INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 44 NUMBER 8 OCTOBER 2004

Celebrating half a century

Covering current developments in high-energy physics and related fields worldwide

CERN Courier is distributed to member-state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August, in English and French editions. The views expressed are not necessarily those of the CERN management.

Editor Christine Sutton
CERN, 1211 Geneva 23, Switzerland
E-mail: cern.courier@cern.ch
Fax: +41 (0) 22 785 0247
Web: cerncourier.com

Advisory board James Gillies, Rolf Landua and Maximilian Metzger

Laboratory correspondents:
Argonne National Laboratory (US): D Ayres
Brookhaven National Laboratory (US): P Yamin
Cornell University (US): D G Cassel
DESY Laboratory (Germany): Ilka Flegel, Petra Folkerts
Fermi National Accelerator Laboratory (US): Judy Jackson
GSI Darmstadt (Germany): G Siegert
INFN (Italy): Barbara Gallavotti
IHEP, Beijing (China): Tongzhou Xu
Jefferson Laboratory (US): Steven Corneliussen
JINR Dubna (Russia): B Starchenko
KEK National Laboratory (Japan): A Maki
Lawrence Berkeley Laboratory (US): Christine Celata
Los Alamos National Laboratory (US): C Hoffmann
NIKHEF Laboratory (Netherlands): Paul de Jong
Novosibirsk Institute (Russia): S Eidelman
Orsay Laboratory (France): Anne-Marie Lutz
PPARC (UK): Peter Barratt
PSI Laboratory (Switzerland): P-R Kettle
Rutherford Appleton Laboratory (UK): Jacky Hutchinson
Saclay Laboratory (France): Elisabeth Locci
IHEP, Serpukhov (Russia): Yu Ryabov
Stanford Linear Accelerator Center (US): Neil Calder
TRIUMF Laboratory (Canada): Marcello Pavan

Produced for CERN by Institute of Physics Publishing Ltd
Institute of Physics Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel: +44 (0)117 929 7481; E-mail: jo.nicholas@iop.org; Web: iop.org

Publishing director Richard Roe
Publisher Jo Nicholas
Art director Andrew Giaquinto
Senior production editor Ruth Leopold
Technical illustrator Alison Tovey
Display advertisement manager Jonathan Baron
Recruitment advertisement manager Jayne Purdy
Display sales Ed Jost
Recruitment and classified sales Yasmin Agilah and Moo Ali
Advertisement production Joanne Derrick, Katie Graham
Product manager Claire Webber

Advertising Jonathan Baron, Ed Jost, Jayne Purdy, Yasmin Agilah or Moo Ali
Tel: +44 (0)117 930 1265 (for display advertising) or +44 (0)117 930 1196 (for recruitment advertising);
E-mail: sales@cerncourier.com; Fax: +44 (0)117 930 1178

General distribution Jacques Dallemagne, CERN, 1211 Geneva 23, Switzerland. E-mail: courrier-adressage@cern.ch
In certain countries, to request copies or to make address changes, contact:
China Chen Huaiwei, Institute of High-Energy Physics, PO Box 918, Beijing, People's Republic of China
Germany Gabriela Heessel or Veronika Werschner, DESY, Notkestr. 85, 22603 Hamburg 52. E-mail: desypr@desy.de
Italy Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Roma
UK Mark Swaisland, CLRC, Daresbury Laboratory, Keckwick Lane, Daresbury, Warrington WA4 4AD. E-mail: m.swaisland@dl.ac.uk
US/Canada Published by *Cern Courier*, 6N246 Willow Drive, St Charles, IL 60175. Periodical postage paid in St Charles, IL.
Fax: 630 377 1569. E-mail: vosses@aol.com
POSTMASTER: send address changes to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel: +41 (0) 22 767 61 11
Telefax: +41 (0) 22 767 65 55

Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

ISSN 0304-288X

CERN COURIER

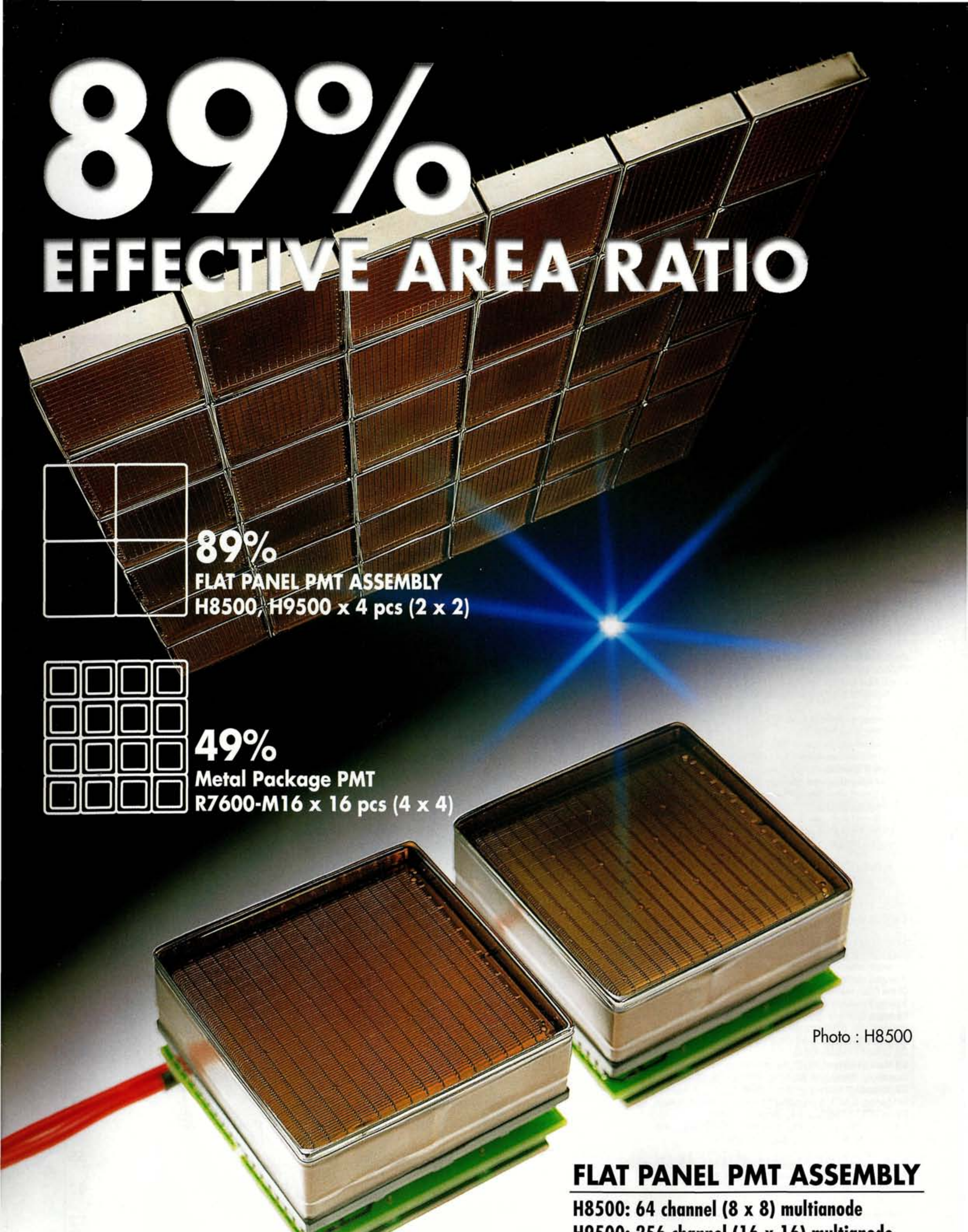
VOLUME 44 NUMBER 8 OCTOBER 2004


New exoplanet discovered p19


Images from the past 50 years p35


CERN hosts UAE students p55

Cover: CERN's 50th anniversary was celebrated on 30 July in the introductory fireworks for the 2004 Fêtes de Genève. The pyrotechnic display told the story of the Big Bang and the emergence of the particles and forces that are studied in experiments at CERN.


89%
EFFECTIVE AREA RATIO
89%
FLAT PANEL PMT ASSEMBLY
H8500, H9500 x 4 pcs (2 x 2)
49%
Metal Package PMT
R7600-M16 x 16 pcs (4 x 4)
Photo : H8500
FLAT PANEL PMT ASSEMBLY
H8500: 64 channel (8 x 8) multianode
H9500: 256 channel (16 x 16) multianode

ACCELERATORS

Cold technology for future linear collider

The International Committee for Future Accelerators (ICFA) has accepted that superconducting technology should be used for a future electron–positron linear collider in the energy range 0.5 to 1.0 TeV – now to be known as the International Linear Collider. In making this decision, ICFA unanimously followed the advice of the International Technology Recommendation Panel (ITRP), which had been charged last November with evaluating and then choosing between two possible technologies, generally referred to simply as "warm" and "cold".

The two technologies, which have been developed in America, Asia and Europe over the past decade, differ mainly in their accelerating structures. In the "warm" version the accelerating cavities are normally conducting and operate at room temperature, while the "cold" technology is based on superconducting cavities that work at a temperature of 2 K.

The normally conducting technology, which has been developed jointly by the Next Linear Collider and Global Linear Collider collaborations, operates at a frequency of 11.4 GHz, in the "X-band" range, with copper accelerating cavities. It would require a tunnel up to 30 km long, with a second parallel tunnel to house the klystrons needed to generate the radiofrequency accelerating fields.

At 1.3 GHz the operating frequency of the accelerating cavities for the superconducting technology, developed by the TESLA collaboration, lies in the "L-band" region. Such a machine would require a longer tunnel, up to 40 km long. However, with superconducting niobium, the transfer of power from the drive klystrons to the electron and positron beams is highly efficient, and nearly all the power is transmitted to the beam; in the warm technology only around one-third of the power is transmitted.

In November last year ICFA's International Linear Collider Steering Committee (ILCSC) appointed the ITRP, comprising 12 experts from America, Asia and Europe under the chairmanship of Barry Barish from the California Institute of Technology. The panel met six times as it progressed from initial planning through visits to test facilities at DESY, KEK and SLAC, to its final deliberations and a conclusion. The members of the panel essentially gave up their normal work for six months while they interacted intensively with the international particle-physics community and with each other. They finally presented their recommendation to ICFA and the ILCSC at a special meeting in Beijing on 19 August. ICFA's endorsement was announced on the following day at the ICHEP'04 meeting in Beijing (see p6).

The International Technology Recommendation Panel. Front row, left to right: Akira Masaike, George Kalmus, Volker Soergel, Barry Barish, Giorgio Bellettini, Hirotaka Sugawara and Paul Grannis. Back row: Gyung-Su Lee, Jean-Eude Augustin, David Plane (secretary), Jonathan Bagger, Norbert Holtkamp and Katsunobu Oide.

"Both the 'warm' X-band technology and the 'cold' superconducting technology would work for a linear collider," explains Barish. "Each offers its own advantages and each represents many years of R&D by teams of extremely talented and dedicated scientists and engineers. At this stage it would be too costly and time consuming to develop both technologies toward construction. The decision was not an easy one, because both technologies were well advanced and we knew the selection would have significant consequences for the participating laboratories."

To help arrive at a recommendation, the panel developed a matrix of evaluation criteria. These included issues of cost and schedule as well as technical and physics operation issues. In the end the superconducting technology had features that tipped the balance in its favour, some of which stem from its lower frequency. The ITRP did however recognize the importance of the work that has been done on warm technology.

In addition to the much lower power consumption of superconducting technology, the panel cited the large cavity aperture and long bunch interval, which simplify operations, reduce the sensitivity to ground motion, permit inter-bunch feedback and may enable increased beam current. They also concluded that the main linac and radiofrequency systems are of lower risk. The construction of the superconducting X-ray free-electron laser will provide prototypes and test many aspects of the linac, and the industrialization of most of the major components for such a linac is already underway.

The panel was keen to stress that it had interpreted its mandate as being to choose a technology not a design. The decision by ICFA to accept the panel's recommendation will now allow the next big step to be taken, to develop the technical design for the International Linear Collider as rapidly as possible. The ILCSC has already secured an agreement that America, Asia and Europe will work together under a central team, and a director and site for the team are now being sought.

CHINA

Physicists meet in Beijing at ICHEP'04...

ICHEP'04, the 32nd International Conference on High Energy Physics, was successfully held in Beijing from 16–22 August, hosted by the Institute of High Energy Physics (IHEP) and the Chinese Academy of Sciences (CAS). As many as 737 physicists attended the meeting, which was opened by Chen Hesheng, director of IHEP, and Bai Chunli, vice-president of CAS.

The programme, as usual for ICHEP conferences, featured plenary talks to review the developments in major topics of interest to the global high-energy physics community, and parallel sessions consisting of talks about recent research results and future plans. There were 25 review talks in the plenary sessions and 296 talks in the 13 parallel sessions. The talks covered a wide range of topics, including electroweak physics, quantum chromodynamics, heavy quark and charm physics, top physics, neutrino physics, particle astrophysics and cosmology, hadron spectroscopy, charge–parity violation, quark matter, the search for new particles, and future accelerators and detectors.

A plenary session in full swing at ICHEP'04, which was held in Beijing, China, in August.

The results from experiments at the Tevatron, the B-factories, the Beijing Electron–Positron Collider (BEPC) and the Relativistic Heavy Ion Collider at Brookhaven, as well as from accelerator-based and non-accelerator-based neutrino experiments also attracted great interest. In particular, experimental results on the possible pentaquark states and their theoretical interpretation were discussed extensively; the majority opinion seems to be that more experimental and theoretical studies are needed before any conclusions can be made. Progress in string theory, extra dimensions, black holes and lattice gauge calculations were also discussed.

The conference was also the occasion for the announcement, on 20 August by Jonathan Dorfan, chairman of the International Committee for Future Accelerators, that the committee had approved the recommendation by the International Technology Recommendation Panel that "cold" technology should be adopted for the future International Linear Collider (see p5).

...and MENU takes eastern flavour for 10th anniversary

Beijing was also the meeting place later in August for the Tenth International Symposium on Meson–Nucleon Physics and the Structure of the Nucleon (MENU2004), which was held at IHEP on 30 August to 4 September. This series of meetings covers a wide range of experimental and theoretical developments in meson–nucleon physics, baryon spectroscopy, photo/electro-production of mesons, dibaryons, structure of the nucleon, chiral symmetry-based effective field theories, quantum chromodynamics-inspired quark models of hadrons, and so on. Previous symposia have oscillated between Europe and North America, but now the BES collaboration at BEPC has become a new member of the "MENU club" through its studies of N* production from J/ψ decays over the past few years, and for the first time MENU went east.

MENU2004 attracted about 150 participants from 23 countries around the world, and there were around 100 talks. The scope of the conference provided ample evidence that the meson–nucleon problem is still as interesting and viable as it was 21 years ago at the first MENU in Karlsruhe in 1983. This time the search for missing baryon resonances and pentaquark states, and the properties of the baryon resonances were the main issues. While the LEPS collaboration at the Spring-8 synchrotron radiation facility in Japan reported some new evidence of the θ pentaquark in their γd experiment, decisive results from high-statistics data at Jefferson Lab (Jlab) in the US are still awaited. Experiments at BEPC, Jlab, the Electron Stretcher Accelerator in Bonn and elsewhere, have reported some new evidence for missing N* resonances.

The next few years will see many important developments in this field, with new facilities at JPARC in Japan and GSI in Germany, major upgrades at BEPC and Jlab, and the transfer of the WASA detector from Uppsala to the cooler synchrotron, COSY, at Jülich. To celebrate the tenth anniversary of MENU, the meeting included an impressive concert of Chinese ethnic folk music, and the delighted participants are now looking forward to a bright future and the next MENU at Jülich in 2007.

DESY

HERA gets set to demonstrate its full potential

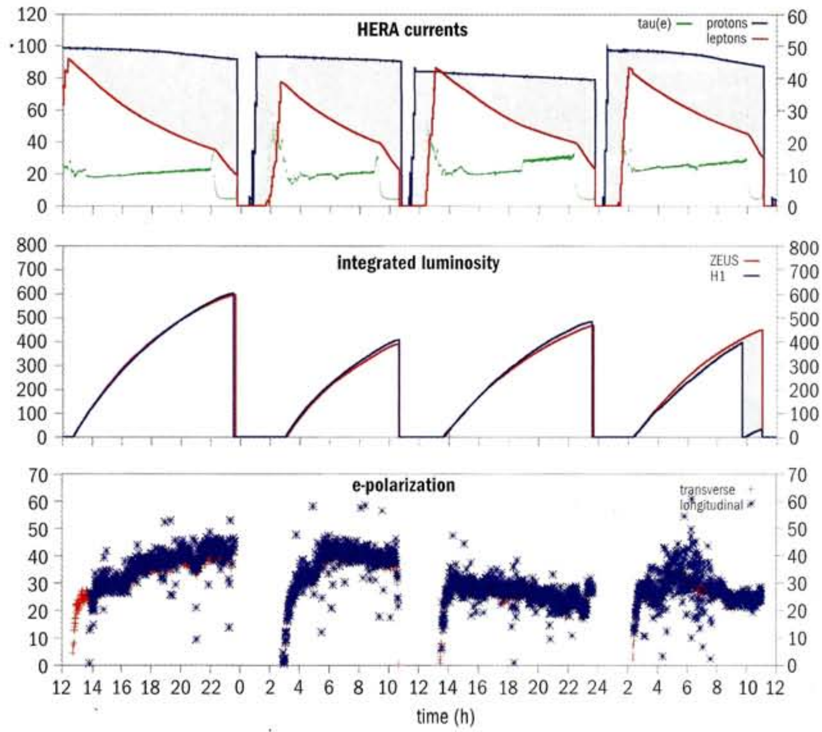
When the electron–proton storage ring HERA at DESY began its summer shutdown in mid-August, it had broken several records. It had delivered a luminosity of $3.8 \times 10^{+31}$ cm^{-2}s^{-1}, exceeding its previous record of $2.0 \times 10^{+31}$ cm^{-2}s^{-1}, with an integrated luminosity of 87 pb^{-1}, which beat the previous record in 2000, and it had become the first storage ring to provide longitudinally polarized high-energy positrons in colliding-beam mode.

It has been a long and hard struggle to get HERA back into successful operation after a challenging upgrade in 2000 and 2001. Unexpectedly severe backgrounds prevented the collider experiments H1 and ZEUS from taking data when HERA restarted in 2001. The main causes were found to be the strong heating of the beam pipe due to the short positron bunches and the intense synchrotron radiation from the positrons close to the experiments. These resulted in a degradation of the vacuum, and the spray of particles from the interaction of the proton beam with the residual gas produced the unacceptable backgrounds.

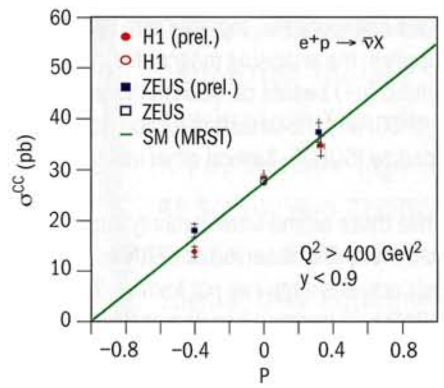
Close collaboration between the HERA machine crew and the experiments, aided by external and internal advisory committees, allowed one problem after the other to be identified, understood and solved. Major changes to the beam collimation system, the vacuum system and the detectors were required. Finally, early in 2004, the improvements were such that H1 and ZEUS were able to take data at the nominal HERA beam currents (100 mA of protons and 50 mA of positrons). From then on, the HERA machine crew could concentrate on steadily increasing the HERA currents while the experimenters could focus on taking data efficiently. In parallel, the positron polarization was improved steadily and values in excess of 50% were reached. However, work still remains to be done to achieve high polarization reliably at high luminosities.

All three experiments at HERA – H1 and ZEUS as well as the HERMES experiment with a polarized gas target – have successfully taken data in 2004, with results already presented at ICHEP'04, the International Conference on High Energy Physics held in Beijing in August (see p6). Examples include the first, long-awaited measurement of the polarization dependence of the weak interaction cross-section by H1 and ZEUS, and the world's first determination of the structure of the proton by measuring the scattered positron and the hadronic final state using a target transversely polarized to the direction of the positron beam by the HERMES experiment. While the results are interesting, they demonstrate that about 10 times more data, taken with both electrons and positrons, are required to exploit the scientific potential of the upgraded HERA collider.

During the two months of the summer shutdown, the HERA crew has continued to improve the vacuum system, exchanged components that have caused inefficiencies in running and carried out the regular safety checks that are legally required. When HERA comes back into operation this month (October), the challenge will be to demonstrate that the machine and its experiments are also able to run and take data efficiently with electrons – as they have now proved they can do with positrons.



A display of the HERA machine cycle demonstrating good performance with, at top, the proton current (blue), the positron current (red) and the positron lifetime (green); at centre, the luminosity accumulated by the experiments H1 and ZEUS; and at bottom, the positron polarization as measured by the two HERA polarimeters.



The polarization dependence of the charged-current cross-section is visible in the measurement shown here, which was made possible by longitudinally polarized positron beams in HERA. The plot demonstrates parity violation in the weak interaction in lepton–proton collisions at the highest energies.

RADIOACTIVE BEAMS

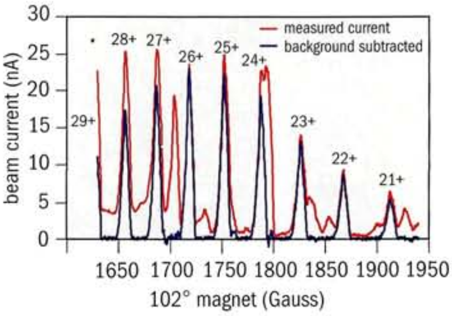
PHOENIX provides successful charge breeding at ISOLDE

A key development for the future of high-energy radioactive ion-beam facilities is the efficient and fast "charge-state breeding" from singly charged ions at low energies (10–60 keV). Recently, a major breakthrough has been made with the first charge breeding with an electron cyclotron resonance (ECR) source at the ISOLDE facility at CERN.

Two processes for the charge breeding of 1+ states to multi-ionized ones are currently available. At ISOLDE the 1+ beam is cooled into a Penning trap before injection into an electron-beam ion source (EBIS), which performs the multi-ionization. At the Laboratory for Subatomic Physics and Cosmology (LPSC), Grenoble (CNRS/IN2P3-UJF-ENSPG), the 1+ beam is captured directly into the dense plasma of a dedicated ECR ion source, the PHOENIX Booster, which ensures the cooling and multi-ionization.

At the end of an EU contract on charge breeding (HPRI-CT-1999-50003), which set up a collaboration of European laboratories to study this important topic, the IS397 experiment at ISOLDE was agreed upon to compare the characteristics of the two techniques. The concept of the PHOENIX Booster has already been chosen for two future facilities, ISACII at TRIUMF in Vancouver, Canada, and SPIRALII at GANIL in Caen, France.

Charge breeding of stable ions with an ECR ion source (ECRIS) has been conceived, studied and improved over the past 10 years at LPSC. The first ECRIS used was MINIMAFIOS,



The spectrum measured for $_{238}U^{n+}$ ions extracted from the IS397 experiment.

by Richard Geller, and since 2000 a dedicated one, the PHOENIX Booster, has been developed together with its associated injection optics by Pascal Sortais and Thierry Lamy. For the primary beams more than 20 elements have been produced by various ion sources (thermo-ionization, glow discharge, ECRs). The parameters measured are the efficiency yields, the charge-breeding times, and eventually, for pulsed modes, the time the multicharged ions are trapped in the device.

The IS397 set-up at ISOLDE duplicates the experiment at LPSC to assure a fully comparable operation. The CLRC Daresbury Laboratory made its PHOENIX source available to the collaboration, together with all its power supplies; the analysing magnet for the multi-ionized (n+) beams came from the test bench at LPSC; and the detection device was provided by ISOLDE. Several other institutes have also contributed with equipment, including Ludwig-Maximilians-Universität with a double Einzel lens and GSI with power supplies.

In the experiment a 50 nA $_{238}U^{+}$ beam from the REX-ISOLDE target was injected in the PHOENIX source. The extracted spectrum (see figure) shows a 2% efficiency for $_{238}U^{26+}$. The $_{96}Sr^{15+}$ and $_{94}Rb^{15+}$ states have also been produced, as well as stable and radioactive ions of the noble gases argon, xenon and krypton.

The main advantages of the technique are the simple technology, the fast tuning and the reliability of the system. For the future development of high-intensity accelerators, it is important to note that there is no limitation on the 1+ primary beam current accepted by the process. This is due to the high density of the ECR plasma, which varies as the square of the radiofrequency used to produce the ionizing plasma. Currently 14 GHz is used, giving a density of a few 10^{12} ions per cm^3. The limitation currently is the ECR breeding of the light elements like lithium, sodium and neon, which is less efficient than the Penning trap–EBIS system. However, one of the goals of IS397 is to conclude in which context each technique is more convenient.

● The charge-breeding collaboration is Ludwig-Maximilians-Universität, Munich, Germany; LPSC Grenoble, France; CLRC Daresbury Lab, UK; ISOLDE, CERN, Switzerland; GANIL, Caen, France; INFN, Legnaro, Italy; Kungliga Tekniska Högskolan, Stockholm, Sweden; and the University of Jyväskylä, Finland.

