertical position. The top buoy is at a depth of 20 m and is easy retrieved by "lassoing" it from the ice surface. The detector is operated via three shore cables.

Leaks in pressure housings or connectors menace all underwater experiments. Earlier, the Baikal group was plagued by leaks, but these hurdles seem to be overcome - none of the more than 300 NT-36 feedthroughs leaked. Another remarkable technological achievement is the QUASAR, a 37cm-diameter hemispherical phototube with 2nsec time resolution.

The Baikal experiment has taken more than 30 million reconstructible events, mostly due to muons generated in the atmosphere above the detector and punching through to a depth of 1 km. However a muon coming from below can only originate from a neutrino, since no other particle can traverse the Earth. The challenge is to separate the few upward muons from the millions of downward ones.

Scanning the 1994 data, two nearly vertically upward muons whose fake probability is less than 3% may herald the coming of age of underwater neutrino telescopes. From the detector deployed this year, 1-2 neutrinos per week are expected against a background of fake events smaller than the signal itself.

Theoretical models suggest that only a detector a hundred times larger than NT-200 would be sensitive enough to detect the feeble fluxes from steady cosmic sources. Questions that can be tackled with NT-200 include searching for burst-like cosmic sources, for neutrinos from annihilation of dark matter particles (WIMPs) in the centre of the Earth, and for magnetic monopoles, as well as doing "standard" cosmic ray physics. The present Baikal detector is seen mainly as a prototype for a future full-scale telescope. With an effective area of about 100,000 square metres, it would be about 50 times larger than NT-200.

Bookshelf

The Quantum Theory of Fields, Volume 2: Modern Applications by Steven Weinberg (ISBN 0521 55002 5, Cambridge University Press, 1996)

This is the second volume of the eagerly-awaited treatise on modern quantum field theory by one of the leading contributors to the revolution in this area of theoretical physics. After Volume 1 (October 1995, page 28) laid the foundations, Volume 2 goes on to describe a wide range of applications that have transformed this subject over the past 30 years.

The emergence of non-abelian gauge theories (Yang-Mills theories) as fundamental theories of the electromagnetic and weak forces in 1967 and the strong force around 1972 led to the Standard Model of elementary particle physics. As well as having been beautifully verified in great detail by subsequent experiments, this has stimulated immense advances in theoretical and mathematical physics. This then is the book's arena.

It begins with the formulation of gauge theories and their renormalization. The subsequent discussion of the renormalization group is presented in great depth, including connections with critical phenomena in statistical physics. Applications of asymptotic freedom to electron-positron and deep inelastic scattering are covered in this and a subsequent chapter.

The chapter on spontaneously broken global symmetry and effective field theory includes a discussion of current algebra, chiral lagrangians and nonlinear sigma models. Spontaneously broken local symmetry (the Higgs mechanism) is naturally applied to the Standard Model but another link is made with condensed matter physics in a section on superconductivity. The chapter on anomalies includes not only the standard treatments of global and local anomalies but a description of general aspects embodied in the 't Hooft consistency conditions which play a crucial role in determining exact properties of four-dimensional field theories.

The final chapter is concerned with extended solutions of Yang-Mills theories - solitons and instantons - that have assumed great significance for the unravelling of non-perturbative effects in many interesting theories. Each chapter is supplemented with exercises and an extensive bibliography. The insight and depth of treatment which singles this book out from others in this field can be largely attributed to Weinberg's authority as an originator of many of the ideas in the book. Even so, certain specialized topics had to be left out - most notably supersymmetry, that has played a pivotal role in the recent elucidation of certain four-dimensional Yang-Mills theories and the structure of superstring theory. Perhaps the community could request a third volume? Experienced researchers and beginning graduate students alike will delight in the gems of wisdom to be found in these pages. This book combines exposition of technical detail with physical insight in a unique manner that confirms the promise of Volume 1 and I have no doubt that these two volumes will rapidly constitute the classic treatment of this important subject.

by Michael B. Green

Review of Reflections on Experimental Science, by Martin L. Perl, World Scientific Publishing, ISBN 981 02 2429X (hbk) price £57, 981 02 25741 (pbk) price £26

Three-quarters of 'Reflections on Experimental Science' - the scientific autobiography of Martin Perl - comprises selected published papers. While these are of undoubted scientific importance, the real jewels in this book are Perl's personal comments and reflections, which appear both as prefaces to each paper and as separate essays. With these he puts the flesh and feeling on his experimental work and on the field as a whole.

His research spans an important period that saw the discovery of the quark/lepton families and the establishment of the standard model. His discovery in 1975 of the tau lepton – for which he received the 1995 Nobel Prize in Physics – signalled the presence of a third quark/lepton family, confirmed two years later at Fermilab with the discovery of the upsilon by Leon Lederman and his colleagues.

Perl's personal recollections of the tau discovery and his views on the future of tau physics form the centrepiece of the book and are an important contribution to the history and sociology of science. In a broader context he provides his own answers as to what are the real motivations for doing the experiments we do, how subjective and constrained are our experiments by the prevailing scientific orthodoxy, and how successful we are at coordinating new accelerators worldwide. Perl's approach and taste in particle physics is refreshing. He has produced a rare book that provides reflection for his colleagues and inspiration for young experimentalists.

By Jasper Kirkby

Books received

Quantum Field Theory, by Lewis H. Ryder, Cambridge University Press, ISBN 0 521 472423 (hbk), 0 521 47814 6 (pbk).

The second edition of this useful book, aimed at students of particle physics and first published in 1985, includes a new chapter on supersymmetry, thus satisfying those who are unable to find their supersymmetry requirements in Steven Weinberg's book.

Electroweak and Strong Interactions, by F. Scheck, Springer, ISBN 3-540-60192-9

An update of Lepons, Hadrons and Nuclei, published by North Holland in 1983, this book aims to provide an understanding of today's Standard Model through the phenomenology of electroweak and strong interactions rather than the formalism of gauge theory.

Black Hole Uniqueness Theorems, by Markus Heusler, Cambridge University Press, ISBN 0 521 56735 1

Volume 6 in the Cambridge series of Lecture Notes on Physics.

Supersymmetric Quantum Cosmology by P.D.D'Eath, Cambridge University Press, ISBN 0 521 55287 7

A Cambridge Monograph on Mathematical Physics, this book, by a black hole authority, a former graduate student of Stephen Hawking, provides a welcome introduction to quantum cosmology.

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Physics monitor

Particle detectors in action

Just over a week after its formal opening on 20 May, French customs officials at the port of Le Havre using a "Sycoscan" electron beam scanning system developed by Paris-based Europ Scan, a subsidiary of Schlumberger Industries, seized seven and a half tonnes of cannabis in a Taiwanese freighter bound for Felixstowe (UK).

In the Sycoscan system, bulky loads such as trucks and containers pass on a conveyor through X-ray beams generated by a 5 MeV beam of electrons. The photoelectrons produced by the X-rays are picked up by an array of 50 multiwire proportional chambers.

Because of Sycoscan's large scale use of these chambers, Georges Charpak, who was awarded the 1992 Nobel Physics Prize for his development of multiwire proportional chambers, was one of the guests of honour at the inauguration of the Le Havre system.

Additional Sycoscan installations are at both ends of the Channel tunnel and at Roissy-Charles de Gaulle airport.

Passing a large container through the beam takes only a few minutes, but the subsequent analysis of the images means each examination takes about a quarter of an hour.

However the resolution and imaging capabilities mean that solid objects can be 'seen' even behind ten centimetres of steel. The three-dimensional images quickly reveal false floors or partitions and objects hidden deep inside innocuous cargoes. The Le Havre cannabis haul was found hidden in cartons supposedly containing pottery.

Previous Sycoscan successes include drugs carefully hidden in industrial equipment, or sealed in concrete and covered in ammonia to deter sniffer dogs.

A French customs officer surveys the contents of a vehicle using the Sycoscan system, in which bulky loads such as trucks and containers pass on a conveyor through X-ray beams generated by a 5 MeV beam of electrons. The photoelectrons produced by the X-rays are picked up by an array of 50 multiwire proportional chambers which can 'see' objects dissimulated behind ten centimetres of steel.

Beam cooling and instability damping - on board ship

The increased control being achieved over all kinds of particle beams was evident from the 11th International Advanced ICFA beam dynamics workshop on beam cooling and instability damping, held on board the SS "Alexander Suvorov" from 18 - 26 June as it sailed along the Volga river and the Volga - Moscow channel between Moscow and Nizhniy Novgorod.

