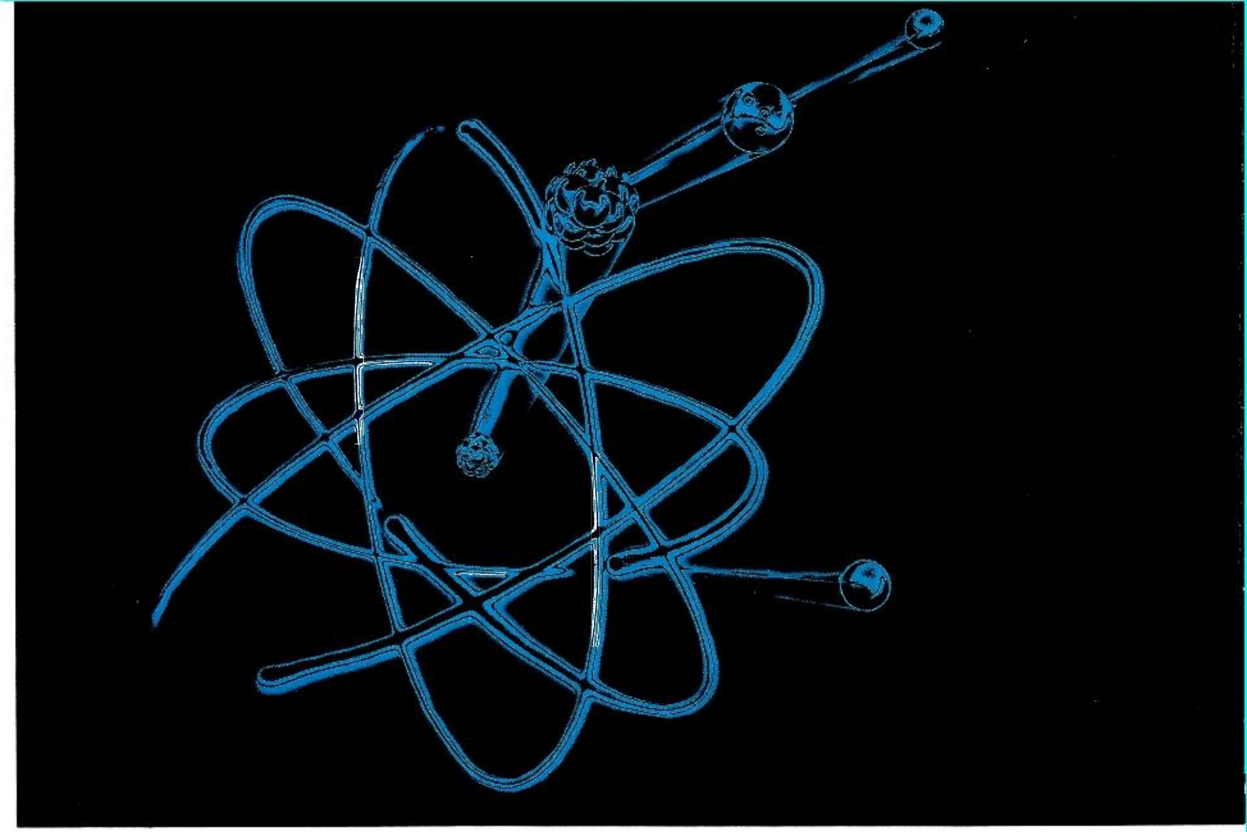
CERN COURIER

International Journal of High Energy Physics

VOLUME 27 3 APRIL 1987



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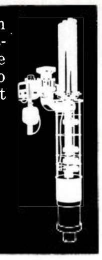

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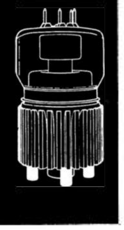

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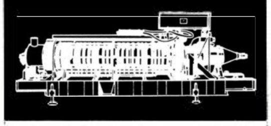

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Belgique: BRUXELLES
Tel. (32-2) 648 64 85
Tx 23 113 THBXL B

Brazil: SAO PAULO
Tel. (55-11) 542 47 22
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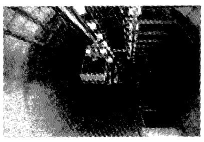
Volume 27
Nº 3
April 1987

CERN COURIER

International Journal of High Energy Physics

Editors: Gordon Fraser, Brian Southworth, Henri-Luc Felder (French edition) / Advertisements: Micheline Falciola / Advisory Panel: R. Klapisch (Chairman), H. Bøggild, H. Lengeler, A. Martin



Cover photograph:
The monorail for transporting personnel and equipment in position in a portion of the 27 km tunnel for the LEP electron-positron collider ring being built at CERN (Photo R. Lewis).

Laboratory correspondents:
Argonne National Laboratory, USA
M. Derrick
Brookhaven National Laboratory, USA
N. V. Baggett
Cornell University, USA
D. G. Cassel
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
G. Siegert
INFN, Italy
M. Gigliarelli Fiumi
Institute of High Energy Physics, Beijing, China
Wang Tajie
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
Anne-Marie Lutz
Rutherford Appleton Laboratory, UK
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Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
J. F. Crawford
Stanford Linear Accelerator Center, USA
W. W. Ash
Superconducting Super Collider, USA
Rene Donaldson
TRIUMF Laboratory, Canada
M. K. Craddock

Copies are available on request from:
China —
Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China
Federal Republic of Germany —
Gabriela Martens
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56
00044 Frascati
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Appleton 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

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

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

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

USA: Controlled Circulation
Postage paid at Batavia, Illinois

Colliderscope

With the new TRISTAN electron-positron collider at the Japanese KEK Laboratory coming into action last November (see January/February issue, page 1), the new SLC Stanford Linear Collider preparing for its first electron-positron collisions (see page 17) and Fermilab's Tevatron proton-antiproton collider now in operation for physics, the big colliding beam machines are setting the particle physics pace.

The world's highest energy particle research programme got underway in January at the Tevatron, with the 4500 ton Collider Detector at Fermilab (CDF) intercepting the particles produced by bringing together stored 900 GeV proton and antiproton beams.

First Tevatron collider operation was in October 1985 with 800 GeV beams and a partially completed CDF detector. Although successful, the particle collision rate was very low. Luminosity (a measure of the collision rate) at the start of this year's run was considerably up on the 1985 figure, but still a long way from the design level (10^{30} cm^{-2} s^{-1}).

Subsequently a marked improvement in proton supply resulted in a healthy antiproton stacking rate, exceeding the figure of 6×10^9 per hour achieved at CERN's Antiproton Accumulator. This spurred the Tevatron team to embark on multi-bunch proton and antiproton operation. Luminosity has reached several 10^{27} and is increasing.

Mastering the complex and tricky manoeuvres for handling antiproton beams takes time. At CERN, first proton-antiproton collisions were achieved in 1981 (with 270 GeV beams), and luminosity crept up gradually over the years, eventually increasing a hundredfold to 3.6×10^{29} (with 315 GeV beams).

Seeking a world-wide strategy

At its meeting in February, CERN's Committee of Council studied the implications of President Reagan's decision to support the US project for an 84 km Superconducting Supercollider (SSC) — see March issue, page 1.

CERN Director General Herwig Schopper reminded the Committee of Council that the dimensions of the tunnel for the 27 km LEP electron-positron collider, now being completed at CERN, had been chosen from the outset to allow room for a proton collider ring above LEP.

In addition to capitalizing on this, the world's largest existing accelerator tunnel, CERN's existing chain of accelerators could be used as injectors for this proton collider with only minor modifications, along with many other parts of CERN's existing infrastructure.

Such a proton collider could achieve energies between 7 and 9 TeV (1 TeV = 1000 GeV) per beam compared to the SSC's proposed 20 TeV per beam. However these CERN energies would still provide interactions between the quarks and/or gluons inside the protons at a few TeV, where many new phenomena are expected to be seen, (see page 27) and for a fraction of the cost of the SSC.

The implications of the CERN project are being studied by the Long-Range Planning Committee set up in 1985 under the chairmanship of Carlo Rubbia and scheduled to issue its final recommendations this year.

CERN's Committee of Council agreed that a hadron collider in the LEP tunnel should be seriously considered as a next step in the exploration of the microcosmos. While the project is studied further and before a definite proposal is worked out, scientific and technical cooperation with the US and other interested non-Member States should be sought, aiming for a wide international collaboration to optimize the use of global resources. These discussions could lead to a world-wide strategy, including possible European contributions to complementary projects elsewhere.

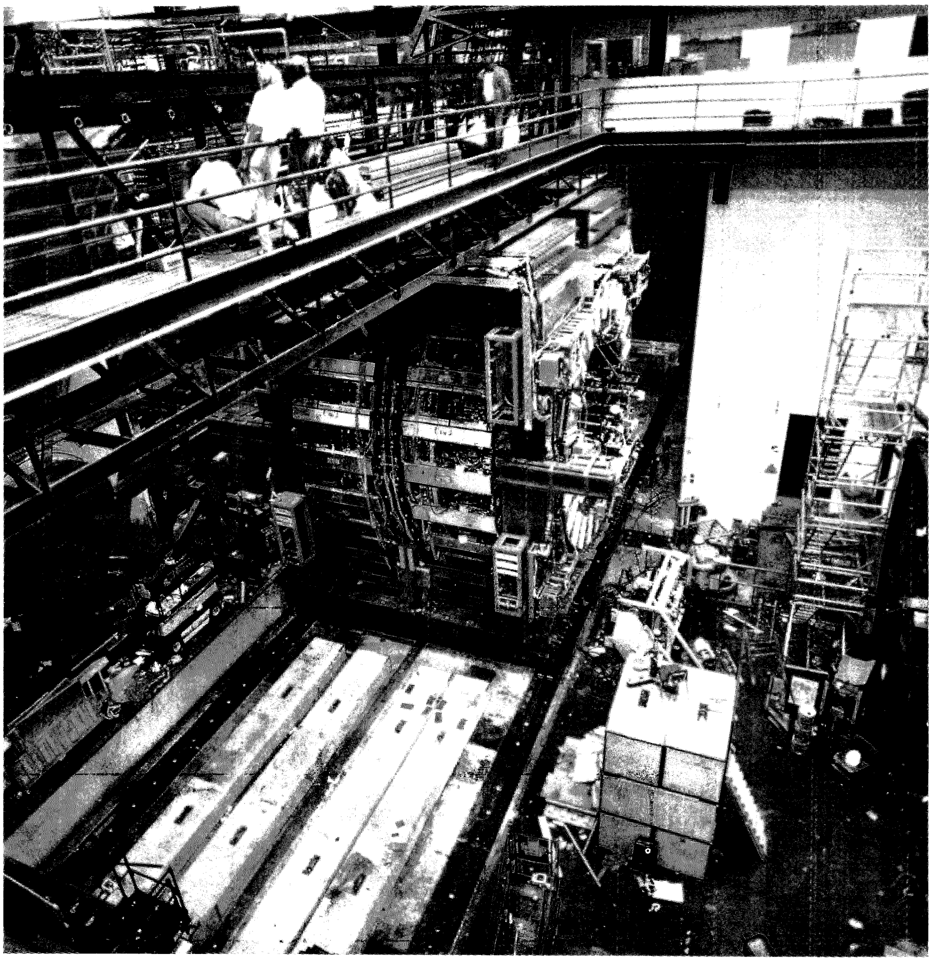
Meanwhile CERN pushes ahead with LEP, scheduled to begin operating in 1989 at electron-positron beam energies around 60 GeV, and subsequently pushed towards its design energy of around 100 GeV per beam.

At CERN, the proton-antiproton collider is scheduled to come on again towards the end of this year, this time with the new ACOL Antiproton Collector ring to boost the antiproton supply (new luminosity target 4.4×10^{30}) and with the big UA1 and UA2 experiments substantially upgraded.

Looking further ahead, the 27 kilometre LEP electron-positron collider at CERN is scheduled to begin operations in 1989, and the HERA electron-proton collider at the German DESY Laboratory in Hamburg joining the fray the following year. In the Soviet Union, the UNK machine could be ready in 1993 (see

The huge CDF Collider Detector at Fermilab rolls steadily at one foot per hour towards its physics position in the colliding proton and antiproton beams of the Tevatron.

(Photo Fermilab)



March issue, page 21). The 84 km US Superconducting Supercollider could be ready as early as 1996 (see March issue, page 1). At CERN, there is increasing interest in a proton collider in the LEP tunnel.

