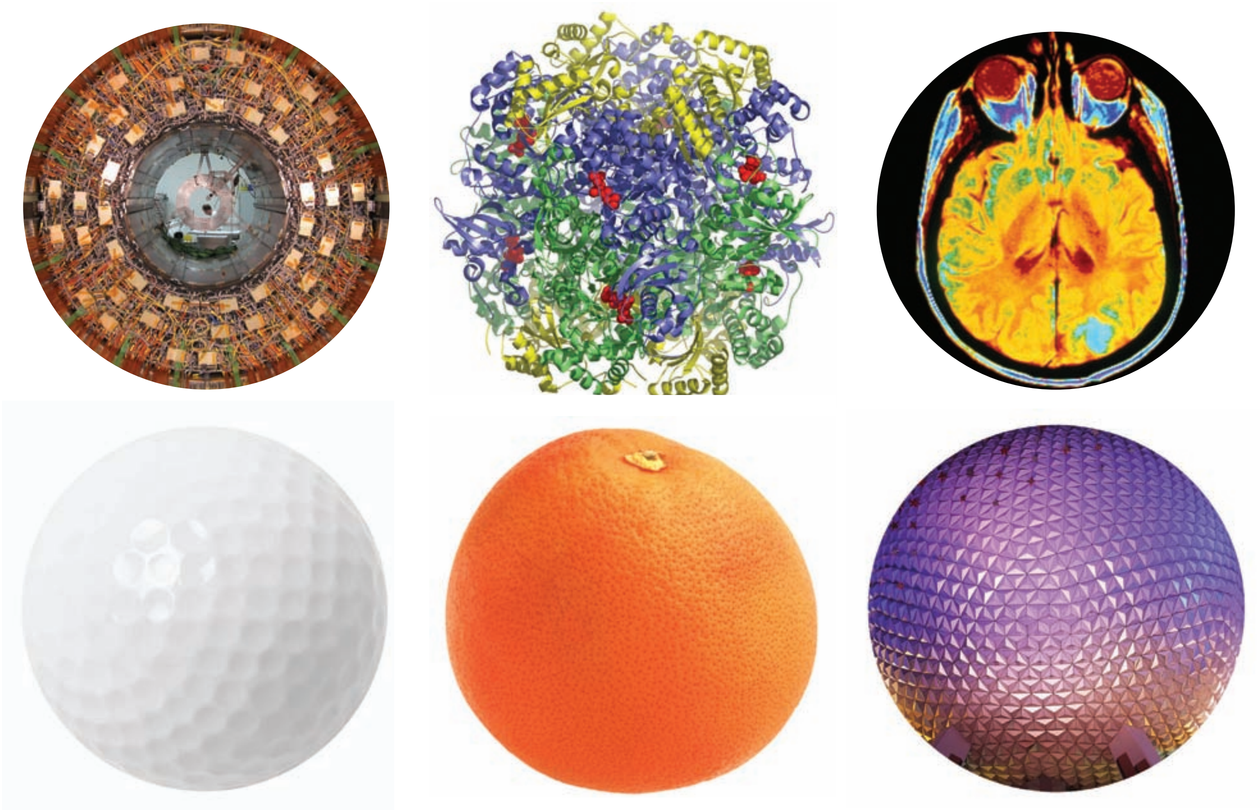
International Journal of High-Energy Physics

CERN COURIER

Volume 49 Number 2 March 2009

On the trail of dark energy



25-31 October 2009

Nuclear Science Symposium
Medical Imaging Conference

Radiation Detectors and Instrumentation and their applications in Physics, Biology, Space, Material Science, Medical Physics and Homeland Security

Plenary Sessions • Oral Sessions • Poster Sessions • Short Courses
Special Topic Workshops • Industrial Exhibits • Companion Program

Abstract Submission Deadline: 11 May 2009

General Chair:
Richard Lanza
MIT, Department of Nuclear Science and Engineering
77 Massachusetts Ave, Building NW13-221
Cambridge, MA 02139-4307 USA

www.nss-mic.org/2009
email nssmic2009@mit.edu
phone 617.253.IEEE (4333)

HILTON DISNEY WORLD, ORLANDO, FLORIDA

IEEE
NUCLEAR & PLASMA SCIENCES SOCIETY
Massachusetts Institute of Technology

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

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

CERN COURIER

VOLUME 49 NUMBER 2 MARCH 2009


New horizons for CERN p15


Searching for dark energy p17


Georges Charpak p24

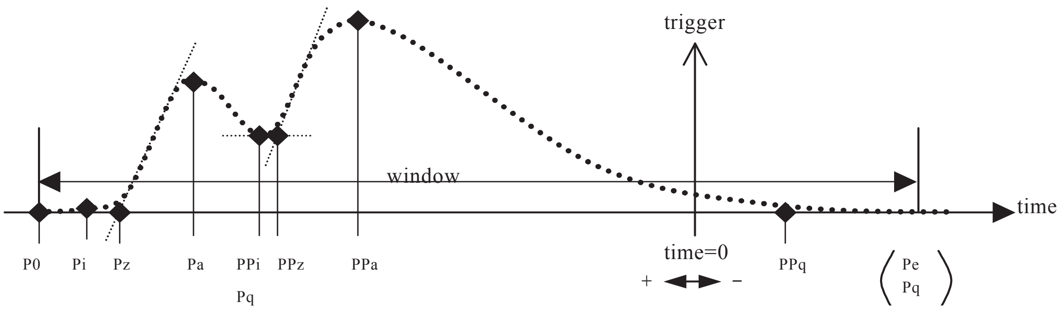
Cover: The South Pole Telescope will allow independent tests for the existence and strength of dark energy – the topic of a recent conference in Munich (p17). (Courtesy Jeff McMahon.)

AVM16: 160 MHz ADC with features extraction

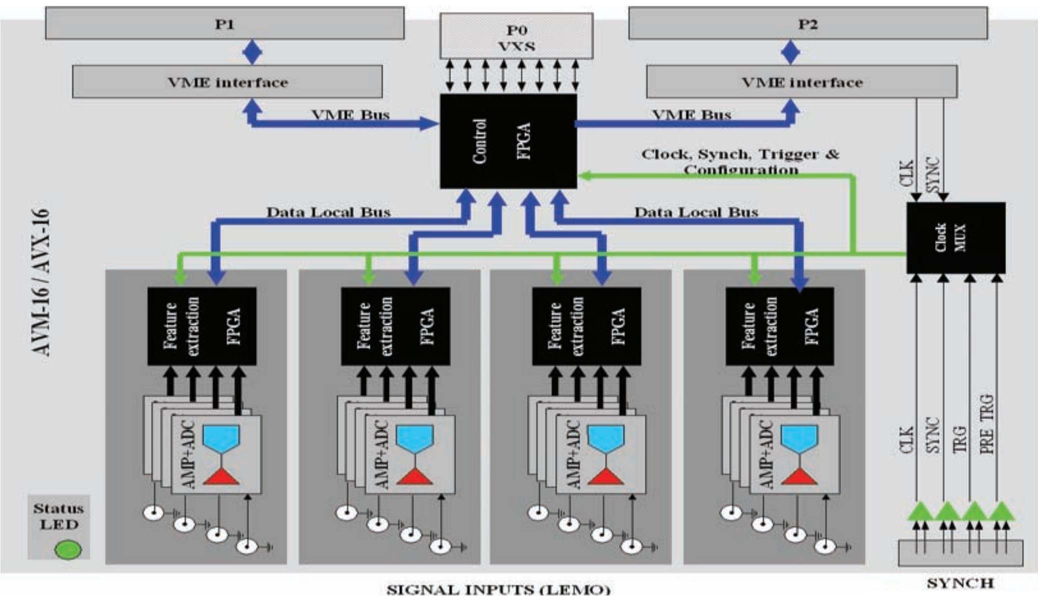
W-Ie-Ne-R presents its new 16 channel VME flash ADC equipped with 5 FPGAs for data preprocessing. The feature extraction FPGA modules allow to compute pulse integrals (also for overlapping pulses), measure and subtract pedestals, extrapolate pulse arrival times with 1.5 ns resolution, extract maxima and minima of the signal and disentangle pile up events in real time. A VXS version will soon be available.

Standard versions

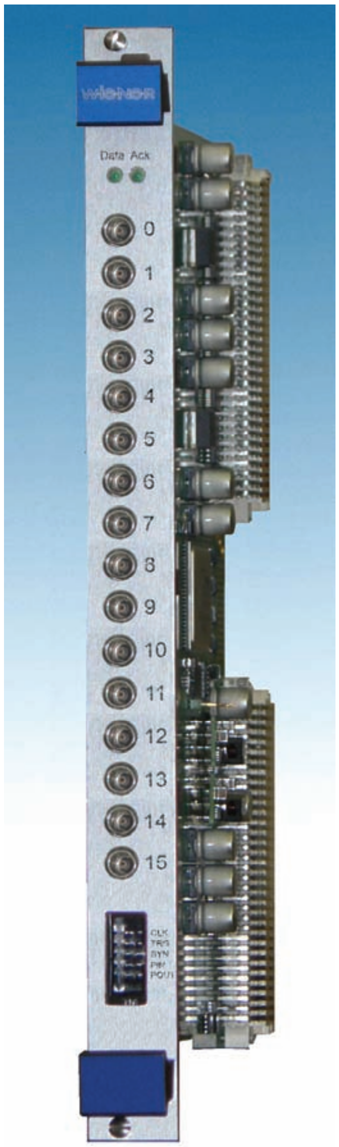
Item	Description
AVM16	16 channel VME flash ADC, 160 MHz, 12 bit, features extraction
AVX16	16 channel VXS flash ADC, 160 MHz, 12 bit, features extraction



Even for pile-up events, the FPGAs extract maxima, minima, timestamps, integrals and pedestals



AVM16 and AVX16 functional diagram



AVM16

www.wiener-d.com

In collaboration with Forschungszentrum Jülich and The Svedberg Laboreatory

Plein & Baus GmbH, Muellersbaum 20, 51399 Burscheid, Germany
Phone: (+49 2174) 6780, Fax: (+49 2174) 678 55

W-IE-NE-R Plein & Baus Elektronik
Werk für Industrie-elektronik, Nuklear-elektronik, Regelungs-technik

LHC NEWS

CERN firms up the LHC schedule

In a workshop in Chamonix on 2–6 February, members of the LHC accelerator and experimental teams, as well as CERN's management, met to formulate a realistic timetable to have the LHC running safely and delivering collisions. The main outcome is that there will be physics data from the LHC in 2009 and there is a strong recommendation to run the machine through the winter until the experiments have produced substantial quantities of data. Such extended running could achieve an integrated luminosity of more than 200 pb^{-1} at 5 TeV per beam.

Meetings in Chamonix were a feature of the annual winter shutdown at CERN during the LEP era, providing a forum where intense discussions led to a clear consensus on objectives for the following year. CERN's director-general, Rolf Heuer, intends for similar meetings to guide operations during the LHC era. The first occasion provided a tough start, as the participants had to agree on the best way to proceed following the incident in sector 3-4 that brought LHC commissioning to a halt last September.

The crucial improvement since the incident in sector 3-4 is a new resistance-measurement system which can detect nano-ohm resistances in the joints. This new system would have prevented September's incident and will prevent all imaginable failures of a superconducting joint in the future. The work on this new detection and protection system was reviewed at the workshop and is already making good progress. Following completion of the design of the two principal electronics boards, the first orders were placed in early February. At the same time, manufacture of the cable segments had begun and installation started in sector 4-5.

Replacement dipoles for sector 3-4 of the LHC are prepared for lowering into the tunnel.

For any "unimaginable" failure of a joint, the installation of new pressure-relief valves will reduce the amount of damage that occurs, compared with last year (*CERN Courier* January/February 2009 p6). The new valves will prevent pressure build-up and collateral damage by allowing a greater rate of helium release in the event of a sudden increase in temperature. Discussions in Chamonix centred on whether to install these pressure-relief valves in one go or to stage their installation over the next two shutdowns. There were many interesting exhanges on this topic and opinions were divided. The CERN management is to make the final decision on this in the week beginning 9 February.

Meanwhile, work continues apace on the repairs at the LHC. At the end of January, a dipole from sector 1-2, which had been identified as having an internal splice resistance of 100 nΩ, was opened up after removal from the tunnel and was found to have little solder on the splice joint. It is likely that a similar small resistance was at the root of the incident in sector 3-4. The LHC teams can now detect a single defective splice *in situ* when a sector is cold and they have identified another dipole showing a similar defect in sector 6-7. This sector will be warmed up and the magnet removed. Each sector has more than 2500 splices, but the resistance tests can only be conducted on cold magnets. Three sectors remain to be tested: sector 3-4, where the incident occurred, and the adjoining sectors, 2-3 and 4-5.

Tests on the magnets were among the important topics under discussions at Chamonix. The participants agreed on teams to work on the detailed analysis of the measurements made during the cold tests of magnets in building SM18 before their installation in the tunnel. New analysis techniques will be devised to provide a complete picture of the resistance in the joints of all magnets installed in the LHC. The aim is to allow an early warning and early correction of any further suspicious splices.
● For up-to-date news, see *The Bulletin* at http://cdsweb.cern.ch/journal/.

Sommaire

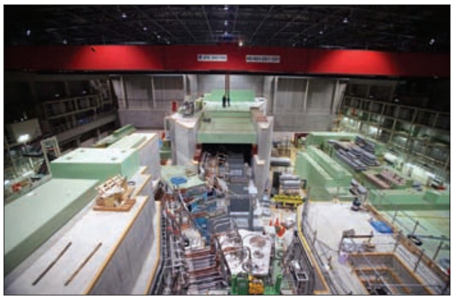
ACCELERATORS

Protons reach the J-PARC Hadron Experimental Hall

The Main Ring at the Japan Proton Accelerator Research Complex (J-PARC) has reached a new milestone with the successful extraction of a proton beam to the Hadron Experimental Hall and then to the beam dump.

J-PARC, a joint project of the Japan Atomic Energy Agency and the KEK laboratory, has been under construction at Tokai since 2001. With a 1600 m circumference and a 500 m diameter, the 50 GeV synchrotron of the Main Ring is the third and final stage in the accelerator complex. The first stage is the linac, followed by the 3 GeV synchrotron. The Main Ring will operate at 30 GeV in the first phase of the project.

The proton-beam tests at J-PARC started in November 2006 and had reached the initial goal for protons in the Main Ring of 30 GeV by December 2008. Then on 27 January, 30 GeV protons were extracted from the Main Ring to the secondary particle-production target, T1, located 250 m downstream in the Hadron Experimental Hall and were transported onwards to the beam dump.



Hadron Experimental Hall. (Courtesy KEK.)

The Hadron Experimental Hall, which is one of two facilities at the Main Ring, will provide beams of secondary particles produced by the protons. These beams will be the most intense secondary-particle beams at this energy and should facilitate several different experiments, including precise measurements of CP violation in K mesons and studies of the collective motions of strange quarks in hypernuclei. To make an abundance of secondary particles available from the primary proton beam has required the development of various methods for handling the high-intensity primary beam. This has required the construction of a dense radiation shield and magnets for the high-radiation area that are rugged enough and easily replaceable if problems arise.

Neutron and muon beams are already available in the Material and Life Science Facility at J-PARC. With the success of the Hadron Experimental Hall, an important goal is to send high-power neutrino beams to the Super-Kamiokande neutrino detector, 295 km away (*CERN Courier* July/August 2008 p19).

NUCLEAR PHYSICS

MSU will host new rare-isotope facility…

The US Department of Energy (DOE) has selected Michigan State University (MSU) to design and establish the Facility for Rare Isotope Beams (FRIB), a new research facility to advance the understanding of rare nuclear isotopes and nuclear astrophysics. It should take about a decade to design and build at an estimated cost of $550 million. FRIB will serve an international community of around 1000 researchers. MSU currently hosts the National Superconducting Cyclotron Laboratory (NSCL). Its director, Konrad Gelbke, will lead the team to establish the FRIB on the MSU campus.

The joint DOE–National Science Foundation Nuclear Science Advisory Committee (NSAC) first recommended as a high priority the development of a next-generation nuclear structure and astrophysics facility in its 1996 Long Range Plan. Since then, the FRIB concept has undergone numerous studies and assessments within DOE and by independent parties such as the National Research Council of the National Academy of Sciences. These studies – in addition to NSAC's 2007 Long Range Plan – concluded that such a facility is a vital part of the US nuclear-science portfolio. It complements existing and planned international efforts, providing capabilities unmatched elsewhere.

The DOE issued a Funding Opportunity Announcement (FOA) on 20 May 2008 to solicit applications for the conceptual design and establishment of the FRIB, to enable fair and open competition between universities and national laboratories. The proposals received were subject to a merit-review process conducted by a panel of experts from universities, national laboratories and federal agencies. The appraisal included rigorous evaluation of the proposals based on the merit review criteria described in the FOA, presentations by the applicants and visits by the merit review-panel to each applicant's proposed site.

● For further information, see www.sc.doe.gov/np/program/FRIB.html.

…and projects to upgrade the NSCL make excellent progress

Despite the winter weather, including more than 50 cm of snow in December, construction continued on the new office wing and the new experimental area for research with stopped and reaccelerated rare isotope beams at the NSCL at MSU. Construction milestones achieved by the end of 2008 included: completing the steelwork for the new experimental area; tearing down one of the original wings of the NSCL building to make space for the new offices; completing the office foundations and underground utilities; and drilling the well for the lift shaft. Work continues on the steel superstructure for the new office block and on masonry for the new experimental area, which is scheduled to be enclosed in February.

Work on the steel structure of the new offices at NSCL started on 15 December 2008. (Courtesy NSCL.)

Indoors, meanwhile, faculty and staff at the NSCL are making strides towards implementing new research capabilities related to a new accelerated beam facility, ReA3. This upgrade, which includes a new linear accelerator and a new experimental area, is funded by MSU and should begin commissioning in early 2010.

ReA3 will provide unique low-energy, rare-isotope beams, which will be produced by stopping fast, separated rare isotopes in a gas-stopper and then reaccelerating them in a linear accelerator. It will make available reaccelerated beams of elements that are typically difficult to produce at facilities based on isotope separation on-line. Among the science opportunities that ReA3 will open is the possibility of measuring a remaining set of nuclear-reaction rates that are necessary for accurate models of nova nucleosynthesis and studying how exotic nuclei with large neutron halos interact at large intranuclear distances.

The balcony that will hold ReA3 and the electron-beam ion trap (EBIT) for charge breeding is complete and ready for devices to be mounted. Development continues on the various components to stop, transport, charge-breed and reaccelerate rare isotopes. These components include the linear gas stopper; the low-energy beamline system from the gas stopper to the EBIT and to the new stopped-beam area; the EBIT charge breeder and mass separator; and the linac.

● For more information, visit www.nscl.msu.edu/ourlab/news/2008/underconstruction.

COSMIC RAYS

MINOS maps the deepest secrets of the upper atmosphere

The MINOS Far Detector is helping to study the weather. (Courtesy Fermilab Visual Media Services.)

A collaborative study by particle physicists and atmospheric researchers has found the first correlations between daily variations in cosmic-ray muons detected deep below ground and large-scale phenomena in the upper atmosphere. The effect suggests that underground muon-detectors could play a valuable role in identifying certain meteorological events and observing long-term trends.

Scott Osprey and colleagues from the UK's National Centre for Atmospheric Science and Oxford University have worked with members of the Main Injector Neutrino Oscillation Search (MINOS) collaboration in analysing data collected between 2003 and 2007 by the MINOS Far Detector, located 705 m below ground in a disused iron mine at Soudan, in Minnesota. The MINOS experiment intercepts a neutrino beam that goes 725 km from Fermilab to Soudan and studies long-baseline neutrino oscillations; the penetrating muons appear as background noise.

The teams have found a close relationship between the rate of muons detected in MINOS and upper-air temperatures from the European Centre for Medium Range Weather Forecasts. In particular, they discovered strong correlations between the muon rate and the upper-air temperature during short-term events (of around 10 days) in the upper atmosphere, or stratosphere, in winter.

When primary comic rays strike the Earth's atmosphere they interact, creating pions and kaons. These mesons in turn decay to produce muons – the most energetic of which penetrate deep below the Earth's surface. The mesons can also interact before they decay, so the number of muons produced depends on the local density of the atmosphere and varies with temperature. An increase in temperature means a decrease in density and, hence, fewer mesons interact and instead decay, increasing the number of muons. Physicists have known of this effect since the Monopole Astrophysics and Cosmic Ray Observatory first observed a seasonal variation in the rate of muons a decade ago (Ambrosio *et al.* 1997).

