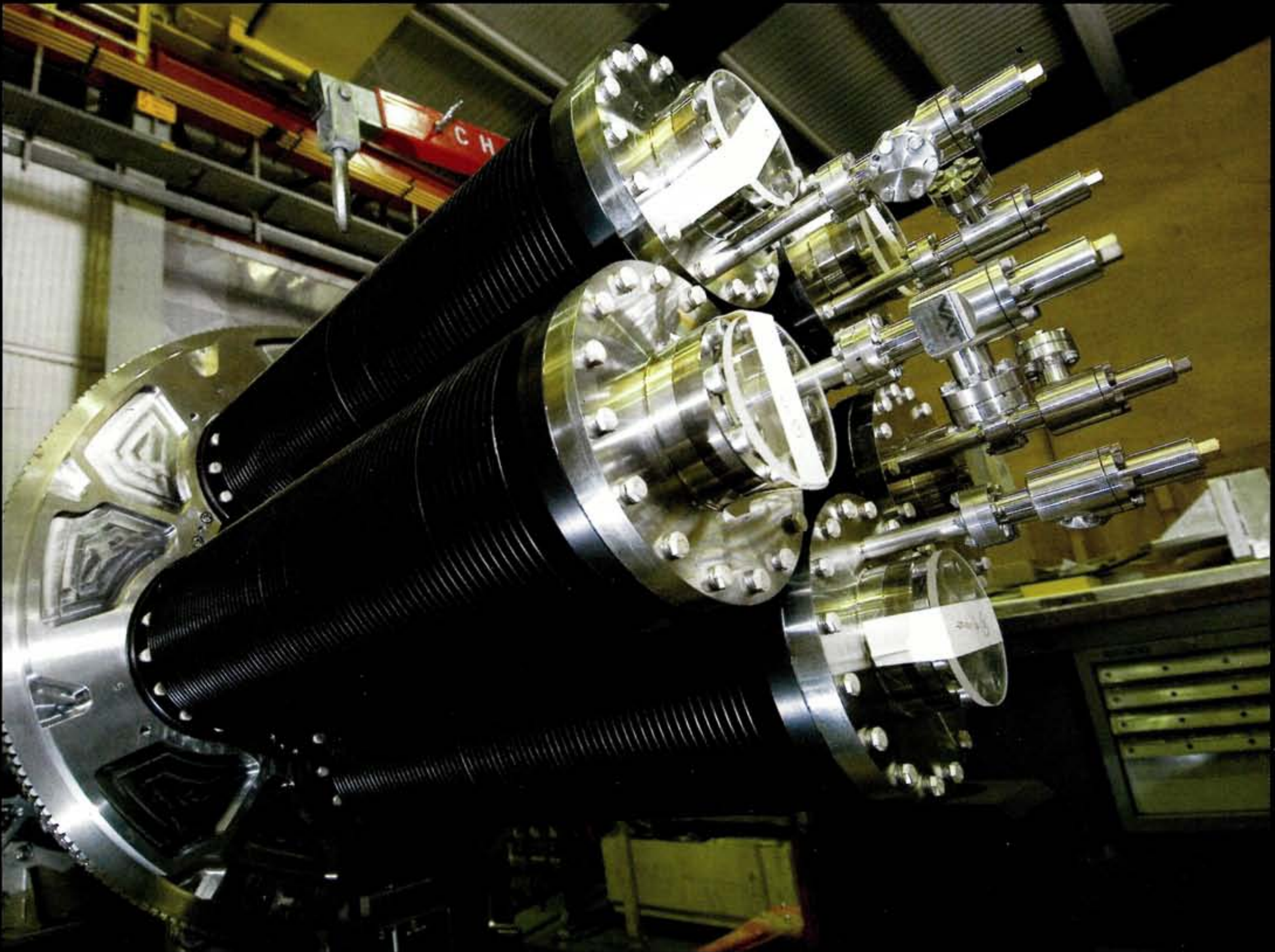
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 45 NUMBER 8 OCTOBER 2005



On target for neutrinos to Italy

DETECTORS
Scintillation counters get a new START p6

PROTON STRUCTURE
Diving deep into the sea of strange quarks p28

VIEWPOINT
A physicist's take on public participation p54

CONTENTS

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

CERN Courier is distributed to member-state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August. The views expressed are not necessarily those of the CERN management.

Editor Christine Sutton
CERN, 1211 Geneva 23, Switzerland
E-mail: cern.courier@cern.ch
Fax: +41 (0) 22 785 0247
Web: cerncourier.com

Advisory board James Gillies, Rolf Landua and Maximilian Metzger

Laboratory correspondents:
Argonne National Laboratory (US): D Ayres
Brookhaven National Laboratory (US): P Yamin
Cornell University (US): D G Cassel
DESY Laboratory (Germany): Ilka Flegel, Petra Folkerts
Fermi National Accelerator Laboratory (US): Judy Jackson
Forschungszentrum Jülich (Germany): Markus Buescher
GSI Darmstadt (Germany): G Siegert
INFN (Italy): Barbara Gallavotti
IHEP, Beijing (China): Tongzhou Xu
Jefferson Laboratory (US): Steven Corneliussen
JINR Dubna (Russia): B Starchenko
KEK National Laboratory (Japan): Youhei Morita
Lawrence Berkeley Laboratory (US): Christine Celata
Los Alamos National Laboratory (US): C Hoffmann
NIKHEF Laboratory (Netherlands): Paul de Jong
Novosibirsk Institute (Russia): S Eidelman
Orsay Laboratory (France): Anne-Marie Lutz
PPARC (UK): Peter Barratt
PSI Laboratory (Switzerland): P-R Kettle
Rutherford Appleton Laboratory (UK): Jacky Hutchinson
Saclay Laboratory (France): Elisabeth Locci
IHEP, Serpukhov (Russia): Yu Ryabov
Stanford Linear Accelerator Center (US): Neil Calder
TRIUMF Laboratory (Canada): Marcello Pavan

Produced for CERN by Institute of Physics Publishing Ltd
Institute of Physics Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel: +44 (0)117 929 7481; E-mail: jo.nicholas@iop.org; Web: iop.org

Publishing director Richard Roe
Publisher Jo Nicholas
Art director Andrew Giaquinto
Senior production editor Seth Burgess
Technical illustrator Alison Tovey
Display advertisement manager Jonathan Baron
Deputy advertisement manager Ed Jost
Display sales Helen Brook
Recruitment and classified sales Yasmin Agilah, Moo Ali and Adam Hylands
Advertisement production Katie Graham
Product manager Claire Webber

Advertising Jonathan Baron, Ed Jost, Helen Brook, Yasmin Agilah, Moo Ali or Adam Hylands
Tel: +44 (0)117 930 1265 (for display advertising) or +44 (0)117 930 1196 (for recruitment advertising);
E-mail: sales@cerncourier.com; Fax: +44 (0)117 930 1178

General distribution Jacques Dallemagne, CERN, 1211 Geneva 23, Switzerland. E-mail: courrier-adressage@cern.ch
In certain countries, to request copies or to make address changes, contact:
China Keqing Ma, Library, Institute of High Energy Physics, PO Box 918, Beijing 100049, People's Republic of China. E-mail: keqingma@mail.ihep.ac.cn
Germany Veronika Werschner, DESY, Notkestr. 85, 22607 Hamburg, Germany. E-mail: desypr@desy.de
Italy Loredana Rum or Anna Pennacchietti, INFN, Casella Postale 56, 00044 Frascati, Rome, Italy. E-mail: loredana.rum@lnf.infn.it
UK Barrie Bunning, Library and Information Services Group, R61 Library, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 0QX, UK. E-mail: B.J.Bunning@rl.ac.uk
US/Canada Published by *Cern Courier*, 6N246 Willow Drive, St Charles, IL 60175, US. Periodical postage paid in St Charles, IL, US. Fax: 630 377 1569. E-mail: vosses@aol.com
POSTMASTER: send address changes to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174, US

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel: +41 (0) 22 767 61 11
Telefax: +41 (0) 22 767 65 55
Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

IoP

CERN COURIER

VOLUME 45 NUMBER 8 OCTOBER 2005

Telescope proves its worth p5

Hands-on particle physics p23

Physics at work at EMBL p43

Cover: A view of the target assembly for the CERN Neutrinos to Gran Sasso project. The target, described in more detail on p6, is now ready for installation below ground.

Introducing *64-bit & multicore* technical computing

JUST RELEASED

MATHEMATICA® 5.2

New in Mathematica 5.2—

- **All-platform support for 64-bit addressing**
- **Multicore support on major platforms**
- **Multithreaded numerical linear algebra**
- **64-bit-enhanced arbitrary-precision numerics**
- **Vector-based performance enhancements**
- **Bundled notebook indexing for desktop search**
- **SSH support for secure remote kernels**

New in Mathematica 5.1 and 5.0—

- **Optimized numerical linear algebra**
- **Industrial-strength string manipulation**
- **Event handling in differential equations**
- **Fully integrated piecewise functions**
- **Integrated support for assumptions**
- **Support for quantifiers and quantifier elimination**
- **Large-scale linear programming**
- **Advanced methods for solving differential equations**
- **Solvers for differential algebraic equations**
- **Built-in universal database connectivity**
- **Integrated web services support**
- **Graphical user interface development tool**
- **Support for more than 60 import/export formats**
- **Highly optimized binary data I/O**

A Selection of Mathematica Features—

Numeric computation: full support for arbitrary and machine precision ▪ hundreds of mathematical functions fully implemented for all parameters ▪ fast sparse and dense matrix operations ▪ solvers for equations and differential equations ▪ finite and infinite sums and products ▪ integral transforms ▪ global optimization ▪ linear programming ▪ automatic or manual algorithm selection ▪ precision control

Symbolic computation: expanding ▪ simplification ▪ factoring ▪ solvers for equations, differential equations, difference equations, and inequalities ▪ sums ▪ products ▪ differentiation ▪ integration ▪ limits ▪ power series ▪ integral transforms ▪ algebraic and semi-algebraic domains

Statistics and data analysis: descriptive statistics of uni- and multivariate data ▪ generalized linear and nonlinear fitting ▪ multidimensional interpolation ▪ convolution ▪ correlation ▪ regression ▪ ANOVA ▪ confidence intervals ▪ distributions ▪ hypothesis testing ▪ statistical plots

Programming: multiparadigm symbolic programming language ▪ support for procedural, functional, list-based, rule-based, and object-oriented programming ▪ advanced pattern matching ▪ just-in-time compilation ▪ platform-independent implementation

Discrete mathematics: combinatorics ▪ graph theory ▪ computational geometry ▪ number theory ▪ Diophantine equations

Graphics: over 50 2D and 3D plot types ▪ graphics language ▪ animations ▪ sound generation

Connectivity: .NET, Java, and C/C++ APIs ▪ import and export filters for over 40 data and image formats ▪ XML support ▪ symbolic language XML

Publishing: full technical document system for presentation, print, and the web ▪ interactive typesetting and graphics ▪ sound ▪ outlining ▪ one-step export to TeX, LaTeX, XML, MathML, HTML, and XHTML

Platforms: Windows, Macintosh, Linux, other Unix platforms ▪ web and grid versions available

User interface: WYSIWYG notebook interface ▪ programmable buttons and palettes ▪ presentation environment with slide show ▪ fully interactive help

Purchase from over 50 countries at store.wolfram.com. For more information: send email to info@wolfram.co.uk; call +44-(0)1993-883400; or locate your area sales representative at www.wolfram.com/international.

WOLFRAMRESEARCH

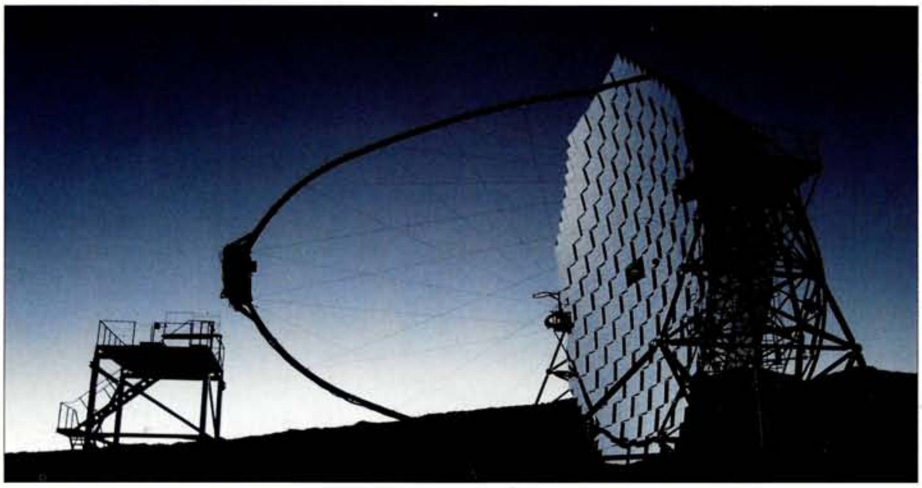
Test *Mathematica* 5.2 on your computer today with our free trial download at www.wolfram.com/m52trial

COSMIC RAYS

MAGIC and Swift capture GRB

The Major Atmospheric Gamma Imaging Cherenkov telescope (MAGIC) at La Palma, Canary Islands, has observed a gamma-ray burst seconds after its explosion was detected by NASA's Swift satellite. It is the first time that a gamma-ray burst has been observed simultaneously in the X-ray and very-high-energy gamma-ray bands.

MAGIC detects cosmic gamma rays through the showers of charged particles they create in the atmosphere (*CERN Courier* December 2003 p7). With a tesselated mirror surface area of nearly 240 sq. m, it is the largest air Cherenkov telescope ever built and has been designed to be more sensitive to lower-energy gamma rays than other ground-based instruments. In this case, it was the ability to track rapidly – and the prompt action of the operators – that allowed the telescope to observe GRB050713A, a long-duration gamma-ray burst, only 40 s after its explosion on 13 July. MAGIC's lightweight and precise mechanics let it rotate completely in 22 s.



Night falls on MAGIC. (Courtesy Robert Wagner, Max-Planck-Institut für Physik, München.)

Observations of GRB050713A began only 20 s after an alert from Swift, a member of the Gamma ray bursts Coordinates Network, which distributes the locations of bursts detected by spacecraft (see p11). In the case of Swift, this is in real time, so MAGIC was able to move on to the burst while it was still active in the X-ray range.

A first look at the MAGIC data did not reveal strong gamma-ray emissions above 175 GeV, and indeed the flux limit derived at very high energies by MAGIC is extremely low, two to three orders of magnitude lower than the extrapolation from lower energies. The upper limit for the flux of energetic gamma rays is consistent with the expected flux of a gamma-ray burst at high red-shift, strongly attenuated by cosmological pair production. These observations were reported at the 29th International Cosmic Ray Conference held in Pune, India, on 3–10 August; a detailed analysis of the data is in progress.

• MAGIC is managed by 17 institutes from Germany, Italy, Spain, Switzerland, Finland, the US, Poland, Bulgaria and Armenia.

LHC

CERN and Poland sign agreement

On 29 July, the rector of the AGH University of Science and Technology in Cracow, Ryszard Tadeusiewicz, and CERN's director-general, Robert Aymar, signed a collaboration agreement relating to the commissioning of the instrumentation and monitoring equipment for the cryogenic system of the Large Hadron Collider (LHC). A team consisting of 12 physicists, engineers and technicians from the AGH University will assist teams at CERN in commissioning the cryogenic system in the tunnel.

Robert Aymar and Ryszard Tadeusiewicz in the LHC tunnel after signing the agreement.

This is the first in a series of agreements that will relate to the commissioning of the LHC's various systems. From the end of this year until the summer of 2007, CERN will enlist the aid of physicists, engineers and technicians from many different institutes in order to complete the tasks associated with the start-up of the accelerator.

Sommaire

CERN

Neutrino project on target for Gran Sasso

The CERN Neutrinos to Gran Sasso project (CNGS) has reached an important milestone with the successful first assembly of the target in a laboratory on the surface. Now the target is being dismantled prior to installation in its final location in the underground chamber.

On schedule for start-up in May 2006, CNGS will send a beam of neutrinos through the Earth to the Gran Sasso laboratory 730 km away in Italy, north-east of Rome, in a bid to unravel the mysteries of these elusive particles. To create the beam, a 400 GeV/c proton beam will be extracted from CERN's Super Proton Synchrotron and directed towards the CNGS target, which consists of a series of graphite rods installed in a sealed container filled with helium. Positively charged pions and kaons produced by the proton interactions in the target will then be focused into a parallel beam by a system of two pulsed magnetic lenses – the horn and the reflector.

The target assembled in its shielding.

A 1 km-long evacuated decay pipe allows the pions and kaons to decay, in particular into muon-neutrinos and muons. The remaining hadrons (protons, pions and kaons) are absorbed in an iron beam dump with a graphite core. The muons will be monitored in two sets of detectors downstream of the dump, and then absorbed further downstream in the rock, while the neutrinos continue on towards Gran Sasso.

The target itself consists of 13 graphite rods, each 10 cm long and 4 or 5 mm in diameter. The first nine rods are interspaced by 9 cm of air, while the last four rods have no air-space between them; the 13 rods are together installed in a target unit. The CNGS target station contains five units – one active with four spares – in a rotatable target magazine. Together with a novel beam-position monitor (an electromagnetic coupler operated in air), the target magazine is installed on an alignment table. The four jacks to adjust the position of this table are fixed on a base table, and the entire assembly is installed inside an array of massive iron shielding blocks.

The neutrino beam will be completely installed by the end of 2005, and the first beam of neutrinos should head off next May.

DETECTORS

ITEP gives scintillation counters new START

Scintillation counters, with their simplicity and fast response, have been the quintessential tool for triggering in particle physics since they were first coupled with photomultiplier tubes (PMTs) some 60 years ago. However, the bulky, fragile, high-voltage-driven PMT looks set to be replaced by a much simpler and smaller silicon device. Thanks to the rapid development of semiconductor technologies during the past decade, the detection of light produced by ionizing particles in scintillating plastic can now be performed efficiently by inexpensive miniature photodiodes.

Pioneering this technique, physicists from the Institute for Theoretical and Experimental Physics (ITEP) in Moscow, who are part of the ALICE collaboration at CERN, have developed a scintillation counter in which the light is read out by high-gain avalanche photodiodes, embedded directly inside the scintillating plastic. The metal/resistive-layer/silicon (MRS) avalanche photodiodes (APDs) have a sensitive surface of 1 mm^2, and when

Members of the ITEP group together with an array of STARTs they have been developing.

operated in the so-called "Geiger" mode provide a million-fold amplification of initial photo-ionization. This makes them sensitive even to single photons in the green region of the visible light spectrum. In contrast with standard PMTs, MRS APDs are biased at a low voltage of 30–50 V, consume little power and are not influenced by magnetic fields. Moreover, their current price is significantly lower than that of PMTs.

The team has developed a detector they call START, for Scintillation Tile with MRS APD Light Readout, which consists of a scintillating plastic plate, a piece of wavelength-shifting optical fibre installed in a circular groove inside the plate, two MRS APDs working in coincidence, an opaque wrapper and a front-end card mounted directly on the detector. Various versions of START have been thoroughly tested using cosmic rays and have shown operational consistency, excellent detection efficiency and good homogeneity.

An area of almost 4 m^2 comprising 170 START tiles, each 15 x 15 x 1 cm^3, has been assembled as part of the Time-of-Flight (TOF) project for the ALICE detector, which is under construction for the Large Hadron Collider. They will be used as cosmic-ray triggers in a larger system of STARTs for regularly testing the ALICE TOF system components.

Further reading

A Akindinov *et al.* 2005 *Nucl. Instr. and Meth. A* **539** 172.

DESY

German Chancellor starts up DESY's free-electron laser

With the push of a button, on 3 August German Federal Chancellor Gerhard Schröder handed DESY's new vacuum-ultraviolet free-electron laser, VUV-FEL, over to the scientists. The VUV-FEL is the world's first free-electron laser for generating the short-wavelength range of ultraviolet radiation, and will open up new insights into fields such as cluster physics, solid-state physics, surface physics, plasma research and molecular biology.

From left: Albrecht Wagner, chairman of the DESY Board of Directors, German Federal Chancellor Gerhard Schröder, Hamburg's science senator Jörg Dräger and DESY research director Jochen Schneider.

The VUV-FEL makes use of new technology developed at DESY from 1992 to 2004 by the international TESLA Collaboration. In a first step, electrons are brought to high energies by a superconducting linear accelerator. They then race through an undulator, a periodic arrangement of magnets that forces them to follow a slalom course and radiate. Thanks to the novel principle of self-amplified spontaneous emission (SASE), this radiation finally emerges in the form of short-wavelength, intense flashes of laser light.

The VUV-FEL produces coherent radiation with a wavelength tunable in the range 6–30 nm and a peak brilliance that surpasses that of modern synchrotron radiation sources by a factor of 10 million. Its very intense radiation pulses last only 10–50 fs, allowing researchers to observe directly the formation of chemical bonds, for example, or the processes that occur during magnetic data storage. In addition, operation of the VUV-FEL will provide important insights for the 3.4 km-long European X-ray laser (XFEL) that is being planned in Hamburg. The XFEL will generate even shorter wavelengths down to 0.085 nm and should begin operation in 2012.

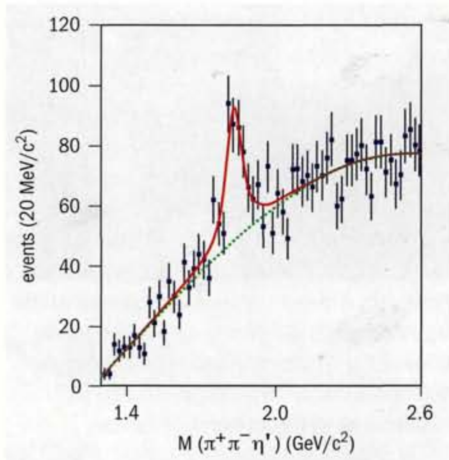
As a user facility, the VUV-FEL will offer five experimental stations at which different instruments can be operated alternately. At present, 29 research projects are planned at the VUV-FEL. These will be carried out by around 200 scientists from 60 institutes in 11 countries. The project's total cost is €117 million, financed 90% by Germany and 10% by international partners.

NEW PARTICLES

BES collaboration observes possible baryonium state

In a sample of 58 million J/ψ events, the BES collaboration at the Beijing Electron Positron Collider (BEPC) has found a clear signal (7.7σ statistical significance) for a new resonance, the X(1835). The signal appears in the $\pi^+\pi^-\eta'$ mass distribution of the process $J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$, where the η' meson is detected in two decay modes, $\eta' \rightarrow \pi^+\pi^-\eta$ ($\eta \rightarrow \gamma\gamma$) and $\eta' \rightarrow \gamma\rho$ ($\rho \rightarrow \pi^+\pi^-$). The results were reported at the Lepton-Photon 2005 conference held in Uppsala.

The peak in the $\pi^+\pi^-\eta'$ mass spectrum is well described by a Breit–Wigner resonance function, with a mass of 1834 MeV/c^2 and a width of 68 MeV/c^2 (BES Collaboration 2005). This mass and width are not compatible with any known meson resonance. However, the properties are consistent with its being the state responsible for the strong threshold enhancement in the $p\bar{p}$ mass that BESII observed in $J/\psi \rightarrow \gamma p\bar{p}$ two years ago (*CERN Courier* September 2003 p9). One possible interpretation of the enhancement is that it is the tail of a "deuteron-like" spin-0 proton–antiproton bound state (baryonium) and its properties match well predictions for a state with a mass around 1.85 GeV/c^2 (Ding and Yan 2005). However, until the spin of the X(1835) is determined and other expected decay modes measured, alternative interpretations cannot be excluded.