A 'typical' detector

A survey of the detectors used for today's big colliding beam machines or planned for tomorrow's can sometimes bring on a feeling of déjà vu. However there is plenty of uncharted physics for the experimental teams to explore without stepping on each other's toes.

The strategy of modern particle physics research with colliders (head-on collisions of stored contrarotating beams) has, as a major element, a 'universal' detector designed to observe the products of the collision with as much detail as the designers can anticipate. Much is known from previous experience about the general character of the collisions but each new energy domain offers the chance of hitherto unknown particles and for unanticipated phenomena.

A 'typical' collider detector tries to totally surround the collision point. (Practically, one must leave room for the beam pipe in which the colliding beams circulate.) Because one can expect hundreds of subnuclear particles, both charged and neutral, to emerge from an 'interesting' collision, the detector must be structured so as to recognize and measure the properties of each of the emerging particles.

Experience shows that new objects or phenomena produced in these collisions are highly transient and manifest themselves in prompt conversions to much more durable and familiar particles, electrons, muons, pions, kaons,... It is by careful study and measurements of the configuration of these well-known objects that new physics becomes apparent. As an illustration, in the 1983 discovery of the Z^0 particle (one of the carriers of the weak force) at CERN, what was actually observed was a pair of oppositely charged electrons (electron and positron) emerging from the debris of the proton-antiproton collisions. The properties of the Z^0 were inferred by measuring a number of these pairs.

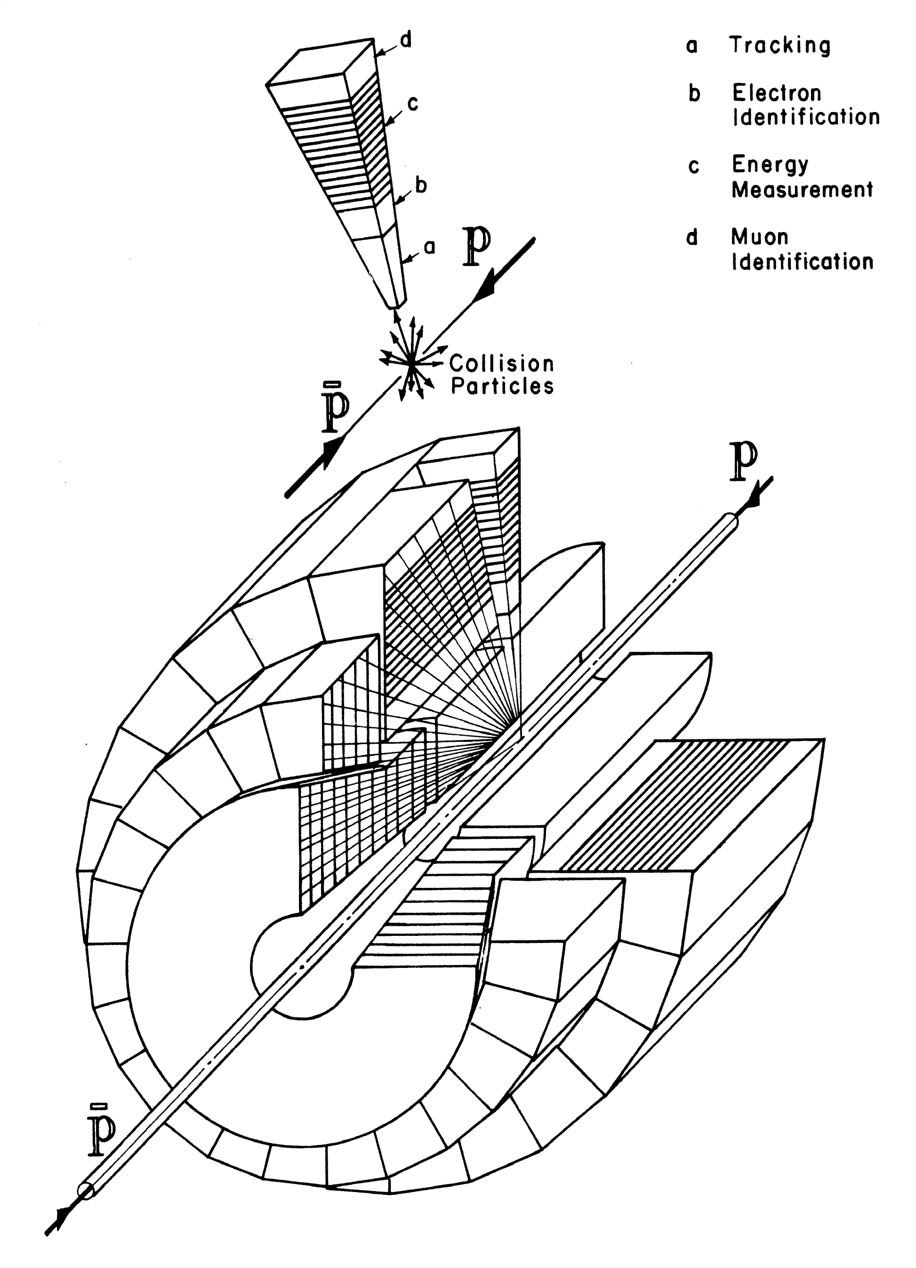
A charged particle emerging from a high energy collision encounters a series of devices as it penetrates into the surrounding detector.

A tracking chamber registers points on the trajectory of the particle with great precision. This chamber sits in a powerful magnetic field and the resulting track curvature is a measure of the momentum (mass times velocity) of the particle.

Leaving the tracking chamber, the particle encounters the 'electromagnetic calorimeter', designed to determine whether or not the particle is an electron. Electrons are totally absorbed in this part of the detector and their energy recorded. Surviving non-electron particles encounter an absorber to *measure the total energy carried. Neutral particles are also absorbed and their energy measured in the 'calorimeter' but leave no tracks in the inner tracking chamber.*

Segmentation of the detector is required because often the tracks are bunched together into a cluster as they emerge from the collisions. The detailed study of these clusters or 'jets' provides valuable information on the behaviour of the quarks deep inside the collision.

On the outside of the detector is a final layer of instrumentation to intercept and record the penetrating muons passing through the rest of the apparatus.



Schematic of the CDF Collider Detector at Fermilab used in the Tevatron proton-antiproton collider, showing the segmentation surrounding the collision point, and the radial structure of the main detector components.

Physics in a spin

The biennial international high energy spin physics meetings (Lausanne, 1980; Brookhaven, 1982; Marseille, 1984) provide a useful focus of attention for the enthusiastic community of followers of a sector of physics rarely lacking in interest and where the unexpected is increasingly expected.

The latest International Symposium on High Energy Spin Physics was held at Protvino (near Serpukhov, USSR) from 22 to 27 September, organized by the USSR State Committee for the Utilization of Atomic Energy. The Organizing Committee under the leadership of L. Soloviev with N. Tyurin, V. Solovianov et al. ensured a smoothly running conference for the 158 physicists from 18 countries who attended. The meeting reflected optimism about the future of spin physics, with many new polarized beam projects and stimulating new results.

One highlight was the report presented by V. Solovianov (Serpukhov) of the successful completion of polarization studies in charge-exchange reactions at Serpukhov. Big and unexpected spin polarizations up to 40 per cent were discovered at 40 GeV, with a polarized target used for the first time in many reactions.

Acceleration of polarized protons up to 22 GeV at Brookhaven was described by A. Krisch (Michigan). The polarization reached 46 per cent, with an intensity of some 2 x 10^{10} protons/pulse (see May 1986 issue, page 17). The successful start-up of a similar programme at the Japanese KEK Laboratory was covered by S. Hiramatsu (KEK). The polarization in the KEK PS machine at 3.5 GeV was about 20 per cent.

K. Heller (Minnesota) gave an extensive review of hyperon polarization in hadron-hadron reactions at high energies. Data accumulated worldwide over ten years show large hyperon polarizations and still lack a convincing explanation.

L. Pondrom (Wisconsin) re-

L. Soloviev of the Institute for High Energy Physics, Serpukhov, USSR, was Chairman of the Local Organizing Committee for the recent International Symposium on High Energy Spin Physics held at Protvino.

viewed the measurements of magnetic moments of baryons and quarks, most deriving from the spin precession technique.

Results from the Brookhaven AGS polarized proton beam were covered by D. Crabb (Michigan). The spin-spin correlation parameter at 18.5 GeV and large transverse momentum in proton-proton elastic scattering tended towards zero (see October 1986 issue, page 16). Comparison with lower energy Argonne data shows a sharp and surprising energy dependence.

New data on the asymmetry seen in reactions at 40 GeV at Serpukhov included a surprisingly big spin effect in negative pion on proton charge exchange reactions at large transverse momentum, presented by B. Khachaturov (Dubna). This disagreed with quantum chromodynamics (QCD) predictions.

D. Underwood (Argonne) and L. Dick (CERN) outlined preparations for two studies at the highest energies in spin physics—the imminent 200 GeV polarized proton beam experiment at Fermilab and the polarized gas jet experiment at CERN. Important results will come from these measurements of spin effects at hundreds of GeV.

1959 Nobel prizewinner O. Chamberlain (Berkeley) concluded that colliding polarized beams at 20 TeV would be possible in the proposed US SSC Superconducting Supercollider if the 'Siberian Snake' scheme worked.

Meanwhile a comprehensive programme of investigations at intermediate energies is going ahead. Parallel session contributions included detailed data to reconstruct the scattering amplitudes, to improve the results of partial wave analyses, to extend the spectroscopy of baryon resonances, and to search for exotic states such as dibaryons and hybrids, as well as experiments on parity-nonconserving effects, etc. A. Masaike (Kyoto) gave experimental results from KEK, and J. Arvieux (Saturne) from Saturne II.

A lot of attention was given to technical developments. S. Jaccard (SIN) reviewed the recent SIN-Montana Workshop on Polarized Sources and Targets. One parallel session highlight was the status of polarized ion sources at INR (Moscow) with successful results from two independent groups (presented by A. Belov and A. Zelensky). Very efficient plasma ionization led to polarized beam currents of up to 10 mA with 76 per cent polarization. The laser source could give 4 mA of protons and 400 microamps for negative hydrogen ions with 65 per cent polarization.

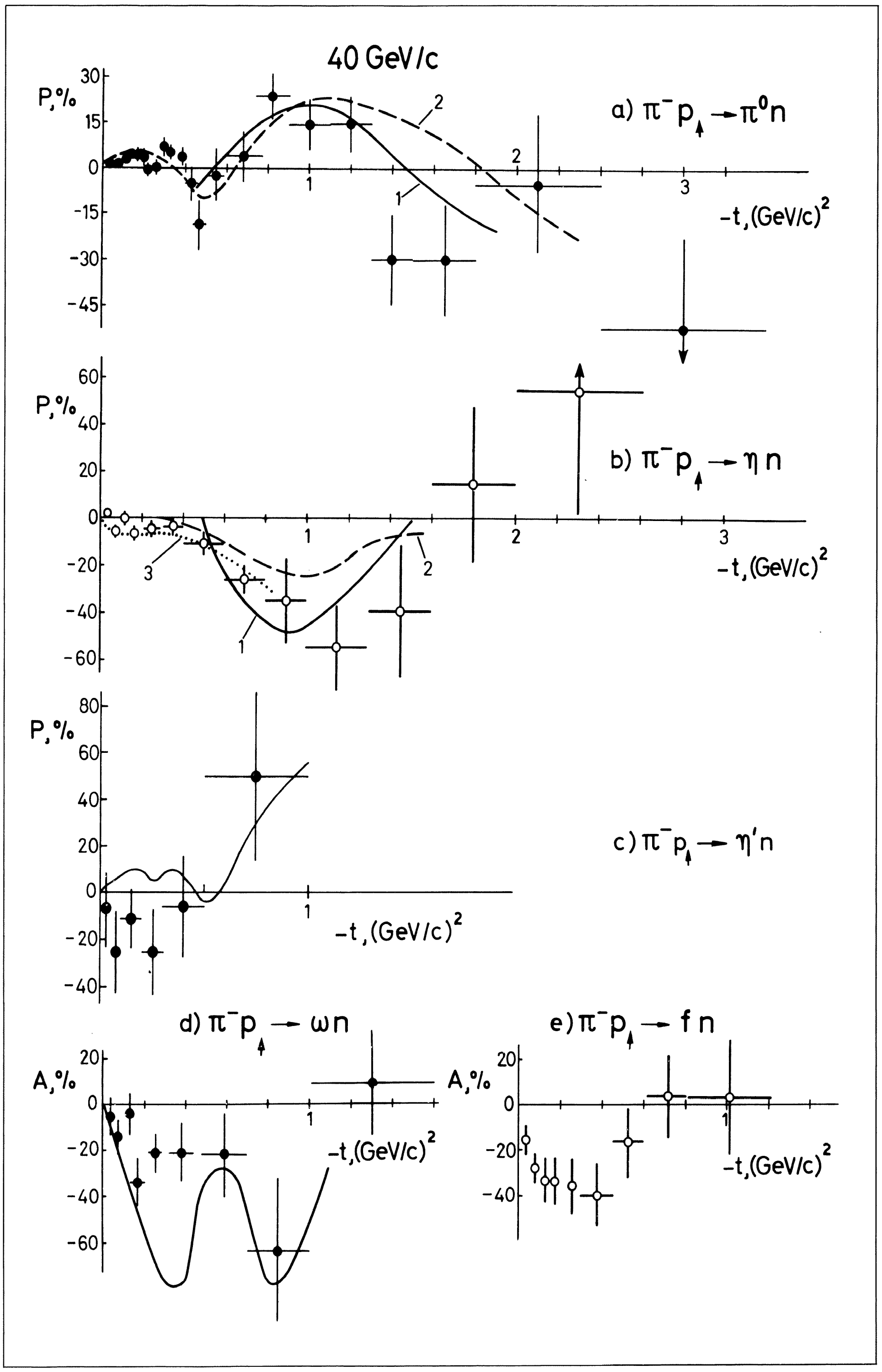
L. Soloviev (Serpukhov) discussed in his plenary talk new insights into the origin of particle spin. Some progress in understanding spin phenomena through QCD was reflected in the report by A. Efremov (Dubna). Polarization effects may be due to angular momentum conservation in a string field, maintained B. Andersson (Lund). H. Lipkin (Argonne) looked at more QCD tests.