Most of the mesons that give rise to the muons detected in MINOS occur at altitudes of around 15 km in the region known as the tropopause, where there is little variation in temperature. However, the mesons also occur in the mid-stratosphere – at altitudes where temperatures fluctuate, particularly in winter. For the analysis, the team defined an "effective" temperature based on an average temperature over the altitudes where mesons occur, weighted by the calculated distribution of meson production.

The results show a striking relationship between this temperature and the number of muons, with correlated changes occurring over periods of only a few days (Osprey *et al.* 2009). The data for the Northern Hemisphere winter of 2004–2005 are particularly interesting. The meteorological data indicate the occurrence of a major phenomenon, known as a sudden stratospheric warming, during February. This was linked to break-up of the winter polar vortex, a polar cyclone that brings cooler weather and which extended over the MINOS site in early February. Prior to that, the 2004–2005 winter had seen the lowest recorded temperatures in the polar stratosphere, and ozone concentration in the polar vortex was anomalously low.

The results show that underground muon data contain information that could identify important short-term meteorological events, over and above the already known seasonal effect. This is interesting for atmospheric researchers, as it provides an independent technique to measure such phenomena. Moreover, physicists have cosmic-ray data from experiments dating back 50 years or more, covering periods when upper-air observations from weather balloons were less reliable than today.

Further reading

S Osprey *et al.* 2009 *Geophys. Res. Lett*. in press.

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

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

Looking for a durable relationship?

Ceramic ball bearings you can rely on for a lifetime.

Our proven ceramic ball bearing technique provides extreme durability under a wide range of operating conditions. Fitting with lifetime lubricated ceramic ball bearings is part of the extensive recital of advantages found in our new turbomolecular pump generation, the TURBOVAC SL. These turbomolecular pumps with mechanical rotor suspension and compound stage excel through a new compact design, improved vacuum performance and a standardized accessories program. In addition, the pumps can be mounted in virtually any position and at any angle. The turbomolecular pumps from the TURBOVAC SL product family have been designed to handle the most advanced and demanding applications and requirements in research and industry.

Get the details at vacuumdetails.oerlikon.com

Oerlikon Leybold Vacuum GmbH
Bonner Strasse 498
D-50968 Köln
T +49 (0)221 347-0
F +49 (0)221 347-1250
info.vacuum@oerlikon.com
www.oerlikon.com/leyboldvacuum

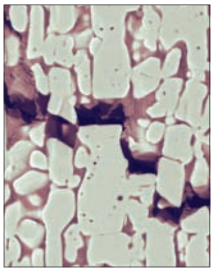
oerlikon
leybold vacuum

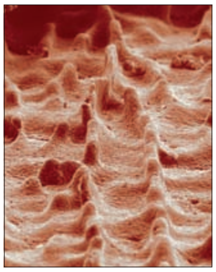
Compiled by John Swain, Northeastern University

Nature inspires tough ceramic

Substances such as bone and shell are strong hybrid materials with many lessons to offer. Taking hints from mother-of-pearl (also known as nacre) Robert Ritchie and colleagues at the Lawrence Berkeley National Laboratory (LBNL) and the University of California, Berkeley, have been making their own versions with dramatic results. This shows, once again, how thousands of millions of years of trial and error on planet Earth gave rise to some good ideas.

Nacre is made of layers of calcium carbonate glued together with a biopolymer such as chitin. The Berkeley team worked with aluminium oxide instead of calcium carbonate, carefully using ice templates to control how the layers grew. They then pressed and sintered what they made and filled in the gaps with polymethyl methacrylate (PMMA) instead of a biopolymer. The result is a highly crack-resistant material that is 300 times as strong (in terms of the energy required to break it) than either of its components. The hybrid is as strong as aluminium, but stiffer, harder and more resistant to abrasion.





Left: in the "brick and mortar" phase of the alumina/PMMA hybrid ceramic, "bricks" of aragonite (calcium carbonate) slide past each other to dissipate strain energy, while the polymer "mortar" acts as a lubricant. Right: the roughness of the new ceramic controls the strength of the interfaces, which is critical in determining the material's overall toughness as it affects sliding in the "mortar" layers. (Courtesy R Ritchie, LBNL.)

Further reading

E Munch *et al.* 2008 *Science* **322** 1516.

Falling objects create water jets

While high-energy physicists will soon be able to study jets at the LHC, Stephan Gekle and colleagues at the universities of Twente and Seville are making headway in understanding a different kind of jet – the kind that jumps up from water when an object is dropped into it. The basic mechanism involved is the collapse of an air cavity carved out in the water by the object as it falls, pushing the water out and up as the cavity itself fills.

The collapse is driven by "inertial focusing" – the concentration of energy as the cavity collapses under pressure from the sides – and surface tension, which also tends to collapse the cavity. By combining theory, experiment and simulation the team developed a near complete description of the process. As the cavity fills with water and also collapses, the water is squirted out of the top – like toothpaste from a tube when squeezed; the effect of surface tension is negligible.

Further reading

S Gekle *et al.* 2009 *Phys. Rev. Lett.* **102** 034502.

Electronic circuit reveals Lamb shift

Quantum fluctuations lead to shifts in energy levels that go under the general name of "Lamb shifts". While these are usually seen in atomic systems, Andreas Wallraff and colleagues at ETH Zurich and Sherbrooke University in Quebec have made an electronic circuit in which the effect can be seen.

A superconducting circuit acting as a qubit (a two-state "artificial atom"), coupled to the vacuum in a transmission-line resonator, undergoes a shift of as much as 1.4% in its transition frequency owing to fluctuations in the quantum vacuum. Engineers may soon have to learn quantum field theory.

Further reading

A Fragner *et al.* 2008 *Science* **322** 1357.

Giant amoebae suggest new origins

Trace fossils – those of tracks left by creatures long ago – are important in calculating when animals first appeared. Mikhail Matz of the University of Texas at Austin and colleagues argue that *Myxomitodes*, a trace fossil nearly two thousand million years old that has been attributed to some sort of early multicellular animal, could actually be from a giant amoeba. As evidence for their case, Matz and co-workers have observed giant, single-celled shelled amoebae of the species *Gromia sphaerica* moving round the ocean floor. The amoebae, which can be up to 3 cm across, leave grooves that bear an uncanny resemblance to the trace fossils and so may force a reinterpretation of their origin.

Further reading

M V Matz *et al.* 2008 *Current Biology* **18** 1849.

Zero-point vibrations are important in liquids

Zero-point oscillations are well known to every physicist, but there are relatively few places where they have significant effects. Larry Ford of Tufts University in Massachusetts and Nami Svaiter of the Centro Brasileiro de Pesquisas Fisicas in Rio de Janeiro have found that the scattering cross-section from zero-point fluctuations in classical liquids rises as the fifth power of frequency, and for some cold liquids it can be a significant part of the scattering in the optical region. For liquid neon the zero-point scattering would be about 13% and would be a significant part of the optical blurring from density fluctuations that would be seen on looking through the liquid. The work is particularly interesting as it probes similar physics to that in the Casimir effect, but deals with a local quantity rather than a global one.

Further reading

L Ford and N F Svaiter 2009 *Phys. Rev. Lett.* **102** 030602.

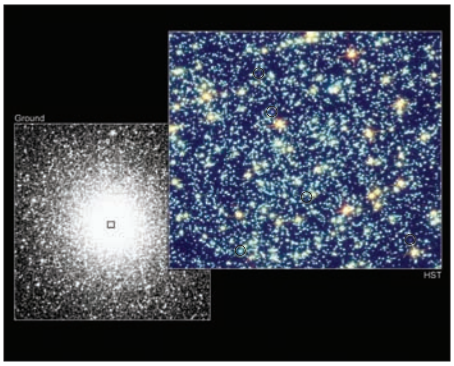
Compiled by Marc Türler, ISDC and Observatory of Geneva University

The primary mechanism of blue stragglers is stellar cannibalism

The long-standing mystery of the origin of blue stragglers in globular clusters has been solved. Researchers have found that these overweight stars do not result primarily from collisions between stars but from stellar "cannibalism" in binary star systems where plasma is gradually pulled from one star to the other to form a more massive, bluer star.

A globular cluster is a spherical body composed of about 100 000 stars tightly bound by mutual gravity (*CERN Courier* July/August 2006 p10). Several tens of these clusters orbit our galaxy. They are usually composed of old stars all born at the same time in a giant star-formation region (*CERN Courier* June 2006 p14). In an old cluster, the most massive stars should have exhausted their hydrogen fuel a long time ago and should have died in supernova explosions. Only low-mass stars, shining redder light, should remain. However, globular clusters do contain several stars that are much too blue and too massive to have survived until now.

The origin of these "blue stragglers" that still fight for life has been a puzzle of stellar evolution for 55 years. As normal stellar formation cannot continue in globular clusters, owing to the quasi-absence of gas, there must be a different mechanism in their dense central cores that can continuously form massive stars. Two main theories emerged over time: that blue stragglers were created through collisions of two stars; or that one star in a binary system was "reborn" by pulling matter off its companion.



The globular cluster 47 Tucanae (left) and its central core (right) imaged by the Hubble Space Telescope revealing several blue stragglers highlighted by yellow circles. (Courtesy NASA Goddard Space Flight Center (NASA–GSFC.)

The new research by Christian Knigge from the University of Southampton, in the UK, and colleagues from McMaster University, in Canada, allows them to favour one of these scenarios. They compared the observed number of blue stragglers in 56 globular clusters with the predicted single–single stellar-collision rate based on the inner density of the clusters. They found no clear correlation, dispelling the theory that blue stragglers are created through collisions with other stars. On the other hand, they did find a strong relationship between the total mass contained in the core of the globular cluster and the number of blue stragglers observed within it. Because more massive cores also contain more binary stars, they inferred a connection between blue stragglers and binaries in globular clusters (Knigge *et al.* 2009).

This research provides strong evidence that the primary mechanism for the formation of blue stragglers is "stellar cannibalism" by the most massive star in a binary system as it pulls material from its lighter companion. What remains to be investigated is whether the binary parents of blue stragglers evolve mostly in isolation, or whether close encounters – failed collisions – with other stars in the cluster are required to form these binaries.

Further reading

C Knigge *et al.* 2009 *Nature* **457** 288.

Picture of the month

This colour composite image of Centaurus A reveals the powerful jets ejected by the supermassive black hole at the heart of the galaxy. The image is composed of submillimetre data shown in orange, an X-ray view from the Chandra satellite shown in blue and a true colour image from the 2.2 m telescope of the European Southern Observatory at La Silla, Chile. At a distance of 13 million light-years, Centaurus A is the closest giant elliptical galaxy to Earth. The violent central activity is hidden behind a dust lane, but is betrayed by the extended jets ending in radio lobes imaged for the first time in the submillimetre (870 μm) by a camera mounted on the Atacama Pathfinder Experiment (APEX). This 12 m dish is a prototype antenna for the Atacama Large Millimetre/submillimetre Array being assembled on the 5000 m high plateau of Chajnantor, Chile. (Courtesy ESO/WFI (Optical); MPIfR/ESO/APEX/A Weiss *et al.* (Submillimetre); NASA/CXC/CfA/R Kraft *et al.* (X-ray).)

CERN COURIER ARCHIVE: 1966

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

CERN

First wire spark chamber at the PS

The first wire spark chamber to be used in an experiment at the PS was installed on the b8 beam line at the end of December. The experiment, by a group led by M Vivargent, R Mermod and K Winter, is one of the investigations into CP violation. It is concerned with the "interference" between the decay amplitudes of K_1^0 mesons, regenerated in a block of carbon, and K_2^0 mesons. The theoretical description involves a phase term which is the sum of a "nucleon phase shift" (introduced by the regenerator) and a "CP violation phase shift" (the main item of information wanted from the experiment).

Data have already been taken on the decay into two pions, which involves CP violation. In June, it is intended to look at the leptonic decay (into pion, muon and neutrino), which only involves the nucleon phase shift. Thus the two different phase shifts can be determined.

The first wire spark chamber installed in a PS experiment, with scintillation counters behind.

The wire spark chamber is part of the equipment that differentiates pions and muons. Optical spark chambers and a magnet define the direction of a charged particle approaching the wire chamber. Between this system and the chamber is a block of iron. A muon will pass through and emerge travelling in virtually the same direction. A pion, however, interacts strongly and can suffer a major deviation. The wire chamber records the position of the particle passing through it, making it possible to distinguish pions from muons.

A conventional spark chamber could be used, but it was decided to gain some experience in the operation of a wire chamber. This recent development in particle-detection technology holds considerable promise for the future. Its great advantage is that it can detect and record the passage of several charged particles at once and provide the required data directly in electronic form. Work on wire chambers of this particular type [using magnetostrictive read-out] was initiated at CERN by G Brautti and development of the chamber and the electronics for the PS experiment was done by M Bott-Bodenhausen and B Friend.

● Compiled from *CERN News* on pp43–44.

Health Physics

There are radiation sources of all kinds on the site. Some are classical, such as the radioactive isotopes used to calibrate detectors, and induced activity created during operation of the accelerators.

Then there is the radiation that comes directly from the machines when they are operating, through the shielding or from the experimental areas where there are secondary beams or extracted proton beams. The nature and energy distribution of this radiation varies from place to place and with the mode of operation of the accelerators. Moreover, the types and the energy of radiation encountered are found only at high-energy accelerators.

To estimate the radiation hazard, the radiation level must be measured. For classical radiation, instruments and techniques known for a long time are used (ionization chambers for on the spot measurements and Geiger-Muller, proportional, or scintillation counters for measuring samples, dust etc). But, since the radiation produced when the accelerators are working is complex and of very high energy,

One of the four permanent radiation-monitoring stations installed on site.

it has proved necessary to develop new methods and instruments.

Over large areas of the site, when the accelerators are operating, it has been found that the radioactivity is not high enough to require special precautions, apart from constant monitoring by means of fixed stations. These have been suitably placed also to monitor the radiation level outside the CERN site, to ensure that the limit fixed by Swiss Federal law (5 rem/30 years for the population as a whole) is not exceeded.

● Compiled from the article on pp45–49.

COMPILER'S NOTE

The 1992 Nobel Prize in Physics was awarded to Georges Charpak "for his invention and development of particle detectors, in particular the multiwire proportional chamber", work done essentially during the 1960s – boom years for detector development (p24). Transistors, integrated circuits and fast, miniaturized component assemblies had liberated detector technology from cumbersome optical recording methods and allowed experimental physicists to go for gold... well...silicon. Innovative detector types and data-collection techniques appeared at an impressive rate, exploiting anything that the electronics industry could provide.

But a hymn less commonly sung is to the allied development of radiation monitoring devices. As accelerators became more exotic so did the attendant problems of radiation detection. For well over half a century our health physicists have met each new challenge – however demanding – in an on-going effort to keep us safe, politically as well as physically.

Upgrade to the Next Generation of High-Performance PCI Express Embedded Systems

IOxOS Technologies launches a comprehensive family of PCI Express based products, including fully featured boards (VME/PXI/VXI/PCIe), an FPGA Design Kit, dedicated IP core libraries and full design support

PCI EXPRESS · VMEbus Technology · MEMBER VITA Open Standards, Open Markets

TOSCA FPGA Design Kit Highlights

- PCI Express GEN1/GEN2 centric
- Network On Chip (NoC) architecture
- Xilinx Virtex-5T, Virtex-6 and Spartan-6
- VHDL sources code fully available
- Full support provided for HW, FW & SW
- Drastic reduction of FPGA development time

PEV 1100 Features

- VME 6U Transparent PCI Express to VME64X
- VME Master/Slave with Slot_1 function
- Full 2eVME and 2eSST support
- PCI Express External Cabling (Spec 1.0)
- Low latency transactions
- Embedded multi-channel chained DMA
- On-board shared memory up to 1024 Mbytes
- FPGA user's area for custom application
- Optical extension up to 100 meters
- Built on Xilinx Virtex-5T FPGA
- Two PMC IEEE 1386.1 / XMC VITA 42.3 sites
- VXI C-Size version available
- API & Libraries available for Linux and Windows

IOxOS TECHNOLOGIES
RELIABILITY BY DESIGN

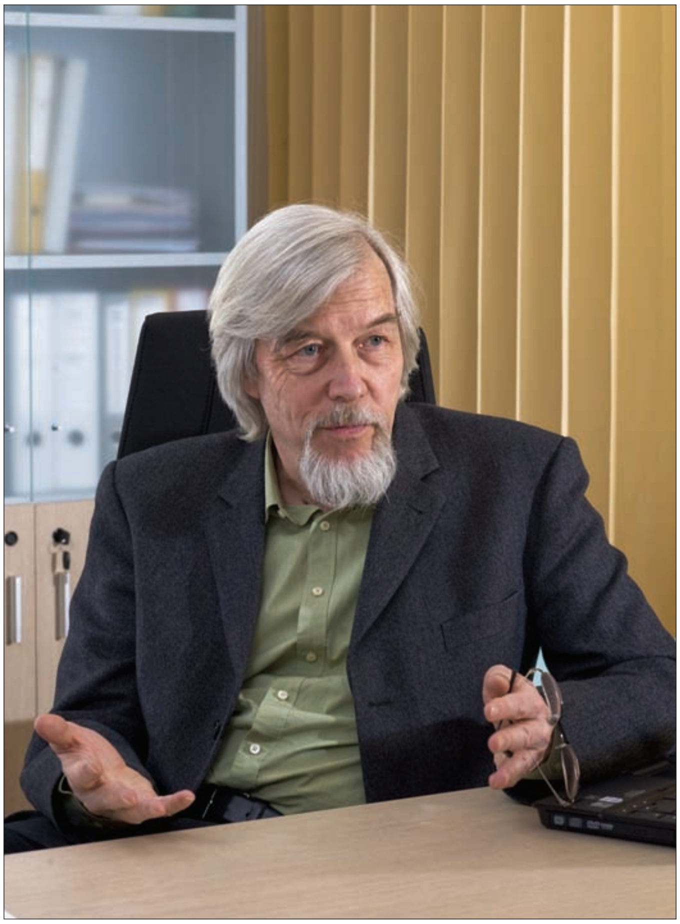
CH-1196 Gland - Switzerland
www.ioxos.ch - info@ioxos-ch
Tel : +41-223647690

CERN sets course for new horizons

On 1 January Rolf-Dieter Heuer took over as director-general of CERN. While he sees physics from the LHC as the immediate top priority, he also has an ambitious and more long-term vision for the organization's place at the centre of particle physics worldwide.

Rolf-Dieter Heuer is no stranger to CERN. He first joined the laboratory's staff in 1984 to work on the OPAL experiment at LEP. Nor is he a stranger to top-level management in particle physics. Having been spokesman of the 330-strong OPAL collaboration from 1994, he took up a professorship at the University of Hamburg in 1998 and became research director for particle physics and astrophysics at DESY in 2004. For the past 10 years he has steered DESY's participation in projects such as the LHC and a future international linear collider. He has also fostered the restructuring of German particle physics at the high-energy frontier. Now he faces new challenges and new opportunities as he takes over the reins at one of the world's largest scientific research centres.

As Heuer begins his five-year mandate as CERN's director-general the first goal is clear: to see LHC physics in 2009. The immediate priority is to repair the machine following the damaging incident that occurred soon after the successful start-up last September. Heuer recalls how smoothly the machine operators established beam on 10 September, with the experiments timing in on the same day (*CERN Courier* November 2008 p26). "This was a big success," he asserts. "When you look back to LEP, it's amazing how fast it went." For Heuer, the start up demonstrated not only that the LHC works, but that it works well. "The LHC as a project is now completed," he adds. In his view, the repairs underway are part of the continuing commissioning process and he has full confidence in the team to have the LHC operating again as expected later this year.



In his role as director-general, Heuer looks forward to the many challenges of steering CERN into the era of LHC physics.

A machine for the world

Longer term, Heuer's vision for CERN stretches to horizons beyond the LHC, not just in time but also in terms of the broader particle-physics arena. This wider view includes several aspects with a common underlying theme of communication, from external relations with other high-energy physics laboratories to the transfer of technology and knowledge to society. One of his first acts as director-designate was to propose a management structure that includes a highly visible external relations office. This is to be a conduit for communication with laboratories and institutes not only in CERN's 20 member states but also in the other nations with which the organization has relations at one level or another.

Another way in which CERN reaches beyond its boundaries as a centre for particle physics is through knowledge and technology transfer (KTT). Here Heuer believes that there should be more emphasis on knowledge, which he feels has not been sufficiently exploited in the past. He stresses that the goal should not ▷

primarily be potential funding, but to make a big impact on global society. "It's great to have additional funding, but that should be secondary. It's not funding that should drive KTT" he says.

