INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

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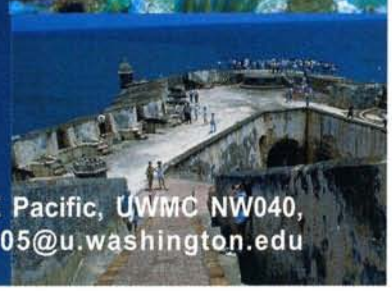

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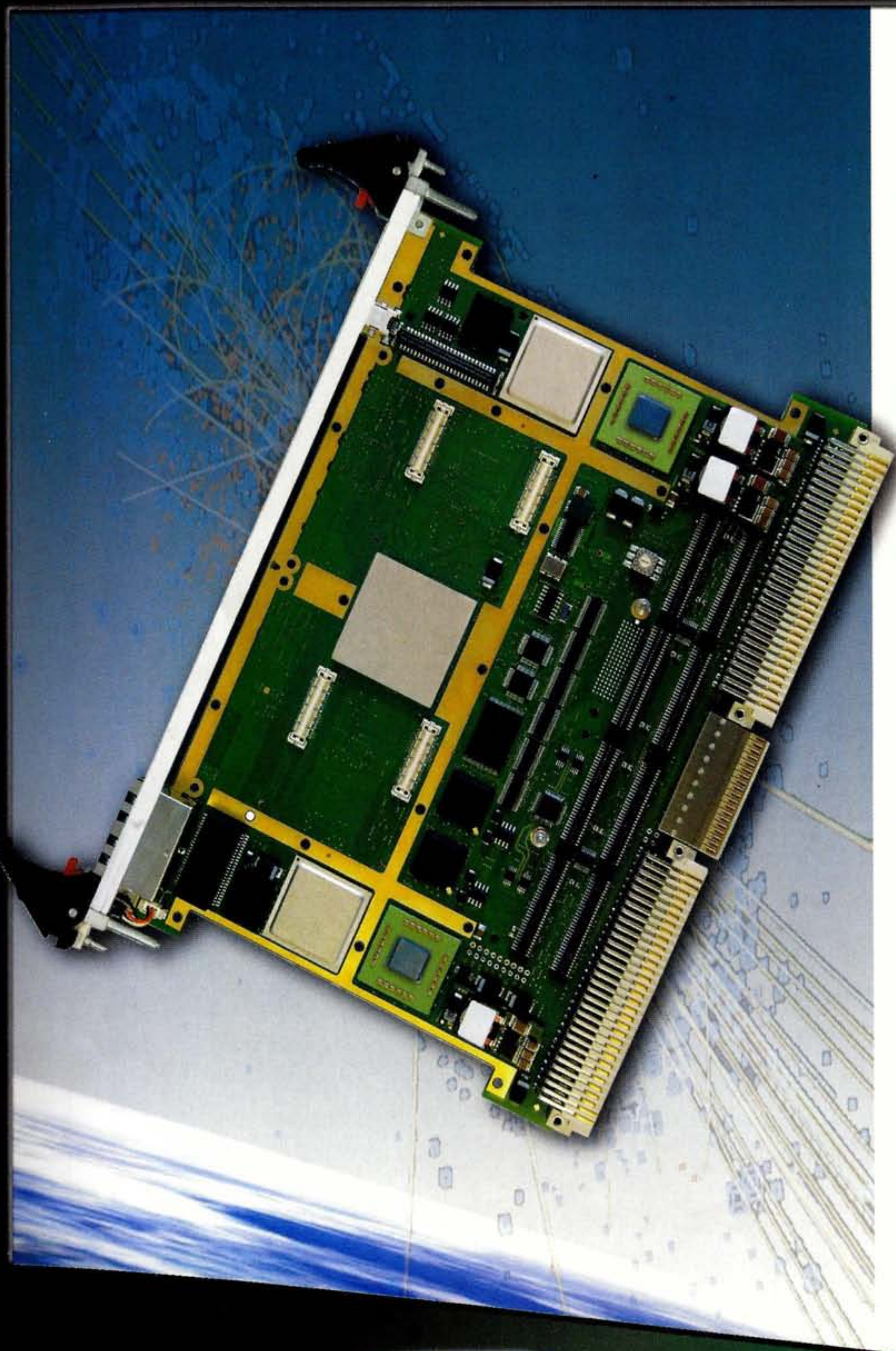
Symposium centres on spin p21

Cover: The HERA collider at DESY is now raring to go after its major luminosity upgrade that began in 2001 (p17). (David Parker/Science Photo Library.)



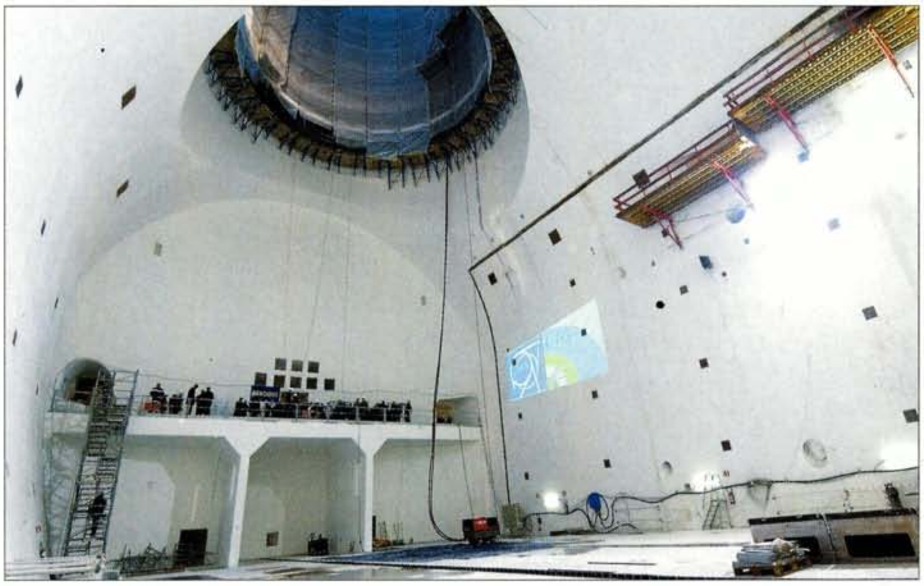
CERN

CMS cavern ready for its detector

On 1 February 2005, the cavern for the CMS detector at CERN was inaugurated in a ceremony attended by many guests, including the Spanish and Italian ambassadors to the United Nations and representatives of the construction companies.

The hand-over of this cavern, a gigantic underground structure 100 m underground near the village of Cessy in France, marks the end of the large-scale civil-engineering work for the Large Hadron Collider (LHC) at CERN.

The second of the new caverns for the LHC experiments, the CMS cavern is the result of several years of work by a consortium of Italian, Spanish, British, Austrian and Swiss civil-engineering companies. Problems arising from the local geology made it a spectacular feat of engineering.



The gigantic cavern for the CMS detector, 100 m underground near Cessy in France.

The new structures built for CMS in fact comprise two caverns, together with two access shafts, for which 250 000 m^3 of spoil had to be removed. The cavern for the detector is 53 m long, 27 m wide and 24 m high. The second cavern, housing the technical services, is adjacent. Unlike the strategy for the ATLAS detector, the various components for the CMS detector are being assembled and tested in a surface building before being lowered into the cavern, starting next January.

Work began six-and-a-half years ago with the excavation of the two access shafts. This was not an easy task given the 50 m deep stratum of extremely unstable moraine that also contains two water tables. To excavate this loose, wet earth, a ground-freezing technique was used, which involved circulating a brine solution at a temperature of −23 °C, followed by liquid nitrogen.

The molasse between the two caverns, which was too weak to withstand the high levels of stress exerted on it, presented a further difficulty and had to be replaced by a huge pillar of reinforced concrete.

To control the environmental impact of the project, special attention was paid to water treatment and to minimizing dust and noise levels. Moreover, the tonnes of spoil were deposited in the immediate vicinity, avoiding noise and disruption on the roads of the nearby villages. These storage areas are being landscaped and will be planted with vegetation between now and June 2005.

WORLD YEAR OF PHYSICS

Celebratory year lifts off in Paris

More than 1000 people including eight Nobel laureates and close to 500 students from 70 countries took part in the Physics for Tomorrow conference in Paris on 13 January. The event took place at the headquarters of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It marked the official launch of the International Year of Physics proclaimed by the UN, which aims to highlight the importance of physics and its contribution to society.

Robert Aymar, director-general of CERN, at the inauguration of the year of physics.

The conference was organized by UNESCO, the lead UN organization for the International Year, together with other organizations from the physics community, including the CNRS and CEA in France and CERN. CERN itself was founded under the auspices of UNESCO, which is one of the observer organizations to the CERN council, so it was appropriate that Carlo Rubbia and Georges Charpak, Nobel laureates from CERN, together with the director-general, Robert Aymar, were among the invited speakers.

During the opening ceremony, Aymar emphasized the crucial roles of physics as the driving force for innovation, as the magnet for attracting and training the most talented people, and in forging partnerships of nations. Rubbia participated in the round table on "What can physics bring to the socio-economical challenges of the 21st century?" and Charpak talked about "Teaching and education in physics".

● This inaugurated a series of events that are taking place all over the world in 2005 to celebrate physics and emphasize its role. For further information see www.wyp2005.org.

COSMIC RAYS

Balloon experiment searches for antiparticles above the Antarctic

The Balloon-borne Experiment with Superconducting Spectrometer (BESS) launched a cosmic-ray spectrometer from Antarctica on 13 December. BESS, a collaboration between the US and Japan, has been studying cosmic rays since 1993 with balloon flights over northern Canada, but this was its first flight in Antarctica with a completely new instrument.

The 2 t detector was carried by a 1 000 000 m^3 balloon from Williams Field near the US McMurdo Station. It flew to altitudes of 37–39 km for a period of 8 days and 17 hours. Flight operations were carried out by the National Scientific Balloon Facility (NSBF) as part of the United States Antarctic Program, supported by NASA and by the National Science Foundation (NSF).

With this new detector the BESS group is continuing the systematic study of low-energy antiprotons in cosmic radiation. These rare particles are a unique probe for understanding elementary particle phenomena in the early universe.

Balloon inflation prior to launching of the BESS-Polar spectrometer. The detector, with its solar-power cells, is in the foreground. The balloon reached an altitude of 37–39 km.

Most cosmic-ray antiprotons are produced in collisions of primary cosmic-ray nuclei with the interstellar gas. However, if an excess of low-energy antiprotons beyond those expected from standard processes is observed, measurements from BESS may provide evidence for the primary origin of some cosmic-ray antiprotons through processes such as the evaporation of primordial black holes or the decay of possible forms of dark matter.

BESS has detected more than 2000 low-energy antiprotons in eight flights from northern Canada over the past 11 years. Most of the antiprotons measured by BESS are clearly secondary products of primary cosmic rays. However, the data obtained during the last solar minimum in the sunspot cycle (which occurred in 1996) suggest a spectrum flatter than expected in the low-energy region, and hence the exciting possibility of novel origins for cosmic antiprotons.

BESS also searches for antihelium in the cosmic radiation, the detection of which would have profound significance for both cosmology and particle physics. Unlike antiprotons, antihelium has a vanishingly small probability of creation by cosmic rays. Furthermore, our current understanding is that the universe is baryon-asymmetric, with an overwhelming dominance of matter over antimatter, and that antimatter stars or galaxies do not exist. The discovery of a single antihelium event would change this view.

The analysis of the BESS data has found no evidence for antihelium while recording more than 7 million helium nuclei, establishing the most stringent upper limit to the existence of antihelium and supporting baryon asymmetry.

In 2001 the BESS group started a project to improve the statistics and to lower the energy threshold of the detector. They developed a new instrument with a much thinner superconducting solenoid magnet and detector system and without an outer pressure vessel. The cryogen lifetime of the new magnet has also been greatly improved, and at polar latitudes a solar-power system increases flight times by more than an order of magnitude compared with typical one-day flights in Canada.

During the 2004 BESS-Polar flight, the data from some 900 million cosmic rays, totalling about 2 Tb, was recorded on an array of on-board hard disks. Following the flight around Antarctica, BESS-Polar descended by parachute to a landing site on the Ross Ice Shelf approximately 900 km from its launch point. A recovery crew was flown to the area, and in a series of flights from the remote Siple Dome Camp to the landing location the data disks and the remainder of the instrument and payload were recovered successfully.

● BESS is a collaboration between KEK, the NASA Goddard Space Flight Center, the University of Tokyo, Kobe University, the Institute of Space and Astronautical Science of JAXA, and the University of Maryland.

ASTROPARTICLE PHYSICS

CAST sheds some light on axions

The CERN Axion Solar Telescope (CAST) collaboration has released the first results from its search for the solar axion, a viable candidate for a dark-matter particle. The result from CAST's first year of operation, submitted to *Physical Review Letters*, does not show evidence for the axion but it narrows down the hunt for this elusive particle.

Axions were theorized more than 25 years ago to explain the absence of charge–parity (CP) symmetry violation in the strong interaction. These neutral, very light particles (in the mass range 10^{-5}–$10\ eV/c^2$) interact so weakly with ordinary matter that they could have survived until now from their birth at the very beginning of the universe, so could contribute to dark matter. However, axions could also be created today, for example near the strong electric field inside the hot plasma core of the Sun, where thermal X-rays could be efficiently converted into axions. These axions would stream out freely and arrive on Earth in quantities larger than solar neutrinos.

CAST, currently the world's only working "axion helioscope", is a prototype superconducting magnet for the Large Hadron Collider that has been refurbished and fitted with X-ray detectors, plus a focusing mirror system for X-rays that was recovered from the German space programme (*CERN Courier* April 2001 p6). The 9 T field in the magnet can convert solar axions passing through CAST into X-rays, with the highest efficiency for such a detector to date.

The CAST axion helioscope points towards the Sun each day at sunrise and sunset.

The first results from CAST show that the axion-photon coupling constant is $g_{a\gamma\gamma} < 1.16 \times 10^{-10}\ GeV^{-1}$ for axion masses below 0.02 eV (Zioutas *et al.* 2004). This new limit is five times smaller than the previous best laboratory measurements, from the Tokyo axion helioscope experiment (Moriyama *et al.* 1998). However, CAST's new result is comparable, in the mass range studied, to the best limit derived from stellar energy-loss arguments. It also excludes an important part of the parameter space that is not excluded by solar-age considerations, which allow an axion–photon coupling somewhat larger than the Tokyo limit.

So far CAST has covered the low end of the axion rest-mass range, $m_a < 0.02\ eV/c^2$. The group is currently remodelling the telescope; filling the two tubes of the magnet with helium gas will keep the X-rays and axions in phase over the magnet's entire length of 9.26 m. This will allow a search for axions of higher mass, covering more of the range expected from theory and not excluded by astrophysical and cosmological observations.

Further reading

K Zioutas *et al.* 2004 http://arxiv.org/pdf/hep-ex/0411033.
S Moriyama *et al.* 1998 *Phys. Lett.* **B434** 147.

DESY

Countries sign up to XFEL agreement

A milestone has been reached on the way towards the realization of the European X-ray Free Electron Laser facility (XFEL). France, Germany, Greece, Italy, Poland, Spain, Sweden, Switzerland and the UK have signed a Memorandum of Understanding in which they agree to prepare the ground for a governmental accord on the construction and operation of the European XFEL research facility until mid-2006. Denmark will also sign up soon. Together with Hungary, the Netherlands, Russia, Slovakia and the European Union, which are present as observers, the signatory countries form a steering committee that coordinates the preparations for the construction of XFEL.

Following a recommendation by the German Science Council, the German federal government decided in February 2003 to go ahead with XFEL as a European joint project to be situated at the DESY laboratory in Hamburg (*CERN Courier* November 2003 p21). Commissioning this research facility, which will be unique in Europe, is to start in 2012. Its cost amounts to about €900 million, which will be borne jointly by Germany and the partner countries.

The memorandum includes working out proposals for detailed time schedules and financing schemes, the future organization structure, the exact technical design and the operation of the X-ray laser. XFEL, with its ultra-short X-ray pulses with laser-like properties, will open up completely new opportunities in a wide range of research, from geological studies to nanotechnology.

ANTIPROTONS

AD stores record number of antiprotons

A new technique for cooling antiprotons has been tested at CERN's Antiproton Decelerator (AD), yielding 50 times more trapped antiprotons per cycle than ever before. Storing and cooling large samples of antiprotons is an important step towards achieving the physics goals of the experiments at the AD, which require the synthesis of exotic atoms such as antihydrogen ($\bar{p}e^+$) and protonium ($p\bar{p}$).

Atoms, including exotic ones like these, can be efficiently synthesized only at chemical-energy scales (a few electron-volts or lower). This is many orders of magnitude below the energy scales needed for the production of antiprotons using an accelerator (a few giga-electron-volts). The AD reduces this gap by decelerating the 3 GeV antiprotons generated when the proton beam from the Proton Synchrotron hits an iridium target down to an energy of 5.3 MeV. This is still too high, however, for electromagnetic traps that can only capture antiprotons at the 10 keV range. Until now, thin "degrader" foils were used to slow antiprotons further, but the efficiency of such a system is low as many antiprotons stop and annihilate within the foils. Indeed, out of the 3×10^7 antiprotons ejected every 2 min in a 90 ns pulse (or "shot") of the AD, only about 25 000 were retained.

Now a team from the Atomic Spectroscopy And Collisions Using Slow Antiprotons (ASACUSA) experiment and CERN have replaced these foils by a radio-frequency quadrupole decelerator (RFQD). This 4 m-long device can decelerate antiprotons to 10–120 keV. In the tests, the antiprotons passed from the RFQD into a standard multi-ring trap (MRT), as was the case with the earlier work with degrader foils. The trap is filled with an electron gas that helps to cool the antiprotons through thermal exchange, as the electron gas dissipates energy through the emission of synchrotron radiation.

ASACUSA's radio-frequency quadrupole decelerator, open to show the four-rod structure along the centre, which crosses 35 resonator chambers formed by the vertical partitions.

During the tests, around 1.2×10^6 antiprotons per AD shot were stored in the MRT for 10 min or more. This is 50 times higher than the previous best values obtained with degrader foils and corresponds to an antiproton trapping efficiency of about 4%.

Further reading

N Kuroda *et al.* 2005 *Phys. Rev. Lett.* **94** 023401.

ATRAP tests new way to make antihydrogen

One goal of future studies with antihydrogen will be to compare its spectroscopy with hydrogen's. This will require the antihydrogen atoms to be trapped long enough for precise measurements to be made, which in turn will need very low antihydrogen temperatures, well below 0.5 K. The ATRAP collaboration at the AD has been experimenting with a new way of producing antihydrogen that might result in suitably low temperatures.

Until now, antihydrogen production has been achieved by bringing cooled antiprotons and positrons together in a nested Penning trap structure (*CERN Courier* November 2002 p5 and December 2003 p5). The new method consists of exciting caesium atoms from an oven with two lasers, and then introducing the caesium into a positron trap. Excited positronium, a bound state of an electron and a positron, is then formed when a positron collides with a caesium atom and captures an electron. These positronium atoms carry virtually all the 10 meV or so binding energy of the caesium atoms. Finally, a fraction of the excited positronium atoms collide with trapped antiprotons to produce excited antihydrogen atoms with a probability that is expected to be much higher than for ground-state positronium.

The velocity distribution of the resulting excited antihydrogen is expected to be the same as that of the trapped antiprotons from which the antihydrogen forms, which can be made arbitrarily low in principle. Verifying this by directly measuring the antihydrogen velocity has not yet been possible, but if the low antihydrogen energy is confirmed, and if the highly excited states can be de-excited, this technique could become the method of choice for producing cold antihydrogen for precise spectroscopic analysis.

Further reading

C H Storry *et al.* 2004 *Phys. Rev. Lett.* **93** 263401.

HEAVY IONS

RHIC starts colliding copper with copper

The Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory in the US has started colliding beams of copper ions. RHIC, which is actually two concentric rings 4 km in circumference, was built to create collisions between heavy ions, in particular gold. The use of intermediate-size copper nuclei – resulting in energy densities that are not as high as in earlier gold-ion runs, but more than was produced by colliding gold ions with much lighter deuterons – is important to understanding the new phenomena that have been observed in the heavy-ion collisions.

