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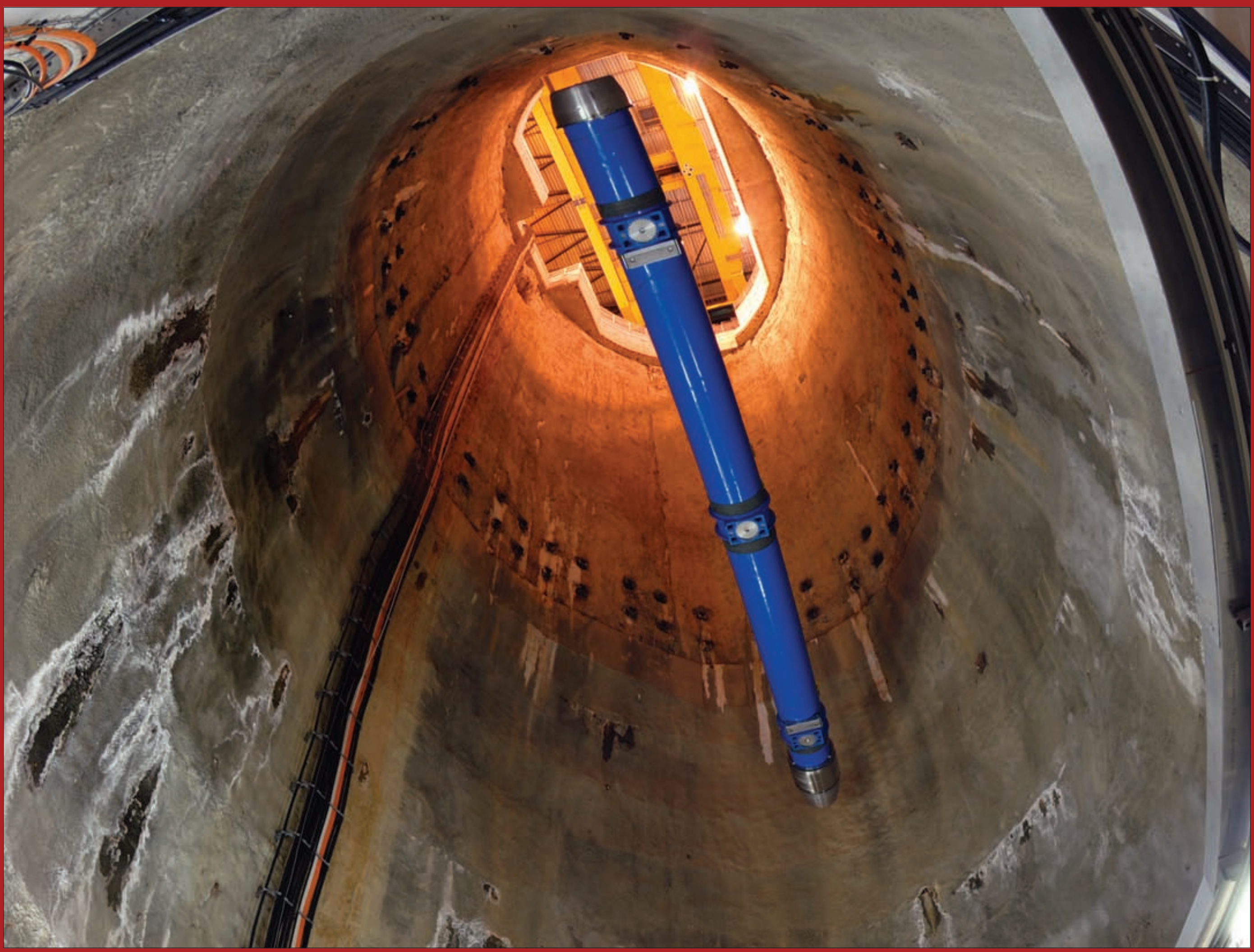

The descent of the last dipole

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

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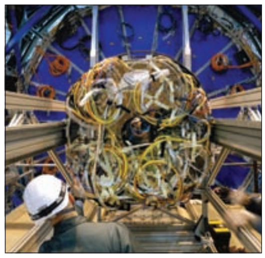


ITS arrives at ALICE p6

The science of beer froth p10

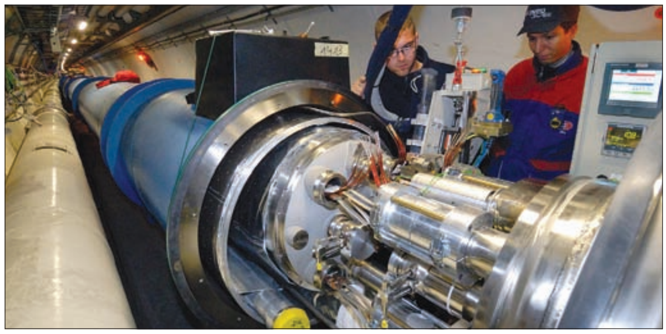
Celebrating first electrons p42

Cover: The last magnet to descend into the LHC tunnel began its journey underground on 26 April, following more than 1700 magnets that had taken the same route over the past two years (p5). All had been tested prior to going underground in a test facility operated largely by teams from India (p19).

NEWS

LHC NEWS

The last dipole makes its descent



Left: The final superconducting magnet for the LHC begins its descent into the accelerator tunnel. Right: Brazers work on the last octant between Points 1 and 2.

On 26 April, the last superconducting magnet for the LHC descended into the accelerator tunnel. The hundreds of guests attending the final lowering ceremony applauded as the superconducting dipole, 15 m long and weighing 34 tonnes, descended through the PM12 shaft. Few of the guests would be well-versed in the Welsh language, but all intuitively understood the inscription on the banner at the top of the shaft: "Magned olaf yr LHC" (Last magnet for the LHC), in honour of Lyn Evans, the LHC's (Welsh) Project Leader.

The PM12 shaft, which was created for the express purpose of lowering the long magnets into the tunnel, has seen 1232 dipoles pass down over the past two years, and 1746 magnets in total. Before going underground, the magnets were fitted with beam screens and underwent final tests and welds in the SM12 hall above the shaft. The lowering operation was a massive challenge owing to the quantity, size and fragility of the items, not to mention the tight deadlines. In addition, it took nearly 10 000 truck journeys to transport the magnets from the various locations where they were stored in France and Switzerland – a total of some 40 000 km, all at 10 kph.

Earlier in the month, on 4 April, work began on the last stretch of interconnections in the LHC as brazers began welding on the final octant, between Points 1 and 2. All of the LHC magnets will be interconnected by September, by which time the teams working on them will have made 123 000 connections in only two years. The task of connecting up all of the machine components has also been a challenge. Vacuum systems, superconducting cables, beam screens, cryogenic pipes and thermal and electrical insulations all have to be interconnected, with each interconnection requiring about 60 operations.

For all of the teams involved, another great challenge is to work in parallel with other ongoing activities. During the final phase, some 200 engineers and technicians, half from CERN and half from the contractor, are working in the LHC tunnel under rather difficult conditions. The work involves a collaboration between CERN, the Krakóv Institute of Nuclear Physics (HNINP) and the Franco–Dutch consortium IEG, which took responsibility for the interconnection work and for supplying welding and brazing machines.

At the same time, physicists and engineers from CERN, Fermilab, Lawrence Berkeley National Laboratory and KEK are preparing to repair 18 sets of structural supports for quadrupole magnets built at Fermilab, one of which failed a high-pressure test in the LHC tunnel in March (*CERN Courier* May 2007 p5). The failure was in a magnet that is part of an "inner triplet" of three magnets, Q1, Q2 and Q3. To fix a design flaw in the supports, the team has proposed to add to each Q1 and each Q3 a set of four cartridges that can absorb the longitudinal force generated during the pressure test. The cartridges are stiff mechanical springs that will be installed parallel to the magnet's cold mass.

The final design reviews for the cartridges will take place at Fermilab and CERN before the end of May and installation of the cartridges in the Q1 and Q3 magnet of at least one inner triplet is scheduled to be complete in early June, in time for the next pressure test. The work can be done in the LHC tunnel, with the magnets in place. Only the inner triplet damaged during the previous pressure test will be removed for repairs of its structural supports.

Sommaire

LHC EXPERIMENTS

CMS celebrates the arrival of the last crystals

The last of the 62 960 lead tungstate crystals arrived at CERN on 9 March, marking the end of a 15 year project for the CMS experiment and the Crystal Clear Collaboration. These crystals will form the 36 supermodules of the barrel electromagnetic calorimeter.

Lead tungstate crystals were chosen because of their high density and ability to stop particles over short distances. In addition, they offer good scintillation properties and radiation hardness. In 1994, the development of the avalanche photodiode detector, which allows small amounts of light to be read in a magnetic field, provided the

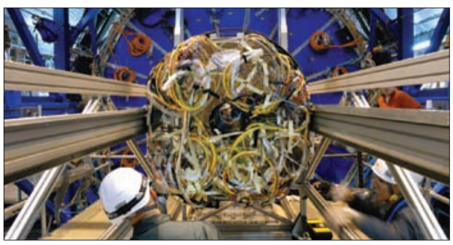
Igor Tarasov inserting the last batch of the CMS lead tungstate crystals into one of the machines that was developed to measure 67 different parameters for each crystal.

possibility of using the crystals. By 1998 the Bogoroditsk factory in the Tula region of Russia had begun producing the crystals. The Shanghai Institute of Ceramics in China supplemented this factory in 2005.

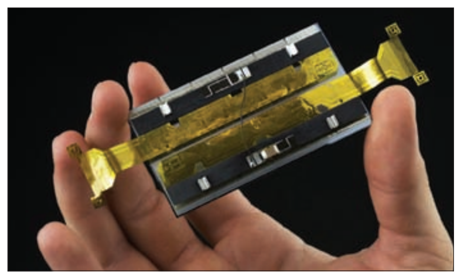
Half of the crystals were delivered to the CERN regional centre and the other half to INFN/ENEA. Each crystal underwent strict quality-control where automatic machines measured 67 parameters. There are 1700 crystals in one supermodule of the electromagnetic calorimeter. The first supermodule was inserted in mid-April and the final one should be installed by June 2007.

The Inner Tracking System arrives at the heart of ALICE

On 15 March 100 physicists and engineers gathered in the ALICE underground cavern to witness the end of a 15 year journey of development, construction, commissioning and testing before the Inner Tracking System (ITS) was inserted into the time projection chamber (TPC) at the heart of the experiment. Using the smallest amounts of the lightest material, the ITS has been made as lightweight and delicate as possible.



The outer layers of the ITS move slowly into the TPC at the heart of the experiment.



One of the ALICE ITS silicon-strip modules.

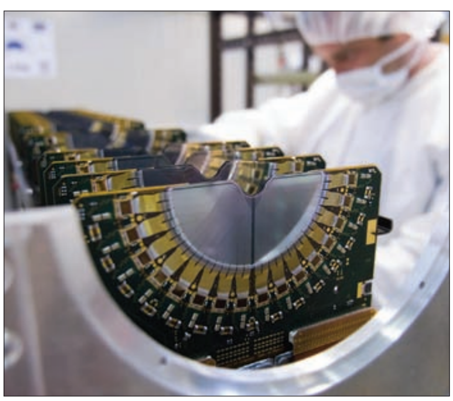
The ITS comprises six layers of high-precision silicon detectors, with double-sided silicon strips in the outer two layers, silicon drift detectors in the middle two layers and silicon pixels in the two inner layers. With almost $5\,m^2$ of double-sided silicon strip detectors and more than $1\,m^2$ of silicon drift detectors, it is the largest system using both types of silicon detector.

The silicon layers were integrated in Utrecht and Torino for a testing phase before being moved to the ALICE underground cavern. Passing the ITS through the TPC was challenging, with barely enough room for it to fit inside. It took two hours to move just a few dozen metres. The four outermost layers have been installed and the silicon pixel detector is scheduled to be installed this summer.

The last module of LHCb's VELO arrives

After 10 years of hard work the last of the 42 modules for the LHCb Vertex Locator (VELO) arrived at CERN in early March. The VELO comprises two rows of 21 double-sided semi-circular silicon detectors, each about 8 cm in diameter. It was designed and constructed at Liverpool University and will be placed just 5 mm from the beam line.

The LHCb experiment will study B particles at the LHC to explore the imbalance between



One half of LHCb's VELO, containing 21 of the double-sided silicon detectors.

matter and antimatter, and the VELO is crucial. It will track particles spraying out of the forward regions of the detector, where the greatest numbers of $b-\bar{b}$ pairs are expected.

The VELO is unique in that it will act as both detector and beam pipe. Special bellows designed at NIKHEF will allow both sides of the VELO to retract to a safer distance of 3 cm away from the beam line while the beam is being set up. In addition, to maintain the LHC vacuum of 10^{-8} millibar, a special corrugated foil will separate the beam line from the VELO detector vacuum. By the summer the VELO team will finish assembly and prepare for installation in the pit.

DETECTORS

THEMIS spacecraft take thin-contact silicon into orbit

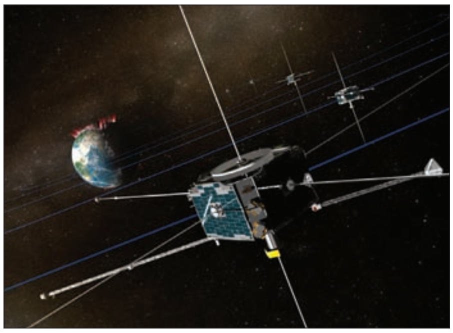
Particle detectors developed for high-energy and nuclear physics often find uses in many other fields. Now silicon detectors with thin entrance contacts have been launched into space aboard the five spacecraft in NASA's THEMIS (Time History of Events and Macroscale Interactions during Substorms) mission. Fabricated at the Lawrence Berkeley National Laboratory (LBNL), the detectors comprise the heart of solid-state telescopes (SSTs). They will study electrons and ions with energies between 25 keV and 6 MeV.

THEMIS will study the Aurora Borealis. Typically, the aurora is seen as a steady greenish-white band of light. Occasionally the band will move south and become brighter. Then, the auroral band may break up into many bands, some of which will move back towards the north, dancing rapidly and turning red, purple and white. This display is caused by an auroral substorm. The THEMIS mission will study the origin of these substorms. The five separate satellites were launched into highly elliptical orbits using a single Delta 2 rocket. The craft are strategically positioned to determine the location and sequence of the events that lead to these colourful displays.

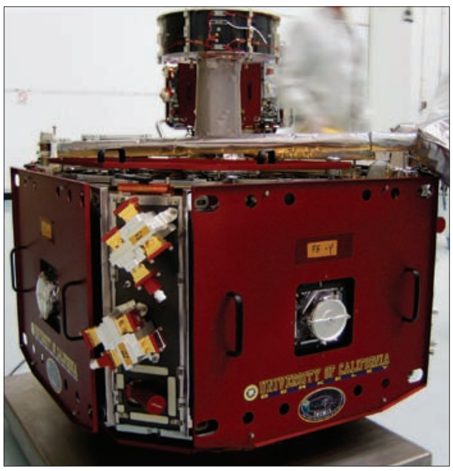
Two SSTs are on board each of the spacecraft. Their purpose is to measure the distribution of energies of the electrons and ions arriving at each spacecraft from different parts of the magnetosphere. LBNL's Microsystems Laboratory fabricated the silicon-diode detectors. They are large-area detectors that have very thin entrance contacts, only a few tens of nanometres thick. This allows them to detect electrons and ions with energies much lower than those that can be detected with standard silicon detectors. The detectors themselves can detect 2 keV electrons and 5 keV protons. However, the low energy threshold of the SSTs is determined not by the detectors, but by the noise performance of the electronics, which is limited by the available power.

Because the detector contacts are so thin, making enough large detectors posed a significant challenge: the project required 80 flight detectors. However, the Microsystems Laboratory provided advanced equipment and processes in an ultra-clean environment that enabled the fabrication of these detectors with high yield.

The SSTs have been commissioned and are now returning scientific data on the magnetosphere during the current "Coast Phase". In December, when the satellites will be in their required orbits, the primary task of studying the auroral substorms will begin.



Artist's impression of the five THEMIS spacecraft in orbit. (Courtesy NASA.)



One of the five THEMIS spacecraft. Its two solid-state telescope (SST) units, each with two opposite-facing SSTs incorporating four silicon detectors each, are mounted on the near edge. (Courtesy LBNL.)

ACCELERATOR BEAMS

Bent silicon crystal deflects 400 GeV proton beam at the Super Proton Synchrotron

A team working at CERN has detected the phenomenon of volume reflection using bent silicon crystals with a 400 GeV proton beam at the Super Proton Synchrotron. The efficiency achieved was greater than 95%, over a much wider angular acceptance than is possible with particle channelling in bent crystals. This effect could prove valuable in manipulating beams at the next generation of high-energy particle accelerators.

Using the ordered structure of a crystal lattice to guide high-energy particle beams is already finding applications through the effect of particle channelling (*CERN Courier* January/February 2006 p37). In channelling a charged particle becomes confined in the potential well between planes of the crystal lattice, and if the crystal is bent, the effect can be used to change the particle's direction (figure 1). However, to be channelled in this way, the particle must have a small transverse energy, less than that of the confining potential well. In a bent crystal, a particle with higher transverse energy may also change direction: it may lose some transverse energy and then become captured, or it may have its transverse direction reversed in an elastic interaction with the potential barrier. This latter process, which changes the particle's direction, is known as volume reflection – and it is this effect that dominates, and therefore becomes more interesting, at higher energies.

In the research at CERN, a team from institutes in Italy, Russia and the US mounted a silicon-strip crystal on a high-precision goniometer. A specially designed holder kept the (110) crystal planes bent at an angle of 162 μrad along the crystal's 3 mm length in the beam direction. Various detectors mapped the trajectory of the particles along the beam line and measured their fluxes.

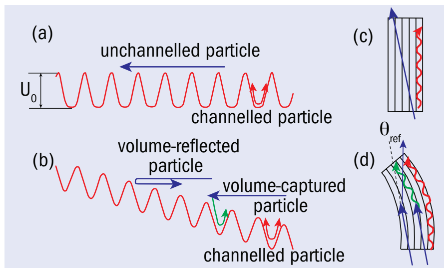


Fig. 1. (a) The periodic planar potential in a straight crystal for positively charged particles. The arrows show a channelled particle oscillatory motion in the potential well and an unchannelled particle, with transverse energy greater than the depth of the potential well U_0. (b) The same situation in a bent crystal. (c) Particle trajectories in a straight crystal. The arrows show volume-reflected, volume-captured, and channelled particles. (d) Trajectories in a bent crystal.

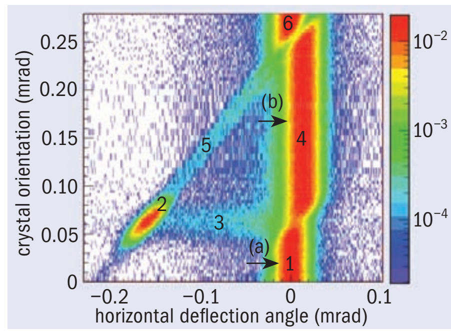


Fig. 2. Recorded beam intensity as a function of the horizontal deflection angle and the crystal orientation. Six regions can be distinguished: (1) and (6) no channelling; (2) channelling; (3) dechannelling; (4) volume reflection; and (5) volume capture. The wider angular acceptance of volume reflection (b) compared with channelling (a) is clearly visible.

