# CERN COURIER

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# CERN COURIER

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Around the Laboratories

*Cover photograph: 'How does it feel to win the 1982 Nobel Prize for Physics?' Cornell theoretician Kenneth Wilson (centre) jubilant with 1965 laureate Hans Bethe (right) and Laboratory Director Boyce McDaniel, holding the celebratory bottle. (Photo Cornell)*

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# Nobel Prize 1982

*Cornell's physics faculty toast the announcement of the award of the 1982 Nobel Physics Prize to Kenneth Wilson.*

*(Photo Cornell)*

The most prestigious award in physics goes this year to Kenneth G. Wilson, the James A. Weeks Professor of Physical Science at Cornell University, Ithaca, New York. The prize is made nominally in recognition of his work in the study of critical phenomena and phase transitions, but the techniques used in this work have shown their worth in many other fields, including elementary particles.

In addition to this work, Wilson has made numerous other contributions to particle physics. These include the development of techniques for analysing the behaviour of nucleons when probed deeply in violent collisions, and in preparing the way for the formulation of gauge theory on a lattice, an attempt to formulate a theory of inter-quark forces which breaks loose from the traditional straitjacket of perturbation theory.

The Nobel award recognizes Wilson's major contributions in the exploitation of the so-called 'renormalization' group approach.

Physics frequently uses different pictures to explain phenomena taking place on vastly different scales. In seeking to understand ocean currents or meteorology there is little point in starting from the basic interaction between neighbouring molecules in a fluid. On the other hand the study of molecular dynamics takes little account of whether the molecules are confined in a test-tube or the Pacific Ocean.

However there are some phenomena which are by nature not local. For example when a fluid boils, it suddenly develops density fluctuations over its whole volume, not just in one isolated spot. This is characteristic of all critical phenomena (changes of state), and any theory must handle the required scaling in a natural way.

Renormalization was introduced into physics with the modern formulation of quantum electrodynamics, where troublesome infinities kept cropping up in the calculations. In renormalization, these infinities are removed according to a well-defined prescription.

Such prescriptions are not unique. While quantum electrodynamics has its conventional renormalization, in principle there is an infinity of possibilities, each with its own set of parameters. Each possibility is equally valid, and produces the same final predictions — the theory is renormalization invariant.

Like the operations behind many other invariances in physics (translation, rotation), these renormalizations can be expressed in terms of repeated operations, described by the mathematical apparatus of group theory.

The groundwork for the renormal-

## Behind the prize

*Kenneth Wilson was born in 1936 in Waltham Massachusetts, was educated at Harvard, and obtained his doctorate at the California Institute of Technology, where he was a student of Murray Gell-Mann. He came to Cornell in 1963, became professor in 1970, and succeeded to the James A. Weeks Chair in 1974. Among his other awards are the Heinemann Prize, the Boltzmann Medal and the Wolf Prize. He has to his credit a mile run in 4 minutes 17 seconds.*

*He is the third Cornell high energy theorist to win the coveted Nobel award. Hans Bethe won it in 1967 for work on energy production in stars, and Richard Feynman, now at Caltech, received the accolade in 1965 for his contributions to quantum electrodynamics.*

ization group was laid in 1953 by Stueckelberg and Peterman and its relevance for condensed matter physics was suggested by Leo Kadanoff.

The group provides a natural framework for handling a wide variety of physical problems involving a change of state, but in itself it is not a theory. It is rare for the Nobel physics prize to be so intimately linked with a mathematical technique, and the attribution of the prize is also something of an accolade for the renormalization group.

Wilson committed himself to the method and exploited it with great success. One notable spinoff (among many others) was the explanation for the 'Kondo Effect', which had remained one of physics' mysteries for some 40 years.

If a nonmagnetic metal is contaminated by a small percentage of magnetic material, simple theories predict how the magnetic susceptibility could decrease with temperature. However in practice it is found that the susceptibility behaves in another way, which now can be understood.

Most of this side of Wilson's work has found applications in the fields of solid state and condensed matter physics. But it is a striking illustration of the breadth of the man's intellect that he is nevertheless on the payroll of Cornell's Laboratory of Nuclear Studies. He is one of the rare examples of a modern theoretician who has not been content with narrow specialization and has mastered vast areas of physics.

# The search

The European Committee for Future Accelerators, ECFA, organized a Conference from 27-30 September under the title 'The Challenge of Ultra-high Energies'. The aims were to discuss possible new acceleration techniques and, if possible, to help identify the most promising and encourage further research on them. Appropriately enough this search for the new took place in the dignified setting of New College Oxford. The fact that New College is many centuries old should have helped put things in perspective.

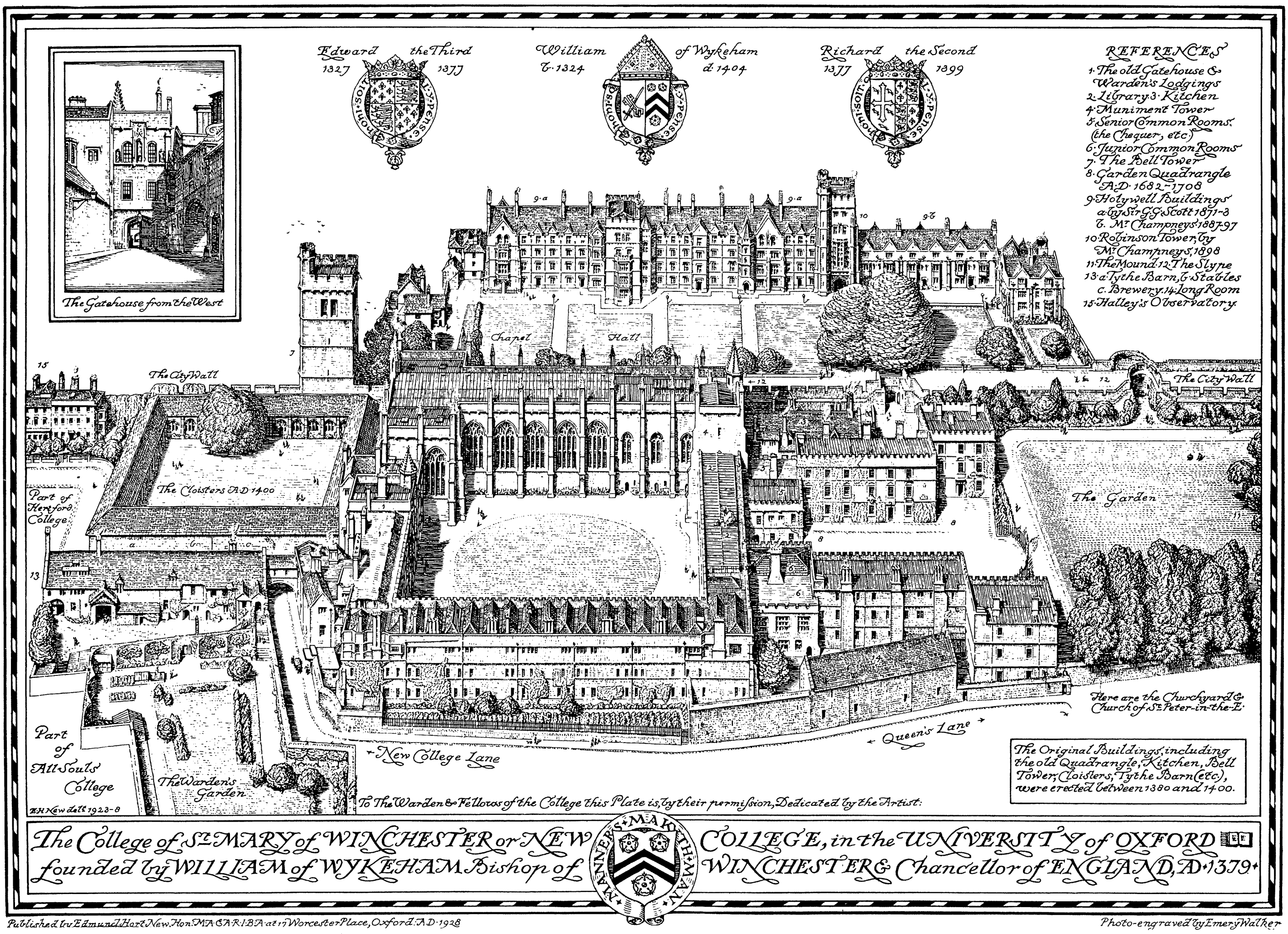
Abdus Salam set the scale in his opening talk when he called for centre-of-mass energies of 100 TeV. Far from accepting the predictions that beyond the next range of energies which will become available to particle physicists, we are heading into a physics desert at still higher energies, he maintained that we could find a physics jungle. The problem is therefore to find the best tools to hack through such a jungle.

The present techniques used in accelerators and storage rings have served magnificently and with increasing efficiency over the past fifty years. Gus Voss pointed out, in reviewing their limitations, that from the technical point of view they could continue to be built to the extent of a storage ring circling the Earth. The problem is fiscal not technical; we must find new acceleration techniques which will make it possible to reduce costs.

Several things are clear — we must have colliding beams for these high energies; superconducting magnets are unlikely to be the economic route; at 100 TeV, we must have linear colliding beams for electron-positron collisions (the cross-over point for economic advantage over a ring is now pitched around 160 GeV per beam); and linac costs and size must be pushed down, particularly

# for new accelerator techniques

*New College, Oxford, established in the fourteenth century. A dignified and not entirely inappropriate setting for the recent conference on achieving ultra-high energies.*



by achieving higher acceleration gradients. Maury Tigner proposed that another couple of restraints should be fed into the equations — we should aim to achieve $10^3$ to $10^4$ eV per dollar, we should have an efficiency of 10 per cent in converting power 'from the wall plug' into power in the beam since it would be difficult to have access to much above 100 MW from the grid. To do all these things, the constant theme throughout the Conference was the achievement of high accelerating gradients.

Collective accelerators, introduced by Andy Sessler, were the first to be considered. They make use of the electric and magnetic fields associated with one set of charged particles to achieve the acceleration and focussing of the desired particles. Probably the most famous variant is the electron ring accelerator, discussed by U. Schumacher, where positive particles are held in rings of electrons. The rings are accelerated at field gradients more gentle than those needed to shake the positive particles loose and the effective accelerating gradient for the positive particles is proportional to the ratio of the particle masses. After fifteen years of development, this concept has been shown to work, but it is expensive and inappropriate for high energies. It may find use only for low energy heavy ions.

Other 'collective' concepts were discussed, including a proposal from F. Winterberger called the 'superaccelerator', which uses an accelerating principle rather like the effect which results in toothpaste finishing up on the other side of the bathroom when the tube is squeezed hard. But the talks which really brought participants to the edge of their seats were those on plasma beat-wave acceleration by T. Tajima, C. Joshi and D. Sullivan.

The essential idea is to use the interference between two laser

*John Lawson, one of the father-figures of accelerator technology, gave a talk entitled 'The physics of particle accelerators' at the recent conference on 'The Challenge of Ultra-High Energies', organized at Oxford.*

beams of different frequencies fired into a plasma to 'organize' the plasma in such a way that it would confront an incoming particle with extremely high accelerating fields. The two beam requirement is necessary to generate beat waves travelling through the plasma at particle velocities rather than the speed of light. The two beams bunch the plasma so that there are successive zones of high positive charge and high negative charge. The theoretical sums indicate accelerating fields of several GeV per m.

The talks communicated the first experimental evidence from work at the University of California, Los Angeles, that plasmas were in fact locking beat waves into place and creating the different charged particle density zones. A multiline carbon dioxide laser of only about $10^{11}$ W per cm$^2$ excited electron density fluctuations resonantly over a 2 cm length for 25 ns, Raman scattering was also demonstrated, producing relativistic electrons in the direction of the laser beam. These are absurdly early days to get excited about these possibilities, but, perhaps more than any other topic at the Conference, this scheme seems to be one which merits investment in research because it has the accelerating gradients we dream about.

The very high electric fields in laser beams themselves are a lure to new acceleration techniques. Unfortunately it is not easy to ensure that a charged particle beam is able to use these fields. Routes covered by Claudio Pellegrini were the inverse free electron laser and Cherenkov acceleration. Firing a laser along the direction of charged particle acceleration doesn't help because desired electric field is perpendicular to the direction of motion. However if we bend the particle trajectories in an undulator, they see a component of the electric field of the laser beam and accelerating gradients of some 500 MeV per m can be imagined. Unfortunately at the higher energies, the need to bend the particle trajectories reduces the acceleration rate because of synchrotron radiation losses. Conceptual designs up to 300 GeV have been done using a free electron laser as the source of laser light, but it is difficult at the moment to see a use for the technique at higher energies. However experiments in several centres have shown that the principle works, which is more than can be said for many of the other concepts presented at the Conference.

Inverse Cherenkov acceleration might provide similar gradients, by ensuring that the laser beam intersects the charged particle beam in a gas at the Cherenkov angle and transfer energy. For example in hydrogen at 1 atmosphere pressure, the Cherenkov angle is 17 mrad and the calculated accelerating gradient is around 500 MeV/m. An experiment at Stanford accelerated electrons of 50 MeV over 7 cm giving an energy increase of 200 keV.

Bob Palmer discussed how to shape the laser beam appropriately using grating structures. In principle, accelerating waves can be set up by illuminating the grating at an angle by two laser beams. Theoretically, a very high accelerating gradient can be achieved (10 GeV/m). Exotic ideas on how to extend grating lifetimes include coating them with ice and shunting them progressively through the beam region. The laser specialists, however, doubt whether any treatment will be effective. The required laser power is beyond what is presently available and experimental support is as yet lacking.

Moving away from lasers, another concept, which appeared in several variants, was what might be termed the 'two beam transformer'. Take a high current, low energy beam and somehow transform the power which is stored in this beam to give high energy to a low (but still implying adequate luminosity) current beam. Previously, Andy Sessler had described such a scheme (at the Los Alamos Workshop earlier this year, see May issue, page 142) with an undulator driver coupled to the accelerating structure, which he feels is not too great a leap from existing technology.

A.N. Skrinsky talked about a 'proton klystron' in which the enormous stored energy of today's highest energy proton beams would be passed through a structure to excite it for the subsequent acceleration of other particles. Gradients of over 100 MeV/m could be feasible and many types of particles could be accelerated. There are not however too many 400 GeV proton synchrotrons lying around with nothing to do, waiting to be used as a klystron.

One of the most interesting talks was from Tom Weiland on a two-beam scheme developed together with Gus Voss and called a wake field accelerator. It involves an intense ring of electrons accelerated in an outer aperture surrounding a central tube where the desired beam is to pass. Fields generated by the passage of the ring percolate through slots and create high accelerating gradients at the central tube (which can be envisaged to go as high as 600 MeV/m). Also the reflected wave could be used to accelerate particles of the opposite charge.

The Conference brought together physicists from the fields of lasers and plasmas as well as the large contingent of accelerator specialists. It seems likely that a much closer intermingling of these different disciplines will be needed en route to new acceleration techniques.

How to move ahead was the subject of an evening discussion. With the big high energy physics Laboratories feeling financial pressures and obsessed with the requirements of their immediate projects, it is not easy to envisage the liberation of money and manpower to pursue 'way-out' ideas for the distant future. But some investment will be necessary in the big Laboratories to take advantage of their broad technological support. This sort of support is not available at most universities.

When considering the length of time which would be needed to sift through the different possibilities and, hopefully, to push one or two of them to the point of practical use, the distant future may not be all that distant. Dennis Keefe pointed out that it has taken some fifteen years to demonstrate the abilities and limitations of the electron ring accelerator concept. Some of the exotic ideas presented at the Conference could require much longer investigation.

Above all it is necessary to encourage young physicists to work on these challenging problems. It was rather strange that new acceleration techniques were being discussed by an audience of experts whose average age was probably over fifty, and it was probably no coincidence that the liveliest papers were given by the youngest participants. There is much to be done, there is probably some beautiful physics and engineering to be encountered and there is the goal of making it possible in the next century to continue the adventure of understanding the nature of matter.