70 scientists from Russia, German, Italy, Sweden, USA, Switzerland, China, Ukraine, Byelorussia, Uzbekistan took part in the on-board workshop, organized by the Joint Institute for Nuclear Research (JINR, Dubna) within the framework of ICFA, the Russian Fund for fundamental research (RFFR), Russian Academy of Science (RAS).

The meeting followed those in Montreux (Switzerland, 1993), and Erice (Italy, 1995) and was dedicated to the 30th anniversary of electron cooling. I.N. Meshkov presented a "jubilee" report on of history and the prospects of electron cooling. Proposed by G.I. Budker in 1966, electron cooling has now been applied in at least nine accelerator centres.

Ions right across the periodic table have been cooled, and extremely

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Workshop ship. The 11th International Advanced ICFA beam dynamics workshop on beam cooling and instability damping was held on board the SS "Alexander Suvorov" as it sailed along the Volga river and the Volga - Moscow channel between Moscow and Nizhniy Novgorod.

monochromatic and collimated ion beams are routinely reached with a relative momentum spread as small as 5 parts in ten million and emittances as small as 10-7 rad m.

Electron cooling has also opened the way to new directions such as laser cooling and the related physics of crystalline beams, which holds the promise of high precision "solid state investigations" with beams of charged particles.

New high voltage electron cooling systems of several MeV are considered by Fermilab and Novosibirsk as the next step following systems in the 2 - 100 keV range which have opened a whole new area of physics.

Electron cooling was naturally a major focus of the workshop but other methods of particle cooling were also covered. D.Möhl (CERN) spoke on recent work with stochastic and electron cooling of ions at CERN's low energy LEAR ring. Stochastic cooling in the existing antiproton facilities and the proposed AD project at CERN (November 1995, page 6) as well as in Fermilab's antiproton source were summarized by F. Pedersen (CERN) and J. McLachlan (Fermilab) respectively. Two other rings (ESR Darmstadt and COSY Jülich) plan to join the club of stochastic coolers this year (report by D. Prasuhn, Jülich). V.Lebedev (formerly of Aarhus and now at CEBAF/Jefferson) covered laser cooling at the Danish ASTRID storage ring (July, page 10).

A. Skrinsky of Novosibirsk reported on "Ionization Cooling and Muon Colliders", with ideas for a muon collider at Novosibirsk and an accelerator system for generating and storing muons. G. Silvestrov and T. Vselovojskaja (Novosibirsk) and A. Lebedev (PIAS) reminded us that although radiation cooling and ionization cooling have great similarities, at presently available energies nature capriciously allows only the former to work for electrons and only the latter for muons.

A series of reports on electron beam physics stimulated extensive debate on space-charge effects in the cooling beam. G.Shirkov's (JINR) work on intense neutralized beams for electron cooling and for Electron Beam Ion Sources (EBIS) was of great interest. The LEAR electron cooling and JINR test-bench teams presented new results on neutralization. S. Gustafsson (INFN Legnaro) described ideas on electron cooling enhanced by insertions acting on the ion beam, and H. Danared (MSI Stockholm), K. Hedblom (Uppsala) and T. Winkler (GSI Darmstadt) reported on electron cooling developments at their respective machines (CRYRING, CELSIUS and ESR).

A lively ensuing discussion on "adiabatic electron beam expansion" showed that this technique brings a net cooling improvement for reasons which are (probably) not fully understood, although a new explanation was suggested by V.Lebedev.

Still on high energy cooling, J.MacLachlan and S. Nagaitsev (Fermilab) presented the ambitious project for a 5 MeV electron cooling system for the 9 GeV antiproton recycler ring.

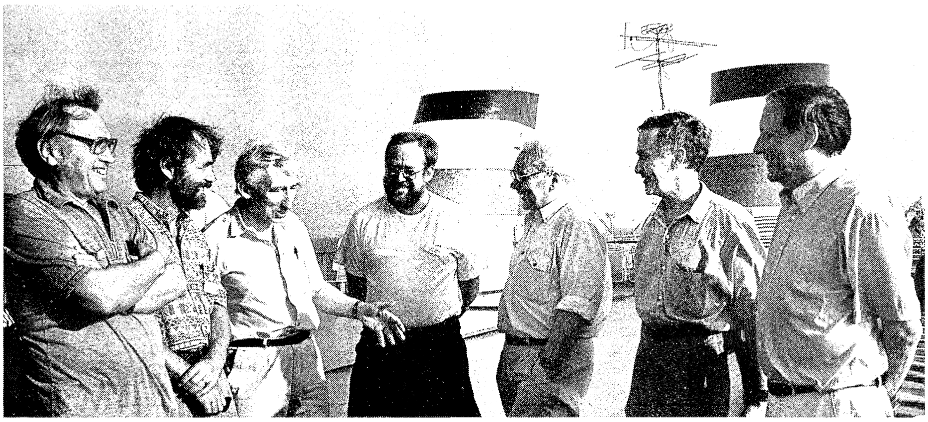
In a session dedicated to cooling exotic beams, G.Schepers (Jülich) described the production of antihydrogen atoms at CERN's LEAR ring (March, page 1). A scheme for antihydrogen synthesis using two overlapping storage rings - an antiproton and a separate positron ring - discussed by I.Meshkov and A.Skrinsky uses relatively low energy with focusing by longitudinal (solenoidal) magnetic fields.

Other 'exotic' schemes foresee similar overlapping cooling rings for colliding or parallel beams of electrons or ions (G. Muenzenberg, GSI), or ions and antiprotons (Kartavsev and Meshkov, JINR) for precision studies which only become possible with cooling.

The conceptual design of a positron storage ring was described in more detail by A. Sidorin and I.Meshkov (JINR). A recently assembled high

On board - left to right: Igor Ivanov (JINR, Dubna), Flemming Pedersen (CERN), Workshop chairman Igor Meshkov (JINR), Stellan Gustaffson (INFN, Legnaro), Andrei Lebedev (Lebedev Institute, Moscow), Alexander Skrinsky (Novosibirsk) and Simon van der Meer (CERN).

(Photos Yu. Tumanov)



resolution beamline for radioactive ions and storage ring projects at Dubna was introduced by A. Lavrentev (JINR). Another cooling application was discussed in the review of beam crystallization by L. Tecchio (INFN Legnaro).

The remainder of the meeting covered instability damping in intense particle beams, such as those required in the CERN SPS in its role as LHC injector, and in electron-positron collider factories. Nonlinear damping of transverse beam oscillations in circular hadron accelerators and colliders was analysed by I.Ivanov and V.Melnikov (JINR). Nonlinear systems can provide a faster damping rate than linear ones.

The damping system proposed for the LHC beams was introduced by T. Linnecar (CERN). V.Danilov and E. Perevedentsev (Novosibirsk) reported on reactive feedback against mode coupling instability, while specialized discussions covered damping of injection oscillations, damping with digital filters, coherent bunch signals at very high frequencies, emittance growth due to noise, and impedances imposed by the feedback system.

Combining cooling and damping in one workshop was very fruitful: stochastic cooling and active damping use similar techniques and all modern cooling rings need dampers to stabilize the high density beams.

The next cooling/damping workshop, in about two years, could be in Denmark. Participants agreed that holding the workshop on board a ship was a great idea. Besides cooling and damping, with the workshop taking place between the 1st and 2nd rounds of the presidential election, participants eagerly followed political developments. The feelings of many colleagues were expressed in Nobel Laureate Simon van der Meer's toast - "For Russia!".

On behalf of the organizing committee, scientific secretary E.Syresin would like to thank all agencies which helped finance the workshop, especially the RFFR and RAS.

