International Journal of High-Energy Physics

CERN COURIER

Volume 46 Number 2 March 2006

The Globe: an emblem for CERN

EUROPE
Strategy group looks to the future p5

RUSSIA
JINR celebrates its 50th anniversary p15

CHINA
Upgrades on course for BEPC and and BES p23

WIENER CFB CAMAC-to-FERA Bridge

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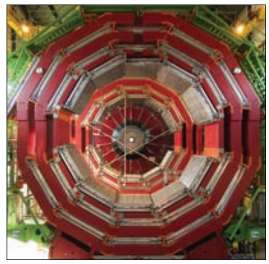
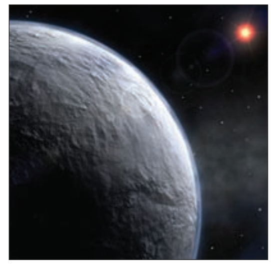


Drift-tube chambers operating p6



Earth-like exoplanet detected p12

Science on Stage dazzles p35

Cover: With the opening of the Globe of Science and Innovation, CERN has a new landmark building for exhibitions and meetings to share the laboratory's work with all sectors of a wider public (p26).

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

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COLLABORATION

Strategy Group sets future course

The impressive breadth and depth of European particle physics was on display in Orsay, France, at an open symposium organized by the CERN Council Strategy Group at the end of January. Established in 2005, the Strategy Group is charged with preparing a long-term vision for European particle physics for presentation to CERN Council at a special meeting to be held in Lisbon on 14 July this year. The Orsay symposium was designed to give a strong voice in the process to a broad spectrum of European particle physicists. Some 400 came together in Orsay, and were joined by representatives of the North American and Asian particle-physics communities and a remote audience of more than 70.

CERN Council's decision to establish the Strategy Group recognizes the distinction between the Council and the laboratory that has become synonymous with the name CERN. CERN Council is an intergovernmental body, established in 1954 to "provide for collaboration among European states in nuclear research of a pure scientific and fundamental character". As such, it is an appropriate choice as the strategic body for particle physics in Europe: an agreement in Council will show the determination of the 20 member states to work together to make the best use of the available resources in uncovering nature's most fundamental secrets.

The task of the Strategy Group is far from simple: Europe's particle-physics landscape is complex, with the CERN laboratory in Geneva, a range of national laboratories that carry out world-class research in their own right, and numerous university- and institute-based groups. "Our aim," explained Torsten Åkesson, chair of the European Committee for Future Accelerators (ECFA) and co-chair of the Strategy Group, "is to be all inclusive, to build on the diversity of European particle physics through a strategy that includes all elements."

CERN Council's Strategy Group is preparing a long-term vision for Europe's particle physics.

The composition of the group is a reflection of this philosophy, with one particle physicist nominated by each of CERN Council's 20 delegations, together with the directors of the major particle-physics laboratories in CERN's member states, and a number of particle physicists from CERN's Scientific Policy Committee (SPC) and ECFA. Åkesson is joined by Ken Peach, chair of the SPC, as co-chair, and there is also a scientific secretary from CERN.

The approach that Åkesson and Peach adopted with the Orsay Symposium was to invite input from members of the European particle-physics community about their wishes and aspirations, while studying existing European and global infrastructure to see how Europe can best contribute to the future of particle physics on the worldwide scale. "If we are to propose a strategy for the future of particle physics in Europe," explained Peach, "we can't operate in a vacuum. We have to listen to what the community wants, particularly the younger members, since this will be their strategy."

The Orsay symposium put the emphasis on discussion, with presentations kept short to allow more time for discussion. The result was a lively and all-encompassing debate. While the major infrastructures – notably the Large Hadron Collider (LHC) and its possible future upgrades, the International Linear Collider (ILC) and future neutrino facilities – dominated proceedings, smaller experiments such as neutrinoless double-beta decay and a possible renewed effort on muon g-2 also had their place. In all the discussions, a key message that emerged was that physics, not technology, should lead the way. Another recurring theme was the date 2010, by which time physics results from the LHC will be pointing the way to future research needs, a full technical design for the ILC will be ready, and the results of the Compact Linear Collider study, CLIC, will have shown whether the concept has a viable future.

The Strategy Group next meets at DESY's Zeuthen laboratory in May to distil all the information gathered in Orsay into a brief draft strategy document. This will be presented to CERN Council in July, where approval will depend on a unanimous vote.

- Further details of the CERN Council Strategy Group can be found at: www.cern.ch/council-strategygroup, where input to this important process for the future of European particle physics is invited until 15 March.

Sommaire

DETECTORS

CMS drift-tube chambers pass cosmic test

The CMS collaboration has for the first time operated a whole sector of drift-tube chambers (DTCs) and detected cosmic muons. This is the first stage in commissioning the CMS Muon Barrel detector prior to installation below ground later in 2006.

Since the summer of 2004, the team building the DTCs – from Aachen, Bologna, Madrid (CIEMAT), Padova and Torino – has been engaged in the delicate and complex operation of installing the chambers in the CMS experiment's iron yoke. The chambers have 12 layers of drift tubes, arranged in three groups of four, two measuring the R-ϕ coordinate and one measuring the z-coordinate. Each layer has up to 60 tubes. Unlike conventional drift-tube systems, consecutive layers are staggered by half a tube-width, enabling the DTCs to generate trigger signals for CMS, using a "mean timer" method.

Chambers constructed in the collaborating institutes are first assembled on the main site at CERN together with their on-chamber cables, pipes and mini-crates. These "dressed" chambers require very few external components to become operational, and so undergo thorough pre-installation tests before being transported to the CMS site at Cessy. There they are inserted into the CMS iron yoke in the surface building. The chambers are then ready for final commissioning tests, which include long data-taking runs that exploit the chamber's self-triggering capability with cosmic muons. By February two of the five wheels in the CMS barrel yoke had been instrumented, and 82 DTCs commissioned.

This first sector test marked the beginning of a long series of tests that will culminate this spring with the CMS Cosmic Challenge. At this point the five barrel wheels and the two endcaps will be pushed together in the surface building and the superconducting solenoid operated for the first time. Segments of all sub-detectors will be present and cosmic muons will be detected and measured. The lowering of the CMS sections into the underground cavern is due to begin in the summer.

Left: the CMS barrel seen from its +z end in the surface building at Cessy. Two out of five wheels of the barrel are already equipped with muon chambers. Right: a snapshot of the online display showing a cosmic muon (white points) through the complete sector.

NEUTRINOS

Last major component installed at CNGS

The magnetic system that focuses the beam of particles arising from the graphite target of the CERN Neutrinos to Gran Sasso project (CNGS) has been installed in its final position in the tunnel. This represents the final milestone of the project prior to testing all systems in preparation for the first commissioning with beam, at the end of May.

The CNGS secondary beam magnetic system consists of two elements: the horn and the reflector, both acting as focusing lenses for the positively-charged pions and kaons produced by proton interactions in the target. Most of these pions and kaons will decay in a 1 km-long vacuum pipe. At the end of this, a barrier, comprising 3 m of graphite and 15 m of iron, will absorb the remaining hadrons, leaving behind a beam of muons and neutrinos. Muons are quickly absorbed downstream in the rock, leaving only muon-neutrinos to traverse the Earth's crust towards the Gran Sasso laboratory 732 km away in Italy.

Both the horn and the reflector came originally from LAL/IN2P3 before major modification at CERN. They are 7 m long and weigh more than a tonne each. They work with high pulsed currents, 150 kA for the horn and 180 kA for the reflector. These currents flow for a few milliseconds at the instant when the proton-beam pulse hits the target.

The heat that the current produces and the energy deposited by stray particles require a complex water cooling system. To avoid modifications in the mechanical properties of the aluminium alloy that makes up the whole system, the temperature must not exceed 80 °C. Cooling power is extracted from the chilled-water network by means of a heat exchanger. Demineralized water is sprayed onto the inner conductor, then collected at the bottom of the horn and the reflector, and finally pumped back to the system in a closed circuit.

The magnetic horn being installed in the CNGS target chamber.

The neutrino beam will be remotely monitored from the newly built central control room at CERN's Prévessin site. The completion of the CNGS project, that is the hand- over to the teams in charge of regular operation of the beam, is planned for mid July.

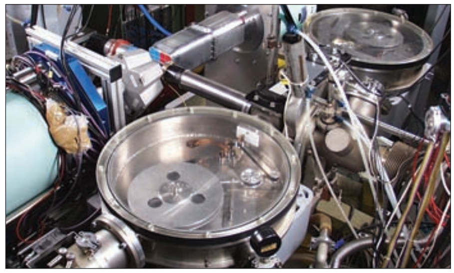
NUCLEAR PHYSICS

Silver isotope exhibits exotic radioactivity

Since soon after its discovery by Henri Becquerel in 1896, radioactivity has been known to involve the emission of helium nuclei (alphas), electrons (betas) and photons (gammas). Then, in 1960, proton-rich nuclei with an odd or an even atomic number Z were predicted to decay through one- and two-proton radioactivity, respectively. Single-proton radioactivity was discovered in 1981, while the first evidence for two-proton radioactivity was obtained in 2002 in the decay of ^{45}Fe.

Now in an experiment on ^{94}Ag, an international team lead by Ivan Mukha and Ernst Roeckl has made the first experimental observation of nuclear decay involving both one- and two-proton radioactivity (Mukha *et al* 2006). The researchers attribute the two-proton emission behaviour and the unexpectedly large probability for this decay mechanism to a very large deformation of the parent nucleus into a prolate (cigar-like) shape, which facilitates emission of protons either from the same or from opposite ends of the "cigar".

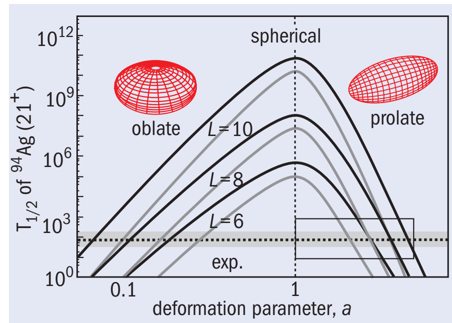
Working at the GSI research centre, the researchers synthesized the lightest known isotopes of silver (^{94}Ag) using nuclear reactions between accelerated ^{40}Ca ions and ^{58}Ni atoms. After purification by online mass separation the ^{94}Ag nuclei were implanted into a catcher positioned in a highly segmented array of silicon and germanium detectors. The simultaneous two-proton emission was identified from a long-lived (0.4 s), high-spin state of ^{94}Ag. This (21^+) isomer is also known to undergo one-proton decay (Mukha *et al* 2005).



The experimental set-up. The beam comes from the right. Two of the germanium detectors are visible at the left and right side of the beam line (Courtesy G Otto, GSI.).

Both disintegration modes were unambiguously identified by "tagging" γ rays that are known to de-excite the high-spin states populated in the daughter nuclei ^{93}Pd and ^{92}Rh for one-proton and two-proton decay, respectively. In particular, the team searched for direct two-proton decay of the isomer by measuring coincidences between double-hit events recorded by the silicon detectors and γ–γ events registered by the germanium detectors. The observed two-proton decay is unexpectedly fast.

This first measurement of correlation data in two-proton radioactivity calls for further experimental studies of the properties of this truly exotic isomer. It also demands a more quantitative theoretical description of the observed two-proton decay behaviour.



Partial two-proton decay half-life ($T_{1/2}$) of ^{94}Ag (21^+) as a function of the nuclear deformation parameter a *which is the ratio of the long to short axes of the ellipsoid. Model estimates for the two-proton decay proceeding as simultaneous three-body breakup (black curves) and quasi-classical ^{2}He decay (grey curves) are shown for angular momenta* L = *6, 8, 10. The nuclear shapes corresponding to the derived deformations are displayed for the* L = 6 *calculation. The experimental $T_{1/2}$ value is shown by the dotted line, the grey region indicating experimental uncertainty.*

Further reading

I Mukha *et al* 2006 *Nature* **439** 298.
I Mukha *et al* 2005 *Phys. Rev. Lett.* **95** 022501.

PARTNERSHIP

CERN consolidates links with Pakistan

On 25 January Pervez Musharraf, president of Pakistan, visited CERN with five government ministers, Parvez Butt, president of Pakistan's Atomic Energy Commission (PAEC), and an eminent former president of the Commission, Ishfaq Ahmad, who pioneered co-operation with CERN. The visit included a tour of CMS, to which Pakistan is making a substantial contribution, and an opportunity for Musharraf to address CERN's Pakistani scientists.

During the visit, Butt and CERN's director-general, Robert Aymar, signed an addendum to the 2003 Protocol Agreement covering the supply of additional equipment for the Large Hadron Collider (LHC). They also signed a letter of intent aimed at strengthening scientific and technical co-operation between CERN and Pakistan. The document envisages an extension of the existing partnership not only in new accelerators, detectors and information technologies, but also in educating and training scientists and technical experts.

Left to right: Pervez Musharraf, president of Pakistan, Parvez Butt, president of the PAEC, and Robert Aymar, CERN's director-general.

In 1994 CERN and Pakistan signed their first formal collaboration agreement, and in 1997 a protocol was signed for the supply of eight huge steel feet for the CMS magnet yoke. This was supplemented in 2000 by a memorandum of understanding for the production of 288 muon chambers and electronic components for the experiment. Three years later, the co-operation gained new impetus with a new protocol of understanding with CERN.

There are currently 75 Pakistani physicists and engineers taking part in three major CERN projects: CMS, ATLAS and the development of the Computing Grid for the LHC (LCG).

LHC PHYSICS

Going beyond the Standard Model

CERN's new five-part new-physics workshop was launched in November 2005 and aims to produce a flavour-physics programme for the next decade.

A five-part workshop has been launched at CERN to study the interplay between the physics of particle flavour and the physics achievable at particle colliders. In particular, it aims to consider the future directions for flavour physics when the Large Hadron Collider (LHC) starts up at CERN in 2007.

Flavour physics and charge-parity (CP) violation have played an outstanding role in the exploration of particle-physics phenomenology for more than four decades. After a long and exciting history of K-decay studies, the experimental stage is currently dominated by the decays of B^+ and B^0_d mesons. Thanks to the efforts at the e^+e^- B-factories at SLAC and KEK, with their detectors BaBar and Belle respectively, CP violation is now well-established in the B-meson system, and for the first time several strategies to test the flavour structure of the Standard Model can be confronted with experimental data.

Further valuable insights can be obtained from studies of the B^0_s system, with first results from experiments at CERN's Large Electron–Positron collider and the SLAC Linear Collider, as well as from Fermilab's Tevatron. In future, the physics potential of B^0_s decays can be fully exploited at the LHC, in particular by the LHCb experiment. Moreover, there are also plans for a "super B-factory", with a significant increase in luminosity relative to the e^+e^- colliders currently operating.

As far as the kaon system is concerned, the future lies in particular in investigations of the very rare decays $K^+ \to \pi^+\bar{\nu}\nu$ and $K_L \to \pi^+\bar{\nu}\nu$, which are very clean from the theoretical point of view, but unfortunately hard to measure. There is a new proposal to measure the former channel at CERN's Super Proton Synchrotron, and efforts to explore the latter at KEK/J-PARC in Japan. There are also many other fascinating aspects of flavour physics, such as charm and top physics, flavour violation in the charged lepton and neutrino sectors, electric dipole moments and studies of the anomalous magnetic moment of the muon.

The hope and final goal of these flavour studies is to find indications of physics beyond the Standard Model and to study its properties. So far, the Standard Model remains in good shape, with the exception of a couple of flavour puzzles that do not give definite conclusions on the presence of new physics. On the other hand, neutrino oscillations, as well as the evidence for dark matter and the baryon asymmetry of the universe, show that the Standard Model is incomplete. Moreover, specific extensions of the model usually contain new sources of flavour and CP violation, which may manifest themselves at flavour factories.

The LHC, it is hoped, will provide direct evidence for physics beyond the Standard Model through the production and decays of new-physics particles that arise, for example, in supersymmetric extensions of the Standard Model. There should be a very fruitful interplay between these "direct" studies of new physics and the "indirect" information provided by flavour physics.

The goal of the new CERN workshop, Flavour in the era of the LHC, is to outline and document a programme for flavour physics for the next decade, addressing in particular the complementarity and synergy between the LHC and the flavour factories with respect to the discovery and exploration potential for new physics. The workshop follows the standard CERN format, consisting of three working groups, which are devoted to the collider aspects of flavour physics at high-Q, the physics of the B-, K- and D-meson systems, and flavour physics in the lepton sector.

The opening meeting with plenary sessions to review the state-of-the-art of these topics, which also started the working group activities, took place at CERN on 7–10 November 2005. This attracted more than 200 participants from all over the world, and was followed by a second meeting at CERN on 6–8 February. There will be two further meetings before the final plenary meeting at the end of 2006 or the beginning of 2007. A CERN report will then publish the results and conclusions of the workshop.

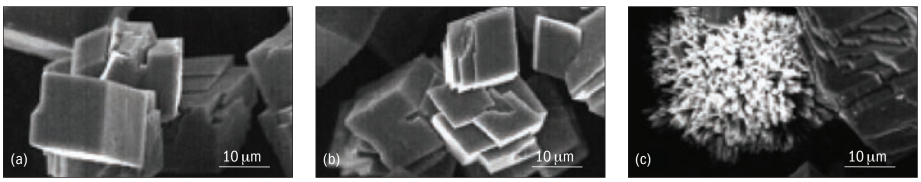
● Anyone interested in joining the workshop is still very welcome. For information, see http://cern.ch/flavlhc. The next meeting will be at CERN on 15–17 May.

Les physiciens des particules du monde entier sont invités à apporter leurs contributions aux *CERN Courier*, en français ou en anglais. Les articles retenus seront publiés dans la langue d'origine. Si vous souhaitez proposer un article, faites part de vos suggestions à la rédaction à l'adresse cern.courier@cern.ch.

CERN Courier welcomes contributions from the international particle-physics community. These can be written in English or French, and will be published in the same language. If you have a suggestion for an article, please send your proposal to the editor at cern.courier@cern.ch.

Compiled by Steve Reucroft and John Swain, Northeastern University

Magnetic fields found to affect aerated water



SEM images of $CaCO_3$ prepared by mixing $CaCl_2$ and Na_2CO_3 solutions at 298 K with (a) vacuum-distilled water, no magnetic treatment; (b) vacuum-distilled water with magnetic treatment; (c) magnetic treatment after aeration of vacuum-distilled water.

The more that physicists and chemists look at water, the more they find that it really is pretty mysterious stuff. For example, magnetic fields can change the rate of scale formation in boilers – a process that is not really understood and is somewhat controversial, even though it has found industrial application. Simpler systems would be easier to study and this is just what Ichiro Otsuka and Sumio Ozeki of Shinshu University in Japan have done. They have found that while a magnetic field does not change the physical properties of pure water, it does change the vibrational spectrum and electrolytic potential of water with dissolved oxygen.

