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CERN COURIER

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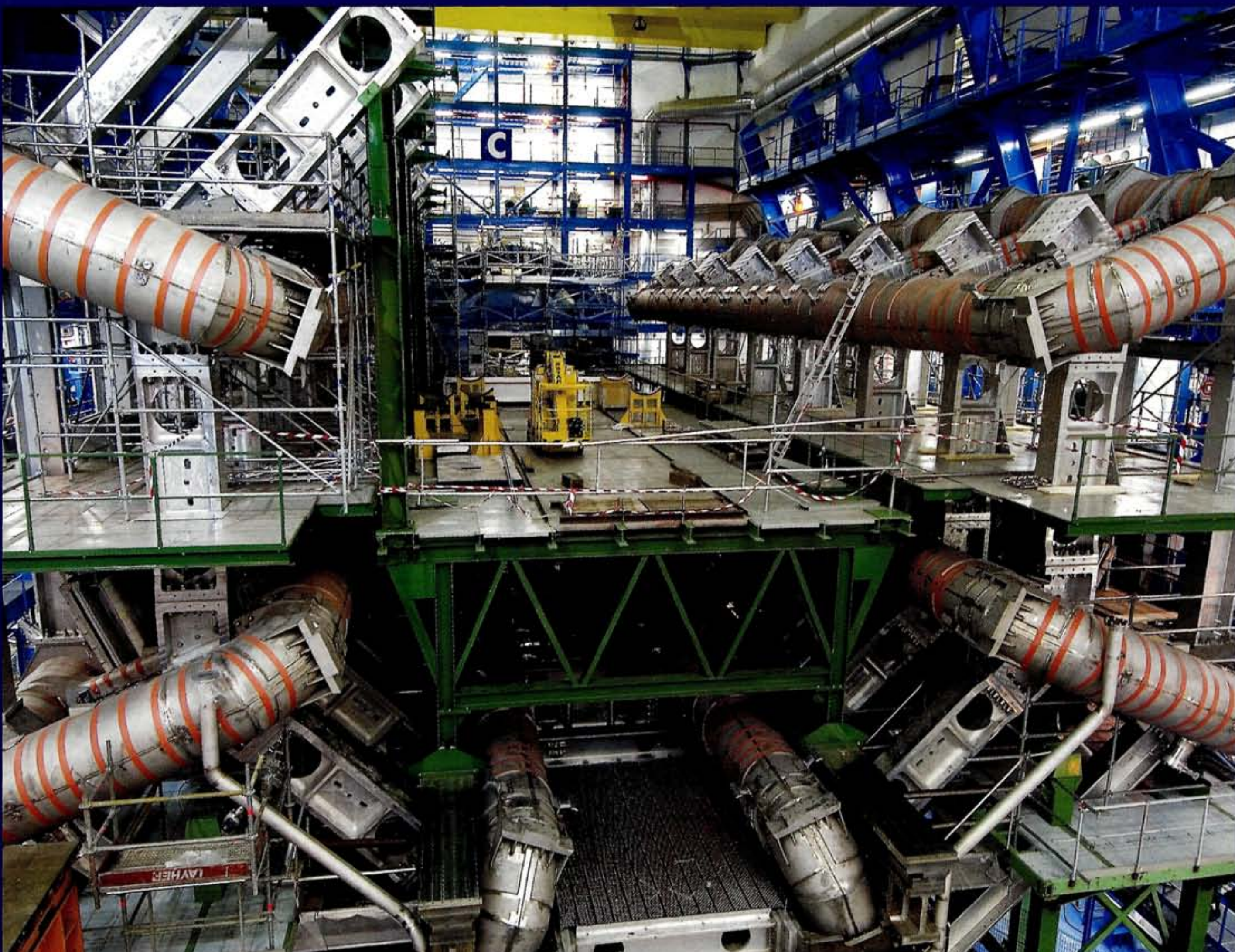

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Mrs Florence ZUBER - florence.zuber@ubifrance.fr
Mrs Isabelle COMMO - isabelle.commo@ubifrance.fr
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CERN :
Mrs Caroline LAIGNEL
caroline.laignel@cern.ch
Tel : +41 22 767 3722
Fax : +41 22 767 7730

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

Advisory board James Gillies, Rolf Landua and Maximilian Metzger

Laboratory correspondents:
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Brookhaven National Laboratory (US): P Yamin
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Publisher Jo Nicholas
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CERN COURIER

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Electron cooling at high energy p5

Mystery of the 10th planet p12

Setting the pace at LEAP-05 p35

Cover: Underground installation of the ATLAS detector at CERN is in full swing, with six of the eight toroid coils in position at the beginning of July. The barrel hadronic calorimeter, visible at the far end, recorded its first cosmic-ray events during July (p7).

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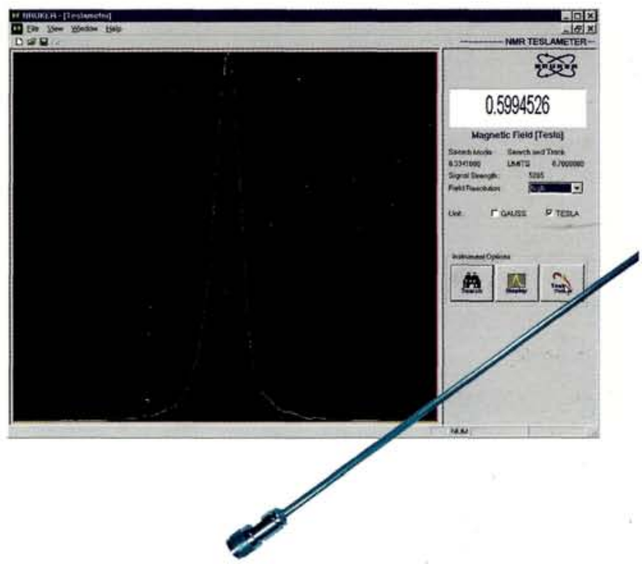

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ACCELERATORS

Fermilab's Recycler beams take electron cooling to new heights

After 10 years of preparation, a team at Fermilab has achieved electron cooling at high energy. On 9 July, on the first attempt, the Electron Cooling Group observed the interaction between an 8 GeV antiproton beam and an electron beam travelling at the same speed. Although commissioning will take another couple of months, accelerator experts have already begun to use the electron-cooling system to reduce the size of antiproton beams prior to their injection into the Tevatron proton–antiproton collider. Ultimately, they hope that electron cooling will increase the collider's luminosity by 50–100%.

Electron cooling, first proposed by Gersh Budker in 1966, is a proven method at low energies, but Fermilab, funded by the Office of Science of the US Department of Energy, is the first laboratory to extend the method to relativistic beam energies (*CERN Courier* June 2002 p21). The higher-energy system has been developed at Fermilab under the leadership of Sergei Nagaitsev, who joined the laboratory in 1995. Installation of the system in the Recycler storage ring, which stores and cools antiprotons, began in August 2004.

The Recycler storage ring (inside black brackets) and its electron-cooling system are located just above Fermilab's Main Injector accelerator (bottom, with red quadrupole magnet). The shiny pipe in the middle is the electron-beam return line. (Courtesy Fermilab.)

Constructed in the late 1990s, the Recycler is 3.3 km in circumference and uses permanent magnets to store antiprotons at 8 GeV. The new electron-cooling system mainly reduces the longitudinal emittance of the beam by "mixing" the antiprotons with a continuous 4.3 MeV beam of electrons, which are provided by a Pelletron accelerator adjacent to the ring. The electron beam, with a current of up to 0.5 A and power of up to 2 MW, travels for approximately 20 m along the same path as the antiprotons, and is then sent back to the Pelletron for recirculation. The electrons interact with the antiprotons, cooling the beam and reducing the spread in longitudinal momentum: antiprotons travelling too fast are slowed down as they bump into electrons, and slow antiprotons are sped up as they are hit by faster electrons.

A stochastic-cooling system, based on the principle invented by Simon van der Meer at CERN in 1972, already reduces the transverse emittance of the Recycler's antiproton beam. With the start-up of the electron-cooling system, it is the first time that two beam-cooling systems have been used concurrently, according to Nagaitsev, and that electron cooling has been used to improve beams for a collider.

- For further details see www.ecool.fnal.gov.

Sommaire

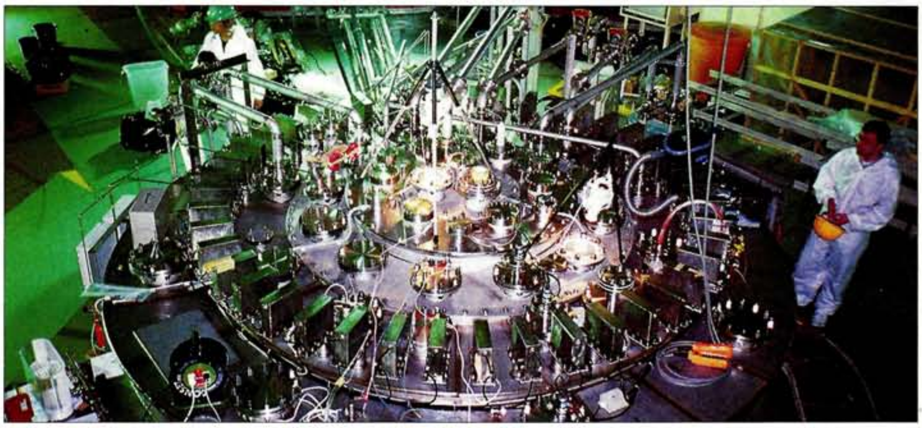
NEUTRINOS

KamLAND detects geoneutrinos

The Kamioka liquid-scintillator antineutrino detector (KamLAND) has made the first observation of "geoneutrinos". This comes just over 50 years since George Gamow, in a letter to Fred Reines in 1953, pointed out the possibility of detecting antineutrinos of terrestrial origin. KamLAND, which has already confirmed neutrino oscillations by detecting antineutrinos emitted from nuclear reactors, has opened up a new window of research, exploring the deep interior of the Earth by detecting geoneutrinos.

Geoneutrinos are created in the beta decays of radioactive isotopes in the Earth (*CERN Courier* October 2003 p20). The current geochemical and geophysical models suggest that the radiogenic power from the ^{238}U and ^{232}Th decay chains is 16 TW, approximately half the total measured heat-dissipation rate from the Earth. This heat helps to drive convective flows in the mantle and the outer core, resulting in plate tectonics, volcanism and terrestrial magnetism. Thus radiogenic heat is a key factor in understanding the Earth's dynamics, formation and evolution. However, since geophysicists have never had a direct way to determine how uranium and thorium are distributed in the Earth's interior, measuring their concentration inside the Earth sheds new light on geophysics.

KamLAND consists of about 1 kt of liquid scintillator, located in the Kamioka mine in Japan (*CERN Courier* April 1999 p22). It can detect geoneutrinos from the ^{238}U and ^{232}Th decay chains through an inverse beta-decay process with a threshold energy of 1.8 MeV. Using data collected between 9 March 2002 and 30 October 2004 with a detector live-time of 749 days, 25 geoneutrino events were obtained after subtracting the number of expected background events, mostly from reactor antineutrinos. Combining the event rate and energy spectrum of candidates yields between 4.5 and 54.2 geoneutrinos, with a central value of 28 at the 90% confidence interval (see figures). This assumes a Th:U mass ratio of 3.9, the value derived from chondritic meteorites and commonly understood to be the same for all materials in the solar system.



A view of the top of the KamLAND detector. (Courtesy Berkeley KamLAND group.)

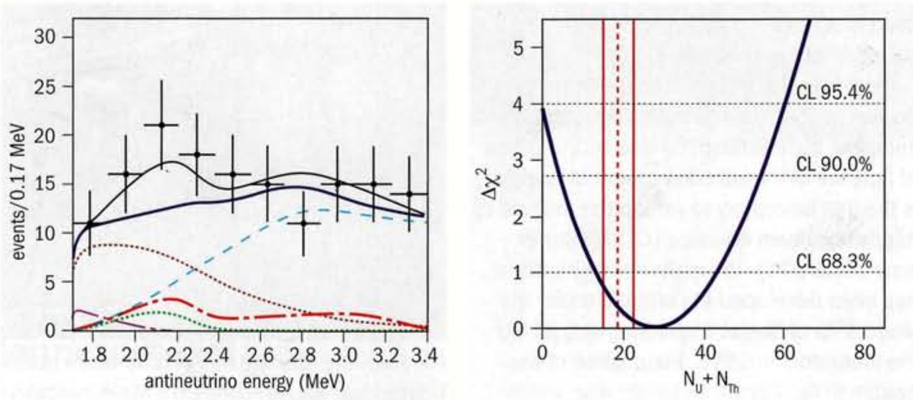


Fig. 1 (left). Electron antineutrino energy spectrum of 152 candidate events with energies less than 3.4 MeV. The lower solid line shows the total expected background spectrum including the reactor (dashed blue line), $^{13}C(\alpha, n)^{12}C$ reactions (thin dotted brown line) and accidental coincidence (dot-dashed purple line) events. Combining the expected geoneutrino signals of ^{238}U (dot-dashed red line) and ^{232}Th (dotted green line), gives the total expected spectrum shown by the upper solid line. Fig. 2 (right). $\Delta\chi^2$ as a function of the total number of ^{238}U and ^{232}Th geoneutrino candidates, assuming a Th:U mass ratio of 3.9. The band gives the value predicted by the current geological model of the Earth.

The result is consistent with the central value of 19 predicted by a geological model, and constrains the flux of geoneutrinos from uranium and thorium to less than $1.62 \times 10^7\ cm^{-2}\ s^{-1}$ at 99% confidence limits. Although the present data have limited statistical power, they nevertheless directly provide an upper limit of 60 TW for the radiogenic power of uranium and thorium in the Earth.

These investigations should pave the way to more accurate measurements, which may develop into a new field of neutrino geophysics. There is a programme currently under way to reduce the radioactive content of the KamLAND detector, but further background reduction will require a new detector location, far away from nuclear reactors. In the future, a worldwide network of geoneutrino detectors would allow the production of a tomographic image of the radiogenic heat distribution.

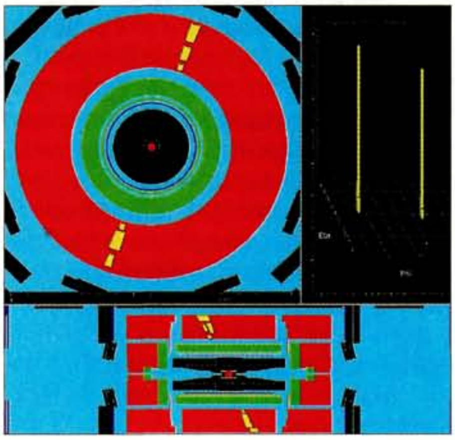
Further reading

T Araki *et al.* 2005 *Nature* **436** 467.

LHC EXPERIMENTS

ATLAS calorimeter records cosmic-ray events underground

On the evening of 21 June, the ATLAS detector, now being installed in the underground experimental hall UX15 at CERN, reached an important psychological milestone: the first cosmic-ray events were recorded by the barrel hadronic tile calorimeter *in situ*. Although only four of the 64 calorimeter slices were included in the trigger, beautiful muon tracks were seen traversing the detector. The purpose-made trigger box selected cosmic rays passing close to the interaction region, thus giving the impression of "back-to-back" tracks.



A cosmic-ray muon recorded by the barrel tile calorimeter of ATLAS on 21 June. The calorimeter has three layers and a pointing geometry. The tile calorimeter appears in red, while the yellow trapezoids represent the energy deposited in the tiles.

An estimated 1 million cosmic muons enter the ATLAS cavern every 3 min, and the ATLAS team decided to use of some of them for the commissioning of the detector. For two weeks, experts of different disciplines from CERN and the experiment (cooling, high-voltage, front-end electronics, data acquisition, offline) worked underground in USA15, the counting room next to the main ATLAS cavern. Their goal was the commissioning of hardware and software systems, monitoring long-term stability and checking module uniformity and performance. The test used final components for the whole signal chain up to the counting room and provided valuable experience for the whole tile calorimeter system.

This is just the first stage of a long ATLAS commissioning programme, which will gradually see more subdetectors taking part. In autumn with a portion of the muon spectrometer already installed in the pit will begin commissioning, and will be joined in spring 2006 by the electromagnetic liquid argon calorimeter after it has been cooled. A complete "slice" of the ATLAS detector ran in a test beam during 2004, but this is the first time that events have been recorded underground.

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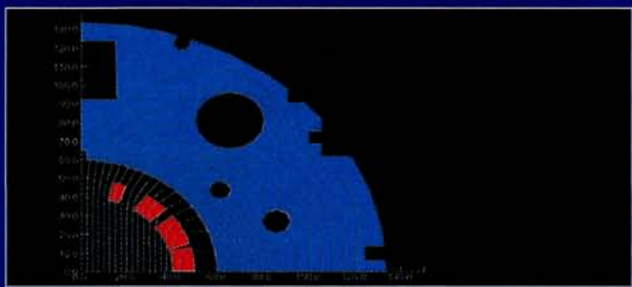
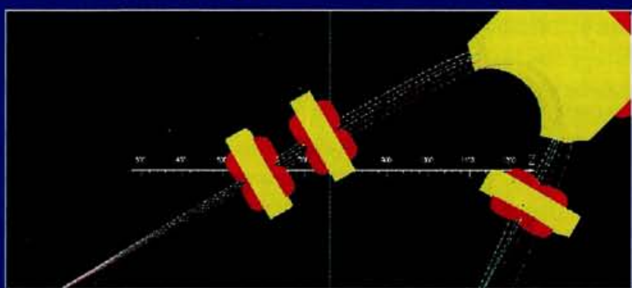


Flux lines for a typical dipole magnet.



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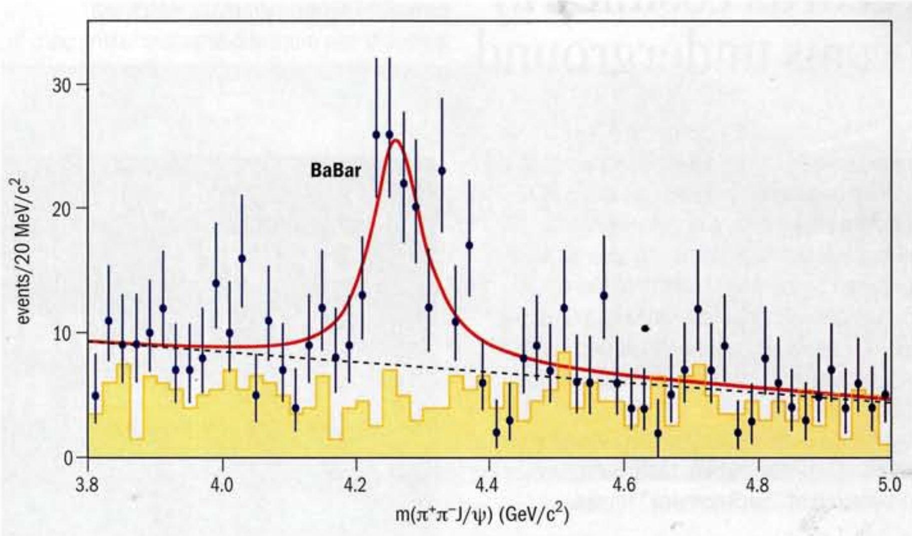
NEW PARTICLES

BaBar collaboration detects new resonance

Charmonium spectroscopy has seen a revival over the past year or so, with various groups reporting heavy charmonium states (*CERN Courier* January 2004 p9). The BaBar collaboration has now added to the list of new states, after a recent study of the initial state radiation process $e^+e^- \rightarrow \gamma \pi^+ \pi^- J/\Psi$ across the charmonium mass range.

The data were collected with the BaBar detector at the SLAC PEP-II asymmetric-energy e^+e^- storage ring, representing a luminosity of 233 fb^{-1} at a centre-of-mass energy slightly above 10 GeV. Candidate J/Ψ mesons were reconstructed via their decays to e^+e^- and $\mu^+\mu^-$. BaBar observed an excess of 125 ± 23 events centred at a mass of about 4.26 GeV/c^2, signifying the presence of one or more previously unobserved $J^{PC} = 1^-$ states containing hidden charm.

At the current level of statistics the number of new states cannot be distinguished and the signal is compatible with a single resonance about 90 MeV/c^2 wide, although the single-resonance fit probability is low. For the moment the particle has been named Y(4260).



The $\pi^+\pi^- J/\Psi$ invariant-mass spectrum showing the peak for the Y(4260).

Further reading

The BaBar Collaboration 2005 http://arxiv.org/abs/hep-ex/0506081.

WEAK DECAYS

Belle observes b→d

The Belle collaboration, with a detector operating at the KEKB facility, has recently reported that they have observed the rare b → d transitions. After analyzing 386 million B meson pairs, they have identified 35 events in which the B meson decays into either a ρ or an ω meson with an accompanying photon, implying a branching fraction $Br(B \rightarrow (\rho, \omega)\gamma) = 1.34 + 0.34 - 0.31$ (stat) + $0.14 - 0.10$ (syst) $\times 10^{-6}$ with a significance of 5.5σ. From this they derive the ratio of CKM matrix elements $|V_{td}/V_{ts}| = 0.200 + 0.026 - 0.025$ (exp) + $0.038 - 0.029$ (theo). This is the first time that such B decays have been observed, due to the low branching fraction.

Belle has also reported evidence for signals in $B^+ \rightarrow \overline{K^0}K^+$ and $B^0 \rightarrow K^0\overline{K^0}$ with significances of 3.0σ and 3.5σ respectively, albeit from a sample of 275 million $B\overline{B}$ pairs. These decay modes are examples of hadronic b → d transitions. The corresponding branching fractions are measured to be $Br(B \rightarrow \overline{K^0}K^+) = 1.0 \pm 0.4 \pm 0.1 \times 10^{-6}$ and $Br(B^0 \rightarrow K^0\overline{K^0}) = 0.8 \pm 0.3 \pm 0.1 \times 10^{-6}$.

Further reading

K Abe *et al.* 2005 www.arXiv.org/abs/hep-ex/0506079 and www.arXiv.org/abs/hep-ex/0506080.

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MEDICAL PHYSICS

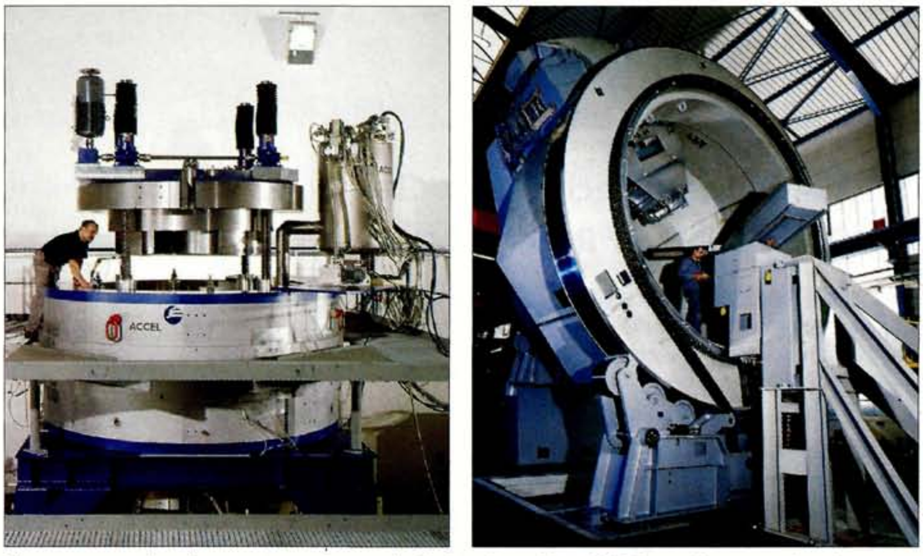
INFN and industry to build new cyclotron for hadron therapy

Italy's National Institute for Nuclear Physics (INFN), ACCEL Instruments GmbH and Ansaldo Superconduttori are to collaborate on a novel superconducting multiparticle cyclotron for hadron therapy. The machine will be based on a concept that has been developed at the INFN Laboratori Nazionali del Sud (LNS) in Catania.

Radiation therapy using hadrons – protons and ions – was proposed by Robert Wilson some 60 years ago, as these particles have a better dose-depth distribution in tissue compared with X-rays. This gives an improved conformity of delivered dose on a tumour, allowing the dose to the tumour to be increased, while reducing the risk to healthy tissue and nearby critical organs. However, the relative size and complexity of accelerators for protons and ions mean that most of the 40 000 patients treated with hadrons to date have been irradiated at large research institutions where appropriate particle beams are available. Only in the past decade have suitable accelerators and beam-delivery systems been developed, and the first few dedicated clinical-therapy facilities for protons have now been built. Many more are in the planning stage.

Ions such as carbon are interesting because different biological mechanisms are involved in their interactions, compared with protons, but therapy systems using ions are even bigger and more complex than those for protons only. Two such facilities are under construction in Europe, one by GSI for the university clinics in Heidelberg, and one at Italy's national hadron-therapy centre, the Centro Nazionale di Adroterapia Oncologica (CNAO) in Pavia, with major involvement from INFN and Ansaldo Superconduttori.