The energy of the gold–gold collisions was predicted to be sufficient to "melt" protons and neutrons to produce a hot "soup" of free quarks and gluons – the quark–gluon plasma. To date, the gold–gold collisions at RHIC have produced some very intriguing data that

The twin accelerators at RHIC have begun producing copper–copper collisions. (BNL.)

indicate the presence of a new form of matter – hotter and denser than anything ever produced in a laboratory. However, while some observations fit with what was expected of quark–gluon plasma, others do not (*CERN Courier* April 2004 p25).

So there has been considerable debate over whether the hot, dense matter being created at RHIC is indeed the postulated quark–gluon plasma, or perhaps something even more interesting. Data already in hand show that the quarks in the new form of matter appear to interact quite strongly with one another and with the surrounding gluons, rather than floating freely in the "soup" as the theory of quark–gluon plasma had predicted. Many physicists are beginning to use the term "strongly interacting quark–gluon plasma" to express this understanding.

The deuteron–gold collisions do not exhibit the same behaviour, leading to the suggestion that what is seen in the gold–gold collisions is not an intrinsic property of the gold ions themselves, but is indeed created in the collisions. The copper experiments will provide another control that will help in understanding how the new phenomena observed are turned on and off, and when.

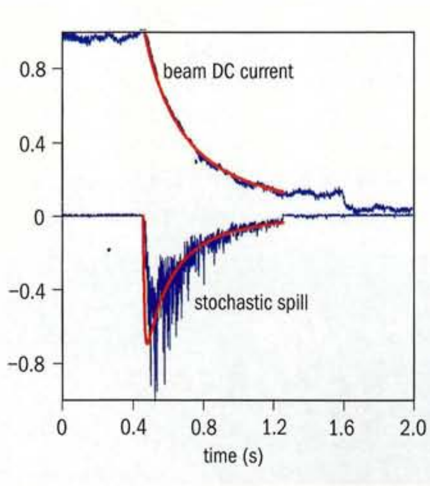
The copper-copper run is expected to last for about 10 weeks, but depends on funding for fiscal year 2005.

ACCELERATORS

U70 tests stochastic extraction scheme

Tests for an advanced slow stochastic extraction (SSE) scheme have been performed successfully at the U70, the 70 GeV proton synchrotron at the Institute for High Energy Physics (IHEP), Protvino, in the Moscow region. A holder of the record for highest-energy accelerator during the late 1960s, the U70 is still in operation today, and the feasibility tests in November and December 2004 may offer an interesting option for future beams.

The SSE concept was pioneered in 1978 by Simon van der Meer at CERN as a spin-off from his work on stochastic cooling, which led to the conversion of CERN's Super Proton Synchrotron to a proton–antiproton collider, and a share of the 1984 Nobel Prize in physics for van der Meer. This technique, yielding long and uniform spills, was later successfully used at CERN in the Low Energy Antiproton Ring (LEAR), achieving extraction times of several hours.



Beam and spill current (blue curves) and their fitted functions (red lines) from the stochastic extraction tests at the U70.

Stochastic extraction is a modification of resonant extraction in which particles are moved to the extraction resonance by random kicks from a noisy radiofrequency system. It has the advantage of being immune to unavoidable ripples in the magnetic optics that deteriorate the spill under resonant extraction. This might prove especially useful to a venerable machine like the U70.

The SSE tests were performed on an ejection plateau at 60 GeV in the U70, with recorded beam and extraction currents as shown in the figure in blue together with the fitted curves in red.

About 90% of the spill is extracted in 0.8 s. The extracted current is not free from AC ripple, but the IHEP engineers are hopeful that they can suppress this in future. The design goal is to obtain ripple-free flat-topped spills lasting 2–3 s or longer.

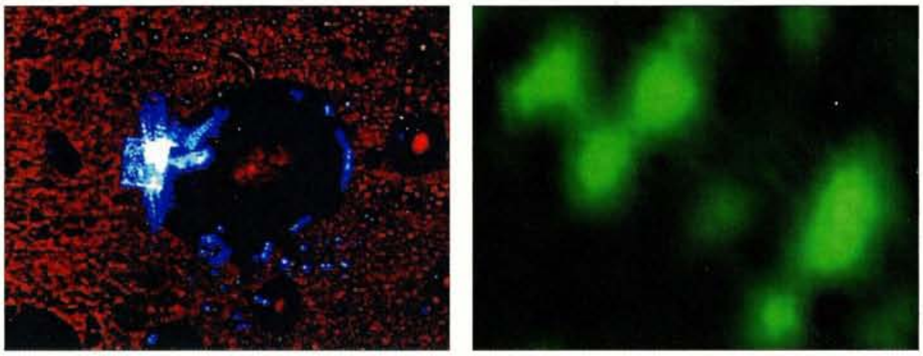
The tests have been deemed a success and the feasibility of SSE at the U70 has been confirmed by the beam measurements. The scheme promises smoother and longer spills, which will improve the machine's functionality.

Compiled by Steve Reucroft and John Swain, Northeastern University

Plasmons make light work for microscopy

A clever new technique could allow biologists to study structures well below the wavelength of light without the need for complex devices such as electron microscopes. The idea in its first concrete implementation is simplicity itself. A sample is placed on a metal-coated glass surface and covered with a drop of glycerin. Laser light shines through the glass and produces surface plasmons (propagating optical modes) in the metal.

Broadly speaking, plasmons can be thought of as a kind of 2D light, with particles that are composites of electrons and photons. They have wavelengths of only about 70 nm, or about an order of magnitude less than visible light. In the new technique developed by Igor Smolyaninov and colleagues at the University of Maryland and Queen's University of Belfast, the glycerin acts like a parabolic dish that can collect plasmons sprayed out from the sample at its focal point. It then forms them into something like a "plasmon beam" that goes back down towards the metal surface. Some of the photon part bounces back up and can be seen with a regular light microscope. The performance is close to what an electron microscope might achieve, but involves no vacuum, high voltage or elaborate specimen preparation.



A "plasmon microscope" formed with a glycerin drop (left) creates an image of a $30 \times 30\ \mu m^2$ array of "nanoholes" (blue square), in which the triplets of the 100 nm diameter holes can be resolved (right).

Further reading

Igor Smolyaninov *et al.* 2005 *Phys. Rev. Lett.* **94** 057401.

New explanation of why we live in 3D

Why do we live in three dimensions? This is an old question going back at least to Paul Ehrenfest who pointed out that neither classical nor quantum atoms are stable if space has more than three dimensions. String theory, which has made the idea of higher dimensions fashionable, usually solves the problem of explaining why we seem to live in three dimensions by arguing that extra dimensions might have curled up and become invisible.

More recent ideas propose that the particles that compose us are confined to 3D "branes", but again – why 3D? Now Ruth Durrer, Martin Kunz and Mairi Sakellariadou offer a new explanation. They say that string theory may naturally force all the higher-dimensional branes to unwind, leaving us sitting on a 3-brane, which we construe as the whole universe.

Further reading:

Ruth Durrer, Martin Kunz and Mairi Sakellariadou 2005 http://xxx.lanl.gov/abs/hep-th/0501163.

Researchers reveal secrets of stalactites

Physics has finally explained the dynamical origin of both stalactites (which hang down in caves) and stalagmites (the ones that grow up from the floor). A team at the University of Arizona has modelled these structures, known collectively as "speleotherms", as free-boundary problems involving water, calcium salts and carbon dioxide. The stalactites and stalagmites are attractors in the space of shapes of things that can grow, so these shapes are basically what must occur.

More precisely, the team derived a geometric law of motion in which the growth rate depends on the local radius and inclination of the stalactite surface. They then used this to allow general initial conditions to evolve towards a universal shape, which they term the "Platonic ideal" of speleotherm growth. The team finds that the essential feature of the growth process is the locally varying fluid layer thickness, which controls the precipitation rate. In particular, this gives rise to an extreme amplification effect near the tip, which produces the characteristic slender form of stalactites.

Further reading

Martin B Short *et al.* 2005 *Phys. Rev. Lett.* **94** 018501.

A sticky business

Gecko lizards can hang from the ceiling by a single toe, thanks to their finely structured feet made of tiny fibres. These allow for huge areas, and thus huge van der Waals forces. But what happens if their feet get dirty?

W R Hansen and K Autumn of Lewis and Clark College in Portland, Oregon, have found that the fibres are so small that most of the time the adhesive forces between a surface (e.g. a ceiling) and dirt are larger than the fibres can overcome. In effect, the feet of the geckos clean themselves as the lizards walk along. The new realization that you can have a very sticky yet self-cleaning surface could revolutionize "biomimetic" robotics, which aims at developing robots inspired by biology.

Further reading

W R Hansen and K Autumn 2005 *Proceedings of the National Academy of Sciences* **102** 385.

ASTROWATCH

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

Missing baryons found in hot gas

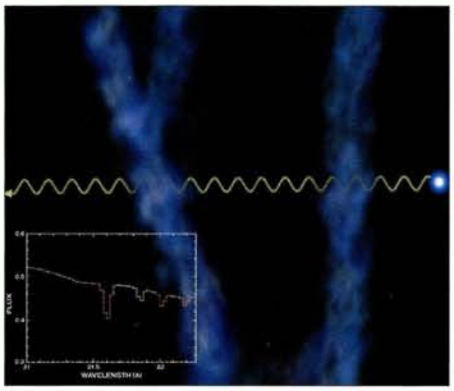
While it is well known that ordinary baryonic matter constitutes only about 5% of the total energy content of the universe, it is probably less commonly appreciated that about half of this "known" matter has never been identified, even in our galaxy's neighbourhood. Now a high-resolution spectrum from the Chandra X-ray Observatory suggests that the missing matter is in the form of diffuse, hot gas, filling vast regions between galaxies.

Baryons – the three-quark particles such as protons and neutrons – are used to define ordinary matter, because the other known particles are either like pions, too short-lived, or like electrons, too light to contribute significantly to the mass of the universe.

The masses of all astronomical objects that have been identified so far by different means are included in this baryonic mass – in particular, planets, stars of all types and black holes, as well as gas and dust – in other words, all the known constituents of galaxies.

According to cosmologists, however, all this amounts to only about half of the existing baryonic matter in the universe, which is itself only about 5% of the matter-energy content of the universe. The remaining 95% seems to consist of about 25% non-baryonic dark matter (*CERN Courier* November 2004 p13) and the balance is dark energy (*CERN Courier* September 2003 p23).

While the nature of dark matter and dark energy remains unknown, Fabrizio Nicastro from the Harvard-Smithsonian Center for Astrophysics and colleagues now claim that they have identified the missing part of



This image shows the absorption of X-rays from the blazar Markarian 421 (on the right) by two intergalactic clouds of diffuse, hot gas. The graph shows a portion of the Chandra X-ray spectrum of this source, with four absorption lines highlighted in colour.

baryonic matter. They have evidence that the elusive baryons are in the form of low-density "warm–hot" intergalactic gas, with a temperature of approximately 1 million degrees. The temperature and very low density of the gas have meant that it has previously escaped detection.

The team did not detect emissions from the gas, but rather absorption by the gas of X-ray radiation from an active galaxy along its line of sight. A strong outburst from the relatively nearby blazar Markarian 421 gave the team an opportunity to obtain the best signal-to-noise spectrum ever measured by the Chandra X-ray Observatory.

A detailed analysis of this spectrum revealed the presence of absorption lines that were identified as being those of highly ionized carbon, nitrogen, oxygen and neon: the most abundant nuclei in the universe besides helium and hydrogen.

Nine of a total of 24 absorption lines belong to two separate regions at distances of 150 million and 380 million light-years, as determined from the measured redshifts of the lines $z=0.011$ and $z=0.027$, respectively. The remaining lines are at a redshift of zero and are therefore associated with gas in our galaxy or in the local group of galaxies.

By assuming that the detected gas has a heavy-element abundance that is one-tenth of that of the Sun, which is typical for intergalactic gas, Nicastro and colleagues were able to extrapolate the total density of baryons along the line of sight to Markarian 421. The result is consistent with the amount of missing baryonic matter and with data from computer simulations.

Indeed, before the detection of this intergalactic gas, simulations of the large-scale structure formation predicted the existence of a warm–hot diffuse gas. This gas, one-millionth of the density of the interstellar medium in our galaxy, is shock-heated by the continuous interaction between galaxies.

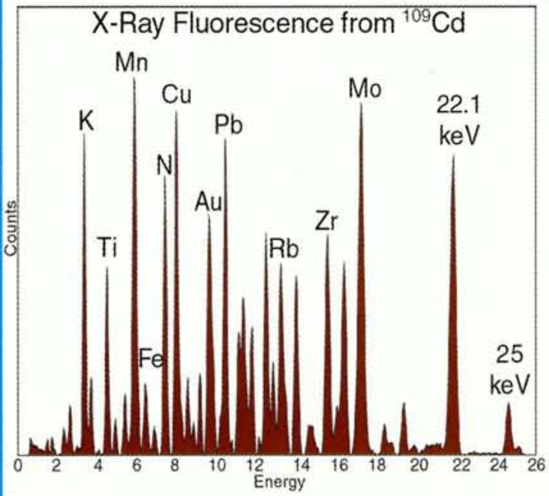
The overall baryon content of this warm–hot gas is quite loosely determined by this first measurement, and certainly needs confirmation by similar studies along other lines of sight. Nevertheless, it is an important step on the track towards understanding the make-up of the universe.

Further reading

F Nicastro *et al.* 2005 *Nature* **433** 495.

Picture of the month

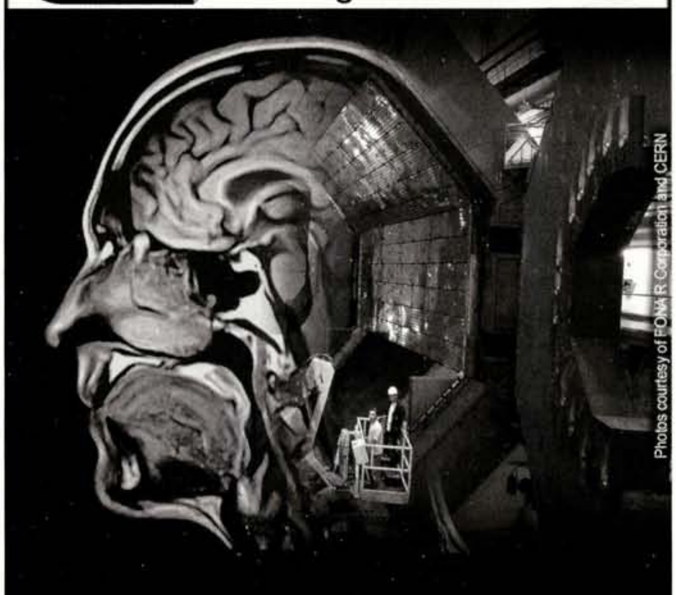
The Trifid Nebula (Messier 20) is a giant star-forming cloud of gas and dust located 5400 light-years away in the constellation Sagittarius. New infrared images from the Spitzer Space Telescope have revealed that the nebula contains 30 embryonic stars and 120 newborn stars. This false-colour picture combines infrared images at wavelengths of 4.5 (blue), 8.0 (green) and 24 μm (red). (Courtesy NASA/JPL-Caltech/J Rho (SSC/Caltech).)


X-Ray Fluorescence from ^{109}Cd
Mn
K
Cu
Pb
Mo
22.1 keV
N
Au
Zr
Ti
Rb
Fe
25 keV
Counts
0 2 4 6 8 10 12 14 16 18 20 22 24 26
Energy


PX4
DIGITAL PULSE PROCESSOR
XR-100CR
X-RAY DETECTOR


XR-100CR
X-RAY DETECTOR


PX4
DIGITAL PULSE PROCESSOR


Photos courtesy of FONAR Corporation and CERN

CERN COURIER ARCHIVE: 1962

A look back to *CERN Courier* vol. 2, March 1962

COUNCIL

Future developments in high-energy physics

Outside Europe, in particular in the US, we expect to see the construction of machines not only of higher intensity than at CERN, but also of considerably higher energy. There are no technical reasons preventing the construction of machines with 10 to 50 times the energy of the CERN PS and up to 100 times its intensity. These machines will be constructed sooner or later.

Scientifically speaking, they would serve two purposes. One is the production of very intense beams, at "lower energy" (that is, the present PS energy), of antiparticles and all kinds of mesons. In this respect, such machines would be many hundred times more efficient than PS-type accelerators, just as the CERN PS is many hundred times more efficient than the Cosmotron or even the Bevatron, for example in the production of antiprotons. The other purpose is the exploration of completely new phenomena that might happen at the high energies attainable with these new machines. When such machines are realized – it may take less than a decade – Europe will again be left behind in this field of physics if no plans for comparable facilities here have been prepared.

It has been seriously questioned whether Europe should keep up its own high-energy research on this new level in the future. The cost of the large machines would lie in a range five to 10 times the cost of the PS. It should, however, be remembered that the total scientific effort in Europe will certainly increase tremendously during the next decade. High-energy physics, even on this scale, would still be appreciably less expensive than some other branches of scientific and technical research, such as space exploration for example. One must keep in mind, however, that high-energy physics aims at the most fundamental questions of science: the basic structure of matter and energy. It is a field of research in which Europe always had a commanding position which must be maintained also in the future.

"One of these possibilities...is the construction of so-called 'storage rings'." J Brüderlein (left), from PS Survey Group, and W Sax, Engineering Drawing Office, are here engaged on levelling the foundation supports for a storage-ring model being built by the Accelerator Research Division.

Even so, the high cost makes it more important to study very thoroughly all possible alternatives and possibilities, so as to find perhaps a way of keeping Europe's high-energy physics in the forefront without having to spend such enormous sums. This is why we have planned at CERN to have an active group studying future possibilities. One of these possibilities already considered is the construction of so-called "storage rings", which would make it possible to use the present PS itself in order to attain what is equivalent for certain special purposes only, to an energy of more than 1000 GeV. It would not give us any beams of high intensity, however. The cost of this project would be about equal to that of the present CERN PS and its associated equipment.

● From the second part of a paper presented by Victor Weisskopf, director-general, to CERN Council in December 1961. (See also *CERN Courier* January/February 2005 p9.)

LAST MONTH AT CERN

Discovery of the antixi

The biggest news of the month was the discovery of the antixi, a positively charged antiparticle produced simultaneously with a negatively charged xi particle by the interaction of an antiproton with a proton. The discovery was made among photographs, taken with the 81 cm hydrogen bubble chamber in the separated antiproton beam of momentum 3 GeV/c just before Christmas, which are now being analysed at the École Polytechnique (Paris), CERN, and Imperial College (London). It was not the only the one, however. While the interpretation of the event was in progress, news was received from Brookhaven that a surprisingly similar event was being analysed there.

Many people besides physicists are involved nowadays in such a discovery. In our case, the PS produced antiprotons by the impact of high-energy protons on a target; beam transport and the particle separator separated the antiprotons from other particles produced; the bubble chamber was operated to give tracks of the nuclear particles; the tens of thousands of photographs needed in order to "capture" such a rare event then had to be processed, and investigated using special apparatus. Finally, calculations had to be carried out on the measurements to prove unambiguously that the particle concerned was in fact the sought-for antixi.

● For further details of this discovery, see *CERN Courier* April 2004 p9.

EDITOR'S NOTE

***CERN Courier* came into being in August 1959, and in 1962 it became a regular monthly publication, appearing in something like its present form.**

Following on from the selection of extracts published during 2004, CERN's 50th anniversary year, this regular archive feature will tell the story of particle physics through the pages of *CERN Courier* from 1962 onwards.

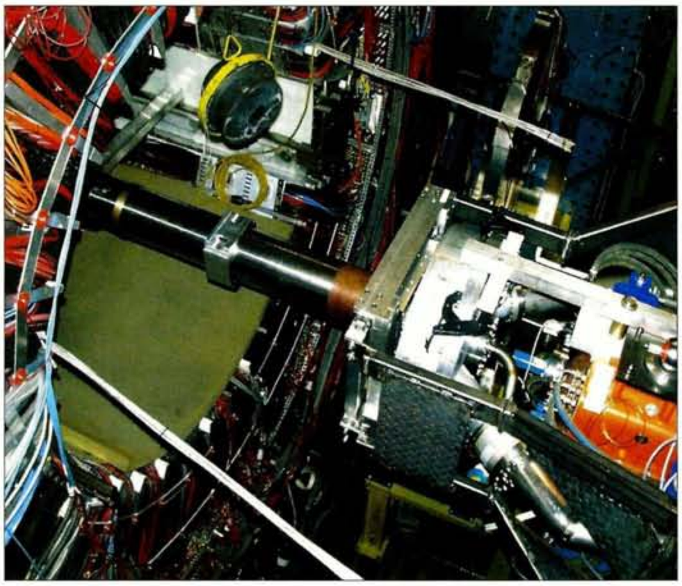
HERA hits new heights

Ferdinand Willeke reports on the challenges faced by the HERA crew to get the accelerator back into full swing after a major luminosity upgrade in 2001.

