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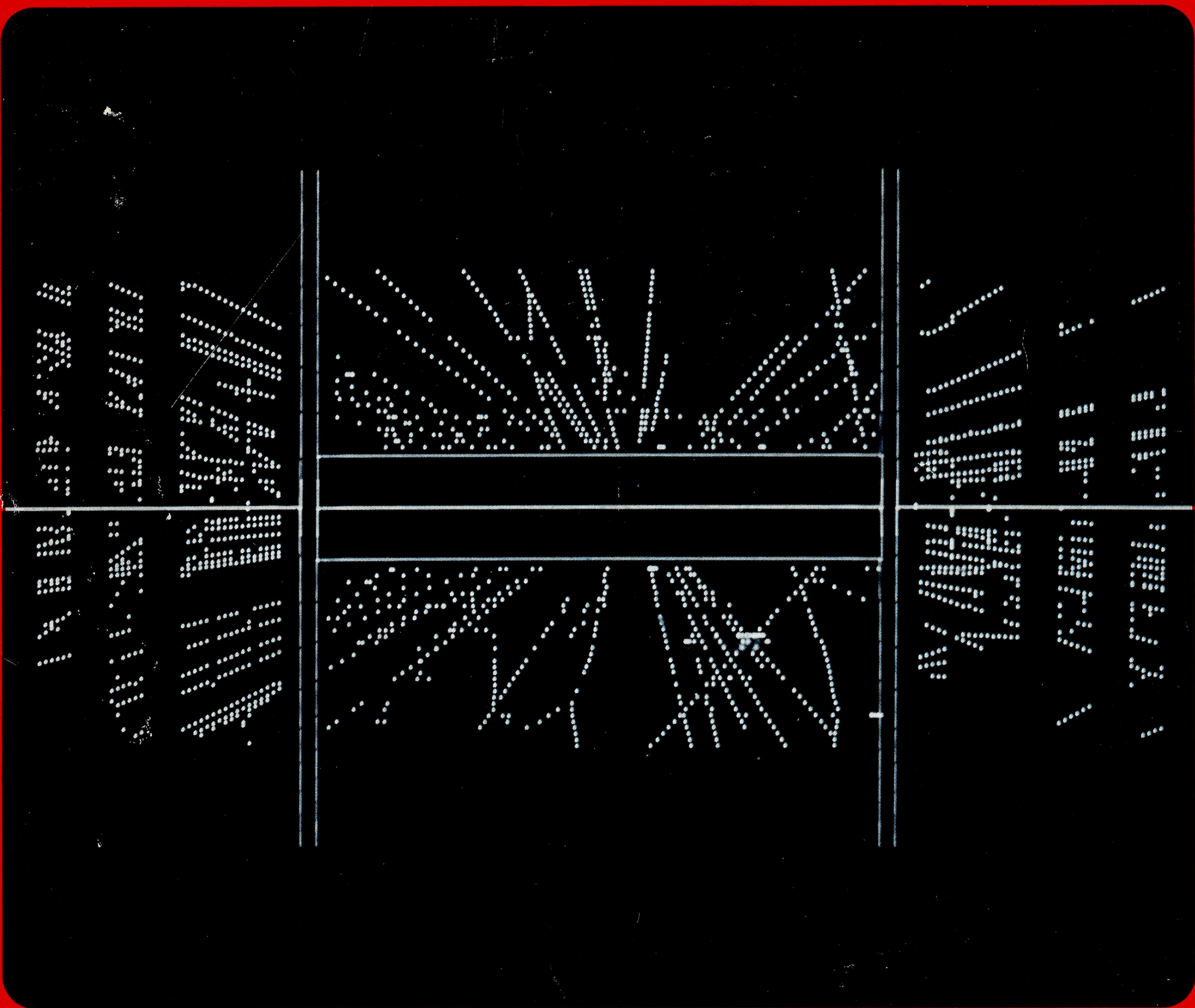

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Laboratory correspondents:
Argonne National Laboratory, USA
W. R. Ditzler
Brookhaven National Laboratory, USA
N. V. Baggett
Cornell University, USA
N. Mistry
Daresbury Laboratory, UK
V. Suller
DESY Laboratory, Fed. Rep. of Germany
P. Waloschek
Fermi National Accelerator Laboratory, USA
R. A. Carrigan
KfK Karlsruhe, Fed. Rep. of Germany
M. Kuntze
GSI Darmstadt, Fed. Rep. of Germany
H. Prange
INFN, Italy
M. Gigliarelli Fiumi
Institute of High Energy Physics, Peking, China
Tu Tung-sheng
JINR Dubna, USSR
V. Sandukovsky
KEK National Laboratory, Japan
K. Kikuchi
Lawrence Berkeley Laboratory, USA
W. Carithers
Los Alamos National Laboratory, USA
O. B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
C. Paulot
Rutherford Laboratory, UK
J. Litt
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
G. H. Eaton
Stanford Linear Accelerator Center, USA
L. Keller
TRIUMF Laboratory, Canada
M. K. Craddock

Copies are available on request from:
Federal Republic of Germany —
Frau G. V. Schlenther
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56
00044 Frascati
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Laboratory, Chilton, Didcot
Oxfordshire OX11 0QX
USA/Canada —
Margaret Pearson
Fermilab, P. O. Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN, 1211 Geneva 23, Switzerland

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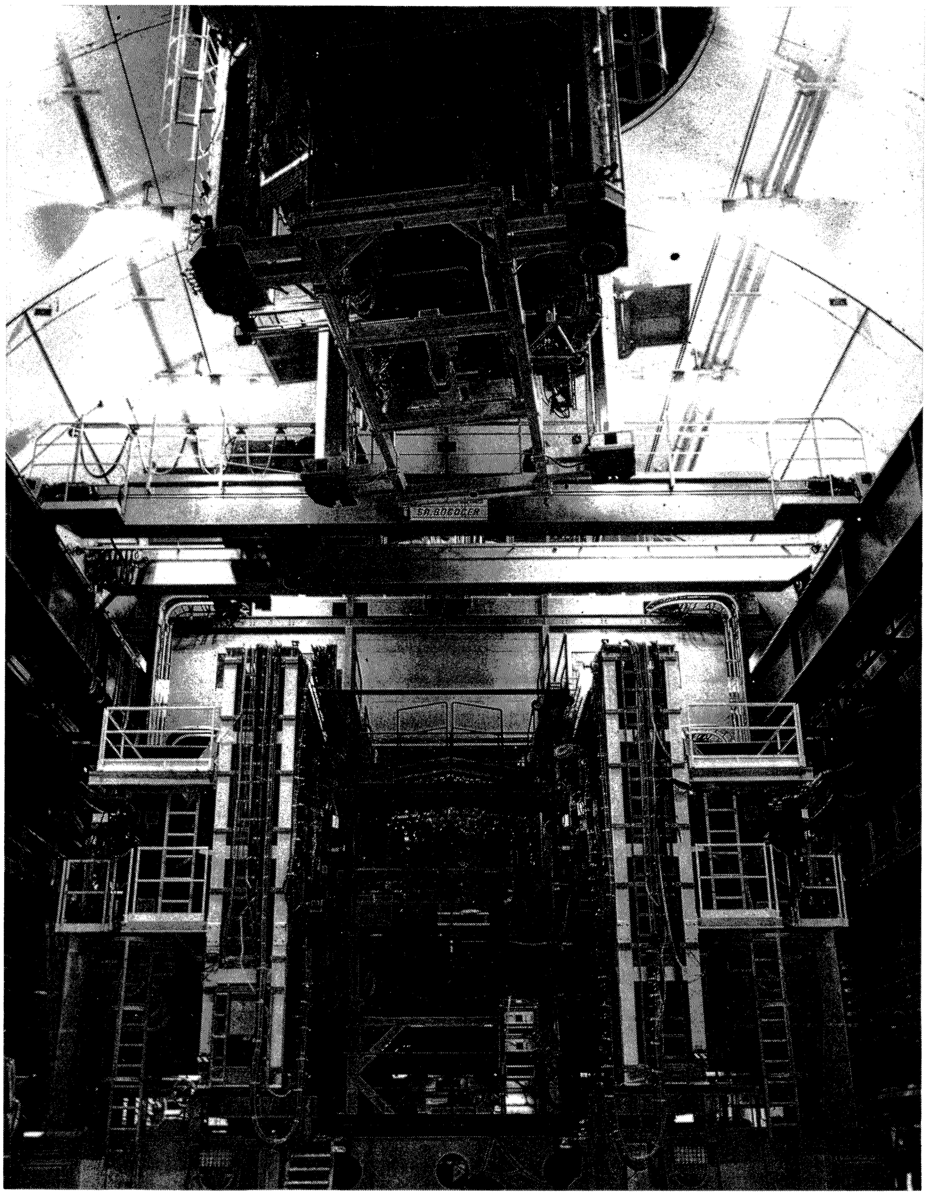
Around the Laboratories

Cover photograph: Tracks from 540 GeV proton-antiproton collisions in the CERN SPS ring as revealed by the UA1 detector. First results from these record collision energies are reported on page 3. (Photo CERN 362.11.81)

Around the Laboratories



The 40-ton structure housing the streamer chambers of the UA5 experiment for the CERN proton-antiproton collider dangles in the air (50 m below ground) as the juggernaut of the UA2 detector is moved slowly towards its position in the SPS ring.

(Photo CERN 266.11.81)

CERN
First results at 540 GeV total energy

The 540 GeV total energy attained in the proton-antiproton collisions in the CERN SPS represents by far the highest collision energy ever reached under controlled conditions. For the first time physicists are able to study in their Laboratory the sort of behaviour which had been seen only with cosmic rays reaching the earth from outer space.

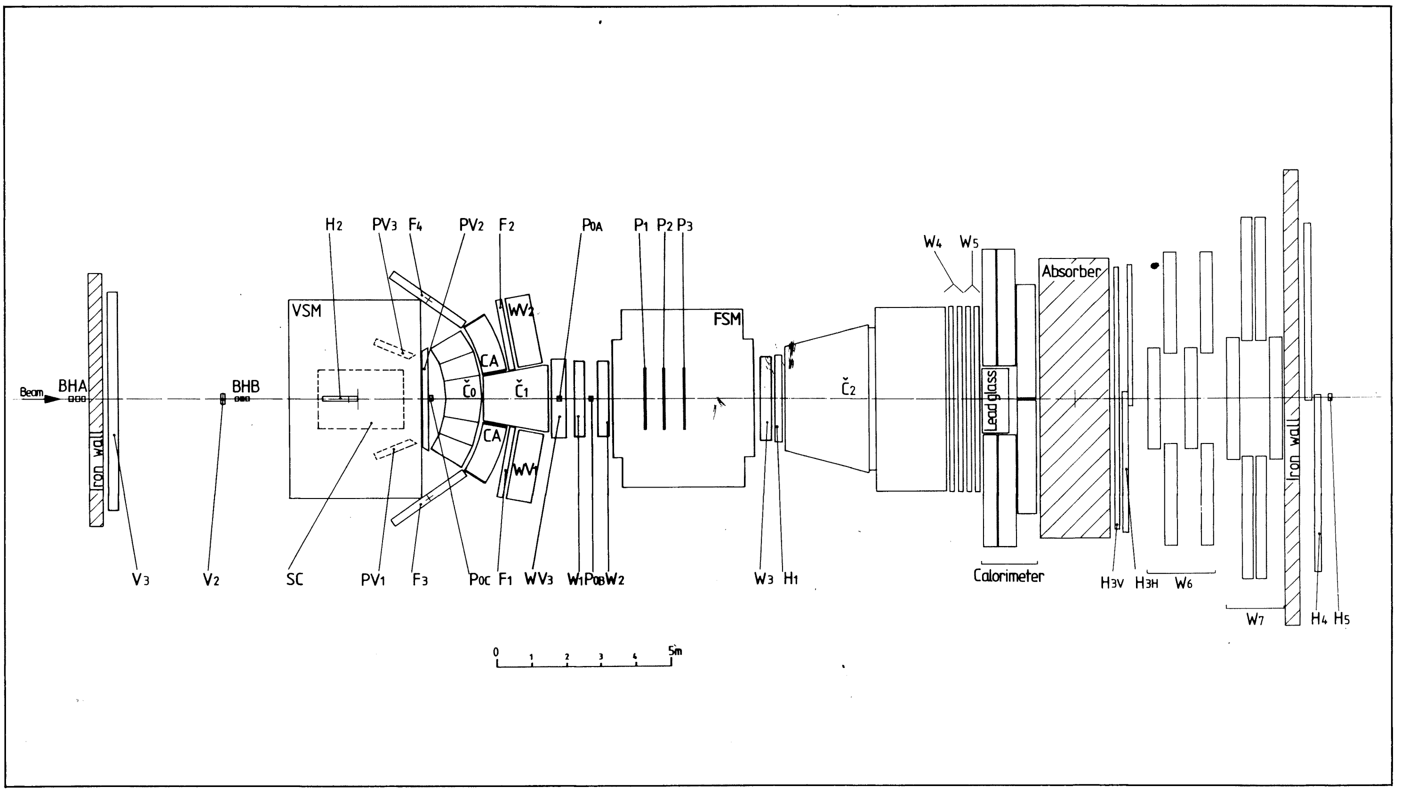
The data amassed so far is meagre by the standards of high energy physics experiments, but is copious in cosmic ray terms. The first samples were recorded during short operating periods late last year, officially designated for machine development. First experiments to take data were the mighty UA1 calorimeter, the UA5 streamer chamber, and the 'Roman pots' of the UA4 group (see December 1981 issue, page 446). After these initial runs, the UA5 apparatus was removed from the LSS4 experimental area and the big UA2 detector (Berne / CERN / Copenhagen / Orsay / Pavia / Saclay) shifted into place. This recorded its first proton-antiproton data early in December.

The initial results from UA1 and UA5 cover the multiplicities and distributions of the particles produced, and show that this extrapolates well from what is known at 'lower' energies at fixed target machines and at the CERN Intersecting Storage Rings. On average, about 25 charged particles are produced, but there is a significant yield of higher multiplicity events. In the central region around the beam pipe (lower values of rapidity), the observed distribution of produced particles does not vary much. About three or four particles are emitted per unit of rapidity. Average transverse energy is high, and appears to be due to a relatively high number of secondary particles, each carrying a comparatively small transverse momentum (about 500 MeV compared to 350 MeV seen at ISR energies).

Although the experiment is primarily designed to work with UA2, UA4 had preliminary data on proton-antiproton elastic scattering from the first runs. With data from the inner detector of UA2, a first indication of the proton-antiproton total cross-section at 540 GeV could soon emerge.

So far, nothing totally unexpected has been seen at 540 GeV, but these are as yet early days. Luminosity attained 5×10^{27} cm^{-2} s^{-1} towards the end of 1981.

Layout of the apparatus used by the European Muon Collaboration (EMC) in the North Experimental Area at the CERN 400 GeV SPS proton synchrotron. For explanation, see text.



More from muons...

Already one of the largest experiments at CERN, the European Muon Collaboration (EMC) has been substantially enlarged. Using an impressive spectrometer, the original Annecy / CERN / DESY / Freiburg / Kiel / Lancaster / Liverpool / Oxford / Rutherford / Sheffield / Turin / Wuppertal collaboration began taking data in the North Experimental Area of the 400 GeV SPS proton synchrotron in 1978. The experiment has amassed valuable results on hadron production by muons and on nucleon structure functions which complements what has been found using high energy neutrino beams at CERN and Fermilab and using electron beams at SLAC.

