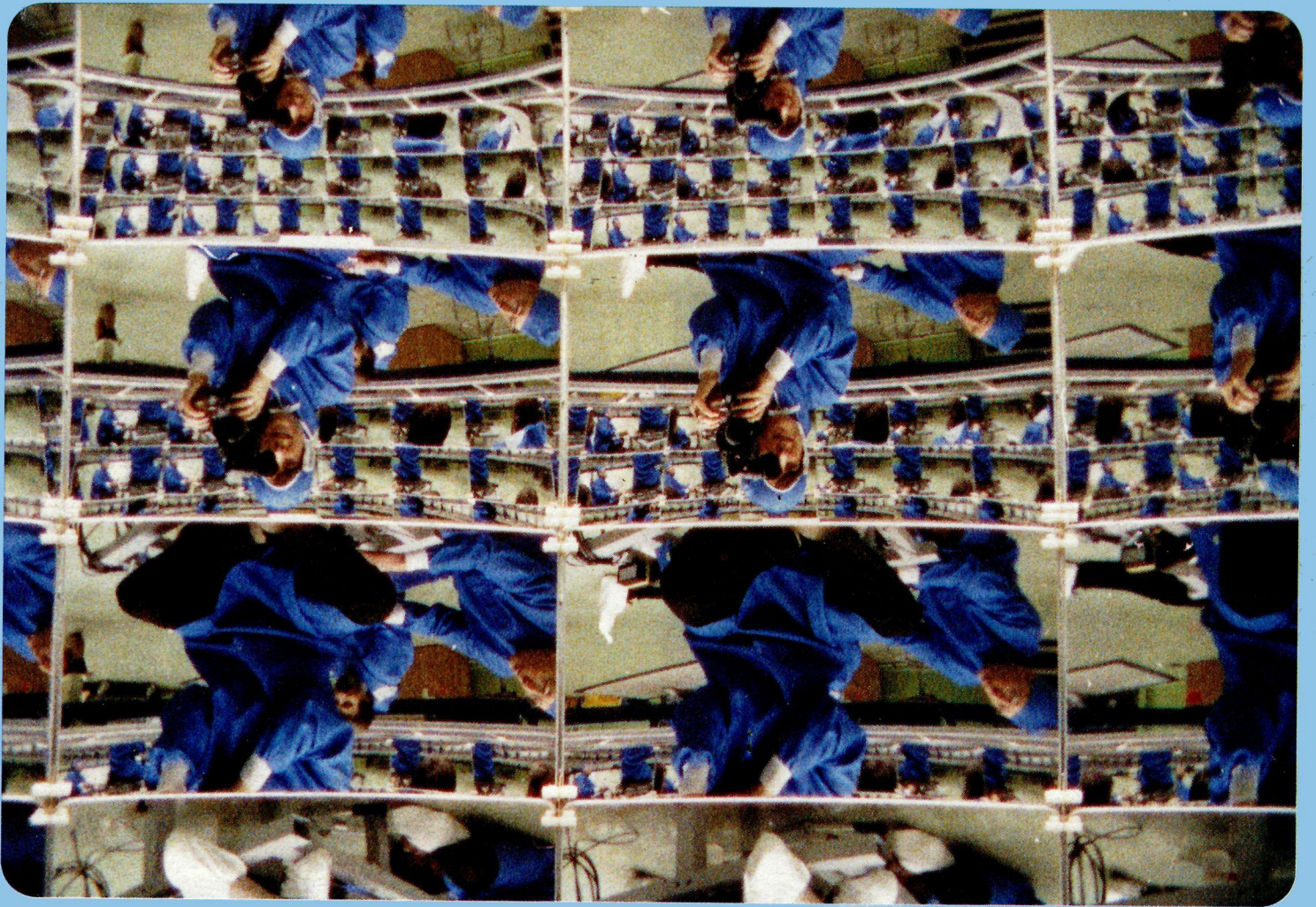


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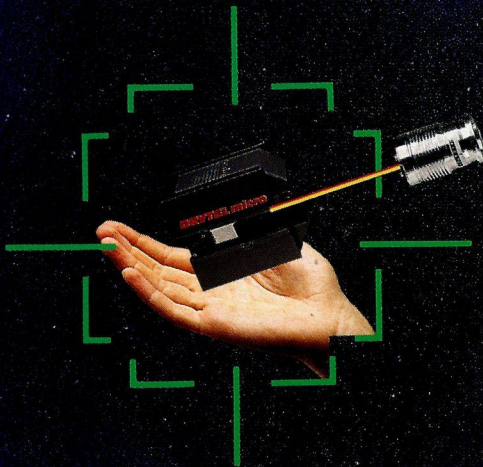
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VOLUME 31

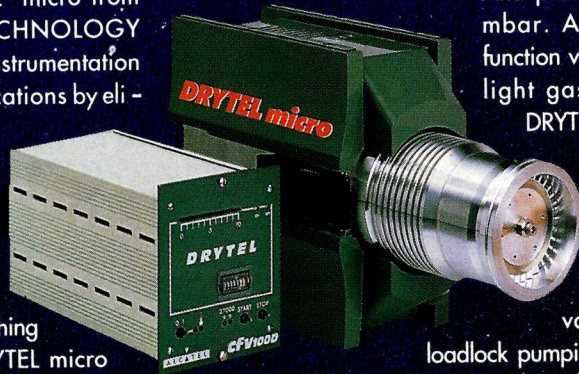


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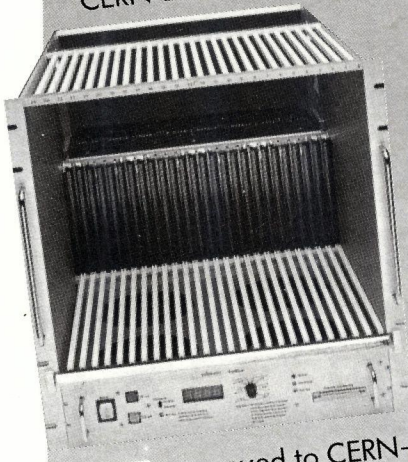
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Physics film-maker Lynn Silverman's view of herself at work as seen in the Ring Imaging Cherenkov Counter (RICH) mirrors of the Delphi experiment at CERN's LEP electron-positron collider (see page 14).

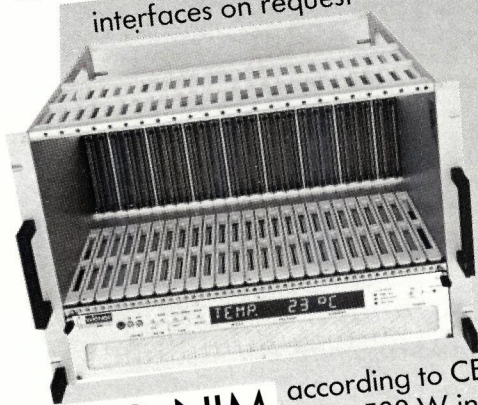
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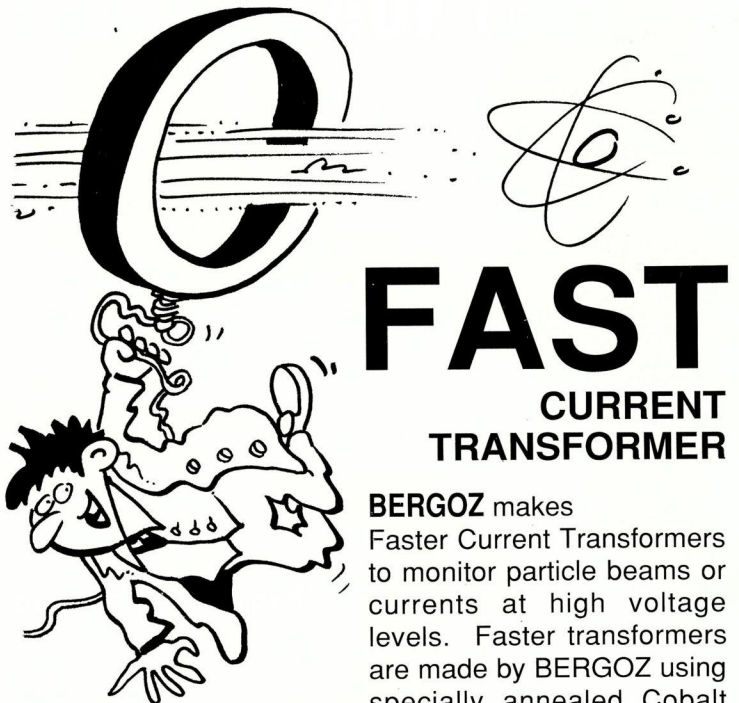
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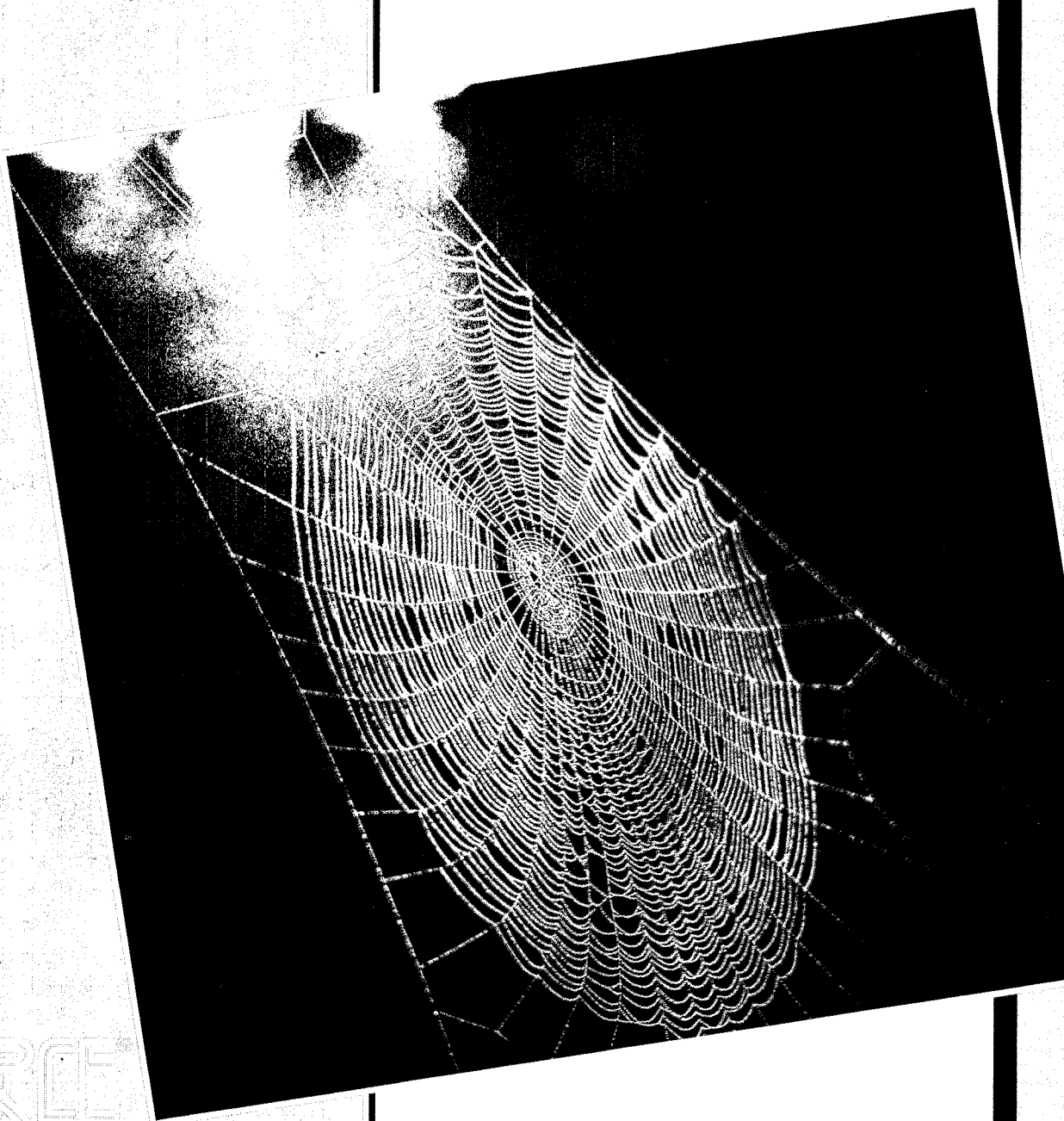
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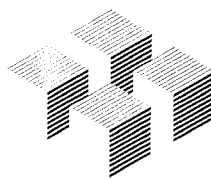
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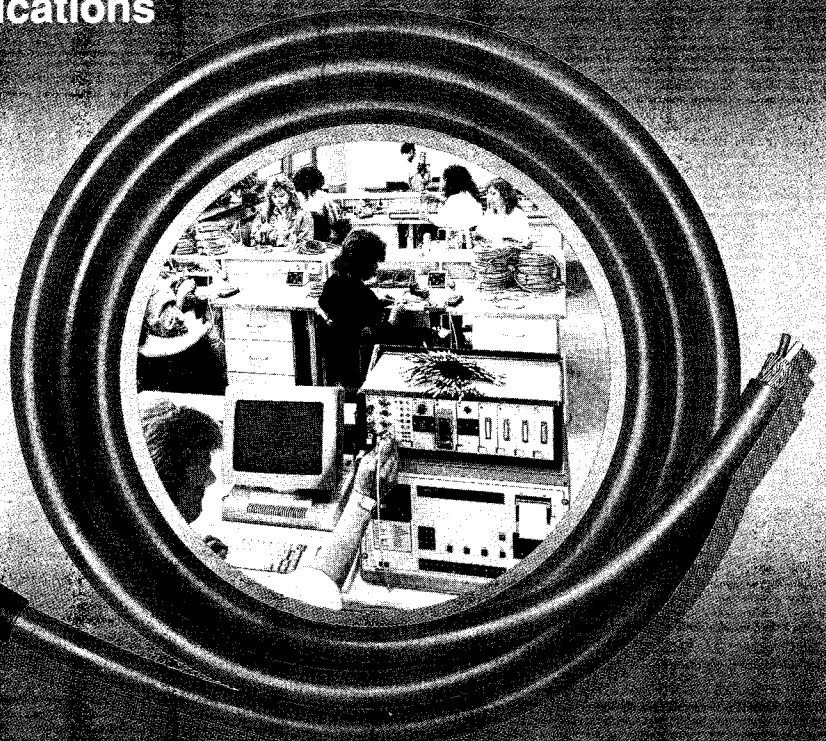
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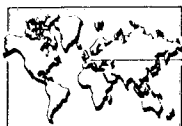


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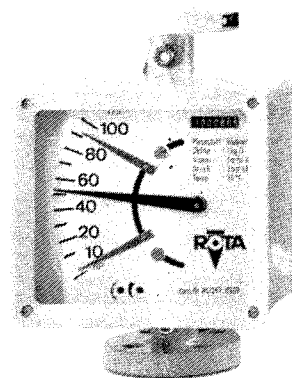
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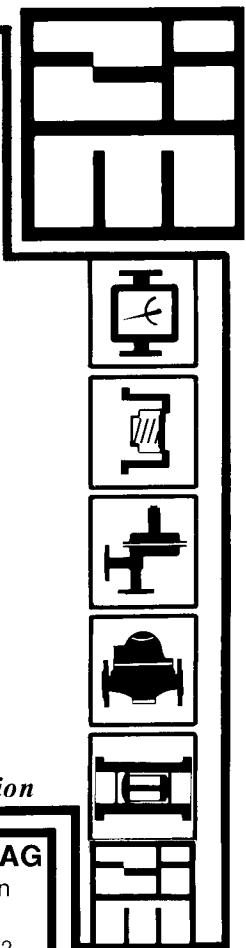
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Triumph for TRIUMF

As stop-pressed in our October issue, the Canadian federal government has offered 236 million Canadian dollars for the KAON scheme proposed for the TRIUMF Laboratory in Vancouver. This amounts to a third of the project construction costs, matching exactly the funding already offered by the provincial British Columbia government.