An ion-therapy system usually requires a synchrotron 16–25 m in diameter as its main accelerator, while most therapy systems based only on protons use compact cyclotrons – being a continuous source, the cyclotron is more suitable for beam scanning across a tumour. In this context, ACCEL has developed a novel superconducting proton cyclotron only 3 m in diameter, with superior beam-delivery characteristics. This forms the particle source for proton-therapy installations at the Paul Scherrer Institute (PSI) in Villigen, and for Europe's first clinical proton-therapy system at the Rinecker Proton Therapy Center (RPTC) in Munich, which ACCEL is currently commissioning.



The superconducting proton cyclotron (left) developed by ACCEL, and its associated gantry.

To combine the advantages of a superconducting cyclotron with the goal of accelerating different species of ions in addition to protons, INFN has developed a concept for a multiparticle-therapy cyclotron. This is based on LNS Catania's extensive experience both with cyclotron technology and operation, and with its successful proton-therapy programme for eye tumours, in which 87 patients have been treated since 2002. Combining this experience with commercial and technical considerations of size and weight for transport, handling and operational environment has led to a machine concept for providing beams of 250 AMeV protons and light ions. Owing to their stronger interaction in human tissue, carbon ions will have limited penetration depth, but will still cover relevant treatment cases, as has been shown by ion-therapy studies in Japan.

The newly formed collaboration between INFN, ACCEL and Ansaldo Superconduttori is designing this multiparticle cyclotron as a solution for the worldwide clinical ion/proton-therapy market that is more cost effective, and less operator and maintenance intensive. While it will have somewhat reduced energies for heavier ions such as carbon, it will have superior beam characteristics compared with synchrotron-based installations.

The novel superconducting accelerator is a clear example of the benefits brought by advances over the past 30 years in the application of superconductivity to accelerators in particle and nuclear physics laboratories. This research is culminating now with the Large Hadron Collider under construction at CERN, where both ACCEL and Ansaldo Superconduttori are heavily involved in the construction of the main superconducting magnets.

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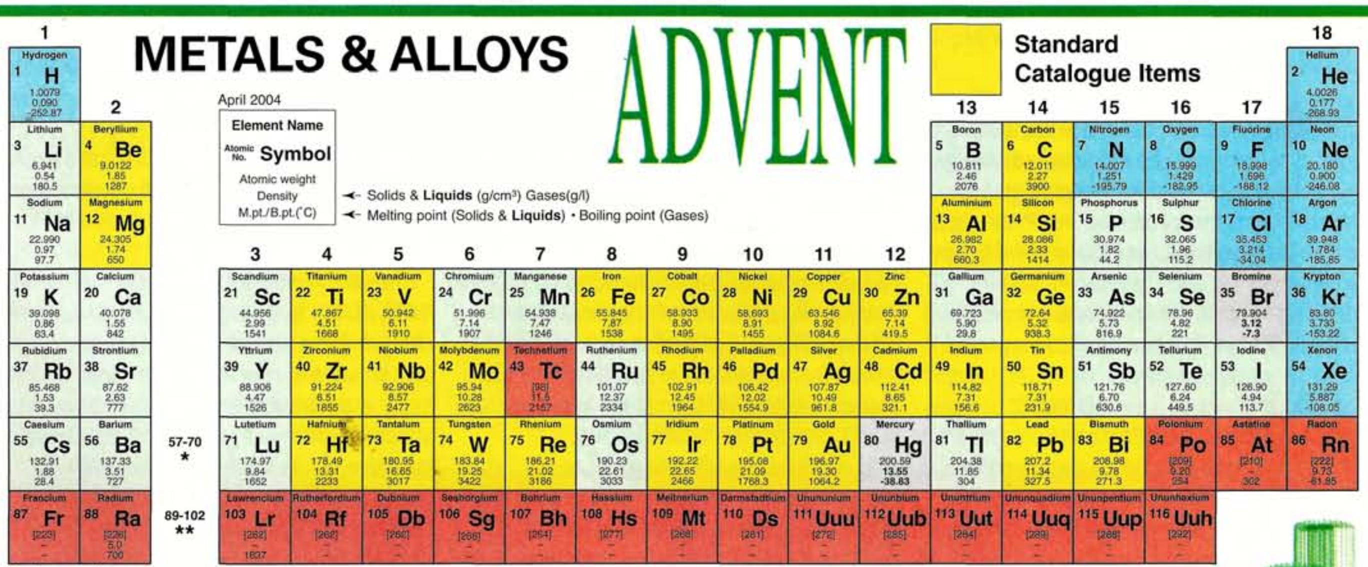

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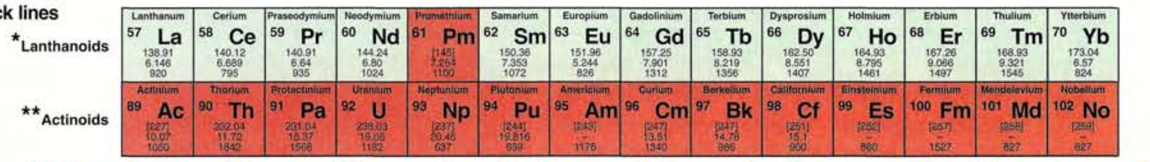

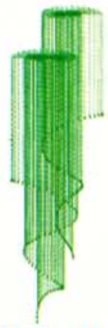

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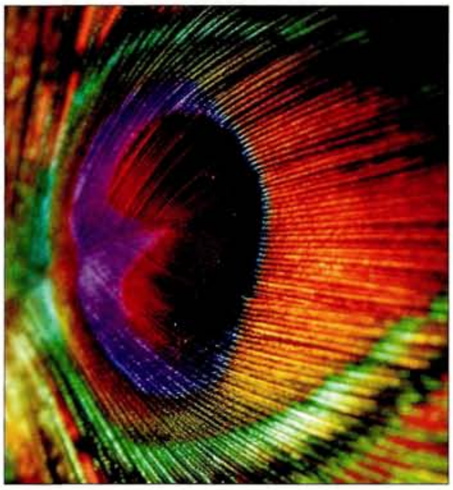
Compiled by Steve Reucroft and John Swain, Northeastern University

Peacock feathers prove photonic crystals cast brown light in nature

The feathers of male peacocks are among nature's most striking displays with greens, blues and other vivid colours, but mixed in there is also brown. It is already known that the bright colours arise from natural photonic crystals – structures with a bandgap that allows transmission of light only at certain frequencies. But where does the brown colour come from?

It had been thought that in the biological world brown originates in pigments, but Yizhou Li and colleagues at Fudan University in Shanghai have extended their work on peacock feathers to find that the browns also arise from photonic crystals.

The team studied the brown barbules – structures on the barbs arrayed on either side of the central stem. They found a subtly different structure for the 2D photonic-crystal lattice in the outer layer (cortex) for the brown barbules compared with the blue, green and yellow. Optical measurements and numerical simulations revealed that differences in the two melanin layers in the photonic-crystal structure, as well as parameters such as lattice constant and number of periods, are important in introducing reflected orange and red components.



It seems that the browns in the feathers of male peacocks arise from natural photonic crystals. (Michael Shake/Dreamstime.com.)

Studies of the complex natural structures producing brown could point the way to extending artificial photonic crystals from almost single-wavelength structures to multiple wavelengths.

Further reading

Yizhou Li *et al.* 2005 Structural origin of the brown color of barbules in male peacock tail feathers *Phys. Rev. E* **72** 010902(R).

Gravity works at a distance of 100 nm

Much recent theoretical speculation implies a possible breakdown of Newton's $1/r^2$ force law at small distances. Performing a Cavendish experiment down to this sort of scale is difficult, but in 2000 Eric Adelberger and his colleagues at the University of Washington showed that gravity is as expected down to 150 μm. A collaboration between Indiana, Purdue, Lucent Technologies, Florida and Wabash has now eliminated deviations from the $1/r^2$ law owing to Yukawa-like forces down to 100 nm. There is, however, a drawback: while the experiment reaches down to a shorter scale than has previously been achieved, it actually tests for the presence of forces 10^{12} times stronger than gravity at that scale.

The group used a disc-shaped pendulum suspended above another disc in their measurements. A copper membrane between the discs helped minimize the effects of electrical forces. Other short-range, non-gravitational effects, such as the Casimir force, also had to be considered.

Further reading

R S Decca *et al.* 2005 Constraining new forces in the Casimir regime using the isoelectronic technique *Phys. Rev. Lett.* **94** 240401.

The shape of acidity

We all learn in school that pH is a measure of the concentration of positive hydrogen ions (i.e. protons), but things look more complex than that. Traditional models were based on the notion of "hydronium" ions, H_3O^+ or $(H_2O{\cdots}H{\cdots}OH_2)^+$, but Jeffrey M Headrick of Yale University and colleagues have had a closer look with vibrational spectroscopy. The hydrated protons are actually clusters of water molecules around a proton with up to 11 water molecules involved, making acidified water much more interesting and complicated.

Further reading

J M Headrick *et al.* 2005 Spectral signatures of hydrated proton vibrations in water clusters *Science* **308** 1765.

Ultrasound causes change in viscosity

Researchers have found a way to control remotely and reversibly a material's viscosity using sound. Takeshi Naota and Hiroshi Koori of Osaka University in Japan have created a substance from small, organic molecules containing platinum dissolved in acetone. The result is an oily liquid, which, when zapped with ultrasound at 40 kHz, turns into a white gel.

The gel can be reversed back into a liquid by heating and perhaps also in response to another burst of ultrasound. This behaviour is mysterious, as sound might be expected to cause things to liquefy rather than to gel. While there are theories about the mechanism, precisely what is going on remains a puzzle.

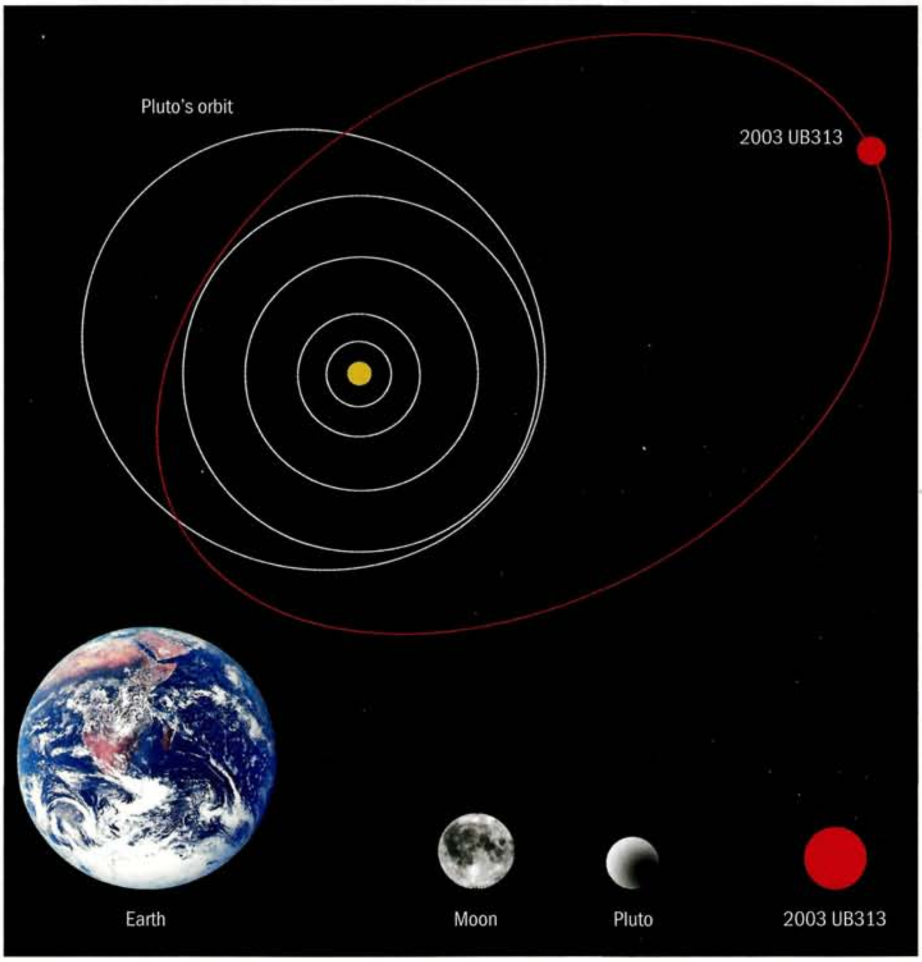
Further reading

Takeshi Naota and Hiroshi Koori 2005 Molecules that assemble by sound: an application to the instant gelation of stable organic fluids *J Am. Chem. Soc.* **127** 9324; DOI:10.1021/ja050809h.

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

Astronomers discover possible 10th planet

Artist's conception of the planet. (NASA/JPL.)



Approximate orbital sizes (top) and diameters (below) of the new planet 2003 UB313 and Pluto compared with other members of the solar system. (Gemini Observatory/AURA.)

A planet larger than Pluto has been discovered orbiting the Sun at more than three times the current distance from the Sun to Pluto. It is a clear member of the Kuiper belt of objects beyond the orbit of Neptune, but being the largest known, it might become recognized as the 10th planet of the solar system.

This new planet, temporarily called 2003 UB313, was discovered with the Samuel Oschin Telescope at the Palomar Observatory by Mike Brown from the California Institute of Technology and colleagues. It is one of around 80 bright objects so far found in the Kuiper belt by an ongoing survey of the outer solar system that started in 2001.

The object appeared in three consecutive image frames of a small portion of the sky taken on 21 October 2003. However, it was so far away that its motion was not detected until the team reanalysed the data in January of this year. Its discovery was announced hastily on 29 July 2005, because of fears that someone could steal the discovery by pointing a telescope at the position of the new planet, which was found to be accessible on the Web.

The planet is currently at a distance of 97 AU (1 AU is the Sun–Earth distance) as deduced from its observed velocity across the sky. However, its highly eccentric orbit will make this reduce to 38 AU – just within the average Sun–Pluto distance – in about 280 years. The size of the planet depends on the amount of light it reflects. If it is reflecting 100% of the Sun's light, it is the same size as Pluto; but it is more likely that it reflects, as Pluto does, only 60% of sunlight, in which case its diameter must be 2860 km, exceeding Pluto's size by 25%. This estimate is corroborated by the similarity of the new planet's infrared spectrum to that of Pluto, as measured by the Gemini telescope on Hawaii, thus suggesting a similar surface covered with frozen methane.

Is it really the 10th planet? Pluto and the new object are clearly very different from the eight other planets. They have eccentric orbits that are tilted with respect to the orbital plane of the other planets by 17° for Pluto and 44° for 2003 UB313. Their distance and size make them the biggest of more than 100 icy bodies beyond Neptune detected so far in the Kuiper belt.

On the other hand, Pluto is so well established as the ninth planet that it will probably keep this status. So will the number of planets stop at Pluto, or will a planet be defined as a body bigger than Pluto? If it were certain that this would be the last such object, it would be tempting to count it as the 10th and ultimate planet in the solar system, but this is likely to remain open for several years.

The final word will be given by the International Astronomical Union (IAU), which will also decide on the planet's name. Persephone is the wife of Hades (Pluto for Romans) in Greek mythology, but this name and the Roman equivalent Persipina have been attributed to the 26th and 399th known asteroids respectively. The new name proposed to the IAU by the discoverers, but not yet announced, is most probably from a different mythological or spiritual tradition.

Further reading

See www.lilahsplanet.com/ (Mike Brown has a baby daughter named Lilah).

CERN COURIER ARCHIVE: 1962

A look back to CERN Courier vol. 2, September 1962

CERN

Instrumentation for the future

Only a few days after the conference on high-energy physics, the lecture rooms of CERN were crowded again for the 1962 International Conference on Instrumentation for High-Energy Physics. This conference also takes place now every two years, under the auspices of the International Union for Pure and Applied Physics, and it has become the practice to hold the two more or less consecutively, to assist the many physicists who wish to attend both. Normally they are held in different places, but special circumstances this year made it easier to have them both at CERN, although this created more work for the Conference Secretariat and a greater disruption of the Laboratory's normal life.

New techniques at ultra-high energies

During the last year or so there has been much discussion and a certain amount of planning of new particle accelerators to produce much higher energies than the 30 GeV at present possible. Values of 300 GeV have been considered, and even 1000 GeV. At the first session of the Conference, J Sandweiss (Yale) reviewed the very pertinent question of the other apparatus required to carry out experiments with such high-energy beams. The conclusion is that present-day techniques will certainly need considerable modification and some will be completely useless. For example, a commonly used method of identifying particles is to time them over a fixed distance – for different particles of the same momentum, the greater the mass the slower the speed and hence the longer the time taken. But with a timing accuracy of 10^{-9} s (a thousandth of a millionth of a second) a distance of nearly 7 km would be required to distinguish between a pion and a kaon at 1000 GeV! The gas Cherenkov counter will still be useful, but would need to be tens, or even hundreds of metres long to distinguish between particles of different mass.

Various novel ways were also discussed of handling the primary proton beam, in order, say, to obtain a very high intensity of neutrinos with the minimum background of other particles. It was obvious from a study of the problem that experiments with such a giant accelerator would need to be performed quite differently from those at present, and that the full potentialities could not be realized without much new development.

At the conference, Simon van der Meer presented work on the first neutrino horn, his invention to increase the flux of neutrinos available at the CERN PS. The horn is seen here under construction.

Recent advances in counter techniques

V L Fitch (Princeton) reviewed the field of electronic counters, dealing with particle detectors of the Cherenkov, scintillation, and solid-state types.

Focusing Cherenkov counters, in which the emitted light is focused on to photomultipliers that produce an electrical signal proportional to the amount of light, have been widely developed in the last year or two. Since the light is emitted only by particles travelling faster than some threshold value, particles of the same momentum but different mass can be distinguished. Out of several examples, one developed at CERN is essentially a tube of hydrogen at a pressure variable between 0.5 and 3 kg/cm^2, 10 m long and 15 cm in diameter. Electrons can be differentiated from a background of pions and muons ten to a hundred thousand times more intense, at a particle momentum of 8 GeV/c. Other Cherenkov counters, using liquid or solid radiators rather than gas, have been combined with "light multipliers" or closed-circuit television systems to give greater sensitivity, and new developments in some laboratories enable both the direction and the velocity of a particle in the counter to be determined.

Also fairly new is the "solid-state" detector, effectively a solid ionization chamber, which can be very useful when small size or the ability to work in high magnetic fields is essential.

Even greater usefulness is promised by a number of new ideas now being developed. Instead of photographing the "lightning" (of a spark) it is possible to "listen to the thunder", and to measure the transmission time of the ultrasonic sound waves from the spark to derive its position. One idea being developed at CERN is to replace the plates by sets of fine parallel wires, oriented and connected in such a way as to record the position of the particle by means of the electrical pulses created by the spark. Another is to construct the plate in the form of a delay line, the time between the application of the voltage pulse and the appearance of the signal being a measure of the position of the spark. All these methods allow the possibility of connecting the spark chambers directly to a computer, for processing and analysing the results.

• Taken from the original seven-page article.

EDITOR'S NOTE

The 1962 International Conference on Instrumentation for High Energy physics followed the July "Rochester" Conference at CERN (see last issue's Archive, *CERN Courier* July/August 2005 p11), and novel detection techniques that would shape experimental high-energy physics to the present day were extensively discussed.

Compiled by Hannelore Hämmerle and Nicole Crémel

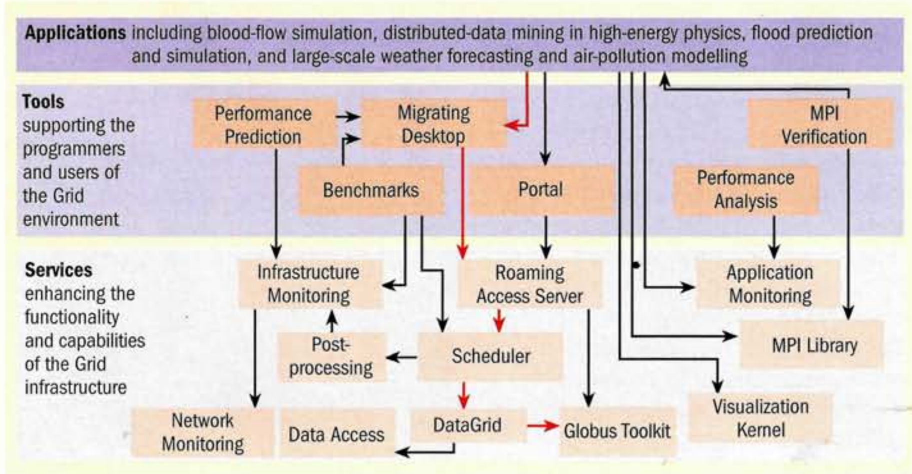
GRID PROJECTS

CrossGrid project concludes

The CrossGrid project has ended after three years, during which time Grid-enabled solutions were developed for computer- and data-intensive applications that are distributed but that require near-real-time responses. The applications, which have already been ported to the Grid environment, include pre-treatment planning in vascular intervention and surgery, support for flood forecasting and management, high-energy physics simulations and real-time filtering, and weather forecasting combined with air-pollution modelling. CrossGrid involved 21 partners from 11 countries and was led by the Academic Computing Centre CYFRONET AGH, Krakow, Poland.

The CrossGrid project architecture includes a number of key software components (see figure). The Migrating Desktop is a user-friendly tool for accessing Grid resources with customized environments for individual users, and is serviced by the CrossGrid Roaming Access Server. The Grid Scheduler, which supports multiple users, and sequential and parallel jobs, enables batch and interactive jobs to be managed simultaneously. The CrossGrid application monitoring infrastructure comprises a distributed, online monitoring system (called OCM-G), and a performance analysis tool (G-PM), which enables the results of performance monitoring to be evaluated and presented, so as to optimize the execution of the application. CrossGrid has developed several other supporting tools and services, shown in the figure, which are geared towards implementing interactivity in Grid computing.

The project has also developed a large European Grid testbed that has 16 sites, complete with security certificates, virtual organizations of users, site administrators and support personnel, and that is fully compatible with the Grid infrastructure of the Enabling Grids for E-science (EGEE) project. This was demonstrated at the EGEE conference in Athens in May 2005, where the CrossGrid flood application won an award for the best Grid application.



The CrossGrid project architecture showing the relationship between key components.

The software development process was accompanied by a research programme that resulted in about 200 scientific publications, some of which will be collected in a book. A series of successful AcrossGrids conferences was organized. The most recent, which was renamed European Grid Conference, was held in Amsterdam in February, and about 300 people participated. This shows the substantial contribution of CrossGrid partners to building the European Grid community. In future, this series of grid conferences will be organized by the CoreGRID project.

CrossGrid software has been available since March under an open-source licence that is based on the EDG General Public Licence. The software tools and components will continue to be supported by CrossGrid partners beyond the end of the project. A tutorial developed by CrossGrid is available for potential users, and is used as a teaching aid at the Institute of Computer Science in Krakow, the University of Amsterdam and the University of Nicosia, accompanying MSc lectures on Grid technologies.

CrossGrid solutions are also being adopted by next-generation research initiatives under the 6th Framework Programme of the European Community, including projects such as EGEE, K-WfGrid and CoreGRID, as well as national Grid initiatives. Members of the CrossGrid Consortium are now working on subsequent proposals for EU Grid projects.

Les gros titres de l'actualité informatique

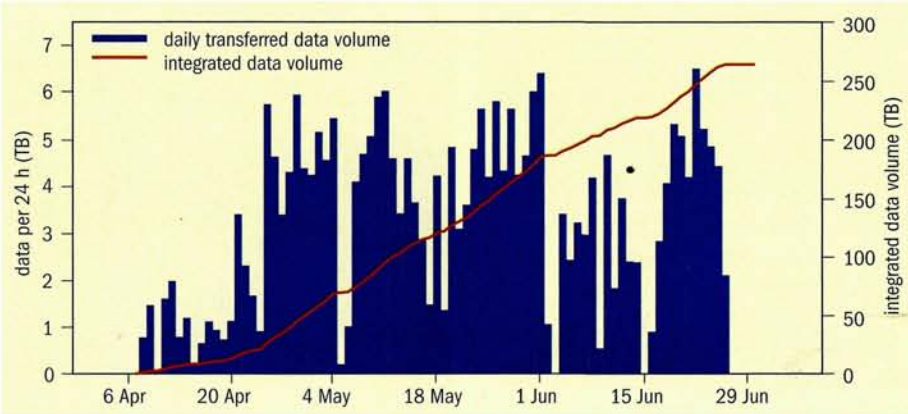
GRID COMPUTING

PHENIX experiment uses Grid to transfer 270 TB of data to Japan

During the polarized proton–proton run that ended in June at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven, Grid tools were used by the PHENIX experiment to send recently acquired data to a regional computing centre for the experiment in Japan. Brookhaven National Laboratory, on Long Island, New York, is home to the RHIC/ATLAS Computing Facility (RCF/ACF), which is the main computing centre for experiments at RHIC and a Tier-1 computing centre for ATLAS. The PHENIX regional computing centre in Japan (CCJ) is at the RIKEN research centre on its Wako campus close to Tokyo.

Going into the polarized proton–proton run, PHENIX faced the challenge that the RCF would be busy reconstructing and analysing gold–gold and copper–copper data recorded in 2004 and 2005. The enormous polarized proton–proton data set was transferred to Japan to make use of the substantial computing resources at CCJ, which is comparable to the PHENIX portion of the RCF.

