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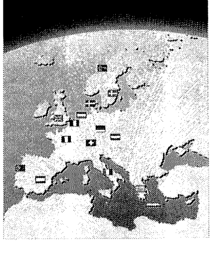

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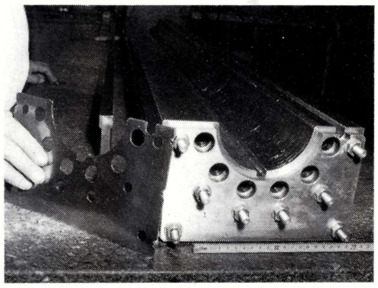

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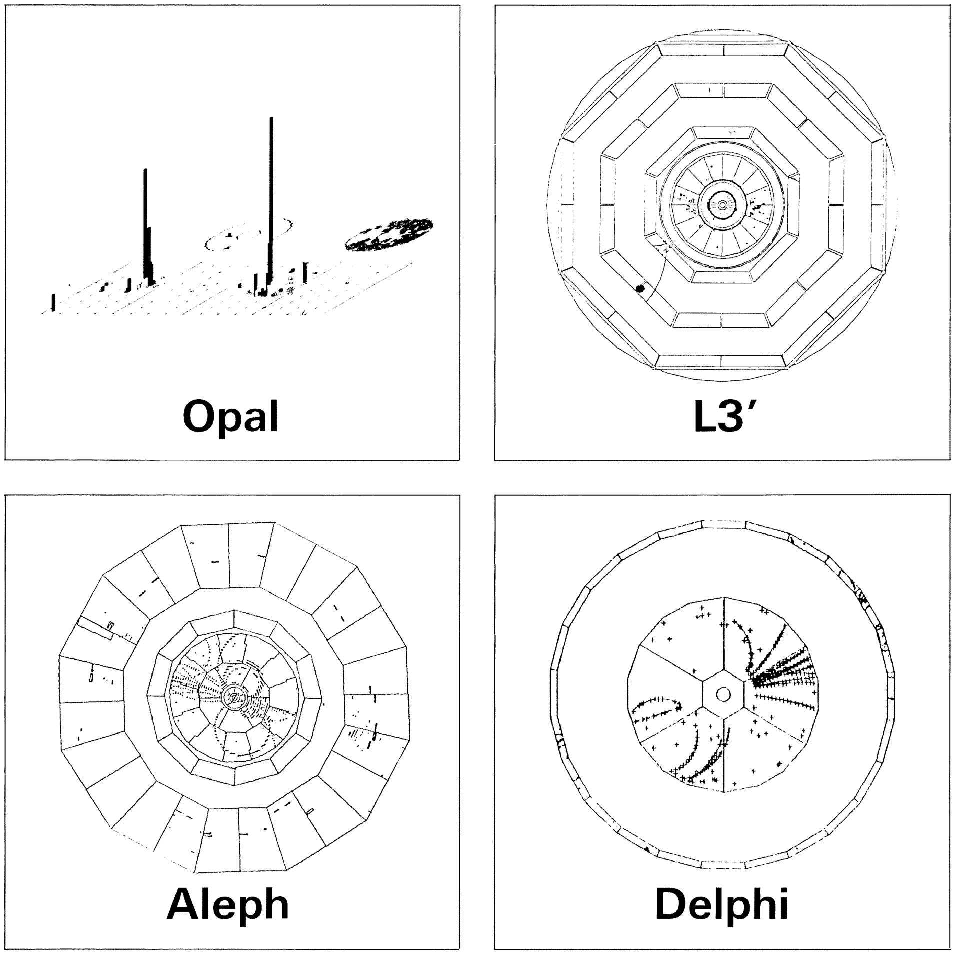
LEP commissioning

Initial Zs in LEP, as seen by the four detectors.



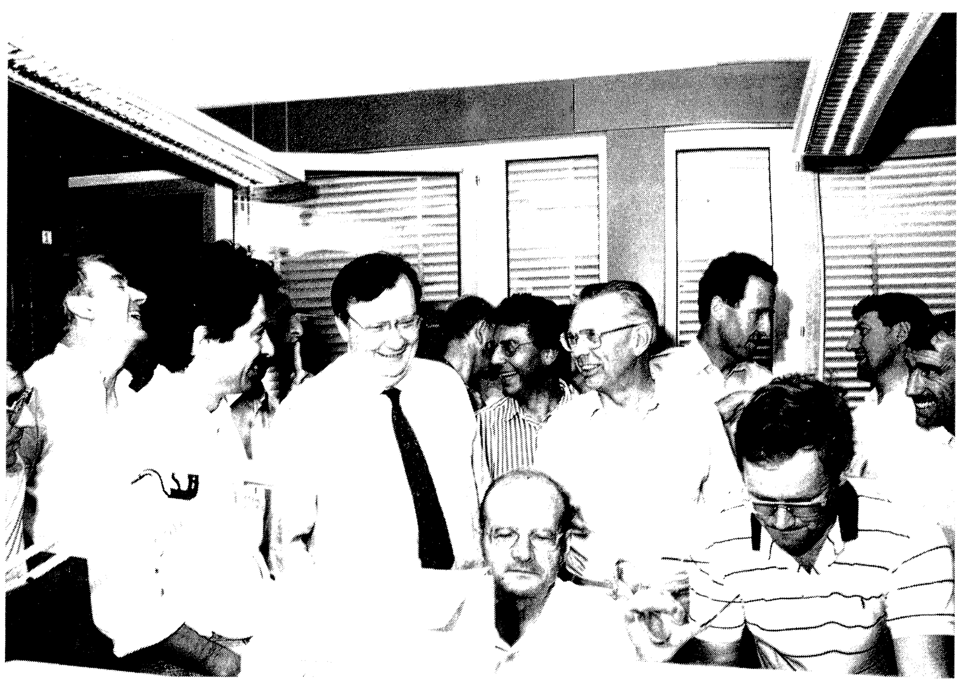
LEP
there be lepton Z!

The particle physics scene this summer was dominated by the commissioning of CERN's new LEP electron-positron collider and the continuing effort by other experiments to contribute to the physics of the W and Z particles, the carriers of the weak nuclear force.

As this issue went to press, LEP was producing its first Z particles and other experiments were announcing important new W and Z results in this rapidly developing physics sector. More news in the October issue.

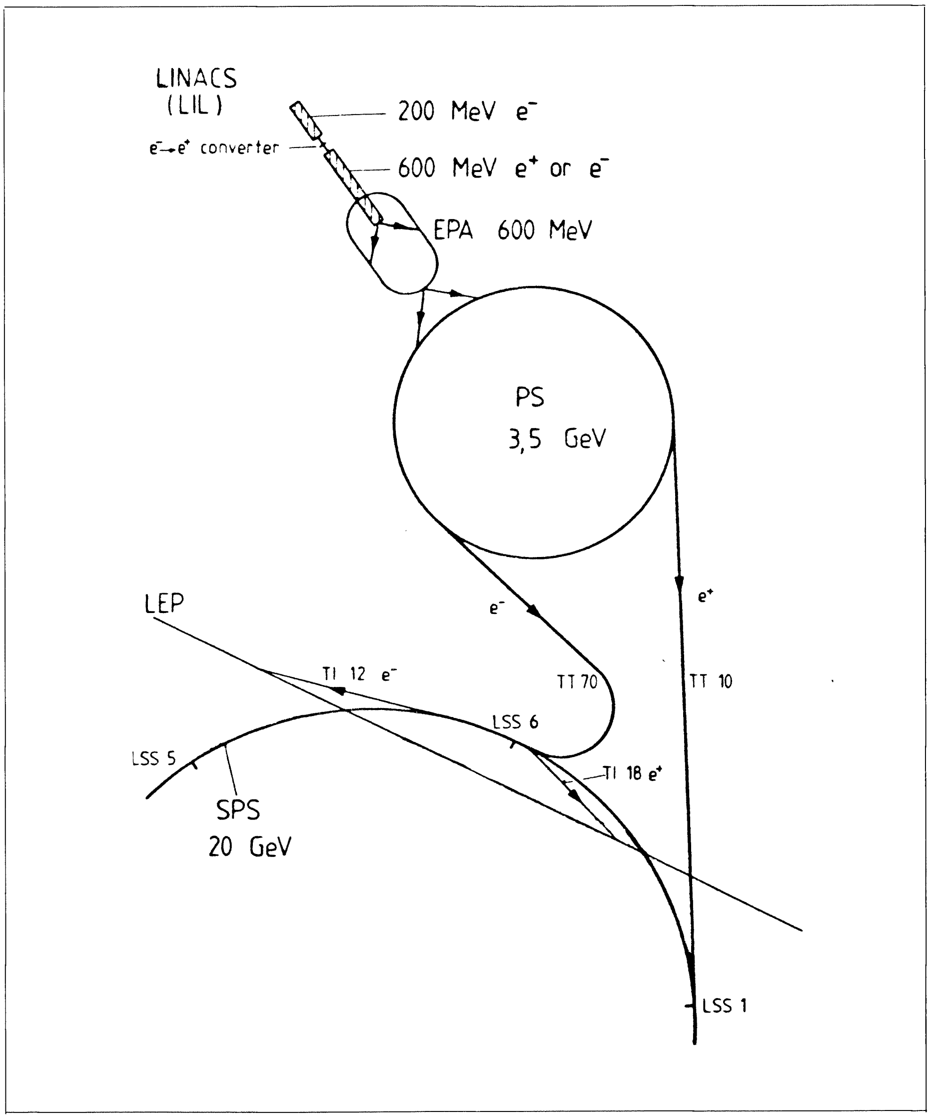
On 14 July, as all France celebrated the bicentenary of its revolution, CERN was the scene of a revolution of a very different kind. At 16.30 hrs, a 20 GeV positron beam went round the 27 kilometres (most of which is under French territory) of CERN's new LEP electron-positron storage ring. After more than a decade of careful planning and preparation, almost six years after groundbreaking, and two years after the start of equipment installation, the LEP team delivered on the day they had told people to mark five years ago.

Following this first injection of positrons, priority was to commission the beam observation monitors. After the first measurements of the beam trajectory, the machine



Jubilation in the LEP control room.

Electrons and positrons for LEP are provided by CERN's complex of interconnected accelerators.



physicists were making the first corrections. Several days later first particles were captured with the radiofrequency system.

Injection from the SPS had initially encountered some difficulties in the standing-wave radiofrequency cavities used for accelerating particles for LEP, but this was soon fixed and there was a steady beam of positrons. Both electrons and positrons were accelerated and extracted on the four lepton cycles, and the transfer line feeding electrons to LEP was commissioned, although no particles were injected at first. Circulating electrons made their appearance in LEP on 25 July.

