CERN COURIER

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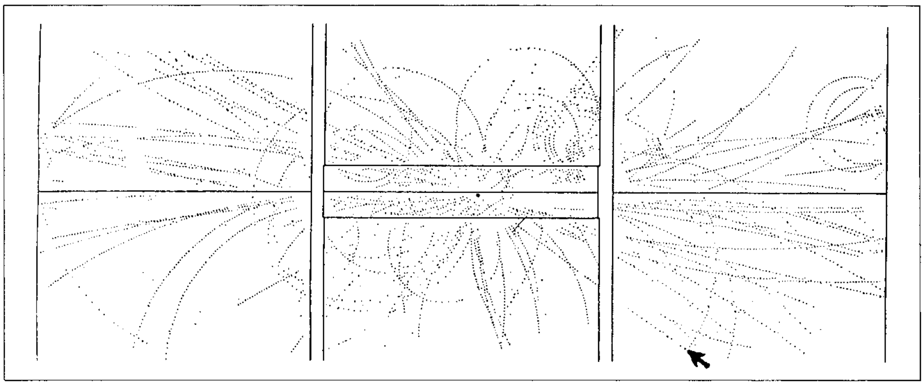
VOLUME 23 N° 2 MARCH 1983

Cover photograph: Some of the reinforcement for the concrete piles (80 cm diameter and more than 11 m deep) which will be sunk into the ground to support the preinjector for CERN's new LEP electron-positron ring (Photo CERN 103.1.83).

First signs of the W



The 65 particle tracks from the UA1 central detector in one of the events producing a single well defined electron (arrowed, bottom right) carrying high transverse energy and indicative of the decay of a W boson.

Excitement was high at CERN during January when results emerged from the recent very successful proton-antiproton collision run at the SPS ring (see January/February issue, page 6). The big UA1 and UA2 experiments have unearthed a handful of events suggestive of the long sought carriers of the weak force.

eliminary information was given at the Rome Topical Workshop on Proton-Antiproton Collider Physics and fuller information was announced at packed CERN seminars on 20 and 21 January when Carlo Rubbia (for UA1) and Luigi Di Lella (for UA2) took their scientific audiences through the brilliant analyses of the complex data emerging from collisions at the highest man-made energies.

This brings us to the threshold of a new era in physics which curiously parallels the development of classical electromagnetic theory by Maxwell in the 19th century and its subsequent confirmation, almost exactly one hundred years ago, with the discovery by Heinrich Hertz of electromagnetic radiation.

Maxwell succeeded in pulling together the descriptions of the electric and magnetic forces, previously considered to have different origins. The inheritance which the 20th century now looks like leaving to physics will be a similar synthesis of the electromagnetic force and the weak nuclear force. Work by a host of theoreticians, crowned by the efforts of Abdus Salam, Steven Weinberg and Sheldon Glashow, has led to the formulation of a combined 'electroweak' theory. This links together the familiar phenomena of heat, light, electricity and magnetism on one side with the relatively less well known world of nuclear radioactive decay on the other.

The weak component of the electroweak force is mediated, according to the theory, by carrier particles called bosons, in much the same way that the electromagnetic component is carried by photons. However the weak bosons are very massive (some ninety times the mass of the proton), and come in three versions; W^+, W^- and Z^0, carrying different electric charges. It is the Ws which have been looked for in the latest proton-antiproton run, since the neutral Z is expected to be about ten times scarcer than the charged bosons. Initially, the Ws were looked for via their decays into an electron (or positron) and a neutrino. The first clue to emerge is the appearance, amongst the spray of particles emerging from the collisions, of a very high transverse energy electron from the disintegration of the heavy W particle.

Some thousand million collisions were clocked up in the latest collider run and a dazzling feat of detector technology and data handling skill has made it possible in both experiments to filter this mass of complex information so quickly to isolate a handful of W candidates.

Information from the tracks picked up by the electronics of the UA1 central detector (the visual tracks have an impressive 'bubble chamber like' quality) and the energy measurements in the surrounding calorimeters reveal six examples of an isolated high transverse energy particle, almost certainly an electron, emerging from a flat background of much less energetic particles. The analysis of the UA2 data reveals four such examples, each with the lone transverse energy electron towering above an otherwise barren landscape.

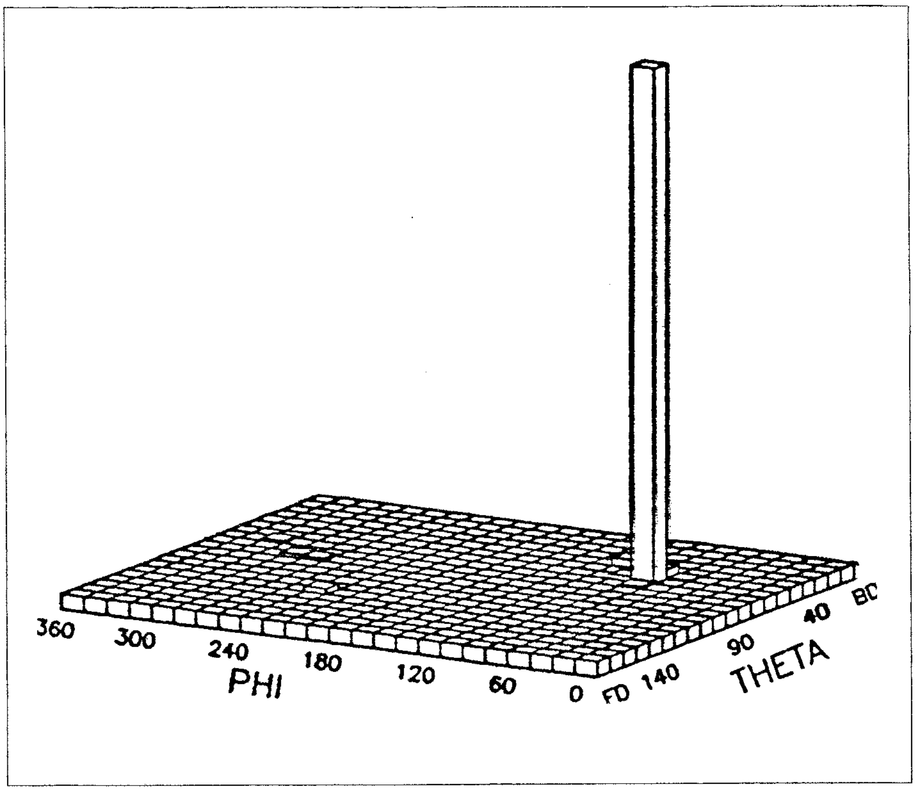
In both experiments, analysis of energy deposition shows that the isolated high transverse energy electron emerging in one direction has an energy imbalance in the opposite direction with no visible particle. This missing energy is suggestive of an invisible neutrino emerging from a W decay.

No alternative mechanisms (either mundane or based on possible new behaviour not seen at lower energies) have been identified to explain all these intriguing events. The likely explanation is therefore that the signals are due to the production and subsequent decay of the charged W boson into an electron and a neutrino. The W should have other decays too, and signs of these could still turn up in the same data sample from the 1982 run.

The initial UA1 results estimate using five of their events that the mass of the W, near 80 GeV, is in line with what is expected from the electroweak predictions. (Detailed results from UA1 can be found in their paper 'Experimental observation of isolated large transverse energy electrons associated with missing energy in 540 GeV collisions', scheduled for publication in Physics Letters B on 25 February.)

This W evidence has been made possible by the ability to collide protons and their antimatter counterparts in the CERN Super Proton Synchrotron ring at an energy of 540 GeV. This is the result of the brilliant invention of 'stochastic cooling' by Simon van der Meer at CERN which has allowed antiproton beams to be produced with sufficient intensity for useful physics experiments. When this was combined with the impeccable quality of CERN accelerator engineering in the construction and operation of the world's most complex particle beam systems, the stage was set for the W particle.

The coming months should provide ample evidence to confirm the initial interpretation, to add to the present handful of candidates, to spot other decay modes and to see the clearer but rarer signature of the Z^0. Meanwhile physicists are gleefully rubbing their hands in anticipation of what is hoped will be an even more fruitful run with the SPS collider, scheduled to begin in April.



A lone 42 GeV transverse energy electron towers above an otherwise barren landscape in an event recorded by the UA2 experiment in the CERN SPS proton-antiproton collider.

'Historic' Rome Workshop

The new physics from the UA1 and UA2 experiments at CERN got an initial airing at the third 'Topical Workshop on Proton-Antiproton Collider Physics', held in Rome from 12-14 January, an apt venue as it was in Rome fifty years ago that Enrico Fermi took the first tentative steps along the long path which led to the modern theory of weak interactions. Winding up the Rome meeting, Leon Lederman said 'This is probably an historic meeting which will be discussed in future years...'

At a press conference organized at CERN on 25 January to announce the discovery of the W particle in high energy proton-antiproton collisions, CERN Director General Herwig Schopper (centre) holds up the January/February issue of the CERN COURIER, whose colour cover photograph showed a typical proton-antiproton event as recorded in the detector of the UA1 experiment. With him are, left to right, Carlo Rubbia (spokesman for the UA1 experiment), Simon van der Meer (inventor of the 'stochastic cooling' technique which made the CERN antiproton project possible), Erwin Gabathuler (CERN Research Director) and Pierre Darriulat (spokesman for the UA2 experiment).

(Photo CERN 245.1.83)

Moving at the speed of light

In the control room of the US National Synchrotron Light Source at Brookhaven on dedication day. Left to right, Nick Samios (Laboratory Director), H. Loweth (Office of Management and Budget), Paul Reardon (joining Brookhaven to lead the Colliding Beam Accelerator project), Arie van Steenbergen (who led NSLS construction), John McTague (NSLS Chairman), and George Keyworth (President Reagan's science advisor).

Among the most remarkable 'spin-offs' from the development of accelerator technology for high energy physics research is the use of synchrotron radiation from stored electron beams. Beginning parasitically fifteen years ago on synchrotrons, such as the DESY machine, and then on storage rings, such as SPEAR at Stanford (plus the dedicated Tantalus ring at Wisconsin), the applications of the radiation emerging from electrons constrained to follow a curved path in a magnetic field are now legion. Synchrotron radiation facilities now abound and it is particularly pleasing that the technology to build and operate the machines and to mount significant research programmes is within the reach of countries with quite modest scientific means.

So much is happening in this field that it would be difficult for the CERN COURIER, whose main purpose is to communicate developments in particle physics, to give a thorough review of present activities. However it is fascinating to take a look from time to time at some of the progress being made with synchrotron radiation facilities, and what follows is a mixed bag of information gathered in recent months.

US National Synchrotron Light Source

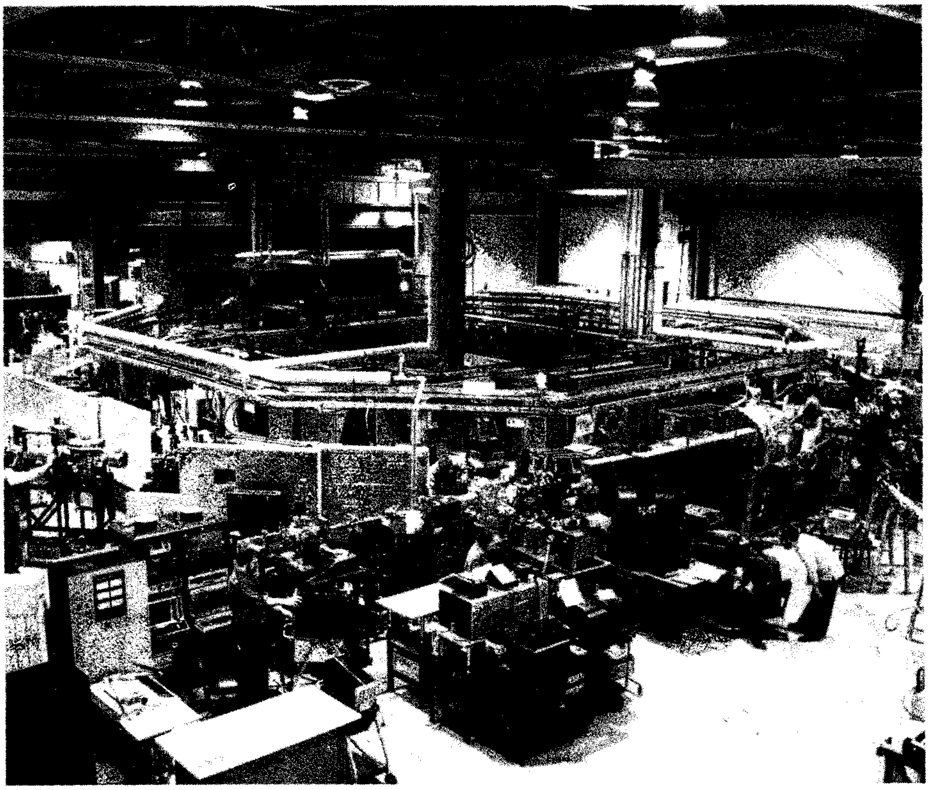
The biggest facility now coming into operation is the US National Synchrotron Light Source, NSLS, at Brookhaven, which was formally dedicated on 22 November with George Keyworth (Director of the US Office of Science and Technology Policy) as the principal speaker. It is appropriate that Brookhaven presently should have pride of place as it is the home of John Blewett, who was the first to identify synchrotron radiation. In his speech at the ceremony, Brookhaven Director Nick Samios also paid tribute to the role of the late Ken Green and Rena Chasman in the design of the NSLS, to Arie van Steenbergen who led machine construction and to Marty Blume for the vigour with which he helped shape the research programme.