In August 2000 the first phase of operation (Run I) of HERA, DESY's electron/positron–proton collider, came to a successful conclusion after the machine reached a luminosity of $2\times10^{31}\,cm^{-2}\,s^{-1}$, surpassing its original design luminosity by 30%. The total luminosity delivered between 1992 and 2000 to the colliding-beam experiments H1 and ZEUS amounted to about $190\,pb^{-1}$, and electron and positron beams with a longitudinal spin polarization of up to 60% were routinely delivered to the HERMES experiment, which uses a gas target. In addition, proton–nucleus interaction rates as high as 5–20 MHz were provided for the HERA-B experiment. The run enabled the four experiments to publish a large number of results on the strong and electroweak interactions as well as physics beyond the Standard Model.

The objective of the second phase of the HERA programme, Run II, was to operate with a greater luminosity, about four times higher than the design luminosity of Run I. The upgrade began in 2001 and proved challenging in several respects. By October 2004 the collider had completed a year of successful running with positrons and could be switched to electron–proton operation, for the first time since 1999.

Nearly 80 new magnets – each weighing up to 7 t – were installed in HERA's proton and electron accelerators during the luminosity upgrade from September 2000 to July 2001.



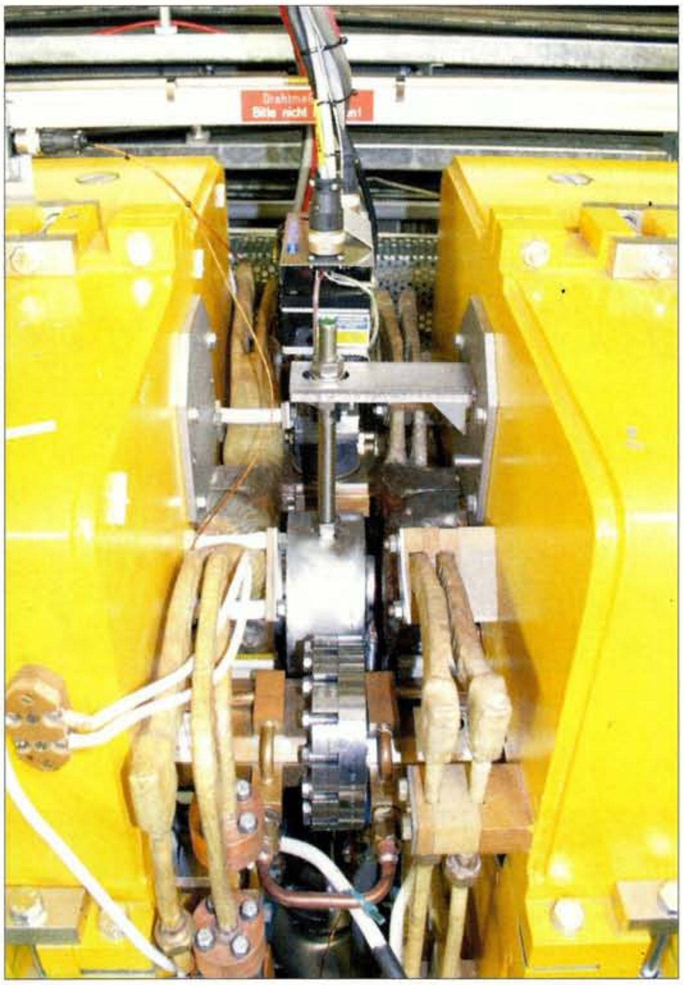
The magnets nearest the collision points had to be built directly into the detectors. This image shows the 25 cm-diameter pipe at the heart of the H1 detector which contains the 1.3 m-long superconducting separator magnet. The magnet is supported at the end seen here, with the helium feed-can, by a magnet girder (just visible on the right). In this picture the part of the calorimeter installed around the magnet has been removed. (Photos courtesy DESY, Hamburg.)

The upgrade challenges

In order to provide the greater luminosity required for Run II, the interaction regions of the colliding-beam experiments had to be rebuilt to reduce the beam cross-section at the collision points by a factor of three, to values of $112\,\mu m \times 30\,\mu m$. In addition, the interaction regions of H1 and ZEUS were to be equipped with pairs of spin rotators to allow for longitudinally spin-polarized lepton beams in collisions with protons.

The requirements of the upgrade represented a challenging engineering project. Strong focusing magnets had to be fitted inside the existing detectors – a task made very difficult by the small apertures involved, the limited available space and insufficient access to support points. In addition, new technologies had to be developed in order to improve the interaction regions still further, which had already been optimized during HERA Run I. The technical novelties developed for the upgrade include large-aperture superconducting combined-function magnets with small outer dimensions, which are supported inside the narrow aperture of the colliding beam-detectors. This means that a beam separation closer to the experiments is necessary to achieve stronger focusing.

Moreover, inside the strong magnetic fields of the superconducting magnets, the lepton beam emits high-power synchrotron radiation. This requires a sophisticated vacuum system to handle the large power loads and to provide at the same time the excellent vacuum pressure of 0.1 nanotorr needed around the detectors for tolerable background conditions. ▷



The space between the magnets is minimized to bring the focusing magnets as close as possible to the interaction point.

The upgraded components were installed during a shutdown from September 2000 to July 2001, which was followed by a period of technical commissioning and commissioning with beam in the autumn of 2001. The high luminosity that can be achieved in the upgraded configuration was demonstrated soon after the accelerator was restarted. In October 2001, a specific luminosity of $L_{spec} = 1.8 \times 10^{30}\ mA^{-2}\ cm^{-2}\ s^{-1}$ was reached with a small number of bunches, a value about two-and-a-half times greater than the ones achieved before the upgrade.

Fighting background problems

For the collider experiments, H1 and ZEUS, however, it was a different story. It turned out that the backgrounds they saw were larger than expected and this prevented turning on the tracking detectors in H1 and ZEUS. There was even a risk of damaging some detector components close to the beam. This led to considerable joint efforts between the accelerator and experimental groups to explore and to understand the reasons for the high background and to develop appropriate countermeasures. These efforts included detailed Monte Carlo simulations of the background conditions, which were benchmarked with accelerator experiments. This process required a considerable amount of accelerator study time. The results and conclusions were discussed during an international workshop in July 2002 and the improvement programme was presented to an international review committee in January 2003.

This thorough analysis led to the conclusion that the backgrounds generated by protons lost in the interaction-region beam correlated with the poor initial vacuum conditions in the new system in the presence of the positron beam. The vacuum recovery was also slowed down by considerable thermal desorption of synchrotron radiation masks inside the beam pipe close to the experiments. This was due to higher-order mode heating at injection energy when the bunches are short. In addition, in the spring of 2002 it became apparent that the ZEUS detector was also being hit by scattered synchrotron radiation. This was caused by a problem with a mask that was actually designed to shield the detector against it.

These problems limited the intensity during running in 2002, and this in turn allowed only slow recovery and conditioning of the vacuum. However, by the end of 2002 a significant improvement in the vacuum at the interaction region and a corresponding reduction of the proton-induced background had been achieved. This indicated that tolerable background conditions with full beam currents would be possible after further conditioning.

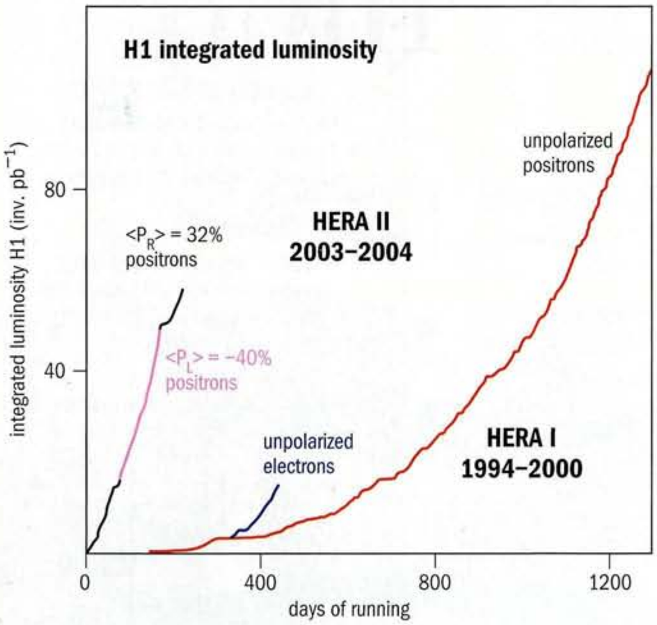
At the same time, the more intricate operational procedures of the upgraded accelerators were consolidated. These include global and local orbit stabilization systems with active feedback, which control the beam orbit to 0.1 mm during injection, acceleration, low-beta squeezing, tuning and luminosity running.

High longitudinal spin polarization of the positron beam was tuned up and measured for the first time simultaneously at all three interactions points during a test run in February 2003. HERA was then able to report the achievement of a world first: the collision of a longitudinally spin-polarized positron beam with high-energy protons (*CERN Courier* April 2003 p5).

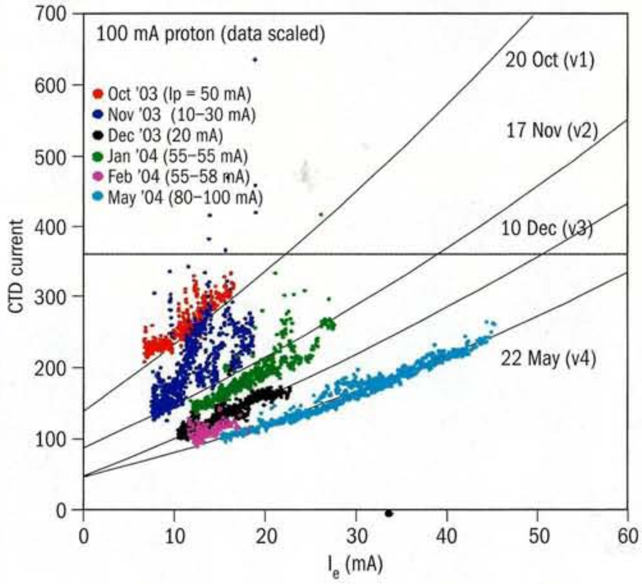
Before this achievement could be exploited in the physics programme, however, the shutdown period from March to July 2003, which was needed to complete the experimental detector upgrades, was used to improve the synchrotron-radiation masks. The shape of the masks was changed to reduce higher-order mode losses of the beam, the cooling of the masks was improved, and the problem with the mask inside the ZEUS detector was resolved. Furthermore the pumping of the beam pipe inside the H1 detector and in a long beam-pipe section inside one of the magnets was improved to speed up the vacuum conditioning. These measures all achieved the desired effects: the vacuum system recovered quite quickly after the shutdown, the higher-order mode heating was reduced considerably and – most importantly – the problem with scattered synchrotron radiation in the ZEUS detector was completely solved.

Back to high luminosity

High-luminosity operation with protons and positrons started after vacuum conditioning with beam in October 2003. However, beam intensities in November and December were limited by new rules on radiation safety, which required an upgrade of the active machine-protection system. This was accomplished by the end of December 2003. Then, from January 2004, the HERA beam currents were increased steadily and the operating currents previously achieved in 2000, of around 100 mA protons together with



Integrated luminosity taken by the H1 experiment at HERA as a function of running day: HERA I with unpolarized positrons and electrons, and HERA II with polarized positrons.



The current in the ZEUS CTD (Central Tracking Detector) as a function of the positron current (I_e) scaled to the nominal proton current of 100 mA. The limit of safe operation is the horizontal line. With the steady operation of HERA the CTD current decreased because of conditioning in the accelerators, until in May it was shown that the ZEUS detector could be operated up to the nominal positron current of about 55 mA.

48 mA positrons, were reached.

From January to June 2004, the HERA luminosity was increased from $1.6 \times 10^{31} cm^{-2} s^{-1}$ to $3.8 \times 10^{31} cm^{-2} s^{-1}$, which is twice the value achieved in 2000. At the same time, the longitudinal positron spin polarization was tuned to values up to 50%. By August 2004, a total integrated polarized positron–proton luminosity of $92 pb^{-1}$ had been delivered to the collider experiments. As a result, all three HERA experiments – H1, ZEUS and HERMES – have successfully taken data in 2004, with interesting first results presented in August 2004 at the International Conference on High Energy Physics in Beijing (*CERN Courier* October 2004 p7).

HERA's luminosity upgrade is nearly complete, and we are now looking at increasing the luminosity again by another 50%. This requires further increasing the beam intensities, and better control of the beam parameters and the specific luminosity. An improvement programme to achieve this goal during 2005 is under way.

The proton background conditions for the experiments steadily improved during the 2004 run. In February 2004, the ZEUS experiment reported excellent background conditions together with large luminosity, and the proton-induced backgrounds in H1 have been demonstrated to be tolerable up to the highest beam intensities. Unfortunately, a number of vacuum leaks in the interaction regions due to a weakness in the design of a flange connection temporarily led to larger vacuum pressure there, resulting in poor background conditions. During a shutdown in August and September 2004, which was required to perform the annual safety tests and some detector repair work, the interaction-region vacuum system was improved further.

After this shutdown, HERA resumed operation with protons and electrons, rather than positrons, for the first time since 1999. To maximize the integrated luminosity of HERA over the coming years, a programme is under way to improve the availability of the components and the overall operational reliability. In addition, a longitudinal broadband damper system is being developed to control coupled bunch instabilities. This will help to control the proton bunch length and will provide a minimum effective transverse beam size so as to maximize luminosity.

The present plan is to continue the electron run until mid-2006, then switch back to positrons and complete the HERA data-taking by mid-2007. The three experiments are ready and eagerly awaiting a large harvest of HERA II data.

Ferdinand Willeke, *DESY*.

Spin time in Italy

The SPIN 2004 symposium in Trieste provided a showcase for the latest developments in this key area of particle and nuclear physics.

Participants relax around a table at the conference banquet at SPIN 2004, which was held in Trieste, Italy.

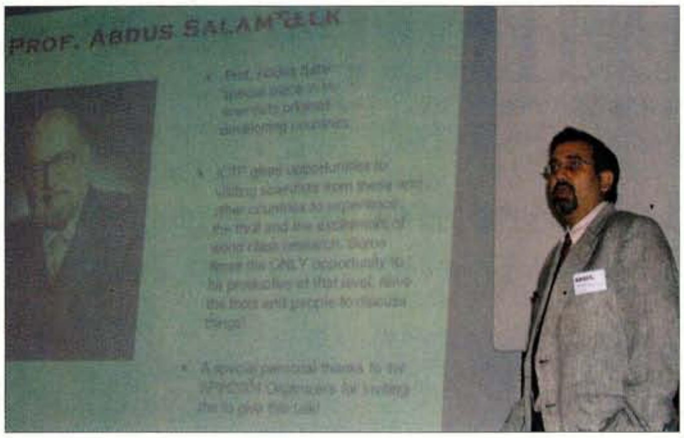
Spin is a key element in particle and nuclear physics, and has always played a paramount role in the study of fundamental symmetries, static-particle properties and the structure of fundamental interactions. Moreover, during the past 15 years, spin physics has enjoyed a true renaissance, with many enthusiastic young people – both theoreticians and experimentalists – entering the field, attracted by new ideas and experimental opportunities.

Last year, around 300 physicists attended the 16th International Spin Physics Symposium, SPIN 2004, which was held on 10–16 October in Trieste, Italy. The event was organized by the Trieste section of the Istituto Nazionale di Fisica Nucleare (INFN) and was hosted by the Abdus Salam International Centre for Theoretical Physics (ICTP) on the beautiful Miramare campus. The symposium also benefited from the support and infrastructure of the nearby International School for Advanced Studies (SISSA).

Participation at SPIN 2004 was highly diverse, with 29 different countries represented. A unique feature was the large contingent from developing countries, made possible thanks to logistic support from the ICTP and sponsorship from the International Union of Pure and Applied Physics. Additional support from the Central European Initiative allowed significant participation from the initiative's 17 member countries. The symposium was also sponsored by the International Spin Physics Committee, the town of Trieste, the Friuli-Venezia Giulia region and a few other local institutions.

SPIN 2004 was structured with plenary and parallel sessions, but no poster session. Instead, more than 160 presentations were accommodated in short communications in the parallel sessions, allowing everybody, in particular the young participants, the opportunity to stand up and present their work. The 20 plenary talks, half of which were given by excellent young physicists, were followed by interesting discussions. In addition, four rapporteurs were asked to give plenary talks to summarize the contributions of corresponding parallel sessions. The plenary sessions included short reports on the specialized workshops supported by the International Committee that had taken place during the previous two years: "SPIN 2003" in Dubna, "Polarized Sources and Targets" in Novosibirsk, "Symmetries and Spin" in Prague, "Polarized Solid Target Materials and Targets" in Bad Honnef, and "Polarized Electron Sources and Polarimeters (PESP 2004)" in Mainz. Following tradition, this last workshop took place the week before SPIN 2004.

It is impossible to summarize in a few pages the large amount of information presented in Trieste. In the following, we give some highlights that are bound to reflect our personal bias. However, all the talks have immediately been put on the web and are accessible to ▷



Abhay Deshpande of Stony Brook talked on future facilities and also gave a tribute to Abdus Salam, who founded the ICTP in Trieste – the host institution for SPIN 2004.

everybody until the time when proceedings become available.

Two of the parallel sessions were dedicated to technical developments in the fields of polarized sources, polarized targets, polarized beams and polarimetry – the essential tools of spin physics. In the session on "Polarized Sources, Targets, and Polarimetry", summarized in the last plenary session by Thomas Wise from Wisconsin, contributions described all of the ongoing activities in the field: polarized electron sources; various aspects of thermal velocity atomic H and D sources, used either as jets or to feed storage cells; new ion sources; polarimetry for a ^{3}He gas target; and solid targets.

Further impressive work was presented in the session on "Acceleration, Storage and Polarimetry of Polarized Beams". In this plenary talk, William McKay from Brookhaven illustrated the enormous progress made there with the Relativistic Heavy-Ion Collider (RHIC). Thanks to the insertion of a partial Siberian snake in the Alternating Gradient Synchrotron, polarization at extraction is now 50% and can be preserved during acceleration in RHIC at 40% (compared with 27% last year). After changing the betatron-tune working point, average luminosity is now $4 \times 10^{30}\,cm^{-2}\,s^{-1}$ at $\sqrt{s} = 200$ GeV. The presentations in this parallel session spelled out the activity at various existing accelerators (AGS, RHIC, COSY, Nuclotron and BATES), as well as the plans for future facilities (JPARC, FAIR, eRHIC), all of which were skilfully summarized by Andreas Lehrach of Jülich. Importantly, a polarized-hydrogen jet target has been installed at Brookhaven and, during the course of 2004, was successfully used to calibrate the polarization of the RHIC proton beam.

Spin physics began in 1921 with the pioneering work of Otto Stern, who discovered the spin of the electron and showed that it has a gyromagnetic ratio, g_e, of about 2. Since then, the study of dipole moments of elementary particles has provided a wealth of information about subatomic physics, and the measurement of the electron and muon anomaly $a = (g-2)/2$ has reached impressive sensitivities. Lee Roberts of Boston described Brookhaven's g–2 experiment, which yields a final result of $a_\mu = 11\,659\,208(6) \times 10^{-10}$ (±0.5 ppm). This is 2.7 standard deviations from the Standard Model value and is a possible indication for new physics (*CERN Courier* November 2004 p6).

In an equally impressive talk, Klaus Jungmann of KVI Goningen reviewed current searches for permanent electric dipole moments, which could also provide an excellent sign of new physics. In this context, Emlyn Hughes of Caltech reported on the past, present and future measurements of parity violation in electron scattering as a means of making precision measurements of the weak mixing angle, θ_W, far from the Z mass, and possibly detecting signals of new physics. Preliminary results from the full data sample of the E158 experiment at SLAC were given out to attendees for the first time as $\sin^2\theta_W = 0.2330 \pm 0.0011$ (stat) ± 0.0010 (syst), a result that pushes any new four-fermion interaction to a scale of $\Lambda_{LL} \sim 10$ TeV (95% confidence level). In addition to these three plenary talks, contributions were presented in the parallel sessions on "Spin and Fundamental Symmetries" and "Spin Beyond the Standard Model". These spanned topics from "Graviton Exchange Effects at High-Energy Colliders" to "New Approaches to Unify Spin and Charge", which were well summarized by Oleg Teryaev from Dubna at the end of the symposium.