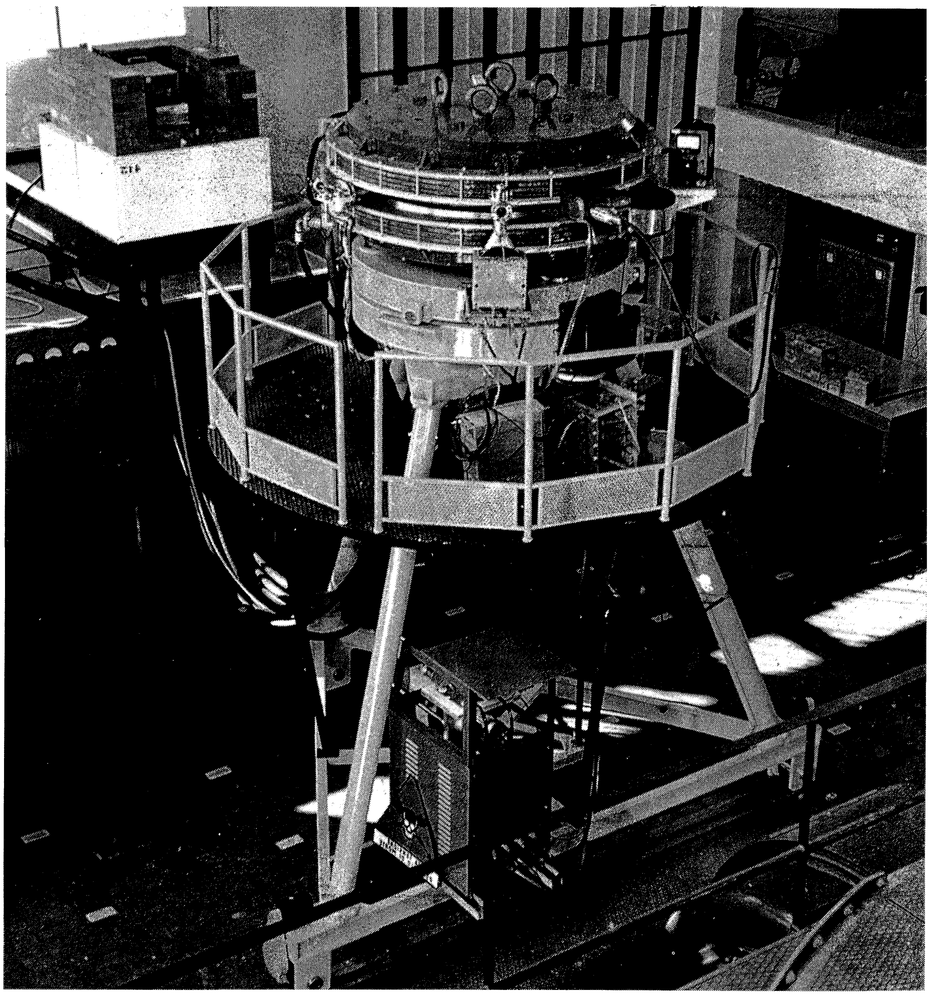
On 27 July positrons were accumulated and stored, the intensity of the stored LEP beam increasing over the following days from 20 to 250 microamps. On 3 August, attention turned to electrons once more, with particles being stored. Later that day, positrons were accelerated from 20 to 47.5 GeV without loss.

Beam currents built up steadily, with positron beam reaching 700 and electrons 300 microamps over the next few days. On 11 August the low beta system came into action to squeeze the beam in the collision points, and there was enough confidence to go for a pilot physics run with 45.5 GeV colliding beams. By 14 August each of the four big experiments – L3, Aleph, Opal and Delphi – had seen their first Z particles. LEP was in business.

During this time, the faithful SPS, using subtle interleaving of acceleration cycles, continued to supply protons for a full programme of fixed target physics at the same time as providing LEP with its electrons and positrons.

Before arriving in LEP, the electrons and positrons have already come a long way, having transited CERN's unique complex of interconnected accelerators. The particles are manufactured by the LIL injector – positrons from an initial 200 MeV high current electron linac providing electron-positron pairs from photon conversion, with a second linac taking electrons and positrons to 600 MeV. They are then stored in the EPA accumulator before being passed to the PS synchrotron for acceleration to 3.5 GeV. Using the same beamlines as the proton-antiproton collider scheme, the particles are then fed into the SPS for acceleration to 20 GeV, ready for injection into LEP.

The commissioning featured regularly updated computer news bulletins. With accurate and up-to-date information readily available, enthusiastic LEP followers could monitor progress without having to pester colleagues who had their hands full.



Forerunner of LEP. Frascati's 60-cm radius AdA electron-positron collider achieved the first electron-positron collisions, at 250 MeV per beam, in 1963. AdA was subsequently moved to the French Orsay Laboratory.

Electron beam machines turn full circle

With the commissioning of CERN's 27-kilometre LEP electron-positron collider, the world's largest electron ring is now in operation. It is almost certain that no larger electron ring will ever be built, although larger machines (for example the proposed US SSC Superconducting Supercollider, with a circumference of 84 kilometres) to handle protons are on the drawing board.

To attain higher electron energies, physicists are now convinced that linear machines and new techniques are needed. The history of electron storage rings thus spans only about a quarter of a century.

In the late 1950s, machine physicists' attention was turning to the possibility of using storage rings to fire two particle beams against each other to obtain higher collision energies. (In firing a single beam against a fixed target, most of the beam energy is 'lost' in the target recoil.) For these ideas, the tide had turned against protons, and physicists were looking at the easier-to-stack electrons.

Three projects got underway. At Stanford, where the Mark III linear accelerator already supplied electrons, a Princeton (Gerry O'Neill, Bernie Gittelman) and Stanford (Pief Panofsky, Burt Richter) collaboration was looking to collide the 500 MeV electron beams held in two rings. At the Soviet Novosibirsk

At the Soviet Novosibirsk Laboratory in May, Director A.N. Skrinsky cuts the cake marking the 25th anniversary of the first electron-electron collision in the VEP-1 machine.

Laboratory, Gersh Budker's team started work on VEP-1, a pair of rings to collide 160 MeV electrons.

However at Frascati in Italy, Bruno Touschek had a different plan. By using electrons and their antimatter counterparts, positrons, he realized that the two beams could be held in a single ring, being brought together at designated collision points. This idea had both physics and economic advantages. The pilot machine, AdA (Annello d'Accumulazione), with a circumference of four metres, supplied its first 250 MeV colliding beams in 1963.

The following year saw electron-electron collisions with the VEP-1 and Princeton-Stanford machines. As well as pioneering a new approach to particle physics, these machines also probed new energy frontiers in the quantum electrodynamical description of inter-electron forces, and discovered the beam-beam effects which still limit collider performance.

A workshop 'Beam-Beam Effects in Circular Colliders' was held at Novosibirsk in May, organized by the ICFA Beam Dynamics Panel.

Developed by a collaboration between CERN and the Austrian firm Elin-Union, a one-metre, 5 cm bore superconducting dipole wound with niobium-tin attained a central magnetic field of 9.5 tesla, a world record for this type of magnet.

Tunnel vision

From the outset, the design of CERN's new LEP electron-positron collider foresaw a large space in the tunnel, enough for a second ring to be mounted above LEP itself. To handle protons, the project for this second ring is called LHC – Large Hadron Collider.

To steer the high energy protons on their course in this ring would need powerful superconducting magnets, capable of being 'ramped' to keep in step with the accelerated particles. The energy of LHC would be governed by the steering power of these magnets, and the CERN Long Range Planning Group, led by Carlo Rubbia, now CERN's Director General, had underlined the importance of a development programme to push for fields of 8-10 tesla.

One line of attack uses niobium-titanium coils with a classical insulation, but requiring cooling with superfluid helium at about 1.8 K. In a collaboration between Ansaldo (Italy) and CERN, a one-metre, 5 cm bore single aperture dipole designed for 8 tesla operation attained fields above 9 T (June 1988, page 13, and November 1988, page 10).

This magnet used 12.6 mm cable based on the superconducting wire developed for the proton ring of the HERA electron-proton collider, now being built at the German DESY Laboratory in Hamburg. It preceded the construction of four magnets with similar geometry, but with the twin apertures needed to accommodate the two beams of a proton-proton collider. These will use 17 mm cable for 10 tesla maximum design field. Featuring special technical solutions, these four magnets are being manufactured by four different European concerns.

The second approach uses 17 mm niobium-tin superconducting cable, operating at normal liquid helium temperature (4.2 K). Due to the brittleness of the niobium-tin compound (Nb_3Sn) and the relatively sharp bending required, the superconducting compound can only be formed in the excitation coils by high temperature reactions after winding. The 'wind and react' technique, used before on a smaller scale, was fostered at CERN by Alfred Asner of the SPS Magnet Group.

The magnets, and particularly the insulation of the coils, need to be robust, having to withstand the thousand degree temperature swing between 700° C (for the niobium-tin reaction) and the cryogenic operating levels, together with the mechanical and dielectric stresses encountered in cooldown, excitation and quenching.

In 1986, a collaboration began between CERN and the Austrian firm Elin-Union, with the former providing the 'wind and react' technology and the niobium-tin cables, and the latter manufacturing the magnets. AMAG (Austria) joined the project, studying and supplying the aluminium alloy collars and shrinking cylinder.

In June, the first one-metre, 5 cm bore dipole wound with niobium-tin was successfully tested at CERN, attaining a bore field of 9.45 tesla at 4.3 K after a few quenches. The maximum field at the cable was 10.05 tesla, with current densities at the 15.05 kA excitation level of 346 and 436 amperes per sq mm in the inner and outer coil layers respectively.

Previously, a 'mirror' dipole of similar dimensions but containing only a single niobium-tin excitation coil (the second being replaced by a magnetic steel mirror insert) attained in February a magnetic field of 10.2 tesla with an excitation current of 17.45 kA.

For both model magnets, the superconducting cables were supplied by Vakuumschmelze (Germany).

These results, both for niobium-titanium and niobium-tin, are world record magnetic fields for accelerator-type dipole magnets and bode well for ongoing progress. The project has been led by A. Asner (now retired) and R. Perin at CERN and by S. Wenger and F. Zerobin for Elin.

LEP PHYSICS
How many types of neutrino?

One of the major outstanding tasks in physics is to count of the number of different types of neutrinos allowed in Nature.

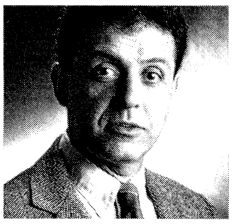
Today's Standard Model of physics sees six types of quark, grouped pairwise into three 'generations'. Although the long-awaited sixth ('top') quark has not yet been seen, physicists are confident that it will turn up.

With each quark-pair generation belongs another particle (electrically charged 'lepton') interacting through electromagnetism and the weak nuclear force of radioactive beta decay. The lightweight electron (0.5 MeV) together with the first generation of 'up' and 'down' quarks make up everyday nuclear matter.

The two subsequent quark generations ('strange' and 'charm', and 'beauty' and 'top') provided exotic nuclear matter in the extreme temperatures of the Big Bang which began the Universe. This matter can be synthesized using high energy particle accelerators or cosmic rays. The corresponding heavier generations of charged leptons are, respectively, the muon, some 200 times heavier than the electron, and the tau, some 17 times heavier still.

Completing the scorecard of basic particles are the lightweight (perhaps massless) neutrinos, released with a charged lepton each time one quark beta decays into another. The three types of neutrino, each associated with a specific quark-pair generation and tagged by the corresponding charged lepton, appear to be immutable. All

This is the second article in a series outlining the physics objectives of CERN's new LEP electron-positron collider, now beginning operation (page 1). The first article (July/August, page 1) described the search for the elusive but vital 'Higgs' symmetry-breaking mechanism of today's electroweak theory.



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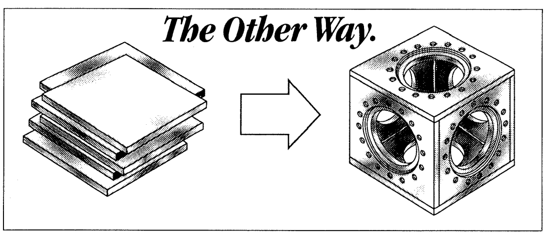

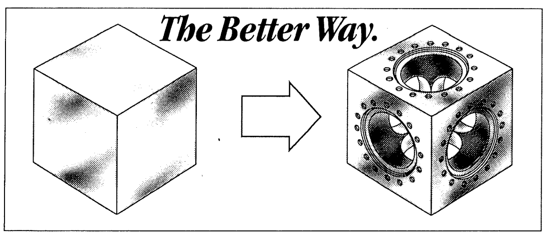

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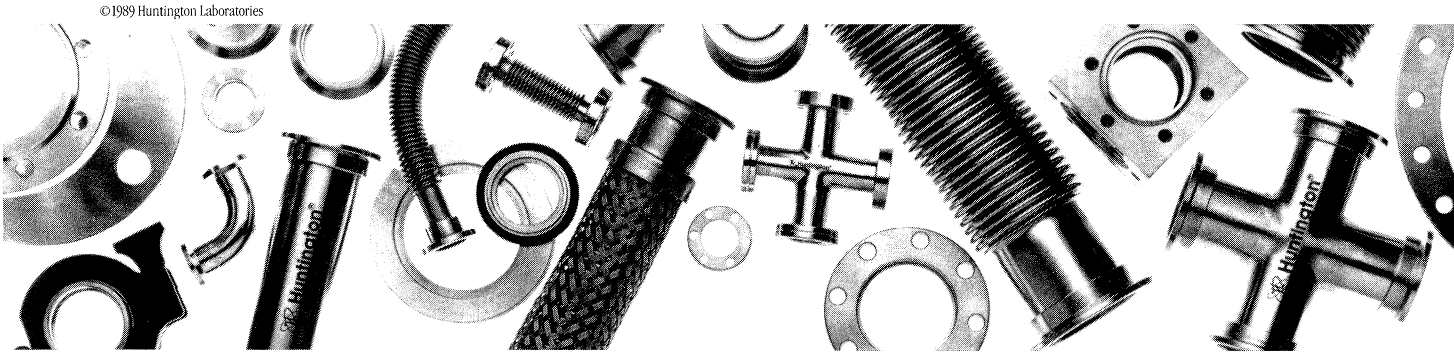


the evidence so far suggests that neutrinos stay electron-type or muon-type, or tau-type, never switching their allegiance.

