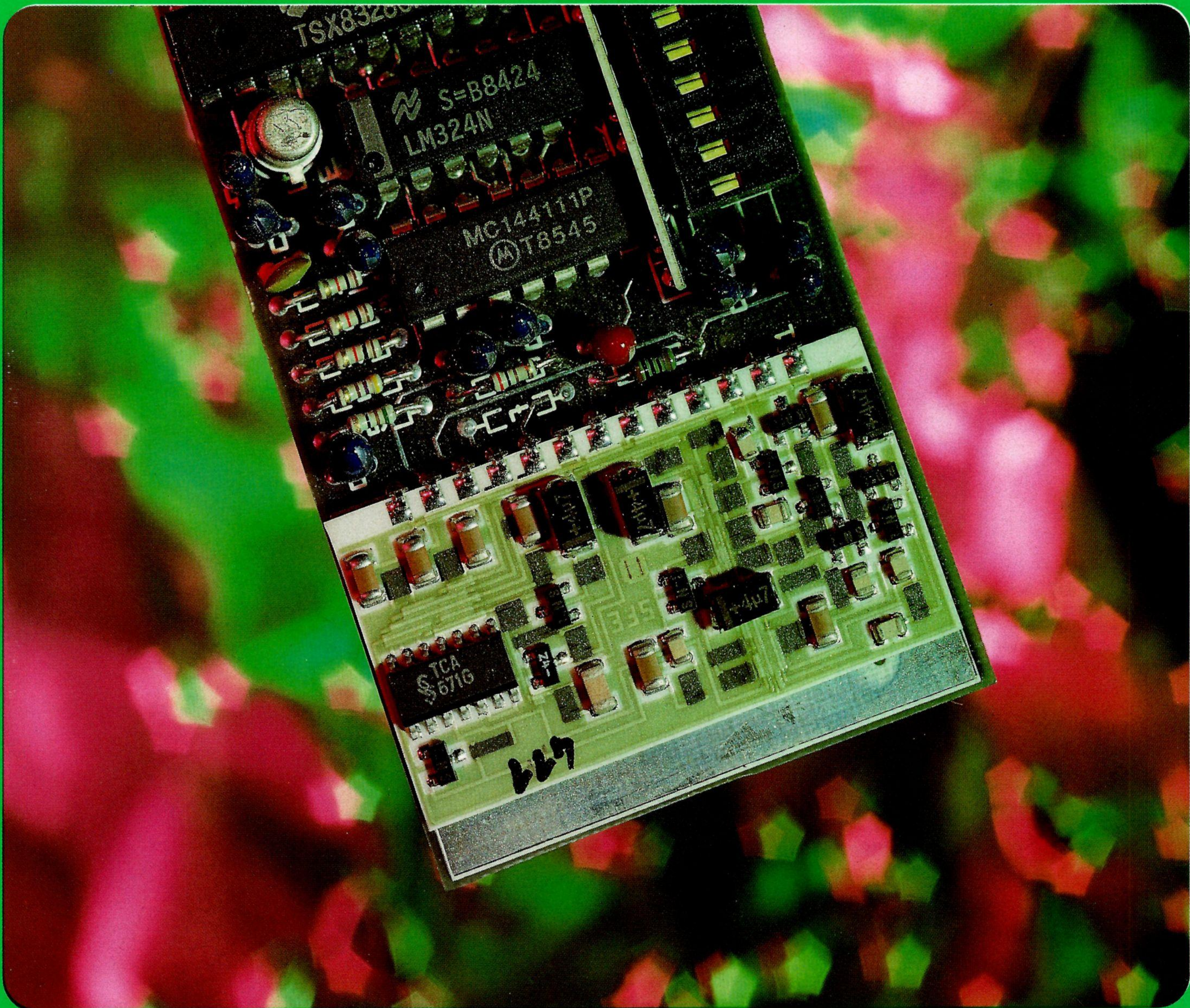
CERN COURIER

International Journal of High Energy Physics



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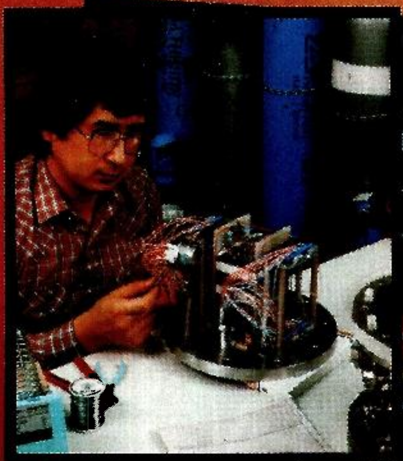

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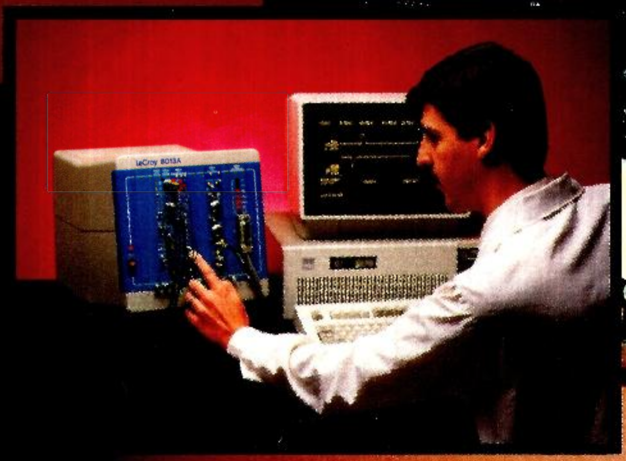

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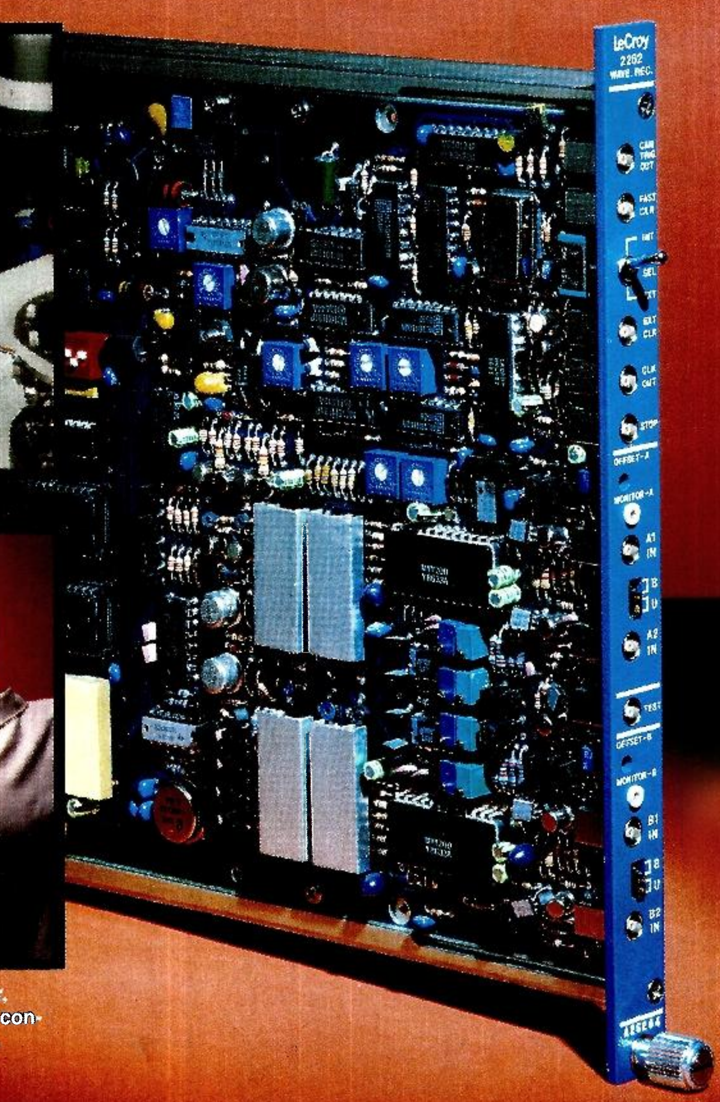

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Volume 27
No. 9
November
1987

CERN COURIER

International Journal of High Energy Physics

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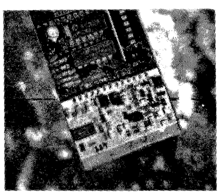

Cover photograph:
The changing face of electronics. A thick film hybrid circuit (below) designed at Munich's Max Planck Institute on a board also equipped with normal discrete components. It is part of the Fastbus-based digitizer designed at CERN for the Time Projection Chamber of the ALEPH experiment at CERN's new LEP electron-positron collider. For more electronics developments, see page 29. (CERN Photo X217.9.87 by Gilbert Cachin)

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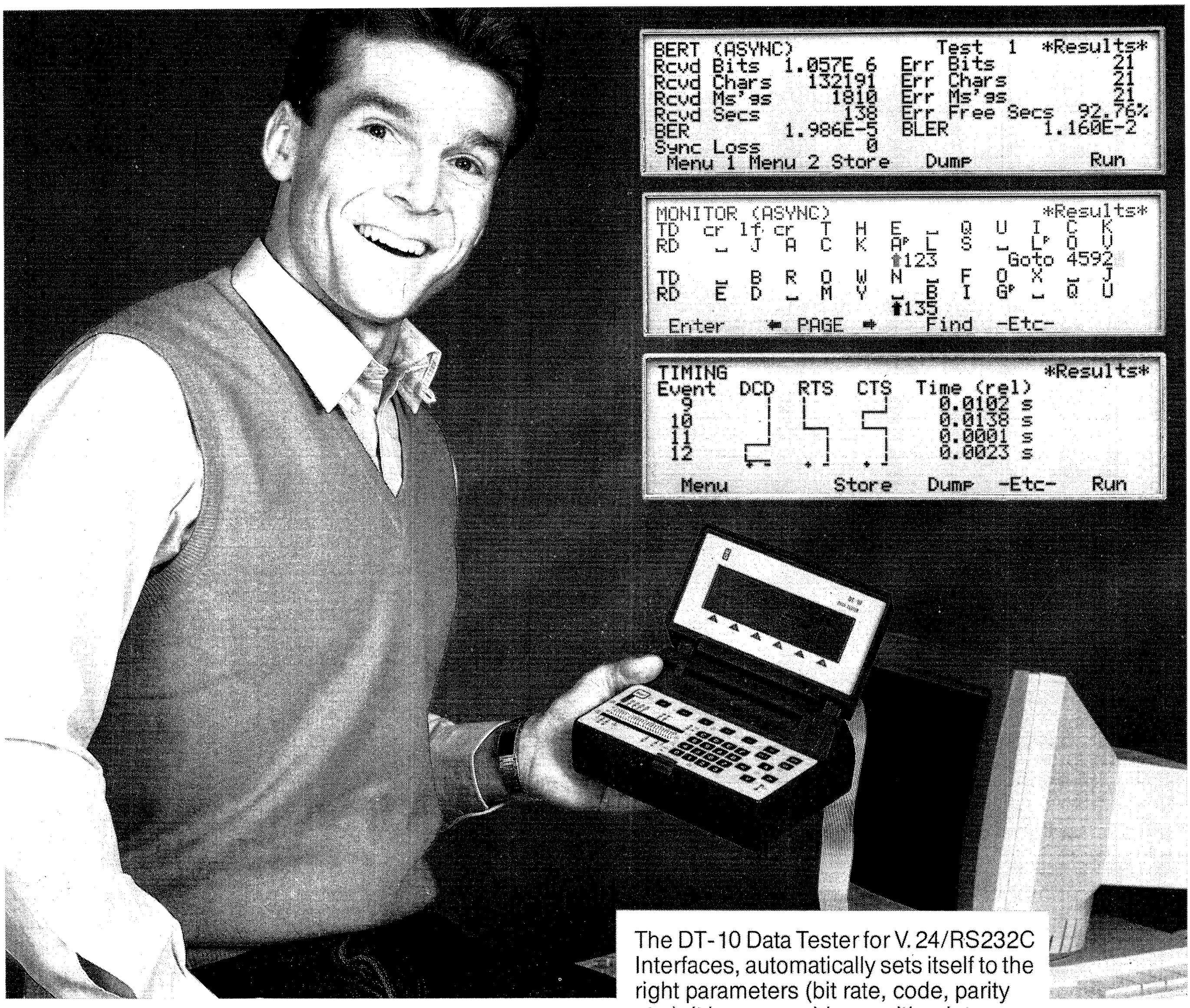
CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management

Printed by: Presses Centrales S.A.
1002 Lausanne, Switzerland

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 419 000
(CERN COURIER only Tel. (022) 83 41 03)

USA: Controlled Circulation
Postage paid at Batavia, Illinois



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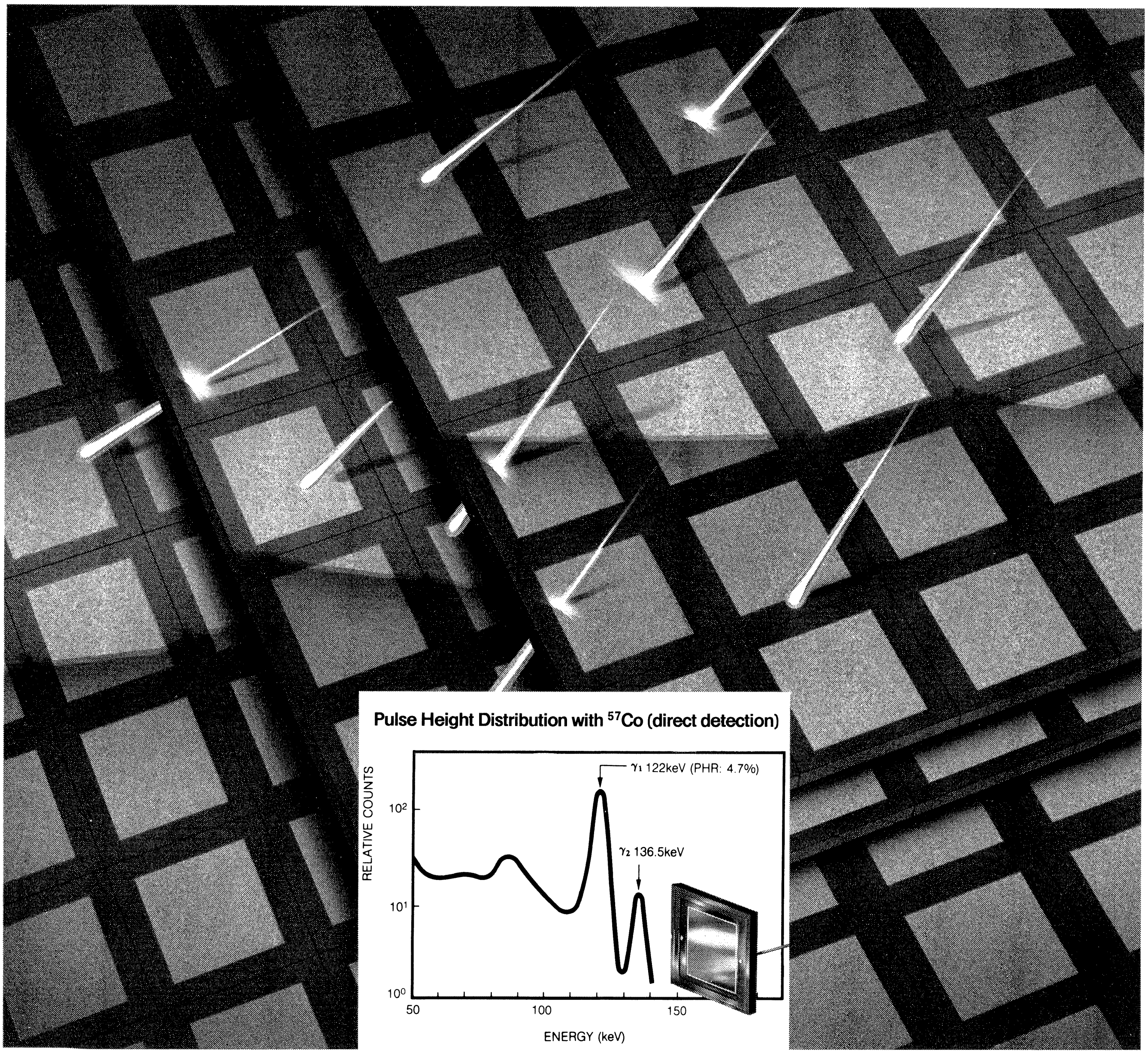

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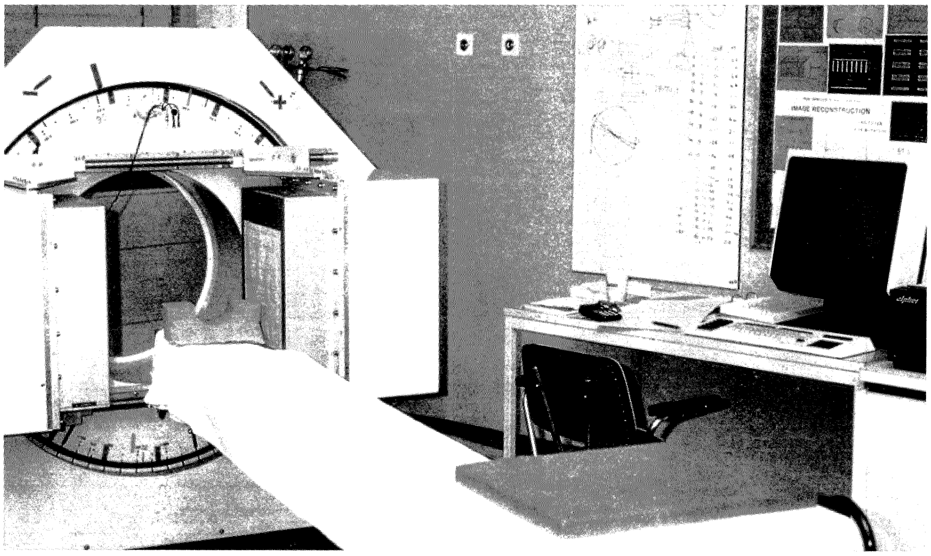
Pinpointing particles

Positron Emission Tomography (PET) apparatus at Geneva Cantonal Hospital, showing the diametrically opposed detectors to pick up the gamma rays emerging from positron annihilations.



The Conference on Position-Sensitive Detectors held at London's University College from 7-11 September highlighted the importance and the growing applications of these precision devices in many branches of science, underlining once again the high spinoff potential for techniques developed inside particle physics.

One particularly fast growing applications field is Positron Emission Tomography – PET – where position sensitive detectors are used to pick up the characteristic gamma rays of positron annihilation. PET scanners are already being used in hospitals particularly to find and study tumours, but their importance in visualizing and measuring the action of drugs is just being realized, according to Terry Jones from the Medical Research Council's Cyclotron Unit at the Hammersmith Hospital in London. Over 80% of the drugs used in the UK can be labelled with suitable tracers. With PET it will be possible to trace any of these drugs to wherever they go in the body. It should even be possible to develop 'magic bullet' drugs which doctors can check in advance on a PET-scanner to make sure they will go only to the parts that need them, with no side-effects anywhere else. The conference was shown some particularly clear pictures of a living thyroid gland, taken by using a positron-emitting iodine tracer with a scanner built by Alan Jeavons of Oxford University.