From E.Syresin and D. Möhl

ICFA Instrumentation Bulletin is back

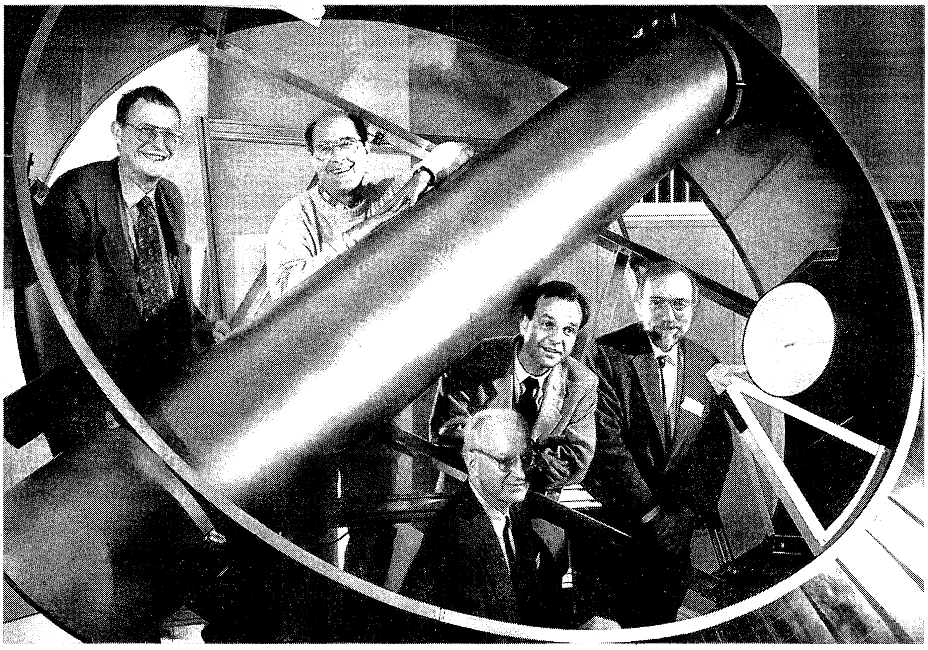
After a few years of absence, the valuable ICFA Instrumentation Bulletin is back; this time published on the Web: http://www.slac.stanford.edu/pubs/icfa/

The ICFA home page is also linked to the SLAC home page under "Newsletters." In principle, Web publishing will allow rapid publication of a paper. In addition, we plan to have a "question-and-answer" page to promote dialogue. After five or six articles have been posted on the Web, we will publish the Bulletin as a printed SLAC-PUB.

A "help" page is available on various publishing formats, as well as instructions on how to submit an article. Articles should be submitted in paper form and electronically (LaTeX files with Postscript figures, or an MS Word diskette).The Web format for the published articles will be postscript (PS) and portable document format (PDF). Authors should submit a brief abstract to give a short overview of the article.

The ICFA Instrumentation Bulletin is intended as a forum for those interested in generic instrumentation. Articles should be short (a few pages) and describe either a novel technique, or a previously unpublished measurement. We also intend to provide a platform for speculative ideas and not-yet-proven concepts. We also invite articles from industry on novel instrumentation techniques. Students, with encouragement from their professors, are especially welcome to contribute. Discouraged are "system" descriptions, or papers describing lengthy analysis or software concepts, which is already supported by a number of other

LISA, Laser Interferometry Space Antenna, is now listed among the 'Cornerstone Missions' of the European Space Agency's Horizons 2000 programme. At the first LISA symposium, held at the UK Rutherford Appleton Laboratory from 9-12 July, leading members of the LISA study team stand inside a actual size model of one of the spacecraft - left to right, top: P. Hough, Glasgow; B. Schutz, Cardiff and Potsdam; below: P. Bender, Colorado; K. Danzmann, Hanover; K. Thorne, Caltech.



periodicals and conferences. The Spring 1996 issue is already available on the Web, and printed as SLAC-PUB-7175.

The new editor is J. Va'vra. Please send contributions to him at Stanford Linear Accelerator Center, Bin 62, P.O. Box 4349, Stanford, CA 94309, USA, e-mail: JJV@slac.stanford.edu

SPACE Gravitational wave searches

Having discovered the carrier particles of almost all the fundamental forces of Nature, physicists aim to complement their investigations of the electroweak and inter-quark forces at work on and within atoms with a search for gravitational waves which transmit the force responsible for the large-scale structure of the Universe. In particular, these waves are sought in space, the only way to reach the low frequency band (10^{-4} - 1 Hz), to which terrestrial detectors are blind because of gravitational and thermal noise.

In this range, signals from compact binary stars in the Galaxy, and from very massive black holes, of up to a million solar masses and anywhere in the Universe, should be detectable with existing interferometry techniques.

LISA, Laser Interferometry Space Antenna, is now listed among the 'Cornerstone Missions' of the European Space Agency's Horizons 2000 programme. The first LISA symposium, held at the UK Rutherford Appleton Laboratory from 9-12 July, reviewed progress and outlined future plans for the mission, scheduled for the second decade of the next century.

CERN/RUSSIA Quantum jump in cooperation

The signing of a new protocol between CERN and Russia marks a considerable increase in joint collaboration and a further consolidation of ties dating back 30 years. As well as directly assisting construction of CERN's new LHC proton collider, the protocol, within the framework of the 1993 CERN-Russia Cooperation Agreement, and with Russia as a CERN Observer State, will provide valuable further stimulus for Russian high technology.

Covering Russian participation in LHC construction and the preparations for its research programme over a ten-year period, the protocol includes two separate in-kind contributions, each with net value to CERN of 67 million Swiss francs, for LHC construction and for the LHC detectors. In addition, a generous contribution from the Joint Institute for Nuclear Research (JINR) at Dubna, near Moscow, will be invested in LHC preparations.

This latest two-way development in CERN/Russian collaboration will be to the mutual advantage of both parties. It will boost the LHC effort en route to completion of the machine at its full design collision energy of 14 TeV. In addition, the increased scope and scale of this challenging work, together with its inherent complexity and sophistication, will provide impetus to Russian science and industry, and provide vital transfer of front-line technology and skills. With Russian involvement in CERN clearly labelled by the participating research institutes, this work provides valuable hands-on training for future team

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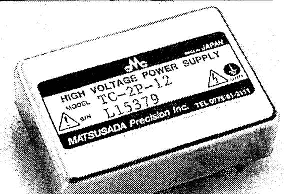

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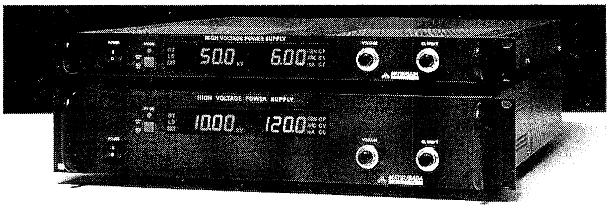

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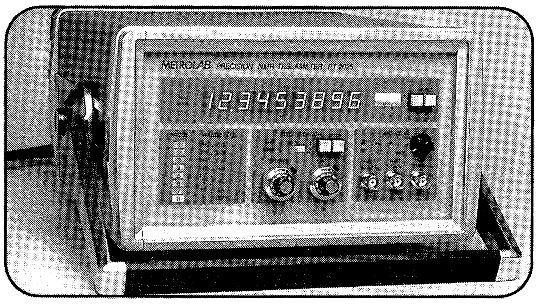

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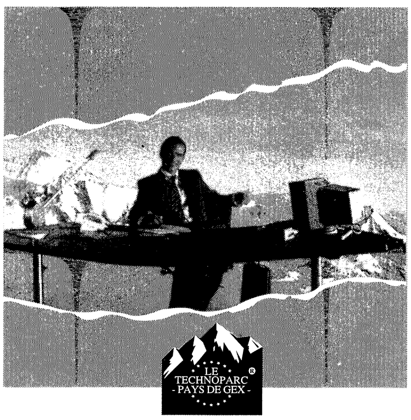
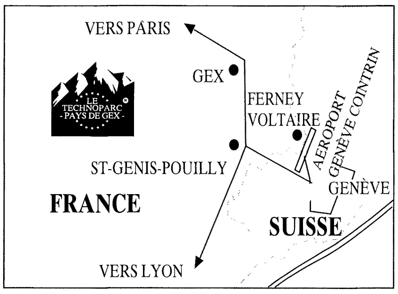




leaders and prevents the dispersion of valuable expertise and manpower.

The new collaboration will continue a tradition which began in 1967 with contributions of CERN equipment (notably for beam handling) and expertise to the 70 GeV proton synchrotron then under construction at Serpukhov, near Moscow. This machine, then the world's highest energy accelerator, was also the scene for joint CERN-USSR experiments, the first examples of such international partnership in physics.

In next development was USSR participation at CERN, notably in the experimental programme at CERN's new SPS proton synchrotron, where Russian institutes made substantial contributions to prestigious detectors, and where they continue to play an essential role in advanced experiments, including the Nomad and Chorus neutrino studies.

For CERN's LEP electron-positron collider, contributions to the experiments were scaled up to industrial proportions, with equipment and material for Delphi and L3 involving several factories as well as hundreds of people at major research institutes. For LEP's energy upgrade to LEP2, Russia provided electrical equipment for cryogenic plant and for power supplies as well as storage vessels for helium gas and distribution lines for liquid helium. All this work was a valuable focus for ongoing effort.

For the LHC, Russian research institutes have been active right across the range of research and development projects, preparing the way for all front-line LHC detectors. For the machine itself, Russian contributions could include magnets for transfer lines to feed the LHC with protons.