The PHENIX data acquisition can sustain a peak data rate of up to 600 MB/s, and runs at a typical rate of 250 MB/s while beam is stored in RHIC. The data were buffered at the experimental site before being transferred and archived in the RCF tape library. A 35 TB disk-storage system (about 60 h at typical data rates) allowed PHENIX to archive and transfer data at a lower steady rate, taking advantage of various breaks in the flood of data. A transfer rate of 60 MB/s sustained steadily around the clock was able to keep up with the incoming data stream.



Daily rates of data transferred from the PHENIX experiment to the CCJ computing centre in Japan (blue), and the integrated data volume (red). Overall, 270 TB of data were transferred.

Initially, PHENIX had planned to transfer the polarized proton–proton data by physically transporting tape cartridges to CCJ. During the early part of the run, however, it was found that network transfer rates of 700–750 Mbits/s could be achieved. A dedicated network path was established from the PHENIX counting house to the BNL perimeter network, and the tape option became a fall-back solution. In the end, not a single tape was shipped.

The principal tool used for the transfer was GridFtp, which proved to be very stable. Brookhaven has a high-speed connection (OC48) to ESNET, which is connected to a transpacific line (10 Gbit/s) served by SINET in Japan. Apart from two half-day outages of ESNET, the transfers continued around the clock for the entire 11 week run.

Approximately 270 TB of data (representing 6.8 billion polarized proton–proton collisions) were transferred to CCJ. After a few days of fine-tuning the transfer parameters, the transfers became part of the regular data-handling operation of the PHENIX shift crews, requiring experts to intervene only occasionally.

This seems to be the first time that a data transfer of such magnitude was sustained over many weeks in actual production, and was handled as part of routine operation by non-experts. The successful completion of this large-scale transfer project demonstrates both the maturity of today's Grid tools and the real feasibility of integrating remote resources into the data-handling and processing chain of large experiments.

RECOMMENDATION

W3C backs XML Key Management System

The World Wide Web Consortium (W3C) has approved the XML Key Management System 2.0 (XKMS 2.0, XKMS 2.0 Bindings) as a W3C Recommendation. XKMS 2.0 is part of the W3C XML Security Framework, which includes the XML Signature, XML Encryption and Canonical XML Recommendations. XKMS, a cornerstone of Web applications security, adds public-key management to the W3C XML Security Framework.

Web applications and services security rely on interoperable components that make it possible to sign, seal, encrypt and exchange electronic documents. All of these functions depend on the management and processing of public keys. Before, these services lacked openly specified, non-proprietary interfaces (APIs). Now, XKMS offers an open, standards-based interface to key management services that has already shown its utility in distributed enterprise security applications.

XKMS 2.0 makes public key infrastructure practical to implement. Standards-based key management enables identity to be communicated across applications and systems, including Web services applications that operate across different trust boundaries.

NETWORKING

GÉANT2 set to boost research in Europe

The significance of the GÉANT2 network to the future of research and education in Europe and around the world was highlighted at its official launch event in Luxembourg on 14–15 June. GÉANT2, which is co-funded by the European Commission under the 6th Framework Programme, will form the pan-European high-performance research networking backbone when it begins productive service later this year.

The project was officially launched by Viviane Reding, the European commissioner for information society and media, who described GÉANT2 as "a truly giant step forward". Reding observed that GÉANT "has abolished the distance between researchers that used to hinder collaboration". In this way, GÉANT2, like its predecessor GÉANT, will be a fundamental building block of the European Research Area, providing the pan-European communications infrastructure necessary to support truly world-class research such as that of the LHC Computing Grid (LCG) project, which has data-transfer requirements unimaginable only a few years ago.

Work to implement the innovative and ambitious hybrid network solution – the first of its kind on an international scale – is under way. The network will use switching technology to provide dedicated point-to-point links when projects wish to transfer large amounts of data, preserving the quality of service on the IP-routed backbone for other users. In this way, GÉANT2 will cater for the widely varying requirements of the research and education community it serves – from the extreme demands of LCG to the much more ordinary-sounding requirements of millions of researchers and students across Europe.

GÉANT2 is "a truly giant step forward", says Viviane Reding, the European commissioner for information society and media.

The project will also develop a layer of services aimed at improving the usability and transparency of the network. During the lifetime of GÉANT2, networking will become part of the everyday lives of millions of researchers. The best-of-breed technologies developed and deployed by GÉANT2 will ensure that Europe's researchers are provided with world-leading services to support them in their work.

ANNOUNCEMENTS

US launches weekly online newsletter

At the end of April, the US science Grid community launched *Science Grid This Week*, a weekly publication that reports news and information about Grid computing projects and collaborations from all fields of science. *Science Grid This Week* is an electronic newsletter that is written for scientists, the Grid computing community and the public. It is available online and e-mailed free of charge to subscribers.

The newsletter includes reports from conferences and workshops worldwide; news about Grid initiatives, education and outreach projects; profiles of scientists and students who work on Grid development; and reports about the science that benefits from it.

For details, see www.interactions.org/sgtw.

New service 'deep-mines' databases

EEVL, an Internet guide to engineering, mathematics and computing, has introduced EEVL Xtra as a free service to help retrieve articles, books, websites, latest industry news, job announcements, technical reports, technical data, full-text e-prints, latest research, teaching and learning resources, and much more.

EEVL Xtra cross-searches more than 20 online collections that are relevant to engineering, mathematics and computing, including content from more than 50 publishers and providers. Databases searched include: arXiv, CISTI, CiteSeer, CSA Hot Topics, Copac, ePrints UK, Euclid Mathematics and Statistics Journals, Inderscience Journals, IoP Journals, NACA Technical Reports and NASA Technical Reports.

For details, see www.eevlxtra.ac.uk.

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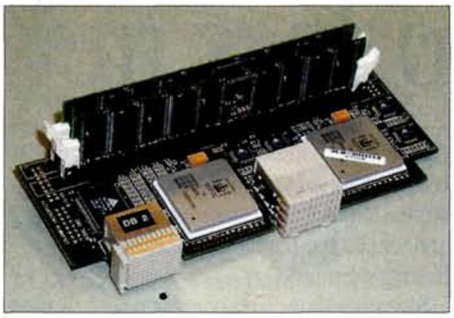
LATTICE QCD

QCDOC computers study quarks


Two 10 teraflop QCDOC computers operate at the Brookhaven National Laboratory.


A QCDOC daughter card with two processing nodes and two 128 MB memory modules.

The commissioning of a new class of massively parallel computers, called QCDOC, should lead to important advances in the numerical study of quantum chromodynamics (QCD), the theory of quarks and gluons. Physicists from Columbia University, the University of Edinburgh, the RIKEN BNL Research Center and IBM's T J Watson Research Laboratory have designed and constructed three 10 teraflop computers optimized for lattice QCD calculations. One machine is now installed in Edinburgh for the use of the UKQCD collaboration, and two computers funded by the RIKEN Laboratory in Japan and the US Department of Energy (DOE) have been installed at the Brookhaven National Laboratory.

QCD, in which quarks and gluons participate in strong interactions and bind to form hadrons, has been viewed as a correct description of nature for the past 30 years. Nevertheless, low-energy QCD poses daunting theoretical challenges. So far this mathematically elegant theory has stymied traditional analytic approaches. However, propelled by the rapid advances in computer technology and a series of important algorithmic innovations, numerical simulation, known as lattice QCD, has proved to be a fruitful pursuit. It offers a "first-principles" demonstration of extraordinary phenomena such as the confinement of quarks, as well as increasingly accurate predictions of particle masses, matrix elements and collective behaviour under extreme conditions (*CERN Courier* June 2004 p23).

The new computers, which are specially designed to tackle this problem, are called QCDOC for "QCD-on-a-chip", reflecting the system-on-a-chip architecture of the computer. Each of the large machines shown above contains 12 288 independent processing nodes. Each node is a stand-alone computer that is fabricated on a 50 million transistor chip and attached to a standard memory module, providing 128 MB of memory per node.

Because of the nearest-neighbour interaction that is inherent in lattice QCD, the processors in QCDOC are joined by a mesh network. A six-dimensional mesh is used to permit efficient calculation in four-dimensional space–time. The extra two dimensions permit four-dimensional surfaces to be folded into the computer and support a new five-dimensional lattice fermion formulation.

The QCDOC chip holds a complete PowerPC processor with a double-precision floating point unit, making the machine standards-compliant and easy to program. The six-dimensional network is fast with low latency, permitting a difficult physics problem to be finely divided among many nodes. With the 4 MB of memory inside each QCDOC chip, if the problem size per node is small, extra efficiency results from avoiding all off-chip memory access. The modular design and low power (8 W per node) make these computers inexpensive to operate and easy to maintain.

Physicists in the US and UK are now putting the three QCDOC machines to work. The bulk of the machine time is devoted to generating large Monte Carlo ensembles that will be used to study the QCD particle spectrum, K-meson decay matrix elements, nucleon structure, and topics in heavy-quark physics central to determining the parameters of the Cabibbo–Kobayashi–Maskawa matrix from experiments (*CERN Courier* July/August 2005 p13). Also under way are similar studies of high-temperature QCD, the physics being explored in heavy-ion collisions.

The US QCDOC will be operated as part of the US National Lattice QCD Computing Project funded by the DOE. This project will also build and operate lattice QCD supercomputers based on commodity computer clusters and high-performance networks, such as InfiniBand. These clusters will be housed at Fermilab and at the Thomas Jefferson National Accelerator Facility. Clusters now have a cost effectiveness on lattice QCD code similar to the QCDOC. The QCDOC will play the major role in generating gauge configurations for the next few years, while the commodity clusters will initially be devoted to analysing these gauge configurations.

SCIENTIFIC COMPUTING

Scientific Linux 4.0 offers new features

The Scientific Linux development team, a collaboration of scientists and computer professionals from Fermilab and CERN, has announced the production release of Scientific Linux 4.0.

Scientific Linux is an operating system developed specially to provide the scientific community with a supported, stable, customizable, freely available operating system that is designed to be compatible with the equivalent commercially supported Linux distribution – RedHat's Enterprise Linux. Scientific Linux, supported by the global research community, is distributed to scientists free of charge.

Each laboratory or university has its own unique Linux requirements, and users can easily customize Scientific Linux for their site's needs. Fermilab and CERN tailor Scientific Linux for their own purposes, while maintaining compatibility, to allow a common operating-system standard for Grid applications and multi-lab experiments. Users have a choice between a version designed for a particular site, if they are at that site, or the generic Scientific Linux, available online from Fermilab and from mirror sites worldwide. Scientific Linux receives daily security checks and regular security updates.

Particle-physics research organizations using Scientific Linux include CERN, DESY, Fermilab, CCLRC Rutherford Appleton Laboratory, SLAC's BaBar experiment, Canada's TRIUMF Laboratory, scientists from IN2P3, the French funding agency, Italy's INFN, and many universities.

Top 10 downloads from the Fermilab site.

"We've received Linux kernels from Rutherford, AFS patched from DESY, scientific applications from Russian scientists, and contributions from universities and labs worldwide," explained Fermilab's Troy Dawson, co-lead developer of version 4.0. "People everywhere keep adding to its value."

Two versions of Scientific Linux – Scientific Linux 3.0.x based on RedHat Enterprise 3, and the recently released Scientific Linux 4.0 based on RedHat Enterprise 4 – are available. Before downloading the newest version though, users are encouraged to check with their local support staff to find out which versions are supported.

For details, see www.scientificlinux.org.

SUPERCOMPUTERS

High-performance APE computers are introduced to US

Computers developed by the Array Processor Elements (APE) project were introduced to the US during a meeting, called Supercomputers for Science across the Atlantic, which was held on 19 and 20 May by the Italian Embassy in Washington.

APE is a European project that began in 1980 at Italy's INFN and that also involves DESY and the University of Paris-Sud. This was the first time that these European supercomputing technologies have been discussed alongside those from America and Japan in such a broad context.

The meeting dealt with the results achieved in the development of powerful supercomputers optimized for theoretical physics calculations, and their possible advantages in other scientific and technological areas. In particular, Array Processor Experiment/Next (apeNEXT) was introduced. This is the latest generation of the special-purpose high-performance computers developed by the APE collaboration, and it has been realized in conjunction with the Italian company Eurotech. At the symposium, equivalent projects to apeNEXT were also discussed, such as the American QCDOC (see p17), and similar systems that have been developed by Japanese researchers.

These powerful supercomputers have been conceived as a response to the complex calculation requirements of theoretical physicists. However, they can also be used in other scientific and technological fields, such as meteorology, geophysics, proteomics and other studies of biological systems.

GRID SOFTWARE

Latest release of Grid middleware runs on Mac OS X

On 1 June the National Science Foundation Middleware Initiative (NMI) released version seven of its Grid middleware, which is available for downloading under open-source licenses. Developed for the academic science and engineering community, NMI-R7 builds on previous work to offer coherent development and access management technologies, while concealing the complex management and security required in a heterogeneous cyber-infrastructure.

NMI-R7 of the GRIDS Center Software Suite provides a baseline Grid software stack by means of conveniently installable binaries for eight Unix-based platforms, including for the first time Mac OS X. The stack is flexible in that only the components of interest need to be configured.

Key components for this release are updated versions of Condor and the Globus Toolkit, including GT4's Web Services Resource Framework. NMI-R7 also includes two versions of the Storage Resource Broker Client: the latest available and a TeraGrid-compatible version.

DATABASES

WAH compression speeds up searches

A new technique to quickly locate interesting "rare events" out of hundreds of millions of particle collisions was presented at the International Supercomputer Conference, held on 21–24 June in Heidelberg. This search technology, known as the Word-Aligned Hybrid (WAH) compression method, was developed and recently patented by John Wu, Arie Shoshani and Ekow Otoo of Lawrence Berkeley National Laboratory.

WAH is currently used in a software package called FastBit to compress bitmap indexes. These provide a method of reducing the response time of queries involving common types of conditions in data objects, by storing pre-computed answers as bitmaps. Because computers can manipulate bitmaps efficiently, bitmap indices efficiently search for interesting records in large datasets.

"In tests conducted using actual data from high-energy physics experiments, we confirmed that our FastBit software is an order of magnitude faster than the best-known bitmap indexing schemes on average," says Wu, the lead developer of FastBit.

The effectiveness of FastBit has attracted the attention of other institutions. At CERN, the developers of ROOT, an object-oriented data-analysis framework, have started evaluating the incorporation of FastBit into their software. Since the ROOT software is used by most major high-energy physics projects around the world, fully integrating FastBit into ROOT would make the efficient search capability of FastBit available to a large user community.

SCIENTIFIC GRIDS

US inaugurates the Open Science Grid

The Open Science Grid (OSG), which is a cyberinfrastructure for large-scale science in the US, is now available for research. The Open Science Grid Consortium officially inaugurated the OSG in July, with a ceremony at the Consortium Meeting in Milwaukee, Wisconsin.

"We're doing something unique – the OSG is a working national-scale computing facility that was built from the bottom up and serves a diverse community of researchers," said Paul Avery from the University of Florida, a member of the OSG Council.

The OSG is built and operated by teams from universities and national laboratories in the US, and is open to research groups from many scientific disciplines (*CERN Courier* November 2004 p17). The OSG Consortium has more than 20 member organizations that contribute manpower and resources to a common cyberinfrastructure. This includes more than 10 000 CPUs and many terabytes of data storage. Experiments in particle and nuclear physics, gravitational-wave physics, astrophysics and biology are under way.

US participants in the CMS and ATLAS experiments are investing heavily in advancing the OSG capabilities and services, and the Tier-1 computing centres at Brookhaven and Fermilab operate as part of both the OSG and Enabling Grids for E-science (EGEE) infrastructures. OSG works with its partners, such as the TeraGrid and EGEE, to enable users to combine resources from different infrastructures.

PRODUCT INFORMATION

Sundance Digital Processing has announced the availability of the FC104, a Digital Down Converter (DDC) IP core which combines flexibility and speed to address the performance requirements of complex digital-signal-processing applications. The company says that the FC104 accepts 16 bit complex data and can process data flows at up to 1 Gigasamples per second continuously, twice as fast as any other DDC core today.

For details, see http://sundance.com.

PathScale, a developer of solutions to accelerate the performance of Linux clusters, has released new benchmark results claiming that its InfiniPath interconnect for InfiniBand outperforms other interconnect solutions by providing the lowest latency across a broad spectrum of cluster-specific benchmarks. InfiniPath enables multiple processors or cores to send messages simultaneously, maintaining constant latency while dramatically improving small-message capacity and increasing effective bandwidth.

For details, see www.pathscale.com.

Calendar of events

September

5–9 Parallel Computing Technologies PaCT-2005
Krasnoyarsk, Russia, http://ssd.sscc.ru/conference/pact2005

12–18 XX International Symposium on Nuclear Electronics & Computing (NEC'2005)
Varna, Bulgaria, http://sunct2.jinr.ru/NEC-2005/first_an.html

18–21 12th European Parallel Virtual Machine and Message Passing Interface Conference
Sorrento, Italy, www.pvmmpi05.jeanmonnet.unina2.it

26–30 iGrid2005
San Diego, California, US, www.igrid2005.org

October

10–15 ICALEPCS'2005
Geneva, Switzerland, http://icalepcs2005.web.cern.ch/Icalepcs2005

16–19 GGF15
Boston, Massachusetts, US, www.ggf.org

November

12–18 Supercomputing – High Performance Networking and Computing
Seattle, Washington, US

30–2 Dec IFIP International Conference on Network and Parallel Computing (NPC 2005)
Beijing, China, http://grid.hust.edu.cn/npc05

December

5–8 International Conference on e-Science and Grid Technologies
Melbourne, Australia, www.gridbus.org/escience

7–9 International Symposium on Parallel Architectures, Algorithms, and Networks (I-SPAN)
Las Vegas, Nevada, US, http://sigact.acm.org/ispan05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Running the Grid on lite

gLite is an ambitious effort to create Grid middleware for a range of scientific applications, based primarily on "best of breed" solutions from other Grid projects. It is now being comprehensively tested and some parts are already in use under production conditions.

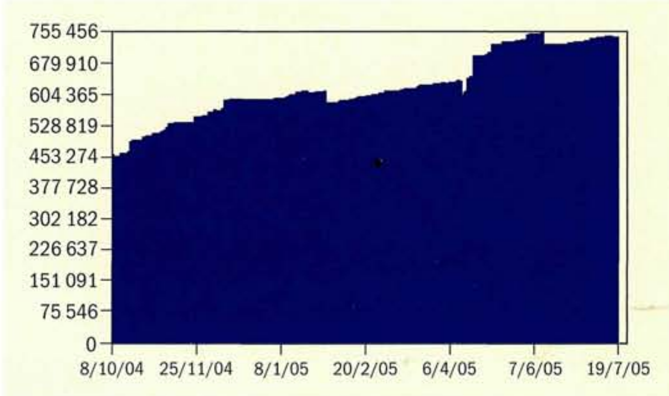
Any Grid infrastructure consists of three basic building blocks: on the one side, the underlying infrastructure (or fabric) providing computing and storage resources; on the other, the users with their applications, wanting to use the resources; and bringing the two together, the so-called "middleware". Aptly named, this software typically consists of a stack of different modules, which act collectively as an intermediary, hiding the multiple parts and detailed workings of the Grid infrastructure from the user. The Grid thus appears as a single, coherent, easy-to-use resource, in which the middleware ensures that the resources are used as efficiently as possible and in a secure and accountable manner.

Many national and international projects are working in the rapidly evolving field of Grid computing, and there are diverse technologies currently available. Recent efforts have focused on closer collaboration between projects to find the best solutions and ensure that viable standards emerge and evolve – a trend that should help to make Grid technology widely accessible to a larger user community.

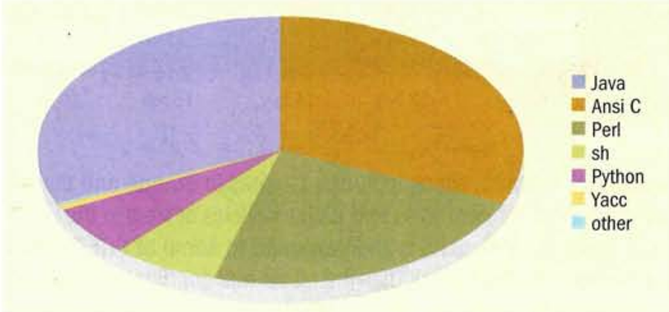
It is in this spirit that the Enabling Grids for E-science (EGEE) project launched its gLite middleware initiative in April 2004. Rather than trying to build a new middleware stack from scratch, the gLite design team included representatives from existing middleware providers (AliEn, Condor, EDG, Globus, etc), as well as other key stakeholders such as people from the Grid-operations activity in EGEE, and partners from related projects, such as Open Science Grid (OSG, see p19) in the US. gLite components were selected based on a thorough analysis of requirements from the pilot application areas in EGEE, biomedicine and high-energy physics.

The gLite middleware is envisaged as a modular system, to allow users to tailor the system to their specific needs by deploying the services they require, rather than using the whole system. The Grid services of gLite follow a service-oriented architecture (SOA), making it easier to connect the software to other Grid services. It will also help users to comply with upcoming Grid standards, for instance the Web Service Resource Framework (WSRF) from OASIS and the Global Grid Forum's Open Grid Service Architecture (OGSA).

Distributed under an open-source licence, gLite is mainly based on middleware from EGEE's predecessor, the European DataGrid (EDG) project, and makes use of components from other ongoing middleware projects (see box, p22). Using existing middleware components developed by many different projects worldwide means that gLite inherits code from other sources. The middleware team in EGEE re-engineers and integrates the different components, which are often written in many different programming languages, into a coherent software suite. Each line of code is measured by how well it complies with coding guidelines and standards defined for each language. Individual units or functions are tested to make sure that they do what they are supposed to do. Functional testing is performed on a distributed test-bed at CERN, the CCLRC Rutherford Appleton Laboratory, NIKHEF and Imperial College, London.



By 20 July 2005, gLite consisted of about 750 000 source lines of code. This has increased steadily from the beginning, with unnecessary and/or faulty lines periodically deleted.



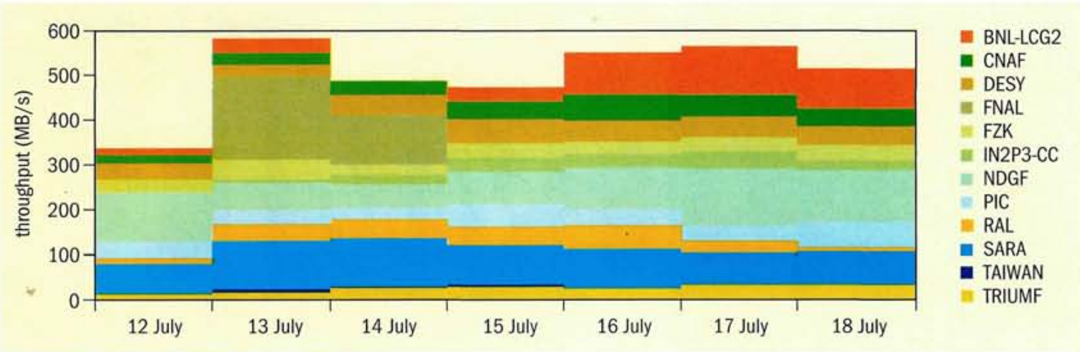
The contributions in terms of source lines of code from the various programming languages involved in gLite.

gLite is being developed in two main cycles with incremental releases in between. On 4 April 2005 gLite 1.0 was released to be certified by the operations team, which gathers experience in running middleware on a large-scale production-level service. After repeating the functional tests on an independent test-bed, the middleware is subjected to stress tests. During this certification step, the middleware is also tested on different "flavours" of operating systems used in the EGEE Grid resource centres. Currently this is mainly Scientific Linux (see p18), but increasingly other architectures are being requested.

Once the middleware is certified, it is deployed on a pre- ▷

gLite services

Service	Description	Elements and their origin (simplified)
Computing element (CE)	Represents a computing resource. Its main function is job management, but it must also provide information about its characteristics and status.	CE Monitor (EGEE); Condor-C (Condor); Gatekeeper (Globus); Local batch system (PBS, Platform LSF, Condor)
Workload management	Grid middleware components responsible for the distribution and management of tasks across Grid resources, so that applications are conveniently, efficiently and effectively executed.	Condor-C (Condor); Logging and bookkeeping (EDG); WMS (EDG)
Information and monitoring	Providing information about the grid – primarily to find available services and their details – and monitoring applications.	R-GMA (EDG)
Storage element (SE)	Represents a storage resource, providing access to data and file-transfer capabilities.	gLite-I/O (AliEn); Reliable File Transfer (EDG); GridFTP (Globus); SRM: Castor (CERN), dCache (FNAL, DESY), other SRMs; FTS (EGEE)
Catalogue	Stores information about the data and metadata that are being processed in the Grid.	File/Replica and Metadata Catalogs (EGEE)
Security	Enables the identification of entities, allows or denies access to services and resources, and provides information for the analysis of security-related events.	GSI (Globus); VOMS (DataTAG/EDG); Authentication (EDG)



Daily average throughput (in MB/s) during one week of the LCG Service Challenge 3. The gLite file-transfer system is used to provide reliable file transfer between sites, and to allow sites to control their resource usage.

production test-bed, which includes 12 sites in Europe and the US that reflect the different sizes and usage policies of sites in the wider EGEE infrastructure. gLite is then exposed to some of EGEE's pilot applications, to test the middleware under real conditions. However, this is not easy, since the pilot applications typically have to access data stored on the production Grid service, thus requiring access to both the production and the pre-production services.

