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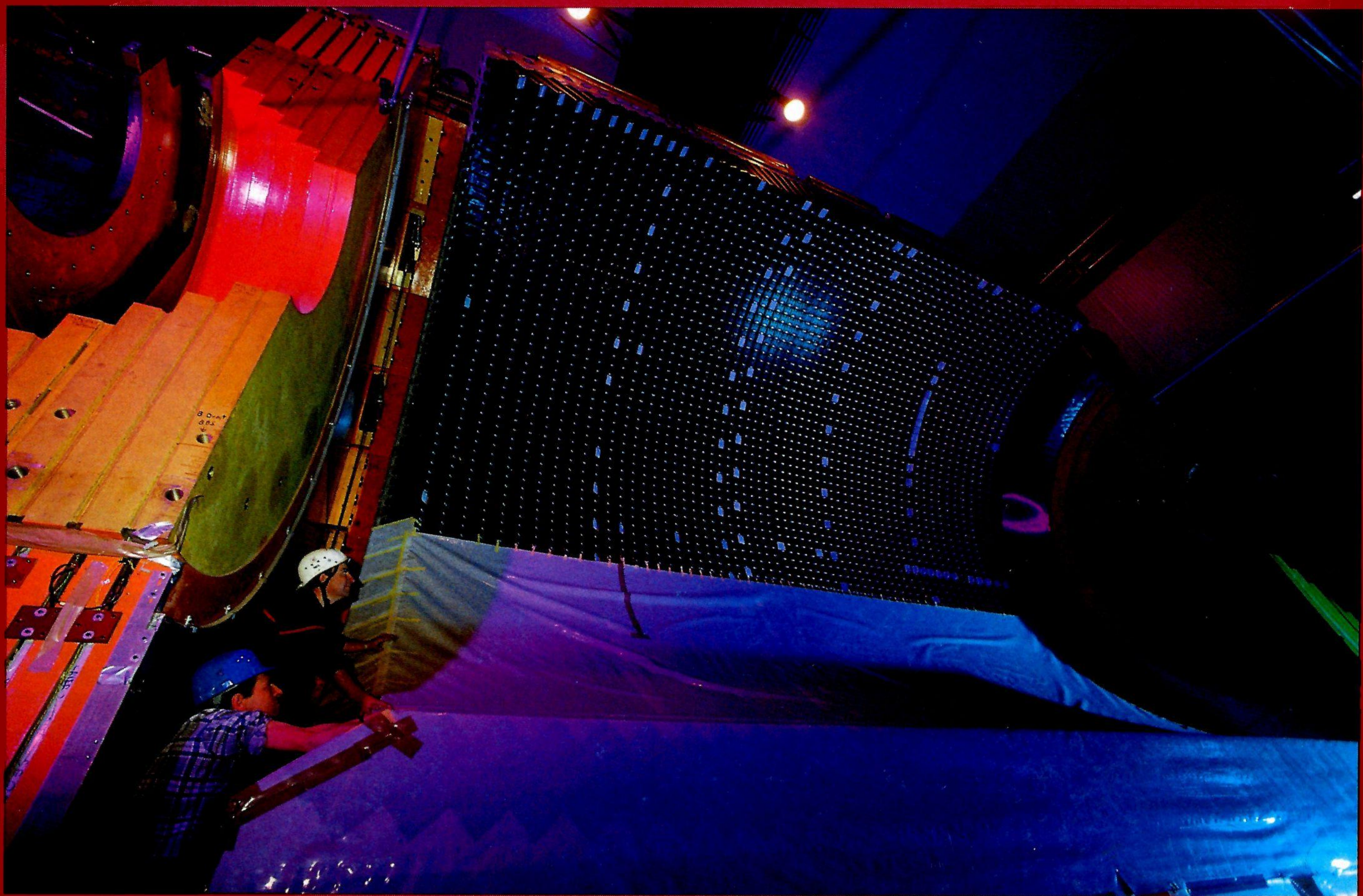

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Covering current developments in high energy physics and related fields worldwide

Cover photograph: The OPAL experiment at CERN's LEP electron-positron collider (Photo CERN EX 81-4-93 / 6).

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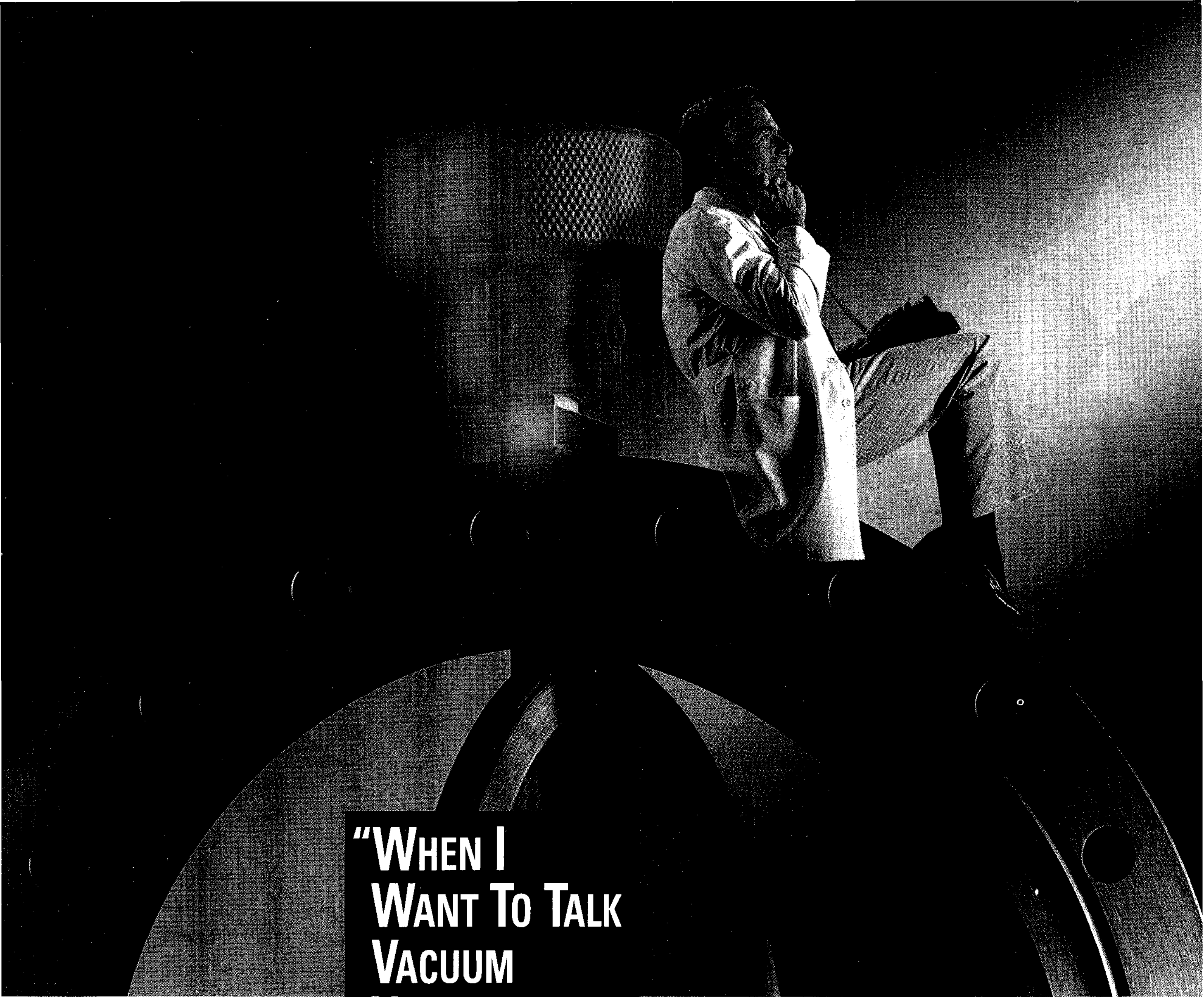
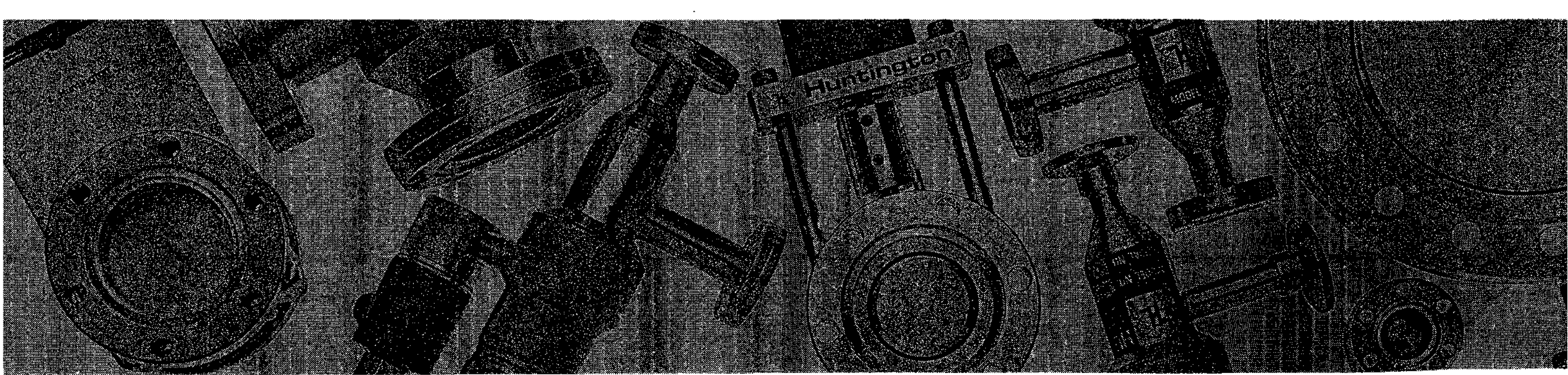




Around the Laboratories

SUPERCOLLIDER The vultures of summer

As the CERN Courier goes to press, the economic vultures are once more circling around the young Superconducting Supercollider lamb. On June 24, the US House of Representatives approved an amendment to stop the 87-kilometre SSC proton collider, now being constructed underground in Ellis County, Texas. With the Senate vote the next step, SSC proponents and opponents are getting their legislative acts together.

Last year, the summer Senate decision reversed an earlier anti-SSC House vote. However unlike last year, when the House vote was buried deep inside a major annual package of energy-related items, this year's motion was SSC-specific. The anti-SSC House vote was also larger: 280-150 as against 232-181 in 1992. Allegations of frivolous SSC expenditure forced US Energy Secretary Hazel O'Leary to don appropriate sackcloth and ashes, and Texas state funding - for long a major SSC pillar - has been deferred while Washington makes up its mind.

With the US preoccupied by its huge budget deficit, many sacrificial lambs are on the market. The SSC is not the only one. But whatever the outcome of this summer's US legislative wrangles, these painful rites will have left their mark. If the SSC is cancelled or delayed, enquiring young minds, eager to grapple with front-line research problems, will turn away from timescales measured in decades rather than years. The sudden evaporation of such a vast project will impoverish the world scene.

The doyen of fundamental physics, Victor Weisskopf, points to a recent shift in science emphasis. Once the fundamental research spotlight was firmly focused on 'cosmic' science - basic physics and astronomy. In the light of new awareness of environmental problems, the emphasis has switched to what he calls 'terrestrial science'. Here immediate applicability and rapid pay-off is the warcry.

This myopic trend is a pity. It is fundamental science which is at the roots of everything else, Weisskopf points out. 'Cut these roots and the whole tree will wither.' (We will return to this Weisskopf message in the next issue.)

In cancelling the SSC, the US may reduce its financial debt, but it will emerge a poorer nation culturally and intellectually.

The Editor

CERN TeV Electron-Positron Linear Collider Studies

The world's highest energy electron-positron collider - CERN's LEP, with a circumference of 27 kilometres - will also be the last such machine to be built as a storage ring.

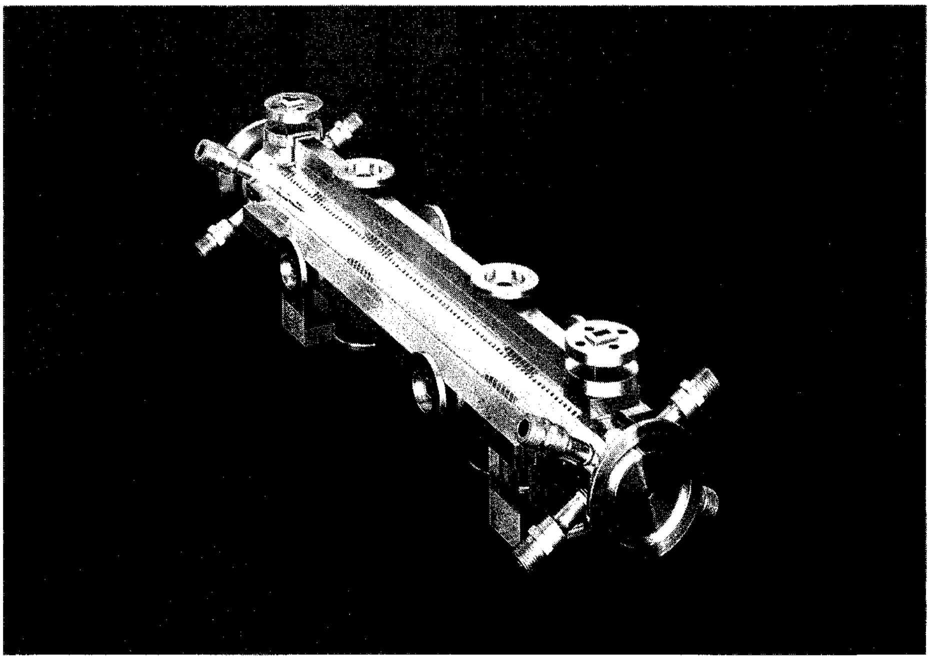
With interest growing in electron-positron physics at energies beyond those attainable at LEP, the next generation of electron-positron colliders must be linear if prohibitive synchrotron radiation power losses are to be avoided.

Very high energy linear colliders present many technical challenges but mastery of SLC at Stanford, the world's first electron-positron linear collider, is encouraging. The physics issues of a linear collider have been examined by the international community in ICFA workshops in Saariselka, Finland (September 1991) and most recently in Hawaii (April 1993). The emerging consensus is for a collider with an initial collision energy around 500 GeV, and which can be upgraded to over 1 TeV. A range of very different collider designs are being studied at Laboratories in Europe, the US, Japan and Russia.

Following the report of the 1987 CERN Long Range Planning Committee chaired by Carlo Rubbia, studies for a 2 TeV linear collider have progressed at CERN alongside work towards the Laboratory's initial objective - the LHC high energy proton-proton collider in the LEP tunnel.

The CERN Linear Collider (CLIC) study group, led by Wolfgang Schnell, has concentrated on a 30 GHz collider with a superconducting

Protoype accelerating section for the main linac of the CLIC scheme being studied at CERN.



drive linac power source. The high frequency allows the high accelerating gradient of 80 MV/m, resulting in a collider 2x4 km long for 500 GeV collision energy and 2x16 km long for 2 TeV. The drive linac power source eliminates the need for large numbers of klystrons, so most of the accelerator tunnel will be empty of active radiofrequency elements.

The design is technologically very ambitious, but with its fundamental simplicity has enormous potential for cost savings, as well as being particularly suited for TeV range energies. The dominant difficulty in a 30 GHz accelerator is however the degradation of the beams due to wakefields. Wakefields deflect the beams when there are misalignment of accelerator components, making the beams blow up. For this reason the CLIC study emphasizes beam dynamics, alignment and the development of very precise accelerator components. In fact CLIC accelerating sections need to be made to dimensional tolerances of a few microns.

A technique of manufacturing accelerating sections from brazed diamond machined discs has been developed at CERN and is now well established. The discs are diamond-tool machined in industry to tolerances of 1 to 2 microns by firms specializing in aspherical optical components. Two full-length, fully-engineered 86-cell prototype accelerating sections have been made, and 10 MW of 30 GHz power has been generated in the CLIC test facility (CTF) using one of the prototypes. The power corresponds to a gradient of 40 MV/m in the section, already half the nominal CLIC gradient.

In parallel, an 11.4 GHz accelerating section has been made using CLIC technology as part of a collaboration with KEK, Japan. This section has achieved 135 MV/m peak and 85 MV/m average accelerating gradients - values limited only by available power (January, page 32).