The team also found that magnetic treatment of aerated water affected the formation of calcite ($CaCO_3$). While magnetic treatment had no effect on $CaCO_3$ crystal formation when they used vacuum-distilled water, when the water was exposed to air or oxygen (O_2) both X-ray diffraction images and scanning electron microscope (SEM) images of the crystals showed marked differences – indicating in particular the formation of aragonite. The team concludes that only when water dissolves O_2, not ionic species, is the water magnetized by changing the magnetic flux over the water, but admits that "the phenomena are still puzzling from the viewpoint of modern science".

Further reading

Ichiro Otsuka and Sumio Ozeki 2006 *J. Phys. Chem. B* **110** 1509.

New perspective on Ohm's law

For the first time it is possible to measure the velocities of electrons (not just the total current) as they flow through a material. Using an electron-spin resonance (ESR) technique in which they put a current-carrying sample in a spatially varying magnetic field, Noam Kaplan of the Hebrew University in Jerusalem and colleagues from Karlsruhe University have managed to track the motion of electrons and measure their speeds.

In fact the team measures the motion-induced phase shift of the ESR signals, in direct analogy to the way that phase-contrast nuclear magnetic-resonance imaging is used to measure blood flow, for example. The new measurements are something of a technical *tour de force* since electrons tend to randomize their motion very quickly. To overcome this, the team used a crystal of an organic conductor $(fluoranthene)_2PF_6$, with electron-spin relaxation times of microseconds, instead of the nanoseconds usual for most materials. This enabled the team to measure the drift velocity of the conduction electrons and so test Ohm's law at a microscopic level. Perhaps not surprisingly, they replicated what would be expected from the well known law, albeit from a rather different point of view.

Further reading

M Drescher, N Kaplan and E Dormann 2006 *Phys. Rev. Lett.* **96** 037601.

UK sets laser record

Juan Diego Ania-Castañón and colleagues at Aston University in the UK have built a laser that is 75 km long. Based on the Raman effect, amplification of a long-wavelength signal is achieved by stimulated emission from atoms pumped by a shorter wavelength. This kind of approach has been tried in the past, but the gain has been very non-uniform, and numerous pump lasers were needed.

The new trick here is to use the Raman effect twice: mirrors at both ends of the laser – in fact 75 km of optical fibre – reflect light at 1455 nm only. Longer than the pump wavelength, but shorter than the signal wavelength, this stimulates Raman emission and makes a very long Raman laser at 1455 nm. This 1455 nm laser then acts as a pump for the amplification (again by the Raman effect) of a signal at 1550 nm, but now with high uniformity.

Further reading

Juan Diego Ania-Castañón *et al.* 2006 *Phys. Rev. Lett.* **96** 023902.

The world's smallest fish starts big debate

There is a new claim for the record for smallest fish in the world. Maurice Kottelat and Tan Heok Hui from the National University of Singapore and colleagues found the little creature in Sumatra. The females grow to just 7.9 mm and the males a little longer. The males are especially interesting as they have a unique set of extra gripping muscles and a fin which seem to help them hang on to the females during mating. The fish also have most of the roof of their skulls missing.

The announcement has provoked other researchers to publicize prior discoveries of tiny fish, sparking a debate on what the words "smallest fish" should actually mean. However, as Kottelat and colleagues point out, "unfortunately, habitat destruction jeopardizes the survival of these fish and thus opportunities for further research".

Further reading

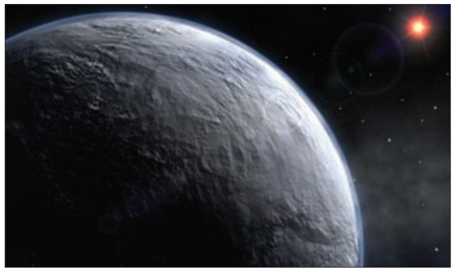
Maurice Kottelat *et al.* 2005 *Proceedings of the Royal Society B: Biological Sciences*, published online DOI: 10.1098/rspb.2005.3419.

Compiled by Marc Türler, INTEGRAL Science Data Centre and Geneva Observatory

Microlensing detects most Earth-like exoplanet

A planet of a mass of only about five times that of the Earth has been discovered at a distance of about 20 000 light years, not far from the centre of the Milky Way. It circles its parent low-mass star in about 10 years at more than three times the Sun–Earth distance. The planet must therefore be very cool with an estimated temperature of −220 °C. The lightest extra-solar planet ever detected around a normal star, it may have a thin atmosphere, like the Earth, but its rocky surface is probably deeply buried beneath frozen oceans. It may therefore more closely resemble a more massive version of Pluto, rather than the rocky inner planets such as Earth and Venus.

Since the discovery in 1995 of the first planet orbiting a star other than the Sun, nearly two hundred extra-solar planets (or exoplanets) have been detected (*CERN Courier October* 2004 p19). Almost all of them orbit nearby stars and have been detected using the radial velocity method, which measures the wobble of the star induced by the gravitational pull of the orbiting planet. However, the newly discovered planet, designated as OGLE-2005-BLG-390Lb, is only the third planet to be discovered through gravitational microlensing, an effect noted by Albert Einstein in 1912.



Artist's impression of the exoplanet and its parent star. (Courtesy ESO.)

The planet was detected because it crossed the line of sight to a background star. By moving exactly in front of the remote star, the mass of the planet and its parent star distort space–time locally and act as lenses, focusing the light of the background star and making it appear brighter.

The first indication of the discovery was the brightening of a star first noticed by the Optical Gravitational Lensing Experiment (OGLE) on 11 July 2005, although it was just one out of about 500 microlensing events detected each year by scanning most of the central Milky Way every night. These events are owing to intervening stars and last about a month. Any planet orbiting a star can produce a small additional signal, lasting days for giant planets down to hours for Earth-mass planets. To detect the signature of low-mass planets, astronomers must observe these events more frequently than OGLE's one survey a night. This was done by an international collaboration called the Probing Lensing Anomalies Network, which is able to observe 24 hours a day with a set of telescopes distributed all around the world. The signal of the small planet was detected during the night of 10–11 August 2005 mainly with the Australian Perth telescope and the Danish telescope at La Silla, Chile.

Microlensing is probably the only method currently capable of detecting planets similar to Earth, which are the most difficult to detect. That the third planet discovered this way is a low-mass planet is encouraging and could mean that they are more common than their larger, Jupiter-like brethren. The quest to find a twin for Earth continues.

Further reading:

J-P Beaulieu *et al.* 2006 *Nature* **439** 437.

Picture of the month

Composite image (left) of the Cartwheel Galaxy, combining data from four different observatories: the Chandra X-ray Observatory (X-rays/purple); the Galaxy Evolution Explorer (GALEX) satellite (ultraviolet/blue); the Hubble Space Telescope (visible/green); the Spitzer Space Telescope (infrared/red). The unique shape of the Cartwheel Galaxy with its huge rim – larger than the diameter of the Milky Way – is likely to be due to a violent frontal collision with the bluish smaller galaxy on the lower left several hundred million years ago. The smaller galaxy produced compression waves in the gas of the Cartwheel as it plunged through it. These compression waves triggered bursts of star formation, which lit up the Cartwheel's rim (*CERN Courier* June 2004 p15). The insets to the right show how each telescope views the Cartwheel in original colours. (Courtesy NASA/JPL/Caltech/P Appleton *et al.*)

CERN COURIER ARCHIVE: 1963

A look back to CERN Courier vol. 3, March 1963

NEWS FROM ABROAD

Tests of British National Hydrogen Bubble Chamber get under way

In the east bubble-chamber building at CERN two impressive-looking magnets have been assembled for some time, and other work is proceeding steadily towards the completion of two new very large bubble chambers.

One of these, the 1.5 m British National Hydrogen Bubble Chamber (BNHBC), has now been successfully tested in England (without its magnet), and the way is now clear for it to be transferred to CERN. After installation in the magnet, the parts of which arrived from England at the end of 1961, it will be operated with a new beam to be constructed in the east experimental area of the proton synchrotron. Tests with protons and pions will probably be carried out later this year, and experiments will then follow, using mainly high-energy kaons and antiprotons.

Preliminary design studies began on the BNHBC in 1957 and work began on the chamber early in 1959. The construction has been a collaborative effort between Imperial College, London, Birmingham University, Liverpool University and the National Institute for Research in Nuclear Science (NIRNS). Also represented on the management committee, under the chairmanship of Prof. C C Butler of Imperial College are University College, London, and the Universities of Cambridge, Glasgow and Oxford. Although all the early experiments will be carried out at CERN, the chamber will eventually return to England for operation with the 7 GeV "Nimrod" synchrotron at the NIRNS Rutherford High Energy Laboratory, Chilton, Berkshire.

Although the 72 inch (183 cm) chamber at Berkeley, US, is longer, this is at present the largest liquid-hydrogen bubble chamber in the world from the point of view of the volume of liquid hydrogen in which tracks can occur and be photographed. This volume is roughly rectangular in section, 150 cm long, 50 cm high and 45 cm deep. Some 500 l of liquid hydrogen are used altogether in the chamber, kept at a temperature of −247 °C and under a pressure of about 6 atm in the main chamber body.

It is when this pressure is decreased suddenly to 3 atm that minute bubbles form along the tracks of any ionizing particles that have just passed through.

For the recent tests, the chamber was assembled in a special building at the Rutherford Laboratory, with appropriate high-pressure hydrogen and other supplies. Control systems and other parts are now being transferred to CERN at the rate of about two lorry loads a week. The bridge will be transported in one piece, followed by the complete chamber assembly – travelling at a maximum speed of 8 km per hour!

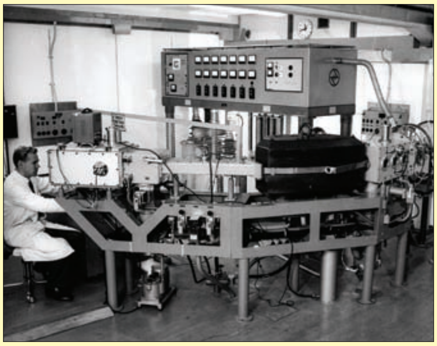
Berkeley Bevatron is back in operation

After being shut down since July last year, while extensive modifications were carried out, the Bevatron, the 6.2 GeV proton accelerator at the University of California's Lawrence Radiation Laboratory at Berkeley, US, was successfully put back into operation during February. The full experimental programme should begin again in March.

Ideas for the alterations began to take shape as far back as 1958 and work has been going on since 1960, when $9.6 million was appropriated for the project by the US Congress. The most basic modification has been the installation of an entirely new proton-injection system, consisting of a 480 kV Cockcroft Walton set and a 19 MeV strong-focusing linear accelerator. By this means, the intensity of the input beam to the synchrotron is expected to be raised by a factor of 20 or more, with a corresponding increase in the full accelerated-beam intensity. Closely linked with this is the installation of facilities for an external proton beam. This will have the major advantage of providing secondary beams of positively charged particles outside the accelerator ring, instead of within the cramped and inaccessible hub area. Other benefits will be obtained in the study of short-lived particles, down to lifetimes of around 10^{-10} s, since detectors can now be placed much nearer to the targets.

Increased beam intensity means more background radiation, with the result that the shielding of the accelerator has had to be considerably increased. The concrete ring surrounding it has been brought up to a uniform thickness of 3 m, and a concrete "igloo" enclosing experimental apparatus has been placed at the hub. Moreover, the entire ring-shaped accelerator has been covered by massive concrete roof beams more than 2 m thick. To support all this shielding, a tunnel was first constructed under the machine and then filled with concrete into which steel uprights were embedded.

CHEMISTRY AT CERN



In this photo of the electromagnetic isotope separator, the source of heavy ions is at the extreme right and the magnet is the black object to its left.

● Used by the Nuclear Chemistry Group to measure reaction products formed in internal targets at CERN's accelerators, this instrument was in a way the forerunner of the Isotope Separator On Line (ISOLDE) facility, which started up in 1967.

JINR celebrates 50 years

This month the Joint Institute for Nuclear Research celebrates its 50th anniversary as a renowned international intergovernmental scientific research organization.

The Joint Institute for Nuclear Research (JINR) was established through a convention signed in Moscow on 26 March 1956 by representatives from 11 founder states. Their aim was to unite their scientific and material potential in order to study the fundamental properties of matter. Nearly a year later, on 1 February 1957 the institute was registered with the United Nations.

JINR is situated in Dubna, 120 km north-east of Moscow on the Volga River. It is known today around the world as a centre where fundamental research, both theoretical and experimental, is successfully integrated with new technology, the latest techniques and university education.

The main fields of JINR's research are theoretical and experimental studies in elementary-particle physics, nuclear physics, and condensed-matter physics. The research programme is aimed at obtaining highly significant scientific results. In nuclear physics alone, around half the 80 or so discoveries in the former USSR were made at JINR. The decision of the General Assembly of the International Committee of Pure and Applied Chemistry to award the name Dubnium to element 105 of the periodic table stands in recognition of the achievements of the institute's researchers and their contribution to modern physics and chemistry.

At present JINR has 18 member states: Armenia, Azerbaijan, Belarus, Bulgaria, Cuba, Czech Republic, Georgia, Kazakhstan, Democratic People's Republic of Korea, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Ukraine, Uzbekistan and Vietnam. Germany, Hungary, Italy and the Republic of South Africa also participate in JINR's activities through bilateral agreements signed at governmental level.

JINR is a genuinely international institution. Its supreme governing body is the Committee of Plenipotentiaries of all 18 member states. The research policy is determined by the Scientific Council, which consists of eminent scientists from the member states, as well as well known researchers from France, Germany, Italy, the US and CERN.

Fig. 1. A meeting of the representatives of the the JINR founder states in 1956. Chief scientific secretary of the Presidium of the Academy of Sciences of the USSR Academician, Alexander Topchiev is speaking. (All photos courtesy JINR.)

Fig. 2. The 10 GeV Synchrophasotron started up in 1957 as the world's highest-energy accelerator, and is still operational today.

From firm foundations

Since its beginnings, JINR has instigated a wide range of research, and scientific personnel of the highest qualification have been trained for the institute's member states. Among them are presidents of national academies of sciences, along with leaders of large nuclear centres and universities in many of the member states.

Before JINR's foundation, the Institute of Nuclear Problems (INP) of the USSR Academy of Sciences had been set up in the late 1940s in the town that was to grow into modern Dubna. The INP had launched a broad research programme on fundamental and applied studies of the properties of nuclear matter using what was at the time the largest charged-particle accelerator – the synchrocyclotron. At the same time, the Electrophysical Laboratory (EPhLAN) of the USSR Academy of Sciences was set up at the same place and it was here that research to develop a new accelerator – the 10 GeV Synchrophasotron (figure 2) – was conducted under the guidance of Vladimir Veksler. When this machine started up in 1957 it was the world's highest-energy accelerator.

By the mid-1950s the world had come to realize that nuclear science could not be kept locked in secret laboratories and that only broad-based international co-operation could ensure progress in this fundamental realm of human knowledge and in the peaceful utilization of atomic energy. In 1954 CERN was established to unite the efforts of Western European countries in studying the fundamental properties of the microcosm. About the same time, under the stimulus of the government of the USSR, the countries then ▷

Fig. 3. The first director of JINR, Dmitri Blokhintsev (centre), pictured in 1956 with the directorate that set up the institute.

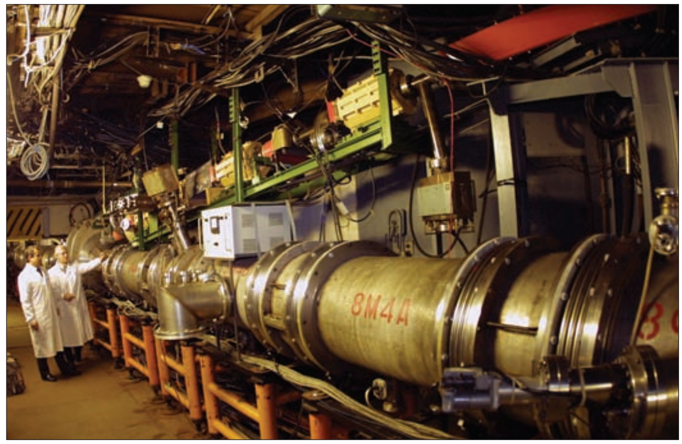


Fig. 4. JINR's Nuclotron – the superconducting synchrotron accelerates nuclei and heavy ions up to 6 GeV/n.

belonging to the socialist world took a decision to establish JINR, based on the INP and EPhLAN.

After the agreement for the foundation of JINR was signed, specialists from all the member states came to Dubna. As the town took on its international flavour, research began in many fields of nuclear physics of interest to the scientific centres of the member states. The first director of JINR was Dmitri Blokhintsev (figure 3), who had just successfully developed the world's first atomic power station in Obninsk. Marian Danysz from Poland and Vaclav Votruba from Czechoslovakia became vice-directors, and together this first directorate led the institute through one of the most difficult and crucial periods in its life – the time of its establishment.

The history of JINR is associated with many outstanding scientists including Nikolai Bogoliubov, Igor Kurchatov, Igor Tamm, and Lajos Janossy. Many others were involved in developing the institute and its main scientific branches, such as Alexander Baldin, Vladimir Veksler, Moissey Markov, Bruno Pontecorvo and Georgi Flerov to name but a few.

The institute today

Since JINR's founding, nuclear research has been marked by important discoveries and crucial changes. In 1961 the JINR Prizes were established, and a group of physicists led by Veksler and Wang Ganchang from China were awarded the first such prize for their discovery of the antisigma-minus-hyperon. No-one doubted at the time that this particle was elementary, but a few years later, this hyperon, the proton, neutron, pion and other hadrons had lost their elementary quality. They turned out to be complex particles consisting of quarks and antiquarks, which have in turn gained the "right" to be called elementary. Physicists at Dubna have clarified to a great extent the concept of the quark structure of hadrons. Among their latest research are the ideas of colour quarks, the hadron quark model known as "the Dubna bag", and so on.

In addition to this mainstream progress over the past 50 years, there has been another, quite opposite theme – research that was far ahead of its time. Fifty years ago, soon after JINR had been established, Bruno Pontecorvo suggested the existence of neutrino oscillations. It took scientists dozens of years to find experimental confirmation of such oscillations, which are now a central issue of the physics of weak interactions. At the 97th session of the JINR Scientific Council in January 2005 Art MacDonald, director of the Sudbury Neutrino Observatory (SNO) received the Pontecorvo Prize for the discovery in SNO of evidence for solar neutrino oscillations.

The modern JINR comprises eight laboratories, each being comparable with a large institute in the scale and scope of investigations performed. It employs more than 6000 people, including more than 1000 scientists, including full members and corresponding members of national academies of sciences, more than 260 Doctors of Science and 630 Candidates of Science, and around 2000 engineers and technicians. The current director, as from 1 January 2006, is Alexei Sissakian, with Mikhail Itkis and Richard Lednický as vice-directors.