The $\pi^+\pi^-\eta'$ invariant mass distribution. The solid curve is the fit to the data; the dashed curve indicates the background function.

Further reading

BES Collaboration, M Ablikim *et al.* 2005 www.arxiv.org/hep-ex/0508025.
G J Ding and M L Yan 2005 *Phys. Rev. C* **72** 015208.

PHYSICSWATCH

Compiled by Steve Reucroft and John Swain, Northeastern University

General relativity versus exotic dark matter

Determinations of the rotation speed of stars in galaxies (galactic rotation curves) based on the assumption that Newtonian gravity is a good approximation have led to the inference that a large amount of dark matter must be present – more than can be accounted for by non-luminous baryonic matter. While there are plenty of attractive theoretical candidates for the additional dark matter, such as a lightest supersymmetric particle (LSP), it is also interesting to look into the details of the calculations that suggest the need for such exotica. Now F I Cooperstock and S Tieu of the University of Victoria have reworked the problem using general relativity in place of Newtonian gravity, and they find no need to assume the existence of a halo of exotic dark matter to fit the observed rotation curves.

This is because even for weak fields and slow speeds, well-known nonlinearities change the character of the solution dramatically. The success of Newtonian mechanics in situations like our solar system can be traced to the fact that in this case the planets are basically "test particles", which do not contribute significantly to the overall field. However, in a galaxy this approximation is not a good one – all the rotating matter is also the source of the gravitational field in which everything rotates.

Further reading

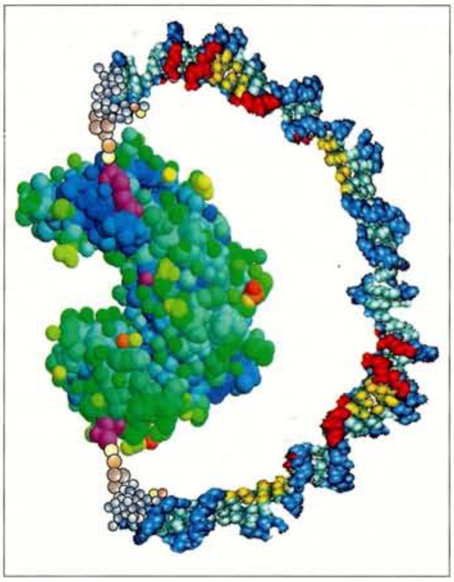
F I Cooperstock and S Tieu 2005 http://xxx.lanl.gov/abs/astro-ph/0507619.

Tiny 'spring' switches enzyme on and off

Enzymes are like nanomachines made out of proteins, and it can be very important medically to find ways to turn them on and off. Now Giovanni Zocchi in the Department of Physics and Astronomy and colleagues at the University of California, Los Angeles, have discovered a way to do this mechanically.

The researchers attached a "molecular spring" in the form of DNA to the enzyme guanylate kinase, coupling two parts of the protein (see figure). They were then able to change the stiffness of the spring by altering external DNA concentrations and so control the enzyme's activity.

The action of guanylate kinase depends on its specific form, which the researchers compare to a vice, with the enzyme being active or "on" when the jaws of the vice come closer. By changing the stiffness of the spring, the team could control the mechanical tension between two points on the enzyme's surface, and thereby open and close the jaws. Measurements of the activity of the enzyme, which catalyses phosphate transfer between certain macromolecules, then revealed that they could indeed turn the enzyme on and off reversibly. The net effect was chemical control of a single protein by mechanical means.



Model of the molecular structure of the enzyme, on the left, with the DNA spring attached. Changing the tension in the spring controls the distance between the "jaws" of the enzyme, and hence its activity.

Further reading

Brian Choi *et. al.* 2005 *Phys. Rev. Lett.* **95** 078102.

Hope for recreating the Hawking effect

Analogues of the Hawking effect are interesting, not least because they are in principle easier to realize than the genuine phenomenon, which needs a black hole. Ralf Schützhold of the Technische Universität, Dresden, and William G Unruh of the University of Victoria have recently suggested what may be the best candidate yet.

Inverting the fact that light propagating in a curved space–time can be thought of as propagating in a non-uniform index of refraction, they show that the propagation of electromagnetic waves of suitable wavelengths in an appropriate waveguide can be described in terms of an effectively curved space–time. The analogue of Hawking radiation should be just about measurable in microwaves with today's technology and suggests a novel approach to studying this exotic effect in a model system. Among the insights that might be gained is some idea of what happens in the trans-Planckian regime.

Further reading

Ralf Schützhold and William G Unruh 2005 *Phys. Rev. Lett.* **95** 031301.

Nanotube used in liquid transistor

A new fluid-based transistor that controls the flow of aqueous ions has been constructed out of a silicon nanotube. Peidong Yang and his colleagues from the University of California, Berkeley, used potassium chloride solution in a 15 μm-long nanotube as the equivalent of a channel in a field-effect transistor, with an external gold electrode playing the role of a gate.

The ability to control the flow of tiny numbers of charged molecules instead of the usual flow of electrons could form the basis for a novel set of devices, running from computing elements through to sensitive chemical sensors.

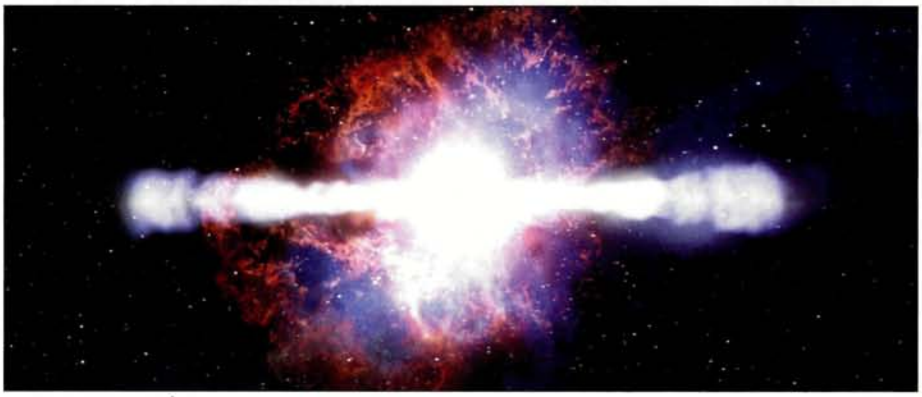
Further reading

Rong Fan *et. al.* 2005 *Phys. Rev. Lett.* **95** 086607.

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

Swift catches afterglows of gamma-ray bursts

The ability of NASA's Swift satellite to point its X-ray telescope rapidly towards gamma-ray bursts is, for the first time, allowing the study of the afterglow phase a minute or so after the actual burst. The results reveal surprising features not expected from current models of burst mechanisms.



Artist's rendering of a hypernova generating a gamma-ray burst. The double-jet powered by the newborn black hole obliterates the star's outer shells. (NASA/GSFC/Dana Berry).

Based on the link between supernovae and gamma-ray bursts (*CERN Courier* September 2003 p15), it is now well established that the long gamma-ray bursts, with durations from about 2 s to a few minutes, result from the formation of a black hole in the core collapse of a dying star. Conservation of angular momentum implies that the rotating stellar matter falling onto the newborn black hole will form a very rapidly rotating disc of plasma and generate strong magnetic fields. These are the typical conditions thought to produce relativistic jets perpendicular to the disc, and a gamma-ray burst will be observed if the jet is pointing towards us.

According to this model, spikes in the light curve of the gamma-ray burst correspond to a series of internal shock waves in the jet. Another, single shock wave is expected when the jet interacts with the outer shells of the dying star. This external shock is then responsible for the gradually fading afterglow that lasts for several hours or days after the prompt gamma-ray burst, and is observed at X-ray energies and sometimes down to the lower energies of the optical or even the radio-wave bands.

This simple scenario was sufficient to explain the afterglows observed in X-rays 6–8 h after bursts by missions such as BeppoSAX or XMM-Newton. Now, however, NASA's Swift spacecraft, launched in November 2004, can slew its X-ray telescope towards a burst within only about a minute of being given its position by the wide-field gamma-ray-burst detector.

The first results published in *Nature* by G Tagliaferri and collaborators show in most cases a surprisingly rapid initial fading of the X-ray afterglow for several minutes, followed by the usual slower decline lasting several hours. A deeper analysis of two events shows that the X-ray counterpart observed about a minute after the burst is brighter than the extrapolated decline of the prompt emission and has a different spectral shape. It therefore seems that the early X-ray emission is related to the afterglow rather than to the gamma-ray burst itself. Current models are, however, not able to explain easily such a rapid fall-off of the afterglow emission.

This picture is further complicated by the recent detection of X-ray flares in the afterglow of two other gamma-ray bursts observed by Swift (Burrows *et al.* 2005). An X-ray flare releasing roughly as much energy as the burst itself occurred about 12 min after the gamma-ray burst of 2 May 2005, GRB050502B. Its sharp peak makes it unlikely to be due to an external shock related to the afterglow. It is more likely to be an internal shock resulting from ongoing accretion onto the newborn black hole in the messy environment expected at the heart of a collapsing–exploding dying star.

Further reading

D N Burrows *et al.* (in press) *Science*.
G Tagliaferri *et al.* 2005 *Nature* **436** 985.

Picture of the month

NASA's Deep Impact mission to study comet Tempel 1 was a great success. This spectacular image shows the splash of light created by the collision of the impactor spacecraft with the comet at a speed of 37 000 km/h. The image was taken by the high-resolution camera of the fly-by craft only 67 s after the impact on 4 July 2005. Linear spokes of light radiate away from the impact site, while reflected sunlight illuminates most of the comet surface. The bright splash is due to scattered light from the collision, which saturated the detector.

The image reveals topographic features, including ridges, scalloped edges and possibly impact craters formed long ago. The impactor spacecraft hit the surface of the comet at probably 20–45° above the horizontal. Mission scientists infer that the crater created by the impact was larger than 100 m in diameter, but they have not yet been able to tease out an image of this crater from behind the cloud of ejecta. (Courtesy NASA/JPL-Caltech/UMD.)

CERN COURIER ARCHIVE: 1962

A look back to CERN Courier vol. 2, October 1962

COLLABORATION

Six months at Dubna

Karl-Martin Vahlbruch, of CERN's Nuclear Physics Apparatus Division, visited Dubna for six months and wrote about life at the laboratory upon his return.

Under the agreement for the exchange of scientists between Dubna and CERN, I had the opportunity, together with Peter Kirstein (Accelerator Research Division), of working at the Joint Institute for Nuclear Research from February until August this year. The Joint Institute was founded by its twelve Member States in 1956, following the example set by CERN, and is situated at Dubna, 137 km north of Moscow. Its director is Prof. D I Blokhintsev. Corresponding to CERN's Divisions, the Institute at Dubna consists of five laboratories:

1. High Energies, with a "synchrophasotron" for 10 GeV protons, under the direction of V I Veksler.
2. Nuclear Problems, with a 680 MeV proton synchrocyclotron. Director, V P Dzhelepov.
3. Theoretical Physics, Director, N N Bogolubov.
4. Neutron Physics, with an impulse reactor. Director, I M Frank.
5. Nuclear Reactions, with a cyclotron for accelerating heavy ions. Director, G N Flerov.

The Institute has a total staff of about 2700, whilst the scientific personnel numbers 300 from the USSR and 200 from the other Member States. The Chinese are the most strongly represented of these, with a group of 50; the group from universities in eastern Germany amounts to 12.

Foreign members of staff are looked after by the "International Department" of the Administration. This helps with such things as housing in Dubna, hotel bookings in Moscow, and permits for travel and residence in other towns of the Soviet Union.

At the Institute, I joined a group under the direction of A F Pisarev, in the Laboratory for Nuclear Problems, which has been engaged for some time on investigations into spark chambers and gas-discharge chambers.

Our main task was the measurement of spin-correlation coefficients in proton–proton scattering around 315 MeV. The necessary spark chambers were constructed and the experiment then done at the synchrocyclotron. Apart from that, we worked on the construction of an image intensifier, consisting of a combination of spark chamber and photocell.

Working at Dubna was really very enjoyable, mainly because of excellent collaboration with the Russian, German and Czechoslovakian members of the team, but also because of the more personal contacts I made with them outside work. The composition of the group had one disadvantage in that everybody spoke better German than I could Russian, so that my knowledge of the language did not progress very much, but on the other hand I was able to learn something in the field of gas-discharge chambers.

When it comes to obtaining materials, however, experimentalists at the Joint Institute suffer from difficulties that are unheard of at CERN. This is mainly because there are no trade directories or catalogues and there is little or no direct collaboration or exchange of views between individual scientists and outside industry.

Life in Dubna was not so easy as it is here in Geneva. The flat my wife and I were able to obtain was pleasant and better than we expected both in regard to size and furnishing. Also the medical care experienced by my wife in Dubna hospital during the birth of our son was good. But there was little variety in the foodstuffs particularly in the winter months.

Dubna is a small town which, apart from its delightful position on Volga, between the River Dubna and the Moscow Canal, offers only limited possibilities. For shopping and for concerts, theatres etc., Moscow is, however, only $2\frac{3}{4}$ hours away by train, and those working at Dubna automatically obtain a residence permit for Moscow, so that no formalities are necessary for such journeys. Moscow, with its many museums, its theatres, and department stores, has everything one might expect from a city compounded of old and new and well prepared for tourists.

• Extracted from a two-page article.

ROYAL VISIT

Queen Frederika and her daughter, deeply interested in a plan of the South hall layout. Later the Queen asked to attend the weekly seminar, given by Léon Van Hove.

Queen Frederika of Greece visits CERN

The visit to the laboratory began with the proton synchrotron – of 28 thousand million electronvolts and the biggest nuclear-physics instrument in Europe. Her Majesty the Queen then went into the workshops of the South hall, where H Faissner and F Krienen showed her the components of the spark chambers intended for neutrino physics. This new branch of physics seemed to be of considerable interest to the Queen. In the South hall, G von Dardel, co-ordinator of neutrino research at CERN, showed the Queen the shielding for the detectors – shielding consisting to a large extent of iron billets belonging to the Swiss Government and lent to CERN to help in the performance of future experiments.

• Extracted from a three-page article.

EDITOR'S NOTE

International relations have always been an important part of CERN and the *CERN Courier*, with visits from dignitaries from member states a regular occurrence. Scientific exchanges with other laboratories also help to strengthen relations between CERN and other international institutes, and those with the USSR held particular significance during the Cold War.

H-jet measures beam polarization at RHIC

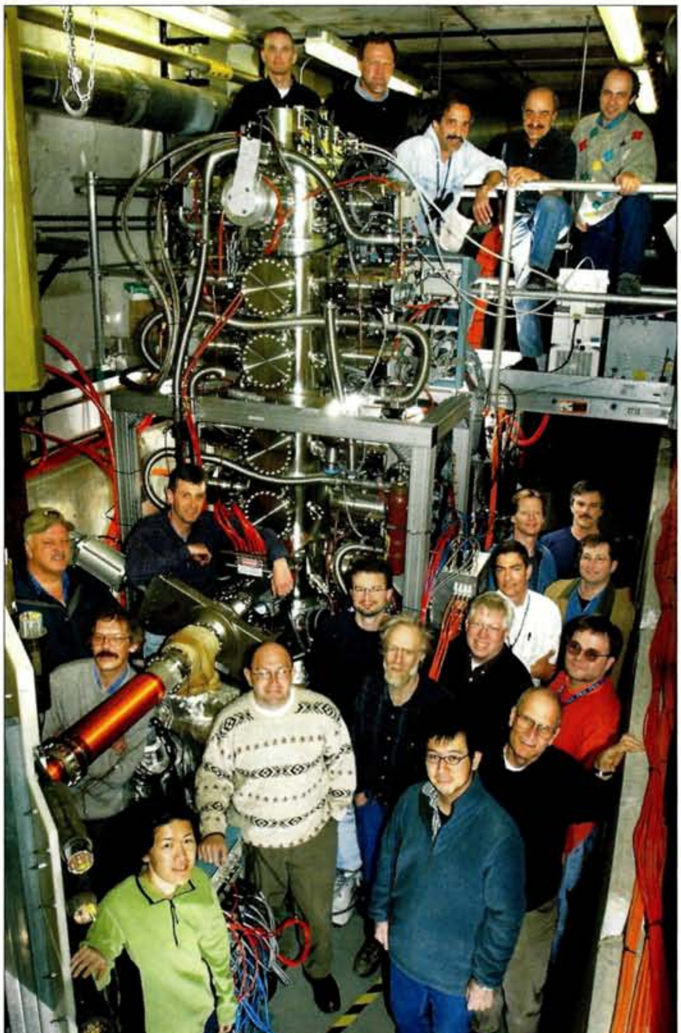
The RHIC accelerator collides 100 GeV polarized protons head-on to study the contribution of gluons to the proton spin. But how is the degree of polarization of the beam known? **Willy Haeberli** explains.

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory is unique. In addition to accelerating heavy ions, it also accelerates spin-polarized protons to high energies and enables the study of collisions between polarized protons with centre-of-mass energies up to 500 GeV.

Collisions between high-energy polarized protons are a powerful way of finding out what is spinning inside, technically known as the "spin structure functions" of the proton. The long-held assumption that the proton's spin is simply the sum of the spins of the three quarks inside the proton has been laid to rest by experiments at SLAC, CERN and DESY. These have shown that less than 30% of the proton's spin is accounted for by the spin of the quarks. Besides quarks, the proton (and neutron) contains gluons – the particles that explain the strong force that binds protons and neutrons in the atomic nucleus. Finding out what contribution gluons make to the spin of the proton and neutron is central to our understanding of nuclear matter.

Several large efforts are under way to study this question. The Common Muon and Proton Apparatus for Structure and Spectroscopy (COMPASS) collaboration at CERN and the HERMES collaboration at DESY bombard polarized protons (protons with their spin axes aligned in the same direction) with energetic muons or electrons. However, these experiments use electromagnetic probes, so the gluons are seen only indirectly.

Collisions between polarized energetic protons at RHIC should offer a more direct view of the gluon spin contribution. For this purpose, bunches of polarized protons are loaded into the RHIC accelerator, with the "blue" beam orbiting clockwise and the "yellow" beam orbiting counter-clockwise. (The beams are named after the coloured stripes on the collider's two rings of magnets.) The two beams meet head-on at several different collision regions of the ring and the resulting secondary particles are observed by four detectors: BRAHMS, PHENIX, PHOBOS and STAR. The polarized protons originate from a special ion source that produces polarized negative hydrogen ions. These then pass in turn through a series of accelerators before being injected into RHIC.



The polarized hydrogen jet target at RHIC surrounded by some of the members of the development team. (Courtesy Roger R Stoutenburgh BNL Photography and Graphic Arts.)

This process is more difficult than it sounds. The polarized protons have a magnetic moment associated with their spin (they act like small compass needles). This raises the likelihood that the spin direction may be lost during the millions of times the pro- ▷

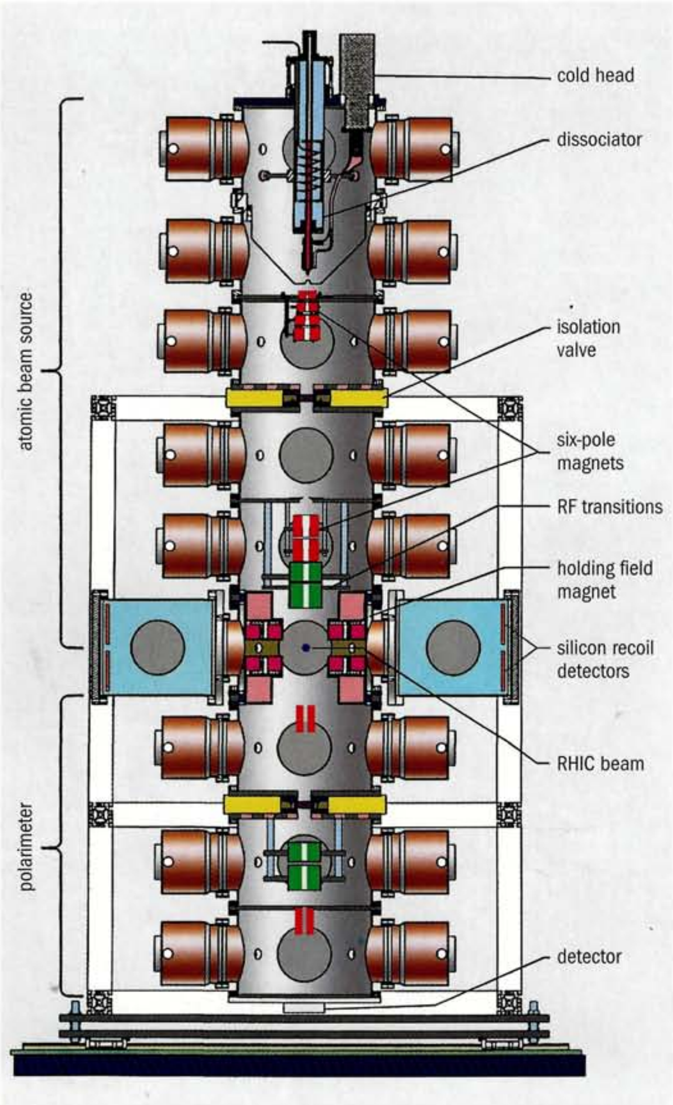


Fig. 1. The overall height of the polarized hydrogen jet target at Brookhaven National Laboratory's RHIC is 3.6 m. The nine-stage differential pumping system is evacuated by nineteen 1000 l/s turbomolecular pumps.

tons orbit the ring, on each turn passing through the hundreds of magnets that are needed to deflect and focus the proton beam. Accelerator physicists avoid this depolarization by using spin precessors known as Siberian Snakes, but the question remains: how do we know the exact degree of polarization (the fraction of particles with spin up versus spin down) after the beam has been accelerated to full energy?

Measuring polarization

The polarization of a beam of protons is measured by inserting a thin target (an analyser) into the beam and observing the number of scattered particles at equal angles to the left and the right of the beam. The left:right intensity ratio depends on how much the beam is polarized (the beam polarization, P) and on how sensitive the scattering process is to the spin direction of the beam particles (the analysing power, A). The problem is that at very high energies there are no scattering processes for which the analysing power is known with sufficient accuracy. At lower energies than those achieved at RHIC, for example at the Proton Synchrotron at CERN and the Alternating Gradient Synchrotron at Brookhaven, moderate-angle elastic proton–proton scattering has been used, based on measurements of the analysing power using polarized hydrogen targets. The analysing power was observed to fall with energy, and the effectiveness of this method is exhausted by around 30 GeV.

However, for small scattering angles, the interference of the electromagnetic and strong interactions is expected to provide a significant analysing power for elastic proton–proton (and proton–nucleus) scattering. This analysing power, which is the basis of the RHIC high-energy polarimeters, derives from the same electromagnetic amplitude that generates the proton's anomalous magnetic moment. Experiment E704 at Fermilab used 200 GeV/c polarized protons from hyperon decay to detect the asymmetry in scattering from a hydrogen target (Akchurin 1993). The largest analysing power, A_N, was about 0.04 but the statistical errors were large. A calculation of the analysing power agreed with these measurements, but they are subject to uncertainties in the strong interaction amplitudes. Hence, an accurate calibration of the reaction is required.

The idea for the beam-polarization calibration at RHIC is simple in principle. Let the high-energy beam cross a jet of polarized hydrogen atoms of known nuclear polarization, and measure the left:right ratio in the number of scattered particles; then reverse the sign of the target polarization periodically to cancel asymmetries caused by differences in detector geometry or efficiency in the left and right directions. This gives the target asymmetry $\varepsilon_{tgt} = P_{tgt} A_N$. Now measure the corresponding asymmetry but with the polarization of the beam particles reversed, to give $\varepsilon_{beam} = P_{beam} A_N$. Since in proton–proton elastic scattering the analysing power A_N, which is a measure of the polarization-sensitivity of the scattering process, is the same no matter which proton is polarized, the ratio of beam asymmetry to target asymmetry, $\varepsilon_{beam}/\varepsilon_{tgt}$, multiplied by the known target polarization, P_{tgt}, gives an absolute measurement of the beam polarization, P_{beam}.

