

# CERN COURIER

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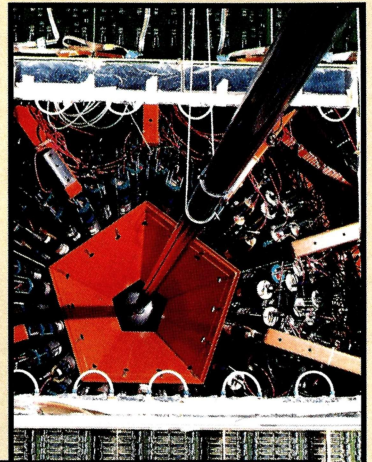
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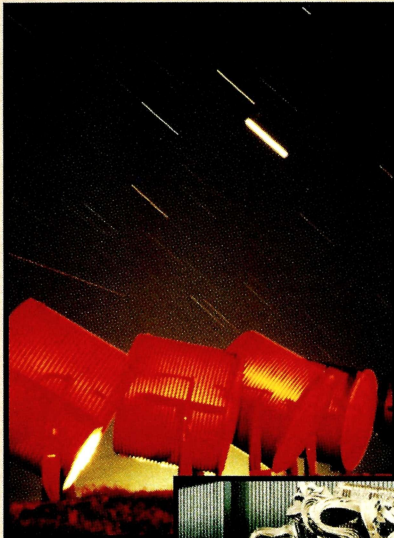
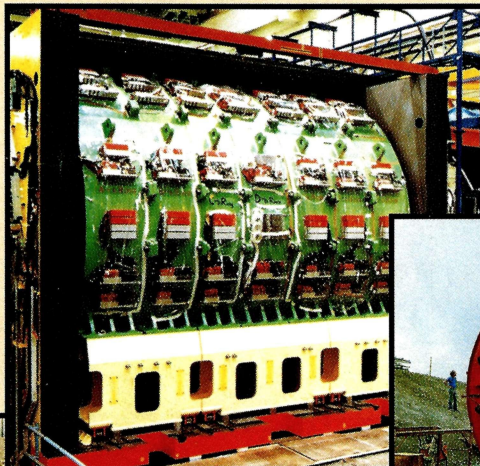


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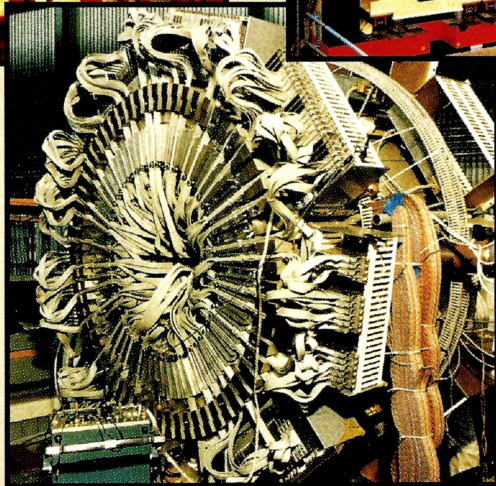
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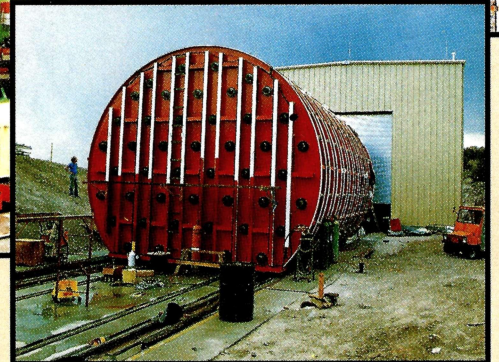
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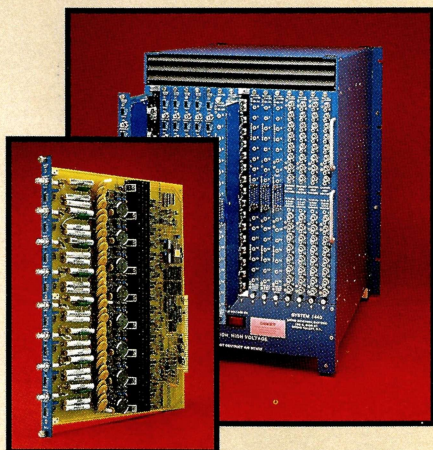


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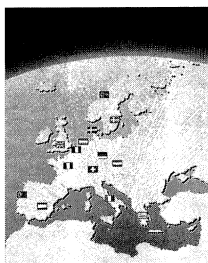
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From a design by CERN's Patrice Loiez for the cover of a CERN brochure.



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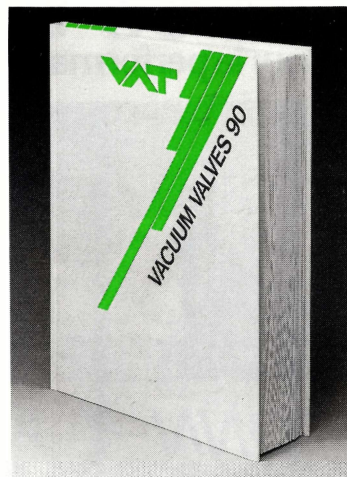
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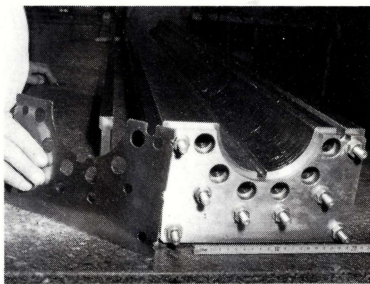
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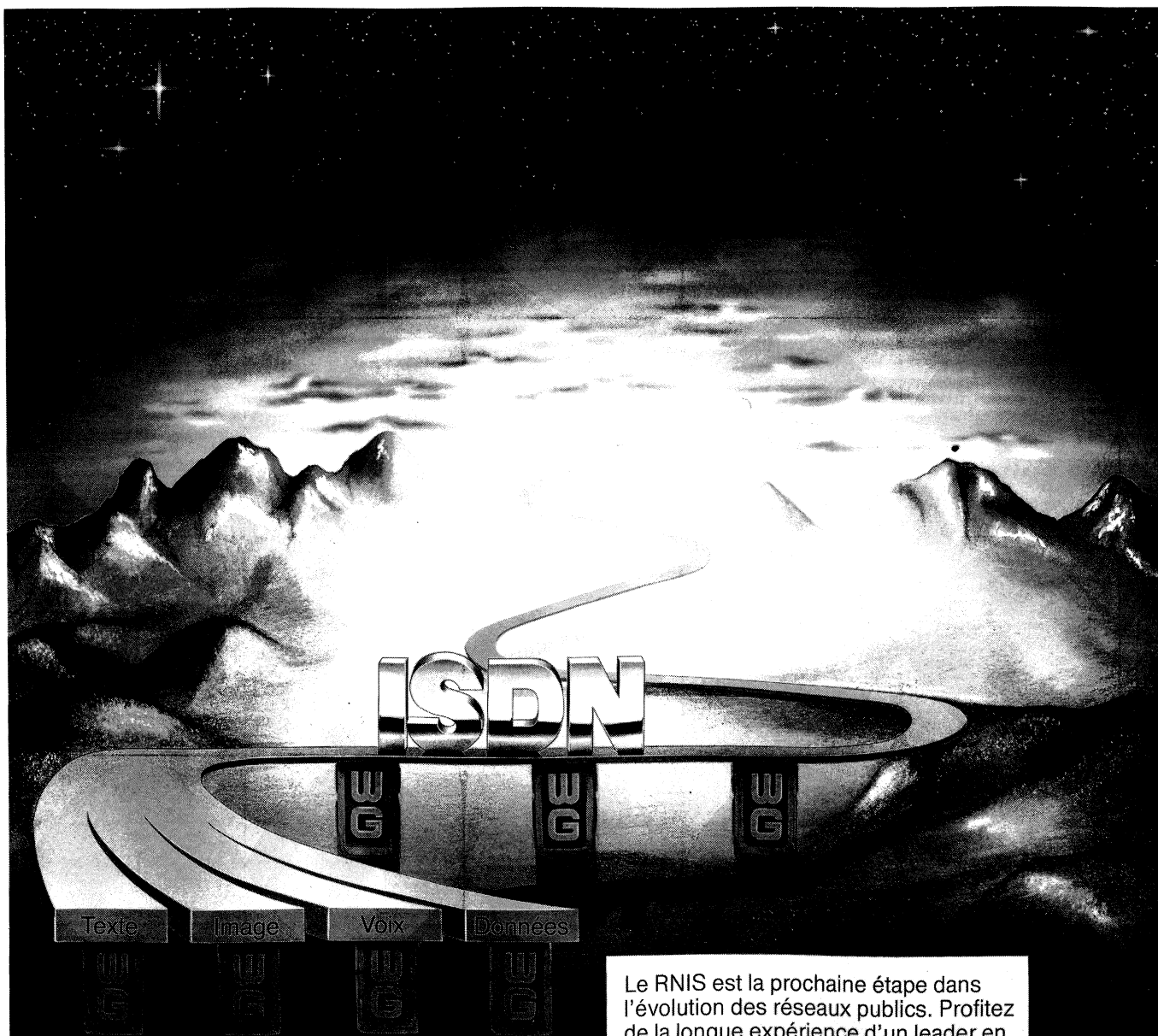
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# LEP commissioning

## LEP there be lepton Z!

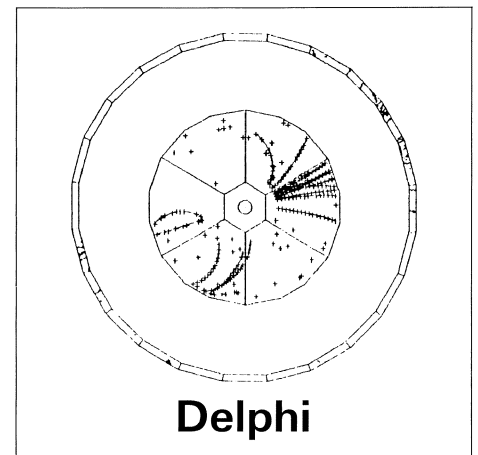
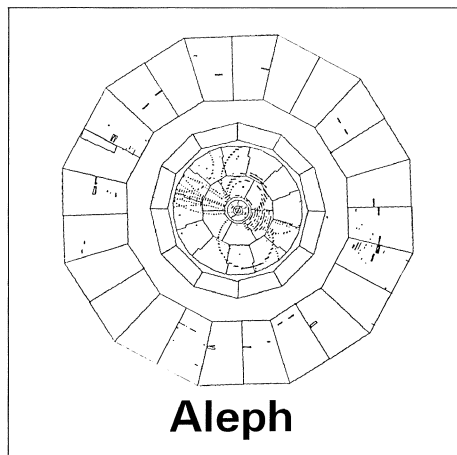
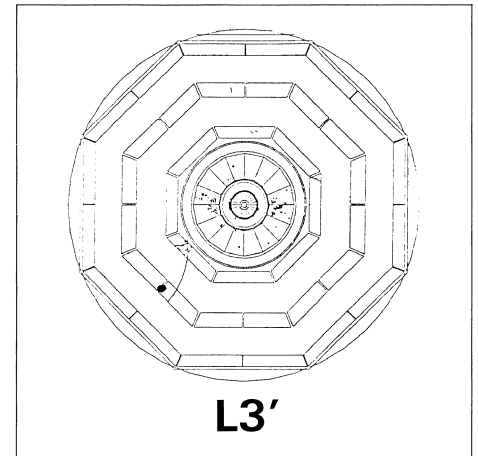
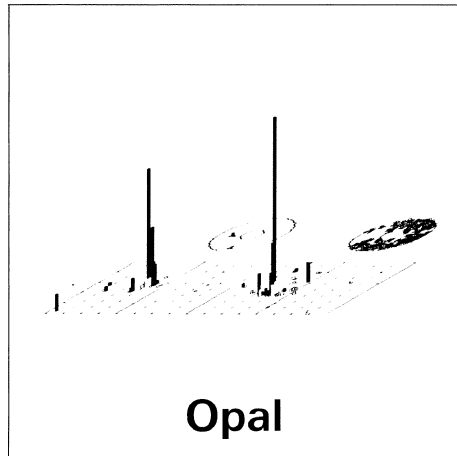
The particle physics scene this summer was dominated by the commissioning of CERN's new LEP electron-positron collider and the continuing effort by other experiments to contribute to the physics of the W and Z particles, the carriers of the weak nuclear force.