# 25 years of Nordita

This year the Nordic Institute for Theoretical Atomic Physics — Nordita — in Copenhagen celebrated the twenty-fifth anniversary of its founding. The institute reflects a great scientific tradition, and continues to provide an important focus of research for physicists from the Nordic countries.

Nordita owes its existence to a history of close collaboration among Nordic physicists. As a result of the

*Nordita — the Nordic Institute for Theoretical Atomic Physics — this year celebrates its twenty-fifth anniversary. Its Copenhagen premises (left) are adjacent to the Niels Bohr Institute.*

*(Photo C. Hansen)*

*One of Nordita's earliest Directorate meetings: seated from left to right, J. Holtsmark, I. Waller, G. Funke, S. Rosseland, H. Wergeland and N. Bohr: standing, O. Klein, A. Bohr, J. Lindhard, E. Hylleraas, J. Bøggild, L. Nielsen, C. Møller, S. Rozental and P. Jauho.*

influence of Niels Bohr in his epoch-making studies on atomic physics in the 1920s and 1930s, the Institute for Theoretical Physics of Copenhagen University (later to become the Niels Bohr Institute) had a strong Nordic flavour from its inception in 1921.

After the upheavals of the Second World War, a high priority was given to investment in the natural sciences. Among the Nordic countries, there was a strong desire to develop the tradition of cooperation in atomic physics and the peaceful uses of atomic energy. In 1945, Sweden offered to subsidize the establishment of an international institute for theoretical and applied nuclear physics, which it wished Niels Bohr to lead. Despite its appeal, this project could not be realized due to strict secrecy surrounding information on atomic energy.

During the immediate postwar years, the idea of a Nordic institute for theoretical physics was much discussed. The development of these ideas went hand in hand with the establishment of CERN. An early proposal by H.A. Kramers in the Netherlands that CERN be located at Copenhagen, and the offer of a site by the Danish authorities, received strong support from Norway and Sweden. When the final choice of Geneva was made, the Nordic representatives at CERN — Torsten Gustafson and Egil Hylleraas — approached Bohr with a proposal to go ahead with the plans for a Nordic theoretical institute.

The negotiations which were to lead to the establishment of Nordita began at a meeting early in 1953 at Göteborg in Sweden, at which a committee was set up comprising Bohr, Gustafson, Hylleraas and S. Rozental. Soon this committee was able to present a proposal containing the guidelines for the future establishment of Nordita. Although initially only Denmark, Norway and Sweden took part in the negotiations, there were high hopes that Finland and Iceland would collaborate.

The proposal was well received in Denmark and Sweden, but despite strong support from Norwegian theoreticians, the situation in Norway was complicated because of the interests of atomic energy.

During the establishment of CERN, it was decided provisionally to set up the CERN theory group in Copenhagen for five years (1952-57). Further decisions on the Nordic Institute were postponed until plans were clearer on the CERN theory front.

Each year the CERN Member States selected a young theoretician to participate in the group under Niels Bohr and which included Christian Møller, Aage Bohr, Gunnar Källén, Ben Mottelson and Stefan Rozental.

During this time, the Copenhagen institute, together with the new theory group, functioned as an international centre, attracting eminent scientists from all over the world.

The transfer of the CERN theory group to Geneva in 1955 coincided with a significant effort by Nordic statesmen. It was clear that there was broad agreement for the idea of a Nordic Institute for Theoretical Atomic Physics. In November a meeting in Stockholm gave additional strong support to the proposal for a Copenhagen centre, and Finland also added its support. Early the following year, it was agreed that the establishment of Nordita be recommended to the research councils of the Nordic countries. In the meetings of the Nordic Council's economic committee, the proposal received strong backing, although Norway at first appeared to be hesitant. However after further discussions, and after the valuable intervention of Swedish Prime Minister Tage Erlander, the Norwegian Government lent its support. At a meeting of the Nordic Council in Helsinki in February 1957, the Nordic Council agreed to the establishment of Nordita, together with a liaison body for atomic energy affairs.

At its first meeting on 25 June 1957, the Nordita directorate elected Niels Bohr as Chairman and Torsten Gustafson as deputy. Decisions on staffing were taken, and the Institute began its work on 1 October 1957.

Initially, Nordita's interests covered a broad field of modern physics, with special emphasis on nuclear and particle physics and the theory of relativity. In 1966, a Finnish proposal to extend Nordita's research into solid state physics found strong support. This has now become one of the main research areas. In more recent years there has been a promising build-up of activity in astrophysics.

Nordita functions as a research centre, a meeting place and stimulus for Nordic cooperation in theoretical physics, and as an educational institution providing fellowship opportunities for younger theoretical physicists from the Nordic area. Through its staff and visitor programme, which is carried out in cooperation with the Niels Bohr Institute, Nordita plays a part in maintaining contact between physicists in the Nordic areas and the broader international community.

*Before Nordita. This 1931 photograph, taken in the auditorium of the Copenhagen Institute for Theoretical Physics at one of its annual congresses, shows in the front row from the left: O. Klein, N. Bohr, W. Heisenberg, W. Pauli, G. Gamow, L. Landau and H. A. Kramers.*

# Around the Laboratories

## DESY
### Status report

During 1982 several major changes and improvements were made in both the accelerators and the experimental installations at DESY. The rebuilt DORIS-II electron-positron storage ring came into action (see September issue, page 275) and the Crystal Ball detector arrived from the US (see June issue, page 191). This detector is now installed in one of the two experimental regions of the DORIS-II ring.

In the meantime the second interaction region of DORIS-II has been occupied by the new ARGUS device (see December 1981 issue, page 447). This was moved into the beam on 6 September and was able to record events just a few weeks later.

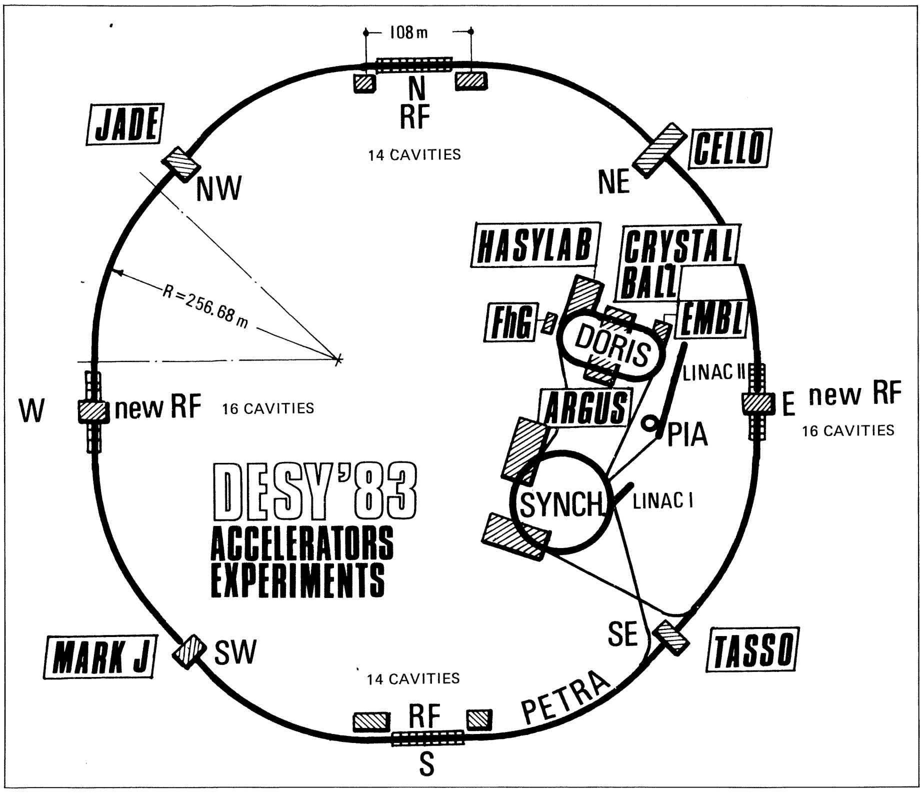
The Crystal Ball detector has already been taking data for some time. As a first task the upsilon resonance was remeasured. In one run of nine days in August, a few thousand hadronic events were recorded in the upsilon region. The integrated luminosity was about 600 inverse nanobarns. Using this data, the mass of the upsilon was found very near the value determined by the Novosibirsk group in an absolute precision measurement (see October issue, page 325). The Crystal Ball value is based on beam energy data from the machine group (no depolarization measurements for an absolute calibration are yet available).

At present ARGUS and Crystal Ball are running at DORIS-II energies around the upsilon (9.45 GeV), before starting work at the somewhat higher energies now available. The peak energy is now 5.6 GeV per beam. The mean luminosity over longer periods of time is continuously improving. There were initially some problems due to the vacuum system, and the mean luminosity was not reaching the expected values. Four acceleration cavities had to be exchanged due to chemical effects on their walls. However the other excellent properties of the machine were not affected. A particular advantage of DORIS-II is the short time required now for the injection of both electrons and positrons.

The DORIS-II ring is also being used for experiments with synchrotron radiation. About one third of the running time is devoted to this task. The specialized HASYLAB laboratory now has 22 fully installed irradiation facilities in its big hall. In addition, five installations of the European Molecular Biology Laboratory and one beamline providing radiation to the bunker of the Frauenhofer Gesellschaft continue to be available. The latter is mainly used for the investigation of X-ray lithography.

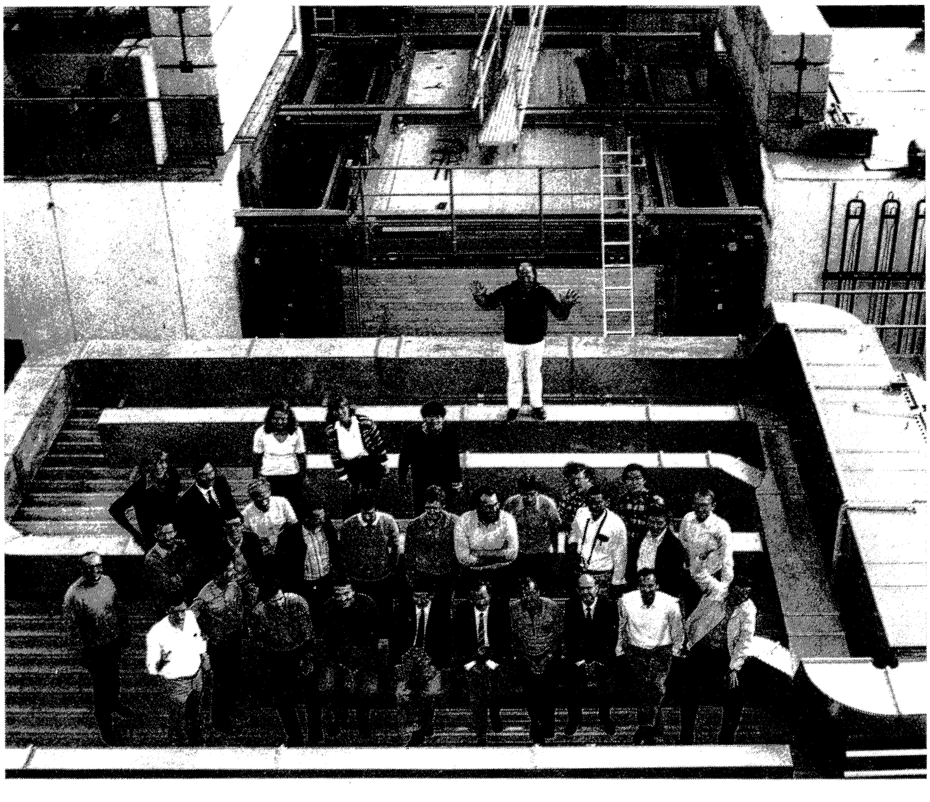
At the PETRA storage ring several important modifications were carried out this summer. The major improvement to the machine consisted of doubling the power supplied to the accelerating cavities. The 60 PETRA cavities are now symmetrically distributed, and are powered by 8 transmitters, each of them providing 1 Megawatt, produced in two klystrons. This now provides 1.4 times the voltage previously available to accelerate particles. The final effect should be an increase of the peak energy of the beam of about ten per cent. PETRA will then surpass 20 GeV per beam. However tests have been delayed due to a failure in the external power supply network. Tests at lower energies have shown

*Current line-up of detectors in the machines at DESY. The 60 r.f. accelerating cavities are now distributed symetrically in the PETRA ring, and the power supply has been boosted.*

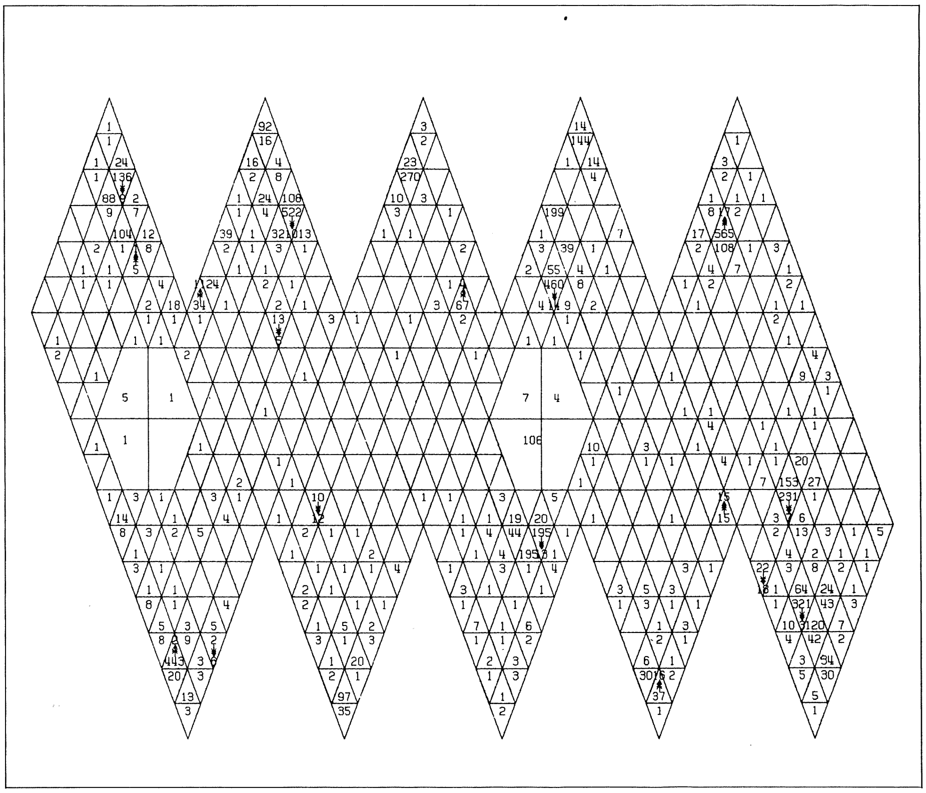


*The ARGUS group on the roof of their control room, after celebrating the positioning of their detector in the DORIS-II ring, seen in the background.*

*(Photo DESY)*



*A hadronic event as seen by the Crystal Ball detector, newly installed in the DORIS-II ring at DESY. Each triangle represents one of the sodium iodide counters in the spherical detector.*



that there are no intrinsic problems. It was also possible to try out four of the new seven-cell cavities which provide improved acceleration capabilities compared with the five-cell ones used at present. The four seven-cell units were left in place and form part of the total complement of 60 cavities.

The superconducting cavity built at the Kernforschungszentrum Karlsruhe (KfK) was tested earlier this year in Hall W at PETRA (see June issue, page 176). These tests were very successful and have been completed (see page 415). The cavity is back in Karlsruhe. In PETRA's Hall E, new tests of superconducting cavities in collaboration with CERN are now being prepared. A five-cell cavity from CERN, operated at 500 MHz, should be installed in January.