Accelerating sections must be installed and aligned to microns over tens of metres in the accelerator tunnel. To do this an active alignment system, measuring and compensating for tiny movements in real time, has been developed using accelerating sections and beam position monitors on silicon carbide girders connected through a system of link rods. The ends of the girders are moved by commercial 0.1 micron-resolution stepping motors, with alignment reference from a photodiode/lens/photodetector system. An alignment test facility in a disused beam transfer tunnel has demonstrated the micron capability of the alignment system, and a new 10 m long alignment test facility is under construction to demonstrate larger scale system behaviour.

Beam position in CLIC will be measured with sub-micron resolution and a few micron precision in resonant monitors fabricated using the same diamond machining technology as the accelerating sections.
A prototype beam position monitor (BPM) has been manufactured and tested in the lab using a small antenna scanned by micromovers. Sub-0.1-micron movements of an antenna have been resolved with this first prototype and measurements made to 3-micron precision.

Maximum physics with the accelerated beams from the two linacs means focusing the beams down to 8 by 90 nanometre spots where they collide head-on at the interaction point. A chromaticity-corrected final focus system also minimizing energy spread from synchrotron radiation in the focusing elements has been developed.

A major and unique CLIC feature is the drive beam power source which replaces the klystrons of more conventional designs. The drive beam travels parallel to the main beam about 1 metre away and

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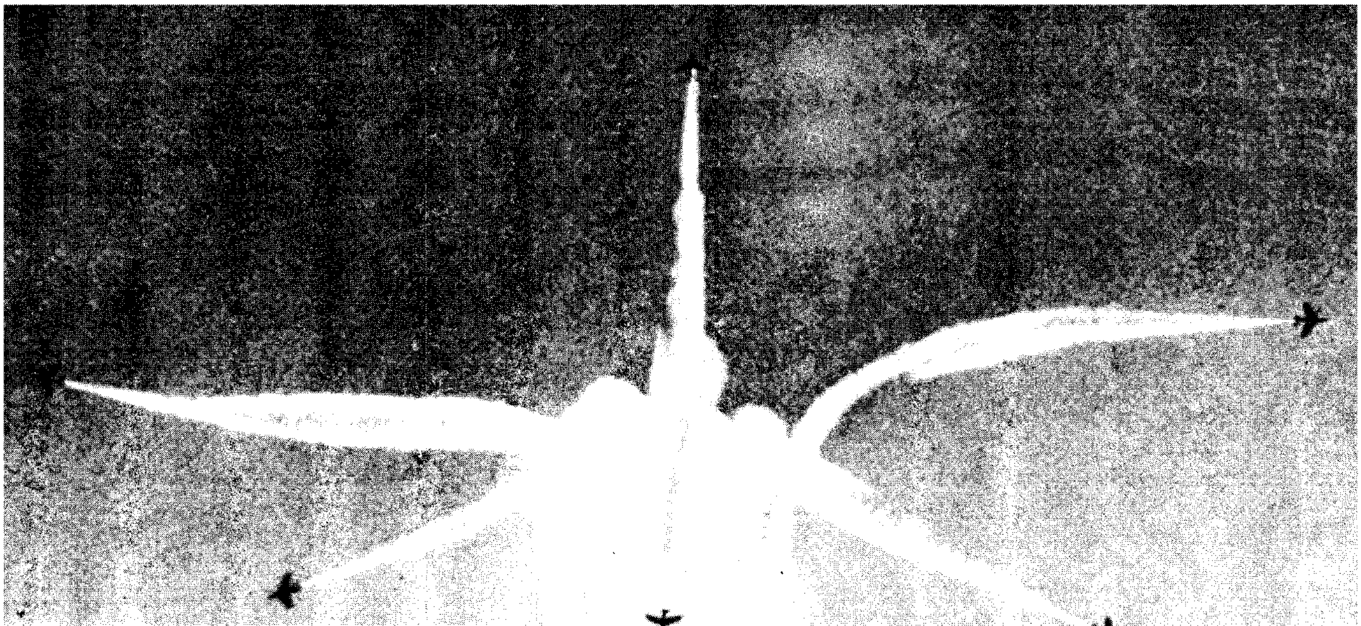

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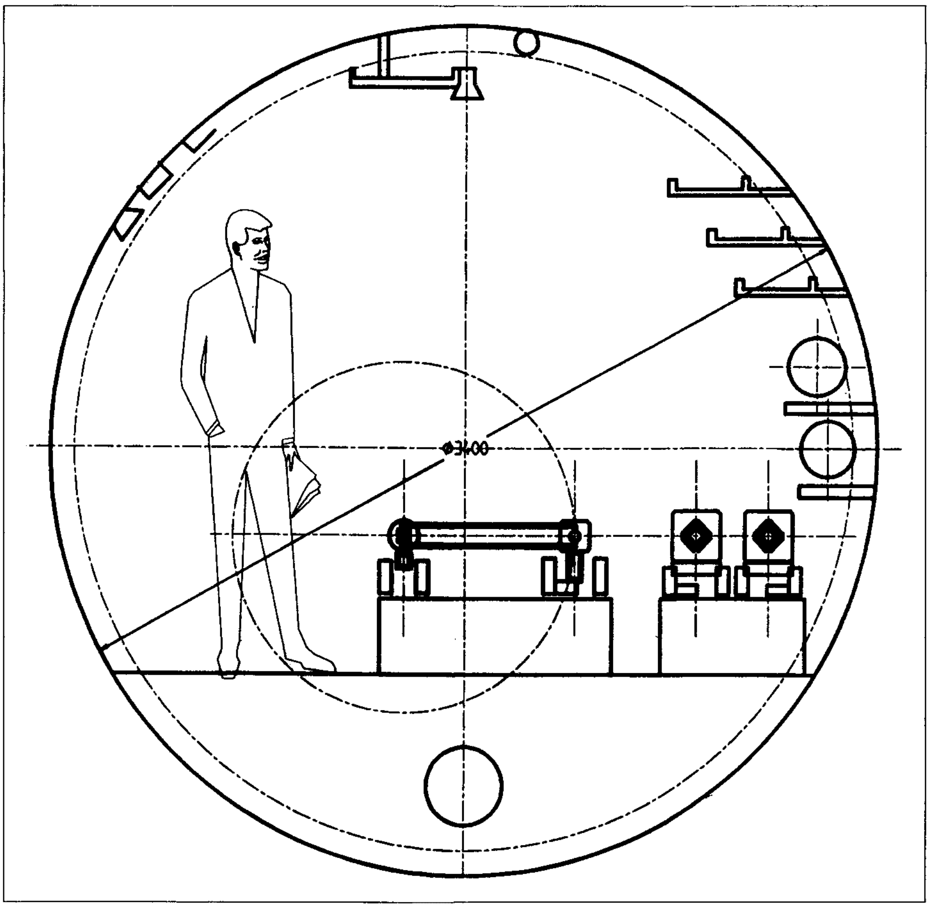
The CLIC tunnel cross-section. Left to right, the drive linac, connecting waveguides, the main linac, and then two transfer lines for drive and main linac injection. Compact technology gives the tunnel an uncluttered look.



30 GHz power is transferred in specially developed structures. The performance of the transfer structure has been verified by computer calculations and tested with stretched wire measurements in a 9 GHz scale model. A 30 GHz prototype is under construction.

The drive beam has a lower energy, an average of a few GeV, but higher current than the main beam, in a train of bunches spaced by 1 cm. Several possibilities of producing this drive beam are being looked at - laser-illuminated photocathodes in radiofrequency guns, an induction linac and a free electron laser, and conventional radiofrequency bunching with magnetic bunch compression.

The first method is being tested in the CTF. A train of short (15 psec) electron bunches generated using a radiofrequency gun with a laser-driven photocathode are accelerated to 60 MeV in a spare LEP injector linac accelerating section.

With demonstration of CLIC technical feasibility well underway, attention shifts towards cost projection. This will be accomplished with the test facilities and through detailed cost estimates of individual components, although the cost of many elements of a linear collider, like the tunnel itself, can be estimated from past experience.

By Walter Wünsch

More polarization in LEP

Handling spin-oriented (polarized) beams at CERN's LEP electron-positron collider has become an important physics goal and reflects the excellent progress being made in mastering the world's largest accelerator and colliding beam machine.

The electrons coasting round the 27-kilometre ring behave like tiny magnets and tend to line up with the machine's magnetic field. Working in the other direction are whole series of depolarizing resonances, strongly enhanced by the high LEP energy, which push the electron spin out of line.

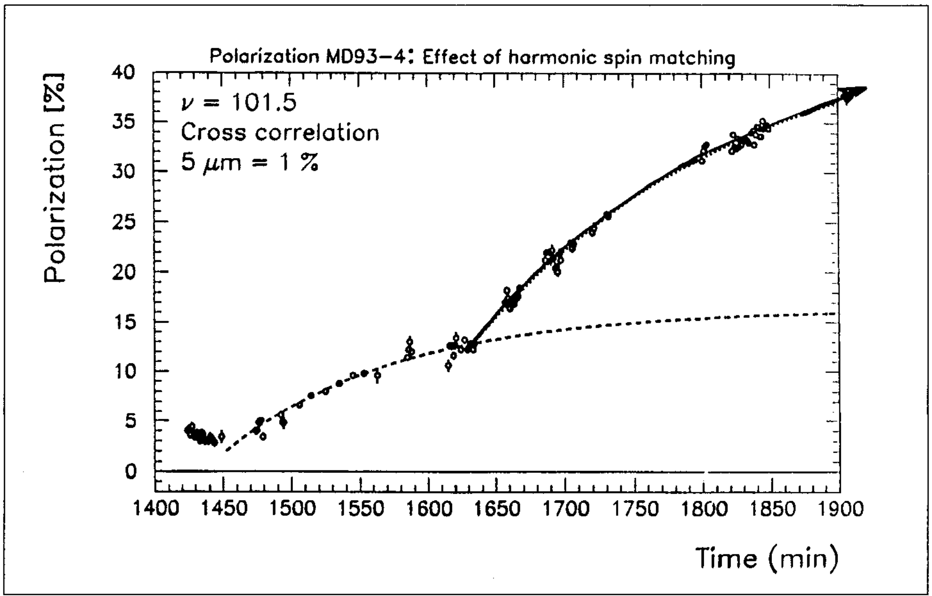
Initial studies in 1990 saw a LEP polarization level of around 10 per cent, a surprise to those pessimists who thought the effect would never be seen in LEP. In 1991, with polarization improved to 18 per cent, accurate energy calibration by resonant depolarization was on the cards.

After a lot of work in the 1992-3 winter shutdown, conditions in LEP this year are a 'dream'. Magnets have been realigned, the beam orbit monitoring (BOM) and the polarimeter upgraded, while the decision to go for a split 90/60 degree betatron phase advance in the arcs (after trying each phase advance separately) is paying off. The polarization level has increased to 35 per cent, with fitted asymptotic levels ranging from 40 to 50 per cent. Harmonic spin matching of a subset of the spin resonances allowed the asymptotic level to be pushed from a 'natural' 25 per cent to the high levels presently observed. It works by feeding in tiny perturbations to the closed orbit over some 7 per cent of the LEP circumference.

The successful compensation of the depolarizing effect of the experimental solenoids by a pattern of orbit bumps opens the possibility of energy calibration in physics conditions. LEP's beam energy can be fixed to a fraction of an MeV in 45 GeV, after correction for tiny effects due to earth tides and temperature. This is below the physics requirement of 1 to 2 MeV, leaving a safety margin.

These successful polarization and other machine studies have not detracted from the main physics business of LEP. Despite an abrupt 1993 commissioning with less chance to check everything out beforehand, the collision score and Z detection rate got off to a good start and continue to climb impressively, promising a bumper LEP harvest. On 1 August LEP's design luminosity of 1.3 x 10^{31} was exceeded in all four experiments simultaneously.

The payoff of artificially compensating for depolarizing resonances which would otherwise mar spin performance in CERN's LEP electron-positron storage ring.



CERN
Intensity records

On 28 July, CERN's veteran 28 GeV PS proton synchrotron (commissioned in 1959) attained a new record intensity with 2.703 x 10^{13} protons per pulse at 14 GeV. Its previous record, dating from 1959, was 2.57 x 10^{13}.

The record followed careful adjustments in the PS itself and in its Booster injector synchrotron. High intensity beams of about 2.5 x 10^{13} protons per pulse were sent to the SPS downstream as a rehearsal for next year's neutrino run. This allowed the SPS to obtain a new intensity record of 3.73 x 10^{13} protons per pulse at 450 GeV.

DESY
First physics from HERA

At the HERA collider at DESY, the dreams of electron-proton scattering experiments are becoming reality, with electron-proton collisions at an energy of about 300 GeV opening up new physics.

Information about the distribution of quarks, antiquarks and gluons inside the proton can now be obtained with a precision never attained before. But there are many other reactions which could provide surprises at these energies.

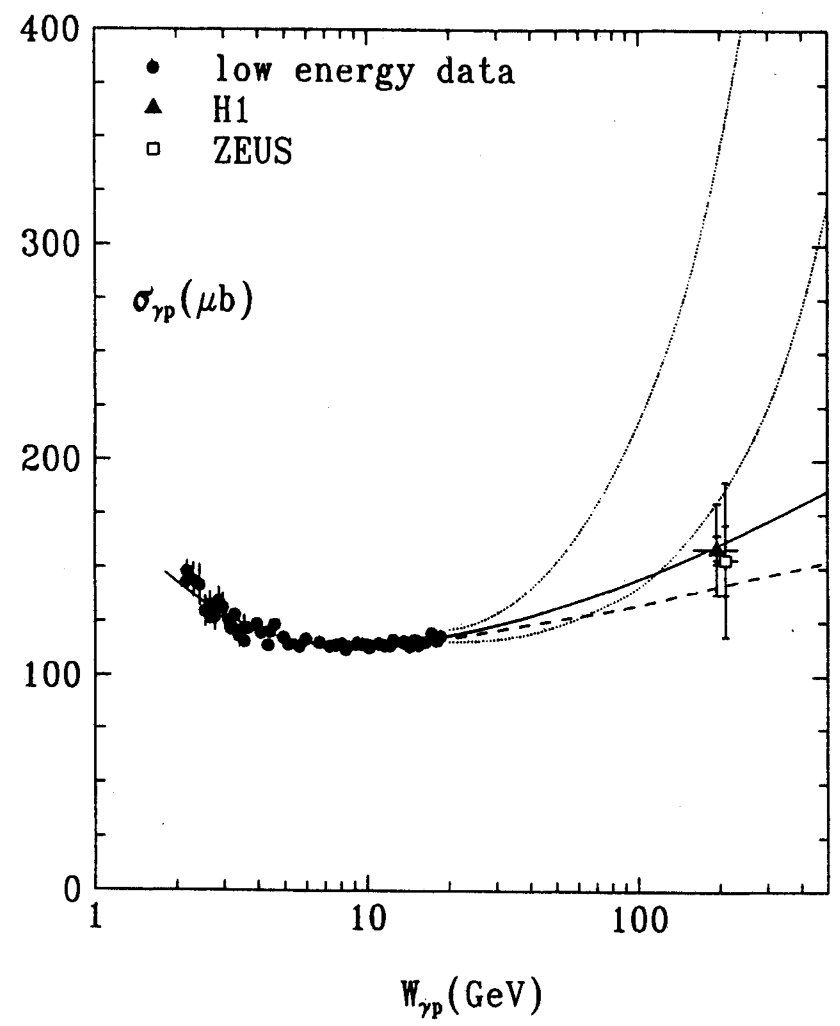
Collisions between HERA's 820 GeV protons and 26.7 GeV electrons started in June 1992. With a total of about 30 inverse nanobarns of integrated luminosity collected up to the winter shut-down (November 1992), the H1 and ZEUS experiments published results which gave a foretaste of things to come.

As most electron-proton interactions take place through the exchange of a photon, this was the first reaction to be studied. When the scattered electron emerges at a very small angle, the mass of the exchanged virtual photon is close to zero and the photon nearly real.

This opens up the study of photon-proton collisions at energies in the region of 200 GeV. The total cross-section for these reactions previously known up to 18 GeV collision energy was 118 microbarn, and was predicted to rise with energy.

From data taken in the first few weeks, the H1 and ZEUS collaborations determined this cross-section to be about 160 microbarn at a mean energy of 200 GeV. This is in excellent agreement with extrapolations

Total cross-section for photon-proton scattering at a mean energy of 200 GeV (right), as measured at DESY's HERA electron-proton collider, including lower energy data from previous experiments. This is in excellent agreement with extrapolations and excludes extreme models which predicted a dramatic rise (dotted line).



and excludes extreme models which predicted a dramatic rise.

