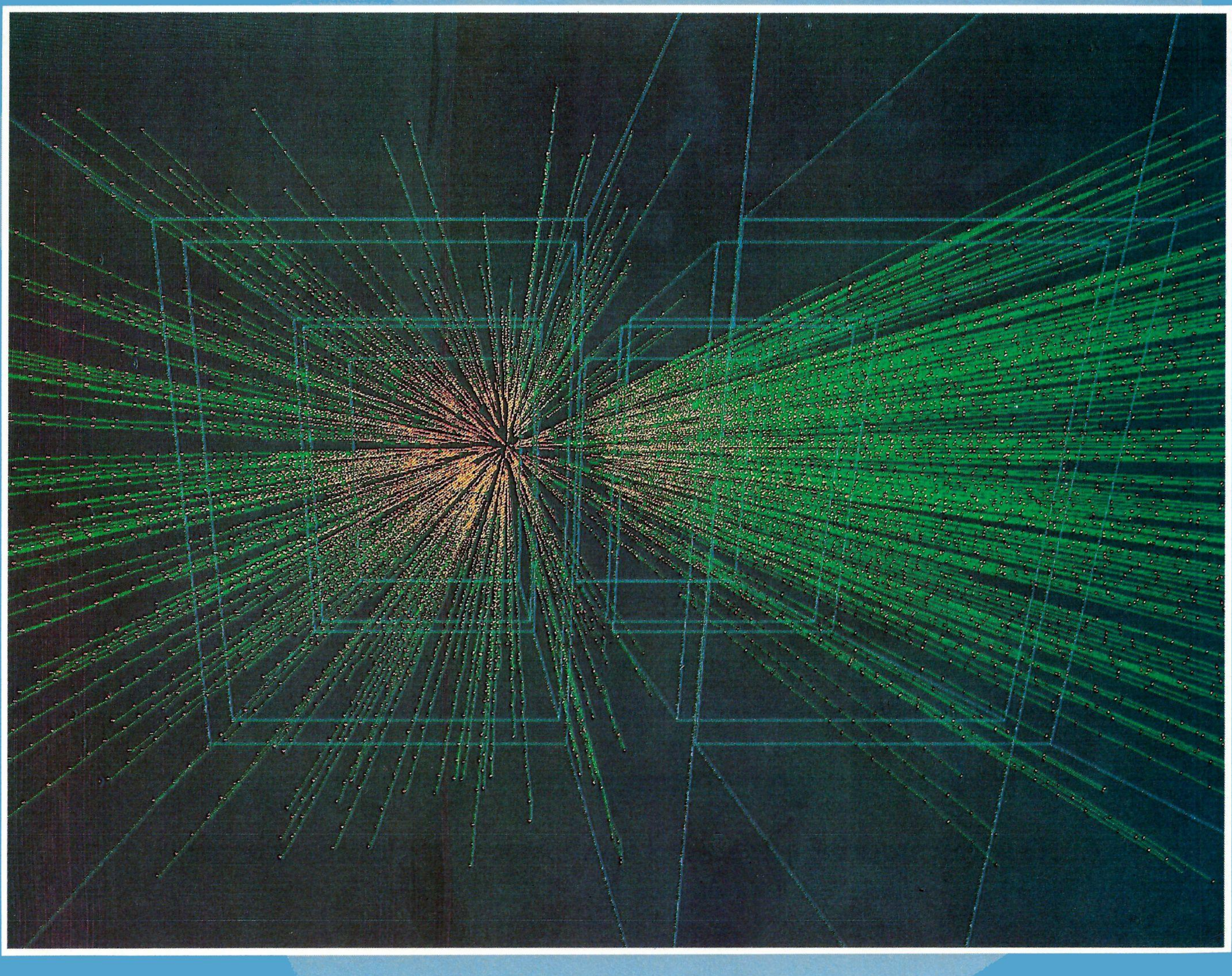
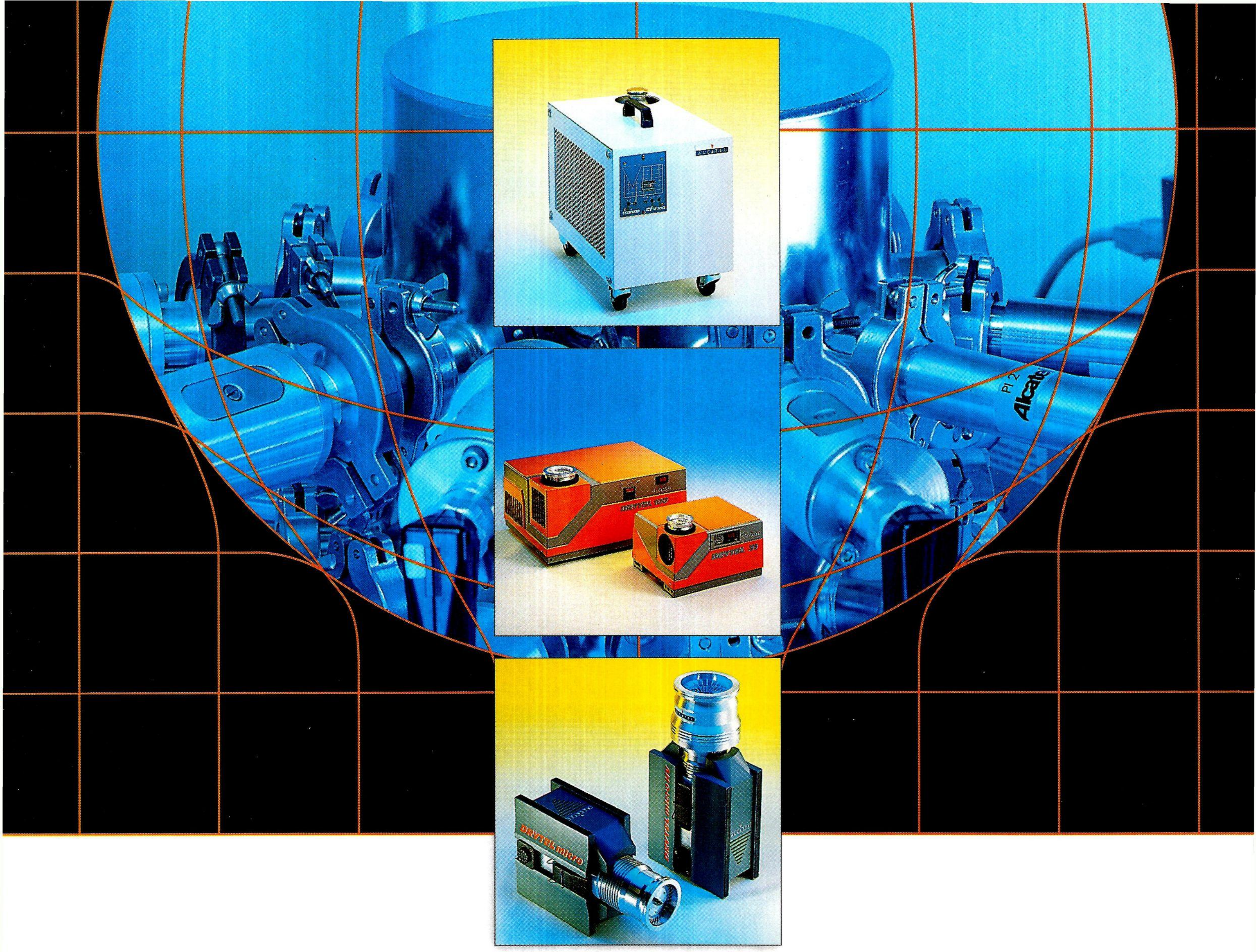
CERN COURIER

INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

VOLUME 35 | 1 | JANUARY / FEBRUARY 1995





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EUROCOM QUARTET Annecy - ALA422 - 04/94

Distributed to Member State governments, institutes and laboratories affiliated with CERN, and to their personnel.

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CERN COURIER is published monthly except January and August in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

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USA: Controlled Circulation
Second class postage paid at Batavia, Illinois

ISSN 0304-288X

Volume 35
No. 1
January/February 1995

Covering current developments in high energy physics and related fields worldwide

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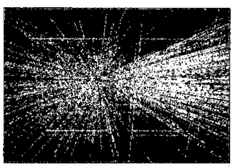

Cover photograph: How the world's highest energies look. At the end of 1994, CERN supplied lead nuclei, accelerated to about 160 GeV per nucleon, representing over 30 TeV of beam energy for each nucleus, to a range of experiments. This shows what happens when lead meets lead in the Time Projection Chamber of the NA49 experiment. With the quest to recreate the quark-gluon plasma which permeated the early hot Universe, definitive results from all these experiments are eagerly awaited.

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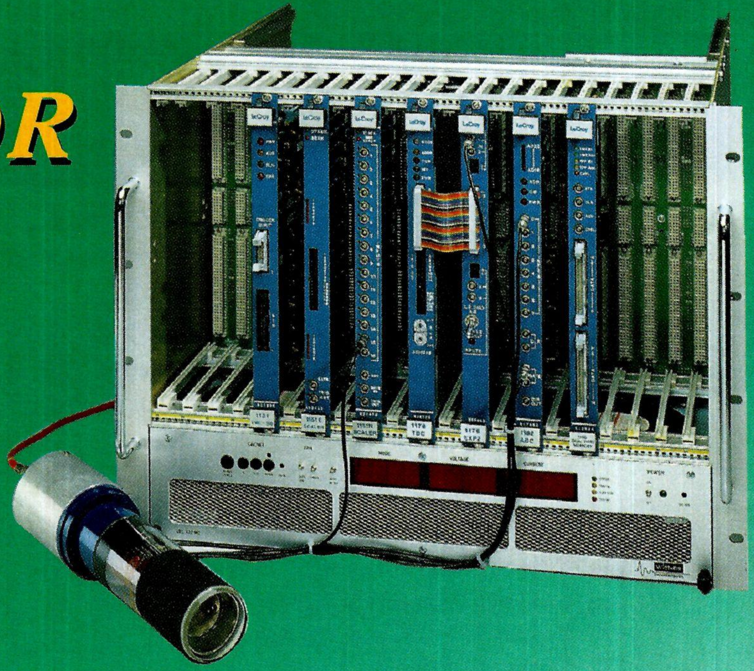

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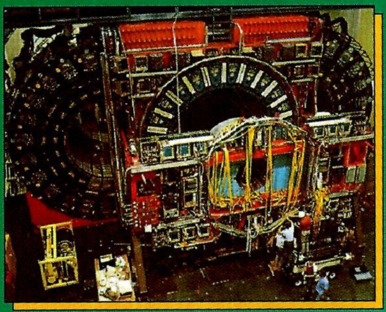
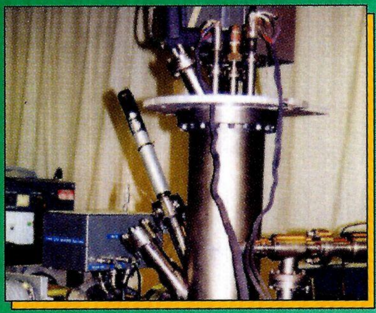


High Energy Physics
courtesy of Fermi National Laboratory.



Time-of-Flight Spectroscopy,
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LeCroy

Innovators in Instrumentation

The ultimate birthday present

Pride, happiness and relief at LHC approval - left to right CERN's Research Director Lorenzo Foa, LHC project Leader Lyn Evans and Director General Chris Llewellyn Smith.

In the final administrative hours of CERN's eventful 40th anniversary year came the unanimous approval on 16 December by CERN's governing body, Council, for the construction of the 14 TeV LHC collider in the 27-kilometre LEP tunnel. After the decision had hung in the balance until the last possible moment, CERN received the best 40th birthday present it could have wished for - a unique machine which will provide a world focus for basic physics research. Far from being relegated to a less productive middle age, CERN is now assured of a bright future.

To allow LHC to be built within a tightly constrained budget contributed by CERN's 19 Member States, the new accelerator will be built in two stages - the first aiming to reach two-thirds of the ultimate collision energy of 14 TeV (7 TeV per beam) and to start experiments in 2004.

Collision energies of 9-10 TeV would open up a research programme with both proton and with heavy ion beams.

In this way the LHC would provide valuable 'front porch' physics before receiving its full complement of superconducting magnets to increase its energy to 14 TeV by 2008. It is only at this energy that the full potential of the physics is realized - probing the behaviour of the quarks and gluons inside the colliding particles in the TeV energy range to open up the mysterious electroweak symmetry breaking ('higgs') mechanism.