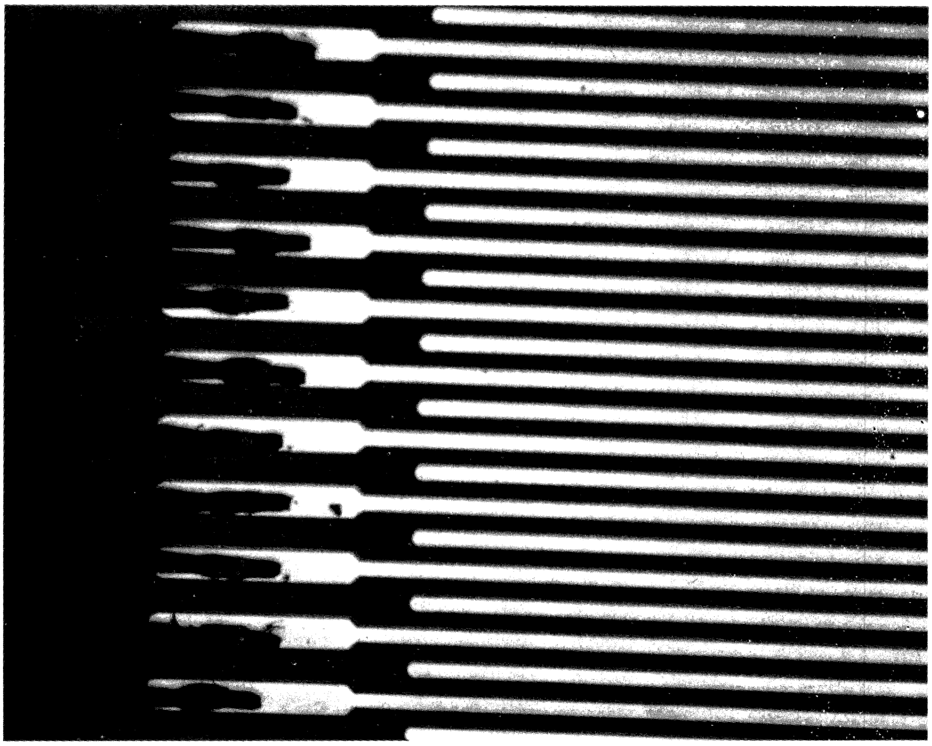
There was a lively debate at the conference between exponents of the established PET techniques, taken over from nuclear physics, and those who wish to use newer particle physics developments. The old guard seem to be holding their ground. They use very dense crystal scintillators which send out a flash of light when they are hit by a gamma ray. This light is converted into an electrical signal by photomultiplier tubes. Until recently the tubes have been large and crude, giving a very blurred picture, but that problem is being solved by 'multianode' tubes being developed by large electronics manufacturers such as Hamamatsu in Japan or Philips in Holland and in France.

Georges Charpak from CERN is the leader of the rival faction, replacing the photomultiplier tubes with a very precise multiwire proportional chamber (MWPC) using fine high voltage sense wires stretched through a special gas mixture. When incoming radiation releases a few electrons in the gas they cause an 'avalanche' breakdown, like a tiny spark but very localized near a wire, and this gives a pulse of charge ten thousand times bigger than the initial bunch of electrons. The disadvantage of MWPCs at present is that they detect a smaller fraction of the arriving gamma rays than a photomultiplier array, so a patient would need a larger dose of radioactive tracer. But new scintillating crystals are being found which match better the light-converting gases used in the chambers.

The newest application of PET came from the chemical engineers, tracing particles inside a 'fluidized bed' – like those used in recent coal-fired power stations or in industrial chemical reactors. Fragments of coal, for instance, move around freely in a bed of inert material such as sand which behaves like a liquid because the grains are spaced out by the strong flow of air through a perforated plate underneath. No one had ever been able to follow actual particles in such a bed, but C. R. Bemrose of Birmingham showed a video film of computer images from a PET scanner showing all the details of the path of a particle deep inside the fluidized sand, moving in loops with the flow of material or occasionally getting stuck in a corner where the flow was less active. He used a multiwire proportional chamber scanner, built with the assistance of the Rutherford Appleton Laboratory.

High precision is more important to the engineers than a low dose of radiation, so multiwire propor-

Silicon strip detector made by Micron Semiconductor (UK) showing the fine wire connections to alternate strips. Used to study the decay of unstable particles, it has a strip spacing of 50 microns.



tional chambers are the natural choice. They are also being used to follow the motion of oil inside jet engines.

Astronomers want to look at distant objects with every available wavelength of light, not just the visible, and they want to know two things about every photon of light they detect; where did it come from, and what was its energy? For example, at the focus of an X-ray telescope on an orbiting satellite they need a position-sensitive detector connected to a computer which can build up multiple superimposed images of the object in view, each image corresponding to a small range of X-ray energies.

A relative of the multiwire proportional chamber – called a 'parallel plate avalanche chamber' – is being used for this, as reported by John Lapington of the Mullard Space Science Laboratory of University College, London. Another related device, used by particle physicists as well as astrophysicists, is the 'gas scintillation proportional detector' (GSPD) which picks up the light given out when radiation is detected in a gas-filled chamber. A GSPD can give a precise image for every individual ultra-violet photon that hits it. But much more sensitive devices are now being developed, using arrays of tiny composite crystal detectors at extremely low temperatures. Damian Twerenbold of the European Space Agency described superconducting junctions which send out an electrical pulse proportional to the energy of the X-ray which hits them, and a competing instrument called a bolometer which actually measures minute changes in the temperature of crystals due to the heating effects of single X-rays.

Everyday electronic circuits exploit the movement of electrons through crystals of silicon. But it is possible to make very pure silicon which can be completely 'depleted', with all movable free electrons removed. Radiation frees bound electrons from the silicon atoms (ionizing them), giving a detectable signal. This principle is used in TV cameras containing charge-coupled-devices (CCDs). CCDs and other silicon detectors are used by particle physicists, especially in experiments to measure the lifetimes of unstable particles containing the heavy quarks. Such particles only travel a few microns before they decay, but that is just the scale for the patterns on a silicon chip.

There were a number of presentations of a super-CCD, a 'random-access pixel device' in which the position and amount of charge of each radiation hit will be read out within a few millionths of a second, rather than waiting many thousandths of a second (a very long time in electronics) for a TV-style scan through all the thousands of separate sensing points. Sherwood Parker of Berkeley reported on his detailed design which will be laid down on silicon in the next few months. If it works it will be of interest to many more users than just the particle physicists.

Multiwire proportional chambers or scintillators with photomultipliers are proving very useful for neutron diffraction. The ISIS pulsed neutron source at the Rutherford Appleton Laboratory provides beams and detectors for a variety of users, including groups developing the new high temperature superconductors. Slow neutrons do not interact directly with a detector. They have to be captured in an atomic nucleus, such as lithium, which breaks up to release charged particles that are detected by scintillation or ionization in the detector. P. L. Davidson from ISIS described a lithium-loaded glass scintillator which sends out its signals down lots of separate optical fibres to sets of photomultipliers.

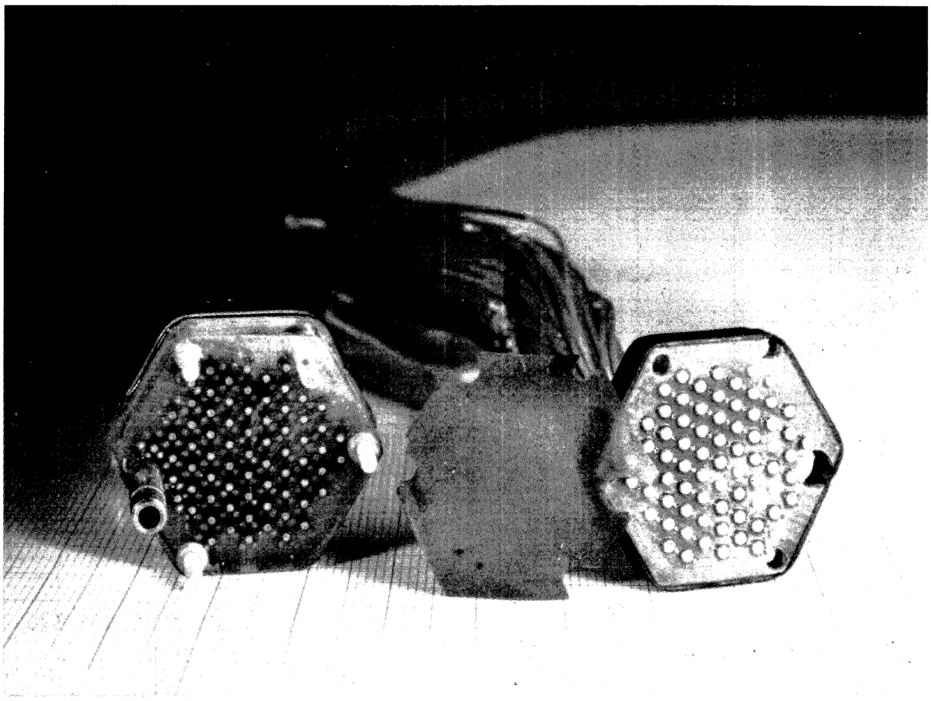
Muscle is one of the most mysterious of biological materials, composed of regular layers of overlapping fibres. A. R. Faruqi of the UK Medical Research Council's Cambridge Laboratory has watched moving muscle simultaneously with a CCD to image the contraction, and with a multiwire chamber to image the changing pattern of X-ray dots, showing the changes in the molecular structure of the fibre layers. Such modern X-ray studies require both sophisticated detection techniques and intense beams of synchrotron radiation, provided by electron storage rings.

Charpak developed his multiwire proportional chambers into another kind of gas-filled detector, the drift chamber, which has proved extremely useful in particle physics. The exact position at which radiation interacts with the gas determines how long it takes for the electrons to drift through a uniform electrical field before arriving at the fine wire where they are detected. Fabio Sauli from CERN told the conference about drift chambers being developed for the large electron-positron (LEP) machine which will run at CERN in 1989. In some of them the electrons drift two metres before they reach the wire. This allows a very large detection volume to be covered by a relatively small (and affordable) number of channels of electronics. He also showed pictures of his own compact drift chamber where the track of an ionizing particle can be localized to about twenty microns, comparable with the precision of many silicon detectors.

The drift idea has now been picked up by scientists building both silicon detectors and detectors filled with liquids. In every application it gives improved position resolution and a considerable reduction in the amount of electronics required. As well as the particle physics possibilities, the conference heard from H. J. P. Kuykens of Delft how a silicon drift chamber might be used to improve the resolution of PET scanners. Liquid drift chambers have good position resolution over a large volume, with a much denser detecting medium than a gas. This is important in detecting neutrinos, which need tons of detector to give a reasonable signal. Liquids also suffer less degradation from intense radiation so they can be used instead of other high-density detectors close to the beam-pipe of an accelerator or storage ring. G. Giorginis and J. Engler from Karlsruhe reported successful experiments on drifting electrons in a cold liquid (liquid argon) or in room temperature organic liquids.

Of the 275 scientists attending the meeting, about 40 per cent were particle physicists, although about 90 per cent of the detectors discussed were developed originally for particle and nuclear physics experiments.

By David J. Miller

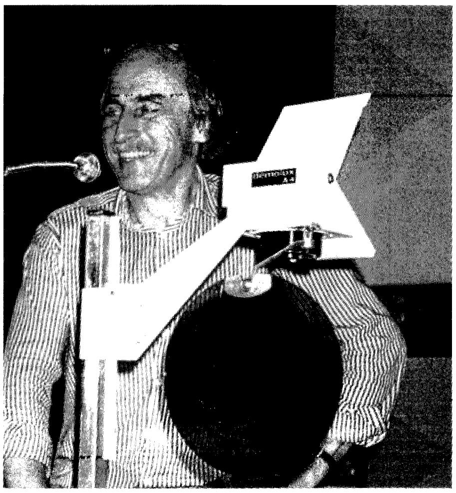


The compact drift chamber (its size can be judged by the large centimetre squares on the graph paper) developed by Fabio Sauli and his group at CERN. With more than 60 sense wires, this detector attains twenty-micron precision, comparable to solid state detectors.

(Photo CERN X567.1.87)

A matter of quarks

Quark Matter announcement from Reinhard Stock, chairman of the organizing committee at the August meeting at Schloss Nordkirchen, near Dortmund.



Quarks are understood to interact through the 'colour' force, carried by gluons. Under normal conditions these quarks are confined – frozen together in 'colourless' states such as protons, neutrons and other strongly interacting particles. However if the quarks are compressed tightly together and/or are 'heated' by increasing their energy, they should eventually break loose from their colour bonds to form a new kind of matter – the so-called quark-gluon plasma. Although QGP has not yet been synthesized in the Laboratory, it was most likely the stuff of the Universe 10^{-5} second after the Big Bang. Thus the search for this 'new' matter is attracting a growing number of physicists, theorists and experimenters from both the particle physics and nuclear physics fields.

Theorists confidently predict QGP formation in the collisions of heavy nuclei at energies available from present machines, so that a glimpse of these post-Big Bang conditions might come soon and relatively cheaply.

With this in mind, the 1987 Quark Matter Conference, held from 24-28 August at Schloss Nordkirchen, near Dortmund, West Germany, focused on the first results obtained last year with nuclear beams in experiments at CERN and Brookhaven. CERN provided higher energies (oxygen nuclei at 60 and 200 GeV per nucleon) while Brookhaven offered heavier nuclei (silicon at 14.5 GeV per nucleon).

At CERN, four major detectors collected data from the oxygen run last year – the WA 80 'Plastic Ball' study, the NA34/2 HELIOS detector, the NA35 streamer chamber experiment, and the NA38 muon pair spectrometer (see December 1985 issue, page 429). This year's run at CERN used the heavier sulphur nuclei to increase the energy densities, and two more major experiments joined the fray – the NA36 Time Projection Chamber and the WA85 group using the Omega spectrometer. In both runs, smaller experiments using special targets ran in parallel. Complementary results came from two Brookhaven studies (Experiments 802 and 814 – see April issue, page 18).

The first workshop on quark matter physics was held in Bielefeld in 1982. Since then periodic meetings have reflected the increasing enthusiasm and confidence in this new physics venture, but this year was the first time that experimental results were available.

It is not yet possible to say if the quark-gluon plasma has been synthesized under laboratory conditions. Maybe the Brookhaven energy is too low and perhaps the CERN nuclei are too small. Yet there are two intriguing clues. The NA38 team reported a suppression of the J/psi resonance in the dimuon spectra from oxygen-uranium collisions producing large transverse energy, while Brookhaven saw five times as many charged pions as kaons. Both these effects had been predicted as indicators of QGP.

Results from the other CERN experiments' 1986 oxygen run can be explained by conventional ordinary nuclear effects. However the 'stopping power' of the incoming nuclei under these conditions is found to be as high as had been hoped, so that a lot of energy (a few GeV) can be compressed inside a nucleon-like volume. This is just what is needed to make QGP, and experimenters are looking forward eagerly to the final analysis of this year's sulphur run.

As well as looking at initial results, the Schloss Nordkirchen meeting looked forward to future projects. Brookhaven has its RHIC Relativistic Heavy Ion Collider plans well advanced, while at CERN attention is turning to the possibility of a dedicated pre-injector providing lead nuclei. US prospects were described by D. Hendrie (Department of Energy), and Pierre Darriulat covered the CERN side.

CERN From oxygen to sulphur

For several weeks during September and October, the CERN accelerators handled sulphur 32 ions, with the SPS synchrotron boosting them to 200 GeV per nucleon. This set up a new world beam energy record of 6400 GeV (6.4 TeV), doubling the figure set at CERN last year with oxygen 16 ions. With interesting clues emerging from the 1986 data, the first results from the sulphur beams are eagerly awaited.

The meeting, organized by R. Santo (Munster), H. Satz (Bielefeld / Brookhaven), H. J. Specht (Heidelberg) and R. Stock (Frankfurt, chairman), brought together about 250 physicists. The next conference in the series will be held next September on the US East Coast.

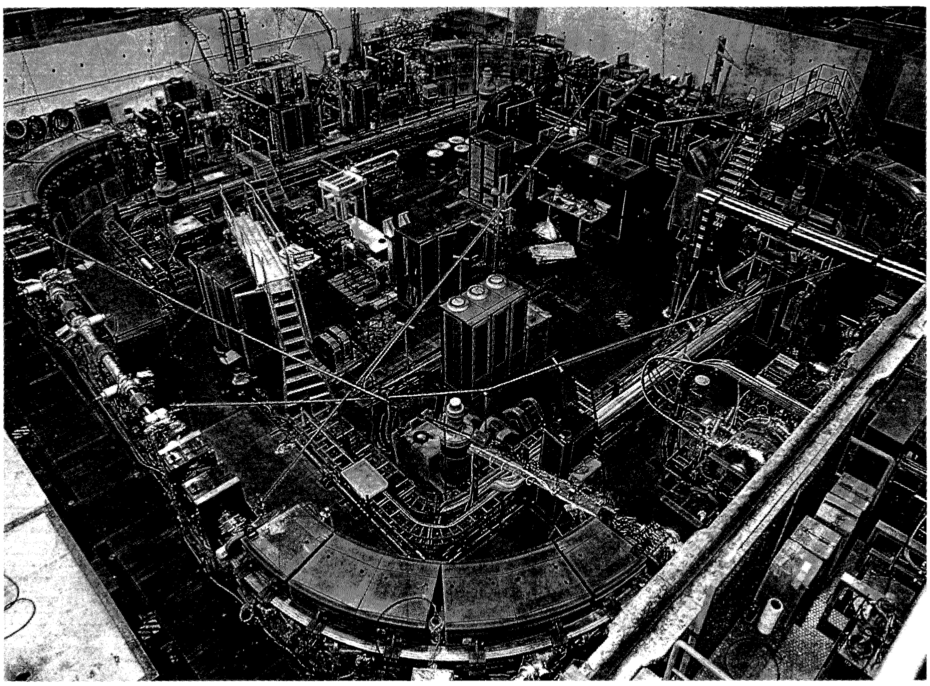
E. Feinberg (Lebedev Institute, Moscow) sings the praises of the hydrodynamical approach to Quark Matter Conference organizing committee member Hans Specht of Heidelberg

(Photos M. Jacob)

Energy not the only frontier

While the push for big new machines to explore high energy frontiers makes the headlines, other avenues for physics progress are still being actively explored. To reflect these efforts, theorists and experimenters from the experiments committees for CERN's two major existing machines – the PS Proton Synchrotron and the SPS Super Proton Synchrotron – joined forces in study groups to look at long term physics perspectives. As one experimenter put it, 'there are frontiers of high complexity and high precision as well as high energy'.

The groups' findings were aired at a special joint open meeting of the two committees at CERN on 31 August and 1 September. Although organized in a CERN con-



The LEAR Low Energy Antiproton Ring – CERN trump card.