The latest spin-spin correlation parameter results in the elastic proton-proton scattering were covered by M. Anselmino (Turin) and S. Troshin (Serpukhov). Both these theoretical approaches are helicity nonconserving and agree with the data.

The quasi-potential approach to the spin effect analysis was discussed by S. Goloskokov (Dubna). V. Petrov (Serpukhov) described the gluon dominance hypothesis and its observable consequences while M. Moravcsik (Oregon) outlined the use of polarization as a probe of particle reaction dynamics.

The concluding talk was given by A. Krisch (Michigan) who underlined the importance of spin and

Polarization data from negative pion on proton charge exchange reactions at Serpukhov show some large spin effects.



polarized beams and targets. He reviewed the list of large and unexpected spin effects obtained during the last ten years, which had shown that pure spin reaction rates are more fundamental than spin averaged ones.

The next Symposium in the series is to be held at Minneapolis in autumn 1988 and will surely continue the spin physics tradition of providing stimulating results.

From S.M. Troshin

Time out from spin. O. Chamberlain (left) with B. Arbuzov (Serpukhov).

Around the Laboratories

CERN
Tau neutrinos

Physicists like to think there are just three kinds of electrically charged leptons—particles interacting through the weak force of nuclear beta decay. Each of these three charged leptons—the electron, the muon and the tau, is associated with its own kind of neutrino (also a lepton, but devoid of electric charge).

The electron and the muon have been known and loved for a long time—the electron for almost a century and muon phenomena for some fifty years (although the muon was not finally identified until the 1940s). The newcomer, the tau, turned up at the big Stanford linac in the middle 1970s.

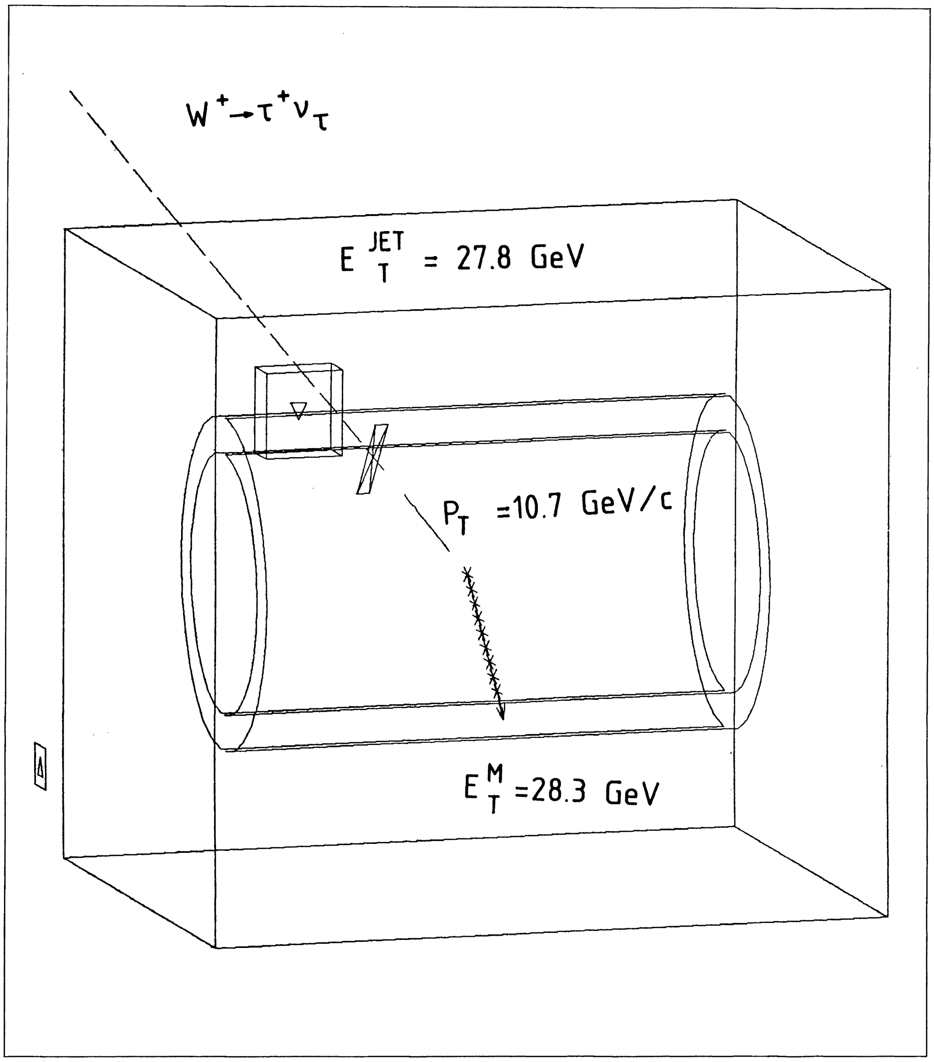
A pattern of three charged leptons and their corresponding neutrinos fits nicely into the current physics jigsaw, but it is difficult to explain why the muon is some two hundred times heavier than its electron cousin and the tau (1784 MeV) is seventeen times heavier than the muon.

Putting aside the question of the seemingly unrelated charged lepton masses, a long cherished idea is that the weak force feels the same for all leptons, regardless of mass or type—so-called 'weak universality'.

This says that the beta disintegration of a nuclear neutron into a proton—releasing an electron and a neutrino—should have the same strength as a decay producing a muon and its neutrino, and again as the breakup of a more exotic particle emitting a tau and its neutrino.

Over the years, many comparisons of electron and muon interactions showed that the underlying strength is indeed the same. To probe the tau sector was more difficult, but recent measurements of the lifetime of the tau by experiments at electron-positron colliders (PEP at Stanford, CESR at Cornell and PETRA at Hamburg) gave an indication of the strength of the tau coupling, showing that it was in line with that of the electron and the muon.

However the kinematic range covered by these tau decays is necessarily limited, and certainly the tau neutrino played no direct part in the proceedings.



The decay of a W boson into a tau lepton and its neutrino, as 'seen' in the UA1 detector at CERN's proton-antiproton collider. The tau is identified through its decay into a narrow 'jet' of hadrons (top), while the neutrino is picked up through 'missing energy'—an energy imbalance around the detector, showing that something has passed through otherwise undetected (bottom).

Enter missing energy

One of the major aims of the UA1 experiment at the CERN proton-antiproton Collider was to detect the long-awaited W particle, the electrically charged carrier of the weak force, identifying it by its decays into an electron or a muon plus the appropriate neutrino.

This was accomplished in 1983 using the 'missing energy' technique to detect the otherwise invisible neutrinos—the energy released sideways in a proton-antiproton annihilation is carefully measured all around the detector. Any imbalance shows that something has flown through undetected.

With the W in the bag, the UA1 team capitalized on the power of the missing energy method to look for other interesting physics. If the W had been seen through its electron and muon decays, why not the tau decay as well?

While electrons and muons can be picked up and identified directly, the highly unstable taus are another matter. UA1 looked for taus through their decay into a narrow 'jet' of hadrons, plus the elusive tau neutrino's missing energy.

Using the vast amount of data collected during three years of careful work (some 10^7 events on tape from 10^{10} proton-antiproton annihilations), 56 events were filtered off after painstaking elimination of electron and muon events and of unwanted background.

These were scrutinized to determine whether the hadron jets had the properties of those expected from taus, and a final sample of 29 tau decays isolated. A kinematical analysis showed that the strength of the tau decays is indeed the same (to within a few percent) as that of electron interactions. Comparing this with the decay rate of Ws into muons seen in the same detector, the tau/muon strength is also equal.

As well as confirming the idea of weak universality, the identification of tau neutrinos through the missing energy technique is the first direct evidence for these particles.

To make the picture even tidier, the same UA1 data says that if there is a fourth lepton beyond the tau, it has to be heavier than 41 GeV (more than 400 times heavier than the tau!). A few additional types of neutrinos cannot be excluded, but this will be tightened up from future colliding beam experiments.

Second-class current?

All the measured properties of the tau particle discovered ten years ago at the Stanford Linear Accelerator Center (SLAC) underline its candidature as the third generation lepton (after the electron and the muon).

However because it is so heavy (1784 MeV), it can decay in many different ways, and there has been trouble in fitting together all the tau decays.

Using data collected over five years, the HRS collaboration (Argonne / Indiana / Michigan / Purdue) at the PEP electron-positron collider at Stanford looked for production of the neutral eta meson (identified through its decay into a pair of photons) in tau decays. (Etas from tau decay were also found through their disintegration into three pions.)

After careful analysis of backgrounds, examples are found of the decay of a (positively charged) tau into a (positive) pion, an eta and an antineutrino. This helps to clear up the tau decay incompatibilities, but the quantum numbers of this decay are unconventional, violating a pattern seen in all other weak interactions.

One useful notion in particle interactions is 'G parity'— a combination of charge conjugation (interchange of particles and antiparticles) and invariance in the (isospin) space describing protons and neutrons as different projections of a nucleon.