This mechanism lies at the heart of the all-embracing Standard Model which so impressively describes today's physics. Impressive as it is, the Standard Model has a long list of quantities which cannot be predicted and can only be measured in experiment.

Until the higgs mechanism is explored, the Standard Model will be powerless to explain many physics features, notably the wide differences in mass scale between the three pairs of quarks and three pairs of leptons from which all known particles are made.

After the December Council meeting, CERN's proud Director General Chris Llewellyn Smith said 'The decision is a major step for the future of high energy physics and CERN. Council's decision represents a 20-year commitment to high energy physics research. I believe this to be a unique commitment to fundamental scientific research and I am honoured by this vote of confidence. We can now proceed with the challenging task of building the LHC and, with the continued support of CERN's outstanding staff, the Organization can look forward to taking further important steps in the understanding of matter. We hope to welcome friends from other countries to participate in the LHC, not only for financial participation but even more for their very important intellectual contributions. The decision has assured a great future for world particle physics and for CERN.'

With CERN already a major world focus for basic physics, several non-Member States - including the USA, Japan, Canada, the Russian Federation, India and Israel - have expressed interest in participating in the LHC programme.

This interest is backed up by resources and know-how, and many of these countries had indicated a willingness in principle to join the LHC effort. However no firm commitments could be given before the project had been approved by CERN Council itself.

The December Council meeting decided on a comprehensive review of LHC progress before the end of 1997. If this reveals that sufficient additional LHC support is forthcoming from non-Member States, then the two-stage plan could be abandoned and the project could revert to its original direct route to 14 TeV.

At the Council meeting, observers from the US and Japan immediately welcomed the decision and indicated that negotiations towards new cooperation with CERN can begin.

However the decision was not taken lightly. In these cost-conscious times, previous attempts to push through LHC approval had run up against difficulties. In particular the June 1994 Council session (September, page 8) saw 17 Member States voting in favour of LHC, with Germany and the UK insisting on special LHC contributions from the Laboratory's two host states, France and Switzerland.

The unanimous vote emerging from the December meeting was contingent on Member States' contributions to the CERN budget (918 million Swiss francs for 1995) being frozen until 1997. Planing will envisage an annual inflation rate of 2% and that Member State contributions will be indexed by 1% from 1998.

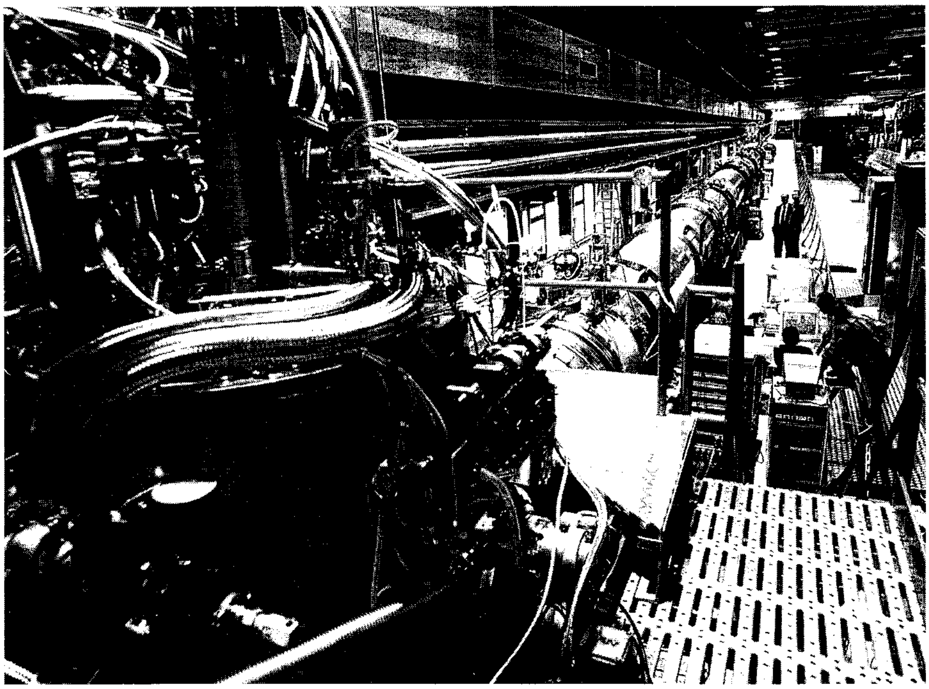
As host states, France and Switzerland will be liable to a 2% indexation. Together they will ensure additional support amounting to some 200 million Swiss francs.

Missing magnet option

LHC's full 14 TeV energy requires 1232 superconducting dipole magnets to bend the beams, 1104 of them arranged in triplets (half-cells) around the ring. The intermediate two-thirds energy option would use a 'missing magnet' configuration, with only two bending magnets in each half-cell, the central position remaining as an empty cryostat.

Installing only two-thirds of the big dipoles obviously makes for initial cost saving, but this would have to be offset against the effort in eventually replacing empty cryostats by the missing dipoles. In the missing magnet scenario, the installed magnets have to be specially aligned (the beam still has to be steered round a full circle) and subsequently realigned for the full magnet complement.

This option is very reminiscent of the missing magnet scheme proposed to facilitate the building of CERN's '300 GeV' proton synchrotron project in the late 1960s. This project went on to become the SPS, commissioned as a 400 GeV machine in 1976, with the lower energy option unused.



This 35-metre string of LHC prototype superconducting magnets ran for 24 hours at 8.36 tesla, the magnetic field required to hold LHC's 7 TeV protons in orbit round the 27-kilometre ring.

Magnet progress

Underlining the already advanced state of LHC development work, on 6-7 December a 35-metre string of powerful LHC prototype superconducting magnets ran for 24 hours at 8.36 tesla, the magnetic field required to hold LHC's 7 TeV protons in orbit round the 27-kilometre ring.

LHC magnet research and development work began in 1986, and has been marked by a series of high field achievements with successively more sophisticated prototypes. The latest success set the scene for the Council decision.

LHC's superconducting bending magnets, now planned to be 14.2 metres long, will operate at a field of 8.36 tesla, the highest ever used in an accelerator. This will be achieved by cryogenics working at superfluid helium temperature, 1.8K. The manufacture of so many magnets to operate reliably is a major challenge for both magnet designers and for industry.

In preparation for the test, the string (two dipole bending magnets together with a quadrupole of the type needed to focus the LHC beams) first briefly attained the 12,350. A current corresponding to the 8.36 T magnetic field. A second test repeated the achievement, with the current holding steady for 24 hours before being

raised to a level corresponding to just above 8.9 T.

The LHC design is under constant review to optimize cost and performance. The beam bending power has been increased by packing in more magnets, lengthening both the individual magnets and the modules into which they are fitted. The latest version has 23 cell modules to each machine octant, with each half-cell consisting of three 14.2 metre dipoles, one 3 m quadrupole and accompanying corrector magnets.

As a result, the nominal 7 TeV beam energy operating level has been lowered from 8.65 to 8.36 T, providing a useful operating margin. At the maximum dipole field of 9T, beam energy is boosted from 7.28 to 7.53 TeV.

The longer dipoles are considered close to the reasonable maximum for installation purposes, although still a few metres shorter than those which had been considered and prototyped for the ill-fated US Superconducting Supercollider (SSC) project.

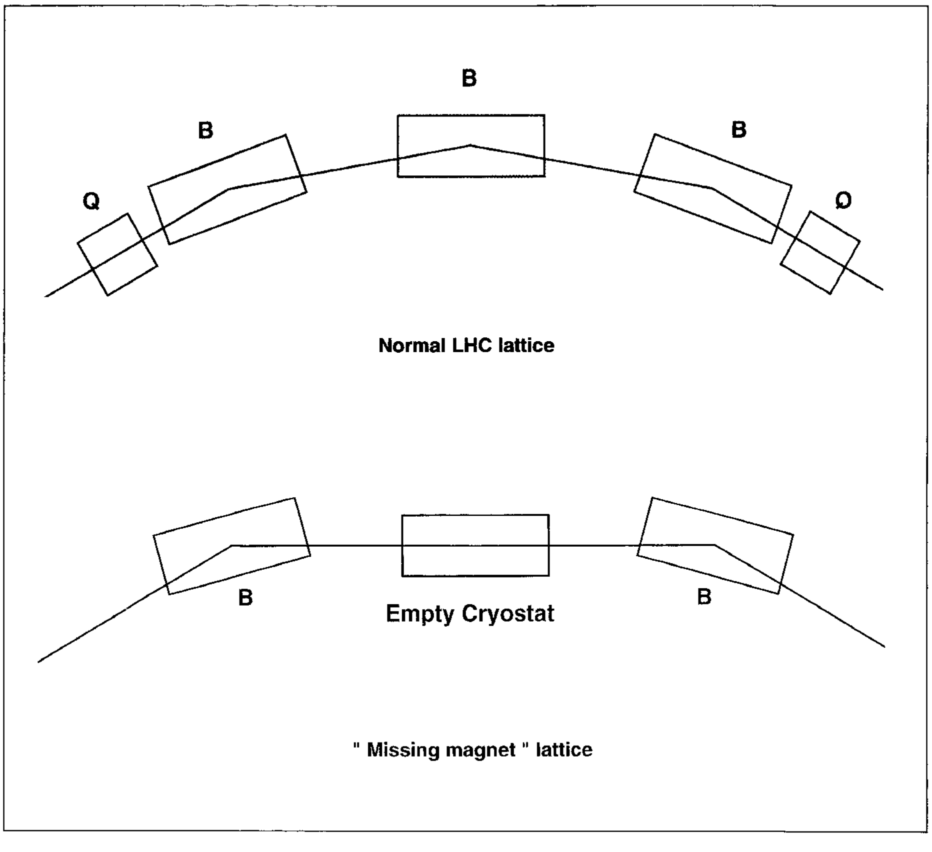
Other design changes include a revised injection scheme from the neighbouring SPS synchrotron. LHC thinking now also focuses on a 'four-feed' plan for the vast accompanying cryogenics, with two octants being supplied with liquid helium from each of four supply points.

On the experimental front, the two major projects - ATLAS and CMS - for detectors to study proton-proton collisions were identified in 1993 after a series of major meetings to study experimental possibilities at the LHC. For heavy ion work, ALICE has emerged as the main contender for a dedicated experiment, while the LHC-B collaboration was established last year for the study of B particle physics. Other experimental possibilities were outlined at a special meeting at CERN on 29-30 November.

The next major milestone in the experimental programme is the formal presentation of the ATLAS and CMS proposals in January.

The formal approval of LHC also means the dismantling of the LHC Detector Research and Development Committee (DRDC), which for the past four years has supervised development work for the technological challenges facing LHC detectors. This work now switches to the LHC Experiments Committee. An article on the valuable groundwork accomplished under the DRDC framework will appear in a forthcoming issue.

(For other Council news, see page 26.)



For its full collision energy of 14 TeV, LHC will use half-cells containing three superconducting bending magnets (B) and focussing quadrupoles (Q). Attaining two-thirds of this energy needs only two dipoles in three, the central site in each half-cell containing an empty cryostat, which will later have to be replaced and the outer magnets realigned.

Steve Myers shows a LEP electrostatic separator to French Atomic Energy Authority High Commissioner Robert Dautray. These separators remove unwanted electron-positron collision points.