ANTIMATTER

ATRAP catches speed of antihydrogen

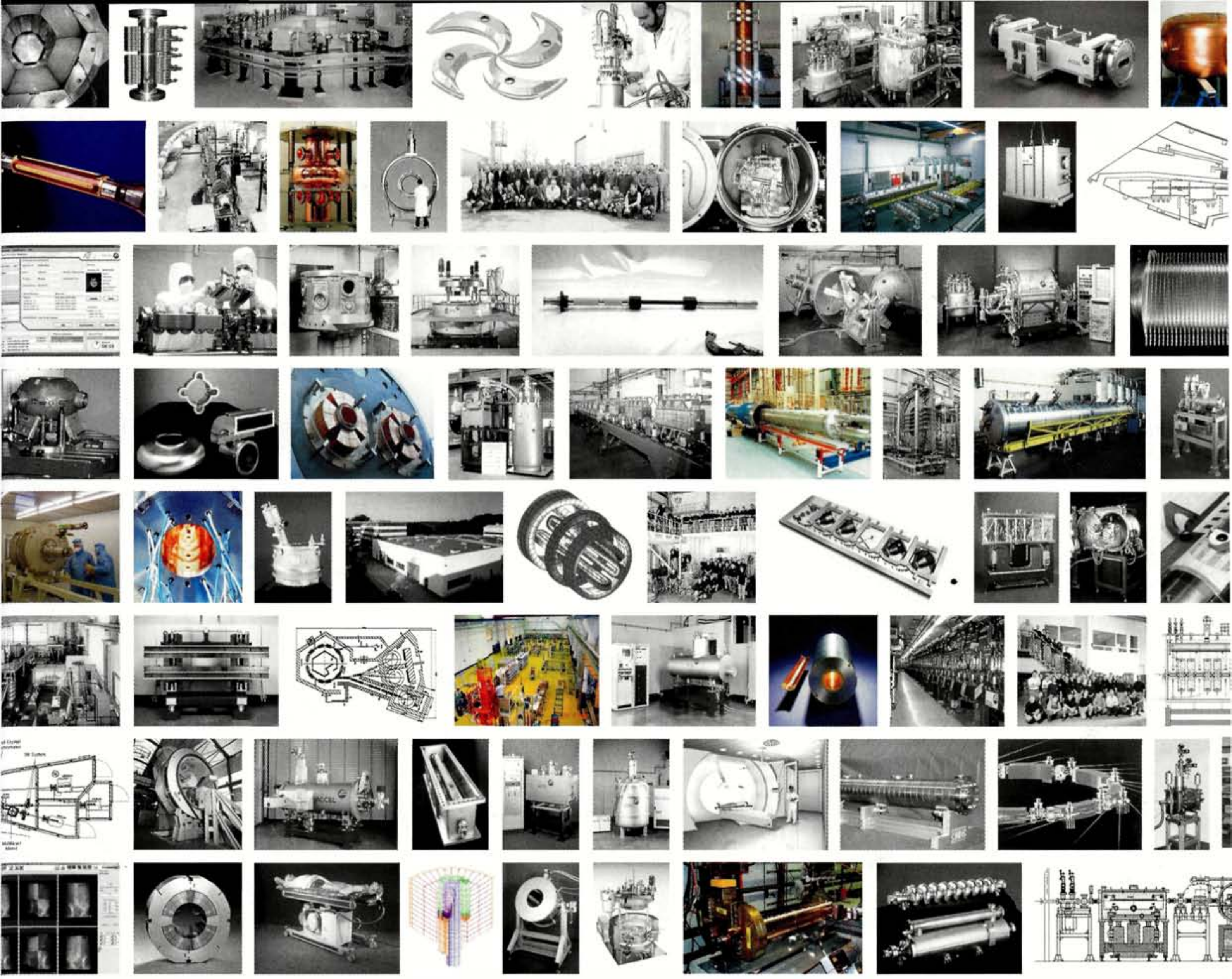
The ATRAP experiment at CERN has made the first measurement of the velocity of slow antihydrogen atoms. This is an important step towards the goal of producing antihydrogen atoms cold enough – that is, slow enough – for precision spectroscopy.

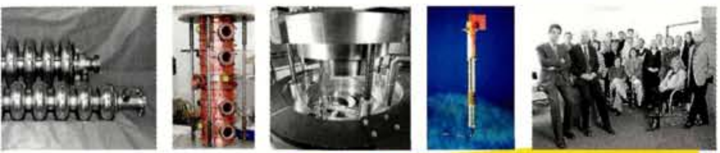
Both the ATRAP and ATHENA experiments at CERN's Antiproton Decelerator announced the production of large numbers of "cold" antihydrogen atoms in 2002 (*CERN Courier* November 2002 p5; December 2002 p5). While these atoms were certainly much colder than those first observed at CERN in 1995, their actual energy was not known. Now the ATRAP collaboration has demonstrated a technique for determining the velocity of those antihydrogen atoms that pass through an oscillating electric field without ionizing.

In ATRAP, antihydrogen atoms form in a nested Penning trap and then move through an electric-field region prior to detection; only those atoms not ionized in the field are detected. The measurement of the atoms' velocity depends on observing how the number of atoms detected varies with the oscillation frequency of a time varying field superimposed on a static field. The slowest atoms will be ionized and never reach the detector, while faster atoms may pass through unaffected depending on the phase of the field they encounter; as the frequency of the oscillating field is increased, fewer atoms will move fast enough to remain unionized. The team found that the most weakly bound atoms to make it through to detection have an energy of 200 meV. This corresponds to a velocity about 20 times higher than the average thermal velocity at a temperature of 4.2 K (Gabrielse *et al.* 2004). The speed of more tightly bound states, which could have lower velocities, could be measured by the same method with a higher static field, but this would require more time.

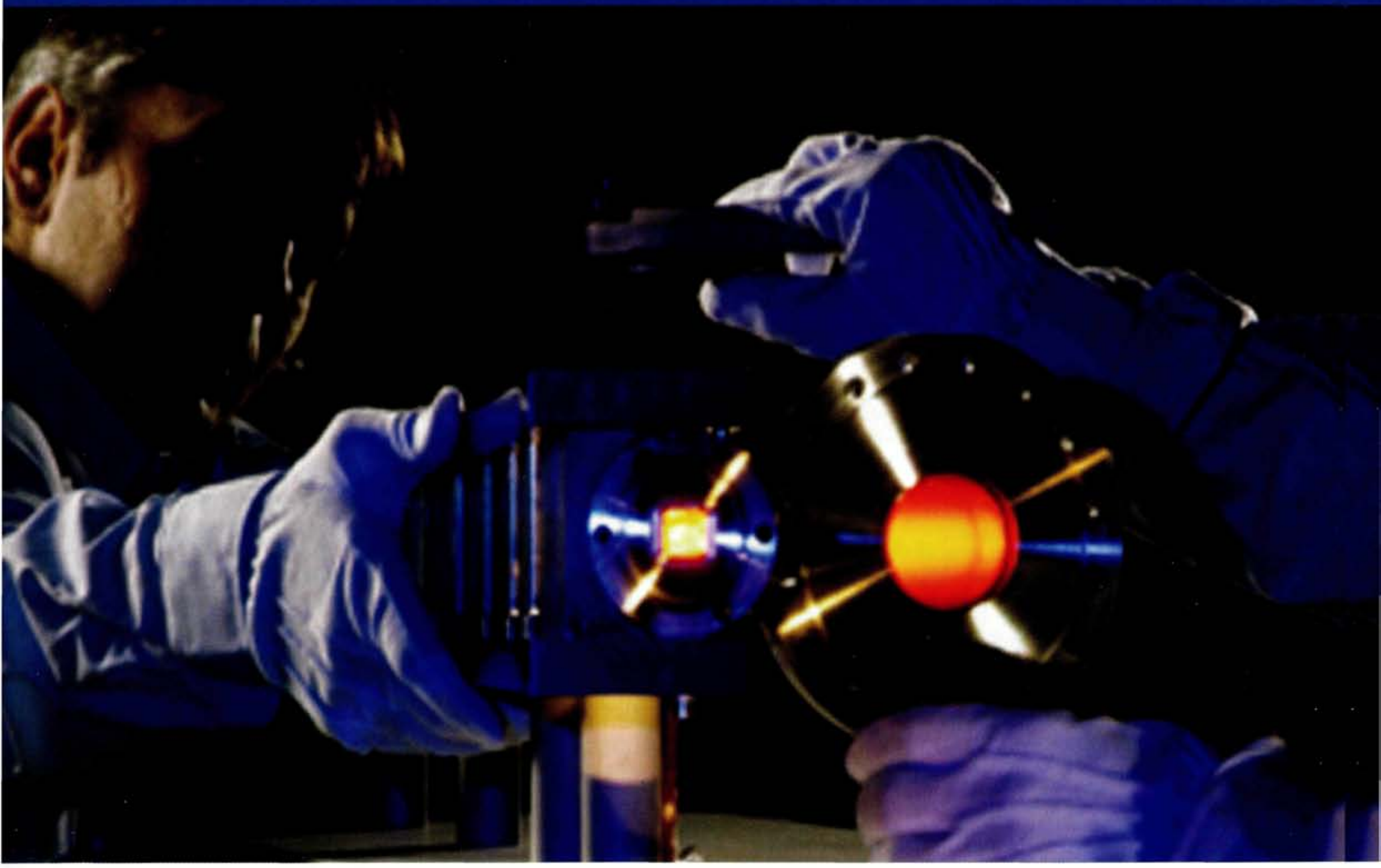
Further reading

G Gabrielse *et al.* 2004 *Phys. Rev. Lett.* **93** 073401.





All you need...



Physics
Magnets
Particle accelerators
Synchrotrons
Ion sources
Electrostatics
Beamlines

Power Converters
Standard
Custom designed
Shim amplifiers

Transducers
Onboard electronics
Rack type
Multichannel

Check out our new website
www.danfysik.com

DANFYSIK

Møllehaven 31 • DK-4040 Jyllinge • Denmark
Tel. +45 4679 0000 • Fax +45 4679 0001
sales@danfysik.dk • www.danfysik.com

To celebrate the 50th anniversary of CERN, we look back at some of the items in the early issues of *CERN Courier*

CERN

The story of the European Organization for Nuclear Research

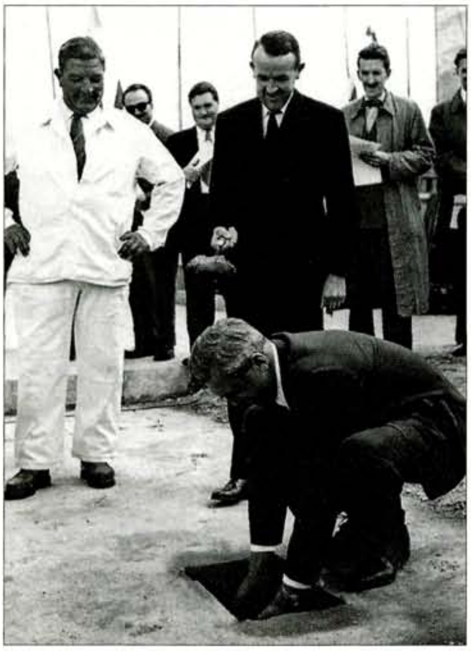
The post-war exodus of an alarming number of European physicists to countries with more advanced research equipment provided the basic agreement for the setting up of a big European centre for fundamental nuclear research. European physicists considered that the equipment of the centre should, above all, include a high-energy accelerator that would allow further research work on mesons, the new particles that were being observed in cosmic rays.

However, the idea of setting up a laboratory for pure research was not born until later. This was because those in favour of international co-operation were aware that public opinion might be willing to accept heavy expenditure on nuclear projects that would sooner or later provide some return, but that it might prove reluctant to countenance the spending of comparable sums on pure scientific research.

As time went by though, public opinion came to realize the need for disinterested research, the basic driving force of progress. Accordingly, Louis de Broglie's proposal at the European Cultural Conference in Lausanne, at the end of 1949, received the attention it deserved. He favoured the creation in Europe of regional research institutes for the types of nuclear research calling for powerful machines. Once the resolution to that effect had been adopted, it was up to an international body to lay the material foundations of European co-operation in fundamental nuclear research.

On 7 June 1950 UNESCO, the United Nations Educational, Scientific and Cultural Organization, held its General Conference at Florence. There, Professor I I Rabi (USA) suggested that the time had come to set up regional co-operative laboratories.

At the instigation of Professor P Auger of UNESCO, another conference was held at the end of 1950 at the European Centre of Culture in Geneva. The necessity of European co-operation prompted Italy, France and Belgium to contribute a total of $10 000. With the UNESCO contribution it became possible to set up a planning office to choose a group of consultants from eight European countries.



The foundation stone was laid on 10 June 1952 in the presence of Swiss and CERN authorities. Felix Bloch, CERN's first director-general, laid the stone on the laboratory site, watched by Max Petitpierre, then president of the Swiss Confederation.

These consultants met for the first time in May 1951. They suggested as a long-term project the construction of the biggest accelerator technically possible and, in the meantime, the construction of a machine with which the European scientists could become familiar with high-energy physics. From the administrative angle it was decided to set up an interim organization responsible for the preparation of construction plans and draft budgets.

In fact, this interim organization had the advantage of bringing together the views of the various governments before they became committed. It was expected that with a budget of about $250 000 the interim organization could complete the design of its accelerators in 12 to 18 months.

EDITOR'S NOTE

Fifty years ago, at the end of September, the European Organization for Nuclear Research, better known simply as CERN, came into being. This extract describing some of the key events in the "pre-history" of CERN is taken from issue 6/7 of the *CERN Courier*. This was the first issue of 1960 and it celebrated the inauguration of the Proton Synchrotron, CERN's first major machine, the construction of which had been foreseen as early as 1951, as the article explains.

The interim CERN

The government delegates met twice more under the auspices of UNESCO, which invited all its European members, including the countries of Eastern Europe. Twelve countries from Western Europe were represented at the two big conferences held in Paris at the end of 1951 and in Geneva at the beginning of 1952.

In Geneva the representatives of 12 European governments signed the convention setting up the interim organization, which came into being on 15 February 1952 with the title of "European Council for Nuclear Research", called "CERN" for short after the initials of the French title. Belgium, Denmark, France, the German Federal Republic, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland and Yugoslavia were then provisionally united to carry out nuclear research. During the whole lifetime of the interim CERN, the United Kingdom remained simply an observer, although the interest shown in the project by that country soon took the shape of new ideas, the provision of consultants and gifts.

The first Council session was held in Paris in May 1952 and the senior staff were appointed. E Amaldi of Rome was appointed secretary-general, and the direction of the four design groups for the Proton Synchrotron, the Synchrocyclotron, the laboratory and the theoretical studies were entrusted, ▷

respectively, to O Dahl of Bergen, C J Bakker of Amsterdam, L Kowarski of Paris and Niels Bohr of Copenhagen.

The Proton Synchrotron group embarked on its ambitious project, the construction of the biggest accelerator in the world, based on a new and untried principle.

The Synchrocyclotron group assumed the task of providing CERN within a short time a conventional machine of up-to-date design and sufficiently high energy to enable the European organization to work in a new field of nuclear physics. It complied with the requirements of speed of construction, high energy and facilities for exploring new fields. By 1957 CERN had at its disposal a 600 MeV synchrocyclotron that was soon being used 24 hours a day and which rapidly provided scientific data of outstanding interest.

In October 1952, at its third session, the Council decided that the future European laboratories should be set up in Geneva. The places originally considered had been Paris, Copenhagen, Arnhem and Geneva. The latter was chosen because of its international nature, its geographical position and Switzerland's offer to make available at Meyrin the 40 hectares of land necessary.

A description of CERN's two machines and of its future installations, and an estimate of capital and operational costs were submitted to the Council in April 1953. These reports were the prelude to the setting up of a permanent organization.

The permanent organization

The convention establishing the permanent organization was signed in Paris on 1 July 1953. The UK, which had been an observer until then, was the first to ratify the convention on 30 December 1953. Once Italy had ratified it, on 24 December 1955, the 12 European nations became jointly committed on specific major issues.

In the meantime, the interim CERN was kept in existence from quarter to quarter until 29 September 1954, the date when the participation of a minimum of seven states was secured. The European Council for Nuclear Research, a provisional body, ceased to exist. It became the "European Organization for Nuclear Research" but kept the initials "CERN", which had been adopted in 1952 for the interim period. Some activity was possible even on the very small budget available. On 17 May 1954 work was started on the Meyrin site.

On 1 October 1954, just after the establishment of a permanent organization, CERN's staff comprised 114 members. In the course of the same month, the Council appointed the director-general of CERN, Professor Felix Bloch (USA), a Nobel prize-winner for physics on temporary leave of absence from Stanford University. Sir Ben Lockspeiser (UK) succeeded Robert Valeur (France) as president of the Council. It was at this time that the Council was organized in its present form, namely with two vice-presidents and with the Committee of Council, the Scientific Policy Committee and the Finance Committee.

● Taken from *CERN Courier* January/February 1960.

POWER CONVERTERS

BRUKER

Principles :

Current or voltage stabilized from % to the sub ppm level

Technologies :

- Linear, Switch Mode primary or secondary,
- Hard, or resonant, Buck,
- Boost, 4-quadrant operation

Limits :

- 1A up to 25kA
- 3V to 50kV
- 0.1kVA to 3MVA

Control :

- Local manual and/or computer control
- Interfaces: RS232, RS422, RS485, IEEE488/GPIB,
- CANbus, Profibus DP, Interbus S, Ethernet
- Adaptation to EPICS
- DAC and ADC 16 to 20 bit resolution and linearity

Applications :

- Electromagnets and coils
- Superconducting magnets or short samples
- Resistive or capacitive loads
- Klystrons, IOTs, RF transmitters

5V/300A for supraconducting magnets
with 10 extra shims

80V/600A, 50kW
linear technology
< 5ppm stability
IEE488

60V/3500A, 210kW
Thyristor controlled (SEM®)
10^{-4}, Profibus

For more informations www.bruker.fr

BRUKER BIOSPIN S.A. • France
34 rue de l'industrie • F-67166 Wissembourg Cedex
Tél. +33 (0)3 88 73 68 00 • Fax. +33 (0)3 88 73 68 79
power@bruker.fr

BRUKER BIOSPIN


Visit us online or Call for a Free Catalogue
MDC
VACUUM PRODUCTS CORPORATION
23842 Cabot Boulevard
Hayward, CA
U.S.A. 94545-1661
Toll-Free 1.800.443.8817
Fax 1.510.887.0626
e-mail: sales@mdcvacuum.com
Order direct from our factories and receive 10% off of our catalogue prices
on MDC Flanges & Fittings, Valves, Roughing Components, Motion & Manipulation, Chambers and Thin Film Deposition products, as well as on ISI Electrical Feedthroughs, Brakes & Envelopes and Sapphire & Quartz Viewports
Limited time offer
Building-Blocks
for Vacuum Science and Technology
e-Vap®
ELECTRON BEAM TECHNOLOGY
High & Ultrahigh Vacuum
Thin Film Deposition Technology
e-Vap®
Electron beam Technology
www.mdcvacuum.com

Compiled by Steve Reucroft and John Swain, Northeastern University

New polymer enables room-temperature plastic magnet

Physicists at the University of Durham in the UK have created the first plastic magnet that operates at room temperature, using a new polymer, PANiCNQ. Naveed Zaidi and colleagues synthesized the new material out of a combination of emeraldine base polyaniline (PANi) and tetracyanoquinodimethane (TCNQ). The measurements made by the group indicate that the material has a Curie temperature above 350 K and, more tentatively, that it is ferri-magnetic (Zaidi *et al.* 2004).

Some of the most compelling evidence for the magnetic nature of the new material comes from magnetic force microscopy, in which sequential images show evidence for the movement of a magnetic domain wall. Intriguingly, the magnetically ordered state apparently develops with time, and this seems to be correlated with structural changes – possibly a gradual alignment of the polymer chains – indicated by X-ray diffraction measurements.

The choice of materials is interesting, with PANi being a metal-like conductor that is stable in air and TCNQ serving as a source of free radicals (i.e. unpaired electrons). PANiCNQ is only about 1/100th the strength of conventional metal magnets, but the researchers are hopeful about improvements. In any case, it is good enough to pick up iron filings, which is already impressive.

Further reading

N Zaidi *et al.* 2004 *Polymer* **45** 5683.
M Killeya 2004 *New Scientist* 28 August p19.

Exotic coat turns fibre into superwire

New superconducting wires made from carbon fibres coated with an unusual magnesium–carbon–nickel compound may offer a great combination of lightness, physical strength and high current-carrying capacity. Phil Adams and David Young of Louisiana State University manufacture the wires by heating nickel-coated carbon fibres in magnesium vapour to produce the superconducting $MgCNi_3$. Estimates of the currents that these wires should be able to carry at absolute zero are some 40 MA/cm^2, corresponding to magnetic fields of 15 T.

This performance is close to what one would expect from more conventional superconductors, but this material is strange even for an exotic superconductor. Lacking the copper and oxygen that go into the cuprate high-T_c superconductors with critical temperatures of around 100 K, this material, with a T_c of 8 K, seems to be another kind of exotic superconductor working via mechanisms that are still not understood.

Further reading

D P Young, M Moldovan and P W Adams 2004 *Phys. Rev. B* **70** 064508.

Following the tracks of the pioneers

The European Space Agency (ESA) may become involved in trying to nail down what has become known as the Pioneer anomaly and perhaps change the way we understand gravity. The effect in question is that the spacecraft Pioneer 10 and Pioneer 11 seem to be following paths that are not what one would expect from present-day theory. At distances of several billion kilometres from the Sun they seem to suffer an unexpected constant acceleration directed towards the Sun, at a level some 10 billion times weaker than the Earth's gravitational pull.

Despite searches for some conventional explanation the effect remains persistent and mysterious. Whether it is to do with dark matter or any of the other present-day cosmic exotica is still unknown, but ESA is now considering a special mission that would measure the Pioneer anomaly a thousand times more precisely than is possible today, so as to lay to rest the question of its reality once and for all.

Further reading

S Turyshev *et al.* 2004 *Physics World* **17(9)** 21.

How nature can carve out a fractal

In introducing the concept of fractals, it's quite common to begin with a discussion of how long a coastline is – clearly the answer depends on the resolution you use. It turns out that an object like this needs to be described by a non-integer dimension a little larger than one and somewhat less than two. Now Bernard Sapoval and A Baldassarri of the Ecole Polytechnique and A Gabrielli of the Enrico Fermi Centre in Rome have gone beyond merely noting this feature of coastlines and have suggested some detailed dynamics that could produce the observed fractal dimension of about 4/3.

A fractal coastline in northern Portugal. (Credit: Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC.)

Their idea is that waves erode the weak points in a smooth shoreline, increasing its length by making it indented. With new weak points exposed by erosion, the same process repeats. The increased roughness of the coastline also increases damping of the waves, so helping to maintain the stability of the larger features. It seems that in this way nature can carve out a fractal.

Further reading

B Sapoval, A Baldassarri and A Gabrielli 2004 *Phys. Rev. Lett.* **93** 098501;
www.aip.org/pnu/2004/split/697-2.html.

Compiled by Marc Türler, INTEGRAL Science Data Centre

The hunt for Earth-sized exoplanets

The discoveries of three new extrasolar planets were recently announced within the space of a week. With masses around or less than 20 times that of the Earth, these new exoplanets are the lightest known so far. After Jupiter- and Saturn-like extrasolar planets, the detection of these Neptune- and Uranus-sized objects represents an important step in the quest for exoplanets similar to Earth.

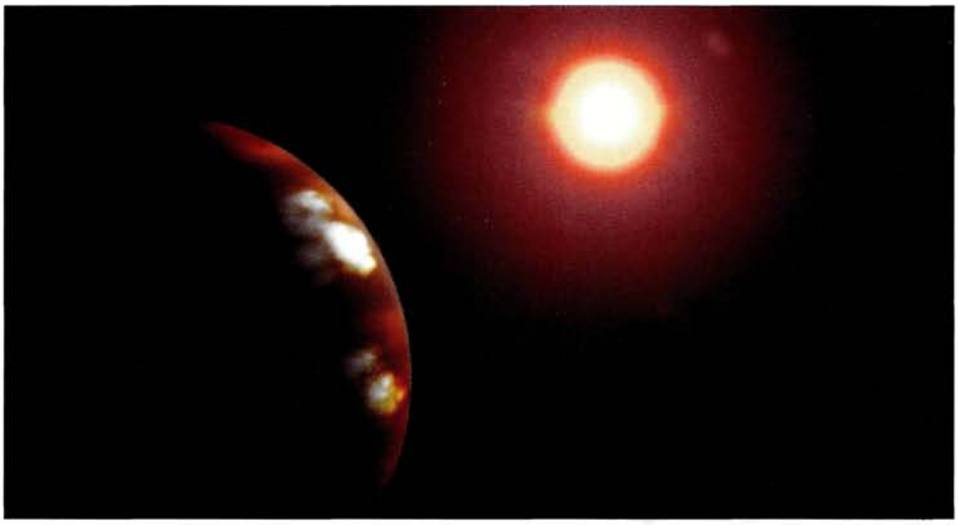
Following the discovery in 1995 of the first extrasolar planet, and fuelled by its enormous impact on the general public, the hunt for exoplanets has already led to the discovery of about 130 planets around nearby stars. Two groups on either side of the Atlantic are leading the race. The European group discovered the very first exoplanet around the star 51 Pegasi and was also the first to announce the discovery of a lightweight planet on 25 August this year. The American group, which has discovered about half of all known exoplanets, responded only one week later by announcing their discovery of two Neptune-sized planets.

The presence of a planet orbiting a star is revealed by its gravitational pull making the star wobble around the centre of mass of the system. The wobbling can be detected in a sequence of radial velocity measurements using high-resolution spectra of the star. This method allows the orbit of the planet – in particular, the period and the distance from the star – as well as a lower limit for its mass to be deduced. Statistically, the true mass will in most cases be not much higher than this limit.

The most precise instrument for detecting exoplanets is currently the High Accuracy Radial Velocity Planet Searcher, HARPS. Installed a year ago on the 3.6 m telescope of the European Southern Observatory at La Silla, Chile, it is able to measure the wobbling of stars with a precision of about 1 metre per second, or around walking speed.

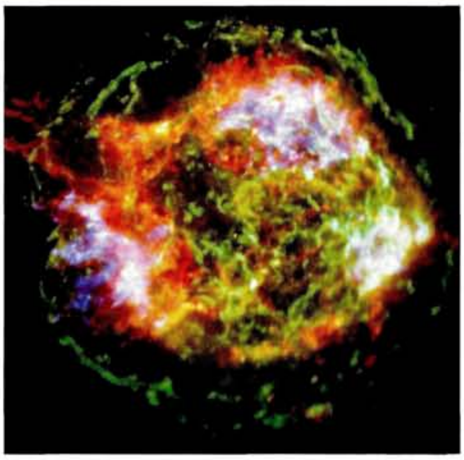
The three newly discovered exoplanets are all very close to their star. Discovered with HARPS by the European group (Santos *et al.* 2004), the Uranus-sized planet (14.5 Earth masses) orbiting μ-Arae accomplishes a full revolution of the star in 9.5 days. The two Neptune-sized planets (17 Earth masses) discovered by the American group have even shorter revolution periods of less than three days. One is orbiting a reddish low-mass star called Gliese 436 (Butler *et al.* 2004), while the other orbiting 55 Cancri is the fourth planet found around this metal-rich star (McArthur *et al.* 2004). Astronomers can only speculate on the true nature of these lightweight planets. They are most likely made of a rocky core surrounded by a small gaseous envelope.

The hunt to detect smaller and smaller exoplanets is far from over. HARPS is able to find planets down to a few Earth masses, paving the way for space missions such as COROT, Eddington and Kepler, which aim to detect a possible transit of the planet in front of the star. The next step will be the direct imaging of the planets with projects such as ESA's Darwin interferometric mission or NASA's Terrestrial Planet Finder. Finding the spectral signature of life in the atmosphere of Earth-like planets will be the ultimate goal of these missions.



An artist's rendition of the newly discovered Neptune-sized exoplanet, which orbits the reddish dwarf star Gliese 436 every 2.6 days. (Image courtesy of NASA.)