The institute possesses a remarkable choice of experimental facilities for physics: Russia's only superconducting accelerator of nuclei and heavy ions, the Nuclotron (figure 4); the U-400 and U-400M cyclotrons with record beam parameters for experiments on the synthesis of heavy and exotic nuclei; the unique neutron pulsed reactor IBR-2; and the Synchrophasotron proton accelerator which is used for radiation therapy. JINR also has powerful and fast computing facilities, which are integrated into the worldwide computer network.

JINR has established excellent conditions for training talented young specialists. Its University Centre organizes research experience annually at the institute's facilities for students from higher-education institutions in Russia and other countries. In 1994, on the initiative of the JINR directorate, and with the active support of the Russian Academy of Natural Sciences, the town of Dubna and the Moscow region administrations established the Dubna International University of Nature, Society and Man. There are dozens of JINR staff members – all renowned scientists – among the university staff. The university educational base is actively developed on the territory of JINR, so that Dubna has become a town of students as well as physicists.

Each year JINR submits more than 500 scientific papers and reports written by about 3000 authors to the editorial offices of many journals and organizing committees. JINR publications are distributed in more than 50 countries. About 600 preprints and communications a year are issued. JINR publishes the journals *Physics of elementary particles and atomic nucleus*, *Physics of elementary particles and atomic nucleus letters*, the annual report on JINR activities, the information bulletin *JINR News*, as well as proceedings of conferences, schools and meetings organized by the institute.

For 50 years JINR has been a bridge between the West and the East promoting the development of broad international scientific and technical co-operation. It collaborates with nearly 700 research centres and universities in 60 countries. In Russia alone – the largest JINR

Fig. 5. JINR's administration building in Dubna, displaying the flags of the institute's 18 member states.

Fig.6. Dubna, January 2006. The 99th session of the JINR Scientific Council. The Russian Federation's minister of science and education Andrey Fursenko is speaking.

partner – co-operation is conducted with 150 research centres, universities, industrial enterprises and companies from 40 Russian cities.

A clear example is JINR's co-operation with CERN, which facilitates decisions about many theoretical and experimental efforts in high-energy physics. JINR is currently participating in the Large Hadron Collider (LHC) project, taking part in development and construction of parts of the ATLAS, CMS and ALICE detector systems and in the LHC itself. Thanks to its supercomputer centre, JINR is also participating in the development of the Russian regional centre for processing experimental data from the LHC, which is planned as part of the LHC Computing Grid project.

International experience

More than 200 scientific centres, universities and enterprises from 10 countries in the Commonwealth of Independent States (CIS) participate in implementing JINR's scientific programme. The institute may be regarded as a joint scientific centre for the CIS countries, functioning successfully on the international scale. The large and positive experience accumulated at JINR for mutually profitable scientific and technical co-operation on the international scale could provide a discussion topic for a meeting of CIS leaders in Dubna in the context of a summit of the CIS member states.

JINR also maintains mutually beneficial contacts with the IAEA, UNESCO, the European Physical Society and the International Centre for Theoretical Physics in Trieste. Each year more than 1000 scientists from JINR's partner states visit Dubna, and the institute grants scholarships to physicists from developing countries. JINR's own researchers are frequent participants at many national and international scientific conferences. In its turn, the institute annually holds up to 10 large conferences and more than 30 international workshops, as well as traditional schools for young scientists.

In the late 1990s, the concept of JINR as a large multidisciplinary international centre for fundamental research in nuclear physics and related fields of science and technology was adopted. The aim is to transfer the results of highly technological research at JINR to applications in industrial, medical and other technical areas, so as to provide additional sources of financing for fundamental research and the organization of new working places for specialists who are involved with these broader topics at the institute. There are also plans for assisting JINR member states to develop new facilities and scientific programmes, such as a cyclotron centre in Bratislava in the Slovak Republic and the DC-60 cyclotron in Astana in Kazakhstan.

JINR has thus entered the 21st century as a large multidisciplinary international scientific centre where fundamental research is conducted in fields related to the structure of matter. It is now integrated with the development and application of new science-intensive technology and the development of university education in related fields of science and it looks forward to its next half century.

Résumé

L'IURN de Doubna fête ses 50 ans

L'Institut unifié de recherche nucléaire (IURN) de Doubna compte aujourd'hui 18 Etats membres et plusieurs Etats associés. Dans ses huit laboratoires, 6000 personnes, dont plus de 1000 chercheurs, travaillent en physique nucléaire et des particules, théorique comme expérimentale, et sur la matière condensée. On note parmi ses nombreuses installations, l'accélérateur supraconducteur d'ions lourds, le Nuclotron, et un centre de calcul puissant intégré dans la Grille LHC. Depuis sa fondation, l'IURN est une passerelle entre l'Est et l'Ouest. Il participe actuellement à la construction du LHC et de ses expériences, et se prépare à en traiter les données. L'IURN a contribué à la création d'une université internationale à Doubna et assiste ses Etats membres dans le mise au point de nouvelles installations.

Boris Starchenko, *JINR Scientific Secretary.*

Germany seeks to fulfil astroparticle aspirations

Axel Lindner reports on the fourth biennial workshop about the status, perspectives and future prospects of research in the field of astroparticle physics in Germany.

The fourth biennial workshop on astroparticle physics in Germany took place at DESY, Zeuthen, in October 2005. It provided scientists in all branches of astroparticle physics, high-energy physics and astronomy with the opportunity to meet representatives of the German Ministry of Education and Research (BMBF) and discuss the status and future strategies of astroparticle physics.

Astroparticle physics in Germany is mainly pursued by the Helmholtz Association – at the Forschungszentrum Karlsruhe (FZK) and DESY – the Max Planck Society and several universities. It has rapidly achieved many successes in various topics, mainly through international collaborations. However, the next generation of experiments will surpass the funding available in Germany and it may be necessary to set priorities even though the advances in many areas are promising. As Johannes Blümer, chair of the Committee for Astroparticle Physics in Germany (KAT) – which is elected by the German astroparticle physics community – noted at the workshop: "Everything is possible, but not all at the same time".

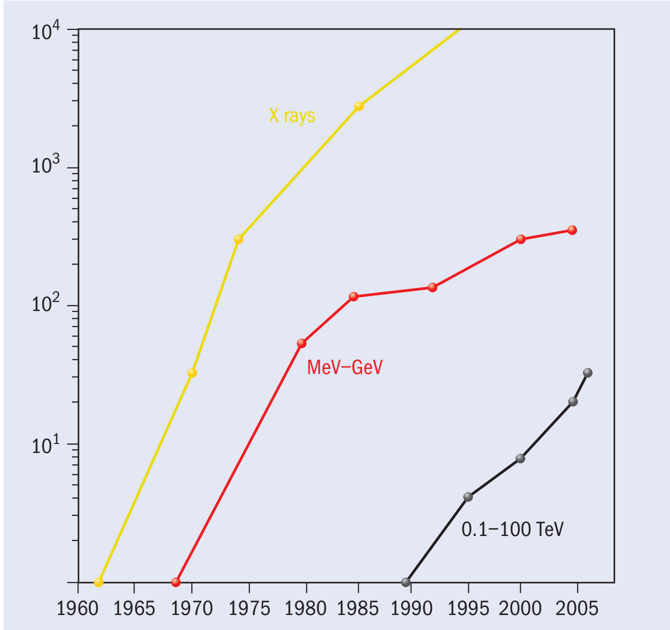


Fig. 1. New windows for astrophysics: the number of established photon sources as a function of the year (compiled by M de Naurois, updated by C Spiering). X-ray and MeV–GeV sources were discovered with satellites, and TeV sources were found by using Earth-bound imaging air Cherenkov telescopes.

Cosmic ray success stories

The main success story in astroparticle physics concerns the observations of the highest energy photons by imaging air Cherenkov telescopes (IACTs). These telescopes register the Cherenkov light emitted by extensive air showers that are initiated by photons in the atmosphere. After a long and sometimes painful period of poking around in the dark, in 1989 the Crab nebula was discovered to be a source of photons of multi-tera-electron-volt energies – the first such astrophysical source. With the latest generation of IACTs – the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope on the island of La Palma and most notably the High Energy Stereoscopic System (HESS) telescope array in Namibia – a wealth of galactic and extragalactic sources has since shown up (figure 1). The German community has a major involvement in both HESS and MAGIC.

This research has opened up a new branch of observational astrophysics, as IACTs have detected mysterious galactic tera-electron-volt photon sources that have no counterpart at any other wavelength. Surely more surprises are to be expected.

In charged cosmic rays, the energy spectrum exhibits what is called a "knee" around 1–10 PeV and for years the solution to understanding the origin of cosmic rays in this energy region seemed to be just out of reach. A detailed multi-parameter analysis of the energy spectrum of groups of chemical elements by the Karlsruhe Shower Core and Array Detector (KASCADE) collaboration at FZK has resolved the knee into successively heavier elements. However, it has hit a wall due to the limited theoretical understanding of high-energy interactions in the atmosphere. Data from the Large Hadron Collider (LHC) at CERN may help to improve simulations of these interactions.

Registering cosmic rays at the highest energies, around 10^{20} eV, the Pierre Auger Observatory (in which German universities and the FZK are major participants) is now moving quickly forward (*CERN Courier* January/February 2006 p8). "Hybrid" events, which were presented at the Zeuthen workshop (figure 2, p20), made a strong impression. Although Auger is not fully operational yet, timescales are such that next-generation experiments need to be discussed now. These include, for example, the Extreme Universe Space ▷

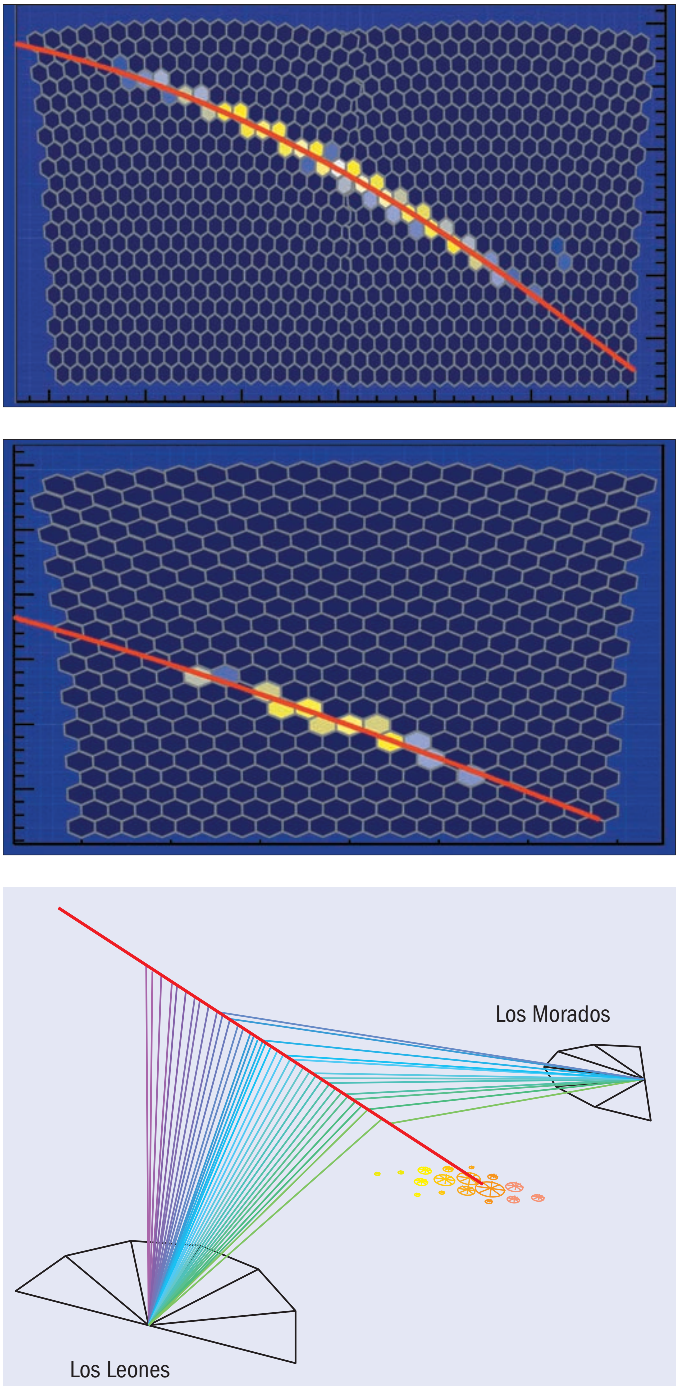


Fig. 2. An event with energy of roughly 15 EeV seen with the Pierre Auger Observatory in two air-fluorescence telescopes (Los Leones, top; Los Morados, middle) and with the surface detector array (bottom), where early signal arrival times are displayed in blue, the latest are in red. (Courtesy R Engel and M Roth).

Observatory, a space-born experiment to observe fluorescent and Cherenkov light from huge air showers. It would provide a sensitive area about one order of magnitude larger than Auger and would be perfectly suited to events above the famous Greisen–Zatsepin–Kuzmin cut-off (if indeed there are any), as well as for neutrino astronomy beyond 5×10^{19} eV.

The measurement of the radio emission from air showers has witnessed its own breakthrough. At the KASCADE ground array, the LOPES collaboration records geosynchrotron radio emission from air showers (figure 3). A realistic modelling of the radio emission has been achieved, which in turn enables the derivation of air-shower parameters from the radio data. The radio technique will allow for potentially very large and cost-effective installations. In the near future, more details will be investigated in conjunction with the Pierre Auger Observatory. This workshop series had its share in this success, as the possibility of new radio measurements was presented at the first meeting in 1999. Financial support was quickly provided by the BMBF and LOPES came into being.

Neutrinos to gravity waves

Following the proof of principle of cosmic-neutrino detection by the Antarctic Muon and Neutrino Detector Array at the South Pole and the array in Lake Baikal, the installation of the 1 km^3 sized IceCube neutrino telescope is now under way at the South Pole, with major participation from DESY and several German universities. IceCube should reach a sensitivity sufficient to identify sources of cosmic neutrinos (*CERN Courier* May 2005 p17). Technology tests by the ANTARES collaboration for a similar neutrino telescope in the Mediterranean have been concluded successfully.

A direct measurement of neutrino mass is badly needed to set the absolute scale for the mass differences derived from neutrino flavour oscillations. The Karslruhe Tritium Neutrino Experiment at FZK is likely to be the ultimate detector for a direct measurement of the neutrino mass from tritium decays. It aims for a mass sensitivity of 0.2 eV. The Germanium Detector Array, which is being pushed by German astroparticle physicists, is used to search for neutrinoless double beta decays and could reach a sensitivity of 0.1 eV for Majorana neutrinos.

Low-energy solar-neutrino spectroscopy is still required for a detailed understanding of the Sun and may prove the existence of matter effects in neutrino oscillations. The BOREXINO experiment, which has German participation, should start taking data in summer 2006. However, technology now allows us to aim for much larger future installations, such as the Low Energy Neutrino Astronomy project (with 50 kt of scintillator), up to 1 Mt water Cherenkov detectors or 100 kt liquid argon "bubble chambers", as are being developed by the ICARUS collaboration. These new experiments would enable the measurement of "time resolved" neutrino spectroscopy in correlation with helioseismology. In addition, they could give access to relic and galactic supernova neutrinos and geoneutrinos, and could provide sensitive results on proton decay.

There are many convincing indirect arguments for the existence of dark matter in the universe. Theories predict weakly interacting massive particles (WIMPs) with masses above a few tens of giga-electron-volts as constituents of dark matter. Workshop participants heard of interesting evidence for galactic dark matter from archival data of the EGRET satellite (*CERN Courier* December 2005 p17). Meanwhile, three strategies are being followed in the hunt for WIMPs: they could be created at particle colliders (one of the prime targets for the LHC), while "natural" WIMPs are being searched for through their annihilation products, by satellites, IACTs and neutrino telescopes, or by elastic scattering processes in specialized detectors. A fourth line of attack is to try to detect axions, which may be created in non-thermal processes in the universe and hence provide cold dark-matter particles with masses in the region of 100 μeV.

There is already a good deal of indirect evidence for the existence of gravitational waves through the observation of energy losses in binary pulsar systems. However, the experimental systems of the Laser Interferometer Gravitational Wave Observatory (LIGO) in the US, the Virgo detector at Pisa in Italy and GEO600 near Hannover in Germany could directly detect gravitational waves, for example from the collision of two neutron stars. Unfortunately, the predicted event rates vary between one in a few years to one in a few thousand years. The advanced LIGO instrument, to which the German Max Planck Society will contribute, will achieve a much higher sensitivity. It is scheduled to start data taking in 2013. The space mission LISA, a joint effort between ESA and NASA, will extend the observational window to much lower frequencies and may even make primordial gravitational waves accessible. The decisions in Europe and the US on LIGO and LISA show the high priority that is being given to this research field, although in Germany only the Max Planck Society is significantly involved so far.

A stimulating one-day multimessenger workshop after the meeting discussed methods to combine observations of photons from radio to tera-electron-volt energies with those of neutrinos, gravitational waves and charged cosmic rays. The aim would be to extend the classical multiwavelength approach of astronomy towards a true multimessenger strategy.

Organizational issues

The total funding of astroparticle physics in Germany for 2005 amounted to approximately €35 million, while the corresponding amount for Europe is about €130 million a year. This may be compared with the investments of roughly €30 million that will be necessary for a next-generation experiment for the direct identification of dark-matter constituents, of about €8 million for each telescope in a next-generation IACT system, or of €500 million for a 1 Mt water Cherenkov detector. It is evident that such installations will be realized only within international collaborations.

An even greater challenge is to create the roadmaps necessary to guide the way into the future of astroparticle physics. Consequently, the scientific community is being asked to produce roadmaps on national, European and international levels. The most important European organizations in this respect are the Astroparticle Physics European Coordination (APPEC) in which funding agencies of 10 European countries are members at present, and the European Strategy Forum on Research Infrastructures (ESFRI). The German KAT takes a central role in linking the roadmaps for the future of astroparticle physics in Europe and Germany.

Astroparticle physics has applied for EU support (€28 million in total) for four projects with important German participation:

- the Integrated Large Infrastructures for Astroparticle Science to concentrate on dark-matter searches, double beta decay and gravitational waves (granted);
- a High Energy Astroparticle Physics Network (not granted);
- KM3NeT to develop a deep-sea facility in the Mediterranean for neutrino astronomy (granted);
- the Astroparticle ERAnet to improve further the coordination within Europe giving a solid operational basis to APPEC (granted).