The quantum chromodynamics (QCD) spin structure of the nucleon was a central issue at the symposium. Plenary talks and parallel sessions covered the present understanding, experimental status, recent developments and future perspectives of the field. In the opening talk of the symposium, Andreas Metz of Bochum gave a comprehensive review of the present knowledge of quark and gluon helicity distributions, generalized parton distributions (GPDs), single-spin asymmetries and transverse-spin effects. In his plenary talk, Vincenzo Barone of Piemonte Orientale discussed transversity and stressed the differences between transversity and helicity distributions, the difficulties related to the measurement of transversity and the importance of intrinsic quark momentum-dependent distributions.

There was a wealth of new results from the major experiments presented in the plenary talks of Delia Hasch from Frascati (talking on HERMES at DESY), Andrea Bressan from Trieste (COMPASS at CERN), Naohito Saito from Kyoto (experiments at RHIC) and Michel Garcon from SPhN–Saclay (experiments at the Jefferson Laboratory), and also in many other parallel sessions, of which we cite only a few.

There is now high-precision data on the structure function g_1 at small x for the deuteron (from COMPASS) and at large x for the proton and neutron (from CLAS at the Jefferson Laboratory). The first measurements of the Sivers and Collins asymmetries have been made on transversely polarized protons, by HERMES, and on deuterons, by COMPASS. Both HERMES and experiments at the Jefferson Laboratory have results (and projections) for deeply virtual Compton-scattering measurements. There are measurements of the gluon polarization $\Delta G/G$ from high p_T hadron pairs (COMPASS) and A_{LL} for π^0 production (the PHOENIX experiment at RHIC). Experiments at RHIC have also made measurements of the cross-section for prompt photon and π^0 production, as well as precision measurements of A_N for proton–proton and proton–carbon elastic-scattering in the Coulomb–nuclear interference region. In a nutshell, the latest results indicate that $\Delta G/G$ seems to be small, hinting at a larger angular momentum contribution to the nucleon helicity; transversity signals definitely seem to be there. Needless to say, it was not an easy job for Gerhard Mallot of CERN to summarize in his rapporteur talk 16 hours of parallel sessions with highly compressed contributions.

The bridge to hadronic physics was represented by the session on "Soft Spin Physics with Photons and Leptons". Plenary talks here were dedicated to the Gerasimov–Drell–Hearn (GDH) sum rule, to nucleon form factors and to other activity at Jefferson Laboratory in "soft physics". As Hans Arends of Mainz explained, with the recent data from the MAMI machine at Mainz and ELSA in Bonn, the GDH sum-rule is now verified at the 10% level for the proton, while the situation for the neutron is not clear and more theoretical work is needed.

The hot issue of the discrepancy between results of G_E^p/G_M^p with the Rosenbluth techniques and with polarization transfer was discussed by Kees de Jager of Jefferson Laboratory. This now seems to be understood, thanks to recent advances in the calculations of the two-photon exchange contributions. The subjects of the third plenary talk of this session, by Raffaella de Vita of Genoa, were the high-precision measurements of g_1 and g_2 at low Q^2, and the study of polarization observables in exclusive and semi-inclusive meson production.

The SPIN 2004 symposium also covered most recent developments in spin physics at intermediate energies and in nuclear physics. Jean-Marc Richard of ISN Grenoble gave a particularly lively talk in which he revisited hadron spectroscopy, summarizing and discussing the dramatic revival of the field that has occurred over the past few months. Barbara von Przewoski of Indiana reviewed the nucleon–nucleon scattering experiments in hadron storage rings with a polarized beam and a polarized internal target at the Indiana Cooler and at COSY in Jülich, and described their impact on phase-shift analysis, meson-exchange models, chiral-perturbation theory and the role of the three-nucleon forces (3NF).

Many other data from ITEP, Protvino and other laboratories were discussed in the parallel session on "Spin in Soft Hadronic Reactions". Kichiji Hatanaka of Osaka reported on the high-precision systematic work that is ongoing at lower energies to establish the theory of the modification of the NN interaction in a medium and, in general, to find evidence for the 3NF in nuclear matter. He also reviewed the contributions presented in the parallel session dedicated to "Spin Physics in Nuclear Interactions".

The symposium could not end without looking to the future. In the last plenary session, Abhay Deshpande of Stony Brook illustrated the physics potential and the machine concept of the eRHIC project at Brookhaven – an electron–proton/nuclei collider that could be operational 10 years from now – as well as the alternative ELIC project at Jefferson Laboratory. Frank Rathmann of Jülich described the polarized antiproton facility at GSI, focusing particularly on the new ideas of measuring transversity in polarized antiproton–proton Drell–Yan processes. With a completely different scenario, and on a much longer timescale, Stefano Forte of Milan communicated to the audience his enthusiasm for the huge physics potential of a future neutrino factory.

During the symposium, tributes were paid to two distinguished members of the International Committee who have passed away since SPIN 2002: Vernon Hughes and Lev Soloviev. Both Myriam Hughes and Tatiana Solovieva attended the symposium and accepted the friendship and gratitude of many of their husbands' colleagues.

• The 17th International Spin Physics Symposium will be held in Kyoto in September 2006.

The future measurement of transversity at the FAIR facility at GSI was a hot matter of discussion, in particular between Raimondo Bertini (left) and Mauro Anselmino of INFN Torino.

Further reading

Proceedings from SPIN 2004 will be published by World Scientific, Singapore, and will include the PESP2004 contributions. See the SPIN 2004 Web page: www.ts.infn.it/events/SPIN2004.

Franco Bradamante *and* **Anna Martin**, *INFN Trieste and University of Trieste.*

News from the frontline in the hunt for exotic nuclei

In Russia last summer 220 scientists attended an international symposium reviewing present and future research into exotic nuclei.

Participants at EXON 2004, the International Symposium on Exotic Nuclei, during a sightseeing excursion around Peterhof.

Nuclei, from the lightest to the super-heavyweights, were the subject of EXON 2004, the International Symposium on Exotic Nuclei held on 5–12 July 2004 in Peterhof, the former royal estate outside St Petersburg, Russia. The participants' main goals were to discuss the latest results and to develop the programme for further joint research in this area of nuclear physics.

Co-organized by the four scientific centres where exotic nuclei are studied – the Flerov Laboratory of Nuclear Reactions (FLNR) at the Joint Institute for Nuclear Research (Russia), RIKEN (Japan), GANIL (France) and GSI (Germany) – the symposium attracted 220 scientists from 23 countries. Eighty-six talks and more than 40 posters covered topics divided as follows: the synthesis of neutron-rich nuclei of light elements and the study of their properties; the synthesis of superheavy elements and the study of their properties; rare processes and decays; beams of radioactive nuclei (production and research programme); and experimental set-ups and future projects.

The first session covered the current experimental and theoretical situation in the investigation of the properties of neutron-rich nuclei. Here talks discussed the problems connected with precision measurements of nuclear masses in the vicinity of the neutron drip-line. The advent of relatively intense beams of exotic nuclei is now allowing the study of their interactions with other nuclei, and the first results of such investigations were presented in several talks. In the course of these studies of exotic nuclei new effects have been discovered, namely the appearance of new magic numbers ($N=16$, $N=26$), the co-existence in the same nucleus of two types of deformation, and an unusual order in nucleon shell filling. These effects were also the subject of a number of theoretical talks.

The latest achievements in the synthesis of superheavy elements were presented by various speakers, and other talks provided theoretical interpretations of the results obtained. Further scientific centres have now joined Dubna in implementing a programme for the production of superheavy elements, in particular at GANIL in France.

Investigations of the structure of transfermium elements (Z > 100) have also become an active area. This field of research involves such high-efficiency equipment as the gamma detectors EXOGAM, EUROBALL, AGATA and others. There were several reports on the results of such investigations, as well as a presentation on the possibility of investigating the characteristics of transuranium nuclei using laser spectroscopy.

The search for exotic states of nuclear matter – multi-neutron systems – has had some interesting results. Talks covered experimental attempts to observe such states, as well as peculiarities in the structure of light exotic nuclei.

One day of the symposium was devoted to large active accelerator complexes and new projects. The results and achievements were highlighted in a number of talks, covering for example the ALTO project at IPN Orsay, the KEK–JAERI joint radioactive nuclear-beam project (RNB), the Radioisotope Beam Factory at RIKEN (RIBF), the K = 130 cyclotron in Jyväskylä, TITAN at TRIUMF, and the first radioactive beams in Brazil. The new projects for accelerator complexes were presented on the last day of the symposium, covering NUSTAR at GSI, SPIRAL-2 at GANIL, radioisotope-beam-based research at RIKEN, and the FLNR cyclotrons at JINR.

Some interesting effects have been recently noticed in the characteristics of nuclear-reaction products and the decays of exotic nuclei while investigating fine structure. Multi-cluster decay has been discovered in the ternary fission of nuclei, and while some talks focused on that problem, others were devoted to the peculiarities of fine-structure effects in the decay of exotic nuclei.

The study of chemical properties of superheavy elements was the subject of a special session. Radiochemical groups from Germany, France and JINR have carried out a number of experiments using fast, selective methods. These include joint experiments on the chemical identification of superheavy elements and the study of their chemical properties, and several talks reported on the results.

One of the themes that aroused a great deal of interest among the participants was public relations. The talks "Russian–German Co-operation at GSI, an Example of Success and Friendship", "Public Awareness of Nuclear Science in Europe" and "JINR: International Scientific Centre Bringing Nations Together" focused on this topic.

A round-table discussion summed up the work of the symposium. Participants agreed that wider collaboration should be established to open up new avenues of enquiry in the synthesis of superheavy elements and the study of their properties, and in investigations with beams of radioactive nuclei, and to develop new projects. They also want theoretical support for the investigations to be increased and for more young scientists to be attracted into the work.

EXON 2004 also offered an interesting cultural programme. There was the opportunity to see the cultural and historic attractions of St Petersburg and its vicinity, cruising on board a ship across Lake Ladoga to stop and admire the Island of Valaam. The next symposium will be held in Russia in two years' time.

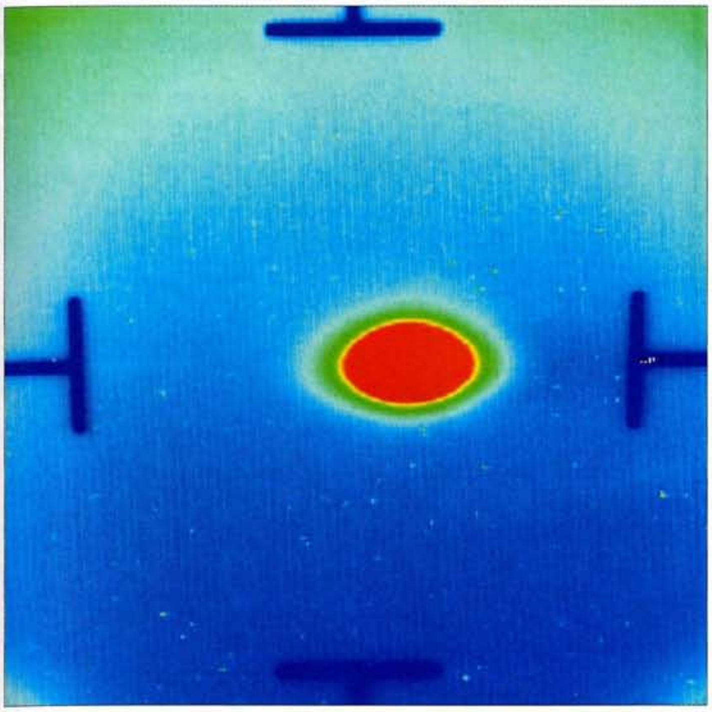
Further reading

See the conference website www.jinr.ru/exon2004/.

Yuri Penionzhkevich, *JINR, co-chairman of EXON 2004.*

The first of the two new beam transfer lines to the LHC was successfully commissioned in autumn 2004. At the first attempt a low-intensity proton beam passed down the line to a few metres before the LHC tunnel.

Protons on t



Computer image of the first beam, which arrived at the last screen monitor in TI 8, a few metres away from the LHC tunnel.

Installed section of TI 8 consisting of a main quadrupole (blue), followed by dipoles, all built by the Budker Institute for Nuclear Physics (BINP) in Novos

When the Large Hadron Collider (LHC) begins operation, two new beam transfer lines, with a combined length of 5.6 km, will bring 450 GeV proton beams or ions from the Super Proton Synchrotron (SPS) to the new machine. Line TI 2 leads from the extraction in long straight section LSS6 in the SPS to the injection point into the clockwise ring of the LHC near interaction point 2. The other line, TI 8, leads from the extraction in LSS4 to the injection point of the anti-clockwise ring near interaction point 8. The first 100 m of this transfer line, called TT40, are shared with the primary proton line to the CNGS facility (*CERN Courier* October 2004 p27) and were commissioned together with the new extraction system in LSS4 in 2003. In October 2004 the complete TI 8 line became operational, with protons travelling the 2.5 km to the LHC tunnel.

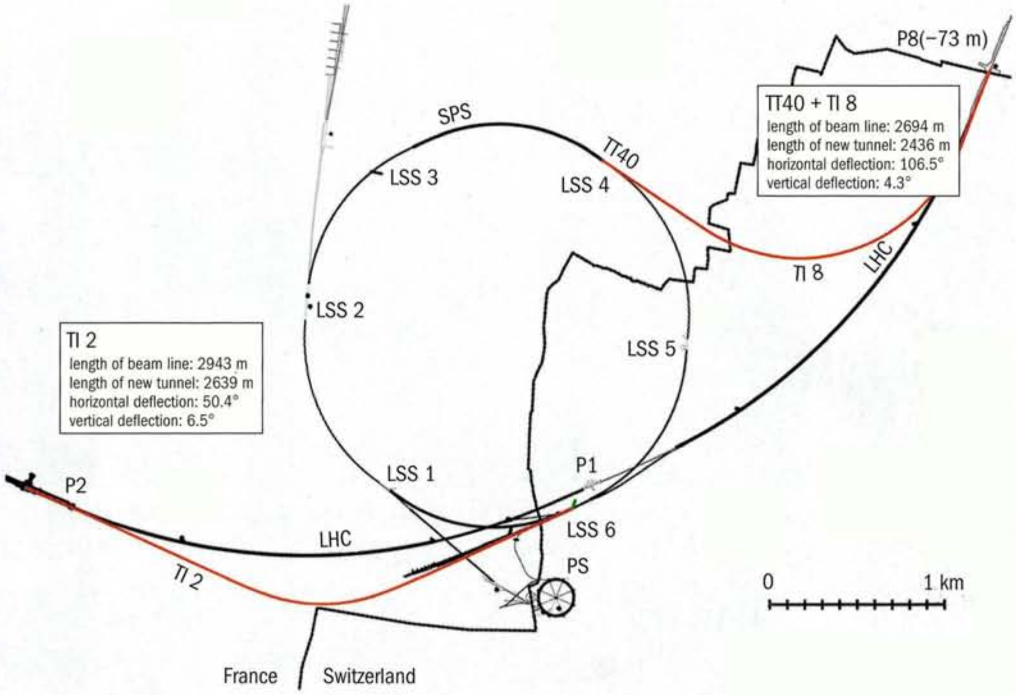
Studies on how to transport beam from the SPS to the LHC began in the early 1990s. Various configurations were investigated, one of them even implying a polarity reversal of the SPS. The use of cryogenic magnets was also considered. Eventually a system using room-temperature magnets was chosen because it was more economical overall, since the transfer lines will operate only during the short periods of LHC filling.

Between them the two transfer lines required the excavation of more than 5 km of new tunnels and enlargements. Excavation for TI 8 began in autumn 1998 with a civil-engineering shaft near the SPS, some 50 m deep and 8 m in diameter. The first enlarged part of the tunnel, TT40, and some adjacent underground works were excavated using machines known as "road headers". However, for drilling the 2.3 km towards the LHC a tunnel-boring machine was used. This had to work its way down to the tunnel that housed the still operational Large Electron Positron (LEP) collider, through a height difference of some 70 m, although this is not usually the preferred way of working. Excavation finished in June 2000 and was followed by lining with concrete, leaving a finished tunnel 3 m in diameter.

By contrast, TI 2 was entirely excavated by road headers. Although the inclination of the LHC tunnel means that the SPS extraction and LHC injection sections are nearly at the same height above sea-level, this tunnel needed a Z-shape vertical profile because of geological constraints (an underground river bed!). Additional magnet groups were required for the vertical bending. The construction of TI 2 and TI 8 involved the excavation of 60 000 m^3 of material and the use of 21 000 m^3 of concrete.

Geodetic referencing work on TI 8 started in autumn 2002, followed by the installation of general services, such as electricity and water cooling, and pulling the power and controls cables. Installation of the magnet system began in December 2003 and finished in May 2004. The relatively restricted space of the transfer tunnels required the development of a new system to transport and install the magnets. This is based on a modular system of "buggies" in the form of very compact tractors with a payload of 9 t

he doorstep of the LHC



a corrector (green) and a series of main ...sibirsk, Russia.

Overall layout of the SPS-to-LHC transfer lines TI 2 and TI 8, with a combined length of 5.6 km. P1, P2 and P8 are interaction points in the LHC; LSS 1 to 6 are straight sections in the SPS.

each, which are fitted with air cushions and in-wheel motors. The wheels can turn on the spot under the load and allow the magnets to be displaced laterally towards their installation position. An automatic guidance system enables the travelling convoy to reach a typical driving speed of around 3.5 km/h. Using this system together with various girders and adapters, more than 400 magnets have been placed in TT40/TI 8, from 300 kg correctors to 13.5 t bending magnets recovered from earlier installations, as well as the 22 t beam dumps. In addition to work on TI 8 and TI 2, the system will be used to install magnets in the main LHC tunnel as well as for the CNGS project, thanks to its versatility.

All 348 main dipole magnets, 179 main quadrupoles and 93 corrector magnets for TI 2 and TI 8, as well as the bulk of the vacuum system, have been built by the Budker Institute for Nuclear Physics (BINP) in Novosibirsk, as part of the contribution of the Russian Federation to the LHC project. These have been transported to CERN by lorry over the 6000 km between the two laboratories. In addition, 73 dipoles and quadrupoles have been reused from the decommissioned PS-to-SPS electron transfer line and the SPS-to-LEP transfer lines. Because of the small emittance of the beam, the apertures of the lines could be relatively small – sometimes no bigger than a postage stamp.

The next stage was to install the beam instrumentation devices, set up the vacuum system and make the necessary electrical and water connections. TI 8 then entered 11 weeks of hardware commissioning to check all the systems individually, such as the magnet powering and polarities, the magnet temperature interlock system, and the read-out of the beam instrumentation devices. Special measures were taken to ensure a sufficient air flow from the ventilation system, and a final verification of the alignment of the beam-line elements took place. The last two weeks before the first beam test in October were used to operate all the systems together from the control room, and a series of "dry runs" allowed the many new components of the control system to be deployed and tested in advance.

For the actual beam tests, the beam dump at the end of the line was supplemented temporarily by additional iron and concrete shielding blocks. This was to minimize the radiological impact on the LHC tunnel and the cavern for the LHCb experiment, where installation is still in full swing. The entire LHC point 8 and several hundred metres in the adjacent LHC arcs were closed. Also the beam tests, spread over two weekends, were scheduled to minimize the impact on the ongoing installation work.

A single-bunch beam with 5×10^9 protons was prepared for the first beam tests. The line was set to 449.2 GeV, the SPS energy measured during the 2003 lead-ion run, and the LSS4 extraction system was set up and re-steered. As soon as the beam dumps at the beginning of the line were retracted, the first bunch of particles travelled through to the end of the installed part of the line, without ▷

Transport convoy carrying a main dipole in the straight part of TI 8, during the initial phase of the installation. The set of engines automatically followed the white guidance line and attained a typical driving speed of around 3.5 km/h.

The commissioning of TI 8 was quickly and successfully achieved thanks to the dedication of the many people who have worked over the years on the two transfer lines.