The NSLS has two rings. A 700 MeV ultraviolet ring (now usually operated at higher energies of up to 800 MeV) gave first beam to experiments in May of last year and can store electron beam currents of 100 mA and hold them for two to three hours. A 2.5 GeV X-ray ring is still in the commissioning phase with beams of a few mA, but the first port was opened in December to bring X-rays to experiments. The u.v. ring is designed to store eventually 1 A and has 16 ports for research over the wavelength ranges from the infrared to the ultraviolet. The X-ray ring has 28 ports for research at shorter wavelengths and there are wiggler and undulator magnets to be incorporated which will further extend the photon energies and the beam brightness. (We will return to the subject of wigglers later.) With the splitting of beams from the ports, the NSLS will be able to accommodate a hundred experiments simultaneously.

The breadth of the NSLS experimental programme, both in pure research and practical applications, and already under way or planned, indicates the significance of synchrotron radiation facilities as research tools at Brookhaven and elsewhere. The programme covers, for example, the study of chemical reactions and structures (including the action of catalysts with applications in energy production which have attracted experiments from the chemical and oil industries), the properties of me-

The ultraviolet ring of the NSLS. It now operates regularly at 750 MeV (beyond its 700 MeV design energy), with a current of 100 mA supporting some eight experiments.

(Photos Brookhaven)



tals, alloys and insulating materials (giving more detailed knowledge of solid state phenomena), biological systems (where the properties of the light beams enable, for example, much more rapid collection of data so that processes in living cells can be followed), lithography (which could result in the ability to produce still more microscopic sub-micron printed circuits), and free electron lasers.

Such has been the demand for experiments at the NSLS that a Phase II development is already being put forward. It aims to liberate more space around the X-ray ring by providing alternative accommodation for experimenters presently lodged near the ring, and to obtain more funds for the development of instrumentation.

Angiography – a medical application

Work at the Stanford Synchrotron Radiation Laboratory (SSRL), has been reported frequently, as it has been supporting an extensive research programme for many years. Based on the SPEAR storage ring, it has been the scene also of major developments in techniques such as the use of wiggler magnets to extend the photon energy range and the use of permanent magnets in such systems (see, for example, May 1981 issue, page 148).

There is much to report in continued progress, but to inject variety into our synchrotron radiation story this month, we concentrate on a particular medical application which is under study at several Laboratories. It concerns the use of monochromatic photon beams in the X-ray region as a rapid and cheap way of carrying out heart scans. The interest in this work is high because present techniques are both unpleasant for the patient (involving probing blood vessels with catheters) and costly (about 7000 Swiss francs a time). Thus examinations are only carried out when people already show signs of heart problems. If an easier and cheaper way of obtaining the same heart information were possible, it would become feasible to screen populations for heart conditions and catch problems at a much earlier and more easily curable stage. Present progress roused great interest when it was reported at the DESY Conference on Synchrotron Radiation Instrumentation last August.

The technique is referred to as 'angiography' — the visualization by radiography of blood vessels into which a contrast medium has been introduced. Iodine is introduced into the blood. Intense monochromatic X-ray beams (allowing short exposure times) from the synchrotron radiation source are tuned so that they can be switched rapidly to either side of the iodine K-absorption edge at 33.16 keV (17 eV from one wavelength to the other). The unwanted information on X-ray absorption by the rest of the body can be eliminated by subtracting the signals at the two wavelengths. However the subtraction related to the iodine in the blood leaves a significant signal because of having crossed the absorption edge. Thus the blood vessels are picked out.

The X-ray flux traversing the body is detected by an array of silicon solid state detectors, and on-line monitoring on a TV screen as the beam is moved gives a series of recorded images. Each image takes a few milliseconds and an entire scan of the heart can be done in about four seconds. The development of this angiography technique could be of great importance for health and for reducing the enormous costs in the current treatment of heart disease.

Image of the blood vessels from a scan of a calf heart using the new technique (see text) made possible by the use of synchrotron radiation beams. It shows just how clearly the vessels can be picked out against the background X-ray absorption by the rest of the body. This scan was done at the Stanford Synchrotron Radiation Laboratory.

Elsewhere in the US

Work at the CHESS facility on the Cornell storage ring was mentioned in the October 1982 issue, page 321. The other important centre to be added to the list is 'Aladdin' at the Synchrotron Radiation Centre of the University of Wisconsin-Madison. It was at this centre (then under a different name) that much of the first interest in using synchrotron radiation was generated many years ago with the Tantalus ring.

The Aladdin ring is designed to reach 1 GeV. First beam was injected in January 1982, but beam stacking and acceleration did not go smoothly. Problems with magnetic field leaking from the inflector and mismatching of kicker magnets have now been overcome. Acceleration was achieved in October, and performance is gradually being improved. There is work on an improved electron gun for the microtron injector and on bunchers to improve electron capture in the ring. Progress is slowed considerably by lack of qualified staff and shortage of funds.*

Novosibirsk

In the Soviet Union there is synchrotron radiation research on synchrotrons in Moscow, Tomsk and Yerevan, and on storage rings at Novosibirsk. A Commission, chaired by Vitaly Goldanski with Sergei Kapitza as Deputy, reviews the activities at the Laboratories.

The work at Novosibirsk is under Gennady Kulipanov, and Institute Director Alexander Skrinsky is actively involved. Three storage rings are in operation and they serve a community of some 67 groups. VEPP-2M has a peak energy of 700 MeV and 100 mA stored beams. It is used as a dedicated light source for several months each year. A helical wiggler can be used to give circularly polarized radiation.

*** Beam was successfully stacked in Aladdin on 20 January**

VEPP-3 at 2.2 GeV is used as a dedicated X-ray source for some six weeks per year. It normally runs with 100 mA beams but this is reduced to 50 mA when a superconducting wiggler (operating with 3.3 T field and twenty poles) is powered. There are also permanent magnet undulators used for optical klystron research. There are about seven experimental stations.

The largest ring, VEPP-4, operates at 5.5 GeV and four ports have been installed to feed some six stations for parasitic experiments. Damping magnet wigglers are used.

The Novosibirsk team has designed and built a 450 MeV ring for the Kurchatov Institute in Moscow. It is the first dedicated facility to be built in the USSR and is led by Boris Rybakoff. A higher energy ring may be added. A 2.5 GeV ring planned for Yerevan does not seem to be going ahead.

Moving outside the Soviet Union, sources are being proposed or built also in China (an 800 MeV ring under construction at Hefei under Professor Bao), Taiwan, India and Brazil. Naturally activity is well developed in Japan (with the Photon Factory at KEK) and in Europe where five centres are in action. The Synchrotron Radiation Source, SRS, at Daresbury was the world's first dedicated source when it came into operation in 1980 (see January 1981 issue, page 8). The DESY Laboratory was also amongst the pioneers in this work. Other European centres are at Orsay in France, Frascati in Italy, and now BESSY in Berlin.

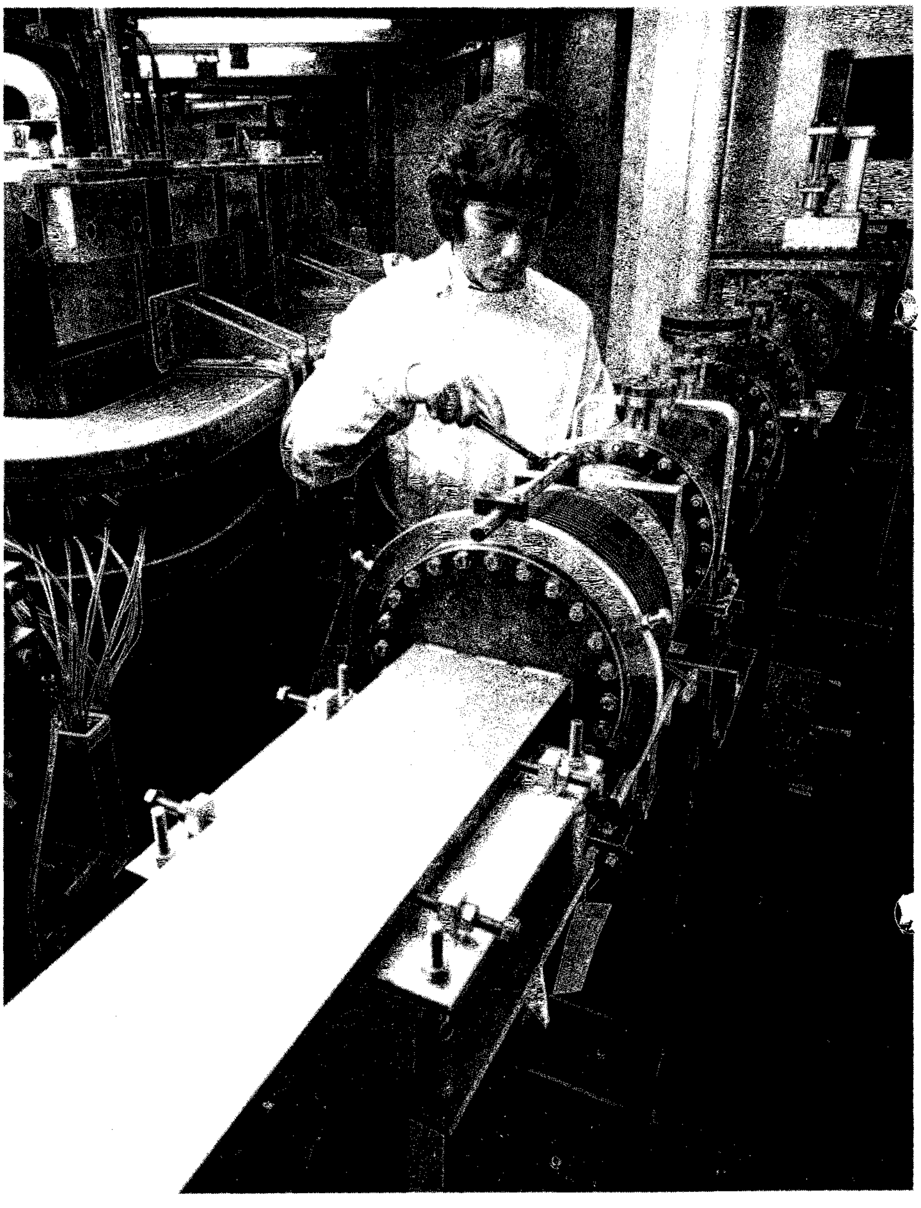
Wigglers and undulators

Initially, synchrotron radiation was regarded as a pain since it sapped energy from the electron beams in accelerators and storage rings. Then the unique properties of this radiation were realized, and synchrotron radiation users started to bemoan the fact that the machines had wasteful straight sections (used for accelerator components or detection systems) where there were no bending magnets to provide radiation. Now, with the advent of wiggler and undulator magnets sitting in straight sections and extending the radiation features, the users bemoan the need for bending magnets. It is likely that the next generation of machines will draw their radiation from wigglers and undulators in straight sections.

In both methods, transverse oscillations are imposed on the electron beam by a regular series of magnets of alternating polarity (so that the beam 'wiggles' along the structure) emerging without any net displacement or deflection. Wigglers came into fashion because the tighter bends that the magnet structure forces on the electrons (compared to the bending magnets of the acceleration or storage ring) extend the wavelength of the emerging radiation towards the X-ray region. Thus

A radiation beam channel at the Daresbury Synchrotron Radiation Source. In 1980, this was the dedicated synchrotron radiation facility in the world to come into operation. Under a recently-signed agreement, the Dutch scientific research community will share the Daresbury synchroton radiation facilities.

(Photo Daresbury)



Reaping the rewards

The 'Prix Metanic' of 60 000 French francs was awarded recently to an unusual multidisciplinary team of molecular biologists and specialists in synchrotron radiation techniques, detector development and data processing. The prize is in recognition of innovations and new techniques in the dynamical study of biological molecular structures.

The work of the team breaks new ground in the study of the time development of biological molecules and molecular structures. It exploits X-ray diffusion and diffraction techniques, using the synchrotron radiation from the DCI ring at Orsay. (Work has also been carried out at the DORIS ring at DESY.) A spherical X-ray detection system was developed by Georges Charpak's group at CERN, and permits high data-taking rates.