Figure 2 shows the horizontal deflection of particles, as measured 64.8 m downstream, for a range of crystal orientations. The effect of channelling is clearly visible when the crystal orientation is about 0.06 mrad, giving a deflection of 165 μrad, which corresponds to the bending angle of the crystal. Here about 55% of the particles were deflected. At larger orientations, this effect disappears as the beam can no longer enter the silicon between the crystal planes. Instead a smaller beam deflection, in the opposite direction, is seen. Here the measured deflection angle of 13.9 ± 0.2 (stat.) ± 1.5 (syst.) μrad agrees well with the calculated prediction for volume reflection of 14.5 μrad. This deflection occurs over a wide range of crystal orientations, corresponding to the bending angle of the crystal; beyond this the crystal appears amorphous and the beam no longer "sees" the (110) layers.

A preliminary analysis indicates an efficiency greater than 95% for volume reflection, which occurs over a far greater range of angles than channelling. This, the team says, suggests new perspectives for the manipulation of high-energy beams, for example for collimation and extraction in high-energy hadron colliders, such as the LHC. For example, a short bent crystal could be used as a "smart" deflector to aid halo collimation in a high-intensity hadron collider, or as a device to separate low-angle scattering events in diffractive physics, close the beam line.

Further reading

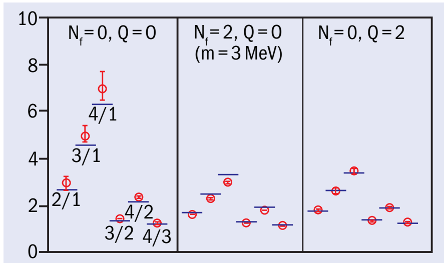
W Scandale *et al.* 2007 *Phys. Rev. Lett.* **98** 154801.

KEK

Symmetry breaking on a supercomputer

The Japan Lattice QCD Collaboration has used numerical simulations to reproduce spontaneous chiral symmetry breaking (SCSB) in quantum chromodynamics (QCD). This idea underlies the widely accepted explanation for the masses of particles made from the lighter quarks, but it has not yet been proven theoretically starting from QCD. Now using a new supercomputer and an appropriate formulation of lattice QCD, Shoji Hashimoto from KEK and colleagues have realized an exact chiral symmetry on the lattice, and observe the effects of symmetry breaking.

Chiral symmetry distinguishes right-hand spinning quarks from left-handed and is exact only if the quarks move at *c* and are therefore massless. In 1961 Yoichiro Nambu and Giovanni Jona-Lasinio proposed the idea of SCSB, inspired by the Bardeen–Cooper–Schrieffer mechanism of superconductivity in which spin-up and spin-down electrons pair up and condense into a lower energy level. In QCD a quark and an antiquark pair up, leading to a vacuum full of condensed quark–antiquark pairs. The result is that chiral symmetry is broken, so that the quarks – and the particles they form – acquire masses.



The ratios of eigenvalues (2/1 etc). N_f is the number of dynamical quarks in the vacuum and Q is the topological charge of the gluon field on the lattice. The centre panel has the result with light dynamical quarks, showing that the QCD simulation (red) reproduces the prediction (blue).

In their simulation the group employed the overlap fermion formulation for quarks on the lattice, proposed by Herbert Neuberger in 1998. While this is an ideal formulation theoretically, it is numerically difficult to implement, requiring more than 100 times the computer power of other fermion formulations. However, the group used the new IBM System BlueGene Solution supercomputer installed at KEK in March 2006, as well as steady improvements of numerical algorithms

The group's simulation included extremely light quarks to give eigenvalues of the quarks. The results reproduce predictions (see figure) indicating that chiral symmetry breaking gives rise to light pions that behave as expected.

Further reading

H Fukaya *et al.* 2007 *Phys. Rev. Lett.* **98** 172001.

Compiled by Steve Reucroft and John Swain, Northeastern University

Efficiency of photosynthesis depends on quantum coherence

Photosynthesis is an amazingly efficient process, capturing 95% or more of the light energy that hits a leaf. Now a study led by researchers at the Lawrence Berkeley National Laboratory and the University of California at Berkeley reveals at least part of how this is done. The trick, revealed by beat patterns in two-dimensional Fourier transform spectroscopy of a bacteriochlorophyll, seems to be that incoming light causes coherent excitation of many different states simultaneously in superposition. This then allows a very efficient search of the various possible reaction complexes into which the energy could be delivered.

The discovery hinged on the two-dimensional electronic-spectroscopy technique developed by the group, which is led by Graham Fleming at Berkeley.

Nature does it by quantum coherence. (Courtesy Chris Harvey/Dreamstime.com.)

This enables the researchers to follow the light-induced excitation energy at it passes through molecular complexes, with a time resolution of femtoseconds. It involves flashing a sample sequentially with femtosecond pulses of light from three laser beams, with a fourth beam to amplify and detect the resulting spectroscopic signals.

The finding contradicts the classical description of the photosynthetic energy transfer process as one in which excitation energy moves step-by-step down the molecular energy ladder from pigment molecules to reaction centres. Instead, the process seems to depend on quantum coherence, which is also what underlies quantum computing. Further research into this effect could lead to a better understanding of how life uses quantum mechanics, and perhaps could also lead to new ways of making solar cells.

Further reading

G S Engel *et al.* 2007 *Nature* **446** 782.

The mathematics of beer foam

Everyone who has drunk a beer has watched the gradual coarsening of the foam that makes up the head, with bubbles coalescing until eventually the head is gone. Robert MacPherson of the Institute for Advanced Study in Princeton and David Srolovitz of Yeshiva University in New York have gone a step further and described these dynamics in mathematical detail.

Previously, the growth of bubbles and similar cellular structures was only understood in two dimensions – a result due to John von Neumann back in 1952. Now, MacPherson and Srolovitz have found an exact extension to three dimensions. Of course, all theoretical results need experimental confirmation, so now all good scientists have a real excuse for a beer after a hard day's work.

Further reading

R D MacPherson and D J Srolovitz 2007 *Nature* **446** 1053.

Beer froth: it's all a question of maths. (Courtesy Alex Bramwell/Dreamstime.com.)

Seeing the world in another colour

Have you ever wondered what it would be like to "see" ultraviolet or infrared – to genuinely perceive it as a different colour? If so, there's some good news from mice. Gerald Jacobs of the University of California in Santa Barbara and colleagues have bred mice with an extra, human-derived eye pigment that gives them the ability to see longer wavelengths than they normally can.

The mice seem to have enough neural plasticity not only to see the extra colour, but also to distinguish it from others. The work could shed light on how tri-colour vision arose in humans and some primates – most mammals have only two eye pigments, but now it seems that it might only require a mutation to make one more.

Further reading

G H Jacobs *et al.* 2007 *Science* 3151723.

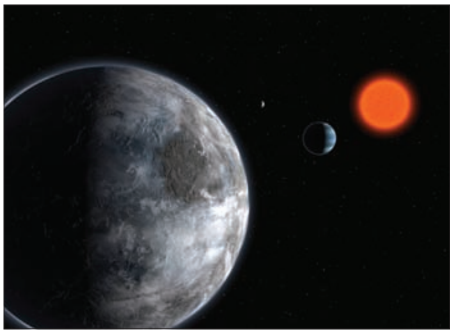
Compiled by Marc Türler, INTEGRAL Science Data Centre and Observatory of Geneva University

Astronomers discover Earth-sized planet in the habitable zone

A rocky planet only five times the mass of the Earth was discovered around the nearby low-mass star Gliese 581. This is the most Earth-like planet known to date and furthermore its orbit is at the "warm" edge of the habitable zone around that star, thus allowing speculation that this planet could harbour life.

The quest for detecting new planets orbiting other stars than the Sun is boosted by the huge impact that this research field has on the general public (*CERN Courier* October 2004 p19). During one week, the Observatory of the University of Geneva was overwhelmed with phone calls from all over the world concerning the discovery and its implications for life in the universe. This mass interest was beyond the expectations of the discovery team led by Stéphane Udry, which simply published its findings in a specialized, rather than an interdisciplinary, scientific journal.

The faint star Gliese 581 is only 20 light-years away and is thus among the 100 closest stars. It is one of some 100 "M dwarf" stars monitored by the High Accuracy Radial-velocity Planet Searcher (HARPS) mounted on the 3.6 m telescope of the European Southern Observatory (ESO) at La Silla, Chile. This high-precision spectrometer previously found a Neptune-mass planet around Gliese 581, but with more observations and refined analysis the astronomers discovered two additional planets by detecting the wobbling that their gravitational pull exerts on the star. The two new planets have masses of five and eight times the mass of the Earth and orbit the red dwarf star every 13 and 84 days, respectively. Although these planets are much closer to Gliese 581 than the Earth is to the Sun, they are located approximately at the warm and cold edges of the habitable zone of such a low-luminosity star. Among the more than 200 extra-solar planets detected so far, some others have been found to be in the habitable zone of their parent star, but they were all bigger gaseous planets.



Artist's impression of the three-planet system around the red dwarf Gliese 581. Liquid water could flow on the surface of the planet in the foreground, which is five times the mass of the Earth. (Courtesy ESO.)

Apart from very exotic low-mass planets orbiting pulsars, the new planet of only five times the mass of the Earth is the lightest extra-solar planet found to date. With a diameter estimated to exceed that of the Earth by only 50% and being in or just at the boundary of the habitable zone makes it the prime subject of interest. According to Udry, the surface temperature of the planet depends on the highly uncertain composition and thickness of its atmosphere. Nevertheless, an equilibrium temperature between −3° C and +40° C was estimated for a Venus-like and an Earth-like albedo, respectively. It is therefore likely that water could be liquid on the surface of this planet, although the strength of the greenhouse effect remains an important unknown.

The existence of liquid water and the possibility of life on this planet cannot be probed directly at the moment and we can only consider it as the best known candidate for future space-mission projects, like NASA's Terrestrial Planet Finder and ESA's Darwin, to search for the signature of water and oxygen in its atmosphere. However, the relatively old and quiet star Gliese 581 has already became one of the most famous stars in the universe and currently focuses all hopes to find a nearby Earth twin.

Further reading

S Udry *et al.* 2007 *Astron. and Astroph.*, in press. See http://arxiv.org/abs/0704.3841.

Picture of the month

To celebrate the 17th anniversary of the NASA/ESA Hubble Space Telescope a breathtaking panoramic view of the inner part of the Carina Nebula was released. The detail on this tiny portion of the full mosaic of 48 frames taken by the Advanced Camera for Surveys (ACS) allows one to imagine what the complete high-resolution image (29 566 pixels × 14 321 pixels) would look like! The Carina Nebula – previously pictured in infrared by Spitzer (*CERN Courier* July/August 2005 p10) – harbours some of the most massive stars in our galaxy. Their intense ultraviolet radiation erodes the dust column shown in this image. What is special here compared with other such "pillars of creation" (*CERN Courier* June 2005 p12 and March 2007 p11) is the double-jet of gas being launched by a newly forming star hidden inside the tip of the dust column. (Courtesy NASA; ESA; N Smith, University of California, Berkeley; and the Hubble Heritage Team, STScI/AURA.)

Calling Captain Vacuum! You have to stop Dr. NoVac! He's sabotaging the outer space turbo-vacuum pump plant.
Mission possible, Commander! Dr. NoVac will soon have taken his last breath. I have what it takes to save all the vacuum! I'm always ready, willing and able when the Void needs me!
That scoundrel wants to repeal the laws of nature and seize power. You've got to cut off his air!
May the Void be with you!
Later, at the outer space vacuum plant.
Ha ha, I've defeated the vacuum! Air for my empire!
This will keep the air outside, Dr. NoVac … and keep the vacuum where it's needed!
Gasp … Captain Vacuum?!
Dr. NoVac drifts vacuumized in space; the Captain is victorious. Now he sets about stabilizing the vacuum in outer space. His special vacuum belt has everything he needs to get the plant running again.
TO BE CONTINUED …

CERN COURIER ARCHIVE: 1964

A look back to *CERN Courier* vol. 4 June 1964, compiled by Peggie Rimmer

NEWS FROM ABROAD

Rutherford Lab inaugurates "Nimrod"

Friday 24 April saw the inauguration of "Nimrod", the 7 GeV proton synchrotron at the Rutherford High Energy Laboratory at Chilton, UK, and the official opening of the laboratory itself. Among many distinguished guests from the field of high-energy physics was our own director-general, Prof. V F Weisskopf, who welcomed the new accelerator as part of the world effort to penetrate into the secrets of nature.

The Rutherford High Energy Laboratory is the first establishment of the National Institute for Research in Nuclear Science, set up in 1957 by the British Government to provide the expensive research facilities required in areas such as high-energy physics and nuclear physics and which are beyond the resources of individual institutions. In this sense it does for British universities what CERN does on a wider scale for the European ones (including the British, of course).

Nimrod was begun in 1957 and was intended from the beginning to be a complementary machine to the CERN PS, giving lower energy but higher intensity. Its design energy was chosen as 7 GeV so as to be reasonably far above the threshold for the production of antiprotons, and the well-established "weak focusing" principal was used as there was much doubt whether the required intensity could be reached with a "strong focusing" design, at that time still unproved.

At the time of its inauguration, Nimrod was operating regularly for 3½ days per week and achieving beam intensities of 3 or 4×10^{11} protons per pulse at 7 GeV. Six experiments were set up around the machine, and among the team leaders were a number of physicists who had been working at CERN during recent years. Among other experiments in preparation are some to be carried out by a collaboration between the "Centre d'Études Nucléaires" at Saclay, French and British universities, and the Rutherford Laboratory itself. A new liquid-hydrogen bubble chamber will be used, belonging to Saclay and developed from their successful 81 cm chamber at present in use at CERN.

Nimrod is now the second most powerful proton synchrotron in Europe and the first in Britain to be capable of producing kaons, hyperons and antiprotons. Its cost, including buildings, was just under £11 million (or rather more than that of the CERN PS). The Rutherford Laboratory also has a 50 MeV proton linear accelerator, operating since 1959, other divisions for applied physics, engineering and administration, and a separate group working on a novel 20 MeV electrostatic-generator project for Oxford University. It has a permanent staff of about 1000, and a budget (for 1963–64) of about £7 million, three quarters that of CERN.

● From information obtained by courtesy of the editor of *Orbit*. Compiled from "News from abroad" pp77–78.

COMPILER'S NOTE

The notion that the Rutherford Laboratory and DESY were "abroad" as far as *CERN Courier* was concerned seems quaint nowadays, reminiscent of the attitude supposedly revealed by the apocryphal British newspaper headline "Fog in the Channel, Europe cut off". Since then the *Courier*, once CERN's in-house magazine, has become *the* International Journal of High-Energy Physics, as a glance at the impressive list of laboratory correspondents on page 3 will show.

Experiments get going at DESY

Europe's largest electron accelerator, the German Electron Synchrotron, DESY, at Hamburg, is also in operation, having accelerated its first beam to full energy at the end of last February.

During last summer the high-frequency system was operated at full power, and the magnet power supply was completed. Assembly of the accelerator parts, with the exception of the vacuum system, was completed in October 1963, and component tests gave satisfactory results.

The linear accelerator, already delivered in 1961, also performed satisfactorily, and the first electron beam was injected into the magnet ring in December 1963. First attempts to accelerate electrons in the ring were made on 7 February 1964, and late on 26 February an energy of 5 GeV was reached for the first time. This was soon raised to 6 GeV, the maximum design energy.

At present the accelerator is operating at about 4.8 GeV with an intensity of between 10^{10} and 3×10^{10} electrons per pulse ($5–15 \times 10^{11}$ electrons per second). Using a preliminary target, bremsstrahlung (gamma-ray) pulses up to 1.6 ms long have been attained with an intensity of about 3×10^{8} effective quanta per 10^{10} electrons. A pair spectrometer is being used to measure the spectrum of the bremsstrahlung. The first experimental results on the scattering of electrons by protons have also been obtained, using the internal electron beam. Measurements have begun on the recoil protons arising from the nuclear production of gamma rays.

An 80 cm liquid-hydrogen bubble chamber has been built at the French laboratory at Saclay, with the help of French physicists and engineers, and was operated successfully there in the middle of June. This chamber, also a development of the one at CERN, is expected to be installed at DESY at the beginning of August 1964. As further examples of the international nature of high-energy physics research, it is worth noting that the linear accelerator for DESY was supplied by an English firm, and that the whole synchrotron is closely similar to the 6 GeV Cambridge Electron Accelerator in the US, put into operation two years ago. Close co-operation has been maintained between the two laboratories, and one of the senior staff of the Cambridge machine spent six months in Hamburg to see the younger one safely into service.

● Based on information kindly supplied by Prof. W Jentschke. Compiled from "News from abroad" pp77–78.

COMPUTING NEWS

Compiled by Hannelore Hämmerle and Nicole Crémel

LHC COMPUTING

French LCG steadily ramps up

Members of the French section of the LHC Computing Grid project during one of the sessions that discussed the progress of the Grid infrastructure for the impending LHC.

More than 70 members of the LHC Computing Grid (LCG) project in France gathered in March to discuss the progress of the French part of the global Grid infrastructure for the LHC accelerator. The meeting was divided into several sessions of presentations by Grid experts, highlighting the challenges of the Grid for the LHC experiments and the progress made during recent months. It was also an occasion to reinforce communication between the representatives of the experiments and the LCG sites.

As the start-up of the LHC approaches, new members have joined the French part of the LCG Grid. Indeed, the data-processing capacity required and the complexity of the installation and management of the equipment, as well as the effort needed to provide and operate a reliable platform for the experiments, have led to a significant increase in the number of staff and the number of French sites.

Several Tier-3 sites have recently joined the ranks of LCG-France. Today, the project is composed of a Tier-1 centre and an analysis facility operated by the IN2P3 Computing Centre (CNRS/CEA), three Tier-2 centres and four Tier-3s. In addition, several sites associated with the French Tier-1 are located in other countries including Belgium, China, Japan and Romania. The four major LHC experiments are supported at all of the sites, which also provide computing resources for non-LHC-related experiments, projects and research fields, mainly in the context of the Enabling Grids for E-sciencE project.

In 2006, the French infrastructure of the LCG Grid was successfully tested during the data-transfer exercises. All the French sites contributed to the exercises and all goals were reached.

For its part, the French Tier-1 centre has to carry out work to resolve problems with electric installation and air conditioning so as to cope with the planned increase of its computing capacity. Despite several difficulties, all of the appropriate measures have been taken to maintain Tier-1 operations while this work on underlying service infrastructure is in progress.

The meeting was also the occasion for site representatives to meet members of the ALICE, ATLAS, CMS and LHCb experiments to exchange views and information, so strengthening links between them. The sites received a clear presentation of the needs of the experiments, not only in terms of computing and data-storage capacity, but also in terms of quality of service and bandwidth requirements.

AWARDS

CERN wins prize for storage systems implementation

CERN is one of the winners of this year's *Computerworld* Best Practices in Storage awards in the category of Systems Implementation for the success of the ALICE data-acquisition system (DAQ). *Computerworld*, a weekly online publication focusing on technology news, announced the recipients of the awards on 18 April at the Storage Networking World Conference.

The Systems Implementation category recognizes the successful design, implementation and management of an interoperable environment and may also demonstrate the ability to source from multiple vendors. Case studies were required to substantiate a successful strategy to maintain a heterogeneous storage network.

The ALICE DAQ team developed their system to buffer up to eight hours of data, reading and writing in a randomized way. Since randomization is much less effective than writing to disks linearly, the ALICE DAQ team used storage software to separate the two data streams to different disks, turning the traffic into a linear recording.

Les gros titres de l'actualité informatique

SUPERCOMPUTING

PACE makes way for European collaboration

Supercomputing centres from 15 European countries have come together to form the Partnership for Advanced Computing in Europe (PACE) initiative to ensure access to a world-class high-performance computing infrastructure for European researchers. At a ceremony in Berlin on 17 April, the partners signed a Memorandum of Understanding for the new initiative.

The need for a high-performance computing service was highlighted in last October's report from the European Strategy Forum for Research Infrastructures. The central idea behind the new European initiative is the joint usage of the capacities of several supercomputers.

