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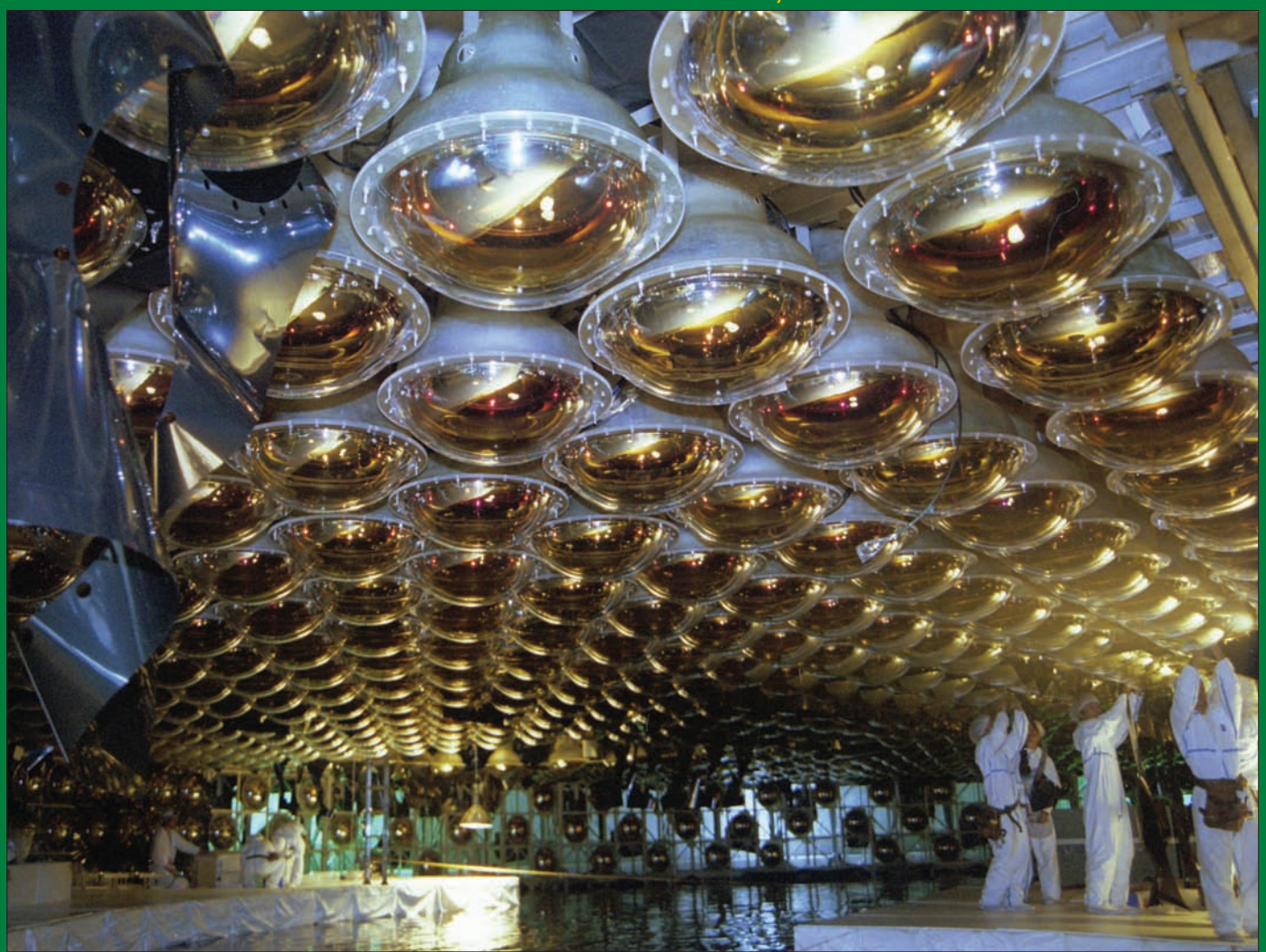
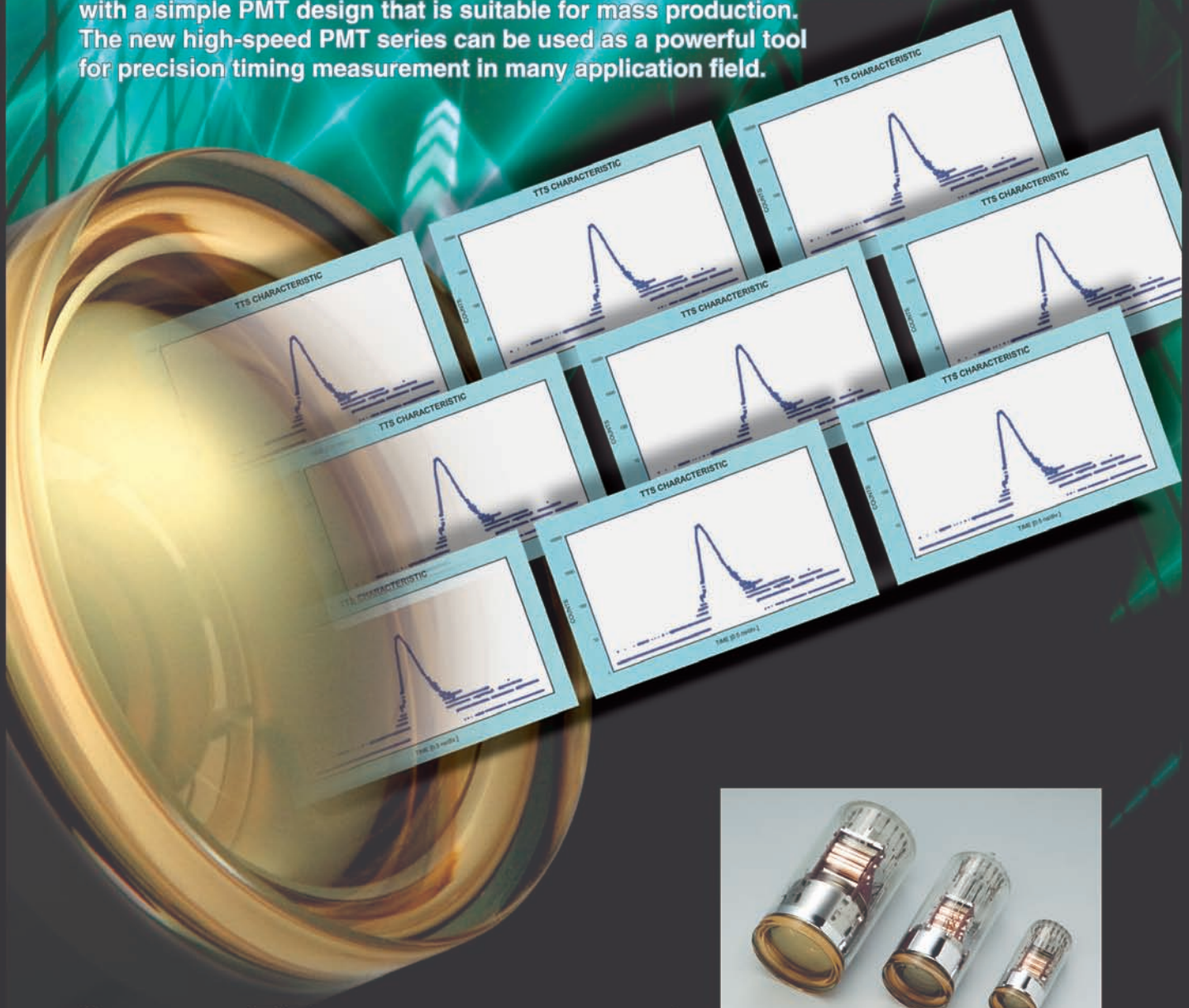


A new life for Super-Kamiokande

New high-speed PMT series

A new series of high-speed photomultiplier tubes (PMT) from Hamamatsu has now appeared on the market. These offer an incredibly small transit time spread that is uniform across the entire effective area. The 2-inch PMT (R9779), for example, yields a TTS of 250 picoseconds. This excellent time resolution has been achieved with a simple PMT design that is suitable for mass production. The new high-speed PMT series can be used as a powerful tool for precision timing measurement in many application field.



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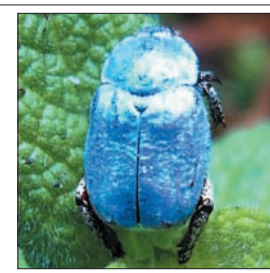
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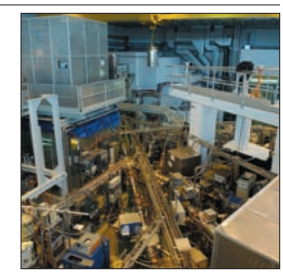
CERN facilities under review p32

Cover: *Installation of photomultiplier tubes in the Super-Kamiokande detector in October marked the start of the detector's full restoration following the destruction of thousands of tubes in 2001 (p6). (Photo courtesy Super-Kamiokande.)*

Standard and Superconductive Magnet Systems

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Lyndon R. Evans, CERN, LHC Project Leader

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ADVERTISING FEATURE

From Prototyping to series production --- 15 years of successful cooperation --- Dipole production at Babcock Noell Nuclear successfully finished.

With the first joint CERN-ECFA study on the feasibility of constructing the LHC in the LEP tunnel in the mid eighties of the last century, CERN started an intensive development programme for the main components as they were not available in the required performance. Even in this early stage, this also included development programmes together with industry in view of an industrialization of the unique components.

One crucial step was the development of dipole magnets, which were required in a huge number and a unique quality concerning homogeneity and intensity of the magnetic field. In own laboratories CERN first manufactured 1m-long models of these dipole magnets. This programme was accompanied by corresponding activities launched by CERN in industry.

The activities started in 1990 at Babcock Noell Nuclear (BNN) with the manufacture of two 10m-long cold masses. The magnets were straight, having a five block structure with aluminium collars and a

superconducting cable of a width of 17mm with a fibreglass insulation. Test results showed that the development has the right direction, but there was still a long way to go in terms of an optimization of the machine parameters.

The first magnets were followed by further prototypes of 10m in length and then finally of 15m length which were bent. Additional features were optimized, like inventing a six-block structure, stainless steel collars, reduction of the cable width to 15 mm and the use of an all polyimide insulation. With the background of the results of the cold tests the development was consistently supported by CERN in order to reach the required magnet performance. Finally the first industrial magnet of the final design was built by BNN.

With achieved results in 1999, a pre-series production of 30 magnets and in 2002 the series production of 386 magnets were contracted by CERN to three suppliers in Germany, France and Italy.

BNN commenced with a clear commitment to produce 3.5 magnets a week and to finalize the production end of 2005 instead of the contractual schedule mid 2006. Of course to achieve this goal CERN also had to go to great efforts especially in the supply of the necessary components. In good spirit and in a very cooperative manner both partners succeeded. Finally BNN finished the production of the dipoles in the required quality as the first of the three suppliers more than 7 months ahead of the contractual schedule.

CERN has recognised this with the Golden Hadron Award for BNN. BNN would like to thank CERN for 15 years of successful cooperation.

Babcock Noell Nuclear GmbH

CERN

LHC's installation makes progress

CERN's director-general, Robert Aymar praised the immense progress made towards the Large Hadron Collider (LHC) project when he addressed the 135th session of the CERN Council on 16 December 2005. "In one year, we have made great progress," he said. "The challenge is not over, of course, but we have great confidence of maintaining the schedule for start-up in 2007."

The LHC is the leading project for the world's particle-physics community. Experiments performed there will investigate perplexing questions including why fundamental particles have the masses they have, and focus on understanding the missing mass and dark energy of the universe; visible matter seems to make up just 5% of what must exist. Physicists will also explore the reason for nature's inclination for matter over antimatter, and probe matter as it existed immediately after the Big Bang.

Aymar's congratulations come after a challenging year with delays imposed by repairing defects in the LHC's cryogenic-fluid distribution system. These delays are now largely recovered. The cryogenic system is now well advanced and installation of the LHC's magnets is progressing rapidly. Almost 1000 of the 1232 dipole magnets have been delivered to CERN and more than 200 magnets are already installed in the LHC's underground tunnel. An average of 20 magnets a week are currently being installed, but this needs to increase to 25 a week in 2006 to reach the 2007 start-up deadline. A review of this schedule is planned for Spring 2006.

The first section of the LHC cryogenic distribution line, corresponding to an eighth of the accelerator, has been tested at a temperature of 10 K since the end of November 2005.

Aymar also informed delegates that CERN's new visitor and networking centre, the Globe of Science and Innovation, opened its doors to the public in September 2005. The Globe is scheduled to host a permanent exhibition about scientific works at CERN, coinciding with the LHC start-up in 2007.

PUBLISHING

Open-access moves ahead for physics

Eighty representatives from several major physics publishers, European particle-physics laboratories, learned societies, funding agencies and authors from Europe and the US met at CERN on 7–8 December 2005 for the first discussions on promoting open-access publishing. One of the results was the formation of a task-force mandated to bring action by 2007.

Open access is currently a hot topic at universities, publishing houses and governments, as digitized documentation and electronic networking become more mainstream. The particle-physics community has already implemented one of the possible ways for open access to work, whereby institutional libraries, such as CERN's, make their own information available on the Internet. The other approach is to work directly with scientific publishers to develop open access to the journals.

The aim of open access is to bring greater benefit to society by allowing electronic access to journals to be free to the public, while being paid for by the authors. The time-honoured practice consisted of publishers financing journals through reader subscriptions and ensuring quality by peer review; however, this model favours the wealthier universities and institutions as they can afford the expensive costs of the journals. The challenge for open access is to maintain the quality guaranteed by academic publishers, while broadening access to the information.

The creation of an open-access task-force comes at a crucial time for the world particle-physics community as 2007 brings the launch of a new major facility, the Large Hadron Collider at CERN.

Sommaire

NEUTRINOS

Super-Kamiokande gets full refit

Operation of the Super-Kamiokande (SK) II detector in Japan was terminated last October after three years of running to begin a full restoration of the detector. Precise studies on neutrinos will resume next June.

The SK detector consists of a cylindrical tank containing 50 000 tonnes of pure water viewed by about 11 000 photomultipliers (PMTs) of 50 cm diameter. The water tank is 40 m in height and 40 m in diameter, and located 1000 m underground. Neutrinos interact with the water and give rise to Cherenkov light, which provides information about the neutrino energy, direction and type or flavour. In 1998, the collaboration announced that neutrinos change flavour – oscillate – which is possible only if the particles have mass. The evidence came from observing neutrinos created by cosmic-ray interactions in the atmosphere. This was followed in 2001 by evidence for the oscillations of solar neutrinos in the combined data from SK and the Sudbury Neutrino Observatory. More recently, the KEK-to-Kamioka (K2K) experiment, using a man-made neutrino beam from KEK to the SK detector has confirmed the oscillations observed in the atmospheric neutrinos.

Several thousands of PMTs in the detector were destroyed in November 2001, when the shock wave from the implosion of one PMT at the bottom of the tank triggered a chain reaction of implosions in more than half the PMTs (*CERN Courier* January/February 2002 p6). In 2002, the detector was partially reconstructed using about 5000 PMTs encased in plastic covers to avoid a similar accident. This partial reconstruction was done quickly in only a year in order to continue the K2K experiment. After three years of operation as SK-II, with half the original density of PMTs, the long awaited full reconstruction of the detector has now begun. Next June, the detector's third phase, SK-III, will start to take data again.

The 50 cm diameter PMTs are encased in a fibre-reinforced plastic cover to prevent a shock wave even if a PMT implodes again.

The discovery of neutrino oscillations has opened up a new window of research with a variety of subjects for SK to tackle. An experiment using an intense neutrino beam from Tokai – Tokai-to-Kamioka (T2K) – is expected to start in 2009. The beam will be produced by a 50 GeV proton synchrotron being constructed at the Japan Proton Accelerator Research Complex in Tokai (*CERN Courier November* 2004 p41). SK-III will be the far detector at a distance of 295 km from the beam-production point. The T2K experiment will determine neutrino oscillation parameters precisely and search for effects of the neutrino mixing angle, θ_{13}, which is so far unobserved.

A longer exposure to atmospheric neutrinos will be important in searching for a resonant matter effect in the Earth and may help to resolve the octant ambiguity in the mixing angle θ_{23}. At the lower energies of solar neutrinos, an up-turn in the spectrum is expected as direct evidence for large-mixing-angle solutions and will provide precise oscillation parameters. The higher statistics from several years of exposure should allow this measurement.

SK could also detect several thousand neutrino interactions from a galactic supernova. Such a large number of events would reveal details of the supernova explosion mechanism, as well as information on the properties of neutrinos. The positive identification of electron-antineutrinos in SK could also be possible in future. Neutrons emitted in antineutrino interactions could be detected through the 2.2 MeV gamma-rays emitted by neutron capture on protons and through interactions with gadolinium dissolved in the pure water.

Lastly, the detection of nucleon decay as predicted by grand unified theories has always been one of the primary topics for SK. Sensitivity to the decay mode $p \rightarrow e^+ + p^0$ will soon reach the level corresponding to a lifetime of 10^{34} years. Decay modes favoured by supersymmetry, which include K mesons in the final state, will become interesting with a longer exposure in SK-III, and the collaboration hopes to observe the first indication of nucleon decay in the near future.

KEK

Belle achieves new luminosity record

By mid-afternoon on 22 November, the Belle experiment at KEK had accumulated an integrated luminosity of 500 fb^{-1} of electron–positron collision data. This integrated luminosity marks a landmark in the progress of the KEKB accelerator and the Belle experiment, which began operation in 1999. It is equivalent to achieving 5×10^{41} crossings of electrons and positrons a square centimetre. More than 500 million pairs of B and $\bar{B}$ mesons have been generated in the collisions.

Jubilant team-members at KEK celebrate Belle's new luminosity record of 500 fb^{-1}.

The original challenge for KEKB was to achieve 100 fb^{-1} in 3 years. The total of 500 fb^{-1} in 6.5 years surpasses this goal. The group now aims to achieve even higher records with various upgrades to the machine.

INDUSTRY

Superconducting RF technology forum unites research and industry

Representatives from European research and industry have established the European Industry Forum for Accelerators with Superconducting RF Technology, EIFast. More than 30 companies and institutes from nine countries sent a total of 64 participants to a meeting to found the forum at DESY on 27 October. They agreed on the forum's statutes and elected the members of the coordination board.

The proposal to create the forum resulted from the considerable industrial interest triggered by several large accelerator projects based on superconducting RF (SCRF) technology, in particular the approved X-ray free-electron laser, XFEL, and the planned International Linear Collider. Both projects use SCRF technology, which has been substantially advanced during the past decade by the TESLA Technology Collaboration. In addition, the TESLA test facility at DESY, built with involvement from European companies, has added to the solid base of expertise in SCRF accelerators in European industry.

Against this background, it was concluded that a forum would further strengthen the excellent position of European science and industry in SCRF technology. Moreover, similar bodies have been established in both the US and Japan.

Members of the EIFast coordination board, elected at the forum's founding meeting at DESY.

Members of European research centres and industrial companies decided to found EIFast at a meeting at DESY in April 2005. Its scope includes all systems and components needed for an SCRF accelerator, including supplies and services. Acting as a common voice for European research and industry, the forum will now try to promote the realization of SCRF projects in a coherent way.

The forum aims to bring research institutes either working in the field of SCRF technology or interested in becoming involved together with industrial companies interested in supplying products to projects based on the technology. The main tasks of the forum include generating support for projects at the political level in Europe, ensuring a flow of up-to-date information about projects between institutes and companies, promoting involvement of industry in projects at an early stage, and supporting the members in gaining access to information channels and decision makers otherwise difficult to obtain.

● For more information and contacts for EIFast see https://trac.lal.in2p3.fr/SCRF.

DESY

HERA hits record annual luminosity

In its 2005 run, DESY's HERA collider achieved the largest integrated luminosity it has ever produced in one year. Colliding 27.5 GeV electrons with 920 GeV protons, HERA delivered a total of 213 pb^{-1} to the experiments H1 and ZEUS in 318 days of running. Compared with the positron–proton luminosity production of 2004, the integrated luminosity and the average luminosity were increased by factors of 2.2 and 1.5, respectively. The peak luminosity reached 5.1×10^{31} $cm^{-2}s^{-1}$ – the design luminosity for the upgraded HERA collider.

This success is particularly remarkable since, compared with running with positrons, additional complications were expected for electron–proton collisions, due to increased synchrotron radiation in the interaction regions and degradations in the lifetime of the electron beam. The synchrotron radiation problems were successfully avoided by improved beam control. Problems with the electron-beam lifetime proved rare and were not relevant for production of luminosity. Nevertheless the electron-beam current reached only 90% of the positron currents in 2004.

The proton intensity improved slightly in 2005 due to improved beam transfer from the injector, while the specific luminosity (luminosity/current) increased considerably beyond the design value owing to the additional focusing of the electron beam by the beam–beam force. The large beam–beam forces made longitudinal electron-spin polarization more difficult: the average peak polarization decreased from 50% in 2004 to 45% in 2005. All in all, however, the operating efficiency improved noticeably compared with the previous running.

Operation at HERA is scheduled to resume at the end of January 2006. Various improvements that have been added during the shutdown – such as refurbished normal conducting magnet coils, enhanced RF interlocks, active damper and feedback systems – will further improve the availability, peak luminosity and background conditions for the run during 2006.

COSMIC RAYS

Auger observatory celebrates progress

On 10 November, the Pierre Auger Observatory (PAO) began a major two-day celebration at its headquarters in Malargüe, Argentina, to mark the progress of the observatory and the presentation of the first physics results at the International Cosmic Ray Conference in the summer 2005. One of several experiments connecting particle astrophysics and accelerator-based physics, the PAO studies extensive air showers created by primary cosmic rays with energies greater than 10^{18} eV. With more than 1000 of the 1600 surface detectors and 18 of the 24 fluorescence detectors currently installed and operating, the observatory will eventually cover 3000 km^2 of the expansive Pampa Amarilla.

Over 175 visitors from the 15 collaborating countries attended the celebration, with guests including heads of collaborating institutions, representatives from supporting funding agencies, delegates from Argentinian embassies, local and provincial authorities, plus press and media teams. On the first day, experiment heads Jim Cronin, Alan Watson and Paul Mantsch presented the history and status of the observatory to the assembled visitors in Malargüe's Convention Center. This was followed by a ceremony on the Auger campus to unveil a commemorative monument made of glass and stone. Ceremony speakers included Malargüe's mayor and the governor of Mendoza Province. Guests then retired to a traditional asado that featured local cuisine and entertainment by folk musicians and tango dancers. On the second day, attendees toured the vast observatory site, including surface detectors on the pampa and one of the remote fluorescence detector buildings.

Experiment head Jim Cronin addressing celebration attendees in Malargüe.

As part of the celebration, the collaboration sponsored a science fair in the observatory's Assembly Building, organized by four local science teachers for teachers and students from high schools in Mendoza Province. Twenty-nine school groups, many travelling long distances to reach Malargüe, presented research projects on topics in physics, chemistry or technology. A team of PAO physicists judged the displays and awarded prizes to the most outstanding young scientists. In March 2006, the opening of a new high school in Malargüe is anticipated, partial funding for which was secured by Cronin from the Grainger Foundation in the US.