The KAON plan is for a high intensity particle beam factory, and would elevate Canada to a position in fundamental physics research in keeping with its place in the seven-nation 'summit' group. So far, Canadian scientists have had to make extensive use of research facilities elsewhere, while the international attraction of the TRIUMF cyclotron, operational since 1974, has waned over the years.

Erich Vogt, Director of the Canadian TRIUMF Laboratory in Vancouver, has been an indefatigable driving force behind the KAON project.



The special federal funding for KAON would be in addition to existing Science and Technology budgets. The federal Canadian and British Columbia governments are actively negotiating on the project, which would also involve additional operating costs for the Laboratory, estimated at about 100 million dollars annually.

The remaining one-third of the construction outlay is expected to come from international partners. An offer worth 75 million dollars from the US was already on paper in 1989.

This international support could come in kind as well as cash. Major particle physics projects elsewhere have frequently benefited in this way – CERN and the USSR have a long history of mutual help, while most recently the HERA electron-proton collider now being commissioned at DESY in Hamburg includes major hardware and manpower contributions from abroad.

Canada was one of the first nations to offer such support for HERA.

The KAON scheme envisages using the existing TRIUMF 500 MeV cyclotron as injector, with beams subsequently passing through a series of five rings – two fast-cycling synchrotrons interleaved with three d.c. storage rings – to finally deliver the required 100 microamps of 30 GeV primary protons.

Thus the cyclotron would first feed Accumulator and Booster rings sharing a common tunnel, with particles subsequently passing into Collector, Driver and Extender rings in a 1070-metre circumference tunnel.

This scheme would boost available particle intensities by a factor of about a hundred, and the result-

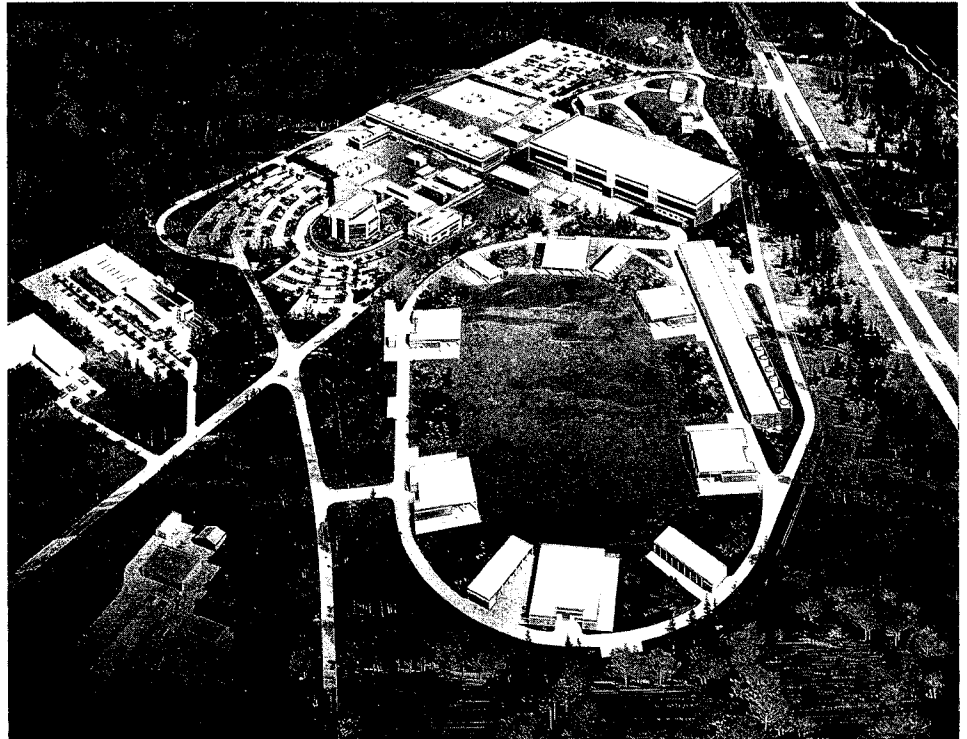
British Columbia Education Minister Stan Hagen, a long-time backer of the KAON project, receives his 'MR. KAON' licence plate from TRIUMF Director Eric Vogt.



ing physics opportunities, covering a broad front, have been examined at an international series of workshops.

Kaons are not the only particles on the KAON menu – the name being an acronym for Kaons, Antiprotons, Other hadrons, and Neutrinos.

Proposed layout of the KAON particle factory at the Canadian TRIUMF Laboratory in Vancouver. The Canadian government has offered a third of the construction money, the regional British Columbia administration another third.



Needles in high-speed haystacks

The new generation of big proton-proton colliders now being planned in Europe and the US aims to open up the collision physics of the constituent quarks and gluons hidden deep inside the proton. Locked inside nuclear particles, quarks and gluons cannot be liberated as free particles, at least under current laboratory conditions. To study them needs microscopes the size of the LHC collider foreseen for CERN's 27-kilometre LEP tunnel and the 87-kilometre Superconducting Supercollider (SSC) planned in the US. But the researchers using these gigantic new microscopes have to have good eyesight – they need the right detectors.

Seeing things this small needs collision energies of some 1 TeV

(1000 GeV) per constituent quark/gluon, or at least 15 TeV viewed at the proton-proton level. Most of the time, the collisions would be 'soft', involving big pieces of proton, rather than quarks and gluons. To see enough 'hard' collisions, when the innermost proton constituents clash against each other, physicists need very high proton-proton collision rates.

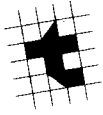
These rates are measured by luminosity. (The luminosity of a two-beam collider is the number of particles per second in one beam multiplied by the number of collisions per unit area of the other beam.) For LHC, luminosities of up to a few times 10^{34} are needed.

Quite apart from the challenge of delivering this number of high ener-

gy protons, having such intense beams continually smashing through physics apparatus makes problems for detector designers.

As well as quickly wearing out detector components, these conditions imply new dimensions of data handling. Proton bunches would sweep past each other some 60 million times per second, each time producing about 20 interactions of one kind or another. Only one in a billion of these interactions would be of the hard kind which interests the physicists, and the instrumentation and data systems would have to filter out interesting physics fast enough to avoid being swamped by the subsequent tide of raw data.

It is as though a passenger in a train, watching haystacks flash



Technopolis Thoiry

Geneva Moves With The Times

Geneva has been closely linked to science from the time it hosted crucial discussions on links between such diverse phenomena as light, chemical reactions and magnetism. Indeed, the city became the home of one of Europe's first major experimental facilities — a giant electrochemical pile designed to test Ampere's theories. This was built by de Saussure two decades after a visit by Volta to demonstrate a more famous, but much smaller, pile on his way to impress Napoleon.

An International Role

Geneva's role in providing a testbed for unified theories of matter continues to this day at CERN where the LEP collider probes nature at the 10^{-18} metre scale by colliding electrons and positrons circulating inside a high vacuum beam pipe buried up to 100 metres below the Swiss and French countryside in a 27 kilometre circular tunnel.

CERN was conceived by scientists and politicians in the late-1940's as a step on the road to post-war reconciliation via a major collaboration on the neutral ground of pure research in a region with a long history of internationalism. With a staff of 3000 and a budget of some 900 million Swiss francs to provide facilities for scientists from 300 institutes, CERN welcomes 6200 visitors each year.

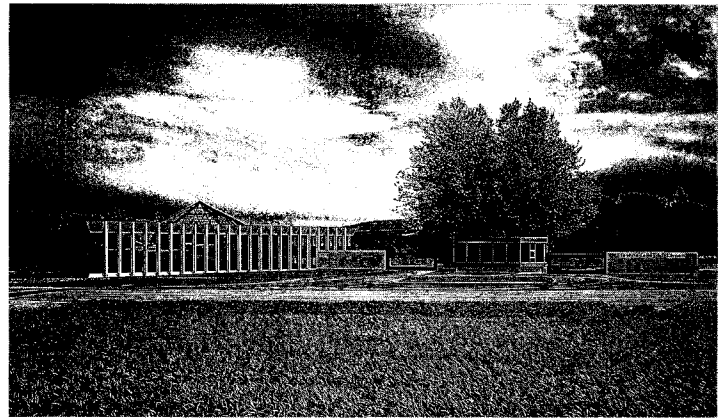
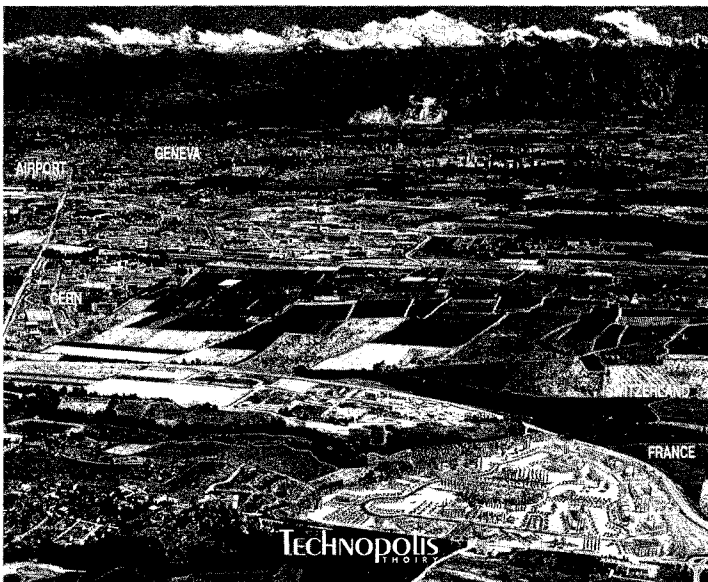
The Technopole Interface

Geneva continues to adapt its role as we move towards the 21st Century. Science parks represent one development and there are now about 300 in the industrialized world. In offering a homogeneous blend of activities and facilities, they generally aim to enhance synergies in an increasingly competitive world.

Unique among the science park concept is the Technopole approach where an outer circle of commercial, governmental and institutional interests come together to promote an inner core of activities providing interfaces between science, technology, new businesses, and higher education. Each Technopolis thus comprises a homogeneous blend of facilities and ancillary services.

The Geneva region's Technopolis is situated just across the Franco-Swiss border from the main CERN campus. The 27 hectare green field site on the outskirts of the village of Thoiry is therefore ideally located to interface with the international physics community. Being only five kilometres by road from Geneva's international airport and main line station is an invaluable advantage.

Looking across the main CERN campus to Geneva from Technopolis Thoiry, outlined as an artist's image.



The Opus One building at Technopolis Thoiry.

Focussing on Applied Physics

LHC, CERN's next major collider, proposed for the LEP tunnel, follows on from past achievements in calling for state-of-the-art superconducting magnets, advanced materials, sophisticated vacuum and cryogenic systems, high power electronics, and a wide range of computer-based facilities to serve all aspects of the machine — from resource management to the imaging of particle collisions in its mega-detectors.

Technopolis aims to allow industry and institutes to participate in, and contribute to, the rich scientific and technical environment by serving as a closeknit interactive base for specialist organizations. In addition to enjoying a convenient window on CERN's extensive sub-contracted requirements, they will be able to arrange collaboration on a formal basis. Technopolis is also working to establish an Institute to provide an interface in applied physics between teaching and research staffs, postgraduates and high calibre technicians coming from industry and R. and D. centres.

A Superb Environment

Robert Hinterberger, Director of a Technopolis Thoiry based computer software company, places great importance on the "perfect working environment". This will continue to be preserved in a balanced development comprising space reserved for accommodation, technical and commercial companies, the technological institute, small scale R. and D. units, and hotels and conference services.

By the same token, while Mr. Benier, the Mayor of Thoiry, is "obviously interested in promoting employment opportunities" he is "also concerned that we preserve the quality of our local environment". Hence recent agreements for a national park in the Jura mountains behind Thoiry, consolidation of road access from Switzerland through to the French motorway system, a cultural centre, a second international school, and the imminent construction of a major world-class shopping centre.



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For the LHC at CERN, research and development work on detector components and techniques is pushing ahead on a wide front. Seen here is the rear of a lead-scintillating fibre calorimeter recently tested at the SPS synchrotron.

(Photo CERN 1.10.91)

past the window at high speed during a thunderstorm, had to locate a single needle hidden in one haystack, without stopping the train.

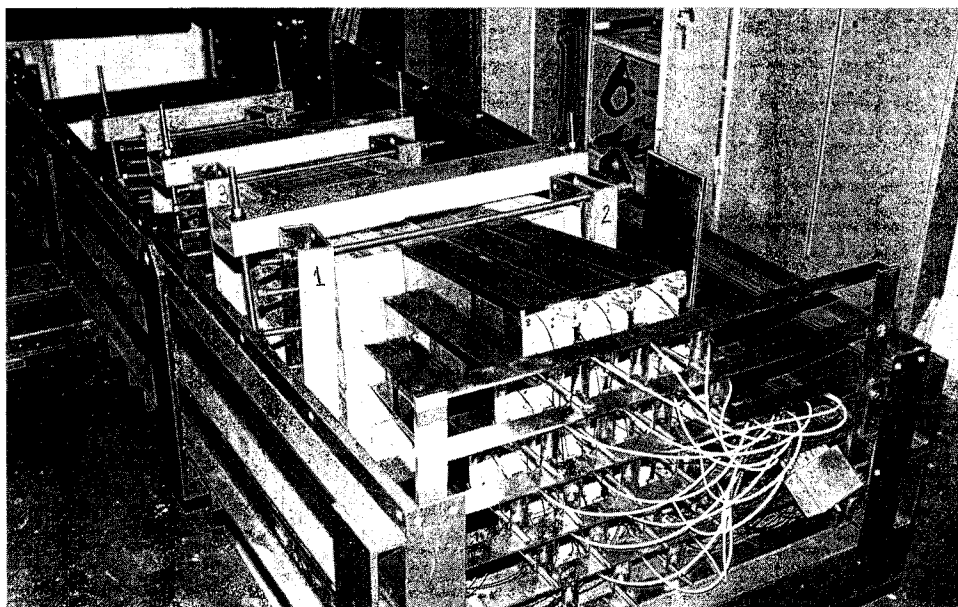
To look for these needles, physicists use detectors built like a series of boxes packed one inside the other, each box doing a special job before the particles pass through to the next. The innermost box is the tracker which takes a snapshot of the collision, tracing the path of the emerging particles.

Quark/gluon collisions, each expected to give a few hundred tracks, would be superimposed on many soft proton collisions, each producing about 25 tracks.