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

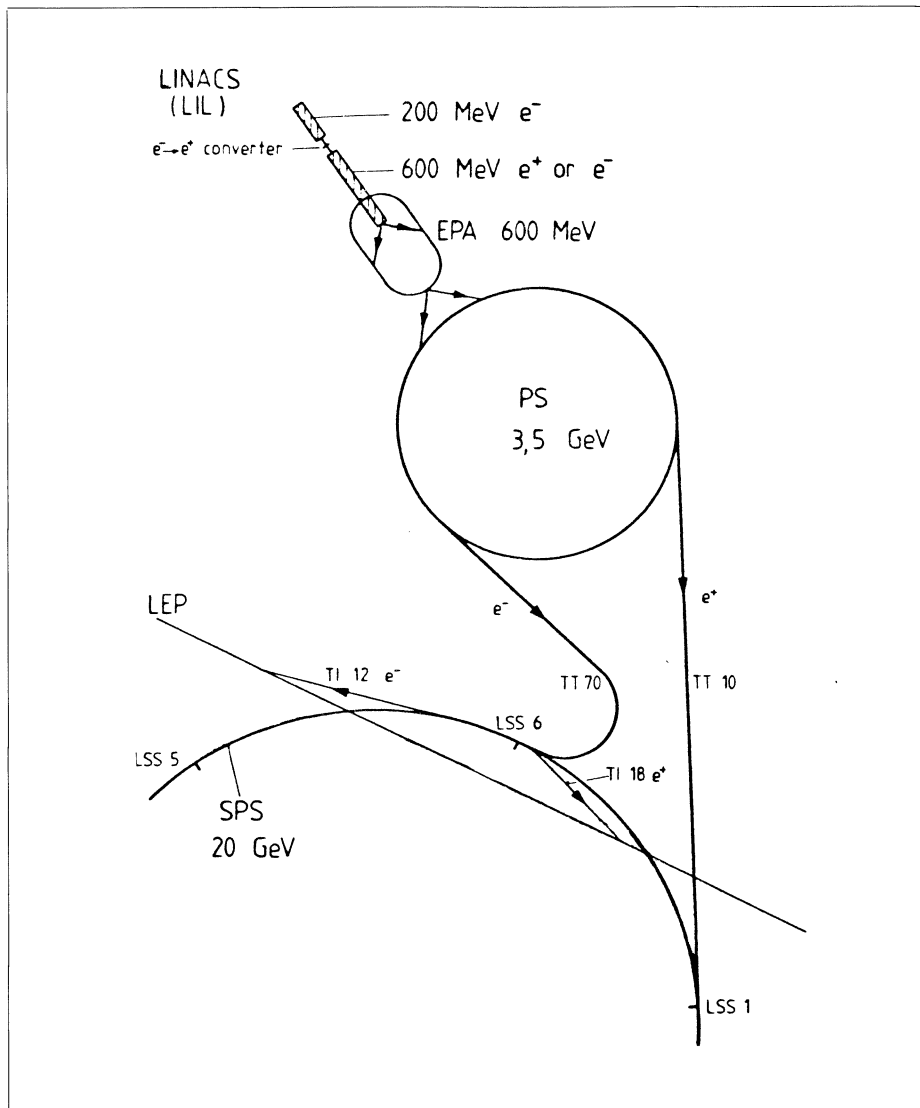
Initial Zs in LEP, as seen by the four detectors.



Jubilation in the LEP control room.



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



celerated 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.

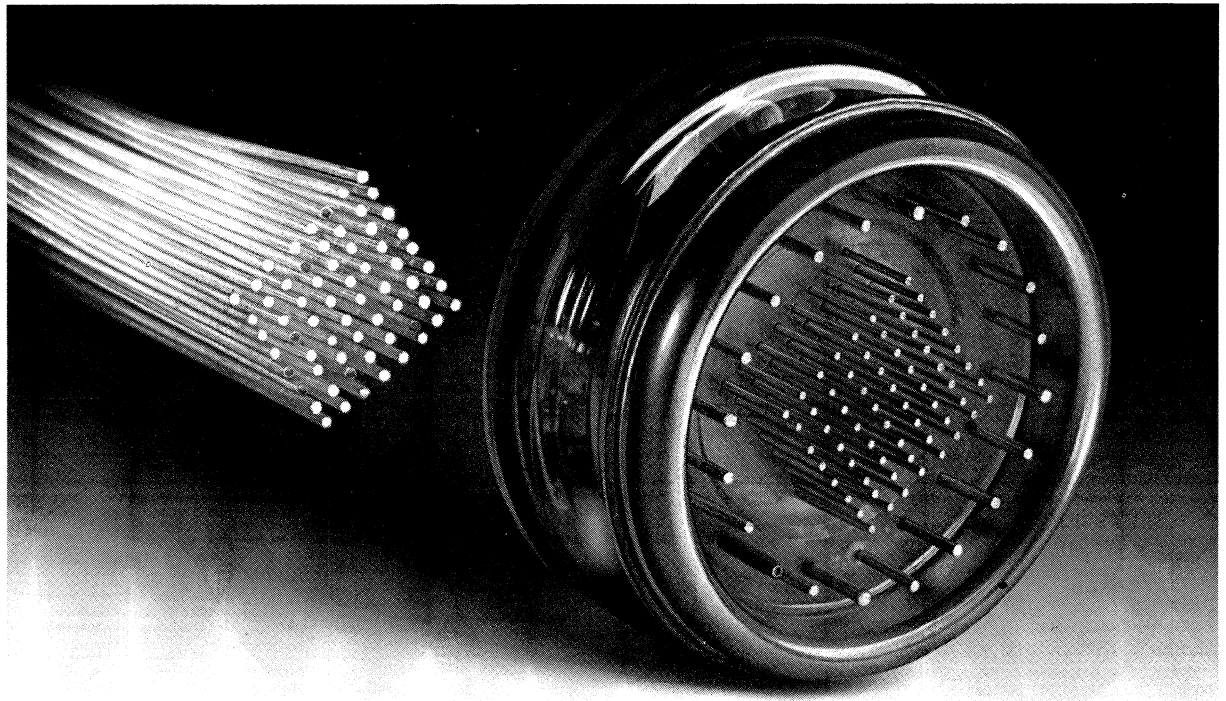
physicists were making the first corrections. Several days later first particles were captured with the radiofrequency system.

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 ac-





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*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.

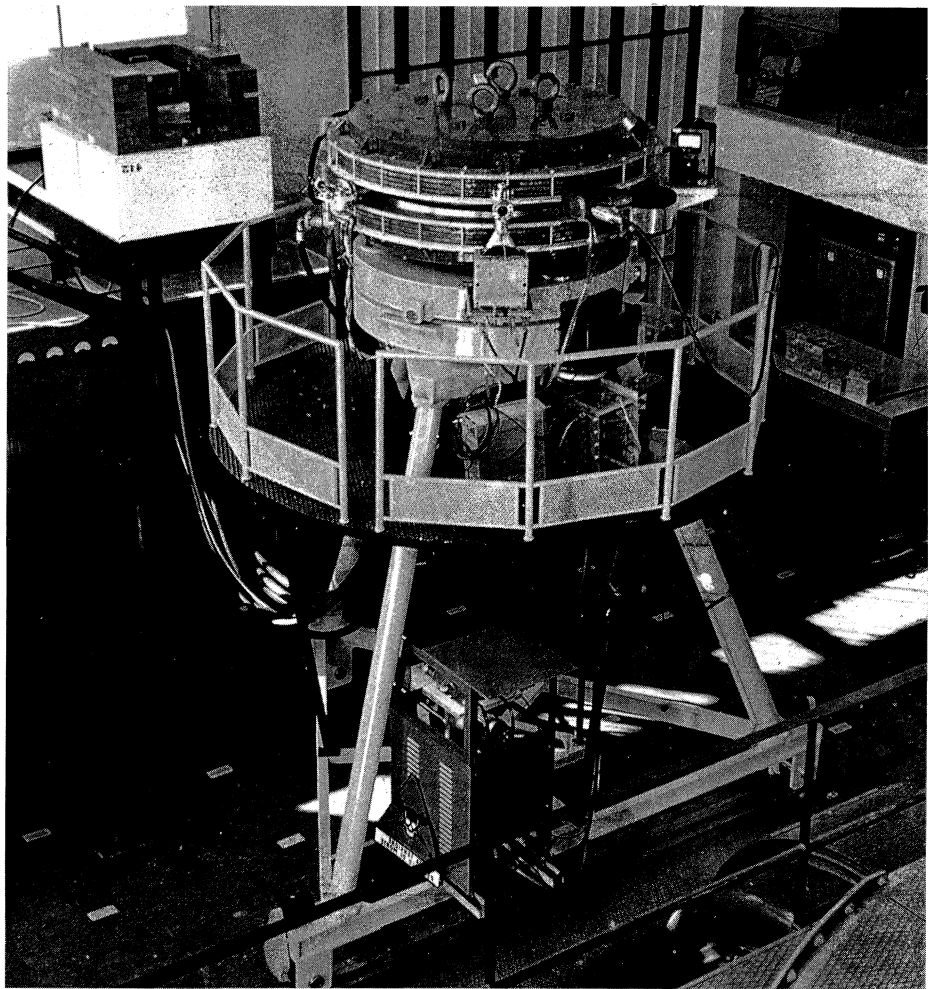
To attain higher electron energies, physicists are now convinced that linear machines and new techniques are needed. The history of electron storage rings thus spans only about a quarter of a century.

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.*





*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.*

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 anti-matter 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 (Anello 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.