SCIENCEWATCH

Compiled by Steve Reucroft and John Swain, Northeastern University

The magnetic mystery

The origin of galactic magnetic fields is a long-standing puzzle. The fields are very weak – on the order of a microtesla – and could have been generated from much weaker "seed" fields, although there have been few viable candidates. Now Kiyotomo Ichiki and colleagues at the National Astronomical Observatory of Japan have demonstrated that these weak fields could be a signature of the early history of the universe before protons and electrons combined to form atoms.

The idea is that density fluctuations in plasma could produce "winds" of photons from high-density regions to low-density ones. This wind would push electrons more than the heavier protons, and give rise to charge separations and rotating electric currents that could have seeded the magnetic fields we see today. The theory is even testable, as it would lead to magnetic fields in regions of space that are very empty of matter (free of stars and galaxies) – something that experiments could conceivably try to detect.

Further reading

Kiyotomo Ichiki *et al Science* DOI:10.1126/science.1120690, to appear in *Science*; online at Science Express: www.sciencemag.org/cgi/content/abstract/1120690.

Photonic crystals make male beetle shine

Photonic crystals have been found to play a significant role in many biological systems, but perhaps none as beautiful as in the male beetle *Hoplia coerulea*, which is found in southern Europe. Jean Pol Vigneron and colleagues of the University of Namur in Belgium have shown that this little fellow owes his striking blue coloration to a 3D photonic crystal structure made of multiple layers of dielectric biological material.

In detail, the structure discovered involves layers of thin plates alternating with rows of parallel rods. This results in a change in the reflected light from blue to violet as the angle of incidence becomes larger. The structure could lend itself to commercial fabrication, albeit not without some effort.

Photonic crystals underlie the iridescent blue–violet colour of this male beetle.

Further reading

Jean Pol Vigneron *et al.* 2005 *Phys. Rev. E* **72** 061904.

Skunk cabbage generates plenty of heat

Symplocarpus foetidus, the plant known in English as skunk cabbage and whose Japanese name, Zazen-sou, means Zen meditation plant, has a property of which a Zen master would be proud: it can maintain its temperature as high as 20°C, even on a freezing cold day. Unlike animals, which generate heat throughout their bodies, the skunk cabbage makes most of its heat through metabolic processes in the spadix, the plant's central spike-like flowering stalk.

Takanori Ito and Kikukatsu Ito at Iwate University in Japan have monitored the temperatures of the spadix in wild skunk cabbages to understand the dynamics of this temperature control. They found that a phase space plot of temperature at separated times is a strange attractor, which they refer to as a Zazen attractor. This is the first demonstration of deterministic chaos in a higher plant.

Further reading

Takanori Ito and Kikukatsu Ito 2005 *Phys. Rev. E* **72** 051909.

Photon pairs get hyperentangled

Most of the time entangled states are thought of in terms of a nonfactorizable wavefunction of two objects – photons, say – with the spins, or another attribute correlated so that what you do to one affects the state of the other no matter where it may be. Now Paul Kwiat and colleagues at the University of Illinois at Urbana-Champaign, US, and the University of Brisbane, Australia, have demonstrated for the first time that more than one characteristic – indeed, every degree of freedom – can be entangled, leading to what is known as "hyperentanglement".

For example, with photons, not only polarizations but also orbital angular momentum and energy can be entangled, as the team has demonstrated experimentally. Possible applications to quantum computing and other quantum technologies are interesting because the discovery means that more than one "qubit" of information can be associated with a single physical particle.

Further reading

Julio Barreiro *et al.* 2005 *Phys. Rev. Lett.* **95** 260501.

Bacteria slow light

The group velocity of light can be made amazingly slow in the right material, but often the apparatus required is rather exotic and requires significant cooling. Pengfei Wu and D V G L N Rao at the University of Massachusetts have made the remarkable discovery that light can go as slowly as 0.091 mm/s in a thin film of bacteriorhodopsin (a bacterial pigment) at room temperature.

More than that, it turns out that this speed can be optically controlled to be anything in a broad range from "snail's pace" to normal light speed, c. The process takes place at high efficiency, being effective for light levels down to microwatts. Bacteriorhodopsin is stable and inexpensive so this could lead to many interesting technologies.

Further reading

Pengfei Wu and D V G L N Rao 2005 *Phys. Rev. Lett.* **95** 253601.

ASTROWATCH

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

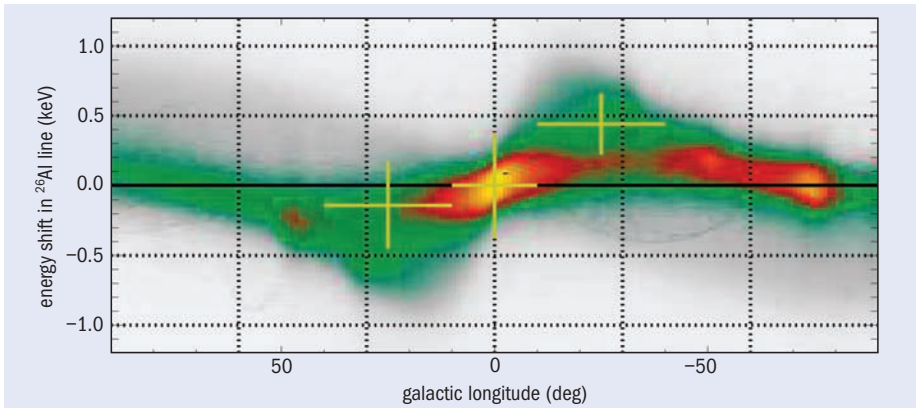
INTEGRAL reveals Milky Ways' supernova rate

One supernova explosion every 50 years in our galaxy: that is the rate that a European team has determined from the observations of ESA's INTEGRAL gamma-ray satellite. This figure is based on the amount of gamma-ray radiation emitted by radioactive aluminium produced in core-collapse supernovae.

With a lifetime of about a million years, radioactive aluminium (^{26}Al) is an ideal tracer of ongoing nucleosynthesis in the galaxy. The decay of ^{26}Al emits a gamma-ray line at an energy of 1.809 MeV. NASA's Compton Gamma-Ray Observatory found in the 1990s that this characteristic emission is distributed along the plane of the Milky Way, as expected if ^{26}Al is mainly produced by massive stars throughout the galaxy. It remained unclear, however, whether the dominant emission towards the centre of the galaxy was due to relatively nearby star-forming regions on the line-of-sight or to the central region itself.

It is this uncertainty that has now been lifted thanks to INTEGRAL's very high spectral resolution. The peak of the emission from ^{26}Al was found to be shifted towards higher energies east of the galactic centre and towards lower energies on the west side. These observations are consistent with the expected Doppler shift due to the rotation of the galaxy. They show that the ^{26}Al emission does follow the global galactic rotation and hence comes from the inner part of the galaxy rather than from foreground regions.

The team, led by Roland Diehl of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, used these line-shift measurements to constrain the best model for the spatial distribution of ^{26}Al in the galaxy.



Shifts in the gamma-ray line from ^{26}Al caused by the Doppler effect along the plane of the galaxy, owing to galactic rotation. The broad distribution is from a three-dimensional model of the spatial distribution of ^{26}Al – based on free electrons in the interstellar medium – that matches the line shifts measured by INTEGRAL (error bars). (Courtesy MPE.)

This distribution was then used to convert the observed gamma-ray flux into the total mass of ^{26}Al in the Milky Way, which was found to be about three times the mass of the sun. Finally, using results from theoretical nucleosynthesis models for a typical stellar population, the team could estimate the current star-formation rate in the galaxy to be about 7.5 stars a year, corresponding to a rate of core-collapse supernovae of 1.9 ($\pm$1.1) events a century.

The rate of two supernovae a century in the Milky Way is consistent with the rate derived from supernovae detected in other galaxies, but exceeds several times the rate deduced from the historic observations of supernova explosions during the past 2000 years. Only eight such events have been recorded – in 185, 386, 393, 1006, 1054, 1181, 1572 and 1604 – mainly by Chinese astronomers. The two last events have been observed more precisely by the famous European astronomers Tycho Brahe (1546–1601) and Johannes Kepler (1571–1630). If we exclude the supernova of 1987 in the Large Magellanic Cloud, no supernova has been seen in the galaxy during the past 400 years. Some events may have gone unnoticed because they were distant and heavily obscured by interstellar dust, but the next supernova in the galaxy will certainly not remain hidden now we can observe the sky as never before throughout the whole electromagnetic spectrum, and even with neutrinos (*CERN Courier* May 2005 p17).

Further reading

R Diehl *et al.* 2006 Nature **439** 45.

Picture of the month

This new Hubble Space Telescope image gives the most detailed view so far of the entire Crab Nebula in visible light. It was assembled from 24 individual exposures of Hubble's Wide Field Planetary Camera 2. The Crab Nebula in the constellation Taurus holds the number one place in Messier's catalogue of the 18th century, which contains approximately 100 diffuse objects. The nebula is now known to be the expanding remnant of the supernova of 1054 reported by Chinese astronomers to be visible in daylight for 23 days and for almost two years in the night sky.

The radio pulsation of the rapidly spinning neutron star at the heart of the nebula was detected in 1968. Being the brightest steady source of X-rays and gamma-rays, the Crab Nebula has become the calibration reference for all high-energy missions. (Courtesy NASA, ESA and Allison Loll/Jeff Hester, Arizona State University.)

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

LOOKING AHEAD

CERN to cross border into France

The 23rd session of CERN Council was held on 19 December 1962, under the presidency of Mr Jean Willems (Belgium). The president opened the session by a tribute to the memory of Prof. Niels Bohr, one of the founders of CERN, who died on 18 November.

Commenting on the progress report of the Organization, Prof. V F Weisskopf, the Director-general, stated that "1962 was a decisive year for CERN...which now has a healthy scientific programme exploiting reasonably well the opportunities of the two accelerators, within the limits of our present state of development".

In a statement concerning the programme and budget, however, Prof. Weisskopf issued a warning, pointing out that the success of our laboratory does not mean that its facilities are fully exploited. Because of insufficient spending in the last few years, much more financial support than is even now proposed would be needed to make the fullest use of all the research possibilities offered at present.

The Member States which brought CERN into being and encouraged it to build the accelerators that are now working, he suggested, should support the exploitation of CERN in the same spirit as they fully supported its construction. Our laboratory, which is at the centre of Europe in the field of high-energy physics, must not fall behind similar laboratories elsewhere in the world, and its capacity of exploitation must not be restrained if it is not to become a second-rate institution.

The Director-general also stated that as CERN is part of this situation it must fulfil the demands for more and better opportunities of work, and more scientific material for study and exploitation, by the rapidly growing number of European scientists entering the field and anxious to contribute to it. As now foreseen, a full exploitation of CERN would require 2200 or more personnel (staff, fellows and visitors) against the 1450 it has now.

Voting the budget for 1963, the Council authorized CERN to spend 94.2 million Swiss francs in 1963 to pursue its basic research in nuclear physics. The sum corresponds to an increase of 13% over the budget voted for 1962, together with an allowance of 3.6% for price increases. From this should be deducted 1.7 million from miscellaneous receipts. Contributions from Member States amount therefore to 92.5 million Swiss francs.

The size of the new experimental hall in the East area of the PS can be seen in this aerial view of a snow-covered CERN. The area of land offered by the French government stretches towards the top of the picture.

Another important development was the Council's approval in principle of an extension of the CERN site into French territory. "CERN could be the first international organization with a site extending on either side of an international frontier", declared Mr. François de Rose, Ministre plénipotentiaire of France.

This new move had its origin as early as 1958, when the then Director-general, Prof. C J Bakker, expressed the fear that CERN might lack space on its present site. A survey of the surrounding area subsequently showed that the most favourable direction for expansion would be on to French territory. An approach was made through the French delegation, and at this meeting of Council the delegates of France gave the news that their Government is willing to put at CERN's disposal an area of land in the Commune of St. Genis (Department of Ain), immediately adjoining the present site. This land, alongside the main road from Geneva to Lyon, would have an area of about 40 hectares (100 acres), that is, about the same as that of the present CERN site, which was placed at the disposal of the Organization by the Swiss in 1953. The Swiss authorities have already been approached by the French and have reacted favourably to this proposal to extend CERN across the frontier.

CERN's use of the area that has been offered poses some problems of a practical, diplomatic and administrative nature, both between CERN and France and between France and Switzerland. It is estimated that it will be about one year before CERN can take possession of the new ground. Building work could then be started on the section nearest to Switzerland; it will be some time, however, before the whole area can be used for buildings of any size.

● Extracted from a two-page article.

THE ORGANIZATION

CERN in a nutshell

The European Organization for Nuclear Research (CERN) came into being in 1954 as a cooperative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues: Austria (1.92 %), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17). Contributions for 1963 total 92.5 million Swiss francs.

The character and aims of the Organization are defined in its Convention as follows: The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.

● This information appeared at the front of each issue of *CERN Courier* in the 1960s.

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COMPUTING NEWS

Compiled by Hannelore Hämmerle and Nicole Crémel

SOFTWARE

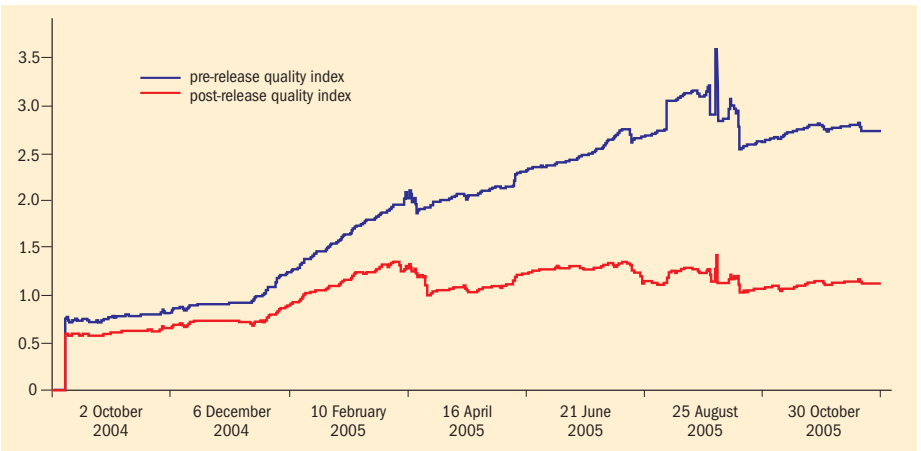
ETICS assures quality on the Grid

On 1 January 2006, an EU-funded project was launched that will improve the coherence and quality of Grid software. The e-Infrastructure for Testing, Integration and Configuration of Software project (ETICS) will integrate existing procedures, tools and resources to create a facility where distributed research projects can integrate their code, libraries and applications; validate the code against standard guidelines; run extensive automated tests and benchmarks; produce reports; and improve the overall quality and interoperability of the software.

Scientific software today is often the product of large distributed collaborations and increasingly uses new technologies like the Grid to solve complex, computer-intensive problems. Owing to a large variety of available tools, programming languages, platforms and so on, these software stacks risk suffering from a lack of coherence and quality. Limited timescales, manpower and funding often prohibit the creation of a dedicated build and test infrastructure for each new project.

ETICS will provide such a capability for software configuration, integration, testing and benchmarking for the scientific community, including software engineering tools and support infrastructures developed by other projects (Enabling Grids for E-sciencE [EGEE], the LHC Computing Grid, the NSF Middleware Initiative) and open-source or industrial entities. To promote international collaboration and facilitate interoperability of analysis already at early stages of development and implementation, ETICS will collect, organize and publish middleware and application configuration information as well as common quality guidelines and principles.

The ETICS project is a spin-off from EGEE. That project's Grid middleware, gLite, is based on middleware from many projects worldwide and inherits code from various sources and languages (*CERN Courier* September 2005 p21). EGEE's software quality assurance has developed ways to monitor code development and adherence to standards. ETICS will make these available to developers of middleware and application software worldwide, as well as a dedicated testing infrastructure.



The defect/kSLOC chart is used to monitor the general quality of the code. The pre-release quality index tends to settle on a constant value that can be taken as measure of the quality of the software development process, whereas the post-release quality index tends to zero as the software reaches maturity. ETICS launched on the first day of 2006.

AUTHENTICATION

Grid researchers get one online identity

A new Grid federation is helping scientists around the world to access computers and information in more than 50 countries and regions simply, securely and easily. The International Grid Trust Federation (IGTF) was established at the 15th Global Grid Forum meeting held in Boston in October 2005, and will bring together organizations representing Asia, the Americas and Europe – from Canada to China and from Portugal to Pakistan. Members provide systems allowing scientists to identify themselves to any Grid resource in the world with just a single online identity in the form of a digital certificate.

"Reliably identifying Grid users and their work is critical to the success of Grid computing across the world," explained Neil Geddes, director of e-science at the CCLRC Rutherford Appleton Laboratory. "The formation of the IGTF is a huge step forward in agreeing mechanisms whereby users of one Grid can seamlessly become users of all Grids, thereby unlocking the full potential of Grid computing worldwide." ▷

Les gros titres de l'actualité informatique

IGTF is a federation of three "policy management authorities", one covering the EU and beyond (www.eugridpma.org), one for the Americas (www.tagpma.org) and one for Asia–Pacific (www.apgridpma.org). Individual members are national certification authorities which issue digital certificates to scientists to enable them to use the Grid, international Grid collaborations which rely on the authorities for authenticating their scientists, and major infrastructure providers which rely on certificates for protecting their resources. These resources include more than 40 000 computer processors and several petabytes of storage – equivalent to millions of DVDs. The federation today has 61 members and covers 50 countries and regions.

● For more on authentication see p21.

CONFERENCE

Python developers swap ideas

The European Python community came together in 2005 for the annual EuroPython conference, held as in 2004 at the campus of the School of Architecture at the Chalmers University of Technology in Göteborg, Sweden. EuroPython brings together developers, designers and business people from the Python and Zope communities, where Zope is a Python-based open-source application server for building content-management systems, intranets, portals and custom applications. The conference attracts a good mix of people, from those who have just started to learn about Python to more experienced users. Also, the "benevolent dictator" and inventor of Python, Guido van Rossum, was again present at the conference and, as usual, always available for a chat.

The 100 talks presented during the three days were categorized into 12 "tracks" and covered a wide range of activities, including success stories of using Python in companies as well as educational talks and tutorials. Frameworks written in Python that help to ease the life both of developers and users were also presented to the attendees, who numbered around 270.

A common theme in the tracks was the methodology used for the development of projects. The clear favourite here was the "agile process", used in virtually all large projects. The main feature of the agile process is that it is a lightweight yet disciplined process aimed at making software development more predictable and efficient. Some, like the Zope and PyPy projects, have even established special teams to analyse and improve the development process. Agile methods emphasize real-time communication, preferably face-to-face, over written documents, and they attempt to minimize risk by developing software in short slices of time, called iterations, which typically last one to four weeks.

EuroPython delegates at the pub event.

Guido van Rossum (far right), "benevolent dictator" and inventor of Python, was at the conference and chatted with delegates.

One such suggestion is "sprint-driven" development, which makes the distributed development effort more efficient, significantly increasing productivity. A "sprint" is a two- or three-day focused development session, where a maximum of 10 developers get together in a room and focus on building a particular subsystem. Sprints are lively bursts of development activity and have proven to be very effective and successful. A panel discussion on methodologies wrapped up this theme, addressing how tools and artefacts can be used in various types of "sprints" (coding, design, requirements, tutorial sprints and so on) to improve the overall product.

In one user example a team of only three people from the R&D department of a pharmaceutical company developed a flexible tool (with around 35 000 lines of Python code) in less than three years. This is now deployed and used by the 1000 targeted users. The success of the project was attributed to good communication, frequent and intensive testing, an excellent architecture and the use of Python as the language of choice for the implementation. The importance of the close interaction between the scientists who use the tool and the software developers who wrote it was emphasized, especially the fact that the developers often had to follow frequently changing requirements.

A definite highlight in the tutorial track for newcomers was the "batteries included" tour of the standard modules library that comes with Python. Also very well received was the tutorial on "Acceptance Testing Using TextTest", a tool that can help developers in various ways. TextTest can, for example, measure CPU time and other system information, and notifies the developer if one of the values is outside a tolerance margin set by the user. In addition, this tool can be used to test a graphical user interface (GUI) by recording which methods and functions the GUI software layer calls then "playing them back" in a later testing session and comparing the results. These tests can be run in batch mode (ideal for test runs during the night) or in parallel mode using various Grid engines (SunGridEngine, LSF, etc).

As every year, one of the two keynote talks was given by van Rossum, from the Python Software Foundation, who presented new features that will be included in future Python releases, as well as giving reasons for rejecting other requests. The second keynote

talk was by Steven Pemberton of CWI Amsterdam, who is best known for his efforts in the World Wide Web Consortium (W3C), and is the chair of the working groups responsible for the XHTML and XForms standards. He was once involved in the development of the ABC language, the forerunner of Python, where he worked together with van Rossum. Pemberton gave an inspiring talk entitled "Hypothesis: Programmers are Humans Too!", arguing that computing languages – the interfaces that the programmers see – have not evolved significantly over the past 30 years. He concluded that it is better (and easier) to change programs than programmers.

The conference concluded as usual with the "lightning talks" session of short talks – a time limit of five minutes was strictly controlled, but in a humorous way. These were in general very illuminating and ranged from specific technical issues to a very lively demonstration on how to give a presentation as well as a call to collect sonnets from the Python community. Other "lightnings" covered new developments of tools and modules for a personal financial management system, for managing WiFi cards under Linux, for an implementation of the XPath 1.0 subset for ElementTree in pure Python, and a library for morphing splines.

Some of the short demos showed how to use Python on a Nokia phone to communicate with a GPS personal digital assistant (PDA) via bluetooth. A short demo from van Rossum showed what you can do with the new generators, which are Python's mechanism for lazy evaluation of a function that would otherwise return a space-prohibitive or computationally intensive list.

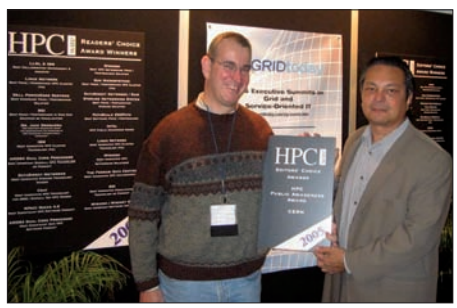
● The next conference will take place at CERN on 3–7 July 2006.

SUPERCOMPUTING

SC|05 showcases high-energy computing

As Grid computing projects gear up to serve data from the Large Hadron Collider (LHC) to thousands of physicists worldwide, scientists and engineers developing the LHC Computing Grid (LCG), the Enabling Grids for E-sciencE (EGEE) and the Open Science Grid travelled to SC|05, the 2005 International Conference for High Performance Computing, Networking, Storage and Analysis held in Seattle on 12–18 November. Members of the Grid collaborations presented talks and posters at the Grid 2005 Workshop and the SC|05 technical programme, and particle-physics applications demonstrating interoperability across multiple Grid infrastructures featured in several SC|05 exhibits.

For the third consecutive year, the high-energy physics team captured first prize in the SC|05 Bandwidth Challenge. Led by the California Institute of Technology, Fermilab, SLAC and the University of Michigan, with participation from CERN and 10 other institutions, the team of physicists, computer scientists and network engineers transferred physics data at a rate of over 150 Gbit/s. The entry provided a showcase for the worldwide Grid system being built for the LHC experiments, using production storage systems and file servers to transfer 475 TB of high-energy physics data in 24 h.