Present techniques allow the molecular structural changes to be studied at 100 millisecond intervals, but the hope is to improve this resolution time down to a millisecond or even less.

a wiggler introduced into a ring of ultraviolet energy (some hundreds of MeV) gives X-rays which previously could be drawn only from machines in the GeV range. The radiation spectrum is similar to that emerging from bending magnets.

In undulators, the magnet structure is so arranged that the electron beam oscillations are squeezed tightly so that the emerging radiation is very bright and concentrated into a very small angle. For an undulator with a large number of periods, the radiation builds up from the successive oscillations and interference gives a large number of almost monochromatic peaks.

Electromagnetic structures are in widespread use but there are two interesting approaches to building such magnet structure for better performance. One has been the use of rare-earth/cobalt permanent magnets which allow fairly high fields in compact short period structures and are generally easier to handle than electromagnets. Such structures have been used at Stanford, Novosibirsk and KEK. One is now proposed for the SPEAR ring at Stanford with a 7.5 mm gap, a period of 1.5 cm and a peak field of 0.35 T. With 3.5 GeV electron beams it would give a peak at 7 keV of far higher brightness than is available from the present bending magnets and wigglers.

The other approach is to use superconducting magnets to achieve higher fields. This has been done at Novosibirsk, Brookhaven, Orsay, KEK and Daresbury. For example at Daresbury a three-pole superconducting wiggler has a 5 T field on its centre pole and with 2 GeV beams gives radiation with a peak critical energy of 13 keV compared to 3.2 keV from the bending magnets of the ring.

Among the future machine designs which are moving in the direction of all wiggler/undulator lattices is the proposed European Synchrotron Radiation Facility, which has been under discussion for the past five years under the initiative of the European Science Foundation. (CERN is to accommodate an ESF European Synchrotron Radiation Facility study group.) In the US, a design under the title 'Advanced Light Source' has been developed at Berkeley with a view to construction on the Berkeley site. Use of crystals to steer the particle beams opens up other synchrotron radiation possibilities (see December 1982 issue, page 414). Ideas to improve the properties of the radiation remain plentiful and the research community interested in using the radiation indeed seems to be expanding at the speed of light!

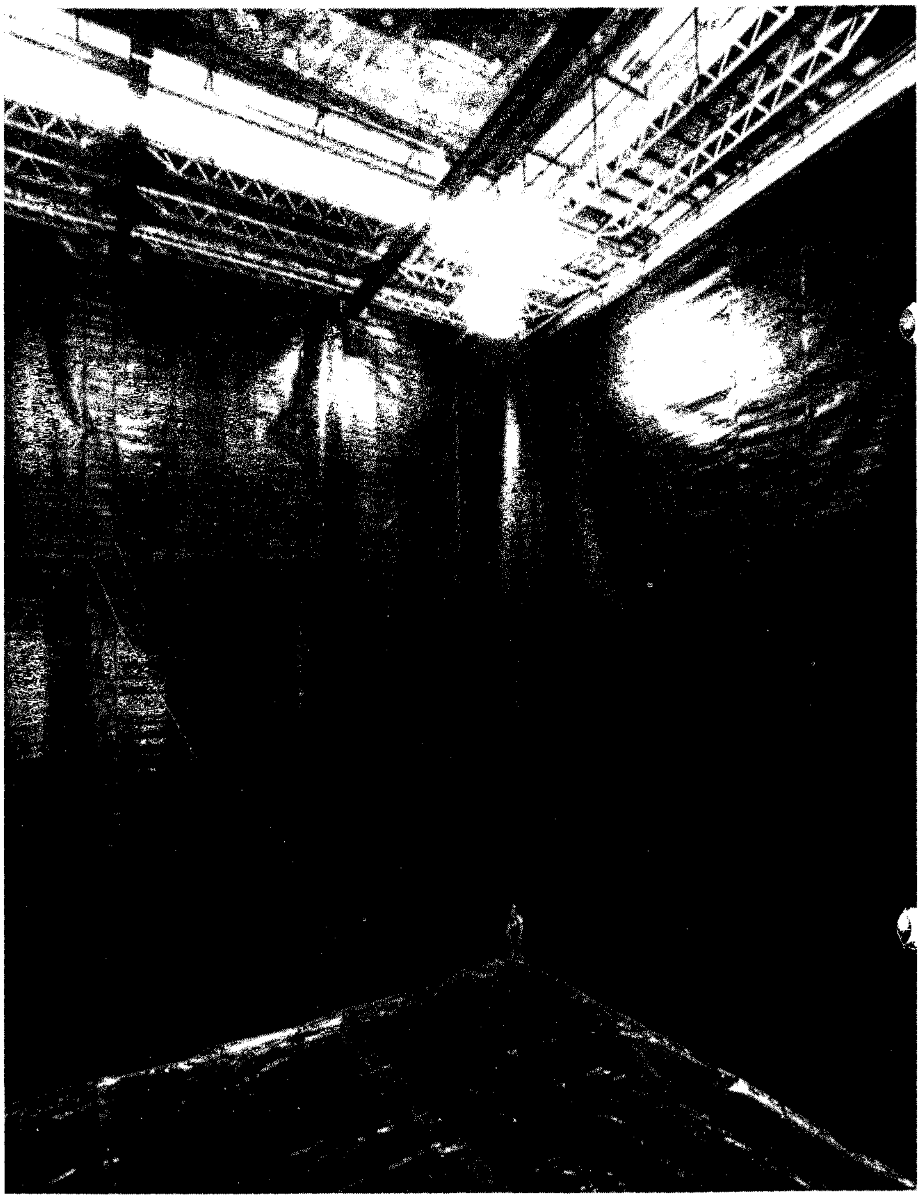
US science underground

Last September 140 scientists met at Los Alamos to discuss the future of underground searches for rare events. The rapid increase in the number and complexity of such experiments, compounded by the difficult scientific environment of most commercial mines, has stimulated proposals to construct a US National Underground Science Facility. The workshop studied the scientific merit for such a facility, including proposed experiments on nucleon stability, solar neutrinos, cosmic ray physics, gravity wave detection, and double beta decay. The participants represented a cross-section of US, European, and Japanese scientists involved in these fields.

Earlier last year, workshops on the next generation of proton decay experiments had been held at Argonne and Snowmass. A consensus had emerged from these meetings to proceed immediately with a detector that could provide detailed information on possible decay modes, in contrast to present experiments concerned primarily with establishing the existence of proton decay. The envisioned fine-grained detector would have a fiducial mass between one and five kilotons with superior capabilities for tracking, energy resolution, and charge determination. Sufficient redundancy to assure background suppression and the flexibility for later expansion of the detector mass were judged essential design features. It is believed that a suitable detector could be built with present technology at a cost of 5–10 million dollars per kiloton.

The discussions at Los Alamos took place against this backdrop and amidst the first reports from the present generation of experiments. S. Miyake reported six proton decay candidates from the Kolar Gold Fields detector, with several of these fully contained, and estimated a lifetime of 7×10^{30} years. P. Picchi described a single unexplained event obtained with the Mont-Blanc NUSEX detector. If any of these candidates survive, the corresponding proton lifetime may permit careful studies of

The tiny figure in the corner illustrates the size of the water tank for the Irvine / Michigan / Brookhaven proton decay search in the Morton Salt Mine, Ohio. The plastic lined reservoir can hold 8 000 tons of water. In a recent run, no positron-pion proton decays were seen, which puts a limit on the proton lifetime. The recent Los Alamos workshop studied the future requirements for more such underground studies.



possible decay branches with future detectors, the results of which would then impose detailed constraints on grand unified models. Yet the abiding concern was the uncertainty relating to backgrounds in present detectors, including the complications of nuclear physics.

The prospect of sophisticated new proton decay experiments attracted the interest of cosmic ray physicists, who believe that large, high resolution detectors deep underground could also provide important new information on cosmic ray secondaries, particularly multiple coincident muons. The sources of cosmic rays, whether they are primordial, the mechanism by which particles are accelerated to energies in excess of 10^7 TeV, and the propagation of cosmic rays locally, in galaxies, and in superclusters all remain provocative questions. To address these questions one must have detailed information on primary composition beyond the present limit of direct observation, a few TeV. In the next few years satellite measurements will extend these observations to 100 TeV where, with information from second-generation proton-antiproton colliders, a direct calibration of cosmic ray secondary measurements in deep underground detectors can be made. Once a firm connection between primary and secondary observations has been established at this energy, underground measurements of more energetic showers might yield a great deal of information on the composition of the parent primary rays at 10^3 to 10^4 TeV.

Ray Davis's description of his long and successful association with the operators of the Homestake mine served as a reminder of opportunities for exploiting commercial underground sites. The puzzle posed by this solar neutrino experiment, which finds a flux of high energy neutrinos three to four times smaller than predicted by the standard models of the sun and weak interactions, is unresolved. To distinguish between possible solar physics and particle physics solutions to this puzzle, a second neutrino measurement employing gallium has been urged for some time. This experiment would be sensitive primarily to the low energy neutrinos from the proton-proton reaction whose flux is nearly independent of the solar model. The lack of funding for a full-scale gallium experiment remains a source of frustration for solar physicists. New proposals for experiments with bromine and molybdenum were also discussed. Although the gallium experiment can be conducted at a depth equivalent to 3500 m of water, others may require shielding of 5000 mwe. This is probably the most severe constraint on the depth of an underground laboratory. It was stressed that the detection of low-energy neutrinos was also an important concern of astrophysicists anticipating the next supernova event.

There were also extensive discussions on gravity waves, double beta decay, and geophysics. In principle, the isolation of a deep underground laboratory would permit an extension of gravity wave measurements to frequencies lower than would be possible on the earth's surface. However the acoustic requirements of such experiments may pose serious problems in a multipurpose laboratory. Some current double beta decay experiments, such as the Mont-Blanc germanium 76 measurements described by Liguori, require modest overburdens to shield against cosmic radiation. In other experiments the worst backgrounds are due to ambient radioactivity, and this could be exacerbated by going underground. Finally, geophysicists stressed that long-term measurements on rock under strain would be of immense practical importance for studies on earthquake prediction and waste isolation.

Early in the workshop a general outline for a National Underground Science Facility had been sketched by A.K. Mann. As the size and budget of such a facility would be comparable to that of a university physics department, a close affiliation with a larger parent laboratory would be economical and would provide access to sophisticated technical support. This, in addition to the realization that most deep mines and tunnels are to be found in the western half of the US, and the Los Alamos tradition of sustaining large technical efforts away from the Laboratory, suggested Los Alamos as a possible parent institution for NUSF.

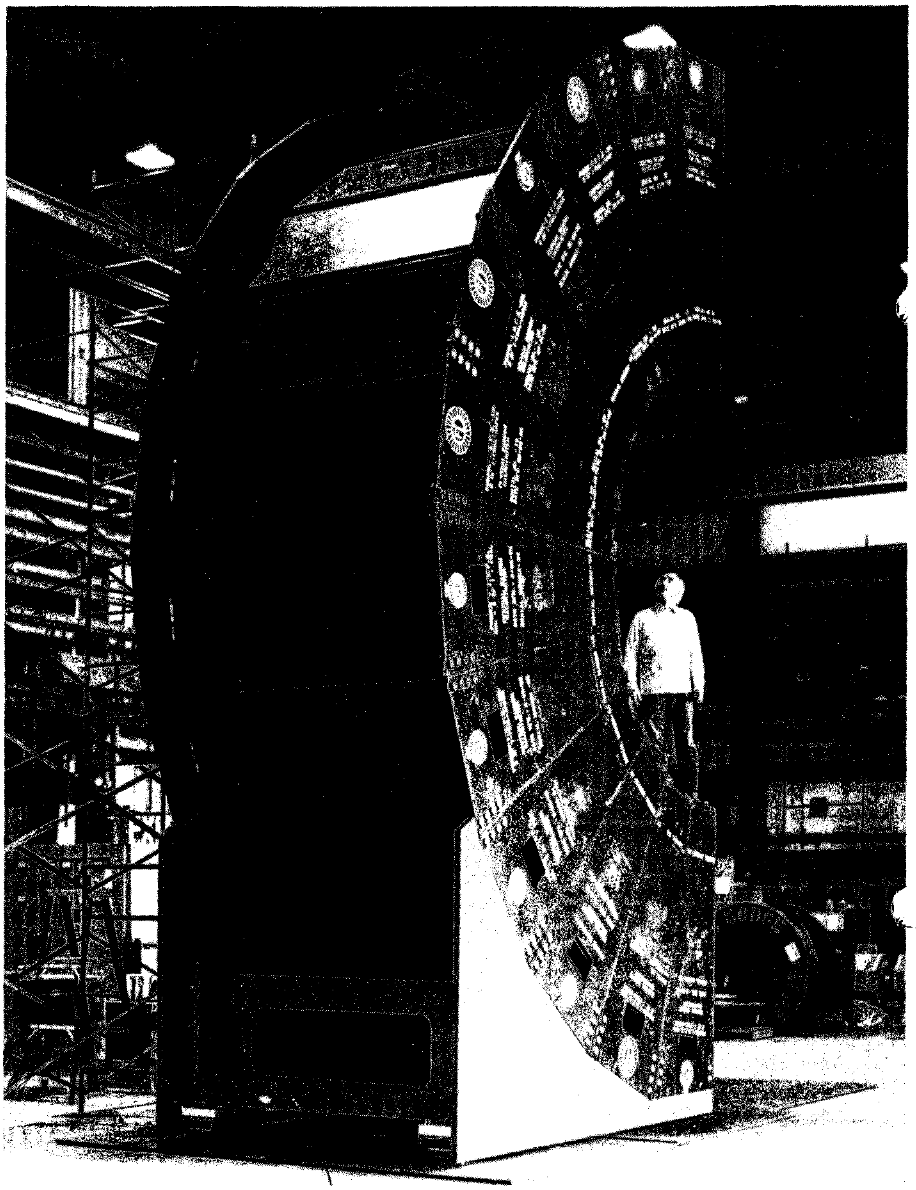
The envisioned Laboratory would be at a depth of more than 3500 mwe with a 12 ft diameter shaft to provide sufficient access. The facility would include two large rooms suitable for massive experiments and additional smaller ones as demand requires. Temperature, ventilation, and humidity controls would provide a normal environment. Floors would be constructed of low radioactivity concrete, with the walls and ceilings rock-bolted and wire-netted. Necessary surface support includes adequate roads, power, and water, small buildings for workshops, computers, storage, and accommodation.

