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LHC: the circle begins to close

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D0 observes single top quarks p6

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A 'mappa mundi' for Grid sites p16

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The day neutrino astronomy began p23

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

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CERN COURIER

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FLASH captures nano-world p8

C N Yang revisits CERN p30

Neutrino detector meets art p40

Cover: As the final countdown begins towards the scheduled start-up of the Large Hadron Collider at CERN later this year, work on the machine and the experiments is proceeding at full pace. An eighth of the machine – sector 7-8 – is now fully interconnected and cool-down has begun (p5), and the production of main quadrupoles and short straight sections is now complete (pp 25 and 27).

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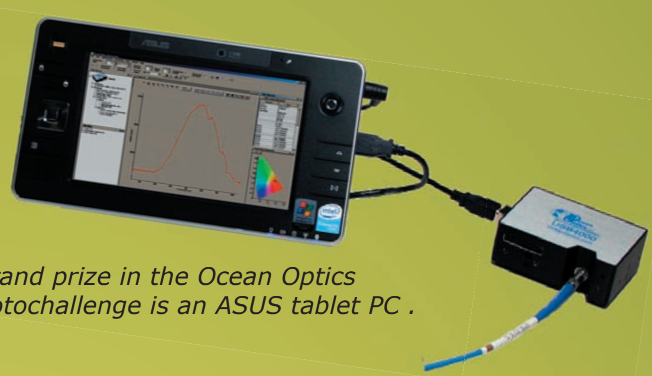

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NEWS

CERN

LHC on course for 2007 start-up

Above: LHC project leader Lyn Evans (left) and Lucio Rossi, head of CERN's Magnets, Cryostats and Superconductors group, in front of the last superconducting main magnet to be delivered to CERN. Right: the 410 tonne first end-cap disc begins its descent into the CMS cavern.

As the final countdown begins towards the scheduled start-up of the Large Hadron Collider at CERN later this year, work on the machine and the experiments has seen a series of achievements during the closing weeks of 2006. The cool-down of the first complete sector – an eighth of the machine – has already begun and installation of the magnets should be completed in March.

At the end of October, the final sector of the cryogenic distribution line, sector 1-2, passed pressure and helium leak tests at room temperature, "completing the circle" for at least one major component of the LHC. The line will circulate helium in liquid and gas phases, at different temperatures and pressures, to provide the cryogenic conditions for the superconducting magnets. The test marked the end of a key part of the project that has had to overcome major difficulties, including manufacturing faults (*CERN Courier* July/August 2004 p5).

Then on 10 November the first complete sector – sector 7-8 – became operational, with the magnets, cryogenic line, the vacuum chambers and the distribution feedboxes all fully interconnected. The interconnection work had required several thousand electrical, cryogenic and insulating connections to be made on the 210 interfaces between the magnets in the arc, the 30 interfaces between the special magnets and the interfaces with the cryogenic line (*CERN Courier* January/February 2004 p35). Although representing only an eighth of the LHC, the fully equipped sector from points 7 to 8 will be the world's largest operating cryogenic system.

Production of the LHC's main magnets has finally finished, with a celebration at CERN on 27 November. In all 1232 main dipole and 392 main quadrupole magnets have been manufactured in an unprecedented collaboration effort between CERN and European industry (see p25 and p27 this issue, and *CERN Courier* October 2006 p28).

The LHC experiments are also continuing to make good progress. On 8 November, the giant ATLAS barrel toroid magnet reached its nominal field of 4 T, with a current of 21 kA in the superconducting coils. At the same time, the first sections of the CMS detector had begun to arrive in the experimental cavern, 100 m below ground. The first forward hadronic (HF) calorimeter, weighing 250 tonnes, led the way on 2 November, with the second HF following a week later. The first end-cap disc, the 410 tonne YE+3, made its 10 h descent on 30 November, followed by YE+2 on 12 December. The third end-cap disc, YE+1, weighing in at nearly 1300 tonnes, was the heaviest piece so far to be lowered, taking 11 h on 9 January.

These milestones were a major feature of a confident report on the LHC to CERN Council at its 140th meeting on 15 December. The meeting also saw the election of Torsten Åkesson of the University Lund as president of Council from 1 January 2007, taking over from Enzo Iarocci. On the same date, Sigurd Lettow replaced Andre Naudi as CERN's chief financial officer.

Sommaire

FERMILAB

Scientists at the D0 experiment discover new path to the top

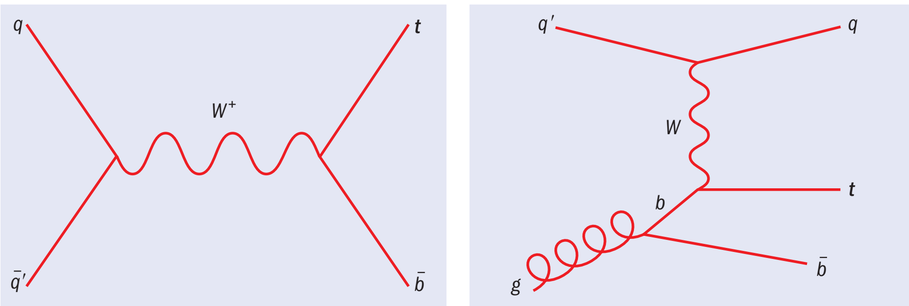


Fig. 1. Processes leading to the production of single top events of the kind seen by D0.

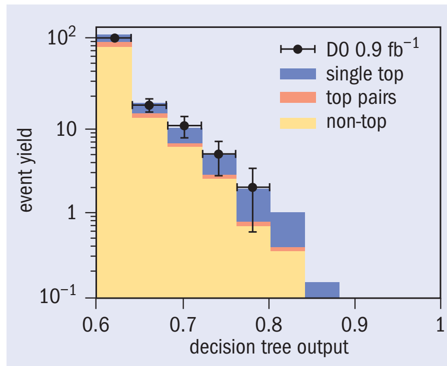


Fig. 2. The discriminant output of the boosted decision tree analysis. The data points are compared to a sum of the expected events from backgrounds and the single top signal process.

On 8 December, scientists from the D0 experiment at Fermilab's Tevatron announced the first evidence for top quarks produced singly, rather than in pairs. The top quark has played a prominent role in the physics programme at the Tevatron ever since it was discovered there nearly 12 years ago. Just before the discovery in 1995, D0 collaborators were already turning their attention to the electroweak production of single top quarks, with theorists suggesting that the cross-section should be large enough to observe in the Tevatron's proton–antiproton collisions.

A top quark is expected to be produced by itself only once in every 2×10^{10} proton–antiproton collisions, through the electroweak processes shown in figure 1. Although the cross-section is not much smaller than for top-quark pair-production, the signature for single top production is easily mimicked by other background processes that occur at much higher rates.

To stand a chance of observing the electroweak process, D0 physicists had to develop sophisticated selection procedures, resulting in around 1400 candidates selected from the thousands of millions of events recorded over the past four years (corresponding to $1\,fb^{-1}$ of collision data). The team expected only about 60 true single top events among all these candidates, so had to exploit every piece of information to establish the presence of the events.

The researchers used three different techniques (boosted decision trees, matrix element-based likelihood discriminants and Bayesian neural networks) to combine many discriminating features in ways that enable single top quark events to be recognized. In this way they effectively reduced the multidimensional system to a single, powerful variable.

With agreement among the three measurements, the D0 team finds the cross-section for single top quark production to be 4.9 ± 1.4 pb, consistent with the Standard Model prediction (D0 Collaboration 2006). They estimate the chance of measuring this value as the result of a background fluctuation at less than 1 in 2800 ($3.4\,\sigma$). This result establishes the first evidence for single top quark production.

The analysis also constrains the magnitude of $|V_{tb}|$, an important parameter of the Standard Model's Cabibbo–Kobayashi–Maskawa (CKM) matrix, which describes how quarks can change from one type to another. If the CKM matrix describes the intermixing of three generations of quarks – with top and bottom forming the third generation – the value of $|V_{tb}|$ should be close to one. Any departure from this value could be a sign of new physics, be it a new family of quarks or some unforeseen physical process. The D0 result provides the first opportunity for a direct measurement of $|V_{tb}|$ and constrains it to lie between 0.68 and 1 with a 95% probability, consistent with the presence of only three generations of quarks.

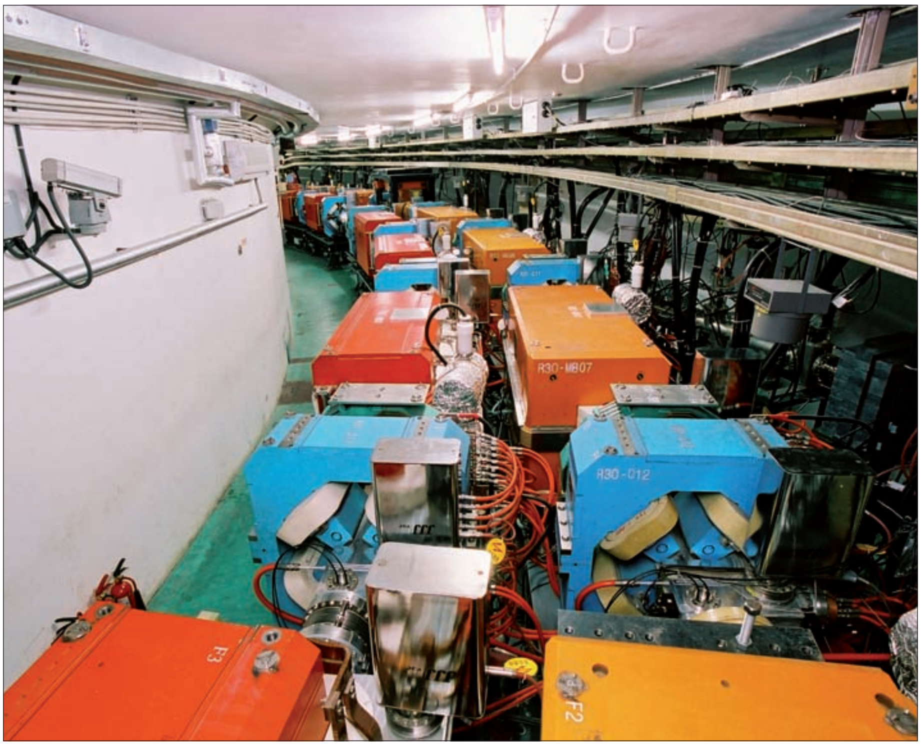
In addition to its inherent success, this analysis is an important milestone in the D0 Collaboration's continued search for the Standard Model Higgs boson. Higgs production is predicted to occur at rates smaller than single top quark production in the presence of substantial "irreducible" backgrounds (including single top). In this regard, D0 is developing a refined ability to "reduce the irreducible", exemplified by this analysis and the recent evidence for the associated production of W and Z bosons (*CERN Courier* September 2006 p6). These high-level analyses and the detailed understanding of the growing data-set are becoming the backbone of D0's search for the Higgs boson.

Further reading

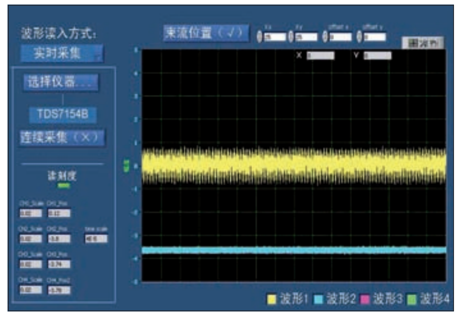
D0 Collaboration 2006 http://arXiv.org/abs/hep-ex/0612052. Submitted to *Phys. Rev. Lett.*

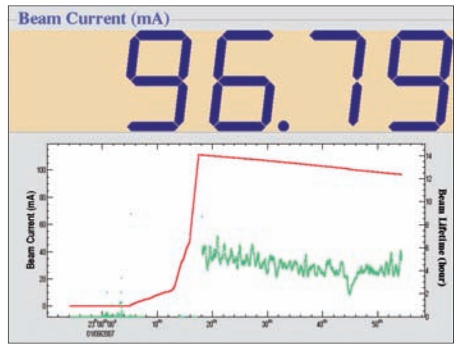
STORAGE RINGS

BEPCII makes progress towards switch-on



The two rings of BEPCII. The synchrotron radiation beam lines are now open to users.


BEPCII's stored beam signal with RF.



Display of the top-up injected beam current (red line) and lifetime (green line).

The BEPCII project, a major upgrade and natural extension of the Beijing Electron–Positron Collider (BEPC), has passed an important milestone with beam now circulating in the outer ring and the synchrotron radiation (SR) beam lines open to users. Obtaining colliding beams will be the next step.

BEPCII consists of two storage rings, with a new ring built inside the original BEPC ring. The two rings will cross at two points to form a collider, with one ring for electrons and one for positrons. BEPCII will operate with beam energy in the range 1.0–2.1 GeV, appropriate for charm production, and with a design luminosity of 1×10^{33} $cm^{-2}s^{-1}$ at 1.89 GeV. The upgraded collider will also provide improved SR performance with higher beam energy and photon intensity than at BEPC.

Construction work on BEPCII started at the beginning of 2004 (*CERN Courier* June 2004 p6). Summer that year saw the installation of new hardware subsystems for the linac injector after the old devices had been removed and commissioning of the upgraded injector linac followed, demonstrating its design performance. Then, after 16 months' hard work, most of the components for the new inner storage ring had been manufactured and tested.

Installation was completed in early November 2006 with conventional magnets installed in the interaction region to enable commissioning of the outer ring with electrons for SR operation. In the meantime, improvement of the cryogenic system and field mapping of the superconducting magnets will proceed at a position out of the beam line.

Commissioning of the outer ring started on 13 November and a beam position monitor revealed the signal for the first turn of beam on the same day. Then, in the early morning of 18 November, the operators obtained circulating beam without RF and stored beam with RF. At the same time, the hardware systems were tested and debugged. Vacuum conditioning with beam followed, and with improving vacuum, orbit correction and other measures, the beam current in the storage ring and the beam lifetime were increased step by step. At the time this issue went to press, the beam current had reached 200 mA with a lifetime of 4 h at 1.89 GeV.

For SR operation, the beam energy was ramped to the required 2.5 GeV and commissioning with the SR beam lines began. The SR beams were then opened to users from 25 December. "This is a milestone of the BEPCII construction towards its final goal," stressed Nobel laureate Tsung-Dao Lee during his recent visit to Beijing.

Commissioning with electron and positron beams in preparation for the first collisions will be carried out after one month of operation for SR users. The plan is then to install the superconducting insertion quadrupoles into the interaction region in the summer and to move the new detector BESIII into place in autumn. The first physics run of BEPCII/BESIII is scheduled to start by the end of 2007.

DESY

X-ray laser pulses light up the nano-world

An international team of scientists using the soft X-ray free-electron laser FLASH at DESY has achieved a world first by taking a high-resolution diffraction image of a non-crystalline sample with one extremely short and intense laser shot. This first successful application of "flash diffractive imaging" opens a new era in structural research.

The experiment suggests that in the near future images from nanoparticles and even large individual macromolecules – viruses or cells – may be obtained using a single ultra-short high-intensity laser pulse. This would provide new possibilities for studying the structure and dynamics of nanometre-sized particles and molecules without the need for the crystallizing required in conventional X-ray structure analysis.

In the experiment at FLASH, the researchers directed a very intense free-electron laser pulse of 32 nm wavelength and 25 fs duration at a test sample, a thin membrane into which 3 μm-wide patterns had been cut (Chapman *et al.* 2006). The energy of the laser pulse heated the sample up to around 60 000 K, making it vaporize. However, the team was able to record an interpretable diffraction pattern before the sample was destroyed. The image obtained from the diffraction pattern showed no discernible sign of damage, and the test object could be reconstructed to the resolution limit of the detector. Damage occurred only after the ultra-short pulse traversed the sample.

Left: the sample used in the single-shot image experiment at FLASH was a membrane measuring 20 μm × 20 μm which was only 20 nm thick, with a milled nanostructure – two cowboys in the Sun. Centre: the reconstruction of the nanostructure as from the diffraction image. Right: diffraction image of sample. (Images courtesy DESY, Hamburg.)

In order to take images of large molecules with atomic resolution, such experiments will have to be carried out using radiation of even shorter wavelengths, i.e. hard X-rays such as the ones that will be produced from 2009 on by the Linac Coherent Light Source (LCLS) in Stanford, or by the European X-ray Free-Electron Laser (XFEL) in Hamburg, which should begin operation in 2013. Since the method demonstrated at FLASH does not require any image-forming optic, it can be extended to these hard X-ray regimes, for which no lens currently exists.

Further reading

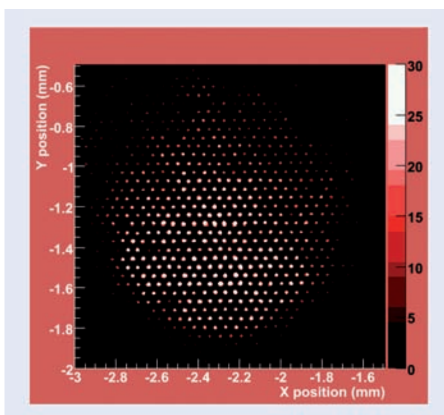
Henry N Chapman *et al.* 2006 *Nature Physics* **2** 839.

DETECTORS

GEM structure makes self-portrait

In 1996 Fabio Sauli at CERN introduced the gas electron multiplier (GEM) – a new idea for gas amplification in particle detection (*CERN Courier* December 1998 p19). The concept has since seen increasing use in particle physics and other applications. Recently Ronaldo Bellazzini and his team at INFN/Pisa have used a GEM-based pixel detector illuminated by ultraviolet (UV) light to produce a "self-portrait" of the GEM amplification structure.

Bellazzini uses a UV lamp to illuminate a caesium-iodide photocathode that is also the entrance window of the gas pixel detector. The light intensity is sufficiently low that the device detects only one photon at a time, each producing a single electron. The electron drifts into a single GEM hole where it knocks further electrons from atoms in an avalanche effect. The avalanche due to the single electron is extracted and a fine-pitch pixel CMOS analogue chip, which is also the charge-collecting electrode, provides a direct reading of the GEM charge multipliers, measuring the centre of "gravity" of the avalanche. If the resolution is good and the noise is low, the centre of gravity corresponds to the centre of the GEM hole.



Measuring the centre of gravity of the avalanches generated in a GEM structure by a single primary electron with 4 μm resolution reveals GEM holes 50 μm apart.

Accumulating thousands of such events produces a map, in effect a "self-portrait", of the GEM amplification structure with individual dots only 50 μm apart. The charge-collecting chip has 100 000 pixels arranged in a honeycomb pattern also at a pitch of 50 μm, providing an intrinsic resolution of the read-out system of only 4 μm, in response to a single primary electron.

Further reading

R Bellazzini *et al.* 2006 *Nucl. Instr. and Meth. A* **566** 552.

ISOTOPE RESEARCH

NSCL reveals plans for $500 million upgrade

A detailed white paper published on 7 December outlines plans for a capability upgrade of the National Superconducting Cyclotron Laboratory (NSCL) located at Michigan State University.

The 415 page document gives a scientific and technical description of a proposed Isotope Science Facility (ISF) that will use a high-power heavy-ion driver linac capable of accelerating beams of all stable elements to 200 MeV/nucleon with up to 400 kW beam power. Rare isotopes produced and separated in flight will be available as stopped, fast and re-accelerated (up to 12 MeV/nucleon) beams.

The cost of building ISF on an undeveloped site on the university's south campus is approximately $500 million, according to NSCL officials.

Illustration of the Isotope Science Facility at Michigan State University, which if built would house the world's most powerful accelerator for rare-isotope research.

The NSCL publication was followed on 8 December by the unedited prepublication release of *Scientific Opportunities with a Rare-Isotope Facility in the United States*, a report by the US National Academies. This declared a next-generation rare-isotope facility to be "a high priority for the United States". The National Academies also found that a new US facility based on a heavy-ion linear accelerator would complement existing and planned international efforts.

Funded by the US National Science Foundation, NSCL is the largest nuclear-science facility on a US university campus and educates about 10% of that country's nuclear-science doctoral students. It serves an international user community of 700 scientists from 35 countries.

● For more information about the planned NSCL upgrade see www.nscl.msu.edu/isf.

SCIENCEWATCH

Compiled by Steve Reucroft and John Swain, Northeastern University

Carbon nanotubes gave Damascus blades an edge...

Damascus blades are famous for their remarkable strength and sharpness, but much of what made these blades great has remained a mystery – until now. Marianne Reibold and colleagues at the University of Dresden have used high-resolution transmission microscopy to analyse steel from the blade of a 17th century Damascus sabre and found carbon nanotubes.

Damascus steel has a very high carbon content but somehow blacksmiths were able to overcome the brittleness that arises from plates of cementite – a compound of carbon and iron – that would form in such high-carbon steel. The team in Dresden has found evidence indicating that cementite nanowires formed in the steel could have been protected by the carbon nanotubes.

The medieval recipe for the steel was highly detailed and included specific woods which may have provided carbon to form the nanotubes. Trial and error optimization of thermal cycling and forging could have lined up the nanotubes. These in turn could have helped organize planes of cementite in a way that provided sharpness without weakening the blade itself.

Further reading

M Reibold *et al*. 2006 *Nature* **444** 286.

...and are used in a device providing one-way heat flow

Rectifiers for electrical current are common, but the analogous devices for heat are less well known. Now C W Chang of the University of California at Berkeley and colleagues have demonstrated a nanoscale device they describe as a "solid-state thermal rectifier", made of carbon and boron nitride nanotubes loaded with heavy molecules.

The device is not understandable in terms of ordinary heat flow carried by linear vibrational modes. Instead, it seems to depend on energy transfer by solitons. Such devices could revolutionize how we deal with heat in applications from microelectronics to large-scale heating and cooling.

Further reading

C W Chang *et al*. 2006 *Science* **314** 1121.

The benefits of wine

The benefits of alcohol, particularly red wine, are well known. Now researchers in the UK have identified what may be the key chemical contributing to vascular health, and which red wines may be best for your heart.

Roger Corder of the William Harvey Research Institute in Barts and The London Queen Mary's School of Medicine and Dentistry and colleagues have investigated the vasoactivity – the effect on the diameter of blood vessels – of key compounds in red wine. These include resveratrol, which occurs in the skin of red grapes. The researchers found that the greatest dilatation comes from oligomeric procyanidins (OPCs). They also found that the best wines for OPCs come from south-west France and Sardinia, where traditional wine-making techniques seem to boost OPC content by as much as a factor of four over other red wines, and where men in particular show increased longevity (Corder *et al.* 2006).

Also, a recent study shows that resveratrol seems to mimic the beneficial effects of calorie-restricted diets (Baur *et al*. 2006).

Further reading

Joseph A Baur *et al*. 2006 *Nature* **444** 337.

R Corder *et al*. 2006 *Nature* **444** 566.

Sleep really does help your memory

Researchers have long recognized that sleep plays some role in the consolidation of memory, in particular when it is accompanied by brain-wave frequencies less than 1 Hz. But are these brain waves part of the memory-enhancing process, or just an indicator of something else going on?

Lisa Marshall and colleagues at the University of Lübeck in Germany have shown that the application of an oscillating voltage of 0.75 Hz to the skulls of human volunteers during early non-REM sleep can actually improve memory. The signal applied was about 1.2 mV per millimetre, which is just enough to produce similar to normal signals at the surface of the brain.

So it seems that low-frequency electrical activity itself plays a role in memory. How long it will be before headbands with the right electronics go on sale to students looking for an edge is anyone's guess.

Further reading

Lisa Marshall *et al*. 2006 *Nature* **444** 610.

Heavy fusion comes to the laboratory

Researchers have demonstrated several ways of achieving table-top fusion, but the fusion of heavier nuclei remained something requiring more exotic equipment (or stars). Now Isidore Last and Joshua Jortner of Tel-Aviv University have calculated that there may be an easy route to nucleosynthesis in the laboratory, using nanodroplets of methane, water and ammonia.

The idea is to blast the droplet with intense femtosecond-long laser pulses. Very strong ionization then leads to a "coulomb explosion" which should be able to fuse nuclei heavier than deuterons. It might even be able to reproduce the reactions of the carbon–nitrogen–oxygen cycle that takes place in stars.

Further reading

Isidore Last and Joshua Jortner 2006 *Phys. Rev. Lett.* **97** 173401.

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

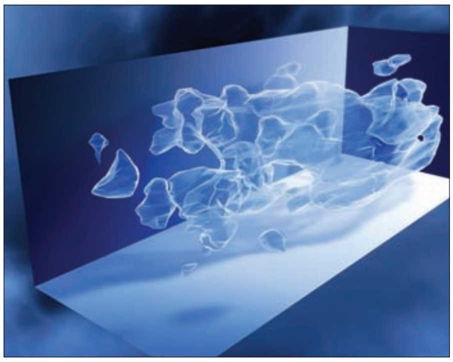
3D map reveals distribution of dark matter

Making a map of something that cannot be seen directly seems almost impossible, but it has been achieved by a wide international collaboration analysing a huge set of observations gathered by the Hubble Space Telescope (HST) and several ground observatories. The result is a 3D map of the distribution of dark matter in a large volume of the universe.