David Foster, left, accepts the HPC Public Awareness Award on behalf of CERN.

CERN's commitment to educating the public about high-performance computing was recognized during SC|05 by *HPCWire*, the online magazine of high-performance computing. The laboratory was awarded the HPC Public Awareness Editor's Choice Award.

"This is a significant honour for CERN," said David Foster, head of CERN's Network and Communications Group. "All our institutional and industrial partners in LCG, EGEE and CERN openlab deserve to share in the credit. The Grid technology that is being deployed for the LHC is inevitably something that spans many institutions, all of whom are contributing to the broader public awareness concerning this new approach to high-performance computing."

CNL ARCHIVE

CNL is 40 years old

After CERN's 50th anniversary in 2004, this year there is another (admittedly smaller) anniversary: the first *CERN Computer Newsletter* (CNL) was circulated in 1966. As CNL celebrates its 40th year, we will take a look back at some of the highlights – and historical curiosities – of the early years of computing at CERN, seen through its pages. You will find a brief look at previous issues of CNL here; for an extended retrospection read the January–March 2006 issue of CNL, available online at www.cerncourier.com.

Why CNL?

"As computing becomes a more and more widespread and complex activity in the laboratory, the need will increase for a means to have a wider general circulation of background information about different aspects of computing activities than is possible with the present system of Computer Notices." (February 1966, from the introduction to the first issue by G R Macleod, the leader of the Data Handling division from 1964 to 1975)

CERN's first computer expires

"The Ferranti Mercury, installed at CERN in 1957, has now been dismantled [...] The

The Ferranti Mercury in building 2 in 1958.

computer was the first to be installed at CERN and remained as the only machine until the arrival of the IBM 709 in 1961." (April 1966)

The end of Fortran?

"FORTRAN: FORmula TRANslating. The most commonly used program language exists in many versions e.g. CERN Fortran. ALGOL: from Algorithm. A more advanced language now available on many computers but rarely efficient for production work. PL1: The new programming language specified by the IBM users' organization (SHARE) and IBM to supplant Fortran." (April 1966)

GRID EVENTS

Meeting highlights Grid potential

At the end of September 2005, the UNESCO Regional Bureau for Science in Europe (ROSTE) and CERN organized a joint event on Grid computing, which was sponsored by Hewlett-Packard (HP). Current and future Grid participants, universities, and research institutions – with a special focus on south-eastern European countries – were invited to CERN to learn about the capabilities and opportunities of the Grid. The event included talks by representatives of existing Grids such as the Enabling Grids for E-sciencE project, but best practices were also presented by regional research institutions and universities on establishing new – and connecting to existing – e-infrastructures.

"Grid computing is as important a shift as the Web has been," said Howard Moore, director of UNESCO-ROSTE. "It will change the face of how science resources are shared and management of results will be handled." The more tangible benefits of Grid computing – access to computing resources and cutting-edge technologies outside the local region – help universities and small research groups to attract students, thus maintaining talent in the area and alleviating the brain drain. Bringing people together to talk about Grid computing can increase researchers' motivation, by giving them the feeling of being part of a bigger whole.

Current and future Grid participants attended the meeting held by CERN and UNESCO.

Over the past decade, countries in south-east Europe suffered emigration of up to 70% of skilled professionals. In 2003, UNESCO launched the Alleviating Brain Drain project with HP to provide Grid computing technology to universities and financial support to encourage young scientists to remain in the region and cooperate with their fellow-nationals living abroad.

The event at CERN was an important step, but the road does not end there, as Bernard Meric from HP pointed out: "Grids will move from scientific research to the citizen. It is just a question of time. A meeting like this can accelerate this movement from scientific research to beyond."

The event led to the decision to hold a training event in Split, Croatia, later this year. This training, to be organized by CERN and SEE-GRID, will act as a pilot event for a CERN School of Computing in Croatia in 2007.

GRID MIDDLEWARE

Middleware has two important additions

Working with research communities to provide development and access management tools for Grid and other research environments, the eighth release of the National Science Foundation Middleware Initiative (NMI-R8) helps to facilitate the complex resource management and security required in a shared cyber-infrastructure.

NMI-R8 marks two important "firsts" for the NMI programme: the addition and integration of Ninf-G, the first non-US developed component included in the GRIDS Center software suite; and GridShib, the first software enabling interoperability between the Globus Toolkit and Shibboleth federating software.

Ninf-G is a GridRPC reference implementation developed at the National Institute of Advanced Industrial Science and Technology in Japan. "With the integration of Ninf-G into the GRIDS Center stack, we're learning about the practical issues of sharing and supporting software across borders and languages, and see this activity as an important pilot study," said Philip Papadopoulos, program director, Grid and Cluster Computing at San Diego Supercomputer Center.

GridShib enables interoperability between the Globus Toolkit and Shibboleth federating software. Researchers who are members of both brick-and-mortar institutions and Globus-enabled virtual organizations can use their local campus credentials to access their distributed Grid-based resources.

NMI-R8 comprises several updated tools, software packages, practice documents, and schema that support institutional and federated identity management environments. The stack is flexible because the components are bundled together as one easy-to-deploy package. Once installed, only the parts of interest need to be configured. NMI-R8 is available to the public for downloading under open-source licences at www.nsf-middleware.org.

W3C RECOMMENDATION

W3C improves features for transforming and querying XML

The World Wide Web Consortium (W3C) has published eight documents in the XML family as Candidate Recommendations, sending a signal to the developer community that powerful new features for transforming and querying XML are ready for implementation.

XSLT 2.0 is a major revision to the very successful XSL Transformations language, which transforms XML content into other formats. XSLT 2.0 standardizes many features and includes stronger support for internationalization and richer tools for the programmer. In addition to new functionality, XSLT 2.0 introduces strong typing and supports the optional use of W3C XML schema. Strong typing is a feature of enterprise-strength programming languages such as Java, C++ and C#, and is designed to reduce errors in programs, slashing the cost of developing and maintaining large systems.

XML Query brings the power of database search and select to XML. With XML Query, one can run cross-vendor cross-database joins between multiple forms of data, including XML documents, XML-native stores, relational database tables and more.

Connections between large applications, databases, operating systems, Web services and Web servers have traditionally used special software that, on demand, converts and manipulates data between the formats used by applications. With a standard way to integrate tools, a standard set of data formats and standard ways to query and manipulate those formats, users will be able to focus on their higher-level business logic and integrate new sources of data much more quickly.

● For a list of all recommendations see www.w3.org/TR/.

PRODUCT INFORMATION

The latest version of **COMSOL Multiphysics**, a software package for scientific simulations and formerly called FEMLAB, has been made public. The name change reflects the growing functionality of the product, which started off as software for finite-element modeling (FEM). The new software can include the whole spectrum of basic CAD formats, and has a new independent script language, COMSOL Script, which allows simulations via the command line. The graphical user interface supports physical units and the software provides new algorithms for the simulation of moving particles and geometrical parameterization. For documentation see www.femlab.ch and www.comsol.com.

Stylus Studio, a provider of XML development tools and components for advanced data integration, has announced the availability of **Stylus Studio 2006 XML Enterprise Edition** and **Stylus Studio 2006 XML Deployment Adapters**. The new release of XML IDE provides a significant upgrade in usability and XML standards compliance, and many new features further simplify XML data integration. The adapters provide high-performance Java components that offer bidirectional, programmatic access to virtually any data source as XML. For more information see www.stylusstudio.com.

Calendar of events

February

13–17 15th International Conference on Computing in High Energy and Nuclear Physics (CHEP06) Mumbai, India, www.tifr.res.in/chep06/

13–16 GGF16 Athens, Greece, www.ggf.org/GGF16/ggf_events_ggf16.htm

March

1–3 TridentCom 2006 Barcelona, Spain, www.tridentcom.org

1–3 EGEE User Forum Geneva, Switzerland, http://egee-intranet.web.cern.ch/egee-intranet/User-Forum/index.html

April

2–6 High Performance Computing Symposium (HPC 2006) Huntsville, Alabama, www.caip.rutgers.edu/hpc2006/

3–7 HEPiX meeting CASPUR in Rome, Italy, www.hepix.org/

25–29 20th IEEE International Parallel & Distributed Processing Symposium Rhodes Island, Greece, www.ipdps.org

June

27–30 ISC2006 Dresden, Germany, www.supercomp.de/, paper deadline 20 February

August

29 – 1 September Euro-Par 2006 Dresden, Germany, www.europar2006.de/, paper deadline 31 January

September

13–15 HPCC-06 Munich, Germany, http://hpcc06.lrr.in.tum.de/, paper deadline 13 March

Intelligent networking – a vital part of today's IT infrastructure

By Wenceslao Lada
Vice President and General Manager, ProCurve Networking, Europe, Middle East & Africa

Whether you consider a computer in its traditional sense to be a means of calculating large numbers quickly or your understanding is closer to the French word for a computer – ordinateur – which implies a tool for organising and managing work, it is clear in this day and age, such a device has a limited use unless connected to other computers via a reliable and intelligent network.

This is as true for a nuclear research establishment as it is for a commercial office although the amount of computing power available to each may be vastly different. Each organisation needs its employees to be able to communicate quickly and easily with each other and the outside world; it needs to be able to add and remove users from the network with the minimum of fuss and effort, and it needs to be able to guarantee its security and integrity.

As a key supplier of networking equipment to CERN, ProCurve Networking by HP has had to ensure that the networks we supply are able to deliver on all the requirements of a world-class organisation. That we are able to do so owes a lot to our own commitment to research and development and careful attention to the most important part of a modern network – the ability to manage it so that control is firmly in the hands of management but the ability of the individual users to operate it is not impaired.

This conundrum is not as easy to solve as it may appear. Traditionally, network security could be realised quite simply by concentrating all decision making in the hands of those controlling the central core of the network and imposing great restrictions on access, bandwidth and flexibility to users throughout the organisation.

An alternative, to have loose central control and devolve responsibility for access control, security and bandwidth control to departments at the edge of the network gave great freedom to users but left the way open for all manner of abuse – ranging from unauthorised access to company data to inefficient use of network infrastructure.

Adaptive EDGE Architecture™

ProCurve Networking by HP has met this challenge with a strategy we call the Adaptive EDGE Architecture™ or AEA. This underpins our whole product design and the intention is to allow control of policies regarding security and resource allocation to be decided upon at the centre of the network while allowing implementation to be pushed out to PC users at the edge. To do this we have had to build in significant intelligence to all our products ranging from the large complex switches and routers which sit in the centre of the network to intelligent switches which are to be found at the edge.

All ProCurve's networking products and solutions are based on proven open industry standards such as Ethernet switching, 802.11 wireless networking and other open standards for delivering power to network devices via the network connection itself, the so-called Power over Ethernet standard. Adhering to open industry standards means we are able to offer our customers best in class value as well as maximum choice and flexibility.

Furthermore, the majority of ProCurve Networking products and solutions are based on our own custom designed ASICs (application specific integrated circuits) which capture our design expertise in mass-produced silicon chips. By cutting down the number of components needed, these ASICs allow us to offer life-time guarantees on many of our products and to offer free software upgrades to enable our installed base of equipment to take advantage of new networking protocols as they become available.

Today's networks are no longer just about connecting computers in a server room to computers on a desktop. As employees become more mobile, they want to access their corporate networks from notebook computers, PDAs or even the latest generation of mobile phone. They will be calling in from wherever they happen to be, which may be from a hotel room, an airport or an Internet café. The modern network has to be able to handle these requests from a variety of media and to respond without sacrificing ease of use or security.

As such, the need to devise policies centrally is as important as ever, so that standard operating procedures can be developed and maintained, but the necessity to devolve the implementation of such policies to the edge of a network is also vital. Otherwise, traffic to the centre would become so congested as to be unworkable and the likelihood of employees attempting to circumvent such policies would increase. Far better for employees to have a workable system that they can trust than to have a well-meaning but autocratic and totally unworkable system that they will lose faith in.

ProCurve Networking by HP has over 25 years experience in the networking industry and has been responsible for many innovations. Its customers include some of the world's leading companies such as SAP, Hilton Hotels and Kodak. Its products are also used in leading universities and research establishments throughout Europe including Sahlgrenska in Sweden, the British Library and the University of York in the UK.

Further information on ProCurve Networking solutions and products is available at: www.hp.com/eur/procurve

ProCurve Networking
HP Innovation

Tackling the challenge of lattice QCD

Don Holmgren describes Pion, Fermilab's new commodity solution for lattice quantum chromodynamics computing, which went online at the end of last year.

The Pion cluster at Fermilab consists of 520 Intel Pentium PCs.

In December 2005, Fermilab brought a new cluster online devoted to lattice quantum chromodynamics (lattice QCD) calculations. "Pion" consists of 520 single-processor Intel Pentium computers connected with Infiniband, and is the latest lattice QCD cluster funded by the US Department of Energy (DOE).

Lattice QCD is the numerical technique used to study QCD, the theory that describes the strong force. Because lattice QCD calculations require such enormous computing power, simplifying assumptions (such as the quenched approximation) have been required in the past to make progress on the supercomputers available (*CERN Courier* June 2004 p23). In recent years, improvements in algorithms and a steady increase in the capabilities of computers have led to more complete lattice QCD simulations. This has enabled lattice theorists to make a number of predictions of physical quantities that were matched by new experimental results with equal precision (Aubin *et al.* 2005a and 2005b, Allison *et al.* 2005, Kronfeld *et al.* 2005 and *CERN Courier* July/August 2005 p13).

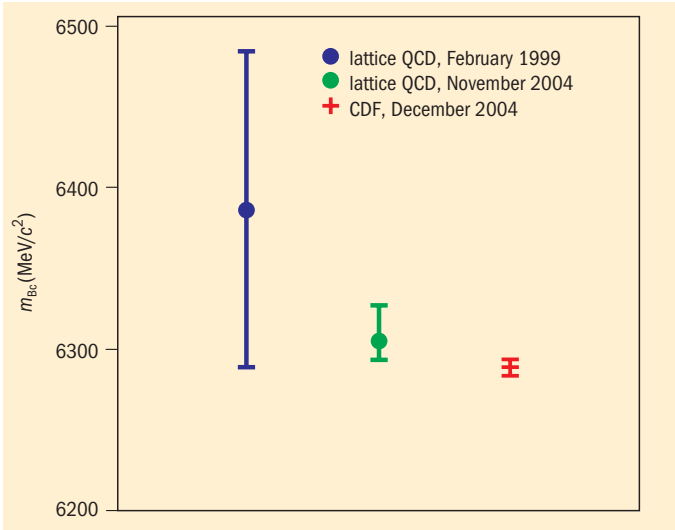
In lattice QCD computations, a finite volume of the space–time continuum is represented within a supercomputer by a four-dimensional lattice of sites. At each site, one or more SU(3) vectors, i.e. 1×3 arrays of complex numbers, represent the field strengths of quarks on the lattice. SU(3) matrices, i.e. 3×3 complex arrays, reside on the links between sites and represent the gluon fields that interact with the quark fields. Performing a Monte Carlo calculation to generate representative configurations of the QCD vacuum involves repeated sweeps through all sites, multiplying the link matrices by neighbouring site vectors and updating their values.

In current lattice QCD problems, the representation of the lattice requires around 10 GB of memory and calculation rates of around 1 Tflops (10^{12} floating-point operations per second) to make reasonable progress. A typical desktop PC is capable of about 1 Gflops.

In recent years, two approaches have been taken in the design of dedicated supercomputers for lattice QCD. The first uses custom processors that include on-chip connections to the neighbouring processors in three or more dimensions. Each processor chip also includes several megabytes or more of on-chip memory. The QCDOC (*CERN Courier* September 2005 p17) and apeNEXT (*CERN Courier* September 2005 p18) machines are examples of this system-on-a-chip approach. The second approach, used on Pion, relies on commodity computers connected via a high-performance network. Although similar to the large Linux farms used for reconstruction processing for experiments at Fermilab and CERN, it is the high-performance network that distinguishes the computer-cluster approach. Also, while the computers in reconstruction farms operate independently, those on a lattice QCD cluster are tightly coupled, constantly exchanging data during the computation.

Purpose-built systems like QCDOC and apeNEXT require several years of design, development and fabrication before they are ready for production. When new, these supercomputers provide the largest capability, with the fastest calculation for a single problem. By contrast, commodity clusters take advantage of each year's newest processors, memory technologies and networks; lattice QCD supercomputers based on clusters can be built relatively quickly and frequently at a lower cost. In terms of performance, the purpose-built US QCDOC machine sustains 5 Tflops, compared with about 1 Tflops for Fermilab's Pion cluster. By the end of next summer, the successor to Pion at Fermilab will sustain about 2.25 Tflops.

The design of lattice QCD clusters requires careful attention to the balance between calculation speed, memory bandwidth and network performance to achieve the most cost-effective designs. Lattice QCD codes require high memory bandwidth and strong floating-point performance. A double-precision SU(3) matrix-vector multiplication, for example, consumes 192 B of operands, produces 48 B of results and uses 66 floating-point operations. This bytes-to-flops ratio of more than 3.6 stresses memory subsystems. Typical Intel and AMD microprocessors, for example, are capable of more than 10 Gflops ▷

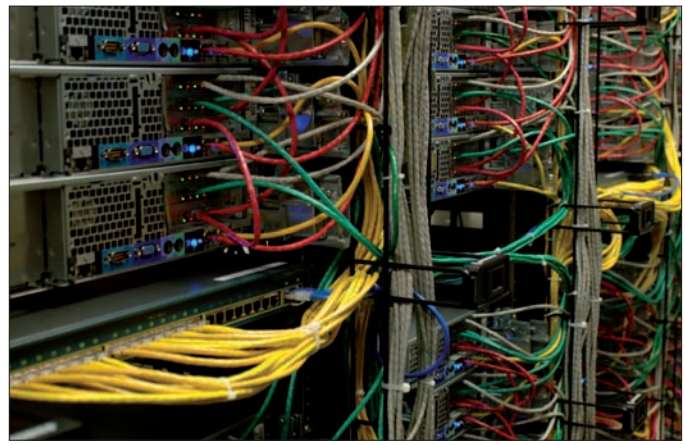


The lattice QCD prediction of the mass of the B_c meson is now approaching the precision of the value measured by the CDF collaboration at Fermilab (Allison et al. *2005).*

when their parallel floating-point instructions (Streaming SIMD Extensions, or SSEs) are used. However, the typical peak memory bandwidths of these processors of about 6 GB/s fall far short of the 40 GB/s that would be required to feed and consume the data for SU(3) matrix-vector multiplications at the peak speed of the SSE floating-point unit. The calculations also stress the networks used to communicate data between the nodes of a cluster, requiring bandwidths and latencies superior to those provided by TCP/IP running over Gigabit Ethernet.

The networking requirements of lattice QCD on clusters have been met by using high-performance switched networks, such as Myrinet, Quadrics or recently Infiniband, or by using multiple Gigabit Ethernet networks running a specialized non-TCP/IP communications stack. The latter approach was used on two clusters built at the DOE's Jefferson Lab. The 2003 machine, "3G", uses six Gigabit Ethernet interfaces connected as a 3D toroidal mesh in which each computer can communicate directly only with neighbours in the positive and negative x, y and z directions. The 2004 machine, "4G", uses a 5D toroidal mesh.The toroidal Gigabit Ethernet mesh machines, pioneered by Zoltan Fodor of Eötvös University, Budapest, and colleagues were very cost-effective because of their use of commodity network interfaces (Z Fodor *et al.* 2003). However, in the past year the newer Infiniband network technology has become more favourable, offering greater performance and flexibility at a low cost. These factors led Fermilab to choose Infiniband for the Pion cluster. One advantage the switched Infiniband network provides for Pion is that any computer in the cluster may communicate directly with any other computer on the network.

Pion uses Intel Pentium 640 processors, each running at 3.2 GHz. With 800 MHz memory buses, these machines have one of the highest memory bandwidths per processor available. Pion was built in two halves, with the first 260 nodes last May and the second 260 in November, and the price per node dropped from $1970 in the spring to $1550 in autumn, with approximately $840 for the computer and $650 for the Infiniband. Pion exceeds 1.7 Gflops per processor on lattice QCD codes, or roughly $0.90/Mflops on the second half.



The Jefferson Laboratory's 3G cluster dates from 2003 and uses six Gigabit Ethernet interfaces connected in a 3D mesh.

On 1 October 2005 the DOE launched a four-year project to support lattice QCD. This follows five years of support for lattice QCD by the DOE Office of Science via the SciDAC Lattice Gauge Theory Computational Infrastructure project, as well as grants used to purchase the US QCDOC in 2004 and 2005. The project will operate the 5 Tflops US QCDOC machine, which resides at Brookhaven National Laboratory, as well as the clusters at Jefferson Lab (3G and 4G, which total 0.55 Tflops) and Fermilab ("QCD", a 0.15 Tflops, 128-node Myrinet cluster built in 2004, and the 1 Tflops Pion).

The project will also support the construction of new machines. In the first year, two clusters will be constructed: a 0.5 Tflops Infiniband cluster based on 256 dual-core Intel processors at Jefferson Lab will come online at the end of March, and a 2.25 Tflops Infiniband cluster based on 1000 dual-core Intel processors at Fermilab will come online by the end of September. Other systems planned for 2007–2009 will provide an additional 11 Tflops of computing power.

Further reading

C Aubin *et al.* 2005 *Phys. Rev. Lett.* **94** 011601.
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A S Kronfeld *et al.* 2005 *Proc. Sci.* **LAT2005** 206.
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Résumé

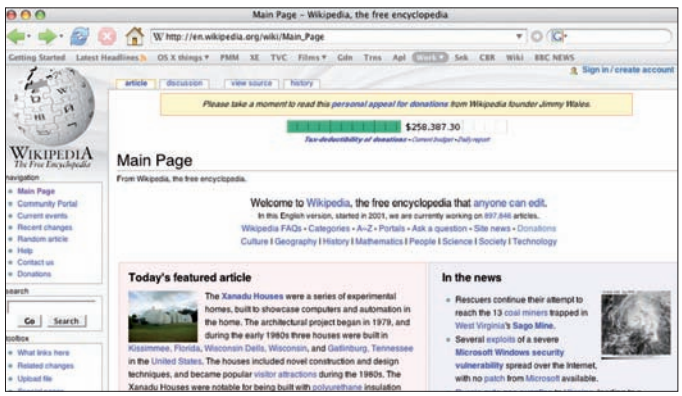
Des grappes d'ordinateurs pour la CDQ sur réseau

En décembre 2005, le Laboratoire Fermi a mis en service la nouvelle grappe d'ordinateurs "Pion" pour les calculs de chromodynamique quantique (CDQ) sur réseau. Cette grappe, qui comprend 520 ordinateurs Intel Pentium à processeur unique interconnectés par un réseau haute performance, Infiniband, tire parti des processeurs, technologies de mémoire et réseaux les plus récents. Les superordinateurs de CDQ sur réseau s'appuyant sur cette technologie peuvent être produits relativement rapidement et à moindre coût que les systèmes spécialisés, dont la conception, le développement et la fabrication s'étendent sur des années.