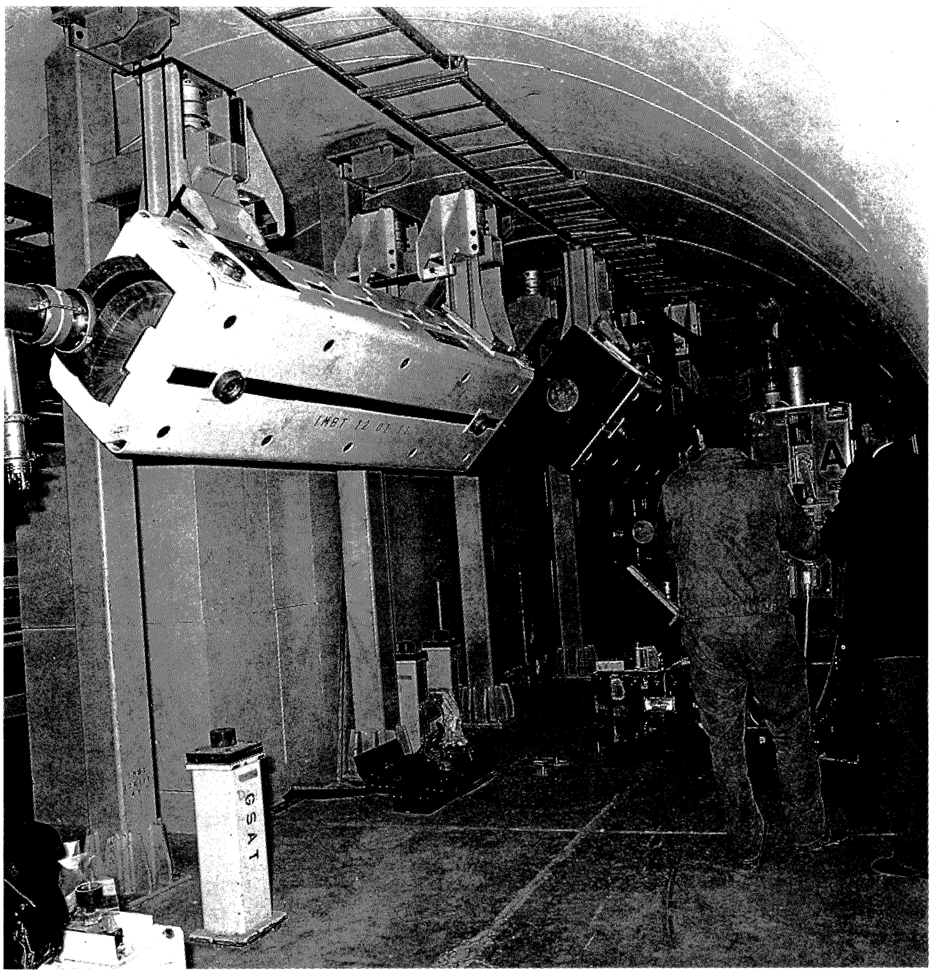
The observed tau decay upsets G parity. One possibility is a so-called 'second-class current', a kind of weak interaction with unusual G parity properties. These were postulated by Steven Weinberg almost thirty years ago to supplement the conventional weak interactions seen in beta decay, etc., but conclusive evidence for them has never been found. What is more, the elegant framework of the electroweak picture, unifying weak and electromagnetic interactions and supremely successful so far, does not have much room for these additional currents.

As the HRS physicists conclude in their paper 'it is important that the results be confirmed or denied by other experiments on tau decay'.

They see signs of another tau decay with a neutral pion produced in addition to the charged pion and the eta. This does not violate any rules, but only a small portion of the observed eta signal can be ascribed to this process. This decay mode is also seen by other experiments studying the disintegration of the tau at electron-positron colliders.

Moment of suspense. Tricky installation of bending magnets to handle the electron beam for LEP to be supplied by CERN's SPS machine. Here these magnets have to run above a proton extraction line (temporarily dismantled to facilitate the work).

(Photo CERN 615.2.87)



Preparing for LEP beams

With the big tunnelling machines' work finished and only a few hundred metres of rock remaining to be cut under the Jura mountains, preparations for CERN's new 27 kilometre LEP electron-positron collider turn towards component installation and preparations for the beams.

LEP electrons and positrons, provided by new linacs and an accumulator ring, are initially injected into the 28 GeV PS 'Proton' Synchrotron and subsequently the 450 GeV SPS Super 'Proton' Synchrotron. Adapting these synchrotrons to handle electrons and positrons involves a lot of work, and the machines were shut down last December for six months to allow the necessary modifications to be carried out and to build the new ACOL Antiproton Collector to boost CERN's antiproton supply.

LEP electrons are supplied by a 600 MeV linac feeding the EPA Electron Positron Accumulator, one-fifth the circumference of the neighbouring PS. EPA acts as a buffer between the fast cycling linac upstream and the relatively slow cycling synchrotrons downstream. 410 MeV electrons from the linac were injected into the EPA ring in June last year, followed in September by 500 MeV beam reaching the PS via EPA.

Although the linac has reached 600 MeV, 500 MeV working was preferred for technical reasons. Electron beam intensities many times the design values have already been achieved in EPA.

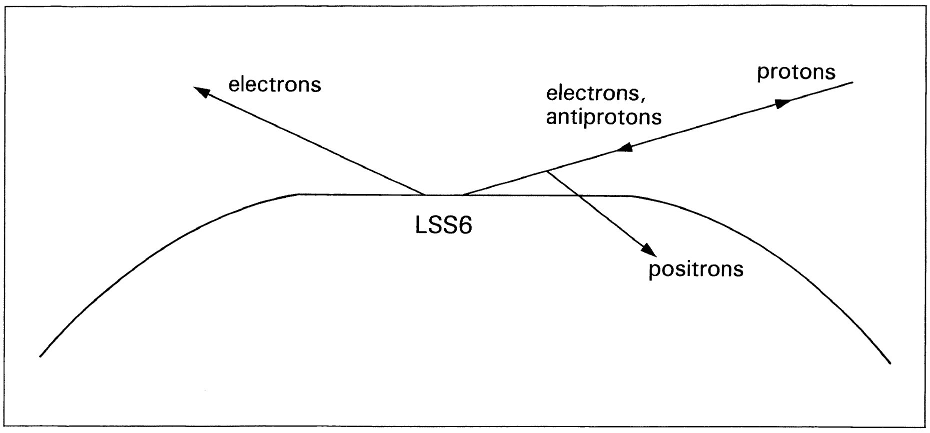
While this was going on, the 200 MeV high current linac to supply the positrons was completed at the input end of the 600 MeV linac. Positron tests in the linac/EPA complex are imminent(*) and the plan is to inject into the PS in June, and into the SPS one month later.

LEP injection envisages positron transfer in two batches, with the eight stored bunches in EPA being sliced in half by a thin electrostatic septum. One batch of eight half-bunches proceeds to the PS, the other batch remains in EPA and is fired in on the next synchrotron cycle. Electrons are also injected in two final batches. Since it takes the synchrotrons only 4.8 s to handle these four batches, the 14.4 s supercycle can also include proton acceleration for fixed target physics.

For LEP, the PS takes 600 MeV particles from EPA up to 3.5 GeV ready for injection into the SPS. Handling these electrons is not straightforward as the PS was designed as a 'combined function' machine with the same magnets both bending and focusing proton beams. Three special 'wiggler' magnets have been built to compensate for anti-damping produced by synchrotron radiation, so as to produce conditions more like those of a separated function machine

* In March, the 600 MeV linac supplied its first beam of positrons.

Schematic of the beamlines snaking in and out of the LSS6 long straight section of CERN's SPS Super 'Proton' Synchrotron. High energy protons are ejected towards the West Experimental Area and low energy antiprotons and electrons, injected from the neighbouring PS machine (not shown), while positron and electron ejection lines will feed the new LEP electron-positron collider now under construction (also not shown).



(with separate magnets for beam bending and focusing). To accelerate the electrons, two 114 MHz radiofrequency cavities have been installed.

One major task is to correctly shape the bunches ready for the SPS, and initial tests last year gave encouraging results. Dedicated PS runs with electrons confirmed expectations that the strong synchrotron radiation given off by the circulating electron beams has a strong effect on the vacuum. During the shutdown, a new PS vacuum chamber made of stainless steel is being installed and will be a considerable help.

When the PS switches on again in June, the initial objective will be to reestablish the machine's 1986 status, when it impressively demonstrated its ability to handle a wide range of particles simultaneously. After so many modifications, this will be no mean feat. Then come the first positrons, followed by ejection into the SPS.

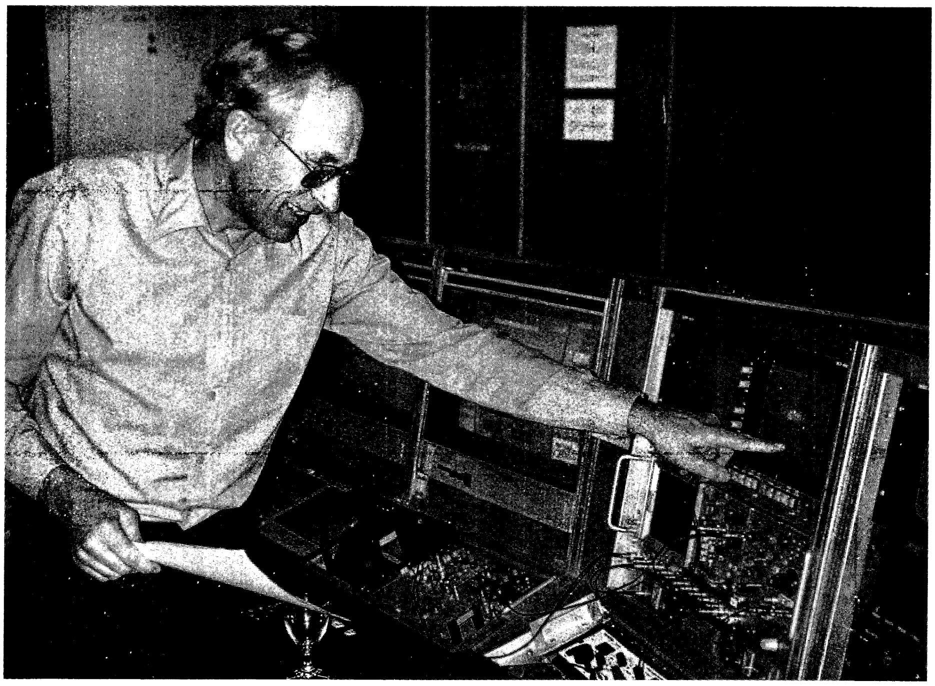
The SPS has to take the 3.5 GeV electrons and positrons from the PS up to 20 GeV, ready for injection into LEP. The electrons and positrons ejected from the PS will use the same transfer tunnels as the antiprotons and protons respectively. The 'LSS6' long straight section, already fitted with beamlines for antiproton injection and for proton ejection towards the West Experimental Area, will also be the scene of positron and electron ejection towards LEP, as well as electron injection from the PS. Squeezing in all this equipment has called for some imaginative designs for both magnets and supports.

The SPS is being fitted with a set of new accelerating cavities each fed by a 200 MHz 60 kW power amplifier. At the same time, the control system is being upgraded and beam observation and monitoring systems extended. Painstaking work is also required to fit all the tungsten diaphragms and lead shielding to protect magnet coils against the synchrotron radiation emitted by the circulating electrons and positrons.

The full manoeuvres required for LEP injection will be rehearsed in 1988, ready for initial operation of the big ring in 1989.

DESY
Beams for HERA nearer

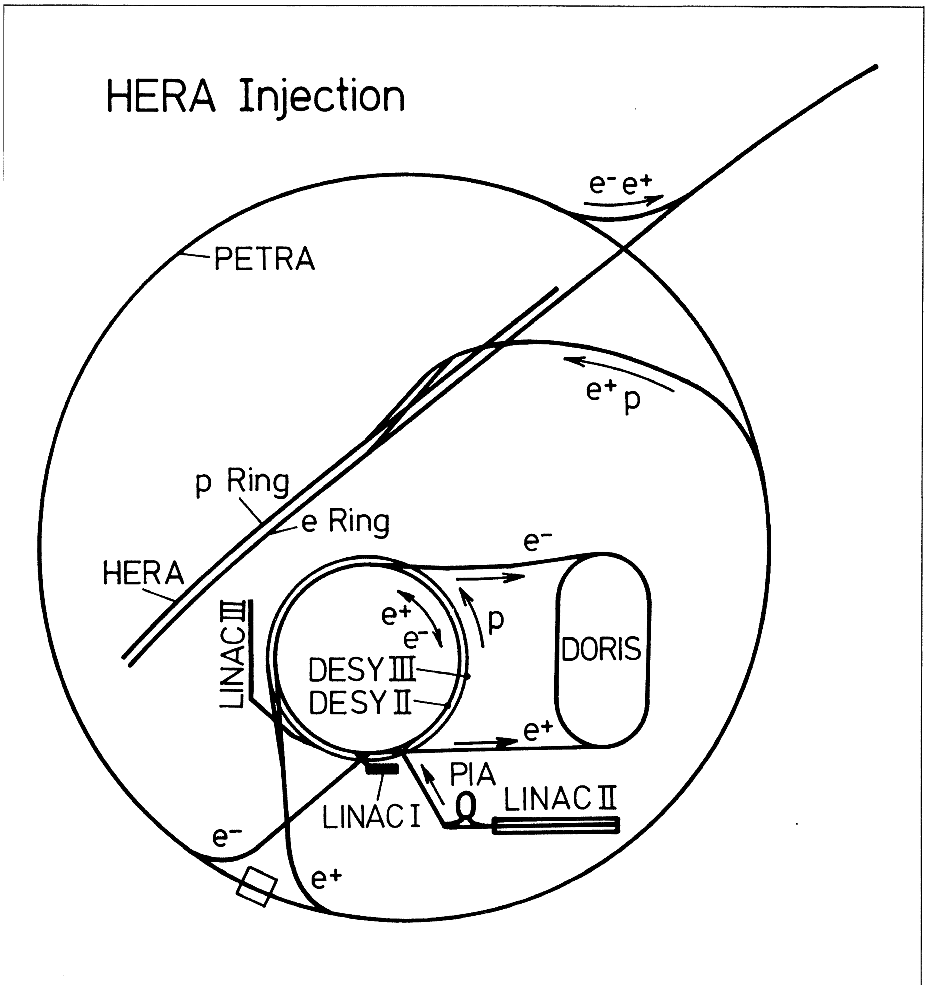
With civil engineering advancing well, preparations for the new HERA electron-proton collider at the German DESY Laboratory in Hamburg, like those for the LEP



Günter Hemmie points to the spot on the screen showing that a healthy beam circulates in the new DESY II synchrotron at Hamburg.