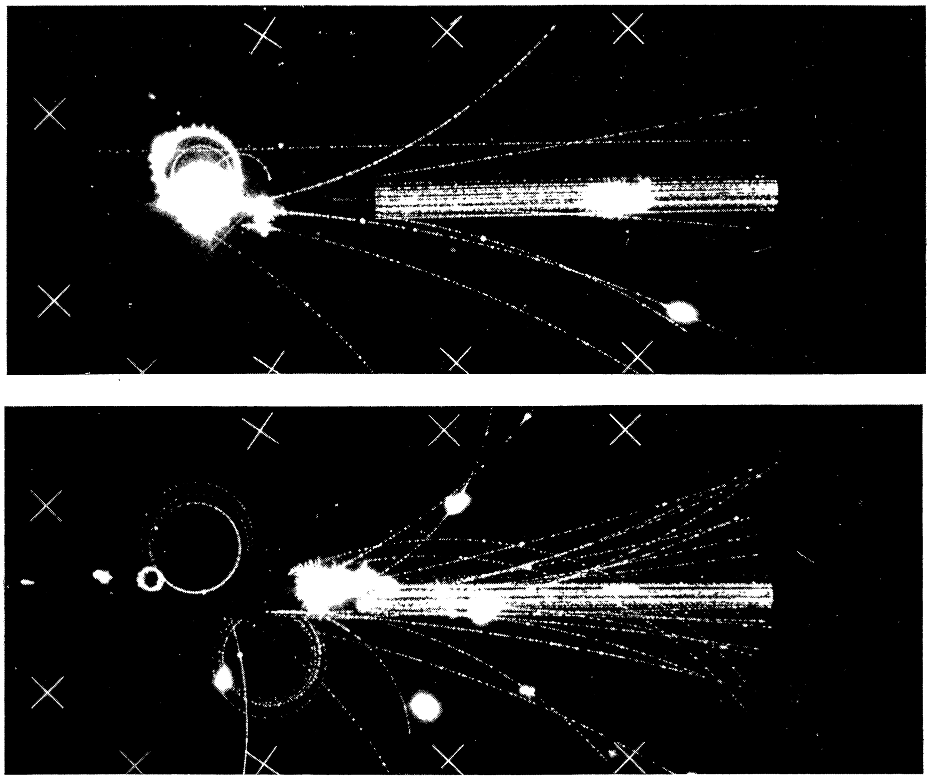
The EMC apparatus has now been extended by the addition of a large vertex detector and downstream particle identification to provide improved analysis of the particles produced in deep inelastic (violent) muon-nucleon interactions. For this, the EMC collaboration has been joined by physicists from Aachen, Hamburg, Mons, Munich, Orsay and Uppsala, making a total of over 120 researchers from 18 institutes in seven countries — a remarkable example of international scientific collaboration!

Initial muon interactions in a 1 m hydrogen or deuterium target are recorded in a 2 m streamer chamber mounted inside a superconducting magnet of inner diameter 2 m (marked VSM in the diagram). New apparatus installed downstream includes two large threshold gas Cherenkov counters (C_0, C_1) and two large aerogel Cherenkov counters (CA), together with proportional chambers (PV1-3) and drift tubes (WV1-3) for recording large angle tracks. The enlarged EMC configuration began working last June, and data taking commenced in July.

Physics aims include the study of events with two or three emergent hadron jets (see May 1981 issue, page 153), and the study and comparison of the hadron production resulting from the excitation of the struck quark (current fragmentation) and the spectator diquark system (target fragmentation). This has already given some interesting results (see December 1981 issue, page 447). Other physics topics include charm production and the forward-backward correlations of produced baryons and strange mesons. Additional information could come from comparing data taken using hydrogen and heavy targets.

Another project is the study of the dependence of structure functions and of hadron production on the quark spins. For this, a 75 per cent polarized muon beam from the SPS

Top, a 'typical' event seen in the new streamer chamber of the European Muon Collaboration's experiment at CERN. However a small fraction of the events show high multiplicity of produced particles (bottom). In both pictures, the undeflected muons are clearly seen.



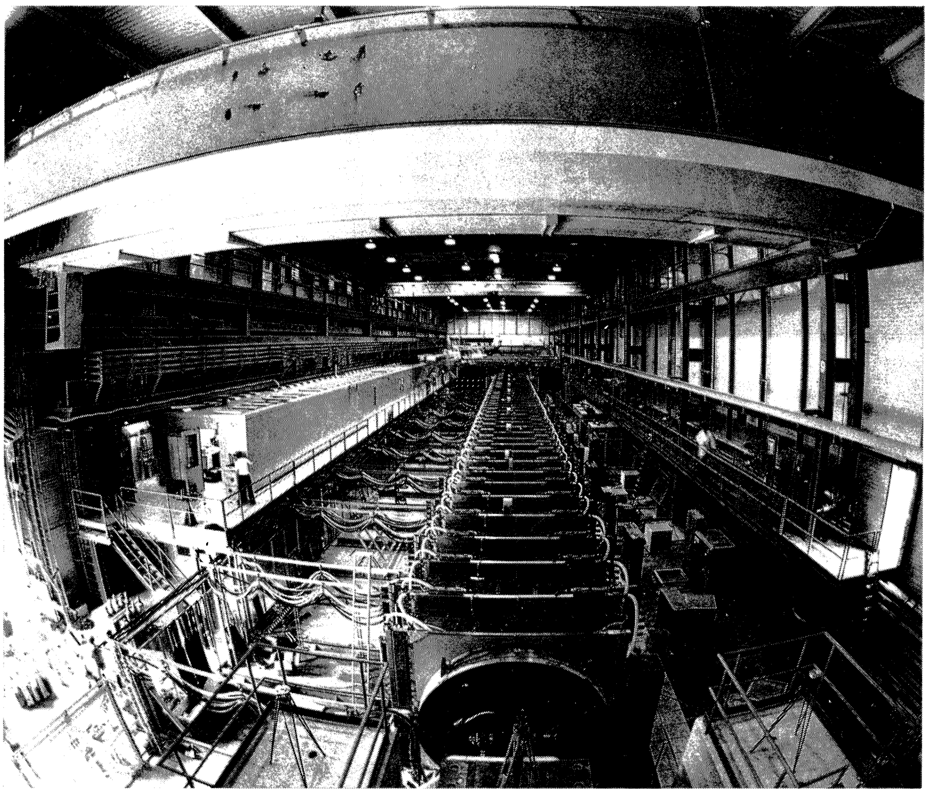
will be used with a big polarized target developed by CERN, Liverpool and Rutherford (see May 1981 issue, page 154). This study will also make use of the new downstream Cherenkov counters.

...electroweak effects with muon beams

Preliminary results from the NA4 experiment (Bologna/CERN/Dubna/Munich/Saclay) using high energy muon beams in the North Area of the CERN 400 GeV proton synchrotron reveal delicate effects due to the interference between weak and electromagnetic interactions. Although there are possible factors still to be taken into account, the results underline once again the standard electroweak model.

Good quantitative evidence in favour of this model was obtained in the historic study at SLAC several years ago which measured the tiny (0.01 per cent) asymmetries in the scattering of polarized electrons due to electroweak interference. In high energy muon-nucleon scattering, larger values of momentum transfers are accessible and the electroweak interference effects should be about a hundred times stronger. This has now been observed in the NA4 experiment by comparing the scattering of positive and negative muons.

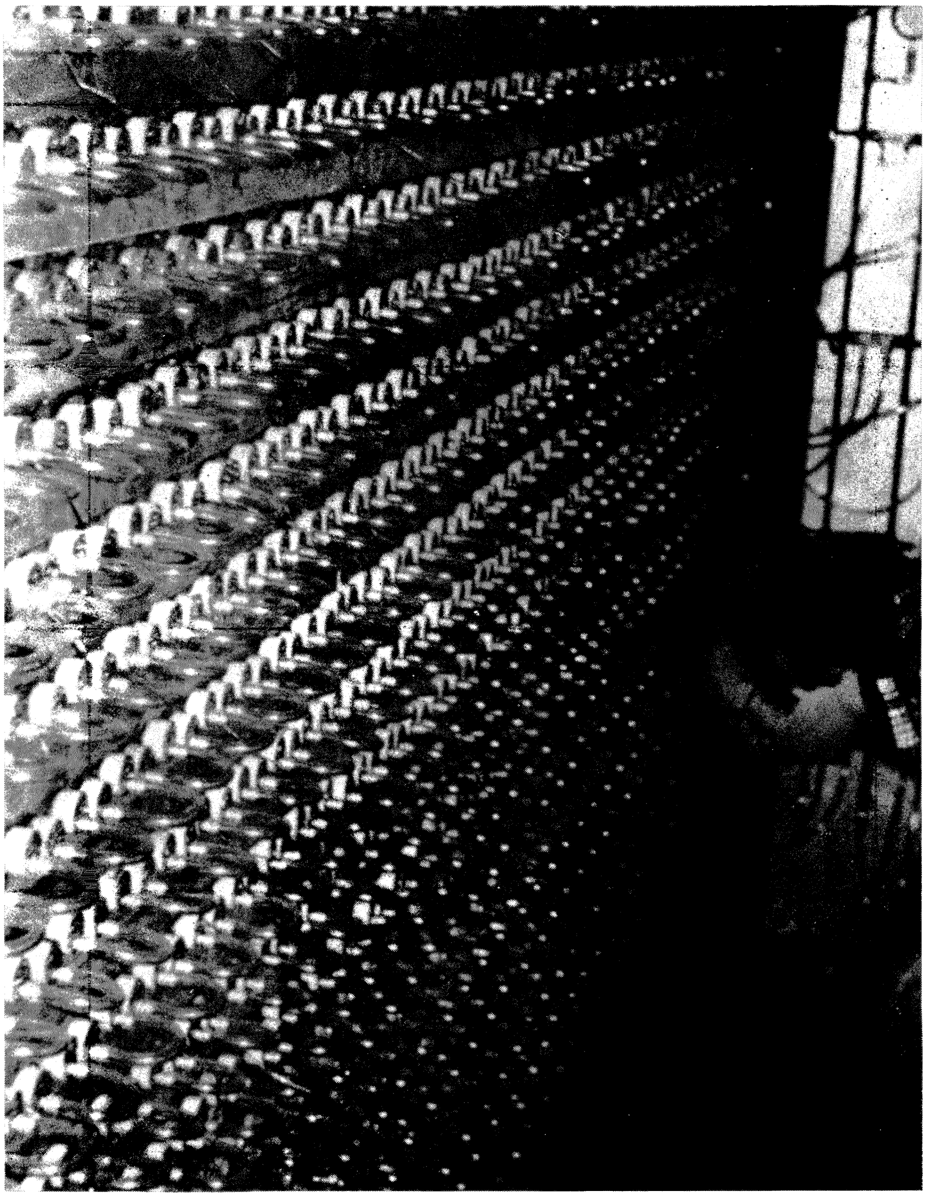
The experiment uses a 40 m-long carbon target along the axis of a 50m-long toroidal magnetized iron spectrometer which traps the scattered muons.



Unusual view of the 50 m toroidal iron spectrometer of the NA4 experiment at the CERN SPS which has seen some electroweak interference effects in high energy muon-nucleon scattering.

(Photo CERN 289.8.78)

Inspecting the Soudan 1 underground detector prior to the installation of the electronics. The ends of some of the 3456 gas proportional tubes can be seen protruding from the iron-loaded concrete calorimeter material.



Data has been taken with both positive and negative muon beams at energies of 120 and 200 GeV. The difference between the observed deep inelastic scattering cross-sections reflects the electroweak interference effects. Preliminary analysis of more than two million events shows agreement with the standard model. The painstaking work of applying small experimental corrections and looking for potential sources of systematic errors is continuing.

UNDERGROUND Soudan mine experiment

Six hundred metres below the surface of the earth in northeastern Minnesota, the Soudan 1 detector awaits a proton decay. This 31-ton device was constructed by high energy physicists in a hundred year-old iron mine, to take advantage of the dense rock overburden as a cosmic ray shield. This is the largest underground iron mine in Minnesota, and was operated until 1963. It is now a National Historic Site and is open to tourists during the summer season as part of Tower-Soudan State Park.

The detector began data collection early last summer. It is composed of a block of iron-loaded concrete, 3 m by 3 m by 2 m high, instrumented with 3456 gas proportional tubes. These 2.7 cm diameter steel tubes are arranged on a 4 cm lattice in 48 layers, with alternate layers at right angles in order to provide two stereo views of each event. The detector is surrounded by a scintillation counter shield, covering the top and four sides. The device is triggered when one or more tubes are hit in each of three out of four adjacent layers.

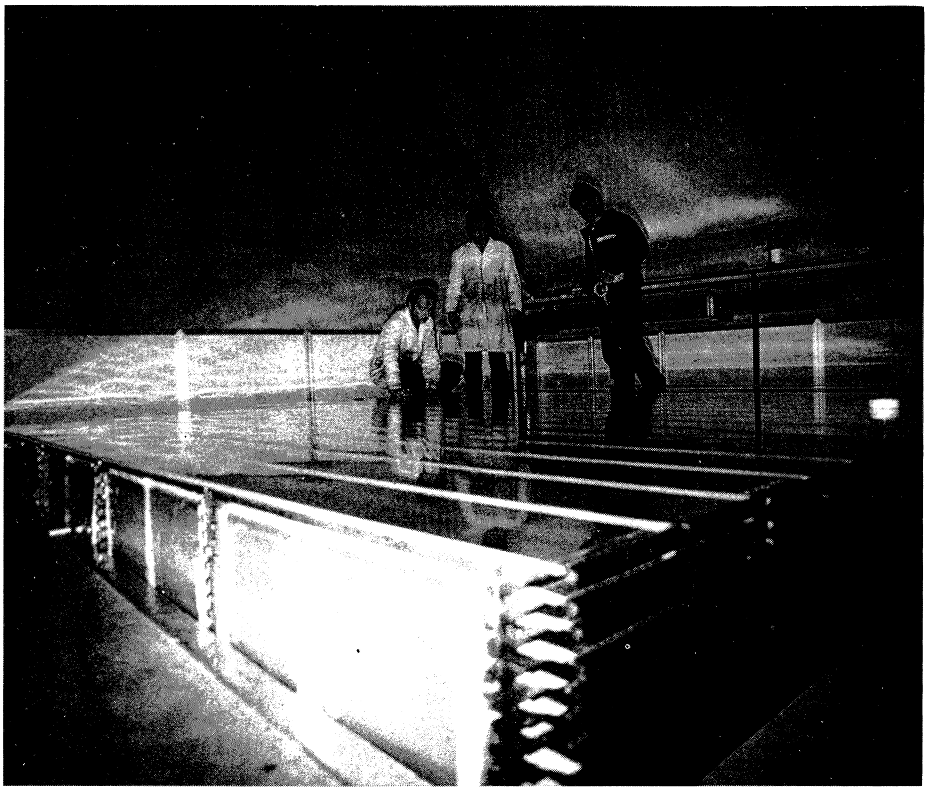
Originally a Minnesota/Argonne collaboration, the Soudan 1 experiment has been joined by a group from Oxford. Together these physicists have now proposed building a 1000-ton tracking calorimeter, 60 m deeper in the same mine. This proposed Soudan 2 detector would use 5 m by 5 m proportional wire/cathode strip planes to view ionization drifting in from calorimeter elements up to 50 cm away. The scheme provides fine granularity in a large device with compact electronics. In addition to having good spatial resolution, Soudan 2 would measure energy loss to assist particle identification and separation of electromagnetic and hadronic tracks. These characteristics will be particularly useful in identifying branching modes of observed proton decays.

