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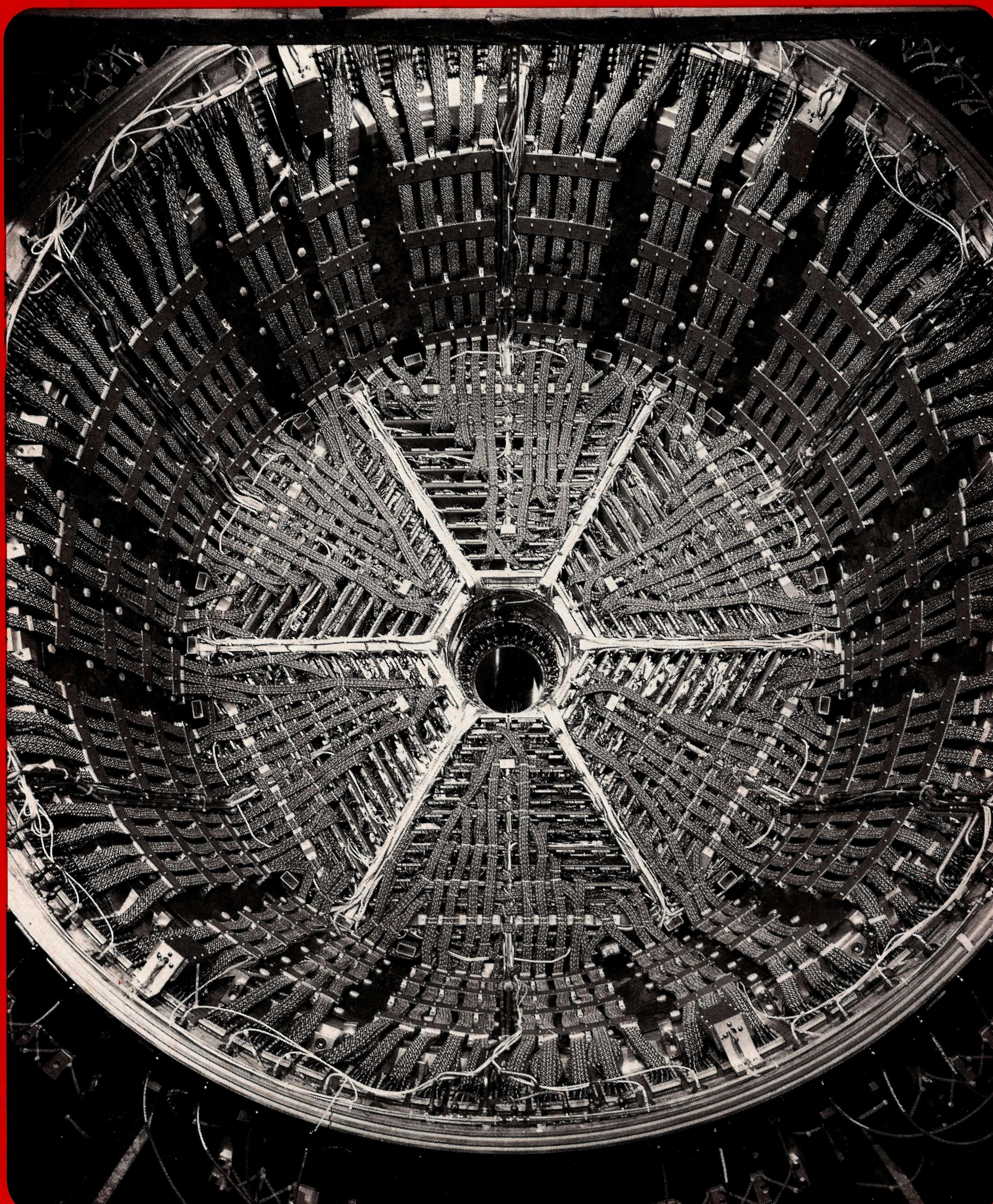

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Cover photograph: End view of the Time Projection Chamber detector recently installed in the PEP electron-positron ring at SLAC — see April issue, page 98 (Photo LBL).

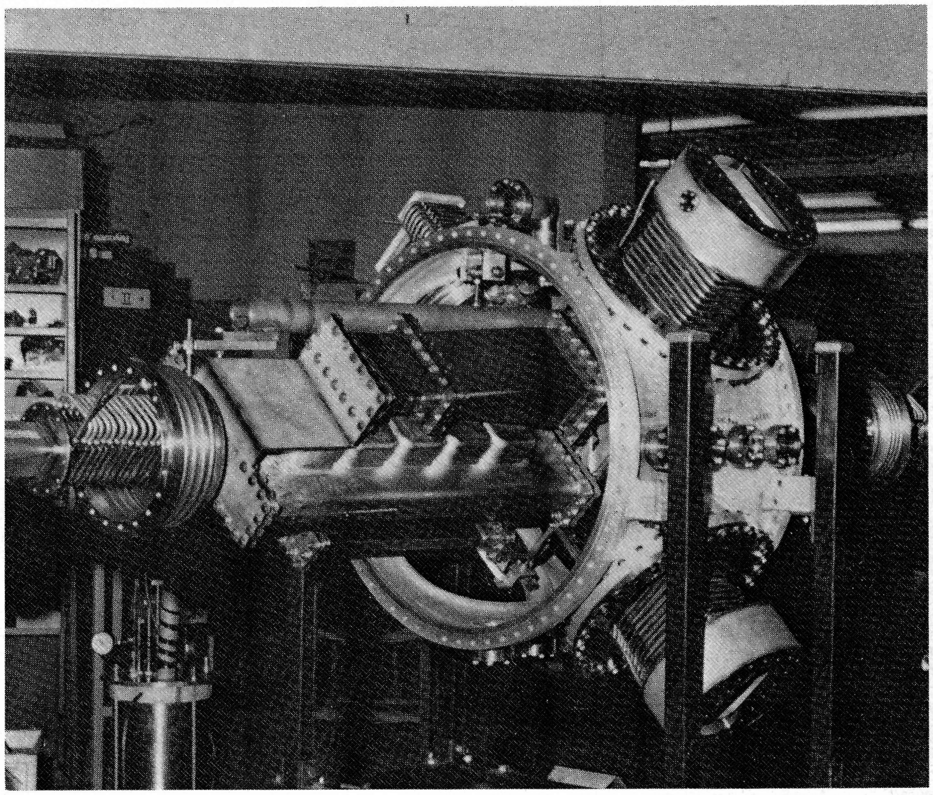
Around the Laboratories

CORNELL / DESY
Superconducting r.f. successes

Following our story last month on the development work going on throughout the world for superconducting radiofrequency (r.f.) accelerating cavities (May issue, page 137), successful tests have been made with prototype cavities at both the CESR electron-positron ring at Cornell and the PETRA ring at DESY.

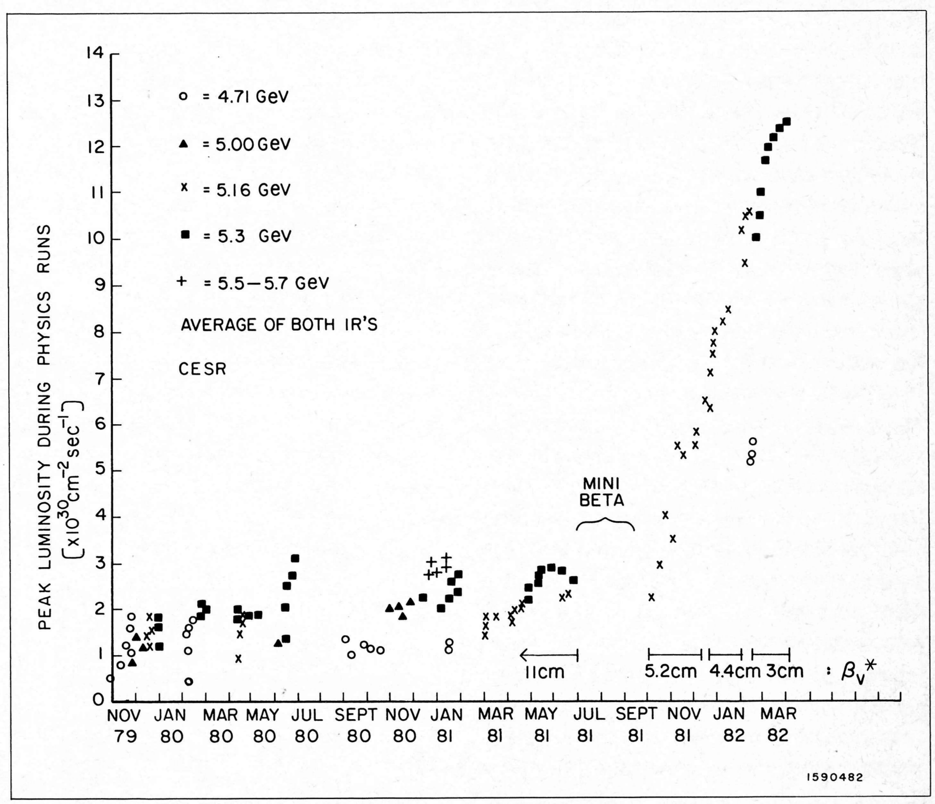
On 18 April, beam was stored in CESR with a prototype superconducting r.f. cavity designed with the proposed CESR II ring in mind. This was the first time that a superconducting cavity had been operated successfully in an electron storage ring. The test 1.5 GHz cavity consisted of two modules, each with five 'muffin-tin' type cells, made from stamped niobium welded together. These were mounted in a shortened version of the cryostat designed for CESR II. The accelerating field gradient under fully beam loaded conditions was 1.8 MV per metre, with an unloaded Q (resonance) factor of 10^9.

By itself, the cavity was able to capture and store a beam of 7.4 mA without instability, twice what would be required in CESR II. With the aid of the normal cavity, a beam of 12 mA was stored. Both runs were at 3.5 GeV, a low energy chosen to emphasize any instabilities that might occur. The beam-induced higher mode power extracted from the cavities was measured and found to agree



The prototype superconducting r.f. accelerating cavity modules developed at Cornell for the proposed CESR II ring, seen here in a test assembly inside a section of the liquid helium vessel prior to final installation.

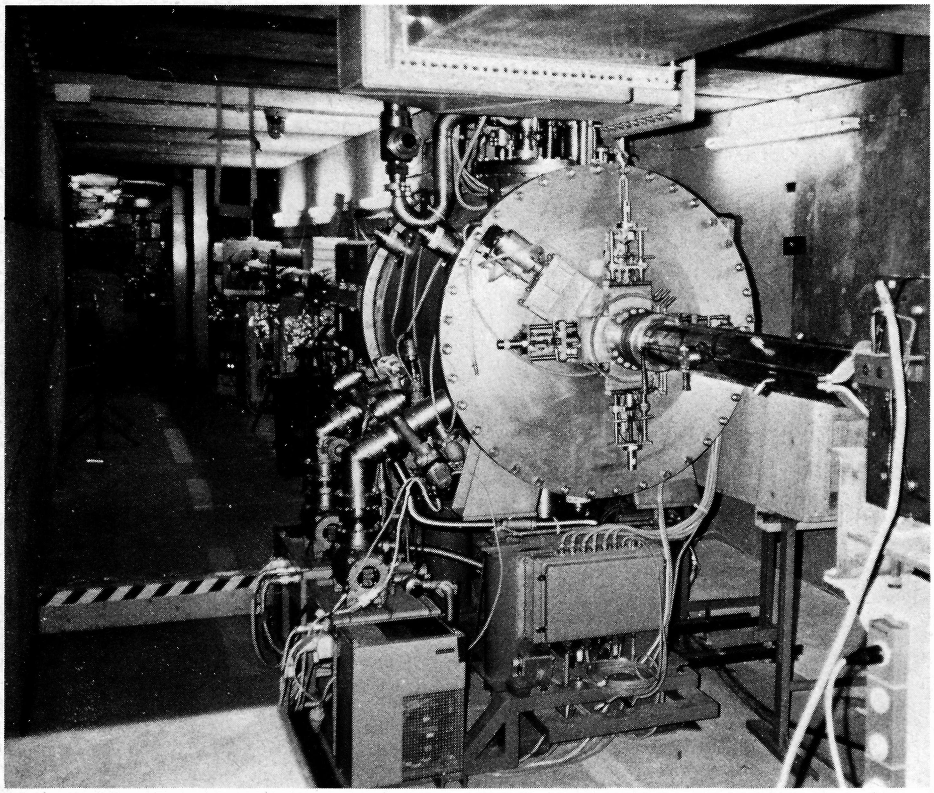
(Photo Cornell)



While tests of prototype superconducting r.f. cavities go on, the luminosity of the existing CESR ring continues to improve. After the installation last summer of mini-beta sections to squeeze to beams, the peak luminosity has been increased now by a factor of four. This is the result of a series of three tighter focusing lattices.

The superconducting r.f. cavity built at Karlsruhe (in collaboration with CERN and DESY) installed in the PETRA ring at DESY. It was successfully tested in the ring at the end of April.

(Photo DESY)



with calculations. As designed, no significant load was placed on the helium refrigerator by these beam-induced higher modes. In another experiment at 5.2 GeV, 10 kW of 1.5 GHz power was coupled to the beam through the superconducting cavity with no adverse effects on the field or heat load levels.

Although the test performed as expected, the test suffered from a few minor difficulties. The accelerating field gradient was limited by manufacturing defects in two of the cells. In addition, a few initial cryogenics problems had to be overcome.