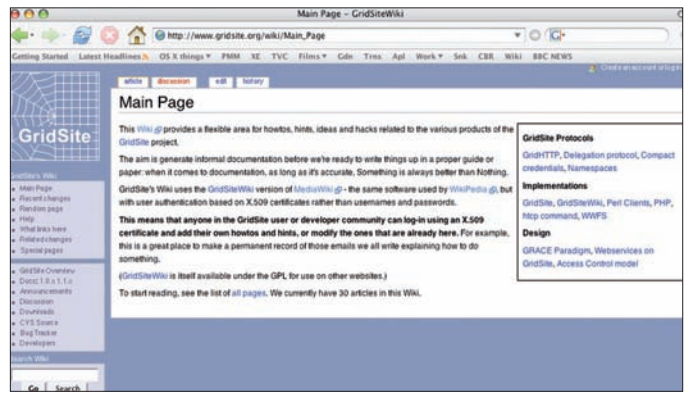
Don Holmgren, *Fermilab.*

Towards a read–write Web

Security efforts led by the LCG and EGEE projects are uniting the Web and the Grid, and helping to fulfil the vision of a worldwide collaborative Web, says **Andrew McNab**.



Thousands of Internet users edit Wikipedia pages every month.



GridPP uses GridSite to authenticate contributors to websites.

When Tim Berners-Lee invented the World Wide Web 15 years ago at CERN, he always intended that it should be easy for people to write to it, not just read from it. But if websites are opened up to additions from everyone, they often get vandalized or "spammed". As well as direct disruption, this can lead to bad publicity, as shown by recent mainstream press coverage of a hoax story about US politician John Seigenthaler in the collaborative encyclopaedia Wikipedia. These problems have put security centre-stage in the development of a true read–write Web. Fortunately, solutions are emerging from large high-energy physics Grid projects.

"Wikis" like Wikipedia are websites where users can add, edit and cross-reference content without learning mark-up languages like HTML. Along with diary-like weblogs and the reader comments they often allow, wikis are a major part of the current trend away from a pure publishing model ("the Web as an electronic book") to a more collaborative model in which users also produce content.

High-profile wikis have been plagued with problems of trust and identity. Although some wikis require a username and password, people running the sites still have no idea who their contributors really are, and the better known wikis have to be constantly on the look-out for offensive or simply irrelevant additions.

Stronger methods of authenticating users are needed, so that they can be held accountable for the additions they make by their peers, the website owners or the authorities, and so that sensitive sections can have restricted access. However, if each website continued to maintain a database of usernames and passwords, then each site would have to bear greater administrative costs compared with giving accounts freely to everyone.

Furthermore, the existing username and password systems also put an increasing burden on the users, who have to maintain more and more accounts. When account details change, such as the user's preferred e-mail address for password reminders, the user is forced to spend time updating this information on all the sites they can remember – or risk losing access when their old e-mail address is no longer active. Users are therefore tempted to use the same passwords at multiple sites, and to store passwords in their Web browser, where they can readily be stolen by computer viruses and Trojans. What is really needed are ways of reusing the same authentication procedure for multiple websites.

Large Grid projects, such as the LHC Computing Grid (LCG) led by CERN, have faced a similar problem: how to give thousands of users access to hundreds of computing facilities while ensuring proper control and logging, without users having to arrange access at each site one by one.

The LCG, the Enabling Grids for E-sciencE (EGEE) and the Open Science Grid (OSG) projects, which have been prominent in high-energy physics, have all settled on using X.509 digital certificates for user and service authentication. X.509 specifies how to store and distribute public and private cryptographic key pairs (which take the form of large numbers), and how to associate them with unique names for users and services. X.509 was originally a standard of the International Telecommunication Union, although a third revision has now been defined by the Internet Engineering Task Force.

Using X.509, users can establish their identity by proving they have the private key associated with it. Since X.509 is based on asymmetric cryptography, it is possible to prove possession by revealing only the public key. In turn, the public key is "signed" by a trusted third-party organization or "Certification Authority", and this digital signature states that it is indeed the public key of the user in question. Grid services accepting X.509-based authentication need to establish trust for only a small number of certification authorities, even though they serve thousands of users.

To simplify the process whereby users and service-owners decide to trust a certification authority, consortia of certification authori- ▷

ties have signed agreements and established criteria that users must meet to receive a signed public key. During the EU DataGrid project (the predecessor of EGEE), a group of European certification authorities formed the EU Grid Policy Management Authority (EUGridPMA) to coordinate their efforts, and published details of approved certification authorities. This year the International Grid Trust Federation has been formed by the EUGridPMA and equivalent PMAs in Asia and the Americas. Preparation for LHC Grid computing has been a major driving force in this area, and is having wider benefits for worldwide Grid interoperability.

The Grid software using X.509 keys to authenticate users is largely adapted from World Wide Web e-commerce systems, implementing HTTPS (HTTP transported over an encrypted channel). X.509 signed keys given to users of the Grid can thus also be used with standard Web servers and Web browsers.

The GridPP project in the UK decided to base authentication for its collaboration website on X.509 Grid credentials, to exploit this crossover. GridPP members at the University of Manchester developed the GridSite security system, a software toolkit and set of extensions to the Apache Web server. As well as support for X.509, GridSite accepts "Distinguished Name" and "Virtual Organization" credentials. Together, these components allowed GridPP members to gain write access to their group's section of the GridPP website, to maintain Web pages or upload documents. However, users have had to write in HTML, providing only the security side of the convenient read–write Web that is beginning to emerge.

To bridge this gap, GridPP has merged GridSite and Wiki technology to give the convenience of a wiki coupled with the security of X.509 credentials. Since the hard work of establishing a user's identity is done once by the certification authority or local contacts, users can install their X.509 signed key in the Web browser then move between GridSite- or Wiki-enabled websites without having to present (and maintain) their username and password again and again.

Although this does not solve the problem faced by public wikis – where users in repressive states or expressing unwelcome professional opinions may have legitimate privacy concerns – it does work well in an academic environment where an article's provenance and author names are already the accepted currency.

- For more information see www.gridsite.org.

Résumé

Vers un Web "lu-écrit"

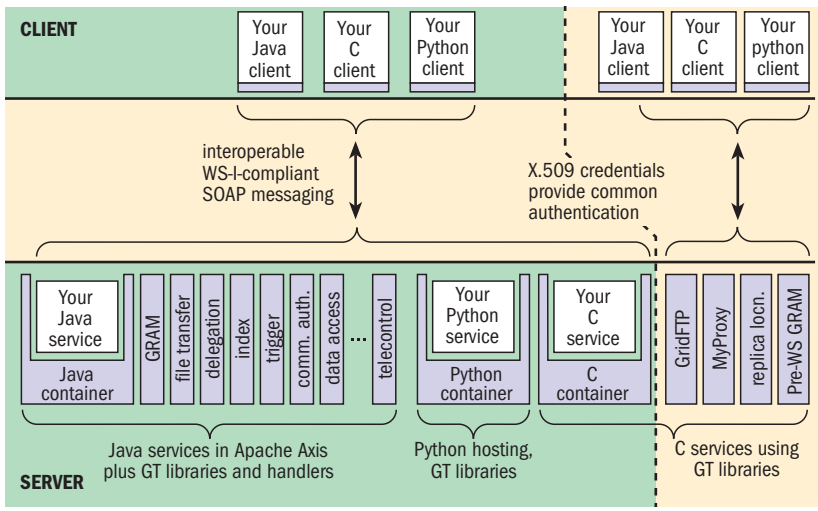
En inventant le World Wide Web il y a 15 ans, Tim Berners-Lee avait non seulement l'intention de permettre aux utilisateurs de lire les pages des sites, mais également de pouvoir y écrire. Mais si les sites Web sont ouverts aux contributions de tous, ils sont souvent vandalisés ou pollués. La sécurité est par conséquent devenue une préoccupation centrale pour le développement d'un Web réellement "lu-écrit". Des solutions commencent à émerger des projets à grande échelle de Grille de calcul pour la physique des hautes énergies. Ces projets font en effet face à des difficultés similaires en donnant à des milliers d'utilisateurs l'accès à des centaines d'installations informatiques.

Andrew McNab, *University of Manchester.*

Globus Toolkit upgrade aids the Grid community

Ian Foster reports on the latest release of the Globus open-source software toolkit.

Globus software has long played a significant role in the LHC Computing Grid (LCG) and related Grid deployments and applications. In 2005 the Globus community achieved the following significant milestones: the release of Globus Toolkit version 4; the establishment of a new community development process; major new funding from the US National Science Foundation and the UK Engineering and Physical Science Research Council; and the establishment of companies focused on supporting commercial use of the software.



GT4 architecture schematic, showing many but not all of the components. The violet boxes denote GT4 code, while the white boxes are user code.

Globus software has been developed since the late 1990s to support service-oriented distributed-computing applications and infrastructures. Core components of the Globus Toolkit (GT) address, within a common framework, basic issues relating to security, resource access, resource management, data movement, resource discovery and so forth. These components enable a broader "Globus ecosystem" of tools and components that build on, or operate with, core GT functionality to provide a wide range of useful application-level functions. These tools have in turn been used to develop a wide range of Grid infrastructures and applications.

A major upgrade

GT4, released on 30 April 2005, provides significant improvements in terms of robustness, performance, usability, documentation, standards compliance and functionality (I Foster 2005). For example, the GRAM job submission service now easily manages 32 000 jobs, up from a few hundred in GT3. A UK e-Science evaluation speaks favourably of the quality, usability and performance of the GT4 code and its documentation (T Harmer *et al*. 2005). It notes, for example, that "GT4 installation was straightforward", "GT4 services demonstrated significant improvements in performance and reliability over their GT3 versions" and "GT4 package descriptions were of a high quality, well structured, and accurate".

GT4 makes extensive use of Web Services mechanisms to define its interfaces and structure its components. Web Services provide flexible, extensible and widely adopted XML-based mechanisms used for describing, discovering and invoking network services. Furthermore, its document-oriented protocols very much suit the loosely coupled interactions that many argue are preferable for robust distributed systems. These help the development of service-oriented architectures: systems and applications structured as communicating services, in which service interfaces are described, operations are invoked, access is secured and so on – all happening in uniform ways.

The figure illustrates the principal GT4 components. A set of service implementations (the bottom half of the figure) implement useful infrastructure services. These address such concerns as execution management (GRAM), data access and movement (GridFTP for data movement, reliable file transfer, OGSA-DAI for database access), replica management (replica location service, data replication service), monitoring and discovery (Index, Trigger, WebMDS), credential management (MyProxy, Delegation, SimpleCA) and instrument management (grid telecontrol protocol). Most are Java Web Services but some (indicated at the bottom right) are implemented in other languages and use other protocols. A powerful authorization framework enables the implementation of diverse authorization policies.

In addition, three containers can be used to host user-developed services in Java, Python and C. These containers provide implementations of security, management, discovery, state management and other mechanisms frequently required when building services. They extend open-source service-hosting environments with support for a range of useful Web Service specifications, including WS Resource Framework (WSRF), WS-Notification and WS-Security.

Finally, client libraries allow client programs in Java, C and Python to invoke operations on both GT4 and user-developed services (top of the figure). In many cases, multiple interfaces provide different ▷

levels of control: for example, in the case of GridFTP, there is not only a simple command-line client (globus-url-copy) but also control and data channel libraries for use in programs – and the XIO library allowing for the integration of alternative transports.

GT4's use of uniform abstractions and mechanisms across these different components means that clients can interact with different services in similar ways, which facilitates the construction of complex, interoperable systems, and encourages code reuse.

Globus is more than software: it is also a community of users and developers, and the infrastructure that supports this community – code repositories, e-mail lists, a problem-tracking system and so forth. To facilitate external contributions, the Globus team recently introduced a community governance and development process, GlobDev, hosted at http://dev.globus.org. A growing number of Grid software projects are hosted and developed there.

Further reading

I Foster 2005 *IFIP International Conference on Network and Parallel Computing* LNCS **3779** 2.
T Harmer *et al.* 2005 *UK e-Science Technical Report Series* UkeS-2005-03.

Acknowledgments

This report describes the work of many talented colleagues and collaborators (see www.globus.org). Work on Globus has been supported in part by the Mathematical, Information, and Computational Sciences Division subprogram of the Office of Advanced Scientific Computing Research, US Department of Energy, by the National Science Foundation (NSF) under its NSF Middleware Initiative and other programmes, and by IBM, DARPA, NASA, Microsoft, the UK Engineering and Physical Sciences Research Council and Department of Trade and Industry, and the Swedish Research Council. The author is also co-founder and chief open-source strategist at Univa Corporation.

Résumé

La boîte à outils Globus s'améliore

Globus Toolkit est développé depuis la fin des années 90 pour fournir des infrastructures et des applications de calcul décentralisées, axées sur le service. Ce progiciel joue un rôle clé pour la mise en œuvre et les applications de la grille de calcul pour le LHC (LCG) et de grilles associées. Dans cet article, Ian Foster commente la version 4 de Globus Toolkit (GT4), le dernier né de ce progiciel de Globus en libre accès pour le calcul sur grille. Disponible depuis avril 2005, GT4 présente d'importantes améliorations, que ce soit en matière de robustesse, performance, convivialité, documentation, conformité aux normes ou fonctionnalités.

Ian Foster, *Math and Computer Science Division, Argonne National Laboratory.*

Quarks matter in Budapest

Quark Matter 2005, the 18th International Conference on Ultra-Relativistic Nucleus–Nucleus Collisions, provided a lively forum for new results in heavy-ion physics.

The Quark Matter conferences have historically been the most important venues for showing new results in high-energy heavy-ion collisions. The 18th in the series, Quark Matter 2005, held in Budapest in August 2005, attracted more than 600 participants from 31 countries in five continents; more than a third were junior participants, reflecting the momentum of the field. The major focus of the conference was the presentation of the new data from the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) together with the synthesis of an understanding of heavy-ion data from experiments at CERN's Super Proton Synchrotron (SPS), including new data from the NA60 experiment. The meeting also covered a broad range of theoretical highlights in heavy-ion phenomenology, field theory at finite temperature and/or density, and related areas of astrophysics and plasma physics.

After an opening talk by Norbert Kroó, vice-president of the Hungarian Academy of Science, the scientific programme of the conference began with a talk by Roy Glauber, who was soon to share the 2005 Nobel prize in physics (*CERN Courier* November 2005 p8). Glauber's calculations in the 1960s laid the foundation for the determination of centrality in high energy heavy-ion collisions – a measure of how close to head-on they are – which is now one of the most elementary and widely used tools of heavy-ion physics. In his talk "Diffraction theory, quantum optics and heavy ions", he discussed the concept of coherence in quantum optics and heavy-ion collisions and presented a new generalization of the Glauber–Gribov model. Further talks in the introductory session were given by Luciano Maiani, former director-general of CERN, who reassessed the main conclusions of the SPS fixed-target programme, and by József Zimányi, of the KFKI Research Institute for Particle and Nuclear Physics in Budapest, who gave an account of the evolution of the concept of quark matter.

It has become a tradition of the Quark Matter conferences to follow the introductory session with summary talks of all experiments. Thus, the first day sets the scene for the discussions of the rest of the week. This short report cannot summarize all the interesting novel experimental and theoretical developments, but it aims at illustrating the richness of these discussions with a few of the many highlights.

One of the main discoveries of the fixed-target heavy-ion programme at the SPS five years ago was the strong suppression of the J/Ψ yield with increasing centrality of the collision, which probed the deconfinement phase transition. Another discovery concerned the significant enhancement of low-mass dileptons, which indicates modification in the medium of vector mesons and possibly provides information about the restoration of chiral symmetry. These major discoveries by the NA50 and CERES experiments at the SPS also raised a significant set of more detailed questions, which were recognized as central to understanding the dynamical origins of the observed effects.

In particular, the dimuon invariant-mass spectrum of NA50 showed an enhancement below the J/Ψ peak, which different theoretical groups ascribed either to a dramatic enhancement of the charm cross-section in the medium, or to significant thermal radiation. Having ▷

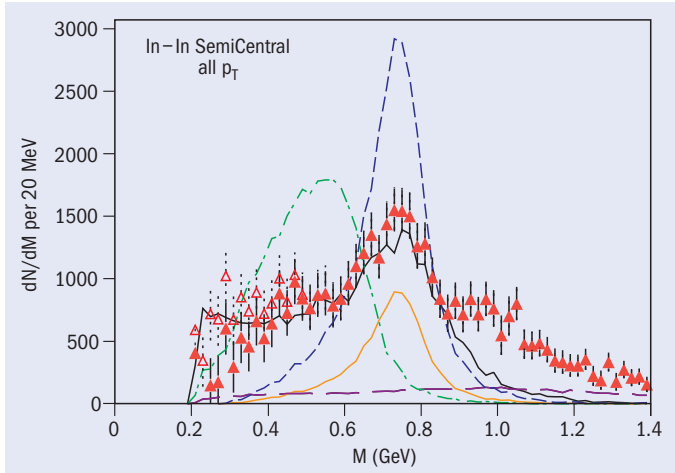


Fig.1. First measurement of modification in the medium of the ρ spectral function in indium–indium collisions at CERN's SPS, as presented by the NA60 experiment. The dashed line shows the unmodified spectral weight of the ρ; other curves are theoretical predictions for a ρ broadening and a falling mass scenario.

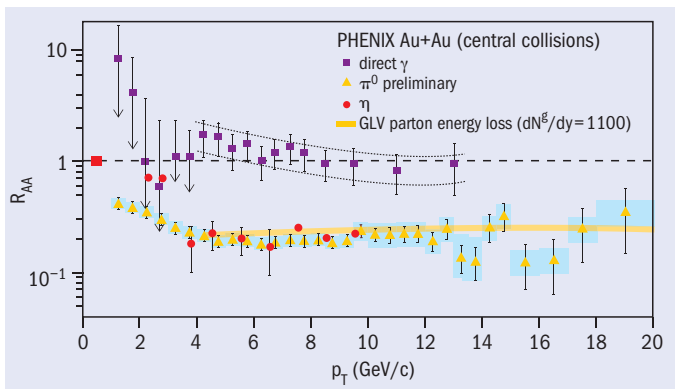


Fig.2. The nuclear modification factor, R_{AA}, as a function of transverse momentum, p_T, for neutral pions (π), etas (η) and photons (γ) in gold–gold collisions at RHIC, as presented by the PHENIX collaboration. Compared with proton–proton collisions, pions and etas are suppressed by up to a factor of five. This "jet-quenching" effect is well reproduced in models (yellow line), which account for strong medium-induced parton energy loss in dense QCD matter created in heavy-ion collisions. By contrast, photons can escape the system without further interaction.

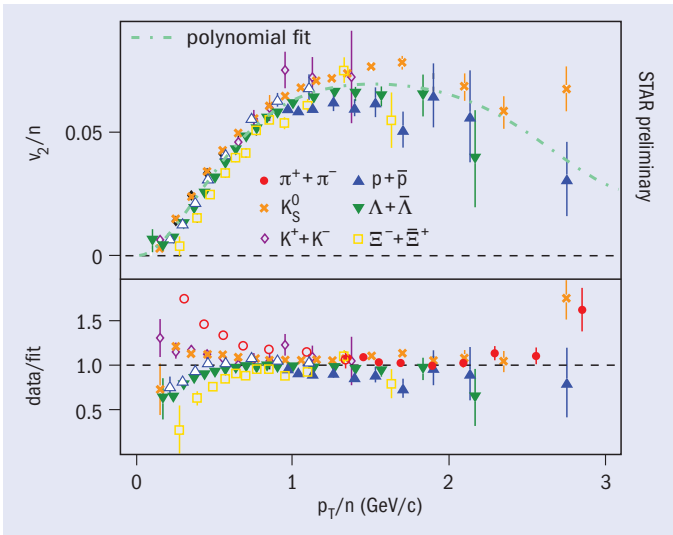


Fig. 3. In nucleus–nucleus collisions, due to collective motion, soft-particle production is strongly preferred to lie within the reaction plane, as measured by the elliptic flow v_2. At intermediate transverse momenta, the elliptic flow of identified hadron species shows a characteristic scaling with valence quark number n, as presented by the STAR collaboration. This supports a quark-coalescence picture of hadronization. Deviations from quark-number scaling at small transverse momenta are accounted for in a hydrodynamic description of the produced matter as a perfect liquid.

implemented a telescope of silicon pixel detectors with improved pointing resolution, NA60 was able to report in Budapest that data taken in the 2003 indium–indium run allow them to rule out conclusively an increased charm cross-section as the source for the dimuon excess. The data are, however, consistent with the exciting possibility of a significant thermal contribution. In addition, for more than a decade, there has been a theoretical debate on whether the embedding of ρ mesons in dense quantum chromodynamic (QCD) matter leads to a shift in the ρ mass, or to a density-dependent broadening, both scenarios being consistent with the original CERES dielectron data. NA60 now concludes, from data taken in the indium–indium run, that the shifting-mass scenario is not consistent with their data, which instead support a broadening induced in the medium (see figure 1, p25). NA60 also presented their first indium–indium measurements of J/Ψ suppression as a function of centrality. These confirm the strong anomalous suppression seen by NA50 in central lead–lead collisions at the SPS.

The SPS experiments NA49, CERES, NA50 and NA57 also showed new results from their continuing data analysis. In addition to earlier high transverse-momentum (p_T) measurements from CERES and WA98, this year NA49 and NA57 showed new results that were extensively compared with the results of the experiments at RHIC.

The central topic of this Quark Matter conference was without doubt the full harvest of the high-luminosity gold–gold run at RHIC in 2004, from which data analyses were shown for the first time. Equally important were results from the successful copper–copper run in the first half of 2005, which had been analysed in time for the conference in a global effort by the participating institutions of the four RHIC experiments. With an integrated luminosity for 200 GeV gold–gold collisions of almost 4 nb^{-1}, this run increased statistics by more than a factor of 10, and made much-wanted information accessible for the first time. One of the most important early discoveries of the heavy-ion experiments at RHIC was the strong suppression of hadronic spectra by up to a factor of five in the most central collisions. This so-called "jet-quenching effect" supports the picture that the matter created in heavy-ion collisions is of extreme density and thus very opaque to hard partons (*CERN Courier* September 2003 p18).

Results from the PHENIX experiment at RHIC now indicate that even neutral pions of $p_T = 20$ GeV show this dramatic energy degradation (figure 2, p25). Moreover, the increased luminosity allowed the STAR experiment to study the recoil of hadron trigger particles up to 15 GeV, and for sufficiently high transverse momenta, this recoil is for the first time observed to punch through the soft background. However, compared with reference data from proton–proton collisions, the particle yield of the recoil is strongly reduced, consistent again with the picture of a medium that is dense and very opaque to partonic projectiles. In further support, PHENIX also reported that high-p_T photons are not suppressed (figure 2, p25), and that photons at intermediate transverse momenta show an excess, which may be attributed to thermal radiation from the hot and dense matter.

Another important piece in the puzzle of reconstructing the properties of the produced matter came from the first measurements of high-p_T single-electron spectra. These spectra are thought to be dominated by the semi-leptonic decays of D- and B-mesons, thus giving for the first time experimental access to the propagation of heavy quarks in dense QCD matter. Data from STAR and PHENIX reveal a medium-induced suppression of electrons, which is of similar size to that of light-flavoured hadrons. There were many parallel talks, by both experimentalists and theorists, which contrasted these data with the theoretical expectation that massive quarks should lose less energy in the medium than massless quarks or gluons due to the so-called "dead-cone effect" in QCD. While a final assessment is still awaited, there was widespread agreement that these data will help significantly in refining our understanding of the interaction between hard probes and the medium, which is much needed for a better characterization of the dense QCD matter produced in nucleus–nucleus collisions.