Mann reported on a comprehensive survey of possible sites he made with R.R. Sharp and other Los Alamos geologists. Opportunities for using deep tunnels, such as Mont-Blanc or Gran Sasso, are rare in the US, so attention focussed on mines and on possibilities for construction. Certain mines, both active and abandoned, may be suitable, provided that ownership-tenant responsibilities can be defined and provided the scientific community can tolerate limitations on access and support facilities. In the case of construction, both tunnelling and vertical shafts were considered. Surprisingly, in the US a vertical shaft may be more economical than a horizontal tunnel. Promising US sites for a tunnel have shallow topography and so would demand a long excavation to achieve a sufficient overburden.

The possibility considered most promising was a vertical-access laboratory to be constructed in the Nevada Research and Development Area, a nonclassified corner of the Nevada Test Site. The hydrology, mineralogy, and thermal characteristics of this site are ideal and exceptionally well studied, surface support facilities are in place, and federal ownership guarantees unlimited access and the potential for future growth. In view of the increasing interest in underground science and the opportunities for scientific economies in a large multipurpose facility, these positive aspects of the NRDA site were felt to more than compensate for the higher initial cost of construction. It was estimated that a NRDA facility could be completed by 1986.

The workshop notified the scientific community of the intent of Los Alamos to prepare a serious proposal for an underground laboratory to accommodate the growing national interest in searches for rare events. The members of that community were invited to consider alternatives to the NRDA proposal, or to make suggestions for improving the Los Alamos proposal, to ensure that the US gets optimal resources as soon as possible.

A 'Roman Arch' for the Fermilab Collider Detector. The complete calorimeter employs four such arches, each containing twelve segments equipped with electromagnetic, hadron and muon detectors.



FERMILAB Milestones

Through the summer and fall, work has been under way on the BO complex to house the Collider Detector at Fermilab. The project has involved severing the main ring tunnel to install the new detector enclosure. On 13 December the bypass road for the ring was completed and it became possible to once more pass from Sector A to Sector B of the tunnel. Magnets for the Saver/Doubler were moving through the bypass by 14 December.

This access is particularly important for the installation and operation of the Tevatron. It was necessary to remove some main ring magnets for BO construction and the pattern of Saver installation was profoundly changed.

The BO complex is a mammoth construction project. It will provide a Collision Hall and an Assembly Hall separated by a movable shielding wall, so that the full detector can be moved back and forth. The entire complex is now roofed over.

Construction on the actual components of the Collider Detector is now under way. A complete semicircular 'Roman Arch' of twelve central calorimeter modules has been assembled for structural tests. The central calorimeter consists of four Roman Arches which surround the superconducting magnet and inner chambers. Each one of the fifteen-ton iron modules contains towers of electromagnetic and hadronic detectors. Slots are incorporated in the back of the iron modules for installing the muon detectors. The calorimeter is being built by an international group with contributions from Argonne, Fermilab, Frascati, Illinois, Pisa, Purdue, and Tsukuba/KEK.

The design for the superconducting solenoid has been carried out jointly by personnel at Fermilab and at Tsukuba University in Japan. Construction of the solenoid will begin shortly in Japan.

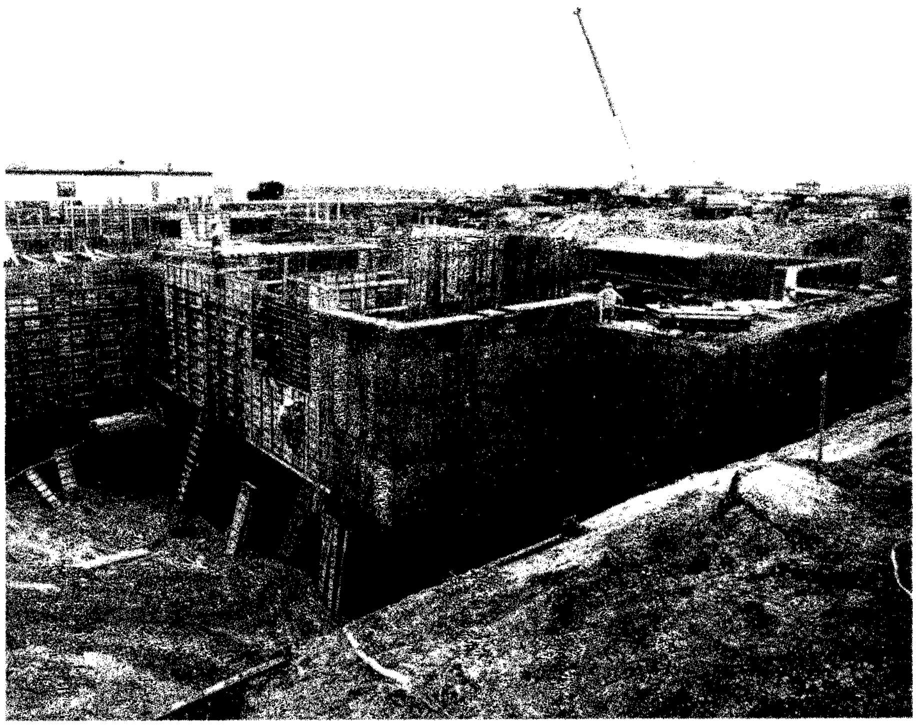
Meanwhile installation of the Doubler/Saver ring is progressing on schedule, and more than 85 per cent of tunnel installation for the Tevatron is complete. This includes upwards of 25 miles of cryogenic piping and hundreds of miles of electrical installation. Close to 700 dipoles have been installed along with more than 200 quadrupoles and 250 other accelerator elements.

Mid-November marked the beginning of work to cool down and operate the E and F Sectors of the ring. This constitutes the beginning of the actual Saver commissioning.

Last winter and spring one-eighth of the Saver ring was tested. In-

Construction work under way in November on the new complex to house the Fermilab Collider Detector. The Collision Hall and Assembly Hall will be separated by a movable shielding wall. The building has now been roofed over.

(Photos Fermilab)



cluded in the test were 2 compressor buildings (A0 and B0), 3 refrigerators (A1, A2 and A3), 2 miles of transfer line, and 2700 feet of superconducting magnets. By comparison, the E and F Sector test is a one-third ring test consisting of 3 compressor buildings, 8 refrigerators, the complete 4-mile transfer line, and 7200 feet of the accelerator. The two sectors include 258 dipoles, 72 quadrupoles, and about 94 other tunnel components.

The goals of this test include successful operation of the controls system, power supplies, and the quench protection monitoring system and work on refrigerator and compressor reliability.

During November the F0, E0, and A0 compressor buildings were started up, liquid nitrogen transfer from the Central Helium Liquefier was begun, and the VAX/PDP-11 computers were integrated into the controls system. By early December the system was operating on pure helium and cooling down of both E and F Sectors had begun.

This test is important for the controls system. With the knowledge obtained from the A-sector test, several improvements in the algorithms to control the refrigerators and compressors have been made and will now be fully tested. One goal is to have a fully automatic system by the end of the test. The task is far from easy; with two sectors working and three compressor buildings and the Central Helium Liquefier in operation, 53 feedback control loops must work in harmony. This number will steadily increase as the rest of the ring becomes operational. Upon completion of the Saver commissioning, there will be 353 control loops in operation.

A second goal for the controls system is to have a 'system' approach to the controls of the compressors to avoid possible oscillations in the transfer line. The compressor controls will be centralized using the VAX computer system instead of only using distributed intelligence residing in the microprocessors that control each of the compressor houses.

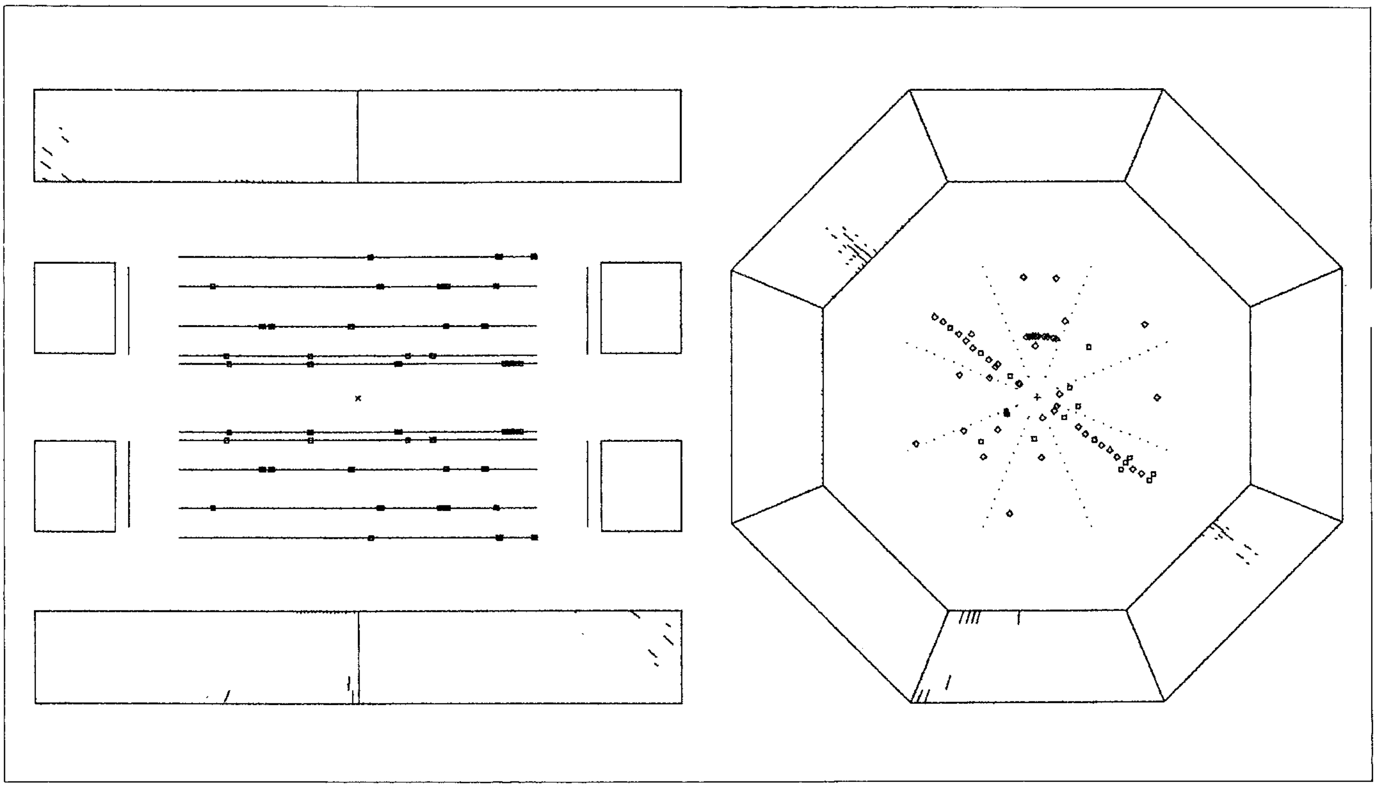
The system has grown considerably in complexity in moving to one-third ring testing. There are four 1 kV power supplies in use, and 8 quench protection monitors communicating through a new link that is in place around the ring. There was much activity both in the service buildings readying the hardware and in the software development. The magnets are full of liquid helium and have been successfully 'hipotted', and the cables between the superconducting bus and the quench protection hardware have been connected. The plans include controlled tests of failure modes, a few detailed studies of certain aspects of the quench protection system, and attempts at extended periods of ramping.