(Photo P. Waloschek)

A beamline map of the German DESY Laboratory in Hamburg updated to include the HERA electron-proton collider now under construction. The new DESY II synchrotron provides electrons (e), and the DESY III machine will supply protons (p). Particles will be transferred to HERA via the PETRA ring, previously used as an electron-positron collider, and the scene of some landmark physics.



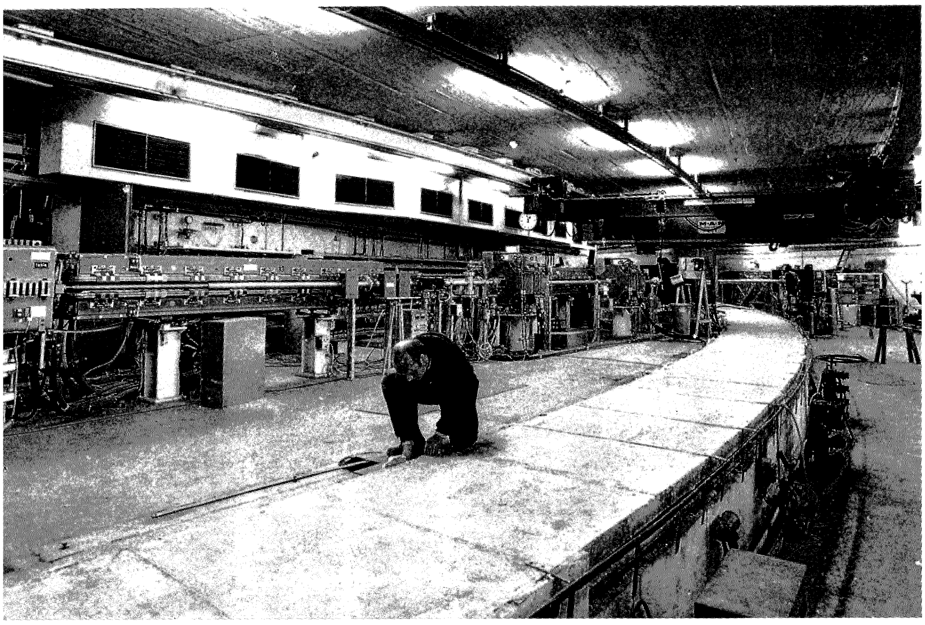
electron-positron collider at CERN, look towards particle beams.

To handle HERA's electrons, a new synchrotron, DESY II, has been built inside the ring long occupied by the original DESY I machine. DESY I ceased operations last November with the end of physics research at the PETRA electron-positron collider (see January/February issue, page 23), and was immediately dismantled.

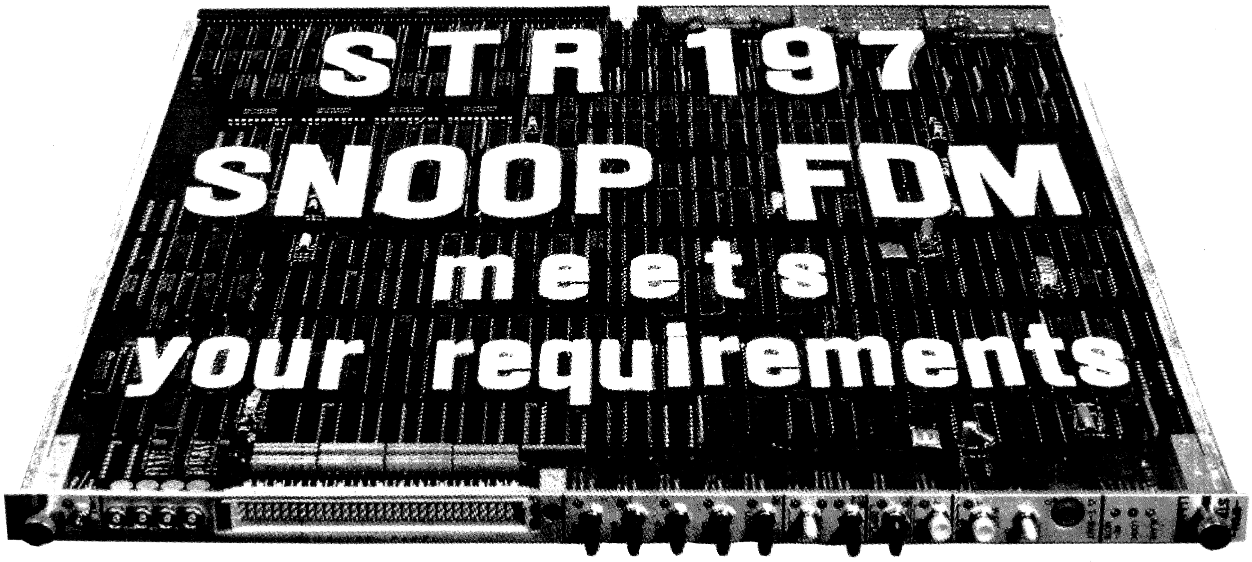
The new DESY II, unlike its predecessor, is a separated function machine, with distinct bending and focusing magnets, and is designed to take particles to about 8 GeV. A major task was to provide the new power supplies. After extensive tests at low magnet currents corresponding to about 1 GeV, DESY II was fully hooked up to these power supplies to deliver a healthy 7 GeV electron beam on 11 February.

Another new machine, DESY III, is to be built to handle HERA's protons, and will use some equipment from DESY I. Installation will begin next year. Meanwhile DESY's first proton beams (in the form of negative hydrogen ions) have passed the new radiofrequency quadrupole and attained 750 keV prior to negotiating the linac.

Protons and electrons from these new machines will be injected first into the PETRA ring, where protons from DESY III will be taken to 40 GeV ready for ejection towards HERA. While waiting for these protons, the proton transfer channels are being tested in the meantime with positrons.



The synchrotron tunnel at the German DESY Laboratory in Hamburg. In the background is the new DESY II machine to provide the electrons for the 6.3 kilometre HERA electron-positron collider ring now under construction. The empty space in the foreground will soon be occupied by the DESY III machine to supply HERA's protons.



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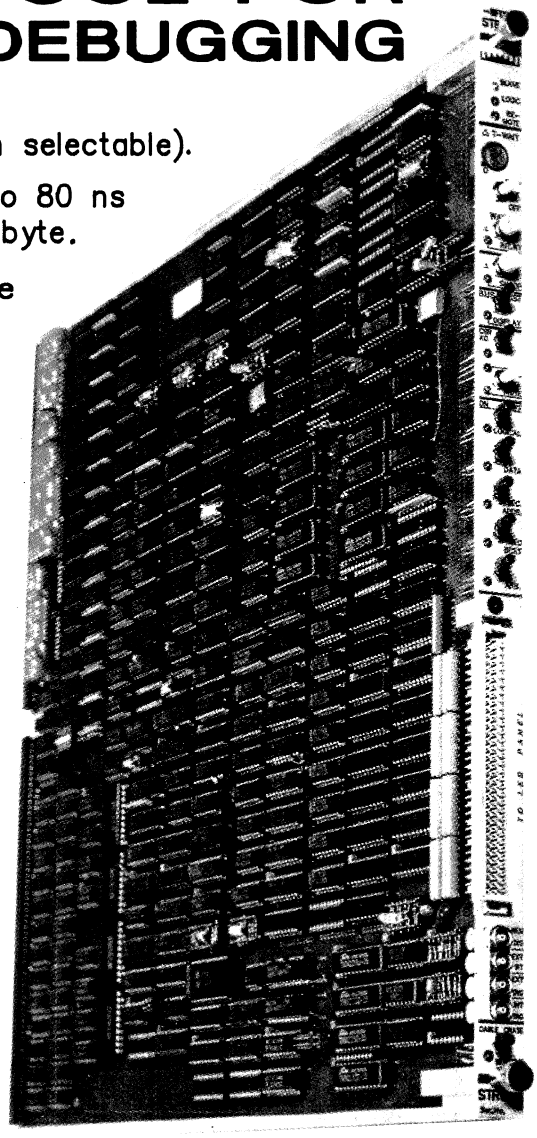

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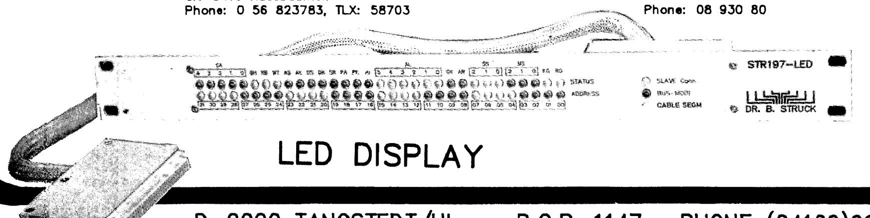

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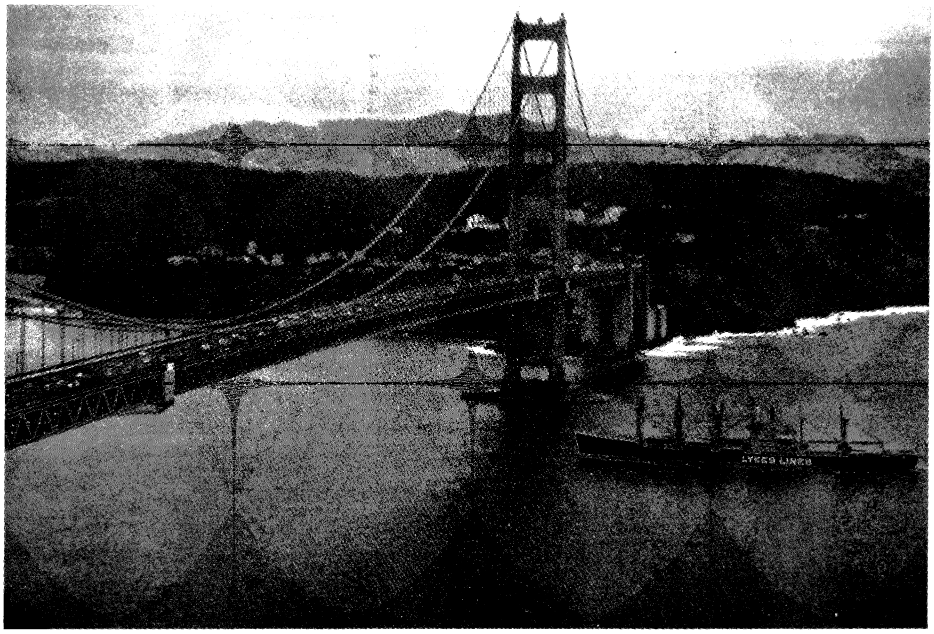
The ship Ruth Lykes sails under the Golden Gate Bridge carrying 2500 tons of steel frame and body for the Stanford Large Detector, eventually to take over from Mark II at the SLC Stanford Linear Collider now being prepared.

(Photo M. Breidenbach)



STANFORD
SLC excitement

Excitement at the Stanford Linear Accelerator Center (SLAC) is high these days. Hardly a week goes by without the achievement of some new goal in the commissioning of the new SLC Stanford Linear Collider.