Director-general Robert Aymar and the LHC project leader, Lyn Evans, joined some of the people involved in the realization and testing of TI 8, during the first beam tests on 23 October 2004.

the need for any "threading" (all corrector elements were set to zero current). In the following hours the necessary calibrations of the beam instrumentation were made and many measurements were carried out, such as energy acceptance, aperture scans, dispersion and optical matching, in part also using higher single-bunch intensities of $3-4 \times 10^{10}$ protons. On the second test weekend, at the beginning of November, some commissioning was also done with multiple bunches per extraction, accumulating a total intensity at the end of the line of 8.6×10^{13} protons over the two weekends.

Although the data are still being analysed, the basic theoretical model of the lines seems to be well confirmed. The trajectory stability was found to be very good and the layout of the beam diagnostics, which performed well, was shown to be appropriate. The new control system, with its extensive array of applications, performed excellently, greatly facilitating the smooth progress of the tests.

The last part of the TI 8 line, in the LHC tunnel itself, and the injection system will be set up soon. The upstream part of the other transfer line, TI 2, is being installed. Since the main LHC magnets will be brought down through a shaft in TI 2 nearly halfway to the LHC, the downstream part of this transfer tunnel must remain empty of line elements to facilitate the transport of the LHC elements into the ring. It will be completed and commissioned once the installation of the main LHC magnets is over.

The commissioning of TI 8 was quickly and successfully achieved thanks to the dedication of the many people who have worked over the years on the two transfer lines. Following on from the commissioning of the LSS4 extraction and TT40 a year ago, this has served as a large-scale test-bed for components and concepts that will be used in the LHC. It also provided an early understanding of the behaviour of the transfer line, which should help to focus attention during the LHC sector test, planned for 2006, on the injection system and the main ring.

Volker Mertens, *CERN*.

Particles meet cosmology and strings in Boston

PASCOS 2004 is the latest in the symposium series that brings together disciplines from the frontier areas of modern physics.

Participants at PASCOS 2004 and the Pran Nath Fest, which were held at Northeastern University, Boston. They include Howard Baer – front row sixth from left – then, moving right, Alfred Bartl, Michael Dine, Bruno Zumino, Pran Nath, Steven Weinberg, Paul Frampton, Mariano Quiros, Richard Arnowitt, Mary K Gaillard, Peter Nilles and Michael Vaughn (chair, local organizing committee).

The Tenth International Symposium on Particles, Strings and Cosmology took place at Northeastern University, Boston, on 16–22 August 2004. Two days of the symposium, 18–19 August, were devoted to the Pran Nath Fest in celebration of the 65th birthday of Matthews University Distinguished Professor Pran Nath. The PASCOS symposium is the largest interdisciplinary gathering on the interface of the three disciplines of cosmology, particle physics and string theory, which have become increasingly entwined in recent years.

Topics at PASCOS 2004 included the large-scale structure of the universe, cosmic strings, inflationary models, unification scenarios based on supersymmetry and extra dimensions, M-theory and brane models, and string cosmology. Experimental talks discussed data from the Wilkinson Microwave Anisotropy Probe (WMAP), neutrino physics, the direct and the indirect detection of dark matter, B-physics and data from the CDF and D0 detectors at Fermilab's Tevatron.

Cosmology and quantum gravity

The issue of dark matter in the universe and prospects for the future were reviewed by Joseph Silk of Oxford and Margaret Geller of the Harvard–Smithsonian Center for Astrophysics. Geller observed that, while the cosmic microwave background combined with large redshift surveys suggests that the critical matter density of the universe is $\Omega_m \sim 0.3$, direct dynamical measurements combined with the estimates of the luminosity density indicate $\Omega_m = 0.1–0.2$. She suggested that the apparent discrepancy may result from variations in the dark-matter fraction with mass and scale. She also suggested that gravitational lensing maps combined with large redshift surveys promise to measure the dark-matter distribution in the universe. The microwave background can also provide clues to inflation in the early universe. Eva Silverstein from SLAC discussed a new mechanism for inflation that results from a strong back-reaction on rolling scalar-field dynamics near regions with extra-light states. She claimed that this leads to a distinctive non-Gaussian signature in the cosmic microwave background, which can distinguish this mechanism from traditional slow-roll inflation.

Cosmology and particle physics connected again in a talk at the Nath Fest by Steven Weinberg of the University of Texas, Austin. He spoke on the analogy between perturbations to the Friedmann–Robertson–Walker cosmology and the Goldstone bosons of particle physics in his talk "Goldstone Bosons Through the Ages". Ali Chamseddine of the Center for Advanced Mathematical Sciences, American University of Beirut, showed that consistency problems on ▷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the action for massive coloured gravitons can be resolved by employing spontaneous symmetry-breaking to give masses to gravitons.

In his talk on quantum gravity, Lee Smolin of Perimeter Institute described rigorous results and the possibility of testing them experimentally. He discussed possible violations of the Greisen–Kuzmin–Zatsepin bound on the upper energies of cosmic rays, which may be observed by the Pierre Auger Observatory, and possible variations of the speed of light with energy, which would be observable by the GLAST gamma-ray observatory. Dark energy in the universe formed part of the talk by Gregory Tarlé of Michigan reviewing the SNAP (Supernova Acceleration Probe) satellite observatory.

Supersymmetry and strings

Strings featured at the symposium on both the cosmic and the fundamental particle scales. In a talk on cosmic strings, Alexander Vilenkin of Tufts presented their current status in view of recent developments in string cosmology. At the opposite end of the scale, other speakers discussed string- and brane-based models in particle physics. Mary K Gaillard of the University of California, Berkeley, presented results from studies of effective Lagrangian theories that arise from compactification of the weakly coupled heterotic string. Models based on D-branes and their implications were discussed by Mirjam Cvetic of Pennsylvania, while Richard Arnowitt from Texas A&M examined the gravitational forces felt by point particles on two 3-branes (the Planck brane and the tera-electron-volt brane) bounding a 5D anti de Sitter (AdS) space with S^1/Z_2 symmetry.

Nima Arkani–Hamed of Harvard and Michael Dine of the University of California, Santa Cruz, discussed string-based landscape scenarios from two different perspectives: whether the landscape does or does not predict low-energy supersymmetry. Arkani–Hamed argued for a high scale for supersymmetry or split supersymmetry while Dine said that, under rather mild assumptions, the landscape seems to favour a low and possibly even a very low scale for supersymmetry breaking. In considering the possibility for inflation in string theory, Boris Kors from MIT discussed a Stückelberg extension of both the Standard Model and the Minimal Supersymmetric Standard Model, recently introduced in collaboration with Pran Nath. In this extension, the vector bosons become massive without spontaneous symmetry-breaking, via condensation of Higgs scalar fields. Furthermore, such an extension implies the existence of a sharp Z boson and may lead to a new lightest supersymmetric particle composed mainly of Stückelberg fermions. In this case, the signals of supersymmetry will change in a significant way and the Stückelberg fermion may become the new candidate for dark matter.

Experiment and phenomenology

A number of talks dealt with supersymmetry phenomenology, specifically with regard to searches for supersymmetry at particle colliders and in dark matter. Howard Baer of Florida State described the possibilities for direct and indirect detection of supersymmetric dark matter, as well as searches at colliders, within the minimal supergravity grand unification (mSUGRA) paradigm. Searches at colliders were also discussed by Xerxes Tata of Hawaii, this time in the light of data from WMAP and other experimental constraints on weakly interacting massive particles (WIMPs). On the experimental side, Rupak Mahapatra of the University of California. Santa Barbara, reported on the world's lowest exclusion limits on the coherent WIMP–nucleon scalar cross-section for WIMP masses above 13 GeV/c^2 based on data from the Cryogenic Dark-Matter Search experiment at the Soudan Underground Laboratory. These results rule out a significant part of the parameter space of supersymmetric models.

Vernon Barger, right, presenting Pran Nath with a replica of an historic plaque from the University of Wisconsin during the Pran Nath fest.

David Cline of UCLA presented the current ZEPLIN II programme for the direct detection of dark matter as a prototype of large liquid-xenon detectors. He then described ZEPLIN IV and other 1 t liquid xenon detectors, and discussed the limiting backgrounds for such detectors in exploring the full range of the SUSY parameter space. Stefano Lacaprara of INFN, Padua, looked at the prospects for dark-matter searches at the Large Hadron Collider, and Rita Bernabei from INFN Rome reviewed the observation of dark-matter signals using the low-background NaI(Tl) detector of the DAMA dark-matter project in the Gran Sasso Laboratory.

Neutrinos and other particles

Several speakers at the symposium emphasized the promising future for neutrino physics and astrophysics. Vernon Barger from Wisconsin gave an in-depth presentation about the status and future prospects of precision neutrino physics. Haim Goldberg of Northeastern discussed galactic and extra-galactic neutrino sources, and Sandip Pakvasa from Hawaii showed how high-energy astrophysical neutrinos can provide information about neutrino lifetimes and mass hierarchies. Tom Weiler of Vanderbilt reviewed the particle physics and astrophysics information encoded in the energy spectrum, arrival directions and the flavour content of such cosmic neutrinos.

The detection of high-energy neutrinos was discussed by Stefan Schlenstedt of DESY–Zeuthen, who gave an update on the AMANDA experiment at the South Pole and the construction of the IceCube experiment for the observation of high-energy neutrinos. Luis Anchordoqui of Northeastern University gave an overview of the current status of the Pierre Auger Observatory being built to detect the highest-energy cosmic rays.

At lower energies, there are new measurements of the solar neutrino spectrum at the Sudbury Neutrino Observatory, using salt to enhance the detection of neutral currents. These were presented by José Maneira of Queen's University, who also described the prospects for using strings of ^{3}He proportional counters to increase ▷

At the banquet, clockwise from left: Sergio Ferrara, Mike Vaughn, Mary K Gaillard, Bruno Zumino, Pran Nath and Paul Frampton.

the sensitivity by a factor of two. Nikolai Tolich from Stanford presented the improved measurement from KamLAND of Δm^2 versus $\sin^2 2\theta$ for neutrino oscillations, while Ion Stancu of Alabama covered the status of the MiniBooNE neutrino oscillation experiment. Hans Volker Klapdor–Kleingrothaus of MPI–Heidelberg discussed the evidence for neutrinoless double-beta-decay using data from the Heidelberg–Moscow experiment, which shows a signal at the 4.2 σ level, and discussed its consequences for particle physics.

Other aspects of particle physics were not neglected. Shiro Suzuki from Saga University presented new results from the Belle experiment at KEK on the measurement of time-dependent charge–parity (CP) violation in $b \rightarrow s$ penguin processes. These yield in an average value 2.4 σ away from the Standard Model value. Continuing with B-physics, Stefano Passaggio of INFN Genova reported the direct observation of CP violation at BaBar in $B \rightarrow K^+\pi^-$ at a confidence level of 4.2 σ. Results from DESY's HERA collider and prospects for HERA II were reviewed by Chiara Genta of INFN Florence, while electroweak results from LEP2, the upgraded Large Electron Positron collider at CERN, were summarized by Roberto Chierici of CERN. Markus Schumacher from Bonn presented results of searches for new physics by the LEP experiments. Recent results from the D0 experiment at Fermilab were presented by Pushpalatha Bhat from Fermilab and Nick Hadley of Maryland. Those from CDF were presented by Un–ki Yang of Chicago and Dmitri Tsybychev from SUNY, Stonybrook. Ernst Sichtermann of Lawrence Berkeley National Laboratory gave the latest status of the muon g–2 experiment at Brookhaven, and William Marciano of Brookhaven reviewed the theoretical implications of the g–2 results.

Other talks dealt with a range of interdisciplinary topics. In his status report on using lattice quantum chromodynamics (QCD) in the calculation of light quark masses and the CP-violation parameter B_K, Rajan Gupta of Los Alamos was able to weave in some early history of the lattice gauge calculations from his time at Northeastern University in the early 1980s. Roman Jackiw of MIT discussed the consequences of a vanishing Cotton tensor, which ensures that the 3D gravitational Chern–Simons term is stationary. He showed that this condition leads to kink solutions and that the effective theory is a new type of dilaton gravity.

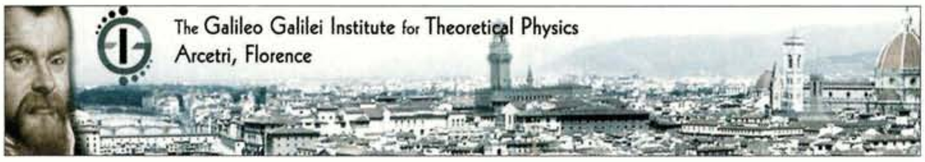
- PASCOS 2005 will be held in the 1600-year-old ancient Korean town of Gyeong–Ju.

George Alverson *and* **Michael T Vaughn**, *Northeastern University, Boston, US.*

ITALY

Florence sets up institute for the study of theoretical particle physics

The Italian National Institute for Nuclear Physics (INFN) and the University of Florence have signed an agreement establishing the Galileo Galilei Institute for Theoretical Physics (GGI), with a remit to organize and host small advanced workshops in theoretical particle physics in its broadest sense. The aim will be to have a significant impact on the corresponding research field. While various institutes for theoretical physics work along similar lines, an institution focused on the physics of fundamental interactions is still lacking in Europe; the GGI will fill this gap.



Each workshop will be devoted to a topic at the forefront of research and for a typical duration of two to three months will host some 10–30 participants, selected from those most active in the field within the international community. The purpose will be to foster discussions, confrontation of ideas, and collaborations among participants. It is expected that the institute will also have an important role in training young researchers.

The GGI is funded by INFN and is sponsored by INFN and the university. It is located in a building made available by the university on the historic hill of Arcetri, near the house where Galileo spent periods of his life and died in 1642.

The GGI's basic referent is the INFN Scientific Committee for Theoretical Physics, which will give its full support to the activities of the institute. These activities will be organized jointly by a Scientific Committee and an Advisory Committee. In the meantime, a Launching Committee has been appointed with the task of giving advice about scientific and management structures and of suggesting criteria for the formation of the Scientific and Advisory Committees. The members of the Launching Committee are David Gross, Giuseppe Marchesini, Alfred Mueller, Giorgio Parisi and Gabriele Veneziano (chair).

The first call for workshop proposals is expected in early 2005, and on 19–21 September 2005 a conference covering the topics of interest for the institute will be held in Arcetri to mark the official opening of the GGI. The first programme should run in the spring of 2006.

WORLD YEAR OF PHYSICS

INFN presents the tools of the trade

A young visitor to "Microscopes of Physics" builds protons or neutrons using magnetic segments simulating up and down quarks.

By speaking through a tube, visitors make waves on a membrane spread with coffee. The liquid "clusters" in some areas, providing a visual metaphor for electrons occurring in orbitals around a nucleus.

For the World Year of Physics the Italian National Institute for Nuclear Physics (INFN) has prepared an interactive exhibition dedicated to the tools that physicists use to observe the world of elementary particles. "The Microscopes of Physics" aims to show what we know about the infinitely small and the infinitely large world that surrounds us. The exhibition also covers the technological applications of nuclear and sub-nuclear physics. Most of the exhibits are interactive and there are many simulations on computers.

The exhibition, divided into four "rooms", is directed at high-school students. In the first two rooms the exhibits, videos and interactive games aim to explain the working of particle accelerators and the experimental techniques used to explore the heart of matter and its fundamental constituents. At the end of the second room, thanks to a 3D video, it is possible to enter a virtual accelerator to understand what happens inside.

The third room is dedicated to the connection between studies of the infinitely small and the understanding of what happens in the universe, to arrive finally at the origin of everything that exists. The room begins with a 3D star model, where it is possible to enter and understand how the fundamental reactions in the heart of a star work.

The final room focuses on the applications that the technologies developed in the basic research have in other fields, from medical applications to heritage preservation.

AWARDS

CERN safety expert receives award for standardization

Helmut Schönbacher, previously of CERN's Safety Commission, has received the 1906 Award of the International Electrotechnical Commission (IEC) for his standardization work on the influence of ionizing radiation on insulating materials.

From 1986 until 2004, Schönbacher led a working group on radiation composed of internationally recognized experts, which edited standards in the IEC 60544 series on the determination of the effects of ionizing radiation on electrically insulating materials.

The group also edited three IEC technical reports on the determination of long-term radiation ageing in polymers. This standardization work and long-term experience from CERN on the ageing of materials by radiation also contributed to research coordination programmes of the International Atomic Energy Agency (IAEA).

Schönbacher, who retired from CERN on 31 January, was a member of the Radiation Protection Group from 1968 to 1988. In 1988 he became group leader and was leader of the Technical Inspection and Safety Division from 1997 to 2002.

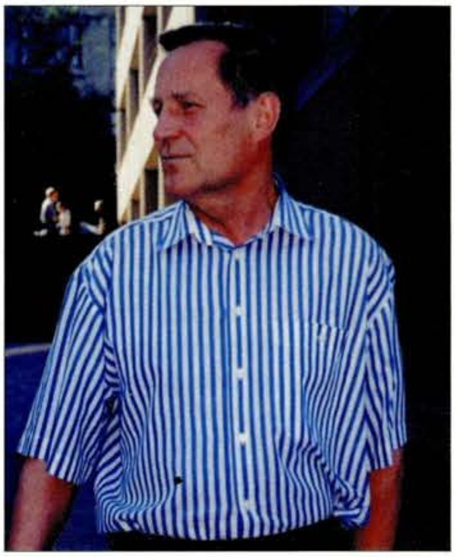
Helmut Schönbacher (right) receiving the award on 18 December 2004 from the president of the Swiss Electrotechnical Committee, Martin Reichle.

European Physical Society requests nominations for particle-physics prizes

The High Energy Particle Physics (HEPP) Board of the European Physical Society (EPS) is calling for nominations for the EPS prizes in particle physics for 2005. The prizes, which will be awarded in a ceremony on 25 July during the International Europhysics Conference on HEPP in Lisbon, are as follows:

- The High Energy and Particle Physics Prize, for an outstanding contribution to high-energy physics in the experimental, theoretical or technological area, will be awarded to one or more persons or to collaboration(s). In accordance with EPS–HEPP regulations, nominations for this prize are accepted only from a broad list of invited world experts.
- The Young Physicist Prize, for outstanding work by one or more young physicists (age less than 35) in the field of particle physics and/or particle astrophysics. Nominations are open and should be addressed to the HEPP–EPS chair Jose Bernabeu (e-mail jose.bernabeu@uv.es) before 15 April.
- The Gribov Medal, for outstanding work by a young physicist (age less than 35) in theoretical particle physics and/or field theory. Nominations are open and should also be addressed to the HEPP–EPS chair by the same date.
- The Outreach Prize, for outstanding outreach achievement connected with high-energy physics and/or particle astrophysics. Nominations are open and should be addressed to Jorma Tuominiemi (e-mail jorma.tuominiemi@cern.ch) before the deadline of 15 April.

Detailed regulations and the list of previous prizes may be found on the Web page of the HEPP Division of EPS at http://eps-hepp.web.cern.ch/eps-hepp/.



Igor Dremin from the Lebedev Institute.

Igor Dremin wins the I E Tamm prize

Igor M Dremin from the Lebedev Institute of Physics has won the 2004 I E Tamm prize from the Russian Academy of Sciences for a broad range of important original contributions to "multifractality and correlations in multiparticle production in QCD".

Dremin has been well known in the particle-physics community since the end of the 1950s, when together with D S Chernavsky he proposed the one-pion exchange model of peripheral hadron interactions, which led to the multiperipheral and multi-reggeon models. His theoretical work on the fractal properties of particle distributions in phase space and the solution of quantum chromodynamic equations for quark and gluon jets predicted new effects and initiated a worldwide series of theoretical and experimental studies.

Dremin has also had original ideas on topics such as "Cherenkov gluons" (ring-like events) and charm in cosmic rays (long-flying cascades) and recent work on wavelet analysis of some physics processes. His originality has also extended to applied problems in reactor physics, aviation and medicine, demonstrating his varied interests.

The Tamm prize is awarded every three years, and Dremin's was announced on 25 January at a session of the Presidium of the Russian Academy of Sciences.

ANNIVERSARY

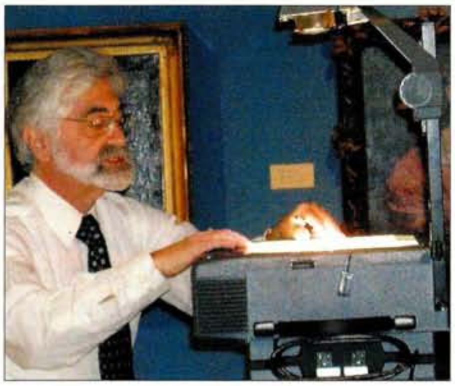
Miami celebrates four decades of conferences on elementary particles

Participants listen to George Zweig recount his discovery of the quark model in the Lowe Art Museum of the University of Miami.