Several components of the gLite middleware are already being incorporated into production use, such as information services in clinical decision support systems and in medical imaging. The LHC Computing Grid (LCG) also makes use of a number of gLite services for its service challenges. LCG will have to deal with huge amounts of data – in excess of 10 PB per year – and so data and service challenges are ongoing to test the infrastructure (*CERN Courier* June 2005 p15). These challenges also affect the development of gLite by prioritizing components of the middleware that need to be ready for a certain challenge. For example, the third LCG service challenge, which started on 26 June, includes a data-throughput test in which the file-transfer service (FTS) of the gLite middleware is used.

The FTS formed part of the incremental release gLite 1.2, released in July, which also included a new version of the virtual-organization membership system (VOMS) and further Condor support of the computing elements. gLite 2.0, which will be released at the end of the year, will focus on secure services, increased robustness and ease of installation, as well as further developments of the core services, incorporating experience gained in the data and service challenges.

Further reading

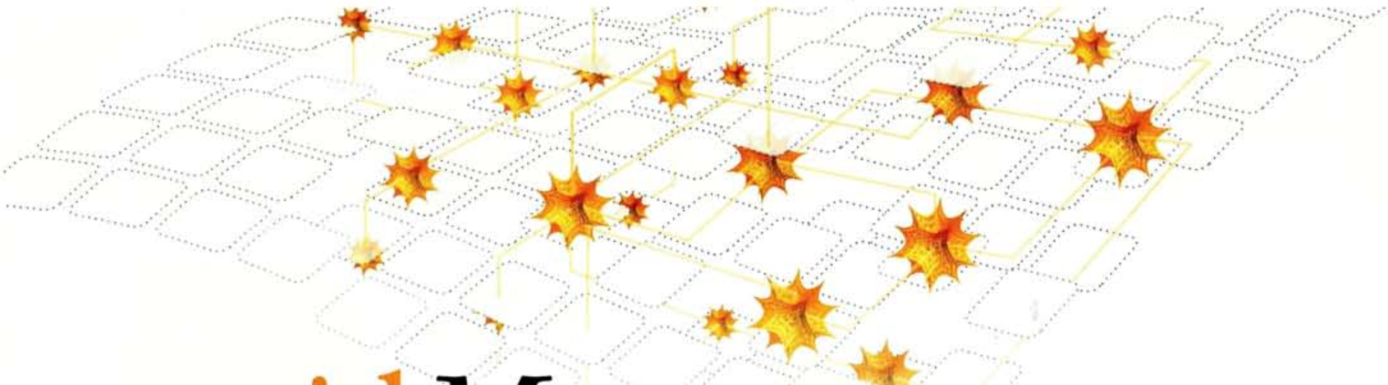
For further information see www.glite.org.

Résumé

Tout glisse sur la Grille grâce à gLite

gLite désigne un ambitieux programme visant à créer un intergiciel de Grille pour diverses applications scientifiques de natures différentes, en exploitant préférentiellement les "meilleures solutions" élaborées dans d'autres projets de grilles. Ce travail de développement est un exemple parfait de collaboration internationale, car les partenaires principaux y sont entrés dès le début de la conception. Actuellement, on soumet l'intergiciel à des essais complets et certaines de ses parties sont déjà en utilisation, dans les conditions de production, en particulier pour les essais d'exploitation de la Grille de calcul du LHC.

Hannelore Hämmerle, *CERN.*



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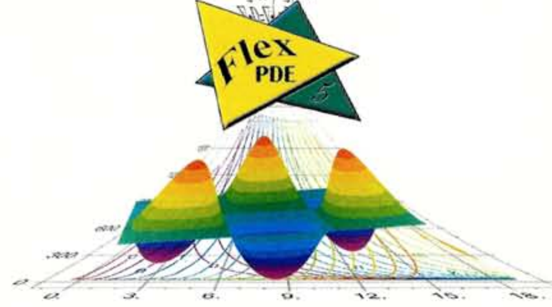

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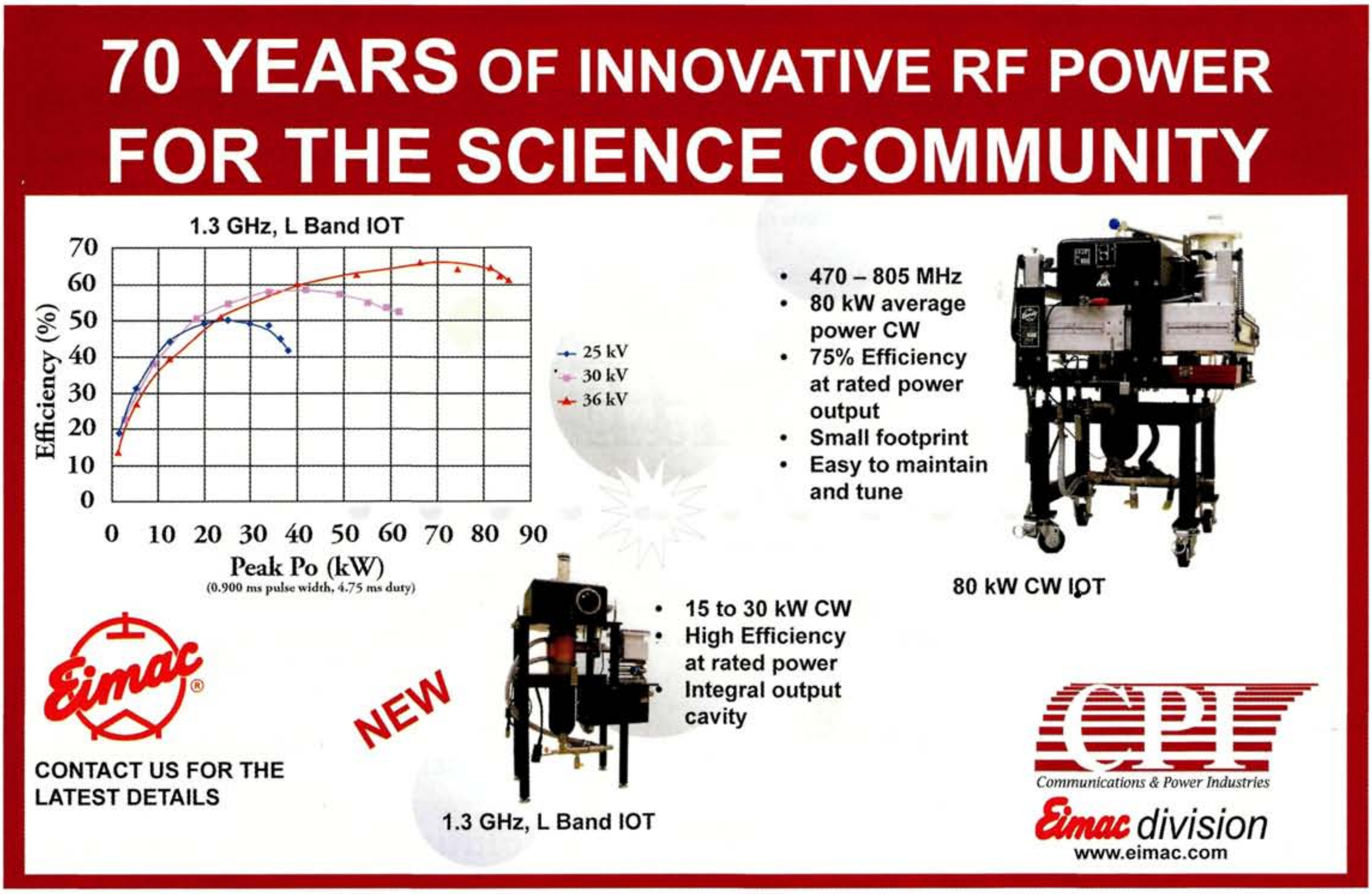
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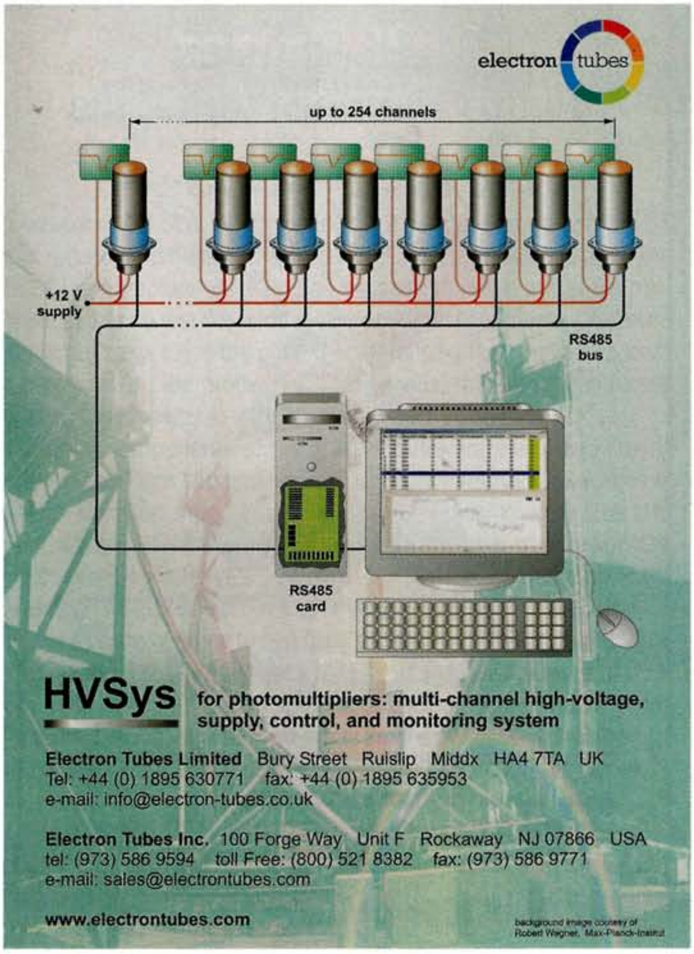
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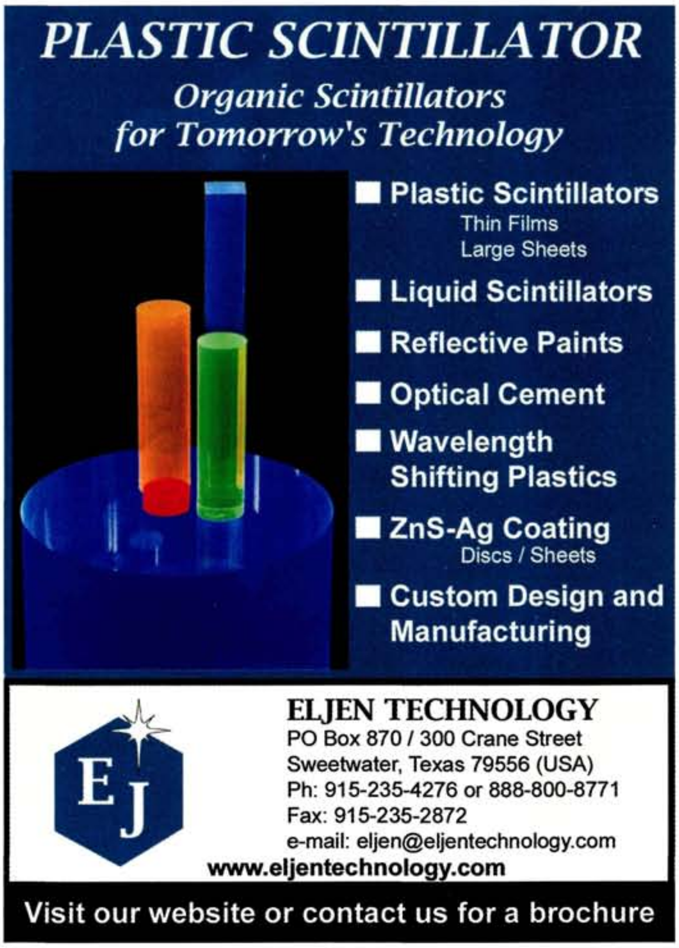
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George Placzek – an unsung hero of physics

Jan Fischer describes the life and work of the Czech physicist, born in 1905, who made important contributions to nuclear physics in the 1930s–1940s.

On 21–24 September, in co-operation with several other scientific institutions, the Masaryk University in Brno is organizing a memorial symposium in honour of the Czech physicist George Placzek, who was born on 26 September 1905 and died on 9 October 1955, soon after his 50th birthday. Placzek was an outstanding scientist who made substantial contributions to the fields of molecular physics, scattering of light from liquids and gases, the theory of the atomic nucleus and the interaction of neutrons with condensed matter. He belongs among the important physicists of the 20th century, setting an example not only through his discoveries, but also by the stimulating style of his scientific work.

George Placzek was born in Brno, Moravia, in what is now the Czech Republic but which in 1905 was part of Austro-Hungary. The oldest son of Alfred and Marianne Placzek, he spent his childhood in Brno and in Alexovice, where the family owned a textile factory, Skene & Co. He had a brother, Friedrich, one year younger and a sister, Edith, 12 years younger. The family was well integrated into the mixed Czech-German language environment around Brno. George studied in the Deutsches Staatsgymnasium in Brno between 1918 and 1924 and then went to the University of Vienna, with three semesters away in Charles University, Prague. He graduated in 1928, having defended his doctoral thesis, which dealt with the determination of density and shape of submicroscopic test bodies, with distinction.

Placzek: little known but highly respected.

Travels in Europe

In 1928, Placzek set off on several years of travel through the main scientific centres of Europe. This was usual for post-docs at the time, although Placzek later markedly avoided countries in which Adolf Hitler was increasingly encroaching upon civil liberties and human rights. He spent three years with Hendrik Kramers in Utrecht, followed in 1930–31 by a short time with Peter Debye and Werner Heisenberg in Leipzig. He then joined a group of young physicists led by Enrico Fermi in Rome, where Edoardo Amaldi became his closest colleague. Then, in 1932, Placzek joined Niels Bohr in Copenhagen where he remained until 1938, with periods of research fellowships or visiting professorships at the universities of Kharkov, Jerusalem, Paris and elsewhere.

Placzek's first scientific interest was in the scattering of light from molecules and the Raman effect. With Lev Landau, he investigated the fine structure of a monochromatic wave in liquids and gases, and together they derived the Landau–Placzek formula for the ratio of intensities of Brillouin and Rayleigh scattering of light. Then in the early 1930s, the scattering of slow neutrons in matter became topical and Placzek was attracted to this problem, first in Rome and later in Copenhagen, where at Bohr's suggestion he and Otto Frisch studied the capture of slow neutrons.

Placzek's work in Copenhagen made him a leading authority on neutron scattering and absorption in matter. In a series of experiments, Placzek and Frisch discovered that the absorption of neutrons depends strongly on the atomic mass of the material and the velocity of the neutrons, while for slow neutrons and light elements the neutron-capture cross-section is inversely proportional to the velocity. He also worked with Hans Bethe on a theory of neutron absorption resonances, deriving important laws and selection rules, and publishing a seminal paper on resonance reactions in 1937. Papers published later by Placzek with Bohr and Rudolf Peierls dealt with the general theory of nuclear reactions and rank among the classics. For example, the well-known optical theorem, connecting the imaginary part of a scattering amplitude with the total cross-section, bears the names of Bohr, Peierls and Placzek. Using the optical theorem and Bohr's drop model of the nucleus, the trio developed a fundamental theory of neutron-induced nuclear reactions.

Hitler's preparations for a systematic occupation of all countries bordering Germany endangered some members of Bohr's international team, including Placzek. The *Anschluss* of Austria in the ▷

spring of 1938 and the seizing of a large region from Czechoslovakia through the Munich treaty in September of that year left no-one in the dark. Bohr decided to move part of his Copenhagen Institute to the other side of the Atlantic. Placzek left Copenhagen for the US in January 1939 and in Princeton, at the beginning of February, he met Bohr, who had been waiting for him impatiently.

George Placzek on the left in Leipzig in 1931, with, behind from left to right, G Gentile, G Wick, F Bloch, V Weisskopf and F Sauter; in front, R Peierls on the left and W Heisenberg. (Courtesy AIP Emilio Segrè Visual Archives, Peierls Collection.)

Across the Atlantic

Placzek's first encounter with Bohr on the other side of the Atlantic provides an interesting illustration of their personal relationship and scientific collaboration. While sources (e.g. Moore 1966, Wheeler and Ford 2000) do not agree exactly on what was discussed during breakfast on 3 February 1939, they do seem to have the same opinion on the following. Bohr found Placzek – "the institute's always stimulating Bohemian" – sitting with Leon Rosenfeld. Their discussion focused on some exciting news from Europe. First, Frisch and Lise Meitner had recently suggested that most of the transuranic elements were produced by a new type of nuclear reaction – the capture of neutrons from uranium fission. Second, Placzek had suggested to Frisch in Copenhagen how he might confirm the existence of fission in a straightforward way, which Frisch promptly did on 13 January 1939.

Bohr, listening attentively, looked up with a big smile: "For one good thing, we're free of transuranic elements." Placzek, the sceptic, 20 years younger than Bohr, commented: "Yes, but now you're in a worse mess. How can you reconcile it with your view of nuclear reactions?". How, he asked, was Bohr going to explain why slow rather than fast neutrons should cause uranium to fission? Why should slow neutrons induce a modest fissioning in uranium, but be captured in thorium?

Bohr suddenly went pale, took Rosenfeld and set off across the campus to his office. He went to the blackboard and worked rapidly, making some rough sketches. In about ten minutes he stopped; he had the answer to the problem posed by Placzek, related to the fissioning of the nuclei. The fission cross-section for slow neutrons must be due to the small amount of the isotope uranium-235, the cross-section increasing as the wavelength of the neutrons increases with decreasing energy.

From 1939 to 1942 Placzek was professor at Cornell University, Ithaca. Later he went to Montreal and Los Alamos, where he contributed to solving problems related to the moderation of neutrons in matter. He was apparently the only citizen of Czechoslovakia to take part in the Manhattan Project, being head of the Theory Group in Chalk River near Montreal, and then in Los Alamos from May 1945. Later he worked for some time in the General Electric Company in Schenectady and in 1948, he obtained a permanent position at the Institute for Advanced Study in Princeton.

In the last years of his life, Placzek went into more depth with his analysis of the elastic and inelastic scattering of light particles in liquids and crystals, aimed at investigating the physical properties of these media. Albert Messiah and Léon Van Hove were among his collaborators and friends in this period (Van Hove 1956, Messiah 1991). During this time, he also visited Europe to lecture on the moderation and diffusion of neutrons and in 1954, the book *Introduction to the Theory of Neutron Diffusion*, by K M Case, F de Hoffmann and Placzek appeared, based on a lecture course Placzek gave in Santa Monica and Los Angeles in the summer of 1949. In autumn 1955, Placzek died in Zurich while he was planning a several-month lecture tour through Italy for the academic year 1955–56.

During his scientific career, Placzek provided a quantum formulation of Raman light scattering, developed the ideas of molecular symmetry and its application in physics, and in collaboration with Bethe, Bohr and Peierls, contributed to the general theory of nuclear reactions. He systematically studied the behaviour of neutrons in nuclear reactions, neutron resonances, scattering and diffusion in matter, and the moderation and absorption of neutrons in crystals and liquids. He was among the first to suggest, independently of several others, that graphite might be used to moderate neutrons. Yet his name is not well known.

The importance of publication

Those who knew Placzek personally agree that his discoveries and results in physics, rich and important as they were, were not sufficiently published; only a small portion of his results appeared in print. As Van Hove points out, Landau's and Placzek's classic results on the scattering of a monochromatic wave in liquids were published in an incomplete form, and were only later discussed in more detail by Jacov Frenkel in his *Kinetic Theory of Liquids*. The same holds for the results on the general theory of nuclear reactions obtained by Bohr, Peierls and Placzek. Amaldi wrote about Placzek in 1956: "The redaction of an article represented an immense effort for him; even important results of his, which he had formulated clearly and in definite form, often remained unpublished."

This trait of Placzek's corresponded to his desire always to deepen his analyses of the phenomena he studied. Moreover, many of his original ideas are implicitly contained in other papers. As an unmerciful critic, Placzek often served as the scientific conscience for his colleagues, stimulating their invention, criticizing their work and forcing them to formulate their scientific ideas clearly. He had a number of characteristics that made him a welcome collaborator and team member: a highly developed critical sense, an ability to understand new problems quickly and to confront them with relevant facts, an unselfish willingness to offer advice and, last but not least, a generous disinterest in participating in the result.

These attributes, as Amaldi explains, reflected Placzek's character. He excelled in general erudition and in a culture anchored in fundamental ideas. He easily learned foreign languages and felt great affection for small nations. He was noted for strict moral principles and a great sense of tolerance.

What little remains

Despite Placzek's long collaboration with Bohr there are only a few photographs and letters in the Niels Bohr Archive in Copenhagen. One possible explanation is that, before moving to America, Bohr obliterated all traces that could help the Nazis pursue the families of those who had fled from occupied countries. In Placzek's fatherland, by the end of 2004, only a few documents had been found: a note in the register of births (containing the names of his parents and grandparents, the godfathers, the rabbi and the midwife), the regular notes of his studies in the Staatsgymnasium high school, and the distasteful entries in the book of the right of domicile. Placzek's parents and his sister died in concentration camps during the Second World War, while his brother died eight days after the Nazis' invasion of Czechoslovakia in March 1939. Recently, however, in connection with the double anniversary of Placzek's birth and death, many interesting documents have been found about his relatives and the history of the whole family in Moravia and North America (Gottvald 2005). These will be presented at the symposium.

Acknowledgements

The author is greatly indebted to Ugo Amaldi, Giuseppe Cocconi, Torleif Ericson, Ales Gottvald, André Martin, Michelle Mazerand, Jack Steinberger, Valentin Telegdi and Jenny Van Hove for providing valuable information relating to George Placzek.

Further reading

For information about the Symposium in Memory of George Placzek (1905–1955) see http://dumbell.physics.muni.cz/placzek/.