Another much awaited result that gave rise to a great deal of discussion was the first statistically significant J/Ψ measurement at RHIC. This was presented by the PHENIX collaboration and showed a similar pattern and strength to that observed in lead–lead and indium–indium collisions at the SPS. This result was of particular interest also to lattice QCD theorists, who now find that the dissociation of the directly produced J/Ψ in a deconfined medium sets in at much higher energy densities than previously expected.

The bulk properties of dense QCD matter reveal themselves not only in the modification of hard processes by the medium, but also in the collective motion of soft particle production and its hadrochemical composition. One of the main discoveries of the first years of running RHIC was the unprecedented large size of the collective flow signals, measured in the asymmetries of particle production with respect to the reaction plane. Remarkably, the measured mass-dependence of the transverse radial and elliptic flow supports the assumption that different particle species emerge from a common flow field. Flow measurements at intermediate transverse momenta follow constituent-quark counting rules and are consistent with quark coalescence as a medium-dependent hadronization scenario (figure 3). Moreover, to the surprise of many, the hydrodynamic

description of the collision in terms of an adiabatically expanding, perfect fluid of vanishing viscosity and heat conductivity appears, at RHIC energies, to be satisfactory for the first time.

Much of the discussion at QM '05 focused on the emerging picture of the matter produced in heavy-ion collisions at RHIC, which, far from being a weakly interacting gas of quarks and gluons, shows features of a strongly coupled partonic system indicative of a perfect liquid. This liquid includes not only the light and strange quarks; the first preliminary data on the elliptic flow of charmed hadrons from the PHENIX collaboration indicates that even charmed quarks participate in the collective expansion of this new form of matter.

The conference saw a lively theoretical discussion about the dynamic mechanisms underlying a possible rapid thermalization. Emphasis was given in particular to the relationship to thermalization processes in Abelian plasmas, to formal analogies with the thermal properties of black holes, and to the possibility that plasma instabilities accelerate equilibration. The intellectual richness of the field was further illustrated by exciting reports from string theory, where theorists have succeeded for the first time in calculating the viscosity to entropy density ratio in the physically relevant, strong-coupling limit of a certain class of thermal non-Abelian gauge theories. The fact that this ratio is found to be very small indicates a non-dissipative behaviour. It raises the exciting possibility that the non-dissipative character of an almost perfect liquid, which may be created in gold–gold collisions at RHIC, could be understood from first-principles calculations in QCD.

From the point of view of heavy-ion phenomenology, the central question of whether more direct signals of negligible viscosity can be established led to another highlight of the conference. The widely discussed idea was that if dissipation is negligible, then energy, deposited by a jet in dense QCD matter, must propagate in a characteristic Mach cone, determined by the velocity of sound in the quark-gluon plasma. Reports about back-to-back particle correlations from PHENIX, which may show such a Mach-cone-like structure, were hotly debated amongst theorists and experimentalists alike (see figure 4). Most importantly, these discussions showed that heavy-ion physics at collider energies has a large set of novel tools available for the controlled experimentation with hot and dense QCD matter, and that the field is moving towards characterizing specific properties of this matter, including its speed of sound, equation of state, and its transport coefficients such as heat conductivity and viscosity.

Past, present and future

The Quark Matter conferences not only highlight the experimental harvest of the recent past and the latest news from theory, they are also the arena for assessing perspectives for the future. The first heavy-ion beam at the Large Hadron Collider (LHC) at CERN is expected in 2008, and heavy-ion researchers are now well prepared for the jump in centre-of-mass energy by a factor of 30 above RHIC. Most importantly, the fact that dramatic medium-sensitive effects persist unweakened at RHIC up to the highest measured transverse momentum strongly supports the expectation that the new kinematic regime accessible at the LHC will provide many qualitatively novel tools for the study of ultra-dense QCD matter.

The LHC will not be the only big player in the field of heavy-ion physics in the next decade. At Brookhaven, the STAR and PHENIX collaborations are lining up for several important detector upgrades,

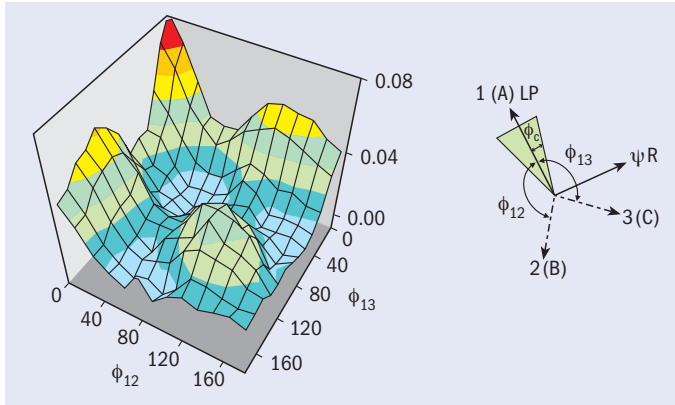


Fig. 4. Three-particle correlation functions are sensitive to the appearance of a Mach cone in the direction opposite to the "near-side" jet. These preliminary PHENIX data from gold–gold collisions at 200 GeV may thus give access to an essential property of a perfect liquid – the non-dissipative propagation of energy in shock waves through matter produced in heavy-ion collisions.

which will significantly enhance their abilities to characterize specific properties of the matter created in heavy-ion collisions. Moreover, Brookhaven envisages a luminosity upgrade of RHIC, which will open yet another class of novel opportunities. Finally, the newly approved Facility for Antiproton and Ion Research at the GSI Darmstadt is preparing for the start of a versatile heavy-ion programme in the next decade. Plenary talks provided overviews of the status and possibilities of these three programmes. The field is now eagerly awaiting its future, the next slice of which will be served at the 19th Quark Matter conference in Shanghai in November 2006.

Further reading

More details about the QM '05 Conference, including an archive of the talks, videos and photos, can be found at the conference home page, http://qm2005.kfki.hu/. See also a press release by the Hungarian Academy of Sciences, www.mta.hu/index.php?id=858&backPid=856&begin_at=30&tt_news=1530&cHash=f55085886a.

Résumé

"*Quark Matter*" *à Budapest*

La 18e Conférence internationale sur les collisions noyau-noyau ultrarelativistes, "Quark Matter 2005", a permis des échanges animés sur les derniers résultats en physique des ions lourds. Elle a porté essentiellement sur de nouvelles données recueillies au collisionneur d'ions lourds relativistes (RHIC) du Laboratoire national de Brookhaven et sur une synthèse de l'interprétation des données sur les ions lourds produites par des expériences menées au Supersynchrotron à protons du CERN (notamment NA60). Figuraient aussi au programme divers grands thèmes théoriques de la phénoménologie des ions lourds, de la théorie des champs à température et/ou densité finies, d'astrophysique et de physique du plasma.

Tamás Csörgö *and* **Péter Lévai**, *KFKI Research Institute for Particle and Nuclear Physics, Budapest,* **Helmut Satz**, *University of Bielefeld, and* **Jurgen Schukraft** *and* **Urs Wiedemann**, *CERN.*

Particles in Portugal: new l

Europe's premier particle-physics conference took place this year on the bank

The 2005 European Physical Society (EPS) Conference on High Energy Physics (HEP) took place in Lisbon on 21–27 July at the Cultural Centre of Belém, beautifully situated on the right bank of the Tagus river, 10 km west of downtown Lisbon. Held in alternate years, the EPS HEP conference starts with three days of parallel talks, followed by a day off, and then three days of plenary sessions. The format thus differs from that of the Lepton–Photon conferences, which are organized in the same year (*CERN Courier*, November 2005 p33), and allows the participation of more "grass-root" and young speakers.

This year a total of 17 sessions yielded a wealth of detailed results from both experiment and theory, including new results from astroparticle physics. One of the highlights was provided by Barry Barish, newly appointed director of the Global Design Effort for the International Linear Collider (ILC). The EPS and the European Committee for Future Accelerators organized a particularly popular "Lab directors' session", which presented status and future plans.

The opening ceremony was honoured by the presence of Mariano Gago, Portuguese Minister for Science, Technology and Universities, who as an experimental high-energy physicist, was also a member of the local organizing committee. As usual, the plenary sessions started with the prize awards. The EPS 2005 High Energy Particle Physics Prize was presented jointly to Heinrich Wahl of CERN and to the NA31 collaboration, with other prizes awarded to Mathieu de Naurois, Matias Zaldarriaga, Dave Barney and Peter Kalmus (*CERN Courier*, September 2005, p43). The next highlight was the invited talk by David Gross of Santa Barbara/KITP, Nobel Laureate in 2004 and EPS Prize winner in 2003. He checked off the list of predictions he had made in the summary talk of the 1993 Cornell Lepton–Photon conference, the majority of which had been confirmed.

Sijbrand de Jong of Nijmegen/NIKHEF and Tim Greenshaw of Liverpool started the main business of the plenary session with talks on tests of the electroweak and quantum chromodynamic sectors of the Standard Model, respectively. The new (lower) mass for the top quark from Fermilab, of 172.7±2.9 GeV, as presented by Koji Sata of Tsukuba in the parallel sessions, gives an upper Higgs mass of 219 GeV at 95% confidence level. Greenshaw discussed how HERA continues to play a major role in precision studies in quantum chromodynamics (QCD) of the proton, now mapped down to 10^{-18} m, or a thousandth of its radius. Such results will be very valuable for the analysis of data from the Large Hadron Collider (LHC). New results on the spin structure of the proton were also reported.

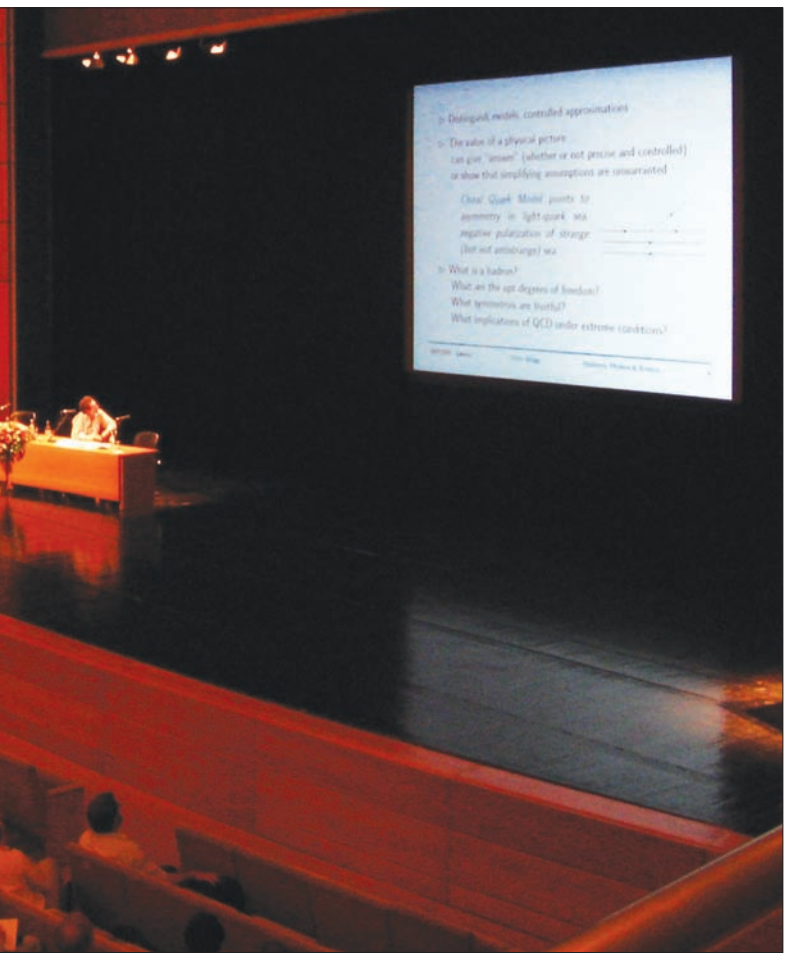
Riccardo Rattazzi of CERN and Pisa then talked on physics beyond the Standard Model and was followed by Fermilab's Chris Quigg, who reviewed hadronic physics and exotics. Rattazzi presented an interesting "LEP paradox": the hierarchy problem, with a presumed light Higgs particle, requires new physics at a low scale, whereas there are no signs of it in the data from CERN's Large Electron–Positron collider. He also reviewed the anthropic approach to the hierarchy problem: we inhabit one of very many possible universes. This many-vacua hypothesis is also referred to as "the landscape", and might have implications for supersymmetry. Quigg reviewed several new states discovered by the CLEO collaboration at Cornell and at the B-factories, and reminded us that the pentaquark states are still controversial.

Following on from the parallel talks, the plenary sessions of HEP 2005 ma
date on such topics as the current status of the Grid projects, the prospect

Near- and more-distant-future possibilities were reviewed by Günther Dissertori of ETH Zurich in his talk on "LHC Expectations (Machine, Detectors and Physics)" and by Klaus Desch of Freiburg in "Physics and Experiments – Linear Collider". Dissertori gave an overview of all the complex instrumentation in the process of being completed for both the LHC and its four major detectors. The first beams are planned for the summer of 2007, with a pilot proton run scheduled for November 2007. All detectors are expected to be

high-energy physics results

s of the River Tagus, near Lisbon. **Per Osland** and **Jorma Tuominiemi** report.



de up the last three days of the conference and brought attendees up to s for accelerators, and new developments in detectors. (Courtesy H Koers.)

ready to exploit LHC collisions starting on "Day 1". Desch presented the ILC project and highlights of the precision measurements it will provide in electroweak physics, in particular, in the Higgs sector.

More theoretical considerations were offered by CERN's Gabriele Veneziano and Yaron Oz of Tel Aviv, who spoke on cosmology (including neutrino mass limits) and string theory, respectively. Veneziano reviewed current understanding, according to which the total energy content of the universe is split into 5% baryons, 25% dark matter and 70% dark energy. The question of what dark energy is was compared with the problem that faced Max Planck when he realized that the total power emitted by a classical black body is infinite. Interesting speculations on alternative interpretations of cosmic acceleration were also discussed. Precision measurements in cosmology have an impact on high-energy physics: they provide an upper bound on neutrino masses, indicate preferred regions in the parameter space of minimal supergravity grand unification, and suggest self-interacting dark matter. Oz reviewed the beauties of strings and their two major challenges: to explain the big bang singularity, and the structure and parameters of the Standard Model. So far, neither is explained, but the consistencies are impressive.

The recently discovered connection between string theory and QCD was described by SLAC's Lance Dixon. An important problem being solved is how to optimize the calculation of multiparticle processes (which might be backgrounds to new physics processes). By ingeniously exploiting the symmetries of the theory, one is able to go beyond the method of Feynman diagrams in terms of efficiency. Roughly speaking, this amounts to first representing four-vectors by spinors, and then Fourier-transforming the left-handed but not the right-handed spinors.

Getting results

Christine Davies of Glasgow presented new results on non-perturbative field theory, in particular in lattice QCD (LQCD). She reported on the very impressive recent advances in LQCD, where high-precision unquenched results are now available to confront the physics of the Cabibbo–Kobayashi–Maskawa (CKM) matrix with only 10% errors on the decay matrix elements. This has been made possible by breakthroughs in the theoretical understanding of the approximations, together with faster computers.

Josh Klein of Austin and Federico Sanchez of Barcelona reviewed neutrino physics results and prospects, respectively. Neutrino physics has become precision physics, and now oscillations, rather than just flux reductions, are beginning to emerge in data from the KamLAND and Super-Kamiokande II experiments in Japan. Sanchez discussed rich plans for the future, with two main questions to tackle. Is the neutrino mass of Majorana or Dirac origin? How can the small angle θ_{13} and the CP-violating phase δ be constrained, or preferably, measured? The plans include the Karlsruhe Tritium Neutrino experiment to study tritium decay, and the GERDA experiment in the Gran Sasso National Laboratory (LNGS), the Neutrino Mediterranean Observatory and the Enriched Xenon Observatory, all of which will look for neutrinoless double beta decay. The Main Injector Neutrino Oscillation Search, the Oscillation Project with Emulsion Tracking Apparatus (OPERA) in the LNGS, and the Tokai to Kamioka (T2K) long-baseline neutrino experiments will all study the phenomena of "atmospheric" neutrino oscillations under controlled conditions, and the Double CHOOZ experiment will further bound the small values of θ_{13}. A new idea is to exploit beams of unstable nuclei, which would provide monochromatic neutrinos. Meanwhile, the CERN Neutrinos to Gran Sasso project will start taking data in 2006, with a neutrino beam from CERN to the OPERA detector.

Flavour physics was the topic for both Gustavo Branco of Centro de Física Teórica das Partículas in Lisbon, in "Flavour Physics – ▷

Heinrich Wahl (centre), with members of the NA31 collaboration. Wahl and the collaboration were jointly awarded the 2005 EPS High Energy Particle Physics Prize . (J Tuominiemi.)

A view of the Tagus river from the Cultural Centre of Belém, which played host to the 2005 European Physical Society (EPS) Conference on High Energy Physics. (Courtesy Boris Kayser.)

Theory (Leptons and Quarks)", and Marie-Hélène Schune of LAL/Orsay, who talked about CP violation and heavy flavours. At the B-factories, the Belle detector is collecting a lot of luminosity, and after a long shutdown, BaBar is back in operation. Many detailed results on CP violation in B-decays were presented at the meeting. The BaBar and Belle results on β or φ_1 are now in agreement, and the CKM mechanism works very well, leaving little room for new physics, although the precision is also steadily improving.

Looking to the skies

Astrophysics was covered by three speakers, with Thomas Lohse of Berlin talking about cosmic rays (gammas, hadrons, neutrinos), Alessandro Bettini of Padova presenting dark matter searches, and Yanbei Chen from the Max-Planck Institute for Gravitational Physics reviewing work on gravitational waves. What and where are the sources of high-energy cosmic rays? How do they work? Are the particles accelerated or due to new physics (decay products) at large mass scales? The Pierre Auger Observatory is beginning to collect data in the region of the Greissen–Zatsepin–Kuzmin cut-off, while neutrino detectors search for "coincidences" (repeated events from the same direction).

The HESS telescopes and other detectors have discovered tera-electron-volt gamma rays from the sky! The origin is unknown, but they are correlated with X-ray intensities. The galactic centre is one such tera-electron-volt gamma-ray point source. It has also been discovered that supernova shells accelerate particles (electrons or hadrons?) up to at least 100 TeV. The searches for weakly interacting massive particles, on the other hand, remain inconclusive. Other experiments are still unable to confirm or refute the observation of an annular modulation seen by the DAMA project at the LNGS.

A major instrument in the search for gravity waves is the Laser Interferometer Gravitational-Wave Observatory, a ground-based laser interferometer that is sensitive in the region from 10 Hz to 10 kHz. The sources include pulsars, and one hopes to detect a signal after the planned upgrade. The Laser Interferometer Space Antenna will be launched in 2015, and will be sensitive to lower frequencies, in the range 0.01 mHz to 0.1 Hz, as might come from super-massive black-hole binaries.

Paula Bordalo of the Laboratório de Instrumentação e Física Experimental de Partículas in Lisbon presented an experimental overview of ultra-relativistic heavy-ion physics. Photon probes are important for the study of the new state of matter observed, as they do not interact strongly and carry information about the early stage of the collision. There is also a related virtual photon or dilepton signal that shows some interesting features. The new state being explored is possibly a colour glass condensate, which is behaving more like a low-viscosity liquid rather than a gas (see p25).

Alexander Skrinsky of the Budker Institute of Nuclear Physics reviewed the status and prospects of accelerators for high-energy physics, covering machines in operation as well as new facilities under construction or planned. Superconductivity is widely used and is being further developed for accelerating structures and for magnets. One important line of development is oriented towards higher luminosity and higher quality beams, including longitudinal polarization and monochromization techniques. There are studies aiming at shorter and more intense bunches, suppression of instabilities involving fast digital bunch-to-bunch feedbacks and minimization of electron-cloud effects. Rapid progress is being made on energy-recovery linacs, recyclers and free-electron lasers, which are being studied for future synchrotron light sources. Higher power proton beams and megawatt targets are being developed and several promising options for neutrino factories are under study. Plasma wake-field acceleration appears to be still in an early stage of development, although it has the potential to achieve very high acceleration gradients.

Grid references

Turning to computing, DESY's Mathias Kasemann described the status of the Grid projects in high-energy physics. The big experiments running today – CDF, D0, BaBar and ZEUS – are already using distributed computing resources and are migrating their software and production systems to the existing Grid tools. The LHC experiments are building a vast hierarchical computing system with well defined computing models. The LHC Computing Grid (LCG) collaboration has been set up to provide the resources for this huge and complex project. The LCG system is being developed with connections to the Enabling Grids for E-science (EGEE) project and the Nordic Data

Grid Facility in Europe and to the Open Science Grid in the US. Basic Grid services have been defined and first implementations are already available and tested. Kasemann's personal prediction was that the data analysis of the LHC experiments will not be late because of problems in Grid computing.

On the detector front, CERN's Fabio Sauli reported on new developments presented at the conference. Interesting progress has been achieved in fabricating the radiation-hard solid-state detectors needed for the LHC and other high-radiation-level applications. One way is through material engineering: choosing materials that are radiation resistant, such as oxygenated silicon, silicon processed with the Czochralski method, or using thin epitaxial detectors. Other solutions have been developed by device engineering, and these include pixel detectors, monolithic active pixels or three-dimensional silicon structures. For high-rate tracking and triggering, gas micropattern detectors, such as the gas-electron multipliers, have found versatile solutions in several experiments. For calorimetry, new materials like lead tungstenate crystals have been adopted in LHC experiments. Also new scintillation materials with large light yield, fast decay time and with high density have been tested.

Boris Kayser from Fermilab closed the conference with an eloquent summary. On the day off, various excursions to charming medieval villages and ancient monasteries all converged on the city of Mafra, where the conference participants met Portuguese students and teachers in a baroque palace dating from 1717. There was also a visit to a precious library created by Franciscan friars, with 36 000 prize volumes (the "arXiv" of its time!) and where bats control the insect numbers (visitors were told). Gaspar Barreira and his colleagues jandled the local organization masterfully, and the many excellent fish restaurants nearby provided a relaxed setting for informal discussions.

● The next EPS-HEP conference, in July 2007, will take place in Manchester, UK.

Résumé

La physique des particules au Portugal

La plus prestigieuse conférence européenne de physique des particules de 2005 s'est tenue à Lisbonne. 17 sessions parallèles ont permis de communiquer une mine de résultats détaillés, notamment en astrophysique des particules. Parmi les moments forts : un exposé de Barry Barish, directeur du Projet mondial de conception du Collisionneur linéaire international, et une "Session des directeurs de laboratoire" sur le présent et l'avenir. On y a présenté divers résultats expérimentaux sur des tests du modèle standard, l'observation des rayons cosmiques de haute énergie et la quête des ondes gravitationnelles, de même que les dernières nouvelles de la théorie des cordes et de l'énergie sombre de l'univers.

Per Osland, *University of Bergen, and* **Jorma Tuominiemi**, *Helsinki Institute of Physics.*

CERN's low-energy frontier

The recent NuPAC meeting at CERN provided an overview of the laboratory's present and future activities in nuclear astrophysics, nuclear-structure physics and related areas.

