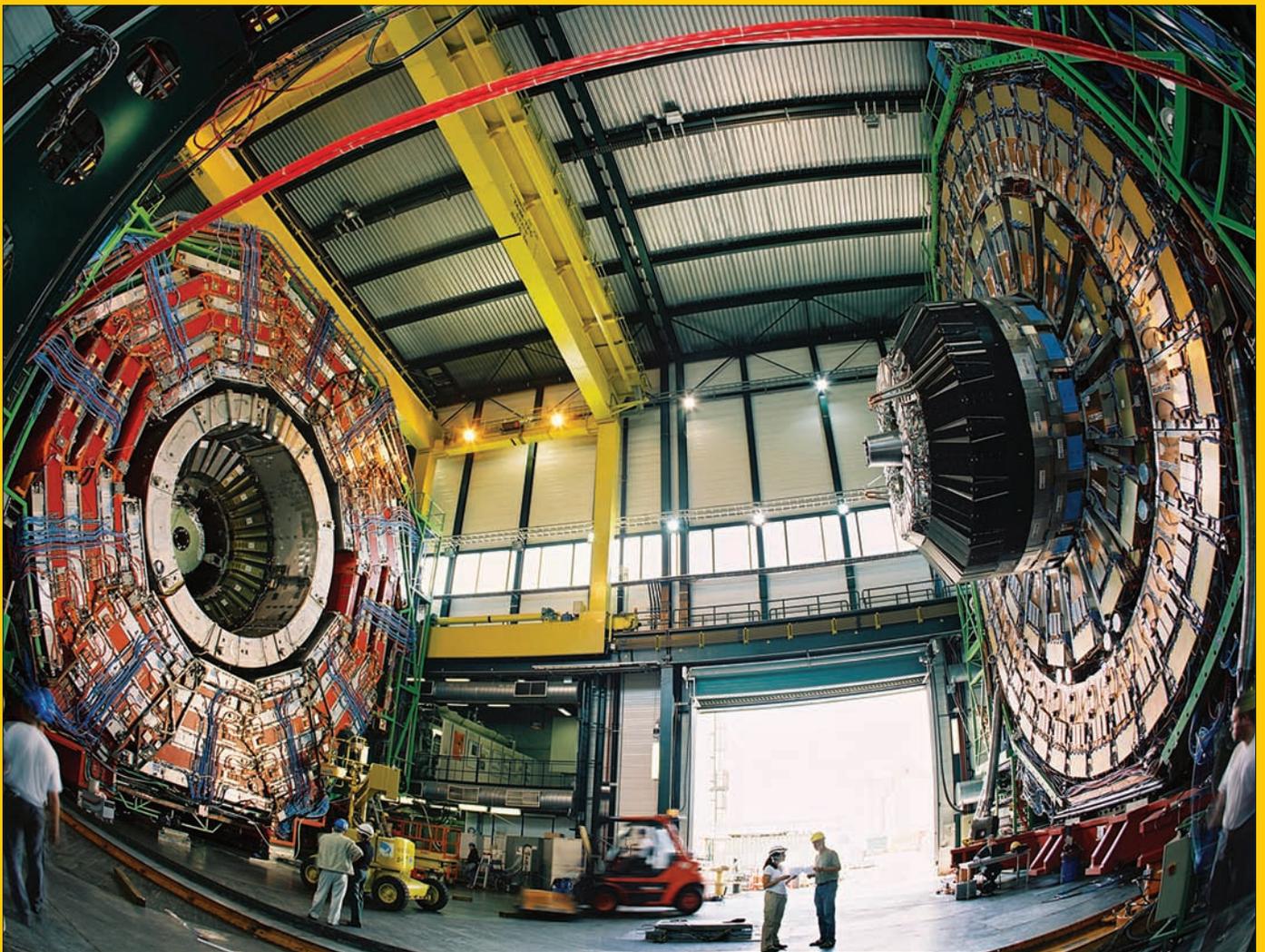


CERN COURIER

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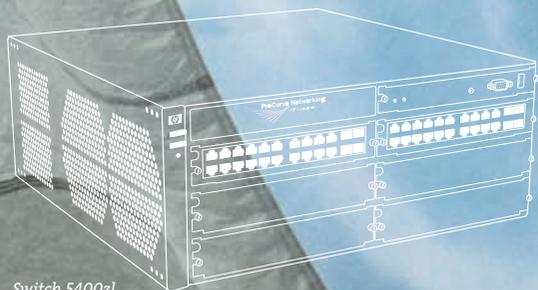
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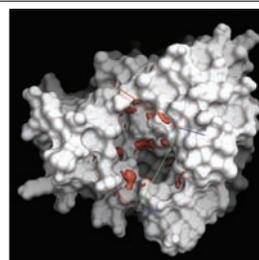


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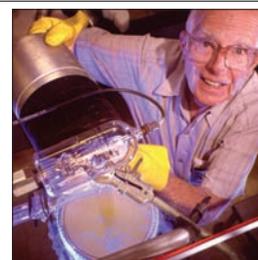
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Cover: The huge pieces of the CMS detector have recently been closed together on the surface (p7). This image, taken during closing, shows one endcap, right, and the barrel, left, into which it slides.

Diamond and Soleil smoothly commissioned their Libera equipped storage rings

The Soleil and Diamond teams have successfully started their storage ring commissioning. They are reporting on the profound impact that **Libera, electron beam position processor**, made during the first phase of the commissioning. We talked to **Jean-Claude Denard**, Diagnostics Group leader, Synchrotron Soleil and **Dr.-Ing. Günther Rehm**, Head of Diagnostics Group, Diamond Light Source.

The first part of the commissioning is behind you, how do you feel?

Rehm: To see electrons circulating and then stored was a great success, and it was a relief for us to see that everything worked as we had hoped. We worked hard for that.

Denard: We are very satisfied because it was very quick. And the Liberars worked fine from the first day.

What was special about the commissioning?

Denard: The machines are very high-tech and one might think that the high-tech part gets in the way. Actually the trivial things (in our case the cryogenic pipes and the water cooling system) cause the major delays.

Rehm: The highlight is certainly completing the first turn. With the turn by turn ability of Libera we were literally able to follow the beam from BPM to BPM to BPM.

What is crucial in managing such a project?

Rehm: On the one hand, you need to understand the technology; on the other you need to communicate with people. Diagnostics has many interfaces: mechanical engineering, vacuum engineering, RF engineering and we have to maintain all these information flows. The same is the case with suppliers like Instrumentation Technologies. It is not the kind of product you just select from a catalogue. You have to understand what you are doing, what the product is doing and get the best out of it. The advantage of a smaller company like Instrumentation Technologies is that it was always the first or the second person I talked to who understood the subject and helped me.



Jean-Claude Denard, Diagnostics Group Leader, Synchrotron Soleil

Denard: We chose the companies we knew we could deal with. It's important that people are disposed to talking, discussing. Soleil's group of accelerator experts wrote the specs, and Instrumentation Technologies did the state-of-the-art design. Choices were made that were not in the specs and had thus to be discussed and agreed upon. The result is Libera, which is the most advanced BPM system so far. For the light sources that follow us the decision is easier as they get a proven product. It would be interesting to count the emails exchanged to get an idea of the intensive communication!

What can you say about the competition between Soleil and Diamond? Your agenda is quite similar.

Rehm: Yes, this creates natural competition. I think we all take it with a smile, and nobody is really taking it too seriously. It's a matter of every day lunch talk: "Did you hear: Soleil now has so-and-so many milliamperes stored...?" But we also have very good contact in terms of diagnostics and we exchange our thoughts and our experience.

Denard: I agree. We could call it healthy competition, as it does not affect the communication between Günther and me – everything is transparent.

What is unique in your opinion about your respective machines?

Denard: The vacuum system with the extensive NEG pumping right from the start, which together with Liberars enables a very short commissioning time. It is also the first time that TANGO has been implemented on a complete machine and this contributed to a fast commissioning, too. In addition I would like to mention the solid state RF power plant, superconducting RF cavity and the total length of the straight sections, which amounts to 1/3 of the circumference.

Twenty-one world light sources are currently using Libera for orbit stabilization. Soleil, Diamond, Australian Light Source and Elettra equipped the whole machine with it.

Rehm: All the recently built 3rd generation light sources aim for more brilliance, which goes along with the smaller beam and the smaller beam is only really useful when it is kept stable. The global approach to fast orbit feedback right from the start is an innovation, which these new light sources have taken as a challenge. Fast connections, which Libera offers, help a lot to make that work. It also helped a lot to make fast orbit feedback something simple to implement. Once you have the global information available everywhere, which we are achieving with our so-called "communication controller" that sends around all the position data, you've got greater flexibility, which you can use to correct your orbit.

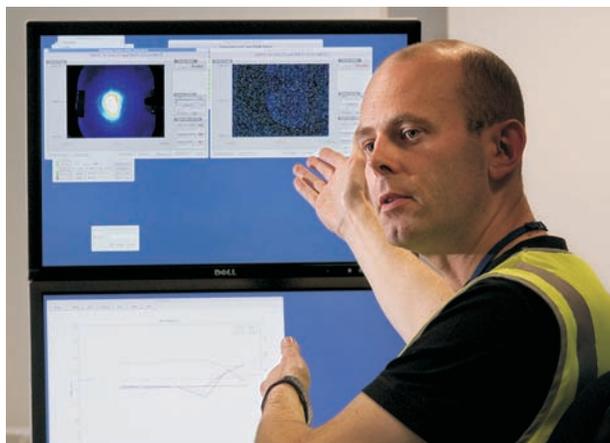
What are your next challenges?

Denard: We need to use the BPMs in slow acquisition mode for slow feedback operation, then in fast acquisition mode for fast orbit feedback. For increasing the stored current and the lifetime, we have to condition the vacuum chamber. The commissioning of the beamlines is starting in September in order to have them operating in January.

Rehm: The challenge will be to use the knowledge we have gained in the next stage of commissioning, which includes narrow gap vessels and insertion devices and then very quickly go on into beamline commissioning.

Thank you both and good luck with the next stage of commissioning!

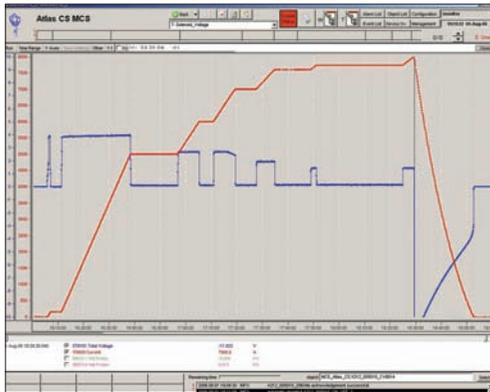
Check the latest commissioning results at:
www.i-tech.si



Dr.-Ing. Günther Rehm, Head of Diagnostics Group, Diamond Light Source.

LHC EXPERIMENTS

ATLAS superconducting solenoid succeeds in full commissioning



The coil current (red line) and voltage (blue line) showing the successful commissioning up to 8 kA.



A toast to celebrate the success of full commissioning. From right: Herman ten Kate, ATLAS magnet project leader; Friedrich Haug, ATLAS cryogenics leader; Roger Ruber, who led the solenoid commissioning at CERN; and Akira Yamamoto from KEK.

The ATLAS Collaboration passed a major milestone during the evening of 1 August. The Central Solenoid, in its final position in the ATLAS cavern and with the final equipment, was commissioned up to 8.0 kA without quenches, exceeding its operational current of 7.73 kA for the magnetic field of 2 T. This makes the ATLAS Central Solenoid the first superconducting magnet to be fully commissioned in the underground areas of CERN's Large Hadron Collider (LHC).

It is 12 years since the team led by Takahiko Kondo and Akira Yamamoto of the KEK laboratory in Japan proposed a thin solenoid magnet for the ATLAS experiment at the LHC. The solenoid provides a magnetic field of 2 T for momentum measurement in the inner detector part of the huge construction. Located inside the electromagnetic calorimeter, it must be thin to present as little material as possible to particles, in particular electrons and

photons, produced in the proton collisions at the centre of the detector. The KEK proposal was to use specially hardened aluminium stabilizer for superconducting cables, saving about 30% in material thickness.

The solenoid also shares a common cryostat/vacuum vessel with the barrel liquid-argon (LAr) calorimeter, eliminating the need for two vacuum-vessel walls. This special configuration meant that the solenoid and LAr cryogenics teams had to collaborate perfectly from the beginning of the design stage all the way through to the commissioning that ended at the beginning of August. A highlight during construction was an exchange of final and test inner vacuum cylinders between the two projects in 2000, when the solenoid and the LAr barrel cryostat, which was the responsibility of Brookhaven National Laboratory, were being manufactured on the same Japanese island (CERN Courier 2001 May 2001 p8).

The solenoid commissioning has not only proved that the solenoid magnet built by KEK performs well, but it has demonstrated that all the control, cryogenic, power, vacuum and safety systems worked coherently – a major accomplishment by various CERN teams. In particular, very-high-precision current generation by the digitally-controlled power supplies enables the magnetic field to be reproduced reliably to an accuracy of 10^{-5} . Following the commissioning, the collaboration also mapped the solenoid field.

Only a few days previously, a site-wide electric power failure had struck CERN for several hours, but thanks to well-designed emergency and recovery countermeasures, the solenoid was commissioned. This success with the ATLAS solenoid was a good start for commissioning even larger and more complex systems for the LHC and its experiments in the near future.

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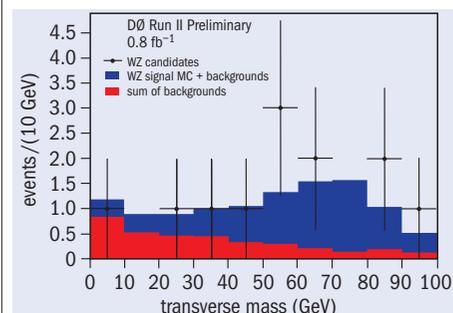
D0 finds evidence for WZ pair production

The D0 Collaboration at Fermilab has announced the first measurement of the cross-section for WZ pair production in proton-

antiproton collisions. The cross-section times branching ratio for the process is the smallest ever measured at a hadron collider. The data

for this result were taken from more than 1 fb^{-1} of total collision data at the Tevatron, and a sample of 1.5 thousand million events.

Making this measurement requires events in which both the W and Z boson decay to leptons, but while such events provide the cleanest signature of WZ events, they constitute only 1.4% of all WZ decays. D0 found 12 events, each containing three charged leptons with high transverse momentum together with missing transverse energy (indicating an undetected neutrino), with an expected background of 3.6 ± 0.2 events. The probability that the background accounts for these 12 events is 4.1×10^{-4} , which constitutes 3.3σ evidence for WZ pair production. With these events D0 measures the WZ production cross-section to be $4.0^{+1.9}_{-1.5} \text{ pb}$, which is consistent with the Standard Model prediction of $3.6 \pm 0.3 \text{ pb}$.



Transverse mass of the WZ candidates. The red gives the sum of the backgrounds, while blue indicates the combined expected (Monte Carlo) signal and background.

The coupling of the weak vector bosons is an important consequence of the non-Abelian nature of the Standard Model, and the rate for the associated production of W and Z bosons in proton-antiproton collisions allows this coupling to be probed. The kinematics of the Z boson decay can also be used to characterize the interaction between the W and Z and provide further constraints on the nature of the electroweak force. In addition, measuring the cross-section times branching ratio for Standard Model processes with such low rates is an important stepping stone in the search for the Higgs boson at the Tevatron.

Further reading

The preliminary D0 result is described at <http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/EW/E15/E15.pdf>.

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LHC dipole installation gets to half-way mark

The installation of the 616th dipole for the Large Hadron Collider (LHC) on 12 July marked the half-way point for the machine's 1232 dipole magnets.

Technicians and engineers continue to work day and night carefully installing 20 magnets a week. This is three times faster than originally planned, with four magnets able to be transported underground simultaneously. However, the 65 team members that are responsible for this task face daily challenges owing to the limited space inside the tunnel. Some areas leave only a few centimetres of leeway, requiring a tightly coordinated operation.

Each of the dipoles weighs 34 tonnes and is 15 m long. Once they have been lowered down the specially constructed shaft on the Meyrin site, they begin a slow progression to their final destinations in the LHC tunnel, taking about 10 hours to arrive at Point 6, the furthest point on the LHC ring. Upon arrival, each of the



The 616th dipole out of 1232, on its way to its final position in the tunnel of the LHC.

dipoles is aligned and interconnected to the magnets that are already installed.

During the summer, the installation of Sector 7-8 of the LHC, comprising the first

continuous chain of magnets and cryostats, along with their cryogenic distribution line, will be completed, in readiness for cool-down and testing before the end of the year.

LHC EXPERIMENTS

CMS gets ready for its descent underground

July saw some major manoeuvres for the CMS detector, as the collaboration prepares to lower it into its final position on the Large Hadron Collider (LHC) at CERN. The two Forward Hadronic Calorimeters (HFs) were transported from CERN's Meyrin site to the surface assembly hall at LHC Point 5 in Cessy, France, during the first part of the month. Then, on 24 July, the CMS magnet yoke was fully closed and locked for the first time.

Transporting the two HFs, which each weigh about 300 tonnes, involved constructing a 65 m trailer around them, which was simultaneously pushed and pulled by trucks at either end. The main road between St Genis, close to CERN, and Cessy was closed during



A 65 m trailer takes one of the two 300 tonne Forward Hadronic Calorimeters to Point 5.

each operation and the police escorted the trucks during each five-hour long journey.

The HFs will be the first major elements to

be lowered into the underground experimental cavern by gantry crane near the middle of September. In the meantime, the 11 large elements (six endcap disks and five barrel wheels mounted with muon chambers) that form the magnet return yoke were closed together for the first time on 24 July, to allow the tests of the giant solenoid to begin (*CERN Courier* July/August 2006 p28). During this process all the yoke elements were precisely aligned with respect to the magnetic axis. The closing procedure was initially quite time-consuming, but progress became quicker with about one working day required to close and lock each element. This is close to the design goal of half a day for each element.

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

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

SPACE

PAMELA looks for dark matter and antimatter

On 15 June, at midday Moscow time, the Bajkonur Cosmodrome in Kazakhstan launched a Soyuz-TM2 rocket carrying the Russian satellite Resurs DK-1. This carried the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA), which will investigate antimatter and dark matter (*CERN Courier* October 2002 p24). A week later, the first scientific data were received, and after a series of tests on the satellite and all the on-board instruments, PAMELA entered continuous data-taking mode on 11 July.

PAMELA will stay in space for at least three years, on a 70° elliptical orbit at an altitude of 300–600 km. Its instruments will measure the flux, energy and characteristics of extragalactic, galactic, solar and interplanetary cosmic rays; it will also investigate dark matter and antimatter in cosmic radiation. More specifically, it will measure cosmic-ray antiproton and positron spectra over the largest energy range ever achieved and will search for antinuclei with unprecedented sensitivity. It will also measure the light nuclear component of cosmic rays and explore phenomena connected with solar



PAMELA lifted off in June aboard the satellite Resurs DK-1. (Courtesy Mark Pearce.)

and terrestrial physics.

The payload, which is 1.3 m high and weighs 470 kg, consists of a magnetic spectrometer comprising a silicon tracker in a 0.48 T field produced by a permanent magnet, together with a time-of-flight system, an electromagnetic silicon tungsten calorimeter, a “shower-tail catcher” scintillator and a neutron detector, all of which are shielded by

an anticoincidence system. Transmission of data takes place several times a day (one complete orbit lasts about 90 minutes) through a telemetry system connected to a main ground station in Moscow. Data are then forwarded to the participating institutes through high-speed connections: an average of 10–20 GB a day (both engineering and scientific information) are collected and transmitted when PAMELA is fully operating.

PAMELA is the result of a collaboration between the Italian National Institute of Nuclear Physics and the Russian Space Agency and research institutes, with the contribution of the Italian Space Agency, and participation in particular of the Swedish Space Agency, the Royal Institute of Technology in Stockholm, the German Space Agency and the University of Siegen, as well as institutes in India and the US. PAMELA is also a recognized experiment, RE2B, at CERN. Tests were conducted in beams at CERN and elsewhere on prototypes, as well as on the detectors in the final flight configuration.

● For further information see <http://wizard.roma2.infn.it/pamela>.

FELS

Japanese source starts lasing at 49 nm wavelength in VUV

On 20 June, the SPring-8 Compact SASE Source (SCSS) prototype accelerator generated its first pulses at a wavelength of 49 nm in the vacuum ultraviolet (VUV) region. This was achieved using an ultra-low emittance beam provided by an electron gun with a newly developed single-crystal CeB_6 thermionic cathode.

The SCSS prototype accelerator is a self-amplified spontaneous emission (SASE) free-electron laser (FEL), similar to the FLASH laser at the TESLA Test Facility (*CERN Courier* June 2006 p7). Built during 2004–2005 at the SPring-8 synchrotron radiation facility in Japan, the SCSS has recently been commissioned. Its main purpose is to test components developed at the RIKEN/SPring-8 centre in R&D for an X-ray FEL to generate wavelengths of 0.1 nm (1 Å) using an 8 GeV electron beam. Funded by the Japanese Ministry of Education, Culture,



The SCSS team at the time of the first lasing.

Sports, Science and Technology, construction of this X-ray FEL is scheduled for 2006–2010.

One of the most challenging features of the SCSS is the use of the CeB_6 single-crystal cathode to generate an ultra-low emittance beam. The 500 kV electron gun produces a beam current of 1 A, which feeds an injector

system of RF cavities and magnetic lenses that have been carefully designed to perform velocity bunching without allowing the emittance to deteriorate. Here the bunch length is compressed several hundred times to produce a beam of a few hundred amps. Then after four C-band accelerating stages, the beam energy reaches 250 MeV.

During beam commissioning, an emittance of 2.9π mm mrad normalized was measured in the injector, for a bunch charge of 0.25 nC and a bunch length of 1 ps at 50 MeV. Then the SCSS team closed the upstream undulator, and after an hour of tuning observed a narrow spectrum peaked at 49 nm in the VUV. This was totally different to the natural undulator radiation (spontaneous mode). After further careful measurements, first lasing was announced on 20 June.

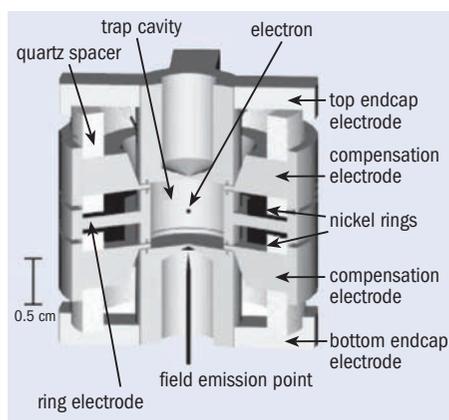
● For more information see <http://www.xfel.spring8.or.jp/>.

FUNDAMENTAL PHYSICS

Trap gives precise new value for fine structure constant

A team at Harvard University has made a new precise measurement of the electron magnetic moment, which in turn allows the fine structure constant to be determined with an uncertainty 10 times smaller than previously attained.

Gerald Gabrielse and colleagues have measured the value of the constant g of the electron, which relates its magnetic moment to the Bohr magneton, $e\hbar/2m$, where e is the size of the charge on the electron, and m is the electron's mass. For a Dirac point particle of spin $1/2$, g should have a value of 2, but quantum electrodynamics (QED) predicts a value slightly higher, owing to vacuum fluctuations and polarizations effects.



The cylindrical Penning trap that Harvard University used to confine a single electron.

To measure g more precisely than before, the Harvard team has resolved the cyclotron and spin energy levels of an electron confined for several months in a cylindrical Penning trap cooled to 100 mK (Odum *et al.* 2006). The value they obtained is

$g/2 = 1.00115965218085(76)$; the uncertainty of 0.76 ppt is nearly six times lower than the most recent accepted value, measured nearly 20 years ago (Van Dyck *et al.* 1987).

Working with Cornell University and RIKEN in Japan, Gabrielse and colleagues have used this new value of g with a prediction from QED involving 891 eighth-order Feynman diagrams, to determine a new value for the fine structure constant, α . They obtain $\alpha^{-1} = 137.035999710(96)$, that is, with an uncertainty of 0.70 ppb – an uncertainty that is about 10 times smaller than for any rival method to determine α (Gabrielse *et al.* 2006).

Further reading

G Gabrielse *et al.* 2006 *Phys. Rev. Lett.* **97** 030802.

B Odum *et al.* 2006 *Phys. Rev. Lett.* **97** 030801.

RS Van Dyck *et al.* 1987 *Phys. Rev. Lett.* **59** 26.

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MISSION AT WARP 7: IN A FLASH, HE'S
REPAIRED THE PUMPS DR. NOVAC SO
THOROUGHLY SABOTAGED – THE VACUUM
HAS BEEN SAVED! AND NOW IT'S TIME
TO DEAL WITH YOU, DOC...

... I'VE FINALLY GOT
YOU CHECK-VACUUM-MATED,
YOU SCOUNDREL. MY TURBOPUMP
PLASMA WHOOSH-O-MATIC IS SO
INGENIOUS AND RELIABLE THAT
YOU'LL NEVER GET ANY
AIR AGAIN.

UGHHHH...
VACUUM?!
ANYTHING BUT
THAT ...

HASTA LA
VISTA, DOC...

THEN COMES
THE SHOWDOWN.