DESY
40 GeV at PETRA and record luminosity at DORIS II

As briefly announced in our previous issue, the PETRA storage ring reached a record collision energy of 40 GeV just in time for Christmas and before the long winter shutdown.

This had been the main goal of the machine's 1982 improvement programme (see December 1982 issue, page 409). The major upgrade consisted of duplicating the power supply (now 8 Megawatts) supplied to the 60 accelerating cavities distributed symmetrically around the PETRA ring. A failure in the external

First electron-positron scattering event recorded by the CELLO group at the higher energies (above 40 GeV) now available at the PETRA electron-positron ring at DESY.



power supply network initially delayed the higher energy tests. Subsequently, difficulties became apparent in running the cavities continuously at higher power. Several high frequency entrance windows were damaged, even running at power values much lower than those of the original tests. Even so, it was possible to crank the machine up to and slightly beyond 40 GeV.

During the current shutdown, 32 new cavities are being installed in the North and South Halls. At the same time the five-cell superconducting cavity from CERN is being installed on schedule in the East Hall. In addition, a 1000 MHz accelerating system is being prepared in the West Hall. It will be able to control the bunch length, if required.

After installation of the extra 32 cavities, there should be no problem in running continuously at the higher energies. The situation will be even better after the delivery of the remaining 20 cavities in the summer, reaching the final complement of 112. PETRA is scheduled to come on again at the end of March.

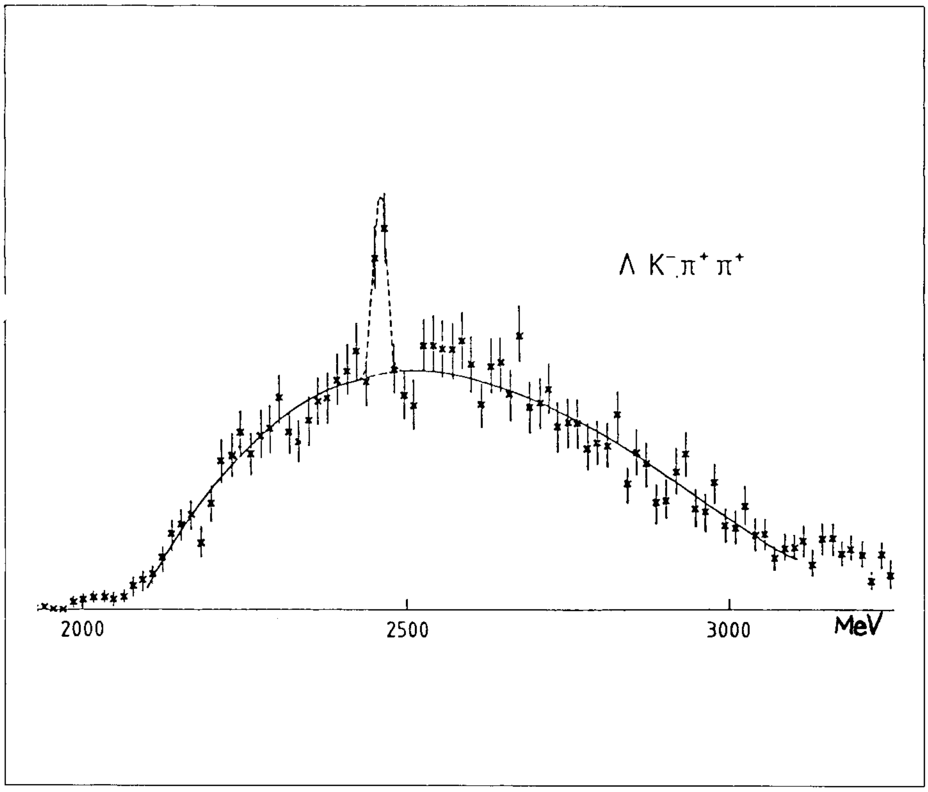
December also saw some good news from the DORIS II ring. The luminosity reached values which had been promised before the DORIS rebuilding was started. The Argus and Crystal Ball experiments were able to use up to 300 nb^{-1} per day integrated luminosity. These values were obtained while imposing a beam current limit of 25 mA due to background problems in the detectors. The dead time of the experiments was about 20 per cent. However the machine is able to provide still higher luminosities and peak values of 10^{31} cm^{-2} s^{-1} were observed. The energy was concentrated in the upsilon region. In August 1978, when the upsilon prime was sighted by the two groups then working at DORIS, the luminosity was a factor 30 times lower!

CERN
Charmed strange baryon

Despite the enormous efforts made to unravel the spectroscopy of charmed particles, the only previously known particles openly carrying the charm quantum number were the D, D* and F mesons, and the charmed sigma and lambda baryons. Of these, only the F meson carries the additional strangeness quantum number — there was no sign of any baryon carrying both charm and strangeness.

However the chances of seeing such particles should be increased by using a beam of hyperons—particles already carrying strangeness. Such an experiment has been carriec

The spectrum from an experiment which used the CERN SPS hyperon beam, showing a clear peak at 2.46 GeV. This is interpreted as a baryon carrying both charm and strangeness. The signal contains 82 events, against 147 of background.



out in the West Experimental Area of the SPS proton synchrotron by a Bristol / Geneva / Heidelberg / Lausanne / London / Rutherford team.

The hyperons (135 GeV negatively charged sigmas) were selected from the secondary SPS beam by a DISC Cherenkov counter (2 x 10^4 sigmas per 1.5 s pulse containing one and a half million negative particles) and hit a beryllium target. The reaction products were measured in a magnetic spectrometer equipped with wire counters and drift chambers, together with threshold Cherenkov counters for identification of protons, kaons and pions. (This SPS hyperon beam has now been dismantled.)

The search concentrated on the production of a lambda baryon (detected by its decay products) and a negative kaon, together with other particles. The selected final states carry the charge (positive) and strangeness (–2) combination which would be produced in the decay of a charmed strange baryon. These quantum numbers could not be produced from the decay of three light (up, down, strange) quarks.

The initial study concentrated on the decays producing a lambda and a negative kaon together with two positive pions. Other final states are still under study. After careful selection and tests to eliminate effects which could produce spurious signals, the four-particle mass spectrum shows a sharp peak at 2.46 GeV containing 82 events. This is interpreted as the positively charged, charmed strange baryon, A. Companion particles are now being sought.

In the data analysis of this experiment, the contents of some 200 magnetic tapes were transferred from CERN to the computers at the Rutherford Appleton Laboratory in the UK using the STELLA satellite high speed data transmission link.

The ghost of baryonium

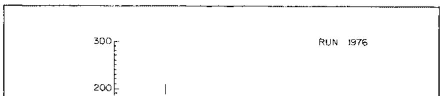
For many years, the fortunes of so-called 'baryonium' states in nucleon-antinucleon annihilation reactions changed with the continual ebb and flow of experimental statistics. At first there were some promising signals, but gradually the sightings became less frequent and it looked as though baryonium was destined for the scrapheap of interesting, but irrelevant, physics ideas.

The initial motivation for the search for baryonium came, oddly enough, from the lack of structure in the nucleon-nucleon channel, where the deuteron is the only commonly encountered bound state. If this is interpreted as being due to a basically repulsive force between two nucleons, then an attractive force might be expected in the 'crossed' nucleon-antinucleon channel.

Candidate baryonium states were reported from a wide range of experiments, but one by one they failed to reappear in searches using larger data samples. In the trade, the joke was that baryonium was being replaced by buryonium!

Most of the initial candidate baryonium signals came in the form of explicit nucleon-antinucleon resonances. One notable exception was provided by a Basle / Karlsruhe / Stockholm collaboration at the CERN 28 GeV PS proton synchrotron studying the interactions of antiprotons brought to rest in a target. This experiment looked for (and found) indications of the gamma rays which would be expected if quasi-free protons and antiprotons fall into tightly bound baryonium states. The gamma spectrum looked quite promising, with evidence for three separate and well defined proton-antiproton bound states.

To confirm these initial findings,



Results from the Basel / Karlsruhe / Stockholm / Strasbourg / Thessaloniki collaboration at the CERN in their searches for signs of 'baryonium' in the gamma rays coming from proton-antiproton annihilations at rest. The peaks indicated by arrows correspond (with increasing gamma energy) to masses of 1771, 1694, 1638 and 1210 MeV. The large peak at 130 MeV gamma energy is expected and produced by a slow negative pion being brought to rest in the target. The later runs used an improved detector system.

the collaboration, including now also Strasbourg and Thessaloniki, embarked on a new experiment at the PS, using an improved detector to pick up the emitted gamma rays with higher sensitivity and to intercept the products of the proton-antiproton annihilations.

Two major runs were carried out, one with 40 million and the other with 110 million stopped antiprotons. Major components of the experiment were modified between runs, which therefore can be considered almost as independent experiments, providing two sets of gamma spectra.

Both spectra were subject to high backgrounds, mainly due to gammas coming from the decay of neutral pions. This background signal had to be carefully removed to isolate any sharp gamma emission lines hidden behind. Two of the lines seen in the initial experiment are confirmed, one previous line becomes less distinct, and other lines begin to show up as well.

The yields are reduced compared with the earlier study, but the experimenters have more confidence in the new experiment. If not in perfect health, baryonium is at least still alive! These results are both interesting and encouraging in view of the experiments starting at CERN's new LEAR low energy antiproton ring this year, which is ideally suited to study these phenomena.

Large angle scattering

In hadron-hadron scattering, two different types of general behaviour can be distinguished. In gentle 'peripheral' interactions, where the interacting particles are only slightly deflected, the force is understood to be transmitted by 'Regge' exchanges. However in more violent collisions producing wide angle deflections, the interaction is assumed to be caused by the forces between the constituent quarks inside the particles.

In principle it should be possible to study hadron-hadron elastic scattering over a wide range of momentum transfer (scattering angle) and see the transition from one type of behaviour to another. Hadron-hadron elastic scattering, over the years, has been extensively studied in the peripheral region. Apart from a few results at high energy, data on large angle scattering for the wide range of different hadron-hadron collisions has been scanty.

An experiment by an Annecy / CERN / Copenhagen / Genoa / Oslo / University College London team using a high intensity unseparated hadron beam from the CERN SPS 400 GeV proton synchrotron has made a survey of this wide angle scattering and finds the theories wanting.

The collaboration has already produced some interesting results on fixed target antiproton, interactions and sees a rich structure setting in at a much lower energy than for the proton-proton case (see July/August 1981 issue, page 246).

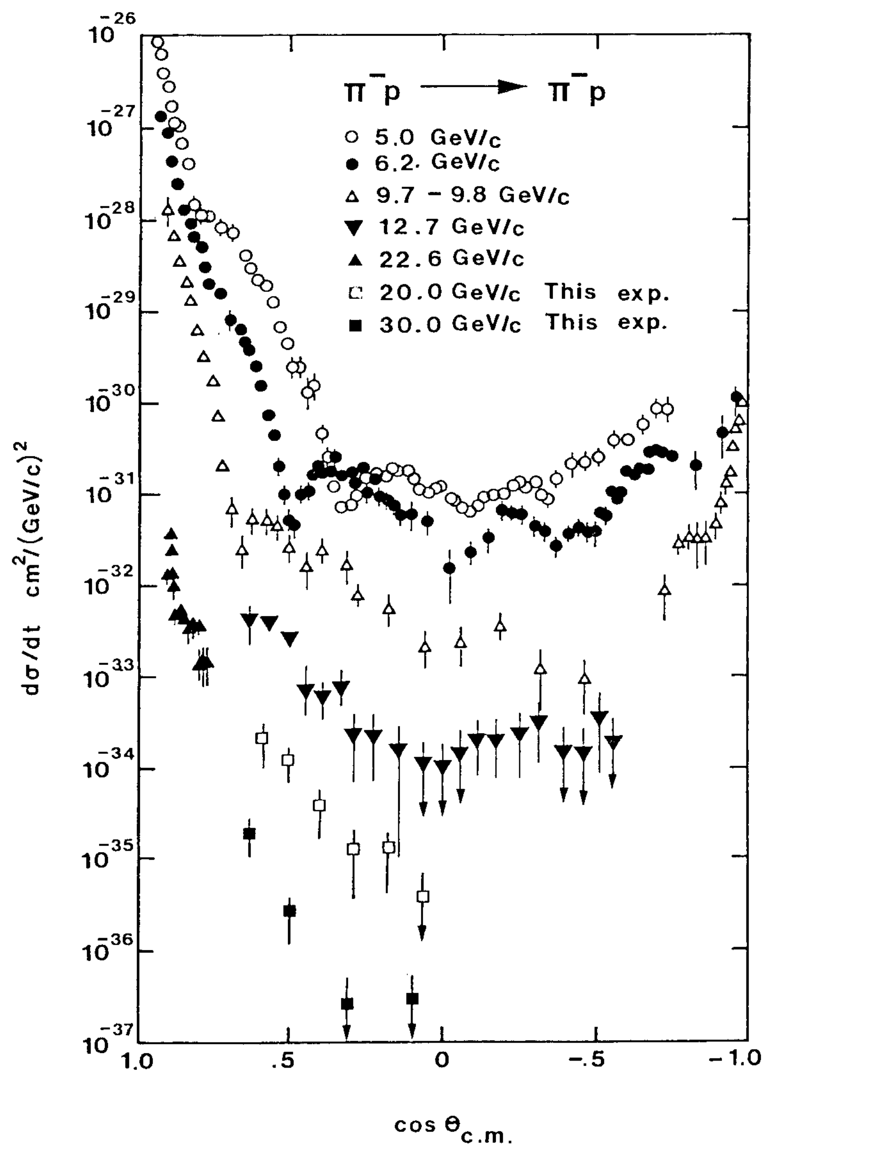
Differential Cherenkov counters (CEDARS) provided the necessary particle identification, with additional instrumentation measuring the beam particles and the beam intensity.