The test demonstrated that these cavities can handle the required fundamental and higher mode power and store a high current electron-positron storage ring beam. The cavities themselves were made by the inexpensive stamping and welding techniques designed for mass production for CESR II. The cryogenic system also has many of the features necessary for operation in a higher energy machine.

Meanwhile at DESY, a 5 GeV electron beam was stored for the first time in the PETRA ring on 27 April, using only one single-cell superconducting cavity. During the subsequent tests, a beam current of 340 microamps in a single bunch was reached and 2 mA were stored in eight bunches, corresponding to a total of 10^{11} electrons.

The superconducting cavity had been built at the Kernforschungszentrum Karlsruhe (KfK) in a collaboration with CERN and DESY. The cylindrical cavity is 26 cm long and 46.6 cm in diameter. It is made of niobium and cooled with liquid helium. It was powered by one of the standard PETRA klystrons with a frequency of 500 MHz. The accelerating field was 2.3 MV/m and could be maintained without difficulty for many hours. The highest value observed was 2.8 MV/m. The Q-value of the cavity was 8.4×10^8.

After this successful start, some other investigations were scheduled. The spectrum of the higher order modes coupled out from the cavity in the presence of a 7 GeV high current beam were to be measured, together with the accelerating field gradient with a 17 GeV beam. Furthermore, the influence of synchrotron radiation on the accelerating field had to be studied introducing artificial orbit bumps.

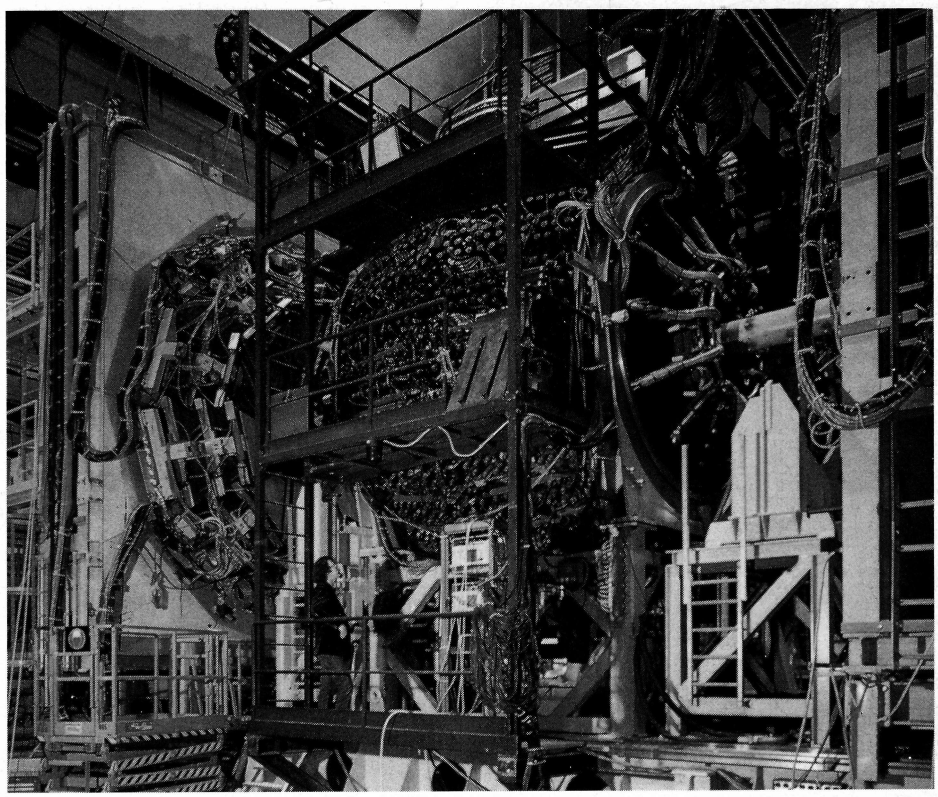
The main purpose of these studies is to provide information for realistic field operation of all components of the system. The manufacture of the cavity and in particular the delicate treatment of the internal surface is sufficiently developed that the fabrication of similar units in larger quantities can be envisaged with confidence. Most parts of the system, including the cryogenics, are designed with a view to bigger units in the future.

The experience gained will be very useful for new developments, in particular for LEP, where superconducting cavities are required to reach the highest energies. Already at PETRA substantial energy savings and better running conditions could be obtained by using superconducting cavities.

Later this year, more PETRA tests are planned, this time using a five-cell superconducting cavity being built at CERN.

CERN
More proton-antiproton results

First physics results are emerging from the UA2 experiment (Bern / CERN / Copenhagen / Orsay/Pavia/Saclay) to augment those already



The UA2 experiment at the CERN SPS proton-antiproton collider. First physics results are now emerging from data taken late last year.

(Photo CERN 293.3.82)

published from other proton-antiproton collision studies at the SPS synchrotron (see the January/February issue, page 3).

Late last year, the UA5 streamer chamber which produced direct visual records of the first 540 GeV total energy proton-antiproton collisions was removed to make way for the UA2 electronic detector, which took its first data before Christmas.

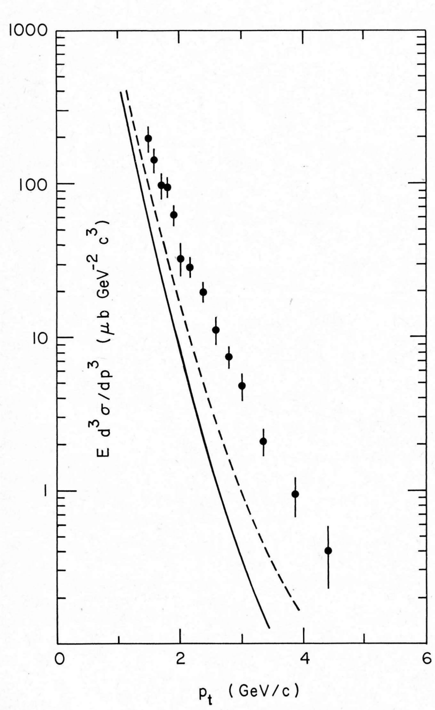
For these initial runs, a wedge had been removed from the central detector for installation of a single arm spectrometer to intercept particles produced at wide angles. It consists of a lead glass array preceded by a scintillator/iron hodoscope and a set of twelve drift chamber planes. It monitors the production of neutral pions (through their decay into photon pairs) in the high energy proton-antiproton collisions.

Such inclusive pion production has been extensively studied at the Intersecting Storage Rings, where it provided some of the first evidence for high transverse momentum reactions in proton-proton collisions. Its study at the much higher collision energies available in the SPS collider could provide useful information on the collisions between the proton constituents (quarks) which are responsible for these high transverse momentum reactions.

The observed photon pair spectrum (only pairs with a transverse momentum exceeding 1.4 GeV were retained) shows a clear neutral pion peak, together with a smooth background attributable to wrong pairings of photons. Imposing stricter conditions on the acceptance of photon pairs enables an eta meson signal to be picked up.

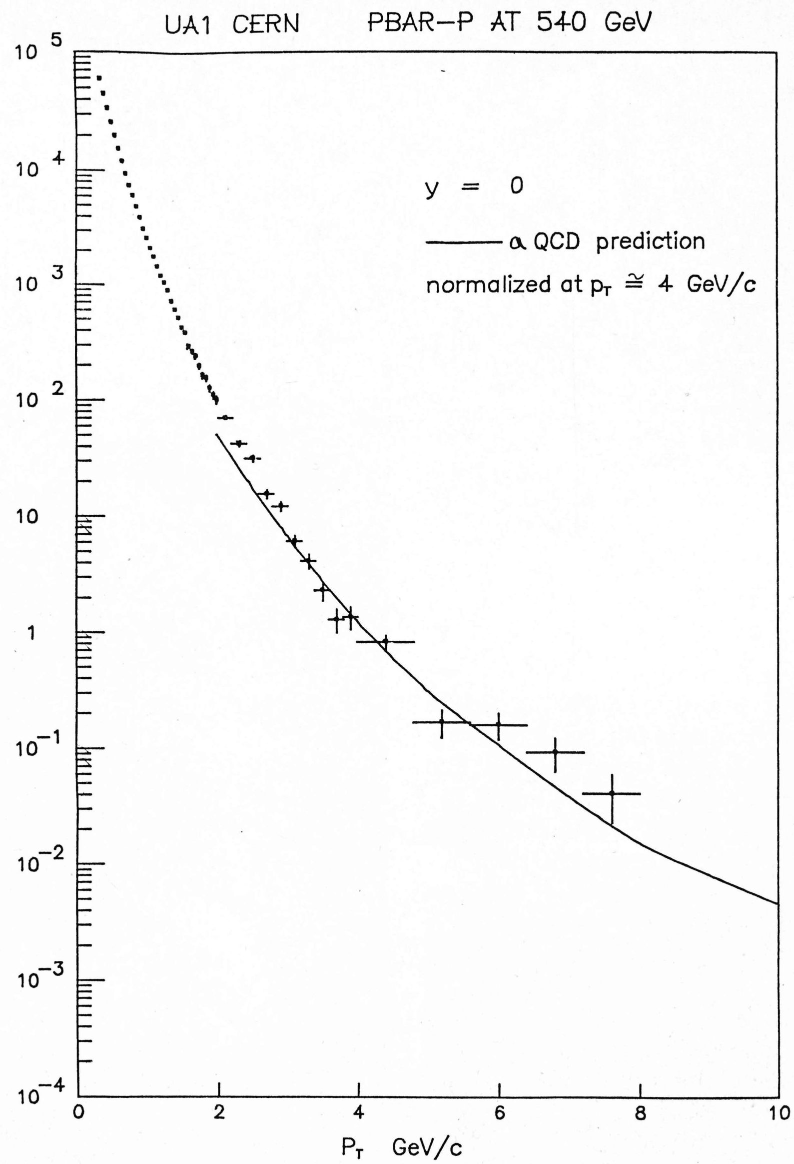
The calculation of the single pion production cross-sections also requires a knowledge of the detector acceptance and of the event rate (luminosity). The former was obtained through a Monte Carlo simulation and the latter from the rate of coincidences in small angle detectors, assuming a value of 38 mb for non-diffractive proton-antiproton scattering.

The results show how the production of single pions varies with transverse momentum. When compared with the results obtained at the ISR (53 GeV total collision energy), it is seen that the production for lower transverse momenta changes relatively little, despite the tenfold increase in collision energy, while production levels at higher transverse momenta increase more strongly.



The invariant cross-section for the production of high transverse momentum single neutral pions (data points) in 540 GeV proton-antiproton collisions as measured by the UA2 experiment. This is compared to the production levels seen at the CERN Intersecting Storage Rings at 53 GeV (solid line) and an extrapolation from ISR to SPS collider energy (dotted line).

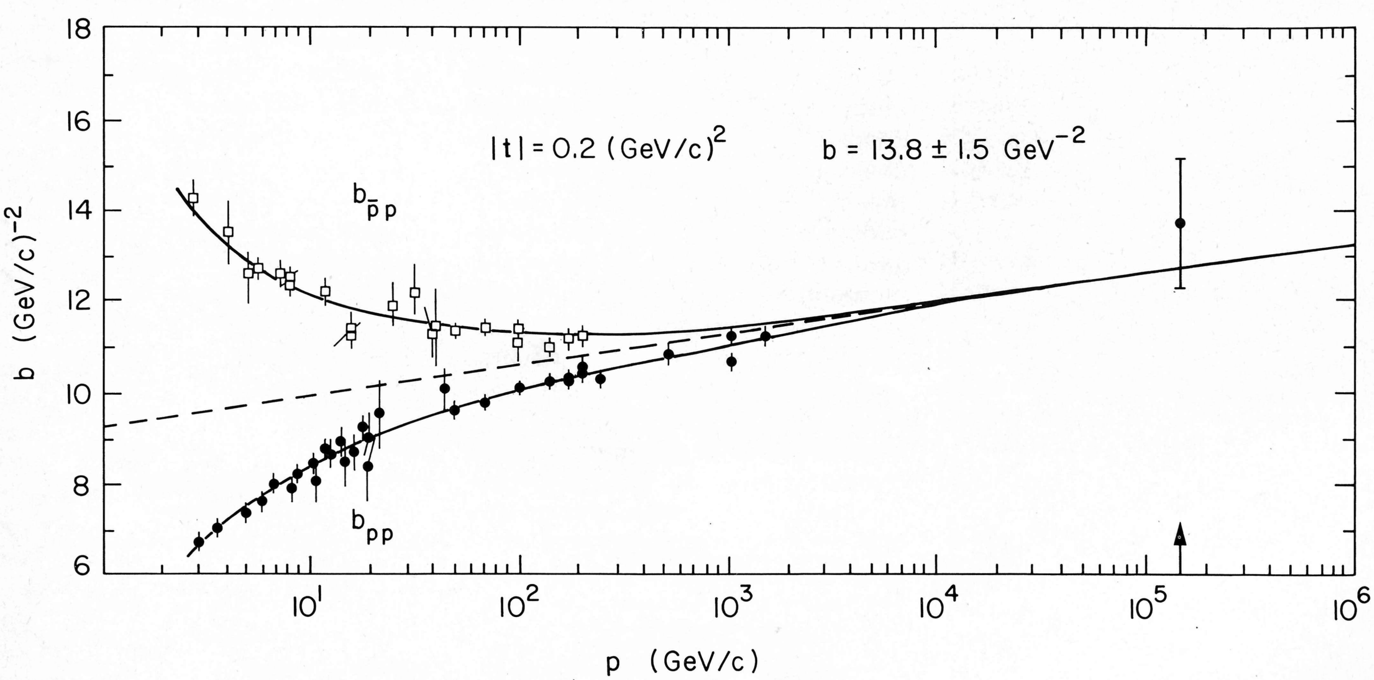
Spectrum of high transverse momentum single particle production in 540 GeV proton-antiproton collisions as measured by the UA1 detector at CERN. The curve superimposed on the data above 1 GeV transverse momentum comes from a quantum chromodynamics model including the classical inverse fourth power dependence of scattering between proton constituents (Rutherford scattering). The data indicate more an inverse fifth power dependence, which the additional mechanisms in the model successfully reproduce.