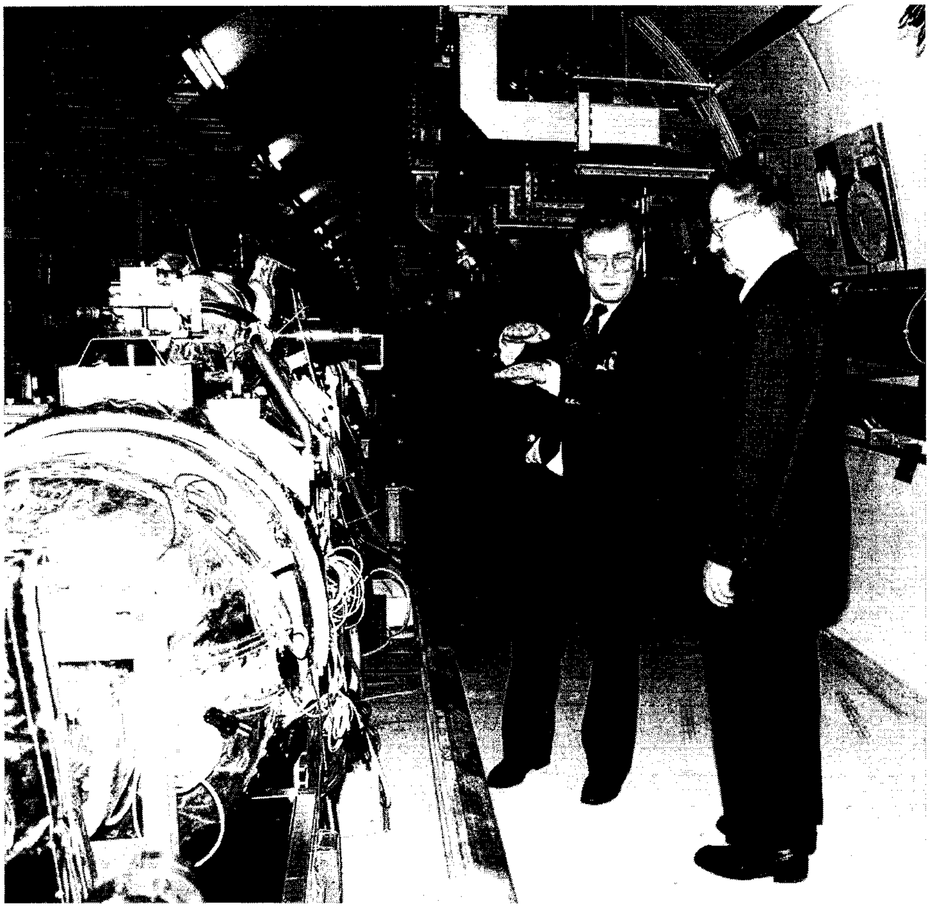
CERN
Another leap at LEP

When the 1994 physics run at CERN's LEP electron-positron collider finished at the end of November, integrated luminosity reached 64.5 inverse picobarns (October 1994, page 1), more than one and a half times as much as collected in 1993, itself 40% more than the 1992 score. So far the four experiments have seen well over 12 million Z particles.

During most of the year, eight-bunch 'pretzel' running (October 1992, page 17) was standard. After five years, the LEP team have few remaining tricks up their sleeves, and the main emphasis in 1994 was to go for optimal efficiency (maximum vertical beam-beam tune shift). This paid off and by late summer, the luminosity aggregate had already surpassed 60 inverse picobarns.

In preparation for the higher energy LEP2 scheme, scheduled to begin operations in 1996, additional beam separators and superconducting radiofrequency accelerating cavities were installed in late summer. Towards the end of the year another harbinger of LEP2 was the abandoning of eight-bunch pretzel running in favour of 'trains' of bunches, foreseen as the standard scheme for LEP2.

During 1994, LEP operations surpassed the magic figure of an inverse picobarn of integrated luminosity in 24 hours, while peak luminosity attained 2.2 x 10^{31} cm^{-2} s^{-1}, well above the design figure of 1.3 x 10^{31}. (In our November issue, we wrongly cited this design luminosity as 1.7 x 10^{31}.) Polarization gives a precision fix on beam energy (September 1993, page 5) to within 1.5 MeV at the Z resonance.



LEP has developed into such a precision machine that it is making its mark on geodesy. The effect of earth tides on the beams, once hailed as a spectacular breakthrough in accuracy (January 1993, page 4), is now considered unfortunate background, with people grumbling about their inability to do anything about it. The behaviour of LEP beams is now limited by another factor nobody can do anything about - rainfall! LEP can now detect the height of the water table in the nearby Jura mountains and the level of water in Lake Geneva.

For LEP1, the major recent performance constraint has been the delicate interaction of the contra-rotating electron and positron beams. More particles could in principle be pumped into the ring to increase the collision rate, but unwelcome beam-beam interactions would set in and spoil the result.

For the higher energy LEP2, the boot is on the other foot. Here the beam-beam interaction will not be so severe, so more particles can be injected. Following experience at Cornell's CESR ring, the idea is to go for several colliding 'trains' with carriages (bunches) of electrons and positrons. The number of trains and carriages is dictated by the ability of the experiments to handle them, and in preparation for higher energy running, this year LEP will go for four

DESY Director Bjorn Wiik enjoys the end of 1994 physics at DESY's unique HERA electron-proton collider, which supplied experiments with 20% more integrated luminosity than targeted.

electron and positron trains, each of four bunches.

The increased collision rate given by this scheme will eventually be a boon at LEP2, where the production rate of W pairs will be thousands of times less than the Z production rate at LEP1.

In preparation for LEP2 commissioning later in the year, delivery of superconducting niobium-coated cavities has been progressing well after some initial acceptance problems. Superconductivity is a very delicate condition to have to preserve, and many precautions have to be taken. The sophisticated surface treatments needed to ensure good cavity performance are being mastered and improved, troublesome heating in the surrounding radiofrequency plumbing is being overcome, and unwelcome 'multipactoring' on the niobium surfaces is being controlled.

LEP experience in 1994 and plans for this year are being reviewed in January during the end-year shutdown at the traditional performance workshop in Chamonix in the French Alps. A report of the workshop will feature in a forthcoming issue.

DESY
Luminous 1994

The 1994 physics run at DESY's unique HERA electron-proton collider supplied the H1 and Zeus experiments with 6.2 inverse picobarns (October 1994, page 1) of integrated luminosity, some 20% more than the target figure.

The luminosity increase was the result of several factors. In 1994 the proton beam was made up of up to 170 bunches (compared with 84 in 1993 and 9 in 1992), giving average proton currents of 40 milliamps (maximum 60), while electron/positron beams were typically 25-30 milliamps.

Switching from electron to positron beam running (sidestepping problems with impurity positive ions) in the middle of the run increased the beam lifetime to about 10 hours.

For positron running, the polarity of the entire 'electron' chain - the DESY synchrotron, PETRA and the HERA electron ring - were all switched. HERA operations for 1995 are scheduled to begin on 3 April.

DARMSTADT
Heaviest of them all (so far)

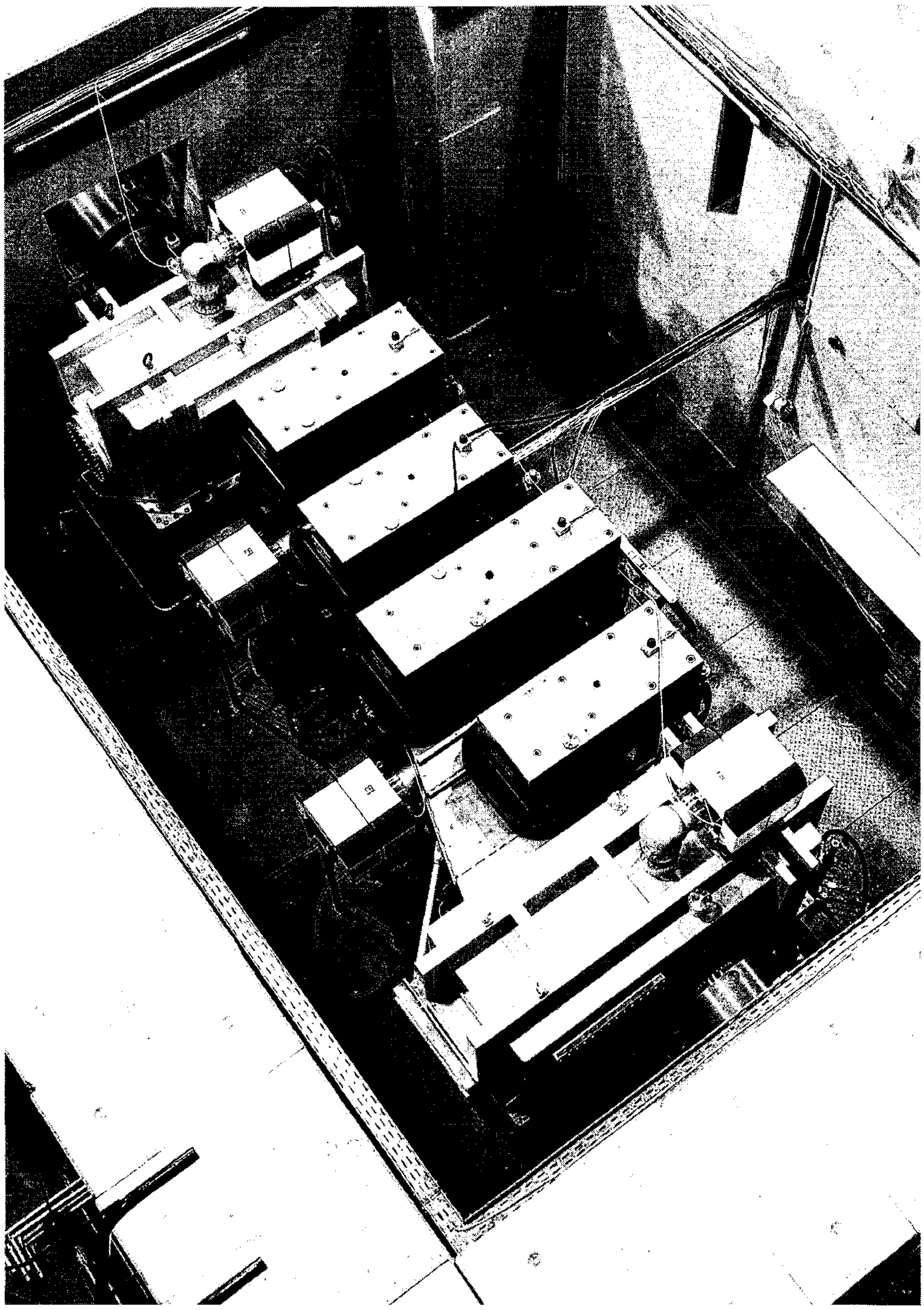
The heaviest nuclei yet, with atomic numbers of 111 and 110, have been synthesized at the GSI (Gesellschaft für Schwerionenforschung) heavy ion Laboratory, Darmstadt.

The breakthrough was made by an international group (GSI/Dubna/ Bratislava/Jyvaeskylae) including Peter Armbruster and Sigurd Hofmann using the SHIP separator for heavy reaction products. This group has already discovered the elements 107, 108 and 109 at GSI.

The element 110 experiment initially fused nickel 62 ions accelerated in the GSI UNILAC on a lead 208 target. The resulting nuclei were sorted by SHIP's velocity filter and an alpha-decay chain could be unambiguously assigned to 269/110. In the Periodic Table, this new nucleus is a heavier cousin of nickel, palladium and platinum.

Subsequently, irradiation of bismuth 209 with nickel 64 produced 272/111, exactly on the 25th anniversary of GSI's founding on 17 December 1969.

SHIP not at sea. The SHIP velocity filter/ separator for heavy reaction products at the GSI heavy ion Laboratory, Darmstadt, has added another feather to its already well-adorned cap with the discovery of nuclei 110 and 111, the heaviest ever seen.



In a series of important pre-experiments to tune the production of nucleus 110, the production of intermediate unstable superheavy nuclei (104 and 108) was examined in the fusion of titanium-50 and iron-58 on lead. As well as finding the optimum projectile energies, this also allowed single neutron evaporation to be studied - the nickel-62/lead-208 fusion reaction produces the 269/110 supernucleus and a single neutron.

A nickel beam energy of 311 MeV produces a chain of 4 alpha decays. This can be assigned to the isotope with the mass number 269 of the element 110 on the basis of delayed alpha-alpha coincidences.
The accurately measured decay data of the daughter isotopes of the elements 108 to 102, obtained in the pre-experiments, were used.
The isotope 269/110 decays with a half-life of (270+520-220) microseconds.

The SHIP group substituted nickel-64 for nickel-62 and were rewarded by formation of the nucleus 271/110.

For element 111, the nuclei decay by alpha emission into 268/109 and 264/107, the heaviest isotopes of these nuclei ever seen.

BEIJING
Green light for feasibility studies on tau-charm factory

Since first collisions were achieved at the Beijing Institute of High Energy Physics BEPC electron-positron collider in October 1989, nine million J/psi and 1.4 million psi primes have been collected, as well as integrated luminosities of five and 23 inverse picobarns collected from respectively the tau threshold and a collision energy of 4.03 GeV.