Picture of the month



This spectacular X-ray false-colour image of the supernova remnant Cassiopeia A is the most detailed image ever made of the remains of an exploded star. It is the result of a one-million-second (11.5 day) observation by NASA's Chandra X-ray observatory. The point source at the centre of the expanding gas bubble, which is 10 light-years wide, is presumed to be a neutron star created during the supernova explosion some 340 years ago. But, unlike the pulsar in the Crab Nebula, this neutron star does not show evidence for pulsed radiation. (Credit: NASA/CXC/GSFC/U Hwang *et al.*)

Further reading

P Butler *et al.* 2004 *ApJ* http://arxiv.org/abs/astro-ph/0408587.
B E McArthur *et al.* 2004 *ApJ* http://arxiv.org/abs/astro-ph/0408585.
N C Santos *et al.* 2004 *A&A* http://arxiv.org/abs/astro-ph/0408471.

The discovery of the weak neutral currents

Dieter Haidt, from the Gargamelle collaboration, describes how the team's major triumph came about and was eventually accepted.

Thirty years have passed since the discovery of weak neutral currents in the Gargamelle bubble chamber at CERN. Today the huge impact of this discovery on CERN, the field of high-energy physics and beyond, is highly visible; then, however, it was received with great scepticism both by CERN and the physics community.

Shortly after the Siena Conference in 1963, André Lagarrigue, André Rousset and Paul Musset worked out a proposal for a neutrino experiment that aimed to increase the event rate by an order of magnitude. This meant building a large heavy-liquid bubble chamber, later named Gargamelle (figure 1), and also forming a large collaboration. The core of the team consisted of members of Orsay, the École Polytechnique and the neutrino experiments with the CERN NPA (Nuclear Physics Apparatus) division 1 m bubble chamber, which were just finishing. In the end, the collaboration consisted of seven European laboratories and also included guests from Japan, Russia and the US.

Fig. 1. The Gargamelle heavy-liquid bubble chamber, installed into the magnet coils, at CERN in 1970.

The challenge

At the end of the 1950s V-A theory was the "standard model" of weak interactions. Its major drawback was its bad high-energy behaviour, which prompted various ideas to cure the problem of infinities. Guided by quantum electrodynamics, a gauge theory, attempts were made to construct a gauge theory of weak interactions, and in the mid-1960s the hypothesized charged intermediate vector boson ($W^{\pm}$) was complemented with a neutral partner to achieve the required cancellations. The invention of the Higgs mechanism solved the problem of having both a gauge theory and massive mediators of weak interactions. The progress made by Sheldon Glashow, Abdus Salam and Steven Weinberg was completed by the work of Martinus Veltman and Gerard 't Hooft, which proved the renormalizability of the theory. So, as 1971 turned to 1972, a viable theory of weak interactions that claimed weak neutral currents as a crucial ingredient was proposed, challenging the experimental groups to provide "yes" or "no" as an answer to the question "do neutral currents exist?".

By that time two neutrino experiments were running, Gargamelle at the CERN Proton Synchrotron and the HPWF (Harvard, Pennsylvania, Wisconsin, Fermilab) counter experiment at what is now Fermilab. Both were confronted with this challenge without preparation. The searches for neutral currents in previous neutrino experiments resulted in discouragingly low limits, and it was somehow commonly concluded that no weak neutral currents existed. In fact, during the two-day meeting in November 1968 in Milan, where the Gargamelle collaboration discussed its future neutrino programme, the words "neutral current" were not even mentioned. On the contrary, the real highlight that attracted the interest of all was the recent observation of the proton substructure at SLAC, provoking the question of what structure would be revealed by the W in the neutrino experiments as opposed to the photon in electron–proton scattering.

Table 1

	ν-exposure	$\bar{\nu}$-exposure
No. of neutral-current candidates	102	64
No. of charged-current candidates	428	148

Although the quest for neutral currents had been ignored, Gargamelle could meet the challenge once the matter of their discovery became urgent at the beginning of 1972. That is to say, scanning and event classification followed the same rules as established in ▷

the previous, NPA bubble-chamber experiment. There was no muon identification, since weak processes were supposed always to transform an initial-state neutrino into a final-state muon. Consequently, there was an unavoidable background of events in which a charged hadron leaves the visible volume of the chamber without visible interaction, thus faking a muon. Events with a muon candidate were collected in one category, A, while events consisting of secondaries that were all identified as hadrons were collected in a second category, B. These category-B events, the so-called neutron stars (n*), were thought to arise when undetected upstream neutrino interactions emitted a neutron that interacted in the chamber. It was then easy to deduce from these events the fraction that did not interact, thus simulating a muon, and to subtract them from the observed number of events in category A.

So, if weak neutral currents indeed existed, they would have induced events consisting of hadrons only, just as the n*s, and they would be waiting to be discovered as part of category B. Consequently, their investigation could be undertaken without any loss of time. The main task was then to find ways of distinguishing neutrino-induced from neutron-induced events.

Three hot months in 1973

The measurements of the inclusive neutral-current (NC) candidates were carried out between September 1972 and March 1973. The observation of an isolated electron in the anti-neutrino film, interpreted as an elastic weak neutral-current interaction on an electron, generated great excitement and inspired the efforts to check carefully each neutral-current candidate (Hasert *et al.* 1973a). For comparison, a charged-current (CC) sample was collected, where the same criteria were applied to the hadrons as for the neutral-current candidates. In particular, the total deposited hadron energy had to exceed 1 GeV. This severe cut was intended to keep the number of n* small.

At the collaboration meeting in March 1973 at CERN it looked as though a discovery was at hand. The number of neutral-current candidates was encouragingly large, as seen in table 1 on p21 (Hasert *et al.* 1973b). Their spatial distributions, as shown in figure 2, suggested first that the vertex distribution of the neutral-current candidates is neutrino-like, since it is flat like the charged-current events; and second that there is no indication of an exponentially falling distribution at the beginning of the chamber, as should be expected if the neutral-current candidates were dominantly induced by neutrons. Both arguments were corroborated by a Monte Carlo simulation of the Orsay group based on the simplifying assumption that upstream neutrino-induced neutrons enter the chamber directly along the neutrino direction.

Yet Jack Fry and Dieter Haidt contested that both arguments were not cogent for two strong reasons. First, the neutrino flux has a broad radial extension, which causes neutrino interactions in the coils surrounding the chamber and thus a flux of neutrons that enters the fiducial volume uniformly from the side. Second, high-energy neutrons generate a cascade, implying that the longer energy-dependent cascade length, rather than the interaction length, defines the relevant measure for the number of background events. Thus, it was unclear whether the neutral-current candidates really contained a novel type of neutrino-induced event or whether they were merely the expected, good-old neutron-induced stars.

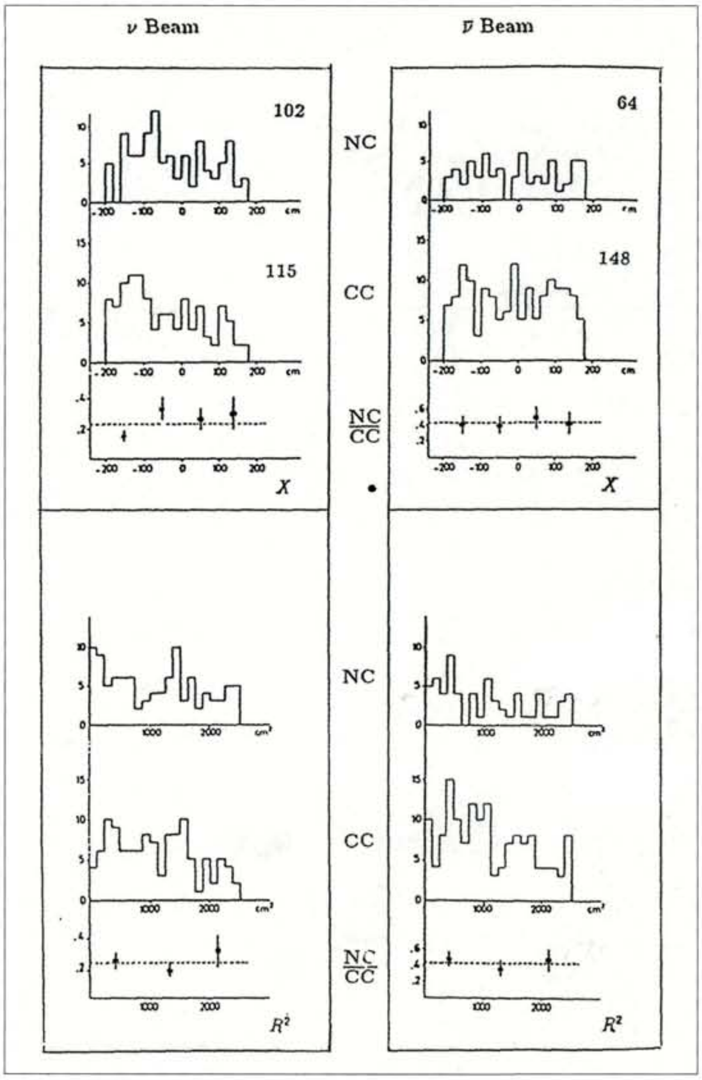


Fig. 2. The spatial distributions of neutral (NC) and charged-current (CC) candidates, as measured in 1973. X is the vertex position along the chamber axis and R is the radial position.

In this situation a detailed neutron background calculation was indispensable. The programme had to take into account the geometry and matter distribution of the chamber, the magnet coils and the shielding, the neutrino flux in energy and radial distributions, the dynamics of the final state, and most of all the neutral hadron cascade. The demanding task consisted of describing realistically the complex final hadron state. The breakthrough was achieved when it became clear that only fast final-state nucleons can generate a cascade and eventually lead to an induced neutron background event satisfying the energy requirement and that, furthermore, the cascade is linear. All the ingredients to the programme were backed up by data, so the predictions did not depend upon free parameters. This ambitious programme (Fry and Haidt 1975) was set up, carried through in the following months, and led in July 1973 to the undisputable conclusion that the neutron-induced background explained only a small fraction of the neutral-current candidates, thus a new effect could be claimed and published (Hasert *et al.* 1973b). In an independent check, Antonino Pullia exploited the ▷

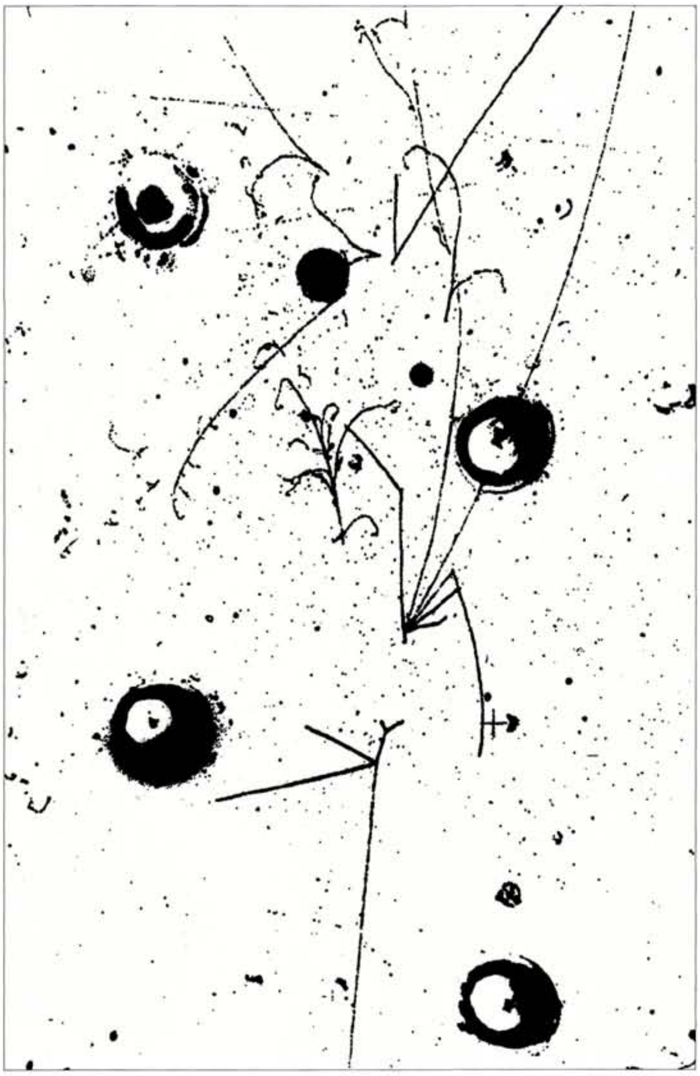


Fig. 3. A 7 GeV proton enters the Gargamelle bubble chamber from below and induces a three-step neutron cascade.

spatial distributions of neutral current and charged-current candidates, providing further evidence that the neutral-current sample was not dominated by neutron stars (Hasert *et al.* 1974).

Attack and victory

The new results were presented at the Electron–Photon Conference one month later at Bonn, together with the results of the HPWF experiment. At the end of the conference, Chen-Ning Yang announced the existence of weak neutral currents as the highlight of the meeting.

Shortly afterwards, the HPWF collaboration modified their apparatus with the net result that the previously observed signal of neutral currents disappeared. This news quickly reached CERN, where it had a dismaying effect and was a cause for distrust of the Gargamelle result. The opponents focused their criticism on the neutron background calculation and in particular on the treatment of the neutron cascade. Although the members of the Gargamelle collaboration withstood all the critical questions, the willingness to accept the validity of the Gargamelle observation had to wait until the end of the year. In a special exposure of Gargamelle to shots of protons with fixed momentum, the prediction of the cascade programme was verified quantitatively and unambiguously by the direct observation of proton-induced cascades in the chamber (figure 3). The results were presented at the American Physical Society conference in Washington in April 1974 (Haidt 1974).

One year after the discovery, at the time of the conference in London in June 1974, overwhelming confirmation for the existence of weak neutral currents came from Gargamelle itself with twice the original statistics (Hasert *et al.* 1974). In the meantime the HPWF collaboration had elucidated the reason why they lost the signal and also affirmed weak neutral currents. Further confirmation came from the new counter experiment of the California Institute of Technology and Fermilab (CITF) collaboration and from the observation of neutral-current-induced single pion events in the 12 ft bubble chamber at Argonne.

The impact

The discovery of weak neutral currents crowned the long-range neutrino programme initiated by CERN at the beginning of the 1960s and brought CERN a leading role in the field. The new effect marked the experimental beginning of the Standard Model of electroweak interactions and triggered huge activity at CERN and all over the world, both on the experimental and theoretical sides. The most immediate success was the prediction of the mass value of the elusive intermediate vector boson, W, on the basis of the Glashow–Salam–Weinberg model, combined with the first measurements of the weak mixing angle θ_W. This led to the idea of building a proton–antiproton collider, which was later realized at CERN and brought about the observation at CERN of the mediators of the weak force, the W and Z (*CERN Courier* April 2004 p13). The neutrino experiments at the CERN Super Proton Synchrotron increased their precision to the point that the first test of weak radiative corrections was enabled. The continuously increasing amount of knowledge on weak interactions justified building the Large Electron Positron collider, LEP, which with its high intensity reached sufficient precision at the energy range of the Z mass and beyond to test electroweak theory at the quantum level (*CERN Courier* May 2004 p21). All the results combined make the search for the Higgs, the last element of the electroweak Standard Model, a central issue for the Large Hadron Collider.

• This article is based on a talk at the symposium held at CERN in September 2003, "1973: neutral currents, 1983: $W^{\pm}$ and Z bosons. The anniversary of CERN's discoveries and a look into the future." The full proceedings have been published as volume 34 issue 1 of *The European Physical Journal C*, and as a book, *Prestigious Discoveries at CERN*, by Roger Cashmore, Luciano Maiani and Jean-Pierre Revol (Springer ISBN 3540207503, September 2004).

Further reading

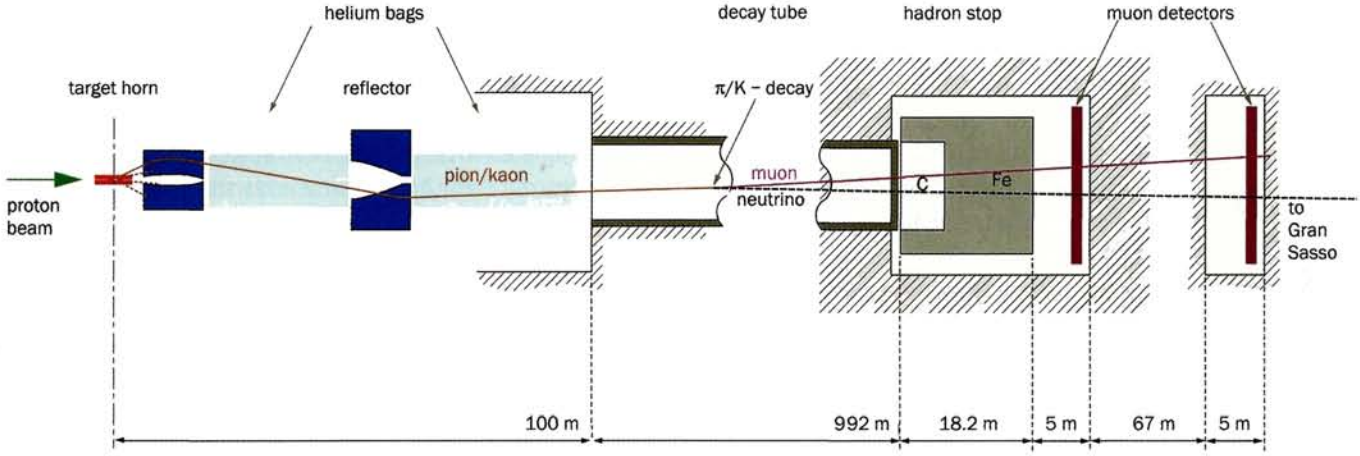
W F Fry and D Haidt 1975 CERN Yellow Report 75-01.
D Haidt 1974 Contribution to the American Physical Society Conference at Washington, April 1974.
F J Hasert *et al.* 1973a *Phys. Lett.* **46B** 121.
F J Hasert *et al.* 1973b *Phys. Lett.* **46B** 138.
F J Hasert *et al.* 1974 *Nucl. Phys.* **B73** 1.

Dieter Haidt, *DESY.*

Photo: CERN

Calling long distance: Geneva to Italy

The CERN Neutrinos to Gran Sasso (CNGS) project is set to deliver its first neutrinos in spring 2006. A key element is the vast decay tube.



The main components of the CNGS neutrino beam, including the 992 m long decay tube. (Courtesy F Pietropaolo, INFN.)

When CERN's Super Proton Synchrotron (SPS) starts up its scheduled run for 2006 it will be continuing the laboratory's long tradition of experiments with neutrino beams, exemplified by the discovery of weak neutral currents in Gargamelle (p21). However, in this case the neutrinos will not be destined for detectors at CERN, instead they will be travelling 730 km to the Gran Sasso underground laboratory in Italy, 120 km east of Rome. There is now unambiguous evidence from solar and atmospheric neutrino experiments that neutrinos can "oscillate" – change from one type to another. The aim of the CERN Neutrinos to Gran Sasso (CNGS) project is to investigate this phenomenon further, over a completely different range of energies and distances. Its muon-neutrino beam will be tuned to produce a maximum number of neutrinos per year with a neutrino energy spectrum best suited to the search for muon- to tau-neutrino oscillations.

The CNGS neutrino beam will originate when 400 GeV protons, extracted from the SPS, strike a graphite target to create pions and kaons. The muon-neutrinos produced in the decays of these particles will form the beam directed towards Gran Sasso. A key component of the beam line is therefore a vacuum tube, with a diameter of 2.45 m and length of 1 km, in which the particles decay. The tube passed its vacuum tests at the end of April this year, an important milestone for the overall project.

The decay process has a natural angular spread; even a perfectly aimed pion beam would still produce a neutrino beam with a large angular divergence. In the case of CNGS the neutrino beam arriving at Gran Sasso will have a radius of about 750 m (1σ). Although this is very large compared with the detector size, it is still important to aim the beam at the detectors at Gran Sasso as accurately as possible. Using the most advanced geodetic techniques, including GPS positioning, the CERN survey team wants to "hit" the target with an error better than 50 m. Since the decay tube acts like a collimator for the neutrino beam, the accuracy with which this tube is put in place is crucial.

In order to aim at the Gran Sasso laboratory, the CNGS facility at CERN – the last section of the proton beam line, the production target, etc – is built on a vertical slope of 5.6% and the decay tunnel passes some 12 m below the tunnel of the Large Hadron Collider (LHC). It was therefore decided in December 2001 to drill a vertical hole down from the LHC tunnel at exactly the position at which the decay tunnel should be located. The first qualitative success occurred on 4 March 2002, when the machine boring the decay tunnel indeed passed below this point. Later measurements showed that the tunnel was accurately located to within a few centimetres. The remaining errors were corrected during the installation of the decay tube inside the tunnel.

Why did the project opt for a decay vacuum? The aim is to have as intense a muon-neutrino beam as possible, and if a maximum number of pions and kaons are to be left "free" to decay, without ▷

Construction: the assembly in the target chamber of the 6 m long sleeves into 18 m long sections of the decay tube.

Natacha Lopez (centre), the engineer at CERN in charge of contracts for the design and construction of the decay tube, with some of the team near, literally, the end of the project.

interaction, it is important to have a minimum amount of material in their path. A decay tunnel with air would have resulted in a 28% loss of particles as compared with a vacuum tube; a tube filled with helium would have led to a 7% loss and would still have required a vacuum chamber to evacuate the air first and contain the helium.

The decay tube itself is a 992 m long steel tube, 2.45 m in diameter and 18 mm thick: it is allegedly the largest standard diameter used in the oleoduct (oil pipeline) industry, and a larger size would have produced little gain in neutrino intensity. The chosen length of 992 m conveniently takes the decay tube beyond the LHC tunnel. A much longer decay path would have produced 20–30% more neutrinos but with a significantly higher fraction of unwanted neutrino species in the beam, and the extra cost would have been prohibitive. Studies showed that with a wall thickness of 18 mm throughout and no anchoring points the tube has enough rigidity to withstand the external air and hydraulic pressures and the effects of beam heating.

At CERN the preparations for CNGS have involved the excavation of some 3 km of new tunnels plus several caverns. The first phase of civil engineering was completed in 2003, with the handover of part of the tunnels from the contractors on 1 August. While excavation work had finished in December 2002, concreting the various caverns, which began in 2002, and the 1.7 km of tunnels took a further 6 months – requiring some 12 000 cubic metres of concrete.

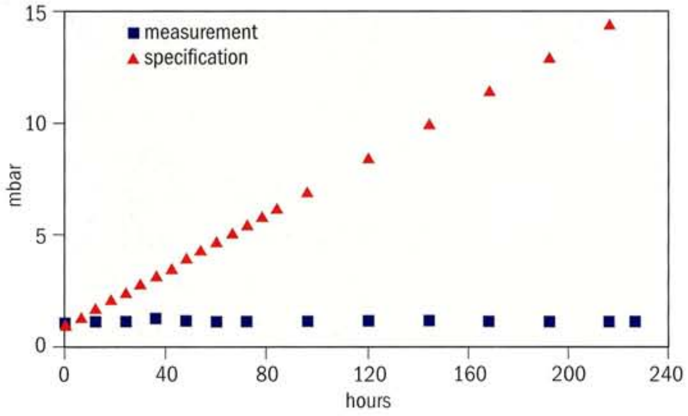
The decay tunnel was excavated by a tunnel boring machine at a diameter of 3.7 m. As the tube itself is 2.45 m in diameter there were two options for installation – leaving the tube in air, which would require steel thick enough to withstand pressure and temperature differences, or embedding it in concrete, in which case the concrete prevents buckling and provides some thermal contact between the "hot" steel tube and the "cold" rock surrounding the tunnel. The option of embedding the decay tube in concrete was chosen as it allows the use of a thinner walled steel tube and gives the best cost/quality ratio overall.

Before the decay tube could be installed, the components of the beam dump had to be transported to the end of the tunnel and assembled. The installation of the "hadron stop", or beam dump, was completed in September 2003. Resembling a three-dimensional "puzzle", the hadron stop consists of more than 400 iron blocks, 76 graphite blocks and 12 aluminium cooling plates. With a total weight of about 2000 tonnes, it is intended to absorb all particles other than the neutrinos and the muons produced with them. The iron blocks were recuperated from the former West Area Neutrino Facility on CERN's Meyrin site.

The decay tube was constructed from metal sheets that were rolled and welded into 6 m long sleeves by a contractor in Italy, before being transported to CERN. With two sleeves per lorry, there were 85 lorry loads altogether. Once at CERN the sleeves were lowered via a 55 m deep shaft into an access gallery and transported 650 m to the "target chamber", where they were welded into sections 18 m long. The welds were then tested visually, with dye for weld penetration, using ultrasound and radiography, before each 18 m section was transported on rails into position in the decay tunnel. Finally the section was aligned and welded to the existing tube, and after further tests of the welding, concrete was injected to seal the tube to the rock of the tunnel. A total of 3.6 km of welds, including those made at the factory, was needed to complete the decay tube. The results of the quality checks are impressive: faults found (and repaired) were at the level of less than 1% of all the welds.

Installation of the decay vacuum tube began on 18 November 2003. Once the initial difficulties had been overcome, it took 24 hours to complete each 18 m section. The full installation was finished on 16 March 2004, and on 1 April the tube was closed ready for pumping down and vacuum testing. The tube sleeves had arrived rusty and humid, but with the aid of a ventilation system, by the time of pumping down the tube was dry, if still rusty. It was then evacuated to less than 1 mbar, sealed and monitored continuously for 10 days. Throughout the test period the pressure remained stable, never exceeding 1.3 mbar. Such a good result was a pleasant surprise: the tube walls must be smoother than expected with very little absorption of water or gas as virtually no outgassing was observed.

Completing the vacuum volume are the entrance and exit windows, designed and built at CERN. For the central part of the entrance win-



For the vacuum test the pumps were stopped, the valves closed and the pressure observed during 10 days. The acceptable pressure rise due to outgassing or a small leak had been specified in the contract for the decay-tube construction, but the measured values were much better than the specification.

dow, where beam interactions must be kept to a minimum, a 3 mm thick titanium window with a diameter of 1.45 m will be used, somewhat larger than the useful beam size at this point. This is currently being built, for installation in January 2006, so a temporary window of 50 mm steel has been installed for the vacuum tests. At the far end of the decay volume, where losses due to interactions are not so critical, a 50 mm thick steel window has been chosen and installed.

All in all the CNGS project is well on course for the scheduled first delivery of neutrinos to Gran Sasso in spring 2006. Meanwhile, progress is being made on the two major experiments, OPERA and ICARUS, that will intercept the neutrinos.

At Gran Sasso installation of the magnetic spectrometer of the first of two "supermodules" for the OPERA experiment was successfully completed in June, with installation of the target section starting in September. The magnet and target section of the second supermodule will be completed in June 2005 and December 2005, respectively. The first supermodule will be fully filled with emulsion bricks by the time of the first beam in May 2006, while the filling of the second one will be completed during the 2006 run.