Assuming that the relative production levels of single pions and of eta mesons remains at the value seen at the ISR, the UA2 data indicates that single photon production (due to quark-gluon interactions) is not likely to exceed 7.5 per cent of the neutral pion signal.

Meanwhile some technical difficulties with the UA1 detector have led to a postponement of the first SPS antiproton run this year.

Proton-antiproton elastic scattering at 540 GeV total energy, as measured by the UA1 experiment at the CERN SPS proton-antiproton collider, can be usefully compared with data collected at lower energies. The 540 GeV behaviour corresponds to the lone point on the far right. (The horizontal scale is the effective beam momentum for a fixed target experiment.) The b parameter gives the shape of the elastic scattering spectrum, and is related to the effective 'size' of the colliding particles. Thus the proton (and antiproton) seems to be getting larger at these newly available energies.



Slowing down the antiproton pace

The antiproton project has so far concentrated on taking the particles stacked in the Antiproton Accumulator (AA) and accelerating them in the Proton Synchrotron (PS) to 26 GeV, ready for injection either to the big Super Proton Synchrotron (SPS), where they are taken to 270 GeV, or to the Intersecting Storage Rings (ISR) where so far they have been accelerated to 31 GeV, although eventually the plan is to cover a range of energies.

But CERN is preparing another powerful string for its antiproton bow. With LEAR (Low Energy Antiproton Ring), now nearing completion in the South Experimental Hall at the PS, the aim is to use intense beams of low energy antiprotons (energy range 0.1 to 2 GeV) to open up the study of nucleon-antinucleon interactions (see April 1981 issue, page 113).

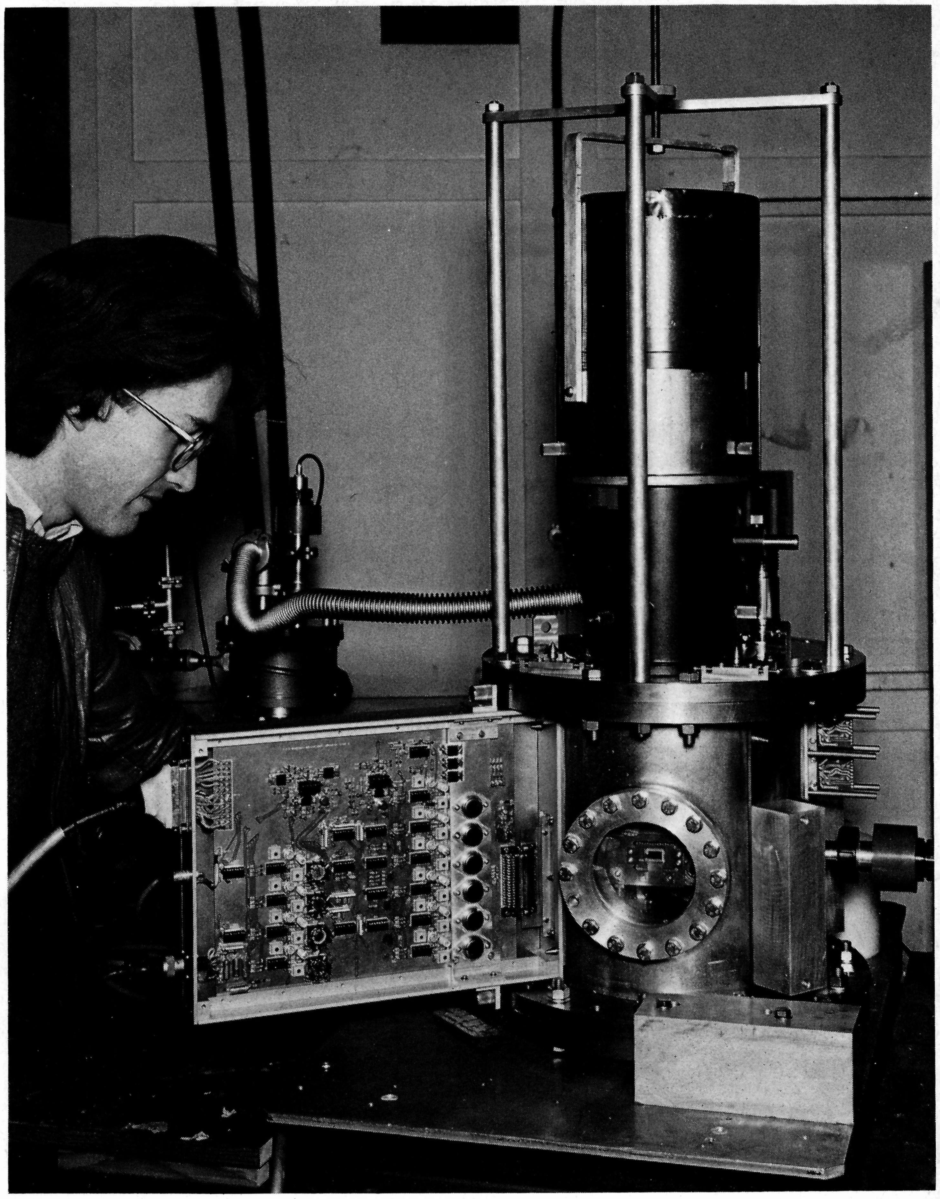
To supply LEAR, the PS will have to decelerate the antiprotons, which emerge from the AA at 3.5 GeV. After lengthy deceleration trials with protons from the PS Booster in April, the PS successfully decelerated antiprotons down to 0.64 GeV, about the energy required for LEAR.

While this was going on, the PS continued to supply particles to other users. The SPS, for example, received 3.3×10^{13} protons per PS 'supercycle' in two bursts for fixed target experiments at the same time as the antiprotons were being decelerated. This is accomplished thanks to the flexible PS operations system which enables different operating conditions to be assembled rapidly together into 'supercycles' catering for the various parallel requirements of PS customers.

Although this deceleration is another antiproton premiere, it is not the first time that the PS has decelerated particles. For tests with the ICE ring for beam cooling experiments, the PS has slowed protons right down to 46 MeV (see July/August 1979 issue, page 203), even slower than they emerge from the linac which feeds the PS.

These antiproton deceleration tests augur well for LEAR, which is scheduled to come into operation later this year and provide another aspect to CERN's unique programme of research using antiproton beams.

At the ISR, a record antiproton current of 3.84 mA and proton-antiproton luminosity of over 10^{27} cm^{-2} s^{-1} has been obtained.



The cryostat assembly which was installed on a test beam at CERN to investigate the possibility of using charge-coupled devices as particle detectors. The CCD can be seen through the vacuum window of the cryostat.

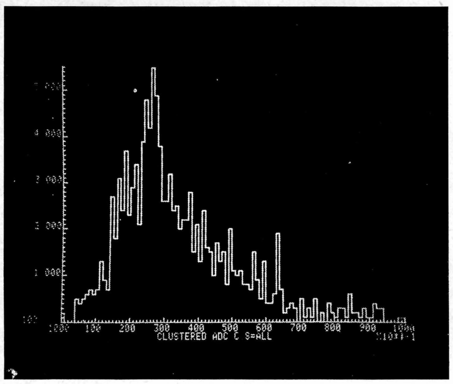
(Photo CERN 18.10.81)

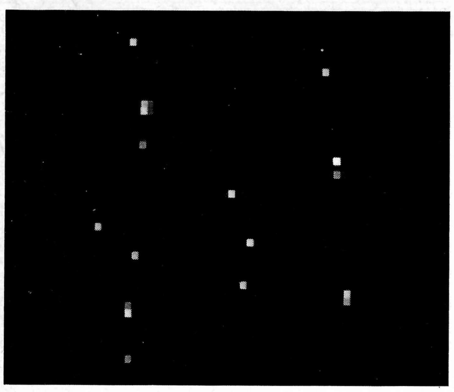
RUTHERFORD
Charge-coupled devices as detectors

It has been obvious for some time that two-dimensional charge-coupled devices (CCDs) have many interesting features which make it worth pursuing their development as detectors of high energy particles. Work on such detectors is under way at SLAC (in collaborations with Berkeley and Michigan) and at Rutherford. Arrays of CCDs could give very good precision (a few microns) in measuring track position and have excellent ability to distinguish between two tracks very close together. The main application of such detectors would be the reconstruction of secondary vertices from the decay of short-lived particles.

An important step towards realizing these abilities has been taken by the group from the Rutherford Laboratory, working in a test beam at CERN. An array of active area 1 cm^2 is positioned in a cryostat in the beam, along with conventional detectors. After putting approximately a thousand beam tracks through the

A pulse height distribution associated with the clusters of hits (usually 1 or 2 pixels) from the beam particles. The characteristic Landau distribution is well separated from the noise, which is in the first five bins (suppressed in the plot).





Magnified reconstruction of 1 mm² of the CCD detector. This area of detector has been traversed by fourteen beam tracks. The resolution with which two tracks can be separated is approximately 60 microns.

detector, the information recorded is read out via a flash ADC system. In these initial tests the pulse heights from all 250 000 pixels (picture elements) are recorded. By using low noise (25 electrons per pixel) analogue electronics the small signals from the beam tracks (about 800 electrons from the 10 micron depletion depth in the detector) become clearly visible.

The next steps will be to include more detectors in the cryostat, so that efficiency and spatial precision can be properly checked and to try some options for achieving very high speed readout. The results achieved so far are considered sufficiently encouraging to justify the manufacture of CCDs specifically tailored to particle detection.

BROOKHAVEN
New beamline in operation

In March, protons were transported to the polarized proton target (PPT) of an experiment by a Brookhaven / Michigan / Argonne / Miami / Copenhagen group, the first to be mounted in the new D line of the Alternating Gradient Synchrotron (AGS). The D beam is split from the A line by an electrostatic splitter followed by thin and then thick Lambertson septum magnets. This split was tested successfully one year ago. With the end of the slow extracted beam running last June, work began on D with construction of the 137-metre line which was completed for this running period. After being separated from the A line, the D beam is transported through a 21° bend formed by nine shimmed dipoles. Because of the gap size of 1½ inch for a vertical beam size of ¾ inch (roughly including 90 per cent of the beam), there was some apprehension as D was commissioned. One particular concern was removing a 45° tilt in the beam caused by horizontal field components in the Lambertson magnets which, unchanged, would scrape the beam in the bend string. All went well and the new beam was commissioned in one hour.

Plans for the D line are to run the PPT experiment this spring and part of next winter. It will then shut down to allow construction of further transport elements to bring the beam to the D target area. Next spring, experiments by Bell / Brookhaven / William & Mary / G. Mason / Virginia State (E754) and Columbia / CERN (E745) groups will begin, using a muon beam from the D target. In addition, two double-arm polarimeters will be constructed this year upstream of the PPT experiment. The polarimeters will be tuned next winter, and will use the results of the present PPT experiment on the analysing power of elastic proton-proton scattering to monitor the polarization of the circulating beam when the AGS accelerates polarized protons, scheduled for later next year.