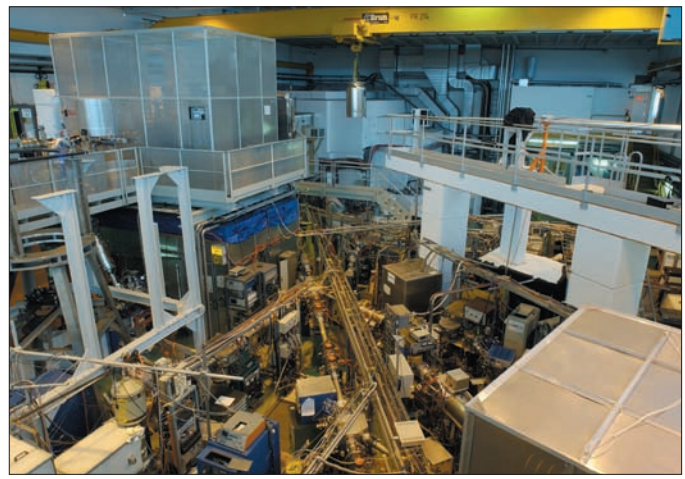
The energies attained at CERN and other particle physics laboratories are useful not only for probing nature's deepest layers, they also enable the study of matter in the relatively low range up to a few million electron-volts. This range is typical of supernovae and X-ray bursters, and is also relevant for most nuclear-structure phenomena. Experimentalists at CERN have exploited these lower energies for many years, and the present status of their achievements and the prospects for further studies were the subject of the recent Nuclear Physics and Astrophysics at CERN (NuPAC) meeting held on 10–12 October 2005.

These activities are concentrated at CERN around the Isotope Separator On-Line (ISOLDE) and Neutrino Time-of-Flight (n_TOF) facilities. Both come under the ISOLDE and Neutron Time-of-Flight Experiments Committee (INTC), which has been asked by the CERN management to review the scientific case for the two facilities. NuPAC is one step in this review process.

In many ways, nuclear-structure physics is experiencing a renaissance. Some of the "basic truths" about nuclear structure, believed to be universal only 20 years ago, are now known to be approximations that hold for stable and close-to-stable nuclei, but that cannot be used further away from stability. For example, we are used to thinking in terms of nuclear shells based on unassailable "magic" numbers. However, it is possible to move far enough away from the stable nuclei for the balance between the number of neutrons and protons in a nucleus to be so disturbed that the magic numbers can and do change. Reaching the regions where this happens and performing detailed studies of how and why the changes occur are important tasks for nuclear physicists. So far "erosions" of the magic numbers $N = 8$, 20 and 28 are known, and it seems that they are at least partly replaced by $N = 6$ and 16, although our present understanding is not complete.

Another change when we move far away from stable nuclei is that continuum states need to be taken into account much more directly because binding energies become low (turning to zero at the neutron and proton driplines, where nuclei are so saturated with an excess of neutrons or protons that they "drip" the relevant nucleon). Experiments can now cross the proton dripline for many elements; and even the neutron dripline, which is further away from stability than the proton one, has been reached and partially crossed for the light elements up to about neon. The structure and dynamics of loosely bound nuclei show new phenomena, such as the spatially extended halo and the "pygmy" resonances at low-excitation energies. This is a challenging area for both experimentalists and theoreticians.

Two of the sessions at NuPAC were dedicated to the evolution of nuclear structure towards and at the driplines. Several theoretical talks outlined how far recent developments have taken us in descriptions of nuclear structure and reaction theory for loosely bound systems, of the evolution of shell structure and nuclear shape as the proton and neutron numbers change, and of the very complex problem the fission process presents. The experimental talks gave examples of the widely different techniques that are used today and planned for the near future.



The ISOLDE facility at CERN. The isotope separators are located behind the wall at the rear, from where beams can be directed into any of the beamlines towards the experiments, some of which are visible in the foreground. The elevated cubicle at the left of the image is the Electron Beam Ion Source, which acts as a charge-state multiplier for the REX accelerator.

Measuring the nucleus

Using the low-energy ISOLDE beams, properties such as mass, radius and magnetic moment can be measured relatively directly and in a model-independent way for "long-lived" states (that is, with half-lives longer than a few milliseconds). Decay experiments also make use of these beams and provide information about many aspects of nuclear structure. For the past four years it has also been possible to perform reaction experiments through post-acceleration in the Radioactive Beam EXperiment (REX-ISOLDE) accelerator. Most of these experiments have used the Miniball gamma-ray detector array.

Speakers at the meeting stressed the importance of the planned energy upgrade of REX-ISOLDE to at least 5.5 MeV per nucleon. This will enable reaction experiments to be performed with all of the 800 and more nuclei that ISOLDE can now produce. Participants also strongly supported the continuation of the beam development programme that is ISOLDE's hallmark. On the "wish list" are beams of even more kinds of nuclei, as well as improved quality (intensity, isotopic purity, phase space extent) for existing beams.

A reliable knowledge of nuclear structure is one of the basic requirements for properly understanding how energy is produced in stars, and thereby how stars evolve. The session dedicated to these

The 185 m-long n_TOF vacuum tube, with members of the design and construction team. In the n_TOF facility, protons strike a lead target to produce an intense neutron beam that travels through the tube, giving rise to a time spectrum that depends on the neutron kinetic energy.

questions presented various aspects of the problems as seen by astronomers, theoreticians and nuclear experimentalists. Half of the heavy elements produced are made in what is known as the s-process, the slow neutron capture that takes place in massive stars in later stages of their evolution. Experimental data are still needed as input for a complete understanding, in particular of the weak s-process component (nuclei below mass number 90). One of the main lines of the future n_TOF physics programme is to measure these neutron-capture processes with sufficient resolution. Explosive astrophysical events – such as supernovae, novae and X-ray bursters – quickly drive nuclei far from the region of stability, and data collected at ISOLDE can benefit in several ways the theoretical modelling of these events.

Further uses

Experiments in nuclear physics dominated the early stages of the investigation into weak interactions. Particle physics has taken the place of nuclear physics for many decades, but nuclei still provide important information through precision experiments that restrict the low-energy limit of the phenomena seen more directly at higher energy. A short session at NuPAC gave two examples of this: on the one hand nuclear measurements are needed to improve further the unitarity test of the Cabibbo–Kobayashi–Maskawa quark-mixing matrix; and on the other hand precision measurements of beta-decays in ion and/or atom traps are sensitive to new interactions. These experiments typically run for up to a decade to obtain the required low level of systematic uncertainties.

A session was devoted to presentations of applications of nuclear physics. Basic data on neutron-capture cross-sections on many nuclei are indispensable to enable further developments of nuclear technologies – for example, the accelerator-driven systems for transmutation or the thorium cycle with its potential for a significant reduction of the amount of radiotoxic waste. As several speakers outlined, it is an important part of the present and future n_TOF programme to provide these data. The application of radioactive nuclei in solid-state physics and life science has been an important facet of the ISOLDE programme for many years, and some of the highlights were presented. A possible future use of radioactive ions as probes of nanostructures was outlined; this again requires isotopically pure beams of high beam-optical quality. Also discussed was the use of radioisotopes in nuclear medicine, where progress in biomedicine combined with the introduction of new high-purity radioisotopes opens new possibilities for diagnosis and therapy.

The last session was devoted to the proposed upgrades of the ISOLDE and n_TOF facilities, and of the proton injectors on which they depend. The ISOLDE community is proposing an upgrade project, HIE (High Intensity and Energy)-ISOLDE, that includes increasing the REX energy to 5.5 MeV/u in 2009, with the goal of reaching 10 MeV/u in 2011. Furthermore, the beam quality will be improved with the help of, for example, new ion sources, an upgraded laser ion source with a trap close to the target, low-energy beam coolers and charge breeders. The target and ion source development programme would be boosted to keep the leading edge in this key field.

The n_TOF community is proposing to restart the facility (after refurbishing the target) and to use a different moderator to increase the proton flux at low energy. It is envisaged that at a later date the n_TOF facility will have a new, shorter TOF tube with a target area that is fully equipped to handle radioactive sources. In principle, such an arrangement could enable sources collected at ISOLDE to be used at n_TOF.

The faster cycling of the Proton Synchrotron (PS) Booster could in the short term provide ISOLDE with more protons. CERN's Accelerator Beams Department is developing a scheme that will permit the Booster to cycle at 900 ms without any additional risk for the aging PS magnets. Further in the future, Linac 4 will make even more protons available for both ISOLDE and n_TOF, and will serve as the first step towards a multimegawatt proton source at CERN, the Superconducting Proton Linac (SPL) (*CERN Courier* September 2004 p31). The long-term goal of the ISOLDE community is to realise the European Isotope Separation On-Line Radioactive Ion Beam Facility (EURISOL) – a high-intensity radioactive beam facility that will enable nuclear physicists to probe even further into the unknown. The SPL would be a suitable driver for EURISOL.

The opportunities at the present nuclear-physics and astrophysics facilities at CERN are clearly not yet exhausted. The proposed upgrades will further boost the scientific reach of the facilities and serve a community of more than 500 users. It will be interesting to follow the development of this programme over the coming years.

Résumé

La frontière des basses énergies pour le CERN

La récente réunion NuPAC, tenue au CERN, a fait le point des activités du laboratoire en astrophysique nucléaire, en physique de la structure nucléaire et dans des domaines connexes. Ces activités sont essentiellement menées aux installations ISOLDE et n_TOF. ISOLDE étudie des propriétés du noyau (notamment sa masse et son rayon) utiles pour comprendre la structure nucléaire, qui joue un rôle dans l'évolution stellaire. L'importance du relèvement de l'énergie de REX-ISOLDE a été soulignée. Des applications de physique nucléaire, telles que les systèmes pilotés par accélérateurs pour la transmutation nucléaire, s'appuient en particulier sur n_TOF.

Mats Lindroos *and* **Karsten Riisager**, *CERN.*

PHYSTAT: making the most of statistical techniques

Roger Barlow looks at the development of the PHYSTAT series of meetings, which bring statisticians together with astronomers, cosmologists and particle physicists.

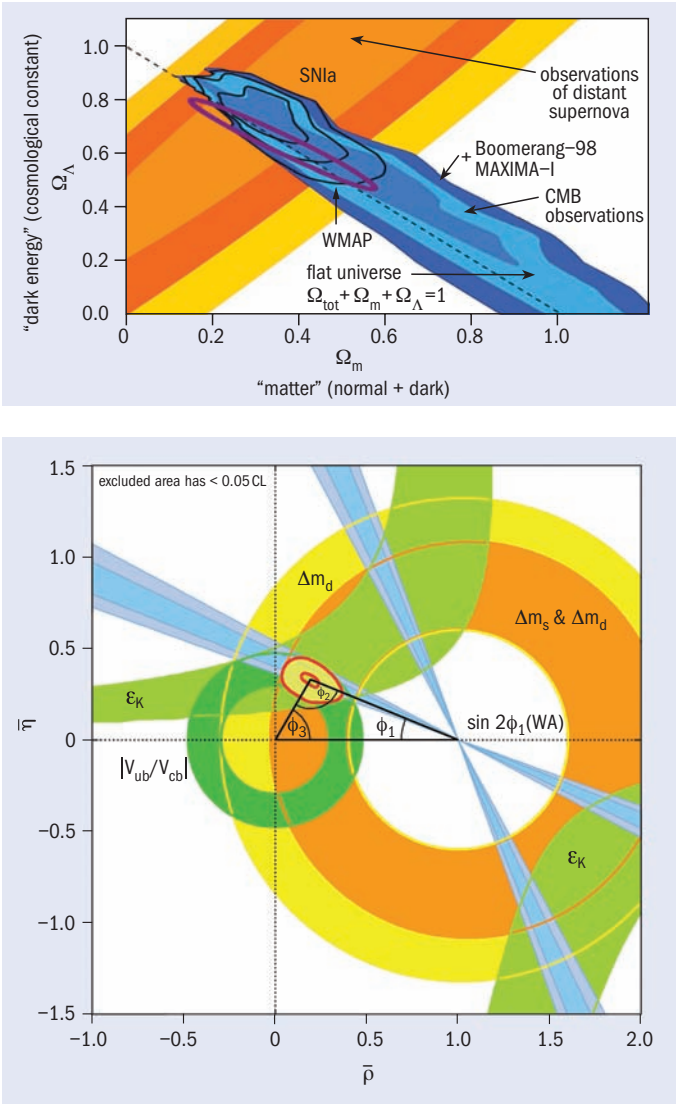
Statistics has always been an essential tool in experimental particle physics, and today this is truer than ever. In the early days emulsions and bubble-chamber photographs were scanned slowly by hand; now modern electronic detectors perform equivalent processing quickly and automatically. However, physicists still classify and count their events and then, eagerly or reluctantly, turn to statistical methods to decide whether the numbers are significant and what results are valid.

As the subject has progressed, new themes have emerged. The high numbers of events obtained by CERN's Large Electron–Positron collider (a Z-factory), the B-factories PEP-II and KEKB at SLAC and KEK respectively, and the experiments at DESY's HERA collider, mean that statistical errors below 1% are now common. Many areas have become dominated by systematic effects, a relatively untrodden and much less well understood field.

On the theoretical side, the high precision of theories such as quantum electrodynamics and quantum chromodynamics means that the tiny uncertainties in their predictions have to be carefully studied and understood. Supersymmetry and other "new physics" models predict signals that depend on several parameters of the theory, and when an experiment fails to see such a signal the restrictions this places on possible values for these parameters has to be worked out. When different experiments probe the same basic theory, we need to evaluate the combined implication of their results.

The science of statistics is also developing fast. The availability of large amounts of processing power opens new possibilities for evaluating statistical models and their predictions. Bayesian statistics is a rapidly growing field in which a great deal of progress has been made. Machine learning techniques, such as artificial neural networks and decision trees, are flourishing, with further applications continually being found that open up new possibilities for exploiting data.

Astronomers and cosmologists are also developing the power and sophistication of their statistical techniques. Telescopes are becoming larger and more powerful, and the readout from their instruments with charge-coupled detectors produces a torrent of data. Observations at different wavelengths, from gamma rays to radio waves, from ground-based observatories and satellites are combined to yield clues about the nature of distant objects, the processes that power them and other features of the universe. Details of the distribution of the cosmic microwave background will, when properly interpreted, tell us what happened in the Big Bang at energies beyond the ▷



Cosmologists and particle physicists share problems in statistics in the observational data. Top, determining the amounts of dark energy and dark matter from cosmic microwave background (CMB) observations (Courtesy Andrew Jaffe, PHYSTAT 2005). Bottom, pinning down parameters of the Cabibbo–Kobayashi–Maskawa matrix (from HEP2005, Lisbon).

reach of man-made accelerators.

The PHYSTAT series of conferences and workshops provide a forum in which different communities can meet and exchange ideas. A first workshop of particle physicists at CERN in 2000 was followed by one at Fermilab in 2001, and then a full conference in Durham in 2002, which benefited from the presence of statisticians as well as physicists. At SLAC in 2003, astronomers and cosmologists were included (*CERN Courier* March 2004 p22). This was so successful that it was repeated at the most recent conference, "Statistical Problems in Particle Physics, Astrophysics and Cosmology", held in Oxford in September 2005 and organized by Louis Lyons.

PHYSTAT 2005 consisted of a wide-ranging programme of parallel and plenary talks. One of the most influential statistical thinkers of the 20th century, David Cox of Oxford University, gave the opening keynote speech, in which he provided an authoritative account of the Bayesian and frequentist approaches to inference. The official programme was supplemented by intense discussions in corridors, coffee lounges and local pubs, as the participants thrashed out ideas that ranged from the philosophical abstractions of the meaning of probability to the pragmatic and technical details of different computer systems.

These techniques are being fed back into the community through the activities of the participants, many of whom are active in analysis on various different experiments, through further meetings (a follow-up afternoon meeting in Manchester attracted 80 particle physicists from the UK), through the academic training programmes offered at CERN and other laboratories, and through graduate conferences and summer schools. There are developing plans for a repository of software that performs these increasingly sophisticated statistical tests. Further workshops are planned for 2006 and beyond.

Further reading

More information can be found at www.physics.ox.ac.uk/phystat05/ and at www.pa.msu.edu/people/linnemann/stat_resources.html.

Résumé

PHYSTAT: comment optimiser les techniques statistiques?

Les statistiques sont un outil essentiel de la physique des particules expérimentale. Le cycle de conférences et d'ateliers PHYSTAT permet à des physiciens, des astronomes et des cosmologistes de rencontrer des statisticiens pour échanger des idées. L'édition 2005, qui s'est tenue en septembre à Oxford, a traité aussi bien d'abstractions philosophiques sur la signification des probabilités que de détails pragmatiques et techniques de divers systèmes informatiques qui, au travers des échanges, ont été diffusés au sein de la communauté. Des plans sont élaborés pour établir une logithèque permettant d'exécuter les essais statistiques toujours plus complexes de l'époque actuelle.

Roger Barlow, *University of Manchester.*

The future looks bright for particle channelling

Techniques that make use of the ordered structure of a crystal lattice to manipulate particle beams are finding an increasing number of applications.

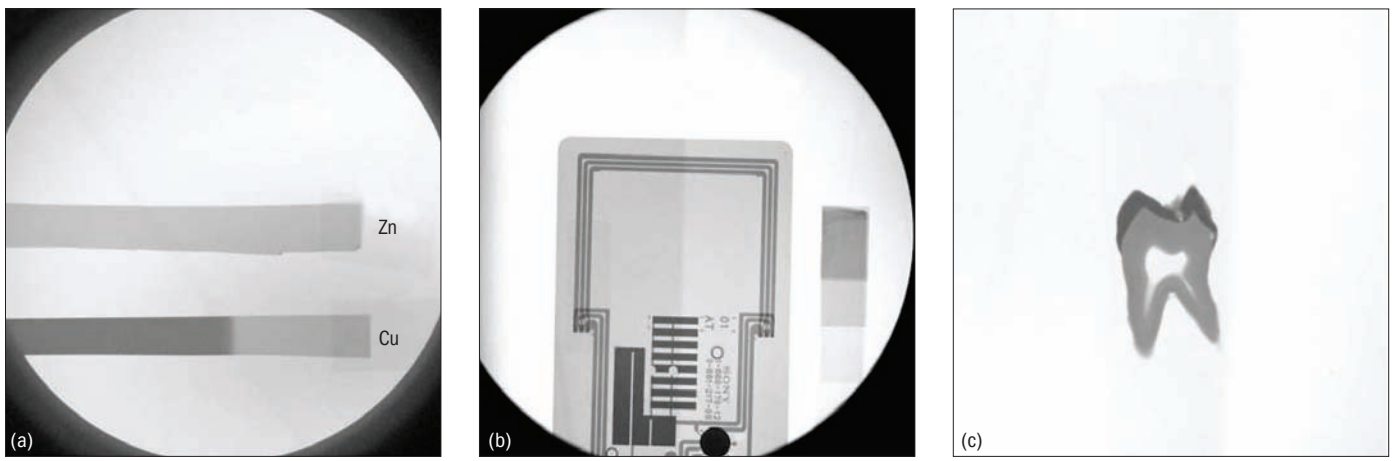


Fig.1. Radiographs using a parametric X-ray radiation beam: (a) foils of copper and zinc at 9 keV; (b) integrated circuit card and alumium step (?) at 13.5 keV; and (c) sample slice of a human tooth at 13.5 keV. (Courtesy Y Hayakawa et al.*)*

When high-energy beams of charged and neutral particles interact with ordered matter, such as crystal lattices and nanostructures, they induce phenomena that are finding an increasing number of applications at particle accelerators. This has led to a great deal of interest both in assessing the current state of the art of this fast-growing field, and in stimulating research collaborations among the different groups involved. The International Workshop on Relativistic Channelling and Coherent Phenomena in Strong Fields, held in Frascati on 25–28 July 2005, provided an appropriate showcase for recent results in the field. The workshop was the latest in a series of successful similar meetings and was merged with the Radiation from Relativistic Electrons and Periodic Structures 2005 symposium in the biannual series that has been organized by Tomsk Polytechnic University since 1993.

Bent crystals

Over the past decade, the understanding of particle steering by a bent crystal lattice has progressed very well, and in particular the accelerator applications of the bent-crystal channelling technique have greatly expanded (*CERN Courier* July/August 2004 p19). Crystal bending and extraction of particle beams has become an established technology at high-energy accelerators, and with the approaching start-up of the Large Hadron Collider (LHC) at CERN, crystal-channelling techniques are providing further applications that are useful in the multi-tera-electron-volt range. One new application proposes bending the LHC protons (or ions) by a huge angle of 1–20° in the 0.45–7 TeV energy range using a bent single crystal of silicon or germanium. This would allow calibration of the calorimeters in the CMS (or ATLAS) detector *in situ*, using an LHC beam of precisely known energy. The simulations presented at the workshop show that such an application at the LHC is feasible. The workshop also reported results from the experiment at the Institute for High Energy Physics (IHEP), Protvino, on crystal bending of 70 GeV protons by 9° (150 mrad) and its application for beam delivery during 1994–2004.

At lower particle-accelerator energies, crystal channelling can be used to produce low-emittance beams useful for medical and biological applications. The success in bending beams of less than 1 GeV was reported from the Beam Test Facility of the INFN's Laboratori Nazionali di Frascati (LNF). Here, a positron beam of about 500 MeV provides the right energy scale for using the facility as a test bench for possible future applications of crystal techniques with light ions in medical machines. This study was made possible through the support of Transnational Access to Research Infrastructure granted to LNF by the European Union as one of the major research infrastructures in Europe to give free access to researchers for the period 2004–2008. The advances in crystal micro-technology for producing micro-beams for possible future applications in radio- ▷

biology and medicine was also reported by the INFN-IHEP collaboration. This work covers the range from lower energies (kilo-electron-volts and mega-electron-volts) to higher energies (giga-electron-volts) and compares channelling techniques with alternative ones.

From Japan, a collaboration from Hiroshima University and KEK reported on an experiment on electron-beam deflection with channelling in silicon crystals at the 150 MeV electron ring of the university's Relativistic Electron Facility for Education and Research. The group plans tests with bent crystals at KEK's Proton Synchrotron and aims to apply crystal deflection of high-energy beams at the Japan Proton Accelerator Research Centre, the 50 GeV high-intensity proton machine currently under construction in Japan.

Undulators and targets

While bent (and also focusing) crystals are well-known tools in accelerators, crystal undulators are just being introduced into experiments. Channelling undulators offer sub-millimetre periods and magnetic fields of the order of 1000 T. Samples of crystal undulators have already been manufactured and tested with X-rays and in channelling proton beams. Now tests using positron beams have been started at IHEP Protvino and at CERN's Super Proton Synchrotron, and are also planned at LNF. The first data from the experiment on positron radiation in a crystal undulator at IHEP were presented at the workshop.

The Yerevan Physical Institute presented calculations on radiation produced by 20 MeV electrons channelled in the crystallographic planes of quartz, both with and without periodic deformations. The institute also plans experiments to study the influence of external fields on channelling radiation.

Intense positron sources using crystal effects are another application of strong coherent fields. A number of talks reported on the theories of coherent radiation and pair production in ordered matter, and CERN's WA103 collaboration reviewed the experimental progress in the field. The KEK–Tokyo–Tomsk–Paris collaboration reported a study of positron production from a thick silicon-crystal target using 8 GeV channelling electrons with high bunch charges.