The trick is to make a jet of known polarization and of sufficient density to achieve reasonable count rates. The Brookhaven polarized-hydrogen jet is produced by an atomic beam source (ABS) in which molecular hydrogen is dissociated by a radio-frequency (RF) discharge, and the resulting atomic hydrogen beam is spin-separated and focused according to electron spin by sets of six-pole magnets (figure 1). The spin of the resulting particles is manipulated by RF transitions, which flip the spin to produce either up or down proton polarization. The principle is not new. Equipment of this type was originally developed for ion sources that produced polarized protons. Work on an ABS for use as an internal target of polarized hydrogen in the Super Proton Synchrotron at CERN was carried out some 30 years ago (Dick *et al.* 1981 and 1986), but was eventually abandoned because the target density (a few times 10^{11} H/cm^3) was insufficient. To get around the low jet density, most recent experiments with polarized hydrogen gas targets use long "storage cells" into which hydrogen atoms from an ABS are injected (Steffens and Haeberli 2004). These storage cells increase the target thickness by a factor of about 100, but at RHIC the need to know the scattering angle of the very-low-energy recoil protons precludes the use of an extended target.

The polarized atomic hydrogen jet constructed for RHIC has achieved a beam intensity of 1.2×10^{17} H/s, which is the highest intensity recorded to date. At the point of interaction with the RHIC beams, the hydrogen beam profile is nearly gaussian and has a full width at half-maximum of 6.5 mm. The areal density of the hydrogen target is $(1.3 \pm 0.2) \times 10^{12}$ H/cm^2.

Hydrogen atoms formed by dissociating molecular hydrogen in an RF discharge emerge through a 2 mm-diameter cooled nozzle (optimum temperature 65 K) and enter a set of tapered six-pole magnets that are made of high-flux rare-earth permanent magnets (these have a pole-tip field of 1.5 T and a maximum gradient of 2.5 T/cm). The magnets are divided into sections to improve pumping. They were designed by elaborate optimization using empirical data on dissociator output versus gas flow and temperature, as well as attenuation by gas scattering in the beam-forming region and in the six-pole magnets. The atomic beam diverges in the first set of magnets, passes a long drift space, and converges in the second set of magnets towards the target region.

Near the point where the RHIC beam intersects the atomic hydrogen beam, a "holding field" provides a very uniform vertical magnetic field. The strength of the field (0.12 T) was chosen to avoid depolarization of the atoms by the periodic electromagnetic field that is produced by the beam bunches. Stringent conditions had to be met by the fringe fields of the guide field magnet to assure a slow adiabatic field change between the six-pole field, the RF transitions and the guide field.

The target polarization is reversed periodically by turning on one or other of two RF coils, which induces spin-flips in the hydrogen atoms. A second set of six-pole magnets and RF coils placed after the interaction point serve to measure the proton polarization at the target. The efficiency of the spin-flip transitions is found to be above 99%. In the finite holding field there is a residual coupling of the proton spin to the electron spin, which results in a net proton polarization of 0.96. The largest uncertainty in the target polarization arises from the uncertainty in the measured contamination of the atomic hydrogen beam by molecular hydrogen, which is unpolarized. Taking into account this dilution, the target polarization is $P_{tgt} = 0.924 \pm 0.018$.

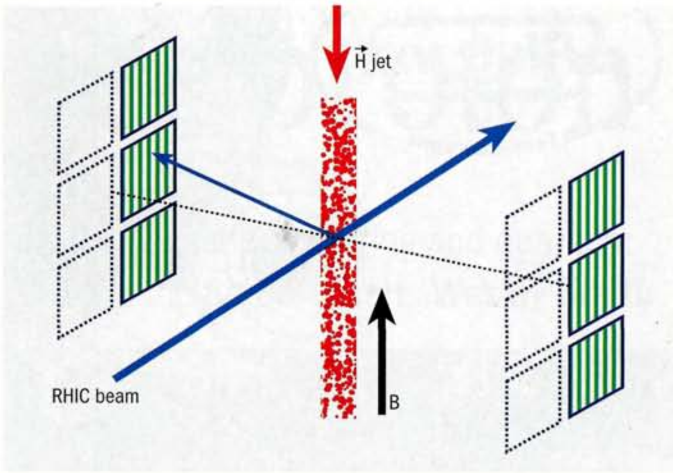


Fig. 2. Six 70 × 64 mm silicon-strip recoil detectors with 16 strips each are located near 90° with respect to the RHIC beam, at a distance of 80 cm from the interaction point.

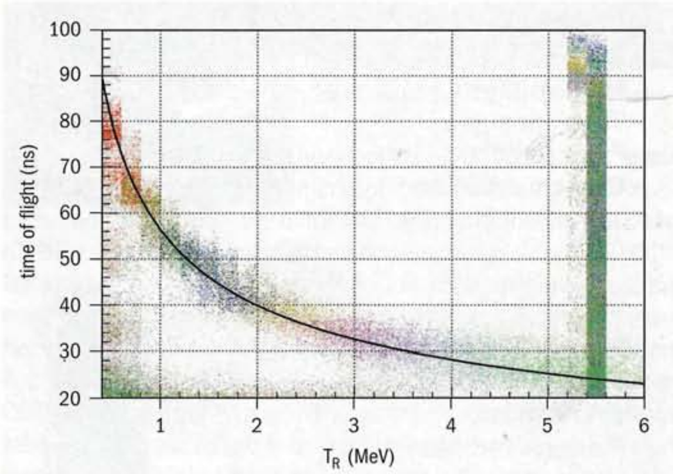


Fig. 3. The correlation between time of flight and recoil energy. The solid line shows the locus expected for protons. The vertical band on the right represents alpha particles from a ^{241}Am source used for energy calibration. Events from different strips are distinguished by different colours.

Results at RHIC

With a target of pure hydrogen atoms, proton–proton scattering with low momentum transfer can be uniquely identified by detecting the recoil proton near 90° with respect to the high-energy beam. The Fermilab experiment E704 showed significant spin-dependence in proton–proton scattering for momentum transfer in the range $|t| = 0.001$–0.03 (GeV/c)^2. This corresponds to recoil protons of a few hundred kilo-electron-volts to several mega-electron-volts.

Recoils are detected in silicon-strip detectors placed 80 cm from the hydrogen jet (figure 2). Recoil protons from proton–proton elastic scattering are identified by their time-of-flight and energy-angle correlation (figure 3). The figure illustrates the clear identification of protons, with the solid curve showing the predicted relationship between proton energy and time of flight. Events from different detector strips are distinguished by colour, and it is this correlation between scattering angle and energy that demonstrates that the scattering is elastic.

The average of $P_{tgt}(\varepsilon_{beam}/\varepsilon_{tgt})$, taken over all energy bins of the recoil detector, determines the beam polarization P_{beam}. In fact, ε_{tgt} and ε_{beam} are measured at the same time by loading into the ring bunches of opposite polarization and reversing the target polarization every few minutes. The results of measurements on the blue beam during early 2004 show $(\varepsilon_{beam}/\varepsilon_{tgt}) = 0.43 \pm 0.02$, where the error is purely statistical. Assuming a target polarization of 0.924 ± 0.018, the RHIC beam polarization was 0.392 ± 0.026. For the measurements in 2005, the detectors were displaced along the RHIC beam direction to allow detection of recoils from both blue and yellow beams. Preliminary results indicate that, compared with 2004, the beam polarization has improved by about 15%, which is an important accomplishment. These results can be used to determine the t-dependence of the analysing power $A_N = P_{tgt}/\varepsilon_{tgt}$ for proton–proton elastic scattering at 100 GeV. The results, which are shown in figure 4, agree closely with calculations based on Coulomb nuclear interference without any hadronic spin-flip.

The polarized hydrogen jet makes it possible to determine the polarization of high-energy protons to an accuracy of a few per cent, without using a model. Theory predicts that the method will be ▷

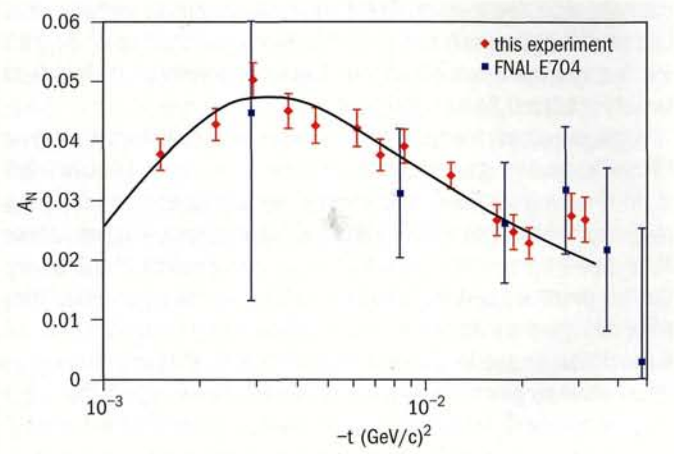


Fig. 4. Results for proton–proton elastic scattering at 100 GeV.

successful over the entire energy range that is accessible by RHIC. The polarized hydrogen jet does not interfere with the operation of the ring. Despite the small target density and without the use of coincidence detection, it has proved possible to cleanly identify proton–proton elastic events with minimal background.

The major drawback of the polarized hydrogen jet is that the low count rate precludes rapid monitoring of the beam polarization – for example, during beam tuning. For this reason, a proton–carbon (pC) polarimeter is used. This permits relative beam polarization to be measured in less than a minute. The polarized hydrogen jet enables the pC polarimeters to be calibrated to an accuracy better than 6%. Thus the polarized-hydrogen target and the carbon target serve complementary roles.

● The development and operation of the polarized hydrogen jet target was a collaboration between BNL (C-AD, Instrumentation and Physics), ITEP (Moscow), IUCF, Kyoto University, Riken BNL Research Center, University of Wisconsin-Madison and Yale University.

Further reading

A good overview of this project is found in papers presented at the SPIN2004 conference by A Bravar, T Wise *et al.*, A Nass *et al.*, H Okada *et al.* and A Zelenski *et al.* (to be published).

N Akchuring *et al.* 1993 *Phys. Rev D.* **48** 3026.
L Dick *et al.* 1981 *Experientia Supplementum* **38** 212.
L Dick and W Kubischta 1986 *Helv. Phys. Acta* **59** 584.
E Steffens and W Haeberli 2004 *Rep. Prog. Phys.* **66** 1887.

Résumé

Jet de H pour mesurer la polarisation du faisceau au RHIC

L'ensemble d'accélérateurs RHIC de Brookhaven produit des collisions frontales entre des protons polarisés de 100 GeV afin d'étudier le rôle des gluons dans le spin du proton. Mais comment déterminer le degré de polarisation du faisceau? C'est très simple en théorie, mais très compliqué en pratique: on mesure la diffusion des particules d'un faisceau frappant une cible d'atomes d'hydrogène dont on connaît la polarisation.

Willy Haeberli, *University of Wisconsin-Madison.*

Deep inside the proton

The DIS 2005 workshop reviewed progress in deep inelastic scattering and quantum chromodynamics, and provided the chance to plan for the future, reports **Wesley Smith**.

Attendees at DIS05 gather on the rooftop terrace of the Monona Terrace Community and Convention Center in Madison, Wisconsin.

DIS 2005 was the 13th in the series of annual workshops on deep inelastic scattering (DIS) and quantum chromodynamics (QCD). Hosted by the Physics Department of the University of Wisconsin-Madison, the workshop was held on 27 April – 1 May at the Monona Terrace Community and Convention Center in Madison.

The workshop, which brought together 280 experimentalists and theorists, began with plenary sessions that featured review talks. Parallel working group sessions followed, and the workshop ended with plenary sessions that included reports from the working groups and a conference summary. The topics of the working groups were: structure functions and low-x, diffraction and vector mesons, electroweak physics and beyond the Standard Model, hadronic final states, heavy flavours, spin physics, and the future of DIS. There were 240 talks in total, replete with many exciting new results.

The working group on structure functions focused on the future. Final measurements from the first period of data-taking at the Hadron Electron Ring Accelerator (HERA) at DESY were shown, alongside the first electroweak measurements from the new HERA data. Attention was paid to new extraction techniques for determining the parton distribution functions (PDFs) and to improving the standard methods. The goal is to improve PDF uncertainties, which play a crucial role for measurements not only at the Large Hadron Collider (LHC) at CERN, but also at Fermilab's Tevatron and in neutrino-oscillation experiments.

New results from the Relativistic Heavy Ion Collider (RHIC) at Brookhaven sparked much discussion of parton evolution and saturation at very low proton momentum fraction x. Strong particle suppression in forward rapidities in deuteron–gold collisions, reported by the BRAHMS, PHENIX and STAR collaborations, hint at the possible mechanism behind parton saturation. At the other end of the x spectrum, new results in the high-x resonance region from Jefferson Lab suggest that future data from there will significantly improve our understanding of proton structure.

The working group on diffraction surveyed the abundance of data over an extended kinematic range from the HERA experiments, which has enabled precise measurements of the diffractive structure functions and extraction of the diffractive parton distribution functions (DPDFs). Several new, independent next-to-leading-order (NLO) QCD fits suggest that the DPDFs are gluon-dominated. Recent results on deeply virtual Compton scattering and exclusive meson production from HERA experiments, and from the Common Muon and Proton Apparatus for Structure and Spectroscopy (COMPASS) experiment at CERN and the CEBAF Large Acceptance Spectrometer (CLAS) at Jefferson Lab, are sensitive to the generalized parton distribution functions (GPDFs). These provide information on correlations between partons, their transverse momentum, and the contribution of the quark angular momentum to the proton spin. A new window on diffractive processes will open at the LHC with the TOTEM detector, integrated with CMS. The FP420 proposal to equip a region 420 m from the ATLAS and/or the CMS interaction point would add to this.

The working group on electroweak physics examined the first measurements from HERA of the cross-sections for charged and neutral-current DIS with polarized leptons, confirming the V–A structure of the electroweak interaction. Participants discussed the impact on the Standard Model Higgs mass of the latest high-precision top-quark mass measurement from the Tevatron (see p21). High-precision measurements of the W mass and the top mass need a good understanding of the structure of the proton, in particular nonperturbative effects, from HERA data. The discovery of single-top events is expected with the increasing integrated luminosity of Run II at the Tevatron, and measurements of the production cross-section could constrain new physics models that modify the coupling of the top quark to gauge bosons. The excess of events with high-p_T isolated leptons reported by the H1 collaboration at HERA could be attributed to the anomalous coupling of top quarks to up quarks. Many recent searches at HERA and the Tevatron have produced inconclusive evidence of new physics, but the substantial increases in luminosity at both colliders make a discovery more likely. Preparations ▷

for searches and precise electroweak measurements at the LHC highlight the machine's vast discovery potential.

The working group on hadronic final states studied the perturbative QCD calculations of jet cross-sections that have been understood with unprecedented accuracy at HERA. These determine the strong coupling constant with a precision that is comparable to the most accurate value obtained in e^+e^- interactions. These achievements pave the way for an understanding of jet production at the LHC. Large theoretical uncertainties (of order 100%) remain for the production of hadrons at small (forward) angles to the incoming proton's momentum, which probes collisions with small momentum fractions x and momentum transfers Q. This is where new dynamical mechanisms associated with scattering at asymptotically high collision energies may turn on.

Recent results from HERA suggest that further theoretical improvements are needed to describe small-x scattering. These may come from developments in higher-order computations, resummation and parton shower models. The latest cross-sections for jet production in Run II at the Tevatron help to constrain the gluon density in the proton, while a comparison of the rates for pion and photon production at RHIC independently confirms the formation of an extended dense quark–gluon medium in the aftermath of gold–gold collisions.

The experimental status of pentaquarks remains ambiguous, but new high-statistics measurements from Jefferson Lab should soon provide a more definite answer. The ZEUS and HERMES experiments at HERA reported observations of a Θ^+ state at around 1520 MeV, whereas H1 at HERA and BaBar at SLAC see nothing. On the other hand, H1 remains unique in reporting the observation of a charmed pentaquark. The CLAS experiment at Jefferson Lab has now accumulated a large sample of photoproduction events from dedicated runs, and with only 1% of the data analysed there is no sign of a Θ^+ (*CERN Courier* June 2005 p7).

The heavy-flavour working group heard that the new heavy-quark PDFs from Martin–Roberts–Stirling–Thorne (MRST) and the Coordinated Theoretical–Experimental Project on QCD (CTEQ) now describe the HERA data on charm structure functions quite well. Recent progress on soft resummation for heavy quarks in DIS should allow its inclusion in PDFs and the extraction of resummed parton densities. New calculations describing the production of D-mesons at the Tevatron can be further extended to DIS processes. A new model for heavy quarkonium production agrees with data from RHIC and the Tevatron, in particular with the J/ψ polarization measurements from the Collider Detector at Fermilab (CDF) at the Tevatron, and PHENIX at RHIC. NLO corrections were shown to improve the description of charmonium production in two-photon collisions. New measurements of the charm and beauty contribution to the proton structure function show good agreement with the predictions based on NLO QCD and gluon densities obtained from global PDF analyses.

New heavy-flavour results are moving beyond the production of single heavy mesons to measure fragmentation parameters, heavy-quark correlations, heavy-quark-jet characteristics and unexplored kinematic regions. While NLO QCD describes charm well, the situation for beauty is less clear. Precise measurements of b-quark production at high p_T or large Q^2 agree with theory, but measurements over the full p_T and Q^2 range are a factor of two higher. In another puzzle, the final measurement of charm production in neutrino–nucleon scattering by the Neutrinos at the Tevatron (NuTeV) experiment excludes a strange sea asymmetry large enough to explain their anomaly on $\sin^2\theta_W$.

The spin physics working group basked in a wealth of new high-precision data from the HERMES, COMPASS and Jefferson Lab experiments on the spin structure functions, which extend the coverage at both low- and high-x and into the transition from the partonic to the hadronic regime. Since the contribution to the proton spin from the longitudinal spin of the quarks is now well established and small, recent measurements and global analyses focused on understanding other spin contributions. New data on transversity distributions were presented by the above-mentioned experiments, and from BELLE at KEK, and STAR and PHENIX at RHIC.

DIS 2005 featured a plenary session devoted to the future of DIS studies. Although HERA is expected to close in two years' time, much of its integrated luminosity is still in the future. This is particularly true for the measurement of the helicity dependence of the charged-current cross-section. There is interest in running HERA for a while at lower energy to extract the longitudinal structure function F_L. There was discussion of the physics potential of continuing HERA beyond 2007 with new injectors, or combining the LHC with a future linear electron collider to produce DIS collisions at the tera-electon-volt scale.

Another proposal, eRHIC, combines an electron accelerator with RHIC to produce an electron–proton and electron–nucleus collider with polarized beams at a centre-of-mass energy in the range 30–100 GeV. There is also a proposal to upgrade the DIS programme at Jefferson Lab from 6 GeV to 12 GeV, featuring DIS at large x and the use of what is effectively a target of free neutrons. Ideas also exist for DIS experiments at fixed targets, particularly at CERN; for neutrino experiments with Minerva at Fermilab; and future neutrino projects based on the Fermilab Proton Driver. These proposals often look at the GPDFs that can be accessed using deeply virtual Compton scattering and that illuminate the structure of hadrons in transverse space.

The workshop attendees emerged with a renewed sense of the importance of DIS and QCD measurements and theory to the future of particle and nuclear physics. They also gained an enhanced appreciation for the range of exciting developments in the field, and a determination to pursue experimental and theoretical opportunities.

• The workshop was sponsored by Argonne, the US Department of Energy, DESY, the US National Science Foundation and the University of Wisconsin-Madison.

Résumé

Les profondeurs du proton

L'atelier DIS 2005, qui s'est tenu à Madison dans le Wisconsin, a passé en revue les avancées récentes en diffusion profondément inélastique et en chromodynamique quantique. Il a aussi permis de planifier l'avenir. Grâce à 240 exposés, les participants ont pu découvrir de nombreux nouveaux résultats stimulants et se faire une meilleure idée de la diversité des développements passionnants dans le domaine et des nombreuses perspectives expérimentales et théoriques qu'offre l'avenir.

Wesley H Smith, *University of Wisconsin-Madison, from summaries provided by the working group organizers.*

Symposium previews the future of hadron colliders

The HCP2005 Symposium, held in the Swiss Alps, discussed the latest results from the Tevatron and the prospect that the LHC will open new scientific frontiers.

The symposium featured a talk by Alvin Tollestrup, who played a major role in discovering the top quark at the Tevatron.

In the early 1980s, CERN initiated the $\bar{p}p$ Collider Workshop series with the aim of communicating and synthesizing the latest results from hadron collider experiments – most recently the Collider Detector at Fermilab (CDF), and the D0 experiment at the Tevatron at Fermilab. This year, with the projected commissioning of CERN's Large Hadron Collider (LHC) in 2007 and the subsequent transfer of physics activities, the series was merged with the LHC Symposium that is devoted to preparing LHC experiments, and renamed the Hadron Collider Physics (HCP) Symposium. HCP2005 was organized by CERN and the Swiss Institute for Particle Physics (CHIPP), and was held in Les Diablerets, Switzerland, on 4–9 July. About 150 participants attended from the Tevatron and LHC experiments.

Ralph Eichler, the director of the Paul Scherrer Institute, gave a welcoming address. This was followed by Georg Weiglein from the Institute for Particle Physics Phenomenology, Durham, who presented an introductory theoretical overview of the role of hadron colliders in studying the Higgs sector of the Standard Model. The first major session was then devoted to machine and experimental studies at the Tevatron and LHC. David McGinnis of Fermilab described current and prospective operations at the Tevatron, where the CDF and D0 experiments are operating well and an integrated luminosity exceeding 1 fb^{-1} has already been delivered to each experiment. CERN's Lyn Evans outlined the progress made in building the LHC, and representatives from each of the LHC experiments described the advanced construction status of the detectors, as well as the new phase of detector integration and commissioning.

Directions for physics

With the goal of maximizing the shared experience of the Tevatron and LHC communities, the symposium was then organized around the key physics directions of hadron-collider research. Each of the physics sessions was introduced by a theorist, who gave an overview of the subject, followed by speakers from the Tevatron and LHC experiments. Sessions were also held on experimental issues such as particle identification, or tracking and b-tagging, in which experts from both communities could present their solutions and exchange ideas.

The first physics session was on the subject of quantum chromodynamics (QCD). It opened with a talk by Keith Ellis from Fermilab on the status and limitations of next-to-leading-order (NLO) and next-to-next-to-leading-order (NNLO) theoretical calculations, together with calculations planned to match experimental "wish lists". The experimental talks described the wealth of data that is becoming available from CDF and D0. There were also several talks about identifying and calibrating jets at the Tevatron and in future at the LHC.

A complementary session dealt with electroweak physics, a field in which some surprises may emerge. Ulrich Baur of the State University of New York presented the status of Standard Model fits and available calculations. This was followed by talks on production measurements of single-vector bosons and vector boson pairs.

The LHC is expected to open new frontiers beyond the Standard Model, so a major session was devoted to existing and future direct searches for new physics. This could be supersymmetry or something more exotic, and might even appear in small deviations in rare B-meson decays measured at the LHCb experiment. No hints of new physics have been found at the Tevatron. However, Anna Goussiou from the University of Notre Dame showed that even with reduced luminosity expectations for the final Run II data sample, the CDF and D0 experiments maintain a non-negligible potential for finding "evidence" of a Higgs boson in the low-mass range, where identification is most difficult for the LHC experiments.