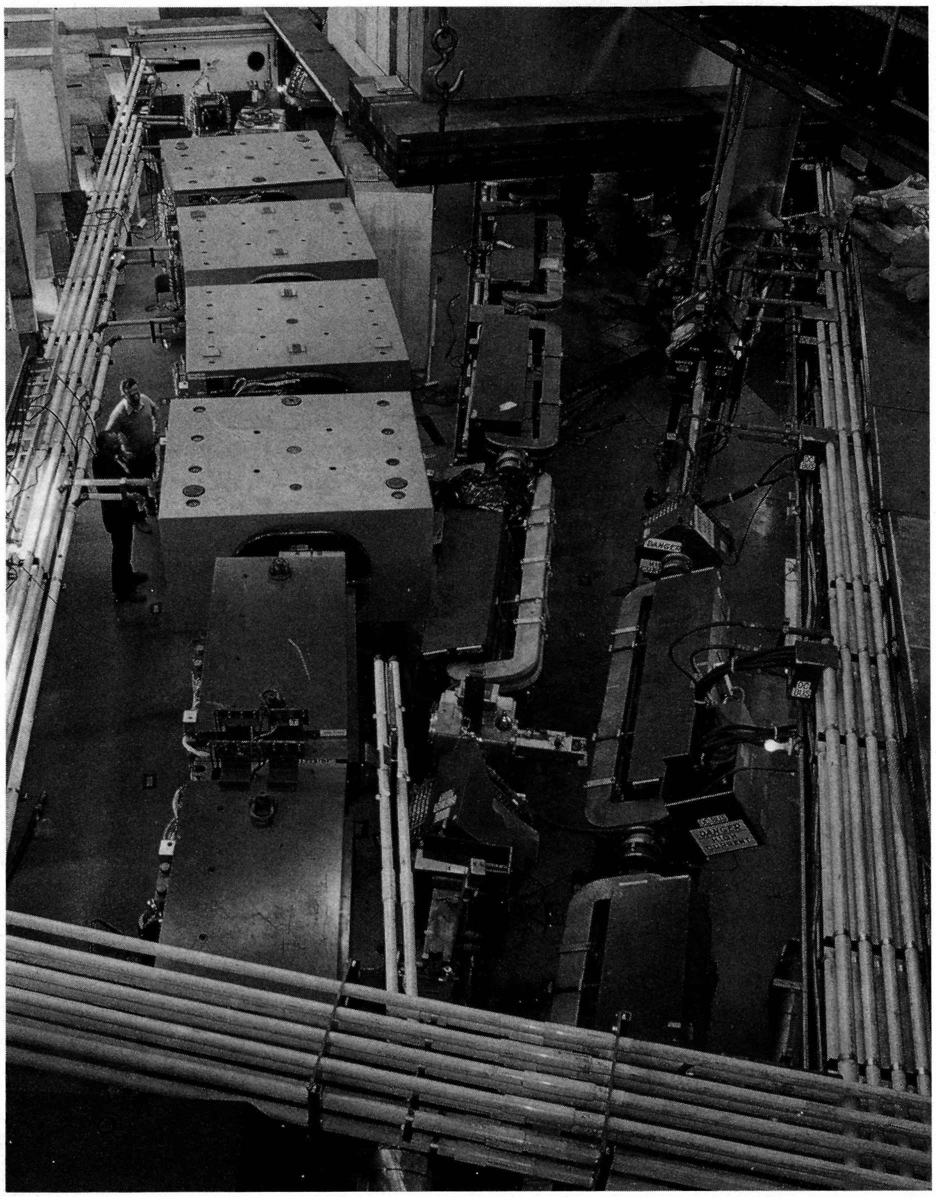
For the future, the construction of a small angle, high intensity kaon beam in the D line is being considered. The North Hall extends an additional 45 metres downstream from the D target, leaving room for one or more new beams. Proposals are welcomed.

The physics topics to be explored by present experiments in D include spin dependence of strong interactions at high transverse momentum, a sensitive quantum electrodynamics test on vacuum polarization, and materials studies using muon spin resonance. The initial PPT experiment will measure proton-proton elastic analysing power with an unpolarized beam on a polarized target. When the polarized beam becomes available next year, the experimenters plan to measure spin-spin correlations. Previous experiments at the Argonne ZGS observed the remarkable result that at large transverse momentum, the reaction rates for particles with parallel spins were four times larger than those for particles with antiparallel spins. This has been a difficult challenge for theory. The Brookhaven experiments will cover a considerably extended range of energy and transverse momentum.

The quantum electrodynamics experiment (E745) will measure the transition energy between higher angular momentum states of muonic helium. Using these states avoids uncertainty in the knowledge of the charge radius of helium and should allow an order of magnitude improvement in vacuum polarization tests of quantum electrodynamics. The experimenters will stop ten-nanosecond pulses of negative muons in helium, induce transitions with a CO_2 laser during the fast initial cascade (lifetimes are 10^{-11} seconds), and detect the transitions by monitoring the emission of X-rays. The experiment will use one of the twelve AGS bunches, kicked out to the extraction channel by a second fast kicker magnet. The remaining eleven bunches will go to the neutrino area. The muon spin resonance group (E754) will use the same muon channel during slow extracted beam running.

Call for proposals

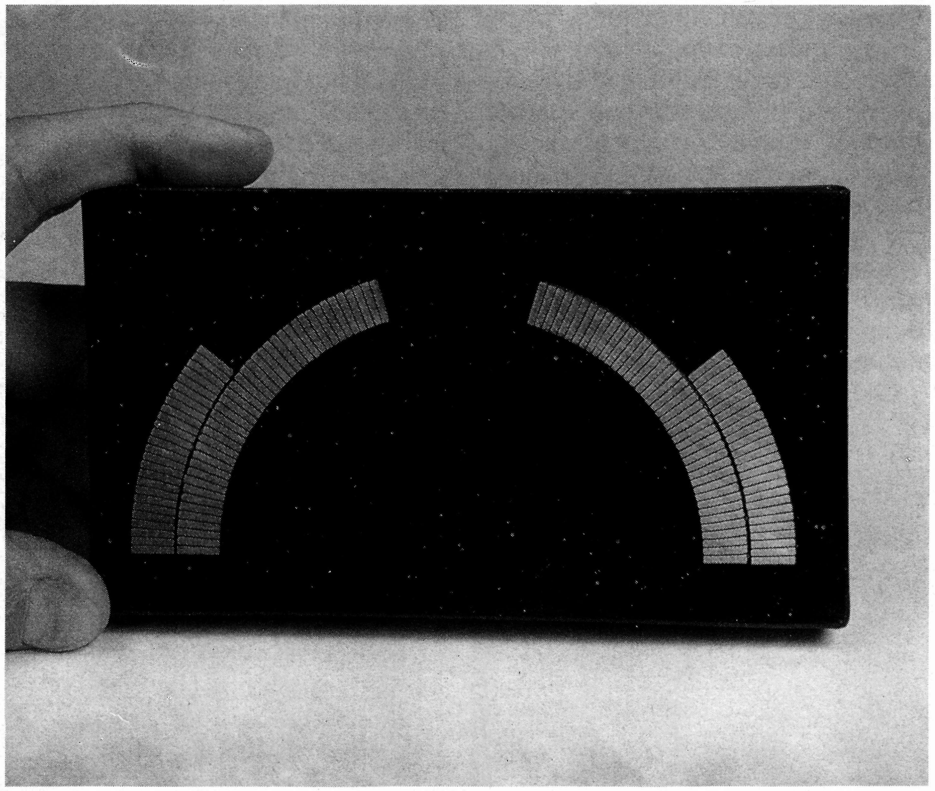
Brookhaven has issued a call for proposals to use polarized proton beams at the AGS. Polarized protons with energies up to 26 GeV can be extracted into several experimental areas. Beam intensities of $10^{10}-10^{11}$ protons per pulse are expected. For further information about experimental facilities, contact Derek Lowenstein, 911B, Brookhaven National Laboratory, Upton, New York 11973, USA. Guidelines for preparing proposals may be obtained from Neil Baggett, 510F. The next meeting of the Brookhaven High Energy Advisory Committee will be held in September or October. To be considered at this meeting, proposals should reach Brookhaven by mid-August. Polarized proton beams are expected to be available in late 1983 or early 1984.



The ring of the Brookhaven AGS at the point where most of the beams are extracted. The beamline nearest the main ring is the new D line serving the polarized proton target. To the right is the older line which downstream splits into beams serving the East Experimental Area.

(Photo Brookhaven)

A model of the cross-section of the new niobium-tin superconducting dipole magnets being developed at Saclay for the proposed Soviet UNK machine, showing the two-layer structure of the coil.



SACLAY
Prototype niobium-tin superconducting dipole

The Département de Physique des Particules Elémentaires at Saclay has for some time been working with the Institute of High Energy Physics at Serpukhov to develop superconducting magnets for use in the Soviet UNK project for a 3000 GeV proton accelerator. Now a prototype niobium-tin dipole has been successfully tested.

This magnet has the same configuration as previous UNK dipoles built at Saclay, with a 90 mm aperture and length 70 cm. In this way, the existing tooling and other equipment can be used. However on imposing such a geometry, in particular the thickness of the coil, the attainable central field is limited to 6 T. This is relatively low, but the main objective was rather to develop appropriate technologies for handling the delicate niobium-tin rather than aiming right away for higher fields. Under the same conditions, niobium-titanium prototypes had reached 4.5 T.

The filamentary niobium-tin composites have to be heat treated for a day at about 700 C, which makes them very brittle. Thus for the prototype dipole, this heat treatment was carried out after winding the coil. First tests gave a central field of 5.3 T and a current of 5550 A. During these tests, the protection systems unfortunately did not allow this value to be exceeded, even though the dipole looks capable of reaching 6 T. More tests are scheduled, but already the experience gained shows that dipoles could be built capable of attaining 8-10 T.

Making history

From 21-23 July in Paris, just before this year's International Conference on High Energy Physics, an unusual meeting—the International Colloquium on the History of Particle Physics—is to be held. Its aim is to survey what happened in the field from the 1930s to the 1950s, with first hand accounts from physicists who made significant contributions during this time.

Any history of this period has to be dominated by the shadow of the Second World War, and particle physics is no exception. The spectacular pace of developments, in experimental discovery and techniques and in the underlying theory, of the early thirties soon began to slow under the weight of economic depression and the gathering clouds of war. Large scale research did not get under way again until the late 1940s.

But when physics did resume, it was soon to benefit from the immense investments made in scientific (particularly nuclear) projects during the war years. The era of Big Science had begun.

The 1930s marked the beginning of particle physics as we know it today. Just fifty years ago this year, the positron was discovered (see May issue, page 143). This confirmed Dirac's prediction of the parallel existence of matter and antimatter and paved the way for the development in the 1940s of quantum electrodynamics, still the paragon of modern field theory. The positron story of the early 1930s was also the precursor of the subtle interplay between particle physics theory and experiment which is such an integral part of modern research.

In addition, 1932 marked the discovery of the neutron, confirming that the atomic nucleus was more complex than had once been thought. This was the first step on the long path to our present understanding of the strong force.

Using natural sources of radiation, Rutherford and his colleagues at the Cavendish Laboratory in Cambridge had seen induced nuclear transformations as early as 1919 and had gone on to develop early forms of particle detectors to improve the efficiency of their experiments.

In the early 1930s came the first induced nuclear transformations using synthetic particle sources, notably the Cockcroft-Walton accelerator. Meanwhile the first cyclotrons were coming into action in the US, and were soon to provide the staple source of higher energy particle beams for laboratory experiments.

The 1930s also saw the first developments in nuclear theory with Yukawa's picture of nuclear exchange forces. There was a brief euphoria when cosmic ray experiments discovered signs of a new 'meson', heavier than the electron but lighter than the proton. Yukawa's nuclear force carriers should interact readily with nuclear matter, but these new mesons appeared to be capable of passing through considerable thicknesses of material. The riddle was not solved until after the war, when further cosmic ray studies found that there were two new particles. There was the pi meson which did interact with nuclear matter and therefore looked a serious candidate for Yukawa's nuclear force carrier. In addition there was the penetrating muon, transparent to the strong nuclear force but interacting instead through the weak force. For many years the muon defied any kind of theoretical explanation.

The resurgence of interest after the war also provided the first evidence for kaons and for hyperons, particles later to be attributed with the new strangeness quantum number. While isospin, developed in the thirties, had showed that the initial description of nuclear forces had to work in an abstract two-dimensional space, the discovery of strangeness was soon to lead to the enlargement of this space to three dimensions. (The notion of quarks, smaller constituents carrying the various nuclear quantum numbers, did not emerge until the early sixties.)

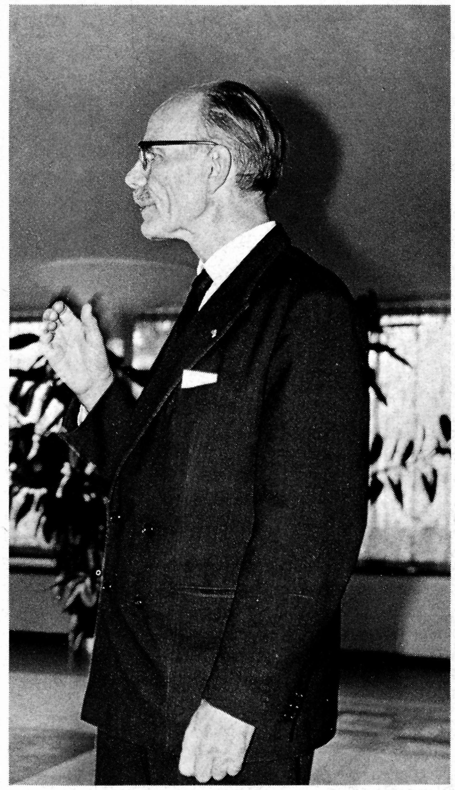
The study of nuclear beta decay under the weak force had also begun in the thirties, and the discovery of a continuous spectrum of produced particles resulted in the then seemingly bizarre prediction of a massless neutrino emitted in beta decay. Physics had to wait until 1956 before the elusive neutrino was discovered, but it was not until several years later that the special behaviour of the weak force became apparent, leading to some particularly elegant theory.

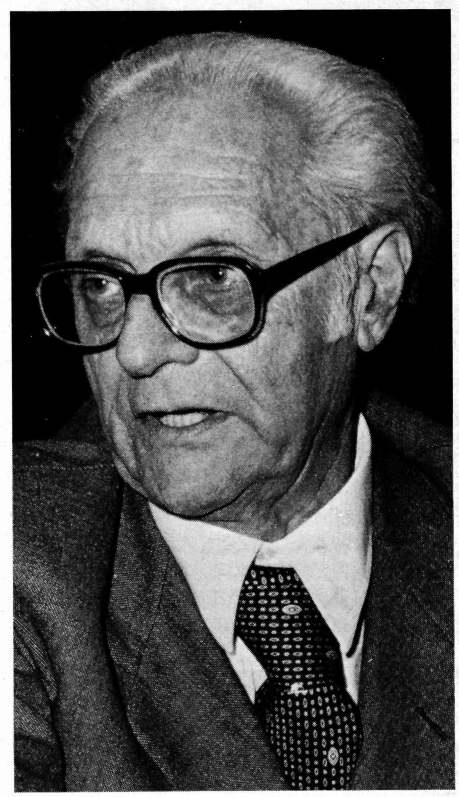
The particle physics achievements of the thirties are now ripe for study and appraisal. Rapporteurs at the forthcoming Paris meeting will include many people who took part in these developments (Bruno Rossi and Charles Peyrou for cosmic rays, Bruno Pontecorvo for neutrinos, Edoardo Amaldi for weak interactions, Nicholas Kemmer for isospin,

Paris History Conference

Further information on the International Colloquium on the History of Particle Physics to be held in Paris from 21–23 July can be obtained from the Colloquium Secretariat, IN2P3, 20 rue Berbier du Mets, 75013 Paris, France.