A precise indication of the number of neutrino types allowed in Nature would provide a good check on the Standard Model and put many cosmology and astrophysics ideas on a firmer footing.

The 1987 supernova and calculations of primordial nucleosynthesis (the fusion of light nuclei – deuterium, helium, lithium – from the protons and neutrons emerging from the Big Bang) suggest that there is room for about three types of neutrinos. But the limit is not rigid and one more type could be squeezed in without too much difficulty.

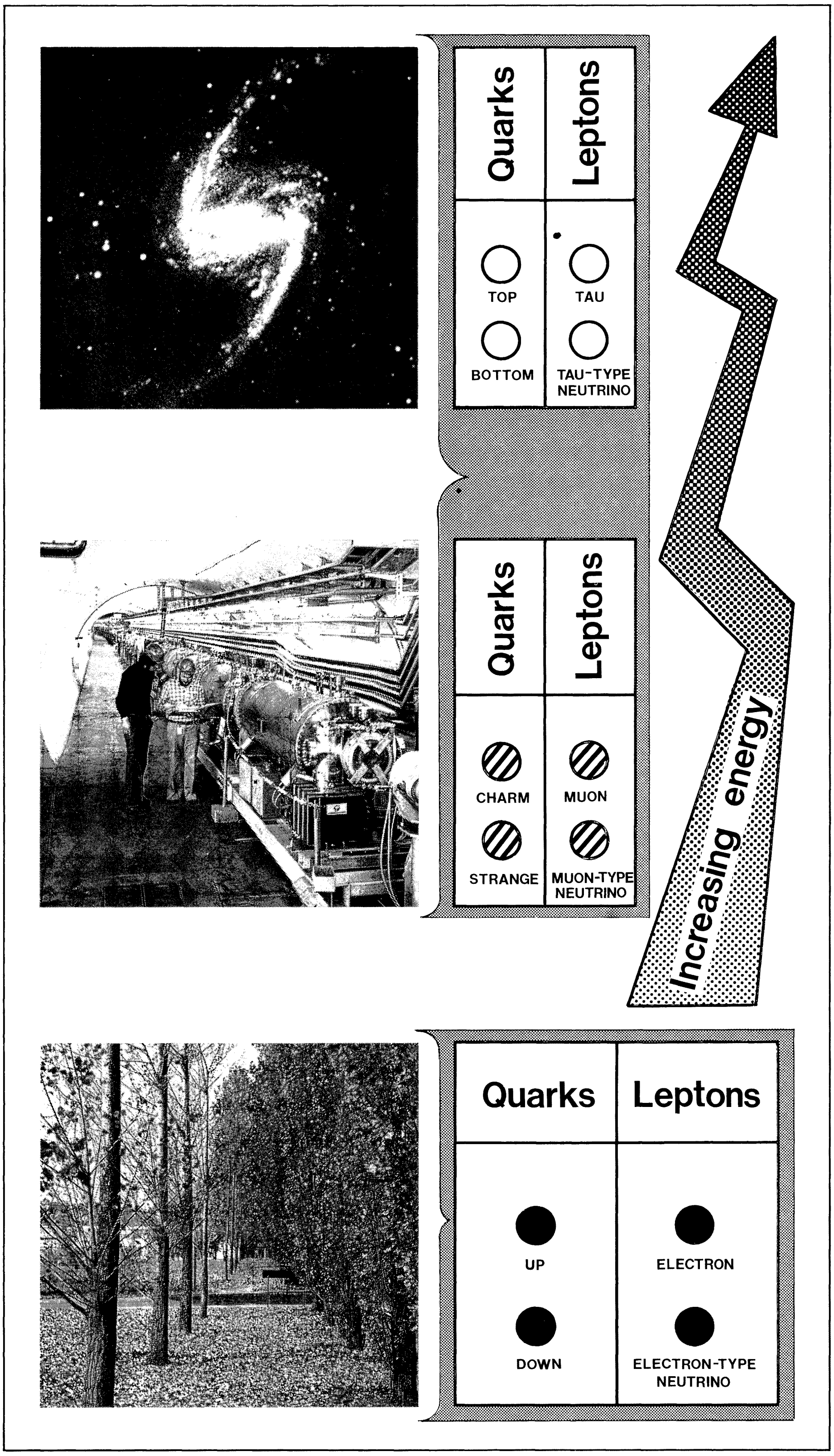
New high energy electron-positron colliders such as CERN's LEP machine and Stanford's SLC linear collider provide a fresh lever on the number of neutrino types, and the big experiments at these colliders will sharpen up our knowledge of the Big Bang.

Neutrinos and the Z

The initial objective at LEP is to open up the supply of Z particles – the electrically neutral carriers of the weak nuclear force. Since it was discovered at CERN in 1983, getting on for a thousand examples have been found in proton-antiproton annihilations at CERN and at Fermilab, and in electron-positron annihilations at Stanford's new SLC linear collider (June issue, page 1, and this issue, pages 6 and 9). LEP aims to make a few thousand Zs per day, even under initial running conditions.

If the Z were a stable particle, it would be a sharply defined resonance – to find it, electron-positron

The constituents of matter as we know them. A quartet of particles (two quarks and two leptons) make up our everyday world. Two heavier additional quartets come into play at the higher energies of astrophysics or in particle accelerators. Counting the number of neutrino types provides a good check on the completeness of this picture.



collisions would have to be precision tuned to the right energy. However because of its role in weak interactions, the Z is far from stable, decaying into oppositely charged leptons, or a quark and an antiquark, or a pair of neutrinos. As a result, the Z is slightly smeared out. Like a radio station, it has a definite bandwidth, with recognizable signals coming in across a well defined range, spread around a central maximum.

The shape and extent of the Z provide vital information about the particle's properties, and an initial task, both at SLC and LEP, is to scan across the low 90 GeV energy range and measure the Z profile. At LEP, the aim is to pin down the width to 50 MeV or better using precision techniques to fix the energy to within about 10 MeV. The profile is also affected by known processes (radiative corrections) and a comprehensive programme of calculations will offset these effects before extracting the final result.

With each neutrino type expected to contribute 170 MeV of bandwidth, a good estimate of the number of neutrino types should emerge fairly rapidly. However any unaccounted-for bandwidth could signal extra neutrino species or other new particles.

Another way to look for neutrinos

Catching neutrinos is difficult – a low-energy neutrino can pass through light-years of absorber and still emerge at the other side, although the chances decrease as the neutrino energy increases. Modern detectors measure neutrinos by the 'missing mass' method, intercepting all the 'visible' products of a particle collision. Pooling released energy-momentum on opposite sides, any mismatch is interpreted as being due to an otherwise invisible particle escaping the detector.

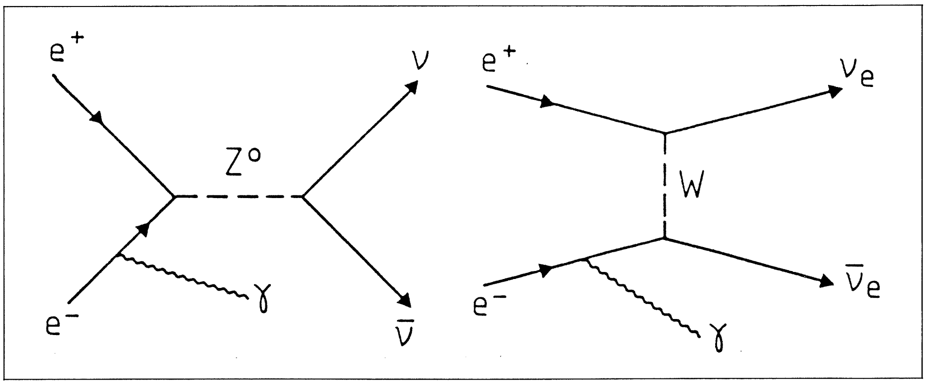
Twenty-five years ago, in the context of new thinking on ways to accelerate electrons to high energies, some Moscow theorists pointed out another way to look for neutrinos. A small fraction of the events would be accompanied by a single, visible, photon recoiling against the neutrinos, providing a direct means of counting neutrinos.

However to be workable, this method needs energy. The results emerging so far from the lower energy electron-positron colliders PEP (Stanford, particularly from the ASP experiment) and PETRA (DESY, Hamburg) provide only a few events, not enough to give an absolute fix on the number of neutrino types. In better shape is the TRISTAN collider at the Japanese KEK Laboratory, where the increased collision energy boosts the recoil photon level sixfold.

However, the advent of Z factories at Stanford's new SLC linear collider and LEP at CERN gives a much higher level of photons, each one recoiling against a pair of neutrinos. The total number of these events is proportional to the number of neutrino species. These results will provide a useful complement to the estimate coming from the measurement of the Z's width. Soon we should know exactly how many types of neutrino exist.

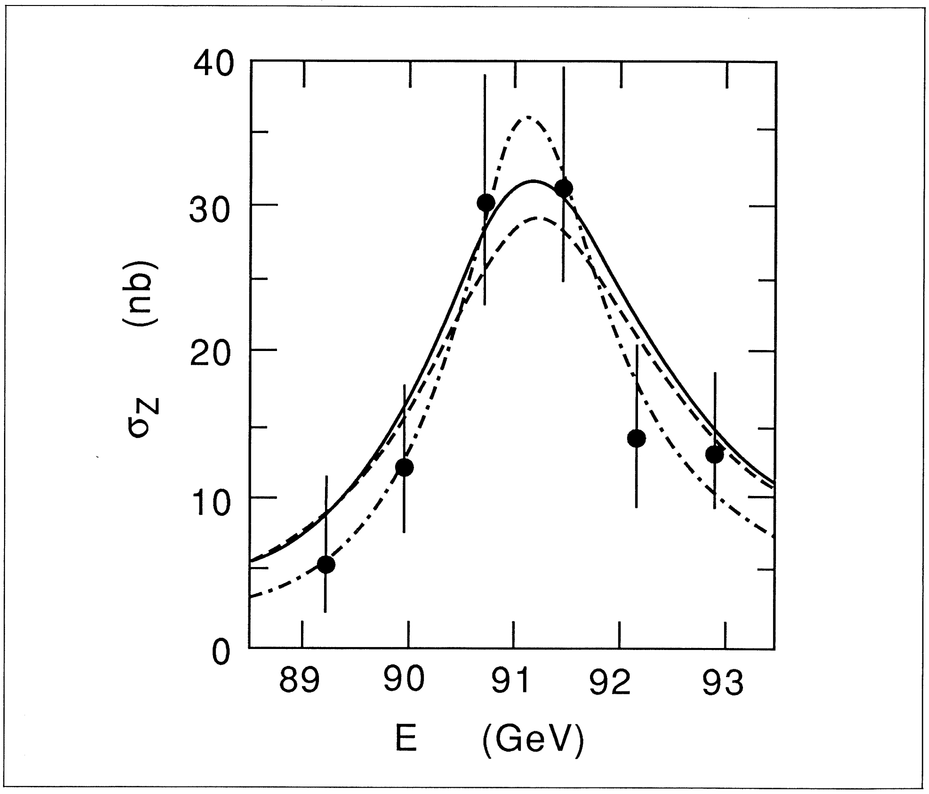
Meanwhile new Z results from SLC and from the experiments at the CERN and Fermilab proton-antiproton colliders prepare the ground (see following stories).