## 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.

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

---

## 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

*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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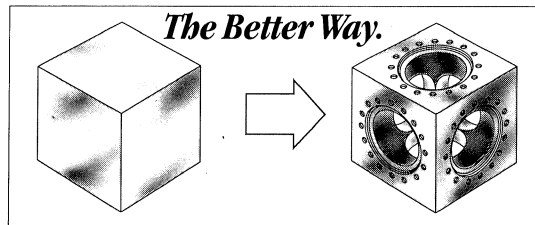
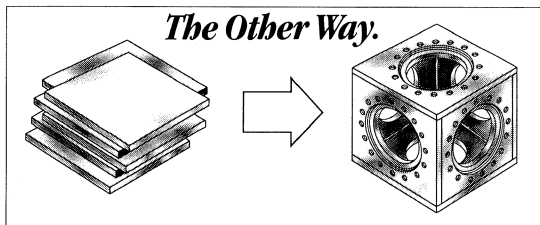
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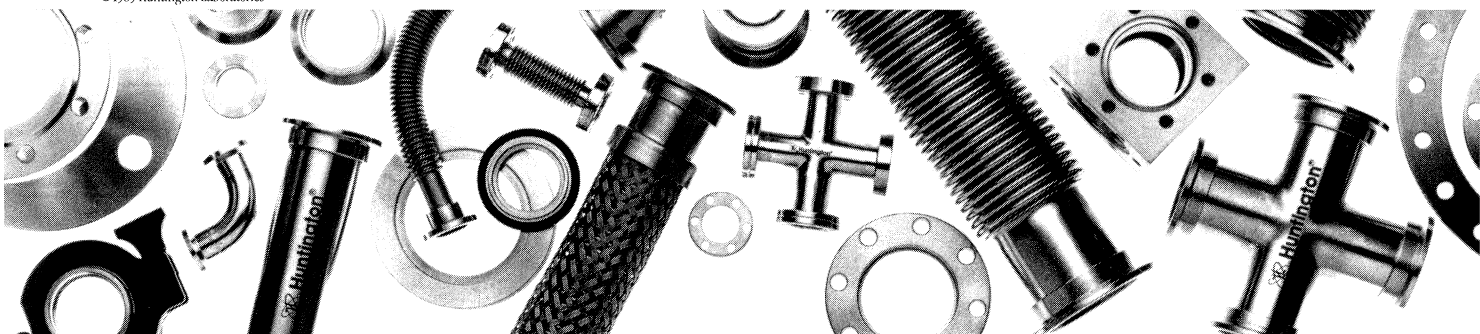
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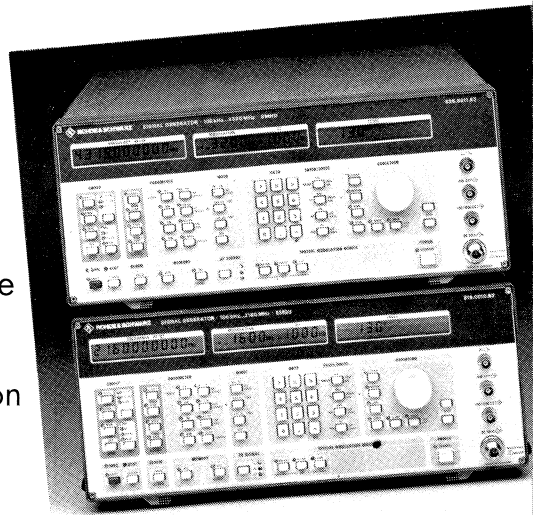
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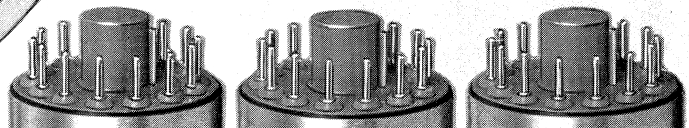


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The constituents of matter as we know them. A quartet of particles (two quarks and two leptons) make up our everyday world. Two heavier additional quartets come into play at the higher energies of astrophysics or in particle accelerators. Counting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

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.

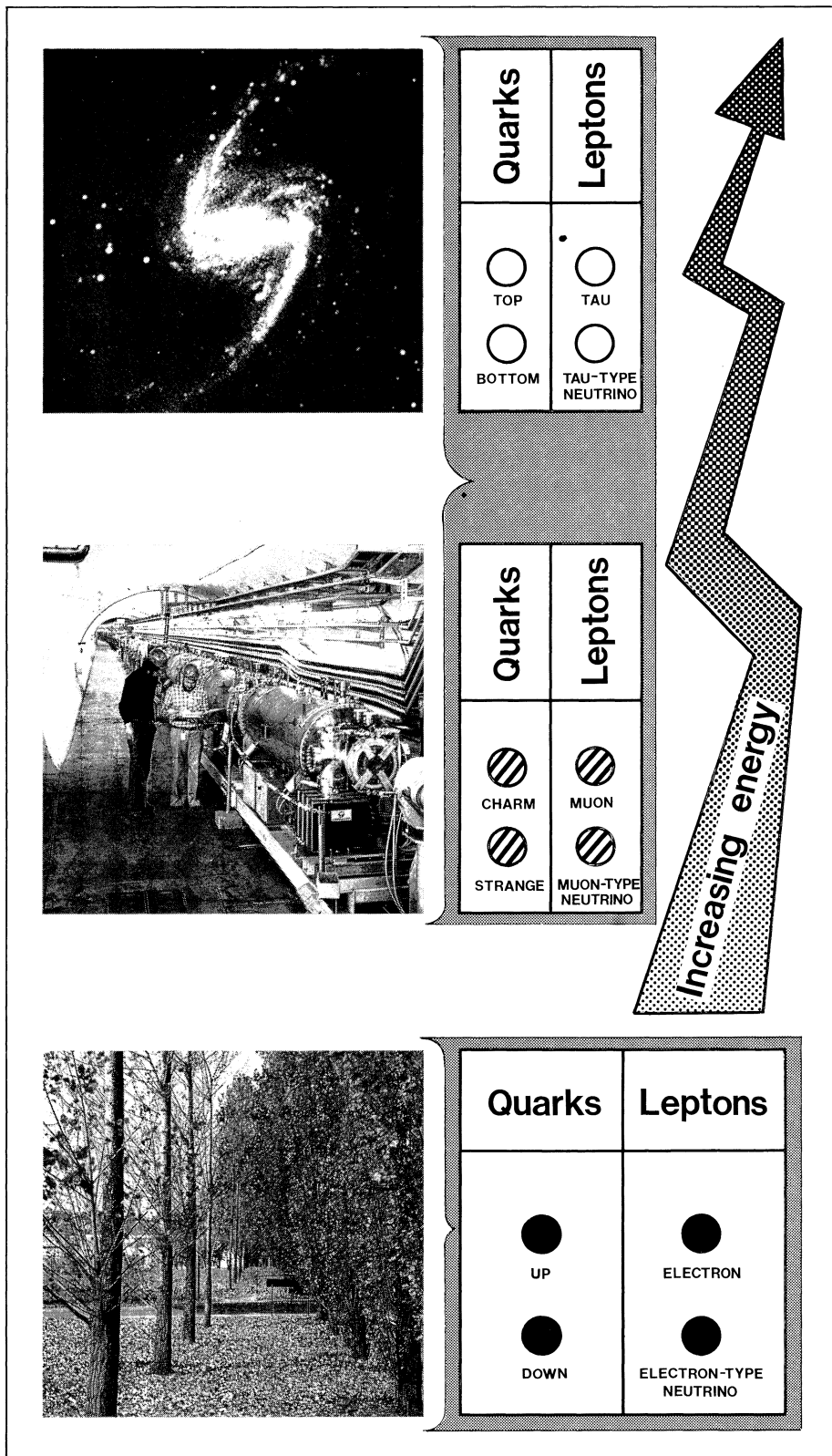
The 1987 supernova and calculations of primordial nucleosynthesis (the fusion of light nuclei – deuterium, helium, lithium – from the protons and neutrons emerging from the Big Bang) suggest that there is room for about three types of neutrinos. But the limit is not rigid and one more type could be squeezed 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



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.

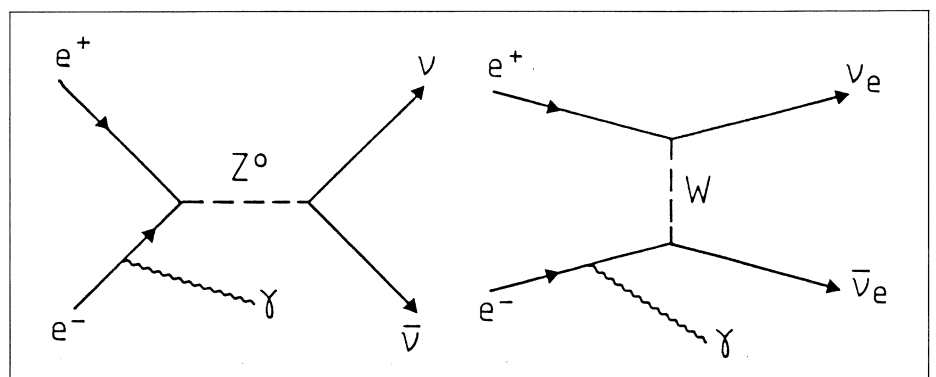
However to be workable, this method needs energy. The results emerging so far from the lower energy electron-positron colliders PEP (Stanford, particularly from the ASP experiment) and PETRA (DESY, Hamburg) provide only a few events, not enough to give an absolute fix on the number of neutrino types. 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 num-

ber 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.*





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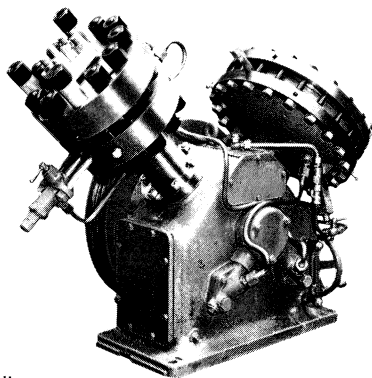
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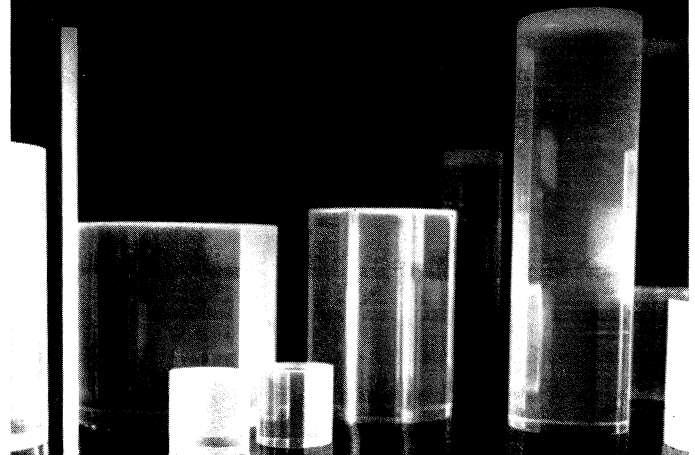
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# Z results

'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.

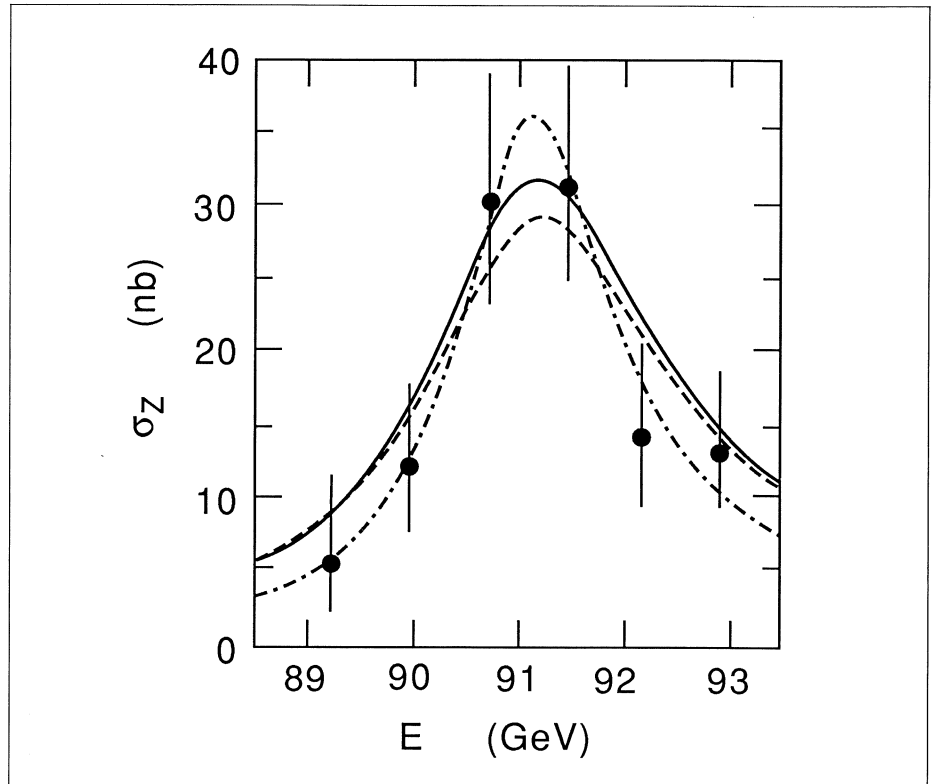
While waiting for the first mass production of Z particles at CERN's new LEP electron-positron collider, fresh results on the properties of this particle come from Stanford's SLC linear electron-positron collider and from CERN's and Fermilab's proton-antiproton colliders.