At the same time, after several years of R&D, the ICARUS experiment, which acts as an "observatory" for the study of neutrinos and the instability of matter, is coming together. In the summer of 2001 the first module of the ICARUS T600 detector successfully passed a series of tests on the surface. This module should be installed at the Gran Sasso laboratory this autumn. An increase in detector mass by the addition of further modules is foreseen and should be ready to receive the CNGS neutrino beam when it starts up.

Konrad Elsener *and* **Christine Sutton**, *CERN.*

Looking at the stars from a well

Observing what goes on in the heart of stars from deep below ground is an effective tool for understanding stellar interiors and the primordial universe, as **Gianni Fiorentini** and **Alessandro Pascolini** explain.

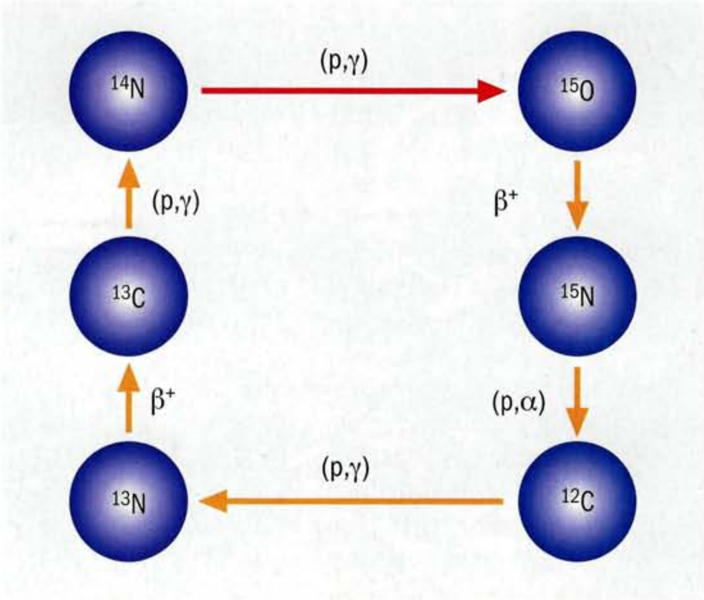


Fig. 1. The CNO cycle: the cycling rate is determined by the slowest reaction, $p + {}^{14}N \rightarrow {}^{15}O + \gamma$, at the top of the figure.

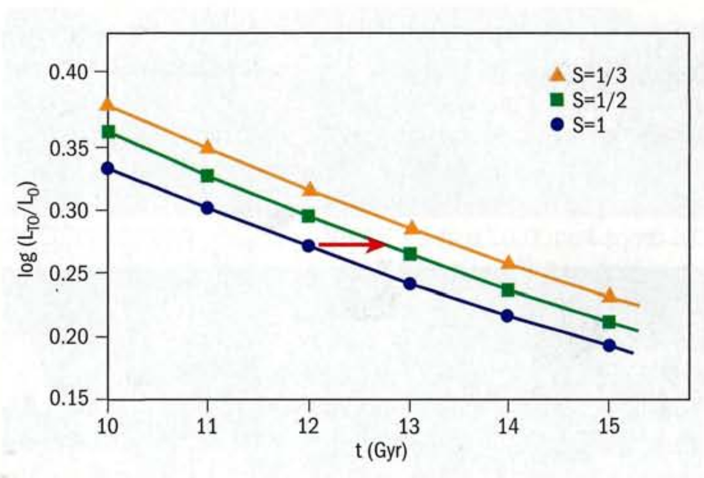


Fig. 2. Graph showing the effect of $p + {}^{14}N \rightarrow {}^{15}O + \gamma$ on the estimated age of globular clusters. For a given luminosity at "turn off", L_{TO}, the estimated globular cluster age, t, increases by about 1 Gyr when the S-factor is halved.

Aristotle's report that "men in pits or wells sometimes see the stars", made in *On the Generation of Animals* (book V, chapter 1), is a legend that was long believed, persisting until the 20th century without being experimentally tested. Similar stories were reported by Giambattista della Porta in 1560, Christof Schneider in 1626, John Herschel in 1836 and Charles Dickens in 1837, among others. But sunlight scattered from air molecules is generally much brighter than the brightest starlight, so it is impossible to see stars with the naked eye during daylight hours, no matter where one is looking from. Physicists today, however, have found methods for looking into stars from the bowels of a mountain. In addition to the observations of solar and supernova neutrinos, nuclear reactions of astrophysical interest are now being studied underground.

LUNA, the Laboratory for Underground Nuclear Astrophysics at Gran Sasso, has recently measured the cross-section for $p + {}^{14}N \rightarrow {}^{15}O + \gamma$, the key reaction of the CNO cycle that fuels stars heavier than the Sun (see figure 1) (LUNA 2004). Shielding against cosmic radiation provided by the surrounding mountain has allowed measurements down to a centre-of-mass energy of 130 keV, and lower energies, close to those of stellar burning, are currently being explored. With the LUNA value of the astrophysical S-factor (a measure of the strength of the nuclear interaction) being about half that previously estimated, the predicted flux of solar neutrinos from the CNO cycle has correspondingly been halved and the age of the galaxy, as deduced from the stellar evolution of globular clusters, has been increased by about one billion years (see figure 2) (Degl'Innocenti *et al.* 2004).

LUNA was conceived during the conference dinner of "Nuclei in the Cosmos '90", which was held at Baden bei Wien in Austria. During *hors d'oeuvre*, Gianni Fiorentini from the University of Ferrara asked Claus Rolfs of the University of Bochum why nuclear reactions could not be measured in the laboratory at the energies at which they occur in stars. The answer was that cosmic radiation provides a formidable background for detecting the extremely slow reaction rates at these energies. By the time of dessert, they had realized that the solution was to install an accelerator in an underground laboratory. The director of the Laboratori Nazionali del Gran Sasso, Enrico Bellotti, was enthusiastic about the idea and the INFN president Nicola Cabibbo immediately endorsed it after receiving an informal letter of intent, which began: "We believe that the Gran Sasso laboratory offers a unique possibility for progress in the measurement of low-energy nuclear cross-sections, which are relevant for nucleosynthesis in stars and in the early universe, as well as for the evaluation of the solar-neutrino flux."

Within a few months LUNA was born, given a name and approved by INFN as a collaboration involving physicists from Bochum, Cagliari, Ferrara, Frascati, Genoa, Gran Sasso and Turin, and ▷

Equation 1

$$\sigma(E) = \frac{S(E)}{E} \exp[-2\pi Z_1 Z_2 \sqrt{\frac{\mu\alpha^2 c^2}{E}}]$$

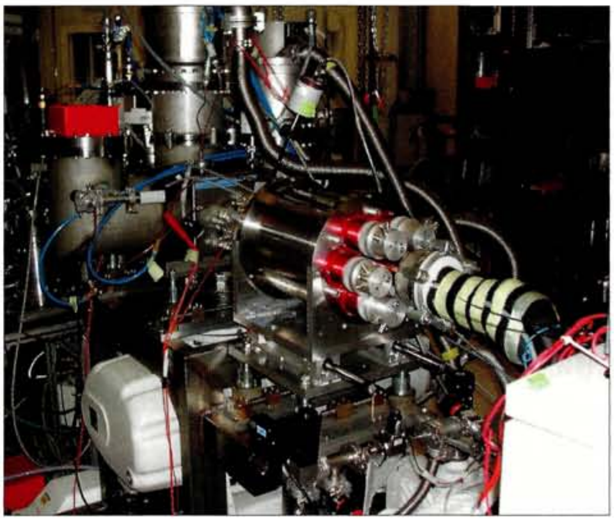


Fig. 3. LUNA at Gran Sasso. The experimental set-up for the p + ^{14}N reaction, showing the bismuth germanate (BGO) summing crystal and the windowless gas target.

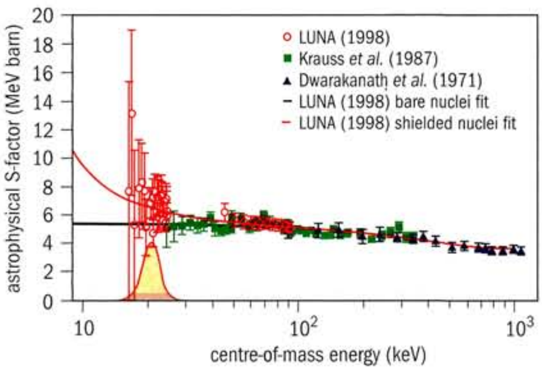


Fig. 4. The astrophysical S-factor of ^{3}He + ^{3}He → ^{4}He + 2p. The shaded area represents the Gamow peak for the Sun. (For detailed references, see LUNA 1999.)

headed by Rolfs. Later, physicists from Debrecen, Lisbon, Milan, Naples, Padua and Teramo joined the group. Carlo Broggini of Padua is currently the spokesperson, succeeding Piero Corvisiero of Genoa.

Nuclear reactions in stars, and at the Big Bang, occur at energies well below the Coulomb barrier $E_c = Z_1Z_2e^2/r$, where nuclear processes are possible only through quantum tunneling, and their cross-sections are exponentially suppressed with decreasing energy. For the collision of two nuclei with atomic numbers Z_1 and Z_2 and reduced mass μ, the cross-section at centre-of-mass energy E can be written as in equation 1, where the exponential factor accounts for the barrier penetration, the astrophysical S-factor S(E) expresses the strength of the nuclear interaction and α is the fine structure constant. As an example, the cross-section for ^{3}He + ^{3}He → ^{4}He + 2p drops from 0.07 b at E = 2 MeV down to 2×10^{-14} b at E = 16.5 keV.

Before LUNA, all experiments had been performed at energies such that $E/E_c > 1/20$, whereas stellar burning occurs at $E/E_c \approx 1/100$. In order to extract S(E) at energies of astrophysical interest, available data had to be extrapolated over a relatively wide energy range, leading to substantial uncertainties. Although experiments had been optimized using the best available techniques, they were basically limited by the effect of cosmic rays. However, the problem can be overcome by carrying out such experiments in an underground laboratory.

LUNA began working initially with a 50 kV electrostatic accelerator (homemade by students at Bochum) coupled with a windowless gas target system. Now, in a second phase, a commercial 400 kV accelerator has been installed at Gran Sasso (see figure 3). The important features of both accelerators are a very small energy spread and a very high beam current, even at low energy. To avoid any interference with the passive detectors at Gran Sasso, the LUNA accelerators are installed in two small, dedicated rooms, separated from other experiments by about 60 m of rock.

The reaction ^{3}He + ^{3}He → ^{4}He + 2p has been measured in the energy window – the so-called Gamow peak – relevant to the Sun (see figure 4) (LUNA 1999). At the lowest energy (E = 16.5 keV) the event rate was as low as two per month. This means that for the first time an important nuclear fusion reaction has been measured in the laboratory at the energies occurring in the Sun. This has reduced the (partial) uncertainty on the Be and B solar-neutrino fluxes produced from this reaction to 3%.

In the Sun the reaction p + d → ^{3}He + γ must occur after deuterium is formed, so that the precise value of its cross-section is unimportant for solar physics, as long as it is much larger than that of the preceding reaction, p + p → d + e^+ + ν. On the other hand, during Big Bang nucleosynthesis the rate of p + d → ^{3}He + γ competes with the expansion of the universe, which dilutes the proton density, so that the cross-section for this reaction is crucial for establishing the primordial deuterium abundance. LUNA has measured this cross-section with an accuracy of the order of 10%, from 22 keV down to 2.5 keV (LUNA 2002). Combining the LUNA results with other input from nuclear physics and observational data of the deuterium abundance, shows that the nucleon to photon density ratio in the first few minutes of the universe is given by $\eta = (5.9 \pm 0.5) \times 10^{-10}$, which is in excellent agreement with the value from cosmic microwave background observations of $\eta = (6.3 \pm 0.3) \times 10^{-10}$, corresponding to a universe that is 400 000 years old.

In the near future, LUNA will measure ^{3}He + ^{4}He → ^{7}Be + γ, which represents the main uncertainty for the prediction of B and Be solar neutrinos and is an important ingredient for estimating the abundance of lithium left from the Big Bang. Measurements in the region of solar energies will be performed at Gran Sasso, whereas those at higher energies will be taken in Bochum.

Further reading

The fact that stars cannot be seen from a pit is discussed in many articles, e.g. www.newscientist.com/lastword/article.jsp?id=lw497.
S Degl'Innocenti *et al.* 2004 *Phys. Lett.* **B590** 13.
LUNA collaboration 1999 *Phys. Rev. Lett.* **82** 5205.
LUNA collaboration 2002 *Nucl. Phys.* **A706** 203.
LUNA collaboration 2004 *Phys. Lett.* **B591** 61.

Gianni Fiorentini, *University of Ferrara and INFN, and*
Alessandro Pascolini, *University of Padua and INFN.*

Postcards from CERN: 50 years through a lens

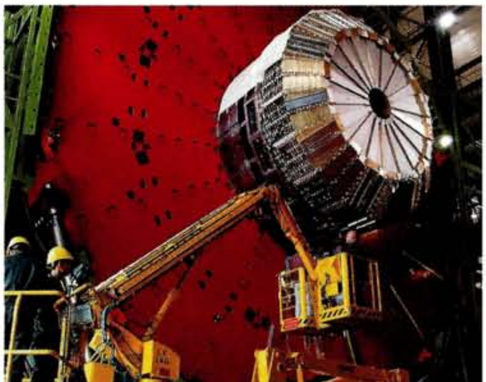
Over the years CERN's photographers have provided an important record of the laboratory's development. This selection provides a glimpse of CERN's history through their eyes.

Geneva was selected as the site for the CERN laboratory at the third session of the provisional council in 1952. This selection successfully passed a referendum in the canton of Geneva in June 1953, and on 17 May 1954 the first shovel of earth was dug on the Meyrin site under the eyes of Geneva officials and members of CERN staff.

An aerial view of modern-day CERN taken in January 2004 shows how the Meyrin site has developed in 50 years. In the background are the buildings at Point 1 on the Large Hadron Collider (LHC) ring, where the ATLAS detector is being installed. In the foreground is Building 40, which was built to provide offices for the physicists working on the LHC experiments.

Installation tests in the LHC tunnel in January 2004: a short, straight section is positioned next to a superconducting dipole.

The underground cavern where the detector for ATLAS – one of four major experiments for the LHC – is being installed, in May 2004.

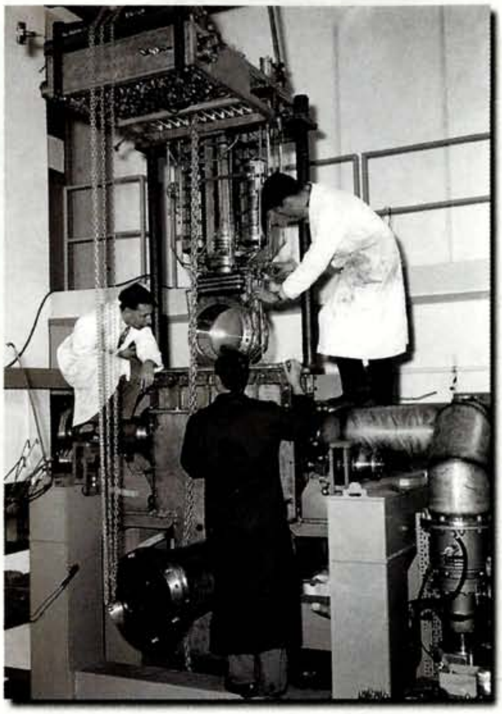


Assembly of the hadron calorimeter for the CMS experiment at the LHC in June 2004.

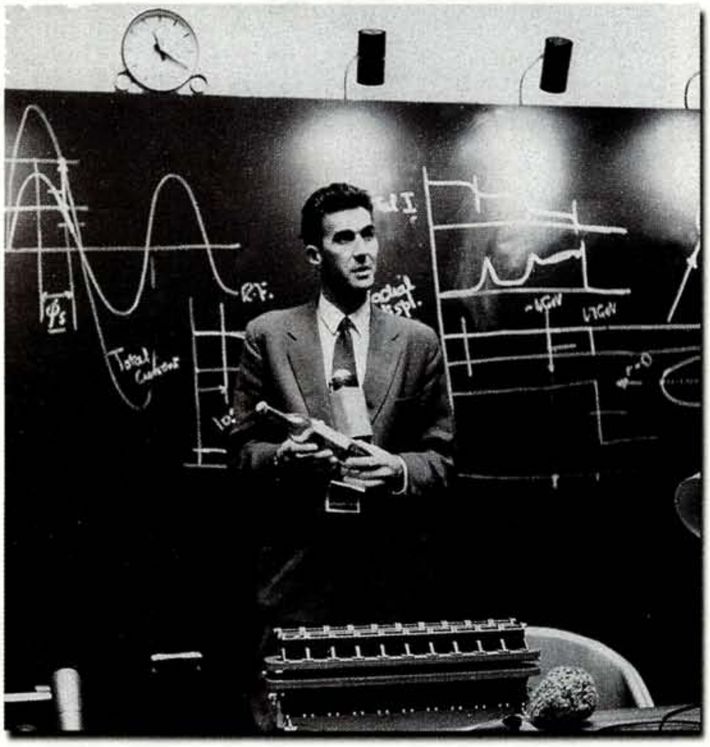
The CERN fire brigade was set up in July 1956 to provide a rapid response in the event of an accident and to tackle the risks specific to the organization's activities. Here are six members of the brigade in 1959.

The upper magnet coil of CERN's first machine, the Synchrocyclotron (SC), is moved over the upper pole discs. Each coil weighed 60 tonnes and measured 7.2 metres in diameter. The SC was commissioned in 1957 and was operational for 34 years.

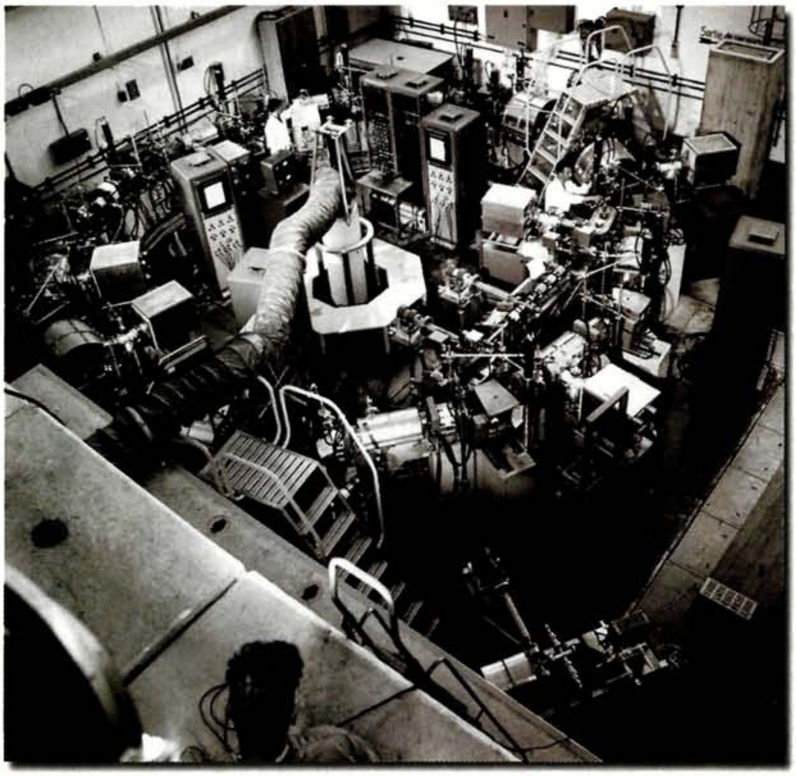
View inside the PS ring in 1964. The PS continues to this day to play a key role in CERN's accelerator complex.



The 30 cm hydrogen bubble chamber, seen here being inserted into its vacuum tank, took its first beam from the SC in 1959 and moved to the PS in 1960.

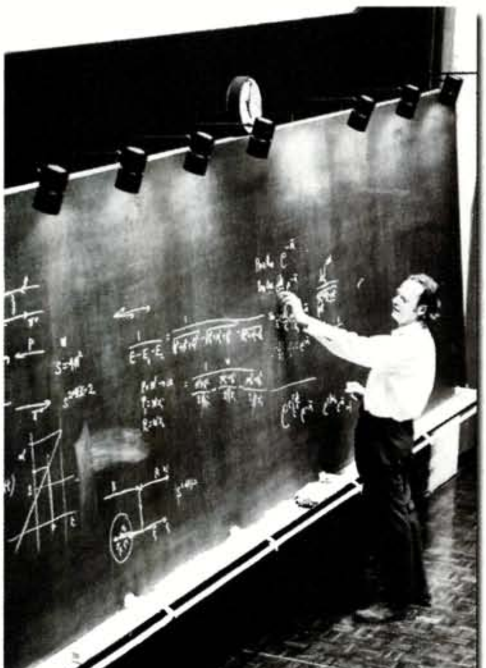


During the night of 24 November 1959 the PS reached its full energy. The next morning John Adams announced the achievement in the main auditorium. In his hand is an empty vodka bottle, which he had received from Dubna with the message that it was to be drunk when CERN passed the Synchrophasotron's world-record energy of 10 GeV. The bottle contained a polaroid photograph of the 24 GeV pulse ready to be sent back to Dubna.



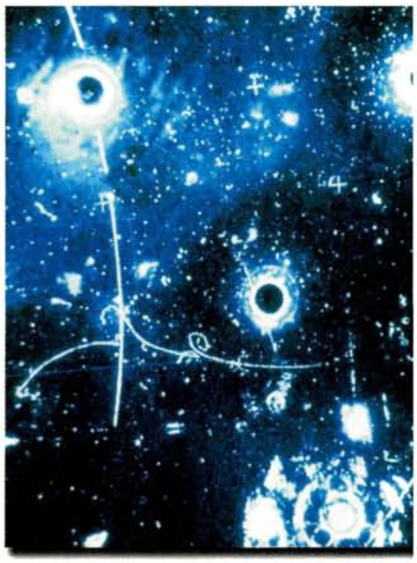
CESAR (the CERN Electron Storage and Accumulation Ring) was built as a machine model for the ISR. The model had to be small, but the particles had to be relativistic, so electrons were chosen. Running from 1964 to 1967 CESAR demonstrated techniques essential for the ISR (and later the proton–antiproton collider), in particular ultrahigh vacuum techniques.

The Intersecting Storage Rings (ISR), the world's first proton–proton collider, started up in 1971, and later provided the first proton–antiproton collisions and the first collisions of beams of heavier ions (alpha particles). This image shows the vacuum chamber at one of the points where the proton beams crossed in the ISR.

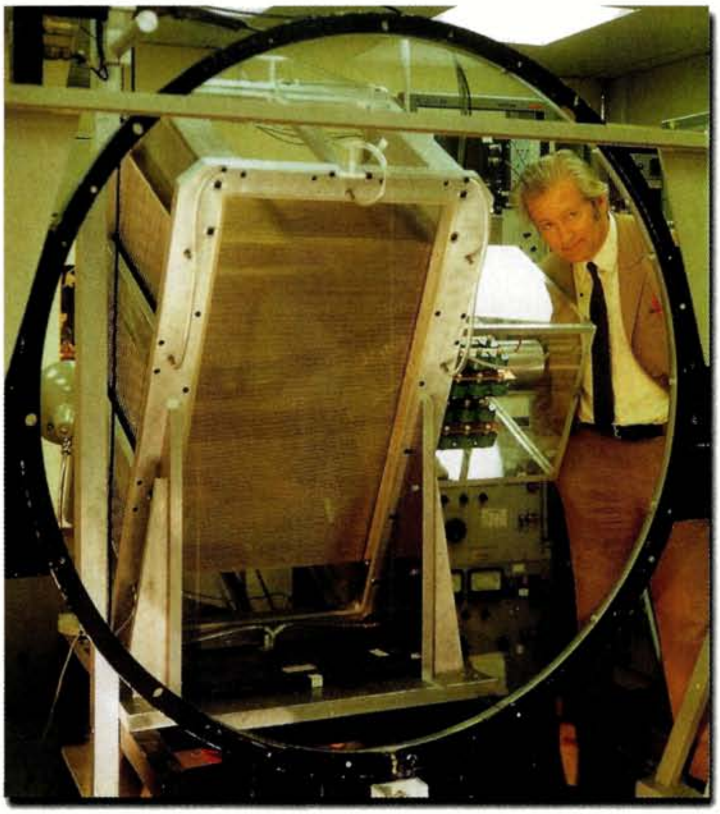


CERN has welcomed many visitors during its 50 years. Here, Richard Feynman gives a lecture in his inimitable style in 1970.

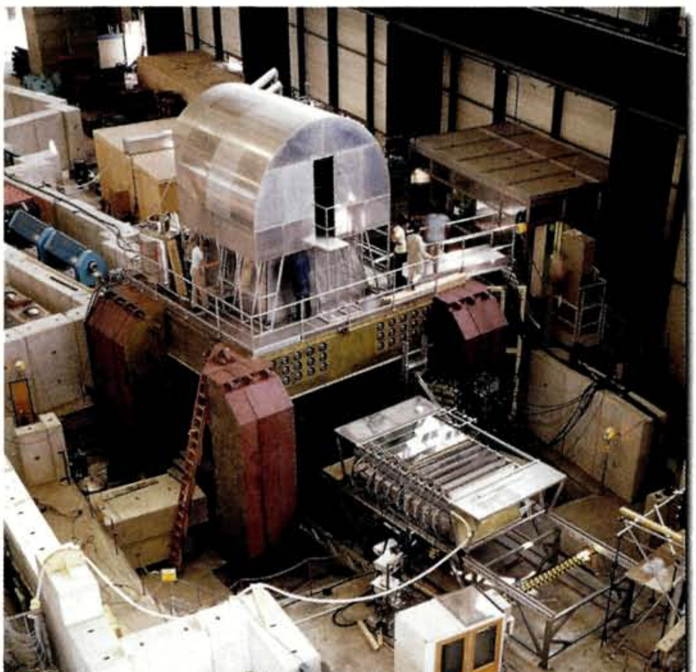
Assembly in progress inside the Gargamelle heavy-liquid bubble chamber, which was built at Saclay in France and came into operation at the PS in 1971. The chamber had a cylindrical body 4.8 m long and 1.85 m wide, with a volume of 12 cubic metres.



In 1973 the Gargamelle collaboration announced the discovery of weak neutral currents. Here in a neutral-current event a neutrino interacts with an electron in the chamber liquid. The neutrino continues unseen, while the electron creates the horizontal branched track.

