

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 43 NUMBER 10 DECEMBER 2003



CERN celebrates discoveries

NEW PARTICLES

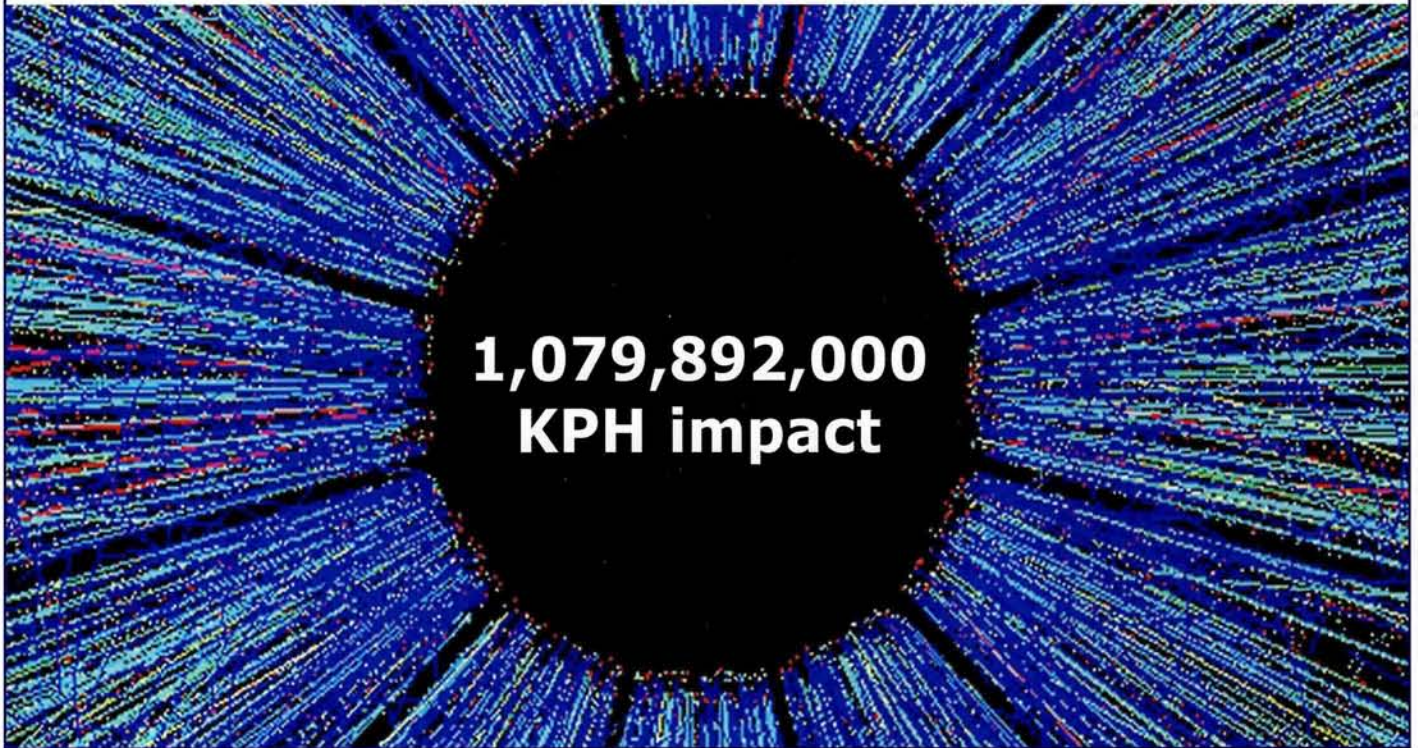
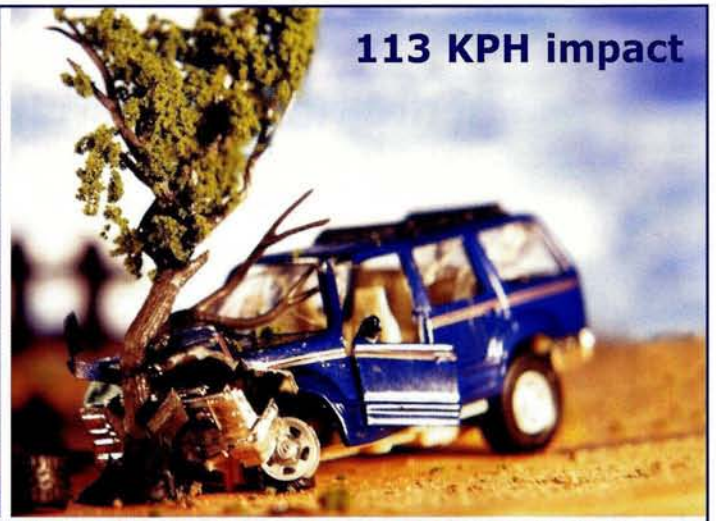
Protons make pentaquarks p5

NETWORKS

Measuring the digital divide p17

SPAIN

Particle physics thrives p30



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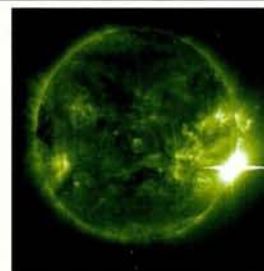


CERN COURIER

VOLUME 43 NUMBER 10 DECEMBER 2003



MAGIC telescope inaugurated p7



Solar flare shines out p15



Veneziano wins APS prize p35

News

5

New five-quark states found at CERN. Cool times ahead for muons at Fermilab. GSI Darmstadt gains credit for new element. MAGIC opens up the gamma-ray sky. Site announced for new X-ray free-electron laser. Heavy feet arrive for the LHC...while correction coils proceed at full speed. Endowment reward for string theorists. Deuterons display surprising spin gymnastics. Grid technology goes to Pakistan. PAEC chairman pays visit to CERN. Auger ready for ultra-high-energy cosmic rays.

Physicswatch

13

Astrowatch

15

Features

Developing countries and the global science web

17

Hilda Cerdeira looks at Internet connectivity and the "digital divide".

Physics from heaven and Earth

19

Felicitas Pauss reports on the HEP-EPS 2003 conference in Aachen.

Can companies benefit from Big Science?

23

A new study shows the impact of CERN contracts on high-tech firms.

Neutral currents and W and Z: a celebration

25

A special symposium celebrated the anniversaries of major discoveries.

Symmetries and structures

29

Siegfried Krewald reports on Hadron Physics at COSY.

Particle physics is thriving in Spain

30

Cecilia Jarlskog accompanied a RECFA visit earlier this year.

Solving cross-section challenges at the LHC

33

Michael Dittmar and James Stirling on the talks at a recent workshop.

People

35

Recruitment

41

Bookshelf

49

Viewpoint

50

Cover: The auditorium at CERN was packed on 16 September for a symposium to celebrate the anniversaries of the discoveries of neutral currents and W and Z bosons (p25). Steven Weinberg is seen giving the opening talk, in which he eloquently described the many steps involved in "The Making of the Standard Model".

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PENTAQUARKS

New five-quark states found at CERN

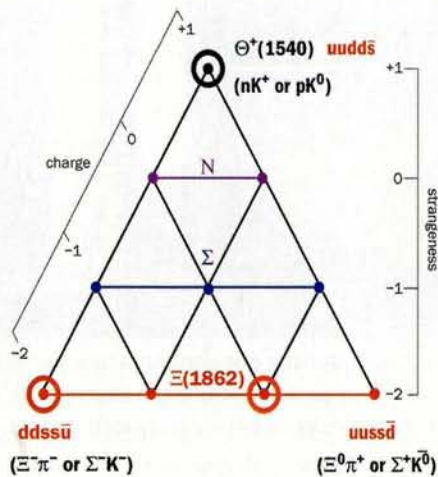


Fig. 1. A hypothetical antidecuplet of pentaquark baryons. The states at the corners of the triangle are manifestly exotic and cannot be made of three quarks. Experiments now see candidates for the three circled members.

Only a few months after the first burst of excitement over the appearance at several laboratories of what seems to be a new five-quark particle, evidence has been found for a different five-quark state that appears to be closely related.

The constituent quark model of hadrons that was invented in the 1960s has been very successful in describing the known baryons as composites of three valence quarks. Quantum chromodynamics (QCD), the theory of strong interactions, does not forbid baryons containing more than three quarks. In fact, such states were proposed a long time ago but no good candidates were found by experiments until recently. The search was revived by the theorists Dmitri Diakonov, Victor Petrov and Maxim Polyakov. They predicted that the masses of the lightest pentaquark ($4q, \bar{q}$) baryon multiplet, an antidecuplet (see figure 1), were rather small and that the width of its lightest member was expected to be very narrow (Diakonov *et al.* 1997). Recent evidence for this state, named Θ^+ , has opened up a new chapter in baryon spectroscopy that will help to elucidate QCD in the non-perturbative regime (CERN

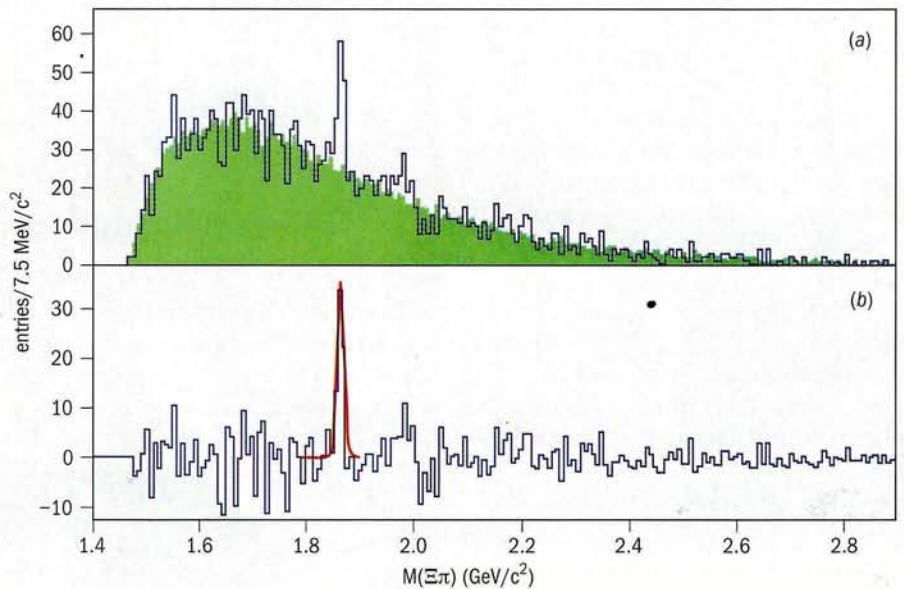


Fig. 2. (a) The sum of the $\Xi^-\pi^-$, $\Xi^-\pi^+$, $\Xi^0\pi^-$ and $\Xi^0\pi^+$ mass distribution; (b) the mass distribution with combinatorial background subtracted and with a Gaussian fit to the $\Xi\pi$ peak.

Courier September 2003 p5). The Θ^+ is a manifestly exotic baryon, that is, it cannot be composed of three quarks. This is also the case for the other two corner members of the antidecuplet depicted in figure 1. The latter have a strangeness of $S = -2$, a charge of $Q = -2, +1$, and form members of an isospin quartet of Ξ states.

Experiment NA49 at the CERN Super Proton Synchrotron has searched for the Θ^+ and the Ξ states in proton–proton collisions at a beam energy of 158 GeV (Alt *et al.* 2003). Tracks of particles produced in the reactions are recorded by the detector's four large time-projection chambers. Their high resolution allows for a precise reconstruction of the particle trajectories and momenta as well as their identification via the measurement of the energy loss in the chamber gas. The reconstruction of secondary decay vertices makes possible the observation of the complex decay chains of the pentaquark states. After suppression of the overwhelming background by suitable selection cuts, the summed $\Xi\pi$ mass distribution shows a narrow peak of 5.6 standard deviations at a mass of $1.862 \pm 0.002 \text{ GeV}/c^2$ (see figure 2). The true

width of the peak must be smaller than the observed full width at a half maximum of $0.017 \text{ GeV}/c^2$, which is consistent with the resolution of the detector.

In fact, peaks are seen at the same mass in the individual $\Xi^-\pi^-$ and $\Xi^-\pi^+$ mass distributions, as well as in those of the antiparticles. No signal has been found yet for the Θ^+ , for which the background in the potentially observable decay channel pK_s^0 is less favourable. The exotic Ξ^{--} with $S = -2$, $Q = -2$ and the Ξ^0 with $S = -2$, $Q = 0$ are good candidates for the isospin quartet of predicted pentaquark states with quark content ($ddss\bar{u}$) and ($duss\bar{d}$). Their discovery represents an important step towards the experimental confirmation of the existence of the hypothesized baryon antidecuplet.

Further reading

C Alt *et al.* 2003 hep-ex/0310014.
D Diakonov *et al.* 1997 *Z. Phys. A* **359** 305.

Tome Anticic, Kreso Kadija, Tatjana Susa, Ruder Boskovic Institute, Zagreb, and Peter Seyboth, MPI für Physik, Munich.

ACCELERATORS

Cool times ahead for muons at Fermilab

The Neutrino Factory and Muon Collider Collaboration – or Muon Collaboration for short – has finished constructing the MuCool Test Area at Fermilab. Researchers will use the US\$1.5 million complex to test the RF cavities and liquid-hydrogen absorbers needed for a muon cooling channel. Spare power units located in Fermilab's 400 MeV linear accelerator will provide RF power of 201 and 805 MHz, and cryogenic equipment will cool the absorbers to 20 K.

The 130 members of the Muon Collaboration have worked for some six years on the design of very intense beams of muons. To cool muon beams in the transverse direction, the collaboration has designed an alternating series of liquid-hydrogen absorbers and RF cavities. The absorbers reduce the momenta of beam particles in both transverse and longitudinal directions, while the cavities reaccelerate the muons in the longitudinal direction.

By the end of December the group will fill and begin testing the first absorber, which was built by KEK in Japan, and around one year from now the group will receive and test a 201 MHz cavity built by Lawrence Berkeley National Laboratory. In the longer term, the international MICE Collaboration plans to use a muon beam line at the Rutherford Appleton Laboratory in the UK to test the system with 200 MeV/c muons. Success will enable – in about 10 years – a new generation of muon sources with a 1000 times higher muon rate



On 14 October members of the Muon Collaboration celebrated the opening of the new MuCool laboratory at Fermilab. Northwestern University donated a transformer (blue structure on the right) and spare stations in Fermilab's linac (shown in the background) will provide RF power.



Fermilab physicists Steve Geer (left), who is spokesperson of the Muon Collaboration, and Milorad Popovic, who oversees the construction of the MuCool laboratory.

and a 100 times reduction in beam phase space, making neutrino factories possible.

The Muon Collaboration consists primarily of

particle and accelerator physicists from laboratories and universities in the US, with additional participation from institutions in Europe and Japan. To secure funding the collaboration is breaking new ground. Traditionally, research and development for accelerators has taken place at national laboratories, with limited participation from university scientists. But tight budgets and ambitious goals have led project leaders in this case to look for more participation and funding from the universities. The collaboration receives money from the US Department of Energy (DOE), the National Science Foundation, the State of Illinois, and some modest funds from Japan. The MuCool buildings at Fermilab are entirely paid for by DOE funds directly provided to the collaboration.

NUCLEAR PHYSICS

GSI Darmstadt gains credit for new element

The Joint Working Party (JWP) on the priority of claims to the discovery of new elements has officially credited the research collaboration led by Sigurd Hofmann at the Gesellschaft für Schwerionenforschung (GSI) with the discovery of element 111. In addition, the four independent experts from the International Union of Pure and

Applied Chemistry (IUPAC) and its physics sister the IUPAP, have officially approved the naming of element 110, also discovered by GSI, as darmstadtium (Ds).

The researchers at GSI first created element 111 in December 1994, when they bombarded a target of bismuth (^{209}Bi) with a beam of nickel (^{64}Ni) and observed three sets of localized alpha-decay chains, which they attributed to the decay of nuclei with 111 protons and 161 neutrons. Two of the decay chains, however, involved isotopes of bohrium and meitnerium (^{264}Bh and ^{268}Mt), which were then unknown. The JWP therefore decided that further results would

be needed. In a repeat of the experiment in 2000, the GSI team observed further decay chains originating from element 111, bringing the total number of events to six. Due to the high quality of the data, the JWP has now accepted the results and confirmed the GSI team's priority for the discovery of element 111.

The JWP also assessed evidence for the production of elements 112, 114 and 116 by GSI and a collaboration led by Yuri Oganessian at the Joint Institute for Nuclear Research in Dubna. Although the JWP found the evidence encouraging, they concluded that confirmation from further results is needed.

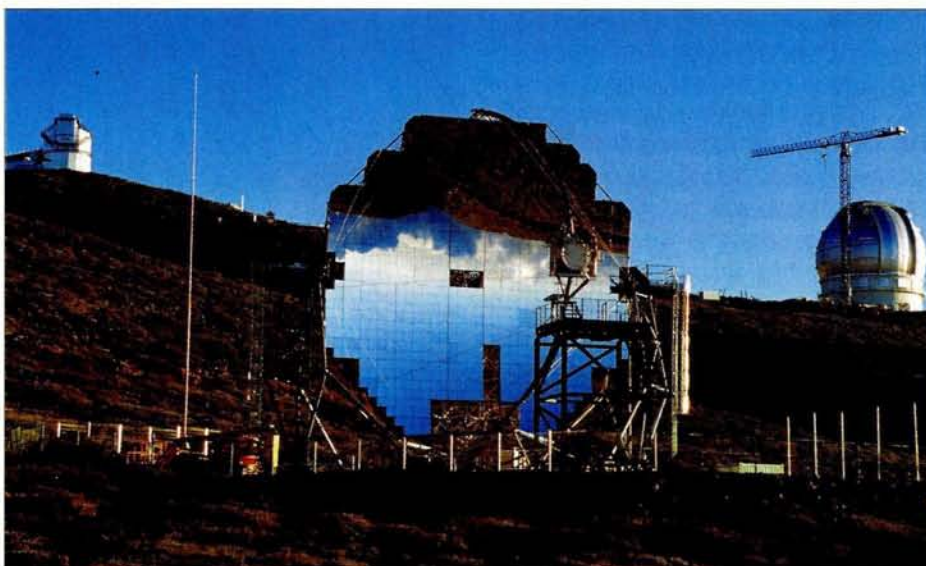
PARTICLE ASTROPHYSICS

MAGIC opens up the gamma-ray sky

The MAGIC telescope, a new-generation instrument for ground-based gamma-ray astronomy, was inaugurated on 10 October at the Roque de los Muchachos astronomical site on the Canary Island of La Palma. The MAGIC (Major Atmospheric Gamma Imaging Cherenkov) telescope's aim is to observe high-energy gamma rays of galactic or extragalactic origin. However, since the Earth's atmosphere is opaque for gamma rays in the multi-GeV energy range, detection must be performed indirectly. When they are absorbed in the atmosphere, high-energy gammas lead to the creation of a shower of secondary particles. It is the flashes of Cherenkov radiation emitted by the charged particles of these air showers that the telescope measures.

MAGIC is the largest and most sensitive air Cherenkov telescope ever built, with a tessellated mirror of 17 m diameter and an energy threshold as low as about 30 GeV (in phase 2 this will be lowered to around 15 GeV). This makes the investigation of the previously unexplored gap between the sensitivity regions of satellite-borne detectors and earlier ground-based experiments possible. The observational programme for the new instrument will open up an entirely new window, not only in gamma-ray astronomy – comprising studies of quasars, active galactic nuclei, black holes and supernova remnants – but also in the search for dark matter and the effects of quantum gravity.

The high performance of MAGIC relies on many technological innovations. Its extremely fast re-positioning time of less than 20 s, for



The MAGIC air Cherenkov telescope in La Palma, with most of the 934 mirror elements that form the 17 m diameter dish already mounted. The optical 10 m GRANTECAN telescope (currently under construction) and TNG, the Italian National Telescope GALILEO, can also be seen in the background. (D Lorenz.)

example, results from the strategy of making all the moving parts of the telescope as lightweight as possible – an issue that is particularly important for the observation of transient phenomena such as gamma-ray bursts. The telescope's more challenging design issues included a mirror support consisting of a carbon-fibre reinforced structure and a low-mass 577 pixel photo-multiplier camera with transmission of the analogue signals by optical fibres.

MAGIC is the first instrument of the European Cherenkov Observatory that is planned for the La Palma site. Within the next

two years MAGIC will be accompanied by a second telescope of equal size, which will then enable the stereoscopic observation of air showers. In the long term, a third telescope with a mirror diameter of 34 m is planned.

The study of high-energy gamma rays is a time-consuming task and requires the observation of many sources. The MAGIC telescope therefore forms one part of a worldwide network of ground-based and satellite-borne detectors.

Further reading

<http://magic.mppmu.mpg.de>.

DESY

Site announced for new X-ray free-electron laser

At a press conference on 29 October, DESY announced that the new X-ray Free-Electron Laser (XFEL) is to be built in the German federal states of Hamburg and Schleswig-Holstein. Construction of the European X-ray laser project (*CERN Courier* November 2003 p21), which was approved by the German Federal Ministry of Education and Research on

5 February 2003, is to start in 2006.

The 3.3 km long facility will begin on the DESY site in Hamburg-Bahrenfeld and run in a north-western direction to the town of Schenefeld (in the district of Pinneberg), which borders on Hamburg. Here, the experimental hall with its 10 measuring stations is to be erected. "We are pleased that we have

found an ideally suited location for the new XFEL in the vicinity of DESY," said Albrecht Wagner, chairman of the DESY Directorate. "Looking far into the future, one could think of connecting the linear accelerator of the X-ray laser with particle accelerators already existing on the DESY site in order to open up new opportunities for science."

INDIA

Heavy feet arrive for the LHC...

The first 800 jacks for one sector of the Large Hadron Collider (LHC) have arrived at CERN from India in recent weeks. After the final acceptance of the pre-series jacks at the end of October, they can now be used to support the LHC superconducting magnets. The jacks are designed to adjust the positions of the magnets, which weigh more than 32 tonnes, with an accuracy of one-twentieth of a millimetre. This is equivalent to moving the weight of eight Indian elephants by the breadth of a human hair.

The 80 kg jacks were designed by the Centre for Advanced Technology (CAT) in India and are being built by Avasarala Automation in Bangalore and the Indo-German Tool Room in Indore. The close collaboration between CAT, the Department of Atomic Energy in India and CERN began in 1996, and the first two batches of jack prototypes were delivered to CERN in November 2000. These prototypes, which are still supporting the test strings in hall SM18, were used to test the manufacturing



The jacks undergoing final pre-shipment inspection by engineers at CAT in India.

principles and design of the jacks. Supporting all the superconducting magnets (dipoles and quadrupoles) of the LHC will require 7000 jacks, which are being continuously delivered to CERN up to mid-2005.

The jacks consist mainly of a central column of variable height supported on spherical

bearings at each end so the column can be tilted. Each dipole rests on three jacks (and another special type for fine corrections), and can be positioned and adjusted with very high precision in all three dimensions. After acceptance of the pre-series, the road is clear for the jacks to be used to support the LHC magnets.

...while correction coils proceed at full speed

The 1000th correction coil made in India for the LHC was handed over at a ceremony at the Department of Atomic Energy (DAE) in Mumbai at the end of September. The small celebration took place during the 9th meeting of the DAE-CERN Joint Committee that follows the progress of the Indian "in-kind" contributions to the LHC. The many items India is providing for the LHC construction include the very valuable and important contribution of superconducting correction windings – 1232 sextupole windings and 616 octupole/decapole windings. Production in India is now running at full speed and in fact exceeds the planned rates.



Anil Kakodkar (centre right), chairman of the Atomic Energy Commission, hands over the 1000th coil to the LHC project leader Lyn Evans, applauded by Philippe Lebrun (right), leader of the Accelerator Technology Division at CERN, Dilip Bhawalkar (left) and A M Puntambekar.