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 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 uncertain-

ty 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.



## FERMILAB One year Tevatron run

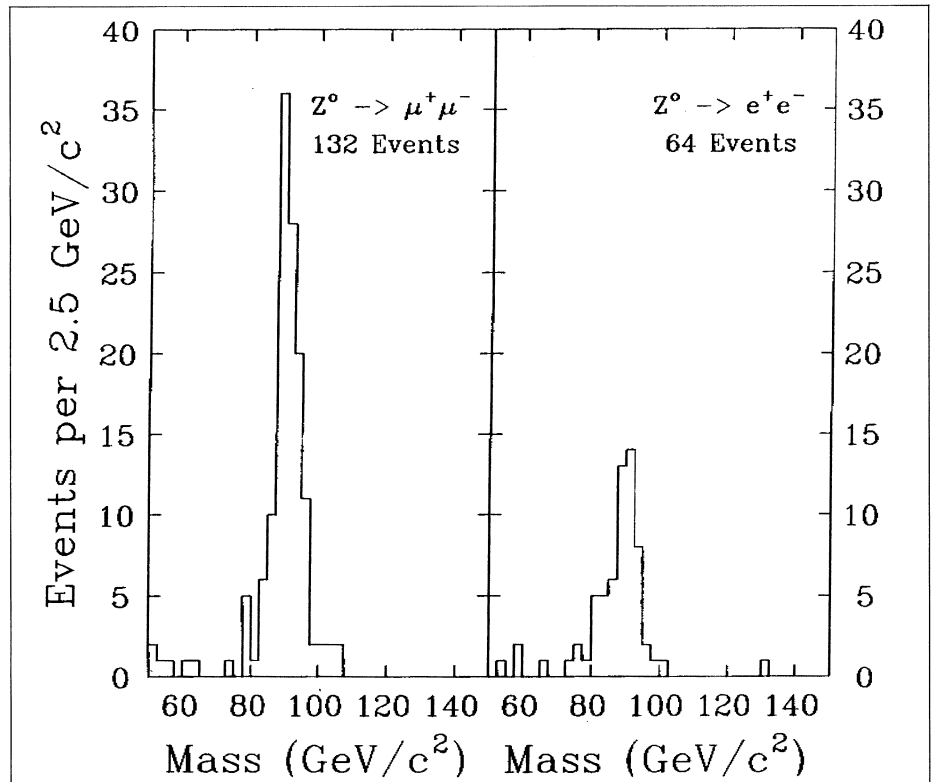
The Fermilab 1988-89 900 GeV on 900 GeV proton-antiproton collider run was successfully ended on 1 June, having started on 20 June last year! During this period the accelerator supplied a world record of 9590 inverse nanobarns of collisions to the CDF detector. Beam was stored for over 4257 hours, and peak luminosity was about  $2.06 \times 10^{30}$ . 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<sup>-2</sup>) 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  $90.9 \pm$

$0.3 \pm 0.2$  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-antipro-

# Around the Laboratories

\* See page 37

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## 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-

ton 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  $2.95 \times 10^{30}$  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  $5.8 \times 10^{10}$  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.



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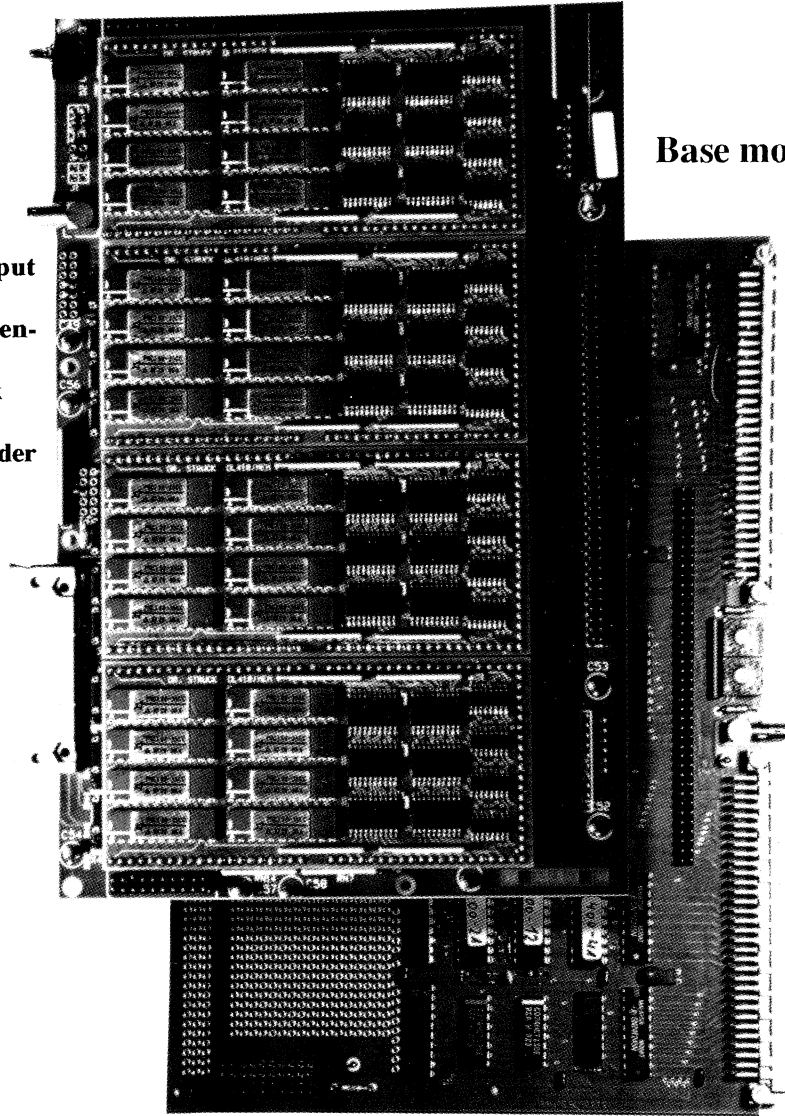
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# STRUCK

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*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.*

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.

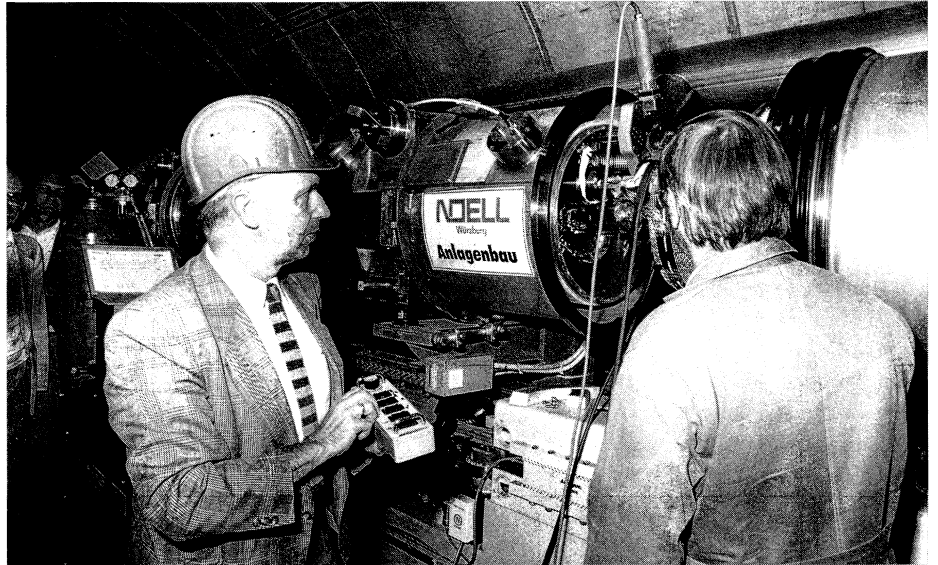
The SSC team is assembling at new temporary headquarters in Dallas, with the Central Design Group migrating from Berkeley. (The address is 2550 Beckley-meade Avenue, Dallas, Texas 75237, telephone (214) 708-9000, bitnet SSCVX1).

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 Com-



mission, 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).

## 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 Alstom (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.

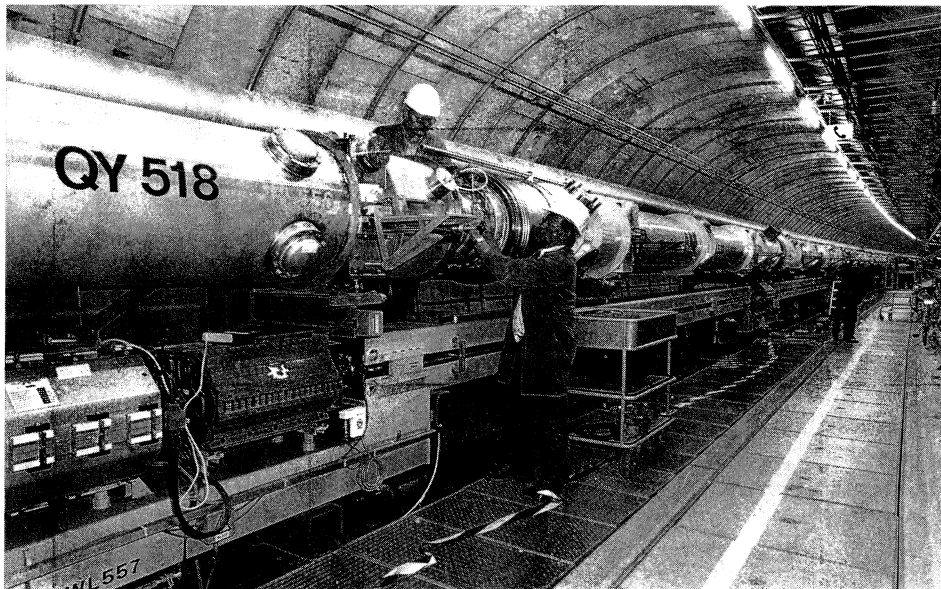
Design of the quadrupoles, development of production tooling and prototype construction were carried out at the French Saclay Laboratory. Saclay staff, in collaboration with DESY, also supervised industrial construction.

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/Fe-

bruary 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).

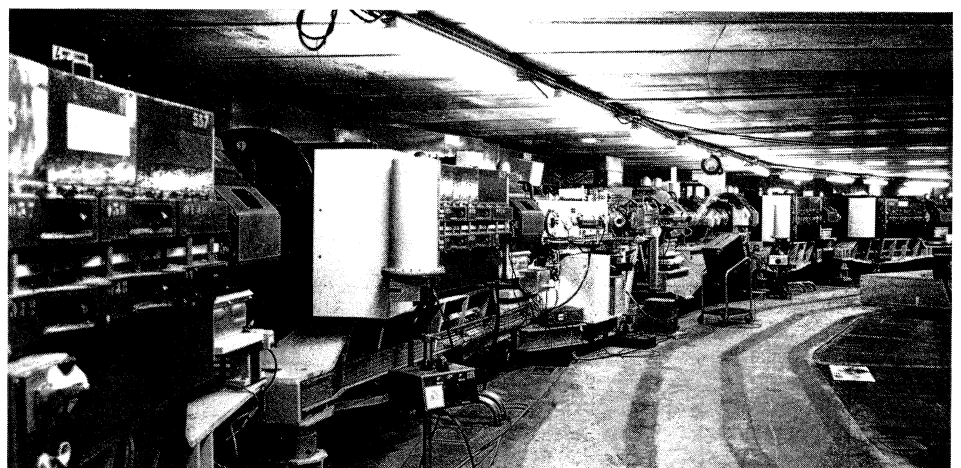
After the commissioning of the MIMAS booster/accumulator ring last year (May 1988, page 5), Saturne can provide high intensity beams of polarized (spin oriented) particles and a range of ion beams extending from carbon to krypton.

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.