Traditional tracking, with a full 'picture' of emerging charged particle tracks bent by a magnetic field (to measure momentum) looks feasible at luminosities up to about 10^{33} . Physics would certainly need higher rates, but this would blind the innermost tracker, and for these runs it would be best removed. However a certain amount of tracking has to be retained, even at higher rates, to pick up the isolated electrons accompanying special processes. Promising tracking technologies include semiconductor microstrips and scintillating fibres.

After the tracker traditionally follows the calorimeter to measure the energy deposited by the emerging particles. As well as measuring the energies of special particles, like photons and electrons, the calorimeter has to be 'watertight'. Any mismatch in energy flow between two sides of the detector ('missing energy') can then be attributed to invisible particles, like neutrinos, escaping the detector, and not to otherwise visible particles disappearing through cracks.

The signals from hard quark/gluon interactions would ne-



cessarily be obscured by 'pile-up' from soft interactions. Overlap from different interactions can be minimized by having a fine-grained calorimeter, and some soft background can be allowed for.

Promising general-purpose calorimeter technologies include liquid argon and scintillating fibre/lead matrices, while dedicated calorimeters for electromagnetic energy measurement could be based on special crystals or noble liquids.

Electrons and muons are very important for this kind of physics, and could be a vital part of special signatures indicative of new processes. Muons, with their ability to pass through thick sheets of absorber, remain an 'easy' option, however requirements for precise momentum resolution could have a major impact on the design of these anyway very large detectors.

Electrons are much less easy to isolate than muons, and would also tend to be masked by other signals. Accurate location with a fine-grain detector would help, but additional electron identification still would be needed. Such information

could be given by correlating calorimeter measurements with upstream signals from the tracker or a dedicated track/preshower detector, or by independent electron identification (using a transition radiation detector).

Seeing anything at all depends on the initial level of event filtering by electronic triggers. These will have to select out one event in ten or even a hundred thousand within a microsecond. In addition, the information coming from different parts of the very large detectors will have to be synchronized, all this some 60 million times a second!

For the SSC, 'generic' research and development work began in 1986, eventually overlapping with the R and D for specific detector subsystems. This overlaps in turn with development work for the two major proposed experiments (October, page 12). For the LHC at CERN, research and development work on detector components and techniques is pushing ahead on a wide front pending the appearance of initial proposals for complete de-

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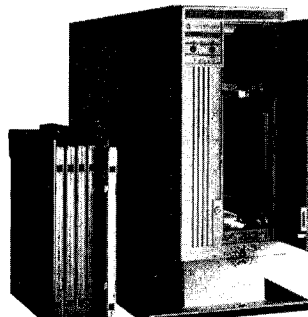
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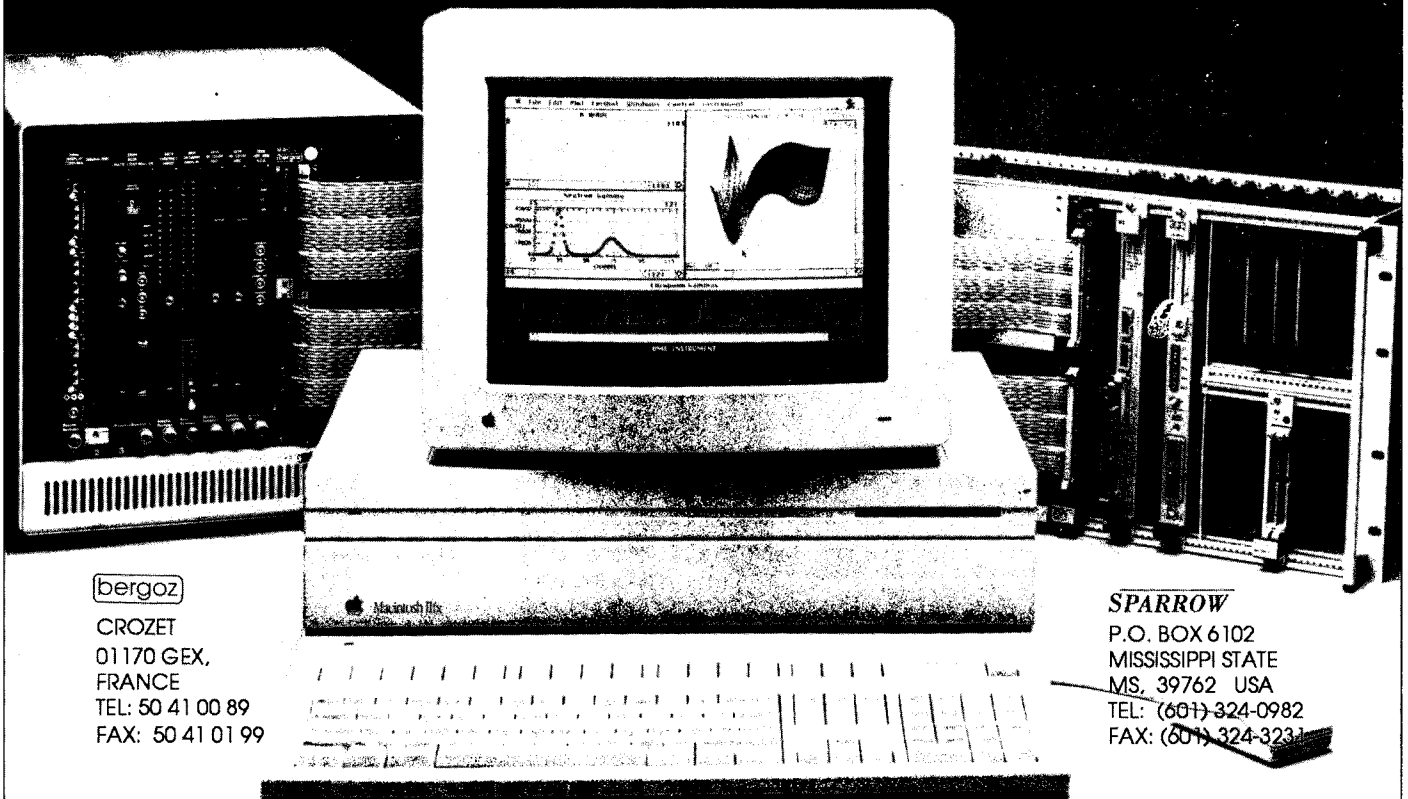
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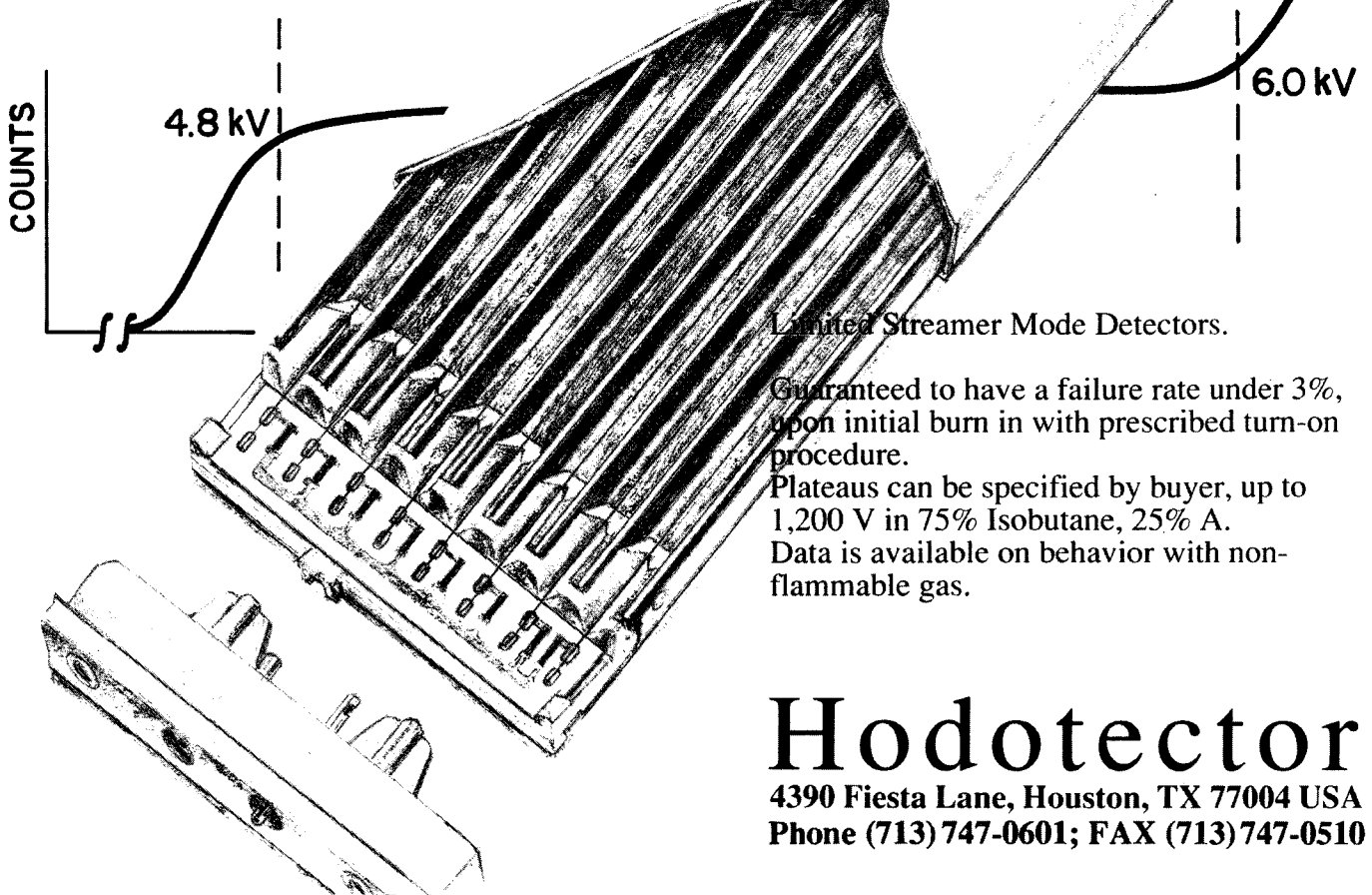
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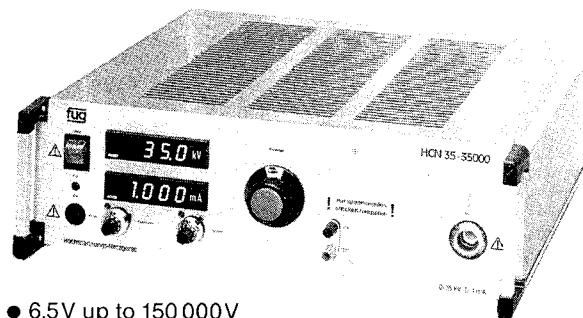
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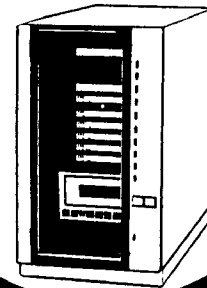
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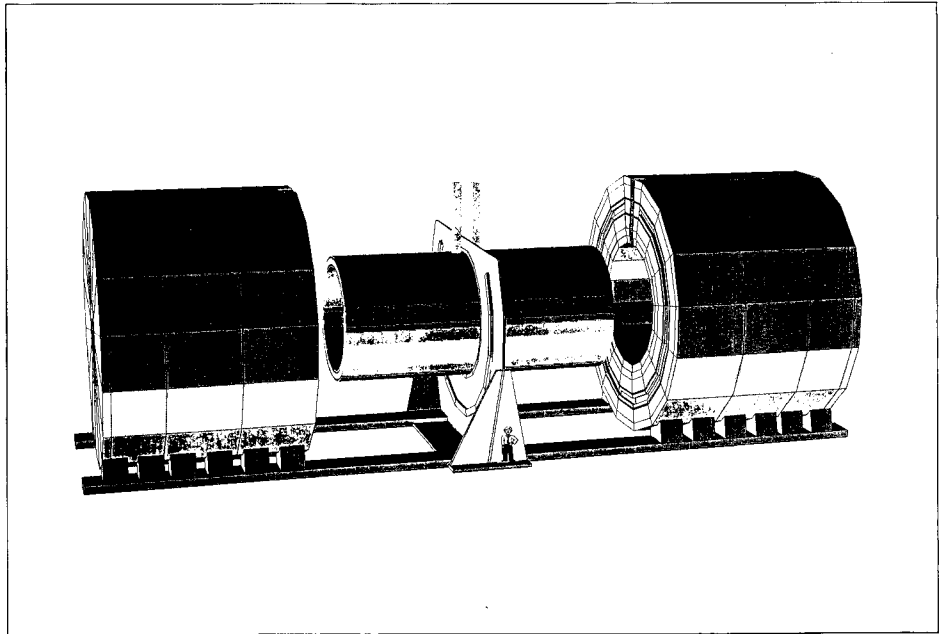
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tectors (October, page 25), while a magnet study group coordinates the designs for the big magnets at the heart of new detector schemes.



A possible superconducting solenoid design for an experiment at CERN's proposed LHC proton collider. For giving an idea of the scale, some people have suggested that the 'standard man' could be usefully replaced by a 'standard dinosaur'.

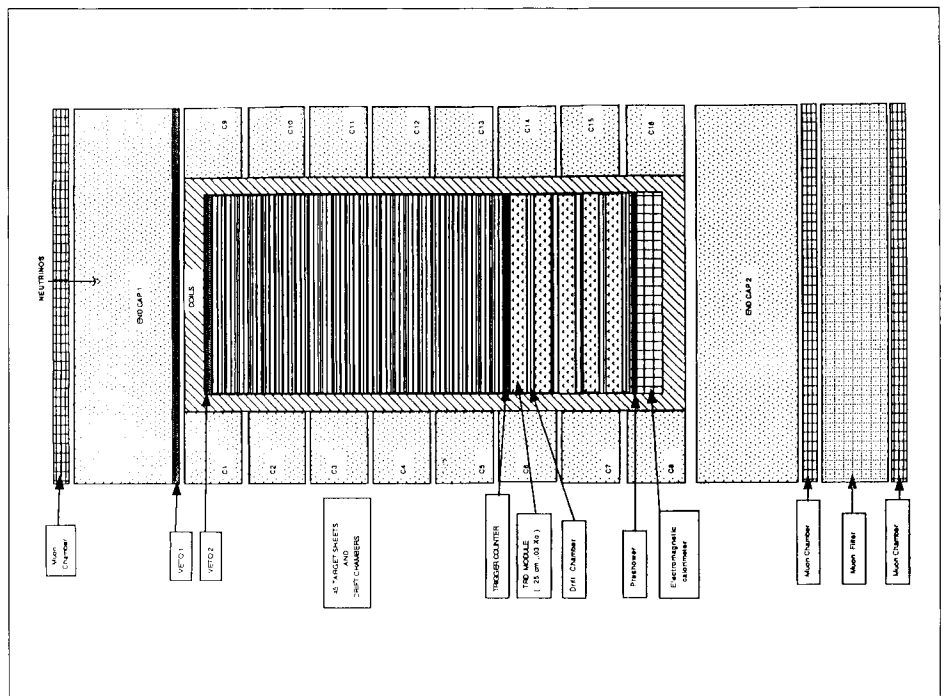
Around the Laboratories

Schematic of the planned WA96 ('NOMAD') neutrino experiment at CERN.