However, Heuer's most ambitious – and perhaps contentious – goals are arguably his aspirations for CERN positioned as a laboratory for the world. In some respects that process has already begun. "We are about to enter the terascale in particle physics," he says. "The LHC will be the world machine for many years."

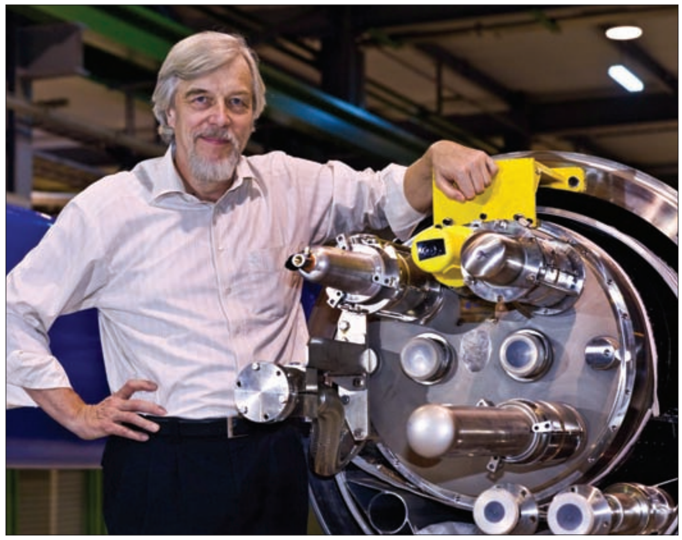
A first priority will be to strengthen CERN's intellectual contribution, so that it has a role beyond that of a service laboratory. "CERN has to provide a service," Heuer explains. "But to provide the best results we need the best people and therefore there needs to be an intellectual challenge." A first step will be to create a new centre at CERN for the analysis and interpretation of LHC data. The idea is to create close contact between staff and users, between experiment and theory. "It should be a focal point in addition to other centres," says Heuer. In particular, he envisages "a centre that fosters open discussion between theorists and experimenters, where people can discuss and perhaps develop common tools". He acknowledges that it will be a challenge, but as he says: "I want to challenge people."

A global view

Out on the broader world stage, Heuer hopes to influence the current panorama in particle physics. He believes that it is important to combine the strengths of the particle-physics laboratories around the world and to co-ordinate the various programmes. In general, "we need breadth with coherence", he says. Starting at home, there are plans for a workshop on "New Opportunities in the Physics Landscape at CERN" in May to look at the future for fixed-target experiments at the CERN.

In this context, breadth also means to venture beyond the conventional boundaries of particle physics, particularly to overlaps with astroparticle physics and nuclear physics, where there are common aspects of experimental methods and theoretical ideas. "We need a closer dialogue with other communities," he explains. "We should not separate fields too much. There are differences but we should emphasize the commonalities and aim for a 'win–win' scenario."

Co-operation and collaboration are key words in Heuer's view. "High-energy physics facilities are becoming larger and more expensive," he points out, "and, to state it positively, funding is not increasing." However, long-term stability in funding is going to be a necessary condition for the future survival of the field. "We need new approaches from funding agencies," he says, "which look beyond national and regional boundaries." One step could be for funding agencies to meet on a more global basis. Here the CERN Council provides a model that these agencies are already studying for, as Heuer notes, "it seems to work".



Because of the LHC, CERN is about to enter the terascale in particle physics – interesting times for the new director-general.

More generally, keeping particle physics and CERN on track for a fulfilling future will no doubt require an organizational form that has yet to be defined. "We need to be open and inventive," says Heuer. "A key word is partnership." He argues that it will be crucial to retain excellent national and regional projects in addition to global initiatives to maintain expertise world wide; for example, he believes that it is essential to have accelerator laboratories in all regions.

"May you live in interesting times" is a supposedly a curse, but taken at face value it could also be a blessing. CERN, and Heuer as director-general, are certainly experiencing interesting times. The hope at CERN and in the wider particle-physics community must be that the future is not only interesting but global and bright.

Resume

Les nouveaux horizons du CERN

Rolf Heuer, qui entame son mandat de cinq ans en tant que directeur-général du CERN, a un objectif prioritaire : des résultats de physique au LHC en 2009. À plus long terme, ses perspectives pour le CERN vont au-delà du LHC, du point de vue temporel comme de la physique. Ses conceptions pour l'avenir, qui tendent toutes à intensifier la communication, concernent notamment les relations avec d'autres laboratoires de physique des hautes énergies et le transfert à la société de la technologie et du savoir. Sur la scène mondiale, Rolf Heuer estime qu'il est important de conjuguer les forces des laboratoires de physique des particules de la planète et de coordonner les divers programmes.

Christine Sutton, *CERN.*

Conference probes the dark side of the universe

An international meeting in Munich brought researchers together to investigate the role of dark energy in the accelerated expansion of the universe. **Georg Wolschin** reports.

During the past decade a consistent quantitative picture of the universe has emerged from a range of observations that include the microwave background, distant supernovae and the large-scale distribution of galaxies. In this "standard model" of the universe, normal baryonic matter contributes only 4.6% to the overall density; the remainder consists of dark components in the form of dark matter (23%) and dark energy (72%). The existence and dominance of dark energy is particularly unexpected and raises fundamental questions about the foundations of modern physics. Is dark energy merely Albert Einstein's cosmological constant? Is it a new kind of field that evolves dynamically as the universe expands? Or is a new law of gravity needed?

In the search for answers to these questions, more than 250 participants, ranging from senior experts to young students, attended the 3rd Biennial Leopoldina Conference on Dark Energy held on 7–11 October 2008 at the Ludwig Maximilians University (LMU) in Munich. The meeting was organized jointly by the Bonn-Heidelberg-Munich Transregional Research Centre "The Dark Universe" and the German Academy of Sciences Leopoldina, with support from the Munich-based Excellence Cluster "Origin and Structure of the Universe". The goal of the international symposium was to gain a better understanding of the nature of dark energy by bringing together observers, modellers and theoreticians from particle physics, astrophysics and cosmology to present and discuss their latest results and to explore possible future routes in the rapidly expanding field of dark-energy research.

Around 60 plenary talks at the conference were held in the central auditorium (Aula) of LMU Munich, with lively discussions following in poster sessions (where almost 100 posters were displayed) and during the breaks in the inner court of the university. There were fruitful exchanges between physicists engaged in a range of observations, from ground-based studies of supernovae to satellite probes of the cosmic microwave background (CMB), and theorists in search of possible explanations for the accelerated expansion of the universe, which was first reported in 1998. This acceleration has occurred in recent cosmic history, corresponding to redshifts of about $z \leq 1$.

An accelerating expansion

Brian Schmidt of the Australian National University in Canberra gave the observational keynote speech. He led the High-z Supernova Search Team that presented the first convincing evidence for the existence of dark energy – which works against gravity to boost the expansion of the universe – almost simultaneously with the

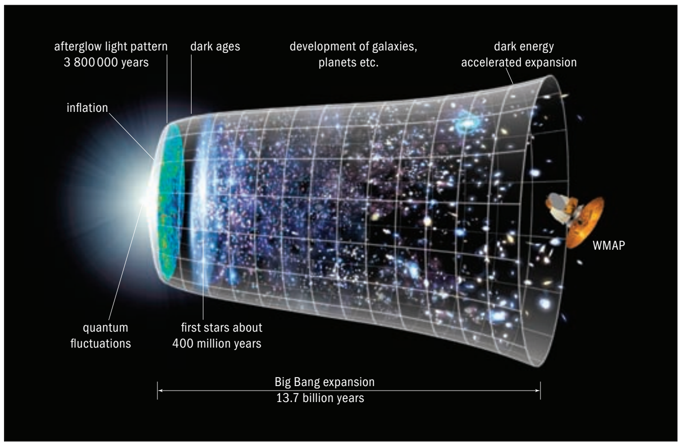


Fig. 1. An illustration of the time evolution of the universe, starting with the Big Bang. (Courtesy NASA/WMAP Science Team.)

Supernova Cosmology Project led by Saul Perlmutter of the Lawrence Berkeley National Laboratory and the University of California at Berkeley. Adam Riess, a member of the High-z team, presented constraints on dark energy from the latest supernovae data, including those from the Hubble Space Telescope at redshift $z > 1$. This is where the acceleration becomes a deceleration, owing to the lessening impact of dark energy at earlier times (figure 1).

Both teams independently discovered the accelerating expansion of the universe by studying distant type Ia supernovae. They found that the light from these events is fainter than expected for a given expansion velocity, indicating that the supernovae are farther away than predicted (figure 2, p18). This implies that the expansion is not slowing under the influence of gravity – as might be expected – but is instead accelerating because of some uniformly distributed, gravitationally repulsive substance accounting for more than 70% of the mass-energy content of the universe – now known as dark energy.

Type Ia supernovae arise from runaway thermonuclear explosions following accretion on a carbon/oxygen white dwarf star and after calibration have an almost uniform brightness. This makes them "standard candles", suitable as tools for the precise measurement of astronomical distances. Wolfgang Hillebrandt of the Munich Max-Planck Institute for Astrophysics presented 3D simulations of type Ia supernova explosions. It is still a matter of debate how standard these so-called "standard candles" really are. Their colour–luminosity relationship is inconsistent with Milky Way-type ▷

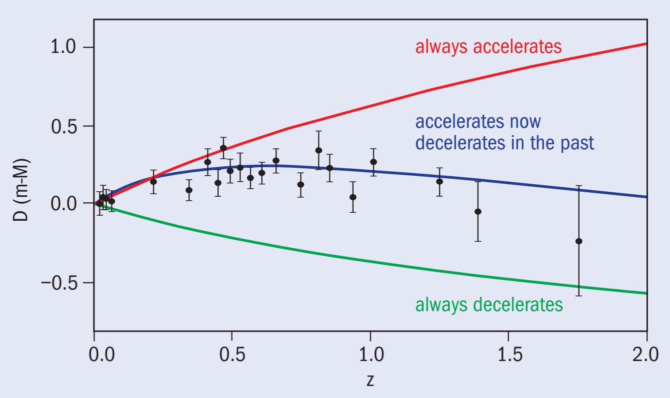


Fig. 2. Expansion of the universe as indicated by luminosity data from type Ia supernovae as a function of redshift, z (A Riess et al.*). (Courtesy Michael Turner, conference summary; Turner and Huterer 2007.)*

dust and, as Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics mentioned, the role of dust is generally underestimated. Future supernova observations in the near infrared hold promise because, at these wavelengths, the extinction by dust is five times lower. Bruno Leibundgut of ESO said that infrared observations using the future James Webb Space Telescope will be crucial in solving the problem of reddening from dust.

As Schmidt pointed out, and others detailed in subsequent talks, measurements of the temperature fluctuations in the CMB provide independent support for the theory of an accelerating universe. These were first observed by the Cosmic Background Explorer in 1991 and subsequently in 2000 by the Boomerang and MAXIMA balloon experiments. Since 2003 the Wilkinson Microwave Anisotropy Probe (WMAP) has observed the full-sky CMB with high resolution. Additional evidence came from the Sloan Digital Sky Survey and 2-degree Field Survey. In 2005 they measured ripples in the distribution of galaxies that were imprinted in acoustic oscillations of the plasma when matter and radiation decoupled as protons and electrons combined to form hydrogen atoms, 380 000 years after the Big Bang. These are the “baryonic acoustic oscillations” (BAOs).

Dark-energy candidates

Eiichiro Komatsu of the Department of Astronomy at the University of Texas in Austin, lead author of WMAP’s paper on the cosmological interpretation of the five-year data, said that anything that can explain the observed luminosity distances of type Ia supernovae, as well as the angular-diameter distances in the CMB and BAO data, is “qualified for being called dark energy” (figure 3). Candidates include energy, modified gravity and an extreme inhomogeneity of space.

Although the latter approach was presented in several talks, the impression prevailed that the effects of dark energy are too large to be accounted for through spatial inhomogeneities and an accordingly adapted averaging procedure in general relativity. Komatsu – and many other speakers – clearly favours the Lambda-cold-dark-matter (ΛCDM) model, with a small cosmological constant Λ to account for the accelerated expansion. The dark-energy equation of state is usually taken to be $w = p/\rho = -0.94 \pm 0.1(\text{stat.}) \pm 0.1$ (syst.) with a negative pressure, p; a varying w is not currently favoured by the data. Several speakers presented various versions of modified gravity. Roy Maartens of the University of Portsmouth in the UK

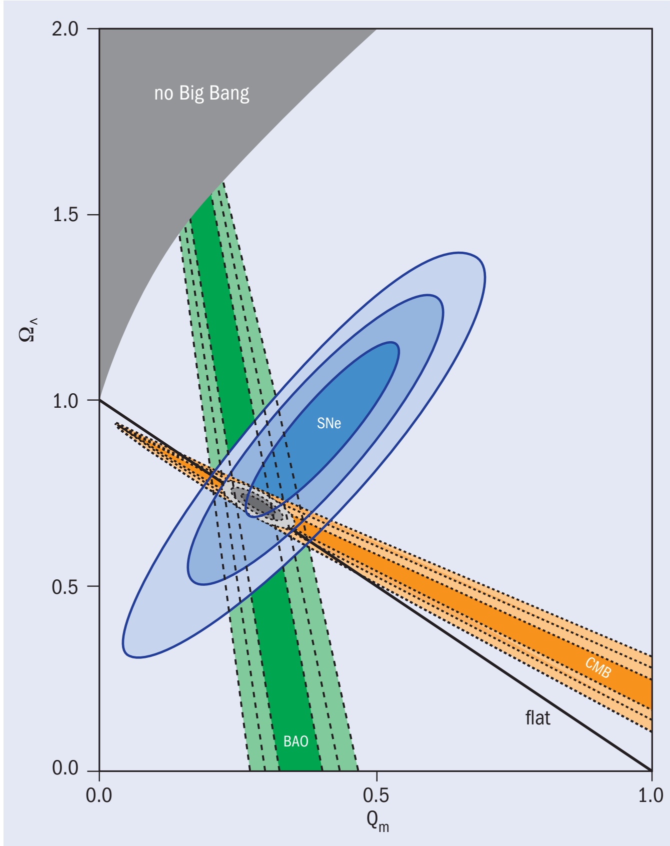
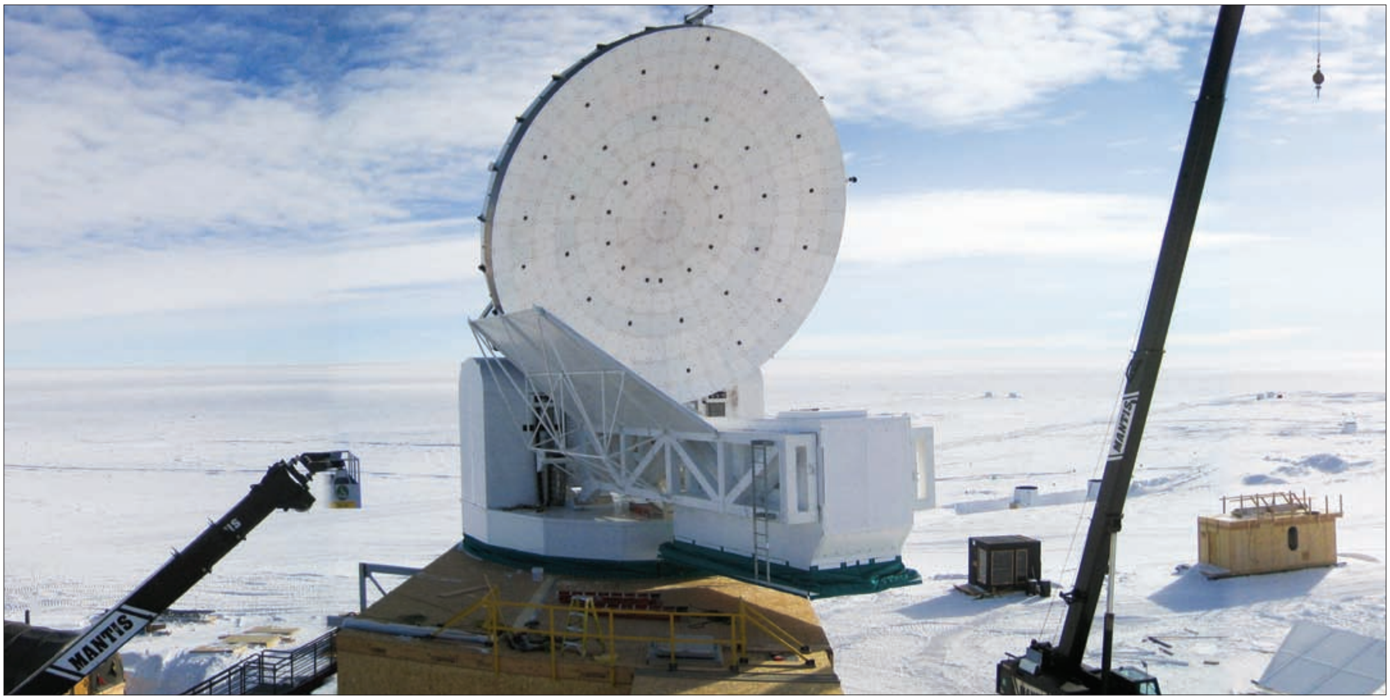


Fig. 3. Evidence for dark energy from observations of type Ia supernovae (SNe), fluctuations of the cosmic microwave background radiation (CMB) and baryonic acoustic oscillations (BAO). (Courtesy Michael Turner, conference summary; Kowalski et al. *2008.)*

acknowledged that ΛCDM is currently the best model. As an alternative he presented a braneworld scenario in which the vacuum energy does not gravitate and the acceleration arises from 5D effects. This scenario is, however, challenged by both geometric and structure-formation data.

Theoretical keynote-speaker Christof Wetterich of Heidelberg University emphasized that the physical origin, the smallness and the present-day importance of the cosmological constant are poorly understood. In 1988, almost simultaneously with but independently from Bharat Ratra and James Peebles, he proposed the existence of a time-dependent scalar field, which gives rise to the concept of a dynamical dark energy and time-dependent fundamental “constants”, such as the fine-structure constant. Although observations may eventually decide between dynamical or static dark energy, this is not yet possible from the available data.

Yet another indication for the accelerated expansion comes from the investigation of the weak-lensing effect, as Matthias Bartelmann of Heidelberg University and others explained. This method of placing constraints on dark energy through its effect on the growth of structure in the universe relies on coherent distortions in the shapes of background galaxies by foreground mass structures, which include dark matter. The NASA-DOE Joint Dark Energy Mission (JDEM) is a space probe that will make use of this effect, in addition to taking BAO observations and distance and redshift measurements of more than 2000 type Ia supernovae a year. The project is



The South Pole Telescope will allow independent tests for the existence and strength of dark energy. (Courtesy Bradford Benson.)

now in the conceptual-design phase and has a target launch date of 2016. ESA's corresponding project – the Dark UNiverse Explorer – is part of the planned Euclid mission, scheduled for launch in 2017. There were presentations on both missions.

The first major scientific results from the 10 m South Pole Telescope (SPT) initial survey were the highlight of the report by John Carlstrom, principal investigator for the project. The telescope is one of the first microwave telescopes that can take large-sky surveys with precision. It will be possible to use the resulting size-distribution pattern together with information from other telescopes to determine the strength of dark energy.

Carlstrom described the detection of four distant, massive clusters of galaxies in an initial analysis of SPT survey data – a first step towards a catalogue of thousands of galaxy clusters. The number of clusters as a function of time depends on the expansion rate, which leads back to dark energy. Three of the detected galaxy clusters were previously unknown systems. They are the first clusters detected in a Sunyaev–Zel'dovich (SZ) effect survey, and are the most significant SZ detections from a subset of the ongoing SPT survey. This shows that SZ surveys, and the SPT in particular, can be an effective means of finding galaxy clusters. The hope is for a catalogue of several thousand galaxy clusters in the southern sky by the end of 2011 – enough to rival the constraints on dark energy that are expected from the Euclid Mission and NASA's JDEM.

The conference was lively and social activities enabled discussions outside the conference auditorium, particularly during the lunch breaks in nearby Munich restaurants. The presentations and discussions all demonstrated that the search for definite signatures and possible sources of the accelerated expansion of the universe continues to flourish and has an exciting future ahead. The results on supernovae and the CMB have led the way, but there is still much to learn. In his conference summary, Michael Turner of the University of Chicago emphasized that "cosmology has entered an era with large quantities of high-quality data", and that the quest to understand dark energy will remain a grand scientific adventure. Future observational facilities – such as the Planck probe of the CMB, which is scheduled for launch around Easter 2009, the all-sky galaxy-cluster X-ray mission eROSITA, ESA's Euclid and NASA's JDEM – are all designed to produce unprecedented high-precision cosmology results that will shed new light on dark energy.