ONCE AGAIN, DR. NOVAC DOESN'T
STAND A CHANCE. SEALED UP
VACUUM-TIGHT BY CAPTAIN
VACUUM'S TURBOPUMP PLASMA
WHOOSH-O-MATIC AND BANISHED
TO A PARALLEL UNIVERSE, HE
VEGETATES IN A STATE OF FAILED
VILLAINY.

TO BE CONTINUED ...

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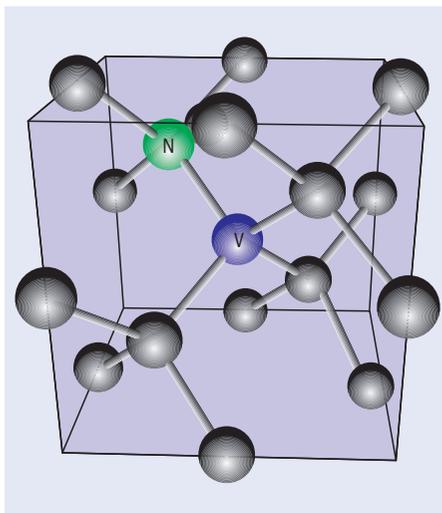
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PFEIFFER  **VACUUM**

Diamonds help achieve quantum coherence

Quantum computing depends on how quantum objects can be coupled coherently. To suppress decoherence, many schemes have involved temperatures at millikelvin levels. Now, Torsten Gaebel of the University of Stuttgart and colleagues in Germany, Australia and the US have achieved long-lived coherently coupled spins at room temperature by implanting nitrogen into high-purity diamonds.

The idea is to create pairs of spins that are close enough to be strongly coupled, while being far enough from other spins to avoid decoherence. Gaebel and colleagues embedded N_2^+ molecular ions into diamond, where the molecules split up to form closely spaced single nitrogen atoms (N). This process also creates vacancies (V) in the diamond lattice, and during annealing at 900 °C the vacancies move and can become trapped next to nitrogen atoms in the diamond



A substitutional nitrogen centre (N) and a neighbouring vacancy (V), which form the structure of the NV centre in diamond.

lattice to form an NV centre. This has an electron spin, which could be used as a qubit, the basic element of a quantum computer; it also has an optical transition that can be used to control it and read it out.

As the yield of NV centres created is low, the researchers demonstrated the potential of the approach by studying the coherent coupling between NV centres and nearby nitrogen atoms. They found a characteristic decay time for coherence of about 350 ms at room temperature. Already a long time, this seems to be limited only by the carbon-13 content of the diamond. This indicates that an array of NV centres, in principle, could be manipulated optically to build a quantum computer.

Further reading

Torsten Gaebel *et al.* 2006 *Nature Physics* **2** 408.

Research reveals why life is left-handed

A long-standing puzzle in biology is the predominance of left-handed amino acids over right-handed ones – a huge violation of parity, which physicists have tried at various times to link to the parity violation well known in the weak interaction. This has often involved invoking sensitive processes far from equilibrium to amplify the incredibly tiny (but nonzero) difference in energies between left- and right-handed amino acids.

Martin Klussmann of Imperial College London and colleagues have now brought us closer to understanding how this imbalance may have occurred. They found that even in

equilibrium, there are reactions catalysed by amino acids that involve some tricky thermodynamics of both solid and dissolved amino acids, and these can result in enormous asymmetries of one handedness of amino acid over the other. As well as helping to understand a basic fact of biology, the work could lead to improved synthesis of medically important molecules, many of which have different properties depending on their handedness.

Further reading

Martin Klussmann *et al.* 2006 *Nature* **441** 621.

Science gets closer to the invisible man

It sounds like science fiction, but a new idea could lead to a form of shielding that would make an object effectively invisible. Ulf Leonhardt of the University of St Andrews in Scotland and John Pendry of Imperial College London and colleagues argue that suitable “metamaterials” could be constructed, at least in the microwave region of the spectrum, that could bend electromagnetic radiation in such a way as to deflect it around an object and then send it on its way as if there had been nothing there.

Normal materials with the required properties are unlikely to be found, so complexes of metal rings and wires would be used to generate the appropriate exotic behaviour. Of course even if this idea works for microwaves, it may not be possible to engineer the right sort of material for the optical region of the spectrum, or for a range of frequencies wide enough to make something that Harry Potter could use.

Further reading

U Leonhardt 2006 *Science* **312** 1777.
J B Pendry, D Schurig and D R Smith 2006 *Science* **312** 1780.

Superlattice mirror forms a sonic laser

Researchers from the University of Nottingham in the UK and the Lashkarev Institute of Semiconductor Physics in Ukraine have made what may be a sonic laser, demonstrating sound amplification by stimulated emission of radiation, that is, a SASER.

Anthony Kent and his colleagues created the device out of stacks of thin layers of AlAs/GaAs that form a superlattice. The layering plays the role of an acoustic mirror, and an electrical

input drives the production of phonons via a rather complicated process involving quantum wells. The operating frequency is in the terahertz range, with wavelengths of a few nanometres making this potentially attractive for many applications, including imaging.

Further reading

A J Kent *et al.* 2006 *Phys. Rev. Lett.* **96** 215504.



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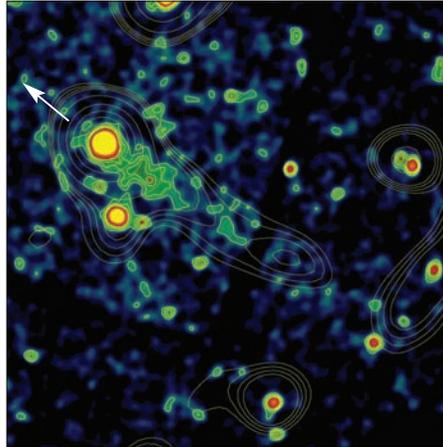
Satellite gives a new view of pulsars

Observations of old pulsars by the European Space Agency's XMM-Newton satellite fail to detect the 1 million-degree hot spots seen around the pole of younger pulsars. The absence of polar X-ray emission in old pulsars casts doubt on the belief that hot spots are produced when charged particles collide with the pulsar's surface at the poles. It suggests instead that the hot spots are heated from inside the neutron star.

Pulsars are strongly magnetized spinning neutron stars, which emit pulsed radiation, first detected at radio frequencies by Cambridge astronomers Jocelyn Bell-Burnell and Anthony Hewish in 1967. Almost 40 years later, these extremely dense stars, which have roughly the mass of the Sun squeezed into a sphere of only about 20 km across, still hold many mysteries. Astronomers think that neutron stars are formed with temperatures of more than a billion degrees (10^{12} K) during the collapse of massive stars.

Observations with previous X-ray satellites have shown that the X-rays from cooling neutron stars come from three regions of the pulsar. First, the whole surface is so hot that it emits X-rays. Second, there are charged particles in the pulsar's magnetic surroundings that also emit X-rays as they move outwards, along the magnetic field lines. Third, younger pulsars show X-ray hot-spots at their magnetic poles.

Until now, astronomers believed that the



X-ray image of PSR B1929+10, one of the five older pulsars with no evidence for polar hot spots. The contours from the ROSAT mission (1990s) are overlaid on the new XMM-Newton colour-coded image. The pulsar – moving at 177 km/s in the direction of the arrow – leaves a trail of X-ray emitting electrons. (Courtesy W Becker/MPE.)

hot spots are heated by the collision of surrounding particles onto the surface of the neutron star. This happens naturally at the poles owing to the channelling of the charged particles along the magnetic field lines. Such a process is expected to be rather independent of the temperature and hence the age of the pulsar. However, this is not what the XMM-Newton satellite observed for five pulsars. Werner Becker from the Max-

Planck Institut für Extraterrestrische Physik (MPE) in Garching and collaborators found no evidence of surface emission, nor of polar hot spots in these pulsars, although they did see emission from the outwardly moving particles.

The lack of surface emission is not surprising because these older pulsars have had several million years to cool down to less than 500 000 °C, the temperature below which they become undetectable by XMM-Newton. However, the lack of polar hot spots is a surprise and means that the particle bombardment of the polar surface is not efficient enough to produce a significant thermal X-ray component.

The XMM-Newton results show that the hot spots fade from view in the same way as the surface-wide emission, thus suggesting a link with the temperature inside the neutron star. As the heat trapped in the pulsar since its birth is carried by electrons, it can be guided to the poles by the intense magnetic field within the pulsar. The new XMM-Newton results support this alternative theory for the origin of the hot spots at the poles of young pulsars. It would mean that the energy heating these polar regions comes predominantly from within the pulsar, rather than from the collision of particles from outside the pulsar.

Further reading

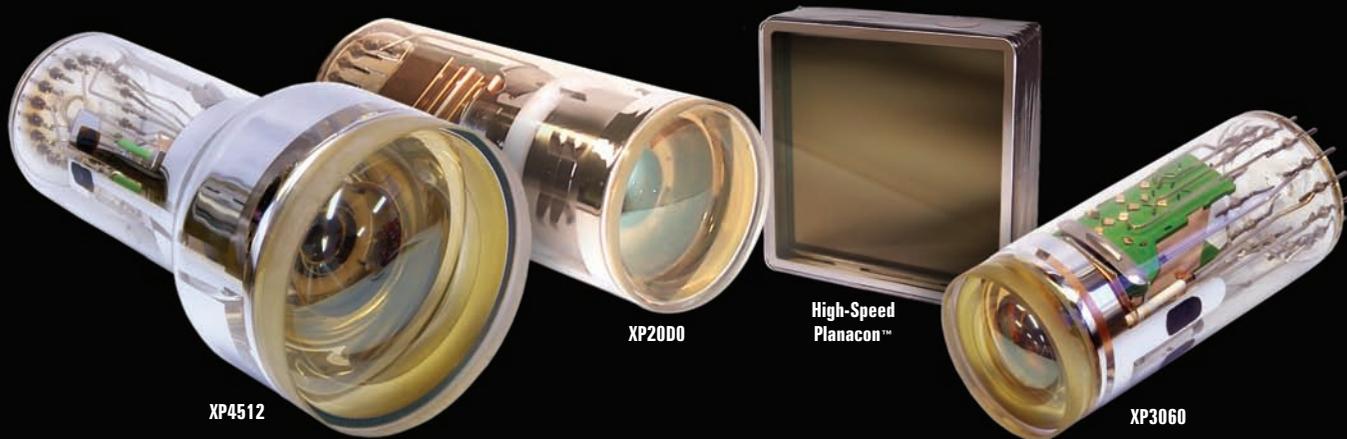
Werner Becker *et al.* 2006 *Astrophysical Journal* **645** 1421.

Picture of the month



This X-ray image taken by NASA's Chandra satellite shows the central region of our galaxy (for a larger view see *CERN Courier* March 2002 p11). The image is roughly aligned with the galactic plane. The super-massive black hole at the galactic centre is located near the dense cluster of stars at the right of the image. Intense X-ray emission from point-like sources in this cluster occurs when winds blowing off the surfaces of massive stars collide with winds from orbiting companion stars; it also comes from stellar corpses in the form of neutron stars or black holes orbiting a normal star in a binary system. The diffuse X-ray emission reveals the presence of very hot gas, which is likely to have been heated by past supernova explosions. (Courtesy NASA/CXC/UMass Amherst/Q D Wang *et al.*)

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NEWS FROM ABROAD

The antixi zero appears at last

The one remaining undiscovered particle in the list of quasi-stable, or so-called “elementary” particles [reproduced in *CERN Courier* May 2006 p13] has been detected in an experiment at Brookhaven, US, reported in *Phys. Rev. Lett.* on 15 August.

Using a beam of separated antiprotons, of momentum 3.69 GeV/c, from the 33 GeV alternating-gradient synchrotron (AGS), physicists from the Brookhaven National Laboratory and Yale University obtained some 300 000 photographs showing interactions between the antiprotons and protons in a 20 inch (51 cm) liquid-hydrogen bubble chamber. Three photographs were found in

which the tracks left by charged particles enabled the physicists to deduce that production had taken place of an antixi particle with no electric charge, the antixi zero.

An antixi zero, produced by antiproton annihilation, leaves no track in a bubble chamber, and the antilambda zero and pi zero into which it decays also leave no tracks. However, in one of the photographs in particular, the positive pion and the antiproton from the decay of the antilambda were identified, as well as the negative xi also formed by the annihilation. Measurements of the tracks of these particles then established the chain of events, leading back to the

production of the antixi zero. The measurements also enabled the lifetime of the new antiparticle to be determined, confirming the expected value of about 10^{-10} s.

Although predicted some years ago, on the basis that every particle has a corresponding antiparticle, there is a certain satisfaction in actually “seeing” an example or two of this rare and somewhat elusive form of matter. What is perhaps more important is that the particles and antiparticles so far discovered now form a complete “family”, with no gaps, and the discovery of any further particles with a lifetime of this order or longer would require the creation of completely new groupings.

Rutherford Lab's Nimrod operates at design energy

The proton synchrotron, Nimrod, at the Rutherford High Energy Laboratory at Chilton, UK, produced its first fully accelerated beam on Tuesday 27 August, with an energy of 6.5 GeV and intensity of 4.9×10^9 protons per pulse. Within an hour, an energy of 8 GeV had been

achieved and the beam current was later increased to 10^{10} protons per pulse at the design energy of 7 GeV. Development will now be concentrated on increasing this intensity to 10^{12} protons per pulse and preparing the programme of high-energy physics experiments.

Nimrod, which cost some £11 m (SwFr135 m), is the second accelerator to be operated by the National Institute for Research in Nuclear Science (NIRNS), the organization set up in 1957 to provide for common use by British universities and similar institutions the large and costly equipment needed for

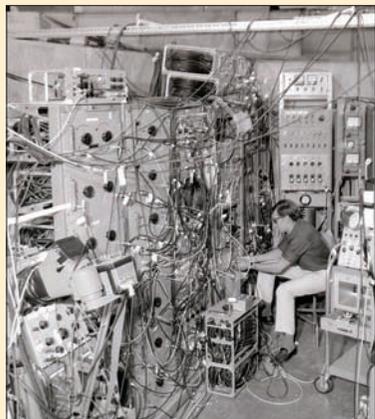
fundamental research that is beyond the scope of individual universities.

The accelerator has a single ring-shaped electromagnet, 47.25 metres in diameter and weighing 7000 tons. Its toroidal vacuum chamber is made from epoxy resin reinforced with glass fibre. Protons are injected by a 15 MeV linac, and make about a million revolutions, in rather less than three quarters of a second, before reaching full energy. The accelerator produces 28 pulses of protons each minute at its design energy. (UKAEA.)

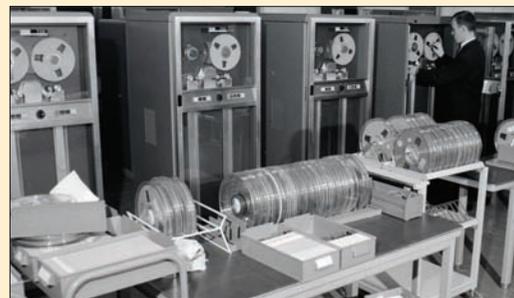
● Extracted from p113.

CERN's contributions to high-energy physics

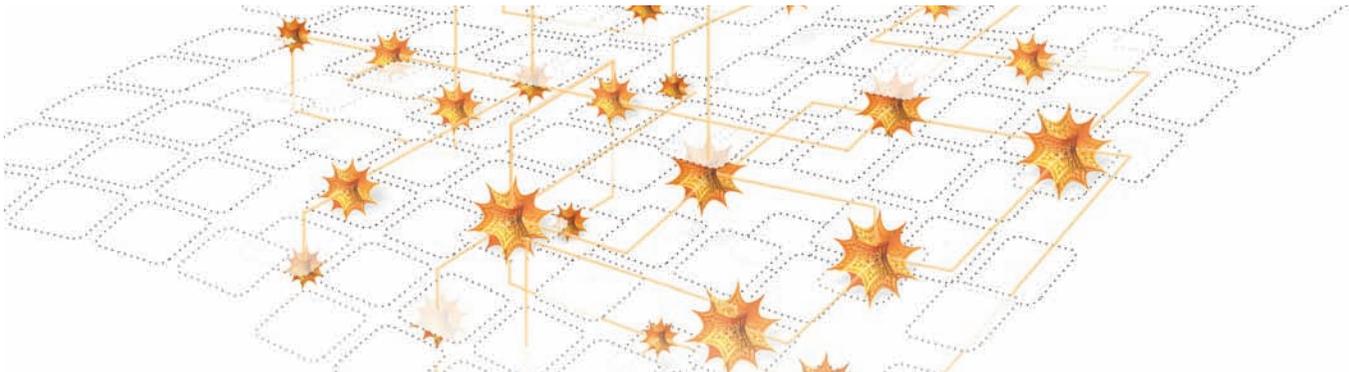
These photographs are from “CERN contributions to high-energy physics” (pp115–117), compiled from results published in the four issues of *Phys. Lett.* of June and July 1963.



Left: Some of the complex electronic equipment used for the experiment to detect electron pairs from antiproton annihilation. The recording oscilloscope in the left foreground photographs the signals from scintillation and Cherenkov counters, providing vital information to be read in conjunction with spark-chamber photographs. To the right of it, the third rack is used for making all the connections for the “logic”, which makes the primary selection of wanted from unwanted events. Other racks contain scalars, delay lines, power supplies, and other auxiliary instruments.



Above: Many of the results were obtained with the aid of CERN's electronic digital computers. Some of the reels of magnetic recording tape are seen here in the 709 computer room, together with the tape units that form the main route into and out of the computer. In September, new units were installed as part of the replacement of the 709 by a 7090.



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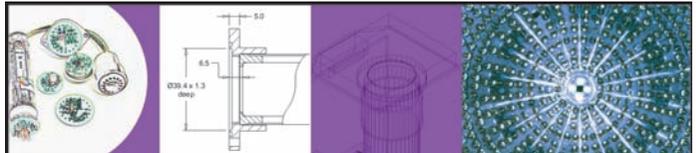
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COMPUTING NEWS

Compiled by Hannelore Hämmerle and Nicole Crémel

EGEE

Grid helps to achieve international digital-broadcasting agreement

During the Regional Radiocommunication Conference (RRC-06) of the International Telecommunications Union (ITU), on 15 May – 16 June, the Enabling Grids for E-science (EGEE) project supported a series of large-scale data-processing activities being carried out by the ITU. These took place regularly during the five-week conference so as to map rapidly the consequences of different scenarios being negotiated. The aim was to establish a new frequency plan for digital broadcasting in Europe, Africa, Arab states and the former USSR.

As well as relying on the ITU's own computing system with 100 PCs, several sites of the EGEE infrastructure provided a computing Grid of more than 400 PCs to work on each analysis in parallel. This simultaneous calculation on the Grid not only came up with the same results in a much shorter time than on the local system, but could also provide extra capacity and additional safeguards on the distributed infrastructure. By using a relatively small subset of a few hundred of the estimated 20 000 PCs of the EGEE Grid infrastructure, the most demanding analysis step could be reduced during the conference



The EGEE sites that were involved in supporting the ITU 2006 data-processing challenge.

from about four hours on the local cluster to less than one hour on the Grid.

A major challenge faced by the conference was to find ways for digital and analogue broadcasting to co-exist on the radio-frequency

spectrum during the transition period without causing interference. The treaty agreement that was signed as a result of the negotiations heralds the development of all-digital terrestrial broadcast services for sound and television.

HIGH PERFORMANCE

Bristol gets new computing power

Three new supercomputers at Bristol University will transform research areas such as the structure of space and time, climate modelling

and the design of novel drugs. At peak performance the multimillion-pound high-performance computers (HPCs) will do more than 13 trillion calculations a second, equivalent to the population of the world using hand-held calculators for about three hours.

In June, Bristol University announced the award of the contract to install the computers to

a consortium led by ClusterVision, working with IBM and ClearSpeed Technology. The largest of the three HPCs will be one of the fastest university research computers in the UK, and is expected to be one of the top 100 computers of its type in the world. It will allow the university's physicists to be among the first to examine results from CERN's Large Hadron Collider.

Echos de l'informatique

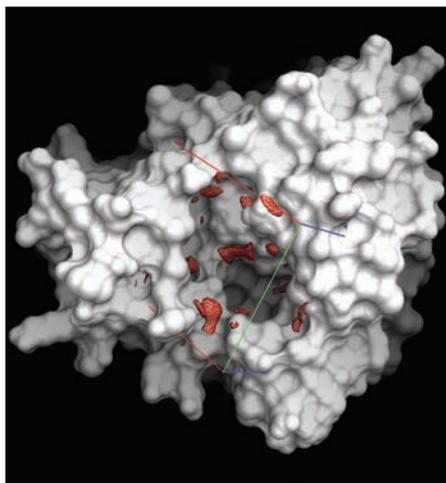
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| Plus de puissance de calcul pour l'Université de Bristol | 17 | Le World Wide Web entre en scène | 19 |
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| | | GEANT2 lance un économiseur d'écran pour célébrer son succès | 20 |

GRID SCIENCE

Biologists use EGEE Grid to find drug compounds to battle avian flu

A collaboration of Asian and European laboratories has used the Enabling Grids for E-science (EGEE) Grid infrastructure to analyse 300 000 possible drug components against the avian flu virus H5N1. The goal was to find potential compounds that can inhibit the activities of an enzyme on the surface of the influenza virus, the so-called neuraminidase, subtype N1. Using the Grid to identify the most promising leads for biological tests could speed the development of the drugs.

The challenge of this *in silico* drug-discovery application is to identify molecules that can dock on the active sites of the virus to inhibit its action. During four weeks in April, scientists used 2000 computers – equivalent to 100 years on a single computer – to investigate the docking of 300 000 compounds against eight structures of influenza A neuraminidases. More than 60 000 files with a data volume of



Researchers are studying the binding pocket of neuraminidase, one of the two major surface proteins of avian influenza viruses. (Courtesy Ying-Ta Wu, Academia Sinica.)

600 GB were created and stored in a relational database. Researchers are now identifying and ranking potential compounds according to the binding energies of the docked models. With the results from the *in silico* screening, they can predict which compounds and chemical fragments are most effective for blocking the active neuraminidases in case of mutations.

Using experience from a data challenge on malaria (WISDOM), the Grid-enabled *in silico* process was implemented in less than a month on three different Grid infrastructures, AuverGrid, EGEE and TWGrid, paving the way for a virtual large-scale drug-screening service. The WISDOM platform performed most of the computing. However, a lightweight application framework called DIANE (see p20) was also adopted in this challenge and used to perform much of the activity to enable efficient computing-resource integration and usage.

WEB NEWS

W3C announces Web authoring for mobiles and a new Web-services recommendation

The World Wide Web Consortium, W3C, has introduced the Device Independence Authoring Language (DIAL) to facilitate authoring for an ever-expanding range of mobile devices. Thousands of mobile devices with a wide range of capabilities are in use today, and people have come to expect the same quality of service and wealth of information available on the move that they find on the Web at their desktop computers. This diversity poses significant challenges to Web designers and mobile operators alike.

DIAL is a language profile based on existing W3C XML vocabularies and CSS modules. These provide standard mechanisms for representing Web page structure, presentation and form interaction. DIAL also

uses the DSelect metadata vocabulary for overcoming authoring challenges inherent in authoring for multiple delivery contexts.

W3C has invited review and discussion with the community of this first public working draft. DIAL has been developed within W3C by the Device Independence Working Group, whose work serves as part of the technical foundation for W3C's Mobile Web Initiative (MWI), making the vision of one Web for all devices a reality.

W3C has also announced that Web Services Addressing 1.0 – consisting of the Core specification and the SOAP Binding – is now a W3C Recommendation. Web Services Addressing 1.0 provides a transport-neutral mechanism for addressing objects in Web-

services applications built on top of uniform resource identifiers.

The new method is called an endpoint reference (EPR). These are designed to solve the issues posed by specific scenarios, such as dynamic generation and customization of service endpoint descriptions (e.g. created for session identification), referencing and description of specific service instances, and flexible and dynamic exchange of endpoint information in tightly coupled environments. In addition to their addressing function, EPRs can serve a role similar to that of a cookie for Web services interactions. Another special feature of EPRs is the metadata bag, which allows additional information to be included with the EPR.

CNL ARCHIVE

The World Wide Web springs into action

After CERN's 50th anniversary in 2004, this year there is another anniversary: the first *CERN Computer Newsletter* (CNL) was circulated in 1966. As CNL celebrates its 40th year, we take a look back at some of the highlights of computing at CERN, seen through its pages. In this issue we concentrate on the 1990s and the articles in *CNL* that were related to the birth of the World Wide Web. For an extended retrospection read *CNL*, which is also available online from www.cerncourier.com.

A project for hypertext and browsable documents at CERN

[...] Depending on its complexity and distribution, a document will be presented to the users in one of the following forms:

- on paper (major manuals, or documents widely distributed outside CERN);
- as plain text for simple terminals (we hope all documents); or
- as a sophisticated version for workstations – these versions will be developed in the context of the hypertext project (currently being launched between ECP and CN). The major long-term aim will be to make machine readable versions browsable from outside CERN (*CNL* 200 July–October 1990).

World Wide Web: Online information for everyone

A world of information is now available online from any computer platform. Information sources at CERN and across the world span subjects from poetry to biochemistry and supercomputing. We summarize the information currently sourced at CERN, and we introduce the WorldWideWeb (W3) program which allows you to browse and search all of the data in a simple and consistent manner.