CERN Neutrino facelift

With the termination this summer of the CHARM II neutrino experiment at the SPS proton synchrotron (October, page 5), CERN's 30-year tradition of neutrino physics came to a temporary halt. However with these enigmatic particles playing a vital role in today's Standard Model but continually reluctant to give up all their secrets, neutrino physics will continue to be in the forefront of this research.

Thus after 15 years of continually being battered by the intense proton beams which create the neutrinos' parent particles, the ageing neutrino facilities at the SPS will be refurbished to service two major



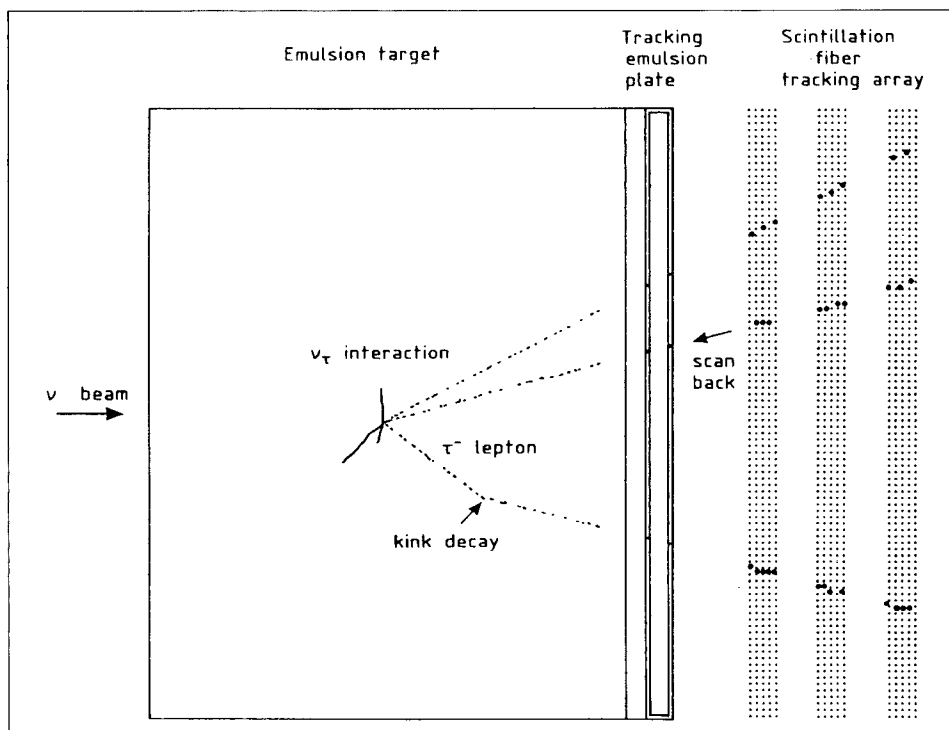
new experiments, scheduled to begin operations in 1994 and marking a third generation of SPS neutrino studies.

The two experiments are WA95 ('CHORUS'), by a large international collaboration including a substantial Japanese contingent and using an 800 kg emulsion target, and WA96 ('NOMAD'), by a Boston/CERN/Dubna/Paris/Saclay/Zagreb team using a powerful magnetic spectrometer.

Some observers have declared that certain aspects of neutrino physics using high energy beams have reached their limit of precision, and that further progress will come from studies of extra-terrestrial particles. However specific corners of neutrino physics still benefit from precision measurements of rare processes, a good example being CHARM II's dedicated study of the very rare neutrino-electron scattering, with five thousand events carefully collected over five years.

In addition, interactions due to the third type of neutrino, that associated with the tau lepton, have never been observed. They would release tau leptons, but seeing their very short (millimetre) tracks involved needs specially designed detectors.

The CERN neutrino beam consists predominantly of muon-type neutrinos. The few tau neutrinos formed through the production and decay of rare charmed particles would be very difficult to detect. However occasional tau neutrinos could also be formed through a periodic switching ('oscillation') of muon neutrinos into the tau variety. Resulting tau leptons would be detected through their decay into specific channels and/or their characteristic decay kink after a few hundred microns of flight.



Schematic of a tau neutrino interaction in the emulsion target of the planned WA95 ('CHORUS') experiment at CERN, with production and subsequent decay of a tau lepton.

Many of the institutes who collaborated in CHARM II are also represented in CHORUS, and are joined by teams from Bari, Berlin, Korea (Gyeongsang and Changwon) and from Japan (Nagoya, Aichi, Gifu, Kinki, Osaka, Toho, Utsunomiya and Yokohama). The experiment's goal of muon-/tau-neutrino oscillations is a challenging one even by neutrino standards. If the oscillations occur at all, then the detector would see at most some 35 events in two years of running.

Tau particles produced by tau neutrinos would be looked for through their subsequent decay into specific channels. A downstream electronic detector consisting of scintillating fibre arrays, a magnetic spectrometer, a high resolution calorimeter and a muon spectrometer will pick up emerging negatively-charged muons and pions and point back to where the tau was produced in the emulsion. Background from similar processes

induced by muon neutrinos will be reduced by accepting only events with the right kinematics.

Emulsions were once the preferred tool of particle physics, but were long discarded because of the difficulty of finding where the incident particles interacted in the emulsion block. Interest revived in the 1980s, with vastly improved computer-assisted scanning techniques and with emulsions well suited to the short decay tracks of very unstable particles.

The Japanese contingent in the new CERN neutrino experiment draws on the experience of the Japanese team which used an emulsion target with a downstream electronic spectrometer in the Fermilab E531 neutrino experiment. This study set out to look at the production of particles carrying charm quarks, and went on to search for signs of neutrino oscillations, setting new limits.

CHORUS' 240 litres of emulsion

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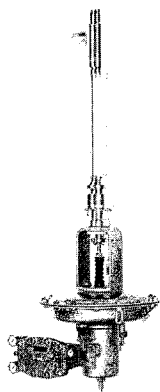
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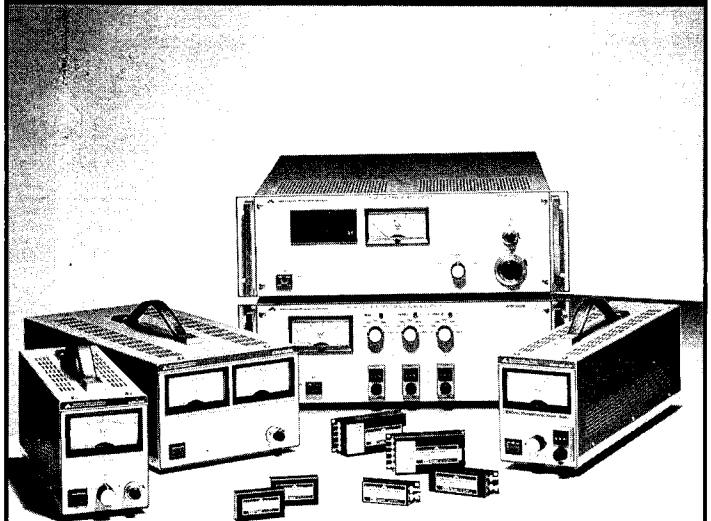
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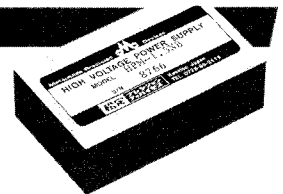
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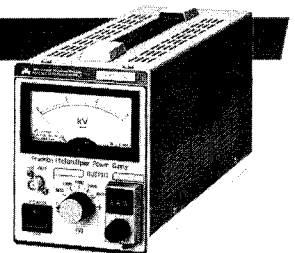
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will be arranged in two stacks each 2.75 cm thick and containing 25 double layers of emulsion on polystyrene foils, with the stacks separated by a scintillating fibre tracker to help follow the event topology in the emulsion.

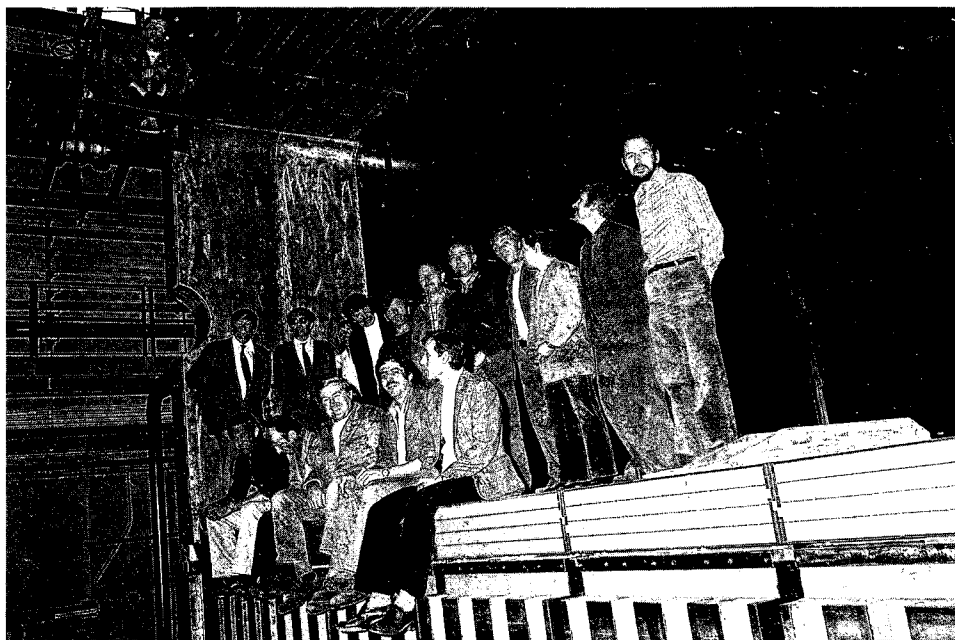
Instead of picking up tau neutrino interactions through the very short track of the resultant tau lepton, NOMAD will use kinematic selection criteria.

A tau lepton decay is accompanied by one or more neutrinos. These particles escape the detector and will only be 'detectable' through momentum imbalance. The magnitude and direction of this 'missing momentum', from careful measurement of all other decay products, will enable NOMAD to flag tau neutrino interactions.

The target for the neutrino beam will be the 2.97 tons of polystyrene/polypropylene foam of the walls of the 145 planes of drift chambers used to track charged particles. In the past, neutrino experiments have used heavy targets to give maximum interactions. However for tau neutrino studies light targets minimize multiple scattering and keep the interactions clean.

The tau lepton can decay into a muon, but since the neutrino beam consists almost entirely of muon neutrinos, this decay is swamped by muon neutrino background. Instead NOMAD will concentrate on the decay of taus into electrons and hadrons. With electron neutrinos making up only about one per cent of the beam, background is manageable. However these electrons have to be carefully disentangled from pions, and the drift chambers will be followed by five modules of transition radiation detectors (TRD).

Transition radiation is produced



Seen here after its completion in 1980, the 800-ton magnet originally built for the UA 1 experiment at CERN's proton-antiproton collider is to be reused for the new WA96 (NOMAD) neutrino experiment at CERN.

(Photo CERN 384.7.80)

when particles cross the boundary between two substances with different dielectric properties. Its intensity depends on the particles' energy, and gives a way of identifying particles.

The polypropylene sheet radiator of each TRD module will be followed by 600 3 m-long, 1 cm-diameter 'straw' tubes filled with xenon and arranged in two layers. A prototype system has been operated successfully at CERN by an Orsay group.

Good electron identification will also rely on the lead-scintillator calorimeter using wavelength-shifting fibres to readout the individual tiles.

The whole detector will be mounted inside the 800-ton magnet used for 12 years in the UA 1 experiment at CERN's proton-antiproton collider, and reinstalled for neutrino studies in the hall originally built for the BEBC bubble chamber.

The magnet will block most particles, allowing through mainly muons, picked up by a down-

stream muon detector using UA 1 components.

As well as looking for signs of tau neutrinos, NOMAD will be well suited for studying all neutrino interactions which release electrons.

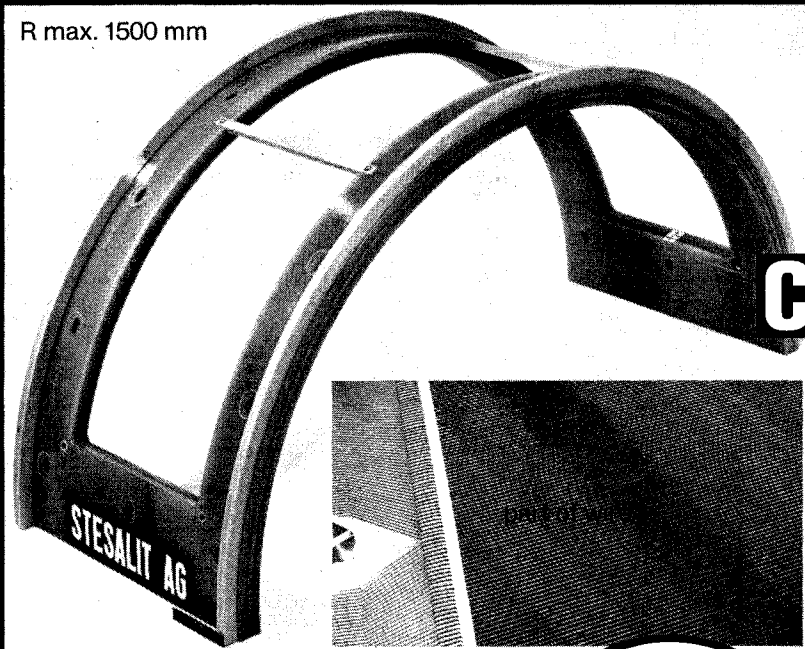
As well as consolidating the Standard Model pattern of particles, observation of tau neutrino interactions through oscillations would also provide hard evidence for neutrino masses, where experimenters now have only limits to go on.

Spin in LEP

While physics at the LEP electron-positron collider pushes ahead, machine specialists continue to make good progress in the machine development programme.

Handling spin-oriented (polarized) beams is a LEP long-term goal. The electrons orbiting in the machine behave like tiny magnets which tend to line up with the machine's magnetic field (Sokolov-Ternov Ef-

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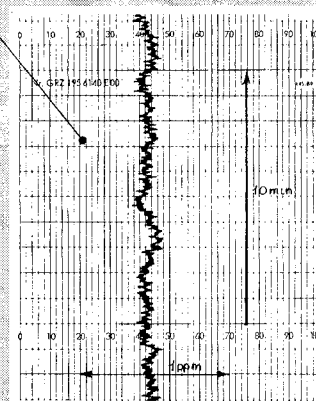
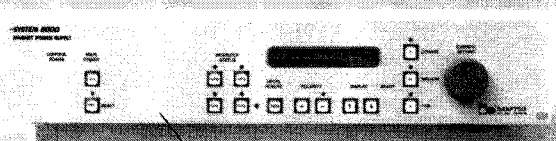
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One of the superconducting radiofrequency cavities to push the energy of LEP particles towards 100 GeV.