(Photo CERN X180.8.87)

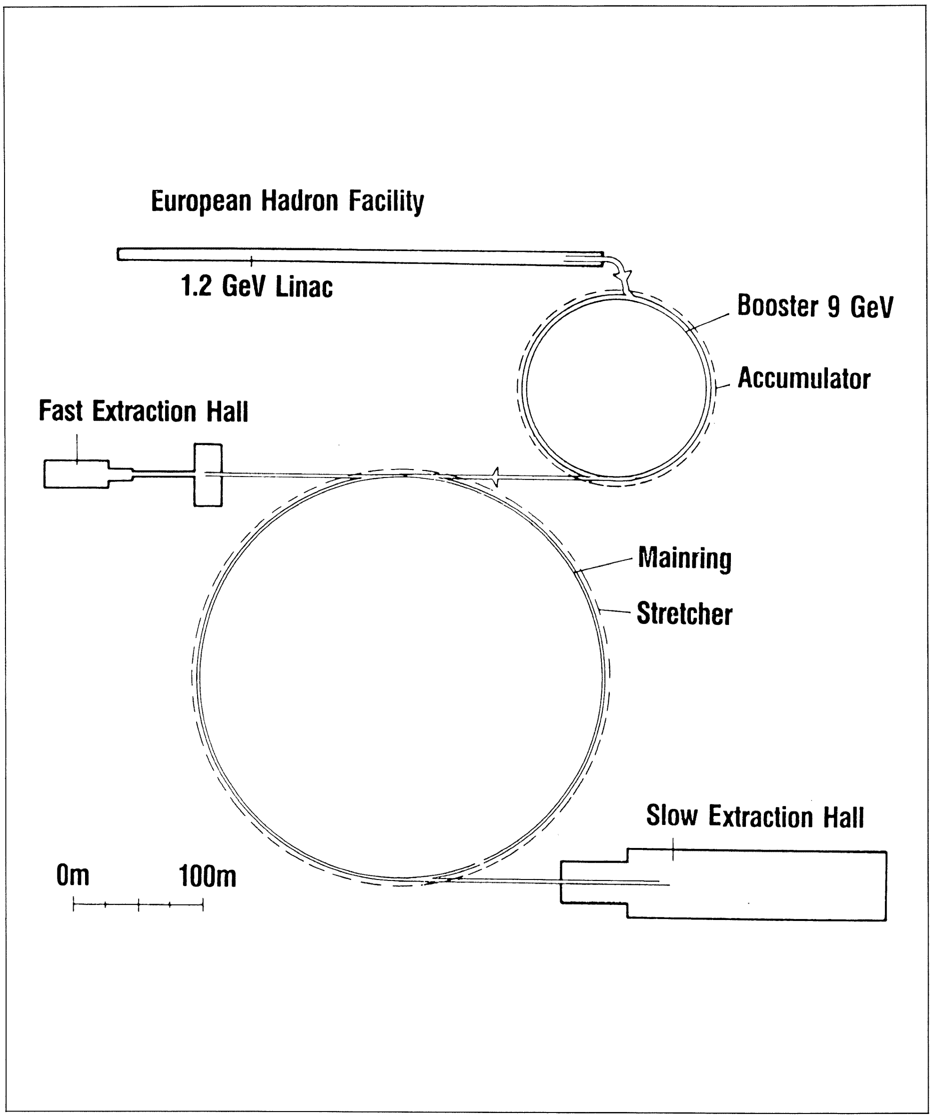
text, the attention was not limited to existing CERN machines and the sessions attracted wide interest from Laboratories further afield with their own preoccupations for the future.

Introducing the proceedings, CERN Director General Herwig Schopper emphasized CERN's tradition of a rich and varied research programme catering for a large user community. Alone, the four big experiments being built for CERN's new LEP electron-positron collider, scheduled to switch on in 1989, do not continue this tradition. Schopper also drew attention to interim recommendations of the CERN Review Committee chaired by Anatole Abragam – 'every effort should be made to keep this variety (of programme) ... for maintenance of the Laboratory's prestige and creativity'.

One CERN trump card is the LEAR low energy antiproton ring. For some six years, CERN was the only place in the world where antiprotons were on tap. Fermilab has now followed suit, but the US Laboratory has not yet embarked on a low energy antiproton programme, preferring for the meantime to concentrate on the high energy sector.

Lucien Montanet covered the possibilities for low energy antiprotons at CERN in the 1990s. The continued exploration of fundamental symmetries was seen as one major objective, including precision measurements of antiproton properties and the study of neutral kaons to probe deeper into the mysteries of CP violation (the almost but not quite exact symmetry of particle-antiparticle and left-right permutation). While the neutral kaons are still the only offenders, the effect could be looked for elsewhere, for example in lambda baryons and their antiparticles.

The proposed European Hadron Facility – aiming to put Europe on the high intensity map.



Spin can still be the joker in the particle physics pack, and Montanet suggested a systematic attack, using polarized targets and possibly beams. Elsewhere, the search for new particle states frequently provides additional insights into the underlying forces, and here LEAR could continue to make important contributions, whether in a gently upgraded form, or with a new superconducting 'SUPERLEAR' ring.

Important progress was made with CERN's Intersecting Storage Rings machine in the last few months of its life, using a gas jet target and a tuned antiproton beam to home in on states difficult to isolate using the conventional approach of colliding electron and positron beams. This could be adopted for LEAR.

The idea of using LEAR to supply trapped antiprotons or even neutral antimatter remains as fascinating as ever.

Away from LEAR, lower energy antiprotons (about 45 GeV instead of the hundreds of GeV normally used) could be stored in the SPS ring for use with the UA6 gas jet target equipment to explore higher energy spectroscopy.

F. Bradamante enthusiastically extolled the virtues of the proposed European Hadron Facility (EHF – see July/August 1986 issue, page 13). This high intensity (microamp) 30 GeV proton machine could bring the requisite physics power to bear on a wide range of questions. Bradamante underlined the need for physics research with high intensity beams of kaons, neutrinos, etc. While the US and Japan have well-developed plans in this area, 'Europe has nothing' he emphasized. A 'green field' version of EHF has been costed at 867 million deutschmarks, less if it exploited some existing Laboratory infrastructure.

CERN's traditional staple diet has been protons from the PS. However the advent of the LEP electron-positron collider called for a sophisticated supply of electrons and positrons. Mike Albrow pointed out the potential of the new EPA electron-positron accumulator for physics.

Additional flexibility could also come from the SPS, and Harry Atherton outlined what additional beams, not necessarily at the highest possible energies, could do.

John Garvey and Guido Altarelli looked at proton-antiproton colliding beam physics with the increased antiproton levels from CERN's new ACOL Antiproton Collector. While Fermilab's Tevatron has walked off with the energy prize, CERN's additional antiprotons, together with the major upgrades for the big UA1 and UA2 detectors, could pay dividends and keep the CERN collider in the physics front line for several years more yet.

The implications of spectroscopy for strong interaction physics were looked into by Frank Close, who wanted to know where the 'glue' is. Gluons are understood to carry the forces between quarks, but so far there has been little indication of particles with constituent gluons instead of, or as well as, quarks. Close outlined a possible strategy to search for all the missing states, and concluded with comparative ratings of different schemes for spectroscopy progress.

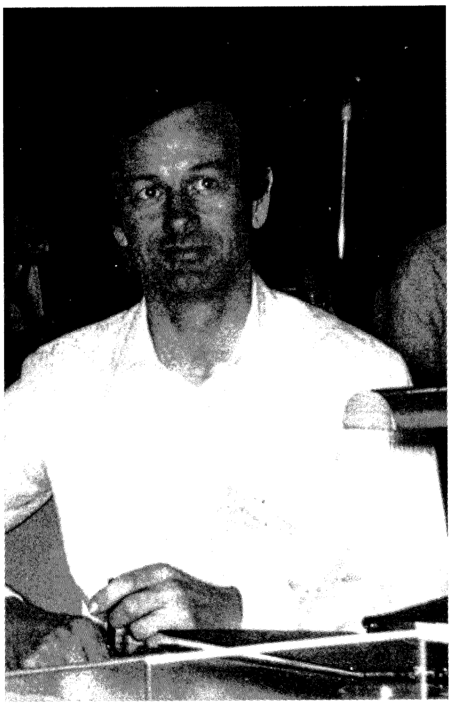
Hans-Jürgen Pirner took up the question of lepton physics, with implications mainly for the SPS, pointing out that the lepton sector of today's Standard Model of particle physics is the least well known. Neutrino parameters in particular are difficult to pin down, and a high intensity beam would be useful.

The search for unusual decays is an area where research investment could provide good value for money. A. Buras (theory) and C. Guyot (experimental setups) provided an interesting counterpoint of theoretical ideas and experimental scenarios. Searches could be mounted for decays forbidden according to conventional ideas, while the study of rare decays test special physics areas. CP violation again came under close examination, where new examples could be looked for.

Finally G. London and R. Stock looked at what had been learned from the brief but highly successful runs last year at CERN using high energy beams of oxygen nuclei. (These promising results were covered in detail at the recent 'Quark Matter' conference at Schloss Nordkirchen near Dortmund in West Germany – see report on page 5). This year's run used sulphur nuclei, twice as heavy, while for the future the experimenters rub their hands at the thought of what beams of lead nuclei could do.

Not all of the ideas mentioned at the meeting will see the light of day, but it is clear that there is a lot of work to do away from high energy frontiers. The continued exploration of CP violation, still poorly understood 23 years after its discovery, the ongoing search for new particle states, and precision measurements of known phenomena were recurring themes in many of the presentations.

Frank Close – looking for glue.



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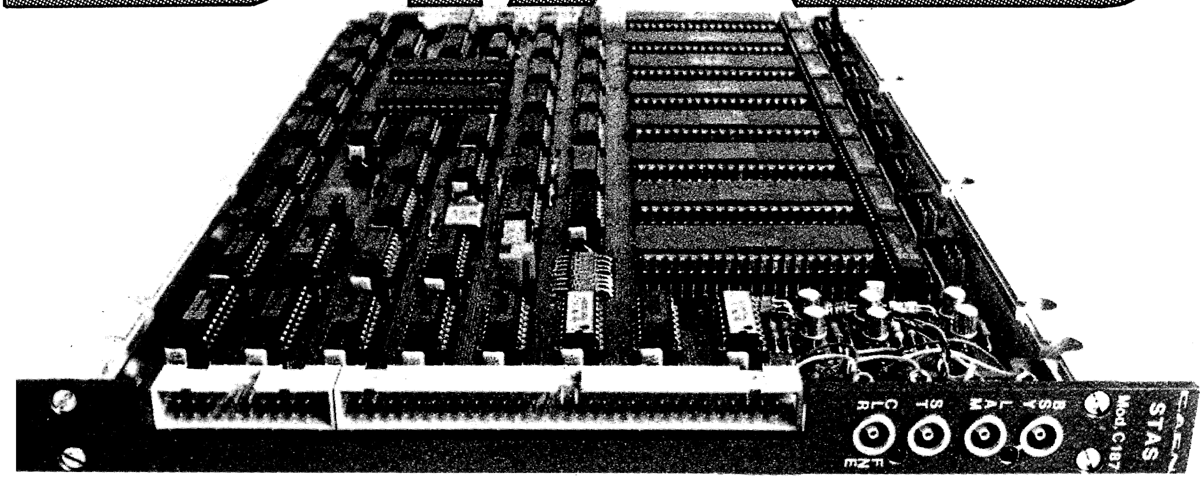

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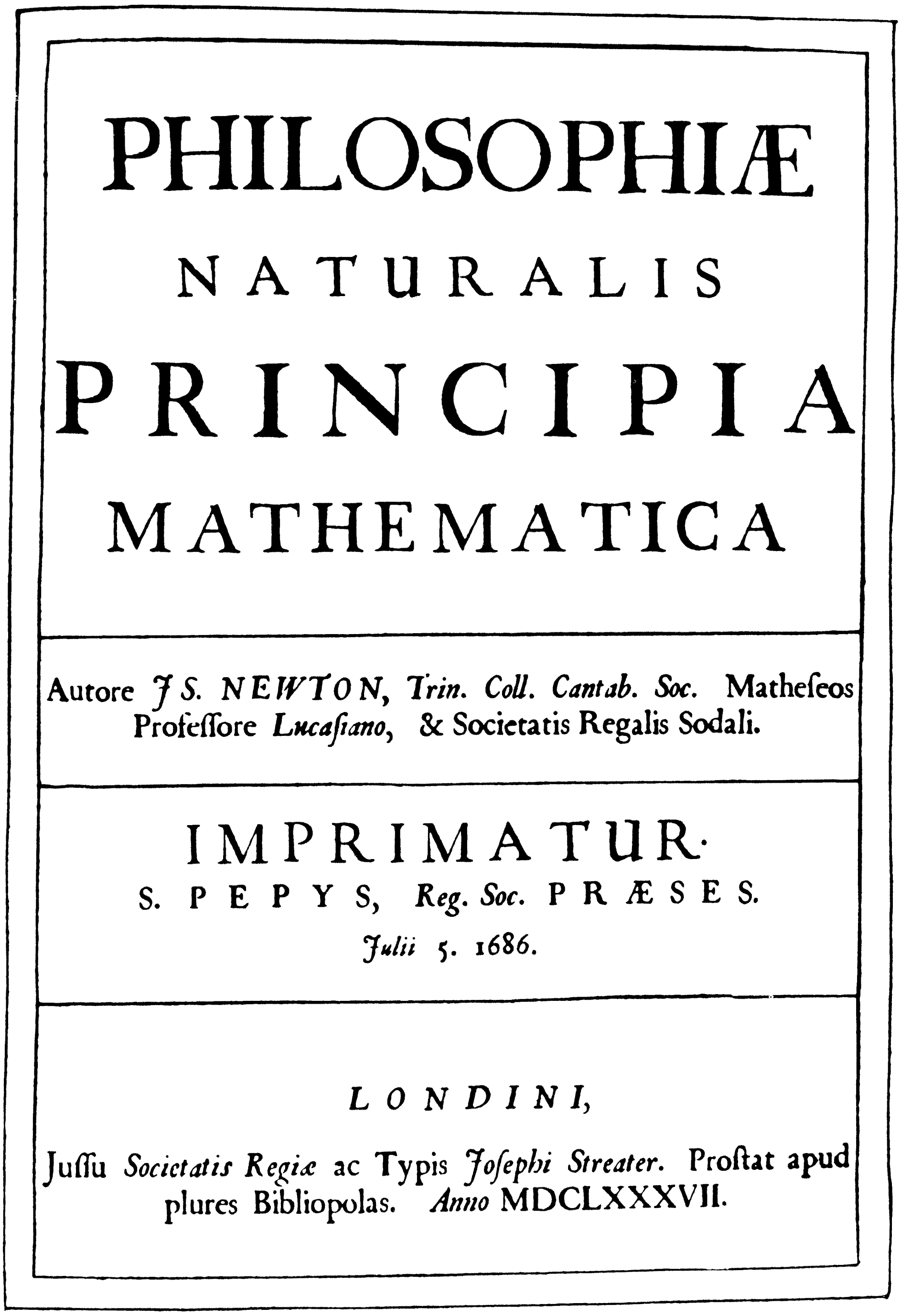
Physics 87

The title page of Newton's Principia, published 300 years ago.



PHILOSOPHIÆ

NATURALIS

PRINCIPIA

MATHEMATICA

Autore *J S.* NEWTON, *Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano*, & Societatis Regalis Sodali.

IMPRIMATUR·

S. PEPYS, *Reg. Soc.* PRÆSES.

Julii 5. 1686.

LONDINI,

Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater.* Proſtat apud plures Bibliopolas. *Anno* MDCLXXXVII.

87 seems an auspicious cycle for physics. This year has seen the first neutrino observation of a supernova and the development of a new class of superconductors which carry large currents at relatively high temperatures. It is also the centennial of several major events in the history of physics which have shaped our present understanding of the universe.

In 1687, Edmond Halley as Secretary of the Royal Society in London wrote to Isaac Newton in Cambridge to confirm that the latter's Philosophiae Naturalis Principia Mathematica was finally ready for publication.

In view of the Royal Society's lack of funds at the time, Halley had undertaken to publish the book at his own expense.

'Honoured Sr, I have at length brought your Book to an end, and hope it will please you. The last errata came just in time to be inserted. I will present from you the books you desire to the R. Society, Mr Boyle, Mr Pagit, Mr Flamsteed and if there be any elce in town that you design to gratifie that way; and I have sent you to bestow on your friends in the University 20 Copies, which I entreat you to accept.'

Two hundred years later, in Cleveland, Ohio, Albert Michelson and Edward Morley failed to detect any effect on the velocity of light due to the movement of its source, a puzzling null result which had to wait 18 years for an explanation by Einstein's revolutionary Special Theory of Relativity.

Also in 1887, Heinrich Hertz, then working in Karlsruhe, was especially busy discovering the electromagnetic radiation suggested twenty years earlier by Maxwell's equations. Not content with this single breakthrough, he saw for the first time the photoelectric effect. For the explanation of this initial example of light waves behaving like particles, the world also had to wait until 1905 and the genius of Einstein.

Three centuries after the publication of Newton's masterpiece, Stephen Hawking and Werner Israel assembled a group of the world's foremost researchers in cosmology, relativity and particle physics for a commemorative meeting '300 years of Gravitation'

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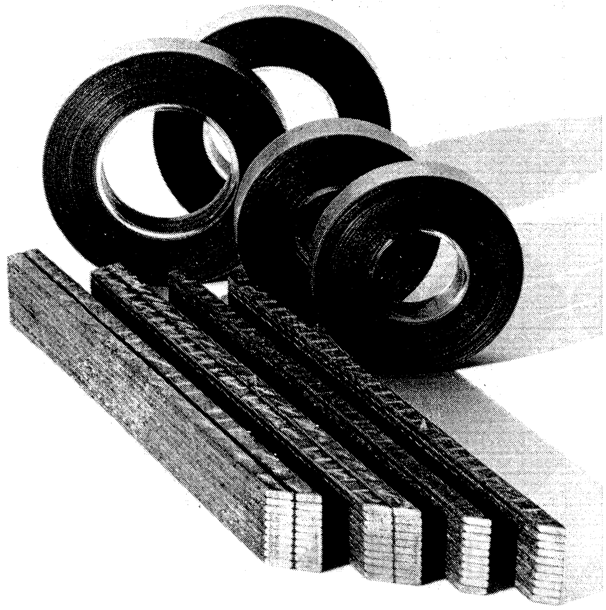

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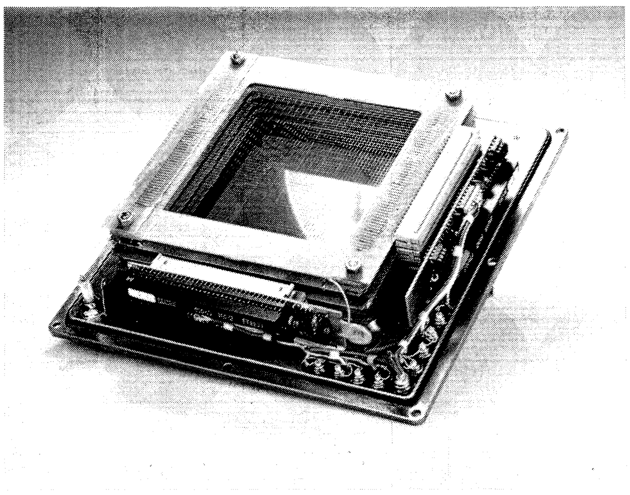

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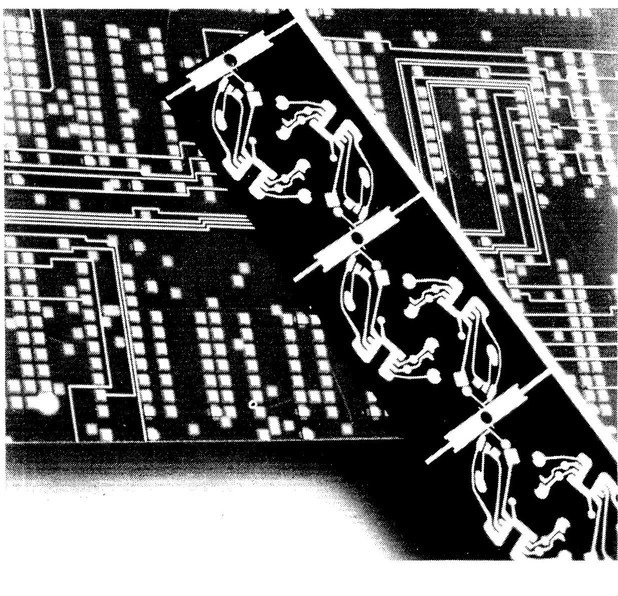
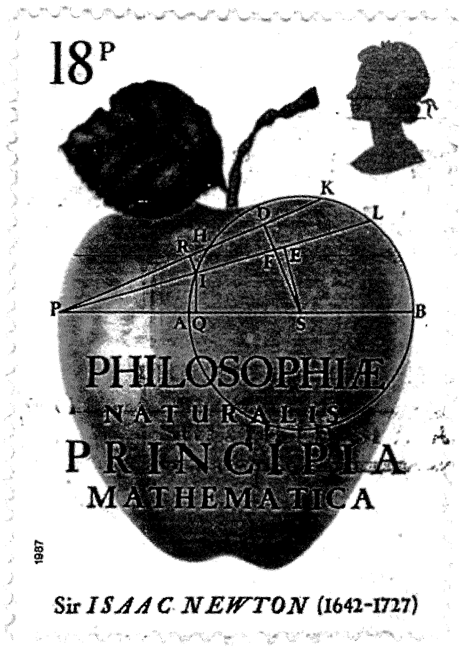


UK postage stamp commemorating this year's tercentenary of the publication of Isaac Newton's 'Principia'.



in Cambridge earlier this year. In addition, Trinity College, Newton's home from 1661 to 1696, organized its own tribute, as did the Royal Society.