Details of all the information, and of how to acquire and install the W3 software on your own machine, are available by typing "telnet info.cern.ch" [...] The browser described here is the simplest interface to the World Wide Web,



This machine was used by Tim Berners-Lee in 1990 to develop and run the first Web server, multi-media browser and Web editor.

which was designed to run on any dumb terminal. A hypertext browser/editor is available under NeXTStep. More powerful interfaces are being developed, including Macintosh, X-Windows, VM full-screen and emacs. Please send any comments, suggestions or queries to www-bug@info.cern.ch. *T Berners-Lee, R Cailliau, J-F Groff and B Pollermann (CNL 204 October–December 1991).*

W3 – Spring releases

The World Wide Web bounds into spring with some exciting software releases from outside CERN [...] Statistics we take on the access to our server show an exponential increase, with a time doubling about every two months, and currently running at around 500 document fetches a day, [...] many of these are from people telnetting to info.cern.ch, so if you haven't installed WWW on your own workstation, please do so! (by Tim Berners-Lee, *CNL* 206 March–April 1992)

New version of Mosaic available

Mosaic is an X11-based application to browse information stored in the World Wide Web system. It has been developed at NCSA and provides at present the best user interface available on Unix workstations.

We have released into the Public Area the Unix, VMS and Macintosh versions of Mosaic 2.2 (*CNL* 215 January–March 1994).

Calendar of events

September

11–14 GGF18

Washington DC, US, www.ggf.org

13–15 HPCC-06

Munich, Germany,
<http://hpcc06.lrr.in.tum.de/>

19–21 European Grid Technology Days 2006

Brussels, Belgium, <http://cordis.europa.eu/ist/grids/event-190906.htm>

21–23 2nd Austrian Grid Symposium in conjunction with 6th Austrian-Hungarian Workshop on Distributed and Parallel Systems

Innsbruck, Austria
www.austriangrid.at/symposium

22–24 6th WSEAS International Conference on Simulation, Modelling and Optimization (SMO '06)

Lisbon, Portugal, www.worldses.org/conferences/2006/lisbon/smo

25–28 IEEE International Conference on Cluster Computing (Cluster 2006)

Barcelona, Spain, <http://cluster2006.org>

28–29 7th IEEE/ACM International Grid Conference (Grid 2006)

Barcelona, Spain, www.grid2006.org

25–29 EGEE conference

Geneva, Switzerland, <http://egee-technical.web.cern.ch/egee-technical/conferences/EGEE06>

October

12–15 8th Real-Time Linux Workshop

Lanzhou, China, www.realtimelinuxfoundation.org/events/rtlws-2006/ws.html

21–23 GCC 2006

Changsha, China, www.vce.org.cn/gcc2006

25–27 eChallenges e-2006

Barcelona, Spain, www.echallenges.org/

November

11–17 SC06

Tampa, US, <http://sc06.supercomputing.org/>

WEB HISTORY

Info.cern.ch is live once more

1990 was a momentous year in world events. In February, Nelson Mandela was freed after 27 years in prison. In April, the space shuttle *Discovery* carried the Hubble Space Telescope into orbit. And in October, Germany was reunified. Then at the end of 1990, a revolution took place that changed the way we live today.

It all began at CERN in March 1989 with an information-management proposal illustrating how information could be transferred easily by creating a universal hypertext. The idea was to

connect hypertext with the Internet and personal computers, thereby having a single information network to help physicists at CERN share all the computer-based information at the laboratory. This was the birth of the World Wide Web, with info.cern.ch as the address of the world's first Web server on a NeXT computer at CERN (see p19). Now after a break of a few years, the URL <http://info.cern.ch> is live again, providing a website that tells the story of this huge breakthrough in information technology.

GRID TOOLS

DIANE creates efficient scheduling on the Grid

A tool for parallel scientific applications, the Distributed Analysis Environment (DIANE), has been successfully used in several processing challenges on the Grid. In April, DIANE was used during the *in silico* drug-discovery application to analyse possible drug components to fight the avian flu virus on the Enabling Grids for E-science (EGEE) infrastructure (see p18). In the following months, the DIANE scheduling layer was also used for a series of large-scale data-processing tasks for the International Telecommunications Union using several Grid sites around Europe (see p17). Originally targeted at investigating distributed ntuple analysis for particle physics, DIANE has become an application-independent user-scheduling tool on the Grid and has been interfaced with a number of applications in various fields.

DIANE is a python framework based on a master-worker processing model, used on top of regular Grid middleware in a transparent way. Worker agents are sent to the Grid as regular Grid jobs. By opening a TCP/IP connection, they register to the master agent, which runs on the user's desktop computer and is the coordination point for the virtual worker pool. Workers may dynamically join and leave

the pool, without disrupting the processing as a whole. The units of computation are a large number of short tasks, which the master allocates to workers directly, bypassing the middleware-scheduling layer. This allows the total job turnaround time to be reduced and also leads to a much faster reaction to errors in task execution by reallocating them to other workers. During the drug-discovery data challenge, it was demonstrated that a scheduler such as DIANE can improve the distribution efficiency on the Grid from less than 40% to more than 80% by optimizing the allocation of the fine-grained computing tasks.

DIANE's python framework allows the easy integration of existing applications, even those as complex as Athena, the analysis framework of the ATLAS experiment at CERN, and will be used to operate part of the Geant4 toolkit. DIANE has also been interfaced to Ganga, a user-friendly Grid interface created in the context of ATLAS and LHCb experiments.

● For more details on the DIANE scheduler, please see the extended version of this article in the *CERN Computing Newsletter* at <http://www.cerncourier.com/articles/cnl>, or go to the DIANE webpage at <http://cern.ch/diane>.

NETWORKS

GEANT2 launches screensaver to celebrate success

A GEANT2 screensaver is now available to download. Available for both Windows and Macs, the screensaver is based on an animation produced last year for the launch of the GEANT2 network, and is designed around the project logo and its strapline "Connect. Communicate. Collaborate."

GEANT2 is the seventh-generation pan-European research and education network, and is the successor to the pan-European multi-gigabit research network GEANT. The project within which the network is funded began officially on 1 September 2004, and will run for four years. GEANT2 is co-funded by the European Commission and Europe's national research and education networks, and is managed by DANTE.

● To download the screensaver go to www.geant2.net/screensaver.



A screenshot of the screensaver produced to mark the launch of the GEANT2 network.

PRODUCT INFORMATION

SigmaPlot 10, the latest version of the Systat Software scientific graphing and data-analysis package, presents a wide range of new graphing options and many workflow efficiency improvements to streamline the graph creation and publication process and to provide greater flexibility for field and lab data analysis. It also includes new features, such as real-time mouse feedback of graph coordinates, and enhancements to the curve-fitting engine.

DIRECT MODULATION MICROWAVE FIBER OPTIC LINKS To 18 GHz

FEATURES:

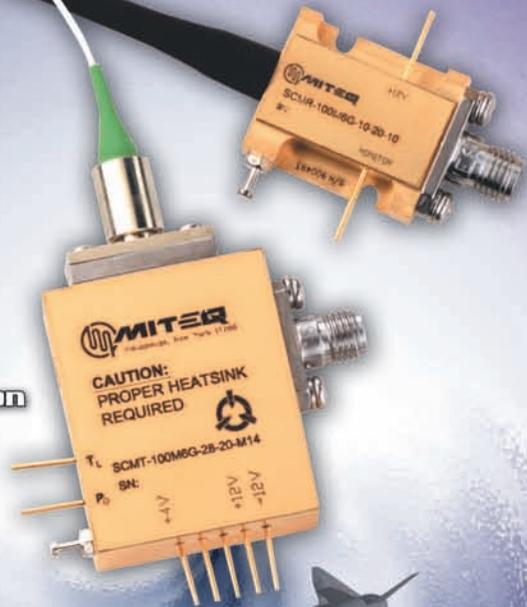
- Three Available Bandwidth Options
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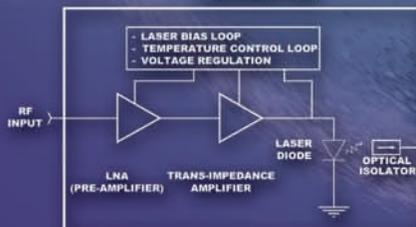
Electrical Specifications
(1 Meter of Fiber)

| Model | LBL | SCM | SCM |
|--|--------------------|--------------------|--------------------|
| Frequency (GHz) | 0.1-3 | 0.1-6 | 0.1-18 |
| Gain (dB) | 10-20 (17 Typ.) | 10-20 (18 Typ.) | 10-20 (18 Typ.) |
| Noise Figure (dB, Max.) | 15 (10 Typ.) | 20 (14 Typ.) | 25 (20 Typ.) |
| Group Delay (ns ptp, Typ.) | 0.1 | 0.1 | 0.1 |
| VSWR (In/Out) | 2:1 | 2:1 | 2:1 |
| Phase Noise (dBc, Typ.) | >100 | >100 | >100 |
| Input Power @P1dB (dBm, Min.) | -14 | -14 | -15 |
| Spurious Free Dynamic Range (dB/Hz, Min.) | 100 (105 Typ.) | 101 (103 Typ.) | 100 Typ. |

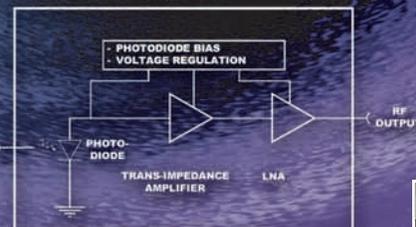


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Nordic Grid activities strengthen the WLCG

Michael Grønager sums up the many Grid projects that are taking place in the Nordic countries, which are helping to extend the network of the Worldwide LHC Computing Grid.

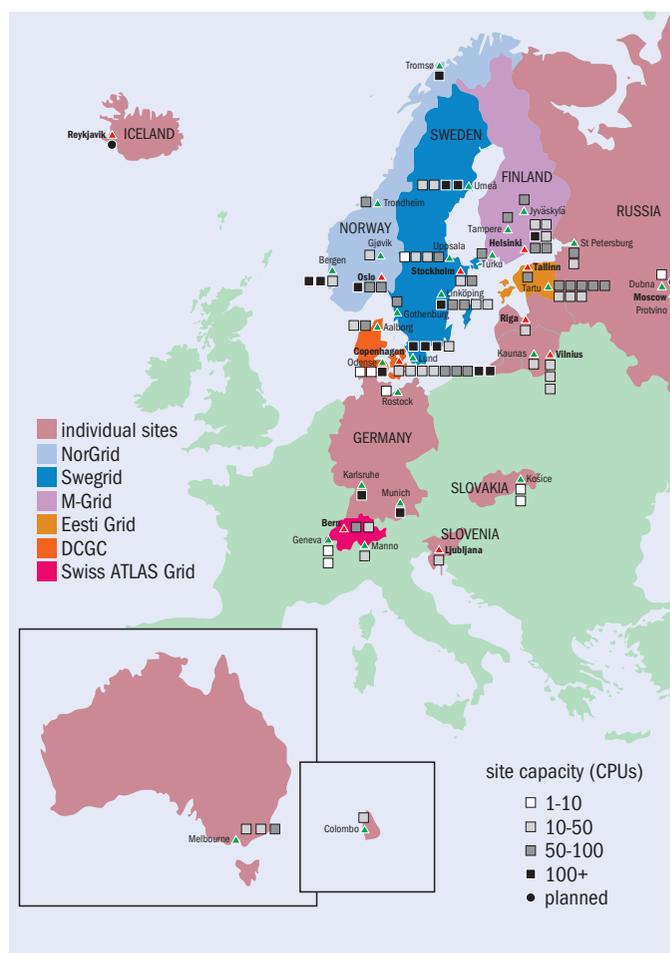
Nordic countries have participated in Grid developments at CERN since the beginning, although at the early stages they already opted for developing their own middleware. Most Nordic Grid projects now use the Advanced Resource Connector (ARC), developed by NorduGrid, while some also use the gLite middleware deployed by the Enabling Grids for E-science (EGEE) project. Several sites are involved both in NorduGrid and in projects such as EGEE, and therefore deploy both ARC and gLite. But let's start from the beginning.

NorduGrid

The EU DataGrid (EDG) project began in 2001, but with no partners in the Nordic high-energy physics (HEP) community. The community therefore decided to create a satellite project collaborating with EDG, and applied for Nordic funding through the NORDUnet2 programme. This project was later named NorduGrid and involved a dozen Nordic universities and high-performance computing centres, representing four Nordic countries, Denmark, Finland, Norway and Sweden. Funding covered test-bed hardware and three postdoctoral research positions.

The project spent a few months testing and installing the then embryonic EDG middleware, and communicated proposals for improvements back to EDG and Globus. It also participated in the EDG integration and testing efforts. However, the planned contribution to ATLAS Data Challenges in 2002, to test the emerging computing infrastructure, seemed likely to be impossible using Grid tools because of many shortcomings, such as problematic job-submission or the information system and monitoring. The decision was therefore taken to write a new solution. NorduGrid thus implemented new versions of the information system, the Grid front-end and other essential components. The EDG project encountered the same problems and later introduced the BDII and Condor-G tools to tackle the difficulties, albeit in a different way. This was the first major divergence between the two middleware solutions, and it still remains today. EDG became the middleware of choice for the LHC Computing Grid (LCG) project and has been further developed into the gLite middleware stack by EGEE.

In mid-2002, NorduGrid emerged as one of the first production-level Grids and continued to grow until it became one of the world's largest Grids in 2004. (For more details on the use and achievements



Nordic Grid projects and other sites using NorduGrid middleware.

of the NorduGrid collaboration see *CERN Courier* April 2005 p13.)

When the funding for NORDUnet2 ceased in 2003, NorduGrid was converted into a collaboration dedicated only to middleware support and development, while deployment of the ARC middleware was taken over by the Nordic DataGrid Facility (NDGF). April 2004 saw the first stable release of the ARC middleware, and since then middleware development has concentrated on adding new

Overview of Nordic Grid projects

| Project/collaboration | Web page | Contact |
|---|----------------------------------|---|
| NorduGrid | www.nordugrid.org | Farid Ould-Saada, University of Oslo |
| KnowARC | www.knowarc.eu | Farid Ould-Saada, University of Oslo |
| Innovative services and tools for NorduGrid (Nordunet3 project) | www.nordugrid.org | Farid Ould-Saada, University of Oslo |
| Nordic Grid Neighbourhood | www.kbfi.ee/projects/NordicGrid/ | Farid Ould-Saada, University of Oslo |
| Nordic DataGrid Facility (NDGF) | www.ndgf.org | Michael Grønager and Oxana Smirnova, NDGF |
| Baltic Grid | www.balticgrid.org | Per Öster, ParallelDatorCentrum |

features and functionalities, leading to the next stable release, scheduled for August 2006. In parallel, efforts were made to extend ARC to new sites, supporting users and improving relations with other Grids with possible future interoperation in mind.

In 2005, several new projects supporting further development of the Grid infrastructure and the ARC middleware were conceived: KnowARC, NDGF (both starting in June 2006) and a NorduGrid continuation project as part of the NORDUnet3 programme, which will start in October 2006.

What then is the relationship between these different projects, and how do NorduGrid and the ARC middleware fit into this scheme? ARC is the open-source middleware coordinated by the NorduGrid collaboration, which is based on a memorandum of understanding between the universities of Copenhagen, Lund, Oslo and Uppsala, plus the Helsinki Institute of Physics. This collaboration provides major contributions to most of the projects. KnowARC and NDGF will be the major contributors to the ARC code base in the coming years.

KnowARC

The KnowARC project will improve and extend the ARC middleware to become next-generation Grid middleware conforming to community-based standard interfaces. It will also address interoperability with existing, well-deployed middlewares. By getting ARC included in the standard Linux distributions, KnowARC will contribute to Grid technology, enabling all kinds of users, from industry to education and research, to set up and use this standards-based resource-sharing platform easily. More than half of the contributors to KnowARC are from outside of the Nordic countries and more than half are not related to HEP, making KnowARC a true all-purpose Grid project.

NDGF

The NDGF project aims to create a seamless computing infrastructure for all Nordic researchers, leveraging existing, national computational resources and Grid infrastructures, and in addition includes middleware developers. NDGF is not a resource provider and does not force researchers to use the Grid, but rather helps researchers to share their resources if this is advantageous for Nordic or international collaborations. In this scheme, HEP fits perfectly, but bio-informatics is expected to become heavily involved as well. After the initial pilot phase, the project has been substantially expanded to include middleware developers.

The first big goal for the NDGF HEP activities is to provide the NDGF Tier-1 centre for the Worldwide LHC Computing Grid (WLCG) infrastructure. As NDGF does not possess any resources, the actual

Tier-1 service will be distributed between the seven largest computer centres in the Nordic countries, utilizing the fact that up-time requirements can be relaxed by redundancy. The middleware used for the computing and storage infrastructure will be ARC, introducing another Grid flavour into the WLCG, together with gLite and OSG.

Organizationally, NDGF is co-hosted with the Nordic Regional Research and Educational Network NORDUnet, following the vision that the Grid and access to computing resources should be no different to other services on the network. Hence, a close coupling between the network for the distributed Tier-1 centres and the computer sharing services is guaranteed.

Further activities

The Nordic countries are also quite heavily involved in the EGEE project in operation and support, applications, training, testing and certification. One of the tasks undertaken by the Nordic countries is interoperability between ARC and the EGEE middleware gLite. Job submission from ARC to gLite is a part of the work programme for the KnowARC project. Training and outreach are primarily targeted by the Nordic Grid Neighbourhood network, which arranges conferences and student exchanges within the Nordic countries, the Baltic states and Russia.

Another Nordic project that deserves to be mentioned is the BalticGrid project. Baltic states traditionally have strong links with the Nordic countries and collaborate closely with NorduGrid, providing both hardware resources and middleware developers. This Grid experience helped to create the BalticGrid project, which introduces gLite services and tools in addition to ARC services that already exist.

Résumé

Les grilles nordiques appuient la Grille mondiale LHC

Les pays nordiques participent au développement de la Grille au CERN depuis le tout début, bien qu'ils aient dès le départ opté pour le développement de leur propre intergiciel. La plupart des projets nordiques utilisent aujourd'hui l'ARC (Connecteur de ressources avancé), élaboré par NorduGrid, en plus de l'intergiciel gLite du projet EGEE (réalisation de grilles pour la science en ligne). En effet, plusieurs sites participent à la fois à NorduGrid et à des projets tels qu'EGEE et font donc appel aussi bien à gLite qu'à ARC. L'article replace ces nombreuses activités de grille nordiques dans leur contexte.

Michael Grønager, NDGF.

ANTARES Collaboration detects its first muons

After many years of tests, the ANTARES neutrino detector deployed in the Mediterranean Sea is using its first full detector line to register the tracks of cosmic-ray muons.

On 14 February 2006 the first fully instrumented ANTARES detector line was deployed and placed at a predetermined place on the bottom of the Mediterranean Sea, about 40 km off the coast of Toulon, and at a depth of 2500 m. On 2 March, a remote-controlled submarine connected the line to the junction box, the terminal at the end of the 40 km telecommunications cable that leads to the shore station at La Seyne-sur-Mer. On the same day the line recorded the first cosmic-ray tracks. This is the first of 12 lines to be deployed over the next 18 months, after many years of tests that have investigated conditions at the detector site and parts of the detector set-up (*CERN Courier* June 2003 p22). An instrumentation line has been taking data smoothly since April 2005 (Aguilar *et al.* 2006).

ANTARES is one of only a few detectors employing natural seawater or ice as the detector medium to search for neutrinos of extraterrestrial origin. These neutrinos may have been produced in high-energy events in the cosmos, travelling towards us undisturbed by intervening matter or magnetic fields. If their direction can be determined then their origin in the universe can be identified. High-energy neutrinos could also be indicators for certain types of dark matter.

The neutrino is weakly interacting and this sets the scale of the detectors. Only truly gargantuan sizes allow the detection of neutrinos with sufficient sensitivity to be useful. It was an idea of Moisey Markov in 1960 that gave impetus to the possibility of neutrino astronomy. He reasoned that if one concentrated on muon-neutrinos through the detection of a muon produced in a charged-current interaction, then the large range of the muon in matter would allow for large effective volumes. The direction of the muon is closely related to the direction of the neutrino, and if the detection medium is water or transparent ice then the muon can be tracked through its emission of Cherenkov radiation.

For ANTARES, the Mediterranean Sea and the rock below the seabed provide the interaction volume, and the water provides the detection medium. Because of its large scattering length for Cherenkov light, the seawater allows excellent timing and, consequently, good directional accuracy can be obtained. The Mediterranean was chosen because it is in the Northern Hemisphere and provides complementary sky coverage, including the centre of our galaxy, to the AMANDA and IceCube detectors that are operating in the Antarctic ice (*CERN Courier* May 2006 p24).

The overall detector consists of storeys suspended at intervals of 14.5 m along a 500 m vertical cable, which is anchored to the sea

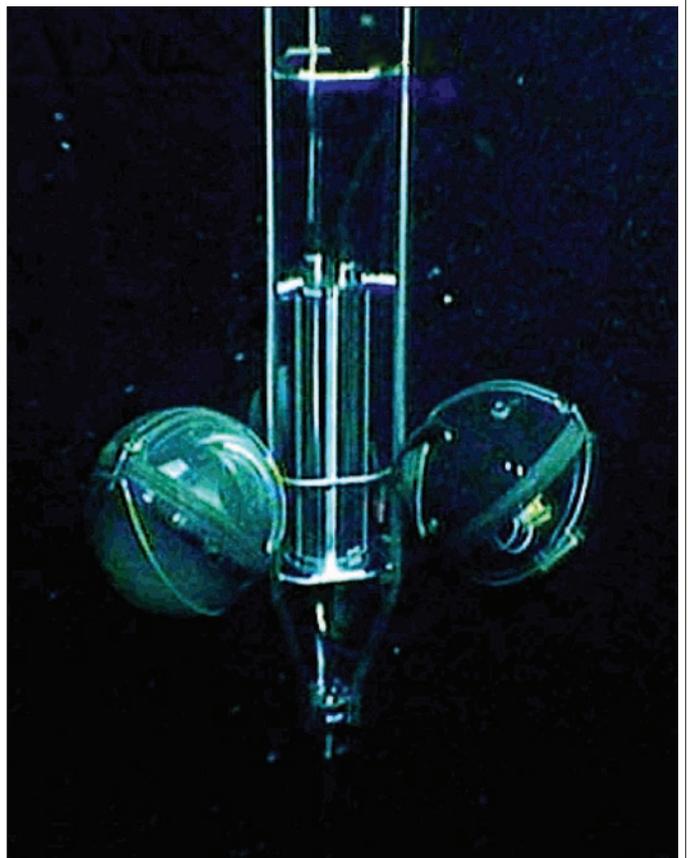


Fig. 1. An ANTARES detector storey deployed 2341 m below the surface of the Mediterranean Sea. (Courtesy IFREMER.)

floor and held vertical by a buoy at the top of the cable. The storeys begin at 100 m above the seabed and there are 25 such storeys on a line. Placing more of these cables at distances of 70 m increases the volume of the detector.

Figure 1 shows a storey *in situ* in the sea, with the glass pressure spheres housing the 25 cm diameter photomultiplier tubes (PMTs) that are used to detect the Cherenkov light. The PMTs point downwards at an angle of 45° with respect to the vertical. Two are clearly visible, whereas the third is hidden behind the titanium cylinder that contains the electronics for the readout and control of the storey, and an electronic compass, plus a tilt meter. A hydrophone, used for

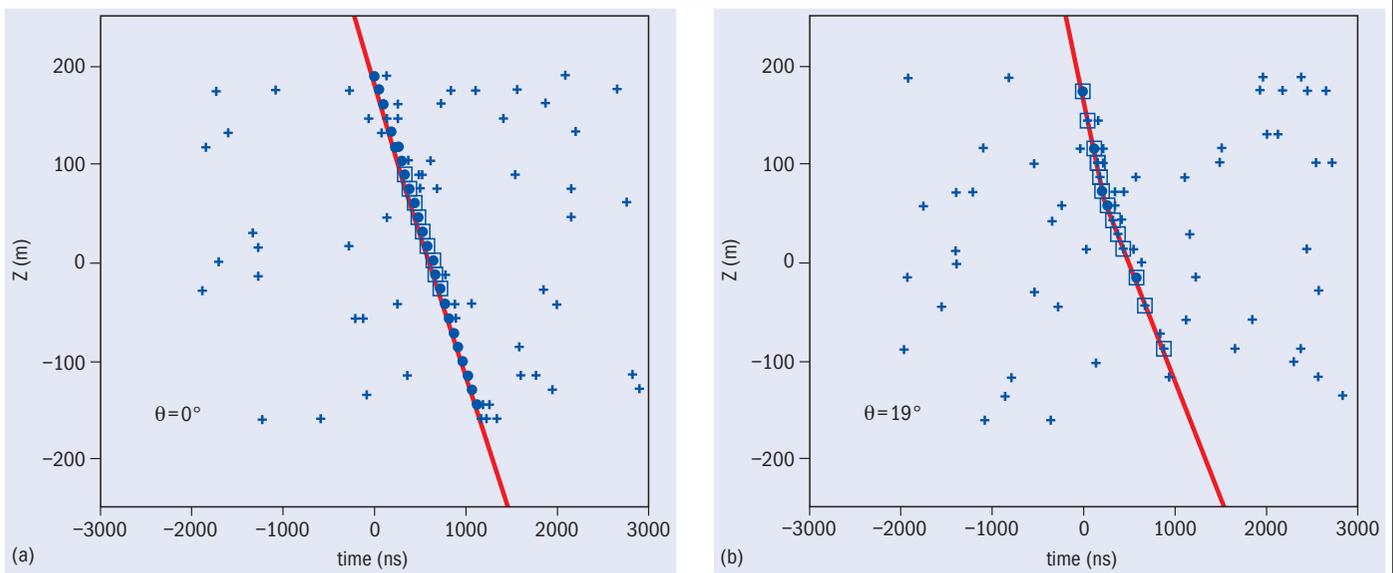


Fig. 2. Examples of reconstructed tracks using the data from the first of the 12 ANTARES detector lines, which was deployed in February and which began data-taking in March: (a) vertical down-going muon; (b) down-going muon at $\theta = 19^\circ$ from the zenith.

acoustic positioning, is located at the bottom of the storey.