(Photo CERN 42.6.91)

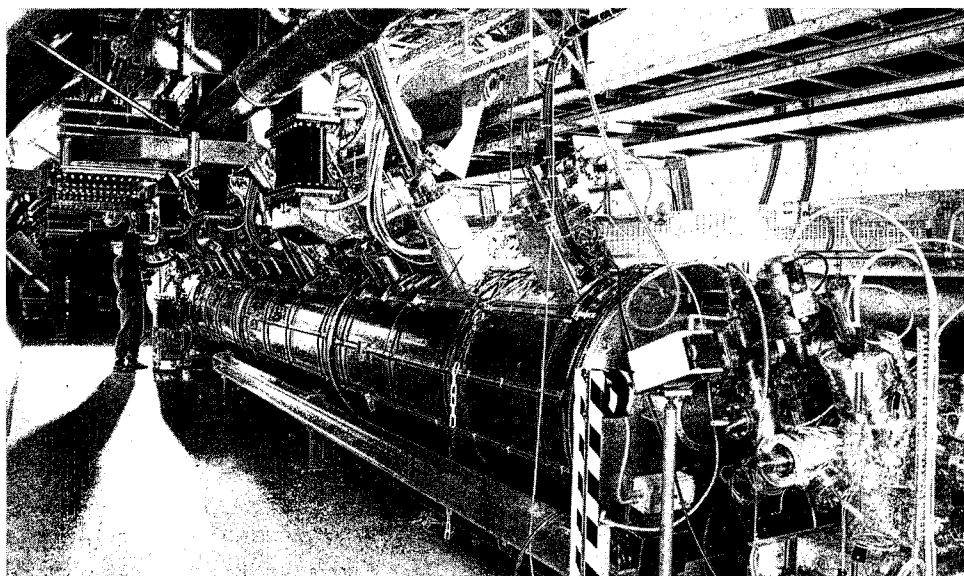
fect). Careful investigation last year (November 1990, page 3) revealed such polarization effects of the order of 10-12 per cent. This was a surprise to those who thought that this was too sensitive an effect to be seen in such a big and complicated machine.

Machine development studies this year have confirmed this polarization, with levels up to 18 per cent – not yet sufficient for physics experiments but still enough for machine specialists to look at the subtle mechanisms involved and aim for improved performance.

Further progress would come by cancelling dominant depolarizing resonances and their satellites by delicate adjustments. With appropriate wiggler magnets in action to 'shake' the beam and boost photon emission, polarization will set in much sooner, and levels above 50 per cent are on the cards. For experiments, the natural vertical polarization direction would have to be turned into the beam direction using special bending magnets, with attendant depolarizing effects minimized.

Creating an artificial depolarizing resonance at LEP's operating energy using a radiofrequency sweep and feedback kicker magnet gives very precise indications of beam energy. Ongoing machine studies are encouraging, suggesting that the mass of the Z particle could eventually be fixed to within a few MeV (a few parts in ten thousand) or better.

So far, the beam energy has been calibrated by accelerating protons in LEP to 20 GeV, and extrapolating the result to LEP's normal operating energy near the Z resonance at 91 GeV, with a precision of 'only' 20 MeV (one part in a thousand). Recently, protons were stored in LEP using three new su-

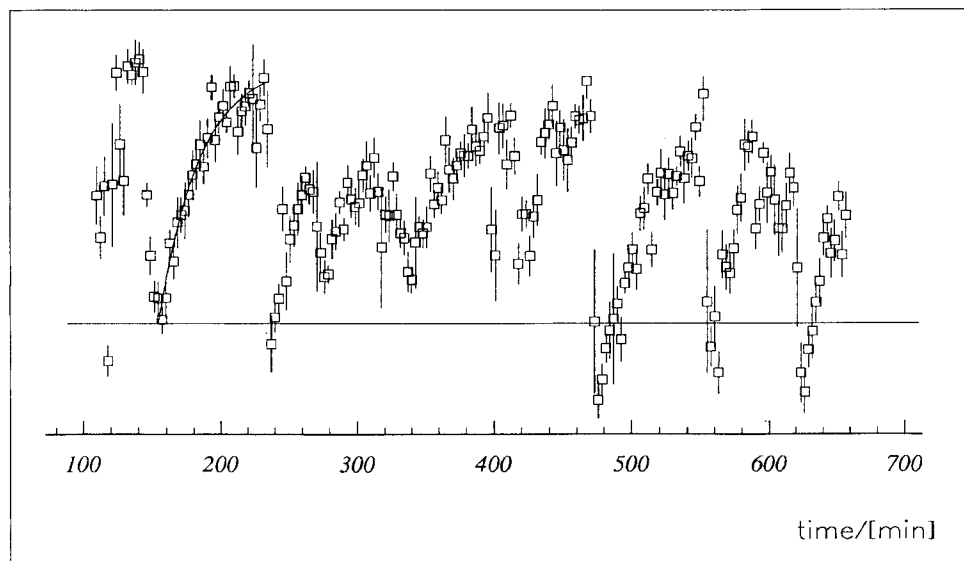


perconducting radiofrequency cavities, the first of 192 which will eventually be installed to take LEP collision energies towards 200 GeV. Thus LEP becomes the first 'proton' storage ring to handle a beam with a purely superconducting r.f. system!

While physics at LEP has already been honed to an impressive level, polarized beams would open the door to increased sensitivity. This would help the now urgent quest

to find new behaviour to help understand today's Standard Model with its many empirical parameters.

It takes about half an hour for about 10 per cent of LEP's electrons to line up with the machine's magnetic field, and about five minutes to artificially 'kill' this polarization. After switching off the depolarizing mechanism, the polarization surges again. On several occasions (right), the depolarizing effect managed to flip over some electron spins.



SUPERCOLLIDER Progress

The first building to be constructed on the Superconducting Supercollider (SSC) site in Ellis County, Texas, the 109,000 sq ft (football field size) Magnet Development Laboratory (MDL), is now practically complete.

Construction has started on the nearby Accelerator System String Test (ASST) building and related buildings, such as those needed to house helium refrigeration equipment, with the Magnet Test Laboratory (MTL) and a magnet delivery shaft coming soon after.

The MTL will be used to test R&D magnets and some of the production magnets as they are delivered for installation in the 87-kilometre tunnel. Magnets will be lowered into the tunnel through the elliptical magnet shaft, 60 feet across at its widest part. Initially the shaft will be used to provide access for the machine that will bore the first section of tunnel next year. This pattern will be repeated during the next few years with five such shafts being used first for access to bore the tunnel, and then for magnet delivery.

About a mile south, near the interaction region where the second major detector will be located, a 16-foot diameter, 265-foot deep exploratory shaft is being dug to examine the underlying rock. (A strong candidate for this second detector is the GEM project – October, page 12.)

On the magnet front, a string of five SSC superconducting dipoles has been successfully tested at Fermilab using magnets of an older design with a 40-mm aperture (last year the SSC design was modified

to 50 mm aperture). The central 'cold mass' of the magnets (coil plus collars and yoke) was built at Brookhaven and shipped to Fermilab for assembly into cryostats and then into the string test configuration for cooling to 4.35 K and operation at the 6500A design current.

A similar string is being prepared for testing next year in the new ASST building on-site using the newer 50-mm magnets now being assembled at Fermilab and Brookhaven by General Dynamics and Westinghouse.

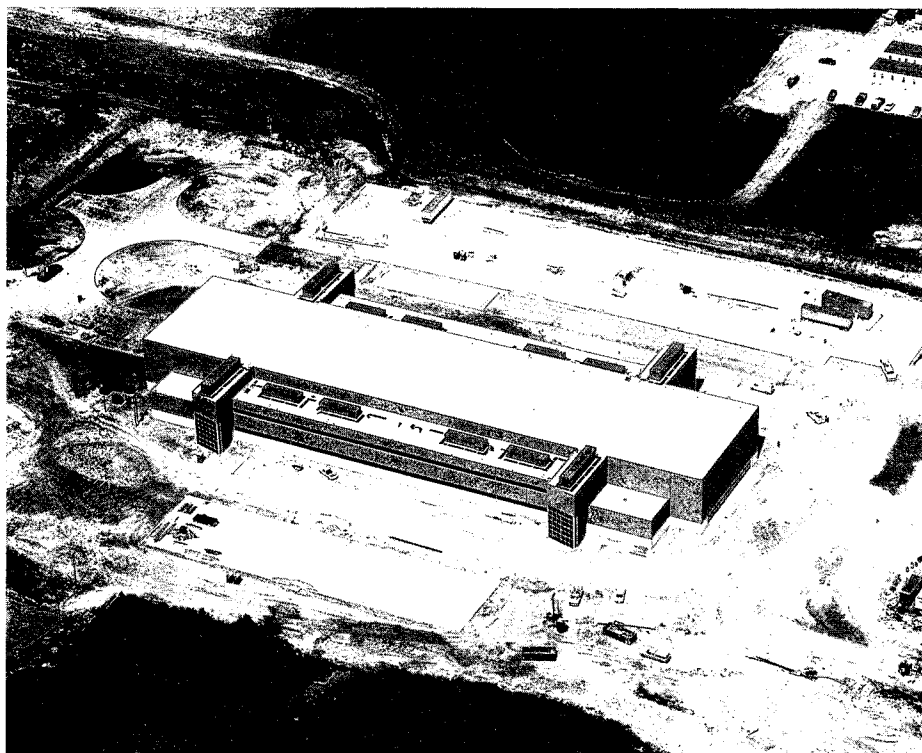
Three companies – Everson Electric of Bethlehem, Pennsylvania, Martin Marietta Strategic Systems of Littleton, Colorado, and Babcock & Wilcox, of Lynchburg, Virginia – have been selected to develop superconducting corrector magnets for the SSC. These corrector magnets adjust the proton beam orbits to compensate for errors due to in-

herent imperfections in the more powerful bending and focusing magnets.

Eventually about 7,000 corrector magnets – dipoles, quadrupoles, sextupoles, and some octupoles and decapoles – will be installed among the approximately 10,600 main dipoles and quadrupoles that will guide and focus the proton beams.

Initially, Everson will make corrector dipoles; Martin Marietta, quadrupoles; and Babcock & Wilcox, sextupoles. Each firm will make use of a different magnet winding technology before the SSC Laboratory decides on a production design.

The first building to be constructed on the Superconducting Supercollider (SSC) site in Ellis County, Texas, is the football-field size Magnet Development Laboratory.





Lynn Silverman's camera – behind the...

CERN Filming experiments

Scientists working in the big experiments at CERN's colliding beam machines have grown used to having cameras peering over their shoulders.

Big experiments in caverns deep underground make compelling viewing, and TV crews frequently come to CERN to take film for news and documentary programmes. The problem is that these experiments are long, drawn-out projects, and progress is difficult to see.

Undeterred, a BBC/Open University team under Andrew Millington arrived in 1979 to cover the historic UA1 experiment at the proton-antiproton collider. After five years of patient work, the result was 'The Geneva Event', a widely-acclaimed one-hour documentary tracing CERN's antiproton project in general and the UA1 experiment in particular from its beginnings through to the award of the Nobel Prizes to Carlo Rubbia and Simon van der Meer in 1984.

The team has been busy for some time preparing a new film on the experiments at today's big electron-positron colliders – LEP at CERN and the SLC Stanford Linear Collider in California.

Cineast Lynn Silverman works in a different way. In contrast to the TV crews, with their bright lights and busy sound engineers, she works alone most of the time. Less obtrusive than the TV crews (her 16 mm camera loaded with high-speed colour negative film shoots with minimal illumination) she patiently follows the ups and downs of research life. The results give a realistic glimpse of what working at the frontier of physics is really like,



... scenes at LEP experiments.

with long periods of carefully coordinated leadup, routine logging of experimental data, coping with setbacks, the joy of accomplishment, and, sometimes, the triumph of discovery.

Lynn learnt her trade in Paris under Jean Rouch, who pioneered film as a medium for anthropology. Lynn's field work project was the UA1 experiment, where six months of filming in 1984 in the wake of the W/Z discoveries resulted in a 47-minute film ('Invisible Energy') on the experiment's quest for new physics.

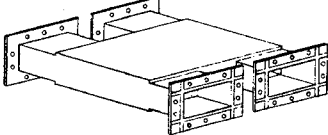
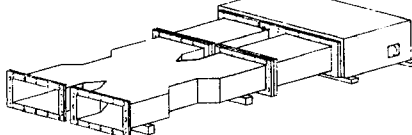
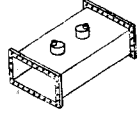
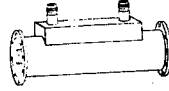

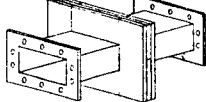
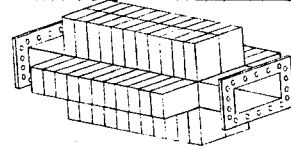
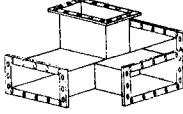
With construction work for the big LEP experiments then just getting underway, Lynn had the opportunity to be with a major experiment from almost the beginning. Choosing the Aleph collaboration, she traced the fabrication of detector components in research centres all over Europe, with the subsequent arrival of the equipment at CERN and the delicate piecing together of the big detector deep underground.

The result, representing five years of patient work, and benefiting from the considerable experience and talent of editor Jeannetta Ionescu, traces Aleph progress from the early days through to the announcement of initial physics results in 1990. There are nice touches – the film captures the different working atmospheres in different countries; ritual kissing in France, Italians singing, a UK radio blaring rock music.

She is now on her third project for a film on a big CERN experiment, the subject this time being the Delphi experiment on the other side of the LEP ring. Filming began in 1988 when most of the detector was constructed and installation getting underway, and continues through to the end of this year.



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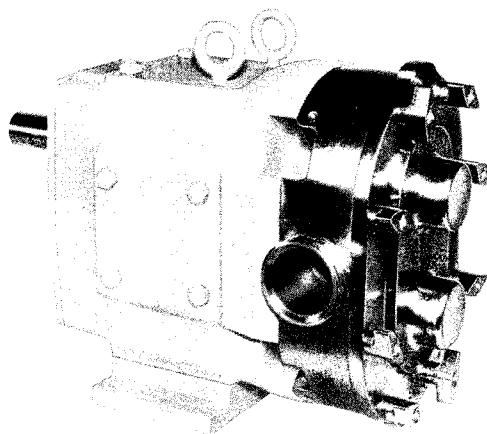
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Brookhaven Associate Director Mel Schwartz – letters of intent for smaller RHIC experiments.



BROOKHAVEN Two large detectors for new Collider

In August the Program Advisory Committee at Brookhaven, along with a Detector Technical Advisory Committee, reviewed updated letters of intent for experiments at the Relativistic Heavy Ion Collider (RHIC) being constructed at the Laboratory.

There were four candidate designs for 'major' detectors: large-scale spectrometer systems, each with a broad physics reach, to absorb the lion's share of the approximately 80 million dollars earmarked for RHIC detector construction.

After a week of committee review, the Laboratory decided to proceed with two such detectors in the first round of RHIC experiments.

STAR, with a time projection chamber to measure hadron production over a large solid angle, was given conditional approval to proceed with a preliminary design. This collaboration is expected to

have its design ready for review by next spring, so that construction can begin by the end of fiscal year 1992.

A second detector will emphasize the measurement of leptons and photons, and will involve a realignment of the three remaining large collaborations that submitted letters of intent. Brookhaven physicist Sam Aronson will organize this new effort. A conceptual design for this detector, which will focus on electrons for the lepton pair measurement, will be developed over the next few months.