According to the terms of the memorandum, the partners will spend the next two years putting together concrete proposals on how best to combine their equipment and expertise to implement the project. In the preparation phase, which will run until 2010, the necessary organizational structures will be created, and clear guidelines will be drawn up concerning the hardware needed at the different locations. When the infrastructure is up and running, a peer-review process will ensure that only scientifically excellent projects gain access to the supercomputer.

The start-up costs of the project have been calculated at €400 million, while annual running costs are likely to be around €100 million. The member states involved in the project will cover most of these costs, with additional funds coming from the EU's Seventh Framework Programme.

The countries involved in the project are Austria, Finland, France, Germany, Greece, Italy, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey and the UK.

COLLABORATION

CERN openlab gains new contributor

In April, the information-technology service provider EDS joined CERN openlab as a new contributor. CERN openlab is a framework for collaboration between CERN and information-technology companies, in a pre-competitive spirit based on open standards. Partners in CERN openlab typically engage in broad-based 3 year collaborations, while contributors work in a more focused 1–2 year collaboration.

EDS provides a broad portfolio of business and technology solutions to its clients, and is credited with having founded the information-technology outsourcing business. The company has joined CERN openlab to gain further experience with the type of Grid technology that is being developed by the LHC Computing Grid (LCG) and Enabling Grids for E-SciencE (EGEE) projects. EDS has already been a member of the EGEE Industry Forum for two years.

In CERN openlab, EDS will contribute to the development and enhancement of tools and systems to monitor Grid services. Grid projects such as EGEE and LCG currently provide a variety of monitoring systems. These range from classical fabric monitors to a relatively new type of monitor activity on the Grid-applications side. The *ad hoc* evolution of these monitors means that there is a risk that important information is not gathered or that multiple monitors store redundant data.

The ATLAS distributed data-management monitoring from Experiment Dashboard.

Data repositories and transport mechanisms have been developed to accumulate sensor data. However, understanding how to present high-level views in an intuitive and useful way, while providing the ability to understand the underlying problems, remains an open issue. EDS engineers will work together with experts and tool providers to evaluate existing solutions. A CERN fellow sponsored by EDS will implement solutions by adapting existing tools, including the Experiment Dashboard, an aggregator of monitor information that has been developed through a collaboration of the EGEE and LCG projects.

● The partners in CERN openlab are HP, Intel and Oracle; contributors are EDS, F-Secure and Stonesoft.

COMPUTERS

Thin clients use less energy at work

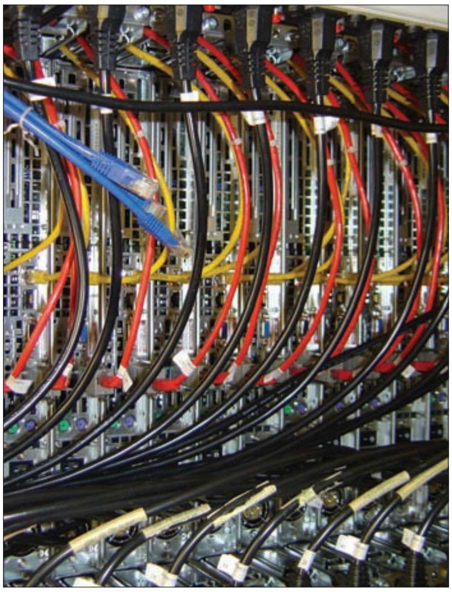
Savings achieved by reducing the electricity consumption of computers may seem insignificant, but in companies with several-hundred employees the kilowatt hours can mount up to a huge electricity bill – not to mention significant CO_2 emissions. In two studies, researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology in Oberhausen, Germany, have investigated the extent to which "thin clients" can save energy and reduce costs.

Thin clients consume up to 50% less electricity. They are "slimmed down" computers that are used solely to input and output data, i.e. computers limited to the functions of the mouse, the keyboard and the screen. The data that are accessed are stored on a central server along with most of the operating system. The advantage is that if a new program is installed on the server or an update is loaded, the software automatically runs on all of the thin clients that can access the server.

In an earlier study, the researchers examined the upfront and running costs of the slim devices. The team based its research on a typical institute, comparable with a small- to medium-sized company with a staff of 150–300 people, which can save up to 70% compared with "normal PCs".

UK GRID

GridPP extends to deal with LHC data



Getting connected: a close-up of GridPP hardware at Queen Mary, University of London. (Courtesy QMUL/GridPP.)

Scientific computing in the UK received a boost at the end of March with the announcement by the Particle Physics and Astronomy Research Council (PPARC) of £30 million further funding for the UK's largest scientific Grid. The GridPP project is building a computing Grid to analyse data from the LHC. The new funding will allow GridPP to continue into its third phase, running until 2011 and covering the period when the LHC starts taking data.

The UK particle-physics Grid currently has more than 5000 processors at 17 sites across the country; with the new funding, this will increase to 20 000 by 2011. GridPP is also integrated with other Grids in the Worldwide LHC Computing Grid project, including more than 35 000 CPUs in 50 countries. This Grid will analyse the petabytes (millions of gigabytes) of data produced by the LHC each year in its study of the basic building blocks of matter.

The GridPP3 grant will cover areas including staff and hardware at the particle-physics Grid sites in the UK, and more general support such as security and operations management.

Calendar of events

June

4–8 TeraGrid '07 Madison, WI, US
www.union.wisc.edu/teragrid07/

5–8 Grid Asia 2007 Singapore
www.ngp.org.sg/gridasia/2007/

5–9 6th International Conference on Large-Scale Scientific Computations Sozopol, Bulgaria
http://parallel.bas.bg/Conferences/SciCom07.html

25–28 WorldComp'07 Las Vegas, NV, US
www.worldacademyofscience.org/worldcomp07/ws

25–29 International Conference on Distributed Computing Systems (ICDCS) 2007 Toronto, Canada
www.eecg.utoronto.ca/icdcs07/

26–29 ISC2007 Dresden, Germany
www.supercomp.de/

27–29 HPDC 2007 Monterey Bay, CA, US
www.isi.edu/hpdc2007/

July

5–8 6th International Symposium on Parallel and Distributed Computing
Hagenberg, Austria
www.gup.jku.at/ispdc

9–12 2007 International Multi-Conference in Computer Science, Engineering and Information Technology
Orlando, FL, US
www.PromoteResearch.org

August

28–31 Euro-Par 2007 Rennes, France
http://europar2007.irisa.fr/

September

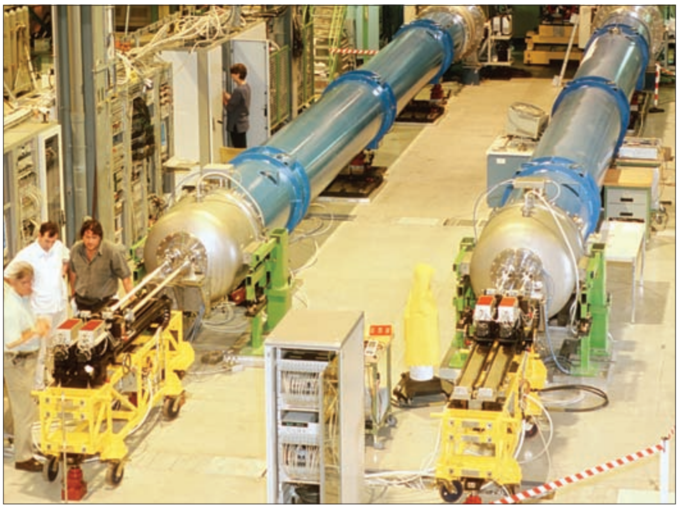
2–7 International Conference on Computing in High Energy and Nuclear Physics (CHEP'07) Victoria, BC, Canada
www.chep2007.com/

October

1–5 EGEE'07 Budapest, Hungary
www.eu-egee.org/egee07

LHC magnet tests: the Indian connection

Over the past four years, cold testing of the magnets for the LHC turned into a sophisticated operation with the help of teams from India, as **Vinod Chohan** explains.



The first two LHC dipoles undergoing tests on the cryogenic benches in the SM18 test facility at CERN's Meyrin site in 2001.

Some of the Indian technical engineers with short straight section magnets in the SM18 test hall in 2006.

The cold testing of 1706 superconducting magnets for the LHC came to a successful completion early this year. This important milestone for the project marked the end of an operation that had begun in 2001, meeting considerable challenges along the way. By the end of 2003 only 95 dipole magnets had been tested, but the effort and innovative ideas that came from the Operations Team enabled the team eventually to meet the target. The majority of the personnel for the tests came from India, for a year at a time, as part of the CERN–India Collaboration for the LHC. Their success provides a unique example of international collaboration in the accelerator domain on an unprecedented scale.

The LHC consists of two interleaved synchrotron rings, 26.7 km in circumference. The main elements of the rings are the 2-in-1 superconducting dipole and quadrupole magnets operating in superfluid helium at 1.9 K (*CERN Courier* October 2006 p28 and January/February 2007 p25.) The total number of cryogenic magnet assemblies – or cryomagnets – includes 1232 dipoles with correctors, 360 short straight sections (SSS) for the arcs with quadrupoles and integrated high-order poles, and 114 special SSS for the insertion regions (IR-SSS) with magnets for matching and dispersion suppression. All of these magnets had to be tested at low temperatures before they could be installed in the tunnel, and for this purpose a superconducting magnet test facility, equipped with 12 test benches and the necessary cryogenic infrastructure, was set up in building SM18 just across the border in France from CERN's Meyrin site.

The magnet testing had several aspects. For each magnet the tests had to verify the integrity of the cryogenics, mechanics and electrical insulation; qualify the performance of the protection systems; train the magnet up to the nominal field or higher; characterize the field; ensure that the magnet met the design criteria; and finally accept the magnet according to its performance in quenches and in training. The workforce to do this consisted of three main teams – the Operation Team, who performed the tests and measurements, supported by the Cryogenics Team and the Magnet Connect/Disconnect Team (known as ICS). In addition, a team known as Equipment Support looked after improvements and on-call trouble-shooting of hardware and software, and a sub-team of ICS handled the movement of the magnets with a remote-controlled vehicle (the ROCLA).

The complexity of the magnets implied a high level of complexity in the test facility, which required its own specific infrastructure, from cryogenic feed boxes and high-current circuits to data acquisition for measurement and control. Assembling the full facility ▷

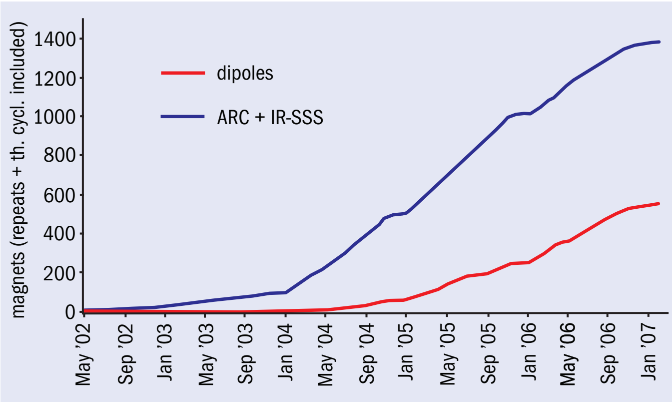


Fig. 1. The cumulative total of magnets cold tested at CERN up to and including the last day of testing on 23 February 2007.

involved several groups from CERN's AB, AT and TS departments working over many years, with the final test bench commissioned in June 2004.

The first testing of series production magnets began in 2001, with two test benches and a limited cryogenic infrastructure. Undertaken by specialists in the magnets and the related equipment, the operation at this stage was more laboratory R&D than a well-defined, structured approach to the test procedure. The first sets of dipoles, comprising around 30 samples from each of the three suppliers, had to be thoroughly tested, with full magnetic and other measurements. This extensive testing, together with the limited operational experience and support tools, meant that some 20–30 days were required to test a magnet during 2001–2002, and only 21 magnets were tested during this period.

To increase throughput, the test facility began to operate round the clock early in 2003. With a final set-up of 12 test benches and a minimum of 4 people a shift, this required a minimum team of 24. The initial plan had been to outsource, but by early 2002 it was clear that this was no longer an option, and also that only a few non-expert CERN staff were available to run the test facility. It was at this time that the Department of Atomic Energy (DAE), India, offered technical human resources for SM18. A collaboration agreement between India and CERN had been in place since the 1990s, including a 10 man-year arrangement for tests and measurements during the magnet prototyping phase. This eventually allowed more than 90 qualified personnel from four different Indian establishments to participate in the magnet tests on a one-year rotational basis (a condition requested by India) starting around 2002.

It was also clear that proper strategies and support tools were needed to meet the target of testing all magnets by the end of 2006. In addition to several reviews aimed at streamlining the process, an extensive study took place to define a selective, reduced set of magnetic measurements needed to qualify and accept a magnet.

A testing renaissance

The overall magnet-test operation involved significant manual effort, and while this remained the case throughout the tests, from mid-2003 the operational process underwent a renaissance, from basic manual data-logging to an efficient, sophisticated and highly automated test-management system. The Operation Team, and in particular the Indian personnel, provided essential feedback for framing new strategies and made significant proposals for improving the throughput. In addition, CERN's web-based network backbone and computer facilities were widely used to develop supporting tools.

A "to-do list" of the minimum set of tests for a magnet was created, with methods developed to reduce human error in the process as much as possible. The list of tests was reflected in templates for a magnet test report. A new website included all of the important documentation, from manuals and templates to troubleshooting procedures and the shift plan. This proved immensely helpful in training new staff as well as in managing the daily activities.

A web-based system called the SM18 Test Management System (SMTMS), based on the to-do list, was developed to generate test-sequences and reports automatically and to store all of the relevant data. This enabled fast, reliable and error-free generation of crucial data. It also made it possible to keep track of the times taken for various phases of the tests, and everyone concerned could keep track of the tests from different locations both within CERN and further afield. An electronic log-book approach, using the network backbone at CERN, ensured easy access and helped to categorize and record faults that occurred during the tests.

Another web-based tool, the e-traveller, ensured a smooth interaction between the teams during setting up and at the end of the tests for a particular magnet. This tool informed the relevant teams about the need for their services on the magnet, using mobile-phone alerts in the appropriate language. This helped the Indian personnel to overcome difficulties in verbal communication with the exclusively French-speaking teams, while maintaining the work rhythm, as well as automatically recording the phases in the tests.

To attain a high throughput it was also necessary to reduce the time and cryogenic resources taken in testing the magnets, including the "training" required to reach the operational magnetic field. In this, the current is increased until the magnet quenches (reverts from its superconducting state to a normally conducting state) and then the process is repeated. In the early stages, each dipole was trained to reach a field about 8% higher than required for LHC operation – a major time-consuming activity. During 2003, the Operation Team observed that the majority of magnets cross their nominal field (8.33 T or 11 850 A) on the second attempt, and that not much additional information on the quality of a magnet came from a third quench or more. This led to a "two-quench rule" being agreed by the magnet experts, in which a magnet was accepted after two quenches providing it crossed the nominal field by a small margin. Later a "three-quench rule" allowed a magnet to be accepted if it had failed the two-quench rule, but crossed a field of 8.6 T (12 250 A) in the third quench. This strategy drastically reduced the overall time for the cold tests.

Another important step towards reducing the overall test time was the introduction of a rapid on-bench thermal cycle for magnets that had a poor performance in the first run. Further time-saving came from the round-the-clock decision-making on the performance of a magnet by the operator, based on the results in the Magnet Appraisal and Performance Sheet, provided by the web-based SMTMS.

Figure 1 shows the cumulative number of magnet tests, includ-

Table 1

The total number of magnets tested each year, including repeats. MM indicates full magnetic measurements.

		2002–2003	2004	2005	2006	2007	Total
Dipoles tested (LHC requires 1232; industry produced)	Fresh	95	356	468	326	15	1260
	Repeat	0	45	45	32	2	124
	Total	95	401	513	358	17	1384
	MM	95	65	58	33	3	254
	% Repeat	0.00	11.22	8.77	8.94	11.76	8.96
	% MM	100.00	16.21	11.31	9.22	17.65	18.35
Main quadrupoles tested, Arc-SSS and 32 of 500 series SSS (LHC requires 392; industry produced)	Fresh	2	49	148	187	11	397
	Repeat	0	3	17	37	3	60
	Total	2	52	165	224	14	457
	MM	2	40	7	10	1	60
	% Repeat	0.00	5.77	10.30	16.52	21.43	13.13
	% MM	100.00	76.92	4.24	4.46	7.14	13.13
IR-SSS (LHC requires 82 matching SSS; CERN produced)	Fresh	0	3	20	59	0	82
	Repeat	0	0	5	7	0	12
	Total	0	3	25	66	0	94
	% Repeat	0.00	0.00	20.00	10.61	0.00	12.77
	MM	0	1	7	21	0	29

Several dipole magnets in various stages of cold testing in March 2004. The remaining test benches, which make up the full complement of 12, are located on the other side of the gantry, which contains the cryogenic and power systems.

ing repeats, since 2003, both for dipoles and for SSS. While throughput was low until the end of 2003, it increased sharply after the introduction of the new tools and strategies. The flat regions at the end of each year are due to the annual shutdown of the cryogenic infrastructure, typically for seven weeks. More details are shown in table 1.

Testing the SSS magnets was a challenging task until the end of 2004, when all of the necessary information had finally been gathered and collated. The special IR-SSS magnets were even more of a challenge as they have a wide variety of types, structures and temperature regimes, and required the collection of a large amount of information for the tests. Each of the 114 magnets needed its own dedicated to-do list. As the table shows, the majority of the special SSS magnets were tested in 2006, together with significant numbers of standard SSS and dipole magnets, marking altogether a remarkable achievement for the year. While delays in delivery of the magnets to SM18 meant that not all of the magnets had been tested by the end of 2006, the target was achieved only a few weeks later by 23 February 2007.

Around 9% of the dipoles required the test procedure to be ▷

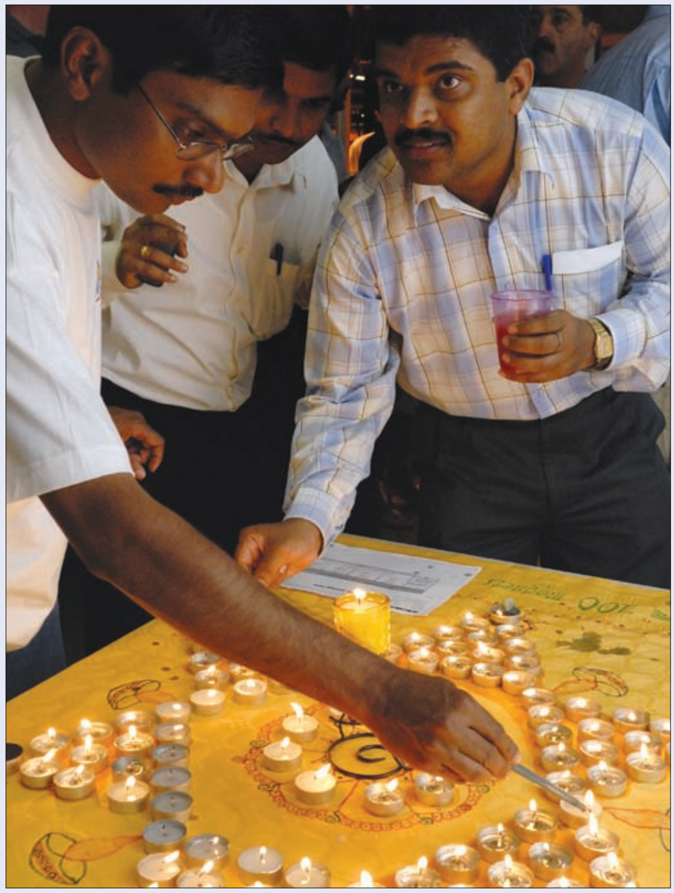
A magnetic year at CERN

To fulfil their roles at CERN, the technical engineers, all specialists in their own fields, had to take a leave of absence from their regular jobs. For example, Praveen Deshpande who was at CERN in 2006 designs instruments for accelerators and lasers, while Sampathkumar Raghunathan and Charudatta Kulkarni work on the R&D of nuclear instrumentation. For Deshpande, the best part about working at CERN was the interaction with different people. "I'm exposed to many people and agencies here, which I don't get at home working in a small design section," he explained in an interview for the *CERN Bulletin*. The logistics of implementing large-scale projects at CERN proved an eye opener. "The template approach with documentation and foresight is important in a big job like this," said Raghunathan. Kulkarni agreed, and further identified excellent leadership skills as an important lesson that he learned.