Because of the rare reactions being studied, intensity was important. The secondary SPS beam typically contained 5×10^7 particles per burst. The two-arm downstream spectrometer covered centre-of-mass scattering angles from 45° to 100°.

In order to minimize apparatus dead time, the trigger was organized into three levels, each successively more sophisticated and consequently with a longer decision time. Hodoscope data was fed into six programmable fast matrix coincidence units for a first selection. Additional matrix logic carried out more accurate tests before passing the data to a specially designed hardwired microprocessor.

A total of some 38 million triggers were analysed, covering 20 GeV negative and positively charged beams, and with 30 GeV negative beam. Most of the selected events correspond to scattering of protons and of positive and negative pions with the fixed target. A few kaon events were intercepted. Under these conditions, no antiproton events were seen.

The data were first compared with the 'constituent interchange model', which assumes that the interactions are built up from constituent quark-quark scatterings. The angular dependence of this model is much weaker than the observed behaviour, particularly at the higher energy.



Negative pion elastic scattering, including new data at higher energies from an Annecy / CERN / Copenhagen / Genoa / Oslo / University College London team. The observed behaviour for large scattering angles changes rapidly with energy.

If the observed pion-nucleon data is used to fit the parameters of the model, then the predictions for kaon-nucleon scattering do not fit the data at all. In particular, the ratio of observed kaon and pion data increases with energy, whereas dimensional arguments suggest it should be fairly constant.

Other candidate models for these interactions also cannot explain the relatively fast falloff in scattering rate with angle. The only recourse is to tinker with the models.

The results show that we are far from knowing all there is to know about the basic behaviour of particle scattering at high energy.

SIN Pion radiotherapy

For the irradiation of human cancers, photons and electrons have been in use for many years, and neutrons were first tried in the early 1940s. Nowadays, protons and heavy ions are being pressed into service, and the meson factories are particularly well adapted to providing negative pions, whose properties are expected to be especially suitable for this purpose.

LAMPF and TRIUMF, with relatively simple beams, were pioneers in the pion radiotherapy field; LAMPF, indeed, has treated some 200 patients over the last five years or so. For a number of reasons, this programme has been cut, but work continues at SIN and TRIUMF. Of these, TRIUMF, like LAMPF, uses a beam-line similar to a conventional one, where a series of dipole and quadrupole magnets delivers pions from a production target to a tumour. At SIN, on the other hand, the approach has been more sophisticated. Using a superconducting layout originated at Stanford University nearly a decade ago, sixty pion beams are delivered isocentrically to the tumour. The technique has two advantages: the solid angle for pion collection is about a steradian, so that a proton beam of relatively low intensity (20 μA) can be used; and the dose can be matched efficiently to the tumour, with minimal damage to neighbouring healthy tissue.

The SIN device, the Piotron, produced its first pions in June 1980, and the first patient was treated in November of that year. As of end 1982, 39 tumours in 34 patients have been treated, from melanomas (skin cancers) perhaps a centimetre across to deepseated abdominal and pelvic tumours of a litre or more.

Results are so far at least in agreement with expectation. No miracle cures have been seen, but in all cases tumours have regressed, sometimes completely. Side effects have so far been less than would have been produced by any conventional treatment of these tumours. This is to be expected, since the technique spares neighbouring healthy tissue better than conventional methods.

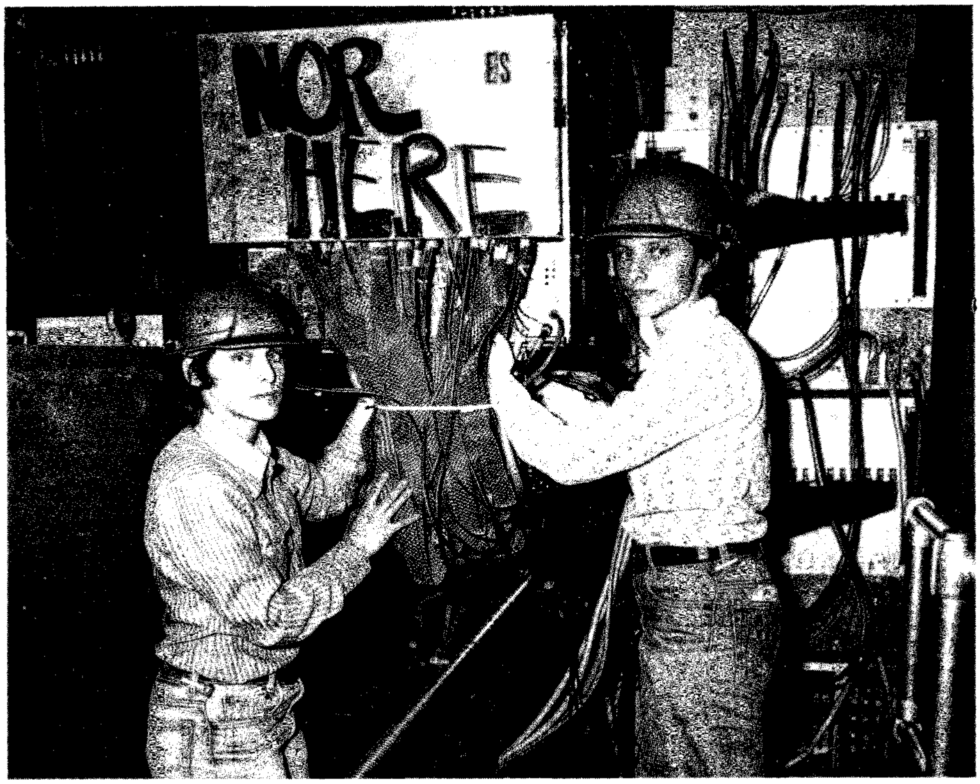
After a serious failure of the vacuum system last July, treatments were re-started in November. It is also hoped soon to start treatments of Glioblastoma, a particularly recalcitrant tumour of the brain.

As well as machines at physics Laboratories like SIN, accelerators at hospitals also provide radiotherapy. For instance the Harvard Cyclotron Laboratory recently treated its 2000th patient with proton beams.

People and things

At work at the CLEO detector at Cornell. Twin Rochester graduate students Joan and Jan Guida check the electronics for the magnet pole tip shower counter. Visible between them is part of the system for moving the pole tip.

(Photo Cornell)



On people

The prestigious Wolf Physics Prize goes this time to Leon Lederman of Fermilab and Martin Perl of SLAC. With their important contributions to the discoveries of the upsilon particle and the tau lepton respectively, these eminent physicists played an important role in shaping our present picture of the underlying quark/lepton picture of the structure of matter.

CERN Director General Herwig Schopper was the speaker at the latest Shulamit Goldhaber Memorial Lecture, an important annual event at Tel Aviv University. The lectures began back in 1965 after Berkeley colleagues of the late Shulamit Goldhaber set up a scholarship for a particle physics graduate student at Tel Aviv. Over the years, these lectures have attracted an impressive list of speakers to Tel Aviv.

Gerson Goldhaber of Berkeley has been elected a Foreign Member of the Royal Swedish Academy of Sciences, an honour reserved so far for only 115 non-Swedes.

'Fortran Optimization' is the title of a new book by Michael Metcalf of CERN, published by Academic Press as part of a series on studies in data processing.

CERN on TV

At the end of January, British TV audiences had a chance to see the film 'The Geneva Event', made by the BBC/Open University team in collaboration with CERN. This film covers the history of the big UA1 experiment at the proton-antiproton collider at the CERN SPS ring. Filming started in 1979 soon after the inception of the experiment, and followed the progress of construction, installation, testing, data-taking, and presentation of the initial results.

B mesons at Cornell

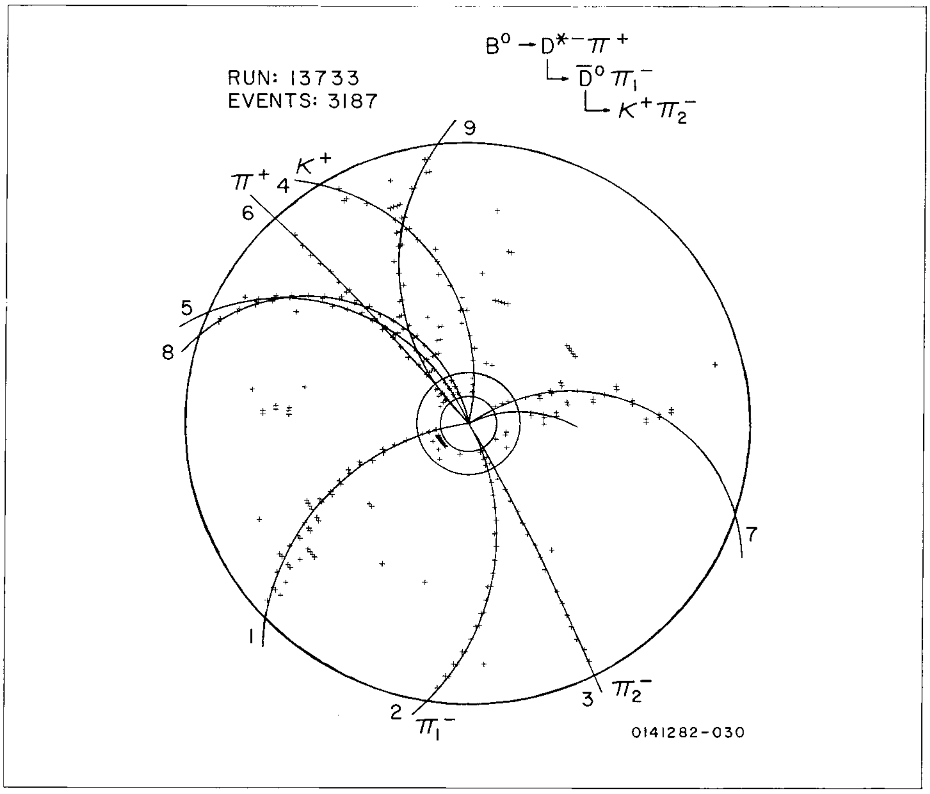
As reported in the January/February issue (page 5), the CLEO group working at Cornell's CESR electron-positron ring have succeeded in reconstructing B mesons. This is the first direct observation of particles openly carrying the new beauty (bottom) quantum number.

This was achieved thanks to high electron-positron collision luminosities and running the machine at a collision energy band near the fourth upsilon resonance.

The upsilons are considered to be bound states of quarks and antiquarks carrying beauty, but the fourth upsilon level (about 10.5 GeV) is the first which has enough energy to decay directly into B mesons.

The B mesons were tracked down through a detailed analysis of their subsequent decays, a high proportion of which involve charmed particles. A careful analysis of possible sources of background ensured that the B meson signals were authentic. As soon as the data shifted away from the appropriate peaks for charmed particle production, or the collision energy tuned away from the fourth upsilon, the observed B meson peak disappeared. The peak corresponds to 5274 MeV, indicating that the fourth upsilon is about 30 MeV above threshold for decay into two B mesons.

In principle there should be both charmed and neutral varieties of B mesons, but with the present data sample the split is not yet visible.



A typical event from the CLEO detector at Cornell's CESR electron-positron ring, showing a neutral B (beauty) meson decaying into a charmed (D) meson and a pion. Tracks and hits in the central drift chamber and beam pipe proportional chamber are shown without the outer detectors, which were not used in reconstructing this event.*

Meetings

The Europhysics Conference on 'Computing in Accelerator Design and Operation', originally scheduled to be held in Warsaw in September 1982, is now to take place in West Berlin from 20–23 September 1983. The papers will be grouped under the headings – Design Aspects of Accelerators, Digital Control of Accelerators, Operational Aspects, and will include aspects of data processing. Chairman of the conference is Prof. R. Zelazny, INR-Otwock, Poland. Chairman of the local organizing committee is Dr. W. Busse, HMI-Berlin.

Further information is available from Mrs. G. Liar de Martin, Hahn-Meitner-Institut Berlin, Postfach 39 01 28, D-1000 Berlin 39, West Germany.