As well as the new protocol, additional contributions to LHC experiments could come through the International Science and Technology Centre - ISTC - the programme funded by the European Union, Japan, Russia and the US to promote the integration of former Soviet Union weapons scientists in fresh projects, and where six particle physics projects have already been approved.

This consolidation of Russian-CERN ties was highlighted at a meeting on Moscow on 8 July in which Science Minister Boris Saltykov explained his country's view of international and national priorities and the importance of spinoff developments from major investments. In this respect the new involvement with CERN is especially timely. For CERN, Research Director Lorenzo Foa looked back over the history and achievements of CERN-Russia collaboration and looked forward to its continued success and mutual benefits.

The consolidation of Russian-CERN ties was highlighted at a meeting on Moscow on 8 July with Russian Science Minister Boris Saltykov (seen here, left, on a 1993 visit to CERN and acompanied by CERN-Russia coordinator Lucien Montanet).

People and things

CERN Council

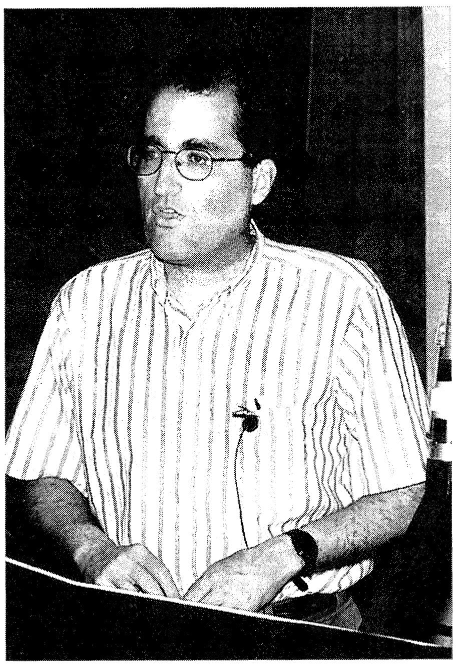
At the meeting of CERN's governing body, Council, in June, Director General Chris Llewellyn Smith reviewed progress for CERN's LHC proton collider, approved by Council in December 1994 as a two-stage project, beginning at an interim energy in 2004 and reaching its full design collision energy of 14 TeV in 2008. However with a full project review foreseen for 1997, the approval procedure had foreseen the possibility of reexamining the two-stage process and reverting to the original plan to go directly to 14 TeV if sufficient commitments to LHC were forthcoming from non-Member States.

A 5 billion yen contribution from Japan (September 1995, page 1) has been received and CERN-Japan relations are progressing well. Earlier this year, an agreement worth $12.5 million was signed with India (April, page 29). In June, a new agreement with Russia provides for contributions to the LHC machine and the detectors, each with net values of 67 million Swiss francs (see page 32), while ongoing discussions with Canada have provided an agreement with the TRIUMF Laboratory in Vancouver for an in-kind LHC contribution to the value of $30 million Canadian. Meanwhile negotiations with the US physics community, the largest single national LHC user group (April, page 29) continue. With such commitments and interest, it is hoped that the 1997 review will approve construction of the LHC as a single stage project to begin experiments at 14 TeV in 2005.

At its meeting, Council approved changes in CERN's divisional structure, effective from 1 January 1997. Romeo Perin becomes head of the new Supplies, Procurement and Logistics Division. Jurgen May succeeds David Williams as head of Computing and Networks Division, and Helmut Schönbacher succeeds Bas de Raad, soon to retire, as head of Technical Inspection and Safety Commission. Graham Ross of Oxford and Sakue Yamada of Tokyo's Institute for Nuclear Study were elected members of the Scientific Policy Committee for 3 years from 1 July.

New Argonne Director

As Argonne celebrates 50 years of scientific and technological achievement as the first US multipurpose national laboratory (June, page 18), Dean E. Eastman, world-renowned expert on the electronic properties of materials and spectroscopy and vice president of technical strategy and development reengineering, IBM Server Group, has been named director of Argonne, succeeding Alan Schriesheim. Prior to his current position, Eastman, 56, also served as IBM director of hardware development reengineering at corporate headquarters and as vice president of systems technology and science at IBM's research division.



Ed Witten of Princeton's Institute for Advanced Study was one of the main speakers at the second string duality workshop organized at CERN in June, following a fruitful first meeting last November. Many theorists are confident that these new directions in supersymmetry (October 1995, page 4) will soon lead to new insights.

DESY's Mr Klystron retires

Hermann Kumpfert, well known for his contributions to the design and development of klystrons for particle accelerators, at the age of 65 formally leaves his position at DESY.

In July 1959 he joined Willibald Jentschke's team building the original DESY 6 GeV (later attaining 7.4 GeV) electron synchrotron in Hamburg. Kumpfert organized and led the operation of this machine, which quickly reached its design parameters. This synchrotron went on to become part of the injection system of the successful series of accelerators - DORIS, PETRA and HERA. For the PETRA electron-positron ring, Hermann Kumpfert organized, in close collaboration with industry, the production of a powerful klystron, the 500 MHz "YK 1300" with a cw output power of 500 kW, subsequently improved to reach 800 kW (the "YK 1304") and used all over the world.

Klystron expert Hermann Kumpfert has retired at DESY.

Distinguished nuclear physicist Carl Dover died on 4 June.

From 1979 Kumpfert became deputy to the Director of DESY's Accelerator Division. His extraordinary abilities as an organizer were much appreciated by Division Leader Gus Voss and later Dieter Trines. His particularly delicate reorganization for the operation of the PETRA ring facilitated the very successful 1978 - 86 experimental runs.

In 1984 the Accelerator Division assumed responsibility for construction of the HERA electron ring, the injection channels for HERA, the modification of PETRA as injector and all civil engineering work for HERA (a separate group was in charge of the superconducting proton ring). Besides his klystron skills, Kumpfert demonstrated again his qualities as manager and organizer. Project control for both PETRA and HERA, in particular the financial aspects, were to a major degree his responsibility.

Finally he became involved in DESY's future plans, contributing to the new linear accelerator projects, developing a unique low-cost pulsed 150 MW S-band klystron and a switching modulator tube, and building industrial collaboration for the development and construction of further 150 MW klystrons.

Hermann Kumpfert can still be reached at DESY address and is willing to continue assisting his colleagues and industrial partners. His official position at DESY was taken over in April by Reinhold Kose.

Carl Dover

Distinguished nuclear physicist Carl Dover died on 4 June of brain cancer at the age of 55. Born in Milwaukee, he studied at MIT, with a doctoral thesis on meson-nucleon systems. After three years in Europe exploring nuclear reaction theory, he came to Brookhaven in 1971, eventually becoming head of the Nuclear Theory Group. He was also an Adjunct Professor at both Yale and the State University of New York at Stony Brook.

Dover was a world authority on physics at the intersection of the nuclear and particle domains and had a profound impact on hadronic research. A much sought-after speaker, his more than 100 invited talks exerted considerable influence. A typical Dover talk covered a synthesis of previous work, identification of open problems, and original calculations directed towards new experiments. In 1977 he began a lifelong collaboration with Avraham Gal, highlighted by an analysis of the first Brookhaven experiment on kaon reactions with carbon 12. From the early 1980s more Brookhaven theorists joined Dover and Gal in studying hypernuclear problems. The identification of lambda orbits over a wide range of mass number, elegantly described by Millener, Dover and Gal, and confirmed at Brookhaven and KEK, provides perhaps the best example of single-particle structure in nuclear physics. As well as hypernuclei, dibaryon production, searches for strangelets and nucleon-antinucleon interactions also benefited from his attention, the latter having a strong influence on work at LEAR.