The workshop marked two decades since the experimental discovery of parametric X-ray radiation (PXR) in Tomsk in 1985: the radiation is generated by the motion of electrons inside a crystal, such that the energy intensity of the radiation depends on the parameters of the crystal structure. PXR has since been a subject of experimental and theoretical research and possible applications at accelerators, and was a subject in many talks at the workshop. A team working at Nuclotron at the Joint Institute for Nuclear Research in Dubna has reported the first observation of PXR from moderately relativistic nuclei in crystals. A nice example of an application is a tunable monochromatic X-ray source based on PXR developed at the Laboratory for Electron Beam Research and Application in Nihon University, Japan. So far the main use of the X-rays there has been in radiography for biological samples such as teeth or bones (figure 1, p37). The contrast of the images was controlled with precise changes of the X-ray energy, a great advantage of a system that uses a PXR beam.

For the future, many interesting directions are foreseen in the field. A great deal of effort worldwide is being put into crystal radiation research and applications. Further progress is expected in applications using bent crystals for beam steering at accelerators. It will be an ideal opportunity to take full advantage of the channelling-crystal potentialities at the LHC and other high-energy accelerators, making crystals to serve for both collimation and extraction. The opportunity to have an extracted beam at a multi-tera-electron-volt machine should stimulate more research at the highest energies into particle interactions with aligned atomic lattices. The first crystal-channelling undulators and their initial tests with positron beams should proceed to the realization of novel radiation sources; thus, new positron-channelling experiments on undulator radiation are eagerly awaited.

The success of the workshop is reflected both in the level of participation, with around 40 specialists coming from different geographical areas, such as Europe, Japan and the former USSR, and in the high quality of the presentations. The resulting papers will be published as a special issue of *Nuclear Instruments and Methods B*, covering nearly all topics of current interest in channelling and radiation in aligned periodic structures at relativistic energies.

Further reading

For the proceedings of the previous workshop held in 2004 see: H H Andersen, S Bellucci, V M Biryukov (eds.) *Nucl. Instrum. Meth. B* **234** 2005 1.

Résumé

La canalisation des particules a le vent en poupe

Les phénomènes induits par des faisceaux de particules de haute énergie interagissant avec de la matière ordonnée trouvent toujours plus d'applications auprès des accélérateurs. Les derniers résultats dans ce domaine en pleine évolution ont été présentés à l'atelier international sur la canalisation relativiste et les phénomènes cohérents dans les champs intenses, tenu à Frascati en juillet 2005. L'atelier a notamment porté sur la canalisation dans les cristaux, tant à haute énergie, au LHC, qu'à basse énergie, dans des applications médicales et biologiques, les onduleurs cristallins, les sources intenses de positons, et l'utilisation de rayonnement X paramétrique en radiographie.

Stefano Bellucci, *INFN/Frascati, and* **Valery M Biryukov**, *IHEP Protvino.*

Tokyo meeting focuses on nucleon-spin problem

Quark spin, gluon spin and the orbital angular momenta of quarks and gluons can all contribute to nucleon spin, but which has the main role? Physicists met in Tokyo to discuss.

Day two of the 5th Circum-Pan-Pacific Symposium on High Energy Spin Physics included dinner at a traditional Japanese house.

Last summer, physicists from 10 countries came to the campus of the Tokyo Institute of Technology for the 5th Circum-Pan-Pacific Symposium on High Energy Spin Physics, held on 5–8 July 2005. The aim of this symposium is to enhance communications among physicists in the circum-pan-Pacific region as well as with guests from other regions, including Europe. Another feature is the active participation of young physicists.

In 1988, the European Muon Collaboration experiment at CERN reported that quark spin makes only a small contribution to the spin of the proton, contrary to what had been believed for many years. This gives rise to the well-known "nucleon spin problem", now being studied by physicists all over the world: what in fact does give the proton and neutron their spin?

At the symposium, the COMPASS collaboration, EMC's successor at CERN, reported on their measurements of the gluon spin's contribution to the nucleon spin for which they use a high-energy muon beam together with the detection of "open charm" and hadron pairs. In addition to a longitudinally polarized deuteron target, COMPASS occasionally uses a transversely polarized deuteron target, and so can measure the Collins effect and hence the transversity distribution $\delta q(x)$ (*CERN Courier* October 2004 p51). $\delta q(x)$, which is the distribution of transversely polarized quarks in a transversely polarized target, is the third distribution function at twist two, along with the momentum distribution $q(x)$ and helicity distribution $\Delta q(x)$.

At DESY, the HERMES experiment has performed quark flavour separation of helicity distributions $\Delta q(x)$ using a ring-imaging Cherenkov detector for hadron identification. Further progress in this experiment has come with a transversely polarized hydrogen target, which has enabled the Collins and Sivers effects to be separately identified for the first time. Identifying each of these effects with both HERMES and COMPASS will also help in understanding the mechanism in hadron reactions, such as the sizeable single-spin asymmetries observed, for example, by the E704 experiment at Fermilab and STAR at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven. A relationship between the Sivers effect and the orbital angular momenta of quarks has been suggested theoretically, and the quark orbital angular momentum could contribute to the nucleon spin.

RHIC uses polarized proton–proton collisions to study the nucleon-spin problem, and both the luminosity and beam polarization are becoming higher every year. Here each proton beam can be ▷

regarded as a bundle of high-energy partons, where gluon–gluon collisions and gluon–quark collisions tell us about the role of the gluon's spin in the proton. The double-spin asymmetry A_{LL} in π^0 meson production has been measured with longitudinally polarized proton beams as a function of transverse momentum, p_t, and transversely polarized proton beams are also used. At the symposium the PHENIX and STAR collaborations at RHIC presented recent data along with interesting plans for the future.

Jefferson Lab also has a variety of experiments to study the nucleon-spin problem. The symposium presented experiments on the quark helicity distribution at large x, deeply virtual Compton scattering, single-spin asymmetries from semi-inclusive hadron detection, investigations in the nucleon resonance region and quark–hadron duality and so on, as well as the plan for a future beam-energy upgrade. High luminosity is one of the merits of Jefferson Lab.

The Belle collaboration at the KEK B-factory reported their analysis of the Collins fragmentation function in the hadronization process in positron–electron collisions, where a non-zero value for the function was observed. This fragmentation function is needed to extract the transversity distribution $\delta q(x)$ from the Collins effect observed in lepton–nucleon scattering.

The symposium also presented plans for a neutrino-scattering experiment to study the spin of strange quarks in the nucleon. In addition, there were theory talks on nucleon-spin structure based on lattice quantum chromodynamic calculations, the chiral quark soliton model, di-quark model and resummation method etc. Here developments in generalized parton distributions were a main topic.

The symposium consisted completely of plenary sessions, so that all the participants could share the same discussions. On the afternoon of the second day, a boat trip was organized at Yokohama Bay, followed by a visit to a Japanese-style garden and a conference dinner in an old traditional Japanese house in the garden.

● For the talks at the symposium see www.nucl.phys.titech.ac.jp/~pacific-spin05/.

Résumé

Une réunion sur le problème du spin du nucléon à Tokyo

L'été dernier, des physiciens de dix pays se sont réunis à Tokyo pour le 5e symposium Circum et Pan Pacifique sur la physique du spin à haute énergie, tenu pour promouvoir la communication des physiciens de la région, entre eux et avec les autres régions, dont l'Europe. Le thème central était le "problème du spin du nucléon": le spin du quark, le spin du gluon et le moment cinétique orbital des quarks et des gluons peuvent tous concourir au spin du nucléon, mais dans quelles proportions? On y a entendu les derniers résultats de l'expérience COMPASS (CERN), de HERMES (DESY), des collisions proton–proton (RHIC) et d'études à plus basse énergie (Laboratoire Jefferson et installation KEKB – expérience Belle).

Toshi-Aki Shibata, *Tokyo Institute of Technology.*

AWARDS

Suppliers win Golden Hadrons

The fourth CERN Golden Hadron awards saw seven suppliers for the Large Hadron Collider (LHC) receive recognition for their high quality of work, respect for delivery dates, flexibility, and adaptability to the demanding working conditions of the project.

The awards went to Kemppi-Kempower (Finland), Metso Powdermet (Finland), Transtechnik (Germany), Babcock Noell Nuclear (Germany), Iniziative Industriali (Italy), ZTS VVU Košice (Slovakia), and Jehier (France).

Babcock Noell Nuclear (BNN) received its award for the successful production of a third (416 cold dipole masses) of the LHC's superconducting dipole magnets, one of the collider's most critical and complex components. BNN produced the magnets eight months ahead of the contract deadline, delivering high-quality magnets with an exceptional performance, despite the insolvency of its parent company in 2002.

Metso Powdermet manufactured most of the end covers for the LHC superconducting magnets and other cryogenic equipment. Metso stepped in and launched a "crash programme" after the company originally holding the pre-series contract refused to deliver. Metso adapted its unique powder metallurgy technique to the LHC, involving melting fine metal powder in a process that replaces welding and reduces costs.

Jehier has designed, and is now producing and delivering, multi-layer insulation (MLI) blankets for the LHC's superconducting magnets, fulfilling CERN specifications. After the delivery of thousands of MLI blanket sets, no non-conformities have been found. Jehier demonstrated its goodwill and flexibility to adapt its production to numerous requests from CERN during the crisis with the cryogenic distribution line, and the company made considerable efforts to supply at short notice.

Representatives of the seven companies with their Golden Hadron awards, together with Lyn Evans, project leader for the LHC.

A leading manufacturer of arc-welding equipment, Kemppi-Kempower produced the only workable prototype of the high-current and high-precision power converter for the LHC, when faced with competition in 2002 from two other suppliers. Subsequently, the Finnish firm received the contract for pre-series and series delivery, and by July 2005, 82 power converters had been delivered and accepted, constituting 42% of the total production.

At the end of 2002, Transtechnik, who provide power electronics for railway applications, went bankrupt having already delivered successful prototypes of the main quadrupole power converters and four-quadrant power converters for the LHC. Fortunately, another firm, Drosten, took over Transtechnik and all the key engineers remained with the company. Transtechnik is now back on schedule, having recouped the time lost due to the financial difficulties.

Since 2003, Iniziative Industriali has installed more than 1600 tonnes of steel structures and several kilometres of piping in the LHC tunnel and underground caverns. This is a great achievement, as more than half the design-specification drawings for the steel structures were unavailable when the contract was initially signed. Iniziative Industriali and its subcontractors have adapted their means of production to satisfy CERN's requirements.

The LHC has required the development of very hi-tech handling devices for installing the big, heavy and fragile superconducting magnets in the very confined space of the LHC tunnel. Specialists in machine engineering and electro-technical products, ZTS VVU Košice in Slovakia, manufactured five equipment-transfer sets for CERN. These robots can carry the LHC magnets from the transport vehicles inside the tunnel and align them with the magnets' support jacks with high precision (0.1 mm).

Julius Wess receives award from Humboldt-University

Julius Wess has been awarded the degree of *Doktor rerum naturalium honoris causa* by the Mathematics and Science Faculty I of the Humboldt-University Berlin to mark the occasion of Einstein World Year of Physics 2005. The award ceremony took place on 25 October in the new physics-institute building in Berlin-Adlershof.

The award recognizes numerous scientific contributions Wess has made to mathematical and theoretical physics, and more specifically his contributions to quantum field theory and anomalies, the discovery of supersymmetry, the development of superspace geometry, and his work on non-commutative spacetime. This work, much of which was done in collaboration with Bruno Zumino, continues to play a key role in present efforts to understand the fundamental structure of space, time and matter.

Julius Wess, right, receives the honorary doctor award from the dean of the Mathematics and Science Faculty I of Humboldt-University Berlin, T Buckhout, centre, and the director of the Physics Institute, Fritz Henneberger.

AWARDS

Herwig Schopper honoured

Herwig Schopper, left, together with the Danish minister for Science, Technology and Innovation, Helge Sander, who presented the UNESCO medals.

Herwig Schopper, CERN director-general 1981–1988, has received the UNESCO Niels Bohr Gold Medal along with Sir Martin Rees, Britain's astronomer royal, and Peter Zoller of Insbruck, a central figure in quantum information. The medals, which were presented at the Danish Royal Academy of Science and Letters on 15 November, recognize scientific excellence, concern with the impact of science, and efforts to promote the free exchange of ideas on a broad international scale.

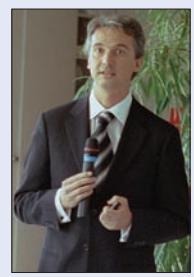
Schopper is president of the International Centre for Synchrotron Light for Experimental Science and Applications in the Middle East (SESAME) council (*CERN Courier* November 2002 p6). This is the second UNESCO award Schopper has received in the past two years. In April 2004, he received the Albert Einstein Gold Medal (*CERN Courier* June 2004 p39).

The Alexander von Humboldt Foundation has made research awards to Joël Feltesse of CEA/Saclay and Bikash Sinha, director of the Saha Institute of Nuclear Physics.

Feltesse has received one of six Helmhotz–Humboldt awards made annually to internationally acknowledged scientists from outside Germany in recognition of their research achievements. These are awarded jointly by the Alexander von Humboldt Foundation and the Helmholtz Association. The award to Feltesse acknowledges his outstanding contribution to the study of deep inelastic scattering and the important role he played in the development of European particle physics during his time as spokesman of the H1 experiment at DESY, as director of DAPNIA at Saclay, and as chair of CERN's Scientific Policy Committee. He was among the first to realize the importance of low x physics in the exploration of high gluon densities in the proton.

Joël Feltesse, left, and Bikash Sinha.

Sinha has received a Humboldt research award for his exceptional achievements in changing the scale and dimensions of nuclear-physics research in India. Sinha, who is also director of the Variable Energy Cyclotron Centre (VECC), worked with the Mumbai-based Bhabha Atomic Research Centre and successfully campaigned for the setting up of heavy-ion accelerators in India. The VECC is currently working on a superconducting cyclotron and a project to develop a radioactive-beam facility.



Patrick Janot du CERN a reçu la médaille d'argent 2005 du CNRS pour l'IN2P3 (Institut national de physique nucléaire et de physique des particules). Ce prix, l'un des plus prestigieux du centre de recherche français, lui a été remis plus particulièrement pour ses travaux lorsqu'il était coordonnateur scientifique du grand collisionneur électron–positon (LEP) au cours des deux dernières années de fonctionnement de l'accélérateur, en 1999 et 2000, et son "rôle central dans la recherche du boson de Higgs" durant cette période. Il s'est notamment illustré en proposant des idées novatrices pour pousser les performances de la machine dans leurs retranchements et atteindre une énergie de 209 GeV tout en optimisant la luminosité.

E-PUBLISHING

J-journals expand into radiation instrumentation

The International School for Advanced Studies (SISSA) and the Institute of Physics (IOP) have launched the new online-only *Journal of Instrumentation* (JINST). Recent years have seen a huge growth in instrumentation science and JINST has been created to support the needs of this expanding community.

JINST covers all fields of radiation instrumentation and deals both with concepts and experimental techniques, as well as with related theoretical aspects, modelling and simulations. Major JINST sections include accelerator science, instrumentation and methods for accelerators and accelerator experiments, detector physics, detectors and apparatus for particle and nuclear physics, methods and apparatus for astronomy and astrophysics, detectors for biomedical applications, instrumentation and methods for medical applications, non-destructive testing, and detector-readout concepts and electronics.

The SISSA–IOP online-only J-journals (JHEP, JCAP, JSTAT) have proved to be remarkably successful in terms of quality and impact. Like its siblings, JINST will feature highly distinguished advisory and editorial boards. Unlike traditional journals, the editorial board of the J-journals is entirely responsible for the peer-review process: authors are thus assured that the fate of their submissions is in the hands of active scientists.

For the first year JINST will available free of charge. As with the other J-journals, papers published in JINST will be available on open-access terms for the first month of publication and all papers will remain free of charge to institutions in developing countries.

● To access JINST see http://jinst.sissa.it or www.iop.org/EJ/journal/jinst.

PERSONALITY

Alexander Skrinsky celebrates his 70th year

Alexander Skrinsky, or Sasha as his friends and colleagues call him, was 70 on 15 January. The occasion was celebrated on 14–16 January at the Budker Institute of Nuclear Physics (BINP) in Novosirirk, where he is director, with an international seminar entitled Selected chapters of modern high energy physics and charged particle accelerators.

An outstanding member of Gersh Budker's Siberian school, Skrinsky went to Novosibirsk after graduating from Moscow University in 1959, and progressed to become director. From the earliest days, he led the pioneering team working on electron–electron and electron–positron colliders. The successful commissioning of these machines, which earned him the Lenin Prize in 1967, opened a new era in experimental high-energy physics. An attempt to extend this work to heavy particles stimulated the development of electron cooling, a technique today exploited all over the world. Now the high-energy physics community is developing the International Linear Collider project, the conceptual design of which was suggested 30 years ago by Skrinsky together with Budker and Vladimir Balakin.

Skrinsky's early fascination with spin dynamics resulted in major developments for polarized beams in colliders, leading to the discovery and subsequent development of resonance depolarization for high-precision measurements of particle masses. For this, Skrinsky and other physicists at Novosibirsk received the State Prize of the USSR in 1989.

Alexander Skrinsky, who was 70 in January, celebrated at the BINP, where he is director.

Skrinsky's wide physics interests are a continual source of fresh ideas, including the optical klystron – a special free-electron laser – and various industrial applications of radiation technologies. For the past few years he has been developing the concept of an international muon collider using ionization muon cooling as he proposed together with Budker in the 1970s. At present he is actively supporting an upgrade of the complex of colliders at Novosibirsk, which will include new acceleration options such as round beams and monochromatization. The aim is to achieve copious production of ϕ mesons and τ leptons.

As a leader of a major Russian physics centre and as a head of the nuclear-physics section of the Russian Academy of Sciences, Skrinsky contributes to the scientific programme of major accelerator laboratories and furthers the interests of Russian physicists in various international projects, in particular construction of the Large Hadron Collider and its detectors at CERN, and experiments at the B-factories at KEK and SLAC. He is an active member of several international committees on scientific politics in high-energy physics.

SUMMER SCHOOL

CERN and Fermilab offer joint hadron-collider summer schools

For the past few years, experiments at Fermilab's Tevatron collider have been exploring uncharted territory at the high-energy frontier of particle physics. With CERN's Large Hadron Collider (LHC) operations to start in 2007, a new era in the exploration of the fundamental laws of nature will begin.

In anticipation of this era of discovery, Fermilab and CERN are jointly launching a series of Hadron Collider Physics Summer Schools, with the aim of offering students and young researchers a complete picture of both the theoretical and experimental aspects of hadron-collider physics. The first school will take place on 9–18 August 2006 at Fermilab; the following one will be at CERN in the summer of 2007.

Preparing young researchers to tackle the current and anticipated challenges of hadron colliders, and spreading the global knowledge required for a timely and competent exploitation of the LHC physics potential, are concerns equally shared by CERN, the LHC host laboratory, and by Fermilab, the home of the Tevatron and host to the CMS collaboration's LHC Physics Center in the US.

The first school will include nine days of lectures and discussions, with one free day in the middle of the period. The emphasis will be on the physics potential of the first years of data-taking at the LHC, and on the experimental and theoretical tools needed to exploit that potential. The school will be focused to attract senior graduate students and recent PhDs in both experimental and theoretical particle physics.

The lectures and discussions will include an introduction to the theoretical and phenomenological framework of hadron collisions, and current theoretical models of frontier physics, as well as an overview of the main detector components, the initial calibration procedures and physics samples, and early LHC results. Examples of physics analyses drawn from the current Tevatron experience will help inform these exchanges.

Scholarship funds will be available to support some participants. Updates, application procedures, and more details will be available at the website for the first school: http://hcpss.fnal.gov.

EXHIBITIONS

Bulgaria welcomes CERN exhibition

In Bulgaria's first CERN exhibition more than 1400 people, many of them students and young physicists, visited the National Earth and Mankind Museum in Sofia on 8–17 November 2005. Permanently staffed by young physicists from Sofia University, there were exhibits about research activities at CERN, and four posters describing Bulgaria's participation.

The inauguration on 8 November took place in the presence of Vanya Dobreva, Vice-Minister for Science and Education, and some 200 guests. Organized by Matey Mateev, president of the Union of Physicists in Bulgaria, the exhibition allowed CERN to present the laboratory and the Large Hadron Collider (LHC). It also underlined the important contribution that Bulgarian physicists are making towards the LHC and experiments at CERN.

CERN's first exhibition in Bulgaria covered the LHC and other experiments at CERN.

EDUCATION

Physicists and teachers unite

On 4–7 July 2005 the beautiful building of the German Physical Society in Bad Honnef outside Bonn hosted EPEC-1, the first EPS Physics Education Conference. Participants from 20 countries gathered to present and discuss education projects and initiatives in physics education. The aim was to provide a forum for new physics-education methods and initiatives, involving school teachers and university teachers in a dialogue and informal alliance to make physics at school and university more interesting.

The conference presented frontline physics from several fields, experiences in physics education and examples of how to use multimedia in education. The Frontiers lectures were much appreciated and it was gratifying to observe the willingness of leading researchers to participate in a conference that was directed primarily towards education. Werner Hoffman of the Max Planck Institute for Nuclear Physics, Heidelberg, spoke on elementary particles and the cosmos; Uwe Czarnetski of Bochum described recent advances in Bose–Einstein condensates and the construction of matter lasers; Klaus Ensslin of ETH, Zurich, discussed the work that he and his group have carried out in nanophysics and the fabrication of nano-scale devices; and Guy de Mortier from the Laboratorie d'analyses par reactions nucléaires, Namur, described some of his many applications of nuclear techniques to problems in medical physics and archaeology.

Among the educational topics, Thomas Trefzger of Mainz described a neat experiment to observe cosmic muons using a thermos flask as a simple Cherenkov detector for cosmic-ray muons. Jef Colle and Frits Hidden presented HiSPARC, the Dutch cooperative project between the scientific community and high schools that aims to detect high-energy cosmic showers with scintillation detectors housed in ski boxes on the roof of several schools in the Netherlands.

There was a general consensus that there should be an EPEC-2 in 2007 where physics teachers and scientists can continue to present their work on making physics education more interesting.

● Talks and reports can be found at www.physik.uni-mainz.de/lehramt/epec/.

PRODUCTS

Acqiris has introduced the first 10 bit, 4GS/s 3U PXI digitizers, with input bandwidths of up to 3 GHz. The dual-channel DC152 and single-channel DC122 units reduce testing and data-acquisition time, making them ideal for high-speed applications. See www.acqiris.com.

Instrumentation Technologies has extended its Libera product family for beam stabilization, introducing Libera Bunch-by-Bunch, which dumps coupled bunch instabilities and helps provide beam users with a more stable orbit. It enables digital signal processing, data storage, fine delay of analogue output, and a sampling rate of up to 500 MHz. For more information see www.i-tech.si/products-libera-bbfp.html.

Ulvac Technologies, Inc, has introduced the MS-E1S microscope, which, with an integrated hot furnace, enables the direct observation of materials samples during heating and cooling experiments, as in semiconductor and metallurgical investigations. The unit integrates a compound optical microscope with an infrared gold image furnace hot stage and a video recording and display system. For further information contact Evan Sohm, tel: +1 978 686 7550, fax: +1 978 689 6300, e-mail: evan_sohm@ulvac.com or see www.ulvac.com.