The PMTs operate at a threshold of 0.4 photoelectrons. All the data produced by the tubes are transferred via an optical cable to the shore, where a farm of computers processes the data to extract interesting events. Because of radioactive potassium present in the seawater, each PMT has a base rate of about 60 kHz; bioluminescent life in the seawater may increase this rate. It is the task of the software running on the computer farm to recognize the presence of a muon track among the background hits. At present the software is able to perform this task up to about five times the base rate. However, conditions at the bottom of the sea can vary significantly. There was a period of relative calm just after deployment, followed by two months of high bioluminescent activity, making data-taking difficult; now the background activity has subsided and normal data-taking has resumed.

The present software selects slices in time and searches for the passage of muons through their time patterns in the PMTs along the string. The final stage of the process is a χ^2 minimization fit to the height versus time pattern. The reconstructed data set is dominated by down-going muons originating from high-energy cosmic-ray showers in the atmosphere. The main signature of a neutrino-induced muon is that it originates from below, in which case the Earth acts as a very effective filter against the directly produced muons.

Figure 2 shows two examples of reconstructed tracks from data from the first ANTARES line. Figure 2a shows a vertical muon track, where the signal propagates down the line with the velocity of the muon, and figure 2b shows a slightly more inclined track identified

by the change in the signal's vertical propagation velocity, before and after the closest approach. So far several thousand tracks of down-going muons have been reconstructed and a few candidates for up-going muons have also been observed.

The ANTARES Collaboration is now in full swing analysing the data coming from this first detector line. The experience of the first line shows that we are on track towards a full neutrino telescope in the Mediterranean and we look forward to several years of data-taking.

Further reading

J A Aguilar *et al.* 2006 <http://arxiv.org/abs/astro-ph/0606229>. For further information about ANTARES see <http://antares.in2p3.fr>.

Résumé

La collaboration ANTARES pêche ses premiers muons

Après de nombreuses années d'étude du site et d'essais des éléments, le détecteur de neutrinos sous-marin ANTARES enregistre des événements avec sa première ligne complète de détecteurs, immergée depuis le 14 février à 40 km au large de Toulon, à 2 500m de profondeur. Onze autres lignes suivront dans les 18 mois à venir. La saisie des données se fait sans problème et l'analyse bat son plein; elle a déjà permis de reconstituer plusieurs milliers de trajectoires descendantes de muons et d'observer une poignée de possibles muons ascendants.

Giorgio Giacomelli, University of Bologna and INFN, and **P Kooijman**, NIKHEF.

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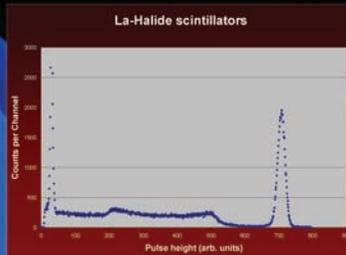
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High Resolution

Top quality

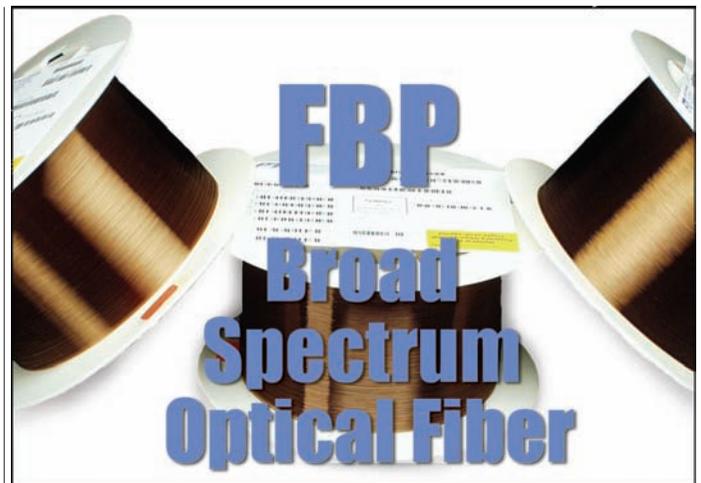


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Nuclear physics helps unravel the universe

The latest international symposium on nuclear astrophysics showed that the field is rapidly evolving, with new observations from astronomy and nuclear physics.

Understanding our universe from basic physics is an ambitious goal involving many disciplines in physics. One key ingredient is nuclear astrophysics, with its focus on explaining energy production and chemical evolution in the universe – topics that are coupled through nuclear reactions that transform elements and may also release energy. The first overview of the synthesis of elements was about 50 years ago, with the work of Geoffrey and Margaret Burbidge, Willy Fowler and Fred Hoyle, and, independently, Al Cameron. Although there had been some important work earlier in the 20th century, this was the defining moment for nuclear astrophysics.

At the end of June, nearly 250 astronomers, astrophysicists, cosmologists and nuclear physicists met at CERN for the ninth Nuclei in the Cosmos meeting to summarize the status of the field. Organized by a team from the Isotope Separator On Line (ISOLDE) and Neutron Time-of-Flight (n_TOF) facilities at CERN, it was dedicated to the memory of Al Cameron, Ray Davis and John Bahcall, all of whom have recently died and had played major roles in helping to understand the production and role of nuclei in the cosmos.

Nuclei, of course, consist of smaller particles and the meeting reviewed recent developments in cosmology and their possible connection to particle physics. While at one time particle physics provided input for calculating the abundances of elements created during the early universe in Big Bang nucleosynthesis, nowadays the results from the Wilkinson Microwave Anisotropy Probe yield the baryonic density of the universe, which is used in calculating the abundances. However some problems in reconciling observations and calculations for the primordial elements remain, in particular for the two stable lithium isotopes, ${}^6\text{Li}$ and ${}^7\text{Li}$.

Analysing nuclear ashes

Optical observations of stars reveal their element abundances. Old stars are metal-poor (following the convention in astronomy that all elements above helium are metals) and the heavy elements in them appear to be made exclusively by rapid neutron capture – the r-process. Only later in galactic evolution does the s-process – slow neutron capture – begin to contribute as well. The relative abundances for elements above barium fit well with r-process abundances deduced for solar-system material, but for lighter elements there are differences that could indicate the presence of a second (“weak”) r-process. The coming years should bring clarification as the amount



Fig. 1. The INTEGRAL gamma-ray satellite provides evidence for nuclear processes in stars through the observation of gamma-ray emission for radioactive isotopes. (Courtesy ESA.)

of observational data will increase significantly owing to the large-scale surveys, the Hamburg/ESO R-process Enhanced Star survey and the Sloan Digital Sky Survey.

Another fruitful source of abundance data comes from presolar grains embedded in primitive meteorites. Here a recent breakthrough has been the extraction of isotopic ratios for many different grains. Such detailed information about isotope abundance helps in constraining the astrophysical conditions in which the grains were formed.

Refinements in knowledge of element abundances are not restricted to distant stars. An improved modelling of the solar atmosphere indicates that solar abundances of most “metals” should be decreased by more than a third. This change arises from a more careful and more dynamic treatment of the outer solar layers.

More direct evidence for nuclear processes in stars comes from the observation of the radioactive isotopes that are produced. High-resolution gamma-ray spectrometers have operated in space for some years, for example on the INTEGRAL satellite (figure 1). ▷

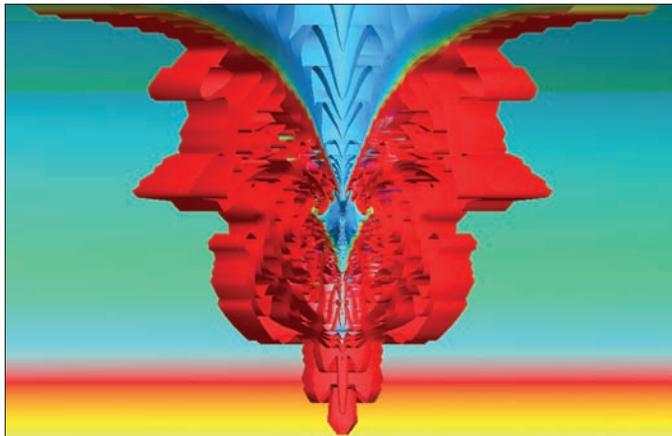


Fig. 2. A possible supernova explosion. The turbulent accretion excites oscillations that generate sound waves, which power the explosion as they propagate outwards. The accretion evolves to become very asymmetric as shown. (Courtesy Adam Burrows.)

Several galactic radioactive decays have been observed through their gamma-emission lines, such as those of ^{26}Al , ^{44}Ti and ^{60}Fe , although the decay of ^{22}Na and positron emission both remain to be seen. Many of the radioactive isotopes found on Earth also stem from stellar events. A recent addition to the list is ^{60}Fe , which has been identified in deep-ocean material by the highly sensitive accelerator mass spectrometer technique, indicating that a supernova exploded near the Earth about 2.4 million years ago.

Understanding stellar events

Modelling the evolution of stars and their sometimes violent end requires the coordinated work of many people. It is rather like assembling a giant multi-dimensional jigsaw puzzle, but one in which the pieces have first to be found. Some researchers concentrate on finding these pieces, while others focus on how to fit them together to form a coherent picture. However, we have still not identified the important ingredients for all stellar events.

For normal, “quiet” stellar burning, the nuclear reactions take place between stable isotopes, but with extremely small cross-sections that are hard to reproduce in the laboratory. Major efforts during the past decade have improved the situation, and participants at the meeting heard of progress on one of the remaining challenges, the reaction $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$, which is a key reaction for the processes responsible for the production of many elements.

At higher temperatures reaction rates increase and reactions involving radioactive nuclei need also to be known. A major highlight at the meeting in terms of nuclear data is a recent good estimate of the reaction rate for the key radiative alpha-capture process on ^{15}O , which has been pursued for more than 20 years. The direct measurement of radiative proton-capture on ^{26}Al and alpha-capture on ^{40}Ca was also presented. Lastly, reaction rates for several neutron-induced reactions were reported; these will have important implications for understanding the synthesis of elements heavier than iron – the “neutron capture elements”.

Very high temperatures belong to the domain of cosmic explosions – novae, supernovae, X-ray bursts and gamma-ray bursts – which have a fascinating history and rightly continue to attract attention. Numerical results presented at the meeting indicate that first-

NiC9 summer school

Nuclear astrophysics is truly interdisciplinary and newcomers need to learn about astronomy and astrophysics as well as nuclear physics. To aid this process, a special school, organized by a team at the ISOLDE facility, was held at CERN the week preceding the Nuclei in Cosmos conference. It was attended by some 50 young scientists with diverse origins, both geographically and in terms of initial science training.

The 12 lecturers at the school covered subjects from cosmology and the properties of neutrinos, through models for normal stars and stellar explosions, to nuclear reactions, and included talks on neutrino experiments at CERN and axion searches. One afternoon was devoted to a visit to the Science Data Centre for the INTEGRAL gamma-ray satellite in nearby Versoix. The students participated actively in the many lively discussions throughout the school, and all stayed for the conference the following week.

generation nova explosions occur at higher temperatures than classical novae. They could therefore be more important players in the early universe, but more studies are needed to confirm this.

A highlight of the conference was the presentation of successful computer simulations of supernova explosions (figure 2). Here, the key new ingredient is to follow the two-dimensional hydrodynamic evolution to long durations after the core-collapse, when the inner part has become a highly non-spherical object with significant fluctuations. The violent conditions in a supernova are perfect for cooking elements and the meeting heard about a new mechanism, the vp-process, in which the strong neutrino fluxes play a more versatile role in the nucleosynthesis than imagined earlier (*CERN Courier* June 2006 p7). An exciting report on quantitative calculations of the r-process suggested that nuclear fission, and in particular neutron-induced fission, might play a very important role for the dynamics in later stages of the r-process.

It was clear from the meeting that nuclear astrophysics is rapidly evolving. The next meeting in the series will provide another snapshot of the status of the field, when it takes place in the US in 2008, hosted by the Michigan State University/National Superconducting Cyclotron Laboratory and the Joint Institute for Nuclear Astrophysics.

Résumé

Les noyaux dans le cosmos

Comprendre notre univers à partir de la physique élémentaire constitue un objectif ambitieux, poursuivi dans de nombreux domaines de la physique parmi lesquels l'astrophysique nucléaire joue un rôle capital. En effet, elle aborde de front la production d'énergie et l'évolution chimique dans l'Univers. Fin juin, la neuvième rencontre “Noyaux dans le cosmos” a réuni au CERN près de 250 astronomes, astrophysiciens, cosmologistes et physiciens nucléaires pour faire le point dans ce domaine. La rencontre a montré que la discipline progresse rapidement grâce à de nouvelles observations en astronomie et en physique nucléaire.

John D'Auria, Simon Fraser University, and **Karsten Riisager**, CERN.

European particle physics gets ready for the future

On 14 July in Lisbon, CERN Council adopted a strategy for particle physics in Europe, which will enable the community to participate fully in an increasingly global adventure.

In June 2005, the president of the CERN Council, Enzo Iarocci, proposed that an *ad hoc* scientific advisory group be established to produce a draft European strategy for particle physics (*CERN Courier* July/August 2005 p5). The Strategy Group was charged to meet at a one-week workshop during the first week of May at Zeuthen, near Berlin, to work out the draft strategy. Council met in Lisbon on 14 July 2006, discussed this draft, and adopted the *European strategy for particle physics* (see box pp30-31).

The Strategy Group brought together a broad competence. It had one member nominated by each of the CERN member states and the directors of the major European particle physics laboratories. In addition, there were eight members from the CERN Scientific Policy Committee and the European Committee for Future Accelerators, who, together with the scientific secretary and the co-chairs, made up the Preparatory Group charged with the work needed to bring the meeting in Berlin to a successful conclusion.

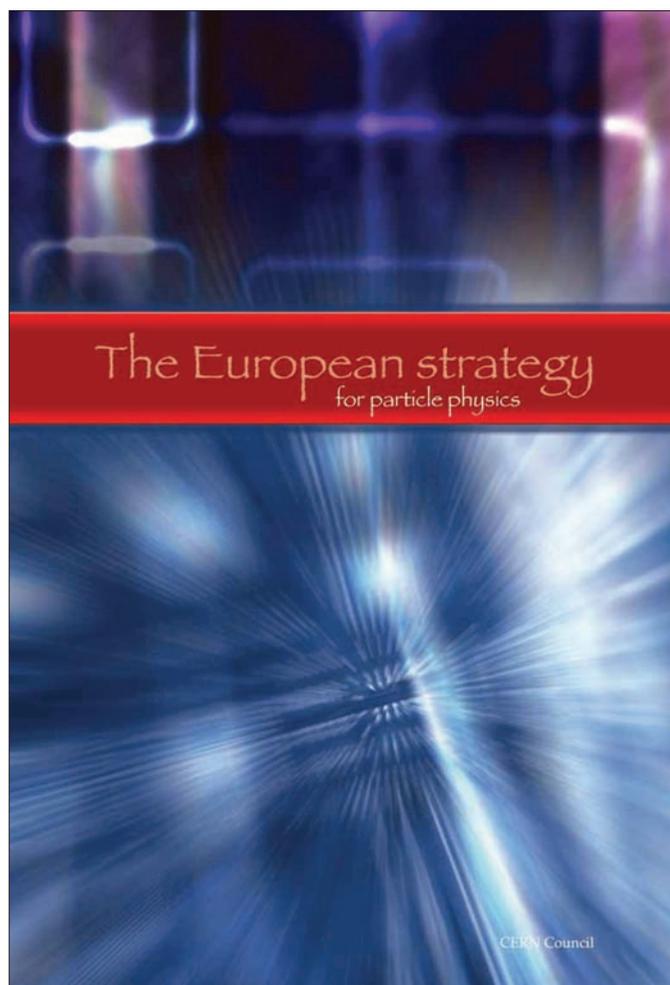
For the Strategy Group meeting seven representatives were also invited from the CERN observer states, and from the Astroparticle Physics European Coordination (ApPEC) Committee, the Nuclear Physics European Collaboration Committee (NuPECC) and the Funding Agencies for the Linear Collider (FALC).

The process towards the *European strategy for particle physics* had four essential elements: the Strategy Group Web page, an open symposium held in Orsay from 29 January – 1 February, a *Briefing Book* containing the information needed to develop the strategy, and the Zeuthen meeting of the Strategy Group.

The Strategy Group Web page was the main channel for communication with the community. Minutes of the Preparatory Group meetings were posted on the website, usually within 24 hours of the meeting. More importantly, it was possible to submit contributions to the discussions through the website; 71 individuals and groups did so. The website also provided a set of links to background material.

The Open Symposium hosted by the Laboratoire de l'Accélérateur Linéaire in Orsay was a key stage in the process. It was attended by more than 400 people, with at least 70 more following the proceedings via a webcast. The programme comprised of a series of talks aimed at identifying the key issues for a range of different topics. A particular feature of the symposium was that more than half of the time was devoted to discussions, and this time was indeed filled with a lively exchange of views.

The *Briefing Book* consisted of three volumes, all of which are accessible from the Strategy Group Web page. The first volume was



The European strategy for particle physics, adopted by CERN Council, outlines actions for the coming decade.

written by the Preparatory Group, and covered scientific activities (largely based on the presentations and discussions in Orsay) and more general issues. The second volume covered the input received via the website, reports from laboratories, funding agencies and others in response to written requests, and other information that the Preparatory Group felt would assist the development of the strategy. The third volume contained the agenda for the meeting in Zeuthen, procedural details, a standardized vocabulary to ▷

The European strategy for particle physics

Particle physics stands on the threshold of a new and exciting era of discovery. The next generation of experiments will explore new domains and probe the deep structure of space–time. They will measure the properties of the elementary constituents of matter and their interactions with unprecedented accuracy, and they will uncover new phenomena such as the Higgs boson or new forms of matter. Long-standing puzzles such as the origin of mass, the matter–antimatter asymmetry of the universe and the mysterious dark matter and energy that permeate the cosmos will soon benefit from the insights that new measurements will bring. Together, the results will have a profound impact on the way we see our universe; *European particle physics should thoroughly exploit its current exciting and diverse research programme. It should position itself to stand ready to address the challenges that will emerge from exploration of the new frontier, and it should participate fully in an increasingly global adventure.*

General issues

1. European particle physics is founded on strong national institutes, universities and laboratories and the CERN Organization; *Europe should maintain and strengthen its central position in particle physics.*
2. Increased globalization, concentration and scale of particle physics make a well-coordinated strategy in Europe

paramount; *this strategy will be defined and updated by CERN Council as outlined below.*

Scientific activities

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; *the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.* A subsequent major luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focused R&D; *to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.*

4. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high-performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

5. It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5–1 TeV, the ILC, based on

superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong, well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

6. Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; *Council will play an active role in promoting a coordinated European participation in a global neutrino programme.*

7. A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena; *Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest.*

8. Flavour physics and precision measurements at the high-luminosity frontier at lower energies complement our understanding of particle physics and allow for a more accurate interpretation of the results at the high-energy frontier; *these should be led by national or regional collaborations, and the participation of European laboratories and institutes should be promoted.*

describe projects and scientific objectives, and the templates for the strategy statement itself.

The full Strategy Group and official observers met at DESY in Zeuthen on 2 May. This first day was open to anyone and was also broadcast via the Web. It was devoted to talks from three invited speakers, the directors of the invited laboratories and the representatives of the observer states. On the second day, six groups studied the frontier questions in particle physics; improved understanding of the Standard Model; non-accelerator physics and the interface to cosmos; the strong interaction and the interface with nuclear physics; organization issues for the universities, national laboratories and CERN; and inter-regional collaboration. On day three, a plenary session covered the reports from the working groups and agreed preliminary conclusions on elements of the strategy. The next day, while a draft working document was assem-

bled based on the previous day's discussions, five groups worked in parallel on the needs of theoretical particle physics, industry, technology and knowledge transfer, education and outreach.

The draft strategy document was discussed at Zeuthen in a plenary session on the fifth day. Participants reached a consensus on the general statements, scientific activities and organizational issues, and provided detailed guidance on the complementary issues, which were incorporated following consultations with the chairs of the appropriate working group, thus fulfilling the remit.

Now that Council has adopted the *European strategy for particle physics*, and with it the responsibility to maintain and update it, the work is done, and the Strategy Group has been dissolved.

Many people were engaged in this process: local organizing committees, speakers and participants at the different discussions.

The European strategy for particle physics (continued)

9. A variety of important research lines are at the interface between particle and nuclear physics requiring dedicated experiments; *Council will seek to work with NuPECC in areas of mutual interest, and maintain the capability to perform fixed-target experiments at CERN.*

10. European theoretical physics has played a crucial role in shaping and consolidating the Standard Model and in formulating possible scenarios for future discoveries. Strong theoretical research and close collaboration with experimentalists are essential to the advancement of particle physics and to take full advantage of experimental progress; *the forthcoming LHC results will open new opportunities for theoretical developments, and create new needs for theoretical calculations, which should be widely supported.*

Organizational issues

11. There is a fundamental need for an ongoing process to define and update the European strategy for particle physics; *Council, under Article II-2(b) of the CERN Convention, shall assume this responsibility, acting as a council for European particle physics, holding a special session at least once each year for this purpose. Council will define and update the strategy based on proposals and observations from a dedicated scientific body that it shall establish for this purpose.*

12. Future major facilities in Europe and

elsewhere require collaborations on a global scale; *Council, drawing on the European experience in the successful construction and operation of large-scale facilities, will prepare a framework for Europe to engage with the other regions of the world with the goal of optimizing the particle physics output through the best shared use of resources while maintaining European capabilities.*

13. Through its programmes, the European Union establishes in a broad sense the European Research Area, with European particle physics having its own established structures and organizations; *there is a need to strengthen this relationship for communicating issues related to the strategy.*

14. Particle physicists in the non-member states benefit from, and add to, the research programme funded by the CERN member states; *Council will establish how the non-member states should be involved in defining the strategy.*

Complementary issues

15. Fundamental physics impacts both scientific and philosophical thinking, influencing the way we perceive the universe and our role in it. It is an integral part of particle physics research to share the wonders of our discoveries with the public and the youth in particular. Outreach should be implemented with adequate resources from the start of any major project; *Council will establish a network of closely cooperating*

professional communication officers from each member state, which would incorporate existing activities, propose, implement and monitor a European particle physics communication and education strategy, and report on a regular basis to Council.

16. Technology developed for nuclear and particle physics research has made and is making a lasting impact on society in areas such as material sciences and biology (e.g. synchrotron radiation facilities), communication and information technology (e.g. the web and grid computing), health (e.g. the PET scanner and hadron therapy facilities); *to further promote the impact of the spin-offs of particle physics research, the relevant technology transfer representatives at CERN and in member states should create a technology transfer forum to analyse the keys to the success in technology transfer projects in general, make proposals for improving its effectiveness, promoting knowledge transfer through mobility of scientists and engineers between industry and research.*

17. The technical advances necessary for particle physics both benefit from and stimulate the technological competences available in European industry; *Council will consolidate and reinforce this connection, by ensuring that future engagement with industry takes account of current best practices, and continuously profits from the accumulated experience.*

Colleagues submitted opinions and ideas, and all involved people were very committed. We are all very grateful for these contributions.

Further reading

See www.cern.ch/council-strategygroup. Information on the Orsay symposium is also available online at <http://events.lal.in2p3.fr/conferences/Symposium06/>. Details of the Zeuthen workshop can be found at www-zeuthen.desy.de/exps/ccsg/.

Résumé

La physique des particules européenne parie sur l'avenir

En juin 2005, le Président du Conseil du CERN, Enzo Iarocci, a

proposé d'établir un groupe consultatif scientifique en vue d'élaborer un projet de stratégie européenne en physique des particules. Le groupe d'orientation stratégique devait se réunir en mai 2006 à Zeuthen (DESY), près de Berlin, pour élaborer sa proposition. Il avait auparavant recueilli les avis des physiciens européens, grâce en particulier à un colloque public tenu à Orsay fin janvier. Le Conseil s'est réuni à Lisbonne le 14 juillet pour discuter du projet et il a adopté le document d'orientation stratégique pour la physique des particules européenne, reproduit ici dans son intégralité. Ce document trace les grandes lignes pour la prochaine décennie.

Torsten Åkesson and **Ken Peach**, co-chairs, CERN Council Strategy Group.