Not so long ago, precision b-quark physics was considered to be almost impossible at hadron colliders. However, thanks to dedicated triggers and excellent tracking capabilities, the Tevatron experiments have world-class results that are in many cases comparable to those from the b-factories. Furthermore, CDF and D0 have a monopoly in studies of the B_S sector. An important request from the theoretical community, which was emphasized in the talk by Luca Silvestrini from INFN/Roma, is for measurements of B_S mixing, in particular ▷

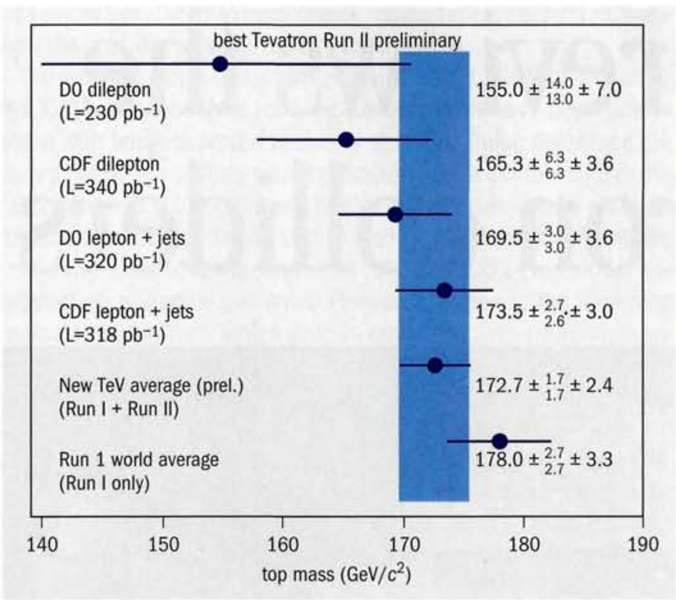


Fig. 1. The Tevatron is pinning down the mass of the top quark.

the parameters Γ_S and Δm_S. Guillelmo Gomez-Ceballos of the Instituto de Fisica de Cantabria presented results from the CDF effort on that topic. There is no quantitative measurement so far, but, with all of the analysis machinery in place, the whole region of Δm_S that is predicted by the mixing triangle can be covered as soon as sufficient data are available. If surprises arise and the value is larger than expected, the LHCb experiment will discover and/or measure with extreme precision this missing piece of the Cabibbo–Kobayashi–Maskawa puzzle.

The results from the Relativistic Heavy Ion Collider (RHIC) at Brookhaven and expectations from the ALICE experiment at the LHC dominated the session on heavy-ion physics. However, talks about CMS and ATLAS, the two general-purpose detectors at the LHC, showed that they will have a vital role in many aspects of heavy-ion physics; for example, in measuring high-p_T jet production.

Top quark results

The last major physics session was dedicated to the top quark. CERN's Fabio Maltoni highlighted the improved experimental conditions that are available at the LHC compared with the Tevatron, and stressed the importance of measuring the properties of the top quark to try to explain its large mass. Tomonobu Tomura of Tsukuba presented the latest mass measurements from CDF and D0 (figure 1), including CDF's new measurement of $174.5^{+2.7}_{-2.6}$ (stat.) ± 3.0 (sys.) GeV, based on a two-dimensional template method. While the preliminary Tevatron average for the top mass is 174.3 ± 2.0 (stat.) ± 2.8 (sys.) GeV, by the end of Run II the Tevatron experiments are expected to measure the mass with a precision better than ±2 GeV. The search for single-top production, as well as preliminary measurements of the $t\bar{t}$ production cross-section, were also described. Arnulf Quadt of Bonn presented the measurements of some t-quark decay properties (for example, the W-helicity) and searches for rare t-quark decay modes. Presentations by the CMS and ATLAS collaborations underlined the rich experimental programme that is expected in the future.

The physics sessions were interrupted by two sessions about preparations for the LHC. A key issue will be lepton identification. One session was devoted to the results and pitfalls from the Tevatron experience, and ended with status talks on the hardware and reconstruction aspects of the LHC experiments. The results seem encouraging, even if experience shows that the real answer only comes under running conditions. A natural follow-up to the b-physics session was a discussion on tracking and b-tagging. The lesson from the Tevatron has been positive and the LHC collaborations seem to be aware of that. The overall computing strategy and preparations for analysing the LHC experiments were widely presented and discussed at the end of the session.

A special guest at the symposium was Fermilab's Alvin Tollestrup. Tollestrup played a crucial role in the machine, detector and analysis activities that led to the discovery 10 years ago of the top quark by the CDF and D0 experiments. In an inspiring presentation, he talked about "the trail to the top", leading to the discovery of the top quark and the ideas that were behind it. Many saw this talk as Tollestrup's way of passing the baton to a younger generation. He also reminisced about a time when particle physics was on a smaller scale, and he stressed the evolution of experimental techniques in particle physics and their consequences.

The theoretical and experimental summaries of the symposium were given by Pierre Binétruy of the Laboratoire d'Astroparticule et Cosmologie (APC) in Paris, and John Womersley of Fermilab and the US Department of Energy. Binétruy stressed the important role of the LHC programme during the coming years. Womersley placed the results presented at the conference in the context of the rapidly evolving jigsaw puzzle of the Standard Model of electroweak and strong interactions, with its extensions and future possible surprises.

Holding the conference in a remote alpine location was a challenge. However, the organizing committee from CERN and CHIPP, the secretaries from CMS and ATLAS (Nadejda Bogolioubova and Jodie Hallman) and the hotel staff made it a success. The only unpredictable factor, the weather, played foul. Although luck held during the welcome drink and an Alpine horn concert, it was mostly raining, and a dinner at 3000 m altitude in the glacier restaurant was immersed in cloud. Only those participants who remained an extra day discovered the beauty of Les Diablerets in brilliant sunshine.

The next meeting of the series will be hosted by Duke University in May 2006, and in summer 2007 the meeting will be hosted by INFN Pisa in or near the town of Pisa.

Further reading

For more details, see http://hcp-2005.web.cern.ch/HCP-2005.

Résumé

Un symposium scrute l'avenir des collisionneurs hadroniques

Des physiciens se sont réunis à la station suisse des Diablerets pour le symposium 2005 sur la physique des collisionneurs de hadrons. Ils ont examiné les derniers résultats du Tévatron et les perspectives d'expérimentation au LHC. Les séances ont traité des aspects théoriques et expérimentaux des grands axes de la recherche à l'aide des collisionneurs de hadrons, ainsi que de problèmes expérimentaux spécifiques comme l'identification des particules, la trajectographie et l'étiquetage des b.

Mario Campanelli *and* **Allan Clark**, *University of Geneva.*

Masterclass spreads the word for physics

Between 7 and 19 March 2005 more than 3000 teenagers from across Europe spent a day working at the frontier of physics in the first European Masterclasses for High School Students. **Michael Kobel** reports on this successful educational event.

The videoconference between centres in different countries created an authentic feeling of international collaboration.

Particle-physics masterclasses began in the UK in 1997, the centenary of J J Thomson's discovery of the electron. It was then that Ken Long of Imperial College and Roger Barlow of Manchester devised a series of one-day events for 16- to 19-year-old pupils and their teachers. Run by particle physicists at various institutes all over the UK and coordinated by the High Energy Particle Physics Group of the Institute of Physics, each year the programme offers a very popular combination of exciting talks and hands-on experience of the interactive graphical display programs that particle physicists use at CERN. More recently, the concept of the particle-physics masterclasses has been successfully adopted by several institutes in Belgium, Germany and Poland on a regular basis.

The World Year of Physics 2005, commemorating Einstein's *annus mirabilis*, was the inspiration for the particle-physics masterclasses to spread even further. It was just enough to mention the idea of a Europe-wide version of this programme for all the members of the European Particle Physics Outreach Group (EPOG) to come on board and try to get institutes in their countries involved. EPOG promotes the outreach activities of particle-physics institutes and laboratories in CERN's member states and acts as a forum for the exchange of ideas and experiences related to particle-physics outreach (*CERN Courier* April 2004 p42). Fifty-eight institutes in 18 countries across Europe, from Athens to Bergen and from Lisbon to Helsinki, participated in the masterclass event, which was centrally coordinated at Bonn University.

As with the original masterclasses, the basic idea of the pan-European event was to let the students work as much as possible like real scientists in an authentic environment at a particle-physics institute, not only to feel the excitement of dealing with real data, but also to experience the difficulties of validating the scientific results. After lectures from practising scientists they performed measurements on real data from particle-physics experiments, and at the end of each day, like in an international collaboration, they joined in a videoconference for discussion and combination of the results.

The measurement of the branching ratios of Z boson decays at CERN's Large Electron–Positron Collider (LEP) was chosen as the main common task at all sites. For this the students had to identify the final states of quark-jets, electron pairs, muon pairs and the notoriously difficult tau pairs from the tracks and signals in various components of LEP detectors. Interactive computer material for this task was available using data from OPAL in the Identifying Particles package from Terry Wyatt at Manchester, or alternatively using DELPHI data in A Keyhole to the Birth of Time by James Gillies and Richard Jacobsson at CERN or in the well known Hands-on-CERN package developed by Erik Johansson of Stockholm (*CERN Courier* March 2002 p18).

To simplify students' access to the unfamiliar world of particle physics, EPOG and the national institutes undertook the immense effort of translating the material into various languages. By the beginning of March, each package was available in at least one of 16 languages, with *Hands-on-CERN* now covering 14 languages, from Catalan to Slovak. This material, including real data for performing the measurements and several extra teaching and learning packages, lays the basis for regularly performing masterclasses at a European level, and is also of valuable use outside the masterclasses. It is available on the Internet and on a CD that was given to each masterclass participant.

The skills required to become a "particle detective" were taught in the morning lectures at each institute. Since in most countries ▷

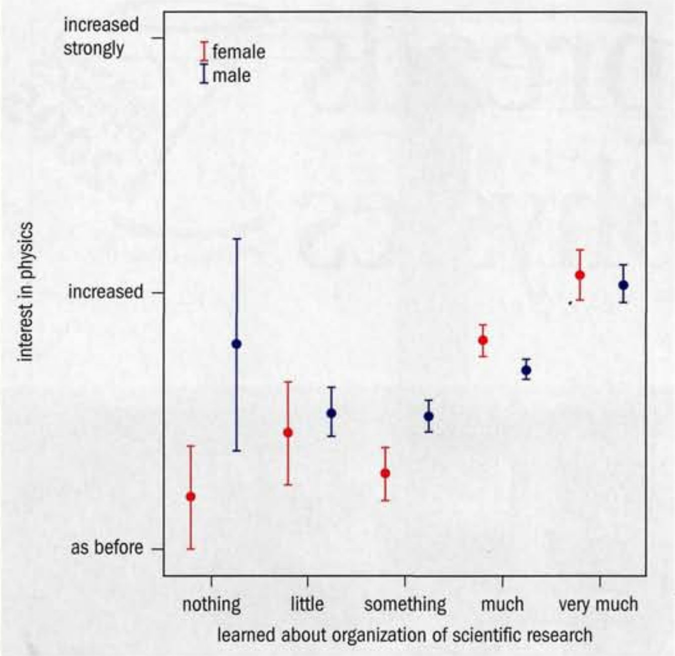


Fig. 1. The students' feeling that they had learned more about the organization of scientific research contributed significantly to a general increase in interest in physics. The points and error bars show the average change of interest; responses from "strongly decreased" up to "strongly increased" were possible.

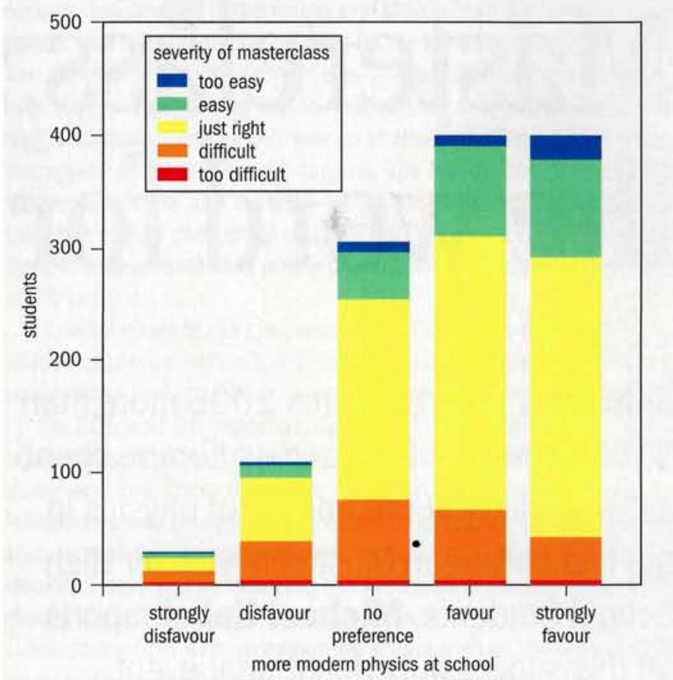


Fig. 2. A clear majority of students would like more modern physics – such as particle physics – to feature in their science lessons at school, a response that is somewhat correlated with the perceived difficulty of the masterclass programme.

particle physics is not normally taught at school, the talks had to go all the way from basic explanations to the world of quarks and leptons. "Easy-to-follow explanations of scientific research" was the immediate reaction of one of the students at Berlin. After some brief training by young researchers from the institute, the students made the fascinating discovery that they were indeed able to identify the elementary particles on the event displays themselves, at least in most cases; it was even more fascinating for them to learn that professional scientists cannot be completely sure either on an event-by-event basis that their identification is right. The exercise was in fact usually performed quite quickly: "What next?" was a frequent demand once the Z-decays were measured.

Another innovative idea of the EPOG European Masterclasses was to hold an international videoconference at the end of each day using the same Virtual Room Videoconferencing System (VRVS) technology as practising scientists. CERN's IT Department and the Slovak group of the Caltech VRVS team provided valuable technical help for the many institutes that had never used this tool before. The link-up was centrally moderated by two inspiring young researchers at CERN: Silvia Schuh from ATLAS, and Dave Barney from CMS (who recently received the 2005 Outreach Prize of the High Energy and Particle Physics Division of the European Physical Society – see *CERN Courier* September 2005 p43). Using English as a common language, the students discussed why, for instance, classes in Helsinki and Vienna found significantly more taus than those in Innsbruck, Heidelberg, Bonn or Bergen. They then assigned systematic errors derived from the differences and ended up with combined measurements, confirming (happily!) the results from LEP. In addition invited scientists at CERN were ready to answer further questions on topics ranging from antimatter and Big Bang cosmology to the daily life of a CERN researcher.

The videoconferences made the students aware that the masterclasses were taking place in other countries, and created the feeling of an international collaboration of researchers. It was "interesting to learn how scientific information is exchanged around the globe", according to one of the comments on the feedback questionnaires, which are currently being evaluated by the Leibniz Institute for Science Education (IPN) at the University of Kiel.

How was it for you?

The first results from the evaluation show that, independent of country and gender, some 70% of about 400 female and 900 male students felt strongly or very strongly that they had learned at the masterclasses how scientific research is organized and carried out. More than 81% liked the masterclasses "much" or "very much", again independent of gender. Moreover, there was significantly higher enthusiasm in Finland, Portugal and the Czech Republic with 96% choosing "much" or "very much", which can mostly be attributed to particularly interesting lectures and a bigger increase in knowledge of particle physics.

The impact on the student's interest showed greater spread between the countries. On average 58% of both male and female students felt that they were generally more interested in physics after the masterclasses, and only 6% were less interested. Again, the masterclasses had a significantly stronger impact in Portugal and Finland, with 86% and 95% of students respectively reporting increased interest. In two countries the female participants benefited especially. While the male participants showed no significant deviation from the average, 78% of the Italian girls and all seven female students in Sweden reported an increased interest in physics. The Swedish girls unanimously marked the highest possible increase in their knowledge of particle physics, and felt more strongly than average that they had learned about the organization of scientific research. For all students both factors correlated very strongly with positive answers to the question on increased general interest in physics (see figure 1). Apart from this, the reactions of the female and male students to the masterclass programme were nearly identical, although in all countries the girls said they thought they knew significantly less about physics than the boys and were significantly less familiar with computers.

Finally, regardless of whether they like their current physics lessons at school, 65% of the students thought that modern physics, like particle physics, should play a bigger part in their science lessons (see figure 2). This question showed the largest variation between the countries. The majority was significantly higher, for example, in Germany, with 75% of the students responding positively, and Portugal with 91%. In Switzerland and Norway, by contrast, not even 30% of the students clearly supported this statement. In the latter two countries more than half of the students found the level of the masterclasses rather difficult, while on average only 19% shared this opinion.

"I got the feeling that I did something which physicists do every day in their experiments, and I felt involved." This statement from a 17-year-old girl shows that the authentic surroundings and the measurements with real data were indeed able to bring modern physics close to the hearts of young people.

• For more details about the event and materials see http://wyp.teilchenphysik.org. The European Masterclasses were sponsored by the High Energy Physics Board of the European Physical Society and the Bundesministerium für Bildung und Forschung (BMBF), and received organizational help from the German Science-on-Stage Executive Office. The EU has acknowledged the success of the first European Masterclasses by nominating the project leader, Michael Kobel, for a Descartes Prize for Excellence in Science Communication for 2005. The project is now competing with 22 other nominees for up to five Descartes Communication Prizes, to be awarded in December in London.

Résumé

Toucher du doigt la physique des particules

Entre le 7 et le 19 mars, plus de 3000 lycéens de toute l'Europe ont pu se transformer pour une journée en physiciens des particules à l'occasion des premiers cours européens pour lycéens (European Masterclasses for High School Students), organisés par le Groupe européen de sensibilisation à la physique des particules (EPOG). Près de 60 lycées de 18 pays européens y ont pris part. Les lycéens ont réalisé des mesures à partir de données expérimentales réelles et ont ensuite pu participer à une visioconférence pour combiner leurs résultats.

Michael Kobel, *University of Bonn.*

HELEN network unites Europe and Latin America

Luciano Maiani describes the creation of the High Energy Physics Latin-American-European Network – HELEN – which aims to promote fundamental physics in Latin America through training the younger generations in high-energy physics.

After I became director-general of CERN in 1999, I had the chance to meet Juan Antonio Rubio, a well known experimental physicist and former collaborator of Carlo Rubbia and Samuel Ting, who is now the director-general of CIEMAT, Spain. In addition to his other good qualities, Rubio has a deep knowledge of Latin America – her people, schools and traditions. We understood that the Large Hadron Collider (LHC) being built at CERN offered a great opportunity to renew old ties with Latin America and to attract to Europe and CERN a new generation of experimental physicists.

The website for the HELEN project, which was launched on 1 August 2005.

In the past, ties between European and Latin American particle physics had been very strong, involving well known physicists such as Cesar Lattes, José Leite Lopez, Roberto Salmeron and many others. Lately, however, Latin American experimental physicists had turned to the US, and Fermilab in particular, as their main point of contact in particle physics. The US had opened up to them and to their students under the enlightened action of Nobel prize-winners such as Richard Feynman, whose stay in Brazil had an enormous influence on the development of fundamental physics there, and Leon Lederman. On the other hand, theoretical physicists in Latin America had always considered CERN as one of their main poles of interest (together with the International Centre for Theoretical Physics, Trieste) with physicists of the calibre of John Ellis, Alvaro de Rújula and Luis Alvarez Gaumé being particularly friendly to Latin Americans.

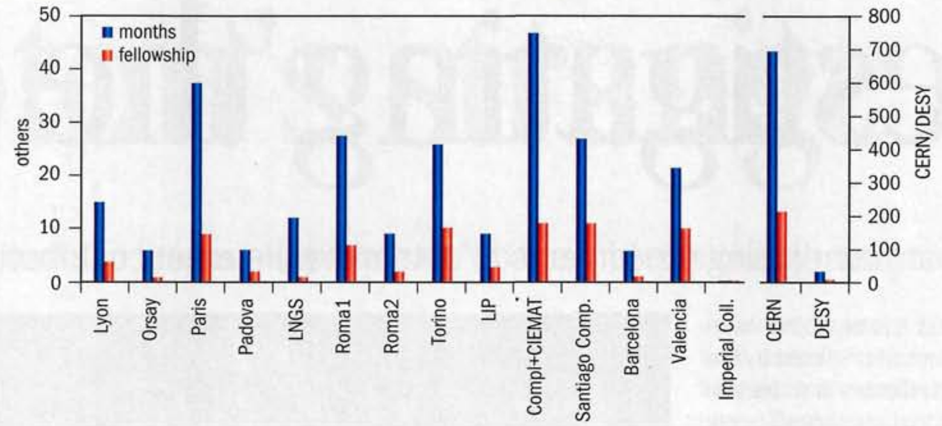
The first step towards rebuilding the relationship with Latin America was launching a biannual CERN-Latin American school of physics. I discussed the matter with Egil Lillestol at the 1999 European School of High-Energy Physics in Bratislava, and we concluded that the conditions were right to go ahead. The first Latin American school, modelled on CERN's long-standing European School of High Energy Physics, was held two years later in Itacuruça, Brazil (*CERN Courier* September 2001 p10). It was a clear success, demonstrating the interest of the younger Latin American generation in European physics, CERN and the LHC.

At the same school, I also saw first-hand a strong interest going in the other direction, with European physicists curious about the Pierre Auger Observatory, the ultra-high-energy cosmic-ray detector being built in Argentina. Indeed, as I learned at Itacuruça, the sum of contributions to the project from CERN member states was already larger than the contribution made by the US via the Department of Energy, a nation historically considered the main partner of Latin American countries.

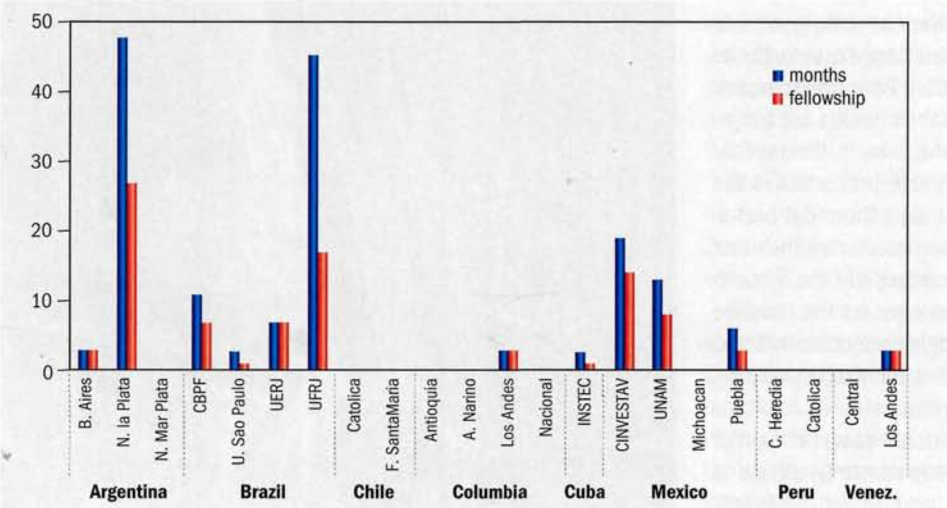
The first Latin American School of High Energy Physics marked the beginning of a new collaboration, but during the following years the problem was how to keep the collaboration going, in view of the difficulties that were arising from financing the LHC. In late summer 2003, Philippe Busquin, the EU commissioner for research whom I had asked for support, pointed out that a programme from the EU Commission, América Latina – Formación Académica (ALFA), was the natural framework for stabilizing relations between CERN and Latin America, by taking advantage of the potential for training young physicists that the LHC offered.