Pierre Auger, one of the honarary presidents of the forthcoming international colloquium on the History of Particle Physics, to be held in Paris in July.

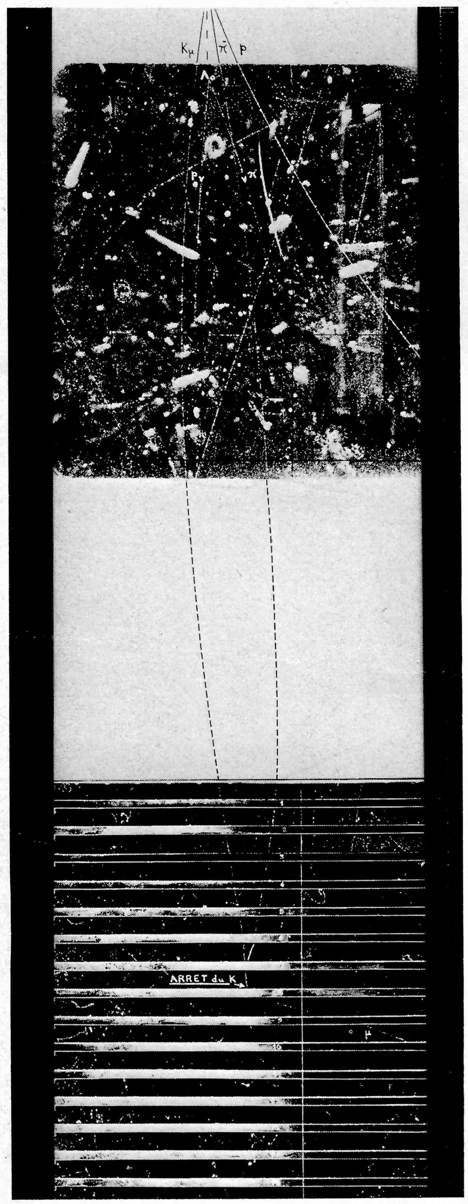




Edoardo Amaldi, scheduled to speak about the history of weak interactions at the Paris History Conference.

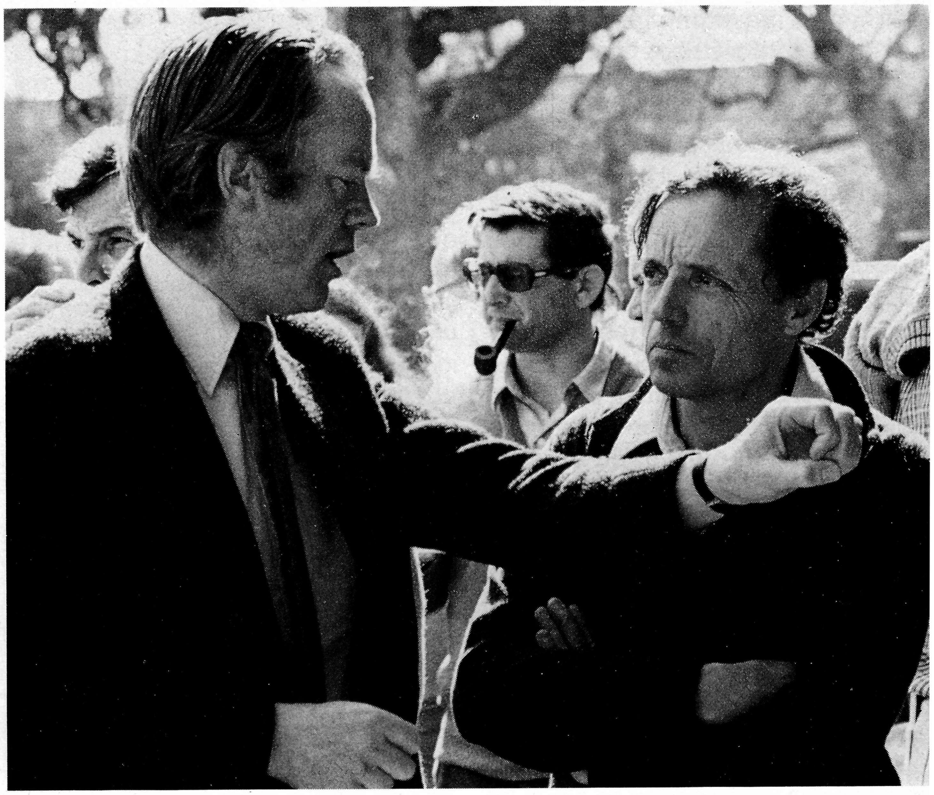
Julian Schwinger for quantum electrodynamics, Murray Gell-Mann for strangeness). The Conference will provide a useful opportunity to cover this ground once more before its history is irrevocably cast.

Particle physics history. One of the cosmic ray events observed at the Pic du Midi in the 1950s by the Ecole Polytechnique team which helped to clarify the understanding of the kaons.



Instrumentation for colliding beam physics

Wade Allison (Oxford, left) and Yves Goldschmidt-Clermont (CERN) exchange ideas during the recent International Conference on Instrumentation for Colliding Beam Physics, held at SLAC.



In February, about a hundred people took part in the International Conference on Instrumentation for Colliding Beam Physics, held at SLAC. This was a sequel to the very successful conference on Experimental Methods for Electron-Positron Storage Rings, held at Novosibirsk in September 1977. However the SLAC meeting cast its net wider, reflecting the increased attention which has been paid to colliding beam physics in recent years. Thus as well as detectors for electron-positron colliders, the meeting could also cover instrumentation for present and future proton-proton, proton-antiproton, and electron-proton colliders.

In his opening address, SLAC Director Pief Panofsky used a recent Chinese proverb to illustrate the growing need for detectors covering large solid angle, the principal concern of the conference. 'A frog in a well says that the sky is no bigger than the mouth of the well. That is untrue, for the sky is not just the size of the mouth of the well. If the frog says that a part of the sky is the size of the mouth of a well, that is true, for it tallies with the facts.' Frogs in wells please take note.

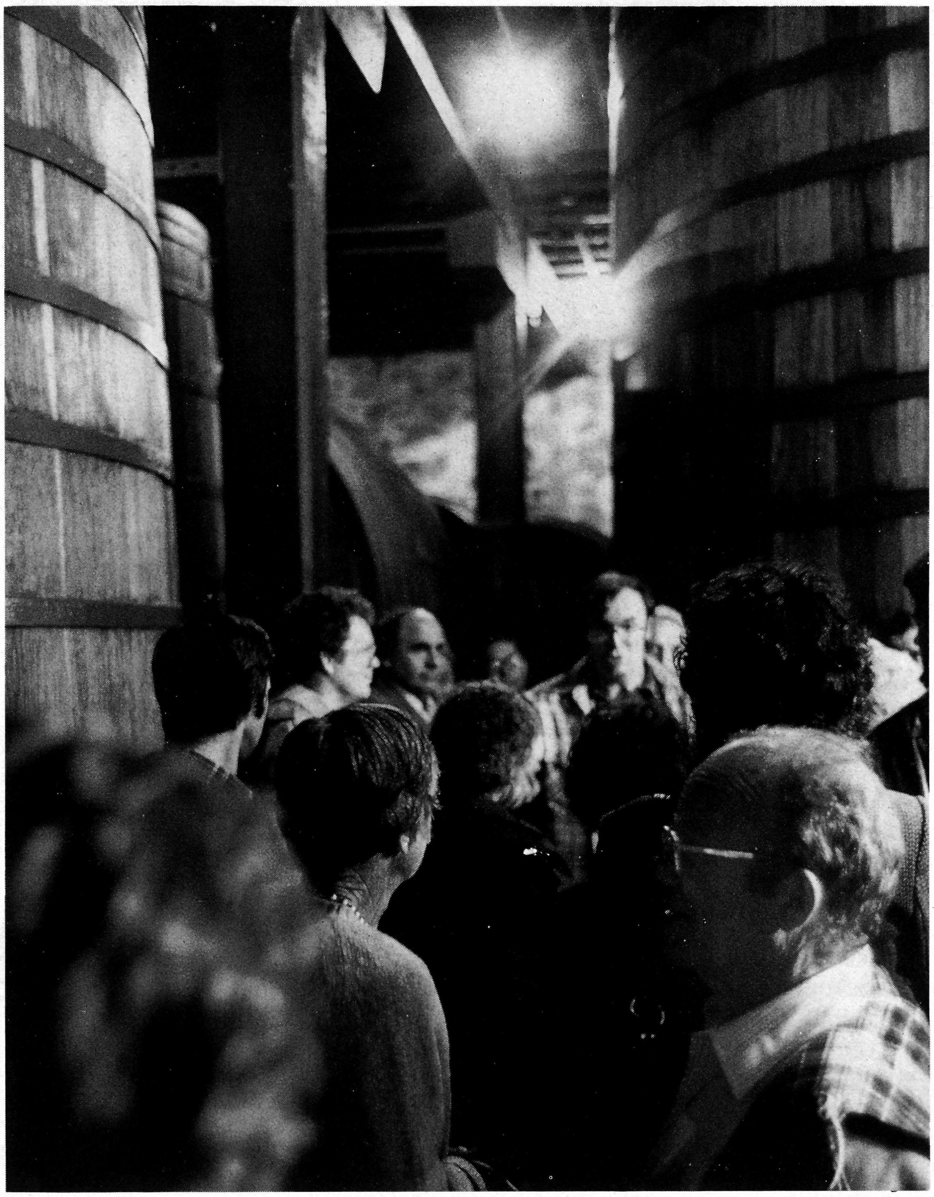
Panofsky also pointed out the increased scope of the SLAC meeting, drawing an analogy with the traditional international electron-photon jamborees which have now grown to encompass many other topics besides, and whose scope is almost indistinguishable from 'general' high energy physics conferences. Perhaps the collider instrumentation meetings will become indistinguishable from general physics instrumentation conferences.

Each day of the conference was usually devoted to one particular topic, with illustrations from either existing or planned detectors. Thus the first day was given over to tracking measurements in magnetic fields, the next to particle identification by the rate of energy loss, then electronics (including trigger processors and data acquisition and processing), then total energy measurements (calorimetry). A recurring theme was the subsequent inclusion of discussion sessions to review the ground which had been covered in these specialized sessions. To stimulate these discussions, the appropriate chairman was cast in the role of 'provocateur'. Although not warranting a full day, other specialized topics covered included Cherenkov and transition radiation, fast timing techniques, polarization and superconducting magnets.

Designers of detection systems have to exploit many, if not all, of these techniques and a number of sophisticated detection systems found themselves used as examples in several different specialized sessions.

While existing techniques continue to be further developed, new ideas are also making their appearance to satisfy the demands of modern physics (see, for example, March issue, page 47). An especially fast developing area (in more ways than one) is that of electronics, where in recent years physics requirements have gone hand in hand with new miniaturization techniques, enabling more complex data handling units to be built more easily and more cheaply.

Whatever physics discoveries are made and machine proposals put forward, a lot more technological ground will have been broken by the time the next collider instrumentation conference comes around.