A few weeks ago, a 47 GeV beam of electrons (sufficient to create Z particles when collided with positrons of similar energy) was taken through the entire north magnet arc to the beginning of the final focus area. The big linac is now running routinely at 47 GeV.

The south damping ring, running with electrons since reconstruction was completed last fall, has been converted for positrons, and particles have been stored. The commissioning schedule is now to extract positrons from the damping ring, accelerate them to 47 GeV and send them towards the interaction point through the south magnet arc. After that, electrons and positrons will be accelerated on the same linac pulse, and then collisions! The SLC physics programme is expected to begin by late spring or early summer.

Mark II gets ready

As preparations for colliding beams at the new Stanford Linear Collider (SLC) enter their final phase, the Mark II detector gets ready to intercept the first electron-positron collisions. The task of moving the big detector from its previous home at the nearby PEP electron-positron ring to the SLC Interaction Hall is now complete and all detector systems are functioning well. After calibration, Mark II will be ready to be moved into the beamline, a process expected to take about three weeks.

BROOKHAVEN
Heavy ion programme

In the search for new forms of nuclear matter under conditions of extreme temperature and density, interest has focused on the use of high energy nuclear beams. At CERN, physics began last year using 3200 GeV oxygen ions, and interesting hints are already emerging (see March issue, page 4). At Brookhaven, the 26-year old AGS Alternating Gradient Synchrotron took on a new role last year, supplying a 232 GeV oxygen ion beam to experiments.

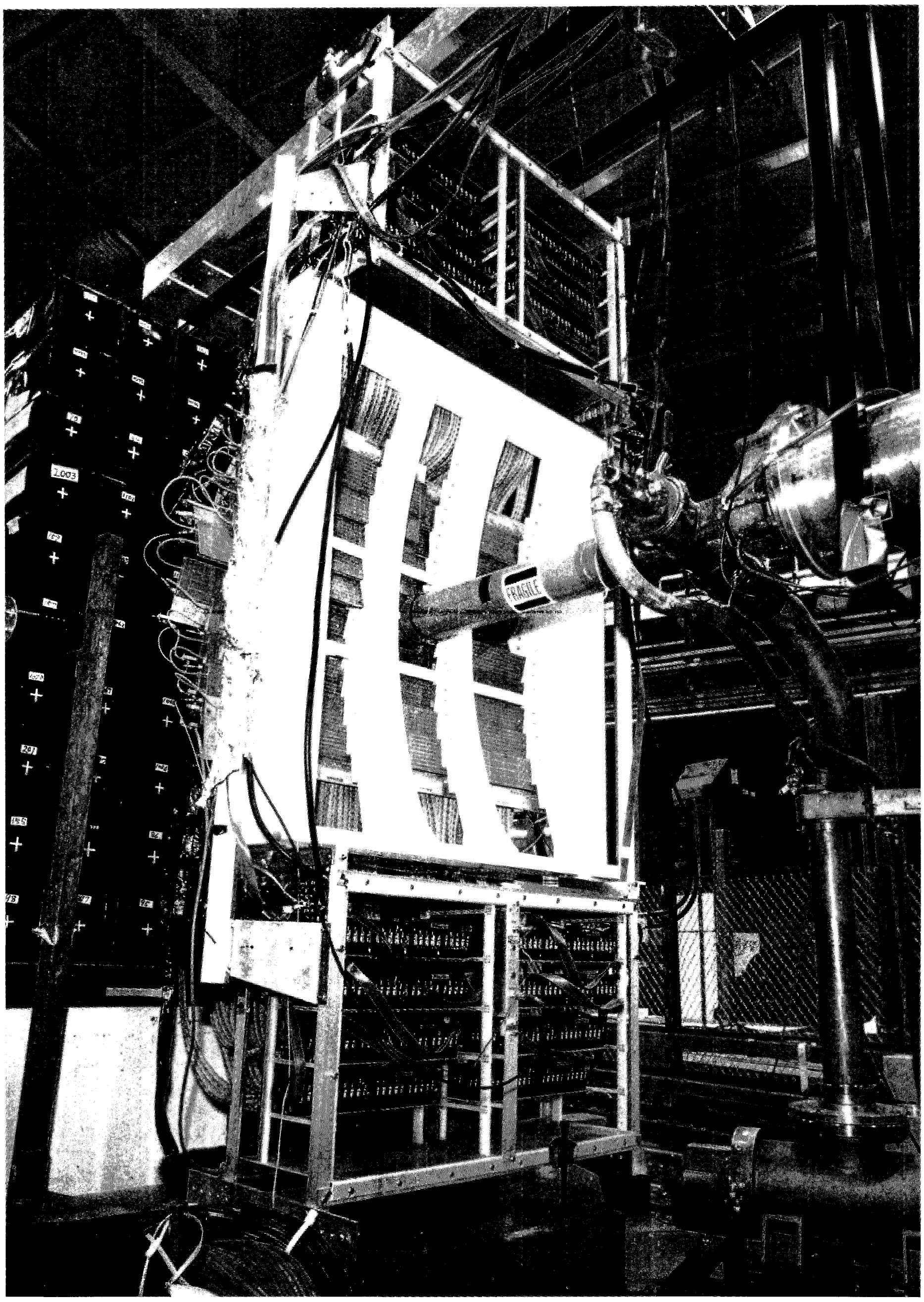
The experiments participating in this first physics run included over 130 scientists from 30 institutions and 10 countries. The run concluded in late November.

Ions with mass up to sulphur are available in the Tandem-AGS system at Brookhaven. A pulsed negative ion source provides a beam which is accelerated and stripped in several stages using the dual Tandems and delivered to the AGS via a 640 metre transfer line. The AGS accelerates the beam from approximately 7 MeV per nucleon to the full nominal momentum of 14.6 GeV per nucleon, when it is slowly extracted into the external beamlines, with up to four lines receiving beam simultaneously. Intensities exceed 10^9 ions per pulse.

Experiment 825, a collaboration of Oregon State, Berkeley, Brookhaven, Marburg, Oslo, Purdue and Studsvik, was the first experiment to utilize the beam. The experiment determines target fragment production levels and recoil properties by measuring the induced product activities by off-line gamma-ray spectroscopy techniques. Prelimi-

Provisional set-up used by an Argonne / Berkeley / Brookhaven / Columbia / Hiroshima / MIT / Riverside / Tokyo collaboration using the ion beam at the Brookhaven Alternating Gradient Synchrotron. In foreground is the multiplicity counter followed by a lead glass array. The target is in the beam pipe.

(Photo Brookhaven)



nary results indicate that the hypothesis of limiting fragmentation (the independence of fragment production rate with beam energy) and factorization (the assertion that the fragment properties can be described as a product of the projectile and target factors) are valid.

Five experiments used passive track detectors. Three of these exposed stacks of CR-39 plastic to study the highly charged projectile fragments. The other two exposed stacks of nuclear emulsions to study total event topologies. Another experiment searched for free quarks by confining the hadron shower from the nucleus-nucleus interactions in mercury and liquid argon.

The most extensive use of the beam was made by Experiment 802, an Argonne / Berkeley / Brookhaven / Columbia / Hiroshima / MIT / Riverside / Tokyo collaboration using a single arm spectrometer, a lead glass array, a target multiplicity counter and beam defining counters. The complete experiment is scheduled for the next heavy ion run but a temporary configuration provided useful information. Preliminary results hint that a major portion of the incoming beam energy is transferred into target excitation, and experimenters eagerly look forward to working with the full detector configuration.

For its Spring run the AGS is scheduled to provide sulphur beams in addition to oxygen and other possible ions. Several new experiments will join the fray, including the calorimeter-based Experiment 814, a collaboration of Brookhaven, CEBAF, CERN, Los Alamos, Michigan State, New Mexico, Pittsburgh, Stony Brook, Tel Aviv, Texas A & M, and Yale. The heavier ions should enable the experiments to explore higher temperatures and densities of nuclear matter, higher still once the booster project is complete, allowing acceleration of ions up to gold.

Accelerator physics

Use or development of particle accelerators is widespread at Brookhaven — the Alternating Gradient Synchrotron (AGS) Department, the Accelerator Development Department, the National Synchrotron Light Source (NSLS), the De-

With the first commercially assembled full-size magnet for the proposed RHIC Relativistic Heavy Ion Collider at Brookhaven are (left to right) Erich Willen, Carl Goodzeit, Eric Forsyth (Acting Head of the new RHIC Division), Harald Hahn (RHIC Technical Coordinator), Arthur Greene and Thomas Ludlam (RHIC Task Force Chairman).

(Photo Peter Horton)

partment of Nuclear Energy, the Physics Department and the Instrumentation Division are all involved.

Now a Center for Accelerator Physics has been established at the Laboratory, headed jointly by Robert Palmer and Claudio Pellegrini. Cutting across departmental lines, CAP will serve as a focus for accelerator physics and for educational programmes aimed at increasing the number of scientists working in the field.

It will also coordinate and promote research and development on new methods of acceleration and on coherent sources of electromagnetic radiation. To facilitate this work, a new Accelerator and Coherent Radiation Test Facility will be built, based at the NSLS. This will use an electron linac with a laser-driven photocathode gun to provide a 50 MeV beam with short pulse length and very low emittance. A high power CO_2 laser system will fire the photocathode and deliver picosecond pulses to the experimental station, synchronized to the arrival of the electron pulse. This linac and associated apparatus will be available for accelerator research for both local and outside groups.

A Brookhaven / Los Alamos / San Diego collaboration led by Palmer is planning to study a 'laser linac' using the picosecond pulse of 10-micron light from the CO_2 laser to drive a linac-like (but open) structure of correspondingly small dimensions. These very fine structures will be etched from silicon. The linac beam, about one micron in diameter, will pass through the structure just as the laser pulse arrives.

Other ideas to be tested include the switched power approach and its relative the microlasertron, and the inverse Cherenkov effect. In the first case, a fast laser pulse triggers a series of high voltage pulses in adjacent gaps between metal discs. The voltage is used either to accelerate electrons directly or to produce electromagnetic power with a chosen wavelength, which could then be used to drive a linac structure. Bill Willis at CERN is also investigating these possibilities.

In the inverse Cherenkov effect light incident at the Cherenkov angle upon a relativistic electron moving in a gas produces a net accelerating electric field. J. R. Fontana of Santa Barbara has been following up this idea.

The coherent radiation source development led by Pellegrini will investigate the use of laser light Compton scattered backwards from a head-on collision with the electron beam. For 50 MeV elec-

Nine-metre magnets

The arrival of the first of three commercially assembled magnets for the proposed Relativistic Heavy Ion Collider (RHIC) at Brookhaven coincided with the announcement of the formation of a RHIC Division. Acting Head is Eric Forsyth, Chairman of the Laboratory's Accelerator Development Department.

RHIC superconducting magnets would have to handle ions right across the periodic table at energies up to 100 GeV per nucleon per beam, requiring fields of about 3.5 T. Prototype 4.5 m units performed satisfactorily (see June 1986 issue, page 5). The latest prototypes are full length (9.7 metre) units assembled by Brown Boveri in Mannheim, West Germany, using coils wound at Brookhaven and some of the special tooling developed for the HERA electron-proton collider being built at the DESY Laboratory in Hamburg. A fourth 9.7 m magnet has been assembled at Brookhaven.

The increasing momentum behind development work for RHIC hardware boosts confidence that a suitable occupant will be found for the 4 km tunnel built several years ago.