Endowment reward for string theorists

String theory in India recently received an unexpected boost when Jeffrey Epstein, a billionaire based in New York, gave string theorists associated with the Tata Institute of

Fundamental Research (TIFR) in Mumbai a cheque for \$100 000 (€86 200). The money will be managed by the Physics Department of Harvard University as a "TIFR String Theory Travel Fund". Andrew Strominger of Harvard, who facilitated the gift, said that this team has "the highest intellectual output per dollar of any such group in the world". A strong collaboration between the Physics

Department at Harvard and TIFR is expected to begin when the young string theorist Shiraz Minwalla of Harvard joins the TIFR in 2004.

The gift is a real reward for the Indian string theorists who have made sustained and influential contributions to the subject of string theory over many years. Important contributions are in the areas of string dualities, black-hole physics, matrix models and cosmology.

POLARIZED BEAMS

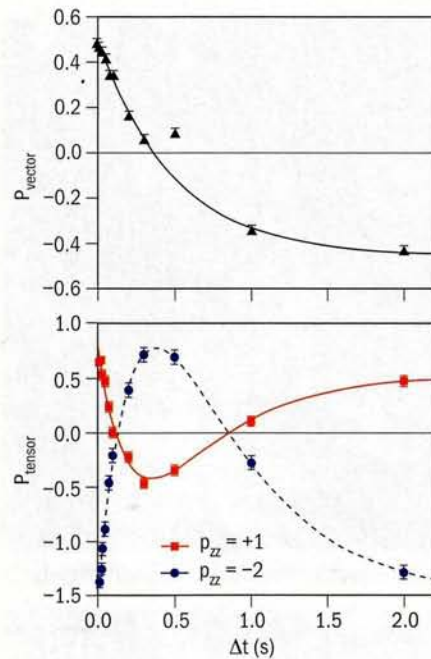
Deuterons display surprising spin gymnastics

Just before the Cooler Ring at the Indiana University Cyclotron Facility (IUCF) passed into history, it produced another impressive result using the ring's unique accelerator physics capabilities. A team of accelerator spin physicists from Michigan and Indiana, led by Alan Krisch, used their RF-solenoid once again to spin-flip a beam of stored polarized particles. However, in this case the particles were not spin-1/2 Fermi-Dirac protons or electrons, but instead were spin-1 Bose-Einstein deuterons, and the results were quite surprising.

Manipulating a deuteron's spin is much harder than manipulating a proton's spin because the deuteron's anomalous magnetic moment is more than 12 times smaller. However, Vassili Morozov, a graduate student, found ways to strengthen the RF-solenoid's strength to its limit, so allowing a first glance at the behaviour of spin-1 particles when their spin is manipulated.

Polarized beams of spin-1/2 protons and electrons are not only easier to spin-manipulate, they are also easier to understand, since their classical spin motion in a ring's magnetic field can only be either counter-clockwise (up) or clockwise (down). The well known polarization of a beam of protons or electrons is simply the difference between the fractions of the beam spinning in these two directions. The vector polarization of a beam of spin-1 deuterons is defined in the same way; however, the vector polarization alone does not fully describe spin-1 particles. There is also a tensor polarization, which involves the fraction of deuterons spinning (classically) in any and all sideways directions perpendicular to the ring's magnetic field. This part of the classical picture for spin-1 particles seems paradoxical.

While the quantum mechanics of spin-1 particles has been known for decades, the behaviour of spin-1 deuterons undergoing



The spin of a stored polarized beam of 270 MeV spin-1 deuterons at the IUCF Cooler Ring. Note the striking behaviour of the spin-1 deuterons' tensor polarization ($P_{zz} = +1$ and -2) as the activation time (Δt) of the RF-solenoid is increased.

spin-manipulation has apparently never been studied experimentally. The upper part of the figure above shows that the deuterons' vector polarization behaviour can be fit to the classical Froissart-Stora equation, as can the polarization of spin-1/2 protons (*CERN Courier* April 2002 p6). The deuterons' vector polarization appeared to be spin-flipped, although with less efficiency due to the smaller anomalous magnetic moment.

By contrast, the behaviour of the tensor polarization was quite striking, and at first surprising. When the spin-manipulating solenoid was activated for a longer time (Δt), both

tensor states ($P_{zz} = +1$ and -2) first reversed their signs as their magnitudes dropped by about 50%. Then, as the spin-manipulation time was further increased, the P_{zz} signs again reversed to their original signs and approached their original values. Notice also that the tensor polarization reached its minimum value at exactly the same place where the vector polarization passed through zero.

It turned out that this striking behaviour of the tensor polarization could be directly related to the vector polarization behaviour by using the known rotational properties of the vector and tensor polarizations of spin-1 particles (see the curves drawn in the figure). This confirmed that polarized spin-1 Bose-Einstein particles were indeed being spin-manipulated. Taken together, the two-part figure shows how all the vector and tensor polarizations of the spin-1 polarized deuteron beam in the Cooler Ring were spin-manipulated and flipped.

Now that the venerable IUCF Cooler Ring has been decommissioned, the Michigan team is continuing deuteron spin-manipulation studies at the 3 GeV COSY Cooler Ring in Jülich, Germany, along with new colleagues from COSY, Bonn and Hamburg, and long-term colleagues from KEK and Brookhaven. In February 2003, the new SPIN@COSY collaboration flipped the first polarized deuteron beam at COSY with about 50% efficiency using a prototype air-core RF-dipole. A new stronger ferrite RF-dipole has recently been successfully tested for use in COSY's polarized deuteron run in December.

Further reading

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K Yonehara *et al.* Proceedings of the Conference on Intersections of Particle and Nuclear Physics, New York, May 2003 (to be published).



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PAKISTAN

Grid technology goes to Pakistan

As a natural extension of its participation in the Large Hadron Collider (LHC) project, Pakistan has begun a deeper involvement in the LHC Computing Grid (LCG). A first step towards this was the Grid Technology Workshop held in Islamabad on 20–22 October, which was organized by Pakistan's National Centre for Physics (NCP) in collaboration with CERN. The primary goal of the workshop was to provide hands-on experience in Grid technology to Pakistani scientists, engineers and professionals, enhancing their skills in Grid-related tools such as Grid architecture, Grid standards and the Globus toolkit.

The workshop was inaugurated by CERN's director-general, Luciano Maiani, who explained that Grid technology will be crucial in exploiting the physics potential of the LHC, which is currently being constructed at CERN by a broad international collaboration that includes Pakistan, as well as China, India, Japan and other eastern and far eastern countries. The inauguration was attended by a number of dignitaries, including Parvez Butt, chairman of the Pakistan Atomic Energy Commission (PAEC), and ambassadors from countries such as Iran, Bangladesh, South Korea and Myanmar. In addition to the participants from Pakistan, several people from CERN attended the workshop.

A variety of talks on the first day was



Participants at the workshop learning about the potential of Grid computing in Pakistan.

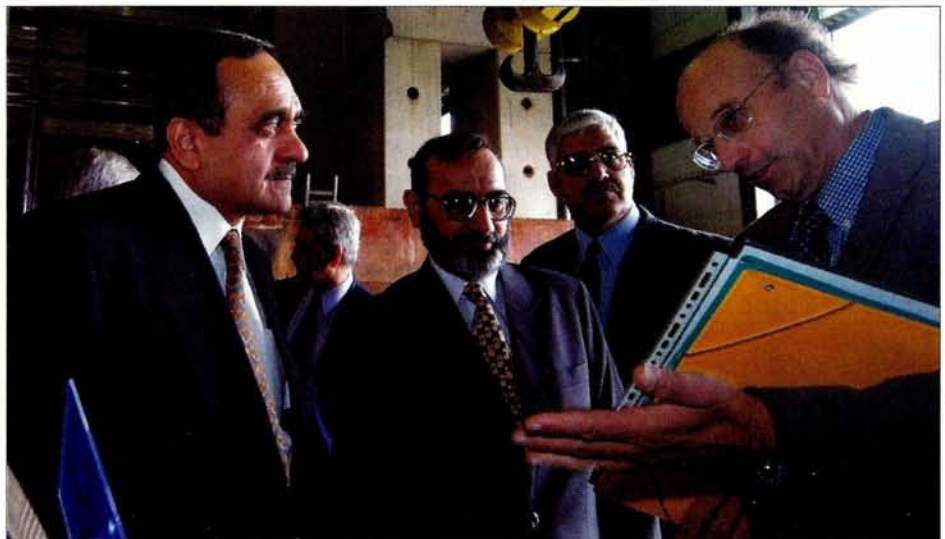
followed by a two-day tutorial session for the 45 participants, who came from 14 different scientific, research and development organizations and universities across Pakistan, including the NCP, the PAEC, the Commission on Science and Technology for Sustainable Development in the South (COMSATS), and the National University of Science and Technology. The Grid tutorials were based on a testbed consisting of nine servers, including computing elements servers, storage element servers, a resource broker server, a server for the Berkeley Database Information Index and

TopGIIS, a Replica Catalogue Server (RLS), and worker node and user interface servers. The host and user certificates for the Grid testbed machines were issued by the French CNRS certificate authority.

The workshop was very well publicized in the local newspapers and on television, and the participants found it both interesting and useful. The next step is to launch an LCG testbed partner site node on the same resources, and the whole exercise will lead to participation in the Data Challenge 2004 (DC04) for LHC computing.

PAEC chairman pays visit to CERN

Parvez Butt, chairman of the Pakistan Atomic Energy Commission (PAEC), visited CERN on 15 October. He is seen here (on the left) in the ATLAS assembly hall with (from left to right) Abdul Hai, Heavy Mechanical Complex-3 project director, Mohammad Naeem, Scientific Engineering Services, and ATLAS spokesperson Peter Jenni. Butt inspected the Pakistan-built saddle supports for the calorimeter, and toured the CMS assembly hall and surface civil engineering works. He also met with members of the Joint CERN-Pakistan Committee.



COSMIC RAYS

Auger ready for ultra-high-energy cosmic rays

With the completion of its 100th surface detector at the end of October, the Pierre Auger Observatory became the largest cosmic-ray air-shower array in the world. The observatory, which aims to detect ultra-high-energy cosmic rays, so far encompasses a 175 square kilometre array of detectors, and will ultimately comprise 1600 surface detectors on 3000 square kilometres of the Argentine Pampa (*CERN Courier* March 2002 p6).

Each Auger surface unit consists of a cylindrical tank filled with 10 000 litres of pure water, a solar panel, and an antenna for wireless transmission of data. Phototubes register Cherenkov light produced in the water by charged particles in cosmic-ray showers, which are triggered at an altitude of 10 to 20 km. The particle showers strike several



In October 2003 Argentinean technicians finished the installation of the 100th surface detector of the Pierre Auger Observatory. (Pierre Auger collaboration.)

tanks almost simultaneously, and the slight differences in the detection times at the various tank positions allows the arrival direction of the cosmic ray to be determined. The Auger

particle detectors are spaced 1.5 km apart in order to sample each air shower's density at numerous locations on the ground.

In addition to the tanks, the observatory will also feature 24 fluorescence telescopes that can pick up the faint ultraviolet glow emitted by air showers in mid-air. The fluorescence telescopes can be operated only during dark, moonless nights, but they provide an independent means of measuring the energy in the showers, and hence of the primary cosmic ray.

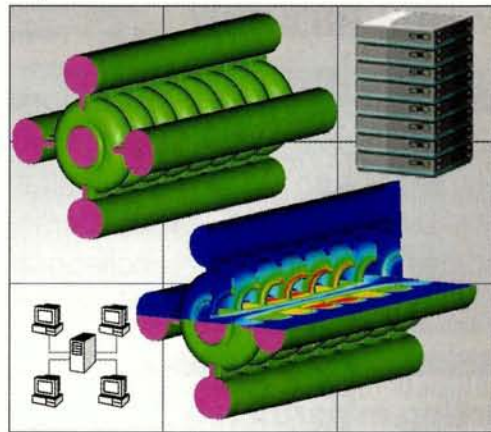
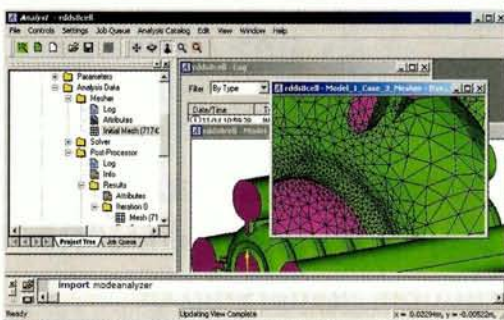
The Pierre Auger collaboration is in the process of preparing a proposal for a second site for its observatory, to be located in the US. Featuring the same design as the Argentinean site, the second detector array would scan the northern sky for the sources of the most powerful cosmic rays.

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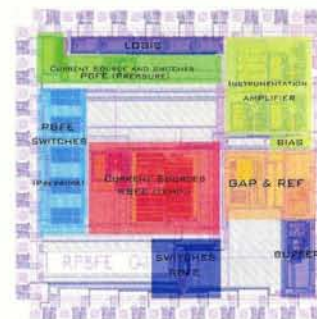
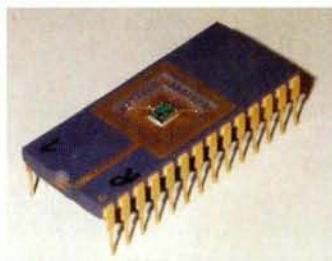
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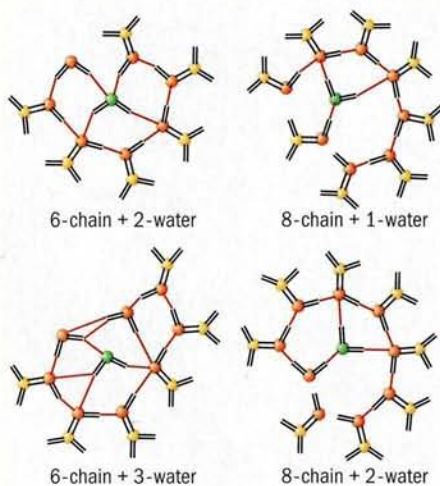
X-ray analysis reveals the wonders of alcohol

Water and alcohol have been found to mix less readily than most people think (perhaps lending support to anecdotal evidence that "artificial vodka", made out of reagent-grade ethanol and fresh water, needs to sit quite a while before it is good to drink).

US and Swedish researchers using the Advanced Light Source at Lawrence Berkeley National Laboratory have used X-ray emission (XE) and X-ray absorption (XA) spectroscopy to study the bonds between molecules of methanol over picosecond and femtosecond timescales. The results not only reveal the incomplete mixing of water and methanol at the molecular level, but also clarify the molecular structure of methanol and cast light on the mixture's thermodynamic properties.

The team has found that liquid methanol consists of both chains and rings of between six and eight molecules. This has reconciled two conflicting views about its structure, both of which had found support in neutron-diffraction studies. When water is added to form an equal mixture, the resulting spectrum is very similar to the added spectra for the two separate liquids.

However, the spectrum of the mixture indicates fewer methanol chains, and further analysis indicates that water molecules bridge the methanol chains to form rings. This, the



Research has shown that methanol chains link up with water to form rings.

researchers say, helps to explain why the increase in entropy is smaller than expected when water and alcohol mix. Certainly there is more to mixing the liquids at the molecular level than is evident in the popular alcohol-water mixtures at the macroscopic level.

Further reading

J-H Guo *et al.* 2003 *Phys. Rev. Lett.* **91** 157401.

Genetic copier is driven by convection

It is always a surprise when a new invention or discovery turns out to have been anticipated by nature, as with the 2 billion year old natural reactor at Oklo in Gabon, Africa.

Dieter Braun of Rockefeller University, New York, USA, and colleagues have shown that the polymerase chain reaction (PCR), which is nowadays used to copy DNA in huge quantities in laboratories around the world, may occur naturally, driven by the simple process of convection.

In the laboratory, DNA is mixed with an

enzyme and cycled through temperatures between 60 and 90 °C. The new idea here is that volcanic vents in the ocean might push chemical mixtures from a hot region near the vent to cooler regions. There, the mixtures' temperature would drop, allowing them to fall back towards the vent, to repeat this motion and form a convection cell where PCR or similar reactions could occur automatically.

The same process could also take place on a smaller scale anywhere that such convection cells form, and could offer an important hint as to how life began.

Further reading

Dieter Braun *et al.* 2003 *Phys. Rev. Lett.* **91** 158103.

Superconductor makes light work

A new pixellated device that could detect not only the position of an arriving photon, but also its energy, has been proposed by Peter Day and Henry LeDuc of the Jet Propulsion Laboratory, together with Jona Zmuidzinas and colleagues at Caltech.

The device exploits the change in kinetic inductance of a small superconductor when some of its Cooper pairs are broken up by an incident photon. The higher the energy of the photons, the more pairs are broken up, and the more slowly a current can respond to outside changes. This effective inductance can be measured with microwave techniques.

While there remains much to be done to make this into a practical imaging device, it could revolutionize astronomy, in particular the measurements of the cosmic microwave background radiation, and lead to many other interesting new applications.

Further reading

Peter K Day *et al.* 2003 *Nature* **425** 817.

Material shows no thermal expansion

A new material made of ytterbium, gallium and germanium has almost zero thermal-expansion coefficient, and, unlike similar substances, conducts electricity.

James Salvador of Michigan State University and colleagues have shown that this intermetallic compound remains the same size between 100 and 400 K. It could have many engineering applications, where high electrical or thermal conductivity is needed in addition to low thermal expansion.

The mechanism is not fully understood, but it seems to be electronic. Electrons move from ytterbium to gallium atoms, making the former shrink while the latter are much the same size. This shrinking just offsets the usual thermal expansion, so the material stays the same size as the temperature changes.

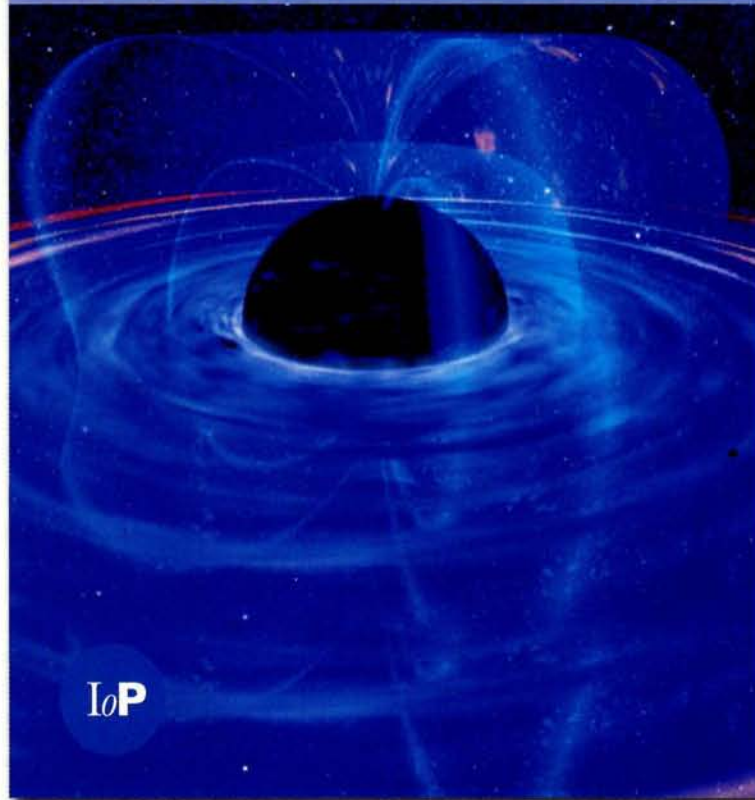
Further reading

James R Salvador *et al.* 2003 *Nature* **425** 702.

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Compiled by Marc Türler

INTEGRAL discovers hidden black holes

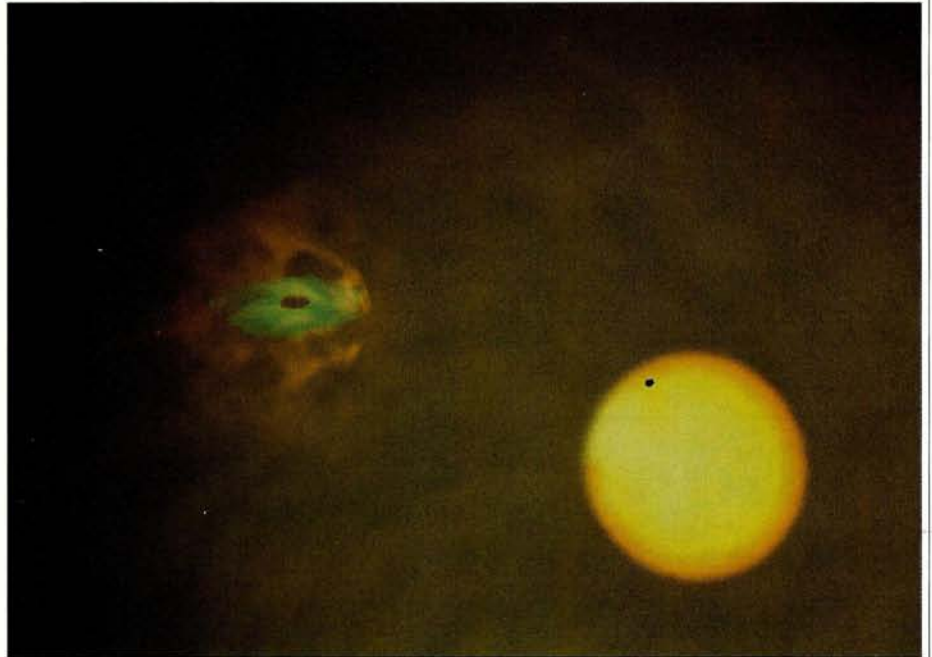
INTEGRAL, the powerful gamma-ray space telescope, has discovered what seems to be a new class of astronomical objects. These are binary systems, probably including a black hole or a neutron star, embedded in a thick "cocoon" of cold gas. They have so far remained invisible to all other telescopes.

This discovery was announced by the European Space Agency (ESA) on 17 October, just one year after the launch of the INTEGRAL satellite to study the most energetic phenomena in the universe (*CERN Courier* October 2002 p10). The first object of this new class, called IGR J16318-4848, was detected by INTEGRAL on 29 January 2003. Because of its similarity to other sources located along the plane of our galaxy, the Milky Way, astronomers concluded that the new object could be a binary system comprising a compact object, such as a neutron star or a black hole, and a companion star.

When gas from the companion star is accelerated and swallowed by the compact object, radiation is emitted at all wavelengths, from gamma rays through to visible and infrared light. About 300 such binary systems are known to exist in our galaxy and are well observed in X-rays, so why had IGR J16318-4848 not been discovered before?

One possible explanation is that it had remained invisible because it is heavily obscured by the surrounding material. As gamma rays are absorbed less by dust and gas than less energetic radiation this could explain why space telescopes that are sensitive to X-rays had overlooked the object, while INTEGRAL, which is specialized in detecting more energetic gamma-ray emission, did see it.

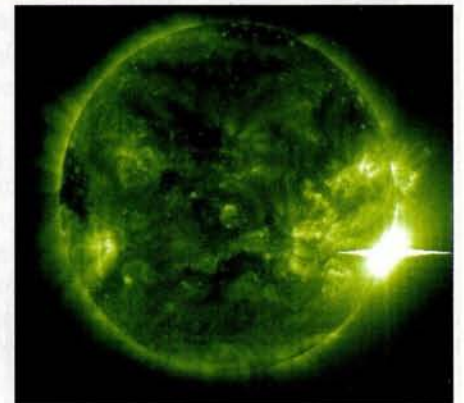
To test this interpretation, astronomers turned to ESA's XMM-Newton space observatory, which observes the sky in X-rays. XMM-Newton detected IGR J16318-4848 last February, and the observations suggest the existence of a dense cocoon of cold gas with a diameter of about the size of the Earth's orbit around the Sun. The obscuring material forming the cocoon is probably "stellar wind", namely gas ejected by the supermassive companion star. Astronomers think that this gas may be accreted by the black hole, forming a dense shell around it. This obscuring cloud traps most of the



An artist's impression of a binary system as discovered by INTEGRAL, in which the light emitted near the black hole shown on the left is heavily absorbed by the strong stellar wind ejected from the supermassive companion star shown on the right. (ESA.)