The technical engineers could also use their free time to further their own knowledge. "Everyone was given the name of someone at CERN who works in a similar field to contact, if we wished. This is for our intellectual development. Because we work in R&D, it is important that we are up to date with new developments, so we are not left behind when we return a year later," explained Kulkarni.

On their days off, the SM18 community organized group visits to tourist destinations, celebrated Indian festivals, such as Diwali, and even formed teams for cricket matches. Many of the technical engineers brought their families over, and some of their children attended local schools. For example, Raghunathan's wife, two children and his mother moved to Switzerland for nine months. His seven-year-old daughter attended a French school for a full academic year. "They all enjoyed living here. My daughter also learned a lot of French. It's an added asset."

At the end of their year at CERN, when the technical engineers returned home, enriched by their experiences, they hoped to incorporate what they had learnt at CERN into their work, in particular the methods of coordinating and managing large-scale projects. However, the experience gained extends far beyond a professional level. The magnet test has facilitated international friendships and even reunited lost ones from home.



The SM18 community celebrated the Hindu festival of Diwali with a party in October 2006, and lit candles to represent the remaining magnets still to be tested. Diwali takes place on the date of the new moon, between the months of Asvina and Kartika on the Hindu calendar (usually in October or November).

Deshpande met friends that he knew from 13 years ago when he was undergoing training, but with whom he had since lost touch, as well as colleagues at the same establishment in India whom he has never met owing to the size of the organization.

● Extract from the *CERN Bulletin* http://bulletin.cern.ch/eng/bulletin.php?bullno=48/2006.

repeated, with repeat rates of a little over 12% for the SSS and IR-SSS magnets. In addition, some 3% of dipoles and 6% of the SSS had to be repaired or were rejected after the cold tests. These results alone justify the effort required for testing all of the magnets under the real cryogenic conditions. Moreover, the successful completion of this huge operation has been a unique example of international collaboration on an unprecedented scale in the accelerator domain.

Résumé

Essais magnétiques pour le LHC: mission accomplie!

Les essais à basse température de 1706 cryoaimants du LHC se sont terminés avec succès en début d'année. Ainsi s'est achevé un travail commencé en 2001, qui s'est révélé très éprouvant. En 2003, seuls 95 dipôles avaient été testés. Cependant, l'équipe en charge, ne ménageant ni ses efforts ni sa créativité, est parvenue en fin de compte à respecter le calendrier. La plupart des personnes qui ont mené à bien les essais venaient d'Inde, pour des séjours d'un an, dans le cadre de la collaboration entre l'Inde et le CERN pour le LHC. Ce succès offre un exemple unique de collaboration internationale de grande ampleur dans le domaine des accélérateurs.

Vinod Chohan, *CERN, on behalf of all members past and present of the SM18 Operations Team.*

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- Beijing Electron Positron Collider II NEG vacuum pumps to ensure 3 x 10^{-10} mbar pressure in the electron-positron rings
- Petra III at Desy - More than 1,5 km of NEG strip to provide distributed pumping capability all around the ring

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Michael Frayn questions our place in the universe

Carolyn Lee talks with famed author and playwright, Michael Frayn, about his journey into the scientific world.


During his visit to CERN, Michael Frayn toured the ATLAS and CMS experiments, as well as giving a colloquium to CERN staff.

When acclaimed playwright, novelist and translator Michael Frayn visited CERN in March there was a distinct air of humility about him. This Tony award winner, who is best known for such plays as *Copenhagen* and *Noises Off*, is genuinely honest and enthusiastic about science – a subject he openly claims he knows little about.

Frayn studied philosophy at Cambridge and went on to study in Russia during the Cold War, eventually becoming one of the leading translators of Russian literature. So, how did he find himself exploring science in his works? It all started in a rather serendipitous way: "When I was six years old there was a gang at school led by a fierce, Amazon-like girl, and because I wore spectacles I was appointed 'gang scientist'. My job was to make explosives for the gang, using chalky soil, sawdust and elderberries." Although he failed in his mission, this sparked his interest in science.

During his twenties Frayn served in the army and made friends with a fellow soldier who was fascinated by science and went on to become a zoologist. It was this friendship that introduced him to quantum theory and the uncertainty principle. As a student of philosophy, he also encountered extraordinary applications for these ideas, but it was not until the 1990s when he wrote *Copenhagen* that he began exploring science on a deeper level. "My only access to science is through the wonderful books that some scientists and science writers produce for the benefit of the lay people. Science becomes a very specialized subject and any non-scientist who ventures into it is a fool. But at the same time, I think you have to be an even bigger fool not to try to understand something, because it's so important."

Frayn indicates that modern, experimental science is possibly the greatest human achievement, affecting everything about the world and our general philosophical understanding of it. However, as Richard Feynman pointed out, to truly understand science, especially physics, one needs to understand mathematics. Despite this struggle to understand, Frayn says that it is important to let a little science into one's life.

After bursting onto the scientific scene with his play *Copenhagen*, to much critical acclaim, Frayn was greatly struck by the generosity with which scientists treated it. He points out that there were a great many mistakes in the play, despite all of his efforts, and was surprised by the graciousness of the letters suggesting that he take another look at certain aspects. Whereas, "People in the arts, I think, take a great malicious pleasure in correcting each other," he says.

Frayn first heard of Niels Bohr and Werner Heisenberg while on the services' Russian course at Cambridge with his friend. Yet, he was only introduced to the story of Heisenberg's visit to Bohr in Copenhagen in 1941 when he read a book by Thomas Powers called *Heisenberg's War*. It was an unusual situation with old friends meeting under tremendously difficult circumstances as the Nazi regime had occupied the city. Many questions remain about the discussions that took place during this tense visit and the idea of such uncertainty sparked Frayn's imagination.

"What fascinated me about the story are the questions it raises: Why did Heisenberg go to Copenhagen? What were his motives? And you can never really know the answer." There is an uncertainty with human motivation and an uncertainty with the behaviour of a particle, and though the reasons are completely different, Frayn indicates that both have a theoretical barrier beyond which the human mind cannot reach, although he does encourage debate on this issue.

As for the scientists that he admires, he says: "All of them! I think Ernest Rutherford was a very interesting figure, and Niels Bohr because he was just a wonderful person. Science writer Richard Dawkins writes so well and tries to reach out to the lay readers, he truly appreciates the beauty of science." He is also sympathetic to Werner Heisenberg, who he feels was put in a difficult position. ▷

Touching the universe

Covering a wide range of disciplines, including linguistics, literature, neuroscience, philosophy and quantum physics, Frayn's latest book, *The Human Touch*, asks whether the world has meaning or order other than what we give to it. The book also explores the similarities between science and fiction, both of which deal with narrative. He suggests that even the most abstract science is trying to tell a story and keep the interest of its audience. *The Human Touch* questions our place in the universe, a recurring theme in Frayn's works. "The plays I've written are about how we organize the world around us, how we try to make sense out of it and try to make sense out of each other. I have been writing *The Human Touch* on and off for the past 30 years and I've tried to confront some of these questions."

During his visit to CERN, Frayn gave a colloquium on his new book to CERN staff. Although a bit intimidated by the level of knowledge at CERN, he seemed to enjoy the opportunity to listen and debate with physicists about some of these philosophical questions.

After touring the ATLAS and CMS experiments, Frayn was stunned by CERN's huge efforts to understand the universe more precisely. "I had no real concept of the sheer scale, the amount of effort and political skill needed, and the extraordinary technological complexity of it all, quite apart from the theories it will be testing. It really is quite amazing." The desire to know our world better is something this philosophical writer appreciates, especially considering that these experiments are being constructed and performed in the sole interest of science, and not for monetary gain or military power.

Further reading

M Frayn 2007 *The Human Touch: Our part in the creation of a universe* (Metropolitan Books, New York).
For Frayn's colloquium at CERN see the web at http://indico.cern.ch/conferenceDisplay.py?confId=a0739.

Résumé

Michael Frayn s'interroge sur notre place dans l'Univers

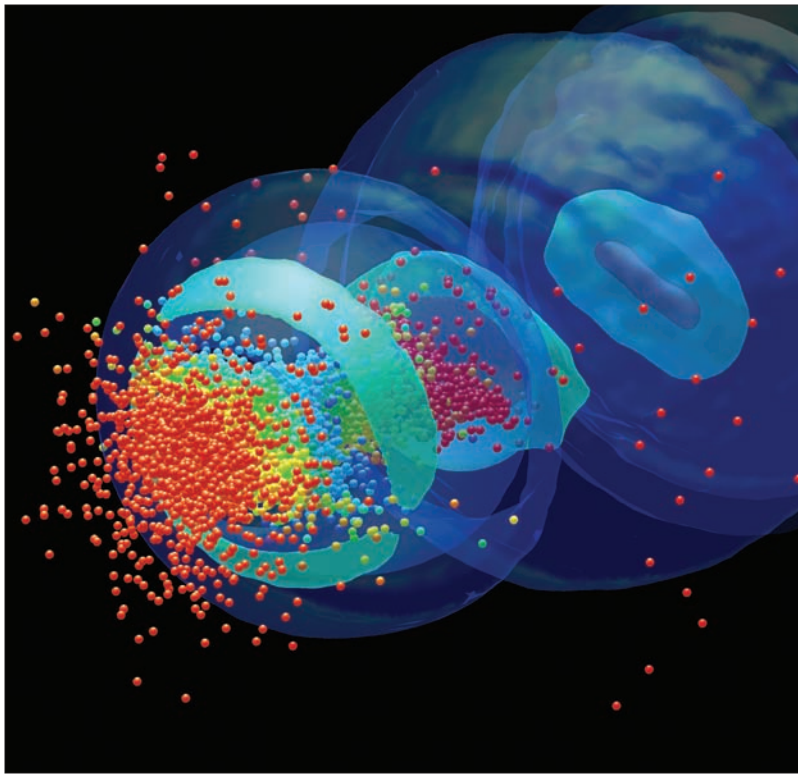
Le célèbre romancier, dramaturge et traducteur Michael Frayn s'est rendu au CERN en mars pour donner une conférence sur son dernier livre The Human Touch. *Frayn a fait son entrée sur la scène scientifique par sa pièce* Copenhague, *qui évoque la rencontre entre Werner Heisenberg et Niels Bohr pendant la Deuxième Guerre mondiale. Dans* The Human Touch, *il s'interroge sur l'existence d'un sens et d'un ordre du monde en dehors de ceux que nous lui donnons. Frayn, qui a tout d'abord étudié la philosophie à Cambridge, est profondément honnête et s'enthousiasme pour la science, un domaine dans lequel il reconnaît ouvertement avoir très peu de connaissances. Dans cette interview, il raconte son itinéraire dans le monde scientifique.*

Carolyn Lee, *CERN.*

Harnessing the power o

Experiments at accelerators have produced many key breakthroughs in particle physics during the past 50 years. Today, as exploration begins of physics at the "terascale", the machines needed are extremely large, costly and time-consuming to build. In 1982, however, recognizing that this is how the field would evolve, the US Department of Energy (DOE) began a programme to develop new ideas for particle acceleration, which has now become extremely active. From the outset it was clear that developing an entirely new concept for accelerating charged particles would be a multi-disciplinary endeavour, requiring a sustained research effort of several decades to come to fruition (HEPAP 1980). Here I would like to examine just how far one advanced concept – plasma-based particle accelerators – has come after 20 or so years of research, and to indicate how it is likely to develop in the next decade.

Chan Joshi reviews recent progress in the develop of plasma-based particle accelerators and conside challenges still to be overcome to turn this concept a practical technology for high-energy physics.



Simulation of SLAC's plasma-wakefield accelerator experiment, which dem energy doubling of 42 GeV electrons in less than 1 m. (Courtesy F Tsung UC

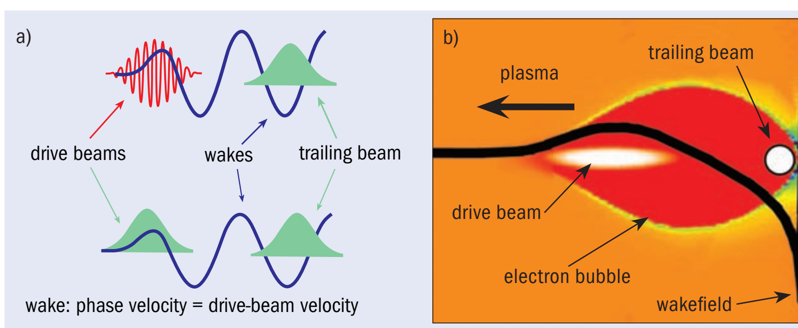


Fig. 1. (a) A simple 1D schematic of how wakefields are excited by a short-las particle-beam (bottom) driver in a plasma. (b) 3D computer simulation of an nonlinear wakefield excited by the drive beam in the "bubble" regime. The wa can accelerate an appropriately phased trailing beam at ultra-high gradients

Historical background

The first suggestions for using "collective fields" generated by a medium-energy electron beam to accelerate ions to high energies can be traced to Gersh Budker and Vladimir Veksler. However, plasma-based accelerators did not take off until John Dawson and his co-workers at the University of California, Los Angeles (UCLA) proposed the use of a space-charge disturbance, or a "wakefield", to accelerate electrons (Joshi 2006; Joshi and Katsouleas 2003). Serendipitously, the ideas that Dawson developed between 1978 and 1985 coincided with the DOE's initiative on advanced accelerator techniques and were supported first in the US and then in other countries.

Wakefields in a plasma can be driven by an intense laser pulse (the laser-wakefield accelerator) or an electron-beam pulse (the plasma-wakefield accelerator) that is about half a plasma wavelength long. In the former it is the radiation pressure of the laser pulse that pushes away the plasma electrons, whereas in the latter this is achieved by the space-charge force of the (highly relativistic and therefore stiff) electron beam. The plasma electrons are predominantly blown out radially, but because of the space-charge attraction of the plasma ions, they are attracted back towards the rear of the laser (or the particle) beam where they overshoot the beam axis and set up a wakefield oscillation. In a 1D picture the wake resembles a series of capacitors where the mostly transverse electric field of the laser (particle) beam has been transformed into a longitudinal electric field of the wake. Charged particles in an appropriately phased trailing pulse can then extract energy from the wakefield (figure 1a).

The mixture of physics disciplines involved meant that even proof-of-concept experiments on plasma accelerators required an expertise in plasma physics, lasers and beam physics. Since such expertise resided in universities, most of the early work was carried out by small university groups. By the 1990s many teams around the world had confirmed that plasma wakes did

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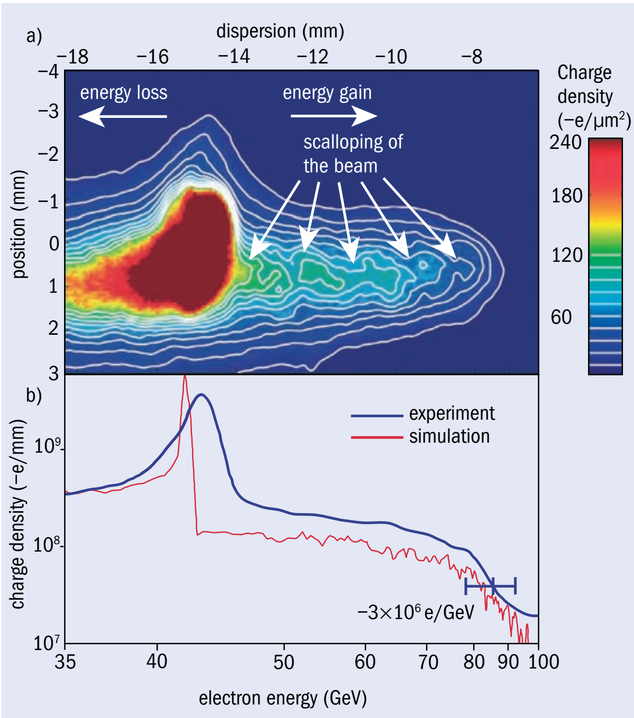


Fig. 2. (a) The energy spectrum observed in the recent UCLA/USC/SLAC experiment E167 at SLAC for the electron beam (initially nominally 42 GeV) after passing through an 85 cm long lithium plasma of density 2.7×10^{17} cm^{-3}. (b) A comparison between the measured spectrum and the simulated spectrum (Blumenfeld et al. *2007). (Courtesy MacMillan Publishers Ltd.)*

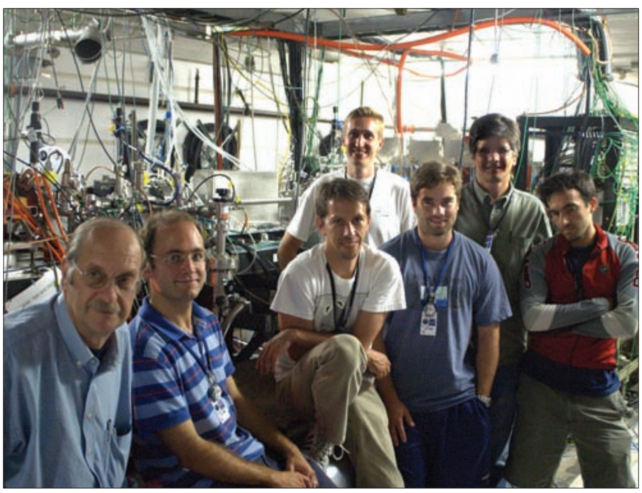


Fig. 3. Some of the team that are involved in the E167 experiment at SLAC. Left to right: R Siemann, R Ischebeck, P Muggli, M Hogan, N Kirby, K Marsh and E Oz.

indeed have accelerating gradients of the order of 100 GeV/m and could accelerate electrons, often trapped from the plasma itself, with a continuous energy spectrum up to 100 MeV. However, there remained two important goals for the proponents of plasma-based accelerators to provide beams of interest to the end user of this technology – the high-energy physics community. They needed to show that plasma accelerators could produce a "monoenergetic beam" of electrons and that the high-gradient acceleration could be maintained over scales of a metre. There has been significant progress in achieving both of these goals in the past couple of years.

The "plasma bubble" accelerator

Most laser-driven and particle-driven plasma-wakefield accelerators now operate in the "bubble regime". Here the drive pulse is so intense that it expels all of the plasma electrons for which subsequent trajectories enclose a "bubble" of ions. The resulting wakefield structure is 3D and the longitudinal wakefield is highly nonlinear (figure 1b). The phase velocity of the wakefield is tied to the group velocity of the drive beam, which is approximately the velocity of light, *c*.

In present laser-wakefield accelerator experiments, even though the phase velocity is relativistic, the accelerating particles eventually outrun the wave in a relatively short distance, of the order of a few millimetres to a centimetre – this is called the dephasing limit. While this dephasing limits the maximum energy gain, it has the benefit of generating a monoenergetic electron beam. How does this happen? First, as the radially blown-out plasma electrons rush back toward the axis, a significant number of them are trapped by the longitudinal field of the wake. Second, this self-trapping is severe enough to load the wake with so many electrons that the energy they extract reduces its amplitude, thereby turning off any further trapping – an effect known as beam loading. As the trapped electrons are accelerated their energy initially increases monotonically. However, eventually the electrons in the front dephase and begin to lose energy, while the electrons behind them continue to gain energy (phase-space rotation). This produces a quasi-monoenergetic bunch.