The violent quark/gluon interactions deep inside the proton (deep inelastic scattering) give one of the best quantitative tests of quark field theory (quantum chromodynamics - QCD). At HERA several new kinematic regions of the electron-parton interaction open up. They extend to much smaller values of the fraction of momentum carried by the struck quark/parton (Bjorken x) and to very high values of the momentum transfer (Q^2).

An example of such studies is the quark/gluon structure (F_2 structure function) for fixed Q^2 (15 GeV^2) down to values of x of a few times 10^{-4}, about 100 times smaller than previously attainable. In this new region the QCD equations are expected to go beyond the usual 'leading log' approximation. QCD is probed here at the frontier between the well-known perturbative and the almost unknown non-perturbative domains. Preliminary plots suggest a rise of the structure function in this small x range.

Another interesting result is multi-jet production in deep inelastic scattering, where the known characteristics and rates cannot be accounted for by the simple quark/parton model process but are well described if higher order QCD contributions are included.

With increased statistics, isolation of individual QCD processes should become feasible.

Measurements will continue in the improved conditions expected for the next runs, beginning this summer. Meanwhile interest is growing in a subset of HERA collisions recorded last year in which proton-related secondaries escape at narrow angles and disappear down the beam pipe. At wider angles, activity is only seen on the side of the emerging electron.

A wide gap

In the collisions of 820 GeV protons and 26.7 GeV electrons at DESY's HERA collider, experiments are seeing events where all secondary hadronic debris emerges on the electron, rather than the proton side, giving a significant gap between the proton and the secondary hadrons.

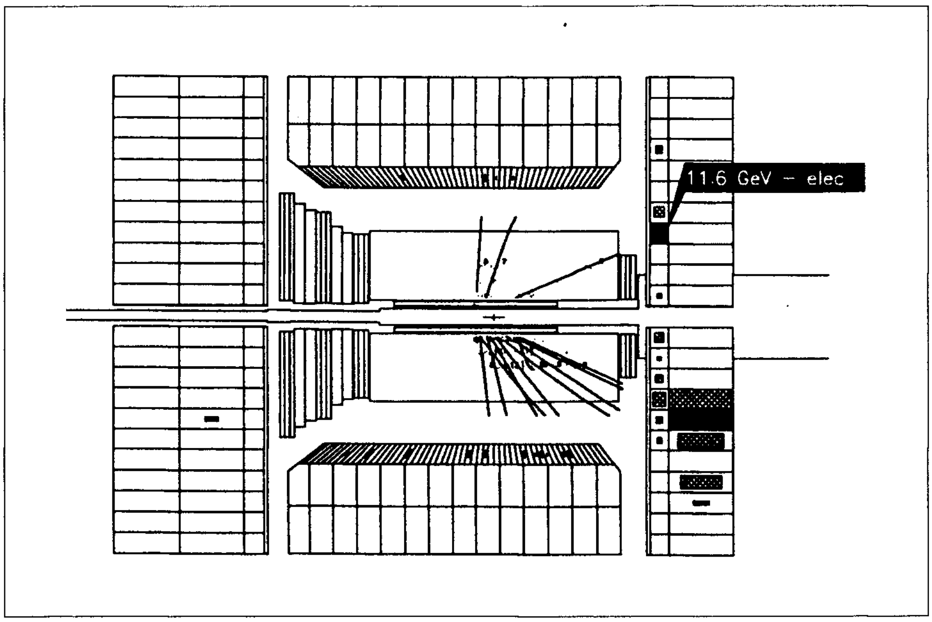
The electron interacts with the hadronic regime of the proton through exchange of a (virtual) photon. The energy, W, of the photon-proton system studied extends from 80 to 260 GeV, and the level of these 'gap' events appears not to vary with W.

The events, about 6% of the total 'deep inelastic' sample where the electron probes deep inside the proton, are also characterized by small x - the participating fraction of the total proton momentum.

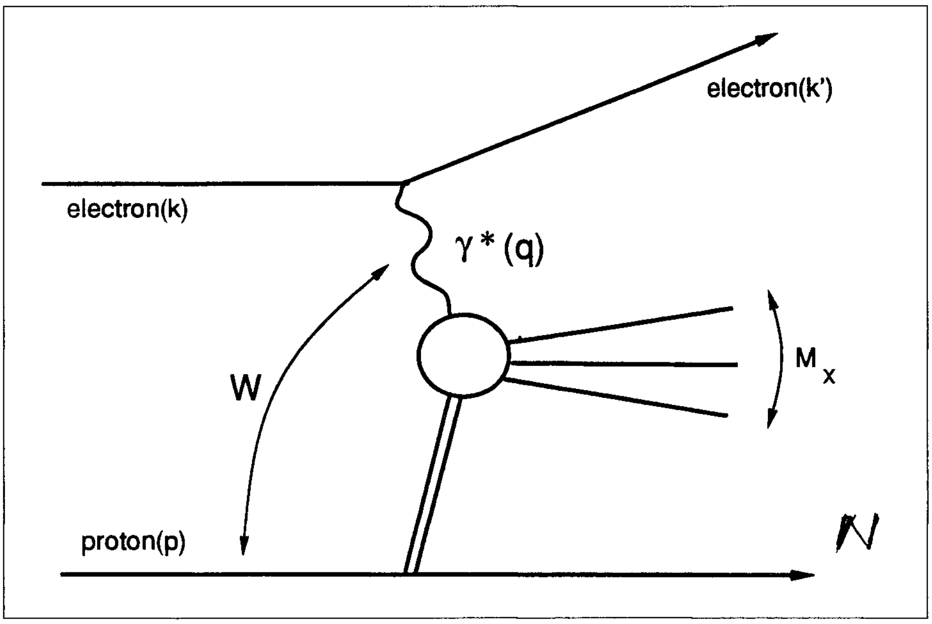
Why such a large gap between the continuing proton and emerging

Above - Interesting high energy HERA proton-electron interaction, as seen in the ZEUS detector, producing a hadronic system which emerges on the electron side (right), rather than sweeping out to the left with the proton.

Below - Mechanism of electron-proton scattering, where the electron interacts (via a photon) with something accompanying the proton, rather than the proton itself.



hadrons? The electron could be interacting (via the photon) with something accompanying the proton. Some physicists point to a pion-like particle, others to something more like a 'Pomeron', the agent of elastic scattering. Whatever it is, it has to stay hadronically intact over the kinematical gap seen in the HERA experiments, with no hadron radiation in or near the proton direction. Another clue would come from monitoring what 'disappears' down the beam pipe in the direction of the proton beam.



30 Years of the HEP-Index

Most physicists can access the SPIRES database covering almost all publications appearing worldwide on particle physics, accelerators, and related subjects. Preprints are included but subsequently eliminated when the corresponding paper appears. This database is updated nightly via Bitnet and has grown to include more than 240,000 publications, starting from 1974.

SPIRES is the administrative data processing system developed and used by Stanford University. The high energy preprint system developed by the Stanford Linear Accelerator Center uses the local SPIRES infrastructure.

This SPIRES application evolved from the well-known HEP-Index which originated at the DESY Laboratory about 30 years ago. As early as 1962, a system to classify and record the increasing amount of high energy physics publications was proposed at DESY by Hans-Otto Wüster, who convinced computerphile and library expert Kurt Mellentin to return from the USA and organize such a system.

For each document all relevant data, including classification codes and keywords are recorded - initially on punched cards but now through computer terminals. The HEP-Index information is printed and an issue has appeared every two weeks since January 1963. At present more than 500 institutes all around the world receive these reports, obtainable from Fachinformationszentrum FIZ Karlsruhe, 76344 Eggerstein-Leopoldshafen, Germany.

Since 1963 the number of publications recorded per year has grown from 1503 to an astonishing 21,407

The HEP-team at DESY led by Dietmar Schmidt (standing, second from left) poses in front of all published volumes of their HEP-Index, covering 30 years of research. (Photo Pedro Waloschek)

in 1992 - about 60 papers per day! The Stanford Linear Accelerator Center joined in 1966 and shared the effort of making and updating the database.

Many other institutes now collaborate, including CERN, which provides preprint data via Bitnet. But still the printed versions of 30 years of the HEP-Index, including the latest issues, can be peacefully consulted in most libraries without having to sit at a terminal.

BROOKHAVEN Booster boost

After three months of intensive dedicated machine studies, Brookhaven's new Booster accelerated 5 x 10^{13} protons over four cycles, about 85% of the design intensity. This was made possible by careful matching of Linac beam into the Booster and by extensive resonance stopband corrections implemented during Booster acceleration.

The best single cycle injection into the AGS Alternating Gradient Synchrotron was 1.14 x 10^{13} protons from the Booster. 1.05 x 10^{13} protons were kept in the AGS, a 92% combined efficiency of extraction, transfer, and injection. The maximum injected intensity achieved in the AGS was 4.5 x 10^{13} (4 Booster cycles). This beam was stored for several milliseconds.

On 22 June the AGS set up a new beam intensity record of 2.241x10^{13} protons per pulse. The existing radiofrequency system limits the ability to capture and accelerate much beyond this. A new power amplifier system will be installed during the October 1993 to January

At a recent Brookhaven Users' Meeting, covering both the Alternating Gradient Synchrotron (AGS) and the RHIC heavy ion collider now under construction. Left to right, Brookhaven Director Nicholas Samios; Associate Director Mel Schwartz; US House of Representatives Committee on Science, Space and Technology member Christine Wegman; US National Science Foundation Physics Division Deputy Director Pat Bautz; Brookhaven Users' Executive Committee Chairman Alex Dzierba of Indiana; Pat Rapp from the US Department of Energy (DOE)'s Division of High Energy Physics; AGS Department Chairman Derek Lowenstein; Dennis Kovar from the DOE's Division of Nuclear Physics; and DOE Division of High Energy Physics Director John O'Fallon.

1994 shutdown period, enabling the 1994 physics run to make use of the full Booster intensity and go for the stated AGS objective of 4×10^{13} protons per pulse.

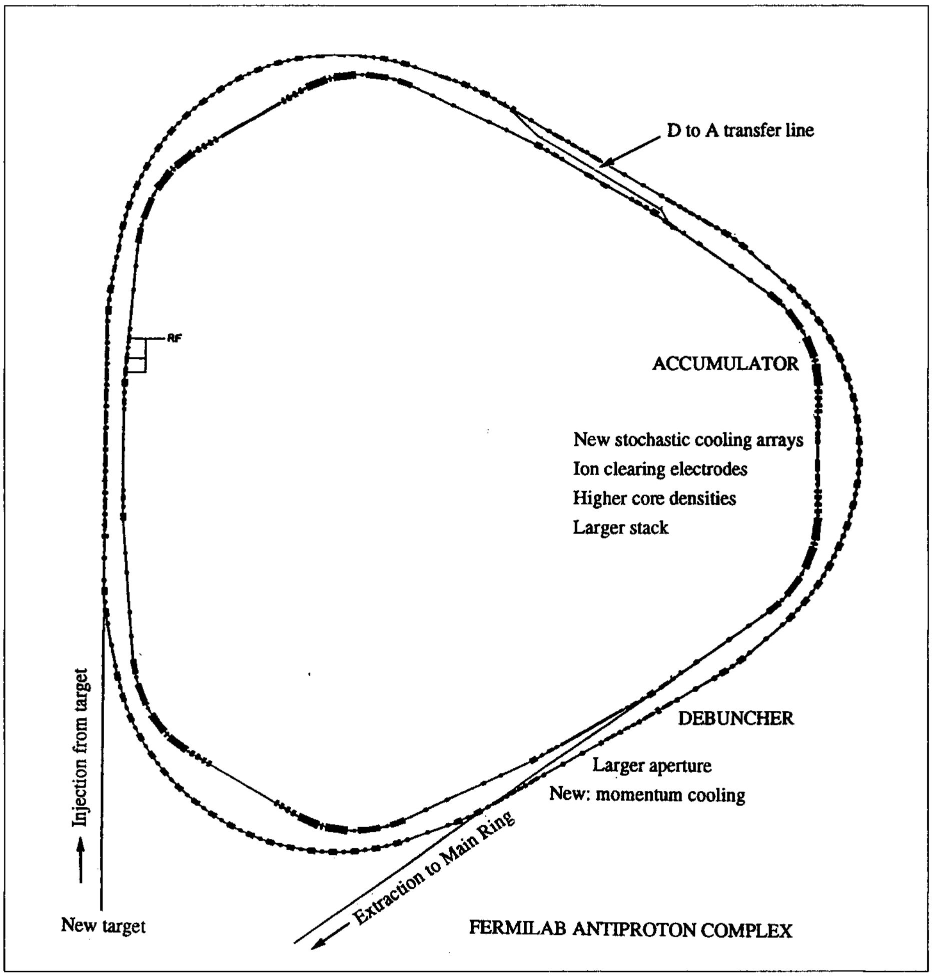
FERMILAB
More antiprotons

The excellent performance of the Fermilab antiproton complex during the recent Collider run and its future potential are the cumulative result of many improvements over the past few years, ranging from major projects like upgrading the stack-tail stochastic cooling system in the Accumulator to minor improvements like automating tuning procedures.

The antiprotons are created when the 120 GeV proton beam from the Main Ring hits the target. A good target should have high yield of antiprotons, should not melt, and should not crack due to shock waves. The old copper target has been replaced by a new one made of nickel. The yield into the Debuncher is 2×10^{-5} antiprotons/proton. While this is only marginally better than for copper, the nickel target has high melting point energy (1070 J/g) and a low rate of increase in pressure with deposited energy, making it the target of choice for the proton intensities expected in the Main Injector era (June, page 10).

Of the broad spectrum of all kinds of secondaries, only a tiny fraction are 8 GeV antiprotons. The 8 GeV negative charge secondaries are bent through 3° by a new pulsed magnet. Instead of a 200-turn magnet with coils separated by epoxy as in the past, the new magnet has one turn carrying 45.5 kA of current. This single turn pulsed magnet uses radiation hard ceramic and is much more robust.

The Fermilab antiproton complex, showing recent improvements.



From the transfer line the "hot" antiproton beam enters the Debuncher ring where its energy spread is greatly decreased at the expense of lengthening the bunch with the help of an RF manipulation called bunch rotation. In addition, the beam is stochastically cooled both in the transverse plane and in momentum. All this has to be accomplished within 2.4 seconds, when a new "hot" pulse arrives.

Hot beam means large beam size and large beam losses. The aperture of the Debuncher ring has been significantly increased by enlarging the physical aperture of all the stochastic cooling kickers by about 15 mm, as well as by centering the cooling arrays, Schottky pickups, and the vertical damper pickup on the beam. With the larger aperture, more "hot" antiprotons arriving in the Debuncher will survive for enough turns to be stochastically cooled and transferred into the Accumulator ring.

Once in the Accumulator, the antiproton beam is cooled by a complex stochastic cooling system consisting of the stack-tail and two core cooling systems. The 1-2 GHz stack-tail system moves the beam from the injection orbit toward the core while betatron cooling improves the beam's transverse emittance.

The core is the final beam destination in the Accumulator and the 2-4 GHz core cooling system ensures as large a stack as possible within a small momentum spread. Transverse core cooling is accomplished with a 4-8 GHz system. Finally, before unstacking, the stack-tail system is turned off and the second (4-8 GHz) core momentum cooling system comes into action, cooling the core to even higher density. The stack-tail momentum cooling system has been upgraded with new cooling kicker arrays.

The Accumulator's ion clearing system has been upgraded and can apply 1 kV at 139 points around the ring. Each of the six accumulator sectors is further divided into 10 sections with current monitoring for each section, handling current from 20 pA to 10 nA. The ion clearing system increased maximum achievable longitudinal core densities by more than a factor of two: removing the ions allowed the 4-8 GHz core momentum cooling system to cool the core to unprecedented densities without causing any instability.

The latest hardware addition to the Accumulator is the quadrupole pickup with associated electronics, to observe quadrupole oscillations from the mismatch between the accumulator and transport lines. This should improve Accumulator to Main Ring transfer efficiency.

Finally the unstacking of the antiproton beam has been greatly improved through the increased core density and other maneuvres.

Many other small improvements enabled the operations crew to more easily and quickly tune Accumulator and Debuncher parameters and improve performance.