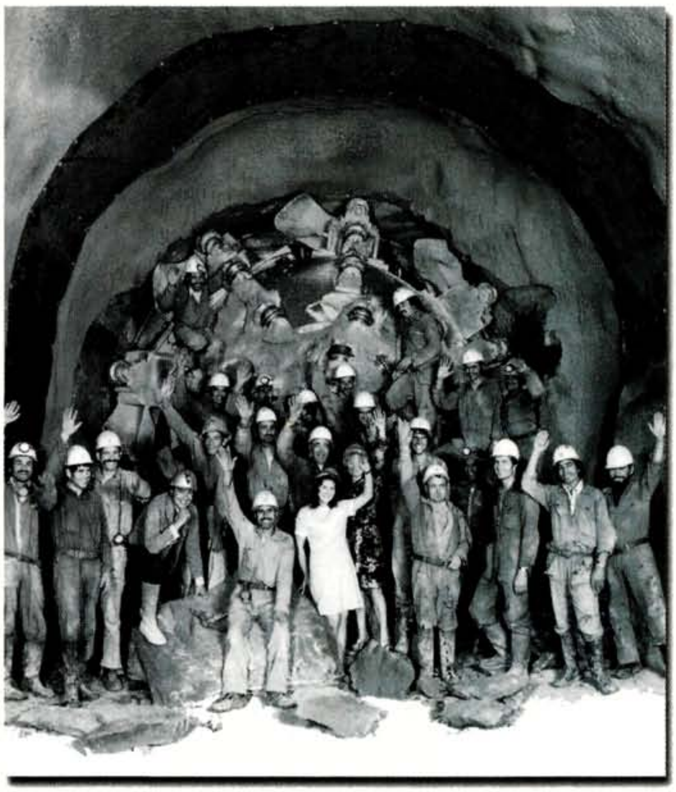


In 1968 Georges Charpak (seen here in 1978) invented the multiwire proportional chamber, which was to revolutionize the field of particle detection and gain him the 1992 Nobel Prize in Physics.



The Omega spectrometer came into action in the West Area at the SPS during 1972. An array of optical spark chambers can be seen withdrawn from the magnet aperture. The "igloo" above the magnet housed the Plumbicon camera system that recorded information from the chambers. No fewer than 48 experiments made use of Omega, exploiting beams of various particles at various energies – first from the PS and then from the higher energy SPS.

The SPS, with its 7 km circular tunnel, extended CERN beyond the Meyrin site. Construction began in 1972. Here the metal structure of the shuttering used when pouring the concrete walls of the tunnel gives a remarkable optical effect.



Two years after the construction of the SPS began, on 31 July 1974, the Robbins boring machine that was excavating the tunnel returned to its starting point.

On 21
discov
collisio
weak r
treated
positro

In 198
for the
Sir Al

ary 1983 the UA1 collaboration, led by Carlo Rubbia, announced the f the charged carrier of the weak interaction, the W, in proton–antiproton t the SPS. Three months later they had also found the Z^0, responsible for the al currents discovered 10 years previously in Gargamelle. In this colour-ure of tracks reconstructed in UA1, a Z has decayed into an electron and a hich fly off in opposite directions (yellow).

rlo Rubbia (centre) and Simon van der Meer (left) received the Nobel prize overy of the W and Z particles at CERN. Here they are talking in 1983 with errison, then president of Council.

The SPS also had a pioneering role in CERN's programme of heavy-ion physics, beginning with beams of oxygen and sulphur ions in 1986. Here a sulphur ion, with a total energy of 6400 GeV, strikes a nucleus in a gold target in the NA35 experiment. A streamer chamber records the resulting shower of particles.

The final stages of preparation in the SPS tunnel in April 1976. The red magnets are some of the 800 or so 6 m long dipole magnets that guide the beams round the machine.

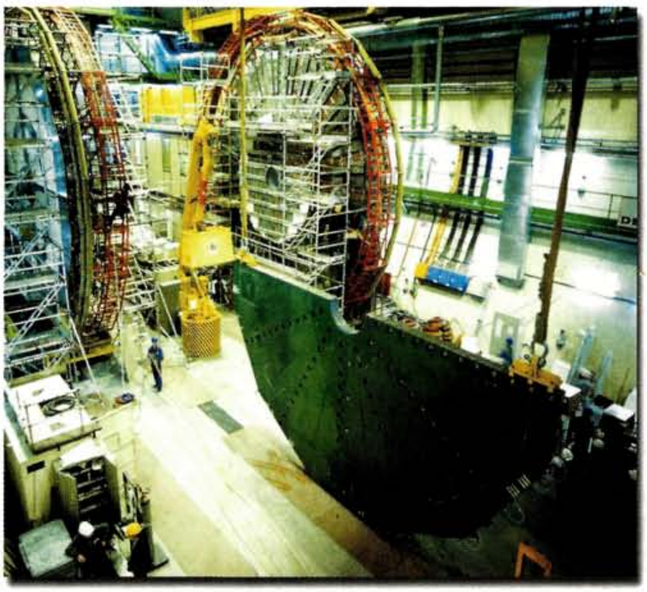
The Antiproton Accumulator, seen here in June 1980, was an important step in converting the SPS to a proton–antiproton collider. It used Simon van der Meer's "stochastic cooling" technique to produce useful beams of antiprotons.

Tim Berners-Lee, seen here in 1994, invented and developed the World Wide Web as an essential tool for high-energy physicists. He conceived HTML, http and URLs using the machine shown on the right in 1990 to develop and run the first Web server, multimedia browser and Web editor.

In 1985 excavation work began for the 27 km tunnel of the Large Electron Positron collider (LEP). This was the most formidable civil-engineering venture in the history of CERN ana Europe's largest civil-engineering project prior to the Channel Tunnel.

One of the monorail trains suspended from the ceiling above the magnet ring in the 27 km long LEP tunnel. The trains were used for transporting goods and people.

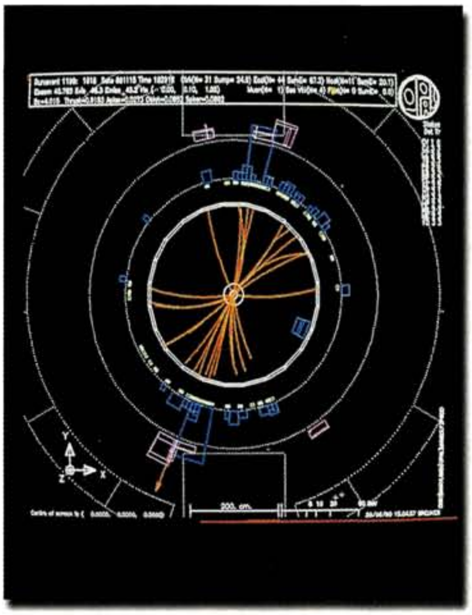
Looking rather as if surrounded by a collection of ornate urns, a technician surveys copper-accelerating cavities used in LEP. From 1996 these were gradually replaced by superconducting cavities that were to double the total collision energy from 100 GeV to just over 200 GeV.



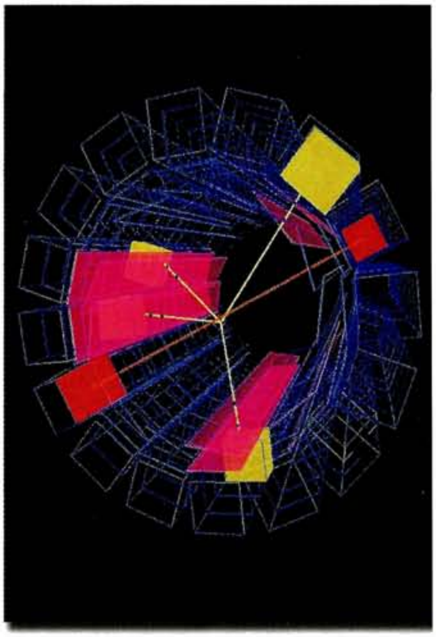
The construction of DELPHI, one of the four detectors at LEP, in January 1989, only seven months before the first collisions. This picture shows the installation of a "half-moon" section for one of the end caps.

A feature of the L3 experiment at LEP was its huge magnet, with much of the detector located within the magnet coils. One of the huge "doors" of the magnet is seen in this view from February 2000.

The segmented barrel of the hadron calorimeter for the ALEPH detector at LEP during construction in 1987; the iron also formed the return yoke for the electromagnet.

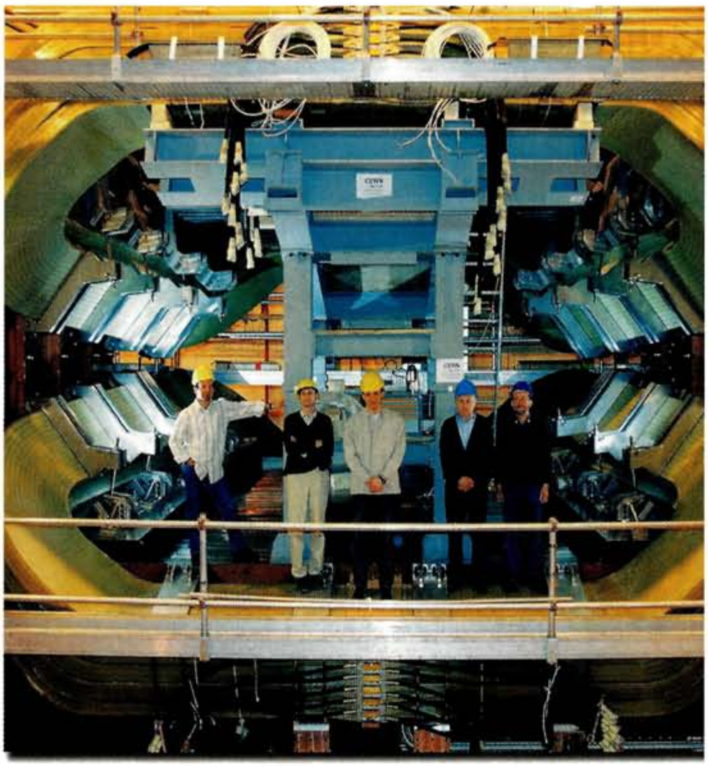


After LEP started operation in August 1989 it became a veritable "factory" for the production of Z^0 particles. This display from OPAL shows the decay of a Z into two jets of particles, originating from a quark–antiquark pair, recorded in June 1990.



The world's first atoms of antihydrogen were observed in the PS210 experiment at CERN in 1995. Seven years later in 2002, the ATRAP and ATHENA experiments began to make antihydrogen atoms by the thousand. This display shows an antihydrogen event recorded by ATHENA in August 2002.

The ALICE experiment, which will study lead– lead collisions in the LHC, is being installed in the cavern previously occupied by the L3 detector. It also makes use of L3's huge magnet.



The LHCb detector will occupy the cavern used by the DELPHI experiment at LEP, and will investigate matter–antimatter differences in B mesons at the LHC. The coils of the detector's huge dipole magnet are seen here in April 2004.

The NSS/MIC conference: a global meeting place

The IEEE Nuclear Science Symposium and Medical Imaging Conference provides a unique – and increasingly popular – annual event for scientists and engineers to come together to review progress in detection and instrumentation techniques.

About 35 years ago the physics community of the Institute of Electrical and Electronics Engineers (IEEE), currently the world's largest professional science and engineering organization with more than 360 000 members worldwide, established the Nuclear Science Symposium (NSS) as one of its major annual events. The NSS had originally evolved from IEEE meetings on scintillation (and then semiconductor) detectors before being formally established in 1969. In the following years interest in the NSS grew substantially with additional subjects being added, including a session on medical imaging, which soon developed into a major parallel conference at the week-long meeting.

The Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC) has since grown into a well known, highly respected, and important event for scientists worldwide working in the fields of particle and nuclear physics instrumentation, radiation detection, the associated hardware, electronics and software, and on applications in fields such as medicine. With the numbers of conference contributions (shared roughly equally between NSS and MIC) almost doubling in recent years, and a record number of more than 1600 scientific contributions received for this year's meeting in Rome, the combined NSS/MIC, together with its specialized workshops, educational courses and industrial programme, has developed into a truly global forum for scientists and engineers active in these fields (see figure 1).

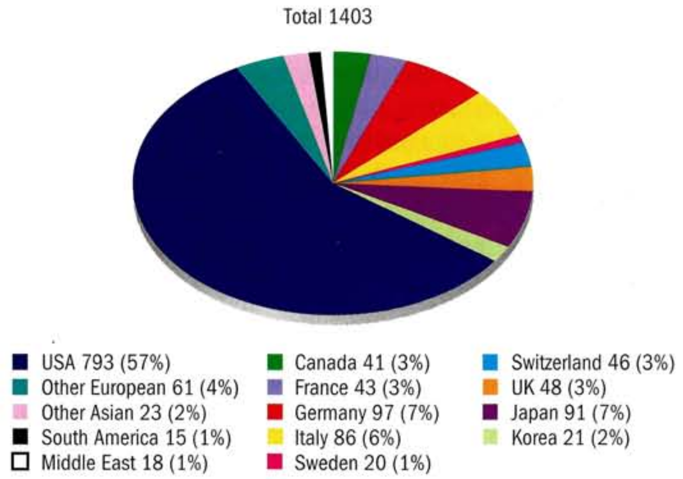


Fig. 1. The geographical distribution of participants attending the 2003 IEEE NSS/MIC conference in Portland, Oregon, reflects the meeting's increasingly international nature.

Early history and mission

The NSS was formally established as a broad nuclear instrumentation conference under the sponsorship of the IEEE Professional Group on Nuclear Science (PGNS). The visionary behind the formation of both the IEEE Nuclear Sciences Society and the NSS was Louis Costrell of the National Bureau of Standards in Washington DC, who later pioneered many nuclear instrumentation standards (such as NIM, CAMAC, FASTBUS and VMEp), with the collaboration of the European Standards on Nuclear Electronics organization and many international collaborators. The PGNS became a full society of the IEEE in 1970, elected its first administrative committee (AdCom) in 1971, and soon combined with the Professional Group on Plasma Sciences to become the Nuclear and Plasma Sciences Society (NPSS). In response to high interest among medical physicists, the Medical Imaging Technical Committee was formed in 1975, chaired by Leon Kaufman of the University of California at San Francisco Medical Center. Others prominent in its formation were Bertrand A Brill of Emory University and Glenn Knoll of the University of Michigan. As an elected member of this first NPSS AdCom, Ray Larsen of SLAC assisted in its organization. By 1990 the medical imaging sessions had grown to the point where the NSS became the joint Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC).

The early NSS/MIC meetings included special sessions on various aspects of nuclear instrumentation, nuclear-reactor controls, detector instrumentation and instrumentation for medical imaging sciences. This was the heyday of the development of new imaging CAT scanners in industry, exciting new modular electronics for accelerator instrumentation and detectors, as well as applications in many areas of nuclear-physics research. With the advent of proportional wire chambers and later custom-built silicon detectors, increasingly sophisticated generations of integrated electronics readout systems for applications in both physics and medicine were developed. ▷

The main mission of the NSS/MIC is to serve the scientific community by providing an annual forum and meeting point to present and discuss work, problems and the latest advances in the relevant fields, to the benefit of all participants. The rapid publication of conference proceedings, including on CD, is invaluable, as is access to the authors at the conference. Papers can also be submitted for publication in peer-reviewed archival journals; this takes much longer but is more prestigious to academics. All publications are distributed worldwide.

Recently, the organizers of NSS/MIC have emphasized their desire for feedback from the scientific community for shaping future meetings. Young scientists doing outstanding work in the various fields covered by the NSS/MIC are particularly encouraged to contribute to the conference. In addition, NSS and MIC technical achievement, fellow, best paper and graduate student awards are presented at the conference both to younger and more mature scientists and engineers nominated by their peers or advisors. (Nominees do not have to be a member of the IEEE or the NPSS).

Typical NSS/MIC programmes consist of plenary, parallel and poster sessions, workshops on specialized topics, educational short courses and an industrial programme with an exhibition and seminars. Special events and an extensive social and companion programme round out the week. This seems to provide an ideal environment for very fruitful, beneficial, and increasingly more important interdisciplinary communication between the various fields, the contributing experts and communities, and their industrial partners. To facilitate and emphasize this important aspect of the meeting, the organizers include as much time and as many opportunities as possible for participants, including those from different fields, to get together. Moreover, seeking constant improvement year-to-year, the organizers are careful to request feedback from all participants.

The joint conference has produced a unique synergy among many disciplines, reaping benefits for a wide range of engineers and scientists. In addition to regular sessions in the various areas of interest, the conference has pioneered the use of posters, continuing education short courses, and special plenary sessions that feature world-class presenters of the latest research on accelerators, nuclear medical imaging, detectors and instrumentation for high-energy physics, space physics, environmental detection, reactor controls and nuclear security systems.

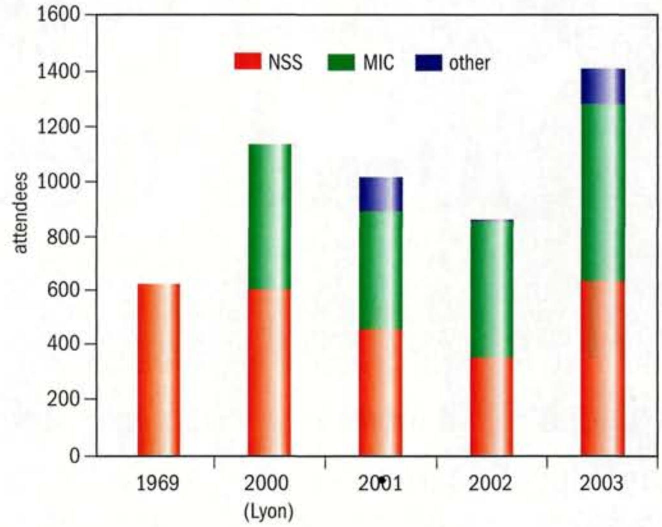
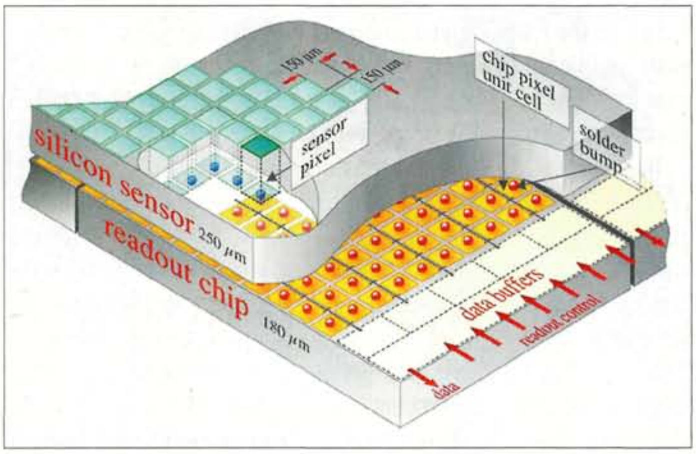


Fig. 2. The attendance at the NSS/MIC conference has grown from 620 in 1969 to a record of 1403 at "Portland2003", with almost equal numbers of NSS and MIC attendees. The first NSS/MIC to be held in Europe, in Lyon in 2000, was also the first to attract more than 1000 attendees. This year's conference, "Rome2004", may well break all current records.



Pixel detectors were a hot topic at the 2003 conference.

Pushing boundaries in Portland

The 2003 meeting in Portland, Oregon, attracted the largest number of participants to date (see figure 2). Chaired by Uwe Bratzler of CERN and NTU Athens (now at Tokyo Metropolitan University) and Maxim Titov of Freiburg University and ITEP Moscow for the NSS, and Mike King and Stephen Glick of the University of Massachusetts for the MIC, with Ralph James of Brookhaven National Laboratory as the overall conference general chair, it provided a comprehensive review of the progress and latest developments in technology and instrumentation and their implementation in experiments for space, accelerators and other radiation environments. The scientific programme underlined the interdisciplinary and synergetic combinations of the NSS and MIC topics, and covered a wide range of applications from radiation instrumentation and new detector materials, to complex radiation detector systems for physical sciences and advanced imaging systems for biological and medical research. Special emphasis was also put on the transfer of technology between fundamental physics research, medical and biological imaging science and industrial applications. More than 572 accepted submissions for the NSS were accommodated in 323 oral presentations and 249 poster contributions.

The field of high-energy particle physics featured widely in Portland, with presentations of innovative research on semiconductor devices by groups working on experiments being prepared for high-luminosity hadron colliders, in particular the Large Hadron Collider (LHC) at CERN, including many impressive front-end electronics systems that are either in or close to being in production. A large number of talks on pixel systems, with comprehensive contributions on deep submicron front-ends, radiation-hard detectors, bump bonding and new integrated approaches, gave good insight into the interplay between

From left to right: Alberto del Guerra (INFN and University of Pisa; Rome2004 IEEE NSS/MIC general chair), Fabio Sauli (CERN Gas Detectors Development group leader; 2004 NSS programme chair) and Uwe Bratzler (CERN ATLAS Project; 2003 NSS programme chair) in discussion at the 2003 conference in Portland, Oregon.

the progress in technology and requirements for tracking close to the interaction point in the high-intensity collider experiments. Many developments, motivated by the prospects of a linear collider where higher resolution, less material and power are mandatory, are pushing the boundaries of semiconductor detector technology.

Progress in micro-pattern gas detectors was represented by more than 30 contributions. The evolution of gaseous detectors to novel 2D and pixel readout electrodes, together with their intrinsic excellent radiation tolerance, rate capability and spatial resolution, extends their applicability to precision tracking at high counting rates in hostile environments, an area that is currently accessible only to silicon detectors. The many sessions on large systems and more specific topics under development underlined that finding the optimum balance between power, cooling capacity, granularity and performance is the key for further progress in the field of detectors.

In Portland, an International Workshop on Room-Temperature Semiconductor X-Ray and Gamma-Ray Detectors, chaired by Ralph James of Brookhaven and Paul Siffert of Laboratoire Phase, Strasbourg, was held in conjunction with the NSS/MIC meeting, and five topical "satellite" workshops covered areas of specific interest. Workshops on the Compton camera and hadron therapy were combined with full-day workshops on topics of major importance for high-energy physicists involved in the current construction or future upgrades of experiments. The workshop "Problems with Detector Fabrication, Testing, Quality Control and Long Term Operation" provided a thorough review of the problems encountered during production, quality control, and medium- and long-term operation of large systems. The "Detector Aging Workshop", a follow-up of the workshop that was held at DESY in 2001, once again gathered many experts on this critical matter. Fruitful discussions took place between the groups running the experiments and others currently building detectors for the BTeV experiment at Fermilab and the experiments at the LHC. Trends were discussed and almost agreed upon! The major concerns for all of the groups seem to be the selection of gas mixture, chamber materials and the associated gas system components, and the problems related to CF4-induced etching on materials. Radiation hardness studies should also be performed for the muon detectors in high-luminosity experiments – systems that are so far comfortably coping with low instantaneous rates and negligible radiation doses.

"The IEEE NSS/MIC will provide a unique forum for the communication and open sharing of experience among a broad range of scientists and engineers worldwide."

Rome and beyond

The IEEE NSS/MIC conference is the instrumentation "Mecca" and is unique in the world; no other conference has such a broad synergistic combination of topics. While its roots are clearly in the US, the IEEE has repeatedly stated its objective to be a truly transnational organization, and its largest growth is currently outside the US. The 2004 NSS/MIC conference is taking place in Rome on 16–22 October at the Ergife Palace Hotel, one of the largest exhibition and congress areas in Europe. The 2004 IEEE NSS/MIC committee includes Alberto Del Guerra of Pisa as general chair; Fabio Sauli and Archana Sharma of CERN as programme chair and deputy chair for NSS, respectively; Sibylle Ziegler of the Technical University, Munich, and Michel Defrise of the Free University, Brussels, as programme chair and deputy chair for MIC, respectively. As it has become an IEEE-wide decision to encourage more conferences outside the US, the NSS/MIC will be held abroad every three to four years. After Lyon in 2000 and Rome in 2004, the next overseas conference is being considered for 2008.

One of the main goals of the IEEE, according to its constitution, is as follows: "The IEEE shall strive to enhance the quality of life for all people throughout the world through the constructive application of technology in its fields of competence. It shall endeavor to promote understanding of the influence of such technology on the public welfare." As our scientific fields, including industry, benefit more and more by transnational interdisciplinary exchange, the IEEE NSS/MIC will continue to help fulfill this mandate by providing a unique forum for communication and open sharing of experience among a broad range of scientists and engineers worldwide.

Further reading

For an extensive overview of the 2003 meeting at Portland, see the talk given at CERN by Mar Capeans, www.cern.ch/PL2003. For further information on the NSS/MIC meeting in general, see www.nss-mic.org, or contact Uwe.Bratzler@cern.ch.

Mar Capeans, *CERN*, **Ray Larsen**, *Stanford Linear Accelerator Center, and* **Maxim Titov**, *Freiburg and ITEP Moscow.*

MEGA INDUSTRIES, LLC

YOUR ONE STOP SOURCE FOR WAVEGUIDE AND COAXIAL COMPONENTS!

Rigid Waveguide

Standard Waveguide components in sizes from WR90 through WR2300. Custom sizes up to WR6200

Semi-flexible Waveguide

Sizes from WR90 through WR2300

Materials: Aluminum, Copper, Phosphor

Coaxial Components

Sizes from 7/8" through 14"

Outer conductor materials: Copper, Aluminum

Impedances: 50Ω, 60Ω, 75Ω, 100Ω–custom

Passive Waveguide and Coaxial components from the tube to the cavity.

Let Mega Industries 25+ years experience be the answer to your RF needs!

Congratulations to CERN on 50 years of service and innovation!

28 Sanford Drive, Gorham, ME 04038 USA Telephone: 207-854-1700 Fax: 207-854-2287
E-Mail: sales@megaind.com Web Site: www.megaind.com

A machine for learning

Ilan Ben-Zvi describes Brookhaven's facility for long-term R&D in advanced accelerator physics, which he directed until recently.

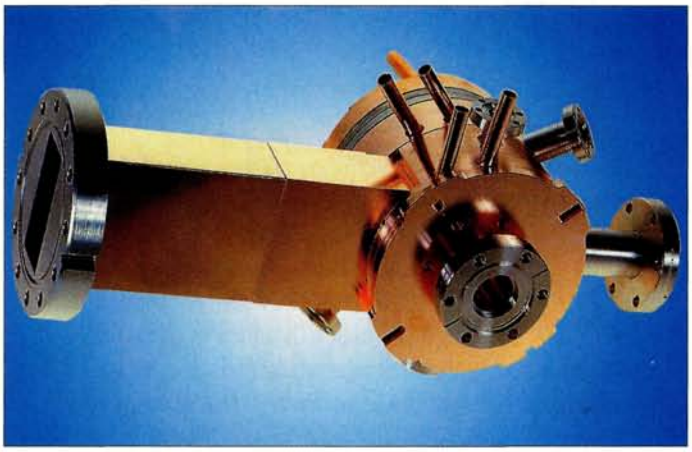


Fig. 1. The latest laser-photocathode radiofrequency gun or "photoinjector", designated Gun IV, was developed at the Accelerator Test Facility and is in use around the world.