Picture of the month

The solar X-ray flare of 4 November 2003 was the strongest recorded since the 1970s. The flare itself is seen here at the lower right of this dramatic extreme ultraviolet image of the Sun captured by the EIT camera aboard the SOHO spacecraft. The horizontal structure across the flare is due to pixel saturation. When this historic flare occurred, the giant sunspot region at its origin was just about to rotate around the Sun's western edge, becoming hidden from our view for two weeks. (SOHO – EIT Consortium, ESA, NASA.)



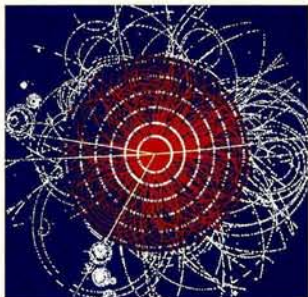
energy produced inside it.

The main author of these results, Roland Walter of the INTEGRAL Science Data Centre in Switzerland, explained: "Only photons with the highest energies (above 10 keV) could escape from that cocoon. IGR J16318-4848 has therefore not been detected by surveys performed at lower energies, nor by previous gamma-ray missions that were much less sensitive than INTEGRAL."

The question now is to find out how many of these objects lurk in the galaxy. XMM-Newton and INTEGRAL together are the perfect tools for the job. They have already discovered two more new sources embedded in obscuring material, and future observations are planned.

Further reading

R Walter *et al.* 2003 *Astronomy and Astrophysics* **411** L427.



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Image shows a simulation by the ATLAS experiment of the decay of a Higgs boson into four muons (yellow tracks).



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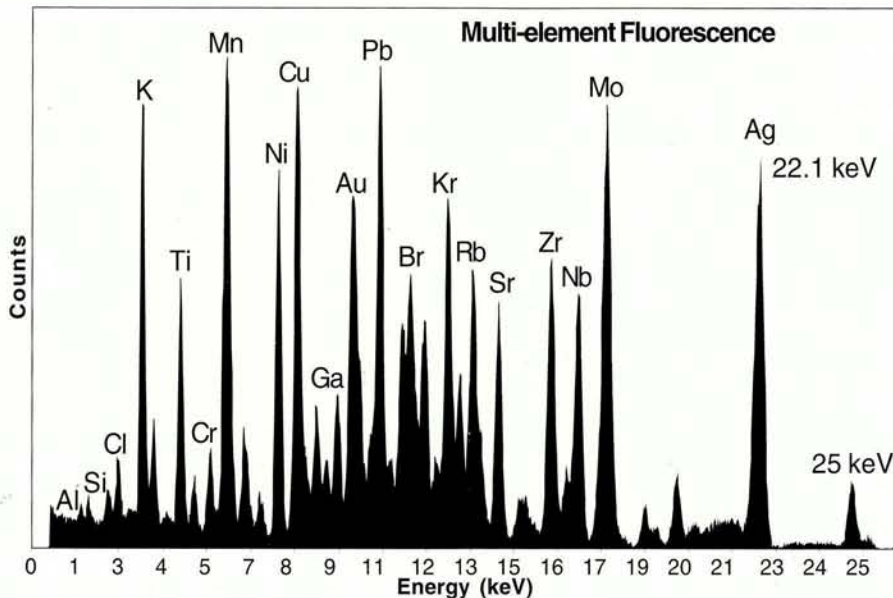
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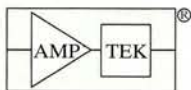
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Developing countries and the global science web

Enabling scientists from developing countries to bridge the gap between rich and poor depends on closing another gap – the “digital divide”. Now the technology exists to monitor this divide, and it reveals some alarming results.

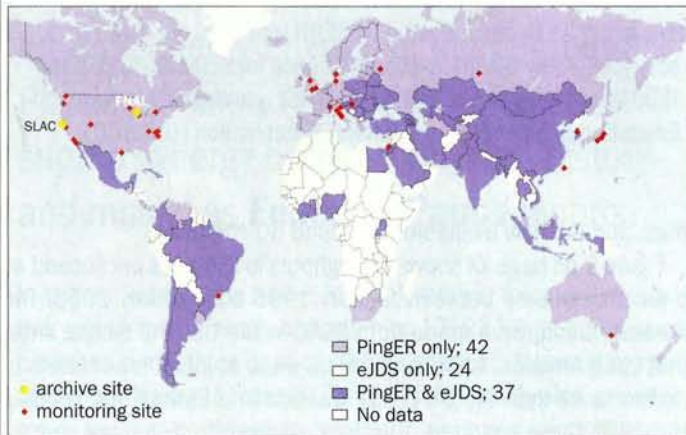


Fig. 1. The countries covered by the SLAC/PingER project, which measures the return time of an Internet packet between a monitoring site and the remote site, and by the electronic Journals Delivery Service (eJDS).

Most developing countries experience great difficulties because of adverse economic conditions and political instability, which means they lag behind in scientific and technological development. Building science facilities can be very expensive, so there is the potential for an enormous gap between the rich and the poor. However, science has been quite successful in leap-frogging this gap, enabling scientists from developing countries to participate in many scientific activities. This has taken many forms, including the interaction between scientists by e-mail, and visits by senior scientists and graduate students. Large facilities have also opened their doors to scientists from economically disadvantaged countries (see *CERN Courier* July/August 2003 p26), literature and equipment has been donated by both organizations and individuals, and conference access has been made available.

With the advent of the World Wide Web and the rapid exchange of information via the Internet, one might naively have thought that much of the gap between developed and developing nations would disappear, even if problems still persisted for those areas of science that need expensive facilities. However, access to information, peer reviewed or not, depends on having the appropriate hardware,

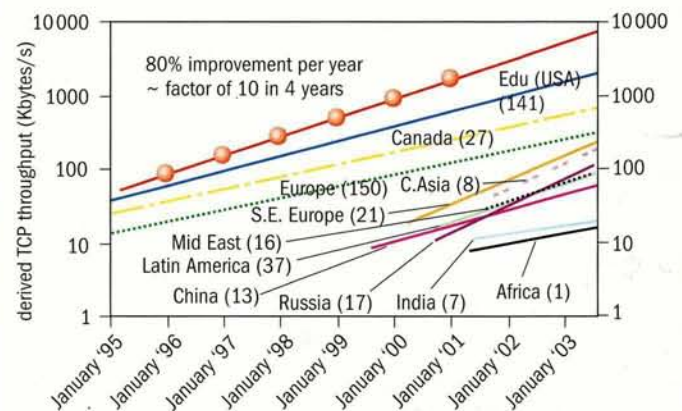


Fig. 2. Trends in derived throughput performance from North America to the different regions of the world. The numbers in parentheses are the number of pairs of monitoring and remote hosts included in the measurements.

i.e. a computer, and Internet connectivity, and there is a serious problem with access to the Internet in developing countries. Gaining access to a computer is more of a question of economics, and one that we will assume will somehow be overcome. In this article we will instead concentrate on the issue of Internet connectivity.

Most of the countries with the lowest income economies have or have had serious problems with bandwidth, as well as with the high cost of access to the Internet. The high cost of connectivity is mainly due to the monopolies that communication companies are able to establish in developing countries. These costs, added to the low bandwidth, do not allow scientists to have timely access to information. In addition, there is also the expense of scientific literature, which is often prohibitive.

In most cases scientists in basic research do not attach economic value to their product, and so are willing to share their knowledge with fellow scientists, independent of their nationality or race. In addition, many scientific publishing companies are run at least partially by scientists, and most are willing to allow those from disadvantaged countries to access their journals, despite the usual high prices. This has given birth to some very successful initia- ▸

tives in areas such as medicine (HINARI – Health InterNetwork Access to Research Initiative), biology (PERI – Programme for the Enhancement of Research Information), agriculture, fishery and forestry (AGORA – Access to Global Online Research in Agriculture), and physics, mathematics and biology (eJDS – electronic Journals Delivery Service). These are run by the World Health Organization, the International Network for the Availability of Scientific Publications, the Food and Agriculture Organization of the United Nations, and the Abdus Salam International Centre for Theoretical Physics (ICTP), respectively, in strict collaboration with major publishing companies and societies.

All these initiatives, even if they use different ways to access the sources of information, have a common characteristic: they allow scientists in the least-developed countries (individually, or through their libraries) to access the best and most appreciated literature in their fields. And in most cases this access is free.

Renowned Ghanaian scientist Francis Allotey, who is active in the politics of science in Ghana, has said: “We paid the price for not taking part in the Industrial Revolution of the late eighteenth century because we did not have the opportunity to see what was taking place in Europe. Now we see that information and communication technology (ICT) has become an indispensable tool. This time, we should not miss out on this technological revolution.”

Up until a year ago it was not clear, despite the efforts of many, whether bridging the digital divide with Africa would be feasible. However, at a recent meeting in Trieste, “Open Round Table on Developing Countries Access to Scientific Knowledge: Quantifying the Digital Divide”, we were able to see that some of the African countries had come up with very ingenious ideas to keep up with ICT. It is clear that Africa has decided to take Allotey’s words to heart, and has engaged in whatever may be necessary to bridge the technological divide. It is therefore more important than ever that the efforts to help them that have already begun do not stop; the results are there to see. If this ICT revolution is not to be missed, scientific institutions must keep up to date, and this in turn relies on the Internet connectivity of these institutions. But do they have it?

For the first time, at the same round table, Les Cottrell of SLAC, Warren Matthews of the Georgia Institute of Technology and Enrique Canessa of ICTP, Trieste, presented results on the connectivity of institutions in Third World countries, using measurements performed by the SLAC/PingER project. Figure 1 on page 17 shows all the countries covered by this project, which measures the return time of an Internet packet between monitor sites and remote sites. Monitoring Internet connectivity or Internet performance in this way gives a good idea of trends – who is catching up, who is falling behind – and also allows a comparison of Internet performance with economic indicators. Since it is a quick way of measuring trends in ICT, decisions on investments can be made quickly enough to avoid irreversible damage.

The PingER project started some years ago to monitor Internet performance for data exchange in the large high-energy and nuclear-physics collaborations around the world. Recently, following an agreement with the ICTP and eJDS, the measurements have been extended to a selection of institutional hosts in developing coun-

The RSIS conference



The Role of Science in the Information Society (<http://cern.ch/rsis>) is a conference on the potential uses for information and communication technologies in ensuring universal and equitable access to scientific data and information. It will precede the **World Summit on the Information Society**, which is being held this month in Geneva. Hosted by CERN, the RSIS event is co-organized by the International Council for Science (ICSU), the Third World Academy of Science (TWAS) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

tries, and are now available for around 80 countries.

Figure 2 on page XX shows throughputs in kilobytes per second as a function of time between January 1995 and January 2003. The measurements were made from SLAC in the US. The results show that Latin America, China and Africa, while at much lower levels of performance than the US (Edu), Canada and Europe, are keeping pace with these countries. Russia is quickly improving, but surprisingly India is lagging behind. This is a piece of information that should worry policy makers in India, as it is a country with a very well developed ICT. So why are their institutions behind? Part of the reason may be the choice of hosts being monitored in India, which are at academic and research institutions. But even so, this means that some institutions are very backward, with very poor connectivity.

The amount of data gathered is not enough to give a complete picture of the whole world, but it does show that the technology to monitor is there. Policy makers from developing countries can benefit from the data, since the information is freely available on the eJDS website (www.ejds.org). Moreover, it can also help when large funding agencies decide to invest in development, and will give an idea of the performance of the various countries. This measure of connectivity should be considered as a new variable in the complex field of economics.

Further reading

For the proceedings of the round table meeting, see www.ejds.org/meeting2003/ictp/programme/.

Hilda Cerdeira, Enrique Canessa and Carlo Fonda, Abdus Salam International Centre for Theoretical Physics, Trieste, and **R Les Cottrell**, SLAC. Cerdeira is a member of the International Advisory Committee for the conference on *The Role of Science in the Information Society*.

Physics from heaven and Earth

The International Europhysics Conference on High Energy Physics of the European Physical Society (HEP–EPS) provided a superb synergy between physics, history and music, as **Felicitas Pauss** reports.

In the tradition of the HEP–EPS conferences, the meeting hosted this year by the University of Aachen on 17–23 July offered two well-balanced parts: three days of parallel sessions, followed by review talks from invited speakers. This formula, which also provides a forum for younger physicists, resulted in a rich and informative set of parallel sessions, illustrating the scientific progress made during the past two years. HEP 2003 also presented a good balance between news “coming from the Earth” (colliders and “terrestrial” neutrino physics) and results “coming from heaven” (astroparticle physics and cosmology).

The plenary meeting was opened by the presentations of EPS prizes to David Gross, David Politzer and Frank Wilczek (the High Energy and Particle Physics Prize), Nima Arkani-Hamed (the Gribov Medal), Guillaume Unal (the Young Physicist Prize), and Rolf Landua and Nicholas Tracas (the Outreach Prize) (*CERN Courier* September 2003 p41). Also during the conference the EPS HEP Board held a special meeting and elected Jose Bernabeu of Valencia as its chairperson, who replaces Michel Spiro of IN2P3 in France.

The scientific plenary sessions began with a very stimulating talk on the birth of neutrino astrophysics by the 2002 Nobel laureate Masatoshi Koshihara of Tokyo. Pippa Wells of CERN then summarized the close-to-final results from the era of the Large Electron–Positron Collider (LEP) and the SLAC Linear Collider (SLC) and the impact they had on electroweak theory. In nearly all domains the quality and accuracy of the final results on Z and W physics were much better than predicted – as, for instance, at a meeting also held in Aachen, 16 years ago, as Daniel Treille from CERN recalled. Summarizing the whole set of available electroweak measurements by performing a global fit shows that the Standard Model (SM) accounts for the data in a satisfactory but imperfect way: the prob-



A stimulating start: 2002 Nobel prize-winner Masatoshi Koshihara delivered the opening talk of the Aachen conference.

ability of the fit is only 4.5%. However, this value increases to 27.5% if the measurement of the weak mixing angle by the NuTeV experiment at Fermilab is excluded. This is the most outlying measurement, but it is suspected that there are “standard” explanations. The other noticeable disagreement unfortunately concerns the two most precise electroweak measurements, namely the spin asymmetry (A_{LR}) at SLC and the forward–backward asymmetry of beauty production (A_{FB}^b) at LEP. These give values of the weak mixing angle differing by 2.9σ , with no hint of an explanation. Ignoring this disagreement and considering only the mean value of the results leads in the strict frame of the SM to the preferred Higgs mass region of $m_h = 91_{-37}^{+58}$ GeV ($m_h \leq 219$ GeV at 95% CL).

An ambiguity that is not yet resolved concerns the theoretical interpretation of the muon $g-2$ measurement obtained in Brookhaven with an experimental accuracy of around 7×10^{-7} . To predict its value requires the inclusion of subsidiary experimental data. Using the hadronic tau-decays leads to a fair agreement between theory and experiment, whereas using hadronic production in low-energy e^+e^- collisions results in an excess of around 2.5σ of experiment over expectation. This disagreement needs further study, especially because the $g-2$ observable is potentially a powerful sign of new physics, in particular of supersymmetry (SUSY).

Beyond the Standard Model

Moving on to the searches for new physics, Arnulf Quadt of Bonn gave an exhaustive review of the direct searches at colliders and updated the existing limits. Unfortunately, besides the D_{sJ} particle found by the B-factories and the pentaquark (see p5) – presented in a special talk by Frank Wilczek from MIT – no discovery has shown up at the high-energy frontier. Nevertheless, the motivation to go beyond the SM is more compelling than ever. Traditionally the routes leading beyond the SM either call for new levels of structure and/or new forces, as technicolour does, or involve an additional symmetry, as in the case of SUSY. Here SM particles and their “superpartners” conspire to solve the hierarchy problem.

While technicolour meets serious problems in passing the \triangleright

tests of electroweak measurements, SUSY, widely discussed in Aachen, keeps its eminent merits. An important and well-known result, derived from LEP data, is the quasi-perfect convergence near 10^{16} GeV of the electromagnetic, weak and strong coupling “constants” in the frame of SUSY.

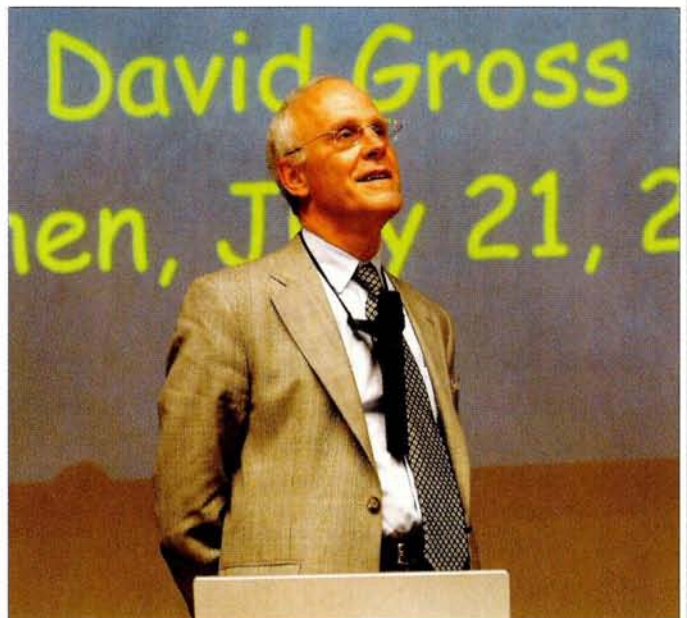
With the diversity of its possible breaking mechanisms, SUSY presents a complex phenomenology with many different mass spectra possible for the supersymmetric particles. However, its minimal version offers a golden test: it predicts a very light Higgs boson, i.e. ≤ 130 GeV (for $m_{top} = 175$ GeV) and even less for all versions of supergravity that are currently considered as reference points for the future. The final lower mass limit of direct searches at LEP is 114.4 GeV, with a 1.7σ effect near 115 GeV. The whole mass window could have been covered with 80 additional superconducting cavities (i.e. 30% more) and the magnificent performances of the accelerating field finally reached at LEP, and its exploration remains the first objective of future research programmes. If SUSY represents the truth, the Large Hadron Collider (LHC) at CERN, or maybe, with much luck and considerable improvements, the Tevatron at Fermilab, will discover SUSY by observing some supersymmetric particles besides the light Higgs boson. But a linear collider will be needed to complete precise measurements in the mass domain such a machine would access.

Other interesting new routes beyond the SM have appeared in recent years and were summarized by Lawrence Hall of Berkeley and Ferruccio Feruglio from Padova, while Jose Barbon of CERN presented the state of the art in the field of superstrings. The “little Higgs” scenario leaves aside the big hierarchy problem for the time being, and tackles first the small hierarchy one, namely the fact that LEP has suggested a light Higgs boson while it pushes beyond several tera-electron-volts all new physics (except SUSY, which can still be “behind the door”). The other new road postulates the existence of extra new dimensions of space, large enough to generate visible effects at future experiments. Such an eventuality – so far uncontradicted by experiments – has to be fully explored and would be an extraordinary opportunity for the LHC. However, as recalled by Treille, it is important to appreciate correctly the existing limits, drawn either from accelerators or from astrophysics.

QCD, beauty and heavy ions

Peter Schleper of Hamburg illustrated the numerous experimental successes of quantum chromodynamics (QCD), the theory of the strong interaction. The values of $\alpha_s(M_Z)$ obtained from very different sectors are now in very good agreement. The nucleon structure and the parton distributions are increasingly better known and understood, thanks especially to HERA at DESY. However, when spin intervenes, our understanding of hadrons is still poor. Pilar Hernandez of Valencia emphasized the progress of lattice simulations, which have become basic tools, crucial for many domains. It is important to underline that much remains to be done in matters of QCD if we are to enter the LHC era in optimal conditions, i.e. with a very good understanding of the SM prediction for the many different topologies that searches will explore. This is particularly true for the indispensable Monte Carlo programs.

Sheldon Stone of Syracuse and Hitoshi Yamamoto of Tohoku



David Gross was awarded the 2003 EPS High Energy and Particle Physics Prize, with David Politzer and Frank Wilczek (see right).

described in great detail the impressive progress of beauty physics. One must first underline the remarkable performances of the B factories, in particular of KEKB in Japan, the first machine to deliver a luminosity of 10^{34} cm⁻² s⁻¹. It is clear that a very successful first round of experiments has been accomplished. The direct measurement of one of the angles of the unitary triangle (called β or ϕ_1 , depending on the continent) via the very clean mode $B \rightarrow J/\psi K_S$ is in excellent agreement with the determination of the tip of the triangle through the measurement of its sides made during the past decade from B and K physics results at LEP and elsewhere. This is another important success of the SM.

However, revealing new physics calls for a much better accuracy. The roadmap, concerning this second round of measurements, defines an ambitious programme, which involves many different beauty decay modes and is extremely demanding from the experimental as well as from the theory side, as described in detail by Thomas Mannel from Karlsruhe. Equally promising are rare K and μ decay modes where the expected performance is very impressive indeed, as for instance in future searches at the Paul Scherrer Institute (PSI) for $\mu \rightarrow e\gamma$ with a sensitivity of 10^{-14} .

Saskia Mioduszewski from Brookhaven reviewed results coming from gold-gold collisions up to 200 A GeV produced at Brookhaven’s Relativistic Heavy Ion Collider (RHIC). The most prominent signatures that could reveal a quark-gluon plasma are not yet available from RHIC, but results are still coming from the Super Proton Synchrotron (SPS) at CERN. For example, the J/ψ suppression, confirmed by the analyses of CERN’s NA50 experiment, keeps all its interest. Unfortunately no unique prediction of this effect exists for RHIC and the LHC. More data are needed: the next should come from the PHENIX experiment at RHIC and from NA60 at CERN.

Hitoshi Murayama and Kevin Lesko, Berkeley, shared the review of neutrino physics, which is in a truly revolutionary era. After the triumph of the SuperKamiokande experiment in Japan, the recent



Frank Wilczek, in addition to receiving his award, delivered a special plenary talk on the subject of pentaquarks.

results of the KEK to Kamioka (K2K) neutrino-oscillation experiment, the Sudbury Neutrino Observatory (SNO) and the Japanese reactor experiment KamLAND have strengthened our knowledge of neutrino oscillations. The main open question is whether there exists a fourth neutrino, of a sterile nature, as suggested by the Liquid Scintillator Neutrino Detector (LSND) at Los Alamos, but strongly disfavoured by the other results. Fermilab's MiniBooNE experiment will settle the matter in the coming years. The big unknown now is the magnitude of the third mixing angle θ_{13} of the neutrino-mixing matrix. Its value will reveal if the ultimate stage in neutrino physics, namely the measurement of CP violation in this sector, is accessible or not.

Oscillations give access only to mass differences. To know the absolute mass values one must consider the beta decay of tritium, which, through its end-point, gives access to m_{ν_e} (present limit at 2.2 eV from Mainz and Troitsk, future one near 0.2 eV from KATRIN in Karlsruhe), and neutrinoless double beta decay. The existence of the latter would imply that the neutrino is of Majorana type. Interesting news concerning neutrino physics also came from cosmology. A combination of the results from the Wilkinson Microwave Anisotropy Probe (WMAP) and the 2dF Galaxy Redshift Survey seems to indicate that $\Sigma m_{\nu_i} \leq 0.71$ eV. This limit implies a mass range for the heaviest neutrino of $0.03 \leq m_3 \leq 0.24$ eV (95% CL). However, at the meeting Steen Hannestad of Odense called for some caution in deriving such limits.

Cosmic particles

Astroparticle physics, covered partly by the plenary talk of Stefan Schael from Aachen and quite abundantly in parallel sessions, is a vast domain, now concerning all types of particles. One of the goals is to extract information about cosmological objects or events, and the number of such non-accelerator research programmes is increasing very rapidly.

