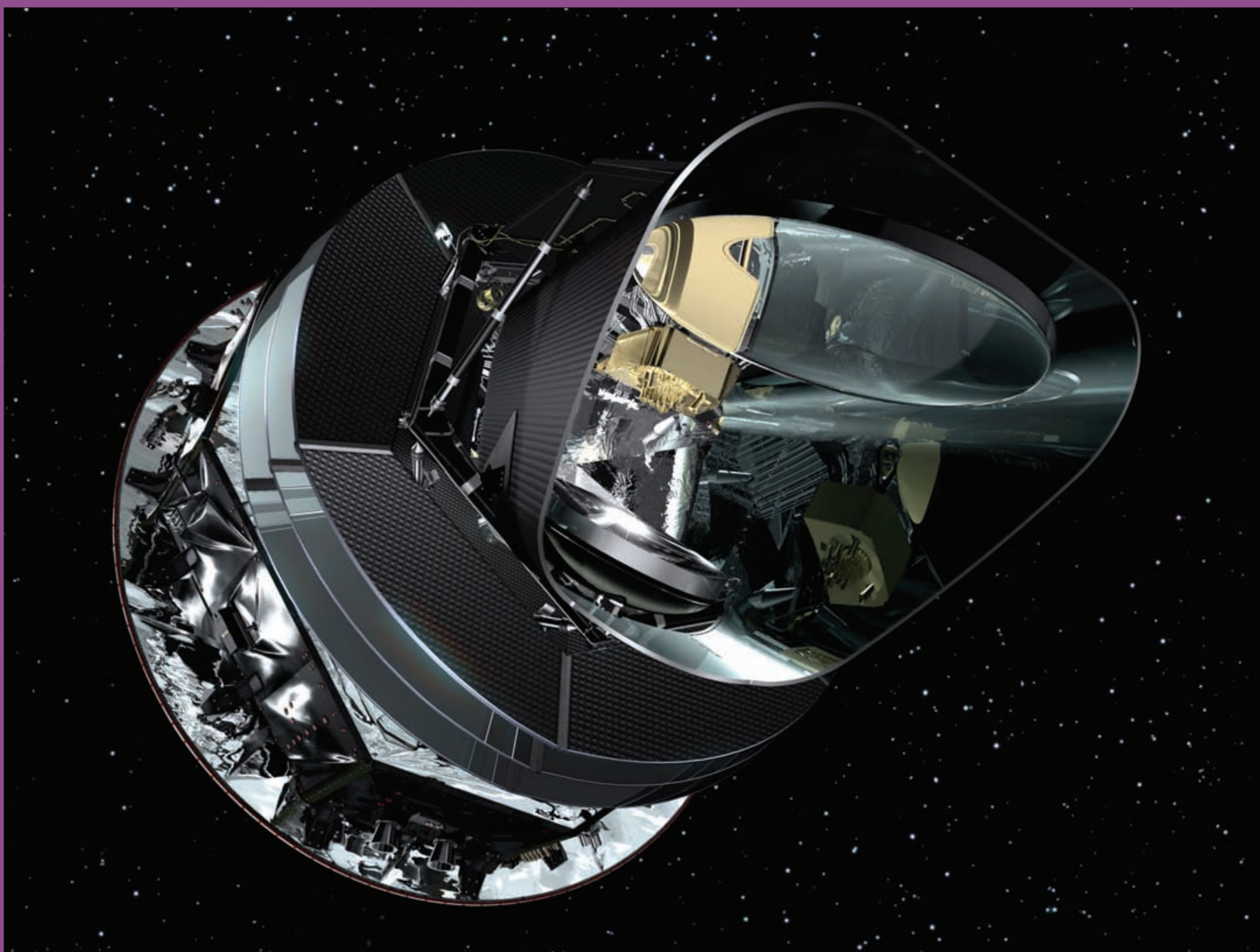
International Journal of High-Energy Physics

CERN COURIER

Volume 49 Number 3 April 2009



Charting the universe with Planck

FERMILAB
CDF and DO observe single top events p9

JEFFERSON LAB
The 12 GeV upgrade gets underway p15

DESY
Workshop focuses on dark matter p31

CERN COURIER

VOLUME 49 NUMBER 3 APRIL 2009

Double the MAGIC p5

The Bonaudi spirit p19

Detecting dark matter p31

News 5

MAGIC becomes twice as good. LHC consolidation work proceeds apace. PAMELA pins down cosmic antiproton flux. ISOLTRAP weighs in with new noble results. Finding the way to polarized antiprotons. CDF and D0 see events with single top quark.

Sciencewatch 11

Astrowatch 12

CERN Courier Archive 13

Features

Jefferson Lab starts its 12 GeV physics upgrade 15

Double the energy and new equipment will extend the scientific horizon.

Frank Bonaudi: wise spirit of the early CERN 19

Colleagues recall his many contributions and accomplishments.

LHeC: novel designs for electron–quark scattering 22

A possible option to allow collisions with electrons at the LHC.

Planck satellite takes off to chart the universe 26

ESA's satellite mission to map the cosmic microwave background.

Knowledge transfer: from creation to innovation 28

Insight into the generation of know-how in five LHC experiments.

Dark-matter research arrives at the crossroads 31

The 2008 DESY Theory Workshop focused on the nature of dark matter.

Faces and Places 35

Recruitment 41

Bookshelf 50

Cover: An impression of ESA's Planck satellite in orbit (p26). (Courtesy ESA/AOES Medialab.).

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
Editorial assistant Carolyn Lee
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) Cosmas Zachos
Brookhaven National Laboratory (US) P Yamin
Cornell University (US) D G Cassel
DESY Laboratory (Germany) Ilka Flegel, Ute Wilhelmsen
EMFCSC (Italy) Anna Cavallini
Enrico Fermi Centre (Italy) Guido Piragino
Fermi National Accelerator Laboratory (US) Judy Jackson
Forschungszentrum Jülich (Germany) Markus Buescher
GSI Darmstadt (Germany) I Peter
IHEP, Beijing (China) Tongzhou Xu
IHEP, Serpukhov (Russia) Yu Ryabov
INFN (Italy) Romeo Bassoli
Jefferson Laboratory (US) Steven Corneliussen
JINR Dubna (Russia) B Starchenko
KEK National Laboratory (Japan) Youhei Morita
Lawrence Berkeley Laboratory (US) Spencer Klein
Los Alamos National Laboratory (US) C Hoffmann
NIKHEF Laboratory (Netherlands) Paul de Jong
Novosibirsk Institute (Russia) S Eidelman
NCSL (US) Geoff Koch
Orsay Laboratory (France) Anne-Marie Lutz
PSI Laboratory (Switzerland) P-R Kettle
Saclay Laboratory (France) Elisabeth Locci
Science and Technology Facilities Council (UK) Peter Barratt
TRIUMF Laboratory (Canada) Marcello Pavan

Produced for CERN by IOP Publishing Ltd
IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel +44 (0)117 929 7481

Publisher Jo Nicholas
Art director Andrew Giaquinto
Production editors Lizi Brown, Jesse Karjalainen
Technical illustrator Alison Tovey
Advertising manager Ed Jost
Recruitment advertisement manager Moo Ali
Advertisement production Katie Graham
Marketing & Circulation Anastasia Ireland

Advertising
Tel +44 (0)117 930 1026 (for UK/Europe display advertising), +1 215 627 0880 (for North American display advertising), or +44 (0)117 930 1027 (for recruitment advertising);
E-mail: sales@cerncourier.com; fax +44 (0)117 930 1178

General distribution Courrier Adressage, 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 Mark Wells, Science and Technology Facilities Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1SZ. E-mail: mark.wells@stfc.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: creative_mailing@att.net
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

 ISSN 0304-288X

IOP Publishing

COSMIC RAYS

MAGIC becomes twice as good

Since the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope began operation in 2003 it has made a host of discoveries about sources of high-energy cosmic gamma rays. This is in large part thanks to having the largest reflector in the world, a tessellated mirror with an area of 240 m^2 (*CERN Courier* December 2003 p7). Now the MAGIC-I telescope is being joined by a sibling, MAGIC-II, which has similar characteristics together with several improvements.

Cosmic gamma rays are important because they serve as direct messengers of distant events, unaffected by magnetic fields. Studies usually rely on satellite experiments, while ground-based Cherenkov telescopes are mainly used for the highest energies. The latter make use of the fact that charged secondary particles, generated in electromagnetic showers in the atmosphere, may emit Cherenkov radiation – photons with energies that are in the visible and UV ranges. Such photons pass through the atmosphere and are observable on the surface of the Earth using sufficiently sensitive instruments.

The two telescopes on La Palma, with MAGIC-I to the fore. (Courtesy R Wagner, MPI für Physics, Munich.)

The MAGIC telescopes on the Canary Island of La Palma are specifically designed to detect Cherenkov radiation resulting from electromagnetic air showers generated by cosmic gamma rays. MAGIC-I was built with emphasis on the best light collection, making gamma rays accessible down to an energy threshold of 25 GeV, which is lower than for any other existing ground-based gamma-ray detector. It now provides an ideal overlap with the Large Area Telescope on the recently launched *Fermi Gamma-Ray Space Telescope*, which has an energy range from 20 MeV up to 300 GeV (*CERN Courier* November 2008 p13).

The new MAGIC-II telescope has the same reflector size as MAGIC-I, although it is made with larger mirrors. Its camera has been modified to increase spatial resolution and sensitivity by hosting a larger number of photomultipliers of higher efficiency. It also incorporates a new read-out system. The new system's gain in sensitivity will be between a factor of two and a factor of three compared with MAGIC-I, depending on energy.

A lower energy threshold means a higher sensitivity to special phenomena – and a deeper view into the universe. It was characteristics such as these that in 2008 enabled MAGIC-I to discover the most distant very-high-energy gamma sources, including the supermassive black hole 3C279, at a record distance of 6000 million light-years – an observation that questions theories on the transparency of the universe to gamma rays (MAGIC Collaboration 2008a). In addition, MAGIC-I revealed pulsed gamma-rays above 25 GeV emanating from the Crab pulsar; this is the highest energy pulsed emission so far detected (MAGIC Collaboration 2008b).

The new MAGIC-II telescope will couple a low threshold with higher sensitivity and resolution, as well as improve further the view of the highest energy phenomena in the universe. A "first-light" ceremony is to take place on 24–25 April at the site on La Palma.

Further reading

For more information about MAGIC, see http://magic.mppmu.mpg.de.

MAGIC Collaboration 2008a *Science* **320** 1752.
MAGIC Collaboration 2008b *Science* **322** 1221.

Sommaire

MAGIC devient deux fois meilleur 5
Les travaux de consolidation du LHC vont de l'avant 6
PAMELA traque un flux d'antiprotons cosmiques 7
ISOLTRAP présente de nobles résultats 7
Sur la voie des antiprotons polarisés 8
CDF et D0 font état d'événements avec un quark t isolé 9
Pourquoi nous avons des empreintes digitales 11
Fermi observe des sursauts gamma surpuissants 12

LHC NEWS

LHC consolidation work proceeds apace

The consolidation campaign for the LHC, which aims to ensure a safe final commissioning and reliable running of the collider is now well under way. On 9 February CERN's management confirmed the restart schedule for the LHC resulting from the recommendations from the previous week's Chamonix workshop (*CERN Courier* March 2009 p5).

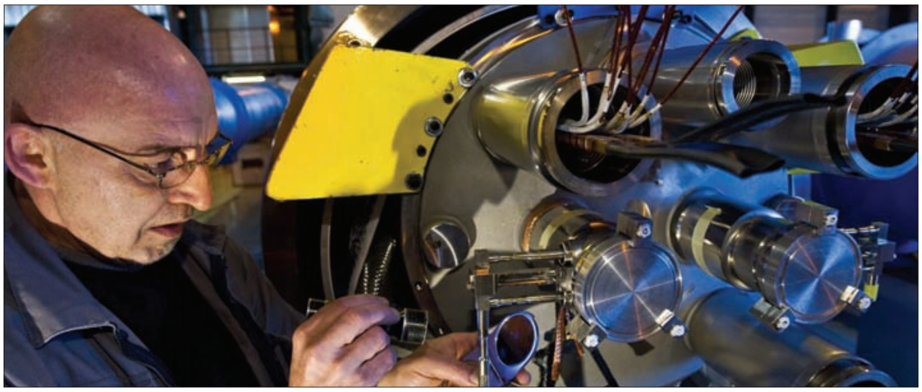
The new schedule foresees first beams in the LHC at the end of September 2009, with collisions in late October. A short technical stop has also been foreseen over the Christmas period. The LHC will then run through to the following autumn to ensure that the experiments have adequate data to carry out their first new-physics analyses and have results to announce in 2010. The new schedule also permits the possibility of lead–ion collisions in 2010.

In Chamonix there was consensus among all the technical specialists that the new schedule is tight but realistic.

According to CERN's director-general, Rolf Heuer, "The schedule we have now is without a doubt the best for the LHC and for the physicists waiting for data. It is cautious, ensuring that all the necessary work is done on the LHC before we start up, yet it allows physics research to begin this year."

This new schedule represents a delay of six weeks with respect to the previous schedule, which foresaw the LHC "cold at the beginning of July". This delay arises from several factors such as the implementation of a new enhanced protection system for the busbar and magnet splices; installation of new pressure-relief valves to reduce the collateral damage in case of a repeat incident; application of more stringent safety constraints; and scheduling constraints associated with helium transfer and storage.

The new pressure-relief system has been designed in two phases. The first phase involves the installation of relief valves on existing vacuum ports in the whole ring. Calculations have shown that in an incident similar to that of 19 September 2008 – which damaged magnets in sector 3-4 (*CERN Courier* January/February 2009 p6) – the collateral damage would be minor with this first phase. The second phase involves adding additional relief valves on all of the dipole magnets, which would guarantee minor collateral damage (to the interconnects and super-insulation) in all worst cases over the life of the LHC.



After the incident in September 2008, magnets were immediately prepared to replace those damaged. Now consolidation work is underway to ensure a safe and reliable restart of the LHC later this year.

The management has decided for 2009 to install the additional relief valves on four of the LHC's eight sectors, concurrent with repairs in the sector 3-4 and other consolidation work already foreseen. The dipoles in the remaining four sectors will be equipped in 2010.

On 18 February, Steve Myers, Director for Accelerators and Technology, reviewed the discussions on the LHC that took place at Chamonix at the public session of the LHC experiments committee. In particular, he described the scenarios that were studied to implement the consolidation measures and resume operation. He also explained that the schedule ultimately adopted will make it possible to obtain more physics data sooner, even though the energy will be limited during this first period to 5 TeV per beam to ensure completely safe operation.

During the last week of February the enhanced quench protection system had a full review from a panel made up of experts from other high-energy physics laboratories from around the world, including the Brookhaven National Laboratory, DESY, Fermilab and the international fusion project, ITER. The enhanced protection system measures the electrical resistance in the cable joints (splices) and is much more sensitive than the system existing on 19 September.

The system has two separate parts: one to detect and protect against splices with abnormally high resistance; the second to detect a symmetric quench. The planning schedule was reviewed to define priorities between these two parts, both of which need to be complete before the restart at the end of September. The review also covered areas such as the technical details of the implementation of the new system, how well it will perform during operation and how "robust" it will be after years of service.

In the preliminary report the panel found that: "The machine-protection staff have demonstrated a deep understanding of the issues involved in the design of the high-resistance-splice detection system." It has "full confidence that the new system will have the ability to give early warnings for suspicious splices measured at the level of 1 nΩ" and that "the symmetric quench protection system, once its design is complete, will be able to detect quenches at twice the normal detection level".

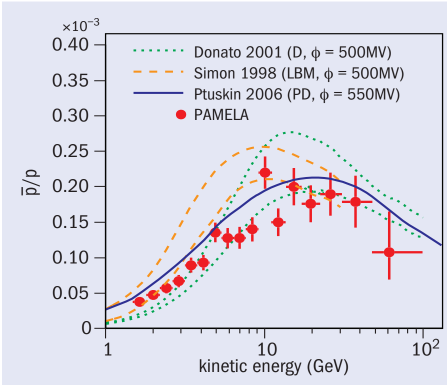
- For a film of Steve Myer's presentation at the open session of the LHCC, see http://indico.cern.ch/conferenceDisplay.py?confId=51221 and for all the presentations see http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=52248.
- For up-to-date news, see *The Bulletin* at http:/cdsweb.cern.ch/journal/.

COSMIC RAYS

PAMELA pins down cosmic antiproton flux

The satellite experiment Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA) has made a new measurement of the antiproton-to-proton flux ratio in cosmic rays with energies up to 100 GeV. The results, which represent a great improvement in statistics compared with data published previously, provide significant constraints on exotic sources of cosmic antimatter.

The PAMELA experiment has been in low Earth-orbit on the Resurs-DK1 satellite since its launch in June 2006 (CERN Courier September 2006 p8). During 500 days of data collection it has identified 1000 antiprotons with energies in the range 1–100 GeV, including 100 antiprotons with an energy above 20 GeV. This is a larger data sample at higher energies than any other experiment has obtained.



The antiproton-to-proton flux ratio measured by PAMELA compared with theoretical calculations for pure secondary production of antiprotons.

Cosmic antiprotons can be made in particle (mainly proton) collisions with interstellar gas but they could also have more exotic origins, for example, in the annihilation of dark-matter particles. Finding out more about the actual production mechanisms requires detailed studies of the antiproton energy spectrum over a wide energy range, which in turn depend on data with good statistics, as PAMELA now provides.

Analysis of the data from PAMELA show that the antiproton-to-proton flux ratio rises smoothly to about 10 GeV, before tending to level off. The results match well with theoretical calculations that assume only secondary production of antiprotons by cosmic rays propagating through the galaxy. This places limits on contributions from other, more exotic sources.

Further reading

O Adriani *et al.* 2009 *Phys. Rev. Letts.* **102** 0511011.

NUCLEAR PHYSICS

ISOLTRAP weighs in with new noble results

Georg Christoph Lichtenberg , the 18th-century philosopher scientist, said: "To see something new, you must build something new." This adage certainly applies on the nuclear scale at CERN's On-Line Isotope Mass Separator, ISOLDE, the pioneering rare-isotope factory. Measurements with the Penning-trap mass spectrometer ISOLTRAP, have determined new masses for several isotopes of the noble gases, xenon and radon, while discovering a new isotope of radon along the way.

ISOLDE is CERN's longest-running facility and has always been at the forefront of development. Now the facility is the key player in the European sixth framework design study for EURISOL, a next-generation facility for isotope separation online (ISOL). At ISOLDE the short-lived nuclides are created using 1.4 GeV protons from CERN's PS Booster. Once produced in the target, these rare species must be ionized efficiently to form secondary beams that can be accelerated and mass-separated for use in experiments. Thus, all ISOLDE targets have a built-in chemically selective ion source.

One of the tasks of EURISOL (in conjunction with the HighInt Marie-Curie Training programme) is the development of an efficient ion source that can accommodate the 50-fold increase in proton beam intensity that will become available at CERN through the upcoming Linac 4 and Superconducting Proton Linac upgrades (*CERN Courier* July/August 2008 p17). This has led to a prototype, the Versatile Arc Discharge Ion Source (VADIS). Its principle rests on the optimization of both the discharge-current densities within the ion-source geometry and the extracted ion-beam intensities (figure 1). The version designed for the selective

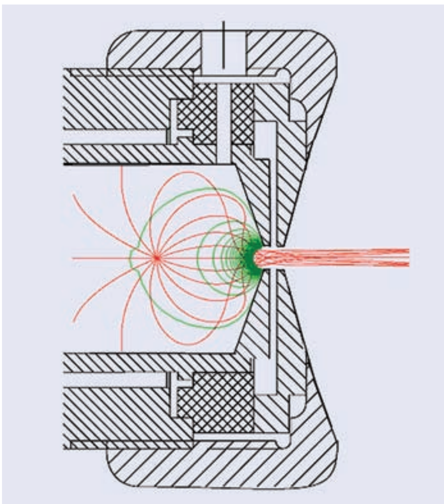


Fig. 1. Cross-sectional view of the VADIS source showing the ionization chamber, electric potential lines (green) and ion trajectories (red).

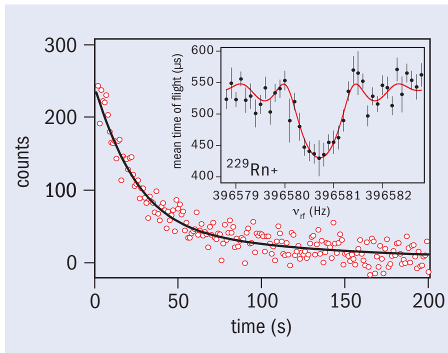


Fig. 2. Observed decay curve of the newly discovered ^{229}Rn isotope from which a half-life of 12 s was determined. The inset shows a time-of-flight cyclotron resonance curve from ISOLTRAP, from which the ^{229}Rn mass was determined.

ionization of noble gases increases ionization efficiency by over an order of magnitude.

VADIS was employed at ISOLDE in 2008 with spectacular results. The experiment in question involved another pioneering facility, ISOLTRAP (*CERN Courier* March and December 2004). ISOLTRAP in effect weighs radioactive nuclides created by ISOLDE using the elegant technique of exciting the cyclotron motion of a single ion in a magnetic field. Knowledge of the mass gives access to the nuclear binding energy, which is not only a rich source of information for nuclear structure, size and shape, but also determines the amount of energy available for radioactive decay and for reactions of major importance for modelling nucleosynthesis, the cooking of elements in stars.

ISOLTRAP first weighed isotopes of xenon ionized by VADIS, determining masses for four more of them. The team then focused its efforts on the neutron-rich isotopes of radon, with impressive results. The experiment determined seven new masses, one for an isotope, ^{229}Rn, that had never previously been observed in the laboratory. As there was no information to confirm this isotope's identity, the experimenters needed to take particular care to make sure it was indeed what they thought it to be. As a result, they also determined the half-live of this nuclide (figure 2, p7), marking the first discovery of a nuclide by Penning-trap mass spectrometry (Neidherr *et al.*). To make things even more interesting, the new radon masses show a unique pattern that provides a link to a special type of nuclear octupole deformation, predicted to occur in this region of the nuclear chart.

Further reading

D Neidherr *et al.* 2009 accepted for publication in *Phys. Rev. Letts*.

BEAMS

Finding the way to polarized antiprotons

The QCD physics potential of experiments with high-energy polarized antiprotons is enormous, but until now high-luminosity experiments have been impossible. This situation would change dramatically with the production of a stored beam of polarized antiprotons, and the realization of a double-polarized high-luminosity antiproton–proton collider. Recent measurements at the Cooler Synchrotron (COSY) at Jülich have for the first time studied the influence of unpolarized electrons on polarized protons, settling a puzzle over the magnitude of such effects.

The collaboration for Polarized Antiproton Experiments (PAX) has proposed a physics programme that would be possible with a double-polarized proton–antiproton collider at the new Facility for Antiproton and Ion Research (FAIR), which is to be built at GSI in Darmstadt (PAX Collaboration 2006). The original idea was to use polarized electrons to produce a polarized beam of antiprotons (Rathmann *et al.* 2005). This triggered further theoretical work on the subject and a group from Mainz proposed using co-moving electrons or positrons (e) at slightly different velocities from the orbiting protons or antiprotons (p) as a means to polarize the stored beam (Walcher *et al.* 2007). When the relative velocities, v, between the e and p are adjusted so that v/c is about 0.002, a numerical calculation by the Mainz group predicts the cross-section for the ep spin-flip to be as large as about 2×10^{13} b. Analytical predictions for the same quantity by a group from Novosibirsk, however, yield a range well below one millibarn (Milstein *et al.* 2008).