Research groups have now seen such monoenergetic bunches in at least half a dozen laser-wakefield accelerator experiments around the world. Recently the group at Lawrence Berkeley National Laboratory, in collaboration with Oxford University, has used a plasma discharge in a 3.3 cm long capillary tube to produce a hydrogen plasma channel. When the team guided a 40 TW laser pulse through this channel, they produced a monoenergetic beam with an energy up to 1 GeV (Leemans *et al.* 2006 and *CERN Courier* November 2006 p5). To go to higher particle energies, laser pulses of even higher power need to be propagated over longer distances in plasma channels. In the next few years we will see if 100 TW class pulses can be guided through plasma ▷

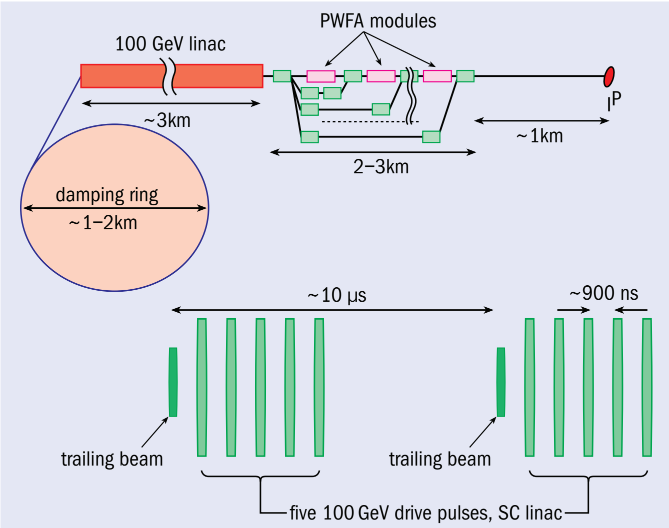


Fig. 4. One arm of a 500 GeV (1 TeV centre-of-mass), multi-stage plasma-wakefield accelerator. A 100 GeV superconducting (SC) linac generates the multi-bunch pulse structure needed to drive the energy-gain plasma wakefield accelerator (PWFA) modules, each of which has an energy gain of 100 GeV. (Courtesy Yakimenko and Ischebeck 2006.)

channels 10–30 cm long with a plasma density in the range of 10^{17} cm^{-3}, to produce 10 GeV pulses of high beam quality.

Plasma-wakefield accelerator

There are fewer particle-beam-driven plasma acceleration experiments compared with laser-accelerator experiments. This is because there are fewer suitable beam facilities in the world compared with facilities that can deliver ultra-short laser pulses. The first beam-driven plasma-wakefield experiments were carried out at the Argonne Wakefield Accelerator Facility in the 1980s. Now however, a series of elegant experiments done at SLAC by the UCLA/USC/SLAC collaboration has mapped the physics of electron and positron beam-driven wakes and shown acceleration gradients of 40 GeV/m using electron beams with metre-scale plasmas (*CERN Courier* April 2007 p5).

In the SLAC experiments only one electron pulse was used to excite the wakefield (Blumenfeld *et al.* 2007). Since the energy of the drive pulse is nominally 42 GeV, both the electrons and the wake are moving at a velocity close to *c*, so there is no relative motion between the electrons and the wakefield. Most of the electrons in the drive pulse lose energy in exciting the wake, but some electrons in the back of the same pulse can gain energy from the wakefield as the wakefield changes its sign.

When the 42 GeV SLAC electron beam passed through a column of lithium vapour 85 cm long, the head of the beam created a fully ionized plasma and the remainder of the beam excited a strong wakefield. Figure 2a (p29) shows the energy spectrum of the beam measured after the plasma. The electrons in the bulk of the pulse that lost energy in driving the wake are mostly dispersed out of the field of view of the spectrometer camera and so are not seen in the spectrum. However, electrons in the back of the same pulse are accelerated and reach energies up to 85 GeV. The measured spectrum of the accelerated particles was in good agreement with the spectrum obtained from computer simulations of the experiment, as figure 2b shows. This is a remarkable result when one realises that while it takes the full 3 km length of the SLAC linac to accelerate electrons to 42 GeV, some of these electrons can be made to double their energy in less than a metre.

Where next?

Over the past 25 years, a relatively small number of dedicated researchers have solved many technical problems to reach a point where plasma-based accelerators are producing energy gains of interest to high-energy physics, but there are still many challenges ahead of us. The one that is often brought up is the energy spread and emittance of the accelerated electrons. Laser experiments have already shown self-trapped electron beams with an energy spread of a few per cent. In a beam-driven plasma accelerator a different plasma-electron trapping mechanism, called ionization trapping, could generate a perfectly phased sub-micrometre beam suitable for multi-stage acceleration, with an extremely low emittance and a narrow energy spread. Then there is the issue of the possible degradation of the beam quality because of collisions and, possibly, ion motion. If these are shown to be important effects then, like beam "hosing" and beam "head erosion" they will represent a design constraint on a plasma accelerator (Blumenfeld *et al.* 2007).

The next key challenge for plasma-based acceleration is to realise high-gradient acceleration of positrons. Positron acceleration is different from electron acceleration in the sense that the focusing forces of positron pulse-generated wakes have nonlinear longitudinal and transverse variation. It may be worthwhile accelerating positrons in linear plasma wakes generated by an electron pulse or by wakefields induced in a hollow channel, but this needs to be demonstrated.

Once electron and positron acceleration issues, including energy spread and emittance, have been addressed, the next key development is the "staging" of two plasma-accelerator modules. Again, for high-energy physics applications each module should be designed to add the order of 100 GeV energy to the accelerating beam. Given the microscopic physical size of the accelerating structure (the wavelength is about 100 μm), it is probably wise to minimize the number of plasma acceleration stages. In fact in the proposed energy doubler for the SLAC linac, only a single plasma-wakefield accelerator module was deemed necessary (Lee *et al.* 2002). In scaling this concept to 1 TeV centre-of-mass energy, one can envision a superconducting linac producing a train of five 100 GeV drive pulses, separated by about 1 μs, but containing three times the charge of the beam pulse that is being accelerated (figure 4). The drive pulses are first separated from one another and subsequently brought back to be colinear with the accelerating beam. Each pulse drives one stage of the plasma-wakefield accelerator from which the accelerating beam gains 100 GeV energy (Yakimenko and Ischebeck 2006). Both electrons and positrons can be accelerated in this manner. Alternatively, one can imagine an e^-–e^- or a γ–γ collider instead of an e^-–e^+ collider, which could greatly reduce the cost of such a machine.

Key challenges

I have described the many fine accomplishments of the advanced acceleration-research community by using the example of plasma-based accelerators. How will this and other concepts for advanced acceleration progress in the next decade? Will they continue to make progress to stay on track for a prototype demonstration of a new accelerator technology in the early 21st century? The answer depends on the availability of one or more suitable experimental facilities to do the next phase of research that I have outlined.

There are several 100 TW class laser facilities in Europe, the US and Asia that should advance the laser-wakefield accelerator to give multi-giga-electron-volt beams. To go beyond this, a high repetition rate, 10 PW class laser facility is needed to demonstrate a 100 GeV prototype of a laser-driven plasma accelerator.

All advanced acceleration schemes will eventually have to face positron acceleration. How and where will experiments on high-gradient positron acceleration be done? The plasma-wakefield accelerator experiments that led to the energy doubling of 42 GeV electrons were carried out at the Final Focus Test Beam (FFTB) at SLAC, which has been recently decommissioned to make way for the Linac Coherent Light Source (*CERN Courier* May 2007 p9). SLAC has proposed a "replacement FFTB" beam line called SABER, which will provide experimenters with 30 GeV electron and positron beams. If adequately supported, SABER could become the premier facility not only for plasma-acceleration research but also for other advanced acceleration concepts.

There are about 40 groups worldwide working in plasma-based acceleration with a critical mass of trained scientists and students who are attracted to the field because it offers many chances to make unexpected discoveries. The time is now ripe to invest in appropriate facilities to take this field to the next level. It could be the critical factor that makes the difference to the future of high-energy physics in the 21st century.

Further reading

I Blumenfeld *et al.* 2007 *Nature* **445** 741.

HEPAP 1980 *Report of the HEPAP Subpanel on Accelerator Research and Development* US DOE Report DOE/ER-0067 UC-34.

C Joshi 2006 *Scientific American* **294** 41.

C Joshi and T Katsouleas 2003 *Physics Today* **56(6)** 47.

S Lee *et al.* 2002 *PRSTAB* **5** 01001.

W P Leemans *et al.* 2006 *Nature Physics* **2** 696.

V Yakimenko and R Ischebeck 2006 "Advanced Accelerator Concepts" *AIP Conf. Proc.* **877** 158.

Résumé

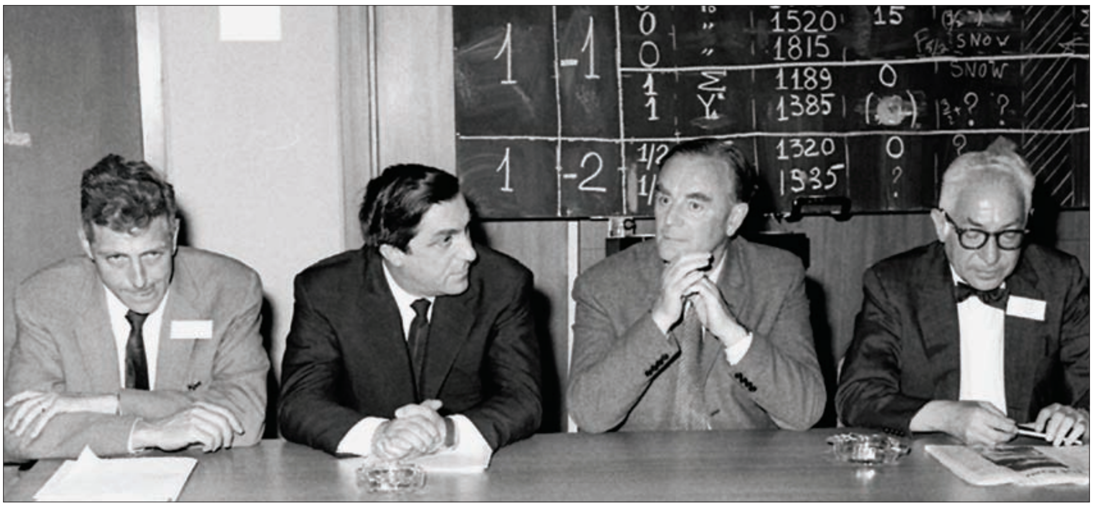
Mettre à profit la puissance du champ de sillage du plasma

On sait depuis longtemps que la physique des hautes énergies aura un jour besoin d'idées nouvelles pour accélérer les particules. Un concept de pointe développé au cours des deux dernières décennies est celui de l'accélérateur de particules à plasma. L'idée est d'exploiter le «champ de sillage» généré dans le plasma par une intense impulsion laser ou une impulsion de faisceau d'électrons pour porter des particules à de hautes énergies. Dans cet article, Chan Joshi fait le point des progrès réalisés récemment dans le domaine et envisage les défis qu'il reste à relever pour que ce concept se mue en une technologie réalisable pour la physique des hautes énergies.

Chan Joshi, *University of California, Los Angeles.*

Puppi: promoting new horizons in physics

Antonino Zichichi provides a personal look at the work of his one-time teacher, Gianni Puppi, his triangle and his vision to open up new horizons in physics.



*Giampetro Puppi, second from left, at the international conference on high-energy physics that was held at CERN in July 1962. This was the 11th "Rochester" Conference and the first to be hosted by CERN (*CERN Courier *July/August 2005 p11). Also pictured are Bernard Gregory (left), Isidor Rabi (far right) and Cecil Powell.*

In 1948 Giampietro Puppi, Gianni to his friends, published a paper in *Il Nuovo Cimento* where he distinguished the neutral counterpart of the muon – now known as the muon neutrino, ν_μ – from the neutral counterpart of the electron, now called the electron neutrino, ν_e (Puppi 1948). Fourteen years later, what Puppi had proposed in his famous paper was demonstrated experimentally by a team led by Leon Lederman, Mel Schwartz and Jack Steinberger (Danby *et al*. 1962). Puppi had calculated three weak processes – pion decay, muon capture and muon decay – and was able to prove that these three different processes were described by "approximately" the same fundamental weak coupling. The coupling of the three vertices of the "Puppi triangle" described all weak processes known at the time with the same strength, represented by the sides of his equilateral triangle.

This work was the first step towards the universality of the weak forces and indeed attracted the attention of Enrico Fermi, since it was the first proof that all weak processes could be described by the same coupling. It came just a year after the discovery by Marcello Conversi, Ettore Pancini and Oreste Piccioni that the negative cosmic-ray "mesons" (now known to be the leptons called muons) were disintegrating as if they were not strongly coupled to the nuclear forces (Conversi *et al*. 1947).

Fermi, together with Edward Teller and Victor Weisskopf, pointed out that the lifetime of this meson was 12 powers of 10 longer than the time needed for the long-sought Yukawa meson to be captured by a nucleus via the nuclear forces (Fermi *et al*. 1947). The solution of the puzzle was soon found by Cesare Lattes, Giuseppe Occhialini and Cecil Powell, who discovered that the cosmic-ray muon was the decay product of a particle, now known as the π meson or pion, which the authors considered to be the "primary meson" (the origin of the symbol π, for primary; Lattes *et al*. 1947).

To prove that rates for pion decay, muon decay and muon capture were "approximately" equal as expected by the universality of the Fermi coupling was indeed remarkable. These were great times for the understanding of the weak forces, and at the time the topic of the universality of the weak interaction was a central focus of the physics community (Klein 1948, Lee *et al*. 1949 and Tiomno and Wheeler 1948). The Puppi triangle played a crucial role in revealing the basic property of the new fundamental force of nature, the strength of which appeared to be so much weaker than that of the electromagnetic and of the nuclear forces.

At this time, cosmic rays provided the only source of high-energy particles, and Puppi made another valuable contribution to the field with his paper on the energy balance of cosmic rays (Puppi 1953). However, the direction of research was soon to change with the advent of particle accelerators and the newly invented bubble-chamber ▷

technology. In 1953 Puppi established the first group of the Bologna section of INFN, which led to the existence of a large collaboration in the field of bubble-chamber physics, leading to the observation of parity non-conservation in hyperon decays in 1957.

I have a personal reason for being grateful to Puppi around this time. When he was research director at CERN (1962–63) and later chair of the Experimental Committee (1964–65), he played a crucial role by being a strong supporter of my Non-Bubble Chamber (NBC) project. Physics was at the time dominated by bubble-chamber technology, and Puppi himself had been fully engaged in promoting the National Hydrogen Bubble Chamber in Italy, and in establishing large international collaborations for the analysis of bubble-chamber pictures. It was the need for powerful computing for this analysis that led him to establish the first computing facility in Bologna, the development of which through the subsequent decades produced what is now the largest computing centre in Italy.

Bubble-chamber technology had revealed an enormous number of baryons and mesons and Puppi was interested in what this could mean. The question arose of whether to encourage other technologies, and in particular to do what? In a meeting in his office as research director at CERN, the subject came up of studying the rare-decay modes of mesons – especially the electromagnetic decay modes. This needed NBC technology. As a typical exponent of the classical culture of Venice, Puppi was open to new horizons and made the point that new technologies had to be encouraged; and this is how the NBC project began. He was no longer at CERN when, in 1968, thanks to the NBC set-up, a new decay mode of the X^0 meson (now η') into two photons was discovered, thus establishing that this heavy meson could not be the missing member of the tensor octet. This was the first step in determining directly the correct value of the pseudoscalar meson mixing.

During a meeting on Meson Resonances and Related Electromagnetic Phenomena at the European Physical Society conference in Bologna in 1971, Dick Dalitz pointed out that it was thanks to physics leaders of the calibre and vision of Puppi that new horizons in the physics of mesons has been opened. The problem of the vector and pseudoscalar meson mixings needed NBC technology in order to be investigated experimentally. These were times when no data on vector mesons existed from electron–positron colliders and direct measurements of the pseudoscalar and vector-meson mixings did not exist. As we now know, to understand the mesonic mixings, it was necessary first to discover the theory of quantum chromodynamics and then to discover instantons. No-one could have imagined these developments, rooted in the physics of mesons, when, in the 1960s, CERN's research director had encouraged the young fellows to propose new ways to go beyond bubble-chamber technology, and the knowledge of the meson-mixings was based only on their masses, which Puppi correctly considered a tautology.

Puppi's scientific interests extended beyond particle physics to space physics, which is why he became president of the European Space Research Organization (ESRO) and co-founder of the European Space Agency (ESA). Also, in the field of ecology and the protection of the treasures of civilization, he founded the Istituto delle Grandi Masse to study, on a rigorous scientific basis, the sea-water dynamics so vital for the future of his beloved Venice.

The last time I had the pleasure and the privilege to meet my teacher was a few weeks before he departed this life in December 2006 (*CERN Courier* April 2007 p41). He never stopped pursuing a multitude of interests, including the future of CERN, having been not only a research director but also a member of the CERN Council. He was very concerned when he learned that the Council now does not always express its full support for the laboratory's activities.

"During my time, the CERN Council was a strong supporter of the decisions taken, always, for the strengthening of the scientific excellence of the results, to be obtained in the most civilized competition mankind can put forward: physics. No one should underestimate the fact that CERN has the remarkable property of being unique in the world." These were his last words.

Further reading

M Conversi, E Pancini and O Piccioni 1947 *Phys. Rev.* **71** 209.
G Danby *et al*. 1962 *Phys. Rev. Lett.* **9** 36.
E Fermi, E Teller and V Weisskopf 1947 *Phys. Rev.* **71** 314.
O Klein 1948 *Nature* **161** 897.
C Lattes, G Occhialini and C Powell 1947 *Nature* **160** 454.
TD Lee, M Rosenbluth and CN Yang 1949 *Phys. Rev.* **75** 905.
G Puppi 1948 *Il Nuovo Cimento* **5** 587.
G Puppi 1953 *Supplemento del Nuovo Cimento* **X** Serie IX.
J Tiomno and JA Wheeler 1949 *Rev. Mod. Phys.* **21** 144.

Résumé

Puppi: pour ouvrir de nouveaux horizons à la physique

Giampietro Puppi est bien connu pour le «triangle de Puppi», par lequel il a fait le premier pas vers l'universalité des forces faibles en 1948. Toujours animé par le désir d'ouvrir de nouveaux horizons à la physique, il a établi le premier groupe de la section de Bologne de l'INFN, puis est devenu une figure importante de la physique de l'espace. Lorsqu'il était directeur de la Recherche au CERN, au début des années 60, à l'heure où l'expérimentation était dominée par la technologie des chambres à bulles, il s'est fait un point d'honneur d'encourager les nouvelles technologies. Dans cet article, Antonino Zichichi nous fait découvrir l'homme, son triangle et sa vision.

Antonino Zichichi, *INFN/University of Bologna and CERN.*

Power and prejudice: women in physics

Why are there so few female physicists? Is there really a problem? **Marianne Johansen** reviews some studies of this emotive issue in search of solid fact.

Physics has always had a relatively low proportion of female students and researchers. In the EU there are on average 33% female PhD graduates in the physical sciences, while the percentage of female professors amounts to 9% (ECDGR 2006). At CERN the proportion is even less, with only 6.6% of the research staff in experimental and theoretical physics being women (Schinzel 2006). The fact that there is no proportional relationship between the number of PhD graduates and professors also suggests that women are less likely to succeed in an academic career than men.

Before examining the findings of various studies, it is worth asking if this low representation of women in physics is a problem – do we actually need more female physicists? In my opinion this question has to be answered from three perspectives: the perspective of society, the perspective of science and the perspective of women.