In Germany the Helmholtz Association has taken the initiative to improve networking between universities and research institutes in the country by funding three "virtual institutes": VIKHOS (high-energy radiation from the cosmos), VIDMAN (dark matter and neutrino physics) and VIPAC (particle cosmology).

Fig. 3. Three of the LOPES radio antennas between KASCADE particle detectors (the white huts).

In conclusion, astroparticle physics is making good progress in Germany and elsewhere. While tera-electron-volt astronomy is firmly established, several other fields are now just reaching the sensitivities for making breakthroughs. Further progress is imaginable only in the context of international collaborations following well-accepted roadmaps. The required organizational structures are being put into place and the next decade will decide on the future of many areas of astroparticle physics.

Luckily, imagination, fascination and fantasy remain unbroken. Astroparticle physicists continue to dream of utilizing the Moon as an ultimate target for observing the interactions of the highest energy cosmic rays or for listening to the feeble sound emitted in neutrino interactions in water and ice.

Further reading

For more details on the fourth workshop on German astroparticle physics see www-zeuthen.desy.de/astro-workshop/. For additional information concerning astroparticle physics in Germany see www.astroteilchenphysik.de/. For APPEC see http://appec.in2p3.fr/ and for the ESFRI see www.cordis.lu/esfri/home.html.

Résumé

Astrophysique des particules tous azimuts en Allemagne

Les chercheurs de ce domaine ont rencontré les délégués de leur ministère (BMBF) à l'occasion du 4e atelier bisannuel national sur le sujet. Le budget actuel ne suffira pas pour mener de front les recherches les plus prometteuses sur la matière noire ou les sources ponctuelles galactiques de rayons cosmiques de très haute énergie, des choix vont donc s'imposer. Les succès des compteurs Chérenkov atmosphériques ont ouvert une nouvelle branche de l'astrophysique dans la gamme des TeV, qui s'appuie aujourd'hui sur les instruments MAGIC et HESS. Pour les neutrinos, le pays participe à AMANDA et au projet IceCube et pour les énergies extrêmes en général – au programme AUGER. L'avenir appartient à la combinaison de toutes les observations, des ondes radios aux ondes...gravitationnelles.

Axel Lindner, *DESY.*

Meeting reviews progress towards the new BEPC

A recent collaboration gathered to hear the latest news on the upgrades to the Beijing Electron–Positron Collider and to the Beijing Spectrometer.

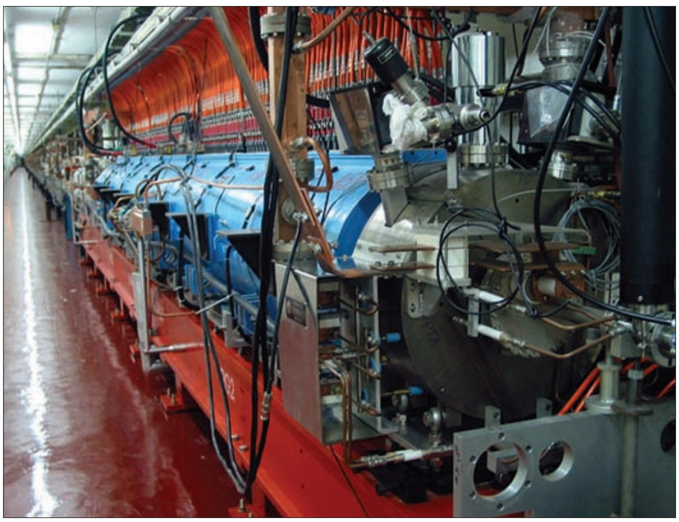


Fig.1. The linac for BEPC II is 202 m long and is constructed in a tunnel 6 m underground. (All photos courtesy IHEP.)

Fig.2. Mock-up of the installation of four pre-alignment units in the tunnel. The first beam collisions are planned for early 2007.

The Institute of High Energy Physics (IHEP) in Beijing is looking forward to a new era as construction of the upgraded Beijing Electron–Positron Collider (BEPC) moves into its final stage.

The BEPC II linac is now in place and installation of the storage ring has started. At the same time, the muon identifier and the superconducting magnet have been installed in the third incarnation of the Beijing Spectrometer (BES III). This was therefore an important time for the BES III collaboration meeting held in January, during which new members from GSI and the universities of Giessen and Bochum were accepted, and a new organizational structure of the collaboration was formally adopted.

BEPC II is a two-ring e^+e^- collider running in the tau-charm energy region ($E_{cm} = 2.0–4.2$ GeV), which, with a design luminosity of 1×10^{33} $cm^{-2}s^{-1}$ at the beam energy of 1.89 GeV, is an improvement of a factor of 100 over its successful predecessor, BEPC. The upgrade will use the existing tunnel, some major infrastructure items, and some of the old magnets. The 202 m long linac of the new machine can accelerate electrons and positrons up to 1.89 GeV with a positron injection rate of 50 mA/min. Its installation was completed in the summer of 2005 and it has reached most of the design specifications.

The collider consists of two 237.5 m long storage rings, one for electrons and one for positrons. They collide at the interaction point with a horizontal crossing angle of 11 mrad and a bunch spacing of 8 ns. Each ring holds 93 bunches with a beam current of 910 mA. The machine will also provide a high flux of synchrotron radiation at a beam energy of 2.5 GeV. The manufacture of major equipment such as magnets, superconducting RF cavities (with the co-operation of the Japanese high-energy physics laboratory, KEK, and the company MELCO) and quadrupole magnets (with the co-operation of the Brookhaven National Laboratory), as well as the cryogenics system, have been completed, and their installation is under way. The pre-alignment of magnets has made good progress. Figure 2 shows the mock-up of the installation of four pre-alignment units in the tunnel. Actual installation in the tunnel will begin soon and beam collisions are expected in the spring of 2007.

The BES III detector consists of a helium-based, small-celled drift chamber, time-of-flight (TOF) counters for particle identification, a calorimeter of thallium-doped caesium iodide CsI(Tl) crystals, a superconducting solenoidal magnet with a field of 1 T, and a muon identifier that uses the magnet yoke interleaved with resistive plate counters (RPCs). Figure 3 (p24) shows a perspective view of the detector.

The wiring of the drift chamber has been completed, and the assembly of the chamber has started. Beam tests of prototypes have been performed at KEK and IHEP with electronics prototypes, and both tests show that all design specifications have been satisfied ▷

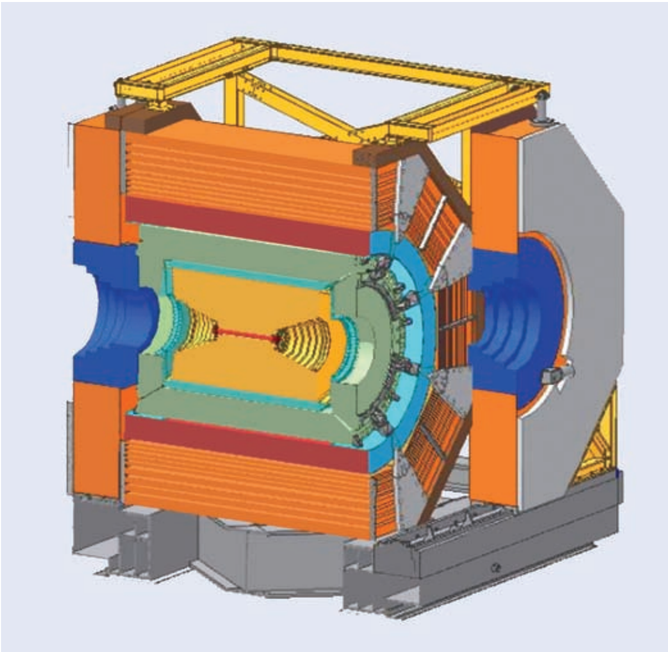


Fig. 3. A perspective view of the BES III detector at IHEP.

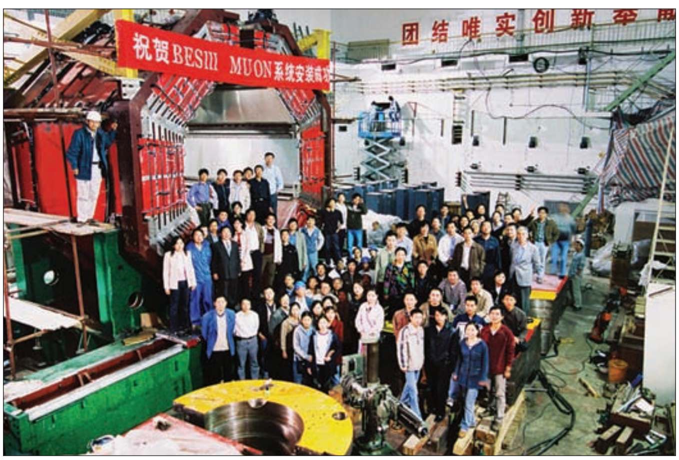


Fig. 4. The BES III group after they successfully completed installing the bakelite RPCs for the muon identifier.

Fig. 5. The superconducting magnet coil during installation into the BES III detector. The next stage is to cool the magnet.

and that the single wire resolution is 110 μm. CsI(Tl) crystals are being produced by Saint-Gobain Crystals, by the Shanghai Institute of Ceramics, and by Hamamatsu (Beijing). More than two-thirds of the crystals have been delivered, with satisfactory light yield, uniformity and radiation hardness. A beam test shows that the electronics noise from the preamplifier, main amplifier, charge digitizer and 18 m of cable was less than 1000 electrons equivalent per crystal, corresponding to about 220 keV of energy.

The scintillator and phototubes for the TOF system will be delivered before summer. All the RPCs for the muon identifier, made of bakelite but without the linseed oil surface treatment, have been manufactured, tested, and installed (figure 4). The average dark current and noise level for all chambers installed after one week's training is 1.6 $\mu A/m^2$ and 0.095 Hz/cm^2, respectively, for a high voltage corresponding to an average efficiency of 95%.

The BES III superconducting magnet is the first of its kind built in China. The vacuum cylinder and the supporting cylinder are made in China, in collaboration with the Wang NMR company of California. The wiring of the superconducting cable and the epoxy curing, the assembly and testing were all done at IHEP, with advice from experts all over the world. The superconducting magnet coil has now been successfully installed into the detector (figure 5) and will be cooled soon.

The latest BES III collaboration meeting was held on 10–12 January at IHEP. More than a hundred collaborators attended the meeting, coming from 21 institutions in 5 countries, namely China, Germany, Japan, Russia and the US. The meeting reviewed the current status of the BES III construction and discussed technical details. The collaboration accepted new groups as members, including teams from GSI, the University of Bochum and the University of Giessen, all from Germany. This meeting was also historic as the governance rules of the collaboration were approved and used for the first time. Under these rules, the Institutional Board was established and Hongfang Chen from the University of Science and Technology of China was elected as the chair, with Weiguo Li from IHEP chosen as deputy chair. Yifang Wang from IHEP was elected as spokesperson, and Yuanning Gao from Tshinghua University and Frederick Harris from the University of Hawaii were elected as co-spokespersons. The next collaboration meeting is scheduled to be held at IHEP on 8–9 June, immediately after the Charm 2006 workshop on 5–7 June, also at IHEP.

Résumé

Le point sur BEPC et BES

La reconstruction du collisionneur électron–positon BEPC se termine. Le linac est en place et, à partir du printemps 2007, les deux anneaux de stockage de BEPC II devraient produire des collisions dans l'unique détecteur BES III avec une luminosité nominale de 10^{33} $cm^{-2}s^{-1}$ dans la région du tau et du charme (E_{cm} = 2.0–4.2 GeV). Le rayonnement synchrotron de BEPC sera également utilisé. Le solénoïde supraconducteur de BES est installé et sera bientôt mis en froid, c'est le premier de ce type jamais construit en Chine. Les essais en faisceau des chambres à dérive et des cristaux de CsI sont satisfaisants. Aucun obstacle non plus n'apparaît sur le chemin des autres systèmes, qu'il s'agisse de temps de vol ou d'identification des muons.

Chen Hesheng, *director, IHEP.*

Le Globe de la science: u

Le Globe de la science et de l'innovation, nouvel espace de rencontre et d'échange e

Le Globe de la Science et de l'Innovation, grand bâtiment sphérique en bois érigé aux portes du site principal du CERN, à Meyrin en Suisse, est devenu un emblème pour le laboratoire. Il a ouvert ses portes l'an passé pour faire partager au grand public, à la population locale et aux partenaires du CERN, les travaux scientifiques du Laboratoire et les technologies qui y sont développées.

Avec 27 mètres de hauteur et 40 mètres de diamètre, le Globe est à peu près de la taille de la chapelle Sixtine à Rome. Repère visuel de jour comme de nuit, il se démarque dans le paysage des vignobles genevois. Symbole du développement durable par sa structure en bois, le Globe porte un message sur la science, la physique des particules, les technologies de pointe et leurs applications dans la vie quotidienne.

Une architecture novatrice

Le bois de l'enveloppe extérieure du Globe de la Science et de l'Innovation a d'abord été utilisé pour le Pavillon suisse à l'exposition universelle de Hanovre en 2000, conçu par l'architecte Peter Zumthor. Ces planches, symbolisant le développement durable, ont ensuite été transformées en secteurs sphériques à claire-voie pour composer l'enveloppe extérieure du bâtiment actuel, conçu par l'ingénieur Thomas Büchi (Charpente Concept) et l'architecte Hervé Dessimoz (Groupe H) pour l'exposition nationale suisse Expo.02.

Le bâtiment, alors nommé Palais de l'Equilibre, était dédié au développement durable. Durant les six mois de l'exposition, il a accueilli 1.9 millions de visiteurs. Après cette exposition, le Gouvernement suisse a réalisé un appel à propositions pour une réutilisation durable de l'édifice. Le CERN a proposé d'en faire un lieu de partage de la culture scientifique, technique et industrielle pour le grand public, ainsi qu'un espace d'échanges sur les technologies innovantes en partenariat avec des entreprises privées et des institutions publiques. La proposition a été retenue et le bâtiment a été offert en 2003 par la Confédération Suisse pour le 50e anniversaire du CERN célébré l'année suivante.

Reconstruit sur le site actuel en 2004, le Globe a été utilisé pour la première fois le 19 octobre 2004 à l'occasion des célébrations officielles du 50e anniversaire du CERN. Des travaux complémentaires de sécurité, d'isolation thermique et phonique ont complété l'édifice.

Un lieu d'échanges entre science et société

Après la période d'inauguration à la fin 2004, le Globe de la science et de l'innovation a été réellement ouvert au public le 16 septembre 2005, avec une exposition temporaire en hommage au prix Nobel de physique du CERN Georges Charpak. L'exposition "Einstein, 100 ans après", inaugurée à l'occasion de la fête de la science 2005, y a ensuite été installée dans le cadre de l'Année mondiale de la physique. Le Globe fonctionne ainsi actuellement avec des activités temporaires qui associent des expositions, des présentations ou des événements. Tourné vers tous les publics visitant le

Le Globe offre une remarquable surface d'exposition. (Concepteurs T Buc

CERN, le bâtiment devient un élément clé de la stratégie de communication du laboratoire.

Dans la perspective de 2007 et de la mise en service du Grand collisionneur de hadrons (LHC), l'accueil des 25 000 visiteurs annuels doit être repensé. Ils peuvent aujourd'hui accéder aux expériences souterraines du LHC qui leur montre le gigantisme des installations nécessaires pour traquer les particules invisibles. L'exposition Microcosm vient compléter l'information de ceux qui le souhaitent. A partir de 2007, les installations du LHC étant en service, il ne sera plus possible d'organiser ces visites souterraines. L'offre pour les visiteurs doit donc évoluer.

La richesse et la diversité des installations du CERN permettront d'organiser des itinéraires thématiques offrant aux visiteurs la possibilité de choisir en fonction de leurs centres d'intérêt: physique, technologie, machines, histoire.... En surface, des expositions sur site permettront de comprendre la physique en train de se faire en sous-sol et de découvrir les techniques associées. Mais les visiteurs qui souhaiteront en savoir plus, appréhender les enjeux, pénétrer dans le monde des particules devront avoir la possibilité d'explorer

n emblème pour le CERN

ntre le CERN, ses partenaires et le grand public, a ouvert ses portes l'année dernière.

i, Charpente Concept, et H Dessimoz, Group H.)

Pendant la construction (haut) et la nuit.

à leur rythme et plus en détail l'univers du CERN. Le Globe de la science et de l'innovation jouera alors un rôle important dans ce renouvellement de l'offre aux visiteurs.

Un outil au service de tous

Pour répondre à cette demande, le bâtiment nécessite des équipements complémentaires. Les différentes fonctions facilitant l'accueil du public ont été rassemblées dans un projet de structure périphérique sur 180 degrés, appelée bâtiment couronne. Le développement de ce bâtiment complémentaire, la transformation du bâtiment hébergeant l'exposition Microcosm, la redéfinition des visites, l'étude d'une future liaison entre les deux côtés de la route nécessitent d'importants moyens. En 2007, une exposition permanente sera inaugurée au rez-de-chaussée du Globe. La physique des particules y sera mise à la portée de tous. Et les technologies innovantes inventées au CERN y occuperont une place importante pour permettre aux visiteurs de comprendre comment le physique du 21e siècle s'inscrit dans leur vie quotidienne.

Le Globe accueille actuellement des expositions temporaires au niveau supérieur. C'est sur ce même étage très spectaculaire (une coupole de plus de 12 mètres de haut!) que peuvent être organisés des événements en collaboration avec les Etats membres de l'organisation, les collectivités locales, les industriels et le grand public.

Expositions temporaires, conférences, animations, rencontres, débats résonneront dans le Globe comme autant de démarches pour développer des liens entre science, industrie et société. Les enjeux sont multiples: augmenter le goût des jeunes pour les sciences, mieux éduquer les futurs scientifiques, informer et former les enseignants, permettre aux citoyens européens de participer à l'évolution des connaissances, comprendre les enjeux scientifiques de notre époque, favoriser les passerelles entre science et industrie, participer au rapprochement des pays, associer le plaisir de la découverte avec le partage des connaissances.

En mettant en place un tel lieu d'échange, le CERN a évidemment aiguisé l'intérêt de nombreux musées et centres de culture scientifique. Le laboratoire devient dans ce domaine un important partenaire jouant le rôle de centre de ressources à la disposition de tous. ▷

Walter Le Croy intervient au "IEEE milestone event" qui a été en particulier sponsorisé par sa compagnie.

Un partenariat exemplaire

Le 26 septembre 2005, le Globe a hébergé un événement de l'Institut international des ingénieurs en électrotechnique et électronique (IEEE). Cette manifestation "IEEE milestone event" a permis de rendre à la fois hommage au CERN pour ses inventions en matière de détecteurs et à l'un de ses brillants physiciens, le prix Nobel Georges Charpak. Ce type d'événement n'est possible qu'avec un réseau de partenaires en l'occurrence ici l'IEEE, la plus grande association au monde pour l'avancement des technologies. Nos remerciements vont à sont Président W Cleon Anderson et à l'ensemble des contributeurs pour leur aide, en particulier le principal partenaire Walter LeCroy.