The year 2004 marked the 40th anniversary of several important developments in physics, such as the experimental observation of charge–parity (CP) violation; the detection of the cosmic microwave background; the Higgs–Brout–Englert mechanism; and the publication of the quark model of hadrons, independently by Murray Gell-Mann and George Zweig. Coincidentally, the first Coral Gables Conference on the physics of elementary particles took place at the University of Miami in January 1964, so 2004 was also the 40th anniversary of this well known series of meetings.

It was with this rich history in mind that the physics department of the University of Miami hosted a topical conference on elementary particle physics and cosmology on 15–19 December 2004. More than 80 physicists from several countries attended this first in a new series of meetings, the so-called Miami 2004 Conference, which took place primarily at the Sonesta Beach Resort on Key Biscayne, Florida.

The focus of Miami 2004 was on recent discoveries and developments in particle physics and cosmology. Approximately half the talks were on dark matter, dark energy or neutrino physics, approximately one-sixth were on quarks and lattice quantum chromodynamics, and the rest were on more theoretical themes involving Lorentz invariance, CPT, gravity, strings, branes and unification beyond the Standard Model.



George Zweig. (Courtesy Osamu Yasuda.)

Two awards were presented at the conference banquet to honour Arnold Perlmutter and Sydney Meshkov, each having attended 33 meetings on particle physics in south Florida since 1964. Both attended the very first Coral Gables Conference, which they helped the late Behram Kursunoglu plan and organize. These awards are for first-time attendees of south Florida conferences to encourage younger physicists to participate in future meetings of the new series, and were given to Lisa Everett and Daniel Chung. They consisted of software packages provided by the manufacturers Wolfram Research and MacKichan Software.

A highlight of the meeting was an historical colloquium, given by George Zweig, detailing his role in the discovery of the quark model 40 years ago. As is well known, Gell-Mann took the name of these fractionally charged constituents of hadrons from a phrase appearing in *Finnegans Wake* by James Joyce. It is perhaps less well known that Zweig made his independent discovery of the model while a post-doctoral fellow at CERN.

The venue for Zweig's talk differed from that of the other presentations. It took place in the Lowe Art Museum of the University of Miami, hence the paintings in the backgrounds of the photographs shown here. The first Coral Gables Conference also took place in the Lowe Museum, in the very same Beaux Arts Gallery. Thus were the historical aspects of the meeting further emphasized. A reception followed the colloquium, provided by the College of Arts and Sciences of the university.

• Complete lists of the session organizers and conference participants, as well as the meeting programme and other details, are available at http://server.physics.miami.edu/~cgc/Miami2004.html.

CO-OPERATION

Iceland warms up to CERN

From left to right: D Blechschmidt (CERN), R Bachman (Science and Technology Policy Council of Iceland), K Olafsson (University of Bergen), A Lipniacka (Bergen), H Jonsson (University of Iceland), F Ould-Saada (University of Oslo), T Jonsson (Iceland), E Tsesmelis (CERN), H P Gunnlaugsson (University of Aarhus), E L Sveinsdottir (Icelandic Ministry of Education, Science and Technology), K Kristjansson (Icelandic Centre for Research) and H Jonasson (Technological Institute of Iceland).

In terms of climate, Iceland is not as cold as it sounds, since it is a large volcanic island; and in terms of science, the country has developed a highly educated and competitive society, despite its remoteness. It now spends more than 3% of its gross national product on R&D, exceeding the goal that the European Union aims to achieve by 2010.

Iceland is also a place of extremes for many other reasons. For example, it is Europe's second-largest island, yet its population is less than that of the Swiss canton of Geneva, where CERN was founded; and just like the University of Geneva, or for that matter CERN, the University of Iceland attracts students and scientists from all over the world.

In 1996, the government of Iceland signed a Co-operation Agreement with CERN to ensure long-term opportunities for the country's physicists to participate in its research projects and unique laboratory facilities. Since then several Icelandic scientists and engineers have worked there.

More recently, encouraged by ambassador Stefan Haukur Jóhannesson, Iceland's representative to the United Nations in Geneva, a CERN delegation visited the Iceland University in Reykjavik and met government representatives. Their aim was to put new life into the Iceland–CERN co-operation. This visit coincided with a Workshop of the NorduGrid Consortium that was held in Reykjavik with the participation of particle physicists from northern Europe.

The CERN delegation and their Icelandic hosts agreed to promote more scientific exchanges, starting by encouraging Icelandic students to participate in CERN's summer student programme; to stimulate contacts between material scientists from Iceland and their colleagues collaborating in relevant R&D projects at CERN (e.g. RD-39, RD-50); and to invite Icelandic scientists to consider joining the (predominantly northern European) community performing experiments at CERN's ISOLDE facility.

Israel increases participation in LHC

Itzhak Levanon (left) and Robert Aymar.

On 29 November 2004, the Israeli ambassador to the United Nations Office at Geneva, Itzhak Levanon, and CERN's director-general, Robert Aymar, signed a new protocol to the Co-operation Agreement between the government of Israel and CERN. This protocol covers a substantial increase in the Israeli contribution to CERN's Large Hadron Collider (LHC) Project. Israeli scientists have been participating in CERN's scientific activities since 1960, and in 1992 Israel became the first non-member state to make regular financial contributions to CERN's budget.

A meeting on 10–11 January at the Max Planck Institute in Munich, to celebrate the 70th birthday of Julius Wess, was attended by physicists from around the world, including Japan, Russia, and the US. Speakers included Bruno Zumino, co-proposer with Wess of supersymmetry (in the West), evidence for which might be discovered at the Large Hadron Collider. Many other talks were given by Wess's former students who are themselves renowned physicists. Here we see Wess with Carola Reinke, secretary of the theory group at the institute. (Courtesy André Martin.)

NEW PRODUCTS

Acqiris had unveiled three new 10-bit digitizers with single-channel sampling of up to 8 gigasamples per second (Gs/s). The DC282, DC353 and DC222 PXI/CompactPCI digitzers offer a choice of front-end input. Synchronous four-channel sampling up to 2 Gs/s, or interleaved dual- and single-channel sampling of up to 4 and 8 Gs/s respectively are available.

For further information tel. +41 22 884 3390, e-mail info@acqiris.com or see www.acqiris.com.

FIZ Karlsruhe, the European partner of science and technology online service STN International, has added EPFULL (the European Patents Full Text database) to its comprehensive portfolio of patent databases. This includes the full text of European patent applications and granted European patents.

For further information tel. +49 7247 808 555, e-mail helpdesk@fiz-karlsruhe.de or see www.stn-international.de.

ISEG Spezialelektronik GmbH has added an eight-/sixteen-channel HV module to its HV multichannel module family, controlled by the CAN bus. The module has an output voltage range up to 4 kV, and offers the functionality necessary for control in large detector systems for particle physics.

For further information contact Ludwig Christians on tel. +49 351 26 996 0, e-mail sales@iseg-hv.de or see www.iseg-hv.de.

LEDtronics has announced its series B618/619 single-contact and series DB618/619 double-contact bayonet-based LED lamps for direct replacement of incandescent bulbs. Two light-emitting angles are offered as standard, in a variety of colours and infrared wavelengths.

For further details contact Jordon Papanier on tel. +1 310 534 1505 extension 120, e-mail jpapanier@ledtronics.com or see www.ledtronics.com.

Westcode Semiconductors has introduced a 100 mm thyristor. Manufactured on a single silicon wafer measuring 100 mm in diameter, the new 5.2 kV device features improved turn-on characteristics and di/dt capability.

For further information tel. +44 1249 444524, e-mail WSL.sales@westcode.com or see the data sheet at www.westcode.com.

MEETINGS

NNN05, the latest conference in the series on the Next Generation of Nucleon Decay and Neutrino Detectors, will take place on 7–9 April at Aussois, Savoie, France, near the Modane Underground Laboratory by the Frejus Tunnel. The topics covered will include proton decay, supernovae neutrinos, high-intensity neutrino beams, atmospheric neutrinos, solar neutrinos, large-detector R&D, and engineering for very large excavations. For further details see http://nnn05.in2p3.fr/.

A **Workshop on Positron Sources for the International Linear Collider** will be held at Daresbury Laboratory, UK, on 11–13 April. The workshop will discuss all the options under consideration for a positron source for the ILC, assess the outstanding R&D issues that will need to be addressed for each of them to become viable, and consider the best ways to do this. The workshop will also consider how the final selection and design of the ILC positron source should be made. For further details, including registration, see www.astec.ac.uk.

QCD 05, the 12th Montpellier International Conference on Quantum Chromodynamics, is to be held on 4–9 July in Montpellier, France. The meeting, which traditionally involves equal mixtures of experimentalists and theorists, and of young and senior physicists, will cover different aspects of QCD – perturbative, non-perturbative and the interface with other fields. For further information see http://w3.lpm.univ-montp2.fr/~qcd/qcd.html.

The **12th Lomonosov Conference on Elementary Particle Physics** will take place at Moscow State University on 25–31 August. The conferences in this series are held in each odd year and bring together about 250 theorists and experimentalists from different countries to review the present status and future prospects in elementary particle physics. The programme will include electroweak theory, tests of the Standard Model and beyond, developments in quantum chromodynamics (perturbative and non-perturbative effects), heavy-quark physics, neutrino physics, astroparticle physics, gravitation and cosmology, and physics at future accelerators. For registration and further details see www.icas.ru/english/12lomcon.htm.

The **2005 Nuclear Science Symposium and Medical Imaging Conference** and **Symposium on Nuclear Power Systems** will take place at Wyndham El Conquistador Resort, San Juan, Puerto Rico, on 23–29 October. Deadline for submission of abstracts is 2 May. For further information see www.nss-mic.org/2005/nss2005.html.

CORRECTIONS

- Apologies to Daniel Schaffer who wrote the article "ICTP at 40" (*CERN Courier* November 2004 p30) for the incorrect spelling of his name in the French edition.
- It should be noted that in figure 1 in the article on deep inelastic scattering at Jefferson Lab (*CERN Courier* December 2005 p23), the best prediction (red curve) is calculated using polarized parton densities extracted from a perturbative QCD fit of the previous world data without the hadron helicity conservation constraint.
- In the report on the ICHEP '04 conference (*CERN Courier* January/February 2005) the value given for Δm^2_{12} for solar neutrinos at the top of p39 should be $(8.3 + 0.6 - 0.5) \times 10^{-5}$ eV^2. Also the correct conference Web address (p40) is http://ichep04.ihep.ac.cn/.

Four hikers from CERN pose with the organization's 50th anniversary flag on their way back from the summit of Mount Kilimanjaro, at 5895 m, the roof of Africa – undoubtedly the highest place to figure in the celebrations last year. Clockwise from top left: Miguel Cerqueira Bastos (accelerator beams department), David Collados Polidura (information technology department), Daniel Cano Ott (n_TOF experiment) and Sandra Sequeira Tavares (physics department).

OBITUARIES

Michail Petrovich Rekalo 1938–2004

Michail Petrovich Rekalo was a leading scientific researcher at the Institute for Theoretical Physics of the National Science Center Kharkov Institute of Physics and Technology, in the Ukraine.

Rekalo was born on 11 July 1938 in the Ukrainian town of Konstantinovka. He graduated in 1960 from Kharkov State University, with a thesis on polarization phenomena in pion and photon scattering on nucleons, a subject in which he was to become a world expert. This marked the beginning of his intensive work in the theoretical physics department, and he later obtained his doctorate at the Joint Institute of Nuclear Research (JINR), Dubna, with a thesis on hadron interaction theory.

In 1974 Rekalo was appointed head of the theoretical physics at Kharkov. His main research work, and that of his team of scientists, focused on the study of hadron electrodynamics. The "Kharkov school" pioneered the understanding and analysis of polarization observables in different processes, such as the electro-disintegration of the deuteron and photo- and electro-production of pions on deuterons.

Rekalo wrote several monographs, text books and popular books on physics. He co-authored more than 300 works on topics in the physics of elementary particles, and he inspired and suggested many others to his students and colleagues. His article on "Polarization phenomena in electron scattering by protons at high energies" (written with A I Akhiezer) showed for the first time that the elastic scattering of longitudinally polarized electrons by polarized protons or the measurement of the polarization of protons scattered by polarized electrons contains all the necessary information for an efficient separation of proton electromagnetic form factors.

Other work was devoted to the photo- and electro-production of particles containing s and c quarks. He suggested a theory of vector meson production in nucleon–nucleon scattering, and also developed a relativistic theory of polarization effects in the disintegration of deuterons by high-energy electrons. Within this theory an effective

method for the measurement of the neutron charge form factor was proposed.

In the 1990s, Rekalo was able to join various international scientific collaborations, leading joint research with physicists from JINR (Russia), Bratislava (Slovakia), Ankara (Turkey), Saclay and Orsay (France), Jefferson Laboratory (US) and CERN. When he first came to France, he was invited to the Saturne National Laboratory. Although his main interest was in quantum electrodynamics, he was very enthusiastic about contact with experimentalists in a different field and found a real pleasure in understanding and interpreting the experiments there.

When given any complex problem he could extract the essential properties from general principles, and only afterwards rely on some model, if necessary. In particular he developed a general model-independent formalism to calculate polarization phenomena for meson production at threshold. This formalism is so general that it applies to light, strange and charmed mesons as well. In this context he suggested experiments that should be done to determine unambiguously the parity of strange and charm particles and the pentaquark.

With the advent of high-intensity polarized electron machines, he could enjoy the realization of the physics that had been his main interest: elastic and inelastic electron–deuteron scattering, parity-violation experiments and especially the measurement of the elastic form factor of the proton. His contacts with the experimentalists of these collaborations were always very stimulating and constructive. He always brought original ideas and deep understanding, as his knowledge was extremely profound, in many fields of physics.

Rekalo was also a dedicated teacher, and for more than 25 years he lectured at the Physical and Technical Department of Kharkov State University. He was recently appointed as visiting professor at the Middle East Technical University (METU), Ankara, where he taught courses on fundamental physics. He typically gave lectures without notes or books; armed with chalk and a blackboard, he could create immediate contact and a lively interaction with his students.

Extremely creative and full of ideas, Rekalo was always ready to interact with people. Very generous in scientific discussions, he had a deep sense of humour, which was sometimes very sharp. He was able to think deeply and to concentrate on physics, where he could focus very quickly on the essential aspects of a problem: complicated and difficult questions were suddenly made very simple and solvable.

Michail Petrovich Rekalo died on 27 August 2004 at Saint-Cloud in France – an invaluable loss for our community. He is remembered by his students and colleagues both as a talented physicist and as a person who sincerely loved science and dedicated his life to it.

Ivan M Neklyudov, Nikolai F Shul'ga and Alexey P Rekalo, NSC-KIPT, Kharkov; Egle Tomasi-Gustafsson CEA, Saclay; Jacques Arvieux and Boris Tatischeff, IPN, Orsay, on behalf of his colleagues and friends.

OBITUARIES

P K "Pasha" Kabir 1933–2004

Prabahan Kemal Kabir, retired professor at the University of Virginia, died on 29 August 2004 at Berhampur (Orissa), India, while swimming in the Bay of Bengal.

Kabir was born in Calcutta on 30 June 1933, and was known to his family and friends as Pasha. His family was prominent in Indian politics, his father being minister of education in the Nehru government. He finished his undergraduate studies in Delhi at age 18, spent two more years there on his MSc under R Majumdar, then came to the US as a doctoral student at Cornell, where his work was on the Lamb shift in helium and his thesis advisers were Hans Bethe and Edwin Salpeter. After completing his PhD, Kabir spent a year (1956–7) at the Institute for Advanced Study at Princeton, when parity violation was large on the agenda, and the following year (1957–8) at Birmingham University in the UK with Rudolf Peierls. Kabir considered Majumdar, Bethe and Peierls as his teachers and mentors.

After Birmingham, Kabir went to teach at the University of Calcutta, but two years later moved to the US as a junior faculty member at Carnegie-Tech. He then went to CERN for two years as a visiting scientist (1963–5), followed by six years on the staff at the Rutherford Laboratory (1965–71) in the UK.

Pasha Kabir in the 1970s on a visit to Poland.

He returned to the US in 1971 as professor at the University of Virginia. This remained his base while he still travelled frequently to Europe and India. He had very many friends in America, Asia and Europe.

Kabir's many contributions in physics centred on symmetry and symmetry violation, especially charge–parity (CP) and time-reversal (T) violation. He edited the book *Developments in the Theory of Weak Interactions*, which reprinted all the important contributions to the field up to 1963, and was author of *The CP Puzzle* (1966), which remains widely quoted as a detailed account of the neutral kaon system. His later description of T violation in the kaon system, without assuming CPT invariance, has been important in stimulating experimental work.

Kabir realized that T violation implies the breaking of detailed balance, and in 1970 he introduced a parameter to describe this in the kaon system; the Kabir parameter was at last measured 30 years later. His name is also given to an important theorem in field theory: the Feinberg–Kabir–Weinberg theorem, the first example of a cancellation of a flavour-changing neutral current (muon to electron).

Kabir suggested and helped to invent many other new ideas, which like his T-violation parameter may take decades to be observed experimentally. Many of his ideas have not appeared as his own publications; he helped friends with aggressive and witty questions on publications for which he was not an author. He was not a follower of recent trends, labouring on symmetries from his time at the Institute of Advanced Study onwards. He had a fiercely independent mind and refused to accept certain new ideas if they clashed with his intuition.

Pasha Kabir was an exceptional and wonderful person – a warm and generous friend and a stimulating and provocative companion. He is sorely missed by his many friends and collaborators throughout the world.

P C Gugelot and P Q Hung, University of Virginia; Gabriel Karl, Guelph-Waterloo Physics Institute; and Sandip Pakvasa, University of Hawaii.

Sergio Fubini 1928–2005

Sergio Fubini passed away on 8 January, aged 76, after a prolonged illness.

Fubini was an outstanding theorist, whose deep insight led to many applications of theoretical models to more phenomenological issues. In the early 1960s, he and his co-workers gave a field-theoretical dynamical basis to S-matrix concepts such as Regge singularities. Then in the mid-1960s his group provided an algebraic formulation of current-algebra and superconvergence sum rules that played an important role in the birth of dual resonance models. Subsequently, at MIT, Sergio and collaborators factorized the dual S-matrix, converting it into an infinite component field theory, opening the way to what soon became string theory.

Sergio Fubini (centre) with Henri Laporte to the left and Franco Bonaudi to the right at their joint 65th birthday celebration.

Wherever Sergio worked, his skill and enthusiasm left a strong mark on students and institutions, such as the universities of Padua and Turin in Italy, MIT and CERN. He was an active member of the CERN Directorate under John Adams and Léon Van Hove where he played an important role in the planning stage of the Large Electron Positron collider. In later years he devoted much effort to promoting a scientific "peace-bridge" in the Middle East that led to the creation of the SESAME synchrotron-radiation laboratory in Jordan. His rich personality will remain vivid in the memory of the many friends and collaborators who had the great opportunity of knowing him and of interacting with him. He will be greatly missed.

Daniele Amati and Gabriele Veneziano, CERN.

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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Postdoctoral Positions on DØ

The DØ group at U.C. Riverside has immediate openings for two postdoctoral physicists. The successful applicants will be based at Fermilab and will be expected to contribute to the operation of the Silicon Microstrip Tracker and the integration of the new Layer 0 into the tracker. In addition, a major role in data analysis is expected, in areas that match those of the UCR group. Experience with tracking detectors and reconstruction software are preferred but not essential. A Ph.D. in experimental high energy physics is required.

The UC Riverside group consists of three faculty (Robert Clare, John Ellison, Stephen Wimpenny), one research faculty (Ann Heinson), two postdocs, and two students. The group has made important contributions to the design and construction of the Silicon Microstrip Tracker and to the tracking and vertexing reconstruction software, and has played a leading role in analysis of DØ data in the areas of top quark and electroweak physics.

Interested persons should send the following application materials to **Prof. S.J. Wimpenny, Department of Physics, University of California, Riverside, CA 92521-0413, USA (e-mail: stephen.wimpenny@ucr.edu)**:

* Curriculum vitae,
* Description of research experience,
* Names and addresses of at least three referees

(The candidate should arrange to have the letters of recommendation sent directly to the address above.)