Rubio and I quickly got the message and started to prepare an application to ALFA. Fortunately, another lucky circumstance made the enterprise possible. Verónica Riquer, a former student of Marcos Moshinsky (a well known nuclear theorist from Universidad Nacional Autónoma de México, UNAM), was a postdoctoral fellow in CERN's theory division. A good friend of Rubio, Riquer somehow knows everybody doing physics anywhere in Latin America, and even has a clear idea of what they are actually doing.

Riquer enthusiastically adopted the project that was going to have a big impact on her for the next few years ("HELEN nos va matar" she warned me in the difficult periods – "HELEN is going to kill us!"). Indeed, she proved the crucial person to connect with high-energy physics groups in Latin America, to get them involved in the hard work of preparing a valid application to the (notoriously difficult) EU Commission and, finally, to convince so many people on a different continent to persuade 22 rectors to sign an agree-



Mobility of physicists going from Latin America to Europe during the three years of the HELEN project. Total number of fellowships is 322; number of months is 1002.



Movement in the other direction, with in total 94 fellowships and 164.5 months.

What is HELEN?

HELEN, the High Energy Physics Latin-American-European Network project, is an academic co-operation programme based on a network between universities and institutes from Latin America and Europe, leading laboratories in particle physics (CERN, DESY and the Laboratori del Gran Sasso) and the Pierre Auger Observatory. The network involves 22 universities and research institutions from eight Latin American countries, 16 from six European countries, and CERN. The goal is to train young generations of physicists in high-energy physics, promoting fundamental physics in Latin America and contributing to the modernization of physics education. The project also aims to facilitate the access of Latin American countries to technological benefits in the areas of accelerators, detectors and information technology. It will additionally promote the integration of the European and Latin American physics communities.

• For more about HELEN see www.roma1.infn.it/exp/helen/. The deadline for applications for the first fellowships is 15 October 2005.

ment with the EU at very short notice. Eventually, the full application was finished during the night of 29 April 2004, and taken by hand to Brussels the following morning, complying exactly with the deadline of 30 April 2004. Riquer left CERN to see her family in Mexico, and Rubio and I could relax. The High Energy Physics Latin-American-European Network (HELEN) now existed.

HELEN is a big project. Over three years, it will involve stays in Europe totalling 1002 months (70% at CERN) for students and young researchers from 22 institutions across eight countries in Latin America, and stays in Latin America totalling 164 months for physicists from seven European countries (about 50% at the Pierre Auger Observatory). In addition, some 15% of the budget is dedicated to visits from professors in the network, to give seminars, oversee students and start new collaborations. Each institution has one reference person (the "interlocutor"), among them Arnulfo Zepeda in Mexico, Alberto Santoro in Brazil and Teresa Dova in Argentina. All in all, we expect a whole new generation of Latin American physicists to be trained in particle physics at the most advanced facilities in the world, and to establish new ties with their European peers.

On a happy day last February, we received the news that HELEN had been approved and that we could start discussing the practical implementation of the contract. In fact, at the time I was in Mexico, spending two months at the Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV). There, I could see first-hand the enthusiasm that HELEN was raising in Latin America. In the few months since HELEN's approval, we have had to refine the project and make it suitable for a contract between the EU and the Università di Roma "La Sapienza", the coordinating institution of HELEN. However, at last, the contract was signed on 28 July and the project officially started on 1 August.

Résumé

HELEN: un pont entre l'Europe et l'Amérique latine

Le réseau Europe-Amérique latine de physique des particules, baptisé HELEN, a démarré officiellement le 1er août. Ce réseau, créé par l'Union européenne, vise à promouvoir la physique fondamentale en Amérique latine par la formation des jeunes générations à la physique des hautes énergies. Luciano Maiani décrit la création de ce réseau, auquel participent 22 universités et instituts de recherche issus de huit pays d'Amérique latine, 16 issus de six pays européens, ainsi que le CERN.

Luciano Maiani, *Università di Roma "La Sapienza".*

Investigatin the pr

Several research groups are conducting experiments to determine the exact contributions of s

A simple understanding of the proton is that it is an object composed of three quarks. However, the rich structure predicted by the theory of quantum chromodynamics (QCD) indicates that this picture is incomplete. A sea of gluons and virtual quark/anti-quark pairs is also present, and this plays an important role, for instance, in accounting for the proton's total spin (see also p15). Now, several research groups are investigating how the quark-gluon sea contributes to other properties of the nucleon. Their specific goal is to determine the exact contributions of the sea's strange quarks to the proton's charge distribution and magnetization. Four major experimental collaborations have weighed in, and their results are beginning to paint a cohesive picture of strange quarks in the proton.

The contribution of the strange quark to these properties is the easiest to pinpoint, because the strange quark is the most accessible of all the sea's constituents. Up and down quarks are the most likely quarks to be present in the sea, because they are the lightest. However, they have the same quantum numbers as the valence quarks, so it is nearly impossible to disentangle their contributions. Strange quarks are the second lightest, so are likely to be the second most significant part of the quark-gluon sea.

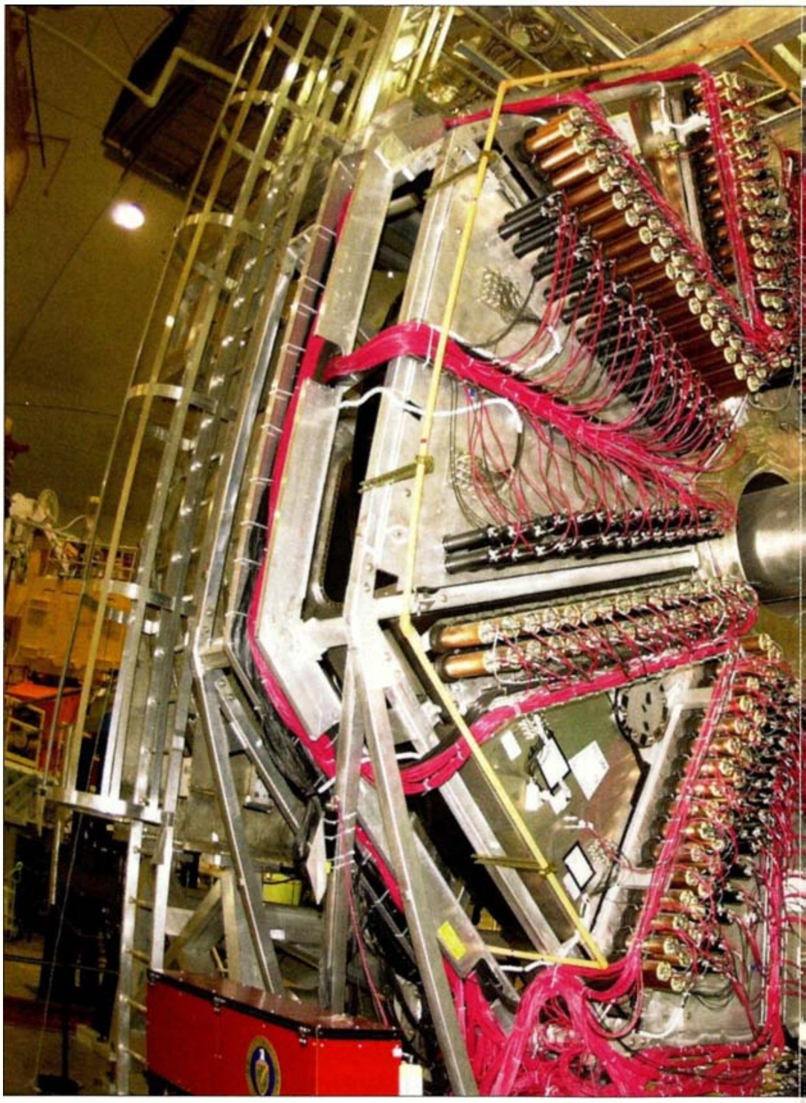
Parity-violating electron scattering offers a promising method of accessing the strange quarks. These experiments study collisions between a beam of polarized electrons and target particles. Specifically, they measure the interference of the electromagnetic interaction, in which a photon is exchanged, and the neutral weak interaction, which involves the exchange of a Z^0 boson. The electrons are polarized, meaning that they are spinning either along their direction of travel (right-handed) or opposite to it (left-handed). This allows the class of electroweak interactions to be separated into the electromagnetic and weak components.

The electromagnetic force is parity-conserving, or mirror-symmetric, so the electron's handedness does not affect scattering rates. The weak force, however, is not mirror-symmetric: it is parity-violating. Therefore, owing to the neutral weak force, a different number of scattering events will be observed when the beam of electrons is right-handed compared with left-handed. A comparison of the weak and electromagnetic pieces allows the experimenters to disentangle the contribution of the up, down and strange quarks.

Meeting the challenge

The experimental challenge arises because the electromagnetic force is much stronger than the weak force, so many scattering events must be recorded to measure the tiny difference, or asymmetry, in scattering rates. In addition, careful attention has to be paid to the possibility of false asymmetries masquerading as the true asymmetry due to the weak force. These can arise, for example, if the beam position or angle on the target changes when the polarized beam is changed from right- to left-handed and vice versa. Typical requirements for these experiments are that these changes must be less than a few nanometres and nanoradians, respectively. Ensuring this stability demands close collaboration between the experimenters and the accelerator physicists and operators, and precise monitoring of the electron-beam characteristics from the source, through the accelerator, and to the experimental hall.

Four research programmes have adopted parity-violating electron scattering to search for the contributions of strange quarks to proton structure. They are the SAMPLE experiment at the MIT-Bates Linear Accelerator Center, the A4 experiment at the Mainz Microtron, and the G0 (G-zero) experiment and Hall A Proton Parity Experiment



Jefferson Lab's G0 detector. G0 required a unique beam pulse structure an

roton's strange sea

strange quarks in the quark-gluon "sea" to the proton's charge distribution and magnetization.

d a custom-built spectrometer that measures over large solid angles.

(HAPPEX) at the US Department of Energy's Jefferson Lab. The various experiments are sensitive to different combinations of strange-quark contributions to the charge distribution and magnetization. These are represented by G_E^s and G_M^s, the strange electric and magnetic form factors, respectively. Experiments using a hydrogen target and a forward scattering angle, including G0, A4 and HAPPEX-H (HAPPEX on hydrogen), all measure a linear combination of G_E^s and G_M^s (the exact combinations differ for each experiment). Disentangling the two form factors requires measurements at both forward and backward angles or with a different target (e.g. helium).

The SAMPLE experiment at MIT-Bates, which is now complete, measured backward-angle electron scattering from hydrogen and deuterium targets at 200 MeV. Cherenkov light produced by electrons scattered with a momentum transfer, Q^2, near 0.1 GeV^2 was focused by an array of mirrors onto a set of 8 inch photomultiplier tubes. The researchers concentrated in particular on obtaining G_M^s, the strange quark's contribution to the proton's magnetic moment (Ito *et al.* 2004 and Spayde *et al.* 2004).

Researchers with the A4 experiment at Mainz use a new type of total absorption calorimeter, making use of 1022 very fast individual crystals of lead fluoride to detect scattered electrons, plus sophisticated read-out electronics. They have measured forward-angle (35°) electron scattering from hydrogen at two values of Q^2, 0.23 and 0.11 GeV^2 (Maas *et al.* 2004 and 2005).

The G0 and HAPPEX experiments at Jefferson Lab took advantage of the high-quality polarized electron beam from the Continuous Electron Beam Accelerator Facility (CEBAF). They have taken data with a 3 GeV beam with up to 86% polarization.

G0 required a unique beam pulse structure and a custom-built spectrometer package capable of measuring over large solid angles. The G0 spectrometer, based on a toroidal superconducting magnet, measures elastically scattered recoil protons over a wide range of forward-scattering angles (and thus a large range of Q^2) simultaneously (Armstrong *et al.* 2005). A time-of-flight technique for identifying the scattered protons required the use of a pulsed beam, with electron bunches arriving every 32 ns. With this pulse structure, the 40 μA electron beam had a large instantaneous current equivalent to 640 μA, providing challenges for the accelerator.

HAPPEX used a pair of high-resolution, small-acceptance spectrometers to measure precisely forward-angle scattering at a single momentum transfer at a time. Initial measurements were made at $Q^2 = 0.48$ GeV^2 with a hydrogen target, and recently data were taken at $Q^2 = 0.1$ GeV^2 using both hydrogen and ^{4}He targets (Aniol *et al.* 2004 and 2005). The hydrogen target allowed the HAPPEX researchers to measure the strange quark's contribution to a combination of the charge and magnetization distributions in the proton. ^{4}He is a nucleus with no net spin, so the helium target allowed them to isolate the strange electric form factor of the proton.

The results from all of these experiments present a cohesive picture of the strange quark's contribution to the charge distribution and magnetization. All are consistent with this contribution being non-zero in the proton.

Figure 1 on p30 shows the G0 and HAPPEX results from hydrogen target data as a function of Q^2. The measured combination of the strange form factors G_E^s and $\eta\, G_M^s$ (η is a kinematic factor) appears to be non-zero, and an intriguing and unexpected dependence on momentum transfer is suggested by the data. At the lowest Q^2 measured so far (0.1 GeV^2), all four experiments provide information about different combinations of G_E^s and G_M^s, as ▷

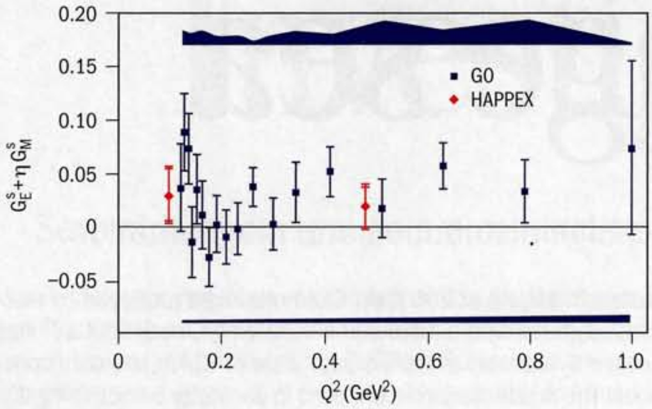


Fig. 1. The linear combination of the strange form factors of the proton, $G_E^s + \eta G_M^s$, taken from the G0 and HAPPEX experiments, is plotted versus momentum transfer, Q^2. η is a kinematic factor that varies roughly as Q^2. The blue bands represent two types of correlated systematic uncertainties in the G0 data.

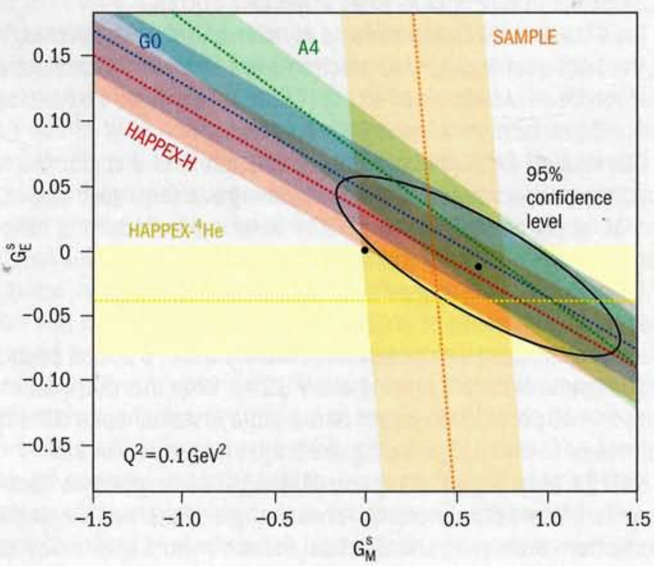


Fig. 2. Experimental range of values for G_E^s and G_M^s from measurements at Q^2 = 0.1. The region inside the ellipse represents the 95% confidence level allowed by present data.

depicted in figure 2. The results favour a positive value for G_M^s, suggesting that the strange quarks reduce the proton's magnetic moment. A negative value for G_E^s, while only hinted at by the data, would imply that the strange quarks prefer to be on the outside of the proton, while the anti-strange quarks favour the interior. However, current experiments are not precise enough for us to state definitively that the strange quark contributions are non-zero.

Within QCD-inspired models, predictions of the strangeness form factors vary tremendously. Of course, the models are of less interest than the predictions of nonperturbative QCD itself, for which our most reliable tool is lattice QCD. In this direction, there has been remarkable progress with a very precise recent determination of the strangeness magnetic moment ($G_M^s = -0.046 \pm 0.019\,\mu_N$), yielding an answer with an uncertainty of better than 1% of the proton's magnetic moment (Leinweber *et. al.* 2005). Testing this prediction will push the upcoming measurements to the limits of their precision.

Meanwhile, the experiments continue. HAPPEX is taking data this autumn, and the collaboration expects to reduce the error bars by a factor of three for both targets. Both the G0 and A4 collaborations have turned their detectors around by 180° and will soon measure backward-scattered electrons at various values of Q^2, which will be primarily sensitive to G_M^s. Combining forward- and backward-scattering results will allow both G_M^s and G_E^s to be individually determined. These additional measurements will allow experimenters to obtain G_E^s and G_M^s over a range of momentum transfers and thus pin down the importance of the contributions of the strange sea to the structure of the proton.

Further reading

K A Aniol *et al.* 2004 *Phys. Rev. C* **69** 065501.
K A Aniol *et al.* 2005 http://arxiv.org/abs/nucl-ex/0506010 and http://arxiv.org/abs/nucl-ex/0506011.
D S Armstrong *et al.* 2005 *Phys. Rev. Lett.* **95** 092001.
T M Ito *et al.* 2004 *Phys. Rev. Lett.* **92** 102003.
D Leinweber *et al.* 2005 *Phys. Rev. Lett.* **94** 212001.
F E Maas *et al.* 2004 *Phys. Rev. Lett.* **93** 022002.
F E Maas *et al.* 2005 *Phys. Rev. Lett.* **94** 152001.
D T Spayde *et al.* 2004 *Phys. Lett. B* **583** 79.

Résumé

Etudes des quarks étranges de la mer dans le proton

Si les trois quarks de valence sont importants pour déterminer les propriétés intrinsèques du proton, des expériences ont montré que la mer de quarks et de gluons présente dans le proton pourrait aussi jouer un rôle capital. Plusieurs groupes de recherche ont entrepris de déterminer les contributions exactes des quarks étranges de la mer à la distribution de charge et à la magnétisation dans le proton. Leurs résultats commencent à faire apparaître une image cohérente des quarks étranges dans le proton.

David Armstrong, *College of William and Mary, and*
Kandice Carter, *Jefferson Lab.*

Network boosts progress in therapy with light ions

ENLIGHT, the European Network for Research in Light Ion Therapy, has had its final meeting. But **Manjit Dosanjh** and **Giulio Magrin** say its crucial work must continue.

The attendees at June's closing ENLIGHT meeting, held in Oropa and organized by TERA, the Italian foundation for hadron therapy.

The European Network for Research in Light Ion Therapy (ENLIGHT), which had its inaugural meeting at CERN in February 2002, was established to coordinate European efforts in using light ion beams for radiation therapy. Funded by the European Commission for three years, the network was formed from a collaboration of European centres, institutions and scientists involved in research, and in the advancement and realization of hadron-therapy facilities in Europe (*CERN Courier* May 2002 p29). The final meeting took place in June in Oropa, an ancient sanctuary in the Italian Alps. Organized by the Italian foundation for hadron therapy, Fondazione per Adroterapia Oncologica (TERA), it was chaired by Ugo Amaldi, whose promotion of hadron-therapy facilities is highly valued and widely recognized.

The meeting went beyond providing a mere platform for discussion for the 100 scientists in ENLIGHT. Following immediately after the 10th Workshop on Heavy Charged Particles in Biology and Medicine (HCPBM), it became an international gathering for ▷

clinicians, radiobiologists, physicists and engineers, and provided an opportunity to demonstrate the latest developments in hadron therapy. There were presentations and discussions on the key areas outlined in the EU project: epidemiology and patient selection; clinical trials; radiation biology; beam delivery and dosimetry of ion beams; imaging; and the economics of hadron-therapy treatment.

ENLIGHT has succeeded in focusing the attention of countries on the importance of hadrons in cancer treatment.

Researchers already know that hadrons are an important alternative to photons for radiation therapy. Conventional radiation therapy with photon beams is characterized by energy release that decreases steeply after a maximum at a depth of 2–3 cm for typical beams. Hadrons, by contrast, release the highest density of energy at the end of their path. Therefore a beam of protons or light ions allows a highly tailored treatment of deep-seated tumours with millimetre accuracy, minimally damaging surrounding tissue.

ENLIGHT has been instrumental in bringing together different European centres to promote hadron therapy, in particular with carbon ions; to establish international discussions comparing the respective advantages of intensity-modulated radiation treatment (IMRT) with X-rays, proton and carbon therapies; and to address the ancillary equipment and methods necessary for such therapies. These efforts have included a study to compare the clinical data for proton therapy (at the Centre de Protontherapie, Orsay) and carbon-ion therapy (GSI) for certain types of tumour (chordomas and chondrosarcomas) at the base of the skull.

Carbon-ion therapy

Clinical trials are conducted for a specific tumour type and location to identify the total amount of dose to be delivered, the optimal number of fractions and the possible combination with other treatments. (Fractions are the number of radiation treatments in which the total required dose is delivered). Experience gained from clinical results obtained with carbon ions at the Heavy Ion Medical Accelerator in Chiba (HIMAC) in Japan and at GSI shows that these particles are very effective at treating tumours as they produce irreparable neighbouring multiple-strand breaks in the double helix of DNA, mainly in the region of the tumour cells; furthermore, post-treatment survival rates are improved.

A group of clinicians from HIMAC presented some remarkable results at the meeting. They conducted trials on "non-small" lung cancers in which the number of fractions was decreased from 16 to 4; for small lung and liver cancers, treatments are carried out in only one or two irradiation sessions; prostate cancer is treated in fewer than 20 sessions, while approximately 30 are needed for proton therapy and 40 for conventional radiotherapy. In the Japanese carbon-ion facility the average number of fractions is reduced to 13, less than half of what is needed for proton or traditional radiotherapy treatment. This simultaneously decreases the patient's discomfort, increases the number of patients that can be treated per year and lowers the cost of the total treatment.

With two new hadron-therapy centres soon to become operational in Heidelberg and Pavia, analysing the cost of ion therapy versus traditional treatment is an important issue. A session of the meeting was devoted to discussing the economic aspects of facilities and treatments, with several European estimates indicating the cost of a hadron-therapy centre to be in the order of €100 million. A study carried out at the German cancer research centre, Deutsches Krebsforschungszentrum (DKFZ), has compared the treatment cost of chordoma at the base of the skull, in which surgical removal is followed by conventional radiotherapy or carbon-ion radiotherapy. A primary 20-fraction treatment with carbon ions has an estimated cost of €20 000–25 000, more than primary conventional radiotherapy. However, hadron therapy becomes more cost-effective in the long term, as it makes recurring tumours less likely. Furthermore, the cost of carbon-ion therapy could decrease if there are fewer fractions.

The meeting also looked at the principles of treatment optimization and planning. The centre at PSI in Villigen has studied treatment planning for intensity-modulated proton treatment (IMPT), in which three or four fields with complex particle fluences combine to create a uniform dose in the treatment volume. In this way, it is possible to optimize the sparing of healthy tissue. A similar project is under study for carbon ions at GSI.

Studies are under way to investigate the implementation of online positron emission tomography (PET) imaging in carbon-ion facilities. The technique uses the positrons emitted by the nuclear fragments of the treatment beam and the imaging systems of the conventional PET. It offers a non-invasive method for comparing *in situ* the planned dose and the dose delivered. The data can be used to correct and redesign planning for subsequent treatment fractions. Work on online PET in proton therapy was also presented.

The meeting also learned of a project that compares the dose distribution achieved with X-rays, protons and carbon ions. The treatment-plan systems available for IMRT – passive scattering and spot scanning for proton beams, and raster scanning for carbon ion beams – are being used to compare the effectiveness of the different radiations in delivering the dose to the target volume while sparing the organs at risk. When implemented, this could become a fundamental daily reference tool for radiotherapists and oncologists.