The absolute energy of the PETRA beam and other important parameters can now be measured using the beam depolarization method. The degree of polarization (in general 60 to 70 per cent) is measured using recoil photons from laser light. The depolarizing resonance is found with the help of small radial magnetic field oscillations produced with the magnets of the PETRA feedback system.

During PETRA's summer shutdown, the PLUTO detector was removed from the NE interaction region and the big CELLO detector was moved in again. During the PLUTO run (which began in September 1981) the CELLO detector was improved in several ways. The granularity of its big lead liquid argon shower counter (electromagnetic calorimeter) was increased by 50 per cent by conveniently rearranging its cells. A beam pipe counter was added. It consists of two layers of drift tubes and provides precise vertex reconstruction and better momentum resolution. In addition, the forward and backward spectrometers were adjusted to the requirements of PETRA's minibeta quadrupoles and to the absence of solenoid compensation coils.

As approved by the DESY Physics Research Committee in its September session, CELLO will now remain in place at least up to the end of 1984. PLUTO, which has been active at the DORIS and PETRA machines since 1974, will be used to test (with cosmic rays) a newly developed drift chamber system. The last runs at PETRA were very successful and the PLUTO group is now busy analysing the collected data, in particular the reactions produced in photon-photon collisions. PLUTO had been prepared for these investigations with the addition of two magnetic spectrometers in the forward and backward regions.

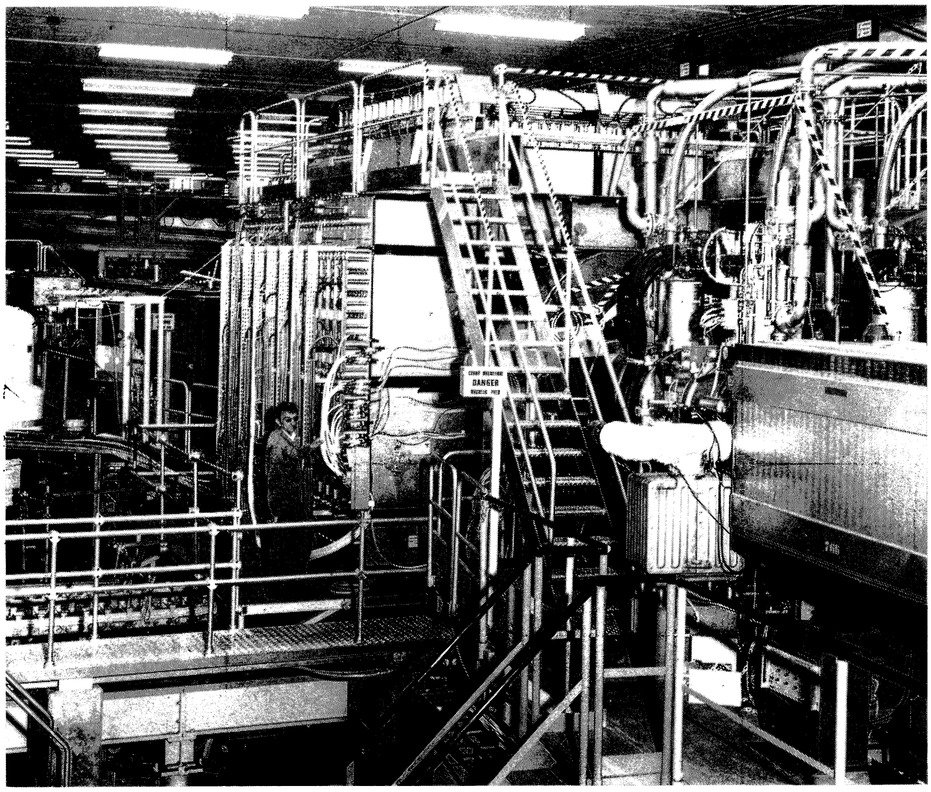
Between January and August 1982, each of the four PETRA interaction regions received a total integrated luminosity of 51 inverse picobarns. About 75 to 80 per cent of this was finally used by the JADE, MARK-J, PLUTO and TASSO experiments.

The TASSO apparatus (Hall SE) was improved this year. Forward and backward spectrometers and a vertex detector were added. The vertex detector includes eight layers of drift chambers and is integrated with a new beryllium vacuum pipe.

No major hardware changes were made at the two remaining detectors JADE and MARK-J. Already at beginning of this year, MARK-J had its drift chamber tubes extended down to about 10 degrees to the beam, therefore improving the coverage of solid angle.

The four PETRA interaction regions are equipped with minibeta quadrupoles. Space for these quadrupoles was made available by eliminating the solenoid compensation coils. The required compensation of the solenoid fields of the detectors is done between CELLO, JADE and TASSO by an appropriate orientation and adjustment of the fields (see July/August 1981 issue, page 237). In fact CELLO has a field twice that of JADE and TASSO. All three fields are oriented in the same sense, as seen by a beam particle orbiting around the ring. At DORIS-II, the field of the ARGUS solenoid had to be compensated locally, since there is no field on the opposite side at the Crystal Ball.

At present, in addition to the data-taking by the six big high energy groups (ARGUS, CELLO, Crystal Ball, JADE, MARK-J and TASSO) and to the HASYLAB investigations with synchrotron radiation, there is increasing activity at DESY to prepare hardware for the proposed HERA machine. Superconducting prototype magnets are being tested, a 400 Watt liquid helium cryosystem installed and several study groups are looking at details of the project.


*The detection system at Intersection 8 of the CERN Intersecting Storage Rings, with its walls of uranium/scintillator hadron calorimeter, a good example of the sophisticated instrumentation now available at the ISR.*

*(Photo CERN 221.7.82)*

## CERN
## Twilight of the ISR

The lifetime of the Intersecting Storage Rings at CERN is being curtailed in order to liberate money, manpower and space for the construction of the LEP electron-positron ring. However the ISR is in the midst of an active experimental programme and in a special meeting on 20 September, physicists met to discuss how to make best use of the remaining time available on this unique machine.

It took a decade of detector improvements at the ISR to go from the first evidence for anomalously high yields of secondary particles from violent (high transverse momentum) collisions to the clear clustering of hadrons seen this year in calorimeter experiments (see October issue, page 327). These clusters ('jets') have also been seen at the SPS proton-antiproton collider.

The SPS collider probes a much higher energy, but the ISR has other attractions. Its luminosity (collision rate) is much higher. It can cover a range of collision energies. And the measurable momentum fraction carried by the produced hadrons is higher than that at the SPS collider. The ISR and the SPS collider therefore cover different, and very much complementary, kinematical regions.

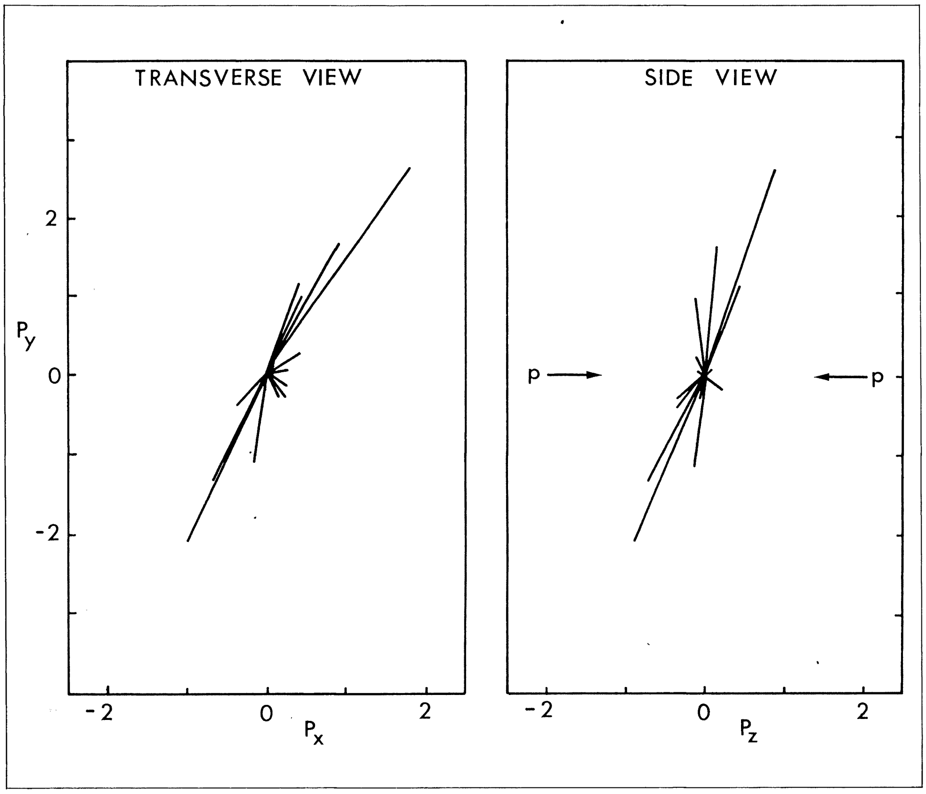
According to our present knowledge of quark and gluon distributions inside nucleons, gluons dominate at lower momentum fractions. This means that the SPS is predominantly a gluon-gluon collider, while the ISR can probe quark-quark scattering.

The ISR also enables identical detectors to make a direct comparison of proton-proton and proton-antiproton interactions. This is an acid test of quark behaviour and could throw considerable light on the nature of the fundamental interactions. The antiproton runs with the ISR so far have really only scraped the surface of some rich physics.

Now that clear jets have been seen, the existing detectors at the ISR can envisage a full programme of jet investigations. Systematic study of these jets provides a good testing ground for quark/gluon (strong interaction) theory, and the ISR will continue to provide useful information right up to the minute it is switched off.

The ISR has had a monopoly of direct photon physics, which investigates the electromagnetic radiation (photons) coming from excitation of the (electrically charged) quarks. The

*Two views of the charged particle momenta produced in an event at the Axial Field Spectrometer at the CERN Intersecting Storage Rings carrying large transverse energy. Such clean jet-like events dominate the sample with more than 12 GeV of transverse energy deposited in one quadrant of the calorimeter.*



study of the accompanying hadrons provides important information. Comparison of photon production in proton-proton and proton-antiproton collisions is especially interesting.

The ISR demonstrated the apparent rapid increase in the production of heavy flavours at higher energies, and the new detector configurations now available will be able to extend this study. The big rise in charm production from fixed target to ISR energies was at first a mystery, but satisfactory explanations can now be proposed as the underlying mechanisms are further studied. However a lot of work remains to be done and a search for beauty could still pay dividends.

As well as handling protons and antiprotons, the ISR can also handle heavier particles, and in 1980 a short run was made with colliding beams of alpha particles. This gave some interesting results (see May 1981 issue, page 163) and further studies could follow up this pioneer work. These ion collisions could give clues to the much sought-after quark/gluon plasma.

In addition to the programme with colliding beams, a gas jet target is being prepared at Intersection 7 for use with a coasting antiproton beam in one ring. This would allow a systematic study of charmonium states and is scheduled as the final curtain to ISR physics.

At the meeting on 20 September, Harald Fritzsch drew an analogy. He reminded the audience of the richness of the Testament Mathématique of Evariste Galois, frantically written during the night which preceded his untimely death in a duel. How much more would we have learnt from Galois' fertile mind if he had been given another night?

## Looking for neutrino oscillations

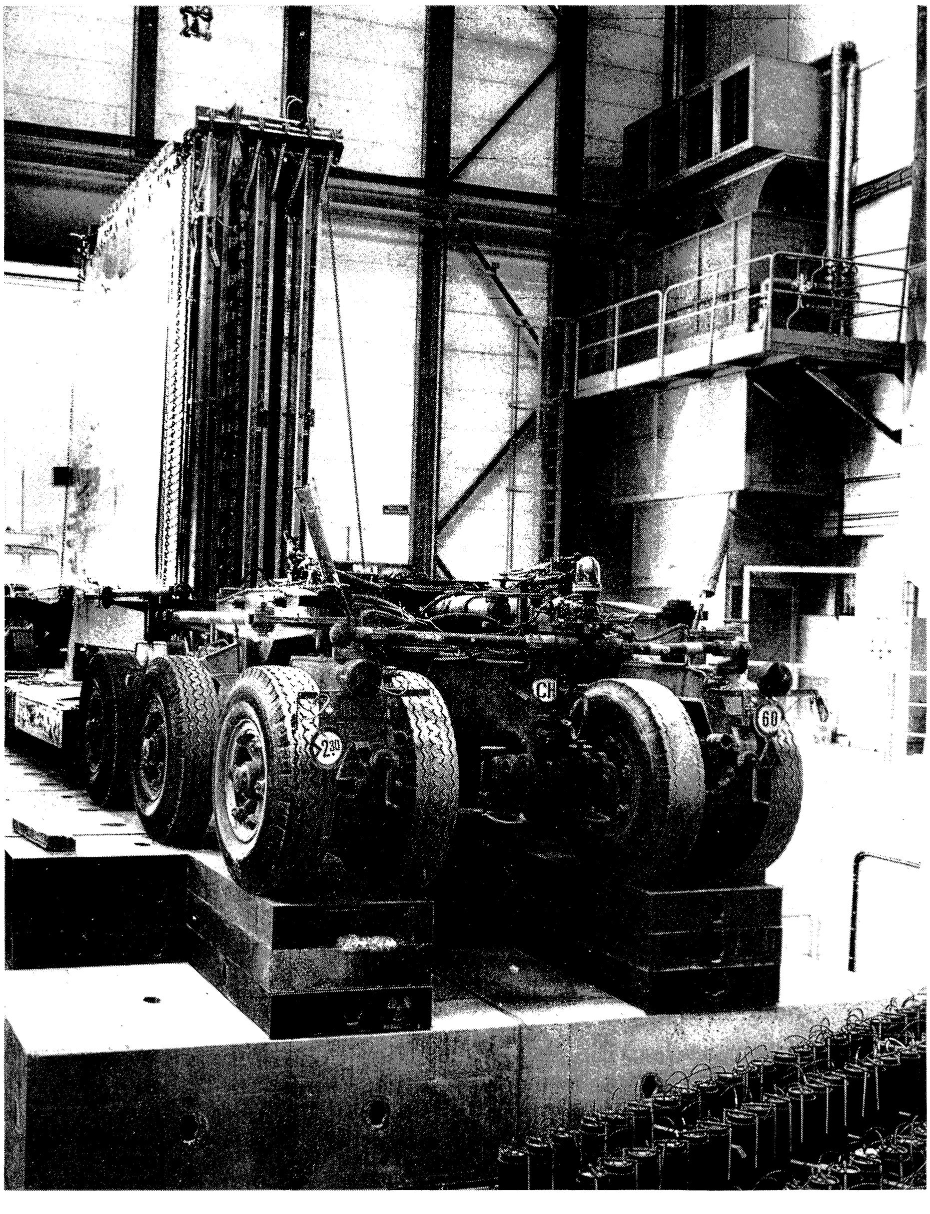
Three experiments are being prepared for data-taking next year which will use a new low energy neutrino beam from the 28 GeV Proton Synchrotron (PS). The rich programme of neutrino physics using the intense beams from the 400 GeV SPS proton synchrotron has been under way since the commissioning of the SPS in 1976 and has now amassed a wealth of information.

But in the bizarre world of the neutrino, high energy is not the only way to discover new behaviour. Recently there has been renewed speculation on whether the neutrino, long thought to be a massless particle, in fact has a small residual mass. In addition, the different types of neutrino encountered in nature (electron and muon types are common and a third tau type is also expected to exist) might not in fact be immutable. Oscillations between different neutrino states could be possible, analogous in certain respects to what happens with the neutral kaons.

To explore these possibilities further, a new low energy neutrino beam is to be provided by the PS. Modules from the CERN/Dortmund/Heidelberg/Saclay (WA 1) and CERN / Hamburg / Amsterdam / Rome / Moscow (CHARM) neutrino counter experiments in the West Experimental Area of the SPS are being set up immediately after the decay tunnel of the neutrino beam, about 150 m from the target. Data recorded in these upstream detectors will be compared with that from the larger detectors downstream. The PS neutrino beam will also pass through the BEBC bubble chamber, where an Athens / Padua / Pisa / Wisconsin group will carry out an additional search.