Evidence for dark matter goes back to 1933 when the Swiss astrophysicist Fritz Zwicky working at the California Institute of Technology (Caltech) deduced that the Coma cluster of galaxies would not remain bound together by gravity without the pull of an additional hidden mass. Over the course of decades, it became clear that dark matter is much more abundant in the universe than visible matter. Recent cosmology results further suggest that most of the dark matter is not made of ordinary matter composed of protons and neutrons, but is of a yet to be discovered non-baryonic nature (*CERN Courier* May 2006 p12).

Direct evidence for dark matter being decoupled from ordinary matter was obtained last year (*CERN Courier* October 2006 p9), an observation difficult to reconcile with alternative theories like Modified Newtonian Dynamics (MOND).

Until now, the ability to derive the spatial distribution of dark matter was limited to individual galaxies and clusters. The new study published in *Nature* goes a step further by tracing dark matter on a much wider scale on the sky and also in depth along the line of sight. The international collaboration led by Richard Massey, also from Caltech, analysed the Cosmic Evolution Survey (COSMOS), a mosaic of 575 pointings of the Advanced Camera for Surveys (ACS) aboard the HST covering almost 2 sq. deg. on the sky, about eight times the area of the Moon. Dark matter manifests itself by the gravitational deflection of light emitted by background sources. This gravitational-lensing effect slightly deforms the shape of remote galaxies. It is this subtle effect that was measured for about 500 000 galaxies in this survey and analysed statistically to derive the projected distribution of dark matter.



Three-dimensional map of the dark-matter distribution in a field of 2 sq. deg. (Courtesy NASA, ESA and R Massey [Caltech].)

The mapping of the dark matter in the third dimension is achieved by carefully selecting galaxies according to distance. Their observed distortion is mainly affected by dark matter at about half this distance. Using this property, a first 3D map of dark matter could be constructed extending from a redshift of 0 to 1. The survey volume is therefore an elongated cone rather than a box extending over about 7 billion light-years. The determination of the distance to the galaxies obtained by measuring their photometric redshift required follow-up observations in 15 wavelength bands by four ground-based telescopes.

The map is quite rudimentary, with little evidence for the expected filamentary or "sponge-like" structure obtained by simulations of the building-up of large-scale structures in the universe. Nevertheless, it shows some evolution from a more homogeneous to a more clumpy distribution of dark matter as expected through self-gravity, and it paves the way to future surveys that should enable this kind of study to have higher resolution and cover much greater volumes of the universe.

Further reading

R Massey *et al.* 2007 *Nature* doi:10.1038/nature05497.

Picture of the month

This small image cannot render the true beauty of this view of the Large Magellanic Cloud. The image, released by the European Southern Observatory (ESO), covers 1 sq. deg. of the sky and with its full resolution of 256 megapixels could cover a wall and remain sharp. The yellowish cloud at the top is a giant star-forming region known as the Tarantula Nebula (*CERN Courier* June 2006 p14). With higher resolution, the ejected material from the historic supernova of 23 February 1987 would be visible to the lower right of this spider-shaped nebula as a tiny ring of glowing gas. A zoom-in video of this supernova remnant is at: www.eso.org/outreach/press-rel/pr-2006/phot-50-06.html. (Courtesy ESO.)

CERN COURIER ARCHIVE: 1964

A look back to CERN Courier vol. 4 January/February 1964, compiled by Peggie Rimmer

CONFERENCE

Conferenza Internationale di Siena sulle Particelle Elementari

At the first conference of a new type on high energy physics, held two years previously at Aix-en-Provence, the centre of interest had been strong interactions. At Sienna, such is the present pace of advance, its place was taken by a development in the study of the weak interactions, namely the neutrino experiment carried out at CERN during the summer of 1963. Since analysis of the results was still in progress, even the conference participants from CERN were anxious to hear the latest news.

The session opened with a talk by G Plass (CERN) describing the high-energy neutrino beam. He was followed by S van der Meer, who described the magnetic horn (a device which afterwards received high praise from more than one speaker from the USA) and the neutrino-flux calculations. F Krienen (CERN) then described the special spark chambers. After this, D H Perkins (Bristol) outlined the results obtained with the bubble chamber, and F Ferrero (CERN) did the same for the spark chambers. The last paper was given by J S Bell (CERN), who examined the theoretical aspects of the results, and the meeting closed with a lively discussion centred around the possible evidence for the existence of the "intermediate boson" or "W-particle".

● Extracted from an article on pp3–6, January 1964.

ECFA

The future of high-energy accelerators

The strong-focusing alternating gradient proton synchrotrons at CERN and at Brookhaven (USA) represent the highest and most sophisticated stage so far reached in accelerator technology. The very successes achieved through the use of high-energy accelerators, however, have raised new problems which are not capable of solution at the machine energies presently available. To achieve "super-high energies", new machines capable of accelerating particles to energies effectively greater by orders of magnitude than those achieved by the CERN PS are needed.

Unfortunately such machines take many years to design and build. With this situation in mind the then Chairman of the CERN Scientific Policy Committee, Professor C F Powell of Bristol University, together with the Director-general of CERN, convened a meeting of leading high-energy physicists in January 1963. This meeting, which constituted itself into the European Committee on Future Accelerators (ECFA), appointed a small working party under the chairmanship of Prof. E Amaldi (University of Rome) to prepare a comprehensive report on the desirable programme of large accelerator construction for Europe and its financial and manpower implications. The working party reported its findings (CERN FA/WP/23) to a full meeting of ECFA in June 1963. These findings were endorsed and passed on to the Scientific Policy Committee, which in turn passed them on to the CERN Council for consideration. At the meeting of CERN Council in December 1963, approval was given for a supplementary budget in 1964 to enable further development of design studies for the new accelerators envisaged in the report, but it was made clear by all concerned that this move did not imply any commitment for later years.

● Extracted from an article on pp15–18, February 1964.

EDUCATION

Our student visitors

The CERN Vacation Student programme in its present form began in 1962. From the start, the aims were:

a) to give a widely representative number of European students an idea of CERN and its work, to spread a wider knowledge of CERN in their home countries;

b) to consider the students as potential Fellows or possibly Staff members;

c) to provide temporary and useful assistance to CERN groups.

CERN is not seeking a supply of cheap unskilled labour for the summer months. We are, in fact, offering undergraduate and postgraduate students in physics or allied subjects the opportunity to gain some practical experience at a laboratory which is foremost in its field. It is thus perhaps not surprising that in 1963 there were over five times as many valid applications as there were vacancies.

● From an article on p8, January 1964.

COMPILER'S NOTE

The cover of *CERN Courier* in January 1964 showed an event from the CERN neutrino experiment and illustrated both the article on the Sienna conference – where the results were first made generally known, and Simon van der Meer introduced the magnetic horn – and the one on the Vacation Student programme, as analysis of such photos was largely in the hands of vacation students. Then, as now, future accelerators were also a key topic for discussion, with a report in February 1964 on the first work of ECFA, which had begun life in 1963. (The long straight track is most probably due to a muon and the other spark pattern has all the characteristics of an electron shower.)

Compiled by Hannelore Hämmerle and Nicole Crémel

EGEE

Record numbers attend EGEE'06

EGEE'06 attracted more than 700 participants to the Geneva conference centre to discuss the status and future of Grid technologies.

The Enabling Grids for E-sciencE (EGEE) conference in September 2006 brought together more than 700 users, major players in the business sector and representatives from many Grid projects. It was the biggest Grid conference in Europe since the Fifth Global Grid Forum in Edinburgh in 2002.

The participants took the opportunity to fine-tune their developments and formulate plans for Grid technologies. In total, a record of more than 30 Grid projects came together from areas varying from regional infrastructures to domain-specific applications, highlighting the strong international collaboration in this field. The Grid community has worked hard to build reliable infrastructures that are now used daily by a broad range of disciplines.

Several uses of the EGEE Grid were demonstrated live during the conference and the best demonstrations of applications on the Grid shown at the conference received a prize: the Climate Data Analysis showed how the Grid can speed up analysis of data and modelling, while the Dashboard for the ATLAS and CMS experiments at the Large Hadron Collider revealed how to monitor the status of Grid resources and the applications using them.

The EGEE project maintains the largest multi-science Grid infrastructure with users in more than 150 virtual organizations and sustained rates of up to 50 000 jobs a day. During summer 2006, the infrastructure sustained more than a million jobs a month. Scientists from diverse fields of research submitted these computing tasks, which ranged from simulations of molecular drug docking for neglected diseases to geophysical analysis of oil and gas fields.

EGEE has also helped develop gLite, a production-quality Grid middleware distribution, which ensures the seamless operation of this global computing facility. gLite was first released for production use in May 2006 and is now deployed by about 80% of the sites connected to the EGEE infrastructure, making it the main middleware distribution used in production.

The challenge faced by EGEE and collaborating projects is now to pave the way for a long-term sustainable Grid infrastructure, ensuring that the resources and knowledge developed during its lifetime are available to researchers in Europe and beyond in years to come. Recently, researchers have demonstrated interoperation with other major national and international Grids, such as the Open Science Grid in the US and the National Research Grid Initiative in Japan.

The next major EGEE event, the EGEE User Forum, will be held jointly with the 20th Open Grid Forum in May 2007 in Manchester, UK. This combined event will strengthen the links between EGEE and the Open Grid Forum and will bring users and standards bodies together to ensure that the establishment of key standards complements the Grid.

Les gros titres de l'actualité informatique

NEWS FROM SC'06

SC'06 unveils Grid computing 'mappa mundi'

Visitors to Supercomputing 2006 (SC'06) held in November in Tampa, Florida, saw a new interactive map that shows nine of the world's largest computing Grids. The map, developed by GridPP in the UK and by CERN, uses *Google Earth* to pinpoint Grid sites on six continents, showing more than 300 sites overall. Like the medieval "mappa mundi", which showed what was known of the world at the time, this is one of the first attempts to show the whole scientific Grid world.

Many of the Grids use different middleware, which makes collaboration difficult. All of the Grids on the map are taking part in the Grid Interoperation Now (GIN) group of the Open Grid Forum, which is trying to bridge the differences and enable seamless interoperation between the infrastructures.

The Google Earth *Grid map. Each dot represents a site that contributes resources to a Grid, with different colours for each Grid. (Image copyright NASA and TerraMetrics.)*

Google Earth displays Grid sites by using a KML file. When the file is opened it adds the locations of the Grid sites to the map. Clicking on a site reveals information such as the name and location of the site, and to which Grid it belongs. The database includes site information from the Enabling Grids for E-sciencE project, the Open Science Grid, the Nordic Data Grid Facility, NAREGI, TeraGrid, PRAGMA, DEISA, the National Grid Service in the UK and the Australian Partnership for Advanced Computing.

● For more information and the file go to www.gridpp.ac.uk/demos/gin_monitor.html.

Physicists push the limits of network data transfer

An international team led by the California Institute of Technology (Caltech) joined forces to set new records for sustained data transfer between storage systems during the Supercomputing 2006 (SC'06) Bandwidth Challenge in Florida. The team involved high-energy physicists, computer scientists and network engineers from Caltech, CERN, the University of Michigan, the University of Florida and Vanderbilt, as well as participants from Brazil (Rio de Janeiro State University, UERJ, and the State Universities of São Paulo, USP and UNESP) and Korea (Kyungpook National University, KISTI).

The demonstration was called High Speed Data Gathering, Distribution and Analysis for Physics Discoveries at the Large Hadron Collider. It achieved a peak throughput of 17.77 Gbit/s between clusters of servers at the show floor and at Caltech. Following the rules set for the SC'06 Bandwidth Challenge, the team used a single 10 Gbit/s link provided by National Lambda Rail that carried data in both directions. Sustained throughput during the night prior to the bandwidth challenge exceeded 16 Gbit/s using just 10 pairs of small servers sending data at 9 Gbit/s from Tampa to Caltech, and eight pairs of servers sending seven Gbit/s of data in the reverse direction.

One of the key advances in this demonstration was the use of Fast Data Transport (FDT), a Java application developed by Caltech that enables stable disk reads and writes coordinated with smooth data flow across the long-range network. FDT streams a large set of files across an open TCP socket, so that a large data set of thousands of files, as is typical in high-energy physics applications, can be sent or received at full speed, without the network transfer restarting between files. By combining FDT with FAST TCP and an optimized Linux kernel known as the UltraLight kernel, the team reached unprecedented throughput levels, limited only by the speeds of the disks. This corresponded to reading at 9 GB/s, or writing at 5 GB/s to a rack of 40 low-cost servers.

Science Grid This Week goes global

Supercomputing 2006 saw the launch of *international Science Grid This Week (iSGTW)*, a weekly e-newsletter for the worldwide Grid community. It reports on Grid computing projects and collaborations, as well as scientific research that uses Grid computing.

iSGTW builds on the success of *Science Grid This Week*, which focused on Grid projects in the US. The new publication will use articles, images, links and multimedia content to tell the story of scientific Grid computing around the world. It is available online and is e-mailed free to subscribers.

iSGTW is a collaboration between the Enabling Grids for E-sciencE (EGEE) and Open Science Grid projects. It is funded jointly by the National Science Foundation and the US Department of Energy's Office of Science through the Open Science Grid; and by the European Commission's Information Society and Media Directorate-General through the EGEE project.

● For more information see www.isgtw.org .

REGIONAL GRIDS

NSF supports collaboration to reinforce Pacific Rim Grid

The US National Science Foundation (NSF) has renewed its support for a grassroots effort by US and Pacific Rim engineers who develop cyberinfrastructure and software tools in tandem with application scientists who use those Grids to advance collaborative science research projects.

The NSF will provide $3.2 million over five years to the Pacific Rim Application and Grid Middleware Assembly (PRAGMA), a four-year-old initiative based at the University of California, San Diego (UCSD). The funding will allow PRAGMA to broaden its impact and accelerate the use and interconnection of Grids around the region.

PRAGMA began as a pilot project in 2002 and was renewed for three years in 2003. It started at the UCSD San Diego Supercomputer Center (SDSC), and is now run by SDSC, the Center for Research in Biological Systems (CRBS) and the California Institute for Telecommunications and Information Technology (Calit2).

With the NSF's renewed support, PRAGMA researchers plan to expand activities on several fronts. They hope to build user communities in two new key application areas: geosciences, through iGEON, the new international counterpart to the Geosciences Network (GEON); and microbial metagenomics – decoding the genomes of entire microbial ecosystems. In addition the new funding will allow PRAGMA to extend its reach into countries that are only now deploying advanced networks or doing Grid research, notably New Zealand and Vietnam, as well as Latin American countries such as Mexico, Chile and Costa Rica.

PRAGMA leaders also hope to go beyond the strict confines of the Asia–Pacific region, particularly to exchange know-how with scientists in the UK, the Netherlands, Switzerland and other European countries now investing heavily in Grids.

NATIONAL GRIDS

Swiss join forces to capitalize on Grids

Researchers in Switzerland have launched the Swiss Grid Initiative to bring together academic and research institutions involved in distributed computing projects to support the research community in using Grids. The initiative will also provide a central hub for collaboration and knowledge dissemination in Switzerland, and will represent the interests of the national research community regarding funding bodies, international projects, standardization bodies and industry.

The Enabling Grids for E-sciencE conference in September 2006 provided the setting for the launch of the Swiss Grid Initiative. This brought together representatives from a dozen national and international Grid projects, including initiatives for specific types of applications as well as Grid technology and related infrastructure projects. Pooling these efforts, the initiative aims to become the national driver for Grids, building on the existing structures to provide a national Grid-computing infrastructure for the research community in Switzerland. Driven by science and the computing needs of the scientists, the initiative will act as a central point to connect the various fields involved and to encourage collaboration between computer science and the applications using the Grid infrastructure. The new initiative will also represent the interests of the national research community in other projects and bodies and enable more effective collaboration across borders.

The next step for the Swiss Grid Initiative will be to formalize the interactions between the different projects involved and to set up the organizational structures. This will involve all interested institutions, with the Swiss National Computing Centre and the Swiss Education and Research Network catalysing the effort.

Calendar of events

January
29–2 Feb
OGF19 Chapel Hill, NC, US, www.ogf.org/

February
15–19
AAAS San Francisco, CA, US, www.aaas.org/meetings/Annual_Meeting/

March
1–2
Spanish Conference on e-Science Grid Computing 2007 Madrid, Spain, http://webrt.ciemat.es:8000/e-science/index.html

3–6
WEBIST 2007 3rd International Conference on Web Information Systems and Technologies Barcelona, Spain, www.webist.org/

26–30
IPDPS 2007, Long Beach, CA, US, www.ipdps.org

April
DEISA Symposium 2007, Munich, Germany, www.deisa.org/news_events/future_events.php

23–27
HEPiX 2007 (spring meeting) Hamburg, Germany, www.hepix.org/

23–27
ACAT 2007 Advanced Computing and Analysis Techniques 2007 Amsterdam, The Netherlands, www.nikhef.nl/acat07/

24–27
HealthGrid 2007
Geneva, Switzerland, http://geneva2007.healthgrid.org/

May
7–11
OGF20 and EGEE User Forum
Manchester, UK, www.ogf.org/, www.eu-egee.org/uf2
OGF20 proposal submission deadline: 9 February. EGEE User Forum abstract submission deadline: 31 January

NETWORKS

High-speed communication link connects Milan and Mumbai

The research-networking organization DANTE has launched a high-speed communication link between India and Europe for students and researchers. Co-funded by the European Commission and the Government of India, the new 45 Mbit/s link connects Milan and Mumbai. It draws India into global research and supports Indian academics in collaborative research in high-energy physics with organizations including CERN.

Co-ordinated by DANTE and India's national Education and Research Network (ERNET), the link enables universities and academic and research institutes in India to collaborate globally via the most advanced international research and education network, GEANT2. The connection is facilitated from Europe by Telecom Italia in Milan and from India by VSNL in Mumbai, and augments the global GEANT2 map, which now links the major continents.

ERNET's partnership with GEANT2 is supported by the EUIndiaGrid initiative, which aims to interconnect European Grid infrastructures with projects in India. The link will also be used for collaborating with CERN, connecting European researchers to colleagues at the Tata Institute of Fundamental Research, Mumbai. The majority of traffic already comes from high-energy physics, and when CERN's Large Hadron Collider starts up later in 2007, the experiments will generate huge amounts of data, which will need to be transferred quickly between Europe and India. Dante, ERNET, the EU and CERN are discussing increasing the bandwidth to at least 622 Mbit/s.

ANNIVERSAIRE

L'IN2P3 fête ses 20 ans à Lyon

Le Centre de Calcul de l'Institut national de physique nucléaire et de physique des particules (IN2P3/CNRS) a célébré le 26 octobre le 20ème anniversaire de son implantation à Lyon-Villeurbanne. Classé parmi les grandes infrastructures françaises de recherche, le Centre de Calcul de l'IN2P3 est une unité du CNRS spécialisée dans la fourniture des moyens de calcul et de stockage de données aux chercheurs et ingénieurs impliqués dans les grandes expériences de physique. Il est financé conjointement par le CNRS et le CEA.

A l'heure de la mise en production du LHC, le CC-IN2P3 s'apprête à augmenter considérablement ses ressources de calcul et de stockage afin de répondre aux besoins de traitement de données engendrés par cet instrument unique. En 2010, la puissance de calcul disponible au CC-IN2P3 devra atteindre plus de 35 millions de SpecInt 2000 (soit environ 17 000 processeurs actuels) et une capacité de stockage de douze petaoctets (soit plus de 1000 serveurs de disques).

Cette augmentation des ressources aura un impact considérable sur le CC-IN2P3 puisqu'il est amené à étendre son bâtiment et à doubler la superficie de sa salle technique. Elle permettra à cet équipement de pointe unique en son genre de renforcer encore son rôle aux niveaux national et international, mais également de multiplier les collaborations au sein de la collectivité locale et régionale.

Avec l'essor de l'informatique, d'autres disciplines scientifiques se trouvent aujourd'hui face à des quantités de données importantes et ne disposent pas de l'infrastructure suffisante pour les traiter. C'est pourquoi, depuis quelques années, le CC-IN2P3 fait bénéficier les chercheurs en sciences de la vie et les industriels de ses ressources et de son expertise, ce qui leur permet d'accélérer considérablement leurs travaux et d'entrevoir de nouvelles perspectives de recherche et de développement.

En présence notamment d'Arnold Migus, directeur général du CNRS, et de Robert Aymar, directeur général du CERN, la journée du 26 octobre fut l'occasion de dresser un bilan de ces vingt dernières années et surtout d'évoquer les nouveaux enjeux et les challenges du CC-IN2P3 pour les années à venir.

Workshop engages PCs in accelerator controls

As the capabilities of PCs increase, they are becoming more and more important for the controls community. **Matthew Bickley** of Jefferson Lab reports from a meeting held there that brought together accelerator-controls experts from all over the world.

The 2006 workshop included an interesting poster session. (Photos courtesy Greg Adams, Jefferson Lab.)

Isamu Abe prize winners Sergei Chevtsov, left, and Jianxun Yan, right, with author and conference chair Matthew Bickley.

On 24–27 October accelerator-controls specialists from institutions in North America, Europe and Asia gathered at Jefferson Lab in Newport News, Virginia. They met to discuss the rapidly growing and changing use of personal computers (PCs) in accelerator-control systems at the 6th International Workshop on Personal Computers and Particle Accelerator Controls, PCaPAC2006.

PCs have become increasingly applicable to the control of accelerators, as their computing capacities have increased exponentially over the last 10 years. Capabilities that once required power available only from expensive, small-market systems offered by DEC, Sun or IBM can now be obtained with commodity hardware offered by many vendors. The price:performance ratio presented by any standard PC makes a compelling case for using PC hardware in accelerator controls wherever possible.

The PCaPAC meeting underscored the importance of collaborative control-system development. Several talks focused on additions to three such systems, TINE, TANGO and EPICS. The diverse contributions to these toolkits, both in content and source, demonstrate the power of leveraged software development across a number of facilities.

TINE originated from the desire of the DESY laboratory to give users a unified software bus above disparate underlying platforms. TINE discussions at PCaPAC centred on its interface layers, including address redirection and integration with other control systems.

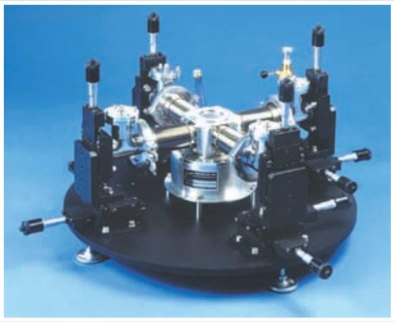
TANGO has been a collaborative effort from its inception. Based on CORBA, this open-source controls toolkit is a registered project in the SourceForge system. The TANGO presentation at the workshop discussed contributions from four TANGO institutions, and mentioned a broad range of new tools, from user-interface applications to code generators and database-integration software.

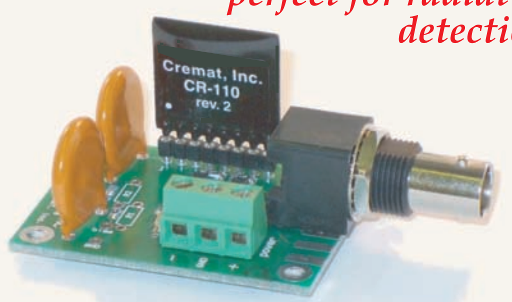
EPICS began at the Los Alamos National Laboratory in the 1980s and includes contributions from dozens of institutions around the world. EPICS-related discussions at PCaPAC included virtual machines at the Spallation Neutron Source, several user tools and implementing a 64-bit .NET interface to the EPICS network protocol.

The workshop also highlighted the increasing reliance on Field-Programmable Gate Array (FPGA) hardware in control systems. The flexibility and power that FPGAs provide are attractive, with capabilities and cost comparable to custom chips, but without their significant development costs. These attributes make a good fit in the controls environment at most laboratories, with their specialized needs and relatively small number of devices.

Participants from a number of institutions discussed the roles that FPGAs play. DESY's Mark Penno talked about their use in the DESY X-ray free-electron laser (FEL) RF-station interlock system, and Giulio Gaio, from the Elettra synchrotron light source, discussed their place in the Libera digital beam-position monitor (BPM) used at Elettra.

Jianxun Yan of Jefferson Lab's FEL facility talked about using FPGAs for the FEL accelerator's BPMs. In this case the FPGAs ▷





are a vital component on the in-house-developed board used for BPM control. Cosylab's Mark Plesko took a broader view, discussing the possibilities of an FPGA that could serve as an entire front-end system. He talked about single chips that could process signals, support a variety of I/O interfaces and include RAM, as well as central processors for executing general control-system software.