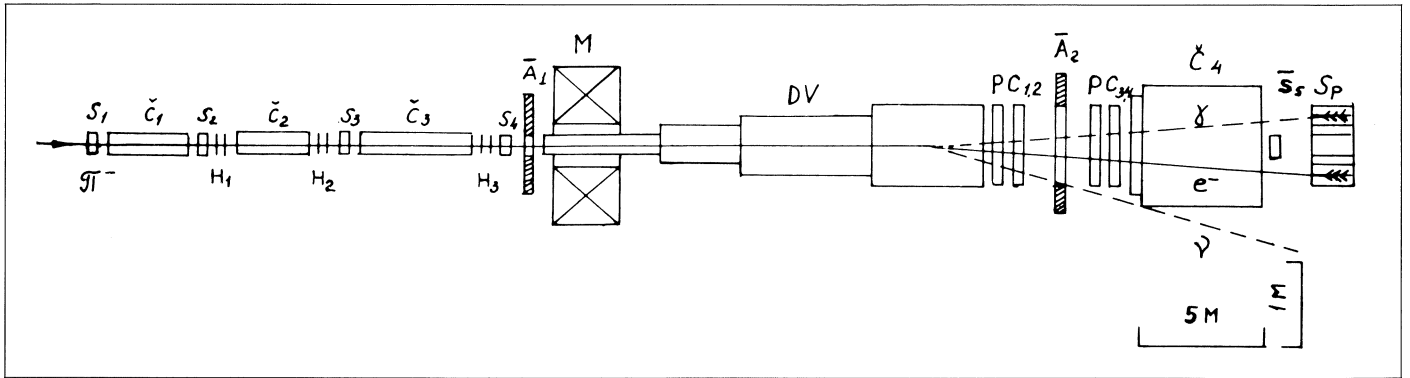
To limit 187.5 keV ion losses by charge exchange on residual gas, a single pulse of krypton 30+ is used (production time 120 ms). In the  $3 \times 10^{-11}$  torr vacuum in MIMAS and  $3 \times 10^{-9}$  in Saturne, no losses are observed.

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 ISTR A 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<sub>4</sub>), 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  $5 \times 10^7$  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 ISTR A 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  $0.41 \pm 0.23$ , 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 ISTR A setup, and the new ISTR A-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





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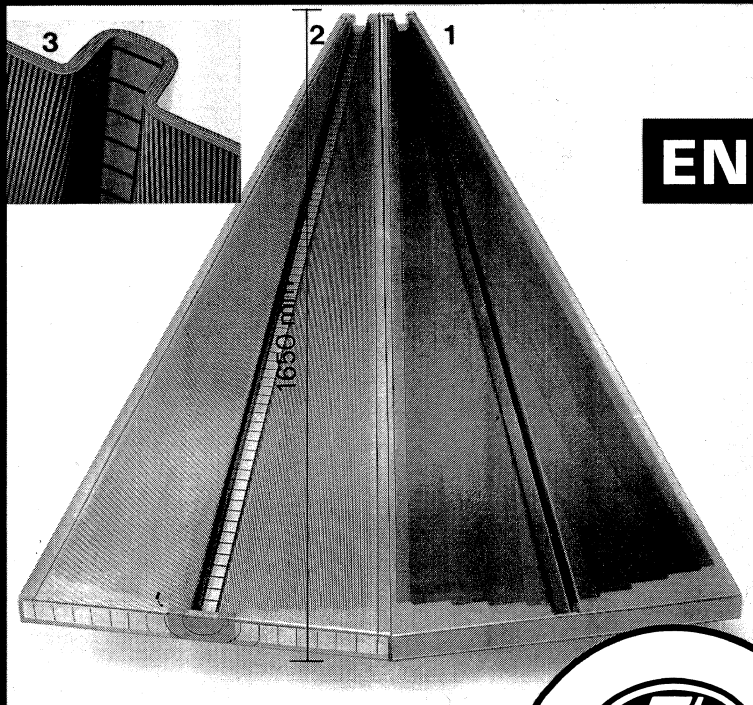
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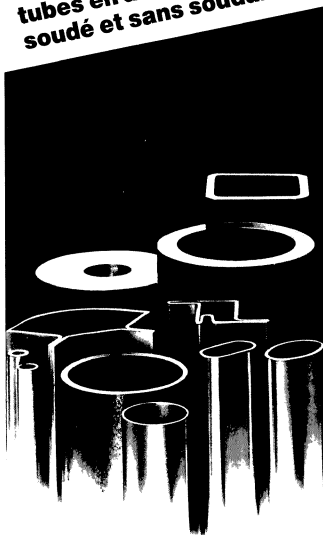


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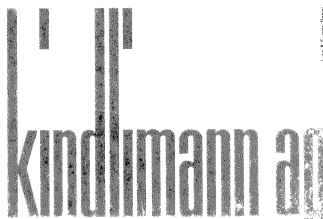
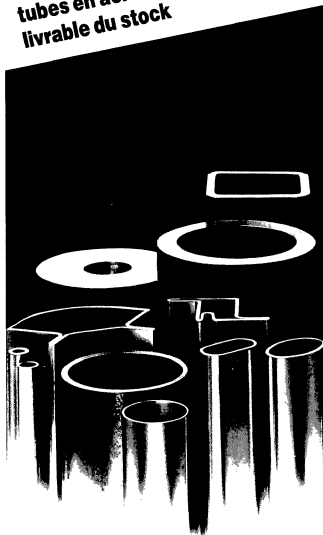
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Some members of the Moscow Institute for Nuclear Research team near the ISTRA lead-glass spectrometer (see page 18) – left to right, O.M. Isakova, V.V. Isakov, V.A. Lebedev, V.N. Marin, A.A. Poblaguev, V.E. Postoev, and experiment leader V.N. Bolotov.



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 ( $\pm 6.4$ ) compared with 56.1 mb ( $\pm 4.7$ ) 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.

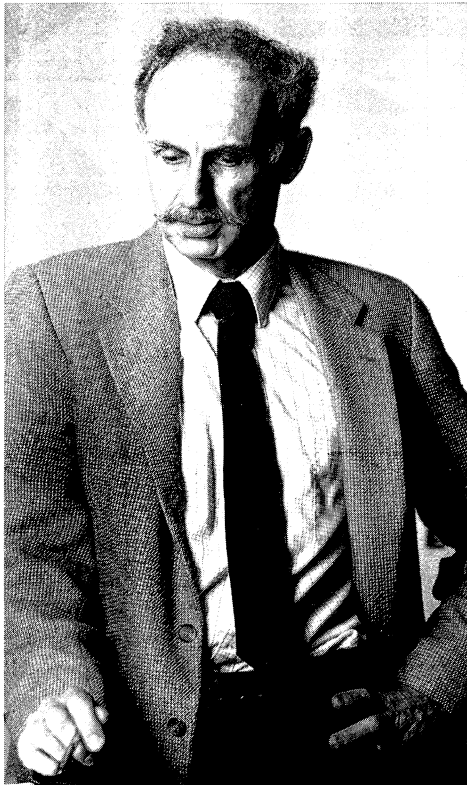
Theorists arguing that the dominant contribution to the rising cross-section is a 'soft' mechanism (the Pomeron) included P. Landshoff, C. Tan, A. Capella and J. Tran Thanh Van. A. White argued that within QCD, jets may be dominant over some energy range but new particle states might appear at higher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



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

*(Photo CERN 569.6.89)*

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## CERN Council

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*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.*

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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.

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## 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 Lillestøl 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.

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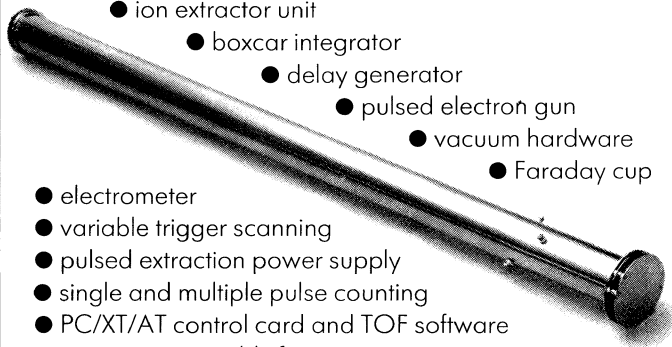
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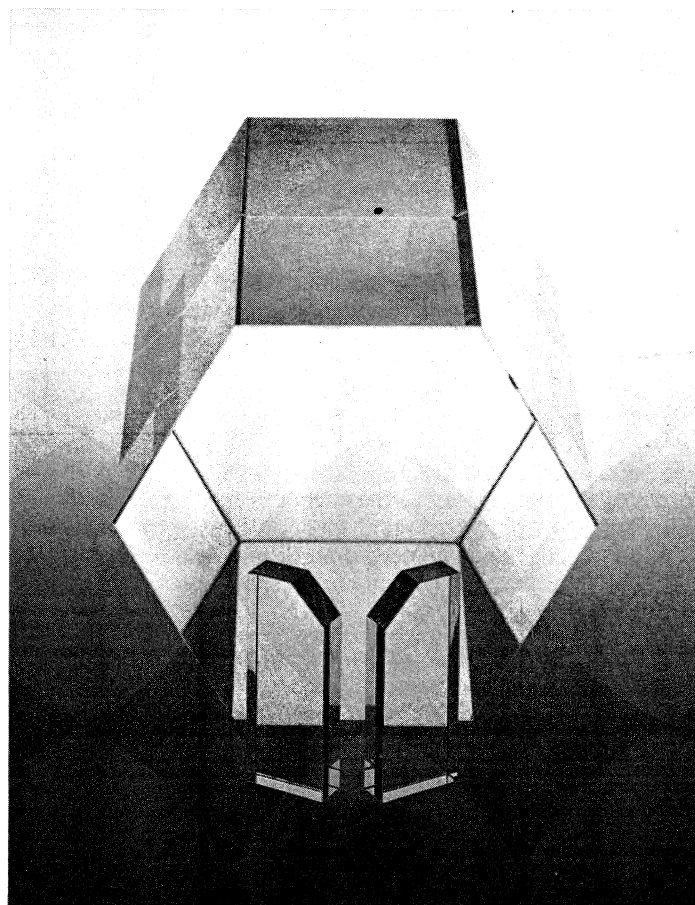
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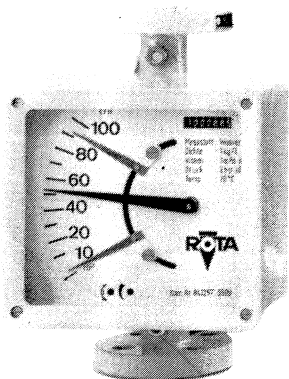
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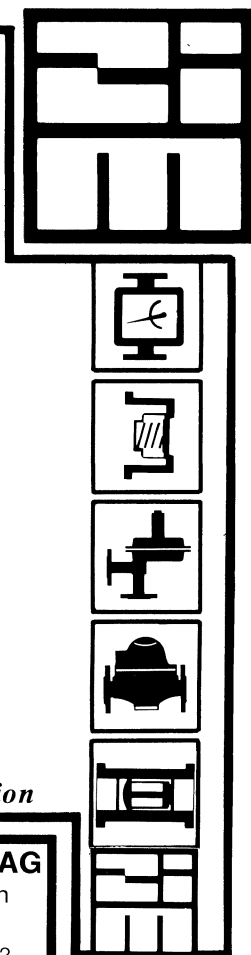


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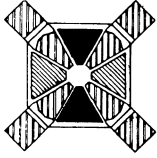
Current experiments in progress are in the collider (CDF) and fixed target (CP violation, Hyperon magnetic moments) programs at Fermi National Accelerator Laboratory under the supervision of Professors Devlin, Watts, and Thomson. Involvement in experiments at other and future facilities such as the SSC is planned.