Further reading

M Kowalski *et al.* 2008 *Astrophysical Journal* **686** 749778.
M Turner and D Huterer 2007 *Journal of the Physical Society of Japan* **76** 111015.
For more information, see www.mpe.mpg.de/events/dark-energy-2008/.

Résumé

Une conférence sur la face cachée de l'Univers

La découverte de l'énergie noire de l'Univers, tout à fait inattendue, soulève des questions cruciales sur les fondements de la physique moderne. Est-ce simplement une constante cosmologique ? Un nouveau type de champ qui évolue de manière dynamique à mesure que se dilate l'Univers ? Ou une nouvelle loi de la gravitation est-elle nécessaire ? En quête de réponses, plus de 250 personnes ont participé à la 3e conférence biennale Leopoldina sur l'énergie noire en octobre 2008 à l'Université Ludwig Maximilian de Munich. Les exposés et les discussions ont prouvé que la passionnante recherche de signatures claires et d'origines envisageables pour l'accélération de l'expansion de l'univers reste féconde.

Georg Wolschin, *University of Heidelberg.*

The light-pulse horizon

Rapid advances in high-intensity laser technology are closing in on the technological breakthrough of a compact particle accelerator, and with it a new means to study the structure of the vacuum. **Gérard Mourou**, **Johann Rafelski** and **Toshiki Tajima** explain.

"According to the general theory of relativity, space without aether is unthinkable; for in such space there (not only) would be no propagation of light ... But this aether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time."
Albert Einstein, 1920.

Aether, the pure air breathed by gods, is not much in fashion in laboratories today. Physicists speak instead of the vacuum, in the context of quantum physics, and quantum vacuum fluctuations that fill space that is free from real matter. How light slips through these fluctuations was first studied in the 1930s by Werner Heisenberg, H Euler, W Kockel and Victor Weisskopf, and later by Julian Schwinger. Their work revealed the first "effective" interaction – the new and unexpected scattering of light on light, and of light on the background electromagnetic field. This interaction originates in quantum vacuum fluctuations into electron–positron pairs and makes the electric field unstable to pair production. Thus any macroscopic electric field is metastable because in principle, it can decay into particles.

The critical field strength for this instability, E_0, arises when a potential of $V_0 = 2mc^2/e = 1$ MV (where m is the electron's mass and e its charge) occurs over the electron's Compton wavelength – that is, when $E_0 = 1.3 \times 10^{18}$ V/m. This leads to vacuum decay into pairs at timescales of less than attoseconds (10^{-18} s). The back-reaction of the particles that are produced screens the field source, giving an effective upper limit to the strength of the electric field. However, as the applied external field decreases in strength, its lifespan increases rapidly: for a field strength of $E = 5 \times 10^{16}$ V/m, the lifespan is similar to the age of the universe so that, for all practical purposes, present-day field configurations are stable.

The Compton wavelength of an electron is one three-millionth of a typical optical wavelength, so vacuum fluctuations do not greatly obstruct the propagation of light. Moreover, as Schwinger showed, a coherent ideal plane light-wave cannot scatter from itself (or be influenced by itself) no matter what the field intensity is. This is the only known form of light to which the vacuum is exactly transparent within the realm of quantum electrodynamics. For non-ideal plane waves, space–time translation-invariance symmetry and quantum coherence only partially protect the propagation of light pulses.

A laser pulse of several kilojoules and just a few wavelengths long is all but a plane wave. Such a pulse pushes apart virtual electrons and positrons, in the near future up to an energy of many giga-electron-volts. If the virtual vacuum waves were to decohere, the light pulse would materialize into pairs. However, by quantum "magic" the deeply perturbed vacuum is restored after the pulse has passed. Thus a single pulse, even though it is not a plane wave, will at present-day intensities slip through the vacuum. Colliding light pulses provide a greater opportunity to interact with the vacuum structure because the magnetic field can be compensated and/or the electric wave-number doubled, thereby enhancing the light–vacuum interaction. Two superposed pulses do not so much interact with each other, but interact together with the fluctuations in the vacuum.

High-intensity pulsed lasers also offer a radical approach to accelerating real particles to high energies. The electromagnetic fields of the laser pulses can be huge: current off-the-shelf, high-power lasers can deliver electric fields as great as 10 GeV/μm (10^4 TeV/m). Metal will typically break down at fields of less than 100 MeV/m – a natural limit and the current standard for accelerator designs based on RF technology. The much higher fields available using lasers promise ultracompact accelerator technology, although the difficulties should not be underestimated. The shorter wavelengths involved imply far better control and precision than with RF acceleration. What helps to push laser technology ahead is the greater intensity of light that is available in comparison with RF. For this reason, laser-pulse technology is the most significant ingredient of laser acceleration, and great progress can now be achieved on timescales of a year.

This was not always so. Until the mid-1980s, efficient ultrashort pulse-amplification that would preserve the beam quality seemed to be unattainable, considering the damage caused to optical devices. A solution emerged in 1985 with the concept of chirped pulse amplification (CPA), in which a short pulse at an energy level as low as nanojoules is stretched by a large factor in time using dispersive elements, such as a pair of diffraction gratings (figure 1, p22). This is possible because of the large number of Fourier frequencies that form the ultrashort pulse. Each frequency takes a different route and hence a different time to traverse the dispersive element. ▷

Fig. 1. The compression chamber of the chirped pulse-amplification system at the LASERIX facility at the Ecole Nationale Supérieure de Techniques Avancées, showing the diffraction gratings.

Fig. 2. The experimental chamber at the Laboratoire d'Optique Appliquée where the interaction of light with matter yields electrons, protons and X-rays. (Photos courtesy Alexis Chezière/CNRS Photothèque.)

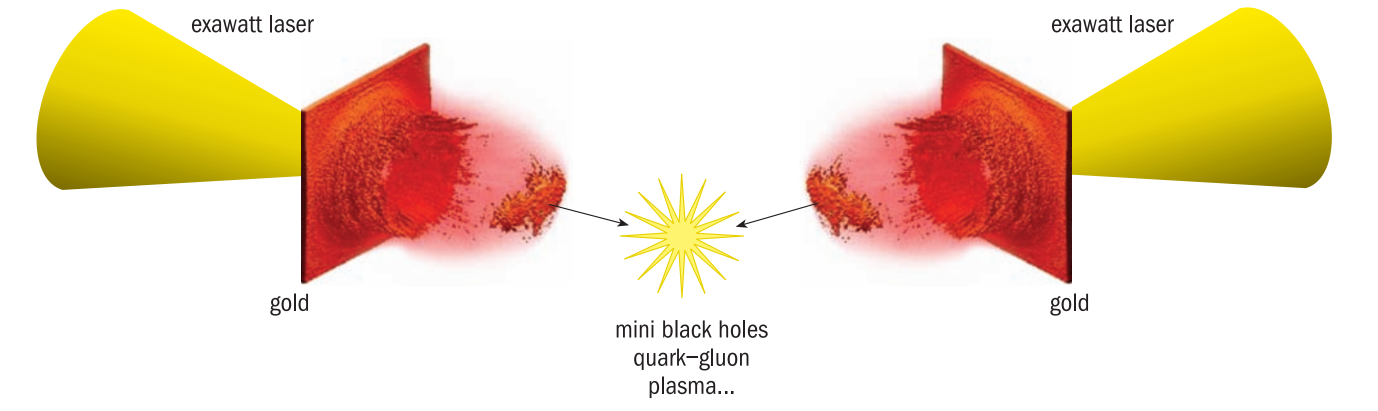


Fig. 3. An illustration outlining the concept for an exawatt laser-pulse, ultracompact heavy-ion collider. (Courtesy T Esirkepov et al. *2004.)*

Once the pulse has been stretched, the red part of the spectrum is ahead, followed by the blue. The stretching factor can be as large as 10^6 yet the operation does not significantly change the total pulse energy. Consequently the pulse intensity drops by the same ratio, i.e. 10^6, implying that the long pulse can be amplified safely, preserving the beam quality and laser components. This concept works so well that in modern CPA systems the pulse is stretched by a factor of 10^6, amplified by 10^{12}, then compressed by a factor of 10^6 back to its initial time structure. A nano- to microjoule primary pulse turns into a pulse of up to kilojoules comprising nearly 10^{22} photons of (sub)micron wavelength. In a nutshell, this pulse is a table-top particle accelerator. The interaction with matter of light pulses containing joules or even kilojoules of energy (compared with the less than microjoules of the most powerful particle accelerators) generates intense bursts of radiation (figure 2).

Accelerating gradients

Nevertheless, laser particle acceleration has had its ups and downs. As the Woodward–Lawson theorem states, direct plane-wave laser acceleration of particles is not possible – you lose what you win in a perfect wave. However, if the intense pulse is so short that it "resonates" with the innate matter(plasma)-oscillations, a huge accelerating gradient is possible. The energy imparted to the particle in each acceleration step can be directly derived from the wave amplitude of the pulse. The short-pulsed nature of the laser is also of great interest in this acceleration method, as is the possibility of using circularly polarized light.

Particle-acceleration schemes use lasers to generate wake waves in plasma in the relativistic regime for electrons in the optical field. A plasma electron density of 10^{16}/cm^3 and a laser intensity of 10^{22} W/cm^2 yields beam energies of 10^9 MeV (1 PeV). This requires a 50 kJ pulse of picoseconds . Such an intense laser pulse is not yet available, but the proposed European Light Infrastructure (ELI) should offer an opportunity to explore this domain. The peak power of ELI will be in the exawatt (10^{18} W) region – that is, 100 000 times the power of the global electricity grid – albeit only over several femtoseconds.

Are there other ways to go from the laser pulse to an intense particle beam? If beam quality is not of great concern, it is possible to exploit the action of the pulse on a foil that is only a fraction of the wavelength thick. At the Trident Laser Facility at Los Alamos National Laboratory, Manuel Hegelich and his team shoot a high-contrast (no preceding light) pulse onto a thin, carbon-diamond nanofoil. Such a pulse is not reflected by the "pre-plasma" formed on the foil but propagates through the foil, where it picks up electrons. The cloud of relativistic, wave-riding electrons generates longitudinal electrical fields, which cause carbon ions to follow electrons, creating two "beams". At ELI such a pulse–foil interaction could provide a source of high-energy relativistic heavy ions, because the pulse intensity that could be achieved would permit direct acceleration of ions in a relativistic regime (figure 3).

The plasma cloud emerging from the foil could form gamma-ray beams suitable for photonuclear physics. Einstein observed that a relativistic "flying mirror" (in this case the plasma) would "square" the relativistic Doppler effect, leading to a boost of photon energy, $\omega = 4\gamma^2\omega_0$, where ω_0 is the original energy and γ the Lorentz factor (figure 4). This effect has been demonstrated, both by using the laser wakefield created on the surface of a solid and by using a relativistically moving plasma of thin foil propelled by the laser beam, from which another laser beam is reflected. It should soon lead to compact coherent X-ray and even gamma-ray light sources. Dietrich Habs and colleagues at the Munich-Centre for Advanced Photonics are pursuing an initial design effort. The gamma rays produced in this way are not only of high energy but also compressed by a factor $1/\gamma^2$ into an ultrashort pulse. The coherent pulse contains increased electromagnetic fields, so the technology leads to ultrahigh electrical-field strengths where the decay of the vacuum becomes observable.

It appears that coherent reflection of a femtosecond pulse is possible from a flying mirror of dense plasma with γ=10 000 – that is, from an electron cloud moving with an energy of 5 GeV. The resulting 400 MeV photon pulse would also be compressed from femtoseconds to 10^{-23} s. Such a pulse could, in principle, be focused into a femtometre-scale volume, the size of a nucleon. On such a small distance scale, 10 kJ would be enough to reach temperatures in the 150 GeV range, which should allow the study of the melting of the vacuum structure of the Higgs field and the electroweak phase transition. Clearly this is on the far horizon, but there are other distance/temperature scales of interest on the journey there. Such a system would allow studies of electromagnetic plasma at megaelectronvolt temperatures and exploration of the quark–gluon plasma on a space–time scale at least 1000 times as great as can currently be achieved. This would be truly recreating a macroscopic domain of the early universe in the laboratory.

Another fundamentally important aspect of the science possible with the extremely high fields in lasers concerns the immense acceleration, a, that electrons experience in the electromagnetic field of the pulses (e.g. up to $a = 10^{30}$ cm/s^2 for an electron in ELI). According to the equivalence principle, this corresponds to an equivalent external gravitation. The effect for the accelerated electron is that the distance, $d = c^2/a$, to this event horizon becomes as short as the electron's Compton wavelength, in which limit experiments can probe the behaviour of quantum particles in the realm of strong gravity. Work is under way to demonstrate Unruh radiation, a cousin of Hawking radiation. (Hawking radiation is thermal radiation in strong gravity, while Unruh radiation arises in the presence of strong acceleration.) Such experiments would allow the study of the extent and validity of the special and general theories of relativity, as well as test the equivalence principle in the quantum regime.

To conclude, high-intensity pulsed lasers, and in particular the proposed ELI facility, offer a novel approach to particle acceleration and widen the range of fundamental physics questions that can be studied (Mourou *et al.* 2006). Light pulses will be able to produce synchronized high-energy radiation and pulses of elementary particles with extremely short time structures – below the level of attoseconds. These unique characteristics, which are unattainable by any other means, could be combined to offer a new paradigm for the exploration of the structure of the vacuum and fundamental interactions. Ultra-intense light pulses will also address original fundamental questions, such as how light can propagate in a vacuum and how the vacuum can define the speed of light. By extension it will also touch on the question of how the vacuum can define the mass of all elementary particles. The unique features of ELI – its high field-strength, high energy, ultrashort time structure and impeccable synchronization – herald the entry of pulsed high-intensity lasers into high-energy physics. This is a new scientific tool with a discovery potential akin to what lay on the horizon of conventional accelerator technology in the mid-20th century.

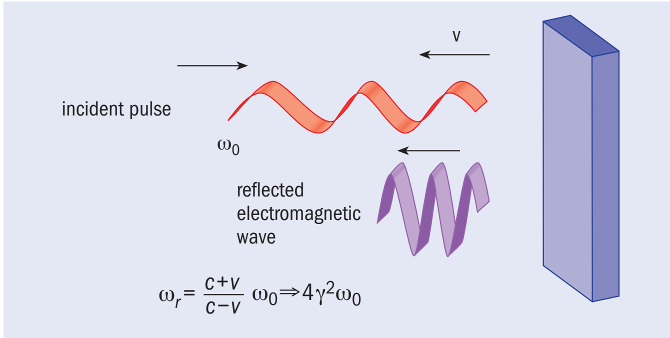


Fig. 4. The relativistic flying mirror greatly enhances the frequency of reflected light. The energy boost of the reflected wave is provided by the kinetic energy of the mirror, and the phase of the reflected wave can remain coherent. (Courtesy S Bulanov et al. *2005.)*

Further reading

S Bulanov *et al.* 2005 *Nucl. Instr. Meth. Phys. Res. A* **540** 25.
T Esirkepov *et al.* 2004 *Phys. Rev. Lett.* **92** 175003.
G Mourou *et al.* 2006 *Rev. Mod. Phys.* **78** 309.

Résumé

La frontière des impulsions lumineuses

Les lasers à impulsions haute intensité ouvrent de nouvelles voies pour l'accélération des particules et élargissent le champ d'investigation en physique fondamentale. De brèves impulsions lumineuses haute intensité peuvent produire un rayonnement de haute énergie synchronisé ainsi que des impulsions de particules élémentaires de structure temporelle extrêmement brève, en deçà de l'attoseconde. Une fois combinées, ces caractéristiques uniques pourraient permettre une nouvelle manière d'explorer la structure du vide et des interactions fondamentales. Le projet européen ELI de lumière extrême pourrait annoncer l'arrivée des lasers pulsés haute intensité en physique des hautes énergies.

Gérard Mourou, *ENSTA, Ecole Polytechnique and CNRS, co-ordinator of the ELI project,* **Johann Rafelski**, *University of Arizona, and* **Toshiki Tajima**, *Ludwig-Maximilians University, Munich, and KEK.* *(JR and TT would like to thank Dietrich Habs, director of the Munich-Centre of Advanced Photonics for his hospitality at LMU Garching.)*

Georges Charpak: ha

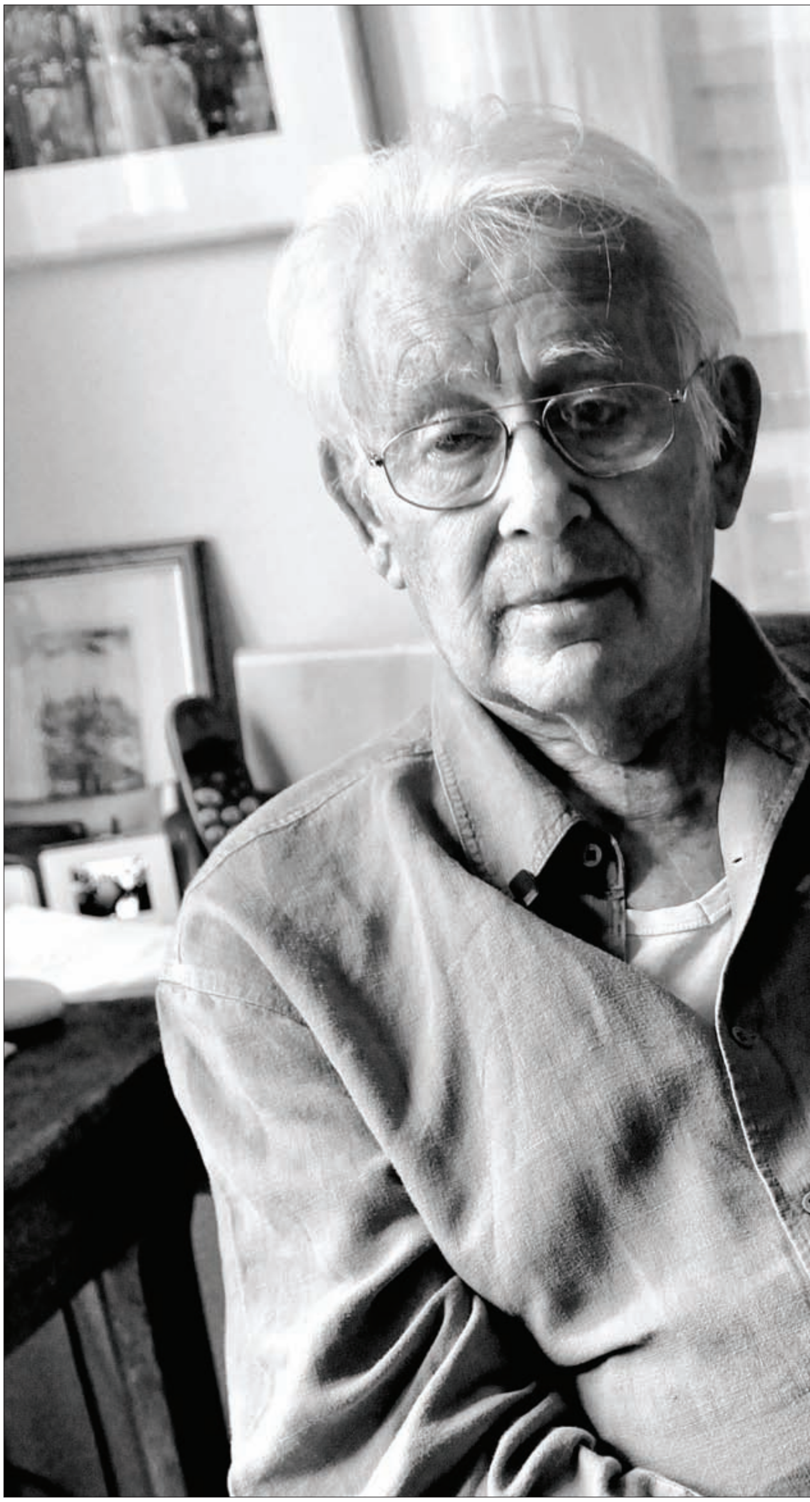
On 8 March Georges Charpak turns 85. Here he talks to **Paola Catapano** about his achievements in physics, his current work in education and his expectations for the LHC.