From Vladimir Visnjic

Washington Accelerator Conference

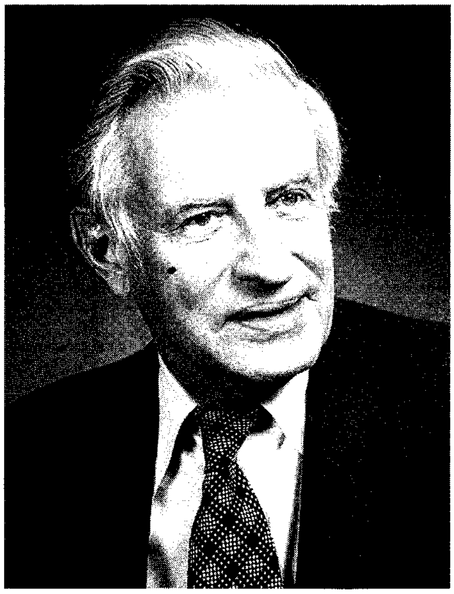
Highlights of the 1993 Particle Accelerator Conference, held in Washington in May, were picked out in the previous issue (page 18).

Talks on the big hadron colliders reflected the sea-change in the accelerator world where the scale, complexity and cost of the front-line projects has slowed the pace of developments (not unlike the scene in particle physics itself).

Speaking before the anti-SSC vote in the House of Representatives in June, Dick Briggs reviewed the situation at the SSC Superconducting Supercollider in Ellis County, Texas. The linac building is near completion and the Low Energy Booster will be ready to receive components early next year. Tunnelling for the Main Ring is advancing rapidly with four boring machines in action. Five miles of tunnel have been completed since January and the pace has now stepped up to nearly a mile each week. The superconducting magnet news is good. Following the successful initial string test of a half cell of the magnet lattice, a two-ring full cell with all associated services is being assembled. The mechanical robustness of the magnet design was confirmed when a dipole was taken to 9.7 T when cooled to 1.8 K. In the Magnet Test Lab itself, ten test stands are installed and equipped.

Preparations for the LHC project in CERN's 27-kilometre LEP tunnel were covered by Giorgio Brianti. Refinement of the high-field, two-in-one magnet design continues and four industrial consortia are building seven 10-metre magnets. A field of 8.7 T corresponds to a collision energy of 14 TeV. A string test of a half-cell (50 m) of magnets is being prepared and should be ready next year. There has been encouraging news for the additional areas of physics accessible to the LHC; the electron-proton option looks rosier following the excellent start at HERA and the ion-ion option looks more attractive after investigations of the use of LEAR as an ion accumulator. The present schedule hopes for project approval in 1994 (which is important for the detector collaborations to establish their funding and get their work underway) and the machine could then be commissioned from the year 2000. It is now intended that operation of LEP 200 for electron-positron physics will be complete before the LHC is installed.

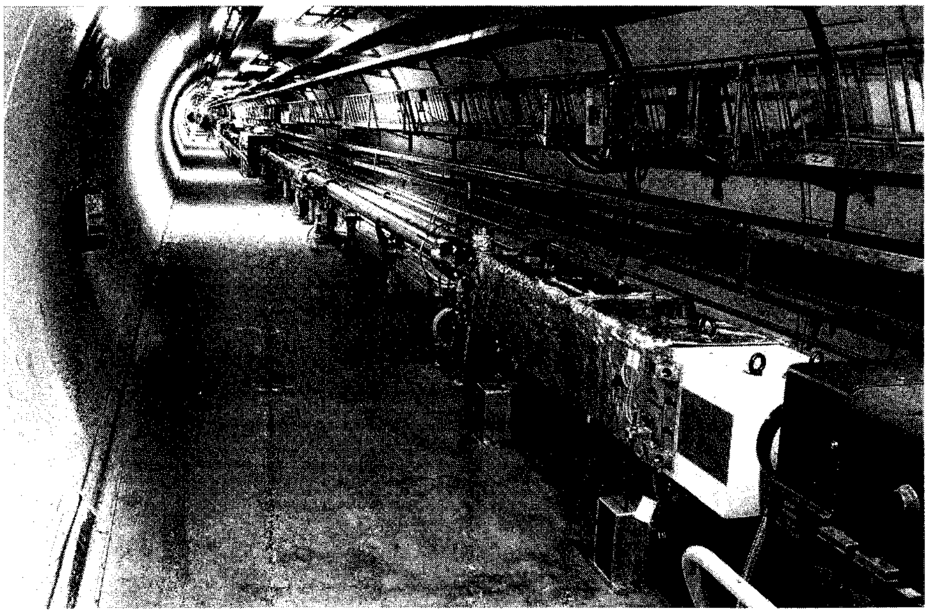
At the Washington Particle Accelerator Conference, John Blewett gave the R.R. Wilson Prize Lecture - "Adventures with Accelerators".



A similar end-date was anticipated for the SSC but indications on the likely funding profile imply stretching out construction to 2003. Government scrutiny has reopened in Washington and the pros and cons of full international collaboration in the project is a major theme in the debate. The present fashion for short-term economic yields is not aligned with the goals and timescales of particle physics research.

Paul Horn from IBM confronted this at the Conference in a talk entitled "Should society fund large accelerators for national industrial competi-

The LEP electron-positron collider tunnel at CERN. A major precision realignment programme over the 1992-3 shutdown got this year's run off to a flying start. At Washington, Lyn Evans reported on LEP progress.



tiveness?". His blunt answer was 'No'! He maintained that the intellectual argument was obviously noble but is insufficient when set against funding for the Arts, less than a hundredth of that for science. This has been sustained up to now because the "unspoken" reason for basic scientific research has been national defence. The arguments related to spin-off technologies could be made for almost any large technological project and even technology-based industries like IBM or AT&T are now having difficulty defending basic (what they call "unfocused") research.

He alleged that the particle physics community has not made a case for the economic value of the research and it was probably difficult, if not impossible, to do so. On the other hand he recognized that the Laboratories attract a reservoir of outstanding intellectual talent and improved access to this talent for industry could be a very positive argument. He did not discuss the value of the basic scientific knowledge that has emerged from the research since the beginning of the century.

One field which did get a very large pat on the back from Paul Horn was synchrotron radiation research. There the involvement and integration of industry is manifest. The rapid expansion of the user community and of the sources which service them continues. J. L. Laclare reported that the 6 GeV European Synchrotron Radiation Facility achieved the design intensity of 100 mA in the multi-bunch mode only four months after the start of commissioning; 135 mA has now been reached and a new goal of 200 mA has been set. Seven undulators are in place and three beamlines have received photons. Routine operation for research will start at the beginning of 1994.

Alan Jackson described similar rapid success at the Berkeley 1.5 GeV Advanced Light Source which started commissioning early this year. By the end of April the design current of 400 mA had been exceeded with 27 mA in a single bunch compared to the 8 mA design figure (June, page 8). Beam lifetimes are increasing steadily and at the time of the Conference, the machine was being baked out to improve the vacuum and take the lifetimes much longer.

It was appropriate in this golden era for synchrotron radiation sources that John Blewett, who played an important role in its pioneering theoretical and experimental work, should be honoured at the Conference. John gave the R.R. Wilson Prize Lecture under the title "Adventures with Accelerators". In the book on accelerators that he wrote with Stan Livingston appeared the famous curves plotting peak available particle beam energies against time. John Blewett participated in quite a number of the points on those curves. Among the most famous were the first GeV proton machine (3 GeV Cosmotron at Brookhaven where he designed the magnet) and the Brookhaven Alternating Gradient Synchrotron. His 1946 paper on synchrotron radiation indicated how it might be verified by orbit shrinkage in a 100 MeV betatron (the vacuum vessel being too opaque to observe the radiation directly). The first visual observation followed at a 75 MeV synchrotron in 1947 ... and the world has never been the same since. He continues to be involved with these machines both at the Brookhaven National Synchrotron Light Source and the recently commissioned 1.3 GeV SRRC in Taiwan.

Fermilab, with high energy proton-antiproton physics all to themselves, gives high priority to the search for the sixth ('top') quark. David Finley reported on the first Tevatron Collider run with two big detectors in action, D0 now having joined CDF. Peak luminosity is being pushed towards 10^{31}. These stores are kept for about a day, and the luminosity is limited by

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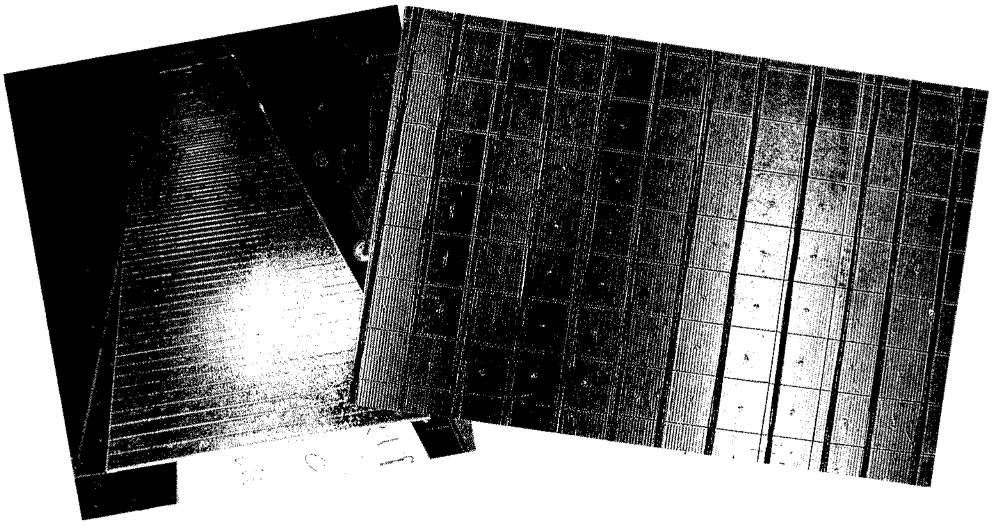

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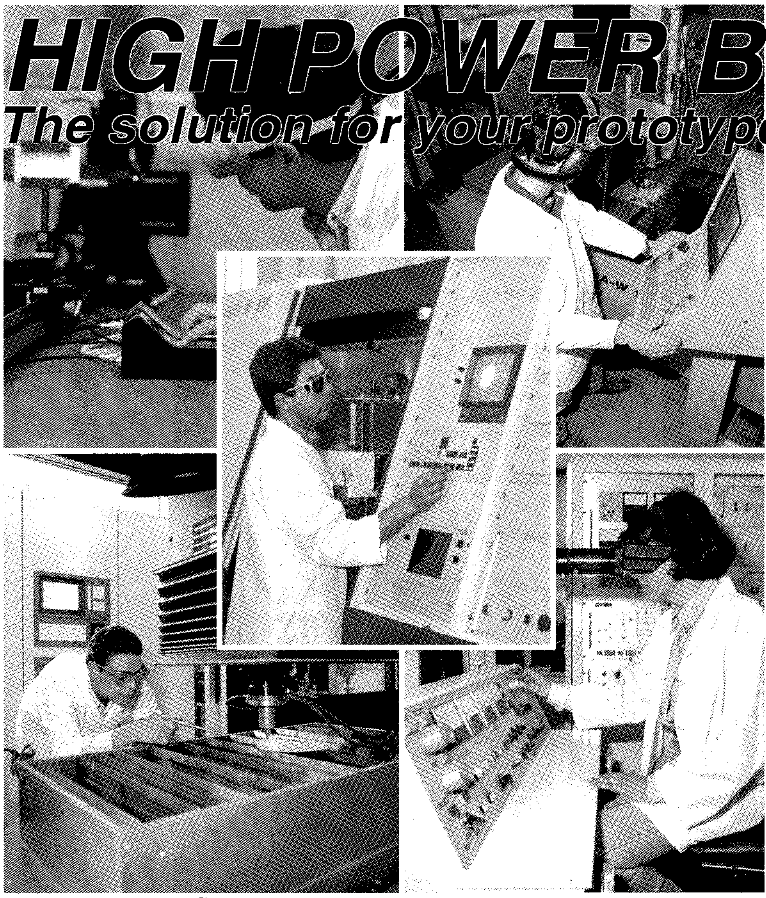

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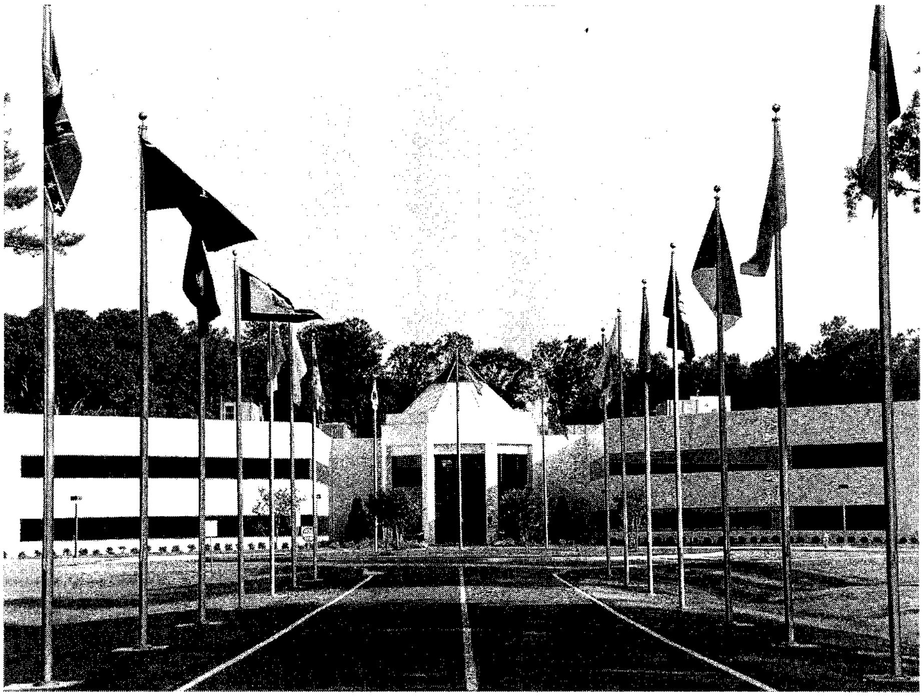
Main Building at the Continuous Electron Beam Accelerator Facility (CEBAF), now nearing completion in Newport News, Virginia. CEBAF personnel were prominent in the organization of the Washington meeting.



the antiproton store (which has been doubled). The linac is being upgraded from 200 to 400 MeV to ease space charge problems in the Booster, and there will be improvements in the Antiproton Source to take the luminosity higher. There will also be more bunches of particles (36 rather than 6 per beam). Lowering the Tevatron's cryogenic operating temperature from 4.5 to 3.5 K will boost the operating energy from 900 to 1000 GeV (1 TeV). The subsequent step would be replacing the existing Main Ring by the Main Injector (June, page 10).

On the high energy frontier, electron-positron linear colliders to take energies beyond those of LEP 200 were reviewed by Bob Siemann. Ideas to provide hundreds of GeV per beam are under study in half a dozen different guises at major research centres in Europe, Japan, the US and Russia. This seems the correct approach at this stage of the game because the different proposals are juggling the parameters of luminosity, power efficiency, technical difficulty and cost. CERN Director General designate Chris Llewellyn Smith in his opening talk emphasized that the eventually chosen technology must be capable of extension to 1 TeV per beam to reach the interesting physics. Test facilities are under construction for each of the schemes and in the next few years interesting results should emerge to guide the final choice.

On the current electron-positron scene, LEP at CERN has achieved its design luminosity, so continuing improvement is now a bonus. Lyn Evans reported on last year's run in which almost three million Z particles were captured by the four experiments. Peak 1992 luminosity was 1.15×10^{31} (subsequently exceeded this year). The two important 1992 beam physics developments were the commissioning of the pretzel beam separation scheme, doubling the number of orbiting bunches in each beam to eight, and operation with new high-tune optics producing smaller beam emittances. This both helped improve luminosity and paved the way for higher energy operation using superconducting radiofrequency cavities.

Superconducting radiofrequency (SRF) figures prominently in several of the linear collider schemes (for example the internationally-supported TESLA route uses SRF to allow high power beams and relax requirements on spot size, while CLIC at CERN has a superconducting linac for its intense drive beam). Thus there is long-term as well as immediate interest in the performance of the newcomers in the application of superconducting r.f. cavities - HERA, LEP 200 and CEBAF - and in the push to higher gradients crowned by the achievement of 34.6 MV/m in a two-cell structure operating at 3 GHz at Cornell. (The TRISTAN ring at the Japanese KEK Laboratory was the first operational collider to permanently use a superconducting accelerating cavity.) At HERA the cavities have now had over ten thousand hours of operation and are providing a third of the r.f. acceleration (50 MV per turn). For LEP series production of niobium-coated copper cavities began in industry last year.

It remains a concern that the high gradients achieved with the cavities in bench tests does not carry over when they are installed in the operating environment of an accelerator or storage ring. There is now over 1 GeV of installed accelerating capability, providing a considerable pool of experience, notably at CEBAF, the recirculating linac scheme being built at Newport News, Virginia, with 338 cavities. So far over 250 have been assembled and almost 50% of them have reached gradients of at least 10

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Philips Optics

Philips Optics

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Physics monitor

MV/m in laboratory conditions.