Recoil photons in electron-positron annihilations – a way of seeing otherwise invisible neutrino pairs.



Z results

'There is a resonance here!' A scan of the electron-positron annihilation rate around 91 GeV at the SLC Stanford Linear Collider shows the sharp peak of the Z particle.



While waiting for the first mass production of Z particles at CERN's new LEP electron-positron collider, fresh results on the properties of this particle come from Stanford's SLC linear electron-positron collider and from CERN's and Fermilab's proton-antiproton colliders.

The Z, the electrically neutral carrier of the weak nuclear force, was first seen at CERN's proton-antiproton collider in 1983, leading to the award of the Physics Nobel Prize to Carlo Rubbia and Simon van der Meer the following year. From then until the first Z results from Fermilab last year, all the world supply of information on this particle came from the big UA1 and UA2 experiments at the CERN collider. As these fresh Z results came in, theorists began to speculate on the possibility of the long-awaited sixth 'top' quark being heavier than 100 GeV. Combined with other measurements, precision fixes of the Z mass provide valuable input.

STANFORD
A new look at the Z

On June 21 physicists working on the SLC Stanford Linear Collider announced initial results on the properties of the Z particle, the first to come from electron-positron annihilations.

Speaking at the Topical Conference of the SLAC Summer Institute, Chris Hearty of Berkeley reported the Z mass/width analysis of the Mark II Collaboration, based on a sample of 106 events recorded during the previous three months.

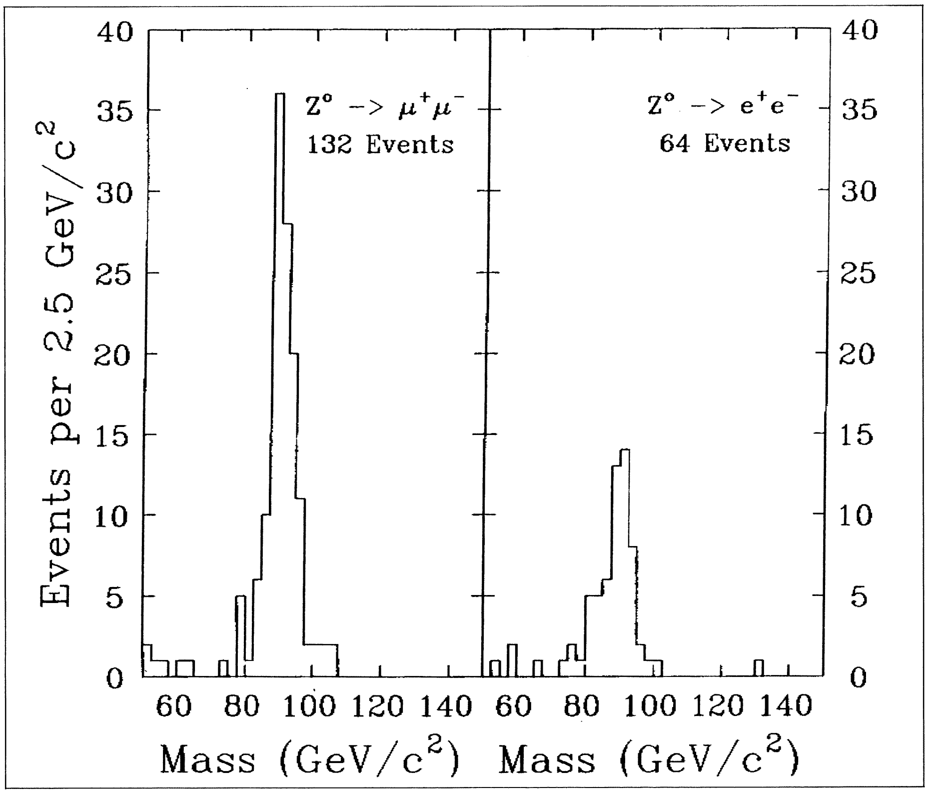
The Mark II is an 1800-ton particle detector built and operated by a collaboration of physicists from Caltech, Johns Hopkins, Berkeley, SLAC, and the Universities of California (Santa Cruz), Colorado, Hawaii, Indiana and Michigan. Since the SLC began producing Z particles in April (see June issue, page 1), the Mark II physicists have measured the electron-positron reaction rate (cross-section) at six values of the total (electron plus positron) energy between 89.2 and 93.0 GeV. 'As you can see, there is a resonance here,' deadpanned Hearty as he showed data peaked about 91 GeV.

Three fits were made to these data, the best-fit Z mass being 91.11 $\pm$ 0.23 GeV. The uncertainty is dominated by random errors due to counting statistics and will come down with additional data-taking. With ten thousand Zs in hand, the quoted error should drop to 0.04 GeV, the absolute accuracy with which the SLC energy is known.

This first batch of data gives upper limits on the Z width and number of light neutrinos – 3.1 GeV and 5.5 respectively. An order of magnitude increase in the number of Zs will improve these limits substantially.

Following Hearty, Tim Barklow of SLAC covered Z decays. In this first sample of hadronic decays, the number of 3-jet and 4-jet events were consistent with expectations. The ratio of leptonic to hadronic decays came in larger than expected, but no firm conclusions could be drawn from this limited data sample.

The Z as seen by the CDF detector at the Fermilab Tevatron.



FERMILAB
One year Tevatron run

The Fermilab 1988-89 900 GeV on 900 GeV proton-antiproton collider run was successfully ended on 1 June, having started on 20 June last year! During this period the accelerator supplied a world record of 9590 inverse nanobarns of collisions to the CDF detector. Beam was stored for over 4257 hours, and peak luminosity was about 2.06 x 10^{30}. The best integrated luminosity in one week was 518 inverse nanobarns. During the run there were 925 stores, of which 133 were ended intentionally, the average length of those stores ending by failure being 9.48 hours.

Last June, the goal had been to collect 1 inverse picobarn (10^{36} cm^{-2}) of integrated luminosity on tape. Reality turned out even better than expectations, and about 4.7 units had been collected by the time the run ended.

A friendly competition between shift crews to see who could write the most data to tape in a single eight-hour shift resulted in a record of 26 inverse nanobarns, almost as much as was collected during the entire 1987 run. The record for a single week was about 0.3 inverse picobarn to tape.

To cope with this high performance, the experiment used a trigger system with four levels. Levels 0, 1 and 2 were debugged last summer and were fully operational by September. The event rejection power of the Level 3 trigger system, consisting of about 50 Advanced Computer Program (ACP) nodes, was steadily increased during the run, eventually attaining a factor of about 3.

Events passing the Level 3 trigger were written to magnetic tape for offline analysis – a total of about 5500 9-track tapes, containing about 6 million events. Offline event reconstruction on a large scale began on two 65-node ACP systems operated by the Fermilab Computing Department at the start of the year.

However to get an early look at interesting physics, certain event types were selected for full reconstruction in a special production cycle. Based on a preliminary event selection, about 600 Z decays into electron-positron pairs and about 5000 W decays into an electron and a neutrino were identified, and the search for the elusive sixth 'top' quark was begun.

The first result to emerge is the mass of the Z. Using the entire 4.7 inverse picobarn data sample, the CDF result, based on 64 Z decays into electron-positron pairs and 132 into muon pairs, is 90.9 ± 0.3 ± 0.2 GeV, consistent with the earlier measurements by the UA1 and UA2 experiments at CERN's proton-antiproton collider, but with improved magnetic analysis.

The continuing data analysis will keep the CDF group busy until the next Collider run begins in 1991.

CERN
Record antiproton performances

CERN's 1988-9 antiproton operations were separated by a three-month shutdown at the beginning of this year. In two three-month runs, the SPS supplied 7810 inverse nanobarns of proton-antiproton collisions (3372 of which were in the 1988 run) over a total stored beam time of 2450 hours (1206 in 1988).

(The performance of a colliding beam machine is measured by its 'luminosity' – the number of particles per second in one beam times the number of particles per unit area intercepted in the other beam. In particle collisions, areas are measured in terms of 'barn' units of 10^{-24} sq cm, the term deriving from a physics remark by Niels Bohr - 'as easy as hitting a barn'. For particle collisions, a barn is gigantic – millibarns and nanobarns are the norm. Accumulated collision data is metered by 'integrated luminosity', expressed as inverse nanobarns or inverse picobarns – a thousand of the former being equivalent to one of the latter.)

Peak SPS collider luminosity occurred on 25 May with 2.95 x 10^{30} per sq cm per s. The best result from a single store was the 97 inverse nanobarns on 7 June, but 14 May had seen 120 inverse nanobarns in a single day. The longest SPS store lasted for 45.5 hours.

Upstream, the antiproton supply attained new highs. The endurance record for a stack in the AA antiproton accumulator was almost 48 days. A best of more than 10^{12} particles came on 8 June, and a peak hourly stacking rate of 5.8 x 10^{10} on 28 May. These performances underlined the success of the ACOL project in upgrading CERN's antiproton capacity.

Physics dividends will emerge in the coming months. One result was the new record low antiproton energies (see page 23).

At the International Lepton/Photon Symposium held at Stanford in August, the UA2 collaboration gave new results for the masses of both the Z and W particles.

While the Z has become the business of the LEP and SLC electron-positron colliders, these machines do not yet have enough collision energy to form the electrically-charged Ws, which would have to be produced in pairs. Thus W information from the experiments at the proton-antiproton colliders will continue to provide important physics input.

Around the Laboratories

* See page 37

SUPERCOLLIDER Update*

With final federal funding decisions still in the pipeline, the US Department of Energy's January confirmation of the Ellis County, Texas, site for the proposed US Superconducting Supercollider (SSC) was accompanied by a promise of some $1,000 million of Texas state construction money. The 84 kilometre ring to collide 20 TeV (20,000 GeV) proton beams would be built underground about 40 km south of Dallas, within easy reach of Dallas-Fort Worth airport, in a semirural setting of flat and gently rolling prairies.

Construction and operation of the SSC would be managed for the Department of Energy by the Universities Research Association (URA), the consortium of 72 universities which currently operates Fermilab. For the SSC venture, URA has two industrial partners – EG and G Inc, which provides engineering, logistic and other technical support, and the Sverdrup Corp., with extensive experience in the management of large construction projects.

Roy F. Schwitters of Harvard, co-spokesman of the Collider Detector at Fermilab (CDF) group, and a member of the team which discovered the hidden charm of the J/psi particle at Stanford's SPEAR electron-positron ring in the mid-70s, has been named Laboratory Director.

Appointed Deputy Laboratory Director and Construction Project Manager is Richard Briggs, formerly Associate Director for the beam research and magnetic fusion energy programmes at Livermore. The Magnet Division will be led by Tho-

mas Bush, formerly with Science Applications International Corp. Helen Edwards, formerly Head of Fermilab's Accelerator Division, will be Head of the SSC Accelerator Systems Division.

The SSC team is assembling at new temporary headquarters in Dallas, with the Central Design Group migrating from Berkeley. (The address is 2550 Beckleymeade Avenue, Dallas, Texas 75237, telephone (214) 708-9000, bitnet SSCVX1).

Appointed to the SSC's scientific policy committee are T. Appelquist (Yale), K. Berkelman (Cornell), L. Di Lella (CERN), J. Friedman (MIT), H. Harari (Weizmann), L. Lederman (Chicago/Fermilab), T. Nishikawa (KEK), L. Okun (ITEP, Moscow), R. Palmer (Brookhaven/SLAC), D. Perkins (Oxford), W. Press (Harvard), J. Rees (SLAC), D. Stairs (McGill), S. Ting (MIT), R. Turlay (Saclay), and S. Weinberg (Austin, Texas).