During the coming year the Program Advisory Committee will consider letters of intent for smaller experiments whose physics objectives should complement those of the larger detectors. Brookhaven Associate Director Mel Schwartz will make a general call for such letters of intent in the near future.

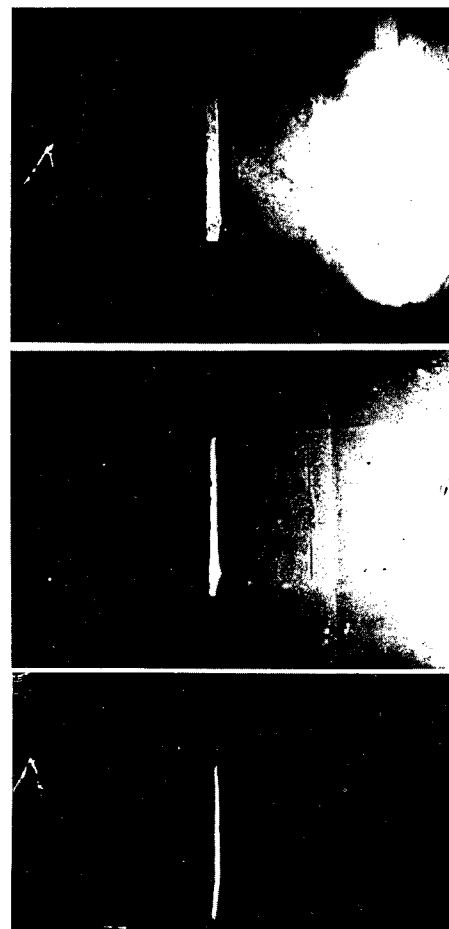
SERPUKHOV Focusing particles by a crystal

With several Laboratories having shown how bent crystals can be used to steer particle beams (May 1990, page 5), a team working at the Institute for High Energy Physics (IHEP) at Serpukhov, near Moscow, has shown how these crystals can also be used to focus particle beams.

The atomic planes and symmetries inside crystals guide ('channel') some of the particles passing through. By using a specially bent crystal, a particle beam can be bent with a power equivalent to that of a huge electromagnet.

Now a team at Serpukhov has demonstrated how such a crystal

Photoemulsion picture of a proton beam at the Institute for High Energy Physics, Serpukhov, near Moscow, transmitted through a bent crystal with a curved exit face. The three images are (from the top) at 0.7, 2 and 3.5 metres behind the crystal, showing the progressive focusing of the bent beam. The top two pictures also show (right) the major portion of the beam passing unaffected through the crystal (0.3 per cent of the particles are bent).



can also focus a beam. The trick is to machine the exit face of the crystal into an arc, so that the particles channeled in different parts of the crystal are bent by different amounts. However this focusing effect is only one-dimensional.

The crystal used was a 2x15x70 mm plate of silicon bent by 24 milliradians, and the exit face ground into a curved shape by a specially designed machine.

A 2 mm-wide beam of 10^7 protons per pulse with an angular opening of ± 0.1 milliradians was focused 3.5 metres from the crystal down to a width of 0.2 mm. The resultant intensity was 3×10^5 protons per pulse (a channeling rate of 0.3 per cent).

The experiment, carried out by physicists from IHEP and from Gatchina, Leningrad, indicates new methods for producing narrow beams and for ejecting beams from internal targets.

BALKANS Building bridges

At a time when upheaval and political unrest in some Balkan countries gives cause for concern, it is good to know that physics, once again, is building bridges between nations.

The new international mobility in the region was marked by a major activity of the Balkan Physical Union – the first Balkan School of Physics, held on the banks of the Bosphorus during the first two weeks of September.

The idea of a scientific union including Albania, Bulgaria, Greece, Romania, Turkey and Yugoslavia was first suggested at a European Physical Society meeting in Helsinki in 1978 in an after-dinner conversation between the late Yugoslav physicist Alexander Milojevic, and Andrei Dorabantu from Romania.

In 1985, when totalitarian regimes were still in power, Milojevic, a man of great humanity and foresight, invited representatives from Balkan countries, including Albania, to a conference in Pristina, Yugoslavia, to promote his idea of a Balkan Physical Union.

The outcome was a protocol for the establishment of the union. Erdal Inonu, then President of the Turkish Physical Society (and now leader of the country's opposition party) telexed 'Even if we Turks cannot be there – our hearts are with you'. The final formal agree-

ment came at a subsequent meeting in Bucharest in 1987.

The programme of this first school in Turkey included introductions to experimental and theoretical high energy physics, nuclear physics, and accelerators and their applications. The full team of lecturers and speakers included Laboratory Directors W. Hoogland (CERN) and A. Wagner (DESY), while W.O.Lock played a well-practiced role of international counselor.

During the School a round-table discussion reviewed the status of accelerator and particle physics in the Balkan countries and looked at ways of encouraging further collaboration in these and related fields, including the establishment of regional centres of excellence.

The outcome was a recommendation to the BPU Executive Committee to set up a study group including a representative from each country, from CERN and from DESY to:

- survey existing facilities and collaborative efforts, including present relations with international organizations;
- identify specific areas in which enhanced collaboration and joint

efforts would be of common benefit;

- make detailed recommendations for action; and
- report back to the BPU Executive Committee.

Meanwhile the first BPU General Conference on Physics was held in Thessaloniki in September. BPU President Gediz Akdeniz and his collaborators look forward to further meetings to reinforce this newly awakened awareness of scientific partnership in the region.

Participants in the First Balkan School of Physics, held in Istanbul in September. The event was the first major activity of the Balkan Physical Union, covering Albania, Bulgaria, Greece, Romania, Turkey and Yugoslavia.



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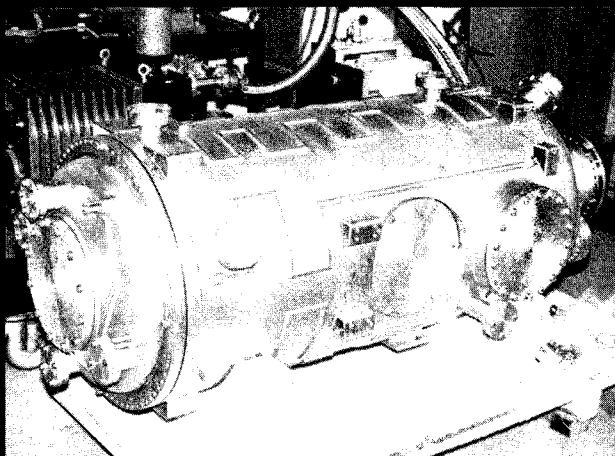
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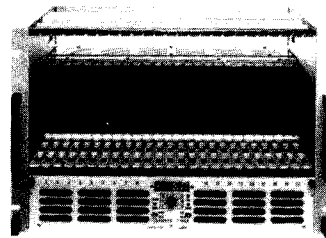


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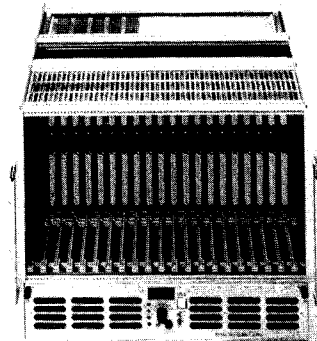
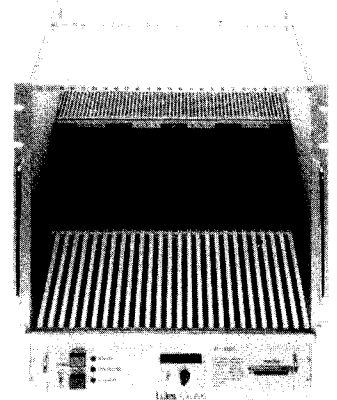
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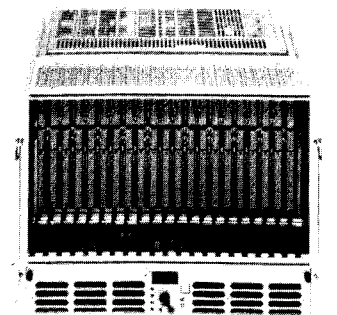
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People and things

*First collisions in HERA!

Following the initial acceleration of protons to 480 GeV on 8 October in the superconducting proton ring of the 6.3-kilometre HERA electron-proton collider at the DESY Laboratory, Hamburg, on 19 October the first electron-proton collisions occurred. Proton energy was 480 GeV (design level 820 GeV) while electrons were at the 12 GeV injection energy (design 30 GeV).

Aerial view of the 844 metre-circumference ring of the European Synchrotron Radiation Facility being constructed at Grenoble, France. Beam has already been accelerated in the smaller injector synchrotron and progress is running several months ahead of schedule.

(Photo: A. Childeric, A. M. Freund)

New Director at Los Alamos

Peter Barnes becomes Director of the Los Alamos Meson Physics Facility (LAMPF), succeeding Edward Knapp, who is retiring.

ESRF beam nearer

In September, an electron beam reached 3 GeV in the booster synchrotron of the European Synchrotron Radiation Facility (ESRF), Grenoble. Acceleration to the full 6 GeV is expected in December, and injection into the 844 m-circumference main ESRF storage ring early next year. Progress is running six months ahead of schedule.



Edwin McMillan 1907-91

As reported briefly in our previous issue, Edwin McMillan died on 7 September.

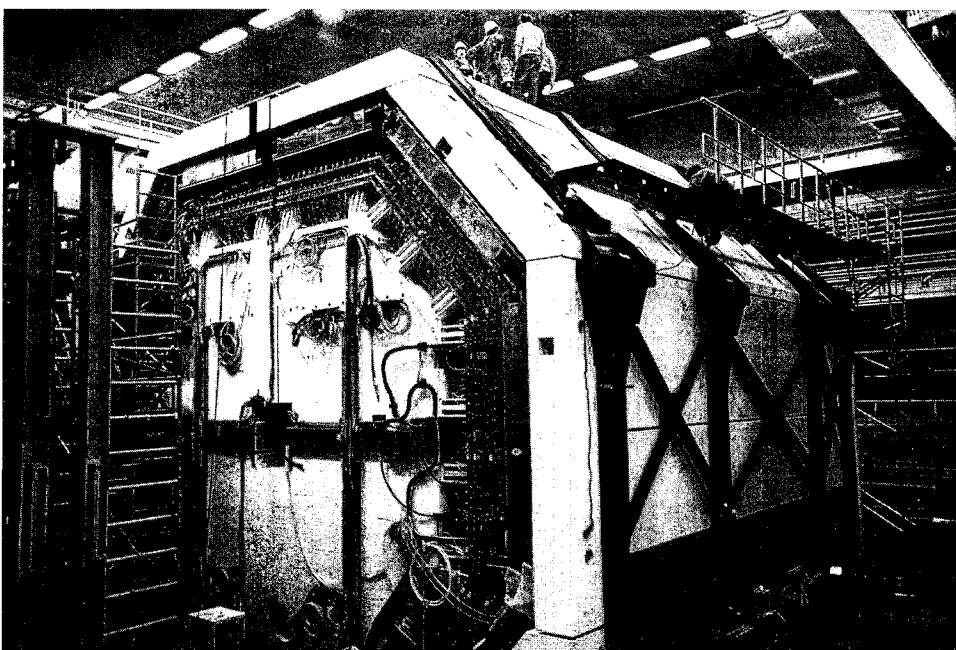
A Californian, McMillan came to Ernest Lawrence's new Radiation Laboratory at Berkeley when Lawrence's new invention, the cyclotron, was being put to work. Following the discovery of artificial radioactivity in Europe, Lawrence was convinced that cyclotron beams could be used to synthesize radionuclides for medical research. In 1934, following up these ideas with M. Stanley Livingston, McMillan discovered the oxygen-15 isotope.

When the target was uranium, the initial result was fission. However McMillan wondered if the neutrons released in the fission process could sometimes 'stick' to the uranium. In 1940, working with Philip Abelson and using neutrons released in the bombardment of

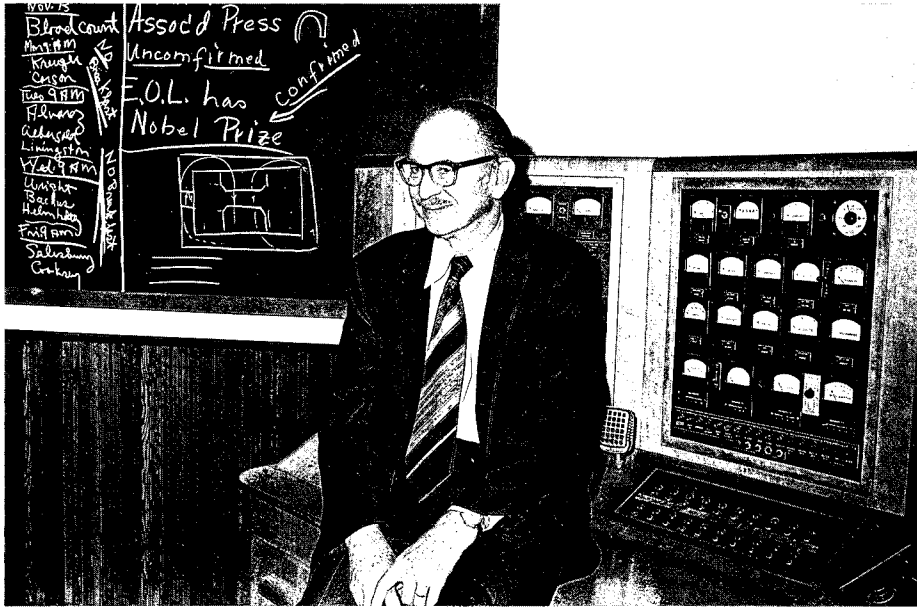
At the HERA electron-proton collider now being commissioned* at the DESY Laboratory in Hamburg, the big H1 and Zeus detectors are being finally checked out prior to being rolled into their respective interactions in the 6.3 kilometre ring before the end of

the year. Seen here is Zeus. H1 has been active for cosmic ray tests for several months. Together the two detectors keep more than 600 physicists busy.

Photo Janet Fraser



Edwin McMillan, pictured at the Berkeley Radiation Laboratory in 1939, after the news of the award of the Nobel Physics Prize to Ernest Lawrence.



beryllium by deuterons from the 60-inch Berkeley cyclotron, he found a new nucleus, heavier than uranium. They named it neptunium, after the distant planet beyond Uranus. (The 1789 discovery of uranium, the heaviest naturally occurring element, came only a few years after Herschel observed Uranus.)

McMillan and Abelson went on to show that neptunium underwent beta decay with a half-life of 2.33 days. A neutron converting into a proton produced a 'heavier' nucleus, logically named plutonium. This new substance was relatively stable, but very fissionable. The rest of the plutonium story belongs to the history of science and of the world.