The workshop presentations culminated with a talk by Doug Neal, a research fellow from Computer Sciences Corporation. He discussed the direction of Web-based technology development and the implied empowerment of users that results. Neal made it clear that mashups, in which content from multiple websites is integrated by third parties, illustrate the possibilities available to Web users and developers. This in turn heightens their expectations and motivates them to pursue a similar level of flexibility and information integration throughout their computer-based interactions. Given the intelligent, creative nature of control-system users, Neal advocated preparation for the rising tide of expectations ahead. In summary, it was an eye-opening presentation, stressing the importance of meeting high user expectations, which will develop from their experience in the wider virtual world.

To foster the development of new controls scientists, each PCaPAC workshop awards the Isamu Abe prize to controls newcomers who have made substantive, innovative contributions. The prize takes its name from the workshop series' co-founder, Isamu Abe of KEK, who passed away in 2002. It celebrates his lifetime of work and his passion for fostering talented young scientists' careers. At the workshop Sergei Chevtsov from the Stanford Linear Accelerator Center and Yan of Jefferson Lab shared the prize.

Chevtsov won for his work and for his outstanding presentation of the Java-based EPICS archive viewer. He presented the status of the software, highlighting its flexibility and laying out plans for the tool. Yan won for his work and for his presentation, Ethernet Based Embedded System for FEL Diagnostics and Controls. His talk showed the cost benefits and design flexibility available from an integrated system with a dedicated embedded processor.

● Workshop papers and presentations are available online at http://conferences.jlab.org/PCaPAC/program.html. The seventh PCaPAC workshop will be in Italy or Slovenia in autumn 2008.

Résumé

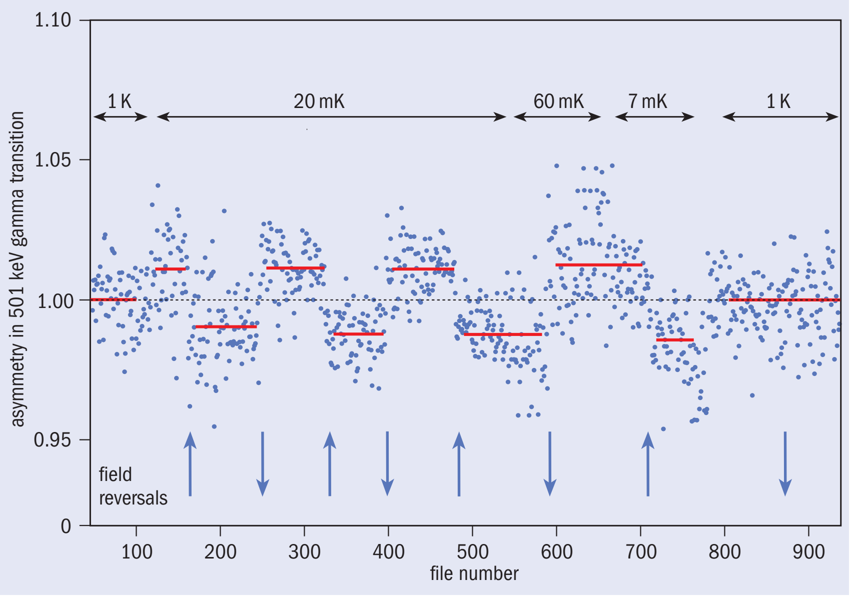
Un atelier sur l'utilisation des PC pour le contrôle des accélérateurs

Avec l'accroissement des capacités des PC, ceux-ci prennent une place de plus en plus importante dans les tâches de contrôle. Matthew Bickley, du Laboratoire Jefferson, rend compte du 6ᵉ Atelier international sur les ordinateurs personnels et les systèmes de contrôle des accélérateurs de particules, PCaPAC2006, tenu en octobre. La réunion du PCaPAC a mis en lumière l'importance du développement de systèmes de contrôle coopératifs. Plusieurs exposés ont porté sur des améliorations apportées à trois systèmes de ce type, TINE, TANGO et EPICS. Les diverses contributions, tant du point de vue du contenu que des sources, apportées à ces boîtes à outils témoignent du poids du développement logiciel démultiplié dans un grand nombre de laboratoires.

Matthew Bickley, *Jefferson Lab*

Recent ISOLDE results revisit parity violation

Results from a recent measurement at CERN's ISOLDE facility are a tribute to the announcement 50 years ago of the first observation of the non-conservation of parity.



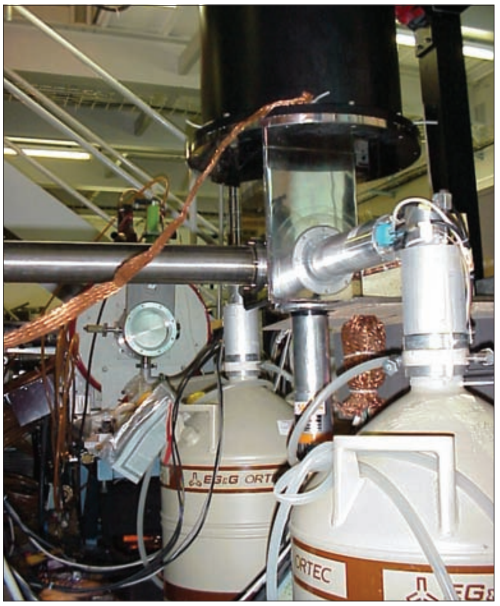


Fig. 1 (left). The asymmetry in the 501 keV transition of ^{180m}Hf at different temperatures. The final field reversal gives a null effect as expected since at 1 K the source is unpolarized. The scatter of the individual points reflects the statistics of each point.
Fig. 2 (right). The dilution refrigerator NICOLE in the ISOLDE hall, with the beam line (to the left), cryostat and Ge detectors visible.

It was 50 years ago last October that Tsung-Dao Lee and Chen Ning Yang suggested that the invariance under mirror reflection that we experience in everyday physical laws – parity symmetry – might be violated on the microscopic scale by the weak interaction (Lee and Yang 1956). They made this truly revolutionary suggestion to solve the so-called $\theta-\tau$ puzzle, which involved two different decay modes of what seemed to be a single particle (now known as the K-meson) and which violated parity conservation. Lee and Yang formulated a description of the weak interaction that enabled parity to be violated, and were later awarded the Nobel prize for their theory.

Proving the theory

Just a few months later, in January 1957, Chien-Shiung Wu of Columbia University and collaborators Ernest Ambler, Raymond Hayward, Dale Hoppes and Ralph Hudson from the National Bureau of Standards in Washington announced that they had successfully confirmed the theory by observing parity non-conservation (PNC) in the beta-decay of a polarized sample of the radioactive ^{60}Co nucleus (Wu *et al.* 1957). PNC has since become a cornerstone of the formulation of the weak interaction and the Standard Model of particle physics, even though its origin remains unexplained.

The experiment used a modified version of a facility at the Bureau of Standards in which the spin of all nuclei pointed in one direction, a feat that required cooling the nuclei in the presence of a magnetic field to a temperature of several millikelvin above absolute zero. Under these conditions, the nuclei decayed under the influence of the weak force and emitted beta particles (electrons) and antineutrinos. In fact, the antineutrinos could not be observed in this system, but the effect on the electrons was measurable. The team showed that, as suggested by the theory of Lee and Yang, the number of electrons emitted in one direction with respect to the nuclear spin direction was significantly greater than the number emitted in the opposite direction, clearly indicating that parity was violated. Had it been conserved, equal numbers of electrons would have been observed in both directions.

Parity violation is characteristic of the weak nuclear force, but the strong nuclear force and the electromagnetic force preserve parity. Since the 1950s, these three fundamental forces in nature have been combined in a single theory – the Standard Model. This model suggests that PNC can also manifest itself in processes that are dominated by the strong and electromagnetic interaction, via the weak interaction part in the nuclear Hamiltonian – but such effects are usually minute and very difficult to observe (Adelberger *et al.* 1985 and Desplanques *et al.* 1980).

In this article we will focus on measurements of PNC effects in bound nuclear systems, where parity mixing occurs between pairs of nuclear states of the same spin as a consequence of the weak part in the Hamiltonian. A PNC effect in a bound system can be written as:

$$PNC_{effect} \propto \frac{|\langle H_{PNC}\rangle| K}{\Delta E}$$

Here $\langle H_{PNC}\rangle$ is the matrix element of the weak Hamiltonian, ΔE is the energy difference between the parity doublet levels and K is a model-dependent amplification factor, related to the ratio between the reduced matrix element of the "normal" gamma decay and the "abnormal" (PNC-enabled) matrix element of the same multipolarity. Table 1 lists several such cases, indicating values of $\langle H_{PNC}\rangle$ and estimates of K for each transition.

Among these cases, the mixing of the levels with spin I=8 in the ^{180}Hf nucleus provides a unique opportunity to study PNC in the electromagnetic and strong sectors, owing to the very large amplification. This amplification, of around 10^9, arises from the details of the nuclear structure, such as the proximity of the 8^+ and 8^- levels to each other, and the very different structure of the 8^- level with respect to the sequence of positive parity levels below, to which it decays (figure 3). In the early 1970s, Kenneth Krane and collaborators at the Los Alamos Scientific Laboratory succeeded in observing parity mixing in the decay of ^{180m}Hf, when they measured a left–right asymmetry of about 1% in the emission of the 501 keV gamma transition (Krane *et al.* 1971a and 1971b).

Revisiting the evidence

This observation has been the only clear-cut demonstration of this type of parity violation until now and, as such, a group of us felt that the case deserved revisiting using the modern techniques of radioactive beams provided by the ISOLDE facility at CERN. During an experiment in October 2005, we produced a beam of ^{180}Hf nuclei in their isomeric (metastable) 8^- level at ISOLDE and implanted it into a magnetized iron foil at around 20 mK inside the NICOLE low-temperature ^{3}He – ^{4}He dilution refrigerator (figure 2).

By detecting the 501 keV decay gamma-rays (figure 4) in two horizontal germanium detectors situated outside the NICOLE refrigerator, fore and aft (0° and 180°) of the polarization direction, we could determine the left–right asymmetry of the decay – a direct consequence, and a direct proof, of PNC. We used another detector, below the beam line at 90° to the axis of polarization, to monitor the 0°/90° ratio that provides a measure of the nuclear polarization and temperature.

The results we obtained show the parity-violating effect in the 501 keV gamma transition (figure 1) in close agreement with the previous experiments. Analysis yields an asymmetry of about 1% (Stone *et al.* 2007) . So the present experiment re-establishes the case of ^{180m}Hf as the prime example of PNC in bound ▷

Table 1

	I	ΔE (keV)	$T_{1/2}$	$\langle H_{PNC}\rangle$	K
^{18}F	0	39	28 ps	<90 meV	112
^{19}F	1/2	110	0.9 ns	380 (100) meV	11
^{21}Ne	1/2	5.7	0.1 ns	<30 meV	296
^{93m}Tc	17/2	0.3	15 μs	0.39 (29) meV	2000
^{180m}Hf	8	57	5.5 h	1.0 (0.1) μeV	2×10^9

Selected previous measurements of PNC effects in bound nuclear systems. K is the amplification factor. ^{180m}Hf stands out as the only case determined with a very high degree of confidence. The magnitude of $\langle H_{PNC}\rangle$ is model-dependent; the errors given reflect only the accuracy of the experiments.

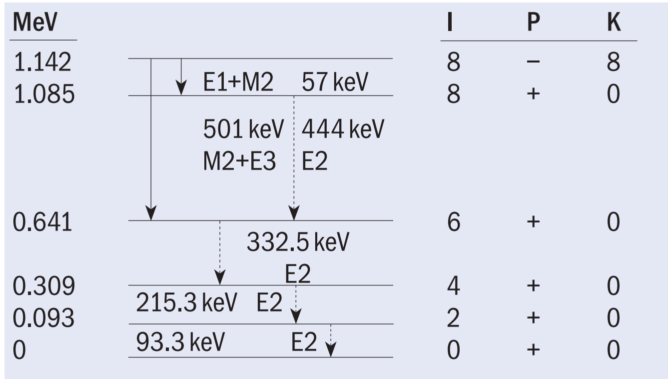


Fig. 3. The level scheme of ^{180}Hf, indicating the 8^-–8^+ doublet, separated by 57 keV and the gamma decay modes. The 8^- level is isomeric with a long half-life of about 5.5 h, due to its K=8 angular momentum projection quantum number. The 501 keV transition exhibits the PNC effect, shown via the parity-violating E2/M2 mixing in addition to "normal" M2/E3 mixing.

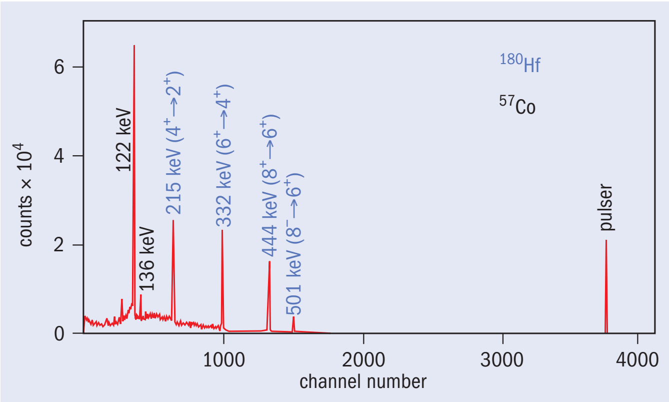


Fig. 4. Gamma-ray spectrum of the decay of the 8^- isomer in ^{180}Hf, showing the gamma-ray cascade to the 0^+ ground state. The pulser peak is used for normalization; the 136 keV transition of ^{57}Co is used as a low-temperature thermometer.

nuclear systems, a fitting tribute, 50 years on, to the work of the pioneering scientists.

Further reading

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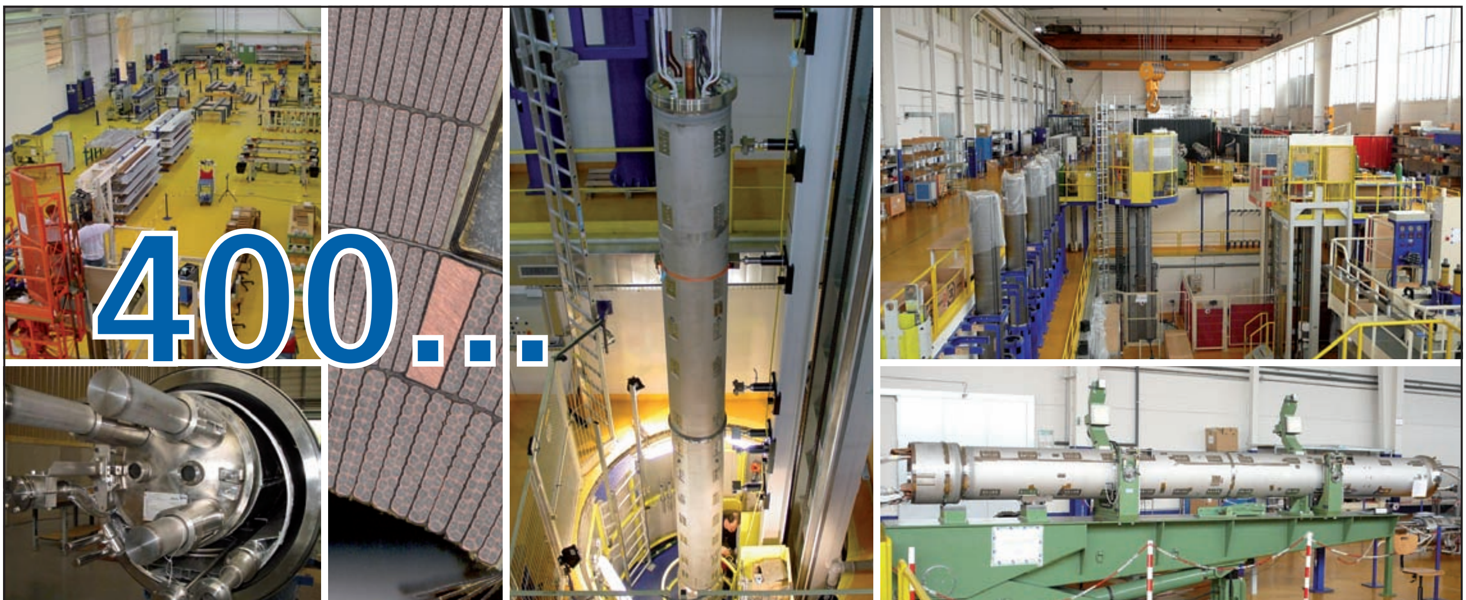
Résumé

ISOLDE se penche sur la violation de parité dans la désintégration γ de ^{180m}Hf

Il y a cinquante ans, le monde de la physique était bouleversé par la découverte de la violation de la parité dans les interactions en raison de la force nucléaire faible. La force nucléaire forte et la force électromagnétique préservent la parité, mais des effets résultant de la non-conservation de la parité peuvent néanmoins être observés dans des processus dominés par des interactions fortes ou électromagnétiques. Certaines désintégrations des systèmes nucléaires liés en sont des exemples. C'est le cas en particulier de la désintégration γ entre deux niveaux de ^{180m}Hf. Les résultats d'une étude récente consacrée à ce processus, réalisée par l'installation ISOLDE au CERN, viennent à point pour célébrer les découvertes de janvier 1957.

Gvirol Goldring *and* **Michael Hass**, *the Weizmann Institute, Rehovot;* **Nathal Severijns**, *University of Leuven;* **Jirina Stone**, *Oxford University and University of Maryland;* **Nicholas Stone**, *Oxford University and University of Tennessee; and* **Dalibor Zakoucky**, *Nuclear Physics Institute, Rez near Prague.*



SN1987A heralds the start of neutrino astronomy

In 1987, detectors recorded a neutrino pulse emitted by SN1987A. **Masayuki Nakahata**, who found the signal in Kamiokande, looks at the ongoing legacy of this historic event.

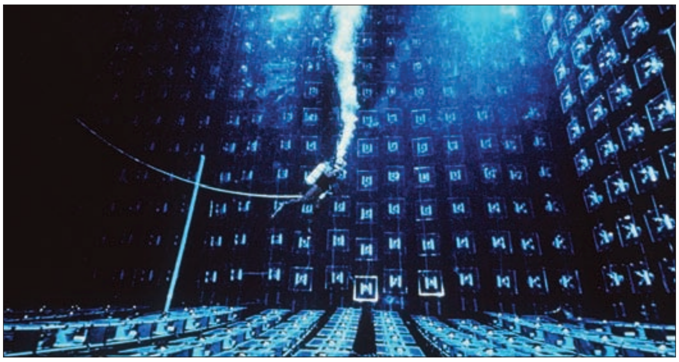


Fig. 1. A diver inspects the photomultiplier tubes of the Irvine–Michigan–Brookhaven detector. (Courtesy IMB Collaboration.)

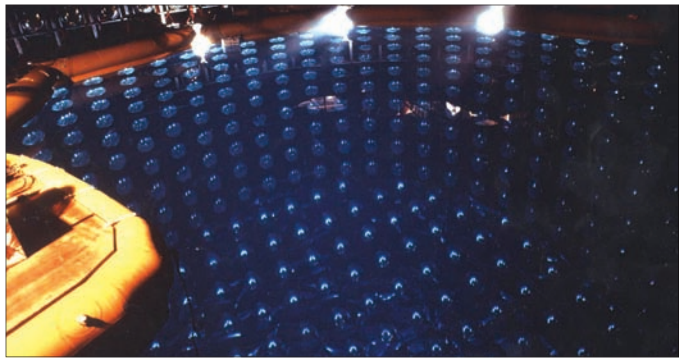


Fig. 2. A view from the top of the Kamiokande water Cherenkov detector in Japan. (Courtesy Kamiokande collaboration.)

Twenty years ago researchers observed neutrinos from the supernova SN1987A – the first detection of neutrinos from beyond our solar system. Underground detectors are now waiting to study the explosion and neutrino properties of the next nearby supernova.

In the early 1980s scientists built the first big detectors underground to search for nucleon decays. Grand unified theories (GUTs), proposed in the late 1970s, unify strong, weak and electromagnetic interactions. They predict that quarks can be transformed to leptons and that even the lightest hadron, the proton, can decay to lighter particles, such as electrons, muons and pions. The predicted lifetime of the proton was then about 10^{30} years, inspiring the construction of detectors weighing several thousand tonnes. The Irvine–Michigan–Brookhaven (IMB) detector in the US, which started data-taking in 1982, was a Cherenkov detector with 7000 tonnes of water viewed by 2048 5-inch photomultiplier tubes (PMTs) (figure 1). It was soon followed by the Kamiokande water Cherenkov detector in Japan. This was a 3000 tonne detector with 1000 20-inch PMTs, and it started up in 1983 (figure 2). Unfortunately, these detectors could not detect a proton decay signal because the lifetime of the proton was ultimately predicted to be much longer than the early GUTs had indicated.

In 1984/5 the Kamiokande collaboration upgraded their detector to look for solar neutrinos. Previously, the only detector searching for solar neutrinos was the Homestake experiment of Ray Davis and colleagues (*CERN Courier* September 2006 p32). The experiment observed a solar-neutrino flux of about a third of that predicted by the standard solar model. This was the famous "solar-neutrino problem", and further experiments were needed to solve the discrepancy. To detect solar neutrinos, the Kamiokande team installed new electronics to record the timing of each PMT. They also constructed an anticounter to reduce gamma rays from the rock and improved water-purification to reduce radon background. The IMB collaboration upgraded their 5 inch PMTs to 8 inch PMTs to lower the detector's energy threshold.

Supernova!

On 23 February 1987 at 0735 (UT), when the Kamiokande detector was ready to detect solar neutrinos, it observed neutrinos from SN1987A. The progenitor of the supernova was a blue giant in the Large Magellanic Cloud, 170 000 light years away. The Kamiokande detector observed 11 events and the IMB detector registered eight. Researchers at the Baksan underground experiment in Russia later analysed their data for the same period and found five events. The neutrino burst observed lasted about 13 s (figure 3 p24).

The theory of stellar evolution predicts that the final stage of a massive star (typically more than eight solar masses) is a core collapse followed by a neutron star or a black hole. As the temperature and density at the centre of stars increase, nuclear fusion produces heavier elements. This leads finally to an iron core of about one solar mass; further nuclear fusion is prevented as iron has the largest binding energy of all elements. When the core becomes gravitationally unstable it triggers the supernova explosion.

The gravitational potential energy of the iron core gives the energy released by the core collapse, which is about 3×10^{53} ergs. Pre- ▷

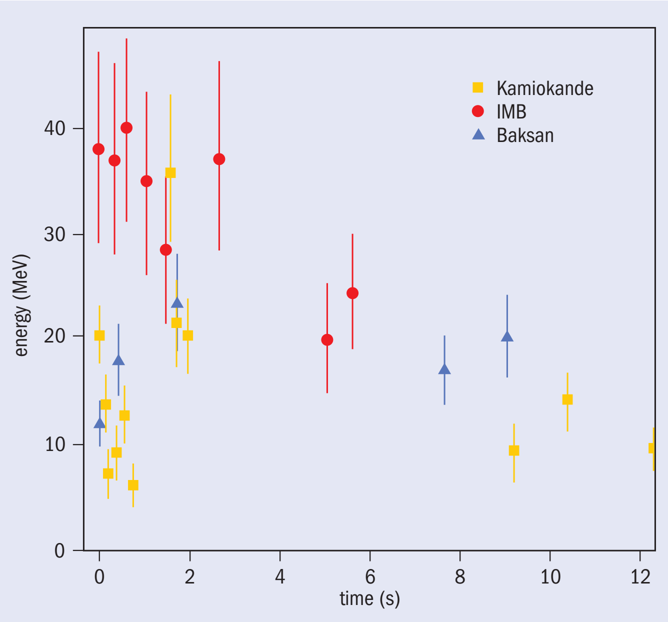


Fig. 3. SN1987A neutrino events observed by Kamiokande, IMB and Baksan showed that the neutrino burst lasted about 13 s.

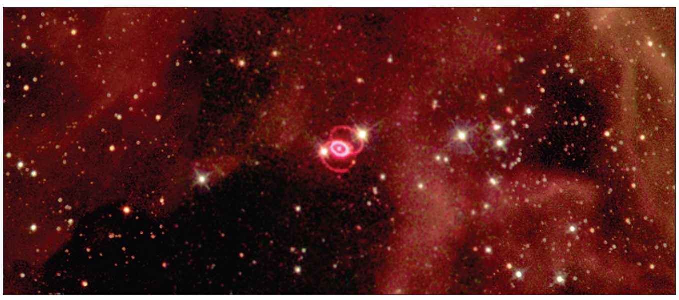


Fig. 4. The Large Magellanic Cloud with SN1987A, centre, in an optical image created from several images of the region taken by the Hubble Space Telescope during the 1990s. (Courtesy the Hubble Heritage Team, AURA/STScI/NASA.)

dictions indicated that neutrinos would release most of the energy, since other particles, such as photons, are easily trapped by the massive material of the star. Researchers used the energy and number of observed events observed by Kamiokande and IMB to estimate the energy released by neutrinos from SN1987A, which was found to agree very well with expectations. This result confirmed the fundamental mechanism of a supernova explosion.