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The High Energy Physics Division Director will have responsibility for the research program of the entire division through long-range planning, preparation of initiatives, establishment of policy and priorities and interaction with funding agencies and with the broader academic and laboratory research communities. In addition, the Director will develop and maintain an excellent scientific staff through promotions and new hires and maintain environmental safety and health standards. The successful candidate should have a Ph.D. degree in particle physics, an internationally recognized research stature, 10+ years of relevant experience and demonstrated leadership and administrative abilities with a commitment to excellence in research.

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(Hochenergiephysik, Teilchenastrophysik)

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Bewerbungen mit den üblichen Unterlagen werden bis zum **15. April 2005** erbeten an den Vorsitzenden der Fachgruppe Physik-Astronomie, Endenicher Allee 11-13, 53115 Bonn.

Physicist Postdoctoral Fellow - ATLAS

The Physics Division of the Lawrence Berkeley National Laboratory (LBNL) is seeking a Postdoctoral Fellow to participate in the ATLAS Experiment at the Large Hadron Collider (LHC) at CERN. The ATLAS Group at LBNL has important roles in the silicon tracking detectors and in physics simulation. The successful applicant is expected to be involved in inner detector software, simulation studies, preparation for physics analysis, and later in the analysis of the first data from the LHC. This is a two-year term position with the possibility of renewal up to a total of five years.

To qualify, the candidate should have a PhD in Experimental High Energy Physics or equivalent experience and demonstrated strong potential for outstanding achievement as an independent researcher.

Interested applicants should submit via email a curriculum vitae, publication list, and three letters of recommendation to SDCheeseboro@lbl.gov. Applications should reference job number PH/017413/JCERN. Questions related to job content and responsibilities should be directed to M. Gilchriese (MGGilchriese@lbl.gov). Applications are accepted until the position is filled. LBNL is an Affirmative Action/Equal Opportunity Employer committed to the development of a diverse workforce.

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Applications should include a curriculum vitae, a publication list and a short summary of teaching and research experience. Electronic mail inquiries may be addressed to SEARCH@LEPP.CORNELL.EDU.
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Experimental Particle Physics ATLAS and Neutrino Experiments Argonne National Laboratory

Applications are invited for experimental postdoctoral fellow positions in the High Energy Physics Division at Argonne National Laboratory to work on the ATLAS experiment at the LHC or on long-baseline and reactor-based neutrino experiments, starting in summer 2005. The Argonne HEP Division's experimental particle physics program includes ATLAS, CDF, MINOS, STAR, ZEUS and Linear Collider detector development.

The Argonne Neutrino Group is seeking candidates with strong backgrounds in particle physics and with good software and analysis skills. The selected candidate would work on the MINOS and NOvA long-baseline neutrino oscillation experiments or on a future reactor experiment to measure the theta-13 mass-mixing parameter. In early 2005, MINOS will begin taking data for definitive measurements of neutrino oscillation mechanisms and parameters in the region suggested by atmospheric neutrino observations. The Neutrino Group is also working on detector development for the NOvA off-axis experiment in Fermilab's NuMI neutrino beam and for reactor-based experiments at Braidwood in Illinois and Double-CHOOZ in France.

The Argonne ATLAS Group is seeking candidates with strong backgrounds in experimental particle physics detectors and analysis. The selected candidate would be expected to contribute both to commissioning and to physics analysis and would be required to spend a significant period at CERN. Knowledge of modern HEP software environments is desirable. The interests of the group cover a wide range of physics topics. However, as members of the ATLAS Tile Calorimeter subgroup, Argonne group members are expected to contribute to physics analyses in which this detector system is involved, namely jet reconstruction and studies of processes involving jets and photons. Commissioning of the tile calorimeter will begin in summer 2005 with LHC turn-on scheduled for 2007.

Postdoctoral appointments are one-year appointments with the possibility of renewal for up to three years. Interested candidates should have obtained a Ph.D. in experimental nuclear or high-energy physics.

Argonne provides an excellent compensation/benefits package. For consideration, please send a detailed resumé, salary history, and the names/addresses of three references through the Argonne website at http://www.anl.gov/jobs under postdoctoral job openings for Requisition HEPDSA HEP.

Argonne is an equal opportunity employer, and we value diversity in our workforce.

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GSI Darmstadt is looking on behalf of its Magnet Technology Group for a

Physicist or Graduate Engineer (TU)

Ref. No.: 3440-05.5

to work on development and planning of cryogenic components (cryostats, distribution systems) of future accelerators at GSI within the framework of the FAIR project.

The principal subjects of the work are:

- Design of cryogenic components
- Analysis of cryogenic losses
- Heat transfer and thermal transition calculations

Expertise in at least one of the following areas is expected:

- Cryogenics
- Process engineering
- Structural mechanics
- Superconducting magnet technology

Training opportunities will be available.

Proficiency in the English language, both written and spoken is required.

The position is limited to a term of 3 years with the possible perspective of a permanent position, pursuant to qualifications and competence.

GSI is an equal opportunity employer and encourages women especially to apply for the positions. Remuneration according to pay scale grouping „BAT" for federal employees in Germany. Disabled applicants will be given preference over other applicants with comparable qualifications.

You will find further information concerning GSI on http://www.gsi.de.

Applications quoting the Ref. No. and including CV, publication list and two letters of reference should be sent by **March 18, 2005** to:

GSI Darmstadt

The National Laboratory for Heavy-Ion Research, a member institute of the Helmholtz-Society of German Research Centres

Gesellschaft für Schwerionenforschung mbH
Personalabteilung
Kennziffer 3440-05.5
Planckstraße 1
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Duke UNIVERSITY

Postdoctoral Position in Experimental Neutrino Physics

The position will involve work on Super-Kamiokande, along with the upcoming T2K (Tokai to Kamioka) experiment.
For inquiries, contact **Professor Kate Scholberg at schol@phy.duke.edu.**
Candidates must have a Ph.D.in experimental particle physics. Applicants should send CV, statement of interest and have three letters of reference sent to:
Neutrino Postdoc Search c/o Manuela Damian, Department of Physics, Box 90305, Duke University, Durham, NC, 27708.
Duke University is a Equal Opportunity/Affirmative Action Employer and particularly encourages women and minorities to apply.
Application deadline: April 30, 2005. Review of applications will begin immediately.

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RESEARCH ASSOCIATE

Superconducting RF for Accelerators

Cornell University

The Laboratory for Elementary-Particle Physics at Cornell University has an opening for a Research Associate to work on the design, development, installation and operation of the Superconducting RF systems for a variety of Accelerators: energy recovery linac and prototype; the Cornell electron-positron colliding beam facility, CESR; and the International Linear Collider. R&D at Cornell is in progress on basic SRF issues related to high gradient, high Q and new materials. Major components under development are superconducting cavities, high power input couplers, high power windows, higher order mode loads, cryostat, refrigeration, RF power distribution, instrumentation and controls. Research Associates generally participate in several of these activities.

This is a 3-year appointment with the expectation of renewal, subject to mutual satisfaction, and the availability of funds under our NSF contract. A PhD in Physics/Engineering is required with related experience in a combination of the areas outlined above.

Please send a cover letter, including curriculum vitae and a publications list to

Dr. H. Padamsee, Newman Laboratory,
Cornell University, Ithaca, NY 14853,

and arrange for three letters of recommendation to be sent. Email correspondence may be directed to search@lepp.cornell.edu.
Cornell University is an equal opportunity/affirmative action employer.

Deutsches Elektronen-Synchrotron

PETRA III

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

Particle accelerators generate highly intense radiation for many innovative applications. After the reconstruction of the PETRA storage ring into a 3rd generation synchrotron radiation source and the construction of the free electron lasers (VUV-FEL and XFEL) DESY will be one of the most interesting places for research with photons world-wide. These new source will open fascinating possibilities for research at nano scales by using extremely focussed photon beams and by exploiting the coherence properties of the sources. We are looking for a

Physicist (PhD)

for the development of innovative X-ray optics. The job profile covers the development of X-ray optical elements and it prototype development.

You are an expert in the field of X-ray optics and diffraction physics and you are experienced in designing and operating beamlines at modern synchrotron radiation sources. It is expected that you will be open for innovative solutions. You are expected to take the initiative in a team oriented of the working environment and you have demonstrated leadership capabilities. If you are interested in this position, please send your complete application papers by indicating the code to our personnel department. For further information, please contact Dr. Weckert on +49 40/8998-4509.

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

Deutsches Elektronen-Synchrotron DESY
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code: 5/2005 • Notkestraße 85 • D-22603 Hamburg • Germany
Phone: +49 40/8998-3392 • www.desy.de
email: personal.abteilung@desy.de

Deadline for applicants: 21.03.2005

Deutsches Elektronen-Synchrotron

XFEL Research

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

Particle accelerators produce high intensive radiation for most diverse, innovative applications. By the planned upgrade of the PETRA storage ring into a 3rd generation synchrotron light source and the construction of the free electron lasers (VUV-FEL and XFEL) DESY will take up an international top position in future research with photons. These novel sources impose high demands on photon detection (multi-element systems with submicrosecond time resolution, high spatial resolution and high quantum efficiency). We are looking for a

Physicist (PhD)

with marked experience record in detector R&D for a corresponding development program in the frame work of a new detector group. The job profile covers definition and elaboration of detector requirements, detector development and tests as well as their actual implementation and application in photon experiments.

Strong and broad-spread knowledge in detector development is thus indispensable. Ideally, the successful candidate proves experience in the application of X-ray detectors in experiments with synchrotron radiation. He or she will show capability of working in a team and readiness for coordination of the collaboration with external research groups. If you are interested in this position, please send your complete application papers by indicating the code to our personnel department. For further information, please contact Dr. G. Grübel on +49 40/8998-2484.

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

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For detailed information about how *CERN Courier* can assist you with suitable advertising options, including magazine advertising and online exposure, please contact Jayne Orsborn.
E-mail: **jayne.orsborn@iop.org**; Tel: +44 117 930 1027.

Deutsches Elektronen-Synchrotron
Particle and Accelerator Physics

DESY

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

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

DESY Fellowships

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

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email: personal.abteilung@desy.de

Deadline for applicants: 31.03.2005

UNIVERSITÄT WÜRZBURG

Am Institut für Theoretische Physik und Astrophysik der Universität Würzburg ist zum 01.04.2006 eine

Professur (W2)

im Beamtenverhältnis auf Lebenszeit für Theoretische Physik wieder zu besetzen. Gesucht wird eine Physikerin oder ein Physiker mit dem Arbeitsgebiet **Theoretische Elementarteilchenphysik**, die/der die vorhandenen Aktivitäten sinnvoll ergänzt. Zu den Aufgaben gehört, das Fachgebiet in Forschung und Lehre zu vertreten. Erwartet werden die Beteiligung an den Lehraufgaben der Fakultät im Fach Theoretische Physik und die Zusammenarbeit mit anderen Arbeitsgruppen an der Universität Würzburg.

Einstellungsvoraussetzungen sind abgeschlossenes Hochschulstudium, pädagogische Eignung, Promotion und Habilitation oder gleichwertige wissenschaftliche Leistungen. Bewerber dürfen das 52. Lebensjahr zum Zeitpunkt der Ernennung noch nicht vollendet haben (Ausnahmen sind in dringenden Fällen gem. Art. 12 Abs. 3 Satz 2 Bayerisches Hochschullehrergesetz möglich). Die Universität strebt eine Erhöhung des Anteils der Frauen am wissenschaftlichen Personal an und fordert nachdrücklich qualifizierte Wissenschaftlerinnen auf, sich zu bewerben. Schwerbehinderte Bewerberinnen oder Bewerber werden bei ansonsten im Wesentlichen gleicher Eignung bevorzugt eingestellt.

Bewerbungen sind mit den üblichen Unterlagen (Lebenslauf, wissenschaftlicher Werdegang, Zeugnisse, Urkunden, Schriftenverzeichnis und Verzeichnis der Lehrtätigkeit) **bis zum 13.04.2005** einzureichen beim Dekan der Fakultät für Physik und Astronomie der Universität Würzburg, Am Hubland, D-97074 Würzburg.

The University of Sheffield

Lecturer in Experimental Particle Physics - 2 Posts

Department of Physics & Astronomy
Salary: from £27,900 per annum

As part of a major initiative the University of Sheffield is seeking to appoint two new Lecturers in Experimental Particle Physics to play leading roles in the ATLAS experiment at CERN. The University of Sheffield ATLAS group is currently contributing significantly to construction and commissioning of the SCT end-cap tracking detectors, development of high level event reconstruction software and preparations for exploitation of ATLAS data. Members of the group hold leadership positions in the ATLAS SUSY Working Group and Radiation Task Force, as well as in offline and Grid computing. The group also has a strong interest in Standard Model physics and experiment calibration using Standard Model channels. Successful applicants will possess a PhD or equivalent in particle physics or a related discipline. Applications from candidates with an interest in hardware work and/or preparations for physics analysis are particularly welcome.

Closing Date: 15 March 2005 Ref. R3588

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email: jobs@sheffield.ac.uk
tel: 0114 222 1631 (24hr)
Please quote Ref. in all enquiries

POSTDOCTORAL RESEARCH POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS
UNIVERSITY OF CALIFORNIA, RIVERSIDE

The Department of Physics at the University of California, Riverside, invites applicants for a postdoctoral research position to work with the high energy physics group on the CMS experiment at CERN.

At the University of California, Riverside, we are carrying out a multi-faceted program of detector development and production and preparation for physics in the CMS experiment. We are seeking a postdoctoral researcher to work on the CMS Silicon Tracker in California. We are working on silicon module production in collaboration with the University of California, Santa Barbara, and setting up a module testing and repair facility at U.C. Riverside. The postdoctoral researcher would also work on preparation for physics with CMS.

Applicants should have experience with high energy physics detectors and testing software, preferably with silicon detectors. Candidates must have a Ph.D. degree in high energy physics. Applications, including vitae, list of publications, and three reference letters, should be sent to:

Professor Gail G. Hanson, Department of Physics
University of California, Riverside, CA 92521-0413, U.S.A.
or by e-mail to Gail.Hanson@ucr.edu or Gail.Hanson@cern.ch

The position will be filled as soon as an appropriate candidate is identified.

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UNIVERSITY OF CALIFORNIA, RIVERSIDE

The University of California is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITÉ DE GENÈVE

The **FACULTY OF SCIENCES** of the University of Geneva, Switzerland, has an opening for a position as

Full or Associate Professor

Experimental particle physics
(Professeur ordinaire ou adjoint)

RESPONSIBILITIES : This full-time appointment includes:
- teaching responsibilities (6 hours per week)
- research responsibilities as leader of a international research group in elementary particle physics.
- administrative tasks at the department and university level.

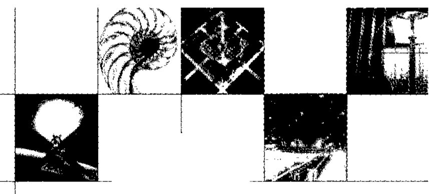
ACADEMIC QUALIFICATION: Ph.D. or equivalent. Appropriate teaching and research experience.

STARTING DATE : October 1st 2006 or as agreed.

Applications, including curriculum vitae, a list of publications and a short research plan should be sent before 1st June 2005, to the Dean of the Faculty of Sciences, 30 Quai Ernest-Ansermet, CH-1211 Geneva 4, Switzerland, where further information concerning the job description and working conditions may be obtained.

Female candidates are particularly welcomed.

PAUL SCHERRER INSTITUT
PSI



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

Within the European collaboration for the "Next Linear Collider" (EUROTeV) PSI is in charge of the conceptual design of a bunch compressor system and to a path length tuning chicane to correct the longitudinal position of the beam.

For those beam dynamic studies, we advertise an

Accelerator Physicist Post doctoral Position

Your tasks
- Conceptual design of a bunch compressor chicane suitable for a multi TeV collider and to a path length tuning chicane to correct the longitudinal jitter of the beam
- Optimisation of the basic parameters of those systems with respect to Coherent Syncroton Radiation effects, microbunching instabilities and dynamic imperfections
- You will work within a motivated team on a subject with a high impact in the accelerator field and frequent exchanges will be established with the International Linear Collider design groups, as for example with CERN (Geneva) and DESY (Hamburg)

Your profile
You have a PhD in physics or electroingineer. An experience in the field of electron accelerator and in particular a background in beam dynamics is required. Furthermore some experience in the utilization of the numerical tools used for particle dynamics is strongly recommended. Emphasis is placed on your ability to work in a team efficiently. This position will offer great opportunities to start your research career in an exciting and multidisciplinary environment.

We are looking forward to your application.

Dr. Marco Pedrozzi will be pleased to answer any questions concerning this position. His phone number is: +41 (0)56 310 32 42, E-Mail: marco.pedrozzi@psi.ch.

Please send your application to Paul Scherrer Institut, Human Resources, Mr. Thomas Erb, ref. code 8514, 5232 Villigen PSI, Switzerland.

Further jobs: www.psi.ch

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RWTH AACHEN UNIVERSITY

With 30,000 students, 10,000 employees and its emphasis on innovative research, RWTH Aachen University is one of the leading universities of technology in Europe. Its teaching and research are characterised by a distinctly international, practice-oriented and interdisciplinary approach.

Full Professor (W2) in Experimental Physics

(Successor to Univ.Prof. Dr. Joachim Mnich)

Faculty of Mathematics, Computer Science and Natural Sciences

We are seeking qualified applicants for teaching and research in the area of Experimental Physics with special emphasis in the area of Astroparticle Physics and/or High Energy Physics. Cooperations with existing groups in Experimental Particle Physics, Astroparticle Physics and Theoretical Physics are expected. The appointment can begin on January 1st, 2006.

Teaching obligations comprise courses for physics students (lectures, excercises, seminars, advanced laboratory courses) and for students of other disciplines. In addition we expect a participation in our graduate school for doctoral students.

You should have a Ph.D. and additional outstanding academic achievements which were performed within the framework of a junior professorship, Habilitation (post – doctoral lecturing qualification), a scientific employment at a university research institution, in economy, administration or any other social field. Didactic skills and university-level teaching skills are expected as well. Applicants should be willing to learn German.

Please send a cover letter stating research aims and a CV to:
An den Dekan der Fakultät für Mathematik, Informatik und Naturwissenschaften der RWTH Aachen, Prof. Dr. W. Thomas, Templergraben 55, 52062 Aachen.
The deadline for applications is April 15th, 2005.

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We welcome applications from persons with disabilities.

POSTDOCTORAL RESEARCH POSITION IN EXPERIMENTAL HIGH ENERGY PHYSICS

UNIVERSITY OF CALIFORNIA, RIVERSIDE

The Department of Physics at the University of California, Riverside, invites applicants for a postdoctoral research position to work with the high energy physics group on the CMS experiment at CERN.

At the University of California, Riverside, we are carrying out a multi-faceted program of detector development and production and preparation for physics in the CMS experiment. We are seeking a postdoctoral researcher to work on CMS tracking software, with an emphasis on physics, based at U.C. Riverside. The postdoctoral researcher would also work on studies for the CMS Physics TDR and serve as a leader and resource for others in the U.S. who want to work on tracking software. The postdoctoral researcher would make frequent trips to CERN and U.S. locations for meetings and consultations.

Applicants should have experience with high energy physics analysis and software. Applicants who are already knowledgeable about CMS software are preferred. Candidates must have a Ph.D. degree in high energy physics. Applications, including vitae, list of publications, and three reference letters, should be sent to:

Professor Gail G. Hanson, Department of Physics
University of California, Riverside, CA 92521-0413, U.S.A.
or by e-mail to Gail.Hanson@ucr.edu or Gail.Hanson@cern.ch

The position will be filled as soon as an appropriate candidate is identified.

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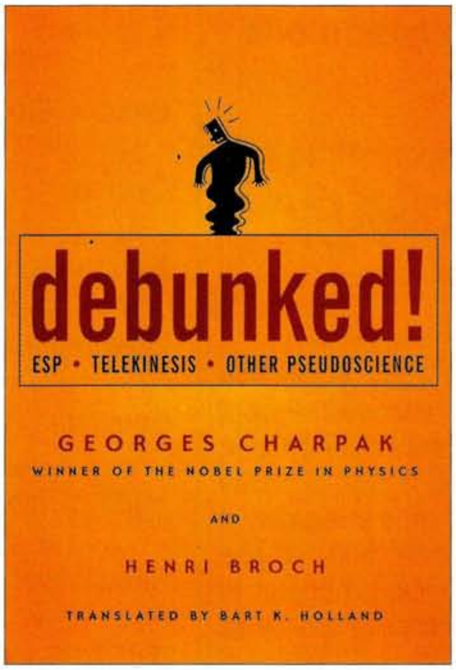
Debunked! ESP, Telekinesis and Other Pseudoscience by Georges Charpak and Henri Broch, translated by Bart K Holland, Johns Hopkins University Press. Hardback ISBN 0801878675, $25.