CEBAF will have two superconducting linacs to achieve 4 GeV c.w. electron beams by fivefold recirculation. Milestones so far are the achievement of 260 microamps at 45 MeV from the injector (design current 200) and 190 microamps at 80 MeV in a recirculation experiment. Half-power tests with one of the linacs gave 245 MeV with a current of 110 microamps; 99 cavities were operating at the design gradient of 5 MV/m. A cryomodule of eight cavities yielded 8 MV/m with beam. Such problems as occurred during the tests were not due to the cavities; the performance limitations at present come from the cryogenics (compressors and pumps). This is an auspicious start to CEBAF commissioning.

CEBAF personnel were prominent in the organization of the 1993 Particle Accelerator Conference. May their machine function as smoothly as the Conference!

By Brian Southworth

Accelerator Awards

Several awards and prizes for achievements in accelerator physics and technology were announced in association with the Washington Particle Accelerator Conference.

The Technology Award went to Tom Collins "for his invention of long straight sections for synchrotrons and storage rings, and his design of the lattices for the Fermilab Main Ring, Tevatron and Anti-proton Source" and to Louis Anderson and Yoshiharu Mori "for their invention of the optically pumped polarized negative hydrogen ion source".

The Robert R. Wilson Prize went to John Blewett "for his many contributions, beginning in the 1930s, to accelerator physics and technology. These contributions include the experimental verification and first indirect observation of synchrotron radiation, the first application of the alternating gradient concept to linear accelerators, and very many developments in the design and construction of accelerators and storage rings".

The Award for Doctoral Thesis Research in Beam Physics went to John Palkovic "for research on the physics of low energy ion beams: particularly for the invention of a new type of Gabor lens, for showing that a Gabor lens is not practical for focusing negative ion beams, for the development of diagnostic techniques to measure the emittance of low energy beams , and for demonstrating that most of the emittance growth in such beams occurs in a halo containing only a small fraction of the beam".

The US Particle Accelerator School Prize for Achievement in Accelerator Physics and Technology went to Richard Sheffield and John Fraser "for their invention of a high brightness electron source by combining a photocathode with r.f. acceleration" and to Marc Ross "for his measurements and analysis of the SLC accelerator and beam properties".

Probing the TeV energy scale

Despite its spectacular success, the Standard Model (SM) is widely believed to be incomplete. In fact there are good reasons to expect that new degrees of freedom, not present within the SM framework, will show up in particle collisions at TeV energies. Novel phenomena are, therefore, anticipated when this energy regime is explored at proton supercolliders such as the SSC or the LHC, and at the next generation of linear electron-positron colliders.

Almost two hundred physicists, with roughly equal representation from North America, Europe and Asia, got together to discuss the physics possibilities of such colliders at the Second International Workshop on Physics and Experiments at Linear Electron-Positron Colliders, held during the last week of April in Waikoloa on the Big Island of Hawaii. It was the second in a series of international workshops which began in Saariselkä, Lapland, Finland in September 1991.

The main theme of the workshop was the physics reach of, and the feasibility of experiments at, linear electron-positron colliders in the 300 GeV - 2 TeV collision energy region. Also discussed were the prospects for physics at electron-photon, photon-photon and electron-electron colliders.

After a welcome address by Frederick A. Harris (Hawaii), Daniel Treille (CERN) in his physics overview discussed the potential of a linear collider in the light of current knowledge and possible new results from present and future accelerators like the SSC and LHC. The status of Stanford's SLC, important to the

Interactions at the Second International Workshop on Physics and Experiments at Linear Electron-Positron Colliders, held during the last week of April in Waikoloa on the Big Island of Hawaii.. Peter Zerwas (left) of DESY, Hamburg, with Stanley Brodsky of SLAC, Stanford.

development of the technology needed for the 'Next Linear Collider', NLC, together with physics results from the SLD experiment, was reported by Martin Breidenbach (SLAC). Bjorn Wiik (DESY) covered the linear collider designs being pursued, including their problems and progress, predicting that by 1996-97 it should be possible to write a proposal with a reliable cost estimate for a 500 GeV linear collider.

Parallel session discussions mainly focussed on experiments to study physics at or beyond the electroweak scale, and on a comparison of the physics capabilities of linear colliders and proton supercolliders. A central issue was the search for physics beyond the Standard Model, which, together with the Higgs boson search, constitute the raison d'être for the exploration of the TeV energy scale. The conclusion was that while much of this exploration can indeed be done at the proton supercolliders, the clean conditions at high energy electron-positron colliders make them ideally suited for elucidating the 'new physics' from proton supercolliders, underlining the complementarity of the electron-positron and proton-proton routes.

Specifically, it was noted that linear colliders operating at 250 - 500 GeV are ideally suited for studying the Higgs boson in the intermediate mass range. Moreover, it should be possible to discover at least one of the Higgs bosons of the minimal supersymmetric model at these machines, and, further, with an integrated luminosity of about 10 inverse femtobarns, it should be possible to distinguish between the SM and supersymmetric Higgs sectors over a wide range of parameters. The high luminosity together with inherently clean conditions of electron-positron collisions will allow experiments to make precise measurements of the top quark and W boson properties (masses, rare decays, anomalous couplings, etc), which, in turn, will stringently test the Standard Model at the scale of electroweak symmetry breaking.

Also extensively discussed were the prospects for discovering supersymmetric particles and the feasibility of using their properties to probe the physics of supersymmetry breaking.

Other physics topics included additional gauge bosons; the possibility of strong symmetry breaking interactions; and the importance of the hadronic structure of the photon for the design of the beams and detectors.

In the discussion on photon-photon collisions, Z pair production was identified as a potentially important background for studies of Higgs boson properties. The possibility of constructing a low energy photon-photon collider for a study of resonance physics and perturbative quantum chromodynamics was also broached.

On the machine side, representatives from the various laboratories discussed the development of linear colliders at CERN, DESY, KEK, Novosibirsk, and SLAC. New developments in polarization were reported by C. Prescott (SLAC) while W. Ash (SLAC) summarized experimentation issues.

In his summary, S. Iwata (KEK) emphasized the importance of linear electron-positron colliders not only as a stringent testing ground for the Standard Model, but first and foremost as a stage where spectacular new physics discoveries might be possible. He also extended an invitation to the Third Workshop in the series, to be held in Japan in the fall of 1995.

This contradicted an earlier extrapolation by banquet speaker Richard Taylor (SLAC) who took the locations of previous workshops to predict that the next in the series would be in Antarctica.

The Workshop was organized by the High Energy Physics Group at the University of Hawaii, under the auspices of ICFA, and was spon-

sored by SLAC and KEK with additional financial support from the US Department of Energy, the US National Science Foundation, the International Science Foundation, and the University of Hawaii. The proceedings will be published by World Scientific.

Particles and cosmology

When the common ground between particle physics, astrophysics and cosmology started to become a developing area, the Institute for Nuclear Research (INR) of the Russian Academy of Sciences had the foresight in 1981 to institute the Baksan Schools on Particles and Cosmology. This now traditional event, held biannually in the Baksan Valley, has gone on to attract international participation.

The site is close to the INR Baksan Neutrino Observatory with its underground and surface installations, including the SAGE gallium solar neutrino detector, the Underground Scintillation Telescope, and the 'Carpet' extensive air shower array. Participation is mainly from experimentalists working in non-accelerator particle physics and particle astrophysics.

The most recent School, held from April 21 to 28, began with an opening address by INR Director V. A. Matveev. J.Frieman reviewed standard big bang cosmology, emphasizing how the recent COBE results and the observations of large-scale galaxy clustering fit into a standard cosmology framework.

For inflationary cosmology, he showed how different models may be tested through their predictions for large-scale galactic structure and for cosmic microwave background anisotropy. A.Stebbins presented details of the large scale distribution of galaxies which, combined with velocity information and microwave background anisotropy data, provide strong constraints on theories of the origin of primordial inhomogeneities.

Inflation requires, and theories of the large scale structure strongly favour the critical value for the cosmic mass density, while, as D.Seckel explained in his lecture on nucleosynthesis and abundances of the light elements, the baryon contribution to this density has to be tens of times smaller. A general review on the observational evidence for dark matter, dark matter particle candidates and the strategy of dark matter searches was given by I.Tkachev, who stressed the gravitational microlensing MACHO searches.

In talks on candidate dark matter, A.Bottino looked at supersymmetric neutralinos and D. Tanner covered the ongoing search for axions. M.Shaposhnikov dealt with electroweak baryogenesis. Here the goal is to explain why the Universe looks devoid of antimatter. After reviewing basics and status of the problem he showed how reasonable matter asymmetry can arise during the first order phase transition, even in the minimal standard model, without any additional sources of CP-violation.

An experimental approach to test non-standard models of CP-violation was presented by Yu.Kudenko, including a new experiment to search for T-violating polarization of the muon in the decays of charged kaons.

In astrophysics, V.Dokuchaev discussed different types of models for ultra-high energy cosmic ray generation in active galactic nuclei, I.Moskalenko talked about TeV gamma-ray emission from close binaries and P.Ghia presented the results from the Gran Sasso EAS-TOP installation in ultra-high energy gamma ray astronomy. Yu.Kopysov described the status and prospects of helioseismology.

So close to the Baksan Neutrino Observatory, many lectures were given over to neutrino physics. J. Valle summarized the data from solar and atmospheric experiments which might suggest that neutrinos are massive, and discussed appropriate theoretical schemes. He showed how this could have implications for a variety of experiments, including those at LEP.

P. Lipari showed how the muon/ electron neutrino anomaly in atmospheric experiments can be interpreted as a consequence of neutrino oscillations.

Lively discussion was triggered by talks on solar neutrinos. The report on the "home" gallium-germanium experiment, SAGE, was given by V.Gavrin, while the 'rival' GALLEX experiment was presented by two speakers: R. Wink highlighting counting and data evaluation, while chemical aspects were discussed by U.Schanda. A. Dar explained why the solar neutrino results reported by SAGE, GALLEX, Kamiokande and Homestake suggest new physics beyond the Standard Electroweak Theory. In particular the MSW effect in certain range of neutrino masses and mixing can explain all four experiments.

Besides SAGE, all major Baksan Neutrino Observatory installations were presented at the school. V.Alexeenko reported on results from "Carpet", and Yu.Novoseltsev discussed electromagnetic cascades generated by cosmic ray muons at multi TeV energies viewed by the

Baksan Underground Scintillation Telescope. A. Smolnikov reviewed double beta decay searches, both at Baksan and elsewhere.

Traditionally, a number of lectures at Baksan schools are devoted to the status and future prospects of underground experiments. Considerable interest was raised by the status reports on two Gran Sasso experiments: G. Giacomelli gave the talk on MACRO and V.Kudryavtsev reported on LVD. E.Bellotti described new techniques for underground physics and discussed three projects, ICARUS, HELLAZ and the Milan group's cryogenic device. Two proposals for future solar neutrino detectors at Baksan were also presented: A. Kopylov discussed the radiochemical lithium-beryllium approach, and V.Cherekhovsky reported on fluorine containing scintillation detector. This next generation of underground experiments will make precise measurements of solar neutrino flux and search for phenomena beyond the standard model like proton decay or neutrino oscillations.

In two talks on underwater detectors, L.Bezrukov reported from the current experiment on Lake Baikal and I.Zheleznykh discussed plans for the NESTOR/SADKO experiment in the Mediterranean.

The 1993 Baksan School was dedicated to the memory of A.A.Pomansky, formerly head of Baksan Neutrino Observatory, who died in April. The formation, development and worldwide reputation of the Observatory where to large extent due to his efforts.

From Igor Tkachev

The strong will of the photon

In 1900 Max Planck introduced the photon, the quantum of the electromagnetic force. The electromagnetic (and electroweak) behaviour of the photon can now be calculated more accurately than experiments can even measure. But as well as mediating electromagnetism, the photon can temporarily dissociate into particles which take part in strong nuclear interactions. This way the photon enters strong interactions through a back door, and this aspect of the photon is far from understood. In this series of articles, Gerhard Schuler looks at what we know about the photon almost a century after Planck introduced the idea.

Among today's elementary particles, the photon, the massless carrier of the electromagnetic force, plays a special role. At high energy, it has a dual character - sometimes pointlike and structureless, elsewhere with a hadronic structure.

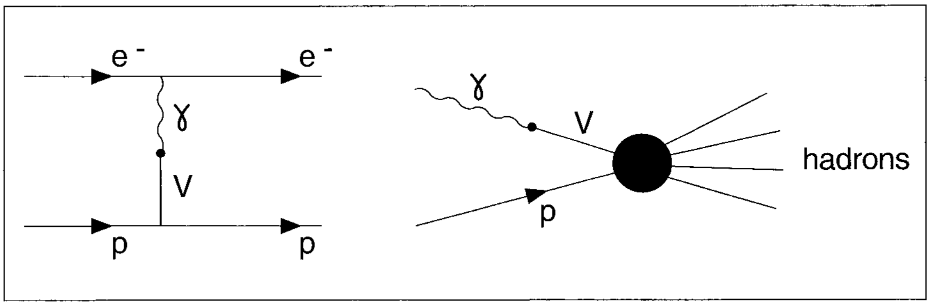
This is reminiscent of the duality of radiation and matter established at the beginning of the century. But while this wave-particle duality is understood in quantum mechanics, we have no complete description of high energy hadronic interactions. Quantum chromodynamics, the field theory of quarks and gluons, comes nearest, but calculations are not always possible. Physicists have to resort to intuitive pictures and models to supplement formal theory.

The hadronic side of the photon is a rich field, both theoretically and experimentally, studied using a range of reactions at all the major front-line accelerators and storage rings, culminating most recently with first data from the new HERA electron-proton collider at DESY, Hamburg.

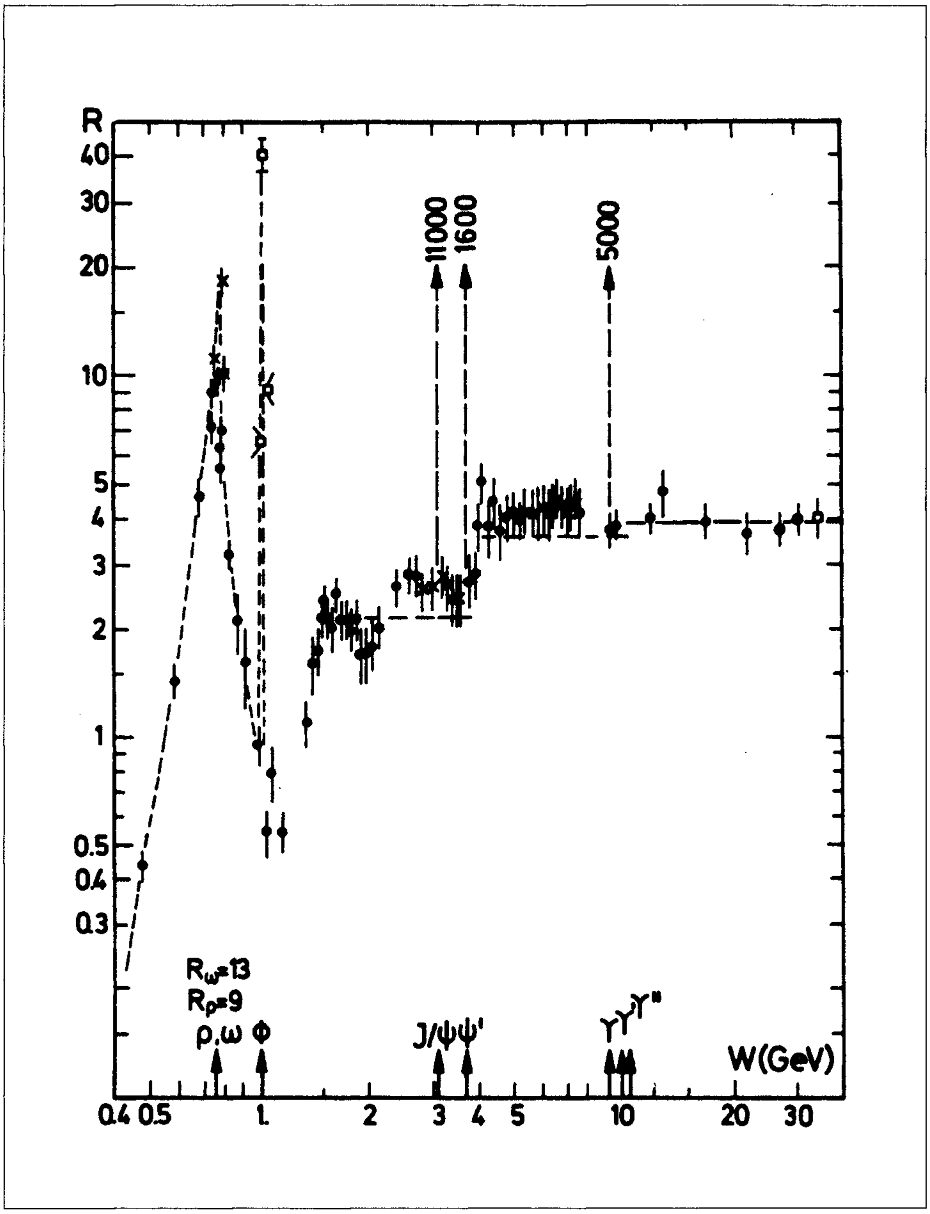
The photon was first regarded as structureless. The first hint of photon structure was probably electron-positron pair creation by photons in an electromagnetic field. In relativistic quantum field theory, a particle contains not only its 'bare' state, but also contributions from all states coupled to it by the interaction. Thus in quantum terms the photon also contains electron-positron pairs, which can materialize in high-energy reactions.