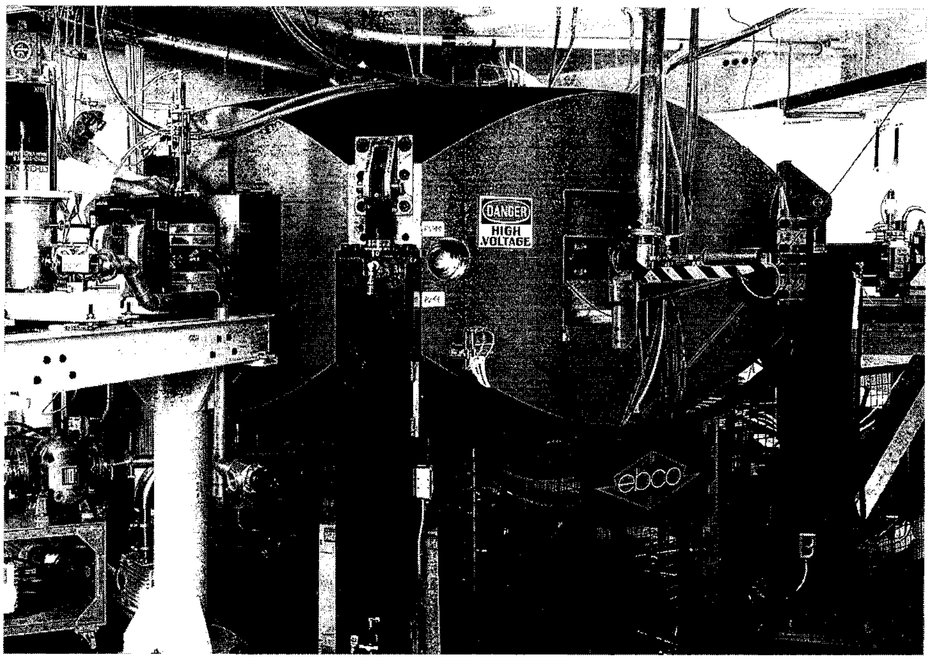
In addition, the BES spectrometer group has obtained several important tau results, including a precise measurement of the tau mass and precision studies of important tau decays. These results were a focus of interest at major meetings last summer.

With many physicists across the world interested in the future of the BEPC/BES complex, in October, came the good news that the Chinese leadership had promised to support Beijing's feasibility study project for a Tau-Charm Factory (tauCF) on the BEPC site.

BEPC's working energy, in the range 3 - 5.6 GeV, covers a high density region of resonances including charmonium, its excited states and production thresholds of many particles, such as the tau lepton pairs and charmed particles(mesons and baryons).

The present experimental statistics and detection resolution at BEPC/ BES are not up to the task of testing the Standard Model to its limit and searching for new physics.
The tauCF would be a logical continuation of BEPC/BES. With a hundred times greater luminosity and tenfold detection accuracy, tauCF could play a decisive role in ongoing physics goals.

A SLAC (Stanford) workshop last summer on tauCF in the B-Factory Era underlined the importance of tauCF, with conclusion that a B-factory cannot replace tauCF. Many scientists have observed that Beijing is one of the best places for a tau-charm factory.



Cyclotron technology transferred to industry - the Ebco TR30 cyclotron installed for Nordion at the Canadian TRIUMF Laboratory in Vancouver is being upgraded from 500 microamps to 1 milliamp operation. (Photo Ebco)

TRIUMF Technology transfer

In our occasional series highlighting the increasingly important area of technology transfer and industrial spinoff from high energy physics, this month the CERN Courier focuses on TRIUMF in Vancouver, Canada's major national facility for research in subatomic physics, a particularly illustrative example of the rewards and challenges involved.

TRIUMF is based on a 520 MeV negative hydrogen ion cyclotron meson factory operated by a consortium of Canadian universities. Although the primary funding from the Canadian government is earmarked for support of basic research, the laboratory has always fostered applications of the technologies available, supporting them with funds from other sources.

At first this "applied programme" involved simply the provision of particle beams for other scientific, medical and industrial uses - protons for the development of neutron-deficient radioisotopes, neutrons for activation analysis, pions for cancer therapy, and muons for chemistry and condensed-matter physics.

Twenty five years on, the technology transfer process has resulted not only in a significantly expanded internal applied programme, with many areas of activity quite independent of the big cyclotron, but also in a number of successful commercial operations in the Vancouver area.

Radioisotope production has been a particularly fruitful source for technology transfer, the early development work leading to two important initiatives - the establishment of a commercial radioisotope production facility on site and the inauguration of a positron emission tomography (PET) program at the University of British Columbia nearby.

In 1979 Atomic Energy of Canada Ltd's isotope production division (now Nordion International Inc.) decided to establish a western Canadian facility at TRIUMF, to produce the increasingly important neutron-deficient radioisotopes obtainable with accelerator beams, primarily for medical applications. This would complement their production of neutron-rich isotopes at nuclear reactors in eastern Canada. To complement the TRIUMF cyclotron beams, a 42 MeV 200 microamp CP42 negative hydrogen ion cyclotron was purchased and brought into operation in 1982.

Increasing demand soon led to this machine working at full capacity, so in 1987, after an extensive market search, Nordion decided to enter into a three-way agreement with TRIUMF and Ebco Industries, a local company which had played a major part in building the 520 MeV cyclotron, to design and construct a 30 MeV 500 microamp negative hydrogen ion cyclotron - the TR30.

This project was pivotal in determining TRIUMF's approach to major transfers of technology to industry.

The choice of a negative hydrogen ion cyclotron stemmed naturally from the requirement for clean extraction of two beams simultaneously, variable in energy (15 - 30 MeV) and intensity, and from TRIUMF's extensive experience with such machines.

A 4-sector magnet was used, with two 45-degree dees. For good maintenance access, negative hydrogen ions were injected from an external source and the 74 MHz radiofrequency amplifier was mounted outside the vault.

The project was a bold move for each of the participants:

Nordion was not only buying a cyclotron that had yet to be designed or tested, but also had to construct additional buildings and install facilities around the new machine as it was being assembled and tested.

Ebco was making a policy decision to build and market cyclotrons commercially, and although the company was quite experienced in the construction of complex electrical and mechanical equipment to customers' orders, this was a new corporate direction.

TRIUMF was embarking on a whole new role of transferring and commercializing technology in a major way, requiring the development of new policies and procedures as the project progressed through the inevitable sequence of demands and deadlines.

Fortunately, some of the inherent challenges of such a venture were mitigated, because all the parties were familiar with each other. Both commercial companies had worked with TRIUMF over a number of years, and the three partners had built up a significant level of mutual trust.

Moreover, the importance of transferring technical knowledge to industry was becoming increasingly recognized in Canada.

All levels of government were trying to derive additional economic and social benefits from the extensive, yet largely untapped, resource base of science and technology being developed in government-funded research centres, such as TRIUMF.

In the present instance this far-sighted view led the British Columbia provincial government to accelerate the project by lending a significant fraction of the construction costs.

A very tight schedule was established, calling for the completion of the cyclotron design in early 1989 and initial operation with two 250 microamp external beams by mid-1990. In fact, commissioning began on schedule and full-intensity beam was being delivered within three months, a performance that was agreed by all three parties to have been very successful. The TR30 has now been in highly reliable operation for four years and is responsible for the majority of Nordion's almost $15 million annual revenue from its Vancouver operations; royalty payments to TRIUMF amount to $370,000 per year.

One of the fruits of the TR30 project was the establishment of a technology transfer office to establish policies and procedures and to negotiate licence agreements with commercial partners. One of its first duties was to finalize an agreement with Ebco for the construction and marketing of further machines, with provision for consulting assistance from TRIUMF.

This has led to the construction of three more small cyclotrons, a TR30/15 in operation at INER Taiwan since mid-1993, providing 8 - 15 MeV negative deuteron beams in addition to negative hydrogen ions, and two smaller TR13 cyclotrons. The latter provide 100 microamp 8 - 13 MeV negative hydrogen ion beams for Positron Emission Tomography (PET) radioisotope production and are of a special compact design for direct installation in hospitals. The prototype is now in operation for the University of British Columbia PET programme while the second TR13 is currently being commissioned in South Korea.

As with any new venture, there have been some routine start-up hurdles and issues for both parties, but Ebco has now received the TRIUMF cyclotron technology and is an internationally recognized manufacturer of cyclotrons.

Overall the TRIUMF and Ebco entry into cyclotron design and manufacturing has been quite successful.

The commercialization policy adopted by TRIUMF recognizes two major goals for its commercial activities: dissemination of technology opportunities to industry for the long-term enhancement of Canadian industry; and generation of additional revenues that can be used to fund research activities peripheral to TRIUMF's primary mandate for basic research.

Among the procedures adopted for new commercialization proposals, the most important is the requirement for a formal review process to evaluate the costs and benefits to TRIUMF.

This review must ascertain whether the prospective commercial associate has a reasonable prospect of making an appropriate return on the investment, and whether TRIUMF

can expect a net benefit, without negative net financial or personnel impacts.

The TR30 experience also taught TRIUMF a number of practical lessons in effective collaboration:

Technology transfer must be viewed as a body contact exercise - knowledge is only transferred effectively through direct meetings between the scientists and the industry representatives;

Technology transfer is usually a much more lengthy process than is originally anticipated by either party;

Technology transfer requires committed individuals on both sides to ride through the inevitable rough spots;

The staff working on both sides must feel that they are being treated reasonably and equitably. Commitments must be kept, and any special rewards must be agreed to by both parties, including representatives of non-participating staff.

In recent years, technology transfer from government-funded research laboratories to industry has been an increasingly popular aim of governments. TRIUMF now has several years' experience with Ebco Industries in transferring cyclotron technology to the marketplace, and both parties have found that although there are invariably unexpected hurdles, these can be overcome with goodwill and effort on both sides.

For TRIUMF it has been a beneficial experience, although not without its challenges. TRIUMF staff have responded well to the new demands and requirements of commercial activity, although for some it has meant learning new processes for maintaining confidentiality and meeting rigid external deadlines.

If there has been one key to success, it has been the commitment by senior management on both sides to find ways to make technology transfer work.

INDIA
Photon multiplicity detector

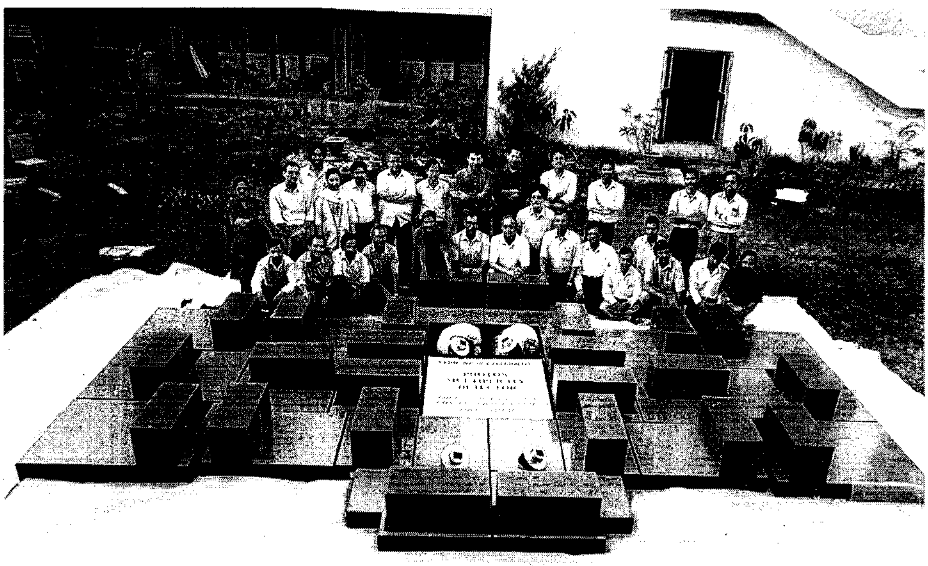
The team of Indian scientists from Calcutta's Variable Energy Cyclotron Centre, Bhubaneswar Institute of Physics, Panjab (Chandigarh), Rajasthan (Jaipur) and Jammu in collaboration with GSI Darmstadt have contributed a large and highly granular preshower photon multiplicity detector (PMD) for the WA98 experiment at the CERN SPS proton synchrotron.

This experiment studies high energy collisions of lead ions and will measure both charged particle and photon multiplicity in a large overlap region.

The motivation for measuring photon multiplicity in ultra-relativistic heavy ion collisions stems from theoretical predictions of changes in the relative production of photons and charged particles in the phase transition of hadronic matter to quark-gluon plasma and its subsequent hadronization.