His wisdom was sought by influential committees and his achievements acknowledged by numerous awards. In addition to his considerable impact on physics, Carl projected a sense that life was worth living, that all problems had a solution, and that he frequently wished to be a part of the solution. In a remarkable effort during his extended illness, he gave several invited talks and continued to

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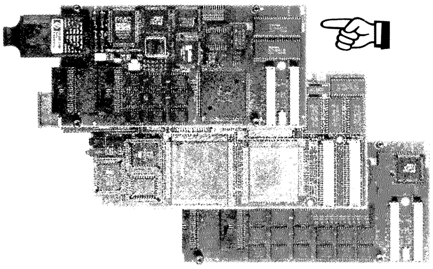

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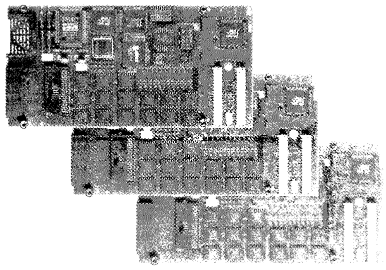

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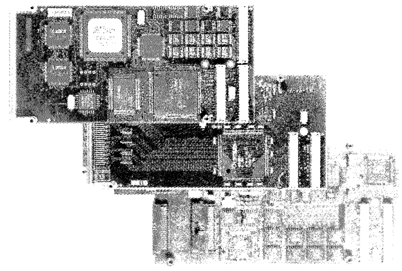

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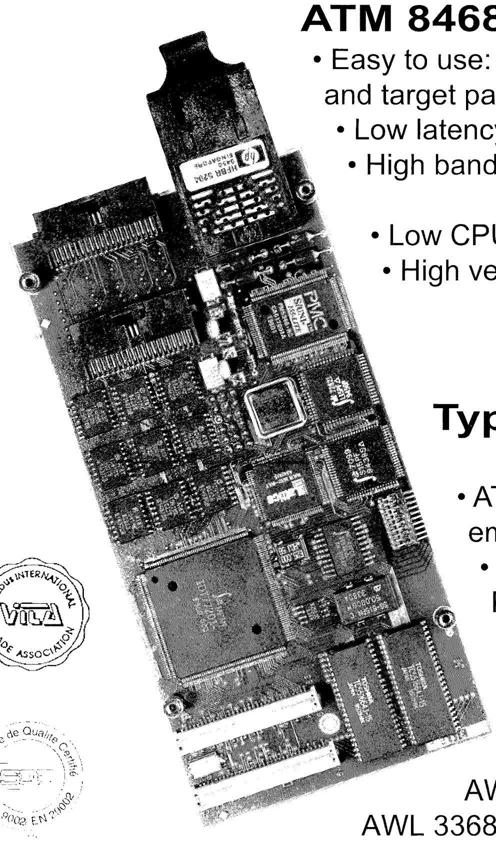

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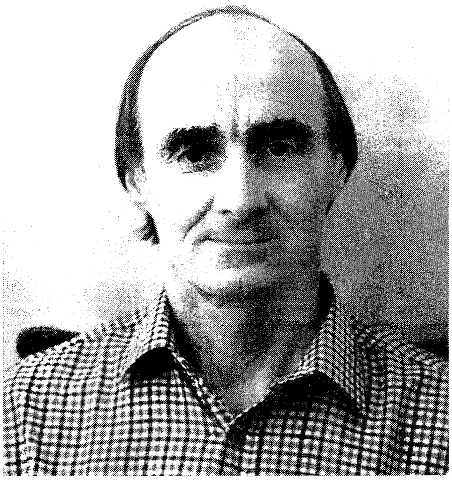
Euan James Squires 1933 - 1996



On 28-29 May a Slovak delegation led by National Academy of Sciences Chairman Stefan Luby (left) and Vice-Chairman Dalibor Krupa (background) and including Peter Mederley of Comenius University, Bratislava, visited CERN. Here Emanuele Quercigh shows them some of the new heavy ion results (July/August, page 1). At CERN, Slovakian physicists are active in the Delphi experiment at LEP and in the heavy ion programme, as well as preparing for research at the LHC.

influence the development of nuclear physics. His enthusiasm for physics and his cheerfulness will be sorely missed, at Brookhaven and in the international community.

From P.D. Bond, S.H. Kahana, D.J. Millener

Euan James Squires 1933 - 1996

Distinguished UK theorist Euan Squires collapsed and died on June 6 while playing cricket, just nine days short of his 63rd birthday. After graduating from Manchester in 1956 and after postdoctoral fellowships at Harwell and Cambridge, a year at Berkeley and a two-year period as lecturer at Edinburgh, he was appointed to the Chair in Applied Mathematics at Durham in 1964 at the age of 31.

Coming from Geoffrey Chew's flourishing school at Berkeley, his principal research interest at that time was in Regge pole theory. Among other contributions to the field he wrote what has become the standard reference book Regge Poles and Particle Physics *(Springer Verlag) with Peter Collins. Although he spent most of his career teaching, researching and frequently administrating (he was department head at the time of his death) in the Department of Mathematical Sciences, Euan remained a physicist at heart. He fostered cooperation with theorists in the physics department, through the establishment of joint seminars, the creation of joint appointments and scientific collaboration, as for example, in the recent textbook* Particle Theory and Cosmology *(Wiley) with Alan Martin and Peter Collins.*

Durham's Centre for Particle Theory, comprising theorists from both departments, is now the largest single group of particle theorists in the UK, due mainly to Euan's endeavours. In later years, like many ex-Regge pole theorists, he became interested in fundamental issues of measurement and quantum mechanics, where he was much influenced by his friend John Bell, with whom he had published papers at Harwell. He organized several encounters between physicists and philosophers, and wrote three non-technical books, the last of which, Conscious Mind in The Physical World, *(Adam Hilger) reveals a long standing philosophical interest.*

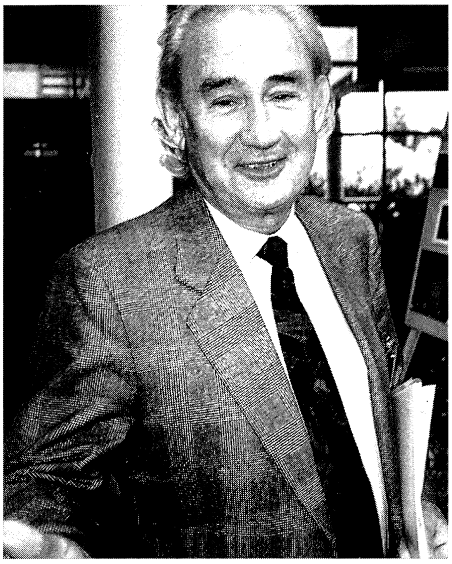
Euan Squires was an extremely energetic man whose interest in athletics and hill-walking spawned two annual departmental events. In addition, he was a very active member of the Baptist Church in Durham. He was always willing to listen to a problem, whether personal or scientific, and in large measure was responsible for the lively, friendly atmosphere at Durham. In all these activities he will be greatly missed.

From David B. Fairlie, Department of Mathematical Sciences, Durham

Clyde Wiegand 1915-1996

Former Berkeley physicist Clyde Wiegand died on 5 July. He was best known as a key member of the team

Marcel Vivargent, founder of the Laboratory of Particle Physics at Annecy (LAPP), France, which proudly celebrated its 20th anniversary this summer (see cover photo).



From Marx to quarks. An exhibition 'From quark to cosmos' at Berlin's Humboldt University from 10 June - 6 July organized by the University and by CERN attracted some 15,000 visitors . The quotation by Karl Marx on the stairway reads 'Die Philosophen haben die Welt nur verschieden interpretiert, es kommt aber darauf an sie zu verändern' - 'Philosophers have interpreted the world differently, the important thing now is to change it'.

(with Owen Chamberlain, Emilio Segrè, and Tom Ypsilantis) which discovered the antiproton at the then new Berkeley Bevatron in 1955, for which Chamberlain and Segrè received the 1959 Nobel Prize. Becoming a graduate student in Segrè's Berkeley research group in 1941, Wiegand later moved with Segrè to Los Alamos for wartime work, and completed his Berkeley doctorate in 1950. He spent the remainder of his research career at Berkeley, working on detectors for particle physics experiment and for use in spacecraft. Wiegand was an old friend of CERN. In 1957 Cornelis Bakker invited him to the new Laboratory to help in the preparations for the programme in electronic detectors, where his outstanding capabilities and experience proved to be of great value.

Siegfried Wouthuysen

Distinguished Dutch theorist Siegfried Wouthuysen died on 9 July. A tribute will appear in the next issue.

LAPP of honour

This summer the Laboratory of Particle Physics at Annecy (LAPP), France, proudly celebrated its 20th anniversary. Founded by Marcel Vivargent as a new French research centre to exploit the proximity of CERN and to tap the academic and industrial potential of Savoy, LAPP has gone on to make significant contributions to important experiments, both at CERN and elsewhere. LAPP's initial flagship at CERN was the UA1 experiment at the proton-antiproton collider, with current major investments in both the Aleph and L3 collaborations at the LEP electron-positron collider as well as the Nomad neutrino experiment. For L3, LAPP played a major role in developing the technology for the BGO crystals used in the experiment's electromagnetic calorimeter. For the future, LAPP has a stake in both the Atlas and CMS major detectors for CERN's LHC proton collider.