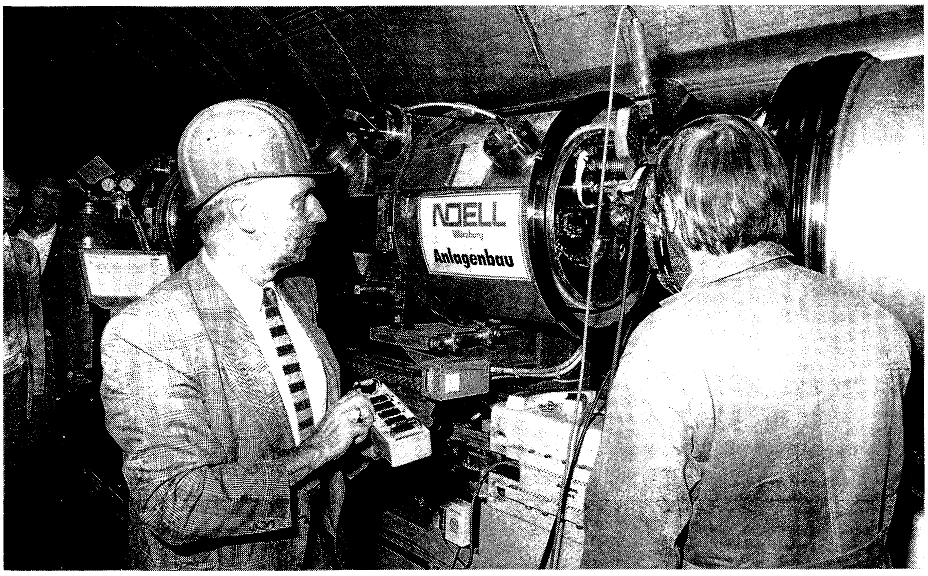
SSC experiments are expected to attract more than 1,000 physicists from all over the world. Plans for selecting the first round will be developed with input from the scientific policy committee and the users. In addition, an international programme advisory committee will be set up.

Precise dates for examining first-round experimental proposals will be set in the fall after the first meeting of the scientific policy committee, however a tentative plan calls for letters of intent by next May, with final proposals by May 1991.

Part of the Texas state support includes $100 million for physics research by qualified scientists, based on national peer review (further information from Edward C. Bingler, Executive Director, Texas National Research Laboratory Commission, 1801 N. Hampton Road, Suite 252, De Soto, Texas 75115).

A symposium on SSC physics and experiments will be held in Dallas from 1-4 October, where the SSC status, opportunities for new physics, experimental programme plans, and possibilities for international cooperation will all be reviewed. Participants will also be able to see the Ellis County site and savour the famous Texas hospitality (further information from Linda Hill, Meeting Management Associates, 4100 McEwan, Suite 101, Dallas, Texas 75244, telephone (214) 386-9403).

On 21 June, DESY Director Volker Soergel started the welding to join the first two superconducting magnets in the proton ring of the HERA electron-proton collider being built at the German DESY Laboratory in Hamburg.



DESY HERA progress

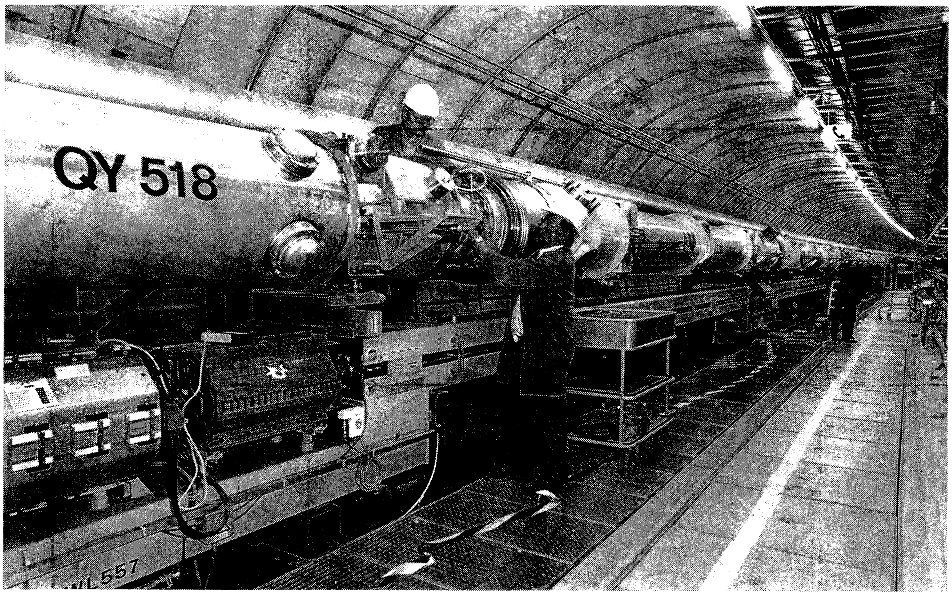
The 246 superconducting quadrupoles for the proton ring of the HERA electron-proton collider have been delivered to the German DESY Laboratory in Hamburg. About half were built by Alsthom (France) as a French contribution to the HERA project. The remaining half were built by German industry – the coils wound and clamped by Interatom-KWU and the magnets assembled by Noell. Superconducting cable was supplied by Vakuumschmelze. Besides the 1.8 m quadrupole magnet, a 12-pole persistent current correction coil, a superferric dipole correction magnet and, in some cases, a superferric correction quadrupole are installed in the quadrupole cryostat.

Design of the quadrupoles, development of production tooling and prototype construction were carried out at the French Saclay Laboratory. Saclay staff, in collaboration with DESY, also supervised industrial construction.

So far some 160 of these magnets have passed their stringent acceptance tests at liquid helium temperatures. Field quality is better than required and the magnets attain a short sample current limit of 7500 A, well above the 5026 A needed for storing 820 GeV protons in HERA, all with little or no training. It is a testimony to the careful Saclay design and the excellent industrial workmanship that all the magnets tested so far meet the

First cell of HERA, with bending magnets, quadrupoles and many other components of the proton ring already mounted above the electron ring.

(Photos J. Schmidt – DESY)



specifications and will be installed in the 6.4 kilometre ring tunnel.

On 3 July, when proton ring installation work was interrupted for three months to allow further commissioning of the adjacent electron ring (where first particles were stored in August 88), 82 superconducting quadrupoles and 10 superconducting dipoles were in place. A forthcoming report will cover series production of the dipoles in Italy and Germany. The conventional magnets to guide HERA's protons over almost a kilometre around the interaction points have also been installed.

The fourfold transfer line (constructed by Linde, with Babcock as subcontractor) to feed helium liquid and gas to the superconducting magnets is in place. The 1.6 kilometre segments linking the North and South experimental halls with the central refrigeration plant are now operational and provide cooling for testing the superconducting solenoid coils of the H1 (North hall) and Zeus (South hall) experiments.

In the meantime the DESY III proton synchrotron (January/February issue, page 15) and its Linac III injector have been tested and are ready to produce 7 GeV protons for transfer to the PETRA ring, their next point of call en route to HERA.

SACLAY
Krypton from Saturne

At the beginning of June, the Saturne synchrotron at Saclay accelerated and supplied its first beams of krypton ions (mass 84).

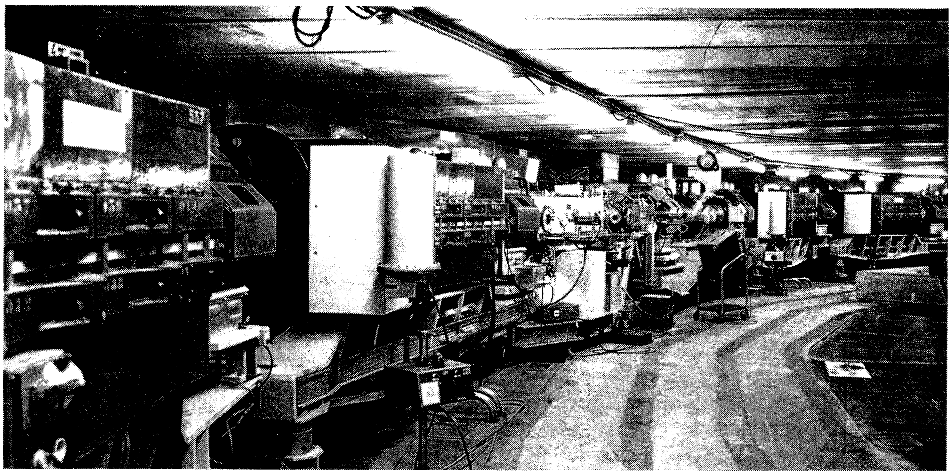
After the commissioning of the MIMAS booster/accumulator ring last year (May 1988, page 5), Saturne can provide high intensity beams of polarized (spin oriented) particles and a range of ion beams extending from carbon to krypton.

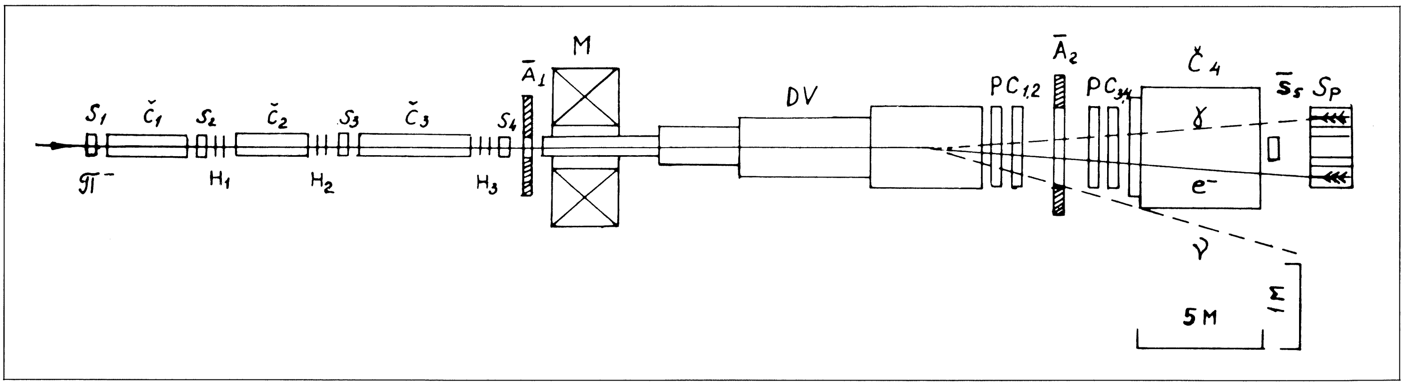
The ions, produced by an EBIS-type source at 12.5 keV per nucleon, are then accelerated by a radiofrequency quadrupole (RFQ) to the MIMAS injection energy of 187.5 keV per nucleon. In storage mode, MIMAS can take, for example, up to seven pulses of nitrogen spaced by 40 milliseconds. After adiabatic capture, the stack is taken to 12 MeV per nucleon and then transferred by kicker magnets during Saturne ramping, with 100 percent recapture.

To limit 187.5 keV ion losses by charge exchange on residual gas, a single pulse of krypton 30+ is used (production time 120 ms). In the 3 x 10^{-11} torr vacuum in MIMAS and 3 x 10^{-9} in Saturne, no losses are observed.

Maximum energies are fixed by Saturne's characteristics and by the charge state of the ions at 3 GeV for protons and about 30

The Saturne ring (top) at Saclay, fed by the MIMAS booster/accumulator (below) has supplied its first beam of krypton ions.





The ISTRA apparatus used by an Institute for Nuclear Research, Moscow, team working at the 70 GeV proton synchrotron at the Institute of High Energy Physics, Protvino, Serpukhov, to study rare decays of pions and kaons. S denotes scintillation counters, and C Cherenkov counters with photomultiplier readout developed at IHEP. Decay products in the vacuum volume DV were detected by proportional chambers (PC), a wide-aperture Cherenkov (C_4), and the Sp total absorption spectrometer containing 480 lead-glass elements.

MeV per nucleon for krypton 30+. With these beams Saturne provides a useful window for the study of nuclear matter.

During the krypton run, extraction attained 20 per cent, allowing 5 x 10^7 charges per burst at 1 Hz for physics. Machine setting was carried out in two phases, with an initial dense nitrogen 5+ pilot beam being used to tune the two synchrotrons.

The beam intensity and reliability provided excellent experimental conditions. A team using the SPES IV spectrometer is studying the role of the incident ion energy in peripheral collisions. The results will show whether, at 200 MeV per nucleon, pure fragmentation – breakup of projectiles and target without deposition of energy – is dominant, or whether there is still room for the energy dissipation seen below 100 MeV per nucleon.