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A Messiah 1991 The early post-war period of Léon Van Hove. A recollection *Scientific Highlights in Memory of Léon Van Hove* ed. F Nicodemi World Scientific.
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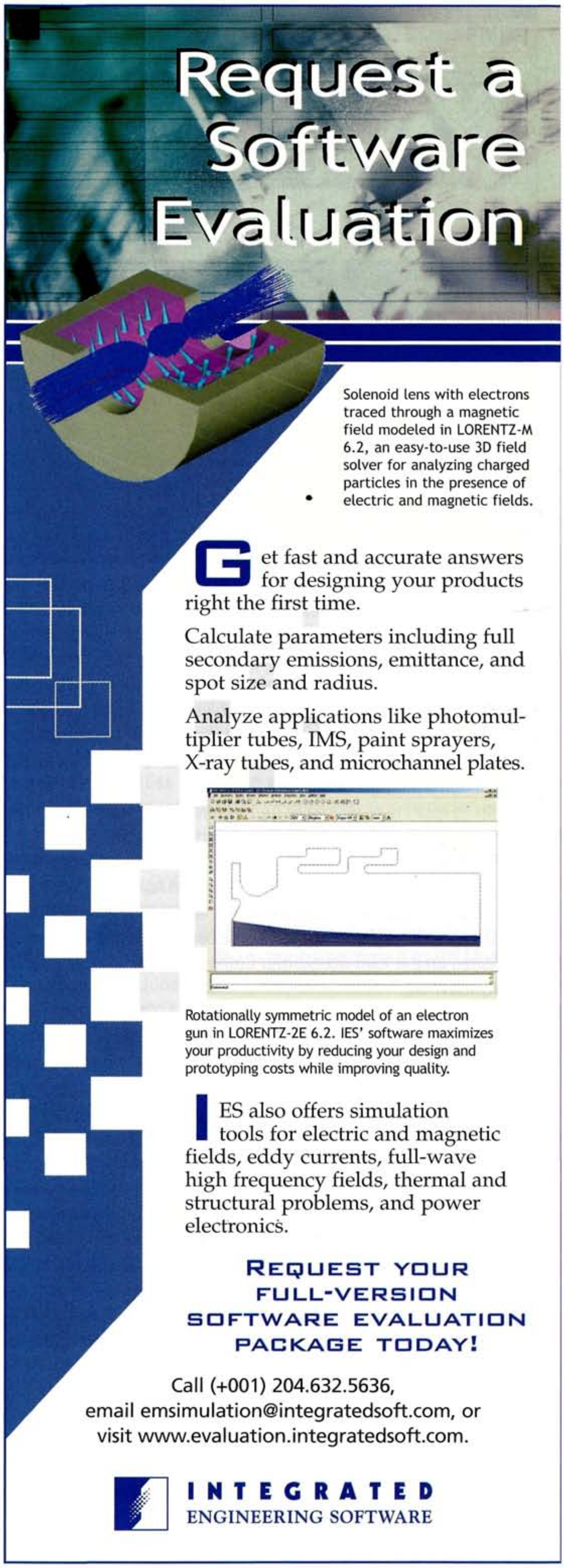
Résumé

Georges Placzek: héros obscur de la physique

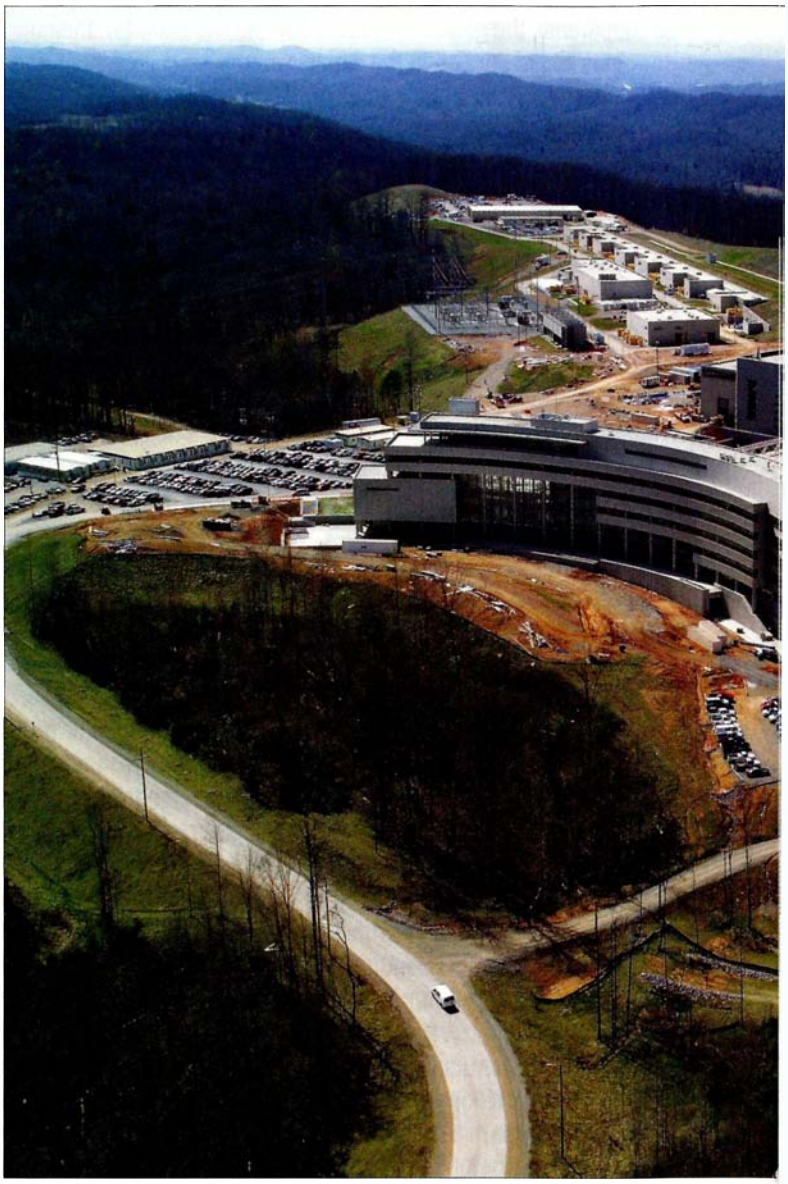
Cette année est à la fois le centenaire de la naissance et le cinquantenaire de la mort du physicien tchèque Georges Placzek (1905–1955). Au cours de sa carrière de chercheur, il a apporté d'importantes contributions aux domaines de la physique moléculaire, de la diffusion de la lumière par les liquides et les gaz et, avec Niels Bohr et Rudolf Peierls, de la théorie générale des réactions nucléaires. Pourtant, son nom n'est pas très connu. Jan Fischer revient sur sa vie et son œuvre.

Jan Fischer, *Institute of Physics, Academy of Sciences of the Czech Republic, Prague.*



Conference brings Ei

This year's major accelerator conference covered impressive progress in the field, and featured events celebrating the World Year of Physics. **Norbert Holtkamp** reports.



The SNS site: a 300 m H^- linac (at rear) – largely superconducting – provide are created. The project goal is to deliver an average beam power of 1.4 MV built by a unique partnership of six US Department of Energy laboratories: A

The 2005 Particle Accelerator Conference (PAC05) took place on 16–20 May, at the Knoxville Convention Center in Knoxville, Tennessee. The conference was jointly hosted by the Oak Ridge National Laboratory Spallation Neutron Source (SNS) – the largest accelerator construction project in the US – and the Thomas Jefferson National Accelerator Facility (JLab), Newport News, Virginia. As usual, the conference covered new developments in all aspects of the science, technology and use of particle accelerators. Unique to PAC05, however, was the special theme of the World Year of Physics, as declared by the United Nations in honour of the centenary of Albert Einstein's *annus mirabilis*, when he published his three papers on light quanta, Brownian motion and the special theory of relativity. These discoveries had a remarkable impact on science which continues to this day.

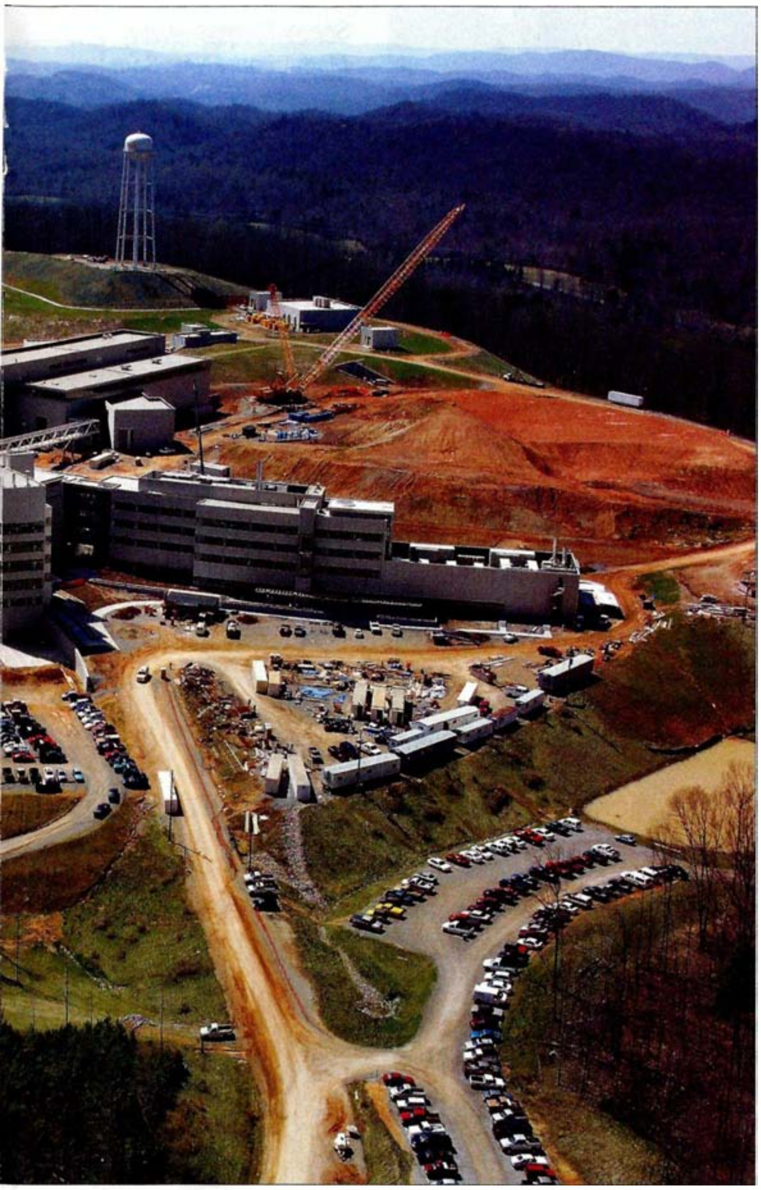
With its exciting programme, the conference attracted more than 1400 accelerator specialists to Knoxville during the week, making it the second largest PAC ever. Geographically, 59% of the attendees were from the US, 25% from Europe, 15% from Asia and 1% from the Middle East, South America and as far away as Australia. Nearly 1400 papers were processed during the conference and will soon be published on the Joint Accelerator Conferences Website, located at www.JACoW.org.

Accelerators present and future

Phil Bredesen, governor of Tennessee and a physicist with a background in accelerators from his student years, welcomed delegates to the conference. The governor talked about the significance of science as a driver of economy and wealth, as well as the importance of continuously supporting education. He was followed by Cecilia Jarlskog from Lund, whose colourful presentation included information about Einstein, the Nobel prize and accelerators. Barry Barish, chair of the International Technology Recommendation Panel for the proposed International Linear Collider (ILC), then explained the technology choice made last year for the machine (*CERN Courier* October 2004 p5) and outlined his role as the new director of the ILC Global Design Effort to design the accelerator while involving all regions of the world (see Viewpoint, p54).

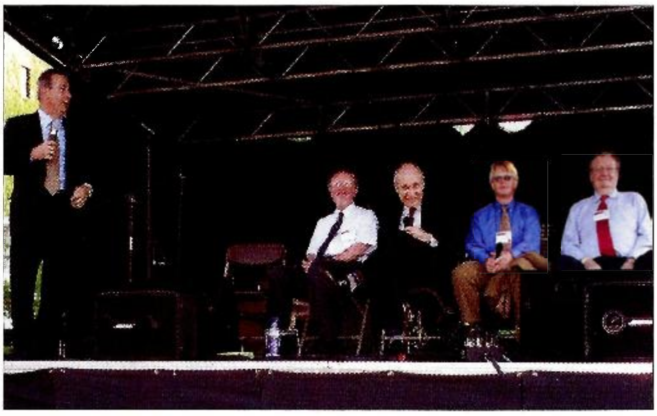
The Monday morning plenary session included highlights from other accelerators, such as the luminosity records of the Tevatron at Fermilab, achieving more than $1 \times 10^{32}\,cm^{-2}\,s^{-1}$; the outstanding performance of Brookhaven's Relativistic Heavy Ion Collider, with its polarized beams; and the race between the B-factories (KEKB in Japan and PEP II at SLAC in the US). The closing plenary session on Friday afternoon included talks on nuclear-physics topics such as the Rare Isotope Accelerator proposed in the US and the Facility of Antiproton and Ion Research (FAIR) project at GSI, as well as accelerator-based materials-science research, and neutrino and high-energy physics. The talks focused on projects that have paved the way for the accelerators that need to be built to address today's pressing questions in all areas of science, and they demonstrated yet again how accelerators have become crucial research tools over the past 50 years.

nstein to Tennessee



s a 1 ms pulse at 60 Hz into an accumulator ring, where 700 ns bunches f on the target; the first beam is expected in June 2006. The SNS has been rgonne, Berkeley, Brookhaven, JLab, Los Alamos and Oak Ridge.

Synchrotron light sources of all sizes and flavours once again dominated the papers presented at the conference, demonstrating how quickly the field is still growing, especially in energy-recovery linacs and short-pulse coherent light sources, i.e. X-ray free-electron lasers (FELs) including the use of self-amplification of spontaneous emission (SASE). Sixteen oral presentations and more than 100 papers were presented on these facilities alone. Vibrant research and planning for new projects are ongoing, with the Linac Coherent Light Source under construction at SLAC and the EUROFEL moving from planning to construction at DESY, as well as the Spring-8 Compact SASE Source in Japan.



Bill Madia (with microphone) moderating questions from the public to (from left to right) Maury Tigner (Cornell), Michael Turner (NSF), Norbert Holtkamp (SNS) and Carlo Rubbia (ENEA/CERN) during the Einstein in the City event.

Einstein was ever-present throughout PAC05, with the conference website incorporating an Einstein quotation on every page, and several special activities during the week. These events began with a violin and piano concert by Jack Liebeck and Inon Barnatan on the Tuesday evening, which recognized Einstein's love of the violin and was introduced by Brian Foster from Oxford University (*CERN Courier* January/February 2005 p41). Then on Wednesday afternoon, the US, Asian and European PAC series joined forces in a special session, "Einstein and the World Year of Physics", organized by Swapan Chattopadhyay from JLab. The session was chaired by Bill Madia of Battelle and included four presentations relating present-day research to Einstein's legacy, by Michael Turner from the National Science Foundation (NSF), Makoto Kobayashi of KEK, Yoichiro Suzuki of Tokyo and Carlo Rubbia from ENEA/CERN.

Einstein in the City

To draw the public's attention to the World Year of Physics, an "Einstein in the City" festival followed the session. Organized with the City of Knoxville, the festival drew conference participants and several hundred others to the World's Fair Park, outside the convention centre. Part of the festival was a science fair for local high-school students, with cash prizes of between $200 and $5000 awarded to projects judged by a team of conference participants. A special panel of four physicists, moderated by Madia, answered science-related questions from the public for about an hour. Questions covered everything from "Why is science useful?" to "How many stars are in the universe?" to "What does an accelerator do?". Other activities included an appearance by "Einstein the Bird" – a talking parrot from the local zoo – and bluegrass music from a local band, as well as plenty of good food and drink.

Another highlight of the conference was the now customary prize ▷

PAC05 participants at the conference banquet. Pictured seated at the table, from left to right, are: Sue Waller, Daresbury Lab; Jan Chrin, PSI; Kelly Hanifan, JLab; Sherry Thomas, JLab; Matt Arena, FNAL; Sam Vanacek, LBNL; Joy Kono, LBNL; Akihiro Shirakawa, KEK; Keith Symon, University of Wisconsin–Madison.

session, in which the winners of several accelerator prizes are recognized and have the opportunity to report on their research. The session chair, Nan Phinney of SLAC, congratulated recipients individually and presented some of the awards. Among them was Keith Symon of the University of Wisconsin–Madison, winner of the American Physical Society's prestigious Robert R Wilson Prize "for fundamental contributions to accelerator science, including the FFAG concept and the invention of the RF phase-manipulation technique that was essential to the success of the ISR and all subsequent hadron colliders". The other APS prize was for an outstanding doctoral thesis by Eduard Pozdeyev from JLab, who performed his doctoral work at Michigan State University. Ron Davidson of Princeton and Tom Roser of Brookhaven National Lab were awarded the Particle Accelerator Science and Technology Award from the Nuclear and Plasma Science Society of the Institute of Electrical and Electronics Engineers (*CERN Courier* June 2005 p39). Wim Leemans of the Lawrence Berkeley National Laboratory (LBNL) and Anton Piwinski of DESY were presented with the US Particle Accelerator School Prize for Achievement in Accelerator Physics and Technology.

While PAC05 ended officially on Friday afternoon, about 400 participants extended their stay by a day to visit the SNS site at Oak Ridge. The SNS is entering its last year before the first beam is scheduled to hit the mercury target and the first neutrons channelled to instruments. So far the beam has been commissioned to the end of the normal conducting linac, up to 157 MeV, and soon the superconducting linac will be turned on to boost the energy to 1 GeV. Later this year the compressor will be commissioned in preparation for user operation, to begin next summer. Tour participants were therefore among the last people to get a glimpse of what has been going on at the site over the past five years, before much of the facility is closed to visitors.

Further reading

The governor's address to PAC05 can be found at www.sns.gov/pac05/bredesen.shtml.

Résumé

Knoxville accueille une conférence sur les accélérateurs

La Conférence PAC05 sur les accélérateurs de particules s'est déroulée à Knoxville, Tennessee, sous l'égide du Laboratoire national d'Oak Ridge – où se construit le plus grand projet actuel d'accélérateur des Etats-Unis, la source de neutrons de spallation – et du Laboratoire Thomas Jefferson. Comme de coutume, la conférence a traité des avancées récentes dans tous les aspects des accélérateurs de particules. PAC05 avait toutefois la particularité d'inclure le thème spécial de l'Année mondiale de la physique.

Norbert Holtkamp, *Spallation Neutron Source Project, Oak Ridge National Laboratory.*

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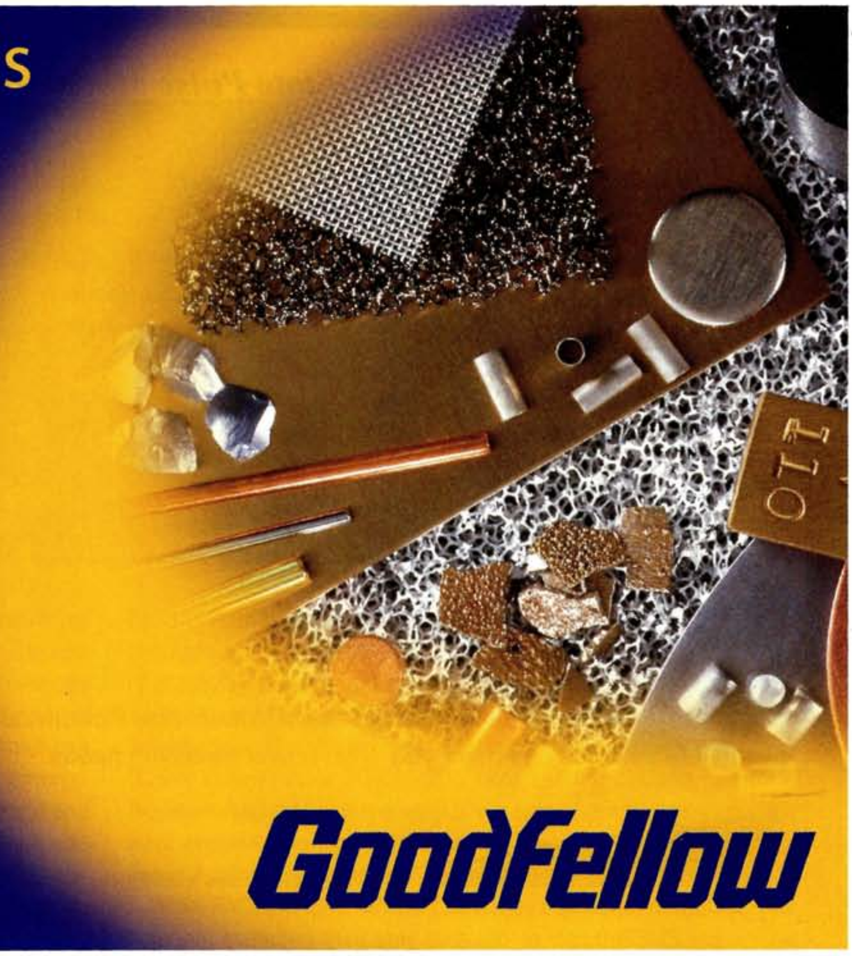

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Slow antiprotons galore

A workshop in Japan in the spring looked at how to make and use beams of ultra-slow antiprotons over a wide range of physics.


Participants enjoy an excellent buffet during the workshop.

In the 50 years since Owen Chamberlain, Emilio Segrè, Clyde Wiegand and Tom Ypsilantis discovered the antiproton in October 1955, an extremely diverse range of research topics has developed that involve antiproton beams with kinetic energies of order kilo-electron-volts or less. This was the subject of the Workshop on Physics with Ultra Slow Antiproton Beams, held 14–16 March 2005 at RIKEN, Japan.

The workshop was motivated by the recent progress in manipulating large numbers of ultra-slow antiprotons that has been made by the antihydrogen and antiprotonic-helium collaborations working at CERN's Antiproton Decelerator (AD). The latest of these developments was in summer 2004. That was when the Monoenergetic Ultra-Slow Antiproton Source for High-Precision Investigations (MUSASHI) group of the ASACUSA collaboration first slowed the 5.3 MeV pulsed AD beam in a radio-frequency quadrupole decelerator (RFQD) to some tens of kilo-electron-volts, then confined and cooled more than 1 million antiprotons in a large multi-ring Penning trap (*CERN Courier* March 2005 p8). The trapping efficiency of about 4% is approximately 100 times higher than any previously achieved. The group also succeeded in extracting antiprotons from the trap as an ultra-slow DC beam of 10–500 eV. The fact that this unique beam can, in principle, be transported for some distance without serious loss makes beam sharing for a variety of experiments a real possibility.

Although the workshop was announced only two months beforehand, it attracted some 70 participants from all the related fields, and covered subjects ranging from fundamental questions about charge-parity–time-reversal (CPT) symmetry and gravitation, to the structure of exotic nuclei, atomic collisions and atomic physics. This report relates just a few of these topics; a full account will soon be published in the *Proceedings* series of the American Institute of Physics.

The early days of antiproton research were reviewed by John Eades of the University of Tokyo. Eades turned back the pages of scientific history in a talk entitled "The Antiproton and How It Was Discovered", quoting the thoughts and opinions of some of the main participants, made both at the time and in retrospect. He underlined the initial doubts and inconsistencies that surrounded Paul Dirac's relativistic-wave equation of 1930, and its final triumph as the positron, antiproton and other antiparticles were discovered.

Klaus Jungmann of the Kernfysisch Versneller Instituut (KVI), Groningen, gave a comprehensive overview of the current status of low-energy antiprotons and other exotic particles, and the experimental opportunities they offer as windows on fundamental forces and symmetries in nature. On the theoretical side, Ralf Lehnert of Vanderbilt University pointed to the large gap that will remain in our understanding of nature at the smallest scales until a consistent quantum theory is developed that underlies both the Standard Model and general relativity. He discussed the so-called Standard Model Extension (SME) as a theoretical framework that may bridge this gap, and which incorporates all Lorentz- and CPT-violating corrections compatible with key principles of physics (*CERN Courier* December 2004 p27). The SME predicts diurnal variations in spectroscopic measurements of matter and antimatter atoms, and could therefore be a guiding principle in designing future antihydrogen experiments.

Antihydrogen atoms and antihydrogen ions

The past three years have seen important progress by both the ATHENA and the Antihydrogen Trap (ATRAP) collaborations in synthesizing and experimenting with antihydrogen atoms at the AD. Some of the main results concern the accumulation of large numbers of positrons and antiprotons in "nested" Penning traps of various geometrical designs, leading to the observation of high formation rates for antihydrogen atoms. An unexpected consequence is that these antihydrogen atoms seem to be created before their constituent antiprotons have been fully cooled, with the result that they are themselves too hot to be easily stored and manipulated with existing techniques. Moreover, they are primarily formed in highly excited Rydberg states, while it is the ground and first-excited states that are of most interest for testing CPT invariance.

These obstacles to preparing usable antihydrogen atoms for physics experiments demand new ideas in trap design, going beyond the configuration of the nested electrostatic potential well used so far. Thus, Jeff Hangst of Aarhus described the present status of the high-field-gradient magnetic multipole trap proposed by the newly formed Antihydrogen Laser Physics Apparatus (ALPHA) collaboration; and Dieter Grzonka of Jülich reported on tests made on long-term electron storage in the ATRAP collaboration's quadrupole magnet, which has a more moderate field gradient. ▷

The storage of neutral atoms of antihydrogen requires the presence of magnetic field gradients to drive the so-called low-field-seeking atomic-spin states towards field minima, and will be essential to carry out high-precision antihydrogen spectroscopy. Since it appears that the atoms are produced in highly excited Rydberg states, they must be stored for long enough to allow them to relax to the ground state. Discussions at the workshop centred on various multipole and quadrupole trap designs that are likely to be useful in preparing such ground-state antihydrogen atoms.

Further new designs involve the so-called "cusp trap", consisting of a potential well formed by two oppositely directed Helmholtz-coil fields, and a high-Q RF trap resonating at two frequencies, which can store positively and negatively charged particles simultaneously.

Ryugo Hayano of the University of Tokyo summarized both the present status of precision spectroscopy of antiprotonic helium and the development of the two-frequency RF trap for antihydrogen synthesis. In the latter, positrons and antiprotons may recombine within a volume of around 1 mm^3, and thus form a source for an antihydrogen atomic beam. Sextupole magnets installed in such a beam could select and analyse specific antihydrogen spin alignments to measure the hyperfine structure of the antihydrogen ground state, much as was done with ordinary hydrogen atoms several decades ago.

Akihiro Mohri of RIKEN, Japan, showed that stable long-term storage of an electron plasma has been achieved at finite temperature in a cusp trap and that this can also trap synthesized antihydrogen atoms in low-field-seeking states. When the temperature of antihydrogen atoms and the magnetic field of the cusp trap are properly set, antihydrogen atoms in the ground state are selectively guided and focused along the magnetic axis, enabling an intensity-enhanced spin-polarized antihydrogen beam to be prepared.

A new path towards gravitational experiments with antihydrogen was proposed by Patrice Perez of CEA/Saclay, who discussed synthesis of antihydrogen ions ($\bar{H}^+$). These could be formed via two-step reactions ($\bar{p} \rightarrow \bar{H} \rightarrow \bar{H}^+$) when a 13 keV antiproton beam passes through a dense cloud of positronium atoms. The resulting $\bar{H}^+$ ions would then be trapped, sympathetically cooled with laser-cooled alkali-earth ions, and finally ionized to the neutral state by a laser-detachment process to create the ultra-cold $\bar{H}$ atoms necessary for detecting the extremely weak gravitational interaction.

Kanetada Nagamine of KEK proposed studying muonic antihydrogen ($\mu^+\bar{p}$), the antimatter equivalent of muonic hydrogen (μ^-p), as an alternative to antihydrogen. The advantage of comparisons between μ^-p and $\mu^+\bar{p}$ is that because of their larger mass, muons probe CPT-violation effects at a distance 200 times closer to the antiproton nucleus than positrons and electrons do.

Further studies

Collision dynamics with antiprotons is also a potentially important subject, in which the antiproton behaves like a heavy electron. Although the Coulomb force is understood, its collision dynamics are not well known when more than three particles are involved. A familiar, puzzling example is the double ionization of helium by fast antiprotons, the cross-section for which is about twice as large as that for protons having the same velocity. Almost 20 years have passed since this observation, but it is not yet fully understood theoretically. This contrasts with the case of bound systems such as antiprotonic helium ($\bar{p}He^{++}$), where the observed transition levels have been theoretically accounted for at the level of one part per billion.