The WA 1-type upstream detector

consists of six modules of the improved iron-scintillator calorimeter, weighing 280 tons. The downstream detector contains 21 modules and weighs 1140 tons. Three modules of the CHARM calorimeter are installed upstream, together with an iron muon filter, provided by the Institute of Theoretical and Experimental Physics, Moscow. Each module contains six marble target slabs 8 cm thick interspersed with a fine-grained array of scintillator counters, proportional counters and streamer tubes. The downstream detector has ten modules.



*A module of the CERN/Hamburg/Amsterdam/Rome/Moscow ('CHARM') neutrino experiment is eased into the upstream experimental area for the new CERN low energy neutrino beam. Data from this upstream detector (and others) will be compared with what is seen in the main detectors some 600 m downstream.*

*(Photo CERN 212.9.82)*

# In the right channel

Studies of 'channelling' have discovered a potentially powerful new method of producing polarized photons which could be exploited in a wide range of experiments.

Lately, a lot of attention has been given to the provision of strong monoenergetic sources of photons for use in a wide variety of structure studies. Synchrotron radiation, bremsstrahlung and positron annihilation are currently considered as the main sources of these photons.

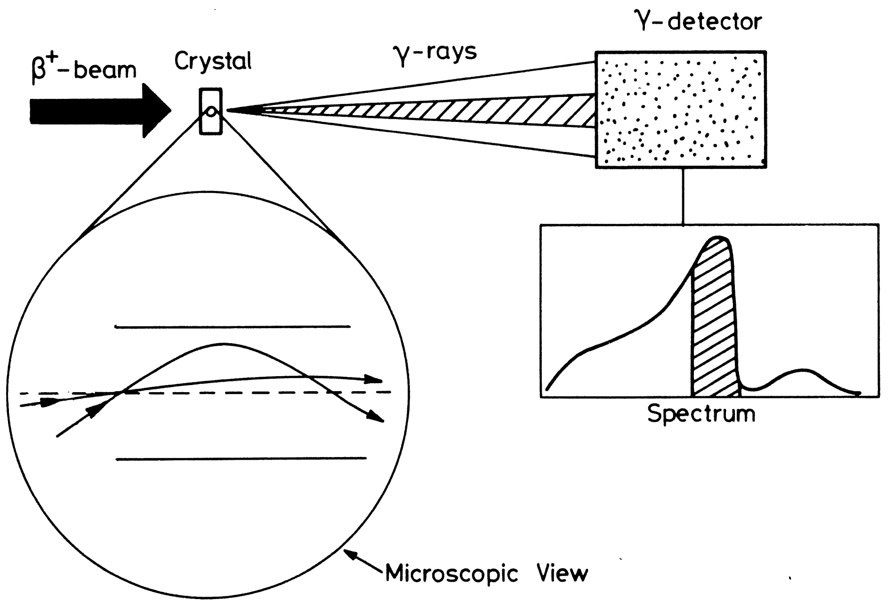
For synchrotron radiation, 'wiggler' magnets are being installed in electron-positron storage rings to boost the emitted radiation. These wigglers force the particles to oscillate, and thereby radiate. The energy of this radiation is usually below 1 MeV, so that it is not suitable for a wide range of experiments.

However a few years ago a new source of radiation — channelling radiation — was found in which the extremely strong steering effect from channelling forces electrons or positrons to oscillate up and down between adjacent crystal planes. Just like a wiggler magnet, this oscillation makes the charged particles emit polarized radiation of a specific energy in a narrow angle in the forward direction.

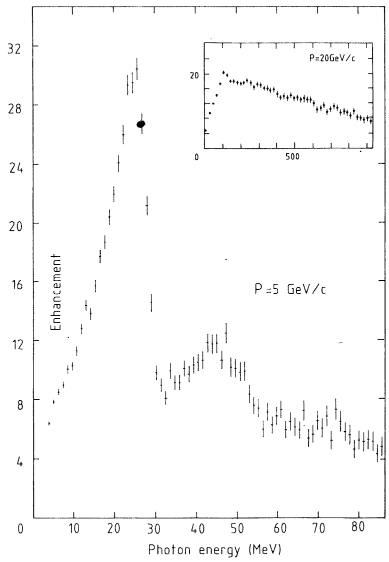
Experiments performed previously at energies of a few GeV found a peak for positrons (a Soviet-US team) while studies with electrons in the USSR revealed a broad photon spectrum.

Last summer the Aarhus / CERN / Strasbourg channelling group, collaborating with the UK photon group, undertook an investigation of channelling radiation from 5-50 GeV electrons and positrons using a secondary beam from the CERN SPS 400 GeV proton synchrotron. For positrons at moderate GeV energies this experi-

*The principle of a channelling radiation experiment. When a beam of positrons is channelled between crystal planes, the particles oscillate and emit radiation. Usually the energy of this radiation depends on the size of the oscillations — the inset ('Microscopic View') shows how two incident beam positrons radiate different energies. However under certain conditions the positrons produce highly monoenergetic photons. The energy is even better defined by collimating the resultant photon beam.*



*Photon spectrum obtained from 5 GeV/c positrons channelled between the planes of a 100-micron thick silicon crystal. The peak can be even better defined by collimating the photon beam. At 20 GeV/c, there is no energy peak.*



ment also found a peak. At higher energies, only a broad enhancement was observed, as was also the case for electrons across the whole energy range. This is because the emitted photon energies are dependent on the oscillations between the planes. However there exists a 'magic' positron energy — for most crystal planes in the 1-10 GeV range — at which the emitted photon energy is independent of the size of the oscillations. The Soviet-American positron experiment was performed near such an energy.

This year, further investigations by the channelling group, now at the 28 GeV PS proton synchrotron, have scanned the 1-10 GeV energy range and confirmed the existence of a 'magic' positron energy for each crystal plane, producing a sharp photon peak. The radiation is so strong that a crystal about 1 mm thick can yield nearly one photon per positron in the narrow peak.

If the emerging photon beam is collimated, a highly monoenergetic supply of photons becomes available. However this requires a highly parallel incident beam, such as is available from a linac, supplying more than $10^9$ particles per s. Hence a comparable yield of monoenergetic photons becomes available in the MeV region, eminently suitable for nuclear physics. The energy can be varied continuously. For 1-10 GeV/c positrons, the photon energy is in the 1-100 MeV region. Like synchrotron radiation, the photons are plane polarized.

If a bent crystal is used to channel the beam (see May 1980 issue, page 111), the resultant radius of curvature is much smaller than that of conventional synchrotrons, so that intense synchrotron radiation is emitted. The interaction between the emitted radiation and the beam particles will give a highly polarized positron beam, opening up further possibilities.

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## KARLSRUHE/DESY
## Experiment on superconducting cavity completed

Earlier this year (June issue, page 175), we reported the start of an experiment with a superconducting radio-frequency accelerating cavity installed in the PETRA storage ring at DESY. This experiment, by a group from the Kernforschungszentrum Karlsruhe, has now been completed with very encouraging results.

The performance of the cavity (accelerating field gradients of 2.3 MV/m and a Q-value of $10^9$) were not affected by deliberate exposure of the high field region to 1.5 W of synchrotron radiation. It was also not affected by six weeks of normal PETRA operation with the cavity at helium temperature and detuned away from the fundamental mode.

After an additional two months of normal PETRA operation with the cavity kept at 80 K, an accidental exposure to clean, dry nitrogen occurred. Initially, this affected performance very badly, but after pumping at a temperature of 50 C for a day and subsequent recooling, the original performance level was restored. The field could even be raised to 3.14 MV/m since a defect in the room temperature part of the input coupling had been repaired.

The higher order mode spectrum excited by the beam was measured in great detail, and all modes which previously had been identified in laboratory measurements were found. Surprisingly a lot of modes are excited above the beam cutoff energy. In those modes for which computed values exist, there was agreement between theory and experiment to within 10 per cent. The higher order mode output coupling system worked so well that even at the highest obtainable PETRA beam currents, less than 1 W higher order mode power was dissipated into the helium while several hundred W were coupled out.

The experiment indicates that a superconducting r.f. cavity can be operated reliably in the taxing environment of a storage ring.

*The upgraded MPS spectrometer at the Brookhaven AGS where candidate signals have been seen for 'glueballs' — particles made up of gluons, but no quarks.*

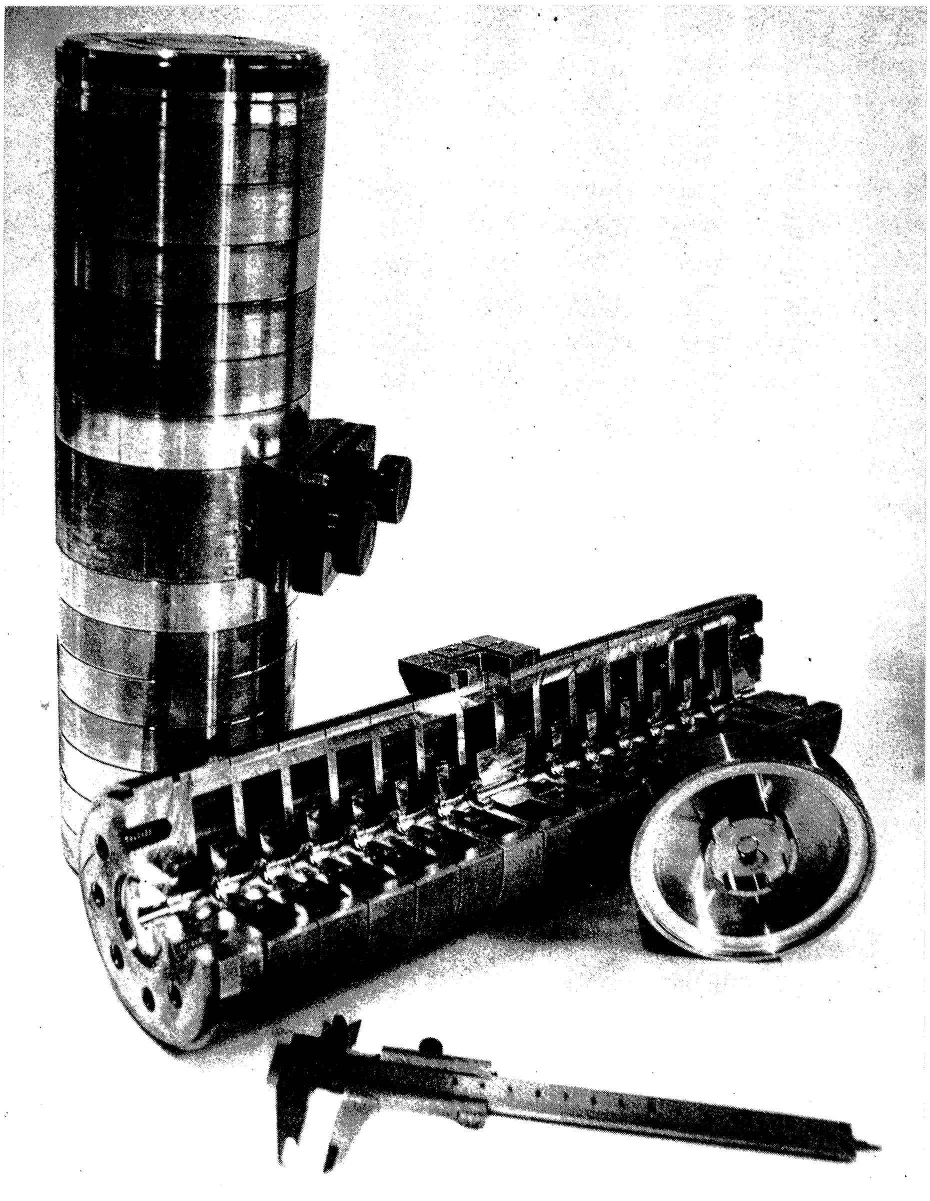
*(Photo Brookhaven)*

## BROOKHAVEN
## Glueballs?

Since 1978, a Brookhaven/City College of New York collaboration has had indirect evidence for glueballs — particles made up of gluons but no quarks. This evidence came from negative pion-proton collisions producing two phi mesons and a neutron — a reaction forbidden by conventional selection rules. Based initially on 100 and later on 170 events, the 'forbidden' signal was seen in the spectrum of the two phis below 2.5 GeV, using the MPS I spectrometer.

The spark chambers of MPS I were replaced by a new system of narrow drift space drift chambers with digitized readout which allowed an order of magnitude increase in data gathering power. In a short run with the improved detector this spring, 1200 clean two-phi events were obtained. A partial wave analysis found two resonances, with isospin zero, spin two and positive parity.

The first resonance is at 2160 MeV and a width of 300 MeV, and the second at 2320 MeV and width 220 MeV. As they are totally forbidden by conventional selection rules, they are considered strong candidates for glueballs. The results were presented by Sam Lindenbaum at the



*On the left is the 16 MeV electron linac test structure, 30 cm long, which has been operated at Novosibirsk reaching 55 MeV per m accelerating gradients. Also shown are a cut-out view of the accelerating structure and a single cell.*

recent Paris Conference.

In principle, the selection rules can be broken by multi-step processes, but elsewhere there is little evidence for this, suggesting that single step processes dominate. The fact that the 'forbidden' signal is so strong indicates that the observed states are primary glueballs and not some multiple effect which mimics glueball behaviour. This could open a new chapter in particle spectroscopy.

## NOVOSIBIRSK
## Preparing for VLEPP

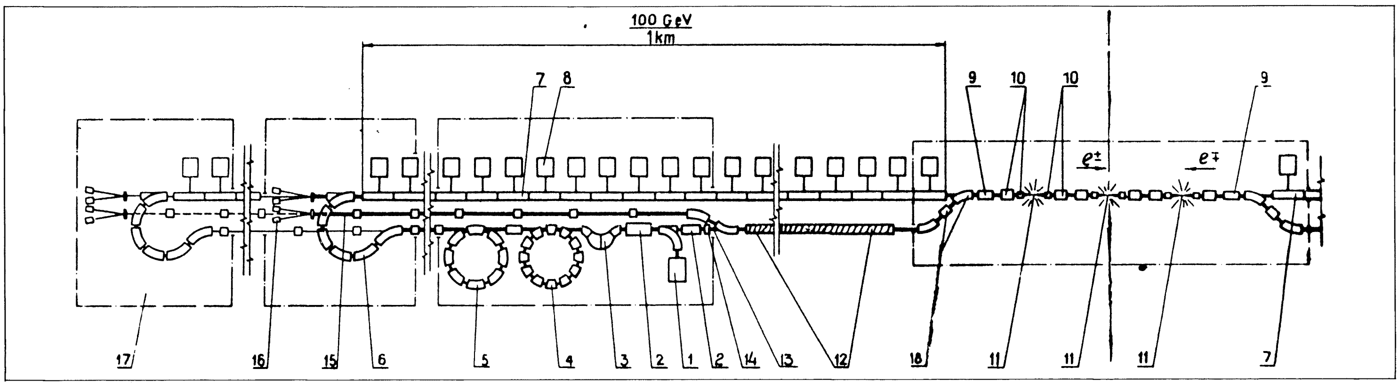
As we reported in the December 1979 issue, page 403, the Institute for Nuclear Physics at Novosibirsk has plans to build a colliding linac beam system known as VLEPP. The ultimate aim is to collide electrons and positrons at an energy of 500 GeV per beam after a first phase with 150 GeV beams which will enable physics to be done at energies beyond LEP. The total length of the first phase system is estimated at about 3 km growing to 10 km for the full 500 GeV beams.

The scheme has the two linacs firing at each other in a straight line. Bunches of $10^{12}$ polarized particles would collide at a repetition rate of 10 Hz. If the beam cross-sections at the collision points (five will be installed in series and could be operated separately) can be kept to a few square microns, a luminosity of $10^{32}$ per cm$^2$ per s would be achieved. After passing through the collision points the bunches are deflected, by a pulsed magnet, through a spectrometer to measure the collision energy. They then enter a long helical undulator where they radiate about 1 per cent of their energy as circularly polarized photons. The emerging polarized particle beam can be used for fixed target experiments while the photons reach a convertor from which electrons (or positrons) are generated. After modest acceleration, storage and cooling rings prepare the particles for injection into the big linac.