The papers presented at the Gravity 300 meeting have been published as a commemorative volume*. Introducing the subject, Stephen Hawking claimed Newton's Principia to be 'probably the most important single work ever published in the physical sciences', and went on to explain how Newton was motivated by Halley to make clear how the elliptical orbits of the planets were due to an inverse square type force directed towards the sun, a result Newton had in fact worked out some years earlier but had not published.

In the Principia, Newton introduced the ideas of absolute time and absolute space, controversial concepts which nevertheless held fast until the advent of Einsteinian relativity more than two centuries later. In the book, Newton did not introduce his idea of 'fluxions' – a form of differential calculus he developed to handle forces varying in magnitude and direction – preferring the historically acceptable geometrical approach, and leaving the door to calculus open for Leibniz.

In the preface to the first edition of Principal, Newton remarked 'I wish we could derive the rest of the phenomena of Nature by the same kind of reasoning for mechanical principles, for I am induced by many reasons to suspect that they may all depend on certain forces'. This hope has not been fulfilled, but, as Stephen Weinberg concludes in the book, 'we are working on it, very much in the Newtonian tradition: the formulation of increasingly comprehensive quantitative laws. From this high viewpoint, all that has happened since 1687 is a gloss on the Principia'.

The 1987a supernova came as a fitting monument to the tercentenary, underlining the importance of the classical theory and at the same time pointing to the future. Gravitation reflects both the sedate beauty of a classical theory and the turmoil of modern research, as exemplified by the contributions to the book.

Upsetting the ether

The Michelson-Morley experiment was one of the big upsets of physics, undermining the considerable confidence that had built up in the ideas of the day and setting the scene for modern physics and the special theory of relativity almost twenty years later.

When the two American experimenters planned their epic study, electromagnetic radiation such as light was believed to travel through some invisible 'ether' that filled all space. If so, radiation from a moving body should travel faster than radiation from a static source. To test this idea, Michelson and Morley built a superbly tuned instrument designed to compare the velocity of light moving in the same direction as the Earth with the velocity perpendicular to the Earth's motion.

After repeated attempts, they found no such evidence for the long-awaited ether. According to their precision experiment, the velocity of light looked to be independent of the velocity of its source. Working independently, Hendrik Lorentz in the Netherlands and George Fitzgerald in Ireland concluded that the paths travelled by the two perpendicular light beams had to depend on velocity. This empirical result was eventually set in context by Einstein, who showed that Newton's absolute benchmarks of space and time were only valid for everyday phenomena, and had to be rethought on the grander scale.

In 1907, Michelson became the first American to receive a Nobel Prize for scientific achievement, but to his death in 1931 remained a staunch opponent of quantum physics and relativity.

In Cleveland, Ohio, where the experiment took place, thirteen of the city's cultural and educational institutions joined in a city-wide six-month celebration entitled 'Light, Space and Time', encompassing the sciences, arts and humanities. Case Western Reserve University, where Michelson and Morley were based, played a leading role, with major symposia on

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** 300 years of Gravitation, edited by Stephen Hawking and Werner Israel, published by Cambridge University Press.*

physics history and modern perspectives held during October.

Hertzian waves

A pupil of Helmholtz, Heinrich Hertz made his initial mark on physics by justifying Maxwell's equations on theoretical grounds. With so much evidence building up to support the idea of electromagnetic radiation, he turned his attention to its detection. Using the apparatus still on view at the Deutsches Museum in Munich, he found that sparks across a gap in a rectangular wire frame could produce sparks in a similar but unconnected circuit. The distance between the transmitting and receiving circuits was gradually increased from 1.5 metres to right across the room.

After this initial discovery, Hertz went on to demonstrate that the radiation could be reflected and refracted like all other waves.

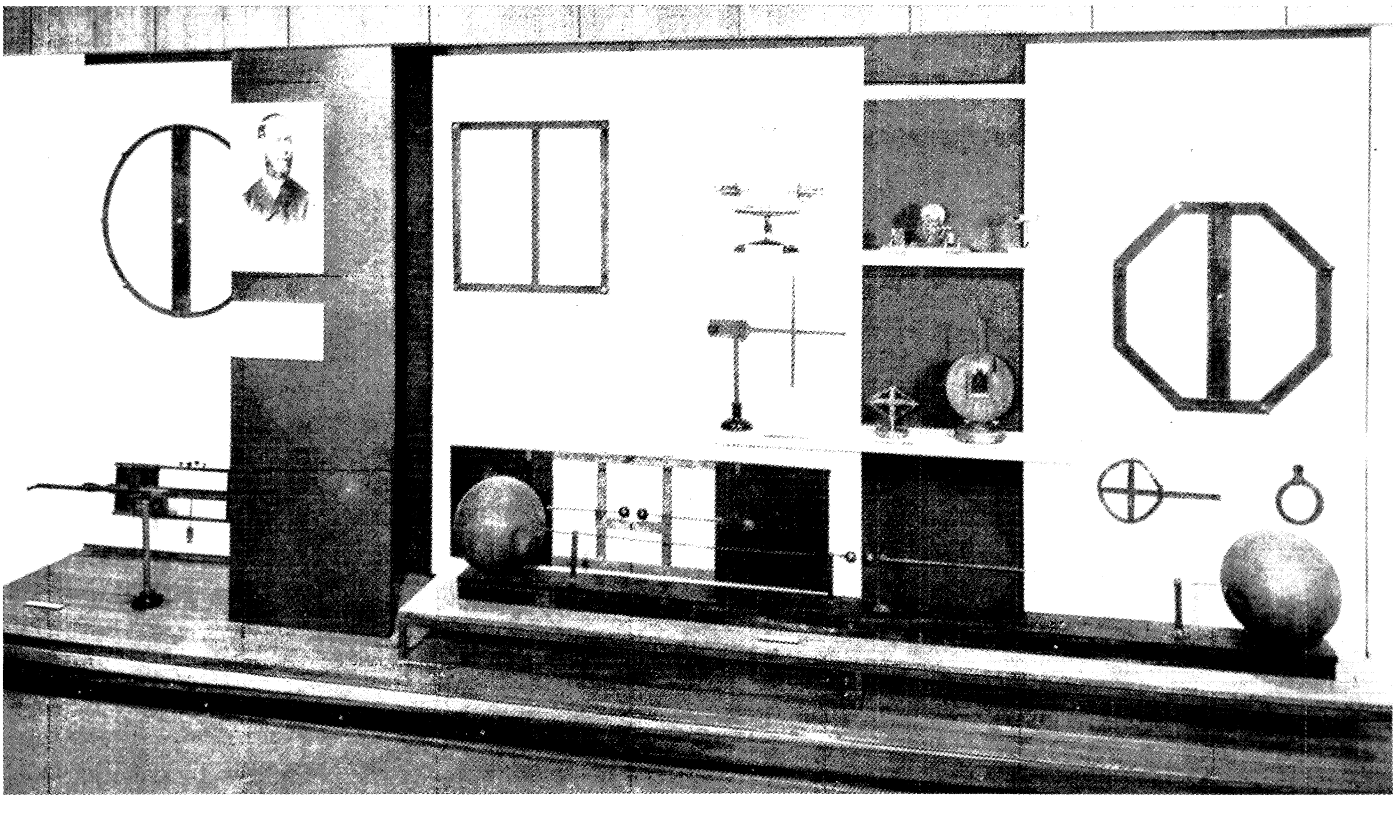
His patient investigations also found that illumination somehow facilitated sparking across a gap in a secondary coil. After carefully adjusting the gap so that no spark was seen in the dark, the spark came back when the lights were on. This was the first evidence for the photoelectric effect – the production of ions by light.

To commemorate Hertz' historic advances, the University of Karlsruhe is organizing a series of lectures culminating in a centenary ceremony on 5 December. A special exhibition will be held early next year. Other Hertz events have been organized in Hamburg, his birthplace, and at the Hertz Institute in Berlin.

G. F.

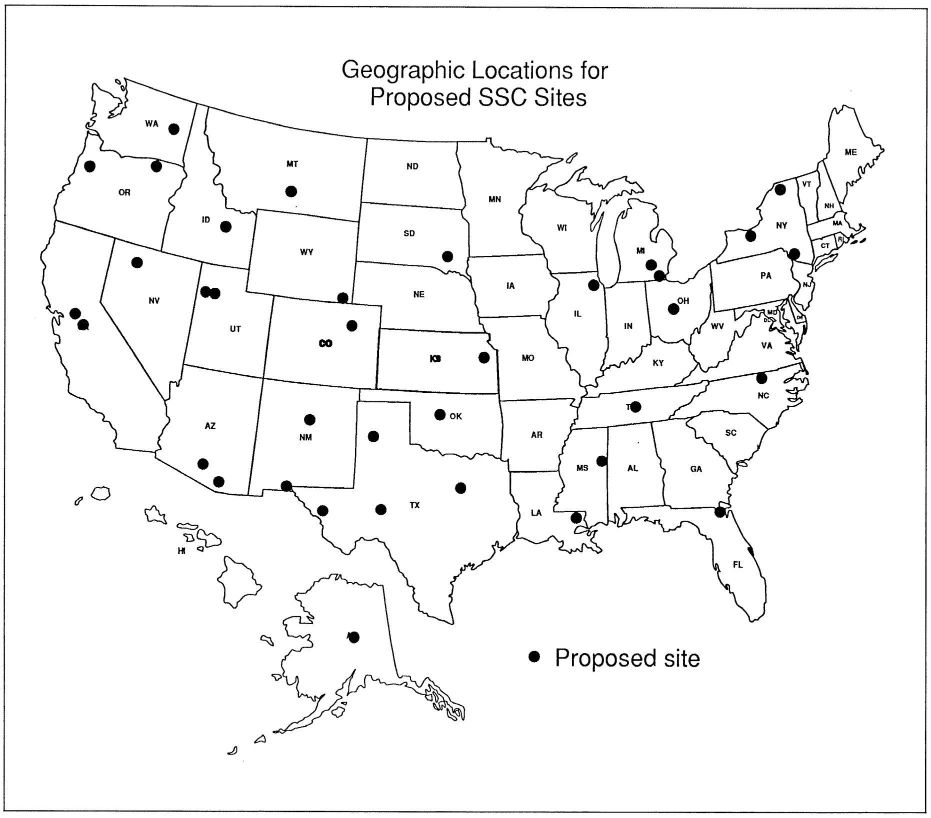
The apparatus used by Heinrich Hertz at Karlsruhe in 1887 to discover electromagnetic waves.

(Photo Deutsches Museum)



Around the Laboratories

SUPERCOLLIDER
Site proposals



36 sites in 25 states are under consideration for the proposed 84 kilometre US SSC Superconducting Supercollider ring to handle 20 TeV proton beams.

In response to the 1 April invitation for site proposals for the proposed US Superconducting Supercollider (SSC), the Department of Energy (DOE) received 43 proposals from 25 states by the deadline of 14.00 hrs on 2 September. About 26 000 separate items (volumes, attachments, appendices, and maps), and 13 tons of proposals were processed and distributed.

On 18 September, the DOE completed screening and forwarded 36 proposals to the SSC Site Selection Committee of the National Academy of Sciences and the National Academy of Engineering. These sites in 25 states met all of the DOE's basic qualification criteria – the land, located entirely in the US, should be made available at no cost to the federal government, and should accommodate the proposed layout of the project. Certain minimum utilities are required, and of course no known unacceptable environmental effects should result.

In the Academy committees' evaluation, primary emphasis will be placed on technical criteria – geology and tunnelling, regional resources, environment, setting, regional conditions, and the availability of utilities. Cost considerations are also significant. The committees' report to the DOE will include the unranked list of the best qualified sites, but the size of the short list has not been predetermined.

Additional geological and environmental information may be requested of finalists and confirmatory investigations will be conducted by DOE. Detailed staff analyses and environmental information will be presented to the DOE Site Selection Energy System Acquisition Advisory Board (ESAAB) as input into the decision process. Based on the Academy committees' evaluation, this additional information, the ESAAB findings, and other input as appropriate, the Secretary may designate the preferred site as early as July 1988.

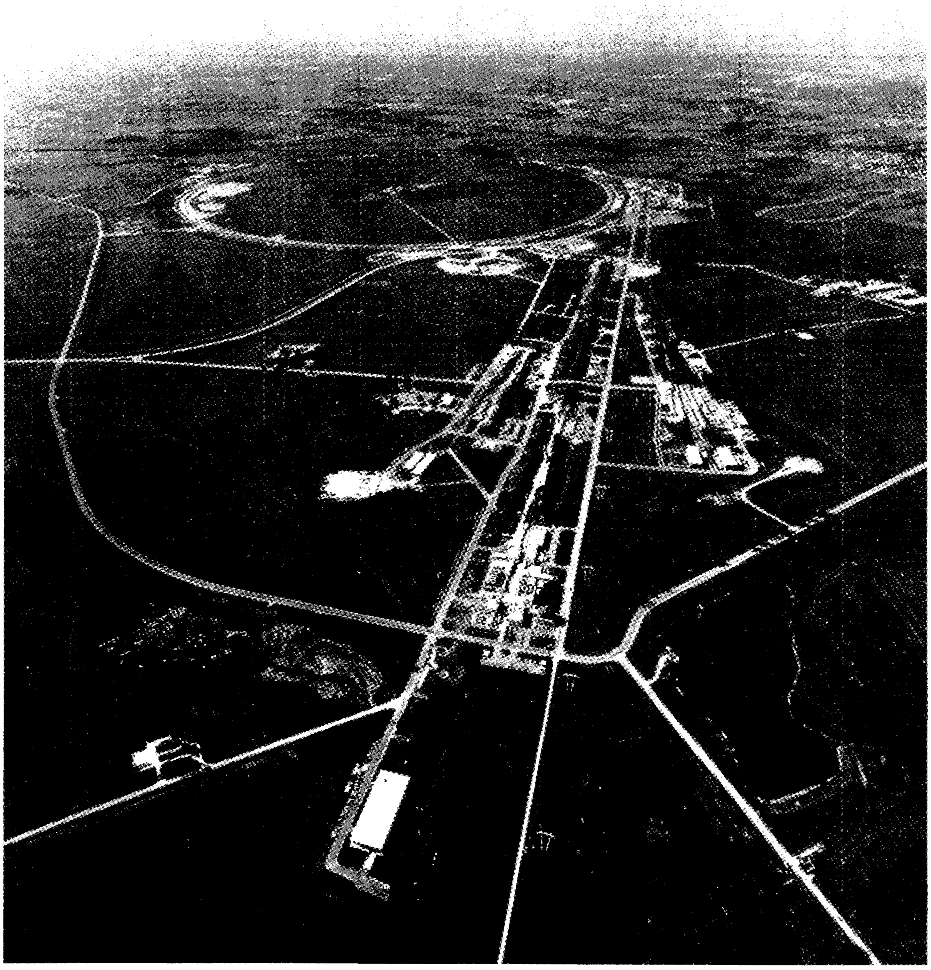
Preparation of an Environmental Impact Statement (EIS) for the SSC has begun, in accordance with the National Environmental Policy Act process. This will include an opportunity for public comment, preparation of a Final EIS and a Record of Decision (ROD). Environmental impacts of constructing and operating the SSC, including those relating to public health and safety will be addressed in the EIS. The issuance of the ROD based on the final EIS will be the last step of the site selection process.

In January 1989, the Secretary of Energy will announce the final site selection following completion of the National Environmental Policy Act process. Preliminary and Final Safety Analyses will be prepared during the design and construction phases of the project.

FERMILAB
Fixed target run begins

Fermilab began a 800 GeV fixed target physics run this summer with almost a full complement of 16 experiments and 15 beamlines. (The only exception was a new polarized beam which will be commissioned at the end of the current running period.)

The beamlines fanning out from Fermilab's Tevatron ring.



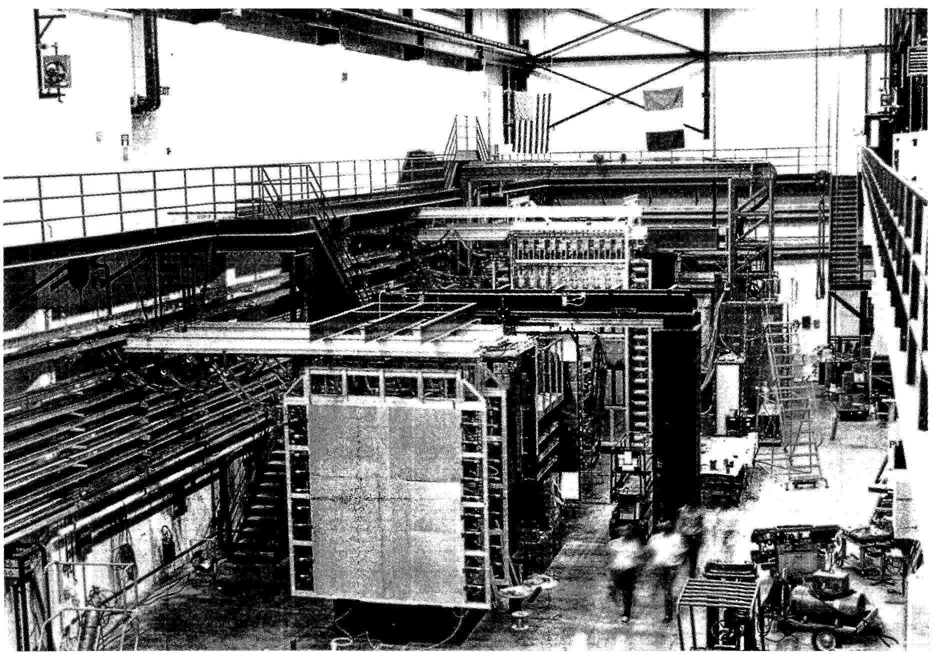
During the previous 800 GeV fixed target run, experiments were serviced by existing beamlines upgraded to transport 800 GeV beam as none of the major new Tevatron facilities were ready.