In hadronic interactions, the photon was again first regarded as structureless (apart from 'radiative corrections' due to the electron-positron pair content). However as

Photon transformation into vector mesons affects both the electromagnetic properties of hadrons (left) and high energy photon interactions (right).



World compilation of the rate for electron-positron annihilation into hadrons, scaled by the corresponding muon pair production rate, has considerably more structure than just the rho, omega and phi mesons.



available photon energies increased to the multi-GeV range, the photon was found to have an internal structure of its own. This looked similar to that of hadrons, except that electromagnetic coupling makes it only 1/137 as strong.

Photon-hadron interactions can be understood if the physical photon is viewed as a superposition of a bare photon and an accompanying small hadronic component which feels conventional hadronic interactions, but with the same quantum numbers as the photon.

The vector meson dominance (VMD) idea says the three neutral vector mesons rho, omega, and phi provide this hadronic component, while the interaction of the bare photon with hadrons becomes negligible at high energies. The need for such vector mesons had became apparent in the late 50s by some puzzling features in nucleon charge distributions.

If the photon can transform into vector mesons, not only should this affect charge distributions and decay probabilities, but also the behaviour of high-energy photon reactions. Starting in 1964 with the first systematic study of rho photoproduction, striking similarities between photon- and hadron-induced processes were found, underlining the value of the VMD picture.

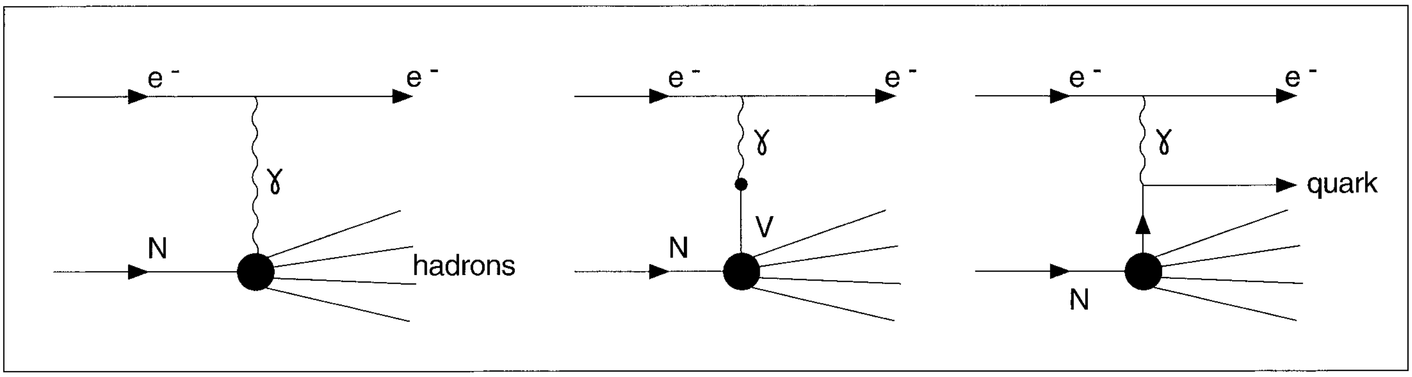
(In 1965, Harvard's Frank Pipkin reported a possible violation of quantum electrodynamics, hitherto an unchallenged theory. At the DESY synchrotron, a team under the young Sam Ting checked this out in an experiment studying the production of heavy photon-like particles in the interactions of high energy photons with nuclei. They found that everything was in order and the theory was still good. Physicists breathed a sigh of relief.

However this showed the importance of heavy photon-like particles, and eventually led to the discovery in the 1970s of the J/psi and upsilon families, bound pairs of quarks and antiquarks.)

Meanwhile the 'breakdown' of VMD came in the late 60s, when more detailed experiments showed that VMD accounted for only about 80% of what was seen in photon-proton collisions. Also electron-positron collider experiments revealed that the photon's hadronic structure is considerably richer than a simple superposition of rho, omega, and phi.

This follows because the production of hadrons in electron-positron

Electron-nucleon scattering through photon exchange (left), and its view as seen by generalized vector dominance (centre) and the quark-parton model (right).



collisions proceeds via annihilation of the electron-positron pair into a virtual (transient) photon which in turn decays into hadrons. The hadronic states seen at electron-positron colliders are precisely those into which a photon can fluctuate.

The first theoretical attempt to include the effects of additional photon constituents led to generalized vector-meson dominance (GVD), with specific models of the heavier states. These states easily supply the missing (about 20%) contribution to the photon-proton rate.

While the original VMD picture predicted a photon-proton rate that was too low, the problem with GVD is how to suppress effects due to the abundant heavier states. This is 'solved' by demanding that the interaction probability of a high mass component decreases with increasing mass.

Because the spectrum of electron-positron annihilation into hadrons falls off relatively slowly with increasing hadronic energy (in fact as its square), the total probability of the hadronic component of the photon increases (logarithmically) with energy, and so diverges! Thus the photon is not a simple composite of its constituents in the sense that a nucleus is a composite of nucleons. This expected increasing probability of finding hadronic material in the photon has been observed in electron-photon scattering.

To understand the results, consider first the 'classical' electron scattering experiment, electron-nucleon scattering. This is mediated by a virtual photon and is characterized by two variables. These may be taken as the photon energy, and the squared momentum transfer, Q^2, between the incident and the scattered electron which measures the virtuality of the photon.

At low Q^2, VMD's principal qualitative feature - providing the photon with a hadronic structure - remains valid. The virtual photon-proton subprocess can be described as a superposition of meson-proton scatterings if the photon-meson couplings decrease as 1/Q2 at large Q^2.

Such a decreasing probability of the photon to fluctuate into vector-mesons is in fact expected. The uncertainty principle says that the probability of a photon interacting hadronically increases with the photon energy but decreases with Q^2.

Rather than falling off with Q^2 as expected in VMD, inelastic electron scattering was found to be surprisingly large. The most striking feature of the pioneer 1969 data at Stanford (SLAC) was 'scaling': when the photon becomes highly virtual (large Q^2), the underlying equations become much simpler and the outcome just 'scales', with the reaction characterized by a dimensionless variable.

Though GVD could be fine-tuned to get rid of its strong Q^2 dependence (and describe the observed dependence on photon polarization), there is a much more natural explanation. Rather than interacting via its hadronic component, the photon ultimately (very high Q^2) becomes the pointlike (structureless) bare photon neglected by VMD or GVD.

The measurements are then understood by picturing the nucleon as made of pointlike objects - partons. Electron-nucleon scattering at large Q^2 is thus the sum of (virtual) photon-quark scatterings, the dimensionless scaling variable being the momentum fraction of the nucleon carried by the struck quark.

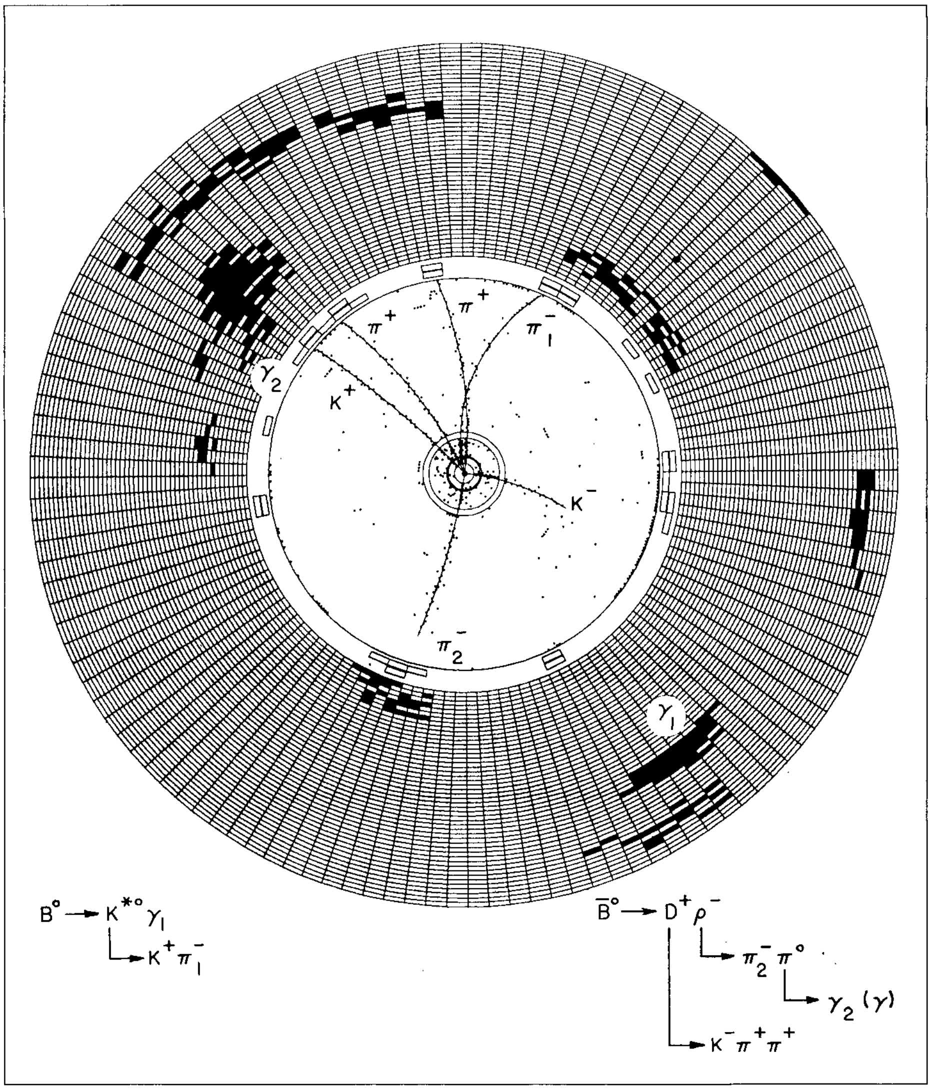
The photon-quark coupling found in electron-nucleon scattering allows also a simple interpretation of electron-positron annihilation into hadrons at high energies: the virtual photon created in the annihilation splits into a quark-antiquark pair which in turn produces the observed hadrons.

Just as proton structure is measured by probing with an electron beam, so can that of the photon. Such experiments were carried out in the 80s at successive generations of electron-positron colliders - Petra at DESY, PEP at Stanford, later VEPP-4 at Novosibirsk, then TRISTAN in Japan and most recently LEP at CERN.

The next article will cover what has been learnt from this physics, and what we hope to learn from future measurements so that we can eventually understand the detailed behaviour of one of the 'simplest' of the elementary particles.

By Gerhard Schuler

Heavy on flavour



The report earlier this year (June, page 1) from the CLEO experiment at Cornell's CESR electron-positron collider of this unconventional B decay underlined the important of subtle effects involving heavy quarks.

The Standard Model makes physics look neat, with its six quarks paired in three 'generations', each quark pair partnered with a lepton and its corresponding neutrino.

The first generation of 'up' and 'down' quarks, partnered with the electron and its neutrino, describes the familiar world around us. But the Standard Model says that the two generations of heavier quarks - strange and charm (partnered with the muon and its neutrino), and beauty and top (with the tau lepton and its neutrino) - while less visible from our everyday viewpoint, are no less important for physics.

The International Symposium on Heavy Flavour Physics, held at McGill University, Montreal, from 6-10 July, showed how the intricate physics of heavy quarks and leptons is steadily being unravelled and how these unusual processes are helping to fill up and refine all parts of the Standard Model.

Instead of being an obscure corner, the once difficult-to-get-at physics of heavy quarks and leptons now forms an essential part of today's science. In some cases measurements in this sector are attaining, and even surpassing, the level of precision attained in the conventional corner populated by up and down quarks and the electron and its neutrino.

The standard six-quark picture is described, but not explained, by the (Cabibbo-Kobayashi-Maskawa - CKM) matrix of quark decay parameters. The elements in this matrix cannot be predicted and have to be measured, but the pattern of the matrix gives some interconnection. Once some elements are known, others can be related. A recurring theme in the meeting was repeated attempts to improve existing measurements of CKM parameters or to get at new ones, in the hope that this would turn up some new Standard Model clue.

With the orthodoxy of the Standard Model, heavy flavour has therefore become a major physics preoccupation. Theorists have developed new

techniques - 'effective theories' - where the heaviness of the extra quarks simplifies their calculations. This gives results, which while approximate, would have been difficult to extract otherwise. Lattice simulations provide complementary insights.

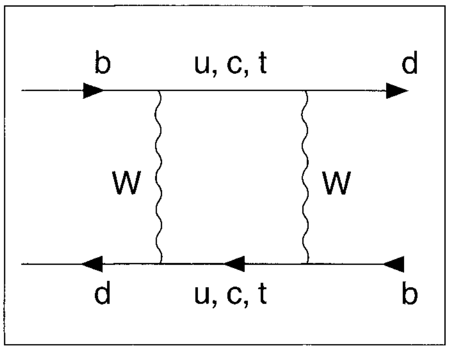
Machine specialists are busy planning new facilities to provide tailor-made conditions for several styles of heavy quark physics, while experimenters, using both proton and electron machines, are putting their ingenuity to good use in extracting precision results, particularly for B particles (containing the fifth - beauty quark) and for tau leptons. An underlying theme in experimental work is the 'tagging' of processes where rare particles are involved - enabling this physics to be rapidly separated out from the less interesting background.

The Montreal meeting opened with Mark Wise of Caltech reviewing the underlying philosophy of heavy quark effective theory, while Thomas Mannel of Darmstadt gave a more technical update.

The recent observation of rare radiative B decays ('penguin' processes) at Cornell (May, page 1) has given new impetus to searches in remote corners of B particle physics. Peter Kim of Cornell surveyed the world windows on B decays and the quest for unconventional B decays which might undermine the foundations of the Standard Model.

These radiative B decays come about through a second order effect, with two reactions connected back to back. Such second order processes seem to play a fundamental role in this kind of physics, and analysis of subtle effects which go through these channels could pay dividends.

The major appeal of B physics is to examine CP violation from a different viewpoint. This discreet disregard for



So-called 'box' diagrams, with two first-order quark processes coupled back-to-back, provide a route to unusual quark effects. This example shows how a B particle can convert into its antiparticle and vice versa.

combined particle-antiparticle and left-right reversal has been seen so far only with neutral kaons. Despite having profound implications for the particle-antiparticle lopsidedness of the Universe, this phenomenon is not understood, and new results would bring valuable insights.

The CP violation theme in its more traditional kaon setting was taken up by Douglas Bryman of TRIUMF, Vancouver. Almost thirty years since the original discovery, this sector, renowned for its difficult measurements, has yet to be wrung dry.

Later in the meeting Michael Gronau of Haifa's Technion pointed out the CP violation potential in the B meson sector, where the parameters are very different to kaons and would give a welcome new perspective. There is a lot of interest in a new possibility at Fermilab's Tevatron, where CP violation could be seen very soon in the decay of B** mesons.

Ronald Poling of Minnesota covered semileptonic B decays (producing particles containing lighter quarks and accompanied by a lepton and a neutrino). Impressive here is the agreement between precision experiments spanning a wide range of energy, from ARGUS and CLEO at the B production threshold just above 10 GeV to the big LEP experiments at CERN, looking at the decay of the Z particle, above 90 GeV.