Afin de développer autour du Globe un réseau pour soutenir son action, le CERN a souhaité créer des outils de dialogue.

Une lettre électronique destinée à toute personne membre du personnel CERN ou non. Le but de cette lettre baptisée Globe-info est de diffuser les informations relatives aux activités éducatives, culturelles, scientifiques, techniques et industrielles du CERN. Ces informations concernent le public le plus large. La lettre annonce les conférences, les expositions, les ateliers, les événements, les visites, les pièces de théâtre, les journées portes ouvertes, les nouveaux documents, les informations scientifiques, techniques ou industrielles.

Nous avons également proposé de créer "Les Amis de la Science et de l'Innovation", un regroupement destiné aux personnes physiques souhaitant soutenir les buts du CERN au travers des actions grand public mises en place.

Enfin, un Club des partenaires du CERN pour la Science et l'Innovation a été mis en place. Ce club réunit à la fois des fondations, des collectivités, des partenaires industriels et des donateurs acquittant une contribution de membre. Pour être membre du Club, les sociétés doivent impérativement adhérer aux objectifs et valeurs du CERN. Le Club permet aux collectivités et aux industriels d'être partenaires des actions vers tous les publics, tels que expositions, conférences, spectacles. De nouveaux projets d'expositions, de bâtiments ou d'éléments scénographiques spectaculaires pourront être réalisés grâce aux aides fournies dans le cadre de ce Club privilégié. Par exemple, en complément du Globe, le bâtiment couronne pourrait permettre dans quelques années de mieux accueillir les visiteurs qui pour une heure ou une demi-journée auront la possibilité d'explorer, visiter, comprendre, échanger, discuter avec les scientifiques et guides du CERN.

Le Club des Partenaires du CERN pour la Science et l'Innovation a pour principal objectif de favoriser la diffusion, auprès des publics cibles, des informations sur la science, la technologie, les débouchés industriels et les grands sujets de débat et d'actualité. En tant qu'organisation internationale, le CERN est habilité à recevoir des dons. Un document est délivré afin que les contributeurs puissent faire valoir leur don auprès des services fiscaux.

Un programme de démarrage éclectique

Ouvert au public depuis peu, le Globe a déjà accueilli une exposition en hommage à Georges Charpak, une exposition sur "Einstein, 100 après", la création en avant-première de l'opéra scientifique Kosmos, des événements, des conférences, des ateliers, des animations et même deux pièces de théâtre ("Signé Jules Verne" de la compagnie genevoise Mimescope et "Einstein au Pays des neutrinos" du physicien François Vannucci).

En février et mars 2006, le Globe propose l'exposition Einstein prolongée, un atelier de physique pour les tout-petits et une pièce de théâtre loufoque et poétique autour des mathématiques, "Mad Math". Suivront une exposition artistique "Utopies Urbaines" organisé avec la commune de Meyrin et une exposition et des animations autour de l'astrophysique.

Par toutes ces actions, le Globe accompagne les quatre missions fondamentales du CERN:

- Apporter des réponses aux questions sur l'Univers
- Repousser les frontières de la technologie
- Former les scientifiques de demain
- Rapprocher les pays grâce à la science

Dans les années à venir, le CERN va se projeter dans un futur très stimulant en démarrant des machines innovantes, en produisant une nouvelle physique et en appuyant sa communication sur ce bâtiment emblématique: le Globe de la Science et de l'Innovation.

Pour en savoir plus

Voir www.cern.ch.

Summary

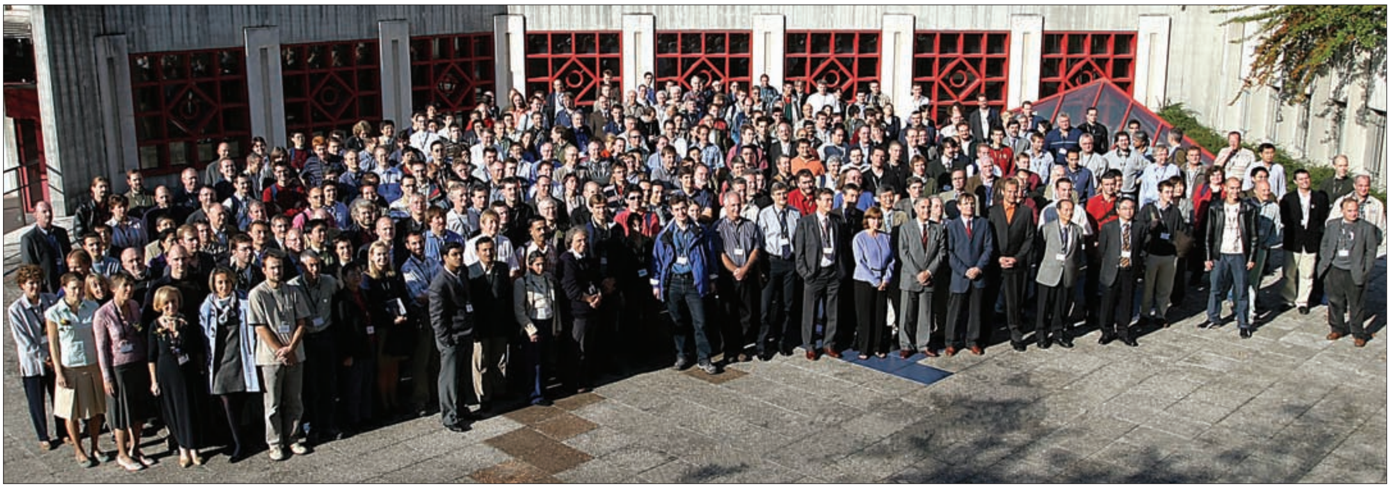
The Globe: an emblem for CERN

The Globe of Science and Innovation is fast becoming a new landmark for CERN. The role of this new spherical wooden building is to share the important work done at CERN not only with those living in the regions of France and Switzerland surrounding Geneva but more generally with the whole of Europe. Only recently opened to the public, the Globe will welcome temporary exhibitions, conferences, events, meetings and debates, all of which will serve to develop links between science, industry and society. A club of the CERN partners for Science and Innovation enables professional bodies and industry to become partners in activities in the Globe for all types of audiences, and will allow projects for new exhibitions and structures to be realized.

Bernard Pellequer, *CERN.*

ICALEPCS 2005: Geneva

In October 2005, control-systems experts from experimental facilities around the world met in Geneva for the EUROPHYSICS conference ICALEPCS 2005. **Axel Daneels** reports.



Participants at the ICALEPCS 2005 meeting pose in the October sunshine for the traditional conference photo.

The International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS) is the prime conference in the field of controls for experimental-physics facilities, namely particle accelerators and detectors, optical and radio telescopes, thermo-nuclear fusion installations, lasers, nuclear reactors, gravitational antennas, and so on. The initiative to create this series of biennial conferences was taken at the end of 1985. An initial group of six laboratories – CERN, the Grand Accelerateur National d'Ions Lourds, the Hahn-Meitner Institut, Kern Forschung Anlage, Los Alamos National Laboratory and the Paul Scherrer Institut – were called upon to create an interdivisional group on Experimental Physics Control Systems within the European Physical Society (EPS) with the purpose, among others, of supporting these conferences. As a next step, CERN offered to organize the first ICALEPCS in 1987, in Villars-sur-Ollon.

The ICALEPCS circulate around the globe with meetings in Europe, America and Asia, co-organized by the EPS-EPCS, under the auspices of the Institute of Electrical and Electronics Engineers through its Nuclear and Plasma Science Society, the Association of Asia Pacific Physics Societies, the American Physical Society, the International Federation of Automatic Control, and the International Federation for Information Processing through its Technical Committee on Computer Applications in Technology.

ICALEPCS 2005, the 10th meeting in the series, fell auspiciously during the World Year of Physics, being held from 10–15 October 2005 at the Geneva International Conference Centre (CICG). It was hosted by CERN together with the Centre de Recherches en Physique des Plasmas (CRPP) of the École Polytechnique Fédérale de Lausanne (EPFL), and chaired jointly by CERN's Bertrand Frammery and Jonathan Lister from CRPP-EPFL. Attendance reached 442, with delegates from 160 laboratories, universities and industries in 27 countries in Europe, America, Asia, and Oceania–Australia.

In the opening session, Axel Daneels of CERN, who is chairman of the International Scientific Advisory Committee and who has steered the ICALEPCS since their inception, introduced ICALEPCS 2005, and invited Carlo Lamprecht, Minister of Economy and Councillor of the State of Geneva to express his welcome and his support to the conference. Co-chair Lister welcomed the participants in his turn and was followed by Jos Engelen, CERN's chief scientific officer, who presented the challenges raised by the CERN's Large Hadron Collider (LHC) project – both the accelerator and the detectors.

Down to business

The first main sessions consisted of status reports on several major new and planned experimental-physics facilities around the world, with an emphasis on controls. Particle accelerators were represented by the LHC, the Japan Proton Accelerator Research Complex and CERN's Low Energy Ion Ring. Synchrotron light sources covered the ELETTRA laboratory in Trieste, the SOLEIL synchrotron at Saint Aubin and the ALBA synchrotron near Barcelona. The fusion community described the controls of the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory, the Angara-5 facility at the Troitsk Institute for Innovation and Fusion Research and the data challenges of the international project ITER. The presentations on telescopes discussed the controls of the Atacama Large Millimetre Array radio telescope in the Andes and the proposed Low Frequency Array in the Netherlands. CERN presented control systems for the CMS and ALICE detectors for the LHC. There were also presentations on the ▷

At the welcome ceremony for ICALEPCS 2005, from left to right: Bertrand Frammery, conference co-chair; Axel Daneels, chairman of the International Scientific Advisory Committee; Carlo Lamprecht, Minister of Economy and councillor of the State of Geneva; the bailiff of the State of Geneva; and Jonathan Lister, conference co-chair.

8 GeV X-ray free-electron laser at the Japanese synchrotron radiation facility, SPring-8, and on VIRGO, the 3 km French–Italian gravitational-wave detection facility.

Special sessions

The session on process tuning, automation and synchronization heard how automation systems are crucial for reliable, coherent, safe and flexible operation of complex facilities such as NIF, VIRGO and the LHC detectors. The operation of tokamaks, such as the Joint European Torus in the UK and the Korea Superconducting Tokomak Advanced Research project, relies on real-time measurements and accurate synchronization systems. Low-level RF control systems were presented for the superconducting RF quadrupoles for the new positive-ion injector, Piave, at the INFN Laboratori Nazionali di Legnaro and for the LINAC-3 cavities at CERN. Synchrotron light sources, such as the Indus-2 storage ring at the Centre for Advanced Technology in Indore and Bessy II in Berlin, rely on orbit control and active feedback loops to position their optical components.

The session on security and other major challenges considered interlock systems combined with alarm-handling systems that monitor facilities operating in harsh environments in terms of radiation, temperature and so on. Security of computing networks for controls is an issue of concern for example at SPring-8 and CERN. The design of control systems for security and dependability was discussed in the context of the Dependable Distributed Systems (DeDiSys) research project supported by the European Union. Dependability covers availability, reliability, maintainability, safety and security.

Experimental-physics facilities are becoming more sophisticated and hence more demanding in matters of controls. However, control systems with many appropriate features are huge projects in themselves, which conflict with the reduction in resources that prevails in the research community. Laboratories are thus being driven into collaboration on the joint development of systems based on commercial hardware and software components – the topic of the session on development approaches. Collaboration frameworks are being developed to assure a streamlined and standard approach when integrating commercial components into a coherent system and to ease debugging, testing, deployment and maintenance. Collaborative projects include the Joint Controls Project for the LHC detector controls; the TANGO project for synchrotron radiation facilities, developed jointly by ALBA, ELETTRA, SOLEIL and the European Synchrotron Radiation Facility (ESRF) in Grenoble; and the ALMA Common Software project for distributed control.

The session on the evolution of hardware technology looked at how control-system architectures are evolving towards a higher granularity, thanks to the availability of small-size boards with an Ethernet port. This approach reduces the cost and improves the overall reliability. More specifically, while standard peripheral component interconnect (PCI) is still being supported for less demanding applications, PCI Express is becoming the only standard for connecting devices with high bandwidth requirements. In the domain of networking, 1 Gbit/s Ethernet is a consolidated standard, but a bandwidth up to 100 Gbit/s can already be found in projects such as ALMA. Networks with a low bandwidth are used as field buses. Programmable logic devices are the building blocks of digital controllers and are replacing complex boards based on digital-signal processors. Their importance is growing as they allow the integration of standard functions with custom application logic.

Middleware frameworks such as NIF's large-scale CORBA framework were one of the topics of the session on the evolution of software technology. These have matured, and attention is shifting from mere deployment towards easier development. Application developers can be now shielded from particular middleware products and testing and integration of components can be facilitated through software simulation. Access to remote distributed resources is increasingly based on Web and Grid technologies. HyperDAQ, an application to provide access to distributed DAQ systems, employs web and peer-to-peer technology. The Virtual Instrument Grid Service, a part of the GRIDCC project, will use Grid computing to control distributed instrumentation.

The session on operational issues considered machine operations, which are tightly coupled to data management, alarm handling and remote collaboration. Operational information is managed through relational databases, as for example the configuration database for the LHCb experiment, while the commercial Geographical Information Systems are being applied to accelerator configuration management. Intelligence is added to alarm-handlers to reduce the incidence of unimportant alarms. Common frameworks, such as CERN's Directory Services, tend to be introduced to integrate diverse systems operationally.

Experimental-physics facilities involve large investments and evolve during their lifetime – the subject of the session on dealing with evolution. Control systems must thus cope with this evolution while protecting the investment, so their architectures must be modular, data-driven and based on commercial products and standards. Examples are the JAPC Code (Java API for Parameter Control) developed to ease the programming of the LHC application software. Evolution often also implies proliferation of computers. Facing this phenomenon and to limit hardware failure and maintenance, SPring-8 has applied virtualization technology by which many computers are accommodated into a reduced number of virtual machines, each with independent resources (CPU, discs etc) as if they were stand-alone. Three virtualization approaches were discussed at the meeting: emulation of hardware or specific guest operating systems; multiplexing of physical resources by software; and application shielding to isolate applications from each other. By contrast, medical accelerators are designed for minimal upgrades and limited improvement during a lifetime, for safety and regulatory reasons.

Additional activities

The scientific programme was complemented by a three-day exhibition involving 17 companies and 10 technical seminars in which companies presented their views on the evolution of their technology as well as their strategy, and which were particularly well attended. In the week preceding ICALEPCS 2005, 150 controls specialists had also attended four workshops: Experimental Physics and Industrial Control System (organized by Matthias Clausen of DESY), ALMA Common Software (organized by Gianluca Chiozzi of ESO), TANGO (organized by Andy Götz of ESRF) and a Joint ECLIPSE Workshop (organized by Clausen and Götz). These workshops were held in France at Archamps, the Haute-Savoie's business park near Geneva, and fully supported by the Conseil Général de la Haute-Savoie. In addition, Markus Völter from Völter-Ingenieurbüro für Softwaretechnologie, Germany, gave a tutorial on Model-driven Development of Distributed Systems at the CICG.

The conference also included a social programme featuring a welcome reception sponsored by Hewlett-Packard; wine-tasting parties, sponsored by the Canton wine producers; an organ and brass concert in the St Pierre Cathedral in Geneva's old town, sponsored by the Republic and Canton of Geneva; a cruise with a banquet on lake Geneva; and at the closing session, an ICALEPCS tenth anniversary cake. Technical visits, attended by more than 120 participants, were organized to two of CERN's LHC experiments (CMS and LHCb), and to the CRPP-EPFL Tokomak.

The registration fee for the 26 participants from industrially emerging nations was waived and 17 of them received an additional grant through one of the following organizations: the EPS, namely the East West Fund and the Young Physicists Fund; the Abdus Salam International Centre for Theoretical Physics; the programme for Scientific Co-operation between Eastern Europe and Switzerland 2005–2008 of the Swiss National Science Foundation and the Swiss Agency for Development and Co-operation; and the International Association for the Promotion of Co-operation with Scientists from the New Independent States of the Former Soviet Union.

At the ends of the special sessions about 80 people took part in a round-table discussion on the in-kind procurement of large systems for collaborative experiments. The future ITER project was taken as an example, although the proposed International Linear Collider will have similar considerations to make. The discussion aroused much interest but generated little conflict. The general agreement was that ITER should be bold and as restrictive as possible on standards and equipment, even though there was no evidence suggesting this has been possible in the past.

The industrial exhibition proved popular at ICALEPCS 2005.

ICALEPCS 2005 closed with an invited talk on the test system for the Airbus 380 and with an invitation to ICALEPCS 2007 in Knoxville, to be jointly hosted by Oak Ridge National Laboratory and Jefferson Lab.

● ICALEPCS 2005 was sponsored by the Swiss Federal Government, through the CICG, the Republic and State of Geneva, the Département de la Haute Savoie in France and its Archamps site, as well as by several industrial companies: Agilent Technologies, Hewlett-Packard and Siemens. DELL, an ICALEPCS 2005 partner, supplied the entire informatics infrastructure. SWISS, the Swiss airline and the ICLEPCS 2005 official carrier, offered a free return flight to an Indian delegate.

Further reading

For more information on ICALEPCS in general see www.icalepcs.org and for ICALEPCS 2005 see http://icalepcs2005.web.cern.ch/Icalepcs2005/.

Résumé

En 2005 ICALEPCS a retrouvé la Suisse

Le CERN et l'EPF de Lausanne ont accueilli la 10e Conférence internationale sur les systèmes de commande des accélérateurs et des grandes expériences de physique, ICALEPCS 2005. Elle a témoigné de l'extension de ces sytèmes dans une multitude de domaines tels que les télescopes optiques et radio, la fusion thermonucléaire, les lasers et les antennes gravitationnelles et présenté les exemples au CERN des expériences CMS et ALICE au LHC. Parmi les sujets traités, on a noté les questions liées à la sécurité des systèmes et des réseaux informatiques, aux environnements rigoureux et à la synchronisation des équipements complexes. Des collaborations croisées se développent pour limiter l'escalade des coûts malgré l'évolution vers une plus fine granularité et l'élargissement des bandes passantes.

Axel Daneels, *CERN.*

AWARDS

Fellowships for US lab directors

Two associate directors of US particle-physics laboratories were among the members of the American Association for the Advancement of Science (AAAS) to receive awards as new fellows at the 2006 AAAS Annual Meeting in St Louis, Missouri, on 18 February. They join other leading figures in US particle physics and related fields that were elected as new fellows by the AAAS Council during 2005.