Joachim Ullrich of the Max Planck Institute, Heidelberg, discussed the importance of studying collision dynamics with antiproton energies in the range of 100 keV for which the time required to traverse atoms or molecules is of the order of 100 attoseconds (as). Since this is comparable to the orbital period of outer-shell electrons in atoms or molecules, crucial information on collision dynamics involving electron–electron correlation can be extracted.

Antiprotonic atoms have long been used to probe neutron density distributions in stable nuclei through studies of antiprotonic X-ray spectra, radiochemistry of the residual nuclei, and the charged pions emitted when the antiprotons annihilate. An antiproton captured in an electronic orbit de-excites to successively lower atomic levels until its overlap with the nucleus becomes appreciable. At this point annihilation takes place with a proton or a neutron near the "surface" of the nucleus (atomic number A), the actual charge state being identifiable from the charge balance of emerging pions; a nucleus of atomic number A-1 results.

Michiharu Wada of RIKEN proposed extending the pion-detection method by storing antiprotons and unstable nuclei in a nested trap. The charge-balance method can be applied to various nuclei including those for which the A-1 nuclei have no bound states. Slawomir Wycech of the Soltan Institute, Warsaw, emphasized that all these measurements test neutron density distributions in different regions of nuclei and yield complementary information on the rms and higher moments of density profiles as low as 0.001 of the central neutron density.

Looking to future antiproton facilities Paul Kienle of the Technischen Universität München discussed the possibility of an antiproton–ion collider at GSI's Facility for Antiproton and Ion Research (FAIR), with energies of 30 MeV and 740 AMeV for protons and ions respectively. Cross-sections for antiproton absorption on protons and neutrons would be measured by detecting residual nuclei with A-1, using Schottky and recoil detectors respectively. This would permit rms radii for protons and neutrons to be determined separately in stable and short-lived nuclei by means of antiproton absorption at medium energies. A general discussion around the subject of ultra-slow antiproton physics ended this extremely fruitful workshop.

Résumé

Antiprotons froids à volonté

Au cours des 50 années écoulées depuis la découverte de l'antiproton, une gamme extrêmement diversifiée de sujets de recherche s'est développée autour des faisceaux d'antiprotons de très basse énergie – dans les kilo-électronvolts et en-dessous. C'était le sujet de l'atelier de la physique avec des faisceaux d'antiprotons ultralents qui s'est tenu en mars au RIKEN (Japon). L'atelier, motivé par les récents progrès accomplis dans la manipulation de grands nombres d'antiprotons ultralents, a examiné les techniques de formation et d'utilisation des antiprotons d'énergie ultrabasse.

Yasunori Yamazaki, *University of Tokyo and RIKEN, and*
John Eades, *University of Tokyo.*

Antiproton physics takes another big LEAP forward

The latest in the Low Energy Antiproton Physics series of conferences in Bonn showed that this field of research is increasingly vibrant and exciting, as **Walter Oelert** describes.

The Wolfgang Paul Lecture Hall, packed long before the public lectures began. (Photos by Dieter Grzonka and Tomek Rozek.)

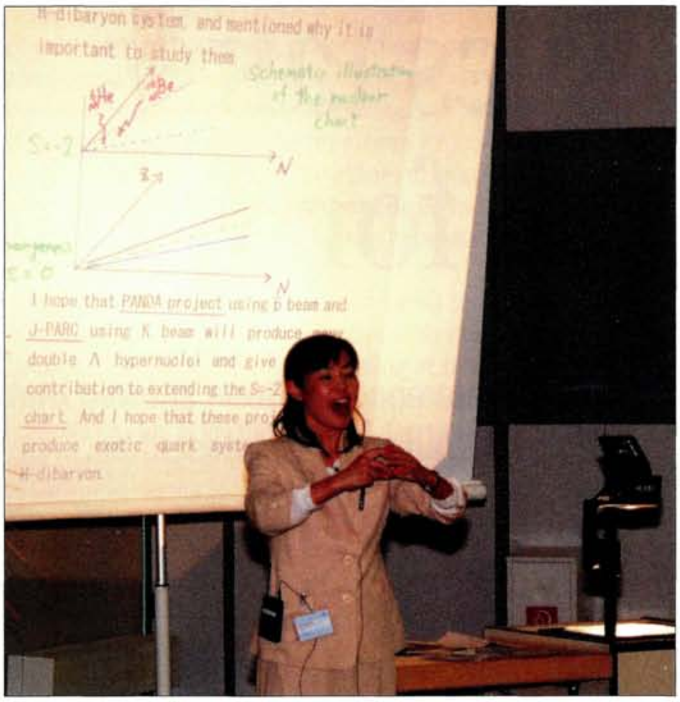
The biennial International Conference on Low Energy Antiproton Physics, LEAP-05, took place in May at the Gustav-Stresemann-Institute in Bonn. Organized by the Jülich Research Centre, it brought together about 150 physicists, including experienced and active users of the former Low Energy Antiproton Ring (LEAR) at CERN and the existing Antiproton Decelerator (AD), as well as potential users of the future Facility of Antiproton and Ion Research (FAIR) at the Gesellschaft für Schwerionenforschung (GSI). The meeting enabled researchers who are interested in using the exciting tool of antiprotons to exchange knowledge about the physics and techniques. The programme covered the whole field of research with antiprotons, from atomic physics at low energies to hadronic reactions at high energies. The conference showed that the field is evolving, with new physics being studied at existing and planned facilities.

Antiprotons at work

The AD began operating in 2000 and its experiments have reported spectacular production rates of antihydrogen atoms as well as topical observations of antiprotonic helium atoms. Though limited to low-energy antiproton research with only a pulsed extracted beam, the AD is regarded as the successor of LEAR after it closed down at the end of 1996, together with the Antiproton Accumulator (AA) and Antiproton Collector (AC). The AC machine was modified to become the AD – a decelerator to slow down the antiproton beam from a momentum of 3.57 GeV/c to 100 MeV/c. During deceleration, the beam undergoes stochastic and electron cooling. The extracted beam intensity is about 3×10^7 antiprotons in a pulse of 90 ns, repeated every 86 s.

The AD delivers antiprotons only at the lowest energy that was available at LEAR, i.e. 5 MeV. For one experiment – ASACUSA – the antiproton beam is further slowed down to about 60 keV with a radio-frequency quadrupole decelerator (RFQD). A possible additional decelerator ring, ELENA, to serve all experiments, would have a cooled beam and would bring a major improvement if installed.

Plans are being realized for a new antiproton facility at GSI, where antiprotons with energy high enough for physics with strange and, especially, charm mesons will be available, in addition to very-low-energy antiprotons. An accelerator complex for research with both ▷



Emiko Hiyama, from Nara Women's University, Japan, talking about three- and four-body structures of S = –2 hypernuclei.

ion and antiproton beams is planned. This would provide an outstanding new experimental facility for studying matter at the level of atoms, protons and neutrons and their sub-nuclear constituents: quarks and gluons.

Research on fundamental symmetries was a very important part of the scientific programme at LEAP-05. Over the past 50 years, experimental tests have made physicists discard certain assumptions about symmetry: first, that physics is invariant under parity (P); and second, that it is invariant under the charge–parity (CP) transformation. Direct CP violation has been established in the decays of K-mesons and, recently, B-mesons. On the other hand, CP plus time-reversal (T) invariance, CPT, is believed to hold – and is partly experimentally verified – to a high degree of accuracy.

The symmetries under T, CP and CPT transformations are connected, and the CPT theorem demands that for each particle or element the equivalent antiparticle has the same mass, lifetime, spin and isospin – but an opposite value for all of the additive quantum numbers. The proof (or disproof) of the validity of this basic symmetry may be the key to such fundamental aspects as the universe's matter–antimatter asymmetry. Physics is still in a phase where it is important to accumulate highly precise experimental data from different leptonic and/or hadronic systems. In this respect, the role of matter–antimatter asymmetry – especially baryonic proton–antiproton physics – is significant.

Probing how antiprotons interact with matter at very low energies is still a topical field for precise studies of the electromagnetic and strong forces and their interplay. High-precision spectroscopy of meta-stable antiprotonic atoms has produced very interesting and unique results. With the accuracy achieved in investigations of antiprotonic helium atoms, the CPT theorem can be tested to a level comparable to the existing bounds from other systems.

An alternative approach is the production and comparison of hydrogen and antihydrogen. A reasonable requirement for a new and unique CPT test of this kind is that it is eventually more stringent than existing tests with leptons and baryons. To make the required high-precision spectroscopic measurements, the hydrogen and antihydrogen atoms have to be at such low temperatures that laser cooling of trapped atoms, which is possible owing to the development of a continuous Lyman-alpha laser, appears to be necessary. Once all the basic technical requirements to produce antihydrogen atoms have been explored and optimized, tests of the gravitational force on antimatter will also be possible, free from the problems associated with charged particles.

When describing the nucleon–antinucleon (N–$\bar{N}$) interaction, it is implicitly assumed that the six-quark N–$\bar{N}$ system can be regarded as a product of quark–antiquark nucleon wave functions with a complex potential that is dominated by the distance between the nucleons. Such a potential predicts a spectrum of many states, if the annihilation part is ignored. There is a rich dynamics of resonances or bound states around thresholds, where the annihilation effects are less dominant, since the phase space for the decay into meson resonances is more restricted. However, the transition from an N–$\bar{N}$ system to a multiquark state, where quarks and antiquarks interact directly by gluon exchange, must be fully understood before invoking exotic mechanisms based on details of the interaction. New dedicated experiments could determine the energy and the quantum numbers of an N–$\bar{N}$ system, clarifying the long-range interaction.

Probing the strong interaction

Antiproton beams are an excellent tool for addressing the regime of strong coupling. In antiproton–proton annihilations, particles with gluonic degrees of freedom as well as particle–antiparticle pairs are copiously produced, allowing spectroscopic studies with unprecedented statistics and precision. Phenomena arise that represent open problems in quantum chromodynamics (QCD) as they have their origin in the specific properties of the strong interaction and represent a major intellectual challenge. Quarks are confined within hadrons; the hadron mass does not balance with the summed mass of the quarks contained; and the characteristic self-interaction among gluons should allow for the existence of glue-balls and hybrids, consisting mainly of gluons and/or glue plus a quark–antiquark pair, respectively.

The charmonium system has turned out to be a powerful tool for understanding the strong interaction. The spectroscopy of the charm–anticharm system helped in tuning potential models of mesons in which the gluon condensate is determined. The gluon condensate is closely related to the charmonium masses since it is the gluon and quark–antiquark condensates that represent the energy density of the QCD vacuum. The QCD spectrum is much richer than in the simple quark model, as the gluons, which mediate the strong force between quarks, can also act as the principle components of entirely new types of hadronic matter: glueballs and hybrids.

The additional degrees of freedom carried by gluons allow glueballs and hybrids to have exotic quantum numbers that are forbidden for normal mesons and other fermion–antifermion systems. Such exotic systems can be identified by observing an overpopulation in the experimental meson spectrum, and by comparing their properties with predictions from models for lattice QCD considerations. Antiproton annihilation experiments have produced very promising results for gluonic hadrons.

A special session spiritedly discussed applications of antimatter, radiation and particle detection, covering well established medical treatments, diagnostic routines, plans for future developments and using nuclear physics to locate land-mines to reduce injuries, especially to children.

One highlight of the conference was a public presentation in the overcrowded Wolfgang Paul Lecture Hall at the University of Bonn, where more than 600 people listened to presentations on modern, high-quality physics and its excitements. At least some listeners were disappointed when these lectures stopped after four hours! The entire LEAP-05 was a brilliant preview of the physics to come from using antiprotons as a special and very effective tool.

● For further information about LEAP-05 see www.fz-juelich.de/leap05. The conference was sponsored by Forschungszentrum Jülich; Deutsche Forschungsgemeinschaft; HiEnergy Technologies, Inc; Deutsche Telekom Stiftung; iseg Spezialelektronik GmbH; Bicron; W-IE-NER, Plein & Baus GmbH; and Pfeiffer Vacuum.

Karting at the Michael Schumacher Centre made a change from antiproton deliberations for participants at LEAP-05.

Résumé

L'antiproton: un autre saut dans les profondeurs de la physique

La conférence LEAP-05, qui vient de se tenir à Bonn au printemps, a rassemblé des chercheurs utilisant ou prévoyant d'utiliser bientôt les antiprotons comme outils de recherche fondamentale. Le programme a traité de l'ensemble de la recherche avec des antiprotons, de la physique atomique à basse énergie aux réactions hadroniques d'énergie élevée. La rencontre a permis aux participants d'échanger leurs connaissances sur la physique et les techniques pertinentes et laissé entrevoir un avenir passionnant, prometteur de physique nouvelle dans les installations actuelles et en cours de préparation.

Walter Oelert, *Forschungszentrum Jülich.*

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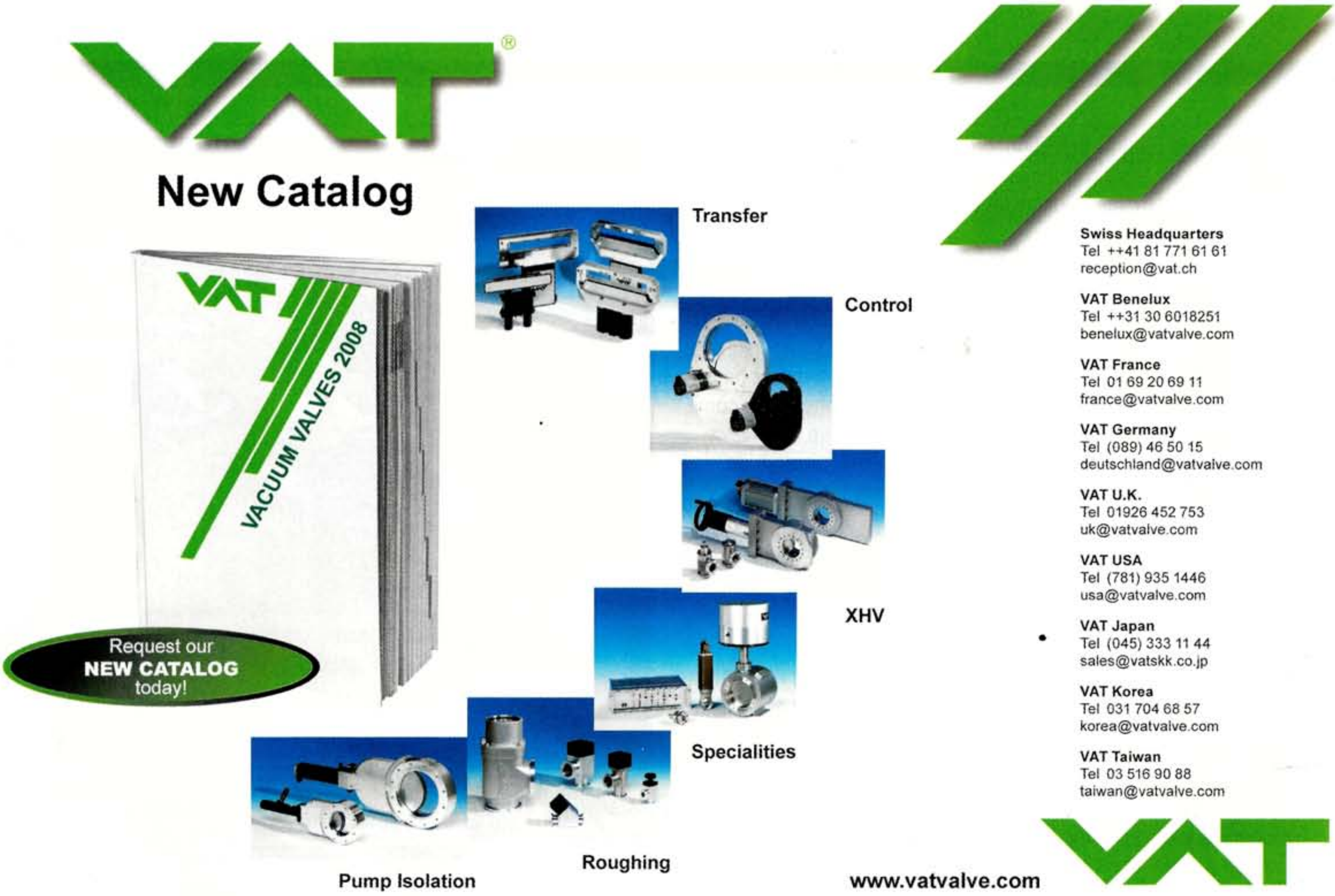

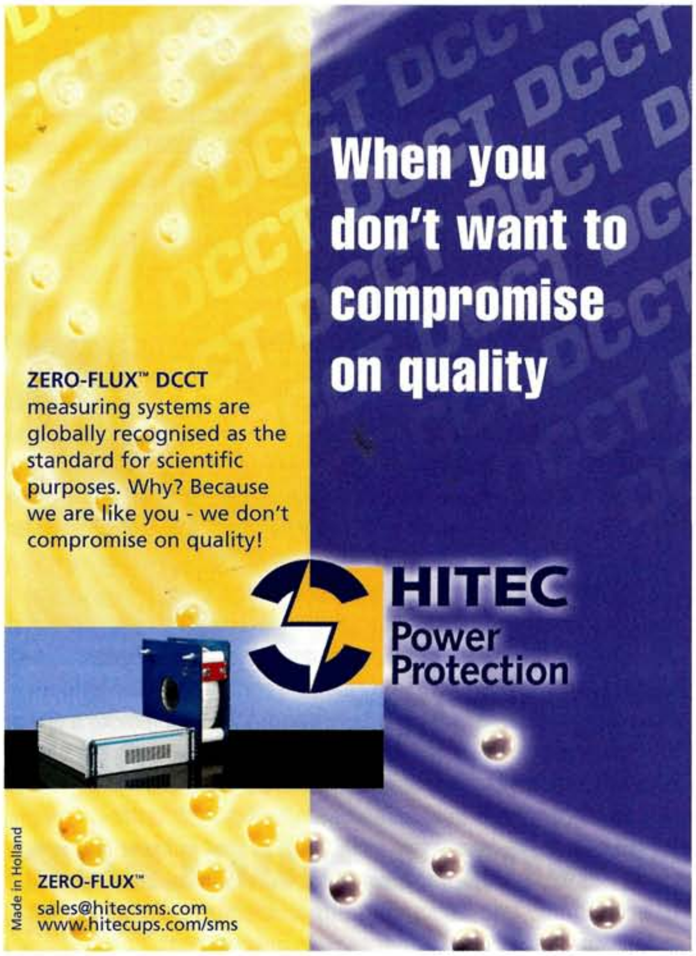

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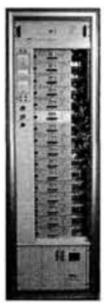

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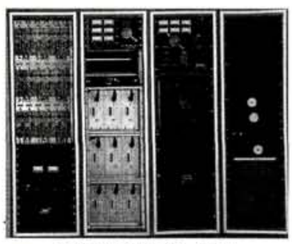

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Berkeley plans CIRCE to fill the terahertz gap

A machine has been proposed at Berkeley that would provide radiation at terahertz frequencies, a valuable source for research.

A team at the Advanced Light Source (ALS) of the Lawrence Berkeley National Laboratory (LBNL) has proposed the construction of a ring-based photon source optimized for generating coherent synchrotron radiation (CSR) at terahertz frequencies. The Coherent Infrared Center (CIRCE) will exploit all the CSR production mechanisms currently available for achieving top-level performance, including a photon flux exceeding by more than nine orders of magnitude that of existing conventional broadband terahertz sources.

Interest in the scientific use of radiation at terahertz frequencies is rapidly increasing: the fields that would benefit range from solid-state physics (semiconductors, metals, superconductors, strongly correlated materials, etc) through chemistry and biology to applications in medical science and security. However, a major problem is that generating radiation of significant intensity in this frequency range, which lies between microwaves and infrared, is not straightforward. Owing to the lack of sources, this region is often referred to as the "terahertz gap", but storage-ring-based CSR sources are very promising candidates for addressing this situation.

CSR occurs when the synchrotron emission from the relativistic electrons in a beam bunch is in phase. This happens when the length of an electron bunch is comparable to, or shorter than, the wavelength of the radiation being emitted. At 1 THz, this is about 300 µm. In the coherent regime the radiation intensity is proportional to the square of the number of particles per bunch, in contrast with the linear dependence of conventional incoherent synchrotron radiation. Considering that the number of electrons per bunch in a storage ring is typically very large (10^6–10^{11}), the potential intensity gain for a CSR source is huge. However, achievable bunch lengths and the shielding effect of the conductive vacuum chamber in storage rings mean CSR can only be generated in the terahertz frequency range (from about 100 µm to a few millimetres).

Although CSR was predicted to occur in high-energy storage rings over half a century ago, it has only been observed in the past few years. Intense bursts of CSR with a stochastic character have been measured in the terahertz frequency range in storage rings at several synchrotron light sources. Work carried out by groups at the Stanford Linear Accelerator Center (SLAC), LBNL and the Berliner Elektronenspeicherring-Gesellschaft für Synchrotron Strahlung (BESSY) showed that this bursting emission of CSR is associated with a single bunch instability (G Shipakov *et al.* 2002, M Venturini *et al.* 2002, J M Byrd *et al.* 2002, M Abo-Bakr *et al.* 2003a). This "microbunching instability" (MBI) is driven by the fields of the synchrotron radiation emitted by the bunch itself. Although interesting in terms of accelerator physics, these bursts of CSR are not very useful as a terahertz source, because they are intrinsically unstable and stochastic.

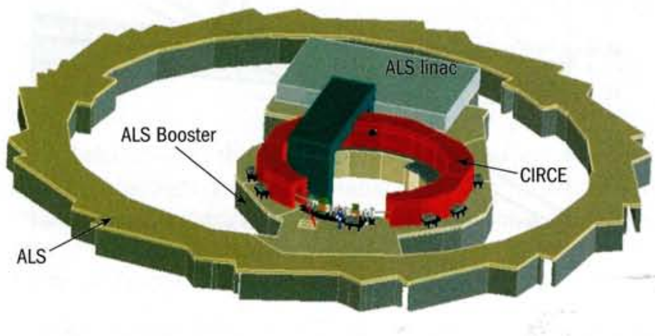

Fig. 1. The CIRCE ring in the ALS complex.

However, CSR emission with remarkably different characteristics was observed at BESSY when the storage ring was tuned to a special mode for short bunches (M Abo-Bakr *et al.* 2002 and 2003b). The emitted radiation was not the quasi-random bursting previously observed but a powerful and stable flux of broadband CSR in the terahertz range – exactly what is required for a source that is useful for scientific experiments. The LBNL, SLAC and BESSY groups together drew up a model that reproduces the observations and can be used for designing a ring-based source optimized for generating stable terahertz CSR (F Sannibale *et al.* 2004a and 2004b).

Terahertz CSR in storage rings

An interesting feature of the CSR spectra measured at BESSY is that they extend to significantly shorter wavelengths than those expected from a Gaussian longitudinal distribution of the bunch. The model developed showed that the synchrotron radiation fields can potentially produce a stable distortion of the bunch distribution from Gaussian towards a sawtooth-like shape with a sharp leading edge. This was ultimately responsible for the observed extension of the CSR spectra towards shorter wavelengths in BESSY. We will refer to this configuration as the "ultra-stable" mode of operation.

Another development in CSR in storage rings, first demonstrated at the ALS and more recently at BESSY, was obtained by exploit- ▷

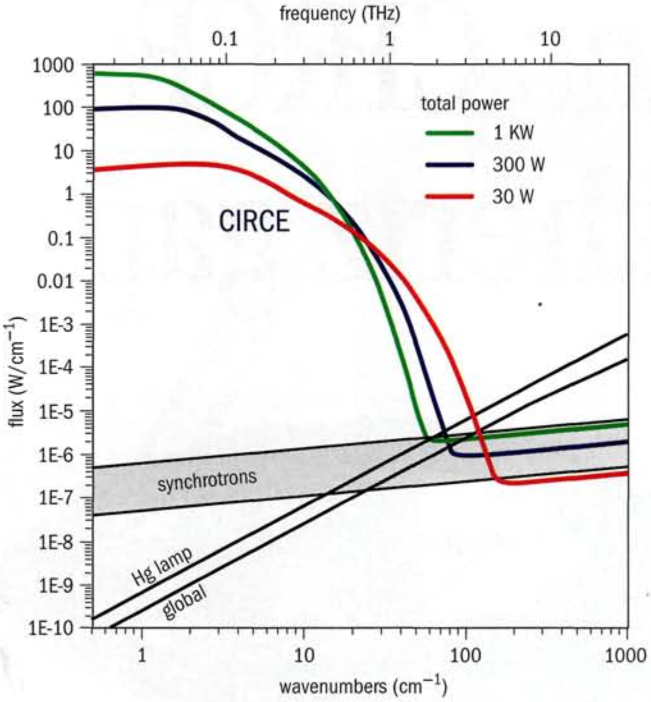

Fig. 2. Flux calculations for CIRCE in the ultra-stable mode of operation compared with conventional synchrotron and thermal far-infrared sources (1 wavenumber = $1/\lambda$). The three CIRCE curves, for three different ultra-stable sets, demonstrate how the CIRCE source can be tuned for high power (green), for extending coherent emission to shorter wavelengths (red) and for somewhere in between (purple).

ing parasitically the "femtoslicing" technique used for producing femtosecond X-ray pulses. In the femtoslicing scheme, the co-propagation in a wiggler of a femtosecond optical laser pulse with a much longer electron bunch generates a modulation of the electron energy in a femtosecond slice of the bunch (*CERN Courier* July/August 2000 p31). When the bunch propagates in a dispersive region, the energy-modulated particles are transversely displaced. Properly masking the synchrotron radiation can remove the part emitted by the core of the bunch while allowing the transmission of the part emitted by the displaced electrons. In this way, femtosecond X-ray pulses are obtained.