Ray Davis: indefatiga

Peter Rosen looks back at the man who brought his deft chemical touch to the s

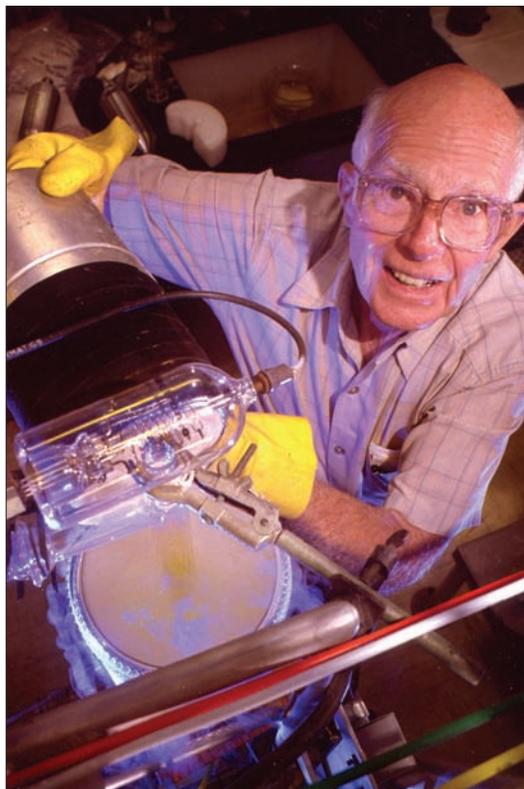
Raymond Davis Jr, discoverer and grand pioneer of the solar-neutrino problem, died on 31 May at the venerable age of 91. In 1968 he discovered the solar-neutrino anomaly and more than three decades later he received the 2002 Nobel Prize in Physics. This followed other experiments based on different techniques, which demonstrated that the anomaly was neither an artifact of his experiment nor an error in the late John Bahcall's theoretical calculations of the neutrino flux from the Sun; it was indeed a real physical effect. Simultaneously, Davis had shown that the Sun generates its energy by nuclear fusion of hydrogen into helium, and that the electron-type neutrinos created in this process change into other types of neutrino during their eight minute journey to Earth.

By his own account, Davis was drawn to the study of neutrinos out of a sense of adventure. He was invited to join the fledgling Brookhaven National Laboratory in 1948 and asked the chairman of the chemistry department about his duties. To his "surprise and delight" Davis was told to choose his own project. In the library he found a review article on neutrinos by H R Crane that clearly indicated that the field was wide open for exploration and rich in problems. Here was the path, leading he knew not where, which would enable Davis to follow his goal of studying nuclear physics using the techniques of physical chemistry.

His vehicle was a nuclear reaction suggested by Bruno Pontecorvo in 1946: a neutrino captured by a specific isotope of chlorine produces an electron and a radioactive isotope of argon. Sources of chlorine were plentiful and cheap, and argon, a noble gas, could easily be extracted from a chlorine solution. Davis counted the atoms of the argon isotope by observing the decay back to chlorine. Over the years, he tested and refined the method so that it became totally reliable as a procedure for measuring even a tiny number of argon atoms produced in Pontecorvo's chlorine reaction.

The only copious sources of low-energy neutrinos are nuclear reactors and the Sun. Reactors produce antineutrinos from the beta-decay of heavy nuclei following the fission of uranium, while the Sun produces neutrinos in the fusion of hydrogen nuclei into helium. When Davis was beginning his experiments, the distinction between neutrino and antineutrino was not well understood and there was a serious possibility that they were identical particles. It was therefore natural for him to use reactors as the neutrino source. In fact, he worked at the Savannah River reactor at the time when Clyde Cowan and Fred Reines were performing their Nobel prize-winning experiment there using inverse beta-decay as their signal. Whereas they obtained a positive result, making the first observation of the antineutrino, Davis obtained a null result with the chlorine reaction, indicating a distinction between neutrino and antineutrino.

Davis then turned his attention to detecting neutrinos from the



Davis in his chemistry lab at Brookhaven, with a component of a neutrino detection system. (Courtesy Brookhaven National Laboratory.)



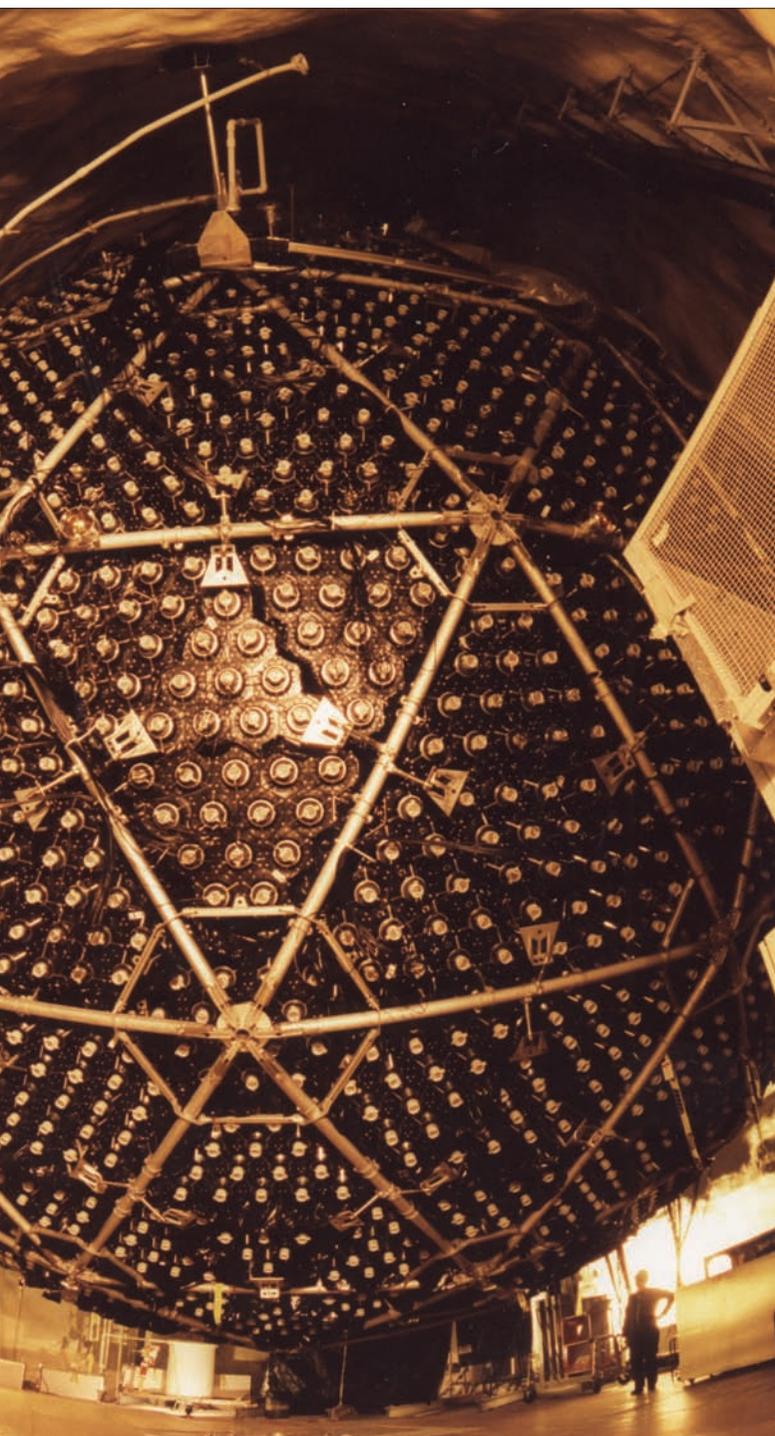
Davis (left) shows Bahcall the tank containing the 100 000 gallons of perchloroethylene cleaning fluid. The photo was taken in the Homestake mine shortly before the experiment began operating.



View of the Sudbury panels, before the experiment began operating.

ble neutrino pioneer

study of neutrinos, and created one of the iconic experiments of the 20th century.



Neutrino Observatory after installation of the bottom photomultiplier tube labling. (Courtesy Ernest Orlando Lawrence Berkeley National Laboratory.)

Sun and recognized that it was necessary to go deep underground to avoid cosmic-ray backgrounds. He also realized that observing neutrinos from the Sun would be a way of demonstrating that it generates its energy via nuclear fusion. In the early 1950s, it was known that the proton–proton fusion chain did not produce neutrinos of sufficient energy to reach the threshold for the chlorine reaction, but by the end of the decade new discoveries in nuclear physics suggested that there were additional fusion chains that produced neutrinos well above the threshold. Davis began to collaborate with Bahcall to design an experiment to observe these neutrinos.

By 1964, they were ready to propose an experiment and they published side-by-side papers in *Physical Review Letters*. Bahcall combined the standard model of the Sun with the relevant nuclear physics to calculate the energies and fluxes of the various branches of the solar-neutrino spectrum. Davis described an experiment to observe the higher-energy neutrinos using a 100 000 gallon tank of cleaning fluid (perchloroethylene) located deep underground. Bahcall tells an interesting story of how Davis persuaded Maurice Goldhaber, then director of Brookhaven National Laboratory, to support the experiment. Knowing that Goldhaber was very sceptical of astrophysical calculations, Davis instructed Bahcall not to mention the solar astrophysics, but to emphasize instead the novel nuclear physics involved in the chlorine reaction. Goldhaber loves a clever idea, having generated many himself, and so, as Davis predicted, he responded positively to Davis' request.

In 1968, Davis reported that the first measurements from the experiment carried out 4850 ft underground in the Homestake gold mine in Lead, South Dakota, yielded a solar-neutrino capture rate approximately a third of that predicted by Bahcall and G Shaviv. This “socially unacceptable result”, as Bahcall later described it, caused widespread concern among both physicists and astrophysicists. Some thought that the problem lay with the experiment, others with the theory and a few with the neutrino. In the end the third option turned out to be correct, but it required an experimental and theoretical odyssey that lasted three and a half decades and ranged all over the world, from the mine in South Dakota to other mines and laboratories deep inside mountains in Japan, Russia and Italy, and finally to a nickel mine at Sudbury in northern Ontario, Canada.

The experiments themselves were remarkable in their uniqueness. Davis' experiment required a 100 000 gallon tank specially built by the Chicago Bridge and Iron Company, and it took 10 railroad tank cars of cleaning fluid to fill it. The detector in Japan was the size of a 10 storey building. It was filled with extremely pure and continuously purified water and was surrounded by 11 000 20-inch phototubes. The neutrino detector in Russia, located deep inside the Caucasus Mountains, contained the world's total supply of ▷

TRIBUTE

gallium, about 60 tonnes. It took two years to produce an additional 30 tonnes of gallium for an independent experiment under the Gran Sasso Mountain of central Italy. The experiment in Canada, originally proposed by the late Herbert Chen many years ago, would not have been possible without the loan of a kilotonne of heavy water from the Canadian government.

Throughout this journey, Davis continued his role as grand pioneer of the solar-neutrino problem. He kept the chlorine experiment going long after he retired from Brookhaven National Laboratory in 1984. He helped to develop the radiochemical experiment based on gallium, sensitive to the most-copious and lowest-energy solar neutrinos from the proton-proton chain, and he followed all the latest developments with a keen interest. Ultimately, at the beginning of the 21st century, the heavy-water experiment at Sudbury measured both the total highest-energy neutrino flux from the Sun and its electron-neutrino component. It confirmed Davis' original results as well as Bahcall's theoretical calculations, and it crowned Davis' claim on the Nobel prize.

Davis had a truly inquiring and adventurous mind. "When I began my work, I was intrigued by the idea of learning something new," he once said. "The interesting thing about doing new experiments is that you never know what the answer is going to be!" He was a scientist of great integrity and modesty: what mattered to him was not himself, but the science in which he was involved. Whenever colleagues asked questions or offered criticisms of his experiment, he would always devise new tests to check their ideas and make any

necessary corrections. But he also had a wry sense of humour: when asked at a conference in the 1970s how much his experiment cost, he replied: "Ten minutes time on commercial television."

Through his persistence, integrity and humility Davis spawned a revolution in neutrino physics and gave us a beautiful example of how different sciences can help one another to make fundamental discoveries. He stands as a model for all aspiring scientists to emulate.

Résumé

Ray Davis: l'infatigable pionnier des neutrinos

Peter Rosen évoque la carrière de l'homme à qui l'on doit l'une des expériences les plus emblématiques du 20e siècle: Raymond Davis Jr, découvreur et grand pionnier du "problème des neutrinos solaires", qui est décédé le 31 mai. Davis a reçu le Prix Nobel de physique en 2002 pour avoir mis en évidence plus de trois décennies plus tôt, en 1968, "l'anomalie des neutrinos solaires". Entretemps, d'autres expériences utilisant différentes techniques ont en effet définitivement prouvé que l'anomalie n'est pas le fruit d'une illusion inhérente à son expérience, ni d'une erreur dans les calculs théoriques du flux de neutrinos solaires effectués par le regretté John Bahcall: il s'agit réellement d'un effet physique.

SPeter Rosen, Office of Science, US Department of Energy, on temporary assignment to the National Science Foundation.

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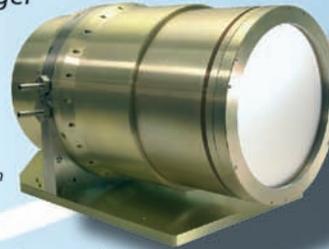
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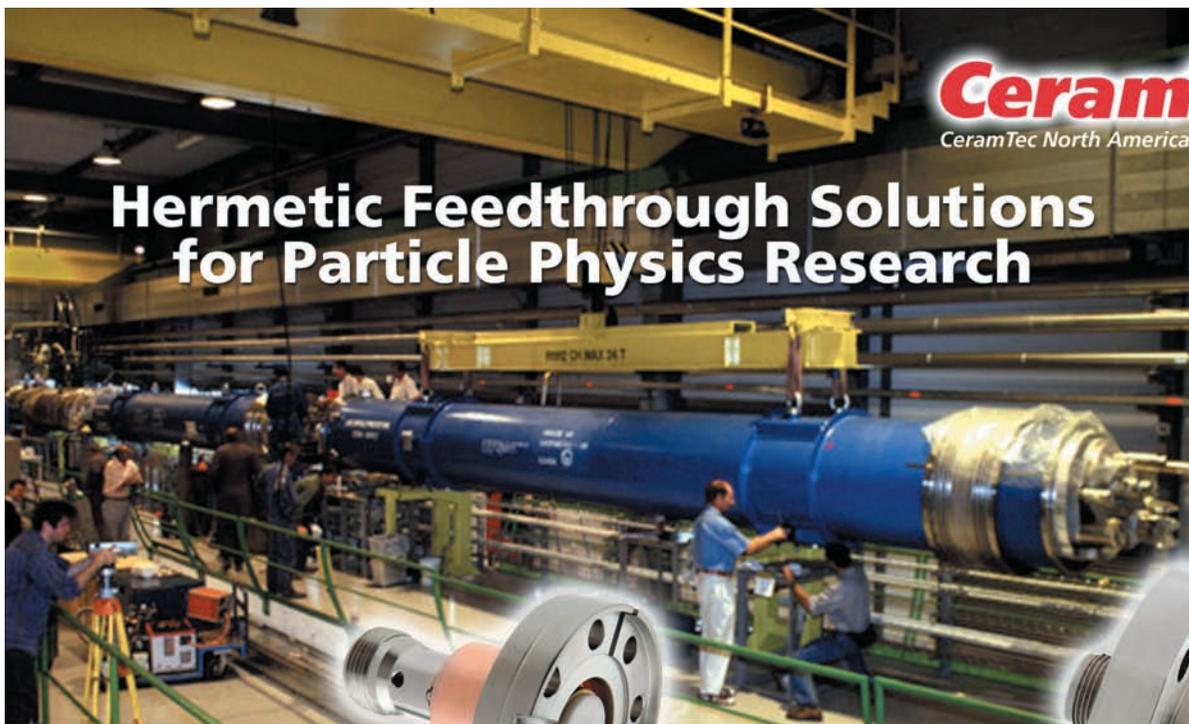
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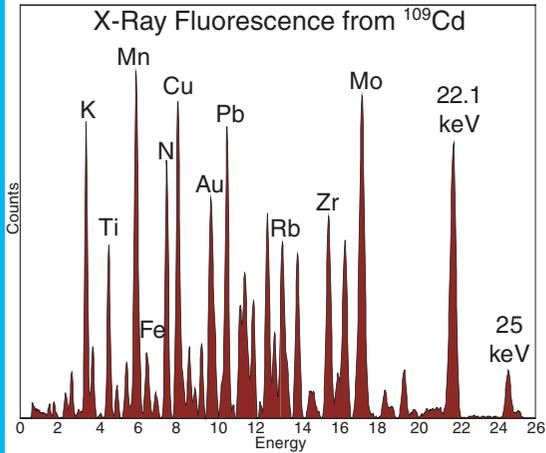
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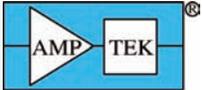


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Charting the course for US particle physics

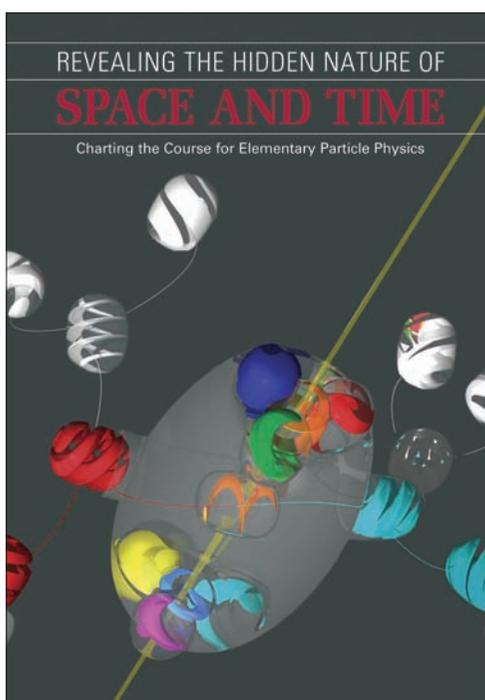
Harold Shapiro reviews the work of the committee that he chaired to recommend priorities for US particle physics during the next 15 years.

I am not a particle physicist. I have spent most of my career as an economist and a university president with a sustained interest in science policy and its relationship to the health of the scientific enterprise and to long-term economic growth. But when the US National Research Council asked me to chair an independent committee of both physicists and non-physicists to look at the future role of the US programme in elementary-particle physics, I welcomed the chance to learn more about this intriguing area of science.

Some might wonder why such an unusual group of experts would be convened to provide advice to the US federal government on particle physics. Indeed, the committee that I chaired included members with expertise in particle physics, other branches of physics, engineering, scientific fields outside of physics, and even several non-scientists. Members from the larger international community of particle physicists were included as well. In many respects the nature of the strategic issues facing the US programme in particle physics required both fresh perspectives from a broader context and penetrating analysis to provide a credible path forward. To be frank, one of the first questions facing the committee was simply, "Does particle physics, especially accelerator-based experiments, still matter?"

During its work, the committee engaged in a comprehensive set of data-gathering activities, including public meetings, letters to and from the global community, and numerous formal and informal discussions with stakeholders around the world. As part of our work, I travelled to the major particle-physics facilities in the US, Europe and Japan. In the US, most of the major facilities are scheduled to be shut down or converted to other uses within the next few years. Europe and Japan, in contrast, have recognized the scientific potential of particle physics and have been increasing their investments.

With respect to the US programme, what I found was a scientific field at a crossroads. Particle physicists could be on the verge of



The report by the Committee on Elementary Particle Physics in the 21st Century sets out the priorities for particle physics in the US.

answering questions that human beings have asked for millennia. What are the origins of mass? Can the basic forces of nature be unified? How did the universe evolve? Why does it have the properties that it does? But even as the scientific opportunities have blossomed, our political and social will to sustain US commitment to this field has faltered. US leadership, together with that of our colleagues abroad, is important because it is critical to reaping the scientific, technological, economic and cultural dividends that come from advancing the scientific frontier.

As the field of particle physics took shape in the middle of the 20th century, America's scientists focused on experiments designed to measure and explain the properties and forces governing the ultimate constituents of matter. Since then, even as the field became increasingly internationalized with distinguished centres abroad, the US has been home to some of the world's most accomplished theorists, a diverse array of experiments, and some of the largest particle accelerators. Moreover

the US has welcomed and greatly benefited from the intellectual and financial input of scientists from around the world. The US role in particle physics both anchored and symbolized the growing distinction and reach of the overall US scientific enterprise.

Before continuing, let me say something about the word "leadership," especially with such an international audience where this term may carry nationalistic or even imperialistic overtones. In the context of current discussions about globalization, "the flat world" and the growing interdependence of national efforts around the world, what does leadership mean for the US in a field such as particle physics? Leadership does not mean dominance, but rather taking initiative at the frontiers, accepting appropriate risks, and catalysing partnerships both at home and abroad. Given the wide distribution of talent and facilities it is not only futile but an irresponsible use of public resources for any country or region to aspire to dominance. In the ▷

Ordered priorities

1. Exploit the opportunities offered by the Large Hadron Collider.
2. Plan and initiate a comprehensive programme to participate in the global effort to complete the necessary R&D to design and plan an international linear collider.
3. Do what is necessary to mount an internationally compelling bid to build the international linear collider on US soil.
4. Seize the opportunities at the intersection of particle physics, astrophysics and cosmology by coordinating and expanding domestic efforts.
5. Pursue an internationally coordinated, staged programme in the physics of neutrinos and proton decay.
6. Pursue precision probes of physics beyond the Standard Model using available resources as a guide to overall level of effort while maintaining diversity.

world that lies before us, leadership will be a shared phenomenon that flows from developing and brokering mutual gains among equal partners. In articulating a strategy for the US, the committee sought a path that leveraged US strengths for the benefit of not only the domestic programme, but also the global enterprise. In terms of scientific facilities, this means that we must move from a paradigm of “We’re going to build this, will you help us?” to one of “What can we build together that will benefit us all?”

The US is now on the verge of forfeiting its role among the international leaders in particle physics. Operations at the Large Hadron Collider (LHC) in Europe will soon begin and it will become the world’s most powerful accelerator. Like many other fields in the physical sciences, federal funding for particle physics in the US has stagnated for more than a decade, and the field is gradually losing US researchers and students. Within a few years, the majority of US experimental particle physicists will be working on experiments that are being conducted in other countries. Simply put, the intellectual centre of gravity is moving abroad and the US has not put forward a compelling strategic vision to contribute to the global enterprise.

This potential retreat of the US programme in particle physics from the scientific frontiers could not be happening at a worse time. Particle physics is entering one of the most exciting periods in its history. The technologies needed to do experiments at the terascale are now available, and both theoretical and experimental results point towards revolutionary new discoveries that will be made at this scale. Physicists could not only discover new dimensions and the particles responsible for mass (or other phenomena unimagined today), but these experiments could also provide clues to the nature of dark energy and dark matter, which are essential to our comprehension of the universe. Indeed in the next few decades particle physics could yield a radical new view of the cosmos.

Even as the Europeans have been finishing the LHC, particle physicists worldwide have been designing the next generation of particle accelerator. Known as the International Linear Collider (ILC), this new tool would comprise two accelerators that fire electrons and anti-electrons at each other head-on, probing conditions that existed just a fraction of a second after the birth of the universe. The ILC is so important and so large an undertaking that it can only arise from a global effort. The potential role of the US in building, supporting, and

perhaps hosting the ILC is now a key to the continued distinction of the US programme. Indeed, participation in the scientific opportunities addressed by the ILC is likely to be important for any nation actively engaged in particle physics, but it is particularly important now for the US because of the absence of any other key strategic focus.

To ensure its vitality in particle physics and to contribute effectively to the global effort, the US must be willing to do three things. First, it must maintain a broad range of theoretical and experimental programmes, since new discoveries often come from unexpected places. Second, it must make a commitment to participating in the direct and controlled exploration of the terascale. In part, that means supporting the work of US scientists at the LHC. It also means investing the risk capital so that the US can be in a position, four or five years from now, to mount a compelling bid to host the ILC – if the US decides then that it is still in its best interests to compete for the ILC. For the US to mount a compelling bid, however, it must not only demonstrate the technical capabilities and economic resources necessary for hosting the ILC, but it must also demonstrate the energy, enthusiasm and commitment that are required to be a credible international partner. Moreover, the science of the terascale is so compelling that the US should play a strong role in the ILC no matter where it is sited. Third, to ensure a responsible use of public funds, the US must make an increased commitment to establishing mutually advantageous joint ventures with its colleagues abroad.

Scientific leadership, like competitiveness, is won generation by generation, but once it is lost it is difficult for the next generation to win it back. Students stop enrolling in graduate programmes, university departments scale back or shut down, researchers emigrate, retire or move to other fields. Maintaining the leading role of the US will need continued federal support, probably at a greater level than at present if the US mounts a compelling bid and is chosen to host the ILC. But the history of science demonstrates that our investments can be expected to repay themselves many times over.

Further reading

For further information and to download the report *Revealing the Hidden Nature of Space and Time* see www7.nationalacademies.org/bpa/EPP2010.html.

Résumé

Etats-Unis: où va la physique des particules?

Harold Shapiro, économiste et président d'université, qui s'intéresse de longue date à la politique en matière de sciences, a présidé le Comité sur la physique des particules élémentaires au 21e siècle, dont la mission était de juger des priorités de la discipline aux Etats-Unis au cours des 15 prochaines années. Dans cet article, il décrit le travail de ce comité indépendant composé de physiciens et de non physiciens, puis il examine la position que son pays devrait s'efforcer d'occuper dans ce domaine de recherche de plus en plus mondialisé, plus particulièrement en ce qui concerne un futur Collisionneur linéaire international.