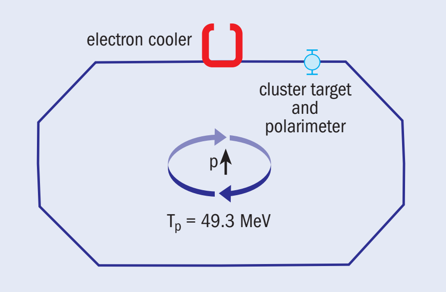


Fig. 1. The COSY ring with electron cooler, cluster target, and proton–deuteron polarization analyser (polarimeter).

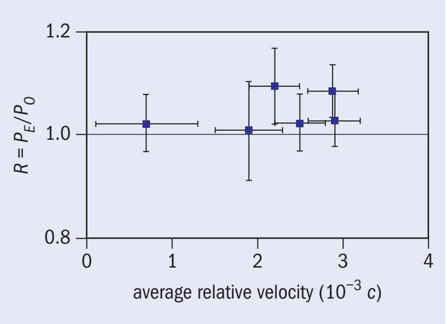


Fig. 2. Ratio of the beam polarization with or without electron beam as a function of the average relative velocity. The horizontal bars indicate the range of velocities that contribute to the measurement. The vertical bars are statistical uncertainties.

To provide an experimental answer to the puzzle, the collaborations for PAX and for the Apparatus for Studies of Nucleon and Kaon Ejectiles experiment joined forces at COSY, where they mounted an experiment that used the electrons in the electron cooler as a target and measured the effect of the electrons on the polarization of a 49.3 MeV proton beam orbiting in COSY. Instead of studying the build-up of polarization in an unpolarized beam, the teams studied the inverse by observing the depolarization of an initially (vertically) polarized beam; they measured the proton-beam polarization using the analysing power of proton–deuteron elastic scattering on a deuterium cluster jet target (figure 1).

Figure 2 shows the results, with the ratio of the measured beam polarizations, P_E and P_0 (Oellers *et al.* 2009). P_E represents the measured polarization corresponding to well defined changes of the electron velocity with respect to the protons. This was achieved by detuning the accelerating voltage in the electron cooler by a specific amount compared to the nominal voltage. P_0 is the polarization measured when the electron beam was off (i.e. no electron target was present). No depolarization effect on the proton beam could be detected within the statistical precision of the measurement. This translates into an upper limit for the ep transverse and longitudinal spin-flip cross-sections of 1.5×10^7 b at a relative velocity of v = 0.002, six orders of magnitude below the numerical predictions. After the completion of the experiment, the Mainz group uncovered a numerical overestimation in their original estimates (Walcher *et al.* 2009).

The result rules out the practical use of polarized leptons to polarize a beam of antiprotons with present-day technologies. This leaves spin-filtering as the only proven method to polarize a stored beam *in situ*, a technique that exploits the spin-dependence of the strong interaction using a polarized internal target (Rathmann *et al.* 1993). At present, a complete quantitative understanding of all underlying processes is lacking, so the PAX collaboration aims to use stored protons in COSY for high-precision polarization build-up studies with transverse and longitudinal polarization. Under these circumstances, the build-up process itself can be studied in detail because the spin-dependence of the proton–proton interaction around 50 MeV is completely known. The internal polarized target and the target polarimeter required for these investigations are currently set up to be installed together with a large-acceptance detector system for the determination of the beam polarization in a dedicated low-β section at COSY.

In contrast to the proton–proton system, the experimental basis for predicting the polarization build-up by spin filtering in a stored antiproton beam is practically non-existent. Therefore, it is of high priority to perform a series of dedicated spin-filtering experiments using stored antiprotons. The Antiproton Decelerator at CERN is a unique facility at which stored antiprotons in the appropriate energy range are available with characteristics that meet the requirements for the first-ever antiproton polarization build-up studies.

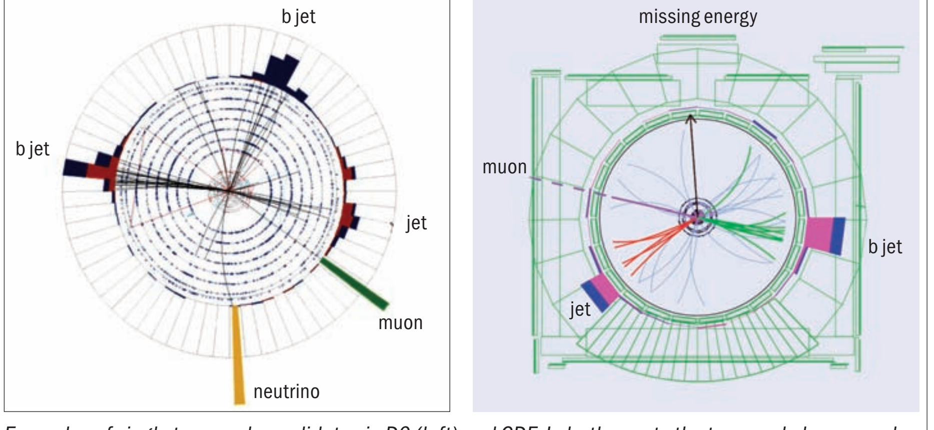
Further reading

I Milstein *et al.* 2008 *Nucl. Instrum. Meth. B* **266** 3453.
D Oellers *et al.* http://arxiv.org/abs/0902.1423.
PAX Collaboration 2006 *Technical Proposal for Antiproton–Proton Scattering Experiments with Polarization*, www.fz-juelich.de/ikp/pax.
F Rathmann *et al.* 1993 *Phys. Rev. Lett.* **71** 1379.
F Rathmann *et al.* 2005 *Phys. Rev. Lett.* **94** 014801.
T Walcher *et al.* 2007 *Eur. Phys. J. A* **34** 447.
T Walcher *et al.* 2009 *Eur. Phys. J. A* **39** 137.

FERMILAB

CDF and D0 report single top quark events

Almost 14 years to the day after the announcement of the discovery of the top quark in 1995, the CDF and D0 collaborations at Fermilab have announced the observation of top quarks produced singly in proton–antiproton collisions, rather than in top–antitop pairs. On 4 March, the two teams submitted their independent results to *Physical Review Letters*. Unlike pair-production of top quarks, which occurs through the strong interaction, the production of single top quarks occurs through the weak interaction and has important implications for possible new physics beyond the Standard Model.



Examples of single top quark candidates in D0 (left) and CDF. In both events the top quark decays and produces a b quark jet, a muon and a neutrino. In the CDF event (right), the arrow indicates the direction of the escaping neutrino. (Courtesy D0 and CDF.)

Only one in every 20 000 million proton–antiproton collisions produces a single top quark, and to make matters worse, the signal of these rare occurrences is easily mimicked by other "background" processes that occur at much higher rates. Both teams have previously published evidence for single top production at Fermilab's Tevatron, CDF last year and D0 in 2007 (*CERN Courier* January/February 2007 p6). These earlier papers reported significance levels of 3.7 σ and 3.6 σ for CDF and D0, respectively. Now both teams report the first observation of the process with a significance of 5.0 σ, based on 3.2 fb^{-1} of proton–antiproton collision data in CDF and 2.3 fb^{-1} in D0.

The analyses also constrain the magnitude of $|V_{tb}|$, an important parameter of the Standard Model's Cabibbo-Kobayashi-Maskawa (CKM) matrix, which describes how quarks can change from one type to another. If the CKM matrix describes the intermixing of only three generations of quarks – with top and bottom forming the third generation – the value of $|V_{tb}|$ should be close to one. In the new analysis CDF finds $|V_{tb}| = 0.91 \pm 0.11(\text{stat.+syst.}) \pm 0.07(\text{theor.})$, while D0 reports $|V_{tb}f^L| = 1.07 \pm 0.12$ where f^L is the strength of the left-handed coupling between the W boson and the top and bottom quarks.

In addition to its inherent success, discovering single top quark production has presented the collaborations with challenges similar to the search for the Higgs boson, in terms extracting an extremely small signal from a large background. Advanced analysis techniques pioneered for the single top discovery are now in use in both collaborations for the Higgs boson search.

Further reading

CDF Collaboration 2009 http://arxiv.org/pdf/0903.0885v1.
D0 collaboration 2009 http://arxiv.org/pdf/0903.0850v1.ft .

Compiled by John Swain, Northeastern University

Fingerprints point to how they developed

Conventional explanations for why humans have fingerprints have suggested help in gripping things and possible benefits for the sense of touch. Now Georges Debrégeas and colleagues at the Ecole Normale Supérieure have used an artificial fingertip and a vibration sensor to lend support to the second of these explanations. Using small pieces of skin-like rubber with either a smooth surface or one patterned like a human fingerprint, they looked at how it vibrated when dragged across a glass slide etched with fine lines.

The results showed that the "fingerprints" produced vibrations up to 100 times stronger. The vibrations were strongest when the etched glass slid perpendicular to the "fingerprint" ridges. This suggests that the geometric lines of real fingerprints developed to boost the chances of rubbing some of the ridges across surfaces in an optimal way.

Tests with false fingerprints suggest that the lines in human fingerprints (above) heighten the sense of touch. (Courtesy Jf123/Dreamstime.com.)

Further reading

J Scheibert *et al.* 2009 *Science* **323** 572.

Intracellular thermometry

While it's commonplace to take the temperature of an ill person, it is not obvious how to measure the temperature inside a single cell. Now Seiichi Uchiyama of the University of Tokyo in Japan and collaborators may have the answer. They have developed a nanogel material with a temperature-dependent fluorescence that can be introduced into the cytoplasm of a cell.

The nanogel shrinks with increasing temperature, which has the effect of forcing out water. This brightens the fluorescence of chemical groups in the gel by reducing the quenching effect of water. The response time is 5 ms and the temperature resolution is about 0.5 °C, which is about 10 times better than previous techniques, without their sensitivity to pH and ionic strengths.

Further reading

C Gota *et al.* 2009 *J. Am. Chem. Soc.* **131** 2766.

Printed transistors come one step closer

Attempts to develop printed transistor circuits using plastic semiconductors have been hampered by the fact that only p-type (hole transporting) plastics have been readily available. Now He Yan of Polyera Corporation in Skokie, Illinois, and colleagues have developed an n-type polymer that is well-suited to printed fabrication techniques and can be used together with p-type materials to make so-called complementary circuits, which use very little power. Simple transistors and circuits have already been made with this technology, so the term "printed circuit" may soon come to mean something very new and interesting.

Further reading

H Yan *et al.* 2009 *Nature* **457** 679.

Giant snakes hint at past global warming

A 58–60 million-year-old fossil skeleton from northeastern Colombia may shed light on global warming. Jason Head, of the University of Toronto, and colleagues estimate that the snake was 13 m long and weighed 1135 kg, the largest known snake in the world.

Snakes, of course, are cold-blooded creatures and need warm conditions to live. The researchers calculate that such an enormous snake would have needed a mean annual temperature of 30–35 °C to survive, or 6 °C warmer than now. This could be bad news, suggesting evidence of an earlier period of global warming uncompensated by any sort of global thermostat.

Further reading

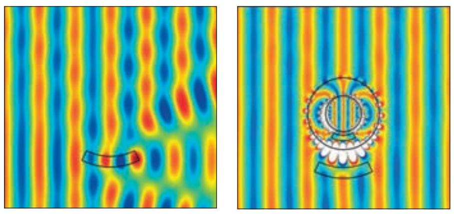
Jason J Head *et al.* 2009 *Nature* **457** 715.

Introducing the invisibility umbrella

Over the past couple of years, much work has developed around using metamaterials to make "invisibility cloaks", which deflect light around them and render objects inside "invisible". Now a new twist from Yun Lai and colleagues at the Hong Kong University of Science and Technology in Clear Water Bay suggests an "invisibility umbrella". This would allow its holder to their surroundings while being shielded from view; that is, the cloaked object actually lies outside the cloak. The cloak depends on the object being hidden, but the object itself can be any shape. The physics of *Harry Potter* is coming closer.

Further reading

Y Lai *et al.* 2009 *Phys. Rev. Lett.* **102** 093901.



Scattering from a curved object (left) is counteracted by the "invisibility umbrella" (right).

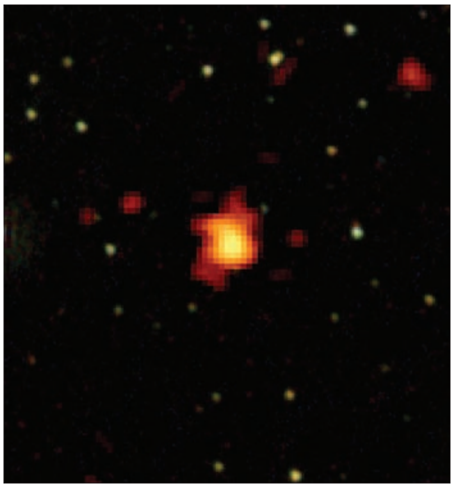
Compiled by Marc Türler, ISDC and Observatory of Geneva University

Fermi sees most powerful gamma-ray burst

The Fermi Gamma-ray Space Telescope has observed the evolution of a gamma-ray burst over six orders of magnitude in photon energy. The combination of its brightness and its remote distance makes it by far the most energetic gamma-ray blast ever seen. Furthermore, the observed delay of the highest-energy emission gives a lower limit on the strength of quantum-gravity effects.

Since the launch of the Swift satellite in November 2004, up to a few gamma-ray bursts (GRBs) are routinely detected every day (*CERN Courier* December 2005 p20). The phenomenon now seems commonplace and only the record-breaking bursts attract public attention. After the "Rosetta stone" GRB 030329 (*CERN Courier* September 2003 p15) and the "naked-eye" GRB 080319B (*CERN Courier* June 2008 p12), here comes the "extreme" GRB 080916C. This giant burst was observed by Fermi, which was launched into space last year (*CERN Courier* November 2008 p13). It is one of the rare bursts detected up to giga-electron-volt energies by the Large Area Telescope (LAT), the main instrument aboard Fermi. In five months the LAT has detected only 3 GRBs out of 58 that were in its field of view, according to the positions provided by the secondary instrument, the Gamma-ray Burst Monitor (GBM).

The burst of 16 September 2008, GRB 080916C, was the brightest observed so far and the only one with a distance determined by an observed redshift. The redshift of $z = 4.35 \pm 0.15$, measured by the



The X-ray afterglow of GRB 080916C appears orange and yellow in this view, which merges images from Swift's ultraviolet/optical and X-ray telescopes. (Courtesy NASA/Swift/Stefan Immler.)

Gamma-Ray Burst Optical/Near-Infrared Detector (GROUND) on the 2.2 m Max Planck Telescope at La Silla, in Chile, locates the collapsing-star event at a distance of 12.2 thousand million light-years. This cosmological distance means that GRB 080916C was intrinsically extremely luminous – at least twice as much as the previous record-holder, GRB 990123, which was observed by the Energetic Gamma-Ray Experiment Telescope aboard the Compton Gamma-Ray Observatory.

The Fermi LAT and Fermi GBM collaborations have jointly published a detailed analysis of the emission of this extreme burst. The combined GBM and LAT spectra – covering the range from 8 keV to 300 GeV – are consistent with a very simple spectral shape. Spectra were extracted for five distinct epochs during the evolution of the burst and all have the simple form of a Band function, which smoothly joins low- and high-energy power laws. A simple physical interpretation for such spectra is synchrotron radiation of charged particles in a magnetic field, but this cannot be confirmed, because the synchrotron self-Compton emission expected in this case could not be detected.

The most interesting result is probably the evidence of a consistently increasing delay of higher-energy radiation during the second peak of the GRB emission. This time lag can be intrinsic to the source or induced by quantum-gravity effects along the path from the remote source to the telescope. The delay by about 16 s of the most energetic photon –13 GeV – with respect to the on-set of the burst allows the researchers to derive a lower limit on the quantum-gravity mass of only about one order of magnitude below the Planck mass. The question of whether the observed delay is intrinsic to the source or results from its long journey through the quantum foam of space–time will eventually be solved with the detection of several other bursts with known redshift and measurable time delays.

Further reading

A A Abdo *et al.* 2009 *Science Express*. DOI: 10.1126/science.1169101.

Picture of the month

The Carina Nebula – 7500 light-years away in the southern constellation Carina, the Keel – is one of the largest and brightest nebulae in the Milky Way. This colour-composite image from the 2.2 m ESO/MPG telescope at La Silla in Chile reveals beautiful details. Spanning about 100 light-years, the nebula is four times as large as the Orion Nebula and far brighter. It is an intensive, star-forming region with dark lanes of cool dust splitting up the glowing gas that surrounds its many clusters of stars. The bright spot at the left of the image centre is Eta Carinae, which is probably the most massive and luminous star in the galaxy (*CERN Courier* July/August 2008 p12). The dark cloud to its right is the famous Keyhole Nebula. (Courtesy ESO.)

CERN COURIER ARCHIVE: 1966

A look back to *CERN Courier* vol. 6, April 1966, compiled by Peggie Rimmer

CERN

Neutrino beams: horns of plenty

In the photograph, the inner conductor of one of the "reflectors" for the new neutrino beam line [at the Proton Synchrotron] is being checked for dimensional accuracy after welding in the West workshop. Designed to increase the flux of neutrinos to a value four times higher than in previous experiments, it will be placed 15 m from the target located in a modified magnetic horn and followed by a second reflector, 4 m long, positioned 50 m from the target. These three devices focus the "neutrino parents" that decay to produce the neutrino beam.

The conductor is 5 m long, with an inner diameter of 20 cm minimum and 2 m maximum, and will take peak pulsed currents up to 500 kA. It is the most difficult component of the reflector to construct and has been made on site (other components are being manufactured outside). It is built from cones of aluminium alloy 2 to 3 mm thick – horizontal bands on the conductor indicate where the separate sections are welded together.

An inner conductor for the new neutrino "horn".

It is hoped that assembly of the reflector, when this inner conductor will be placed inside its large cylindrical outer conductor, will begin at the end of May and that tests will be completed in July and August. The reflector will then be installed with the many other components in this complex beam line.

● Featured in *CERN News* p68.

COLLABORATION

Visit to Serpukhov

At its Meeting in December 1965, the CERN Council approved the initiative of Professor Weisskopf in pursuing the possibility of collaboration with the Russian accelerator Laboratory at Serpukhov. At the end of that year, five physicists from CERN visited Serpukhov, where the Soviet 70 GeV proton accelerator is under construction. Soon afterwards, the Director of the Laboratory, A A Logunov, and several of his colleagues spent a week in CERN, opening up possibilities of future collaboration.

The Serpukhov project started several years ago, under the guidance of physicists from the Moscow Institute of Experimental and Theoretical Physics. Preliminary work on the site began in 1960. The project recently became more autonomous under the name "Serpukhov Institute for High Energy Physics", IHEP. Construction work received new impetus and a programme for the preparation of beams and experiments was launched. Part of the work takes place on the site itself and part is done by teams temporarily stationed at Dubna. The experimental physics staff now numbers about 70, and is expected to grow to a size comparable to CERN's in about two years. The accelerator design is done at the Research Institute for Electro-Physical Equipment in Leningrad, which centralizes this type of work for the entire Soviet Union. The parts are built by industry.

The CERN visitors and their hosts in front of the Laboratory headquarters at Serpukhov. From left to right: B Montague (CERN), A A Filippov (Dubna), A Rousset (Ecole Polytechnique and CERN), A A Logunov (Serpukhov), M Ferro-Luzzi (CERN), J M Perreau (CERN), Y D Prokoshkin (Serpukhov) and R M Sulaiev (Serpukhov).

While in Serpukhov, the question on our lips was: "When do you expect the first accelerated beam?" The best estimate our hosts gave us was two years (end of 1967), with a margin of error of minus two months, plus one year. They asked us to make an estimate on the basis of what we had seen. Instead of a wild guess, we wished our friends the best of luck in reaching this date, which must be dear to all their hearts. [The 100 MeV linac injector went into operation in July 1967, beam tuning began on 29 August and on the night of 14 October a record proton energy of 76 GeV was achieved].

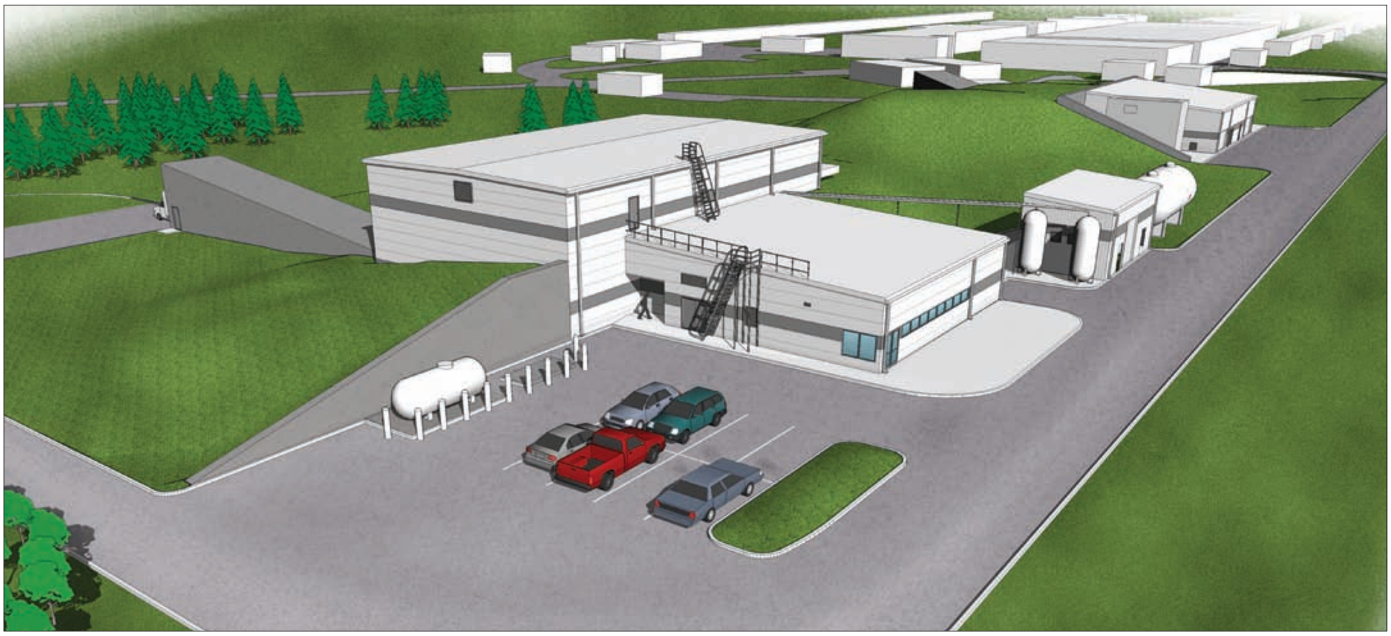
● Compiled from the article by Y Goldschmidt-Clermont pp69–70.

COMPILER'S NOTE

Paul Dirac held that "a physical law must possess mathematical beauty", an opinion vehemently shared by Albert Einstein. Constructed two millennia apart, the robust arches of the Pont du Gard aqueduct and the slender catenaries of the Millau viaduct, both in the South of France, are material structures evincing physical laws that are, of themselves, beautiful.