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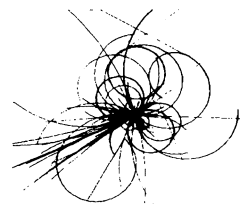
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*Satoshi Ozaki (right) returns to Brookhaven in October as Head of the proposed RHIC Relativistic Heavy Ion Collider under Laboratory Director Nick Samios (left).*

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*On people*

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*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.*

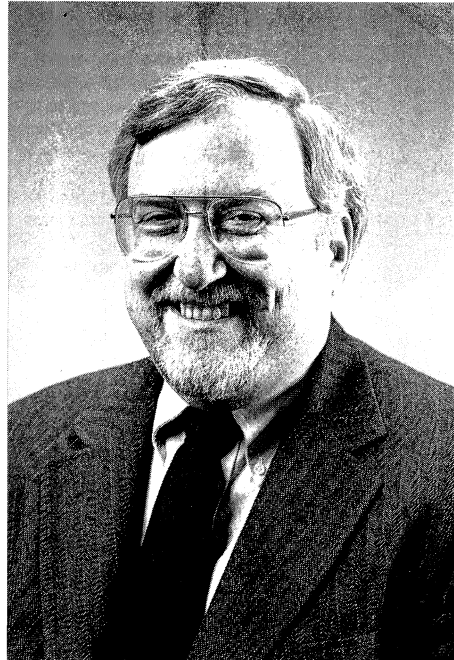


*At the beginning of July, Soviet physicist Andrei Sakharov (right), with his wife Elena Bonner (seated, left) visited CERN to see some of the Laboratory's new developments and experiments. Here they talk to Jack Steinberger in the control room of the Aleph experiment at the new LEP electron-positron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

*(Photo CERN 497.6.89)*



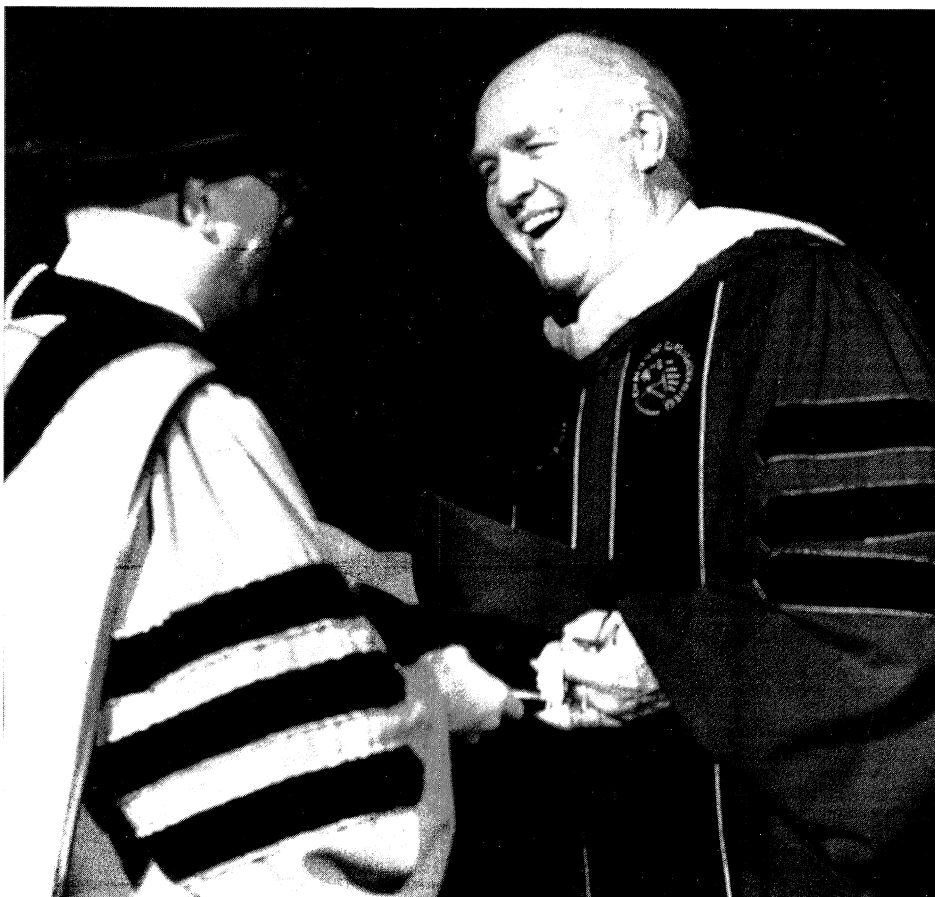
*J. Richie Orr (left), is Fermilab's new Associate Director for Administration, while Denis Theriot (right) becomes the Laboratory's Associate Director for Technology.*



*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 lead 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.*



*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.*



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 by 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 Institut 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 successful 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: SIEMSEN@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 TASC 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 Astrophysics) 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**

## Fellows In Accelerator Technology

Applications are invited from individuals with a PhD degree and/or major training in the physical sciences or engineering who wish to launch careers in accelerator design and development.

Successful candidates will be appointed Fellows in Accelerator Technology at Brookhaven National Laboratory (BNL). Appointments are for a period of one year, renewable for a second year. Fellows are expected to select their investigations from among the general objectives of the accelerator physics program at BNL.

The Alternating Gradient Synchrotron (AGS) Department is responsible for the operation of a 200 MeV proton linac, and the 30 GeV AGS which provide proton, polarized proton and heavy ion beams. New BNL initiatives are underway in the construction of a 1.5 GeV booster synchrotron for protons, polarized protons, heavy ions, and a proposal to construct a 30 GeV stretcher ring.

The Accelerator Development Department is responsible for a proposal to build a relativistic heavy ion collider (RHIC), and research and development effort directed towards the Superconducting Super Collider (SSC).

The National Synchrotron Light Source (NSLS) Department is responsible for the operation of two electron storage rings, with energy of 0.75 and 2.5 GeV, for the production of synchrotron radiation. The NSLS development program is directed toward improving the ring performance, new undulator and wiggler insertion devices, and coherent radiation sources, and the construction of a compact x-ray lithography source.

The Center for Accelerator Physics promotes R&D in all areas of accelerator physics and is building the Accelerator Test Facility, consisting of a 50 MeV linac, NdYag laser, and a high power CO<sub>2</sub> picosecond laser to study laser acceleration of particles and coherent radiation sources.

Scientists and engineers of any nationality are eligible to apply. Salaries are competitive, and Fellows are eligible for comprehensive employee benefits and relocation allowances. Candidates should send a detailed resume to: P.E. Hughes, Alternating Gradient Synchrotron Department, Brookhaven National Laboratory, Associated Universities, Inc., Upton, L.I., N.Y. 11973. Equal Opportunity Employer. M/F.



### ISTITUTO NAZIONALE DI FISICA NUCLEARE (I.N.F.N.)

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, starting on April-Mai 1990.

The successful 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)  
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).

The annual gross salary is lit. 24,000,000, corresponding to lit. 1,600,000 net per month, plus travel expenses from home Institution to I.N.F.N. Section or Laboratory and return.

Deadline for application is **December 31, 1989**.

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

For further information and application forms, please apply to:

Fellowship Service  
Personnel Office  
Istituto Nazionale di Fisica Nucleare (INFN)  
Casella Postale 56  
00044 Frascati (Roma) Italy.

### Supervisor of Mechanical Engineering and Drafting Services

The Lab for Nuclear Science is seeking an individual with the demonstrated ability to provide mechanical engineering services to a forefront experimental physics community, as well as the ability to supervise a drafting facility which includes at least three design drafters, or their equivalent. Experience with the use of computer-aided drafting and design systems software, and the ability to instruct others in the use of the same necessary. Ability and desire to keep the drafting and design systems at the forefront of technology is essential. Candidates should be thoroughly familiar with and capable of applying basic elements of analysis of stress and strain, including modern extensions such as finite element analysis; also, sufficient background in fluid mechanics to be able to analyze and apply hydraulic-circuit design, magnet cooling systems, etc., as well as full command of general elements of machine design. It is particularly important that candidates be able to interface between physicists, graduate students, engineers, drafters, and mechanical shops.

**Requirements:** A Bachelor's degree in mechanical engineering and five years of experience, two years of which are in a supervisory capacity, will be considered the minimum qualifications for this position. Demonstrated success in an environment of experimental physics would be of great value. **Please send two copies of resume and cover letter referencing Job No. R89-115 to Richard Adams, MIT Personnel Office, 400 Main Street, Cambridge, MA 02139.**

MIT is an Equal Opportunity/Affirmative Action Employer  
MIT is a non-smoking environment



## ACCELERATOR PHYSICS POSITIONS

The MIT-Bates Linear Accelerator Center has positions available in the field of accelerator physics and engineering with particular emphasis on construction and commissioning of the South Hall Ring. We currently operate a two-pass recirculating linac which produces a high quality one GeV electron beam for nuclear physics research and are adding a pulse stretcher/storage ring.

### Accelerator Physics/Engineer

Individual to help define the instrumentation and diagnostic requirements of the ring under construction. Will be involved in the commissioning, testing and operation of the ring and linac, particularly with respect to the beam diagnostics. Will also participate in calculations to evaluate the effects of ring hardware components on beam behavior. These calculations will contribute to defining the specifications of hardware to be placed within the ring. This individual will interact with the engineers who are responsible for the hardware design, particularly in the area of beam instrumentation.

**Requirements:** A B.S. in Physics or Engineering is the minimum qualification. Experience with ring hardware particularly beam diagnostics will be important. Experience with accelerator operation desirable. **Job No. R89-126**

### Accelerator Physics/ Applications Programmer

Individual to perform calculations related to the operation and commissioning of the ring under construction including closed orbit correction and polarization. Will also participate in the development of the computer modeling component of the ring computer control system. Existing programs will be used as well as special purpose software to be adapted or written. Applications software to display beam data and to be used in the control of beam parameters will be written. Will be involved in the commissioning and operation of the ring and linac system, particularly with computer modeling applications.

**Requirements:** A B.S. in Physics or Engineering is the minimum qualification. Programming experience in FORTRAN and C important. Familiarity with both VMS and UNIX systems desirable. Experience with accelerator operation and/or design also desirable. **Job No. R89-125.**

Interested candidates should send two copies of both cover letter and resume **referencing appropriate Job No. to: Richard Adams, C/O MIT Personnel Office, Bldg. E19-239, 400 Main St., Cambridge, MA 02139.**

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MIT is a non-smoking environment

# MIT

## PROJECT ENGINEER

Fermi National Accelerator Laboratory, an internationally renowned high energy physics research facility located 48 kilometers west of Chicago, Illinois, is upgrading its Tevatron accelerator complex. The sophisticated improvements planned for the upgrade program include a 150 GeV synchrotron containing 300 new high-performance electromagnets. We are currently seeking a talented senior-level professional to assume complete responsibility for the management of the development and fabrication of such magnets.

Management responsibilities will include overseeing and directing of all technical aspects of the magnet system from concept to finished product. Included will be product design, model evaluation, production tooling development, prototyping, magnet production and quality assurance. Administrative management responsibilities will include project planning, scheduling, cost control and reporting.

A minimum of 5 years engineering experience and an MS in mechanical or manufacturing engineering are required for the position. A background in successful project management and knowledge of materials, design, structural analysis, manufacturing and quality control are essential.

Fermilab offers an attractive salary and benefits package and a stimulating environment. For consideration, please forward resume and salary history to:

**Mr. James L. Thompson,  
Fermi National Accelerator Laboratory,  
P.O. Box 500, Batavia, Illinois, 60510, U.S.A.**

*An Equal Opportunity Employer M/F.*

## UNIVERSITY OF VICTORIA DEPARTMENT OF PHYSICS AND ASTRONOMY VICTORIA, BRITISH COLUMBIA, CANADA

### FACULTY POSITION IN PHYSICS

Applications are invited for a tenure-track position at the rank of Assistant Professor to commence in 1990. The position is in the area of Experimental Intermediate and High Energy Physics. The successful applicant will have an established research record and have an interest in undergraduate and graduate teaching.