The enigma of ultrahigh-energy cosmic rays, beyond the Greisen-

Zatsepin-Kuzmin (GKZ) cut-off, remains unsolved. Even their existence is still to be demonstrated definitively, as current experiments cannot settle the issue. The Pierre Auger Observatory, now in its initial phase (see p11), should provide the answer and perhaps say something about their nature. The main objective of gamma astronomy, on the other hand, is to fill the gap between low energies (a few giga-electron-volts, the domain of satellites) and high ones (a few hundred giga-electron-volts, the threshold of ground-based detectors up to now). Preliminary results from HESS in Namibia and the imminent start of MAGIC on La Palma (see p7) were reported in the parallel sessions. Astrophysics of high-energy neutrinos, detected either by atmospheric Cherenkov telescopes, such as AUGER and the Extreme Universe Space Observatory (EUSO) under study, or by sub-ice experiments, such as AMANDA and its successor ICECUBE at the south pole, and submarine experiments, such as ANTARES in the Mediterranean Sea (*CERN Courier* June 2003 p22) and NESTOR in Greece (*CERN Courier* November 2003 p23), is certainly a fascinating objective. However, the proof of principle has still to be demonstrated and no detection of high-energy neutrinos of extra-terrestrial origin has been reported so far.

The content of the universe

As for cold dark matter, whose contribution to the content of the universe has been accurately determined by WMAP (23%), the search is in full swing. For the baryonic part (4.4%), the possibility that it could be due mostly to dark objects like "failed stars" is now excluded. Instead, gas and dust may be the answer. For non-baryonic dark matter, the neutralino (the lightest SUSY particle) and the axion are still the favoured candidates. The DAMA experiment at the Gran Sasso National Laboratory (LNGS), now with a further year of data, continues to present a result that suggests a seasonal variation in its counting rate, for a very low threshold. An unidentified systematic effect is not excluded and it is important to confirm this observation in an independent manner. Neither the Cryogenic Dark Matter Search (CDMS) nor the EDELWEISS experiment under the French Alps confirms it, and at first sight they seem to exclude the mass and cross-section regions corresponding to the DAMA effect. However, this conclusion has to be considered with caution, given the very low threshold used by DAMA, as well as the potential role of spin-dependent interactions.

A striking result from 2003, well illustrated in Aachen by Schael, is WMAP's measurement of the power spectrum of the microwave background with a much better accuracy than previously. From the position and the respective heights of the observed peaks, a large number of cosmological parameters have been extracted with an impressive accuracy. The flatness of the universe seems in particular to be proven without ambiguity. As Viatcheslav Mukhanov of Munich underlined in his lively talk, WMAP appears to have confirmed two of the three major predictions of inflation: the flatness of the universe, linked to the superluminal expansion, and the existence of density perturbations corresponding to a quasi scale-invariant spectrum (inflation actually predicts a slight deviation from invariance, which still needs experimental confirmation). The third prediction, the existence of gravitational waves originating from inflation, is out of reach of the interferometer experiments, including the space mission ▷

LISA. However, relevant information can come from the experimental programmes able to measure the cosmic microwave background radiation (CMBR) polarization, in particular WMAP itself and, later, the PLANCK mission. On the contrary, the various models of inflation on the market are still rather unconstrained by the present data and the nature of the inflation remains a deep mystery.

R&D on the road ahead

The most innovative aspects of instrumentation were reviewed by Daniel Fournier of Orsay. All the breakthroughs he described could happen only as a result of long and vigorous R&D activity: its continuation is a key for the future of our field. As David Stickland of Princeton illustrated, this must be accompanied by a mutation of the computing means and of the distribution of information on a worldwide scale: this is the aim of the Grid.


An important part of the conference was devoted to the Road Map for High Energy Physics discussed in a joint session of the European Committee for Future Accelerators (ECFA) and EPS. This round table was supplemented by a comprehensive review from Cornell's Maury Tigner of accelerator R&D. The near future is clearly dominated by the LHC, which should start up in 2007. It is well-known, but it is important to recall the challenge of the LHC (the machine as well as the detectors), the vital importance of its success and the enormous physics potential it offers. Given the

timescale that a new project implies, it is however crucial to plan the longer-term future. The choice of an e^+e^- linear collider, which should complement the LHC through the accuracy of its measurements, is unanimous. This too is a difficult enterprise that requires intense accelerator R&D, as Tigner discussed. He also argued for a stronger involvement by high-energy physicists in the R&D of accelerator physics. This important suggestion – influencing the future of particle physics – should be supported.

Treille gave an impressive conference summary. He highlighted the most important results presented and included additional information, thus giving a very comprehensive overview of the present status and future perspectives of our field. The résumé presented here is certainly influenced by this concluding talk.


This conference in the beautiful town of Aachen was organized in an exemplary way. The participants enjoyed not only a very stimulating conference, but also a welcome reception by the city of Aachen in the "Aula Carolina", a place of ancestral dignity, and an exceptional event on Monday evening – a performance of Verdi's *La Traviata*, arranged specially for this conference. Christoph Berger and his local organizing committee did an outstanding job indeed. They have set high standards for the forthcoming 2005 EPS HEP conference, which will take place in Portugal.

Felicitas Pauss, ETH Zürich.



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Can companies benefit from Big Science?

The findings of a recent study reveal the significant and widespread impact on high-tech companies of contracts with CERN.

Several studies have indicated that there are significant returns on financial investment via "Big Science" centres. Financial multipliers ranging from 2.7 (ESA) to 3.7 (CERN) have been found, meaning that each Euro invested in industry by Big Science generates a two- to fourfold return for the supplier. Moreover, laboratories such as CERN are proud of their record in technology transfer, where research developments lead to applications in other fields – for example, with particle accelerators and detectors. Less well documented, however, is the effect of the experience that technological firms gain through working in the arena of Big Science. Indeed, up to now there has been no explicit empirical study of such benefits.

We have therefore analysed the technological learning and innovation benefits derived from CERN's procurement activity during 1997–2001. Our study was based on responses from technology-intensive companies of some financial significance. The main aim was to open up the "black box" of CERN as an environment for innovation and learning. Our findings reveal a variety of outcomes, which include technological learning, the development of new products and markets, and impact on the firm's organization. The study also demonstrates the importance of technologically challenging projects for staff at CERN. Together, these findings imply ways in which CERN – and by implication other Big Science centres – can further boost technology transfer into spill-over benefits for industrial knowledge and enhance their contribution to industrial R&D and innovation.

The method and sample

The empirical section of the study had several parts. First, a series of case studies was carried out, to develop a theoretical framework describing influences on organizational learning in relationships between Big Science and suppliers. The theoretical framework for the study is indicated in figure 1. A wide survey of CERN's supplier companies was carried out from autumn 2002 to March 2003. Finally, a parallel survey was carried out among CERN staff responsible for coordinating purchase projects in order to explore learning effects and collaboration outcomes at CERN.

The focus of the survey was CERN-related learning, organizational and other benefits that accrue to supplier companies by virtue of their relationships with CERN. The questionnaire was designed according to best practice with multi-item scales used to measure

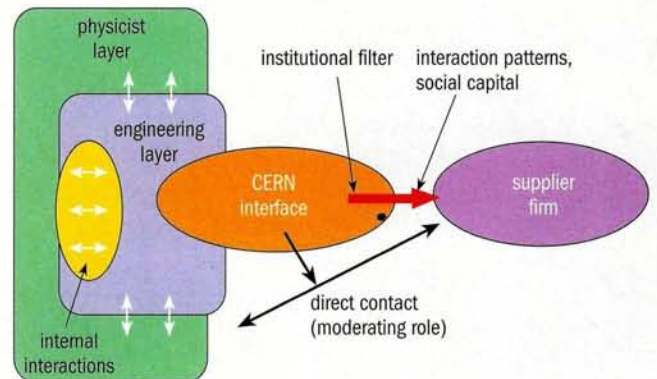


Fig. 1. The theoretical framework of the study.

both predictor and outcome variables. All scales were pre-tested in test interviews, and the feedback was used to iron out any inconsistencies and potential misunderstandings.

The base population of the study consisted of 629 companies – representing about 1197 million SwFr (€768 million) in procurement – which were selected as being technology-intensive suppliers with order sizes greater than 25 000 SwFr (€16 000). This base population was selected from a total of 6806 supplier companies, which generated supplies worth 2132 million SwFr (€1368 million) during this period (see table overleaf). The selection procedure therefore indicates that around 10% of CERN's suppliers are firms that are both genuinely technology-intensive and also of some financial significance; when combined, they represent more than 50% of CERN's total procurement budget during the period under study. We received 178 valid answers to our questionnaire from 154 of these companies, most of which were still supplying high-technology products or services to CERN beyond 2001. These answers formed the basis for our statistical study.

The findings

The learning outcomes documented in the study range from technology development and product development to organizational changes. The main findings show that while benefits vary extensively among suppliers, learning and innovation benefits tend to occur together: one type of learning is positively associated with other types of learning. Technological learning stands out as the main driver. Indeed, 44% of respondents indicated that they had acquired significant technological learning through their contract with CERN.

The study revealed important signs of development of new businesses, products and services, and increased internationalization ▷

The selection process

Resulting firms	Selection steps	Procurement budget (millions)
6806	companies that had supplier projects with CERN between 1997 and 2001	2132 SwFr (€1368)
1128	selection of technology-intensive procurements according to these criteria: orders exceeding 25 000 SwFr, no civil engineering, no standard products, no services	1324 SwFr (€847)
629	technology-intensive procurements identified from internal CERN interviews	1197 SwFr (€768)
154	178 questionnaires received	503 SwFr (€322)

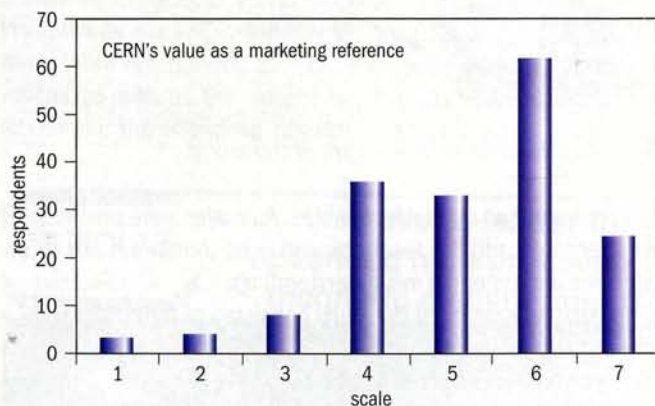


Fig. 2. The great majority of respondents indicated that CERN's value as a marketing reference is strong.

of sales and marketing operations. As many as 38% of all respondents said they had developed new products as a direct result of their contractual relationship with CERN, while some 60% of the firms had acquired new customers. Extrapolating to the base population of 629 suppliers suggests that some 500 new products have been developed, attracting around 1900 new customers, essentially from outside high-energy physics. In addition, 41% of respondents said they would have had a poorer technological performance without the benefit of the contract with CERN, and 52% of these believed they would have had poorer sales.

Virtually all CERN's suppliers appear to derive great value from CERN as a marketing reference (figure 2). In other words, CERN provides a prestigious customer reference that firms can use for marketing purposes. As a result of their interaction with CERN, 42% of the respondents have increased their international exposure, and 17% have opened a new market.

Suppliers also find benefits in terms of organizational effects from their involvement in CERN projects, such as improvements to their manufacturing capability, quality-control systems and R&D processes. In particular, 13% of the respondents indicated that they

had formed new-product R&D teams and 14% reported the creation of new business units. A final aspect of the impact on organizational capabilities concerned project management, with 60% indicating strengthened capabilities in this area.

In examining what determines the outcomes of the relationships between suppliers and CERN, we found that learning and innovation benefits appear to be regulated by the quality of the relationship. The greater the social capital – for example, the trust, personal relationships and access to CERN contact networks – built into the relationship, the greater the learning and innovation benefits. This emphasizes the benefits of a partnership-type approach for technological learning and innovation.

In particular we found the frequency of interaction with CERN during the project to be relevant, together with how widely used the technology was at the start of the project, and the number of the supplier's technical people who frequently interacted with CERN during the project.

During the study we also interviewed physicists and engineers at CERN, to cross check the information provided by the companies. These interviews highlighted the benefits that these interactions with industry have for CERN personnel. We observed that the mutual beneficial effect is independent of the level of in-house experience and participation in high-tech projects, confirming the importance of maintaining an active "industry-Big Science" interaction. Furthermore the results confirmed the importance of technologically challenging projects for the high levels of knowledge acquisition and motivation of highly qualified staff at CERN.

The implications

The study has shown that to a larger scale than foreseen, many suppliers have benefited from technological and other types of learning during the execution of contracts with CERN. The benefits suggest that for companies that are participating in highly demanding and cutting-edge technological projects, conventional procurements and stringent requirements are not the most appropriate modes of interaction, especially if learning and innovation are to be nurtured in the long term. For a Big Science organization such as CERN, some measures to facilitate true partnership and some thoughts on how to maintain the efficiency of the derived benefits for projects with long life-span development, either within the present financial and commercial rules or through other possible routes, will have to be carefully investigated. In particular procurement policy should involve industry early on in the R&D phase of high-tech projects that will lead to significant contracts.

Lastly, note that the methodology developed is not specific to CERN. It would be interesting to determine if and how these findings from CERN compare with those of other Big Science centres.

Further reading

The results of the survey have been published as CERN Yellow Report CERN-2003-005. See <http://preprints.cern.ch/cernrep/2003/2003-005/2003-005.html>.

Erko Autio and Ari-Pekka Hameri, Helsinki Institute of Physics, and **Marilena Bianchi-Streit**, CERN.

Neutral currents and W and Z: a celebration

A special symposium held at CERN in September celebrated the anniversaries of the laboratory's major discoveries that underlie the modern theory of particles and forces.

Twenty years ago, in 1983, CERN announced the discovery of the W and Z bosons, a feat that earned the laboratory its first Nobel prize in 1984. Ten years previously, physicists working at CERN had found indirect evidence for the existence of the Z particle in the "neutral currents". These discoveries together provided convincing evidence for the electroweak theory that unifies the weak force with the electromagnetic force, and that has become a cornerstone of the modern Standard Model of particles and forces.

These breakthroughs brought modern physics closer to one of its main goals: to understand nature's particles and forces in a single theoretical framework. James Clerk Maxwell took the first steps along this path in the 1860s, when he realized that electricity and magnetism were manifestations of the same phenomenon. It would be another hundred years, however, before theorists succeeded with the next stage: unifying Maxwell's electromagnetism with the weak force in a new electroweak theory.

In 1979, three of the theorists responsible for the electroweak theory, Sheldon Glashow, Abdus Salam and Steven Weinberg, were awarded the Nobel prize. In 1984, Carlo Rubbia and Simon van der Meer from CERN shared the prize for their part in the discovery of the W and Z particles. The results ushered in more than a decade of precision measurements at the Large Electron-Positron collider (LEP), which tested predictions of the Standard Model that could be calculated thanks to the work of theorists Gerard 't Hooft and Martinus Veltman, who shared the Nobel prize in 1999.

A big celebration

To celebrate the 30th and 20th anniversaries, respectively, of the discoveries of neutral currents and the W and Z bosons, CERN held a special symposium on 16 September. The authors (some 250) of the papers that announced the discoveries were invited to attend, together with others who had played valuable roles in the development of the Standard Model, including Glashow, Weinberg and Veltman. Weinberg gave the opening talk – a masterful discourse on "The making of the Standard Model". He began in the 1950s, which he described as a time of frustration after the triumph of quantum electrodynamics, before moving on to an account of his own contributions to electroweak theory during the second half of the 1960s. He also mentioned the



The symposium began with a talk by Steven Weinberg (left), who recalled various developments that led to the discoveries of neutral currents and the W and Z bosons. Weinberg shared the 1979 Nobel Prize for Physics with Abdus Salam and Sheldon Glashow, for their work in developing the electroweak theory. One of the many players in the events described by Weinberg was fellow theorist Luciano Maiani (right), CERN's current director-general. In the symposium's final talk he looked forward to the future of particle physics in the era of the LHC at CERN.

work of many other physicists, some of whom were in the audience.

An important step towards confirming electroweak unification came in 1973, when the late André Lagarrigue and colleagues working with the Gargamelle bubble chamber at CERN observed neutral currents – the neutral manifestation of the weak force that had been predicted by electroweak theory but never previously observed. Later in the same decade, Rubbia proposed turning the laboratory's most powerful particle accelerator into a particle collider, an idea that received the support of the then directors-general, John Adams and Léon Van Hove. By colliding counter-rotating proton and antiproton beams head on, enough energy would be concentrated to produce W and Z particles. This was made possible, in particular, through van der Meer's invention of "stochastic cooling" to produce sufficiently dense antiproton beams.

In the second presentation at the symposium, Georgio Brianti described CERN's various contributions to accelerators and beams, beginning in 1961 with van der Meer's invention of the magnetic horn to provide a more intense neutrino beam by focusing the charged particles (mostly pions) that decay to provide the neutrinos. A decade later the Intersecting Storage Rings became the world's first proton-proton collider, and also the test-bed where stochastic cooling was invented. *(text continues on p28.)* ▷



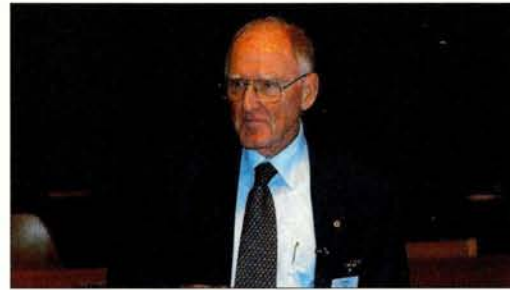
The panel discussion on the future of particle physics was chaired by Carlo Rubbia, who received the Nobel prize in 1984 for his indomitable efforts that led to the discovery of the W and Z particles at CERN in 1983. (Photo: M Jacob.)



Peter Zerwas (left) and John Ellis talk at dinner. At the symposium Zerwas had summarized the achievements of LEP, while Ellis looked forward to the exciting discoveries that await the next big collider, the LHC. (Photo: J-P Revol.)



Don Perkins (right) from Oxford University, who was involved in the discovery of neutral currents with Gargamelle, participated in the panel discussion. Here he takes time at the reception afterwards to talk with Sheldon Glashow (centre) – who shared the 1979 Nobel prize with Steven Weinberg and the late Abdus Salam – and Joan Glashow.



Georgio Brianti, for many years a leading figure in accelerator development at CERN, recalled the contributions of accelerator physicists and engineers in making the discoveries possible.



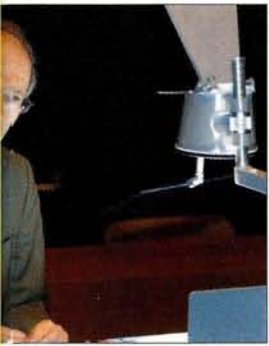
Dieter Haidt discusses the Gargamelle experiment.



In a session on the Large Hadron Collider, Lyn Evans (left), director of the Large Hadron Collider, described the difficulties of building the detectors.



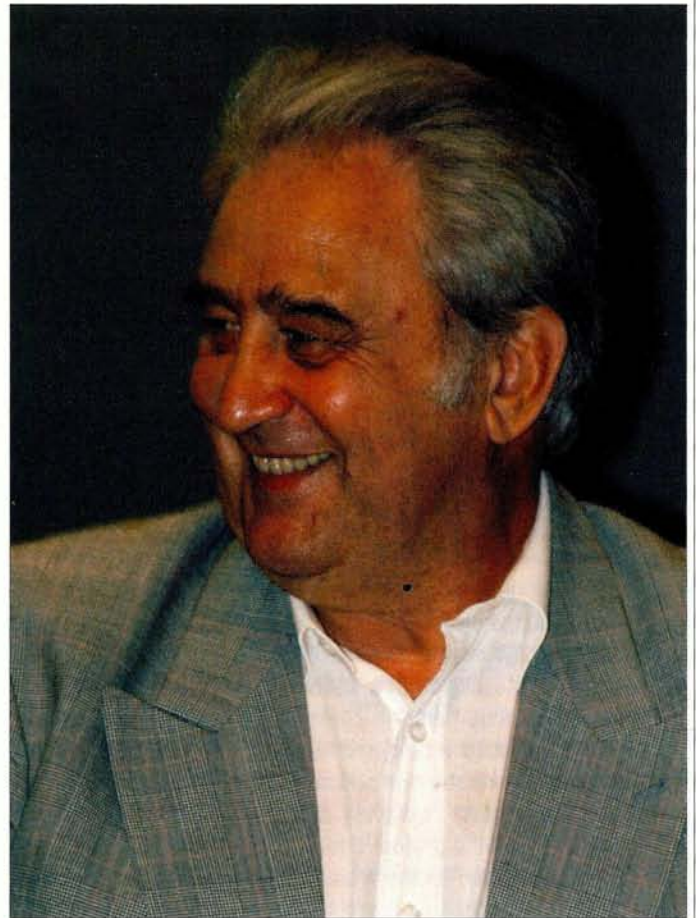
Here 1974 Nobel laureate Sam Ting (left) listens intently, together with John Ellis, Georges Charpak, Steven Weinberg and Carlo Rubbia. In the centre of the image are Herwig Schopper (left) and Luciano



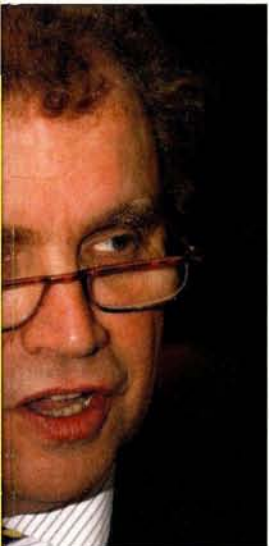
the history of the
at CERN.



Georges Charpak (left), Nobel laureate in 1992, talked of the developments in particle detectors that he instigated at CERN, and took part in a panel discussion that also included 1999 Nobel laureate Martinus Veltman.



Pierre Darriulat, spokesman of the UA2 experiment in 1978–1985, gave an account of the discovery of the W and Z particles at CERN, and acknowledged Carlo Rubbia's vital role in setting CERN on the course that led to the discovery.



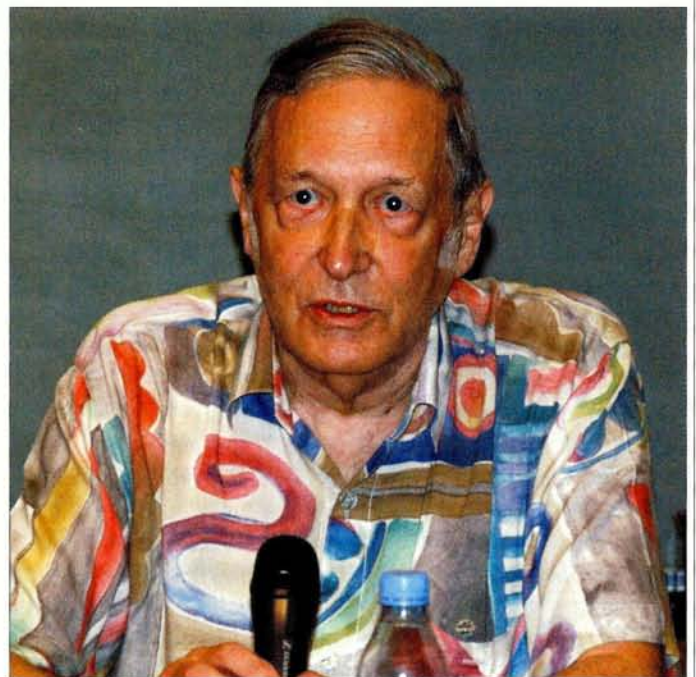
LHC Project, considered the accelerator challenges, Jos Engelen (centre), and Paul Messina, of Caltech, talked of the computing demands.



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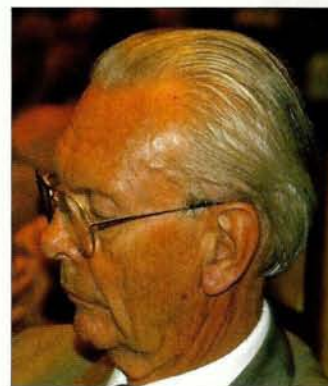
Contributions during the discussion included those from CERN's Fabiola Gianotti (left) and Ignatios Antoniadis, who presented views of the future as seen from the perspective of the current generation of experimenters and theorists.