The photon multiplicity detector consists of a matrix of scintillator pads placed in light-tight boxes and mounted behind the lead converter plates. The light from the scintillator pads is transported to the readout system using wavelength shifting (WLS) fibres. Developing on the team's earlier experience with a smaller version for the WA93 experiment (September 1991, page 16), several modifications were incorporated to improve light collection and transport. Use of improved WLS fibres, short WLS pieces to minimize self-absorption, and thermal splicing with long clear fibres were some of the important changes incorporated. Tests showed signficantly improved light collection.

The boxed modules of the Photon Multiplicity Detector after final assembly in India before despatch to CERN.



The scintillator pads were fabricated at all the five collaborating centres in India and the complicated assembly in the detector box modules carried out at the Variable Energy Cyclotron Centre, Calcutta. More than 400 lead converter plates were machined in Calcutta to rigorous tolerances of 0.2 mm. The assembled detector box modules and lead plates were shipped to CERN in spring 1994 for tests and installation.

The WA98 PMD consists of over 50,000 scintillator pads of sizes varying from 15 to 25 mm square and are assembled in 26 light-tight box modules. Each fibre matrix of 38 rows and 50 columns is read out using an image intensifier and CCD camera system. At present the PMD uses 26 readout cameras from the old UA2 experiment, including 20 units on loan from CERN.

The detector covers an area of 21 square metres in the forward region. Its total weight with the stand and lead converter plates is about 6 tons. A central hole about 1 metre square avoids problems with overlapping showers. The detector took its first data during the lead ion run late last year (December 1994, page 15).

COMPUTER OPERATING SYSTEMS HEPiX news

In October the North American and European Chapters of HEPiX (the HEP UNIX group established to share worldwide high energy physics experience in using the UNIX operating system - March 1994, page 18), held meetings at Fermilab and Saclay.

The two-day Fermilab meeting attracted over 30 attendees from some 12 sites in the US, as well as representation from CERN.
The three-day European meeting two weeks later was attended by some 70 people from 30 sites in Europe, the US and Japan.

Both meetings featured some common themes such as the growth in the use of AFS (the Andrew File System) for distributed access to central filebases, and the continuing trend away from mainframes towards farms of UNIX workstations and/or servers.

Other topics of interest included an update of the POSIX standards efforts, an online presentation of an experimental graphics interface, first impressions of new utility for batch job control in UNIX, the latest news on the spread of the HEPiX login scripts and a review of trends in magnetic tape technology.

Detailed minutes are in preparation and will be published in the HEPNET.HEPiX news group in due course. In the meantime, the transparencies presented in many of the sessions at both conferences can be consulted via the World-Wide Web at URL http://wwwcn.cern.ch/hepix/meetings.html

In September came a suggestion that both Chapters should merge to better share experiences and pool resources into specific working groups. This was discussed and agreed. Now a single HEPiX organization exists, with conferences alternating between Europe and North America, interspersed with meetings to coincide with the Computing in HEP (CHEP) series, where meetings are held every 18 months. The schedule for the next two years is Prague (May 31 to June 2), Rio de Janeiro (September 25 - 27), US or Canada in Spring 1996 and Europe in Autumn 1996.

It was also agreed to set up some working groups, the first devoted to AFS-related matters. Others will be announced in the HEPiX newsgroup. A Steering Committee is being formed, and a call for more volunteers for it and for the working groups will also appear in the newsgroup shortly.

Alan Silverman

Physics monitor

Collision course. Delegates at the second workshop on the Physics Potential and Development of Muon Colliders, held in Sausalito, California, in November.

Muon colliders

The increasing interest in the possibility of positive-negative muon colliders (October 1994, page 24) was reflected in the second workshop on the Physics Potential and Development of Muon Colliders, held in Sausalito, California, from 16-19 November, with some 60 attendees.

It began with an overview of the particle physics goals, detector constraints, the muon collider and mu cooling, and source issues.

The major issue confronting muon development is the possible luminosity achievable. Two collider energies were considered: 200 + 200 GeV and 2 + 2 TeV. The major particle physics goals are the detection of the higgs boson(s) for the lower energy collider, together with WW scattering and supersymmetric particle discovery.

At the first such workshop, held in Napa, California, in 1992, it was estimated that a luminosity of some 10^{30} and 3×10^{32} $cm^{-2} s^{-1}$ for the low and high energy collider might be achieved (papers from this meeting were published in the October issue of NIM). This was considered a somewhat conservative estimate at the time.

At the Sausalito workshop the goal was to see if a luminosity of 10^{32} to 10^{34} for the two colliders might be achievable and usable by a detector. There were five working groups - physics, 200 + 200 GeV collider, 2 + 2 TeV collider, detector design and backgrounds, and muon cooling and production methods. Considerable progress was made in all these areas at the workshop.

The muon collider has a powerful physics reach, especially if muon polarization can be maintained. One interesting possibility is the direct observation of the supersymmetric higgs. The detector backgrounds will be considerable due to high energy muon decays upstream, however the working group concluded that these backgrounds might be manageable.

One key to achieving a high luminosity collider is the collection of a maximum of muons from pion decays. This is far from trivial and leads to conclusions from groups 2 and 3 that the present uncertainty in luminosity is of order $10^{2\pm1}$ (these orders of magnitude unfortunately span the range from being uninteresting to being very interesting!). Hopefully this uncertainty can be reduced before the next meeting.

Perhaps the most interesting aspect of a muon collider is the need to cool the positive and negative muon beams over a very large dynamic range.

Three experimental programmes were discussed and are being initiated to study muon cooling: at Brookhaven, Fermilab, and a UCLA group is proposing to study cooling and acceleration in crystals at TRIUMF.

One major conclusion of the meeting is that muon colliders are complementary to both proton-proton (LHC) and electron-positron (NLC) colliders, especially for the higgs Sector and for the study of supersymmetric particles.

The third meeting in this series will be held in San Francisco, California, in December. Another workshop, addressing machine issues, will be held on Long Island in October. Proceedings of the Sausalito workshop will be published by the American Institute of Physics.

From David Cline UCLA

Cosmic rays of the highest energies

With the objective of designing a new detector to probe the behaviour of the highest energy cosmic rays, a Giant Airshower

Detector Design Group is at Fermilab for six months (until end-July). The initial concept is for a 5000 square-kilometre airshower array with a fluorescence detector at the centre.

The group will produce a document with a review of scientific justification, a technical design, a survey of possible sites, and a cost estimate with options.

The construction of large detectors in both the northern and southern hemispheres is an international undertaking. Hosted by Fermilab, the Design Group is also supported by the US National Science Foundation, UNESCO and the Grainger Foundation.

Further information from Robin Ruschman, MS122, Fermilab, PO Box 500, Batavia, Illinois 60510, e-mail DESIGN_GROUP@FNAL.GOV

The following statement from Alan Watson of Leeds, UK, underlines the aims of the project:

Cosmic rays are now known to span the energy range from 10^9 to beyond 10^{20} eV and to be, predominantly, the nuclei of atoms from hydrogen to iron. Above 10^{14} eV the particles are so rare that their detection relies on measurements of the giant cascades or extensive air showers created in the atmosphere which may be observed with arrays of particle and optical detectors at ground level. The flux of particles falls inversely as the square of the energy until above 10^{19} eV only about one per km^2 per year is collected. The origin of these particles is unknown and how Nature can accelerate them to energies, which represent the most significant departures from thermal equilibrium found in the Universe, is a major astrophysical puzzle.

There is suggestive evidence from a number of experiments that above 10^{19} eV the cosmic rays are protons. If so, an origin within our own galaxy can be excluded as the protons would propagate rectilinearly and sources within our galaxy would be readily identified. By contrast the arrival direction distribution is isotropic, within the limited statistics, even beyond 10^{20} eV where only a handful of events have been detected. This result is extremely paradoxical as sources at large distances (beyond about 30 Mpc) are strongly excluded by the existence of such events. The point is that above 4×10^{19} eV protons and heavier nuclei interact with the primordial 2.7 K microwave background radiation through well-understood reactions of particle and nuclear physics and are rapidly degraded in energy.

The existence of the most energetic event yet detected, 3×10^{20} eV, implies that it must have originated within 20 Mpc of the earth. However the arrival directions of this event and others of similar energy do not point to any unusually energetic objects within our galaxy or elsewhere and the lack of appropriate electromagnetic acceleration processes has even led to speculation that the particles are created in the collapse of massive cosmic strings which are topological relics of the early universe.

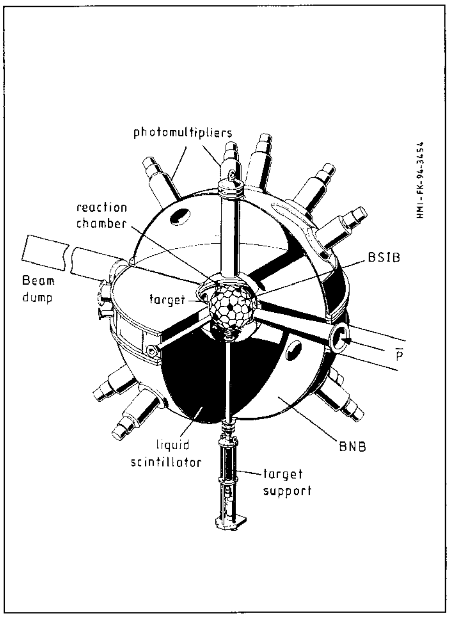
The results obtained so far derive from the independent efforts of groups in four different nations and are based on only a few hundred records above 10^{19} eV. To increase this sample significantly requires an international effort in which all the nations historically involved, and others, are eager to participate. We propose to construct a device with an aperture of 5000 km^2 sr. Such an instrument would allow 5000 events to be recorded annually above 10^{19} eV and, with the capability of accurate energy and mass determinations, provide data to confront conflicting ideas about the origin of the most energetic particles in Nature. Preliminary cost estimates indicate that this will be a \$60 - \$100 M project which requires a detailed design study to bring to the proposal stage.

Antiprotonic heating of nuclei

The bulk properties of nuclear matter such as viscosity, elasticity, heat capacity, and phase transitions from a liquid-like to a gaseous state are not well known. Moreover they can be studied for very small pieces of nuclear matter only.

For this work nuclei have to be excited to the very limit of stability and their decay properties carefully registered. The specific excitation process, however, may also stimulate a decay with its own stability limit. The most common excitation method so far, heavy-ion reactions, is indeed very effective in heating nuclei thermally, but at the same time introduces strong rotations, shape distortions and considerable compression in the nuclear complex. It seems difficult to disentangle these effects.

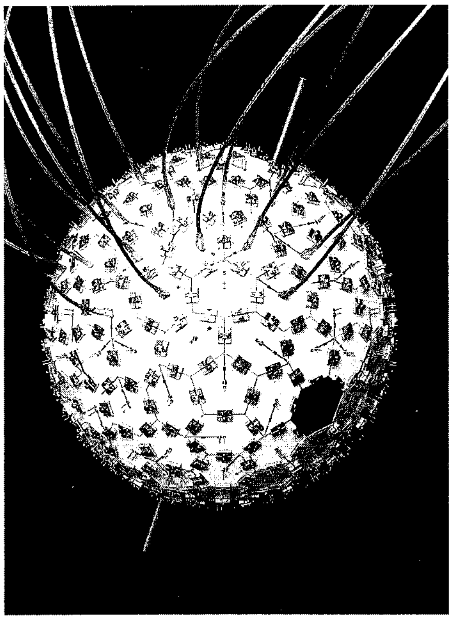
These ambiguities can be avoided by a soft or radiation-like heating of nuclei with pions of kinetic energies around 200 MeV. For these pions a nucleus is essentially a black disc. Since a single pion does not transfer enough heat, several pions have to be absorbed simultaneously in the nucleus.



Full solid angle detectors for the PS208 experiment at CERN's LEAR low energy antiproton ring - neutron ball (BNB) with silicon ball (BSIB).

This can be accomplished by the annihilation of an antiproton with one nucleon in a nucleus, resulting in about five pions. Antiprotons at low energies annihilate outside the surface - in the nuclear 'stratosphere'. Thus only a small fraction of the produced pions can be absorbed by the nucleus. At high antiproton energies of about 1 GeV the annihilation site is much closer to or even inside the nuclear surface (an 'underground' explosion) with absorption of several pions and production of very hot nuclei with excitation energies of up to 1 GeV. This method of antiprotonic heating is exploited at CERN's LEAR low energy antiproton ring by the PS208 collaboration: HMI-Berlin, GANIL-Caen, TU-Munich, Warsaw, FZ-Rossendorf, IPN-Orsay, IPN-Moscow, and CERN.