Physicist Georges Charpak joined CERN 50 years ago on 1 May 1959. He retired from the organization in 1991 and now lives in Paris, where he studied and worked for the CNRS before coming to CERN. In August 2008 I visited him (with a cameraman and photographer) at his apartment in rue Pierre et Marie Curie. There is perhaps no better address for a physicist who developed detection techniques that have not only allowed a deeper study of the structure of matter but also found important applications in medicine and other fields. This work led to his Nobel Prize in 1992.

The photo session was to complete CERN's *Accelerating Nobels* exhibition with photographs by Volker Steger, which was one of the features of the LHC inauguration (*CERN Courier* December 2008 p26). As we entered Charpak's chaotic but charming office, he made jokes about his Nobel Prize: "Ca devait être une année creuse" ("It must have been a slack year") for the Nobel Committee. Then he patiently accepted Steger's request to make a drawing of his discovery with coloured pens on a big sheet of white paper, and finally to sit for the photo session.

The caption that he added to his drawing of a wire chamber is a good summary of the value that his contribution made to particle physics: "D'un fil isolé à des centaines de milliers de fils independents" ("From an isolated wire to hundreds of thousands of independent wires"). As Charpak explains in his latest book (p44), in 1968 his first $10 \times 10\ cm^2$ proportional multiwire chamber "was perfectly capable of detecting in an independent way, and on each of the wires, separated by a millimetre, the pulses produced by the nearby passage of an ionizing particle. In this way we could fill the space with thousands or hundreds of thousands of wires to visualize the trajectory of charged particles".

This was an experimental technique that many others had attempted but had until then produced catastrophic results, ending in the destruction of "a thousand dollars' worth of amplifiers". What was missing was an understanding of the formation of pulses in a proportional multiwire chamber. Charpak realized that they were produced by the movement of positive ions, which induced pulses of opposite polarity near the wires. This approach to solving experimental problems, through an in-depth study of the phenomena involved, reveals the theoretical physicist's spirit in Charpak. His secret dream, as he confesses in his book, has always been to be a theoretician.



Georges Charpak at his apartment in Paris, where he continues his "personal fight agai

rdwired for science

gainst obscurantism" with important projects in science education. (Courtesy M Struik.)

You had a long career in experimental physics. Which result are you most proud of?
It was my first experiment, with Richard Garwin and Leon Lederman (five scientists signed the paper), and CERN's first large experiment at the time: g-2 (*CERN Courier* December 2005 p12). That was an extraordinarily elegant experiment. At last, we had contributed to measuring the magnetic moment of the muon to some 10 decimal places, and that was a real tour de force.

Then, of course, came our research on wire chambers, which were very small and became huge – with large groups making all sorts of experiments, also with cosmic rays. They were incredibly successful. The teams using wire chambers in medical applications are very small – I like teams where I can keep human contact with people and where I can minimize bureaucracy.

The wire chambers led to the Nobel Prize in Physics. What did this bring to you?
Free coffee whenever I entered a bar, a lot of visibility in the streets of Paris because of the television – people still stop me to express their admiration – a lot of travelling and even a dozen pairs of shoes that were offered by fans.

What would your advice be to a young physicist who would like to receive the Nobel prize?
If I were a young experimentalist, I would do experimental physics with cosmic rays because they enable you to reach much higher energies than at the LHC, even if you have to build a $1 \times 1\ km^2$ or $10 \times 10\ km^2$ detector, and even if there's only one good event per year – that one event will bring something extraordinary. Then I think that sooner or later physics will need very good thinkers – theoreticians who are able to imagine new things. Theoretical physicists have an important role to play, provided that they do not become dictators. I understand the excitement that they get from the prospects in high-energy physics today. I think physics is experiencing a rejuvenation.

After your research work at CERN, you devoted your time to the industrial applications of detectors. Tell us about that.
I do not have the gifts to be a department – or even group – leader. I've never been anything like that outside my own group. I'm very unorganized and I hate hierarchies. Very quickly my small detectors were used inside big detectors, but when I saw groups with more than 1000 physicists I became scared. So I decided to switch to the application of my detectors to medicine and biology. I have had some success in radiology for children – the best instrument available is still the one that I proposed.

Another question is to see whether it will sell, or flood hospitals because it is the best, but this unfortunately is a commercial ▷

Charpak with members of the first g-2 team at CERN. Left to right: J C Sens, Charpak, Th Muller, F J M Farley and A Zichichi.

question. Physicists are not necessarily businessmen. You can have as many Nobel Prizes as you want, but once you go out to industry it's a completely different story. I go to many conferences on children's diseases, I make presentations about the instruments I make, but the difficulty is in introducing these new instruments to hospitals. You need the approval of the US Food and Drug Administration and the agreement of insurers to reimburse, and this is not my competence. But I am not ruined yet and I'll go on.

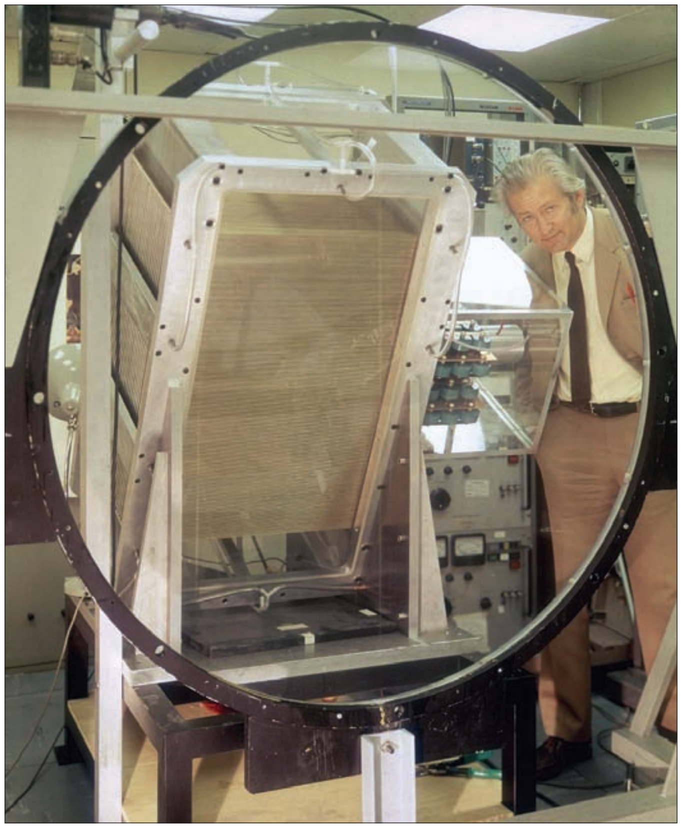
What are you busy with at the moment?

I am annoyed because I lost part of my autonomy after a small accident. I survive. I continue doing some physics – that's the easiest – and I am working on a book to teach nuclear physics to children. I took out a patent three months ago, and built a detector 50 times less expensive than a standard one. I hope to be able to offer cultivated people the possibility of buying a book for their children that is written by very good physicists (I did not do it all by myself). I have proposed building instruments that make measuring radioactivity a very trivial thing. So I am working in education.

For the last 12 years I have been involved with a huge educational project, La Main à la Pâte, which certainly is my most important contribution to society – schools in the Amazon basin practise La Main à la Pâte. This new educational method based on learning science through direct experiment is becoming more and more popular. We need a revolution in science education because we live in a world where obscurantism has too big a role, for my taste, and this is my personal fight against obscurantism in collaboration with people from around the world. I received a prize for it in Mexico together with Leon Lederman, which was a very pleasant surprise for me. It indicated that what we do in France with children has reached such a level, that even in a place as monopolized by the US as Mexico is, our work is recognized.

CERN's immediate future lies with the LHC. What discoveries do you expect?

We expect the unknown – to see things that are not necessarily foreseen by theory. Because there are still mysteries in physics – dark matter, for example – there are answers from theoreticians and there are many questions from experimentalists like myself. If theory were completely accurate we would not need to build an accelerator.



Seen through a lens: Charpak with a multiwire chamber at CERN in 1973.

The LHC might bring unexpected results, and the fact that we have a suspicion about the existence of a form of matter that is not the same as the one that makes up the known universe is very exciting. Personally, I find it very amusing to expect new matter. Is it true or false? If it's false it's a myth, and maybe some people will have to give back their Nobel medals because they will have foreseen false entities. But if it is true, it is very exciting because there are still extraordinary things to discover in the universe. Young people who enter the field now are lucky that this physics is not completed.

● For a longer video version of this interview in French, visit http://cdsweb.cern.ch/record/1138212.

Résumé

Georges Charpak : programmé pour la science

Georges Charpak est arrivé il y a 50 ans au CERN, où il a mis au point de nouvelles techniques de détection pour la physique des particules dans le cadre de travaux qui lui ont valu le prix Nobel de physique en 1992. Ces techniques, qui ont permis d'étudier plus en détail la structure de la matière, ont trouvé d'importantes applications en médecine et dans d'autres domaines. Charpak a pris sa retraite du CERN en 1991 et continue de travailler sur d'importants projets pour l'enseignement des sciences dans le cadre de son « combat personnel contre l'obscurantisme ». Dans cet article, il explique à Paola Catapano son travail, passé comme présent, son point de vue sur le prix Nobel, et ce qu'on peut attendre du LHC.

Paola Catapano, *CERN.*

CERN leads the way with novel beam extraction

A team of researchers at CERN has developed a new, more-efficient technique, known as multiturn extraction, for extracting beam from a circular particle accelerator.

In 2001 a team at CERN proposed a new scheme for ejecting beam from a circular particle accelerator over a few turns using magnets that generate nonlinear fields. The aim was to replace the so-called continuous transfer (CT) technique, which is used to transfer protons between the PS and the SPS for fixed-target physics and the CERN Neutrinos to Gran Sasso (CNGS) project.

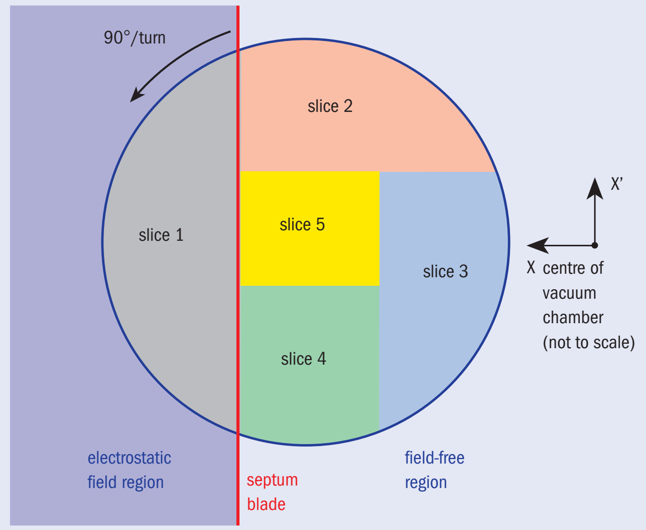
CT dates from the 1970s and is based on slicing beam onto an electrostatic septum that is used to split off some of the orbiting beam. In the scheme, the horizontal tune (the number of betatron oscillations per turn, Q_H) is set to 6.25 so that the beam rotates by 90° in phase space every turn. A system of slow- and fast-pulsing dipoles (acting on a few milliseconds and microseconds, respectively) is used to displace the proton beam horizontally across the septum so that at each turn approximately one-fifth of the beam is sliced off by the septum blade (figure 1). This slice is then deflected by the field of the septum so that it enters into a second septum downstream – the magnetic extraction septum. The whole beam is extracted in five turns.

The choice of a five-turn extraction is dictated by the use of two PS cycles to fill the SPS ring, which has a circumference that is 11 times as large as that of the PS. By ejecting the beam over five turns at the end of two consecutive PS cycles, ten-elevenths of the SPS circumference is filled. One-eleventh of the circumference remains empty to avoid interference between the circulating beam and the transient times of the SPS injection kickers.

Making beamlets

In the new scheme, which has been named multiturn extraction (MTE), the beam is split horizontally into five beamlets – one in the centre and four in stable islands of the horizontal phase space. These islands are generated by nonlinear fields of sextupole and octupole magnets and are separated by sweeping the horizontal tune through the stable one-fourth resonance, $Q_H = 6.25$ (figure 2, p30). The beamlets circulate in the PS until they are moved, turn by turn, beyond the magnetic extraction septum by dedicated slow and fast closed bumps. The separation of the beamlets that is necessary to avoid intercepting the extraction septum is controlled by the value of the horizontal tune at the end of the resonance crossing, as well as by the strength of the nonlinear magnets. This method no longer requires the electrostatic septum.

This approach has several advantages compared with the original CT extraction. First, there is no interaction between the beam ▷



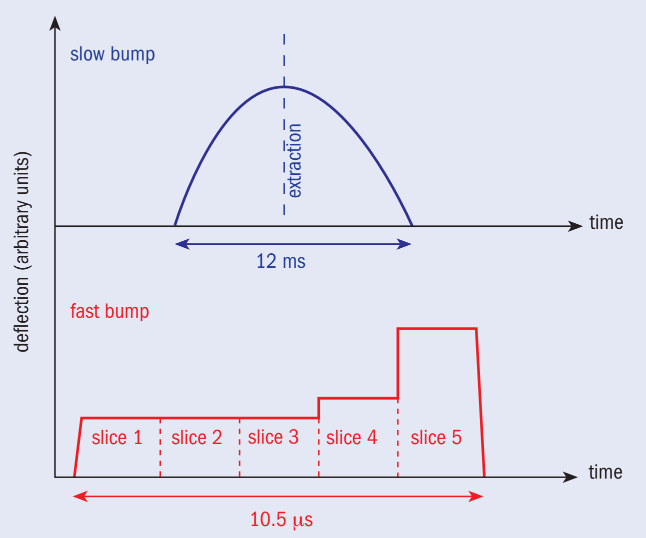


Fig. 1. In continuous transfer, the septum blade slices off approximately a fifth of the beam on five sequential turns, each slice then being deflected by the electrostatic field (top). Slow and fast orbit bumps are used to move the beam across the septum (bottom).

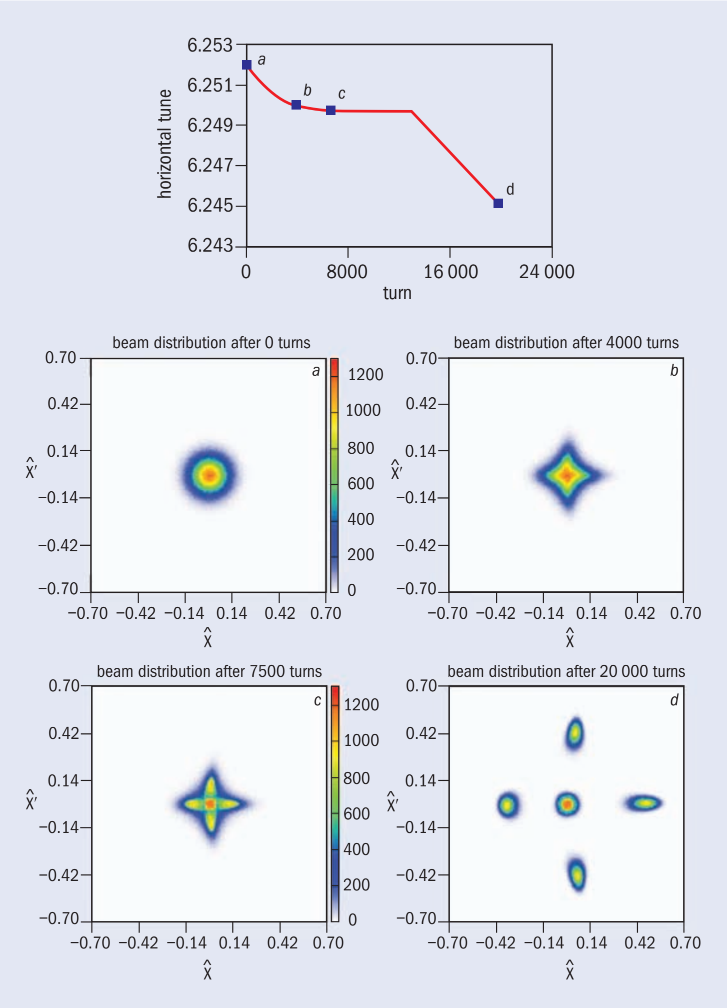


Fig. 2. *In multiturn extraction, five islands of beam are generated by non-linear fields in sextupole and octupole magnets. They are separated by sweeping the horizontal tune through the stable one-fourth resonance, $Q_H = 6.25$ (top).*

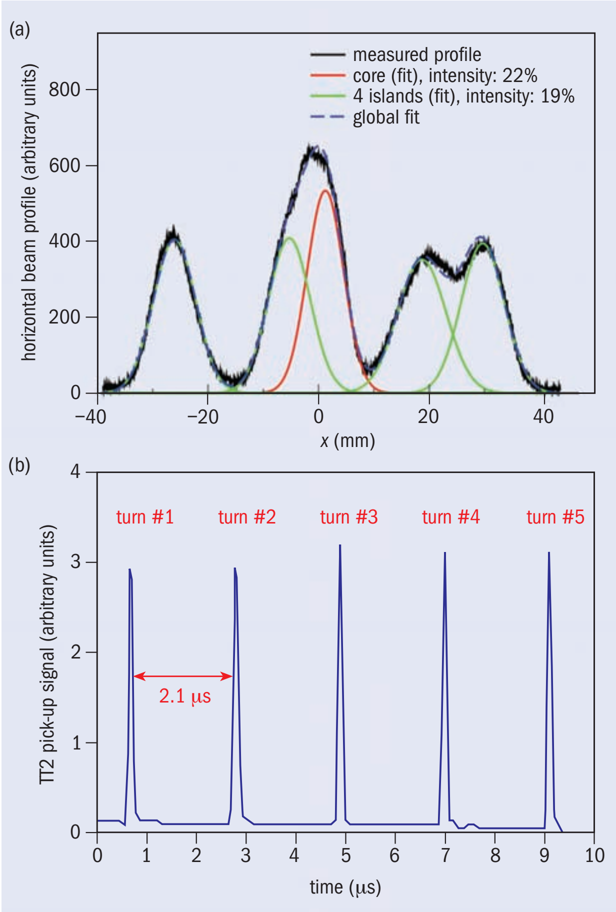


Fig. 3. *(a) The measured horizontal beam profile in the PS at the end of the splitting process, with a fit of the five beamlets superimposed onto it. (b) The summed signal of a pick-up in the TT2 transfer line: each one of the five peaks corresponds to a beamlet extracted over a single turn and the distance between them corresponds to the PS revolution time.*

and the septum blade, the losses of which limit high-intensity operations. Second, the beamlets trapped in the islands can have the same intensity, emittance and optical parameters at extraction. This eases the matching with the receiving accelerator, which would not be possible with CT. Third, several parameters, such as the strengths of the nonlinear magnets, the speed at which the resonance is crossed and the final horizontal tune, are available to adjust and optimize the parameters and separation of the beamlets simultaneously. In CT, only the fast-bump amplitude can be used to equalize the intensities or emittances of the beamlets. Moreover the MTE scheme can be time reversed, which could allow a multiturn injection (MTI) based on stable islands.

MTE in practice

To complement the theoretical analysis, extensive measurement campaigns began at the PS in 2002 to assess the feasibility of loss-free beam-splitting by crossing the stable one-fourth resonance. This was essential before undertaking any hardware upgrade of the PS machine, such as new octupole magnets and fast dipoles for a dedicated orbit bump. In 2004 the tests achieved the necessary loss-free beam-splitting even with a high-intensity, single-bunch beam of about 6×10^{12} protons. The next step was to ensure that an equal intensity was shared between the four beamlets trapped in the islands and the beam core. To avoid unwanted transient effects in the SPS, the scheme has to give a maximum difference of about 5% in the relative intensities of the islands and the core. In tests, the best beam-sharing that we achieved was about 18% in each of the four islands and about 28% in the central core. This intensity ratio is slightly out of specification but should be compared with the accuracy of the determination of the beamlets' profiles and hence their intensity, which is a few per cent.

The positive outcome of the experimental tests led to the approval of the PS MTE project. This should provide a considerable reduction of beam losses in the PS, which is particularly crucial for the production of high-intensity proton beams for CNGS (*CERN Courier* November 2006 p20). The project, started in 2006, should last until 2010 with the peak effort for hardware production and installation occurring during the winter shutdown of 2007/2008 and first beam commissioning by mid-2008.