JINR Dubna

While visiting Yerevan (Armenia) in June, V.G.Kadyshevsky, Director of the Joint Institute for Nuclear Research (JINR), Dubna, and Vice-Director A.N.Sissakian were received by Armenian President L.Ter-Petrossian. They discussed participation of Armenian scientists in the research programme of JINR (of which Armenia is a member state) as well as ways of using to the fullest possible degree the scientific potential of this country in the domain of nuclear and particle physics studies. Touching upon the ongoing cooperation of JINR with CERN, in which Armenian physicists are involved, the President noted that this cooperation is progressive and serves as a rapprochement of peoples of different countries.

On 2 March 1997, the Joint Institute for Nuclear Research Dubna, will award the G.N.Flerov Prize for outstanding research in nuclear physics. The contest is for individual participants only, and contenders

Distinguished Greek theorist Dimitri Nanopoulos of Texas A and M University, a frequent visitor to CERN's Theory Division and well known for his contributions to supersymmetry, was recently presented with Greece's prestigious Medal of the Order of Honour.

Lecturers and students at this year's Joint Universities Accelerator School, organized jointly by the European Scientific Institute and the CERN Accelerator School, with the support of 'CLUSTER' a consortium of 11 Universities of Science and Technology within the framework of the European Union, at the French Geneva Campus in Archamps. Two courses are offered early in 1997 - Accelerator Physics and Accelerator Technologies.

should send a brief abstract of their research on a particular subject, if possible enclosing copies of major publications, to be received not later than January 31, 1997 to: Dr.B.I.Pustylnik Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia; Tel.: (7 095) 924 39 14; Fax: (7 096 21) 65083, E-mail: oyuts@ljar9jinr.dubna.su

Meetings

The 2nd. International Symposium on Symmetries in Subatomic Physics to be held at the University of Washington, Seattle, WA, USA from June 25-28, 1997. Contact Ernest Henley, e-mail Henley@phys.washington.edu or Physics, Box 351560,University of Washington, Seattle, WA 98195-1560, USA.

A Workshop on Special Functions and Differential Equations will be held from 13 - 24 January 1997 at the Institute of Mathematical Science, Madras, India. Information from: Professor K. Srinivasa Rao, e-mail rao@imsc.ernet.in or the Workshop Convener, e-mail: wssf97@imsc.ernet.in Institute of Mathematical Sciences
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Joint Universities Accelerator School

The Joint Universities Accelerator School at Archamps (France, near Geneva) announces two courses for 1997: Accelerator Physics from 13 January - 14 February, and Accelerator Technologies 17 February - 21 March 1997.

Applications and scholarship requests should be sent as soon as possible to the JUAS Coordinator: Dr M. Rey-Campagnolle, e-mail: juas@wwwjuas.cern.ch Fax: +41 22 7850314 Phone: +41 22 76 75734

Each course includes about 100 hours of lectures, tutorials, seminars and visits to nearby installations in CERN, ESRF and PSI and is completed by an examination (optional) giving credits that a European student may use in his/her home university (ECTS). More information is available at http://wwwjuas.cern.ch/juas/

The Joint Universities Accelerator School, organized jointly by the European Scientific Institute and the CERN Accelerator School, with the support of 'CLUSTER' a consortium of 11 Universities of Science and Technology within the framework of the European Union, has taken place every year since 1994 from January to March at the French Geneva Campus in Archamps. The aim is to provide comprehensive background learning in accelerator physics and associated technologies. It is intended for graduate students in physics or engineering, from all universities in Europe, with no preliminary knowledge on accelerators. It also addresses professionals on continuing training programmes - the schedule is organized to make possible part-time attendance. Lecturers are from CERN, ESRF (Grenoble), PSI (Villigen) and other laboratories in Europe.

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To formally apply for one of these positions, please send resume (indicating Reference #) to: Staffing, Reference #, Los Alamos National Laboratory, MS 286, Los Alamos, NM 87545. Affirmative Action/Equal Opportunity Employer. Individuals with disabilities needing reasonable accommodation should call (505) 667-8622. A Teletype Device for the Deaf (TDD) is available by calling (505) 665-5357. Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy.

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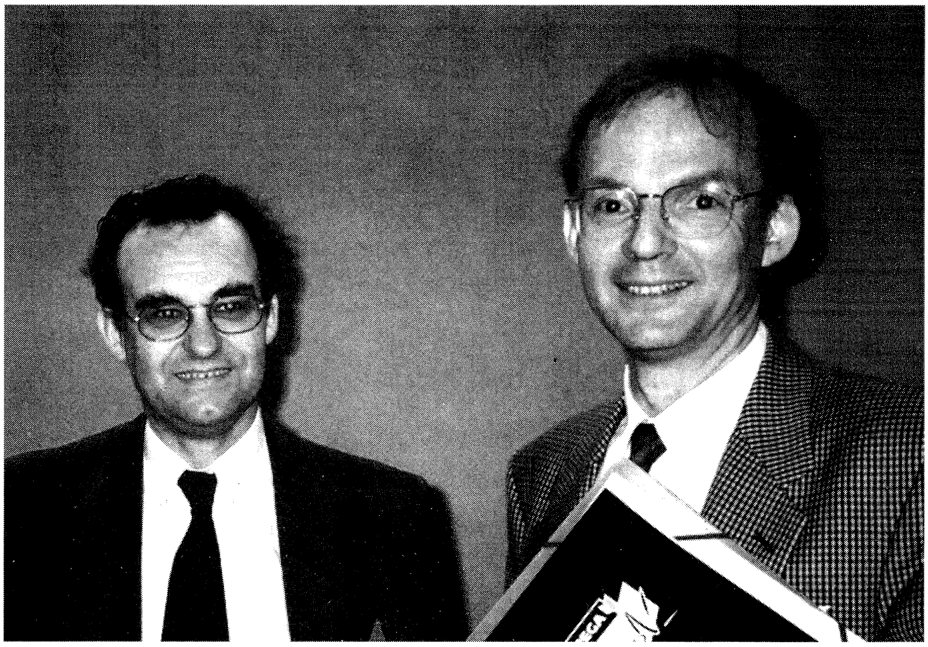
FACULTY POSITIONS IN PHYSICS
University of California, Berkeley

The Physics Department of the University of California, Berkeley intends to make at least two faculty appointments effective July 1, 1997. Candidates from all fields of physics are encouraged to apply. Appointments at both tenure-track assistant professor and tenured levels will be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to **Professor Roger W. Falcone, Chairman, Department of Physics, 366 LeConte Hall #7300, University of California, Berkeley, CA 94720-7300,** by Monday, November 25, 1996. E-mail applications will not be accepted. Applications submitted after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

Tenure Track Assistant Professor Position State University of New York at Stony Brook

The Department of Physics seeks applications for a tenure-track Assistant Professor position in high energy physics, to be filled by September 1, 1997. Stony Brook works on the DØ experiment at the Fermilab, SuperKamiokande, and the CMS experiment at the LHC. The successful candidate is expected to play a strong role in the DØ experiment at the Tevatron which is now approved for a major upgrade, to be completed in 1999, and to teach at the undergraduate or graduate level, and to supervise doctoral research. Applications, including a complete resume and the names of five referees, should be sent to Professor Peter Paul, Department of Physics, State University of New York, Stony Brook, NY 11794-3800. (Fax: (516) 632-8176; E-Mail: PETER.PAUL@SUNYSB.EDU). Stony Brook encourages applications from minority and women candidates.



On 5-7 June, a symposium 'The Mathematical Beauty of Physics' was held at Saclay in honour of the distinguished French theorist Claude Itzykson who died on 22 May 1995. Seen here are two of Itzykson's co-authors - right, Jean-Bernard Zuber of 'Quantum Field Theory', and Jean-Michel Drouffe of 'Théorie statistique des champs'.

CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to cern.courier@cern.ch

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

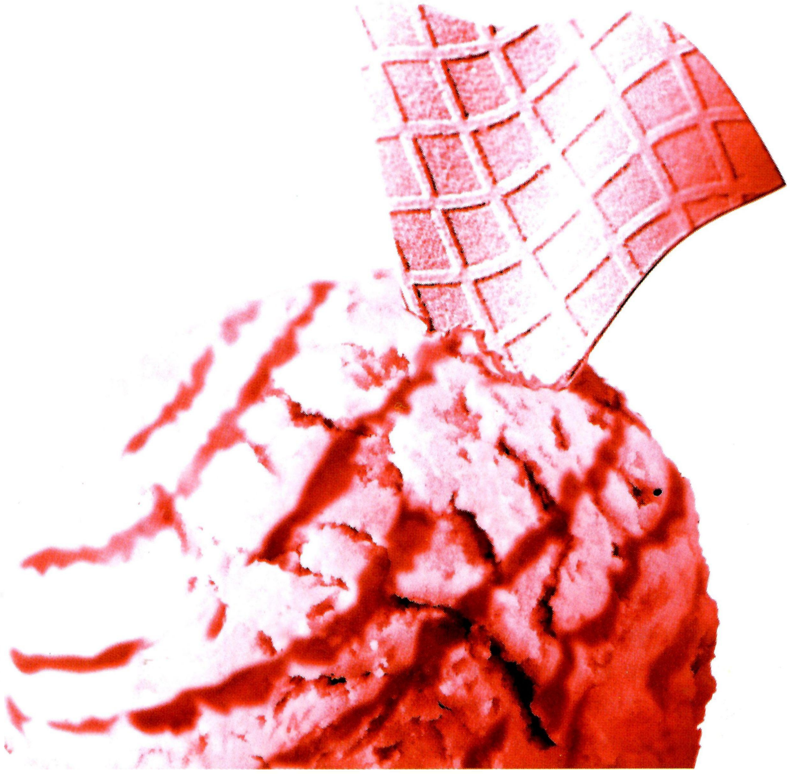
Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

Never mind the weak interactions, here's the LHCs! The 7th CERN Ha(r)dronic Festival on 19 - 20 July attracted more than a thousand people for the long awaited return of the "Les Horribles Cernettes", seen here giving a first order effect.

Science and tourism in Beijing. Two symposia - 'Some rigorous results in particle physics' and 'Simplicity and complexity' - organized in Beijing this summer by T.D. Lee, H.C. Ren, W.C. Chao and S.Q. Feng attracted notable visitors including (left to right): Albert Libchaber of Rockefeller, well known for experiments on the approach to chaos and in the physics of biology; Pierre Hohenberg of Yale (dynamical systems and approach to chaos); Mrs. Mandelbrot; particle theorist Nicola Khuri of Rockefeller; Ms. Song; Mrs. Khuri; Mrs. Ren; Mrs. Feigenbaum; Mrs. Libchaber; fractal pioneer Benoit Mandelbrot of IBM; chaos pioneer Mitchell Feigenbaum of Rockefeller; Mrs. Hohenberg.

(Photo André Martin)

Hinter einem raffinierten Genussmittel...



Advertisements in CERN COURIER

Format A4 **Monthly publication**

All advertisements are published in both English and French editions. Second language versions accepted without extra charge.

Space (page)	Actual size (mm) width by height	Cost per insertion (Swiss Francs)			
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Closing date for positive films and copy .... 1st of month preceding cover date. The cost of making films and of translation for advertisements are charged in addition.

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These rates are effective for the year 1996.

Inquiries for Europe:

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Telephone: 022/767 41 03
Telefax: 022/782 19 06

Inquiries for the rest of the world:

please see page III

DESY

Applications are invited for the position of an

experimental physicist

The candidate is expected

- to take responsibility for a component of the **HERA-B** detector at the electron-proton accelerator HERA
- to participate in the data analysis
- to take a leading role in the research program of the **HERA-B** collaboration.

Applicants should have a PhD degree in physics, several years experience in experimental elementary particle physics and be active in the research in this field. They should have an established record in analysis of particle physics experiments and be able to coordinate the work in close collaboration with the physicists and technicians of the **HERA-B** experiment.
The appointment will be indefinit with a salary according to federal tarifs (BAT Ib, IIa depending on experience and ability).

Letters of application including C.V., list of publications and the names of three referees should be sent to the personnel department until 15. Oktober 1996.

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY
Notkestraße 85
D-22603 Hamburg
Tel.: +49-40-8998 3628

UNIVERSITÉ DE MONTRÉAL

Postdoctoral Position in Particle Physics

The Particle Physics Group at the Université de Montréal invites applications for a position at the postdoctoral level. The candidate is expected to contribute to the on-going research projects of the group in experimental high energy physics, which include OPAL at LEP, ATLAS at LHC and BABAR at PEP II. The appointment is for two years with a possibility of extension and the successful applicant will work primarily in Montréal.

Interested candidates should send curriculum vitae and three letters of reference to: Prof. Viktor Zacek, Département de Physique, Groupe de Physique des Particules, Université de Montréal, Case postale 6128, succ. centre-ville, Montréal (Quebec) H3C 3J7, Canada. Email: zacekv@lps.umontreal.ca

Applications will be accepted until Oct.31, or until the position is filled. *In accordance with immigration regulations, preference will be given to citizens or permanent residents of Canada.*

Research Scientist
Institute of Particle Physics

Applications are invited for a position as a Research Scientist with the Institute of Particle Physics of Canada (IPP). Candidates should preferably have three years of postdoctoral experience and a demonstrated record of accomplishment in experimental high energy particle physics. The Research Scientist appointment is associated with an academic position at a Canadian university and includes the right to hold research grants and to supervise graduate students. Such an appointment may lead to permanence after three years of employment.

The current program of IPP includes the following experiments: OPAL at LEP; ZEUS and HERMES at HERA; rare keon decays (E787) at Brookhaven; CDF at the Tovatron; ATLAS at the LHC; and BABAR at the SLAC B-factory.

The choice of experiment and university affiliation will be determined by mutual agreement between the candidate and the IPP.

Send curriculum vitae and the names of three referees for receipt before September 30, 1996 to:

R.K. Carnegie, Director
Institute of Particle Physics
Department of Physics
Carleton University
1125 Colonel By Drive
Ottawa, Ontario K1S 5B6
Canada
Fax: (613) 520-7548
E-mail: carnegie@physics.carleton.ca

In accordance with immigration regulations, preference will be given to citizens and permanent residents of Canada.

Max-Planck-Institut für Physik
Munich, Germany

Post Doc Position

The Max-Planck-Institute of Physics invites applications for a post doc position for the HERA-B experiment at DESY.

The HERA-B experiment is designed to study CP-violation in the B-system. The detector is under construction. The Max-Planck-Institute is involved in development and construction of the silicon-vertex-detector. The successful candidate is expected to contribute to all phases of detector construction and commissioning. Participation in the preparation of analysis software is also expected.

The contract will initially be limited to 2 years, with the possibility of extension up to five years. Candidates should have good knowledge of experimental high energy physics, and should hold a PhD or equivalent in physics. Interested applicants should submit a statement of research interests, a curriculum vitae, a list of publications, and arrange for letters of support from three referees. These items and a letter of application should be sent to:

Max-Planck-Institut für Physik
c./o. Mrs. Katja Harwat
Föhringer Ring 6
D-80805 München

Further information can be obtained from Dr. Iris Abt (EMail: isa@mppmu.mpg.de). Applications should be sent as soon as possible, at the latest 6 weeks after publication.

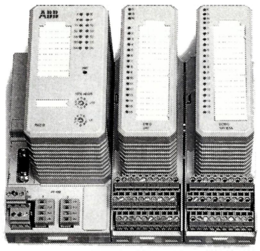
Laboratori Nazionali di Frascati dell'INFN
EU Postdoctoral Fellowships (TMR Programme)

We invite applications for postdoctoral fellowships (one to two years) in theoretical, experimental physics (high energy physics, astroparticle physics, nuclear physics, synchrotron radiation and gravitational wave detection), and accelerator physics at the Laboratori Nazionali di Frascati of INFN.
Applicants must be nationals of an EU member state (excluding Italy), or an associated state, age under 35 and have a PhD degree (or equivalent level of education) or 4 years' full-time research activities at post-graduate level. Furthermore the candidate should not have carried out research activities in Italy for more than 18 months in the last two years. More information on the TMR Programme are on the WWW page: http://www.cordis.lu/trur/home.html
The Laboratori Nazionali di Frascati is part of the Istituto Nazionale di Fisica Nucleare and is situated on a pleasant hill about 20 km south of the centre of Rome. It is reachable within 30 min from Rome by train or in 5 min from the town of Frascati. Some 150 researchers work in the Laboratory on the different activities. The 1 Ge V e+e machine DAΦNE (Phi factory) to study CP violation and hypernuclear physics is currently under commissioning.