At the same time, because of the longitudinal dispersion in the ring, the modulation in energy induces a density variation in the longitudinal distribution as the bunch propagates along the ring. The characteristic length of these longitudinal structures starts from tens of micrometres (a few tens of femtoseconds duration) immediately after the laser-beam interaction region in the wiggler. It quickly increases to the order of a millimetre, before finally disappearing in a few ring turns. These structures radiate intense CSR in the terahertz range with appealing characteristics: very short CSR pulses (of the same order as the laser pulse length), which extend the CSR spectrum towards shorter wavelengths (to about 10 μm or about 30 THz) than those in the ultra-stable mode; high energies per terahertz pulse (tens of micro-joules); and terahertz CSR pulses intrinsically synchronous with the femtosecond laser and X-ray pulses (allowing for a variety of pump–probe experiments and/or electro-optic sampling techniques). The main limitation is the relatively low repetition rate (a few kilohertz), which is imposed by present laser technology.

Designing CIRCE

In designing the CIRCE ring, the team has provided for optimized versions of all the techniques for generating terahertz CSR as described. Figure 1 on p39 shows a 3D layout of the ring inside the ALS facility. The ring, 66 m in circumference and operating at 600 MeV, is designed to be located on top of the ALS Booster Ring shielding and will share the injector with the ALS Storage Ring.

Figure 2 shows the impressive flux of CIRCE, calculated for three settings of the ultra-stable mode of operation. The gain of many orders of magnitude in the terahertz frequency range over the existing conventional source is clearly visible. Figure 3 shows how the femtoslicing mode complements the ultra-stable mode of operation in CIRCE. The calculated spectra for the two modes together cover the entire terahertz range from wavelengths of about 10 μm (30 THz) to about 10 mm (0.03 THz). The energy per terahertz pulse in the example used for the femtoslicing case is about 8.5 μJ, which when focused onto a sample would provide an electric field of about 10^6 V/cm. Current laser technology should allow repetition rates as high as 10–100 kHz.

The vacuum chambers in the dipole magnets and the first in-vacuum mirror have been designed for the efficient collection of terahertz synchrotron radiation. The design calls for three ports with 100 mrad horizontal by 140 mrad vertical acceptance for each of the 12 dipole magnets, giving a potential total of 36 dipole beam lines in CIRCE. The layout of the ring also includes six 3.5 m straight sections that can be used for insertion devices for possible future sources (as for the case of the wiggler in the femtoslicing scheme).

The CIRCE team has completed a detailed feasibility study that includes electron-beam linear and nonlinear dynamics studies, the design of all the magnets, the design of the special high-acceptance dipole vacuum chamber, and evaluating the compatibility of CIRCE with the ALS facility. Also, the team has experimentally investigated resonating modes that could be excited by the electron beam in the high-acceptance dipole vacuum chamber.

These modes, potentially dangerous for the electron-beam stability, have been measured and characterized by means of radiofrequency measurements in a prototype dipole chamber. No

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"show-stoppers" have been identified and CIRCE is part of the current five-year strategic plan for the ALS.

• See also http://CIRCE.lbl.gov/. For an historical review of the work on CSR in storage rings see Murphy 2004 below.

Further reading

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Résumé

CIRCE: combler le fossé des térahertz

Une équipe à la Source de lumière avancée (ALS) du Laboratoire national Lawrence de Berkeley propose la construction d'un anneau totalement optimisé en source de photons produisant un rayonnement synchrotron cohérent dans la gamme de fréquence des térahertz. Ce Centre infrarouge cohérent, CIRCE, viserait des performances maximales, avec un flux de photons dépassant de plus de neuf ordres de grandeur ceux des sources térahertz "classiques", large bande, actuelles.

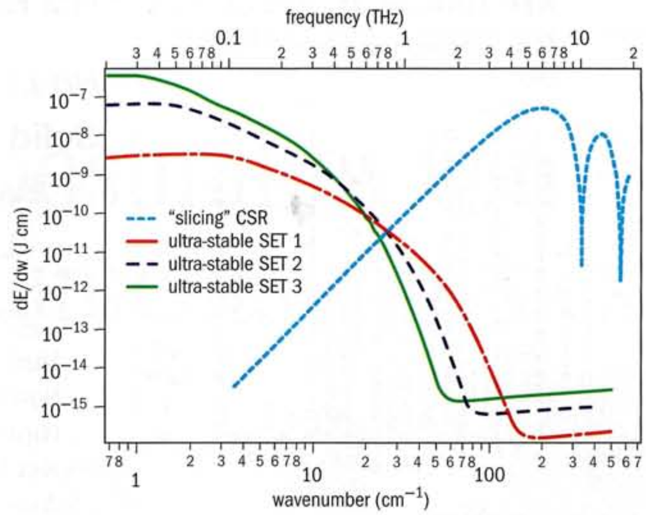

Fig. 3. Calculation of the energy per pulse per wavenumber for CIRCE in three sets of the ultra-stable mode and for an example of the femtoslicing mode of operation (wavenumber = 1/λ).

John M Byrd, **Michael C Martin** *and* **Fernando Sannibale** *for the CIRCE Team, Lawrence Berkeley National Laboratory.*

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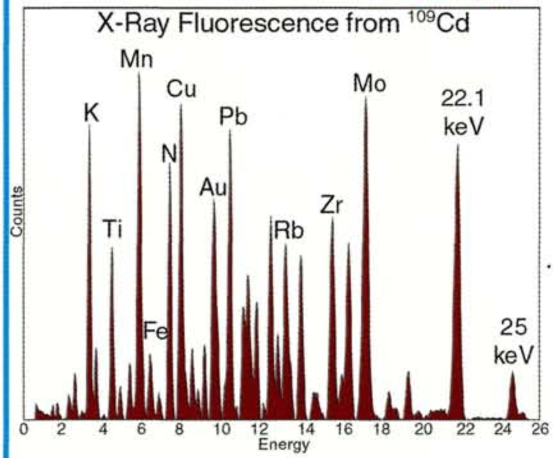

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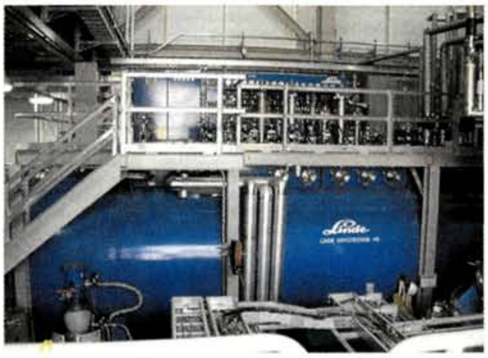

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AWARDS

Rubakov and Shaposhnikov win INR prize for fundamental physics

Valery Rubakov, from the Institute for Nuclear Research (INR) of the Russian Academy of Sciences in Moscow, and Mikhail Shaposhnikov, from the Swiss Federal Institute of Technology in Lausanne (EPFL), have been awarded the Markov Prize for 2005. INR established the prize in 2002 in memory of Moisey Alexandrovich Markov, a strong proponent of research in underground and deep-underwater neutrino physics, and one of the founders of INR.

Rubakov and Shaposhnikov received the prize for their outstanding contributions to studies of the cosmological effects of gauge interactions and for the development of novel ideas of space–time and gravity. One of their best-known papers concerns electroweak non-conservation of baryon and lepton numbers at high temperatures (written with Vadim Kuzmin), a cornerstone of the modern theory of the early universe. In 1983 Rubakov and Shaposhnikov also conjectured that we live on a four-dimensional brane embedded in a multidimensional space–time, and suggested a mechanism for matter localization on the brane.

Left to right: Mikhail Shaposhnikov, Albert Tavkhelidze (chairman of the expert committee of the Markov Prize), Valery Rubakov and Victor Matveev (director of the INR).

EPS physics prizes awarded in Lisbon

The 2005 prizes of the High Energy and Particle Physics (HEPP) Division of the European Physical Society (EPS) were awarded on 25 July at the start of the plenary sessions for the International Europhysics Conference on High Energy Physics, HEP2005, in Lisbon.

The 2005 EPS-HEPP Prize was awarded jointly to Heinrich Wahl of CERN, for his "outstanding leadership of challenging experiments on CP Violation", and to CERN's NA31 Collaboration, "which showed for the first time direct CP Violation in the decays of neutral K mesons". Wahl, who retired in 2003, had a long association with CP-violation experiments from his arrival at CERN in 1969. He was spokesman of NA31 and a major proponent of its successor, NA48.

Mathieu de Naurois of the Laboratoire de Physique Nucléaire et de Hautes Energies, IN2P3/CNRS, received the EPS-HEPP Young Physicist Prize for "his new ideas and decisive contributions" in the cosmic gamma-ray experiments, CELESTE and HESS. His new method for analysing Cherenkov images of atmospheric showers has enabled many new results in HESS and the detection of new sources near the galactic centre.

The EPS-HEPP Gribov Medal was awarded to Matias Zaldarriaga of Harvard, for his "important theoretical contributions to cosmology, with impact also on the theories of fundamental interactions". This work includes developing an efficient method for calculating the observed cosmic microwave background (CMB) fluctuations in a given cosmological model; realizing the importance of polarization in the CMB and the possibility of measuring it; and pointing out the importance of the effect of gravitational lensing by local matter on the CMB background.

There were two recipients of the 2005 Outreach Prize – Dave Barney of CERN and Peter Kalmus of Queen Mary, University of London. Barney received the prize "for promoting the fascination of particle physics to the public, in parallel to his research work in the CMS collaboration at CERN. His impressive and successful efforts are concentrated around the CMS experiment, but also reaching far beyond his own experiment". Kalmus is rewarded "for his long-standing and major personal involvement in particle-physics outreach". In recent years, he has given talks for schools and the public to a total audience of some 24 000 in countries ranging from the UK, Ireland and France to South Africa, Singapore and India (*CERN Courier* January/February 2005 p45).

AWARDS

Bologna honours neutrino pioneer

On 17 June the University of Bologna awarded an honorary degree, *Laurea ad honorem*, in astronomy to Masatoshi Koshiba, emeritus professor of the University of Tokyo. Grzegorz Rozenberg, head of the Leiden Centre for Natural Computing at Leiden University, received the *Laurea ad honorem* in informatics.

Koshiba is one of the pioneers in neutrino astrophysics research. He designed the Kamiokande and subsequent Super-Kamiokande water Cherenkov detectors for astroparticle physics experiments and received the 2002 Nobel Prize for Physics for his pioneering work in neutrino astronomy.

During the day, a workshop on "Perspectives in Neutrino Physics and Astrophysics" was held in the Ulisse room of the Bologna Academy of Sciences. The main aim of the workshop, which was attended by about 90 physicists, was to make a simple assessment of the main problems in the field. The key speakers were Ettore Fiorini on "Is the Neutrino a Majorana or a Fermi Particle?", David Plane on "The 3 neutrinos: Others?", Lauro Moscardini on "Neutrinos and Large Scale Structures", Milla Baldo Ceolin on "Observation of the Universe with Neutrinos" and Gianluigi Fogli on "Neutrino Oscillations". Several other subjects were discussed in a round table of distinguished researchers in astroparticle physics. Tullio Regge and Paolo Strolin concluded the workshop with personal recollections on neutrino astrophysics and Koshiba's contributions to the field.

Matatishi Koshiba with his honorary degree diploma from the University of Bologna.

UK rewards senior particle physicists

David Saxon, dean of physical sciences at Glasgow University, is to be awarded the Order of the British Empire (OBE) for services to science, as announced in the Queen's Birthday Honours list for 2005. Saxon leads the Experimental Particle Physics Research group at Glasgow, with interests principally in the ZEUS experiment at DESY, and ATLAS at CERN. He is a former member of the DESY Physics Research Committee and of the CERN Scientific Policy Committee and was a member of the 2002 CERN External Review Committee.

Ian Halliday, formerly head of physics at Swansea University, was made an honorary fellow of the university during a graduation ceremony at Swansea's Guildhall on 18 July, 2005. Halliday was one of the first physicists in the UK to recognize the potential of high-performance computing in theoretical particle physics. During his time at Swansea, he co-founded the theoretical particle physics research group, and until his retirement in March 2005, he spent seven years as chief executive of the Particle Physics and Astronomy Research Council (PPARC) where he oversaw the UK's annual £300 million investment in research into these fields.

CELEBRATION

Transuranic pioneer is 90 years young

On 15 July, around 150 friends and colleagues gathered to wish Albert Ghiorso a happy 90th birthday and celebrate his scientific achievements at a symposium held in his honour at the Lawrence Berkeley National Laboratory (LBNL). Eleven speakers reminisced about his seven-decade scientific career, from a 1941 stint building Geiger counters at LBNL (then known as the "Rad Lab") to his current work at the laboratory's 88 inch cyclotron.

After the US joined the Second World War, Ghiorso followed Glen Seaborg from Berkeley to the Manhattan Project's metallurgical laboratory in Chicago. There, Ghiorso began inventing new instruments for detecting nuclear radiation. As the Manhattan Project developed, he made time for basic research, and in 1944–45 he helped discover elements 95 and 96 (americium and curium), using plutonium targets irradiated with deuterium. After the war, he returned to Berkeley, where he used the 60 inch cyclotron to produce elements 97 and 98. In 1952 his group found elements 99 and 100 in debris from the first H-bomb test in the Pacific. 1955 marked the birth of "single-nucleus physics" when element 101 was discovered via 17 individually counted atoms. Elements 102 through 106 followed, with increasingly sophisticated detectors probing smaller cross-sections and shorter half-lives.

Ghiorso invented many of the machines and detectors used to search for heavy elements. He developed the recoil technique that made single-nucleus detection possible, and helped design the HILAC and SuperHILAC ion accelerators. In the early 1970s, he proposed combining the SuperHILAC with the Bevatron proton accelerator, producing the BevaLAC – the first relativistic heavy-ion accelerator.

Ghiorso's work is also reflected by the many younger people he mentored. Their respect and friendship were evident at the symposium.

At the celebration, Rick Gough, right, of LBNL's Accelerator and Fusion Research Division presented Al Ghiorso with a sign bearing his name. An area at LBNL will be named in Ghiorso's honour.

TRAINING

Early-Stage Training comes to CERN

CERN has welcomed the chance to host Early-Stage Training (EST) researchers, as part of the European Commission's Sixth Research Framework Programme (2002–2006). The initiative is one of the Marie Curie actions – the brand name adopted by the European Commission for several measures it is taking to enhance the mobility and training of European researchers.

The concept is aimed at researchers without a PhD who, in the previous four years, have completed a degree that gives access to PhD studies. One aim is to help young researchers by offering them access to host organizations that can provide both a stimulating, "hands-on" research environment and complementary training.

CERN has a broad spectrum of suitable research challenges, and enough staff with the skills needed to supervise talented students. It also offers a remarkable, multicultural, international environment, in which researchers learn how to work in international collaborations. CERN is well placed to provide training in a range of complementary skills that are best learned early in a professional career. These can include improving language skills, making convincing presentations to other researchers, presenting research to the general public in interesting ways, understanding research financing, and writing proposals.

While CERN has several programmes for short-term stays, all of which are managed by the Fellows, Associates and Students group (FAS) in Human Resources (HR), none of these programmes is specifically focused on the EST phase. So, encouraged by both the previous and present CERN management, a Marie Curie Group (MCG) has met regularly to generate several responses to the three calls for proposals that have been made since 2003 for Marie Curie EST hosts. This group comprises members from all departments, including the FAS team from HR, which is responsible for the overall management of this new programme, and people from the Directorate Services Unit – European Union (DSU–EU), who coordinate relations between CERN and the EU.

Hands-on training: Marco Boccioli, from Italy, is one of the Early-Stage Training researchers currently at CERN, where he will spend two years working on the detector control system for the ALICE experiment.

As with almost all competitive calls, the first major work consisted of understanding the precise aim of the call, and seeing how that could fit in with what CERN could provide. The departmental representatives in the MCG looked for areas where young researchers would be beneficial, and prepared detailed explanations of the work they could do. HR looked after the general issues, including explanations of how people coming to CERN under this scheme would be integrated into the normal work of the laboratory, and would be able to take advantage of the many regular training programmes (language training, technical training, academic training, etc). DSU–EU ensured that all proposals went through the electronic submission procedure on time and with all of the required material attached.

Many individuals inside and outside the MCG were also involved in the complex task of ensuring that people arriving at CERN under this programme would be in a contractual situation that respected the requirements of both CERN and the EU.

In an extremely competitive environment, the MCG's efforts have been well rewarded. The first EST call, for example, had an overall success rate of less than 6%. However, over the three calls, six CERN proposals have been accepted, in varied areas that include IT, electronics, control systems, accelerators, theoretical physics, and radiation protection. They represent a total funding of some €9 million, covering 145 researcher-years.

Researchers appointed under this scheme will be at CERN from 2004 to 2009, with as many as 25 individuals present at peak times. Up to 30% of the resources can be used to support young EST researchers coming from outside the more than 30 countries that participate in the EU's Framework Programme. This is a welcome contribution from the European Commission's Sixth Research Framework Programme to the personnel resources available at CERN during the completion of the LHC and the start-up of the physics programme.

MEETINGS

The second **Cairo International Conference on High Energy Physics** (CICHEP II) will be held on 14–17 January 2006. Organized by the German University in Cairo (GUC), this is the sequel to CICHEP I held in January 2001, and to the first GUC Workshop on High Energy Physics held in January 2005.

The conference aims to bring together scientists from universities and research institutes all around the world to discuss current developments, new trends, results and perspectives in high-energy physics. The main theme will be theoretical, phenomenological and experimental aspects of high-energy physics, including the status of the Standard Model, flavour problems and CP violation, SUSY models and grand unification, neutrino physics, string theory, dualities and M-theory, astrophysics and cosmology. The deadline for registration is 1 December 2005. For further information see www.math.guc.edu.eg/site/.

VISITS

Lino Baranao, second from right, president of the National Agency for the Promotion of Science and Technology in Argentina, toured the ATLAS experiment's underground cavern during his visit to CERN on 9 May. Here he is seen with ATLAS spokesperson, **Peter Jenni** (left), and the ATLAS Muon System project leader, **Giora Mickenberg**, listening to **Karino Loureiro** (right), an Argentinian student at the University of Wisconsin.

The vice-minister-president of the Flemish government, **Fientje Moerman**, visited CERN on 12 June. Her tour included the CMS cavern, where she is seen with **Walter van Doninck** of Vrije Universiteit Brussel (right), together with **Andreas De Leenheer** of Ghent University (centre left) and **Eddi De Wolf** of Antwerp University (centre right).

On 30 June, **Mosibudi Mangena**, South Africa's minister for science and technology (left), visited CERN and spent time at the ALICE experiment, in which physicists from the University of Cape Town participate. Here the ALICE spokesperson, **Jürgen Schukraft** (centre) explains a point to the minister and **Glaudine Mtshali**, ambassador for South Africa to the UN in Geneva.

NEW PRODUCTS

CVI is offering new mirrors and anti-reflection coatings for transmissive optics, designed for fibre-laser wavelengths. Coatings are optimized for both wavelength-and laser-damage characteristics. CVI has also produced a cleanable silver-coated mirror, which will become a standard coating for their protected silver (PS) mirror products. To find out more contact Lynore Abbott, tel. +1 505 296 9541, e-mail labbott@cvilaser.com or see www.cvilaser.com.

Kulite has announced a range of robust miniature pressure sensors that operate at cryogenic temperatures, covering a range from −195.5 to +120 °C. The CCQ-093 and CCQ-062 series, with cylindrical sensors 9.5 mm in length and a diameter of 2.4 or 1.7 mm, respectively, can be incorporated in user-designed probes. They are suitable for use in all nonconductive, noncorrosive liquids or gases. For further information, tel. +49 6192 29000 or +44 1256 461646, or e-mail info@kulite.de or sales@kulite.co.uk.

LEDtronics has introduced a low-profile, surface-mount, full-spectrum red, green and blue LED. The SML5050RBG1K-TR measures 5.5 × 5.5 mm and provides high-intensity light with a viewing angle of 120°. Depending on colour, luminous intensities are in the range 150–500 mcd at 20 mA. The company is also offering STP30XC super-white, hi-flux LED light strips for signs, displays, etc. For further information contact Jordan Papanier, tel. +1 310 534 1505 ext. 120, e-mail jpapanier@ledtronics.com or see www.ledtronics.com.

Resolve Optics provides miniature colour zoom lenses (type 207) that match the resolution of high-quality CCTV cameras. Measuring 50 × 34 × 31 mm, the 6–18 mm f/2.8 lenses can remain in focus from infinity down to 35 mm in front of the lens. For further information tel. +44 1494 777100, e-mail sales@resolveoptics.com or see www.resolveoptics.com.

CORRECTION

In "Tsunami earthquake detected in ATLAS cavern" (*CERN Courier* April 2005 p6), the vertical scale was given as micrometres (μm); it should have been millimetres (mm).

LETTERS

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

The costs of open access

Ken Peach advocates open access to scientific literature (*CERN Courier* June 2005 p50) but doesn't deal with who will pay for the essential services that the journal publishers provide. Two that concern me are archiving and keeping up on the rest of physics.

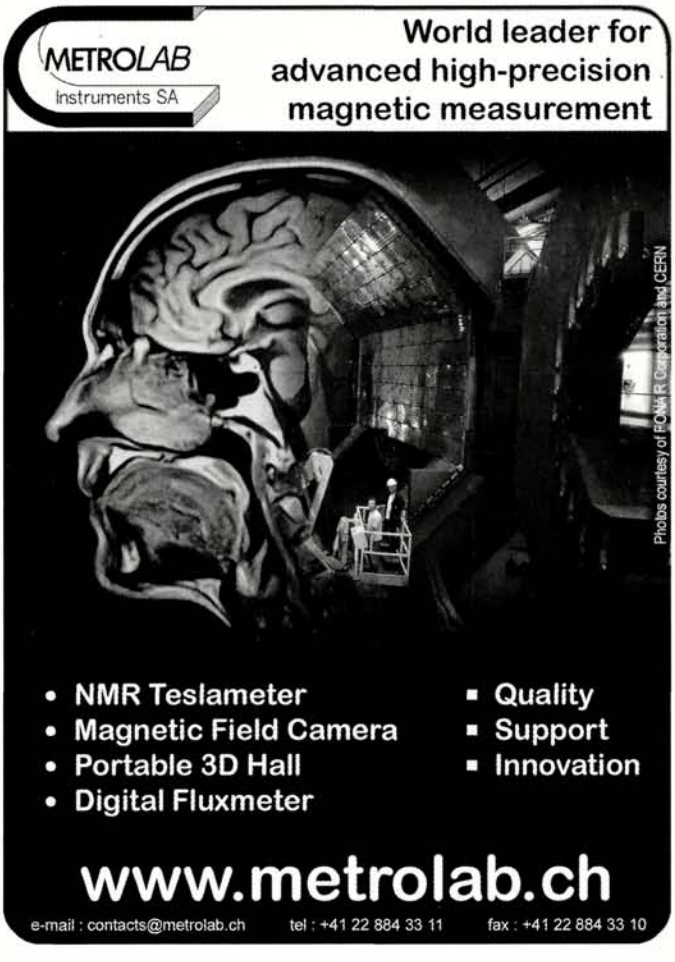
In the open-access world, who will be responsible for keeping research results available for the long term? I can now access any article published in more than 100 years of existence of the *Physical Review*. In this case the American Physical Society has taken responsibility for keeping the material available as computer operating systems evolve and as storage media change. This needs to be paid for and it is part of the subscription fee that would be abolished in the new world.

In keeping up with science how should I choose what to read? I do not need journals for the latest news in experimental high-energy physics – I keep up with that through the preprint server. I do, however, want to keep up with other areas, and have neither the expertise nor the time to sort through everything to find the important article that might be submitted to a site open to everything. The journals, their editors, and their referees do the screening for me. If we are not all to become narrow specialists, this needs to be paid for too.

In a future where the open-access movement has won out, I see a world where only the latest papers are available to be read and where it becomes much more difficult for a scientist to know what is going on in areas outside his or her own narrow speciality.
Burton Richter, SLAC.

I would like to support Ken Peach's viewpoint that the community of high-energy physicists needs to take more initiative in favour of open-access publishing. Clearly, the question of how to cover the costs for such publishing is not trivial. However, in the case of conference proceedings the conference organizers are responsible for the financing of the publication and it should therefore not be a problem to apply the principles of open-access publishing at least in this case. Some publishers are in fact quite receptive to open-access publication, but one must, of course, bring the issue up when negotiating the publishing order.