Two highlights of this present run are the increased efficiency of the Tevatron and the commissioning and data taking of three big fixed target beamlines and detectors in the new Muon, Wideband, and Meson West Areas.

During the first nine weeks of running, the accelerator surpassed the peak intensity record from the previous run, reaching more than 1.7×10^{13} protons per pulse. Compared with the start-up of the previous run, twice as many protons per week have been accelerated this time, with the highest accumulated weekly proton intensity reaching 1.06×10^{17}. In addition, a record 127 hours of beam was reached during one week.

One of the three new beams leads to the Muon Experimental Hall and Experiment 665, studying muon interactions at energies of up to 750 GeV in a variety of targets, looking at the hadrons recoiling from violent muon collisions in hydrogen and heavy nuclei, and measuring the quark content (structure functions) of these targets. It involves a collaboration Argonne, California (San Diego), Fermilab, Freiburg, Harvard, Illinois (Chicago), Poland, Maryland, MIT, the Max Planck Institute (Munich), Washington, Wuppertal and Yale.

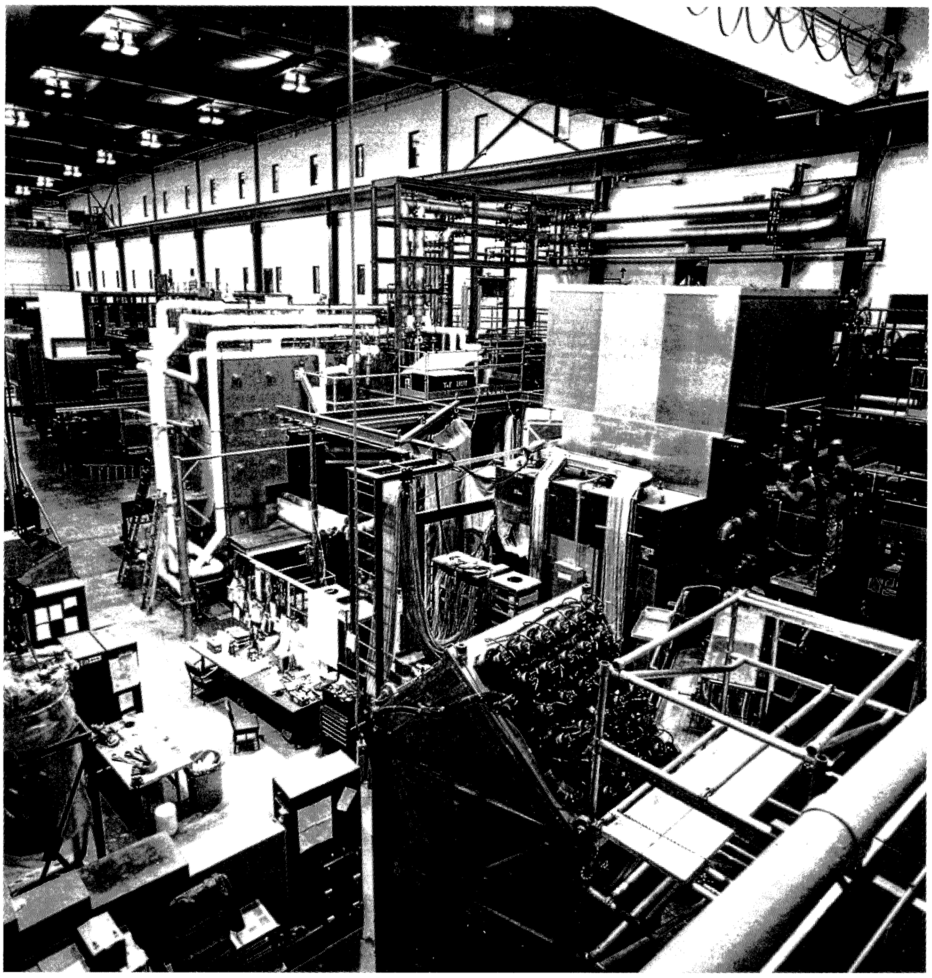
The second new major experiment is E687 in the Wideband Beam, looking at the photoproduction of charm and beauty, especially photo-excited states containing



Experiment 687 in the Tevatron Wideband Beam looking at the photoproduction of states containing heavy quarks includes a large Italian contingent.

Fermilab Experiment 665 studies muon interactions at up to 750 GeV and among other things will measure the quark content of different nuclear targets.

(Photos Fermilab)



charmed quarks, charmed D mesons and lambda-C baryons, J/psi and psi prime, and heavier states containing bottom quarks. The collaboration includes Colorado, Fermilab, Illinois, INFN Frascati and Milan, the University of Milan, Northwestern and Notre Dame.

The third new experiment is E706 in the Meson West Beamline, studying the gluon content of hadrons by analyzing the direct photons from collisions of pions, kaons, and protons with a variety of targets. It uses a very large liquid argon calorimeter. Housed in the same experimental hall and running simultaneously is experiment E672, whose special interest is the particles produced in association with J/psi and high mass muon pairs. E706 involves physicists from Delhi, Fermilab, Michigan State, Minnesota, Northeastern, Pennsylvania State, Pittsburg, Rajasthan and Rochester, while E672 covers Arizona, California Institute of Technology, Fermilab, Florida State, George Mason, Illinois at Chicago, Indiana, Serpukhov, Maryland, Michigan and Rutgers.

With the upgraded beamlines and detectors and with the three new large experiments, Fermilab's investment in the Tevatron is up and running and users are already reaping the rewards with lots of data at high energy. After the inaugural physics run of the Tevatron proton-antiproton collider (see May issue, page 18), the full fixed-target programme got underway with physicists optimistic of new results. It is scheduled to run until the middle of December, when the big CDF detector will take over for five months of proton-antiproton collisions.

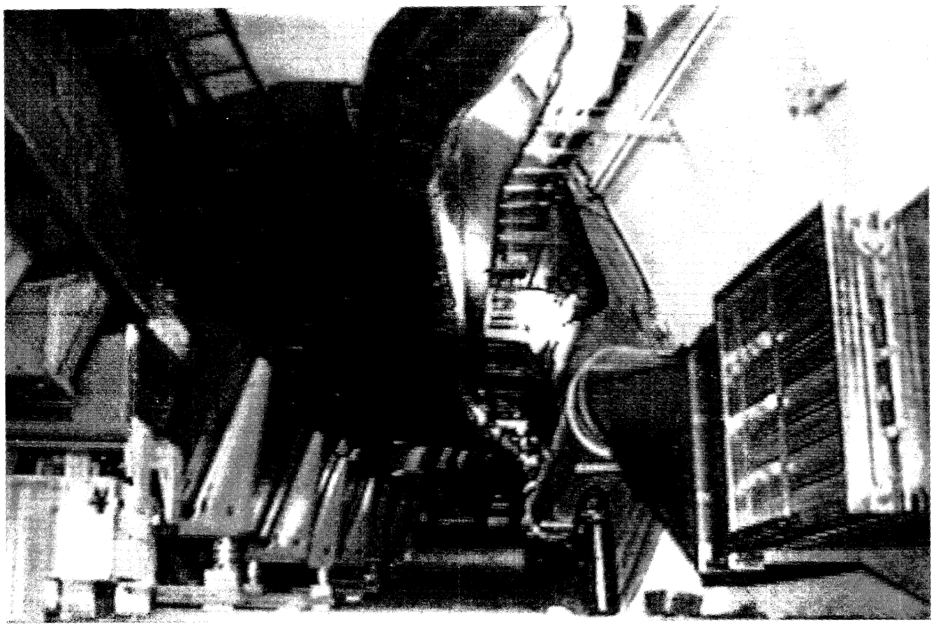
CERN
Crash programme for LEP

To push work on the LEP electron-positron collider forward as quickly as possible, the installation team has embarked on a crash programme to fit out the first 2.8 kilometre octant of the 27 kilometre ring. The aim is to have the necessary equipment for beam handling and control in position and working so that a positron beam from the SPS can be injected into this sector of the LEP ring next July, slamming into a beam dump at the far end.

This challenging goal will provide valuable working experience of major LEP components and enable subsequent installation work in the remainder of the ring to be optimized.

As the crash programme was getting under way in September, the SPS Super 'Proton' Synchrotron pointed the way by accelerating its first beam of positrons to 12 GeV, the highest positron energy possible with the existing SPS radiofrequency accelerating system. New radiofrequency equipment will soon be added to take the SPS positrons (and electrons) up to 20 GeV ready for injection into the LEP main ring.

LEP's electrons and positrons are supplied at 500 MeV by the



▲ *First magnets and equipment for the LEP electron-positron collider installed in the 27 kilometre tunnel.*

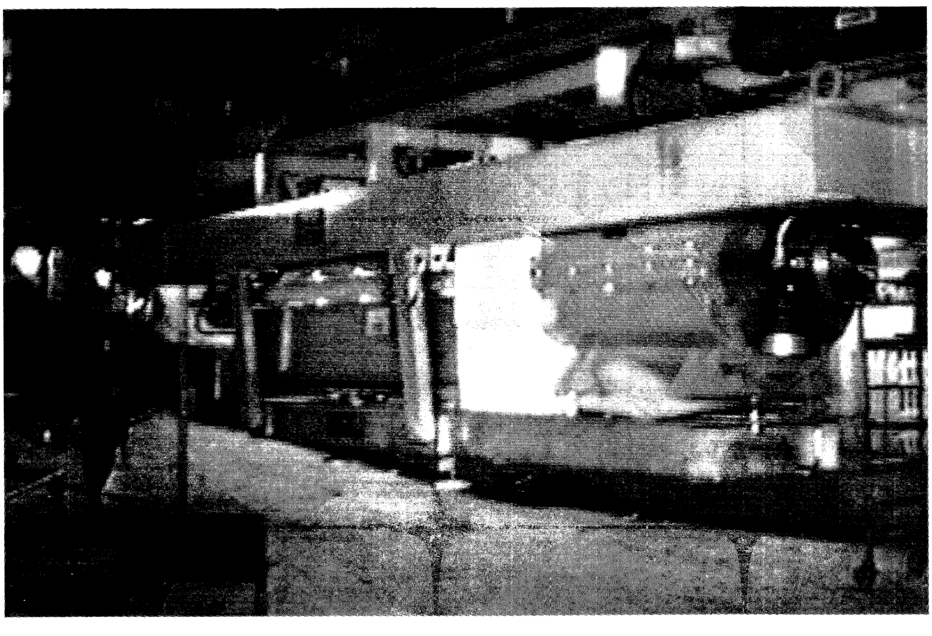
(Photo CERN 257.9.87)

▼ *Transporting equipment for the LEP ring by the tunnel monorail.*

(Photo CERN 256.9.87)

new LPI LEP Pre-Injector (see September issue, page 33) and taken on to 3.5 GeV by the PS 'Proton' Synchrotron.

Meanwhile the initial trickle of completed LEP components is building up to a steady flow, and the sophisticated installation techniques (see July/August issue, page 1) are getting into their stride.



Civil engineering work on the remainder of the tunnel nears completion. All the signs are that the first LEP beams are less than two years away and on schedule.

Neutral kaons

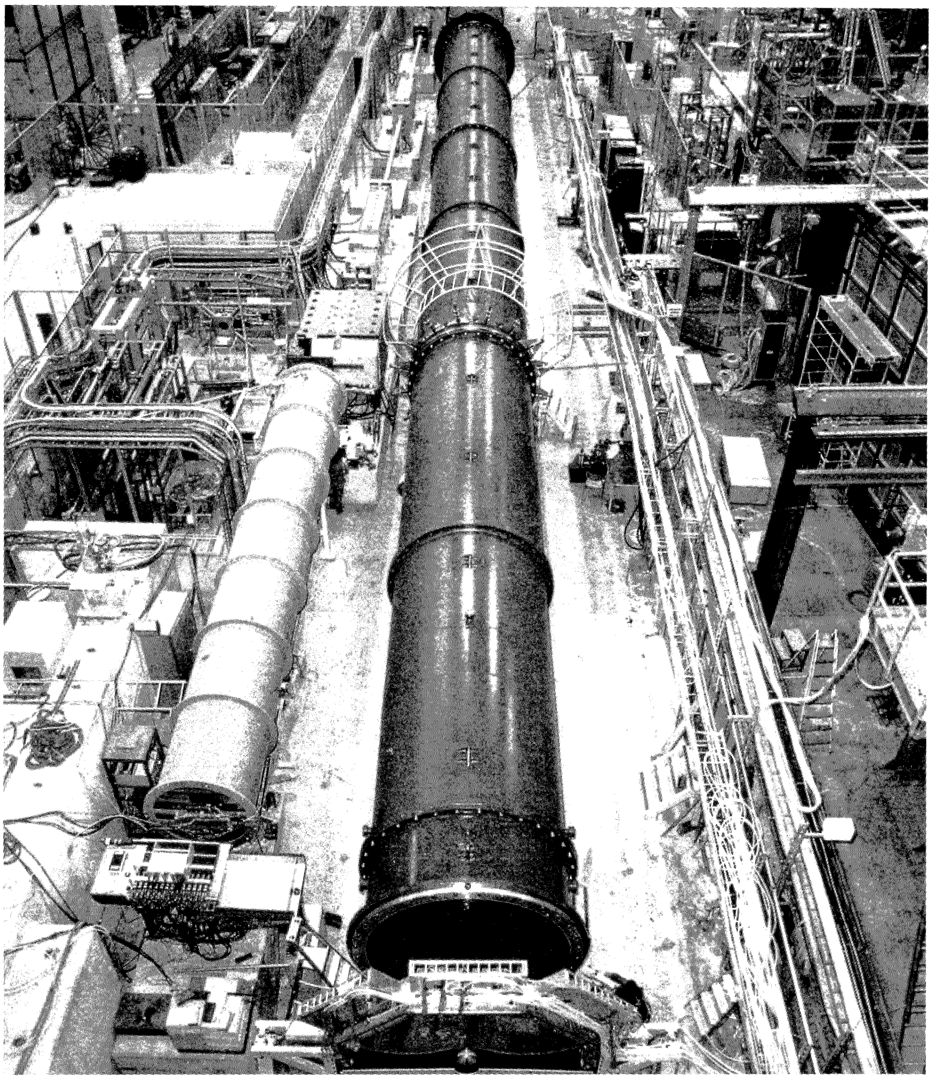
Until 1964, CP symmetry was sacrosanct – physics was unchanged whenever particles and antiparticles and left and right were interchanged simultaneously. Then a historic experiment at Brookhaven by J. W. Cronin and V. L. Fitch took a closer look at neutral kaons. These come in two varieties – a short-lived kind which likes to decay into two pions, and a long-lived one preferring to go to three pions. The Brookhaven experiment found that about one long-lived kaon in every five hundred managed to decay into two pions, revealing the neutral kaons' scant regard for CP, and physicists have searched hard ever since for further clues to this mystery.

Five years ago, a CERN / Dortmund / Edinburgh / Mainz / Orsay / Pisa / Siegen collaboration began building an imaginative detector to compare the decays of long-lived and short-lived kaons into electrically charged or neutral pairs of pions.

The idea was to record the two-pion decays of both kinds of kaons in the same detector simultaneously. Long-lived kaons travel further before disintegrating than do their short-lived counterparts. So while the experiment produces its long-lived kaons from the incident high energy beam at a target 250 metres upstream of the detectors, the target producing short-lived kaons is closer to the detectors and mounted on rails inside

The 110 metre vacuum chamber of the CERN / Dortmund / Edinburgh / Mainz / Orsay / Pisa / Siegen experiment studying neutral kaons.

(Photo CERN 288.6.84)



a 110 metre-long vacuum chamber. In this way the experiment is able to watch the 'arrival' of the short-lived kaons.

Preliminary results emerging from the analysis of the painstakingly amassed data – two hundred thousand decays of long-lived kaons into neutral pion pairs, and a million into charged pion pairs, together with three million short-lived kaon decays – show something very interesting.

The relative decay rates of the long- and short-lived kaons into neutral and into charged pion pairs are not the same – the difference being a few per cent. This preliminary result, if confirmed, would rule out certain candidate mechanisms for CP violation, the most important single advance for this kind of physics in the 24 years since Fitch and Cronin's experiment.

A spinoff from this precision study is the first sighting of short-lived kaons decaying into pairs of photons. With the neutral pion pairs copiously produced by these kaons themselves giving lots of photons, the direct decay into photon pairs was always masked.

DESY
TRIUMF for HERA

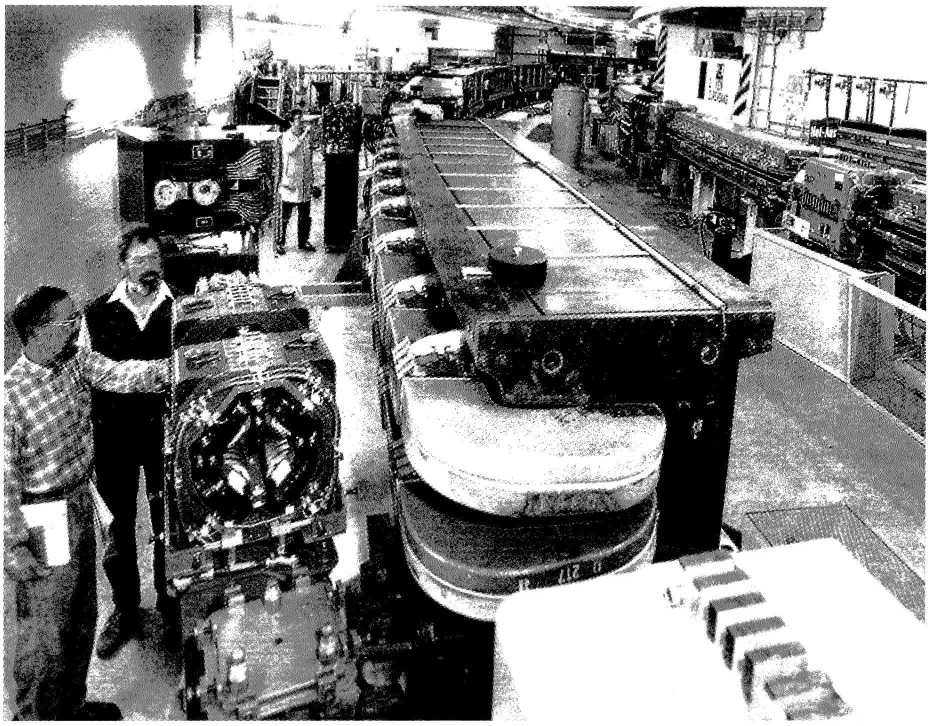
Canada is making important contributions to the construction of the electron-proton collider HERA in Hamburg. Components worth nearly 9 million Canadian dollars are provided for the preacceleration of protons, according to an agreement just signed between the German DESY Laboratory and the Institute of Particle Physics (IPP) of Canada.

Atomic Energy of Canada Limited (AECL) will provide the 50 MHz radiofrequency acceleration system for protons of both the modified PETRA ring and the superconducting HERA proton ring.

The 80 metre beam transport system between the new Linac III (for negative hydrogen ions) and the 300 metre circumference proton synchrotron DESY III was designed and built by the Canadian TRIUMF Laboratory in Vancouver, and has already been delivered to DESY. It consists of 2 dipole magnets, 15 quadrupoles (plus 3 spare units) and 7 double steering dipoles, including mechanical supports and adjustment devices.