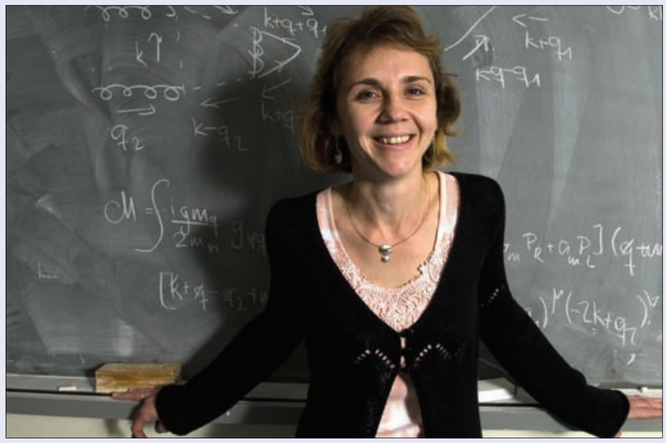
Starting from the viewpoint of society, there are several issues to consider. First, physics is a field of innovation. Many technological advancements that have a huge impact on society and everyday life come directly or indirectly from physics. Being a physicist therefore means having access to people and knowledge that set the technological agenda.

Second, in many countries research and academic positions are regarded as high-status jobs. Academic staff are often appointed to committees that fund research projects or advise governments on issues that are closely related to their field of expertise. As such, scientists influence the focus of research and the general development of society.

Finally, it is a democratic principle that power and influence should be distributed equally and proportionally among different groups in society. An EU average of 9% female physics professors does not even come close to equal representation in this field. The fact that women fund research through tax payments adds to the demand for more female scientists.

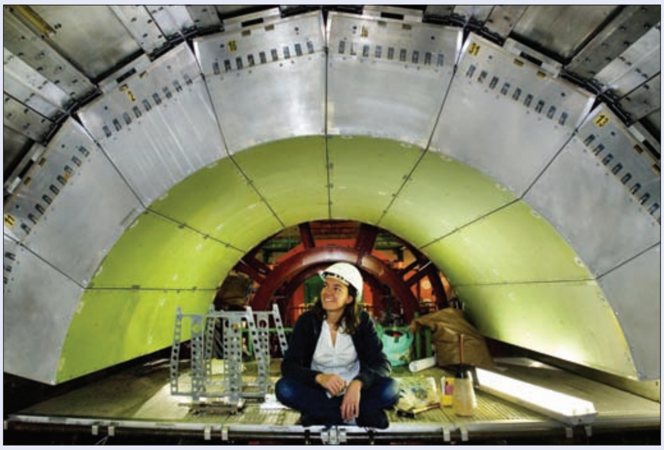
From a scientific point of view, the lack of women represents a huge waste of talent. For physics to develop further as a science, it needs more people with excellent analytical, communicational ▷

A dramatic imbalance



Margarete Muehlleitner is a theoretical physicist, a French university lecturer and a fellow in CERN's Theory Group. She says that in Germany, her home country, "Only a small percentage of women studying physics go on to do a master's degree, and even fewer go further than that in their subject. As far as I know, about 1% of university physics professors are women, a situation that hasn't changed much in 100 years!" In her opinion, this dramatic imbalance between the sexes can be explained by two problems. "Women don't think they are capable of making a career in physics or maths. I personally thought I was too stupid to make it and didn't dare try. I actually studied engineering for a year before I finally decided to venture into physics." In addition to this problem of mentality, the childcare infrastructure for toddlers and infants is virtually non-existent in Germany. "In Germany it is simply impossible to have children and pursue a career in science, where you need to be 150% committed. I was lucky enough to have a husband who was willing to follow me wherever I went and to spend two years at home taking care of our child while he continued his studies." Having a baby can pose problems for women who want to pursue a career in science. "I was afraid of getting left behind and so carried on going to lectures during my maternity leave," she says. In her opinion, girls in Germany need to be taught right from secondary-school age that they are just as capable of studying science as men are.

Patience and perseverance



Francesca Cavallari is a physicist with Italy's National Institute for Nuclear Physics (INFN) and a member of the CMS collaboration. She says that more women study science in Italy than in other European countries, but they tend to go into teaching rather than research. "It's a pity, because women are well suited to research. They have more patience and perseverance. What's needed is a balance between men and women." During her career, she has never felt discriminated against, but she sometimes notices some misgivings about women's abilities in sectors such as electronics and anything to do with heavy machinery, which are considered, wrongly, to be masculine. "There is an implicit lack of confidence," she says. "We have to quickly prove our abilities and then everything's fine." She feels that there are not enough women in senior positions in research, especially at CERN. "At INFN, my boss, Marcella Diemoz, is a woman, but she is an exception in the research field. Having women in senior positions could encourage young women to follow in their footsteps."

Positions of seniority

For Pauline Gagnon, a physicist on the ATLAS experiment at CERN, one of the problems for women in physics is the way in which the highest positions are distributed. She says that statistically the number of women in positions of seniority should have increased by now, based on the number of women working in the sciences. Indeed, although the average number of working female researchers across the EU is nearly 40%, a recent study shows that in 2004 women filled only 11.3% of A-grade management positions in the natural sciences, and only 5.8% in A-grade engineering and technology positions. Gagnon's response was to join with other ATLAS women to form the ATLAS Women's Network, which meets for lunch once a week to network and to discuss ways to improve the situation for women both in ATLAS and at CERN. Her advice to aspiring female physicists? "Don't give up," she says. "And don't stay isolated. Seek the support of other women."

and social skills. There are also reports that departments without women suffer in many ways (Main 2005).

From the perspective of women, they will of course benefit from increased influence in society, but contributing to physics is not only about struggling for influence and power. Fundamental questions have been asked throughout history by men and women alike. Contributing to physics is to participate in a human project, driven by curiosity and wonder that seeks to understand the world around us.

What the studies find

So why do women fail to advance to the top levels in academia? Some reports state that it is because women are less likely to give priority to their career (Pinker and Spelke 2005), while others cite inferiority in the ability to do science compared with men or the lack of some of the abilities necessary to be successful in science. For example, one report suggests that men are on average more aggressive than women, and that this characteristic (among others) is necessary to succeed in academic work (Lawrence 2006). What these reports have in common is that they all conclude that there will never be as many women as men in academia because of innate differences between the genders, and also that these differences are the main reason for the under-representation of women.

Other reports state that women do not succeed in physics because of prejudice, discrimination and unfriendly attitudes towards them. Studies have shown that women need to be twice as productive as men to be considered equally competent (Wennerås and Wold 1997). In fact both men and women rate men's work higher than that of women (Goldberg 1968). There is also the psychological mechanism called "stereotype threat", which causes individuals who are made aware of the negative stereotypes connected to the social group to which they belong – such as age, gender, ethnicity and religion – to underperform in a manner consistent with the stereotype. White male engineering students will for instance perform significantly worse on tests when they are told that Asian students usually outperform them on the same tests (Steele 2004). It is important to remember that these prejudices are present in most human beings and do not necessarily arise from bad will or conscious hostility.

A survey designed to identify issues that are important to female physicists also reported on their negative experiences as a minority group owing to the male domination in the field (Ivie and Guo 2005). In this survey 80% state that attitudes towards women in physics need to be improved, while 65% believed discrimination is a problem that needs to be dealt with. This survey also reported on positive experiences among female physicists, in particular their love for their field and the support that they have received from others.

To produce an exhaustive list of reasons for why so few women are able to reach the highest positions in academia would be a tedious endeavour with many conflicting opinions. However, if we agree that we need more women in physics, it is clear that we need to take action. In this regard it is important to recognize that some of these actions will also be beneficial to men, improving their ability to succeed in a scientific career.

In academia several things can be changed to eliminate discrimination and hostile attitudes towards women (and men):

- Transparency in selection processes for scholarships, funding and positions, i.e. making all evaluation done by the selection committees public so that any discriminating mechanism can be unveiled. This will also benefit men, since they are also subjects of discrimination (Wennerås and Wold 1997).
- Investigate hostile attitudes in institutes and laboratories. Those who discriminate tend not to see how their behaviour affects their environment, and those discriminated against are usually reluctant to admit it. The Institute of Physics in London visits institutes, on invitation only, to investigate their attitudes towards women (Main 2005).
- Make the career path more predictable. Both genders suffer from the unpredictability and requirement of mobility in an academic physics career, and this can also conflict with the desire to start a family (Ivie and Guo 2005).
- Awareness of discrimination. Nobody wants to discriminate against others; the use of stereotypes and prejudice is a part of the human mind. It is therefore important to be aware of how these properties affect the way that we evaluate and treat others. Awareness of discriminating procedures have caused changes. Both the US National Institutes of Health (Carnes 2006) and the Swedish Medical Research Council (Wennerås and Wold 1997) changed their routines after being made aware that their evaluation and recruitment schemes were prejudiced against women.

There is no doubt that the under-representation of women in physics is a sensitive issue. Women and men who have never experienced discrimination or bias towards their gender often feel repelled when the issue is discussed. However, I believe the numbers speak for themselves: women do not have the same possibility to succeed in academia as men. As individuals we would like to think that we can all approach any branch of society without being met with hostility or bias, no matter what ethnic group, social class, religion or gender we might belong to. In the end most women would just like to be able to make the same mistakes, produce the same number of papers and be respected, accepted or rejected on the same conditions as their male colleagues, not more, not less.

● With thanks to the ATLAS Women Group, David Milstead, Robindra Prabhu, Helene Rickhard, Josi Schinzel, Jonas Strandberg and Sara Strandberg.

The interviews are reproduced from an article published in the *CERN Bulletin*, issue 10, 2007, http://bulletin.cern.ch/eng/articles.php?bullno=10/2007&base=art##Article2.

Further reading

M Carnes 2006 *Nature* **443** 868.
European Commission Directorate-General for Research (ECDGR) *She Figures 2006. Women and Science: Statistics and Indicators*. ISSN 1018-5593. See the web at http://ec.europa.eu/research/science-society/pdf/she_figures_2006_en.pdf.
P Goldberg 1968 *Trans-Action* **5** 267.
R Ivie and S Guo 2005 *Proceedings from the 2nd IUAP International Conference on Women in Physics*.
P Lawrence 2006 *PLoS Biology* **4** 13.
P Main 2005 Talk at the Nordic Conference for Women in Physics, Bergen. See http://web.ift.uib.no/nwip2005/DOCS/SESSION_1/PeterMain.ppt
S Pinker and E Spelke 2005 *The Science of Gender and Science. Pinker vs. Spelke: A Debate*, www.edge.org/3rd_culture/debate05/debate05_index.html.
J Schinzel 2006 "Statistics for Equal Opportunities 2005" (Draft), CERN 2006.
C Steele 2004 *Steele Discusses "Stereotype Threat"*. See the web at www.mtholyoke.edu/offices/comm/csj/092404/steele.shtml.
C Wennerås and A Wold 1997 *Nature* **387** 341.

Résumé

Pouvoir et préjugés: les femmes et la physique

La physique a toujours compté relativement peu d'étudiantes et de chercheuses, et le pourcentage encore plus faible de professeures suggère que les femmes y ont de moins bonnes perspectives de carrière universitaire que les hommes. Pourquoi si peu de femmes? Marianne Johansen, cherchant à comprendre le phénomène au-delà des anecdotes et des opinions, se penche sur des études qui ont porté sur cette question délicate en quête de faits concrets. Elle en conclut que les femmes n'ont pas les mêmes perspectives de carrière que les hommes et fait apparaître comment on pourrait remédier à ce déséquilibre. Dans cet article, quelques physiciennes des particules évoquent de plus leur propre expérience.

Marianne Johansen, *Stockholm University.*

AWARDS

Lefrançois wins first Prix André Lagarrigue

Jacques Lefrançois (centre) with Michèle Leduc (third from left) of the French Physics Society.

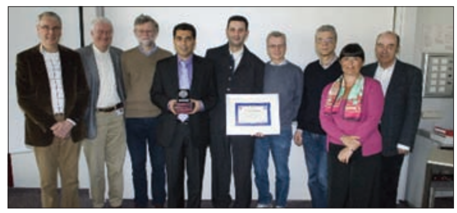
In a ceremony at the Laboratoire de l'Accélérateur Linéaire (LAL), Orsay on 29 March, Jacques Lefrançois received the new Prix André Lagarrigue from the president of the French Physics Society, Michèle Leduc. Guy Wormser, director of the LAL, which instituted the prize, Michel Spiro, director of IN2P3 and president of the International Jury, and representatives of the co-financing institutions (CEA, CERN, École Polytechnique, IN2P3, LAL and University Paris-Sud) joined in congratulating the prize winner after a cheerful recollection of Jacques Lefrançois' achievements and leadership.

Fibernet and Quantum receive ALICE awards

In a ceremony on 9 March, the ALICE Collaboration recognized Fibernet Ltd, based in Yokneam, Israel, and Quantum Corp., of San Jose, US, for their outstanding contributions in meeting demanding or unusual requirements.

Fibernet Ltd was rewarded for the excellent and timely assembly of the silicon strip detector (SSD) boards of the inner tracking system with cable connections. Special low-mass cables, just a millimetre in diameter, connect the inner parts of the SSD to the outside world. Owing to the limited space in the centre of ALICE, it was necessary for the assembly to have no twists between the three sets of conductors. Fibernet Ltd created cables containing a total of 25 000 wires that were supple and could easily be laid out in any curve.

Quantum Corp. received its award for the high-performance cluster file system, StorNext, which has been deployed by the ALICE data-acquisition system, as well as for its outstanding co-operation and support in implementing the software. The ALICE experiment is expected to generate a petabyte of data a month and it required a way to store the data temporarily before transferring it to the CERN mass-storage systems. Quantum Corp. provided the highest performance for this task, along with a co-operative and helpful attitude.



Yehuda Mor-Yosef (centre) and Shon Shmuel (centre left) of Fibernet Ltd at the ALICE awards ceremony in March.

Derek Barrilleaux (centre), Ewan Johnston (centre left) and Lance Hukill (centre right) of Quantum Corp. receive their award.

MUSIC

Tiecke with his home-made barrel organ.

Physicist makes ATLAS muon chamber sing in his home-made barrel organ

NIKHEF physicist Henk Tiecke showed that particle detectors can make good music when he used pipes cut from spares for the ATLAS Monitored Drift Tube (MDT) detector as part of his Dutch-style barrel organ.

Tiecke, who worked on the ZEUS experiment at DESY until retiring last summer, visited some colleagues working on the production of the ATLAS chambers at NIKHEF in 2005. He noticed that the aluminium tubes they were using to build the chambers were about 3 cm in diameter – just the right size to provide the lower tones in his barrel organ. So for fun he replaced 19 of the 35 pipes by cutting up one of the spare MDT detector tubes, and was able to play at NIKHEF during festivities for the shipment of the first chambers to CERN.

SLAC

Panofsky celebrates his 88th birthday…

Panofsky celebrates his 88th birthday with his wife Adele and several hundred well-wishers.

WKH "Pief" Panofsky celebrated his 88th birthday at SLAC on 24 April. Surrounded by about 200 well-wishers – including several past and present lab directors and a string quartet – Panofsky modestly accepted abundant praise and congratulations.

"Pief's life has been extraordinary by any definition of that overused term," said SLAC's director, Jonathan Dorfan. "His optimism, his warmth, his patience, his integrity, his kindness, his sense of humour, his courage and his persistence haven't wavered or altered one bit during all these years."

The founder and first director of SLAC, Panofsky has had a profound impact on elementary-particle physics. In parallel with his career in science, he avidly pursues two other interests of equal historical significance: arms control and international security policy.

…and LCLS electrons bring the ice cream

In April physicists and engineers at SLAC's Linac Coherent Light Source (LCLS) delivered the first electron bunch using the newly installed injector system, so marking the start of commissioning for the new free-electron laser (*CERN Courier* May 2007 p9). SLAC employees celebrated the event by eating dessert and sending an outsized electron bunch of their own floating harmlessly into the California sky.

Sunshine and refreshments were plentiful as more than 600 people turned out for an afternoon of ice cream, calypso music and crowd-surfing nylon balloons screened with "e^-". Director of construction, John Galayda, threw out the floating "electron bunch" to start the event. A team of directors – including Galayda and Dorfan – then lined up to serve more than 25 gallons of ice cream to an eager crowd.

At the queue for dessert, floating electrons celebrate the start of LCLS commissioning.

CELEBRATION

Denisov celebrates his 70th

Sergey Denisov from the Institute of High Energy Physics (IHEP), Protvino, celebrated his 70th birthday on 4 May. His talents, enthusiasm and unlimited capacity for work have won him the regard and admiration of all who work with him.

In the 1970s Denisov led the construction of the multi-purpose spectrometer Sigma at IHEP, which yielded important results on, for example, deep inelastic hadron scattering and the dynamics of J/Ψ production. Since the late 1980s, he has led the Tagged Neutrino project at IHEP, currently used to study decays of charged kaons and cosmic rays. He has also been involved in research at CERN (with DELPHI and ATLAS) and Fermilab (with E672 and DØ). His achievements include developments of gas Cherenkov counters, high-resolution liquid-argon spectrometers, high time-resolution scintillation counters and radiation-resistant high-pressure gas calorimeters.

Denisov has been professor at Moscow State University since 1980. Many young and mature scientists have received an excellent education and friendly advice under his leadership. He was elected corresponding member of the Russian Academy of Sciences in 1997, and is a member of the Scientific Councils of IHEP and the Skobeltsyn Institute of Nuclear Physics in Moscow. He won the Lenin prize in 1986 and the Cherenkov prize of the Russian Academy of Sciences in 2002.

Sergey Denisov, who turned 70 in May.

CENTENARY

The enduring legacy of Vladimir Veksler

Vladimir Iosifovich Veksler, the outstanding Soviet scientist, was born 100 years ago on 4 March 1907. He was widely known for his discovery of the phase-stability principle in 1945, independently from Edwin McMillan in Berkeley. The application of this principle in accelerator technology made it possible to increase substantially the energies achievable in a particle accelerator. It led to dramatic changes in experimental high-energy physics as a new opportunity arose to conduct systematic experiments at accelerators with intense particle beams with set parameters, complementing studies with cosmic rays. Accelerators based on the new principle were built in the US, at CERN, at the Joint Institute for Nuclear Research (JINR) in Russia, and in Germany and other countries. These machines were the basis for a number of fundamental discoveries.

Working at the Lebedev Physics Institute of the USSR Academy of Sciences (PIAS), Veksler organized scientific expeditions to the mountains to study cosmic radiation and designed the first Soviet synchrotrons at PIAS. In the hard post-war years he led the project to build a synchrophasotron in Dubna, which at that time was the largest accelerator, with a proton energy of 10 GeV. The realization of this project became possible only because of the high esteem in which Veksler was held, and his immense talent as a scientist and as an organizer. The start-up of the synchrophasotron in 1957 was acknowledged as an outstanding achievement of Soviet science. Recently, in March, the world scientific community celebrated the 50th anniversary of the accelerator's commissioning.

Vladimir Iosifovich Veksler, 1907–1966.

Veksler proposed further new ideas for particle-acceleration principles. These were studied under his guidance in tests at JINR with models of various systems. He established a large school of engineers and physicists who became leading specialists at JINR, and at its member-state institutions and other scientific centres.

A full member of the USSR Academy of Sciences, Veksler also worked as academician-secretary to the Department of Nuclear Physics and as a member of the Presidium. He established the journal *Nuclear Physics* and was its first chief editor. For several years he headed the High Energy Physics board of the International Union of Pure and Applied Physics.