MOSCOW
Looking at rare decays

The first stage of a new study of some rare decays of negatively-charged pions and kaons has been completed by scientists of the Institute for Nuclear Research of the Soviet Academy of Sciences, Moscow. The experiment used the ISTRA apparatus to take data from 1984-8 using a secondary beam of the 70 GeV proton synchrotron at the Institute for High Energy Physics, Protvino, Serpukhov.

In the decay of a pion into an electron, a neutrino and a photon the structure of the quantum mechanical amplitude includes the two currents (vector and axial vector) of the weak nuclear interaction. The structure of this amplitude is essential for other meson radiative decays (such as a kaon into two pions and a photon).

Theoretical arguments (conserved vector current) link the vector current contribution to the decay of a neutral pion into two photons, but the axial vector part needs input.

In the Moscow experiment, the decay products of negatively charged pions and kaons of momenta 17 and 25 GeV/c respectively were analysed over a wide angular range. The ratio of axial vector to vector contributions was obtained as 0.41 ± 0.23, excluding a negative value reported in previous experiments, and an independent estimate obtained for the vector coupling of the pion. The branching ratio (relative decay probability) for this type of pion decay was measured as $1.61 \pm 0.23 \times 10^{-7}$. Branching ratios were also measured for a range of kaon decays.

Additional elements (magnet spectrometer, hadron calorimeter and muon identifier) have been added to the ISTRA setup, and the new ISTRA-M version will go on to make further investigations of rare kaon decays.

CONFERENCE
Elastic and diffractive scattering

Elastic scattering, when particles appear to 'bounce' off each other, and the related phenomena of diffractive scattering are currently less fashionable than the study of hard scattering processes. However this could change rapidly if unexpected results from the UA4 experiment at the CERN Collider (January/February 1988, page 32) are confirmed and their implications tested.

These questions were highlighted at the third 'Blois Workshop' on Elastic and Diffractive Scattering, held early in May on the Evanston campus of Northwestern University, near Chicago. (The title

Some members of the Moscow Institute for Nuclear Research team near the ISTRA lead-glass spectrometer (see page 18) – left to right, O.M. Isakova, V.V. Isakov, V.A. Lebedev, V.N. Marin, A.A. Poblaguev, V.E. Postoev, and experiment leader V.N. Bolotov.

stems from the inaugural meeting held four years ago at the Château de Blois.)

The theme of this year's workshop was the interface of 'soft' and 'hard' processes in quantum chromodynamics (QCD, the candidate theory of quark dynamics – in this context soft and hard respectively mean small and large transverse momenta, according to whether the interactions occur on the surface or deep inside the struck protons).

Improved understanding of QCD has motivated ambitious theorists to look at the elastic and diffractive arena. At present this translates into a variety of claims (and counter-claims) that calculations based on QCD can explain a variety of effects. Summarizing the meeting, P. Landshoff declared that there was 'much more dynamics than at Blois in 1985' – a trend he found very encouraging.

Opening the meeting, André Martin reviewed the status of elastic scattering, emphasizing the importance of continuing experiments. Many important ideas can be tested, even though precise predictions are not always available. The measurement of the total cross-section (reaction rate) at Fermilab's Tevatron Collider by experiment E710 has been eagerly awaited following the excitement generated by the CERN result. If the CERN result (a large real part of the scattering amplitude) anticipates a 'new threshold' then a large cross-section is expected at Fermilab energies.

R. Rubinstein presented preliminary E710 results for the total cross-section of colliding 900 GeV proton and antiproton beams – 85.5 millibarns (± 6.4) compared with 56.1 mb (±4.7) for 150 GeV beams. Since the errors at the two energies are correlated (with the luminosity) and the lower energy value fits well with other results, the central value of 85.5 mb could have more significance than the large error implies. It is consistent with the new threshold interpretation of the UA4 result but is not large enough to unambiguously resolve the issue. The systematic error due to the luminosity is soon expected to come down.

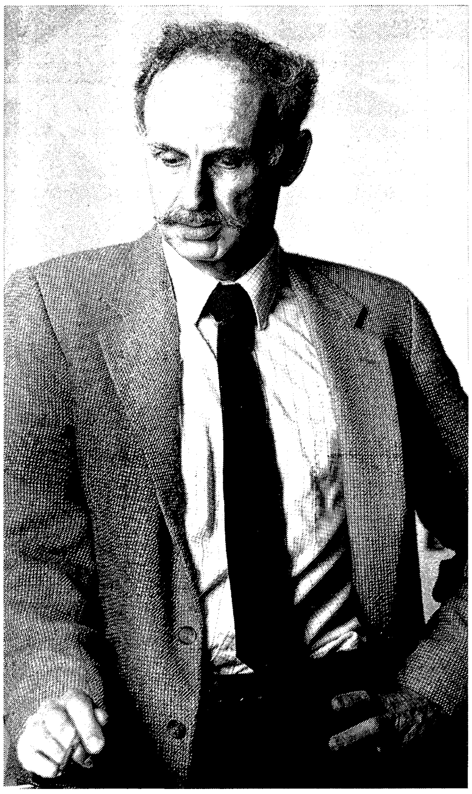
Theorists arguing that the rising total cross-section reflects an increased production of 'jets' – narrow sprays of particles due to 'hard' constituent quark interactions – included B. Margolis, M. Ryskin, N. Nikolaev, F. Halzen, I. Sarcevic, L. Durand, and P. Kluit. Ryskin described the 'Leningrad Programme', claiming that perturbative QCD is indeed 'valid for large cross-section processes at high energy because the characteristic transverse momenta of gluons (quarks) increase with energy'. Halzen appealed to cosmic rays to argue that above total collision energies of 4 TeV (4000 GeV), all events have jets.

Theorists arguing that the dominant contribution to the rising cross-section is a 'soft' mechanism (the Pomeron) included P. Landshoff, C. Tan, A. Capella and J. Tran Thanh Van. A. White argued that within QCD, jets may be dominant over some energy range but new particle states might appear at higher transverse momenta.

M. Schub reviewed results from the CDF detector at Fermilab, pointing out that the increase in transverse momentum with energy is due mainly to the production of low transverse momentum particles. N. Morgan described related results from E735, an experiment searching for evidence of quark-gluon plasma.

T. Meyer reviewed the extensive programme of (double Pomeron) studies from CERN's Intersecting

Roy Rubinstein – preliminary results for the elastic scattering of 900 GeV protons and antiprotons.



Storage Rings, where virtual states intrinsically present in the vacuum are 'kicked' into reality when two protons glance past each other. M. Albrow outlined possible extensions of these experiments using multi-TeV proton beams at proposed new colliders. C. Peroni described additional diffractive physics – Pomeron-photon collisions – at the HERA electron-proton collider now being built at the German DESY Laboratory in Hamburg.

Cosmic ray results were reviewed by T. Gaisser who emphasized the model dependence involved in extracting the proton-proton cross-section from the proton-air data. G. Yodh looked at exotic cosmic ray events, in particular the excess muons produced by what are apparently high energy photons.

K. Goulianos gave a general review of diffraction. Although it was disappointing to have no new experimental results on diffractive production processes, although the UA8 experiment at CERN was not represented at the meeting and although the CDF collaboration is still deep in analysis, this did not seem to hinder theoretical speculations.

From Alan White

CERN
Real cool antiprotons

CERN and Fermilab are the world's two major sources of antiprotons for physics experiments. At CERN's antiproton complex, operational since 1981, the particles have been taken as high as 450 GeV per beam. At Fermilab, where first antiproton beams appeared in 1985, the energies are regularly ramped to 800 GeV.

However CERN has several strings to its antiproton bow. The LEAR low energy antiproton ring takes the particles down to kinetic energies of 5.9 MeV for a unique range of experiments. For the special physics objectives of a Harvard/Mainz/Washington team – to slow down antiprotons as much as possible to measure their static properties – even these subdued energies are far too high.

Ultra-low energy charged particles are usually caught and stored in Penning traps, where an electrostatic quadrupole field locks the normal cyclotron magnetic field revolutions. Using such a trap, a lone electron was once kept for ten months!

The thermal vibration of trapped particles is often suppressed by a cold 'buffer' gas, however this technique is unsuitable for antiprotons, which quickly annihilate with the protons and neutrons of ordinary nuclei. Instead, a gas of electrons at cryogenic temperatures (4.2K) surrounds the antiprotons and absorbs their thermal energy.

Robert Tjoelker (Harvard) exults at achieving cryogenic antiprotons in an experiment at CERN's LEAR low energy antiproton ring.

People and Things

In the experiment at CERN, antiprotons from LEAR are channeled into a series of cylindrical electrodes inside a 6 T magnetic field and a gas of ultracold electrons. The voltage applied to the final electrode makes ultracold particles turn round in the magnetic field and head back towards the first electrode. At the right moment, a few hundred nanoseconds later, the voltage on the first electrode is raised, snaring the antiprotons. Residual thermal vibration can be damped by absorbing energy as induced currents (resistor cooling).

After storage (as long as twelve hours for the lowest energy antiprotons, even longer for keV energies), the voltage on the exit electrode is increased, allowing the antiparticles to escape and annihilate in a target, releasing pions picked up by a cylindrical scintillator.

Last year the experimental team cooled their antiprotons down to about the region of a single electron volt. One aim is to measure the antiproton's inertial mass – any tiny mass difference between protons and antiprotons giving a vital clue to the basic symmetries of physics. However a precision mass measurement needs very cold antiprotons with minimal residual thermal energy.

This year, the electron cooling really showed what it could do, taking antiprotons down to millielectron volts, equivalent to just a few degrees above absolute zero. This way, proton and antiproton masses were compared (and found equal) to a few parts per million, a 25-fold improvement on the previous best measurement and a new milestone for physics. Not content with this, the ambitious team hopes to improve this precision by a further factor of at least a hundred.

A helping hand. The staff of CERN's new Users' Office.

(Photo CERN 569.6.89)

CERN User boom

CERN's attraction for scientists has rocketed. Even before LEP came into operation, the experimental programme covered a wide spectrum, with the proton-antiproton collider, fixed-target programme and high energy ion beams at the SPS on the high energy side, together with low energy antiprotons at LEAR and separated beams of isotopes in ISOLDE. With LEP, CERN's research attractions gain a new dimension (see page 4).

To cater for the growing population of visiting researchers, Experimental Physics (EP) Division has set up a Users' Office as an interface between CERN and its users, providing direct communications channels, and on-the-spot advice and assistance when needed. It also enables users' requirements and suggestions to be referred to CERN management. Its current head, Giorgio Goggi (to be succeeded next year by Egil Lillestol of Bergen), is assisted by a staff of eight.

In parallel a new impetus has been given to the Advisory Committee of CERN Users (ACCU), strengthening its links with both CERN management and with scientific authorities in CERN's Member States. Policy matters on CERN-user relations are continually addressed and reviewed by ACCU, whose current chairman is Peter Norton from the UK Rutherford Appleton Laboratory.

CERN Council

Speaking on CERN's Scientific Programme and Budget Estimates for 1990-93 at the June meeting of CERN's governing body, the Council, Director General Carlo Rubbia underlined the richness of CERN's science and pointed out the Laboratory's increasing attractiveness, as reflected by the number of visiting scientists.

Following a recommendation of the recent CERN Review Committee led by Anatole Abragam, CERN is also looking to extend scientific and technical cooperation with the many non-Member States, both in Europe and further afield, already involved in its work and a special Working Group under Council Vice-President Cayetano Lopez reported earlier this year. To reinforce the spirit of cooperation fostered by recent exploratory discussions and to put ongoing collaboration on a firmer footing, Council delegates voted for a Rubbia suggestion to set up framework agreements with individual countries.

At the Council meeting, Hans Hoffmann, currently a member of the DESY directorate, was appointed Director of Administrative and Technical Tasks at CERN for three years from 1 January 1990. Walter Hoogland, currently Scientific Director of NIKHEF-H, Amsterdam, was appointed CERN Director of Research for three years from 1 July 1989. John Thresher's appointment of Director of Research was extended for three years from 1 July. Günther Plass, deputy leader of the LEP project and leader of CERN's LEP Division since 1983, was appointed Director of Accelerators for three years from 1 January 1990.