Harold T Shapiro, Princeton University, was chair of the Committee on Elementary Particle Physics in the 21st Century.

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Workshop focuses on top-quark physics

More than 80 physicists from all over the world met in January in the ancient Portuguese town of Coimbra to take part in the International Workshop on Top Quark Physics, TOP2006.



Lynne Orr explains the physics of the top quark at future colliders.



The old town of Coimbra is located on a hill on the north bank of the River Mondego, with the university at the summit. The workshop took place in the department of mathematics.

Coimbra, in central Portugal, was the country's capital from 1143 to 1255 and in historical importance ranks behind only Lisbon and Oporto. Its university was founded in 1290 and was the only one in Portugal until the beginning of the 20th century. Its ancient setting contrasted well with the central theme of TOP2006: the top quark, discovered only in 1995 in experiments at Fermilab's Tevatron.

The workshop itself grew from the idea of developing a strong collaboration between theorists and experimentalists who are interested in studying the properties of the top quark. The first properties of this unique particle were measured during Run I of the Tevatron by the CDF and D0 experiments; with Run II more data are now becoming available. Though not yet sufficient to perform the precision tests required to challenge (once again) the Standard Model, the data acquired so far are already providing valuable information on top-quark physics. The knowledge of the physics of the top quark will then enter a totally new phase – the precision era – with the

start-up of the Large Hadron Collider (LHC) at CERN, foreseen towards the end of 2007.

Why is top interesting?

The top quark is the heaviest quark found ($m_t = 172.5 \pm 2.3 \text{ GeV}/c^2$) and is still believed to be a fundamental particle. It completes the third-generation structure of the Standard Model, as the isospin partner of the b (bottom) quark. Why it is so heavy and why its Yukawa coupling to the Higgs field (after spontaneous symmetry breaking) is of the order of 1 is a mystery. Its solution requires an answer to the question: does the top quark play a special role in the electroweak symmetry-breaking mechanism of the Standard Model?

Although mainly produced via the strong interaction at particle colliders (double production via gluon-gluon fusion or $q\bar{q}$ annihilation), the top quark decays through the weak force to a b quark and a W boson with a branching ratio of almost 100%. Because of their large

large mass and decay rate ($\Gamma = 1.42$ GeV at next-to-leading order), top quarks, unlike any other quark, are produced and decay as free particles. With a very short lifetime (around 10^{-25} s), the top quark decays before hadronization can take place. For the same reason no toponium bound states with sharp binding energy are expected in the Standard Model; any evidence of a $t\bar{t}$ bound state would be a sign of physics beyond the model. The flavour-changing neutral-current decays of the top quark are also highly suppressed in the Standard Model, with branching ratios at the level of around 10^{-12} to 10^{-14} ; any evidence of decays such as $t \rightarrow qZ, q\gamma$ or qg would therefore constitute a sign of new physics.

Top-quark properties

The first day of the workshop was dedicated to the current theoretical and experimental status of top-quark physics, in the morning and afternoon sessions, respectively. C P Yuan of Michigan State University recalled the need for a precise measurement of the top-quark mass to constrain the Higgs mass when combined with the measurement of the W mass. Within the context of current theoretical knowledge, the day also covered the importance of the rate of single top production at colliders (not yet observed) as a probe for the element V_{tb} in the Cabibbo–Kobayashi–Maskawa matrix. He also stressed the fact that the different channels (s, t and Wt) that contribute to single top production are important processes for the search for physics beyond the Standard Model.

Aurelio Juste from Fermilab reviewed the current experimental status of the top quark starting from the total cross-section measurement at the Tevatron, with a relative precision of around 25% in Run I, dominated essentially by statistics. In Run II, with a luminosity of 2 fb^{-1} , this error is expected to be reduced to about 10%. The mass is by far the most precisely measured property of the top quark, with a relative error less than 2%. The top charge, anomalous couplings and single top production were also discussed.

The second day examined the experimental methods used to select top quarks at colliders, and the leading-order and next-to-leading-order generators and theoretical methods available for understanding the data. Evelyn Thomson of the University of Pennsylvania presented the experimental methods that are used in the selection and analysis of top-quark decays at hadron colliders. In particular, she discussed the importance of the trigger, the difficult question of the background rejection and estimation (as W+jets and Z+jets), the need for a detailed calibration and determination of the jet energy scale (a major source of systematic error), and b-tagging, a key tool to reduce the background. She stressed the need to fine-tune the available Monte Carlo to reproduce data accurately. Available top-selection tools involve multivariate analysis and different statistical techniques.

Werner Bernreuther, of RWTH (Rheinisch-Westfälische Technische Hochschule) Aachen, described spin effects in hadronic top-pair production and polarized top decays, $t\bar{t}$ spin correlations (which are transferred to the decay products), and the possible existence of heavy $t\bar{t}$ resonances. As the top polarization is reliably calculable, it is well suited for experimental checks of the predictions of the Standard Model and its extensions. Bernreuther concluded that the top-quark physics is an excellent probe to test electroweak symmetry breaking and that it provides powerful observations to determine the structure of the $t\bar{t}W$ vertex. Sergey Slabospitsky of the Institute for High Energy Physics, Protvino, and Borut Kersevan of the Josef

Stefan Institute presented the status of the important event generators that are being developed and used at the Tevatron and LHC to simulate top production and decays.

Top prospects

The prospects for top physics on the up-coming colliders were discussed on the third day of the workshop. In the morning, Dominique Pallin of Blaise Pascal University presented the expected performance of the LHC as a top factory. In particular, he showed the work going on for early top-quark studies, such as the measurement of the $t\bar{t}$ production cross-section and the top mass, as well as the determination of the W and top polarizations, in the lepton+jets channel. The top quark is a very useful calibration tool for early data (for the jet energy scale, b-tagging, trigger etc), which can also be used to check detector performance. With the increase of luminosity at the LHC many precision measurements of top-quark properties will be possible.

In the afternoon, Lynne Orr of the University of Rochester gave a talk about top physics at the LHC and a future International Linear Collider (ILC). She described the electroweak symmetry breaking mechanism and the hierarchy problem. She also discussed top-quark physics in models beyond the Standard Model, which are possible solutions to this problem: supersymmetry, little Higgs, technicolour and its descendents, and modified space-time models with extra dimensions. Finally, the sensitivity of different top-quark couplings at the LHC and ILC was reviewed. Brian Foster of Oxford University presented the status of the ILC.

Finally John Womersley, of the CCLRC, Rutherford Appleton Laboratory, presented a lively and appealing workshop summary talk. He also covered the status and the open questions in particle and astroparticle physics. All in all, the workshop was a fruitful opportunity for interesting discussions on the exciting subject of top-quark physics. The participants are looking forward to the next workshop, which will probably take place two years from now, where the latest results of the Tevatron's Run II and the first results from the LHC in top-quark physics will be presented and discussed, and new challenges to the Standard Model will be tested.

Further reading

For more details see <http://nautilus.fis.uc.pt/personal/top2006/>.

Résumé

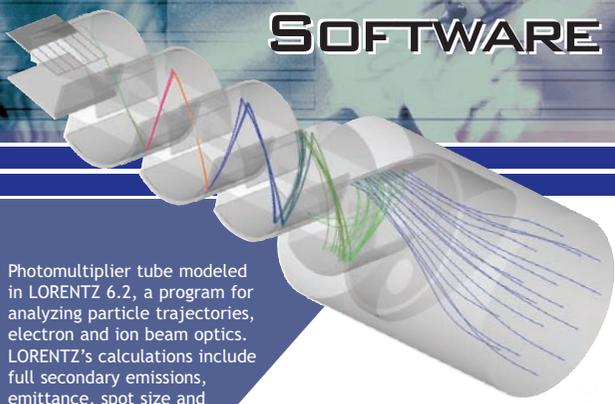
La physique du quark t au Portugal

Plus de 80 physiciens du monde entier se sont réunis dans l'ancienne capitale du Portugal, Coimbra, pour TOP2006, un atelier international sur la physique du quark t. Le but visé est de renforcer les relations entre les expérimentateurs et les théoriciens intéressés par l'étude des propriétés du t. La période d'exploitation du Tevatron au Laboratoire Fermi avait permis de mesurer de premières propriétés de cette remarquable particule; la période II apporte aujourd'hui de plus en plus de données. Celles dont on dispose apportent déjà des informations précieuses sur la physique du quark t.

António Onofre, Laboratório de Instrumentação e Física Experimental de Partículas (LIP)/Universidade Católica Portuguesa, and **João Carvalho**, LIP-Coimbra.

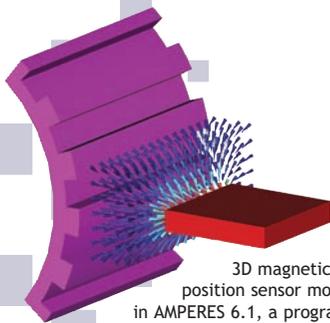
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Photomultiplier tube modeled in LORENTZ 6.2, a program for analyzing particle trajectories, electron and ion beam optics. LORENTZ's calculations include full secondary emissions, emittance, spot size and radius. Image courtesy of ADIT.

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FACES AND PLACES

LABORATORIES

Philanthropist pledges \$70 m to Homestake Underground Lab



South Dakota governor Mike Rounds (third from right) and philanthropist T Denny Sanford (fourth from right) prepare to cut the ribbon at the official dedication of the Sanford Underground Science and Engineering Laboratory in the former Homestake gold mine.

At the official dedication of the Homestake Underground Laboratory on 26 June, South Dakota resident, banker and philanthropist T Denny Sanford created a stir by pledging \$70 m to help develop the multidisciplinary laboratory in the former Homestake gold mine. The mine is one of two finalists for the US National Science Foundation effort to establish a Deep Underground Science and Engineering Laboratory (DUSEL), which will be a national laboratory for underground experimentation in nuclear and particle physics, astrophysics, earth sciences, engineering, biology and education. Planned physics experiments include searches for neutrinoless double-beta decay, searches for dark matter, long-baseline neutrino studies, nuclear astrophysics, low-energy solar neutrinos, proton-decay, supernovae neutrinos and geoneutrinos.

Sanford's gift will be in three installments. The first installment of \$35 m, in 2007 and 2008, is specifically targeted for developing infrastructure at 4850 ft (a depth of about

4200 m water equivalent). In November 2005 the Homestake Collaboration issued a call for letters of interest from scientific collaborations that were interested in using the interim facility. The 85 letters received comprised 60% proposals from earth science and 25% from physics, with the remainder for engineering and other uses.

The second installment of \$20 m by 2009 will create the Sanford Center for Science Education – a 50 000 ft² facility in the historic mine buildings. The centre is intended for elementary-school through university students, as well as for developing new methods of teaching science and engineering. The third installment of \$15 m provides funding to drain the facility completely, to expand Homestake down to 8000 ft and develop a laboratory at 7400 ft. These developments will permit Homestake to host a full programme of research in physics, earth science and engineering, as well as a world-class education programme.

Sanford has a history of philanthropic

donation in South Dakota, including major contributions to a children's hospital centred at the University of South Dakota, and other educational and child-oriented endeavours. His gift expands the alliance supporting the Sanford Underground Science and Engineering Laboratory at Homestake (SUSEL), joining the State of South Dakota, the US National Science Foundation (NSF) through its competitive site selection process, the Homestake Scientific Collaboration and the international scientific community. The gift anticipates continued support from the state, the NSF and the scientific community.

● Homestake invites enquiries from potential users in the international scientific community. Additional information can be obtained from www.lbl.gov/nsd/homestake or by contacting the Homestake principal investigator, Kevin Lesko (e-mail ktlesko@lbl.gov), or the executive-director of the South Dakota Science Technology Authority, Dave Snyder (e-mail David.Snyder@state.sd.us).

COLLABORATION

ASPERA gets set to aim for the stars

Representatives from 16 European national funding agencies that are responsible for particle astrophysics gathered at the headquarters of the Centre national de la recherche scientifique (CNRS) in Paris on 20 July for the launch of the AstroParticle European Research Area (ASPERA) network. This is a three-year ERA-NET activity under the Sixth Framework Programme of the European Commission (EC), with an EC contribution of €2.5 m. Its aim is to improve coherence and coordination across European funding agencies for financing astroparticle physics.

ASPERA has come about through the Astroparticle Physics European Coordination (ApPEC), a consortium of national funding agencies, the aims of which are to develop long-term strategies, express the views of European astroparticle physics in international forums, and establish a system of peer-review assessment applicable to projects in astroparticle physics.

Europe is a leading worldwide player in astroparticle physics, involving about 2000 European scientists in some 50 laboratories. The current programme costs almost €100 m a year and the cost of proposed future large infrastructures is near €1 bn. This level of activity means that it is necessary to consolidate existing coordination among the different projects at the European level.

ASPERA will study funding and evaluation in Europe and will identify formal and legal



barriers to international coordination. It will define a roadmap on infrastructures and R&D, and will test the implementation of new European-wide procedures of common funding of large infrastructures and the accompanying R&D. The further linking of existing astroparticle physics infrastructures will also be explored. A common information system (a database and a website) will be constructed and studies on the differential emergence of particle astrophysics in various European countries will be performed. The network is coordinated by CNRS.

In particular, the proposition for a roadmap that is being prepared by ApPEC's Peer Review Committee will be examined in a series of workshops with the aim of formulating a common action plan, including common evaluation and funding schemes, for the upcoming large infrastructures on high-energy neutrino, gamma-ray and cosmic-ray telescopes, gravitational antennas and underground observatories for dark matter, double beta-decay, low-energy neutrinos and proton decay. These efforts surrounding the roadmap will also take account of similar European efforts in particle physics (the CERN

Council Strategy group, see p29) and astrophysics (the European strategic planning group for astronomy, ASTRONET), and will be input, through ApPEC, to national agencies and European committees on large infrastructures (such as the European Strategy Forum on Research Infrastructure). Coordination with other regional roadmaps, in the US and Asia, will also be sought, with a view to optimal distribution of global infrastructures.

The participants at the launch workshop agreed that ASPERA's programme, the importance of which cannot be underestimated, will be daunting and challenging, fully justifying the motto *Per aspera ad astra* ("with difficulty to the stars").

● At the outset, ASPERA comprises the following funding agencies: CNRS (France), BMBF (Germany), CEA (France), FCT (Portugal), FNRS (Belgium), FOM (Netherlands), FWO (Belgium), INFN (Italy), MEC (Spain), MEYS (Czech Republic), SNF (Switzerland), DEMOKRITOS (Germany), PPARC (UK), PTDESY (Germany), FECYT (Spain) and VR (Sweden), together with CERN. One of its goals is to include all European national agencies that have programmes in astroparticle physics. For further information contact Thomas Berghoefer (e-mail Thomas.Berghoefer@desy.de). For information about ASPERA in general, contact the coordination manager, Nathalie Olivier (e-mail nolivier@admin.in2p3.fr).

INDUSTRY

ALICE collaboration presents awards to two Italian suppliers

During the "ALICE week" held on 19–23 June in Bologna, the collaboration honoured two Italian suppliers, Istituto Trentino di Cultura (ITC)-irst and MIPOT SPA.

ITC-irst (Trento) Microsystems Division has produced 600 silicon double-sided sensors with consistency in quality and reliability. These sensors are installed in the inner tracking system, very close to where collisions will take place. ITC-irst was also rewarded for its important contribution to the offline computing project for ALICE. The Automated



ALICE honoured two Italian industry winners.

Reasoning Systems Division has provided ALICE with the RuleChecker software, which

periodically checks the successive releases of the ALICE code and reports any violations.

The second company, MIPOT SPA, Cormons, has assembled silicon-strip sensors with all the remaining elements necessary to produce the silicon-strip modules. The silicon-strip detector is made of 1698 of these modules, providing more than 2.7 million analogue detection channels. The fabrication of the modules requires non-standard manufacturing, custom-made equipment and highly skilled personnel.

AWARDS

CERN physicist wins Einstein Medal

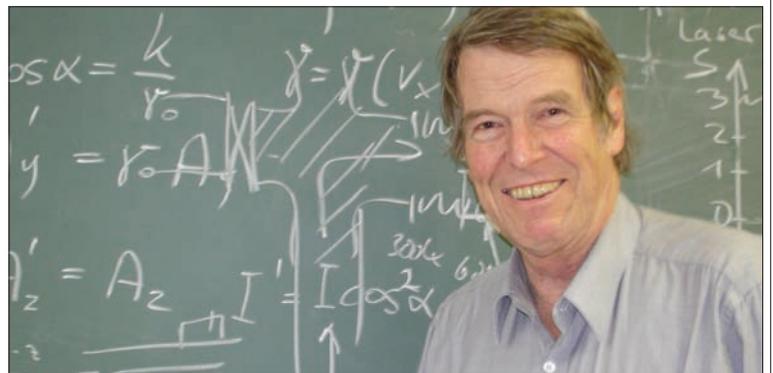
On 29 June CERN's Gabriele Veneziano was awarded the prestigious Albert Einstein Medal for significant contributions to the understanding of string theory. The Albert Einstein Society in Bern gives the award to individuals whose scientific contributions relate to the work of Einstein. Former recipients include exceptional physicists such as Murray Gell-Mann in 2005, along with Stephen Hawking and Victor Weisskopf.

Veneziano, a member of the CERN theory team since 1977, led the Theory Division from 1994 to 1997 and has already received many prestigious prizes for his outstanding work, including the Enrico Fermi Prize in 2005, the Dannie Heineman Prize for Mathematical Physics of the American Physical Society in 2004, and the Pomeranchuk Prize of Moscow's Institute of Theoretical and Experimental Physics in 1999.



Gabriele Veneziano won the 2006 Albert Einstein Medal for his work on string theory.

EPS honours two physicists for their work on nuclear masses



David Brink was one of the two physicists honoured this year. Heinz-Jürgen Kluge was rewarded for expanding our knowledge of nuclei.

Two versatile physicists won this year's Lise Meitner Prize from the Nuclear Physics Board of the European Physical Society (EPS) at the 7th Radioactive Nuclear Beams conference in Cortina d'Ampezzo in July. Theorist David Brink, formerly of Oxford University, and experimentalist Heinz-Jürgen Kluge of GSI, Darmstadt, have both worked on nuclear masses and have enriched nuclear physics.

The EPS rewarded Brink for "his many contributions to the theory of nuclear structure and nuclear reactions over several decades,

including his seminal work on the theory of nuclear masses using Skyrme effective interactions, nuclear giant resonances, clustering in nuclei and quantum and semi-classical theories of heavy-ion scattering and reactions". Brink's work continues, and he has written a book with Ricardo Broglia on the pairing interaction and nuclear superfluidity.

Throughout his career Kluge has had strong links with CERN and its ISOLDE facility. He received the Meitner Prize for "key contributions to our knowledge of the masses, sizes, shapes

and spins of nuclei through a number of decisive, sophisticated and brilliant experiments, which combine atomic and nuclear physics techniques". A particularly important step in the late 1980s, when Kluge led the ISOLDE group, was introducing precision Penning traps for storing radioactive nuclei with half-lives down to less than a second, thereby allowing absolute mass measurements for nuclei far from the line of beta-stability. This work inspired similar traps all over the world, many built by Kluge's students.

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FACES AND PLACES

WORKSHOP

BNL meeting discusses heavy quarkonia

More than 100 experts from at least 40 research centres and universities met at Brookhaven National Laboratory (BNL) on 27–30 June for the 4th International Workshop on Quarkonium, organized by the Quarkonium Working Group (QWG). Participants discussed the latest experimental results and theoretical developments, and reviewed the present and near future of heavy-quarkonium physics.

The discoveries of the J/Ψ resonance at BNL and SLAC in 1974, and of the Υ resonance at Fermilab in 1977 (quickly confirmed at DESY and CERN), with the parallel unveiling of a whole family of new particles, led to an unexpected new direction in particle physics in the 1980s. These charmonium and bottomonium states, known as heavy quarkonia, are formed by a bound state of a heavy quark–antiquark pair. They allowed a careful testing of quantum chromodynamics (QCD), which is now the accepted theory for the strong interaction in the Standard Model, replacing the phenomenological models previously employed. Moreover, since heavy-quarkonium states can decay either hadronically or electromagnetically, or (in the case of the B_c meson) weakly, they can be used to scrutinize the Standard Model using distinct processes in different energy regimes.

Today, heavy quarkonium remains ideal for checking and applying recently developed theoretical frameworks – for example, effective field theories such as non-relativistic QCD – to cope with the complexity of our low-energy hadronic world. The QWG was set up in 2002 to exchange ideas and information between experimentalists and theorists in quarkonium physics (*CERN Courier* March 2003 p6). One of its first results was the preparation of a CERN Yellow Report (Bambrilla *et al.* 2005), which provides a comprehensive, state-of-the-art overview of heavy-quarkonium theory and experiment, covering spectroscopy, decay and production, in-medium effects, and the determination of QCD parameters, and also addresses the possibility of new physics beyond the Standard Model.

The recent discovery of new narrow states by the Belle, BaBar and CLEO experiments stresses the continued relevance of quarkonium, which could provide an interpretation of the states, and hence a deeper

insight into QCD. In addition, the properties of production and absorption of heavy-quark bound states in a nuclear medium are fundamental to understanding QCD at high density and temperature: quarkonium states are considered to be one of the most important probes of the phase transition from normal nuclear matter to the deconfined state of matter likely to have been present at the beginning of the universe. Quarkonium is being studied in this context at the Relativistic Heavy Ion Collider (RHIC) at BNL, and will also be investigated at the Large Hadron Collider (LHC) at CERN.

One aim of the QWG is to bring theorists and experimentalists together to exchange results, needs and ideas, and to promote proposals for new measurements; another is to facilitate interaction between the quarkonia working subgroups. These were achieved during the meeting at BNL. As well as discussing theoretical advances, special attention was paid to experiments currently collecting data, such as those at the Beijing Electron Positron Collider, the Cornell Electron Storage Ring, the KEKB facility, HERA at DESY, the Tevatron at Fermilab, the PEP-II B-factory at SLAC, and RHIC. Recent results from experiments at CERN's Super Proton Synchrotron were also discussed. The potential of forthcoming LHC experiments, the upgrades foreseen at BES-III in Beijing and at RHIC, the PANDA experiment at the future Facility for Antiproton and Ion Research, and the ideas for a Super B-factory triggered great interest and excitement. There was also substantial interest in the results of numerical studies using first principles on the lattice.

The next workshop will be at DESY in October 2007. This will be the start of the LHC era, but eagerly awaited results from experiments that are already running are expected by then. The high-energy LHC frontier will be complemented by high-precision experiments exploring lower energy scales. Heavy-quarkonium physics will continue to play an outstanding role in the coming years.

Further reading

N Bambrilla *et al.* CERN-2005-005,
<http://arxiv.org/abs/hep-ph/0412158>
 For further details on meetings and other activities of the QWG, see www.qwg.to.infn.it.

CELEBRATION

Berkeley symposium honours Swiatecki

A symposium on the Current Trends in Nuclear Physics was recently held at Lawrence Berkeley National Laboratory to honour Wladyslaw Swiatecki on his 80th birthday. Forced to flee his native Poland after the Nazi invasion in 1939, Swiatecki settled in England, where he received his doctorate under Rudolph Peierls in Birmingham in 1950. After several years in Denmark and Sweden, he moved to Berkeley in 1957, where he is still active.

Swiatecki is best known for his extensive work on macroscopic properties of nuclei, both static (such as the nuclear droplet model) and dynamic (especially the one-body dissipation resulting from the interaction of the nucleons with the evolving nuclear shape). His work has had a broad impact on the field, including nuclear shell effects,



Wladyslaw Swiatecki at the symposium to mark the occasion of his 80th birthday.

nuclei at high spin, and superheavy elements.

Following the first relativistic nuclear collisions at Berkeley's Bevalac, Swiatecki helped to shape the conceptual framework for these interactions. He introduced the "participant spectator" picture, which formed the basis for many models, including the widely applied fireball model.

Throughout his career, Swiatecki has maintained a keen interest in general physics, particularly relativity and the foundation of quantum mechanics. He is a member of the Royal Danish Academy of Sciences and Letters and the Polish Academy of Arts and Sciences. He was awarded the Smoluchowski Medal of the Polish Physical Society, and received an honorary degree from the Jagiellonian University in Krakow in 2000.

VISITS



Krzysztof Kurzydowski, left, undersecretary of state, ministry of science and education in Poland, met with CERN's director-general, **Robert Aymar**, and attended a Resources Review Board meeting at CERN on 24 April. Kurzydowski also toured the ATLAS experimental area during his visit.



CERN welcomed the first deputy-minister of foreign affairs, **Jaroslav Basta**, left, from the Czech Republic, for the first time on 20 June. ATLAS spokesperson, **Peter Jenni**, right, along with CERN physicist, **Ivan Lehrs**, accompanied Basta to the ATLAS underground cavern.



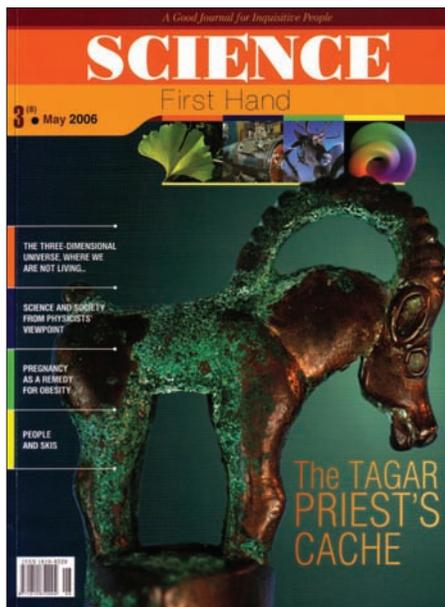
Serge Dassault, centre, chair of the Dassault Group and Socpresse and senator of Essonne, participated in the Amicable Economic and Social Council of France at CERN on 15 June. Dassault visited the underground cavern of the ATLAS experiment together with his son, **Olivier**, right, and **Jean Jacques Blaising**, head of the Physics Department. The participants also toured the LHC magnet assembly and testing hall, and the surface assembly hall and experimental cavern of the CMS experiment.