There has been extensive work to simulate the explosion of a supernova, taking into account the detailed nuclear physics and with the recent addition of multi-dimensional calculations. However, no simulation has produced an explosion. Something seems to be missing and further investigation and more experimental data are needed. Although the observation of neutrinos from SN1987A confirmed the supernova scenario, the observed number of events was too small to reveal details of the explosion.

The next event

More recent underground detectors will give very valuable information when the next supernova burst occurs. The Super-Kamiokande detector has a photo-sensitive volume of 32 000 tonnes viewed by 11 129 20-inch PMTs. It can detect about 8000 neutrino events if a burst occurs at the centre of our galaxy (a distance of about 10 kpc). Super-Kamiokande should be able to measure precisely the time variation of the supernova temperature by detecting the interactions of emitted antineutrinos on free protons. Neutrino–electron scattering events, which are about 5% of the total events, should pinpoint the direction of the supernova.

The kilotonne-class liquid-scintillator detectors, LVD in the Gran Sasso National Laboratory and KamLAND in Japan, will give additional information as they have a lower energy sensitivity and contain carbon. The IceCube detector, currently being built at the South Pole, can detect a supernova neutrino signal as a coherent increase of their PMT dark rate (*CERN Courier* May 2006 p24).

Although the supernova rate expected in our galaxy is only one every 20–30 years, a detection would provide an enormous amount of information. Scientists are proposing megatonne-class water Cherenkov detectors to detect proton decay and investigate neutrino physics, for example CP-violation in the lepton sector (*CERN Courier* July/August 2005 p18). If such detectors are built, they could observe a supernova in nearby galaxies every few years.

Supernovae have occurred throughout the universe since just after the Big Bang. The flux of all supernova neutrinos, known as supernova relic neutrinos (SRN), is intriguing. The expected flux of SRN is about several tens per square centimetre per second. The first five years of data from Super-Kamiokande gave an upper limit on the flux about three times higher than this expectation. By improving detection, it may soon be possible to detect SRN.

The neutrino data of SN1987A also yielded data on elementary-particle physics. It provided a limit on the mass of the neutrino of less than 20 eV/c^2 (which in 1987 was competitive with laboratory experimental limits) and an upper limit on the neutrino lifetime. Future supernova data could provide something new in elementary-particle physics, for example, if the neutrino-mass hierarchy is inverted and a close supernova is detected, the energy spectrum of supernova neutrinos could reveal the hierarchy.

● A conference to discuss supernova data from the past 20 years and what could be learned from a future supernova will be held at Waikoloa, Hawaii, on 23–25 February 2007. For further information see http://sn1987a-20th.physics.uci.edu/.

Résumé

SN1987A et la naissance de l'astronomie des neutrinos

Le 23 février 1987, des détecteurs terrestres ont enregistré des signaux provenant de neutrinos émis par la supernova SN1987A – c'était la première fois que des neutrinos provenant de l'extérieur de notre système solaire étaient détectés. Dans cet article, Masayuki Nakahata, qui a découvert le signal dans le détecteur Kamiokande, au Japon, évoque cet événement historique et ce qu'il a révélé sur les supernovas. Il évoque aussi les détecteurs souterrains qui attendent actuellement la prochaine supernova à proximité. Un tel événement serait l'occasion, non seulement d'observer de près ce type d'explosion, mais aussi d'étudier les propriétés des neutrinos et de détecter des neutrinos émis par de précédentes supernovas.

Masayuki Nakahata, *ICRR, University of Tokyo.*

Quadripôles: un transfert réussi vers l'industrie

Le dernier quadripôle principal pour le LHC a été livré au CERN. La fabrication de ces aimants complexes, dans le cadre de la contribution exceptionnelle de la France au LHC, est le fruit d'une collaboration entre le CERN et le CEA-Saclay, et d'un transfert de technologie dans l'industrie.

Joël Touet du CEA-Saclay examine un bobinage chez ACCEL lors du lancement de la production dans l'entreprise allemande.

Mi-novembre 2006, la 392^{e} et dernière masse froide d'un quadripôle principal du LHC était livrée au CERN. L'arrivée de cet aimant destiné à focaliser les faisceaux du LHC concluait une collaboration de 17 ans entre le CERN, le CEA-Saclay et l'industrie européenne.

La conception, les essais et la fabrication des aimants quadripôles du LHC ont été réalisés dans le cadre de la contribution exceptionnelle de la France au LHC. En 1996, le CERN, le CEA et le CNRS signaient un protocole d'accord pour le futur grand accélérateur en présence du Ministre Français de l'Education nationale et du Secrétaire d'Etat à la recherche. Au terme de cet accord, le département Dapnia du CEA-Saclay réalisait l'étude, la fabrication de trois prototypes, le lancement de la production dans l'industrie et le suivi de la fabrication des masses froides des sections droites courtes. Le CNRS prenait en charge l'étude des cryostats et de l'assemblage des sections droites courtes (p27).

En réalité, l'accord venait formaliser une collaboration entamée à la fin des années 80, reposant sur le savoir faire du CEA éprouvé avec la fabrication des quadripôles supraconducteurs de la machine HERA de DESY à Hambourg. À partir de 1989, deux prototypes de quadripôles avaient été conçus par le CEA-Saclay, dont l'un avait été testé au sein de sa section droite courte dans la première chaîne de test du LHC dès 1994. La signature de l'accord de collaboration donnait toutefois un nouvel élan à la collaboration. Le CEA et le CNRS s'engageaient sur une importante contribution en ressources humaines: 200 hommes-an étaient dévolus à quatre domaines techniques spécialisés, dont 75 hommes-an du CEA pour les masses froides des quadripôles. A la fin de la collaboration, la contribution du CEA-Saclay pour les quadripôles se sera en réalité élevée à 92,5 hommes-an.

Fin 1996, les paramètres des aimants quadripôles étaient définis. Une particularité de ces aimants tient à leur grande variété. Les 360 masses froides des arcs comptent 40 variantes et les 32 unités destinées aux régions de suppression de dispersion comptent 16 variantes. Cette diversité est due aux multiples combinaisons d'aimants correcteurs montés aux deux extrémités des quadripôles, à l'intérieur des masses froides. De surcroît, les quadripôles peuvent avoir une fonction focalisante ou défocalisante. Enfin, les interfaces vers le cryostat et vers la ligne d'alimentation en hélium liquide diffèrent également.

Cette complexité et les évolutions de la machine dans son ensemble expliquent que l'appel d'offre dans l'industrie n'ait été lancé que trois ans plus tard, fin 1999. A son terme, l'entreprise allemande ACCEL Instruments s'est vue attribuer la construction des aimants quadripôles et leur assemblage dans leur masse froide. Pour accueillir cette production, ACCEL a spécialement transformé deux immenses halls industriels désertés, à Troisdorf près de Bonn. Une fosse de huit mètres de profondeur a été creusée et aménagée afin d'assurer l'assemblage des masses froides à la verticale.

L'outillage et les procédures de fabrication avaient été développés pendant la première phase de la collaboration. Pour préparer la fabrication en série dans l'industrie, le CEA-Saclay avait en effet écrit les spécifications pour les outillages de bobinage, de frettage des ouvertures et d'assemblage des culasses ainsi que pour le montage des composants dans leur masse froide. Des méthodes de vérification avaient été développées avec le CERN. Dès avril 2001, le CEA-Saclay débutait le transfert de la technologie et de l'outillage développés pour les cinq premières masses froides.

La production d'une masse froide consiste à bobiner quatre bobines supraconductrices, puis à les fretter dans des colliers en inox qui doivent résister aux forces électromagnétiques. Les performances de l'aimant dépendent de la précision et de la qualité du bobinage et du frettage. Le bobinage doit être réalisé avec une précision de l'ordre de la vingtaine de micromètres pour le positionnement du conducteur sur une longueur de 3,2 mètres. Deux ouvertures frettées sont montées dans une culasse com- ▷

A gauche: l'assemblage des masses froides de six mètres de long est réalisé verticalement. Les aimants correcteurs et le quadripôle avec les bus-bars sont alignés avant que le tube d'inertie en acier ne soit glissé autour. A droite: en décembre 2004, des membres du CERN, du CEA-Saclay et les employés d'ACCEL fêtent la production de la centième masse froide de quadripôle.

Le projet en chiffres

- 5 ans de production.
- 10 ans de collaboration.
- 56 variantes toutes catégories.
- 92,5 hommes-an pour le CEA.
- 392 masses froides avec quadripôles.

mune constituée de tôles poinçonnées en acier à faible teneur en carbone. Afin d'augmenter sa capacité de production, ACCEL s'est équipé d'outillages supplémentaires. L'étape la plus délicate était d'obtenir des bobines régulières avec ces nouveaux outillages. Le transfert de savoir-faire et le suivi de la production impliquaient une présence régulière des experts du CEA dans l'entreprise. Deux techniciens du CEA-Saclay ont assuré le transfert de technologie chez ACCEL. De même, le démarrage de la fabrication a été suivi par deux techniciens en permanence et un ingénieur du CEA-Saclay une semaine sur deux.

Les aimants et les masses froides ont été soumis à des mesures électriques et mécaniques après chaque étape de fabrication. Avant la livraison, des tests de pression et d'étanchéité ont été exécutés avec un équipement spécifique. Un système de gestion des non-conformités constituait un outil important du suivi de fabrication. Néanmoins, le délai de plusieurs semaines entre la fabrication et le test d'un aimant à froid au CERN rendaient les corrections d'erreurs difficiles. Pendant ce laps de temps, de nombreuses masses froides étaient fabriquées. Toute déviation devait donc être connue le plus tôt possible pour être corrigée.

Mi-2002, le premier aimant quadripôle sortait de l'usine. Testé au CERN, il démontrait d'excellentes performances. Alors que le courant nominal requis est de 11 870 ampères, la première transition résistive (quench) survenait à 12 631 ampères. Ce premier essai confirmait la fiabilité de la conception et autorisait la poursuite de la fabrication de série.

La production de composants aussi complexes n'a pas été pour autant sans mal. La montée en cadence a en partie été retardée par des délais de livraison des composants fournis par le CERN et ses contractants. Une grande partie de ces composants – le câble supraconducteur, le métal des colliers et des culasses, les aimants correcteurs, les bus-bars et les diodes – étaient en effet fabriqués par d'autres firmes et laboratoires et ont subi des aléas de qualité et de délais. Alors que la fabrication était à mi-parcours, les tests ont fait apparaître des valeurs de perméabilité magnétique trop élevées de l'acier austénitique pour environ 10% des colliers de frettage. La décision de choisir astucieusement la position dans la machine des aimants incriminés, afin que les effets parasites s'annulent, a permis de limiter le retard. Le fournisseur de l'acier a amélioré la qualité des tôles pour les lots de colliers suivants.

Au plus fort de la production, quatre masses froides étaient produites chaque semaine. En décembre 2004, la livraison de la 100^{e} masse froide était célébrée. En novembre 2006, 10 ans après la signature de l'accord de la collaboration CERN–CEA, et six ans après celle du contrat avec ACCEL, la production des masses froides des quadripôles principaux du LHC était terminée.

L'étroite collaboration entre le CEA-Saclay et le CERN a été le moteur de ce succès. Les deux laboratoires ont combiné leur expertise et savoir-faire dans un esprit de confiance mutuelle et en respectant des procédures de contrôle de la qualité bien élaborées. Les difficultés techniques ont ainsi pu être surmontées et la technologie innovante de fabrication a pu être transférée à une entreprise industrielle qui s'est montrée volontaire et tout à fait capable d'exécuter cette fabrication complexe.

Summary

Quadrupoles: a successful transfer to industry

The last cold mass for a main quadrupole magnet for the Large Hadron Collider arrived at CERN in December, concluding 17 years of collaboration with the CEA in Saclay in the context of the special contribution of France to the LHC project. CERN and the CEA first developed these magnets to focus the LHC beams before transferring the technology to industry. The German company ACCEL then took care of the production process. The design and manufacturing were complicated because of the large variety of configurations for the 392 cold masses, and there were delays in the supply of components. Nevertheless, thanks to a strong collaboration, the difficulties were overcome.

Jean-Michel Rifflet, *CEA-Saclay, DSM-Dapnia et* **Theodor Tortschanoff**, *CERN.*

SSS: le pari gagnant de la collaboration

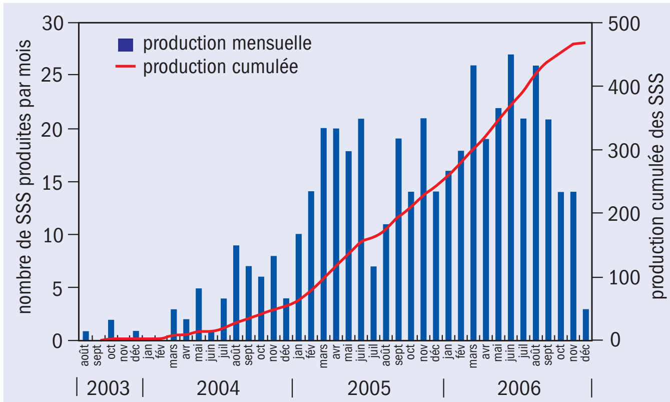
Réalisée dans le cadre de la contribution exceptionnelle de la France au LHC, la conception des sections droites courtes (SSS) est le fruit d'une collaboration entre le CNRS et le CERN. La production industrielle, réintégrée sur le site du CERN, prend fin.

Les dernières des 474 sections droites courtes du LHC sont en cours d'achèvement sur le site de Prévessin du CERN. La réussite de cet assemblage, qui a débuté il y a quatre ans, est le fruit d'un travail étroit entre le CERN et ses partenaires industriels. Elle marque également l'aboutissement d'une collaboration de 10 ans entre le CERN et le CNRS.

Les sections droites courtes (appelées SSS de l'Anglais Short Straight Sections) sont les assemblages contenant les quadripôles supraconducteurs principaux de focalisation du LHC, fabriqués par l'entreprise allemande ACCEL (p25), ainsi que les quadripôles d'insertion assemblés au CERN. En plus de ces aimants principaux, les SSS intègrent une grande variété d'aimants correcteurs, de systèmes d'instrumentation et de diagnostic, d'amenées de courant, de composants de cryogénie et du vide.

Intégrer tous ces éléments dans l'espace étroit des cryostats, tout en respectant les spécifications rigoureuses de charges thermiques sur le système cryogénique, constituait un défi pour les ingénieurs et dessinateurs du CERN et du CNRS. La conception était également rendue complexe par les mouvements au sein du cryostat. Les contractions thermiques causées par les variations de température (les aimants du LHC sont refroidis à 2 K) entraînent en effet des mouvements des composants. La stabilité et le positionnement géométrique précis de l'ensemble doivent pour autant être respectés. Etant donné le nombre important d'unités à assembler, un autre défi tenait au développement de méthodes d'assemblage à l'échelle industrielle. Enfin, un plan d'assurance-qualité très complet devait être mis en oeuvre pour s'assurer du respect des spécifications.

Après l'approbation du projet LHC en décembre 1994, la conception finale des SSS a débuté en février 1996 avec la signature par le CERN et les deux instituts français CEA et CNRS d'un protocole de collaboration prévoyant plusieurs accords techniques d'exécution. Le premier accord, entre le CEA de Saclay et le CERN, portait sur la réalisation des masses froides des quadripôles supraconducteurs (p25). Le deuxième accord, entre l'IN2P3 du CNRS et le CERN, couvrait la conception industrielle des cryostats des SSS et de tous les équipements nécessaires à leur assemblage, réalisée par le bureau d'études de la division accélérateur de l'Institut



Ce diagramme montre la montée en cadence de l'assemblage des sections droites courtes, suivant une lente courbe d'apprentissage tout au long des quatre années de production.

de physique nucléaire (IPN) d'Orsay.

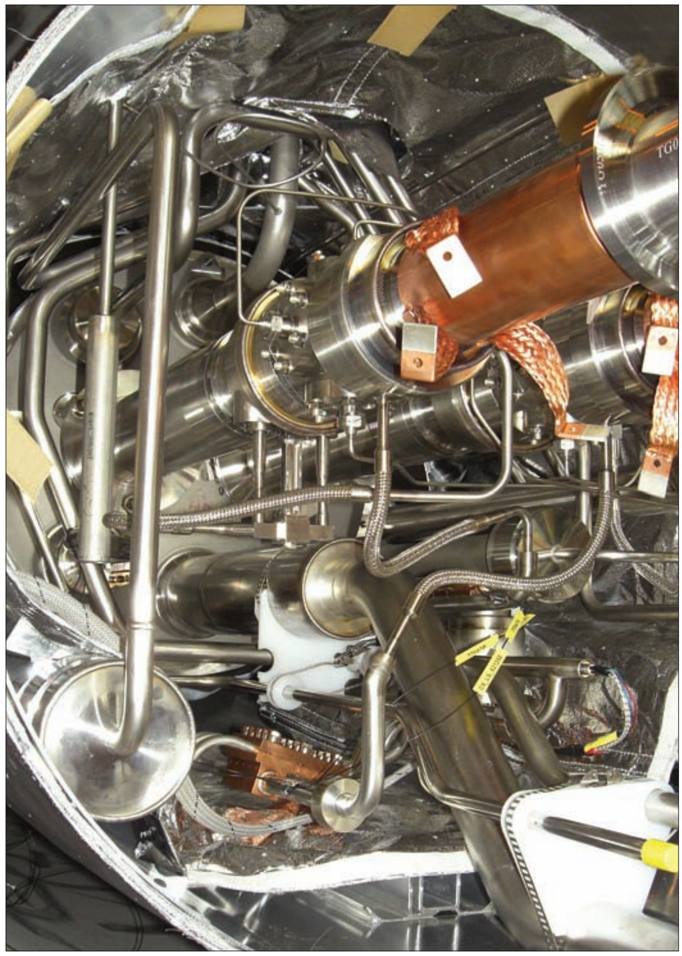
Dans le cadre de ce deuxième accord, le CERN pouvait tirer parti de ses compétences dans la conception de cryostats et de son expérience acquise lors de la réalisation des deux premiers prototypes de SSS testés dans la première chaîne de test du LHC dès 1994. Le CERN avait la responsabilité de définir les paramètres principaux de la conception et du pilotage du projet. Le CNRS, s'appuyant sur ses ressources en ingénierie et son bureau d'étude, avait comme mission l'étude de détail du cryostat, l'étude des outillages d'assemblage des SSS, la participation à la réalisation de deux prototypes pour la deuxième chaîne de test du LHC, le lancement et la participation au suivi des fabrications et des assemblages de série.

Les sections droites courtes comprennent un grand nombre de variantes et leur assemblage est complexe. Les 474 unités comptent 60 types de cryostats, ce qui donne, en ajoutant les différentes masses froides, au total 136 variantes. Pour documenter un tel ensemble, le CNRS a produit au total plus de mille dessins techniques et une quarantaine de documents, des notes de calcul aux spécifications. Tous ces documents ont été validés par les ingénieurs du CERN et sont aujourd'hui disponibles dans le sys- ▷

Le projet SSS en chiffres

- 4 ans de chantier d'assemblage au CERN et 50 techniciens et ouvriers en pic de production.
- Plus de 5 km de soudures étanches sur les circuits cryogéniques.
- 10 ans de collaboration.
- 100 hommes-an (65 pour le CNRS et 35 pour le CERN).
- 474 SSS et 136 variantes.
- Plus de 1000 dessins techniques.

La production des sections droites courtes a été réintégrée au CERN. Le hall d'assemblage, surnommé «Legoland» du fait des multiples variantes de sections droites courtes à assembler, a compté jusqu'à 50 ouvriers et techniciens.



Cette vue d'une extrémité d'une section droite courte dans son cryostat laisse entrevoir la complexité de l'assemblage, avec les dizaines de connexions à réaliser pour les systèmes électriques, du vide, de cryogénie ou les moniteurs de position de faisceaux autour des tubes de faisceaux.

tème informatique de gestion de données d'ingénierie.

Pour faire face à la complexité du projet et combler les difficultés liées à la distance entre le CERN et l'IPN d'Orsay, l'utilisation des technologies de l'information pour la gestion de projet s'est avérée indispensable. Le CERN a mis au point des moyens informatiques de communication, d'approbation et d'archivage des documents et de gestion des données très adaptés à ce travail de collaboration à distance. Ces outils, tels qu'EDMS (Engineering Data Management System), CDD (CERN Drawing Directory), les routines informatiques pour le transfert de dessins CAO et la transformation en format HPGL, ont largement été utilisés. Un rôle crucial a été rempli par les réunions de revue de projet, qui se sont déroulées tout au long de la collaboration, et qui ont permis, à chaque étape critique, d'en assurer le pilotage.

A l'automne 2002, suite à l'insolvabilité de l'entreprise allemande BDT en charge de la fabrication et de l'assemblage des SSS, le CERN a repris le travail à son compte. Cette décision stratégique majeure d'internaliser l'assemblage sur son site permettait d'éviter les inévitables retards engendrés par le lancement d'un deuxième appel d'offre. Un ancien atelier du CERN fut réaménagé en quelques mois, devenant opérationnel à l'automne 2003. Pendant que le CERN reprenait en main l'approvisionnement des composants fabriqués dans une dizaine de sociétés européennes, une petite équipe d'ingénieurs et de techniciens du Laboratoire européen se chargeait d'organiser l'atelier, de planifier la production, d'élaborer les procédures d'industrialisation et de rédiger le plan d'assurance qualité. L'exécution du travail, dans le cadre d'un contrat à obligation de résultats, fut confiée au consortium ICS, déjà en charge de l'assemblage au CERN des cryostats des aimants dipôles du LHC. Deux sociétés furent choisies pour le contrôle qualité: l'Institut de Soudure français, pour contrôler la conformité des soudures, et le consortium Air Liquide-40/30, pour vérifier l'étanchéité des circuits cryogéniques et du vide.

L'assemblage d'une section droite courte consiste essentiellement à introduire une masse froide, préalablement équipée d'écrans thermiques, dans une enceinte à vide qui isole thermiquement les aimants opérant à 2 K. Mais le travail le plus important consiste à intégrer des composants spécifiques à chaque SSS. Les composants à assembler sont préalablement inspectés, testés et préparés en kits selon le type de section à assembler. Cette approche valut au chantier le qualificatif humoristique de «Legoland». Gérer les stocks de plus de 400 sortes de composants à combiner selon

136 types d'assemblages s'est avéré un vrai casse tête, justifiant la mise en place d'une plate-forme logistique dédiée, pilotée par trois personnes à temps plein. Les techniques d'assemblage couramment employées sont le montage mécanique, les travaux de chaudronnerie, le soudage TIG et MIG sur acier inoxydable et aluminium, le brasage cuivre/inox ou le brasage de câbles supraconducteurs.

Jalonnant la phase d'assemblage, les inspections et les tests intermédiaires nécessaires pour valider la qualité du travail comportent des contrôles géométriques, des tests de continuité et d'isolation sur les circuit électriques des aimants et leur instrumentation, des tests de polarité des aimants pour dépister les erreurs de câblage, des inspections de soudure (visuelles et aux rayons X). Des tests d'étanchéité des circuits de cryogénie et du vide sont également menés à l'aide de détecteurs à spectrométrie de masse d'hélium. Plus de 5 km de soudures étanches pour les circuits cryogéniques et plus de 2500 tests d'étanchéité ont été réalisés. Les tests ont permis de localiser et de réparer 73 fuites. Ce plan d'assurance qualité rigoureux a permis d'intercepter plus de 550 non-conformités critiques aussi bien au cours de l'assemblage qu'à la réception des composants.

La figure (p27), illustrant le rythme de production des SSS en fonction du temps, montre clairement la courbe d'apprentissage jusqu'à la maîtrise des procédés d'assemblage et de l'organisation de la production: une seule section droite courte était assemblée par mois en 2003, contre 20 au moins par mois en 2006. L'assemblage de chaque SSS durait entre deux et quatre semaines, selon la complexité. Lorsque l'activité a atteint son pic, 50 personnes, ouvriers et techniciens, étaient présentes dans l'atelier.

L'aboutissement de ce projet marque la fin d'une expérience très riche et unique. La durée de 10 ans de la collaboration, la complexité du LHC et les technologies de pointe auxquelles il a fallu faire appel ont constitué autant de défis pour la gestion technique, la gestion des ressources et la coopération des équipes entre deux instituts culturellement et géographiquement éloignés. Le défi de l'internalisation de l'assemblage a été gagné, prouvant qu'il est possible de mener à bien un travail industriel au sein même d'un laboratoire de recherche. Cette réintégration de l'assemblage au CERN, redoutée au début, a vite montré ses atouts: en ayant un accès immédiat et permanent à l'atelier, le CERN a pu anticiper et exercer un pilotage réactif, gage du succès.