While the Soudan 2 proposal is being discussed with the funding agencies on both sides of the Atlantic, Soudan 1, which is both a prototype and an actual experiment, is continuing to record data. An average of one muon every 24 seconds penetrates the 1800 m water-equivalent of overburden and strikes the detector. This muon rate is sufficiently high to permit convenient monitoring of the detector performance. Because of the high efficiency of the scintillation counter shield and of the proportional tubes themselves, the muon-induced background is expected to be small. Simulations have shown that the expected proton decay signal in Soudan 1 will be greater than the neutrino-induced background for nucleon lifetimes of 4×10^{30} years or less. For this decay rate and current theoretical estimates of branching ratios, the detector would yield about four reconstructed decays and one neutrino background event during a two-year exposure.

Although no proton decay candidates have yet been observed, the cosmic ray events seen by Soudan 1 so far may prove to be quite interesting in themselves. About 35 events out of 1000 are more complicated than the usual single muon tracks which pass straight through the detector. One quarter of these interesting events have multiple muons, which can be studied in great detail thanks to the high resolution of the detector. Indeed, an event has been observed in which thirteen parallel muons simultaneously pass through the sensitive volume. Most of the other interesting events show showers of various types. Some showers appear monolithic, with a highly ionizing central core, and are presumably of electromagnetic origin.

In addition to fine spatial and energy loss measurements, the Soudan 1 detector records the time structure of each event in 100 to 300 nsec intervals for a period of 7 microseconds around the trigger time. This will permit the group to observe muon decays and to search for slow, penetrating particles such as heavy leptons and magnetic monopoles. With these capabilities, the Soudan 1 detector has special attractions.

Preparations 3000 m below ground in a garage off the Mont-Blanc road tunnel for a nucleon decay search by a CERN/Frascati/Milan/Turin collaboration.



Building beneath Mont Blanc

Some 3000 metres below the summit of Mont Blanc, in a 'garage' near the middle of the 12 kilometre road tunnel linking France and Italy through the Alps, a CERN/Frascati/Milan/Turin collaboration is busy assembling a 160-ton passive detector to search for signs of proton decay and other unusual phenomena.

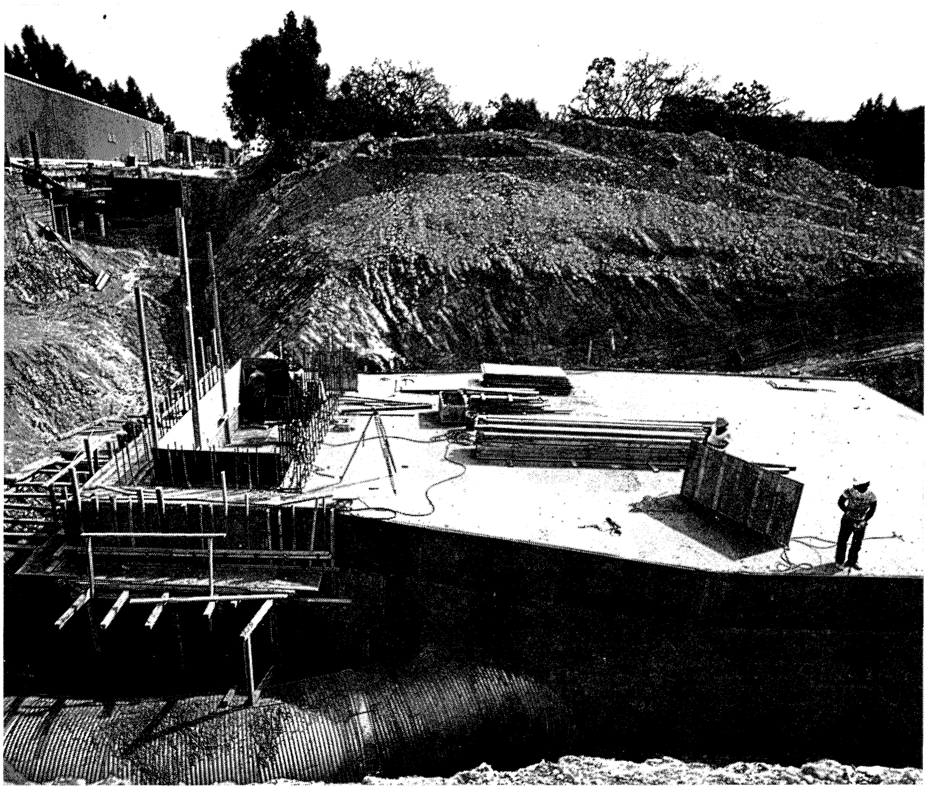
The complete 3.5 m cubic detector will contain 134 iron plates, each 1 cm thick and weighing about a ton, interspersed with 43 000 streamer tubes (see July/August 1981 issue, page 252). These tubes are first prepared at Frascati and subsequently come to CERN for mounting, prior to installation in the tunnel. While construction and assembly of the streamer tubes began some time ago, preparations in the tunnel began only last September. With assembly of the iron 'castle' now complete, installation of the streamer tubes is under way, and if all goes well, the detector could go live soon.

Setting up such a big detector just off a busy road tunnel is not without its problems. The garage has in fact already been used by Milan physicists for double beta decay searches, however the new project called for the installation of antinoise doors, air conditioning, mains lighting, running water, etc.

Unloading the large components of the detector into the garage is a tricky business. One lorry carries the

Last summer, excavation began for the construction of the Damping Rings for the proposed SLAC Linear Collider. By November (after this photograph was taken), general construction was complete and the junctions with the linac resealed to enable installation work to continue while the linac is running.

(Photo Joe Faust)



major part of the load and parks just outside the tunnel entrance, while a second lorry, equipped with a crane, then ferries back and forth, delivering the detector components to the experimental site. Manœuvering the lorry outside the experimental site means interrupting the traffic, as inside the tunnel there is only one lane in each direction.

After so much careful preparation, the physicists are hoping that their well-shielded fine-grain detector will soon provide new evidence to guide our understanding of the relationship between the different forces found in Nature.

STANFORD Towards the new collider

A major milestone in the research and development programme for the SLAC Linear Collider (SLC) project was passed recently with the completion of the vault to house the SLC Damping Rings.

The idea behind this collider is simplicity itself — two linear accelerators are aimed at one point to collide electrons and positrons. The reasons for choosing this route, instead of continuing the tradition of colliding beams in a storage ring, are economic. The additional r.f. power, needed to compensate for the steeply rising energy losses through synchrotron radiation, makes the cost of storage rings increase as the square of their energy. On the other hand linear machine costs increase only as the first power of the energy.

The SLC aims to use the existing SLAC linac to produce both an electron and a positron beam for collisions at centre-of-mass energies up to 100 GeV. As well as opening up a new era of accelerator technology, this project is aimed at an exciting new energy range to explore weak interactions.

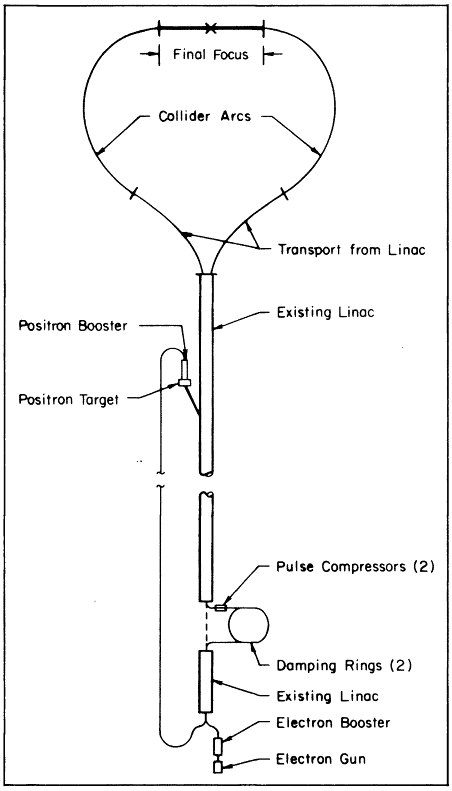
The project requires the construction of two damping rings, a new electron injector, a positron target and return line, the collider arcs, and the final focusing system to bring the particle bunches into collision.

The electron gun produces the required 5×10^{10} electrons to fill a single r.f. bucket, corresponding to a bunch about a millimetre long. With this beam accelerated to about 35 GeV and dumped into a heavy target, enough low energy positrons would be produced and brought back to the injection end of the linac to provide the required intense positron beam.

Although the positron and electron bunches would be both intense enough and short enough, neither would be small enough across for use in the collider. The positron beam, with its diffuse production process, would be about 100 times too big. The two bunches must be accelerated to about 1 GeV and stored in the new Damping Rings, where after several milliseconds the emittance of the bunches would be small enough for them to be reinjected into the linac for subsequent acceleration.

These are the pieces, but there is a long way to go before they can all fit smoothly together. It is a bit like having to juggle with four balls. The positron and electron rings each have two bunches. On 'go', both electron bunches but only one positron bunch are taken out of the rings and injected into the linac. The positron bunch and the first electron bunch make it to the end of the linac, where they are diverted into the two arcs for the trip round to the collision point. The second electron bunch — the last in the train — is diverted about two-thirds of the way along

The schematic 'tennis racket' diagram showing the principle of the proposed new SLAC Linear Collider (SLC). This requires a major research and development effort – even the 'existing linac' would have to be substantially refitted.



the linac into the positron target. This produces a positron bunch which is accelerated to 200 MeV and brought back to the input end of the linac, accelerated to 1.2 GeV and injected into the positron damping ring. At the same time, two new electron bunches are delivered by the electron gun and injected into the now empty electron ring, completing the cycle. The whole process would take some tens of microseconds and would be repeated 180 times per second.

The project requires a major research and development effort. Even the main component, the existing linac, has to be substantially refitted for the precision control and monitoring required for SLC operation. Of the several development programmes now under way, the construction of the Damping Rings has been the most evident. Last June, excavation for the heavy concrete vault to house the rings began. By November, general construction was complete and the underground vault covered over. The junctions of the two tunnel pipes with the linac were made and temporarily resealed to allow work on the rings to continue while the linac is running.

Linac beams will be extracted and reinjected in a common septum region of the linac (the 'tennis racket diagram' is only schematic), and will circulate clockwise in the two 35 m circumference rings, stacked one above the other in the new vault. Operating at 1.2 GeV, each ring will have about 50 powerful bending magnets and 40 quadrupoles in a lattice designed to achieve fast damping and low emittance. The return lines to the linac will be equipped with a small accelerating cavity which, together with the transport line, will compress the beams from 6 mm to 1 mm. One line would accommodate special solenoids for handling polarized electron beams.

First tests with injection of electrons into one ring are scheduled for this fall, and reinjection into the linac early next year.

CORNELL
Higher luminosity and improved detector

Both interaction regions of the CESR electron-positron storage ring at Cornell had major alterations during a three-month shutdown when mini-beta insertions were installed to improve luminosity. The conversion coincided with introduction of a superconducting coil in the CLEO detector. The entire CLEO detector was taken apart to remove the aluminium coil and the opportunity was taken to tidy up the inner drift chamber (removing troublesome 'hot' wires and replacing broken ones). Various components underwent minor improvements and a major change was the installation of ionization-loss detectors in all eight octants. These replaced Cherenkov counters in four of the octants. CLEO is now in its originally planned configuration with a symmetrical detector around a superconducting coil.

The mini-beta configuration reduces the distance between interaction point and first quadrupole from 3.6 m to 2.2 m. The original quadrupoles are still used in the new configuration but the compression of the interaction region left no room for compensating solenoids normally used to cancel out the rotation induced by the main CLEO solenoid. Instead, the compensation is now

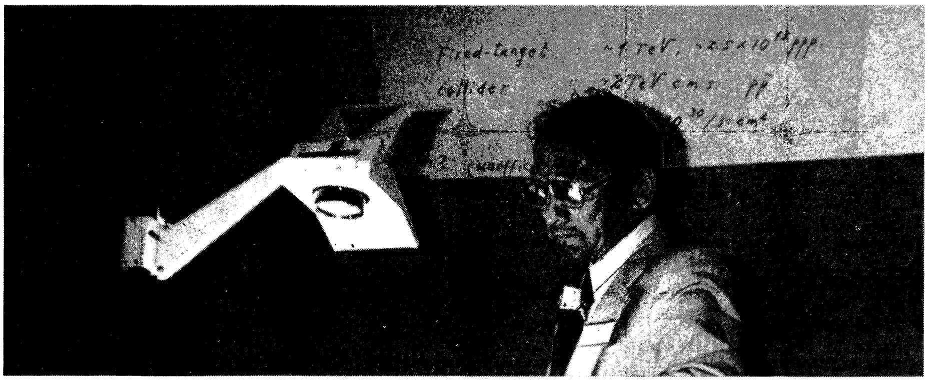
Results from upsilons

The CLEO and CUSB experiments at the CESR electron-positron storage ring at Cornell have made a speciality of the study of upsilon resonances. The decays of the first three states, which are narrow, provide a useful testing ground for models of heavy quark dynamics and for quantum chromodynamics (QCD) predictions. The masses and decay parameters of these narrow upsilons behave as expected, and the QCD scaling parameter comes out as 100 + 34 – 25 MeV.

The fourth upsilon is much broader, due to decays into beauty mesons. This resonance therefore provides additional information, which favours a conventional six-quark picture. Exotic models, proposed to sidestep a sixth quark, do not look good.

At the recent HERA meeting at DESY, Gus Voss (above) described world possibilities for electron-proton collisions, and S. Ohnuma reported on the good progress being made with superconducting magnets for the Fermilab Doubler/Saver. Similar magnets are being proposed for HERA.

(Photos DESY)



done by three pairs of rotated quadrupoles — two on a carriage allowing precise rotation around the beamline, the third further away in the arcs of the ring. The first quadrupoles are mounted on rail systems which allow variation of the quadrupole distance, and permit access to the CLEO poles and inner detectors. In the CUSB interaction area, this rail system allows the quadrupoles to be pushed in as close as 1.8 m to the interaction point.

After about two months of operation, luminosity has been increased by a factor of 2.5, and there is room for greater increases as the beam current is raised. So far the time has been spent in investigating high luminosity lattices that produce minimum background in the two experiments. Initial trials showed that the compensating scheme worked according to plan, and that high luminosity could be achieved. However both experiments were troubled by high background rates from electrons hitting masks near the interaction regions. The CUSB experiment, which occupies a very small space along the beam, was successfully shielded using lead outside the beam pipe. CLEO does not allow efficient shielding of the masks. A short interruption of operations in mid-December allowed removal of some of these masks, which caused more trouble than they were worth.

Meanwhile the experiments have been running mainly on the third upsilon, looking for transitions to intermediate states. Peak luminosities have been over 7×10^{30} per cm^2 per s per interaction region. Integrated luminosities of over 50 per nb per fill, and over 200 per nb per day are accumulated by each experiment. Efforts will now be concentrated on increasing the peak currents and luminosities.

The CLEO superconducting coil has not posed any major problems. Operation has been at around 0.5 Tesla, waiting for all the iron of the magnet pole pieces to be installed. With full pole pieces CLEO will run at 1 Tesla. The coil has already been tested at higher fields.