OUTREACH

Journal gives first-hand look at science. . .

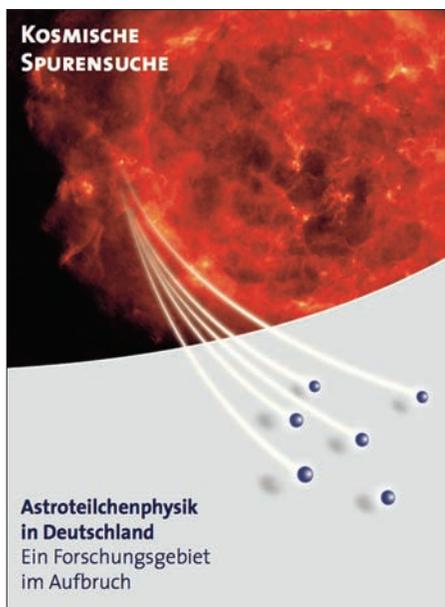
The Siberian Branch of the Russian Academy of Science is taking science to the public in an engaging way with its “journal for inquisitive people”, *Science First Hand*. Published bi-monthly in separate English and Russian editions, the format “is not quite typical of academic publications”, says editor-in-chief academician Nikolai Dobretsov.

Closer in look and feel to *National Geographic* than many learned-society magazines, *Science First Hand* presents non-technical articles written by scientists from across the range of research in Russia. Recent issues include a series looking at the work of the Budker Institute of Nuclear Physics, including an interview with the director, Alexander Skrinsky, and articles from the institute’s young researchers. For further information and subscriptions see www.sibsciencenews.org.



. . .and new brochure highlights the progress of German astroparticle physics

Germany is building a strong reputation in research in topics that cross the boundary between particle physics and astronomy, ranging from gamma-ray astronomy to dark matter. Now the Committee for Astroparticle Physics in Germany has published an illustrated brochure on the current German contributions to the field. *Kosmische Spurensuche: Astroteilchenphysik in Deutschland* provides a detailed overview of the current and planned activities, which take place in locations from the South Pole to the African desert, and from deep tunnels to volcano summits. The brochure can be downloaded as a PDF from the website at www.astroteilchenphysik.de, or can be ordered by writing to Forschungszentrum Karlsruhe GmbH, Stabsabteilung Öffentlichkeitsarbeit, Postfach 3640, 76021 Karlsruhe, or by e-mailing info@oea.fzk.de.



CORRECTION

CERN Courier wishes to apologize for an unfortunate error made during the editorial process in the article on Ettore Majorana in

the July/August issue of CERN Courier (p23), in which Laura Fermi, the wife of Enrico Fermi, was referred to as his daughter.

NEW PRODUCTS

Cedip Infrared Systems have announced an acquisition trigger module that enables its range of high-performance infrared cameras to measure precisely and characterize transient thermal events, even for microsecond exposure times. With extremely short electronic latency times and a digital-output data stream, it is possible to know the state of recording almost instantaneously. For further details contact Emile Comee (tel: +33 160 370 100 or e-mail cedip-marketing@cedip-infrared.com), or see www.cedip-infrared.com.

CeramTec North America Corporation has launched a 0.25 inch power-plug feed-through and cable assembly for simple and safe high-power connectivity, handling up to 25 kV and 100 A. Like all of CeramTec’s Hermetic products, it is built for extreme conditions, including temperatures from -269 °C to 450 °C. The feed-through is leak-tight to $< 1 \times 10^{-10}$ atm-cc/s. For more information tel: +1 864 682 3215, e-mail sales@ceramtec.com, or see www2.ceramtec.com.

PI (Physik Instrumente) LP offers the new M-403/M-414 precision linear translation stages. The integrated low-fraction ball screws combine high duty-cycles and velocities with minimum incremental motion of 0.1 µm. All models are equipped with high-precision linear guiding rails and recirculating ball bearings. Their high load capacity allows them to carry up to 50 kg and to push/pull up to 100 N. For more details contact Stefan Vorndran (tel: +1 508 832 3456, e-mail stefanv@pi-usa.us), or see www.pi.ws.

The **SAES Getters Group** is upgrading its PaGeWafer production line at the headquarters in Lainate to process 8 inch wafers for wafer-level MEMS, in addition to the 4, 5 and 6 inch formats. PaGeWafer comprises a wafer with a patterned getter film a few micrometres thick, that is placed onto specific cavities of any shape and depth. By providing maximized absorption of any active gases like H₂O, O₂, CO, CO₂, N₂ and H₂, it guarantees long-term stability to vacuum or to inert-gas atmosphere in wafer-to-wafer hermetically bonded MEMS devices. For further information contact Marco Moraja (tel: +39 029 317 8489, e-mail marco_moraja@saes-group.com), or see www.saesgetters.com.

OBITUARIES

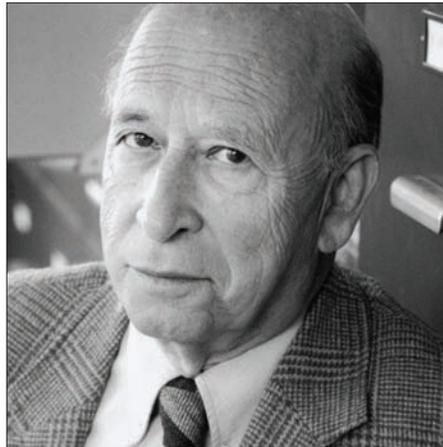
Valentine L Telegdi 1922–2006

A major figure of physics, Valentine Telegdi, passed away in April. An international personality, he had strong links to Switzerland as a student and as a professor at the Federal Institute of Technology (ETH) Zürich. After his retirement from ETH Zürich he was a permanent unpaid visitor at CERN, except for three months each winter, which he spent in California. It was there that he died on 8 April of complications after an operation for an aneurism.

Born in Budapest on 11 January 1922, Val attended technical schools in Vienna and Brussels, before making a living from 1940 to 1943 in a patent attorney's office in Milan. He then moved to Switzerland, where he obtained a Master of Science degree as a chemical engineer at EPUL (now EPFL) in Lausanne in 1946. His initial application to attend ETH Zürich was rejected on formal grounds, but the decision was reversed after E C G Stückelberg, whose lectures he had attended, intervened in his favour with Paul Scherrer. At ETH Val was assigned a problem using nuclear emulsions, which led to his PhD under the joint direction of Scherrer and Wolfgang Pauli. It was in Zürich in 1950 that he met Lidia (Lia) Leonardi, who became his wife and who was an ideal partner for him.

In 1951, under recommendation by Viki Weisskopf, Val was offered an instructorship at the University of Chicago, then a hotbed of physics with people such as Subramanyam Chandrasekhar, Enrico Fermi and Edward Teller, with Robert Garwin and Murray Gell-Mann among the young staff. After Fermi's death in 1954 Val took over the leadership of the emulsion group and was given tenure in 1956. He was named Enrico Fermi Distinguished Service Professor in 1972. He returned to Europe in 1976 to a professorship at ETH Zürich, until his retirement in 1989, though he spent much of his time at CERN.

It is difficult to list all of Val's achievements, but many involved the muon: in 1957, in collaboration with Jerome Friedman, he contributed to the proof of parity violation in the decay chain $\pi-\mu-e$ using the emulsion technique; in 1957 proof of the V-A structure of neutron β -decay; in 1961 and 1962 theory and experiments on the hyperfine effect in muon capture, demonstrating its V-A structure; in



1970 the first precise measurement of the fine-structure constant obtained from the hyperfine splitting in muonium (in Val's words, "I entered the inverse millionaire's club for accuracy"); in 1958 the invention of a stroboscopic method for measuring the muon magnetic moment; in 1959 the BMT equation of motion of a spin in a magnetic field, obtained together with Val Bargmann and Louis Michel, essential for g-2 experiments with polarized muons in storage rings, and one of the small team that carried out the first g-2 measurement at CERN; and in 1983 a direct determination of the helicity of the muon neutrino.

Val and his associates performed many important experiments on the $K_S^0 K_L^0$ complex. In a pioneering experiment at the Bevatron in 1957 they established the existence of a long-lived component carrying the "wrong" strangeness; and in 1978 they provided the first quantitative evidence for the regeneration of K^0 mesons by the atomic electrons. In the 1980s, Val's group in Zürich initiated the NA10 experiment at CERN, which studied the Drell-Yan production of muon pairs, allowing the extraction of the pion structure function and a precise study of scaling. After his retirement in 1989 he was still scientifically active and published 11 papers, including historical papers on Fermi, Leo Szilard and others.

Val's own comment on these achievements was his famous joke: "My main contributions to physics are negative: the minus sign in the V-A interaction of the neutron and muon-capture." In fact, together with the early

experiments on parity violation, these played a central role in establishing the validity of the V-A structure of the weak-interaction coupling.

His scientific stature was recognized by his election to the US National Academy of Sciences, and as a foreign member of many other national academies, including those of France, Germany, Great Britain, Hungary, Italy, Russia and Sweden. He received many scientific prizes, the most prestigious being the Wolf Prize, awarded to him jointly with Maurice Goldhaber in 1991.

He was a member of the Scientific Policy Committee at CERN, being chair from 1981 to 1983. While chairman, he and Herwig Schopper convinced the USSR to let Lev Okun attend the committee meetings as a Russian delegate. This was very important for improving East-West relations and collaboration.

Val was a physicist typical of the 1950s who enjoyed working in small groups. His style was individualistic and he enjoyed ingenious experimentation. He had a taste for finding measurements that were crucial to advancing the subject. He was also deeply interested in the history of past experimental discoveries and vital measurements. He considered that there were important lessons to be learned from these and that the ingenuity and intellectual achievements of great experimentalists were greatly underestimated in textbooks and by the physics community.

He took a great interest in languages and was a true polyglot. He mastered French, English, German, Hungarian, Italian and Swiss-German fluently and managed many more. He liked art, especially modern works such as those of Hans Emi and Paul Klee, and enjoyed good food and wine both in restaurants and at home, where he had a five-star cook in the person of Lia. He had a well-earned reputation for his sharp wit and an infinite store of appropriate jokes. Indeed, while a student in Zürich he had honed this to such perfection that he was employed by a well-known café as an imitator and joke-teller to attract clients. We shall remember him as a sometimes demanding but wonderful friend.

Torleif Ericson, CERN, Klaus Freudenreich, ETH Zürich, and André Martin, CERN.

Markus Eduard Fierz-Biber 1912–2006

The theoretical physicist Markus Fierz passed away on his 94th birthday in June, surrounded by his family in Küsnacht near Zürich. With him, not only has an eminent scientist left us, but also a universal mind, able to encompass art, natural science and the history of mankind.

Markus Fierz was born in Basel on 20 June 1912, the first of twins to Eduard Fierz and Linda Emma Fierz-David. The family moved from Basel to Zürich in 1917, when his father, a senior chemist with the pharmaceutical company Geigy, was offered a chair in chemistry at the Federal Institute of Technology (ETH) Zürich. In 1918 his mother was stricken by influenza, and as her recovery was slow she sought help from Carl Gustav Jung with his analytic psychology. This later proved important, when Fierz became the assistant and collaborator of Wolfgang Pauli, who suffered a psychological crisis and was cured by Jung.

Fierz attended high school in Zürich until 1931, enrolling the same year in the University of Göttingen to study physics and biology. There he enjoyed lectures by Hermann Weyl and also read the works of Emmanuel Kant. He returned to Zürich in 1933, where he continued studying at the university. Attending lectures in theoretical physics by Gregor Wentzel (University of Zürich) and Pauli (ETH Zürich), he decided to study this discipline in depth.

For his PhD Fierz investigated the reaction $e^- + p \rightarrow n + \nu_e + \gamma$ and discovered – to lowest order in the electric charge – the divergence of the cross-section that stems from long-wavelength photons. He obtained his PhD from the University of Zürich in 1936 and spent the summer semester in Leipzig, where Werner Heisenberg had formed a school. In July, Fierz accompanied Heisenberg to a conference in Copenhagen, also attended by Pauli, who proposed that Fierz should become his assistant. Fierz accepted the offer and returned to Zürich.

In 1938 Pauli suggested that he should write a “habilitation” thesis, and this led Fierz to consider the spin structure of a field with special relativistic covariance and to master difficulties that arise for spin values greater than 1/2. In the thesis, submitted in 1939,



Eminent theoretical physicist Markus Fierz-Biber, in 1970. (Courtesy Barbara Kruck.)

on massive and massless free fields, Fierz proved the relation between spin and statistics: Bose–Einstein statistics for integer spin values and Fermi–Dirac statistics for half-integer values. Forty years later he was awarded the Max Planck Medal for this derivation in 1979. Thereafter Fierz was a fierce defendant of basic chiral dotted and undotted spinor components.

The habilitation thesis led to work with Pauli, where the methods were extended to electromagnetically interacting fields. The comparison of local transformations arising for massless charged fields with spins 2 and 3/2 was ahead of its time: it can be extended to the full local gauge group of supergravity, as Sergio Ferrara, Dan Freedman and Peter van Nieuwenhuizen showed in 1976.

In 1940 Fierz took a position as assistant and “Privatdozent” at the University of Basel, which he held until 1943, when he was made associate professor, becoming “Ordinarius” in 1944. Then in spring 1959 he was appointed director of the Theory Division of CERN. However, Pauli had died in December

1958 and Fierz was soon named as his successor. He stayed for a year at CERN, succeeding his mentor and friend Pauli at the ETH Zürich in 1960. He remained there until he retired in 1977.

After his eminent papers on fields with higher spin, Fierz intensively studied general relativity, although this work can be traced only incompletely from his publications, which include a discussion of Weyl transformations within the Jordan–Fierz–Brans–Dicke theory and a treatise on spinors. In 1989 he received the Albert Einstein Medal for the totality of his work as a researcher and teacher, and for his mediation of general cultural values.

Fierz served for many years as the Swiss scientific delegate to CERN Council and was a founding father, together with Res Jost and Jean-Pierre Blaser, of the Swiss Institute for Nuclear Research founded in 1968. This was fused in 1988 with the Federal Institute for Reactor Research to form the present-day Paul Scherrer Institute.

Fierz played the violin from his youth, and it was as a member of a string quartet that he met Menga Biber. The two music lovers were married in 1940. In Switzerland, spared from action, the Second World War brought an era of restricted freedom in both the arts and natural science. Both Fierz and Jost, with whom Fierz developed a lasting friendship after they met in 1950 at the Institute for Advanced Study in Princeton, belonged to a generation that was part of these unfolding times. Colleagues of Fierz, Jürg Fröhlich and Klaus Hepp, wrote, “Together with his colleague and friend Res Jost, [Fierz] coined research, style and atmosphere at the Theory Institute, which then was a magnet with international attraction for all theorists with a taste for a mathematical view of physics. The intellectual overview of the two colleagues generated a uniting spirit at the Institute, never felt any more since their departure.”

We lose in Markus Fierz an outstanding physicist and a most original creative artist, maybe close to the ideal of the “glass bead player” of the novel by Hermann Hesse. He will be remembered with honour.

Peter Minkowski, Institute for Theoretical Physics, University of Bern.

Edmund “Ted” Bellamy 1923–2005

Edmund “Ted” Bellamy, who died aged 82 on 11 December 2005, was an outstanding scholar who made a significant contribution to the development of high-energy physics (HEP) in post-war Britain and the birth of experimental HEP in Pisa, Italy. Born in Liverpool in 1923, he graduated at King’s College, Cambridge, in 1948, then worked on his PhD at the Cavendish Laboratory.

In 1952, Ted took up a lectureship in Glasgow, joining the team preparing experiments for the 300 MeV electron accelerator. Never short of ideas, he developed a high-pressure ionization chamber for combined dE/dx -E measurements while waiting for the accelerator to be tuned and ready to start. In this creative period he interacted energetically with all of his Glasgow colleagues, in particular with Phil March who later followed him to Westfield College.

In 1960 he was appointed to the newly established chair of physics at Westfield College, University of London, and was charged with setting up a department there. First, however, he spent a sabbatical at the University of Pisa, working with a newly formed group on neutral pion photoproduction at the new 1100 MeV electron synchrotron at Frascati. The Pisa group was young and inexperienced, but included physicists who would later play a significant role in particle physics. With his young colleagues, Ted measured the lifetime of the neutral pion, exploiting the Primakoff effect – the first observation of this



mechanism. He contributed enormously to the education of the experimental particle-physics group and Giorgio Bellettini and Lorenzo Foà remember with gratitude his intellectual generosity and openness.

Ted played a major part in transforming Westfield from a small, all-female, mainly liberal arts institution into a mixed college with a key position in the natural sciences. He served as dean of sciences and later as vice-principal. His profound knowledge of the foundations of physics enabled him to establish research programmes in nuclear and solid-state physics besides his own specialty, particle physics. He later created a small but influential HEP Theory Group.

The first particle experiments at Westfield, conducted with colleagues at University College London, included developing an original system that coupled optical spark chambers to vidicon cameras, a method used later in experiments at the Rutherford

Laboratory on Nimrod, whose construction Ted had actively promoted. He spent 1966 at Stanford, in the groups of Robert Hofstadter and Martin Perl, then returned to London and joined the CERN Omega project. Having united the Westfield team with a small Southampton group led by Steve Frank, they contributed to a modification of the FRAMM spectrometer, installed at the CERN SPS by several Italian groups. The NA7 experiment accurately measured the kaon and pion form-factors in the space- and time-like regions. At the end of the analysis Ted presented the concluding seminar in the main CERN auditorium. From NA7 he moved with the same groups to start the ALEPH experiment at the Large Electron–Positron collider, at the forefront of physics of that time.

In 1984 Westfield College merged with Queen Mary and Royal Holloway Colleges, but Ted decided not to join them and returned to Pisa as visiting professor for two years; he also spent a year at the University of Florida. Returning to the UK, he and his wife Joan moved to Long Hanborough near Oxford and Ted, who had always been a keen sportsman and had as an undergraduate captained the football team at King’s College, took up golf and captained a group of elderly golfers known as the Earwigs.

His collaborators from Pisa and his Westfield colleagues will forever hold a deep respect for Ted as a physicist and a fond memory of his delightful personality.
Giorgio Bellettini and Elliot Leader.

MEETINGS

LRT 2006, the Topical Workshop in Low Radioactivity Techniques, will take place on 1–4 October at the CNRS centre in Aussois, France. The workshop, organized by the Modane Underground Laboratory, will bring together experts in low-background techniques for a variety of presentations and discussions. For further information and online registration see <http://lrt2006.in2p3.fr/>, or contact Pia Loaiza (e-mail ploaiza@ism.in2p3.fr).

The **EPO Online Services Annual Conference 2006** will be on 4–5 October at the Lisboa Congress Centre in Lisbon, Portugal. The theme

is Enabling Partnerships, and speakers from industry and the European Patent Office will discuss the forthcoming European Patent Network. For more information see www.eponline.org, or contact Richard Schiettekatte (e-mail rschiettekatte@epo.org).

AUSHEP06, the Australasian High Energy Physics and Medical Physics Conference 2006, will be held on 17–20 October in Christchurch, New Zealand. The goal is to showcase high-energy and medical physics in New Zealand and Australia and provide opportunities for international collaboration.

For further details see www2.phys.canterbury.ac.nz/~jcw83/conf/index.php.

The **Joint ECT*-RBRC School on QCD Spin Physics** will be on 30 October – 8 December at the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*), Trento. The ECT* and the RIKEN-BNL Research Center (RBRC) organized this doctoral training programme to bring the excitement and challenges of spin physics to young physicists in the hope that many of them will work on experiments or associated theoretical issues. For more details see www.ect.it.

2007



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Summary Talk

- Fabio Sauli (CERN, Geneva, CH)

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Lecturer posts in Accelerator Physics

Initial salary will be in the range £30,901 to £40,202 for a Lecturer appointment and £30,901 to £47,300 at Reader level, including London weighting.

The Physics Department at Royal Holloway University of London is offering two permanent academic appointments in the field of accelerator physics. One of these is in conjunction with the Accelerator Science and Technology Centre (ASTeC) at CCLRC, for activities based largely at the Rutherford Appleton Laboratory in Oxfordshire.

Royal Holloway and the University of Oxford have recently established the John Adams Institute for Accelerator Science as a Centre of Excellence for advanced and novel accelerator technology, providing expertise, research, development and training in accelerator techniques, and promoting advanced accelerator applications in science and society.

As part of an expanding programme we are inviting applications for two new posts with expertise as follows. For both posts we seek highly motivated individuals with a PhD in a relevant field and appropriate post-doctoral experience.

Post 1 (ref: KB/004583)

For this appointment, at Reader or Lecturer level, we are particularly seeking applicants who can contribute to and expand our current programme, which is focussed on beam diagnostics and delivery systems for the International Linear Collider. However we would also welcome applications from individuals who could develop a new programme in other areas of accelerator physics.

Post 2 (ref: KB/004581)

This post, at Lecturer level, is partially funded by ASTeC and about 50% of the time will be spent at the Rutherford Appleton Laboratory collaborating with CCLRC based initiatives. We particularly welcome applications from individuals with expertise in areas such as advanced lasers and optics, particle tracking codes, accelerator physics, or the properties of materials under extreme conditions. About 20% of the duties will be associated with undergraduate and/or postgraduate teaching in the Physics Department at Royal Holloway.

Royal Holloway is one of the larger colleges of the University of London, situated on a pleasant campus about 25km west of central London, close to the town of Windsor and to Heathrow Airport. Further details about the Physics Department and the John Adams Institute can be found on our web site at www.rhul.ac.uk/physics and at www.adams-institute.ac.uk.

Applications should have a PhD in particle physics, accelerator physics or an area related to the posts.

Informal enquiries about the posts can be made to Professor Grahame Blair (+44 1784 443513 or G.Blair@rhul.ac.uk).

Further details and an application form are available from the Personnel Department, Royal Holloway, University of London, Egham, Surrey TW20 0EX; telephone: 01784 414241; fax: 01784 473527; e-mail: recruitment@rhul.ac.uk Please quote the appropriate reference number. The closing date for receipt of applications is the 30 September 2006. Interviews are expected to be held during the week beginning 30 October 2006.

We positively welcome applications from all sections of the community.

Economic Development for Physicists from Developing Countries

Workshop Programme, 27 November – 1 December 2006

Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

This one week residential workshop on '**Economic Development for Physicists in Developing Countries**' is designed for physicists in developing countries who would like to learn entrepreneurial/commercialisation skills. The development of entrepreneurial skills and attitudes now form a vital part of the education programme. The aim of the workshop is to foster the culture of enterprise that will help physicists in their careers help them make positive contribution to the economy of their countries.

Vital aspects of the workshop include: how to spot opportunities, identification of market need, how to protect intellectual property, need for confidentiality, patenting, how to bring developments to market, licensing, raising capital, funding, venture capitalist route, legal issues, incubation, etc. This workshop will also provide delegates an opportunity to engage with successful role models who are expert in their field and to discuss real life issues, barriers and challenges. A number of case studies will be discussed providing an excellent opportunity to understand the issues involved and to identify the best practice from the example. Various transferable skills like negotiation, interpersonal and communication can be learned from the group activities and networking.

The workshop is organized by the International Union of Pure and Applied Physics, the Abdus Salam International Centre for Theoretical Physics, the Institute of Physics and the European Physical Society.

Grant Application & Registration

Grant Application Deadline: 30 September 2006

Grants are available to delegates from developing countries to cover the registration costs, subsistence cost and travel expenses.

Applications should be sent to Dr Dipali D Chauhan (see below for full details) and should include:

- name, address, and other contact details (email, telephone, fax);
- a brief summary of qualifications and career to date;
- a short statement (up to 250 words) describing why the workshop will be useful to you;
- a letter of support from a referee;
- amount required to cover travel expenses.

Please return your application by mail, fax or email latest by **30 September 2006**. **All the selected delegates will be informed by 5 October 2006**.

If you need any documentation for VISA application, please contact us for further information.

Dr Dipali D Chauhan, The Institute of Physics, 76 Portland Place, London W1B 1NT, Tel: +44 207 470 4825, Fax: +44 207 470 4848, Email: dipali.chauhan@iop.org



Institute of Physics



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Deutsches Elektronen-Synchrotron Grid Computing



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

The Computing group at DESY is providing computing resources for the simulation and analysis within the scope of international experimental and theoretical Particle Physics as well as Particle Astrophysics. For our site at Zeuthen we seek a

Scientific associate

to participate in the DESY Grid projects.

One task is the development, installation and upgrade of the LHC Grid infrastructure at DESY, especially in the context of the Tier2 projects for the CERN experiments ATLAS and CMS.

Another field of activities is the participation in the development of experiment specific Grid software for ATLAS (e. g. Job monitoring, Production system).