Veksler's attributes were highly appreciated both in the Soviet Union and abroad. Together with McMillan, he won the prestigious Atoms for Peace award in 1957 for discovering the phase-stability principle. The Russian Academy of Sciences has established the Veksler Prize for outstanding work in accelerator physics. His name is recorded in the names of streets in Dubna and CERN, and the JINR Laboratory of High Energies is also named after him and his successor Alexander Baldin.

Veklser passed away on 22 September 1966. He died at the height of his creative power, but he left behind a deep imprint in science. His ideas are still being developed in many scientific centres around the world, as well as in PIAS and JINR where he worked actively; they are still the basis for new research into mysteries in the structure of matter.

SYMPOSIUM

Egypt and the LHC

The Centre for Theoretical Physics (CTP) at the British University in Egypt held its first symposium on Supersymmetry at LHC: Theoretical and Experimental Perspectives in Cairo on 11–14 March. It attracted around 100 participants from more than 30 countries, including 40 attendees from Egypt.

The 60 talks covered the main lines of developments in what is a very active field, and key issues were discussed. The meeting also provided an ideal opportunity for discussion among experts and scientists from Egypt and the local region, with the possibility for future collaborative research.

The symposium addressed several main topics. Phenomenological Aspects of Particle Physics included supersymmetry, CP violation in K and B systems within the Standard Models or beyond, fermion masses and neutrino oscillations, and the phenomenological implications of extra dimensions. The session on Formal Aspects of Particle Physics focused on progress in string theory, flux compactification, extra dimensions and models with warped geometry.

Cosmological Aspects and Particle Physics included topics such as dark matter and dark energy in supersymmetric models, and hybrid inflation and baryon asymmetry in the universe. Experimental Aspects of Particle Physics covered the potential discovery of the Standard Model Higgs particle and supersymmetric particles at the LHC.

Proceedings will be published as a special issue of *Journal of Modern Physics*.

Attendees at the symposium in Cairo.

MEETING

The **Second International Accelerator School for Linear Colliders** will be on 1–10 October 2007 at the Ettore Majorana Center, Erice, Sicily. The school will offer an eight-day programme, with lectures covering basic accelerator topics (e.g. synchrotrons, linacs, superconductivity and beam–beam interactions) and advanced topics. Most of the advanced topics will focus on a future International Linear Collider (e.g. sources, bunch compressor, damping ring, superconducting RF linac, beam delivery, instrumentation, feedback, conventional facilities and operations). There will also be a lecture dedicated to room-temperature RF and the Compact Linear Collider study. The school welcomes young physicists to apply, in particular those who are considering changing to a career in accelerator physics. For more information on registration etc. see www.linearcollider.org/school/2007/. The deadline for applications is 1 June 2007.

OBITUARY

Jean Gervaise 1921–2007

Jean Gervaise, a pioneer of metrology at CERN, passed away on 10 April. Under his leadership, metrology at CERN acquired international renown.

Despite the disruptions caused by the Second World War, Jean completed an engineering degree at the École Nationale des Sciences Géographiques in Paris, which led to a first job in the prestigious Geodesy Department of the Institut Géographique National (IGN). The rich experience he acquired here helped to form his great professional qualities, as well as the main traits of his character as a private individual and as a public figure. Jean not only had bold and pertinent technical ideas, he was also a flamboyant and experienced practical man who was not afraid to speak his mind.

Sent to CERN on a temporary mission by the IGN, he arrived with André Decae on 13 December 1954 to design the Proton Synchrotron positioning metrology, or "alignment", to use the official jargon. The project challenged the tools available at the time and thus required innovative solutions. The mission became a secondment that later resulted in the award of a first CERN contract starting on 1 January 1956. This marked the beginning of an extraordinary career imbued with the enthusiasm and innovative spirit of CERN's pioneers.

As the person in charge of what is generally known as the Survey Group (also Alignment, Metrology and Topometry, and Applied Geodesics over the years), Jean succeeded in meeting the increasingly challenging needs of successive machines and experiments, acquiring the necessary new skills, initiating the development of specific methods and instruments (distinvar-wire and laser-offset measuring devices) and achieving technical performances that gained him international recognition. His developments have found applications not only in particle accelerators but in many other scientific, technical and industrial domains.

Gervaise taking measurements with invar wire and a theodolite on a pillar at the PS.

Jean's remarkable innovations and achievements from the start of his career led to a brilliant PhD from the University of Munich in 1965. Passionate about geology and geomechanics, he looked back with particular fondness on the search for and geotechnical classification of possible sites for the Super Proton Synchrotron (SPS), which he regarded as one of the great periods of his career. Other highlights include technical and methodological developments for the underground north-finding gyroscopes, and his daring decision to base the piloting of the tunnelling machines for the SPS and the Large Electron–Positron (LEP) collider on unusually long distances between reference points issued from the surface, thus generating significant savings. The required precision seemed inconceivable but it proved a great success in both cases. The acquisition of an exceptional distance meter (known as the Terrameter, with a precision of 1 mm per 10 km) gave LEP the world's most precise geodetic network ever. This enabled conclusive checks of the high-precision geodetic use of GPS to be carried out, and the results were greeted with great excitement at a conference in 1985 on the first applications of GPS technology for precision positioning.

Jean was also a manager with an eye on both CERN's future and that of his colleagues, always concerned for their personal development, that they enjoyed harmonious relations and that they were happy in their work. Conscious of the importance of education and communication, he was particularly attentive to the training of young people. This was the start of a tradition that has been continued and even reinforced by his successors, as the group has welcomed more than 250 trainees. Following his retirement in 1986, Jean helped to found the CERN Pensioners Association and served a term of office as its chair.

It would be impossible to conclude without mentioning the man behind the public figure. He was a good and true friend to those who knew him, hospitable and generous, and always ready – together with his wife Madeleine – to welcome you to his home or to his table. We will not forget the happy times that we spent with him nor the warmth of his personality.

Michel Mayoud, successor to Jean Gervaise from 1986 to 2005.

NEW PRODUCTS

Cedip Infrared Systems has unveiled Titanium – a new series that combines high performance, compactness and a removable lens interface that gives flexibility in the optical path. The infrared systems are available with a broad range of detectors that achieve a sensitivity of less than 18 mK even at the highest frame rates. The company has also announced the CARTHAGE series of advanced video-processing modules for researchers wishing to develop and build their own thermal-imaging systems. The ruggedized modules are offered either as stand-alone units or pre-integrated with detector and imaging lens assemblies. For more information on either of these products contact Emilie Cornee, tel +33 160 370 100, e-mail cedip-marketing@cedip-infrared.com or see www.cedip-infrared.com.

Specialized Imaging Ltd has combined its SIM-8 Ultra Fast Framing camera with the SC Optoscope Streak Camera from Optronis GmbH, to create a new simultaneous framing and streak camera system. Benefitting from the SIM-8 f2.8 imaging beam-splitting optics the new system can deliver a distortion-free image of the primary image to eight separate output ports where ICCDs capture individual frames at rates up to 2×10^9 fps and exposures as short as 500 ps. For further information contact Wai Chan, tel +44 144 282 7728, fax +44 144 282 7830, e-mail info@specialised-imaging.com, or see www.specialised-imaging.com.

Oxford Instruments NanoScience has launched three innovative new products. Integra AC helium recondensing systems offer high performance at low temperature and high magnetic field with significant savings in helium running cost. The systems incorporate a low-vibration pulse-tube refrigerator to reduce helium loss during low-temperature insert and superconducting magnet operation. The Triton DR Cryofree dilution refrigerator features innovative technology to eliminate the use of a conventional pumping system. The 16T Active Shield Cryofree Magnet, enables efficient use of lab space through a significant reduction of stray magnetic field. Active shielding of the stray magnetic field of the 16T Cryofree magnet provides a 15 times reduction in the 5 gauss stray field volume. For further information contact Neil Killoran, tel +44 186 539 3200, fax +44 186 539 3333, e-mail neil.killoran@oxinst.co.uk, or see www.oxford-instruments.com.

CORRECTION

In the May issue, the article "Coupled-clusters point to faster computation" (p9) refers to solving an equation with 109 variables. The problem is of course much more complicated: this should read "10^9 variables".

RECRUITMENT

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

UNIVERSITY OF LIVERPOOL

Department of Physics

Research Associate in Experimental Particle Physics

£27,465 pa

You will join the Liverpool Particle Physics Group working on the ATLAS experiment at the CERN LHC. The Group has played a major role in the design and construction at Liverpool of one of the two ATLAS End-Cap silicon trackers and will be heavily involved in commissioning this detector and monitoring its performance.

A range of physics studies is underway within the group ranging from searches to Standard Model measurements. We are also contributing to the development of b-tagging code and electron and photon identification. The group has direct access to the 940 CPU Tier 2 facility in the Department as well as access to other major computing facilities via the Grid.

You should have a PhD in experimental particle physics and will be expected to take a major role in studies exploiting the unique physics available at the LHC to the ATLAS experiment. The post is available for three years.

Job Ref: B/012/C **Closing Date: 22 June 2007**

For full details, or to request an application pack, visit
www.liv.ac.uk/working/job_vacancies/ or e-mail: jobs@liv.ac.uk
Tel 0151 794 2210 (24 hr answerphone)
Please quote job ref in all enquiries.
COMMITTED TO DIVERSITY AND EQUALITY OF OPPORTUNITY

Bonn University, Institute of Physics
has an opening in
Experimental Particle Physics

universitätbonn

Junior Faculty Position (Hochschulassistent, A13 a.Z.)

Experimental Particle Physics at the Large Hadron Collider

Applicants shall be interested to carry out research in the experimental particle physics group at Bonn University, lead by Norbert Wermes. The group does experiments at the Large Hadron Collider LHC (CERN) within ATLAS, and carries out detector hardware developments in the field of semiconductor detectors for particle physics experiments.

Applicants are expected to have a strong interest in LHC-Physics, in particular Higgs-Physics.

The position is a Junior Faculty Position (A13) with the possibility to acquire a "Habilitation". Salary and benefits follow the German standards for state officials. The duration is fixed for two successive periods of three years (Beamter auf Zeit).

The position can be filled immediately (1.7.2007). Interested candidates are requested to submit their CV and professional experience together with 2 letters of recommendation.

Preferential consideration will be given to women according to §49 UG (NRW) if they are equally qualified and possess the same level of competence and professional achievements. Disabled applicants with the same qualifications as other candidates are preferably employed.

Applications should be sent to
Mrs. V. Gebhardt
Physikalisches Institut der Universität Bonn,
Nussallee 12, D-53115 Bonn, Germany
tel. +49-228-733225, fax. +49-228-733220 (valja.gebhardt@uni-bonn.de)
For further Information please contact Prof. N. Wermes,
tel. +49-228-733533, http://hep1.physik.uni-bonn.de

HadronPhysics I3
Study of Strongly Interacting Matter

HadronPhysics I3
Study of Strongly Interacting Matter

European Commission

Transnational Access to Research Infrastructures

The Integrated Initiative "HadronPhysics I3", financed by the European Commission and coordinated by the Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, Italy, combines in a single contract several activities, Networking, Research Projects and Transnational Access. The Transnational Access activity involves 9 infrastructures (INFN-LNF, DESY-HERMES, FZJ-COSY, FZJ-NIC/ZAM, GSI-SIS, U. MAINZ-MAMI, ZIB, LU-MAXLAB, UU-TSL). Its objective is to offer the opportunity for European research teams, performing or planning a research project at these infrastructures, to

APPLY FOR EC FUNDED ACCESS

including the support for travel and subsistence expenses.

The only eligible teams (made of one or more researchers) are those that conduct their research activity in the EU Member States or in the Associated States.

Information about the modalities of application and the **Calls for Proposals** can be obtained by visiting the HadronPhysics I3 web site http://hadronphysics.infn.it/

University of Heidelberg

Heidelberg Graduate School of Fundamental Physics

The Heidelberg Graduate School of Fundamental Physics (HGSFP) at the University of Heidelberg, which is being established in the framework of the Excellence Initiative of the German Federal and State Governments, invites applications for

Ph.D. Scholarships

in its core areas of modern fundamental physics: (a) Particle Physics and Cosmology, (b) Astronomy and Cosmic Physics and (c) Quantum Dynamics and Complex Quantum Systems. The HGSFP combines Ph.D. projects at the forefront of international research in the areas mentioned above with a rich and thorough teaching program. Further information can be found on the School's web site: http://www.fundamental-physics.uni-hd.de.

Membership in one of the two International Max Planck Research Schools (IMPRS) for Astronomy & Cosmic Physics (http://www.mpia.de/imprs-hd) or for Quantum Dynamics in Physics, Chemistry and Biology (http://www.mpi-hd.mpg.de/imprs-qd) is envisaged if appropriate.

We invite highly qualified and motivated national and international students to apply. Applicants should hold a Master of Science in physics or equivalent degree. At equal level of qualification, preference will be given to disabled candidates. Female students are particularly encouraged to apply.

Applications for scholarships should arrive by **June 15, 2007**. Applicants have to initiate their application registering via a web form available at http://www.fundamental-physics.uni-hd.de/scholarships.php.

ESRF

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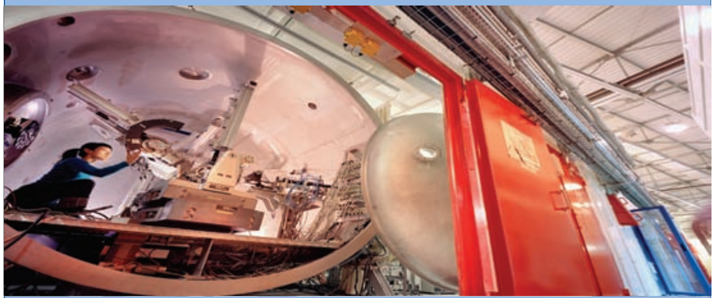

Physics and Chemistry, Life Sciences and Medicine, Earth and Environmental Sciences, Surface and Materials Sciences.

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PHYSICS DEPARTMENT

The Physics Department at Brookhaven National Laboratory seeks to fill a Scientific Staff Position as an Assistant or Associate Scientist. This position, under the direction of D. Lissauer, requires a Ph.D. in experimental high-energy physics. Candidates are expected to have extensive experience in physics analysis or detector systems, be active in the Analysis Support Center, and will be expected to help lead one of the physics analysis efforts in ATLAS. We seek candidates with significant accomplishments and promise for future achievements in high energy physics. Successful candidate is expected to play an important role in the collider physics program at BNL. Research will be on the ATLAS experiment at the LHC in Geneva, Switzerland. BNL is involved in many aspects of the ATLAS experiment. It is an ATLAS Tier-1 computing facility. It is designated as one of the US ATLAS Analysis Support Centers. The Omega Group has significant responsibilities in ATLAS for Liquid Argon Calorimeter, Cathode Strip Chambers in Muon Spectrometer, High Level Trigger, Technical Coordination, as well as software development for the event data model, detector performance and analysis tools. The physics analysis effort focuses on understanding the early physics potential at Large Hadron Collider, search for Higgs and supersymmetric particles. The level of the position will be based on the background and experience of the selected candidate. Interested candidates should submit CV, publication list and a brief (<1 p.) statement of research interests to Dr. David Lissauer (**lissauer@bnl.gov**) referencing Job #KH4571. Brookhaven National Laboratory is an equal opportunity employer committed to building and maintaining a diverse workforce.

BROOKHAVEN
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www.bnl.gov

JSA Jefferson Science Associates, LLC
Thomas Jefferson National Accelerator Facility

Director for the Thomas Jefferson National Accelerator Facility

Jefferson Science Associates, LLC – the Southeastern Universities Research Association and Computer Sciences Corporation / Advanced Technologies Division joint venture that serves as the management and operations contractor for the U.S. Department of Energy's Jefferson Lab in Newport News, Virginia – invites nominations and applications for the position of Lab Director. JSA seeks a strong, visionary scientific leader with effective management skills who enjoys stature among peers in the scientific and lab communities.

The successful candidate will be responsible for leading and managing all Lab initiatives and activities for this world-class research facility, including its strategic planning and building of a comprehensive external relations program to serve and promote the interests of the Lab. Reporting to the JSA Board, the Director is also the President of JSA and is responsible for the Lab's 700-plus staff and total annual budget of approximately $100 million.

Jefferson Lab is a national laboratory for nuclear physics research. As a user facility for more than 2000 scientists worldwide, its primary mission is to conduct basic research to advance the understanding of the fundamental constituents of the atomic nucleus and their interactions. The Lab has achieved US leadership and world-class status in its core competency in superconducting radio frequency accelerator technology.

Send nominations and applications to: **Dr. Jerry Draayer, 1201 New York Ave., NW; Suite 430; Washington, DC 20005** or **draayer@sura.org**. Submit a resume and outline of qualifications/accomplishments by 15 June 2007.
Dr. Thomas Appelquist of Yale University is chair of the Search Committee.

JSA is an Equal Opportunity / Affirmative Action Employer. For details, see ***www.jsallc.org***.

CSCS
Swiss National Supercomputing Centre

The Swiss National Supercomputing Centre is an autonomous unit of ETH Zurich, providing, developing and promoting technical and scientific services for the Swiss research community in the fields of high-performance and high-throughput computing including the Swiss Grid Initiative.

We currently have a vacancy for a **Grid System Engineer & Supporter** for the support and development of the EGEE and LCG infrastructure, middleware and applications at CSCS.

Main duties

- Operation of the Grid services of the CSCS LCG Tier2 site in close interaction with the EGEE German/Swiss (DECH) federation and with the Swiss Institute of Particle Physics CHIPP
- Participation in the development, testing and deployment of middleware components
- Technical support of the procurement and installation of infrastructure upgrades
- Participation in the operation and maintenance of the Grid infrastructure (HW & SW) and deployment of the middleware
- Participation in the Regional Operation Center for the DECH federation

Qualifications required

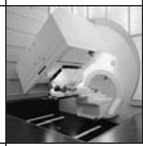
Candidates shall have a university degree in computer science, engineering or a related field and have experience in the administration of Linux servers and clusters. Moreover, it is expected that candidates have experience in at least two of the following fields:

- Grid technologies, middleware integration and deployment, preferably of the EGEE/LCG middleware stack
- Security services, especially PKI
- Web Service technologies, SOAP/XML
- Software engineering and development processes

Fluency in English is mandatory, knowledge of Italian, German or French is an asset. Applicants can send their resume to **hr@cscs.ch**.

PAUL SCHERRER INSTITUT

PSI



The Paul Scherrer Institute is a centre for multi-disciplinary research and one of the world's leading user laboratories. With about 1200 employees it belongs as an autonomous institution to the Swiss ETH domain and concentrates its activities on solid-state research and materials sciences, elementary particle physics, energy and environmental research as well as biology and medicine.

With a broad program in experimental particle physics and with research facilities like the world's most intensive low energy muon beam, the Swiss Spallation Neutron Source SINQ, the Swiss Light Source, and an Ultra-Cold neutron source under construction, the Paul Scherrer Institut offers a wide field of applications in particle detection. Examples include the search for very rare muon decays, the search for the electric dipole moment of the neutron, and the study of material properties with diffusion of slow neutrons. The detector group within the Laboratory of Particle Physics develops and constructs in particular position sensitive gas ionization detectors.

To lead the activities of the group and to help planning its future development we seek an experienced and outstanding

Detector physicist as group leader

Your tasks

- Leadership of the detector physics group including professional, personal and organisational matters
- Design of detector systems, supervision and coordination of their development and construction
- Proposition of new detectors for new experiments together with users of the PSI facilities
- Participation in experiments within the research program of the Laboratory for Particle Physics including development, operation and analysis

Your profile

You have a Ph.D. in Physics with a strong background in experimental particle physics. You have a broad knowledge and expertise in several of the following fields:

- design, realization and test of particle detectors, such as gas ionization detectors like Drift chambers or GEM's
- conceiving and steering the development of the associated readout electronics
- detector simulation

You are skilled in project management and you like to work with a highly motivated team of technicians and engineers collaborating with users of the PSI facilities. A good command of English and German is required.