MEETINGS

The **International Accelerator School for Linear Colliders** will take place on 19–27 May at Sokendai, Hayama, Japan. Organized by the International Linear Collider (ILC) Global Design Effort, ICFA Beam Dynamics Panel and the ILC Steering Committee, the primary focus of the school will be on the ILC, but it will also cover multi-tera-electron-volt colliders, such as the Compact Linear Collider. This seminar-style school is intended for graduate students, postdocs and young researchers. Applications are welcomed from physicists who are considering changing their career from experimental physics to accelerator physics. Students from around the globe will be accepted into this first global accelerator school for linear colliders. For further information contact Yoko Hayashi, KEK, tel: +81 29 864 5214, or e-mail ilc-school@milk.kek.jp or see www.linearcollider.org/cms/?pid=1000171.

The **XXVI Physics in Collision** conference will take place in Búzios, Rio de Janeiro on 6–9 July. These international conferences, which began in 1981, comprise invited talks and contributions in poster sessions. Speakers review and update key topics in elementary-particle physics with the aim of encouraging informal discussions on new experimental results and their implications. For further details see http://omnis.if.ufrj.br/~pic06/.

LETTERS

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

In my proof that four-legged tables can be put in equilibrium, what matters of course is that the feet form a perfect square (*CERN Courier* December 2005 p9). The top can be anything, in particular a disc. The next step is to extend the proof to the case where the four feet are on a circle, for instance, form a rectangle, and also a half hexagon, like the tables you find in the "salle des pas perdus" at CERN or in certain conference rooms. *André Martin.*

CORRECTIONS

In the obituary for John Bahcall, who died in August 2005 (*CERN Courier* December 2005 p41), his year of birth was unfortunately incorrectly given as 1935. John was in fact born in 1934. *CERN Courier* offers its apologies to all concerned.

In the obituary for Cesare Mansueto Giulio Lattes, who died in March 2005 (*CERN Courier* November 2005 p48), the first sentence implied that Lattes was the last surviving member of the team that discovered the pion. Hugh Muirhead is however still with us, and *CERN Courier* would like to wish him well and apologise to him and his family for any undue upset this error may have caused.

RECRUITMENT

For advertising enquiries, contact *CERN Courier* recruitment/classified, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel: +44 (0)117 930 1027. Fax: +44 (0)117 930 1178. E-mail: sales@cerncourier.com.
For more information about publication dates, deadlines and advertising rates, please contact Adam Hylands (e-mail: adam.hylands@iop.org).

GSI Darmstadt

The position of

Scientific Director

at the Gesellschaft für Schwerionenforschung mbH (GSI) in Darmstadt is to be filled with effect from 1 April 2007.

The GSI is a member of the Helmholtz Association of National Research Centres and receives 90% of its funding from the Federal Government and 10% from the State of Hesse. The GSI conducts heavy ion research in the fields of nuclear physics, nuclear chemistry, atomic physics, physics of dense plasmas, materials research, radiation biology and related areas. It operates a system of heavy ion accelerators and numerous experimental plants for this purpose.

The GSI currently employs approximately 1000 members of staff. In addition, a further approximately one thousand external scientists from around 35 different countries conduct research work using the GSI's accelerators each year. The GSI's budget for 2005 amounted to approximately 85 million euro. More detailed information is available at http://www.gsi.de/

A European accelerator centre with unique opportunities for research in the above-mentioned fields is to be established in Darmstadt under the „FAIR – Facility for Antiproton and Ion Research" project, which is to be conducted jointly with European and international partners (construction due to begin 2007/2008). The GSI will assume a leading role in the construction and subsequent operation of FAIR.

Apart from being responsible for the scientific work of the GSI, the Scientific Director is thus also responsible for cooperation in FAIR. He or she will represent the centre and its research activities in dealings with third parties, particularly at the interface between science and politics, and will be familiar with the German and European science system. He or she will promote the scientific and structural development of the GSI within the framework of the Helmholtz Association's programme-based funding and in the light of international competition.

Candidates should have an outstanding scientific profile, excellent powers of leadership, the ability to take decisions, social talents, the willingness and ability to communicate with and motivate others, extensive managerial experience with complex organizations, and outstanding skills in the communication of research and science. Experience with the management of large-scale projects, preferably also at international level, is an advantage. Candidates should also demonstrate abstract planning ability, organizational skills and the ability to assert themselves, and should have experience in the field of international cooperation.

The appointment will be for a period of five years. Reappointment is possible. Remuneration will be based on the salary scale for senior university professors.

The members of the Helmholtz Association have set themselves the goal of promoting women in leadership positions. Applications from women are therefore especially welcome.

Please send your application, enclosing relevant documents, within six weeks of the publication of this advertisement to:

The Chair of the Supervisory Board of the
Gesellschaft für Schwerionenforschung mbH
- Dr. Beatrix Vierkorn-Rudolph -
- Private and Confidential -
Bundesministerium für Bildung und Forschung
(Federal Ministry of Education and Research)
53175 Bonn
Germany

Faculty Position in Accelerator Physics

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

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

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

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

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

Faculty Position in Theoretical Elementary Particle Physics

The Stanford Linear Accelerator Center at Stanford University invites applications from outstanding candidates from all areas of elementary particle theory for a tenure-track faculty appointment.

Candidates should have demonstrated their ability to carry out independent research in theoretical particle physics at the highest level. The position includes opportunities for classroom teaching and supervision of Stanford graduate students. The position allows a close interaction with the experimental program at the Stanford Linear Accelerator and with the program of the new Kavli Institute for Particle Astrophysics and Cosmology.

Applicants should submit a curriculum vitae, publication list, and statement of current research interests and future plans, and should arrange for four letters of recommendation to be sent to: **Professor Lance Dixon, Theory Search Chair, MS 81, SLAC, P.O. Box 20450, Stanford, CA 94309-0450.** All material should arrive in **February 2006.**

Stanford University is an equal opportunity employer and is committed to increasing the diversity of its faculty. It welcomes nominations of and applications from women and members of minority groups, as well as others who would bring additional dimensions to the university's research and teaching missions.

Deutsches Elektronen-Synchrotron
Accelerator physics

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 running of Free-Electron Lasers like the VUV-FEL and the XFEL electron sources with excellent beam quality are needed. For the development of such electron guns a test facility for rf photo injectors was realized at DESY Zeuthen (near Berlin). We are searching a

scientific associate

participating in the photo injector project.
We expect you to have a Ph.D. in physics or engineering. You have substantial knowledge and professional experience in one or more of the following fields: accelerator physics, solid state or surface physics, software development for data acquisition systems, hardware development of accelerator subsystems or beam diagnostics. You will contribute significantly to the upgrade and the optimization of the facility. It will be expected that you take over responsibility for a sub-project like e. g. the further development of photocathodes or a deflecting rf-cavity. You like to work in a motivated team of physicists and engineers and have a good knowledge of the English language. In the framework of the position shift work may be necessary at times. For further information, please contact Dr. Frank Stephan, phone: +49 33762-77338 (frank.stephan@desy.de, http://www.desy.de/pitz). Please send your complete application documents (application letter, detailed CV, publication list, high school and university reports, adresses of three referees) to our personnel department.

The position is limited to 2 years at the beginning.

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

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association

Kennziffer: 5/2006 · Platanenallee 6 · D-15738 Zeuthen · Germany
Phone +49 33762-77240 · www-zeuthen.desy.de
email: personal.abteilung-zeuthen@desy.de

Deadline for applications: 28.02.2006

UNIVERSITY of GLASGOW

DEPARTMENT OF PHYSICS AND ASTRONOMY

Research Assistant

£20,044 – £30,002

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

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

The University is committed to equality of opportunity in employment.

www.gla.ac.uk

DIRECTOR OF RHIC/US ATLAS COMPUTING FACILITY

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

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

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

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

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

BROOKHAVEN NATIONAL LABORATORY

A passion for discovery.

www.bnl.gov

UNIVERSITY of CALIFORNIA Riverside

FACULTY POSITION IN COSMOLOGY/PARTICLE ASTROPHYSICS

Department of Physics
University of California, Riverside

The Department of Physics at the University of California, Riverside, is seeking an outstanding individual for a faculty appointment in the area of cosmology/particle astrophysics. This appointment will initiate a new program at UCR, which will complement existing programs in Astronomy, Astrophysics and Elementary Particle Physics. The appointment will be at the Assistant, Associate or Full Professor rank, as appropriate. The appointment will be effective July 1, 2006.

We encourage applications from candidates capable of instituting and sustaining a vigorous research program, and having an outstanding record of research achievement and leadership in one or more areas relevant to the field, such as dark matter or dark energy, structure formation, or the early universe. Candidates are also expected to support the training of graduate students and teach at the undergraduate and graduate levels.

Salary will be competitive and commensurate with qualifications and level of appointment.

Applicants should submit curriculum vitae, list of publications, statement of research and teaching objectives, and names and addresses of four references. Applications should be directed to: **Chair, Cosmology Search Committee, Department of Physics, University of California, Riverside, 3401 Watkins Drive, Riverside, CA 92521-0413**

Review of applications will commence on February 1, 2006, but the position will remain open until filled. For more information please visit the UCR web site at **www.ucr.edu**, the College of Natural and Agricultural Sciences at **www.cnas.ucr.edu**, and the Department of Physics at **http://www.physics.ucr.edu/** .

UCR UNIVERSITY OF CALIFORNIA, RIVERSIDE

The University of California is an Equal Opportunity Employer committed to excellence through diversity.

TENURE TRACK and POSTDOCTORAL positions in NEUTRINO ASTROPARTICLE PHYSICS

The NESTOR Institute for Astroparticle Physics, which recently became part of the National Observatory of Athens (NOA), invites interested physicists to apply by November 21 for the tenure track position of Associate Researcher (grade gamma). Furthermore, the NESTOR/NOA Institute will have a number of tenured (Research Director or Principal Researcher levels) or other tenure track openings in the near future, inquiries are encouraged.

The NESTOR Institute has been awarded a Center of Excellence grant by the General Secretariat for Research and Technology.

IN ADDITION: The Physics Departments of the Universities of Athens and Cyprus, the Institute of Nuclear Physics at the National Center for Scientific Research "Demokritos" and the NESTOR Institute for Astroparticle Physics/NOA are seeking candidates for a number of postdoctoral Research Associate positions (at varying seniority levels) in the field of Neutrino Astroparticle Physics. Candidates should have experience in the fields of Experimental Particle, Nuclear or AstroPhysics.

The groups mentioned above play leading roles in the NESTOR experiment, hosted by the NESTOR Institute, or the KM3NeT (Cubic kilometer Deep Sea Neutrino Telescope) collaboration and form a significant part of the proponents for the KM3NeT Design Study which has been recently funded by the 6th FP of the E.U. Successful applicants will participate in the ongoing NESTOR experiment and/or the design and development of the KM3NeT project. Further information for all the above positions can be obtained at the NESTOR Institute (www.nestor.org.gr) or by contacting the Institute at email:secretary@nestor.org.gr

ALBERT-LUDWIGS-UNIVERSITÄT FREIBURG

The Faculty of Mathematics and Physics invites applications for a

Junior Professorship in Theoretical Physics (W1)

in the field of theoretical particle physics with emphasis on phenomenology. It is desirable that the candidate participates in the Graduiertenkolleg "Physik an Hadron-Beschleunigern", especially in the field of LHC physics. The successful candidate will participate in the teaching duties of the department at the level of 4 (6) hours per week. Prerequisites for a junior professorship are as specified in § 51 Abs. 2 LHG. Required is an excellent research record in theoretical particle physics.

In case the candidate has been employed before or after obtaining the PhD degree, the combined duration of employment and PhD thesis should be less than 6 years. The Junior professorship is limited initially at 4 years and can be extended up to 6 years in total.

The university is seeking to increase the number of female faculty members and therefore especially encourages suitably qualified women to apply. Applicants with a physical handicap will be given preference over other candidates when they have equal qualifications.

Applications (with a curriculum vitae, copies of certificates, list of publications and teaching records) should be sent by 15 March 2006 to Dekan der Fakultät für Mathematik und Physik, Eckerstr. 1, D-79104 Freiburg, Germany.

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

Staff position in Theoretical Hadron Physics (tenure track)

Ref. No.: 1810-05.62

We are seeking an outstanding individual with expertise in lattice gauge theory to strengthen the theoretical activities in the area of non-perturbative QCD. He/she is expected to build and lead a research group of international visibility in the field of numerical simulations for hadron spectroscopy and/or QCD thermodynamics and to actively participate in conceptual theoretical developments in the framework of the FAIR project. Involvement in the teaching of advanced courses in hadron physics at one of the nearby Universities is envisaged.

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

Applications including curriculum vitae, list of publications and statement of research and teaching experience should be sent not later then **28.02.2006** to

GSI Darmstadt

Gesellschaft für Schwerionenforschung mbH
Personalabteilung
Ref. No.: 1810-05.62
Planckstraße 1
64291 Darmstadt
GERMANY

THE UNIVERSITY *of* LIVERPOOL

Department of Physics

Physicist/Engineer (Prinicipal Experimental Officer)

£31,525 - £39,935 pa

Joining the High Energy Physics Group (HEPG), you will work in the area of radiation tolerant tracking detector development. Current work includes the LHCb vertex detector (VELO), the ATLAS SCT and future upgrades for the LHC programme including pixel technology and you will take a leading role in the LHCb programme.

You should hold a PhD in experimental particle physics, or closely allied research involving position sensitive detectors. Familiarity with development and testing of solid state devices, data acquisition systems and some experience with HEP software would be a strong advantage. The post is available for three years.

Quote Ref: B/626/CERN **Closing Date: 20 February 2006**

For full details, or to request an application pack visit www.liv.ac.uk/university/jobs.html or e-mail jobs@liv.ac.uk Tel: 0151 794 2210 (24 hr answerphone), please quote Ref: in all enquiries

COMMITTED TO DIVERSITY AND EQUALITY OF OPPORTUNITY

Heavy Ion Physics Post Doctoral Fellow

Job# 018686. The Relativistic Nuclear Collisions (RNC) program at Lawrence Berkeley National Laboratory invites outstanding recent PhD recipients to apply for post-doctoral positions. The successful candidates will conduct Heavy Ion experiments using the STAR detector at Relativistic Heavy Ion Collider. Candidates may work in any field of heavy ion physics but preference will be given to those who express interest in heavy flavor physics. One postdoctoral position is reserved for a candidate with a strong interest in building innovative, new technology, silicon detectors for heavy flavor physics measurements. A postdoctoral fellow is normally appointed for two years, with a one year extension possible upon review. For further information about the RNC program or the Berkeley Lab Nuclear Science Division's research programs, please visit **http://www.lbl.gov/nsd**

Applicants should apply online at **http://jobs.lbl.gov** with reference to **Job #018686**. In addition, applicants should submit a curriculum vitae, a publication list, a statement of research interests and arrange to have three letters of reference sent to **Dr. James H. Thomas, MS 70R0319, 1 Cyclotron Rd., Berkeley, CA 94720-8169** or via email to **JHThomas@lbl.gov**. Please mail or email all materials by March 31, 2006. LBNL is an equal opportunity employer committed to developing a diverse workforce.

BERKELEY LAB

Classified advertising

CERN Courier and cerncourier.com offer the only print and online recruitment service that has a direct route to highly skilled job seekers in high-energy physics and related areas.

"*CERN Courier* is one of the best media to reach and attract the cutting-edge scientific profiles we're looking for at the ESRF. Advertising in *CERN Courier* adds value to our recruitment." **Cécile Davan**, *Recruitment advisor, ESRF*

"DESY has chosen *CERN Courier* to advertise in because of the popularity of the magazine – it is read all over the world. It is a great opportunity to advertise in such a prestigious publication and to reach outstanding scientists and fellows." **Christina Grimm**, *Human Resources, DESY*

For further information please contact **Adam Hylands Tel: +44 (0)1179 301 027 Fax: +44 (0)1179 200 726 E-mail: adam.hylands@iop.org**

BOOKSHELF

Astroparticle Physics by Claus Grupen, Springer. Hardback ISBN 3540253122, €37.40, (£27, $59.95).

Claus Grupen provides a comprehensive and up-to-date introduction to the main ideas and terminology of the study of elementary particles originating from astrophysical objects. In fact, as is evident from the historical introduction, astroparticle physics reaches beyond elementary particles and includes gamma radiation, X-rays, gravitational waves, and extensions of the current Standard Model.

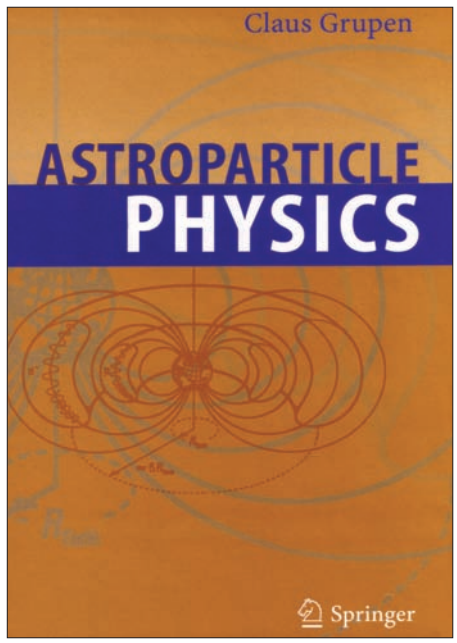
The style and presentation of the material make the book accessible to a broad audience with a basic knowledge of mathematics and physics. A good selection of simple exercises with solutions increases its pedagogical value and makes it suitable as a textbook for an undergraduate course. Non-specialists who want to follow the main issues of current research in the field or to have a general overview before more advanced readings can also benefit from Grupen's book.

A distinguishing feature of the book is the use of relatively simple models directly tied, where possible, to experimental data; these illustrate physical mechanisms or problems without unnecessary details. The main physical motivations for a theory are introduced, its experimental consequences discussed together with the current status of the key parameters and the expected future developments. Both the pedagogical nature and the emphasis on the experimental basis of models are signalled by a chapter dedicated to particle and radiation detectors and, especially, by the many instructive figures and diagrams that illustrate data and their theoretical interpretations.

A good third of the book deals with cosmic rays, our main experimental window on the universe. Grupen presents the astronomy of neutrinos, gammas and X-rays, and discusses and reviews the basic mechanisms for particle acceleration and production, and important topics such as extended atmospheric showers initiated by the highest-energy cosmic rays or gamma-ray bursts. This part constitutes the foundation of astroparticle physics.

The next largest part of the book, about one quarter, is devoted to the thermal history of the early universe, including an extensive description of Big Bang nucleosynthesis.

Introductions to standard cosmology and to basic statistical mechanics are included. In addition there is a concise description of the important information carried by the cosmic



microwave background radiation – in particular, the bearings of the latest measurements of the radiation's angular anisotropy on key cosmological parameters, such as the total energy density, the baryon-to-photon ratio and the Hubble constant.

Before the stimulating overview of some of the open problems and perspectives of the field the author reserves two chapters for inflation and dark matter. These fundamental concepts in modern astrophysics not only answer specific experimental and theoretical questions (rotational curves of galaxies, monopoles, flatness, etc), but raise new ones and stimulate experimental tests.

Marcello Lissia, INFN/Cagliari and University of Cagliari.

A Physicist's Labour in War and Peace: Memoirs 1933–1999 by E Walter Kellermann, Stamford House Publishing. Paperback ISBN 1904985092, £8.99.

The story of the flight of Jewish physicists from the Nazis and their allies in the 1930s is well known, told usually in the context of major players, such as Albert Einstein, or Enrico Fermi. So it is interesting to read of how the events of that time touched someone less well known, but who nevertheless went on to a full and rewarding career in physics. In 1937 Walter Kellermann fled to the UK, where he was to establish his career in physics, in particular in cosmic rays. This book is his story.

After completing his schooling in Berlin, Kellermann left his native Germany in 1933, as the Nazis were making it impossible for Jews to enter university there. To continue his studies, he went to Austria – not the best choice – where he had relatives in Vienna. University regulations there were flexible and after only four semesters he was accepted as a physics-research student with Karl Przibram. Then with German occupation imminent and a DPhil to his credit, he fled to Britain in October 1937, and with some ingenuity secured work at Edinburgh University under Max Born. It was there that he made an important contribution to solid-state physics, calculating for the first time the phonon spectrum.

With the outbreak of war in 1939, Kellermann found himself interned, like many others, despite his refugee status, and was even sent to Canada on a dangerous voyage, during which the internees were kept in a barbed-wire enclosure. Fortunately, he was soon released, and joined the teaching staff at Southampton University.

After the war, Kellermann moved to join Patrick Blackett's group at Manchester, to work on cosmic rays. This was to become his field for the rest of his academic life, in particular from 1949 onwards at Leeds University. At Leeds, he was one of the main instigators of the extensive air-shower detector array at Haverah Park, the forerunner of major modern projects such as the Pierre Auger Observatory. In the early 1970s his "15 minutes of fame" came when Kellermann's group observed a bump in the hadron energy spectrum in cosmic rays, detected in an innovative hadron calorimeter. This could have been due to a new particle, which the researchers dubbed the Mandela. Sadly, the bump was eventually found to be due to a burned-out connection in the detector's custom-built computer. Soon afterwards, Kellermann reached retirement age, but went on to a second career in science policy in Britain, the subject of the final chapter.

Kellermann's account makes fascinating reading, describing the aspirations and frustrations of a physicist who was not centre stage, but moved among a cast of famous names. These included not only Born and Blackett, but also Klaus Fuchs, best known as a spy. The book also presents a revealing view of the British university system, with some alarming examples of racism, in particular in the 1930s and 1940s when departments were keen to keep down the number of refugees.

Christine Sutton, CERN.

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Opera

Music to your ears

2D & 3D electromagnetic modelling

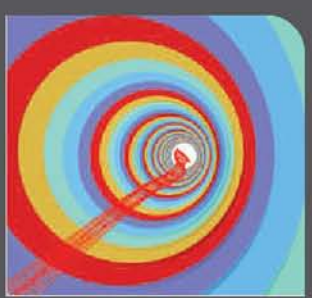
If you're aiming for design excellence, you'll be pleased to hear that OPERA, the industry standard for electromagnetic modelling, gives you the most powerful tools for engineering and scientific analysis.

Designed for parameterisation and customisation, OPERA is incredibly easy to use and has an extensive toolset, making it ideal for a wide range of applications. What's more, its high performance analysis modules work at exceptional levels of speed, accuracy and stability, even with the most demanding models. As a result millions of elements can be solved in minutes, leaving you to focus on creating outstanding designs.

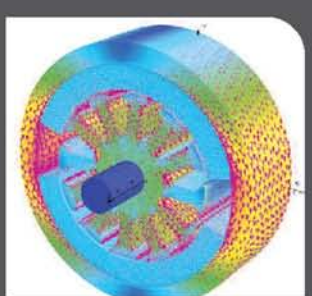
Fast, accurate model analysis

- Actuators and sensors – including position and NDT
- Magnets – ppm accuracy using TOSCA
- Electron devices – space charge analysis including emission models
- RF Cavities – eigen modes and single frequency response
- Motors – dynamic analysis including motion

Don't take our word for it – order your free trial and check out OPERA yourself.



Electron trajectories through a TEM focussing stack



B-field in a PMDC motor

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Vector Fields
software for electromagnetic design

Tools for Discovery

CAEN

Overview

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

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

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

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

Highlights

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

Applications

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

CAEN Nuclear

For more information, call us at +39.0584.388.398 or visit our website at

www.caen.it