Much more modest in scope, the horns built to manipulate the electrically charged progenitors of neutrino beams also possess an intrinsic beauty. (See *Wikipedia* for a simple and clear description of how these horns work.) An example, graceful if a little careworn, can be seen in the lower gallery of CERN's Microcosm exhibition and a modern example is currently at work for the CERN Neutrinos to Gran Sasso project (*CERN Courier* October 2006 p5).

On a political rather than aesthetic front, while the world was buffeted by the fluctuating tensions of the Cold War – the 1961 Berlin crisis, the 1963 Cuban missile crisis – scientists at CERN and in the Soviet Union patiently persisted in setting up collaborative projects that, whatever the scientific outcomes, must rank among their finest non-scientific achievements.



Jefferson Lab will gain a fourth experimental hall housing the GlueX experiment to study quark confinement through exotic hybrid mesons.

Jefferson Lab starts its 12 GeV physics upgrade

For new studies of quark confinement, nucleon structure, the physics of nuclei and the Standard Model's limits, Jefferson Lab has begun awarding contracts to double the 6 GeV energy of the Continuous Electron Beam Accelerator Facility, upgrade its experimental halls and add a fourth hall.

The US Department of Energy's (DOE) Thomas Jefferson National Accelerator Facility in Newport News, Virginia, has awarded four contracts as it begins a six-year construction project to upgrade the research capabilities of its 6 GeV, superconducting radio-frequency (SRF) Continuous Electron Beam Accelerator Facility (CEBAF). The resulting 12 GeV facility – with upgraded experimental halls A, B and C and a new Hall D – will provide new experimental opportunities for Jefferson Lab's 1200-member international nuclear-physics user community.

The contracts are the first to be awarded following DOE's recent approval of the start of construction (*CERN Courier* November 2008 p9). The DOE Office of Nuclear Physics within the Office of Science is the principal sponsor and funding source for the $310 million upgrade, with support from the user community and the Commonwealth of Virginia. Under a $14.1 million contract, S B Ballard Construction, of nearby Virginia Beach, will build Hall D and the accelerator tunnel extension used to reach it as well as new roads and utilities to support it. Hall D civil construction is expected to last from spring 2009 until late summer 2011.

Two further contracts are for materials for Hall D's particle detectors and related electronics. Under a $3.3 million contract, Kuraray of Japan will produce nearly 3200 km of plastic scintillation fibres for the new hall's largest detector – a barrel calorimeter approximately 4 m long and nearly 2 m in outer diameter. This calorimeter will detect and measure the positions and energies of photons produced in experiments. Its precision will allow the reconstruction of the details of particle properties, motion and decay. Under a $200 000 contract, Acam-Messelectronic GmbH of Germany will provide some 1440 ultraprecise, integrated time-to-digital converter chips for reading out signals from particles in experiments.

Last, a $1.5 million contract has gone to Ritchie-Curbow Construction of Newport News for a building addition needed for doubling ▷

the refrigeration capacity of CEBAF's central helium liquefier, which enables superconducting accelerator operation at 2 K.

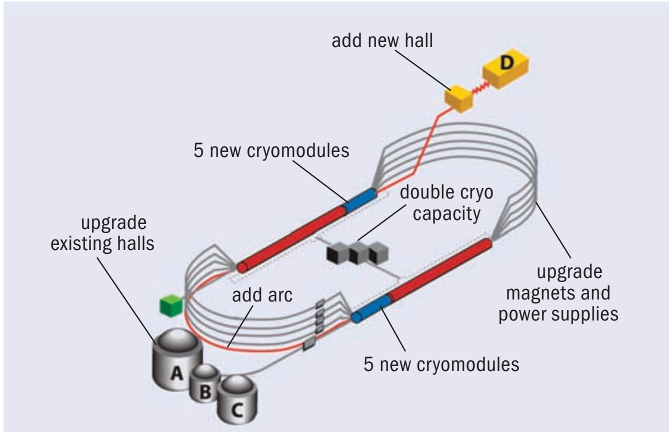
CEBAF already offers unique capabilities for investigating the quark–gluon structure of hadrons. Since operations began in the mid-1990s, more than 140 experiments have been completed. The experiments have already led to a better understanding of a variety of aspects of the structure of nucleons and nuclei, as well as the nature of the strong force. These include the distributions of charge and magnetization in the proton and neutron; the distance scale where the underlying quark and gluon structure of strongly interacting matter emerges; the evolution of the spin-structure of the nucleon with distance; the transition between strong and perturbative QCD; and the size of the constituent quarks. The beautiful programme of parity violation in electron scattering has permitted the precise determination of the strange quark's contribution to the proton's electric and magnetic form factors, with results that are in excellent agreement with the latest results from lattice QCD. This programme has placed new constraints on possible physics beyond the Standard Model.

New opportunities

Careful study in recent years by users and by the US Nuclear Science Advisory Committee has shown that a straightforward and comparatively inexpensive upgrade that builds on CEBAF's existing assets would yield tantalizing new scientific opportunities. The DOE study *Facilities for the Future of Science: A Twenty-Year Outlook* recommended the 12 GeV upgrade as a near-term priority. This 20-year plan used plain language to explain why. Speaking of quarks, it read: "As yet, scientists are unable to explain the properties of these entities – why, for example, we do not seem to be able to see individual quarks in isolation (they change their natures when separated from each other) or understand the full range of possibilities of how quarks can combine together to make up matter."

The 12 GeV upgrade will enable important new thrusts in Jefferson Lab's research programme, which generally involve the extension of measurements to higher values of momentum-transfer, probing correspondingly smaller distance scales. Moreover, many experiments that can run at a currently accessible momentum-transfer will run more efficiently at higher energy, consuming less beam time. For the first time nuclear physicists will probe the quark and gluon structure of strongly interacting systems to determine whether QCD gives a full and complete description of hadronic systems.

The 12 GeV research programme will offer new scientific opportunities in five main areas. First, in searching for exotic mesons, in which gluons are an unavoidable part of the structure, researchers will explore the complex vacuum structure of QCD and the nature of confinement. Second, extremely high-precision studies of parity violation, developed to study the role of hidden flavours in the nucleon, will enable exploration of particular kinds of physics beyond the



Schematic of the CEBAF configuration at Jefferson Lab, illustrating components of the 12 GeV upgrade. (All images courtesy Jefferson Lab.)

Standard Model on an energy scale that cannot be explored even with the proposed International Linear Collider.

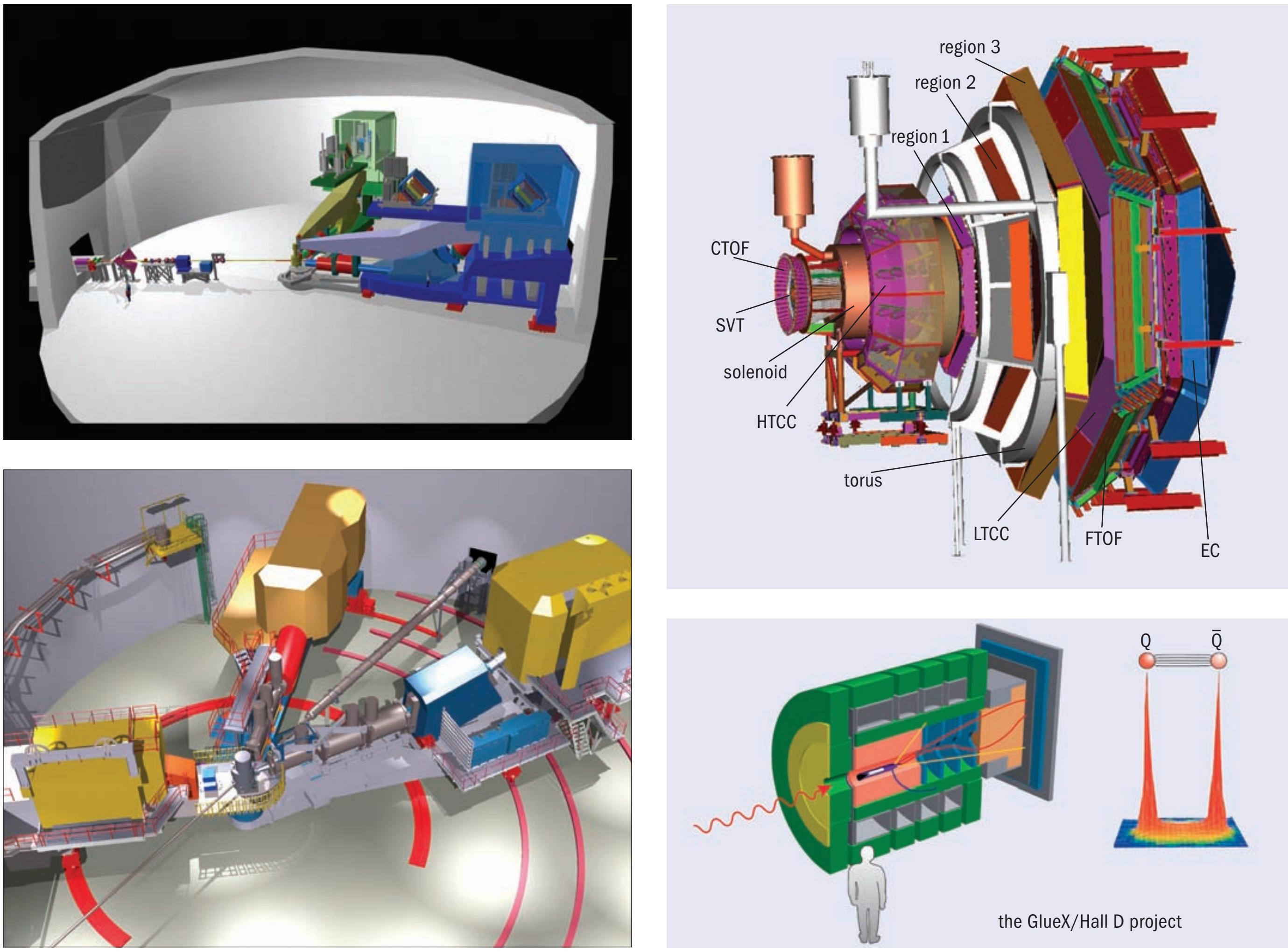
The combination of luminosity, duty factor and kinematic reach of the upgraded CEBAF will surpass by far anything available through this kind of research. This will open up a third opportunity: by yielding a previously unattainable view of the spin and flavour dependence of the distributions of valence partons – the heart of the proton, where its quantum numbers are determined. The upgrade will also allow a similarly unprecedented look into the structure of nuclei, exploring how the valence-quark structure is modified in a dense nuclear medium. These studies will yield a far deeper understanding, with far-reaching implications for all of nuclear physics and nuclear astrophysics.

Lastly, the generalized parton distributions (GPDs) will allow researchers to engage in nuclear tomography for the first time – discovering the true 3D structure of the nucleon. The GPDs also offer a way to map the orbital angular momentum carried by the various flavours of quark in the proton.

New equipment

The CEBAF accelerator consists of two antiparallel 0.6 GV SRF linacs linked by recirculation arcs. With up to five acceleration passes, it serves three experimental halls with simultaneous, continuous-wave beams – originally with a final energy of up to 4 GeV, but now up to 6 GeV, thanks to incremental technology improvements. Independent beams are directed to the three existing experimental halls, each beam with fully independent current, a dynamic range of 10^5, high polarization and "parity quality" constraints on energy and position.

The new Hall D will be built at the end of the accelerator, opposite the present halls. Experimenters in Hall D will use collimated beams of linearly polarized photons at 9 GeV produced by coherent



Experimental equipment for the 12 GeV physics programme. Top and bottom left: Hall A will be used for large-installation experiments such as parity-violation studies; a new spectrometer in Hall C will have excellent momentum resolution and luminosity up to 10^{38} to study the valence-quark regime. Top and bottom right: the upgraded spectrometer in Hall B and the new GlueX detector in Hall D will have good momentum/angle resolution and high multiplicity reconstruction to study generalized parton distributions and quark confinement respectively.

bremsstrahlung from 12 GeV electrons passed through a crystal radiator. To send a beam of that energy to that location requires a sixth acceleration pass through one of the two linacs. This means adding a recirculation beamline to one of the arcs. It also requires augmenting the accelerator's present 20 cryomodules per linac with five higher-performing ones per linac. Each 25-cryomodule linac will then represent 1.1 GV of accelerating capacity. The maximum energy for five passes will rise to 11 GeV for the three original halls, with experimental equipment upgraded in each.

As of early 2009, not only have the first contracts been awarded, but solicitations have been issued for about 40% of the total construction cost. CEBAF's upgrade is the highest-priority recommendation of the Nuclear Science Advisory Committee's December 2007 report *The Frontiers of Nuclear Science: A Long Range Plan*. "Doubling the energy of the JLab accelerator," the report states, "will enable three-dimensional imaging of the nucleon, revealing hidden aspects of its internal dynamics. It will test definitively the existence of exotic hadrons, long-predicted by QCD as arising from quark confinement." Efforts to realize this new scientific capability are now well underway.

Further reading

For more information, see www.jlab.org/12GeV.

Résumé

Le Laboratoire Jefferson en route vers les 12 GeV

Le Laboratoire national Thomas Jefferson National,dépendant du ministère de l'Énergie des États-Unis, vient de signer quatre contrats qui marquent le commencement d'un projet de construction de six ans visant à augmenter les capacités de recherche de son accélérateur supraconducteur à radiofréquences à faisceau continu d'électrons de 6 GeV. L'accélérateur de 12 GeV qui verra ainsi le jour sera doté de halls expérimentaux A, B et C améliorés et d'un nouveau hall D, ce qui ouvrira de nouvelles possibilités d'expériences aux 1 200 chercheurs en physique nucléaires utilisateurs de ce laboratoire. De nouvelles études pourront être menées sur le confinement des quarks, la structure des nucléons, la physique des noyaux et les limites du modèle standard.

Allison Lung *and* **Claus Rode**, *Jefferson Lab.*

INTERNATIONAL CONFERENCE ON MAGNETISM

KARLSRUHE ICM 09

ICM 2009

July 26 - 31 2009 Karlsruhe Germany

www.icm2009.de

Strongly Correlated Electron Systems
Quantum and Classical Spin Systems
Magnetic Structures and Interactions
Magnetization Dynamics and Micromagnetics
Spin-Dependent Transport
Spin Electronics
Magnetic Thin Films
Magnetic Particles and Nanostructures
Soft and Hard Magnetic Materials and their Applications
Novel Materials and Device Applications
Magnetic Recording and Memories
Measuring Techniques and Instrumentation
Interdisciplinary Topics


Bildstelle Stadt Karlsruhe, Stadtplanungsamt, Lammstr.7, D-76124 Karlsruhe

Plenary and Half-Plenary Speakers

Phillip W. Anderson*, Princeton
David Awschalom, Santa Barbara
Yuriy M. Bunkov, Grenoble
Albert Fert, Orsay
Peter Grünberg, Jülich
Shoji Ikeda, Sendai
Daniel Loss, Basel
Sadamichi Maekawa, Sendai
Roderich Moessner, Dresden
Stuart S. P. Parkin, San José
Roman V. Pisarev, St. Petersburg
Theo H. M. Rasing, Nijmegen
Frank Steglich, Dresden
Yoshinori Tokura, Tokyo
Chandra Varma, Riverside
Martin Wegener, Karlsruhe
Wolfgang Wernsdorfer, Grenoble
Shoucheng Zhang, Stanford

*to be confirmed

Important Dates and Deadlines

Abstract submission: February 28, 2009
Acceptance of abstracts: March 31, 2009
Reduced fee and hotel reservation: May 31, 2009
Paper submission: May 31, 2009

Further information

www.icm2009.de

Contact

ICM 2009 Secretary
Universität Karlsruhe
Physikalisches Institut
D-76128 Karlsruhe
Germany

E-mail: icm2009@pi.uka.de

ICM 2009 will incorporate the International Conference on Strongly Correlated Electron Systems (SCES).

ICM 2009 will be hosted jointly by the Universität Karlsruhe and Forschungszentrum Karlsruhe, one of the twelve National Helmholtz Research Centers. These two institutions recently joined forces to found the Karlsruhe Institute of Technology (KIT).

Forschungszentrum Karlsruhe GmbH in der Helmholtz- Gemeinschaft

KIT Karlsruhe Institute of Technology

Deutsche Forschungsgemeinschaft DFG

IUPAP

Karlsruhe

The ICM 2009 will be conducted in accordance with the IUPAP principles as stated in the ICSU-Document "Universality of Science" (sixth edition, 1989) regarding the free circulation of scientists for international purposes. In particular no bona fide scientist will be excluded from participation on the grounds of national origin, nationality, or political considerations unrelated to science.

Franco Bonaudi: wise spirit of the early CERN

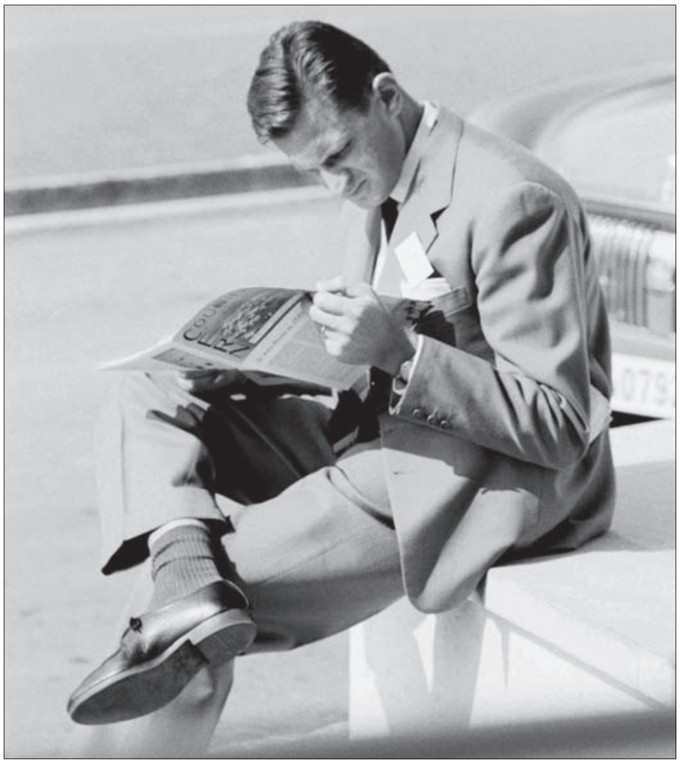
Colleagues of Franco Bonaudi recall some of his major contributions to accelerators and experiments at CERN, from the very first days to the highly successful LEP project.

Franco Bonaudi, who died on 21 December 2008, was one of the first electronic engineers to work for CERN. In July 1952, two years before the organization was formally created, he was sent from Rome by Edoardo Amaldi to Liverpool, to learn about synchrocyclotrons. Speaking only some basic English, he arrived in Liverpool with Frank Krienen, assistant to Cornelis Bakker, the newly appointed team leader for the 600 MeV Synchrocyclotron (SC) that was to be CERN's first accelerator facility. Bonaudi got on so well with his hosts and his new boss that, as well as perfecting his English and learning about accelerators, he acquired valuable training in dealing with industrial firms, as Krienen had earlier worked in the research laboratories of Philips at Hilversum (*CERN Courier* July/August 2008 p25).

Krienen and Bonaudi left Liverpool when the CERN staff started to gather close to the Geneva site where the new European laboratory was to be built. Most of the SC team were housed in barracks at Geneva's airport, but Bonaudi, with Joop Vermeulen, was soon dispatched to a hut on the Meyrin site to oversee the construction of the accelerator. The staff of the infant CERN numbered around 150 at that time and were of many different nationalities and nearly all strangers to the region. Communicating in poor English, they worked together as family and friends – the first CERN telephone directory contained private numbers. Bonaudi said of that period: "We made real friendships". At the same time, they rapidly completed their professional task and the first beam circulated in the SC on 1 August 1957.

Meanwhile, a much larger undertaking was progressing well, with the construction of the 24 GeV PS. Before the machine saw its own first beam on 24 November 1959, Bonaudi had become leader of the Apparatus Layout Group and so taken his first steps from machine builder towards experimental support, which was to become his greatest strength. Theo Kröwerath, a charismatic figure who progressed from driving a tank to being responsible for CERN's Transport Group, still remembers the trips to suppliers that he made with Bonaudi at that time and believes that he owes his professional success to those, like Bonaudi, whose approach epitomized the spirit of the early CERN. This ethos was grounded in a tremendous respect for the work of all members of a team, whether they were engineers, physicists, technicians, mechanics or crane drivers, with – an added speciality of CERN – the more nationalities in a group, the better.

In 1963, with construction of the SLAC 20 GeV linear accelerator just beginning, Bonaudi went to California for a year to help to design the experimental areas. He shared an office with David Coward, who remembers that Bonaudi's experience proved invaluable. He made significant contributions to designs of radiation shielding, for both personnel and experimental equipment, and to the design of the distribution of utilities throughout the SLAC experimental areas. He also actively participated in the physics meetings that helped to establish the nascent SLAC experimental physics programme. At the same time, Bonaudi made friends for life and helped to initiate a successful series of exchanges of physicists and engineers.



Bonaudi reads the second edition of the CERN Courier, *which contained news about commissioning the PS during the summer of 1959.*

Back at CERN, Bonaudi was asked to design the experimental areas for the Intersecting Storage Rings (ISR), based on the space and facilities indicated by some initial ideas for experiments. Construction began in 1966, with CERN's Meyrin site extended into France to accommodate the machine. Bonaudi, as head of the ISR General Layout Group, was responsible for building the halls ▷

for experiments and the tunnels for the whole machine. The group included its own civil engineering section and later had sections for both electrical cabling and power distribution. Taking over responsibility for the control and signal cabling – invariably underestimated for physics and machines alike – revealed another insight into Bonaudi's way of solving problems. When cabling teams fell behind schedule, he would invite all of the members of the group to join him on a cable-pulling weekend. Such was his popularity that it was always a huge success, with everybody knowing that "the boss" would be working harder than anyone, on the worst part of the task. His unspoken motto was: "Let's get the job done as simply and quietly as possible."

From the ISR to LEP

With the ISR construction satisfactorily completed and first beams colliding in January 1971, Bonaudi converted his construction team into the ISR Experimental Support Group, which offered extensive assistance to the many and diverse experiments. It is worth noting that, while it was necessary to excavate a few pits to create more space under the collision regions for some of the later, larger experiments, the halls proved to be correctly dimensioned, though some of the built-in flexibility, such as demountable machine piers, was never needed.

Both John Adams and Léon Van Hove, as executive and research directors-general respectively, recognized Bonaudi's success at the ISR. As a result, he became a much appreciated member of the directorate with responsibility for the entire CERN accelerator complex. His mandate included the period when the SPS was converted into a proton–antiproton collider, following the proposal by Carlo Rubbia. Bonaudi chaired the committee of accelerator experts that defined the final layout of the whole project and chose stochastic cooling, invented by Simon van der Meer at the ISR, to produce the low-emittance, 3.5 GeV beams of antiprotons. This latter choice, together with the decision to accelerate the antiproton beam in the PS before injection into the SPS – an essential point that Bonaudi recognized and finally decided – was the key to the success of the Nobel Prize-winning project.

After completing his three-year term in the directorate, Bonaudi was delighted to be invited to join the UA2 experiment and work hands on with particle detectors, namely the central calorimeter, from testing to data taking. Pierre Darriulat, who was the spokesman of the UA2 experiment, recalls that Bonaudi's colleagues on UA2 liked him a lot, and respected him highly for his wisdom. On many occasions where a difficult decision had to be made, his advice was taken and followed. In Darriulat's words: "He visibly enjoyed the exciting research atmosphere and the contacts with younger colleagues, and his relations with the members of the collaboration were of a very close and profound friendship."