Also participating in the round table was Simon van der Meer, who shared the 1984 Nobel prize with Carlo Rubbia.



Distinguished physicists participating in the panel discussion included Robert Aymar (left), who is to become CERN's director-general in January 2004, and theorist Lev Okun from ITEP.



Among the array of guests, former CERN director-general Herwig Schopper.

Dieter Haidt then took up the story of the experiments, with his presentation on the discovery of neutral currents. In the early 1970s Haidt, now at DESY, was a member of the Gargamelle collaboration. He described the background to the search for neutral currents, and the difficulties encountered in convincing everyone that they had indeed been observed in Gargamelle. Ultimately the discovery led to the high-precision neutrino experiments at CERN, and allowed the prediction of the mass of the W boson from electroweak theory – which in turn led to the proton–antiproton project.

By 1981 the search for the W and Z particles was on. The observation of W particles by the UA1 and UA2 experiments was announced at CERN on 20 and 21 January 1983. The first observation of Z particles by UA1 followed soon after, with the announcement on 27 May (*CERN Courier* May 2003 p26). Pierre Darriulat, who was spokesperson of UA2 in 1978–1985, recalled the background to the decision to go ahead with the programme of converting the Super Proton Synchrotron (SPS) to a proton–antiproton collider, and cast his own personal illumination on the nature of the competition between the two experiments, UA1 and UA2.

With the discovery of the W and Z particles, electroweak theory became truly established. The challenge was now for a different kind of collider – LEP – to provide a precision test-bed for the theory. In the final presentation of the morning, Peter Zerwas from DESY looked back on the era of LEP, 1989–2000, and its many tests of the Standard Model of particle physics – testing not only electroweak theory but also quantum chromodynamics, the theory of the strong interaction.

A challenging future

In addition to reflecting on past findings, speakers at the symposium also looked to the future of CERN, in particular the Large Hadron Collider (LHC), which is due to start up in 2007. By colliding particles at extremely high energies, the LHC should shed light on such questions as: why do elementary particles have mass? What is the nature of the dark matter in the universe? Why did matter triumph over antimatter in the first moments of the universe, making our existence possible? And what was the state of matter a few microseconds after the Big Bang? These are the topics that John Ellis from CERN covered in the first presentation after lunch.

This was followed by a session on the challenges of the LHC. Lyn Evans, director of the LHC Project, presented the challenges of constructing and operating the collider; Jos Engelen, currently director of NIKHEF and soon to be chief scientific officer at CERN, described the challenge of building the detectors for the LHC; and Paul Messina, of Caltech, talked of the challenges to be met once the LHC and the experiments are running, when vast amounts of data will need to be collected and analysed.

The discovery of the W and Z particles owed much to the development of detector techniques, in particular by Georges Charpak at CERN, who was rewarded with the Nobel prize in 1992. In his presentation, Charpak recalled his early days at CERN, when he was invited to come to the laboratory for six months only to stay eventually for many years, leading many developments in particle detectors. He also spoke of the opportunities for spreading enthusiasm for physics to the younger generations.

In the final presentation CERN's director-general Luciano Maiani gave his personal view of the future of the organization, and its importance for particle physics in general. This was followed by a panel discussion on the future of particle physics, chaired by Rubbia – a former director-general as well as Nobel laureate. Panel members included Robert Aymar, who will be director-general of CERN from 1 January 2004, Lev Okun, of ITEP, Donald Perkins of Oxford University, and van der Meer and Veltman, as well as symposium speakers Charpak, Darriulat, Maiani and Weinberg. Among the many points discussed, one of the most important, as Rubbia said in his summary, is that "we should not underestimate the surprise capacity of the LHC".

The symposium was organized by Roger Cashmore and Jean-Pierre Revol. Many of those attending had participated in the discoveries being celebrated – and many of the younger members of the audience will hope to participate in future discoveries at CERN, in particular in the coming years with the LHC.

Further reading

See www.cern.ch/cerndiscoveries.

The proceedings of the symposium will be published as: 1973: neutral currents, 1983: W^\pm and Z^0 bosons – the anniversary of CERN's discoveries and a look into the future *The European Physical Journal C* **34** 1.

Symmetries and structures

Siegfried Krewald reports the news from the Hadron Physics at COSY workshop.

On 7–10 July this year around 120 physicists convened at the Physikzentrum, at Bad Honnef in Germany, to attend the Hadron Physics at COSY workshop. Experimenters and theorists discussed the key questions that can be addressed with cooled beams of polarized and unpolarized protons and deuterons, in particular at the cooler synchrotron, COSY, at the Forschungszentrum Jülich.

The workshop began with an overview of charge symmetry breaking (CSB) by Gerald Miller of Seattle. If the up and down quarks had the same mass, quantum chromodynamics would be invariant under the exchange of up and down quarks. However, such charge symmetry is broken by electromagnetic effects and the mass difference of the up and down quark. This makes the neutron heavier than the proton, which is essential for the stability of the hydrogen atom. Investigating CSB effects is an important way to determine the masses of the up and down quark, two fundamental parameters of the Standard Model. On the theoretical side, Weinberg's concept of effective field theories has provided an important tool, enabling precision calculations of CSB to be made.

Alena Opper of Ohio reported on the recent experimental breakthroughs in identifying CSB in the reactions $np \rightarrow d\pi^0$ and $dd \rightarrow \alpha\pi^0$ (*CERN Courier* June 2003 p8). CSB is also being investigated in pion production at COSY. A photon detector would create the unique possibility of studying the mixing of the two lightest scalar mesons, the isoscalar $f_0(980)$ and the isovector $a_0(980)$, which is induced by CSB. The reactions $pn \rightarrow d\pi\eta$ and $dd \rightarrow \alpha\pi\eta$ promise to be particularly clean tools for independently quantifying the a_0-f_0 mixing model, to help resolve the controversy as to whether or not these systems have a quark–antiquark structure.

The hyperon–nucleon interaction is an ideal testing ground for studying the breaking of another symmetry, $SU(3)_{\text{flavour}}$, in hadronic systems. So far, relatively few data obtained in the 1960s and recently at KEK are available on hyperon–nucleon scattering at low energies, so production experiments must be used instead. Ben Gibson of Los Alamos and Ashot Gasparyan of ITEP reported on theories for $K^+d \rightarrow \gamma YN$ and $pp \rightarrow K^+YN$. They showed how to isolate final-state interaction effects by studying polarization observables and how to extract independently the spin dependence of the hyperon–nucleon scattering length model. This is relevant for understanding hypernuclei and the structure of strange matter.

In the near future, COSY will provide precise data on meson production in reactions involving polarized baryons. These data will be both a challenge and an opportunity for effective field theories. New data on η , ω and φ meson production were presented in separate sessions. In addition, the production of scalar mesons is of special interest because of the possible mixing with glueballs, as Eberhard Klempt of Bonn explained.

Baryon resonances are an important part of the research pro-



Participants at the Hadron Physics at COSY workshop.

grammes of many accelerator facilities for hadron physics. Maxim Polyakov of Bochum presented his predictions for the pentaquark, Θ^+ , a baryon that does not fit into the standard three-valence quark structure (see p5). Wolfgang Eyrich of Erlangen reported on hyperon production in proton–proton reactions and pointed out the possibilities for confirming the existence of the Θ^+ with hadronic reactions. Another candidate for “exotic” structure, the Roper resonance $N^*(1440)$, is also under intense experimental investigation. Polarized electrons will be used at the electron-scattering facility MAMI in Mainz to discriminate the Roper contribution from the background, while the experiment CLAS at JLAB uses electroproduction to study isobars as a function of the photon virtuality. The COSY facility offers polarized protons and deuterons as incident particles, as well as the alpha particle in inverse kinematics. Here, the alpha particle can be used as a scalar-isoscalar probe.

Hadronic interactions are also of fundamental interest for the spontaneous breakdown of chiral symmetry, as described in the review by Volker Metag of Giessen. The current masses of the up and down quarks are only a few per cent of the proton mass, indicating that the bulk of hadronic mass is due not to the Higgs mechanism but to the spontaneous breakdown of chiral symmetry. An important question is whether chiral symmetry is restored at high nuclear densities. Studies of deeply bound pionic atoms and two-pion production on nuclei are viable tools for exploring these issues.

The extension of the GSI laboratory at Darmstadt, approved earlier this year, offers the prospect of studying hadron physics with antiprotons at energies up to 15 GeV. Hans Gutbrod of GSI presented the planned new research facilities, while Bernhard Franzke, also from GSI, outlined the design of the High Energy Storage Ring (HESR). Helmut Koch of Bochum then introduced the highlights of the charm-physics programme at HESR, and the role of charm in the nuclear medium was addressed by Jim Ritman of Giessen.

Further reading

See www.fz-juelich.de/ikp/theorie/hpc2003.

Siegfried Krewald, Forschungszentrum Jülich.

Particle physics is thriving in Spain

Earlier this year an ECFA sub-panel visited Spain and found, as **Cecilia Jarlskog** describes, a young and rapidly expanding community of particle physicists.

Particle physicists were a rare commodity in Spain when the country joined CERN in 1961 as the organization's 14th member state. The civil war (1936–1939) had virtually created a scientific void; in George Orwell's words from *Homage to Catalonia*, "It is not easy to convey the nightmare atmosphere of that time." Blas Cabrera Felipe, who could have created a modern school of physics, left the country in 1939 and died in exile in Mexico in 1945, age 67. Nor was science a priority in the aftermath of the war. "In fact it is difficult to understand why Spain joined CERN, devoid as she was of a scientific community in the field," says the distinguished Spanish physicist Pedro Pascual.

Nonetheless, joining CERN gave a cardinal impetus to the development of particle physics in Spain. So when the country left CERN at the end of 1968 it was under vigorous protests from a small community of young and enthusiastic Spanish physicists. Fourteen years later, in 1983, Spain was welcomed back to CERN, now much better prepared for the challenges lying ahead.

Among the duties of the European Committee for Future Accelerators (ECFA) are visits by a sub-panel called RECFA (Restricted ECFA) to the CERN member states. The aim is to gauge the status of particle physics and closely related disciplines and to help improve the prevailing conditions by making recommendations to physicists, funding agencies and politicians.

Past problems

On its first visit to Spain, in 1983, RECFA noted that it would take time and real dedication to build up a community of experimental physicists in the country. Another issue of concern was the urgent need for networking facilities for high-energy physics – both within the country and for connections with other member states – because of, as RECFA phrased it, "the very large distances separating the universities in Spain".

Now, 20 years later, the distances are no longer perceived as large yet networking is still an issue, albeit on a much more sophisticated level. The unprecedented need for computing and



From left to right: Juan Alcaraz, Enrique Fernandez, Mireia Dosil, Manuel Aguilar and Domènec Espriu at the European Committee for Future Accelerators meeting in Barcelona.

networking has led for example to the LHC Computing Grid (LCG) project (*CERN Courier* October 2003 p9), with strong participation from Spain.

This year, in a welcome speech delivered on behalf of the minister of science and technology, the RECFA members were reminded that, ever since Spain rejoined CERN, the country has taken its responsibilities very seriously. In 1983 a special programme (the National Plan for Particle Physics and Large Accelerators) was created, within the framework of the Spanish "National Plan for R&D". This programme, which funds participation in international experiments and pays some personnel costs, is still running. "The creation of the National Plan for R&D is the single most

important event in the history of Spanish science," says Enrique Fernandez, a former chairman of ECFA. Indeed, RECFA was delighted to learn that the Spanish investment has paid off handsomely – the growth of the community and the quality of the work are impressive.

Experimental particle physics in Spain is a young field, taking off in 1983 when the country rejoined CERN. By then, however, the period of rapid expansion at the universities had come to an end. In Spanish universities, positions are usually created as a response to the required teaching load, so the new experimental groups could not reach the critical mass needed for efficient participation in large collaborations. In addition, finding jobs at universities for engineers and technicians has always been very difficult.

To overcome these obstacles, Spanish physicists have in the past repeatedly expressed their desire to have a national institute, similar to INFN in Italy or IN2P3 in France. This was a major theme of RECFA visits in 1992 and 1997, and it resurfaced at this year's meeting where it received strong support from the sub-panel. An important point is that Spain has 17 regions, each with its own government. These are responsible for education, which was formerly dealt with by the central authorities. This decentralization favours a multifaceted system, where research centres are funded by several sources, local as well as national. Indeed, there has been increasin



Drift-tube chambers from Spain, made for the CMS barrel muon detector, are tested and then stored at CERN.



The Spanish company Felguera Construcciones Mecanicas SA has built a number of 25 m long vacuum vessels for the superconducting toroid barrel system of the ATLAS detector. Here one of the vessels arrives at CERN. (Photo: P Collins.)

support for particle physics from several regional governments. Therefore RECFA recommends that a national institute be created, but with a structure loose enough not to jeopardize local support.

Current structures and activities

In Spain, research in particle physics is carried out at universities as well as at non-university research institutes or centres. Most of the funds for specific projects, such as participation in Large Hadron Collider (LHC) experiments, are granted by the Ministry of Science and Technology, on a competitive basis through the National Plan for Particle Physics and Large Accelerators.

Experimental particle physics has in fact grown rapidly in Spain compared with many other countries. Currently the field is being pursued not only in Madrid, Valencia, Barcelona and Zaragoza, as was the case some years ago, but also in Santiago de Compostela, Santander, Granada and Seville. The amount of work carried out is vast and this article can give only a brief account.

A major centre for research is CIEMAT, the Research Centre for Energy, Environment and Technology in Madrid, which is financed by the Ministry of Science and Technology. It is a big organization

with around 1150 employees, half with university degrees. CIEMAT has five research departments, one of them being the Department of Fusion and Elementary Particles. In addition, it has departments that can provide technical services and R&D support. This enables the researchers at CIEMAT to play a leading role in detector construction and R&D projects. Current activities include the construction of the barrel muon detector of CMS and participation in nTOF experiments at CERN, as well as an experiment at the PSI to determine the muon-decay coupling constant 20 times more accurately than previously. In astroparticle physics, CIEMAT is a major partner in the AMS experiment, to be performed on the International Space Station.

Several specialized research institutes are primarily funded by the Consejo Superior de Investigaciones Científicas (CSIC), an agency of the Ministry of Science and Technology. CSIC operates nationwide and provides funds for around 100 research institutes within a broad range of disciplines, similar to the structure of CNRS in France. Its prioritized areas of research include:

- elementary particle physics, including work at CERN;
- LHC computing and Grid technology;
- neutron physics – nTOF at CERN, and experiments at ILL in Grenoble and at the proposed European Spallation Source;
- synchrotron-radiation research at the ESRF, Grenoble, and at LURE, Orsay;
- detector and accelerator technologies.

The largest institute for particle physics funded by CSIC is the Instituto de Física Corpuscular (IFIC) in Valencia. Here, CSIC-funded researchers and those of the University of Valencia share premises for reasons of synergy. Experimental and theoretical research is performed primarily in areas of high-energy, nuclear and astroparticle physics. There are several activities in high-energy physics, among them construction of the ATLAS detector and the Grid project at CERN. Nuclear-physics activities include nTOF, and work at ISOLDE (CERN), GSI (Darmstadt), LNL (Padova) and in Jyväskylä, Finland; nuclear medicine is another line of research. IFIC is participating in the neutrino project ANTARES and in the gamma-ray mission INTEGRAL. IFIC is also an excellent centre for theoretical physics. The Instituto de Física de Cantabria (IFCA), at the University of Cantabria in Santander, is also co-financed by CSIC and the university. The institute participates in CMS and Grid projects as well as in the CDF experiment at Fermilab.

A centre of somewhat different character is the Institut de Física d'Altes Energies (IFAE) in Barcelona, which is a consortium between the local government and the Autonomic University of Barcelona (UAB). In addition to its own staff, the institute has associate members who are affiliated with the UAB or the University of Barcelona (UB). IFAE has the status of an institute of UAB and as such its members are allowed to teach doctoral courses at the university. This facilitates contact with young students, avoiding the danger of isolation that affects some free-standing research institutes.

Current projects at IFAE include detector construction for the ATLAS experiment and work on the Grid project, as well as participation in the CDF experiment. The astrophysics experiment MAGIC, for the detection of cosmic gamma rays, constitutes another major activity (see p7). The institute is also moving into the domain of neutrino physics by analysing data from the K2K experiment in Japan, and ▷

it intends to participate in the proposed second-generation experiment, J-PARC-Nu. R&D, especially pertaining to the development of a novel X-ray detector for use in medical imaging, is another major activity. Many projects in theoretical particle physics are carried out at IFAE as well as at UAB and UB. In addition the UB has a small group that is involved in the BaBar experiment at SLAC and is participating in the LHCb experiment at CERN and the Grid project.

The university environment

Madrid is a centre for substantial activity in particle physics at two universities. Researchers from the Autonomic University of Madrid (UAM) have for a long time been involved with the ZEUS experiment at DESY. A UAM group is also participating in the construction of the ATLAS detector and another has started working on CMS. Researchers from the Universidad Complutense de Madrid (UCM) are contributing to the MAGIC experiment. Both universities have strong theory groups. Recently, a joint CSIC-UAM Institute has been created, which will no doubt strengthen theoretical particle physics in Spain and lead to further excellence.

Researchers from the University of Santiago de Compostela are engaged in the Auger Project (see p11) as well as in the construction of the LHCb detector. They have also been heavily involved in the DIRAC experiment at CERN. The University of Granada, meanwhile, is a newcomer in the area of experimental particle physics, having begun only in 2002. The Granada group is participating in the preparation of the ICARUS experiment, to be done at the Gran Sasso Laboratory in Italy. Theoretical particle physics, by contrast, has a longer history in Granada.

For 15 years Spain has also had an underground lab, Canfranc, situated in a tunnel between France and Spain. During this time the laboratory has undergone several upgrades; current research projects include double beta-decay experiments and searches for dark matter.

Finally, it is interesting to note that the nTOF experiments at CERN attract a rather large community of scientists from Spain, not only from large centres for particle physics but also from polytechnic universities and the University of Seville. Grid computing is another "unifying project", with the Spanish groups participating in LHC experiments working together to set up the necessary infrastructure. A scientific information centre, the Port d'Informació Científica (PIC), coordinates these efforts.

The impact of the Large Electron-Positron (LEP) collider on the Spanish particle-physics community has been remarkable. Work at LEP has led to 64 PhD theses and about 1000 publications. In addition about 20 PhDs are awarded each year in theoretical particle physics. As mentioned above, both the increase in the size of the community and the financial support have been very substantial compared with the pre-LEP era. There are now around 270 experimenters and 150 particle theorists in Spain.

RECFA found that Spanish experimental particle physicists are at the forefront of international research and make an impressive contribution. They are indispensable partners in the collaborations to which they belong. RECFA was also very impressed by the vitality and intellectual leadership of the theoretical particle-physics community in Spain, which the committee found to be among the strongest in Europe.

The Ramón y Cajal initiative

The Spaniard Santiago Ramón y Cajal (1852–1934) was an unusually indefatigable and creative scholar. He won a Nobel Prize in 1906 for his work on the structure of the nervous system. His experience that "unfortunately, nature seems unaware of our intellectual need for convenience and unity, and very often takes delight in complication and diversity" is perfectly in accord with that of many particle theorists who are often puzzled when experiments show that their simple and beautiful theories are rejected by nature.

The Ramón y Cajal Programme, which honours his memory, has operated since 2001. Based on a competitive selection procedure, this programme offers five-year grants to PhD holders, irrespective of nationality. The recipient is expected to work in Spain in a strategic research area. It is planned that the receiving institution will progressively take over the financial responsibilities for the researcher in question. Since the start of this programme, around 2000 grants have been awarded.

Evidently, a programme of this magnitude cannot run indefinitely. Nonetheless, it is of vital importance, for Spanish science in general and particle physics in particular, that it be continued somehow. As emphasized by RECFA, only in this way will the excellent young Spanish physicist abroad be able to return home and be a part of the successful story of particle physics in Spain.

For further information on the Ramón y Cajal Programme, see www.mcyt.es/CAJAL.

Despite the Spanish success story, however, serious structural problems loom on the horizon. Finding permanent positions at the universities for gifted young physicists is currently deemed to be almost impossible, not only for demographic reasons but also because of a downward trend in the number of first-year physics students (in the past two years, however, this number has been more stable). Solving this problem would require finding new methods of funding.

Another issue of great concern is the lack of engineers and technicians at universities because, in general, there are no permanent positions available in these categories. These people, vital to research, have access only to temporary positions, supported by project funds, or to posts created within regional institutes.

The above problems must be solved urgently. The present major commitment of Spanish universities and institutes to the LHC project is expected to result in a repeat of the success story of LEP. Spain is an attractive country for high-level scientists, postdocs and visitors. There are great opportunities – but much more could be done if only the necessary funds and posts were available.

Further reading

For a more detailed account of Spain's contributions to particle physics, see <http://committees.web.cern.ch/Committees/ECFA/RecfaNotes1.html>.

Cecilia Jarlskog, CERN.

Solving cross-section challenges at the LHC

A small workshop held recently in Switzerland considered the challenges to be overcome before accurate cross-section measurements can be made at the LHC.

For three days in October the population of Binn, a beautiful village in the Oberwallis in Switzerland, increased by almost 20% when 23 experimental and theoretical particle physicists attended a workshop on cross-section measurements at the Large Hadron Collider (LHC).

The main purpose of this small workshop, organized by Günther Dissertori and Michael Dittmar of the CMS group at ETH Zürich, was to investigate how well the different types of physics reactions and reaction ratios expected at the LHC can be measured and calculated. About half the time at the workshop was devoted to thought-provoking review talks, while the rest remained free for questions, discussion and critical comments.

The workshop began with an introduction to general aspects and problems of cross-section measurements at the LHC. The participants were reminded that in addition to the experimental uncertainties from efficiency, backgrounds and the machine luminosity, there are potentially important theoretical uncertainties in the calculations, such as those arising from uncertainties in the parton distribution functions (PDFs) and from unknown higher-order corrections. It was also pointed out that normalizing various interesting high- Q^2 reactions to the well-understood and abundant production of W and Z bosons at the LHC could dramatically reduce systematic errors. This might particularly help with errors arising from the absolute-luminosity measurement and from PDF uncertainties. For some reactions the estimated theoretical and experimental uncertainties are of similar size, and an especially large effort will be needed to understand and, if possible, reduce the uncertainties.

A look ahead

The next two sessions were devoted to the theoretical and experimental aspects of cross-section calculations and their potential limitations at the LHC. While today it is obviously not possible to know exactly how the ATLAS and CMS general-purpose detectors will per-



The tiny village of Binn welcomed extra inhabitants in October.

form once the LHC starts, it is already clear that many important measurements and calculations will be much more difficult than corresponding ones at previous high-energy colliders, such as the Large Electron-Positron Collider (LEP). Several talks therefore addressed the question of systematic limitations at previous high-energy collider experiments, particularly for reactions that are relevant to the LHC. For example, there was general agreement that absolute measurements of α_s with a precision comparable to that achieved at LEP will be impossible at the LHC.

Since all the high- Q^2 reactions

of interest at the LHC result from collisions of the quark and gluon constituents of the proton beams, the accuracy of a cross-section calculation relies on a precise knowledge of the parton distribution functions – that is, the quantities that describe how the momentum of a fast-moving proton is shared among its constituents. There were presentations on the latest PDF results from the H1 and ZEUS experiments at HERA, which clearly demonstrated the impressive precision that has already been achieved. The precise information on the quark and gluon PDFs that can be extracted from the HERA structure function data leads in turn to very accurate (± 1 – 2%) predictions for the W and Z production cross-sections, and their ratios, at the LHC.