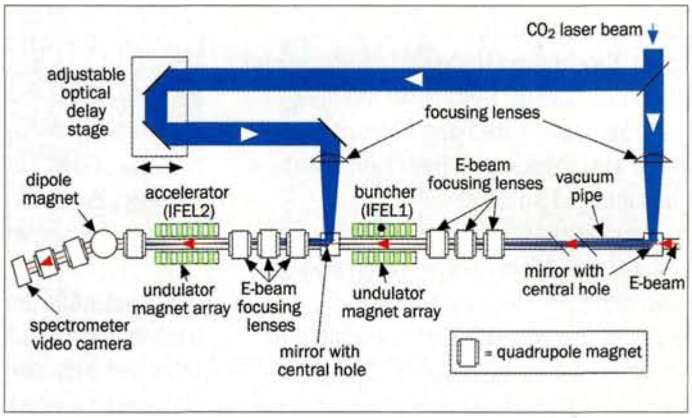


Fig. 2. A schematic of the Staged Electron Laser Accelerator (STELLA). The beam is accelerated in the experiment by two wigglers and a laser beam to demonstrate a mono-energetic acceleration by a laser accelerator.

The Accelerator Test Facility (ATF) at the Brookhaven National Laboratory is the first advanced accelerator facility designed and built to serve the community active in advanced accelerator research. A proposal-driven user facility, it is dedicated to long-term R&D in the physics of particle and laser beams. The users, who come from universities, national laboratories and industry, carry out R&D on advanced accelerator physics, studying in particular the interactions of high-power electromagnetic radiation and high-brightness electron beams, including laser acceleration of electrons and free-electron lasers (FELs). Other topics include the development of electron beams with extremely high brightness, photoinjectors, electron beam and radiation diagnostics, and computer controls.

The core of the ATF consists of a high-brightness photoinjector electron gun, a 75 MeV linac, high-power lasers synchronized to the electron beam to a picosecond level, four beam lines (most equipped with energy spectrometers) and a sophisticated computer-control system. The facility, which has been in operation since 1992, provides the best high-brightness electron beams up to an energy of 75 MeV, with, for example, a normalized rms emittance of 0.8 µm at a charge of 0.5 nC. The bunch length is variable from 1 to 8 ps, with a bunch compressor to extend the range down to 100 fs.

The users enjoy an extensive support infrastructure, which has a few tens of million dollars of investment and is embedded in a large and highly capable national laboratory. ATF staff provide the users with close support and expertise in electron beam-dynamics, lasers and optics, advanced diagnostics, energy spectrometers and computer control. This support is free of charge, while the use of other resources at Brookhaven, as well as the dedicated equipment for experiments, are the responsibility of the users. The users' activities are reviewed by the ATF Programme Advisory Committee, which includes members from various universities and national laboratories. The committee keeps the number of users relatively steady.

The publication rate from experiments at the ATF is high, with an average of more than three papers in *Physical Review* per year. The facility is also an excellent training ground for graduate students in accelerator physics and the physics of beams, with on average more than two graduations a year. While a large number of students come from nearby Stony Brook University, the majority come from universities across the US and throughout the rest of the world. The ATF staff is proud of its contribution to graduate education in accelerator and beam physics, through education and support of the students.

The ATF receives steady support from the US Department of Energy, which has enabled the facility to evolve not only in terms of hardware and staff expertise but also in terms of stability and the superb performance of the electron and laser beams. This environment is beneficial to the difficult, cutting-edge experiments in advanced accelerator and coherent source physics that are carried out by the users.

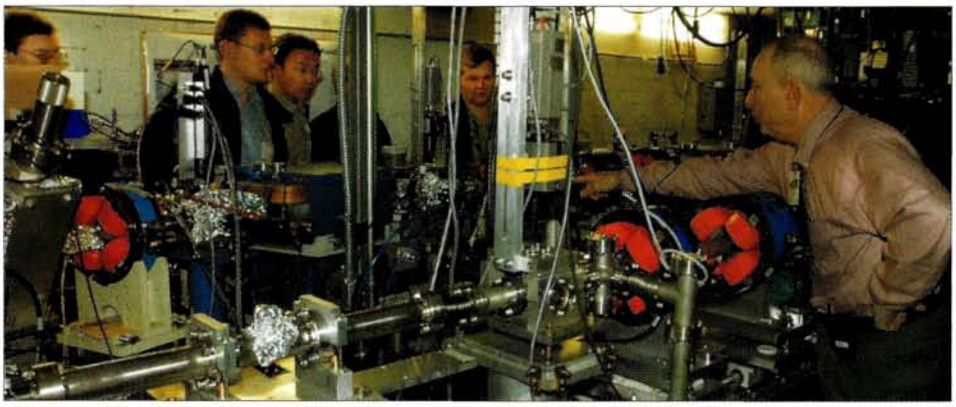
From photocathodes to plasma wake fields

The work of the ATF has pioneered metallic photocathodes such as copper, magnesium and, most recently, niobium, for robust, good quantum efficiency operation. These photocathodes are now found everywhere in the world and are also produced industrially. The same holds true for the radiofrequency (RF) guns, with the celebrated Brookhaven one-and-a-half-cell S-band series of guns. The series now stands at Gun IV (see figure 1), while a new superconducting continuous-wave RF gun is being developed. Examples of advanced diagnostics undertaken at the ATF include the first ▷

The 11th workshop on Advanced Accelerator Concepts

"The best AAC workshop ever," said participants of the 11th Advanced Accelerator Concepts (AAC) workshop, held at Stony Brook University (SBU) on 21–26 June. Sponsored by the Advanced Technology R&D Group of the Office of High Energy Physics within the Office of Science of the US Department of Energy, SBU, Brookhaven National Laboratory and Advanced Energy Systems of Medford, New York, the workshop attracted more than 190 participants from nine countries, including 47 students

Advanced accelerator physics covers long-term R&D in accelerator physics, including R&D for new concepts, and devices and technologies in accelerator and beam physics. Topics in advanced accelerator R&D include laser acceleration of ions and electrons, wake-field acceleration, novel high-power radiofrequency sources, new diagnostics, free-electron lasers, and high-brightness electron-beam generation. Laser-acceleration methods cover many approaches, such as the use of beam- or laser-driven plasma wake fields and electromagnetic structure-based acceleration.



Ilan Ben-Zvi, chair of the Advanced Accelerator Concepts workshop, talks with a group of participants during a visit to the Accelerator Test Facility at Brookhaven.

The scientific programme of the workshop included 21 plenary invited talks and eight parallel working groups. Talks on research highlights included a presentation by Chan Joshi of the University of California, Los Angeles, who described accelerating electrons by a plasma wake in SLAC's E164X experiment, where electrons at 28 GeV gained 4 GeV in 10 cm of plasma. Lawrence Berkeley National Laboratory's Wim Leemans discussed generating and accelerating electrons by a laser-plasma wake field, thereby achieving an energy of more than 85 MeV with excellent beam quality over a distance of a few millimetres in a tabletop device. Victor Malka of the Laboratoire d'Optique Appliquée, France, described the production by laser plasma wake-field acceleration of a high energy of 170 MeV of high beam quality. The workshop programme also included a visit to the Brookhaven Laboratory and its Accelerator Test Facility.

• The presentations of the plenary talks and the summaries of the working groups are available on the workshop's website at www.bnl.gov/atf/AAC04.htm.

slice-emittance measurement, the first pulse-length measurement using shot-noise driven fluctuation in incoherent radiation, high-resolution phase-space tomography and more. The ATF is also developing high-performance plasma capillary channels that channel the carbon-dioxide laser beam and provide a convenient source of plasma for a variety of experiments. Most recently, R&D is being carried out on optical stochastic cooling of hadron beams.

By far the most important aspect of the ATF is the research carried out by its users. Milestone experiments in laser acceleration include the work on inverse Cherenkov acceleration and the inverse free-electron laser (IFEL). STELLA, the Staged Electron Laser Acceleration experiment, has successfully used two laser accelerators (both IFELs), demonstrating the steady production of 3 fs electron-beam bunches (figure 2). With this configuration STELLA II has shown monoenergetic laser acceleration for the first time (*CERN Courier* March 2004 p7).

Experiments on the development of laser-photocathode RF guns include the "Next Generation Photoinjector", or Gun III in the ATF series. Others concern the generation of unique radiation sources, including the pioneering high-gain harmonic-generation FEL that set a new trend towards coherent, ultrashort pulse X-ray FELs. The VISA experiment at the ATF, which served as a proof-of-principle experiment for the Linac Coherent Light Source project at SLAC (*CERN Courier* March 2003 p5), reached saturation at visible wavelengths and demonstrated the generation of harmonics, their growth and saturation properties and the relationship to microbunching. The Compton scattering experiment to investigate Compton scattering between energetic electrons and laser beams produces a record of about 10^8 hard X-ray photons per pulse of a few ps.

Most recently, a plasma wake-field experiment demonstrated the phase relationship between the accelerating and focusing component of the plasma wake. This showed a 90° phase difference, thus allowing plasma wake accelerators to accelerate and focus the beam at the same phase.

Further reading

The ATF's website can be found at www.atf.bnl.gov.

Ilan Ben-Zvi, *Brookhaven National Laboratory.*

• On 5 August, after 15 years as director of the ATF, Ilan Ben-Zvi decided to step down to devote his energy to the electron-cooling project for the Relativistic Heavy Ion Collider at Brookhaven and R&D for the associated energy-recovery linac. He has passed the helm of the ATF to his deputy, Vitaly Yakimenko.

The new transversity council of Trento

A recent workshop on new developments in nucleon spin structure, held at the ECT* in Trento, revived memories of the famous Council of Trento of 1530.

During physics workshops experts generally get together to present the outcome of recent work, confront and discuss new ideas, gain inspiration for further work, and incidentally start new collaborations. Sometimes, however, the conditions are so favourable that all workshop activities seem to be oriented towards a unique common goal. Each participant feels like a member of one team co-operating to accomplish a well defined goal. This is just what happened during the international workshop on "Transversity: New Developments in Nucleon Spin Structure" in June 2004, which brought together some 40 leading experimental and theoretical physicists in the field of nucleon spin structure at the European Centre for Theoretical Physics (ECT*) in Trento, Italy.

Many interesting talks were presented by renowned experts, supplemented by shorter, but no less inspiring, talks by PhD students and postdocs. The talks illustrated and substantiated the rapid developments in the new field of transverse spin physics. Indeed, the results presented were so encouraging that the idea emerged spontaneously to devote part of the scheduled (and unscheduled) discussion time to the preparation of a document, soon christened *The Trento Convention*, which would contain all relevant notations and conventions that are crucial for the achievement of further progress in this field. The document, which is now well under way, will soon be submitted to the e-print archives. While it has been set up by a few representatives (A Bacchetta, U D'Alesio, M Diehl and A Miller), it is in a sense co-authored by all the workshop participants. Just like the famous First Vatican Council that took place in Trento almost 500 years ago in 1530, the document represents a common frame and a common language for an unambiguous comparison between theory and experiment. It will be an indispensable tool to boost further developments in this field.

Why is such a seemingly technical subject as transverse spin physics so fascinating? From recent cosmological observations, for instance by the WMAP satellite, we know that visible matter represents only 4% of the universe. Of this small percentage only a minute fraction can be attributed to the mass of the quarks, for which – most likely – the Higgs mechanism has to be invoked. The remaining, and by far the largest, part of the mass of the visible universe has a dynamical origin. It is the dynamics of the quarks and gluons in the nucleon, as governed by the theory of strong interactions – quantum chromodynamics (QCD) – that needs to be

Andy Miller (left) and John Collins discuss spin physics during the transversity workshop dinner in Trento.

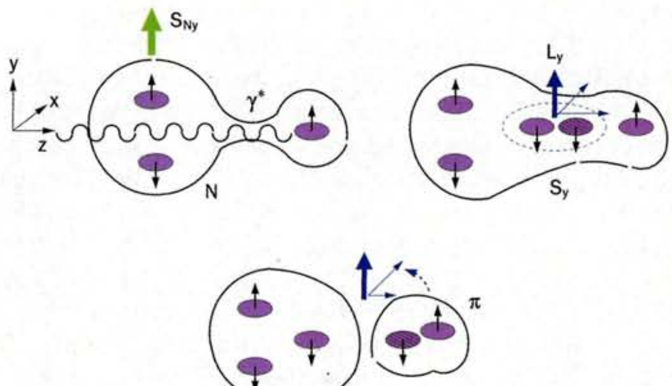


Fig. 1. The Collins effect in a sketch suggested by Xavier Artru of Orsay in the context of the Lund fragmentation model. A virtual photon hits a valence quark at the end of a flux tube; the flux tube stretches and eventually breaks down; a quark–antiquark pair is created in the $^3P_0$ state with the quantum numbers $J^P = 0^+$ of vacuum, i.e. with orbital angular momentum $L_y = 1$ and spin $S_y = -1$; the pair rotates in space and colour around the breaking point; a pion is formed and deviated upward by this rotation, while the residual hadron is deviated downward.

fully understood to be able to account for the mass of the nucleon and hence that of the visible universe. It is this quest that drives theorists and experimentalists alike to study the transverse spin structure of the nucleon, giving access to subjects such as the orbital motion of quarks – a crucial ingredient of parton dynamics.

In the famous EMC (European Muon Collaboration) experiment at CERN, it became evident in 1988 that only a small fraction of the proton spin is carried by the helicities of the valence quarks. Since then much work has been done in unravelling the origin of the proton's spin, in particular identifying the carriers of nucleon angular momentum in the framework of QCD. Thanks to a tremendous effort in both experiment and theory, we now know how to encode information on the dynamics of polarized quarks and gluons into a formalism that can be rigorously derived from QCD. This effort has also led to the definition of new observables and the introduction of methods to measure new effects associated with these observables. Transverse spin is an example of such a new observable, and it has generated considerable interest as it enables the study of the spin structure of the nucleon while "switching off the gluon contribution". Moreover, the first observation of transverse spin effects in experiments – as presented at the workshop – gives indirect evidence for the existence of quarks with non-zero orbital angular momentum in the nucleon.

Only slightly more than a decade ago it was realized by Robert Jaffe of MIT among others that there is a third leading-order quark distribution function apart from the well known structure function F_2 and the spin-dependent distribution function g_1. This distribution of transversely polarized quarks in a transversely polarized nucleon, also known as "transversity", is nowadays acknowledged as a crucial ingredient of the spin structure of the nucleon. However, until less than a year ago no data on this distribution function existed. On the other hand, measurements of transverse spin distributions would not only enable the study of the issues mentioned above (on spin effects without gluons and orbital motion), but would also make it possible to verify QCD predictions on the deformation of this quark distribution in polarized nucleons (known as the nucleon tensor charge) and the novel QCD evolution properties of this distribution function. Unfortunately, transversity is experimentally very difficult to access because it involves a simultaneous flip of the helicity of both the struck quark and the target; it is, to use some jargon, a "chiral-odd" object. For that reason another chiral-odd object is needed to arrive at a measurable (i.e. chiral even) cross-section. This can be realized in polarized Drell–Yan ($p\uparrow p\uparrow \rightarrow l^+l^-X$) or semi-inclusive processes with hadron beams ($pp\uparrow \rightarrow \pi X$) or lepton beams ($lp\uparrow \rightarrow l'\pi X$).

In semi-inclusive processes, experimentally an azimuthal asymmetry is searched for in the produced π mesons. Such an azimuthal asymmetry – i.e. with pions preferentially produced in one hemisphere rather than the other with respect to the scattering plane – may arise for two reasons. Assuming a string breaking mechanism, a quark–antiquark pair with a non-zero internal angular momentum is produced (see figure 1, p51) and/or the struck quark already had some intrinsic orbital angular momentum. These mechanisms are known as the Collins and Sivers effects, respectively. For years it was commonly believed that they had to be suppressed because they violate invariance under the time-reversal transformation. However, as was shown by Stanley Brodsky of SLAC and Dae Sung Hwang of Sejong University

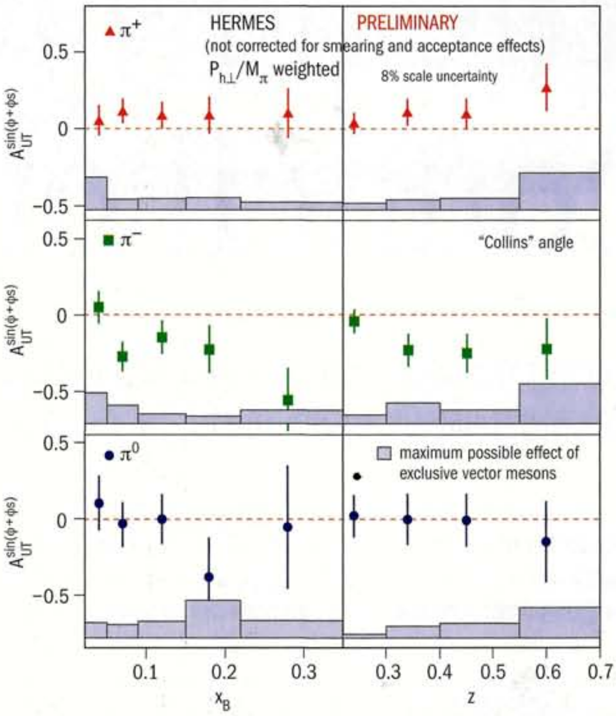


Fig. 2. Azimuthal asymmetry for deep-inelastic lepton-induced inclusive pion production from transversely polarized protons, as obtained in the HERMES experiment at DESY. Data are plotted against the Bjorken variable x_B and the light-cone momentum fraction z of the pion (HERMES 2004).

in Seoul (the latter being present at the workshop), a residual interaction with the jet remnants enters the description of these reaction processes and prevents the time-reversal argument from being applicable. The proper description of this additional interaction was addressed by several speakers at the workshop, including Andreas Metz of Bochum and Dennis Sivers of Portland, indicating that there exists a possible link to chiral-symmetry breaking effects in QCD.

The first data on azimuthal asymmetries observed in deep-inelastic lepton scattering on transversely polarized proton targets were presented at the workshop by Andy Miller for the HERMES experiment at DESY (figure 2) and Rainer Joosten for COMPASS at CERN. These data represent only the beginning of a whole new generation of experiments that enable measurements of single-spin asymmetries as small as a few percent, while they are differential in two to three kinematical variables. Other collaborations, such as STAR and PHENIX at the Relativistic Heavy Ion Collider at Brookhaven and CLAS at the Thomas Jefferson Laboratory, presented other asymmetry measurements that give information on related processes. Moreover, the HERMES collaboration showed first results for the azimuthal asymmetry related to the Sivers mechanism, which – the data being non-zero – provided direct evidence of the existence of quark orbital angular momentum.

On the theoretical side much progress has been obtained in studying the universality of the transverse-momentum-dependent parton distribution and fragmentation functions. Both John Collins and Andreas Metz argued that this universality, or process independence, is now almost completely established for deep-inelastic scattering, e^+e^- annihilation and the Drell–Yan process, although it

Two members of the organizing committee of the Trento workshop, Marco Radici (right) of INFN Pavia and Gerard van der Steenhoven of NIKHEF.

is still under debate for proton–proton annihilation because of the complicated field-theoretical structure of the diagrams involved. In parallel, an increasing number of groups – including Leonard Gamberg at Pennsylvania State University, Umberto d'Alesio from Cagliari, Aram Kotzinian of CERN and others – are calculating these functions either within models or by means of lattice QCD simulations, as discussed by Philip Haegler of Regensberg, in order to interpret both new and existing data. At the workshop it became clear that, despite the large amount of work already done and in progress, it is still too early to draw definite conclusions. Many speakers insisted that a new global analysis of all direct and indirect measurements is needed to make further progress. For that reason the development of *The Trento Convention* is very timely.

This is a rapidly changing field, and new experimental and theoretical avenues are currently being explored. The former, presented by Delia Hasch of Frascati, include azimuthal asymmetries with inclusive detection of two pions, upgrades of existing experiments and the use of polarized antiproton beams and targets to extract transversity from Drell–Yan measurements at the future HESR ring at GSI (which was presented by Frank Rathmann). New theoretical avenues include the first exploratory calculations of chiral-odd objects on the lattice, and the study of the relationship and complementarity between transverse-momentum-dependent (chiral-odd) parton distributions and the (chiral-odd) generalized parton distributions, which give a picture of the transverse distribution of partons in three-dimensional space, as described by Markus Diehl of DESY and Matthias Burkhart of New Mexico State/ECT*.

Although only a first small sample of data on azimuthal asymmetries with transversely polarized targets is as yet available, the field is already confronted with rapid experimental and theoretical developments giving new insights into the QCD structure of the nucleon in general and the role of orbital angular momentum and transverse spin in particular. In Trento this gave rise to an outspoken enthusiasm, illustrated by the many lively discussions. All of this reflects the enormous activity in this relatively new branch of QCD physics.

Further reading

HERMES collaboration 2004 http://arxiv.org/abs/hep-ex/0408013.

Marco Radici, *INFN Pavia, and* **Gerard van der Steenhoven**, *NIKHEF.*

50 YEARS OF CERN

A winter's tale – 1963 and 2004

Roger Anthoine (right), the CERN Courier*'s first editor, with Albert Picot of Geneva's Conseil d'Etat at CERN in May 1961.*

A snow-covered aerial view from 2004 shows how CERN's main site at Meyrin has developed in the four decades between this photo and the one below.

Aerial photos have been an important part of documenting CERN's progress ever since construction of the laboratory began. Some, such as the one on the right, have an interesting history of their own. Roger Anthoine, the first editor of the *CERN Courier*, was also a qualified pilot and on 23 January 1963 he flew a Piper Super Cub up to an altitude of about 1220 m (about 730 m above CERN) to take some photographs. Here he recalls his flight as pilot/photographer.

"The day was endowed with a crystal-clear atmosphere after a three-day blizzard. I used that particular aircraft because it was possible to open a large side window, thus avoiding the optical distortion caused by Plexiglas panels. The drawback was of course the gale-force freezing wind that was howling in the cockpit. According to my diary, the temperature at ground level was −20 °C and if the laws of meteorology are correct it must have been around −25 °C where I was flying. I should add that the pilot/photographer wore for the occasion two padded army jackets, a leather flight helmet under a woollen balaclava and...one glove, the unprotected hand being used to trigger the shutter of my Rolleiflex 6 × 6 cm camera, which was safely strapped around my neck.

While taking this aerial view in 1963, Roger Anthoine – who was also at the controls of the aeroplane – braved a temperature of −25° C.

For those who would ask how one can simultaneously operate a camera and a light aeroplane lacking an autopilot, this is no complicated trick, no different from what you do in-flight to adjust maps. All you have to do is to trim the plane level, adjust the power setting, squeeze the stick between the knees and all is set for enough time to aim the camera, press the trigger and reload as required with the Rollei.

In those days air traffic was not as heavy as it is today. Airspace control was also much simpler, however, my notes show that I managed to share the approach with a Caravelle coming into runway 05 at Geneva's Cointrin Airport."

Forty-one years after Roger Anthoine's experience, almost to the day, a helicopter flew around the CERN site on 30 January 2004. The mission was to film CERN for the Swiss television channel TSR, who kindly allowed CERN's photographer Maximilien Brice to hitch a ride to take some stills. Again it was crystal clear and cold, around −10 °C. As a "hitch-hiker", Max had a small aperture through which he could aim his Nikon F5, clasped in his gloveless hands. His photographs, two of which are shown here, reveal how a handful of buildings and a first accelerator have blossomed into an entire machine complex.

AWARDS

Bjorken and Callan awarded the Dirac medal for 2004

James Bjorken, professor emeritus of physics at Stanford University, and Curtis Callan, professor of physics at Princeton University, have been awarded the 2004 Dirac medal. They are being honoured for their theoretical investigations in the 1960s and 1970s, which led to the use of deep-inelastic scattering for shedding light on the nature of strong interactions.

Bjorken has been recognized as the first to realize the importance of deep-inelastic scattering and the first to understand the scaling of cross-sections, an insight that ultimately bore his name – the Bjorken scaling of cross-sections. Callan, together with Kurt Symanzik (now deceased), reinvented the perturbative renormalization group (in a form that now bears the name Callan–Symanzik equations) and recognized these groups as measures of scale-invariance anomalies. Callan has applied these techniques to analyses of deep-inelastic scattering and has made substantial contributions to particle physics and, more recently, string theory.

The annual award, which includes $5000 for each winner, is sponsored by the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, and is given to scientists who have made significant contributions to theoretical physics and mathematics. The announcement of the Dirac medal is made on 8 August, the anniversary of the birth of Paul Dirac, who was a close associate of the ICTP.

UK's Institute of Physics honours particle physicists

Theoretical and experimental particle physicists figure among the 2004 winners of Britain's most prestigious prizes for physics, awarded by the Institute of Physics (IOP). The IOP's own Paul Dirac medal and prize goes this year to CERN's John Ellis for "his highly influential work on particle-physics phenomenology; in particular on the properties of gluons, the Higgs boson and the top quark". One of the IOP's premier awards, the Dirac medal and prize is made for outstanding contributions to theoretical (including mathematical and computational) physics.

The Duddell medal and prize, in memory of William du Bois Duddell, the inventor of the electromagnetic oscillograph, is awarded for outstanding contributions to the advancement of knowledge through the application of physics, including the invention or design of scientific instruments or the discovery of materials used in their construction. It is shared this year by Geoff Hall of Imperial College London, Alessandro Marchioro from CERN and Peter Sharp of the Rutherford Appleton Laboratory and CERN. The trio received the Duddell award for their "development of radiation-hard analogue electronics for silicon detectors, enabling their use as a means of precision detection and measurement of charged-particle production at the Large Hadron Collider".

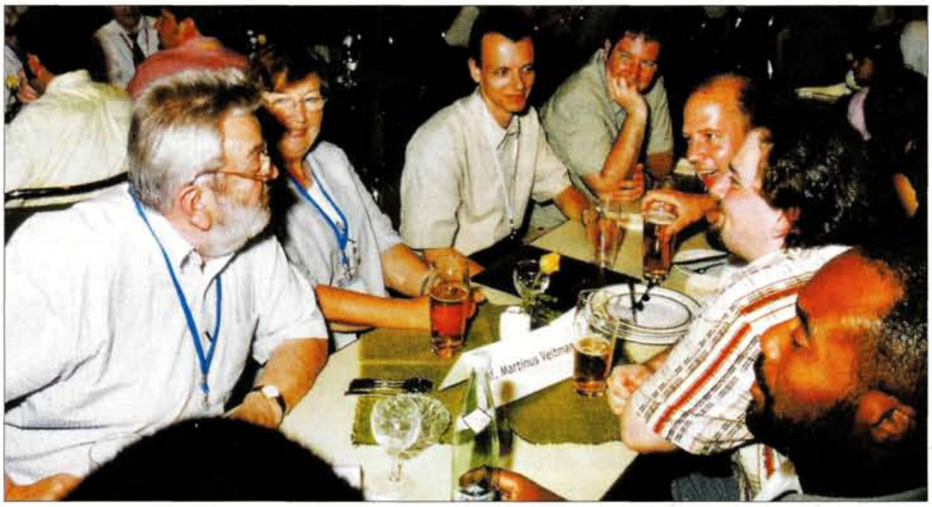
The Maxwell medal and prize, which is given for outstanding contributions to theoretical physics in the past 10 years, is awarded to Clifford Victor Johnson of the University of Durham. He receives the award, which is intended to recognize physicists in the early part of their careers, for "his outstanding contribution to string theory, quantum gravity and its interface with strongly coupled field theory, and in particular for his work on understanding the censorship of singularities, and the thermodynamic properties, of quantum space–time".