Swapan Chattopadhyay, associate director for accelerators at the Thomas Jefferson National Accelerator Facility (Jefferson Lab), was awarded the distinction of fellow for his "fundamental contributions to accelerator science, including phase-space cooling, innovative collider designs and pioneering femto-sources, and for mentoring accelerator scientists at facilities worldwide, especially in developing countries". He is responsible for all aspects of Jefferson Lab's accelerator and Free-Electron Laser (FEL) programmes, including R&D and operations, maintenance and upgrades of the Continuous Electron Beam Accelerator Facility and the FEL.

Samuel Aronson, associate laboratory director for high-energy and nuclear physics (HENP) at the Brookhaven National Laboratory, became a fellow for his "leadership in the science and management of experimental particle physics, especially heavy-ion physics at Brookhaven National Laboratory". The HENP directorate encompasses the Collider-Accelerator Department, the Physics Department, the Superconducting Magnet Division, the Instrumentation Division and the Center for Accelerator Physics.

Swapan Chattopadhyay, left, and Samuel Aronson, received AAAS fellowships in February.

Neil V Baggett, advisor for planning and communication in the high-energy physics programme of the Office of Science of the US Department of Energy, was also elected as a fellow. He receives the honour "for significant achievements in fundamental physics research and for important contributions to the research and educational programmes of the US Department of Energy".

In cosmology and astroparticle physics, Michael Turner, astronomy and astrophysics professor at the University of Chicago, was honoured "for his exceptional research in the evolution of the earliest universe, explaining its significance to the public, and for co-founding the interdisciplinary field of particle physics and cosmology".

Lastly, C W Francis Everitt, research professor at the Hansen Experimental Physics Laboratory of Stanford University also became a AAAS fellow. Everitt is principal investigator for Gravity Probe B, the NASA satellite launched in April 2004 that uses four ultra-precise gyroscopes to make precise measurements of the geodetic effect and the frame-dragging effect predicted by the general theory of relativity.

Honorary degree for CERN's Fabio Sauli

The celebrations of the 30th anniversary of the Université de Haute Alsace in Mulhouse in October 2005 culminated in a ceremony to award CERN's Fabio Sauli the title of *Doctor Honoris Causa*. The distinction, presented by Guy Schultz, university president, honours Sauli's lifelong activity in the development of advanced detectors for particle physics.

Under Sauli's direction, CERN's Gas Detectors Development group – which was founded and led for many years by Georges Charpak – has continued to contribute many innovations to the field and to the training of a generation of scientists. Schultz himself was Sauli's doctoral student in the 1970s, and participated in developing high-accuracy drift chambers. The most recent development in the group, the Gas Electron Multiplier, has been adopted by experiments both at CERN and worldwide, owing to its exceptional performance with extreme particle fluxes.

Having reached the CERN age limit, Sauli retires this month, but intends to continue his scientific work in association with INFN-Trieste, contributing to the design of experiments making use of novel technologies, and lecturing on advanced instrumentation at various universities.

CERN's Fabio Sauli, left, receiving the title of Doctor Honoris Causa *from Guy Schultz, president of the Université de Haute Alsace. (Courtesy Université de Haute Alsace.)*

CELEBRATION

La Sapienza honours Bernardini's 75 years…

Carlo Bernardini, one of the physicists who built the first electron–positron storage ring, AdA in 1960, celebrated his 75th birthday at a symposium held in his honour at the University of Rome La Sapienza. A description of the making of AdA and its first operation was reported in *Il Nuovo Cimento* on 19 December 1960 in an article entitled "The Frascati Storage Ring", by Bernardini, Gianfranco Corazza, Giorgio Ghigo and Bruno Touschek. Forty-five years later, Bernardini retired from teaching and his friends and colleagues paid homage to his long and multifaceted career.

The symposium, held on 5 December 2005, contained both a physics and technology session, including talks by Nicola Cabibbo, Emilio Picasso and Ugo Amaldi, as well as a science and society session. Cabibbo described the long list of physics results to have come out of electron–positron storage rings, from the early days of the first paper by Cabibbo and Raul Gatto on physics at electron–positron accelerators, published in *Physical Review Letters* in March 1960, to the latest Belle and BaBar results, mentioning also the Large Electron–Positron collider (LEP) achievements in precision physics. Picasso recalled the early days of LEP construction, including the search for the site and the final decision. Amaldi focused on the importance of accelerators in medicine, noting the existence of nearly 9000 such accelerators in the world.

Carlo Bernardini, who celebrated his 75th birthday at a symposium held in his honour.

Another testimonial was given by Giuseppe Di Giugno, who recalled the historic night when electrons were first accumulated in AdA.

The afternoon session on science and society was chaired by Tullio de Mauro, former Minister of Education and well known linguistic scholar, who illustrated Bernardini's activity as Senator of the Italian parliament and his tenure as dean of science at La Sapienza University. The session also emphasized Bernardini's participation in the peace movement, Unione Scienziati Italiani per il Disarmo, and his contribution to public awareness of science as director of the science magazine, *Sapere*. Luciano Maiani, former director-general of CERN, chaired the final session, in which further testimonials were given by Bernardini's students and colleagues, among them Michelangelo de Maria, who noticed the extraordinary capacity of Bernardini to communicate with friends and antagonists alike. The symposium was closed by Giorgio Salvini, former president of the Instituto Nazionale di Fisica Nucleare and director of Frascati when AdA was built.

…and Princeton celebrates Polyakov's 60th

A special symposium was held at Princeton University on 5–6 November 2005 to honour Alexander Polyakov, a leading figure in theoretical high-energy physics. Polyakov received his Masters degree from Moscow Institute of Physics and Technology and his PhD from the Landau Institute of Theoretical Physics in Chernogolovka, where he stayed until 1989, before moving to Princeton University in 1990.

The first of Polyakov's papers, "Spontaneous symmetry breaking of strong interaction and absence of massless particles", was written with Alexander Migdal in early 1964, before Peter Higgs' famous papers were published. The two theorists, both 19 at the time, had essentially discovered what later became known as the Higgs mechanism. Owing to several unfortunate circumstances, this Migdal–Polyakov paper was published in the *Journal of Experimental and Theoretical Physics* only in 1966, two years after it had been completed.

Polyakov has since been instrumental in numerous developments with a profound impact on high-energy physics: the Migdal–Polyakov conformal bootstrap, 't Hooft–Polyakov monopoles, Belavin–Polyakov–Schwarz–Tyupkin instantons, Polyakov's Liouville theory and Polyakov strings. His 1984 paper "Infinite conformal symmetry in two-dimensional quantum field theory", with Alexander Belavin and Alexander Zamolodchikov, has classic status; it became a Bible for string theorists. He was awarded the Dirac Medal in 1986, and the Lorentz Medal in 1994 for his work in quantum field theory, especially the theory of critical phenomena.

From left to right: Alexander Polyakov, Mikhail Shifman and Paul Wiegmann at the symposium held in Polyakov's honour.

In the past decade Polyakov's results (along with those of Juan Maldacena and Edward Witten) played a crucial role in the emergence of the so-called holographic descriptions of quantum chromodynamics. Within this approach the theory of quarks and gluons is presented as a limiting 4D theory at the boundary of the 5D bulk, which is governed by a certain gravity model (AdS/CFT correspondence and its modifications). This line of research is currently experiencing an explosive development.

Polyakov's other interests include theory of turbulence and string cosmology. He has been a key contributor to Burgers turbulence, which is now a central interest for much of the hydrodynamics community.

OUTREACH

Record webcast unites physicists worldwide

Gareth Mitchell presents the webcast link from Imperial College London.

On 2 December 2005, towards the end of the World Year of Physics, CERN organized an international marathon webcast, Beyond Einstein, which for 12 hours brought together physics communities from the four corners of the globe. The event, the first of its kind organized on this scale, attracted 30 000 spectators on the web and in participating studios. Pakistani national television broadcast all 12 hours of programming, an Italian channel also provided coverage, and many more people tuned in on satellite television.

The event was broadcast live on the Internet from CERN's Globe of Science and Innovation, and similar locations around the world were connected via Tandberg videoconference – the Telecom Future Centre in Venice, Imperial College London, Fermilab, the Exploratorium in San Francisco with scientists from SLAC, the Bloomfield Science Museum in Jerusalem) and the National Science Education Centre in Taipei). From these seven main platforms, viewers were taken on a world tour to other physics laboratories and science museums, visiting virtually every time zone. In a particular highlight, and one of the most technically difficult sections of the show, CERN and Imperial College linked up with the South Pole to discuss the IceCube experiment, neutrino physics and the search for dark matter.

● See http://beyond-einstein.web.cern.ch/beyond-einstein/.

New particle-physics website for the UK is open to everyone

2006 sees the arrival of a new UK website that is dedicated to particle physics – Particle Physics UK. This new site is an update of the previous ppUK site and aims to provide a portal to all the best particle-physics information on the web.

The new Partical Physics UK website is aimed at anyone with an interest in the field.

As the international entry point to particle physics in the UK from Interactions.org and other sites for global experiments, the new site will include links to all the UK particle-physics groups, as well as academic databases, seminar dates, pages for the general public, resources for teachers and news updates from around the UK. In the future, the site will also provide a strong platform for promoting the Large Hadron Collider in the UK.

The Particle Physics and Astronomy Research Council is funding the new website, which is hosted at the CCLRC Rutherford Appleton Laboratory.

● www.particlephysics.ac.uk.

Science on Stage '05 illuminates physics

The opening ceremony included a dazzling juggling show with dramatic light effects, augmented by a teachers' sheet explaining some of the scientific concepts of juggling.

The 2005 Science on Stage festival was held at CERN on 21–25 November, when 500 or so participants from 27 countries – mainly science teachers but also some university lecturers, science-outreach specialists and students – had the opportunity to share their experience of teaching science. They attended presentations and shows, took part in workshops and visited a fair with stands offering ideas on how to make school science lessons more appealing.

The festival, organized by the EIROforum partnership between major European science institutions including CERN, marked the end of two years of projects promoting science in most of Europe; the most exceptional projects from each country were presented at the festival. To allow teachers to benefit from the ideas presented, all the demonstrations will be available on the Science on Stage website at www.scienceonstage.net.

MEETINGS

The 6th Rencontres de Vietnam will be held in Hanoi on 6–12 August. This international conference will focus on Challenges in Particle Astrophysics, and topics include ultra-high-energy cosmic rays, dark matter, dark energy, neutrinos and gravitational waves. An important motivation is to provide a means of contact between the Vietnamese and the Western scientific communities. More detailed information on the conference can be found at http://vietnam.in2p3.fr/2006/.

WORKSHOP

Vertex 2005 is a cascade of information

The annual Vertex meeting is traditionally held near water and this year's meeting was no exception. The 14th International Workshop on Vertex Detectors, Vertex 2005, was held on 7–11 November at Nikko, Japan, at a site surrounded by lakes, waterfalls, mountains and historical monuments, all of which were made more spectacular by splendid autumn colours.

Forty-eight invited participants came to Nikko to discuss topics related to vertexing and tracking. Major ongoing experiments such as BaBar, Belle, D0, ZEUS, CDF, PHENIX, ATLAS, ALICE, CMS and LHCb reported on their vertex detectors and upgrade plans. Many talks reported developments from ongoing R&D projects across the world aimed at future large-scale high-energy physics projects, especially the Super LHC (SLHC) and the International Linear Collider (ILC). Other highlights included talks on the use of silicon detectors at a neutrino factory, and on the application of high-energy physics vertex-detector technology in medicine (the DEAR-MAMA project), X-ray crystallography (PILATUS), in space (GLAST) and as diagnostic instrumentation for current and future tokamak fusion experiments.

Radiation hardness is already one of the important keywords for current detectors. Future upgrades in luminosity, such as at the KEKB B-factory and at SLHC, pose major challenges to designers of vertex detectors, and it was pointed out that for the ILC "better" detectors are needed, rather than "bigger." For front-end electronics the "big four" goals remain lower power, low mass, ever-higher radiation tolerance, and higher speed/performance. These goals must be met at the same time as practical challenges such as process obsolescence, cost and complexity of new processes are addressed.

Vertex 2005 participants gathered in Nikko.

In addition to the intensive sessions and discussions in the corridors, the participants enjoyed a tour of the world-famous shrines and temples of Nikko, a banquet of Japanese dishes, and refreshing hot-springs.

● Proceedings are available online at http://www-conf.kek.jp/vertex2005/.

OBITUARIES

Carlo de Marzo 1941–2005

Carlo de Marzo died on 24 September 2005 after a short fight with cancer. He was Professor of Experimental Physics in Bari, where he taught courses in general physics and in nuclear and subnuclear physics. During his long scientific and academic career he held important positions and was a member of several scientific and administrative committees. He was director of the Istituto Nazionale di Fisica Nucleare, Bari section, from 1982 to 1988 and of the physics department at the University of Bari from 1987 to 1993.

Carlo was born in Torino, Italy, on 26 May 1941. He graduated in 1967 in physics at the University of Bari, under the supervision of G Giannelli. He then joined the group coordinated by L Guerriero. Carlo did experimental research at Brookhaven National Laboratory and Argonne in the US on pion–nucleon scattering experiments, making important contributions to detector development, as well as to the implementation of innovative data-analysis techniques. He then participated in hadron–nucleon scattering experiments at Fermilab and in deep-inelastic hadron–proton scattering experiments at CERN. Since 1986 his research activity focused on astroparticle physics. He promoted

international experiments, in which many young researchers from Bari participated under his leadership. These included the MACRO experiment at the Gran Sasso Laboratories.

One of Carlo's interests was the search for antimatter in space. He became actively involved in the Wizard experiment, carried out by a large international collaboration, including NASA. The experiment used complex detectors mounted on balloons flown at a height of 40 km. The research was later pursued through the construction of the PAMELA detector, to be flown soon on a Russian satellite at heights of 300–600 km. Recently Carlo became interested in neutrino astrophysics and in underwater neutrino telescopes. He was the Italian representative in the ANTARES experiment and was promoting the NEMO Project for a second-generation neutrino telescope, both in the Mediterranean Sea.

The results of Carlo's activities have been published in more than 240 papers in international journals and in conference proceedings. He wrote teaching notes and textbooks, among which *Maxwell e la fisica classica* (*Maxwell and classical physics*) was published by Laterza, Bari in 1978.

Carlo attached great importance to the popularization of science. He wrote articles and gave several talks on astroparticle physics and the history of science. He was very active in the cultural life of Castellana Grotte, his home town, and in particular in the Circolo Culturale Pivot and in the Gruppo Puglia Grotte (a speleological society). During his prolific scientific and academic activity, Carlo was a guide for many young students in physics, several of whom now work in research institutions and in university education.

The MACRO, PAMELA, ANTARES and NEMO collaborations.

Eugene L Feinberg 1912–2005

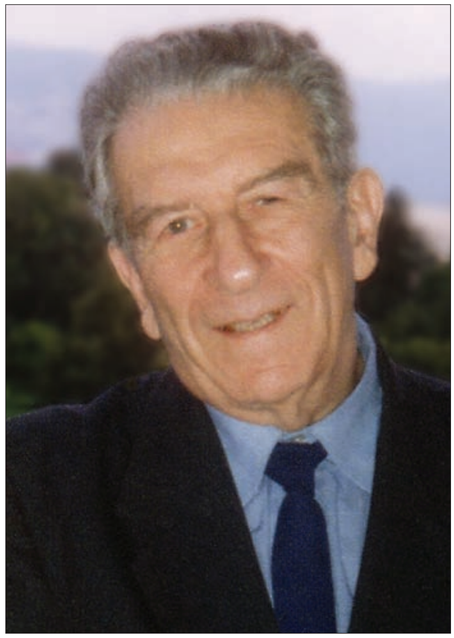
Eugene Feinberg, the doyen of the Theory Department of the P N Lebedev Physics Institute and one of the patriarchs of Russian science, has passed away. His name is associated with an unquenchable and lively interest in a wide range of physics problems. He possessed a harmonious combination of logic and intuition characteristic of the highest level of intelligence.

Feinberg, born in Baku, moved with his family to Moscow in 1918. He graduated from Moscow University and three years later started work in the Theory Department of the Lebedev Physical Institute. In his PhD thesis in 1939 he formulated the theory of ionization of atoms in nuclear beta decay. The guiding idea was that the atom is ionized as a result of a "shake-up" of atomic electrons when the charge of the nucleus changes, and the work led to a series of theoretical and experimental studies. This interest in nuclear and high-energy physics remained throughout Feinberg's life, but it did not set boundaries on his scientific activities.

During the Second World War Feinberg actively worked on radiophysics problems directly tied to his country's military potential. He worked out novel approaches in the theory of radiowave propagation along the surface of the globe, which were drastically different from the Sommerfeld–Weyl approach. As a result he solved difficult and important problems. (His results were summarized in the 1961 monograph *Propagation of Radio Waves along the Earth's Surface*, which was reprinted in 1999). In 1943 he created a new method for the objective recognition of an acoustic signal in the presence of high-level disturbances, which was verified in practice, and then together with S G Gershman, he designed a system that was later widely used by the navy.

Feinberg later worked on the theory of the uranium–graphite reactor and neutron deceleration (1944–1949) and discovered the monochromatization of neutrons as they slow down. This led to the suggestion, with L E Lazareva and F L Shapiro of a method of neutron spectrometry based on the deceleration time.

Notable among Feinberg's earlier results in nuclear and particle physics are his prediction of coherent inelastic processes in the



Feinberg in 1998. (Courtesy A Martin.)

meson–nucleus interaction (1941) and of diffraction dissociation of hadrons together with Isaak Pomeranchuk (1953). In similar work Feinberg formulated for the first time, and solved in principle, the problem of the existence and observability of the electron in a non-equilibrium state, when the electron has partly lost its electromagnetic field. He expanded his conclusions to non-equilibrium hadrons whose properties can be studied via their subsequent interactions with nucleons inside a nucleus. The solution of this problem is closely connected with the understanding of the important role of interference phenomena and of the process formation time when a particle travels through matter.

Feinberg paid special attention to the mechanism of inelastic processes in high-energy interactions of hadrons. In 1951–1953 he was already emphasizing the importance of peripheral processes in hadronic interactions. The one-meson exchange model later developed by his pupils formed the foundation of the multiperipheral scheme of inelastic processes. He later predicted the direct generation of leptons and photons in a hot hadronic medium (1959–1961) and quark–gluon plasma (1976), as well as the generation of hadrons with high transverse momenta (1967). Hundreds of physicists are now studying these effects. He also calculated production cross-sections for deuterium, tritium and helium antinuclei, which were later confirmed experimentally, and contributed to the ideas and papers of the last 10 years on clarifying the role of constituent quarks in extreme states of nuclear matter.

Feinberg also made considerable contributions to cosmic-ray physics and had close ties with experiment. During his last years he actively worked with experimentalists on automatic pattern recognition in emulsions.