To make the scheme realizable, several aspects of accelerator technology will have to be pushed further. Progress at the Stanford Linear Collider (see June 1981 issue, page 199) is being watched closely and there is a programme of research and development at Novosibirsk itself. An important feature of the design is a very high accelerating gradient along the linacs (100 MeV per m) so as to keep the overall size of the collider reasonable. The hope that such a gradient can be achieved is based on single cell cavity measurements, carried out in 1978, when gradients of 150 MeV per m were achieved in specially designed structures.

In May of this year an accelerating

*The VLEPP scheme to achieve very high energy electron-positron colliding linac beams. The numbers indicate — (1) The electron injector, (2) Preaccelerator for 1 GeV, (3) Debuncher, (4) Storage ring, (5) Cooling ring prior to injection, (6) Buncher, (7) Linac accelerator, (8) R.f. power sources, (9) Pulsed deflecting magnet, (10) Focusing lenses, (11) Collision points, (12) Helical undulator, (13) Emerging beam of circularly polarized photons, (14) Converter to give new particles, (15) Residual electron beam, (16) Fixed target electron or positron experiments, (17) The extension for higher energies after the first phase, (18) Energy measuring spectrometer.*



structure 30 cm long was tested and a gradient of 55 MeV per m was reached. Special klystrons were designed and constructed to feed power to the structure at levels up to 20 MW with 5 cm wavelength. The klystron power now seems to be the limiting factor in achieving higher accelerating gradients. The VLEPP project needs 1 GW pulsed r.f. generators spaced 5 to 10 m along the linacs to provide some 1000 GW in the first phase and some 4000 GW at full energy. The power consumption from the mains are 15 and 40 MW respectively. A prototype generator has been operated. An electron beam of the desired quality was achieved and the power was pushed to 0.5 GW.

## CORNELL
## CLEO's counters

Identification of charged particles by measuring their ionization in matter is one of the oldest techniques in nuclear physics. In elementary particle physics this technique has also been used in bubble chamber and counter experiments, but it has only recently been possible to develop the fast, large solid angle devices that can complement the momentum measurements made in large drift chamber spectrometers.

Particle identification by measuring ionization is complicated by the fact that the energy lost to ionization in passing through matter has large fluctuations, first calculated by Landau. These large fluctuations imply that many measurements must be made in order to determine the most probable ionization value that is characteristic of the particle type.

The JADE chamber at PETRA and the TPC chamber at PEP measure both the ionization and the momenta of tracks in the same device. In the CLEO (Cornell / Harvard / Ithaca College / MIT / Ohio State / Rochester / Rutgers / Syracuse / Vanderbilt) experiment at Cornell's CESR ring, ionization is measured in dedicated energy loss counters contained in each of the eight octants surrounding the drift chamber and superconducting

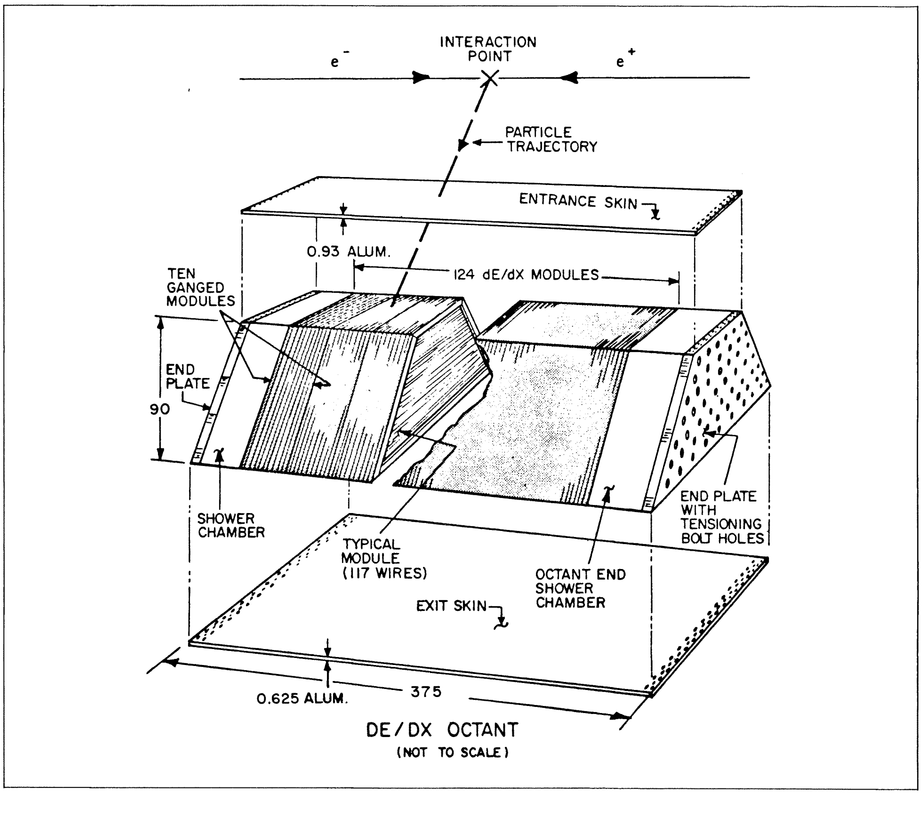


*Diagram of one of the octants of energy loss counters in the CLEO detector at Cornell's CESR electron-positron storage ring.*

coil. The last of these were installed in the summer of 1981, replacing Cherenkov counters that were used while the energy loss counters were being developed and built.

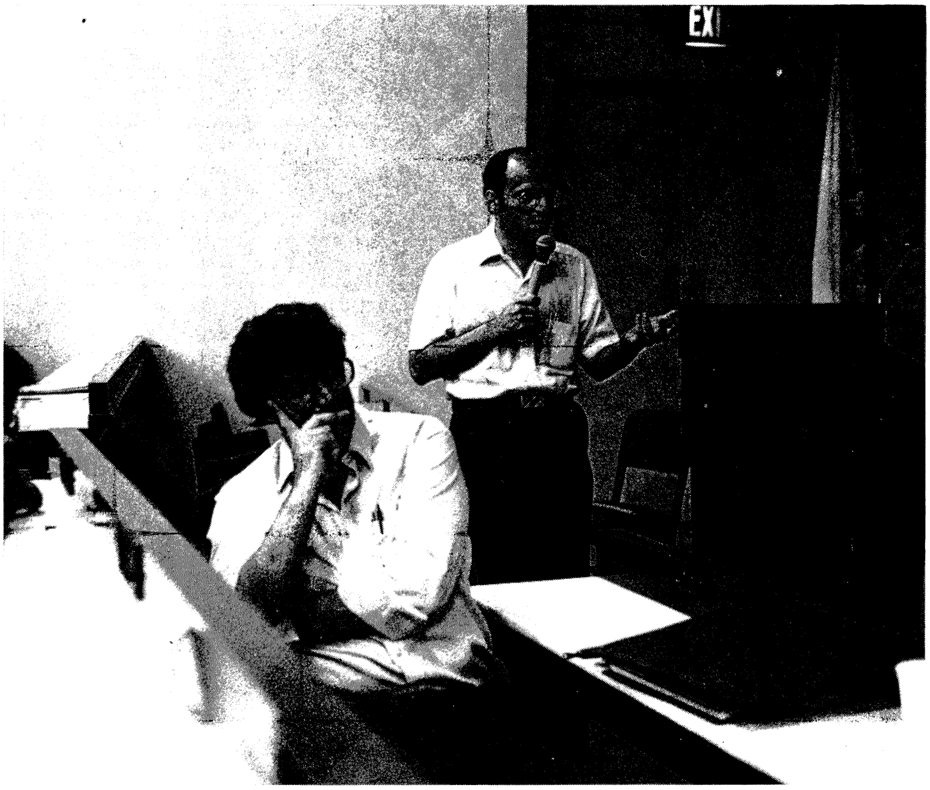
Each counter consists of 124 modules, each of which has 117 wires for sampling the ionization. Below 1 GeV/c momentum, bands corresponding to the ionization produced by pions, kaons and protons are visible. At higher momentum, it is not possible to identify individual particles with the presently achieved 6 per cent resolution; it is only possible to separate particles statistically.

The energy loss counters, working together with time-of-flight counters, can identify charged kaons over the momentum range 0.45 to 1.0 GeV/c. This is a very interesting momentum interval because it includes a large fraction of the kaons resulting from decays of heavier particles. These have been detected by the CLEO group by reconstructing them from their decay products, using identified kaons.

The substantial $D^0$ (charmed meson) production from the fourth upsilon resonance is especially significant as a possible stepping stone to reconstructing B (beauty) mesons, the particles resulting from a beauty quark combining with lighter quarks. Measurements of the momentum distributions of electrons and muons from the fourth upsilon reported by the CLEO and the CUSB (Columbia / Stony Brook / Louisiana State / MPI-Munich) groups at CESR establish a lower limit of 90 per cent for the branching ratio of the decay of a beauty quark into a charmed quark (see November issue, page 367). These c quarks should appear in charged or neutral D mesons, possibly from the decay of $D^*$ mesons. Hence it may be possible to reconstruct B mesons by working backward from D mesons.

*Gary Feldman (with microphone) and David Leith consider a point at this year's SLAC physics institute.*

*(Photos Joe Faust)*



# STANFORD
# Particle physics institute

SLAC hosted 376 physicists during this year's annual Institute on Particle Physics. This year marked the tenth anniversary of the Institute, which attracted participants from fourteen countries in Europe, Asia and Latin America as well as the US. Faithful to its sucessful tradition, the Institute consisted of a seven-day school followed by a three-day topical conference. The courses, addressed mainly to postdoctoral experimentalists (but attended as well by seasoned theorists!), had the theme of Physics at Very High Energies, while the topical conference brought results from current experiments.

Both theorists and experimentalists focused on what should be learned from the future machines. R. Cahn (Berkeley) presented a brilliant summary of old and new physics at hadron colliders, and J. Dorfan (SLAC) explored the experimental consequences of the standard model and of the supersymmetric theories presented in the lectures by L. Susskind (Stanford). Drawing from both theory and accelerator science, B. Wiik (DESY) captivated the audience's attention with a presentation of the physical motivation and technological challenges of electron-proton colliders. In the same vein, R. Stiening (SLAC) talked about electron-positron linear colliders and R. Diebold (Argonne) presented the plans for a 20 TeV x 20 TeV hadron collider. The semilogarithmic Livingston chart, showing the evolution of accelerator energies with time, was often presented but with a new twist: some speakers also indicated their retirement year on the plot, reflecting the desire for a speedy pace

After-dinner entertainment at this year's traditional SLAC physics institute.

of new construction. Standing problems in weak interactions, such as lepton scattering, proton decay and neutrino oscillations were reviewed in the courses by M. Strovink (Berkeley) and H.H. Williams (Pennsylvania).

The afternoon discussion sessions, followed by social hours and dinners on the SLAC lawns, contributed to the productive and congenial atmosphere of this School.

The eighteen lecturers contributing to the Topical Conference presented experimental results from experiments at all accelerator centres. Results from the CERN proton-antiproton collider attracted intense attention, both for their physics content and as examples of new large spectrometer systems. The modern accent on lepton production and lepton beams was reflected in the results from neutrino experiments and the big electron-positron colliders.

The final session, stimulated by the recent possible observation of a magnetic monopole by B. Cabrera (Stanford), digressed from the central topic of the meeting, with lectures by F. Wilczek (Santa Barbara) on properties of monopoles and by Cabrera on experimental aspects of his search. The topical conference closed with a fascinating expose linking particle physics and cosmology given by G. Steigman (Bartol Research Institute).

The tenth SLAC Institute on Particle Physics lived up to the expectations of all those that have come to appreciate this unique educational and professional gathering as a yearly opportunity for refreshing their knowledge and renewing their enthusiasm for physics.

*(We thank Giora Tarnopolsky for this report.)*

## ARGONNE
## Pulsed neutron source in demand

The Intense Pulsed Neutron Source (IPNS-I) is in heavy demand for experiments. This source is a 500 MeV proton synchrotron producing neutrons by spallation in a heavy metal target. The research programme started last year and the machine is providing fluxes of $7.5 \times 10^{14}$ neutrons per $cm^2$ per s over the energy range 0.001 to 10 eV with a pulse repetition rate of 30 Hz.

Major instruments for use by experimental teams now include two powder diffractometers, a single crystal diffractometer, two chopper spectrometers, a small angle scattering diffractometer and a crystal analyser spectrometer.

Over 100 scientists are involved in the programme, attracted by the high neutron beam intensities, matched only by the Japanese neutron source at the KEK Laboratory. The studies cover an impressively wide field, including investigations on the effect of radiation on insulators, on the structure of chemicals used as catalysts in the petrochemical industry, on the structure of tooth enamel, and to search for an electric dipole moment of the neutron.

## Supersymmetry confronts experiment

At a well attended workshop earlier this year at CERN, experimentalists and theorists discussed the prospects of detecting new particles or other phenomena resulting from 'supersymmetry'.

Supersymmetry, or fermion-boson symmetry, is relatively new, having been studied only in the last ten years or so. By extending the space-

# People and things

time symmetry of standard relativity, it puts to one side the time-honoured prescriptions of the Pauli Exclusion Principle.

In the orthodox picture of particle physics, the basic particles (quarks and leptons) are fermions, carrying half units of intrinsic angular momentum (spin) and obeying the Pauli Exclusion Principle, which limits the way the available energy levels can be occupied. The force carriers (photons and other field quanta) are bosons, carrying integer spin.

Supersymmetry requires counterparts to the familiar particles. These additional particles have similar properties, except that they carry different spin. This means that the supersymmetric 'twins' of conventional particles have different statistics — fermions become bosons and vice versa. Hence sleptons and squarks from leptons and quarks, while photons and gluons give photinos and gluinos.

As yet supersymmetry has no experimental evidence to back it, but theorists continue their studies undaunted, claiming that the idea is so elegant and appealing that it 'just has to be true'. It could also help explain problems in other areas.

One of the main goals of present-day theory is the prospect of 'grand unification', which extends the symmetry of the successful 'electroweak' synthesis of the electromagnetic and weak forces to bring in the strong interactions as well.

Attractive as this idea might be, it suffers from the notorious 'gauge hierarchy problem'. The electromagnetic and weak interactions are predicted to blend at an energy of about 100 GeV. Below this energy, the symmetry of the unified electroweak picture is broken into conventional weak interactions and electromagnetism. This unification energy has to be increased by a prodigious amount, about a dozen orders of magnitude, before all the interactions are expected to become of comparable strength in the full symmetry of grand unification.

One possibility is that supersymmetry becomes valid in part of this yawning energy gap, thus solving the gauge hierarchy problem in a natural way. But supersymmetry becomes broken at lower energies, giving the conventional picture.

This offers the exciting possibility that a whole new world of particles could be awaiting discovery, and that the physics 'desert' predicted by some theorists could turn out to be a mirage.

The CERN workshop was organized by Demetrios Nanopoulos, Aurore Savoy-Navarro and Charling Tao, and the proceedings are available as a CERN preprint, ref. TH.3311/EP.82/63.