More detailed information on the Laboratory activities can be obtained from the following contact persons:
Theory, F. Palumbo, tel. +39 6 94032887, palumbof@lnf.infn.it
H.E.P., P. Campana, tel. +39 6 94032898, campana@lnf.infn.it
Astrop.Phys., A. Marini, tel. +39 6 94032424, azm@lnf.infn.it
Nucl. Phys., N. Bianchi, tel. +39 6 94032320, bianchi@lnf. infn.it
Accel.Phys., M. Preger, tel. +39 6 94032272, preger@lnf.infn.it
Synchr.Rad., C.R. Natoli, tel. +39 6 94032881, natoli@lnf.infn.it
or on the www page (http://www.lnf.infn.it/).

Fellows will be employed under the EU's general conditions governing research training fellowships and will receive an allowance in ECUs per month to cover subsistence and mobility expenses, tax and social contributions and cost of attending conferences, travel expenses, etc... Global monthly allowance will be of about 3000 ECUs.
The selected candidates will be asked to apply to the next round of EU selection which has the closing date of 16 December1996. A letter of application (where the activity of interest must be specified) and a CV should be sent to: EU Fellowships Programme, Mrs. M. Cristina D'AMATO
Laboratori Nazionali dell'INFN, Via E. Fermi, 40 - 00044 Frascati (Italy)
tel. +39 6 94032373, fax: +39 6 94032475
E-mail: damato@lnf.infn.it
to arrive by 15 October 1996 for the participation at the December EU selection. Applicants should also arrange for two letters of recommendation to be sent at the above address by the same dates.

...steckt unsere raffinierte Prozesssteuerung.



Der Zwang zu immer höherer Produktivität steigt. Wie klein oder gross Ihr Betrieb auch ist, Ihre Infrastruktur muss sich jederzeit an den technischen Fortschritt anpassen können. Deshalb gibt es jetzt eine einfache Lösung, die das ermöglicht. Die noch mehr leistet und noch weniger kostet: Den neuen Advant® Controller 70, die kleine Prozessstation im Automatisierungs-System von Advant® OCS. Damit haben Sie auf nur 8,4 x 16,2 x 12,2 cm Ihren grossen Nutzen: Sie programmieren schneller. Und Sie arbeiten umweltgerechter, produktiver und qualitativ besser. Von Advant® OCS sind übrigens viele Unternehmen begeistert, vermutlich bald auch Sie. An der «Swiss Automation Week» zeigen wir Ihnen gerne mehr.

Advant® OCS an der «Swiss Automation Week» 17.–20. September 96

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European Synchrotron Radiation Facility

EUROPEAN SYNCHROTRON RADIATION FACILITY

Grenoble, France, the ESRF has constructed a state-of-the-art facility to produce and make use of synchrotron radiation for scientific research. This synchrotron radiation is extracted from a third generation storage ring currently delivering the highest level of brilliance in the world. The storage ring is fed by a booster synchrotron, itself fed by a pre-injector linac. The facility is operated 24 hours a day. In 1996, 22 ESRF beamlines are providing beams to the users, a number to go up to 30 by 1998. The ESRF will thus support scientists in the implementation of fundamental and applied research on the structure of condensed matter in fields such as Physics, Chemistry, Crystallography, Earth Science, Biology and Medicine, Surface and Materials Science. Financing of the ESRF is shared by twelve European countries.

The Machine Division was responsible for the original design, assembly and commissioning of the accelerator complex of the facility. Having entered into a second phase, it now operates and is developing the source. We are now seeking to recruit the (m/f)

Machine Director

The function: The Machine Director along with the Directors of Research and Administration reports directly to the Director General of the Institute. He/she is responsible for the operation and development of the complex of three accelerators (comprising the radiation source) and for a series of insertion devices and beamline front ends. He/she heads the Machine Division with responsibility for its annual budget (≃ 60 MFF in 1996 excluding personnel costs) and staffing plans. There are about 70 staff members in the Division, but the Director can also call on the technical assistance of the Technical Services and Computing Services Divisions.

Qualifications and Experience: The successful candidate will have proven managerial skills including the handling of finance and personnel. With regards to the machine as such, the main goal of the Division is to maintain the excellent performance and availability levels attained in operation; this will be a priority for the new Director. In terms of absolute performance, the machine has greatly surpassed the original target specifications with a routinely served brilliance 100 times higher than expected. Such a machine should always be outstanding and a series of upgrades are now being prepared for the medium term. The successful candidate will ideally have expertise in the field of operating a synchrotron light source, with experience at a third generation light source being highly appreciated.

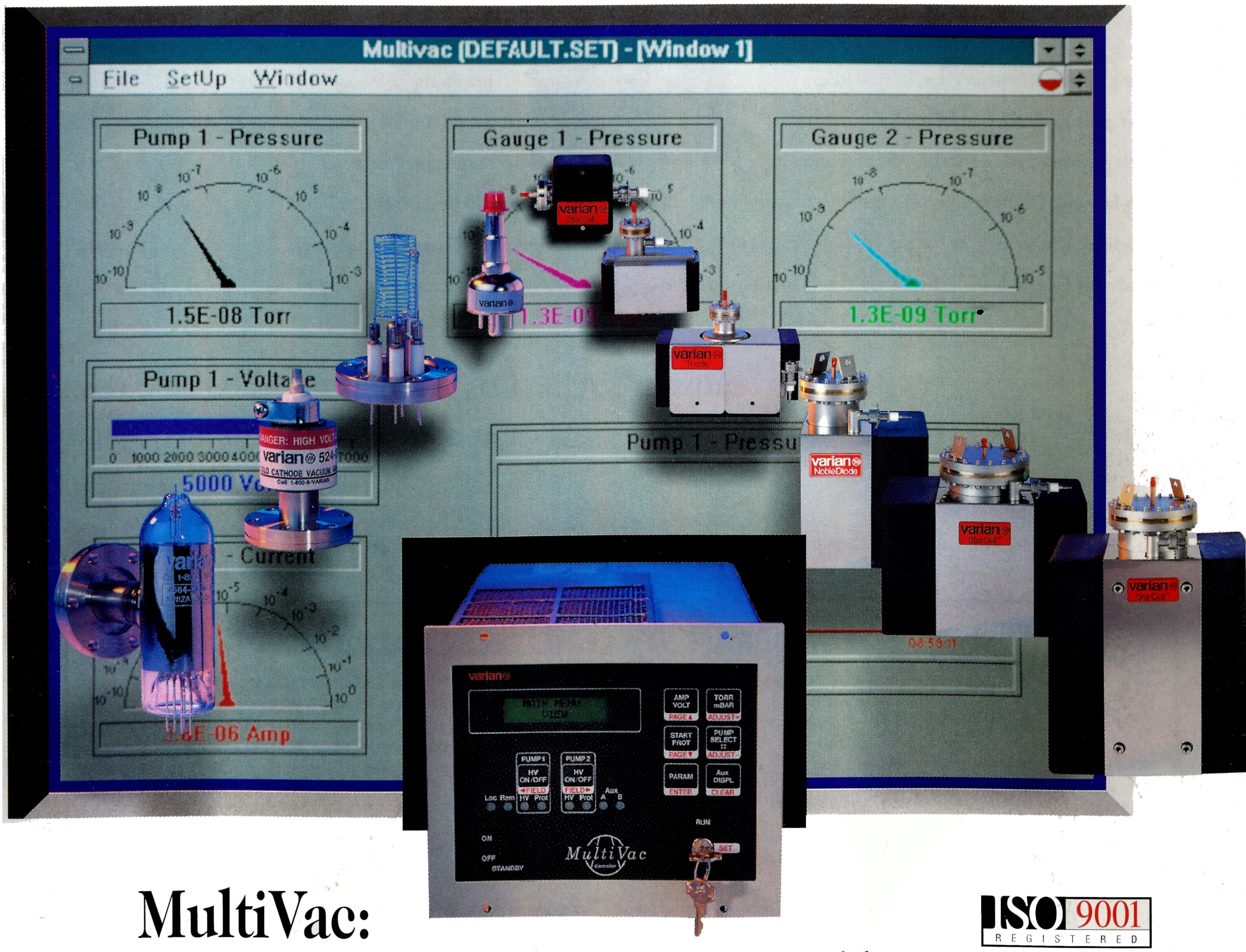
The working language at the ESRF is English. The initial contract will be for a five-year period.

If you are interested, please send your application by 15 September 1996 to the Chairman of the ESRF Council, B.P. 220, F-38043 Grenoble cedex 9, FRANCE.

in Grenoble FRANCE

UNIVERSAL COMMUNICATION

Take control over your ion pumping needs



MultiVac:
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Varian's MultiVac Controller operates up to two different ion pumps and two gauges, simultaneously and independently. So whether you need to operate a single pump, or have an application that demands multiple pumps, gauges, and computer control, MultiVac is the only controller you'll need.

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