Even so, it is possible that measurements at the LHC could constrain the PDFs even further. For example, the ratio of W^+/W^- production at the LHC is very sensitive to the u/d quark PDF ratio in the proton. Using the most up-to-date PDFs yields an uncertainty of about 1.5% on the prediction for the W^+/W^- ratio. A measurement error smaller than this at the LHC will further constrain the u/d ratio. In principle a precision measurement of the kinematic distribution of charged leptons from Z decay could yield information on the weak mixing angle $\sin^2\theta_W$, but it is likely that the residual PDF uncertainties will in practice preclude any improvement in the accuracy of $\sin^2\theta_W$ achieved so far at LEP and the SLAC Linear Collider. \triangleright

Another session focused on the status of higher-order perturbative corrections in quantum chromodynamics (QCD). Although there has been steady progress in the calculation of these corrections in recent years, with some cross-sections now known to next-to-next-to leading order (NNLO) accuracy, there are still some important background processes that are known only to leading order (for example, $\bar{t}t$ and $\bar{b}b$ production in QCD). Without at least the full next-to leading order (NLO) corrections to such processes, it is very difficult to estimate the uncertainty in the prediction, and this can have important implications for the unambiguous identification of new physics signals at the LHC.

An important development in the past year has been the implementation of exact NLO contributions in parton-shower Monte Carlo event generators. In particular, the MC@NLO program, which is based on the HERWIG Monte Carlo event generator, already includes many of the most important processes. However, the experimenters were quick to come up with a long wish-list of additional processes. It was not difficult to agree on a common list of "most wanted" QCD corrections, but the theorists were adamant that without a breakthrough in calculational techniques, the existing theoretical technology will not be able to cope with providing many of the required NLO or NNLO corrections before the LHC starts.

LHC processes in detail

During the second day of the workshop, four sessions were devoted to more detailed presentations and discussions of particular LHC processes. These were the production of Drell-Yan lepton pairs, the production of events with massive boson pairs and subsequent leptonic decays, and the measurement of jet-production processes that arise from quark-quark, quark-gluon and gluon-gluon scattering. During the second half of the afternoon the participants split up into more specialized working groups to focus on PDFs, high-mass Drell-Yan lepton pairs, the physics of jets and the systematics of potential backgrounds for exotic processes. The final Saturday evening session addressed the question of systematic uncertainties in background processes, which could limit the LHC's potential to make discoveries.

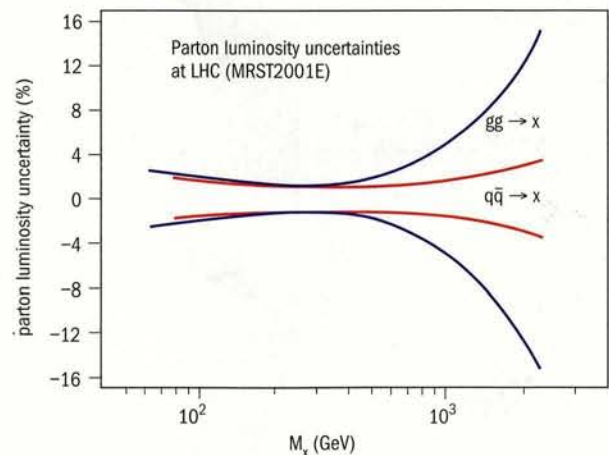
Using a few examples from ATLAS and CMS search simulations for (SUSY) Higgs particles and other exotics, some particularly problematic signatures could be identified and analysed. Unfortunately it became obvious to most participants that the hypothetical large statistical significance of some of these exotic particles is not the full story, as in reality these signatures will be completely hidden in the uncertainties of the backgrounds.

While it is obviously difficult to quantify fully the limits of each individual signature, it is possible to conclude that to achieve signal-to-background ratios below, for example, 0.5 (0.25) – excluding the few exotic signatures that provide narrow mass peaks – the backgrounds need to be controlled to better than 10% (5%). Only in rare cases can such precision be obtained from Monte Carlo simulations, therefore data-based background estimates will almost certainly be required. The Saturday evening session concluded with short reports from the working groups about outstanding problems that should be addressed in detail during the coming years.

At the final summary session on Sunday morning, there was unan-

Challenges in a mountain paradise

"Binn past, present and future" was the subject of the talk at the dinner on the last night of the workshop, given by the honorary community president Karl Imhof, who had been mayor of Binn for 16 years. He presented a fascinating insight into the 2000 year history of Binn and the Binn Tal. He explained how the Binn Tal became a nature preserve in 1964 and thus avoided the despoliation caused by hydroelectricity or modern ski tourism. He also showed slides that reminded the audience that life in this small mountain paradise is not without problems. As in many mountain villages, the shortage of employment opportunities has caused a gradual decline in population as young people move away. The slides showing some exceptionally snowy winters in Binn gave an impression of great beauty and tranquillity, but they were also a reminder of the associated dangers from avalanches.



The figure shows the uncertainty in the predicted gluon-gluon and quark-antiquark luminosities that arises from the uncertainties in the input parton distribution functions. The uncertainty varies with the mass of the heavy object (X) that the gluons or quarks produce, becoming large for very heavy objects.

imous agreement that the meeting had been a great success, particularly because it enabled participants to step outside the routine of daily work and to think in depth about some of the most important issues facing experimenters and theorists in preparing for the start of the LHC. The success of the meeting could also be judged by a comment from one participant during an additional "special session" on Sunday afternoon: "This was the first conference where not only participated in all the sessions but even listened to all the talks." Falling asleep would in any case have been difficult during this last "session": a four-hour hike to the Mässersee and back

Further reading

Details about the workshop and the different presentations can be found at <http://www.eth.ch/WorkShopBinn>.

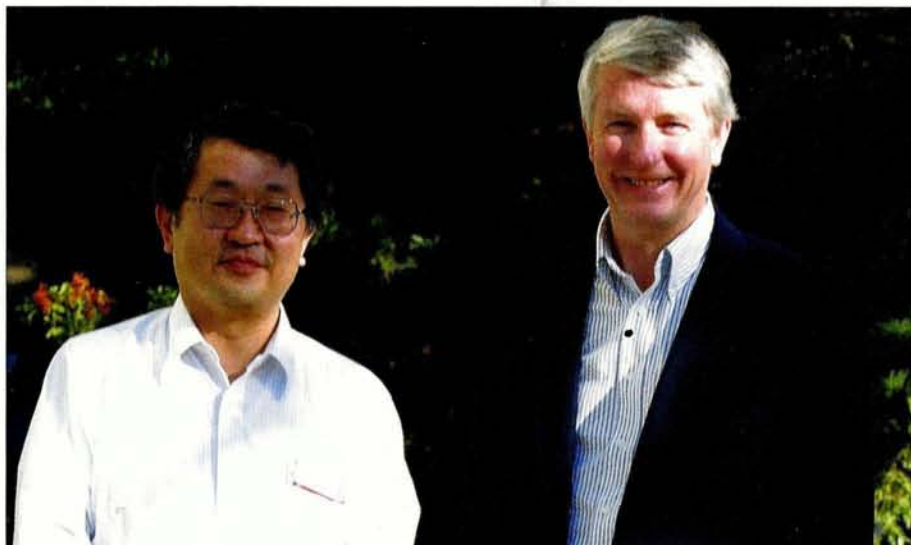
Michael Dittmar, ETH Zürich, and **James Stirling**, IPPP Durham

AWARDS

APS announces winners for 2004



CERN's Gabriele Veneziano, who has won the APS's 2004 Dannie Heineman Prize.



Katsunobu Oide (left) of KEK and John Seeman of SLAC have been awarded the 2004 Wilson Prize for their work on high-luminosity B-factories. (Diana Rogers/SLAC.)

The American Physical Society has announced many of its awards for 2004, with recipients who work in particle physics and related fields, from neutrino astrophysics to colliding-beam techniques.

Wick Haxton of the University of Washington has won the Hans A Bethe Prize, which recognizes outstanding work in the areas of astrophysics, nuclear physics, nuclear astrophysics or closely related fields. The society said the prize was "for his noteworthy contributions and scientific leadership in the field of neutrino astrophysics, in particular for his success in merging nuclear theory with experiments and observations in nuclear physics and astrophysics".

Nuclear physics is also recognized by the Tom W Bonner prize for outstanding experimental research in the subject. The winner is George F Bertsch of the University of Washington, "for his many varied contributions to nuclear-structure and reaction theory, which have guided and illuminated experiments for four decades".

The Edward A Bouchet Award recognizes a distinguished minority physicist who has made significant contributions to physics research. It has been awarded this year to Juan Maldacena of the Institute for Advanced Study, Princeton, "for providing a deeper

understanding of the correspondence between string theory in d space-time dimensions and Yang-Mills theory in $d-1$ dimensions, and for communicating fundamental principles of theoretical physics to the general public, including Spanish-speaking audiences".

CERN's Gabriele Veneziano is the recipient of the Dannie Heineman Prize for mathematical physics, which he receives "for his pioneering discoveries in dual-resonance models which, partly through his own efforts, have developed into string theory and a basis for the quantum theory of gravity".

Cosmology is the focus of the 2004 Maria Goeppert-Mayer Award for outstanding achievement by a woman physicist in the early years of her career. This has been awarded to Suzanne Therese Staggs of Princeton University, "for her original and lasting contributions to experimental cosmology, in particular in the area of cosmic microwave background studies, and for leadership in multi-institutional collaborations to measure CMB anisotropy".

Arie Bodek of the University of Rochester receives the W K H Panofsky Prize in experimental particle physics, "for his broad, sustained, and insightful contributions to elucidating the structure of the nucleon, using

a wide variety of probes, tools and methods at many laboratories".

The JJ Sakurai Prize for outstanding achievement in particle theory is shared this year by Ikaros Bigi of the University of Notre Dame and Anthony Ichiro Sanda of Nagoya University, "for pioneering theoretical insights that pointed the way to the very fruitful experimental study of CP violation in B decays, and for continuing contributions to CP and heavy flavour physics".

The Robert R Wilson Prize for achievement in the physics of particle accelerators is also shared between researchers at institutes in Japan and the US. Katsunobu Oide of KEK and John Seeman of SLAC are rewarded for "technical leadership and direct contributions to the development of high-luminosity B-factories at KEK and SLAC. These machines have set new world records for luminosities in colliding-beam storage rings".

Particle physics also features this year in the Leroy Apker Award for undergraduate achievement from a PhD-granting institution. Peter Onyisi of the University of Chicago is the winner for the paper "Looking for new invisible particles", about the search for new physics that might be indicated by exclusive photons with missing energy in the opposite direction in the CDF detector at Fermilab.

NETWORKING

CERN and Caltech win network-speed prize

CERN demonstrated the newest Grid technology and highlighted advances in networking through optical fibres at the International Telecommunication Union's exhibition Telecom World 2003, held in Geneva on 12–18 October.

Using the latest high-speed, high-quality Virtual Rooms Videoconferencing System (VRVS) technology developed by Caltech, the Internet2 conference in Indianapolis was transmitted live to the stand.

Among the many activities, visitors watched the awards ceremony in Indianapolis for the new Internet2 land-speed record, which was achieved by an international team in the framework of the European Union DataTAG project. On 1 October, 1 Tbyte of data was transmitted across more than 7000 km between Starlight in Chicago and CERN in less than 30 minutes. This is equivalent to transferring a full CD in 1 s or a full-length DVD movie in 7 s.

Just before the award ceremony, CERN and Caltech broke the record again with a multi-gigabit per second transfer between the



Wolfgang von Räden (centre), CERN's IT Division leader, congratulates Harvey Newman of Caltech (left) and Olivier Martin of CERN (right) on the award for a new Internet2 land-speed record.

exhibition centre and Los Angeles. This time, the data were transmitted a greater distance, measured as the product of the achieved bandwidth (bits/second) and the terrestrial distance between the nodes.

AWARDS

Neutrino research and national security share White House's Enrico Fermi Award

John Bahcall, Raymond Davis Jr and Seymour Sack are the winners of this year's Enrico Fermi Award. The award is administered by the US Department of Energy for the White House, and recognizes scientists of international stature for their lifetimes of exceptional achievement in the development, use or production of energy.

The trio received the award on 22 October at a conference in Washington, DC. The conference, Nuclear Energy and Science for the 21st Century: Atoms for Peace Plus Fifty, marked the 50th anniversary of the speech by President Eisenhower to the UN General

Assembly on the peaceful uses of the atom.

Bahcall, from the Institute for Advanced Study, Princeton, and Davis, of the University of Pennsylvania, received the award "for their innovative research in astrophysics leading to a revolution in understanding the properties of the elusive neutrino, the lightest known particle with mass".

Sack, who retired from the Lawrence Livermore National Laboratory in 1990 and continues as a research associate, received the award "for his contributions to the national security of the US in his work assuring the reliability of nuclear weapons."

CERN

Horst Wenninger retires from CERN

Horst Wenninger, who has been and continues to be a major influence on the development of CERN, retired in September after 35 years.

After participating in bubble-chamber experiments at CERN while working as an assistant at the University of Heidelberg in the 1960s, Wenninger joined the BEBC project in 1968. He worked as a member of the BEBC construction and operations team for almost 20 years, becoming the group leader during the time of its full exploitation, and seeing the termination of the project in 1984.

In 1989, Wenninger became leader of the new Accelerator Technologies (AT) Division, which regrouped major technology groups working on the LEP II energy upgrade programme. At the same time he continued R&D on superconducting magnets, prepared specific technologies for the LHC, such as cryogenics and vacuum, and was appointed research-technical director when the LHC project was fully approved in 1996.

He took an active part in the launch of Technology Transfer (TT), in particular with groups at CERN working on superconducting cavities and the TESLA collaboration.



Wenninger: a key player in CERN's history.

ARMENIA

Yerevan hosts school for experimenters



Seventy-five students attended the 2003 European School on High Energy Physics.

The 2003 European School on High Energy Physics was held in Tsakhkadzor near Yerevan, Armenia, on 25 August – 6 September. The school was organized this year by JINR and CERN, together with the International Center for Advanced Studies at Yerevan State University. This is the first time that one of the JINR member states has organized one of these schools, which occupy a special place in the development of relations between CERN and JINR.

The schools aim to teach various aspects of high-energy physics, but especially theoretical physics, to young experimental physicists, mainly from the member states of CERN and JINR. This year the scientific programme of the school was based on six series of lectures entitled Field Theory and the Standard Model (Ian Aitchison, Oxford), Flavour Physics and CP Violation (Robert Fleischer, CERN), Astroparticle Physics (Igor Tkachev, Moscow), Beyond the Standard Model (Gregory Gabadadze, Georgia), Neutrinos (Serguei Petkov, Bulgaria) and Quantum Chromodynamics (Alexander Khodzhmirian, Armenia). There were also lectures on Cosmic-ray Physics (Ashot Chilingarian, Armenia) and Multiparticle Dynamics (Ioseb Manjavidze, Georgia).

In the discussion sessions, the 75 students from around 30 European countries received help from the discussion leaders: Laura Covi, DESY; Dmitri Fursaev, JINR; Alexei Pivovarov, JINR; Tilman Plehn, CERN; Michael Plumacher, CERN; and Oleg Teryaev, JINR.

One of the interesting events of the school was the opening of the exhibition Science Bringing Nations Together in the main hall of Yerevan University. This exhibition is dedicated to international co-operation between scientists and their role in uniting nations. A number of posters were especially devoted to the cooperation of the Caucasus republics with world research centres, including CERN and JINR.

As well as an extensive cultural programme, which allowed students to acquaint themselves with many of the historical places of Armenia, a trip to two cosmic-ray stations was organized. At the first stop at Nor Amberd, Chilingarian gave a lecture on cosmic-ray physics and experiments with cosmic rays in Armenia. The second station is situated at almost 3200 m above sea level on the slopes of Mt Aragats, Armenia's highest mountain. Here the students were able to see modern experimental equipment for detecting cosmic rays.



On 6 October, the Polish minister of science and chairman of the State Committee for Scientific Research, **Michal Kleiber**, visited CERN. He is seen here (left) in the CMS assembly hall with CMS spokesperson **Michel Della Negra**. He also toured the ATLAS assembly hall and underground cavern and the LHC superconducting magnet string test hall.



The Croatian minister of science and technology, **Gvozden Flego**, visited CERN on 23 September. He toured the NA49 and CAST experiments, the LHC magnet test hall, the CMS assembly hall and the ALICE cavern, where he is seen here (right) with **Jürgen Schukraft**, ALICE spokesperson.



JINR vice-director and director of the Bogoliubov Laboratory of Theoretical Physics, **Alexei Sissakian**, is among three newly elected foreign members of the National Academy of Sciences of Armenia. Sissakian, who is also co-chairman of the CERN–JINR joint scientific committee, has taken part in a number of experiments at CERN, and has been involved in the CERN–JINR schools (see left) for many years.

SCHOOLS

Particle physics in a Benedictine monastery

From 2–12 September, 55 students from Germany, Switzerland and Austria studying for PhDs and diplomas in particle physics came together in the monastery at Maria Laach in Germany to attend the 35th Maria Laach School on High Energy Physics. This year the school concentrated on two of the most prominent issues in current particle physics: LHC physics and cosmology.

Maria Laach is a working monastery and the high-energy physics school is the only non-Christian, and by far the biggest, group to which the monastery offers hospitality in its guest wing. The school therefore offers a unique experience to most of the participants, beginning each day at 5.15 a.m. when the bells of the world-famous romanesque church at Maria Laach call the monks for their morning prayer. The school's participants are allowed to attend these impressive religious services, and also to join the monks in their refectory for traditional meals at lunch and dinner.

"It is the combination of intense, high-level scientific discussions of cutting-edge particle-physics topics and the integration of the participants into the tradition of an active monastery that makes the unique atmosphere of the Maria Laach school," Sigggi Bethke of MPI Munich, the chairman of this year's school, explained.

This year's lectures proved to be just as exceptional as the location. Ansgar Denner from PSI presented an in-depth explanation of electroweak symmetry breaking and CERN's Michelangelo Mangano discussed the physics challenges and opportunities at the LHC from a theoretical perspective. The experimental view was presented by Kerstin Hoepfner from Aachen, and John Ellis from CERN gave an overview on theories beyond the Standard Model. The rapidly evolving field of astroparticle physics was illuminated in a colourful and well-animated computer presentation by Werner Hofmann from MPI Heidelberg, who also gave an entertaining review of the past 20 years of particle physics, from the perspective of a physicist in the year 2023. Michael Turner from Chicago showed the fascinating developments in cosmology and illustrated their implications for the fate of our universe



Father Athanasius (left), the guest monk from the Maria Laach monastery, and the school's chairman Sigggi Bethke.



Lectures were held in the historical main hall of the Maria Laach monastery.



Lively discussions continued during the breaks. Here, Father Athanasius (centre), and to the right of him Johann Bienlein, who founded the school 35 years ago, with John Ellis (second from left) and Reinhold Ruckl (right), talk to students in the garden of the monastery.

with a stunning set of transparencies. Lessons to be learnt from B-physics were presented by Bernhard Spaan from Dresden, and the physics prospects of a future linear collider were exemplified for the TESLA case by Markus Schumacher of Bonn.

The afternoon sessions saw tutored exercises and the students' presentations of their own work. In the evenings, after-dinner talks served to broaden discussions by also dealing with non-physics issues. Among other topics, science journalism, the computational challenges associated with lattice quantum chromodynamics, and the question of how particle-physics funding will evolve in the

frame of ongoing European integration were discussed. The guest monk, Father Athanasius, triggered an evening-long discussion on the question of how the traditional concept of life realized in a Catholic monastery still fits into our modern view of the world. The fact that the school has been conducted in an uninterrupted series for the past 35 years, and that the number of applicants by far exceeds the number of available places illustrates that the concept and the unconventional spirit of the school remains up to date.

The lecture notes from this year's school are available at <http://maria-laach.physik.uni-karlsruhe.de/2003>.

OUTREACH

Irish students pay a virtual visit to CERN

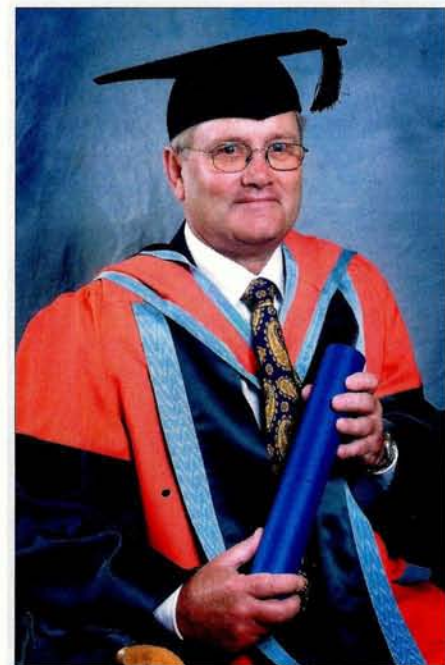


Left to right: Paul Bove, Ariane Frey, John Ellis, Jim Virdee and Mike Lamont talk to Irish students connected to the PS control room by the latest videoconferencing technology.

One might expect that 200 students meeting physicists in the PS control room at CERN would disturb normal operations. However, the physics students from Dublin, Republic of Ireland, and Armagh, Northern Ireland, were not physically there – they were connected to CERN by the latest video technology. So on 6 October the PS control room had to accommodate only two additional screens and six physicists from CERN.

Organized by Steve Myers, head of the Accelerator Beams Division, and a graduate of Queen's University Belfast, and Ronan McNulty, a lecturer at University College Dublin, the videoconference was a pilot project that will be expanded to bring this technology to many more schools in Ireland.

The virtual visit was made on the 100th anniversary of the birth of ETS Walton, the Irish physicist who split the nucleus with John



Steve Myers paid a visit (real, not virtual) to Belfast earlier in the year on 2 July, where he was awarded the honorary degree of Doctor of Science (Engineering) for his services to the subject by his alma mater, Queen's University Belfast.

Cockroft in 1932, for which they were awarded the Nobel Prize for Physics in 1951. The students were taken on a virtual tour around CERN and allowed to challenge the scientists with questions about physics and its uses.

The students also used the opportunity to get to know the panel as people, not just physicists, and asked them how they became involved with CERN.

LETTERS

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

A nursery for CERN's leadership

I was pleased to see again the picture of CERN's PS magnet group (*CERN Courier* October 2003 p38). I do not know to what extent all readers are aware that it turned out to be a "pépinière" (or "nursery" in English, in the horticultural sense) for high-level CERN leadership: one Nobel laureate (Simon van der Meer), two directors (Giorgio Brianti and

Günther Plass, previously division leaders) and two division leaders (Bastiaan de Rad and Lorenzo Resegotti).

How did this come about? I do not quite know the answer. Maybe in the early days CERN was particularly attractive to "adventurous", enterprising, capable and highly educated young people, and in those days the screening was rather strict. My own application was via the Ministry in Bonn, and I was told that Werner Heisenberg had to endorse it before it could continue to CERN; subsequently I was interviewed by John Adams, Mervyn Hine and Christoph Schmelzer. *Helmut Reich, University of Fribourg.*

CORRECTIONS

On p43 of the September 2003 issue, an error was made in the caption for the photograph of the Armenian ministerial visit to CERN. The name of the vice-director of JINR, shown on the second from right of the picture, is of course Alexei Sissakian. Many apologies.

On p5 of the November 2003 issue, the results of the latest global analysis by the SNO collaboration of solar and reactor neutrino measurements should have read $\Delta m^2 = 7.1 + 1.2 / -0.6 \times 10^{-5} \text{ eV}^2$.

OBITUARY

Krzysztof Rybicki

1938–2003

On 27 March, after a short battle with cancer, Krzysztof Rybicki, professor at the Institute of Nuclear Physics (INP) in Cracow, passed away.

Until his very last days he participated in many high-energy physics activities, both as a researcher and as a member of numerous committees and councils. At his home institute he was head of the Leptonic Interactions Department and chairman of the INP's Scientific Council. In January 2000 he became a member of CERN's Scientific Policy Committee and from 2002 he served on the High Energy Particle Physics Board of the European Physical Society.