We expect you to have a university diploma in Physics, Mathematics or Computer Science. In addition you should have a good knowledge in Grid middleware, in Linux system administration and in programming (C, C++, Java, script languages like Python, Perl). You like to work in a motivated team of physicists and engineers and have a good knowledge of the English language. We offer an interesting and advanced work in a scientific environment.

The position is limited to 2 years.

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

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Deadline for applications: 15.09.2006



Physics & Astronomy Department

UCLA

Tenure Track or Tenured Faculty Position in Theoretical Particle Physics

The Department of Physics and Astronomy at UCLA invites applications and nominations for a tenure track or tenured faculty position in theoretical particle physics, starting July 1, 2007 in the areas of collider physics, physics beyond the Standard Model and strong interactions, including perturbative, non-perturbative (lattice) and computational aspects. We are seeking candidates with an outstanding record of past accomplishments and exceptional promise for future growth in research, as well as excellent teaching skills.

Applicants should submit a Curriculum Vitae, a list of publications, a brief description of research interests and goals, and should have three letters of reference sent directly to:

**Professor Joseph Rudnick, Chairman, Attention: Particle Theory Search,
Dept. of Physics and Astronomy, UCLA, Los Angeles, CA 90075.**

Nominations may be sent to the same address.

Applications should be received by December 15, 2007.

UCLA is an equal opportunity employer.



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Department of Physics

PHD SCHOOL ON PHYSICS, ASTROPHYSICS AND APPLIED PHYSICS

The International Research Doctorate School in "Physics, Astrophysics and Applied Physics", established by the Department of Physics, the Department of Chemistry, Biochemistry and Biotechnology for the Medicine, the Institute of Applied Physics, of the Milano University, and by the Department of Mathematics and Physics of the Brescia University, opens 35 PhD positions.

The School awards: 1 fellowship of 12000,00 Euro per year net, plus 20 fellowships of about 9930,00 Euro per year net. Non EU citizens and EU citizens, non resident in Lombardy, qualify for a financial support for lodging and travel. The candidates can apply starting from July 28, 2006; the deadline for the application is September 30, 2006.

The Doctorate School offers a three years long international training curriculum, with intensive courses, series of seminars, research stages in high quality, public and private Laboratories for fundamental and applied Physics. The students will be involved in research projects in all mainstream areas in Physics, namely: Condensed Matter, Quantum Optics, Nanotechnologies, Biophysics, Biotechnology, Accelerator and Underground Particle Physics, Nuclear Physics, Astroparticle, Astrophysics, Cosmology, Theo-retical Physics, Applied Super-conductivity, Electronics, Earth Physics, Environment, Medical and Health Physics.

Information and application form can be found in the following web sites: <http://www.unimi.it/ricerca/dottorati/15434.htm> and http://www.fisica.unimi.it/~postlaur/phys/Concorsi/Concorsi_di_Ammissione.html



University of Hamburg

Faculty of Mathematics, Informatics and Natural Sciences
Department of Physics
Institute for Experimental Physics

The Institute for Experimental Physics invites applications for the position of a **Professor (W2) for Experimental Particle Physics (Astroparticle-Physics – Succession Prof.G.Heinzelmann)**

Through its work on HEGRA and HESS the Physics Department has contributed significantly to TeV-gamma-astronomy. The candidate will lead the activities of the Institute in astroparticle-physics. Collaboration with the local groups working in experimental and theoretical particle physics and in astro-physics is strongly encouraged. Participation in the SFB 676 "Particle, Strings and the Early Universe", which supports this research, is expected.

Teaching of 8 hours weekly, which includes undergraduate and graduate lectures, labs, tutoring, seminars and the supervision of diploma and PhD students, is required.

A PhD in physics and demonstrated achievements in astroparticle-physics as well as experience in teaching and/or the supervision of students are required.

The University of Hamburg is an equal opportunity/affirmative action employer and welcomes the application of qualified women. Handicapped applicants will be given preference in case of equal qualifications.

The position is open starting Jan. 1st 2007. Applications, including a CV, academic records, list of publications and the names of three persons willing to provide further information on the candidate, should arrive by **Sept. 30th 2006** at: **President of Hamburg University, Referat Personal&Organisation 632.5, Moorweidenstr.18, D-20148 Hamburg.**

For further information contact: **Robert.Klanner@desy.de +49 (0)40 8998 2558.**

Post-Doctoral Position

The experimental high energy physics group at the University of Hawaii invites outstanding applicants for a position of Postdoctoral Fellow. Full time, federally funded and renewable for second and third year depending on funding and satisfactory performance. The successful candidate will participate in the Belle experiment at the KEKB asymmetric e^+e^- collider at the KEK laboratory in Japan. The primary goals of the experiment are to investigate CP violation in the decays of B mesons and search for physics beyond the Standard Model. The Hawaii Belle group participates in the analysis of Belle data, the development and commissioning of a second generation CMOS pixel detector for the ILC (International Linear Collider) and Super-KEKB upgrade, and the operation of the sub 100ps resolution time-of-flight detection system.

Minimum Qualifications: PhD in experimental high energy physics is required; experience with modern electronics, particle detectors and data analysis techniques is desirable.

Stipend: commensurate with experience and qualifications.

To Apply: submit curriculum vita and arrange for three letters of recommendation to be sent to Prof. Gary Varner, c/o Ms. Janet Bruce, Department of Physics and Astronomy, University of Hawaii at Manoa, 2505 Correa Road, Honolulu, HI 96822.

Recruitment will remain open until position is filled; however, applications received after December 15, 2006 may not receive full consideration.

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Joint Fellowships in Accelerator Science

Fermi National Accelerator Laboratory, USA, and Imperial College London, UK, have established two three-year joint fellowships in accelerator science.

The posts will be hosted by the Imperial HEP Group and it is expected that the fellows will spend approximately 50% time in each location. The posts will enhance the Imperial College Group's R&D program in Accelerator Science where there is common ground with the Fermilab program. This will be directed towards a future neutrino facility and/or linear collider.

You will be expected to hold a PhD in accelerator science or experimental particle physics or have equivalent experience. Each fellow will hold a contract of employment with Imperial College London but, as half the time will be spent at Fermilab, the fellow must satisfy the necessary US visa and Department of Energy regulations. Starting salary in the range £29,090 to £30,710 depending on experience. An additional travel allowance will apply to these positions.

A job description and an application form can be obtained from Ms Paula Brown, HEP Group, Department of Physics, Blackett Laboratory, Imperial College London SW7 2AZ (email Paula.Brown@imperial.ac.uk). Candidates should arrange for 3 letters of reference to be sent to Ms. Brown. For a full version of this advert please refer to <http://www.imperial.ac.uk/research/hep/vacancies/accel.htm> Please quote ref: 0012 on all correspondence

The closing date for applications is 22 September 2006.

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Applications are invited for a permanent University Lectureship and a 5-year fixed-term Departmental Lectureship in Accelerator Physics, part of the John Adams Institute for Accelerator Science (JAI), Oxford.

One of these posts will be a joint appointment with the CCLRC Accelerator Science and Technology Centre, to work on the International Linear Collider, focussed on beam dynamics and beam transport simulations. Further particulars and information on how to apply are available on <http://www.physics.ox.ac.uk/pnp/jobs/jai-UL-fp.htm> The second post will work on the Neutrino Factory and the Muon Ionisation Cooling Experiment (MICE). Further particulars and information on how to apply are available on <http://www.physics.ox.ac.uk/pnp/jobs/jai-DL-fp.htm>

Further information on both posts can be obtained from Mrs Sue Geddes, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK, e-mail: s.geddes@physics.ox.ac.uk fax: +44 (0)1865 273417, Informal enquiries about this post may be made to Professor Ken Peach, k.peach@physics.ox.ac.uk The application deadline for both posts is 15th October 2006.

The University is an Equal Opportunities Employer.

www.ox.ac.uk/jobs

2007 Chamberlain Fellowship

Lawrence Berkeley National Laboratory (LBNL) is located in the San Francisco Bay Area on a 200-acre site in the hills above the University of California's Berkeley campus and is managed by the University. A leader in science and engineering research for more than 75 years, LBNL is the oldest of the U.S. Department of Energy's National Laboratories.

The LBNL Physics Division invites outstanding recent Ph.D. recipients to apply for the 2007 Owen Chamberlain Fellowship in experimental particle physics and cosmology. Students who expect to receive their Ph.D. degree by the spring of 2007 are also invited to apply.

A Chamberlain Fellow is appointed for three years, with two years of extension possible upon review. Upon appointment, a Chamberlain Fellow is given time to review the Division's research program, and may choose to participate in any aspect of it. With the Division Director's approval, he/she may also pursue new initiatives within experimental particle physics or cosmology. In addition to his/her salary, a Chamberlain Fellow receives a \$5,000 annual research supplement. Funding for new initiatives is available through a competitive Laboratory-wide program.

Opportunities for participation in exciting and diverse physics programs are found both at LBNL and on the UC Berkeley campus, including research mentorship of physics Ph.D. students. Close interactions with local astrophysics communities are possible, as are the relationships with nuclear and accelerator scientists, and there is access to world-leading computation facilities. For information on the LBNL Physics Division's research program, please consult <http://www-physics.lbl.gov>.

This Fellowship honors Berkeley Nobelist Owen Chamberlain, who (with Emilio Segre, Clyde Wiegand, and Thomas Ypsilantis) discovered the antiproton at the Berkeley Bevatron in 1955.

Applications will be considered starting **October 16, 2006**. To be considered, please submit your curriculum vitae, publication list, and statement of research interests in a single attachment on line at <http://jobs.lbl.gov>. In addition, at least three letters of reference must be emailed to Chamberlain.Fellow@lbl.gov by **October 29, 2006**. Please reference **Job #019247**.

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Deutsches Elektronen-Synchrotron
Particle and Accelerator Physics



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

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

DESY Fellowships

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

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

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Deadline for applications: September 30, 2006

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DEPARTMENT OF PHYSICS

Two Lectureships in Astrophysics

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As one of the elements of a major strategic investment in the Physics Department, which includes a £44m development of research and teaching facilities and an injection of new posts, the University invites applications for two Lectureships in Astrophysics. The successful candidates will have excellent research records or have demonstrated outstanding research potential, and will lead research in an area related to the Astrophysics Group's core interests in observational and theoretical work on the formation and cosmological evolution of galaxies and larger scale structures, including the astrophysics and feedback of active galaxies. The Bristol Astrophysics Group makes major use of international ground and space-based observational facilities in pursuit of its research aims, working at the lowest accessible radio frequencies, to CMB studies at cm and mm wavelengths, to significant programmes with the VLT and HST, and major studies with Chandra and XMM-Newton. The Group wishes to make these new appointments to consolidate and broaden its thematic research base.

Informal enquiries (not applications) can be made to Professor M Birkinshaw, mark.birkinshaw@bristol.ac.uk or Professor D Worrall, d.worrall@bristol.ac.uk

Lectureship in Experimental Particle Physics

£28,850 - £37,643

The successful candidate will have an excellent research record or have demonstrated outstanding research potential in the subject area, and will take a leading role in a vibrant research programme as a member of the Linear Collider Flavour Identification (LCFI) Collaboration. You will be involved with all aspects of the LCFI programme, including developing a silicon pixel vertex detector for the International Linear Collider and the software tools to exploit it, and will be expected to drive the effort on physics studies within the Bristol LCFI group. The Bristol particle physics group has designed and built major components of the trigger for ZEUS, BaBar and CMS. We have contributed to the mechanical design of RICH detectors for LHCb and electromagnetic calorimeter endcaps for CMS, and the group has played leading roles in the analysis of data from both ZEUS and BaBar. This experience, expertise and the associated infrastructure is now being used to support a major expansion of activities on the ILC, within the framework of LCFI.

Informal enquiries (not applications) can be made to Professor N Brook, n.brook@cern.ch or Dr J Goldstein, j.goldstein@rl.ac.uk

Further details and an application form can be found at www.bristol.ac.uk/vacancies Alternatively you can telephone (0117) 954 6947 or e-mail recruitment@bristol.ac.uk (stating postal address ONLY), quoting reference number 12360.

The closing date for applications is 9.00am, 18th September 2006.

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A major exhibit encompassing the full spectrum of equipment, instrumentation, products, software, publications, and services is scheduled for November 28–30 in the Hynes Convention Center. Convenient to the technical session rooms and scheduled to complement the program, the MRS Fall Exhibit offers everything you need all under one roof.

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A full display of over 915 books will be available at the MRS Publications Desk.

STUDENT OPPORTUNITIES

Graduate students planning to attend the 2006 MRS Fall Meeting are encouraged to apply for a Symposium Assistant position and/or a Graduate Student Award.

CAREER CENTER

A Career Center for MRS members and meeting attendees will be open Tuesday through Thursday.

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Various meeting formats—oral, poster, round-table, forum and workshop sessions—are offered to maximize participation.

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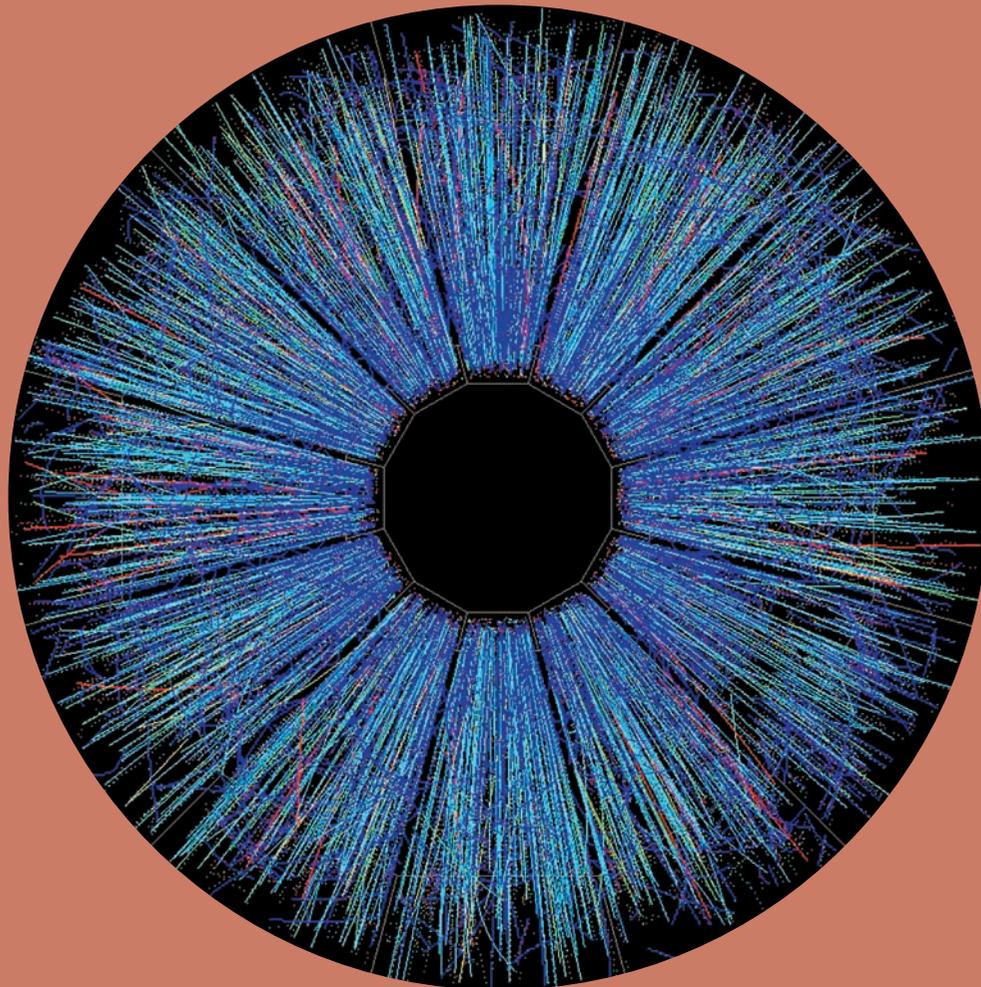
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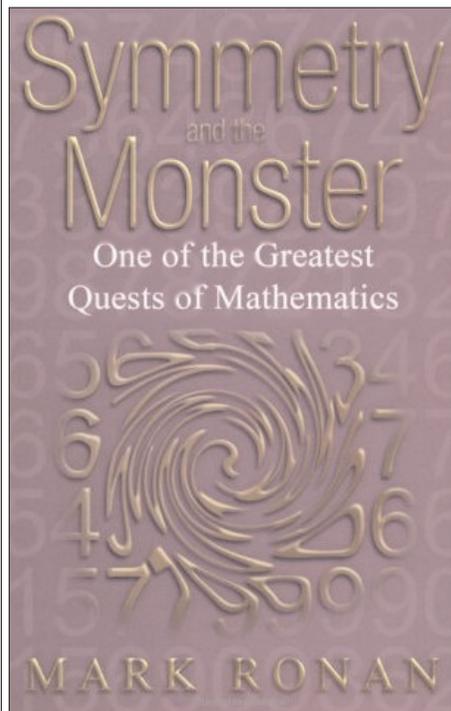
Image: End view of a collision of two 30-billion electron-volt gold beams in the STAR detector at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. Courtesy of Brookhaven National Laboratory

Institute of Physics PUBLISHING

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BOOKSHELF

Symmetry and the Monster: One of the Greatest Quests of Mathematics by Mark Ronan, Oxford University Press. Hardback ISBN 0192807226, £14.99 (\$27).



Simple symmetry groups are groups of geometric operations (rotations, reflections, etc) that cannot be decomposed into simpler groups. *Symmetry and the Monster* is about identifying and classifying the finite simple symmetry groups and discovering exceptions that do not fit into the overall pattern. The largest exception is the Monster. This book is the first telling of a mathematical odyssey spanning two centuries and the biographical accounts linking the technical sections are lively and informative, although they become more reticent as we reach modern times with living protagonists.

Ronan insists on calling simple groups the “atoms of symmetry” (atoms are not simple) and classifying them in “periodic tables”. However, even Ronan’s first table is mysterious, with Lie groups classified in

“families”, labelled A through G (rows), operating in dimensions 1 through 9 (columns). Ronan does not tell the reader what the family members have in common, but says that some groups don’t appear because they are not “simple” or are the same as others. For example, D3 is apparently the same as A3. And it doesn’t get any easier.

Oxford University Press considers this book “a must-read for all fans of popular science”. In his blog, Lieven le Bruyn, professor of algebra and geometry at the University of Antwerp, suggests that “Mark Ronan has written a beautiful book intended for the general public”. However, he goes on to say: “this year I’ve tried to explain [...] to an exceptionally good second year of undergraduates, but failed miserably [...] Perhaps I’ll give it another (downkeyed) try using *Symmetry and the Monster* as reading material”.

As an erstwhile mathematician, I found the book more suited to exceptional maths undergraduates than to the general public and would strongly encourage authors and/or publishers to pass such works before a few fans of popular science before going to press. *Peggie Rimmer, Satigny.*

Books received **Theory and Phenomenology of Sparticles: An Account of Four-Dimensional $N=1$ Supersymmetry in High Energy Physics**

by Manuel Drees, Rohini M Godbole and Probir Roy, World Scientific. Hardback ISBN 9810237391, £62 (\$108). Paperback ISBN 9812565310, £37 (\$64).

A theoretical and phenomenological account of sparticles, this book provides a comprehensive, pedagogical and user-friendly treatment of the subject of four-dimensional $N=1$ supersymmetry, as well as its observational aspects in high-energy physics and cosmology. Search strategies for sparticles, supersymmetric Higgs bosons, nonminimal scenarios and cosmological implications are some of the many topics that are covered. Additional features include self-contained presentations of collider signals of

sparticles plus supersymmetric Higgs bosons and of supersymmetric cosmology.

Brane-Localized Gravity by Philip D Mannheim, World Scientific. Hardback ISBN 9812565612, £33 (\$58).

In this book the author provides a detailed introduction to the brane-localized gravity of Randall and Sundrum, in which gravitational signals can localize around our four-dimensional world in the event that it is a brane embedded in an infinitely sized, higher dimensional anti-de Sitter bulk space. Mannheim pays particular attention to issues that are not ordinarily covered in brane-world literature, such as the completeness of tensor gravitational fluctuation modes, and the causality of brane-world propagators. This self-contained development of the material that is needed for brane-world studies also contains a significant amount of previously unpublished material.

Iron Dominated Electromagnets: Design, Fabrication, Assembly and Measurements by Jack T Tanabe, World Scientific. Hardback ISBN 981256327X, £29 (\$48). Paperback ISBN 9812563814, £17 (\$28).

Written by one of the foremost specialists, this book is devoted to the design of low and medium field electromagnets, the field level and quality (uniformity) of which are dominated by the pole-shape and saturation characteristics of the iron yoke. *Iron Dominated Electromagnets* covers a wide scope of material ranging from the physical requirements for typical high-performance accelerators, through the mathematical relationships that describe the shape of two-dimensional magnetic fields, to the mechanical fabrication, assembly, installation and alignment of magnets in a typical accelerator lattice. Derived from lecture notes used in a course at Lawrence Livermore National Laboratory, it is a useful resource for students planning to enter high-energy physics, as well as those already working with particle accelerators.



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Fighting malaria by accident

Ben Segal gives some background to the Africa@home project.

Like several other novel projects I've worked on in the past, this one started "by accident". One day in 2005, colleagues in the communications team at CERN's IT Department were approached by Informaticiens Sans Frontières, a non-governmental organization (NGO), for advice on setting up a Grid or distributed computing project that could be showcased at the World Summit on the Information Society (WSIS) being held in Tunis in November that year. For example, could an "African Grid" help to bridge the digital divide? This idea fitted in well with CERN's own efforts for the WSIS, and the director general was supportive.

Having spent the last few years of my CERN career managing part of CERN's first Grid project, plus 20 years or so helping developing countries advance their Internet know-how, I realised this would be a very tall order indeed. But by coincidence, I had been working since 2004 with some students on a project called LHC@home, which involved a simple and democratic Grid-style technology called BOINC (*CERN Courier* April 2005 p18). This allows people to volunteer their spare PC computer power to help design the Large Hadron Collider.

Experience with LHC@home had convinced us that volunteer computing projects could be set up with relatively modest means on the BOINC platform. LHC@home now has 30 000 computers contributing to beam stability simulations, but it is also a powerful outreach tool. It has helped create a lively online community of thousands of volunteers around the world who are keenly interested in how the LHC is progressing. One of the fascinating things is that the volunteers receive a virtual form of credit for the processing they do, and they compete between each other for who can get the most credit! Such plentiful and cheap computing resources could be an attractive reward for deserving projects and researchers in developing countries.

Convinced that we could do something equally useful and appealing for the WSIS, we went in search of resources. Thanks to a small grant from the Geneva International Academic Network (GIAN), a student team set up the new project, called Africa@home, at CERN last



Ben Segal, second from right, with the Africa@home project team at CERN.

autumn. The team involved three computer-science students from the universities of Copenhagen, Geneva and Basel, and two young African researchers, all working under my technical supervision.

Africa@home is a website conceived and coordinated by CERN that can host a range of volunteer computing projects for Africa. The first application is *MalariaControl.net*, a computer-intensive simulation program developed by researchers at the Swiss Tropical Institute (STI) and adapted by the CERN-based student team. It began production in July and currently harnesses more than 6000 volunteer computers.

Malaria is responsible for about a million deaths each year in sub-Saharan Africa, and is the single biggest killer in children under five. The *MalariaControl.net* program simulates in detail how malaria spreads through Africa. Running the simulations on thousands of volunteer computers enables researchers to better understand and improve the impact of introducing new treatments. Speaking about the results obtained so far, Tom Smith of STI said that it has really opened up new scientific horizons for his team – they have already done more epidemiological modelling in a few months than they could have achieved on their own computer cluster in a few years.

A key objective of the project was to involve African academic institutions in the software development. It was thanks to the efforts of two local NGOs, ICVolunteers and Informaticiens sans Frontières, that two researchers from the University of Bamako in Mali and the Agence Universitaire de la Francophonie in Bamako and in Yaoundé, Cameroon, were able to join the project team based at CERN.

The server hardware was obtained by resurrecting several obsolete CERN-IT disk servers, literally from the "cemetery", where such equipment waits for destruction. Three useable servers were recuperated after considerable work, again an excellent training exercise. After initial tests at CERN the production server was installed at the University of Geneva, a development server was sent to the STI and a spare remained at CERN.

By autumn 2005 the system was ready for tests with a small group of experienced BOINC volunteers. The project was presented in public for the first time at the WSIS meeting in Tunis, where it attracted much attention, including a radio broadcast on the BBC World Service. More extensive testing began early in 2006 with 500 "typical" volunteers, and improvements and extensions to the malaria model being continually incorporated by STI. In this test phase of several months, Africa@home was able to run simulations equivalent to 150 years of processing time on a single computer. When a press announcement of Africa@home was made in July the response was phenomenal: within only a few days we passed from 500 to nearly 3000 volunteers and more than twice that number of PCs. This is currently enough for the project to handle, though we should open up for several thousand more volunteers in the autumn.

The GIAN foundation has just awarded another grant to the Africa@home partners to adapt other applications of significance to Africa to run on volunteer computers, including epidemiological modelling of diseases such as tuberculosis and HIV/AIDS. The World Health Organization will also be helping. This extended project will train technical staff at African universities to manage the servers that run the volunteer projects, and help African researchers create their own similar projects. Apart from BOINC's obvious ability to harness "free" computing power from richer countries, I believe that mastering modern open-source software such as BOINC is an excellent and practical way to train and motivate students and researchers in developing countries.

Ben Segal, CERN.

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