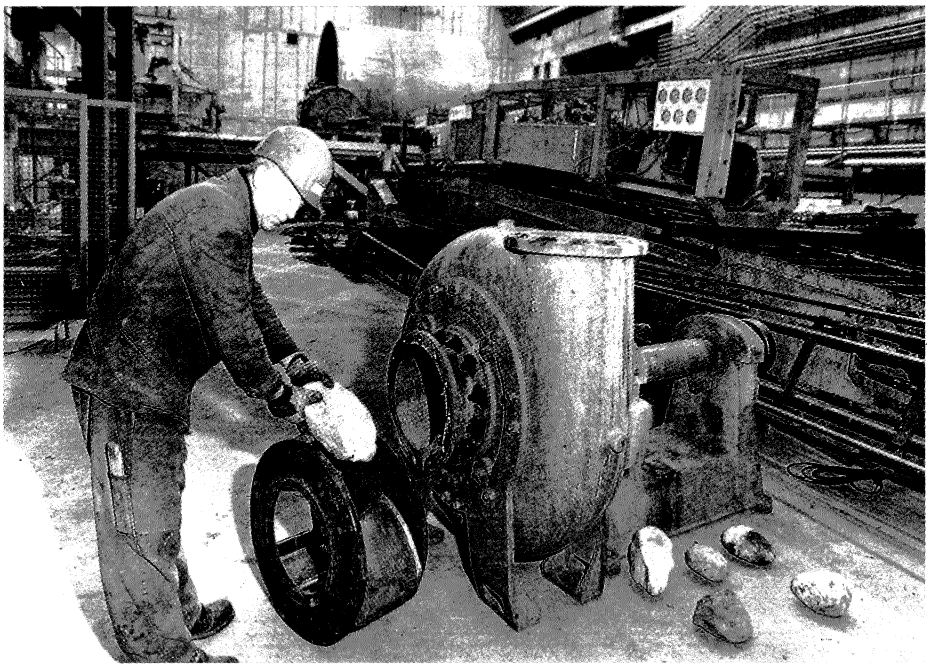
In addition, most parts of the vacuum system (flanges, bellows etc.) have been supplied. They are now being welded to vacuum pipes at DESY and will be installed soon. Also the full beam diagnostic system has been built by TRIUMF.

Linac III will provide negative hydrogen ions at 50 MeV, which reach the synchrotron through the TRIUMF transport line. In a special bypass provided by the Institute of Physics I of the University of Hamburg consisting of four kicker magnets and an electron-stripping foil, the negative hydrogen ions



▲ *Beamline equipment (left) provided by the Canadian TRIUMF Laboratory to link DESY's Linac III with the DESY III proton synchrotron (centre), being shown by DESY-TRIUMF collaboration coordinator Lutz Crigee (left). On the right is the operational DESY II electron/positron synchrotron.*

▼ *The glory that was HERAKLES. With the 6.3 km tunnel excavated for the electron-proton collider at the DESY Laboratory in Hamburg, the HERAKLES tunnelling machine is dismantled. In the foreground is the pump and some of the stones it managed to push out, suspended in a clay-mud mixture.*



will be converted into protons and guided into a synchrotron orbit.

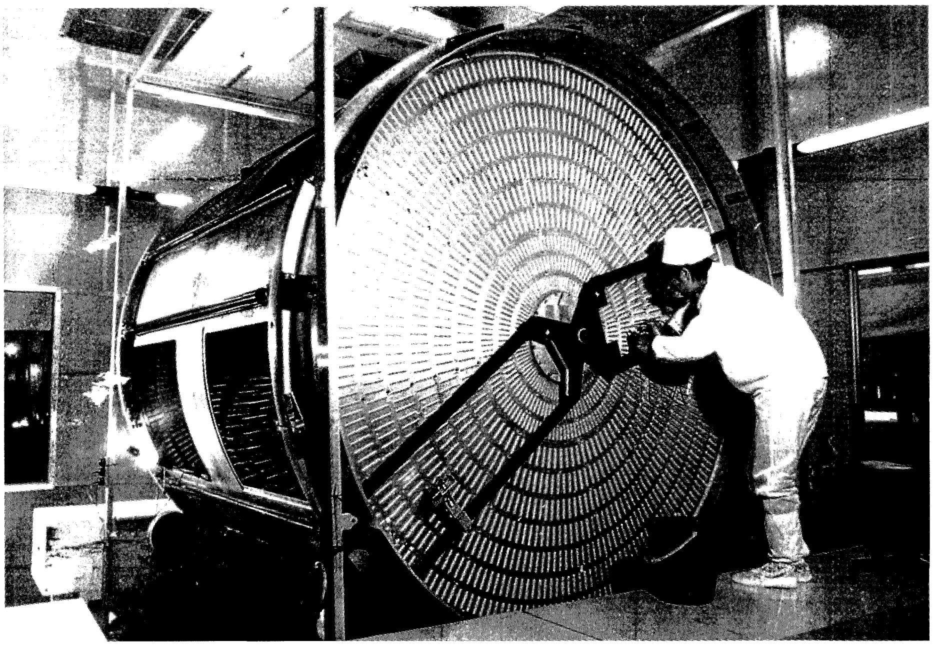
Injection (with the kicker magnets on) takes place during 30 microseconds, corresponding to ten revolutions in the synchrotron. The bypass kickers are then turned off and the circulating protons, conveniently bunched, are accelerated to 7 GeV and injected into the 2.3 km long PETRA ring. In PETRA the protons will be further accelerated to 40 GeV and sent to the superconducting HERA proton ring, where they will finally reach 820 GeV. The proton beam will collide head-on with the 30 GeV electron (or positron) beam of the HERA electron ring in two interaction regions – Halls North and South. These will be the homes of the H1 and ZEUS experiments respectively.

While installation work in the HERA tunnel forges ahead, the big superconducting magnet test hall at DESY has started operation, cooling down one of the nine-metre prototype magnets already available. These magnets were designed, developed and wound at DESY and provided with cryostats by Brown Boveri of Mannheim.

In November the first industrially produced magnet is expected to arrive from the Italian Ansaldo-LMI-Zanon consortium. The Italian Istituto Nazionale di Fisica Nucleare is providing half of HERA's 420 dipoles, while the second half will be produced by Brown Boveri according to the same design.

BEIJING
Chinese positrons

Recent landmark in the development work for the new Beijing Electron-Positron Collider (BEPC)



Assembly of the main drift chamber for the BES detector to be installed at the BEPC electron-positron collider now under construction at Beijing.

was the production of the first positron beam in China. BEPC is designed to take electron and positron beams to between 2.2 and 2.8 GeV in a storage ring fed by a linac supplying 1.4 GeV beams.

The input end of the linac has now produced 99 MeV positrons using eight accelerating stations powered by four klystrons. The first five stations take an electron beam to 150 MeV to bombard a positron production target, and the final three stations take care of the positively charged beam. Without the production target, the electron beam alone can be taken to 250 MeV.

The other design goals for the positron source have been attained. The positron production rate is 2 per cent of the electron yield per GeV, the beam current (2.5 mA) has exceeded the 1.5 mA design figure, and the beam radius is good at less than 2.5 mm.

Meanwhile wire stringing for the main drift chamber of the BES magnetic detector was completed in the summer. BES will be installed at one of the BEPC interaction regions. As well as the main drift chamber, it will consist of a central drift chamber, a system of time-of-flight counters, an electromagnetic shower counter, muon identifier and conventional magnet (see June issue, page 5).

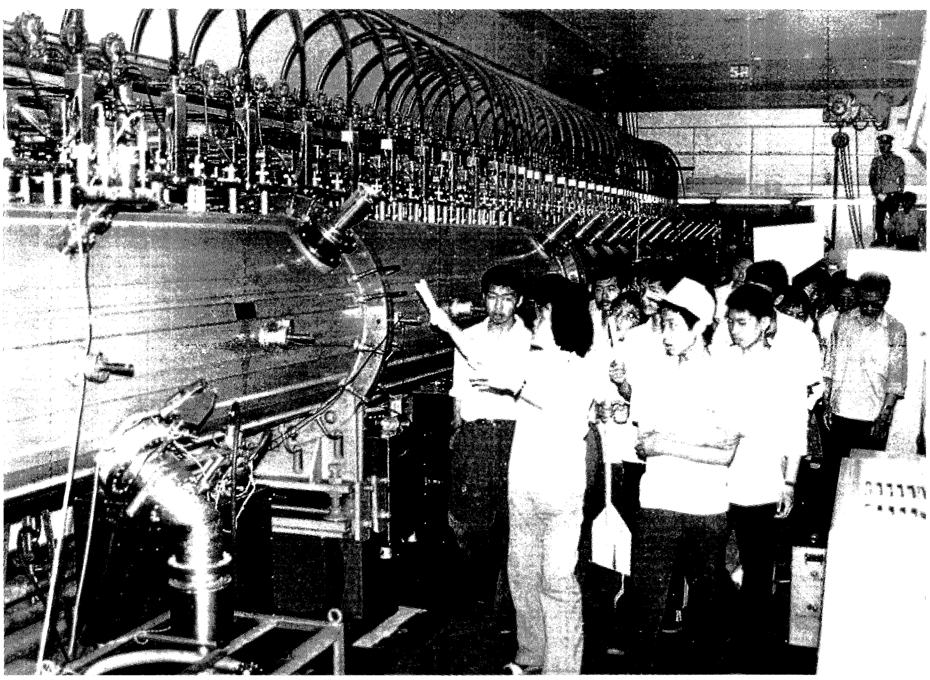
The BES main drift chamber designed for better than 200 micron precision, consists of ten concentric cylindrical layers with an inner radius of 155 mm, outer radius 1150 mm and active length 2200 mm. Each layer will measure energy loss to help with particle identification. A government aerospace factory in Guizhou, in the southwest of the country, supplied the frame of the chamber and stringing of the total of 19 380 wires (2808 sense wires) began in January.

GANIL Channelling heavy ions

A fast charged particle entering disordered matter (a gas, liquid or amorphous solid) is slowed down by a random succession of collisions. But when the projectile is injected into a single crystal, in a direction close to that of a crystal axis, its penetration is no longer random but is channelled by atomic rows or planes that behave like safety barriers on a highway, keeping the projectiles on course and preventing them from penetrating atomic nuclei in the target.

This channelling phenomenon has been known for more than 20 years for electrons and light ions but has not hitherto been explored with highly charged heavy ions. To do so, the right beams had to be available and it had to be possible to align beams and crystals to a few thousandths of a degree.

GANIL, the French heavy ion machine at Caen, has the right conditions for generating heavy ion beams with their electrons eliminated, i.e. either fully stripped or almost so, and with good emittance (low angular dispersion). The highly charged ions such as xenon result from stripping electrons with

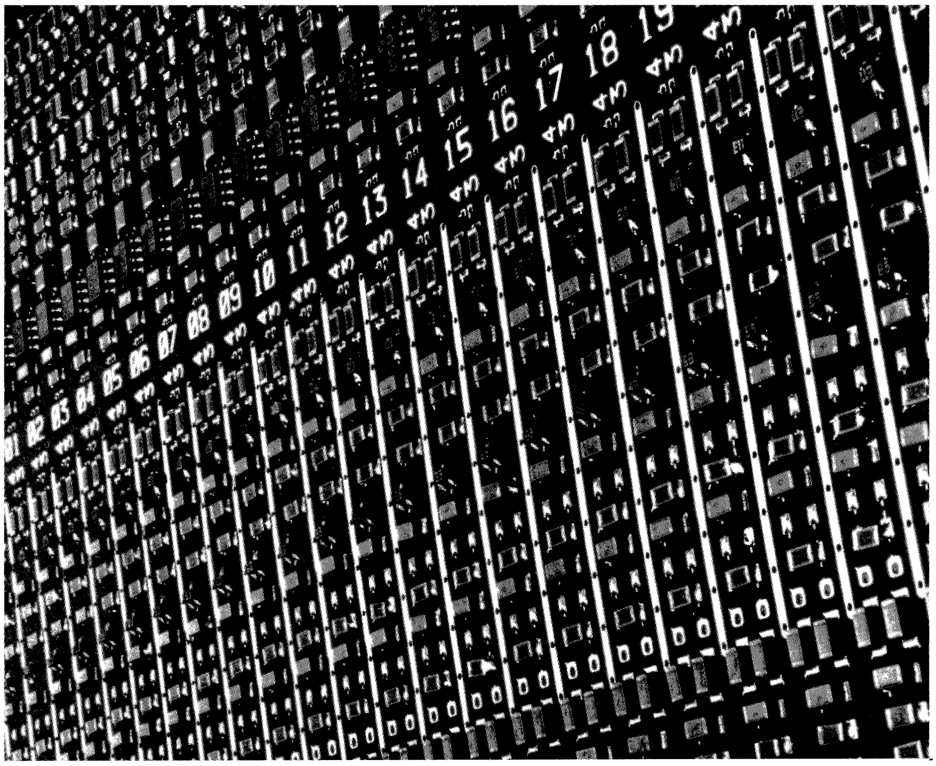


The Institute of High Energy Physics in Beijing attracted some 5000 curious visitors when its doors were open to the public for two days this summer.

a thin foil. They then have to be sorted so that the desired charge state can be conveyed to the crystalline sample. This is done by the specially designed magnetic spectrometer LISE (Lignes d'Ions Super Epluchés).

Physicists from Bordeaux, Lyon, Paris, Caen and Strasbourg recently exploited the high quality of secondary ion beams of Xe^{54+} (xenon atoms stripped of all electrons), Xe^{53+} (atoms with only one electron, termed 'hydrogen-like') or Xe^{52+} ('helium-like' atoms) to study how they are channelled in silicon monocrystals. They were able to show that the channelled ions were much less likely than unchannelled ions to capture an electron. For channelled ions, the usual collision method of capture cannot occur and only radiative capture (the inverse of the photoelectric effect) can take place. With still more refined measurements based on coincident X-ray emission it should be possible to demonstrate the effect of the spacing of atoms aligned in rows on all these phenomena and thus acquire a better grasp of the basic mechanisms underlying channelling.

ELECTRONICS Surface mount technology gains a foothold



A Fermilab amplifier shaper discriminator board using surface mount technology.

Traditionally, printed circuits with leaded components and hybrid circuits have been the backbone of electronic circuit construction for high energy physics. More recently semi-custom and custom integrated circuit designs have become more widespread, while SMT (surface mount technology) is increasingly being used by electronics design engineers as another option.

A surface mount circuit differs from a conventional leaded component board in that components are attached to the substrate without the aid of holes or feed-through mechanical hardware. Generally, the components are miniaturized and attached to both sides of the substrate.

The hybrid circuits used for many years in a wide variety of applications usually use surface mount circuits assembled on alumina substrates and with screened and fired resistors, while surface mount circuits prefer FR-4 substrates with chip resistors.

Many industries are implementing surface mount technology designs to improve their products. Compared to leaded printed wire boards, surface mount circuits are generally 40% to 60% smaller, perform better due to their lower inductance and capacitance, and can be less expensive, depending on choice of components.

In most cases surface mount does not compete with custom or semi-custom IC designs because these designs aim for extreme size reduction. The advantage of surface mount is primarily lower cost for lower quantity production runs and shorter turnround time for construction of prototype and production quantities.

While hybrids and surface mount circuits have about the same circuit density, the latter have a couple of advantages. Considerably larger circuits can be fabricated in surface mount because the substrate material is not as fragile as with hybrids. Circuits can be prototyped considerably faster. Also, a circuit can be prototyped in-house with surface mount on FR-4 and then later fabricated on alumina substrate.

To understand the advantages

The Percola computer, the brainchild of H. J. Herrmann. The design, assembly and programming of the machine are the work of J.-M. Normand (right), who worked as project leader with M. Hajjar (left), who is writing his thesis.

and problems associated with this technology, engineers and scientists at physics laboratories have been exploring a variety of applications, driven mainly by a need for more compact electronics for large experiments.

Surface mount is not expensive. For a modest outlay and in a small space, prototype surface mount circuits can be assembled and surface mount and hybrid circuits repaired, as is done in CERN's Research Divisions.

At CERN, most applications concentrate on thick film hybrids – recent examples include FASTBUS cable segment drivers, and preamplifiers and shaping arrays for the central detectors being built for the LEP electron-positron collider. At Fermilab, both analog and digital surface mount circuit boards ranging from thumbnail to album size have been designed and installed. Examples include several different detector preamplifier boards, a FADC differential line receiver, memories, a front-end input latch and readout shift register board, and multichannel ASD (amplifier shaper discriminator) boards.

When ASDs were manufactured, they were the largest known surface mount board. Assembly was a challenge because of the boards' size and density. However automated equipment rose to the challenge.

As experiments and accelerators grow in complexity and size, the need for smaller, improved circuits will continue to drive future electronic designs. While it is certainly true that custom ICs and hybrid circuits will play important roles, surface mount has taken a foothold in particle physics and can be expected to take on added significance in the future.

SACLAY
PERCOLA in action

Developed by the Institute of Fundamental Research of the French Commissariat à l'énergie atomique (CEA) in collaboration with the Elementary Particle Electronics and Computer Department at the Centre d'études nucléaires in Saclay, where it was built, the new Percola computer is a dedicated device for performing lengthy numerical simulations in statistical mechanics for disordered systems of the percolation type.

The percolation concept allows systems composed of large numbers of possibly interconnected objects to be described statistically. In such a system the number of objects and interconnections govern whether communication over long distances is feasible or not. Between the two categories, there is a precise transition threshold, termed the percolation threshold. The project that the computer is engaged on at present is intended to improve by one order of magnitude the true values of critical indices characteristic of the behaviour of electrical conductivity at the percolation threshold in a system of random resistors.