Krzysztof was born in Cracow on 25 February 1938. After graduating from Jagellonian University in 1960, he joined the Cracow high-energy physics group led by Marian Miesowicz, who pioneered experimental high-energy physics in Poland. Krzysztof's early work dealt with cosmic-ray interactions in emulsion experiments, including the first measurement of the elastic proton–nucleus cross-section in the tera electron volt range. Between 1968 and 1972 he played an important role in the first studies of particle production at the Serpukhov accelerator. During that time he published, together with Oleg Czyzewski, the work on the multiplicity distribution that described all the data with a universal parameterization, the Czyzewski–Rybicki Formula. This contributed to the formulation of the famous KNO scaling.

In the early 1970s, Krzysztof formed an electronic-detector group together with Michal Turala, which under Krzysztof's leadership grew to a department of almost 30 people. It was the first group in Poland to design and



construct hardware for high-energy physics experiments. Because of Poland's political isolation and "technology gap" at the time, this was a real venture, but soon afterwards, spark, proportional and drift chambers constructed in Cracow were successfully used in experiments at CERN and Dubna. Since that time hardware development has become an important contribution of the Cracow group, and soon after other Polish groups initiated similar experimental activities.

In 1973 Krzysztof began a very fruitful and long-lasting co-operation with the CERN–Munich team, which later developed into the Amsterdam–CERN–Cracow–Munich–Oxford–Rutherford (ACCMOR) collaboration. It also marked the start of his group's participation in many international collaborations working on experiments at CERN, DESY and KEK. He also initiated and coordinated the participation of Polish physicists and engineers in the construction of the HERA accelerator.

Although engaged in many organizational tasks, Krzysztof never gave up his own work on physics analysis, actively studying heavy flavours, for example. In ACCMOR, he worked on charm hadroproduction, in particular spin effects, double-charm correlation and absolute branching fractions, and he played a

key role in the first measurement of the spin of the Λ_c . However, hadron spectroscopy was his real passion, dating back to 1973 when he began work on partial wave analysis for $\pi^+\pi^-$ and K^+K^- systems using unique polarized-target data from the CERN–Cracow–Munich experiment. He continued these studies until his very last days, recently in collaboration with theoreticians from INP, on work that contributed to a revival of the $\sigma(600)$ meson.

Krzysztof understood his duties from a broader perspective than just his personal career. He strove for a high level of research in Poland, and was highly dedicated to nurturing young physicists. For many years he lectured at Jagellonian University, and most of the members of his team were former students.

Krzysztof lived and worked during difficult times in Poland. Yet his life – strongly rooted in a deep faith that matured during his long-lasting friendship with Karol Wojtyła (Pope John Paul II) – is an example of constructive work regardless of external circumstances. With an optimism and competence that expressed his motto "Nulla dies sine linea", he realized brave ideas, even when others considered them too risky. These efforts had a significant impact on the development of experimental particle physics in Poland.

Krzysztof's collaborators benefited greatly from his broad knowledge, deep insight, comprehensive judgement and excellent intuition. Outside physics, he was a scholar, with a seamless knowledge of history and literature, as well as fluency in Latin. He was also an active tourist, familiar with almost all of the Polish kayak and mountain routes. For all these reasons, we sought advice from him not only in physics, but in all aspects of life. His unexpected death was a shock for all of us. We deeply miss his friendship, wisdom and guidance.

*Grazyna Nowak and Maria Rozanska,
INP-Cracow.*

NEW PRODUCTS

Acqiris has released two multifunctional signal analyser boards. The AP240 and AP235 are for applications where random noise must be removed from signals acquired with very high event rates. Both feature full front-end signal conditioning with up to 1 GHz bandwidth and dual-channel capability with synchronous acquisition. For more details see www.acqiris.com.

Instrumentation Technologies is launching a new product line, Libera, which enables trouble-free commissioning, accurate beam-position monitoring, and local and global feedback-building. With analogue and digital boards housed in a single enclosure and supported by easily adaptable software, Libera also features programmable gain and bandwidth. For further information call +386 5 333 2300, e-mail info@i-tech.si or see www.i-tech.si.

SIH Cryogenics Group has announced its latest 4.2 K Gifford McMahon cryocooler. With a single phase, 1.2 kW, multi-voltage, air-cooled compressor, the SRDK-101D offers 0.1 W at 4.2 K. For "next generation" cooling, the SRP-052A 4 K Pulse Tube offers great potential for improved reliability and lower vibration. It has no moving parts within the cold head and a separated valve unit. For more details see the website at www.shicyogenics.com.

RECRUITMENT

For advertising enquiries, contact CERN Courier recruitment/classified, Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.

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NORTHERN ILLINOIS UNIVERSITY/ ARGONNE NATIONAL LABORATORY Joint Tenure-Track Assistant Professorship in Accelerator Physics.

Northern Illinois University (NIU) and Argonne National Laboratory (ANL) seek to hire a highly creative and productive individual in accelerator physics who will

- (1) contribute toward developing the Rare Isotope Accelerator, a superconducting heavy-ion linear accelerator (<http://www.phy.anl.gov/ria>) and
- (2) strengthen and diversify the accelerator physics program at NIU (<http://nicadd.niu.edu/research/beams>).

The successful applicant must have a Ph.D. in physics or a related field at the time of application and is expected to do independent research, teach effectively at the undergraduate and graduate levels, and direct M.S. and Ph.D. students. A competitive start-up package is available, and the selectee will become a member of the Northern Illinois Center for Accelerator and Detector Development (<http://www.nicadd.niu.edu>). Primary interest is in candidates who are strong in beam physics and nonlinear dynamics; however, candidates with exceptional skills in experimental accelerator physics are encouraged to apply.

Send (via e-mail is preferred) a letter of application, curriculum vitae, summary of research accomplishments, and names and addresses (including e-mail and phone) of at least three references to:

**Prof. Court Bohn, Department of Physics,
Northern Illinois University,
DeKalb, IL 60115;
Tel: (815)753-3546; Fax: (815)753-8565;
E-mail: clbohn@nicadd.niu.edu.**



Review of applications began October 1, 2003 but will continue until position is filled.

Women and minority candidates are especially encouraged to apply.
NIU and ANL are Equal Opportunity/Affirmative Action Employers.

UCIrvine

University of California, Irvine

Postdoctoral Position

Neutrino and Neutrino-Oscillation Physics

The University of California, Irvine invites applications for one or more Postdoctoral Scholar positions in neutrino and neutrino-oscillation physics. Our group is heavily involved in the continuing Super-Kamiokande and K2K experiments in Japan. We are also participating in the JPARC nu long-baseline oscillation experiment to search for θ_{13} and leptonic CP violation and a proposed high-statistics measurement of exclusive neutrino cross-sections with the MINERvA experiment at Fermilab. The successful candidate(s) will join in analysis of our on-going experiments and take a major role in the design and realization of the new ones. Positions could begin as early as January 1, 2004, if a suitable candidate is identified, at a starting salary of \$35,304 - \$46,056. A Ph.D. (or equivalent degree) in high-energy particle physics is required. Candidates with experience in neutrino detection/data analysis or neutrino interaction/oscillation phenomenology, and meeting the highest standards of character and professional integrity, are particularly encouraged to apply.

Interested candidates should provide a curriculum vita and arrange to have three letters of recommendation sent by January 31, 2004 to

Professor D. Casper, Department of Physics and Astronomy,
4129 Frederick Reines Hall, University of California,
Irvine CA 92697-4575,
dcasper@uci.edu (949) 824-6946.

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FACULTY POSITION IN EXPERIMENTAL NUCLEAR PHYSICS INDIANA UNIVERSITY

The Physics Department at Indiana University seeks outstanding candidates for a tenure-track assistant professor position in experimental nuclear physics to start in Fall 2004. We are searching for strong applicants with the potential to become intellectual leaders in any subfield of nuclear physics or its intersections with astrophysics and/or particle physics. An ability to teach physics effectively in the classroom and through supervision of research at both the undergraduate and graduate levels is essential. IU physicists play leadership roles in high energy spin physics at BNL, neutrino physics at FNAL, fundamental neutron physics at NIST/LANL/ORNL, and hadron spectroscopy at TJNAF. The collective technical resources, infrastructure, and support staff in the Physics Department and at the associated Indiana University Cyclotron Facility (IUCF) allow IU physicists to develop experimental apparatus on a scale normally possible only at national labs. Detailed information on current projects can be found at <http://www.physics.indiana.edu> and <http://www.iucf.indiana.edu>. We especially welcome applications from women and minority candidates. Please mail a CV, publication list, and research plan and arrange for a minimum of three letters of recommendation to be sent to:

**Faculty Search Committee, c/o Prof. W. M. Snow, Dept. of Physics,
Indiana University, Swain Hall West 117, Bloomington IN, 47405-7105**

Applications received by December 1, 2003, will receive priority.

Indiana University is an Affirmative Action/Equal Opportunity Employer.



UNIVERSITY OF FLORIDA

EXPERIMENTAL PARTICLE ASTROPHYSICS FACULTY POSITION

The Department of Physics, University of Florida, invites applications for a tenure-track Assistant or Associate Professor in the field of Experimental Particle Astrophysics.

The successful candidate will play a leadership role in a new experimental research effort, joining an active faculty housed in a new physics building with extensive laboratory space and computer facilities. Specific examples of research programs of interest include high-energy cosmic rays, cosmic microwave background observations, non-accelerator based neutrino studies, gamma ray astronomy, dark matter searches, and gravitational wave detection. Further faculty hires in the field are anticipated. Candidates are expected to have a PhD degree, or equivalent, and postdoctoral experience, and to be able to teach physics effectively at all levels. Applicants should submit a CV, publication list, and a statement of research interests and plans, and should arrange to have at least three letters of recommendation sent. All correspondence should be sent to:

**Chair, EPA Search Committee, c/o Mrs. Y. Dixon,
Department of Physics, PO Box 118440,
University of Florida,
Gainesville, FL 32611-8440.**

To ensure full consideration, all application materials must be received by January 1, 2004.

Women and underrepresented minorities are strongly encouraged to apply. The University of Florida is an Affirmative Action/Equal Opportunity Employer.

For further details on this position, please see:
<http://www.phys.ufl.edu/department/jobs/epasearch.html>

Max Planck Institute for Physics

(Werner Heisenberg Institute)



MAX-PLANCK-GESELLSCHAFT

The Max Planck Institute for Physics is one of the world's leading research institutes, focused on particle and astroparticle physics from both an experimental and a theoretical perspective.

Our research activities in astroparticle physics comprise participation in the gamma ray telescope MAGIC at La Palma Observatory, the future space mission EUSO, and the CRESST dark matter search at Gran Sasso.

The Max Planck Institute for Physics invites applications for two

Postdoctoral Positions in ultra-high-energy cosmic-ray physics and in high-energy gamma-ray astrophysics

to strengthen our EUSO and MAGIC groups.

EUSO is an experiment for UHE cosmic-ray observations, looking down onto the earth's atmosphere with a wide angle telescope from the International Space Station. EUSO will achieve a 300-1000 times larger aperture than currently running experiments and measure with high precision UHE cosmic rays above the GZK energy.

MAGIC is the world's largest ground based Cherenkov telescope to study the deep universe with high energy gamma rays above 30 GeV. There are many observational targets, e.g. AGNs, GRBs, Pulsars, and SNRs. However, the scientific objectives are not only the study of astrophysical sources, but also the investigation of fundamental physics, such as the search for Dark Matter and tests of the validity of Lorentz invariance. The first telescope is operative since October 2003 and construction of the second telescope has already started.

The position is limited to initially two years, with the possibility of an extension by another four years. Salary is according to the German federal pay scale (BAT). Candidates with an experimental background in cosmic-ray physics, gamma-ray physics or neighbouring fields, such as elementary particle physics and astrophysics, are encouraged to apply. Applications from women are particularly welcome. The Max Planck Society is committed to employing more handicapped individuals and especially encourages them to apply.

More information on the institute can be found on our homepage: <http://www.mppmu.mpg.de>

Interested scientists should send their application (including a CV and list of publications) until the end of February 2004 and arrange for three recommendation letters to be received by the same date.

Max Planck Institute for Physics

(Werner Heisenberg Institute)

Prof. Dr. Masahiro Teshima

Föhringer Ring 6,

80805 München, Germany

e-mail: mteshima@mppmu.mpg.de

Faculty Position

High Energy Theoretical Physicist

The Department of Physics at the University of California at Davis invites applications for a faculty position in theoretical high energy physics. Appointment at any level is possible depending upon qualifications and experience. The successful candidate will be the first of three planned new appointments directed toward pursuit of exciting new ideas and challenges associated with the interface between formal theory and phenomenology. Priority will be given to candidates with recognized leadership in this area and the ability to help plan and implement the High Energy Frontier Theory Initiative (HEFTI). The successful candidate should also have a strong interest in interpreting new phenomena as the relevant experimental data becomes available. Interaction and overlap with the particle cosmology group is anticipated. A formal High Energy Frontier Theory Institute is a strong possibility.

The existing high energy group consists of four theoretical and six experimental faculty. The theorists have a broad spectrum of interests including supercollider physics and phenomenology, supersymmetric modeling and superstring phenomenology, Higgs physics, brane models, lattice QCD, weak-interaction and heavy quark physics, solvable models, and quantum gravity. The experimentalists have major efforts at Fermilab and are active members of the LHC CMS collaboration.

The successful candidate will have a Ph.D. in physics or the equivalent and be expected to teach at the undergraduate and graduate levels.

This position is open until filled; but to assure full consideration, applications should be received no later than January 12, 2004. The targeted starting date for appointment is July 1, 2004. To initiate the application process, please mail your curriculum vitae, publication list, research statement, and the names (including address, e-mail, fax, and phone number) of three or more references to:

Professor Shirley Chiang, Chair
Department of Physics
University of California, Davis
One Shields Avenue
Davis, CA 95616-8677

Further information about the department may be found on our website at <http://www.physics.ucdavis.edu>.

The University of California is an affirmative action/equal opportunity employer. The University undertakes affirmative action to assure equal employment opportunity for minorities and women, for persons with disabilities, and for special disabled veterans, Vietnam era veterans, and any other veterans who served on active duty during a war or in a campaign or expedition for which a campaign badge has been authorized.



Department of Physics University of California, Davis



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You will pursue an active research programme with international impact as part of the theoretical particle physics group. Your research interests and experience should both broaden and strengthen existing research in the area of phenomenology and Beyond the Standard Model physics. You should be able to teach undergraduate physics, and possibly astronomy, at all levels and postgraduate theoretical particle physics. Informal enquiries can be made to Professor Christine Davies, +44 (0)141 330 4710, e-mail: c.davies@physics.gla.ac.uk Visit our website at <http://www.physics.gla.ac.uk> for further details on the department.

For an application pack, please see our website or write quoting

Ref: 10224/L/A1 to the Recruitment Section, Human Resources Department, University of Glasgow, Glasgow G12 8QQ.

Closing date: 16 January 2004.

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Post-Doc Research Scientist in Experimental Nuclear Physics

- Term: 2 or 3 years
- Start date: April 1, 2004
- Location: Jefferson Lab, Newport News, VA
- Subject: Photoreactions on the nucleon and few-body nuclei, primarily our newly approved experiment on photopion production from the nucleon with polarized beam and targets; service work for the Hall-B Collaboration at the 20-25% level
- Expertise/experience: Data acquisition and analysis/nuclear particle detectors
- Required: Ph.D. in medium-energy, electromagnetic, and/or few-body nuclear physics

Applicant should send a curriculum vitae and a one-page statement of research interests, and have three letters of reference sent direct to:

Professor B.L. Berman, Department of Physics
George Washington University, Washington, D.C. 20057

[fax: (202) 994-3001; e-mail: berman@gwu.edu; website: <http://www.gwu.edu/~c>

Review of applications will take place as received and will continue until the position is filled. The George Washington University is an Equal Opportunity—Affirmative Action Employer. Women and minorities are particularly encouraged to apply.

THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON DC



UNIVERSITY COLLEGE LONDON

Department of Physics and Astronomy

High Energy Particle Physics Group - Two Lectureships in Experimental Physics

Applications are invited for the above positions to commence in October 2004, or as soon as possible thereafter.

The High Energy Particle Physics Group has active research programmes in hadron collider physics (the ZEUS experiment at HERA, the CDF experiment at Fermilab and construction of the ATLAS experiment at the LHC), neutrino physics (the MINOS long-baseline neutrino oscillation search experiment and the NEMO-III double beta decay experiment), the linear collider sector and R&D for development of the global computing GRID.

Full details are available at <http://www.hep.ucl.ac.uk/>

It is proposed to appoint two experimentalists in relevant areas to extend and strengthen the work of the Group. Applicants with an interest in neutrino physics or the linear collider sector are particularly encouraged to apply, as these are the sectors we primarily wish to enhance. It is also part of the Group's strategy to augment its detector construction capability, and hence applicants with a potential programme in this area are encouraged.

Further details about the posts are available at <http://www.hep.ucl.ac.uk/positions>.

The successful applicant will have an established record of significant research and the potential to become a leader in the field. He/she will also be expected to show evidence of competence in teaching at undergraduate and postgraduate level. Candidates wishing to transfer a long-term fellowship are welcome to apply.

Salary scale in the Lecturer (A-B) range: £22,191 to £33,679 (pay award pending) plus £2,134 London Allowance, plus relocation benefits.

Applications, accompanied by a full CV, including a statement of research interests and plans, plus contact details of three referees, should be sent to Professor B R Martin (brm@hep.ucl.ac.uk), Head of Department of Physics and Astronomy, University College London, Gower St, London WC1E 6BT. Informal enquiries may be made to the HEP Group Leader, Professor P Clarke (clarke@hep.ucl.ac.uk).

The closing date for applications is **Friday, 16th January 2004**.

UCL Taking Action For Equality

FACULTY POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS

The Department of Physics at the University of California, Riverside, is seeking an outstanding individual for a faculty appointment in experimental high energy physics. The appointment will be at the tenure track assistant professor level. The position is intended to strengthen our program of electron-positron collision physics with the BABAR experiment at SLAC. UCR has a well established program in the area of electron-positron collisions. In addition to BABAR, we participate in the OPAL and L3 experiments at LEP. The Department also has strong efforts in the DO and CMS hadron collider programs, theoretical high energy physics, heavy ion physics, condensed matter physics, and astrophysics.

The successful candidate is expected to initiate and maintain a vigorous research program with international prominence, and to demonstrate excellence in teaching at both the undergraduate and graduate levels. A Ph.D. in physics and postdoctoral experience in experimental high energy physics are required.

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

Candidates should submit a letter of application, curriculum vitae, statement of research interests, and list of publications to:

Chair, Experimental High Energy Physics Search Committee
Department of Physics
University of California, Riverside
Riverside, CA, 92521-0412
USA

Full review of applications will begin January 12, 2004.

The position will remain open until filled.



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Tenure Research Position for Computational Astrophysics Laboratory

RIKEN invites applications for a tenure researcher position at Computational Astrophysics Laboratory. Computational Astrophysics Laboratory, changed from Computational Science Division of Advanced Computer Center, started to promote astroparticle physics on highest energy cosmic-rays. The candidate is expected to play a major role to promote Extreme Universe Space Observatory (EUSO) mission in Japan. See <http://euso.riken.go.jp/> for the details of EUSO mission. Applicants may be under 50 years old and must have Ph. D. and excellent background in astrophysics and astro-particle physics. The successful applicant will be expected to take up this position April 1st, 2004 or later.

An applicant is requested to supply the following materials to Dr. Toshikazu Ebisuzaki, Computational Astrophysics Laboratory, RIKEN, Hirosawa 2-1, Wako, Saitama, Japan 351-0198. (1) a full curriculum vitae with photograph, (2) a list of publications (3) a copy of each of three key publications, (4) a statement explaining research experience, reasons for his/her applications, and research plan in Computational Astrophysics Laboratory (within 4 pages in A4), and (5) a recommendation letter and the names and addresses of two scientists who may comment on the application. Application deadline is January 8th, 2004. An email submission in pdf format is accepted for applicants outside Japan. For further information, contact to Toshikazu Ebisuzaki:

FAX: +81-48-467-4078
E-mail: ebisu@postman.riken.go.jp



Postdoctoral Research Associate in Subatomic Physics

The I.U. subatomic physics group has an active program with experiments to study nucleon structure, nuclear dynamics, and the properties of the weak interaction. The wide range of activities being performed by 11 faculty members involve leadership roles in studies of parity violation in thermal neutron-proton capture at LANSCE, flavor and spin structure of the nucleon at RHIC with the STAR detector, and neutrino oscillations with the miniBooNE experiment at Fermilab. Local facilities include a 200 MeV cyclotron and a 240 MeV synchrotron. While the major programs on these no longer include nuclear physics, they do provide excellent facilities for development and testing. The laboratory also provides excellent personnel infrastructure to enable strong participation in major off-site projects. Opportunities are available on all major research projects. For further information, please access our Web site at <http://www.iucf.indiana.edu>.

Initial appointments as research associate will be for one year, with possible renewal for two additional years. A Ph.D. in experimental subatomic physics is required. Applications for postdoctoral positions are accepted on a continuing basis and starting dates can be adjusted to suit the situation of the candidates.

Send résumé, bibliography and contact information for three references to

Dr. John M. Cameron, Director
Indiana University Cyclotron Facility
2401 Milo B. Sampson Lane, Bloomington, IN 47408 USA
FAX: 812-855-6645 Email: cameron@iucf.indiana.edu

IU is strongly committed to achieving excellence through cultural diversity. The university actively encourages applications and nominations of women, persons of color, applicants with disabilities, and members of other underrepresented groups. Indiana University is an Affirmative Action/Equal Employment institution.

Grid.Opportunity@cern.ch

The Opportunity

The IT Department at CERN*, the European Organization for Nuclear Research near Geneva, Switzerland, is actively recruiting for **several major international computer Grid projects** that the Department is leading. **Over 30 new positions need to be filled in the coming six months, in areas including software development, data management, technology evaluation, computer centre operations, dissemination activities and secretarial support.** Typically, the positions are for 2-4 years, and will give highly motivated Europeans an opportunity to take part in some of **the most ambitious IT projects of the decade.**

The Challenge

CERN and its partners worldwide must be able to store and manage **petabytes of data** and process it on a globally distributed Grid of **tens of thousands of processors** by 2007, when the Large Hadron Collider, the largest scientific instrument in the world, is due to begin operation. The LHC Grid activities will be at the vanguard of the development of Grid technology for all of European science, and **top IT companies are collaborating** closely with CERN on this development. Grid activities led by the IT Department at CERN include:



CERN is leading a collaboration with the High Energy Physics Community worldwide to deploy the Large Hadron Collider Computing Grid (LCG). LCG-1 went online in September 2003, and will be extended and upgraded continuously during the run up to LHC operation in 2007. Positions at

CERN and in partner organizations are periodically being opened and more specific information is available at www.cern.ch/lcg.



Enabling Grids for E-science in Europe

CERN is leading **EGEE**, a consortium of 70 partners to provide a Grid Infrastructure for all of European Science. EGEE will be one of the largest efforts worldwide to build a production Grid infrastructure. The project is slated to start in April 2004, with recruitment opportunities opening now. More specific information is available at www.cern.ch/egee.

Grid infrastructure. The project is slated to start in April 2004, with recruitment opportunities opening now. More specific information is available at www.cern.ch/egee.



The **CERN openlab** for DataGrid applications is an industry-sponsored activity to develop new solutions for the Data-Intensive Science of the Large Hadron Collider.

Sponsored by Enterasys Networks, HP, IBM, Intel and Oracle, the CERN openlab periodically has openings.

For more information see www.cern.ch/openlab.

FOR MORE INFORMATION about CERN's Grid activities and Grid technology in general, please visit "Grid@CERN" on the Grid Café website at www.gridcafe.org, where there are also links to employment opportunities at CERN and with CERN's partner organizations. If you would like to be periodically updated about Grid-related employment opportunities in the IT Department, please email

Grid.Opportunity@cern.ch.