Studying the properties of these hot nuclei needs measurement of all nuclear decay products such as neutrons, protons, alphas and heavier particles up to fission fragments. This is done with two full solid angle detectors: the Berlin Neutron Ball (BNB) and the Berlin Silicon Ball (BSIB) installed at LEAR.



Close-up of the PS208 silicon ball, composed of 158 pentagons and hexagons.

The neutron ball is a spherical shell with an outer diameter 160 cm, filled with a liquid scintillator doped with gadolinium. This scintillator counts all emitted neutrons by registering the capture gamma-rays of delayed neutrons. Inside the shell 158 silicon detectors are arranged on the inside of a 20 cm diameter sphere. The silicon ball measures the energy, particle species and angular correlations of all charged nuclear particles.

The decay of hot nuclei with antiprotons is studied up to the maximum LEAR energy of 1.25 GeV. Initial results show the expected highly efficient antiprotonic heating of nuclei. Ongoing analysis will reveal decay characteristics near the critical point of the nuclear liquid-gas phase instability.

DESY Theory Workshop 1994

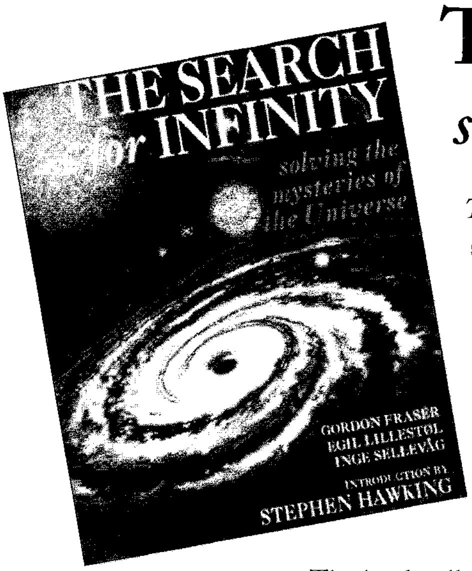
For 1994, the traditional annual DESY Theory Workshop was devoted to supersymmetry. This is a novel symmetry relating bosons (normally force-carrying particles) and fermions (which normally feel the forces).

In supersymmetry, bosons could have fermion counterparts, and vice versa.

Although this subject is still largely a theorist's playground, many of the particles and phenomena predicted by models of low energy supersymmetry now seem within reach of present and planned future accelerator experiments, and this was one of the main reasons for choosing a more speculative theme after more phenomenological orientations in recent DESY Theory Workshops.

After the welcome by DESY Director General Bjorn Wiik, attention was immediately focused on experimental aspects. P. Steffen (DESY) presented the latest results from HERA. In the following talks, K. Honscheid (Ohio), S. Lammel (Fermilab) and S. Komamiya (CERN and Tokyo) reviewed the experimental situation at electron-proton, hadron and electron-positron colliders, respectively. They discussed the most recent limits for supersymmetric particles (still none in sight!), as well as precision experiments where deviations from the standard model might show up.

The workshop was treated to a first rate introduction to the MSSM ("minimal supersymmetric standard model") by F. Zwirner (CERN), who clearly explained the motivation for going supersymmetric and reviewed the basic structure of the MSSM, its



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solving the mysteries of the Universe

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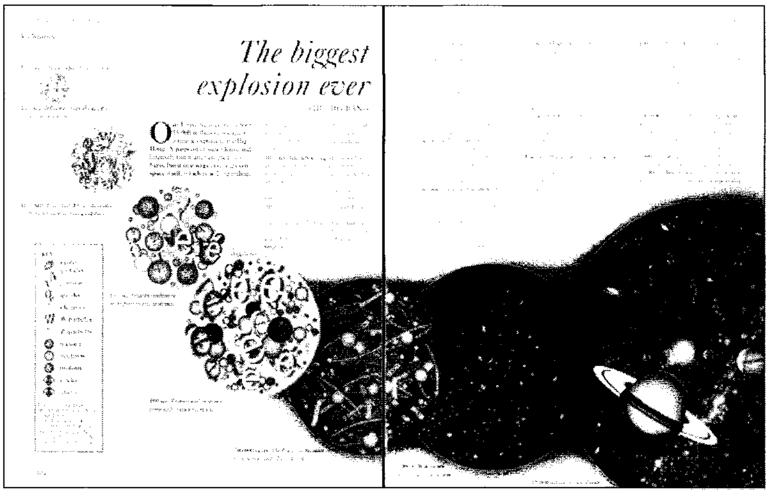
The book tells the story of the search for the ultimately small, from the early days of atomic physics to modern particle accelerators, and how the conditions necessary to reveal quarks replicate those of the first moments of the Universe – elegantly linking particle physics and cosmology, while at the same time providing straight-forward explanations of the basics of modern physics.



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DESY Director Bjorn Wiik (left) with supersymmetry pioneer Julius Wess at the traditional annual DESY Theory Workshop, which for 1994 was devoted to supersymmetry.

particle content and couplings, as well as the soft breaking terms necessary to avoid immediate conflict with experiment.

This was followed by a systematic discussion of the Higgs sector by H. Haber (Santa Cruz), where the first hints of new physics could appear. However, he also made clear that it may not be easy to distinguish standard and non-standard Higgs bosons. Symmetries beyond the standard model, and in particular supersymmetric grand unification were treated in detail by G. Ross (Oxford) and S. Raby (Ohio), who capitalized on the recent precision data from CERN showing that coupling constant unification is compatible with supersymmetric grand unification (the original non-supersymmetric unification already having been ruled out). They also discussed more specific predictions of these models for gauge couplings and fermion masses.

The second day started with discussions of "non-standard supersymmetric standard models" by U. Ellwanger (Orsay) and R-parity violating models by J. Bagger (Baltimore). R-parity distinguishes, roughly speaking, known particles from their (as yet unseen) superpartners. Conservation of R-parity means that SUSY particles can only be pair-produced, hence the lightest supersymmetric particle ("LSP") is stable.

These talks emphasized that, although the MSSM is the simplest realization of supersymmetry in the standard model, many other possibilities remain. Especially for models where R-parity is broken, the relevant experimental signatures might be very different from the missing energy signals commonly assumed to be the most direct experimental manifestation of low energy supersymmetry. Experimentalists were thus advised to keep an open mind for new and unconventional models while looking for supersymmetry.

Next, A. Masiero (Padova) showed the way beyond terrestrial experiments in his overview of supersymmetric astroparticle physics, stressing that supersymmetry provides plenty of candidates for the invisible 'dark matter' of cosmology, independently of whether one prefers the hot or the cold dark matter scenario.

After this excursion into outer space, P. West (London) brought the audience back down to earth in his review of non-renormalization theorems (i.e. the most general statements about cancellation of divergences between boson and fermion loops in supersymmetric theories), reminding everyone that these still provide the main motivation for introducing supersymmetry, offering a possible resolution to the hierarchy problem (explaining "unnaturally" large ratios such as that between top and up quark masses). Finally, the status of and the difficulties with supersymmetry breaking were reviewed by H.P. Nilles (Munich); despite a number of proposed breaking mechanisms (spontaneous, "soft", "stringy", or by gravitino condensates), no satisfactory solution of this important problem has yet been found.

More theoretical aspects of supersymmetry were discussed on the last day, when attention turned to 'superstrings' - supersymmetric versions of a theory of one-dimensional extended objects, the "strings". In a spirited review of superstring unification, L. Ibanez (Madrid) reviewed the state of the art in superstring model building, a more demanding task than the construction of "superstring inspired" field theory models that were once fashionable.

The replacement of point particles by strings as fundamental entities is believed to be necessary in order to cure the ultraviolet divergences of perturbative quantum gravity. He especially mentioned new possibilities for constructing 'stringy' grand unified theories (necessitating the use of higher level representations of

Kac Moody algebras). J. Louis (Munich) presented the latest results on how to compute gauge couplings from superstring theory (using such advanced mathematical tools as the theory of modular forms) as well as new non-perturbative mechanisms of supersymmetry breaking. While superstring theory has greatly added to our understanding of perturbative quantum gravity, key questions of a conceptual nature remain unresolved (or are not even asked by many superstring practitioners).

These issues were addressed by E. Verlinde (CERN), who proposed to use black holes as a "probe" to investigate the fate of space and time in a superstring theory of quantum gravity. He also turned attention to the question of what the fundamental gauge symmetry of superstring theory might be, citing recent progress on "duality symmetries". In the final talk and in lieu of a conference summary, supersymmetry pioneer J. Wess (Munich) opened new horizons beyond supersymmetry, introducing the notion of "quantum space". These have coordinates which are not ordinary commuting (nor anti-commuting) numbers, but more abstract mathematical entities called "q-numbers".

The workshop showed that there is still quite a way to go until we know which is the correct (supersymmetric?) model of particle physics. Nonetheless, even after 20 years of supersymmetry, theorists (and many experimentalists!) remain enthusiastic and convinced that supersymmetry is too beautiful a concept not to be used by Nature.

H. Nicolai

Books received

The CERN Courier has received an impressive consignment of new books from World Scientific Publishing, and hopes to include reviews in coming months.

Lectures in Particle Physics by Dan Green of Fermilab (ISBN 9810216823 HC £63, 9810216831 SC £35), imaginatively presented, World Scientific Lecture Notes - Vol.55;

Instantons in Gauge Theories , edited by M. Shifman (ISBN 9810216815 HC £62, 9810218265 SC £35), a collection of reprinted papers;

Development of Perturbative QCD by Guido Altarelli of CERN (ISBN 9810217021 HC £58, 981021703X SC £35), a collection of review articles, talks, and lecture notes;

Salam Festschrift edited by A. Ali, J. Ellis and S. Randjbar-Daemi (ISBN 9810214219 HC £80, 9810214227 SC £39), talks from a conference to honour Abdus Salam, held at ICTP, Trieste, in March 1993, and Volume 4 in World Scientific's Series in 20th Century Physics;

Selected Papers of Abdus Salam (with commentary), edited by A. Ali, C. Isham, T. Kibble and Riazuddin (ISBN 9810216629 HC £64, 9810216637 SC £31), a fine volume for Salam admirers, Volume 5 in World Scientific's Series in 20th Century Physics;

B decays (Revised, 2nd edition) edited by Sheldon Stone of Syracuse (ISBN 9810218362 HC £64, 9810218974 SC £25), a collection of contributions;

A Career in Theoretical Physics by Philip W. Anderson (ISBN 981021717X HC £58, 9810217188 SC £28), a collection of articles and papers, Volume 7 in World Scientific's Series in 20th Century Physics;

Knots and Physics (2nd edition) by Louis H. Kauffman of Illinois, Chicago (ISBN 9810218564 HC £64, 9810216580 SC £40), fascinating.

People and things

CERN Council

At the December meeting of CERN's governing body , the Council (which approved the LHC machine, see page 1) Paul Levaux was elected Vice President of Council and Marcello Gigliarelli Fiumi Chairman of the Finance Committee, both for one year, while Jacques Lefrançois of Orsay was elected to the Scientific Policy Committee. Within CERN, Lyndon Evans was appointed LHC Project Leader and Maurice Robin Head of Administration.

Eugene Paul Wigner 1902-95

One of the few remaining links with the birth of quantum mechanics was severed with the death on 1 January of Eugene Paul Wigner at the age of 92. His work was characterized by the introduction of unusual concepts and esoteric but powerful mathematical techniques which went on to prove their worth in the hands of other researchers, sometimes many years later.

Born in Budapest (his Hungarian name was Jeno Pal) in 1902, he first came to prominence as Erwin Schrödinger's assistant in Berlin in 1926-7 with his powerful treatment of quantum systems of many particles obeying the Pauli Exclusion Principle. Following a suggestion by his mathematician friend John von Neumann, he introduced the idea of mathematical group theory into quantum mechanics, where it has played a powerful role ever since. Wigner applied the techniques to the classification of atomic spectra and to nuclear structure.

Michal Turala becomes Leader of CERN's Electronics and Computing for Physics (ECP) Division, succeeding Pier-Giorgio Innocenti.

In Berlin and subsequently at Göttingen (under Max Born) he continued this work, and introduced the concepts of parity (left-right reversal) and time reversal as a special quantum mechanics operations, underlining the radical thinking this new physics required.

With Pascual Jordan, he invented a new quantum technique for describing field theory which, although not fully relativistic, opened the door to Dirac's standard treatment.