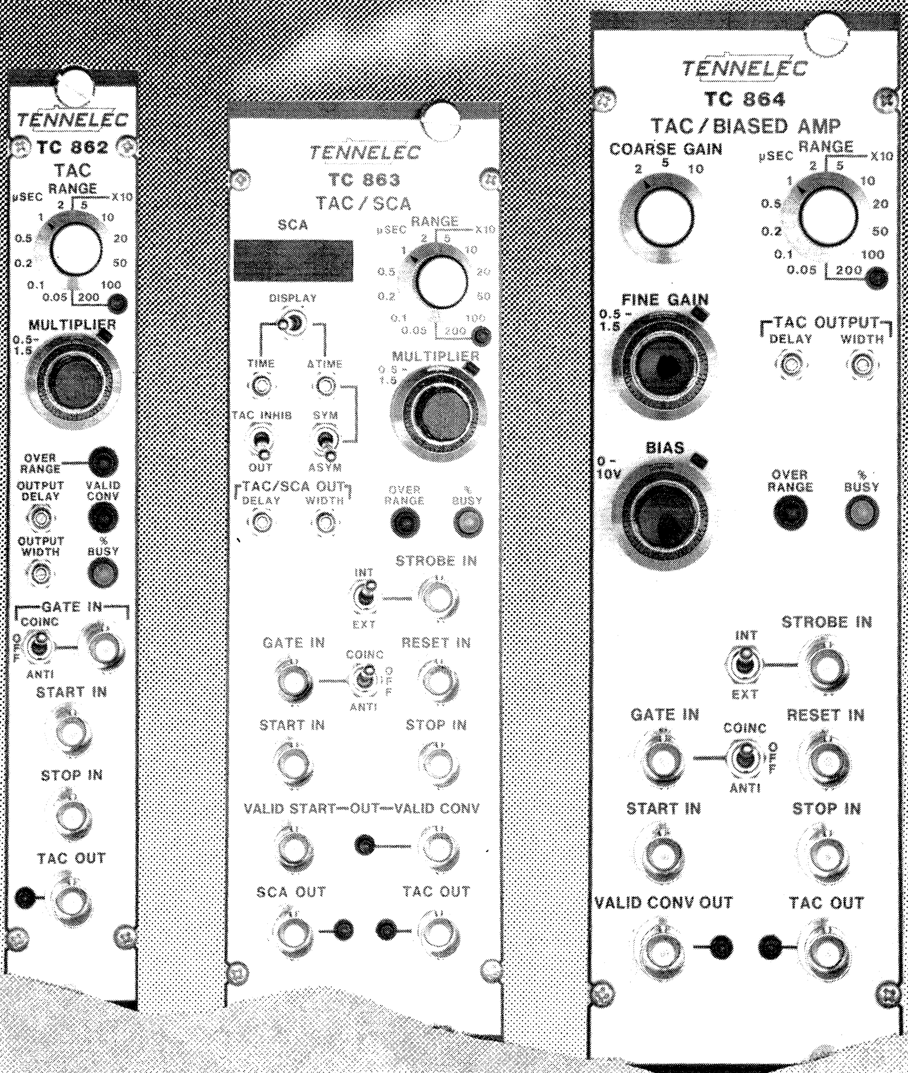
The building of the machine began in January 1985 and it has been in service since May of this year. It is 10 per cent faster than the Cray XMP supercomputer, for at least one class of problems with the same 64 bit floating point precision, for the modest overall cost of less than a million French francs (170 000 dollars).

Although best suited to one particular algorithm, the Percola has all the characteristics of a completely programmable 64-bit floating point computer, and has a potential for future use on other problems. Its architecture is of the pipeline type with internal parallel operation resulting from the fact that its component parts are independent. It can operate either in scalar or in pipeline modes, and its top calculation speed in pipeline mode is 25 Megaflops.

By J.-M. Normand

PEAK PERFORMANCE

In Time-To-Amplitude-Converters



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People and things

Retiring ECFA Chairman Jean Sacton of Brussels (left), seen here with CERN's LEP Project Director Emilio Picasso.

(Photo CERN 274.12.85)

On people

Walter Hoogland, Director of the Dutch national NIKHEF Laboratory in Amsterdam, becomes Chairman of the European Committee for Future Accelerators (ECFA) from 1 January 1988, succeeding Jean Sacton of Brussels.

During his term of office, unexpectedly prolonged last year, Jean Sacton has consolidated ECFA as a forum for all sections of the European particle physics community and has done a great deal to ensure that the European voice is heard on the world stage.

A retirement milestone was passed earlier this year by Gordon Munday. After playing a vital role in coordinating the beams supplied by CERN's Proton Synchrotron (PS) with the vagaries of physics requirements, he went on to become Leader of the PS Division from 1973 to 1981, overseeing the evolution of the PS from a proton accelerator in its own right to a beam factory for other machines. In recent years he has put in much unstinting work as Chairman of CERN's Staff Policy Group and as Deputy to Technical Director Giorgio Brianti.

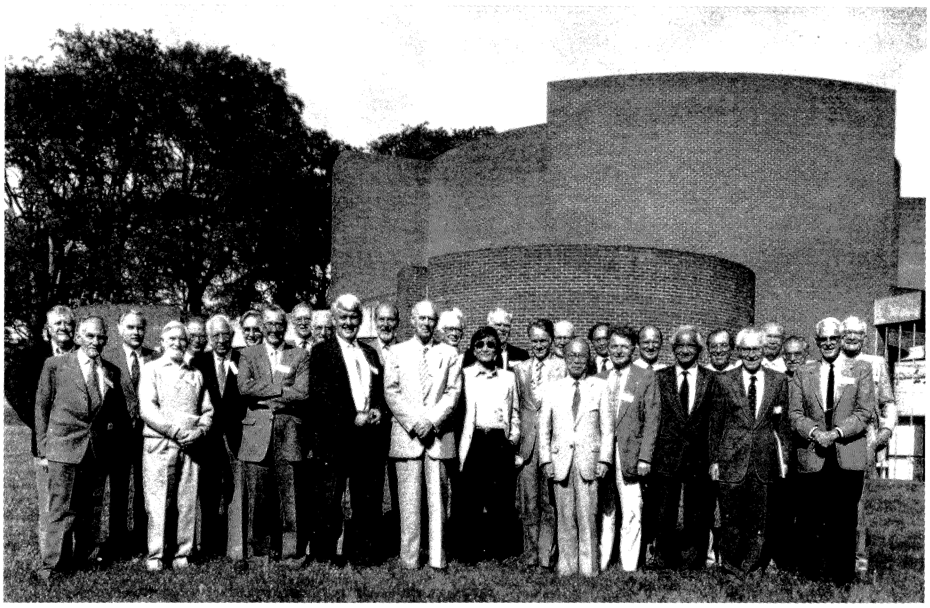
Moves at Fermilab

William A. Bardeen has become Head of Fermilab's Theoretical Physics Department, succeeding Chris Quigg who recently moved to the Central Design Group of the proposed US Superconducting Super Collider (SSC) as Deputy Director for Operations.

Jeffrey Appel becomes the Head of Fermilab's Computing Department, succeeding Hugh Montgomery who moves to the Research Facilities Department and becomes spokesman of experiment E665 in the Tevatron muon beam. Jack Pfister continues as Associate Head of the Computing Department, with primary responsibility for central computing.

▼ The 1987 JINR-CERN School of Physics, held at Varna, Bulgaria, in September was the tenth in the series organized by the Joint Institute for Nuclear Research (JINR, Dubna, USSR) and CERN. Seen here, left to right, at the School are CERN Director General Herwig Schopper, P. K. Markov of Bulgaria's Institute of Nuclear Energy and Nuclear Research, and Ch. Christov, Academician of the Bulgarian Academy of Sciences.

Participants at the 'Interactions and Structures in Nuclei' meeting held at the University of Sussex, UK, in September to mark the 65th birthday of Denys Wilkinson.



Interactions and Structures in Nuclei

From 7-9 September distinguished physicists from many parts of the world assembled at the University of Sussex in the UK to honour Sir Denys Wilkinson on his 65th birthday. The stimulating and enjoyable meeting also coincided with his retirement as Vice-Chancellor of the University or, as he put it, his 'emergence from retirement' from physics! (In fact his contributions to nuclear physics have continued unabated during his 11 vice-chancellorian years.)

The programme reflected his broad interests over 40 years in many aspects of nuclear and particle physics, astrophysics and cosmology, and there was also frequent mention of his expertise in the field of bird navigation. The talks covered nuclear models (J. P. Elliott), heavy ion radioactivity (G. A. Jones), electromagnetic properties of nuclei (A. Arima, A. Richter), mesonic and quark effects (M. Rho, A. Faessler), weak interactions (J. Deutsch, E. Warburton, F. Boehm), elementary particles, cosmology and astrophysics (T. Kibble, J. Barrow, M. Goldhaber, W. Fowler), experimental developments (E. W. Vogt, G. Charpak) and symmetries (E. Henley). After-dinner talks in a lighter vein were given by Fay Ajzenberg-Selove on Denys Wilkinson's involvement with the light nuclei and by Ken Allen and Dave Alburger on his contributions to physics in Cambridge, Oxford and Brookhaven.

At the end of the conference Denys Wilkinson discussed some recent developments in nuclear physics, particularly the question as to whether a quark description for the nucleus is needed.

From Roger Blin-Stoyle

1988 CERN School of Physics

The 1988 CERN School of Physics will be organized jointly by the Nuclear Research Centre 'Demokritos', Athens and CERN. Its basic aim is to teach various aspects of high energy physics, but especially theoretical physics, to young experimental physicists, mainly from the Member States of CERN.

It will be held in Lefkada, Greece, from 18 September to 1 October 1988. Further information from the Organizing Secretary, Miss S. M. Tracy, CERN School of Physics, CERN, 1211 Geneva 23, Switzerland.

Asian superstrings

The first and highly successful Asia-Pacific Workshop on High Energy Physics, devoted to Superstrings, Anomalies and Field Theory, was held in Singapore this summer and brought together 60 participants from 12 countries. The opening address was given by Zhou Guangzhao, President of the Chinese Academia Sinica. Invited pedagogical lectures were intended to introduce new subjects from first principles. Talks in this category were: A. P. Balachandran (Wess-Zumino Terms and Quantum Symmetries), C. Itzykson (Conformal and Modular Invariance in 2-dimensional Field Theory) and R. Jackiw (Update on Anomalous Theories). The remaining invited talks covered research results. The second Asia-Pacific Workshop, this time on Collider Physics, is tentatively scheduled for summer 1989 in the People's Republic of China.

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The selection criteria to be applied in evaluating candidates include: overall scientific excellence; experience in the construction, operation and development of free-electron lasers, storage ring radiation sources, large laser systems, or accelerators; demonstrated ability to attract significant funding for research; and demonstrated ability to manage major experimental research projects.

The deadline for applications is January 15, 1988; the University desires to fill the position no later than the fall semester, 1988. Interested persons should send a curriculum vitae, including the names of at least four references, to:

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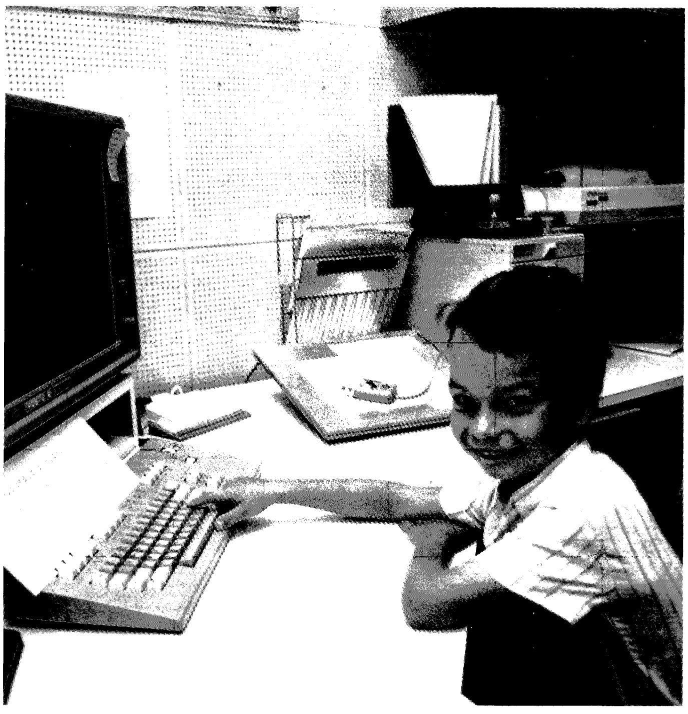
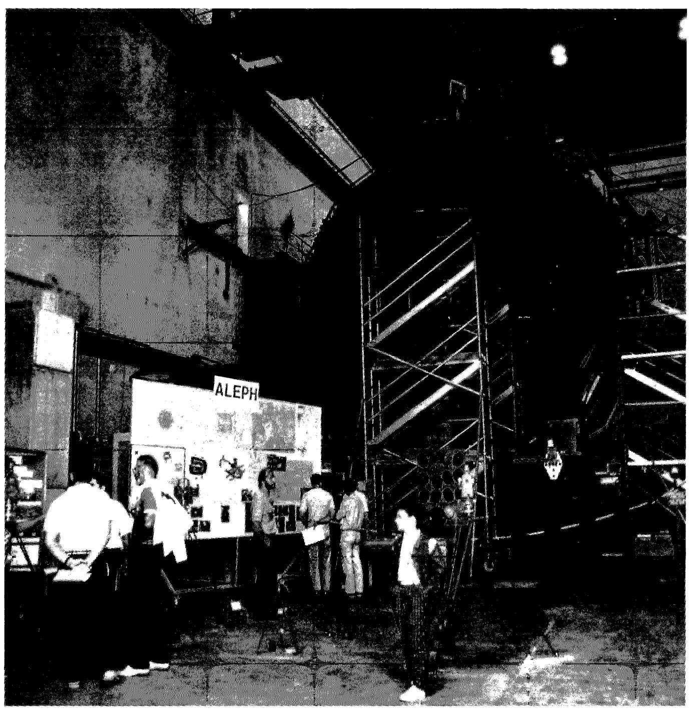
Electronic Mail

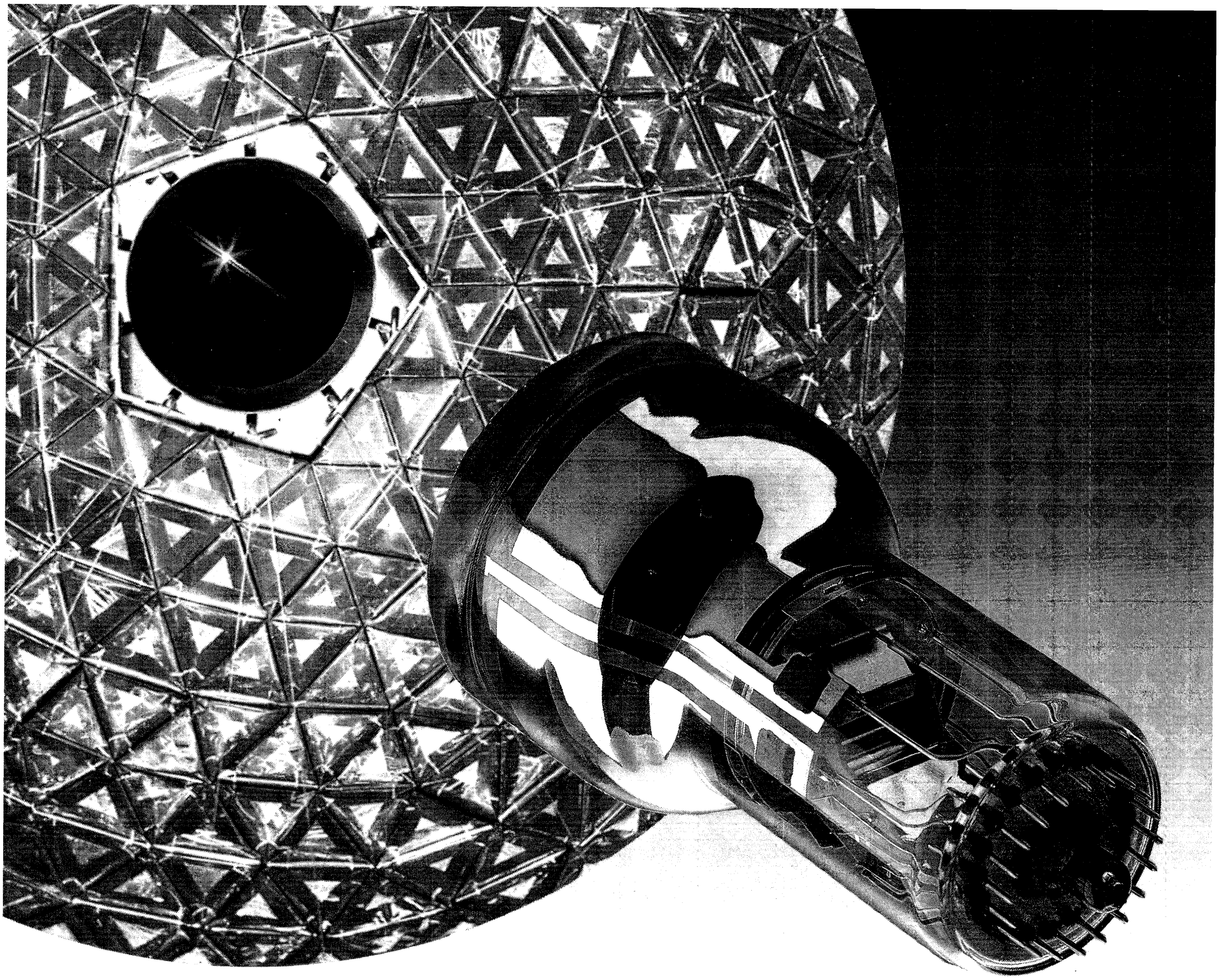
The CERN Courier editorial desk can be contacted through electronic mail using the EARN/BITNET communications network. The Editor's address is

COURIER@CERNVM

CERN's Open Day in September was a great success. Among other things, visitors could ride the monorail for the new LEP electron-positron collider (left), try their hand at computing, or be dwarfed by the magnet assembly for the ALEPH experiment at LEP.