Bonaudi's wisdom was soon required again by CERN for the LEP project. He was invited to join the project management team with responsibility for the experimental areas. The four, deep, underground areas in CERN's first project to be classified as an Installation Nucléaire de Base by the French government required a new approach to safety throughout the construction and installation phase. Bonaudi took these aspects seriously and the low accident rates during the project show how successful he was.

The director-general of the time, Herwig Schopper, notes that

Bonaudi (far left) on 27 January 1971, as Kjell Johnsen, who led the construction team for the ISR, announces that the first-ever interactions from colliding protons have been recorded.

Bonaudi's responsibilities for the infrastructure of the LEP experiments – which involved getting the complicated detectors and all of the necessary services installed in time – represented a formidable challenge. It was made particularly tricky by the changing time-schedule that arose from difficulties with the LEP tunnelling. "If the experiments were ready to take data at the turn on of the machine, it was in great part thanks to the untiring efforts of Franco," says Schopper. Both Schopper and Emilio Picasso, the LEP project leader, stress the importance of Bonaudi's presence on the LEP Management Board. "Franco's regular contributions at meetings were always appreciated for the competence of his intervention, and we always followed his suggestions," Picasso recalls. "I also greatly appreciated that, thanks to him and his group, the collaboration with the physics community was smooth and successful."

Once the LEP beams were successfully circulating in 1989, Bonaudi's attention returned to particle detectors, this time taking on the task of scientific secretary of the Detector Research and Development Committee, which advised the director-general on the numerous detector R&D projects being launched for the future high-luminosity LHC. While some might see this as a routine task, for Bonaudi it was an opportunity to work with friends and colleagues from the detector community, as he prepared for retirement from CERN in March 1993.

Retirement meant more time to devote to helping people in other ways, and Bonaudi immediately became involved in training and education, in particular in his home city of Turin, where he was appointed a member of the Academy of Science in 1991. He gave lectures on detectors and accelerators at both Turin University and the Politecnico, where he had completed his own studies in 1950. Even before retiring, in 1988 he became an active member of the scientific committee of the Associazione Sviluppo Piemonte (ASP: the Association for the Development of Piedmont), taking care of the relationship between ASP and CERN.

Throughout the 1990s, Bonaudi gave seminars and lectures to complement courses at Turin University on accelerators and detectors. In 1991 he was one of the founding organizers of the successful school for Italian young researchers and doctoral students, Giornate di studio dei Rivelatori. Emilio Chiavassa, professor

Directors at a meeting of CERN Council in 1977, Sergio Fubini (left) with Bonaudi, who was Director of Accelerators in 1976–1978.

Bonaudi (second from left) on a platform at the Split-Field Magnet in June 1975, surrounded by counters for the R406 experiment at the ISR.

of physics at Turin, recalls: "Franco was not only a promoter and organizer of the school, but actively participated every year with enthusiasm and competence." Now in its XIX edition, the school held on 10–13 February was subtitled "Scuola F Bonaudi" in his memory. In addition, he gave many courses on accelerator physics and detectors at the Politecnico, where he was, says Piero Quarati, "a reference point for all the engineering students who went to work at CERN for their laurea or PhD".

Elsewhere, Bonaudi was sought after as a member of several advisory committees, notably at the INFN-Frascati Laboratory.

Andrew Hutton, director of the Accelerator Division at the US Thomas Jefferson Laboratory, who chaired the DAΦNE Machine Advisory Committee, particularly appreciated his experience at the interface between the accelerator builders and the experimenters. "While Franco had the technical understanding of both groups," says Hutton, "more importantly, he had the personality to be able to bridge the mutual incomprehension between them. Franco always aimed to help everyone see the best way forward and to understand the point of view of the other side, so everyone left his meetings with the sense that they had gained something – a rare talent." Bonaudi organized a series of meetings between the DAΦNE accelerator builders and the future experimenters, bringing to the Machine Advisory Committee the results of the consensus that he had engineered. "In the committee he was always low key, adding a word here and there to facilitate the discussions," remembers Hutton. "What I came to realize only later was that he was aware that I had never chaired a committee like this before, and he was steering me away from pitfalls and mistakes without anyone, including me, being aware of it."

This ability was also appreciated outside Italy. For a number of years Bonaudi was invited *ad personam* to be a member of more than one advisory committee for the European Southern Observatory (ESO), and he also chaired a working group. Per Olof Lindblad, who was the representative of the ESO Council on another group, recalls that Bonaudi made particularly constructive contributions concerning the roles of a project scientist and the need for a project manager for the Very Large Telescope.

Bonaudi's concern for others was always evident, whether driving the elderly and needy for a Swiss charitable organization or actively participating in the Middle East Scientific Collaboration (MESC). Eliezer Rabinovici, professor of physics at the Racah Institute of Physics, the Hebrew University, Jerusalem, recalls: "The group of scientists and interested people that gathered under the umbrella of the MESC was very colourful. We prepared together the activities highlighted by the very special meetings in Dahab and Turin." In particular, the meeting in Turin was the first occasion when the idea of the Synchrotron-light for Experimental Science and Applications in the Middle East – SESAME, the synchrotron radiation laboratory created under the auspices of UNESCO in Jordan – was introduced to a middle-eastern audience.

Franco Bonaudi's contribution to CERN is obvious and inestimable. He helped to shape the successful, world-renowned research organization that we know today. His influence went far beyond the boundaries of CERN and, no matter where, all of his colleagues remember him as a great friend, the wisest of men, who will be sorely missed. It was a privilege to know and work with him.

Résumé

Franco Bonaudi : un sage du CERN

Franco Bonaudi, décédé en décembre 2008, était l'un des tout premiers ingénieurs en électronique du CERN. Il avait rejoint l'Organisation à ses débuts pour travailler à la construction du Synchrocyclotron de 600 MeV. Dans cet article, ses collègues et amis évoquent des contributions majeures qu'il a apportées dans le domaine de l'appui aux expériences du CERN, notamment auprès des anneaux de stockage à intersections (ISR) et du Grand collisionneur électron-positon (LEP). Son expérience à l'interface entre les constructeurs d'accélérateur et les expérimentateurs , ainsi que son tempérament calme ont fait de lui un membre très apprécié de nombreux comités, au CERN et ailleurs.

His former colleagues and friends. **Keith Potter**, *with assistance from* **Giorgio Brianti**, **Hans Hoffmann**, **Kurt Hübner**, **André Martin**, **Luisa Passardi**, **Marilena Streit-Bianchi** *and others, in addition to those quoted in the text.*

LHeC: novel designs for electron–quark scattering

A possible future option to allow electrons to collide with protons or heavy ions at the LHC is under close scrutiny through a newly established ECFA–CERN workshop.

Abdus Salam, at the Rochester Conference in Tbilisi in 1976, considered the idea of "unconfined quarks" and leptons as a single form of matter, in contrast to the distinctions between them in the Standard Model. Some 30 years later, it is appropriate to ask if a high-performance electron–proton collider could be built to investigate such ideas, complementing the LHC and a pure lepton collider at the tera-electron-volt energy scale. Entering this unexplored territory for electron–quark scattering is a challenging prospect, but one that could yield vast rewards.

On 1–3 September 2008, some 90 physicists met at Divonne, near CERN, for the inaugural meeting of the ECFA–CERN Large Hadron Electron Collider (LHeC) workshop on electron–proton (ep) and electron–ion (eA) collisions at the LHC. The workshop will initially run for two years, and a diverse mixture of accelerator scientists, experimentalists and theorists will produce a conceptual-design report. This will assess the physics potential of an electron beam interacting with LHC protons and ions, as well as details of the electron–beam accelerator, the interaction region, detector requirements and the impact on the existing LHC programme.

HERA, at DESY, was the previous ep machine at the energy frontier. By the time it ceased operation in 2007, its 15-year programme had led to many new insights into strong and electroweak interactions, provided much of the current knowledge of the parton densities of the proton and placed important constraints on physics beyond the Standard Model (*CERN Courier* January/February 2008 p34).

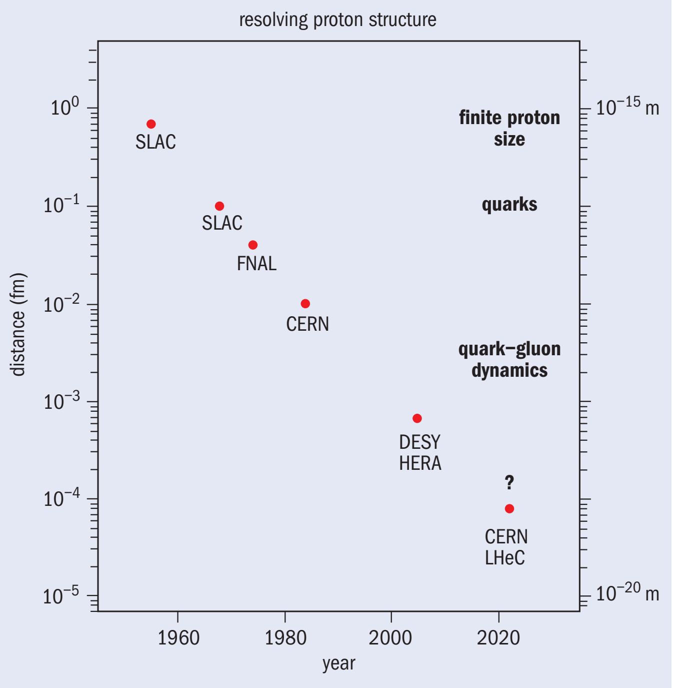


Fig. 1. Distance scales resolved in successive lepton–hadron scattering experiments since the 1950s, and some of the new physics revealed.

Physics potential

A new era of high energy and intensity for proton beams is now beginning with the switch-on of the LHC. Preliminary estimates suggest that the addition of an electron beam could yield ep collisions at a luminosity of the order of 10^{33} cm^{-2}s^{-1} and a centre-of-mass energy of 1.4 TeV (J Dainton *et al.* 2006). This would probe distance scales below 10^{-19} m (figure 1). In comparison, the best performance ever achieved at HERA was a luminosity of 5×10^{31} cm^{-2}s^{-1} at an ep centre-of-mass energy of 318 GeV (figure 2). The large luminosity and energy increases set the LHeC apart from other future ep colliders previously considered. If realized, it would lead to the first precise study of lepton–quark interactions at the tera-electron-volt scale and would have considerable discovery potential.

The workshop in Divonne began with remarks from CERN's chief scientific officer, Jos Engelen, who expressed CERN's interest and support for the study. Encouragement from ECFA was sent via its chair, Karlheinz Meier of Heidelberg, and the involvement of the nuclear-physics community was highlighted by Guenther Rosner from Glasgow, now chair of the Nuclear Physics European Collaboration Committee (NuPECC). In his opening lecture, Guido Altarelli of Rome introduced the wide-ranging possibilities of ep physics at the "terascale" and urged that ep/eA collisions must happen at some point during the LHC's lifetime. The chair of the LHeC steering group, Max Klein of Liverpool, then summarized previous promising work on the topic and the aims of the new workshop. Following the opening session, the meeting split into smaller groups to discuss specialized issues in more detail, with each group reporting its findings at the conclusion of the meeting.

An LHeC would be uniquely sensitive to the physics of massive electron–quark bound states and to other exotic processes involving excited or supersymmetric fermions. Beyond the search for new

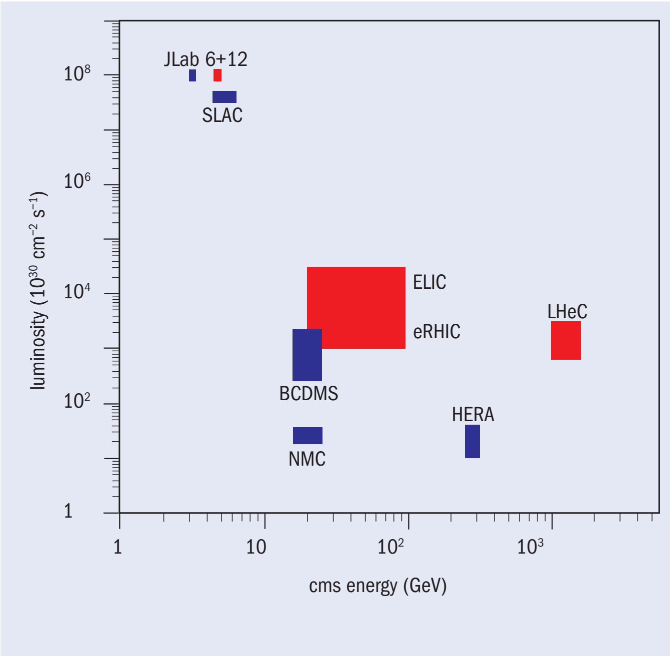


Fig. 2. Energies and luminosities of selected previous (blue) and proposed future (red) lepton–proton scattering facilities – Jefferson Lab's (ELIC) and Brookhaven's (eRHIC) versions of an electron–ion collider and the LHeC. Jefferson Lab's 12 GeV upgrade (p15) is also shown (JLAB 6+12).

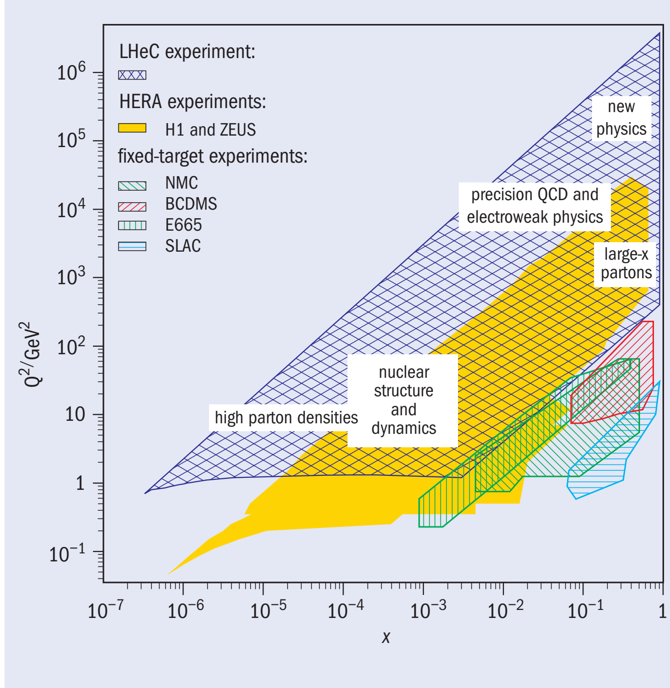


Fig. 3. Kinematic plane in Bjorken-x and resolving power Q^2, showing the coverage of fixed-target experiments, HERA and the LHeC. The mapping of the planned physics programme onto this plane is also indicated.

particles such as these, the LHeC would complement the LHC in the investigation of the Standard Model and in understanding new physics. Light Higgs bosons would be produced dominantly through WW fusion and could be precisely studied in decay modes such as $b\bar{b}$, which is expected to be problematic at the LHC. At the LHeC, top quarks would be produced copiously, both singly and in pairs, in the relatively clean environment offered by ep scattering.

With LHeC data the parton densities of the proton could be measured at momentum-transfer-squared beyond 10^6 GeV^2 and at small fractions of the proton momentum (with Bjorken-x below 10^{-6}), which are previously unexplored regions (figure 3). The kinematic range covered would match that required for a full understanding of parton–parton scattering in LHC proton–proton (pp) collisions. LHeC data would constrain each of the quark flavours separately for the first time, giving unrivalled sensitivity to the heavy quarks and to the gluon density over several orders of magnitude in x. In the process the strong coupling-constant could be measured to unprecedented precision.

Such an ep collider would provide an unrivalled laboratory for the study of strong-interaction dynamics. It would access a low-x region where quarks that are usually "asymptotically free" meet an extremely high background-density of partons. Various novel effects are predicted, including a well supported conjecture that, in protons at LHC energies, pairs of the densely packed partons begin to recombine into single quarks or gluons.

An LHeC would also allow for the scattering of leptons off heavy ions, which also has outstanding potential because all current knowledge of nuclear-parton distributions has been obtained in fixed-target experiments. The LHeC would extend the x and Q^2 ranges explored by up to four orders of magnitude, offering an understanding of the initial partonic states in LHC heavy-ion collisions and amplifying the sensitivity to the new physics of ultradense partonic systems. Electron–deuteron scattering would allow the first exploration of neutron structure at collider energies, leading to further unique studies of parton densities and to tests of long-proposed relationships between diffraction and nuclear shadowing.

Accelerator challenges

To realize these wide-ranging physics possibilities the main challenge lies in bringing the LHC's protons or heavy ions into collision at high luminosity with a new electron beam, without inhibiting the ongoing hadron–hadron collision experiments. Working groups are pursing two basic lay-outs of the electron accelerator for the conceptual design report, in order to understand fully the advantages and consequences of each.

An electron beampipe in the same tunnel as the LHC has the advantage of high luminosity, beyond 10^{33} cm^{-2}s^{-1}, at energies of 50–70 GeV for reasonable power consumption (figure 4, p24). According to a preliminary study, synchronous ep and pp LHC operation appears to be possible. This set-up would require by-pass tunnels of several hundred metres around existing experiments. These ducts could be used to host the RF infrastructure and could be excavated in parallel with normal LHC operations. Injection to an electron ring could be provided by the Superconducting Proton Linac (SPL), which is under consideration as part of the LHC injection upgrade (*CERN Courier* July/August 2008 p17). A further option for an initial phase of the LHeC is to use multiple passes in the SPL for the full electron acceleration, which could produce energies of around 20 GeV.

An alternative solution for the electron beam is a linear accelerator (linac) with somewhat reduced luminosity but with an installation that is decoupled from the existing LHC ring (figure 5, p24). The linac could use RF cavity technology under development for the ▷

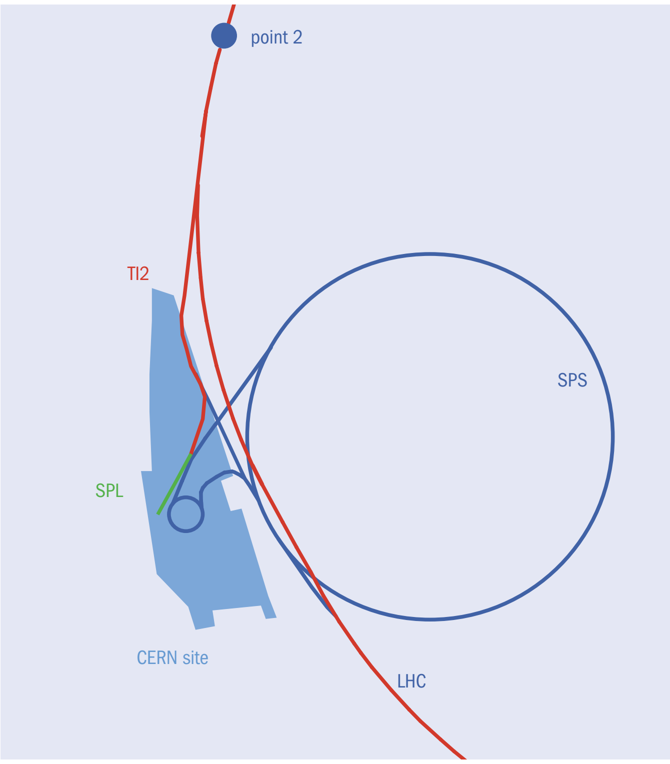


Fig. 4. Sketch of a possible layout to inject an electron beam into the LHC ring, using the SPL and the TI2 connection to the LHC tunnel.

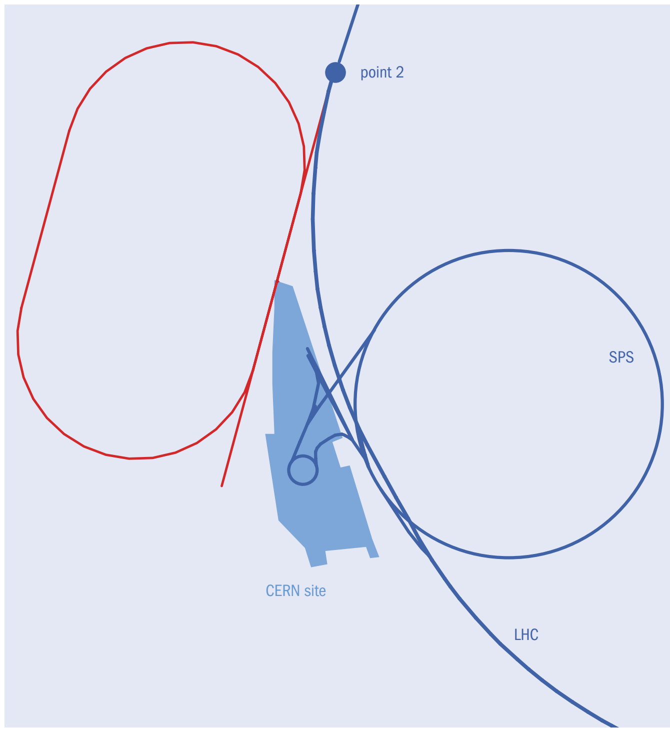


Fig. 5. A possible layout in which an electron linac arrives tangentially to the LHC, after multiple passes around a "racetrack" that makes full use of the linac accelerating structures.

proposed International Linear Collider, in either pulsed or continuous-wave mode. Power and cost permitting, it could produce energies of 100 GeV or more and provide electron–quark collisions at a centre-of-mass energy approaching 2 TeV.

Detailed calculations of the LHeC electron-beam optics have led to proposals for the layout of the interaction region, which is also a major consideration for the detector design. The highest projected luminosities, which are required to probe the hardest of ep collisions, may be achieved by placing beam-focusing magnets close to the interaction point. However, measurements at small angles to the beampipe are also important for the study of the densest partonic systems at low x and the hadronic final state at high x. Among the many interesting ideas, one proposed design involves instrumenting the focusing magnets for energy measurements. A first detector study for ep and eA physics at the LHeC includes high-precision tracking and high-resolution calorimetry, which would lead to a new level of precision in ep collider experiments.

Following an interim report presented to ECFA at the end of November 2008, the conceptual design work on an ep/eA collider at the LHC continues, with a second major workshop meeting scheduled for 7–8 September 2009. If realized, this facility would become an integral part of the quest to understand fully the new terascale physics that will emerge as the LHC era unfolds.

Further reading

For more about the project, see http://www.lhec.org.uk.
J Dainton *et al.* 2006 *JINST* **1** 10001.

Résumé

LHeC : nouveau projet sur la diffusion électron-quark

L'éventualité d'un programme de collisions électrons–protons ou électrons–ions lourds au LHC est actuellement examinée de près par un atelier ECFA–CERN, récemment créé. Lancé en septembre 2008, cet atelier LHeC devrait initialement durer deux ans. Pendant cette période, un groupe de spécialistes des accélérateurs, d'expérimentateurs et de théoriciens va tenter de rédiger un rapport conception préliminaire. Ce rapport devra évaluer le potentiel du point de vue de la physique d'un faisceau d'électrons entrant en interaction avec des protons et des ions dans le LHC, et préciser certains points concernant l'accélérateur à faisceau d'électrons, la région d'interaction, les caractéristiques requises pour le détecteur et l'impact sur le programme actuel du LHC.