Implementing MTE has involved a considerable number of hardware modifications in the PS ring. The slow bump that is used to displace the split beam towards the magnetic extraction septum is generated by six magnets, each with independent power converters. This is necessary to shape the bump to optimize the available mechanical aperture. (Originally the extraction bump was generated by only four magnets that shared a common power supply.) The fast bump that is used to move the split beam across the extraction septum is generated by three fast dipoles (kickers) with three new pulse-forming networks (PFNs). In addition, new octupole magnets have been designed and built – two straight sections have each been equipped with two sextupoles and one octupole to generate and manipulate the stable islands used for beam trapping. Globally, a review of the mechanical aperture, in the light of higher requirements imposed by the split beam, implied the need for a larger vacuum chamber in the extraction region, including the complex y-shaped chamber at the extraction point. A second phase will be implemented during the winter shutdown of 2009/2010. This will aim to improve the performance of the kickers in the ring and in the transfer line, the latter being used to correct the trajectory variations among the extracted turns.

Extraction testing

In May and June 2008 beam splitting was resumed using the newly installed sextupoles and octupoles, again achieving a loss-free process with a single bunch of about 3×10^{12} protons. At the same time the new slow bump was commissioned so that it was ready for the extraction tests in July 2008 when the PFNs, completed and hardware-commissioned, became available for the beam tests. Then, on 1 August, five beamlets with almost the same intensity were successfully created from a single bunch of 3×10^{12} protons and extracted in the first part of the transfer line, TT2, to the SPS. Figure 3a shows the measured horizontal beam profile in the PS at the end of the splitting process, with a fit of the five beamlets superimposed. Figure 3b shows the intensity signal of a pick-up in the TT2 transfer line. Each of the five peaks corresponds to a beamlet extracted over a single turn, whereas the distance between them corresponds to the PS revolution time of 2.1 μs.

The rest of the commissioning period until the end of the SPS-physics run on 3 November 2008 was dedicated to studying the best longitudinal structure for beam delivery and injection into the SPS, and it included a campaign of measurements of the optical parameters in the transfer line between the PS and the SPS machines. In the end it was possible to extract from the PS a beam bunched on harmonic number $h = 16$, corresponding to 16×5 beamlets, for a total intensity of about 0.7×10^{13} protons. This beam was injected into the SPS, accelerated and then extracted onto the CNGS target to produce the first neutrinos from an MTE beam.

Figure 4 shows the signal from the fast beam-current transformer in the SPS after the injection of the second PS cycle. The two batches separated by the gaps required by the finite rise time of the SPS injection kickers are clearly visible, as well as the bunched structure. During the last part of the PS run, when the SPS was already shut down, it was possible to set up a new completely debunched MTE beam – that is, with the longitudinal structure that provides the best SPS performance – with a total intensity of about 1.3×10^{13} protons. This yielded typical extraction efficiencies of 97–98%, with peaks of 99%. This is the maximum theoretical efficiency, given the unavoidable losses owing to the finite rise time of the PS extraction kickers. The corresponding extraction efficiency for a CT beam with

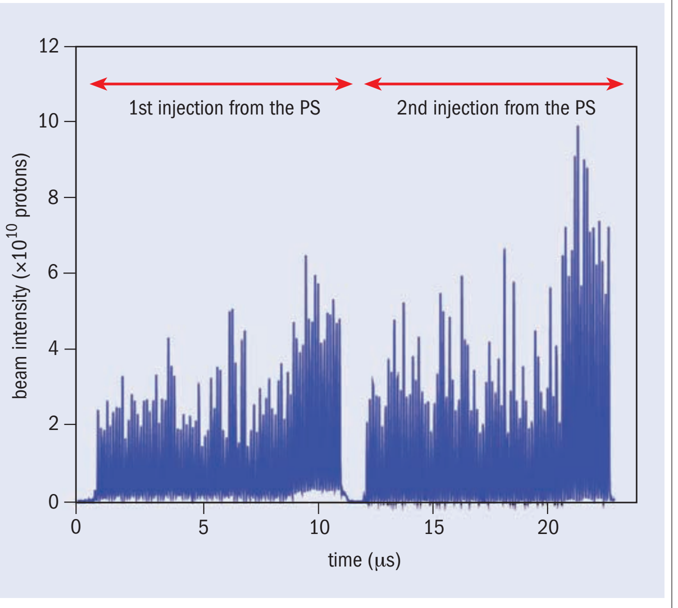


Fig. 4. The signal from the fast beam-current transformer in the SPS after the injection of the second PS cycle. The two batches are clearly visible.

the same intensity is 95%. In addition, the losses for MTE are localized around the extraction magnetic septum, while in the case of the CT, the losses are distributed through a wider part of the machine circumference, affecting a larger number of active elements.

For the 2009 start-up the plan is to begin by delivering CT beams to the SPS, but to resume MTE operation with a view to replacing the low-intensity CT extraction for fixed-target physics by mid-2009. Soon after, the beam for CNGS will also be generated with MTE, with the intensity gradually increased towards the nominal value.

Further reading

For all MTE-related documents (design report, publications and talks), visit http://ab-project-mte.web.cern.ch/AB-Project-MTE/Documents.html.

Résumé

Le CERN propose une nouvelle extraction de faisceau

Une équipe a développé au CERN une nouvelle méthode plus efficace pour extraire le faisceau d'un accélérateur de particules circulaire. Cette méthode, « l'extraction multitours », sert à transférer des protons entre le PS et le SPS pour les expériences avec cibles fixes et le projet CNGS (Neutrinos du CERN vers le Gran Sasso). Elle remplacera la technique du transfert continu, utilisée actuellement pour fournir le faisceau à ces expériences. Des tests concluants ayant validé le concept, le matériel nécessaire a été produit et installé en 2007-2008. La nouvelle méthode sera utilisée pour les expériences avec cibles fixes et pour le CNGS en 2009.

Andrea Franchi, **Simone Gilardoni** *and* **Massimo Giovannozzi**, *CERN, on behalf of the MTE project members (http://ab-project-mte.web.cern.ch/AB-Project-MTE/WhoAreWe.html). Roberto Cappi, who was involved from the start in developing the new technique, retired from CERN in 2003.*

APPOINTMENTS

Nigel Smith to become director of SNOLAB…

Nigel Smith is to be the new director of the SNOLAB International Underground Science Facility in Sudbury, Ontario, with effect from 1 June. He will replace Tony Noble who has served as SNOLAB's director for three years.

Smith is currently deputy divisional head (with responsibility for precision weak physics) and group leader (for dark matter) at the UK's Rutherford Appleton Laboratory. He is also project manager for the Boulby Underground Facility in northern England and the ZEPLIN III Dark Matter experiment, as well as a visiting professor at Imperial College, London.

Smith received his BSc from Leeds University in 1985, followed by a PhD in astrophysics from Leeds in 1991. He then served as a lecturer at Leeds and a research associate at Imperial College London before moving to the Rutherford Appleton Laboratory as group leader 1998. His early research work was in studies of ultra-high-energy gamma rays from astrophysical sources using extensive air-shower arrays in the UK and at the South Pole.

Nigel Smith will move to Ontario. (Courtesy STFC.)

Since 1992 he has been actively involved in the development and operation of underground detectors to search for weakly interacting dark-matter particles and has been a leader of the research programme at the Boulby underground facility.

…and Mnich takes over as DESY's research director

Joachim Mnich has taken over as research director of the high-energy physics and astrophysics sector at DESY. He succeeds Rolf-Dieter Heuer, who took over as director-general of CERN on 1 January (p15).

Mnich grew up in the Rhineland and studied physics and electrical engineering at RWTH Aachen. He wrote his doctoral thesis on the Mark J experiment at the PETRA electron–positron storage ring at DESY. He then moved on to work on the L3 experiment at LEP at CERN, from 1988 to 1999. He earned his habilitation (post-doctoral) qualification from RWTH Aachen in 1995 and accepted a professorship there in 2000.

The new DESY research director. (Courtesy DESY.)

In 2005 he became the leading senior scientist at DESY and professor at the University of Hamburg. From 2006 to 2007 he was head of the CMS group at DESY, before being appointed deputy to Heuer on the DESY board of directors.

TU Darmstadt appoints Rüdiger Schmidt as honorary professor

The Technische Universität (TU) Darmstadt has appointed CERN's Rüdiger Schmidt as an honorary professor. The distinction is in recognition of his annual contribution, since 2001, to education at the university's physics department on the topic of accelerator physics.

Schmidt joined CERN after receiving his PhD from the University of Hamburg in 1984 and has been involved in several accelerator projects, including the SPS proton–antiproton collider, LEP and the LHC. For several years he headed the programme for technical and doctoral students and participated in the CERN Accelerator School, both as lecturer and as tutor. He has supervised many students, several at PhD level.

The Superconducting Cavity Group at CERN and the Institute of Nuclear Physics at TU Darmstadt have worked together for many years on the development of superconducting cavities for accelerator applications, under the leadership of Achim Richter. Current collaborative work between CERN and TU Darmstadt, led by Schmidt and Norbert Pietralla from Darmstadt, focuses on the protection of accelerators operating with high beam intensity, in particular the LHC.

Rüdiger Schmidt (left) and Achim Richter celebrate the appointment. (Courtesy TU Darmstadt.)

The academic co-operation between CERN and TU Darmstadt has also fostered the education of students in accelerator physics since the mid-1980s, when Herbert Lengeler began teaching an annual course on accelerator physics at Darmstadt before he retired and was succeeded by Schmidt.

AWARDS

Darriulat receives André Lagarrigue Prize

Pierre Darriulat, a former research director of CERN and now professor of physics at the Vietnam Auger Training Laboratory (VATLY) in Hanoi, has been awarded the 2008 André Lagarrigue Prize.

The prize, instituted by the Linear Accelerator Laboratory at Orsay under the aegis of the French Physical Society, is for front-line researchers who have had responsibility for machine or detector construction performed in a French laboratory or in close collaboration with French groups, and who have derived the maximum scientific benefit from such projects.

Darriulat has been honoured in recognition of his outstanding career at the Commissariat à l'Énergie Atomique, the Lawrence Berkeley Laboratory and CERN from 1964 onwards. At CERN he managed the experiments at the Intersecting Storage Rings before taking charge of the UA2 collaboration from 1980 to 1986. UA2 participated in decisive discoveries at the SPS proton–antiproton collider, in particular with the observation in 1982 of high-transverse-momentum quark jets coming from collisions in the collider, followed by the W and Z bosons in 1983.

As research director at CERN from 1987 to 1994, Darriulat supervised the LEP experiment programme. After his retirement he founded VATLY, a facility dedicated to studying high-energy cosmic rays.

Pierre Darriulat founded the VATLY laboratory in Hanoi during his retirement. (Courtesy VATLY.)

Doctor Honoris Causa *John Ellis in his laurel wreath surrounded by Uppsala University colleagues, from the left Johan Rathsman, Richard Brenner, Olga Botner, John Ellis himself, Tord Ekelöf, Allan Hallgren and Gunnar Ingelman. (Courtesy Uppsala University.)*

Uppsala awards honorary degree to Ellis

On the 23 January, John Ellis, a senior staff physicist of CERN's Theory Unit, was awarded the degree of Doctor *Honoris Causa* at Uppsala University.

The honour is in recognition of his leading contributions to the development of the fundamental theories in elementary particle physics, including supersymmetry, and their implications for cosmology, and for the vital role he has played in the scientific motivation and promotion of future large particle-accelerator projects.

Scandale (left) receives the Order of Merit from Italy's consul-general. (Courtesy W Scandale.)

Italy honours Walter Scandale

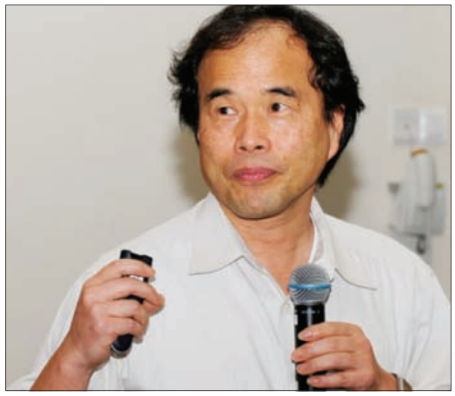
On 9 December 2008, CERN's Walter Scandale received the decoration of Knight of the Order of Merit of the Italian Republic, one of Italy's highest decorations. He was awarded the medal by the consul-general of Italy in Geneva on behalf of the President of the Italian Republic in recognition of his services to Italy in the field of science.

The citation described his work in helping Italian physicists to integrate socially at CERN and in evaluating national technical and scientific programmes proposed by the Italian research agency INFN. In addition, his numerous international contacts and collaborations with laboratories worldwide have contributed to enhancing the know-how of Italian partners in the field of particle physics.

ANNIVERSARY

Singapore meeting recalls 75 years since Solvay 1933

The conference in Singapore attracted a large number of participants. (Photos courtesy NTU.)



CERN's Tatsuya Nakada was one of the speakers.

On 27–29 November 2008, more than 120 physicists from around the world gathered at the Nanyang Executive Centre in Singapore to reflect on progress in particle physics and look to exciting new frontiers at the Particle, Astrophysics and Quantum Field Theory conference.

The meeting took place 75 years after the Solvay Congress of October 1933, which featured, among others, the accelerator pioneers John Cockcroft and Ernest Lawrence. With the public airing of the neutrino hypothesis by Wolfgang Pauli at the congress, followed by the publication of the paper on four-fermion interactions by Enrico Fermi, dated 31 December, 1933 was indeed a seminal year. Seventy-five years later, the field of particle physics has now crossed a new threshold with the recent inauguration of the LHC.

Eminent speakers at the meeting in Singapore included Gerard 't Hooft, Martin Perl, Harald Fritzsch and Kazuo Fujikawa. Reports on current experiments included Daniel Green on CMS, Jim Thomas on discoveries at RHIC, Tatsuya Nakada on flavour physics at the LHC, Takaaki Kajita on neutrino oscillations and Yifang Wang on the Daya Bay experiment.

● The conference was organized by the Institute of Advanced Studies, Nanyang Technological University (NTU), and co-sponsored by the National University of Singapore. For further information, see www.ntu.edu.sg/ias/upcomingevents/PAQFT08/Pages/default.aspx.

WORKSHOP

Diffraction attracts physicists to the Riviera

Last September, the Mediterranean resort of La Londe-les-Maures, France, welcomed participants to the International Workshop on Diffraction in High-Energy Physics, "Diffraction 2008". With a rich and multifaceted scientific programme, the fifth meeting in this series of biennial workshops proved a particular hit, attracting 110 participants from 20 countries.

In a nutshell, diffraction in particle physics refers to hadronic collisions at high energies and moderate momentum-transfers. Such processes are dominated by the vacuum quantum-number exchange known as the Pomeron, whose nature and properties are still unclear. Diffraction provides the opportunity to scan the "hardness" of the interaction in a broad region, making it a unique tool for studying the interplay between "soft" and "hard" phenomena of strong interactions. This is reflected in the variety of theoretical approaches, which can be based on perturbative quarks and gluons, take inspiration from Regge-theory for Pomeron exchange or introduce new degrees of freedom characteristic of strongly coupled theories.

DESY's electron–proton collider, HERA, has dominated the experimental study of diffraction over the past decade. Although data-taking at HERA has now stopped, new analyses continue to appear, as DESY's Voica Radescu revealed. The ZEUS, H1 and HERMES collaborations also presented their recent results on inclusive and various exclusive reactions, in particular on deeply-virtual Compton scattering, which theorists are actively studying. With new data from the Tevatron proton–antiproton collider at Fermilab, and in anticipation of the LHC era, the focus is now shifting towards diffractive phenomena at hadronic colliders.

There were reports on new diffraction results from the Tevatron,as well as prospects for the LHC, from Dino Goulianos of the Rockefeller University and Risto Orava from Helsinki. One burning topic concerned the production of central systems separated from the protons by large rapidity gaps, a major goal being the double-diffractive production of Higgs bosons at the LHC. Subtle details of this calculation sparked many lively discussions during the workshop.

The spin-physics programme was exceptionally rich this time. Barbara Badelek of Warsaw reviewed new results from the COMPASS experiment at CERN and there were also reports on new data from the CEBAF

Large Acceptance Spectrometer at Jefferson Lab, HERMES at DESY, as well as the PHENIX and STAR experiments at RHIC at Brookhaven. There are currently various proposals for phenomenological approaches to spin asymmetries in hadronic reactions to improve understanding of the proton's spin structure.

The theory part of the workshop benefited from talks on the rise of the total cross-section, presented by CERN's André Martin, Claude Bourrely of the Université de la Méditerranée, and Peter Landshoff of Cambridge. Perturbative QCD approaches based on the Dokshitzer–Gribov–Lipatov–Altarelli–Parisi (DGLAP) and the Balitsky–Fadin–Kuraev–Lipatov (BFKL) equations also dominated the theory presentations. These govern the evolution of the nucleon structure as the process becomes "harder" or more energetic. Joachim Bartels of Hamburg, Lev Lipatov of the Petersburg Nuclear Physics Institute and Victor Fadin of the Budker Institute of Nuclear Physics presented new results on the properties of the BFKL equation, while several younger theorists discussed its application to various processes.

There is an ever increasing consensus that new nonlinear collective-QCD phenomena become increasingly important at high energies. These do not simply call for modifications of the BFKL and DGLAP approaches but may require a new language and formalism. Examples of this metamorphosis were presented at the workshop. One topic that has particularly flourished in recent years is AdS/QCD – QCD in terms of the anti-de-Sitter space/conformal field theory correspondence. This is a vast programme exploiting duality between higher-dimensional gravity and certain four-dimensional gauge theories to gain insight into strong interactions at large coupling, when the perturbative methods fail. Stanley Brodsky from SLAC, Guy de Téramond of the University of Costa Rica and Yuri Kovchegov of Ohio State University explained the emergent picture of hadrons in this approach.

A Renaissance-style castle, overlooking the splendid scenery of the French Riviera, provided a refreshing atmosphere for the participants at Diffraction 2008. (Courtesy Diffraction 2008.)

● Diffraction 2008 was co-organized by Université de la Méditerraneée and IN2P3; DESY-Hamburg, Università della Calabria and INFN, and Temple University, Philadelphia. For further details of the programme, visit www.cs.infn.it/diff2008.

MEETINGS

PHIPSI09, the International Workshop on e^+e^- collisions from Phi to Psi – 2009, will be held at the Institute of High Energy Physics, Beijing, from 13 to 16 October. The sixth in a series that started in 1999, the goal is to discuss in detail the state of the art of various problems in hadronic physics at e^+e^- colliders from low to high energy, and the potential of existing and future facilities. For more information, see http://bes.ihep.ac.cn/conference/phipsi09/index.htm; or e-mail phipsi09@ihep.ac.cn.

The **19th Ion Beam Analysis Conference** is to take place on 7–11 September at the University of Cambridge. In the year of the 100th anniversary of the first Rutherford back-scattering (RBS) experiment, this biennial conference plans to celebrate the developments that have taken place over the past 100 years to make the RBS technique so invaluable in understanding materials and surfaces. For further information, see www.iba2009.org/.

NEW PRODUCTS

Pfeiffer Vacuum has announced a range of HiCube modular pumping stations for applications including accelerators, analysis and surface physics. The modular design allows versatility to satisfy requirements in the range of 35 l/s to 685 l/s pumping speeds. A compact version is available as the HiCube Eco, with pumping speeds of 35 l/s to 67 l/s. For further information, see www.pfeiffer-vacuum.net.

Unitemp has introduced a new range of compact vacuum ovens and dryers, manufactured by ESPEC. The range consists of three basic chambers, the VAC-100/200/300 PR, which have been developed for testing items such as adhesives and electronic or electrical components, at low pressures and high temperatures. The pressure goes from atmospheric down to less than 133 Pa, with a temperature control range of 40–200 °C. For more information contact Paul Brown (tel: +44 1628 850611; or e-mail paul@unitemp.co.uk).

OBITUARIES

Giuseppe Cocconi 1914–2008

Giuseppe Cocconi, a central figure in particle physics and cosmic rays, passed away at the beginning of November aged 94.

Born and raised in Como, it was there that Giuseppe developed his passion for astronomy. Following the advice of a friend and fellow astronomer, he went to study physics at Milan University. Shortly after completing his studies, he was invited by Edoardo Amaldi to go to Rome in February 1938 and spend six months at the Institute of Physics where work on cosmic rays was starting. There, Giuseppe met Enrico Fermi, Gilberto Bernardini, and others. With Fermi in particular, he worked on the construction of a cloud chamber to study meson decay.

In August 1938, back in Milan, Giuseppe laid the foundations there for research into cosmic rays. He worked mainly with Geiger counters at sea level and at Plateau Rosà and Passo Sella, in the Alps, until 1942, when he was called for military service to do infrared research work in Rome for the Italian Air Force. While in Milan, he met Vanna Tongiorgi, who was his student. They co-authored a first paper in 1939 on the nature of secondary radiation in cosmic rays and married in 1945. In 1942, Giuseppe was appointed professor at Catania University, a post that he took up only at the end of 1944, owing to the fighting during the Second World War.