Georges Charpak will, as they say, need no introduction to most readers of the *CERN Courier*. Henri Broch, author of *Au Coeur de l'Extraordinaire* and a contributor to the American magazine *Skeptical Inquirer*, is perhaps less familiar to English-speaking readers. Now, their short book *Devenez Sorciers, Devenez Savants* has been translated into English by Bart Holland, with the title *Debunked! ESP, Telekinesis and Other Pseudoscience*.

Pseudoscientific mumbo-jumbo has been engulfing the US long enough for an extensive sceptical literature to have grown up around it. Stories about firewalking, dowsing and spoon-benders have already been dealt with by James Randi in *Flim-Flam!*, Martin Gardner in *Science: Good, Bad and Bogus*, and, less originally in my opinion, by Victor Stenger in *Physics and Psychics*. Charpak and Broch treat all these matters with new insight and humour, but include many new examples to show that even France, home of the Cartesian philosophy of doubt and scepticism, is now apparently ready to believe almost anything, provided it is vouched for by fashionable figures in show business or the media.

Thus, in 1982, Broch found that among undergraduate science students at Nice, 52% believed relativistic time dilatation to be pure theoretical speculation, while 68% thought that paranormal spoon-bending was scientifically proven. More recently, Elizabeth Teissier, astrological adviser to millions (including, she would have us believe, François Mitterrand), was awarded a PhD by the Sorbonne for a thinly disguised PR job vaunting her craft.

I cannot resist mentioning two of my own favourites here: Paco Rabanne, the famous fashion designer, ran away from Paris before the 1999 eclipse because he was afraid the sky might fall on his head; and the failed rock musician and racing-car writer Claude Vorilhon, a.k.a. Rael, recently got word about particle physics from the Elohim – the "extraterrestrial guardians", he says, "of peace, non-violence and harmony at all levels of infinity". Vorilhon e-mailed many physicists to pass on the message not to mess with the universe by constructing super-colliders; science is good and should be unlimited as long as it fuses elements, it would seem, but it should never be used when breaking or cracking infinitely small particles. As Charpak and Broch point out, the more vague, hollow and absurd the claim, the deeper the truth drawn from it – a phenomenon they term the "Well Effect".

In his introduction, Bart Holland explains that he has tried to be true to the French original. The result will sometimes be quite confusing to English-speaking readers unfamiliar with what he calls the "glorious Gallic rhetorical style". In addition, he has not always followed his own rule of keeping sections dealing with popular French culture and public figures intact, but has supplemented them with explanatory footnotes. In several cases, I had to turn to the original version to put arguments into context.

In their final chapter, Charpak and Broch strongly criticize the media, which they see as the natural ally of science and reason, for often (unwittingly or not) promoting the bogus claim that all ideas are of equal value, under the guise of journalistic even-handedness. The authors also differ from their English-language counterparts in that they see wider dangers in pseudoscience, such as its threat to democracy and the emergence of a multinational big business to market it. The authors' parting advice to the reader is that critical faculties should be allied with human ones. This was more or less the position taken by Sir Walter Raleigh, who once wrote, "The skeptick doth neither affirm nor deny any position but doubteth of it, and applyeth his Reason against that which is affirmed, or denied, to justify his non-consenting." He was beheaded shortly afterwards.

John Eades, Tokyo.

Kosmische Impressionen – Gottes Spuren in den Naturgesetzen (Cosmic Impressions – Marks of God in the Laws of Nature) by Walter Thirring, Molden Verlag. Hardback ISBN 3854851103, €24.80.

A number of popular books have been published in recent years describing cosmological evolution from the Big Bang to the origin of human life. In this book, the author has the courage to leave well trodden ways and to try to explain the most abstract concepts in modern physics – the amalgamation of Einstein's general theory of relativity with quantum mechanics – in words comprehensible to non-experts.

His main message is that the cosmos and nature, as we discover them, have evolved as a mixture between the laws of nature and accidental conditions that leave room for unscientific arguments. The climax of the book is a discussion of the anthropic principle in its various forms, which is criticized from a rational point of view. In the end, it is admitted that a purely rational explanation of cosmic evolution cannot be given and religion has to come in. However, on the way to this knowledge, one discovers a grandiose picture of nature that teaches us to respect the miraculous complexity of the universe.

Before he comes to the final conclusion, Thirring covers many topics starting with the evolution of the cosmos: the Big Bang, the origin of the chemical elements, the formation of stars, the peculiarities of our planetary system and the origins of life. The latest achievements in particle physics, the role of black holes, supranovae and the breaking of symmetry rules are presented. The author also amusingly suggests a new word "Kleberlinge" (a little something that sticks things together) as the German translation of "gluons".

The author has the courage to mention some fundamental questions that are usually swept under the carpet in daily scientific life, e.g. "What really is mass?", "Is matter divisible infinitely often?" and "Do Feynman integrals contain an element of teleology?". On almost every page, one becomes aware that the author – a mathematical physicist – is an outstanding expert in this field. He starts most explanations from the mathematical or basic physical concepts, but avoids all complicated formulae and exposes the reader only to very simple expressions and calculations that should be known from early schooling.

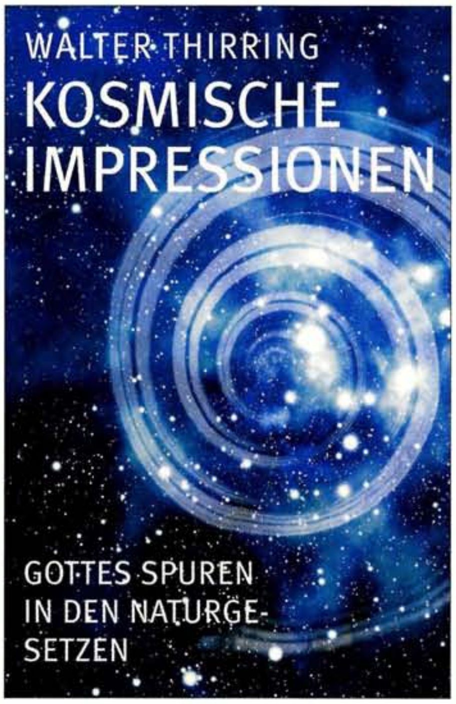
A typical example is the way in which Thirring treats the formation of life. This topic is discussed almost exclusively from the point of view of the increase of order in living things, which does not contradict the universal law of increasing disorder (entropy). In a kind of play (covering 17 pages and involving elements of chaos theory), the author shows that mathematical rules exist that allow the creation of order even if entropy as a whole increases, obeying the basic theorems of thermodynamics. The chapter on the special role of water in the existence of life and its strange properties is very nice.

Thirring acquaints the reader with the typical way of scientific thinking in orders of magnitude, which regrettably is not applied as much outside of the natural sciences. But he also asks the reader to follow logical deductions that might not be so easy for laypersons. On the other hand, he considers some old problems from a fresh view, which is sometimes quite amusing – for example, the comparison between the age of the universe as deducted from the Bible and that derived from modern scientific experience.

Interspersed throughout the text are anecdotes concerning meetings between the author and some famous physicists such as Albert Einstein and Wolfgang Pauli. Quite rightly, preference is given to the author's Austrian compatriots who have sometimes not received the proper credit, such as Fritz Houtermans and Bruno Touscheck.

Finally, a few technical remarks may be added. In order not to scare the reader, the author has relegated some topics to annexes. However, the mathematical level in the annexes is not too different from some chapters in the text; one would have liked to have a more extended reach. The publisher has done a careful job, and only a few printing errors could be detected.

For readers who are eager to learn about the fundamental concepts concerning cosmological development, the structure of matter and the interplay between the laws of nature, this book will give a good overview. It is not easy bedside reading and requires some effort to follow the arguments of the author. However, no mathematical knowledge



is required and many parts are amusing to read. The language is almost poetical, in particular when more philosophical issues are discussed, but in the more scientific parts, this might lead to misunderstandings. The *leitmotiv* of the book is: "There are things whose development is decided by the laws of nature; there are things whose fate is outside human reason; but all this is determined by a higher authority." This book, like many others, cannot answer questions such as "Where do I come from?" or "What is the sense of my life?" mentioned in the foreword by cardinal Franz König, because there is no scientific basis for the answers. It proves, however, that there is no conflict between truth in science, based on reproducible experiments, and truth in religion, based on revelation.

Herwig Schopper, University of Hamburg and CERN.

Virtual Worlds: Synthetic Universes, Digital Life and Complexity by Jean-Claude Heudin (ed), Westview Press. Paperback ISBN 0813342864 $35 (£26.50).

Now published in paperback, this book aims at developing a new understanding of the role of computer-generated "virtual worlds" in science, business, computer games, education, training and simulation. It introduces the virtual world as a field and reviews its historical roots, goals and methodology. Contributors investigate relationships between the natural and the artificial, and address technical developments and practical applications.

Quantum Field Theory of Many-Body Systems: From the Origin of Sound to an Origin of Light and Electrons by Xiao-Gang Wen, Oxford University Press. Hardback ISBN 0198530943, £44.95 ($79.50).

This Oxford graduate text provides a paedagogic and systematic introduction to the new concepts and quantum-field theoretical methods in condensed-matter physics. Topics covered in the book include boson condensation, Fermi and fractional statistics, topological/quantum order, spin liquids and string condensation.

Contemporary Accelerator Physics by Stephan Tzenov, World Scientific. Hardback ISBN 9812389008, $76 (£46).

This non-traditional book on accelerator theory aims to create a reference material containing contemporary methods of classical mechanics, statistical physics and plasma physics that are relevant to the physics of charged particle beams. These include the Hamiltonian formalism, canonical perturbation theory, the renormalization group and the Vlasov equation.

Beautiful Models: 70 Years of Exactly Solved Quantum Many-Body Problems by Bill Sutherland, World Scientific. Hardback ISBN 9812388591, $78 (£48). Paperback ISBN 9812388974, $38 (£23).

This book provides a broad introduction to the subject of exactly solvable many-body quantum systems, including Bethe's famous solution of the 1D Heisenberg magnet. It is suitable for graduate students and non-experts who want an overview of some of the classic and fundamental models in the subject.

Direct Nuclear Reactions by Norman Glendenning, World Scientific. Hardback ISBN 9812389458, $68 (£41).

Reprinted 20 years after first publication, this classic text aims to provide the novice with the means of becoming competent in research on direct nuclear reactions, and the experienced researcher with a detailed discussion of advanced topics. It assumes only a modest knowledge of quantum mechanics and some acquaintance with angular momentum algebra.

A fundamental base for the future

In 2005, more than ever, we must continue to nurture fundamental research if we are to sustain technology, argue **Manjit Dosanjh** and **Hans Hoffmann**.

In 1905 a young man working in the Bern patent office produced three publications on light quanta, special relativity, and the sizes and movements of molecules. The young man was, of course, Albert Einstein and 1905 was later called his *annus mirabilis*. The resulting theories provided insight into the cosmos, elementary particles and states of matter, and paved the way to our current understanding of matter and the universe. However, these papers also helped to lay the foundations for the economy of today, and it is for this reason that we should consider the International Year of Physics of 2005 more about looking forward than looking back.

In his work 100 years ago, Einstein was driven by his innate desire to understand the universe about him. Such curiosity-driven research creates new "breaking" knowledge – discoveries with the potential to have new, revolutionary effects in all domains of human interest. From televisions and electron microscopes to global-positioning systems (GPS) and mobile phones, there are numerous examples of breakthroughs that might not have been achieved through applied research and technology alone.

Nowadays many of the fundamental questions in physics continue to concern the structure of the universe. We can describe many of the features of the matter we know in the universe to considerable precision, but we also know that this "visible" matter constitutes only about 5% of the total energy of the universe. We know almost nothing about the remaining 95% – dark matter and dark energy. Extending our knowledge of this unknown 95% is by itself a good reason for pursuing fundamental research in this direction; and CERN, with the Large Hadron Collider project, is leading one of the efforts to further this understanding. More important, however, is the potential for this fundamental research of today to lead to the technological innovations of tomorrow, possibly as unsuspected as GPS and the World Wide Web were in 1905.

The Year of Physics also offers an important opportunity to emphasize why continued basic research, particularly in the field of physics, is essential for the 21st century in solving key problems – such as sustainable energy and protecting the environment – and in contributing to health and education, not only in the developed nations, but throughout the world. The late Abdus Salam, a physics Nobel laureate, believed that the gap between rich and poor nations was one of science and technology (*CERN Courier* April 2003 p46). In 1988, he wrote that "in the final analysis, creation, mastery and utilization of modern science and technology is basically what distinguishes the South from the North. On science and technology depend the standards of living of a nation".

The European Union has acknowledged this view of the importance of science and technology, since it wants to become the most advanced knowledge-based economy on the planet before the end of the decade. The US believes itself to be in that position anyway for the foreseeable future. But what of the developing world? With the support of most nations, the UN has declared eight "Millennium Development Goals", which are aimed at cutting world poverty by half in the coming decade and saving tens of millions of lives in the process. However, as Calestous Juma, the coordinator of the Task Force on Science, Technology, and Innovation for the UN Millennium Project 2005, has stated, "It is inconceivable that the eight Millennium Development Goals can be achieved by 2015 without a focused science, technology and innovation policy."

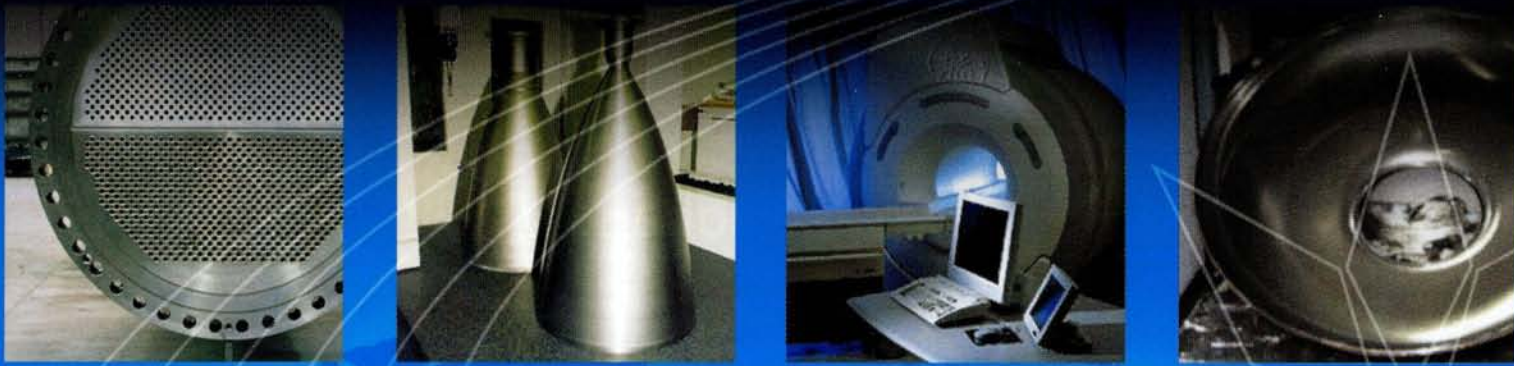
Such a focused effort requires the will of many nations to work together. Fifty years ago, CERN came into being in the wake of the Second World War. A handful of scientists and politicians, in Europe and America, had the vision and energy to launch a unique undertaking: the establishment of a centre of excellence for Europe. Today CERN is known to be open to the world. Forgetting their differences of nationality, religion or culture, scientists from around the globe converge at CERN to work together, all sharing a common goal. This melting pot is one of the keys to the laboratory's success. Based in their own countries, members of collaborations not only provide most of the ambitious experimental apparatus, but they also contribute to a novel, global, powerful information and communication infrastructure using their own countries' industries and talents in a fair and constructive partnership. And the motivation for all this: cutting-edge physics.

Such collaborative efforts can be obviously applied to the current goals of the developed world. Similar collaborative and global scientific efforts also need to be applied to the goals of the countries on the less fortunate side of the digital and other divides. But underlying all must be the will to continue with curiosity-driven research, which will surely bring unknown benefits. We must allow scientists to keep on asking questions and searching for the answers. To quote Einstein: "We shall require a substantially new manner of thinking if mankind is to survive."

Manjit Dosanjh and Hans Hoffmann, CERN.

Further information

www.physics2005.org/
www.un.org/millenniumgoals/
www.unmillenniumproject.org/reports/index.htm



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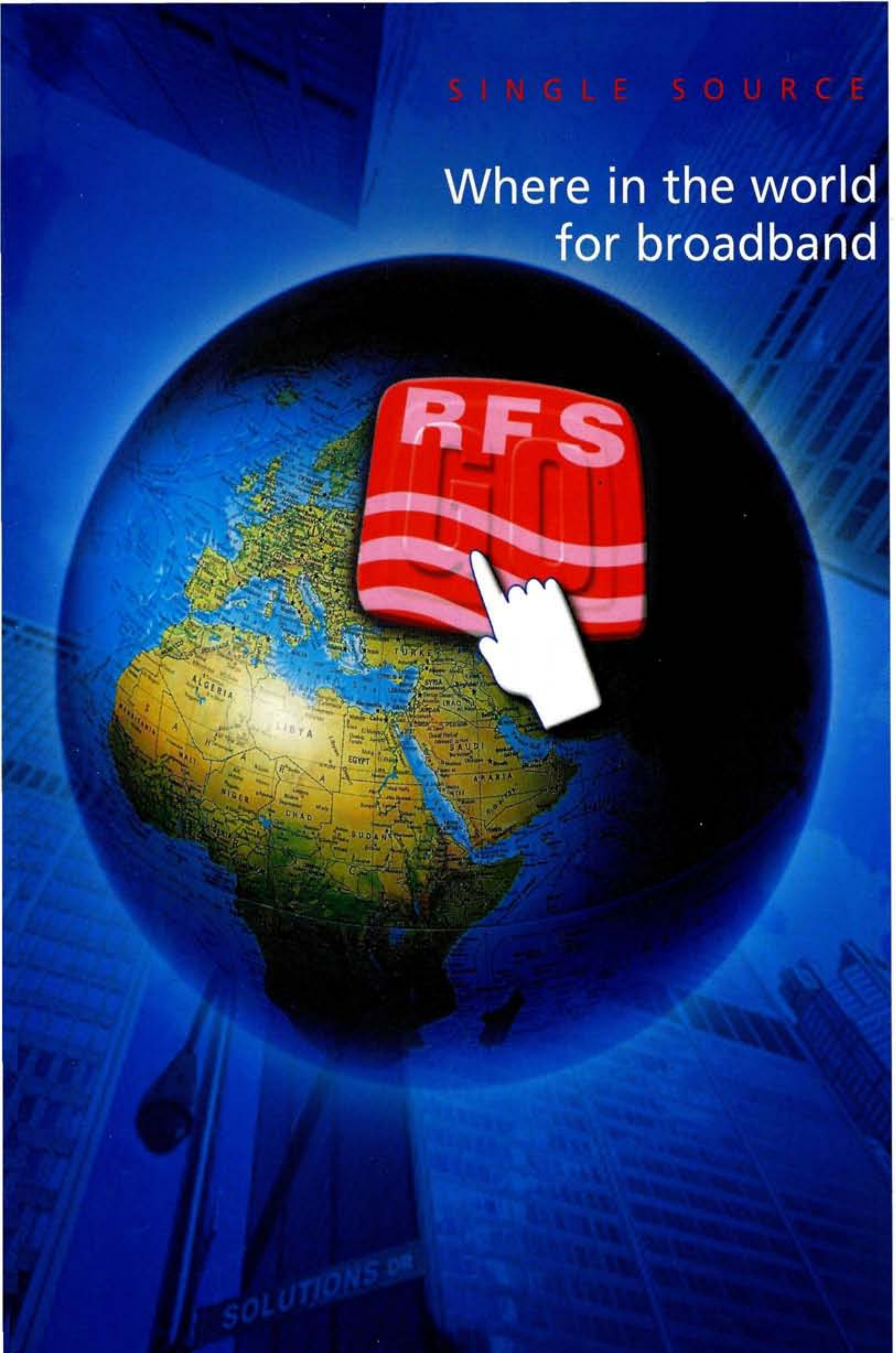

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