Facilities for the future

There are a variety of facilities with highly specialized beams available for studying specific radiobiological aspects in Europe that could be more usefully organized on a wider basis. This was discussed during the meeting, with proposals ranging from identifying a single European facility for studying radiobiology in hadron therapy to the creation of a European network of existing and new facilities. In both cases, the EU framework programmes are seen as potential funding sources, with a common European "Experiments Committee" to approve experiments and allocate beam time.

In the ENLIGHT network the characteristics of synchrotron-based hadron-therapy centres have been studied to optimize designs for a possible second-generation hadron-therapy facility. The work has involved the optimization of injection and extraction systems, the beam diagnostic, monitoring of the treatment, and the dosimetry.

In the final session, the role and effect of the ENLIGHT initiative and future perspectives were discussed. It was acknowledged that the network has certainly succeeded in focusing the attention of European countries on the importance of hadrons in cancer treatment. Four national centres have been approved: Heidelberg Ion Therapy (HIT); the Centro Nazionale di Adroterapia Oncologica (CNAO) in Pavia; MedAustron in Wiener Neustadt; and ETOILE in Lyon. There is an increasing interest in further initiatives and more countries are expressing interest in creating national projects, in particular Sweden, the Netherlands, Belgium, Spain and the UK.

Interest in the industry is increasing rapidly. Several companies with experience in proton accelerators are preparing to launch carbon-therapy machines on the market. For example, Roberto Petronzio, president of the Istituto Nazionale di Fisica Nucleare (INFN), announced an agreement between INFN, Ansaldo Superconduttori and ACCEL to develop and launch a 250 MeV/u superconducting cyclotron suitable for protons and carbon ions (*CERN Courier* September 2005 p9).

The interest in carbon-ion therapy is also crossing the Atlantic back to the US, where the initial pioneering studies using hadrons began more than 50 years ago at Lawrence Berkeley Laboratory. Although the most recent facilities installed in the US are based on proton accelerators, there is growing interest in using heavier ions, and building dual systems for both proton and carbon ions is becoming more likely.

A major success of ENLIGHT has been the creation of a multidisciplinary platform, uniting traditionally separate communities so that clinicians, physicists, biologists and engineers with experience in carbon ions and protons work together. It was unanimously acknowledged that ENLIGHT has been a key catalyst in building a European platform and pushing hadron therapy forward. Discussions are under way to continue this fruitful network, as it is felt that ENLIGHT is a crucial ingredient for progress and therefore should be maintained and broadened.

• ENLIGHT consists of the following members: the European Society for Therapeutic Radiology and Oncology (ESTRO); CERN; the European Organisation for Research and Treatment of Cancer (EORTC); GSI; the Deutsches Krebsforschungszentrum (DKFZ); the Fondazione per Adroterapia Oncologica (TERA); the Karolinska Institutet; the ETOILE project; the Forschungszentrum Rossendorf (FZR), Dresden; the Hospital Virgen de la Macarena, Sevilla; and Charles University, Prague.

Résumé

Le réseau ENLIGHT dynamise la thérapie par ions légers

ENLIGHT, Réseau européen de recherche sur la thérapie par les ions légers, a récemment tenu sa dernière réunion. Financé par l'UE pendant trois ans, le réseau avait pour mission de coordonner les recherches menées en Europe sur l'utilisation des faisceaux d'ions légers (hadrons) en radiothérapie. La réunion a fait ressortir les avancées dans ce domaine et le rôle-clé qu'a joué le réseau en rapprochant différents centres européens pour promouvoir la thérapie hadronique, en particulier à l'aide d'ions carbone.

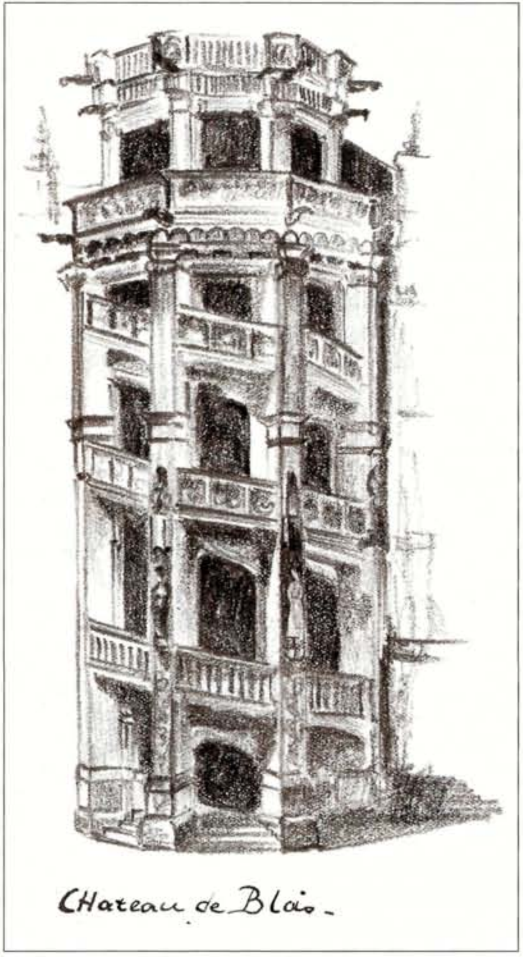
Manjit Dosanjh, *CERN, and* **Giulio Magrin**, *TERA.*

Pomerons return to Blois

Pomeron physics and QCD met once again at the XIth International Conference on Elastic and Diffractive Scattering: Towards High Energy Frontiers.

Twenty years ago the first "Blois Workshop" was organized by Basarab Nicolescu of the University Paris VI and Jean Tran Thanh Van of the University Paris Sud in the historic Château de Blois. Now, the 11th conference in this international biannual series focusing on elastic scattering and diffraction returned to Blois on 15–21 May 2005. Organized by the original team plus Maurice Haguenauer of the Ecole Polytechnique, it set the scene for future high-energy studies in this field.

Blois Workshops have taken place all over the world, and the meeting is now a scientific forum for researchers trying to unravel the foundations of elastic scattering and diffraction from first principles in quantum chromodynamics (QCD). Originally a rather specialized field, this has moved towards the centre of high-energy QCD studies. This is particularly because measurements at HERA and Fermilab show that diffractive events, where a scattered proton remains intact in a high-energy inelastic collision, constitute a surprisingly high proportion of the entire rate. Recent measurements from the ZEUS and H1 detectors at HERA show that approximately 10% of the deep inelastic lepton–proton scattering cross-section is diffractive.



The spiral staircase of the Château de Blois was an attractive motif for the meeting. (Drawing by T van Vlijmen; reproduced with permission.)

High-energy elastic and diffractive scattering is traditionally explained in Regge theory as a result of pomeron exchange. Here the system exchanged between projectile and target carries the quantum numbers of the vacuum (*CERN Courier* April 1999 p29). Events with large gaps in the rapidity distribution occur even in hard collisions involving very high momentum transfers. Such "hard diffraction" has now become firmly established, initially at the Intersecting Storage Rings (ISR) and Super Proton Synchrotron (SPS) at CERN in proton and antiproton collisions, and now most clearly at HERA in positron–proton collisions, and in proton–proton collisions at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven and the Tevatron at Fermilab.

With the advent of QCD, hard diffraction became attributed to the exchange of two or more gluons with net zero colour, and these processes are now an important observable for understanding fundamental aspects of the strong interactions. At the conference, Peter Landshoff from Cambridge and Sandy Donnachie from Manchester reviewed the apparent dichotomy between the soft and hard aspects of pomeron exchange and the phenomenological manifestations, such as the remarkable growth with energy of the cross-section for hard diffractive electroproduction of vector mesons. Theorists are beginning to develop formalisms that encompass the transition between hadron and quark–gluon degrees of freedom and the duality between the two descriptions.

QCD also predicts the existence of a C-odd three-gluon exchange, which through interference with the pomeron exchange leads to remarkable charge asymmetries in diffractive reactions.

One interesting nuclear diffractive phenomenon is the demonstration of QCD "colour transparency" by the E791 fixed-target experiment at Fermilab, which measured the diffractive dissociation of a high-energy 500 GeV/c pion into two high-transverse-momentum jets while leaving the target nucleus intact. The experiment confirmed the remarkable prediction, based on the gauge interactions of QCD, that the small quark–antiquark Fock component of the pion projectile interacts coherently on every nucleon in the nucleus without absorption or energy loss, in dramatic contrast with traditional Glauber theory. The diffractive dijet experiment also provides crucial information on the quark–antiquark wavefunction of the pion. Other diffractive experiments that explore the structure of the photon are now in progress at HERA.

Contrary to parton-model expectations, the rescattering of the quarks with the spectator constituents shortly after the nucleon has been struck by the lepton critically affects the final state in deep inelastic scattering (DIS). The rescattering of the struck quark from gluon exchange generates dominantly imaginary diffractive amplitudes. This gives rise to a dijet effective "hard pomeron" exchange – a rapidity gap between the target and the diffractive system – while leaving the target intact. The diffractive cross-section measured in diffractive deep inelastic scattering can be interpreted in ▷

terms of the quark and gluon constituents of an effective pomeron as in the model by Gunnar Ingelman and Peter Schlein. Since the gluon exchange occurs after the interaction of the lepton current, the pomeron cannot be considered a pre-existing constituent of the target proton. The rescattering contributions to the DIS structure functions are not included in the target proton's wavefunctions computed in isolation, and cannot be interpreted as parton probabilities. The resulting gluon exchange matches closely the phenomenology of the soft colour interaction model. Gluon exchange in the final state also leads to Bjorken-scaling the Sivers single-spin asymmetry, a T-odd correlation between the spin of the target proton and the production plane of a produced hadron or quark jet.

Participants at the 11th meeting included many of those present at the first Blois Workshop held 20 years ago.

The connections between diffraction and coherent effects in nuclei such as shadowing and anti-shadowing are also now being understood. Diffractive deep inelastic scattering on a nucleon leads to nuclear shadowing at leading twist as a result of the destructive interference of multistep processes within the nucleus. In addition, multistep processes involving Reggeon exchange lead to anti-shadowing. In fact, since Reggeon couplings are flavour-specific, anti-shadowing is predicted to be non-universal, depending on the type of current and even the polarization of the probes in nuclear DIS.

Saturation under focus

A central focus of the 2005 Blois conference was the physics of "saturation", a QCD phenomenon that limits particle production when the underlying gluonic scattering subprocesses significantly overlap in space and time. At very high energies, the gluon density is so high that two scatterings have the same probability as one. The theory of saturation is based on the Balitsky–Kovchegov equation and its extensions, and has analogues with stochastic methods used in other areas of statistical physics. The effects of saturation can be observed in the small-x, high-energy domain of deep inelastic lepton scattering at HERA, thus providing a window into nonlinear aspects of QCD.

The theory of saturation predicts a parameterization of the HERA data ("geometrical scaling") that gives a remarkably good description of the deep inelastic structure functions at small-x in terms of a single scaling variable. The high occupation number of gluons can even lead to the formation of a "colour glass condensate", which may be causing a decrease of particle creation at forward rapidities in heavy-ion collisions at RHIC.

The nonlinear gluon interactions of QCD also underlie the physics of the hard Balitsky–Fadin–Lipatov–Kuraev pomeron, which is postulated to control the energy dependence of hard reactions, as well as the distribution of particle production at very small values of x and extreme values of rapidity.

Remarkably, Juan Maldacena's "anti-de-Sitter-/conformal-field-theory (AdS/CFT) duality" between conformal gauge field theory and string theory in 10 dimensions has begun to make an impact on QCD studies. The mapping of quark and gluon physics onto the fifth dimension of anti-de Sitter space is providing insight into the gluonium spectrum that controls the pomeron trajectory and light-quark hadron spectroscopy. Moreover, it explains the success of QCD counting rules for hard elastic scattering reactions using the methods of Joseph Polchinsky and Matt Strassler.

The AdS/CFT correspondence also explains the dominance of the quark interchange mechanism in hard exclusive reactions, and gives a model for the basic light-front wavefunctions of hadrons that incorporates conformal scaling at short distance and colour confinement at large distances. Lattice gauge theory is also making an impact on the QCD physics of high-energy collisions.

Much of the phenomenological work in pomeron physics was pioneered by loyal participants in the Blois conference series. Many of the original participants of the first Blois Workshop attended the 20th anniversary conference and presented their current work. While the discussions at the first Blois Workshop centred on results from the ISR at CERN and the first data from the SPS as a proton–antiproton collider (with predictions for the Tevatron and Superconducting Super Collider projects), the XIth International Conference had speakers reporting the latest experimental results from the Tevatron, from polarized proton–proton (and proton–carbon) experiments using fixed and jet targets at RHIC (see p15), and from HERA at DESY. HERA II running has started and a significant and welcome statistical increase in diffraction data is expected before the machine closes down in 2007.

The experimental efforts under way regarding forward physics at the Large Hadron Collider (LHC) at CERN were extensively discussed; the large increase in reach in x and Q^2 in proton–proton and nucleus–nucleus collisions will provide significant tests and advances for QCD-inspired diffraction phenomenology and calculations. There was also speculation that the Froissart bound for the total proton–proton cross-section will be saturated at the LHC, with its value controlled not by pion exchange but by the exchange of the lightest glueball, as originally predicted by Nicolescu. An exciting possibility for the future is observing the Higgs boson in doubly tagged diffractive collisions $pp \rightarrow p + H + p$ at the LHC; the Higgs would be found as a peak in the missing mass spectrum, rather than in a specific decay channel.

A number of presentations addressed existing and new cosmic-ray detector arrays, where the discrepancy above the Greisen–Zatsepin–Kuzmin cut-off between the excess in the Akena Giant Air Shower Array (AGASA) and the fall-off in the High Resolution Fly's Eye (HiRes) experiment continues to generate interest. Some proposals for very forward instrumentation at the LHC are dedicated to providing benchmarks for simulations of cosmic-ray shower initiation: the Centauro and Strange Object Research (CASTOR) detector in TOTEM/CMS for forward electromagnetic showers, and in the proposed LHCf for the measurement of forward π^0s. Zero-degree neutron calorimeters, which are operating successfully in the experiments at RHIC, will have counterparts in the heavy-ion programme at the LHC, but would also be very useful and complementary tools in the measurement of diffraction in proton–proton collisions.

The diffractive production of vector mesons and single hard photons at HERA provides a way to select and determine different generalized parton distributions (GPDs), the quantum-mechanical parton wavefunctions, of the proton. Early results from HERMES and from the H1 and ZEUS experiments seem to be in close agreement with current GPD models. A number of talks discussed the physics of other exclusive diffractive reactions such as two-photon collisions, which are sensitive to the vector meson distribution amplitudes as well as the exchange mechanism. Double-charm production, an indication of an intrinsic heavy-charm component in thé proton wavefunction, was demonstrated by the SELEX experiment at Fermilab. The production of pentaquarks and other exotic quark bound states was reviewed with the conclusion that the situation is still very confused, with seemingly contradictory results.

At this anniversary, a number of overviews were presented surveying the progress in diffractive physics, both experimentally and theoretically, made over the past 20 years. Alan Krisch of Michigan told the story of his pioneering measurements of hadronic spin effects, and the extraordinarily large spin correlations that were discovered in large-angle elastic proton–proton scattering and that are still only partially understood. Konstantin Goulianos of Rockefeller University gave an overview of diffraction, both soft and hard, as measured at the Tevatron and its connection to results from HERA. Gunnar Ingelman of Uppsala presented the enormous evolution in understanding of hard diffraction since it was first observed by UA8 at CERN's proton–antiproton collider.

The overall atmosphere of the conference was one of expectation: for the data from the new runs that have started at the Tevatron and at HERA II, and from the LHC which will start running around the time of the next Blois conference. Indeed, the next two meetings may well see significant progress in the understanding of both soft and hard diffraction.

• In a short article only a few contributions can be properly attributed. See http://lpnhe-theorie.in2p3.fr/EDS05Accueil.html for full credit to the contributors and more on their presentations.

Résumé

Les pomérons reviennent à Blois

Il y a vingt ans, Basarab Nicolescu (Université Paris VI) et Jean Tran Thanh Van (Université Paris-Sud) organisaient dans le célèbre château de Blois un atelier consacré à la diffusion élastique et diffractive. En cette année 2005, du 15 au 21 mai, la onzième conférence internationale itinérante bisannuelle sur ce thème est revenue à son berceau et l'équipe d'origine, à laquelle s'est joint Maurice Haguenauer de l'Ecole polytechnique, en a repris l'organisation. La conférence a suggéré des orientations pour les recherches futures dans ce domaine des hautes énergies.

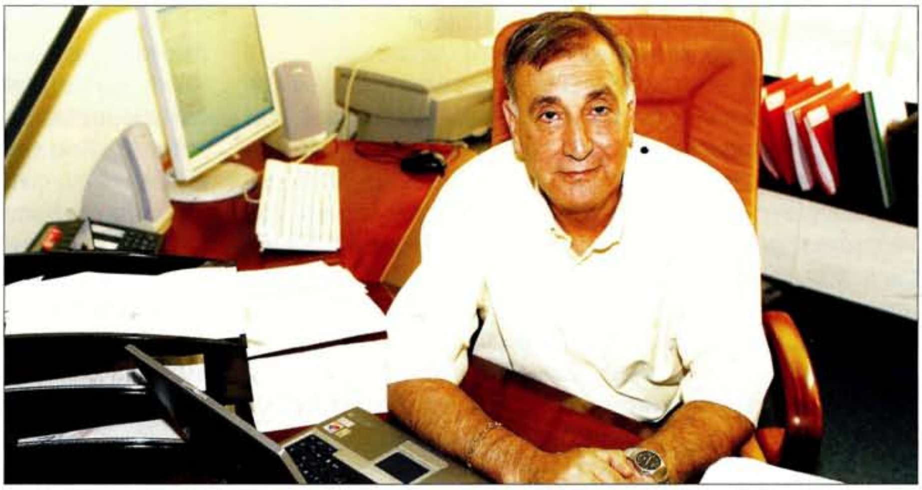
Stanley J Brodsky, *SLAC, and* **Michael Rijssenbeek**, *Stony Brook University.*

LABORATOIRES

La construction d'un projet ambitieux: SPIRAL2 at GANIL

Depuis le 1er juillet, le Grand accélérateur national d'ions lourds (GANIL), situé à Caen en France, est doté d'une nouvelle équipe de direction mandatée pour cinq ans. Cette équipe a été fortement renforcée pour faire face à deux défis: construire dans un cadre européen, dans le temps et l'enveloppe budgétaire prévue, SPIRAL2, la nouvelle machine à faisceau de noyaux exotiques récemment décidée; tirer le meilleur profit scientifique du GANIL actuel avec les faisceaux exotiques de première génération, le Système de production d'ions radioactifs accélérés en ligne (SPIRAL).

Sydney Gales, scientifique de haut niveau, occupe le poste de directeur; Marcel Jacquemet, ingénieur du Commissariat à l'énergie atomique (CEA) aux larges compétences, assure à la fois les fonctions de directeur adjoint et chef du projet SPIRAL2; Philippe Chomaz, chercheur internationalement reconnu, est l'adjoint du directeur en charge de la physique; enfin Marek Lewitowicz, ancien directeur adjoint ayant activement milité pour l'acceptation du projet SPIRAL2, assure la direction scientifique.



Sydney Gales a pris la direction du GANIL le 1er juillet dernier.

Sydney Gales, physicien au Centre national de la recherche scientifique (CNRS), débute sa carrière d'expérimentateur à l'Institut de physique nucléaire d'Orsay. Il y soutient sa thèse en 1976 et initie des collaborations internationales sur la physique des "états géants" du noyau avec les grands laboratoires: l'université de l'Etat du Michigan, l'Installation du cyclotron de l'université d'Indiana, le JINR de Doubna, Le Centre de recherches pour la physique nucléaire d'Osaka. De 1986 à 1994, il est le chef de projet de la collaboration européenne qui conçoit et construit le premier cyclotron européen supraconducteur, l'Accelerateur Groningen-Orsay (AGOR), à Groningen. Sydney Gales participe à l'élaboration de la politique scientifique au sein d'instances scientifiques telles que le Comité de coordination de physique nucléaire expérimentale, dont il devient le président de 1996 à 1999, la Fondation pour la science européenne ou l'Organisation de coopération et de développement économiques (OCDE). Il est, en outre, membre des comités de revue de grands laboratoires comme GSI en Allemagne, ou RIKEN au Japon. A ces activités s'ajoute l'expérience approfondie de la gestion de la recherche: en tant que directeur de l'Institut de physique nucléaire d'Orsay (1994–2002) et au titre de directeur scientifique adjoint de l'Institut national de physique nucléaire et de physique des particules (IN2P3) du CNRS (depuis novembre 2004).

Sydney Gales réunit ainsi l'expérience nécessaire à la direction d'un laboratoire tel que le GANIL – laboratoire commun au CEA/Direction des sciences de la matière et au CNRS/IN2P3 – qui fédère les communautés scientifiques utilisant les faisceaux qu'il délivre actuellement et ceux, uniques, que produira SPIRAL2, nouvelle machine européenne dans un avenir proche. Au coeur de cette prochaine installation, un accélérateur linéaire supraconducteur générant des faisceaux d'ions les plus intenses au monde, produira en abondance neutrons et noyaux exotiques. SPIRAL2 ouvrira ainsi de nouveaux horizons à la physique et à l'astrophysique nucléaire, mais aussi à l'étude des matériaux sous irradiation dans les domaines de l'énergie et des applications médicales.

Marcel Jacquemet est le chef du projet SPIRAL2. Son expérience dans la construction de grands instruments, tel le grand interféromètre VIRGO dont il a été le directeur technique de 1992 à 1996, et ses qualités de management éprouvées à plusieurs reprises, encore tout dernièrement comme directeur adjoint du département d'Astrophysique, de physique des particules, de physique nucléaire et de l'instrumentation associée au CEA Saclay, lui donnent des atouts pour mener à bien cette entreprise ambitieuse comportant des défis technologiques. La réussite du projet SPIRAL2 repose sur la nécessaire coordination de la participation de laboratoires français et européens à sa construction. Nécessitant un investissement total est de 130 millions d'euros, ce projet témoigne de la volonté conjointe de la région de Basse-Normandie, des organismes – CEA, CNRS – du gouvernement français, et de l'Europe de voir aboutir cette réalisation en 2010.

APPOINTMENTS

John Womersley chosen to take charge of particle physics at RAL

John Womersley has joined the UK's Council for the Central Laboratory for the Research Councils (CCLRC) as director of particle physics, based at the Rutherford Appleton Laboratory. He will be responsible for the particle-physics research programme and he will also advise the CCLRC on its future particle-physics strategy.

For the past year, Womersley has been in Washington as scientific adviser to the associate director of high-energy physics at the Department of Energy. He takes over on 1 October from Ken Peach, who has stepped down to take up his new post as director of the John Adams Institute for Accelerator Science (*CERN Courier* June 2005 p37).

Womersley: RAL's particle-physics director.

Womersley, who was born and educated in the UK, moved to the US after completing his DPhil at Oxford in 1986. After time at the University of Florida, Florida State University and the Superconducting Supercollider in Texas, he moved to Fermilab and in 1999 became co-spokesperson of the D0 experiment at the Tevatron. His past research includes the design and construction of high-energy-physics detectors, computing and software, and data analysis. He is already well known to many in the UK's particle-physics community.

Brookhaven names Sally Dawson as chair of its physics department

Sally Dawson became chair of the physics department at the US Department of Energy's Brookhaven National Laboratory on 1 July. She succeeds Samuel Aronson, who has become associate laboratory director for high-energy and nuclear physics (*CERN Courier* June 2005 p37). She has been acting chair since January 2005.