Max Klein, *University of Liverpool, and* **Paul Newman**, *University of Birmingham.*

Planck satellite takes o

As European scientists completed final preparations for the launch of the Planck satellite, **Antonella del Rosso** visited the mission's base in Italy to find out about the goals and the instruments that will be used to map the cosmic background radiation.

ESA's Planck spacecraft is the first European satellite dedicated to the study of the cosmic microwave background (CMB) radiation. Due to be launched on 29 April aboard an Ariane 5 rocket from ESA's launch site in Kourou, French Guyana, Planck's primary goal is to determine the cosmological parameters of the universe and to survey astronomical sources. Scientists are hopeful that it should also answer many other fundamental and astrophysical questions.

The satellite will orbit at the second Lagrangian point (L2) of the Earth–Sun system at 1.5 million km from the Earth (figure 1). From this position, Planck will explore the unknowns of the cosmic background radiation – the relic radiation that brings with it many secrets of the history and evolution of the universe. For 380 000 years following the Big Bang, all of the dramatic events that steered the evolution of the universe, its geometry and properties were imprinted and memorized in the CMB.

The CMB today permeates the universe and has an average temperature of 2.725 K, though observations have revealed slightly colder and hotter spots known as anisotropies. Highly accurate studies of where these anisotropies are and what produced them may allow researchers to decode a wealth of information about the properties of the universe. Planck's task – 13.7 billion years after the Big Bang – is not an easy one, however, because the radiation signal is feeble and is embedded in all of the other galactic and extragalactic signals, each emitting at different frequencies.

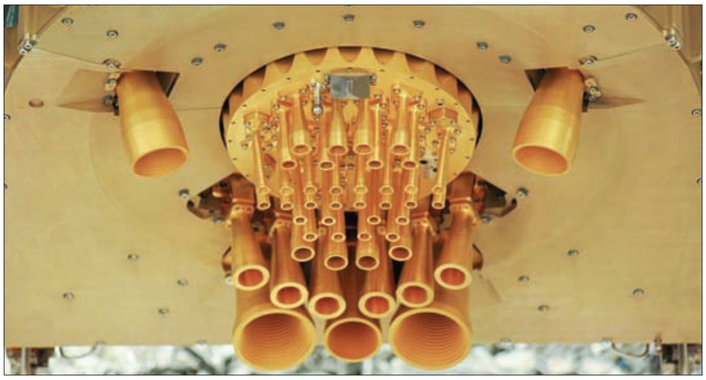
Following in WMAP's footsteps

The first two scientific missions to map the CMB and its anisotropies were NASA's Cosmic Background Explorer (launched in 1989) and the Wilkinson Microwave Anisotropy Probe (WMAP, launched in 2001). The data from these two satellites confirmed that the universe is flat, that its expansion is accelerating and that only 4% consists of known forms of matter. Nevertheless, given the lower accuracy of previous experiments, many questions remain concerning the nature of dark energy (73% of the universe) and dark matter (23%), as well as the processes that marked the infancy of the universe.

Planck comes eight years after WMAP and is designed to improve significantly on those results. The satellite is equipped with both the Low Frequency Instrument (LFI) and the High Frequency Instrument (HFI). "Together, the two instruments will scan the universe in nine frequency channels, with a sensitivity that is 10 times better than that of WMAP," says Reno Mandolesi of the Italian Institute of Space Astrophysics and Cosmic Physics in Bologna (IASF-BO/INAF). He is also the principal investigator of the consortium that built the LFI. "However, the main improvement of Planck, with respect to previous missions, is in the suppression and control of systematic effects. The HFI and LFI employ two different detection techniques and this drastically reduces the systematic effects. Both instruments operate at cryogenic temperatures, at which the intrinsic noise coming from the devices is reduced to a minimum," he adds.

The systematic effects can also be controlled by an appropriate choice of orbit- and sky-scanning strategy. "WMAP was the first satellite to orbit round L2 and Planck will fly in a similar orbit. From L2 the noise from the Earth is drastically reduced," confirms Mandolesi. Also, from this position the satellite's telescope can always be protected from illumination from the Earth, the Sun and the Moon, thanks to the optimal design and observational strategy.

The LFI is an array of 22 radiometers, each one made of an antenna to capture the signal and cryogenically cooled (20 K) electronics – a



Antennas for the HFI and LFI. (Courtesy Luca Valenziano IASF-BO/INAF.)

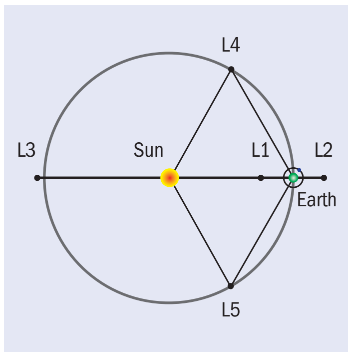
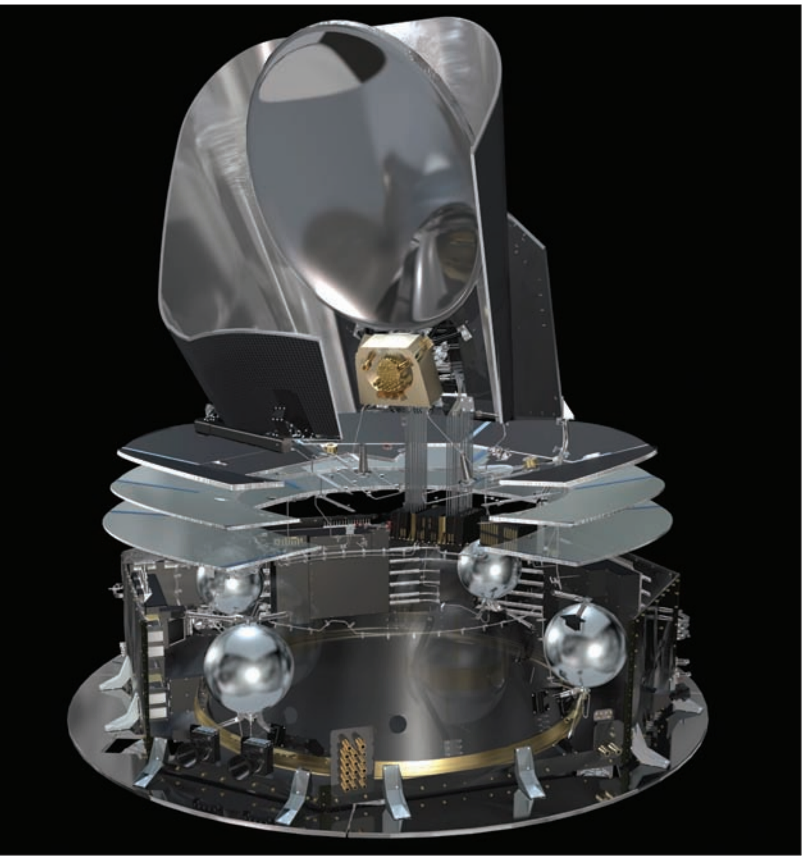


Fig. 1. Location of the second Lagrangian point (L2, not to scale) – one of five positions where the gravitational pull of the Earth and Sun fixes the relative position of an object.

Members of Thales Alenia Space inspect the completed spacecraft in Cannes. (Courtesy Luca Valenziano IASF-BO/INAF.)

This cut which o instrum

off to chart the universe



cutaway view of the Planck satellite shows in detail the telescope's primary mirror, ch directs radiation via a secondary mirror to the array of antennas connected to two ruments, the LFI and the HFI. (Courtesy ESA/AOES Medialab.)

combination of ultralow-noise amplifiers and high-electron-mobility transistors – for read-out. "Low-noise temperature fluctuations in the amplifiers are a crucial factor in the measurement," says Mandolesi. "The LFI radiometers meet the requirements for both noise and bandwidth, with low power consumption at all frequencies – and they establish world-record low-noise performances in the 30–70 GHz range. This is particularly important considering that the main noise sources come from our own galaxy and have their minimum around the 70 GHz frequency," he explains.

The HFI is an array of 48 bolometric detectors that is placed at the focal plane of the Planck telescope. These will measure the energy of the incident CMB radiation in six frequency channels between 100–857 GHz, with sensitivity in the lower frequencies close to the fundamental limit set by the photon statistics of the background. The HFI was designed and built by a consortium of scientists led by Jean-Loup Puget of the Institut d'Astrophysique Spatiale in Orsay. The detectors operate at the cryogenic temperature of 0.1 K, obtained using a cryochain of sorption, mechanical and dilution coolers.

Signals from the CMB are polarized in two types of mode, known as E-modes and B-modes. The E-modes have already been measured (Kovac *at al.* 2002; Page *et al.* 2007). All of the LFI channels and four of the HFI channels can measure the intensity of the CMB radiation as well as its linear polarization. "By combining the signals measured by the LFI and HFI, Planck might be able to discover the B polarization mode, which is linked to the existence of the primordial gravitational waves" says Mandolesi.

"In some cosmological models it could even be possible to find signatures that might correspond to scenarios with extra dimensions of the universe. Also, the mass and quantum fluctuations that occurred at 10^{-35} s after the Big Bang, and might have affected the cosmic inflation, can be explored by studying the polarization modes of the CMB with high accuracy. Furthermore, Planck's excellent sensitivity might allow the discovery of interesting physics hidden behind the non-Gaussian distribution of the temperature anisotropies predicted by many cosmological models," he explains.

Planck will start collecting physics data after a three-month period of commissioning in orbit. Six months later the scientific teams will start the analysis, aimed at the early release of a catalogue of compact sources, the first to be made at so many frequencies. It is expected to become public about 15 months after the launch. A core team of about 100 scientists supporting the Data Processing Centre in Trieste will carry out the processing and analysis of LFI data. The HFI data will be processed by a distributed system involving several institutes in France and the UK. The satellite will accomplish two complete surveys of the sky over 14 months and the hope is that this will be extended to four surveys.

Further reading

For more about Planck, see www.esa.int/SPECIALS/Planck/.
J Kovac *et al.* 2002 *Nature* **420** 772.
L Page *et al.* 2007 *ApJ. Supp.* **170** 335.

Résumé

Planck part cartographier l'Univers

Planck est le premier satellite européen consacré à l'étude du rayonnement micro-onde cosmique. Il sera envoyé dans l'espace le 16 avril prochain à bord d'une fusée Ariane 5 à partir de la base de lancement de l'ESA à Kourou, en Guyane française.Le satellite transporte deux instruments : l'instrument haute fréquence et l'instrument basse fréquence. Ensemble, ils vont balayer l'Univers à la recherche d'une large gamme de fréquences, avec une sensibilité 10 fois supérieure à celle des sondes précédentes. L'objectif est de cartographier le rayonnement cosmique de fond et d'analyser de façon très précise les anisotropies de température. Ces mesures devraient permettre aux chercheurs de décoder énormément d'informations sur les propriétés de l'Univers.

Antonella del Rosso, *CERN*.

Knowledge transfer: from creation to innovation

A study of five LHC experiments – ALICE, ATLAS, CMS, LHCb and TOTEM – provides an insight into how knowledge is generated and transferred as a result of the collaborative nature of scientific and technological processes. **Beatrice Bressan** explains.

There have been many studies of economic returns to member states from purchasing. The most recent report to be published clearly indicates that European industry values highly the benefits that result from technological learning (*CERN Courier* December 2003 p23). In the LHC experiments almost half of the participants are from non-member states of CERN and many contracts are placed in nonaffiliated countries. Thus the spillover of technological learning from high-energy physics now extends worldwide.

However, CERN's potential may well be underutilized when it comes to industry. It could probably enhance the spectrum of its technological impact by paying more attention to the management of technological learning and by fostering more-explicit exchanges of new technological developments outside the needs of just the purchasing sphere. This is particularly important today because developments in high-energy physics can take up to 20 years before their impact is felt outside the field.

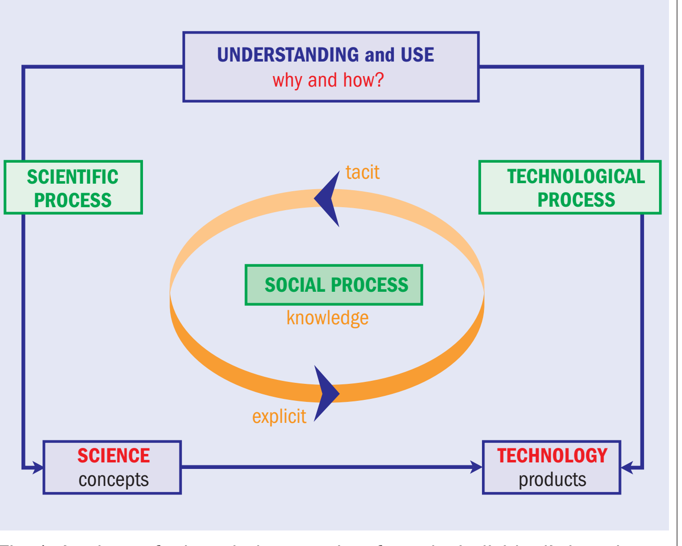


Fig. 1. A scheme for knowledge creation: from the individual's learning process to knowledge acquisition in an organizational context and knowledge transfer via the technological process to boost innovation.

The basis for the study

A recent study by Helsinki University and CERN, entitled *Knowledge Creation and Management in the Five LHC Experiments at CERN: Implications for Technology Innovation and Transfer*, has made a detailed analysis of knowledge transfer in the context of the LHC experiments ALICE, ATLAS, CMS, LHCb and TOTEM. This both conceptualizes and confirms with quantitative data CERN's role in the creation of knowledge.

Each year hundreds of young people join CERN as students, fellows, associates or staff members taking up their first employment. This continuous flow of people – who come to CERN, are trained by working with CERN's experts and then return to their home countries – provides a useful example of knowledge and technology transfer through people. The new study provides evidence that the social process of participation in meetings, the acquisition of skills in different areas and the development of interests through interaction with colleagues are key elements in the learning process.

The study analysed 291 replies to a questionnaire handed out during LHC-experiment collaboration meetings, which asked questions concerning individual perception and assessment of knowledge acquisition and transfer, as well as the means used to communicate knowledge. The respondents consisted of CERN users (79%) and staff members (21%), with 80% of them physicists. Some 70% of respondents were younger than 40.

Figure 1 illustrates the model for the pattern of knowledge acquisition and transfer on which the study was based. It is important to underline that within this scheme, and indeed in general, only individuals can create knowledge, which expands from tacit-to-explicit knowledge through social interaction. Tacit knowledge is essentially individual and cannot necessarily be communicated and shared in a systematic or logical manner. It has to be converted into words or numbers that are understood easily enough to be shared and become explicit. However, not all individual tacit knowledge becomes explicit. Explicit knowledge is something more formal and systematic. It can be expressed in words and numbers, is easily communicated and shared in the form of written and spoken language, hard data, scientific formulae and codified procedures.

For organizations to be effective in the process of knowledge transfer they must provide a context in which individuals can hold both formal and informal discussions to steer new ideas as well as foster collective learning. Economists and sociologists see this

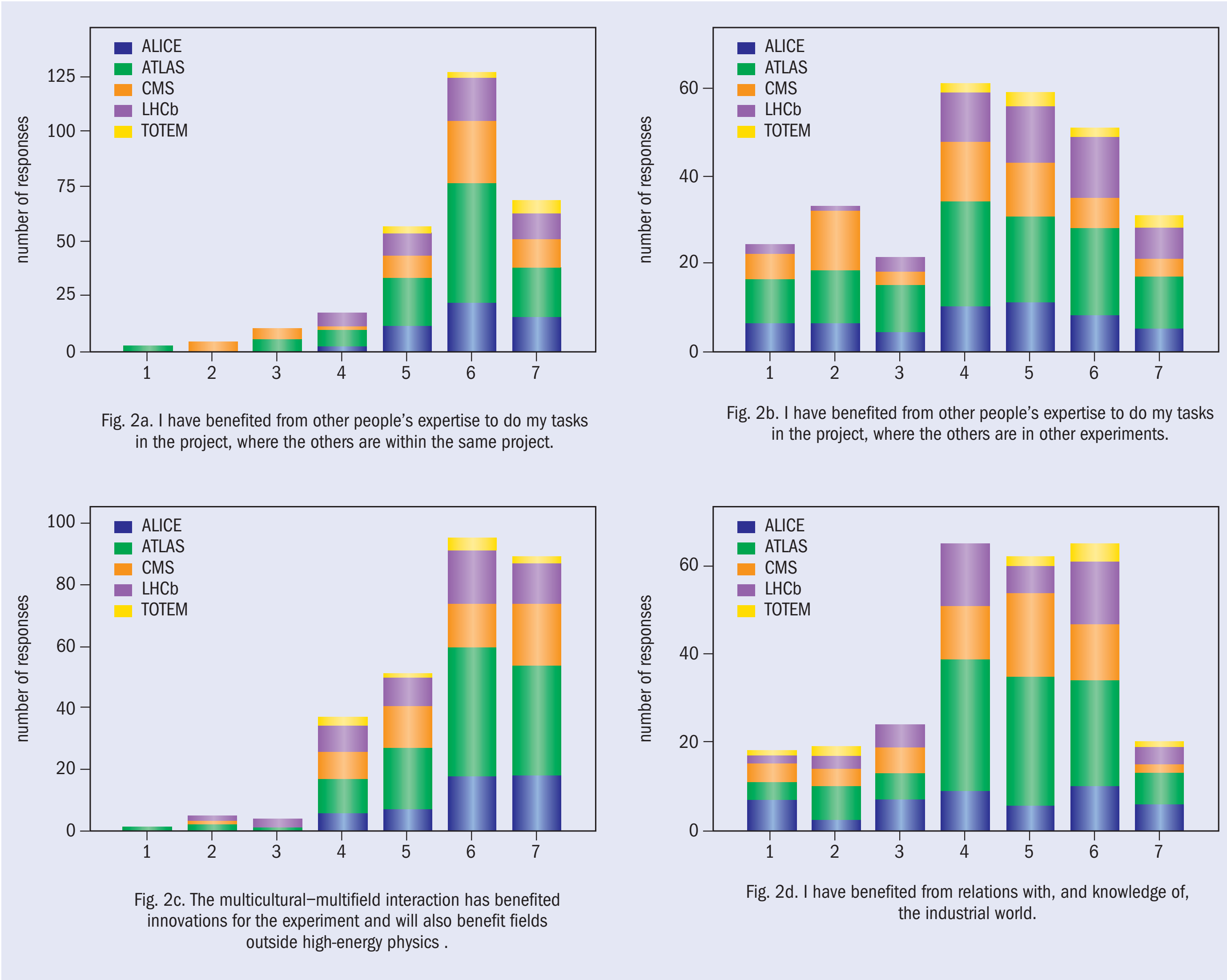


Fig. 2. Examples of the responses in the survey to statements about learning benefits: 1 = disagree, 7 = agree.

knowledge generation as being particularly important because it underlies societal and technological innovation and is of relevance to the industrial and wider world.

One of CERN's core assets is individual and organizational learning – the latter being the social process where a group of people collectively enhance their capacities to produce an outcome. The creation of organizational knowledge amplifies the knowledge that is created by individuals who spread it at the group level through dialogue, discussion, experience sharing or observation.

Learning benefits

Large experiments, such as those at the LHC, form the hub of an institutional and organizational network. The interactions between individuals – both among teams and within teams that share a common interest – as well as between experiments, are important routes for knowledge transfer, according to the study (figures 2a and 2b). Such interactions are enabled by the organizational structure of the collaboration and by the frequent use of modern communication tools, such as e-mail and websites. Furthermore, the results indicate that knowledge acquisition in the multicultural environment plays a mediating role in the interaction between social capital constructs (social interaction, relationship quality and network ties) and outcomes related to competitive advantage (invention development and technological distinctiveness). In short, the fertile environment of the LHC experiments fosters a dynamic, interactive and simultaneous exchange of knowledge both inside and outside the collaborations (figure 2c).

Individuals can create and expand knowledge through the social process, which also involves industry at various phases of project development. The study was unable to assess the interaction with industry completely because it was carried out towards the end of the installation phase, when R&D was over and most of the important, challenging orders had already been placed. There was, therefore, not much need of follow-up and contact with industry. Nevertheless, the respondents generally agreed that they had benefited from relationships with and knowledge of industry (figure 2d). It was clear that only a select group of people had been in charge of relations with industry; the scarcity of data (for the reasons explained previously) did not allow their profile to be characterized.

The study also assessed the personal outcomes of knowledge ▷

transfer, which were found to be substantial in all of the experiments. These were evaluated in terms of the widening of scientific interests and knowledge; the expansion of social networks; and the enhancement of scientific skills at many different levels (planning, data analysis, paper writing) with the acquisition of new technical and technological skills. These positive outcomes span a wide age-range, demonstrating a benefit to both young and experienced physicists. The domains of useful technological learning ranged from physics to detector technologies, electronics, information technologies and management. The many innovative developments can be categorized as follows: 41% in detector technologies; 33% in computing; 25% in electronics: and 1% in other areas. The results also show the importance of management in large physics collaborations (94 of 291 respondents had a management and co-ordination role in addition to their physics or engineering functions). Almost 50% of the respondents underlined the positive effect on their career of having performed managerial functions.

The development of these personal skills, which fall into four categories (learning technical skills, learning scientific skills, improving social networking, and increasing employment potential in the labour market) should be managed, used and catalysed to target individual development to improve opportunities in the labour market for individuals working in high-energy-physics environments. The researchers who responded to the study also showed a certain amount of entrepreneurship, with a positive approach towards going to work for companies or towards creating their own company (~6%). Of those who would consider going to work for a company, about half are below the age of 55.

These results should encourage further research studies into how best to foster learning and innovation of "big science" enterprises.

Further reading

To know more about the results of the enquiry, see http://cdsweb.cern.ch/record/1095892?ln=en.

Résumé

Transfert de connaissances : de la création à l'innovation

Le flux continu de personnes qui viennent travailler au CERN, y sont formées par des experts puis repartent dans leur pays d'origine constitue un exemple concret de transfert de connaissances par les personnes. Une étude récente fournit une analyse détaillée de ce transfert de connaissances dans le cadre des expériences du LHC ALICE, ATLAS, CMS, LHCb et TOTEM. L'étude confirme, par des données quantitatives, l'importance du rôle que joue le CERN en matière de création de connaissances, et montre le volume de connaissances généré et transféré dans les processus scientifiques et technologiques, en identifiant les principaux éléments du processus d'apprentissage.

Beatrice Bressan, *CERN.*

Dark-matter research arrives at the crossroads

The 2008 DESY Theory Workshop, which was entitled Dark Matter at the Crossroads, focused on the exciting prospects worldwide for unravelling the microscopic nature of the mysterious dark matter in the universe. **Andreas Ringwald** sheds some light.

There is overwhelming evidence that the universe contains dark matter made from unknown elementary particles. Astronomers discovered more than 75 years ago that spiral galaxies, such as the Milky Way, spin faster than allowed by the gravity of known kinds of matter. Since then there have been many more observations that point to the existence of this dark matter.

Gravitational lensing, for example, provides a unique probe of the distribution of luminous-plus-dark matter in individual galaxies, in clusters of galaxies and in the large-scale structure of the universe. The deflection of gravitational light depends only on the gravitational field between the emitter and the observer, and it is independent of the nature and state of the matter producing the gravitational field, so it yields by far the most precise determinations of mass in extragalactic astronomy. Gravitational lensing has established that, like spiral galaxies, elliptical galaxies are dominated by dark matter.