We are looking forward to your application.

For further information please contact Dr. Ansgar Denner, ph.+41 (0)56 310 36 62, e-mail: ansgar.denner@psi.ch.

Applicants should submit a curriculum vitae, a list of publications and the names of possible referees to: Paul Scherrer Institut, Human Resources, Mrs. Hedwig Habersaat, ref. code 1413, CH-5232 Villigen PSI, Switzerland.

Deadline for applications: 24.06.2007

Further job opportunities: www.psi.ch

Science & Technology
Facilities Council

The Science and Technology Facilities Council will bring strategic leadership and an integrated approach to UK investments in large national and international research facilities, whilst continuing to deliver world-class science, technology and people for the UK. The Council is involved in some of the world's most exciting research projects – like the Diamond Light Source Synchrotron and the Large Hadron Collider – and will develop new areas of science and technology – with your help.

Radio Frequency Engineer/ Scientist Band 4/5 (VND358/07)

Band 4 £31,100 to £35,543
Band 5 £24,638 to £27,998 dependent on skill set

Required for the Science and Technology Facilities Council, Daresbury Laboratory in the Accelerator Science and Technology Centre (ASTeC). The Centre's role is to carry out feasibility and design studies in new accelerator projects and to undertake accelerator Research and Development. This vacancy, is in the Radio Frequency (RF) team which designs, builds, develops and supports advanced RF systems for high-energy particle accelerators. The successful candidate will contribute to the design, procurement, and commissioning of high power RF amplifiers and ancillary systems relevant to the various accelerator projects currently under development within ASTeC.

At present the RF Group is contributing to a number of accelerator based projects, which include; crab cavity RF system development for the International Linear Collider, installation and commissioning of the superconducting RF linacs for the Energy Recovery Linac Prototype (ERLP) at Daresbury, RF amplifier system development for the Muon Ionisation Cooling Experiment (MICE) taking place on ISIS at Rutherford Appleton Laboratory and the design of RF systems needed for the Fixed Field Alternating Gradient (FFAG) demonstrator (EMMA) project, scheduled for operation on ERLP in 2010. The group is also working on the development of high brightness electron sources and superconducting RF systems for the exciting fourth generation light source proposal 4GLS. In addition this team supports the development and operation of the SRS, the UK national light source facility based on a 2 GeV electron storage ring at Daresbury.

Candidates must be highly motivated engineers or scientists. They should be qualified to degree level or equivalent in a relevant science or engineering subject and have an interest in RF aspects of accelerators. For a Band 4 position, the applicant must have experience of managing a small team involved in the design, manufacturing, testing and commissioning of RF systems and the necessary project management expertise to deliver medium to large scale projects.

Salary on appointment is awarded according to relevant experience. An index linked pension scheme, flexible working hours and a generous leave allowance are also offered.

For informal enqueries about this position please contact Mr Peter McIntosh (p.a.mcintosh@dl.ac.uk) or Tel: 01925 603899.

For further information and how to apply: please visit www.scitech.ac.uk, telephone 01925 603467 or e-mail recruit@dl.ac.uk, quoting reference VND358/07.

Closing date: 19 June 2007.

The Science and Technology Facilities Council (STFC) is committed to Equal Opportunities and is a recognised Investor in people. A no smoking policy is in operation.

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INVESTOR IN PEOPLE

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

The Forschungszentrum Karlsruhe GmbH, member of the Helmholtz Society, is one of the leading research centers of Europe.

Our **Institute for Nuclear Physics** (IK) invites applications for the position of a

Post Doctoral Researcher

focused on investigations of cosmic induced background to the EDELWEISS Dark Matter Search. The position is connected to the "Sonderforschungsbereich Neutrinos and Beyond: Weakly Interacting Particles in Physics, Astrophysics and Cosmology".

EDELWEISS is performed in the Laboratoire Souterrain de Modane (LSM) in France using up to 100 bolometers operated at 20mK to search for heat-and-ionization signals from WIMP elastic scattering off Ge target nuclei. The cryostat holding the bolometers is surrounded by a system of plastic scintillators detecting muons to suppress muon-induced neutron background. The successful applicant will work mainly at the site of FZK, in the design, building and installation of a special underground neutron monitor and will perform measurements in combination with the existing muon veto system at LSM. She or he will be involved in the data acquisition of EDELWEISS and will further develop detailed Monte Carlo models of muon-induced spallation processes and detector responses.

Formal requirements for this position are a PhD in nuclear or (astro-) particle physics and a profound knowledge in experimental techniques of particle detection. Experience with Monte Carlo methods and simulation codes such as GEANT4 is desirable.The contract is initially limited for two years with the possibility of extension.

We prefer to balance the number of female and male employees in our company. Therefore we encourage women to apply for this job.

For further information please contact Dr. Klaus Eitel, IK, phone +49-7247-82-3701, Email: klaus.eitel@ik.fzk.de.

Please send your complete application (covering letter, curriculum vitae, list of publications and two letters of reference) until June 30th referring the vacancy number 16/2007-e to:

Forschungszentrum Karlsruhe GmbH
Attention Mrs. Gätcke
Personnel Department
P.O.Box 36 40,
D-76021 Karlsruhe, Germany
or apply online at our homepage
www.fzk.de/jobs

Internet: www.fzk.de

Deutsches Elektronen-Synchrotron
Particle Physics

DESY

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

The ZEUS group is responsible for operation and the data analysis of the ZEUS experiment. In addition the ZEUS group participates in experiments at the LHC at CERN and performs detector development for future accelerators. For our team we are looking for an experienced

Physicist (Ph.D.)

You will play a leading role in the reconstruction and analysis of the ZEUS data. Further on you will participate in the future projects of the group, for instance at the LHC at CERN.
You should hold a Ph.D. in Physics and have held at least one postdoc level position. Experience with data reconstruction and analysis, preferably in the area of tracking is required. An interest in University level teaching and in advising of Ph.D. students is desirable. The job requires close collaboration with DESY groups and with the institutes participating in the ZEUS collaboration. Applicants should submit their application (including cv, list of selected publications and contact information of 3 referees) quoting the reference number to our personnel department. You may also contact Tobias Haas (+49 40/8998-3281 or tobias.haas@desy.de) for further information.

Salary and benefits are commensurate with those of public service organisations in Germany. DESY is an equal opportunity, affirmative action employer and encourages applications from women. DESY has a kindergarten on site.

Deutsches Elektronen-Synchrotron DESY
Member of the Helmholtz Association
Code: 64/2007 · Notkestraße 85 · D-22603 Hamburg · Germany
Phone: +49 40/8998-3392 · www.desy.de
E-Mail: personal.abteilung@desy.de

Deadline for applications: June 25, 2007

INDEX TO DISPLAY AND RECRUITMENT ADVERTISERS

DISPLAY

RECRUITMENT

The German National Laboratory for Heavy-Ion Research, member institute of the Helmholtz Association of German Research Centres, has an immediate opening for a

Postdoctoral Position

Ref. No.: 3410-07.30

in the Beam Diagnostics Group.

Within the framework of the planned FAIR facility the successful candidate will cover the following tasks in the field of heavy-ion synchrotrons and beam transfer lines:

- Layout, realization and documentation of beam position monitors (BPM)
- Design and construction of test setups for BPMs and quality assurance
- Project coordination in a team of engineers and physicists
- Layout and realization of rf-based diagnostics and feedback methods

The beam diagnostics group consists of approx. 25 physicists, engineers and technicians with high expertise. Apart from a profound physics background candidates should have proven record in accelerator physics, rf-technology, digital signal acquisition, complex data analysis and large scale research projects. The ability for team- and target-oriented work is mandatory. For further information please contact Dr. Schwickert, e-mail: m.schwickert@gsi.de, tel.: ++49 6159 71 1432

The position is limited to a term of three years, with the possibility of an extension within the scope of the German Wissenschaftszeitvertragsgesetz. Remuneration is according to pay scale grouping TVöD for federal employees in Germany. GSI is an equal opportunity, affirmative action employer and encourages applications of women. Persons with disabilities will be given preference over other applicants with comparable qualifications.

Applications including curriculum vitae, list of publications as well as two letters of reference should be sent not later than June 29, 2007 to:

HELMHOLTZ | GEMEINSCHAFT

GSI Darmstadt

Gesellschaft für Schwerionenforschung mbH
Personalabteilung
Ref. No. 3410-07.30
Planckstraße 1
64291 Darmstadt
GERMANY

GANIL — GRAND ACCELERATEUR NATIONAL D'IONS LOURDS — LABORATOIRE COMMUN DSM/CEA-IN2P3/CNRS

Spiral2

Engineer Position

The Spiral2 facility which is presently under construction at GANIL, Caen, will deliver exotic radioactive beams. The radioactive ion beams will be produced by two methods: 1) neutrons, produced by the bombardment of intense deuteron beams on a converter, will impinge on a high temperature (~ 2000 deg C) uranium carbide target, 2) from heavy ion beams on various targets.

These radioactive ions produced will be sent to various experimental areas: low energy beams towards the DESIR facility, and post-accelerated beams towards existing experimental areas (after charge boosting and acceleration in the existing cyclotron.

The successful candidate will participate in the definition and necessary R&D of the radioactive beam production system. He/she will be part of a collaboration involving laboratories both inside and outside France and should have the qualities to integrate into team. The candidate should have a relevant knowledge of chemistry at high temperature, nuclear physics and a relevant experience in the development of systems for the production of radioactive ions (experience with ion sources will be an assess). Knowledge of quality assurance, nuclear safety and project management is required. Fluent English also required.

The candidate will be recruited at the level of Ingénieur de Recherche in the CNRS (Centre national de la Recherche Scientifique, France) for a contract of 3 years.

Applications and requests for information should be sent to:
GANIL- Secrétariat Général- A. Kahwati
BP 55027
14076 Caen Cedex 5 - France e-mail: kahwati@ganil.fr
For technical information, please contact Marie-Hélène MOSCATELLO
Phone : **+33 2 31 45 45 26**, e-mail: moscatello@ganil.fr

BOOKSHELF

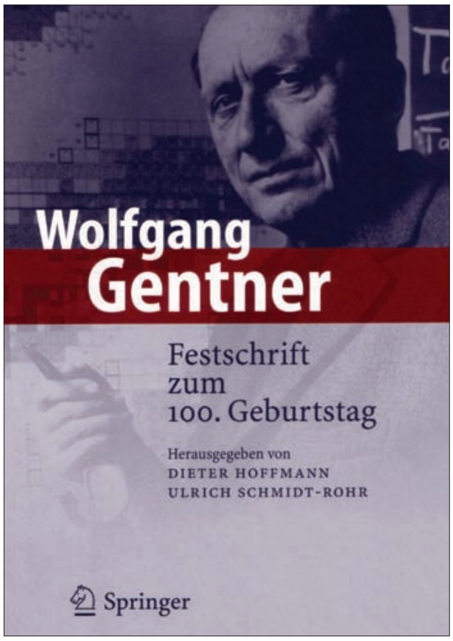
Wolfgang Gentner, Festschrift zum 100. Geburtstag by Dieter Hoffmann and Ulrich Schmidt-Rohr, Springer. Hardback ISBN 9783540336990, €79.95 (£57.50, $109).

This book presents a collection of writings in honour of the late Wolfgang Gentner, which was prepared for a colloquium to celebrate the centenary of his birth (23 July 1906). It offers a unique opportunity for colleagues, pupils and friends who knew Gentner – and even more so for those who never met him – to read about his life as a scientist, naturalist, teacher, manager and politician. Readers can also learn more about the generation of scientists, including Gentner, who built a new Europe of scientific collaboration after the disaster of the Second World War. They can appreciate the great merit, vision and efforts of this co-founder of CERN and DESY, who was also the founding director of the Max Planck Institute (MPI) for Nuclear Physics at Heidelberg.

In the early 1950s, Gentner played a key role in Germany together with Otto Hahn and Werner Heisenberg. Through contributions by contemporaries, the book allows the reader to grasp how Gentner realized his vision of international collaboration on scientific research, through the foundation of CERN. It also makes clear how much we owe him for the restart in the early 1950s of fruitful scientific relations between Israel and Germany, and how enthusiastically he promoted scientific collaboration between CERN and the Soviet Union.

The book was conceived by Ulrich Schmidt-Rohr and Dieter Hoffmann, professors of physics and science history at the MPIs in Heidelberg and Berlin, respectively. Despite the untimely death in April 2006 of Schmidt-Rohr, who had been a close collaborator of Gentner at Heidelberg and was author of several books on the history of nuclear-physics laboratories and research in Germany, Hoffmann completed this remarkable overview of Gentner's life, scientific work, and achievements, which spans more than five decades.

The four-part book is published in German, which is somewhat of a pity. Part I, Studien zu Leben und Werk von Wolfgang Gentner [Studies of the life and works of Wolfgang Gentner], includes, however, an original contribution in English by Sir John Adams, which is accessible to all interested readers at CERN (CERN/DOC 82-3 January 1982 p9).



Adam's appraisal of the man who was not only co-founder of CERN, but who was also at one time or another a CERN director, chair of the Scientific Policy Committee and president of the CERN Council, is worthwhile reading as an authentic record of the early years of CERN. Other chapters of Part I cover topics such as Gentner and big science, Gentner and the public, Gentner and the promotion of German–Israeli scientific relations, and Gentner's "hobby", Kosmochemie und Archäometrie [cosmochemistry and archaeometry].

Part II, Erinnerungen an Wolfgang Gentner [Memories of Wolfgang Gentner], contains a collection of personal recollections from collaborators, pupils, friends and family members. Here there are stories about his family life and about the typical working atmosphere in physics institutes of the time, including memories of Valentine Telegdi and Victor Weisskopf serenading Gentner on the occasion of his 60th birthday symposium. In short, the reader is taken back to the good old times and the reading is just fun!

Part III contains a collection of Gentner's articles and speeches, for example, Aus der frühen Geschichte der gamma-strahlung [About the early history of gamma radiation] and Forschungs einst und jetzt [Research then and now]. This includes two talks related to his hobby, the application of scientific methods to solve questions of archaeology. Gentner was indeed in his later years much attracted by topics related to Kosmochemie and Archäometrie, fields at the intersection of natural and cultural science. Finally, Part IV provides the bibliographic collection of all of Gentner's publications.

All in all, the book does a marvellous job of tracing the life and scientific achievements of one of the most remarkable and influential scientists and science politicians of post-war Germany and Europe.
Horst Wenninger, CERN.

Books received

Lectures on Quantum Mechanics by Berthold-Georg Englert, World Scientific. In three companion volumes, hardback ISBN 9812567909, £66 ($115) for the set. (Each volume is also sold separately with an individual ISBN number.)

These three volumes of lectures are independent of each other and largely self-contained. *Volume 1: Basic Matters* introduces quantum mechanics and does not assume prior knowledge of the subject. It emphasizes the general structure as the necessary foundation of any understanding. *Volume 2: Simple Systems* covers the step to Dirac's more abstract and much more powerful formalism, followed by reviews of quantum kinematics and quantum dynamics. *Volume 3: Perturbed Evolution* includes the basics of kinematics and dynamics, such as discussions of Bohr's principle of complementarity and Schwinger's quantum-action principle. Undergraduates in physics, chemistry, mathematics and engineering, as well as physics lecturers will find volumes 1–2 useful; graduate students in physics will find volume 3 of interest.

Genève et ses savants by Isaac Benguigui, Éditions Slatkine. Paperback ISBN 2832102352, SwFr33.

This book, written in French, focuses on the achievements of physicists, mathematicians and chemists from 18th- and 19th-century Geneva. The discoveries and inventions made by these scientists came from meticulous and long-term work. The extraordinary rise of science in Geneva was due to its favorable environment at the crossroads to the European currents of ideas. Physicists, mathematicians and chemists travelled the continent forming a network of relations, thus allowing them to benefit best from the advances in their respective sciences.

Theory in the computer age

Vladimir Zelevinsky says that the story of the nuclear-shell model shows the power of human–computer symbiosis

Some years ago, it was customary to divide work in the exact sciences of physics, chemistry and biology into three categories: experimental, theoretical and computational. Those of us breathing the rarified air of pure theory often considered numerical calculations and computer simulations as second-class science, in sharp contrast to our highbrow elaborate analytical work.

Nowadays, such an attitude is obsolete. Practically all theoreticians use computers as an essential everyday tool and find it hard to imagine life in science without the glow of a monitor in front of their eyes. Today an opposite sort of prejudice seems to hold sway. A referee might reject an article demonstrating the nearly forgotten fine art of rigorous theoretical thought and reasoning if the text is not also full of plots showing numerous results of computer calculations.

Sometimes it seems that the only role that remains for theoreticians – at least in nuclear physics, which I know best – is to write down a computer code, plug in numerical values, wait for the results and finally insert them into a prewritten text. However, any perception of theorists as mere data-entry drones misses the mark.

First, to write reasonable code one needs to have sound ideas about the underlying nature of physical processes. This requires clear formulation of a problem and deep thinking about possible solutions.

Second, building a model of physical phenomena means making hard choices about including only the most relevant building blocks and parameters and neglecting the rest.

Third, the computer results themselves need to be correctly interpreted, a point made by the now-famous quip of theoretical physicist Eugene Wigner. "It is nice to know that the computer understands the problem," said Wigner when confronted with the computer-generated results of a quantum-mechanics calculation. "But I would like to understand it, too."

We live in an era of fast microprocessors and high-speed internet connections. This means that building robust high-performance computing centres is now within reach of far more universities and laboratories. However, physics remains full of problems of sufficient complexity to tax even the most powerful computer systems. These problems, many of which are also among the most interesting in physics, require appropriate symbiosis of human and computer brains.

Consider the nuclear-shell model, which has evolved to be a powerful tool for achieving the most specific description of properties of complex nuclei. The model describes the nucleus as a self-sustaining collection of protons and neutrons moving in a mean field created by the particles' co-operative action. On top of the mean field there is a residual interaction between the particles.

Applying the model means being immediately faced by a fundamental question: What is the best way to reasonably restrict the number of particle orbits plugged into the computer? The answer is important since information about the orbits is represented in matrices that must subsequently be diagonalized. For relatively heavy nuclei these matrices are so huge – with at least many billions of dependent variables – that they are intractable even for the best computers. This is why, at least until a few years ago, the shell model was relegated for use describing relatively light nuclei.

The breakthrough came by combining the blunt power of contemporary computing with the nuanced theoretical intellect of physicists. It was theorists who determined that a full solution of the shell-model problem is unnecessary and that it is sufficient to calculate detailed information for a limited number of low-lying states; theorists who came up with a statistical means to average the higher-level states by applying principles of many-body quantum chaos; and theorists who figured out how to use such averages to determine the impact on low-lying states.

Today physicists have refined techniques for truncating shell-model matrices to a tractable size, getting approximate results, and then adding the influence of the higher-energy orbits with the help of the theory of quantum chaos. The ability to apply the shell model to heavier nuclei may eventually advance efforts to understand nucleosynthesis in the cosmos, determine rates of stellar nuclear reactions, solve condensed-matter problems in the study of mesoscopic systems, and perform lattice QCD calculations in the theory of elementary particles. Eventually, that is, because many answers to basic physics questions remain beyond the ken of even the most innovative human–computer methods of inquiry.

So yes, one can grieve over the fading pre-eminence of theory. However, few among us would want to revert to the old days, despite our occasional annoyance with the rise of computer-centric physics and the omnipresent glow of the monitor on our desks. As for my opinion, I happen to agree with the chess grandmaster who, when recently complaining about regular defeats of even the best human players by modern chess computers, said: "Glasses spoil your eyes, crutches spoil your legs and computers your brain. But we can't do without them."

Vladimir Zelevinsky, National Superconducting Cyclotron Laboratory, Michigan State University.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