DESY
Physics for HERA

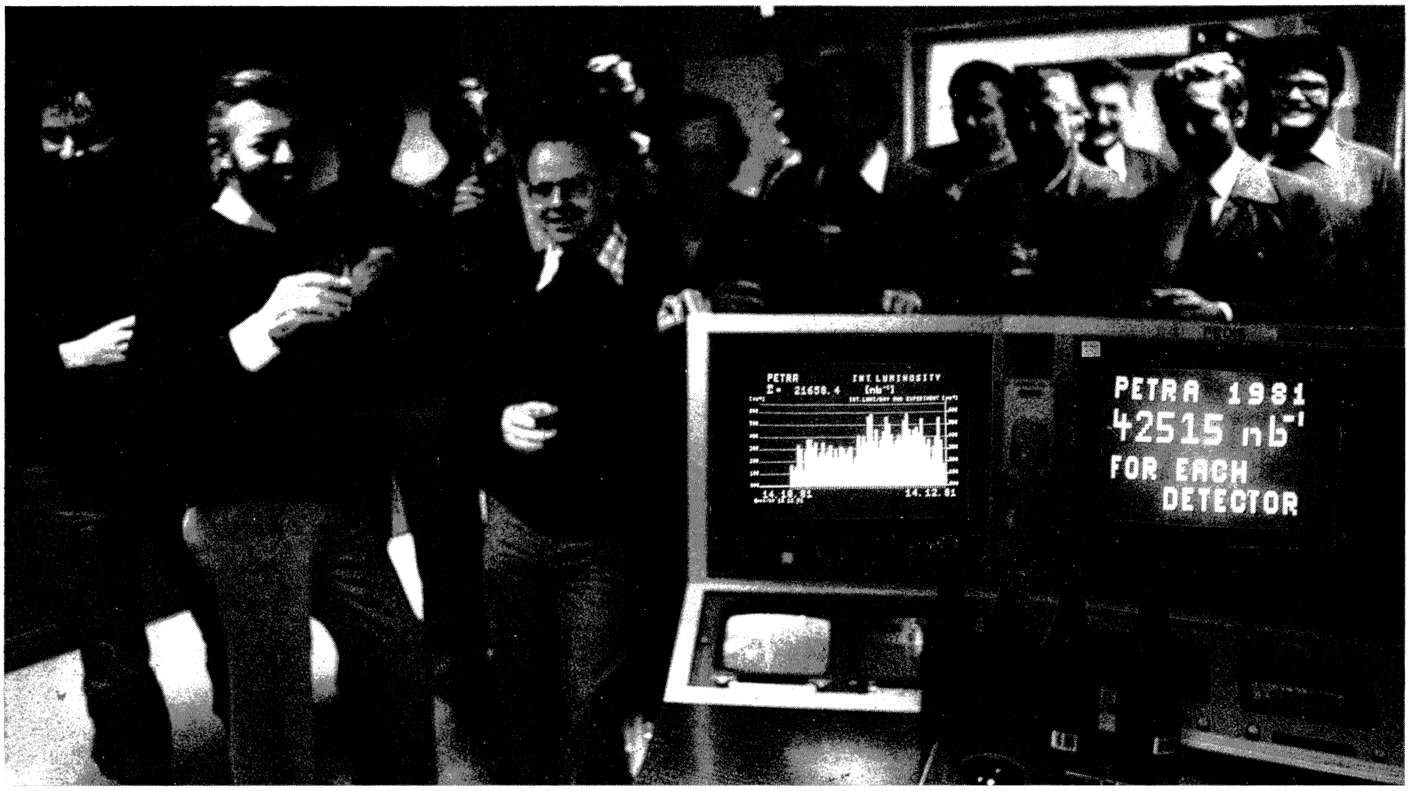
In October, a further HERA meeting was organized jointly by ECFA and DESY, and took place this time at the University of Wuppertal. About 120 physicists from 10 countries discussed many aspects of the physics which could be done with the HERA electron-proton collider proposed for DESY. At the same time, latest news was given on the status and prospects for the project.

In his opening address, chairman J. Drees emphasized the four goals of the meeting — presentation of the latest technical proposal including new machine parameters, a realistic comparison of HERA with other electron-proton projects, a report on progress with superconducting magnets, and discussion of the experiments possible at HERA, taking the latest developments into account.

Following this outline, HERA preparations coordinator Björn Wiik presented the July version of the technical proposal, the work of about fifty physicists and engineers from 23 institutes (including DESY). Following the initial studies for the HERA machine, many improvements have been incorporated (see for example June 1981 issue, page 205). Wiik explained in particular the changes for the superconducting magnets, which are now planned to have a cold bore and be practically identical to those successfully developed for the Fermilab Doubler/Saver ring.

Representatives of the PETRA operations group and the JADE, Mark-J, PLUTO and TASSO collaborations at DESY celebrate in the control room at the end of a successful electron-positron run at 17.5 GeV per beam. In about six weeks during November and December, each of the four experimental groups collected a luminosity of 17 000 inverse nanobarns, despite a four-hour energy-saving shutdown every working day.

(Photo DESY)



Next speaker was Gustaf-Adolf Voss of the DESY directorate who gave a comprehensive worldwide survey of current electron-proton projects. Of these, only two, TRISTAN in Japan and HERA, have been explicitly planned for electron-proton collisions. Among the world's list of electron-proton projects, HERA scores well on both luminosity and energy.

After detailed technical discussions, further talks covered theoretical ideas. Guido Altarelli and Don Perkins emphasized the importance of testing quantum chromodynamics and electroweak theory at high momentum transfers which probe deeper inside matter and could show whether quarks and leptons are indeed pointlike, or whether they in fact have an internal structure.

In his concluding remarks, John Ellis summarized the numerous theoretical ideas and expectations for the physics with HERA. New structure functions could be measured and new particles found. Grand unification, supersymmetry and Higgs particles could be explored. There appear to be many fields in which only a machine like HERA can provide new insights.

FERMILAB Silicon detector workshop...

The outstanding physics developments of recent years have included the discovery of charm and beauty flavours and of the tau lepton. The short lifetimes involved have directed interest towards techniques to measure the decays of these particles. It is becoming increasingly clear that silicon microstrip detectors and 'live' silicon targets may be particularly well suited to this new physics. These devices also appear to be important for a variety of other applications to deal with high particle multiplicities and high energies.

Much progress has recently been made, particularly in Europe, on the application of solid-state techniques to high energy instrumentation, and a topical Workshop was organized at Fermilab on 15–16 October on the use of silicon detectors. The meeting, organized by Tom Ferbel from Rochester, had two major goals — firstly to inform experimenters on recent advances in the development of finely segmented silicon detectors, and secondly to bring together some of the world experts in the field to evaluate the feasibility of constructing detector systems that could complement present-day tracking devices for ultra high energies, large multiplicities and small inter-particle distances.

The Workshop opened with an excellent state-of-the-art review by H.M. Heijne from CERN. Heijne also presented his group's impressive achievements in developing microstrip hodoscopes in association with the Enertec division of Schlumberger. He emphasized repeatedly that the key to large-scale application of silicon strip devices was the development of adequate electronic readouts. The electronic challenges were then tackled by V. Radeka from Brookhaven. He described the general problem of signal formation, noise and position readout in these low signal detectors and discussed a particular system envisaged for future collider operation, possibly at ISABELLE. C. Damerell of Rutherford gave a concise review of present and future possibilities for charged-coupled devices (CCDs) in the localization of charged particle trajectories.

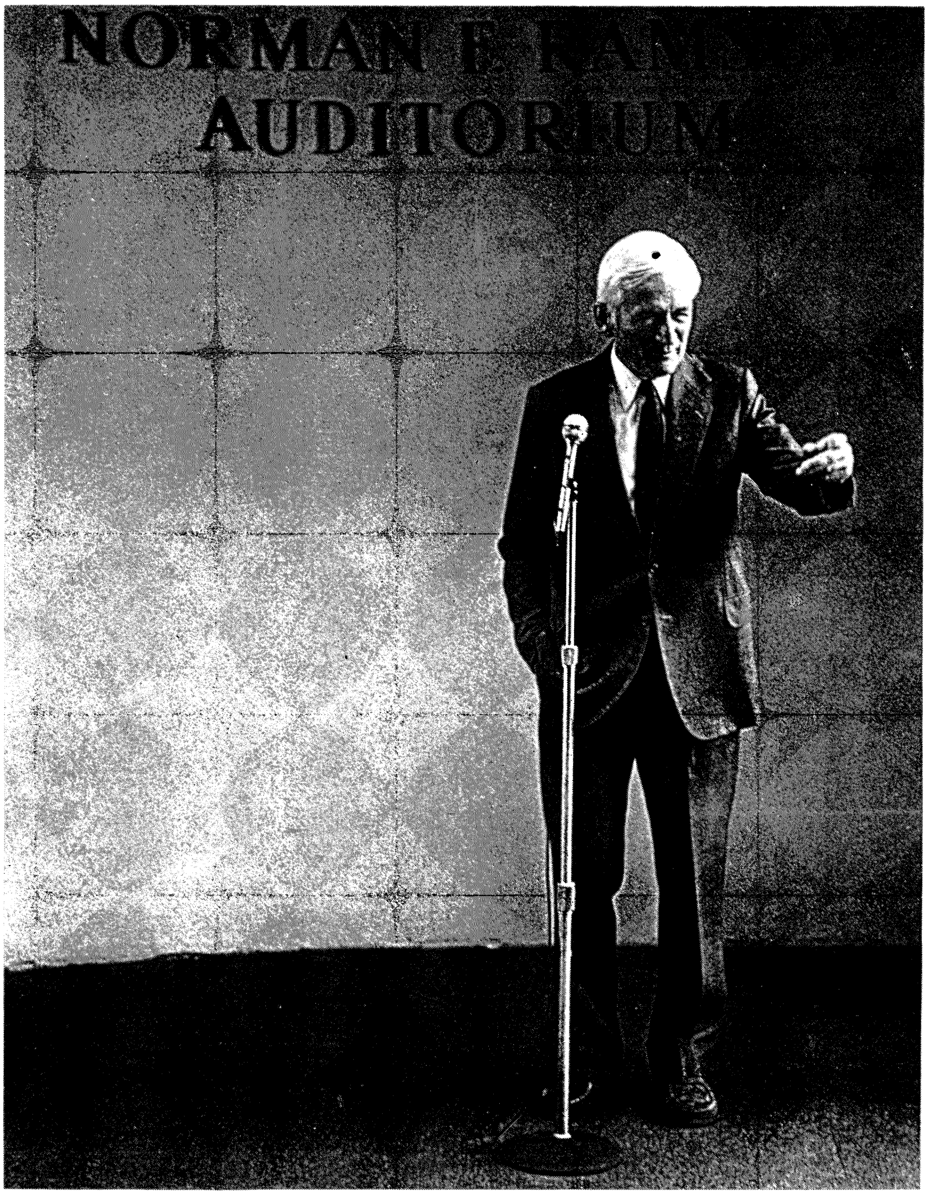
The status of silicon dectector development in the United States (especially efforts at Berkeley to measure decays of short-lived particles) was described by G. Kalbfleisch from Oklahoma. P. Shepard from Pittsburgh described a novel scheme based on the storage of ionization charge in shallow traps in doped silicon crystals operated at cryogenic temperatures. R. Carrigan of Fermilab then reviewed the possibilities of using bent silicon crystals for channelling particle trajectories. A more intense presentation on the development of solid-state detectors based on CCD concepts was given by A. Bross from Berkeley. P. Manfredi from Pavia ended the first day with a fine lecture on the design of electronics for silicon telescopes.

On the evening of 15 October, a special seminar was held in the Fermilab Users' Center. T. Ludlam from Brookhaven and W. Vernon from San Diego spoke on future prospects for semiconductor detectors in high energy physics. In particular, ideas were presented on how to deal with readout of mega-channels of information. The evening session closed with rather encouraging remarks from commercial representatives L. Levit of LeCroy Systems and M. Martini of ORTEC.

The second day of the Workshop covered the latest work in Europe. G. Bellini from Milan spoke on measurements of D meson lifetimes. B. Hyams from CERN, fully equipped with samples of his silicon counters and electronics, discussed the development of ten-micron resolution devices in collaboration with EMI. His colleague, G. Lutz from MPI Munich, presented a parallel approach for instrumenting a ten-micron resolution system for spectrometers at CERN. A. Menzione from Pisa described extensive efforts in manufacturing silicon detectors while J. Poinsignon from Saclay presented details of an

At a ceremony on 1 October, the Fermilab Auditorium was officially named the 'Norman F. Ramsey Auditorium' in honour of the first president of Universities Research Association (which operates Fermilab for the US Department of Energy). Ramsey (seen here) is Higgins Professor of Physics at Harvard.

(Photo Fermilab)



ambitious programme for building a multi-thousand channel detector for a CERN experiment. Finally, J. Killiany of the US Naval Research Laboratory described studies of radiation damage and hardening of silicon devices.

The Workshop was attended by about 150 physicists and, judging from the remarks in the halls, it was successful in meeting its goals. It showed rather dramatically that silicon devices have already found a niche in high energy physics. There have been great strides forward, particularly in Europe, both in the Laboratories and in attracting commercial firms. The silicon age in high energy physics looks as if it is here to stay for a while.

Because of the great interest, the Workshop proceedings will be published shortly. For more information, write to T. Ferbel, Department of Physics, University of Rochester, Rochester, New York, 14627, USA.

...and direct photon workshop

A workshop held from 26–28 September at Fermilab was devoted to the theory of and experiments on direct photons. Attended by over 60 physicists, it was organized by Dennis Judd of Fermilab and Ed Berger of Argonne.

Direct single photon production at high momentum transfer (a quark-gluon interaction) provides a clear test of quantum chromodynamics. To illustrate this, Jeff Owens of Florida State reviewed QCD theory along with many of the calculations for single direct photon production. He pointed out that the calculations of leading term approximations suffer from a variety of kinematical definitions as well as gluon structure function ambiguities. These variations in kinematics change the prediction by as much as a factor of two at an energy of 31 GeV.

Reinholdt Ruckl discussed the constituent interchange model contribution to the direct photon cross-section. Geoffrey Fox's talk centred on the hadronic final states in high transverse momentum collisions and encompassed the development of the possible away-side jets in direct photon measurements. Francis Halzen reviewed the present world data in earlier direct photon experiments and the relation of the data to theory.

Peter Koehler summarized the current and planned experiments at the CERN SPS proton synchrotron. There was also a presentation and discussion of the past and current data by experimentalists including Brad Cox (covering Fermilab studies) and Tom Ferbel, Steve Pordes and David Leventhal (covering experiments at the CERN ISR).

The experimental data indicated that it is difficult to isolate a signal coming from a direct photon from those arriving at a detector due to neutral meson decays. Low transverse momentum experiments also suffer from the presence of a bremsstrahlung component. As a result it is not clear that the ratio of photons to neutral pions is the most revealing quantity to measure in the proposed experiments. The results of the workshop suggest that one should look at jet correlations coupled with a direct gamma trigger.

LOS ALAMOS
Nuclear spectroscopy with pions

Recent experiments at the LAMPF 800 MeV proton linac have shown that pion-nucleus scattering provides a powerful new tool for investigating the structure of nuclear states. The strong isospin and spin dependence of the elementary pion-nucleon interaction can be exploited to unravel the neutron and proton parts of the reaction mechanism as well as the spin structure of nuclear excitations. It appears that no other nuclear probe is as effective as the pion for such studies. Such large differences exist in the spectra of the inelastic scattering of positive and negative pions on carbon 14 that when comparing the two spectra, measured under identical conditions, one physicist remarked, 'it hardly seems like the same nucleus.'