INDIANA UNIVERSITY
CYCLOTRON FACILITY

ELECTRICAL ENGINEER

The Indiana University Cyclotron Facility has an opening for an Electrical Engineer to participate in the expansion and support of a dynamic accelerator laboratory of international reputation.

The primary responsibility of this position is to provide the engineering support for the high current and high voltage power supplies of the present and future accelerators. These responsibilities include the design, "hands-on" development, installation, and troubleshooting of the following systems: High precision current regulated power supplies, pulsed power supplies, high voltage power supplies, analog control systems, motor drivers, AC power distribution systems, and grounding arrangements. Other responsibilities include the direction, training, and supervision of accelerator support electronics technicians, and participation in long-term research and development projects.

This is a continuing full-time position in the IUCF Professional Ranks wich provides excellent opportunities for professional growth. A B.S. degree in Electrical Engineering is required and two years' experience working in a scientific laboratory is preferred.

Send resume and names of three persons as reference to:

Robert Woodley
Indiana University Cyclotron Facility
2401 Milo B. Sampson Lane
Bloomington, Indiana 47408, USA
(812) 855-5194

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Experience in low temperature physics and or particle physics is requested. The appointment is limited to 5 years.

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Switzerland
Tel. (031)65 85 66/65 40 64

SUPER COLLIDER ENGINEERS & PHYSICISTS

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

Qualifications and Experience

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

Cryogenic Engineers

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

Engineering Physicists

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

Electrical Engineers

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

Computer Scientists and Engineers

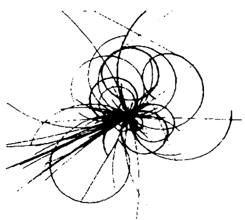
Real Time Digital Control Systems, Interface Circuit Design, High Speed Data Acquisition, Expert Systems, Network Design, Database Design and Management, Human Interface Systems and other related areas.

Physicists

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

Mechanical Engineers

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



Send complete resume with references and salary history to:

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SSC Laboratory
2550 Beckleymeade Ave.
Suite 260
Attn: Dept. CC-9-89
Dallas, Texas 75237

Super Collider

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Satoshi Ozaki (right) returns to Brookhaven in October as Head of the proposed RHIC Relativistic Heavy Ion Collider under Laboratory Director Nick Samios (left).

On people

Satoshi Ozaki returns to Brookhaven in October to become Head of the proposed RHIC Relativistic Heavy Ion Collider. After 20 years at Brookhaven, Ozaki returned to Japan in 1981 to become Director of the highly successful TRISTAN project at the Japanese KEK Laboratory. Commissioned in November 1986, this three kilometre ring provided the world's highest energy electron-positron collisions until the start this year of physics with the new SLC Stanford Linear Collider.

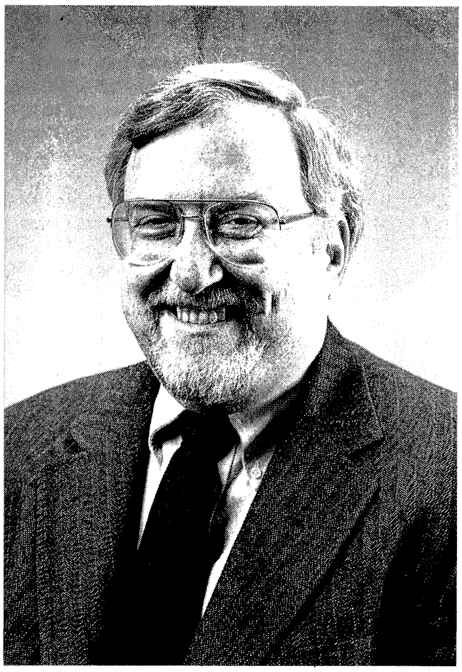
A celebration to honour many years of valuable contributions to Danish physics by Otto Kofoed-Hansen took place earlier this year at Riso National Laboratory, where as Research Director from 1956-68 he created the research department of the new centre. Earlier, his beta decay studies at the Niels Bohr Institute led on to the development, with Karl Ove Nielsen, of 'on-line' mass separation experiments, the precursor of the ISOLDE isotope separator at CERN, with which he was particularly involved during his time at CERN from 1968-76.

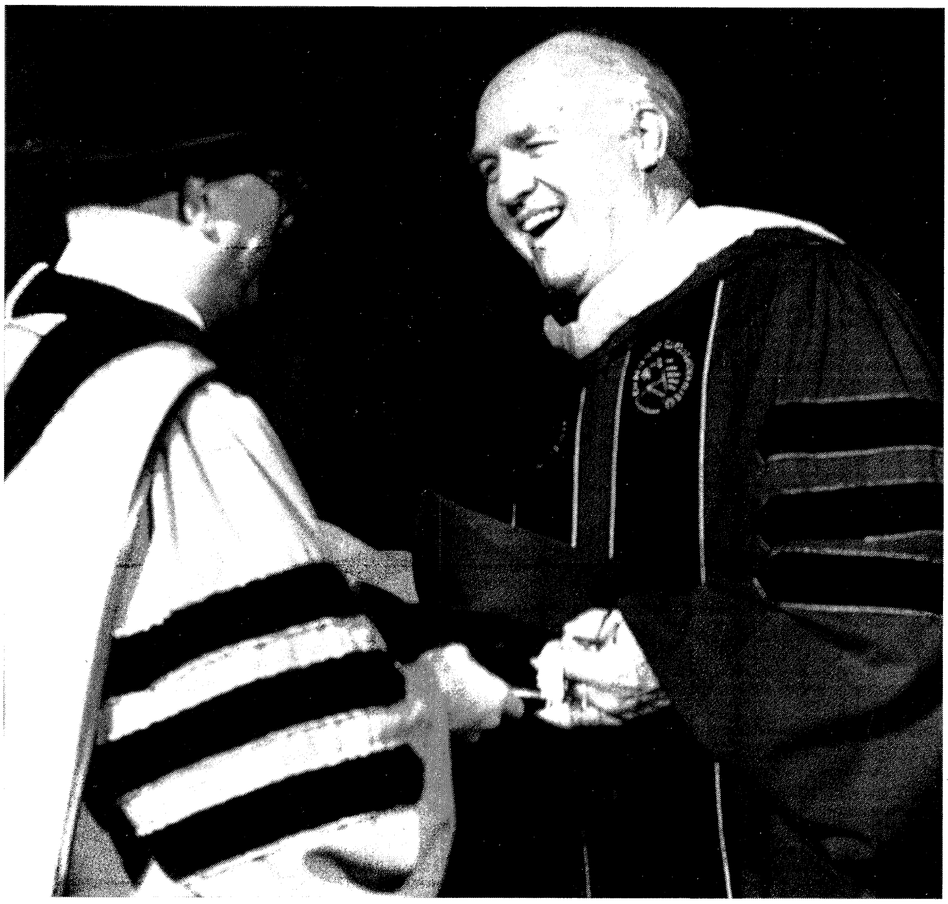
David Gray, Associate Director, Science, at the UK Rutherford Appleton Laboratory, was awarded the OBE in the Queen's Birthday Honours List in June.

At the beginning of July, Soviet physicist Andrei Sakharov (right), with his wife Elena Bonner (seated, left) visited CERN to see some of the Laboratory's new developments and experiments. Here they talk to Jack Steinberger in the control room of the Aleph experiment at the new LEP electron-positron collider.

(Photo CERN 497.6.89)

J. Richie Orr (left), is Fermilab's new Associate Director for Administration, while Dennis Theriot (right) becomes the Laboratory's Associate Director for Technology.





25 years Director of High Energy Physics for the US Government and now President of Southeastern Universities Research Association – SURA, the governing body of the new CEBAF electron machine being built at Newport News, Virginia - Bill Wallenmeyer (right) receives an honorary degree from Purdue President Steven C. Beering.

At the annual general meeting of the Norwegian Physical Society in Bergen in June, Carsten A. Lütken, presently a fellow at NORDITA, Copenhagen, after having spent two years at CERN, was awarded the Norsk Data Prize for elementary particle physics for his research into string theories.

At the tenth International Free Electron Laser Conference, held last year in Jerusalem, an annual prize for excellence in free electron laser research was inaugurated. The first prize has been awarded to John Madey of Duke University, North Carolina for his 'pioneering research that stimulated widespread development of the Free Electron Laser'. He initiated FEL research while at Stanford in the early 70s, going on to led the Stanford team that made the first successful FEL demonstrations in 1975-76, confirming his theoretical predictions, and collaborating with the French group initiating short wavelength (ultraviolet) studies at the ACO electron rings.

Karel Gaemers, leader of the Amsterdam University theory group since 1981, has taken up the position of research director of the Dutch Institute for High Energy Physics, NIKHEF-H, for a period of three years, succeeding Walter Hoogland who becomes a Research Director at CERN.

UNIVERSITY OF GRONINGEN
THE NETHERLANDS

Professor in experimental nuclear physics

(vacancy number: 890704/3723)

The Kernfysisch Versneller Instituut (KVI) of the University of Groningen is seeking applications and nominations for the newly created position of Full Professor in experimental nuclear physics.

The KVI is one of the two national centers for nuclear physics in the Netherlands. It is jointly sponsored bij the University of Groningen and FOM, the Dutch funding agency for fundamental research in Physics. The research is carried out in collaboration with universities and laboratories within and outside the Netherlands. In addition to its research program in experimental and theoretical physics the KVI has small but substantial activities in atomic and applied nuclear physics.

The institute has extensive experimental facilities. The present K = 160 MeV cyclotron will be replaced in the first half of the nineties by a K = 600 MeV cyclotron, AGOR, with superconducting coils capable of accelerating both light and heavy ions (protons to 200 MeV, and fully stripped heavy ions to 95 MeV/u). This cyclotron, presently under construction at the Institute de Physique Nucléaire in Orsay, has been designed and is being built in a Dutch-French collaboration that also foresees in a joint scientific exploitation of the new facility. Funds have been made available for the design and construction of a spectrometer matched to AGOR, while at the University of Utrecht the construction of a 4 pi detector system has started. In addition to the work directed towards its own facilities, the KVI is participating in several international collaborations, the major one being the TAPS project at the GSI.

The succesful applicant he/she will have a major responsibility for the research program of the KVI. He should have a proven ability for original and fundamental research in nuclear physics, and he should have the capability to stimulate and direct the future research activities of the institute, especially around AGOR.
He should be willing to take on his share in the responsibilities for the institute as a whole which may include the directorship of the KVI. He is expected to contribute to the teaching of the Physics Department and to learn the Dutch language in a reasonable time.

The salary scale will be determined by age and experience with a maximum salary of Dfl 157.000,- per year. The conditions of employment are the conditions of the Government including participation in the Pensionfund (ABP).

Further information on this position can be obtained from the chairman of the selection committee, Professor Dr. R.H. Siemssen, telephone 0031 50 63 35 56, BITNET: SIEMSSEN@KVI.NL.

Applications and nominations will be received including a curriculum vitae and a list of publications until November 1st, 1989 by the Director of Personnel, University of Groningen, P.O. Box 72, 9700 AB Groningen, The Netherlands.

Department of Physics
University of Toronto

TENURE TRACK FACULTY POSITION
HIGH ENERGY AND NUCLEAR PHYSICS

The Department of Physics plans to make one or possibly two tenure track appointments with starting date of July 1, 1990 at the rank of Assistant Professor.
Applications for these positions from candidates in the areas of experimental or theoretical high energy and nuclear physics are invited. Candidates with demonstrated or potential excellence in research and teaching are sought.
Members of the high energy group are collaborating in the study of charm, beauty and tau physics with the ARGUS detector, in the construction of the ZEUS detector for the study of high-energy electron-proton collisions at HERA and in the operation of the CDF detector at the Fermilab proton-antiproton collider.
Major areas of experimental nuclear research include: intermediate energy nucleon-nuclear reactions using accelerators at TRIUMF and IUCF, heavy-ion physics using TASCC and measurement of nuclear cross sections of astrophysical interest using low-energy particle accelerators.
Theoretical activities include an investigation of quark physics phenomenology, the development of technicolour models and gauge field theories or particle physics and gravity, the development of soliton models and models of nuclear collective motions, and the application of group theory and symmetry to problems of subatomic physics.
Theoretical applicants interested in work at the interface between astrophysics and particle physics would find interactions with CITA (Canadian Institute of Theoretical Astrophyics) attractive.
Applications consisting of a curriculum vitae; list of publications; summary of research interests; a detailed research proposal; and the names, addresses and FAX numbers of three referees should be sent as soon as possible, and no later than October 30, 1989 to

Professor M.B. Walker, Chair,
Department of Physics,
University of Toronto,
Toronto, Ontario, Canada, M5S 1A7.