Strong evidence for the fact that most of the dark matter has a non-baryonic nature comes from the observed heights of the acoustic peaks in the angular power spectrum of the cosmic microwave background measured by the Wilkinson Microwave Anisotropy Probe, because the peaks are sensitive to the fraction of mass in the baryons. It turns out that only about 4% of the mass of the universe is in baryons, whereas about 20% is in non-baryonic dark matter – a finding that is also in line with inferences from primordial nucleosynthesis.

Gabriele Veneziano presents the 2008 DESY Heinrich-Hertz Lecture on Physics entitled "Space, time and matter". This is for the general public and is held during the workshop. (Courtesy DESY Hamburg.)

A host of candidates

This leaves some pressing questions. What is the microscopic nature of this non-baryonic dark matter? Why is its mass fraction today about 20%? How dark is it? How cold is it? How stable is it?

Progress in finding the answers to such questions provided the focus for the 2008 DESY Theory Workshop, which was held on 29 September – 2 October. Organized by Manuel Drees of Bonn, it sought to combine results from a range of experiments and confront them with theoretical predictions. It is clear that the investigation of the microscopic nature of dark matter has recently entered a decisive phase. Experiments are being carried out around the globe to try to identify traces of the mysterious dark-matter particles. Since the different theoretical candidates appear to have quite distinctive signatures, there are good reasons to expect that from a combination of all of these efforts a common picture will materialize within the next decade.

Theoretical particle physicists have proposed a whole host of candidates for the constituents of non-baryonic dark matter, with fancy names such as axions, axinos, gravitinos, neutralinos and lightest Kaluza–Klein partners. The best-motivated of these occur in extensions of the Standard Model that have been proposed to solve other problems besides the dark-matter puzzle. The axion, for example, arose in extensions that aim to solve the strong CP problem. It later turned out to be a viable dark-matter candidate if its mass is in the micro-electron-volt range. Gravitinos and neutralinos, on the other hand, are the superpartners of the graviton and the neutral bosons, respectively. They arise in supersymmetric extensions of the Standard Model, which aim at a solution of the hierarchy problem and at a grand unification of the strong and electroweak interactions. In fact, neutralinos ▷

are natural candidates for dark matter because they have cross-sections of the order of electroweak interactions and their masses are expected to be of the order of the weak scale (i.e. 100 GeV). This leads to the fact that their relic density resulting from freeze-out in the early universe is just right to account for the observed amount of dark matter.

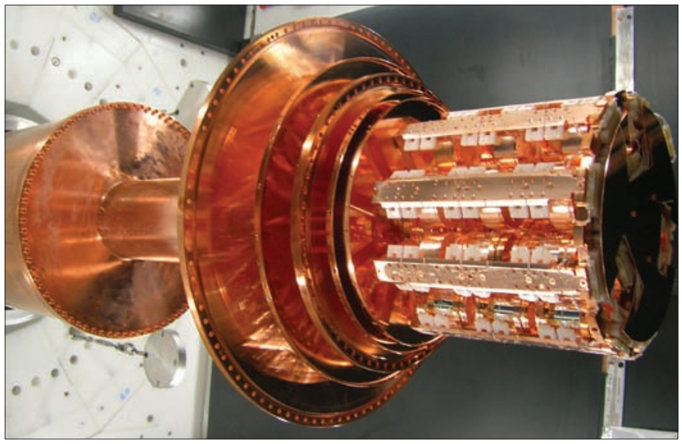
Neutralinos belong to the class of weakly interacting massive particles (WIMPs). Such particles seem to be more or less generic in extensions of the Standard Model at the tera-electron-volt scale, but their stability (or a long enough lifetime) has to be imposed. This is not necessary for super-weakly interacting massive particles (superWIMPs), such as sterile neutrinos, gravitinos, hidden sector gauge bosons (gauginos) and the axino. For example, unstable but long-lived gravitinos in the 5–300 GeV mass range are viable candidates for dark matter and provide a consistent thermal history of the universe, including successful Big Bang nucleosynthesis.

Detecting dark matter

Owing to their relatively large elastic cross-sections with atomic nuclei, WIMPs such as neutralinos are good candidates for direct detection in the laboratory, yielding up to one event per day, per 100 kg of target material. The expected WIMP signatures are nuclear recoils, which should occur uniformly throughout the detector volume at a rate that shows an annual flux modulation by a few per cent. Intriguingly, the DAMA experiment in the Gran Sasso National Laboratory has seen evidence for such an annual modulation. However, there is some tension with other direct-detection experiments. Theoretical studies have revealed that interpretation in terms of a low-mass (5–50 GeV) WIMP is marginally compatible with the current limits from other experiments. In contrast to DAMA, which looks just for scintillation light, most of the latter exploit at least two observables out of the set (phonons, charge, light) to reconstruct the nuclear recoil-energy.

Many different techniques based on cryogenic detectors (e.g. the Cryogenic Dark Matter Search), noble liquids (e.g. the XENON Dark Matter Project) or even bubble chambers, are currently employed to search for WIMPs via direct detection. Detectors with directional sensitivity (e.g. the Directional Recoil Identification From Tracks experiment) may not only have a better signal-to-background discrimination but may also be capable of measuring the local dark-matter, phase-space distribution. In summary, these direct experiments are currently probing some of the theoretically interesting regions for WIMP candidates. The next generation of experiments may enter the era of WIMP (astro) physics.

The axion is another dark-matter candidate for which there are ongoing direct-detection experiments. Both the Axion Dark Matter Experiment (ADMX) in the US and the Cosmic Axion Research with Rydberg Atoms in a Resonant Cavity (CARRACK) experiment in Japan exploit a cooled cavity inside a strong magnetic field to search for the stimulation of a cavity resonance from a dark-matter axion–photon conversion in the microwave frequency region, corresponding to the expected axion mass. While they differ in their detector technology – ADMX uses microwave telescope technology whereas CARRACK employs Rydberg atom technology – both experiments are designed to cover the 1–10 μeV mass range. Indeed, if dark matter consists just of axions then it should soon be found in these experiments. The CERN Axion Solar Telescope, meanwhile, is looking for axions produced in the Sun.



Worldwide, many experiments are trying to unravel the particle constituents of dark matter by searching for indirect signatures at accelerators and in cosmic rays, as well as for direct signatures in the laboratory. The Cryogenic Rare Event Search with Superconducting Thermometers is aiming at the direct detection of WIMPs. In its second phase it is using detectors based on scintillating crystal ($CaWO_4$) absorbers, operating in a cold box at around 10 mK. (Courtesy CRESST.)

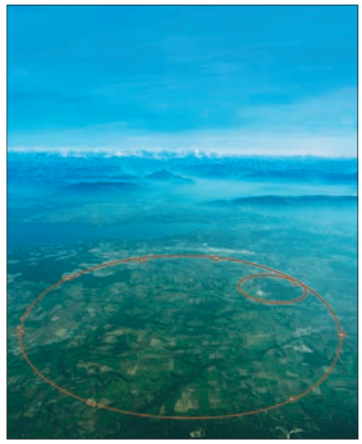
There are also of course possibilities for indirect detection. Dark matter may not be absolutely dark. In fact, in regions where the dark-matter density is high (e.g. in the Earth, in the Sun, near the galactic centre, in external galaxies), neutralinos or other WIMPs may annihilate to visible particle–antiparticle pairs and lead to signatures in gamma-ray, neutrino, positron and antiproton spectra. Moreover, superWIMPs (e.g. gravitinos), may also leave their traces in cosmic-ray spectra if they are not absolutely stable.

Interestingly, the Payload for Antimatter Matter Exploration and Light-Nuclei Astrophysics (PAMELA) satellite experiment recently observed an unexpected rise in the fraction of positrons at energies of 10–100 GeV, thereby confirming earlier observations by the High Energy Antimatter Telescope balloon experiment. In addition, the Advanced Thin Ionization Chamber balloon experiment has reported a further anomaly in the electron-plus-positron flux, which can be interpreted as the continuation of the PAMELA excess to about 800 GeV. The quantification of these excesses is still quite uncertain, not least because of relatively large systematic uncertainties. It is well established that they cannot be explained by the standard mechanism, namely the secondary production of positrons arising from collisions between cosmic-ray protons and the interstellar medium within our galaxy. However, a very conventional astrophysical source for them could be nearby pulsars.

On a more speculative level, these observations have inspired theorists to search for pure particle-physics models that accommodate all results. Generically, interpretations in terms of WIMP annihilation seem to be disfavoured, because they require a huge clumpiness of the Milky Way dark-matter halo, which is at variance with recent numerical simulations of the latter. This constraint is relaxed in superWIMP scenarios, where the positrons may be produced in the decay of dark-matter particles (e.g. gravitinos).

It is clear that one of the keys to understanding the origin of the excess in the positron fraction is the accurate, separate measurement of positron and electron fluxes, which can be done with further

Experiments in space and on Earth are searching for indirect signals of dark matter in the spectra of cosmic radiation. Left: a rendering of the Fermi Gamma-Ray Space Telescope *in orbit; centre: a phototube for the IceCube experiment at the South Pole; right: the PAMELA satellite experiment being prepared prior to launch. (Courtesy General Dynamics C4 Systems, IceCube collaboration, PAMELA Project.)*



The LHC at CERN will provide the opportunity for indirect detection of dark matter through the discovery of new particles, such as neutralinos.

PAMELA data and with the Alpha Magnetic Spectrometer satellite experiment. Furthermore, distinguishing different interpretations of the observed excesses requires a multimessenger approach (i.e. to search for signatures in the radio range, synchrotron radiation, neutrinos, antiprotons and gamma rays). Fortunately the Fermi Gamma-Ray Space Telescope is in orbit and taking data (*CERN Courier* November 2008 p13). Together with other cosmic-ray experiments it will probe interesting regions of parameter space in WIMP and superWIMP scenarios of dark matter.

Dark matter at colliders

Clearly, at colliders the existence of a dark-matter candidate can be inferred only indirectly from the apparent missing energy, associated with the dark-matter particles, in the final state of the collision. However, such a measurement can be made with precision and under controlled conditions. To extract the properties, such as the mass, of dark-matter particles, these final-state measurements have to be compared with predictions from theoretical models. In a supersymmetric extension of the Standard Model, for example, with the neutralino as the lightest superpartner, experiments at the LHC would search for signatures from the cascade decay of gluinos and squarks into gluons, quarks, leptons and neutralinos. This would show up as large missing transverse-energy in events with some jets and leptons. The endpoints in kinematic distributions could then be used for the determination of the dark-matter candidate's mass, which could be compared with the mass determined eventually by measurements of recoil energy in direct-detection experiments.

This complementarity between direct, indirect and collider searches for dark matter is essential. Although collider experiments might identify a dark-matter candidate and precisely measure its properties, they will not be able to distinguish a cosmologically stable particle from one that is long-lived but unstable. In turn, direct detection cannot tell definitely what kind of WIMP has been observed. Moreover, in many superWIMP dark-matter scenarios a direct detection is impossible, while detection at the LHC may be feasible. For example, if the lightest superpartner is a gravitino (or hidden gaugino) and the next-to-lightest is a charged lepton, experiments at the LHC may search for the striking signature of a displaced vertex plus an ionizing track.

In many cases, however, precision measurements from a future electron–positron collider seem to be necessary to exploit fully the collider–cosmology–astrophysics synergy. In addition "low -energy photon-collider" experiments – such as the Axion-Like Particle Search at DESY, the GammeV experiment at Fermilab and the Optical Search for QED magnetic birefringence, axions and photo regeneration at CERN, where the interactions of intense laser beams with strong electromagnetic fields are probed – may give viable insight into the existence of very lightweight, axion-like, dark-matter candidates.

In summary, there is evidence for non-baryonic dark matter that is not made of any known elementary particle. We are today in the exploratory stage to figure out its microscopic nature. Many ideas are currently being explored in theories and in experiments, and more will come. Nature has given us a few clues that we need to exploit. The data coming soon from accelerators, and from direct and indirect detection experiments, will be the final arbiter.

Further reading

For more information about the workshop, see http://th-workshop2008.desy.de.

Résumé

La recherche sur la matière noire arrive à un tournant

De nombreux indices montrent que l'Univers contient de la matière noire composée de particules élémentaires inconnues, mais ces observations laissent subsister bien des interrogations. Quelle est la nature microscopique de cette matière noire non baryonique ? Jusqu'à quel point est-elle sombre, froide et stable ? C'est autour de ces questions que s'est articulé l'atelier de théorie 2008 de DESY « Dark matter at the Crossroads ». Alors que la recherche sur la nature microscopique de la matière noire entre dans une phase déterminante, l'atelier s'est attaché à rassembler les résultats d'un grand nombre d'expériences avant de les confronter aux prédictions théoriques.

Andreas Ringwald, *DESY.*

FACES AND PLACES

APPOINTMENTS

TRIUMF's associate director moves on to new challenges

After more than 20 years Jean-Michel Poutissou has stepped down from his dual role of guiding TRIUMF as its associate and science director to take up new challenges within the laboratory. He has been a leading figure throughout the mandates of four directors and a period of significant changes. He has represented TRIUMF on the world scientific stage by serving on countless international committees, review panels etc, and with his even-handed judgement and good humour, his was a well respected and steady hand on the wheel at TRIUMF. His accomplishments were recognized in 2006 with the French Chevalier de la legion d'Honneur, the highest decoration in France.

Poutissou received his first degree in engineering physics from the Institut National des Sciences Appliquées in Lyon in 1965. This was followed by a PhD in nuclear physics from the Université de Montréal in 1972, with a post-doctoral position in the TRIUMF group immediately afterwards until 1974. He joined TRIUMF as a research scientist in 1978 and was science division head and associate director from 1988 until January 2009.

TRIUMF's new scientific vision involves greatly expanding its nuclear-medicine programme. Poutissou has been selected to lead the new division for the interim. He will return to research life with the Tokia-to-Kamioka long-baseline neutrino collaboration in Japan after his retirement this year.

Poutissou moves on after 20 years of dedicated service at TRIUMF. (Courtesy TRIUMF.)

Chilingarian takes over at Yerevan

Ashot Chilingarian has become the director of the Yerevan Physics Institute (YerPhI) as from the end of 2008. He is also head of the Cosmic Ray Division, one of five divisions st YerPhI. He takes over from Hrachia Asatryan.

Chilingarian, who will celebrate his 60th birthday on 18 May, earned his PhD in 1984 followed by a DSc in physics and mathematics from YerPhI in 1991. He has been at the institute since 1971, first as a scientist and then as a senior scientist. In 1993 he became the deputy-director of the institute as well as head of the Cosmic Ray Division. He has also been a lecturer in physics and software engineering at Yerevan State University (YSU) since 1975.

Chilingarian's expertise is in high-energy astroparticle physics, particle-detector instrumentation and advanced statistical computation, including Bayesian and neural network models. His current research interests include the origin of galactic and solar cosmic rays, the detection of secondary cosmic-ray fluxes on the Earth's surface, space weather and solar-terrestrial connections. He is the founder of the Aragats Space Environment Center on Mt Aragats, which is equipped with new, hybrid particle detectors that simultaneously measure charged and neutral fluxes in secondary cosmic rays. He is also the originator of the concept of the worldwide network of particle detectors for research in space weather and solar physics, the Space Environment Viewing and Analysis Network (SEVAN). Nodes of the SEVAN network are now operating in Armenia, Bulgaria and Croatia.

Ashot Chilingarian takes the reins at Yerevan. (Courtesy Narine Khachatryan.)

AWARDS

Bogoliubov Prize seeks candidates

The Joint Institute for Nuclear Research (JINR) has opened applications for the 2009 N N Bogoliubov Prize for Young Scientists. The prize, established in 1999 in memory of the eminent physicist and mathematician Nikolai Nikolaevich Bogoliubov, is awarded to young researchers (up to 33 years) for "outstanding contributions in theoretical physics related to Bogoliubov's scientific interests – nonlinear mechanics, statistical physics, quantum field theory and elementary-particle theory".

The prize is awarded to a scientist who has shown early scientific maturity and whose results are recognized worldwide. Applicants should try to emulate Bogoliubov's skill in using sophisticated mathematics to attack specific physics problems.

To take part in the competition, send your CV and a one- to two-page abstract of submitted papers in electronic form to: V I Zhuravlev, the Directorate of the Bogoliubov Laboratory of Theoretical Physics of JINR (Joliot-Curie str. 6, 141980 Dubna, Moscow Region); or e-mail bltp@theor.jinr.ru, no later than 1 August 2009. The winners will be announced on 23 August 2009, during the conference dedicated to the 100th anniversary of Bogoliubov's birth.

INTERNATIONAL COLLABORATION

Egypt is new associate member of JINR

In early March, a delegation of the Arab Republic of Egypt headed by the president of the Egyptian Agency of Scientific Research and Technology (ASRT), Mohamed Tarek Hussein made a two-day visit to JINR. The Egyptian guests were received by the director of JINR Alexey Sissakian, the scientific leader Vladimir Kadyshevsky and vice-directors Mikhail Itkis and Richard Lednický. On 3 March Hussein and Sissakian signed an agreement admitting the Arab Republic of Egypt as an associate member of JINR.

During the visit, the Egyptian delegation learnt about the history of JINR and its scientific policy, fundamental research, innovation projects and educational programme, as well as about the institute's new opportunities in the Special Economic Zone. Hussein spoke about the structure of ASRT and its interactions with the scientific community. He described co-operation with European and Asian states and the "four-P cycle" used in the academy's activities: from publication to patent, prototype and the final product. The Egyptian delegation also toured JINR's laboratories and discussed plans for co-operation with the institute and with the laboratories' leaders.

Alexey Sissakian (left) and Mohamed Tarek Hussein sign the agreement for Egypt to become an associate member of JINR. (Courtesy JINR.)

DONATION

Hanoi library receives books left by Maurice Jacob

At the beginning of February the Vietnam Auger Training Laboratory (VATLY) at the Institute for Nuclear Science and Technology (INST) in Hanoi received an important delivery from CERN: the collection of *Physics Reports* that Lise Jacob, Maurice Jacob's widow, had kindly donated to the institute's library. The shipping was organized by Maurice's former colleague at CERN, André Martin, together with the help of Annick Lyraud, as well as members of the library and the transport group at CERN.

The books were received at the institute by Dang Quang Thieu, from the directorate of INST and Pierre Darriulat, a former senior physicist at CERN who was recently awarded the André Lagarrigue Prize (*CERN Courier* March 2009 p33). The collection arrived in excellent condition and, following their transfer to the library, a plaque on the wall will acknowledge the donation. In their new home the collection of books will be of great benefit to not only the physicists at the institute but also to those at other physics laboratories in Hanoi, who will be able to access them.

Dang Quang Thieu (left) and Pierre Darriulat with Maurice Jacob's collection of Physics Reports *in Hanoi. (Courtesy Pierre Darriulat.)*

POET'S CORNER

Higgs boson

With apologies to Hilaire Belloc, *The Microbe*.

Higgs boson is so very small
You cannot make him out at all,
But scientists aspire to see
His footprint in the LHC.
No jointed tongue to lie beneath
A hundred curious rows of teeth,
But many bubble trails make lots
Of puzzles for atomic swots,
Researchers, who with pints of Bass
Debate the real cause of mass
And cry "Oh boson, have you been?
For you have never yet been seen."
These scientists, who claim to know,
Assure us that it could be so...
Oh! Let us ever, ever doubt
What nobody is sure about.
– Tony Herbert, Hampshire

● The author submitted this poem to the website of the *Material World* programme on BBC Radio 4 after coverage of CERN and the start-up of the LHC. (Courtesy Tony Herbert.)

VISITS

King Albert II of Belgium (centre) visited CERN on 19 February. He toured the CMS experiment with **Tijinder Virdee** (left), the CMS spokesperson, and **Denis Favart** (right), of the Université Catholique de Louvain. Lyn Evans, the LHC project leader, and Karel Cornelis, of CERN's Beams Department, provided a brief introduction to the particle collider. The king also signed the CERN guest book and met several Belgian scientists.

Italian minister for foreign affairs **Franco Frattini** (centre) visited CERN on 29 January. After a tour of the ATLAS experiment he attended a presentation on the four major LHC experiments, given by the director-general, **Rolf-Dieter Heuer**. He also met eminent Italian scientists at CERN, including Nobel Laureate **Carlo Rubbia** (right), **Antonino Zichichi** of the INFN and University of Bologna (second left), and CERN's director of research and scientific computing **Sergio Bertolucci** (far left).

Nguyen Thien Nhan, Vietnamese deputy prime minister and minister of education and training (centre), toured the ATLAS experimental cavern during a visit to CERN on 3 February. He was also accompanied by **Peter Jenni** (left), ATLAS spokesperson, and **John Ellis** (right), adviser to CERN's director-general on relations with non-member states.

Actors **Tom Hanks** (centre left), **Ayelet Zurer** (centre right) and director **Ron Howard** (far right) were at CERN on 12 February to unveil to the press some select footage from their film adaptation of Dan Brown's novel *Angels & Demons*. A press event was held in the Globe of Science and Innovation, and journalists visited the ATLAS experiment. Also participating were LHCb physicist **Tara Shears** (second from left) and former spokesperson of the ATHENA antihydrogen experiment, **Rolf Landua** (second from right) and CERN's director of research and scientific computing **Sergio Bertolucci** (far left).

OUTREACH

Pakistani students learn Grid Computing

The Khwarizmi Science Society (KSS), Pakistan's leading grass-roots science organization for promoting ideas between students, teachers, journalists and the public, held a lecture on the LHC Computing Grid at Punjab University's Physics Department on 5 January. The speaker was Ashiq Anjum, who currently works at the University of the West of England in the UK and has been associated with CERN for the past seven years.

The popular lecture was part of the KSS's International Year of Astronomy celebrations, organized under the leadership of the society's president, Saadat Anwar Siddiqi, professor at Punjab University's Centre for Solid State Physics. The goal was to introduce the concept of Grid computing and motivate young Pakistani students, budding engineers and the large national pool of computer scientists towards working in this flourishing field of computing. Punjab University, based in Lahore, is the Alma Mater of Pakistan's only Nobel Laureate, Abdus Salam, and is one of Asia's oldest and most prestigious universities.

Ashiq Anjum during his popular lecture on "The LHC Computing Grid", later broadcast on TV.

The speaker described the computing challenges of the LHC and explained how data from the experiments are distributed through a multi-tier network of data centres, Pakistan's point of contact being the National Centre for Physics in the capital, Islamabad. The talk was concluded by a lively question-and-answer session, where, for example, Anjum explained how the Grid and its reincarnated version, "the Cloud", could help Pakistan and the developing world in its problems concerning computational drug design, alleviate health conditions and make education accessible to all.

The lecture was preceded by a welcome address by Saadat Anwar Siddiqi, who appreciated the Higher Education Commission's effort to telecast the lecture live throughout institutes in Pakistan. The local press was also present and later broadcast the lecture on television.

OBITUARIES

Johannes C Sens 1928–2008

Johannes C Sens, a physicist and engineer with a long association with CERN, passed away on 3 November 2008 in Nice following complications after surgery. He was considered one of the pioneers of the first muon g-2 experiments at CERN and an instrumental figure in the work leading to the discovery of the fifth quark.

Known as Hans, he was born in the Netherlands and spent his formative years living under German occupation. He initially pursued a classical education but after spending a few years in a Jesuit seminary, in 1953 he obtained a degree in engineering at the Technical University of Delft. Hans then enrolled at the University of Chicago, where he studied under Enrico Fermi. After Fermi passed away, Hans gained his PhD working on muons with Valentin Telegdi at the University of Chicago before moving to CERN in 1958, at the same time as Leon Lederman; together they initiated a study of the methods of measuring g-2 for the muon (*CERN Courier* December 2005 p12).