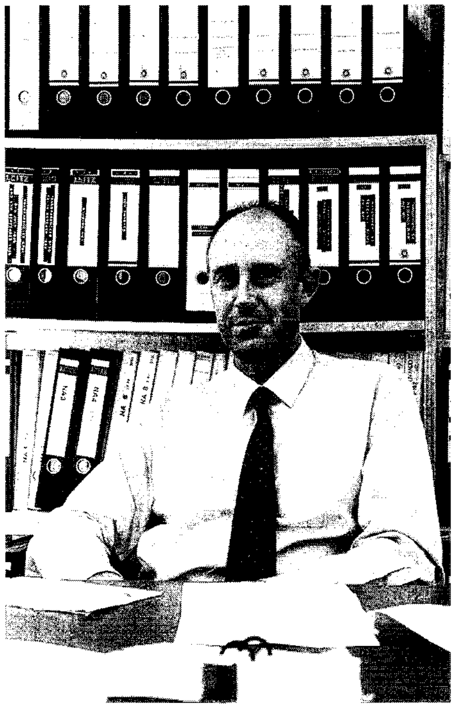
In the early 1930s he made major efforts to understand the nature of nuclear forces and in 1937 introduced the idea of isotopic spin (now called isospin) to describe the interrelation of proton and neutron forces in the nucleus.

He left Europe in 1935 for a post at Princeton. Apart from a spell in Wisconsin from 1936-8, he remained at Princeton for the remainder of his career.

In 1939, Wigner and Leo Szilard drafted the famous letter to US President Roosevelt, eventually signed by Wigner's friend Albert Einstein, pointing out the military potential of uranium fission.

Showered with honours, he was awarded (with Maria Göppert Meyer and Hans D. Jensen) the Nobel Physics Prize in 1963 for his pioneer

Giorgio Goggi becomes Leader of CERN's Particle Physics Experiments (PPE) Division, succeeding Jim Allaby.



work in helping to understand atomic and nuclear structure and nuclear forces. His sister, Margit, was Paul Dirac's wife.

On people

Vitaly Ginzburg of Moscow's Lebedev Institute and Yoichiro Nambu of Chicago share the prestigious Wolf Physics Prize for 1994-5. Ginzburg is cited for his important contributions to elementary particle physics, including recognition of the role played by spontaneous symmetry breaking and its analogy with superconductivity, and the discovery of the colour symmetry of the strong interactions. Nambu explained the connection between symmetry breaking and the lightness of the pion, and introduced SU3 as the symmetry of the colour quantum number, as well as carrying out pioneer work on relativistic string theory.

Le support publicitaire pour équipements scientifiques et techniques

Le COURRIER CERN (CC) est la revue internationale traitant de l'actualité dans le domaine de la physique des hautes énergies. Distribuée aux spécialistes de tous les grands laboratoires du monde, actifs dans cette branche dynamique de la recherche fondamentale, le CC constitue la vraie source d'informations pour les chercheurs, ingénieurs, administrateurs, etc... Rédigé dans une langue simple et publié simultanément en français et en anglais, le CC est peu à peu devenu le moyen de communication entre les physiciens des particules élémentaires de l'Europe, des Etats-Unis, de la CEI, du Japon, de la République populaire de Chine et d'ailleurs.

Publié au CERN Suisse, il bénéficie de la collaboration de correspondants dans les laboratoires d'Argone, Berkeley, Brookhaven, Cornell, Fermi, Los Alamos et Stanford (USA), d'Orsay et Saclay (France), de DESY et Karlsruhe (RFA), de Frascati (Italie), de Rutherford (Royaume-Uni), du PSI (Suisse), de Doubna, Novosibirsk et Serpoukhov (CEI), du KEK (Japon), de TRIUMF (Canada) et de Beijing (Chine).

Les crédits pour la physique des hautes énergies atteignent, en Europe, environ 1,8 milliard de francs suisses. Aux Etats-Unis, ils se montent à quelque 1,1 milliard de dollars.

Une annonce dans le COURRIER CERN est diffusée systématiquement parmi la plupart des spécialistes des grands laboratoires de recherche en physique des hautes énergies.

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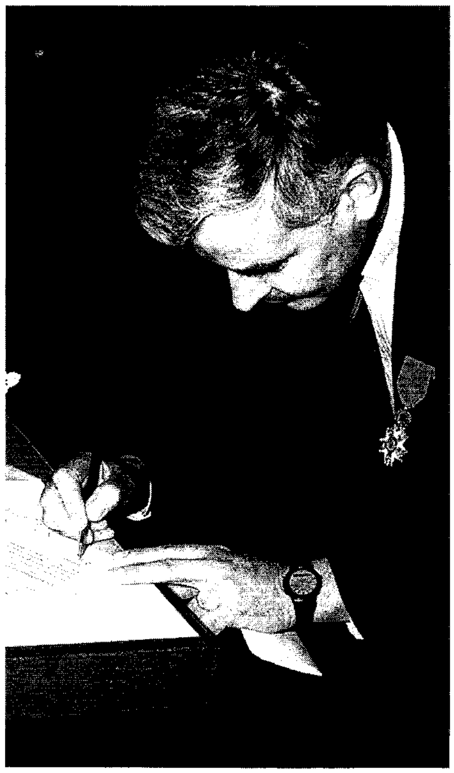
Martha Krebs (left), Director of the Office of Energy Research, US Department of Energy, at CERN on 30 November accompanied at the L3 experiment at LEP by (left to right) then PPE Division Head Jim Allaby, John O'Fallon, Director of the Office's Division of High Energy Physics, and L3 spokesman Sam Ting.

Maurice Jacob proudly signs the official acknowledgement of his Légion d'honneur award after receiving his medal from CERN Council President and former French Science Minister Hubert Curien at CERN on 22 November.
(Photo CERN 23.11.94/21)



Chen Ning Yang of the State University of New York at Stony Brook is awarded the prestigious Bower Science Prize for 1994. With Robert Mills, C.N. Yang developed in 1954 the 'Yang-Mills' formalism which underpinned much subsequent development in our understanding of gauge field interactions. Several years later, with T.D. Lee, he pointed out the possibility of parity violation in weak interactions. In 1957 Yang and Lee were awarded the Nobel Physics Prize. The Bower Science Prize was instituted in 1990.

After the formal retirement of Gustav-Adolf Voss last year, Dieter Trines becomes head of machines at the DESY Laboratory in Hamburg. Voss remains at DESY as an adviser. More details in our next issue.

More antiprotons at Fermilab

In December, Fermilab's antiproton source set a series of records, including a one hour antiproton stacking rate of 6.8 x 10^{10}/hr and a stack of 207 x 10^{10} antiprotons.

Edoardo Amaldi Foundation

Nicola Cabibbo is the new President of the Fondazione Edoardo Amaldi. Founded in 1992 to commemorate one of Italy's leading scientists and CERN founding father, who died in 1989, the Foundation is based in Piacenza. It brings together local government, private firms and national agencies.

With the new appointment, the Amaldi Foundation intends to reinforce its character as a cultural entity operating at the national level. Professor Cabibbo was a pupil and collaborator of Edoardo Amaldi, and is now a member of the Science Faculty at Rome University La Sapienza. President of the Pontifical Academy of Sciences, Nicola Cabibbo is also President of ENEA (the Italian National Agency for New Technologies, Energy and the Environment) and a fellow of the Accademia Nazionale dei Lincei.

In almost two years of activity, the Amaldi Foundation has launched many initiatives. Among the more significant can be counted the annual Amaldi Lectures, held at the Piacenza site of the Catholic University and given, in 1992, by the American physicist Wolfgang Panofsky ("Management and disposition of excess weapons plutonium"), in 1993 by Nobel Laureate for Physics Georges Charpak ("Multiwire cham-

DEUX POSTES D'ENSEIGNANTS

Le LPNHE est un laboratoire de recherche expérimentale comptant environ 100 personnes dont 40 physiciens. Il est engagé dans les expériences Delphi, Cat, H1, Nomad, Babar et le projet Atlas.

Deux postes permanents sont susceptibles d'être ouverts aux **concours pour la rentrée 1995** :

- un poste de "Maître de Conférences de 1ère classe" de l'Université Paris 6, réservé au renforcement du groupe Atlas LHC en instrumentation,

- un poste de "Professeur de 2nde classe" de l'Université Paris 7.

Des informations complémentaires peuvent être obtenues auprès de :

Monsieur BANNER :
LPNHE IN2P3/CNRS
Universités de Paris 6 et 7
4, Place Jussieu Tour 33 - RdC
75252 Paris Cedex 05 Tél. : 44 27 41 79

POSTDOCTORAL POSITION OPEN AT UNIVERSITY OF CALIFORNIA, SAN DIEGO

A postdoctoral position is currently open for recent or nearly-finished Ph.D.'s. Project involves the development and testing of novel resonant structure for possible future high energy linear accelerators. (See recent publications of D.R. Smith, N. Kroll, et al. on photonic band gap structures.) Candidate will be responsible for performing tests on low energy beam line at national facilities. Experience in accelerator level microwaves, cryogenics, and beam parameters helpful. Competitive Postdoctoral Research Physicist salary level dependent on experience and capability. Such salary is based on current University of California pay scales.

In conformance with applicable law and University policy, the University of California is an affirmative action/equal opportunity employer.

Interested candidates should send resume, including references, as soon as possible, bu no later than February 28, 1995 to:

Dr. Sheldon Schultz
UCSD, Physics, 0319
9500 Gilman Drive
La Jolla, California 92093-0319
619-534-4078
Fax: 619-534-6301
e-mail: sschultz@ucsd.edu

FACULTY POSITION ACCELERATOR PHYSICS Indiana University

The Department of Physics at Indiana University-Bloomington invites applications for a tenure-track faculty position at the assistant professor level in accelerator physics, for an appointment to begin fall 1995, or later. The department has an established graduate program and is inviting applications from Ph.D. physicists with experience in accelerator design who are interested in joining a strong academic and research program in accelerator physics. Responsibilities include teaching and supervising graduate student research in accelerator physics at the Indiana University Cyclotron Facility or other major facilities. Indiana University is a major research institution with strong programs in accelerator-based nuclear and high energy particle physics and a 50-year history of forefront accelerator development and construction. Present facilities include a 200 MeV separated-sector cyclotron and a 500 MeV storage ring/synchrotron with electron cooling. A new injector system for the Cooler consisting of an RFQ and small synchrotron has recently been funded. Several senior faculty members in physics and IUCF staff members with experience in accelerator design also are involved in the accelerator physics program.

To apply please send a complete vita (including a description of research interests, accomplishments, and a list of publications), and arrange for a minimum of three letters of reference to be sent to:

Professor S.-Y. Lee
Chair, Search Committee
Department of Physics
Indiana University
Bloomington, IN 47405

Applications must be received by the closing date of February 27, 1995. Indiana University is an Equal Opportunity/Affirmative Action Employer.

Advertisements in CERN COURIER

Format A4 **Monthly publication**

All advertisements are published in both English and French editions Second language versions accepted without extra charge.

Space (page)	Actual size (mm) width by height	Cost per insertion (Swiss Francs)			
		1 insertion	3 insertions	5 insertions	10 insertions
1/1	185 x 265	2150	2040	1950	1840
1/2	185 x 130 90 x 265	1280	1200	1100	1020
1/4	90 x 130	750	680	630	590

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Supplement for:
- one additional colour — 1500 SwF
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Covers 2 and 3 (one colour) — 2000 SwF
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Publication date — 1st of month of cover date
Closing date for positive films and copy — 1st of month preceding cover date
The cost of making films and of translation for advertisements are charged in addition.
Screen offset — 60 l/cm (150 English)
Advertisements cancelled after 1st of month preceding cover date will be invouced.

These rates are effective for the year 1995.

Inquiries for Europe:
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CH - 1211 Genève 23 Suisse
Telephone: 022/767 41 03
Telefax 022/782 19 06

Inquiries for the rest of the world:
please see page III.

A symposium and subsequent proceedings at CERN on 7 December marked the 60th birthday of Ugo Amaldi.

*Leading a UK industrial mission to CERN in November, Under-Secretary for Trade and technology Ian Taylor (right) is shown a UK-designed and built trigger processor board for the Aleph experiment at LEP by Mike Green of London's Royal Holloway and Bedford College.
(Photo CERN 18.11.94)*

Chen Ning Yang - Bower Science Prize

bers") and, in November 1994, by the then European Commissioner for Research Antonio Ruberti ("Cooperation in education and training").