Following research at Fermilab and the Lawrence Berkeley Laboratory, Dawson joined Brookhaven in 1986, and led the high-energy theory group from 1998 to 2004. She has served on many national and international committees, and was chair of the American Physical Society's particle-physics division in 2004. Since 2004 Dawson has been vice-chair of the National Research Council's EPP2010 particle-physics review, and since 2001 she has been an adjunct professor at the C N Yang Institute for Theoretical Physics at Stony Brook University.

The physics department at Brookhaven operates three of the four major experiments at the Relativistic Heavy Ion Collider (RHIC). Nuclear physicists in the department are also helping to drive a laboratory-wide initiative to upgrade RHIC to RHIC II, increasing the collider's rate of particle interactions tenfold, and to add an electron ring to RHIC to create the eRHIC for colliding electrons with protons. In addition, physicists from the department are participating in the ATLAS detector for the Large Hadron Collider (LHC) at CERN.

NEW PRODUCTS

Acqiris now offers a compact, portable multi-channel data-acquisition system that delivers essential oscilloscope properties in a small, modular package. The new MAQbox systems can accommodate multiple digitizers, feature a scope-like graphical user interface and have up to 28 high-speed channels. The MAQbox software provides easy remote control from a laptop and enables simultaneous monitoring and control of data-acquisition systems at different locations. For further information see www.acqiris.com.

Fujikura Europe has announced the FID-20, a real-time operational data detector for installing and maintaining fibre links. Battery-operated, it detects light from a fibre and displays the presence of different kinds of signal with their traffic directions. It is available with and without an optical power meter. For more details tel. +44 208 240 2000 or see www.fujikura.co.uk.

Pfeiffer Vacuum has introduced the OnTool Booster pump, the first turbo pump that goes from atmosphere to high vacuum, eliminating the need for a backing pump. With an ultimate pressure of less than 1×10^{-5} mbar, it has a low vibration level that prevents movement of critical parts, and its compact size permits direct mounting to a tool. It is ideal for clean applications that operate without particulate matter, corrosive gases or condensation. For further information tel. +1 603 578 6500 or see www.pfeiffer-vacuum.com.

JULICH

STORI'05 conference looks ahead to the future of FAIR

Participants at STORI'05 photographed at the Gustav Stresemann Institute, Bonn.

STORI'05, the 6th International Conference on Nuclear Physics at Storage Rings, took place on 23–26 May 2005 at the Gustav-Stresemann-Institut, Bonn. It was organized by the Institute for Nuclear Physics of the Research Centre Jülich, and attended by more than 100 participants from all over the world.

STORI conferences started as the Symposium on Nuclear Physics at Storage Rings in 1991 in Lund and 1994 in St Petersburg. Since being renamed, three conferences have taken place in Bernkastel-Kues, Bloomington and Uppsala. The sixth meeting saw a return to Germany.

In the 26 invited and 39 contributed talks at STORI'05, topics ranged from atomic physics at storage rings, through aspects of nuclear physics, to hadron physics. They included the latest results from the Cooler Synchrotron (COSY) in Jülich, GSI in Darmstadt and DAFNE at Frascati. A number of contributions that related to the future Facility for Antiproton and Ion Research (FAIR) attracted special attention. This major European project for atomic, nuclear and hadron physics will rely on the successful operation of storage rings. In particular ideas for experiments with polarized antiprotons were presented, which will yield unique information about the spin structure of the nucleon (transversity). During an excursion the participants could visit the COSY accelerator and its detection systems.

STORI'05 was supported by the German Federal Ministry of Education and Research (BMBF), Deutsche Forschungsgemeinschaft (DFG), Gesellschaft für Schwerionenforschung (GSI), Darmstadt and FZJ, and Hans Ströher from Jülich headed the organizing committee. The next STORI conference will be in 2008 in Lanzhou, China, at the Institute for Modern Physics (IMP) of the Chinese Academy of Sciences. The chairman will be Wenglong Zhan, director of IMP.

MEETINGS

The international workshop **e^+e^- Collisions from ϕ to J/ψ** will be held at the Budker Institute of Nuclear Physics, Novosibirsk, Russia, on 27 February – 2 March 2006. Past workshops were at Novosibirsk (1999), SLAC (2001) and Pisa (2003). For further details see www.inp.nsk.su/conf/phipsi06.

CORRECTION

In the item on the visit to CERN of Lino Baranao, president of the National Agency for the Promotion of Science and Technology in Argentina (September p46), errors occurred in two names. The picture shows Giora Mikenberg (second left) and Karina Loureiro (right). Apologies to all concerned.

AWARDS

Gell-Mann receives 2005 Einstein Medal

Left to right: Murray Gell-Mann, Peter Minkowski, president of the scientist board of trustees of the Albert Einstein Society, and Samuel Schmied. (Courtesy E Ruchti, Brügg.)

Murray Gell-Mann, well known as the "father" of quarks and for his many contributions to theoretical particle physics, has been awarded the Albert Einstein Medal for 2005 – the World Year of Physics and the centenary of Einstein's *annus mirabilis*. The medal is awarded by the Albert Einstein Society to individuals for outstanding scientific findings, works or publications related to Einstein.

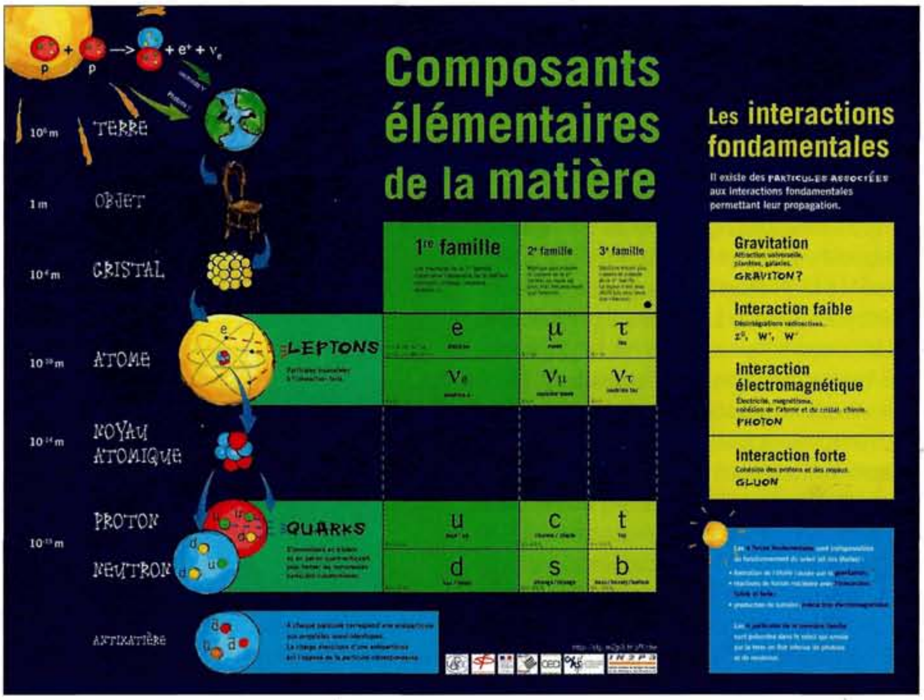
Samuel Schmied, president of the Swiss Confederation, presented the medal in a ceremony in Bern on 9 July. Gell-Mann is the third particle physicist to receive the medal.

Skrinsky receives a Kapitsa Gold Medal

Alexander Skrinsky, director of the Budker Institute of Nuclear Physics in Novosibirsk, has received a prestigious P L Kapitsa Gold Medal from the Russian Academy of Science (RAS). Skrinsky received the medal for his work on the construction of storage rings for studies in particle physics and for various applications as sources of synchrotron radiation. The medal has been awarded since 1994.

L'ANNEE MONDIALE DE LA PHYSIQUE

Les particules s'affichent dans les lycées



Au cours de cette Année Mondiale de la Physique, de nombreuses initiatives sont prises dans tous les pays pour promouvoir cette science et essayer de transmettre au grand public l'intérêt de ces recherches et la passion qui anime les chercheurs. Le relatif désintérêt pour la physique, qui se manifeste par une baisse du nombre des étudiants au cours du premier cycle universitaire, se produit au collège et au lycée. Il est donc important d'essayer d'agir à ce niveau. Le caractère trop académique du programme de physique au lycée, au moins en France, peut en être une raison. D'où l'initiative d'un groupe de chercheurs du CNRS et du CEA, piloté par Guy Wormser (Laboratoire de l'Accélérateur Linéaire d'Orsay) de montrer dans chaque classe de physique en France une affiche des composants élémentaires de la matière.

Ce tableau résume plus de 100 ans de recherches en physique subatomique (entre 1895, découverte de l'électron, et 2000, établissement de l'existence du neutrino tau) dont pratiquement rien n'est enseigné dans les lycées français. Il complète le vénérable tableau de Mendeleïev (1868) qui occupe les murs de ces classes depuis plus de 50 ans, pour réveiller la curiosité scientifique des élèves et susciter quelques vocations de futur chercheur dans la discipline.

L'affiche a été réalisée par des élèves de l'Ecole Estienne de Paris, école d'art graphique renommée, à partir d'un cahier des charges établi par les chercheurs et des professeurs du secondaire. Le tableau des composants élémentaires est accompagné de la liste des interactions fondamentales et des particules associées. L'existence de l'antimatière est indiquée. Le soleil a été choisi comme exemple pour montrer que notre univers a besoin de l'ensemble de ces forces et particules pour fonctionner et que l'infiniment petit a des liens intimes avec l'infiniment grand. Les quelques éléments du programme scolaire (ordres de grandeur, composition de l'atome, désintégrations nucléaires) ont été intégrés du mieux possible.

Vingt mille affiches seront envoyées début octobre à tous les lycées français avec la participation active du Ministère de l'Education Nationale. Elles seront accompagnées d'un livret d'explications pour que chaque professeur de physique puisse répondre aux questions des élèves. Une première diffusion dans cinquante classes en juin 2005 a reçu un accueil très favorable. Chaque lycée recevra, en outre, un CD-ROM décrivant avec beaucoup plus de détails la physique subatomique ("Particles Adventure" développé par des physiciens du CPEP à LBNL). Un site Web, http://sfp.in2p3.fr/affiche, encore en construction, contient l'ensemble de ces documents et accueillera bientôt un forum interactif où les élèves pourront poster leurs questions et commentaires.

Une collaboration internationale se crée pour étendre cette initiative à d'autres pays (Le Canada et l'Inde ont déjà déclaré leur intérêt) Le CERN, via son groupe de professeurs de "Physics on Stage", va fournir des traductions de l'affiche en plusieurs langues. La version Web sera bientôt "cliquable" pour raconter l'histoire de chaque particule plus en détail. (N'hésitez pas à contacter Guy Wormser si vous voulez participer d'une façon ou d'une autre à ces projets: Guy Wormser wormser@lal.in2p3.fr).

La valeur de cet initiative réside moins dans l'affiche elle-même que dans sa diffusion à très grande échelle en partenariat avec l'Education Nationale. Pour un coût modeste (le budget total de l'opération a été de 41 k€), 500 000 élèves en France seront en contact presque quotidien avec la physique subatomique, pendant les trois années de leur séjour au lycée. Comme cette affiche peut durer une bonne dizaine d'années, c'est au total plusieurs millions de futurs citoyens qui auront acquis une meilleure connaissance du monde magique et mystérieux des particules élémentaires et qui pourront ainsi soutenir une recherche active dans ce domaine.

How you can help

For the World Year of Physics, a group of French physicists has designed a poster (see http://sfp.in2p3.fr/affiche) of the elementary components of matter. This is being deployed in physics classes in France's 3600 high schools. The poster is being translated into many European languages, together with the accompanying booklet and CD-ROM. If you would like to help with extending the initiative to other countries please contact Guy Wormser (e-mail wormser@lal.in2p3.fr).

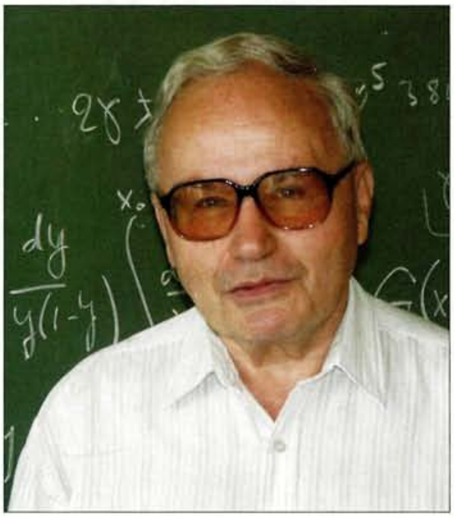
NOVOSIBIRSK

Baier and Sidorov of the Budker Institute celebrate 75th birthdays

Vladimir Baier, an eminent particle-physics theorist from the Budker Institute of Nuclear Physics in Novosibirsk (BINP), is 75 on 27 September. Having started his scientific career in the Lebedev Institute in 1955, Baier joined the BINP soon after its foundation and contributed much to forming its theory division. In 1959, well before experiments began in 1964 at the electron–electron collider VEP-1 in Novosibirsk, he advanced the idea of electron–positron colliders with their high potential for physics. He has taught for many years at the Novosibirsk University and many of his students are now well known scientists.

Baier is known for his fundamental contributions to quantum electrodynamics (QED) at high energies including the theory of inelastic processes, radiative corrections, radiative polarization and radiative return. Together with his students he formulated the operator approach to QED in external fields and developed a universal quasi-classical method for describing high-energy processes, and created one of the pioneering works on the theory of free-electron lasers. More recently, his team has developed a new area in QED: the theory of interactions of electrons, positrons and photons with oriented crystals. Recent work also includes the theory of the influence of multiple-scattering (the Landau–Pomeranchuk–Migdal effect) and external fields on basic electromagnetic processes.

Veniamin Sidorov will be 75 on 19 October. An outstanding member of Gersh Budker's school, Sidorov started his career at the Kurchatov Institute after graduating from Moscow University in 1953, but he has been closely linked to the BINP since 1961, when he moved to Novosibirsk and joined the pioneering work on electron–electron and electron–positron colliders. Here his laboratory had to develop novel techniques of particle detection for collider experiments and solving this problem allowed tests of QED, studies of vector mesons and the first observations of two-photon and multihadronic production.



Baier (left) and Sidorov (right), who are both celebrating their 75th birthdays this autumn.

For more than 25 years, Sidorov and his many colleagues systematically studied e^+e^- annihilation into hadrons using increasingly complex detectors, from OLYA and ND to CMD2 and SND at VEPP-2M, and from MD-1 to KEDR at VEPP-4. The low-energy collider VEPP-2M was particularly fruitful: analysis of large data samples collected over 25 years significantly improved our knowledge of light vector mesons and the total hadronic cross-section, providing important information for precision tests of the Standard Model using the muon anomalous magnetic moment.

In the late 1980s, the broad scope of Sidorov's interests helped to start work on the low-dose digital X-ray devices for medical diagnostics. First developed and produced at BINP, they are now in mass-production at two Russian factories.

Sidorov's outstanding organizational abilities allowed him to serve as a deputy director of BINP, one of the largest Russian physics centres, for 23 years and to contribute significantly to preserving a high level of research in recent years.

Understanding the potential of B-factories, he supported participation of physicists from Novosibirsk in the Belle and BaBar experiments at KEK and SLAC respectively, and actively contributes to the Belle experiment. His efforts as a coordinator of the Russian-Japanese scientific exchange helped develop various high-energy physics projects.

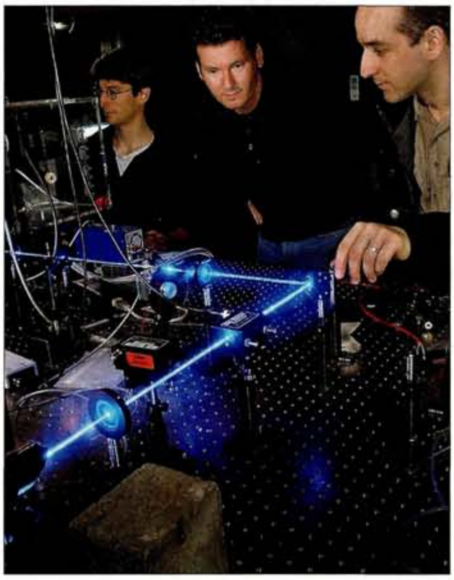
MOLECULAR BIOLOGY

EMBL welcomes physics students

Physics and life meet at the level of the molecules that make up our cells. Molecular biology aims to understand life at all scales: from the structure of single molecules up to the way they work together in complex systems to create organisms. These are some of the most challenging problems in science today, and to tackle them, biology is increasingly integrating approaches from physics, mathematics and chemistry. The International PhD Programme at the European Molecular Biology Laboratory (EMBL) has found a successful model for doing this, welcoming predoctoral students, not only from the life sciences, but also from many other fields. After an intensive course that exposes the students to the spectrum of EMBL research, they join scientific groups and often lead fascinating projects that are equally challenging for scientists in all these fields.

One area in which physicists have been crucial is the development of synchrotron radiation for use in biology. EMBL builds and operates X-ray beamlines at the German synchrotron radiation facility at DESY in Hamburg and at the European Synchrotron Radiation Facility (ESRF) in Grenoble. At both sites, scientists, technicians, mathematicians and engineers work closely together to develop and improve methods to obtain atomic-resolution maps of molecules from protein crystals. Their innovations in technology and software are changing the way researchers design and test new drugs.

Another challenge is to observe life at resolutions that cannot be captured by traditional instruments. Synchrotrons reveal molecular details; electron microscopes provide images of larger structures such as cell organelles. Most cellular action happens between these levels as molecules self-organize into machine-like complexes. A new method called electron tomography, being co-developed by Achilleas Frangakiss, combines electron-microscope images taken from different angles into three-dimensional pictures in which molecular machines appear as fuzzy shapes. Researchers hope to identify different components with pattern-recognition software that docks higher-resolution maps of the molecules onto the shapes.



Christian Tischer, Philippe Bastiaens and Anthony Squire. The group is developing new microscopy methods to observe directly the interactions of proteins inside cells.

Ernst Stelzer is a physicist whose microscopy group has repeatedly produced innovations that have had an immediate impact on biological research. The team's photonic-force microscope reveals new aspects of molecular mechanics by trapping nanometre-sized beads attached to proteins in "optical tweezers", then tracking the bead at megahertz rates and with nanometre precision. This has enabled Stelzer and his colleagues to take precise measurements of the viscosity of the cell membrane for the first time, detecting structures that had previously never been observed directly. They have also gained unique insights into the kinetics of single molecules.

Recently the same group invented the selective plane illumination microscope (SPIM), which can watch dynamic processes in living organisms. The SPIM passes a microscopically thin sheet of light through a sample, which is quickly scanned from different directions. The resulting stacks of images are assembled into a high-resolution three-dimensional data set. The instrument has been used to study processes such as how axons crawl through tissues in developing embryos, hard-wiring the brain. Developmental biologist Jochen Wittbrodt uses the instrument to study how this process is disrupted by mutations that have been found in common genetic diseases.

Another interdisciplinary field involves the intersection between computers and biology. One challenge involves analysing complex data such as the genomes of humans and other organisms. Our knowledge of gene functions changes on a daily basis, and databases such as those managed at EMBL's European Bioinformatics Institute in the UK must be constantly updated. Given the pace of new discoveries, this will only be possible if scientists can create effective text-mining tools to extract information from biomedical literature. Developers such as Dietrich Rebholz-Schumann and Peer Bork have been working on this, drawing on ideas from linguistics, mathematics and particle-physics software.

Among the most complex tasks for computational biology are simulations of living processes – ranging from how amino acids fold into proteins to creating dynamic models of cellular structures. In "systems biology" the aim is to combine models with experiments to describe these processes. François Nédelec's group, for example, is simulating the behaviour of proteins that make up the "mitotic spindle", the structure that divides chromosomes during cell division. This work draws on complex processes from physics, models of the behaviour of networks, and other interdisciplinary work.

So the doors are open at EMBL and other molecular-biology institutes to students of physics and other disciplines – all those who wish to participate in some of the most exciting questions in today's science and who are not afraid to give their life an exciting new twist.

• Information about the PhD programme is at www.embl.de/training/phdprogramme/index.html. The application deadline for admission in 2006 is 1 November 2005.

OBITUARIES

Paul Singer 1934–2005

Paul Singer, the theoretical particle physicist and influential advocate for science, died in February 2005 after a short fight with cancer.

Paul was born in 1934 in Roman, Romania, and emigrated to Israel after graduating from high school. He served in the Israeli army while completing his BSc at the Technion in Haifa, where he also gained his DSc in 1961, under Nathan Rosen (of the Einstein–Podolsky–Rosen paper). Paul then went to the US, before returning to the Technion in 1964. He became a professor in 1969, and held the Charles Wolfson chair from 1990 until 2002, when he retired.

Paul's research included various decays of hadrons. With Laurie Brown he suggested in 1964 a light scalar state, the "Brown–Singer particle", now the Σ. His collaboration with Svjetlana Fajfer yielded 24 papers on D and B decays. In his most cited 1987 paper, with Nilendra Deshpande, Gad Eilam, Peter Lo and Josip Trampetic, Paul's deep knowledge of radiative K decays (e.g. in his three papers with Moshe Moshe) led to the use of radiative B decays for predicting the mass of the top quark. Paul was proud of this prediction when top was discovered in 1994.

As vice-president for academic development (1976–1980) and senior vice-president (1990–1994), Paul led the institute to new heights in research and helped absorb many students and scientists from the former Soviet Union. His most influential position was as chair of the Israel Science Foundation (ISF) from 1995 to 2000. Under his leadership, it became the largest contributor to basic research in Israel. As deputy chairman of the Israeli Directorate of European Frameworks (1997–2005) he advanced Israel's stature in the EU.

Paul is survived by his wife Yocheved and their son Ido. We miss a friend, collaborator and a person of integrity and honesty, and we miss his wit and wisdom.

Eilam Gad, Michael Gronau and Moshe Moshe, the Technion, Haifa.

GSI Darmstadt

one of the leading laboratories in heavy ion and hadron physics, member of the Helmholtz Association, and the

Johannes Gutenberg-Universität Mainz

invite applications for the joint position of

Leading Scientist and Full Professor (W3)

We are seeking an outstanding individual in the area of experimental hadron physics (non-perturbative QCD) who will also represent this area in teaching at the University Mainz. GSI Darmstadt and the University Mainz provide a broad spectrum of activities in hadron physics with hadronic and electromagnetic probes in particular in the framework of the FAIR Project and MAMI-C.

He/she will lead a research division at GSI and is expected to participate in the scientific program of GSI in close collaborations with the University Mainz and other German and foreign research institutions.

After the appointment to Professor at the University the successful candidate will be granted a leave of absence to GSI (Agreement between Rheinland-Pfalz, the Johannes Gutenberg-Universität Mainz and GSI of 02.02.1983).

GSI and the University are equal opportunity, affirmative action employers and encourage applications from women.

Applications including the curriculum vitae, the list of publications, and research experience and teaching records should be sent in duplicate until October 31, 2005 to

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

UNIVERSITY OF ALBERTA
EDMONTON, ALBERTA, CANADA

www.careers.ualberta.ca

Faculty Positions in Experimental and Theoretical Particle Physics

The Department of Physics at the University of Alberta (www.phys.ualberta.ca) invites applications for two faculty positions in subatomic physics. One of the successful candidates will be nominated for a Canada Research Chair (www.chairs.gc.ca) at either the Tier I (senior) or Tier II (junior) level, depending on experience. The other successful candidate will be offered a tenure track appointment at the Assistant or Associate Professor level.