Giuseppe's decade of cosmic-ray work in Italy concluded with the publication of five articles and a letter in the December 1946 issue of *Physical Review*. Shortly after, in 1947, he received an offer from Hans Bethe of a post at Cornell University where work on cosmic rays was being reorganized after Bruno Rossi had moved to MIT. Giuseppe remained at Cornell as a full professor until 1963. Together with Vanna he performed cosmic-ray experiments at the university and at Echo Lake in the Rocky Mountains. After Cornell's electron synchrotron and Brookhaven's Cosmotron became operational, Giuseppe, a good friend of Albert Silverman and Bob Wilson, alternated his work between cosmic rays and accelerators.

Giuseppe's cosmic-ray work in Italy and the US appears in about a hundred papers, most of them written either alone or with Vanna and/or Kenneth Greisen. The range of subjects is very wide, from extensive air-showers and penetrating showers – including very high-energy showers hinting at galactic or even extragalactic origin – to the interaction of very high-energy cosmic-ray particles with matter and considerations on the origin of cosmic rays. Also noteworthy are the observation of neutrons as a component of cosmic radiation (with the accompanying phenomenon now known as spallation) and Giuseppe's "fireball" model for ultrarelativistic nucleon–nucleon collisions.

Cocconi. (Courtesy Anna Sinclair Cocconi.)

During sabbatical leave at CERN in 1959–61, Giuseppe, with his experience at the Cosmotron and with cosmic rays, contributed to setting up the experimental programme for the PS – which came into operation in November 1959. He performed a series of measurements on proton–proton elastic and inelastic scattering and proton–nuclei total cross-sections. Back in the US he continued this programme at the Brookhaven accelerator to measure large-angle scattering for two more years.

Giuseppe wrote his most widely known paper with Philip Morrison at a time both were visiting CERN. In this paper, published by *Nature* in September 1959, they showed that the best frequency to search for signals from intelligent extraterrestrials is 1420 MHz, corresponding to the 21 cm line of neutral hydrogen. The Search for Extra-Terrestrial Intelligence (SETI) based on the Cocconi-Morrison paper continues today.

In 1963 Giuseppe and Vanna joined CERN and he, Alan Wetherell, Bert Diddens and others formed a group working at the PS on proton–proton scattering. They found that the slope of the diffraction peak shrinks with energy, a phenomenon that was soon interpreted as a manifestation of the exchange of Regge-poles – the so-called Pomeron.

Giuseppe was Director of Research at CERN from 1967 to 1969. He was enthusiastic about the perspective promised by the Intersecting Storage Rings, and his group joined forces with Ugo Amaldi, Giorgio Matthiae and their team from Rome that had proposed to study small-angle proton–proton scattering with the technology now known as "Roman pots". This led to the discovery that the proton–proton cross-section rises with energy, showing that the proton expands with energy, and the correlated discovery that the nuclear–Coulomb interference becomes positive at high energy (as predicted by dispersion relations).

Later Giuseppe and the CERN–Rome collaboration moved to neutrino physics and, together with the group led by Klaus Winter, formed the CERN–Hamburg–Amsterdam–Rome collaboration. Giuseppe was especially interested in the delicate measurement of the elastic scattering of neutrinos on electrons.

After retirement in 1979, he maintained an active interest in experimental work at CERN and in the progress of the new accelerators. At same time he followed progress in the field of cosmic rays and astrophysics.

Giuseppe enjoyed the respect of many great physicists. As a man of culture and vision, he was curious and attentive to what was going on in the world, not only in the field of physics. He was also kind and ready to listen, straightforward but humble in his relations with his colleagues, always ready to admire other people's success, and happy to share his knowledge with juniors. His refusal to associate with academies, and his lack of interest in prizes and honours, as well as his wish after his retirement not to talk publicly of his scientific life, are well known. He was a great physicist.

His colleagues and friends.

Franco Bonaudi 1928–2008

Franco Bonaudi in Italy in 2008. (Courtesy Monique Bonaudi.)

Franco Bonaudi, one of the true pioneers of CERN's accelerators, passed away on 21 December 2008.

Even before the first provisional CERN Council meeting of May 1952, Franco, a young research engineer at the Politechnico di Torino agreed to go to Liverpool, at Edoardo Amaldi's request, to learn about synchrocyclotrons and join the study group led by Cornelius Bakker for the first CERN accelerator, the 600 MeV Synchrocyclotron. Two years later, from a barrack in the centre of the Meyrin construction site, he quickly learnt how to deal successfully with industrial partners, a skill he continued to use in leading the apparatus-layout group of the PS and throughout his career at CERN.

In 1963 he spent a year's sabbatical at the Stanford 20 GeV linear accelerator, where he helped design the experimental areas and establish a successful exchange programme of physicists and engineers between SLAC and CERN. On his return he designed the future experimental areas of the Intersecting Storage Rings (ISR), and in 1967 took responsibility for the ISR General Layout Group. The ISR saw its first colliding beams on 27 January 1971, by which time Franco was fully occupied in the installation of experiments as leader of the ISR Experimental Support Group.

Franco was CERN's Director of Accelerators from 1976 to 1978. This was a crucial period when the SPS was turned on, Carlo Rubbia's idea of converting the new ring into a $p\bar{p}$ collider was shown to be feasible; and the Initial Cooling Experiment ring proved that a successful antiproton accumulator could be built using Simon Van der Meer's stochastic cooling. But Franco never felt at home in the directorate and much preferred working directly with his engineering and physics colleagues. Joining the UA2 experiment led by Pierre Darriulat, he participated in the discovery of the W and Z bosons, CERN's Nobel Prize-winning successes of 1984.

In 1983, Emilio Picasso, the new project leader for LEP, asked him to bring his talents to the management team and take responsibility for the design and construction of the experimental areas. Once the LEP beams were successfully circulating in 1989 and the experiments taking data, Franco became scientific secretary of the Detector Research & Development Committee, a new committee advising the research board and the director-general on the numerous detector development projects looking forward to very-high-rate, 14 TeV collisions in the LHC.

Franco retired from CERN in March 1993 after 41 years of dedicated work. For many years he continued his scientific work as a member of advisory committees for the European Southern Observatory and INFN Frascati, as well as giving accelerator physics seminars and courses in Torino. He also helped his lifelong friend, the late Sergio Fubini, to establish with Eliezer Rabinovici a scientific "peace-bridge" in the Middle East, which later led to the creation of the SESAME synchrotron-radiation laboratory in Jordan.

He appreciated life to the full, enjoying music and the arts. He was particularly knowledgeable about classic films. Always curious and with a range of interests, he was a great conversationalist; fascinated by language and languages, he took classes in Swiss-German and Russian to add to his near-perfect English, French, German and native Piedmontese and Italian. He was always receptive and scrupulously fair and, above all, a leader remembered with gratitude and respect by all who worked with him.

Franco's mark on the first four decades of CERN's existence is such that the inscription on the tomb of the architect Sir Christopher Wren would be equally appropriate: "*Si monumentum requiris circumspice*". For Franco's memorial, just look around CERN.
His friends and colleagues.

Neil Tanner 1930–2008

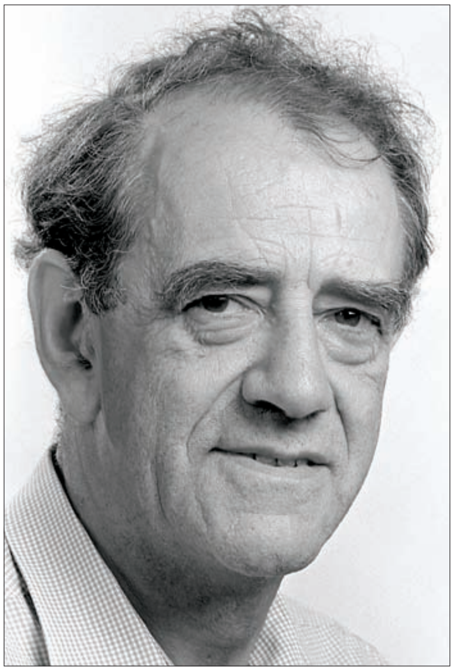
Neil William Tanner, who was well known over many years among the international nuclear physics community, passed away on 11 December 2008.

Neil was born in Melbourne and, on graduation from Melbourne University in 1953, was awarded an Overseas Scholarship by the Commission for the 1851 Exhibition. He joined the nuclear structure group in the Cavendish Laboratory at Cambridge, working with Tony French on the reactions leading to the production of ^{12}C in stars.

On gaining his doctorate, Neil went to California Institute of Technology, at the invitation of W A Fowler, to continue his studies in nuclear structure on the Van de Graaff machines there. While there he made important measurements on the limits of parity violation in strong interactions, before returning to England to take up a research post in the new department of nuclear physics set up by Denys Wilkinson at Oxford University.

Using the tandem accelerators at Harwell and Aldermaston, and later the coupled electrostatic accelerators in Oxford, Neil supervised an expanding group of students exploiting new ion beams and new detectors, such as multigap spectrometers, to explore the theory of the giant dipole resonance and resonance fluctuations. In the 1960s, interest in pion physics brought him to the Synchrocyclotron at CERN and his close association with Ernst Michaelis helped him to become a valued member of the team.

Soon after arriving in Oxford, Neil was elected to a Fellowship at Hertford College, where he quickly went beyond his expected role as a dedicated tutor. Concerned about negative aspects of college admissions procedures, he initiated changes that helped applicants from state schools and improved the academic standing of the college. Outraged protests from those whose privileged positions had been undermined dwindled as the justice and the benefits of the reforms became apparent.



Nuclear physicist Neil Tanner (Courtesy Oxford Physics Department.)

Neil was also an enthusiastic supporter of the college boat club and was instrumental in the construction of a new college boathouse. After retirement he became the iconic patron of the physics society, named in his honour.

In the 1990s, Neil turned his attention to neutrino studies, strengthening the Oxford-based group at the Sudbury Neutrino Observatory in Ontario, Canada. He made important contributions to the optical design of the detectors and to the reduction of backgrounds.

Neil married in 1956 and is survived by his wife, Margaret, and by a daughter and two sons.

Friends and colleagues.

RECRUITMENT

For advertising enquiries, contact *CERN Courier* recruitment/classified, IOP Publishing, Dirac House, Temple Back, Bristol BS1 6BE, UK.
Tel +44 (0)117 930 1027 Fax +44 (0)117 930 1178 E-mail sales@cerncourier.com
Please contact us for information about rates, colour options, publication dates and deadlines.

HadronPhysics2

Study of Strongly Interacting Matter

Transnational Access to Research Infrastructure (TARI)
INFN - Laboratori Nazionali di Frascati

HadronPhysics2 - Integrating Activity

Contract No. 227431
01/01/2009 – 30/06/2011

TARI is the acronym for Transnational Access to Research Infrastructures. It is one of the three blocks of activities (networking, joint research and transnational access) that make up the Integrating Activity "Strongly Interacting Matter" (acronym: "HadronPhysics2"), financed by the European Commission and coordinated by INFN.

The objective of TARI is to provide researchers from Member States and Associated Countries with free access supported by the European Commission to the major research infrastructures in Europe.

Founded in 1955, the Frascati National Laboratories are the oldest and largest laboratories of INFN, the Italian agency devoted to fundamental research in nuclear and subnuclear physics. The LNF cover an area of 140000 m^2 and are located about 20 km from the centre of Rome. They can be easily reached by car, by plane (two international airports), by bus and by train.

LNF Facilities on the electron-positron machine DAΦNE supported by HadronPhysics2

* Particle and Nuclear Physics
* Beam Test Facility

The EC financial support will serve to provide access "free of charge" to external users, including all the infrastructural, logistical, technological and scientific support (including training courses, travel and subsistence for users).

Information about the Calls for Proposals for Access to LNF within Hadronphysics2, and the modalities for Applications, can be found at the LNF website, http://www.lnf.infn.it in the EU PROGRAMS section.

Max Planck Institute for Physics
(Werner Heisenberg Institute)

Physicist Positions

The *Max-Planck-Institut für Physik* (MPP) participates in the Belle and SuperBelle experiments at KEK in Tsukuba, Japan. For SuperBelle the MPP is developing a pixel vertex detector which has to work at extremely high luminosities, facing high backgrounds and radiation doses up to 10 Mrad. The detector will use DEPFET active pixel sensors, which are produced in the semiconductor laboratory of the *Max-Planck-Institut für Physik* and the *Max-Planck-Institut für Extraterrestrische Physik.*

The MPP offers two post-doctoral positions for this project, one with an emphasis on hardware development, and one on detector optimization and physics analysis. Successful applicants are expected to coordinate and supervise the development of the sensors and prepare for the physics analyses to come. Experience in the design, construction and operation of vertex detectors in colliding beam experiments, as well as experience in B-physics experiments would be advantageous. A third position is available for the analysis of the physics data from the Belle experiment. This position is linked to the flavor physics groups within the Excellence Cluster Universe. Applicants should have a strong interest in data analysis and B physics.

The three positions are immediately available. Contracts are initially limited to two years with a possibility of extension. Salary range and benefits are commensurate with the German public pay scale (TVöD Bund). 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 further information please contact Prof. Christian Kiesling (cmk@mppmu.mpg.de), or Dr. Hans-Günther Moser (hgm@hll.mpg.de), or Dr. Frank Simon (frank.simon@universe-cluster.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 March 31 2009 at the following address:

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

MAX-PLANCK-GESELLSCHAFT

Ericsson Industry PhD Studentship
University of Oxford

The University of Oxford has a **3 year STFC CASE studentship with Ericsson UK Ltd starting October 2009**. The student is expected to work on the **R&D of an optoelectronic readout system** for the Inner Detector at the CERN super-LHC.

Applications will be accepted until **13.03.2009**. For information about application formalities please visit:
http://www.physics.ox.ac.uk/pp/grad/Grad-appl_home_and_EU.htm
Applications are welcomed from all physics and engineering departments.

For information about the project please contact **Dr Cigdem Issever, c.Issever1@physics.ox.ac.uk or see http://www.physics.ox.ac.uk/pp/Ericsson%20Industry.pdf.**

The University of Edinburgh
SUPA Advanced Fellowship in Experimental Particle Physics
ATLAS experiment

Applications are invited for an Advanced Fellowship, tenable for up to four years. The particle physics group is in the process of joining the ATLAS experiment. We are seeking a scientist with a strong research record in particle physics to play a prominent role in shaping the portfolio of our activities within ATLAS. This will be in collaboration with the University of Glasgow as part of the Scottish Universities Physics Alliance.

Application details: http://www.jobs.ed.ac.uk/
Deadline: 25th March 2009
Contact: Dr. Phil Clark P.J.Clark@ed.ac.uk

For the best careers in physics, visit Jobs at **cerncourier.com**

BOOKSHELF

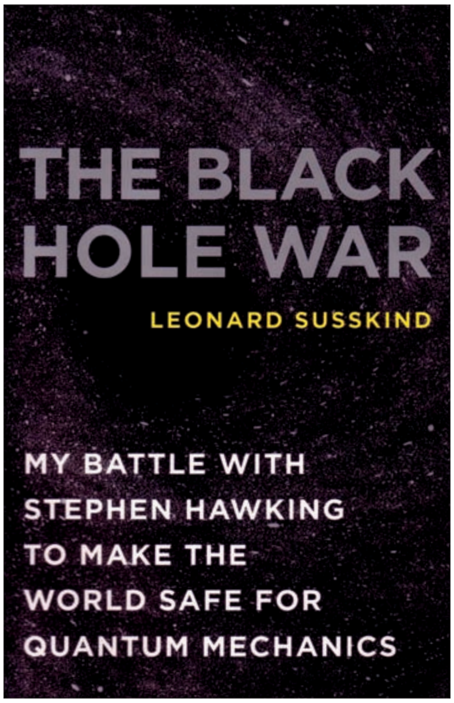
The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics by Leonard Susskind, Little Brown and Company. Hardback ISBN 9780316016407, $27.99.

Despite appearances, you will not encounter Stephen Hawking in an armoured wheel chair, Lenny Susskind wearing a short spade and a net, or Gerard 't Hooft with a spear and a shield; all three in the gladiator's arena. This book contains a lot of drama, but most of it happens in the heads of these physicists and in their discussions. All three, the main characters of the book, are good friends and respect each other profoundly.

In the 1970s Hawking studied quantum mechanics near black holes and made the remarkable discovery that they are not black after all. They radiate energy with an apparently thermal spectrum, the temperature of which is inversely proportional to the mass of the hole. For the black holes that occur in nature at the centre of galaxies, or as the final products of the deaths of supermassive stars, this radiation is completely negligible. So, what was the point? Elaborating on his computations, Hawking concluded that in this process, if some information is gobbled up by the hole once it passes its event horizon, it will be forever lost. There is no way to retrieve it.

This was the starting shot in the war, and what a shot it was. As Susskind explains in great detail, it rocked the boat of physics so badly that it almost caused it to sink.

The claim was made in the late 1970s but 't Hooft and Susskind learnt about it in a special meeting in 1981, in the attic of Werner Erhard (of "est" fame). Many physicists at the time dismissed the problem, but our two heroes recognized the mortal blow that it represented to the heart of quantum mechanics. A basic feature in the quantum description of nature is the conservation of information. In more technical terms, we believe that no matter how complex a process, it will never violate the unitarity of quantum evolution in time. The formation of a black hole out of ordinary stuff – and its subsequent evaporation – should not represent an exception despite its complexity. Hawking put his finger on a fundamental issue that hindered the possible unification of general relativity and quantum mechanics, which was a major preoccupation of Albert Einstein and many after him.



Hawking had clearly won, by surprise, the first battle. This we learn at the beginning of the book. The rest describes Susskind's strategy of attrition until he could claim victory a quarter of a century later.

In sharing the author's path to victory you will learn a lot of deep physics: the basis of quantum mechanics; the fundamental characteristics of black holes; the need to use string theory and some of its tools developed in the 1990s – arcane notions such as the principles of black-hole complementarity, the discovery of D-branes by Joe Polchinski and, above all, the holographic principle that appeared first in the study of the problem by Susskind and 't Hooft, but that was masterfully formulated in string theory by Juan Maldacena. There are many other heroes in this story: Strominger, Vafa, Sen, Witten, Callan, Horowitz, Giddings, Harvey, Thorlacius and Russo etc. – who all provided the ammunition necessary to demolish Hawking's edifice, to the point that he surrendered by around 2003.

In parts three and four of the book, the going gets necessarily rough. The ideas are deeply unfamiliar and one may from time to time feel some form of mental saturation. Being a consummate storyteller, the author punctuates the more difficult passages with a good deal of irreverent and iconoclastic humour. Read the chapter "Ahab in Cambridge". His description of life and academia in Cambridge, England, is hilarious. Indeed, throughout the book you will get a good number of laughs.

In all, the book presents a fascinating and intellectual adventure in accessible terms where you can learn some of the more challenging ideas in modern theoretical physics. The author follows to the letter Einstein's mandate of making things as simple as possible, but not simpler. It is original, honest, profound and fun. You could hardly ask for more.

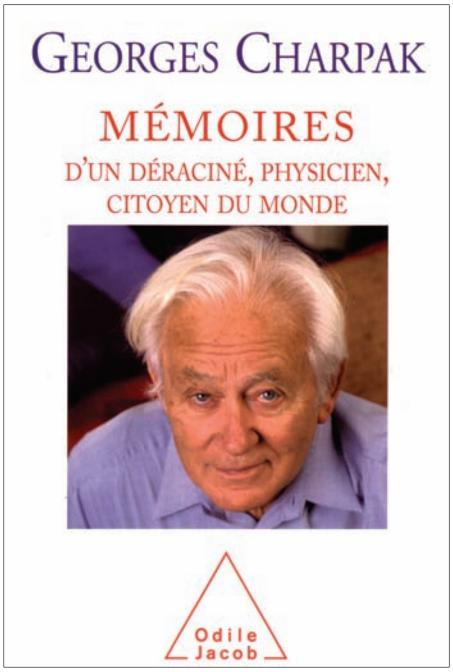
Luis Alvarez-Gaume, CERN.

Mémoires d'un Déraciné, Physicien, Citoyen du Monde by Georges Charpak, Odile Jacob. Paperback ISBN 9782738121844, €23.

Eighty-five years and at least three lives' worth of living unfold in the three sections of these memoirs by Georges Charpak with the contributions from François Vannucci, Roland Omnès and Richard L Garwin.