In 1966 he became correspondent of the USSR Academy of Sciences and in 1997 full member of the Russian Academy of Sciences. He received numerous prestigious prizes.

In addition to science, Feinberg's interests included fiction, music and art. Indeed, his late wife, daughter of an old Bolshevik executed by Stalin upon his return from exile, was a distinguished musicologist. He discussed the problems of interrelationships of science and art in his book *Cybernetics, Logic, Art* (1981) later translated as *Art in the Science Dominated World* (1987) and in *Two Cultures* (translated as *Zwei Kulturen*, 1988). His essays on great scientists of the 20th century were collected in *The Epoch and the Personality* (1999). Feinberg was also a brilliant lecturer and teacher, presenting subjects with ultimate clarity; he taught in Gorkii and in Moscow.

The purity of his moral principles, was the most salient feature of Feinberg's personality. This dictated his active position as a citizen, his engagement in propagating the truly scientific view of the world and in revealing pseudoscience for what it is. His deep involvement in the fate of his fellow citizens was shown most vividly in his support of Andrei Sakharov during Sakharov's exile to Gorkii and in his defence of the memory of Sergei Vavilov against unjustified accusations. Feinberg's enormous charm attracted numerous people towards him. For this reason, he had many friends in Russia and in the world, in particular at CERN. They will always remember him.

Igor Dremin, Lebedev Institute, and André Martin, CERN.

Richard Dalitz 1925–2006

The Dalitz plot, Dalitz pairs and Castillejo–Dalitz–Dyson poles have made the name of Dick Dalitz, who died on 13 January, a byword in high-energy physics for half a century. With his death, international physics has lost a major figure and Britain has lost one of its greatest unsung scientists.

Born in Dimboola, Australia, Dalitz gained degrees in mathematics and physics at Melbourne University, moving to the UK in 1946 to study for a PhD at Cambridge. He then worked at Bristol University for a year, before joining Rudolf Peierls in Birmingham in 1949. In 1953 he was given leave to visit the US for two years, working primarily at Cornell. He then joined the faculty at Chicago and its Enrico Fermi Institute for Nuclear Studies in 1956. He returned to the UK to work again with Peirels in 1963, this time as Royal Society Research Professor at Oxford University, a post he held until his retirement in 1990.

Dalitz's thesis was in nuclear physics and dealt with 0^+ to 0^+ transitions in oxygen; forbidden as transitions involving real photons, due to angular momentum conservation, they occur by means of e^+e^- emission. This experience led him to his first seminal contribution with his work at Birmingham in 1951 on Dalitz pairs, a phenomenon that has been used for example to measure the parity of the π^0.

Among the particles found in cosmic rays at this time were two known as the τ and the θ, which had the same mass and lifetime; however, the τ decayed into three pions, the θ into two. In 1953 Dalitz began to look at the decays of the τ into three pions and in doing so introduced into physics what he modestly called a "phase-space plot", but which everyone now knows as the Dalitz plot. This revealed that the τ particle had even spin and odd parity, eg $J^P = 0^-$, while the decay $\theta \rightarrow 2\pi$ and conservation of parity implied $J^P = 0^+, 1^-, 2^+ \ldots$ for the θ. Thus was born the τ–θ puzzle: how could two mesons have the same masses and lifetimes and yet have different quantum numbers?

The puzzle persisted for two years, during which Dalitz mused to colleagues that perhaps the law of parity was not true, even though all the evidence said otherwise. However it was T D Lee and C N Yang who realized that the law of parity had been tested only for the strong and electromagnetic interactions. For the weak interaction at work in the θ/τ decays, it was an open question, and it was Lee and Yang who earned the Nobel prize when experiment proved their hypothesis correct that the weak interaction violates parity. The τ and θ are indeed the same particle, known today as the charged kaon.

Richard Dalitz, who died in January, aged 80.

By the end of the 1950s Dalitz plots were being made of data coming from bubble chambers at the new high-energy particle accelerators. Soon the first examples of what would eventually turn into scores of short-lived resonances were found.

It was around the time that Dalitz moved to Oxford, in 1963, that a path through the maze of particles opened up. Murray Gell-Mann gave the name "Eightfold Way" to the emerging idea that the particles could be collected into families based on a more fundamental trio of "quarks". What was less clear was whether these quarks were just a mathematical convenience or were themselves real particles.

For Dalitz, quarks were real. In his model, the laws that determine the rotational states that electrons can take up within atoms were applied to the quarks within the proton and the resonances. In a remarkable talk in Tokyo in 1965 he proposed that the quarks could be raised into different energy states, following the established rules of non-relativistic quantum mechanics. This implied the existence of many baryon resonance states with spins and parities in agreement with the emerging data.

Over the following decades many other examples of meson and baryon resonances were discovered, notably by application of Dalitz plots, and the quark model became established as the explanation of the menagerie of particles.

Dalitz was also interested in hypernuclei – atomic nuclei in which a nucleon had been replaced by a strange baryon. He collaborated with Avraham Gal in this area for many years. He was also intimately involved with the identification of the top quark. With Gary Goldstein he worked out a geometrical method by which experimental data could be used to deduce the top mass, which they applied to an early possible event from Fermilab. The conclusion was that if this event indeed signalled top production, the top quark mass must exceed 130 GeV.

Dalitz brought many scholars to Oxford and trained generations of students, including Chris Llewellyn Smith, a future director-general of CERN. Following retirement he remained an inspirational figure to students new and old, continuing to work on theoretical physics with undiminished enthusiasm.

Among activities outside of physics, Dalitz researched the origins of the Dalitz name, and wrote on the history of the Wendish people, who survive to this day in a few villages between Cottbus and Berlin. His curiosity led him to cast new light on aspects of Wendish history, including a biography of the poet Mato Kosyk.

Frank Close, Oxford.

RECRUITMENT

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UNIVERSITY OF TORONTO

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Eidgenössische Technische Hochschule Zürich
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The Institute for Theoretical Physics of ETH Zurich invites applications for a permanent position as a

Senior Scientist

in Theoretical Elementary Particle Physics, with particular emphasis on physics at present and future high energy colliders.

Tasks

The successful applicant is expected to carry out a high profile independent research program, and to maintain and strengthen the existing cooperation with the experimental ETH Institute for Particle Physics (H1 and CMS experiments).

Participation in the joint ETH/Zurich University graduate student training program in elementary particle physics is welcome.

Requirements

Applicants must hold a doctorate in theoretical physics. Several years of postdoctoral research experience which have established the applicant as an independent research leader are expected.

Position

The position is permanent and full-time.

Applications should be addressed to:

Prof. Jürg Fröhlich,
Departementsvorsteher,
D-PHYS,
ETH-Hönggerberg,
CH-8093 Zürich

Application deadline is **March 31, 2006**.

Enquiries concerning the position may be made to
Prof. Daniel Wyler
(wyler@physik.unizh.ch)

Postdoctoral Position at Syracuse University

The Syracuse University High Energy Physics group seeks to fill a Postdoctoral position involving activities within the VELO group in LHCb and the RD50 collaboration, both related to the installation and commissioning of the VELO detector and R&D towards novel Si precision tracking devices for future LHC upgrades. The work will be done mostly at Syracuse with possible stays at CERN. The Syracuse group is also involved in the CLEO-c experiment, thus physics analysis opportunities are available. The Syracuse group includes four faculty, two research faculty, two PostDocs and six graduate students.

Interested candidates should send their CV and arrange for three letters of recommendation to
Prof. Sheldon Stone
(stone@physics.syr.edu),
Syracuse University,
Physics Dept.,
201 Physics Bldg.,
Syracuse,
NY 13244-1130.

Syracuse University is an Affirmative Action/Equal Opportunity Employer

SLAC — Experimental Research Associates

STANFORD LINEAR ACCELERATOR CENTER

The Stanford Linear Accelerator Center (SLAC) is one of the world's leading laboratories supporting research in high energy physics. The laboratory's program includes the physics of high energy electron-positron collisions, high luminosity storage rings, high energy linear colliders and particle astrophysics.

Post doctoral research associate positions are currently available. Areas of research opportunity may include:

- B physics with the BaBar detector at PEP II.
- The particle astrophysics program focused on the gamma ray telescope GLAST and the dark energy experiment LSST.
- R&D toward a future linear collider detector.
- Neutrino-less double beta decay experiment EXO.
- SLAC participation in ATLAS.

These positions are highly competitive and require a background of research in high energy physics and a recent PhD or equivalent. The term for these positions is two years and may be renewed.

Applicants should send a letter stating their physics research interests along with a CV and three references to **Jean Lee, jeanlee@SLAC.Stanford.EDU, Particle and Particle Astrophysics, SLAC M/S 75, 2575 Sand Hill Road, Menlo Park, CA 94025 USA.**

Deutsches Elektronen-Synchrotron
Particle and Accelerator Physics

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.

For the experiments H1, ZEUS and HERMES at the ep collider HERA and for the preparations of the International Linear Collider ILC (accelerator and experiments) several

DESY Fellowships

at Hamburg and Zeuthen are announced. Young scientists who have completed their Ph.D. and are younger than 33 years are invited to submit their application including a resume and the usual documents (curriculum vitae, list of publications and copies of university degree). They should arrange for three letters of recommendation to be sent to the personnel department of DESY. The DESY Fellowships are awarded for a duration of 2 years with the possibility for prolongation by one additional year.

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. DESY has a Kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association
code: 21/2006 • Notkestraße 85 • D-22603 Hamburg • Germany
Phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applications: March 31, 2006

NSCL

Faculty Position in Accelerator Physics

The National Superconducting Cyclotron Laboratory at Michigan State University is seeking outstanding candidates to fill a faculty position in accelerator physics. The successful candidate should provide a significant increase in the scope and depth of the MSU accelerator physics program, play a leadership role in developing future facility upgrade options, and contribute to the accelerator physics graduate education program at MSU.

The NSCL is the premier rare isotope facility in the U.S. The Laboratory has the tradition of close interaction between groups providng an ideal mix of cutting-edge technical infrastructure and an intellectually stimulating open academic environment.

The accelerator physics group is comprised of 2 faculty and 9 professional scientific staff. Accelerator physics R&D has strong infrastructure support from experienced design and manufacturing groups. A strong program of R&D in superconducting rf technology has been developed with necessary facilities in place. Theoretical and experimental research on space charge dominated beams is being pursued. A strong program on linac and cyclotron design for basic research and medical applications have been a core activity in the laboratory for many years.

Depending upon the qualifications of the successful applicant, the position can be filled at the assistant, associate, or full professor level. Applicants please send a resume, including a list of publications, and the names and addresses of at least three references directly to
Professor Richard York, Associate Director for Accelerators, National Superconducting Cyclotron Laboratory, Michigan State University, 1 Cyclotron, East Lansing, MI 48824-1321. For more information, see our website at **http://www.nscl.msu.edu**.

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

GSI Darmstadt one of the leading laboratories in heavy ion and hadron physics, member of the Helmholtz Association invites applications for a

Senior staff member in experimental heavy ion physics

Ref. No.: 1100-06.11

We are seeking an outstanding individual with expertise and demonstrated track record in the area of relativistic heavy ion physics. The successful candidate will develop and lead a physics program with the ALICE detector which is currently being built with strong GSI participation at the CERN LHC. He/she will also coordinate the ALICE tier 2 analysis center which will be setup at GSI. Significant experience with large scale computing is a prerequisite for this position.

GSI is an equal opportunity, affirmative action employer and encourages applications of women. Disabled applicants will be given preference over other applicants with comparable qualifications.

Applications including curriculum vitae, list of publications and statement of research and teaching experience should be sent not later then **March 31, 2006** to

GSI Darmstadt

Gesellschaft für Schwerionenforschung mbH
Personalabteilung
Ref. No.: 1100-06.11
Planckstraße 1
64291 Darmstadt/GERMANY

EGO European Gravitational Observatory

2 Year Postdoc Fellowships at the European Gravitational Observatory (EGO)

Virgo is a gravitational wave detector aiming at the detection of gravitational waves generated by galactic and extra-galactic astrophysical sources. It is based on a laser interferometer with arms 3 km long & located at EGO near Pisa in Italy.

Suspension Control (Ref. FL-CM-01)

- Participate to the commissioning of the interferometer within the general goal of reaching the interferometer design sensitivity and operate the interferometer for long scientific runs (preparation of data taking periods & detailed analysis of the suspension control system performances during these periods).
- Develop & implement the mirror suspensions control.
- Study & reduce the noise related to these controls.
- Develop automatic procedures to allow the operator team to operate, monitor and diagnostic the suspensions control system.
- Required background in control systems, electronics, mechanics and interferometry. A PhD thesis in the field of interferometers gravitational wave detection with laser & in particular on subjects such as mirror suspension systems, suspended cavities control and interferometer noise hunting would be a title of merit. Fluent English required.

Environmental Monitoring (Ref. FL-CM-02)

- Fellowship dedicated to the commissioning & development of the environmental noise monitoring system.
- Participate to the commissioning of the interferometer within the general goal of reaching the interferometer design sensitivity & operate the interferometer for long scientific runs study & reduce the effect of such noise on the Virgo interferometer.
- Maintain, characterize & improve the existing set-up for the environmental noise monitoring.
- Study the coupling of the environmental disturbances into the interfer-ometer output signals & propose strategy to reduce this coupling.
- Develop automatic procedures required to allow the non-expert people, to operate, monitor and diagnostic the environmental monitoring system.
- Required background in sensing devices, electronics, signal processing and interferometry. A PhD thesis in the field of gravitational wave detection with laser interferometers & in particular on subjects such as sensing devices, environmental noise monitoring and interferometer noise hunting would be a title of merit. English required.

To apply send CV using the EGO Application Form, to be found at **http://www.ego-gw.it/public/organization/jobs/Employment_App_Form.doc** to **jobs@ego-gw.it** asap quoting the vacancy ref.

UNIVERSITY of GLASGOW

DEPARTMENT OF PHYSICS AND ASTRONOMY

Research Assistant

£20,044 – £30,002

A 34 month position is available to develop "3D" silicon detectors for use in the Diamond Light Source Synchrotron. You will have (or expect soon to receive) a PhD, or have an equivalent level of experience, in experimental particle physics or semiconductor detector development for a related discipline. You will be expected to design, develop and test innovative radiation detection structures and systems. In addition a modest involvement in Departmental Teaching is expected. The post is based in Glasgow but will involve periods of work at the Diamond Light Source, and elsewhere.

For further information on the post and method of application please see http://ppewww.ph.gla.ac.uk/3DRA.html Informal enquiries can be made to Dr Chris Parkes, email: c.parkes@physics.gla.ac.uk quoting Ref 11959/DPL/A3. Closing date: 28 February 2006.

The University is committed to equality of opportunity in employment.

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UNIVERSITY of GLASGOW

Postdoctoral Position in Experimental Low-Energy Particle Physics at Indiana University

The Nuclear Physics group at Indiana University is seeking a strongly motivated experimentalist for a postdoctoral position, available immediately. The successful applicant will be expected to be actively involved in low-energy, "table top" particle physics experiments: a new search for the electric dipole moment of the electron using a paramagnetic solid sample; and development of a solid-oxygen based source of ultracold (neV) neutrons for fundamental physics measurements. Responsibilities will involve several aspects of each project, ranging from design and construction tasks to data acquisition and analysis, making use of techniques from cryogenics, condensed matter and neutron physics, and high-voltage and low-noise electronics. Experience in one or more of these techniques is preferred but not essential.

Initial appointment will be for one year, with possible renewal for up to two additional years. A Ph.D. in experimental physics is required. Applications will be accepted on a continuing basis until the position is filled. Applicants should submit a CV and a statement of research interests, and arrange to have three letters of recommendation sent to:

Prof. C-Y Liu
Indiana University Cyclotron Facility
2401 Milo B. Sampson Lane, Bloomington, IN 47408
tel: 812-855-2896, fax: 812-855-6645 or electronically (preferred) to CL21@indiana.edu.

Indiana University is an Equal Opportunity/Affirmative Action Employer, with a strong commitment to excellence through diversity.

Post-doctoral/Software Specialist Positions in Experimental High Energy Physics
University of Texas at Arlington

The High Energy Physics group at the University of Texas at Arlington (UTA) is looking for candidates for post-doctoral associate positions and / or software specialist positions to work on the ATLAS Experiment at CERN, Geneva, Switzerland. The UTA group contributes to many areas in ATLAS: Calorimetry, as a Tier 2 computing center, distributed computing for data analysis and Monte Carlo production, as well as data taking and physics analyses.

The successful candidates will specifically be expected to play a leading role in the development of a distributed data analysis and production system, participate in distributed computing operations, and act as consultants for physicists using the developed systems, providing documentations and tutorials. The successful candidates are expected to interact with the existing group members. Applicants should have excellent knowledge of programming languages as well as a recent Ph.D in experimental high energy physics or computer science with strong interests in basic research. Expertise in python is desirable.

Applications should include a curriculum vitae, publication list, and statement of research interests. Candidates should have at least three letters of references sent directly to **jaehoonyu@uta.edu** or

Dr. Jae Yu, Dept. of Physics, SH108, University of Texas, Arlington, TX 76019, USA

These positions are available immediately. Please email all materials to **jaehoonyu@uta.edu.**

Please contact **Dr. Kaushik De (kaushik@uta.edu,817-272-2813)** or **Dr. Jae Yu (jaehoonyu@uta.edu, 817-272-2814)** for more information.

UTA is an Equal Opportunity and Affirmative Action Employer.

GSI Darmstadt one of the leading laboratories in heavy ion and hadron physics, member of the Helmholtz Association invites applications for a

Staff member in experimental heavy ion physics (tenure track)

Ref. No.: 1100-06.10

We are seeking an outstanding individual with demonstrated expertise in the area of relativistic heavy ion physics and experience with large detector systems. He/she is expected to participate in the research program on hadronic matter at high baryon density currently pursued with the FOPI detector at GSI. The successful candidate will play an important role in the upgrade and future physics program of the FOPI detector as well as in the design and construction of future experiments in this field at FAIR. The position is limited to a term of 5 years.

GSI is an equal opportunity, affirmative action employer and encourages applications of women. Disabled applicants will be given preference over other applicants with comparable qualifications.

Applications including curriculum vitae, list of publications and statement of research and teaching experience should be sent not later then **March 31, 2006** to

GSI Darmstadt

Gesellschaft für Schwerionenforschung mbH
Personalabteilung
Ref. No.: 1100-06.10
Planckstraße 1
64291 Darmstadt/GERMANY

DIRECTOR OF RHIC/US ATLAS COMPUTING FACILITY

The Physics Department at Brookhaven National Laboratory invites applications for the position of Director, RHIC/US ATLAS Computing Facility.