An important prelude to seeing CP violation in neutral B mesons is to see the particles 'mix' - the quantum mechanical interplay of two different electrically neutral particles having a common decay channel. Hans-Gunther Moser of CERN reviewed the latest status of these measurements, where the Aleph experiment at LEP has seen the time dependence of B mixing. Kenneth Johns of Arizona described a new B mixing measurement, this time by the D0 experiment at Fermilab's Tevatron collider.

David Brown of CERN covered the electrically neutral weak couplings of heavy quarks. Here new measurements are rounding out the precision electroweak picture. Information on B asymmetries from the decays of Z particles produced by polarized electrons at Stanford's SLC linear collider is now complementing the mass of precision data from LEP at CERN, with better B identification at LEP playing an important role.

Together these approaches give additional limits on the mass correlation of the unseen sixth (top) quark and the 'higgs' particle at the root of electroweak symmetry breaking. While not seen in final states, these particles are nevertheless at work deep in the production mechanisms. It appears that the top quark lies below 213 GeV and could easily be around 170 GeV, with no higgs caveat.

A not unrelated prolific sector is the decay of Z particles into tau leptons, with many correction terms common to both the quark and lepton decay channels of the Z. John Swain of Northeastern reviewed the extensive contributions from the four experiments at CERN's LEP electron-positron collider, where data continues to accumulate and where tau polarization measurements are

Position in Accelerator Physics at the Aarhus Dual Purpose Storage Ring

The Institute for Synchrotron Radiation Aarhus (ISA), which is responsible for running the storage ring - ASTRID - and beamlines, invites applications for a position in accelerator physics. ASTRID operates half-time for storage of positive/negative ions and molecules and half-time as a synchrotron radiation (SR) source (580 MeV electrons). Concerning ion storage, the research programs focus on laser cooling, electron recombination/cooling, and lifetime measurements of metastable ions and molecules. In SR three beamlines with monochromators are operational at present: 1) a line dedicated to X-ray microscopy, 2) a solid state physics line using a Zeiss PGM (SX 700), and 3) a solid state and atomic physics line using a new spherical grating monochromator (SGM) developed and constructed in Aarhus. A new multipole undulator and beamline have just been funded and will be constructed and installed during the coming two years. A micropole undulator is also under construction.

Candidates having experience at an electron/ion storage ring are highly desirable. The successful candidate shall take part in operation and development of the storage ring facility and will also be encouraged to take part in the research programs. Activities may include RF-systems and beam dynamics calculations. ISA is located in the same building as the Institute of Physics and Astronomy, together with the newly funded Aarhus Center for Advanced Physics - ACAP - with major activities centered around the storage ring facility.

Applicants should submit a curriculum vitæ and list of publications together with the names of 3 professional references not later than October 15, 1993, to Professor E.Uggerhøj, Director of ISA, University of Aarhus, DK-8000 Aarhus C, Denmark.

Further information (newsletters, etc.) can be obtained from ISA on request.

CRN Centre de Recherches Nucléaires de Strasbourg

Professorships in experimental physics : one in high energy and one in nuclear physics

The CRN has a wide ranging field of research with emphasis on nuclear physics and high energy studies. Nuclear physics experiments are performed at national and European facilities existing in the field. A new local accelerator, the VIVITRON, will be operational at Strasbourg by the end of 1993 as well as large multidetectors arrays (e.g. EUROGAM). The research activity of the Professor will focus on this facility in large international collaborations.

High energy experiments are essentially done at CERN at LEP (DELPHI) or with ultrarelativistic heavy ions (Na50, Wa97). There is also a substantial involvement in R&D for LHC experiments essentially in RD28 (gas microstrips). The Professor will take over a large responsability in the development of research towards LHC, especially for the conception and realisation of detectors and electronics.

Teaching: Both Professors will have to teach at Université Louis Pasteur de Strasbourg at all levels.

Applications to be done before octobre 1993 to :
Secrét. Direction CRN F - 67037 Strasbourg Cedex
Tél. : (33) 88 28 62 87 Fax : (33) 88 28 62 92
Contact for N.P. : F.A.Beck (e-mail BECK @frcpn11)
Contact for H.E. : W.Geist (e-mail GEIST @ vxcern)

continually being refined. Dean Karlen of Carleton looked at measurements of B lifetimes. The substantial differences between the lifetimes of different mesons on the charm sector are not reflected with B particles, but small systematic differences could give valuable new insights.

Guido Martinelli of Rome surveyed progress in computer simulations which overcome fundamental calculational difficulties by using conceptual lattices. Form factors from this and other approaches to quark calculations are beginning to agree with each other and with experiment.

The decays of tau leptons into hadrons has often been a sensitive area. Hermann Kolanoski of Dortmund pointed out that a few per cent of the expected decays are 'missing', but no specific channel can be held responsible.

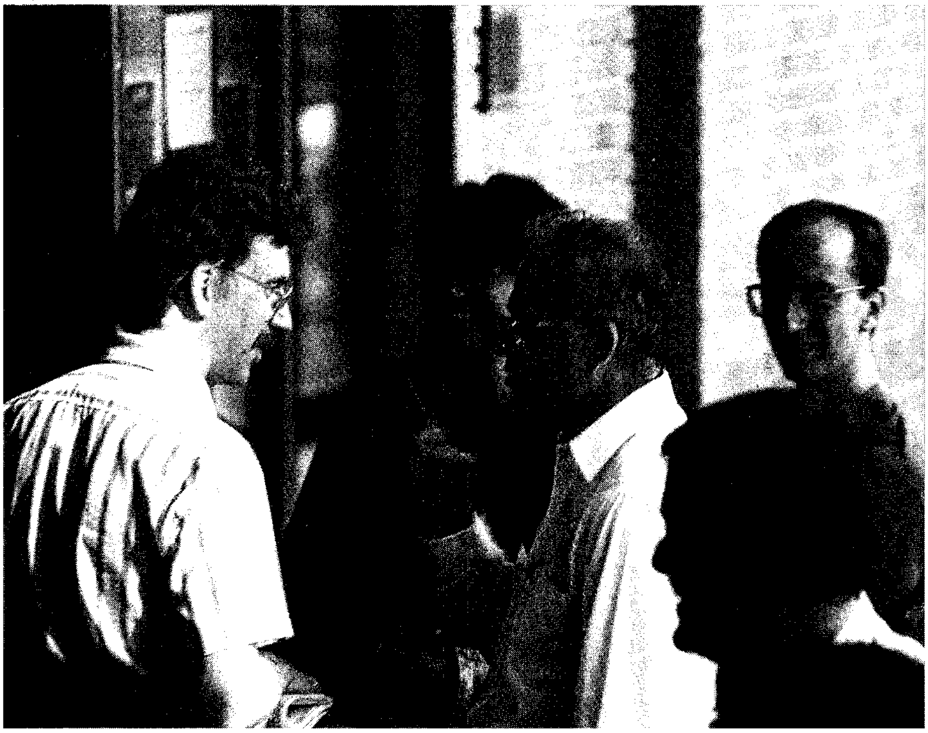
Sheldon Stone of Syracuse reviewed the rich and detailed field of hadrons produced in B decays. In this patchwork, pieces can be taken out and fitted in elsewhere, while details of quark mechanisms are at, or approaching, a level where they merit further attention.

W.J. Marciano of Brookhaven stepped back from the detail of new measurements to survey the underlying quark decay parameters. While CP violation is not understood, it is naturally incorporated in the Cabibbo-Kobayashi-Maskawa matrix of empirical quark decay parameters. On the other hand the more easily visible and therefore familiar left-right (parity) asymmetry of weak decays does not fit into the CKM scheme. A basic question, according to Marciano, is to understand the relation between quark masses. Is the top quark heavy or is it just that the others are light?

A concerted attack on several experimental fronts, backed by good theoretical intelligence, is starting to lift the cover from this difficult corner of heavy flavour physics. However to remove the cover completely might need the collision rate of LEP, the polarization potential of the Stanford SLC, and all the best things combined from the LEP experiments.

The upshot, said Jacques Lefrançois of Paris Sud in his concluding talk, is that a B factory is needed to attack this physics head-on. Given the modest cost of such machines, the world should be able to afford more than just one.

By Gordon Fraser



At the International Symposium on Heavy Flavour Physics, held in Montreal from 6-10 July, Local Organizing Committee Chairman D. Macfarlane (left) talks to Jacques Lefrançois (Paris Sud), who gave the summary talk at the meeting. Behind them is Marie-Claude Lemaire of Saclay, while David Brown of CERN is on the right.

People and things

On 28 June, several days after the meeting of CERN's governing Council, Russian Science Minister Boris Saltykov (left) and CERN Director General Carlo Rubbia signed an updated cooperation agreement between Russia and CERN. At the Council meeting, A. Skrinsky, speaking as Saltykov's special representative, had said 'the three years foreseen for the duration of the new CERN-Russia Cooperation agreement ... should constitute a reasonable transition period in developing long-standing relations, with the final goal of the Russian Federation's full CERN Membership.'

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N. V. Baggett

TRIUMF Laboratory, (Canada)
M. K. Craddock

CERN Council

At the meeting of CERN's governing body, Council, on 25 June, former French Minister of Research Hubert Curien was elected President, for a period of one year from 1 January 1994, to take over from Sir William Mitchell of the UK, who has held the office for three years.

At the same meeting, the Czech Republic and the Slovak Republic separately became Member States, the former Czech and Slovak Republic having become a Member State in January 1992. With the other existing Member States (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and the United Kingdom) this brings the number of CERN Member States to 19.

The Russian Federation declared its intention to seek Membership State status. A. Skrinsky, speaking as special representative of Russian Science Minister B. Saltykov, said 'the three years foreseen for the duration of the new CERN-Russia Cooperation agreement, now in preparation, should constitute a reasonable transition period in developing long-standing relations, with the final goal of the Russian Federation's full CERN Membership.' He also pointed out Russia's firm intention to make a major contribution to the construction of the LHC proton-proton collider to be built in the 27-kilometre LEP tunnel.

On 28 June, several days after the Council meeting, Russian Science Minister Boris Saltykov and CERN Director General Carlo Rubbia signed the updated cooperation agreement between Russia and CERN.

At the Council meeting, a new CERN management structure was approved for January 1994, when Christopher Llewellyn Smith will begin his five-year term as Director General, succeeding Carlo Rubbia. Helmut Weber continues as Director

INFN

ISTITUTO NAZIONALE DI FISICA NUCLEARE

Post-doctoral fellowships for non Italian citizens in the following research areas: Theoretical Physics (n.8) Experimental Physics (n. 14)

Applications are invited for one year fellowships, which will start from September to November 1994.

Fellowships are intended for young post-graduates (candidates should not be more than 35 years of age at the time of application).

Each fellowship is granted for one year, and may be extended for a second year.

The annual gross salary is lit. 30,000,000, plus travel expenses for a return trip from home Institution to I.N.F.N. Section or Laboratory. Lunch tickets will be provided during working days.

Candidates should submit an application form and a statement of their research interests, including three letters of reference.

Applications should reach I.N.F.N. not later than November 30, 1993.

A decision will be taken and communicated within April 1994.

The successfull applicants may carry on their research at any of the following laboratories and sections of I.N.F.N.:

National Laboratories of Frascati (Rome), National Laboratories of Legnaro (Padova), National Southern Laboratories (Catania) and National Gran Sasso Laboratory (L'Aquila).

INFN Sections in the universities of:

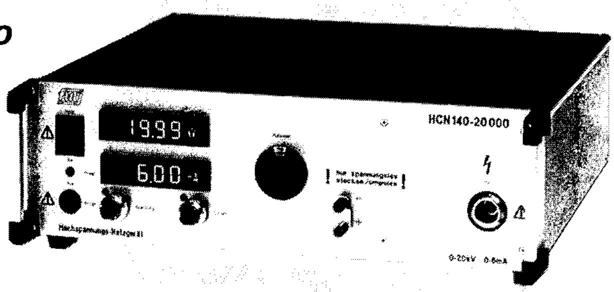
Turin, Milan, Padua, Genoa, Bologna, Pisa, Rome "La Sapienza", Rome II, Naples, Catania, Trieste, Florence, Bari, Pavia, Perugia, Ferrara, Cagliari, Lecce and National Institute for Health (Rome).

Enquiries, requests for application forms, and applications should be addressed to: *Fellowship Service - Personnel Office, Istituto Nazionale di Fisica Nucleare (INFN) - Casella Postale 56 - 00044 Frascati (Roma) Italy.*

UNIVERSITY OF OXFORD
DEPARTMENT OF PHYSICS

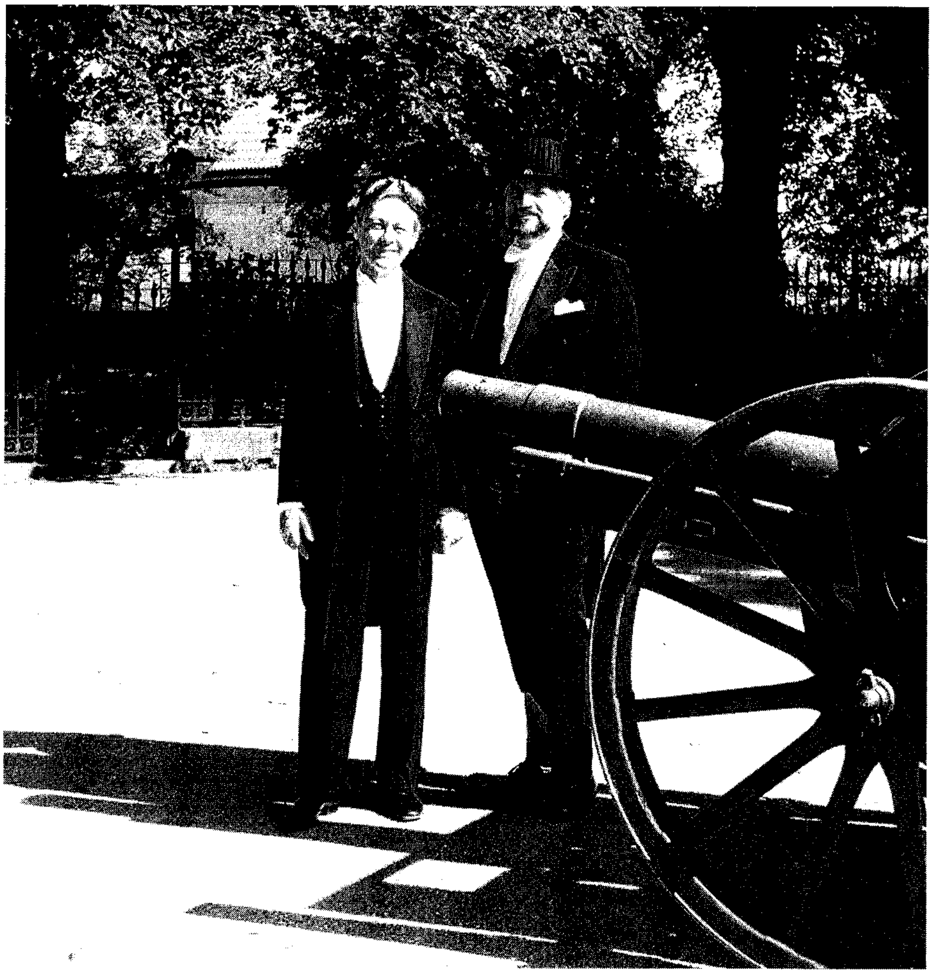
UNIVERSITY LECTURESHIP IN THEORETICAL PHYSICS
in association with Balliol College

Applications are invited for the above post available in the Department of Physics with effect from 1st January, 1994, from candidates with research interests in the area of Elementary Particle/Field Theory. The stipend will be according to age on a scale which is currently £ 13,601 - £ 26,803 per annum. The successful candidate may be offered a Tutorial Fellowship in Theoretical Physics at Balliol College, for which additional emoluments and benefits would be provided. Further particulars may be obtained from Prof. D. Sherrington, Theoretical Physics, 1 Keble Road, Oxford, OX1 3NP (Tel. 0865) 273952, FAX (0865) 273947, Telex 83295 NUCLOX G. Email Margaret@thphys.ox.ac.uk. Applications (8 copies except in the case of overseas candidates when only one is required) should be submitted to Prof. Sherrington by 18th October, 1993. These should include a curriculum vitæ, list of publications, a brief statement of research interests/plans and teaching experience, together with the names of three referees, preferably with telephone and fax numbers and Email addresses.