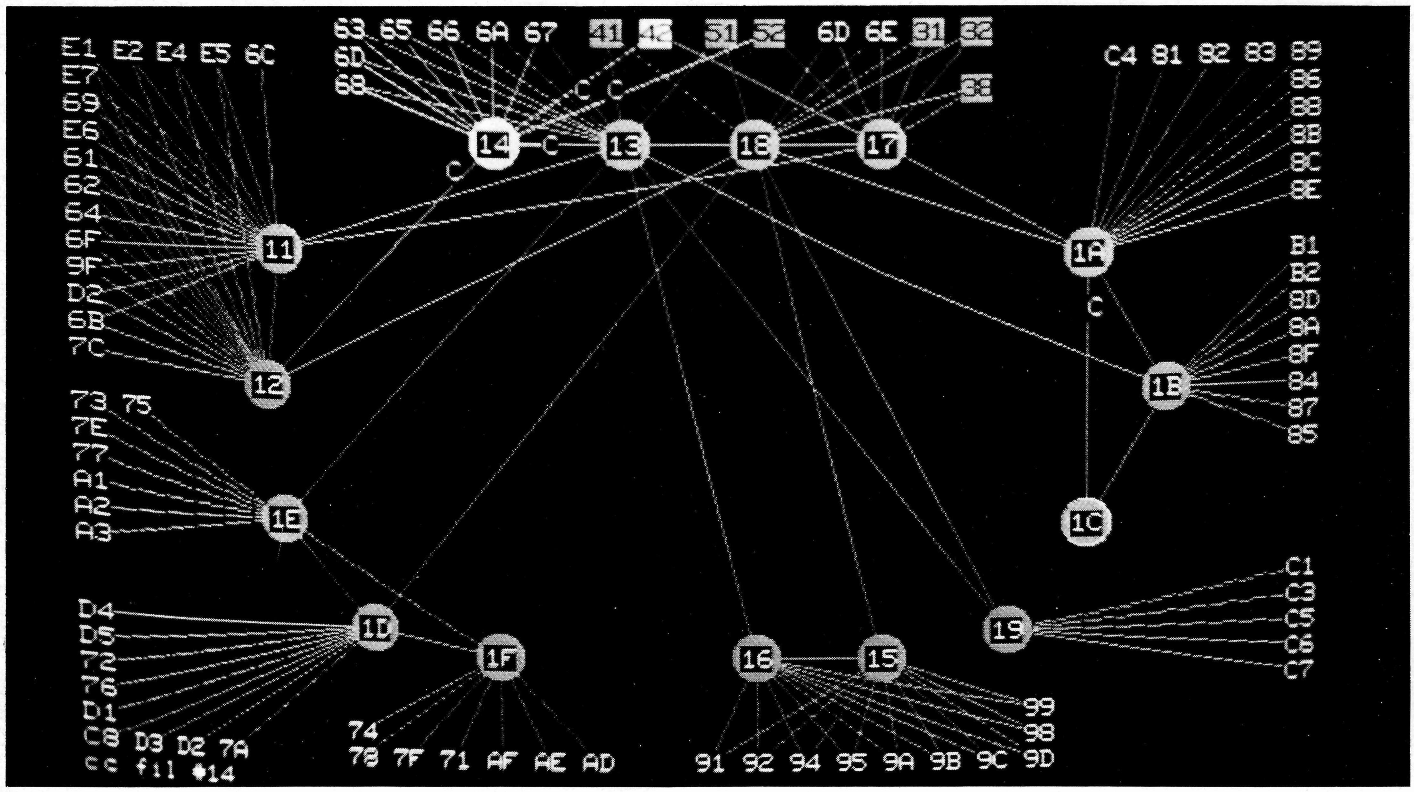


For the free day at the SLAC Instrumentation Conference, a tour of California's Napa Valley wineries was arranged. Ignoring the explanation being offered, SLAC Director Pief Panofsky (foreground) prefers instead to contemplate the enormity of the storage installations.

(Photos Joe Faust)

Making CERNET work

by J.M. Gerard



The configuration of the CERNET computer communications network as seen on the operator's console, showing the various links between host, node and subscriber computers.

(Photo CERN 235.4.82)

Practically ever since CERN began acquiring large mainframe computers it has been attempting to make their computing power available to the minicomputers in experimental areas. Early attempts to link directly on-line to the computer centre were made difficult by the inability of the mainframe operating systems to cater for the mixture of on-line real time data analysis with off-line batch environment work and, later, terminal access. For this reason, the idea of on-line data acquisition and analysis in the computer centre was temporarily abandoned in favour of two alternative approaches, which were pursued in parallel.

One approach involved using the central computers only in batch mode, using a dedicated front-end to support data-links and file handling. This was implemented in a system called FOCUS which was in operation from 1968 until the end of 1978. Here a CDC 3000 lower series computer was equipped with data links to various experimental setups. By means of terminals connected to FOCUS the physicists could send data sample files to the CDC 3000 file base, manipulate source files, initiate transfer of jobs (including the data sample files) to the central CDC computers and retrieve output for inspection or printing. At its peak (1970-1975) FOCUS was handling about 20 simultaneous terminal users and about 10 data-links, plus three Remote Job Entry stations. However, its services were tending to become overstretched and it could not easily be extended to include the central IBM computers, installed in 1976.

In an alternative approach, for the large Omega detector, a medium size CII 10070 computer was purchased specifically to provide real-time data analysis and associated support facilities including terminals. Data communications were handled by a network of PDP-11 computers called OMNET. The CII 10070 was logically in the centre of this network, with the terminals being connected to the various PDP-11s. This system also lasted until the end of 1978, at which time the CII 10070 was discarded as outdated, expensive to maintain and not powerful enough. However, the OMNET PDP-11 network was retained and has been connected to CERNET.

During the mid-1970s it became clear that both FOCUS and the Omega data handling system would need to be replaced. With the sophistication of modern mainframe computers and operating systems and the proposed acquisition of large IBM mainframes and mass storage facilities to complement the existing CDC mainframes, it was also felt that the various experimental facilities could benefit by being integrated into the

The muon beam experiments in the North Area of the CERN SPS were among the first to be linked to CERNET. The photograph shows the counting room of the European Muon Collaboration experiment.

(Photo CERN 448.10.81)

main computer centre. In addition, one had to take into account the growth, both inside and outside CERN, of other computer networks constructed for particular purposes.

The decision was thus made in 1975 to construct a general purpose data communications network (now called CERNET) inside CERN, to be used for computer-computer communications. The performance should be such as to allow data transfer at speeds comparable to that of writing data onto magnetic tape.

One important general criterion laid down from the beginning was that centralized recording of raw data was not an objective. In other words, it was to remain standard policy that the recording, on magnetic tape, of raw data generated by physics experiments should be done on minicomputers at the experiment. However the possibility of sending samples of the raw data to the central computers for analysis on a much shorter timescale than that obtainable by physical transfer of a magnetic tape was considered extremely important.

It was also clear that the lifetime of CERNET was likely to be at least ten years. Over such a timescale it is very difficult, if not impossible, to forecast the exact requirements of all the likely subscribers. Therefore the objectives had to be widened to include general purpose facilities over and beyond those specific to the collection and analysis of event samples.

After completion of a preliminary feasibility study, the first phase of the CERNET project was authorised in December 1975, with the design aim to provide data-link connections from the SPS North Experimental Area to the computer centre for experiment data sample calculations, and switchable and extendable data-link features for medium speed traffic between computers on-site.

This was completed by the end of 1978, by which time the basic packet switching network was in regular service, with six switching node computers and twenty user computers communicating with the CDC and IBM central computers. The first user was the European Muon Collaboration experiment, which used CERNET regularly from March 1978 to process data on the IBM 370/168, whilst the first user of the network services to the CDC 6400/7600 was experiment NA4 (using the same muon beams) from September 1978.

The second phase of the development was to extend the CERNET service to the West Experimental Area and other parts of the site, and to augment the user services and operational facilities provided through the network. These included more extensive file access and transfer facilities, remote job entry from user computers and output retrieval, resource-sharing between the IBM and CDC systems and, finally, the control centre software for operation of the network. By the end of 1980, this second phase was completed.

The computers

CERNET consists of computers interconnected by high speed data links. It provides program-to-program communication between these computers, using a packet-switching technique for the transmission of messages.

The computers making up CERNET are either subscriber or node computers. The subscribers are those connected to CERNET primarily for communications. Most subscribers are simply user computers, i.e. computers in physics or en-

CERNET is being developed with a view to using new public data communications networks. This shows the 'gateway' to link CERNET with public packet switched networks based on the international X25 standard.

(Photo 234.4.82)

gineering applications which use services provided by, or through, CERNET. A few subscribers, however, have a special status as host computers in that they provide some kind of computing service to other subscribers.

The nodes, together with the data links, form the communications subnetwork. This provides the basic functions of accepting packets of information (in a standard format and up to 2046 bytes long) from subscribers, transmitting them via an appropriate route through the subnetwork and delivering them to the subscriber to which they were addressed.

Each subscriber is connected to a node, whilst each node has at least two, and often three or more, connections to other nodes. Nodes often have been installed in pairs and hardware link switches have been built to enable some groups of links for subscribers to connect to either node of a pair. In this way, alternative routing and some hardware redundancy has been built into CERNET in order to ensure a very high level of availability of the communications subnetwork. This is necessary as the CERN accelerators and the central computer service run 168 hours per week for several weeks at a stretch during experiment periods, whereas the CERNET team is not staffed to provide more than a single shift, five days per week maintenance service. Thus in most cases of data link or node failure a user will continue to obtain a connection through CERNET to a host by alternative routing, allowing time for the maintenance services to repair the fault.

The nodes at present in service are Modcomp Classic 7860 or Modcomp II/45 computers. The Classics are installed in the regions of highest network traffic, in particular the CERN Computer Centre, whilst the II/45 s are installed in the North and West Experimental areas and the Experimental Physics Division Laboratory area. The furthest nodes are some 5 kilometres from the Computer Centre. Two more nodes (Classics) have been installed in the new Underground Experimental Areas. All of the nodes use a version of Modular Computer System's MAXCOM operating system which has been extensively modified at CERN to meet CERNET specific requirements.

The principal hosts connected to CERNET are the large CDC and IBM systems in the Laboratory's computer centre. These are the CDC Cyber 170/730 and Cyber 170/720 systems (which are the front-ends to a CDC 7600, itself not directly attached to CERNET) and the IBM 3081 system. An IBM-compatible Siemens 7880 is replacing an earlier IBM 370/168. Practically the whole range of services provided by the Computer Centre is available to the CERNET user computers.

The user computers connected to CERNET are mainly minicomputers dedicated to some specific application. This may be a physics experiment, where the mini carries out the function of data acquisition or equipment control, or it may be in physics support, where the mini is used to carry out software development or equipment testing. The user computer is usually one of the minicomputers which are at present supported in CERN. These are Norsk-Data ND-10 or ND-100 systems, Digital Equipment PDP-11 or VAX-11, or Hewlett Packard HP21mx.

The data links

The data links of the network have been designed and built at CERN. They are full duplex links capable of transmission speeds of several Megabits per second over several kilometres, and use asynchronous serial transmission over twisted pairs in standard cables. All of the links, whether they are inter-node or node-subscriber, are logically identical. However the interfaces for the subscribers are built in the form of CAMAC modules, whereas those for the Modcomp node computers are made in a form suitable for direct connection to the Modcomp input/output units. The use of CAMAC allows the same data link interfaces to be used for all types of subscriber computers and is convenient in a laboratory where all the computers used in experiments have CAMAC installed. The CAMAC CERNET data link modules are now commercially available.

Communications and software

Communications between programs in different CERNET subscriber computers are made by the exchange of messages between them. In principle this is quite simple, requiring three main steps. Firstly the two partners must agree to communicate and a transmission path, a logical link, be opened between them. Secondly the messages must be transmitted correctly or any error condition reported. Thirdly the logical link must be closed down at the end of the communication. In practice even the simplest communication will involve two subscriber computers and at least one node and two data links. The opportunities for confusion and error are legion, so to ensure an orderly communication requires the specification of sets of rules, or protocols, which govern different aspects of each communication.

In CERNET three levels of protocol are required of the subscribers. At the lowest level the line protocol defines transmission of packets between adjacent computers. At the intermediate level the end-to-end protocol defines transmission of messages between two subscriber computers. At the highest level is the file access protocol, defining file transfers and file operation between a subscriber and a host, and the virtual terminal protocol, defining communication between a terminal on a subscriber and a host.

In practice, these various levels of protocol are handled by standard computer software packages, leaving the end user to see only the higher levels of service required. Increasingly, also, these software packages are being transferred into microcomputers integrated into the attached CAMAC equipment.

External connections

In the last couple of years there has been a concentration of effort, in both Europe and America, to provide for digital data communications on a country or continent-wide scale. For this a set of international standards has been proposed based on the packet switching technique and known globally by the code X25. Switzerland currently has a prototype version of an X25 public packet switching network, called Telepac, which should start to offer a service late in 1982 (for Switzerland only), and be augmented by links to the equivalent networks in other European countries and North America from 1983.

It is of obvious interest to CERN to make use of the possibilities of these public networks for communications with other Laboratories. This interest led in 1980 to a new development programme with, as goals, provision of computer to computer connections with the outside world, support for connection of computer terminals in CERN to computers in the outside world, and vice versa, and provision of a general service for any equipment obeying the X25 standards.

Because the various CERNET protocols were in existence well before the exact definition of X25, and are in use by a large community inside CERN, the most reasonable approach is to provide a 'gateway' system. The gateway performs the conversion between the CERNET and the X25 protocols. It is implemented on a particular CERNET node which in turn is connected via a high speed line to the Swiss public network.

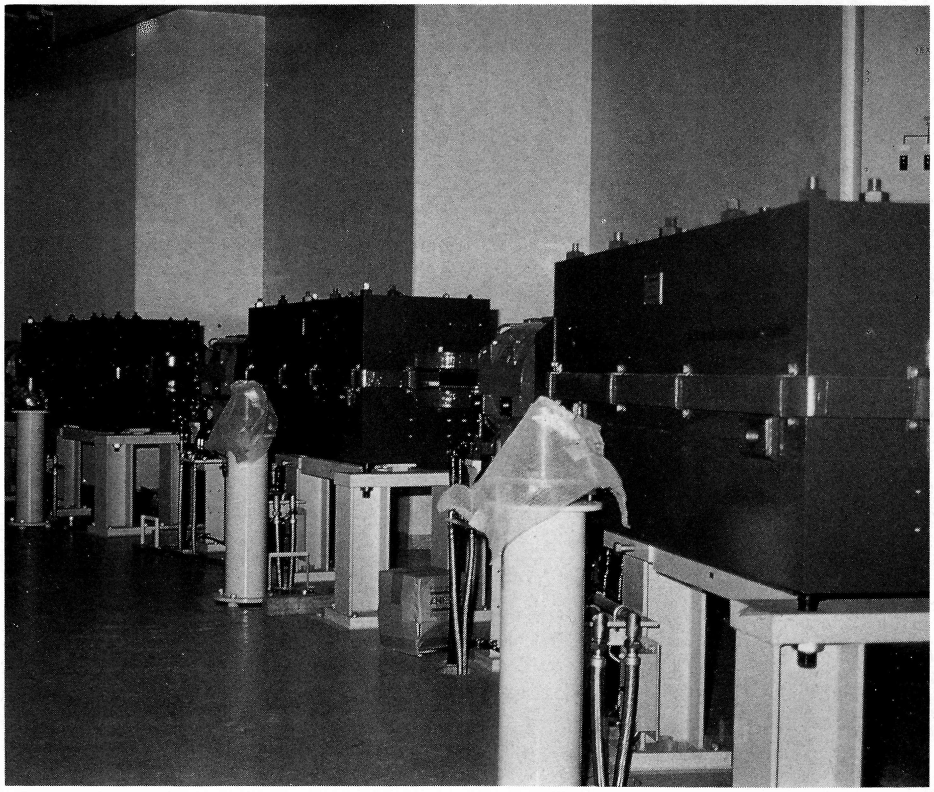
The gateway system is intended to become the standard way to interconnect CERNET subscribers to the various X25 networks. As such it should help to improve data communications between the various Laboratories, and thereby assist both the current CERN programme and the LEP project.