The Foundation is also co-promoter with the European Physical Society of the Amaldi Prize for the best school thesis in physics. The Prize will be presented in Piacenza in 1995 and has attracted 50 entries from 11 different countries.

Foremost among the Foundation's 1995 commitments is the hosting in Piacenza of the Amaldi Conference, an international meeting of the world's scientific academies to discuss topics relating to disarmament.

Edoardo Amaldi was the moving spirit of these annual meetings and, on his death, the Conferences adopted his name. More than 50 scientists from all over the world are expected to be in Piacenza for the next meeting.

*Harald Fritzsch receives the German Physical Society's medal for science writing from Society President H. G. Danielmeyer.
(Photo G. Groote, Bad Honnef)*

PROFESSOR - ASSOCIATE PROFESSOR TENURE TRACK POSITIONS

ECOLE DES MINES DE NANTES
DEPARTEMENT de PHYSIQUE SUBATOMIQUE et des TECHNOLOGIES ASSOCIEES (SUBATECH)

The Laboratoire de Physique Subatomique et des Technologies Associées (SUBATECH) at Ecole des Mines de Nantes, is searching for candidates with outstanding ability and experience in Nuclear Physics, associated detectors and software developments for appointment at the Professor / Associate Professor levels. The SUBATECH Laboratory is a joint Laboratory of the University of Nantes, Ecole des Mines de Nantes, Centre National de la Recherche Scientifique (CNRS/IN2P3). It has developped experimental programs in nuclear physics at GANIL, CERN-SPS and CERN-LHC as well as applied research for nuclear waste and environment problems.

The candidate is expected to participate to a research program as well as to implement a teaching program and industrial relationships for engineering students. Basic knowledge in french is required.

Applicants are requested to submit CV, research accomplishments and interests, as well as names of five referees to:

Pr. Daniel ARDOUIN
Directeur du Laboratoire SUBATECH
ECOLE DES MINES DE NANTES
3, rue Marcel Sembat
44049 NANTES cedex 04

University of Copenhagen

Niels Bohr Institute for Astronomy, Physics and Geophysics

Professorship in Theoretical Nuclear Physics

A professorship in theoretical nuclear physics at the Niels Bohr Institute will become available as of July 1, 1995.

The new professor must have a broad theoretical background, and is expected to play a leading role in the development of nuclear physics. Nuclear physics is conceived as ranging from nuclear structure and reactions to hadronic physics and phenomenological QCD. The successful candidate must have contributed with original and outstanding research within these broad confines of nuclear physics and must have the ability to build a research group.

The nuclear theory group at the Institute works in an integrated way with the NORDITA nuclear theory group. Together they cover the subjects nuclear structure, heavy ion physics near the Coulomb barrier, hadronic structure and QCD, hot and dense nuclear matter and high energy nucleus-nucleus collisions as well as atomic clusters. The general theme could be termed many-body systems under extreme conditions. There is an active international guest program, and the Institute hosts centers in theoretical astrophysics and the physics of non-linear phenomena and it has a very active group in theoretical high energy physics. Further there are experimental programs in nuclear structure and high energy heavy ion collisions.

It is considered very important that the new professor in nuclear physics works in close contact with the other theory groups at the Institute and NORDITA and with the experimental nuclear physics groups.

The chosen candidate is expected to take part in the teaching activities of the Institute at all levels, including supervision of graduate students. It is expected that the new professor will take the lead in creating a new course in nuclear theory at the graduate level. The language of instruction for undergraduate courses is Danish, but English will be accepted for the first two years of the appointment.

The application must include a *curriculum vitae* and a complete list of publications with a special indication of which publications are considered most relevant for this position. Information about teaching experience must also be enclosed.

The applicants' qualifications will be evaluated by a specially appointed Committee. The entire report of the Evaluation Committee will be sent to all applicants and must be treated as confidential. The Evaluation Committee may ask for supplementary material, which the applicant then must provide in the requested number of copies.

Information about research plans, facilities and staff may be obtained from the Director, Professor Ole Hansen, Niels Bohr Institute for Astronomy, Physics and Geophysics, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark; telephone: +45 35325292, fax: +45 35431087, E-mail: oleh@nbi.dk.

The professorship is a tenured position under the Ministry of Education. The annual salary is approximately 415,000 DKK after contributions to the pension scheme.

The application, *marked "211-45/94-5207"* and written in English, must formally be made to the Rector of the University of Copenhagen and mailed to the Faculty of Science, Blegdamsvej 3, DK-2200 Copenhagen N, Denmark. *Applications, in order to be considered, must have been received by the Faculty of Science no later than March 15, 1995.*

Three copies of the application, and in addition three copies of a brief outline of proposed research, should be mailed to the Director of the Niels Bohr Institute for Astronomy, Physics and Geophysics. No further material should be forwarded until requested.

DESY

DESY announces several

'DESY Fellowships'

for young scientists in experimental particle physics to participate in the research mainly with the HERA collider experiments H1 and ZEUS or with the fixed target experiments HERA-B and HERMES. These fellowships will be available in future twice a year.

DESY fellowships in experimental particle physics are awarded for a duration of two years with the possibility for prolongation by one additional year.

Interested persons, who have recently completed their Ph.D. and who should be younger than 32 years, are invited to send their application including a résumé and the usual documents (curriculum vitae, list of publications, copies of university degrees) until 31 March 1995 to DESY, Personalabteilung - V2 -, Notkestr. 85, D-22607 Hamburg. They should also arrange for three letters of reference to be sent until the same date to the address given above.

As DESY has laboratories at two sites, in Hamburg and in Zeuthen near Berlin, applicants may indicate at which location they would prefer to work.

SCHOLA GENEVENSIS 1559

UNIVERSITÉ DE GENÈVE

ANNOUNCEMENT

The Group of Applied Physics announces an opening, beginning October 1, 1995 for a position of

FULL PROFESSOR or ASSOCIATE PROFESSOR in APPLIED PHYSICS

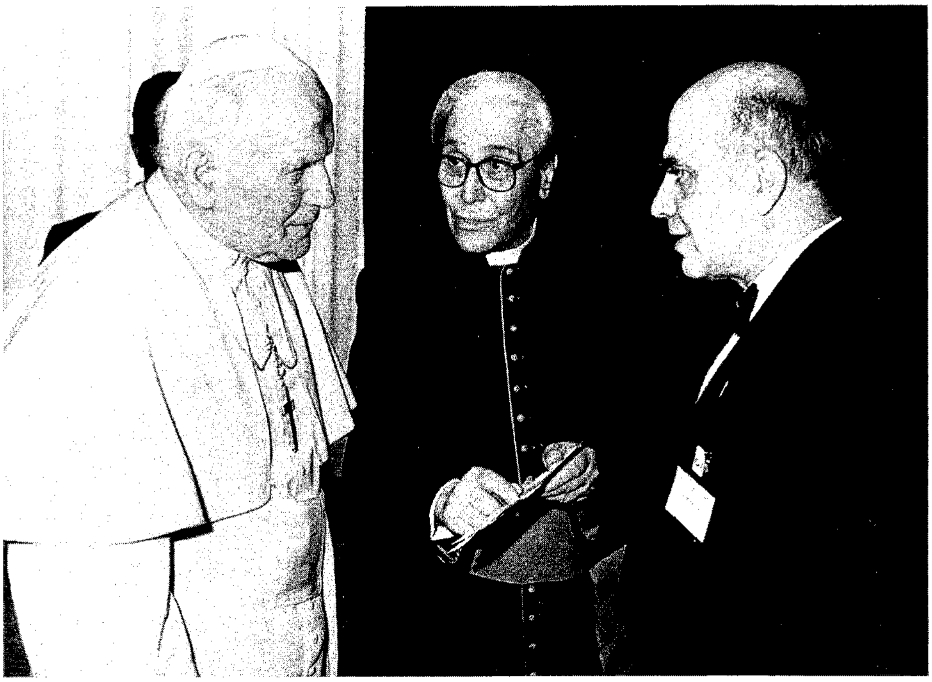
It concerns a full time appointment, comprising 6 hours of teaching in French of introductory physics and optics as well as research work in applied optics combining fundamental aspects and the latest technological developments.

The applicant should have a Ph.D. in physics, or an equivalent degree, and experience in physics teaching and in leading a research group in optics.

Applications, including a curriculum vitae and a list of publications, should be sent by March 1, 1995 to the Dean of the Faculty of Science, 30, quai Ernest-Ansermet, CH-1211 Geneva 4, Switzerland, where additional information on the job description and working conditions may be obtained.

N.B. In an effort to involve both men and women in teaching and research, the University hopes to receive a greater number of applications from women.

Rudolf Muradian (right) has been appointed a member of the Pontifical Academy of Sciences. Well known for contributions to particle, nuclear and mathematical physics as well as astrophysics, much of which has been done at the Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, and the Byurakan Astrophysical Observatory in Armenia. He is seen here with Mons. Renato Dardozzi, the Pontifical Academy of Sciences' Director of Chancellery, and the Pope.



Muons from Japanese investment in UK Laboratory

In November, first muons were produced from a new £10 million beamline at ISIS, the world's most powerful pulsed neutron and muon source at the UK Rutherford Appleton Laboratory.

This is the outcome of a 1990 accord between RIKEN (the Japanese Institute of Physical and Chemical Research) and the then SERC (UK Science and Engineering Research Council) under which RIKEN funded construction of the muon facility at ISIS, built using Japanese and UK expertise and exploited equally by Japanese and UK scientists.

After evaluation and tests, Japanese scientists will embark on a research programme including muon-catalysed fusion using negative muons, while UK researchers will concentrate on using positive muons in a range of experiments to probe the microscopic magnetism of a variety of materials, including high temperature superconductors.

German science writing award

Distinguished Munich theorist and physics author Harald Fritzsch was recently awarded the German Physical Society's medal for science writing. His books, translated into

Inside the 'FermiShelter' a prototype modular tornado shelter developed by Fermilab and a local firm, North Star Chicago Precast through a US Department of Energy Cooperative Research and Development Agreement.

many languages, have strengthened the awareness of the message of basic scientific research.

Meetings

DAFNE 95, the second workshop on physics and detectors for the DAFNE F-factory at Frascati will be held on April 4-7 1995, with the aim of reviewing the status of theory and experiments. Topics will include: CP Violation, Kaon Interactions and Decays, Low Energy Hadron Spectroscopy and Tests of Quantum Mechanics. The workshop will be based on invited talks and roundtable discussions. Attendance will be around 150 persons. For information Email DAFNE@IRMLNF.

The Seventh Lomonosov Conference on "Problems of Fundamental Physics" organized by the Interregional Centre for Advanced Studies (Moscow), Skobeltsyn Institute of Nuclear Physics and the Faculty of Physics of the Moscow State University, the Joint Institute for Nuclear Research (Dubna), the Institute for High Energy Physics (Protvino) and the Institute for Nuclear Research (Moscow) will be held at the Moscow State University, Moscow, Russia from 24 August to 30 August. The programme includes foundations of quantum mechanics, theory of space-time and frontiers of particle physics. Further information can be obtained from the Organizing Committee: studenik@srdlan.npi.msu.su

CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to courier@cernvm.cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

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A whole new generation of PMTs

Hamamatsu Photonics is pleased to announce the birth of a whole new generation of Photomultiplier Tubes. The METAL PACKAGE PMT features all of the high sensitivity and fast response of its predecessors, but is only 1/7th the size. With the development of miniature metal vacuum packages and ultra-thin dynodes, you now have a whole new world of PMTs to choose from. Hamamatsu Photonics first put the most modern technology available to work in designing the electrodes for the multiplier section, using computer simulations of electron trajectories, and then turned to our own original precision processing technology to make a new dynode to within 1/10th thickness its conventional size. With these breakthroughs, we are proud to bring you a new modular configuration with a built-in power supply and drive circuit. And what's more, it runs on a low voltage of only +12 V.

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The smallest photomultiplier tube in the world
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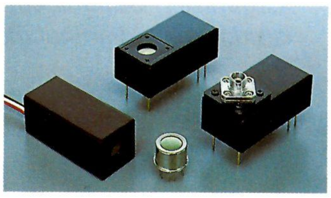
METAL PACKAGE PMT



PHOTOSENSOR MODULES
Left: H5783 (cable output type) Center: H5773 (on-board type which allows to mount directly on a printed circuit board) Right: H5773 with fiber connector

HAMAMATSU PHOTONICS K.K., Electron Tube Center
314-5, Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-01 Japan. TEL:81-539-62-5248 FAX:81-539-62-2205 TLX:4289-625

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