The current research interests of the Department in this area include rare decay experiments at TRIUMF and Brookhaven National Laboratory and the SLD experiment at the Stanford Linear Collider, as well as active participation in the proposal for a KAON facility based program at TRIUMF. In the future the group intends to maintain a balanced program of physics at High Energy Colliders and Fixed Target Facilities. The close proximity of the TRIUMF Laboratory affords the opportunity for involvement in the TRIUMF program, and provides facilities for technological support and test beams for detector development, not normally present in a university department.

The University of Victoria offers equal employment opportunities to qualified male and female applicants. Women are particularly encouraged to apply. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents.

Applications with curriculum vitae, publication list, and names and addresses of at least three referees should be sent to:

**Professor L.P. Robertson, Chairman  
Department of Physics & Astronomy  
University of Victoria  
VICTORIA, B.C.  
V8W 2Y2**

Applications will be accepted until **October 1, 1989.**

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.

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#### Award for LeCroy

---

LeCroy Corp, whose innovative electronic equipment is widely used in high energy physics experi-

ments, 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.

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#### Making history

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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 be-

ing 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.

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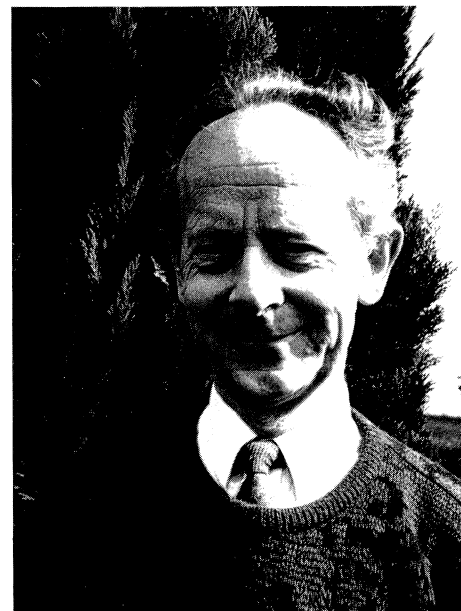
#### Uncle Albert

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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

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Russell Stannard – The Time and Space of Uncle Albert



# STANFORD UNIVERSITY ASSOCIATE DIRECTOR

The Stanford Synchrotron Radiation Laboratory (SSRL) is seeking a scientist or engineer to lead a group of accelerator physicists, engineers, technicians and operators responsible for the operation, maintenance and development of spear when it becomes a fully dedicated synchrotron radiation source with its own injector during the next year.

The group will also have involvement with the operation and development of PEP as a synchrotron radiation source as plans for such activities clarify.

Ph. D. required in related field and appropriate experience with accelerators and synchrotron radiation.

Demonstrated ability to provide scientific and technical leadership and a strong interest in achieving major advances in the production of synchrotron radiation.

University rank will be senior research associate or professor (research), depending on qualifications.

Applicants should write to

**Professor Herman Winick**  
**Stanford Synchrotron Radiation Laboratory**  
**Stanford University**  
**P.O. Box 4349**  
**BIN 69 Stanford, CA 94309,**

enclosing a curriculum vitae and names of at least two references.

*Stanford University is an equal opportunity employer.*

# EULIMA

## EUROPEAN LIGHT ION MEDICAL ACCELERATOR

The proposed European Light Ion Medical Accelerator is designed to give improved radiotherapy treatment using light ions of about 400 MeV per nucleon.

The EULIMA feasibility group is funded by the Commission of the European Communities for a period of 18 months and located at CERN, Geneva.

Appointments will be made in the near future to two positions, concerned with:

a) beam dynamics inside a large superconducting separate sector cyclotron,

b) injection and extraction studies.

**Candidates should have a physics or engineering degree,** with Ph.D or practical equivalent experience. Experience of accelerator design and computer simulation would be advantageous.

For further information apply as soon as possible to:

**P. MANDRILLON, EULIMA Feasibility group, c/o CERN PS Division,  
CH-1211 GENEVA 23**

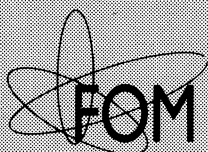
Telephone: (22) 767.22.93      Telefax:(22)785.05.15

### Foundation for Fundamental Research of Matter

*The foundation FOM is an organisation for research in the area of physics with some 1100 employees. Research is executed by task-forces at university laboratories and institutes.*

*The National Institute for Nuclear Physics and High Energy Physics (NIKHEF) in Amsterdam is one of these institutes, a cooperation of FOM, the Free University (VU) in Amsterdam, the University of Amsterdam (UvA) and Catholic University of Nijmegen (KUN).*

*The NIKHEF staff counts of about 350 people, spread over two sections. Most experiments of the Nuclear Physics section (K) use the own electron accelerator MEA. For the experimental program of the High Energy Physics section (H) the facilities of CERN and DESY are used.*



## Experimental high energy physicists m/f

Applications are invited for post-doctoral and tenure-track positions in Particle Physics Research at the section High Energy Physics of the National Institute for Nuclear Physics and High Energy Physics (NIKHEF) in Amsterdam.

The institute is involved in experiments at CERN (UA1, Delphi and L3) and DESY (Zeus); it also has a small theory group. The academic staff, including PhD students, consists of about 60 physicists. Technical support is provided by well equipped mechanical and electronic workshops. The institute has its own, up to date, computing facilities.

### Requirements

Candidates should have a PhD degree, preferably in Experimental Particle Physics. Applicants may be considered for a tenured position when they have at least several years of post-doctoral experience with a strong record of accomplishment. It is assumed that successful applicants will join one of the

present experimental teams.

They should demonstrate originality and initiative in their research activities and possibly help initiating future research directions of the laboratory.

### Information

Further information can be obtained from the Scientific Director, prof. dr. K.J.F. Gaemers, telephone 20-5925001.

### Applications

Letters of application, including curriculum vitae, list of publications and the names of at least three references are to be sent within three weeks after publication of the advertisement to the personnel officer mr. T. van Egdom, P.O. Box 41882, 1009 DB Amsterdam, the Netherlands.



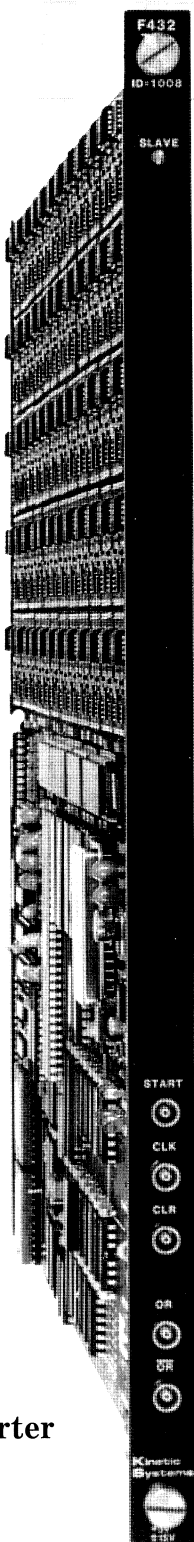


# FASTBUS

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The KineticSystems F432 64-channel, Single-Hit Time-to-Digital Converter (TDC) is the first commercially available FASTBUS device with the precision to resolve time intervals within  $\pm 25$  picosecond steps. It measures the time between a common start input and one of the 64 stop channels, which are precision time-to-amplitude converters (TACs) developed by KineticSystems. Each TAC is multiplexed to a common analog-to-digital converter and digitally corrected to compensate for offset and gain errors, insuring accuracy and long-term repeatability.

Sixty-four TDC channels are packaged on a standard single-width FASTBUS card. Each analog channel is an individual daughter board utilizing surface-mount devices for convenient in-the-field servicing. The multilayer mother board contains digital-corrected circuitry, memory, and a complete FASTBUS interface. The common start and all 64 stop inputs connect to the TDC through a half-height connector card via the module's rear auxiliary backplane. Auxiliary inputs are differential ECL, terminated into 100 ohms.

The F432 is a Slave module, implemented using the FASTBUS Address/Data Interface (ADI) chip set and Programmable Array logic devices. Readout is usually performed by a data-gathering Master, such as our F820 Scanner Processor (SP) or F930 Block Mover II. The TDC's most efficient method of readout is by a unique block transfer read of zero-suppressed data memory minimizing the number of FASTBUS read operations. Sparse data scan and single-word data transfers are also supported. Of course, raw data is always available for those who like to keep it all. The pedestal value for each channel is automatically subtracted from raw input data and stored in memory as Pedestal corrected data. In this way, corrected data is read directly by the host, eliminating the need for special-purpose modules for on-the-fly pedestal subtraction. The pedestal values may be downloaded or obtained by selecting the pedestal calibration mode.

**Contact Us Now For More Information**

## **Kinetic Systems International S.A. Europe**

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D-7800 Freiburg  
West Germany  
Tel: 761 33 265  
FAX: 761 232 46

### U.S.A.

11 Maryknoll Drive  
Lockport, Illinois 60441  
Tel: (815) 838 0005  
TWX: 910 638 2831  
FAX: (815) 838 4424

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

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### Meeting

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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.

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### Hospital fluorine-18, continued

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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.

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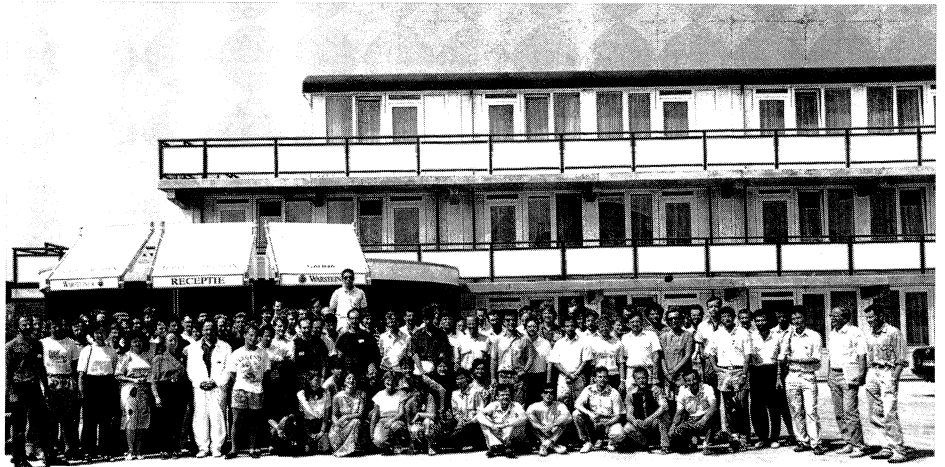
### Astrophysics at Berkeley

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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-

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)



## 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 'Kopflinik', 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. Wannemacher 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.



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#### *Pniewski and Bialkowski*

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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.