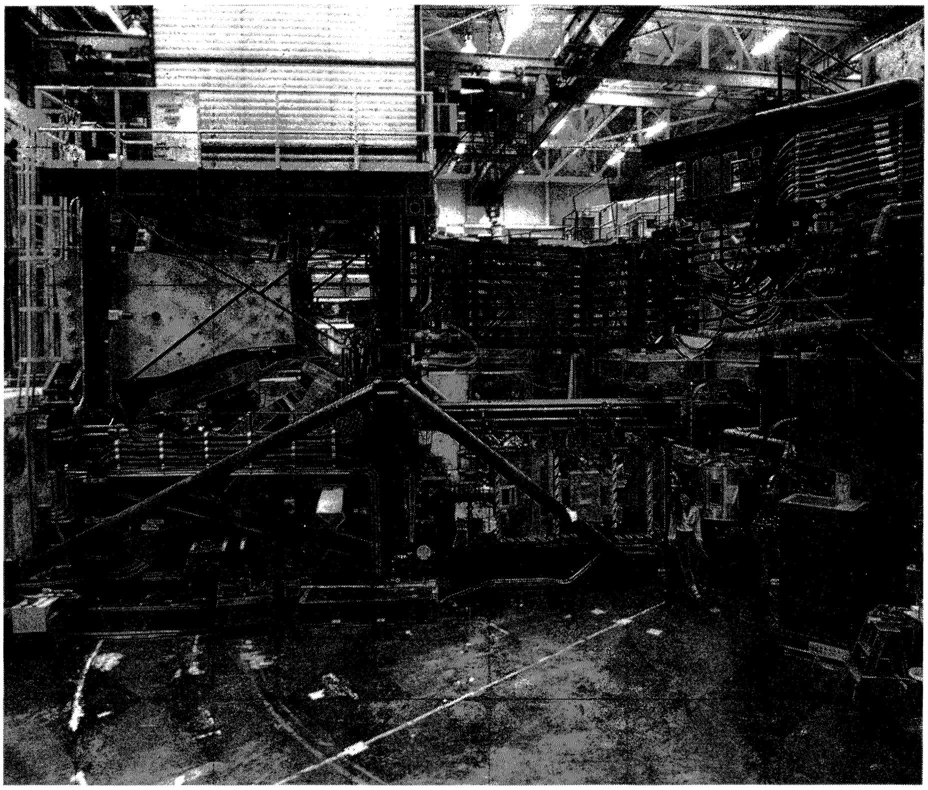
The measurements were made possible by the pion beams of high intensity, high resolution, and variable energy provided by EPICS (Energy Pion Channel and Spectrometer).

The usefulness of pion beams is due to the 1232 MeV nucleon resonance with spin and isospin quantum numbers 3/2, 3/2. Between 100 and 300 MeV the pion-nucleon interaction is dominated by this resonance. Consequently, the cross-section for elastic positive pion-nucleon scattering is about nine times larger than that for negative pions. Conversely, the elastic cross-section for negative pions on neutrons is nine times larger than that for positive pions. If the free pion-nucleon interaction is not altered significantly by the presence of the other nucleons in a pion-nucleus collision (an assumption called 'the impulse approximation'), then these large ratios should also be observable in scattering off nucleons in a nucleus. This should be true for transitions involving only neutrons or only protons. On the other hand, if roughly equal numbers of neutrons and protons are involved, then the positive to negative pion ratio would be closer to one.

Nuclear physicists seeking confirmation of these ideas were delighted by the discovery of a pure neutron

The high resolution pion spectrometer EPICS used for nuclear physics studies at Los Alamos. Recent experiments have provided interesting new results in pion-nucleon scattering.

(Photo Los Alamos)



excitation in carbon 13. A state at 9.50 MeV was found strongly excited in negative pion scattering but only weakly excited with positive pions. The measured positive to negative pion cross-section ratio, R, is approximately 1/9, strongly suggesting that the transition is due solely to a change in the neutron configuration. This is confirmed by the measured angular and energy dependence of the cross-section. With the theoretical analysis, there is a convincing case for identifying this 9.50 MeV transition as an orbit jump by a neutron.

Shortly after the carbon 13 results were obtained, the inelastic scattering was measured for radioactive carbon 14. It came as a great surprise that several specific states had ratios R significantly larger than 9. An explanation was suggested by the physicists from the University of Minnesota, Los Alamos National Laboratory, the University of Texas, and New Mexico State University, who performed the experiment.

The observed behaviour indicates that the neutron structure has something special. The carbon 14 ground state contains a small component (10 to 20 per cent) in which two of the neutrons are in a higher shell than expected. With negative pion beams, the role of this small neutron configuration is enhanced relative to the larger proton configurations because of the strong coupling of negative pions to neutrons. For one state, the neutron and proton components of the transition amplitude interfere constructively, giving a ratio R close to one. However for another state with similar quantum numbers they appear amost to cancel, giving a very small negative pion cross-section.

The marked behaviour provides a stringent test for our understanding of neutron and proton transition amplitudes in nuclei and for the behaviour of the pion-nucleon interaction in nuclei.

The pion itself has no spin. However when it scatters off a nucleon it can change the nucleon spin. At the energies where the 1232 MeV nucleon resonance dominates, the behaviour of the reaction mechanism with scattering angle is known. For a target nucleus whose ground state has angular momentum zero, the transition to a state in which the total angular momentum is not equal to the orbital angular momentum will require such a transfer of spin. Such 'unnatural parity transitions' are readily distinguishable from natural parity transition by the observed dependence on scattering angle.

This type of measurement provides a powerful new way to probe the spin dependence of nuclear transitions.

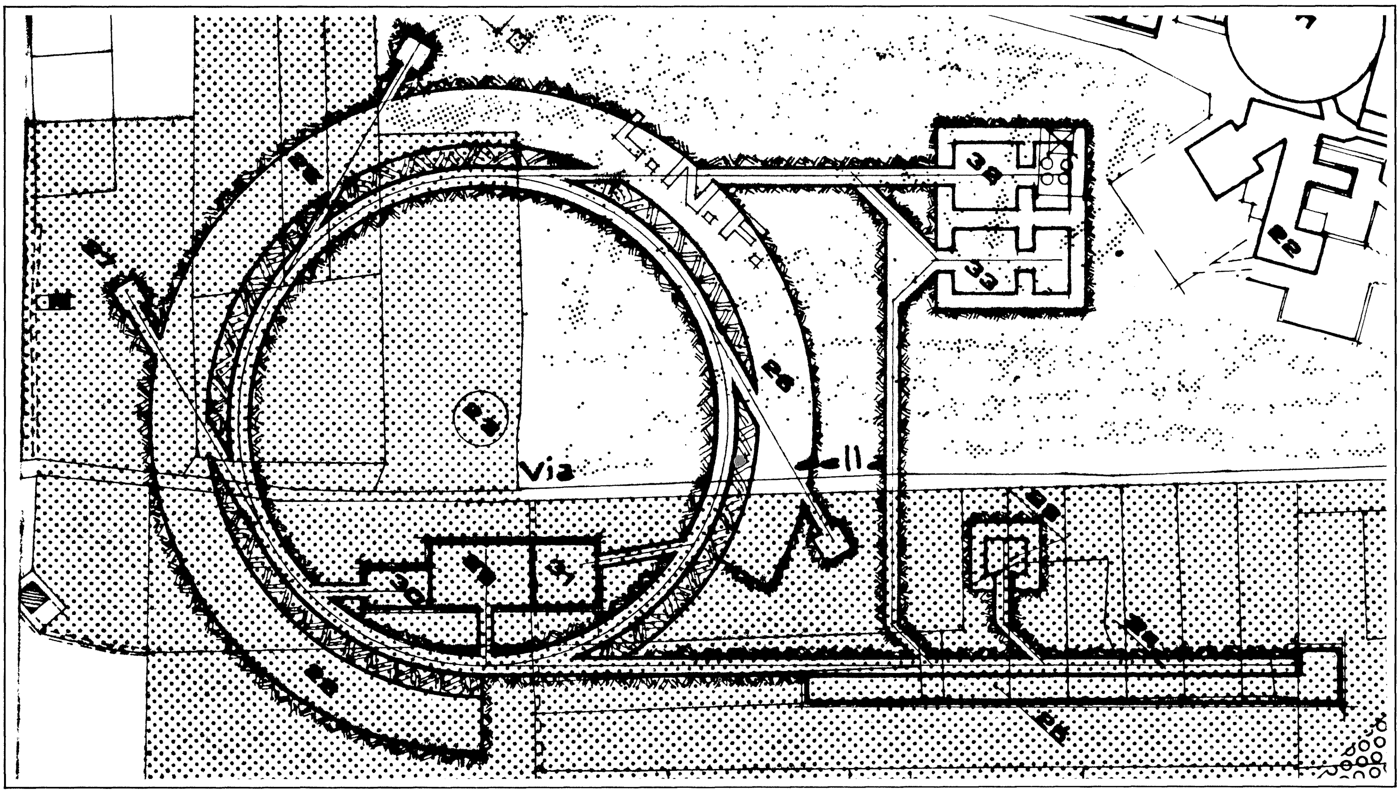
FRASCATI ALFA 3 project

The multipurpose ALFA 3 project has three main scientific aims — intermediate energy nuclear physics using intense continuous electron and photon beams, synchrotron radiation experiments with hard X-rays, and neutron spectroscopy using an intense neutron source.

ALFA is short for 'Allungatore Linac Frascati con ADONE' meaning 'stretcher ring for the Frascati linac using ADONE'. In fact the first idea, put forward some years ago, was to obtain a high duty factor for coincidence experiments with electromagnetic probes, using the ADONE ring as a stretcher ring to convert the pulsed beam from the 350 MeV conventional Frascati linac in a continuous one.

Subsequently, because of the obvious limitations due to the fixed structure of ADONE, and in order to

Sketch of the proposed ALFA 3 project at Frascati, which foresees a 1100 MeV electron linear accelerator feeding a 460 m circumference stretcher/storage ring. As well as acting as injector for the ring, the linac could also be used as a neutron source and for nuclear physics experiments.



optimize both physics (in particular as far as energy was concerned) and machine requirements, a completely new electron machine was proposed, with a 1.1 GeV electron linac and a long (460 m circumference) stretcher ring. (The suffix 3 after ALFA indicates the three scientific fields covered by the new facility, rather than the number of revisions of the proposal.)

The dimensions of the ring and a linac energy spectrum compression system mean that r.f. cavities are not required. However by inserting an r.f. system and by using a suitable number of magnetic elements of the lattice, the stretcher can be utilized as an ordinary storage ring providing an energy of 3.5 GeV, and able to create synchrotron radiation, and monochromatic and polarized gamma rays by backward Compton scattering of laser light, while also carrying out internal target experiments. In particular, the synchrotron radiation facility has the so-called All Wiggler Machine (AWM) configuration, with up to 40 light ports from normal and superconducting wigglers installed in the straight sections of the machine.

A neutron source, obtained by the high power electron beam from a low energy (100 MeV) linac output is also planned. A second neutron source, at the high energy end of the linac, enriched in fast neutrons for studies of radiation damage, could also be envisaged.

Finally, it is always possible to use the pulsed beam of the linac — which has an optimum energy spread after the compression system — for conventional single arm experiments in future nuclear physics experiments.

These various advantages and the flexibility to handle different areas of research are seen as the main benefits of using the linac stretcher method to obtain a continuous electron beam.

TRIUMF Kaon factory physics

The second TRIUMF Kaon Factory Physics Workshop was held on 10–14 August, 1981. About a hundred physicists participated in the meeting, which consisted of fifteen invited talks and four afternoon workshop sessions, and proved to be a stimulating and productive event.

The discussions centred on identifying the most important physics that could be studied with a machine providing an increase in intensity of two orders of magnitude in primary proton beam over present accelerators in the energy range 8 to 20 GeV, and on establishing some preliminary guidelines on the desirable properties of secondary beams at such a machine.

Overall it appeared that a very good case could be made for building at least one kaon/neutrino factory somewhere in the world. About ten experimental set-ups could be identified, each of which would make possible several years of important experiments needing the extra beam intensity or purity which such a machine could provide. The main research topics would be charge-parity violation, rare kaon and hyperon decays, baryon spectroscopy, kaon-nucleus interactions and hypernuclei.

The most obvious area of study is CP violation. The kaon system is still the only one in which this phenomenon is observed and, in spite of recent progress in constructing gauge theories of fundamental interactions, it has not yet been satisfactorily explained. More precise measurements of CP violating parameters could help clarify the origin of CP violation, test ideas of grand unification, compare alternative extended electroweak models and study gluon corrections in QCD.

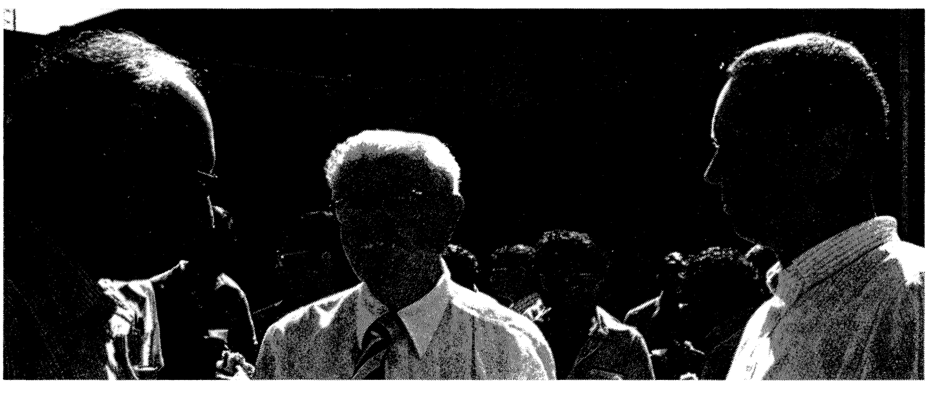
The study of rare kaon decays would also be greatly aided by higher intensity beams. Rare decays can be divided into two categories. First those which involve transition between particle families and thus probe physics at mass scales not directly accessible with accelerators. An example is the decay of the long-lived kaon into a muon and an electron which provides a crucial test of technicolour schemes. Second are those which are allowed as higher order electroweak interactions, such as kaon decays into a pion, electron and positron. Improved measurement of these processes would help reinforce the standard model or discover deviations from it.

Neutrino physics was also discussed. For experimental reasons, a useful neutrino beam would require the addition of a proton storage ring. With a primary beam in the 10 GeV range, a useful neutrino beam of a few hundred MeV, not available at present, could be obtained. Important experiments with such a facility include a precise determination of the Weinberg angle through neutrino scattering and measurements on neutrino oscillations and masses.

The baryon spectrum up to 2 GeV is not that well known. Better measurements of both masses and branching ratios would enable a more stringent comparison to be made with promising new predictions. Polarization measurements in kaon scattering are particularly important.

Because of the weak positive kaon-nucleon interaction, scattering on nuclei should be free of the distorting effects that confuse nucleon and most pion scattering experiments. Positive kaons may therefore prove to be as useful a nuclear probe as very low energy pions but over a broader energy range and with shorter wavelengths.

Improvements in negative kaon beam intensity and purity will make possible systematic measurements on hypernuclei and their excited states — perhaps allowing the study of gamma rays in coincidence — in the same way that is taken for granted for ordinary nuclei. A systematic study of different types of hypernuclei — from the deuteron up – will provide crucial information on both the hypernuclear interaction and on many-body effects.