Current and future usage

CERNET now provides a 168-hour per week service over the complete CERN site. It consists of sixteen node computers plus over seventy subscriber computers. It offers file transfer and remote access facilities at speeds of many kilocharacters per second. The load on it is constantly growing, so that to or from the central IBM type computers alone the weekly traffic is of the order of 15 000 000 000 characters, equivalent to a transfer of the complete Geneva telephone directory every few minutes.

The future? CERNET will continue to offer valuable services for many years yet. In the meantime new development work will be required to foresee and prepare for the next generation of accelerators, experiments and general services.

People and things



As reported in our May issue (page 147), the Photon Factory for synchrotron radiation research at the Japanese KEK Laboratory has recently accelerated the first 2.5 GeV electron beams in its 50 x 70 m oval storage ring, a section of which is shown here. After the tests, the ring was shut down for improvements to the vacuum system and installation of experimental equipment.

Walter Heitler

One of the early great men of modern theoretical physics, Walter Heitler, died late last year. After working with Max Born in Göttingen, he went to the UK in 1933, and after a spell as Director of the Dublin Institute for Advanced Studies, Dublin, Ireland, transferred to Zurich. His main contributions were in the fields of molecular forces, cosmic rays and radiation theory. In particular his work 'Quantum Theory of Radiation' was for a time the classic work on quantum electrodynamics before the emergence of the modern theory as developed by Feynman, Dyson, Schwinger, Tomonaga and others.

Horst Gerke

Horst Gerke, leader of the DESY high frequency systems group, died in January at the age of 50. He had worked at DESY since 1957 and had been actively involved in the construction of all DESY accelerators. He was also well known at CERN and at SLAC. He contributed to many important developments, including recently the 1000 MHz PETRA system and the new DESY cavities with high shunt impedance. His human qualities were highly appreciated by his colleagues. He was always directly involved with the work going on, in close contact with his collaborators and maintaining a great interest in social problems. In his exceptionally successful career, he began as a specialized workman, went on to earn the title of engineer and attained a DESY position as research staff member. His group, temporarily headed by Heinz Musfeldt, who also leads the h.f. transmitter group, is now implementing many of Gerke's ideas, including PETRA energy ramping and the 1000 MHz system.

Marseille for muons

Each year, the big European Muon Collaboration meets at one of its member institutes outside CERN. The Collaboration, comprising some 120 physicists from nearly twenty institutes in seven countries, uses the high energy muon beams from the CERN 400 GeV synchrotron in a comprehensive programme of research. Over the years, the Collaboration has expanded as members have migrated to other research centres and formed new groups. A recent example is the group at Luminy Marseille, which from 17–19 May played host to this year's Collaboration meeting.

Conference postponed

The Organizing Committee of the Europhysics Conference on 'Computing in Accelerator Design and Operation', originally scheduled to be held in Warsaw this September, announces with regret that due to the present situation in Poland the Conference is postponed. It is hoped that it will be held about a year later.

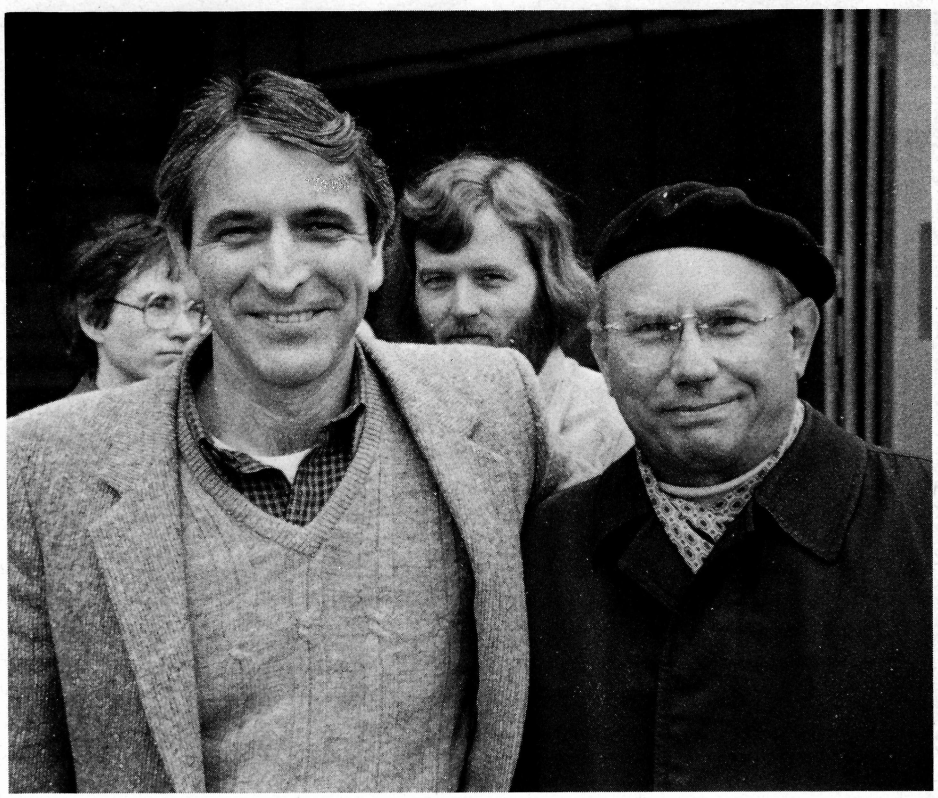
Rome theory meeting

In March, Rome was the venue of an informal particle theory meeting in a series organized cyclically by the Paris Ecole Normale Supérieure, the University of Utrecht and the University of Rome. Experimental talks gave an overview of recent results. Theoretical talks covered topics of current interest, including

The American truck carrying the central part of the fragile Crystal Ball detector, previously used at the SPEAR ring at SLAC, emerges from a Galaxy military transport at Frankfurt airport on 18 April. Its arrival at DESY was celebrated two days later in the experimental hall of the DORIS ring.

(Photo DESY)

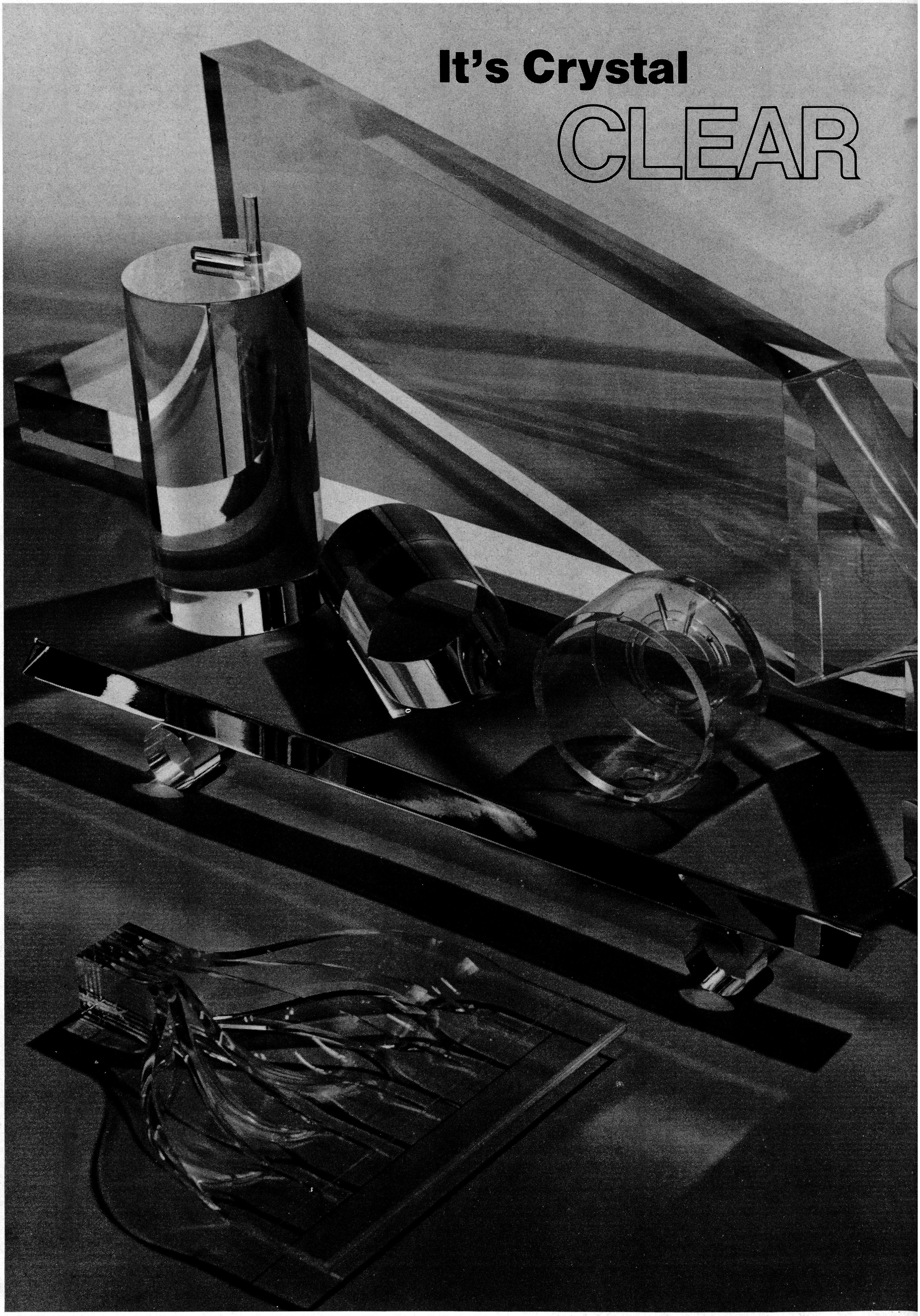
results on hadron spectra from computer calculations of quantum chromodynamics theory on a lattice, spontaneous breaking of supersymmetries, quantum string theories, etc. These meetings, which are much more specialized than major physics conferences, provide an opportunity for long and profitable discussions.



Elliott Bloom (left) and Hans Bienlein, spokesmen of the new Crystal Ball collaboration at DESY, pictured just after the arrival of the main detector at DESY.

(Photo DESY)

It's Crystal CLEAR



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BC-416	42	4.0	434	economy scintillator
BC-418	67	1.36	391	ultra-fast timing
BC-422	55	1.6	370	ultra-fast counting
BC-430	45	16.8	580	with Si photodiodes
BC-434	60	2.1	425	high temperature
BC-438	55	2.1	425	high temperature
Liquid				
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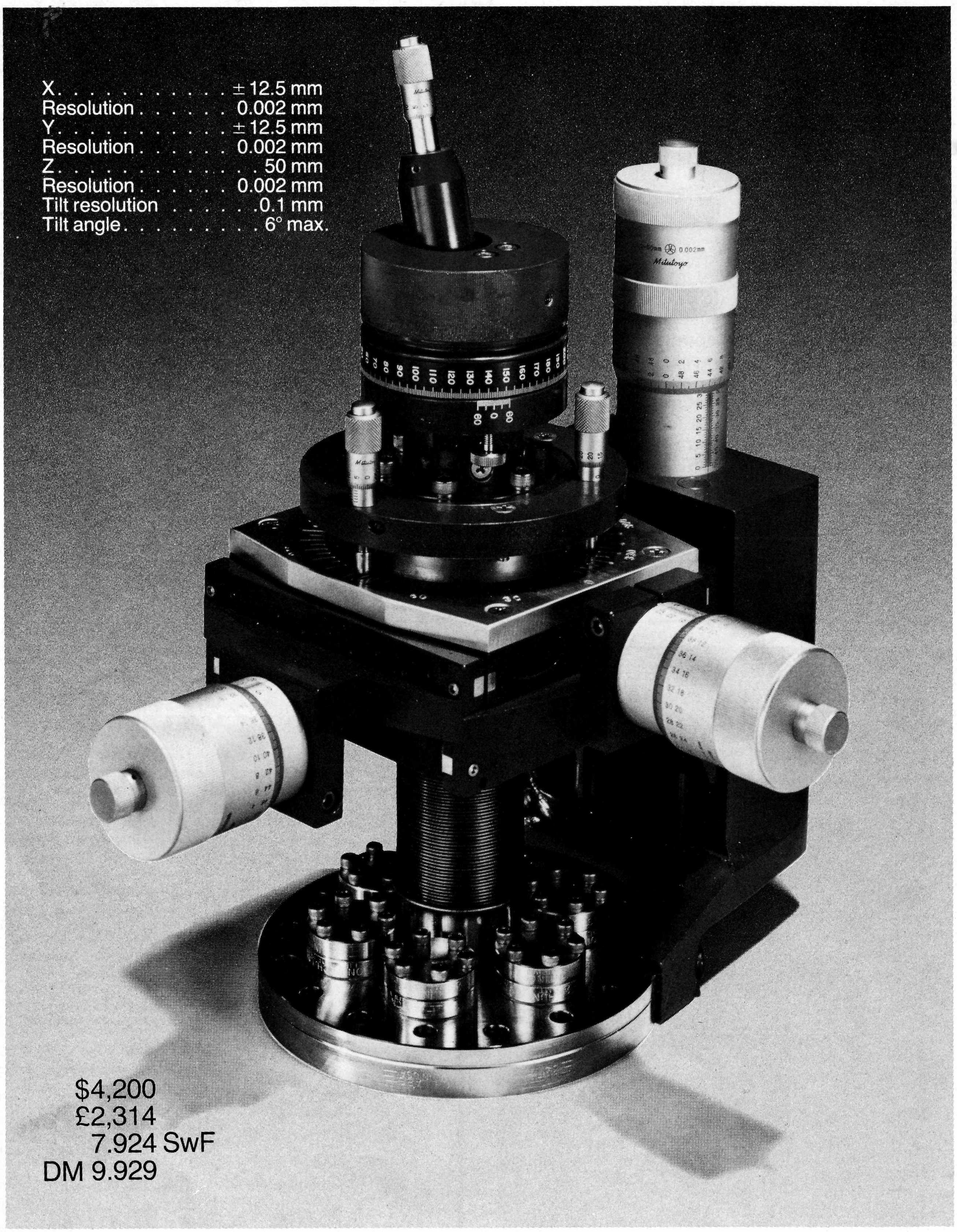