As well as physics experiments, McMillan had always been deeply interested in the cyclotrons which supplied the particle beams. After his arrival at the Radiation Laboratory in the 30s he had shown how a cyclotron's magnetic field could be adjusted by 'shimming', and had developed beam extraction techniques and electronic control sys-

tems. Returning to Berkeley after the War, he turned to the completion of the new 184-inch 'super-cyclotron', a project first mooted in 1939. Here the classical fixed-frequency cyclotron technique was running into relativity problems. As the proton approached the velocity of light, it got heavier, spoiling the fixed-frequency resonance. McMillan's idea was to modulate the radiofrequency accelerating the protons (an idea proposed independently by V.I. Veksler in the USSR). The technique, first demonstrated on the old 37-inch machine, was immediately applied to the big new machine, and subsequently to a new electron synchrotron. In 1949 McMillan collaborated in experiments which showed how mesons could be produced by high energy gamma rays.

In 1951 he shared the Nobel Chemistry Prize with Glenn Seaborg for their pioneer work on transuranic nuclei. With Veksler he shared the 1963 'Atoms for Peace' Prize, and last year he was awarded the US National Medal of Science.

In 1958, with Ernest Lawrence critically ill, McMillan was appointed Deputy Director of the Radiation Laboratory, and when Lawrence died on 27 August, McMillan assumed the Director's mantle. Under his leadership, which lasted until 1973, the Laboratory became an interdisciplinary science centre, with 'Radiation' being officially dropped from its title in 1971, when it became known as the Lawrence Berkeley Laboratory. After his retirement, he visited CERN three times.

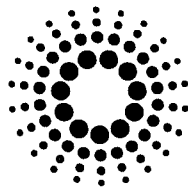
In 1941 he married Elsie Blumer, Ernest Lawrence's sister-in-law. Edwin McMillan was a prime example of the versatile talent which has characterized American physics, with researchers turning their hand to accelerator development and application, theory and experiment with equal success.

Meetings

A Workshop will be organized at RWTH Aachen from 9-13 June 1992 on 'QCD - 20 Years Later'. Results from high energy experiments and their theoretical implications will be discussed as well as the non-perturbative hadron sector. Further information from P.M.Zerwas, Inst.Theor.Physik (E), RWTH Aachen, D-5100 Aachen (Germany); bitnet TOOZER at DHHDESY3

A workshop on Photon Radiation from Quarks is being held in Annecy (France) from 2-3 December. There will be presentation of LEP results and theoretical ideas on QCD tests, electroweak tests and searches for new particles. Information from P. Mättig, CERN-PPE, 1211 Geneva 23, Switzerland, e-mail MAETTIG at CERNVM.CERN.CH

In Grenoble, France, The European Synchrotron Radiation Facility is constructing a state-of-the-art storage ring for 6 GeV electrons and/or positrons to be operated as a high-brilliance synchrotron radiation source in the field of X-rays from 1994 on. Financing of the ESRF is shared by twelve European countries. The objectives of the ESRF are to support scientists in the implementation of fundamental and applied research on the structure of condensed matter in fields such as



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New staff coming from outside the Grenoble area benefit from installation allowances, non-French staff also benefit from an expatriation allowance.

If you are interested, please state your name, address and the reference number to us in Grenoble, and we shall provide you with an «Application Form» and further information.

Engineers and Technicians

to assist the Scientists

3 Software Engineers (ref. 2148) and **1 Software Technician (ref. 2527)** for the Programming Group; to implement and develop applications for scientific data acquisition and data handling. Knowledge of advanced UNIX systems, C and/or Pascal is necessary. A background in scientific instrumentation would be advantageous.

3 Engineers (ref. 6121) and **5 Technicians in Computing (ref. 4537)** for data acquisition and for the definition and operation of a scientific computing environment within the Computing Services.

3 Mechanical Engineers, 2 for the Beamline Project Group (ref. 2145) and **1 for the Technical Services (ref. 6117)**; in charge of the engineering of beamline components, from the design up to the final installation. A mechanical engineering education on university level is required, as well as some years of experience in one of the following fields: Ultra High Vacuum, Precision Mechanics, Robotics or Instrumentation.

3 Beamline Technicians (ref. 2521) with expertise in mechanics, electronics, vacuum, cryogenics to be directly assigned to beamlines and assist the scientist in the design and construction of beamlines and scientific instruments.

Deadline for returning the application forms: 13.12.1991.

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UNIVERSITY OF VICTORIA RESEARCH ASSOCIATE POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS

The University of Victoria invites applicants for a Research Associate position in experimental high energy physics. The position will be based initially in CERN commencing January 1992, and is for work in the OPAL experiment at LEP.

The University of Victoria's responsibilities in OPAL include the upgrading and running of the DN10,000 based online reconstruction system for OPAL data. The successful candidate would be expected to assume a major role in the operation and support of this system.

Candidates should have a Ph.D. in particle physics and some experience with UNIX based computer systems. Interested candidates should send curriculum vitae and the names of two referees to either:

A. Astbury
Dept. of Physics
& Astronomy
University of Victoria
P.O. Box 3055
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Senior Staff & Five-Year Fellowship Positions in High Energy Nuclear Physics

Lawrence Berkeley Laboratory's Nuclear Science Division is searching for a person with outstanding creative ability, leadership and experience in the field of experimental high energy nucleus-nucleus collisions for appointment directly to the Senior Staff. Prospective candidates with a background in either nuclear or high energy physics are encouraged to apply. The Division's ongoing programs in high energy nucleus-nucleus collisions are described below. Job #A/6640.

A position for a Five-Year Divisional Fellow is also open for a person with outstanding promise and creative ability with interest in experimental high energy nucleus-nucleus collisions. The successful candidate is expected to join and assume a leadership role in one of the Division's ongoing efforts. The appointment will be for a term of five years, with the intention of promotion to a Senior Staff position. Job #A6639.

Active experimental programs are presently being carried out in this field at the CERN SPS, the Brookhaven AGS and the LBL Bevalac. For the future, a CERN SPS Pb-beam experiment is planned and the Division has taken a lead-role in designing and developing an experiment for the Relativistic Heavy Ion Collider (RHIC) presently under construction at Brookhaven.

Applicants are requested to submit 3 curriculum vitae, list of publications, statement of research interests, names of three references, and indicate job # to: Dr. John W. Harris, Chair, Search Committee, c/o Employment Office, MS90/1042, Lawrence Berkeley Laboratory, One Cyclotron Road, Berkeley, CA 94720 USA, as early as possible and before the closing date of January 2, 1992. An equal opportunity/affirmative action employer.



Neutrons from protons

A Workshop on Pulsed Advanced Neutron Sources for Physics, organized by the Joint Institute for Nuclear Research, Dubna, near Moscow, and the Institute for Nuclear Research of the USSR Academy of Sciences, and held at Dubna in June, looked at the target-moderator system required for the SIN-45 intense pulsed neutron source based on the proton beam of the kaon factory planned for the Academy's Institute for Nuclear Research.

This machine will deliver 45 GeV protons and a beam current of 125 microamps. The pulsed thermal neutrons could open up interesting experiments in condensed matter and neutron physics.

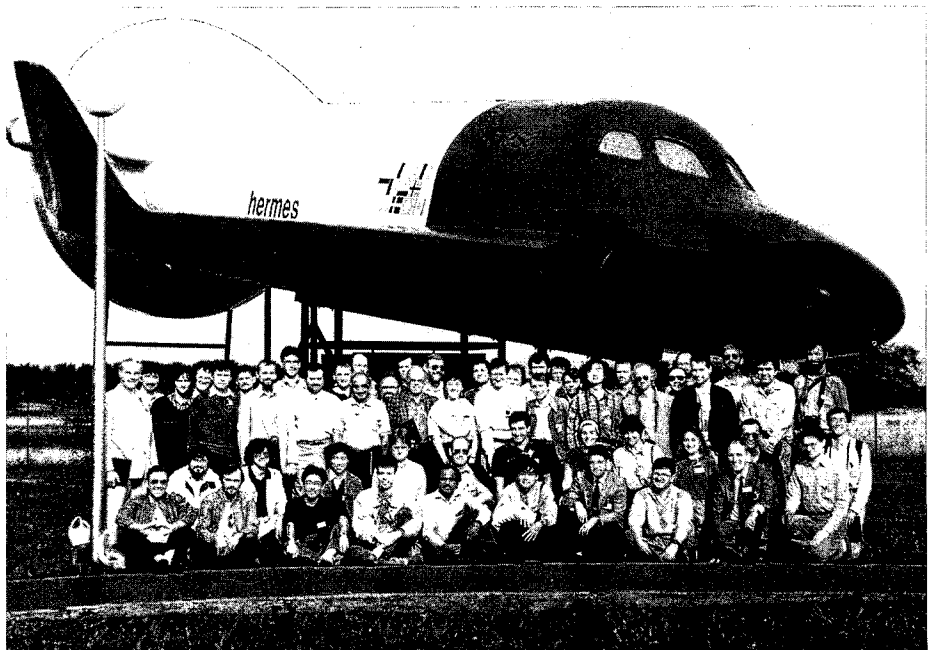
CERN Accelerator School

The CERN Accelerator School (CAS) programme for 1992 includes courses on Magnetic Measurement and Alignment, to be held in Montreux, Switzerland, from 16-20 March, and on General Accelerator Physics, organized jointly with the Finnish Research Institute for High Energy Physics, to be held in Jyväskylä, Finland, from 7-18 September. Further information from Mrs. S. von Wartburg, CERN Accelerator School, CERN, 1211 Geneva 23 Switzerland, e-mail casmag at cernvm.cern.ch or casfin at cernvm.cern.ch for the two courses respectively. The general course will be followed up by a more advanced course about a year later. At the end of 1992 the Joint US-CERN School will organize a course in Spain on particle factories. Details are still under discussion.



▲ Participants at a workshop earlier this year at Dubna, near Moscow, looked at the target-moderator system required to produce an intense beam of pulsed neutrons from the 45 GeV proton beam of the planned kaon factory at the Institute for Nuclear Research of the USSR Academy of Sciences.

▼ Noordwijkerhout in the Netherlands was the venue for this year's Advanced Accelerator Course, the fourth in the CERN Accelerator School series, organized this year in collaboration with the NIKHEF-H high energy physics centre in Amsterdam. As well as the latter, students also visited the European Space Agency's nearby ESTEC research centre, where they saw preparations for the European Hermes space shuttle which will be launched by Ariane-5 vehicles.



Laboratory correspondents

Argonne National Laboratory, (USA)
M. Derrick

Brookhaven National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

CERN, Geneva, (Switzerland)
G. Fraser

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
M. Bodnarczuk

GSI Darmstadt, (Germany)
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INFN, (Italy)
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IHEP, Beijing, (China)
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KEK National Laboratory, (Japan)
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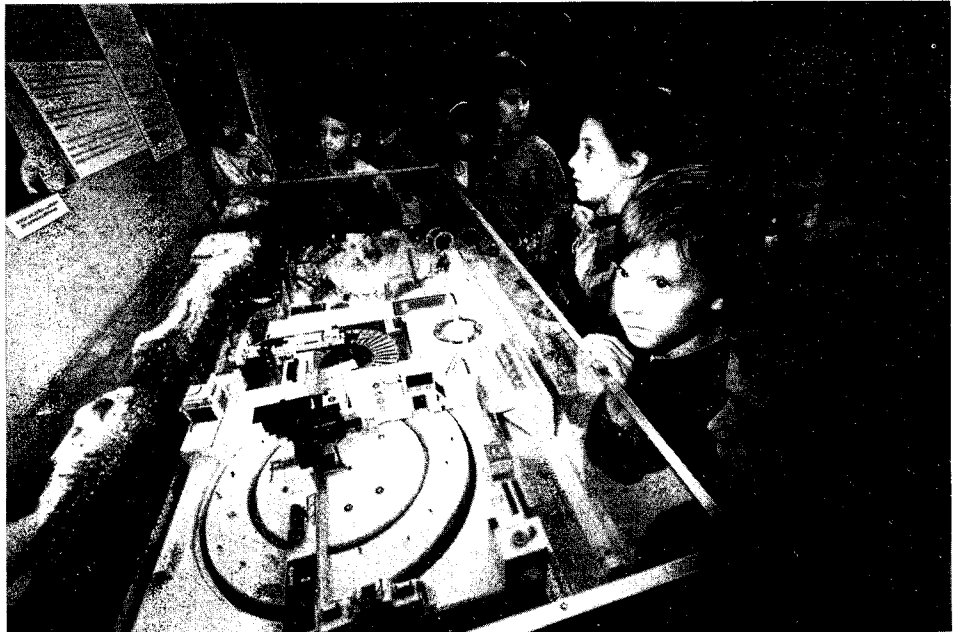
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Elisabeth Locci

IHEP, Serpukhov, (USSR)
Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
W. Kirk

Superconducting Super Collider, (USA)
N. V. Baggett

TRIUMF Laboratory, (Canada)
M. K. Craddock



9-11 year-old children from the Ecole active de Malagnou in the Geneva area brought their idea of CERN to the Laboratory. Rather than trying to build an exact scale model, the children presented their interpretation of the installations and how they function.

(Photo CERN 58.9.91)

Gaisser of Bartol, Delaware and A. A. Watson of Leeds as coordinating editors. First issue will appear next year.

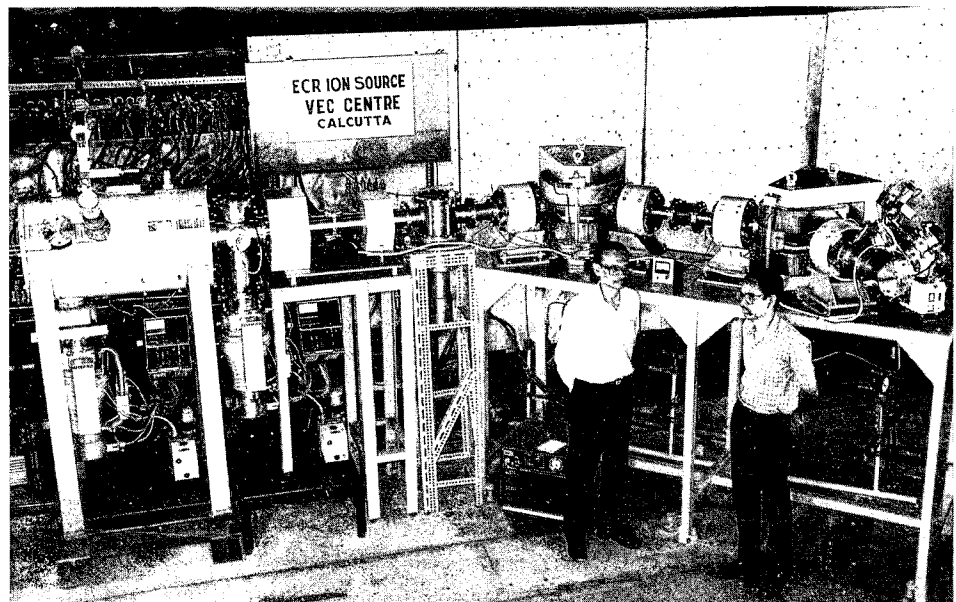
Astroparticle physics

Reflecting the increasing overlap of cosmic ray physics, astrophysics, cosmology and particle physics is a new journal 'Astroparticle Physics', published by North Holland. Covering high energy cosmic ray physics and astrophysics, particle cosmology, particle astrophysics, high energy gamma ray astronomy, neutrino astronomy and all associated instrumentation, the new journal has V.S. Berezinsky of the Gran Sasso Laboratory and Moscow, T.K.