The Third International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions will be held from 26–29 September at Brookhaven. Nuclear and high energy physicists will discuss recent progress in theory and experiment regarding the formation of new states of matter in very high energy nucleus-nucleus collisions. Particular emphasis will be paid to the prospects for future experiments with existing and proposed accelerators. For further information please contact the conference secretary, Ms Rae Greenberg, Physics Dept, Building 510A, Brookhaven National Laboratory, Upton, New York 11973 USA.

The Scottish Universities' Summer School in Physics will be held in Edinburgh from 31 July to 20 August. The topic this year is 'Statistical and Particle Physics — Common Problems and Techniques'. The school will follow immediately after the STATPHYS conference to be held in Edinburgh from 25–29 July. Further information from the School Secretary, A. Walker, Department of Physics, University of Edinburgh, James Clerk Maxwell Building, King's Buildings, Mayfield Road, Edinburgh EH9 3JZ, UK.

The first Asia Pacific Physics Conference will be held in Singapore from 12–18 June, and the subjects to be covered include high energy physics and nuclear physics. The Conference is sponsored by the National University of Singapore, the Singapore Institute of Physics, the Physical Society of Japan, the Southeast Asian Theoretical Physics Association, and the International Centre for Theoretical Physics at Trieste. Further information from the Conference Chairman, Department of Physics, National University of Singapore, Kent Ridge, Singapore 0511.

A Workshop on Time Projection Chambers and experiments using them will be held at the TRIUMF Laboratory, Vancouver, Canada, from 23-25 June. Further information from the co-chairmen: E.P. Hincks, Physics Dpt., Carleton University, Ottawa, Canada, K1S 5B6 or J.A. Macdonald, TRIUMF, UBC Campus, Canada V6T 2A3.

The first European Southern Observatory (ESO) — CERN Symposium will be held at CERN from 21-25 November. It subject will be Large Scale Structure of the Universe, Cosmology and Fundamental Physics. The Scientific Organizing Committee is composed of G. Setti (ESO) and L. Van Hove (CERN), cochairmen, J. Audouze, J. Ehlers,

E. Fiorini, H. van der Laan, D. Nanopoulos, M.J. Rees, D.N. Schramm, D.W. Sciama and G. Tammann. The attendance to the Symposium will be limited to approximately 150 participants.

More spin-off from the equipment used in particle physics

During the closing session of the third World Congress on Nuclear Medicine in Paris, the French national association of public hospital engineers awarded the prizes for the competition it had organized on the development of new techniques in nuclear medicine. The criteria used to judge the twenty projects put forward were originality and the impact on technological development.

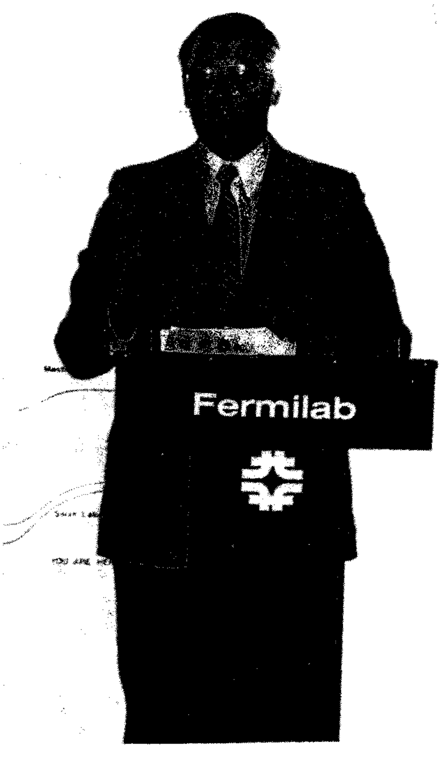
One of the prizes was awarded to a joint project by French scientists and engineers from three laboratories: Françoise Soussaline (the Frédéric-Joliot hospital, CEA), Hoan Nguyen Ngoc and Jack Jeanjean (from the applications group of the linear accelerator laboratory, Orsay) and Lazhar Hadjeris, Roland Marbot, Philippe Miné and Hoang Xuan Thong (from the high energy physics Laboratory at the Ecole polytechnique, Palaiseau). Using a fast bipolar microcomputer developed for particle physics requirements, this team created a system for on-line correction of defects in geometric linearity and in the uniformity of scintigraph pictures produced by gamma cameras.

This system can improve diagnosis by improving picture presentation. It also opens the way to quantitative analysis of the fixation of radioactive elements.

CERN Accelerator School

CERN is in the process of setting up an Accelarator School which will have a continuing mission in close collaboration with institutions in the Member States to promote the transfer of knowledge in the field of particle accelerators. Some examples of proposed activities: to organize courses in accelerator science and technology at postgraduate level; to assist universities to find lecturers for basic courses in accelerator physics; to coordinate supervision of thesis work on accelerator subjects in collaboration with universities; to arrange lectures and promote studies on advanced and novel accelerator techniques. Formation of the School is at an early stage under the leadership of Kjell Johnsen at CERN (1211 Geneva 23, Switzerland), who would be happy to receive constructive comment on the proposed role of the school. Further information on the School's activities will be published in the CERN COURIER as plans advance.

A colloquium to mark the sixtieth birthday of theoretician Rudolf Haag was held recently at the II Institute for Theoretical Physics of the University of Hamburg.



Governor Jim Thompson of Illinois visited Fermilab recently, where he announced the establishment of a 31-member Governor's Commission on Science and High Technology. Members include Leon Lederman and Frank Cole of Fermilab, and Walter Massey of Argonne.

(Photo Fermilab)

Alignment Engineer

The Stanford Linear Accelerator Center (SLAC) seeks an engineer with a post graduate degree to work on the many challenging alignment problems in the construction of the Stanford Linear Collider (SLC), the upkeep and improvement of the existing accelerator systems and the design and maintenance of physics detectors.

The foremost immediate task will be the conceptual design and technical implementation of the SLC alignment system in collaboration with a PhD physicist. Tolerances to be met are typically in the several part-per-million region.

The applicant's educational background should be in geodesy, metrology, surveying, or in another closely related field with emphasis on geodesy. Knowledge in computing and statistics is required.

This is a career position. Salary will be commensurate with education and experience. Please direct resumes or inquires to the SLAC Employment Office c/o Joan Minor, Stanford Linear Accelerator Center, P.O. Box 4349, Stanford, California 94305 U.S.A. An equal opportunity employer.

SLAC *Stanford Linear Accelerator Center*

UNIVERSITY OF OXFORD

Department of Nuclear Physics

Research Assistants in High Energy Physics

The Department of Nuclear Physics expects to make two appointments to positions on the Research Assistant (RAIA) scale. The appointees will be expected to take part in construction, running and physics analysis of experiments. The present accelerator-based research programme includes $e^+ e^-$ experiments at DESY and eventually LEP; the EMC, EHS and BEBC neutrino experiments at the CERN SPS: and a neutrino experiment at the Tevatron. Non-accelerator experiments include the Soudan 2 project on proton decay and one on the detection of solar neutrinos. In making appointments, preference would be give to EHS and to BEBC/Tevatron neutrino experiments.

The appointments are for 3 years in the first instance, with possible extension to 5 years maximum. Salary is on an age related scale of 6375 £ per annum at age 24 rising by annual increments of 410 £. Membership of the USS pension scheme is obligatory and involves 6.25 per cent salary contribution from the member and 12 per cent from the University.

Applicants should have experience in the field of experimental high energy physics. Applications including curriculum vitae and names of 2 referees should be sent to

Professor D.H. PERKINS,
Department of Nuclear Physics,
Keble Road,
OXFORD / OX1 3RH / England,

by March 31, 1983.

XP 2008 and XP 2012 contribute in UA1 and UA 2 $\bar{p}p$ CERN experiments with

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	∅ (mm)	type		16h/0,3µA (%)	1-0,1µA (%)		
XP2008	32	super A	10	1	1	200	8
XP2012	32	bialkali	10	1	1	200	7,2
XP2202	44	bialkali	10	1	1	200	7,4
XP2212	44	bialkali	12	1	1	250	7,5
XP2030	70	bialkali	10VB	0,5	0,8	40*)	7,2
XP2050	110	bialkali	10VB	1	1	40*)	7,5

*) with a specially tailored bleeder

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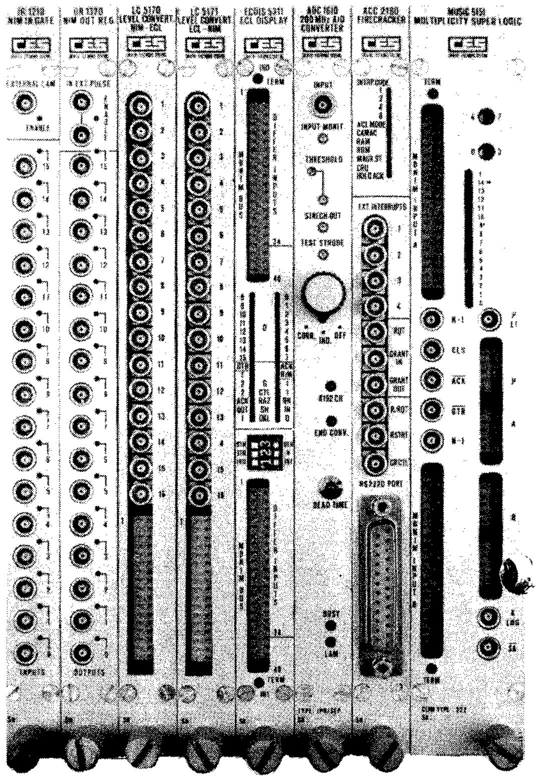

CAMAC Units:

High energy physics:

IG	1210	16bit NIM input gate
LC	5170	NIM to ECL single-width low cost converter
LC	5171	ECL to NIM single-width low cost converter
MUSIC	5151	Multiplicity super logic (CERN specs)
ECDIS	5311	ECL/MBNIM fast trigger display
ADC	1610	8192ch. 200MHz spectroscopy ADC (IPN Orsay specs..
HM	2161#	16K 32bit 1MHz histogramming memory
DPM	2162#	16K 16bit true dual port memory
ACC	2160	167ns TMS 99000 based fast processor
ACC	2180#	200ns DEC J-11*(PDP 11/70 power) fast processor

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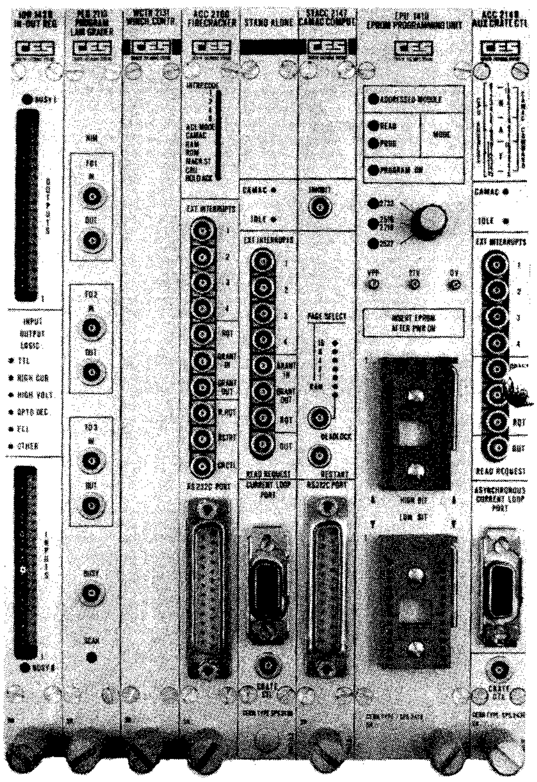
Process control:

TMS	99000-based systems where the maximum speed is required
DEC	J-11* based systems offering software portability between host and targets.

Each system includes ACCs, crate controllers, high speed static RAM memory extensions, EPROM memory extensions, and peripheral interfaces

IOR	1420	general purpose input/output register
PLG	2113	Programmable LAM grader
WCTR	2131	Winchester disk controller
WIN	2130	5 MByte Winchester disk
BHT	2330	Branch highway terminator plug (no slot required)

units under development



Eurocard units:

The CES line of Eurocard based processors are designed to complement the CAMAC processors as low cost front-end extensions.
They use the standard G-64 bus and complement the GESPAC line of processors by adding the Texas Instruments family to the other 8 and 16 bit processors already available in this standard.

GESMPU-4A	68000 8Mhz CPU, 64 Kbyte EPROM, 16 Kbyte RAM, 1 RS232C port, 3 interval timers.
CESMPU-9	9995 12 MHz CPU, 64 Kbyte EPROM, 16Kbyte RAM, 2 RS232C ports, 3 interval timers.
CESMPU-10	99105 24 MHz CPU,64K byte EPROM, 16Kbyte RAM, 1 RS232C port, 1 interval timer.

Contact either CES or GESPAC for the Eurocard units.