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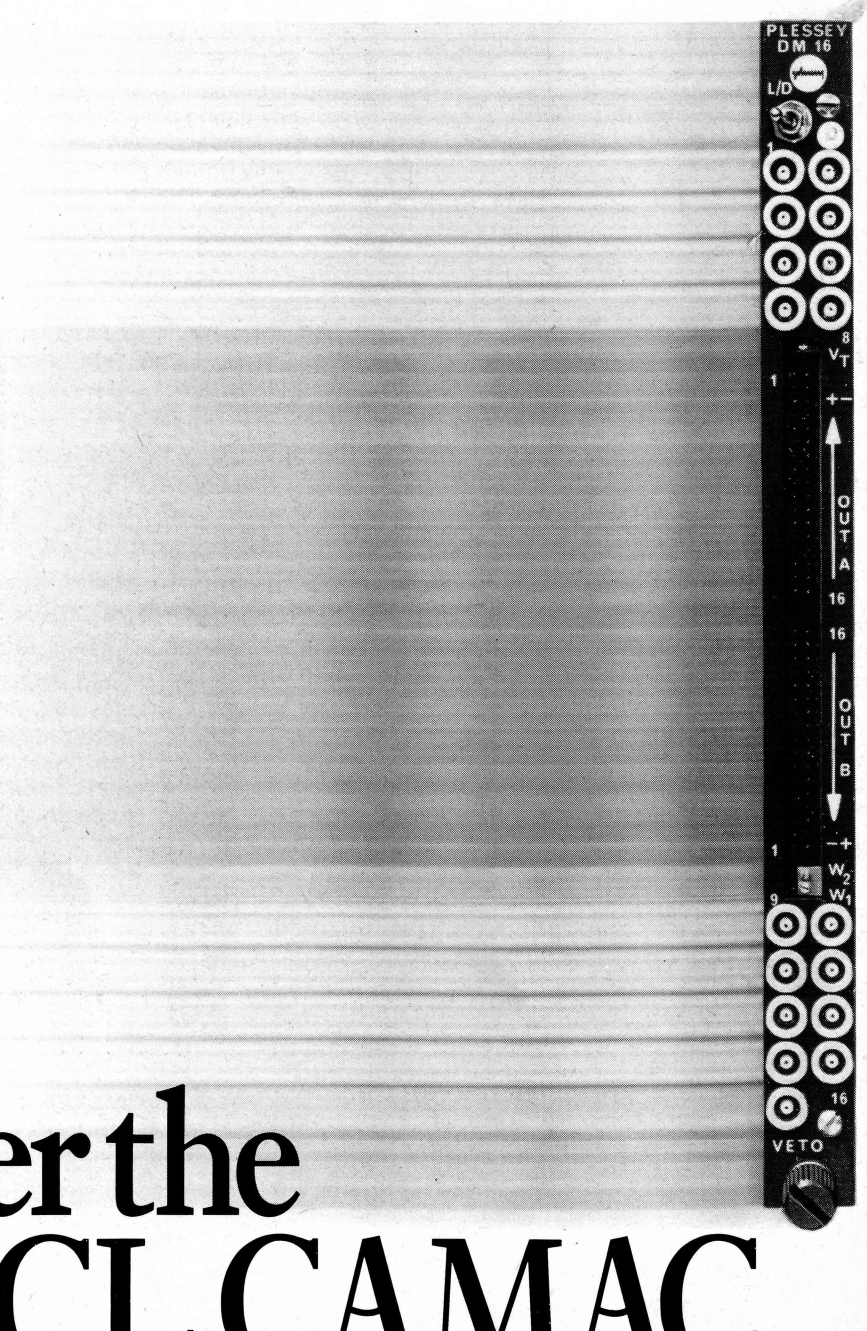

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XP2020Q	bialkali on quartz	280	12	1,5	2,4	0,25	0,25
XP2233B	trialkali	250	12	2,0	3,2	0,50	0,70
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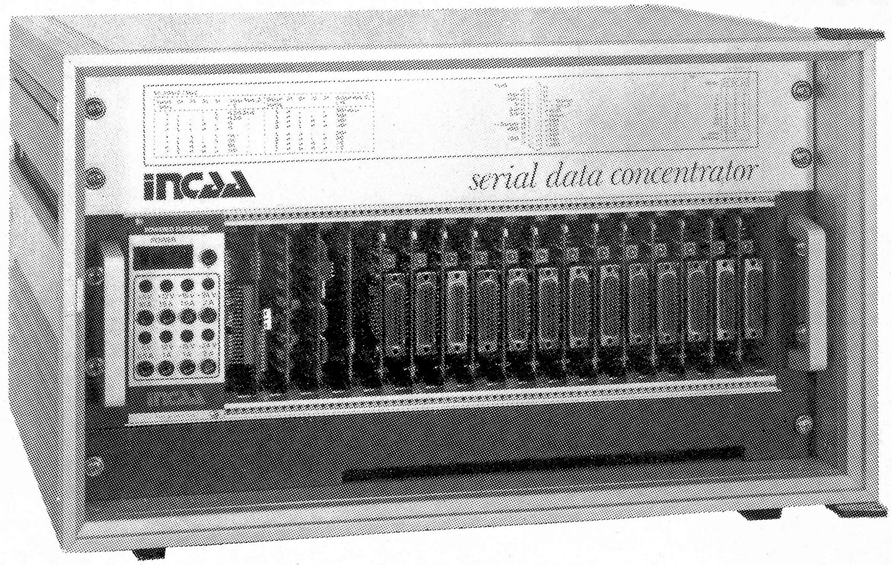

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THE COMPATIBILITY BOX

INCAA announces a new black box to solve your interface problems. We call it PIT - the programmable interface translator.

The PIT is a small, self-contained micro computer system with only a single control switch, a pair of D-connectors and indicators on the outside.

All aspects of synchronous and asynchronous communication are programmable: transmission speed, parity, databits, X-on/X-off, block length, handshake signals.

Code conversion is programmable, e.g.: ASCII to Baudot, EBCDIC to ASCII etc.

String conversion allows the conversion of a single character to a string of characters and vice-versa.

The control switch has two positions: PROGRAM and RUN.

Programming is conversational by means of a simple visual display terminal.

On switching to RUN, the PIT will be configured to the conditions set during programming.

The programmed conditions are battery-backed and will remain in operation until altered by further programming.

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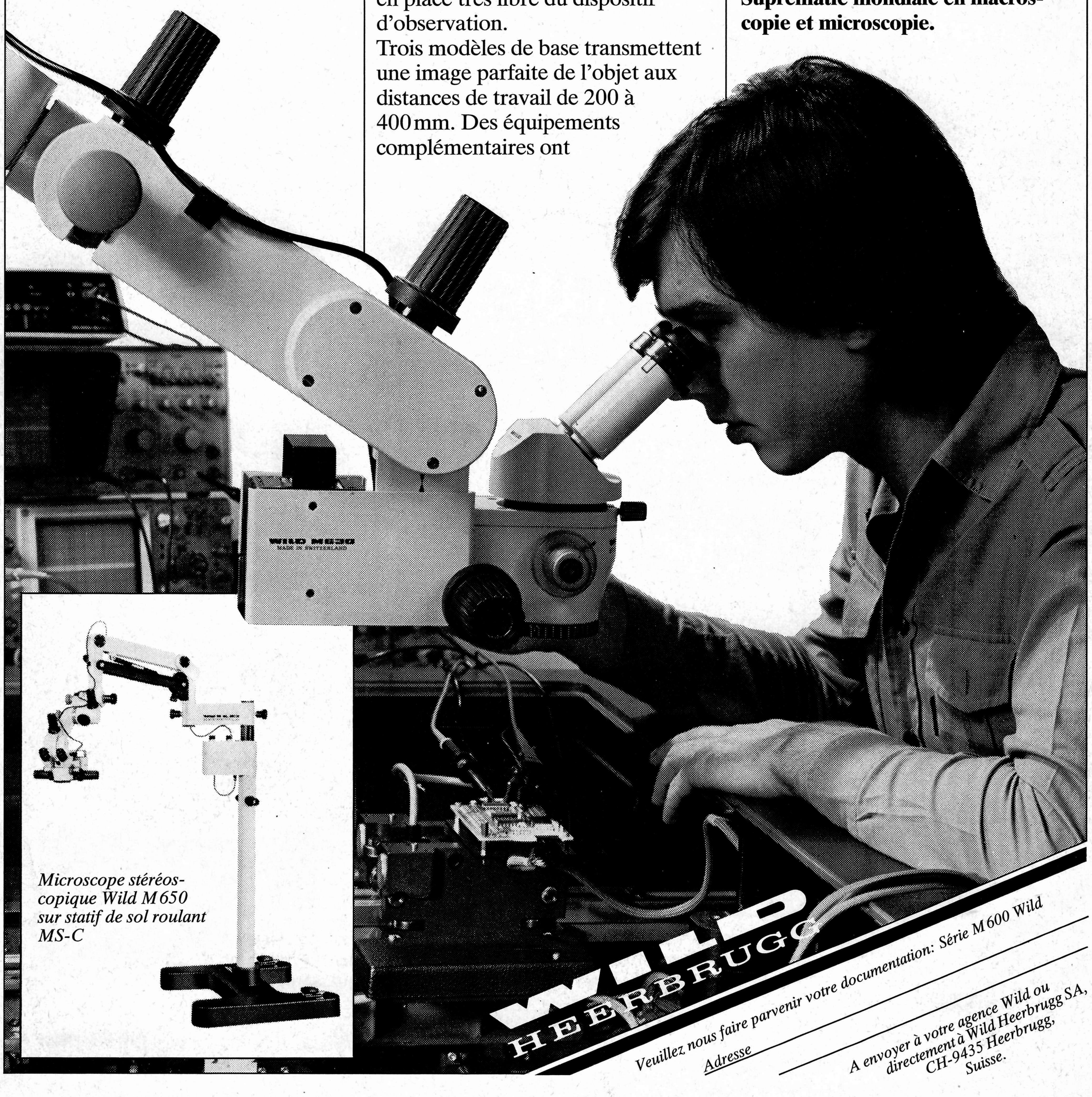
Nouveaux microscopes stéréoscopiques de la série M600 Wild pour saisir tous les détails, même dans les endroits à peine accessibles.

Les systèmes optiques exceptionnels des microscopes stéréoscopiques de la série M600 Wild permettent d'observer sans difficulté le relief des détails les plus fins. Les observations peuvent se faire temporairement sur des objets ne pouvant être déplacés, mais aussi lorsque l'instrument doit être approché, dans des conditions donnés, d'un endroit peu accessible.

Le système modulaire des instruments de la série M600 Wild comprend divers statifs de sol roulants ou fixes, des statifs de table et des statifs muraux, pour une mise en place très libre du dispositif d'observation.

Trois modèles de base transmettent une image parfaite de l'objet aux distances de travail de 200 à 400 mm. Des équipements complémentaires ont été prévus pour les prises de vues cinématographiques ou photographiques, la télévision, les mesures et l'observation simultanée par plusieurs personnes. Il est indispensable de nous consulter au plus vite. ■

Wild Heerbrugg et Leitz Wetzlar: Suprématie mondiale en macroscopie et microscopie.



Microscope stéréoscopique Wild M650 sur statif de sol roulant MS-C

WILD HEERBRUGG

Veuillez nous faire parvenir votre documentation: Série M600 Wild

Adresse

A envoyer à votre agence Wild ou directement à Wild Heerbrugg SA, CH-9435 Heerbrugg, Suisse.