Summary

SSS: a collaborative winning gamble

The last of the 474 short straight sections (SSS) for the LHC have been assembled at CERN. These sets of magnets to focus the beams contain, among others, the main superconducting quadrupoles, and they have been developed and produced in the context of the special French contribution to the LHC project. CNRS (Institut de physique nucléaire d'Orsay) designed and assembled the 136 variations of SSS in collaboration with CERN. More than a thousand technical drawings were needed to document the project. Following the insolvency of the company in charge of production, CERN took over the assembly, showing that a laboratory could successfully lead industrial work.

Vittorio Parma, *CERN*

Rooted in symmetry: Yang

During his latest visit to CERN, Nobel laureate **Chen Ning Yang** talked to *CERN Courier* about s

Chen Ning Yang first came to CERN in 1957, the year he shared the Nobel Prize in Physics with Tsung-Dao Lee for their proposal that the weak interaction violates parity symmetry – at a fundamental level, the mirror symmetry between left and right is broken. Almost 50 years later, Yang was again at CERN speaking to a packed auditorium about his thoughts on the important themes in physics over the second half of the 20th century. He can do so with authority: he not only knew great physicists such as Wolfgang Pauli and Paul Dirac, but he has also made many fundamental contributions to physics from the 1950s onwards.

When Yang arrived at CERN in 1957 the theory group was housed in a hut at Cointrin by the villa visible still behind fences surrounding the airport, and he recalls meeting people such as Jack Steinberger, Oreste Piccioni and Bruno Ferretti. But the visit also had a personal significance for Yang, who had lived in the US for 12 years, having left his native China in 1945. In the US he had gained his PhD, working under Edward Teller at Chicago University, and by 1957 he was married with a six-year-old son. It was a time of difficult relations between China and the US, with no possibility for Yang and his new family to meet with his parents in either country. However, the trip to Geneva offered Yang the opportunity to arrange for his father to come from China for a six-week visit and meet his wife and son. This happy experience was repeated on further visits to CERN in 1960 and 1962.

Throughout his long career Yang made many contributions to physics, achieving two of his best-known contributions to particle physics – Yang–Mills theory and parity violation – by the time he was 34. Yang says that he was fortunate to come into physics when the concept of symmetry was beginning to be appreciated.

In the 1920s people did not like the concept of symmetry, as they were sceptical of its new mathematics of groups – there were those who even talked of "the group pest". But in the 1930s physicists began to realize that symmetry was necessary to describe atomic physics; in particular, symmetry groups explained the structure of the Periodic Table. By the 1940s its application had extended to nuclear and particle physics.

Yang worked on group theory for his PhD thesis under Teller, and this firmly anchored his interest in groups and the emerging field of symmetry in particle physics. He now reflects: "When young, the best thing that you can do is to launch yourself into a field that is just beginning." This is exactly what Yang did.

Yang–Mills theory

By 1954 he had written with Robert Mills what he still regards as his most important paper, laying out the basic principles of what has become known as Yang–Mills theory. The theory is now a cornerstone of the Standard Model of particle physics, but at the time it did not agree with experiment. "We couldn't escape the question

Above: Yang at the site of the CMS detector with spokesperson-elect Jim Vi
Above right: Yang delivering his colloquium. Right: at lunch theorist André M
illustrates a point while Yang and Jack Steinberger (right) listen attentively.

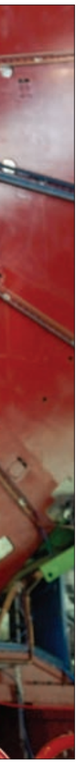
of the mass of the spin-1 particles that come out of it," recalls Yang, "although we did discuss it at the end of the paper and implied that there may be other reasons for the mass not being zero." So why did they write the paper? Yang says that he appreciated the beauty of the structure and believed that it should be published. Samuel Goudsmit, who together with George Uhlenbeck had discovered the electron's spin, was the editor and speedily published the paper.

On the subject of his Nobel prize-winning work with Lee, Yang says he was very proud of the paper on parity violation. "It caused a great sensation because of its 'across the board' character," he recalls. "It was relevant to nuclear physics as well as high-energy physics. There were hundreds of experiments in the following two years." The paper was published on 1 October 1956, and on 27 December C S Wu and her colleagues had the results that demonstrated that the parity is violated in weak decays. Yang says that Wu contributed more than just her technical expertise: "She did not believe the experiment would be so exciting, but believed that if an important principle had not been tested, it should be. No-one else wanted to do it!"

Since 1957 Yang has visited CERN many times and has seen

reflects on a life of physics

some of his early work, his impressions of the LHC and his thoughts about the future of physics.



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Martin

the latest accelerator installations, each larger and more complex than the previous generation. This time he was taken to see preparations for ATLAS and CMS, the huge general-purpose detectors being built for the LHC. Yang says that seeing these installations is "very educational for a theorist who doesn't tangle with these complex detectors and the engineers who are putting it all together". He was "more than impressed" he says: "It is quite unbelievable. My only regret is that I may not be around to see the results."

The changing face of particle physics

As the detectors become larger and more complex they are also being built and run by physicists and engineers who are collaborating on a very large scale. How particle physics is done has changed a great deal in the 50 years since Yang's first visit to CERN. "Now group members are named by countries," Yang says. "We have progressed from teams of colleagues in an institute, to several institutes, to several countries." At CMS in particular he was impressed by all the young people from different countries who were participating in data-taking tests during his visit.

Looking to the future, Yang believes that astronomy is going to be an exciting field because so many peculiar aspects not yet understood will provide many opportunities for exploration. More fundamentally, he thinks that while the nature of physics has changed in the 21st century it will continue to thrive, resulting in important contributions to science.

So what of high-energy physics? Is it coming to an end? Yang believes that the type of particle physics studied over the past 50 years is not likely to continue for two reasons: one external and one internal. He points out that his generation was fortunate in that they launched into the unknown where there was a great deal to be discovered. Now, he says, we have reached marvellous collaboration efforts with the LHC, but there are limits to what governments will support. This is the external factor: funding will limit expansion unless there is some bright new idea. "We need to reduce the budget by a factor of 10," he says.

As for the internal factor, he sees that the subject faces more difficult mathematical structures. He notes that field theory today has become highly nonlinear and is very difficult compared with what was thought to be difficult in the 1940s.

In the meantime, what does he think will be the most important discovery at the LHC? "Everybody is focusing on the Higgs and most feel it will be discovered," he observes. "But," he adds, "it may be more exciting eventually if it is not discovered."

Further reading

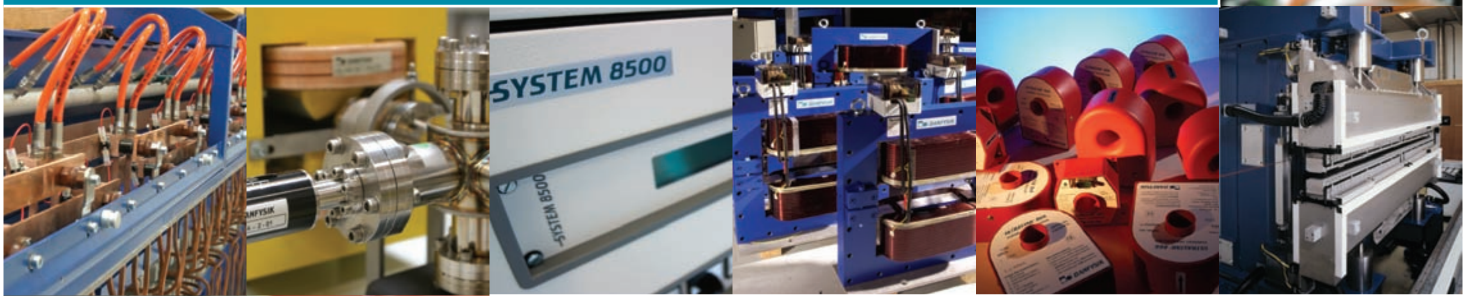
Yang's colloquium at CERN, "Thematic melodies of twentieth century theoretical physics: quantization, symmetry and phase factor", is available on the Web at http://agenda.cern.ch/fullAgenda.php?ida=a063396.

Résumé

Une vie consacrée à la physique: Chen Ning Yang

Chen Ning Yang est venu pour la première fois au CERN en 1957, année où il a reçu le prix Nobel de physique conjointement avec Tsung-Dao Lee pour leur découverte de la violation de parité dans l'interaction faible. Près de 50 ans plus tard, Yang est revenu au CERN, où il a présenté une conférence dans un amphithéâtre bondé, donnant son point de vue sur les grands thèmes de la physique de la deuxième moitié du XX^{e} siècle. Au cours de sa longue carrière, il a apporté de nombreuses contributions à la physique. Il a formulé ses deux théories les plus célèbres – la théorie Yang-Mills et la violation de la parité – avant l'âge de 34 ans. Au cours de sa visite, il a évoqué pour CERN Courier *ces travaux de jeunesse; il a aussi donné ses impressions sur le LHC et sur l'avenir de la physique.*

Christine Sutton, *CERN.*



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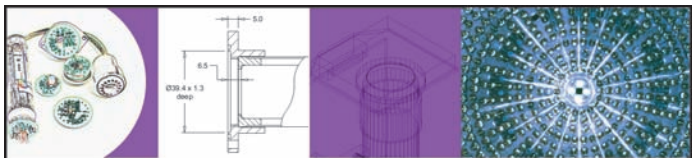


photomultipliers
photomultiplier accessories

Physicists gather for an extravaganza of beauty

Lively discussions and precise measurements dominated Beauty 2006, the latest international conference on B-physics. **Neville Harnew** and **Guy Wilkinson** report.

The 11th International Conference on B-Physics at Hadron Machines (Beauty 2006) took place on 25–29 September 2006 at the University of Oxford. This was the latest in a series of meetings dating back to the 1993 conference held at Liblice Castle in the Czech Republic. The aim is to review results in B-physics and CP violation and to explore the physics potential of current and future-generation experiments, especially those at hadron colliders. As the last conference in the series before the start-up of the LHC, Beauty 2006 was a timely opportunity to review the status of the field, and to exchange ideas for future measurements.

More than 80 participants attended the conference, ranging from senior experts in the heavy-flavour field to young students. The sessions were held in the physics department, with lively discussions afterwards. There were fruitful exchanges between the physicists from operating facilities and those from future experiments (LHCb, ATLAS and CMS), with valuable input from theorists.

The conference reviewed measurements of the unitarity triangle, which is the geometrical representation of quark coupling and CP-violation in the Standard Model. The aim is to find a breakdown in the triangle through inconsistencies in the measurements of its sides and its angles, α, β and γ (φ_2, φ_1 and φ_3), as determined through CP-violating asymmetries and related phenomena.

The statistics and the quality of the data from the first-generation asymmetric energy e^+e^- B-factories are immensely impressive. The BaBar and Belle experiments, at PEPII and KEKB respectively, passed a significant milestone when they reached a combined integrated luminosity of $1000\,fb^{-1}$ ($1\,ab^{-1}$), with 10^9 $b\bar{b}$ pairs now produced at the $\Upsilon(4S)$. The experiments are approved to continue until 2008 and should double their data-sets.

The B-factories have studied with high precision the so-called golden mode of B-physics, the decay $B^0 \rightarrow J/\Psi K_s$. The CP-asymmetry in this decay accesses $\sin 2\beta$ with negligible theoretical uncertainty and the measured world-average value in this and related channels is now 0.675 ± 0.026. The four-fold ambiguity in the value of β can be reduced to two by measuring $\cos 2\beta$ in channels such as $B^0 \rightarrow D^*D^*K_s$. The results now strongly disfavour two of the solutions, although higher statistics and further theoretical effort are necessary to verify this interpretation.

A possible hint of physics beyond the Standard Model may appear in the measurement of $\sin 2\beta$ in $b \rightarrow s$ "penguin" decays (e.g. $B^0 \rightarrow \varphi K_s$). There is a $2.6\,\sigma$ discrepancy in the value averaged over a number of channels, namely $\sin 2\beta = 0.52 \pm 0.05$, when compared with the charmonium measurement. We need more data to resolve this ambiguity, and eagerly await further studies of these penguin processes at the LHC.

Oxford provided an appropriate setting for the most recent B-physics conference, Beauty 2006. (Courtesy Stuart Bebb.)

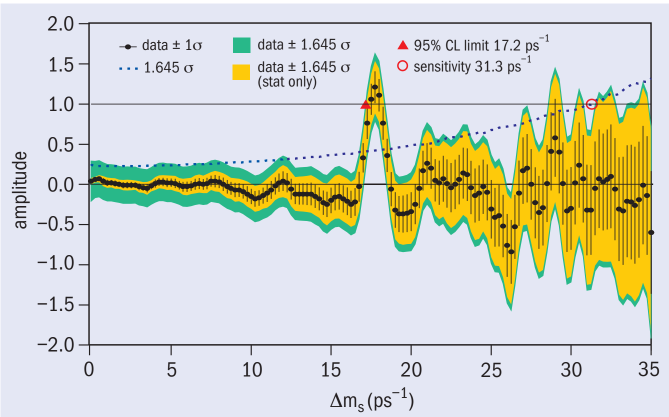
BaBar and Belle have also produced important results related to the angles α and γ. The γ measurements are particularly interesting as it had generally been assumed that this parameter was beyond the scope of the B-factories. The angle is measured through the interference of tree-level $B^\pm \rightarrow D^{(*)}K^\pm$ and $B^\pm \rightarrow \bar{D}^{(*)}K^\pm$ decay amplitudes. This strategy is intrinsically clean, and leads to a combined result for γ of $60(^{+38}_{-24})°$. The errors are still large and a precise measurement of γ is impossible at the B-factories. However, the LHCb experiment at CERN will improve the error on γ to less than 5°, with measurements contributing from the B_u, B_d and B_s sectors.

Year of the Tevatron

Despite the great successes of the B-factories, Beauty 2006 focused on B-physics at hadron machines, and 2006 has been the "Year of the Tevatron". The CDF and D0 experiments at Fermilab's Tevatron have not only demonstrated the proof-of-principle of B-physics at hadron machines, but have also made measurements that are highly competitive and complementary to those of the B-factories, in particular through the unique access that hadron machines have to the B_s sector. The results indicate the future at the LHC, where there should be 100 times more statistics.

The highlight of the conference was the first $5\,\sigma$ observation of ▷

Beautiful minds. Participants at Beauty 2006 at Keble College.



The amplitude of the B_s oscillation frequency shown as a function of Δm_s. Zero amplitude signifies no oscillation whereas a true B_s oscillation will yield an amplitude of unity; the CDF collaboration finds a 5σ signal at a value of 17.8 ps^{-1}.

B_s oscillations, presented by the CDF Collaboration (*CERN Courier* June 2006 p8). They reported the mass difference between the mass eigenstates, Δm_s, as 17.77 ± 0.10 (stat) ± 0.07 (syst) ps^{-1}, in agreement with Standard Model expectations. Data from hadronic channels, such as $B^0_s \rightarrow D_s\pi$, have greatly enhanced the statistical power of the analysis; this measurement relies on the precision vertex detector. The measurement of Δm_s and Δm_d allows the ratio of Cabibbo–Kobayashi–Maskawa (CKM) matrix elements $|V_{td}|/|V_{ts}|$ to be extracted with around 5% systematic uncertainty (with input from lattice theory), which fixes the third side of the unitarity triangle with the same precision.

The study of rare processes dominated by loop effects provides an important window on new physics and should have significant contributions from new heavy-particle exchanges. The Tevatron experiments are intensively searching for the very rare decay $B_s \rightarrow \mu\mu$, which is expected to have a branching ratio of order 10^{-9} in the Standard Model, but is significantly enhanced in many supersymmetric extensions. The Tevatron is currently sensitive at the 10^{-7} level and is striving to improve this reach. The LHC experiments will explore down to the Standard Model value.

Towards the LHC

With the start-up of the LHC, B-physics will enter a new phase. Preparations for the experiments are now well advanced, as are the B-triggers necessary to enrich the sample in signal decays. Talks at the conference described the status of the detectors and their first running scenarios. The LHC pilot run scheduled for late 2007 will yield minimal physics-quality data, but will be invaluable for commissioning, calibrating and aligning the detectors. Researchers will accumulate the first real statistics for physics measurements in summer 2008. Key goals in the first two years of operation will be the first measurement of CP violation in the B_s system; a measurement approaching the Standard Model value (around 2°) of the B_s mixing phase in $B_s \rightarrow J/\Psi\varphi$; the likely first observation of the decay $B_s \rightarrow \mu\mu$; studies of the B angular distributions sensitive to new physics in the channels $B_{u,d} \rightarrow K^*\mu\mu$ and precise measurements of the angles α and γ. LHCb will cover a wide span of measurements, whereas ATLAS and CMS will focus on channels that can be selected with a (di-)muon trigger.

Participants at the conference made a strong science case for continued B-physics measurements beyond the baseline LHC programme, to elucidate the flavour structure of any new physics discovered. On the timescale of 2013, the LHCb collaboration is considering the possibility of upgrading the experiment to increase the operational luminosity to 10 times the present design, to accumulate around 100 fb^{-1} over five years. In addition there are two proposals on a similar timescale for asymmetric e^+e^- "Super Flavour Factories" at luminosities of around 10^{36} cm^{-2} s^{-1} – SuperKEKB and a linear-collider-based design (ILC-SFF) – each giving some 50 ab^{-1} of data by around 2018. The LHCb upgrade and the e^+e^- flavour factories largely complement each other in their physics goals.

Social activities enabled discussions outside of the conference room. Keble College provided accommodation and hosted the banquet at which Peter Schlein, the founder of the conference series and chair for the first 10 meetings, was thanked for his efforts over the years and his pioneering contributions to B-physics at hadron machines.

The conference was extremely lively: B-physics continues to flourish and has an exciting future ahead. The B-factories and the Tevatron have led the way, but there is still much to learn. Heavy flavour results from ATLAS, CMS and, in particular, LHCb seem certain to be a highlight of the LHC era.

Further reading

For more information see www.physics.ox.ac.uk/Beauty2006/.

Résumé

La physique en beauté

Des débats animés et des mesures précises au menu de Beauty 2006, conférence internationale sur la physique des B, qui a eu lieu en septembre à Oxford. Ces réunions, organisées régulièrement depuis 1993, ont pour objet d'examiner les résultats de la physique des B et des recherches sur la violation de CP, et d'explorer le potentiel pour la physique des expériences actuelles et futures, en particulier dans les collisionneurs de hadrons. Il a été question des dernières nouvelles sur les mesures du triangle d'unitarité, d'éléments de la physique au-delà du modèle standard, et des perspectives liées au démarrage du LHC. On retiendra tout particulièrement la présentation par la collaboration CDF de la première observation 5 σ des oscillations B_s.

Neville Harnew *and* **Guy Wilkinson**, *University of Oxford.*

Uppsala brings neutrino telescopes back to Earth

Physicists met in Uppsala to consider how the next generation of high-energy neutrino detectors can contribute to new physics as well as to study cosmic phenomena.

Neutrino telescopes are the biggest particle detectors. IceCube, currently being built at the South Pole, will have a 1 km^3 instrumented volume when complete, and a similar project, KM3NET, is planned for the Mediterranean. Detectors such as AMANDA and the Baikal Neutrino Telescope have reached effective detection areas of tens of thousands of square metres. These huge arrays of photomultiplier tubes buried deep in clear ice or water primarily search the sky for high-energy neutrinos from violent cosmic phenomena, including gamma-ray bursts, active galactic nuclei and supernovae remnants. However, detecting extraterrestrial neutrinos can also provide a unique window on physics beyond the Standard Model of particle physics, the topics ranging from searches for new particles to the effects of extra dimensions.

On 20–22 September 2006 the Department of Nuclear and Particle Physics of Uppsala University hosted the first Workshop on Exotic Physics with Neutrino Telescopes. It focused on physics with neutrino telescopes, beyond astrophysics. The next generation of such detectors will be operational in less than a decade and will push the sensitivity of new physics to levels that can probe many existing theoretical models. At Uppsala we felt that it was timely to provide a forum to summarize the current status and where we can go in the next few years.

Research in underground labs or in accelerators is an important counterpart to searches using neutrino telescopes. The first session reviewed accelerator results on new physics beyond the Standard Model in the post-LEP era, and discussed where the LHC will lead. It also summarized the results and perspectives of searches in underground labs. These searches complement each other, and the understanding of any new effect will need signals observed using different detection techniques to be coherently interpreted.

Searching for dark matter

There were also reviews from the smaller experiments such as MACRO, Super-Kamiokande or the Baksan Neutrino Observatory. During the 1990s, these collaborations provided the first limits on searches for new particles and dark matter, as well as on scenarios for new fundamental physics.

The search for dark-matter candidates is perhaps the most developed of the "exotic" topics covered by neutrino telescopes, both theoretically and experimentally. Particle physics provides several candidates for dark matter in the form of weakly interacting massive particles (WIMPs) that have survived from the Big Bang. The neutralino of the minimal supersymmetric Standard Model (MSSM) is one of them, but the lightest Kaluza–Klein mode, which arises in models with extra space–time dimensions, is also viable. If they exist, such particles should cluster gravitationally as halos in galaxies, and by the same principle accumulate in the centre of heavy objects, such as the Sun or the Earth. If the concentration is high enough, they could annihilate in pairs, producing neutrinos as a by-product. Neutrino telescopes are looking for an excess of neutrinos from the centre of the Sun or the Earth, which would indicate this process. There are competitive limits from the MACRO, Super-Kamiokande, Baksan, Baikal and AMANDA detectors, and experiments have begun to probe MSSM parameter space.

The IceCube hot-water drill bores to 2500 m. (Courtesy A Karle.)

More exotic candidates of dark matter exist as non-topological solitons, or Q-balls. These are coherent stable states of quark, lepton and Higgs fields, and contrary to other WIMPS, they can be heavy, up to 100 TeV. Q-balls can leave a signature in a detector by catalysing proton decay as they pass through – the photomultiplier tubes of neutrino telescopes will record the Cherenkov light of the proton decay products. Another possibility is stable strange-quark matter in the form of nuclearites, with baryon numbers up to 10^{23}, but low values of Z/A, the ratio of atomic number (Z) to atomic mass (A). Such particles could also explain cosmic rays above the Greisen–Zatsepin–Kuzmin (GZK) cut-off, if next-generation air-shower arrays confirm such high-energy particles. ▷

Mini black holes and multi-bangs

The production of mini black holes in the collisions of high-energy neutrinos with the partons in matter nuclei is one manifestation of low-scale gravity. If the centre-of-mass energy of the interaction exceeds the Planck scale, a microscopic black hole can form in the interaction. However, in our 4D world, the Planck scale lies at energies of the Planck mass, around 10^{19} GeV, while the best man-made accelerators reach only tera-electron-volt energies (10^3 GeV) in the centre of mass. But in 4+D space–time dimensions the Planck scale may be much lower, and a 10^{10} GeV neutrino interacting with a nucleus inside the detector could produce a mini black hole. Although this might seem an extremely high energy, such neutrinos should be guaranteed by interactions of the flux of cosmic rays with the all-permeating cosmic-microwave relic photons.

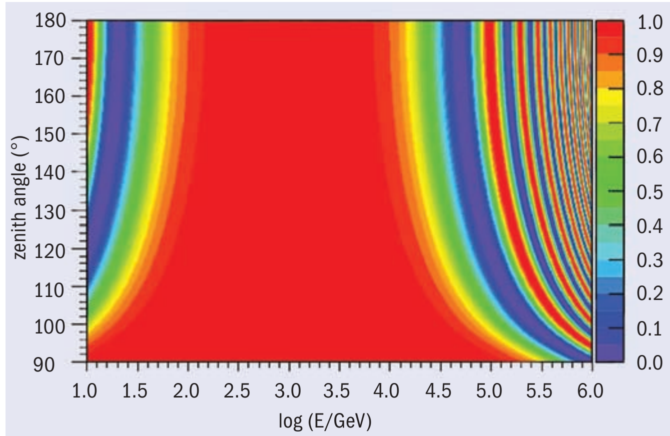
A neutrino telescope could detect the immediate Hawking evaporation of a mini black hole in a burst of Standard Model particles (in around 10^{-27} s) through the emission of Cherenkov light by the products. There are many free parameters in models with extra dimensions and the uncertainties in the predictions are large. However, up to 10 black-hole events a year could be expected in a 1 km^3 detector in the most favourable scenarios, taking into account the existing limits on the ultra-high-energy neutrino flux.

The gravity models at tera-electron-volt energies provide another intriguing possibility: elastic neutrino–parton scattering through the exchange of D-dimensional gravitons. Unlike in black-hole production, the neutrino is not destroyed, and continues on its way ready for another elastic interaction after a mean free path that, for a given energy, depends on the number of extra dimensions. The energy lost in each interaction goes into a hadronic shower, producing a very unusual signature in a neutrino telescope: multiple particle showers without a lepton among them. Current calculations predict that a 1 km^3 detector could detect a handful of events each year, probing up to D = 6 extra dimensions.