We are particularly interested in candidates involved in experimental or theoretical particle physics. However, we encourage outstanding scientists in all areas of subatomic physics to apply. Applicants must have established an excellent research track record and be committed to teaching at the undergraduate and graduate levels. The successful candidates will be expected to build strong research programs, supervise graduate students and teach both undergraduate and graduate courses.

The Department has about thirty-six faculty members with research interests in subatomic physics, astrophysics, condensed matter physics, geophysics and medical physics. Our subatomic group includes members with interests in collider physics, particle and nuclear astrophysics, and the standard model. We have excellent electronics, machine shop and computational facilities.

Initiatives by the Governments of Alberta and Canada provide exceptional opportunities for additional funding to establish new research programs at the University of Alberta.

See, for example, www.gov.ab.ca/sra, www.icore.ca, www.gov.ab.ca/is/ahfser and www.innovation.ca for further information.

The application should include a curriculum vitae, a research plan and a description of teaching experience and interests. The applicant must also arrange for at least three confidential letters of reference to be sent to the address below. Consideration of applications will begin on December 1, 2005, but applications will continue to be accepted until the positions are filled. The start date for these positions is July 1, 2006. Applications and reference letters should be sent to:

Particle Physics Search and Selection Committee
Dr. John Beamish
Chair
Department of Physics
University of Alberta
Edmonton, Alberta, Canada T6G 2J1
Fax: (780) 492-0714
Email: dept@phys.ualberta.ca

Deadline: December 15, 2005

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. If suitable Canadian citizens and permanent residents cannot be found, other individuals will be considered. The University of Alberta hires on the basis of merit. We are committed to the principle of equity in employment. We welcome diversity and encourage applications from all qualified women and men, including persons with disabilities, members of visible minorities, and Aboriginal persons.

Deutsches Elektronen-Synchrotron
HERMES - Experiment

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.

The international HERMES collaboration investigates the structure of hadrons and nuclei, with special emphasis to spin, at the HERA collider of DESY in **Hamburg**. A position is open for a

Postdoc

Your tasks will range from the commissioning of the new recoil detector to the analysis of the first physics data. You have a Ph.D. degree in physics and experience in experimental particle physics. Further information concerning the position is given by Dr. W.-D. Nowak (Wolf-Dieter.Nowak@desy.de). Please send your curriculum vitae, certificates and a list of publications to our personnel department in Zeuthen and arrange sending three letters of reference.

The position is limited for two years with a possible one year extension.

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 employer.

Deutsches Elektronen-Synchrotron DESY
member of the Helmholtz Association

code: 88/2005 · Platanenallee 6 · D-15738 Zeuthen · Germany
Phone +49-33762/7-7240 · www-zeuthen.desy.de
email: personal.abteilung-zeuthen@desy.de

Deadline for applicants: 30.11.2005

Head, Fermilab Technical Division

Fermilab seeks an exceptional individual to serve as Head of its Technical Division (TD). Located on a 6800 acre campus 40 miles west of Chicago, Illinois, Fermi National Accelerator Laboratory currently operates the world's highest energy particle accelerator for research into the fundamental properties of matter and is the leading US high energy physics laboratory. Fermilab is operated by the Universities Research Association for the US Department of Energy.

The TD holds responsibility for the development and fabrication of accelerator components in support of the current operating program, and research and development in the technologies that will support future forefront accelerator facilities. Current major R&D activities include growing programs in the development of superconducting RF technologies for the International Linear Collider and Proton Driver, and superconducting magnet development in support of LHC upgrades. The TD is supported with an annual budget of approximately $30,000,000 and employs approximately 220 people.

The TD Head provides leadership and management of the division in execution of its responsibilities including the establishment and achievement of technical, budgetary, schedule, staff development, and ES&H goals. In addition the TD Head plays a leadership role within Fermilab in charting the operating program and future directions for the laboratory.

The successful candidate for this position will have demonstrated leadership, management, communications, and technical abilities. A strong background in accelerator technologies or related fields, including a PhD or equivalent experience, is required. Prior experience with superconducting RF systems is desirable.

Interested parties requiring more information, or applicants for this position, should contact:

Steve Holmes, Associate Director for Accelerators
Fermilab, MS105
P.O. Box 500
Batavia, IL 60510, USA
holmes@fnal.gov
630-840-3211

Applications should include a curriculum vitae, publication list, and the names of three references.

Fermilab is an Equal Opportunity Employer - M/F/D/V

Fermilab

The National Institute for Subatomic Physics in the Netherlands (NIKHEF) has several openings for

PhD students and postdocs in astroparticle physics

NIKHEF coordinates and supports major research activities in experimental and theoretical subatomic physics in the Netherlands. The institute is involved in large-scale experiments at CERN, DESY, Fermi-Lab, and SLAC.

Applications are invited for postdoctoral research associates and graduate students in the astroparticle physics research group. This group is involved in the development, construction and exploitation of deep-sea neutrino detectors in the Mediterranean Sea. More in particular, the group participates in the ANTARES and KM3NeT collaborations. Within these collaborations NIKHEF is leading the information technology developments, including read-out systems based on modern optical data transmission techniques and advanced filtering and reconstruction software.

Successful applicants will participate in the commissioning of the ANTARES experiment, the analysis of the first data and/or the design and development of the future KM3NeT project.

Further information can be obtained from the web (www.nikhef.nl), or the NIKHEF programme leader, prof. dr. G. van der Steenhoven (phone +31 20 592 2145, email: gerard@nikhef.nl). Applications should be sent to NIKHEF, att. Mr. T. van Egdom, PO Box 41882, NL-1009 DB Amsterdam, the Netherlands, or by email to pz@nikhef.nl.

NIKHEF

Department of Physics University of California, Davis

Faculty Position in High Energy Theoretical Physics

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

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

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

This position is open until filled; but to assure first round consideration, applications should be received no later than December 5, 2005. The targeted starting date for appointment is July 1, 2006. To initiate the application process, please mail your curriculum vitae, publication list, research statement, and the names (including address, e-mail, fax, and phone number) of three or more references to:

High Energy Theory Search Committee
Department of Physics
University of California, Davis
One Shields Avenue
Davis, CA 95616-8677

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

The University of California is an affirmative action/equal opportunity employer.

Kavli Institute
For Cosmological Physics
At The University of Chicago

KICP Postdoctoral Research Fellow at the Rank of Research Associate

The KICP invites applications for one or more NSF Funded Postdoctoral Research Fellows (at the rank of Research Associate) from young scientists of exceptional ability and promise who will have received a PhD. in Physics, Astrophysics or related fields by September 2006. The appointee(s) will be expected to conduct original research in experimental, numerical or theoretical cosmology in an inter-disciplinary environment. The initial appointment is for one year, renewal annually, for up to three years. Our positions at the rank of Research Associate have competitive salaries and carry faculty-level benefits. Institute Fellows have the freedom to work on any of the efforts in our Institute.

Research at the Kavli Institute for Cosmological Physics (KICP), based at the University of Chicago, is focused on interdisciplinary topics in cosmological physics: characterizing the Dark Energy, studying the inflationary era, and understanding the highest energy gamma and cosmic rays. Experimental studies of the CMB (polarization anisotropy and the Sunyaev-Zel'dovich effect) and Cosmic Infrared Background; analysis of cosmological data including CMB data and large-scale structure survey data; analysis of Sloan Digital Sky Survey data; high energy astrophysics with photons and cosmic rays; direct detection of Dark Matter particles and numerous topics in theoretical cosmology constitute the current slate of activities. The KICP is seeking to expand the fellowship program to include researchers working on innovative data analysis techniques for large-scale structure, CMB, and other cosmological data. The KICP also has active visitors, symposia, and education/outreach programs. Information about the KICP can be found at **http://kicp.uchicago.edu/**.

An application consisting of a Curriculum Vitae, a statement of research interests, and at least three letters of recommendation should be sent to **centerfellow@kicp.uchicago.edu or to Stephan Meyer, Director, Kavli Institute for Cosmological Physics, 5640 S. Ellis Avenue, Chicago, IL 60637.**

Review of applications will begin on November 15, 2005 for positions that will begin in the Summer or Fall of 2006. The position will remain open until filled.

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

MICHIGAN STATE
UNIVERSITY

Tenure Stream Faculty Position
Experimental High Energy Physics
Michigan State University

The Department of Physics and Astronomy at Michigan State University invites applicants for a tenure stream assistant professor position in experimental high energy physics. We expect to fill the position at the assistant professor level although a more senior appointment may be considered for exceptional individuals. Candidates should have post-doctoral experience, a clear record of research achievement and a strong interest in teaching. The successful applicant will be expected to participate in preparations for physics analysis involving the ATLAS detector at the Large Hadron Collider now being constructed at CERN. Applicants should submit a resume, including a one-page statement of research interests, a list of publications, and have three letters of reference sent to **Prof. Maris Abolins, Search Committee Chair, Department of Physics and Astronomy, 4208 Biomedical Physical Sciences Building, Michigan State University, East Lansing, MI 48824-2320 (hepfacsearch@pa.msu.edu).** Review of applicants will begin after November 15, 2005 and continue until the position is filled.

MSU is an Affirmative Action/Equal Opportunity Institution.

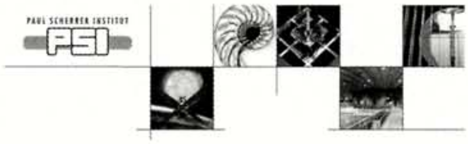
Postdoctoral Research Fellow

The TWIST Group at TRIUMF has an immediate opening for a Postdoctoral Research Fellow. Information on the TRIUMF Weak Interaction Symmetry Test can be found at **http://twist.triumf.ca**

The successful candidate will be expected to provide leadership and expertise in different aspects of TWIST, such as verification of simulations using the GEANT package, track reconstruction, analysis, detailed studies of systematics, and operation of the detector. A PhD in nuclear or particle physics, or the equivalent, is required. Preference will be given to those applicants within five years of their degree.

The initial term of the appointment will be one year, renewable upon mutual consent, and subject to continued project funding. For full details on this exciting research opportunity, and for application procedures, please visit TRIUMF'S Employment Opportunities, and click on Competition No. 975 **http://www.triumf.info/**

TRIUMF is an equal opportunity employer, and advises that in the event where two final applicants are equally qualified, preference will be given, if applicable, to the Canadian citizen or permanent resident.



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.

For our **Department Large Research Facilities (GFA)** we are looking for a

Head of the Laboratory

Accelerator Facilities and Systems

Your tasks

As Head of the Laboratory for Accelerator Facilities and Systems with its approximately 50 staff members you will have the responsibility for operating, maintaining and developing the high intensity proton accelerator complex for research and the superconducting medical cyclotron for proton therapy. You will lead the intensity upgrade program of the proton accelerator complex and perform fundamental research in accelerator physics.

Your profile

You are experimental physicist with excellent knowledge of the physical aspects of accelerators with an outstanding record in this field. Proven leadership and the ability to motivate people are essential requirements.

We are looking forward to your application by October 31, 2005.

Applications including a curriculum vitae and publication list as well as the names and addresses (including email) of at least three references should be sent to: Paul Scherrer Institut, Human Resources, Mr. Thomas Erb, ref. code 8500, 5232 Villigen PSI, Switzerland.

For further information please contact Prof. Dr. Albin F. Wrulich, Tel. + 41 (0)56 310 31 28, E-Mail: albin.wrulich@psi.ch.

Further job opportunities: **www.psi.ch**

University of California at Berkeley
Physics Faculty Positions

Pending budgetary approval, the Physics Department of the University of California, Berkeley intends to make three faculty appointments effective July 1, 2006. One position is targeted for Biophysics. One is targeted for Experimental Particle Physics. Candidates from all fields of Physics are invited to apply for the third position. Appointments at both tenure-track assistant professor and tenured levels will be considered.

Applications must be postmarked by **Wednesday, November 23, 2005.** In addition, please arrange to have one letter of recommendation sent in by this date. UC Berkeley's Statement of Confidentiality can be found at: http://apo.chance.berkeley.edu/evalltr.html

E-mail applications will not be accepted. Applications submitted after the deadline will not be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to:

Marjorie D. Shapiro, Chair, University of California, Berkeley, Department of Physics, 366 LeConte Hall #7300, Berkeley, CA 94720-7300, Fax: (510) 643-8497

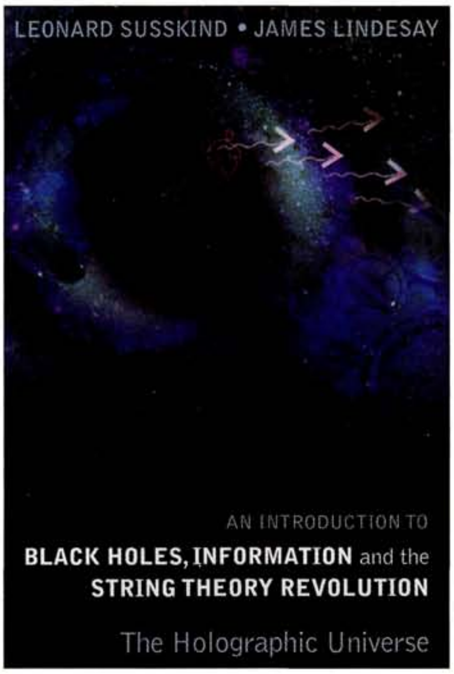
The University of California is an Equal Opportunity, Affirmative Action Employer.

INDEX TO DISPLAY ADVERTISERS

The index is provided as a service and, while every effort is made to ensure its accuracy, *CERN Courier* accepts no liability for error.

BOOKSHELF

An Introduction to Black Holes, Information and the String Theory Revolution: The Holographic Universe by Leonard Susskind and James Lindesay, World Scientific. Hardback ISBN 9812560831, £17 ($28). Paperback ISBN 9812561315, £9 ($14).



Black holes have attracted the imagination of the public and of professional astronomers for quite some time. The astrophysical phenomena associated with them are truly spectacular. They seem to be ubiquitous in the centre of galaxies, and they are believed to be the power engines behind quasars. There is little doubt of their existence as astronomical objects, but this very existence poses deep and unresolved paradoxes in the context of quantum mechanics when one tries to understand the quantum properties of the gravitational field.

For many readers, the title of this book may sound odd because the contents have little to do with the astrophysical or observational properties of black holes. If you look for nice pictures of galaxy centres and gamma-ray bursts, you will find none. If, however, you are looking for the deep paradoxes in our understanding of quantum-field theory in nontrivial gravitational environments, and the riddles encountered when trying to harness the gravitational force within the quantum framework, then you will find plenty.

At the end of the 19th century, Max Planck was confronted with serious paradoxes and apparent contradictions between statistical thermodynamics and Maxwell's electromagnetic theory. The resolution of the puzzle brought the quantum revolution. When Albert Einstein asked himself what someone would observe when travelling at the same speed as a light beam, the answer revealed a fundamental contradiction between Newtonian mechanics and electromagnetic theory.

The resolution of these problems led to the relativity revolution, first with special and then general relativity. Sometimes experiment itself is not the only way towards progress in our understanding of nature. Conceptual paradoxes often provide the way to a deeper view of the world.

In the 1960s, largely due to Roger Penrose and Steven Hawking, it became understood that under very general conditions, very massive objects would undergo gravitational collapse. The end state would be a singularity of infinite curvature in space–time shrouded by an event horizon – the last light surface that did not manage to leave the region. The horizon is a profoundly non-local property of a black hole that cannot be detected by local measurements of an unaware, infalling observer.

Classically, black holes were supposed to be black. However, in the early 1970s Jacob Bekenstein and Hawking showed that black holes must necessarily have very unsettling properties. As Bekenstein argued, if the second law of thermodynamics is supposed to hold, then an intrinsic entropy must be assigned to a black hole. Since entropy measures the logarithm of the number of available states for a given equilibrium state, it is logical to ask what these states are and where they came from.The entropy in this case is proportional to the area of the black-hole horizon measured in Planck units (a Planck unit of length is 10^{-33} cm). This is vastly different from the behaviour of ordinary quantum-field theoretic systems.

Meanwhile, Hawking showed that if one considers the presence of a black hole in the context of quantum-field theory, it radiates thermally with a temperature inversely proportional to its mass, so the hole is not black after all. If the radiation is truly thermal, this raises a fundamental paradox, as Hawking realized. Imagine that we generate a gravitational collapse from an initial state that is a pure state quantum-mechanically. Since thermal radiation cannot encode quantum correlations, once the black hole fully evaporates it carries with it all the subtle correlations contained in a pure quantum state. Hence the very process of evaporation leads to the loss of quantum coherence and unitary time evolution, two basic features of quantum-mechanical laws.

These puzzles were formulated nearly 30 years ago and they still haunt the theory community. It was, nevertheless, realized that resolving these puzzles requires deep changes in our understanding of both quantum mechanics and general relativity, and also a profound modification of the sacrosanct principle of locality in quantum-field theory.

This book is precisely dedicated to explaining what we have learned about these puzzles and their proposed solutions. Assuming that some of the basic features of quantum mechanics (such as unitary evolution) and general relativity (such as the consistency of different observers' observations, no matter how different they may be) do indeed hold, the authors analyse the conceptual changes that are required to accommodate strange phenomena such as black-hole evaporation.

In the process, they masterfully present a whole host of subjects including quantum-field theory in curved spaces; the Unruh effect and states; the Rindler vacua; the black-hole complementarity principle; holography; the Maldacena conjecture and the role of string theory in the whole affair; the notion of information in quantum systems; the no-cloning theorem for quantum states; and the general concept of entropy bounds.

A remarkable feature of this book is that relatively little specialized knowledge is required from the reader; a cursory acquaintance with quantum mechanics and relativity is sufficient. This is impressive, given that the authors cover some of the hottest topics in current research.

The technical demands are low, but conceptually the book is truly challenging. It makes us think about many ideas we take for granted and shakes the foundations of our understanding of basic physics. It provides a rollercoaster ride into the treacherous and largely uncharted land of quantum gravity. This book is highly recommended for those interested in these fascinating topics.

The authors end with the sentence: "At the time of the writing of this book there are no good ideas about the quantum world behind the horizon. Nor for that matter is there any good idea of how to connect the new paradigm of quantum gravity to cosmology. Hopefully our next book will have more to say about this." We hope so too.
Luis Alvarez-Gaume, CERN.

Quaternions, algèbre de Clifford et physique relativiste par Patrick R Girard, Presses Polytechniques et universitaires romandes. Broché ISBN 288074606X, 68CHF (€45.50).

Ce livre propose une introduction pédagogique à ce nouveau calcul, à partir du groupe des quaternions, avec des applications principalement dans les domaines de le relativité restreinte, de l'électromagnétisme classique et de la relativité générale. C'est le premier ouvrage sur le sujet rédigé en langue française depuis près de 30 ans. Il s'adresse aux étudiants, professeurs et chercheurs en physique et en sciences de l'ingénieur.

Méthodes quantiques: Champs, N-corps, diffusion par Constantin Piron, Presses Polytechniques et universitaires romandes. Broché ISBN 2880746116, 42CHF (€28).

Cet ouvrage constitue une introduction à la théorie des champs quantiques très différente des exposés habituels le plus souvent formels. Rédigé par l'un des spécialistes francophones en la matière, il est particulièrement clair et didactique, illustré de nombreux exemples et exercices corrigés.

Pulsed Power by Gennady A Mesyats, Springer. Hardback ISBN 0306486539, €227 (£157, $249).

Meysat provides an in-depth coverage of the generation of pulsed electric power, electron and ion beams, and various types of pulsed electromagnetic radiation, with a wide range of methods for producing up to 10^{14} W of power for pulse durations from 10^{-10} to 10^{-7} s. The physics of pulsed electrical discharges, properties of coaxial lines, spark gap switches, various plasma and semiconductor switches and their use in pulse generators are covered, as well as the production of high-power pulsed electron and ion beams, X-rays, laser beams and microwaves.

Foundations of Modern Cosmology (Second Edition) by John F Hawley and Katherine A Holcomb, Oxford University Press. Hardback ISBN 9780198530961, £33.99.

The new edition of this thorough, descriptive introduction to the physical basis for modern cosmological theory includes the latest observational results and provides the background material necessary to understand their implications, with a special focus on the concordance model. Emphasis is given to the scientific framework for cosmology, beginning with the historical background and leading to an in-depth discussion of the Big Bang theory and the physics of the early universe.

VIEWPOINT

When physics needs the public

Herman White argues the case for public participation in the decision-making process for the International Linear Collider.

Decision-making in high-energy elementary particle-physics research is usually highly technical, sometimes political, and often very passionate. And now, in the 21st century, scientists have come to realize that the public not only has the right to know what science we do, but should also be involved in many decisions of that scientific work. This is precisely what the particle-physics community has set out to accomplish with the design process and creation of the world's next big particle accelerator.

Outside of space exploration, it is sometimes assumed that large populations are not interested in science, but the International Linear Collider (ILC) is an accelerator that will collide particles of matter and antimatter to help solve some of the true mysteries of the quantum universe. So how can the public be involved in the design of such a complex facility?

In August, I was among the nearly 700 participants in the 2005 International Linear Collider Physics and Detector Workshop held in Snowmass, Colorado. A number of my colleagues around the world engaged in the global design effort have been studying the technical issues and understanding the limitations of the proposed facility for some years. Now, in addition to the physics, a communications group is focusing on how this facility will affect the public when completed, and how physicists should communicate our work to decision-makers and the public.

In many scientific disciplines, the research community often communicates to the public on laboratory experiments by reporting the benefits after the designs are completed, during the building of the apparatus (if any), and after the research results are assembled. For the ILC project, communication was a high priority from the very beginning. At the ILC workshop, Judy Jackson of the Fermilab Office of Public Affairs and a member of the ILC Communication Group invited Douglas Sarno, head of The Perspectives Group, Inc. of Alexandria, Virginia, to lead a seminar on the public-participation process.

Courtesy Fermilab Visual Media Services.

At the seminar, Sarno instructed us on elements of the process: identify members of the public and the "stakeholders"; examine and include the public values; and seek input from all sides when issues arise. He helped us recognize the benefits of this effort in general, and showed how real participation in the process leads to decisions.

There can be a range of participation in this process, from minimal participation where the public is informed only of the general scientific goals and information, to the other end of the spectrum where the final decision on the project implementation is in the hands of the public. The former can be accomplished by reading materials, websites, public lectures and personal contacts, while the latter might additionally require ballots, elections, citizen referendums or chief-executive initiatives. For the ILC, the specifics of the ideal public-participation process lie somewhere in between, and of course input from the public is required to find the right level. When we think about access to materials, land use, ecology and economic impacts due to the resources that are required, large scientific projects are never isolated from the public.

I am now convinced that the ILC project will benefit from a high level of public participation. Because of the very long tradition of international participation in particle-physics research, and the international character of this project, the public-participation process should include all the countries and regions contributing to the project, taking into account the role of local communities. I believe our discussion helped those participating in this seminar gain a broader view of how the decisions concerning the ILC might include a public perspective, independent of region.

However, the ILC is a complex facility and the science that motivates the need for this facility is equally complex, which of course means that decisions are multifaceted and interwoven primarily with physics issues. Nevertheless, a host of other considerations and opportunities will include resource and design issues, communication, organization, a construction timeframe, the world-community effort and – usually before any actions – a decision. The level at which the public is included in this decision process could also be viewed as a complex question.

My experience in public communication leads me to conclude that involving the public early in the design and description of our scientific research, and continuing that involvement, is crucial to an effective partnership between the public and the scientific proponents of our research. Although it is a noble goal to teach particle physics to the public and government leaders, this may not always be necessary. It is important to convey the excitement and the impact of the ILC project on society, and to earnestly listen to the response of policy-makers and members of the public about all of our science. It is vital to gain and sustain the trust of the public, so that the inevitable changes in this research project will be embraced and perhaps even understood as a regular component of fundamental research.

Herman White, Fermilab.