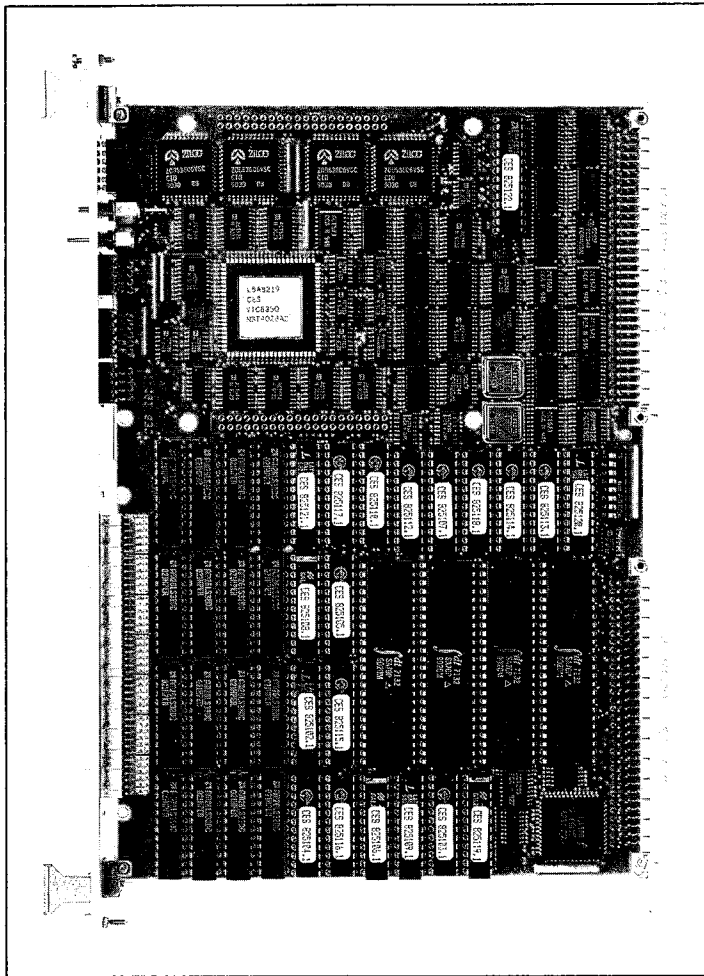
Vienna Wirechamber meeting

Contributions for the 1992 Vienna Wirechamber Conference, to be held from 17-21 February, should be sent to the Institut für Hochenergiephysik, Nikolsdorfer Gasse 18, A-1050 Vienna, by 30 November.

The Electron Cyclotron Resonance (ECR) heavy ion source at the Variable Energy Cyclotron Centre, Calcutta, India, became operational on 16 May. The cyclotron, utilized since 1981 for accelerating light ions, now provides beams of heavy ions, substantially extending the range of research at the Centre.



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Applications are invited for postdoctoral research associate positions to work on SSC detector design and R&D, and the DO detector at Fermilab. The positions offer opportunities for both hardware and software activities. Stony Brook High Energy Group is involved in construction and commissioning of the DO detector, which will have its initial physics run in early 1992.

We are also actively participating in the design of a new major detector (GEM) at SSC.

We are looking for candidates who would contribute substantially to this effort - on physics goals, hardware specifications and simulation efforts.

Participation in DO physics is expected, particularly after preparation of the technical proposal for GEM. Applications, including vitae and three letters of reference, should be sent to

**Professor Mohammad Mohammadi, Dept. of
Physics, SUNY at Stony Brook,
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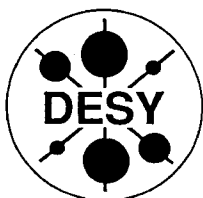
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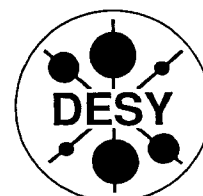


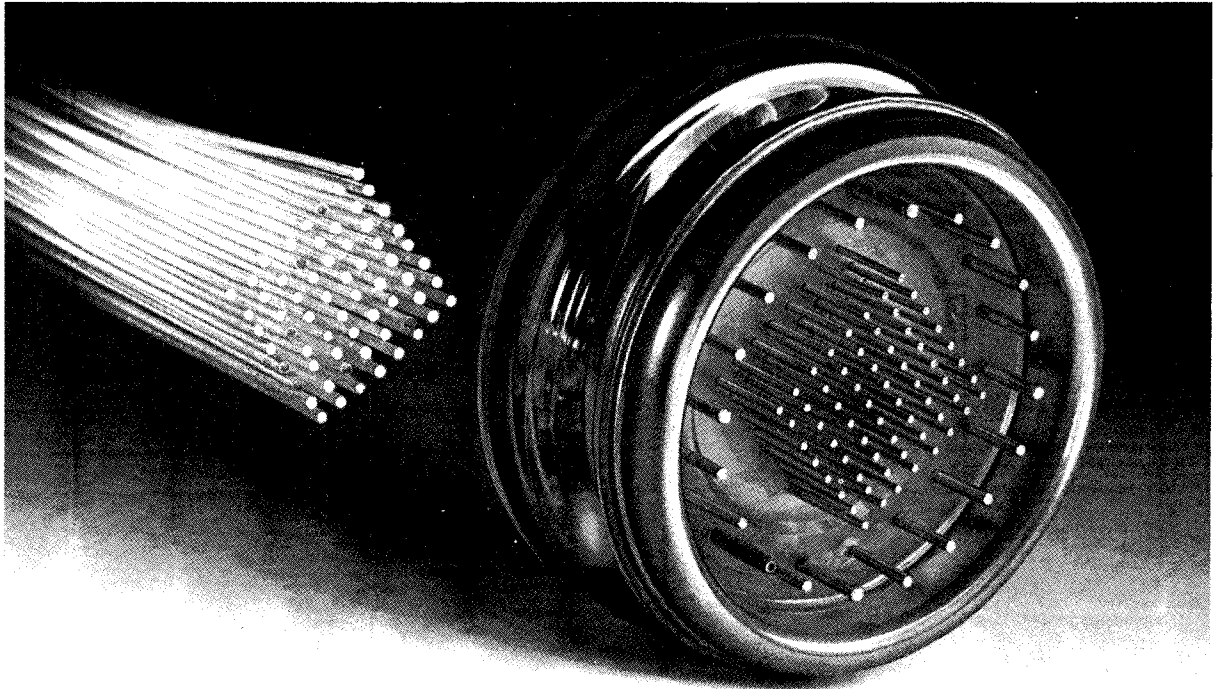
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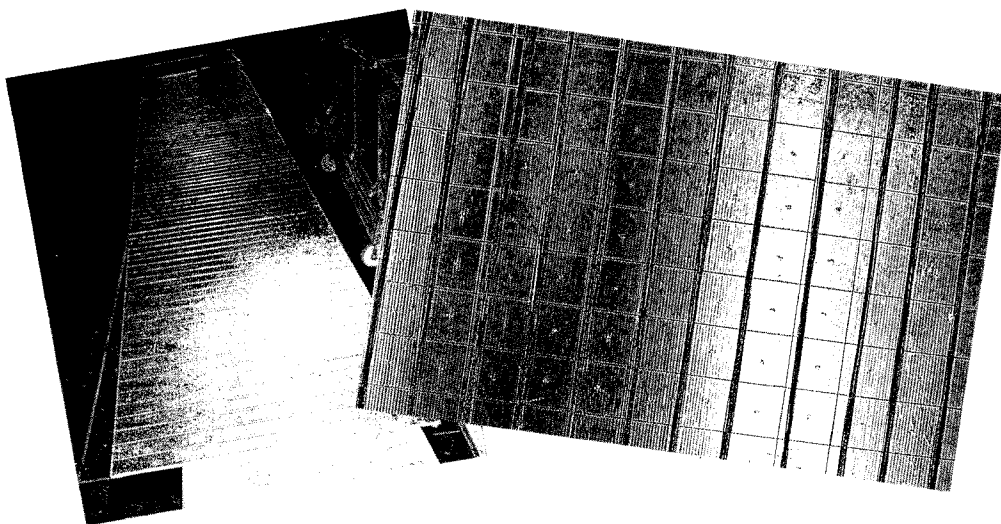
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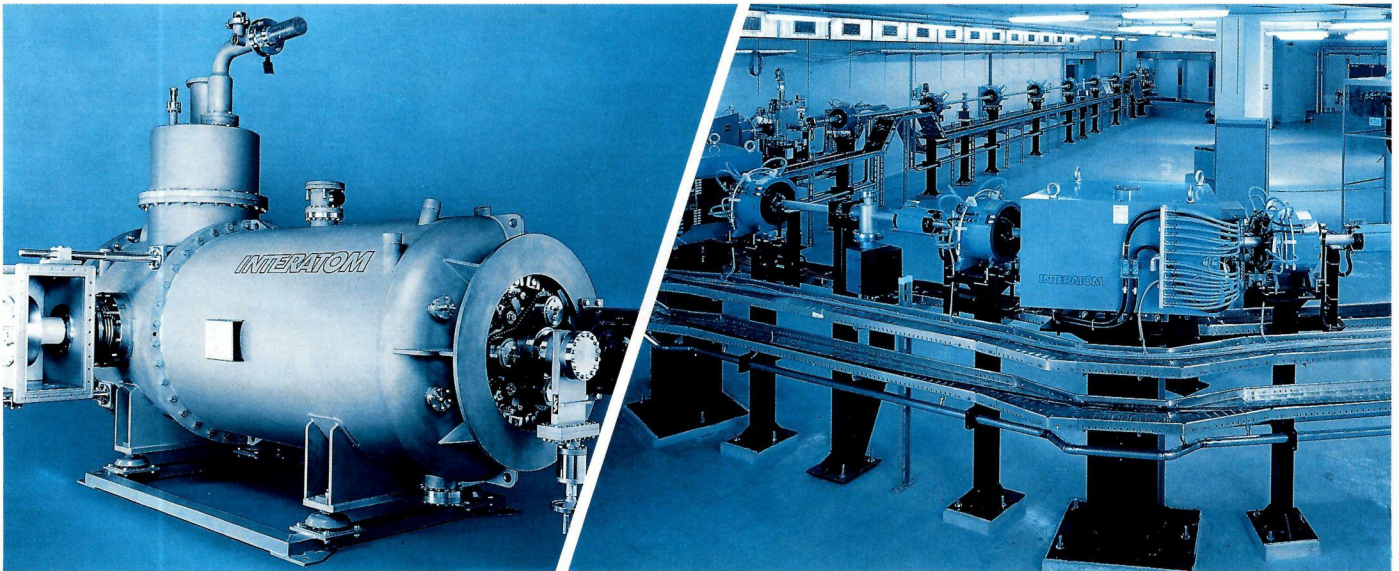


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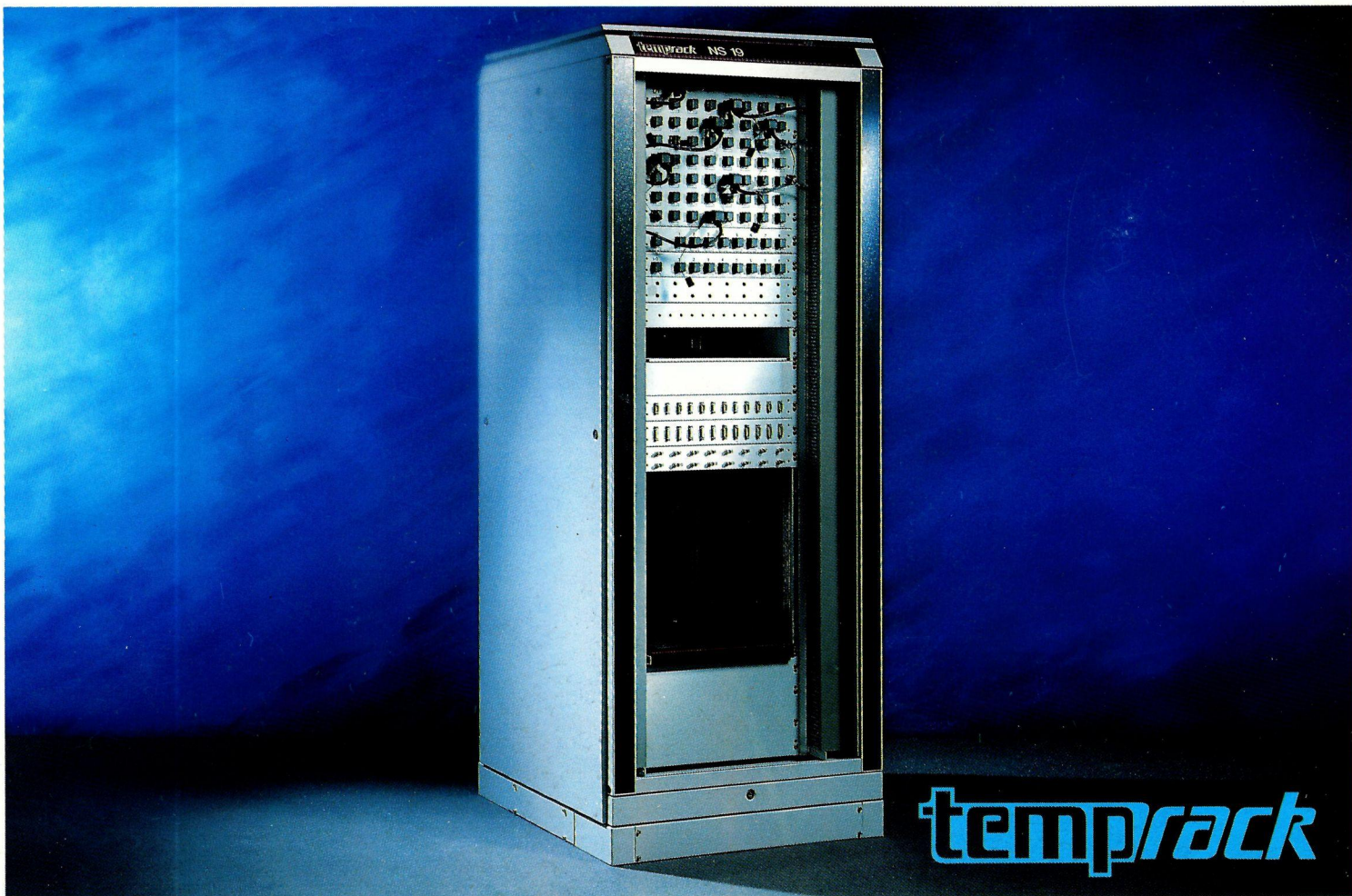
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LA PLATE-FORME POUR LE RÉSEAU



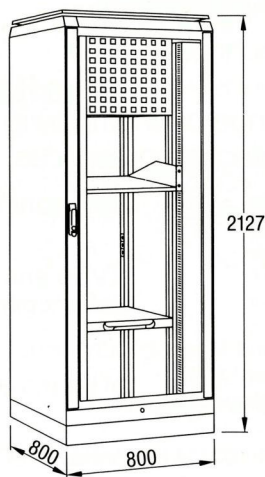
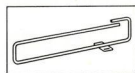
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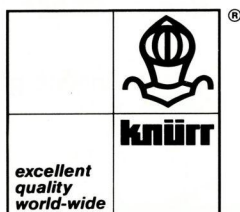


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