The 1960 g-2 team, photographed with the magnet that was used. Left to right: Francis Farley, Johannes Sens, Georges Charpak, Theo Muller and Antonino Zichichi.

In 1966, after working on various experiments with muons, Hans left CERN to join the Foundation for Fundamental Research on Matter in the Netherlands and the University of Utrecht. With the advent of the Intersecting Storage Rings at CERN he became spokesman of the CERN-Holland-Lancaster-Manchester collaboration there.

In 1976, during a leave of absence in the US, he played a major role in Lederman's experiment that discovered the Υ particle and hence the fifth quark, b. He later spent several years (between 1979 and 1986) at the Stanford Linear Accelerator Center working with fellow Dutch collaborators on electron–positron and photon–photon collisions at the PEP collider.

Hans then returned to particle physics at CERN and worked on the development of the analysis programmes for the L3 experiment, led by Samuel Ting, at LEP. He retired in 1993 but spent time at the Academia Sinica and the National Central University of Taiwan, and he was most recently associated with the Institut Non-Linéaire de Nice.

From 1966 to 1994 Hans taught courses in particle physics at the University of Utrecht and supervised work on a number of MSc and PhD theses. He deliberately avoided accepting administrative functions, consistently giving priority to research and teaching. His life-long passion for research was evident in his efforts over the past few years to conduct and publish research in what was for him a new field, astrophysics. He was elected lifetime member of the Royal Netherlands Academy of Arts and Sciences as well as the European Academy of Arts, Sciences and Humanities.

With his passing, the particle-physics community has lost a highly distinguished and dedicated physicist, researcher and teacher who committed himself sincerely to the advancement of physics. He had many friends around the world and was respected for his deep and wide professional knowledge, devotion to scientific research, scientific vision, teaching talent and warm relationships with colleagues. His intellect, charm and open character will be missed by us all.

He is survived by two brothers, Paul and Cees, a sister Elly, his three children Paula, Alexandra and Erik-Jan, as well as a granddaughter, Maria Leonor.

Erik-Jan Sens.

Frank C Shoemaker 1922–2009

Frank C Shoemaker, a leading high-energy particle physicist, died on 11 February 2009 in Hightstown, New Jersey, aged 86.

Frank was born in Ogden, Utah, the second of five sons, all of whom went on to earn PhDs. He spent his high-school years in Boise, Idaho, where he met his future wife, Ruth Elizabeth Nelson; they both attended Whitman College in Walla Walla, Washington and were both elected to Phi Beta Kappa. Following graduation and marriage, the Shoemakers worked at the Radiation Lab at Massachusetts Institute of Technology on the development of radar for use during the Second World War. After the war Frank received his PhD in physics from the University of Wisconsin, Madison, and moved to Princeton to begin his nearly 40-year career with the university's physics department. He was made a full professor of the university in 1962.

Frank was a founder member of the university's experimental particle-physics group. He led the reconstruction of the university's Palmer Cyclotron following a fire in 1952 and, in the course of his research, performed pioneering experiments on the strong focusing of particle beams. He then went on to lead the design and construction of the 3 GV Princeton-Pennsylvania Accelerator and served as associate director of the accelerator programme from 1962 to 1966. In 1968–69, he took a year-long leave of absence from Princeton to become the first head of the Main-Ring group at the

Frank Shoemaker with canine companion. (Courtesy Barbara Shoemaker.)

National Accelerator Laboratory (later named Fermilab) in Illinois and led the design and construction of the facility's 1 km radius main accelerator ring. He also suggested the introduction of the herd of bison that still grazes around the accelerator.

Returning to Princeton in 1969 Frank played critical roles in the university's experiments at the Brookhaven National Laboratory and Fermilab, which provided confirmation of the new QCD theory of strong interactions and the unified theory of weak and electromagnetic interactions. He served as principal investigator from 1972 to 1985. Following his retirement from teaching in 1989 he played a major role in the Booster Neutrino Experiment, MiniBooNE, at Fermilab.

During the course of his career he authored or co-authored more than 100 papers and articles, became a Fellow of the American Physical Society and a member of Sigma Xi. He was awarded an honorary doctor of science degree by his Alma Mater, Whitman College, in 1978.

Frank served as director of undergraduate physics studies from 1981 to 1989. It was in this role that he transformed the teaching of introductory physics at Princeton. He was a dedicated teacher and served as mentor to generations of students and junior faculty.

In addition to physics, his main passions were his family, classical music, sailing and dogs. His home was never without a canine companion until the few years just prior to his death and music always filled the air. After his retirement he travelled the globe together with his wife Ruth, visiting all 50 states and 5 continents. After nearly 57 years of marriage, Ruth died in 2001. Frank is survived by his daughters Barbara Shoemaker and Mary Mittnacht, and a brother, Sydney Shoemaker.

His family and colleagues.

MEETINGS

The **XXIth Rencontres de Blois**, "Windows on the universe", will be held on 21–26 June in the Château de Blois, Loire Valley. This year sees the 20th anniversary of this series of conferences; moreover, 2009 is the International Year of Astronomy. To celebrate these two events, Nobel laureates James Cronin, Riccardo Giacconi, David Gross, Martin Perl, George Smoot, Jack Steinberger, Joseph Taylor and many other well known scientists will attend and give a lecture. For registration and abstract submission for talks in parallel sessions, see http://blois.in2p3.fr.

The **5th Patras Workshop on Axions, WIMPs and WISPs** will be held at the IPPP in Durham on 13–17 July. The workshop will address the physics case for the particles that are beyond the Standard Model and will review collider as well as astrophysics experiments. There will also be discussions on new laboratory experiments searching for WIMPs, axion-like particles and other weakly interacting sub-electron-volt particles (WISPs). See http://axion-wimp.desy.de.

The **2009 Europhysics Conference on High Energy Physics**, the biennial conference organized by the High-Energy Particle Physics Division of the European Physical Society, will take place on 16–22 July at the Jagiellonian University in Krakow. The first three days of the conference are reserved for parallel sessions and the last three days (starting on 20 July) for plenary talks. There will also be a poster session. A joint EPS-ECFA meeting will take place on the afternoon of 18 July; 19 July is reserved for excursions. Conference registration, abstract submission and hotel registration is open and available at http://hep2009.ifj.edu.pl/bulletins.php. The deadline for hotel reservations is 8 May.

The **29th International Conference on Physics in Collision (PIC 2009)** will take place on 30 August – 2 September at Kobe University, Japan. The programme is composed of invited talks and poster sessions. Invited speakers will review and update key topics in elementary particle physics to encourage informal discussions on new experimental results and their implications. Topics include electroweak physics, neutrino physics, astroparticle physics, heavy-flavour physics, QCD physics and Higgs and physics beyond the Standard Model. For more details, see www.research.kobe-u.ac.jp/fsci-epp/pic2009/; or e-mail pic2009@person.kobe-u.ac.jp.

ICALEPCS 2009, the **12th International Conference on Accelerator and Large Experimental Physics Control Systems**, will be held on 12–16 October at the Kobe International Conference Center in Kobe. The conference is open to participants worldwide involved in the field of controls and having an interest in the challenging aspects of experimental physics control systems, i.e. control systems for facilities such as particle accelerators, particle detectors, telescopes and nuclear fusion facilities. For more details, see http://icalepcs2009.spring8.or.jp.

NEW PRODUCTS

Aerotech has announced the new PlanarHD air-bearing stage, featuring several design enhancements for increased throughput in ultrahigh precision applications, such as semiconductor processing. The stage, with a travel of 500 mm × 500 mm, includes larger air-bearing surfaces for improved characteristics, as well as higher power linear-servo motors on both axes to deliver a 2 m/s scan velocity with a positioning resolution of up to 0.25 nm, repeatability to 50 nm and accuracy to ± 300 nm. For further details, contact Cliff Joliffe on tel +44 118 940 9400; fax +44 118 940 9401; e-mail cjolliffe@aerotech.co.uk; or visit www.aerotech.co.uk.

Hiden Analytical has developed the EPIC series of quadrupole mass spectrometers designed with maximum flexibility for use in UHV and XHV pressure regimes, with measurement of neutrals, radicals and positive and negative ions. Integral timers provide data-acquisition gating for pulsed-gas and ion experiments with gating resolutions to 100 ns. Applications include molecular beam analysis and laser reaction studies, together with all of the functions of a high-performance residual gas analyser. For more information, see www.HidenAnalytical.com; tel +44 1925 445 225; fax +44 1925 416 518; or e-mail info@hiden.co.uk.

Physik Instrumente (PI) has developed the new N-380/N-381 NEXACT ceramic linear-motor actuators. The new actuator is based on the "Piezo walk" principle and replaces classical lead-screw actuators, combining high forces and long travel ranges with subnanometre resolution in a small package. Features include a 1 kg push/pull force, 30 mm travel and 10 mm/s speed, a self-locking, stiff design and non-magnetic and vacuum-compatible options. For more information, contact David Rego on tel +1 508 832 3456; fax +1 508 832 0506; e-mail info@pi-usa.us; or visit www.pi-usa.us.

The **Rubis Precis/Micropierre Group** has extended the Rubis Precis works at Charquemont by 500 m^2, as well as having commissioned a new ultramodern facility of 2100 m^2 at the works of Micropierre at Besançon. The group specializes in the production of high-precision, micro-mechanical assemblies integrating hard materials (mainly sapphire and ceramics) with metals (stainless steel, titanium, gold and platinum). These assemblies are mounted by techniques that include press-fitting, setting, brazing or laser welding. For further details, e-mail rubis@rubis-precis.com; fax +33 3 816 86834; or visit www.rubis-precis.com.

Lake Shore Cryotronics has introduced the new Model 336 temperature controller, available with four standard inputs, four control outputs and a total of 150 W of low-noise heater power. Two independent heater outputs providing 100 W and 50 W can be associated with any of the four inputs and programmed for closed-loop temperature control in proportional-integral-derivative mode. The controller's zone-setting feature allows temperatures to be monitored and controlled seamlessly from 300 mK to over 1500 K. For further details, tel +1 614 891 2244; fax +1 614 818 1600; e-mail info@lakeshore.com; or visit www.lakeshore.com/336.html.

RECRUITMENT

UNIVERSITY OF OXFORD

www.ox.ac.uk/jobs

J.A.I.

Mathematical, Physical and Life Sciences Division

Department of Physics

Director of John Adams Institute for Accelerator Science University of Oxford & Royal Holloway, University of London in association with Wolfson College Oxford and a University Lectureship in Accelerator Science University of Oxford & STFC Rutherford Appleton Laboratory in association with Wolfson College Oxford

The John Adams Institute for Accelerator Science, based in the Sub-department of Particle Physics at the University of Oxford and in the Department of Physics at Royal Holloway University of London (RHUL), was established in October 2004 as a joint venture between the two universities as part of a major initiative in accelerator science, and is supported by the Science and Technology Facilities Council and Diamond Light Source Limited. There are currently 15 academic staff, 9 research staff, more than 20 research students and a large number of technical staff associated with the Institute. The current portfolio of projects includes the R&D for a future high-energy linear electron-positron collider and a neutrino factory, the Muon Ionisation Cooling Experiment (MICE), the development of non-scaling Fixed-Field Alternating Gradient accelerators for a variety of applications including Charged Particle Cancer Therapy using protons and light ions, novel light sources and ultra-short x-ray pulses, plasma wave accelerator diagnostics, and upgrades to ISIS and the LHC. The Institute also has a vigorous outreach programme. More details about the John Adams Institute can be found at **http://www.adams-institute.ac.uk**.

The Director of the John Adams Institute for Accelerator Science

Grade RSIV: Salary to be negotiated.

The Institute is seeking to appoint a Director at professorial level, replacing Professor Ken Peach, who will retire next year. The successful candidate will have an outstanding international reputation in accelerator science. The Director will be responsible for the academic leadership and strategic goals of the Institute, for maintaining the high-quality academic training programme and the extensive links with the UK and international accelerator and particle physics communities, other academics and industry. He or she will be responsible for the current programme in accelerator science and the future development of the field. The Director, who will be employed by the University of Oxford on a stipend in the RSIV range (Professorial equivalent) at a level to be negotiated, will be predominantly based in Oxford, and will hold a supernumerary Fellowship at Wolfson College Oxford. Informal enquires about this post may be made to Professor Brian Foster, email:b.foster@physics.ox.ac.uk or +44 1865 273323, and further particulars are available at **http://www.physics.ox.ac.uk/pp/jobs/JAI-Director-fp.htm**. The deadline for applications is Friday 15 May 2009. Interviews will be held on 1 June 2009; candidates should keep this date free in case they are called for interview.

University Lectureship in Accelerator Science, jointly with the STFC Rutherford Appleton Laboratory

£42,351 - £56,917 pa

The Institute is also looking for a University Lecturer in Accelerator Science to work on R&D topics of common interest to the Institute and the STFC Accelerator Science and Technology Centre (ASTeC), mainly based on programmes presently under way at the STFC's Rutherford Appleton Laboratory in Oxfordshire. This is a joint appointment with the ASTeC; the salary will be on the Oxford UL scale from £42,351 to £56,917 pa. The successful candidate will be offered a supernumerary Fellowship at Wolfson College Oxford. The appointee will undertake lecturing, research and administration within the John Adams Institute and the Sub-department of Particle Physics in Oxford, and will undertake research at the Rutherford Appleton Laboratory. Applications are welcome in any area of accelerator science. This work involves close international collaboration. Informal enquiries about this post may be made to Professor Ken Peach, email: k.peach1@physics.ox..ac.uk, and further particulars are available at **http://www.physics.ox.ac.uk/pp/jobs/JAI-UL-fp.htm**. The deadline for application is Friday 15 May 2009. Interviews will be held on 29 June 2009; candidates should keep this date free in case they are called for interview.

Applicants should submit before the deadline of 15 May 2009 a letter of application setting out how they meet the selection criteria set out in the further particulars, supported by a curriculum vitae, a publications list, a statement of research interests, and the names and addresses of three referees, to Mrs. Sue Geddes, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK, email: s.geddes@physics.ox.ac.uk, Fax: 0044 1865 273417. Applicants should state whether they wish to be considered for the Directorship or the Lectureship.

Committed to equality and valuing diversity

The Strategic Helmholtz Alliance "Physics at the Terascale" (http://www.terascale.de) is a research network supported by the Helmholtz Association and comprises the research centres DESY and FZ Karlsruhe, 18 German universities and the Max-Planck-Institut für Physik. Within the framework of the worldwide investigation of the fundamental properties of matter using accelerators at the highest energies, the Alliance will sustainably concentrate and advance the expertise and strengths of the participating institutes.

Accelerators | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

MONTE CARLO•

DESY, Hamburg location, is seeking:
Physicist Ph.D. (m/f)

The Analysis Centre of the Helmholtz Alliance "Physics at the Terascale" at DESY supports German physicists working on analysis at ATLAS, CMS and ILC in areas like Monte Carlo generators, parton distribution functions and statistics tools. The Monte Carlo group is a major activity of the Analysis Centre. The group consists of theoretical and experimental physicists working on all aspects of MC generators. The group supports validation and tuning of existing Monte Carlo event generators. It also organizes schools, tutorials and discussion days on MC issues.

The position
The successful candidate is expected to actively contribute to and shape these areas. He or she is expected to be active in the tuning and validation of existing Monte Carlo event generators. Therefore, experience in tuning and validation in either pp and/or ep environments is considered an advantage. A close collaboration with the experiment is necessary. The candidate is also expected to carry out research within one of the Alliance projects for about 50% of his or her time, preferably within one of the LHC experiments.

Requirements
- Ph.D. in physics
- Interest and experience with Monte Carlo event generators, especially with their tuning and validation
- Good communication skills

For further information please do not hesitate to contact Thomas Schoerner-Sadenius (thomas.schoerner@desy.de), Judith Katzy (judith.katzy@desy.de) or Hannes Jung (hannes.jung@desy.de).

Applications including a letter of application, CV, academic records as well as a list of publications and the names of three persons who can provide further information about the candidate should be addressed to:
Prof. Ian Brock (Scientific Manager of the Helmholtz Alliance)
DESY, Notkestraße 85, D-22607 Hamburg (Ian.Brock@desy.de)

The position is limited to the current end of funding of the Helmholtz Alliance, 30 June 2012.

Salary and benefits are commensurate with those of public service organisations in Germany. DESY operates flexible work schemes. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is an English-speaking Kindergarten on the DESY site.

Deadline for applications: 27 April 2009
Code: 28/2009

EXCEPTIONAL REWARDS, CENTRAL OXFORD

Why does a leading Quant Fund want to recruit leading scientists in 2009?

You're searching for the elusive building blocks of the universe. We're searching for elusive alpha in global financial markets. We should talk.

Who Are We?

OxFORD ASSET MANAGEMENT is an investment management company situated in the centre of Oxford. Founded in 1996, we're proud of having generated positive returns for our investors each year, including 2008, especially as many assets are managed for pensions, charities and endowments. We blend the intellectual rigour of a leading research group with advanced technical implementation. We like to maintain a low profile and avoid publicity. Nobody comes to work in a suit and we are a sociable company, enjoying an annual ski-trip away together.

What Do We Do?

We use quantitative computer-based models to predict price changes in liquid financial instruments. Our models are based on analyzing as much data as we can gather and we actively trade in markets around the world. As these markets become more efficient, partly because of organizations like ours, we must have new insights and develop improved models in order to remain competitive. Working to understand and profit from these markets provides many interesting mathematical and technical challenges, especially as markets become increasingly electronic and automated. We enjoy tackling difficult problems, and strive to find better solutions.

Who Do We Want?

Although most of us have advanced degrees in mathematics, computer science, physics or econometrics from the world's leading universities and departments, we are just as interested in raw talent and will consider all outstanding graduate applicants. We expect all prospective candidates to work efficiently both in a team environment and individually. We value mental flexibility, innovative thinking and the ability to work in a collaborative atmosphere. No prior experience in the financial industry is necessary. We want to hear from you if you are ambitious and would relish the challenge, opportunity and excellent compensation offered.

Software Engineers

We are seeking outstanding software engineers to develop and maintain system critical software running in a 24-hour production environment. You will be responsible for all aspects of software development on a diverse range of projects, such as automating trading strategies, integrating third party data into our system and the development of data analysis tools. You will have the following:

- A high quality degree in computer science or related discipline
- C++ experience that demonstrates your ability to work efficiently in a fast paced environment
- Extensive knowledge of the development life cycle, from prototyping and coding through to testing, documentation, live deployment and maintenance

Desirable experience includes Linux, scripting, working with large numerical data sets, and large scale systems.

Quantitative Researchers & Modellers

We are seeking outstanding researchers to build quantitative models of financial markets within our research and development team. You will be responsible for projects from the initial idea-generation stage through to implementation and execution. You will undertake research using large and often complex data sets, employing different computer programming languages (mostly C++) and our in-house development library infrastructure.

You will have experience in some of the following areas: numerical analysis, optimisation, signal processing, statistics (including robust techniques), stochastic processes, time series analysis, volatility / GARCH modelling.

How to apply

Please email or post CV with covering letter to:

Address
Dr Steven Kurlander,
Oxford Asset Management,
13-14 Broad Street,
Oxford OX1 3BP
United Kingdom

Email cern2009@applytooxam.com

Telephone +44 1865 248 248

Closing Date
Ongoing

Start Date
Spring 09 – ongoing

Benefits
Health Insurance (including family),
Pension Scheme,
Life Insurance.

OxFORD
ASSET MANAGEMENT

GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

The Physics Department of the Georg August University of Göttingen advertises a

Full Professorship (W3 salary scale) in Theoretical Physics with research focus "Quantum Theory in the range of Elementary Particle Physics and Cosmology"

to be filled by Oct 01, 2009.

The successfull applicant shall represent the Physics Department's Research Focus "Particle Physics and Astrophysics" in the Theory Division. She/he will investigate the fundamental interrelations between Elementary Particle Physics and Cosmology by her/his research profile in a broad range of Quantum Physics. A scientific interaction with the experimental and observational research groups in this area is expected.

Teaching obligations include the participation in all graduate and undergraduate curricula provided at the Physics Department (Bachelor of Science, Master of Science, Bachelor (two subjects) (teaching profession), Master of Arts in Education, Diploma (to be discontinued), PhD).

The formal requirements for the recruitment follow § 25 NHH. The Public Law Foundation Göttingen University holds the right of appointments. Details can be given upon inquiry.

Applications from foreign countries are expressly encouraged. A part-time appointment can possibly be given. Handicapped candidates are given priority, if equally qualified. The University of Göttingen is determined to increase the percentage of female professors. Therefore, we strongly encourage qualified female scientists to apply.

Applications with the standard documents (CV, index of publications, presentation of teaching and research record, diplomas) should be sent by **April 15, 2009** to:

Dekan der Fakultät für Physik, der Georg-August-Universität Göttingen
Friedrich-Hund-Platz 1, D-37077 Göttingen, GERMANY

GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

The Department of Physics

invites applications for a

W2-Professorship Experimental Physics with denomination Particle Physics

at the Second Physical Institute. We seek an internationally renowned individual with research focus in experimental high energy physics. The candidate is expected to complement and strengthen the particle physics activities with regard to the research topics and methods used. The present research focus (physik2.unigoettingen.de) is placed on the operation and data analysis of the ATLAS experiment at the LHC and on detector development in the BMBF-Research Centre (Forschungsschwerpunkt) FSP-101; we expect the applicant to play an active role in the FSP-101 ATLAS.

We expect a strong commitment to deepen the Göttingen research focus within the field of particle- and astrophysics in cooperation with the Institutes of Theoretical Physics and Astrophysics. The successful candidate will also have a strong commitment to teaching and will take part in the teaching program of the Department of Physics at both the undergraduate and graduate levels. The Department of Physics with its new building offers a very good scientific and technical infrastructure.

As a Public Law Foundation, the University of Göttingen holds the right of appointment. Preconditions for appointment are laid down in § 25 of the Higher Education Law of Lower Saxony of 26.02.2007 (Official Law Gazette of Lower Saxony, Nds. GVBl. 5/2007, p. 69). Further details will be explained on request. We explicitly welcome applications from abroad. Under certain circumstances part-time employment is possible. The University strives to increase its proportion of female staff and specifically encourages qualified women to apply. Disabled persons with corresponding aptitude for the position will be favoured.

Interested candidates are requested to send their application, including a curriculum vitae, description of their scientific and teaching career, publication list with emphasis on the five most important publications and certificates no later than **April 24, 2009**.

Please send your application to:

Dekan der Fakultät für Physik, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany

Max Planck Institute
for Physics
(Werner Heisenberg Institute)

ATLAS Postdoctoral Position

The *Max-Planck-Institut für Physik* participates in the ATLAS experiment at the Large Hadron Collider (LHC) at CERN. Its researchers contributed to the design, construction and commissioning of the Semiconductor Tracker, the Hadron Endcap Calorimeter and the Muon Spectrometer of the ATLAS detector. The maintenance and calibration of these detector components and the preparation for the analysis of the first data including the operation of an ATLAS Tier-2 computing center are major present activities.

We invite applications for a postdoctoral position in experimental particle physics within our ATLAS Group. Candidates are expected to contribute to the operation of the ATLAS detector, to the development of reconstruction or analysis software, and to the data analysis, in particular to searches for the Higgs boson or for supersymmetric particles, and to measurements of Standard Model processes in which the group is involved.