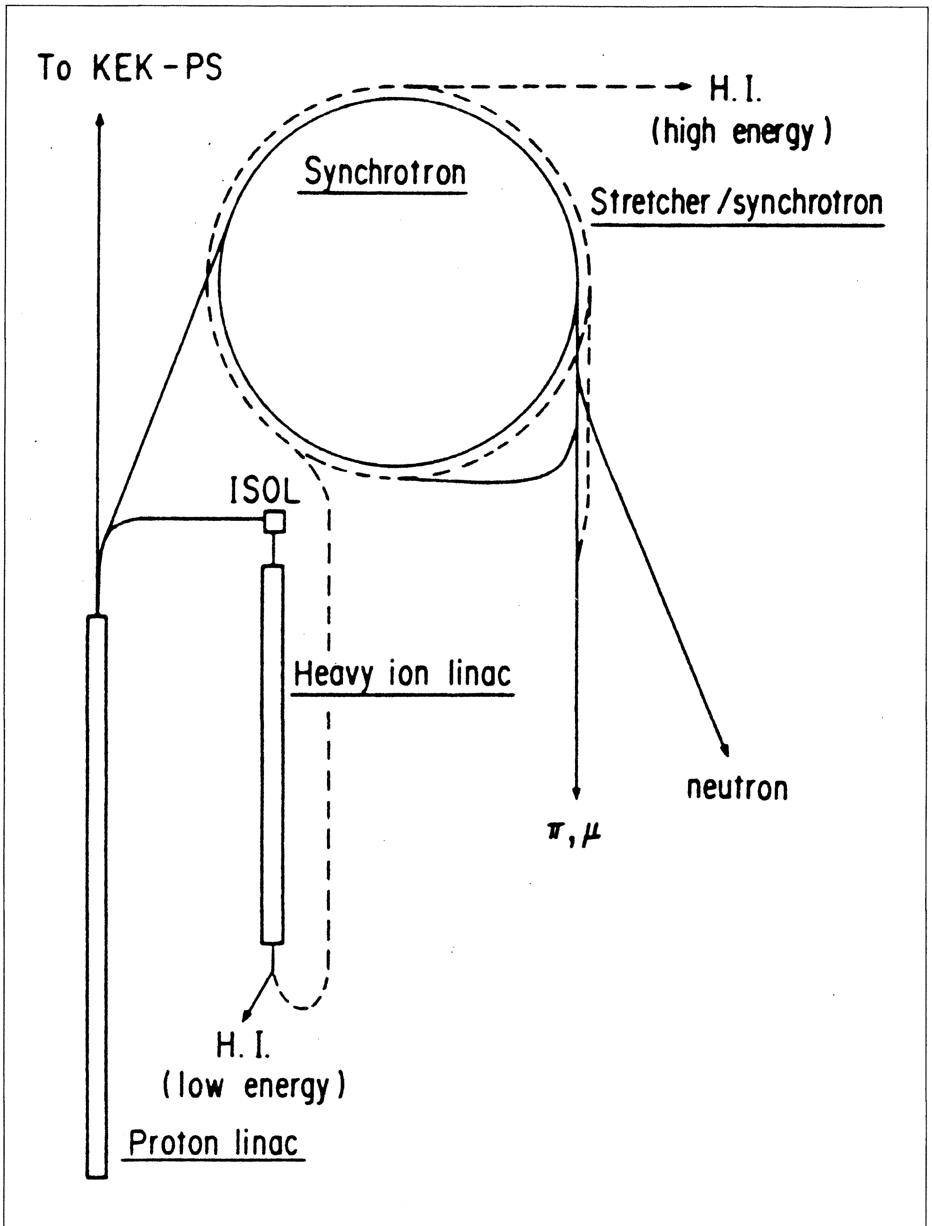
trons one expects an intense pulse of 5 keV X-rays to be emitted with very low emittance. Such a source could have useful applications in solid state physics and medicine.

Other experiments being studied and prepared by Pellegrini and co-workers are: free electron lasers in the micrometre wavelength region for the study of optical guiding and other physics aspects; an inverse free electron laser using the CO_2 laser and a wiggler magnet to raise the beam energy to several hundred MeV.

Kirk McDonald of Princeton is interested in using the facility to study non-linear quantum electrodynamics effects expected when an electron beam interacts with intense laser light. An example would be the absorption of several photons by an electron followed by the emission of a single photon with higher energy.

WORKSHOPS
Hadron facilities

Sketch of the proposed twin-ring Japanese Hadron Facility at the national KEK Laboratory, to provide beams of both hadrons and heavy ions (H.I.).



'Hadron facilities'—high intensity (typically a hundred microamps), medium energy (30-60 GeV) machines producing intense secondary beams of pions, kaons, etc., are being widely touted as a profitable research avenue to supplement what is learned through the thrust for higher and higher energies.

This interest was reflected at an International Workshop on Hadron Facility Technology, held in Santa Fe, New Mexico, from 2-5 February. As well as invited talks describing the various projects being pushed in the US, Europe and Japan, the meeting included working groups covering linacs, beam dynamics, hardware, radiofrequency, polarized beams and experimental facilities.

Los Alamos Meson Physics Facility (LAMPF) Director Gerald Garvey described the physics that these machines would open up. Our present understanding would be tested by searching for exotica and/or by looking for rare decays, forbidden according to contemporary ideas but, if found, indicative of new underlying physics.

This message was underlined by Lee Teng of Fermilab in his summary talk, showing how high precision measurements (anomalous muon magnetic moment, proton decay searches, symmetry violation, etc.) can and have contributed to physics progress.

The KAON project for the Canadian TRIUMF Laboratory, covered by Mike Craddock, is still in contention (see April 1986 issue, page

Meeting

'Pion-Nucleus Physics'—a meeting to examine and discuss future directions and new facilities at the Los Alamos Meson Physics Facility (LAMPF) will be held from 7-21 August at Los Alamos. Further information from Roberta Marinuzzi, LAMPF Liaison Office, MS H831, LANL, Los Alamos, NM 87545, USA.

20). Although national funding is not immediately forthcoming, there is some regional (British Columbia) support.

F. Bradamante of Trieste outlined the ideas behind the proposed European Hadron Facility (see July/August 1986 issue, page 13). Additional physics could come from neutrino beams, possibly intercepted in a big detector planned for the Italian Gran Sasso underground laboratory.

Interest in Japan is centred on a hybrid scheme for the national KEK Laboratory—a 2 GeV high intensity source with a supplementary proton stretcher ring/heavy ion synchrotron, explained Motohiro Kihara. With hadron beams, and with heavy ions up to 1 GeV/nucleon, this has some attractive physics possibilities.

Horst Foelsche described how Brookhaven's new Booster will increase proton intensities at the Alternating Gradient Synchrotron and allow more types of ion to be accelerated. For the proposed RHIC Relativistic Heavy Ion Collider (see page 21), there is physics interest in a wide range of energies, not just the upper limit.

The LAMPF II proposal for Los Alamos has foundered, regretted Arch Thiessen, and alternative ideas for an Advanced Hadron Facility have yet to crystallize. One new idea was for a superconducting pion linac.

A contribution from Yves Baconnier of CERN described experience gained at CERN's 28 GeV Proton Synchrotron, a veteran machine but at the same time a most modern one, thanks to continual upgrades. This experience suggests that high intensity hadron machines might not simply be scaled-up versions of existing machines, and could encounter new problems with radiation levels and with beam extraction.

As well as looking at dedicated hadron machines, the meeting also served as a forum for developments on fast cycling proton machines to provide neutrons through spallation. In this area too, new projects are afoot.

From Horst Schönauer

Neutrinos

About 80 neutrino afficionados attended a workshop at Brookhaven from 5-7 February to hear the latest experimental results and to discuss the future of this fascinating field of physics. Much attention centred on the search for neutrino oscillations, where neutrino types can interchange. Preliminary results were reported from two new experiments carried out at the Brookhaven Alternating Gradient Synchrotron (AGS) in the past year. Both see tantalizing hints that there may be oscillations between electron-type and muon-type neutrinos.

A Columbia / Illinois / Johns Hopkins collaboration sees an excess of electrons produced by a

Brookhaven Neutrino Workshop Organizing Committee - standing Wonyong Lee (Columbia, left) and François Vannucci (Paris and Boston) with Brookhaven members (seated, left to right) Michael Murtagh, Katherine Einfeldt and Alan Carroll.

(Photo Mort Rosen)

Accelerator Physicists

The Lawrence Berkeley Laboratory will shortly enter the construction phase of the 1-2 GeV Synchrotron Radiation Source Project. The source consists of a 1-2 GeV electron storage ring fed by a 1.5 GeV synchrotron and a 50 MeV linac. We invite applications for 2 positions within the Accelerator System Group for:

Staff Scientist II

The incumbent will assist in finalizing the parameters of the various components of the 1-2 GeV Synchrotron Radiation Source. Will participate in all aspects of Source commissioning and will play an active role in developing the Source to its fullest potential.

The successful candidate must have demonstrated experience in accelerator physics and have a proven track record in design or utilization of circular or linear accelerators. Must have specific experience in one or more of the following fields: rf design, magnet design, diagnostics, linear dynamics, control systems, feedback systems. Prefer a PhD in Physics.

Staff Scientist III

Reporting to the Head of the Accelerator Systems Group, the incumbent will bear primary responsibility for defining the detailed specifications of the storage ring for the 1-2 GeV Synchrotron Radiation Source. Will lead integration of the subsystems of the light source. Will play a lead role in the commissioning of the source. Will provide technical direction and supervision to project staff.

The successful candidate will be an experienced Accelerator Physicist, with proven expertise in the design and commissioning of electron storage rings or electron synchrotrons. Will have particular experience in at least one of the following fields: rf (design, coupled bunch instabilities), magnet design, diagnostics, control systems, feedback systems.

To apply, send 2 copies of curriculum vitae, representative publications and the names and addresses of three references to: Lawrence Berkeley Laboratory, #1 Cyclotron Road, Employment Office 90-1042, Berkeley, CA 94720. Refer to Job #A/4091 for Staff Scientist II and Job #A/4090 for Staff Scientist III. An Equal Opportunity Employer. M/F/H.

LAWRENCE BERKELEY LABORATORY

narrow band beam of muon neutrinos hitting a 250-ton detector 1 kilometre from the neutrino production target. About 17 more electron events were observed than expected from electron neutrino contamination in the beam and from backgrounds, principally due to neutral pions. Although further work on the error analysis is needed, confidence in the effect is mounting.

A Boston / Brookhaven / CERN / Paris collaboration brought to the AGS a detector previously used in the low energy neutrino beam at CERN, where it reported signs of an excess of electron events. When the CERN low energy neutrino programme finished, the experiment moved to the AGS, and the results now seem to confirm the initial finding. This 10-ton detector aims for a clean separation of electron showers connected and disconnected from the interaction vertex (the latter type would be expected from background). Using the wide band beam with its higher neutrino flux, an excess of 35 electrons were seen, which again boosts confidence.

Earlier results from experiments at CERN (BEBC bubble chamber) and at Brookhaven were also reviewed. These found no evidence for oscillations and gave limits on the parameters involved which exclude the new results.

Frank Merritt of Chicago summarized, saying that while the present experiments were unlikely to prove the existence of oscillations, the effects were not likely to go away either. Physicists now want to look for a variation in the electron event signal with the distance from the neutrino source. A two detector experiment would be a major step in this direction.

The participants were not without ideas along these lines, proposing that a second detector could be built further away but still inside the Brookhaven fence, floated in Long Island Sound, or established even further afield.

What breaks the symmetry of the weak and electromagnetic forces?

Though highly successful, the unified theory of weak and electromagnetic forces is incomplete in one crucial respect: we do not know the exact mechanism that breaks the symmetry between the two forces. In searching for it we are searching for a new fundamental force of nature and for new forms of matter associated with it.

The unification of the electromagnetic force and the weak nuclear force is one of the great achievements of contemporary physics. It was accomplished by the discovery of a symmetry which relates the two forces to one another, allowing us to view them as different manifestations of a single unified force. The unified theory was dramatically confirmed by the discovery at CERN in 1983 of the W and Z particles as predicted by the theory.

Despite this success, a very fundamental aspect of the theory is not yet understood. The photon, which 'carries' or mediates the electromagnetic force, has no mass. If the symmetry of the unified theory were exact, the W and Z particles, which carry the weak force, would also be massless. In fact the very large W and Z masses, roughly 100 times heavier than a hydrogen atom, are responsible for profound differences in the electromagnetic and weak forces. The W and Z masses show that the symmetry of the unified theory is not perfect but is rather 'broken' or approximate. To complete the unified theory we need to find the symmetry-breaking mechanism.

For the theory to be calculable, we know that the symmetry-breaking mechanism must be 'spontaneous', a technical term referring to systems whose forces are perfectly symmetric but have a preferred state of lowest energy which is not symmetric. An ordinary iron magnet is an example: though the fundamental laws of magnetism are spatially symmetric so that the magnetic force could equally well point in any direction, the magnet settles into a state of lowest energy in which all its magnetic subcomponents are aligned along a particular (though arbitrary) direction. The symmetry is broken by a direction selected 'spontaneously' by the state of lowest energy from among all the equally likely possible directions.