The RHIC Computing Facility and the US ATLAS Tier 1 Center are co-located and co-operated in the Physics Department at Brookhaven National Laboratory. This joint facility is responsible for supplying computing support to the RHIC experiments at BNL and to US participation in the ATLAS experiment at the CERN LHC. The facility is committed to using Grid computing technology to making its resources available and is one of the lead institutional participants in the Open Science Grid.

Responsibilities of this position include establishing organizational structures, approving the hiring of all staff, translating institutional, agency and user requirements into specific technical and managerial goals, overseeing planning processes directed toward accomplishing those goals, and representing the facility and its interests in a wide range of venues.

Brookhaven seeks a leader in the field of scientific computing. Qualified candidates must have an in depth grasp of modern high performance computing technology and the experimental nuclear and particle physics mission to which it is being applied. They must have demonstrated organizational, managerial, and leadership skills in the context of a major scientific/technical project. A Ph.D. is required, along with significant relevant experience.

The starting date for the position is flexible. Please send a CV and three letters of recommendation, before May 1, 2006, electronically to: dawson@bnl.gov or mailed to: S. Dawson, Chair, Physics Department, Bldg. 510 Brookhaven National Laboratory, Upton, NY 11973-5000. Documents need to be received by May 1, 2006. BNL is an equal opportunity employer and encourages all qualified candidates to apply.

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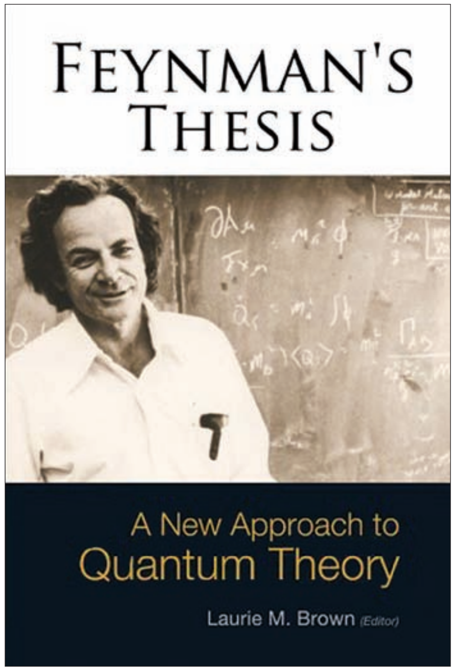

Feynman's Thesis: A New Approach to Quantum Theory by Laurie M Brown (ed.), World Scientific. Hardback ISBN 9812563660, £17 ($28). Paperback ISBN 9812563806, £9 ($14).

The title pretty much sums up this interesting short book, the latest Feynman work to be published since his death in 1988. It reproduces, in modern typeset, Feynman's PhD thesis entitled "The Principle of Least Action in Quantum Mechanics". In it Feynman outlined his brilliant reformulation of quantum mechanics in terms of the path integrals that now bear his name, together with two supporting papers and a preface.

Historians and physicists alike will enjoy this easy-to-read little book (119 pages plus the preface). Supplementing the thesis itself, which is just 69 pages long (if only all theses said so much in so little space), are reprints of Feynman's "Space–Time Approach to Non-Relativistic Quantum Mechanics", which was published in *Reviews of Modern Physics* in 1948 and Paul Dirac's "The Lagrangian in Quantum Mechanics". Dirac's paper is a little harder to find since it's from the *Physikalische Zeitschrift der Sowjetunion* and dates back to 1933. These provide excellent supporting material and in many ways bracket the thesis. Dirac's paper is not as widely read as it should be, and is of great importance as it provided much of the initial impetus for Feynman's work, making quite explicit the role of $\exp(iL\,dt/\hbar)$ as a transition amplitude between states separated by an infinitesimal time dt, and its connection to the classical principle of least action. Feynman's article is certainly well known and is perhaps rather more formal than the thesis itself, and therein lies much of charm of this book.

Brown also provides a 16 page introduction that essentially walks the reader through reading the thesis, summarizing the content of each section and adding many interesting historical anecdotes and quotations.

The thesis itself is a masterpiece of clear exposition. While there is little in the thesis that is likely to surprise most physicists, it is written in Feynman's uniquely chatty style, and reminiscent of the famous Feynman lectures. It is a delight to read and is likely to offer an insight, even to non-physicists, into both physics and the workings of Feynman's mind. I would not hesitate to recommend the book to anyone – working physicists, historians, philosophers and even "curious fellows" who would like to "peek over the shoulder" of one of the 20th century's great physicists at work.

John Swain, Northeastern University.

Pioneers in Art and Science: Art, Poetry and Particle Physics by Ken McMullen (dir.), University of the Arts London and The Arts Council. DVD ISBN 072871096X, £14.99.

Where do art and physics meet, and what kind of interaction might they enjoy? In this hour-long film, CERN physicists Michael Doser (anti-hydrogen experimenter) and John March-Russell (theorist) talk to author and artist John Berger (best-known for his 1972 book *Ways of Seeing*) and Ken McMullen, artist and director of the film.

Their discussion is interspersed with sequences of sculptures, installations and other artworks inspired by particle physics – most from the Signatures of the Invisible exhibition of 2000–2001. I particularly liked Paola Pivi's *Prototype 3* installation of needles on wires performing a kind of synchronized dance and McMullen's work, *Lumen de Lumine*, featuring two women (or perhaps one woman, mirrored) whirling balls of light round and round in unison. There are also brief close-ups of famous physics equations being written on a whiteboard, for instance Paul Dirac's dynamics of spin 1/2 fermions (which led him to predict the existence of antimatter).

The core of the film is the frequently thought-provoking discussion between the scientists and artists. Subjects covered include the symmetry of physics equations versus the arrow of time; what Berger calls "the banal question" of how the huge costs of particle physics can be justified (to which Doser replies that, first, both art and science go beyond the everyday to give meaning to life and, second, pure research can give rise to wholly new types of technology, not just incremental improvements); the contrast between "risky" experiments that hope to gain fundamental insights and "safe" ones that accumulate data; classical versus probabilistic physics ("Where does necessity come into the quantum world?" Berger asks); the search for authenticity in art and for purity in science; and the mesmerizing quality that equations can hold for a physicist, even when they may be used to develop something like the H-bomb.

It is notable that the artists are asking the questions, and the physicists are providing answers. The flow of influence seems to be one way. The profound, often counter-intuitive ideas that science in general, and physics in particular, throw up – quantum theory, antimatter, chaos theory, multiple dimensions – provide non-standard concepts and metaphors to inspire artistic work.

How art might inspire or influence physics is less obvious. In the film, Doser and March-Russell don't ask Berger or McMullen about their techniques, purposes, or productions. But perhaps the art/science interaction is asymmetric. The general culture that art helps to shape is the pond in which the working physicist swims. And it's not just pure science that takes time – sometimes more than a century, as Doser points out – to be absorbed into the general culture; the same is true of radically new art.

Interactions of art and physics such as this film can play an important part in making scientific ideas more widely assimilated. Much work and funding go into sometimes rather patronizing efforts to increase the "public understanding of science" – as if bombarding children (and adults) with enough gee-whizzery is bound, sooner or later, to make them interested. This film, like the Signatures of the Invisible exhibition, stands for a more sophisticated and long-term approach, in which science, via art in this case, feeds ideas and inspiration to the broader culture.

● The DVD includes a number of additional items: extracts from the discussion not included in the main feature; a 15 minute film about the manufacture in a CERN workshop of McMullen's sculpture *In Puris Naturalibus*; and a reading and discussion of Simon Weil's poem, "Chance".
Michael Marten, Science Photo Library, London.

Art meets science: Paola Pivi and her installation of dancing needles, Prototype 3.

Books received

Theory of Neural Information Processing Systems by A C C Coolen, R Kühn and P Sollich, Oxford University Press. Hardback ISBN 0198530234, £75 ($154.40). Paperback ISBN 0198530242, £30 ($64.50).

Presenting an explicit, coherent and up-to-date account of the modern theory of neural information-processing systems, this book has been developed for graduate students from any quantitative discipline, including physics and computer science. It has been class-tested by the authors over eight years and includes exercises, notes on historical background and further reading. Appendices provide further background, including probability theory, linear algebra and stochastic processes.

Hadronic Physics from Lattice QCD by Anthony M Green (ed.), World Scientific. Hardback ISBN 981256022X, £54 ($88).

The aim of this book is to introduce lattice quantum chromodynamics to non-specialists, in particular undergraduates and graduates, theorists and experimentalists, who have a background in particle and nuclear physicists. In particular it chooses topics that generally have analogies with more conventional areas in these fields, such as the interquark potential and interactions between hadrons.

Massive Neutrinos in Physics and Astrophysics, 3rd edition by Rabindra N Mohapatra and Palash B Pal, World Scientific. Hardback ISBN 9812380701, £76 ($103). Paperback ISBN 981238071X, £34 ($46).

The third edition of this well-known book provides an up-to-date discussion of the latest massive-neutrino results for the active researcher, and an introduction to various related theoretical and phenomenological issues for the non-expert. Elementary discussions on topics such as grand unification, left–right symmetry and supersymmetry are presented, and there is special emphasis on the implications of neutrino discoveries for the nature of new forces.

Selected Papers (1945–1980) With Commentary, 2005 edition by Chen Ning Yang, World Scientific. Hardback ISBN 9812563679, £29 ($48).

First published more than 20 years ago, this collection of Chen Ning Yang's personally selected papers has been reprinted with the edition of two further articles published in 2003 and 2005. Supplemented with Yang's insightful commentaries, the book provides a valuable window on research in physics from the end of the Second World War to the beginning of the 1980s. It includes the seminal work with T D Lee on the non-conservation of parity and the work with R L Mills that led to modern gauge theories.

Progress in String Theory: TASI 2003 Lecture Notes by Juan M Maldacena (ed.), World Scientific. Hardback ISBN 9812564063, £62 ($108).

Intended mainly for advanced graduate students in theoretical physics, this comprehensive volume covers recent advances in string theory and field theory dualities. It is based on the annual lectures given at the School of the Theoretical Advanced Study Institute (2003), a traditional event that brings together graduate students in high-energy physics for an intensive course given by leaders in their fields.

Time for accelerator experiments

Fulvia Pilat describes the work of the team that does machine physics experiments at Brookhaven's RHIC, to advance new techniques and understanding of the beams.

It is the owl shift on a Wednesday in the Relativistic Heavy Ion Collider (RHIC)/AGS Main Control Room (MCR). Instead of the usual quiet work of the night operation crew, who efficiently attend to the needs of the accelerators and the RHIC physics experiments, the MCR is bursting with activity. It is an accelerator-physics experiments (APEX) night: teams of physicists, supported by machine specialists and operators collaborate on testing the latest and newest beam techniques proposed for RHIC. Ever since its first years of operation, RHIC has not only fulfilled its main purpose of delivering luminosity to its physics experiments (PHENIX, STAR, BRAHMS and PHOBOS), but has also supported an organized beam-experiments programme.

The RHIC APEX team, standing from left: Gregory Marr, Mike Blaskiewicz, Waldo Mackay, Vadim Ptitsyn, Alexei Fedotov, Christoph Montag, Vladimir Litvinenko, Haixin Huang, Mei Bai, Rob Michnoff. Seated from left: Todd Satogata, Fulvia Pilat (APEX coordinator) and Thomas Roser. The other APEX team members not pictured above are Rama Calaga, Peter Cameron, Angelika Drees, Wolfram Fischer, Yun Luo, Nikolay Malitsky, S Y Zhang.

The goals of the machine experiments are to explore new and advanced beam techniques, to foster machine performance, including development and testing of new diagnostics, and to widen the experimental understanding of accelerator physics. Beam experiments entail a longer time scale than the day-to-day optimization of machine performance: it typically takes a year for a technique successfully demonstrated in beam experiments to become fully operational.

The accelerator-physics programme for an upcoming run at RHIC is formulated and discussed at a regular summer workshop, and beam-experiment proposals are submitted in the autumn and reviewed and prioritized by an internal committee before the start of the run, typically in winter. Twelve hours a week for beam experiments are scheduled during the physics running time, with enough flexibility to minimize the impact on the overall programme.

The accelerator-physics topics that have so far received the most attention and effort are those aimed at overcoming limitations on the performance of RHIC, namely intra-beam scattering and the electron-cloud-induced pressure rise that occur during ion operations, and beam–beam effects and polarization during operations with polarized protons. Many of these performance issues at RHIC are common to other high-energy colliders.

Collaboration with other institutions and laboratories is a natural and strong component of the RHIC beam-experiments programme, and accelerator physicists from other laboratories actively participate in experiments of mutual interest. Colleagues from CERN in particular have actively contributed to non-linear studies and the development of correction techniques that have eventually led to the reduction of the beam size at the experimental interaction point, resulting in increased luminosity. The development of new instrumentation and diagnostic techniques is another example of collaboration with CERN. These include the feasibility test of tune feedback during acceleration and the precise observation of electron-cloud formation – issues that are very relevant to the future performance of the Large Hadron Collider.

Future beam-experiments work at RHIC will focus on supporting and preparing for the planned RHIC upgrades: a ten-fold increase in luminosity in RHIC heavy-ion collisions, made possible by a full-energy electron-cooling system planned for early in the next decade, and the eventual addition of an electron beam for electron–ion collisions. Near-term activities to support future projects include the development of a new magnet lattice with higher focusing to reduce the effect of intra-beam scattering, and tests of how the machine operates with an increased number of bunches.

With Run 6 scheduled to start at RHIC in February 2006, after a couple of weeks of machine set-up and performance optimization, we are looking forward not only to delivering polarized-proton collisions to our physics experiments, but also to APEX with polarized proton beams.

Fulvia Pilat, APEX coordinator

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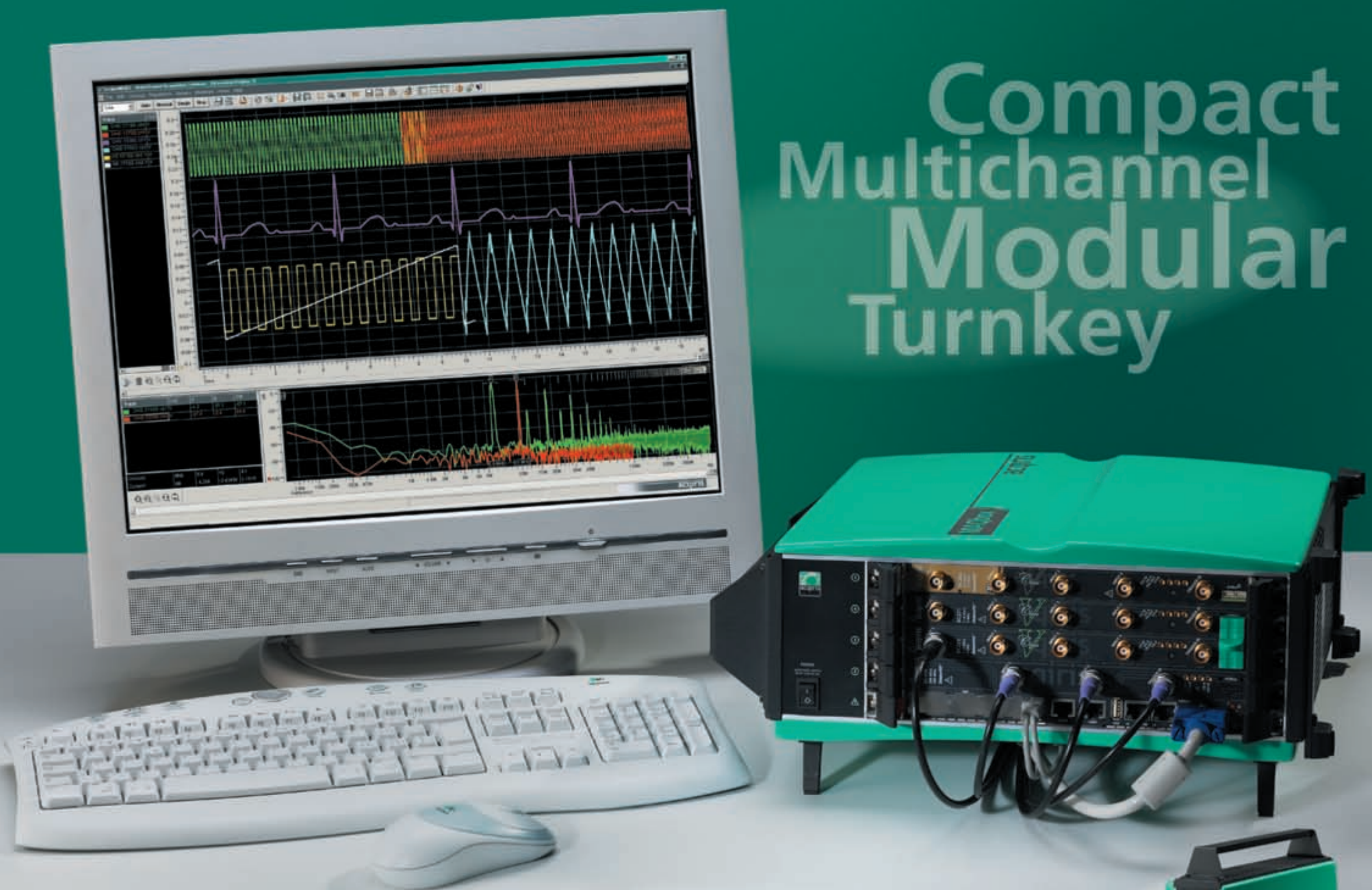

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Hamburg, Germany

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Tools for Discovery

CAEN

Overview

The N1728 is a new NIM four-channel digital pulse processor and waveform digitizer.

The N1728 can work in "oscilloscope" mode, continuously storing waveforms (10 ms wide buffer with pre-trigger capability) and "Energy" mode, providing real time trapezoidal shaping, with a wide range of programmable filter parameters, and energy determination.

A dedicated digital trigger algorithm allows very low energy threshold operation ensuring immunity to noise effects.
A digital Constant Fraction Discriminator (CFD) has been implemented for applications requiring accurate timing.

N1728 (NIM/USB2) 4 ch. 14 bit 100 MHz Digital Pulse Processor & Waveform Digitizer

Highlights

- 4 channel 14 bit 100 MHz FADC
- "Oscilloscope" mode/transient recorder with 10 ms wide waveforms buffer with pre-trigger capability
- "Energy" mode with real time trapezoidal shaping and energy determination
- Excellent integral linearity
- Digital trigger and CFD
- Trigger time stamping and counting information
- Base Line Restoration and pile-up rejection
- Programmable coincidence/veto time windows on all channels

Applications

- High resolution spectroscopy with germanium, silicon, CdTe, GaAs, HgI2 detectors in high counting rate environments
- Gamma ray tracking and Depth Of Interaction measurements in large volume segmented semiconductor detectors or PET systems
- Particle identification and n/γ discrimination in scintillation, semiconductor or gas filled detectors via Pulse Shape Analysis techniques