NOBEL TIMES

Young physicists meet Nobel laureates in Lindau

The 54th annual meeting of Nobel laureates, and the 18th of physics laureates, took place on 27 June – 2 July in Lindau, Germany. The original aim of these reunions was to help German scientists restore contacts with world leaders in their fields of research. What began with mainly German audiences of students and young researchers in physics, chemistry and medicine has, half a century later, grown into a truly international event. This year more than 500 students from 21 countries worldwide came to meet the laureates.

The lectures given were not only on work that won medals. Douglas Osheroff, a one-time member of the board investigating the Columbia shuttle accident, pointed out that apart from organizational weaknesses, insufficient attention to the basic principles of physics was also to blame. Ivar Giaever recalled the pitfalls he experienced when starting a high-technology biophysics enterprise, Robert Richardson dealt with pseudoscience and related gadgetry, while Sir Brian Josephson spoke on fact and fantasy in science. More predictably, Masatoshi Koshiba outlined the development of neutrino astrophysics, Gerardus 't Hooft introduced supertheories and Martinus Veltman wittily scanned the history of particle physics from Röntgen to the Large Hadron Collider.



Food for thought: Martinus Veltman, left, in animated after-dinner discussion with students from many nations at the 54th Nobel laureates meeting. (Photo Annette Jordan.)

Laureates and the audience interacted in a round-table discussion on the role of astrophysics in tackling many riddles of the universe. Another discussion on the relative merits of fundamental and applied physics showed such evaluation to be meaningless, as one kind of research often leads to another; however, potential applications can work wonders in attracting funding.

These meetings are most valuable in offering students numerous opportunities for talking to the leading personalities in their chosen professions. The laureates too benefit from lively conversations with the new generation of scientists. During its existence this unique institution has brought hundreds of laureates into contact with many thousands of students. Alfred Nobel may not have foreseen such a positive consequence of his generosity.

LETTERS

CERN Courier welcomes letters from readers. Please e-mail cern.courier@cern.ch. We reserve the right to edit letters.

Remote analysis sixties style

Possibly the wording was a little imprecise, but the impression given in the article on the Fermilab DO collaboration (*CERN Courier* September 2004 p16) was that this experiment is one of the first ever to distribute real collision data to remote sites for analysis and for the purpose of accessing additional computer resources. But in fact such a practice had been well established over a very long period.

In 1962 at CERN the di-boson experiment at the Proton Synchrotron generated a huge amount of data in the form of photographically recorded spark-chamber events. The following year the same group (D Caldwell, L W Jones *et al.*), of which I was a member, performed an even more ambitious experiment on πp and Kp elastic scattering, during which some 1.2 million events were recorded, a staggering amount by the standards of the day. Not only was the total computer power available then at CERN inadequate, but so were the human resources necessary for digitizing the data and for the processing involved. I recall that at one stage I was the biggest user of the CERN 7090.

In the end we decided to utilise in addition as much computer power as we could find outside CERN, and I spent nearly a year "on the road" going to anywhere that had spare computer capacity. Not only did I use the newly installed 7090 at Darmstadt every weekend from Friday night to Monday morning, but very soon the 7094 at Michigan University, the MIT 7090, as well as many other under-used mainframes too.

Of course in 1962/63 it was impossible to transfer data over any network, so this needed to be carried on magnetic tape from one place to another, much to the puzzlement and suspicion of numerous customs officials around the world. But within a year most of the data had been analysed.

The frustration of carrying so much data around and the necessity of digitizing photographic data convinced me (and others) that the future lay with digital data recording and on-line transfer of data to remote mainframes. In 1964 I wrote to Mervyn Hine, as the most senior directorate member who might have influenced matters, to suggest that CERN set up a system for the on-line transfer of digital data to the central computer facilities, using a mini-computer as a front-end. He was sympathetic, but it was a long time until the scheme was implemented.
Vasilii Zakharov, Cheshire, England.

CERN

Summer student programme extends its welcome to the UAE

Each year CERN plays host to more than a hundred young physicists who attend the summer student programme, coming not only from CERN's 20 member states but also from countries including Israel, Japan, Madagascar and the US. This year, for the first time, they were joined by students from the United Arab Emirates. Five theoretical physics and medical physics students from the United Arab Emirates University (UAEU) spent eight weeks attending lectures and working with experimental teams.

The practical work available at CERN has been on a different scale from that at UAEU. Aminah Al Abdouli and Shaikha Al Kalbani worked with the CMS/Crystal Clear group; Mariam Al Yateem and Alya Ali Binghurair assisted on muon chambers for the ATLAS experiment; and Mariam Al Hassani did programming for the ALICE collaboration.

All five have another year of work towards their degrees, and after that the possibility of further academic work or a move into the practical application of medical physics. Medical physics is a relatively new field in the UAE, and contributing to its development would be an opportunity the students would appreciate. "Physics is difficult to study – but I like a challenge," said Shaikha Al Kalbani. "As well as that, physics is going to be a useful asset to my country. I think it's important and helpful to everyone."

From left to right, in the Crystal Clear laboratory at CERN, Chafia Hejase de Trad with UAEU students Shaikha Al Kalbani, Alya Ali Binghurair, Mariam Al Hassani and Aminah Al Abdouli. (The fifth student, Mariam Al Yateem, is not pictured.)

Chafia Hejase de Trad, who will be one of their lecturers in the next academic year, was also at CERN to discuss the opportunities for future collaboration. The university plans to start MSc programmes in both general and medical physics, so the opportunity to collaborate with CERN is both useful and timely.

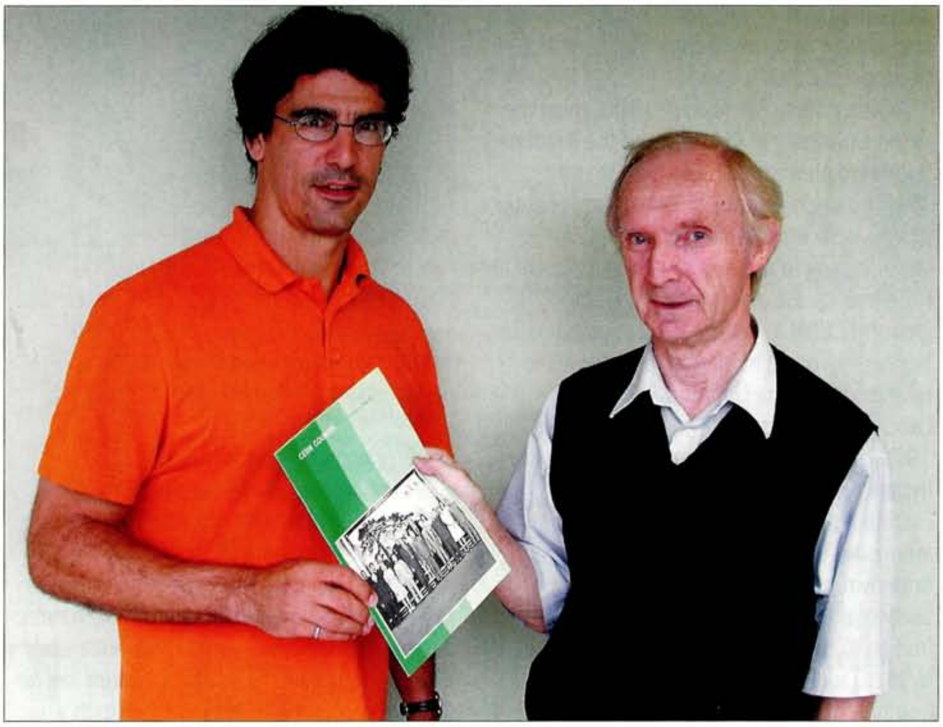
MEETINGS

The third "epoline" Annual Conference, which is organized by the European Patent Office, will take place at the Salzburg Congress in Austria on 23–24 November. The conference will examine the latest developments in on-line patent management and information dissemination, and its contribution to European Union innovation.

The two-day conference will consist of several sessions, mainly hands-on training for both epoline on-line patent management and esp@cenet patent information – conducted separately in English, French and German – along with seminars on patent procedure and presentations on a range of intellectual property issues. For further information, see the conference website at www.epoline.org/events/salzburg/en/intro.html.

CERN COURIER

TRIUMF's correspondent steps down after 29 years



Changeover at TRIUMF: Mike Craddock, right, with his successor Marcello Pavan and the CERN Courier *for October 1975, the first issue in which one of Mike's articles appeared.*

In May 1975 Brian Southworth, then editor of *CERN Courier*, took on a correspondent from TRIUMF, Canada's national laboratory for particle and nuclear physics. Michael (Mike) Craddock had been with the TRIUMF laboratory since its very beginnings, as he had joined the Physics Department at the University of British Columbia in 1964, just in time to help in drafting the proposal for the laboratory and later in building the 500 MeV 100 μA H^- cyclotron. From 1981–1994 he served as head of TRIUMF's Accelerator Research Division, and was responsible for the design of the 30 GeV KAON (Kaon–Antiproton–Otherhadron–Neutrino) factory accelerator chain. His more recent interests have included collimation at the Large Hadron Collider, synchrotron light sources and radioactive ion storage rings. Now retired, he is also stepping down as our correspondent, but his interest in physics is continuing with fixed-field alternating-gradient synchrotrons (FFAGs) for accelerating muons, which he says is "perhaps a suitably far-out project for a retiree!" His last article for the *Courier* was, appropriately, on FFAGs (*CERN Courier* July/August 2004 p23.)

Replacing Mike is Marcello Pavan, who assumed the duties of TRIUMF's first Outreach Coordinator in April 2003. Prior to that his research was primarily as an experimentalist in the field of pion–nucleon chiral dynamics. Recently, his research activities have shifted towards the nuclear astrophysics programme at TRIUMF's ISAC facility, working with the DRAGON and TUDA groups. While juggling all his responsibilities at TRIUMF for outreach, communications and research, Marcello says he wonders how on earth he will be able to fill Mike Craddock's considerable shoes as TRIUMF's new CERN correspondent, but he promises to try his very best.

Mike will indeed be a hard act to follow. Many thanks, and good luck for the future.

NEW PRODUCTS

Del Mar Ventures is offering a Faraday optical isolator for use in eliminating back reflections in laser systems. It consists of a Faraday rotator and two polarizers; the Faraday rotator is made from a magneto-optical rod placed inside a permanent magnet. The total transmittance is 80% and models are offered with reverse isolation of 38 dB or 60 dB. For further information, call +1 858 481 9523, e-mail: sales.dvm@femtosecondsystems.com, or see the website at www.femtosecondsystems.com.

Electron Tubes has developed a miniature 12 mm bialkali photomultiplier with a fast response, which should be useful for measuring fast transients in photon counting in applications where space is at a premium. The 9001V01 includes a voltage divider in an insulated housing, and features a rise time of 700 ps and very low dark counts of $10\ s^{-1}$. For further information, e-mail: info@electron-tubes.co.uk, tel: +44 1895 630771, or see www.electrontubes.com.

Heinzinger electronic GmbH is offering high-voltage power supplies designed specifically for charging capacitors, as part of its standard range of products. The new PNCcap series is based on the PNC series of power supplies, with a range of accuracies and stabilities up to 0.0001%. For further information, please contact Peter Bannert on tel: +49 8031 2458 61, or e-mail: peter.bannert@heinzinger.de.

Thales Electron Devices has announced the TH 713 inductive output tube. Developed to meet the requirements of the X-FEL (X-ray free-electron laser) and the ERL (energy recovery linac), the TH 713 is a very-high-efficiency tube that is intended for applications requiring low continuous-wave power in superconducting cavities. It delivers 15 kW continuous-wave output power with a typical gain of 20 dB and a bandwidth of 1 MHz at −1 dB. For further information, please contact Gilles Khong, on tel: +33 1 30 70 36 40, or e-mail: gilles.khong@thales-electrondevices.com.

OBITUARIES

Arthur Roberts 1912–2004

Arthur Roberts, centre, during the International Conference on Instrumentation for High Energy Physics at CERN in July 1962. On the left are Sir John Cockcroft (with his back to camera) and Ernst Michaelis.

Arthur Roberts, who was well known not only as a particle physicist but also as a musician and composer, passed away on 22 April 2004 at his home in Honolulu, Hawaii.

A native New Yorker, Art studied both music and physics at university. A bachelor's degree from the City College of New York (part of the City University New York system) was followed in 1933 by a degree in piano performance from the Manhattan School of Music and a PhD in physics from New York University in 1936. Art then moved to Cambridge, Massachusetts, and although he continued with music through teaching at the England Conservatory of Music, his career became more weighted towards physics, with joint positions with the cyclotron group at MIT and the Harvard Medical School. Here he was the physicist on the team that pioneered the use of radioactive isotopes in medicine by treating hyperactive thyroids with radioiodine.

Art moved to the MIT Radiation Laboratory in 1941, where he led the development of microwave beacons used by British and US "Pathfinders" during the Second World War in 1944–1945. After the war, he moved to the University of Iowa, and in 1950 to the University of Rochester. At Iowa he had worked on the measurement of the magnetic moment of the neutron and deuteron, and at Rochester his research became still more oriented to particle physics, with an investigation of the pion–nucleon interaction at the synchrocyclotron. Here he also helped to found the famous series of "Rochester Conferences".

Another move followed in 1960, this time to the University of Chicago and the Argonne National Laboratory. It was here that Art invented the ring imaging Cherenkov counter (RICH), now widely used for particle identification in many high-energy physics experiments. He also brought a research group to CERN in 1961–1962, and later became involved in the planning for what became the Fermi National Accelerator Laboratory, or Fermilab, where he moved in 1970 and became involved in research in hyperon physics.

During the 1970s Art began to become interested in the possibility of building an underwater neutrino "observatory", in particular in the deep waters off Hawaii. He moved to the University of Hawaii in Honolulu in 1980 together with John Learned and neutrino pioneer Fred Reines, where they made the first studies for an underwater neutrino detector with the DUMAND project. This was his last physics project, and its history was the subject of his last paper, which was published in 1992.

Art is perhaps as well known among the physics community for his musical talent, which lightened many a conference with songs he had composed about physics and the academic life, including probably most famously "Take away your billion dollars". In a more serious vein, he wrote "Overture for the dedication of a nuclear reactor", which was premiered by the Oak Ridge Symphony Orchestra in 1955.

We will miss the "bard of physics".
John Learned, Honolulu.

Eliane de Modzelewska (née Bertrand) 1917–2004

On 6 July 2004 one of the best-known personalities in the history of CERN passed away in Geneva. Eliane de Modzelewska first joined the would-be international laboratory when, in the years 1952–1953, she was chosen in Rome by Edoardo Amaldi to assist in the pioneering, early steps that led to CERN. Her experience in diplomatic circles (the French Embassy in Rome), her mastery of languages (Italian, English and Russian, as well as her native French) and, most important, her lively, enthusiastic character made her ideally suited for the job.

Eliane moved to Geneva in 1954 and initially took up quarters, together with the CERN directorate services, in the Cointrin Villa. Being responsible for the secretariat of the CERN director-general, and therefore for all top-level relations, she was a central figure in and around the CERN Council and its committees. She worked with nine director-generals, from Edoardo Amaldi, with the provisional Conseil Européen pour la Recherche Nucléaire (1952–1954), to Herwig Schopper, and was present at all the important occasions. Much of the smooth operation of CERN, and of the good image of the organization in the eyes of the member states, are to her credit. Eliane sought and enjoyed the company of friends and colleagues on many festive occasions and was the life of every such party. Many of her colleagues remember her personality with emotion, and pay respect to her memory.
Franco Bonaudi, Commugny.

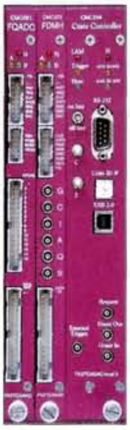
SUPPLIER INFORMATION

Janis Research

Custom Dilution Refrigerator Stages

The Janis JDR-100 Dilution Refrigerator stage provides 15 mK base temperature and 100 µW cooling power using a single mechanical He3 pump. Janis also offers customized models, with user specified length, experimental volume, access ports, support structure, and wiring to meet almost any requirement.

Janis Research Company, Inc.
2 Jewel Drive, PO Box 696
Wilmington, MA 01887-0696 USA
Tel: +1 978 657-8750
Fax: +1 978 658-0349
E-mail: sales@janis.com
Web: www.janis.com



A Camac Triple Play

Start with the cmc081 Fera compatible 16 channel charge integrating ADC. Think of it as a 4300 on steroids. 15 bit dynamic range, 11 or 12 bits, sliding scale and still only 8.5 µs deadtime.

Add a CMC203 FeraDriver/memory/histogrammer. It's like a 4301 and 4302 and histogrammer combined. The features you need that were left out of the 4301 such as event counters, timeouts for error recovery, automatic clears, busy outputs and much more. The 1Mword memory is either a FIFO buffer or histogram space (large enough for a crate full of 081's).

Top it off with a CMC100 FastCamac Crate Controller. With its built in Lam Grader, list processor and 1Mword memory, it can empty the CMC203 at FastCamac speeds. And then your laptop computer can read it out at 50 Mbytes/s over USB 2.0. Camac for the 21st century!

CMCAMAC, 24 Halley Drive, Pomona, NY 10970 USA
Tel: +1 845 364 0211
E-mail: info@cmcamac.com

SHI Cryogenics Group

SHI Cryogenics Group is the world's largest supplier of 10K and 4.2K Gifford McMahon cryocoolers to medical and research applications. We are able to provide unbeatable cooling capacities, orientation-free operation, on-site service solutions.

Also, visit our website to see our latest range of 4.2K and 77K Pulse Tube cryocoolers

www.shicryogenics.com

SUPPLIER INFORMATION

- **Do you want to promote your latest catalogue?**
- **Have you recently upgraded your company website? Or do you just want to increase the traffic?**
- **Have you had a new product launch that you want to continue to promote?**

If you have answered YES to one or more of these questions then you should reserve your space on the Supplier Information page.

FOR ONLY £660.00, 50 WORDS OF TEXT AND AN IMAGE OF YOUR HOMEPAGE, LATEST CATALOGUE OR NEW PRODUCT YOU CAN APPEAR ON FEBRUARY'S SUPPLIER INFORMATION PAGE.

Call Ed Jost or Jonathan Baron on +44 (0)117 930 1026 or +44 (0)117 930 1265 respectively to be included.

THE UNIVERSITY *of* LIVERPOOL

The Cockcroft Institute for Accelerator Science and Technology

Director

Attractive salary

The Cockcroft Institute has recently been established as an international institute for Accelerator Science and Technology. It will be a centre of world-class research and development, and will provide the intellectual focus, educational infrastructure and essential scientific and technological facilities for UK scientists and engineers to take a global lead in future accelerator design, construction and operation. It will collaborate actively with UK high-technology industry in contributing to future projects in the field – nationally and internationally. The Institute is a joint venture of six organisations which are all committed to developing a global centre of excellence: Lancaster University, the Universities of Liverpool and Manchester, the Daresbury Laboratory (the Council for the Central Laboratory of the Research Councils CCLRC), the Particle Physics and Astronomy Research Council (PPARC), and the North-West Development Agency (NWDA).

A scientist with an outstanding international reputation in the science and technology of particle accelerator systems is sought to be inaugural Director of the Institute. S/he will be based in a new and purpose built site at the Daresbury Laboratory in England. S/he will have prior experience in the operation of a major accelerator facility and must be able to demonstrate an ability to lead, manage and direct teams of scientists and engineers, to take a strategic view of the scientific and technological programme of the Institute, and to have the necessary interpersonal skills to establish and develop major links with industrial partners. The Director will also hold a Chair in the University of Liverpool.

For more information, including how to request an informal and confidential discussion about the appointment, or how to apply, please refer to our advisor's website at **WWW.SAXBAM.COM/ARC** using reference BLIC/C or email BLIC@SAXBAM.CO.UK. If you do not have access to the internet/email please telephone **+44 (0) 1483 409 713** (during office hours).

A first consideration of applications will be made in late October.

SAXTON BAMPFYLDE HEVER

THE AMROP HEVER GROUP

WE HIGHLIGHT SCIENCE

The European Synchrotron Radiation Facility (ESRF) is Europe's most powerful light source. It is located in the unique scientific environment of Grenoble, in the heart of the French Alps.

The ESRF offers you an exciting opportunity to work with international teams on a wide range of scientific subjects using synchrotron light: Physics and Chemistry, Life Sciences and Medicine, Earth and Environmental Sciences, Surface and Materials Sciences.

ESRF

Scientists
Post-doctoral fellows
PhD students
Engineers
Technicians
Administrative staff

Have a look at our vacancies at: **www.esrf.fr**

Contact us at: recruitment@esrf.fr

UNIVERSITÄT DORTMUND

Im Fachbereich **Physik** ist zum 01.10.2005 eine

Universitätsprofessur C3

für Phänomenologie und Grundlagen der Elementarteilchen

zu besetzen.

Das Arbeitsgebiet der Bewerber/Bewerberinnen sollte auf dem Gebiet der Flavourphysik (schwere Quarkzerfälle, Neutrinophysik, etc.) und wenn möglich, Anwendungen in der Astroteilchenphysik liegen.

Die Bereitschaft zur Zusammenarbeit mit den experimentellen Arbeitsgruppen (BABAR, ATLAS, LHC-B, Amanda/ICECUBE, H1) ebenso wie die Mitarbeit im Graduiertenkolleg "Physik der Elementarteilchen an Beschleunigern und im Universum" und am Forschungsband "Modellbildung und Simulation" wird erwartet.

Eine angemessene Beteiligung in der Lehre und der Selbstverwaltung wird erwartet.

Habilitation oder habilitationsadäquate Leistungen werden vorausgesetzt. Es gelten die Einstellungsvoraussetzungen des § 46 HG des Landes NRW. Es wird darauf hingewiesen, dass ab 01.01.2005 die W-Besoldung gilt.

Es wird darauf hingewiesen, dass die Bewerbungen von Frauen ausdrücklich erwünscht sind und Frauen bei gleicher Eignung, Befähigung und fachlicher Leistung bevorzugt berücksichtigt werden, sofern nicht in der Person eines Mitbewerbers liegende Gründe überwiegen. Die Bewerbung geeigneter Schwerbehinderter ist erwünscht.

Bewerbungen mit Lebenslauf, wissenschaftlichem Werdegang, Schriftenverzeichnis und Angaben über die bisherige Lehrtätigkeit sind bis zum **31.10.2004** zu richten: Dekan des Fachbereichs Physik, Universität Dortmund, D-44221 Dortmund (Deutschland).

FACULTY POSITION

Experimental Particle Physics
Indiana University

The Department of Physics invites applications for a tenure-track faculty position in collider-based high-energy particle physics to start Fall 2005. The Department has a strong experimental particle physics program at the energy frontier with faculty members playing leading roles in experiments currently taking data and preparing for the future: the D0 experiment at Fermilab, the ATLAS experiment at CERN, and R&D for a future e+e- linear collider. More information is available at http://physics.indiana.edu/xxx. We seek candidates with a Ph.D. in physics, outstanding leadership qualities, and proven or potential excellence in both research and teaching. Applicants should submit a curriculum vitae, list of publications, statement of research interests and proposed activities, and arrange for at least three letters of reference to be sent to:

HEP Search Committee
Attn: Prof. Rick Van Kooten
Physics Department, Swain West 117
Indiana University
Bloomington, IN 47405 USA

Applications will be reviewed beginning December 15, 2004 until the position is filled. E-mail inquiries and questions may be addressed to:

search_hep@hep.physics.indiana.edu

Indiana University is an Affirmative Action/Equal Opportunity Employer. Applications from women and minorities are particularly encouraged.

LEDERMAN FELLOWSHIP

Experimental Particle or Accelerator Physics

The Fermi National Accelerator Laboratory (Fermilab) has an opening for a postdoctoral Lederman Fellow in experimental particle physics or accelerator physics. The successful candidate must have demonstrated outstanding ability in research. In recognition of Leon Lederman's commitment to the teaching of physics at all levels, he or she will be expected to participate, for a small fraction of the time, in physics outreach. The successful candidate will have a choice among experiments, which include Tevatron and LHC collider experiments, neutrino experiments, other fixed target experiments and astroparticle physics experiments, or research on accelerators. See **http://www.fnal.gov/** for more information.

Candidates should have obtained a Ph.D. in experimental particle or accelerator physics after August 31st 2003. The appointment is normally for three years with an extension possible. To apply write to **Dr. Michael Albrow (Chair of Lederman Fellowship Committee), Fermi National Accelerator Laboratory, MS 122, P.O.Box 500, Batavia, IL 60510-0500**. Applicants should send a letter including their research experience and noting any experience or interest in teaching and outreach, a curriculum vita, publication list and the names of at least four references. The deadline for applications is **December 10, 2004**.

Fermilab

Deutsches Elektronen-Synchrotron DESY

DESY is world-wide one of the leading accelerator centres exploring the structure of matter. The main research areas range from elementary particle physics over various applications of synchrotron radiation to the construction and use of X-ray lasers.

The ZEUS/F1 group is responsible for the operation of the ZEUS experiment, analysis of HERA data and is involved in detector development for use in future experiments. The laboratory in Hamburg invites applications for a

Physicist (PhD)
in experimental particle physics

with postdoctoral experience in high energy physics.
The successful candidate will participate in the further development of ZEUS online and offline software and consolidate the continuing success of the experiment. Further you will participate in data analysis and collaborate in the silicon pixel detector development project aimed at future applications in elementary particle and photon physics.
You have proven knowledge of software development and data processing on large distributed computer systems and experience with hardware programming and detector development. The ability to participate in teamwork, to lead groups and to supervise students is required. If you are interested in this position, please send your complete application papers to our personnel department. For further information, please contact Dr. Zeuner on +49 40/8998-3150.

Salary and benefits are commensurate with public service organisations. DESY operates flexible work schemes, such as flexitime or part-time work. DESY is an equal opportunity, affirmative action employer and encourages applications from women.