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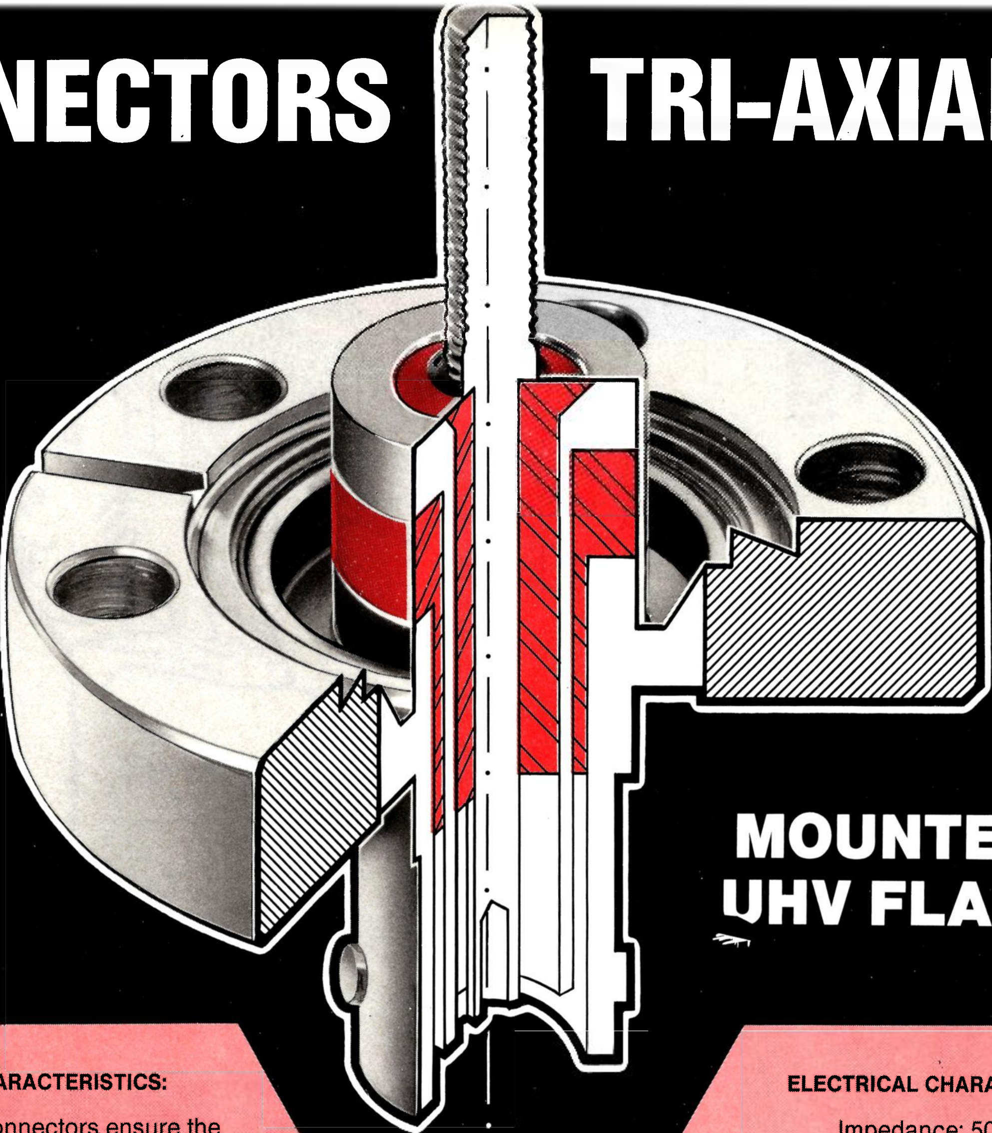

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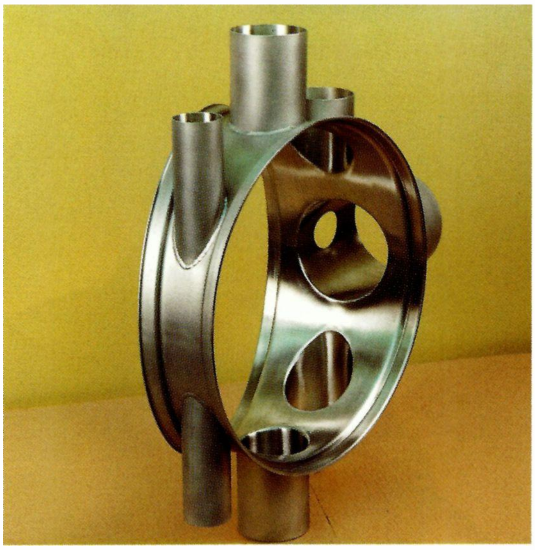
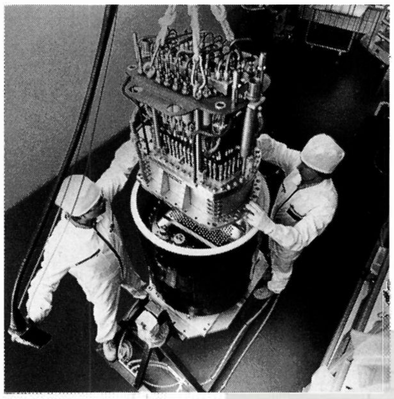
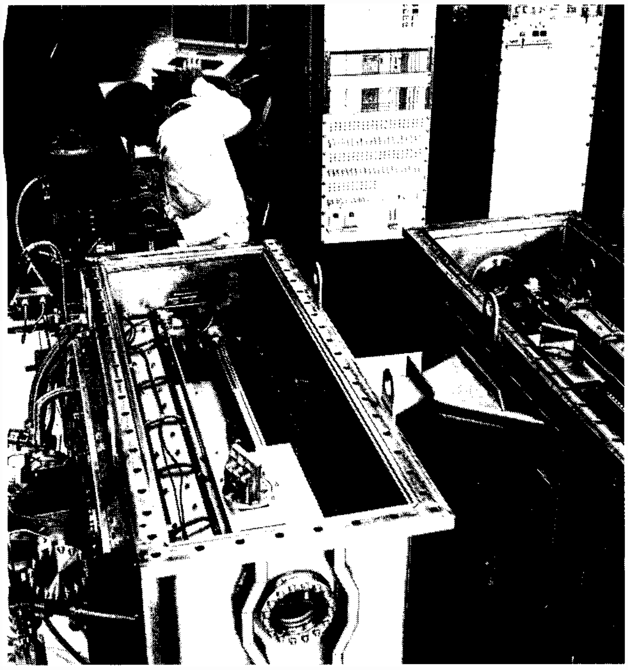


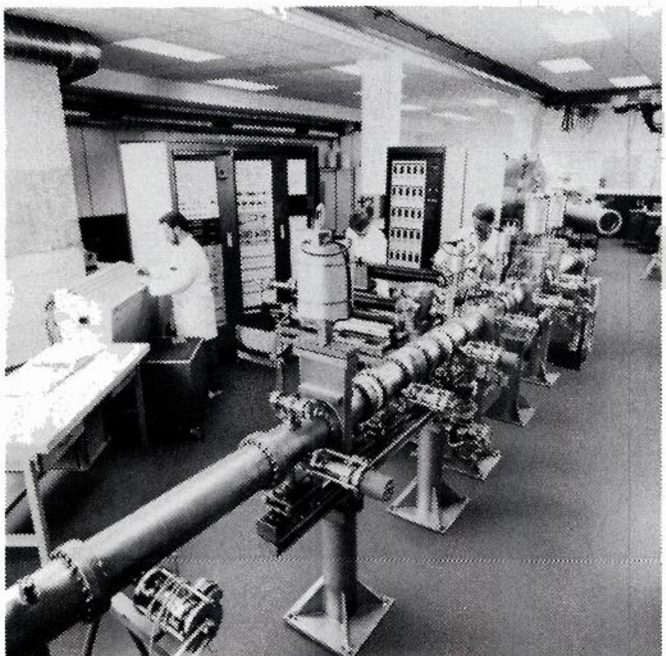
P.I.N.I. (Plug In Neutral Injector). The ion source generates a hydrogen ion beam of up to 80 A which, after neutralization, is used for neutral gas injection heating in nuclear fusion experiments.





Double crystal spectrometer for the detection of plasma impurities in nuclear fusion experiments. The characteristic X-radiation can be analyzed over a broad spectral range with a repetition rate of about 1 Hz, due to simultaneous rotation and translation of the two crystals.

Surface analysis of probes from nuclear fusion experiments by atomic and nuclear spectroscopy. In a compact UHV multichamber system probes are transferred to the analysis stations by precision driving and indexing systems.



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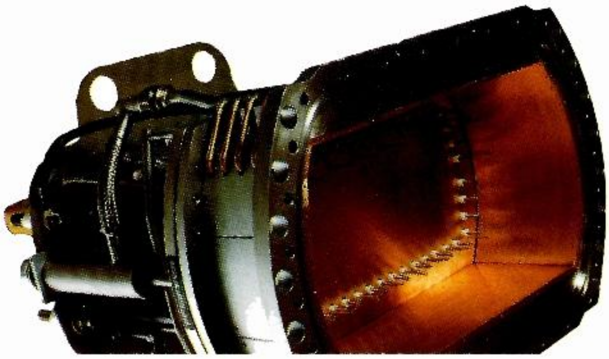

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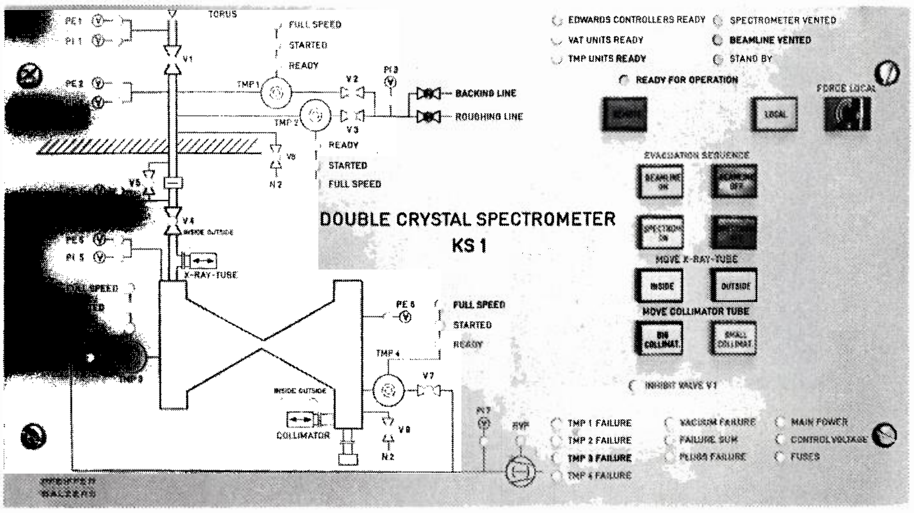
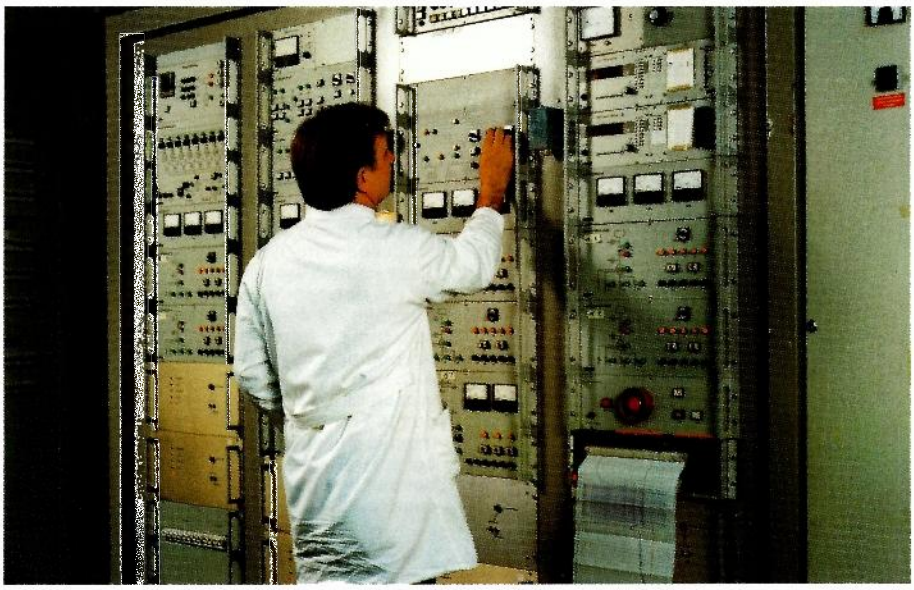
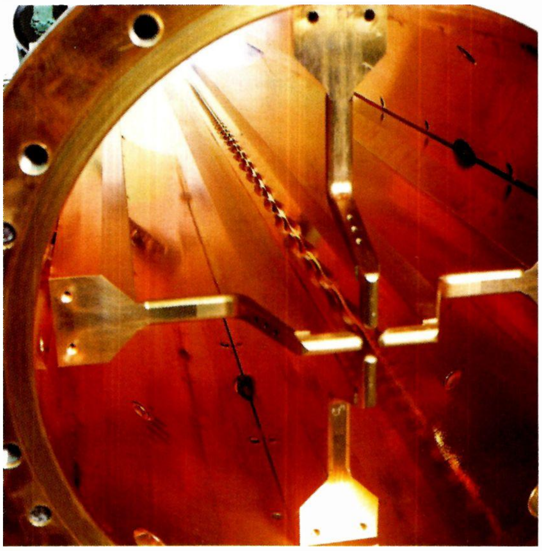


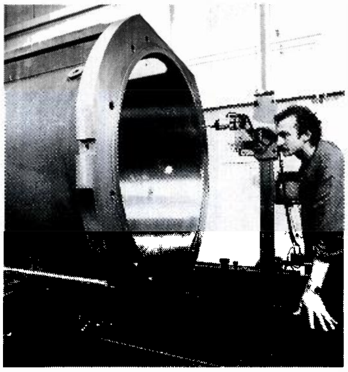


Accelerators and storage rings

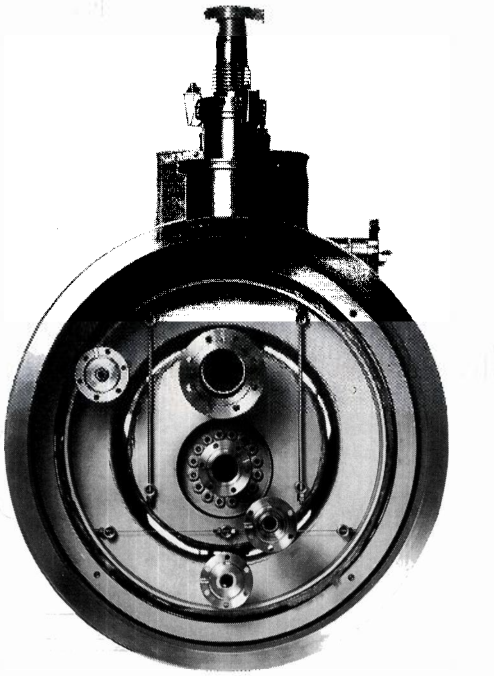
- Cryostat systems for superconducting cavities
- RF quadrupole accelerators
- Alvarez structure as a linear accelerator for protons
- UHV dipole and quadrupole chambers for beam steering and beam diagnostics
- Electrostatic septum chambers
- Gas jet targets for scattering experiments



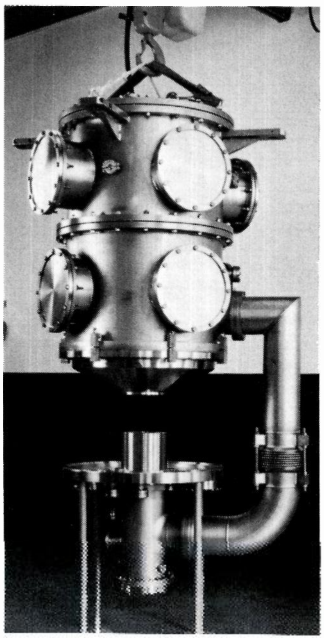
RFQ linear accelerator. The accelerator structure of this Radio Frequency Quadrupole consits of 4 vanes with wavelike pole tip design. These vanes are manufactured on CNC machines with an accuracy of ± 3 microns.



Dimensional inspection of an approx. 3,5 m long module of an Alvarez structure on an X-Y-Z measuring machine. Ten of these modules form the three resonator tanks of the proton linear accelerator for HERA at DESY.



View into a 1,8 K cryostat for a superconducting electron-recyclotron accelerator. Superfluid helium is used for cooling. The heat dissipation of a cryostat module housing a 20-cell cavity resonator is less than 3 watts. (The schematic diagram is shown in the background).

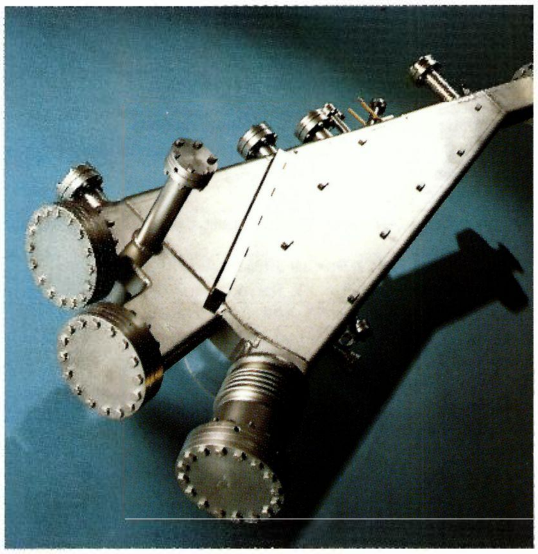


Gas jet target for the CELSIUS storage ring in Uppsala. A hydrogen cluster beam with a target thickness of up to 10^{14} atoms/cm^2 can be produced using a two stage cooling system for the nozzle and skimmer together with three differential pumping stages. A special cryo pump is used as the beam dump. The equipment is shown without scattering chamber and without vacuum pumps.

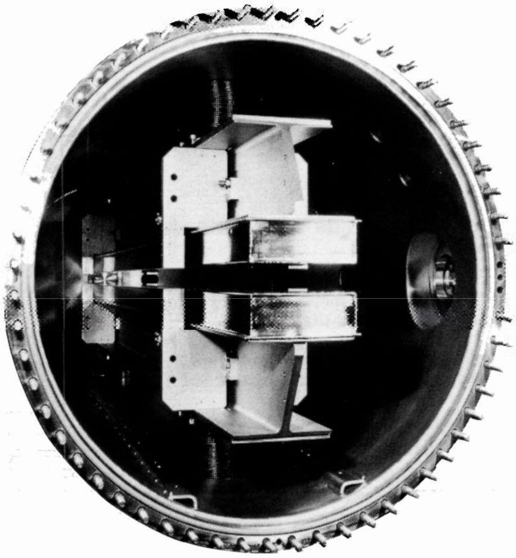
Synchrotron radiation

- **Normal incidence monochromators with integrated grating change mechanisms**
- **Toroidal grating monochromators for different wavelength ranges**
- **Irradiation plant for X-ray lithography**
- **Wiggler/Undulator with encapsulated permanent magnets in ultrahigh vacuum**

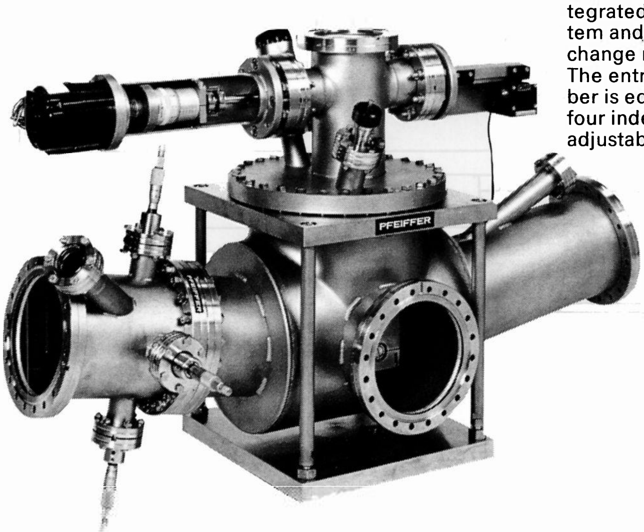
Dipole chamber for Synchrotron radiation at the BESSY I storage ring



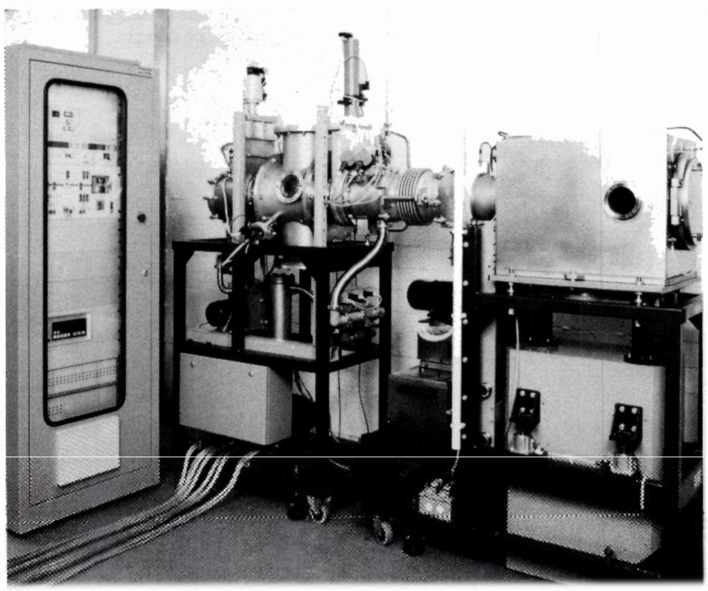
Wigglers/Undulators are used on modern synchrotron radiation sources to increase the photon flux. Inherent is high precision, both of mechanics and of the control system, as well as UHV compatibility, which is needed for storage rings.



Toroidal grating monochromator with integrated drive system and grating change mechanism. The entrance chamber is equipped with four independently adjustable slit blades.



Irradiation plant for X-ray lithographic production of microstructures. In addition to mechanical accuracy, the required repositioning accuracy of the mask is obtained by controlling the temperature inside the chamber to an accuracy of 0,1 °C.



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PH 800 001 PE (8703) Printed in Liechtenstein

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