In accordance with Canadian Immigration requirements, this advertisement is directed to both Canadian citizens and permanent residents of Canada.

The University of Toronto encourages both women and men to apply for this position.

RICE

EXPERIMENTAL RESEARCH POSITIONS

HIGH ENERGY PHYSICS
INTERMEDIATE ENERGY PHYSICS

The T. W. Bonner Nuclear Laboratory will soon have three vacant research positions to be filled this autumn. One or two appointments are for **postdoctoral fellows**. One or two, however, will be made at the level of **Assistant Research Scientist** for an initial three-year period. The successful candidate will already have some postdoctoral experience during which he or she has demonstrated capacities for leadership and independence in research. This appointment may be renewable and could lead to promotion to Associate Research Scientist.

The Bonner Lab has a diverse research program with planned, approved, and/or ongoing experiments at **Brookhaven**, **Fermilab**, **CERN**, **TRIUMF**, **LAMPF**, and **CEBAF**. Physics topics include spin effects in high energy hadron production, high p_t jets, the spin structure of the proton and neutron (SMC), antiproton-induced nuclear heating, QCD exotica, and strangeness production in heavy ion collisions. The group consists of seven experimental and two theoretical faculty, two postdoctoral fellows, and about fifteen graduate students. The style of the laboratory is that most group members participate in all experiments; in particular, postdoctoral fellows gain a wide variety of experience by working in both fields.

Rice is a small private university, dedicated to excellence in the academic enterprise. The beauty and serenity of the campus, the proximity of dynamic Houston, the fourth largest city in the U.S., the temperate climate - all these contribute to making Rice an extraordinary location for study and research. An added attraction will soon be the nearby SSC Laboratory. Rice is an Equal Opportunity Employer.

Resumes: Professor B. E. Bonner, Director
Bonner Nuclear Lab, Rice University, Houston, TX 77251-1892

Efim S. Fradkin (right) receives a 1988 Dirac Medal of the International Centre for Theoretical Physics (ICTP), Trieste, from Antonino Zichichi. Centre is ICTP Director Abdus Salam.

Efim Samoilovich Fradkin of Moscow's Lebedev Institute, one of the 1988 recipients of the Dirac Medal of the International Centre for Theoretical Physics, Trieste, received his award on 11 July. (The other 1988 medal winner, David Gross of Princeton, received his award in April – see June issue, page 29).

Fradkin was cited for his 'many fruitful contributions to the development of quantum theory and statistics'. His work on formal solutions and important identities in quantum field theory has led to important new insights in modern field theory and in the description of extended objects such as strings and membranes.

Award for LeCroy

LeCroy Corp, whose innovative electronic equipment is widely used in high energy physics experiments, has been named 1989 National Subcontractor of the Year by the US Small Business Administration after having been nominated by Los Alamos National Lab.

With headquarters in Chestnut Ridge, New York, the firm also has outlets in Europe, with regional headquarters in Geneva, Switzerland.

Making history

The Andrew W. Mellon Foundation in New York has recently announced the award of a grant of $31,000 to CERN. It is the first grant the Foundation has made to the Organization, and is to be used by John Krige to study the preservation of historically important documents from a major experiment at CERN in which a number of institutes collaborated. The work is part of a more general project being coordinated by the Center for the History of Physics of the American Institute of Physics. It adds a European dimension to similar studies being made of multidimensional collaborations at four significant American accelerator centres – Brookhaven, Cornell, Fermilab and SLAC, Stanford.

Uncle Albert

The Time and Space of Uncle Albert' by physicist Russell Stannard (Faber and Faber, UK) introduces the Special Theory of Relativity in a refreshingly different way. Aimed at teenagers but appealing to young and old alike, the book sets out to demystify what unfortunately remains for many a mysterious corner of contemporary culture. In the book, Uncle Albert, a thinly disguised famous scientist, has got stuck, and his niece Gedanken helps him think his way out. Vivid

Russell Stannard – The Time and Space of Uncle Albert

Held this year in Egmond-aan-Zee, the Netherlands, from the end of June, the eleventh in the series of Schools of Physics organized jointly by CERN and the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, attracted over a hundred students from both CERN and JINR Member States and from elsewhere, seen here outside the School's 't Zuiderduin Hotel venue.

(Photo E. Lange, MPI Munich)

stuff, with spaceships and computers. Other areas of modern physics would be more difficult. How about 'The Uncertainty of Uncle Werner'?

Meeting

The first biennial Conference on Low Energy Antiproton Physics – a new series which is a merging of the LEAR Workshop and the European Symposium on Proton-Antiproton Interactions and Fundamental Symmetries – will take place in Stockholm from 2-6 July 1990. Contact persons are Per Carlson (PC at SESUF51) and Jon-And Kerstin (KER at SESUF51 or KJA at CERNVM), Manne Siegbahn Institute, Frescativ. 24, S-10405 Stockholm, Sweden, phone +46 (0)8 150360.

Hospital fluorine-18, continued

The July/August issue (page 23) described how CERN is making fluorine-18 for positron-emission tomography (PET) studies at Geneva's Cantonal Hospital. Switzerland, where manufacture has been boosted following the arrival of a PET scanner, the second in Switzerland (and the second to be supplied commercially). A special car service has also significantly speeded up transportation of the 110-minute half-life isotope from the Institute to Geneva.

Astrophysics at Berkeley

Initially funded by the US National Science Foundation, a Center for Particle Astrophysics has been set up at Berkeley under Bernard Sadoulet. Supported by theoretical studies, the Center's research in-

Heavy ion therapy

The possibilities and potential of high energy beams of heavy ions for tumour therapy were examined at a meeting in May in Heidelberg and Darmstadt, West Germany. Through collaboration between the Heidelberg University Radiology Clinic, the German Cancer Research Centre in Heidelberg, and the GSI heavy ion Laboratory, Darmstadt, this technique could soon become available in Germany.

In the morning sessions in the Heidelberg 'Kopfklinik', Joe Castro of Berkeley reported on the clinical successes achieved with heavy ion beams at Berkeley, the only place in the world where this therapy is currently available.

G. Kraft of GSI explained the potential advantages of heavy ions – accurate target localization, and increase in dosage as well as biological effectiveness with depth. G. Gademann from the University Radiology Clinic outlined the planned trials. If the project is given the go-ahead, the effect of heavy ions on five different tumour types will be assessed in a clinical report after seven years.

In the afternoon, participants saw GSI heavy ion facilities (June, page 13), and Paul Kienle described the new requirements for a therapy centre, including a special injector, an ion beam scanning device, a fragment separator and a positron camera, the last two providing vital accurate control of the target volume of the ion beam prior to irradiation.

M. Wannenmacher of the University Clinic declared that heavy ion therapy is both achievable and clinically necessary, and looked forward to the necessary resources being made available.

As CERN COURIER is 'put to bed' news comes from the USA of first construction money, to the tune of $225 million, approved for the SSC. Below is an artist's rendering of the SSC site (Courtesy of Texas National Research Laboratory Commission).

cludes the search for 'dark matter', the study of residual background radiation from the early Universe, the measurement of basic cosmological parameters and probing the large-scale structure with both existing instruments and the new Keck telescope.

The NSF funding is part of a $24.7 million move to boost US science research through the establishment of 11 Science and Technology Centers.

Pniewski and Bialkowski

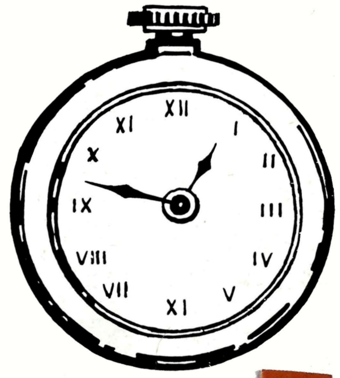
Joint discoverer of hypernuclei in 1952 with Marian Danysz, the Polish physicist Jerzy Pniewski died on 16 June. In 1962 he joined with Jarusz Zakrzewski and others in the European K minus collaboration at CERN and saw the first double hypernucleus in an emulsion stack. Pniewski, with H. Piekarz, J. Piekarz, B. Povh, V. Soergel and others, then discovered electromagnetic transitions in hypernuclei in counter experiments at CERN. He was for many years Director of the Institute of Experimental Physics and then Dean of the Physics Faculty at Warsaw University. Among his many awards was the Marian Smoluchowski Medal, the highest honour of the Polish Physical Society.

Grzegorz Bialkowski died on 29 June. He was a particle theorist, concentrating on dispersion relations, Regge poles, and the damped cascade model of hadronic interactions with nuclei. He worked with distinction at CERN, Saclay, Torino and Trieste as well as in his native Poland. Bialkowski was a person of broad culture – a poet, philosopher, educationalist and humanist, as well as a physicist. He was elected Rector of Warsaw University in 1985 at a difficult phase of his country's history and was a successful Solidarity candidate elected as Senator to the Polish parliament. He was never able to participate in its meetings.

Jerzy Pniewski

Grzegorz Bialkowski

It's about TIME . . .



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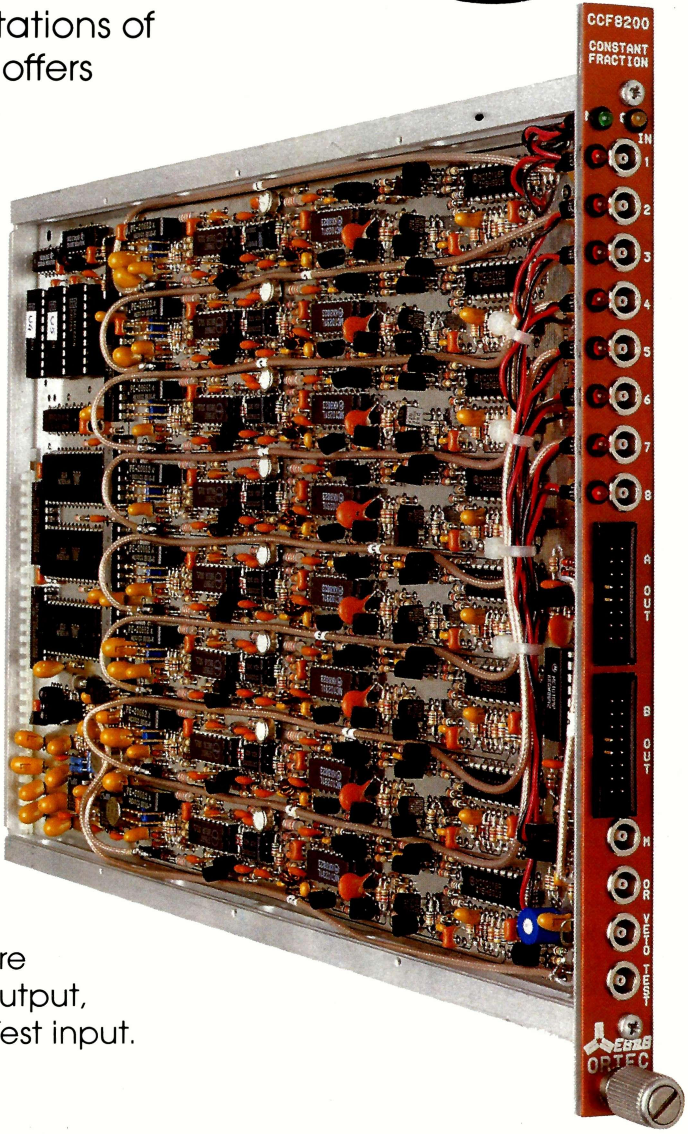

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