Salary and benefits are according to the German public service pay scale (TVöD Bund). The contract is initially limited to three years with the possibility of extension. The Max Planck Society is an equal opportunity employer committed to increasing the participation of women wherever they are underrepresented. The Max Planck Society is committed to employing more handicapped individuals and especially encourages them to apply.

For questions please contact Dr. Hubert Kroha (kroha@mppmu.mpg.de). Applicants should send a cover letter with curriculum vitae, list of publications and statement of research interests and arrange for three letters of recommendation to arrive no later than April 30, 2009 at the following address:

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
c/o Ms. A. Schielke
Föhringer Ring 6
D-80805 München, Germany
schielke@mppmu.mpg.de

MAX-PLANCK-GESELLSCHAFT

ESRF
The European
Light Source

European Synchrotron Radiation Facility

We Highlight Science

The ESRF is a multinational research institute, employing 600 staff, located in Grenoble in the heart of the French Alps. The ESRF is financed by 19 countries and carries out fundamental and applied research with synchrotron (X-ray) light.

In the context of an upgrade of the accelerator systems, we are currently seeking:

Radio Frequency Engineer

for the development and implementation of high power 352 MHz solid state RF amplifiers
http://www.esrf.eu/Jobs/Technical/4134

Engineer in Power Electronics

for the development of accelerator magnets and associated power supplies
http://www.esrf.eu/Jobs/Technical/4135

Interested candidates may send a fax (+33 (0)4 76 88 24 60) or e-mail (recruitm@esrf.fr) with their address, to receive an application form, which can also be printed from the web.

Deadline for applications: 30th April 2009.

Foundation for Fundamental Research on Matter

The Foundation for Fundamental Research on Matter (FOM) promotes, co-ordinates and finances fundamental research of international standard/calibre in The Netherlands. It is an autonomous foundation responsible to the physics division of the national research council NWO. FOM employs about 900 people, primarily scientists (including PhD students) and technicians, who work at FOM research institutes and research groups at universities. FOM is chiefly financed by the NWO (Netherlands Organisation for Scientific Research) Governing Board and NWO Physics and can be considered as the Physics Division of NWO. In addition to the government funds of NWO, FOM acquires financial means from the European Union and through collaboration with the industry and universities. For additional information see www.fom.nl.

FOM

Nikhef is the national institute for subatomic physics in the Netherlands with about 240 employees: 145 physicists, 75 engineers / technicians and 20 employees for General support. Based in Amsterdam, it is a collaboration between four universities and the funding agency FOM. The institute co-ordinates and supports major Dutch activities in experimental subatomic physics, among them the ATLAS, LHCb and Alice experiments at the Large Hadron Collider at CERN and several astroparticle physics projects, such as the ANTARES neutrino telescope, the Auger cosmic-ray observatory and the Virgo gravitational wave interferometer. Nikhef has in addition a theory department.

Nikhef has an opening for a

staff scientist

with tenure in the B-physics programme.

Requirements

The applicant must have a PhD and an excellent research and publication record in particle physics. Applicants are judged as to creativity, competence in modern information technology, ability to establish an active research line including supervision of PhD students and the ability to communicate developments through seminars as well as public lectures.

Information

Further information can be obtained from the leader of the B-physics group, prof. dr. Marcel Merk (phone +31 20 5925107 or by email Marcel.Merk@nikhef.nl or from the chairman of the selection committee, prof. dr. Eric Laenen, (phone +31 20 5925127 or by email Eric.Laenen@nikhef.nl). Job interviews are foreseen in week 22 until 24, 2009.

Applications

Candidates are invited to send their application, including curriculum vitae, list of publications as well as three letters of reference before May 7th, 2009 to Nikhef, att. Mr. T. van Egdom, P.O. Box 41882, NL-1009 DB Amsterdam, or by email to Teus.van.Egdom@nikhef.nl.

Please quote vacancy nr: 090148

All qualified individuals are encouraged to apply.

NIKHEF

LAL

Tél. : +33 1 64 46 83 00
Fax : +33 1 69 07 94 04
Web : http://www.lal.in2p3.fr

A Orsay le 23 février 2009

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE
IN2P3 du CNRS et Université PARIS-SUD 11
Centre Scientifique d'Orsay - Bât 200 - B.P. 34
91898 ORSAY Cedex (France)

Description de poste :
Directeur technique du Laboratoire de l'Accélérateur Linéaire d'Orsay

Le Laboratoire de l'Accélérateur Linéaire (LAL) :

Le LAL est une unité mixte de recherche de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) du CNRS, et de l'Université Paris Sud. Il compte environ 335 personnes reparties en 100 physiciens, 200 ingénieurs et techniciens et 35 administratifs. Le personnel technique est réparti entre des services généraux (réalisation mécanique, infrastructures et sécurité, achats et logistique) et des services d'ingénierie qui travaillent en symbiose avec les groupes de physiciens (mécanique, électronique, informatique, étude et réalisation d'accélérateurs). Le LAL a également en charge plusieurs pôles et plateformes technologiques au service de l'ensemble de la communauté. Pour en savoir plus sur le LAL :
http://www.lal.in2p3.fr/spip.php?article176

Le Directeur Technique :

Le directeur technique assure la coordination de l'ensemble des services techniques généraux et d'ingénierie. Il est membre de l'équipe de direction du laboratoire aux côtés du directeur, du directeur adjoint et de la responsable administrative.
Ses fonctions comportent :

- le suivi des grands projets impliquant les équipes techniques du laboratoire,
- la proposition des évolutions structurelles du secteur technique du laboratoire,
- l'élaboration de la politique concernant les personnels techniques et la proposition des recrutements à effectuer,
- la proposition d'une politique d'acquisition d'équipements de laboratoire,
- le suivi des évolutions en matière de locaux et infrastructures techniques,
- le plan campus et le futur déménagement du laboratoire rendront ce secteur critique dans les prochaines années,
- les réalisations techniques avec différents partenaires : laboratoires voisins, laboratoires partenaires dans certaines collaborations, partenaires industriels... Une attention particulière sera portée à la valorisation des compétences existantes.

Le directeur technique devra faire preuve d'une forte capacité d'organisation. Ce sera un homme de terrain très présent auprès des personnels dont il obtiendra l'adhésion aux choix stratégiques de la direction par le dialogue et l'explication. Au-delà d'une solide compétence technique, ce seront ses qualités de manager et de meneur d'hommes qui assureront le succès de sa mission. La langue de travail sera le français.

CDD d'une durée de 3 ans renouvelable une fois.

Merci d'envoyer CV et lettre de motivation à : personnel@lal.in2p3.fr

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

Research Associate

The Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE) has an opening for a Research Associate to work on research and development for a broad range of topics involving RF superconductivity for particle accelerators.

Please provide an application and arrange to have at least three letters of reference sent to: Dr. Hasan Padamsee, Chair, Search Committee, Laboratory for Elementary-Particle Physics, Newman Laboratory, Cornell University, Ithaca, NY 14853 USA.

Applications should include a curriculum vita, publication list, summary of research experience and interests. Electronic to search@lepp.cornell.edu. For a complete description of the ad, please visit www.lepp.cornell.edu and click on Jobs.

Cornell is an equal-opportunity/affirmative action employer.

Accelerators | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY

PHOTO INJECTOR .

DESY, Zeuthen location, is seeking:
Scientist (m/f)

DESY

DESY is one of the world's leading centres for the investigation of the structure of matter. DESY develops, runs and uses accelerators and detectors for photon science and particle physics.

State-of-the-art electron sources with excellent beam quality are indispensable for next generation light sources like free electron lasers. Such electron guns are being developed and operated at the PITZ photo injector test facility at Zeuthen (near Berlin).

The position

- Participation in one of the international leading groups for the development of RF photo injectors consisting of physicists and engineers of different nationality
- Development of innovative concepts, techniques and applications for new electron sources as well as diagnostics components
- Participation in the experimental characterization of electron sources
- Responsibility for parts of the PITZ project
- Contributions to FLASH and the European XFEL
- Participation in the shift operation of PITZ

Requirements

- Excellent university degree in physics or engineering, including a PhD
- Sound knowledge and experience in optics (laser and incoherent radiation) and/or accelerator physics and technology
- Some experience in project leadership
- Proficiency in German and English
- Willingness to travel abroad and to participate in international conferences
- Good communication skills

For further information you may also contact Dr. Frank Stephan (+49 33762 7-7338 or frank.stephan@desy.de).

DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women.

Please send your application quoting the reference code, also by E-Mail to:
Deutsches Elektronen-Synchrotron DESY
Human Resources Department | Code: 16/2009
Notkestraße 85 | 22607 Hamburg | Germany Phone: +49 40 8998-3765 |
E-Mail: personal.abteilung@desy.de
Deadline for applications: 30 April 2009
www.desy.de

The Helmholtz Association is Germany's largest scientific organisation.
www.helmholtz.de

HELMHOLTZ | ASSOCIATION

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Cryophysicist

The ORNL Physics Division seeks a physicist with experience in design, construction, and operation of large milli-Kelvin cryogenic systems for a leading role in the neutron electric dipole moment (nEDM) search in preparation at the Spallation Neutron Source in Oak Ridge. The nEDM project is a multi-institution project supported by the US, DOE, and NSF. The experiment includes the design, construction, and operation of a 1000 liter container of liquid helium at 0.3 K using a high-flow dilution refrigerator and a dedicated helium liquefier. Many components include the deliberate transport of 3He between separate volumes in the few hundred milli-Kelvin regime via novel techniques.

The successful candidate will play a leading role in the design, assembly, and commissioning of the entire nEDM cryogenic system. The successful candidate will work with ORNL technical staff and external collaborators to assemble, test, and operate the cryogenic systems. At times, it may be desirable for the candidate to participate in the testing of components at participating institutions.

Candidates must have significant experience in the design, maintenance, and operation of the technology for attaining sub-Kelvin conditions – to include dilution refrigeration systems and superfluid helium. Experience with magnetic fields and electronic instrumentation is also highly desirable, as is a background in nuclear and/or neutron physics. The candidate should hold a Ph.D. or equivalent, have experience with a large experimental project, and have published work on similar experiments.

For further consideration, please visit **http://jobs.ornl.gov/** and reference posting Cryophysicist in the keyword search field. Oak Ridge National Laboratory is an equal opportunity employer.

Universität Bielefeld

Heisenberg-Professorship (W2) in Theoretical Particle Physics

The Department of Physics invites applications for a professorship in Theoretical Particle Physics. Candidates should have an outstanding record of research especially in the area of QCD precision calculations applied to physics of proton-proton-collisions at the LHC as well as the electron-positron-collisions at a future Linear Collider. They should have overlapping research interests to the existing research areas (thermal field theory, lattice QCD, cosmology) and should participate in the activities of the International Graduate School "Quantum Fields and Strongly Interacting Matter".

The successful candidate will take part in the regular teaching activities of the Faculty, in particular those in theoretical physics. We expect corresponding pedagogical abilities and enthusiasm.

Formal requirements are a PhD and additional scientific merits, which will be evaluated during the selection procedure.

Applicants should also apply to the DFG for a Heisenberg Professorship at the same time. To be appointed they have to successfully take part in the DFG's review process and to be selected by the university. The initial appointment is for 5 years, funded by the DFG. After a positive evaluation the position will become tenured.

The University of Bielefeld is an equal opportunity employer, and we particularly appreciate handicapped and female applicants. In case of equal qualification and suitability, female applicants will be given priority.

Applications including the usual material should be sent by April 30, 2009 to

The Dean
Faculty of Physics
Bielefeld University
Postfach 10 01 31
D-33501 Bielefeld
dekanat@physik.uni-bielefeld.de

Max Planck Institute for Physics
(Werner Heisenberg Institute)

The Max Planck Institute for Physics invites applications for a

Postdoctoral position

focused on the commissioning of the GERDA experiment.

The GERDA experiment is designed to investigate the nature of the neutrino and its absolute mass-scale by searching for the neutrinoless double-beta decay of ^{76}Ge. The goal is to either establish the Majorana nature of the neutrino or push the relevant exclusion limits to the mass-scale indicated by neutrino oscillations. The experiment uses the novel approach of shielding crystals with a cryogenic liquid.

The successful candidate is expected to take a leading role in following and helping the commissioning phase of the GERDA experiment. This will involve frequent travelling to the Laboratori Nazionali del Gran Sasso underground laboratory (LNGS). The candidate will also be responsible for evaluation of Monte Carlo simulations of the GERDA setup and the comparison of the first GERDA data with expectations from these simulations. First data of the GERDA experiment are expected this year.

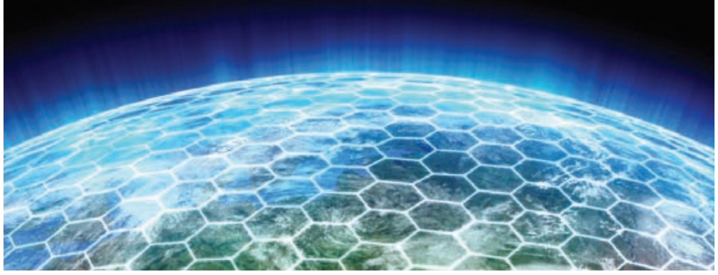
Formal requirement for this position is a PhD in experimental physics. The candidate should have a background in nuclear-, particle-, or astroparticle physics and a good knowledge of programming. Experience with HPGe diodes, C++, Root and GEANT 4 are an advantage.

Salary and benefits are commensurate with the German public service pay scale (TVöD Bund). The contract is initially limited to 2 years, with the possibility of an extension. The Max Planck Society is an equal opportunity employer. One of its goals is to increase the percentage of women in positions where they are underrepresented. Women are especially encouraged to apply. The Max Planck Society is committed to employing more handicapped people. Applications of handicapped people are particularly welcome.

Further information may be obtained from Dr. Béla Majorovits (bela@mppmu.mpg.de) or Prof. Allen Caldwell (caldwell@mppmu.mpg.de). Applicants should submit an application letter, a statement of research interests, a curriculum vitae, a list of publications, and arrange for three letters of support to arrive no later than April 30 at

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
c/o Ms. F. Rudert
Föhringer Ring 6
D-80805 München
Germany

MAX-PLANCK-GESELLSCHAFT



BOOKSHELF

Relativity: A Very Short Introduction by Russell Stannard, Oxford University Press. Paperback ISBN 9780199236220, £7.99.

In the series of *Very Short Introductions* by Oxford University Press there have been nuggets and non-nuggets. The book *Relativity* is definitely a nugget.

We can all do the simple maths and use Pythagoras's theorem but I have always found it difficult – even from Albert Einstein's popular little book – to gain some "more intuitive" understanding of relativity. Russell Stannard's text is the best that I have read.

He begins with the familiar: simultaneity, constancy of the speed of light, the paradox of the twin astronauts and so on. In each case he goes straight to the heart of the phenomenon – and each time I felt that I came out with a deeper understanding and better appreciation of how simple it all is. Stannard has in this short work collected all of the best analogies that I have come across while also managing to keep the reader smiling with some tongue-in-cheek remarks.

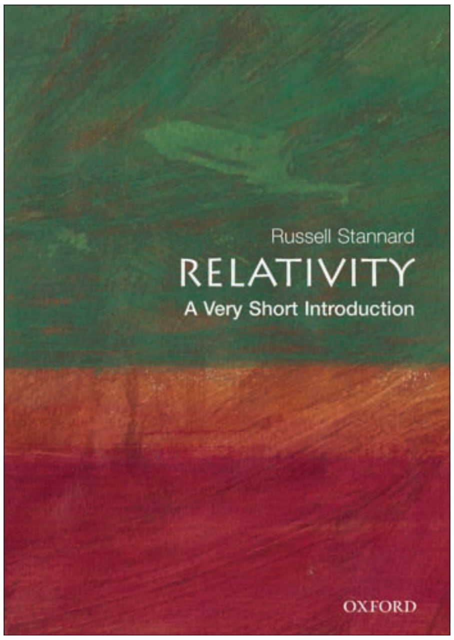
There are a number of mathematical expressions sprinkled throughout the text; and they are not beyond the abilities of the interested layperson. The drawings and formulae are good, with artwork that is vastly better than in some of the other volumes in the series. However, OUP has still not got it all entirely right. For example, the square root symbol – important in this particular text – is just a V symbol. Weird.

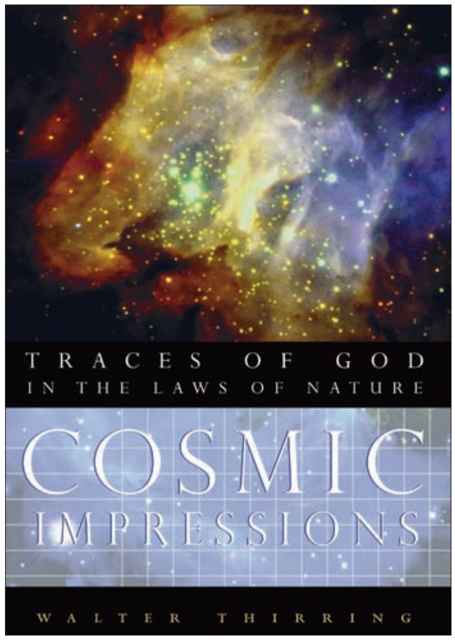
In all, this is a pleasant book to read. It reminds one of how strange reality really is and how difficult it is for us humans to make simple mental models. This book is to be recommended.

Robert Cailliau, CERN.

Cosmic Impressions: Traces of God in the Laws of Nature by Walter Thirring, Templeton Foundation Press. Paperback ISBN 9781599471150, $19.95.

This is a translation from German of *Kosmische Impressionen: Gottes Spuren in der Naturgesetzen* so, in principle, I should have little to add to the excellent review by Herwig Schopper (*CERN Courier* March 2005 p48). The book is a presentation of the universe, its history and its laws, as well as covering cosmology, physics, chemistry and biology. It describes the fantastic progress of our knowledge from the end of the 19th century to the present. Thirring's point of view is that the structure of the universe is so beautiful, and the conditions of our existence on Earth so miraculously set, that it is difficult not to see the signs of a superior architect behind it all. Whether or not you agree with the author (I do), this volume is extremely informative for everybody. It also contains colourful accounts of the encounters between Thirring (not only a witness but an important player) and the great men who made these incredible changes to our views of the world. (For more details, see Schopper's review.)





The book makes it clear to all, including atheists, that naive positivism à la August Comte is dead. First you have the probabilistic nature of quantum mechanics: if you take a uranium nucleus you cannot predict if it will decay tomorrow or in one million years. Even in purely classical mechanics, you cannot predict the evolution of a complex system from initial conditions known with an arbitrarily small uncertainty beyond the "Lyapounov time". Moreover, in nature you find spontaneously broken symmetries, which break in an unpredictable way. Many people, such as Murray Gell-Mann, think that the universe can be randomly projected on certain states at random times. Therefore we are far from the "clockmaker" God of Descartes. Despite all of this, however, the predictivity of physics has never been as fantastic as now: the calculated value of the magnetic moment of the electron given to 12 digits agrees perfectly with the experimental value.

Like Schopper, I can only recommend this book. The author makes a considerable effort to avoid technicalities. As a scientist, I am not in a position to say whether someone without a scientific background could follow it, but I believe that it is ideally suited to engineers, especially accelerator engineers, who aren't always aware of the beautiful endeavour to which they contribute so much.

André Martin, CERN.

Books received

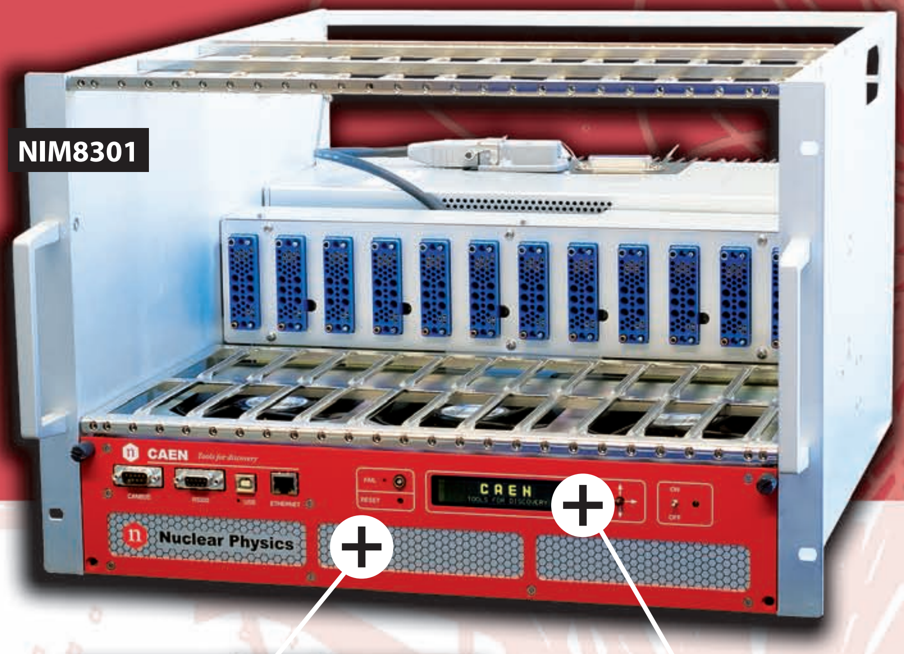
The Thermodynamic Universe: Exploring the Limits of Physics by B G Sidharth, World Scientific. Hardback ISBN 9789812812346, £29 ($58).

This text examines developments that are leading to a paradigm shift and a new horizon for physics, at a time when the underlying principle of reductionism is being questioned. Presenting the new paradigm in fuzzy space–time, it is based on some 100 published journal papers and two recent books. This work has predicted correctly epoch-turning observations, for example, that the universe is accelerating with a small cosmological constant driven by dark energy – when the prevalent line of thinking was the exact opposite. Regarding a unified description of gravitation and electromagnetism via fluctuations, several other highlighted features presented are in complete agreement with experiments.

CAEN Electronic Instrumentation
Tools for Discovery

NIM8300 - Powered Crates Family

NIM8301



removable

removable

NIM8300 Crate Series

The NIM8300 crate series consists of a NIM mechanics and a removable Linear Power Supply (150W, 300W and 600W available).
The NIM standard, despite of its age, is still a great choice for building a small and flexible setup for high resolution measurements with electronics such as amplifiers, ADCs, timing and logic units and also LV/HV power supplies.

Smart fan units for NIM Crate

- The fan unit and power supply are removable
- The fan unit has an OLED technology graphic display
- The fan unit houses 4 remote interfaces: CANBUS, TCP/IP, RS232, USB 2.0
- All the operating functions are available through a smart user interface using an ergonomic joystick

	NIM8301	NIM8302	NIM8303
Mechanics	7U bin - 12 slot, 2U space for fan tray	5U bin - 12 slot (10 free), non ventilated	5U bin - 12 slot, non ventilated
Max Output Power	300/600 W	150 W	300/600 W
Remote Control	RS 232, USB (2.0), CAN bus, Ethernet	N.A.	N.A.
Maximum Currents	17/45 A @ ±6V 3.4/18 A @ +/-12 V 3.4/8 A @ +/-24 V 0.3 A @ 115Vac (optional)	5 A @ ±6V 3.A @ ±12 V 1.5 A @ ±24 V	17/45 A @ ±6V 3.4/18 A @ +/-12 V 3.4/8 A @ +/-24 V 0.3 A @ 115Vac (optional)

www.caen.it

Small details
Great differences