Tests of fundamental physics

It is now eight years since Super-Kamiokande announced the observation of neutrino oscillations, and this effect continues to be the only established observation of physics beyond the Standard Model. We understand neutrino oscillations as a typical quantum-mechanical superposition effect between propagation (mass) and flavour states. However, there can be other causes of oscillations if certain fundamental physics laws are broken at some scale. These include violation of the equivalence principle (VEP), where the different neutrinos couple differently to the gravitational potential, violation of Lorentz invariance (VLI), where the different neutrinos can achieve different asymptotic velocities giving rise to velocity-induced oscillations, or non-standard neutrino interactions with matter at very high energies.

Results from Super-Kamiokande, MACRO and the Sudbury Neutrino Observatory show that, if they exist, such processes are subdominant, and there are limits on their relative strength. However, their dependence on the energy of the neutrino makes such processes interesting for large-scale neutrino telescopes. While the wavelength of standard oscillations is proportional to E_ν, in the case of VEP or VLI the oscillation wavelength is proportional to $1/E_\nu$, and neutrino telescopes will provide much better sensitivity, for example by looking for distortions of the angular dependence of the high-energy tail of the atmospheric neutrino flux.



The expected survival probability of the atmospheric muon–neutrino flux if Lorentz invariance is violated at a level of 10^{-27} parts in c as a function of zenith angle and neutrino energy. A typical oscillation pattern arises because the maximal velocity eigenstates are not mass eigenstates.

Other contributions to the workshop covered the possibility of explaining trans-GZK cosmic rays as neutrinos with an increased interaction cross-section with matter at ultra-high energies; strongly interacting neutrinos; and how top-down scenarios can produce high-energy neutrinos from the decay products of super-massive Big Bang relics or topological defects. No doubt a discussion on vortons or monopolonia belongs to a workshop on exotic physics.

Fifty physicists from 16 countries attended the workshop. The Ångström laboratory, housing the Uppsala University physics departments and the newest building in one of the oldest universities in Europe, provided a pleasant venue for the meeting.

Further reading

All talks are available on the workshop Web page, which is at www.isv.uu.se/epnt.

Résumé

L'atelier d'Uppsala ramène les neutrinos sur Terre

Les télescopes à neutrinos, construits au départ pour rechercher les neutrinos de haute énergie issus de phénomènes cosmiques violents, peuvent aussi constituer une fenêtre d'observation exceptionnelle sur la physique au-delà du modèle standard, qu'il s'agisse de la recherche de nouvelles particules aux effets des dimensions supplémentaires. La prochaine génération de détecteurs sera à pied d'œuvre d'ici 10 ans. Ces dispositifs auront une sensibilité à la nouvelle physique qui leur permettra de mettre à l'épreuve un grand nombre de modèles théoriques existants. Le premier atelier consacré à la physique exotique des télescopes à neutrinos, qui a eu lieu à l'Université d'Uppsala en septembre, a été consacré à la contribution que ces nouveaux grands détecteurs de neutrinos peuvent apporter à la nouvelle physique, en sus de leur exploration des phénomènes cosmiques.

Carlos de los Heros, *University of Uppsala.*

APPOINTMENTS

Lockyer to become next TRIUMF director…

Nigel Lockyer will be the next director of TRIUMF, as announced by the chair of the TRIUMF Board of Management, Feridun Hamdullahpur. Lockyer brings to TRIUMF a wealth of experience and knowledge, along with strong management and interpersonal skills. He takes over from Alan Shotter, who will step down after five years on 1 May.

Lockyer was born in Scotland and raised in Canada. He gained a BSc degree in 1975 from York University in Toronto and a PhD from Ohio State University in 1980. A professor of physics at the University of Pennsylvania since 1984, his research has focused on high-energy particle-physics, most recently at FermiLab, where he was co-spokesperson for the CDF experiment in 2002–4.

Lockyer will take over at TRIUMF in May.

His other interests include medical applications of physics, in particular positron-emission tomography and proton cancer therapy, both of which are important parts of TRIUMF's applied programme. In 2006 he received the APS Panofsky Prize (*CERN Courier* December 2005 p33).

…while Chattopadhyay moves to Crockcroft

Swapan Chattopadhyay, currently associate director of Jefferson Lab, is to become the inaugural director for the newly created Crockcroft Institute – one of the UK's two new centres for accelerator science and technology. In addition, the universities of Lancaster, Liverpool and Manchester have made him the first chair of Accelerator Physics in the UK. He will take up his new position in March.

These new appointments reflect Chattopadhyay's contributions to phase space cooling, innovative particle colliders, novel synchrotron-radiation production and ultra-short femtosecond X-ray sources. His achievements also include the development of postgraduate education in accelerator physics and engineering and a number of successful industrial collaborations with hi-tech commercial partners.

AWARDS

Nanopoulos receives 2006 Onassis prize

Dimitri Nanopoulos has won the 2006 Onassis International Prize for his achievements in the natural sciences. Established by the Onassis Foundation in 1978, the International Prizes Program honours individuals and organizations for services in specific areas, including culture, social contribution and the environment. The prize is not necessarily given every year – this was the first award since 2000.

Nanopoulos pioneered some of the most important links between the present understanding of astroparticle and particle physics and the ultimate unification of the universe with superstrings. His many contributions to research have had an impact on related fields ranging from particle physics and cosmology to fundamental quantum theory and quantum-inspired models of brain function. Nanopoulos currently holds the Heep Chair in Particle Physics at Texas A&M University, and in 2005, he became president of the Greek National Council for Research and Technology and also Greece's national representative to both CERN and ESA councils.

Nanopoulos (centre) receives the Onassis prize from the President of the Hellenic Republic, Karolos Papoulias (right).

HEPP calls for 2007 prize nominations

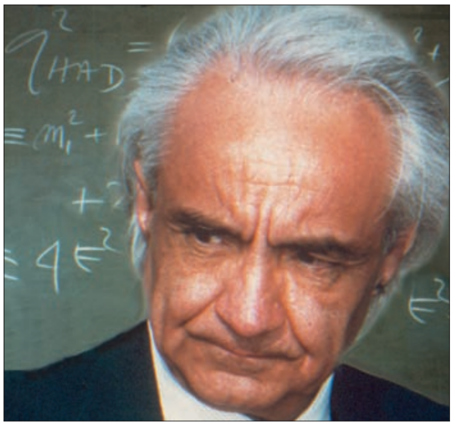
The EPS High Energy Particle Physics Board (HEPP) is calling for nominations for its Young Physicist Prize, the Gribov Medal and the Outreach Prize. This year HEPP will award the prizes in a ceremony at the International Europhysics Conference on High Energy Physics on 19–25 July in Manchester. Information on these prizes can be found on the HEPP Board website at http://eps-hepp.web.cern.ch/eps-hepp/prizes.html together with the list of the former prize winners.

Nominations for the Young Physicist Prize and Gribov Medal should be sent to David Wark (D.L.Wark@rl.ac.uk) before 15 April, and nominations for the Outreach Prize to Jorma Tuominiemi (Jorma.Tuominiemi@cern.ch) before 15 April.

Freedom prize honours Zichichi

Liberal International, the world network of liberal and democratic parties, has awarded Antonino Zichichi its prestigious Prize for Freedom, which each year recognizes extraordinary contributions made by individuals towards freedom, democracy, rule of law and peace. In the ceremony in London on 12 December, Lord Alderdice, president of Liberal International, praised Zichichi for his contribution to science, particularly emphasizing his 40 year contribution to peace, progress and freedom worldwide.

In 1962, Zichichi founded the Ettore Majorana Centre and Centre of Scientific Culture in Erice, Italy, which has become a leading physics-research centre. Since 1986, he has presided over the World Laboratory, which works in collaboration with developed countries and aims to support scientific elites and projects in developing countries, where 1000 international and 30 000 national scholarships have already been granted.



Zichichi, who receives the Prize for Freedom.

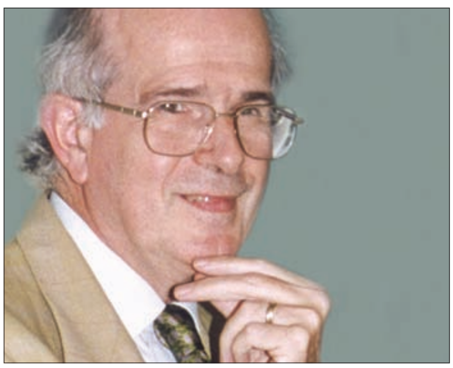
Zichichi is also the co-founder of the World Federation of Scientists (WFS), which promotes international collaboration, and has led the fight against planetary emergencies for more than 20 years. He was president of the NATO Committee of Disarmament, and an EEC representative in the Scientific Committee of the International Centre for Science and Technology in Moscow.

In his acceptance speech, a lecture entitled From the Nuclear War Emergency to the Cultural Emergency – The Contribution of the World Federation of Scientists to the Planetary Emergencies, Zichichi argued that the production of nuclear energy should be managed so as to guarantee the availability of the energy necessary per capita to everyone the world over, and not just the privileged few.

FPS awards new Prix André Lagarrigue to Lefrançois

Jacques Lefrançois has received a new prestigious award created in honour of André Lagarrigue. The French Physics Society (FPS) has instituted the prize on the occasion of the 50th anniversary of the Orsay Linear Accelerator Laboratory (LAL). Lagarrigue, well known for his leading role in the discovery of weak neutral currents with the Gargamelle bubble chamber at CERN in 1973, was director of LAL from 1969 until his death in 1975. The new prize, which is co-financed by the FPS with the CEA, CERN, Ecole Polytechnique, IN2P3, LAL and the University Paris Sud 11, will reward a senior physicist who, in the spirit of Lagarrigue, has led the construction of large experimental apparatus, extracting the best from it in a strong French team effort.

Lefrançois, now emeritus research director at CNRS, has spent his career at LAL, where he was director from 1994 to 1998. He had a leading role in very precise measurements on the φ meson at the Orsay colliding ring, and then in the construction, implementation and data handling of NA3, the first large dimuon experiment at CERN. His career peaked in the ALEPH experiment at the Large Electron–Positron collider, where he was responsible for constructing the electromagnetic calorimeter and directed the collaboration from 1990 to 1993. He continues to help build equipment by working on the calorimeter electronics for the LHCb experiment.



Lefrançois, who wins the Lagarrigue prize.

Viyogi receives 2006 Helmholtz–Humboldt award

The Alexander von Humboldt Foundation has granted Yogendra Pathak Viyogi a 2006 Helmholtz–Humboldt research award for his outstanding contributions to experimental physics, including front-ranking programmes in nuclear physics and the study of quark–gluon plasma.

Viyogi designed, developed and built photon multiplicity detectors at CERN's Super Proton Synchrotron (SPS), the Relativistic Heavy-Ion Collider at Brookhaven National Laboratory, and the ALICE experiment at CERN. His group discovered hydrodynamic-like emission patterns in relativistic heavy-ion collisions at the SPS and made unique contributions to the study of fluctuations of neutral and charged particles. From 1989 until 1991 he was a visiting scientist at GSI in Germany.

Viyogi is now leading a team from India, including five universities and two institutions, that will contribute to research of compressed baryonic matter at the future Facility for Antiproton and Ion Research in Germany.

LHC suppliers come up trumps at awards

The fifth Golden Hadron awards recently honoured four suppliers for the LHC project, for their flexibility, responsiveness and commitment during the challenging working conditions. This year's awards mark the first time that a team from CERN has won the prize. The awards went to Draka Comteq BV and Mauerhofer & Zuber, the Intertec, Cegelec and Spie-Trendel (ICS) consortium, Rial Vacuum and the CERN main workshop.

The awards recognized Draka Comteq BV and Mauerhofer & Zuber for the supply and installation of the optical-fibre cabling system for data transmission for the LHC and three of the main experiments (ALICE, CMS, LHCb), as well as for other CERN sites. It is the world's largest optical-fibre project in terms of density and complexity. High-pressure, air-blowing devices broke a world record during installation in the LHC tunnel for the longest cable blown into a tube in one go.

Members of the CERN team receive their award in the Globe of Science and Innovation.

The ICS consortium not only fulfilled its contractual obligations in assembly of the cryomagnets, including 1232 dipole magnets and 474 short straight sections to be prepared in their cryostats, but also demonstrated great flexibility in agreeing to additional tasks. This included repairs to the faulty modules of the cryogenic line in 2004, especially during the Christmas holidays. ICS also contributed to reinstalling sector 7-8. With the help of 150 people from various CERN services, 800 000 hours were put into the project.

Rial Vacuum produced special components for the cryostats of the short straight sections, including around 100 vacuum barriers. These will be crucial in keeping these sections under vacuum and at the correct cryogenic temperatures. Rial Vacuum manufactured them on time and to excellent quality, as well as making components that should have been made by other companies.

Finally, the CERN main workshop team won a Golden Hadron award for their exceptional contributions to the LHC in times of crisis. The main workshop, involved with mechanics and subcontracting, assembly techniques and surface treatment, is made up of 90 people. They provide practical and technical expertise for multidisciplinary projects, tackle difficult techniques and help with emergencies. They also contributed to the LHC's cryogenic distribution line, repairing faulty components, service modules and elbows and assembling half of the first sector. For the distribution feed boxes, they helped to manufacture, assemble and test the complex systems that transfer electric current from room temperature to cryogenic temperature.

University of Bologna presents honorary physics degrees to Glashow and Barish

On 2 October the University of Bologna awarded honorary degrees in physics to Sheldon Glashow of Boston University and to Barry Barish of Caltech. In his doctoral lecture, Glashow spoke on Simplicity, Symmetry and Small Matrices, recollecting the development of theoretical particle physics and his path to the Nobel prize. Barish, in contrast looked ahead in his lecture on The Future of Particle Physics; the Case for Building another Huge Particle Accelerator, which involved technology, large worldwide collaborations, money and politics.


Glashow, left, joins in applause while Barish, centre, receives his honorary degree.

During the same day, the Bologna Academy of Sciences held a small workshop, Beyond the Standard Model. The main aim was to make a short assessment of the main open problems in high-energy physics. The following morning Bologna university and town organized a public meeting on the topic Are scientists really useful? From quarks to portable phones: how fundamental research enters into our houses. Barish, Glashow and CERN's Alvaro De Rújula spoke and then answered questions, guided by Paola Catapano of CERN.

● For more about the workshop see www.df.unibo.it/honorem2006/workshop.html.

The PHENIX experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory has elected a new spokesperson to replace Bill Zajc (right). At a ceremony on 14 December PHENIX announced that the successor would be Barbara Jacak (left), a professor of physics at Stony Brook University. Zajc, a professor of physics at Columbia University, served as PHENIX spokesperson since 1997 and left voluntarily after nine years.

ART

Super-Kamiokande inspires new ‘living’ glass sculpture

Tom Na H-iu – linking with death on a cosmic scale. (Photo Richard Learoyd, courtesy Shiraishi Contemporary Art Inc.)

At the 2006 Singapore Biennale art festival, the artist Mariko Mori exhibited a “living” glass sculpture, responding in real time to signals from the Super-Kamiokande neutrino detector in Japan. Tom Na H-iu is a 3.2 m high glass structure illuminated by an internal LED that is connected to the detector at the Kamioka Observatory. The name of the sculpture refers to a place in Celtic mythology inhabited by the souls of the dead before they are reborn, and its shape reflects Celtic standing stones. Its connection to Super-Kamiokande links it to death and rebirth on a more cosmic scale, with the origin of neutrinos in supernovae, the death throes of stars (see p23). Japanese by birth, Mori studied art in London and now lives in New York.

CELEBRATION

Logunov celebrates his 80th birthday

Anatoly Alekseevitch Logunov celebrated his 80th birthday on 30 December 2006. A founding father of the Institute for High Energy Physics at Serpukhov, Protvino, he was director from 1963 to 2003, with an interruption in 1974–1991 when he was vice-president of the USSR Academy of Sciences and also rector of Moscow State University in 1977–1992. From 1967 to 1972, he led the construction of the 70 GeV proton synchrotron at Serpukhov, then the most powerful accelerator in the world, and made great efforts to develop its physics programme on an international basis.

Logunov’s important contributions include work with Nikolai Nikolaevich Bogoliubov and Dmitrii Vasil’evich Shirkov on the inclusion of the gauge parameter in QED into the realm of the renormalization group, making it “running”, and the finite energy sum rules, developed with Lev D Soloviev and Albert N Tavkhelidze, which became an important step towards formulating the duality concept.

In recent years Logunov has concentrated on problems in gravitation, pushing forward the theory of the gravitational field based on the strict respect of the conservation laws with a non-zero graviton mass as a fundamental property. His theory explains the observational data and predicts the cyclic cosmological evolution of the universe, but denies the existence of black holes.

ACCELERATORS

Nice welcomes European cyclotron meeting

About 80 physicists, engineers and industry representatives attended the European Cyclotron Progress Meeting (ECPM XXXV) in Nice on 2–4 November 2006, organized by the Cyclotron Laboratory of the Antoine Lacassagne cancer centre in Nice and the company Accelerators for Industrial and Medical Applications (AIMA).

At the meeting, the progress in cyclotrons and the latest developments in fixed-field alternating-gradient machines showed the ties between these accelerators both in hadron therapy and future high-intensity applications. The most exciting contributions included talks on the Future of Hadron Therapy by Jean-Pierre Gerard from the Antoine Lassagne centre and on Trends in Nuclear Physics with Rare Isotope Beams by Marek Lewitowicz from the heavy ion accelerator, GANIL. An industrial exhibition organized during the meeting allowed the attendees to develop close contact with accelerator industrial partners.

● For more information see www.aima.fr.

SCHOOL

CERN's introductory accelerator course comes to Poland

On 1–13 October 2006, for the first time since the CERN Accelerator School (CAS) was set up, the general accelerator-physics course, Introduction to Accelerator Physics, took place in Zakopane, at the foot of the Tatra Mountains in Poland. Organized in collaboration with the National Atomic Energy Agency, Warsaw, and the AGH University of Science and Technology, Cracow, the course attracted 113 participants representing 26 nationalities. Although most of the participants originated from Europe, some students came from as far away as Canada, China, India and the US.

Students at the CERN Accelerator School at the foot of the Tatra mountains in Poland.

The intensive programme comprised 35 lectures and three seminars by local Polish lecturers, as well as tutorials where the students were split into groups, a poster session where students could present their work, and periods of guided and private study. The participants appreciated the study periods, which encouraged collaboration and knowledge-sharing in solving problems, and allowed them to get to know each other better and to establish useful contacts. The students could also visit the famous Wieliczka salt mines and the old town of Cracow.

Feedback from the students after the course was very positive, praising the high standard of the lectures as well as the interesting and pleasant surroundings and excellent organization. The next CAS course will be a specialized course on Digital Signal Processing, which will take place in Sigtuna, Sweden on 1–9 June.

● Information on CAS can be found at www.cern.ch/schools/CAS.

RESEARCH CENTRES

Cluster of Excellence attracts funds to Munich/Garching

Several institutes in Munich/Garching have received funding for a major joint initiative to be known as Origin and Structure of the Universe: the Cluster of Excellence for Fundamental Physics.

The formation of this research cluster follows decisions announced in October by the German Research Foundation in the first round of its Excellence Initiative. These decisions earmarked a total of €1.9 billion for promoting top-level research during 2006–2011. The purpose of the funding is to provide an environment in which astrophysicists, particle physicists and nuclear physicists can work together to investigate some of the deepest unsolved questions of modern science, concerning in particular the origin and structure of the universe.

Munich/Garching is already one of the largest centres in the world for research in fundamental physics and astrophysics, with the Munich Technical University, the Ludwig Maximilians University, the Max Planck Institute for Astrophysics, the Max Planck Institute for Extraterrestrial Physics and the Max Planck Institute for Physics forming the cluster. The funding will provide for 10 new junior research groups with tenure track professorships for the group leaders.

● Further information is available online at www.universe-cluster.de.

CORRECTIONS

In the December issue, in the diagram of spin 3/2 baryons in "CDF collaboration finds new baryons that contain b quarks" on p9 the (ddd) state (bottom left) should be labelled as Δ^-, not Ω^-. Also, the states shown here containing one or two s quarks or b quarks are more usually denoted by Σ^* and Ξ^*, with Σ and Ξ being reserved for the spin 1/2 states, as in the accompanying article.

In the article "Particle accelerators take up the fight against cancer" the number of people who develop cancer in developed countries every year was stated incorrectly on p17. It is some 40 000 per 10 million inhabitants, not 40 000 per 1 million.

In the photo in "Rochester conference goes back to Russia" on p21 the person talking with Albrecht Wagner was wrongly identified as Jonathan Dorfan, director of SLAC. It is David Saxon, dean of the Faculty of Physical Sciences at Glasgow University.

Apologies to all concerned.

NEW PRODUCTS

Agilent Technologies has introduced the Agilent 5400 AFM/SPM, a high-precision instrument offering atomic resolution for a variety of research and teaching applications. The Agilent 5400 has easy-to-use features and an affordable price to appeal to a broad audience. Its modular system can be used for applications including general surface characterization and nanolithography. The system also can be upgraded easily to the Agilent 5500 AFM/SPM. For further details contact Janet Smith, tel: +1 970 679 5397, e-mail janet_smith@agilent.com, or see www.agilent.com.

Fujikura Europe has launched a range of cables using the innovative FutureGuide SR15 optical fibre, with low bend radius. Magi-Tsuyo Cable is an ultra-flexible patch cord cable that is highly durable to allow for extreme cable bend during installation. Indoor cable is a low bend-radius cable for up to 12 fibres, which can be laid flat and sustain high compression forces. For more information contact Neil Bessant, tel: +44 208 240 2027, Web: www.fujikura.co.uk.

HiTek Power has introduced a dual 5 kV/60 kV rack-mounted power supply for ion-implantation applications. The 5 kV section has a continuously variable 250 V – 5 kV output for shallow implants. The 60 kV section is intended for deeper implants and offers a continuously variable 5–60 kV output. For further details e-mail sales.uk@hitekpower.com or see www.hitekpower.com.

id Quantique has announced the id201 near-infrared photon counter, which allows the bias voltage to be adjusted to control the detection efficiency, with four preset values. Alternatively, users can smoothly scan the bias voltage. The module covers 900–1700 nm. In the visible range, the id101 is the world's smallest single-photon detection module, and can be easily mounted on a custom printed circuit board. For more details contact Leonard Widmer, tel: +41 223 018 371, e-mail: Leonard.widmer@idquantique.com or sales@idquantique.com, or see www.idquantique.com.

LEDtronics has created a multiple voltage bi-polar LED bulb. This versatile bulb can replace many incandescent bulbs, functioning in a broad range of voltages. It comes in a T3 ¼ bayonet base that mounts directly into industry-standard sockets. For further details see www.ledtronics.com.

Vector Fields has launched a major evolution of Concerto, its high-frequency electromagnetic package, providing the means to rapidly create and optimize complex radio and microwave designs. Concerto series 6 offers a comprehensive suite of electromagnetic design capabilities, using powerful geometric modelling to provide 2D and 3D simulation and design optimization. For more information tel: +44 186 537 0151 or +1 630 851 1734, e-mail: info@vectorfields.com, or see www.vectorfields.com.

MEETINGS

The **3rd Joint ILIAS–CERN–DESY Axion–WIMPs Training Workshop** will be at the University of Patras on 19–25 June. This first joint meeting will include lectures on axions and WIMPs, as well as presentations with recent results. For further details about submission and registration contact Konstantin Zioutas (chair) at zioutas@physics.upatras.gr, or Josef Jochum at josef.jochum@uni-tuebingen.de or axel.lindner@desy.de.

The **XXVII Physics in Collision** symposium on elementary- and astroparticle physics will be at LAPP (Laboratoire de Physique des Particules d'Annecy-le-Vieux), Annecy, on 26–29 June. The conference, chaired by Helenka Przysiezniak (helenka@lapp.in2p3.fr), has invited talks and poster sessions. For further information including registration see http://lappweb.in2p3.fr/PIC07/index.php.

A **PHYSTAT Workshop on Statistical Issues for LHC Physics Analyses** will be at CERN on 27–29 June. A main theme will be statistical issues related to the discovery of new phenomena, which should be relevant for the LHC. For further details, contact Albert de Roeck (deroeck@mail.cern.ch) or Louis Lyons (l.lyons@physics.ox.ac.uk), or see the website at http://cern.ch/phystat-lhc.

OBITUARIES

Melvin Schwartz 1932–2006

Melvin Schwartz was one of the outstanding contributors to the great advances of the past half century in our understanding of elementary particles and their interactions. After a most distinguished career and after struggling for several years with hepatitis and Parkinson's disease, he passed away on 28 August 2006 in Twin Falls, Idaho. He is survived by his wife Marilyn, "foremost among the people who have given my life focus, meaning and direction" (Schwartz 1988), three children and six grandchildren.