### *Successful proton-antiproton run at CERN*

*October and November saw a very successful run for proton-antiproton collisions (270 GeV per beam) in the CERN SPS machine. Physics experiments were able to accumulate substantially more data than they logged in the initial runs with the collider last year. Thanks to the operations team being able to provide up to three circulating bunches of protons and of antiprotons, to the commissioning of the low beta systems around the two experimental areas, and to the sterling work of the Antiproton Accumulator and the faithful PS providing the precious antiprotons, peak luminosity was pushed above $10^{28}$ $cm^{-2}$ $s^{-1}$, with low backgrounds. This was good news for the intermediate boson hunters.*

*A special seminar at the Institute of Theoretical and Experimental Physics, Moscow, recently marked the sixtieth birthday of the eminent Soviet theoretician Karen Ter-Martirosyan.*

*Members of the 'CHARM' (CERN/Hambourg/Amsterdam/Rome Moscow) neutrino experiment at the CERN SPS proton synchrotron photographed at a recent collaboration meeting held at ITEP, Moscow. The impressive results from this experiment and its future plans were presented at a special symposium, attended by many notable Soviet theoreticians, including Bruno Pontecorvo.*

## Paul Dirac 80

*The resurgence of interest in magnetic monopoles this year is especially well timed, as it coincides with the 80th birthday of Paul Dirac, one of the chief creators of modern quantum mechanics. He also predicted the existence of the positron, the antiparticle counterpart of the electron. But in a paper published in 1931 (even before the existence of the positron had been confirmed by Anderson), Dirac went further and showed that basic arguments could also support the existence of free magnetic charges. The magnitude of these charges would be simply related to other physical constants. Earlier this year, Blas Cabrera at Stanford reported evidence for just such a Dirac monopole passing through his apparatus (see July/August issue, page 220).*

*Although this observation has yet to be confirmed, it is worth noting Dirac's own words in his 1931 paper. After having recognized the possibility that magnetic monopoles could exist within the formalism of quantum mechanics, he said 'under these circumstances one would be surprised if Nature had not made use of it'.*

## Oppenheimer Prize

*For their contributions to elementary particle physics, Maurice Goldhaber of Brookhaven National Laboratory and Robert E. Marshak of the Virginia Polytechnic Institute and State University are the joint recipients of the J. Robert Oppenheimer Memorial Prize, awarded annually by the Center for Theoretical Studies at the University of Miami since 1969.*

## Letters of Intent for Stanford Collider

*Nine letters of intent to propose detectors for the SLAC Linear Collider were received for consideration by the Laboratory's Experimental Program Advisory Committee, who will advise SLAC's Director on possible 'marriage, murder and merger' moves to arrive at more complete proposals.*

*Three letters considered new detectors, five letters offered modifications to existing installations (Crystal Ball, MAC, TPC, Mark II and HRS), and the ninth could coexist with most larger detectors.*

## SLAC Summer Institute

*The traditional SLAC Summer Institute on Particle Physics will be held next year from 18—29 July.*

*Further information from Anne Mosher, Bin 62, SLAC, PO Box 4349, Stanford, California 94305, USA.*

## *Running at CERN*

*The annual CERN 'Cross' — a 5.6 km run over a hilly circuit in the West Experimental Area — was won overall this year by polarized target specialist Tapio Niinikoski in a record time of 18 min 30 sec. Second was Dave Dallman of the UA 1 experiment in 18 min 38 sec, with EP Division Personnel Officer Werner Zapf six seconds further away in third place. By today's standards, this is no 'fun run', and does not attract the hundreds of weekend joggers seen at other outings. Also contrary to what usually happens elsewhere, the older men outperform the youngsters — the winner of the Men's (no age limit) category turned in a time of 19 min 15 sec, equivalent to sixth place in the 'Veterans' (over 37 years) class, won by Niinikoski.*

*Lightening the fare on the same bill were also races for women and juniors, with the Houlmann family earning the collective trophy (fifth place in the Veterans, another fifth in the Ladies' 1.8 km race, and a first in the Boys under 14).*

*The big annual running event at CERN, attracting hundreds of participants, is the traditional relay race round the Meyrin site — a 3.9 km circuit covered by teams of six runners. The teams have to belong to some kind of identifiable unit (experiment, group, service, etc.) to avoid élite combinations. Most teams can find one good runner, but making up the six is not always easy! For the past two years, this race has been won by a team from the UA 1 experiment. This year UA 1 managed to field five teams, so that a good proportion of the experiment's 140-odd physicists were active that day.*

*The CERN Courier would like to hear from race organizers at other Laboratories with a view to establishing some worldwide comparison of performances.*

*On behalf of the UA 1 'Strollers', Dave Dallman accepts from LEP Project Director Emilio Picasso the team trophy for this year's traditional relay race round the CERN site.*

# Staff and Postdoctoral Positions for Accelerator Physicists and Engineers

Argonne National Laboratory has several openings for qualified scientists and engineers interested in developing advanced concepts for accelerator facilities to be used in nuclear and particle physics. Previous experience with accelerators is advantageous but junior candidates with good academic records and a strong interest in accelerator physics are encouraged to apply. Salary and position will depend upon qualifications and experience.

Principal current activities in the Physics Division include the GeV Electron Microtron (GEM) project which is developing designs for a national C.W. 4 GeV electron accelerator facility, and the ATLAS project, the world's first superconducting accelerator for heavy ions. Related activities in other areas of the laboratory include design of advanced proton accelerators for spallation neutron sources, accelerator development using a rapid cycling synchrotron (proton source for the Intense Pulsed Neutron Source, IPNS), research on stochastic cooling in collaboration with Fermilab, and accelerator research with a high intensity picopulse electron linear accelerator. We offer superior benefits, as well as excellent potential for professional recognition. Interested persons should write:

**Director of the Physics Division**
**Building 203**
**Argonne National Laboratory**
**Box D-PHY-88**
**Argonne, IL 60439**
**Or telephone: Dr. Harold E. Jackson**
**(312) 972-4013**

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DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY HAMBURG

DESY in Hamburg is seeking an experimental physicist for participation in the storage ring development program of the laboratory, in particular the application of superconductive techniques.

Applicants should have a degree in physics. Experience in cryogenics would be useful. Appointments are initially for three years, with the possibility of becoming indefinite.

**Please write to Professor P. Söding**
**Deutsches**
**Elektronen-Synchrotron DESY**
**Notkestrasse 85**
**D-2000 Hamburg 52**
**(West Germany)**

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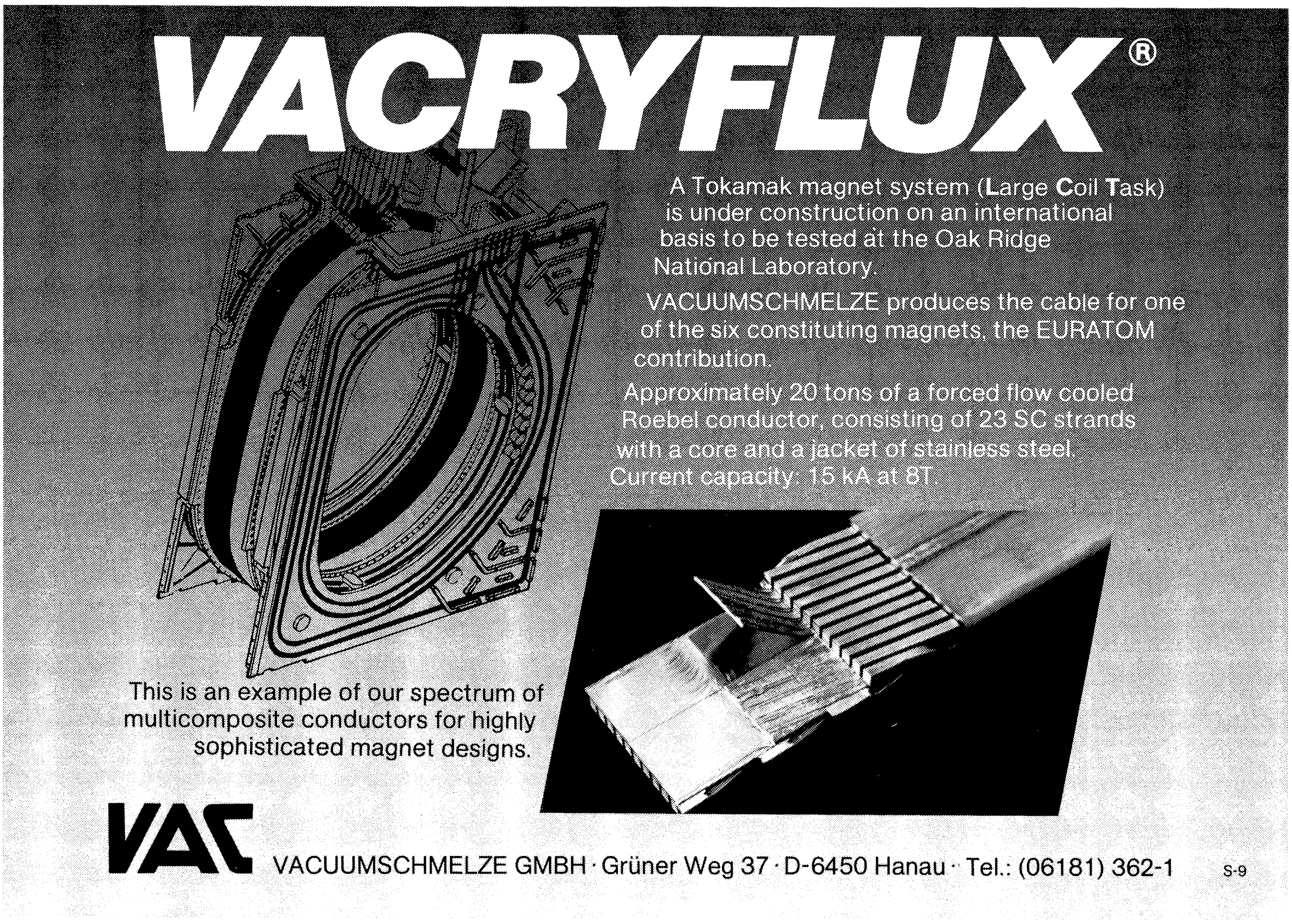

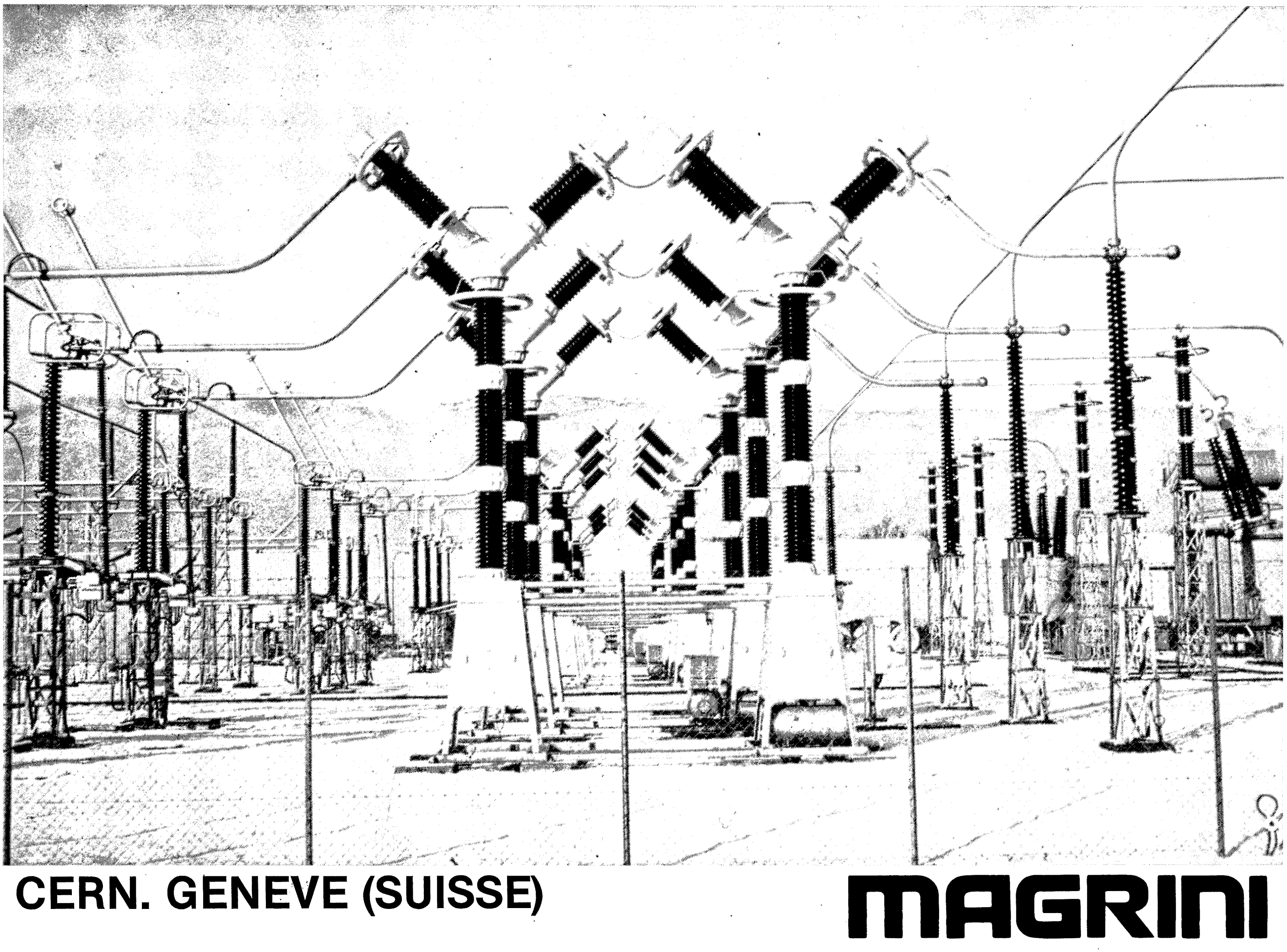

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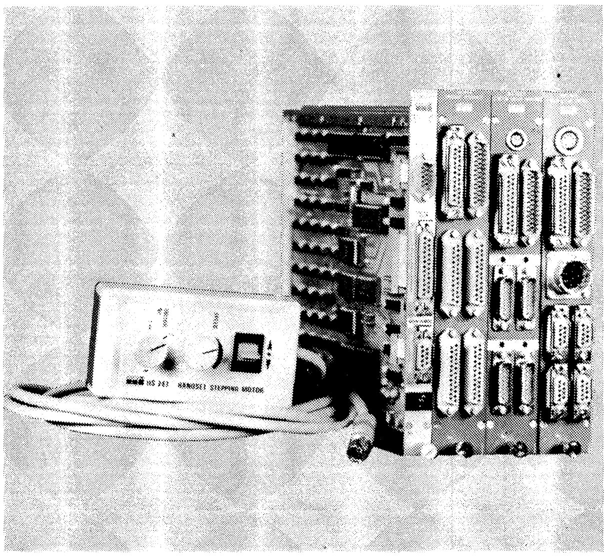

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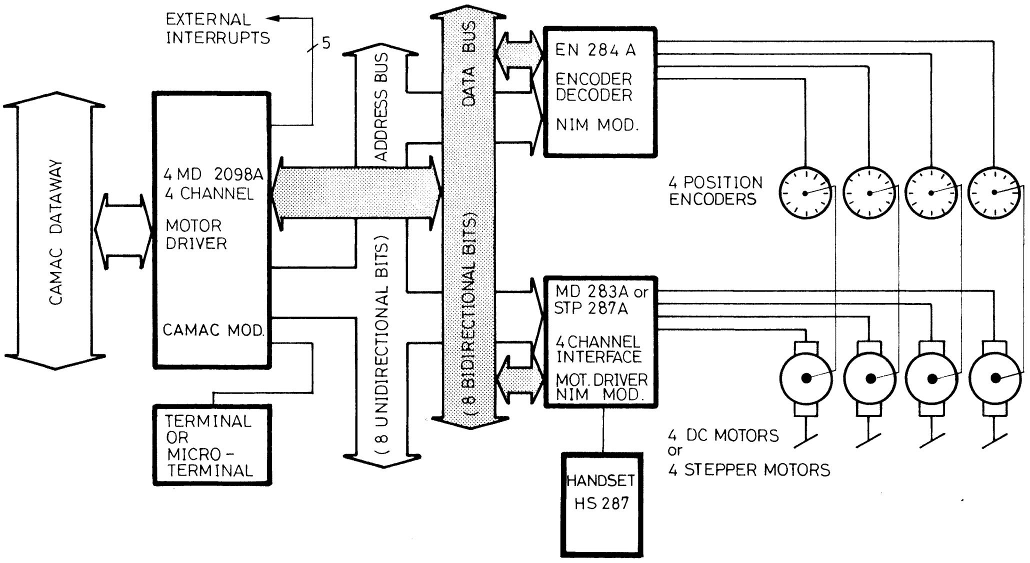