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association
code: 79/2004 • Notkestrasse 85 • D-22603 Hamburg • Germany
Phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applicants: 15th November 2004

cerncourier.com

POSTDOCTORAL FELLOW

The Relativistic Nuclear Collisions Program (RNC) of the Nuclear Science Division at Lawrence Berkeley National Laboratory (LBNL) is seeking outstanding candidates to fill a postdoc position. The RNC Program plays a lead role in the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at LBNL. Candidates having interests in spin physics at RHIC are invited to apply. In addition to physics analysis, RNC has major detector responsibilities in STAR and a strong detector R&D program. LBNL is the host of the National Energy Research Supercomputing Center, which provides a valuable computing resource to the Nuclear and High Energy Physics communities.

This is a two-year term appointment with the possibility of renewal. Interested candidates should have obtained a PhD in Nuclear or High Energy Physics within the last two years.

To apply, please send a CV, a list of publications and the names of three references via email (our preferred method) to: genscіemployment@lbl.gov or mail to Lawrence Berkeley National Laboratory, One Cyclotron Road, MS: 50-4037D, Berkeley, CA 94720. Applications should reference job number NS/017449/JCERN and must be received by December 1, 2004. LBNL is an equal opportunity employer committed to developing a diverse workforce.

BERKELEY LAB

LAWRENCE BERKELEY NATIONAL LABORATORY - ATLAS

The Physics Division at Lawrence Berkeley National Laboratory (LBNL) has the following opportunities available to work on the ATLAS Experiment at the Large Hadron Collider (LHC) at CERN.

Divisional Fellow

LBNL is seeking a scientist with outstanding promise and creative ability in the field of experimental high-energy physics. The appointment will be as a Divisional Fellow for a term of up to five years, with the expectation of promotion to a career position as a Senior Staff Scientist. An immediate appointment as a Senior Staff Scientist may be considered in exceptional cases.

The successful candidate will take a leadership role in the ATLAS program at LBNL in preparation for the data taking and analysis phase of the ATLAS experiment. The current ATLAS program at LBNL includes major efforts in LHC physics and simulation, software development and the silicon pixel and silicon strip systems for the ATLAS tracking detectors. Berkeley will have a long-term leading role in physics analysis and in future detector upgrades to ATLAS. Candidates should have several years of experience in experimental particle physics beyond the PhD and have demonstrated leadership capabilities. Applications should reference job number PH/017298/JCERN and must be received by December 3, 2004.

Postdoctoral Fellow

The ATLAS group also has an opening for a Postdoctoral Fellow to be involved in our ongoing activities and later in analysis of the first data from the LHC. This is a two-year term position with the possibility of renewal up to a total of five years. To qualify, the candidate should have a PhD in Experimental High Energy Physics or equivalent experience and demonstrated strong potential for outstanding achievement as an independent researcher. Applications should reference job number PH/017413/JCERN and will be accepted until the position is filled.

For either position, applicants should submit via e-mail a curriculum vitae, a publication list and a statement describing their research experience and future interests, as well as arrange to have three letters of recommendation sent to sdcheeseboro@lbl.gov. Please reference the appropriate job number when applying. LBNL is an Affirmative Action/Equal Opportunity Employer committed to the development of a diverse workforce.

BERKELEY LAB

CORNELL

TENURE-TRACK PROFESSORIAL POSITION

Theoretical Particle Physics

Cornell University

The Department of Physics at Cornell University invites applications for a tenure-track Assistant Professor appointment in theoretical particle physics, to begin in Fall 2005 or later. Outstanding applications at a more senior level may be considered in exceptional cases. We are seeking highly qualified candidates committed to a career in research and teaching. We are encouraging applications from candidates with interests in any area of high-energy physics, including string theory, particle cosmology, physics beyond the Standard model, and Standard Model physics.

Applicants should send their curriculum vitae, publication list, a brief description of their research interests, and arrange for three letters of reference to be sent to:

Prof. Matthias Neubert, Search Committee Chair
Newman Laboratory for Elementary-Particle Physics
Cornell University, Ithaca, NY 14853

Applications received before November 15, 2004 will receive fullest consideration, although later applications may also be taken into account. Cornell University is an equal opportunity, affirmative action employer.

POSTDOCTORAL ASSOCIATES AND VISITING RESEARCHERS

Institute of Nuclear Physics (IFJ PAN)
Polish Academy of Sciences
Krakow Poland
http://www.ifj.edu.pl/ang/index.html

The Institute of Nuclear Physics has an opening for two postdoctoral research associates within the Department of Particle Theory for 24 months each, with approximate starting dates of 01/01/2005 and 01/01/2006.

Salary: 47000 euro/year, subject to corrections and deductions, supplemented with mobility allowances according to the general rules of the "Marie Curie Actions". Positions for senior researchers, ranging from 2 to 12 months and with salary of 70500 euro/year, subject to corrections and deductions, are also available. For details see
http://mc-opportunities.cordis.lu/show-PRJ.cfm?obj_id=6828

The closing date for the first meeting of the postdoctoral associate selection committee: 04 Oct 2004. However the positions will remain open until suitable candidates are found.

The positions are financed by the European Union Marie Curie Actions: Human Resources and Mobility, under contract MTKD-CT-2004-510126 "Calculational Tools and Methods for Physics at Large Hadron Collider" in partnership with CERN Physics Department. The MTKD contract ends in summer 2008. See
http://mc-opportunities.cordis.lu/show-VAC.cfm?obj_id=7342

The candidate should satisfy the eligibility criteria.

The group is seeking research associates to join the project of development of the Monte Carlo Programs and calculational techniques for phenomenological studies of the LHC physics.

Applicants should have a Ph.D. in theoretical or experimental particle physics. Interested candidates should provide a curriculum vitae, a list of publications, and arrange for two letters of reference to be sent to: Prof. Stanislaw Jadach.

The group offers opportunity to collaborate, in particular, with the following scientists: Jadach, Skrzypek, Placzek, Richter-Was, Was, Jezabek and Golec-Biernat, known for their achievements in phenomenology of experiments at LEP, LC, LHC and HERA. The experimental groups from IFJ PAN participate directly in these experiments.

Contact: Prof. Stanislaw Jadach, Institute of Nuclear Physics,
Polish Academy of Sciences ul. Radzikowskiego 152 31-342 Krakow
tel. +48-12-662-8010, fax +48-12-662-8012 Stanislaw.Jadach@ifj.edu.pl or Stanislaw.Jadach@cern.ch

PhysicsJobs @ physicsweb.org

NSCL

High Performance Computing Physicist

The National Superconducting Cyclotron Laboratory (NSCL) invites applications for a Postdoctoral or staff position in Computational Physics.

Candidates should have a PhD or MSc in Physics with a strong background on parallel computer codes and FORTRAN programming. MSU is in the process of acquiring an SMP and a loosely coupled computer cluster.

The successful applicant is expected to collaborate with NSCL scientists in the conversion of accelerator and nuclear physics codes to run in parallel computers, and in the development of new codes of common interest in support of the NSCL research program. The position is for two years, with the possibility of an extension. The position will start in the fall of 2004.

Applicants should send an application letter with a full CV, including a list of publications to:

Chasity Fudella, NSCL, Michigan State University,
1 Cyclotron Laboratory, East Lansing MI, 48824-1321
or by email: fudella@nscl.msu.edu.

In addition the applicants should arrange to have two letters of reference sent to the above address.

Michigan State University is an Affirmative Action/Equal Opportunity institution. Women and minorities are especially encouraged to apply.

Kavli Institute
For Cosmological Physics
At The University of Chicago

KICP Postdoctoral Research Fellowship

The KICP invites applications for one or more NSF Funded Postodoctoral Research Fellowships from young scientists of exceptional ability and promise who will have received a PhD. in Physics, Astrophysics or related fields by September 2005. The appointee(s) will be expected to conduct original research in experimental or theoretical cosmology in an interdisciplinary environment. The initial appointment is for one year, renewal annually, for up to three years. Our positions have competitive salaries and carry faculty level benefits. Institute Fellows have the freedom to work on any of the efforts in our Institute.

Research at the Kavli Institute for Cosmological Physics (KICP), based at the University of Chicago, is focused on interdisciplinary topics in cosmological physics: characterizing the Dark Energy, studying the inflationary era, and understanding the highest energy cosmic rays. Studies of the CMB (polarization anisotropies and the Sunyaev- Zel'dovic effect) and Cosmic Infrared Background; analysis of Sloan Digital Survey and other large-scale structure data; high energy astrophysics with photons and cosmic rays, direct detection of Dark Matter particles and numerous topics in theoretical cosmology constitute the current slate of activities. The KICP also has active visitors, symposia, and education/outreach programs. Information about the KICP can be found at **http://kicp.uchicago.edu/.**

An application consisting of a Curriculum Vitae, a statement of research interests, and at least three letters of recommendation should be sent to **centerfellow@kicp.uchicago.edu** or to
Bruce Winstein, Director, Kavli Institute for Cosmological Physics, 5640 S. Ellis Avenue, Chicago, IL 60637.

The application deadline is December 1, 2004 for positions that will begin in the Summer or Fall of 2005.

The University of Chicago is an Affirmative Action/Equal Opportunity Employer.

LANCASTER UNIVERSITY

D-Zero Research Associate

A three year Research Associate position (job ref A363) is available immediately to work on offline track reconstruction and B-hadron physics. We have major responsibility for the maintenance and improvement of the offline track reconstruction software that we supplied for Run 2 of the Tevatron and we also expect the successful applicant to contribute to our B physics data analysis efforts, possibly in the measurement of BS mixing. The successful applicant should have a PhD in experimental particle physics and will be based at Fermilab for some or all of the duration of their contract.

Initial salary: £21,640 plus overseas allowances. Closing date: 31st October 2004.

For further information online, please visit http://www.hep.lancs.ac.uk/jobs

We positively welcome applications from all sections of the community

EGO European Gravitational Observatory

The European Gravitational Observatory, a French-Italian consortium dedicated to the research on gravitational waves, operates the 3 km-long VIRGO detector, located in Pisa–Italy.

EGO is recruiting:

Data Acquisition and Control Engineer — **Ref. CO/SY/03**
Interferometer Operator — **Ref. OP/OP/02**

Job descriptions are available on: **www.ego-gw.it/employment.htm**

CORNELL

TENURE-TRACK PROFESSORIAL POSITION
Experimental Elementary-Particle Physics
Cornell University

We are seeking an outstanding individual for a tenure-track professorial position in experimental elementary-particle physics at the level of Assistant Professor. In addition to teaching undergraduate and graduate courses, responsibilities will include supervision of graduate students and participation in the research program of the Laboratory for

Elementary-Particle Physics, which is currently based on the CESR e+e- storage ring and the CLEO experiment. Future directions are expected to include significant involvement in the international linear collider as well as a nearer term program in a hadronic collider environment. CLEO provides a unique opportunity for high precision measurements at the D and D_s production thresholds in addition to studies of the Upsilon family and the J/Psi. The Laboratory envisions a substantial role in both the particle physics and accelerator development of the linear collider. A PhD in Physics and experience in experimental elementary-particle physics is required. The position will be available in summer 2005. Please send an application and at least three letters of recommendation to:

Prof. James Alexander, Search Committee Chair
Newman Laboratory, Cornell University, Ithaca, NY 14853

Applications should include a curriculum vitae, a publication list, and a short summary of teaching and research experience. Applications received before December 15, 2004, will receive full consideration. Electronic submissions and mail inquiries may be addressed to search@lepp.cornell.edu.

Cornell is an equal pportunity/affirmative action employer.

University of Zurich

The Faculty of Science of the University of Zurich invites applications for a

Professorship in Experimental Particle or Astroparticle Physics

starting on September 1, 2006. The new professor is expected to establish and lead a successful research group at the Physik Institut, to contribute to the PhD and Masters programs in Experimental Physics and to undergraduate teaching. She or he will find a very stimulating environment in many areas of experimental and theoretical particle physics, astroparticle physics and cosmology at the University of Zurich, the ETH Zurich and at the nearby Paul Scherrer Institut. The successful applicant will be able to profit from the excellent technical infrastructure of the Physik-Institut.

Applicants are invited to submit a curriculum vitae, a publication list and a summary of their research interests by January 31, 2005 to Prof. Dr. H. Berke, Associate Dean, Dekanat der Mathematisch-naturwissenschaftlichen Fakultät der Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland. The application materials should also be submitted in a single Word or PDF file to jobsmnf@zuv.unizh.ch.

For more detailed information, please visit our website www.physik.unizh.ch or contact Prof. Dr. U. Straumann, Physik-Institut der Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland (strauman@physik.unizh.ch).

Indiana University
Post Doctoral Position
ATLAS Analysis on TRT

The Indiana University high energy physics group has an opening for a postdoctoral research associate to work on the ATLAS experiment. This position could begin in January, 2005. The Indiana University group has played a leading role in the construction of the Barrel TRT project for the inner detector of ATLAS. We are also actively participating in the ATLAS GRID project and prototype Tier 2 center. The goal of this position will be to participate in data analysis and assist with the installation and operation of the TRT detector. We anticipate that the first year of this position will be at Indiana University's Bloomington Campus with subsequent years at CERN.

A Ph.D. or equivalent degree in Physics is required.

Applicants should send a curriculum vitae, a description of research experience and interests, and arrange for three letters of reference to be sent, to

H.Ogren , Department of Physics, Indiana University,
727 E. Third St., Bloomington IN 47405,

or via e-mail to **ogren@indiana.edu.**

The deadline for receipt of materials is December 1, 2004, but late applications will be considered until the position is filled.

Indiana University is an Equal Opportunity/ Affirmative Action Employer.

INDEX TO DISPLAY ADVERTISERS

The index is provided as a service and, while every effort is made to ensure its accuracy, *CERN Courier* accepts no liability for error.

Technische Universität München

In der Fakultät für Physik der TU München ist zum frühestmöglichen Zeitpunkt eine

C3- bzw. W2-Professur a. Z.

für Theoretische Astroteilchenphysik zu besetzen. Gesucht wird eine Wissenschaftlerin / ein Wissenschaftler für das Arbeitsgebiet Theoretische Astroteilchenphysik. Eine Beteiligung am Sonderforschungsbereich Astroteilchenphysik (SFB 375) und im Gradiertenkolleg 1054 „Energy of New Phenomena" ist erwünscht. In der Lehre wird von der zukünftigen Stelleninhaberin / dem Stelleninhaber neben der Vertretung des engeren Fachgebietes die Beteiligung an den allgemeinen Lehraufgaben der Physik erwartet.

Einstellungsvoraussetzungen sind ein abgeschlossenes Studium an einer wissenschaftlichen Hochschule, pädagogische Eignung, Promotion und Habilitation oder Nachweis gleichwertiger wissenschaftlicher Leistungen, die auch in einer Tätigkeit außerhalb des Hochschulbereiches erbracht sein können.
Schwerbehinderte werden bei gleicher Eignung bevorzugt berücksichtigt. Bewerberinnen oder Bewerber dürfen zum Zeitpunkt der Ernennung das 52. Lebensjahr noch nicht vollendet haben. Ausnahmen von der Altersgrenze können in dringenden Fällen zugelassen werden (vgl. Art. 12 Abs. 3 Satz 2 BayHSchLG). Die Stelle ist auf 5 Jahre befristet.

Die Technische Universität strebt eine Erhöhung des Anteils von Frauen in Forschung und Lehre an und bittet deshalb Wissenschaftlerinnen nachdrücklich, sich zu bewerben.
Bewerbungen mit den üblichen Unterlagen (Lebenslauf, Zeugnisse, Urkunden, Publikationsliste einschließlich ausgewählter Sonderdrucke) werden bis

31.12.2004

erbeten an den

Dekan der Fakultät für Physik der TU München,
85747 Garching b. München

SUBSCRIBE TODAY AND SAVE UP TO 35% Institute *of* **Physics** PUBLISHING

THE FUEL CELL REVIEW

Competitive intelligence on hydrogen and fuel-cell technologies

- ✓ **Are you working in the fuel-cell supply chain?**
- ✓ **Would you like to learn direct from the industry experts?**
- ✓ **Do you want to be kept up-to-date on R&D and technology transfer?**
- ✓ **Do you find it hard to source authoritative analysis of the latest technological advances?**
- ✓ **Would it save you time and effort to find all your information needs in one publjcation?**
- ✓ **Would you like to SAVE up to 35% on the cost of a subscription?**

Sample articles from each issue are available for free on our website – **fcr.iop.org**

If you answered YES to any of the above questions then you need look no further. *The Fuel Cell Review* is a unique bimonthly publication that guarantees to deliver in-depth analysis and incisive commentary on the R&D, emerging technologies and applications that will take fuel cells into the main stream.

It will provide you with an informed perspective on the latest developments across all levels of the fuel-cell supply chain. Along with in-depth journalism from our in-house science and technology editors, every issue brings you the most respected names in the industry, reviewing the critical subjects of the day.

Valuable coverage you will not be able to find anywhere else.

Can you afford to miss an issue?

Subscription order form

✓ Yes, I would like to subscribe to *The Fuel Cell Review*

- ☐ 1 year (6 issues) £149/$269/€219
- ☐ 2 years (12 issues) £224/$404/€329 - **SAVE 25%***
- ☐ 3 years (18 issues) £291/$525/€427 - **SAVE 35%***

Rates for libraries available on request

*offer ends 31 December 2004

Your details

Name:

Job title:

Company:

Department:

E-mail:

Address:

Postcode:

Country:

Tel: Fax:

Nature of business:

CODE: AD2

Please return to

The Fuel Cell Review, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE

Tel. +44 (0)117 930 1034 **Fax** +44 (0)117 930 1178
E-mail fcr@iop.org **Web** fcr.iop.org

Three easy ways to pay

☐ **Credit card** - please charge my Amex/Visa/Mastercard

Card no. ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry date: ☐☐/☐☐

Signed:

Dated:

☐ **Cheque** made payable to IOP Publishing Ltd

☐ **Please invoice me**

No-risk money back guarantee

If you are not entirely satisfied with this product, you can cancel your subscription at any time and receive a full refund for any unmailed issues – no questions asked!

☐ IOP Publishing Ltd may write to you about other services and products that may be of interest. Tick this box if you do not want to receive such information.

☐ Tick this box if you do not want to receive such information by e-mail.

☐ IOP Publishing Ltd may occasionally pass your details on to other reputable companies whose products and services may be of interest. Tick this box if you do not want to receive such offers.

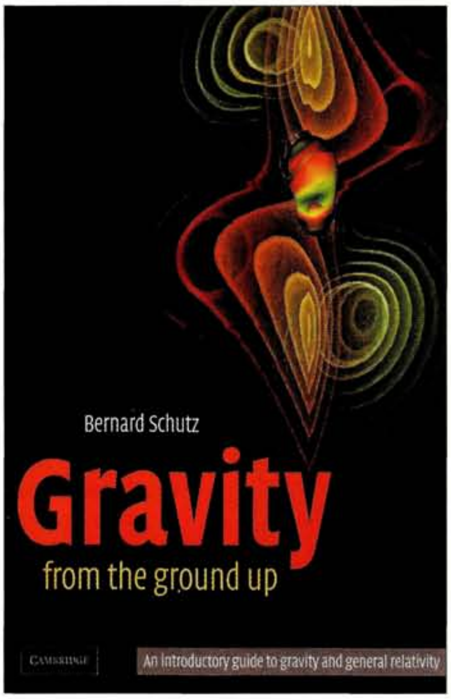
BOOKSHELF

Gravity from the ground up by Bernard Schutz, Cambridge University Press. Hardback ISBN 0521455065, £30 ($45).

This beautifully produced book is evidently the result of a labour of love by physicist Bernard Schutz, who refers to it as "the book" in the dedication to his daughters. There is a sense that this, more than his advanced textbooks, is the book that Schutz always wanted to write. In it he provides an introductory guide to gravity and general relativity, not only for undergraduates but also for the general reader who yearns for more detail than is often found in more "popular" books on these topics.

The title reveals the structure of the book. Chapter by chapter, Schutz begins with gravity on Earth and then moves out into the solar system, to the stars and galaxies beyond, to finish with the Big Bang and questions currently at the frontiers of research in gravity. On the way the reader first encounters the work of Galileo and Newton and finds out how Einstein stands on their shoulders, then learns how the Sun and other stars live and die, and moves on to discover neutron stars and black holes – exotic objects that now figure frequently in the news as well as in science fiction.

There are many books that cover the same topics, but rare are those that attempt to be simultaneously engaging and didactic. As with Steven Weinberg's *The Discovery of Subatomic Particles* (Cambridge University Press 2003), Schutz writes for people who not only want to be amazed but who also want to know how it is that scientists know all the amazing things they talk about on beautifully made documentaries. As the author says, "this book is not a 'gee-whizz' tour of the universe: this is a book for people who are not afraid to think". There is no calculus, no advanced mathematics, but there are equations that require a little high-school algebra. Moreover, recognizing that we live in the computer age, Schutz provides a website to support the book with programs that can be downloaded, and modified, to provide the results of complex calculations and solutions to exercises that are part of the "investigations" presented in the book. Visit www.gravityfromthegroundup.org to find out more.



Christine Sutton, CERN.

Books received

Path Integrals and Quantum Anomalies by Kazuo Fujikawa and Hiroshi Suzuki, Oxford University Press. Hardback 0198529139, £55 ($99.50).

A self-contained introduction to the path-integral method in field theory and its applications to quantum anomalies, this book assumes no previous knowledge beyond advanced undergraduate quantum mechanics. The subjects covered – from Schwinger's action principle to recent developments in lattice gauge theory – are relevant to particle and high-energy nuclear theory, conformal field theory, applications to condensed matter theory and string theory.

Quark–Gluon Plasma 3 by Rudolph C Hwa and Xin-Nian Wang (eds), World Scientific. Hardback ISBN 9812380779, £87 ($118).

In this review monograph on quark–gluon plasma (QGP), different theoretical and experimental aspects of the effort to produce QGP in relativistic heavy-ion collisions are covered by various experts in the field. This is the third volume in a series on the subject, and the first such monograph to focus on the implications of the experimental results from the Relativistic Heavy Ion Collider at Brookhaven.

Singular Null Hypersurfaces in General Relativity by C Barrabès and P A Hogan, World Scientific. Paperback ISBN 9812387374, £36 ($48).

This book presents a comprehensive view of the mathematical theory of impulsive light-like signals in general relativity. Such signals can result from cataclysmic astrophysical events, and as the sub-title of "Light-like signals from astrophysical events" suggests, the topic has applications in relativistic astrophysics and cosmology, as well as in alternative theories of gravity deduced from string theory.

Quark Model and High Energy Collisions by V V Anisovich, M N Kobrinsky, Yu M Shabelski and J Nyiri, World Scientific. Hardback ISBN 9812386998, £73 ($98).

This second edition is an updated version of the book published in 1985. QCD-motivated, it gives a detailed description of hadron structure and soft interactions in the additive quark model, and is aimed at graduate students and researchers in particle and nuclear physics.

Origins: the early days of CERN

François de Rose recalls the first discussions that ultimately led to the birth of CERN.

In 1946 a commission of the United Nations Security Council was entrusted with the task of making proposals to bring atomic energy under international control. It was one year after the devastation of Hiroshima, and the idea of such control had been approved by all the governments. The commission was made up of influential scientists who had the knowledge that was needed to understand the problem fully and of politicians and diplomats representing the governments' interests. It was in this capacity as a diplomat that I represented France on the commission and was able to establish trusting and friendly relations with many of my countrymen who were scientists, as well as with foreign scientists, first and foremost among whom was Robert Oppenheimer, who was to play a very important role in the creation of CERN.

In the course of the many conversations I had with Oppenheimer in the US, in which we were often joined by other Frenchmen, who were my scientific and technical advisers, he confided his worries about the future development of fundamental physics in Europe. "Almost all we know, we have learnt in Europe" is the substance of what he said. He himself had been a pupil of Niels Bohr in Copenhagen. "But in the future," he continued, "research is going to require industrial, technical and financial resources that will be beyond the means of individual European countries. You will therefore need to join forces to pool all your resources. It would be fundamentally unhealthy if European scientists were obliged to go to the US or the Soviet Union to conduct their research."

Early in 1950, convinced by this argument, Francis Perrin, then high commissioner for atomic energy in Paris, and I began to visit the main European research centres that would need to be persuaded. We met with a favourable response from Edoardo Amaldi in Italy, Niels Bohr in Copenhagen, Paul Scherrer in Switzerland and possibly Werner Heisenberg in Germany, if I remember correctly, but we were given a cooler reception in other capitals. Nevertheless, the idea was now on the table and was no doubt starting to take root in people's minds. Moreover, it came on top of an appeal on similar lines from the European Centre for Culture in Geneva, led by Denis de Rougemont from Switzerland and Raoul Dautry from France. It was then that Isidore Rabi, a Nobel prize winner, made his crucial speech at the UNESCO General Conference in Florence in June 1950. Speaking on behalf of the US, he more or less said the same thing that Oppenheimer had said to us in private.

This speech marked a definite turning point, persuading the majority of European scientists and their governments to adopt a resolution authorizing UNESCO to "assist and encourage the formation and organization of regional centres and laboratories in order to increase and make more fruitful the international collaboration of scientists". Pierre Auger, UNESCO's director of natural sciences, took matters in hand and, at the end of 1951, managed to organize a conference of all European scientists and government representatives, which I had the honour to chair and at which it was decided to establish the European Council for Nuclear Research.

The fundamental ideas, namely the goals that all the pioneers of what was to become CERN set themselves, consisted first of all in promoting European co-operation in this vital area. CERN was thus the first venture on a European scale and I can say that Robert Schuman, who was then French minister of foreign affairs and one of Europe's founding fathers, was immediately in favour of it. A second goal was to reintroduce complete freedom of communication and the sharing of knowledge into this branch of science.

It should be realized that, in the wake of Hiroshima, people were afraid of science and of nuclear science in particular. "The physicists have known sin" said Oppenheimer, and the consequence of using scientists' work for military purposes was the imposition of secrecy and the lack of communication between research centres. By immediately taking the opposite approach to fundamental research in its statutes, CERN was following the great tradition of science knowing no boundaries. The ambitions of these pioneers were more than fulfilled, since CERN is today home to scientists from all over the world, including the US, China, Japan and Russia, all working together and in teams on the same research, the results of which are published in full.

Another of my memories concerns the extension of the CERN site into France. After the construction of the 28 GeV Proton Synchrotron, it soon became apparent that, in the time-honoured fashion, this was only a scale model of more powerful machines to come. The area that Switzerland had been able to set aside for CERN could not be extended on the Swiss side. Luckily, the site ran alongside the border with France, and the land in that area was essentially being used for farming. The continuation and development of CERN's activities were therefore dependent on extending the site into France, thus requiring a parcel of around 500 hectares of French land to be made available to an international organization with its headquarters in Switzerland. I prepared a dossier, which was submitted to the then French president, General de Gaulle, by the minister of foreign affairs, Maurice Couve de Murville. That is how CERN became – and I think remains to this day – the only research centre to straddle the border of two countries.

François de Rose, a French diplomat, was involved in the creation of CERN from the very beginning. He went on to hold office as president of the CERN Council from 1958 to 1960, during which time he helped to prepare the laboratory's extension into French territory.