Mel's contributions to physics were marked by his deep commitment, his penetrating insight, his originality and his need to be independent. He was born in 1932 in New York, to immigrant parents. "My interest in physics began at the age of 12 when I entered the Bronx High School of Science... The four years I spent there were certainly among the most exciting and stimulating in my life, mostly because of the interaction with other students of similar background, interest and ability." He went on to Columbia University, and in 1953 entered its graduate school of physics, "at that time unmatched by any in the world, largely a product of the late Professor I I Rabi".

In 1955 Mel became my doctoral student. Don Glaser had invented the bubble chamber in 1952, which for the next two decades dominated as the tool for learning about the then mysterious "strange" particles. Together with two other graduate students, Jack Leitner and Nick Samios, we managed in 1955 to put together a practical device, the first bubble chamber to do an experiment at Brookhaven, in 1956. This clearly demonstrated the power of the new technique, and even gave some, unfortunately statistically inadequate, evidence of parity violation, some months before its discovery by C S Wu and colleagues. In the following years the team went on designing, constructing and experimenting with increasingly large bubble chambers, some filled with propane, one with liquid hydrogen. We learnt about the properties of the strange particles, including in 1956 the discovery of the Σ^0, in 1957 observation of the violation of parity in

Melvin Schwartz with a spark chamber that was used in the research that ultimately led to the 1988 Nobel Prize in Physics. (Courtesy Brookhaven National Laboratory.)

Λ^0 decay, and in subsequent years other properties of strange particles and of pions.

Probably Mel's most remarkable and productive contribution was his insight in 1960 that neutrino beams can be produced and would permit advances in our understanding of the weak interaction. T D Lee motivated this with a question at an afternoon coffee in the Columbia physics department (unfortunately I was not present). "TD" asked: "All we know about the weak interaction is based on observations of particle decay, and therefore very limited in energy. Could there be another way towards progress?" Mel came to the idea of beams of neutrinos. Two new proton accelerators had just been completed, one at CERN and one at Brookhaven, and for the first time these offered the possibility of producing beams of neutrinos of sufficient energy and intensity to make such experiments feasible.

Mel's short *Physical Review Letter* was followed by a longer one by Lee and C N Yang, listing more than a dozen questions that might be resolved with the help of neutrino beams. These included: is there more than one kind of neutrino, are there heavy intermediate bosons, and are there neutral currents? Many of these questions were then indeed resolved by experiments using neutrino beams. It should also be remembered that in 1959, some months before Mel's publication but unknown to Mel, Bruno Pontecorvo had proposed an experiment using neutrinos. Pontecorvo's focus was more specific and limited than Mel's. He proposed using neutrinos produced together with muons to discover whether, in their subsequent nuclear interaction, they produce electrons, precisely the experiment that we were to perform.

The first neutrino-beam experiment was in 1962 at the new Brookhaven 30 GeV proton accelerator, the Alternating Gradient Synchrotron. Not only did Mel conceive this experiment, but he also led it technically, in particular in the design of a newly invented detector, the spark chamber. Some 30 neutrino events permitted the conclusion that muons were produced, but not electrons, and this in turn demonstrated that these neutrinos produced in conjunction with muons must be different from the neutrinos produced in beta decay in conjunction with electrons. This was also an important step on the way to our learning about the association of the fermions into families. The experimental team, besides its three Columbia University faculty members, included two graduate students, Nariman Mistry and Konstantin Goulianos, one postdoc, Jean-Marc Gaillard, and Gordon Danby of Brookhaven. It was honoured in 1988 with the Nobel prize to Mel, Leon

Lederman and myself.

In 1966 Mel left Columbia for Stanford University, where the 3 km long 30 GeV electron linear accelerator was nearing completion. There his career was marked by three original experiments. The first, in 1967, showed that the decay $K_L \rightarrow \pi^{+/-} + \mu^{-/+} + \nu$ has a CP-violating charge asymmetry, an important contribution to the evolving understanding of CP violation. This was followed by the first "beam dump" experiment, a search for new physics of the kind that led to the discovery of the τ neutrino in 2000 at Fermilab. The electrons of the linear accelerator were absorbed in a metal target, immediately followed by a shield to absorb hadrons and muons, and then a detector to see what one might find. The results were never published, although there were two events, in retrospect probably owing to the neutral current, which was discovered three years later in 1973 in the Gargamelle bubble chamber at CERN. The frustration that Mel experienced with this experiment, because of what he considered inadequate support by the laboratory, had a large influence on his subsequent career. The third experiment, during 1975–82, was the search for and discovery of the atom consisting of a pion and a muon. This experiment was in my opinion beautifully designed. It found 155 events that clearly showed that, with a branching ratio of 4×10^{-7}, the muon and pion in the decay $K_L \rightarrow \pi + \mu + \nu$ are emitted as an atom.

"During the 1970s, lured in part by the new industrial revolution in Silicon Valley, I decided to try my hand at a totally new adventure, Digital Pathways Inc... a company dedicated to the secure management of data communication." In 1983 Mel resigned his Stanford professorship to devote himself full time to the increasing burdens of his industrial adventure.

Following the award of the Nobel prize in 1988, Mel left the company and resumed his research career, becoming the much appreciated associate director of high-energy and nuclear physics at Brookhaven National Laboratory, where he was instrumental in guiding the research programme of the Relativistic Heavy Ion Collider, then under construction. A decade of results from these experiments have shed much light on the very interesting, but also very difficult, question of the role in these high-energy gold–gold collisions of the quark–gluon plasma expected in quantum chromodynamics.

In 1994 Mel returned to the faculty of Columbia University as I I Rabi Professor. Columbia also honoured him with the John Jay award and the Alexander Hamilton Medal. He retired in 2000.

One of the privileges of my career in physics was the contact with fine and interesting people. Melvin Schwartz was a completely outstanding figure.

Jack Steinberger, CERN.

Further reading

Melvin Schwartz's autobiography (1988), Nobel Foundation, Nobelprize.org.

David Owen Williams 1944–2006

Many people, not only at CERN but also throughout the world, were saddened to learn that their friend and colleague David Williams had died from cancer on 24 October.

David came to CERN from the University of Cambridge in 1966, with a degree in physics and a Masters in computer science. At the time he was one of the few people in the laboratory with formal computer training, as opposed to the physicists who learned on the job. These were very early, if not pioneering, days for computer-science courses, and Cambridge was among the front-runners in the subject. Joining what was called the Documents and Data (DD) Division, David worked first on software for analysing bubble-chamber photographs. He subsequently led the group that supported experiments with hybrids of bubble chambers and electronic detectors, and then the group supporting online computing in experiments. He thus witnessed the enormous changes that took place in particle physics as the era of bubble chambers came to an end and the powerful, compact mini-computers revolutionized the data collection.

Armed with this experience, David moved on to become deputy-leader of DD in 1985 and then leader of the re-named Computing and Networks Division in 1989, the year that the Large Electron–Positron Collider started up. He held this position until 1996, when the Member States approved the Large Hadron Collider and its experiments. At this time the central mainframes and supercomputers were changing to a completely distributed computing environment acquiring, processing, managing and analysing the hundreds of terabytes of data produced by the experiments at CERN. This then moved to a reasonably coherent desktop environment for

David Williams, who died in October 2006.

the more than 10 000 staff and researchers worldwide who use CERN's computing facilities. It was also the period in the division when Tim Berners-Lee and collaborators, with David's strong support, created the World Wide Web. As division leader, David had the foresight to encourage studies that ultimately led to the programming paradigm shift from Fortran to C++.

The period 1996/7 was a time of change for David. He actively fostered the development of the Internet in Europe, not just as a tool for scientific research but also as a motor for Europe's overall economic development. This naturally led to his holding a number of positions at national and European level. He was president of the Trans-European Research and Education Networking Association (TERENA), from 1999 to 2003. He made a pioneering contribution through the SERENATE study and developed a strategic vision of the future of research and education networking. He was also a member of various UK committees dealing with e-science and was chair of the e-Science Advisory Board of the UK's Council for the Central Laboratory of the Research Councils.

With this broad view, coupled with his energy and managerial talents, it was natural that David moved on at CERN to be responsible for the overall coordination of CERN's relations with the European Union, a post he held until the end. He played a highly significant role in formulating and obtaining European Commission support for the European part of the LHC worldwide computing environment, now almost ready for the LHC start-up in 2007. He was able to persuade the Commission to admit CERN to the Framework Programme (FP), and helped to formulate and organize the FP5 and FP6 projects European DataGrid and Enabling Grids for E-sciencE in Europe.

For those who knew him, David was always a private person, unwilling to talk about himself or worry others with his problems. However, the well merited award in 2005 of an honorary professorship at Edinburgh University was a source of enormous personal satisfaction to him. Many people will remember him as being generous and supportive, always ready to spring to the defence of someone who he considered to be wrongly criticized. He also had the habit, when attending scientific talks, to ask the questions that others were afraid to ask. Although David had usually understood perfectly, this gave the speaker the opportunity to clarify points that had previous been somewhat obscure.

Much sympathy goes out in this difficult time to David's wife Lidy and to his children, Mark and Marietta, and their families.
Colleagues and friends.

LETTER

EGRET and dark matter

Reading the article "Rochester Conference goes back to Russia" by G Kozlov and S Eidelman in the December 2006 issue of *CERN Courier* [p21], I found to my great surprise the following statement: "Techniques for the direct and indirect detection of dark-matter particles are rapidly developing, with indications for positive signals from DAMA and EGRET still persisting, as described by Alessandro Bettini...", while my statement on EGRET was just the opposite.

The correct sentence, which can still be found written in my transparencies on the conference website, is:

"We now have first generation data from EGRET, but claims for dark matter evidence are not reliable due to the uncertainties both in the data and in the cosmic rays propagation (provided error bars are taken into account properly). A large improvement in data is expected in the future from GLAST."
Alessandro Bettini, INFN/Padova.

RECRUITMENT

For advertising enquiries, contact CERN Courier recruitment/classified, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel +44 (0)117 930 1196. Fax +44 (0)117 930 1178 E-mail sales@cerncourier.com
Rates per single column centimetre: standard $94/€75/£52, academic $88/€71/£49, courses and calls for proposals $85/€68/£47.
Please contact us for more information about colour options, publication dates and deadlines.

The Faculty of Physics of the **Technische Universität München**, the **Max-Planck Institute for Physics** and the **Cluster of Excellence** *'Origin and Structure of the Universe'*

invite applications for

Five Junior Professorships / Junior Research Group Leaders

The Cluster of Excellence 'Origin and Structure of the Universe' has recently been installed at the Campus Garching within the Excellence Initiative of the federal government of Germany. The cluster is operated jointly by the physics departments of the two Munich Universities, the Max-Planck Institutes and ESO. It aims at a deeper understanding of fundamental forces and dynamics driving the expansion of our universe, the creation of elements and of large scale structures observed in our universe. For this it will install 10 new research groups working in the key areas of science relevant to this field.

Within the framework of the cluster we are seeking candidates for five positions of Junior Research Group (JRG) leaders with special focus on nuclear-, particle- and astroparticle-physics. Four of these JRG-leaders will also become assistant professors (Junior professorship/ salary scale W1) at the Faculty of Physics of the Technische Universität München (TUM) for initially 3 years with possible extension. The evaluation for tenure at the Physics Department of the Technische Universität München (salary scale W2) or the Max-Planck Institute (MPP) (salary scale TV-L 14) will start after three years.

The successful candidates are expected to create and lead a JRG in one of the following fields:

- Detector Development in Particle Physics (Experiment - MPP)
- Low Energy Neutrino Physics (Experiment - TUM)
- Fundamental Physics with Neuwtrons (Experiment - TUM)
- Strange Hadronic Matter (Experiment - TUM)
- New physics beyond the standard model (Theory - TUM)

Besides profiting from scientific infrastructures present on the campus Garching the groups will also be integrated in transregional research activities either ongoing or planned. Active participation in the teaching program for experimental/theoretical physics at the Faculty of Physics and of the Cluster is required.

Formal requirements for these positions are a Diploma from an University or an University for applied sciences, pedagogical qualifications and specialized skills for scientific research which are documented by a PhD. Other scientific accomplishments, gained possibly also outside academia, are welcome. No formal habilitation is required. Applicants should have several years of experience in the corresponding fields of physics.

The advancement of women in the scientific field is an integral part of the clusters and the university's policy. ***Women, therefore, are especially encouraged to apply***. Persons with disabilities will be given preference over other applicants with equal qualifications.

Details on the different positions can be found on

http://universe-cluster.de (→jobs)

Applicants should complete the corresponding web-forms until 28.02.2007.

Dean of the Faculty of Physics
Physics Department
Technische Univ. München

Excellence Cluster Exc153
c/o Prof. Dr. S. Paul
Physics Department
Technische Univ. München

Jefferson Lab
Thomas Jefferson National Accelerator Facility

HALL B STAFF SCIENTIST

SALARY RANGE:
$63,600 - $100,600 (SS II) / $79,700 - $126,100 (SS III)

The Hall B group at Jefferson Lab is seeking an internationally recognized staff physicist with broad experience in electromagnetic nuclear physics and the operation of large scale detectors in an electron beam environment. The Hall B group operates the CEBAF Large Acceptance Spectrometer (CLAS). CLAS supports a broad research program to study the structure of nucleons and nuclei ranging from the nucleon spin structure, the study of excited baryons and mesons, to studies of generalized proton distributions in deeply virtual Compton scattering and the study of quark hadronization in nuclei. The successful candidate will have responsibility for the execution of a diverse experimental physics program, and the hardware and software support of the CLAS detector and other instrumentation in Hall B. Individual will actively engage in the research effort and assume a lead role in the conceptual planning, proposal development, design, implementation, and operation of experiments, and initiate new research proposals. A portion of effort should be devoted to future projects at Jefferson Lab.

The qualified individual will have a PhD in Experimental Nuclear or Particle Physics and at least 5 years of postdoctoral experience in an experimental nuclear or particle physics environment, or an equivalent combination of education and experience. Candidate should have demonstrated leadership in several research programs and the ability to conceive original physics experiments with electromagnetic probes. A strong background in a technical area such as instrumentation, software design or data analysis is required. Demonstrated ability to lead a team effort to achieve high quality experimental research and broad experience in electromagnetic particle or nuclear physics as well as experience with large acceptance detectors is required.

All applications, copies of unpublished work and letters of reference should be submitted no later than February 28, 2007.

Applicants should apply online at: www.jlab.org/jobline/ or email: jobline@jlab.org, submitting a curriculum vitae and copies of recent (un)published work, and arrange to have letters from three references sent to: JSA/Jefferson Lab Human Resources Consultant, 628 Hofstadter Road, Ste 2, Newport News, VA 23606.

Jefferson Lab is an Affirmative Action/Equal Opportunity

National Superconducting Cyclotron Laboratory at MICHIGAN STATE UNIVERSITY

A world-leading laboratory for the production and study of rare isotopes

NSCL is expanding its capabilities and invites applications for

Positions in Accelerator Physics and Engineering

National Superconducting Cyclotron Laboratory (NSCL) has approximately 300 employees, including 28 faculty members and more than 100 graduate and undergraduate students. A major focus for accelerator development work for the next three years will be the design, fabrication, and commissioning of a reaccelerator for rare isotopes, including a charge breeder Electron Beam Ion Trap, radio-frequency quadrupole (RFQ), and linac with superconducting quarter wave resonators and superconducting solenoids. NSCL has an active Accelerator Physics graduate program with thesis work typically done in collaboration with the MSU departments of Physics and Astronomy, Electrical Engineering, Computer Engineering, Mechanical Engineering, and Chemical Engineering and Materials Science.

NSCL state-of-the-art design and machining capabilities make it possible to mount leading research and development programs with appropriate timeliness. The laboratory has active accelerator physics and engineering research and development programs in:

- Superconducting Radio Frequency (SRF) technology, including research and development of accelerating structures appropriate for particles from a few percent to 100 percent the speed of light; basic research, including materials science-based investigations directed toward better fundamental understanding of SRF processes and their efficacy; and development of low-level radio-frequency control systems.
- Superconducting magnet technology for high field applications in high radiation environments.
- Beam dynamics studies including space charge of RFQs, superconducting linacs, and cyclotrons.
- Electron Cyclotron Resonance source and Electron Beam Ion Trap development.
- Engineering and design of large-scale accelerator facilities.

MSU has been advancing knowledge and transforming lives through innovative teaching, research and outreach for 150 years. Its fourteen degree-granting colleges attract scholars worldwide who are interested in combining education with practical problem solving.

Information about NSCL can be found at **www.nscl.msu.edu**; information about accelerator physics research can be found at **groups.nscl.msu.edu/accel_rd/**; information about NSCL faculty appointments can be found at **www.hr.msu.edu/HRsite/Documents/Faculty/Handbooks/nsclfacpos**; information about staff appointments can be found at **www.hr.msu.edu/HRsite/Documents/Faculty/Handbooks/NSCL.**

Applicants should send a letter of application, a résumé, including a list of publications, and the names and addresses of at least three references to **Prof. Bradley M. Sherrill, University Distinguished Professor of Physics, NSCL, Michigan State University, East Lansing, MI 48824-1321**.
Michigan State University is an Affirmative Action/Equal Opportunity institution. Women and minorities are especially encouraged to apply. Appointment levels depend on qualifications; salaries are competitive.

NSCL

MICHIGAN STATE UNIVERSITY

Advancing Knowledge. Transforming Lives.

UNIVERSITY OF HELSINKI

University of Helsinki Finland
Professor in Experimental Particle Physics

The Faculty of Science at the University of Helsinki, Finland, invites applications for a full professorship in Experimental Elementary Particle Physics. The professorship is a joint position of the Department of Physical Sciences (**www.physics.helsinki.fi**) and the Helsinki Institute of Physics (**www.hip.fi**).

The candidate should lead research projects, which are part of the research programme of the Helsinki Institute of Physics. Currently the main experimental effort is within the CMS collaboration at CERN. Teaching experience at undergraduate and graduate level is expected. Candidates, who do not have Finnish as their mother tongue, are expected to teach in English.

The salary is based on the salary system applied in Finnish universities. The basic salary will be in the range 3874-4954 €/month. This amount will be complemented by a part up to 46 %, which is based on the personal performance.

For further information please contact:
Professor Juhani Keinonen,
Director of the Department of Physical Sciences,
phone.: +358 9 191 50601, e-mail: Juhani.Keinonen@helsinki.fi, or
Professor Dan-Olof Riska, Director of the Helsinki Institute of Physics,
phone.: +358 9 191 50520, e-mail: Dan-Olof.Riska@helsinki.fi.

Information on the preparation for the application documents can be found at the web-page of the Faculty of Science, **http://www.helsinki.fi/facultyofscience/**.

The applications should be addressed to the **Faculty of Science, University of Helsinki** and mailed to the **Registrar of the University, P.O. Box 33 (Yliopistonkatu 4), FI-00014 University of Helsinki, Finland.**

The deadline for the applications is **February 21, 2007**.

LANCASTER UNIVERSITY DEPARTMENT OF PHYSICS

Lectureship in Experimental Particle Physics

A university lectureship (tenure track faculty position) is available immediately for a suitably qualified applicant to work in the experimental particle physics group at Lancaster (http://www.lancs.ac.uk/depts/physics/research/particle/epgroup.html). The group's current programme includes ATLAS at the LHC, D-Zero at the Tevatron, the T2K neutrino oscillations experiment in Japan and the International Linear Collider project. The successful candidate is expected to play a leading role in one or more of these activities. In addition, the group is also involved in accelerator science and technology at the Cockcroft Institute (http://www.lancs.ac.uk/cockcroft-institute).

This is a long term career position with teaching and administrative responsibilities as well as the opportunity to carry out research in one of the most highly rated physics departments in the UK. Candidates should have a PhD in experimental particle physics and at least several years of postdoctoral experience. We are seeking an individual with an established track record of high impact research and with the potential to become a leading figure in the field. Salary will be in the range £32,471 - £38,772 depending on experience. **Closing date: 28th February 2007.**

The Department of Physics (http://www.lancs.ac.uk/depts/physics/physics.htm) was awarded the top 5*A grade in the 2001 UK Research Assessment Exercise (http://www.hero.ac.uk/rae) – one of only four departments given this distinction. About half of the academic staff members are involved in PPARC-funded research (experimental particle physics, accelerator science and cosmology). Informal enquiries can be made to Professor Peter Ratoff (p.ratoff@lancaster.ac.uk) and/or Dr Roger Jones (Roger.Jones@cern.ch) and further information can be obtained online at **http://www.hep.lancs.ac.uk/jobs. To apply or receive further information online, please visit http://www.lancs.ac.uk/depts/personnel/jobs or telephone Personnel Services, quoting appropriate reference A791 on answerphone +44 1524 846549.**

We positively welcome applications from all sections of the community.

Director

Harvard University

Laboratory for Particle Physics and Cosmology

The Laboratory for Particle Physics and Cosmology (LPPC) at Harvard University is seeking candidates for the position of Laboratory Director. It is expected that the successful candidate will qualify for appointment as a Senior Research Fellow in the Harvard Department of Physics. The qualifications for this position are equivalent to those for a tenured faculty position at a major research university.

The LPPC research program is funded by the U. S. Department of Energy and includes the ATLAS experiment at CERN, the BaBar experiment at SLAC, the CDF, MINOS, and NOvA experiments at Fermilab, and the Pan-STARRS and LSST experiments in observational cosmology.

As LPPC Director, the successful candidate will be responsible for the coordination of LPPC research activities, the management of grant funding, the supervision of the laboratory technical staff, and the oversight of the laboratory facilities and computers. As a Senior Research Fellow, the successful candidate will participate as a senior level physicist in one or more of the LPPC research projects. It is expected that the division of time between administrative responsibilities and research activities should be approximately equal. In addition, there may be opportunities for the successful candidate to teach in the Department of Physics.

Applicants for this position should have extensive research experience in either particle physics or observational cosmology. Demonstrated leadership and interpersonal skills are essential. To apply, please send a CV, a statement of interest, and arrange to have three letters of reference sent to

Director Search
c/o Professor Gary Feldman
LPPC
Harvard University
18 Hammond Street
Cambridge, MA 02138

Applications and letters of reference can also be emailed to **lppc@physics.harvard.edu** (pdf files preferred). We will begin considering applications on March 2, 2007, but will continue to accept applications until the position is filled.

Harvard is an equal opportunity, affirmative action employer. Applications from women and minority candidates are especially encouraged.

UNIVERSITY of GLASGOW

DEPARTMENT OF PHYSICS AND ASTRONOMY

Research Associate in Experimental Particle Physics

£25,889 – £31,840, Ref 12938/DPV/A3.

Taking a leading role in analysis of first data, you will support the commissioning of the Vertex Locator and work on future developments for the LHCb Experiment at the CERN Large Hadron Collider. You will have a PhD in experimental particle physics, and have extensive knowledge in a research related field. You will have undertaken physics studies or an analysis relevant to the needs of high-energy colliders. Funding is available for 24 months.

Informal enquiries can be made to Dr C Parkes,tel: +44 (0)141 330 5885, email: c.parkes@physics.gla.ac.uk or Dr P Soler,tel: +44 (0)141 330 4153, email: p.soler@physics.gla.ac.uk For further information on the post and method of application see www.physics.gla.ac.uk/ppe/jobs/LHCb.html

Closing date: 2 March 2007.

The University is committed to equality of opportunity in employment.

POSITIVE ABOUT DISABLED PEOPLE

www.gla.ac.uk

UNIVERSITY of GLASGOW

The **Cluster of Excellence** *'Origin and Structure of the Universe'*

invites applications for

Fellows
Postdoctoral Scientists
Doctoral Students

The Cluster of Excellence 'Origin and Structure of the Universe' has recently been installed at the Campus Garching within the Excellence Initiative of the federal government of Germany. The cluster is operated jointly by the physics departments of the two Munich Universities, the Max-Planck Institutes and ESO. It aims at a deeper understanding of the physics of fundamental forces and their interaction with matter that drives the expansion of the universe, the creation of elements and of large scale structures observed in our universe. For this it will install 10 new research groups working in the key areas of science relevant to this field, and create positions for research fellows, postdoctoral scientists and doctoral students.

The fields of science covered range from cosmology and astrophysics, astro-particle physics to particle- and nuclear physics, pursued theoretically and experimentally.

In the **fellow program** we seek the best scientists in the field of fundamental physics. They will be selected in a competitive scheme across the various fields of research from within the cluster. Selected candidates will be invited to join an existing research group of their choice. Support will be given for the duration of 2 years. Selection panels are held about twice per year.

Postdoctoral researchers will work in specific groups and on well defined projects, outlined in more detail in the specific job description. The position is for initially 3 years.