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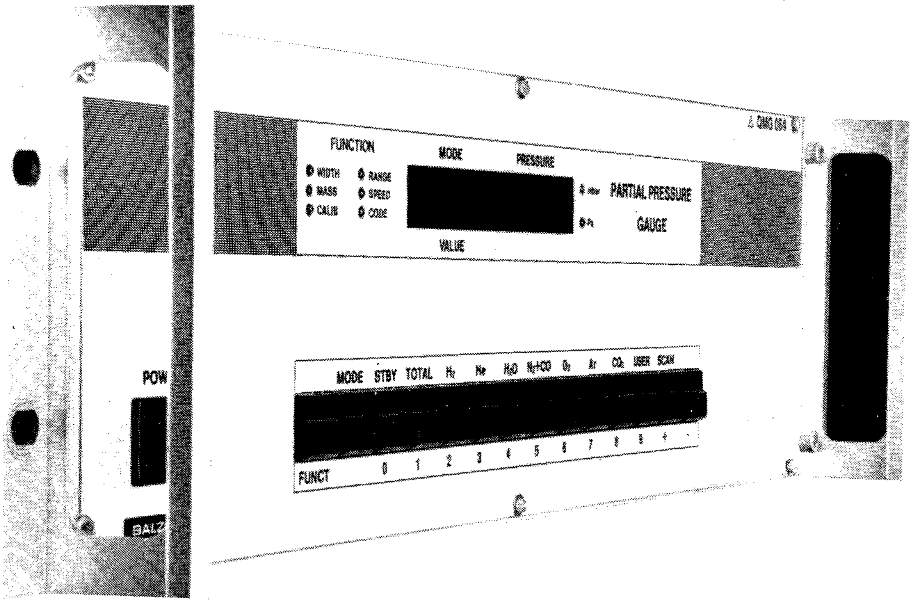
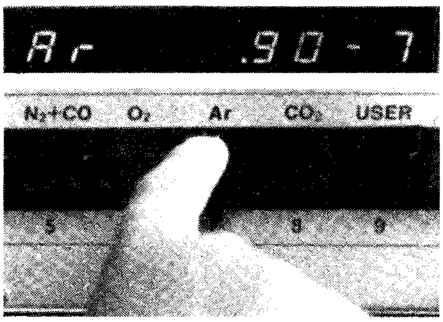
The ‹intelligent› vacuum gauge QMG 064



The new vacuum gauge QMG 064 gives you a choice of

- total pressure measurement
- up to 8 partial pressures
- spectra in the 1 to 64 amu range

with the display in either milibar or Pascal. The QMG 064 represents the new generation of vacuum gauges with integrated microprocessor which offers the user an ease of operation hardly imaginable a few years ago.



Balzers programs seven of the eight channels for the following gases: H_2, He, H_2O, N_2 + CO, O_2, Ar and CO_2. Simply by pushing a button the vacuum technologist can leave the interpretation of significant gas components to the fast and reliable partial pressure gauge.

BALZERS

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Stampfenbachstrasse 48
CH-8035 Zürich
Tel (01) 363 32 66
Telex 52 278

BG 800 177 PE DN 7445

I would like detailed information on the QMG 064

Name

Company

Address

City

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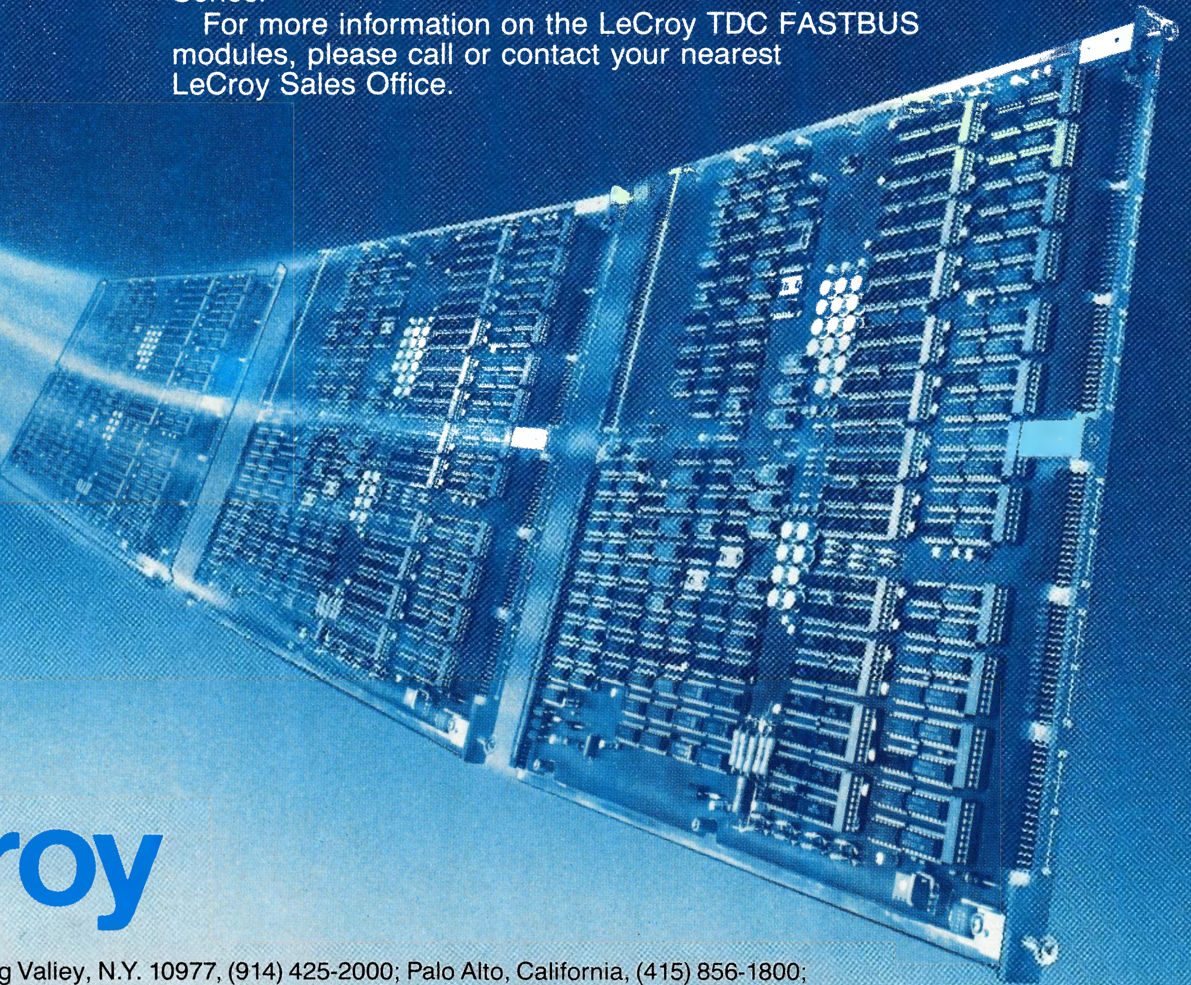
1ST in FASTBUS Data Acquisition A Multihit TDC

Data Acquisition in FASTBUS is available now with LeCroy's Model 1878 and 1879 96-Channel Multihit TDC modules. These TDC's use the new exciting FASTBUS standard and provide sophisticated high speed multiprocessor control and readout and versatile test capabilities.

Featuring 9-bit dynamic range, the Model 1879 provides programmable clock rates up to 500 MHz, corresponding to a resolution of 2 nsec. The lower cost Model 1878 offers 8-bit dynamic range and 4 nsec resolution. The TDC's use a digital encoding scheme, derived from a crystal controlled clock and as a result, they are easy to understand and require no gain calibration. Based on a high speed Silicon-on-Sapphire (SOS) circuit pioneered at Brookhaven, the TDC's provide high density yet low power dissipation for reliable operation.

Look to LeCroy for the latest in FASTBUS data acquisition modules featuring unprecedented high channel multiplicity, self test and calibration, and convenient trigger processor connections. Coming soon, the 96-Channel ADC Series, the next in the LeCroy FASTBUS Module Series.

For more information on the LeCroy TDC FASTBUS modules, please call or contact your nearest LeCroy Sales Office.

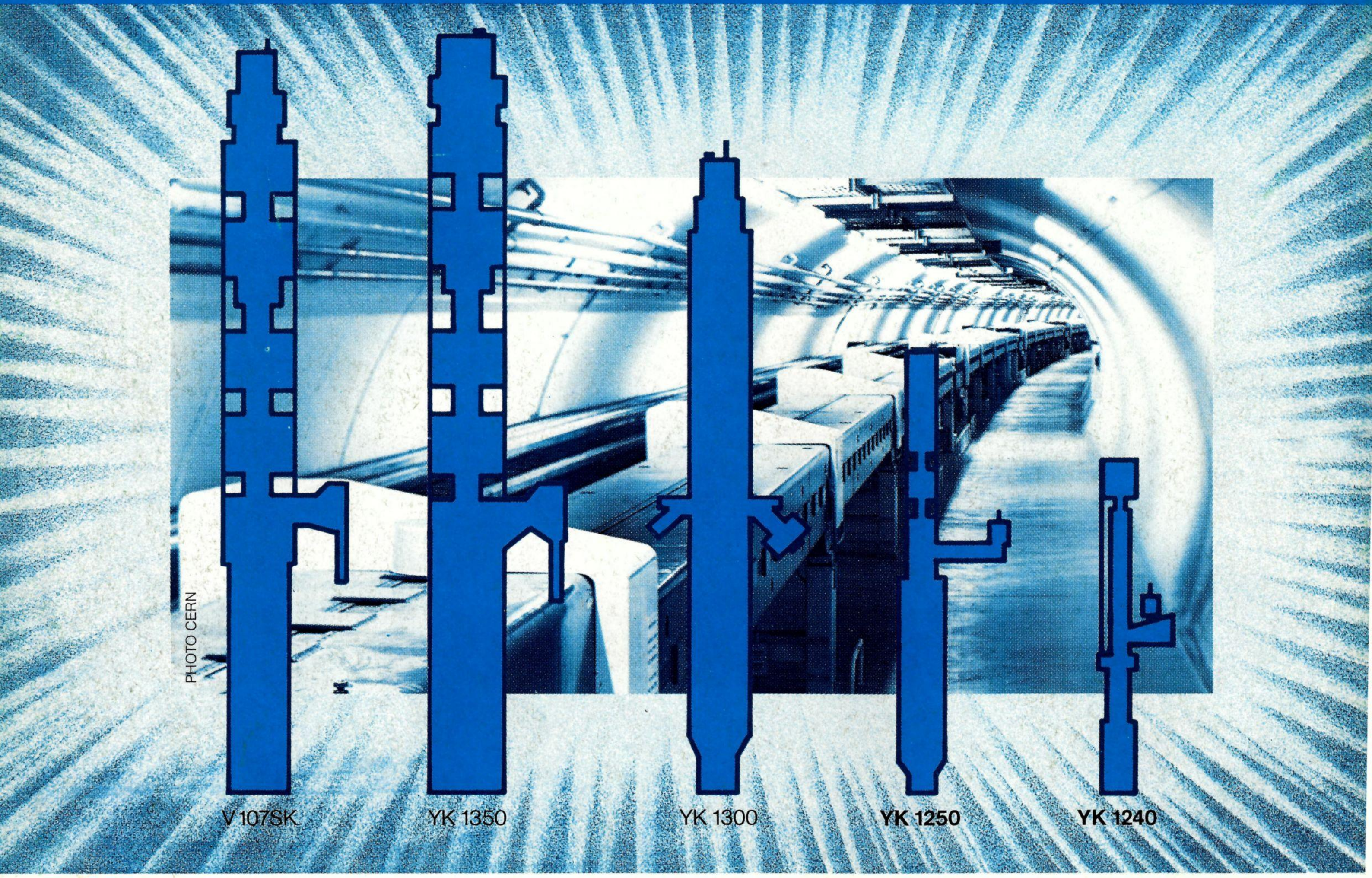


LeCroy

700 S. Main St., Spring Valley, N.Y. 10977, (914) 425-2000; Palo Alto, California, (415) 856-1800; Geneva, Switzerland, (022) 98 97 97; Heidelberg, West Germany, (06221) 28192; Les Ulis, France (6) 907.38.97; Botley, Oxford, England, (0865) 72 72 75. Representatives throughout the world.

Electronics.
We provide the components.

VALVO



More Big Klystrons for Big Science

Valvo herewith present the smallest big klystrons to reach ambitious aims in big science. Small in size but large in RF-power the klystrons YK 1240 and YK 1250 cover the higher frequency range.

YK 1240 operating at 1300 MHz delivers 325 kW RF-power with 1 second pulse every 5 minutes. The RF-power heats the plasma in the Tokamak ASDEX at lower hybrid frequencies in order to study the fusion conditions.

YK 1250 operates at 1000 MHz being a harmonic to the existing 500 MHz acceleration frequency of PETRA. The output power is more than 350 kW cw. This second RF-frequency system turned out to be the most powerful measure in order to decrease turbulences induced by the cavities in the bunch.

Valvo is a member of the worldwide Philips organization. Please contact your nearest Philips representative.

VALVO

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