*From January 1st 2004, CERN's IT Division is expanding into a 400-person Department. For more information on the Department's activities, and employment opportunities, see www.cern.ch/it.



The Fermi National Accelerator Laboratory (Fermilab) invites applications for:

LEDERMAN FELLOWSHIP EXPERIMENTAL PARTICLE PHYSICS

Applicants should have demonstrated outstanding ability in research and, in recognition of Leon Lederman's commitment to the teaching of physics at all levels, experience and interest in physics outreach. The successful candidate will have a choice among experiments, which include Tevatron collider experiments, neutrino experiments, other fixed target experiments and non-accelerator projects (dark matter search cosmic ray observatory), or research on accelerators. See <http://www.fnal.gov/> for more information.

Candidates should have obtained a Ph.D. in particle or accelerator physics since Jan 1st 2002. The appointment is normally for three years with an extension possible. Applicant should send a letter including their research and outreach experience and interests, a curriculum vita, publication list and the names of at least four references. One reference should specifically address the outreach experience. **The deadline for applications is December 6th 2003.** To apply write to **Dr. Michael Albrow – Experimental Physics Projects Department Head, Fermi National Accelerator Laboratory, MS 122, P. O. Box 500, Batavia IL 60510-0500.** (albrow@fnal.gov) EOE M/F/D/V



INDEX TO DISPLAY ADVERTISERS

Amptek Inc	1
Babcock Noell Nuclear GmbH	5
C4i	1
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The activities of the Theory Group include: phenomenology and field theory of high energy processes in Quantum Chromodynamics and Electroweak Interactions and Lattice Gauge Theory. For details see <http://www-zeuthen.desy.de/theory/>. For Fall 2004 the Theory Group at Zeuthen has openings for

Postdoctoral Positions in Elementary Particle Theory BAT-O IIa

Interested candidates, who have completed their Ph.D. and who are younger than 33 years are invited to apply. Please send your application, including a list of publications, a research statement and 3 Letters of Reference to the Department of Human Resources until Dec. 15. 2003. Later applications may be considered. Further information concerning the positions is given by Dr. J. Blümlein (johannes.bluemlein@desy.de). The positions are limited for two years. Salary and benefits are commensurate with public service organisations.

DESY is an equal opportunity, affirmative action employer and encourages applications from women.

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Deadline for applications: 15.12.2003



Postdoctoral & Graduate Positions in String Theory and Quantum Gravity

The string group of the University of Kentucky invites applications for postdoctoral and graduate positions in string theory, quantum gravity, or related areas beginning September 1, 2004. Information about our research program is available at www.pa.uky.edu/strings. Applications and recommendation letters should be sent by Dec. 19 to either Prof. Sumit Das or Prof. Al Shapere, Dept. of Physics, U. of Kentucky, Lexington KY 40506, USA, or to shapere@pa.uky.edu. The University of Kentucky is an equal opportunity employer.

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FACULTY POSITION IN ACCELERATOR PHYSICS

The Department of Physics at the University of California, Riverside, invites highly qualified applicants to apply for a new faculty position in accelerator physics. This position may be filled at either the assistant professor or tenured associate professor level. The appointment will be effective July 1, 2004.

The Department is seeking outstanding candidates with exceptional research records and demonstrated excellence in teaching. The successful candidate is expected to establish a leading edge research program involving graduate students in what will be a new area in the Department and contribute to Department teaching at all levels. The Department currently carries out research in experimental and theoretical condensed matter physics, astrophysics, and high-energy physics.

Candidates for this position are required to have a Ph.D. or equivalent degree in physics. Salary will be competitive and commensurate with qualifications and level of appointment. Candidates should submit a letter of application, curriculum vitae, list of publications, evidence of teaching skills, and evidence of an outstanding research program. Candidates should also provide evidence of leadership and initiative since accelerator physics will be a new area in the Department. They should arrange to have three letters of reference sent to the Department and be willing to submit additional references on request. Letters should be sent to:

Chair, Accelerator Physics Search Committee
Department of Physics
University of California, Riverside
Riverside, CA 92521-0413
U.S.A.

Full review of applications will begin January 1, 2004.
The position will remain open until filled.



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RESEARCH ASSOCIATE EXPERIMENTAL ELEMENTARY PARTICLE PHYSICS

Cornell University

The experimental high energy physics group at Cornell University has an opening for a Research Associate to work on the CLEO-c experiment at the Cornell Electron Storage Ring. This experiment provides a unique opportunity for high precision measurements in the Upsilon family, at the J/Psi, and near the DD and DsDs production thresholds. These measurements will play a significant role in future unitarity constraints through both direct contributions and through precision calibration and testing of QCD calculation techniques. The high statistics radiative J/Psi sample will provide a powerful laboratory for the search of exotic QCD resonances, such as glueballs and hybrids. The successful respondent will also play a lead role in the development of a Linear Collider Detector R&D program at Cornell.

Appointments are nominally for three years with the possibility for renewal beyond that, subject to mutual satisfaction and the availability of funds under our NSF contract. A PhD in experimental elementary particle physics is required. The salary range is \$45,000-\$50,000 commensurate with experience. Please send an application including curriculum vitae and a publications list to Prof. James Alexander, Newman Laboratory, Cornell University, Ithaca, NY 14853, and arrange for at least two letters of recommendation to be sent. Email correspondence may be directed to search@lepp.cornell.edu.

Cornell is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

Post-Doctoral Position

Applications are invited for an experimental physicist to develop Cadmium Zinc Telluride X-ray and gamma-ray semiconductor detectors for their application in space-borne telescopes, and to analyze and interpret astrophysical X-ray and gamma-ray data.

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After the appointment to Professor at the Technische Universität Darmstadt the successful candidate will be granted a leave of absence to GSI.

GSI and the Technische Universität Darmstadt are equal opportunity, affirmative action employers and encourage applications in particular also from women. For the employment § 71 of the Hessian University Law in its version from 31.07.2000 applies (http://www.hmwk.hessen.de/hhg/HHG_31_07_2000.pdf)

Applications, including the curriculum vitae, the list of publications, and research and teaching records, should be sent not later than January 19, 2004 to

Wissenschaftliche Geschäftsführung der
Gesellschaft für Schwerionenforschung mbH
Planckstraße 1
64291 Darmstadt
GERMANY



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

The Swiss Federal Institute of Technology in Lausanne (EPFL) invites applications for an assistant professor appointment (tenure track) in its Institute of Theoretical Physics, tentatively beginning in the fall semester of 2004.

We seek an outstanding young physicist active in theoretical high-energy physics, preferentially at the interface with astrophysics/ cosmology. Experienced candidates seeking a higher-level position may be considered. The successful candidate is expected to lead an independent research program, interacting with existing projects in theoretical particle physics and cosmology and to teach at both graduate and undergraduate levels.

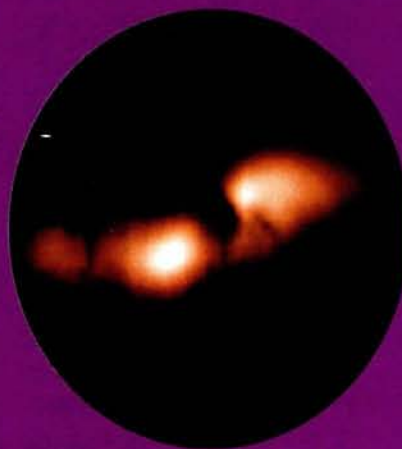
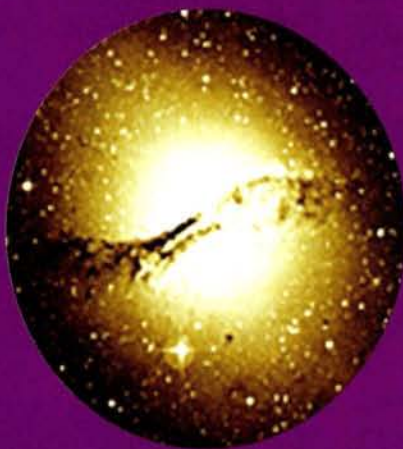
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Applications with curriculum vitae, publication list, a concise statement of research plans and the names and addresses (including e-mail) of five references should be sent before **February 15, 2004** to the following address:



**Professor Giorgio Margaritondo, Dean,
EPFL - Faculty of Basic Sciences, CH-1015 Lausanne, Switzerland**
(e-mail: giorgio.margaritondo@epfl.ch)

For additional information, please contact:
Prof. Mikhail Shaposhnikov, Institute of Theoretical Physics,
EPFL, BSP-Dorigny, CH-1015 Lausanne, Switzerland
(e-mail: mikhail.shaposhnikov@epfl.ch),
and consult <http://itp.epfl.ch/>, <http://sb.epfl.ch/>,
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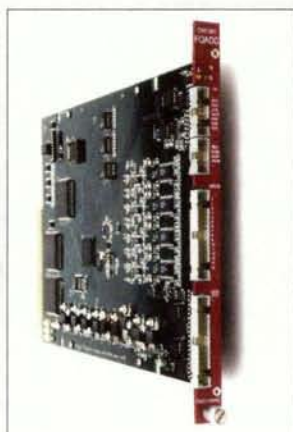


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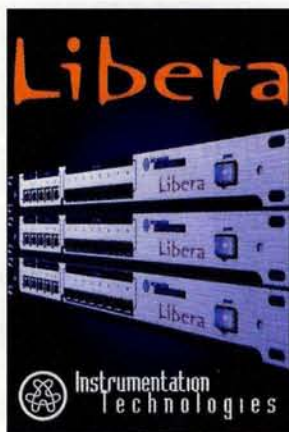
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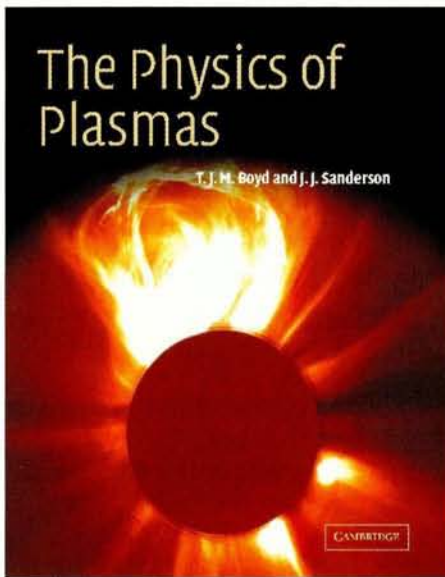
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The Physics of Plasmas by T.J.M. Boyd and J.J. Sanderson, Cambridge University Press. Hardback ISBN 0521452902, £80 (\$120). Paperback ISBN 0521459125, £29.95 (\$50).

Plasma physics is the study of the ionized state of matter; most of the baryonic matter in the universe is in the plasma state. Plasmas occur quite naturally whenever ordinary matter is heated to temperatures greater than 10^4 K. The resulting plasmas are electrically charged gases or fluids. They are profoundly influenced by the long-range Coulomb interactions of the ions and electrons, and by magnetic fields, either applied externally or generated by currents within the plasma.

The plasma medium is inherently nonlinear because the electromagnetic fields are produced self-consistently by the charge density and currents associated with the plasma particles. The dynamics of such systems are complex, and understanding them requires new concepts and techniques. Plasma physics describes elementary processes in completely or partially ionized matter, using well-known principles at the microscopic level.

The Physics of Plasmas provides a

systematic approach to the subject by discussing the models used to describe plasmas, starting with particle-orbit theory, then proceeding to the fluid description, magneto-hydrodynamics, wave modes, the kinetic description, radiation processes, nonlinear effects, and ending with a chapter on the mathematical structure underlying the theoretical models used in plasma physics.

The book provides a comprehensive and refreshing view of plasmas concentrating on the physical interpretation of plasma phenomena. It is advertised as ideally suited to advanced graduate and graduate students of physics, astronomy, applied physics and engineering, with which I wholly agree. The advanced researcher will also find the book of interest and value in its treatment of both natural and laboratory plasmas. In fact anyone interested in plasma physics will find it a very useful book.

Bob Bingham, Rutherford Appleton Laboratory.

The Discovery of Subatomic Particles, Revised Edition by Steven Weinberg, Cambridge University Press. Hardback ISBN 052182351X, £18.95 (\$25).

I have been an admirer of this book since its first edition 20 years ago, and have recommended it on many courses for the general public, where people might be making their first encounter not only with particle physics but with physics itself. In my opinion that is the great strength of Weinberg's book: it sets the discoveries of the first subatomic particles – the electron, proton and neutron – against a background of experimentation in physics, explaining in simple terms how we know that this is the way that matter is.

The electron, the longest- and best-known of subatomic particles, takes up the first half of the book, which is enriched by “flashbacks” to discuss topics such as energy and electric and magnetic forces. These subjects may be the bread-and-butter of the physicist's world, but they are often less than obvious to most

other people, who left these ideas behind when they left school. By presenting such concepts in an historical manner, Weinberg allows the reader to learn in a way that mirrors how the physicists of the 18th and 19th centuries themselves learned.

The members of the subatomic “zoo” discovered in the second half of the 20th century – from neutrinos to gluons – are covered in 10 or so pages at the end of the book. As Weinberg points out, it was not his intention to write another popular book on modern physics, and nowadays there are other books that readers can pick up once they have read Weinberg's. This revised edition, however, brings the section on the modern particles up to date, and Weinberg has also taken the opportunity to point out the links between the historic discoveries and the work of particle physics today. I'm pleased the book is back in print and shall certainly continue to recommend it.

Christine Sutton, CERN.

Books received

Fundamentals in Hadronic Atom Theory by A. Deloff, World Scientific. Hardback ISBN 9812383719, £46 (\$68).

This is the first book to describe the theory of hadronic atoms and the unique laboratory they provide for studying hadronic interactions at threshold. With an emphasis on recent developments, it is aimed at advanced students and researchers in nuclear, atomic and elementary particle physics.

Finite Element Methods for Structures with Large Stochastic Variations by Isaac Elishakoff and Yongjian Ren, Oxford University Press. Hardback ISBN 0198526318, £45 (\$74.50).

Published in the series of Oxford texts on applied and engineering mathematics, this book is the first to discuss the finite-element method for structures with large stochastic variations. It has an impressive bibliography.

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The case for investing in the future

Earlier this year 14 Nobel laureates wrote to the president of the CERN Council to encourage the member states to support some non-LHC research and R&D on future detectors and accelerators. Here we print their letter and the reply from the president of Council, **Maurice Bourquin**, and the director-general of CERN, **Luciano Maiani**.

Dear Professor Bourquin,

The European laboratory for particle physics, CERN, is often cited as the jewel of international collaboration. Created almost half a century ago by a consortium of 11 governments, CERN is now the world's largest research laboratory, with 20 member states and significant support and collaboration from many other nations. Its scientific accomplishments are legion. CERN has been the worldwide leader in elementary-particle research for decades past and, hopefully, it will continue to be for decades to come.

The research carried out at CERN by its member states is "pure" in the sense of being guided primarily by the drive to understand the universe in which we live. It is an established fact that the practical consequences of even the most apparently exotic research have always been plentiful and unexpected: the Web, born at CERN, is only one example.

CERN is now embarked on an ambitious and fascinating endeavour: the construction of the Large Hadron Collider (LHC) and the deployment of large detectors to exploit it. Scientists within and outside the discipline of particle physics agree on the necessity for the timely completion of this promising project.

A series of circumstances has led its governing Council to require that all of CERN's efforts, resources and manpower be focused on the LHC. While this may have become unavoidable, we wish to point out that such measures will be extremely damaging to the long-term future of the laboratory.

The scope of research now being done at CERN, as well as R&D for future CERN projects not related to the LHC, has already been reduced to a bare minimum. The moratorium on most lines of research will virtually terminate the training of the next generations of high-energy physicists. The severe cuts on R&D will have similar consequences for the training of accelerator and detector scientists,

engineers and technicians. Moreover, with the absence of sufficient current long-term investments, there will be no further endeavours, CERN will have no post-LHC future, and its member states will have lost their leadership role in one of the most fundamental sciences. The CERN experience is not something that can be restarted "at the turn of a key".

To remedy this situation, we would suggest that a small percentage of the CERN budget be earmarked for continued and renewed non-LHC research and for further R&D on future detectors and accelerators. We suggest that an appropriate ad hoc committee be constituted to study this proposal in detail. A modest effort of this kind would restore the enthusiastic morale once shared by all CERN personnel and users engaged in the quest for new knowledge; would preserve and transmit to future generations the carefully honed art and know-how underlying our discipline; and would enable CERN to continue to contribute to a better Europe and a better world.

We encourage the governments of the member states of CERN to weigh the present restrictive measures against a relatively small effort that would have an enormous impact upon the present and future research accomplishments at CERN, with considerable benefits to both science and society.

Sincerely,

Georges Charpak, Val L Fitch, Sheldon L Glashow, Gerard 't Hooft, Leon Lederman, Tsung-Dao Lee, Martin L Perl, Norman F Ramsey, Burton Richter, Carlo Rubbia, Martinus J G Veltman, Jack Steinberger, Steven Weinberg and Chen Ning Yang.

cc. Professors Aymar and Maiani, the members of Council and the members of the Scientific Policy Committee.

Maurice Bourquin and Luciano Maiani reply:

We feel very honoured that such a distinguished panel of scientists thinks so highly of

the organization and of its achievements and shows concern about its future.

CERN was forced to make painful choices at the end of 2001, when the organization was confronted with a funding shortfall for the completion of the LHC project. In line with the recommendations of the External Review Committee, CERN management submitted a long-term plan, in June 2002, aimed at focusing resources and manpower on the LHC machine and experiments. The target of commissioning the machine in April 2007 was confirmed. The plan was finally accepted by Council in December 2002, and it puts the LHC construction on a firm, if very tight, basis.

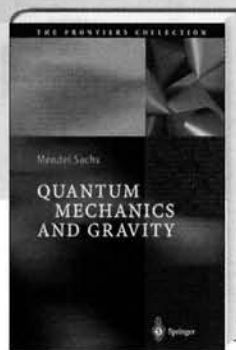
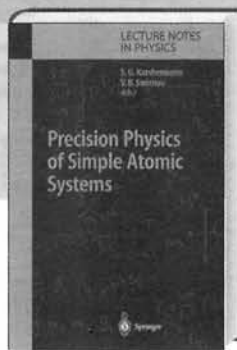
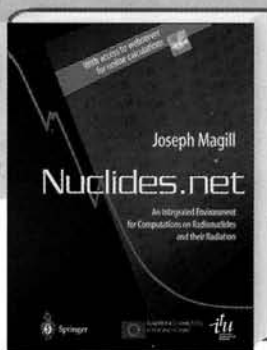
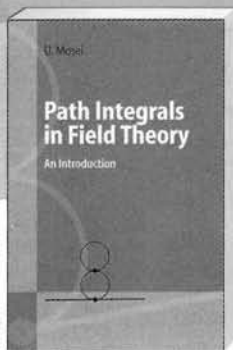
The LHC is the worldwide priority in high-energy physics. The reduction in the scientific activities at CERN during the LHC construction was the price to pay for the future possession of this powerful tool.

A limited number of ring-fenced parallel activities have been maintained, however, to keep a minimum of scientific diversity (COMPASS, long base-line neutrino beam, low-energy antiprotons, low-energy nuclear and neutron physics) or to preserve vital options for CERN's future (CLIC and its test facility and the design of the front-end of the Superconducting Proton Linac).

While submitting to Council the strategic decisions that have been adopted at the end of 2002, CERN management and several delegations pleaded with Council to consider providing additional resources to ensure an extension of CERN's scientific activities, once the LHC financial situation was consolidated.

We welcome the recommendations made by the authoritative panel of Nobel laureates and we are sure they will help in opening a new fruitful discussion with the member states on the future of CERN and of international research in particle physics.
Maurice Bourquin, president of CERN Council; Luciano Maiani, director-general of CERN.

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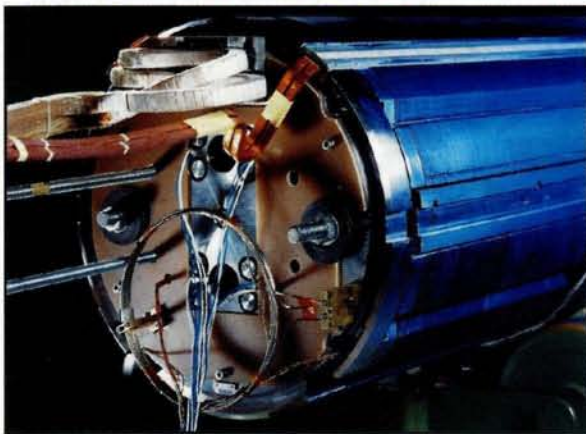
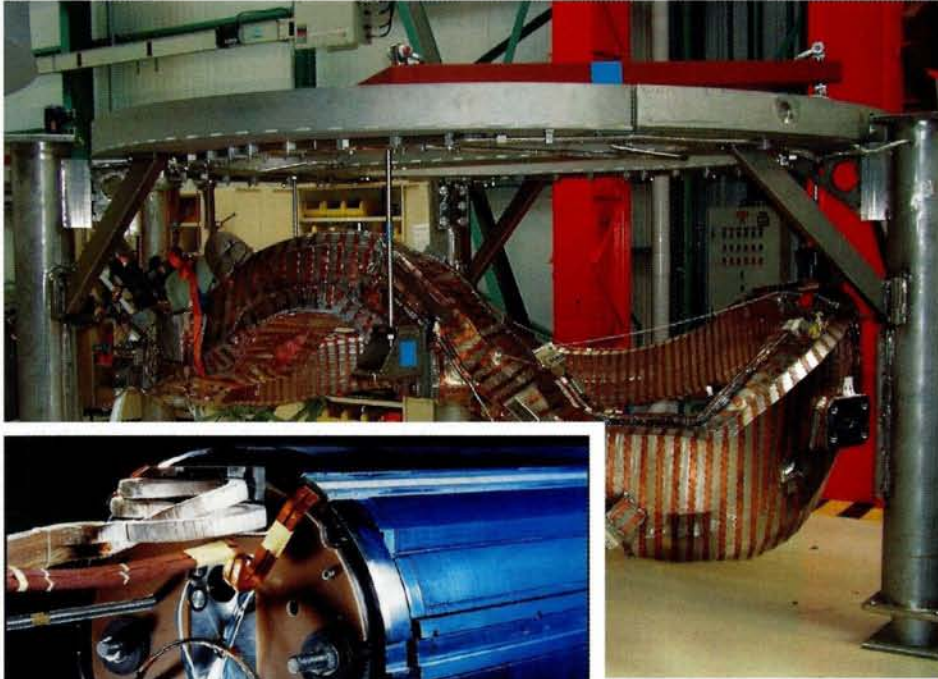
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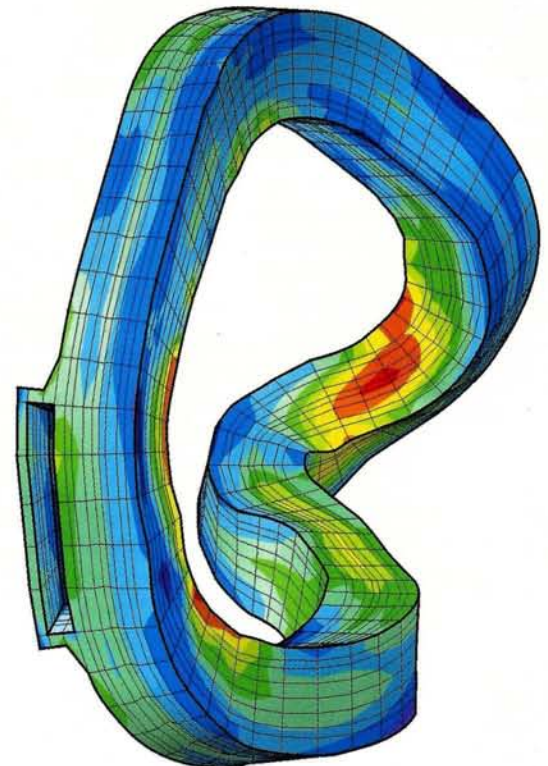


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