Left to right, Bob Adair, Reg Richardson and Eugene Pauli consider the possibilities for kaon factories.

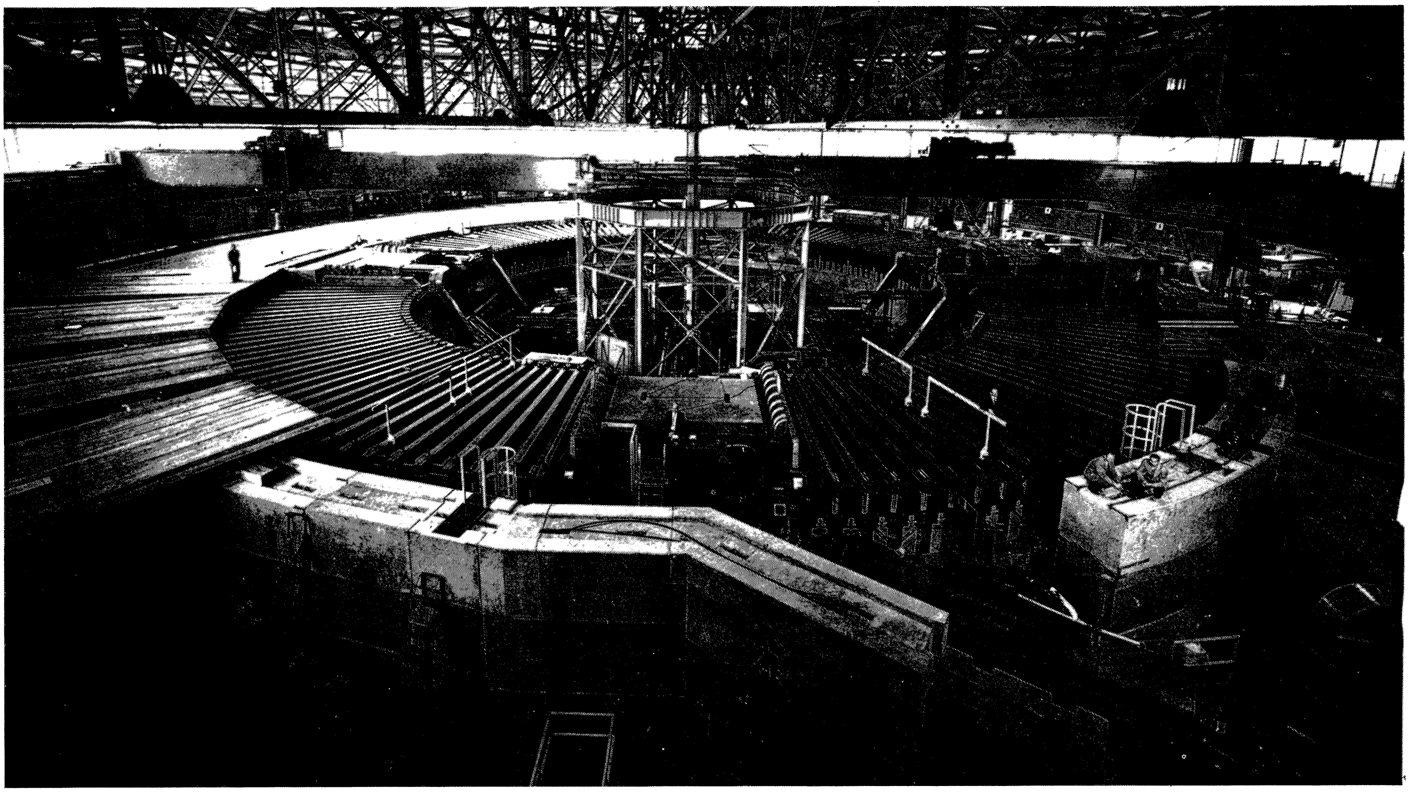
(Photo TRIUMF)

New possibilities with nucleus-nucleus collisions

by W. Willis

The Bevatron at Berkeley, now part of the Bevalac and scene of experiments with high energy heavy ion beams. However these energies of several GeV per nucleon may be insufficient to reveal important phenomena in nucleus-nucleus collisions.

(Photo LBL)

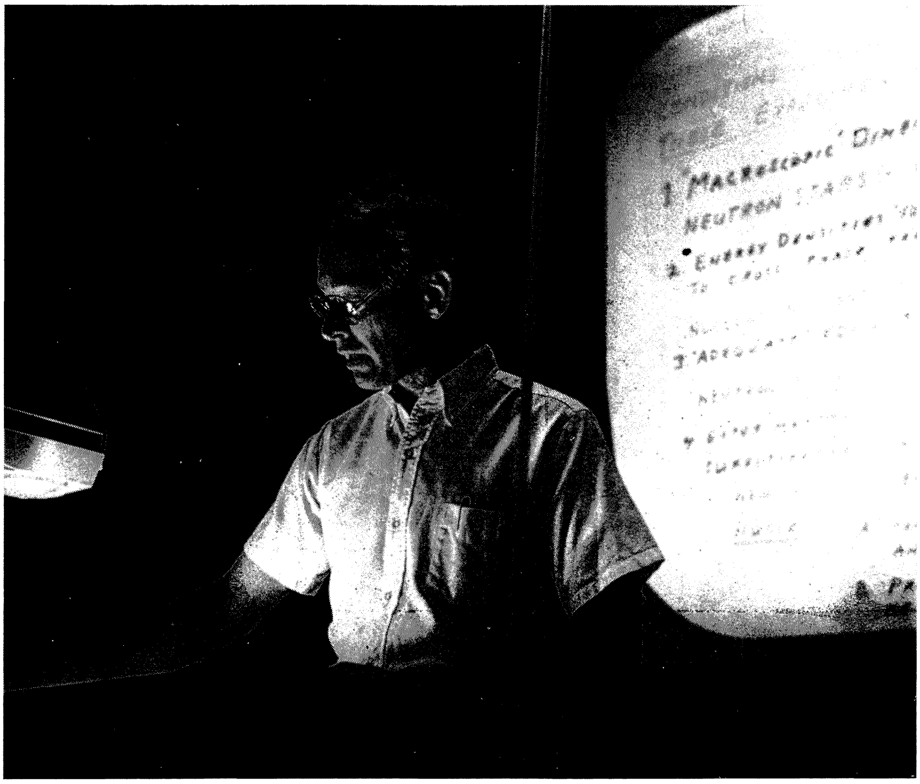


Quarks and gluons exist; they are nearly massless, but it is very hard or even impossible to knock them out of the proton. It is now widely believed that this strange state of affairs is due to the properties of the physical vacuum state as it now exists in our part of the Universe. In this view, the ground state of the vacuum is not that familiar from quantum electrodynamics (QED). That state is basically empty space, perturbed by fluctuations which occasionally give rise to a virtual electron-positron pair. In the quantum chromodynamic (QCD) theory of quarks and gluons, the stronger and more complicated forces give rise to a state which cannot be described as a perturbation on empty space. Instead, the physical vacuum has properties which resemble those of a physical medium. For example, the colour field is completely excluded, or at least strongly repelled, from a definite macroscopic volume of physical vacuum. This effect confines the quarks and gluons, which carry colour, inside the hadrons. On the scale of hadrons, quantum fluctuations make the phenomena more complex, but a simple picture postulates that the strong colour fields inside the hadron create a local volume of space which behaves more like the perturbative vacuum state, reverting to the physical vacuum state outside. This concept has been quantitatively expressed by the bag model, with some success.

This physical vacuum is also supposed to explain the origin of broken symmetries. An analogy is a perfectly symmetric sphere of iron. Above the Curie temperature the state has spherical symmetry. At low temperature, the ground state will be magnetized, with the magnetic field pointing in an arbitrary direction determined by quantum fluctuations. The symmetry of the state has been broken, without any arbitrary direction entering in the laws of nature. By a quite similar mechanism, the parameters of the physical vacuum could determine the seemingly arbitrary breaking of symmetries in particle physics, though the fundamental laws remain symmetrical.

It seems that the physical vacuum has acquired properties reminiscent of Maxwell's ether. At least, so we are asked to believe. Maxwell introduced his ether for plausible reasons, but crucial experimental tests were found, and the theory was found wanting. Experiments could test the idea that the physical vacuum is not identical to the perturbative one.

Our vacuum state has no consequences for the testing of special relativity and probably none for (macroscopic) general relativity. Fortunately, another classical experiment on the vacuum is predicted to show striking results. The effect is due to the predicted instability of the physical vacuum state in the presence of high energy density or matter density. Under these conditions, the lower energy state is that based on the perturbative vacuum: empty space with real and virtual quarks and gluons traversing it, without colour confinement. This change to a qualitative different state is in fact expected to occur, under suitable conditions, as a sharp phase transition. The origin in this transition is that the physical vacuum state is supposed to arise from ordered virtual constituents which are disrupted by thermal agitations, or the colour fields of dense matter. The analogy of the iron sphere is again valid: the spontaneous symmetry breaking of the physical vacuum is a low-temperature phenomenon. The 'Curie temperature' of the vacuum is of the order of the QCD scale parameter.



Bill Willis – proposing new ways to measure the properties of the vacuum.

An idealized experiment

Planck showed how far-reaching conclusions can be arrived at by analysing a volume of vacuum surrounded by walls in thermal equilibrium with the radiation in the interior. Let us follow him, adding equipment which will measure gluons as well as photons. Imagine a large box with thick walls at a certain temperature. The radiation emitted through a small aperture is measured. Alternatively, if we want to be sure of what happens in the middle of the box, a high energy proton beam is sent through the aperture, and Compton scattering of photons and gluons is measured.

At low temperature, we will detect photons filling the box with the Planck distribution, but no gluons. Why not, since massless thermal gluons should be emitted by the walls? The answer is supposed to be that the physical vacuum filling the box forces a thermal gluon back into the wall.

As the temperature of the wall is raised, there are more — and more energetic — thermal gluons emitted. They penetrate slightly further into the vacuum. Finally, the temperature approaches where the ordered structure of the virtual particles in the physical vacuum is so much disrupted that the perturbative vacuum state is energetically preferred. Very near this temperature, large-scale fluctuation appears in the vacuum, with a mixture of colour-confining and unconfining regions. The phenomenon of critical opalescence will render the box opaque to the high energy protons at that point.

Above the transition temperature, we will find freely propagating gluons and quarks filling the box. The situation at the small aperture is more complex, since it is a boundary with the physical vacuum in the world outside. Only constituent combinations which are colourless can make it to the outside world.

Suppose the walls are heated further so that the constituents enter the regime of asymptotic freedom and their interactions are decreasing as they are heated. It seems there is no limit to the temperature. The 'limiting temperature' observed in hadronic interactions must be a confinement effect, and indeed the Hagedorn temperature of 160 MeV is close to that estimated for the critical temperature.

The elements of this analysis which must be transferred to a real experiment are the following:

– The size of the box. The scale is given by the QCD scale parameter, about half a fermi. The box must be larger than that. Evidently, the proton is not large enough.

- The temperature. One should be able to sweep through the region 100–400 MeV, or thereabouts.
- A sufficient degree of thermal equilibrium must be established.
- The probes must be able to examine the interior of the 'box' — affording measurements of sufficient subtlety to distinguish the conditions above and below the transition, and the critical phenomema.

Real experiments

First, some possible approaches along conventional experimental lines. Consider, first, proton-proton collisions. We know that the distributions of the particles in the 'beam jets' as well as in high transverse momentum jets closely resemble those in the jets from high energy electron-positron annihilations. The latter reflect the characteristics of the fragmentation of single quarks. It follows that ordinary proton-proton collisions show no signs of the presence of many constituents, spread over a volume and in some sort of equilibrium — the conditions we wish to produce. It is possible that some rare events are somewhat more suitable for our purpose, but it does not seem likely that they will go far enough towards satisfying the first three conditions above.

We can think of using protons incident on a nuclear target. Here again we can profit by a considerable body of knowledge from recent experiments. For example, if we consider the system in which the proton is at rest, and consider the proton fragmentation products after it has been struck by the incident nucleus, we know that they are not very different from those after the proton has been struck by another proton. Consider, instead, the nucleus to be at rest. The proton passes through, making several collisions. The fast forward products do not fragment until they have left the nucleus (see the previous remark). The slower particles are emitted at larger angles, and do fragment inside the nucleus. Their fate is a hard one, however. These fragmenting particles have energies of a few GeV or less, and they enter a volume of cold nuclear matter where they are outnumbered by 'stationary' nucleons at the odds of typically ten to one. They create feeble cascades, where the creation of a few pions is partially counterbalanced by pion absorption. No wonder that the observed increase in pion multiplicity, in comparison with proton-proton collisions, is only between two and three in the heaviest nuclei. There is no possibility of heating a large volume to an interesting temperature. Instead, the energy provided is dissipated in a large mass of cold nuclear matter.

We come rather naturally to consider nucleus-nucleus collisions at high energy. First we note that accelerators, linear or circular, act upon the charge. A fully stripped heavy ion has charge Z times that of a proton, and A times the mass, with A roughly twice Z. The total energy of a nucleus produced by the accelerator is thus about Z/2 times that of a proton from the same accelerator. Even for a medium size nucleus, say argon, this is a big factor. Given that we needed to heat a large volume, the fact that the energy is distributed over a number of particles is not a disadvantage. Quite the contrary, since this energy can be deposited in the target with reasonable efficiency, which is of course not the case when trying to heat a nuclear volume with one very high energy proton.

Some idea of the character of these collisions can be gained by considering the number of pions produced. In proton-proton collisions at the energy of the CERN Intersecting Storage Rings, about 20 pions are produced. In central collisions of nuclei, essentially all the nucleons interact. Cascading is not very important, so one might expect that pion multiplicities are roughly linear in A, consistent with cosmic ray results. Collisions of heavy nuclei at very high energies should give thousands of pions.

Naïvely, we could suppose that these pions are created in the volume of the two nuclei before the system has had time to disassemble. Note, however, that if each pion is supposed to occupy the volume attributed to it in the bag model, there is not room for that many pions. We may suppose that the matter is rather in the form of quarks and gluons, forming pions as the density falls to the appropriate value. Here, however, we make contact with the considerations on the role of the physical vacuum.

We know that the nucleus is made of nucleons, not a big bag of quarks. In fact, most of the volume inside a nucleus is occupied by the vacuum — not by the nucleon bags. In the collisions just described, it seems very likely that the conditions are created where that physical vacuum is unstable, and at each point there is a transition to a perturbative vacuum filled with quarks and gluons. We then indeed have a big bag. The surface presumably emits pions as long as the temperature is high enough. In suggestive language, 'the surface boils pions at the Hagedorn temperature'.

We can begin the discussion by noting that most of the common observables are not very useful. Most hadrons will have at last scattered near the surface of the interaction volume, largely erasing the information about their previous history. It is not sensible to go to such trouble to provide a good surface-to-volume ratio, and then selectively to observe the surface. Weakly interacting probes are called for. Most of our considerations must then deal with photons, or virtual photons observed as lepton pairs.

The emitted photons and leptons, for example, could be used in an attempt to observe the phase transition. The energy of the nuclei is varied, and the temperature indicated by the transverse momentum and mass distribution is determined. The rate of photon emission is then determined as a function of temperature. As the transition temperature is passed, the character of the particles producing the radiation changes, and one would expect a change in the number of the photons produced, or in the slope of the photon production versus temperature.