In the unified theory the symmetry is not spatial but is rather abstract, relating the photon to the W and Z. But in this case we do not even know the force, analogous to magnetism in the example above, that induces the state of lowest energy to select a symmetry-breaking 'direction'. In searching for the symmetry-breaking mechanism we are searching for a new force and for the particles which carry it. The search is very difficult since we know neither the mass of the new particle(s) nor the strength of the force they carry.

Searching for the symmetry-

BATES LINEAR ACCELERATOR CENTER

The **Spectrometer Systems Group** invites applications for staff physicist positions. The primary responsibility lies in maintaining and upgrading the large magnetic spectrometers used in single-arm and coincidence studies of electro- and photo-induced reactions on nuclei at intermediate energy. Additional responsibilities include advising and assisting experimenters, preparing adequate documentation, participating in target development, and helping to develop new detector systems, particularly those suitable for experiments with 1 GeV CW and polarized electron beams; development of a solid knowledge of electronic instrumentation and micro computers will be required. It is expected that members of the Spectrometer Systems Group participate actively in the research program. Candidates should have a Ph.D. in physics and several years' applicable experience. Job# R87-193.

The **Computer Group** invites applications for a staff position as Data Acquisition Systems Physicist. The primary responsibility lies in maintaining and extending data acquisition system hardware and software using CAMAC interfacing on micro-VAX computers. This will include testing and maintaining currently supported systems, consulting with and assisting experimentalists, and isolating and repairing faults. A background in experimental physics, an ability to work with users, and communication skills are essential. Job # R87-194.

Applicants for either position, please send two copies of resume to Mr. Richard Adams, c/o the MIT Personnel Office, E19-239, 77 Massachusetts Avenue, Cambridge, MA02139. Please refer to the appropriate job number.

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RESEARCH ASSOCIATE POSITIONS AT YALE UNIVERSITY

Applications are invited for Research Associate positions in Particle Physics at Yale University. Recently a major new experiment to measure precisely the anomalous g-value of the muon has been approved at Brookhaven National Laboratory, and one position will involve principally work at BNL (with a Guest Appointment at Brookhaven) to develop this experiment. Some part-time opportunity may be available for participation in other experiments in muon physics, if desired. A strong background in experimental particle physics or accelerator physics is required. A second position is available for muon physics experiments at the Los Alamos Meson Physics Facility. Salary dependent on experience of candidate.

Appointments are for two years, renewable. Appointments to be made at earliest possible date. Interested candidates should send a curriculum vitae and publication list and arrange to have three recommendation letters sent to:

Professor Vernon W. Hughes,
Chairman of Search Committee,
Department of Physics,
Yale University,
P.O. Box 6666,
New Haven, Connecticut 06511.

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UNIVERSITY OF TORONTO

The Department of Physics plans to make

several tenure-stream appointments

in the next few years, of which at least one will be in Experimental High Energy Physics.

In anticipation, the Department invites applications for this position from qualified candidates for NSERC University Research Fellowships, which could begin July 1, 1988. NSERC University Research Fellows must be Canadian citizens or permanent residents. Fellows carry out research, supervise graduate students and have teaching loads comparable to starting assistant professors.

Successful candidates may in special circumstances be considered directly for a tenure-stream position as assistant professors.

Applications, consisting of a CV, list of publications, summary of research interests, a detailed research proposal, and the names of three (3) referees should be sent before June 1, 1987 to:

Professor R.E. Azuma
Chairman, Department of Physics
University of Toronto
Toronto, Ontario, Canada M5S 1A7.

EXPERIMENTAL HIGH ENERGY PHYSICS

The Department of Physics at Indiana University invites applications for a tenure-track faculty position in experimental high-energy physics.

The appointment is authorized at the assistant professor level, but the position may be upgraded to associate professor for a person with outstanding accomplishments.

The high-energy physics group has an active program in accelerator-based experiments at SLAC (SLC: MARK-II and polarized beams), Fermilab (DO and E672) and Brookhaven (search for glueballs and hybrid states).

To apply please send a complete vita, a description of research interests and accomplishments, a list of publications and a minimum of three letters of reference to:

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Applications should be received by **April 15, 1987.**

Indiana University is an Equal Opportunity/Affirmative Action Employer.

An error was made in last month's advertisement. This position is not associated with the Indiana University Cyclotron Facility.

breaking force and particles will be a principal goal of the next generation of particle accelerators currently under construction or proposed for the next decade. Two big electron-positron colliders, the SLC (Stanford Linear Collider) scheduled to begin operation this year, and LEP at CERN, which will begin operation in 1989, will be able to search for a possible symmetry-breaking particle called the 'Higgs boson' provided it is not heavier than about half the mass of the W particle.

The Tevatron proton-proton collider now in action at Fermilab provides the highest collision energies in the world and will search for 'supersymmetric' particles which could generate the lowest energy symmetry-breaking state inducing the W and Z masses.

One of the attractions of still higher energy projects such as the US Superconducting Supercollider, SSC, or a proton collider in the LEP tunnel at CERN, providing collision energies many times that of the Tevatron, is that the symmetry-breaking mechanism, whatever it might be, is more likely to show itself. Even if the new particles are too heavy to be produced directly, they should betray their presence by inducing an abnormally large number of collision products containing pairs of W and Z particles. If the new particles are not so heavy, the abnormal W and Z pair products will not be seen, but instead the new particles will themselves be copiously produced and could be studied in detail.

From a paper by Michael Chanowitz of Berkeley presented at the recent meeting of the American Physical Society and the American Association of Physics Teachers in San Francisco.

People and things

A tribute to Louis de Broglie, who died in March, will appear in our next issue.

On people

Yuri Orlov has joined Cornell as Senior Research Scientist. His research interests there include accelerator theory (nonlinear dynamics) and the application of quantum mechanics methods to the study of human perception and psychology.

Ernst Wilhelm Otten of Mainz receives the Genter-Kastler Prize awarded by the Société Française de Physique and the Deutsche Physikalische Gesellschaft. The award was established in 1986 and went first to Edouard Brezin of Saclay for his work on phase transitions. Otten is thus the first German to receive the award. His scientific work centres on the study of nuclear properties through atomic hyperfine structure measurements using sophisticated techniques. Much of this has been carried out at the ISOLDE on-line isotope separator at CERN.

The Wigner Medal for 'outstanding contributions to the understanding of physics through group theory' goes to Feza Gürsey of Yale for 'his essential role in the discoveries of symmetries in particle physics'.

Retiring from CERN is emulsion specialist Guy Vanderhaege. When he arrived from Brussels some thirty years ago, emulsions were one of the major methods used in particle physics. Over the years, detector fashions have come and gone. Apart from a spell in administration, he has always remained an enthusiastic proponent of emulsion experiments, and has played a vital role in coordinating the CERN emulsion programme.

Paul Matthews 1919-1987

Wheels turn in circles, and emulsion experiments now make up one of the largest user groups for the new high energy ion beams at CERN.

Paul Matthews

British theoretician Paul Matthews died after a road accident in February. Maturing in the heady days of modern field theory in the 1950s, he made many important contributions to its development. After work at Princeton, Cambridge, Birmingham and Rochester, he developed, with Abdus Salam, an influential theory school at London's Imperial College. At CERN, he was a member of the Scientific Policy Committee from 1972-77. An outstanding teacher and far-sighted administrator who also found time to write several books, he chose after his retirement to return to Cambridge, quietly to pursue physics.

George H. Vineyard

George H. Vineyard, former Director of Brookhaven National Laboratory and President-elect of the American Physical Society, died in February. During his period as Brookhaven's Director from 1973-1981, the Laboratory pursued a strong programme in basic research and, in response to national needs, considerably increased its applied research, particularly in the energy area. Also during his tenure, the National Synchrotron Light Source, the world's most powerful source of X-rays and ultraviolet light, was developed and constructed. He resigned as Laboratory Director to return to full-time research in theoretical solid state physics.

CEBAF progress

On Friday February 13, bulldozers began clearing a 200 acre (80 hectare) site at Newport News, Virginia, for the proposed US Continuous Electron Beam Accelerator Facility (CEBAF) to provide high energy electron beams for nuclear physics. Some 16 million dollars of construction funding is available this fiscal year, but the main construction budget request of 33.5 million dollars is still in the pipeline.

A status report on the project and plans for the scientific programme will be discussed at the 1987 CEBAF Summer Workshop from 22-26 June. This will also include the annual users group meeting.

Meetings

The XI International Workshop on Weak Interactions will be held in Santa Fe, New Mexico, from 14-19 June. Discussion sessions covering current topics in weak interaction physics will allow active participation by workshop attendees. Both accelerator- and non-accelerator-based research will be on the agenda. For information contact G. J. Stephenson, MS D434, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA.

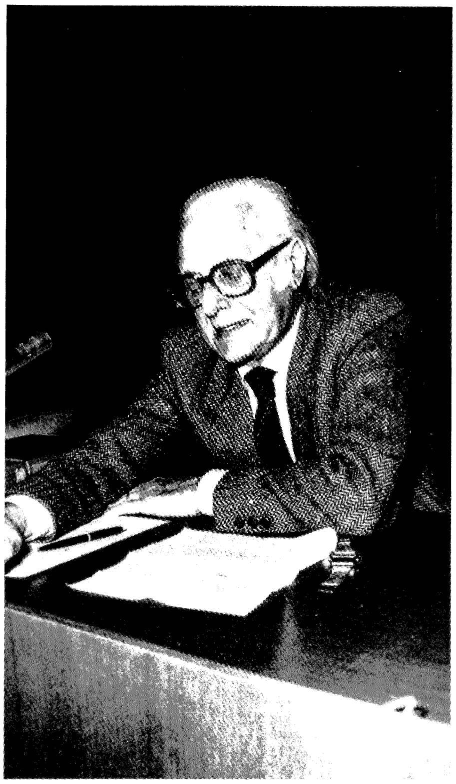
Workshop on SSC experiments

The Division of Particles and Fields of the American Physical Society and the Central Design Group of the proposed US SSC Superconducting Supercollider are organizing a Workshop on Experiments, Detectors and Experimental Areas for the SSC, to be held at Berkeley from 7-17 July. The primary goals are to explore the SSC's experimental possibilities and their impact on the machine parameters. There will be four large working groups — covering high, intermediate and low transverse momentum physics, and exotic particle searches. Further information from the Workshop Secretary, Lawrence Berkeley Laboratory, , 50B-2270, 1 Cyclotron Road, Berkeley CA 94720, USA.

Group photograph of Fermilab Users Executive Committee members. Standing (left to right): Phyllis Hale (Fermilab), Daniel Green (Fermilab), Anna Jean Slaughter (Yale), Thompson Burnett (Washington), Bruce Winstein (Chicago), David Buchholz (Northwestern), Majorie Shapiro (Harvard), Neville Reay (Ohio) and James Wiss (Illinois). Seated are Hugh Montgomery (Fermilab, Secretary), Tom Ferbel (Rochester, Chairman) and Melissa Franklin (Illinois). Not on the photograph are overseas members Rosanne Cester (Turin) and Angelo Scribano (INFN, Pisa).

(Photo Fermilab)

Edoardo Amaldi — learning from history.



Going down in history

Among the CERN pioneers present at the small ceremony to launch publication of the first volume of CERN's History (see March issue, page 27) was Edoardo Amaldi. With characteristic perceptiveness, he commented that he had learned much from the book about what had been going on around him in those early days, adding that he was glad he hadn't known at the time, otherwise he could never have carried on! After suspecting that only those with good secretaries leave enough archive material to interest historians, he recalled some of the events of the early days which the historians had missed. According to Amaldi, much of the 'CERN spirit' derived from regular frequentation of a small Paris bistro near UNESCO headquarters.

Supernova neutrinos

As southern hemisphere astronomers witnessed a gigantic supernova explosion towards the end of February, underground neutrino detectors all over the world picked up bursts of particles. Details in next issue.

At CERN, Herbert Lengeler (back to camera) introduces Federal German Research and Technology Minister Heinz Riesenhuber (left) to superconducting cavities such as will be used to take the energy of LEP's electron and positron beams towards 100 GeV. Looking on is CERN Director General Herwig Schopper.

(Photo CERN 851.2.87)

CERN Courier tops 20 000

In February, the total monthly circulation of the CERN Courier topped the 20 000 mark (English edition more than 14 000 copies, French edition more than 6 000). The circulation has risen steadily over the years, but heavy demand for copies in recent months has pushed the figure up faster. Distribution centres are listed on page III.

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