*Jerzy Pniewski*



*Grzegorz Bialkowski*



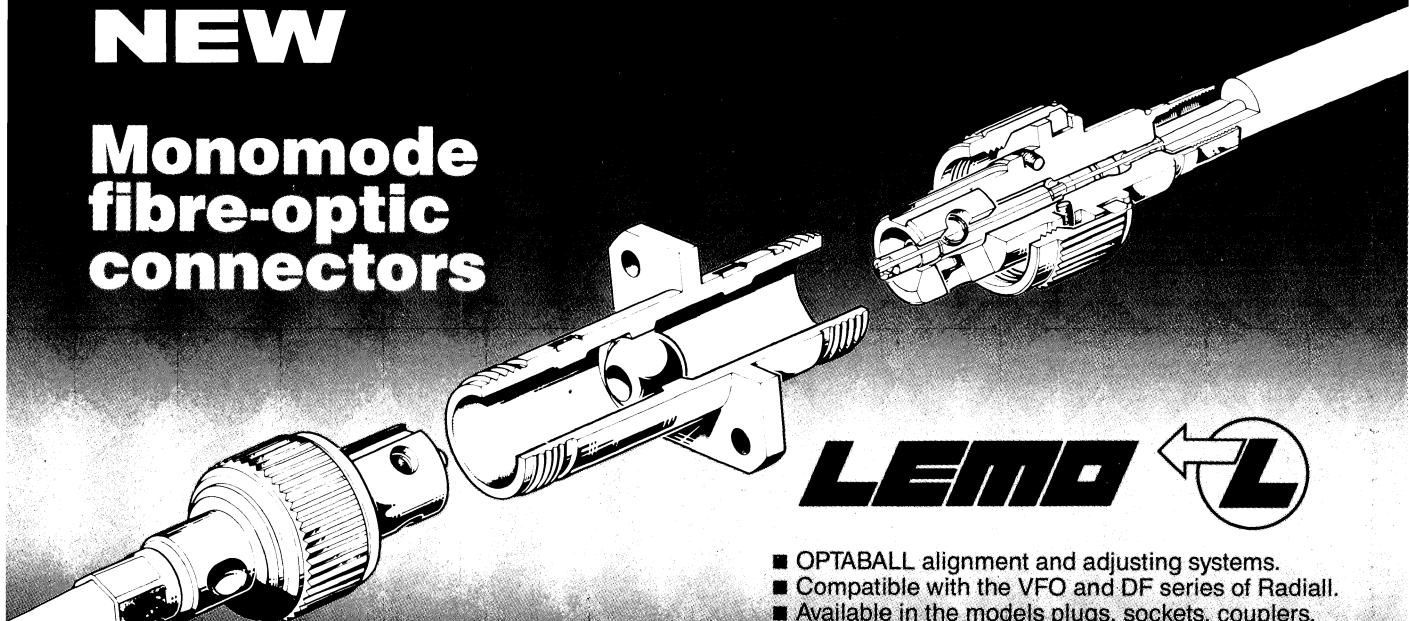
Grzegorz Bialkowski died on 29 June. He was a particle theorist, concentrating on dispersion relations, Regge poles, and the damped cascade model of hadronic interactions with nuclei. He worked with distinction at CERN, Saclay, Torino and Trieste as well as in his native Poland. Bialkowski was a person 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.

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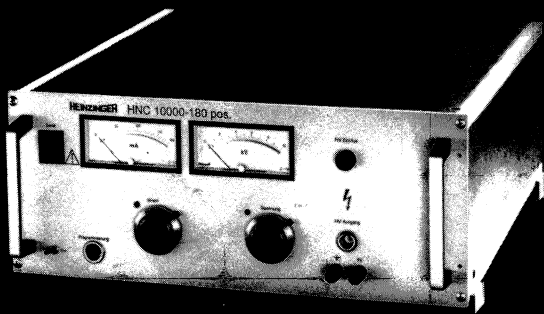
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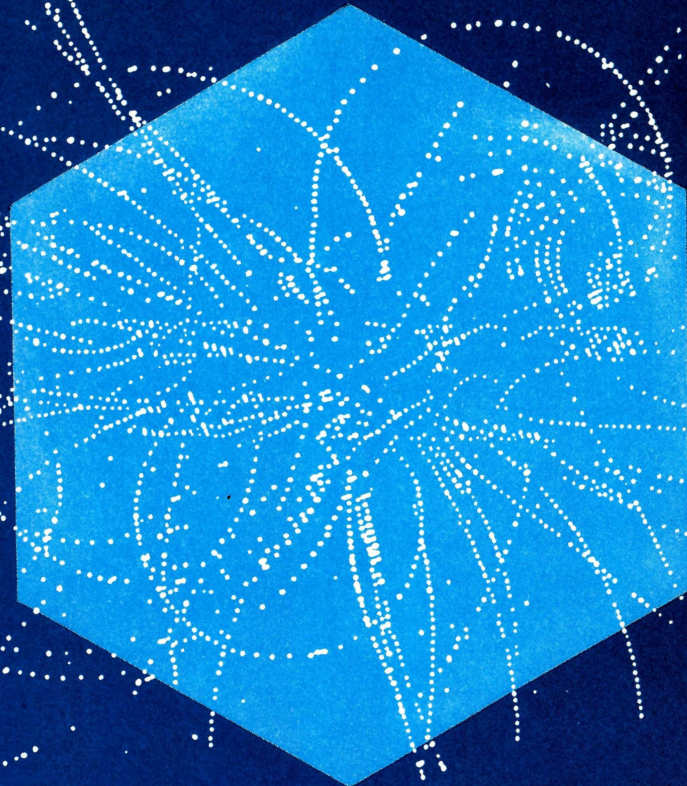
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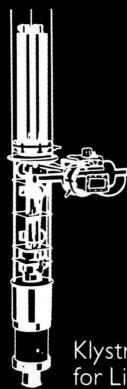




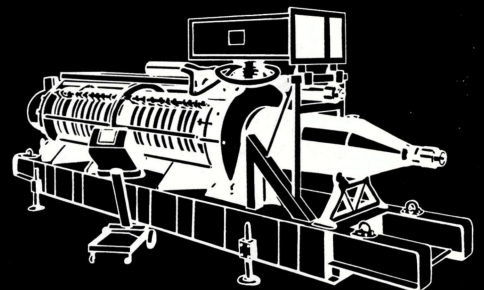
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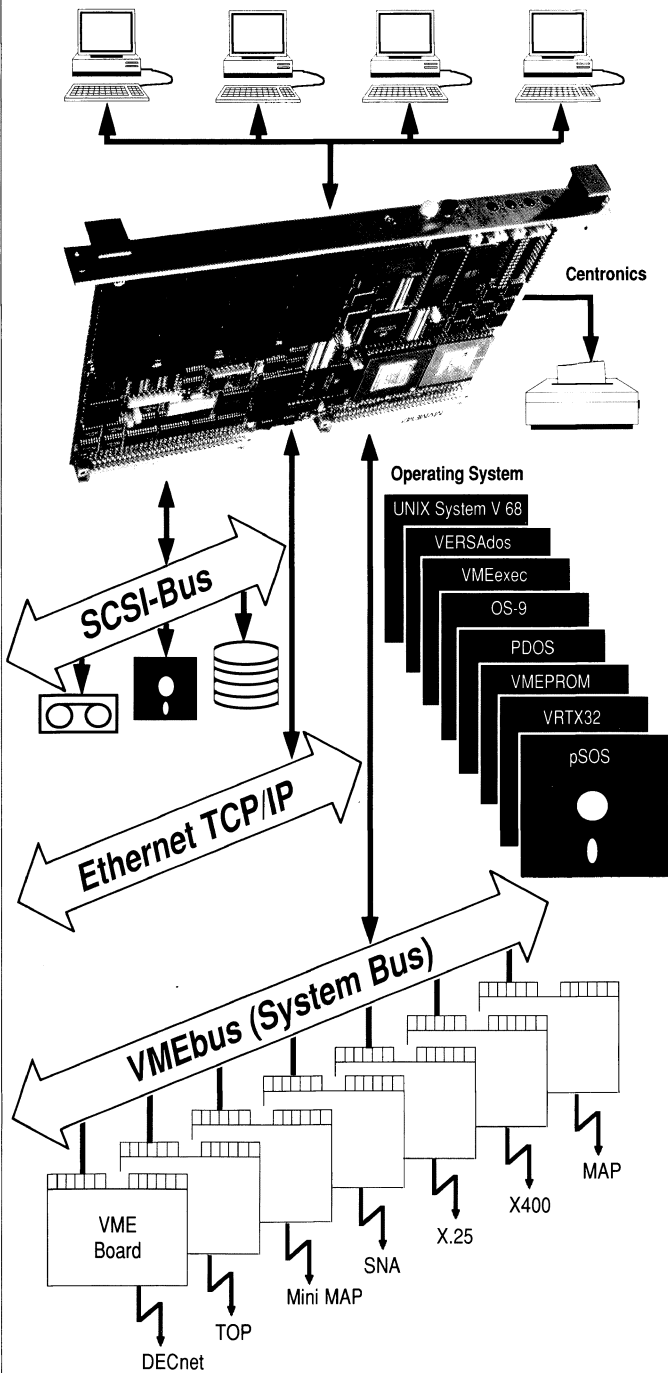
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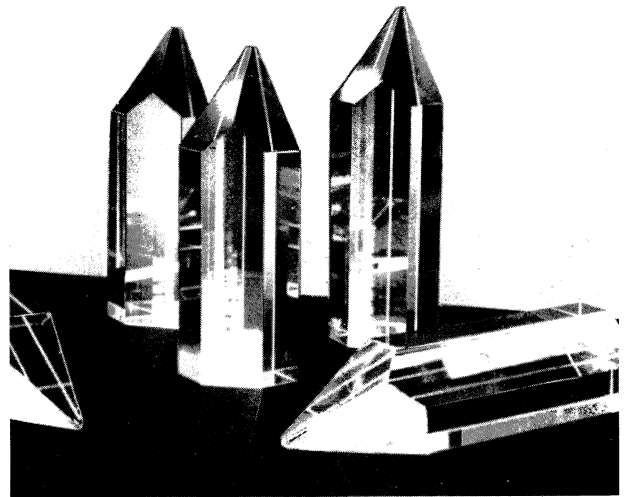
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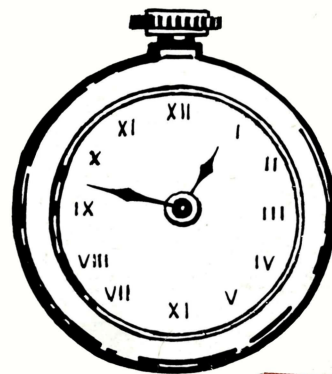
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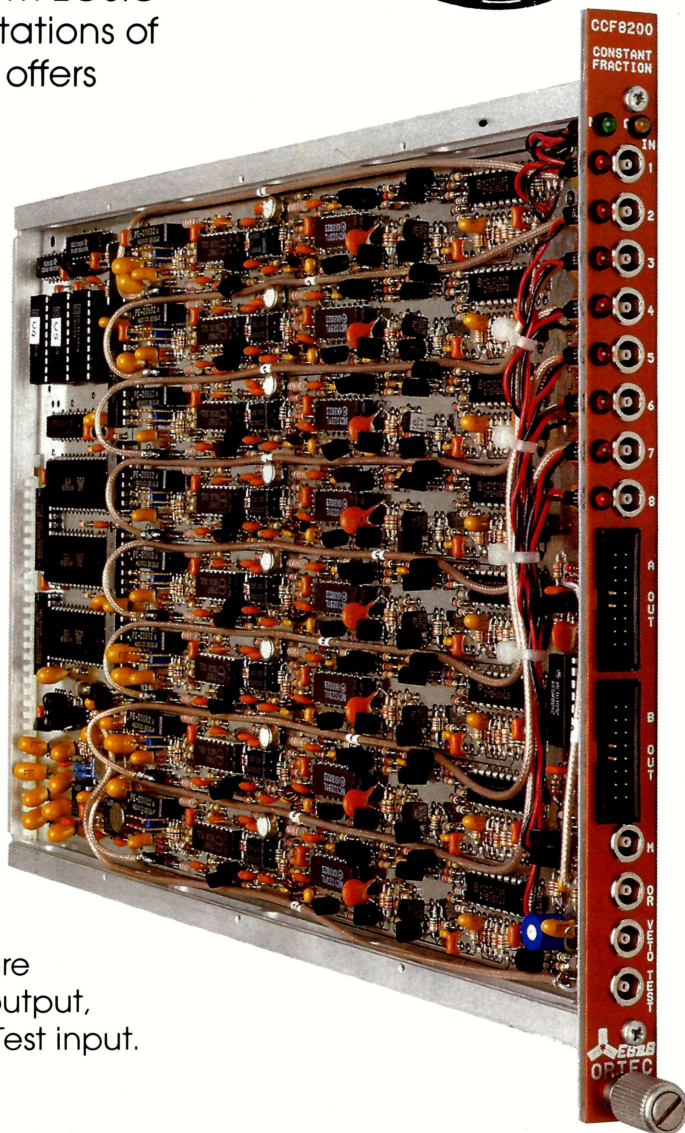
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