It may be too naïve to suppose that spectral measurements will show such a subtle effect as the disappearance of bag boundaries. Correlation measurements may be required, such as searches for changes in the small mass lepton pair spectra, or in the identical particle interference measurements.

Since we have only rough estimates of the transition temperature, only rather crude notions of 'temperature' in collisions, and as yet no direct data relevant to the temperature inside nuclear collisions, we cannot say anything precise about the energies necessary to produce temperatures above the critical temperature. It seems clear that the energies investigated at Berkeley and Dubna, a few GeV per nucleon, are not sufficient and the further investigation of these phenomena must await the availability of much higher energy nuclear collisions.

Workshop

A Workshop on Quark Matter Formation and Heavy Ion Collisions is being held from 10-14 May at the University of Bielefeld, Federal Republic of Germany. Its aim is to study both theoretical aspects of the formation of a quark-gluon plasma in heavy ion collisions and the experimental problems arising in its detection. The meeting will consist of a four-day session for about 80 participants, followed by a general session on 14 May open to anyone interested. For further information, contact H. Satz, Department of Physics, University of Bielefeld, D-48 Bielefeld, Federal Republic of Germany.

People and things

LEP authorization

The project to build a large electron-positron storage ring, LEP, at CERN already had the backing of the twelve CERN Member States (see December 1981 issue, page 439), but three votes remained subject to conditions. At a CERN Council meeting in December this 'ad referendum' was lifted by the Netherlands, Norway and Sweden. The LEP project thus has the unconditional support of all Member States.

Meanwhile the LEP project team has continued to work on the optimization of the designs for the machine components and of the location of the underground LEP ring itself. A new location is to be proposed to the Host States (France and Switzerland) which reduces the length of ring under the Jura mountains. It is also planned to tilt the plane of the ring. More information soon.

Also at its December session, the CERN Council elected Sir Alec Merrison as its President, in succession to Jean Teillac. V. Telegdi and K. O. Nielsen were re-elected as Chairmen of the Scientific Policy Committee and Finance Committee respectively. K. Tittel was appointed a new member of the SPC.

At CERN, Roy Billinge was appointed as Leader of Proton Synchrotron Division and Maurice Jacob as prospective Leader of Theory Division. Tributes were paid to Gordon Munday (Proton Synchrotron), Constant Tièche (Finance), and Gunther Ullmann (Personnel) for their exceptional contributions to the work of CERN during their many years as Division Leaders.

Warm tributes were paid to Jean Teillac at the December session of CERN Council. Professor Teillac had served as President of Council for almost four years.

A symposium was held at the Massachusetts Institute of Technology on 16 October to mark the 60th birthday of Francis Low (centre), seen here with Val Fitch (left) and Marvin Goldberger.

(Photo M.I.T.)

On People

Ettore Fiorini of the University of Milan has been awarded the Feltrinelli Prize for Physics by the Academia Nazionale dei Lincei. The award was in recognition of his experimental work in particle physics, much of which has been carried out at CERN. He was the leader of the Milan group in the Gargamelle collaboration during the series of neutrino experiments which included the discovery of weak neutral currents. Using counters, he obtained important results on parity violation in nuclei and, in a series of experiments carried out deep underground, on double beta decay. Ettore Fiorini is spokesman for the new experiment on nucleon decay being mounted in the Mont Blanc Tunnel by a CERN/Frascati/Milano/Torino collaboration *(see page 7)**.*

70th birthday of Willibald Jentschke

Over 200 pupils, ex-collaborators and friends of Willibald Jentschke met at DESY on 8 December to celebrate his 70th birthday. Two scientific lectures, organized by the University of Hamburg and DESY were held in the afternoon. First speaker was Dieter Haidt, talking on neutral currents in weak interactions. He covered the discovery of neutral currents made at CERN during Jentschke's directorship and Jentschke's participation in the SLAC polarization experiment which measured parity violation due to neutral currents. Second speaker was Erwin Bodenstedt, Jentschke's first assistant in Hamburg, who spoke on nuclear magnetic moments, a subject well known to Jentschke due to his early nuclear physics activities in Austria before 1945.

Afterwards, at a dinner at DESY, the Dean of the Physics Faculty of the University of Hamburg, Peter Staehelin, told some nice stories about the start of DESY. Hans-Otto Wüster, well known at CERN and now leader of the European JET project in England, and also a colleague of Jentschke during early years of the DESY Synchrotron, amused the guests with Jentschke anecdotes. Original manuscripts, about 25 years old, were shown (as transparencies) by Gerhard Soehngen, one of Jentschke's clo-

At an event held at DESY to mark his 70th birthday, Willibald Jentschke (left) chats with CERN Director General and former DESY Director Herwig Schopper (centre) and present DESY Director Volker Soergel (right).

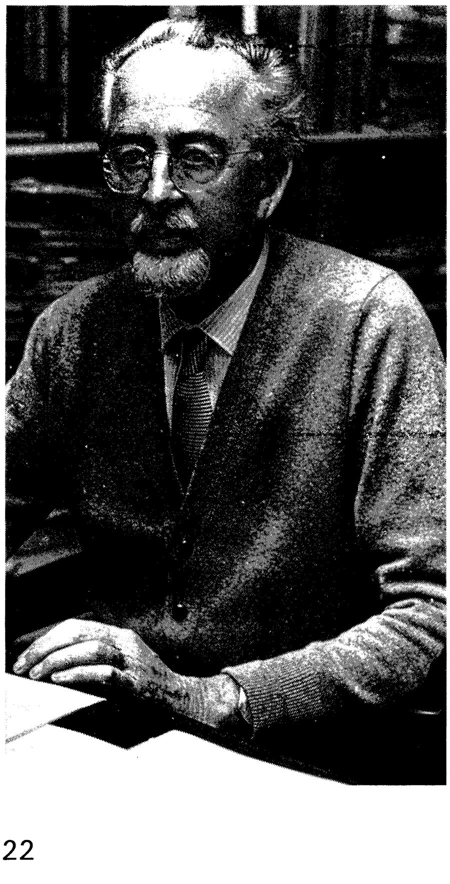
(Photo DESY)

sest collaborators at DESY.

Herwig Schopper presented Jentschke with one of the windows used to illuminate the Gargamelle bubble chamber, as a gift from CERN.

Christian Möller

The 14 January marked the second anniversary of the death of Danish theoretician Christian Möller. After studying under Niels Bohr, he went on to investigate the theory of the interaction between two relativistic electrons, well before the presently-accepted methods of quantum electrodynamics had been established. The outcome of this work was the formula for the scattering process which bears his name. Subsequently he played an important role in the development of both nuclear theory and quantum electrodynamics. Above all, he devoted himself to general relativity, where he tried to find a formalism free of singularities. His book on general relativity has been translated into many languages and is one of the standard works of modern physical theory. At various times he served as Director of Nordita, as a member of CERN's Scientific Policy Committee and as Secretary of the Royal Danish Scientific Society.



Christian Möller

Conferences

The fifth International Symposium on High Energy Spin Physics will be held at Brookhaven National Laboratory from 16-22 September. As well as covering spin experiment and theory, this meeting will also cover techniques for polarized beams and targets. Further information from the Symposium Secretary, Mrs. A. Bell, Bldg 911B, Brookhaven National Laboratory, Upton, New York 11973, USA.

The traditional SLAC Summer Institute on Particle Physics will be held this year from 16-27 August. Further information from Anne Mosher, Bin 62, SLAC, PO Box 4349, Stanford, California 94305, USA.

An Advanced Study Institute on Techniques and Concepts of High Energy Physics will be held July 1-12 in Lake George, NY (the Adirondack Mountains of New York State). This is the second in the series of Institutes started at St. Croix in 1980. It is sponsored by NATO Advanced Study Institutes Program, United States Department of Energy, National Science Foundation, Fermi National Accelerator Laboratory, and the University of Rochester. The anticipated main program of lectures is: C. Baltay, Columbia University – Neutrino Interactions; J.D. Bjorken, Fermilab – Accelerators and Storage Rings; N. Cabibbo, University of Rome – Particle Physics in the 1980s; F. James, CERN – Probability, Statistics and Associated Computational Techniques; C. Llewellyn Smith, Oxford University – Grand Unified Theories; F. Sauli, CERN – New Developments in Track Chambers; P. Söding, DESY – e^+e^- Interactions.

Anyone interested in attending should apply as soon as possible and request a reference letter from a senior colleague to be mailed to: T. Ferbel, Fermilab, Mail Station 888, P.O. Box 500, Batavia, Illinois 60510.

Deadline for applications is March 15.

The Seventh International Conference on Experimental Meson Spectroscopy will be held at Brookhaven National Laboratory, 14-16 April 1983. The conference will cover experimental results in light and heavy quark spectroscopy, relevant theory and spectrometer systems. Contact S.-U. Chung and S.J. Lindenbaum, Co-Chairmen, Organizing Committee, Brookhaven National Laboratory, Upton, New York, 11973.

International Commission on Particles and Fields

New members of the IUPAP International Commission on Particles and Fields have been elected. The members of the commission are as follows:

Chairman:

L.D. Solovoyev
Institute for High Energy Physics
Protvino
142 284 Serpukhov
(Moscow region)
USSR
Telephone 289 27-32
Telex 412 657 IPHE SU

Secretary:

Y. Yamaguchi
Department of Physics
Faculty of Science
University of Tokyo
7-3-1 Hongo, Bunkyo-ku
Tokyo 113
Japan
Telephone 03 812 2111
(Ext 4134)
Telex UTPHYSIC J23472

Members:

M. Blazek
Institute of Physics
Czechoslovak Academy of Sciences
Dubravska cesta
899 30 Bratislava
Czechoslovakia

M.L. Goldberger
California Institute of Technology
Pasadena
California 91125
USA

P. Lehmann
Centre d'études nucléaires
DPh/PE - Direction
91191 Gif-sur-Yvette Cedex
France

E. Lohrmann
Deutsches Elektronen Synchrotron
Notkestrasse 85
D-2000 Hamburg 52
Federal Republic of Germany

P.K. Malhotra
Tata Institute of Fundamental Research
TIFR
Homi Bhabha Road
Bombay 400 005
India

I. Mannelli
Istituto di Fisica
Università di Pisa
Piazza Terricelli 2
56100 Pisa
Italy

V.A. Matveev
Institute for Nuclear Research
USSR Academy of Sciences
60th Anniversary Prospekt 7A
Moscow 117312
USSR

K. Strauch
Physics Department
Harvard University
Cambridge
Mass. 02138,
USA

L. Van Hove
CERN
CH-1211 Genève 23
Switzerland

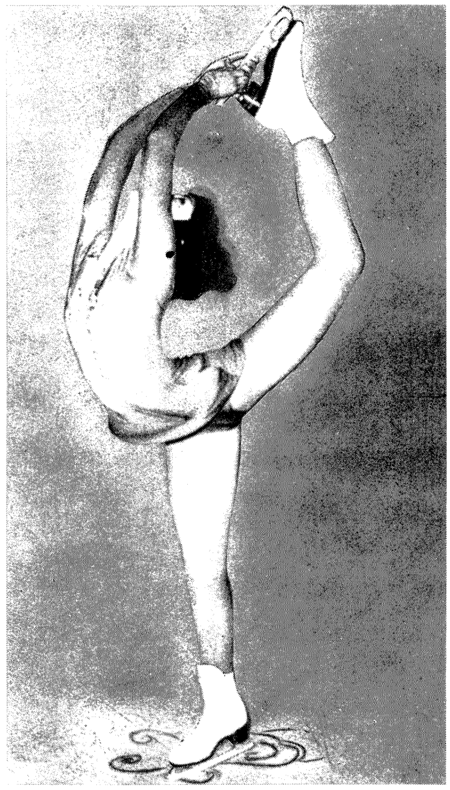
G. Von Dardel
Institute of Physics
Particle Physics Division
Sölvegatan 14
S-223 62 Lund
Sweden

ICFA meeting

The International Committee for Future Accelerators (ICFA) held its sixth meeting at Protvino, USSR, on the occasion of the ICFA Workshop on very high field (10 Tesla) superconducting magnets. In two previous Workshops organized by ICFA the possibilities and limitations of very high energy machines were examined, the problems that their design and construction would present were identified and solutions to these problems were put forward.

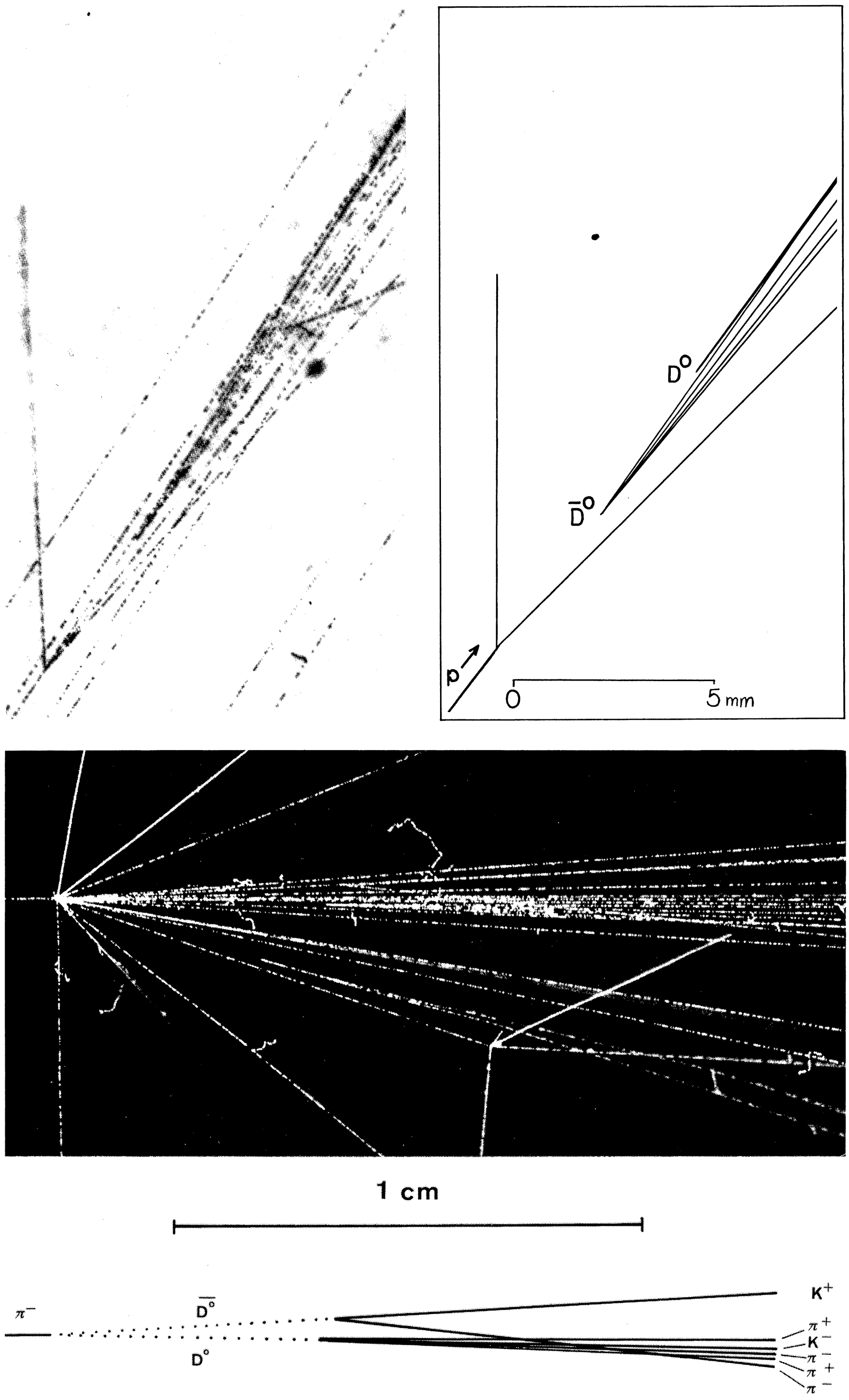
Amongst the subjects discussed at the ICFA meeting at Protvino was the problem of developing the new technologies needed by future accelerators and colliders and of encouraging new ideas which might enable higher energy machines to be built at less cost per GeV. At the present time, all the big Laboratories are hard pressed to operate their existing machines and to build the new ones — Tevatron, ISABELLE, UNK and LEP — and there is very little effort and money now available to study the problems of future machines. In an attempt to use whatever effort that can be made available by the big Laboratories in the most efficient way and to encourage small laboratory and university groups to be interested in these problems, ICFA recommended that

One way of illustrating spin — a detail from the poster advertising the forthcoming International Symposium on High Energy Spin Physics.