As an example of this, I can report that the organizing committee of the Lepton–Photon 2005 symposium has negotiated with World Scientific to publish the proceedings in a limited number of paper copies as well in an open-access electronic version. The publishing agreement stipulates that the conference organizer shall buy a minimum number of paper copies from World Scientific, but also that the publishers shall make the proceedings available on the Web, allowing free access to all interested parties.
Tord Ekelöf, Uppsala, chair of the organizing committee for Lepton–Photon 2005.



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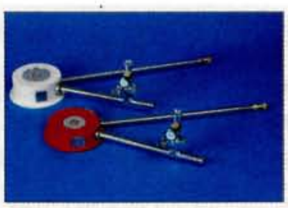

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Faculty Position in Theoretical High-Energy Physics

at Ecole Polytechnique Fédérale de Lausanne (EPFL)

The EPFL invites applications for a tenure-track assistant professorship in theoretical high-energy physics. Experienced candidates seeking a higher-level position may be considered.

We seek outstanding scientists with interests in particle cosmology, physics beyond the standard model, and particle phenomenology.

The successful candidate will establish and lead a vigorous, independent research program, interact with existing projects in particle physics and cosmology, and be committed to excellence in teaching at both the undergraduate and graduate levels. Significant start-up resources and research infrastructure will be available.

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Applications including a curriculum vitae, publication list, concise statement of research and teaching interests as well as the names and addresses (including email) of at least five references should be submitted in PDF format via the website http://sb.epfl.ch/partphyssearch by **December 15, 2005.**

For additional information, please contact Professor **M. Shaposhnikov** (mikhail.shaposhnikov@epfl.ch) or consult the following websites: http://sb.epfl.ch/en, http://itp.epfl.ch and http://www.epfl.ch/Eplace.html

The EPFL is an equal opportunity employer.

The Physics Department of the Massachusetts Institute of Technology invites applications for the faculty positions described below. Faculty members at MIT conduct research, teach undergraduate and graduate physics courses and supervise graduate and undergraduate participation in research. Candidates must show promise in teaching as well as in research. Preference will be given to applicants at the Assistant Professor level.

Applicants must submit a curriculum vitae, a list of publications, and a brief description of research interests and goals. Applicants must arrange for three letters of reference to be sent directly to the appropriate search committee chair by the search deadline.

THEORETICAL NUCLEAR AND PARTICLE PHYSICS

The Center for Theoretical Physics is conducting a broad search for several theoretical physicists interested in fundamental physics from QCD to the Planck scale. This includes nuclear and particle theory both within and beyond the standard model. It also includes string theory, quantum gravity, and the interface of all these areas with astrophysics and cosmology. Applicants should submit the materials above-mentioned by November 12, 2005 to: **Professor Robert Jaffe, Building NE25-4010, MIT Department of Physics, 77 Massachusetts Avenue, Cambridge, MA 02139-4307**

MIT is an Affirmative Action/Equal Opportunity employer. Women and minority candidates are strongly encouraged to apply.

Massachusetts Institute of Technology

SLAC
STANFORD LINEAR ACCELERATOR CENTER

The Wolfgang Panofsky Fellowship Call for nominations

The Panofsky Fellowship was created in 1989 to honor SLAC's founder and first Director, Wolfgang K. H. Panofsky. It is designed to recognize those exceptional and promising young individuals who would most benefit from the unique opportunity to conduct their research at SLAC. The fellowship carries a five year term with salary and benefits comparable to an Assistant Professorship at SLAC. Panofsky Fellows may carry out research in one or more areas of the SLAC program: elementary particle physics, accelerator physics, beam physics, particle astrophysics, and/or cosmology.

Nominations may be submitted by Faculty or Senior Staff of any institution conducting research related to SLAC's program. Candidates for the Fellowship should be early in their postdoctoral careers yet widely recognized as having exhibited the potential for exceptional scholarship, breadth, innovation and leadership.

The candidate's curriculum vitae, publication list, and a brief research plan should accompany the nomination letter. The nominator should arrange for three additional reference letters to be sent. All supporting documentation should be sent to: **Panofsky Fellowship Chair, SLAC MS 43, 2575 Sand Hill Rd., Menlo Park, CA 94025 USA**. All material must be received by November 1, 2005 for consideration.

For further information, contact lilian@slac.stanford.edu, or see www2.slac.stanford.edu/panofsky_fellow.

SLAC is an equal opportunity, affirmative action employer.

The Vienna University of Technology (VUT) and the Austrian Academy of Sciences (AAS) plan to strengthen the field of experimental particle physics. Therefore, the VUT plans to fill the following position:

University Professor for Particle Physics at the Faculty of Physics of the VUT

As a joint appointment the AAS offers the position of a

Director of the Institute for High Energy Physics of the AAS.

The candidate is expected to strengthen the visibility of particle physics in research and teaching and public outreach. The tenured professorship will be affiliated with the Atomic Institute of the Austrian Universities (ATI).

The research expertise of the candidate should cover particle physics as broadly as possible with the primary emphasis upon experimental particle physics.

The Institute of High Energy Physics (HEPHY) of the AAS has at present a staff of about 60 employees. It participates in research programs at the highest international level, in particular within the frame of Austrian's membership at CERN. Other fields encompass detector development, data analysis, accelerator physics, and phenomenology. The main research activity will be centered at this institute. Office space and related infra-structure will also be provided at the ATI.

Applicants are expected to meet the following qualifications:

- outstanding and internationally recognized scientific achievements in the field of experimental particle physics
- broad knowledge of all aspects of particle physics
- ability and willingness to satisfy obligations related to the involvement of the institute at CERN
- leadership qualification and excellent didactic ability
- to be able to improve the visibility of particle physics in the public
- to represent and to strengthen the curriculum "Technische Physik" in research and teaching, in particular to teach mandatory courses of the physics curriculum, and to supervise theses at the graduate (Diplom) and PHD level.

The holder of this position must have a related and completed Austrian or equivalent foreign academic education.

The Vienna University of Technology is committed to increase female employment in leading scientist positions. Qualified female applicants are expressly encouraged to apply and will be given preference when equally qualified.

Applications with detailed curriculum vitae, list of publications, as well as copies of the five main publications should be directed with the data line **October 14, 2005** to the Dean of the Faculty of Physics, Univ.Prof. Dr. Gerald Badurek, Getreidemarkt 9/130, A-1060 Wien, Austria. The written application also should have a CD-ROM enclosed containing the complete material of the application.

Deutsches Elektronen-Synchrotron
Particle and Accelerator Physics

DESY

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

For the particle physics programme at HERA – experiments H1, ZEUS and HERMES – and the preparation of the international linear collider and its experiments several

DESY Fellowships

are announced.

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

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

Deutsches Elektronen-Synchrotron DESY
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Phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applicants: 30.09.2005

INFN Istituto Nazionale di Fisica Nucleare

POST-DOCTORAL FELLOWSHIPS FOR NON ITALIAN CITIZENS

IN THE FOLLOWING RESEARCH AREAS
THEORETICAL PHYSICS (N. 10)
EXPERIMENTAL PHYSICS (N. 20)

The INFN Fellowship Programme 2005-2006 offers 30 (thirty) positions for non Italian citizens for research activity in theoretical or experimental physics.
Fellowships are intended for young post-graduates who are under 35 years of age by October 20, 2005.
Each fellowship, initially, is granted for one year and then, may be extended for a second year.
The annual gross salary is EURO 28.000,00.
Round trip travel expenses from home country to the INFN Section or Laboratory will be reimbursed, also lunch tickets will be provided for working days.
Candidates should submit their application form, a statement of their research interests and enclose three reference letters.
Candidates should choose at least two of the following INFN sites, indicating their order of preference.

- INFN Laboratories:
  Laboratori Nazionali di Legnaro (Padova), Laboratori Nazionali del Gran Sasso (L'Aquila), Laboratori Nazionali del Sud (Catania), Laboratori Nazionali di Frascati (Roma);
- INFN Sections in the universities of:
  Torino, Milano, Padova, Genova, Bologna, Pisa, Napoli, Catania, Trieste, Firenze, Bari, Pavia, Cagliari, Ferrara, Lecce, Perugia, Roma "La Sapienza", Roma "Tor Vergata", "Roma Tre".

The research programs, must be focused on the research fields of the Section or Laboratory selected (http://www.infn.it).
Applications must be sent to the INFN no later than October 20, 2005.
Candidates will be informed by May 2006 about the decisions taken by the INFN selection committee.
Fellowships must start from September to November 2006. Requests for starting earlier accepted.
Information, requests for application forms, and applications should be addressed to Istituto Nazionale di Fisica Nucleare, Direzione Affari del Personale, Ufficio Borse di Studio - Casella Postale 56 - 00044 Frascati (Roma) Italia.

ISTITUTO NAZIONALE DI FISICA NUCLEARE
IL PRESIDENTE
(Prof. Roberto Petronzio)

UNIVERSITY OF OXFORD

Mathematical and Physical Sciences Division
Department of Physics

Temporary Lectureship in Theoretical Physics

The Department of Physics proposes to appoint a Departmental Lecturer in Theoretical Physics for a period of three years starting from 1st January 2006, or as soon as possible thereafter. The salary will be on a scale of up to £25,699 p.a. (as at 1st August, 2004) with higher discretionary points in exceptional circumstances.

The successful candidate will be required to teach part of the theoretical physics graduate lecture course, to assist with the supervision of graduate students, and to conduct original research. The research interests of candidates should overlap those of the Particle Theory Group, with some preference for the general area of astroparticle physics.

Further particulars of the post are available from Miss Margaret Barnes, The Rudolf Peierls Centre for Theoretical Physics, 1 Keble Road, Oxford OX1 3NP (e-mail: margaret@thphys.ox.ac.uk). Applicants should submit four copies (one in the case of applicants based overseas) of a letter of application supported by a curriculum vitae, a description of teaching experience, a list of publications and a statement of research interests, together with the names of three referees (not more than two from the same institution). The application should be sent to Miss Barnes at the above address to arrive no later than 30th September 2005 quoting reference number DR05/002. Referees should be asked to send their letters (by post or e-mail) directly to Miss Barnes by 30th September 2005.

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ESRF

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The ESRF is a multinational research institute, situated in Grenoble, France and financed by 18 countries, mostly European. It operates a powerful synchrotron X-ray source with 30 beamlines covering a wide range of scientific research carried out by several thousand external users each year. The ESRF employs about 600 staff and is organized as a French société civile.
As part of the Machine Division, the Theory Group is responsible for the analysis and development of all beam physics aspects of the accelerator complex. It seeks to optimise a wide range of parameters, aimed at the continuous improvement of machine performance. We are now recruiting an

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Interested candidates should send a fax (+33 (0)4 76 88 24 60) or e-mail (recruitm@esrf.fr) with your address, to receive an application form. This form may also be printed from the Web:

http://www.esrf.fr/

Deadline for application : 30 September 2005

WILSON FELLOWSHIP IN EXPERIMENTAL PHYSICS

The Wilson Fellowship program at Fermilab seeks applications from Ph.D. physicists of exceptional talent with at least two years of post-doctoral work. The fellowships are awarded on a competitive basis and support physicists early in their careers by providing unique opportunities for self-directed research in experimental physics. Fellows will work on the Fermilab particle physics experiment of their choice. The Fermilab experimental program includes collider physics at both the Tevatron and LHC, studies of neutrino and astroparticle physics, as well as R&D for future colliders and high intensity beams.

The Wilson Fellowships are tenure track positions with an annual salary fully competitive with university assistant professorships. The appointment is for an initial term of three years and can be renewed for an additional two years upon the completion of a successful review after the first two years.

Each candidate should submit a research statement describing a proposed research program, a curriculum vitae, and should arrange to have four letters of reference sent to the address below. Application materials and letters of reference should be received by October 31, 2005.

Materials, letters and requests for information should be sent to:

Wilson Fellows Committee
Fermi National Accelerator Laboratory
MS122, Attention: Cathryn Laue
P.O. Box 500, Batavia, IL 60510-0500
Email: wilson_fellowship@fnal.gov

Additional information is available at:
http://www.fnal.gov/pub/wilson_fellowships.html
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FACULTY APPOINTMENT
THEORETICAL HIGH ENERGY PHYSICS

The Physics Department and the Enrico Fermi Institute at the University of Chicago invite applications for a faculty appointment in Theoretical High Energy Physics. We are encouraging applications from candidates with recognized accomplishments in areas such as: physics of the standard model and beyond; collider physics; and particle cosmology. The successful candidate should have a doctoral degree in physics, and is expected to establish an independent research program while effectively contributing to the Department's undergraduate and graduate teaching programs.

The appointment is expected to be at the Assistant Professor level. Appointment at a tenured level may be possible for an exceptionally well qualified candidate. The following materials: curriculum vitae, a brief research statement and bibliography of publications should be sent to the Enrico Fermi Institute Director's Office address listed below. In addition, three letters of reference should also be sent to the Enrico Fermi Institute Director's Office by November 1, 2005:

University of Chicago, Enrico Fermi Institute, Director's Office, RI-183, 5640 Ellis Avenue, Chicago, IL 60637. Questions may be addressed by email to: Ms Nanci Carrothers: n-carrothers@uchicago.edu

Complete applications must be submitted by November 1, 2005 to receive full consideration. Review of applications will start in the Autumn, 2005, and will continue until the position is filled. To ensure full consideration, applications should be received no later than November 1, 2005.

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THE UNIVERSITY OF
CHICAGO

UNIVERSITY of GLASGOW

DEPARTMENT OF PHYSICS AND ASTRONOMY

SUPA

Research/Academic Fellowship (RCUK) in Theoretical Particle Physics
£19,460 - £29,128

Under the Research Council's UK Academic Fellowship scheme the University of Glasgow is offering a Research/Academic Fellowship in Physical Sciences that will provide for the translation of an active young researcher into a permanent academic position within the University (for more details, including duties, see http://www.rcuk.ac.uk/acfellow/). You will be expected to develop an independent research programme with international impact as part of the theoretical particle physics group and make a progressive input over the period of the Fellowship to the teaching activities of the Department.

Your research interests and experience should both broaden and strengthen existing research in theoretical particle physics in the area of phenomenology and Beyond the Standard Model physics (http://www.physics.gla.ac.uk/ppt/). There are extensive opportunities to collaborate with other theorists and experimentalists in Scotland under the auspices of the Scottish Universities Physics Alliance (http://www.supa.ac.uk/). You should be able to teach undergraduate physics, and possibly astronomy, at all levels and postgraduate theoretical particle physics.

Informal enquiries can be made to Professor Christine Davies, +44 (0)141 330 4710, e-mail: c.davies@physics.gla.ac.uk

For an application pack, please see our website or write quoting Ref 11457/HRL/A3 to the Recruitment Section, Human Resources Department, University of Glasgow, Glasgow G12 8QQ.

Closing date: 7 October 2005.

The University is committed to equality of opportunity in employment.

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UNIVERSITY of GLASGOW

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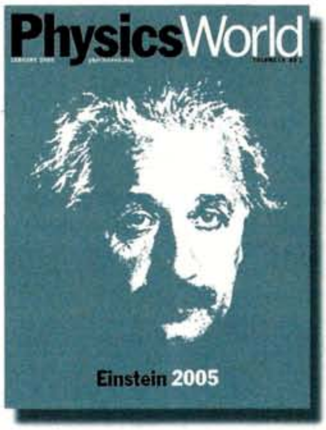

PhysicsWorld

Imperial College London

Department of Physics

Two Fixed-Term Research Lecturer Posts in High Energy Physics (refs: 0008 & 0009)

The High Energy Physics Group in the Blackett Laboratory, Imperial College London seeks applicants for two fixed-term research lectureships in Experimental Particle Physics.

Appointment **(ref: 0008)** is a four-year, fixed-term post to work on the T2K experiment.

Appointment **(ref: 0009)** is a three-year fixed-term post to work on one of the group's LHC experiments.

The Group has an active experimental programme embracing the LHC-B and CMS experiments at the LHC and the T2K experiment in Japan. Other activities involve the D0, BABAR and ZEUS experiments and accelerator and detector R&D aimed at future facilities with the MICE and CALICE experiments. Further details of the group's programme may be found on: http://www.imperial.ac.uk/research/hep

The person appointed for post 0008 will participate in the design and construction of the 280m near detector for T2K. The particular emphasis is on the development of the simulation of the detectors, the analysis tools and the hardware and electronics for the 280m electromagnetic calorimeter. Relevant experience would be helpful. There will be no mandatory teaching load for the first year and only light duties in year two, normal teaching duties will be expected thereafter. For further information please contact Prof Dave Wark, D.Wark@imperial.ac.uk

The person appointed for post 0009 will participate in one of the group's LHC experiments with the emphasis on data analysis. The group has a tradition in heavy flavour physics and expertise in this area would be valuable. The postholder will be expected to take a normal teaching load. For further information please contact Prof Peter Dornan, P.Dornan@imperial.ac.uk

The starting date for the positions will be by negotiation but is expected to be no later than 1 January 2006. The salary will be in the range £30,710 - £40,430 per annum depending on qualifications and experience. Job descriptions and application forms can be obtained from the following website: http://www.imperial.ac.uk/employment/research/index.htm Alternatively, please contact Ms Paula Brown, tel: +44 (0)20 7594 7823, email: paula.brown@imperial.ac.uk

Completed forms should be sent, with a full CV and list of publications, to Ms Paula Brown, Department of Physics, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2AZ.

Closing date: 30 September 2005.

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VIEWPOINT

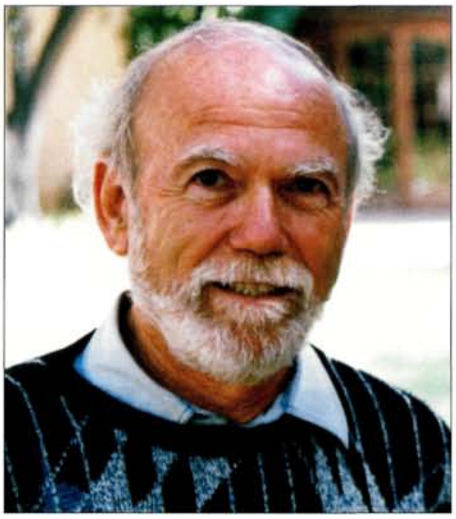
Collaboration without borders

Barry Barish asks how the particle-physics community can continue to foster its hallmark of fruitful international collaboration.

One of the things we do well in particle physics is collaborate with each other and internationally to carry out our science. Of course, individual and small collaborations are a trademark of modern scientific research and many of us have developed lifelong colleagues and friends from different cultures through our scientific interactions. Even during times when political situations have been constraining, scientific contacts have been maintained that have helped to break down those barriers. For example, during the heat of the Cold War, personal interactions were greatly hampered, yet scientific bonds persevered and some of those connections provided crucial ongoing contacts between Western and Soviet societies.

When I was a student at the University of California, Berkeley, I did my PhD research at the "Rad Lab", now called Lawrence Berkeley National Laboratory. I recall being immediately surprised both by the number of foreign or foreign-born scientists at the lab and by how little it seemed to matter. For me, having grown up as a local Californian boy, this was an eye-opening experience and a terrific opportunity to learn about other cultures, customs and views of the world. After a while, I pretty much took it for granted that we scientists accept and relate to each other in ways that are essentially independent of our backgrounds. However, it is worth reminding ourselves that this is not the case in most of society and that we are the exception, not the rule.

I have often wondered what it is that unifies scientists. How can we work together so easily, when cultural, political and societal barriers inhibit that for most of society? After all, hostilities between countries and cultures seem to continue as an almost accepted part of our modern existence. I won't theorize here on what enables scientists to work together and become colleagues and friends without regard to our backgrounds. Instead, I would like to briefly explore whether the nature of how we collaborate will, or should, change.



Particle physics is increasingly focused on the programmes at our big laboratories that house large accelerators, detectors and support facilities. These laboratories have essentially come to represent a distributed set of centres for high-energy physics, from which the intellectual and technical activities emanate and where physicists go to interact with their colleagues. Fermi National Accelerator Laboratory (Fermilab), Stanford Linear Accelerator Center (SLAC), the High Energy Accelerator Research Organization (KEK) and Deutsches Elektronen-Synchrotron (DESY) are examples of national laboratories that play this role in the US, Japan and Germany. CERN is a different example of a successful regional laboratory that has provided Europe with what is arguably the leading laboratory in the world for particle physics and with a meeting place for physicists from Europe and beyond.

One essential ingredient in the success of particle physics is that the accelerator facilities at the large laboratories have been made open to experimentalists worldwide without charge. This principle was espoused by the International Committee on Future Accelerators (ICFA) and, I believe, it has been crucial to widening participation.

It is interesting to contemplate how international collaboration might evolve as we go beyond the regional concept to a global one, like the International Linear Collider (ILC). The organizational principles for building and operating the ILC are not yet defined, but the idea is to form a partnership between Asian, American and European countries. Such an arrangement is already in place for the accelerator and detector R&D efforts. The general idea is to site the ILC near an existing host laboratory, to take advantage of the support facilities. However, the project itself will be under shared management by the international stakeholders. The experiments are expected to consist of large collider detectors similar to those at present colliders, but with some technical challenges that will require significant detector R&D over the next few years.

As we plan for the ILC, we want to ensure that we create a facility that will be available to the world scientific community. What needs to be done to ensure that we maintain the strong collaborative nature of our research and how do we create a true centre for the intellectual activities of our community? What should we require of the host country to assure openness to the laboratory and its facilities? How can we best include the broad community in the decision-making that will affect the facilities that are to be built? Is it time to consider new forms of detector collaboration and/or should we contemplate making the data from the detectors available to the broader community after an initial period (as in astronomy)?

I raise such questions only as examples, not to imply that we should change the way we do business, but to encourage us to think hard about how we can create an exciting international facility that will best serve our entire community and enable productive and broad collaboration to continue in science.

Barry Barish, Linde professor of physics at Caltech and director of the Global Design Effort for the International Linear Collider.

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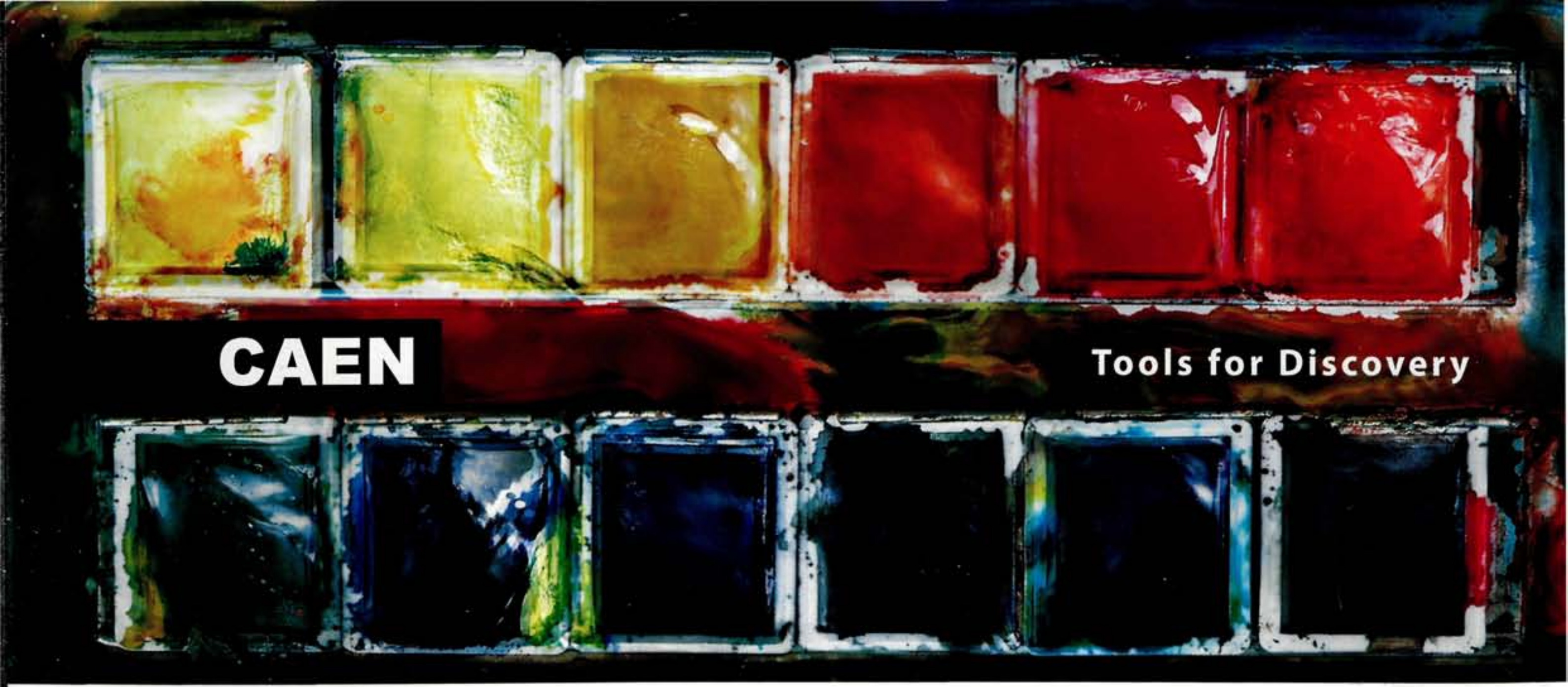

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