Uprooted as a child from his native town on the Polish–Ukrainian border during the anti-Semite persecutions of the Russian civil war, he narrates the tribulations of a central-European immigrant in the first part of the book, entitled "Déraciné" (Uprooted). This is the account of his incredible early destiny, from his arrival in France at the age of seven, through his brilliant secondary studies in Paris to his engagement in the struggle against Fascism and subsequent imprisonment, and finally his survival of deportation to Dachau.

Charpak's career as a physicist "started at age 24 and was more complex than that of most young French scientists". This sets off the second part "Physicien", which is entirely devoted to physics and – through the account of his career – a golden age of physics. After liberation, he first joined the Ecole des Mines ("not the right choice," he says on p24) before finally moving to the laboratory of Frédéric Joliot Curie at the Collège de France, where he specialized in particle detection. A detailed account follows of all the steps in the invention of the multiwire chamber, from Curie's lab through Charpak's career at CERN to applications in medicine. This is all complete with images, anecdotes and original documents. "One of the ambitions of the book," Charpak writes on the back cover, "is to show the extraordinary construction of particle physics in the space of one century". For this reason he asked Vannucci to write



an in-depth but accessible explanation of the meaning of the Standard Model, which is included in this section.

Another objective of the book is to "throw light on the imminent threat to all the treasures accumulated by civilizations over thousands of years, if we do not change radically the way that mankind manages its material and spiritual richness, its creativity and the education we give to children".
The last part, "Citoyen du monde" (Citizen of the world), written with Richard Garwin, details another chapter of Charpak's life, devoted to the teaching of science to the young and towards the cause of total nuclear disarmament – "le danger toujours plus pressant ... non seulement pour la paix mais pour la survie même de l'humanité" (the most pressing danger, not only for peace but for the survival of mankind).

Personal anecdotes provide another enjoyable feature of the book. As Charpak says, he "did not hesitate to describe ... his short-term dreams", such as his research on fossil sound in ancient objects and his attempts to sell a comedy scenario inspired by *Dr Strangelove* to Hollywood.
Paola Catapano, CERN.

Discrete Symmetries and CP Violation: From Experiment to Theory by Marco Sozzi, Oxford University Press. Hardback ISBN 9780199296668, £55 ($110).

During the past decade there have been important experimental results on CP violation both in the K-meson sector, with the precise measurement of ε'/ε, and in the B-sector, with the discovery of CP violation in B^0 decay. The state of the art was summarized in 2003 (*Uncovering CP Violation, Experimental Clarification in the Neutral K Meson and B Meson Systems* by K Kleinknecht, Springer 2003) and also in a number of summer schools' proceedings (e.g. *CP Violation in Particle, Nuclear and Astrophysics* by M Beyer (ed), Springer 2002, and *CP Violation from Quarks to Leptons* by I Mannelli, A I Sanda (eds), IOS 2006). However, the most recent textbooks dedicated to CP violation were published nearly 10 years ago (*CP Violation* by I Bigi and A I Sanda, Cambridge University Press 2000; by G C Branco, L Lavoura and J P Silva, Oxford University Press 1999). Thus, the time was ripe for a new compendium that would also discuss how the field might evolve and which problems remain unsolved. From the experimentalist's point of view, the new book by Marco Sozzi does the job very effectively.

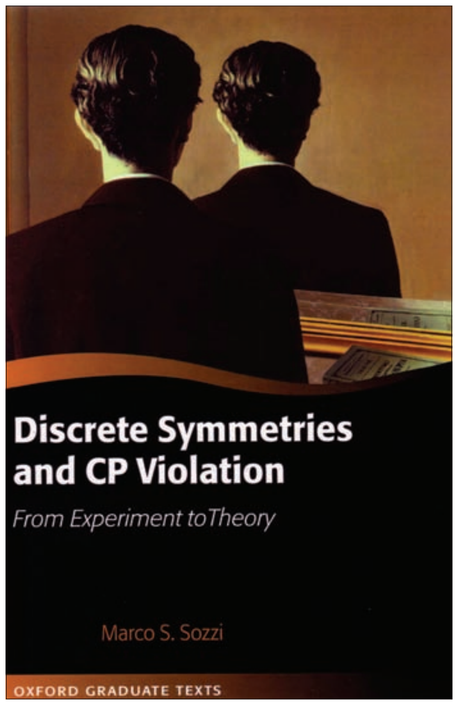
The book evolved from lecture notes for undergraduate and graduate students. With 550 pages subdivided into 11 chapters plus a coda, six appendices, nearly 600 references (about a quarter of them dated after the year 2000) and 28 experiments described in detail, it turns out to be not only a source book for courses in physics but also an excellent companion in the search for symmetry. It is 80 years since Hermann Weyl published *Gruppentheorie und Quantenmechanik*, which with Eugene Wigner's book *Gruppentheorie und hire Anwendung auf die Quantenmechanik*, published in 1931, was to provide the foundations for the study of discrete symmetries in the atomic and subatomic worlds. In this respect Sozzi's book stands on the shoulders of giants.

The book's structure is one of a modern encyclopedia. The chapters are all self contained, with suggested further reading and a number of exercises (a good method for some subtle topics but there are no hints to the solutions). Each opens with quotations by people ranging from Roger Bacon to members of the rock band Queen, and Sozzi inserts many more in the text to bring it alive.

Chapter 1 sets the general discussion on discrete symmetries, within a quantum formalism suited to the description of microscopic and elementary phenomena. The next three chapters deal with parity, charge conjugation and time reversal in some detail. Chapter 5 discusses CPT symmetry and the connection between spin and statistics. The breaking of CP symmetry – the topic of the title – is first introduced in general terms in chapter 6, where the reader learns how the kaon's features opened the way to the discovery of CP violation in 1964.

Contrary to the case of parity violation, CP violation was not immediately accepted by the whole physics community. A conclusive piece of evidence came just one year later with the detection of the interference between the two-pion state obtained from K_S decays and that obtained from the newly discovered K_L decays. In the words of the protagonists, the observation of CP violation was a purely experimental discovery – a discovery for which there was no precursive indication either theoretical or experimental. As Sozzi comments, "experiments come with a certain season, at a certain time, at a certain place" and, anyway, discoveries are still paced by technical advances.

Chapter 7 moves on to give details of the system in which CP violation was detected, namely neutral, flavoured mesons, while chapter 8 discusses the kaon system both from a phenomenological view and as a template for heavier flavoured mesons. These



heavier mesons are dealt with in chapter 10, which gives their relevance in determining the flavour structure of the Standard Model, briefly introduced in Chapter 9.

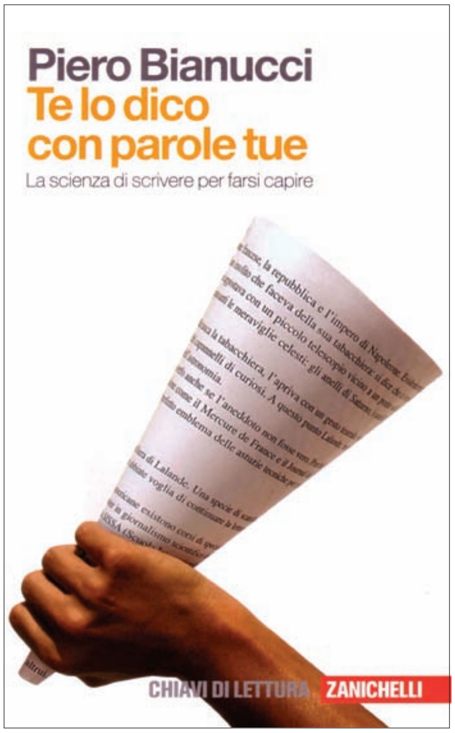
Finally, chapter 11 considers more speculative topics: the symmetries of the gravitational field; the strong CP problem; the cosmic connection with the possibility of an asymmetric universe and the three requirements that Andrei Sakharov thought necessary for baryon asymmetry to evolve from an initial symmetric state; and finally some of the baryogenic models within grand-unified theories. Nor are mirror matter and even chirality in living matter forgotten. The appendices provide a reminder of some of the theoretical tools and of how to handle systematic errors.

Te lo Dico con Parole Tue (Telling it in your own words) by Piero Bianucci, Zanichelli. Paperback ISBN 9788808195302, €9.80.

Piero Bianucci is a well known Italian science journalist. In 1981 he founded one of the most popular science weekly publications, *Tuttoscience*, nowadays a regular rendezvous for many readers and school classes. He is also the author of many books, mainly about astrophysics and cosmology. One noticeable thing about him is that, although not a scientist, his writing is always accurate and well documented. *Te lo Dico con Parole Tue* (unfortunately available only in Italian) is the first book in which he shares the secrets of a good science communicator.

The book is quite timely as scientists are increasingly requested to communicate to society not just the results of their work but, more specifically, its raisons d'être. They are "requested" in that funding increasingly depends on how well a given experiment is able to sell its objectives. The problem is that, in parallel, the scope of science broadens, and therefore specializes, so much so that even experts of the same level but in different fields may find it difficult to understand each other. Scientists often appear to become caught in webs of jargon where objects and procedures acquire strange names, thus increasing the distance between the original (and fascinating) curiosity-driven question and the practical work.

In this scenario, there is a major role for the scientific journalist. As Bianucci points out in his book, "the journalist is not just the translator of an obscure jargon"; he/she is



the missing link in the chain, the potential solution of the problem of communication between scientists and society. Bianucci gives guidelines on how to write a readable text, regardless of the initial intrinsic difficulty of the specific topic. He explains in practical terms how to select the information that is newsworthy, how to distinguish between trustworthy and non-trustworthy sources, and he advises on how to speak with the primary scientific source.

I liked the book. It gives clear examples, tells you real stories and reads so well that you can finish it in just a few hours. The book is multifunctional: if you are a journalist, you will find it to be a useful manual; if you are a scientist, you will learn how to turn your work into a story with media appeal; if you are a simply a reader, you will learn about effective science communication.

Antonella Del Rosso, CERN.

Books received

Beyond the Hoax: Science, Philosophy and Culture by Alan Sokal, OUP. Hardback ISBN 9780199239207, £20 ($34.95).

In 1996 Alan Sokal, a professor of physics at New York University, wrote a paper for the cultural-studies journal *Social Text*, entitled *Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity*. It was reviewed, accepted and published. Sokal immediately confessed that the whole article was a hoax – a cunningly worded paper designed to expose and parody the style of extreme postmodernist criticism of science. The story became front-page news around the world and triggered fierce controversy. In *Beyond the Hoax* Sokal turns his attention to a new set of targets – pseudo-science, religion and misinformation in public life. The book also includes a hugely illuminating annotated text of the hoax itself, and a reflection on the furore it provoked. This intelligent and lucid analysis will appeal to academic as well as general readers.

Concepts of Modern Physics: The Haifa Lectures by Mendel Sachs, Imperial College Press. Hardback ISBN 9781860948213, £29 ($58). Paperback ISBN 9781860948220, £16 ($29).

This book highlights foundational issues in theoretical physics in an informal and open style of lecture. It expresses the flow of ideas in physics — from Galileo and Newton to the contemporary ideas of the quantum and relativity theories, astrophysics and cosmology — as explanations for the laws of matter. The book leaves it to the reader to decide which of these 20th century ideas in science will carry over to the 21st century for our further comprehension of the laws of nature in all domains, from elementary particles to cosmology. Academics, undergraduates and general-interest readers will find this book a useful resource.

Quantum Mechanics: Its Early Development and the Road to Entanglement by Edward G Steward (contribution by Sara M McMurry), Imperial College Press. Hardback ISBN 9781860949777, £39 ($75). Paperback ISBN 9781860949784, £29 ($55).

This book explains the origin and establishment of quantum mechanics and explains mathematics in a digestible form along with a descriptive survey of developments up to the present day. The mathematical treatment closely follows the original treatment, but in modern terms, using uniform symbolism as much as possible and with simplifications (e.g. the use of one dimension instead of three) to avoid unnecessarily complicated mathematics. It will interest those studying physics as well as those studying the history of science.

The genius of Rutherford revisited

John Campbell takes a further look into the "father of the atom".

One of two stamps issued by New Zealand in 1971 to mark the centenary of Rutherford's birth. The formula represents his transmutation of nitrogen to oxygen by an alpha particle – the first induced nuclear interaction and in effect the first successful alchemy. (Courtesy J Campbell.)

In the December 2008 issue of *CERN Courier*, Cecilia Jarlskog delved into the Nobel Archives at the Royal Swedish Academy of Sciences to learn more about why Ernest Rutherford didn't receive a second Nobel Prize. In research for my book on Rutherford, I had access not only to the Nobel Archives but also to Rutherford's papers and other archives, which cast further light on this topic. From these I was also able to correct some common misconceptions about the young Rutherford, not least from Arthur Eve's excellent first official biography, published in 1937. For example, in the first nine lines of the first paragraph in Eve's book there are seven errors or points that need explanation.

Eve knew Rutherford from when he was a distinguished scientist until his death, and he was guilty – as are so many since – of wrongly projecting Rutherford's genius back into his childhood. As Jarlskog quotes, Eve wrote that Rutherford "had no difficulty in obtaining scholarships and prizes"; my own research found the truth to be quite the contrary.

The reality is that Rutherford in essence took two attempts at any scholarship he ever gained: from primary school to secondary school (and had Edward Paisley not crashed in English, Rutherford would never have received that one); from secondary school to the University of New Zealand (on his first attempt in 1888 he passed matriculation but did not come high enough on the list for a scholarship, so he stayed an extra year at school for another attempt); and from university to an overseas scholarship (he was ranked second of the two candidates who applied for the nomination to the sole biennial Exhibition of 1851 Science Scholarship available to New Zealand graduates, but the top candidate withdrew, leaving Rutherford's the only nomination for 1895).

It is true that Rutherford received the undergraduate maths prize every year while at Canterbury College. However, in his first year he shared it with Willie Marris (a classicist and later governor of Assam). In the second and third years he was beaten by, and then equal with, Marris. The prize was awarded to Rutherford because a student could hold only one scholarship and Marris also won the classics scholarship, which he elected to keep. It should not be overlooked that there were only four or five candidates each year in mathematics with honours. In summary, Rutherford obtained his early prizes and scholarships through hard work and perseverance, not from natural brilliance.

The missing second Nobel

When it comes to a second Nobel Prize, Rutherford made several discoveries and inventions that, had they been his only discovery, would have made him a serious candidate. For example, on arrival at Manchester, Rutherford, an expert in the conduction of electricity in gases, needed a less tiresome method of recording alpha particles. So with the help of the excellent assistant whom he had inherited, Hans Geiger, he developed the Rutherford–Geiger detector, which with later minor modifications became the Geiger–Müller tube. There have been nine Nobel Prizes awarded for detectors of ionizing rays and particles, but there has never been one for the first detector to record arrivals permanently – which became the oldest type still used in everyday service.

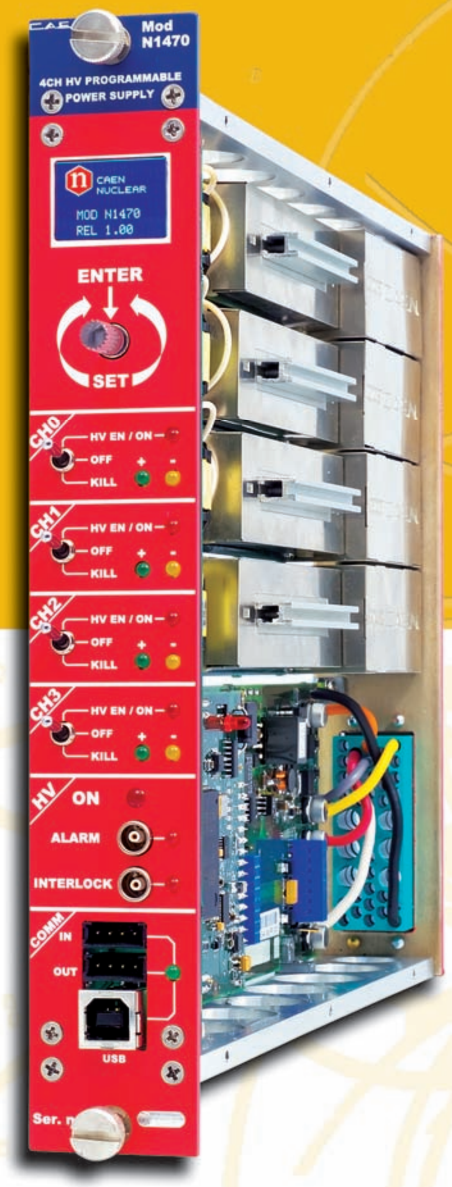
Some 26 Nobel Prizes have been awarded for the discovery of, or theories linking, subatomic and subnuclear particles. This began with the electron but there was never one for the nuclear atom or the proton. The Nobel Committee thought that Niels Bohr, who got his start in Rutherford's lab and placed the electrons around Rutherford's nuclear atom, had made the bigger advance. Had Rutherford not already received a Nobel Prize, it would have been appropriate that he and Bohr shared one.

There were five Nobel Prizes awarded for inducing nuclear reactions (induced radioactivity, neutron activation, fission, the accelerator and transuranics), but there was never one for the first induced nuclear reaction, when Rutherford did so using alpha particles in 1918. Put another way, it is curious that there was never a Nobel Prize for the world's first successful alchemist – Rutherford changed nitrogen into oxygen, which was an endeavour that had eluded chemists for centuries.

There are several other examples of work that deserved, but failed, to win a second Nobel Prize. The Nobel Archives explain why. After the 1908 prize, Rutherford's later discoveries and the elite positions that he occupied meant that a second prize would not have enhanced his already great fame. As the eulogy in the *New York Times* more eloquently stated: "It is given to but few men to achieve immortality, still less to achieve Olympian rank, during their own lifetime. Lord Rutherford achieved both. In a generation that witnessed one of the greatest revolutions in the entire history of science, he was universally acknowledged as the leading explorer of the vast infinitely complex universe within the atom, a universe that he was first to penetrate."

John Campbell, University of Canterbury, is the author of Rutherford Scientist Supreme *(AAS Publications 1999) and www.rutherford.org.nz, and producer of an upcoming documentary,* Rutherford.

CAEN Tools for Discovery Electronic Instrumentation



N1470

High Performance - Low Cost

4 Channel Programmable HV Power Supply

- 4 channels in 1U NIM module
- Automatic range selection: ±3 kV / 3 mA, ±4 kV / 2 mA, ±8 kV / 1 mA
- Channels with individually selectable positive or negative polarity
- SHV coaxial output connectors
- Common floating return
- Low Ripple (typical <15 mV)
- 16 bit resolution
- Up to 5nA Imon resolution
- Programmable ramp-up / ramp-down (1-500 V/s)
- Under/over-voltage alert, overcurrent and max. voltage protection
- Graphic colour display
- Daisy-chain capability
- Local control
- Remote control (USB2.0/RS485) and TCP/IP via CAEN NIM 8301 crate
- Interlock logic for board enable
- Selectable DC input

Can be a System!

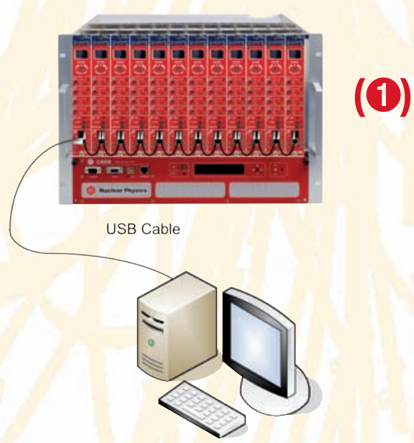
- **Remote control up to 128 channel**
- **Modules daisy-chained can operate in several Crate**

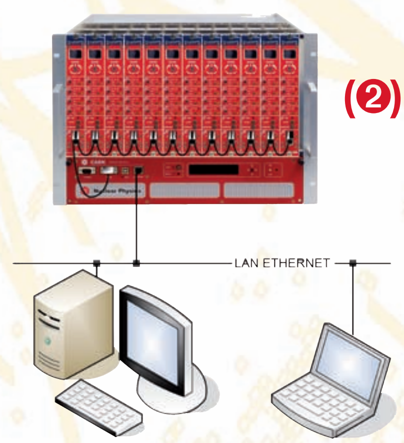
Module control can take place either locally, assisted by a Graphic colour display, or remotely, via USB (1) or RS485 (1)

It is also controllable via TCP/IP (2) by the Smart Fan Unit of CAEN NIM 8301 crate

Voltage & Current analogue monitor **HV-ON LED**

New innovative local control: encoder and colour display will make the setting easier than ever!





www.caen.it

Small details Great differences