Due to circumstances beyond our control, the photographs used in the advertisements for A. PASTA (Pirelli Group) and CEAT CAVI which appeared on page 464 of our December 1981 issue were transposed.

Production and subsequent decay of charmed D^o and $\bar{D}^o$ mesons as recorded in small bubble chambers at CERN. Top left is an event from the LEBC chamber with a schematic alongside. Below is an event from the BIBC chamber. These and other measurements are helping to pin down the lifetime(s?) of these particles.



international teams are established to initiate and guide studies during the coming years.

Although it is not yet possible to be sure what kinds of machines or what energies will be required by the research towards the end of this century, it seems clear that machines of higher energy than those now being built will require the development of new techniques and that this kind of work takes a very long time. In order to provide a focus for the work of the teams, ICFA recommended that the two types of machines studied in the previous ICFA Workshops — a proton accelerator for 20 TeV energy which could also be used as a collider, and an electron-positron collider of more than 300 GeV per beam — should be used as the starting point for the work of the teams since they present the kind of design and technical problems typical of future machines and they can be used to assess the feasibility of new ideas for reaching higher energies.

Realizing that it will take many years to develop new machine designs and new technologies, and to encourage and develop new accelerator ideas, ICFA recommended that the teams should remain together for long periods of time even though their members may only be able to spend a fraction of their time on these studies. In this way ICFA hopes that the designs and the technological basis for future machines will be available when they are needed.

These recommendations have been sent to the world's major high energy Laboratories for their comments and Sir John Adams (CERN) has been asked to coordinate the activities of the international teams.

High Energy Experimental Physics

Two positions in high energy experimental physics are available at DESY. The positions offer the opportunity to participate in experiments at the electron-positron storage ring PETRA.

The first position will be permanent. Salary: BAT I b.

Candidates should have several years of experience in experimental high energy physics with an outstanding record in research. They should be able to take part in shaping the research program of the laboratory.

The second position will be limited to a duration of three years. Salary: BAT II a / I b.

Candidates should have a degree in physics, preferably have some experience in experimental high energy physics and be under 30 years of age.

Please apply as soon as possible to

Professor Erich Lohrmann
Deutsches Elektronen-Synchrotron DESY
Notkestrasse 85, D - 2000 Hamburg 52
Federal Republic of Germany

TRIUMF

(A research facility located on the UBC campus)

ACCELERATOR PHYSICIST

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The work will be mainly experimental and will include items such as RF cavities, electrostatic and magnetic fields, ion optics, electromagnetic focussing devices, beam diagnostics, ion sources, vacuum equipment and precise mechanical structures.

Candidates should have a degree (preferably M.Sc. or Ph.D.) in Physics or Engineering Physics, or equivalent. Previous experience with accelerators is preferred but junior candidates with good academic records and a strong interest in accelerator physics are encouraged to apply. Salary will depend upon qualifications and experience.

Please reply in writing, outlining qualifications and experience to:

TRIUMF Personnel (Competition No. 305)
3004 Wesbrook Mall
University of British Columbia
Vancouver, B.C. V6T 2A3
Canada

Applicants should reply as soon as possible but not later than February 28, 1982.
TRIUMF offers equal employment opportunities to qualified male and female applicants. Among candidates meeting all of the above qualifications preference will be given to Canadian citizens or landed immigrants.

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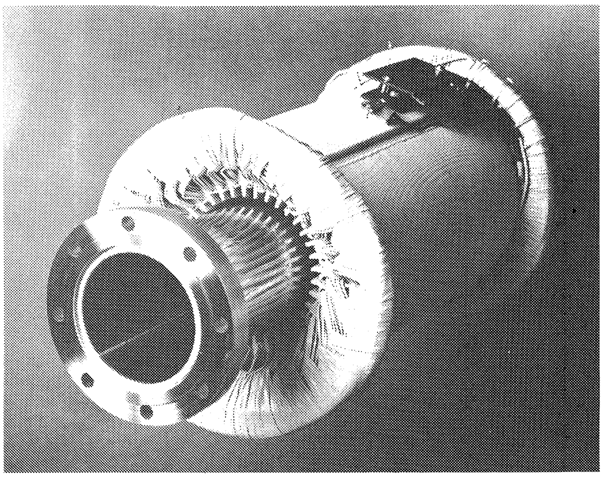

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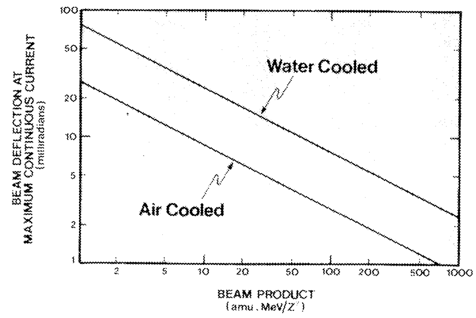

Optional accessories include independently controllable power supplies, vacuum chambers and mounting stands.

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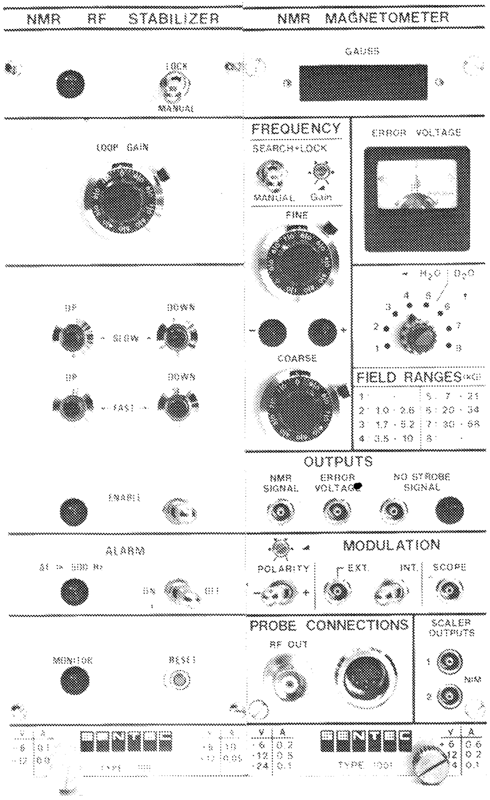

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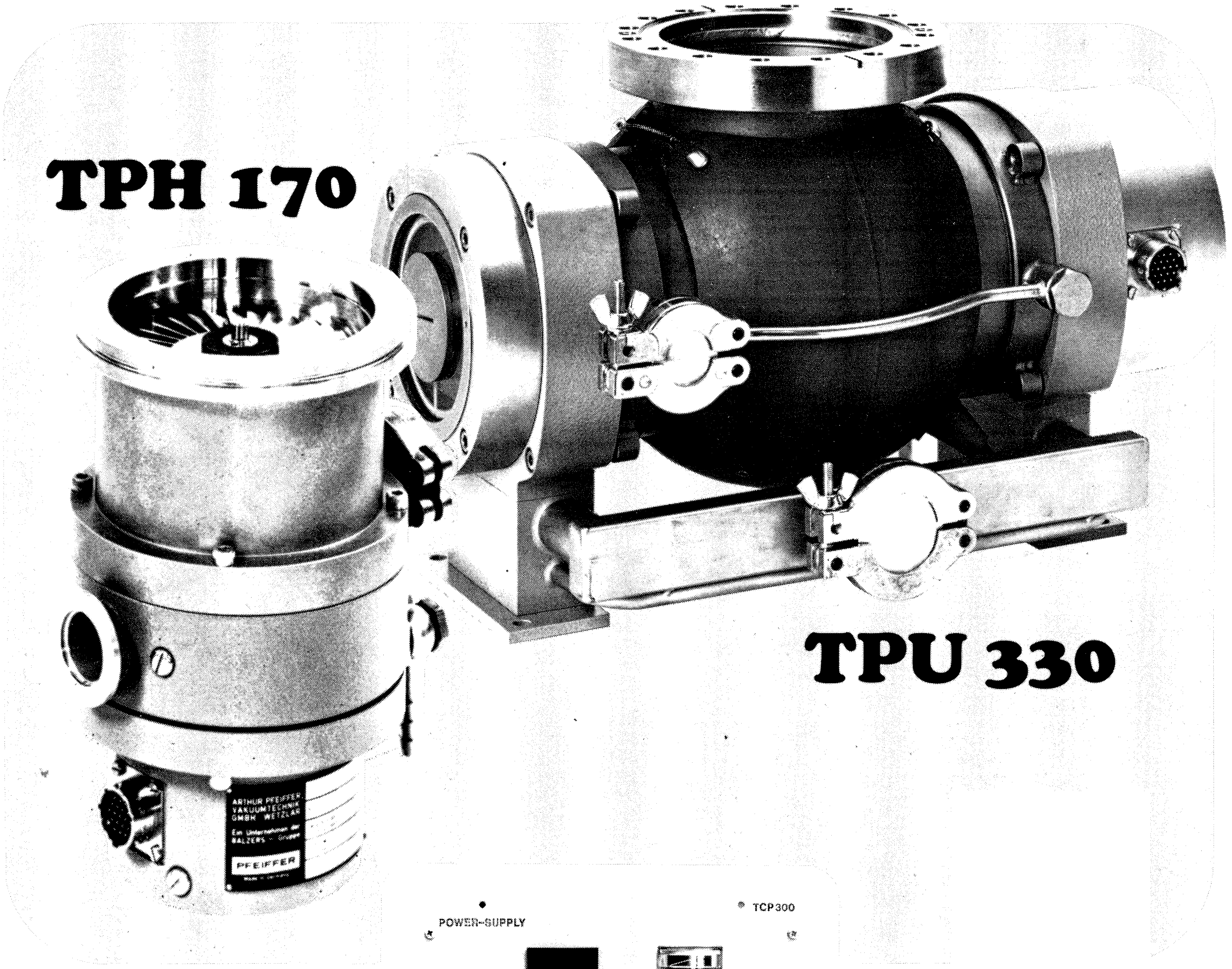

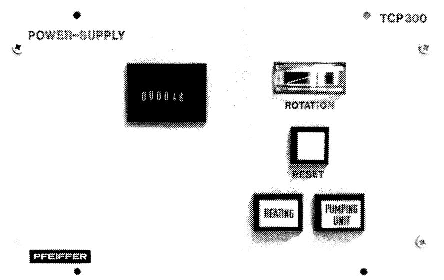

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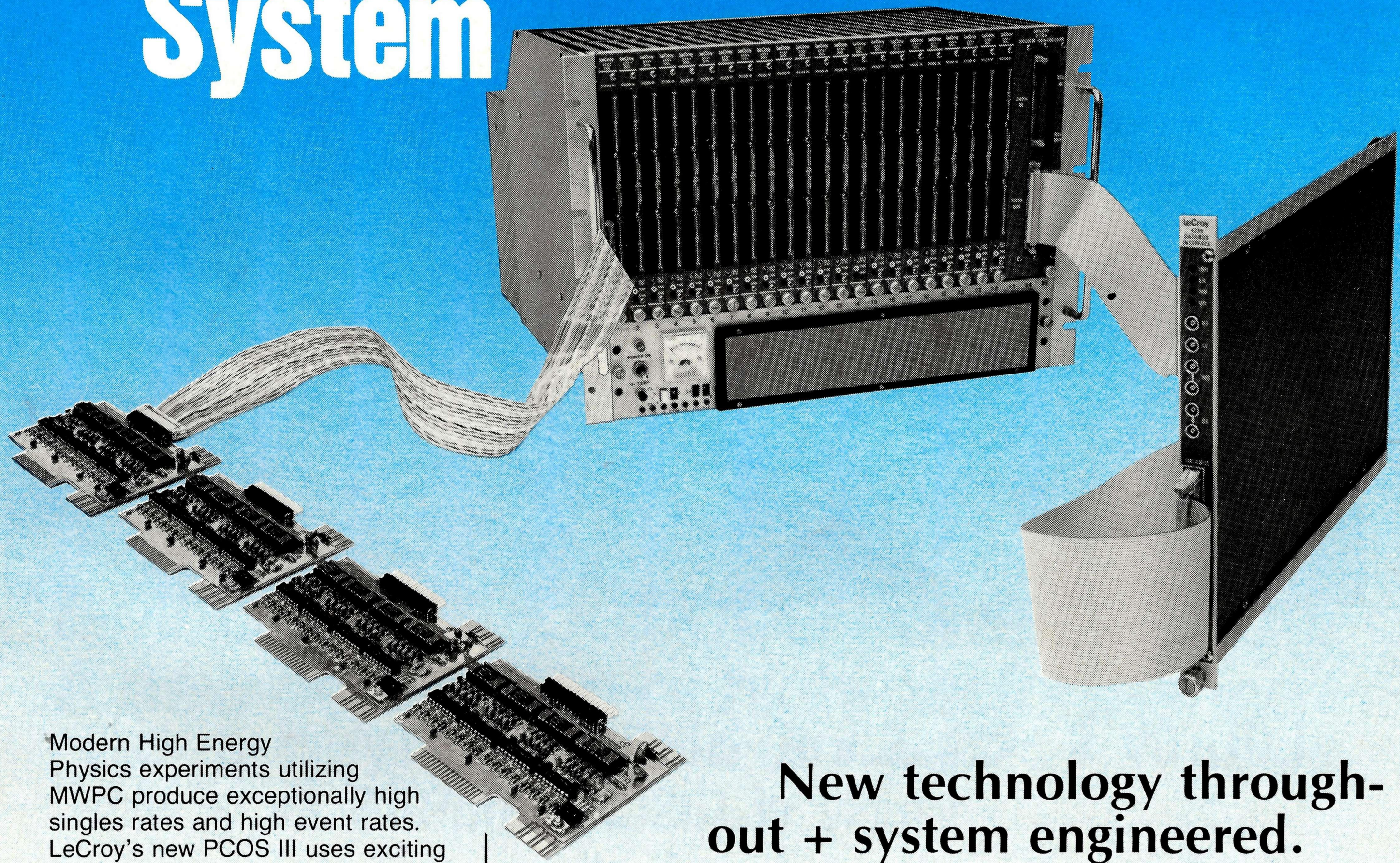

Modern High Energy Physics experiments utilizing MWPC produce exceptionally high singles rates and high event rates. LeCroy's new PCOS III uses exciting advanced technology to produce a totally integrated system for these applications.

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