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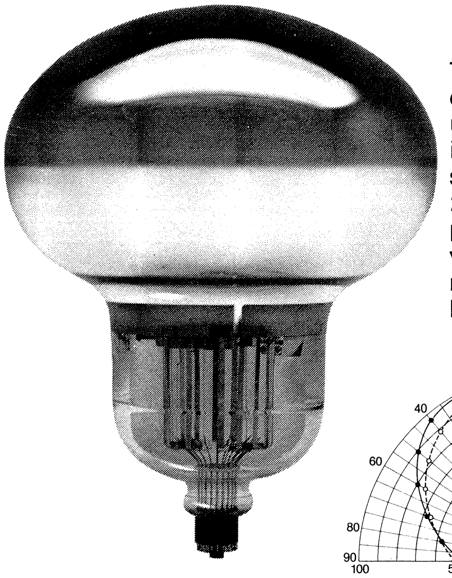

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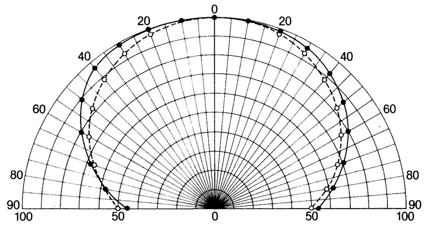

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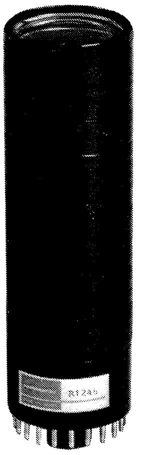

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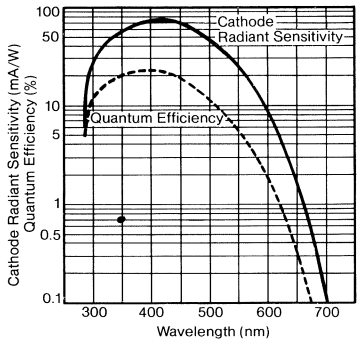

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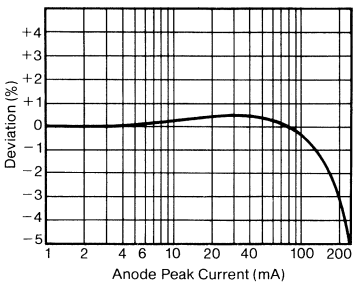

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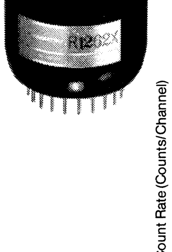

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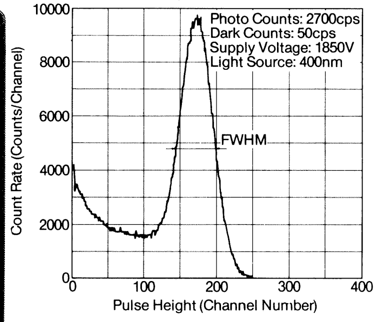

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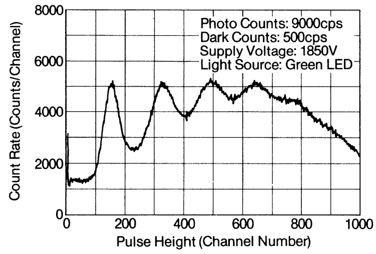

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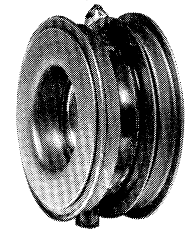

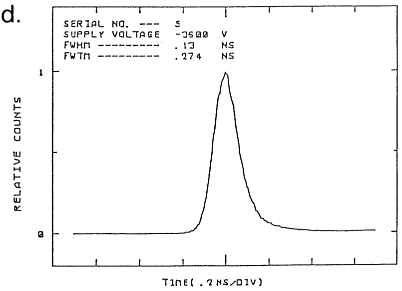

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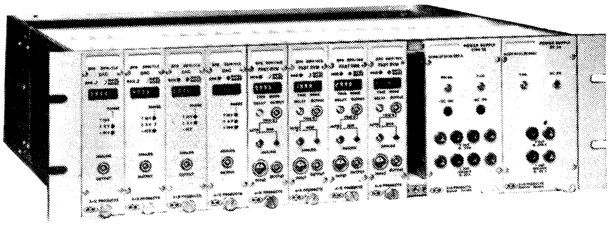

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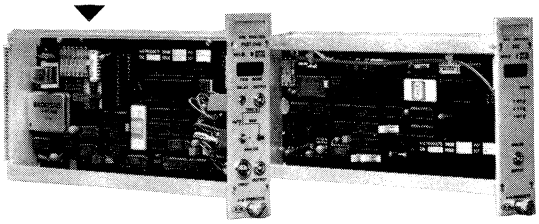

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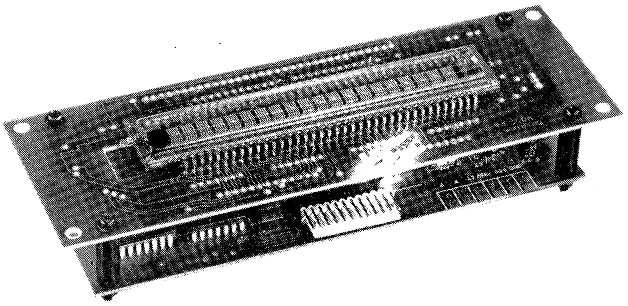

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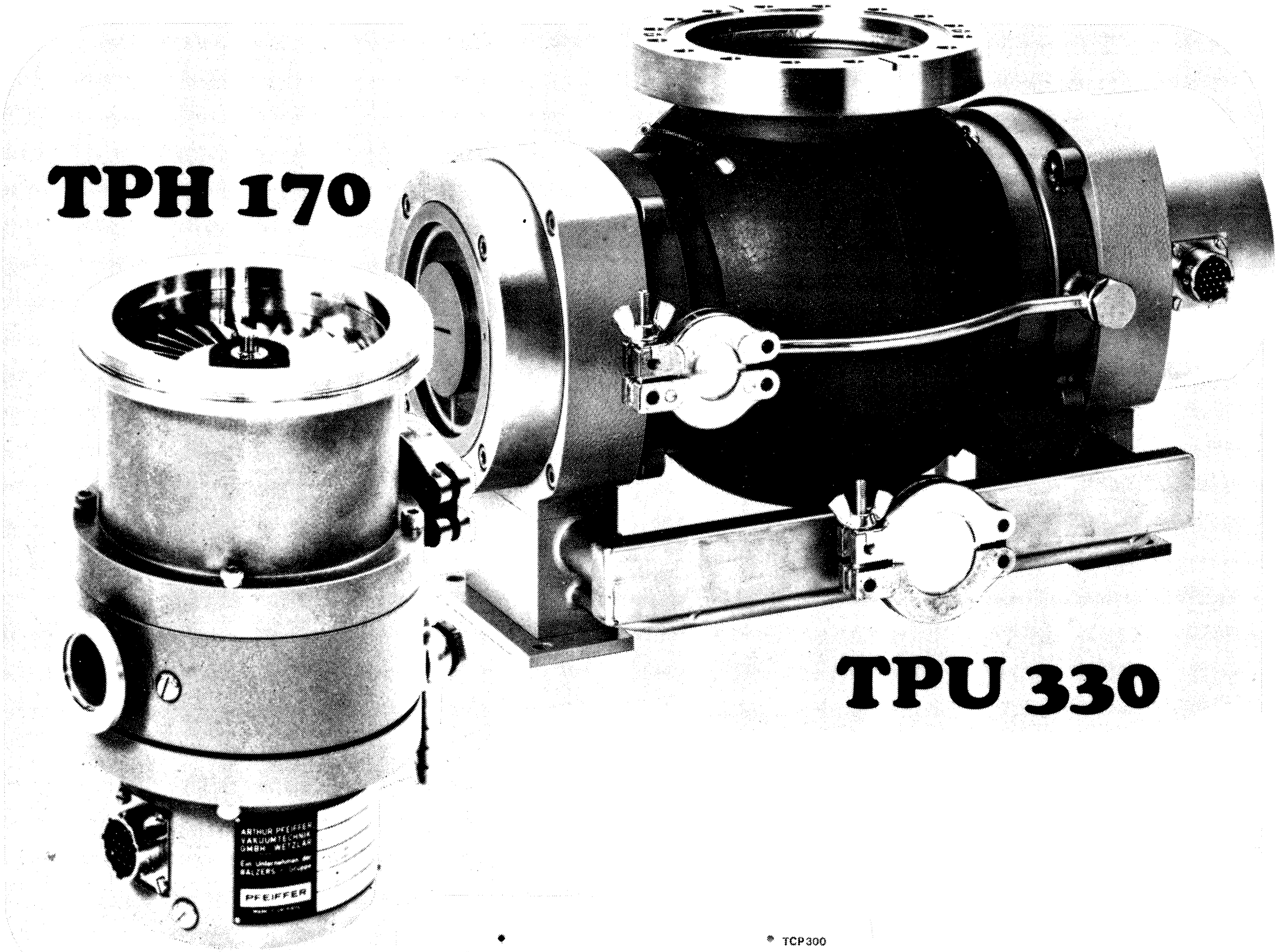

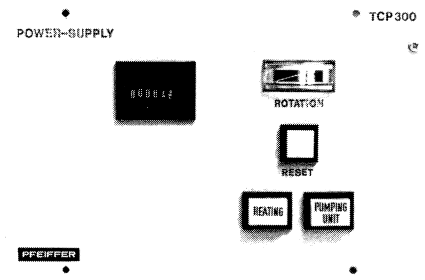

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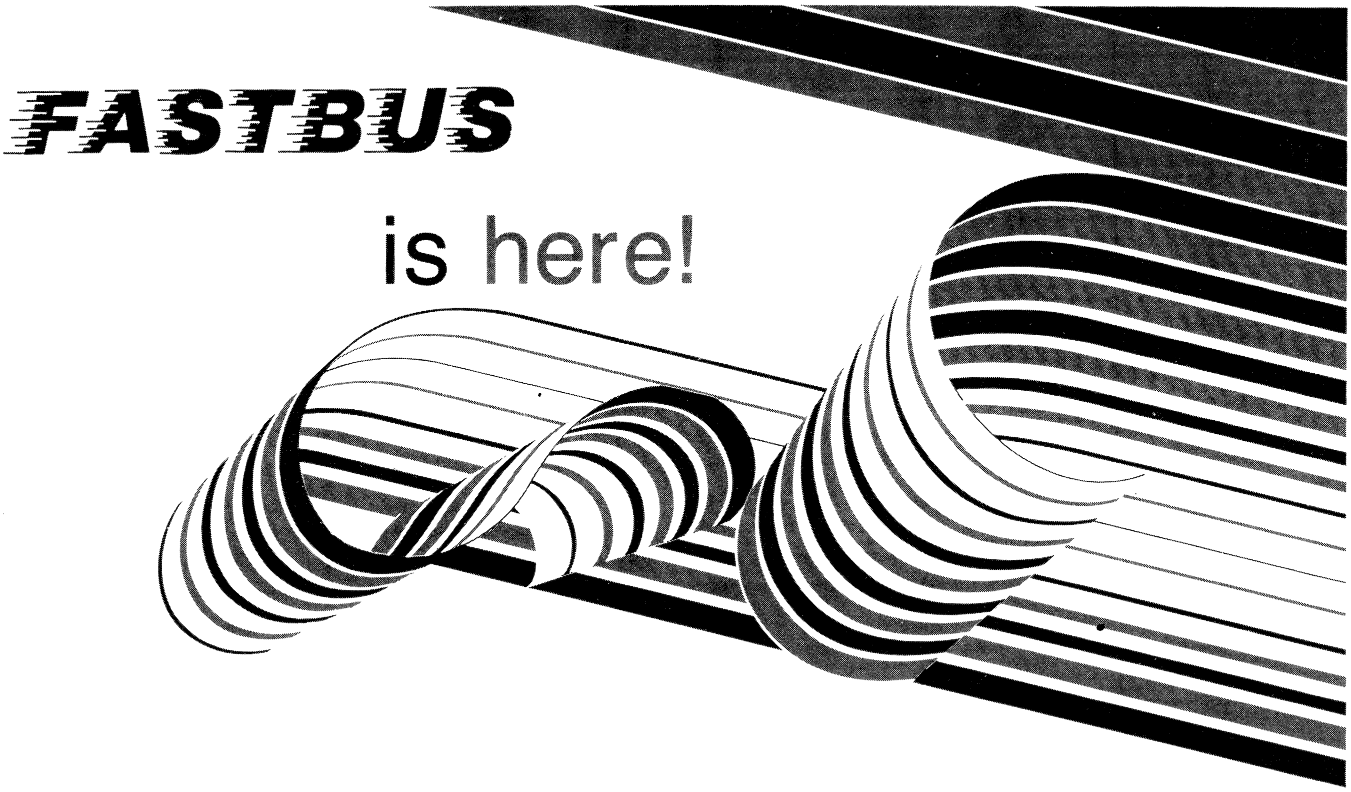

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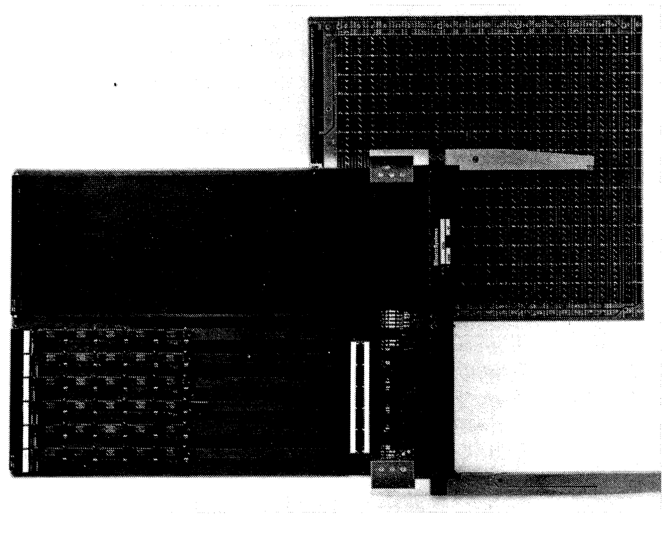

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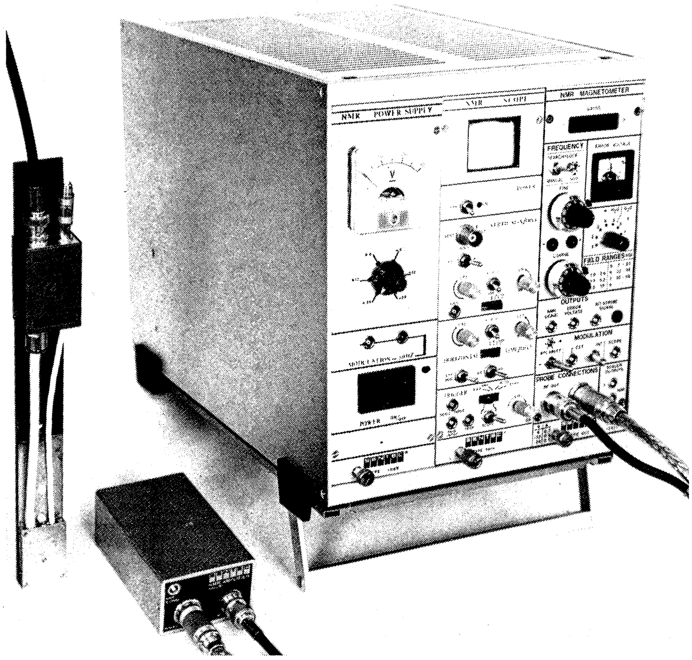