HCN 140-20000

Ugo Amaldi (left) of CERN and Milan, and spokesman of the Delphi experiment at LEP since its inception, received the degree of Doctor of Philosophy Honoris Causa of the University of Uppsala, Sweden, on 4 June. With him at the cannon which fired a traditional salute in his honour is Tord Ekelof of Uppsala.



of Administration for 1 year. Pierre Darriulat and Walter Hoogland continue as Research Directors until 30 June 1994, when Lorenzo Foa will take over for 3 years. Horst Wenninger will become Research/ Technical Director for 3 years. Kurt Hübner will become Director of Accelerators for 3 years, with Daniel Simon taking his place as Leader of the Proton Synchrotron (PS) Division. Lyndon Evans will become Associate Director for Future Accelerators for 3 years, with Karl-Heinz Kissler taking his place as Leader of SPS/LEP (SL) Division.

On people

Benoit B. Mandelbrot of IBM's Thomas J. Watson Research Center receives the 1993 Wolf Prize for Physics. The citation reads - 'by recognizing the widespread occurrence of fractals and developing mathematical tools for describing them, he has changed our view of nature.'

Ugo Amaldi of CERN and Milan, and spokesman of the Delphi experiment at LEP since its inception, received the degree of Doctor of Philosophy Honoris Causa of the University of Uppsala, Sweden, on 4 June.

Thomas P. Wangler has been appointed a Fellow of Los Alamos National Laboratory. As member of the Laboratory's Accelerator Technology Division, he is well known for his contributions to the development of radiofrequency quadrupoles (RFQs), to the physics of intense ion beams, and to the design of linear ion accelerators. He is a frequent visitor to CERN, where he has most recently been involved in the commissioning of the new RFQ injector.

Masao Kotani 1906-93

Distinguished Japanese theorist Masao Kotani died on 6 June. Outstanding contributions over a wide fields of science, covering atomic and molecular physics, molecular biophysics and information science, earned him the premier Japanese award, the Order of Culture, in 1980 in the presence of the Emperor.

After World War II, his efforts helped Japanese physics to take its rightful place on the world stage. He also played an important role in establishing the KEK Laboratory. His students included former director of Tokyo's Institute for Nuclear Study Yoshio Yamaguchi and first KEK Director Shigeki Suwa.

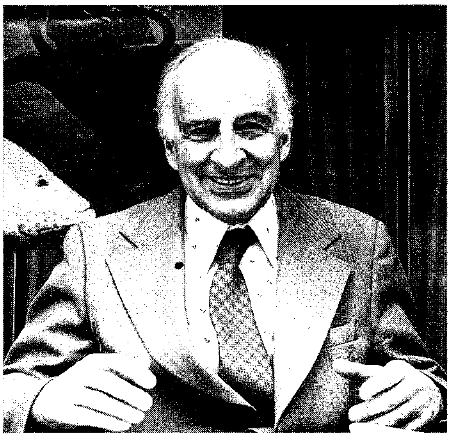
Martin Leneke

Martin Leneke, well known at the DESY Laboratory for his coordinator role at the PETRA electron-positron collider and for his important contributions to the HERA injection scheme, died on 26 May at the age of 49.

Ilya M. Kapchinsky

Ilya M. Kapchinsky of ITEP Moscow, well known as the inventor of the

David Horn (left), Dean of the R. and B. Sackler Faculty of Exact Sciences at Tel Aviv University and Israel's Observer at CERN Council, with Raymond Sackler at a meeting of the University's Board of Governors in May.



22 August marked the 80th birthday of Bruno Pontecorvo, who has been working at the Joint Institute of Nuclear Research, Dubna, near Moscow, for many years. His career, which began with Enrico Fermi in 1934, has greatly influenced weak interaction physics in general and the neutrino sector in particular.

radiofrequency quadrupole (RFQ) accelerator, died in May. In Russia, he planned and directed the construction of several linear accelerators.

Books

In 1960, theorist Sidney Drell received a phone call which changed his career. Since that call he has split his time between physics and US national security policy. His new book 'In the Shadow of the Bomb - Physics and Arms Control' (American Institute of Physics, ISBN 1-56396-058-3) reflects this split. Half the book is about physics and physicists (chapters on Panofsky, T.D. Lee, Weisskopf, Gell-Mann, de-Shalit, and a whole section on the late Andrei Sakharov); half is about arms control, terminating with a section on prospects after the cold war. A series of essays, the book makes interesting and offbeat reading for physicists.

Salam festschrift

The talks at the 'Salamfest' meeting at Trieste in March (June, page 22) are being published as a 700-page festschrift by World Scientific (ISBN 98102-14219).

Together at a ceremony at the Palais de la Découverte in Paris on 9 June in honour of the late Francis Perrin, who died in July 1992, were (left) François de Rose, President of CERN Council 1958-60, and Jean Teillac, President of CERN Council 1978-81.

vrije Universiteit amsterdam

Full professor in experimental physics m/f

Vacancy number 600.3041

Applications are invited for the position of full professor in experimental physics in the Nuclear Physics Group at the Department of Physics and Astronomy.

The Group has an extensive research programme at the 1 GeV electron accelerator AmPS of the National Institute for Nuclear Physics and High Energy Physics (NIKHEF) at Amsterdam and is preparing for research at international facilities. In addition, also through a NIKHEF collaboration, the Group participates in experiments on deep inelastic scattering of high energy muons at CERN. The programme at AmPS includes the study of nucleon correlations and delta excitation in nuclei. As the future research direction the Group envisages the study of hadron structure. In addition, participation in projects such as CP violation and neutrino physics experiments is being considered.

Requirements and qualifications

The appointee is expected to play a leading role in the current research programme with AmPS at NIKHEF and also to initiate and conduct research at other facilities. In addition he/she should take part in teaching and management activities of the Department.

The candidate should have a profound knowledge of the field and a record of outstanding experimental research in subatomic physics. A prominent role in an international collaboration is a strong advantage. Proven teaching capabilities and managerial abilities are required. The candidate is expected to be able to raise external research funds.

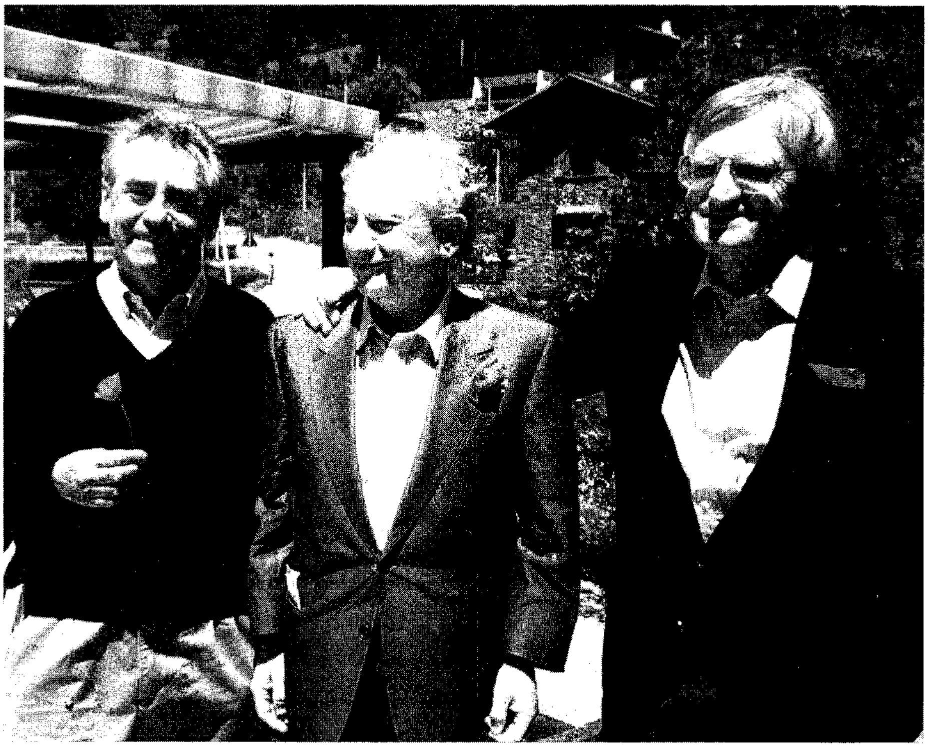
Salary

The salary will be according to the Dutch Civil Servants Code, to a maximum of *f* 11.342,- gross a month (excl. 8% holiday allowance).

Information

Further information may be obtained from professor G. van Middelkoop, tel. +31 20 548 2468 or +31 30 28 06 57 (private).
Letters of application together with curriculum vitae, a list of publications and the names and addresses of three references should be sent before September 30th 1993 to:
Vrije Universiteit, secretaris Faculteit der Natuurkunde en Sterrenkunde, De Boelelaan 1081,
1081 HV Amsterdam, The Netherlands.

Three CERN veterans retiring this year whose activities together span a wide field of activities are (left to right) Henri Laporte, former head of the Laboratory's civil engineering, including LEP construction work, distinguished theorist Sergio Fubini, and Franco Bonaudi, who has overseen several generations of CERN accelerator facilities on an ever-increasing scale. They were snapped by Maurice Jacob at a meeting of friends from CERN and Turin at Etroubles in the Aosta Valley, Italy.



Meetings

The 14th International Conference on Physics in Collision will be held at Florida State University, Tallahassee, Florida, from 15-17 June 1994. Further information from physcoll94@fsuhep.physics.fsu.edu

From 4-8 October, the Third International Workshop on Software Engineering, Artificial Intelligence and Expert Systems for High Energy and Nuclear Physics will be held under the sponsorship of the German and European Physical Societies in Oberammergau. Further information from becks@physik.uni-wuppertal.d400.de or becks@cernvm.cern.ch

With longitudinal spin effects having given a series of physics surprises (EMC Effect, neutron spin structure), attention is turning to the companion transverse polarization, where first results should soon emerge. Among the organizers of a recent special workshop in Geneva to discuss the prospects for this side of spin were Ed Berger (left) of Argonne and Bertrand Vuaridel of Geneva.

Lawrence Jackson Laslett

Lawrence Jackson Laslett died on May 7, aged 80. One of Ernest Lawrence's graduate students in the golden age of the cyclotron, Laslett went on to make important scientific contributions over a wide field, particularly in particle accelerator design. His last 30 years were spent at Lawrence Berkeley Laboratory (LBL), where he was active in research until January 1993.

After his PhD in 1937, he and Sten von Friesen built the first European cyclotron in Copenhagen. After the war, at Iowa State, Laslett made significant contributions to weak-focusing synchrotron design, as well as being active in photonuclear research and spectrometer design. A participant in MURA (Midwestern Universities Research Association) he was a leader in alternating gradient focusing theory, and worked with Cornell on the orbit theory of their first strong-focusing electron synchrotron. He also participated in the

Lawrence Jackson Laslett

initial plans for experiments using colliding beams.

In 1955-56 Laslett turned to digital computation, a tool used with precision and delight for the rest of his career. In that year, with James Snyder and Richard Christian, he did the first digital computation of magnetic fields. He also developed the first integrated programs to calculate particle orbits. By careful attention to fine details, he showed by digital computation that conditions are chaotic.

During World War II he worked on airborne radar at the MIT Radiation Laboratory. From 1961 to 1963 he headed the first office of High Energy Physics at the US Atomic Energy Commission.

In 1963 Laslett returned to Berkeley to work at LBL. He worked on the 200-BeV accelerator design, and made major contributions to the Electron Ring Accelerator design and to all aspects of the Heavy Ion Fusion accelerator programme. Throughout these years he was busy with calculations of fields and on stochasticity. In collaboration with A. Sessler and V. Kelvin Neil, his landmark contributions on collective instabilities opened a new aspect of accelerators to analysis and correction.

When he formally retired in 1987, his major papers were collected and published by the laboratory. The sheer volume was startling. Many people are known for significant contributions in individual fields such as orbit theory, chaos, field computation, instabilities, or spectrometer design. Jackson Laslett made major contributions to every one of these fields, combining great analytical power and rigour with deft physical thinking.

On a personal level, Laslett was exceedingly modest, but quietly shared his insights, work, and perspective, so that many figures today revere him as a mentor. Jackson Laslett was sparing of words, embarrassed by praise. But his twinkling blue eyes bespoke his joyousness in his world of work, family, and friends. It was a great joy to work with such a splendid scientist and person.

From his friends and colleagues

EPS Prize

The European Physical Society's High Energy and Particle Physics Prize goes this year to Martinus Veltman of Michigan (Ann Arbor) for his pioneering work in applying field theory to weak interactions. The prize was awarded during the International Europhysics High Energy Physics Conference in Marseille at the end of July. Previous winners of the prize have been Georges Charpak (1989) and Nicola Cabibbo (1991).

Sick editor

The CERN Courier's Editor was sick as this issue went to press, but tried valiantly to do his best in the circumstances. Recalcitrant contributions have been held over for the October issue, while several missing illustrations have not been chased with their habitual vigour. Alert readers will surely spot unintentional lapses in editorial vigilance.

NESTOR workshop

A small workshop in Pylos, Greece, from 19-21 October will survey the current status of neutrino astrophysics and the possibilities for the proposed NESTOR underwater neutrino telescope (November, page 16). E-mail resvanis @ vx.cern.

France: VELIZY-VILLACOUBLAY
Tel.: (33-1) 30 70 35 00
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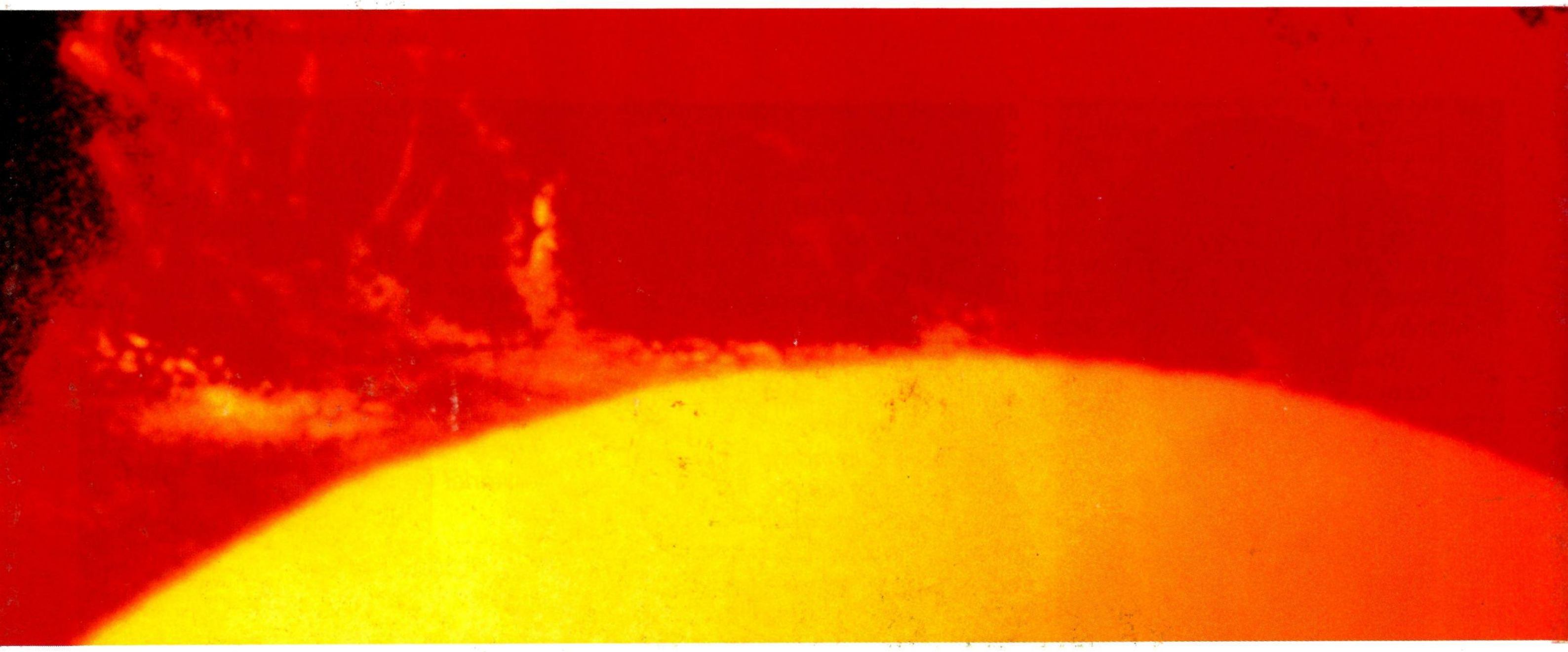
ELECTRON TUBES FOR PARTICLE ACCELERATION AND FUSION.



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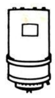

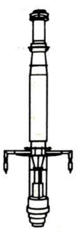

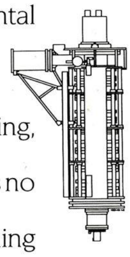

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