Doctoral students, selected by a PhD committee will be assigned to a specific project and supervisor. The successful candidates will be enrolled at the University of the supervisor which will also award the doctoral degree in physics The student's progress will be followed by two independent advisors. Funding is for three years.

Besides profiting from scientific infrastructures present on the campus Garching the groups will also be integrated in transregional and international research activities either ongoing or planned. Doctoral students will follow a structured PhD program. Interdisciplinary weekly seminars and journal clubs organized by the cluster as well as the large visiting-scientists program offer excellent opportunities for young researchers to broaden their scientific horizon and start new collaborations.

Active participation in the teaching program for physics at the faculties of physics and of the Cluster is welcome.

The advancement of women in the scientific field is an integral part of the clusters and the university's policy. ***Women, therefore, are especially encouraged to apply***. Persons with disabilities will be given preference over other applicants with equal qualifications.

Details on the different positions can be found on

http://universe-cluster.de (→ jobs)

Applicants should complete the corresponding web-forms.

Excellence Cluster 'Origin and Structure of the Universe'
c/o Prof. Dr. Stephan Paul
Physics Department
Technische Universität München

Laboratoire de l'Accélérateur Linéaire d'Orsay (LAL Orsay)

Head of Accelerator R&D department

LAL Orsay is the largest French laboratory within CNRS (Centre national de la Recherche scientifique) devoted to particle physics and cosmology. With a total staff of 320 physicists, engineers and technicians, it is one of the major labs in our field with strong participation in a dozen of major scientific endeavours. LAL has a long tradition of accelerator R&D and construction. In this context much of our work is performed in collaboration with international partners (CERN, DESY).

We are seeking to recruit an **RF Engineer / Accelerator Physicist as a Group Leader for our Accelerator Design and Construction Group**. The present interests of the group, consisting of 20 staff members and working in close relationship with a strong mechanical and engineering group of 60 people, are centred on Linear Colliders (ILC, CLIC) and the European X-ray Free Electron Laser. Our main current activities are in the domain of radio-frequency photo-injectors and RF power couplers and these activities may be extended to include polarised positron sources, beam instrumentation and beam delivery optics. Candidates with an excellent knowledge of accelerator science, proven management skills and experience in one or more of the domains mentioned above are encouraged to apply.

Fixed term contract of public service (1 year) level research engineer , diploma engineer degree or Doctorate .
Salary: 2200 / 2900 euros depends experience

Applications, including a curriculum vitae, can be mailed to:
Service du Personnel, Laboratoire de l'Accélérateur Linéaire, B.P.34 91898 Orsay Cedex, France.

Informal enquiries can be made to
C. Arnault (tel.: 33 (0)1 64 46 84 24, e-mail: arnault@lal.in2p3.fr)
A research grant, up to 800 k€, can be requested from the French National Research Agency (ANR) under certain conditions, in association with this position.

MIT
Massachusetts Institute of Technology

It takes everyone at MIT to be MIT.

Computer Services Manager

The Laboratory for Nuclear Science's Computer Services Group (CSG) seeks a manager to oversee the overall delivery of both research and administrative computer services to faculty, staff, and students (about 200 users). The successful candidate will need to have a working knowledge of Linux, Windows, and Macintosh operating system environments which are supported by the CSG for the theoretical and experimental high energy and nuclear physics research computing programs at MIT. LNS maintains its own subnet within MIT. The CSG provides network connectivity for several hundred hosts and multiple protocols. This group also supports ORACLE for the financial and administrative groups in LNS.

Requirements: An advanced degree in a technical field, preferably with a background in physics or an equivalent combination of education and experience. A minimum of five years of relevant experience desirable; at least two of which should be managerial experience of a complex computing facility, preferably in an educational and/or research environment. Excellent written, verbal, and interpersonal communication skills and a service orientation required. Should be able to organize and manage staff within the constraints of a given budget. Must be capable of capitalizing on new developments in the computing field to enhance the quality of computing support and be able to deliver these new relevant technologies to LNS researchers in a timely manner.

In addition to applying online at http://web.mit.edu/jobs, interested applicants should submit three letters of reference to:
Dr. Stephen Steadman, c/o Kenneth L. Hewitt, MIT, 26-516,
77 Massachusetts Avenue, Cambridge, MA 02139-4307.
Please reference job number mit-00003661.

MIT is an equal opportunity/affirmative action employer. Applications from women, minorities, veterans, older workers, and individuals with disabilities are strongly encouraged.

http://web.mit.edu

LIGO

SENIOR OPTO-MECHANICAL/ SYSTEMS ENGINEER

The Caltech/MIT Laser Interferometer Gravitational-Wave Observatory (LIGO) seeks a highly motivated, skilled and experienced senior project engineer to join its team.

LIGO is sponsored by the U.S. National Science Foundation to research, develop, and implement techniques for the detection of astrophysical gravitational waves.

The successful candidate will: direct/identify and perform system design tradeoffs and systems engineering; direct/perform mechanical dynamics analysis for active vibration isolation systems; manage configuration control and documentation; oversee the implementation of quality assurance aspects; collaborate with scientific personnel and management to specify and coordinate/manage interface requirements between major subsystems; collaborate with subsystem leaders and senior management to determine acquisition/procurement strategy (e.g., make or buy); oversee precision optomechanical instrument fabrication; be responsible for the procurement of hardware components and systems; help to coordinate the assembly, installation and commissioning of the systems at the LIGO observatories. Requirements: BS (MS or PhD preferred) degree in ME, Optical Engineering or Physics. Must have 8 yrs of exp in optomechanical instrument design, analysis and fabrication. Systems engineering and/or integration experience for large physics experiments is essential. Experience in 3D modeling (Solid Works preferred), as well as experience in finite element dynamic modeling is necessary. Good spoken and written communication skills, as well as being adept with Microsoft Word and Excel. Exp in active vibration isolation; ultra-high vacuum; low thermal noise design; precision machining or metrology; or modal dynamics survey is desirable. Facility with analysis tools such as Matlab, Mathematical and/or Zemax, is highly desirable.

Applicants should send curriculum vitae, list of publications and patents, and contact info for at least 3 professional references to: HR@ligo.caltech.edu.

3 letters of recommendation should be sent directly to Cynthia Akutagawa at HR@ligo.caltech.edu. PDF submittals preferred.

To view a complete job description, go to: http://www.recruitingcenter.net/clients/CalTech/publicjobs/controller.cfm?jbaction=JobProfile&Job_Id=13279&esid=az

More information about LIGO available at www.ligo.caltech.edu

Caltech is an Affirmative Action/Equal Opportunity Employer.
Women, minorities, veterans, and disabled persons are encouraged to apply.

LIGO

RESEARCH ENGINEER, MECHANICAL

The Caltech/MIT Laser Interferometer Gravitational-Wave Observatory (LIGO) seeks two highly motivated, skilled and experienced mechanical engineers to join its Livingston, Louisiana observatory team. These positions are 3-year term positions.

The Observatory is pursuing a vigorous program to improve the sensitivity of its initial detectors, interleaved with astrophysical observations at progressively higher sensitivities.

Successful candidates will contribute to an R&D program for detector technology improvements, leading to Advanced LIGO-- a major detector retrofit planned for 2008 through 2013. Principal job functions include: design/analysis/implementation of high performance vibration isolation systems, suspension and active control of precision optical assemblies; assembly procedures and tooling; alignment fixtures; management and support of competitive procurements; oversight of fabrication, including shop liaison; test and characterization of dynamics and performance; participation in assembly, installation and commissioning.

BS degree in ME, Physics, or closely related field required, plus 5 yrs exp demonstrating excellence in: 3D CAD (Solid Works preferred); finite element analysis; fabrication management, including QA and process inspection. Proficiency in one or more of the following is necessary: vibration and acoustics; optical suspension systems; feedback control systems or active structures; optomechanical, precision design; ultrahigh-vacuum technology.

Applicants should send CV, list of publications and patents, and contact info for at least 3 professional references to: HR@ligo.caltech.edu.

3 letters of recommendation should be sent directly to Cynthia Akutagawa at HR@ligo.caltech.edu. PDF submittals preferred.

To view a complete job description, go to: http://www.recruitingcenter.net/clients/CalTech/publicjobs/controller.cfm?jbaction=JobProfile&Job_Id=12777&esid=az

More information about LIGO available at www.ligo.caltech.edu

Caltech is an Affirmative Action/Equal Opportunity Employer.
Women, minorities, veterans, and disabled persons are encouraged to apply.

Jefferson Lab
Thomas Jefferson National Accelerator Facility

HALL LEADER
PHYSICS DIVISION

Salary Range:
$79,700 - $126,100 (SS III) / $96,700 - $152,700 (SSS)

Jefferson Lab seeks an experienced physicist to assume the duties of Hall Leader for the Hall C Group. Reporting to the Associate Director for Physics, the Hall C leader is responsible for overall management of the Hall C physics program, supervision of the scientific staff, postdoctoral fellows, engineering, & technical staff. A key responsibility is leading the development of experimental research proposals, including: apparatus development & installation, data collection & analysis, & presentation and publication of scientific research carried out in the hall. The Hall Leader: acts as contact person for User groups; allocates support for User research; oversees the operation of the Hall's experimental equipment; manages the budget for Hall C operations & new equipment construction projects & maintains a positive EH&S culture. A major responsibility over the next decade will be the development and execution of the scientific program that will use the 12 GeV Upgrade beams, including the construction, installation, commissioning, & use of the new experimental apparatus needed in Hall C for that program, integrating the 12 GeV design and construction efforts with the ongoing 6 GeV research program in the hall.

The successful candidate will have a Ph.D. in Experimental Nuclear or Particle Physics or the equivalent combination of education & experience. At least ten years of professional experience in intermediate energy nuclear physics or closely related areas (including a minimum of three years in the management of an internationally-recognized subatomic physics research group) is required. Technical knowledge of a broad variety of equipment, detectors, targets, and experimental programs associated with nuclear physics, and experience managing large installation projects are also essential. Scientific excellence, as demonstrated by publications in nuclear physics journals, & demonstrated supervisory, planning, problem solving, decision making, & communication skills are critical.

Applicants should apply online at: www.jlab.org/jobline/ or email: jobline@jlab.org, submitting a curriculum vitae and copies of recent (un)published work, and arrange to have letters from three references sent to: JSA/Jefferson Lab Human Resources Consultant, 628 Hofstadter Road, Ste 2, Newport News, VA 23606.

Jefferson Lab is an Affirmative Action/Equal Opportunity

UCL

UCL Department of Physics and Astronomy
High Energy Physics Group

Lecturer in Physics

Applications are invited for the above position, to commence on or before 1st September 2007.

We are looking for an outstanding experimental particle physicist who will be at the forefront of the physics effort with early data from the ATLAS experiment at the LHC, as well as contributing to the teaching of the department.

The high energy physics group has a strong ATLAS programme, spanning discovery physics and the standard model, and including technical contributions to the tracking, trigger, data acquisition system and several major software projects. We also have an involvement in plans for detector upgrades for forward physics and higher luminosities. The ATLAS group operates within a vibrant research group spanning experimental neutrino physics, current and future collider experiments and particle phenomenology. Full details are available at: http://www.hep.ucl.ac.uk.

The successful applicant will have an established record of significant research and the potential to become a leader in the field. S/he will also be expected to show evidence of competence in teaching at undergraduate and postgraduate level. Salary scale in the Lecturer range: £29,138 to £39,160 p.a., plus £2,472 London Allowance, and relocation benefits.

Further details about the post are available at: www.hep.ucl.ac.uk/positions. Application forms can be downloaded from:
http://www.ucl.ac.uk/hr/docs/download_forms/job_app.doc
Application forms, accompanied by a full CV, including a statement of research interests and plans, plus contact details of three referees, should be sent to: Professor J Tennyson (hod.physast@ucl.ac.uk) Head of Department of Physics and Astronomy, University College London, Gower St, London, WC1E 6BT. Informal enquiries may be made to the HEP Group Leader, Professor Jonathan Butterworth (j.butterworth@hep.ucl.ac.uk).

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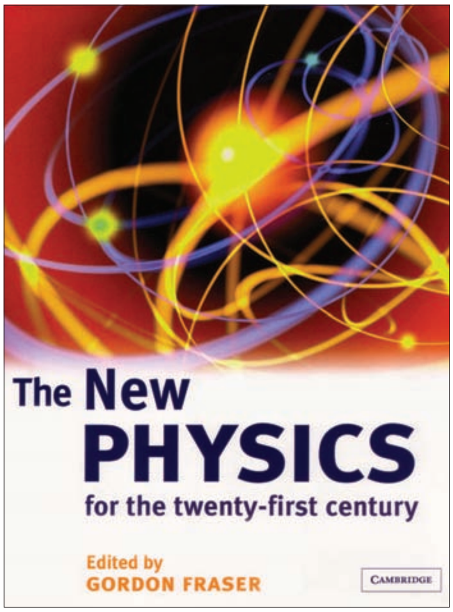
BOOKSHELF

The New Physics for the 21st Century by Gordon Fraser (ed.), Cambridge University Press. Hardback ISBN 9780521816007, £30 ($60).

Seventeen years ago a book called *The New Physics* illuminated – vividly for the layperson and sensibly for the student – a series of scientific advances and philosophical obsessions, and it trailed them as signposts for the future. As so often happens, the future went off in a somewhat different direction. While Paul Davies was editing the first volume, physicists wondered loudly and publicly about dark matter and cosmic strings; black holes and the end of time; grand unification theory and cosmic inflation; the new window on the universe by the yet to be launched Hubble Space Telescope; and the claim by the Nobel prize-winner Luis Alvarez that an asteroid had crashed into the planet 65 million years ago and ended both the Cretaceous era and the dinosaurs. In fact, Alvarez and his planet-bruising bolide never got a mention in the Davies volume, but at the time there seemed quite a lot else to be getting on with.

What a difference the decades make. In the past 17 years, experimental physicists have delivered a fifth state of matter in the Bose–Einstein condensate; slowed light down first to walking speed and then to a complete standstill; dropped the idea that time might run backwards and instead proposed interminable heat death in an ever expanding cosmos; demonstrated quantum entanglement and teleportation; mapped the fluctuations in the cosmic background radiation; introduced branes and apparently dropped cosmic strings; and discovered dark energy in a big way – so big that it accounts for three-quarters of everything. Nanotechnology emerged as both engineering obsession and practical investment, amid royal alarm in the UK about global death by grey goo. The Hubble telescope went up with a faulty mirror, and NASA launched its International Space Station but seemed to run out of steam. Global warming – physics at a practical level for most people – announced its arrival with a procession of record temperatures globally, and the debate about the Cretaceous catastrophe flowered into a much larger argument about asteroid impact-warning and deflection.

Physics never seemed so glamorous,



but student numbers continued to fall and university departments continued to close. The old *New Physics* didn't look so new and now CERN's own Gordon Fraser has produced a companion volume of 19 essays, just as substantial, just as wide-ranging, and in some cases just as much fun.

Physics is not easy (it is after all done by PhDs, not dilettantes) but each essay begins comprehensibly and even enticingly, before diving quite briskly into mathematics, hard argument and occasionally hostile language. (Did Michael Green, writing about superstring theory, really have to head a section "beyond the naive perturbative approximation"?) Chris Quigg looks at particle physics and puts the Large Hadron Collider handsomely in its scientific context. But Fraser plays no special favourites. Nanoscience is there, and the Grid, and there are welcome surveys of biophysics and medical physics; the last essay is a reminder that without the physics of imaging, some neuroscience would be little more than voodoo.

All the classical preoccupations – cosmology, astronomy, gravity and the quantum world – get a fresh look. Robert Cahn's survey of the physics of materials is a big help for the benighted. Ugo Amaldi ends the volume with a handsome canter through the connections between physics and society, and echoes many of the themes tackled in the book's previous 18 chapters. The bad news is that physics still has an image problem. The good news is that this time Alvarez gets a mention, although not for bolide impacts, dinosaurs or the present concerted international effort to identify and track near-Earth objects. No, he gets a mention for not solving the world's energy crisis: to be fair, for admitting that, for a few exhilarating moments, he thought that he had solved the world's fuel problems for all time by fusing a proton with a deuteron to form helium-3. This anecdote appears, a little unkindly, under the heading "usable knowledge".

Tim Radford, former science editor of the Guardian.

Books received

Experimental Techniques for Low-Temperature Measurements: Cryostat Design, Material Properties, and Superconductor Critical-Current Testing by Jack W Ekin, Oxford University Press. Hardback ISBN 9780198570547, £65 ($125).

This extensively illustrated book presents a step-by-step approach to the design and construction of low-temperature measurement apparatus. The main text describes cryostat design techniques, while an appendix provides a handbook of materials-property data for carrying out designs. Tutorial aspects include construction techniques for measurement cryostats, operating procedures, vacuum technology and safety. Many recent developments in the field not previously published are covered in this volume.

Quantum Optics: an Introduction by Mark Fox, Oxford University Press. Hardback ISBN 9780198566724, £49.95 ($89.50). Paperback ISBN 9780198566731, £24.95 ($44.50).

This is a modern text on quantum optics for advanced undergraduate students. It provides explanations based primarily on intuitive physical understanding, rather than mathematical derivations. There is a strong emphasis on experimental demonstrations of quantum optical phenomena, in both atomic and condensed-matter physics. Other topics include squeezed light, Hanbury–Brown–Twiss experiments, laser cooling, Bose–Einstein condensation, quantum computing, entangled states and quantum teleportation. The book also includes worked examples and exercises.

Six secrets of successful institutes

Mike Lazaridis, co-founder of the company behind the BlackBerry, explains how he has applied business strategy to establish a world-class theoretical-physics institute.

I started a company, Research In Motion, while I was still at the University of Waterloo in Ontario, Canada. By the late 1990s we had developed the BlackBerry handheld mobile device. As a result I found myself in a position where I could invest in an area that I am passionate about and one that could make a big difference.

Spot an opportunity. Having observed that research funding is usually thinly spread, I decided to start a theoretical-physics institute that would focus on science that is fundamental to all human progress and at which Canada can excel.

Promote scientific openness. My driving motivation for establishing the Perimeter Institute (PI), located next to the University of Waterloo, is that I feel fundamental science needs more support. What worries me is that governments all around the world seem to be listening to the same consultant. They ask scientists to do something that will benefit the economy within five years. Of course, governments are under pressure to balance budgets and be accountable – that's reasonable. But some of that pressure is getting transferred to universities, with unfortunate results.

Science is a global enterprise based on co-operation and openness. If you say to universities that they must justify their research with patents and licences, you collapse that openness. Efforts to commercialize too early are making researchers more secretive, hampering their ability to excel, without necessarily helping business. I wanted to challenge this trend.

Concentrate on core competencies. A strategic decision we made when creating the Institute in 1999 was to focus on a couple of very specialized fields, quantum gravity and quantum foundations, because we felt these were areas where a relatively small, high-quality team could make a big difference. This is the same strategy that originally made BlackBerry a success: it focused on doing one thing – "push e-mail" – very well

Lazaridis: "There's reason for balancing good science with good outreach."

rather than competing on all features. So for the first few years, PI focused on recruiting top-class researchers in these two areas to ensure that research efforts were of international calibre within a relatively short period. As the Institute's reputation builds, we are branching out a bit more.

Build a focal point. The other decision we made early on was to house the Institute in an outstanding building. Before we built it, we spent two years going around the world and talking to people in theoretical-physics institutes and theory departments at universities, asking them what works and what doesn't. Based on this, we put together some specifications and organized a competition, where we really let the architects go wild. The result is a building with a design that has won several prizes and is internationally recognized.

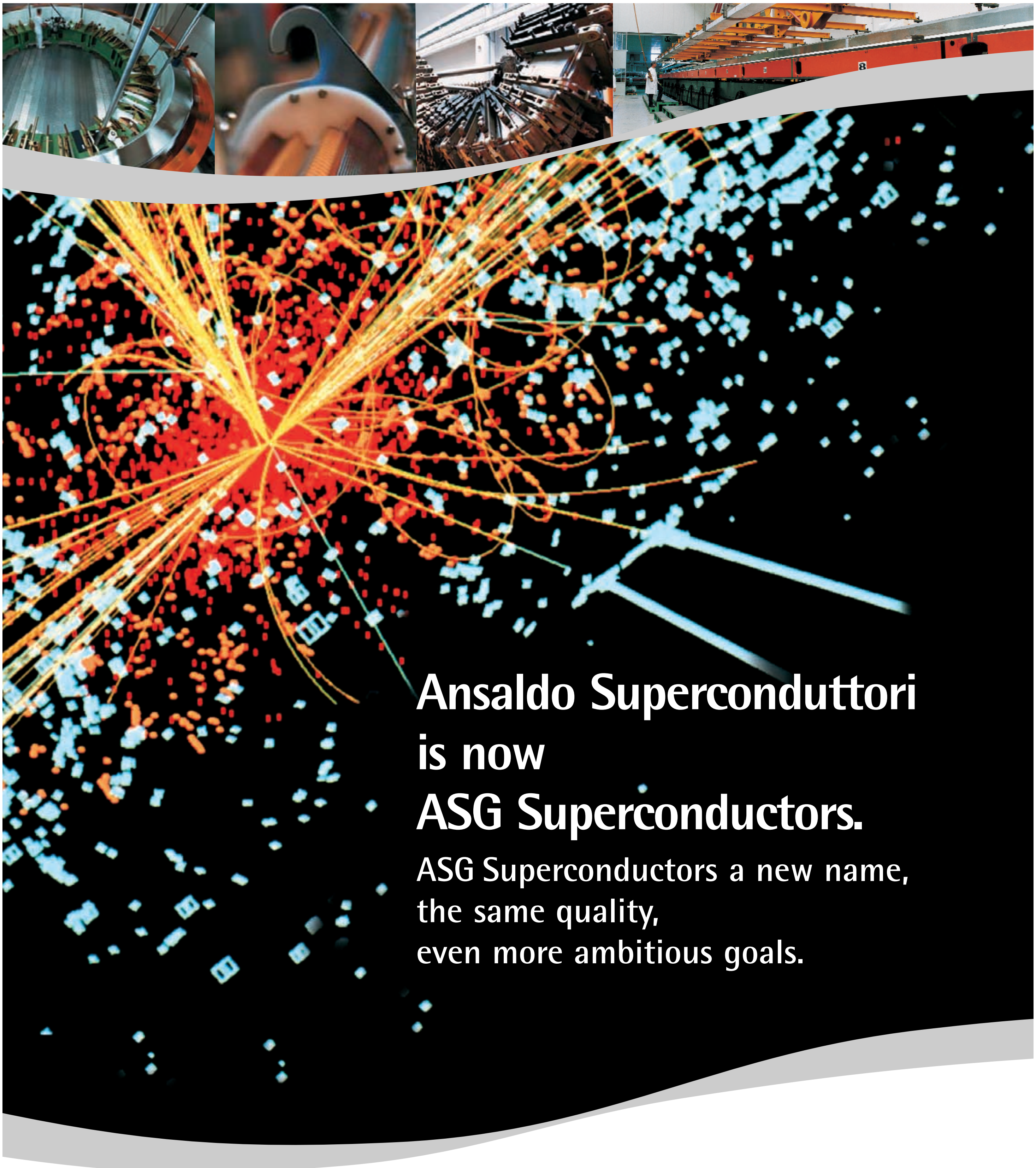
Attract investment. I invested C$100 million of my own money in PI to get it started. For the longer term it was critical to get government support. Convincing government officials took a huge effort. Part of the challenge is that not many politicians understand basic science, let alone know how to value it. This means that a lot of funding is done almost entirely on your ability to explain the benefits and on their faith in you. Early on, all levels of government (local, provincial and federal) saw the benefit of PI and decided to support the Institute with a total of about C$55 million dollars. More recently, and now that the Institute is established, a further C$50 million in public investment was warmly received.

Present your product. In the long run, you can't rely on faith alone. So although excellent science is crucial to success that's really only half of the story. The other half of the Institute's activities is about outreach. For example, PI has a summer-school programme for students from all over Canada and around the world. PI also goes on tour across Canada to give classroom instruction about physics to both students and teachers.

PI also has a programme of monthly public lectures. Sometimes we'll have scientists like Roger Penrose discuss a weighty topic; other times we'll have debates about science with well-known historians and journalists. Waterloo has a population of only about 100 000, yet every month we fill a 550 seat lecture theatre, and there's always a queue outside on standby. That's how much interest you can generate in science, if you make the effort to open it up for people and make the research accessible.

And that's success. Because ultimately, these are the people who vote for the governments which fund the research. If they don't benefit from and believe in what we're doing, it's always going to be an uphill struggle. So in addition to directly helping students, teachers and members of the general public, there's reason for balancing good science with good outreach. We have to move beyond relying on faith.

Mike Lazaridis is founder and co-CEO of Research In Motion, makers of BlackBerry handheld devices, as well as chancellor of the University of Waterloo. Additional information about PI is available at www.perimeterinstitute.ca.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