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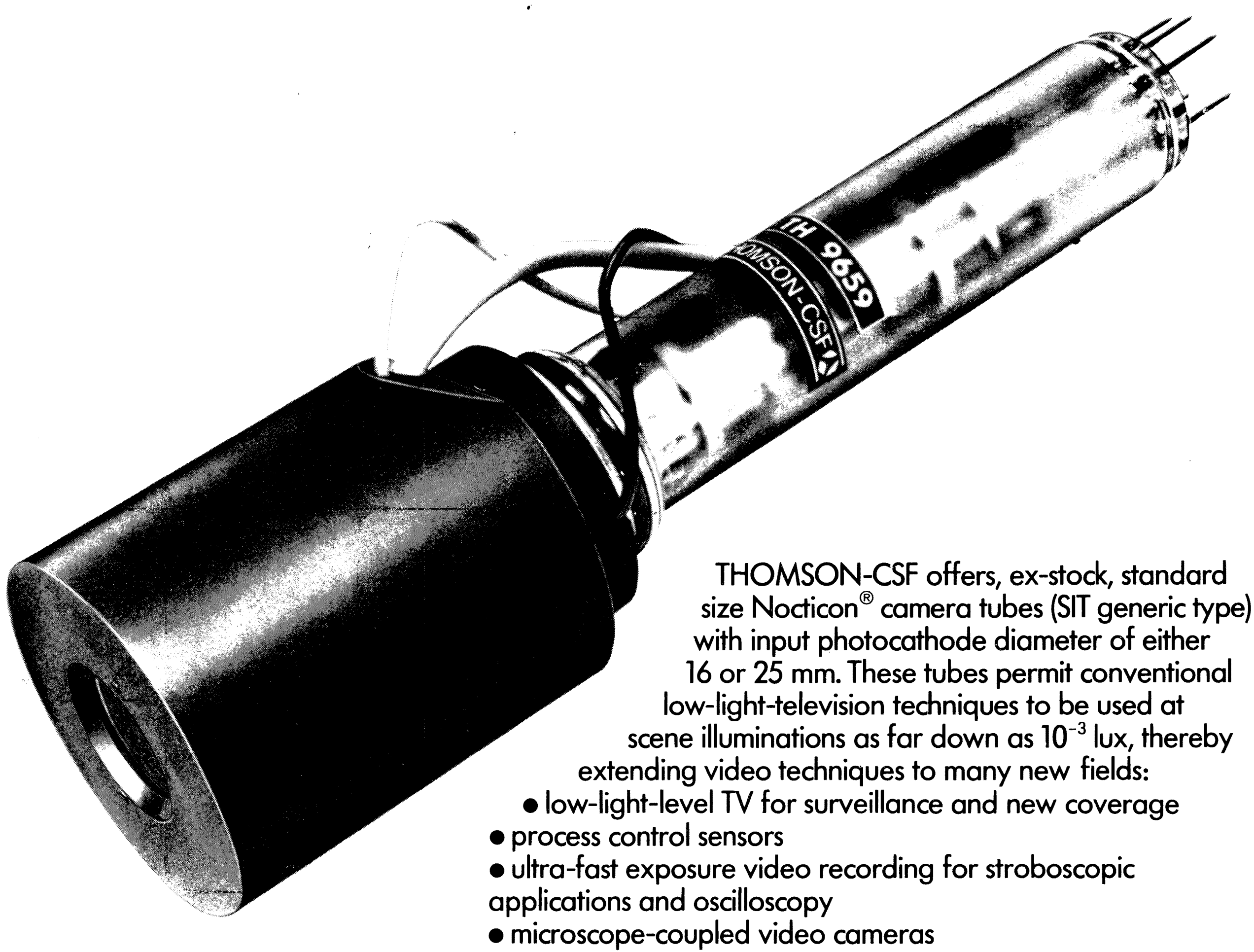
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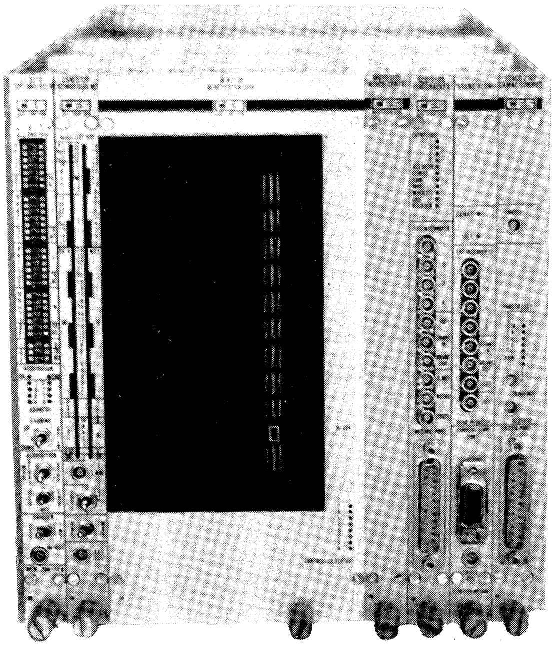
**-portable** The basic system (front-end processor) requires only one slot in any CAMAC crate; the largest system (multi-user remote work station) requires only twelve slots and can be delivered in a special mini-crate.The Crate controllers can be either A2,L2,NORD controllers or stand-alone computers like the STACC 2147 or STACC 2167.

**-easy to use** The processors can be used without any specialised knowledge.The test systems include EPROM resident NODAL, editors, graphic applications;the software for the front-end processors can be developed on and loaded from any host computer;the CERNET connection of the remote work station includes the WYLBUR bridge for job submission and the INDEX processor.

**-fail-safe** At any time you can switch between local resources and computer centre resources.Locally, up to 128KByte are available for program development with floppy disc and Winchester disc connection.Program and/or data back-up can be executed locally on the Winchester disk or remotely on the host.A high speed (70ns) dual port memory structure enables transfers of data/programs to the host computers through the portable CERNET connection at the maximum network speed. These two modes of operation-local developement and local execution of programs compiled on the hosts-render the system extremely versatile.

## Configurations

| | | |
|---|---|---|
| Stand-Alone test systems: | | |
| STACC | 2147 | TMS9900 based CAMAC computer |
| STACC | 2167/105 | TMS99105 based CAMAC computer |
| STACC | 2167/110 | TMS99110 based CAMAC computer |
| WIN | 2130 | 5 Mbyte fixed Winchester disk |
| WCTR | 2131 | Winchester controller |
| WIN | 2132 | 5 Mbyte removable Winch. disk |
| CPC | 4110 | 12-slot minicrate |
| D-450 | | graphic console |
| Front-end processors: | | |
| ACC | 2160/105 | TMS99105 based aux. crate ctr. |
| ACC | 2160/110 | TMS99110 based aux. crate ctr. |
| Portable CERNET interface: | | |
| Sender/Receiver | | network driver |
| ACC | 2160/105 | single-user interface |
| STACC | 2167/105 | multi-user interface |



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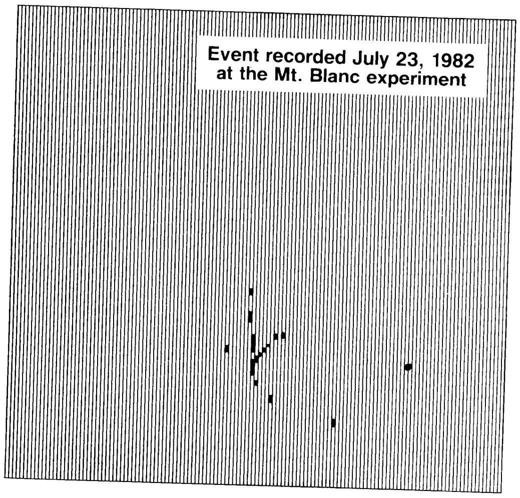
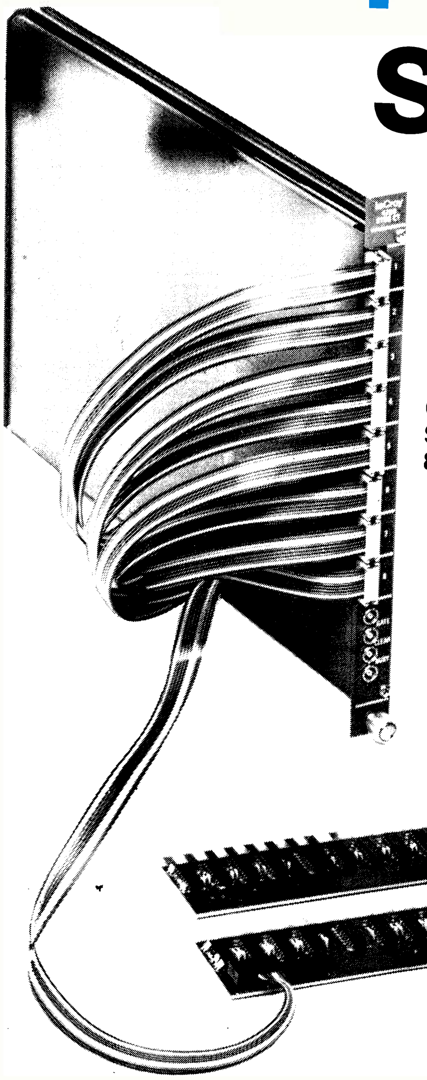
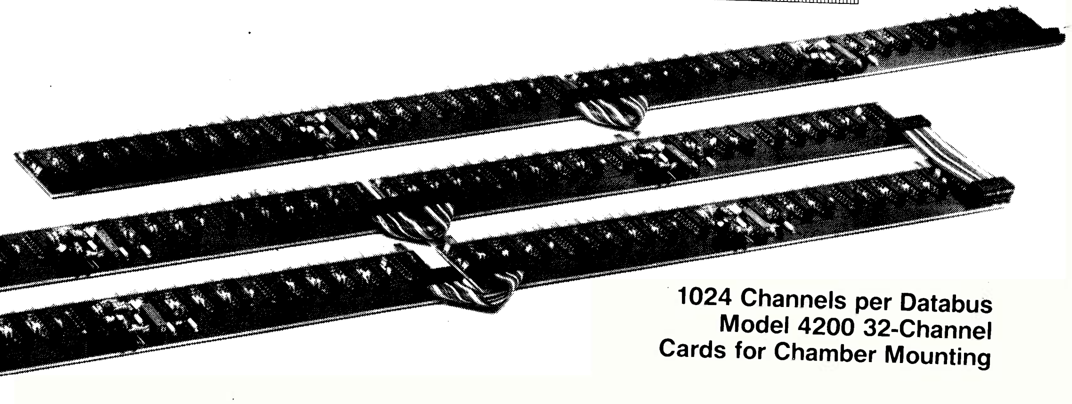
# The Streamer Tube Operating System

# STOS


Event recorded July 23, 1982
at the Mt. Blanc experiment


CAMAC Model 4700
STOS Controller
8192 Channels


1024 Channels per Databus
Model 4200 32-Channel
Cards for Chamber Mounting

**LeCroy Research Systems has designed and built the complete readout electronics for the Mont Blanc Proton Decay Experiment consisting of more than 100,000 channels of streamer tube electronics.**

LeCroy's Streamer Tube Operating System (STOS) consists of amplifiers, discriminators, and temporary data storage in a chamber-mounting package, plus a CAMAC readout controller. The system achieves low cost per channel plus high reliability through the use of custom-built monolithic circuits. It offers diode-protected inputs and prompt OR's compatible with trigger logic requirements.

The Mont Blanc experiment demonstrates that STOS is a viable solution to the demanding price and reliability requirements of large scale Streamer Tube Readout. More than 150,000 channels of STOS have been supplied to the proton decay experiment, CERN, DESY, and others at unprecedented low prices.

The next generation of gas tube detector electronics, permitting more advanced performance at even lower cost, is presently in design. For more information on these systems, call or contact your nearest LeCroy Sales Office.

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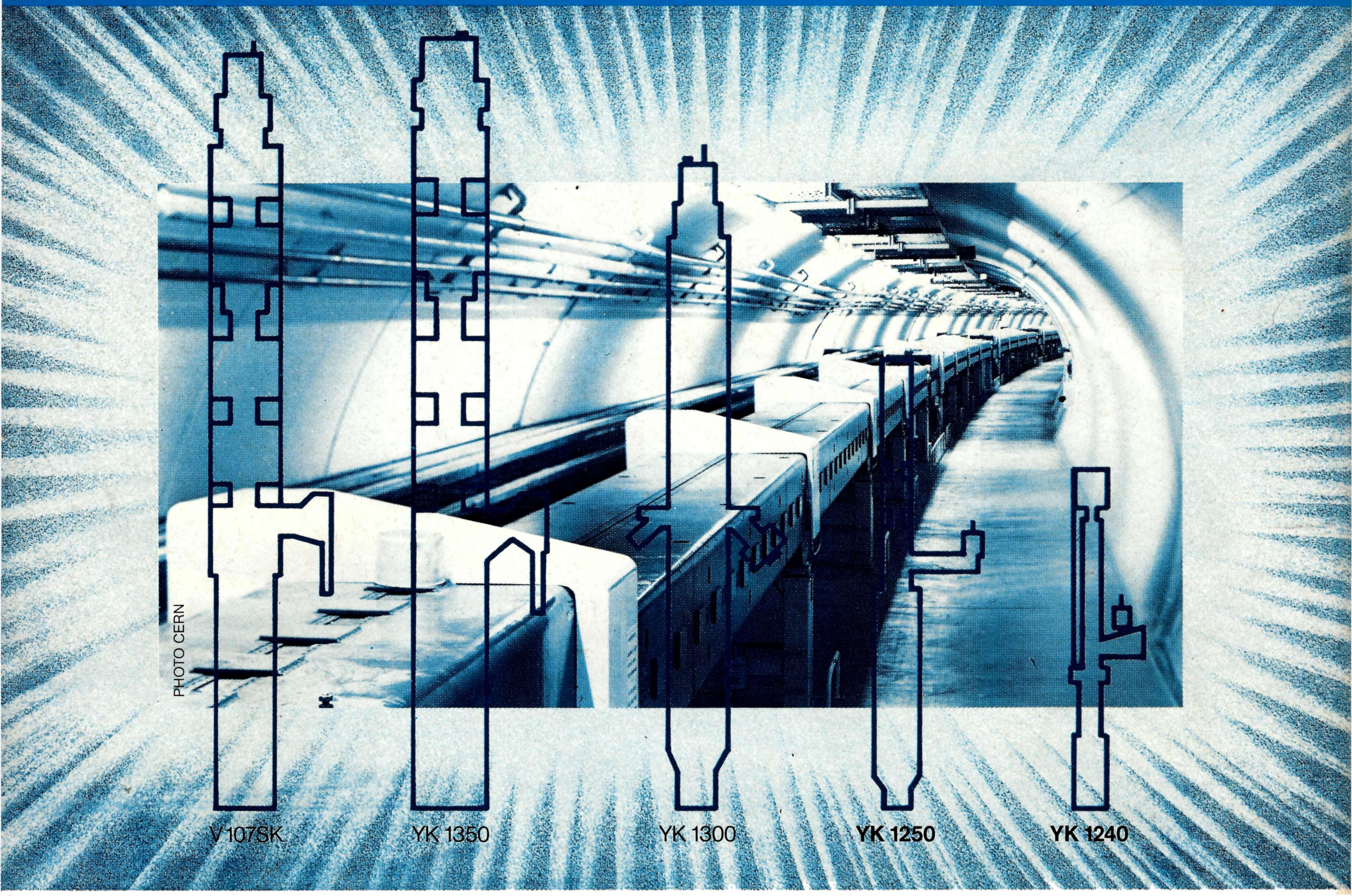

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